thermo scientific

Helios G4 PFIB
HXe / UXe / CXe models
User Operation Manual

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ThermoFisher
SCIENTIFIC

FreeRTOS Licensing Information

This product contains FreeRTOS software. Upon request, Thermo Fisher Scientific Company will provide you with the FreeRTOS source code and any modifications to the FreeRTOS source code made by Thermo Fisher Scientific.

Trademark Acknowledgments

Production Acknowledgments

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Helios G4 PFIB
Table of contents

Chapter 1 Overview

Helios G4 PFIB Series List of Features 8
DualBeam System 11
System Components 12
Options 15

Chapter 2 Safety & Handling

User safety manual 17
General Guidelines 18
Site Requirements 18
Handling System Crates 18
User's Guide Messages 19
System Operation, Maintenance and Service 20

Chapter 3 System control

System Layout 22
Hardware elements 22
Power off 26
System states 27
Vacuum system 37

Chapter 4 User Interface

Software 40
Software interface elements 41
Microscope Server Software 45
Microscope Control Software 48
Entering Commands 152

Chapter 5 Getting Started

Starting the UI 160
Guide to System Settings 161

Beginning Your Session 162
Preparing the Sample 167
Obtaining an Image. 169
Working with Detectors 171
Optimizing the Image. 187
Selecting Beam Conditions 197
SEM Imaging Modes. 200
Capturing and Handling a Single Image 206
Recording Movies (Multiple Image Capture) 211
Stage Movement Limits 219
Moving the Stage. 221
Nav-Cam (In-Chamber Navigation Camera) 232

Chapter 6 EasyLift NanoManipulator

About EasyLift 235
EasyLift Software Control 236
EasyLift: Needle Exchange/Calibration Alignment 241
EasyLift Needle Control 246

Chapter 7 Patterning & Milling

Patterning 248
Rocking Polish 274
Application files 284
Milling 288

Chapter 8 Gas Injection System & MultiChem

Gas Injection module 303
MultiChem 307
Basic Processes 312
Precautions 319
MultiChem Gas Names 320

MultiChem Pattern Application Files 320
MultiChem Supervisor Alignments 321

Chapter 9 Alignments

About Alignments 328
General Description and Structure 331
Alignment List 333
E-column: Emitter Startup 335
E-Column: User Alignments 336
E-Column: Supervisor Alignments 337
E-Column: Auto U-Mode Source Centering 338
E-Column: Aperture Map Selection 339
E-Column: Magnification Correction 340
E-Column: Supervisor tests 341
210 - Ion Column Alignment 342
I-column: Aperture Lifetime 343
I-column: Alignments 344
Source Mechanical Alignment 345
Stage Alignments 346
External Plasma Cleaning / Plasma Cleaning 347
Vacuum Actions 349
Detectors Alignments 350
Automatic Alignments 351

Chapter 10 Applications

Account Manager Application 356
Data BackUp Application 361
Diagnostic Auto Report Application 362

Chapter 11 Maintenance

Cleaning Procedures Overview 364

Stage Maintenance 366

Chapter 12 System Options

Manual User Interface 370
Manual User Interface GC 371
Joystick 372
Uninterruptible Power Supply (UPS) 373
External Current Measurement (Keithley Picoamper Meter) 375
Fast Beam Blanker 376
Multi Stub Holder 376
I-Beam Charge Neutralizer 377
CryoCleanerEC 380
Quick Loader 386
CryoMAT Loader 395
Mirror Detector Protective Shutter 406

1 Overview

This chapter provides a brief description of the Helios™ G4 PFIB Series DualBeam™ systems.

Topics include:

- *Helios G4 PFIB Series List of Features*
- *"DualBeam System" on page 11*
- *"System Components" on page 12*
- *"Options" on page 15*

The Helios G4 PFIB series DualBeam systems integrate ion and electron beams for FIB and SEM functionality in one machine. Users can switch between the two beams for quick and accurate navigation and milling. Convergence of the SEM and FIB at short working distance allows precision "slice-and-view" cross-sectioning and analysis at high resolution.

The Helios G4 PFIB series DualBeam systems are unique in their ability to deliver the fastest TEM sample preparation performance in addition to providing highly flexible failure analysis capability on advanced semiconductor devices.

This SEM/FIB combines the most advanced scanning electron microscope (SEM) and focused ion beam (FIB) technologies with innovative gas chemistries, detectors, and manipulators. Featuring unsurpassed SEM resolution, image quality and stunning Tomahawk™ (Helios PFIB HX, CX) and Phoenix™ (Helios PFIB UX) FIB performance, imaging, milling, or preparing samples is fast and easy for semiconductor and data storage labs, research facilities and industrial applications.

Helios G4 PFIB Series List of Features

- A separate support PC offers a connection to a local area network (LAN).
- 1920 × 1200 screen resolution on up to three LCD monitors.
- The user interface integrates all functionality within a Microsoft® Windows® operating environment for full digital control.
- The high accuracy five-axis (X, Y, Z, Rotation, Tilt) stage provides full coverage of samples with computer control and automation of all axes for precise sample manipulation.

  There are 3 microscope models differing in the stage:

  HXe: ultra high resolution stage
  UXe: 110 mm stage
  CXe: 150 mm stage
- Automatic vacuum system with turbo-molecular pumping.
- The **EasyLift** manipulator supports higher yields for TEM sample lift-out through an intuitive, integrated user interface and attachment to a TEM grid for further analysis. It allows for final thinning of the sample to be accomplished after attachment to the TEM grid holder.
- **Gas Injection System** (GIS) – Advanced control of gas chemistries including proprietary gases for enhanced precision deposition or bulk material removal.
- **MultiChem** (up to 6 gaseous, liquid, and solid precursors) gas delivery system for optimized beam assisted deposition or etching based on gas mixing.
- **iFast Developer's Kit Professional** software and starter recipes for either ex-situ lift-out or in-situ inverted samples to provide a solid platform for implementing customized sample recipes to locate and process demanding features in a routine manner.
- **Cell Navigator**™ is an integrated software application used to count to a target cell for processing after locating a defect electrically. SEM-based, damage-free, robust, and reliable, Cell Navigator's stage-less navigation solves the problem of cell counting.
- 3-point alignment for improved navigation accuracy on individual die and conversion to user-based coordinate system.

- Navigation Alignment allows alignment of imported images for location of subsurface features and high-accuracy beam placement.
- The MUI (manual user interface) offers additional flexibility for controlling magnification, beam shift, focus, contrast & brightness, and astigmatism correction.
- Optional retractable **DBS** detector.
- The design of the optional retractable **STEM 3+ detector** improves the sensitivity to materials with similar atomic mass.

Figure 1-1 Helios G4 PFIB HXe

User Interface

The user interface consists of a single high-level user shell employing applications programs with vector parameter files defining specific instrument settings for particular applications ensuring reproducibility of complex procedures.

An intermediate software layer, acting on instructions from the application layer, controls the column, detector(s), stage, EDX, and vacuum functions. This layer also provides management of image capture, storage, and data output devices.

A manual user interface (MUI) offers additional flexibility for controlling magnification, beam shift, focus, contrast and brightness, correcting an astigmatism.

Localization

If any language is localized within the UI, a user can select it from the drop-down menu on the right side of the menu bar.

User Logon

All user level accounts run under the same Windows 7 account, and are the only types of account available to the customer under normal circumstances.

Refer to the Startup chapter for startup and logon/logoff functions.

Online Documentation

Access this document and related documents in PDF format at any time by pressing **F1** or by selecting **Help > Online Documentation**. Click a hypertext link in the menu that appears to access the desired document.

DualBeam System

Users can switch between the two beams for quick and accurate navigation and milling.
See *"Principles of SEM Imaging " on page 169.*

Ion Column

The Phoenix™ and Tomahawk™ ion columns provide fast, precise and reliable milling, patterning, and ion imaging of the sample surface. The exceptional low-voltage performance is proven to produce the world's best quality thin samples for high resolution scanning TEM (S/TEM) or atom probe microscopy. It has excellent ion image resolution: 4.5 nm (4.0 nm) @ 30 kV at coincident working distance (WD). With its integrated differential pumping and time-of-flight correction, the ion column also delivers a tighter beam and a more accurate scan profile for extremely precise ion milling.

Electron Column

The Elstar™ electron column with the UC+ source mode (only Helios G4 PFIB UX) takes advantage of Thermo Fisher Scientific most advanced Hexalens™ design for ultimate image resolution at low beam energies. It offers nondestructive imaging capability at a working distance optimized for ultrahigh resolution and can produce images magnified over 500 000× in SEM mode 1 and > 2 500 000× in the SEM Mode 2.

FIB/SEM Capabilities

FIB/SEM DualBeam systems provide an expanded range of capabilities not possible with separate FIB and SEM tools:

- Electron beam high-resolution images of FIB cross sections without eroding the feature of interest.
- Real-time cross-section images with the electron beam during FIB milling.
- Focused electron beam charge neutralization during FIB milling.
- Focused ion beam charge neutralization during SEM imaging.
- High resolution elemental microanalysis of cross sections.
- Image sample surface with the electron beam during navigation without erosion or gallium implantation from the ion beam.
- TEM sample preparation with *in situ* conductive coating.

Control of the Beams

DualBeam systems ideally position the point of interest for simultaneous ion beam cross-sectioning and electron beam viewing. Separate scan generators for the two beams permit coupled or independent scan patterns and magnifications. Imaging while milling aids in defining milled features.

Immediate electron beam images of cross sections are possible without stage motion or sample transfer. Immediate high-resolution SEM imaging after FIB milling also prevents exposure of milled cross sections to atmospheric contaminants.

System Components

Imaging

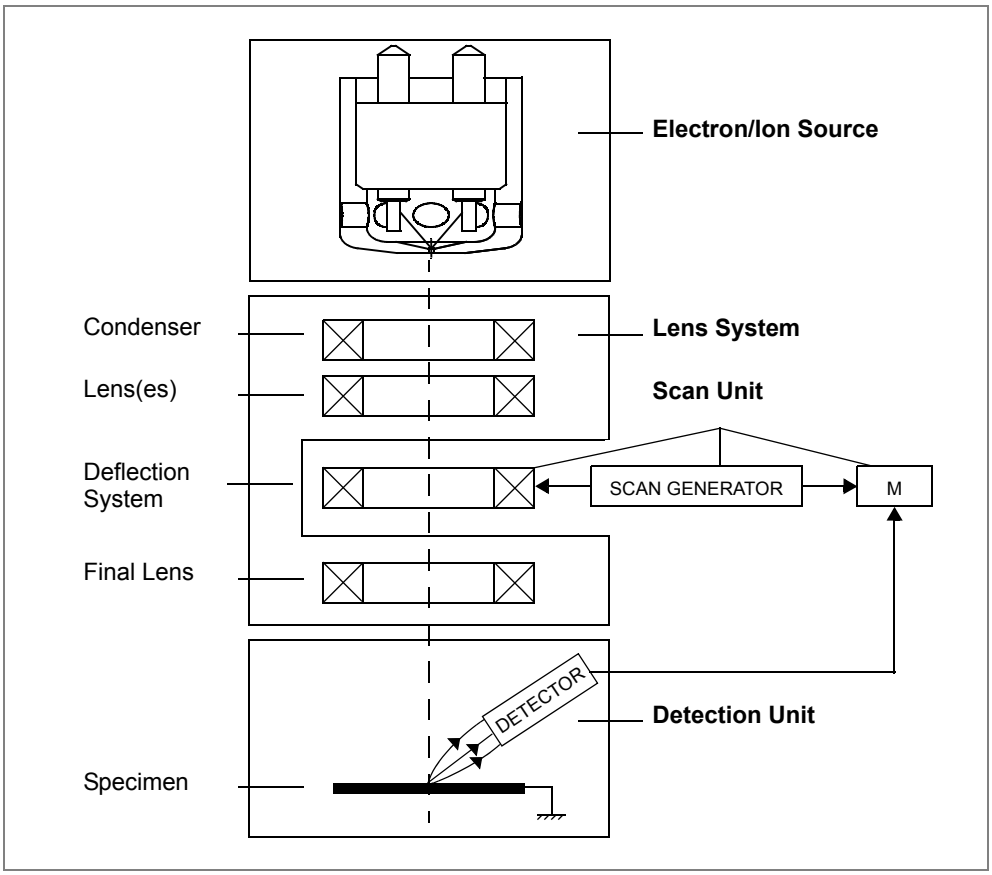
The main components used for imaging of the samples:

- **Electron / Ion source**
  The beam of electrons or ions (particles) is emitted within a small spatial volume with a small angular spread and selectable energy.
- **Lens system**
  The beam enters the lens system consisting of several electromagnetic or electrostatic lenses and exits to hit the specimen surface.
- **Scan unit**
  The scan generator signal, fed to the deflection systems, moves the beam in a raster pattern over the specimen area. This signal, modulated by the detection system signal produces the onscreen imaging of the specimen surface.
- **Detection unit**
  Particles striking the specimen react with atoms of the sample surface in various manners:

  – The electron beam produces electrons and photons (X-rays).
  – The ion beam produces ions, electrons, and photons (X-rays).

  The detector system picks up the particles or photons, converts them into a digital signal which is then sent to the control PC and shown on the monitor.

Figure 1-2 Column Schematic Overview



Computer Control

The xT microscope Server and Microscope Control (user interface) software integrate SEM and FIB functionality within a Windows 7™ operating environment.

These software consist of programs defining specific instrument settings for particular applications, ensuring reproducibility of complex procedures (for instance imaging, management of image capture, storage, and data output devices, etc.). They also control instrument hardware (the column, detector(s), stage, EDX, vacuum functions, etc.).

Vacuum System

The entire particle path from electron and ion sources through their respective columns to the specimen must be under vacuum so that the particles do not collide with air molecules. Various levels of vacuum are necessary, so a Turbo Molecular Pump (TMP) backed by a scroll pre-vacuum pump (PVP), obtains the necessary specimen chamber pressure.

In operation, the electron column is always pumped to high vacuum. The specimen chamber is at the pressure required for the given state.

Stage

The Helios G4 PFIB system has a computer-controlled high-accuracy five-axis piezo stage for small samples. It offers precision sample computer software controlled manipulation and automation of all axes for overall spatial orientation on highly repetitive or extremely irregular samples.
See *"Stage Movement Limits " on page 219*.

Sample exchanges take place through a chamber door that exposes the specimen stage when opened. An exchange through the chamber door takes several minutes. Optional Quick Loader could be used instead.

Software and interlocks protect the system against a damage and users against an injury.

Gas Injection System

Multiple gas injectors can be installed for material deposition in conjunction with either electron or ion beam pattern definitions. Electron beam-induced deposition offers the advantage of not sputtering the deposited material or implanting gallium simultaneously.

Flexible, reliable, and safe gas injection system (GIS) also provides enhanced etching capability for high aspect ratio milling with minimal redeposition, preferential etching of cross-section surfaces prior to SEM imaging, and rapid milling of TEM sections.

Up to five GIS beam chemistries can be installed on the system, depending on the system configuration. This self-contained apparatus allows the precursor material to be contained entirely within the vacuum system for simple, flexible, and safe operation.

See *"Gas Injection module" on page 303* for more information.

MultiChem Gas Delivery System

MultiChem is an option on the Helios G4 PFIB system.

See *"MultiChem" on page 307* for more information.

Image Viewing and Capture

Because the amplified detector signal is shown synchronously with the beam scanning, there is a correspondence between brightness of an image point on the monitor screen and the signal detected at the corresponding point on the specimen.

Magnification is the ratio of the size of the viewing monitor screen to the size of the area scanned on the specimen. Higher magnification is achieved by reducing the size of the area scanned on the specimen.

Analysis Capability

Convergence of the SEM, FIB, and X-ray detection system (e.g., EDX—Energy Dispersive X-ray or EDS—Energy Dispersive X-ray Spectroscopy) at short working distance allows precision "slice-and-view" cross-sectioning and chemical analysis at high resolution of surface and subsurface features.

Various vendor options are compatible with the instrument.

Options

A range of hardware and software options are available for your system. This range will be extended when new items become available.

See *"System Options" on page 369* for detailed information.

Contact your Thermo Fisher Scientific sales representative for detailed information on system options.

2 Safety & Handling

This chapter contains safety and handling guidelines for operating the system.

Topics Include:

- *"General Guidelines" on page 18*
- *"Site Requirements" on page 18*
- *"Handling System Crates" on page 18*
- *"User's Guide Messages" on page 19*
- *"System Operation, Maintenance and Service" on page 20*

User safety manual

The dedicated User safety manual provides information for personal safety and maintenance procedures while operating this system.

This manual is provided both as a PDF and hard copy print out and is required reading for the end user. It is accessible directly from the Microscope Control software (UI) from the **Help** menu / **Safety Manual** item.

General Guidelines

- Do not operate the system until you have a thorough understanding of this safety section. There may be additional limitations to safety and handling mentioned elsewhere in this manual.
- Do not remove or bypass any safety items or electrical circuits.
- Never operate the equipment with any guards or shields missing. If it is necessary for guards and shields to be removed for service, replace them before operating the equipment.
- Obey all **WARNING** and **CAUTION** signs mounted on the equipment. Do not remove any of these signs.
- Do not operate the equipment at a temperature higher than the maximum designed limit stated on the equipment data plate.

Site Requirements

Verify that the site safety and environmental requirements, which are the responsibility of the operator, are satisfied. This information can be found in the system specifications and/or preinstall documentation.

In particular, pump exhaust requirements, electrical supply and grounding (earthing) requirements, and floor loading (plus any local codes regarding earthquake safety) are important safety issues.

Handling System Crates

Do not open the system crates without an Thermo Fisher Scientific service engineer or representative present. If crates are opened prior to the arrival of an Thermo Fisher Scientific service engineer or representative, the system warranty may be invalidated.

WARNING!	**TIPPING HAZARD** Crates are heavy. To avoid tipping, refer to crate markings for centers of gravity.

User's Guide Messages

The User's Guide contains NOTE, CAUTION, WARNING, and DANGER messages to which you should pay close attention. These messages provide important information for safe operation.

NOTE	A Note emphasizes information requiring special attention.
CAUTION	A yellow Caution message appears when special handling is required to prevent product damage.
WARNING!	An orange Warning message appears when special handling is required to prevent personal injury or death.
DANGER!	**HAZARD DESCRIPTION** A red Danger message identifies an immediate personal risk of injury or death and gives appropriate precautions.

System Operation, Maintenance and Service

Only Thermo Fisher Scientific trained service engineers may perform service and maintenance. Operators and service personnel must be trained on potential safety hazards and safe techniques, and must observe all warnings and cautions encountered on the system and in the manuals. **No person should perform any operation without prior training.**

NOTE	Only service personnel certified by Thermo Fisher Scientific are authorized to service the equipment.

If conditions arise under which you do not know how to proceed, contact Thermo Fisher Scientific Customer Service at 1-503-726-2800, or email *cshelpdesk@fei.com*. Within the United States use the toll free number 1-866-MYFEICO (1-866-693-3426).

Thermo Fisher Scientific electron optical equipment is perfectly safe when correctly installed and operated. However, when **inexpert (unauthorized) modifications** are made, the following hazards can occur, which can result in personal injury or equipment damage if recommendations and instructions are not followed.

- Shock hazard
- Radiation hazard
- EMC hazard
- Mechanical hazard
- Static magnetic hazard

Deviating from directions given by Thermo Fisher Scientific Company may void your warranty. If you have any doubt regarding procedures, contact safety personnel at your company, Thermo Fisher Scientific, or representatives of your state, territory or province, or federal government.

3 System control

Topics include:

- *"System Layout" on page 22*
- *"Hardware elements" on page 22*
- *"Power off" on page 26*
- *"System states" on page 27*
- *"Vacuum system" on page 37*

NOTE	Before starting the system, verify the presence of: • Electrical power • Compressed air • Cooling water • Nitrogen for venting With the exception of nitrogen, interlocks prevent the vacuum system from operating if the others are not present.

System Layout

The table top includes the EMO switch, system power button, at least two flat panel monitors, keyboard with MUI, joystick, and mouse. Two computers sit on the floor beneath the tabletop.

Other Software and Hardware

Call Customer Service for advice before installing software or hardware that is not required for system operation. Other software, such as screen savers or hardware network cards, may corrupt the system control software under some circumstances and may invalidate the warranty.

For more detailed information about Windows® 7, refer to the *Microsoft® Windows™ User's Guide* shipped with your system.

Hardware elements

The system is computer-controlled. As such, it has a *Microscope Computer* that must be turned on (use the power button on the PC) to operate the microscope by means of the software. It contains all system and application software plus online documentation. It activates the startup conditions for the system from a software base.

The *support computer* (option) can hold some other software utilities. It is connected to the local area network (LAN) and acts as a firewall to the system. It contains the Navigator™ application software as well as communications with the EDS systems.

The *switch box* switches the keyboard and the mouse to either of the two computers.

The control software facilities and data are shown graphically on the *LCD monitor* and are superimposed around and on the image. The other LCD monitor is used either as an extended desktop of the Microscope computer or as the Support computer monitor.

To control software utilities, one can use a *keyboard*, a *mouse*, the *joystick* (option) or the *Manual User Interface* (option).

System Power button

The console / system power is activated by pressing the power button located on the microscope console front panel. This switches the sub-systems on and allows the interface and communication with the Microscope computer, from which most of the functions are activated via the software control.

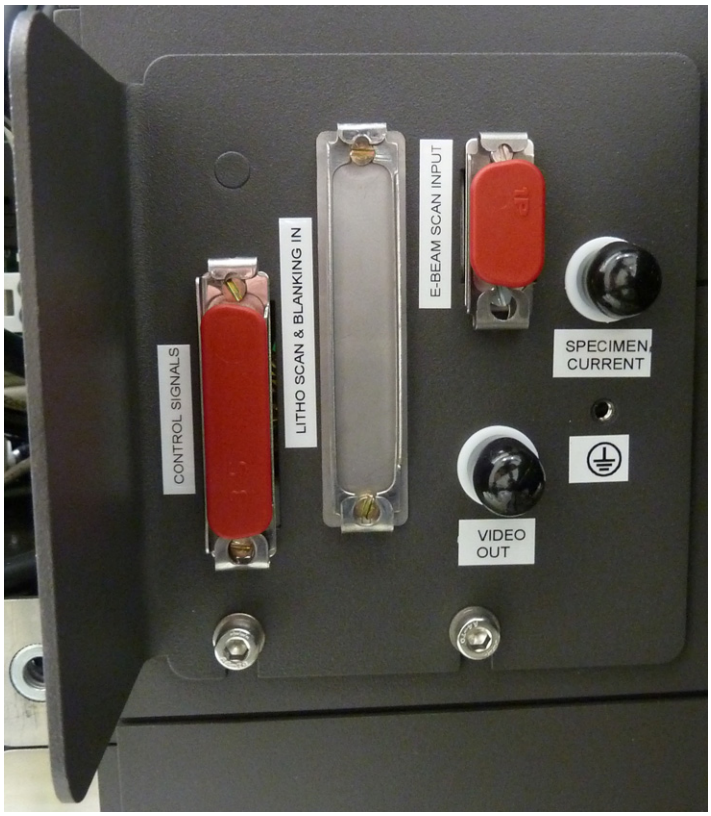
The power button indicates several system states:

- *green lit* – the Full Operation state
- *amber lit* – the Standby system state
- *not lit* – the Complete shutdown system state

Figure 3-1 System Power button

External connectors panel

The External connectors panel is located on the back of the microscope console.



It is used to connect 3rd party equipment to the following connectors:

- CONTROL SIGNALS / E-BEAM SCAN INPUT / VIDEO OUT

  These connectors are used for the connection of EDX, WDX and lithography systems, provided by 3rd party suppliers. Do not connect anything else to these connectors!

- SPECIMEN CURRENT

  This connector is used together with the Keithley picoamper meter (option) equipment.

- Ground point

  The point is intended for a defined ground connection between a microscope and a 3rd party module. This connection is not a safe ground!

- ELPHY SCAN & BLANKING IN

  Not used.

Mains switchboard

The Mains switchboard is located on the back of the microscope console.

Output power sockets are used for other microscope optional equipment.

WARNING!

Power sockets are used for equipment delivered and installed by Thermo Scientific. It is forbidden to use these sockets by a user for any purpose!

Breaker switches

- PVP1 F5
- PVP2 F6
- BAKE OUT IGP F4
- BAKE OUT EC F2
- PC&MICR F1
- MAINS S1

Mains input 230 VAC (the large blue plug) is placed under the MAINS S1 breaker switch.

Power off

The system has protection against power failures in the sense that the different components of the system are not likely to be damaged. However, a power failure is never good for the system. It might affect the ultrahigh vacuum levels of the columns and the overall stability of the system.

Take sufficient measures to avoid power failures. If a power failure occurs while the instrument is completely operational, the microscope enters a safe state and the following happens:

- Electron and ion accelerating voltage is switched off.
- Electron and ion emission is switched off.
- The specimen chamber automatically vents gently.
  The vacuum in the instrument is no longer supported by running pumps. The column isolating valves close to save the vacuum in the source area.
- The microscope computer and the support computer are switched off. The momentary adjustments of all system parameters (accelerating voltage, magnification, stage positions, etc.) are lost if they have not been saved prior to the failure.

NOTE	If the power failures occur occasionally it is recommended to use the microscope Uninterruptible Power Supply (UPS - option).

If the system was down less than 45 minutes, it can be recovered according to the returning to operation after Complete shutdown state procedure (see below). If the system has been off for a longer time, an Thermo Fisher Scientific service engineer may have to bring the system back into operation.

Emergency off

This is similar to that which would happen after a mains power off (see above).

WARNING!	The microscope console water chiller (option – separate device in the microscope vicinity) is powered separately via its individual power cord. Hazardous voltages may be present in this equipment even when the microscope power plug is disconnected!

CAUTION	An Thermo Fisher Scientific service engineer or an authorized user must restart the system after an emergency power off.

EMO buttons (optional S2 kit)

To switch off the electrical power completely in case of emergency, push any of the red EMO (*Emergency OFF)* buttons arranged in the vicinity of the system (see the User safety manual).

Emergency Off without EMO buttons

Switch off the Mains breaker labeled **MAINS S1** (see Mains switchboard above),

or

Disconnect the mains plug from the microscope console mains input socket or from the electrical connection box (see User safety manual).

System states

The systems is started at the time of installation to obtain an adequate high vacuum and will remain on unless there is a power failure or emergency. There are several system states:

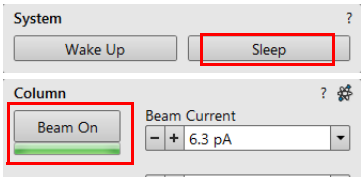
- *Complete shutdown* – for service and emergency reasons
  This state can be set only by a Thermo Fisher Scientific engineer.
- *Standby* – for when the system will not be used for a longer period
- *Overnight* – for when the system will not be used overnight
- *Full operation* – when the system working

Overnight state

If you don't plan to use the system overnight, follow the procedure:

1. Log off an actual user.
2. Switch off the monitor.

If you don't plan to use the system for several next days, follow the procedure:



1. Click **Sleep** button on the Beam Control page.
   The ion column source switches off completely. This is seen by reduction in the Source progress bar in the column module when the ion beam is selected.

NOTE	Turning off the ion column source impacts its lifetime.

Caution!	The GIS heaters are also switched off, but not the MultiChem heaters!

2. Click **Stop UI** on the Server bar. This action also logs off the current user.

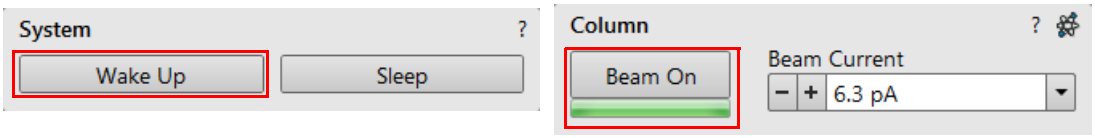
3. Switch off the monitor.

Returning to operation

1. Switch on the monitor.
2. Log on to the UI.
3. Turn on the accelerating voltage of the beam(s) and GIS / MultiChem heaters (if needed).

When the last session was ended by the Sleep button:

4. Click the **Beam Control** page or the **Sample Exchange** window / **Wake Up** button. The ion column source turns on. This is seen by an increase in the Source progress bar in the column module when the ion beam is selected.



The high voltages are also switched on, the CIVs are opened, and the GIS heaters are turned on.

The Beam Control page then indicates that the system is ready and only the **Sleep** button is active.

Standby Mode

Standby mode is a system shutdown process different from the system being completely turned off. It is used when the system will not be used for longer time.

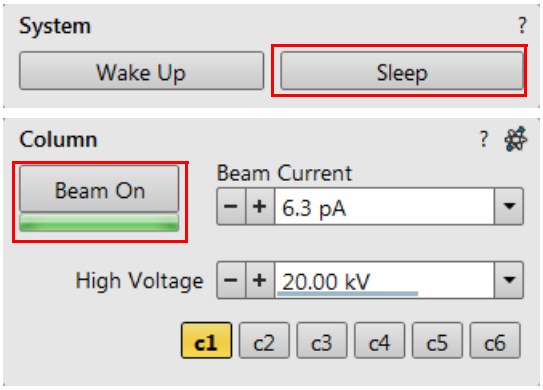
In the Standby state, most of the components are turned off. The only things left powered are the ion column IGP, electron column IGPs, electron emission, roughing pumps, and turbos. The chamber is **not** vented.

The system can be left in this state if utilities (water, air, nitrogen), other than electrical need to be disconnected. When Standby state is selected to recover from a failure, it is better then to restart the microscope PC before restarting the microscope.

The system power button will be amber during standby.

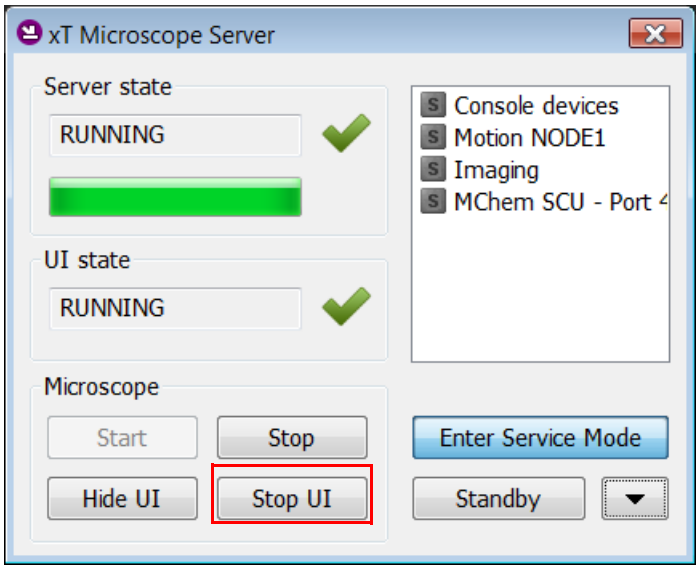
To enter Standby state

1. Remove your sample, if needed, and pump down.
2. On the Beam Control page, click **Sleep**. The ion source and HT, as well as the electron HT, will be turned off.



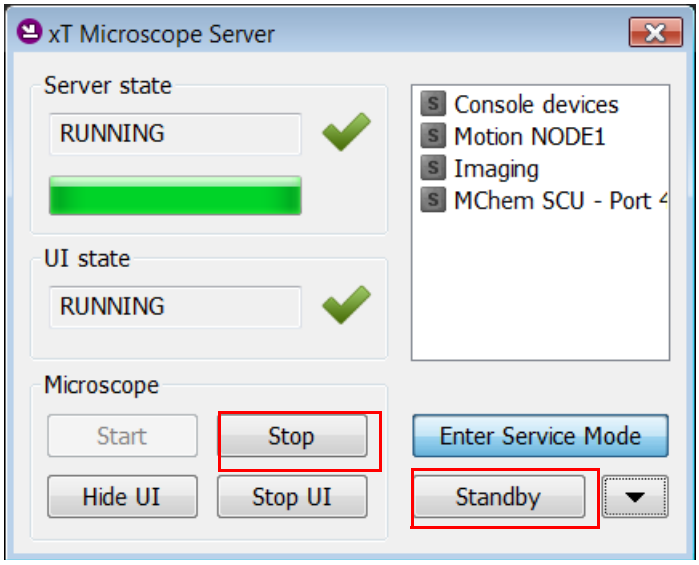
3. Select **Stage > Tilt 0°** (**Ctrl** + **E**).

4. Click **Stop UI** to stop the UI.



5. Double-click the **green progress bar**.

6. Click **Stop** to stop the server. Wait until the xT microscope Server stops, then click **Standby**.



7. Select **Yes** in the dialog box that appears and the system will enter the Standby mode.

   It is possible now to shut down the system and support computers if needed.

Returning to operation

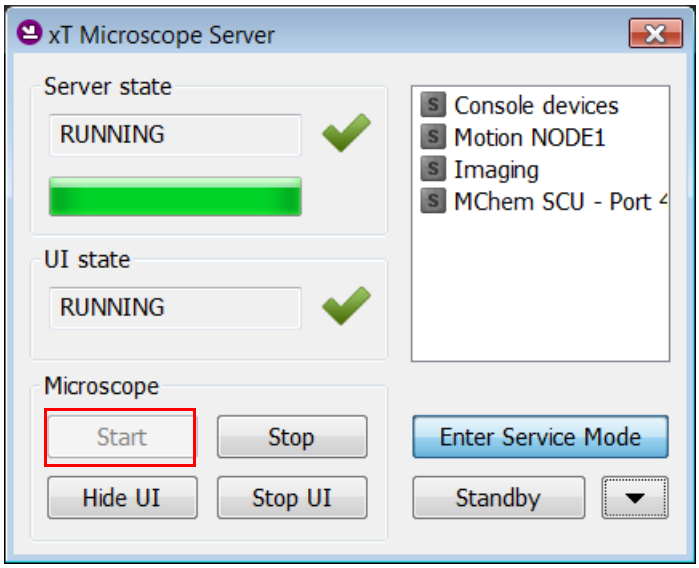
NOTE	If the system is in Standby mode, wait at least 30 seconds before switching back to full power mode.

It is assumed here that all external supplies are present. The startup procedure is fully automatic.

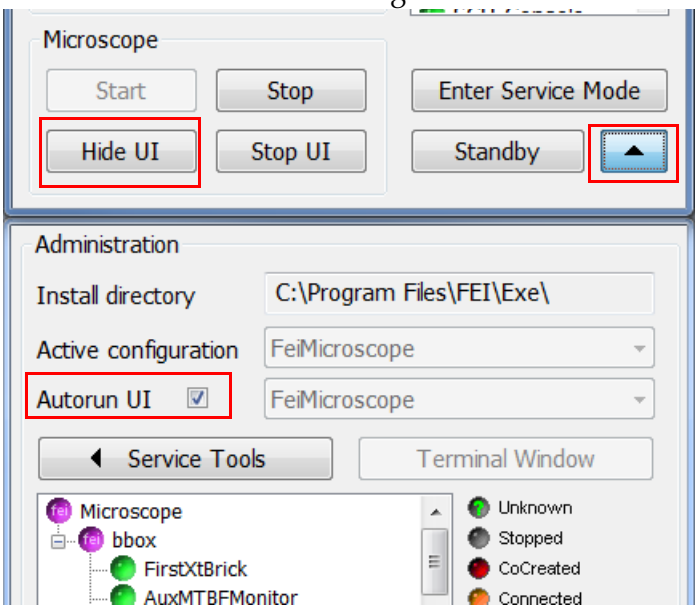
1. Press the **System power switch**.

2. Turn on the system and support computers.

3. Start the software by clicking on the *FeiSystemControl.exe* shortcut icon on the desktop.
4. In the xT Microscope Server dialog box that appears, click **Start**.



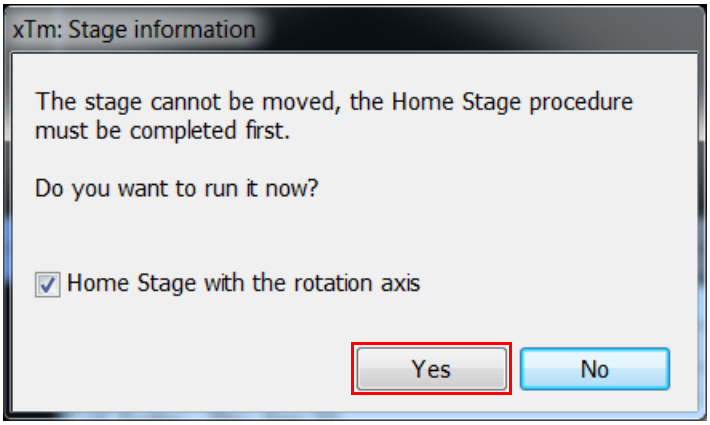
5. Click **down / up arrow**. Wait until the dialog is fully functional (all LEDs are green) and click **Show / Hide UI**. This step is unnecessary if the **Autorun UI** check box is ticked in the Advanced section of the dialog box.



6. Once the microscope server has started, the splash screen appears, followed by the dialog box. Log on with your microscope account (user name and password) to activate the UI and click **Log On**.

7. Click **Wake Up** on the Beam control page to start the ion source, if needed.

8. Select **Yes** in the Stage Information dialog to home the stage.



The system is now ready to use.

Complete System Shutdown

WARNING!

The Complete shutdown and startup of the hardware from Complete shutdown are restricted to the Thermo Fisher Scientific service engineer or an authorized user.

Complete shutdown should be performed only if absolutely necessary and for the shortest possible time, so as to recover the column vacuum without the necessity of a system pump. Normally, one would only perform a complete shutdown for transportation of the system or for service actions, such as repair to essential electrical and air supplies. The shutdown procedure brings the system to a nonpowered state, where the vacuum in the both the ion and electron column area is no longer supported by running pumps and IGPs. All valves are closed and the sample chamber is vented.

The emission characteristics of the source are dependent on the shape of the tip. When the source is turned off, it cools. Reheating the source during startup changes the shape and emission characteristics dramatically, requiring the column to be aligned. It also reduces the lifetime of the source.

To completely shut down the system

1. Set the system to Standby state (see above).
2. Shut down the system and support computers.

3. Switch off the breaker switch labeled **MAINS S1** on the cabinet back, on the far right side of the row (see Mains switchboard above).

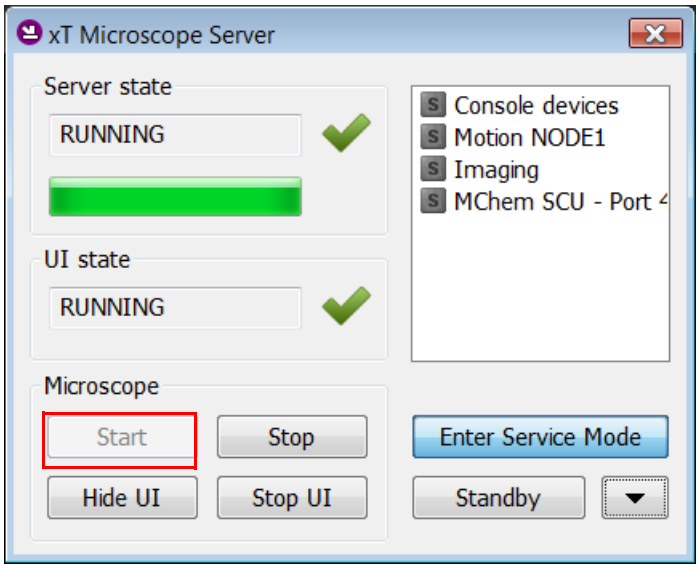
Returning to operation

The Startup procedure must be followed whenever the system has been shut down for service or due to a power failure. After startup has been initiated, observe the system for the first 30 minutes to confirm that the IGPs show sufficient vacuum to continue and complete the procedure:

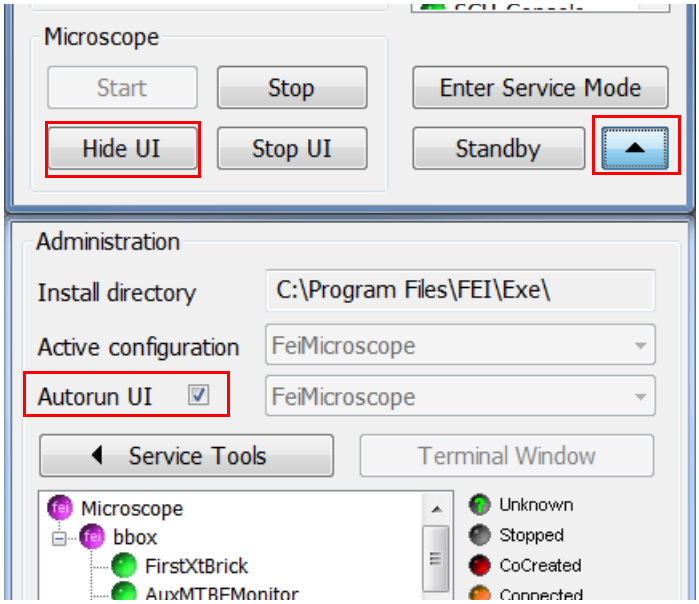
1. Press the system power switch.

2. Turn on the system and support computers.

3. Start the software by clicking on the *FeiSystemControl.exe* shortcut icon on the desktop.
4. In the xT microscope Server dialog box appears, click **Start**.

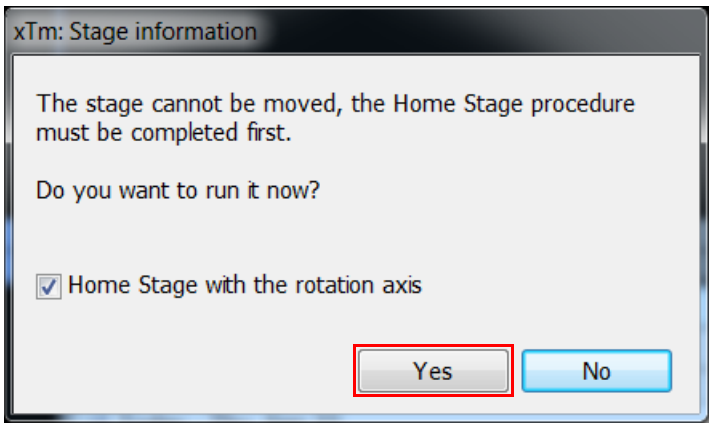


5. Click **down / up arrow**. Wait until the dialog is fully functional (all LEDs are green) and click **Show / Hide UI**. This step is unnecessary if the **Autorun UI check box** is ticked in the Advanced section of the dialog box.



6. Once the microscope server has started, the splash screen appears, followed by the dialog box. Log on with your microscope account (user name and password) to activate the UI and click the **Log On** button.

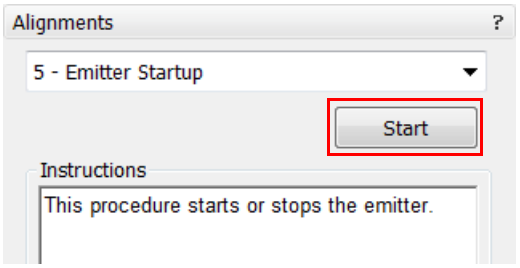
7. Select **Yes** in the Stage Information dialog to home the stage.



The stage must be homed before full operation of the UI is possible. If the stage is not homed at the first shown dialog, it can be homed by selecting **Stage > Home Stage** later (see *"Stage Menu" on page 68*).

CAUTION	Home the stage without rotation only if there is a possible risk of some in-chamber damage associated to rotation.

8. After you have logged on to the UI, you will find that the column IGP is turned off and the pressure is unknown. To turn on the IGP, go to the Alignments page and select **E-column: Emitter Startup**; click **Start**, and then follow the instructions.



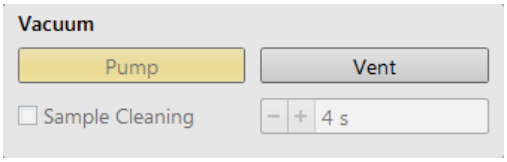
NOTE	When vacuum pressures are too high while following the instructions for starting IGPs, a bakeout is required. If this is the case, a trained Thermo Fisher Scientific Service Engineer or an Thermo Fisher Scientific trained user must restart the system.

9. Click **Wake Up** on the Beam Control page to start the electron and ion emission. **If the emission does not start, call a Thermo Fisher Scientific Service representative.**

When both sources are started, the system is ready to use.

Vacuum system

The system has the these vacuum sections:



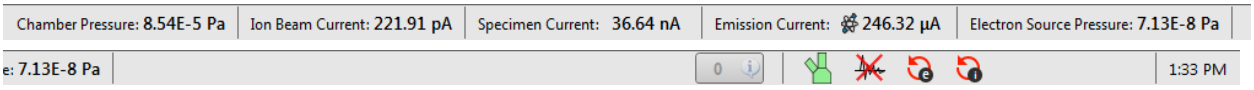
- Electron source / column
- Ion source / column
- Specimen chamber

When in operation, the electron source and column section are always under high vacuum. The specimen chamber is at the pressure required for the given state (Pump / Vent) or mode (HiVac / LoVac / ESEM).

Vacuum Status

The vacuum status controls are in the *Vacuum* module. The *Pump* button starts pumping the chamber for the operating pressure and the *Vent* button starts venting the chamber for a sample exchange.

At the bottom right side of the status bar the actual vacuum status is represented by the colored icon (representing the two vacuum sections schematically), which may have three possible colors with the following meanings:



- **Green** – PUMPED to a desired vacuum mode
- **Orange –**transition between two vacuum statuses (pumping, venting, or purging)
- **Gray** – *VENTED* to atmospheric pressure

4 User Interface

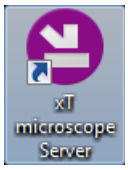
This chapter gives an overview of the Microscope control software for the Helios G4 PFIB series systems. It describes the functionality of each part of the user interface. Graphics illustrating the choices help you locate specific features.

The software interface controls most system functions, including imaging, milling, patterning, detection and analysis, scanning and magnification, image gathering, manipulation and output, stage and vacuum.

Topics include:

- *"Software" on page 40*
- *"Software interface elements" on page 41*
- *"Microscope Server Software" on page 45*
- *"Microscope Control Software" on page 48*
- *"Beam Control Page" on page 102*
- *"Navigation Page" on page 110*
- *"Detectors Page" on page 122*
- *"Patterning page" on page 132*
- *"Sample Preparation Page" on page 137*
- *"Alignments Page" on page 138*
- *"Entering Commands" on page 152*

Software



The software control contains graphics applications within the Windows 10 operating environment:

- *xT microscope Server:* starts and stops basic microscope functions
- *Microscope Control* (*UI* – User Interface): controls all system functions including imaging, image and movie gathering / manipulation / output, detection and analysis, scanning, magnification, stage navigation, chamber and column pressure, etc.
- *User Management*: ensures users admission to both the operating system, Windows 7, and the Microscope Control software

Password policy

After the software installation there are two initial users / passwords common for the OS Windows and the Microscope Control software (UI):

- User: supervisor / Password: supervisor
- User: user / Password: user

The users are permitted to control general operation functions, but not advanced technical maintenance. Most technical maintenance is taken care of by an Thermo Fisher Scientific service engineer who has the rights to enter the Service Mode.

The first time logging into the Windows 7 operating system, a user is automatically forced to change his or her password. After that the UI accepts it and enables logging in from that point on.

Each password (either for any new user or after the 90 day period expiration) has to meet the following conditions:

- at least 7 characters long
- the stem must be significantly different from a previous password and shouldn't contain a complete dictionary word or user name
- must contain at least one character from each of these character groups:
  – Uppercase letter
  – Lowercase letter
  – Number
  – Symbol (/, *, –,+ etc.)

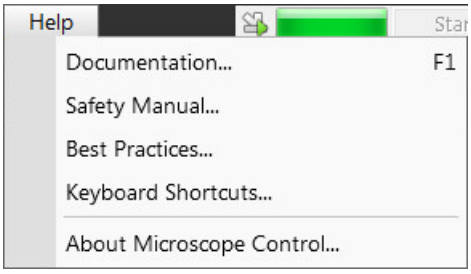
Software interface elements

Tooltips

First-line help is integrated in the software as tooltips. Hover the cursor over an item on the user interface to see a short explanation of the item.

Online Documentation

Access the complete online version of this document from the Help menu or by clicking **F1**.



Hyperlinked Help

Click the blue hyperlinks in the online document, including the Contents and Index, to jump to useful related subject information.

Context Sensitive Help

Click on the question mark at the right of each section to access that section in the online documentation.

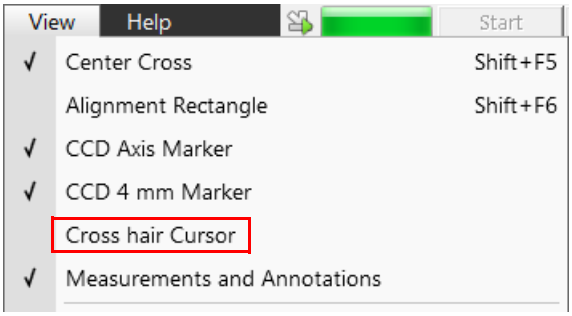
Unique Interface Elements

Cursors

The two main cursor modes are:

- Arrow cursor
- Crosshair cursor

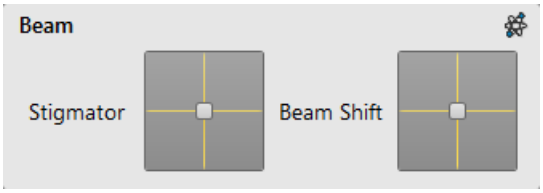
By default, the Arrow cursor or standard Windows cursor appears unless you choose **Crosshair Cursor** from the View menu.



The Crosshair cursor is useful for aligning patterns or features.

Two-Dimensional X-Y Controls

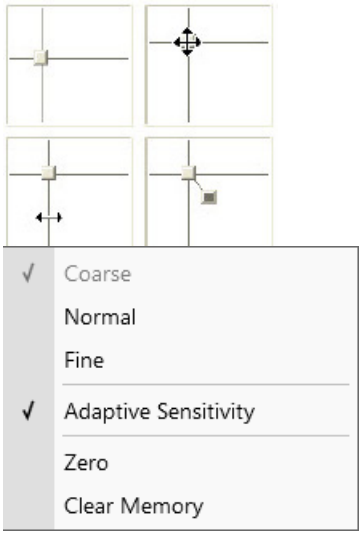
Two-dimensional (2D) X-Y controls are represented by a square with an X-Y grid. The position of the crosshair is related to the actual settings; the full range of the parameters is represented by the perimeter of the box. See the 2D X-Y controls for Stigmator and Beam Shift on the beam module.



Clicking and dragging anywhere inside the box changes the active display cursor to the 4-ended arrow and positions it to the screen point corresponding to the actual control value (minimum in the middle of the screen and maximum at the edges). It can be dragged in four directions. To fix the values, release the mouse button.

Magnification affects the sensitivity of the X-Y control. At higher magnification, you may have to drag and release several times to achieve the same adjustment as at lower magnification levels.

In Quad Image mode, the crosshair covers the active window with the same range of operation as in Single Image mode. As a result, movements are more sensitive in Quad Image mode.



Right-clicking on the 2D box opens a context menu with choices:

- *Coarse / Normal / Fine* item – sets the mouse sensitivity necessary for the full range from a long to a short mouse path.
- *Adaptive Sensitivity* item – adjusts the mouse control response to be the same at any magnification.
- *Zero* item –brings the control value to zero and the cursor to the center of the box.

- *Clear Memory* item – clears condition values, that have been remembered automatically during the relevant 2D control use. These remembered values are used to estimate new values, that have not yet been remembered.

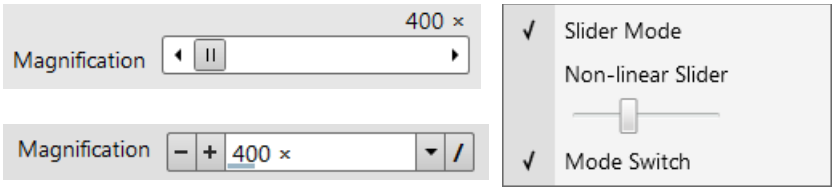
The menu may contain fewer functions or some other functions that are available for that particular parameter. Selecting the corresponding menu item activates the function.

Adjusters

Adjusters allow the user to change parameters (such as contrast, brightness etc.) in a continuous way.

Right-clicking on the adjuster shows a context menu with choices. Ticking / clearing the **Slider Mode** option switches two possible ways of slider control. Ticking the **Mode Switch** option adds the mode switch button to the right side of the slider, which enables to quickly switch between these modes.

Figure 4-1 Adjuster Controls



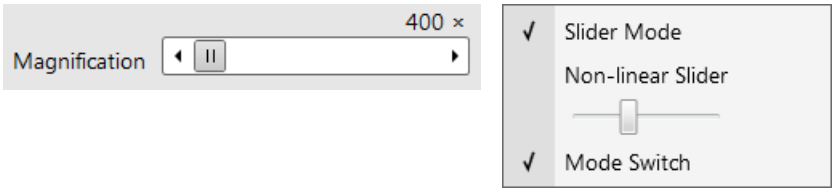
Slider Mode

In this mode adjusters always have a label and a readout at the upper right corner – double-clicking on it enables to enter a precise value and a unit in particular cases using the keyboard.

Clicking on & dragging the middle adjuster button or clicking on the bar is used for coarse adjustments, while clicking on small end arrows is for fine adjustments (single step increments).

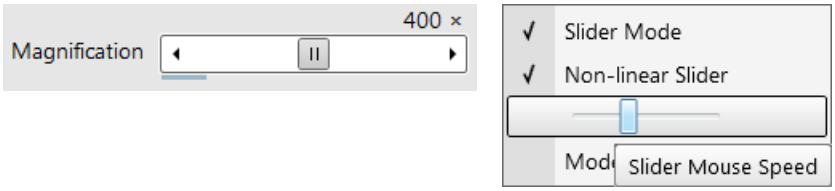
- **Slider Mode** (**Non-linear Slider** cleared) – the adjuster button position always corresponds to the actual parameter value within an available range.

Figure 4-2 Adjuster Controls Linear



- **Slider Mode** (**Non-linear Slider** ticked) – has an exponential response – the further from the center is the adjuster button pulled, the larger is the relative change. The adjuster button always snaps back to the center of the slider, but a dimension of the small bar under the slider corresponds to the actual parameter value.

Figure 4-3 Adjuster Controls Non-linear



- It is possible to increase / decrease the **Slider Mouse Speed** (sensitivity) by dragging the context menu slider to the right / left.

Not Slider Mode – Drop Down List Boxes

This mode is used for values that have both a continuous range and list of presets. It also offers direct value editing to achieve total control.

Figure 4-4 Adjuster Controls Non-linear

- Clicking on the **-** / **+** sign selects previous / next value from the predefined list (see appropriate Preferences) but only shows one value in the text area.
- Clicking on the **down arrow** on the right side of the adjuster or the value itself expands a drop down list of available values – if it extends further than is visible, a scroll bar appears. Clicking on a value from the list enters it as the actual one, the drop down list automatically closes and the change of the setting is immediate.
- Double-clicking on a value in the text area enables to edit it. It is also possible to click on & drag the small bar under the

numerical value to continuously change the setting (where applicable).

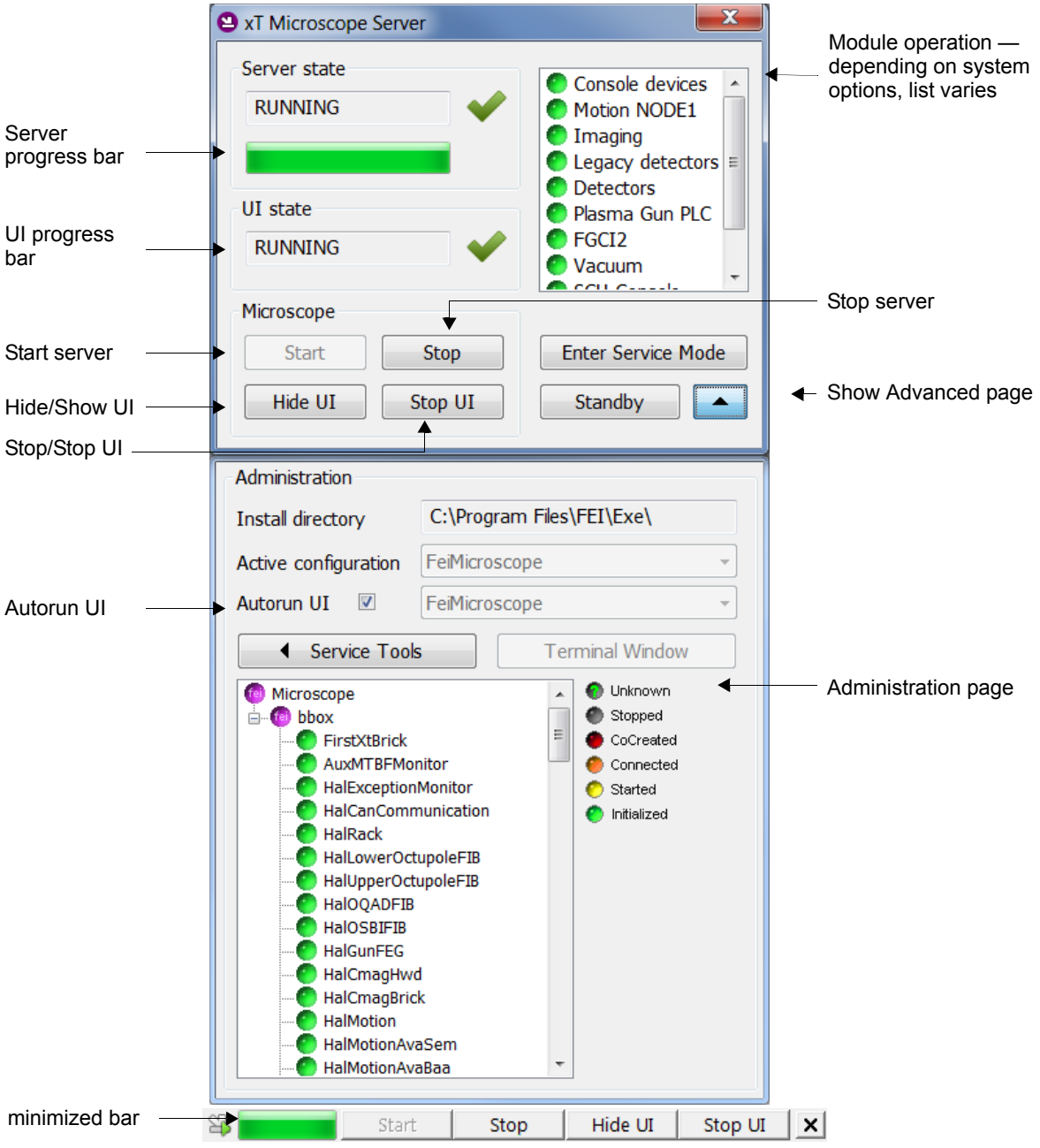
Table 4-1 Adjusters Controls

Interface Item	Description
	Switches between Slider and Not-slider modes
Not-slider mode	
	**Text Box:** For user-specified values. • Type a value; press **Enter** to go to that value. • Or double-click on a value in the text area to edit it. **Down Arrow:** Shows the whole list of values. • Click a value in the list to enter it as an actual value shown at the top right of the control and in the text area.
	Selects the next lower value in the preset list.
	Selects the next higher value in the preset list.
Slider mode	
	Makes small decreasing adjustments.
	**Bar: Clicking m**akes largest adjustments in single steps. **Center Slider:** When dragged left or right, makes adjustments over the full range: the further from center, the larger the change. ***Linear*** – the adjuster button position always corresponds to the actual parameter value ***Exponential*** – the adjuster button always snaps back to the center of the slider, but dimension of the small blue bar corresponds to the actual parameter value
	Makes small increasing adjustments.

Microscope Server Software

When starting the system, progressive dialog boxes for the server and UI are shown. Launch the server first by clicking the **Start** button.

Figure 4-5 Startup Dialog Box



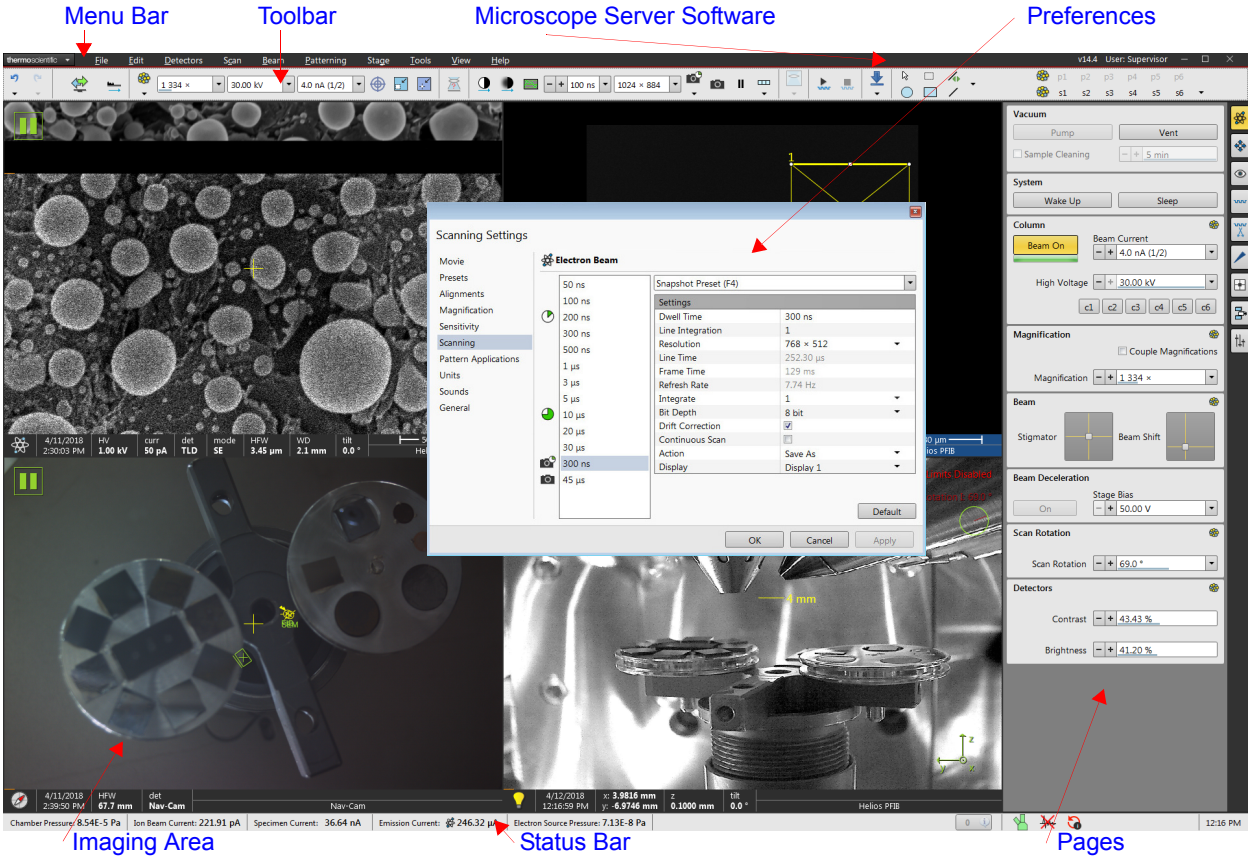
The Startup dialog can be minimized once the UI is established by right-clicking in the top bar of the dialog. This opens another dialog box that offers the chance to minimize the Server to the top bar of the UI. Dopuble-clicking the xT Microscope Server header has the same functionality.

Table 4-1 xT Microscope Server Interface Overview

Interface Item	Description
Server State	Shows the state of the xT Microscope Server software: **RUNNING** or **STOPPED.** During a transition between these states, **STARTING** or **STOPPING** is shown.
UI State	Shows the state of the Microscope Control (UI) software: **RUNNING** or **STOPPED.** During a transition between these states, **STARTING** or **STOPPING** is shown.
Module Operation	Shows the modules operating on the system. The label and behavior on some module buttons change depending on the actual state.
Microscope:	
Start	Starts the xT microscope Server.
Stop	Stops the xT microscope Server. If the UI is running, it closes it before stopping the Server.
Enter Service Mode 	*This mode is* protected by the service password. It offers elevated rights to run specific Alignments and Service tools for servicing the microscope. When the system is in the Service mode, warning is shown in each display.
Show UI / Hide UI	Toggles to show/hide the UI main window.
Start UI / Stop UI	Starts/stops the UI software.
Standby	Closes the UI, stops the xT microscope Server, and brings the console to the Standby mode (see below).
Advanced	Shows the Administration module containing information helpful when calling for service (specifying the software operation / hardware function state).
Administration module: Shows when **Advanced** is clicked.	
Install directory	Specifies where the software is installed.
Active configuration	Shows the active configuration.
Autorun UI	When selected (the default), the **Start** button automatically starts UI after starting the Server.
Service Tools	*Opens the side pane with some specific applications.*
Terminal Window	Opens a logging record.
Administration page	Shows the bricks in the software and some check boxes for administrative purposes.

Microscope Control Software

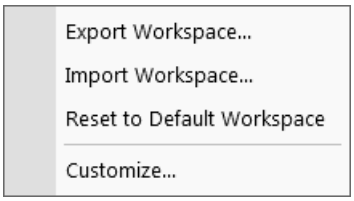
Microscope Control—also called user interface (UI)—consists of several elements that comprise the main window, showing status and control features. Control of some or all of these items is made via the mouse, keyboard, or the MUI pad.



The main window control interface elements consist of the following areas and pop-up windows:

- **Menu bar**: Contains all operation menus and submenus.
- **Tool bar**: Contains all icon button functions.
- **Preferences**: Presets operating conditions.
- **Imaging area**: Four displays or single display providing independent image functionality modes. Every display has its ***Image databar*** containing all data information entered by preference for storage/printout of the image.
- **Status bar**: Contains all data information entered by preference for storage/printout of the image.
- **Pages**: Contains all pages made up of several modules.

Workspace customization



It is possible to change the UI layout by right-clicking any free toolbar or sidepane (pages) area and selecting **Customize…** item.

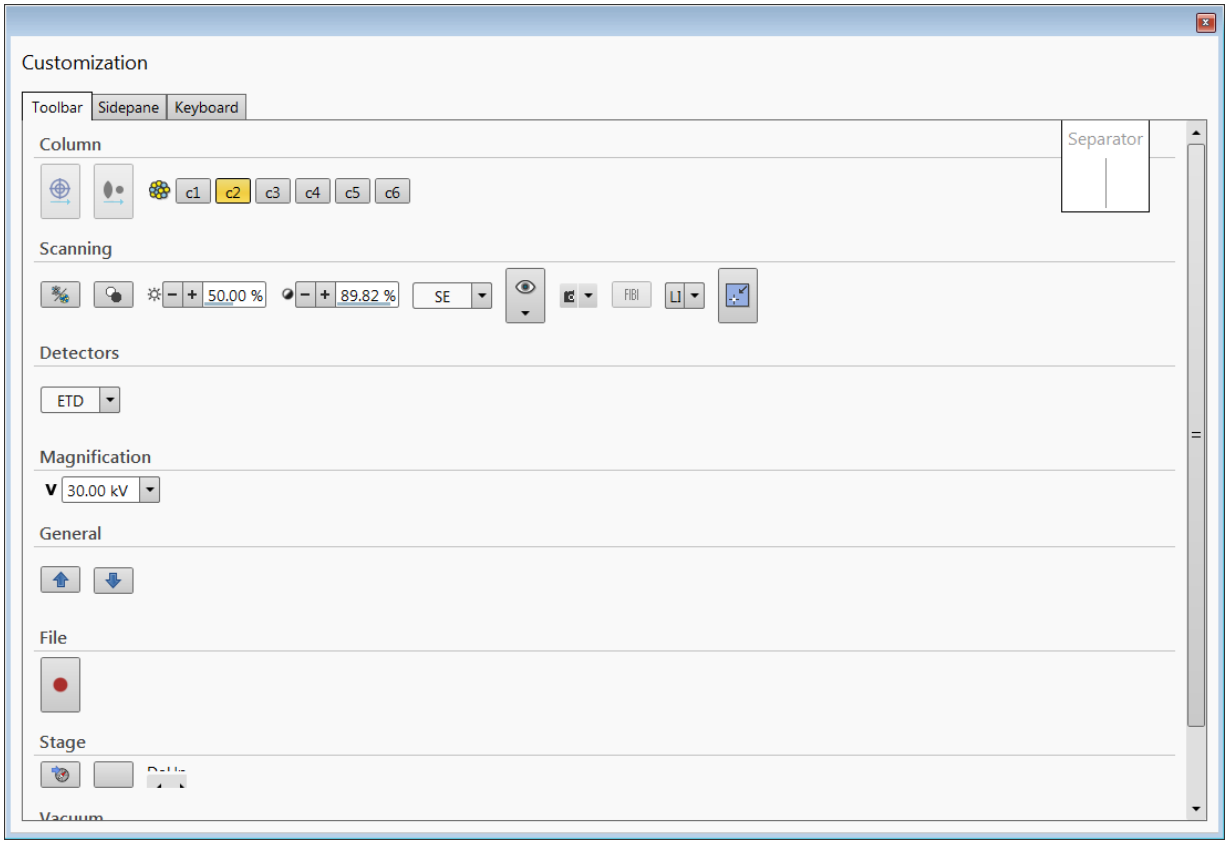
A user can save / load layouts by selecting the **Export / Import Workspace…** item to / from the Workspace configuration (**.workspace*) file.

Clicking the **Reset to Default Workspace** item restores the factory UI layout, which is the one described in this manual.

Toolbar customization

Selecting the **Toolbar** tab adds a red triangle to each toolbar item enabling to change its size. By clicking & dragging any item it can be moved to a new position within the toolbar area; dragging it out from the toolbar area to the customization window eliminates it from the layout. Clicking & dragging a new item from the Toolbar tab to the toolbar area adds it to the layout.

Figure 4-6 Toolbar customization

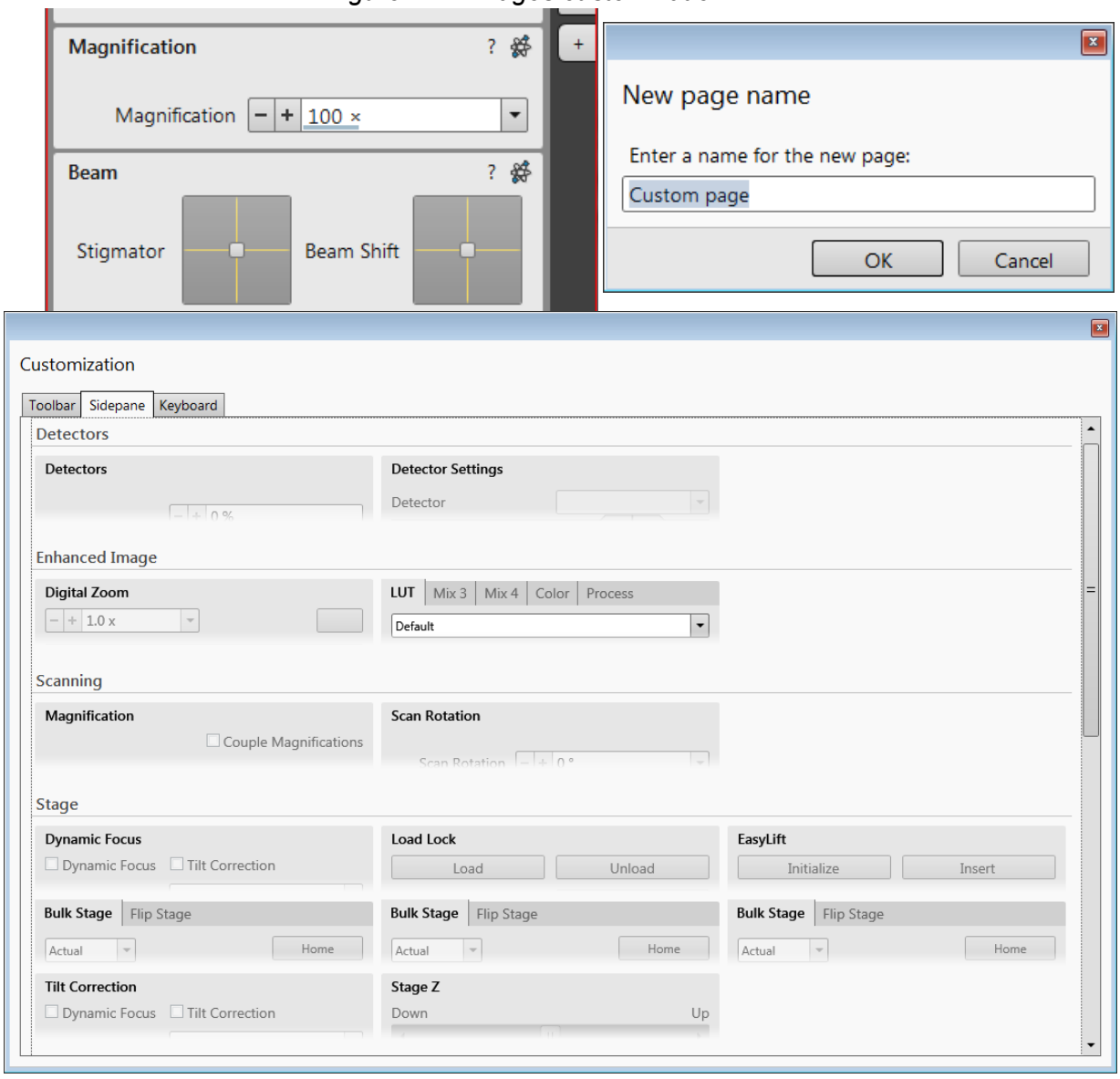


Sidepane (Pages) customization

Selecting the **Sidepane** tab adds a red border to the pages area. By clicking & dragging any module it can be moved to a new position within the pages area; dragging it out from the pages area to the customization window eliminates it from the layout. Clicking & dragging a new item from the Sidepane tab to the page area adds it to the layout.

By clicking the **+** page button calls the dialogue requiring a **New page name** input; by clicking the **OK** button a custom page is created.

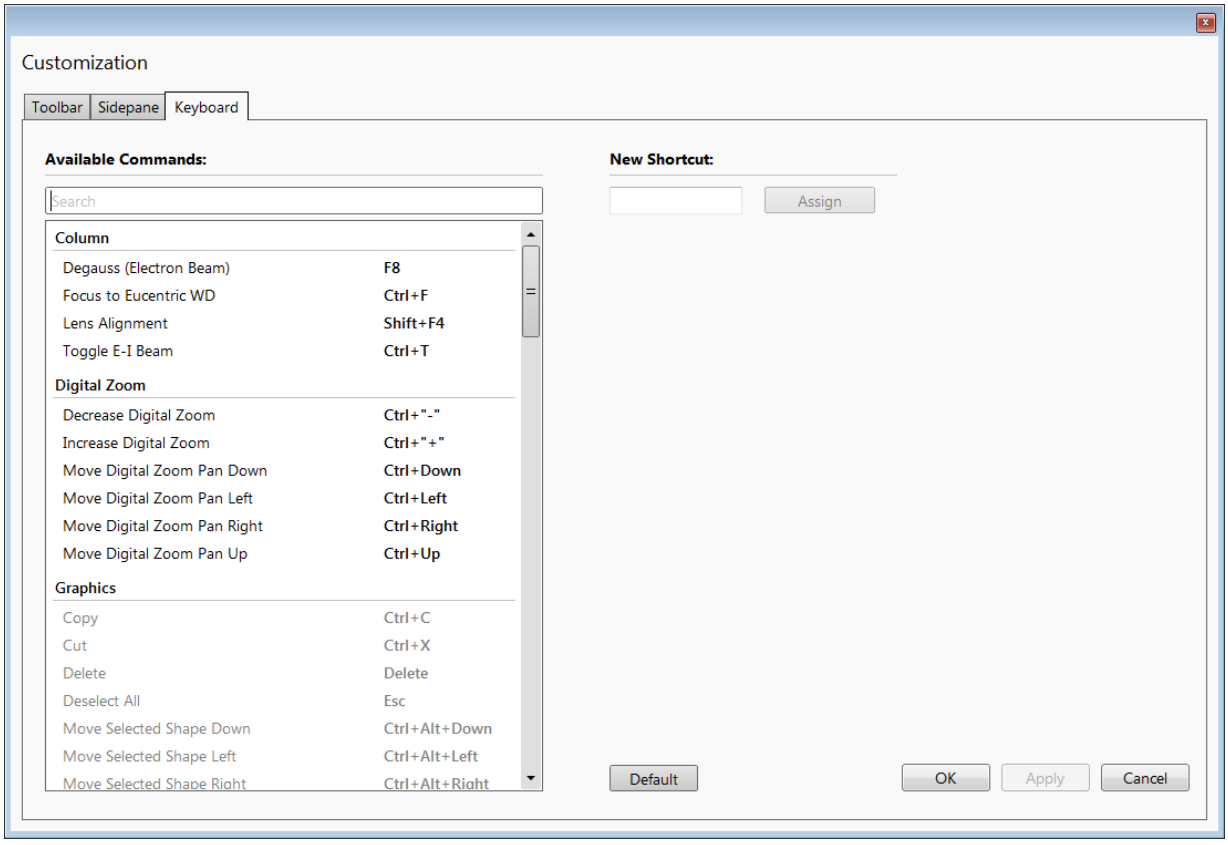
Figure 4-7 Pages customization



Keyboard (Shortcuts) customization

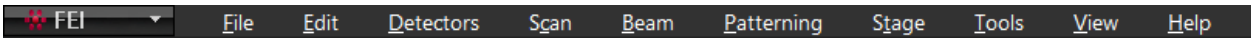
It is possible to customize factory shortcuts within the **Kayboard** tab. To change the factory setting search a desired functionality, enter a **New Shortcut** to the edit field and click the **Assign** button. To revert to the factory setting click the **Default** button.

Figure 4-8 Shortcuts customization



Menu Bar

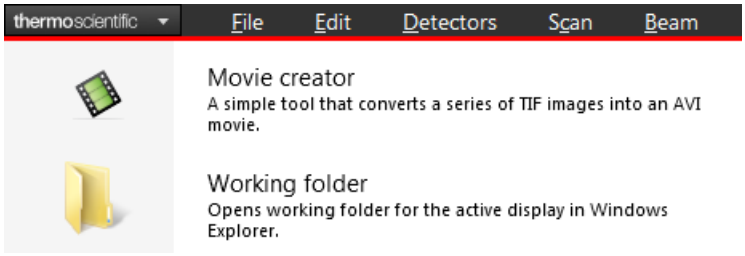
Select pull-down menus from the menu bar.



- using Mouse
  Click the menu name to show that menu and then click on the desired selection.
- using Keyboard
  Press **Alt** + the underlined letter to show that menu; press the up or down arrow keys to step through the choices in that menu; press **Enter** to make the selection. Or press the left or right arrow keys to navigate between menus.

Thermofisher menu MD- check

Standalone applications for particular use are listed here. It is also possible to start them.



- Movie creator
- Working folder
- If there are more applications installed with the system, they are listed here just as in the Windows start menu:
  all programs / company / Applications / for instance:
  VolumeScope, Auto Slice and View, iFast, AutoTEM, …

File Menu

Use the File menu (**Alt + F**) for opening, saving, importing, exporting, and printing files, and for recording movies, logging off, and quitting the software application.

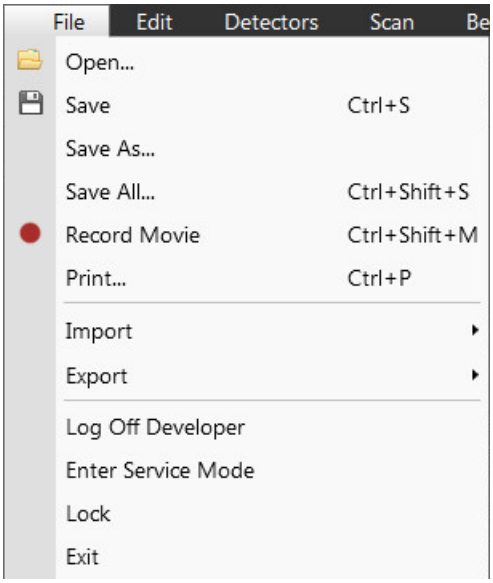


Table 4-1 File Menu Overview (1 of 5)

Menu Item (Shortcut Keys)	Description
Open	Shows a standard dialog box for opening previously stored images in **.tif (8, 16, or 24 bit), *.jpg,* or **.bmp* file format. The dialog box opens to the last path used.
Save (Ctrl + S)	Saves the image with an incremental label at a predetermined location to ensure that every image is saved as a new file. This is also used when a restored image has been updated in any way, such as a LUT change, and it is necessary to overwrite the original.

Table 4-1 File Menu Overview (2 of 5)

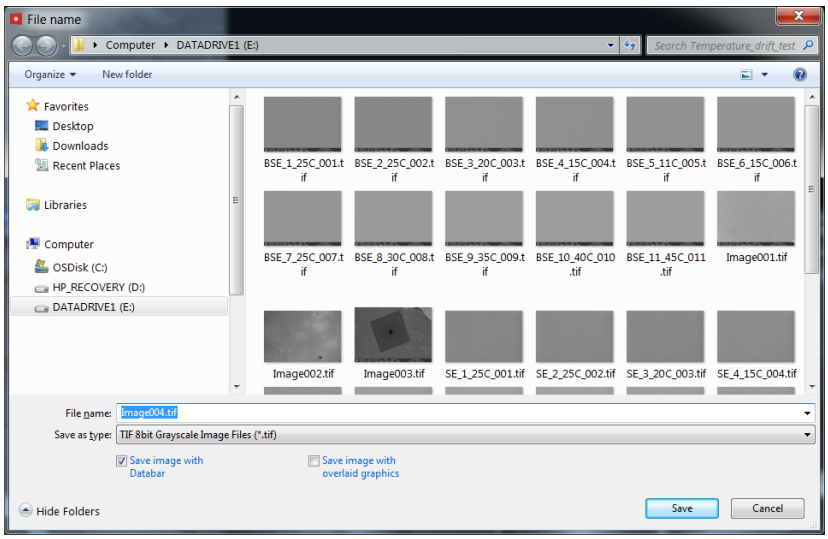
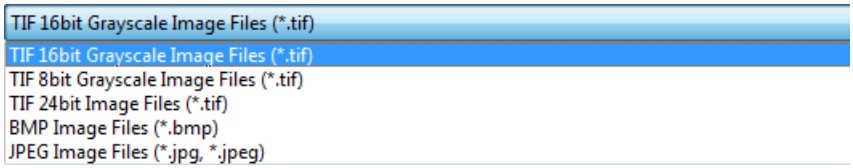
Menu Item (Shortcut Keys)	Description
Save As...	Shows a standard dialog box for saving images with a new file name and location.   By default, the dialog shows the location and the name last used to save/open a file in the current display. You can choose: • A different location, name, or suffix. • A different image format: Supported file formats are TIF 8/16/24 bit, JPG and BMP, but only files saved from UI in TIF format contain the active processing information that could be used later for an image databar setting (see the *"Databar Configuration" on page 98*). • To save the image with or without the databar. • To save the image with or without overlaid graphics. *The settings are remembered per display and used for the subsequent Save actions.*

Table 4-1 File Menu Overview (3 of 5)

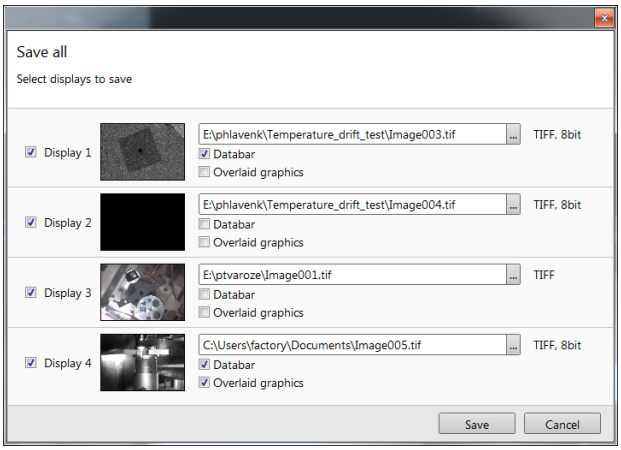
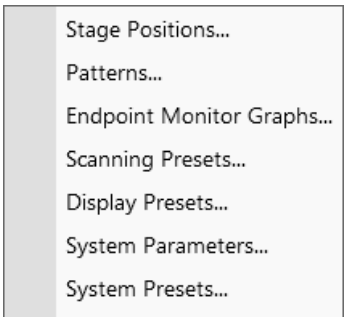
Menu Item (Shortcut Keys)	Description
Save All... (Ctrl + Shift + S)	Shows the Multiple Photo Save as dialog box.  This allows you to individually save images in all four displays at the same time and select the name, location, and file format for each image.
Record Movie 	Starts the recording of videos, one for each of the image displays at the same time. If a display is paused when starting the video, only the first image with a time stamp is stored. Creates digital video files *(*.avi)* for dynamic experiments. The tick next to this menu item and the change of the corresponding toolbar icon indicate the movie is recording. When Record Movie is active, the icon changes to a red square. When clicked, it stops the movie function. See *"Recording Movies (Multiple Image Capture)" on page 211*.
Print... (Ctrl+P)	Opens the standard Print dialog box for selecting a choice of printer and settings suitable to print an image. See *"Printing an Image" on page 211*.
Import / Export 	When selected, shows a list of file types for importing: • Stage Positions: **.stg* files • Patterns: **.ptf* files, see *"Patterning presets" on page 91* • End-Point Monitor Graphs: **.epm* files • Scanning Presets: **.scp* files, see *"Scanning Presets" on page 92* • Display Presets: **.qps* files, see below. • System Parameters: **.par* files (see below) • System Presets: **.syp* files After you select a type, the Open dialog box shows. When opening the file, parameters or data saved with it are restored. Note The ***Intensity Profile Data*** are not possible to import.

Table 4-1 File Menu Overview (4 of 5)

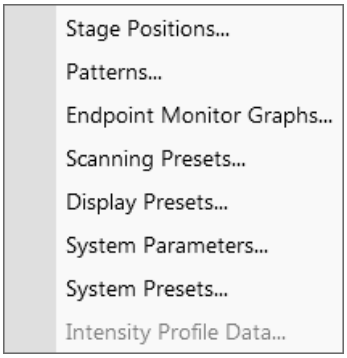
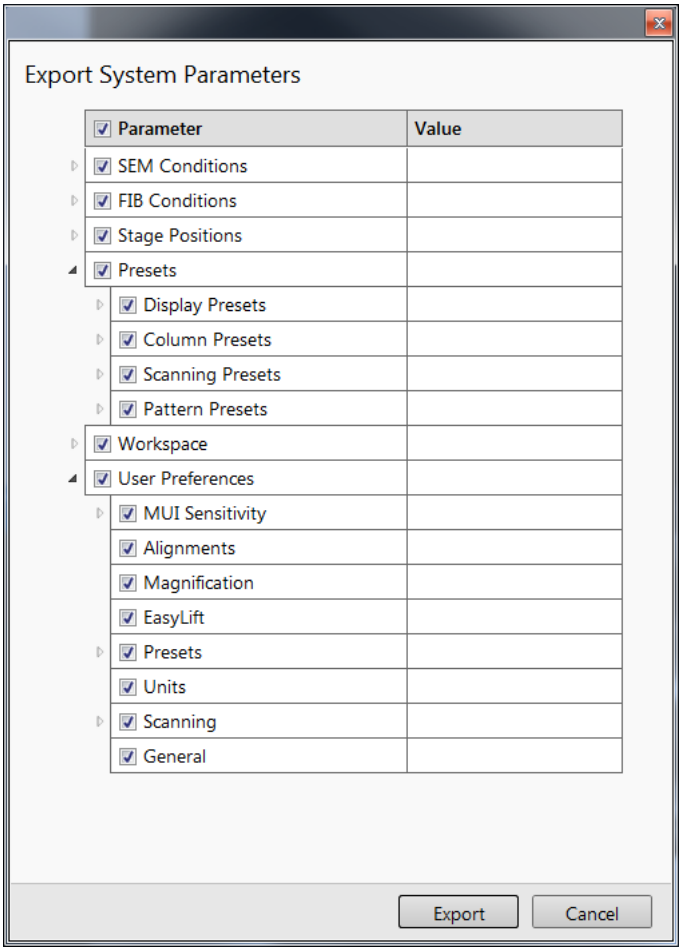
Menu Item (Shortcut Keys)	Description
Export System Parameters 	When selected, shows a list of file types for exporting (see Import, above). Clicking the **System Parameters** item causes the **Export System Parameters** dialog box to appear:  Click the down arrow on the left for expanded details about each selection. This functionality allows you to export a comprehensive system setup and then later quickly reload for different sample types. You can easily export the complete system configuration or select only the specific parameter(s) in which you are interested (*.par* files).
Log Off Factory (User Name)	Logs off the current user and provides the Log On dialog box for the next system user. When the user logs off, the system goes to a safe state; the accelerating and detector voltages are switched off automatically.
Lock	Locks the microscope to prevent undesirable operation of another user.

Table 4-1 File Menu Overview (5 of 5)

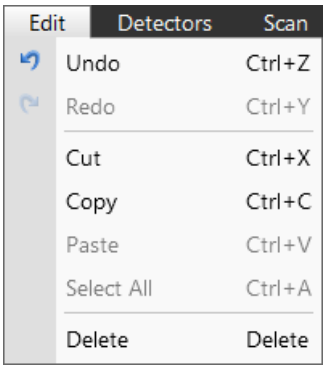
Menu Item (Shortcut Keys)	Description
Exit	Closes the user interface, but leaves you in the operating system environment with the server still running (accelerating and detectors voltages are switched off for security reasons). To activate the UI again, click **Start UI** on the server bar.

Display Presets

It is possible to import and export settings for all displays (beam type, detector type & mode & settings, enhanced image settings). The parameters can be reviewed on the Import / Export System Parameters dialog box.

Edit Menu

Use the Edit menu (**Alt+E**) for standard Windows editing functions: **Copy**, **Cut**, **Paste**, **Delete**, and **Select All**.



Detectors Menu

Use the Detectors menu (**Alt + D**) to select a detector or to mix signals from multiple detectors. The selected detector for the active display has a tick mark next to its label and its operating mode in brackets (if applicable). See *"Detectors Page" on page 122* and *"Working with Detectors" on page 171*.

NOTE Only the detectors installed on your system will appear in the Detectors menu.

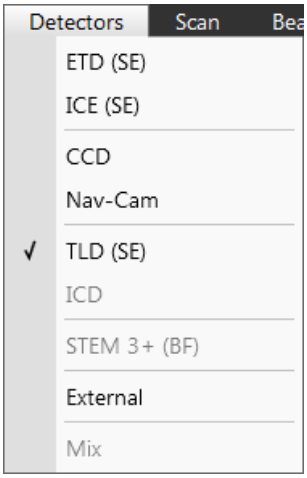


Table 4-2 Detectors Menu Overview (1 of 2)

Menu Item	Description
ETD (SE)	Selects the Everhart Thornley detector (ETD), a scintillator photomultiplier type detector monitoring electrons generated by the primary beam interaction with the sample surface. See *"Everhart Thornley Detector" on page 173*.
TLD (SE)	Selects the through-the-lens detector (TLD). See *"Through Lens Detector" on page 174*.
ICE (SE)	Selects the ICE detector. See *"ICE Detector" on page 175*.
ICD	Selects the ICD detector. See *"In-Column Detector (ICD)" on page 176*.
STEM 3+	Selects the STEM detector. See *"STEM Detector" on page 179*.
MD	Selects the MD detector. See *"Mirror Detector (MD)" on page 176*.
External	Selects a third party video signal.
CCD	Selects the charge-coupled detector (CCD camera) showing the inner space of the sample chamber.
Nav-Cam	Selects the in-chamber navigation camera. See *"Nav-Cam (In-Chamber Navigation Camera)" on page 232*.

Table 4-2 Detectors Menu Overview (2 of 2)

Menu Item	Description
Mix	Allows mixing of signals from 2 or 3 detectors. You can mix 1st and 2nd display detector signals in the 3rd display. Also activates the function of the Mix 3 or Mix 4 on the Processing page, Enhanced Image module (see *"Mix 3 and Mix 4 Tabs" on page 128*).

Scan Menu

Use the Scan menu (**Alt + C**) to control scanning functions.

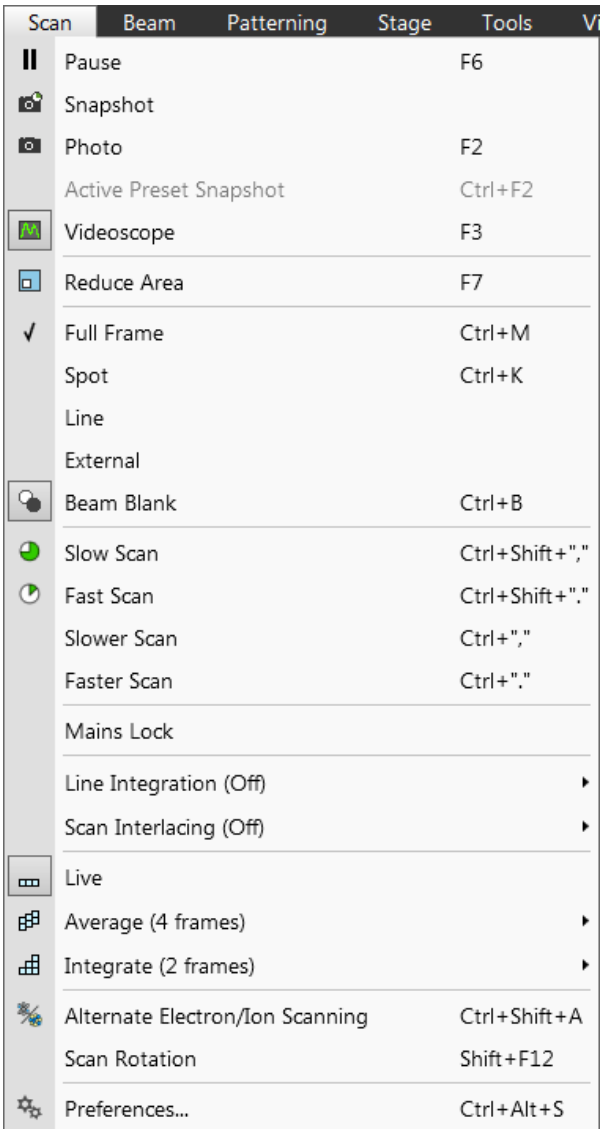


Table 4-3 Scan Menu Overview (1 of 4)

Menu Item (Shortcut Keys)	Description
Pause (F6)	Pauses the image. Click once and the scan stops immediately without finishing the frame. When Pause is active, clicking again releases the pause function and returns the scanning to the original condition prior to pause. Also available on the *"Toolbar" on page 84*.
Snapshot (F4 / Ctrl + F4)	Activates a preset scan that is useful for quick frame grabs. See the Preferences *"Scanning Section" on page 144*. The second button press stops image acquiring at active line and pauses an imaging. • Press **F4** to activate Snapshot for the electron beam from a preset display. • Press **Crtl + F4** to activate Snapshot for the ion beam from a preset display. Also available on the *"Toolbar" on page 84*.
Photo (F2)	Activates a preset higher resolution slow scan. The second icon click stops image acquiring at active line and pauses an imaging. The result can be stored on the hard drive with the Save command in the File menu by using the next available label/number in a predetermined folder. Save As can be used if the folder and label need to be changed prior to saving. See the Preferences *"Scanning Section" on page 144*.
Active Preset Snapshot (Ctrl + F2)	Starts image acquisition of the activated snapshot preset. See the Preferences *"General Section" on page 147*. **Note:** *Holding the* **Shift** *key while clicking the* **Photo** *icon /* **Active Preset** *button or when pressing* **Shift + F2 / Ctrl + Shift + F2** *takes an electron beam Snapshot / Active Preset Snapshot from all displays with the same beam at once.*
Videoscope (F3)	Toggles the show of the videoscope on or off, showing the video intensity along the currently scanned horizontal line for correcting the contrast and brightness. Also available on the *"Toolbar" on page 84*. See *"Using Videoscope (F3)" on page 189*.

Table 4-3 Scan Menu Overview (2 of 4)

Menu Item (Shortcut Keys)	Description
Reduced Area (F7)	When selected, the reduced area appears with the same dimensions and at the last known place on the screen. On activation, it restores the last used scan condition. You can also adjust scan parameters independently on the full-frame setting: • **Moving:** Place the mouse cursor over the selected area. The cursor changes to a 4-ended arrow. Click and drag the selected area to the desired position and release the mouse button. • **Changing the size:** Place the mouse cursor over the edge of the selected area. The cursor changes to a 2-ended arrow, either horizontal or vertical. A corner can also be used to move two sides. Click and drag the side out or in to obtain the desired size and release the mouse button. When the Reduced Area frame is being manipulated, it turns yellow until released, then it reverts to green. See also the behavior when iSPI mode is ON and patterning is running *"Fast iSPI Mode" on page 264*. Also available on the *"Toolbar" on page 84*.
Full Frame (Ctrl + M)	Default scanning mode; this is the normal scanning mode, typical for general navigation and imaging.
Spot (Ctrl + K)	Selects Spot mode and allows you to move the beam around the screen by the mouse click. The spot position is represented by a green cross.
Line	When selected, the image freezes and a green horizontal line shows on the imaging display. The beam scans along this line, using the line time defined for the selected scan speed. When you choose Line, the cursor changes to an arrow. Move the cursor to the desired vertical position and click the left mouse button.
External	Activates external control of the scanning system, such as beam control from an EDX X-ray system. The external scanning mode is indicated by the External label in the image databar.
Beam Blank (Ctrl + B)	Activates deflection of the beam. This can be used to reduce beam exposure on the sample.
Slow Scan (Crtl + Shift + ,)	Brings the scanning condition to the preset value held on the Scan section of the Preferences dialog box. Also available on the *"Toolbar" on page 84*.
Fast Scan (Crtl + Shift + .)	Brings the scanning condition to the preset value held on the Scan section of the Preferences dialog box. Also available on the *"Toolbar" on page 84*.
Slower Scan (Crtl + ,)	Brings the scanning condition to the next slower scan value held on the Scan section of the Preferences dialog box.

Table 4-3 Scan Menu Overview (3 of 4)

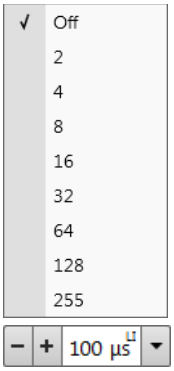
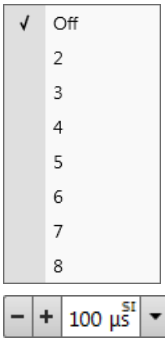
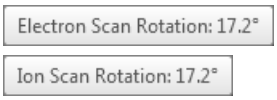
Menu Item (Shortcut Keys)	Description
Faster Scan (Crtl + .)	Brings the scanning condition to the next faster scan value held on the Scan section of the Preferences dialog box.
Mains Lock	Synchronizes the mains frequency to the scan system.
Line Integration 	Repeats each line scan several times (from 2 to 255) before proceeding to the next line. Signal data collected from these passes are integrated and shown as an actual image line. This imaging method reduces sample charging (in comparison with single pass with longer dwell time) and improves overall image quality. **Note:** *When Line Integration or Scan Interlacing is active, it is represented in the toolbar scan speed spinner with the letters LI / SI.*
Scan Interlacing 	Splits an imaging area into blocks defined by the number of lines (from 2 to 8). In the first instance, the first line of each block is scanned, then the second one, etc. This imaging method significantly reduces sample charging. **Note:** *When Line Integration or Scan Interlacing is active, it is represented in the toolbar scan speed spinner with the letters LI / SI.* **Note:** *Scan Interlacing can be effectively applied only for certain combinations of dwell time vs. scanning resolution. The overall frame time should not exceed 300 ms.*
Live	This default mode causes the image to remain unfiltered for collecting raw direct images—one frame follows another, mostly in Live/Slow scan. Also available on the *"Toolbar" on page 84*.
Average	Continuously averages a specified number of frames (2 or more), selected from the list, resulting in a better signal-to-noise ratio. This process continues until stopped by changing the scanning condition or by pausing the display. This is used mostly in a fast scan mode to reduce noise in fast scanned images. During averaging, the image is updated continuously, and actions such as focusing, moving the stage, etc., can still be performed. The number of frames can be selected as a preset from the toolbar dropdown list associated with the Average function. Also available on the *"Toolbar" on page 84*. **Note:** *The Average is also set independently for the optical display (option), but using averaging with more than 4 frames is not recommended, especially when moving the stage.*

Table 4-3 Scan Menu Overview (4 of 4)

Menu Item (Shortcut Keys)	Description
Integrate	Allows accumulative noise reduction by true integration over a number of frames (1 or more), selected from the list. This process continues until the selected number of frames is reached and then pauses the display automatically, freezing the final image. During and after image accumulation, you cannot change the focus or perform other image-influencing actions. This can be used as an alternative to slow scanning to obtain high quality images of slightly charging specimens. The number of frames can be selected as a preset from the submenu or from the toolbar dropdown list associated with the Integrate function. Also available on the *"Toolbar" on page 84*. **Note:** *As the scanning could take a significantly long time period, press* ***Ctrl + R*** *(Restart Scan) to restart it from the beginning.*
Alternate Electron / Ion Scanning **(Ctrl + Shift + A)**	Alternates between electron and ion imaging in two separate displays. A message shows in the affected displays. All scanning parameters are changed during switching of the displays, so under some settings, it may take a significantly long time to complete.
Scan Rotation **(Shift + F12)** 	Activates the onscreen tool to rotate the scan and align the image. It has no effect on the stage movements and is solely a scan coil function, but is used to orient the image relative to mechanical rotation and detector direction. A non-zero scan rotation is indicated by an icon in the Status bar for the electron and ion beam independently, and its value can be shown as a tooltip. 
Preferences... **(Ctrl + O)**	Opens the Preferences dialog box. See *"Preferences" on page 139*.

Beam Menu

Click Beam (or **Alt + B**) to open the Beam menu.

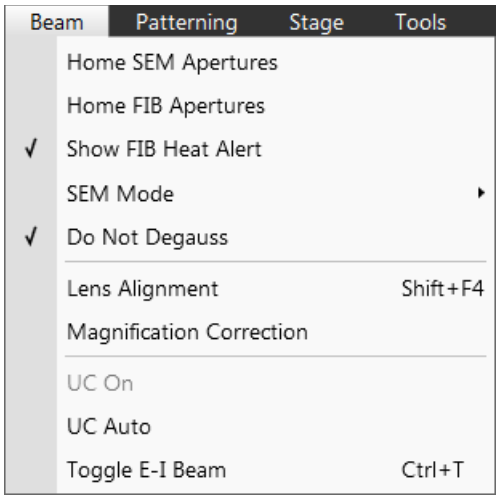


Table 4-4 Beam Menu Overview (1 of 2)

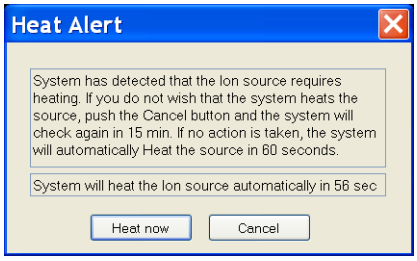
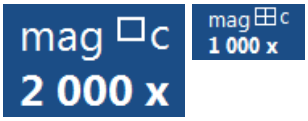
Menu Item (Shortcut Keys)	Description
Home SEM Apertures	Runs the SEM aperture home procedure.
Home FIB Apertures	Runs the FIB aperture home procedure.
Show FIB Heat Alert	Enables/disables auto heat. We recommend leaving this **enabled**. FIB auto heating controls the level of ion emission. When the emission does not meet the required conditions and **Show FIB Heat Alert** is selected, you are notified via the Heat Alert message and asked for corrective action to heat the LMIS back to working conditions.  • Click **Cancel** to stop the auto heating. • Click **Heat Now** to heat immediately. • If neither button is clicked, auto heating will begin in 60 seconds. A countdown timer appears above the buttons. Auto heat will not activate if the system is taking a snapshot or milling.

Table 4-4 Beam Menu Overview (2 of 2)

Menu Item (Shortcut Keys)	Description
SEM Mode	*(Electron column only.)* Shows a submenu for selecting three modes of imaging available for use with the electron beam with the TLD detector: • Mode 1: Field Free • Mode 2: Immersion (UHR) • Mode 3: EDX Each mode has its own electron beam and magnification presets that are editable on the Detector page for Mode 2 TLD. Also available from the *"Toolbar" on page 84*. See *"Detectors Page" on page 122* and *"SEM Imaging Modes" on page 200*.
Do Not Degauss	Disables the automated Immersion lens degauss procedure to accelerate some operations, such as switching from SEM Mode 2 Immersion (UHR) to ion beam imaging. For patterning it is recommended to allow the Degauss functionality. See *"Milling" on page 288*.
Lens Alignment (Shift + F4)  	*(Electron column only.)* Toggles lens alignment mode on the Beam page for the objective lens fine alignment. The scanning condition changes to a fast scan, the lens modulator turns on, and a green target cross appears in the center of all SEM image displays. Clicking & holding the left mouse button activates a 4-ended arrow cursor. Dragging the mouse aligns the beam with respect to the objective lens to reduce the movement swing. This in turn eliminates or reduces the movement during focusing. Also available from the *"Toolbar" on page 84*.
Magnification Correction 	Applies the **E-column: Magnification Correction** alignment influences on imaging. The letter "c" is added to the appropriate databar fields (Mag, HFW) and the "Magnification Correction" text is added to the imaging display.
UC On **Only available for the Helios G4 PFIB UX**	Starts UC mode for the electron beam. See *"Electron Source Modes" on page 201*.
UC Auto **Only available for the Helios G4 PFIB UX**	Automatically starts the UC-mode when particular conditions are satisfied.
Toggle E-I Beam (Ctrl + T)	Quickly toggles electron and ion beams to be used in the selected display for imaging.

Patterning Menu

Use the Patterning menu to control the patterning processes. For detailed process description see the *"Patterning & Milling" on page 247*.

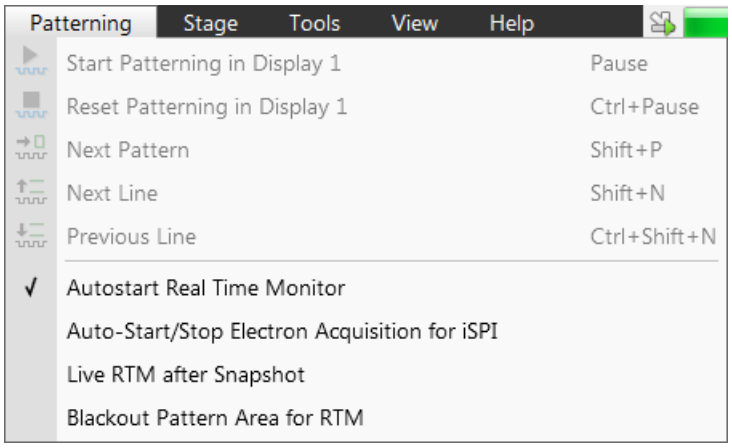
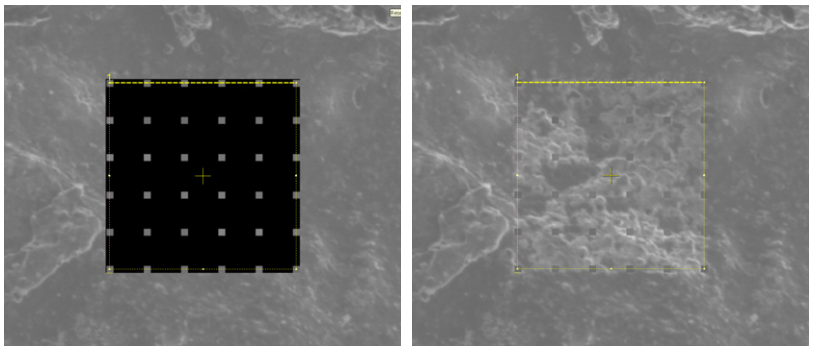


Table 4-5 Patterning Menu Overview (1 of 2)

Menu Item (Shortcut Keys)	Description
Start Patterning in Display #	Draw a pattern to enable this selection. Begins patterning with the pattern selected on the Patterning page. Shows the display number in which the patterning will occur and a Pause command. Click **Pause** to temporarily stop patterning; click **Pause** again to unpause and continue patterning. Also available from the *"Toolbar" on page 84*.
Reset Patterning in Display # (Ctrl + Pause)	Resets patterning to the beginning of the pattern procedure.
Next Pattern (Shift + P)	If multiple patterns have been drawn, stops milling the current pattern and continues with the next pattern. Also available on the *"Patterning page" on page 132*.
Next Line (Shift + N)	Enabled when the cleaning cross-section is used. Stops milling the current line and continues with the next line. Also available on the *"Patterning page" on page 132*.
Previous Line (Ctrl + Shift + N)	Enabled when the cleaning cross-section is used. Stops milling the current line and continues with the previous line. Also available on the *"Patterning page" on page 132*.
Autostart Real Time Monitor	Releases the Pause function for the display with patterns to enable an automatic start of the RTM when patterning starts. See *"Real Time Monitor" on page 270*.
Auto-Start/Stop Electron Acquisition for iSPI	When iSPI (intermittent switching between patterning and imaging) mode is enabled (*"Patterning page" on page 132*), the electron beam and image acquisition automatically starts /stops when patterning process starts / is paused or stopped.

Table 4-5 Patterning Menu Overview (2 of 2)

Menu Item (Shortcut Keys)	Description
Live RTM after Snapshot	RTM feature continues automatically after taking a snapshot.
Blackout Pattern Area for RTM	Blacks out the pattern background where the RTM is shown. The visibility of the individual patterning pixels is greatly enhanced (this is especially important for patterns with extremely large pitch or very thin lines).  See *"Blackout Pattern Area for RTM" on page 273*.

Stage Menu

Click **Stage** (**Alt + S**) to open the Stage menu.

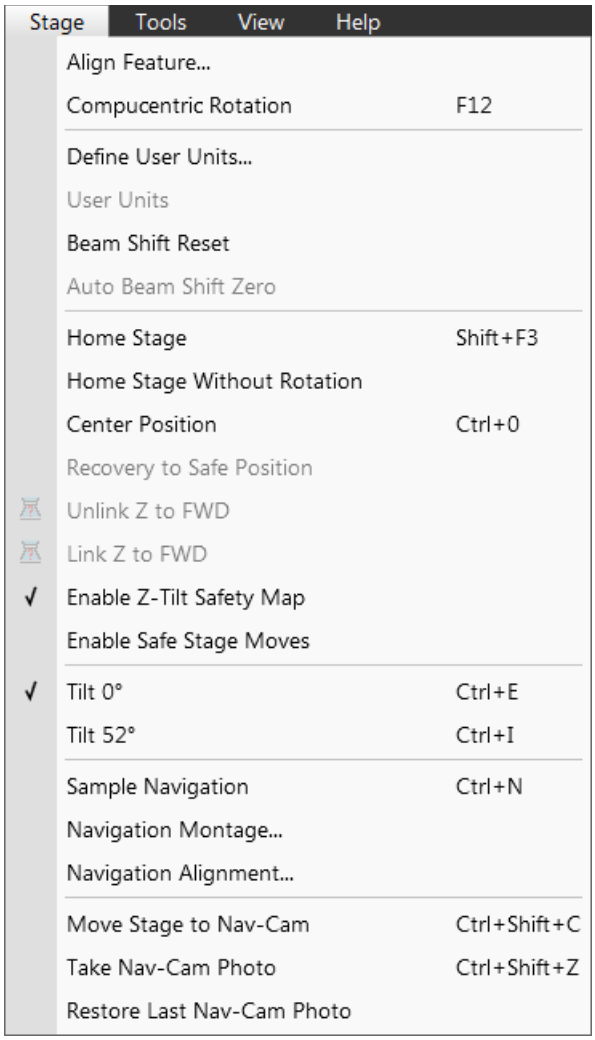


Table 4-6 Stage Menu Overview (1 of 5)

Menu Item (Shortcut keys)	Description
Align Feature…	Starts a procedure using stage rotation that helps orient a linear feature to either of the stage movement directions, X or Y. See *"Align Feature" on page 223*.

Table 4-6 Stage Menu Overview (2 of 5)

Menu Item (Shortcut keys)	Description
Compucentric Rotation (F12)	Places a green circle in the active display. By rotating the circle, a different viewing orientation of the sample area can be achieved. This is compucentric stage rotation. Stage rotation keeps the observed feature in the center of the field of view. If this does not occur, perform the alignment to locate the stage center and calibrate the stage.
Define User Units...	Activates a series of dialogs that guide you in determining the User Unit values for X and Y movements of the stage. These are used in relative movements associated with stage mapping of regular features. See *"Defining User Units" on page 226*.
User Units	Organizes the stage software to recognize the defined user units rather than the default metric measurements. The X and Y coordinates now operate in User Units and are shown in the Location module by the UU symbol. See *"User Units" on page 229*.
Beam Shift Reset	Begins the Beam Shift Reset procedure to zero beam shift. A feature observed with a non-zero Beam Shift is automatically moved back to the imaging center using the stage. See *"Electron Beam Shift Reset" on page 222*.
Auto Beam Shift Zero	Automatically resets the beam shift each time it reaches the maximum value during the Get moves and corrects the image position with a stage movement.

Table 4-6 Stage Menu Overview (3 of 5)

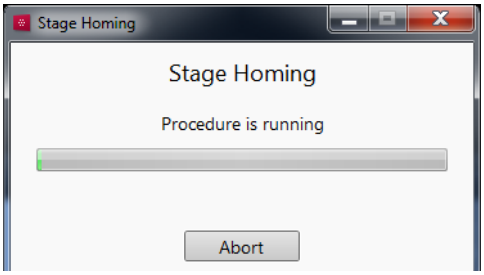
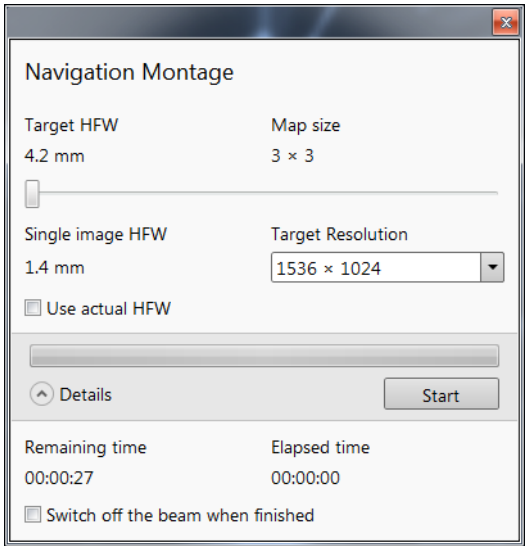
Menu Item (Shortcut keys)	Description
Home Stage (Shift + F3)	Starts a procedure that moves all motorized axes to their hardware limits and ensures that the physical stage position agrees with the coordinates readout. During the procedure the **Stage Information** dialog box shows its progress.  The stage axes are moved to their end-switches in the following order: 1. Z (lowest position), 2. T (tilt), 3. X, Y and R (rotation) at the same time. When the stage is homed correctly it ends up in the following position: • X / Y position is set to the factory pre-set stage rotation center of 0, 0 • R = 0° • T = 0° • Z = preset long working distance (depends on the stage type)
Home Stage Without Rotation	Performs a Home Stage function without rotating the stage. When the stage is homed without rotation, the stage reference for Rotation is grayed out. This is useful when a large sample is inserted and stage rotation could cause a collision with equipment inside the chamber. By default, the function is enabled and automatically reverts back to the enabled status after every venting/pumping cycle.
Center Position (Ctrl + 0)	Moves the stage to coordinates X = 0, Y = 0, the center position.
Recovery to Safe Position	If the stage position is out of a safe zone, the dialog warns and refers to run this functionality.
Unlink Z to FWD	Shows Z-coordinate as a value corresponding with the distance from the home position.
Link Z to FWD	Sets the Z coordinate value to the actual free working distance (FWD) value. This allows accurate movement between the top surface height of the sample and the end of the immersion lens. The related toolbar icon image changes according to the Z-coordinate status. See *"Toolbar" on page 84*.

Table 4-6 Stage Menu Overview (4 of 5)

Menu Item (Shortcut keys)	Description
Enable Z-Tilt Safety Map	Some movements of the tilted stage are not safe because of a possible collision with the final lens. The table (not user editable) with a pair of values indicates the maximum safe Tilt angle for a certain Z value when coupled. It can be used to guarantee safe usage of the stage (tilt restriction) for flat samples only and when a proper Link Z to FWD is established.
Enable Safe Stage Moves	Some movements of the stage are illegal because of possible collision with the end lens. A legal movement of the axes depends on the position of the Z axis. The relation between the extreme positions of the other axes and Z indicate the extreme allowed positions. This relation can be used to guarantee safe usage of the stage only when a flat sample is used, and a proper link between Z and the FWD is established. When enabled, Safe Stage Moves will make legal movement with all axes on irregular surfaces and at high angles of tilt.
Tilt 0° (Ctrl + E)	Sets stage tilt to 0°, perpendicular to the electron beam.
Tilt 52° (Ctrl + I)	Sets stage tilt to 52°, perpendicular to the ion beam.
Sample Navigation (Ctrl + N) 	Toggles the on/off function that enables you to navigate live FIB or SEM images (scan field) to desired places on a sample using either a paused or loaded image of that sample (usually taken at much lower magnification). Sample Navigation can be selected independently for any display, regardless of its current content and status. A tick mark next to the menu item indicates that the function is selected for the active display. As soon as this display is paused, the Sample Navigation indicator appears in the upper right corner of the display. The indicator is green as long as the paused image can be used to navigate the live images; otherwise, it turns red (e.g., when the stage rotation or tilt changes). **Note**: *To make sure this function works properly, the stage rotation value for the captured image and the corresponding live images must be the same.*

Table 4-6 Stage Menu Overview (5 of 5)

Menu Item (Shortcut keys)	Description
Navigation Montage...	Opens the Navigation Montage dialog box, which is used to take the image of the sample to be used in sample navigation (see above).  • **Target HFW**: Sets the horizontal field width target range (in mm). • **Map Size**: Indicates the number of tiles. • **Estimated Time**: Shows the estimated time of the procedure. • **Single Image HFW**: Indicates the HFW of each tiles. • **Use actual HFW**: When selected, uses the actual image HFW. • **Start**: Begins taking the image. • **Close**: Closes the dialog box. See also *"Sample Navigation / Navigation Montage" on page 231*
Navigation Alignment...	Opens the Navigation Alignment wizard. See below.
Move Stage to Nav-Cam	Moves the stage to the Nav-Cam position. See *"Nav-Cam (In-Chamber Navigation Camera)" on page 232*.
Take Nav-Cam Photo	Automatically runs the Nav-Cam image procedure.
Restore Last Nav-Cam Photo	Restores the last photo taken with the Nav-Cam.

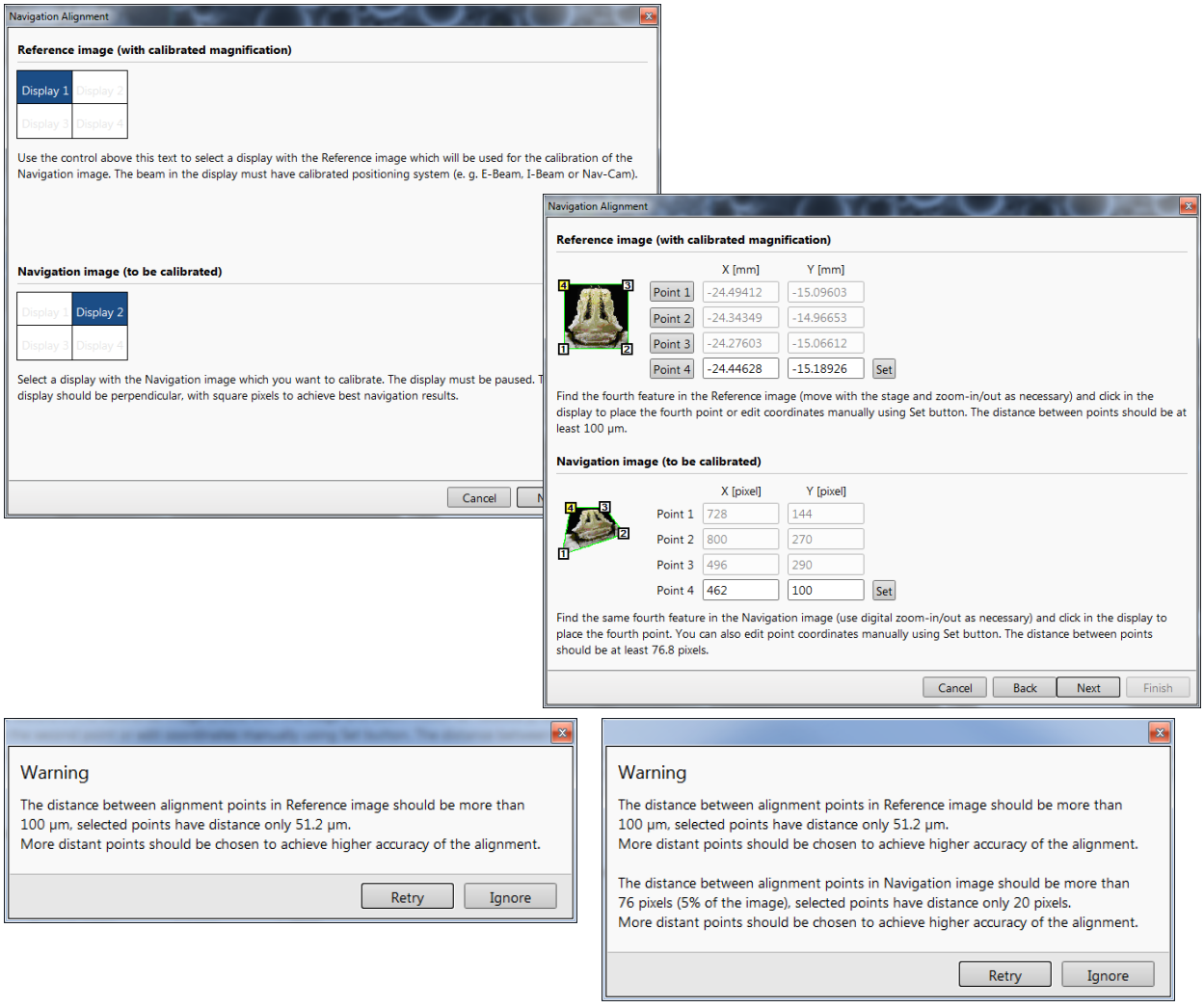
Navigation Alignment

This procedure in comparison to the Navigation montage or Nav-Cam (option) enables to use any loaded or paused Navigation image, which is calibrated according to the live Reference image.

Follow the instructions given within the process (6 dialogs) and calibrate 4 image points. If 2 points are sufficient for desired purposes, click on the *Compute 2pt alignment* button to finish the process after setting 2 align points.

The Navigation Alignment wizard aligns the Navigation image according to the Reference image.

Figure 4-9 Navigation Alignment Wizard



When any point setting does not satisfy system requirements an Warning message informs a user.

Tools Menu

Click **Tools** (**Alt + O**) to open the Tools menu.

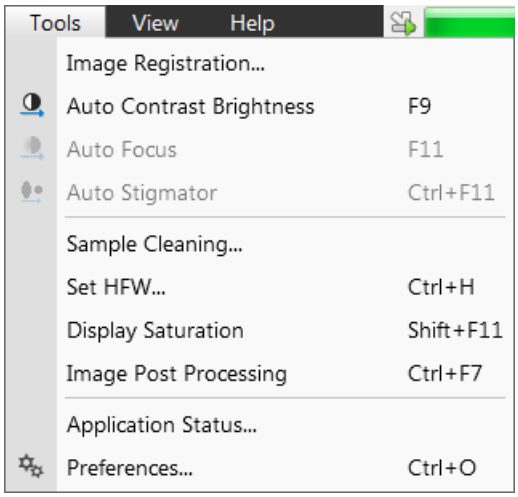


Table 4-1 Tools Menu Overview (1 of 2)

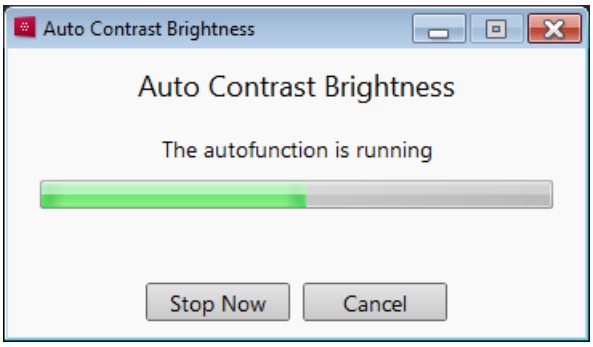
Menu Item	Description
Image Registration	This functionality is used to interconnect images of the same area of interest acquired from different sources or at different conditions (for instance images acquired from optical and SEM microscopes, images acquired at various depth of focus etc.) (see below).
Auto Contrast Brightness (F9 / Shift + F9)	Enabled during live imaging. Activates the automatic contrast and brightness (ACB) routine. The system attempts to set the Contrast and Brightness of the selected detector in the active display to suit the actual sample and conditions so that the majority of gray levels is shown. This functionality is available for both beams and for paused imaging. Also available from the *"Toolbar" on page 84*. **Note:** *When ACB is activated, a progress dialog box appears. The function can be interrupted by clicking* ***Stop Now****, leaving the imaging at the actual stage of progress. Clicking* ***Cancel*** *before the function ends returns the imaging back to its original status.* 

Table 4-1 Tools Menu Overview (2 of 2)

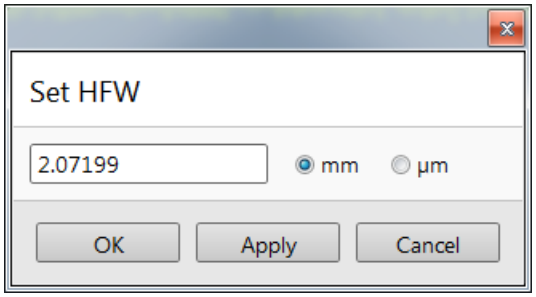
Menu Item	Description
Auto Focus (F11)	Activates the automatic focus (AF) routine. The system attempts to correct the focus independently of the working distance or set Z-coordinate. This functionality is available for both beams. Also available from the *"Toolbar" on page 84*. **Note:** *When AF is activated, a progress dialog box appears. The function can be interrupted by clicking* ***Stop Now****, leaving the focus (WD) at the actual stage of progress. Clicking* ***Cancel*** *before the function ends returns the imaging back to its original WD value.*
Auto Stigmator (Ctrl +F11)	Activates the automatic procedure to correct an astigmatism.
Sample Cleaning	Starts the sample cleaning procedure according to the Plasma Cleaning alignment (see below).
Set HFW (Ctrl + H)	Enables to set the desired Horizontal Field Width, i.e. the width of the scanned area. This is an alternative to the setting of magnification. 
Display Saturation (Shift + F11)	Shows the saturation status of the image for the selected display. Oversaturated areas of the image (white areas) are shown in blue and undersaturated areas (black areas) are shown in yellow.
Image Post Processing (Ctrl + F7)	Changes image properties according to the **Image Enhancement module > Process tab** setting. See *"Process Tab" on page 131*.
Application Status...	Opens a window above the display 4 that shows a continuously updating status of the system. See *"Application Status" on page 79*.
Preferences... (Ctrl + O)	Opens the Preferences dialog box. See *"Preferences" on page 139*.

Image Registration

Click the **Tools** menu / **Image Registration** and follow the prompts at the top of the window:

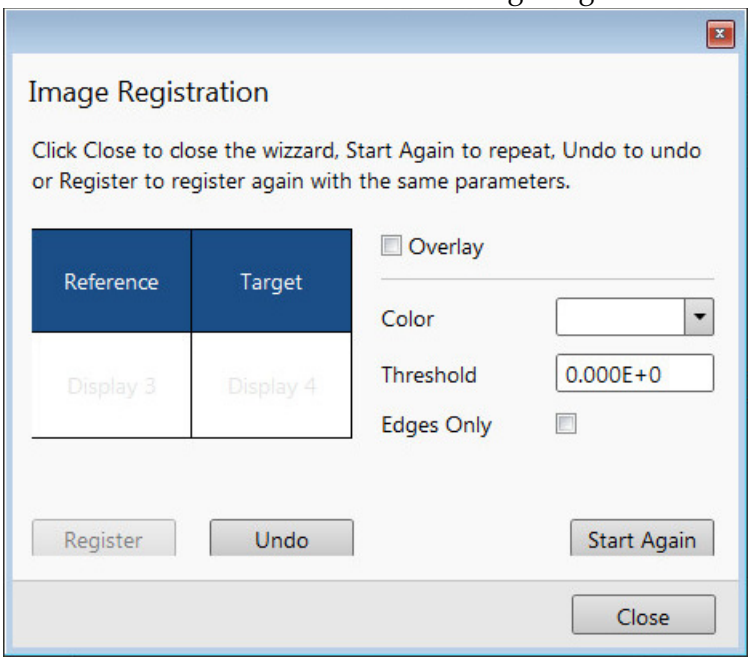
1. Select the display with the **Reference** image.
2. Select the display with the **Target** image (the one that will be transformed).

3. Select 1, 2 or 3 corresponding pairs of points in both the reference and target images.

NOTE	When selecting 1 point, image is shifted only, 2 points shifts and rotates it and by selecting 3 points it is skewed furthermore.

4. Click the **Register** button to apply the transformation.

Click the **Close** button to close the Image Registration window.



Click the **Start Again** button to repeat the procedure in the same way with the changed (or another) target and reference images placed in the same or different displays. Clicking the **Undo** button restores the image to the situation before the last transformation.

Clicking the **Overlay** check box shows a copy of a registered target image (in selected **Color**) over the reference image which reveals a quality of the registration and enables to compare information from both images. The **Threshold** value (0 to 255) determines which gray levels of the target image are shown in the overlay and the **Edges Only** check box ensures to display only the edge outlines.

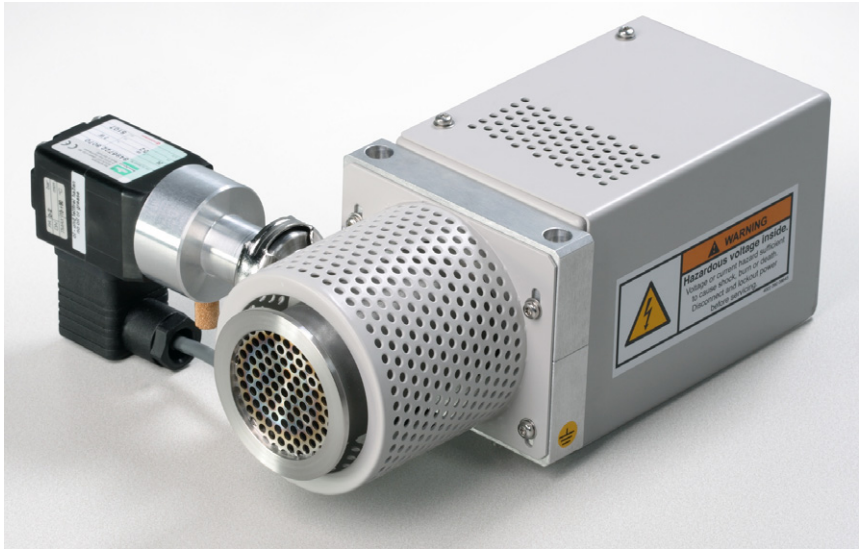
After registration the micron bar and magnification of the target image take on the same values of the reference image. Any operation that is applicable to an acquired SEM image can be applied to a transformed image, including saving a file.

Sample Cleaning

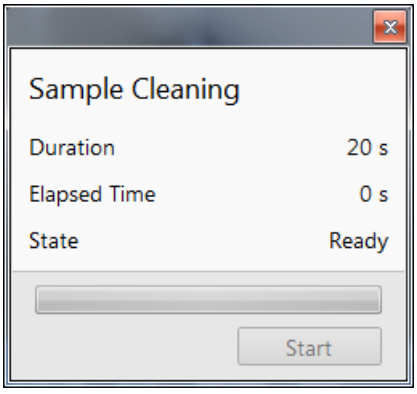
Select **Tools > Sample Cleaning** to start the Sample Cleaning procedure, which is an efficient process for removing very thin contamination layers that are typically formed by hydrocarbon residues remaining on vacuum parts after conventional cleaning or could be transferred into the microscope chamber with a sample.

The plasma cleaner generates free oxygen radicals that react with hydrocarbon molecules on the surfaces to form CO, CO_2, and H_2O molecules that can be pumped away. It is operated at vacuum conditions similar to the low vacuum operation (~50 Pa).

Figure 4-10 Plasma Cleaner



The Sample Cleaning procedure uses cleaning times up to 5 minutes. The time is set in the **Plasma Cleaning** Alignment (see *"External Plasma Cleaning / Plasma Cleaning" on page 347*).



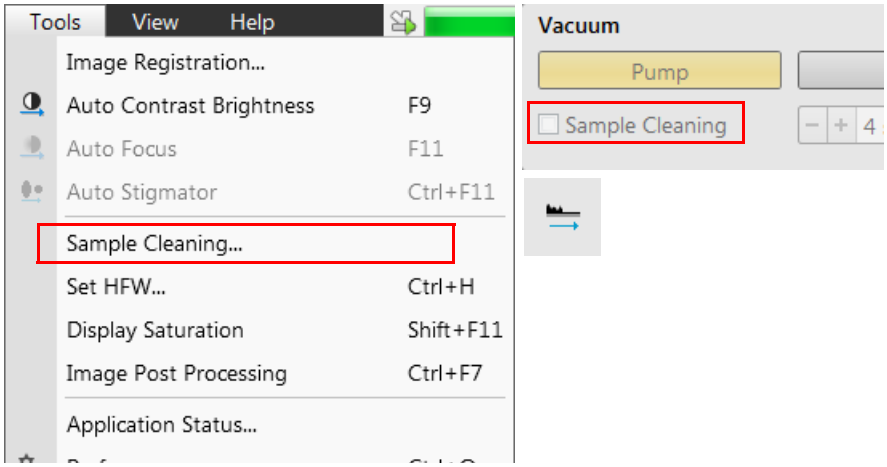
For avoiding typical "weak" contamination artefacts during high resolution imaging (image darkening), 1-2 minutes plasma cleaning duration in combination with cryo cleaning (see *"CryoCleanerEC" on page 380*) should be sufficient. When bulky deposition is visible (mostly on image corners), 5 minutes duration is recommended.

NOTE	Porous, biological or hydrocarbon based samples cannot typically be viewed without the presence of contamination artefacts even after plasma cleaning. This is caused by the presence of contamination source in the sample itself. Sometimes, poor image quality could be caused by e-beam etching and re-deposition of etched material also.

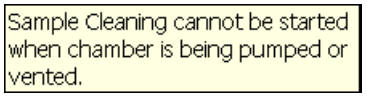
Sample Cleaning Procedure

1. Move the stage to the lowest Z-axis position.
2. Select **Tools > Sample Cleaning** to start the procedure, or click the toolbar button.

   It is possible to start the procedure from the vented state by ticking the **Vacuum** module / **Sample Cleaning** check box.



A dialog box or tooltip will appear onscreen if there any conditions that will not allow it to begin.



3. Move the stage back to the observation position.

When the procedure is finished or aborted by a user, the system remains evacuated. During the procedure run, stage moves are disabled temporarily.

CAUTION	Always retract EDS / WDS / EBDS detector before plasma cleaning! Avoid leaving sensitive carbon containing samples (e.g., photo resist) inside the chamber during Plasma Cleaning procedure, as they may be etched by the cleaning process. Any material that can create or release oxide easily (e.g., silver) should not be plasma cleaned (Au-C resolution test samples could be left inside the chamber during the Sample Cleaning procedure).

Application Status

Opens a window above display 4 that shows a continuously updating status of the system.

Figure 4-11 Application Status

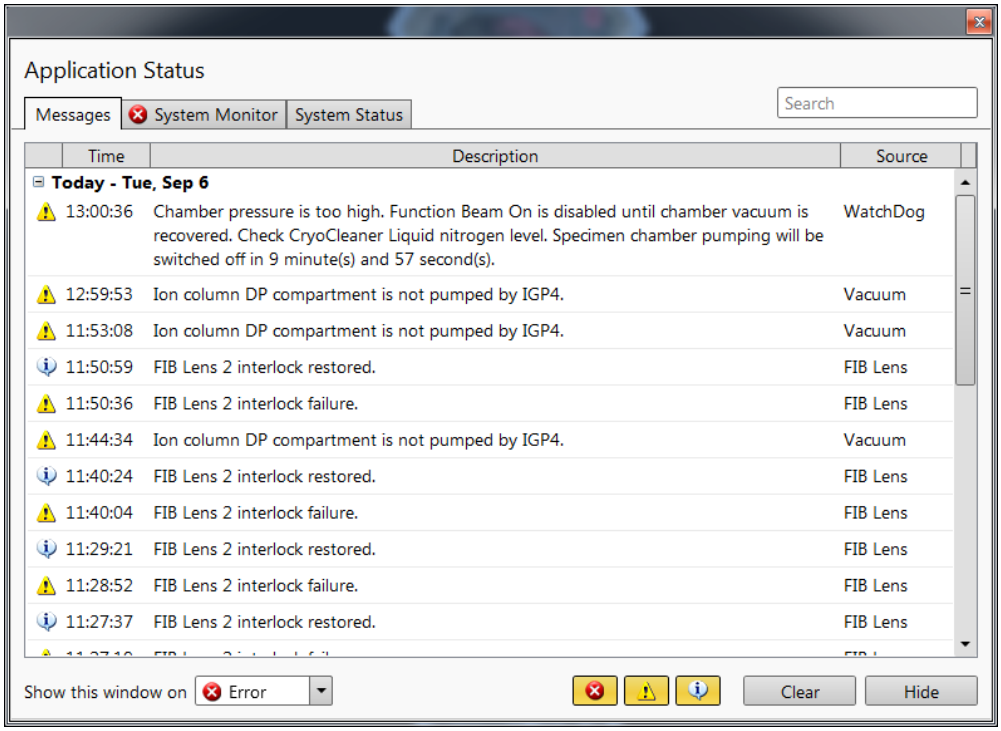
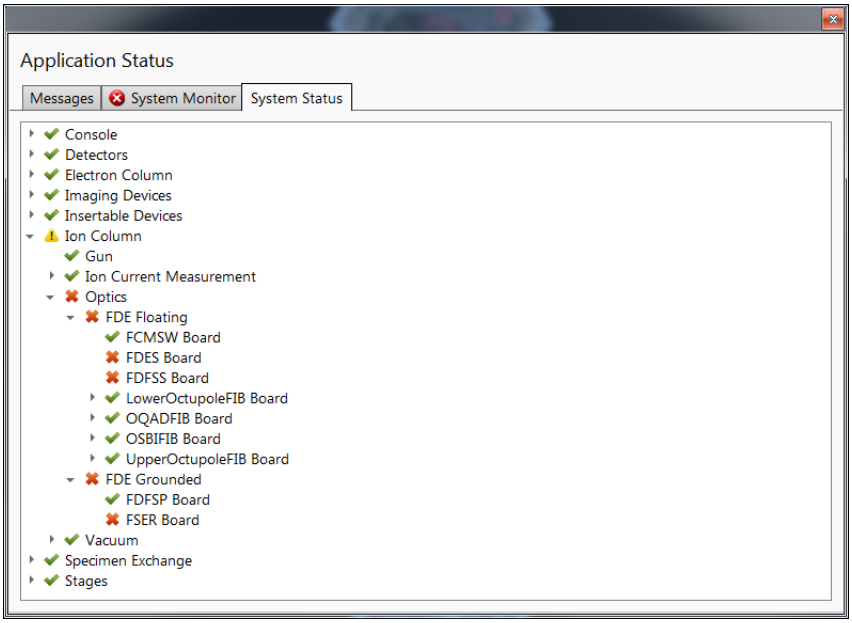


Table 4-1 Application Status Window Overview

Interface Item	Description
Messages Tab	Shows the message area with severity icon, time, description, source, and sort function. **Severity icon key:**  • = warning • = error • = information
Popup on Message Severity	Choices are: • **None**: Will not appear. • **Error**: Appears only for the most sever errors when the system cannot continue without intervention. • **Warning**: Appears only for upcoming events, such as when the FIB needs to be heated. • **All**: Appears only for upcoming events, such as when the FIB needs to be heated.
Clear	Clears the messages list.
Hide	Hides the dialog box.
System Status Tab	Shows the status of the various system components at any given time. 

View Menu

Click **Window** (**Alt + W**) to open the View menu.

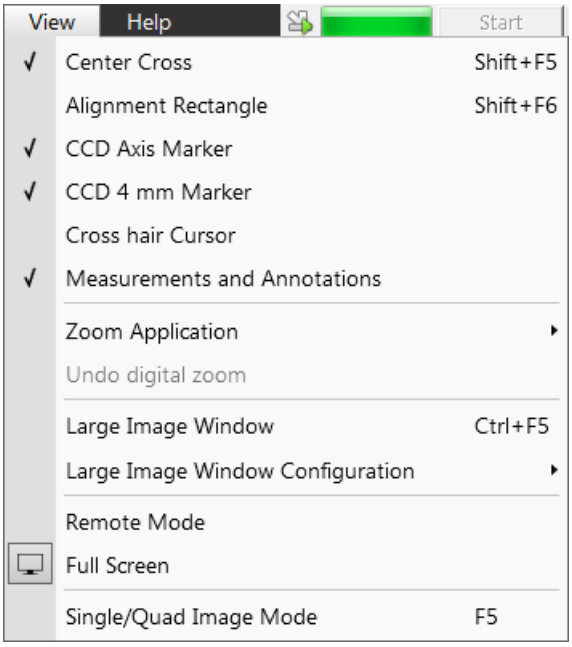


Table 4-2 View Menu Overview (1 of 3)

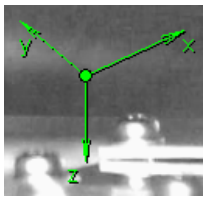
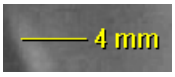
Menu Item (Shortcut keys)	Description
Center Cross (Shift + F5) 	Places a cross in the center of each display. This function is automatically used in Alignment procedures to aid the centering of features and can be used to align a sample against a stored image in another display.
Alignment Rectangle (Shift + F6)	Places a dashed rectangle in the center of all electron displays. This function is used to aid in controlling illumination for some Alignment procedures automatically.
CCD Axis Marker 	Shows X, Y, and Z axes in the CCD display to help the user with 3D orientation.
CCD 4 mm Marker 	Places a short horizontal line with 4 mm label in all optical displays to help with sample positioning to a correct working distance and with the first focusing.
Crosshair Cursor	Changes the mouse cursor into a crosshair cursor. The crosshair cursor is useful in aligning patterns or features.

Table 4-2 View Menu Overview (2 of 3)

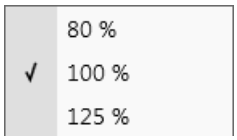
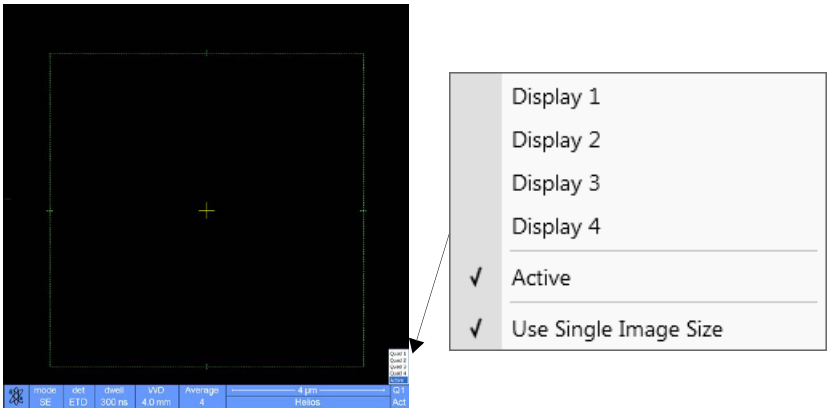
Menu Item (Shortcut keys)	Description
Measurements and Annotations	Ticking this items makes measurements and annotations toolbar icons active, otherwise they are not accessible (greyed out).
Zoom Application 	This functionality enables to enlarge / reduce the Microscope Control application controls size (labelling texts, icons etc.).
Undo / Redo Zoom #x	Toggles the digital zoom to redo or undo. Digital zoom can be set from the Measurement and Annotation page by increasing or decreasing the magnification for the active display. Redo Digital Zoom retains the last magnification factor set by digital zoom and, when selected, sets the magnification factor in the active display to that stored. When the Redo Digital Zoom has been activated, the menu item reverts to **Undo Digital Zoom**. Selecting this brings the image back to normal magnification by negating the factor created by digital zoom. **Note:** *To revert the last step use the Edit menu / Undo (Ctrl + Z) functionality, which is also available at the toolbar.*
Large Image Window (Ctrl + F5)	Activates/deactivates full screen imaging on the secondary monitor.
Large Image Window Configuration	Allows a selection of any display to be shown as Large Image Window. These options are also available in the bottom right corner of the large image window. 
Remote Mode 	Enables a correct UI image at the remote site. It is also used for remote servicing. Use of this function slightly decelerates the UI performance and it is shown in the bottom left display corner.
Full Screen	Ticking this item extends the UI to maximal size with respect to the screen.

Table 4-2 View Menu Overview (3 of 3)

Menu Item (Shortcut keys)	Description
Single / Quad Image Mode (F5)	Toggles the imaging from 1 display to 4 displays and vice-versa. In Single Image mode the display list is selectable to be shown individually in the single image mode. When you switch from Quad Image mode to Single Image mode, the active display is the one that becomes full screen. Quad Image mode is useful for comparing images of the same sample area setup with different beams, detectors, or scan properties.

Help Menu

Click **Help** (**Alt + H**) to open the Help menu.

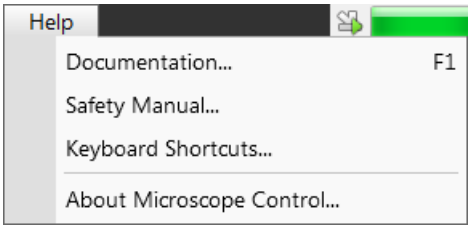


Table 4-3 Help Menu Overview

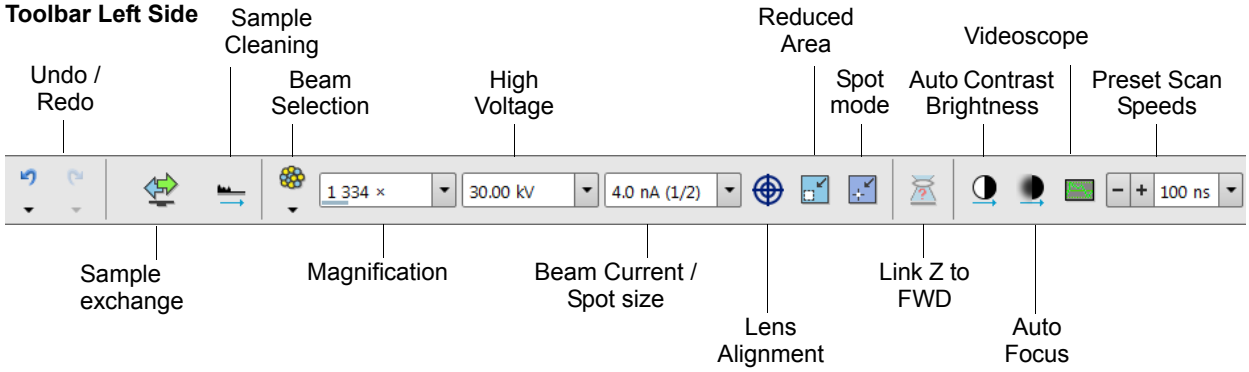
Menu Item	Description
Documentation… (F1)	Shows this complete user guide in PDF format using an embedded Acrobat Reader with its useful navigation, search, and selection tools.
Safety Manual…	Opens the User safety manual.
Keyboard Shortcuts…	Shows a list of keyboard shortcuts, as shown in *Table 4-4 on page 154* and *Table 4-5 on page 155*.
About Microscope Control...	Shows the software version and date of release.

Toolbar

The toolbar shows functional buttons linked to the most frequently used system controls. Rest the cursor on the button without clicking on it to see its highlighted caption or tooltip.

Select system functions with the buttons in the toolbar. Whenever you select a function, the corresponding button is highlighted to indicate that a function is active (except autofunctions, that show a progress dialog box).

Toolbar Left Side



Toolbar Right Side

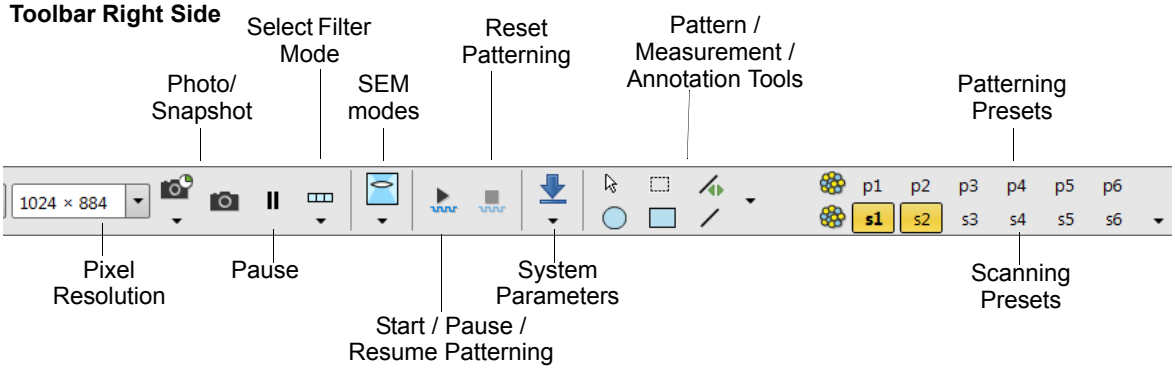


Table 4-4 Toolbar Overview (1 of 8)

Icon	Description
Undo / Redo 	The undo / redo buttons assist to return / re-run the last actions. Actions used in history are accessible by clicking the down arrow and they can be re-used separately or any continuous sequence of actions can be selected and re-used as a group. **Note:** *Some particular actions (alignments etc.) cannot be returned and sometimes the system clears the history.*

Table 4-4 Toolbar Overview (2 of 8)

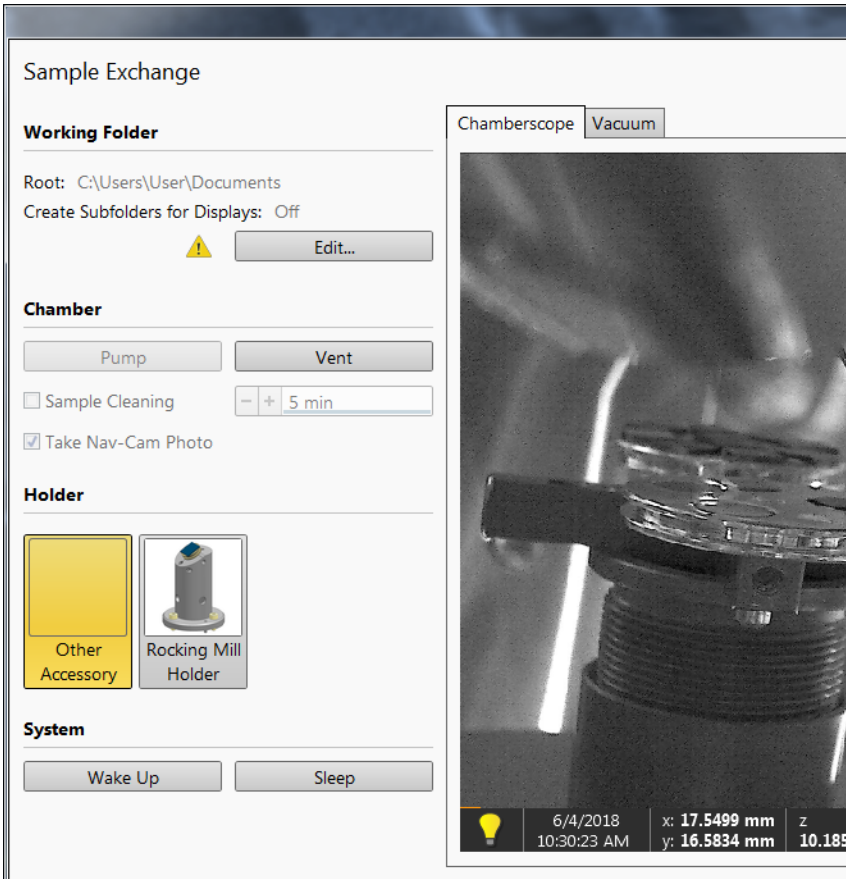
Icon	Description
Sample Exchange 	The window containing complete instructions for sample exchange and information about the system vacuum status. In addition it is possible to set various working environment and start-up actions:  • Working folder for images storing with subfolders for each display • Automatic Sample cleaning when pumping the chamber down • Take Nav-Cam Photo automatically • Holder and other accessories selection • Set System Wake Up and Sleep states
Sample Cleaning 	Starts the Sample Cleaning Procedure.
Beam Selection: Only one beam is active at any time, but can be operated independently for each display image area. The beam can also be selected on the *"Beam Menu" on page 64* or press **Ctrl + T** to toggle between electron beam and ion beam.	
Electron Beam 	Selects the electron beam as the primary beam for control.

Table 4-4 Toolbar Overview (3 of 8)

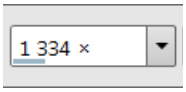
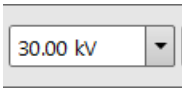
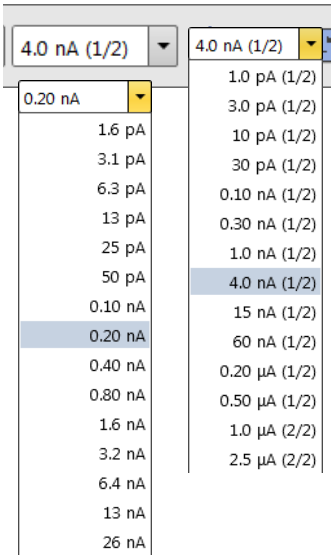
Icon	Description
Ion Beam 	Selects the ion beam as the primary beam for control.
Optical Beam 	Selects the CCD camera as the primary beam for control.
Nav-Cam 	Selects the Nav-Cam as the primary beam for control.
Column Settings: The value ranges for these presets are specific for the electron and ion beams and can be changed on the Preferences, see *"Presets Section" on page 140*.	
Magnification/HFW 	Selects the magnification or horizontal field width for the selected column. Click to show a list of the preset values. The selected value is shown in the text box and applied immediately.
High Voltage 	Selects the high voltage (HV) for the selected column. The value is then shown in the list and the column condition changes to that value.
Beam Current 	Selects the beam current for the selected column. The value is then shown in the list and the column condition changes to that value. The maximum E-beam current for the UC mode is 100 pA. The aperture holes for the FIB wear out with regular use so multiple apertures are available for commonly used beam currents, which is noticeable by doubling the beam current value. Thermo Fisher Scientific service engineers can mark certain apertures unavailable for use. Unavailable apertures are marked in the beam current list with -..- so they cannot be selected. If you do try to select one of the unavailable apertures, the following *Application Status* message appears. 
Lens Alignment   	**Electron beam only**: activates/deactivates the final lens alignment mode for the fine alignment. The scanning changes to the fastest scan value, the lens modulator turns on, and the green target cross appears in the center of all electron beam imaging displays. Clicking and holding the left mouse button activates a 4-ended arrow cursor. The mouse motion starts the final lens alignment. Also available from the *"Beam Menu" on page 64*.

Table 4-4 Toolbar Overview (4 of 8)

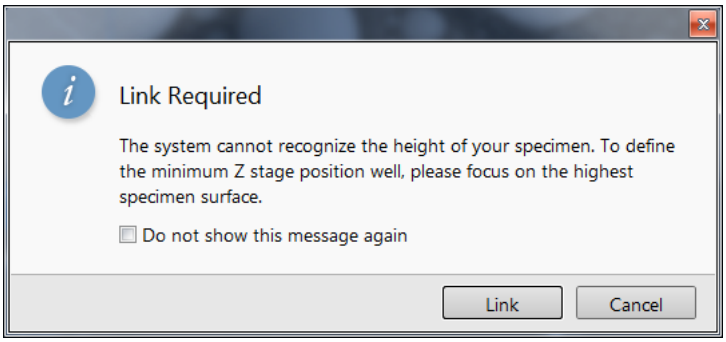
Icon	Description
Reduced Area 	Allows selection of a reduced scanning area within the current image resolution. This is useful when focusing and correcting an astigmatism as the scan speed is faster in the smaller area. The reduced area appears in the middle of the screen. The surrounding image is the actual image in the framestore. Pressing F7 again returns you to full frame. Also available from the *"Scan Menu" on page 59*.
Spot mode 	Sets Spot mode scanning conditions.
Link Z to FWD	Sets the Z coordinate value to the actual free working distance (FWD) value.  The toolbar icon changes to reflect the Z-coordinate status:  • **Grayed icon**: The function is disabled because either the stage has not been homed, the HV is switched off, the ion beam is selected, or all displays are paused.  • **Red question mark**: The function is enabled and the link between Z and FWD is unknown. Use the function as soon as possible, after properly focusing the image.  • **Red circle**: The function is enabled. Z is roughly linked to FWD, but it needs correction. This could happen after changing the sample, focusing and linking Z to FWD at a long working distance (WD), and then moving the stage to a short WD. Focus the image carefully at a WD around 4 mm and use this function again.  • **Green 2-ended arrow**: The function is enabled to allow further corrections of the Z-coordinate, Z is properly linked to FWD. It is now safe to change the WD by setting a Z coordinate in the Stage module. Also available on the *"Stage Menu" on page 68*.
Auto Contrast Brightness 	Activates the automatic contrast and brightness routine. *Autofunctions are only enabled during live imaging.* Also available on the *"Tools Menu" on page 74*.

Table 4-4 Toolbar Overview (5 of 8)

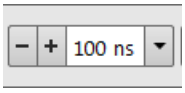
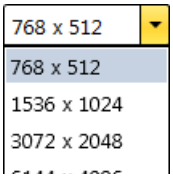
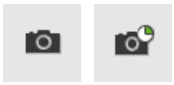
Icon	Description
Auto Focus 	Activates the automatic focus routine for either beam. *Autofunctions are only enabled during live imaging.* Also available on the *"Tools Menu" on page 74*.
Videoscope 	Shows the video signal intensity along the currently scanned horizontal line for correcting the contrast and brightness. Also available on the *"Scan Menu" on page 59*.
Scan Speeds: These controls provide slow or fast scanning capabilities. When either of the two presets is active, its respective icon is highlighted. Clicking any of these items changes the scan speed. The presets are defined on the *"Scanning Section" on page 144*. These controls are also available on the *"Scan Menu" on page 59*.	
Preset Scan Speeds + / - 	Shows the selected scan speed preset: • **+**: Increases the scan speed in predefined increments. • **-**: Decreases the scan speed in predefined increments.
Pixel Resolution 	Shows the predefined image size (screen pixel resolution) for viewing or capturing an image. *These presets are not editable from the dropdown list, but they can be changed on the "Scanning Section" on page 144.*
Photo / Snapshot 	For a quick image, activates a single scan at a preset scan setting that pauses at the end of the frame. The result can be automatically saved on the hard drive to a predetermined file location using the next available label/number if set on the *"Scanning Section" on page 144*.
Pause  	Pauses the image. The behavior is set on the Preferences *"General Section" on page 147*: • Click once and the scan will stop immediately without finishing the frame, or • Click once to stop scanning at the end of the frame. • Click twice to pause the scan immediately at the present position. When Pause is active, clicking again releases the pause function and returns the scanning to the original condition prior to pause. When Pause is clicked again, two vertical green bars surrounded by a green box appear in the top left corner of the full screen or active display. Depending on the selected beam, a tooltip states "Not allowed to start image acquisition. Sample is not under this beam." • When the stage is under the optical beam, you cannot scan or pattern with the FIB or SEM. • When the stage is under the FIB or SEM, you cannot scan with the optical beam.

Table 4-4 Toolbar Overview (6 of 8)

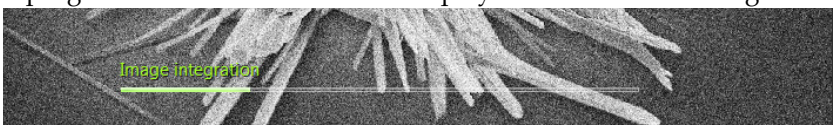
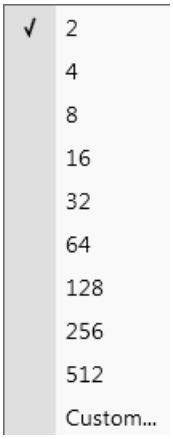
Icon	Description
Select Filter Mode: This section contains four items related by conditions of filtering of the raw scanned image. Clicking the icon itself changes the Live/Average/ Integrate mode in cycle. Click the down arrow to access the preset list for number of frames. If you select one of these three options from a frozen (paused) image state, the imaging will start automatically without the need to unpause it, using the selected filter mode. These selections are also available on the *"Scan Menu" on page 59*.	
Live 	Starts Live imaging with one frame following the other. The image remains unfiltered for collecting direct images, mostly in Live/Slow scan. This is the raw scanned image with no filtering.
Average 	Starts Average imaging. Continuously averages a specified number of frames (2 or more), resulting in a better signal-to-noise ratio. Select the number of frames to be averaged in the dropdown list box. During averaging, the image is updated continuously and actions such as focusing and moving the stage can still be performed. This process will continue until stopped by change of scanning condition or by freezing the result.
Integrate 	Starts Integrated imaging. Allows accumulative noise reduction by true integration over a number of frames and freezes the final image. Select the number of frames to be averaged in the dropdown list box. This process continues until the predefined number of frames is reached, and then stops and freezes automatically. A progress bar shows in the active display as the frames are integrated. 
Preset number of frames 	Selects the number of frames for Average and Integrated imaging. Click the arrow to the right of the button to show the dropdown list showing the number of frames for each value of Average or Integrate. Live is always 1 frame. Select one of these values to update to that condition. Frame values for Average and Integrate are independent of each other and of scan speeds, so values can be preset for particular scan, beam, and display conditions. Set a filter per display, per beam so that live and filtered images of a beam can be seen at the same time; if a new beam is selected, it reverts to the preferred setting for that beam.

Table 4-4 Toolbar Overview (7 of 8)

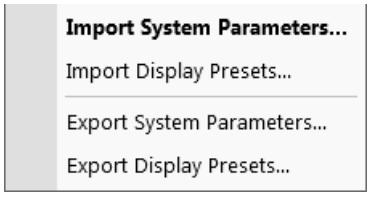
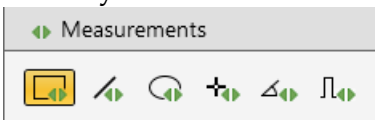
Icon	Description
Select SEM Mode 	*Only active for the electron beam.* Shows one of three SEM (final lens) modes: • **Mode 1: Field-Free** – For low magnification searching of the samples or sample area. • **Mode 2: Immersion** – A higher resolution mode for viewing the sample at a higher magnification. • **Mode 3: EDX** – Used for EDX operation where the lens is used as a magnetic trap for backscattered electrons (BSEs) during EDX analysis. Also available on the *"Beam Menu" on page 64*. See *"SEM Imaging Modes" on page 200*.
Patterning     	Starts, resets, pauses, and resumes patterning. The icons change according to an actual process status. The system response could delay a little until transitions finish. • Click the **Start** button to start the patterning. The button changes to pause button. • Click the **Pause** button to pause the patterning. The button changes to resume button. • Click the **Resume** button to resume the patterning. The button changes to pause button. • Click the **Stop** button during patterning or when patterning is paused to reset the patterning. The button changes to inactive state (gray). • Clicking the **Stop** button during an image acquisition finishes it and subsequently pauses the patterning. The button changes to active state (black). Scanning conditions: • When the stage is under the optical beam, you cannot scan or pattern with the FIB or SEM. • When the stage is under the FIB or SEM, you cannot scan with the optical beam. Also available on the *"Patterning Menu" on page 66*.
Import / Export System Parameters 	Shows a submenu with selections of importable / exportable items.  Selecting an item opens a standard Open/Save As dialog box for choosing a location and file name (see **File** menu **/ Import / Export** item).

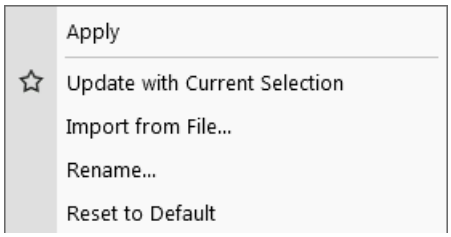
Table 4-4 Toolbar Overview (8 of 8)

Icon	Description
Patterns / Measurements / Annotations 	The toolbar set of 6 graphic tools (2 cursors and 4 shapes) last time used and the drop-down arrow for selection of more ones enables to quickly access the Patterns / Measurements / Annotations tool. Clicking on the icon activates (orange background) / deactivates (grey background) the appropriate functionality. The numerical values of linear distances, diameters, angles, or areas of the image are updated while drawing and shown alongside or within the finished measured item. The Measurement tool dimensions scale with the image; when changing magnification, the shown tools change their size accordingly. On the contrary, the Annotation shapes and texts have their sizes fixed relatively to the display.
Intensity Profile tool 	**Intensity Profile** delineates the imaging profile across a freely selected line with a set of properties. • **Dynamic Y Range**: Normalizes the line profile and shows information across the full Y axis range. If the line profile only has gray scale information from bin 100–200, selecting **Yes** for Dynamic Y Range stretches the profile to show the low bin (100) at the zero point of the graph and the high point (200) at the 255 point of the graph. This allows you to better analyze the profile if it does not have data in the full range of 0–255. • **Integration Width:** Integrates the profile over a user-selected pixel width, to minimize signal noise and smooth the profile.

Patterning presets

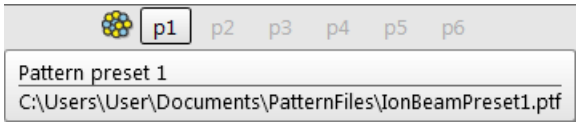
By default there are 6 empty toolbar Pattern presets (labelled p#) for each (electron / ion) beam. Clicking on any one imports predefined set of patterns into the active display.

Right-clicking on any Pattern preset button calls up the context menu:

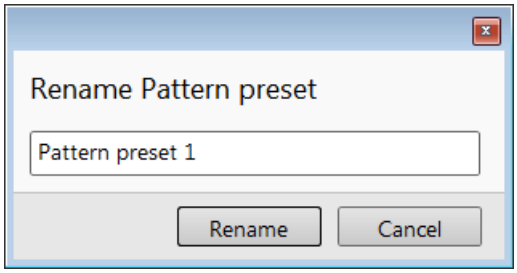


- Clicking on the **Apply** item (the same as clicking the button directly) loads parameters from this file and corresponding patterns are drawn in the active display. To start patterning under loaded conditions follow the patterning process.
- Clicking on the **Update with Current Selection** item assigns patterns directly from the active display, saves the setting to

the file and automatically applies it to the selected preset button. Tooltip shows the location and a file name.



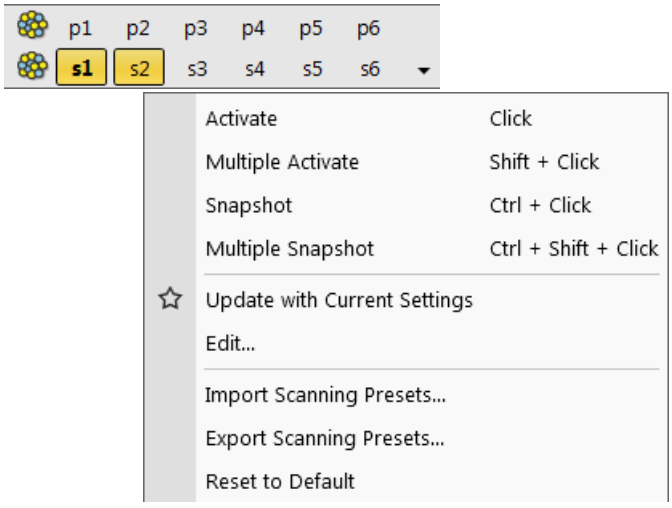
- Any toolbar Pattern preset button can be assigned to an individual .ptf file (with all patterning parameters exported via the **File** menu / **Export** / **Patterns** or **System Parameters** item) by selecting **Import from File…** item.
- To rename the pattern preset button click the **Rename…** item.



- Clicking on the **Reset to Default** item brings all settings to the factory presets.

Scanning Presets

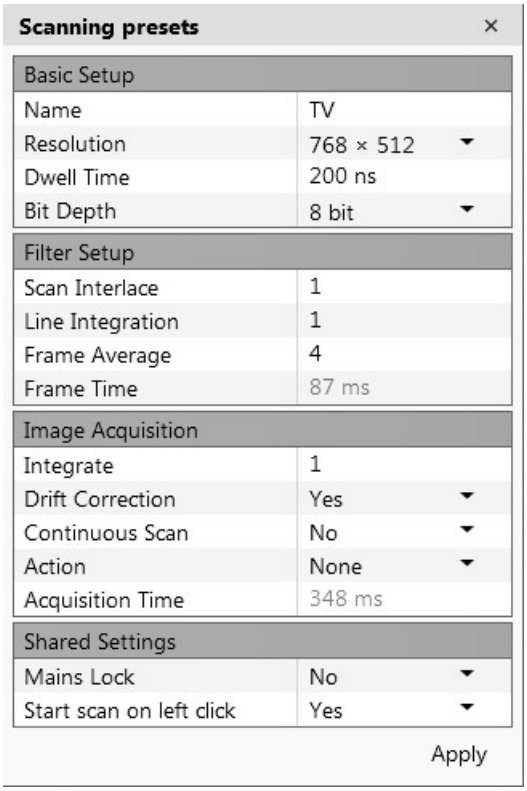
By default there are 6 factory toolbar **Scanning presets** (labelled **s#**) for each (electron / ion) beam. Clicking on any one sets scanning conditions for active beam (dwell, resolution etc), display (filter) and starts image acquiring with corresponding parameters. Right-clicking on any Scanning preset button calls up the context menu:



- Clicking on the **Activate** item highlights the button (orange background) and starts image acquiring or just activates the

preset according to the **Scanning presets** property editor / **Shared Settings** section / **Start scan on left click** item setting (Yes / No). The **Multiple Activate** item has the same functionality in all compatible displays (same beam).

- To start image acquiring is possible also using the *Scan* menu / **Active Preset Snapshot** (Ctrl + F2) item.
- Clicking on the **Snapshot / Multiple Snapshot** item starts snapshot acquiring from selected / all compatible displays.
- Clicking on the **Update with Current Settings** item updates selected Scanning preset with actual scanning settings.
- Clicking on the **Edit** item opens selected Scanning preset property editor. It is also possible to use the toolbar expand / hide arrow with the same effect.



Click the **Apply** button to store edits and close the Property editor.

- It is possible to **Import / Export Scanning Presets** from / to a file (.scp).
- Clicking on the **Reset to Default** item brings all settings to the factory presets.

Select any of six presets to activate image acquisition according to preset parameters.

NOTE	**Shift + clicking** the **Photo** icon (or **Shift + F2**) takes an electron beam Snapshot from all displays at once. **Ctrl + clicking** the **Scanning preset** button takes an electron beam Snapshot of the active display only. **Ctrl + Shift + clicking** the **Scanning preset button** takes a snapshot from all available electron or ion beam displays (depending on the active beam) at once. The same keystrokes will interrupt the acquisition process.

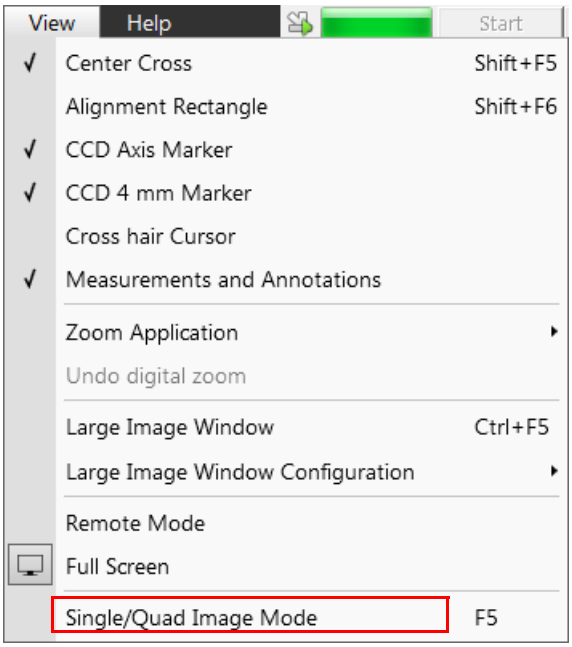
Imaging Area

The Microscope Control software shows images via four independent image windows called **displays**. All displays can contain a live image from any detector (including External and CCD), paused images, or images loaded from a file. Additionally, display 3 can show a mix of imaging from displays 1 and 2, and display 4 can show a mix of imaging from displays 1, 2 and 3.

The image window includes the image area plus the databar, and it shows the scanned area image and any defined patterns. You can interact with the images or draw patterns on them.

The four displays can be shown either all at the same time in Quad Image mode or one zoomed display at a time in Single Image mode.

To choose the image display mode, select the appropriate View menu item or press the **F5** toggle key. Click in a display to select it. Pressing **Ctrl + Tab** selects each display in turn.



1	2
3	4

In Quad Image mode, display 1 is top left and display 4 is bottom right.

Quad Image mode is useful for comparing images of the same sample area taken with different beams or scan properties.
See *"Setup for Imaging with Either Beam" on page 169*.

When you select a display, you give it the input focus—that is, you designate it as the part of the user interface that receives mouse and keyboard input. The display with input focus has a blue databar. The other displays have gray databars.
See *"Databar Color Coding Status" on page 97*.

Note that you can continue live imaging in one display even when you have given focus to another.

When you switch from Quad Image mode to Single Image mode, the display with input focus is shown on the full screen. If a non-imaging part of the user interface (such as a page or dialog box) has the input focus when you switch to Single Image mode, that last display to have input focus is shown on the full screen and recovers the input focus.

Depending on the display content and the status, some mouse functions are available over its area:

- **Electron imaging** (including External and Mix): Focus, astigmatism correction, Beam Shift, magnification change

(coarse, fine), zoom (in/out), Contrast and Brightness, lens alignment, Scan/Compucentric Rotation, XY-move (Get or Track moves)

- **Ion imaging** (including External and Mix): Focus, astigmatism correction, Beam Shift, magnification change (coarse, fine), zoom (in/out), Contrast and Brightness, Scan/Compucentric Rotation, XY-move (Get or Track moves)
- **Optical imaging**: 4 mm Marker placement, Compucentric Rotation, Z-move (Track moves), Tilt

NOTE	Due to a hardware limitations, some detectors cannot be used simultaneously. They can still be selected for different displays at the same time, but if one of them is started, the other displays with incompatible detectors are automatically paused. The optical imaging is automatically activated (if it is paused), when the venting procedure starts. When it is paused and any stage movement takes place, the pause icon turns red and a list of changed axes is shown.

Image Databar

Optional instrument, imaging and labelling information are shown at the base of all displays. The configuration and available items differ for the beam selected (Electron / Ion / Optical / Nav-Cam) for the selected display.

NOTE	The Databar information are always related to the live imaging. If the imaging is paused or an image is loaded from a file, they could differ from actual system conditions.

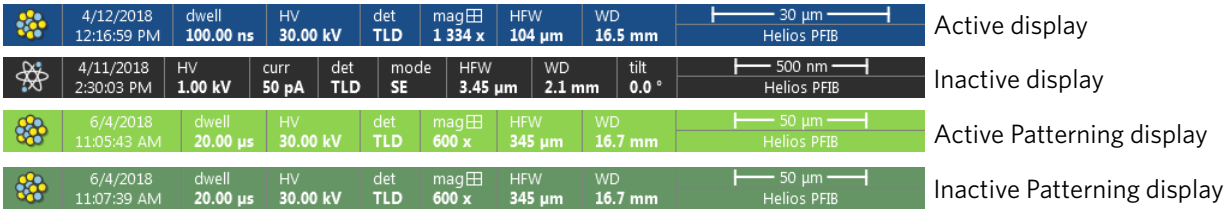
Databar Color Coding Status

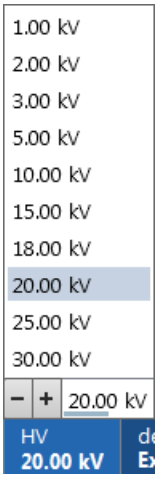
In Quad Image mode, the active image area has a blue databar. Other image windows have databars in different colors (see following table).

Table 4-5 Databar Color Coding Status

Display Status	Scan Condition	Background Color	Text Color
Selected	Live	Blue	White text
Not selected	Live	Gray	White text
Selected	Pause	Blue	White text
Not selected	Pause	Gray	Black text
Selected	Patterning	Light green	White text
Not selected	Patterning	Dark green	White text

Figure 4-12 Image databar examples





Menu Access

Click on some of the image databar fields to access an active menu with appropriate choices related to that field.

Databar Configuration

To set information included in the databar right-click on any display databar and click on & drag desired *Available Item* to the *Visible Items* field. Items can be placed in any order (by dragging the item up / down within the list) and expand or contract automatically to fit the display width as long as there is enough room, which influences all displays with the same beam.

The *Micronbar* area scales to the magnification.

Clicking on the *Choose Bitmap* item opens a dialog to select a bitmap to be loaded into the databar (if the *Bitmap* item is ticked).

To label databar, double-click on the Label field and fill in the dialog. It can be set independently for each display.

Figure 4-13 Databar Configuration / Label Editing

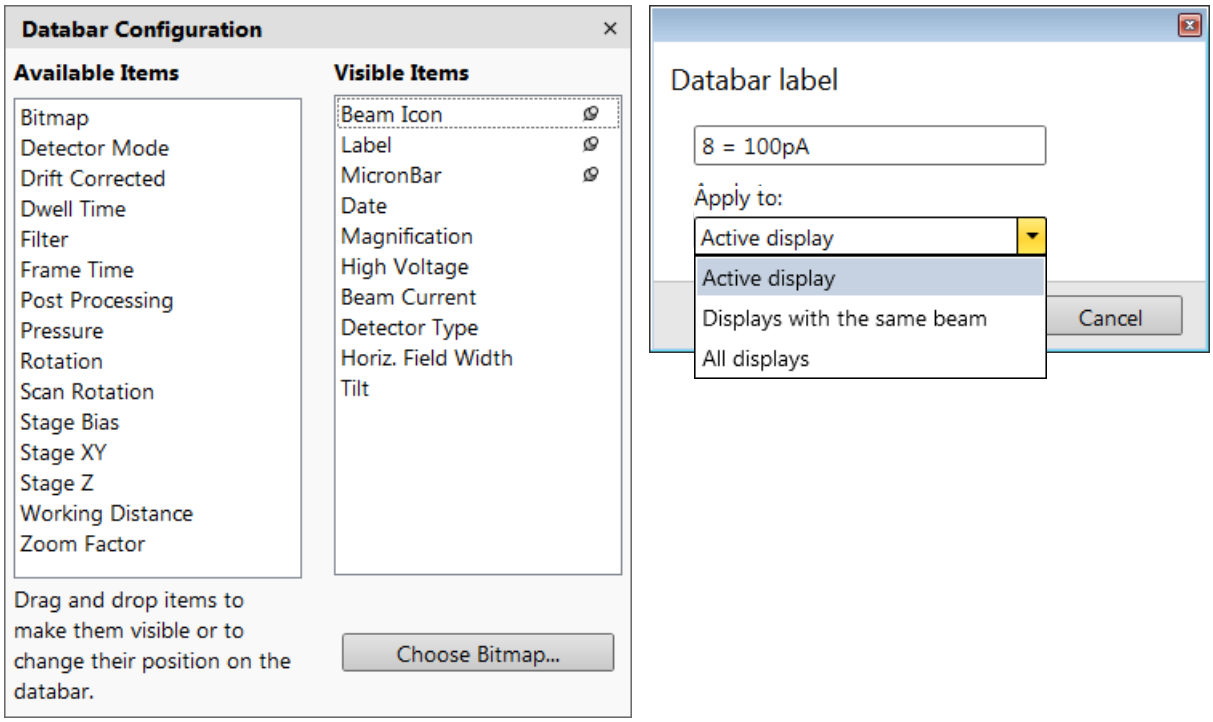


Image Properties

Double-click the micron bar to access the Image Properties dialog box to view the full set of properties relating to the image in the display. If you leave the dialog box open and click in the databar of another display, the property data changes accordingly for the image in the new display.

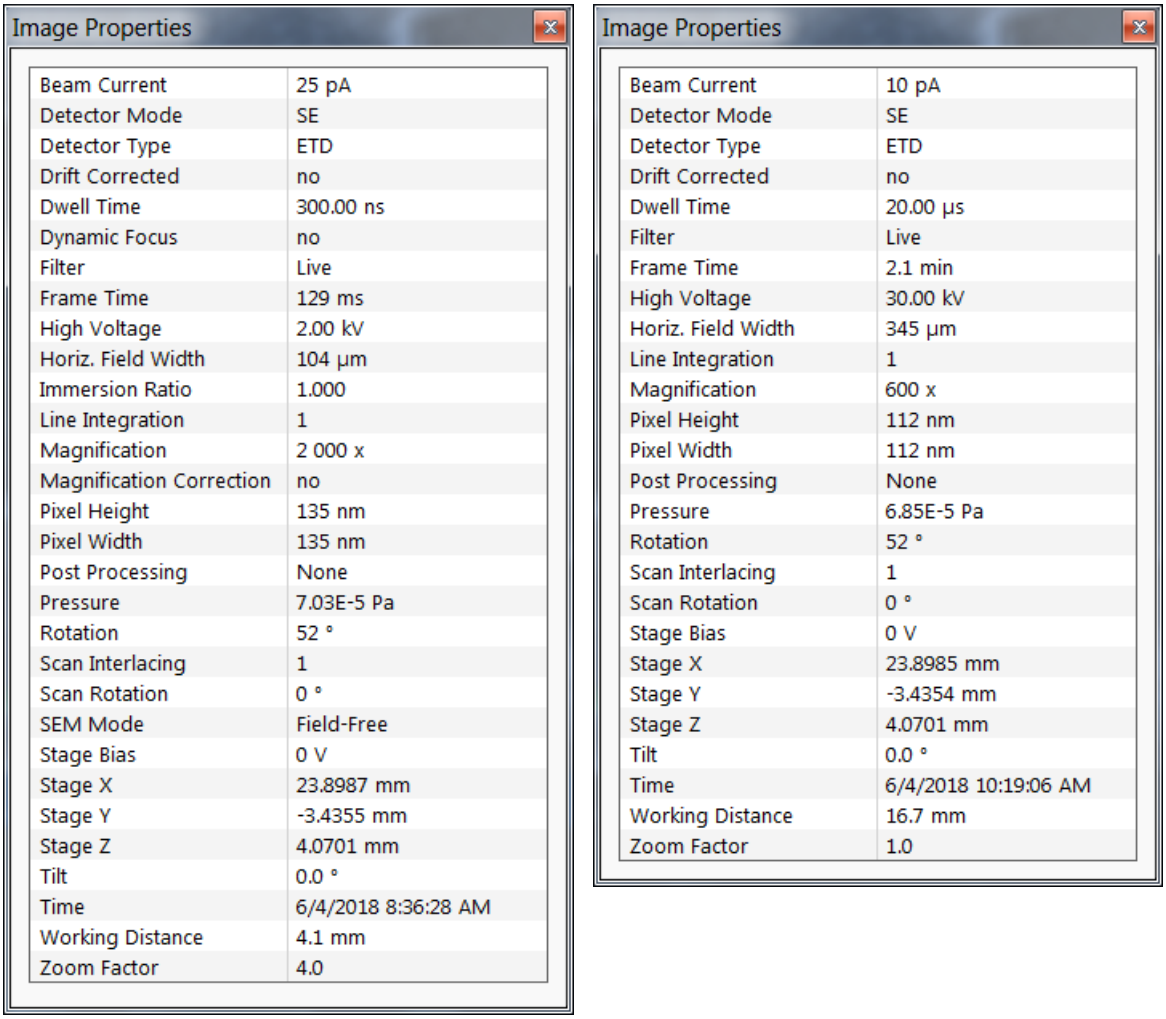


Image Properties

Beam Current	25 pA
Detector Mode	SE
Detector Type	ETD
Drift Corrected	no
Dwell Time	300.00 ns
Dynamic Focus	no
Filter	Live
Frame Time	129 ms
High Voltage	2.00 kV
Horiz. Field Width	104 µm
Immersion Ratio	1.000
Line Integration	1
Magnification	2 000 x
Magnification Correction	no
Pixel Height	135 nm
Pixel Width	135 nm
Post Processing	None
Pressure	7.03E-5 Pa
Rotation	52 °
Scan Interlacing	1
Scan Rotation	0 °
SEM Mode	Field-Free
Stage Bias	0 V
Stage X	23.8987 mm
Stage Y	-3.4355 mm
Stage Z	4.0701 mm
Tilt	0.0 °
Time	6/4/2018 8:36:28 AM
Working Distance	4.1 mm
Zoom Factor	4.0

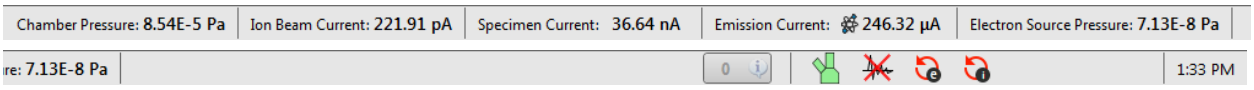
Image Properties

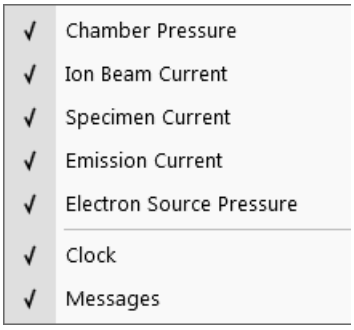
Beam Current	10 pA
Detector Mode	SE
Detector Type	ETD
Drift Corrected	no
Dwell Time	20.00 µs
Filter	Live
Frame Time	2.1 min
High Voltage	30.00 kV
Horiz. Field Width	345 µm
Line Integration	1
Magnification	600 x
Pixel Height	112 nm
Pixel Width	112 nm
Post Processing	None
Pressure	6.85E-5 Pa
Rotation	52 °
Scan Interlacing	1
Scan Rotation	0 °
Stage Bias	0 V
Stage X	23.8985 mm
Stage Y	-3.4354 mm
Stage Z	4.0701 mm
Tilt	0.0 °
Time	6/4/2018 10:19:06 AM
Working Distance	16.7 mm
Zoom Factor	1.0

Status Bar

The Status bar can be found at the base of the UI screen and it contains several user selectable items and information about running system processes (patterning for instance). These parameters may change due to the application being monitored at any time.

Figure 4-14 Status Bar (divided to left / right part)





Right-click on the Status bar and tick items to be shown:

- **Chamber Pressure** – the specimen chamber pressure
- **Ion Beam Current** – correct ion beam current value in case the beam is blanked
  When it reverts into operation (unblanked), the value has no point.
- **Specimen Current** – the electron current reaching the specimen
- **Emission Current** – the electron / ion current reaching the specimen
- **Electron Source Pressure** – pressure in the corresponding vacuum system section
- **Clock** – can be shown at the bottom right window corner
- **Messages** – Application Status incoming notice can be shown

The vacuum status is also indicated by the color of the chamber icon:

Green = pumped to the desired vacuum mode
Orange = transition between two vacuum states
Gray = vented

When you hover the mouse over any icon, a corresponding tooltip appears with actual status for the parameter(s) or just an information.

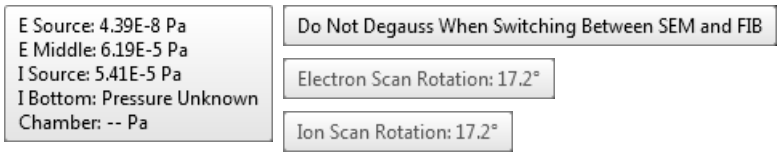
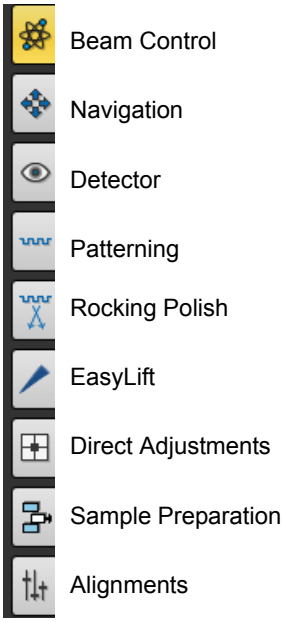


Table 4-1 Status Icon Overview

Icon	Function
	Dual column and chamber vacuum: Green columns and dark chamber = operating vacuum in columns but chamber is to atmosphere.
	Dual column and chamber vacuum: Green columns and orange chamber = operating vacuum in columns and chamber pumping down, venting or purging.
	Dual column and chamber vacuum: Green columns and chamber = operating vacuum reached in all sections.
	Stage axes lock/unlock: Closed lock indicates any or all axes locked.
	Dynamic Focus: Shows when Dynamic focus is on.
	Scan rotation: Shows independently for electron and ion beam when Scan Rotation is not zero.
	External: Shows when the External scan mode is operating.
	Degauss: Shows when **Do Not Degauss** is ticked on the Beam Menu.

Pages

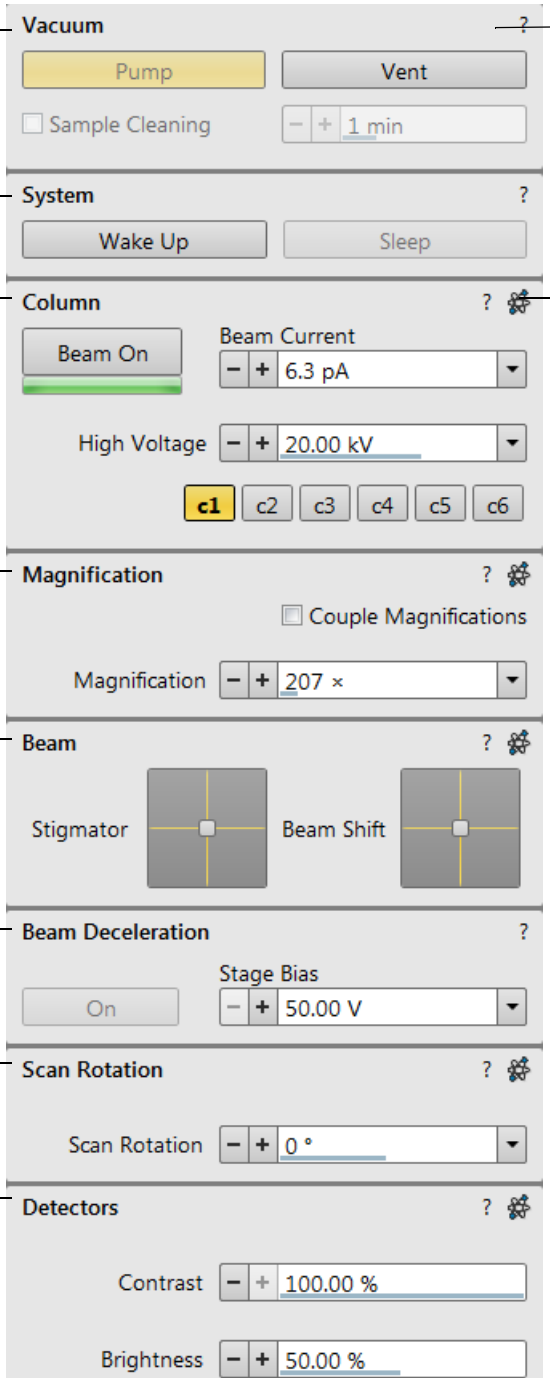


The system software controls are organized into control pages and are placed on the top right side of the UI screen. Rest the cursor on the icon to read its tool-tip. The selected page has an orange background. These pages are divided into smaller modules for specific functions. The most frequently used controls appear as modules on more than one page.

Beam Control Page

Use the Beam Control page for vacuum control to pump and vent the system and to control the electron and ion columns. For operational details, see Chapter *"Getting Started" on page 159*.

Figure 4-15 Beam Control Page



See *"Vacuum Module" on page 103*

See *"System Module" on page 103*

See *"Column Module" on page 104*

See *"Magnification Module" on page 107*

See *"Beam Module" on page 107*

See *"Beam Deceleration Module" on page 109*

See *"Scan Rotation Module" on page 109*

See *"Detectors Module" on page 110*

Click the ? to access online help for that module.

This symbol represents the selected column type: electron or ion.

Use the toolbar buttons to switch the column type as necessary for operating in individual displays.

Vacuum Module

Use the controls in this module to control the pressure in the specimen chamber.

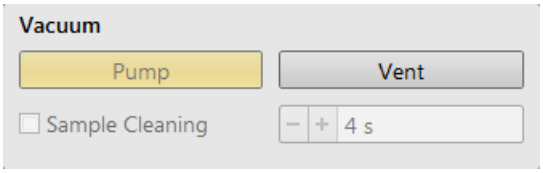


Table 4-1 Vacuum Module Overview

Interface Item	Description
Pump	Starts the pump down procedure for the sample chamber and column. For turbomolecular pump (TMP) systems, evacuating the sample chamber is immediately through this pump. When the chamber is evacuated, the system allows high voltage to be switched on when the pressure in the chamber and the column are ready for operation.
Sample Cleaning	Starts to pump out the system, performs the Sample Cleaning procedure, and keeps the chamber evacuated. See *"Sample Cleaning" on page 77*. Preset adjuster enables to set sample cleaning procedure duration.
Vent	Initiates the following sequences for the respective columns and GIS system after a user confirmation: • **Electron column**: Switches high voltage (HV) off and closes the column isolation valve (CIV). • **Ion column**: Blanks the beam and closes the CIV. HV is brought back to 5 kV. • **GIS system**: Closes the GIS, retracts the GIS needles, and turns off the GIS heaters.

System Module

Use the controls in this module to start and stop the system.
See *"Beginning Your Session" on page 162*.

Table 4-2 System Module Overview

Interface Item	Description
Wake Up	Turns on the electron and ion beam accelerating (high) voltage, starts the ion source, starts the electron source (if it is switched off) and starts GIS heating (under some conditions).

Table 4-2 System Module Overview

Interface Item	Description
Sleep	Turns off the electron and ion beam accelerating (high) voltage, stops the ion source, and turns off GIS heating. **Note:** *Stopping the ion source impacts the life time of the source.*

Column Module

Use the controls in this module to set the electron and ion beam conditions.

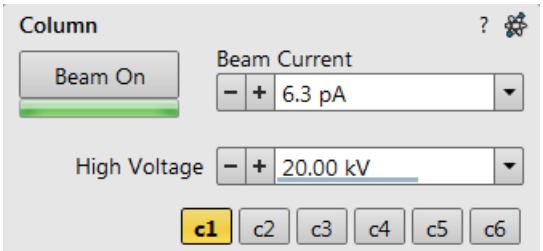


Table 4-3 Column Module Overview

Interface Item	Description
Beam On	Initiates the following sequences for the respective columns: • **Electron column**: Switches high voltage on/off and opens/closes the column isolation valve (CIV). • **Ion column:** Opens/closes the CIV, selects the last-used aperture, selects the preselected high voltage, and turns the ion source on if it is not already running. Color Key: **Orange** = activated / **Gray** = deactivated.
Beam Current	Preset adjuster used to change the overall beam current using preset values (see *"Presets Section" on page 140*).
High Voltage	This preset/continuous adjuster is used to change the overall high voltage either continuously or using preset values (see *"Presets Section" on page 140*). • The electron column range is from 350 V to 30 kV in regular mode and down to 50 V with beam deceleration mode • The ion column range is from 500 V to 30 kV. • The current high voltage value is shown in the text area of the adjuster, toolbar, and in the image databar (if selected in *"Image Databar" on page 97*).

Column Presets

Column presets simplifies microscope operation to users. Microscope software comes with 6 pre-defined sets of various column parameters separately for electron and ion beams (depending on the active display) represented by the Column Presets buttons labelled c#. A user can change these settings to easily choose the operating conditions according to his needs.

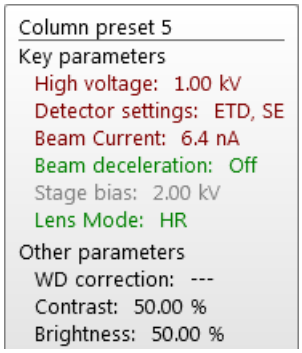
The column preset is applied with a click, a progress dialog is shown. The button becomes highlighted (orange background) when all actual microscope settings match the preset parameters (column conditions for active beam and detector settings for active display). The bold labeled button indicates the last applied column preset.

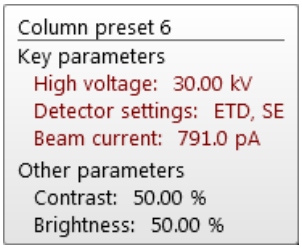
Note the behavior that is not obvious:

- The sequence of parameters being applied with the Column preset button click may change depending on imaging mode (SEM modes or Beam deceleration mode).
- SEM imaging modes are also covered in column presets.
- Beam is not switched on automatically when a column preset is applied.
- It can happen that a column preset cannot be completely applied because it is not possible to set some parameter (particular detector not available, stage bias value out of the range or incompatible SEM imaging parameters - range of accelerating voltage at given working distance). In such a case an application status error message is shown.
- Mix detector cannot be used for a column preset.

A tooltip is shown when leaving mouse cursor over any preset button giving parameters overview divided into 3 areas (**Preset name / Key parameters / Other parameters**). There are different tooltips depending on the beam selected for the active display.

Tooltip dialog / Detector settings line contains information in format <detector>, <detector mode>. Particular settings of a detector custom mode is not supported in column presets.

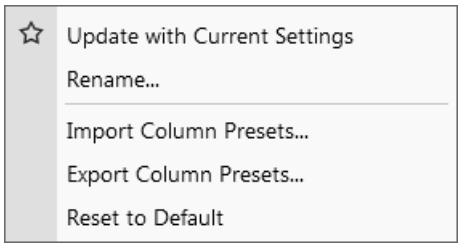




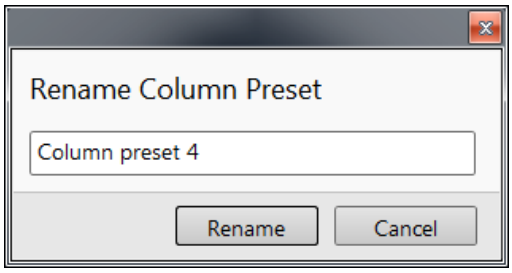
Parameters are colored, which indicates:

- **Green** – actual microscope setting matches the column preset
- **Brown** – actual microscope setting differs from the column preset
- **Grey** – Value is not relevant when respective component is switched off

Right-clicking on any preset button calls up the context menu:



- Clicking on the **Update with Current Settings** item updates selected preset button with actual settings.
- Clicking on the **Rename** item enables to rename the selected preset button.



- It is possible to ***Import/Export Column Presets*** from / to a file (.clp).
- **Reset to Default** button – restores the default settings for all column presets (for both beams).

Magnification Module

Use the controls in this module to set the imaging magnification. See also *"Magnification" on page 194*.

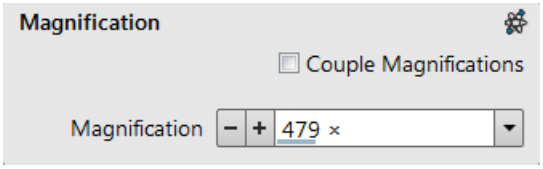


Table 4-4 Magnification Module Overview

Interface Item	Description
Couple Magnification	Couples (locks) the magnification of both beams.
Magnification	Adjusts the magnification. • Clicking the **end arrow** increases/decreases magnification by 5%. • Clicking between the **end arrow** and the **middle button** increases/decreases magnification by 20%.

Beam Module

Use the controls in this module for correcting of beam astigmatism and beam shift for both beams.

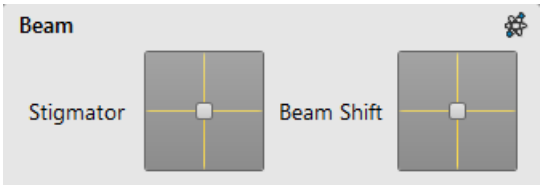


Table 4-5 Beam Module Overview (1 of 2)

Interface Item	Description
Stigmator 2D control	Used to correct image astigmatism. The crosshair cursor indicates the actual stigmator setting. Click in the 2D X-Y control. The hand cursor appears onscreen. • Move the mouse left to right to modify the X-stigmator. • Move the mouse up and down to change the Y-stigmator. The stigmator range is coupled with the magnification. When the stigmator has been adjusted correctly, release the left mouse button. The position of the cross in the reserved adjustment area updates. You can also use the **Shift** + right mouse button for stigmation.

Table 4-5 Beam Module Overview (2 of 2)

Interface Item	Description
Beam Shift 2D control	Allows you to change the beam shift setting. It is useful for fine imaging shifts without stage movement. The crosshair indicates the actual setting of the beam shift. Click in the 2D X-Y control. The hand-cursor appears onscreen. • Move the mouse left to right to modify the X-direction. • Move the mouse up and down to change the Y-direction.

Beam Module Right-Click Menu

Right-click over the 2D X-Y control to access a context menu. The menu may contain less or some other functions that are actually available for the particular parameter. Selecting the corresponding menu item activates the function.

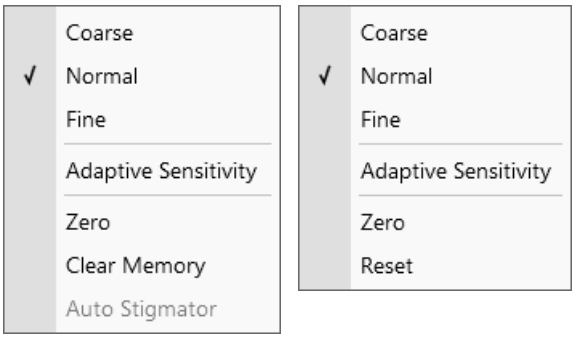


Table 4-6 Beam Module Right-Click Menu overview

Menu Selection	Description
Coarse	Sets the mouse sensitivity to coarse, where a long mouse path is necessary for the full range.
Normal	Sets the mouse sensitivity to normal, where a normal mouse path is necessary for the full range.
Fine	Sets the mouse sensitivity to fine, where a short mouse path is necessary for the full range.
Adaptive Sensitivity	Sets the mouse control response to be the same at any magnification.
Zero	Returns the control value to zero and the cursor to the center of the box.
Clear Memory	Clears condition values that have been remembered automatically during the considered 2D control use. These remembered values are used to estimate new values that have not been remembered yet.
Auto Stigmator	Starts automatic correction of an astigmatism.
Reset	Resets any mouse control setting to default.

Beam Deceleration Module

Beam Deceleration applies a negative potential (stage bias) to the stage, which influences both primary and secondary electrons. It allows the deceleration of the primary beam to between 50 to 4000 V landing energy. See *"Beam Deceleration Mode" on page 202*.

CAUTION	Because of the proximity of the stage and column, electrical breakdown can occur, resulting in damage to the system and/or sample.

Table 4-7 Beam Deceleration Module Overview

Interface Item	Description
Stage Bias	Applies the selected voltage to the stage. **At stage tilt greater than 0°, do not go above 300 V.** Use the presets to simplify the use of beam deceleration. You can also select the predefined or custom stage bias presets directly using the databar. The databar selection only becomes active when the Beam Deceleration mode has been activated by clicking **On**.
On	Turns stage bias on/off. • FIB imaging/patterning cannot be done when stage bias is active (**On**). • The quick databar selection only becomes active when stage bias is active (**On**). • EasyLift **can not** be inserted when stage bias is active (**On**). • Stage Bias can not be enabled if EasyLift is inserted.

Scan Rotation Module

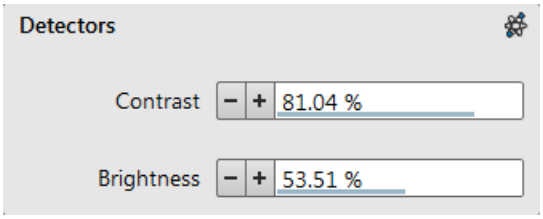
Use the adjuster to set scan rotation. See also *"Scan Rotation" on page 230*.

This preset/continuous control adjuster gives access to set rotation angles as well as a variable angle values.

Detectors Module

Use the continuous adjusters in this module to change contrast and brightness. The values are remembered for each detector and display. The adjusters are disabled if the detector is not available or cannot be controlled, such as the CCD camera or an External detector.

Figure 4-16 Detectors Module



Regardless of the detector actual gain range, the contrast and brightness range is always 0 - 100 (%) and the small/large step size is 0.1/1 (the brightness step size may differ for some detectors in order to achieve a sufficient sensitivity).

You can also double-click on the **value** shown within the adjuster to manually enter a value.

See also *"Working with Detectors" on page 171*.

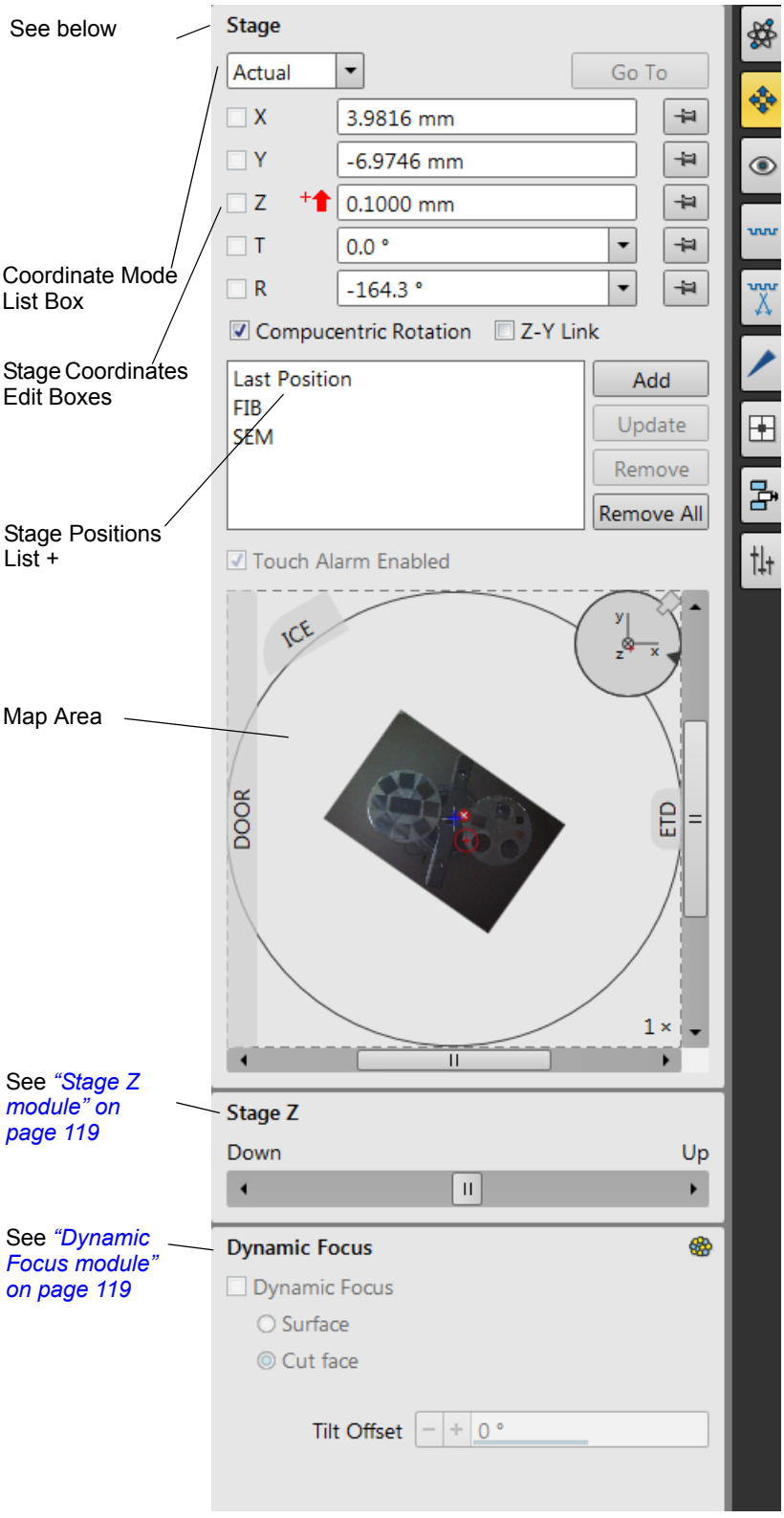
Table 4-1 Detectors Module Overview

Interface Item	Description
Contrast	Controls the *contrast* (electronic gain) of the active detector. You can also **Ctrl + click** & drag the mouse from **left to right** to adjust contrast.
Brightness	Control the *brightness* (voltage offset) of the active detector. You can also **Ctrl + click** & drag the mouse **up and down** to adjust Brightness.

Navigation Page

The Navigation page contains the essential elements for stage navigation. The Stage module content varies with the different system types.

Figure 4-17 Navigation page



Stage Module

The module shows numerical values of a particular stage position and a list of saved positions for selection. In addition it shows the location of positions on the stage in a visual map form.

Figure 4-18 Stage Module

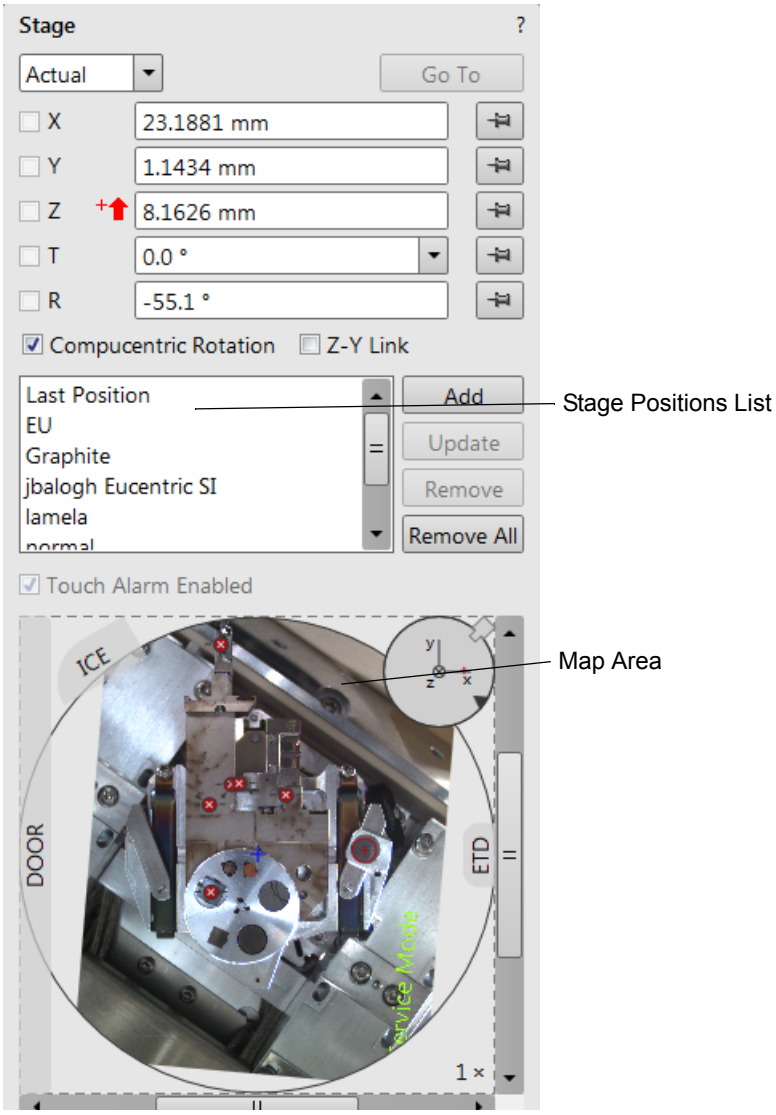


Table 4-1 Stage Interface Items Overview (1 of 3)

Interface Item	Description
Coordinate Mode drop down list	• **Actual mode (default):** Shows actual position coordinates in the edit boxes. It is used by the Last Position. The **Add**, **Update,** and **Remove** buttons are active. The **Go To** button is inactive. • **Target mode:** Activates when clicking a stored position or when editing a coordinate value. The **Go To** button becomes active; click it and the stage will drive to that location. The **Add**, **Update,** and **Remove** and buttons are active. • **Relative mode:** Moves the stage by a given value and repeats it several times, if needed. It is used to make repetitive or equal movements in relation to a key point or points. The **Add**, **Update**, **Remove,** and **Go To** buttons are active.
Go To button	Clicking **the button** causes the stage to go to the currently shown position (in Actual mode) or to move relative to the current position (in Relative mode). Shortcuts: • Press **Enter** after editing any coordinate value. • Double-click a stored location to move the stage to the desired position immediately. During the stage motion, the **Go To** button changes to **Stop**, which stops the stage immediately. **Go To** is disabled if the Last Position is selected in the location list; it is enabled in all other cases.
Compucentric Rotation check box	When the check box is ticked, the *R* coordinate operates as the Compucentric Rotation function and does not physical rotate the stage.
Z-Y Link check box	When the check box is ticked and the stage is tilted, the system compensates for the observed point of interest shifting during stage move, which allows to make a Z-axis move with a tilted stage while keeping the point of interest in the field of view. This makes it much easier when imaging with electron beam at shorter working distances to accurately reach the eucentric position / beams coincidence (milling position).

Table 4-1 Stage Interface Items Overview (2 of 3)

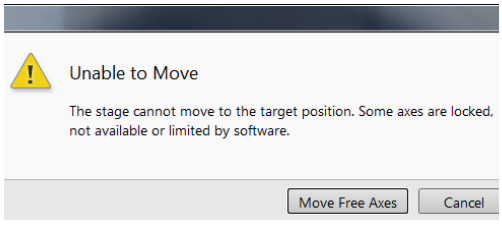
Interface Item	Description
Stage Coordinates	Select a stage position from the stage position list. The numerical information of X / Y / Z / T / R axes are shown in the separately editable Edit boxes for the selected position. Enter target position values to drive the stage to; a tick in the box to the left of the axe indicates axe(s) to be moved. This functions irrespective of coordinate mode. **Use caution when setting the Z value:**   **CAUTION** There is a danger of hitting the pole piece! If the Link Z to FWD procedure did not pass, a red arrow next to the Z axis alerts the positive Z-axis stage moving direction is up. It means raising a value in the Z axis edit box causes moving the stage up towards the pole piece. After running the Link Z to FWD procedure, the symbol and the stage moving direction changes. The black arrow next to the Z axis indicates the positive Z-axis stage moving direction is down. **Editing a Coordinate** • **Actual Mode:** With the Last Position selected, deselecting the current position (so no position is selected at all) changes the mode to Target and disables the **Update** button. The **Go To** button is active. Check boxes become ticked. To update any other position, enter new values in any of the edit boxes. This changes the mode to Target and enables the **Update** button (the position remains selected). Check boxes become ticked. If no position is selected, the edit boxes can be filled and the mode changes to Target. The **Go To** button is active. Check boxes become ticked. • **Relative Mode:** Editing a coordinate changes the mode to Target. The **Go To** button is active. Check boxes become ticked. The units of measure follow the **Preferences > Units** setting, unless the **Stage > User Units** function is active, in which case UU is shown for X and Y. See *"Defining User Units" on page 226*.  By default all axes are unlocked. Any and all movements can be locked by clicking on the appropriate pushpin button. This is also graphically shown in the Status area as an closed lock.  Unable to Move The stage cannot move to the target position. Some axes are locked, not available or limited by software. Move Free Axes Cancel The software locks prevent inadvertent stage movement of selected axes during particular applications. The edit boxes for locked axes are disabled (grayed) and the stage does not move in these directions. Axes that are locked do not move when the **Go To** button is activated. When the stage movement is required in locked direction (trying to move to the stored position), a warning dialog appears.

Table 4-1 Stage Interface Items Overview (3 of 3)

Interface Item	Description
Stage Location List	Shows the list of stage locations and the **Last Position**, which is the stage position before any movement. • Double-click anywhere in the circle area to mark a new location and move the stage to it. The selected position becomes the current active position and it is highlighted in the list and also on the map. • Clicking a nonselected item will select it, which causes the corresponding position to be shown in the edit boxes. • Clicking a position when it is already selected will start inline editing of the item's name (renaming it). Pressing **Enter** or clicking a different item confirms the new name. If the new name is already in the list, a warning is given and the editing is resumed (with the incorrect name). Pressing **Escape** restores the old name, cancelling the renaming. • Double-clicking an item is the same as clicking it and then clicking **Go To**; it immediately moves the stage to that position. • The list always contains the Last Position. Selecting Last Position shows the last stage position moved to and changes to this position can be updated as long as the Last Position item is selected. • When the stage coordinates are edited manually, the selected position will be deselected if it is the Last Position, while for any other position **Update** will become enabled (and the item will remain selected).
Add	Creates a new entry in the stage position list using the currently shown position. The new entry is called Position X, where X is 1, 2, 3, etc. If an item with the new X already exists, the value is incremental until a unique name is obtained. You can rename the new entry. Press **Enter** to rename the new entry. **Add** is disabled in Relative mode (you cannot store a relative position), and enabled in Actual mode.
Update	Stores the edited position under the currently selected name and position (overwriting the old position), without asking for confirmation. **Update** is disabled in Relative mode. In Actual mode it is enabled only when a position is selected in the location list.
Remove	Deletes the currently selected item in the Location list. It is enabled when a position is selected in the Location list, but only if this position is not Last Position.
Remove All	Removes all user created stage positions from the list.
Touch Alarm Enabled check box	When this check box is ticked, stage movement is stopped, and the Touch Alarm warning dialog appears whenever the stage or a conductive specimen touches the objective lens or any other equipment conductively connected to the chamber. This functionality is also used when the stage engines rise their power above a determined level.

Map Area

The map area represents the total range of the stage in X & Y axes. It shows the location of positions on the stage in a visual map. Click within the stage map area to drive the stage to the selected position. Positions can be stored in a file and contribute to a map of locations that can be reintroduced at a later date for re-investigation of the same sample.

Figure 4-19 Map Area Elements

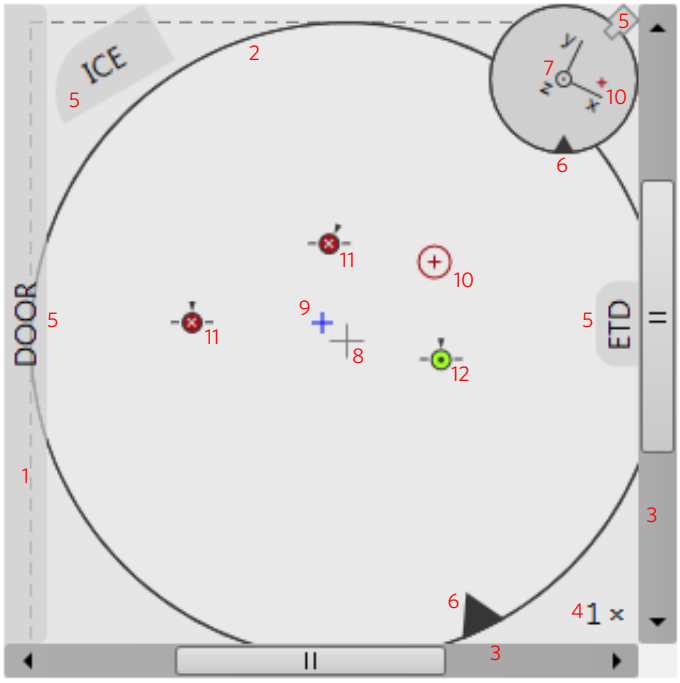


Table 4-1 Map Area Elements

Number	Function
1.	**Light gray rim (dashed line)**: physical limit of the stage movement along the X and Y axes
2.	**Dark rim (continuous line)**: the sample holder outline
3.	**X / Y scroll bar**: to move the map area at different magnification factors
4.	**Magnification** factor of the map area (1× – 100×)
5.	**Stage rotation overlay**: Chamber door / ETD / ICE / CCD camera
6.	**Notch (black triangle)**: rotation marking (active control within the Radar view)
7.	**Radar view X / Y / Z (perpendicular lines)**: stage axes
8.	**Gray +**: mechanical stage center: X = 0, Y = 0

Table 4-1 Map Area Elements

Number	Function
9.	**Blue +**: map area center
10.	**Red + in a red circle / Red + (Radar view)**: actual stage position
11.	**White × on a red background**: a stored location (rotation noted by the black triangle)
12.	**Black ● on a green background**: a stored position selected (highlighted) in the location list)

Map Area Right-Click Menu

Right-click in the map area to access the drop-down menu.

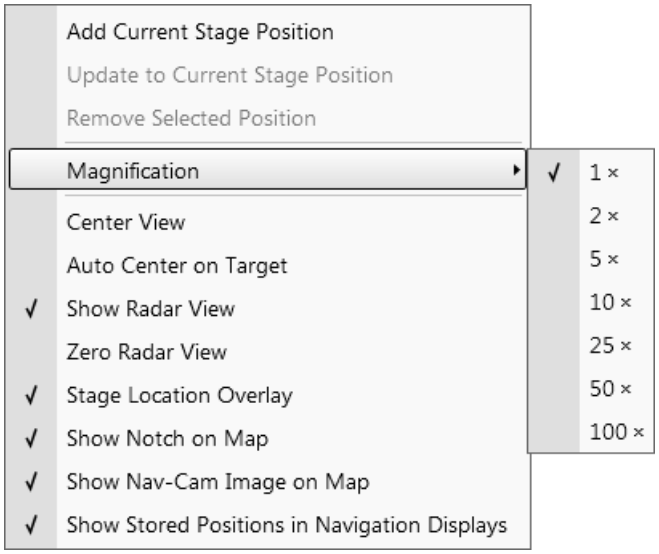


Table 4-2 Map Area Right-click Menu Overview (1 of 3)

Menu Selection	Description
Add current stage position	Adds the new stage position at the blue cross to the location list. In this way, the list can be compiled for particular applications. The blue cross turns black and receives a black circle around it. The **Add** button has the same functionality.
Update to current stage position	Stores the (edited) coordinate values under the currently selected name (after confirmation in the overwriting dialog that appears). The **Update** button has the same functionality.
Remove selected position	Deletes the selected location(s) from the map and from the location list. The **Remove** button has the same functionality.

Table 4-2 Map Area Right-click Menu Overview (2 of 3)

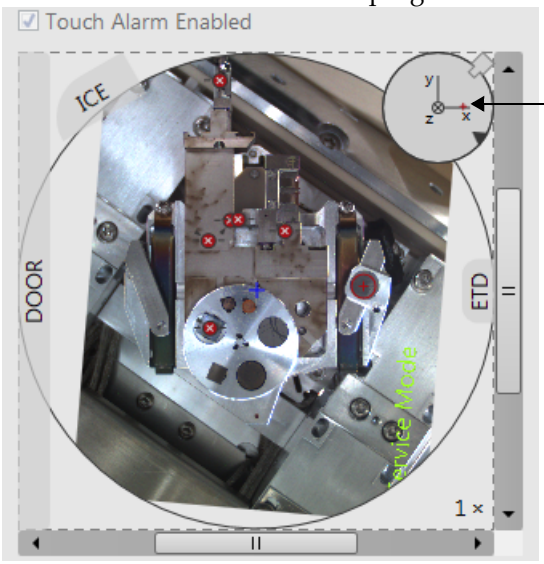
Menu Selection	Description
Magnification	Provides a submenu for selecting the map area magnification factor (8 on the Map Area Elements illustration). The resulting multiple value is seen in the bottom right-hand corner of the map area. Scroll bars appear, if necessary, to move over the whole map area.
Center view	Brings the selected location to the center of view rather than the stage axial center.
Auto center on target	When selected and the Magnification factor is used, the active location remains in the center of view.
Show Radar View	Shows The small circle in the top right of the stage area.  *It* relates to the true rotational condition of the stage at any time. By holding down the left mouse button on the black triangle on the perimeter of the circle and moving it around to another angle position, the stage will follow the action promoted on release of the mouse button. The large circle remains in the same state to represent true X and Y directions. All positions that incurred rotation of the stage in their stored location maps will show rotation condition in the radar view when restored to the current position. Orientation is seen by the update of the small triangle and the clock hand lines in the radar view circle.
Zero Radar View	Resets the stage rotation to 0°, that is represented by the black triangle 12 o'clock position.
Stage location overlay	Toggles the detector and chamber door position show in relationship to a sample.
Show Notch on Map	Shows the sample notch as a blue triangle on the perimeter of the stage map.

Table 4-2 Map Area Right-click Menu Overview (3 of 3)

Menu Selection	Description
Show Nav-Cam Image on Map	Switches the Nav-Cam image show in the map area.
Show Stored Positions in Navigation Displays	Switches the stored positions show in navigation images.

Stage Z module

Moves the stage up and down with a speed based on the slider motion. Enabled when Z is linked to FWD.

Dynamic Focus module

The module contains controls to correct the tilted image. This functionality is different for the electron and ion beams.

Figure 4-20 Dynamic Focus module (electron beam)

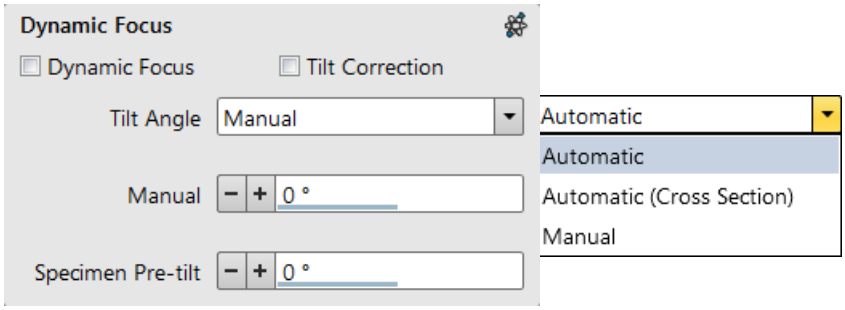


Table 4-1 Dynamic Focus module overview (1 of 2)

Interface Item	Description
Dynamic Focus	Tick the check box to switch **Dynamic Focus** on or off. When it is on, the scan slowly proceeds from top to bottom and the focus point is automatically changed according to the positive tilt of the specimen. The focus should be sharpest in the middle of the image, then the image should be sharp all the way from top to bottom. Dynamic Focus can only be used with scan rotation at zero. You must enter Specimen Pre-Tilt for the calculations to be accurate. Dynamic Focus can be used for a strongly tilted specimen (either by the specimen surface itself or by stage tilt), when the depth of focus is not sufficient. It results in an image with overall sharpness. Dynamic Focus is usually used at low magnification and it works only in Mode 1.

Table 4-1 Dynamic Focus module overview (2 of 2)

Interface Item	Description
Tilt Correction	Tick the check box to switch **Tilt Correction** on or off. Because the image is a 2D representation of a 3D object, certain projection distortions occur. The more highly tilted the specimen is, the more foreshortened its image will be. Applying a tilt correction compensates for foreshortening in one direction on a flat specimen at a known tilt angle (80° range) and when the tilt axis is parallel to the scan line. Tilt Correction can only be used with scan rotation at zero. You must enter Specimen Pre-Tilt for the calculations to be accurate. For example, a square grid image will appear rectangular when you tilt the specimen. Applying Tilt Correction will correct the aspect ratio and restore the square appearance.
Tilt Angle	
Automatic	Dropdown box for selecting tilt angle: • **Automatic**: Applies an automatic operation of the Dynamic Focus and/or Tilt Correction. Use Automatic if the correction angle to be used is the same as the stage tilt angle (including Specimen Pre-Tilt, see below). When cleared, the Manual check box is enabled. • **Automatic (Cross Section)**: Sets to cross section. • **Manual**: Enables the Manual linear adjuster (below). All selections stretch the image based on the tilt angle.
Manual	When selected, allows you to manually set the tilt angle from –90° to +90°. This is useful when the Dynamic Focus with Automatic Tilt Angle does not give satisfactory results (or cannot be used at all because the specimen is tilted in a direction different from the stage tilt. This check box is only enabled when the Automatic check box is cleared.
Specimen Pre-tilt	Specifies a specimen pre-tilt for the Dynamic Focus and/or Tilt Correction calculations to be accurate. Enter the specimen tilt angle on the slider and then select an appropriate check box. If Tilt mode is Manual, the slider value indicates the absolute angle that should be used for the compensations (regardless of the actual stage tilt angle or specimen pre-tilt).

Figure 4-21 Dynamic Focus module (ion beam)

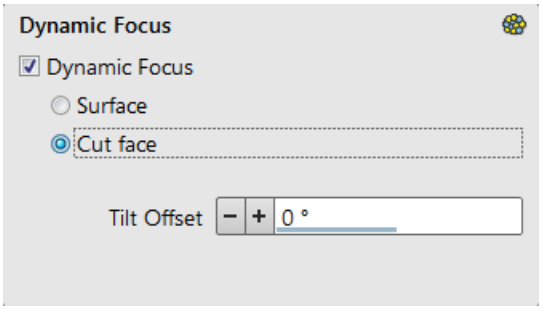


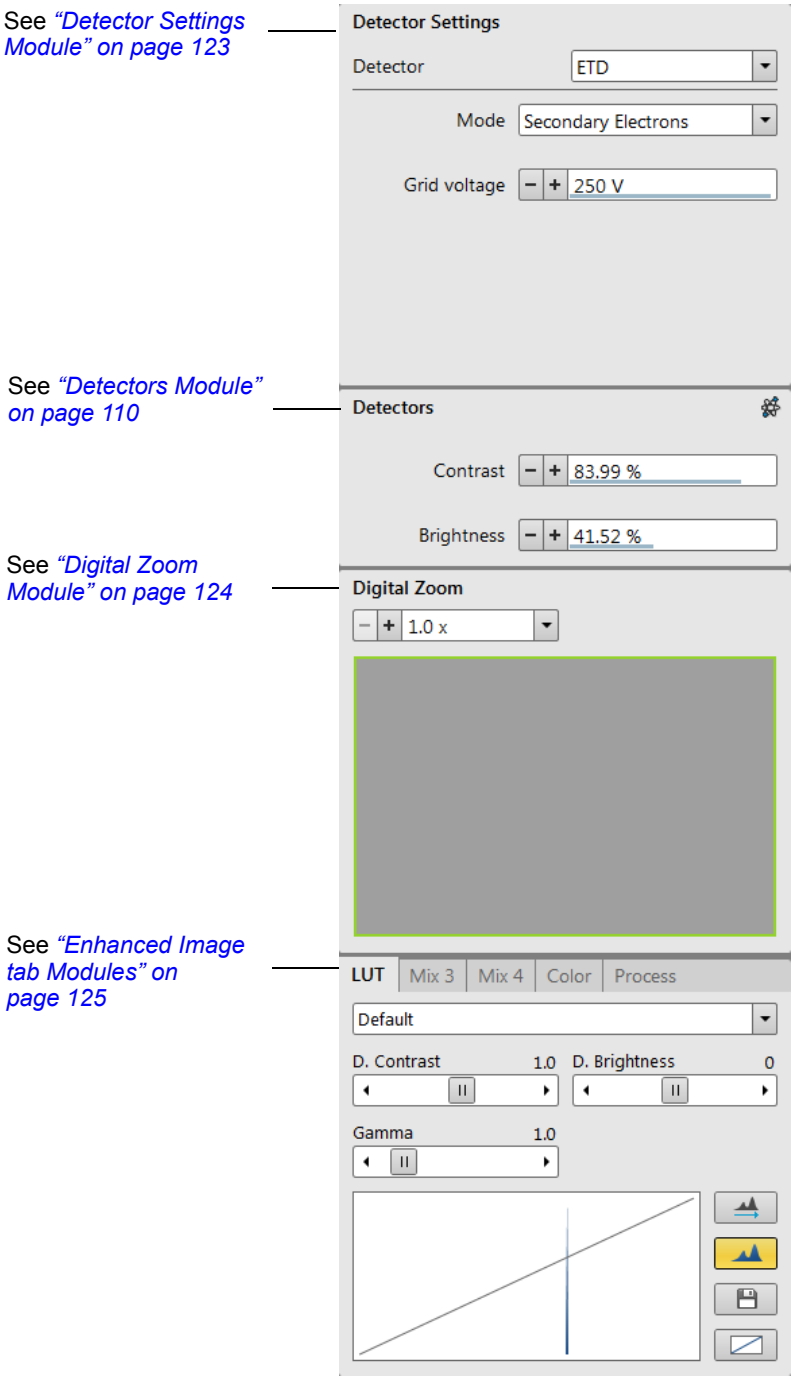
Table 4-1 Dynamic Focus module (ion beam) overview

Interface Item	Description
Dynamic Focus	Tick the check box to switch **Dynamic Focus** on or off.
Surface	Tick the radio button to
Cut face	
Tilt Offet	

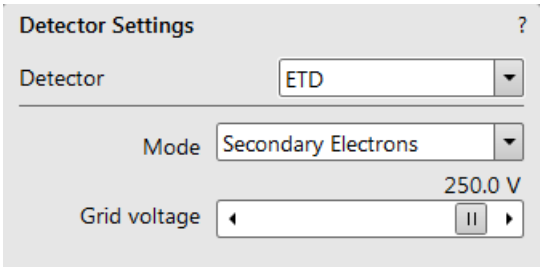
Detectors Page

The Detector Settings page shows the available detectors and activates the mode selection and controls for imaging with the active detector. See *"Working with Detectors" on page 171*.

Figure 4-22 Detector Settings Page



Detector Settings Module



Use the controls in this module to choose the selected display detector and adjust its parameters.

The Detector list box contains list of detectors actually available for the selected display (the same as enabled items in the Detectors menu). The list box always shows the detector actually selected in the selected display.

The rest of the module dynamically changes according to the selected detector and its parameters, which may change from display to display.

See *"Working with Detectors" on page 171* for information on specific detectors and procedural information.

Table 4-1 Detector Settings Module Overview (1 of 2)

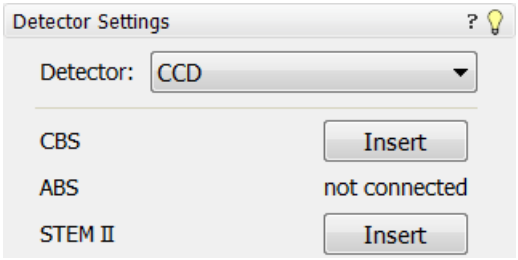
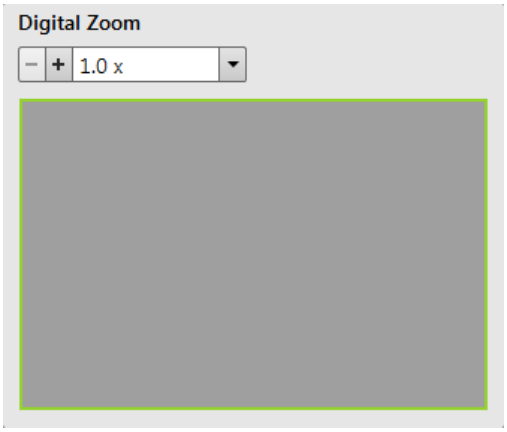
Menu Item	Description
Detector	Shows a menu of the detectors installed on the system and their associated modes. The active detector in a display can also be selected from the Detectors menu. See *"Detectors Menu" on page 58*. When a retractable detector is selected, additional buttons appear for **Insert/Retract**, or it can be inserted if the CCD camera display is selected while on the Detectors page. 

Table 4-1 Detector Settings Module Overview (2 of 2)

Menu Item	Description
Mode	Shows the available modes for the selected detector. Depending on the beam mode in operation, only the relevant detectors and mode will appear in the list. Mode options are: • **ETD, Electron Beam Mode 1:** Secondary Electrons, Backscatter Electrons, Custom • **ETD, Ion Beam:** Secondary Electrons, Secondary Ions, Custom See *"ETD Settings" on page 173*. • **TLD, Modes 1 & 3**: Secondary Electrons, Backscatter Electrons, Custom • **TLD, Mode 2**: Secondary Electrons, Backscatter Electrons, Charge Reduction, Down-hole Visibility, Custom. See *"TLD Settings" on page 174*. • **ICE, Ion Beam**: Secondary Electrons, Secondary Ions, Custom. • **ICE, Electron Beam**: Secondary Electrons, Back-scattered Electrons, Custom. See *"ICE Detector Settings" on page 175*. • **STEM**: Bright Field (BF), Dark Field (DF), High Angle Annular Dark Field (HAADF), Custom Annular, and Custom Angular. See *"STEM segmentation" on page 183*.
Custom Settings	Moving the sliders while in any defaulted mode will switch the Custom mode into operation and the default condition will be overridden. • Custom settings for ICE are Grid, Scintillator, and Converter. • Custom settings for TLD are Suction Tube Voltage and Mirror.

Digital Zoom Module

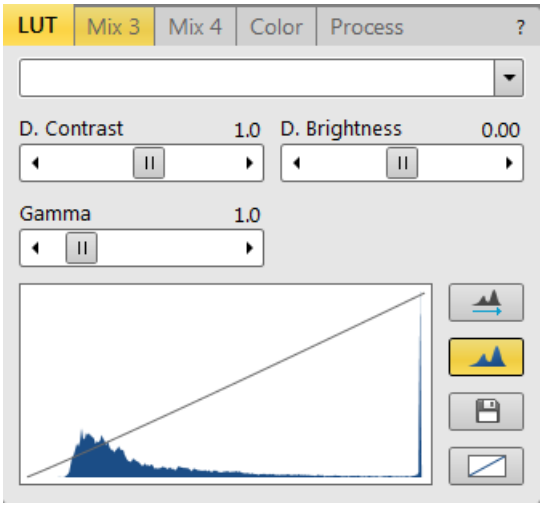


The procedure takes place in the computer memory only and helps to navigate across the enlarged view. It can be used on live images, still images for the electron beam, ion beam as well as the CCD Image.

Table 4-2 Digital Zoom Module Overview

Interface Item	Description
+	Enlarges the view in the selected display.
-	Reduces the view in the selected display.
Green Bordered Area	Click and drag the green bordered area or click inside the green rectangle and move it by **Ctrl + keyboard arrows** to change an observed area in the selected display.  Press the **Ctrl + +/-** keyboard button to enlarge / reduce imaging in the selected display. When the digital zoom is applied, the icon appears in the appropriate display.

Enhanced Image tab Modules



Consists of a series of tabbed sections offering various digital image enhancements.

Digital processing does not influence the original (raw) image stored in the image memory, and therefore can be modified or switched off (undone) completely at any time. Digital image enhancement can be applied to any detector image, including CCD, and also to paused or loaded images. In contrast to detector contrast and brightness functions, image enhancement functions are applied only the active display, independently from other displays' settings.

Table 4-3 Enhanced Image Module Overview

Interface Item	Description
LUT tab	Contains tools for monitoring and modifying graylevel distribution (histogram) of a grayscale image. The digital image processing defined in this section is the first one applied to the image (possibly after integration or averaging).
Mix 3, Mix 4 tabs	In Mix detectors mode, display 3 can show a mixed image from displays 1 and 2 images and display 4 can show a mixed image from displays 1, 2 and 3 images.
Color tab	Use the Color tab to colorize a grayscale image.
Process tab	Use the Process tab to set parameters that adapt the image when clicking the **Apply** button, or when selecting the **Tools > Image Post Processing** (**Ctrl + F7**).

LUT Tab

The LUT (look up table) tab contains tools for monitoring and modifying graylevel distribution (histogram) of a grayscale image. The digital image processing defined in this section is the first one applied to the image (possibly after integration or averaging).

Figure 4-23 LUT Tab Overview

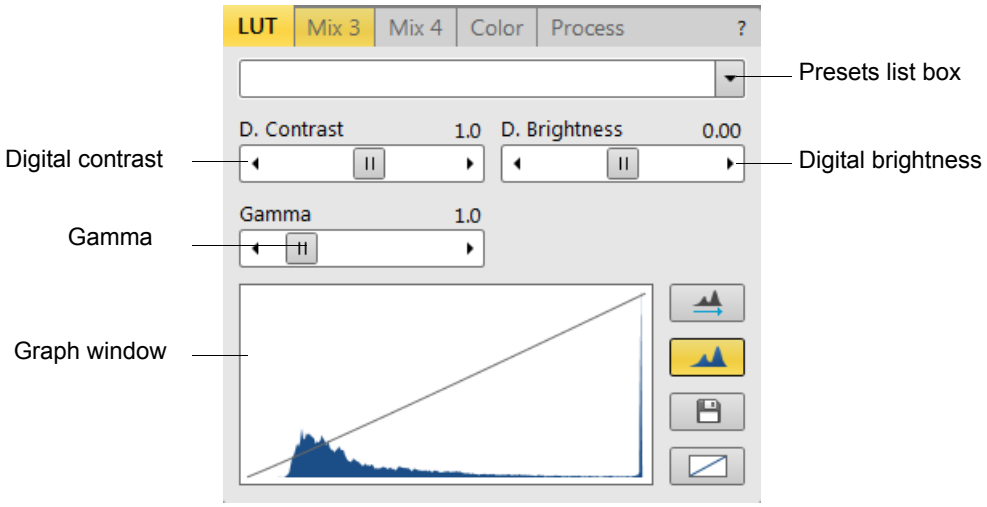


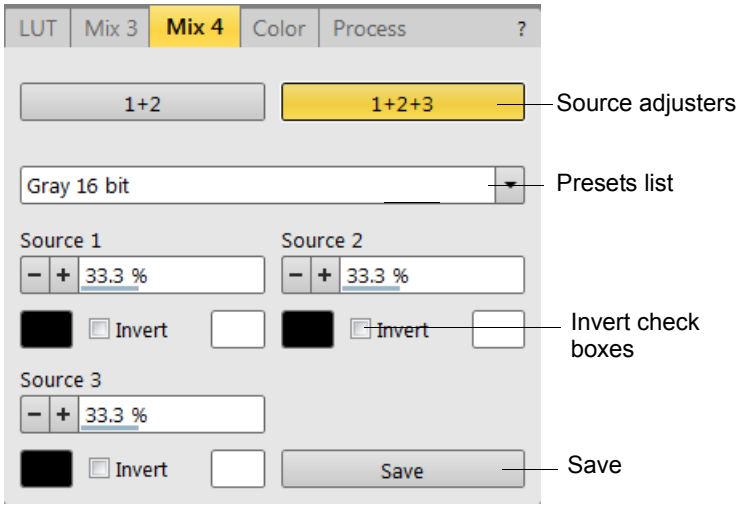
Table 4-1 LUT Tab Overview

Interface Item	Description
Presets List Box	**D**ropdown menu selects the digital contrast/brightness/gamma values at once using a predefined or custom preset.
Digital Contrast Continuous Adjuster	Sets contrast in a range from –10 to +10 (negative values lead to an inverse imaging).
Digital Brightness Continuous Adjuster	Sets brightness in a range from –2.0 to 2.0.
Gamma Continuous Adjuster	Corrects image brightness nonlinearly in a range from –10 to +10.
Graph Window	Shows (blue line) an applied modification. Original/modified values are on the horizontal/vertical axis.
Histogram 	Shows the gray-level histogram corresponding to the active display image. The left and right sides of the histogram correspond to black/white pixels in the original image, and the height of each red line is proportional to the number of pixels with the corresponding gray value. The LUT line on top of the histogram represents the combined user and system LUT.
Auto levels 	Sets the digital contrast, brightness, and gamma parameters automatically according to the imaging/image quality.
Save 	Saves the actual settings as the custom preset.
Default 	Restores the default values.

Mix 3 and Mix 4 Tabs

The Mix feature operates in displays 3 and 4 and are enabled only if **Detector > Mix** is selected for display 3 or 4. It uses the processed images (Average/Integrate, Digital Contrast, Digital Brightness, Digital Zoom), not the raw detector signals.

Figure 4-24 Mix 4 Tab Overview



Any combination of live and paused images can be mixed together, providing all mixed images have the same pixel resolution. However, there are some logical limitations and behaviors:

- The Average and Integrate filters are disabled.
- Pause/Resume influences the mixed image only, not its sources. The Mix display is always paused immediately regardless of the actual scanning status.
- The CCD image is not mixed.

NOTE	In the Mix 3 tab the Source 3 controls and the Select 1+2+3 button are disabled.

Table 4-1 Mix 4 Tab Overview

Interface Item	Description
Mix buttons **Select (1+2) / (1+2+3)**	Selects between displays 1+2 or displays 1+2+3 mixing modes.
Presets List	Allows you to select the mixing ratios and colors using pre-defined or custom presets.
Source 1 - 3 Linear Continuous Adjusters	Tunes the mixing ratio of display 1–3 images. The value of each adjuster (0–100%) says how big a part of the resulting image composes the corresponding source image. Changing one source value automatically changes the other two values so that the sum of all source values is always 100%.
Color selection boxes	Allows color selection, replacing the source image black (left)/white (right). The image grayscale is linearly transformed to a new color spectrum before it is mixed with other image(s). **Note:** *Color images (see Color tab) are converted to grayscale ones before mixing.*
Invert check boxes	**I**nverts the corresponding source image spectra. It has the same effect as exchanging the left and right colors selection.
Save	Saves the actual setting as the custom preset.

Color Tab

Use the Color tab to colorize a grayscale image. The tab will be disabled if an image is already colored with the use of the Mix 3/Mix 4 tab. It cannot be colored again.

Figure 4-25 Color Tab Overview

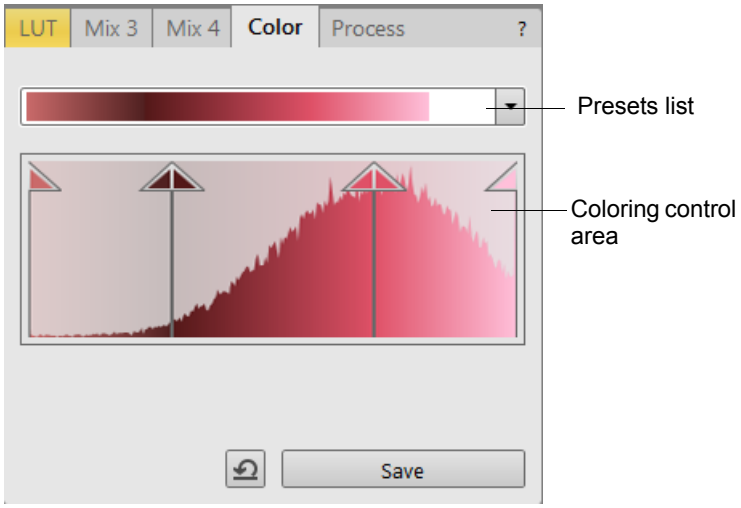


Table 4-1 Color Tab Overview

Interface Item	Description
Presets List	Allows you to select the color profile using pre-defined or custom presets.
Coloring Control area	Shows the active display image histogram and allows you to create a color profile. • Right-click in the histogram area to add the vertical borderline with a divided triangle on top. • Right-click onto an existing borderline to remove it. • Click and drag a borderline to change its position along the histogram. • Click on the left/right part of the triangle to select the left/right border color. The imaging grayscale between two borderlines is linearly transformed to a new color spectrum.
Reset button	Switches on/off the actual color settings for the active display image.
Save button	Saves the actual setting as the custom preset.

Process Tab

Use the Process tab to set parameters that adapt the image when clicking the **Apply** button, or when selecting the **Tools > Image Post Processing** (**Ctrl + F7**).

NOTE	This functionality works only with grayscale images (not colored via the Color tab) that are paused or with loaded saved ones.

Figure 4-26 Process Tab Overview

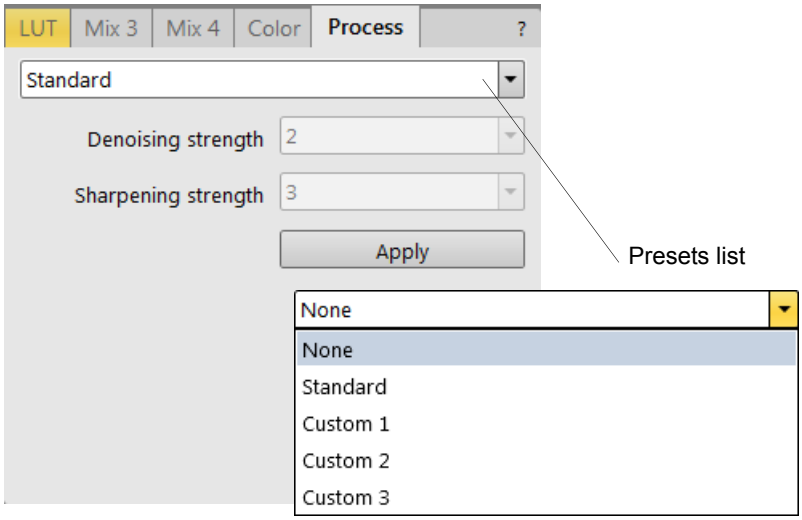


Table 4-1 Process Tab Overview

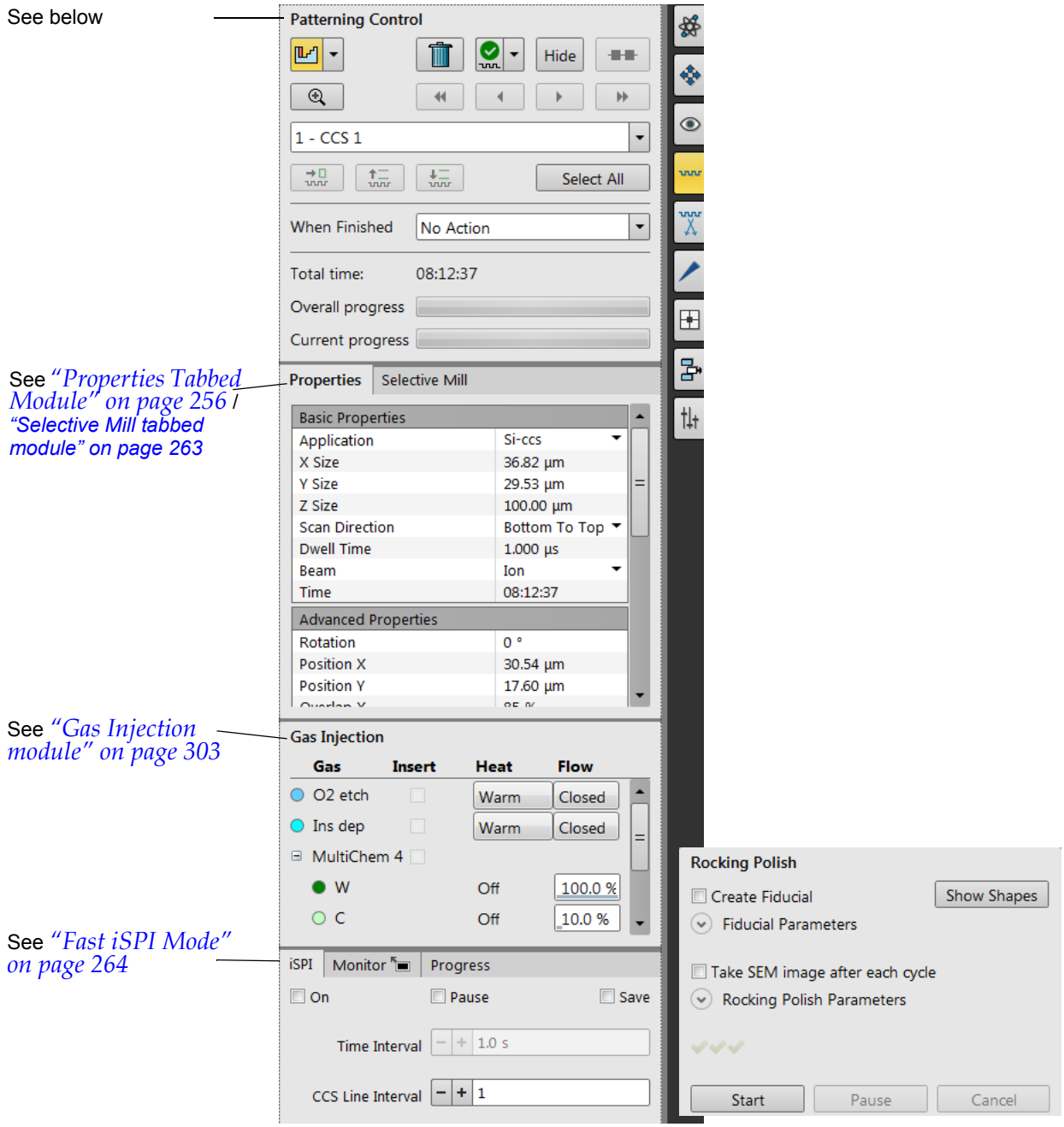
Interface Item	Description
Presets List	Selects how much denoising and sharpening you want to use. Selections are: **None, Standard, Custom 1, Custom 2,** and **Custom 3**. The defined presets can be recalled later to process an image.
Denoising Strength	Removes dust and scratches from the image. Choices are 0, 1, 2, 3, or 4.
Sharpening Strength	Influences the image sharpness. Choices are 0, 1, 2, 3, or 4.
Apply	Applies the changes.

Patterning page

Use the Patterning page for milling, depositing, and etching a pattern onto the sample surface with the beam and for controlling the gas injection systems (GISs). The similar Rocking Polish page offers additionally controls for polishing of milled areas.

For operational details, see *"Patterning" on page 248*.

Figure 4-27 Patterning page / Rocking Polish module

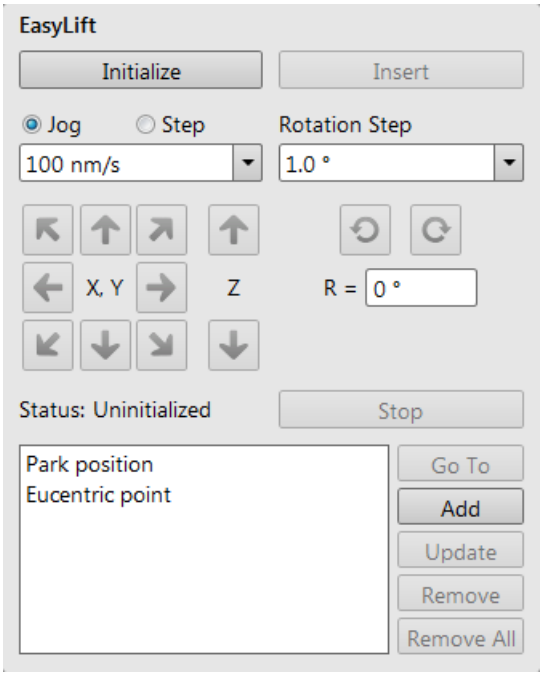


EasyLift Page

The EasyLift module is only present with the EasyLift NanoManipulator (option).

See chapter EasyLift for more detailed information.

Figure 4-28 EasyLift Module



Direct adjustments page

The Direct Adjustments page shows separate control modules for electron and ion beams settings. Ion beam control is available only for accelerating voltages below 8.06 kV.

Ion Beam Settings

Figure 4-29 Ion Beam Settings

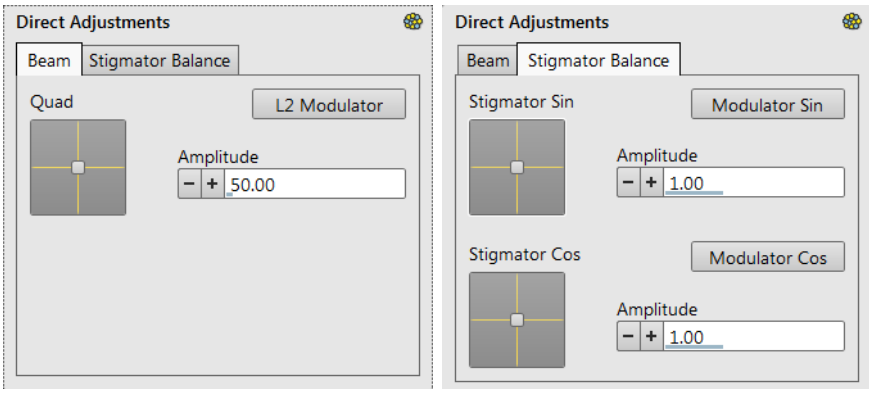


Table 4-1 Ion Beam Settings Overview

Interface Item	Description
Beam tab	
Quad 2D control	Minimizes the objective imaging shift during focusing.
L2 Modulator	Starts automatic L2 voltage oscillation (periodically under- and over-focuses imaging in a narrow range) to facilitate the process. Try to bring the rotation center to the screen center (if the magnification is too high, the rotation could seem like a linear motion instead of a rotation).
Amplitude	Slider sets the modulation amplitude.
Stigmator Balance tab	
Stigmator Sin/Cos 2D controls	Sets the astigmatism lenses to bring the beam into the center. The crosshair indicates the actual stigmator setting, which minimizes imaging shift during astigmatism correction. Clicking anywhere inside the 2D control changes the cursor to 4-ended arrow and moves it to the screen position corresponding to the actual stigmator value (minimum in the middle of the screen and maximum at the edges).
Modulator Sin/Cos	Starts modulation of stigmator lenses in X/Y axis.
Amplitude	Slider sets the modulation amplitude.

Electron Beam Settings

Figure 4-30 Electron Beam Settings

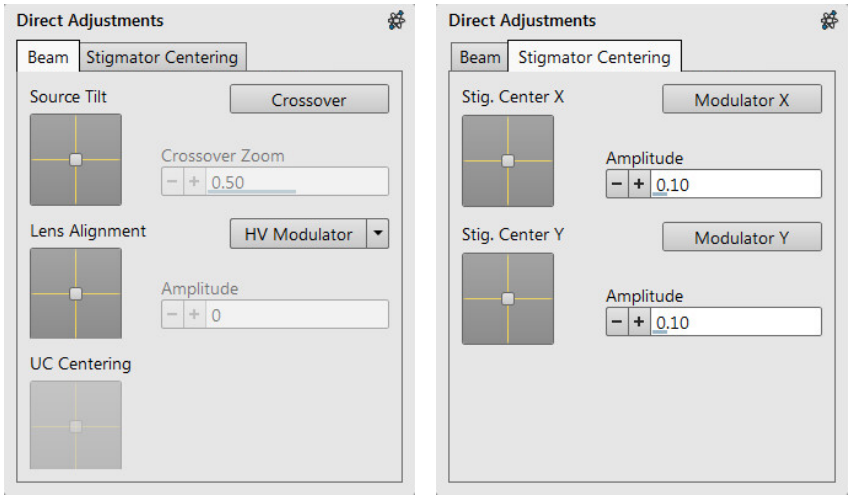


Table 4-1 Electron Beam Settings Overview (1 of 2)

Interface Item	Description
Beam tab	
Source Tilt	Corrects an imaging illumination drop by changing an effective angle of the beam coming from the gun area into the electron column.
Crossover	The imaging shows the electron source tip instead of the sample surface.
Crossover Zoom	Slider sets the crossover image magnification.
Lens Alignment	Minimizes the objective imaging shift during focusing. The 2D control indicates an actual beam position setting relative to the final lens aperture.
Lens Modulator Lens Modulator (Recommended) HV Modulator	Dropdown list includes: • **Lens Modulator**: Starts automatic objective current oscillation (periodically under and over-focuses imaging in a narrow range) to facilitate the process. Automatically selected when the accelerating voltage is > 3 kV. • **HV Modulator**: Starts automatic accelerating voltage oscillation (periodically under and over-focuses imaging in a narrow range) to facilitate the process. Automatically selected when the accelerating voltage is < 3 kV. Try to bring the rotation center to the screen center (if the magnification is too high, the rotation could seem like a linear motion instead of a rotation).
Amplitude	Slider sets the modulation amplitude.

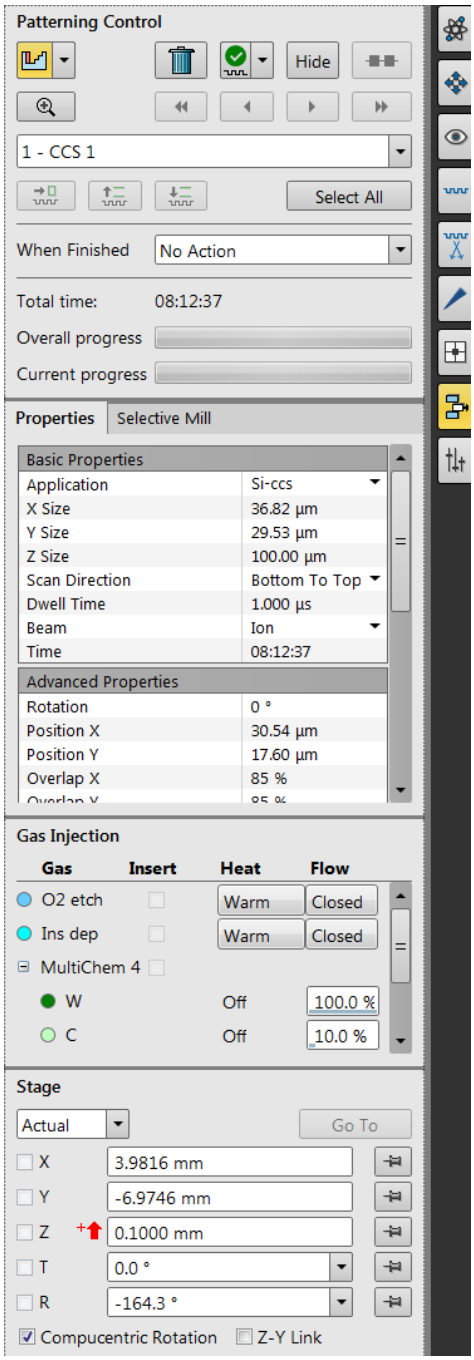
Table 4-1 Electron Beam Settings Overview (2 of 2)

Interface Item	Description
UC Centering **Only available for the Helios G4 PFIB UX**	Centers the UC beam through the U-mode aperture.
Stigmator Centering tab	
Stigmator Center X / Y	Sets the astigmatism lenses to bring the beam into the center. The crosshair indicates the actual stigmator setting, which minimizes imaging shift during astigmatism correction. Try to bring the rotation center to the screen center (if the magnification is too high, the rotation could seem like a linear motion instead of a rotation).
Modulator X / Y	Starts modulation of astigmatism lenses in X/Y axis to enable stigmator center procedure.
Amplitude	Slider sets the modulation amplitude.

Sample Preparation Page

The Sample Preparation page is a combination of parts of the Patterning page, Beam Control page, and Navigation page. Use it for sample preparation, especially TEM sample preparations, to reduce the number of mouse clicks.

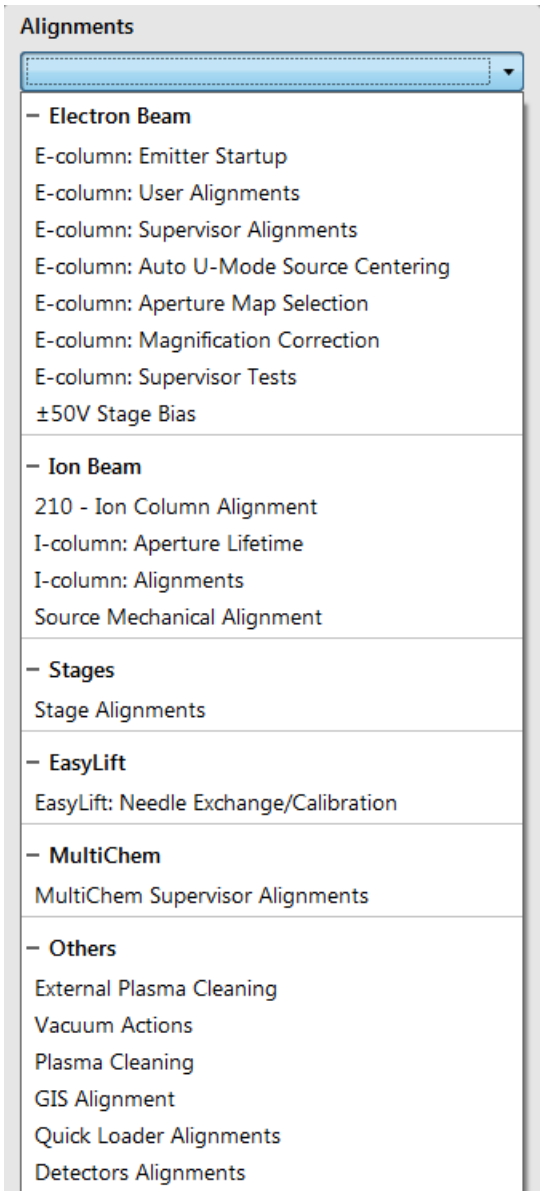
Figure 4-31 Sample Preparation Page



Alignments Page

The Alignments page is used to align the columns and determine fine tuning for the system.

Figure 4-32



The software stores column parameters such as Gun Tilt X, Y, Gun Shift X, Y, and other data that ensures minimum image shift when focusing and stigmating images.

See the Chapter Alignments for information on the complete list of alignment procedures.

Preferences

Select **Preferences** from the Scan or Tools menu or press **Ctrl + O** to access the Preferences pop-up window. The Preferences dialog consists of sections listed at the left side of the window, the menu from which it is chosen dictates the section opened on entry.

Clicking the required section opens it and allows changing and presetting conditions for a group of the related functions. Only one section can be opened at any time. The items chosen and changed remain valid (for a specific user) until changed again.

Some of the preference controls are beam dependent. In this case, an active beam type is indicated by the corresponding icon and items change accordingly.

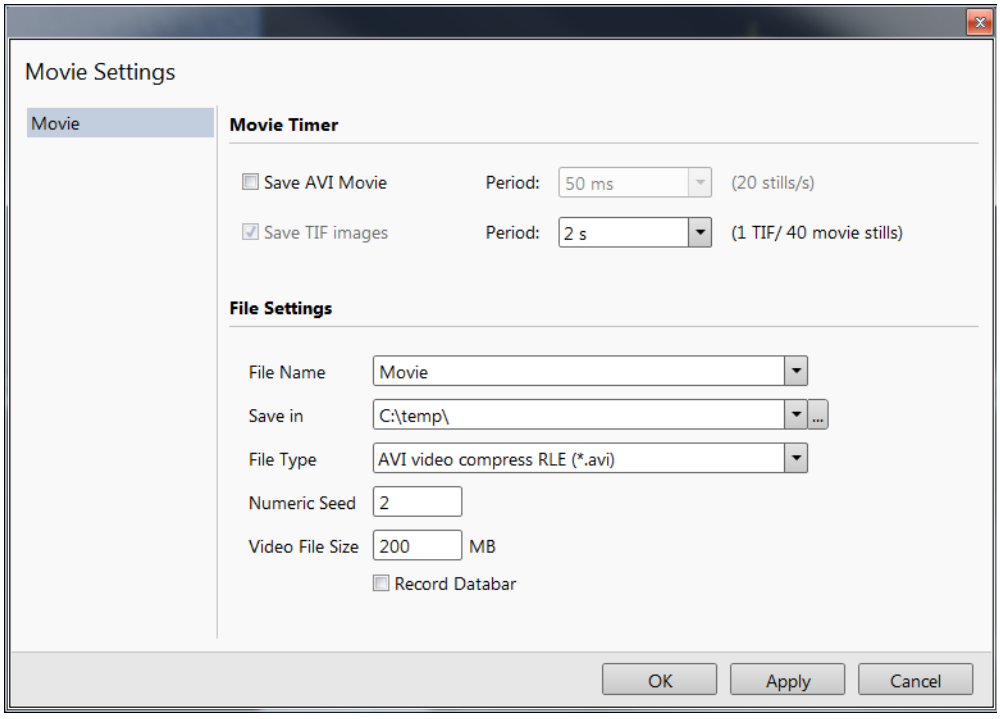
Movie section

This section provides two groups of controls:

- Timer to set up the movie frame rate
- File to set up the path name and format of the resulting movie.

For procedural information, see *"Recording Movies (Multiple Image Capture)" on page 211*

Figure 4-33 Movie Preferences



Presets Section

Use this section to change the preset values in the High Voltage, Magnification, EasyLift (option) and Stage dropdown lists. The electron and ion beams have separate preset lists.

Click the **Add** button, add new value and confirm the entry; the new value is sorted into the list. Click the **Delete** button to delete selected value.

The **Default** button on each tab sets the factory presets values.

Figure 4-34 Presets Preferences

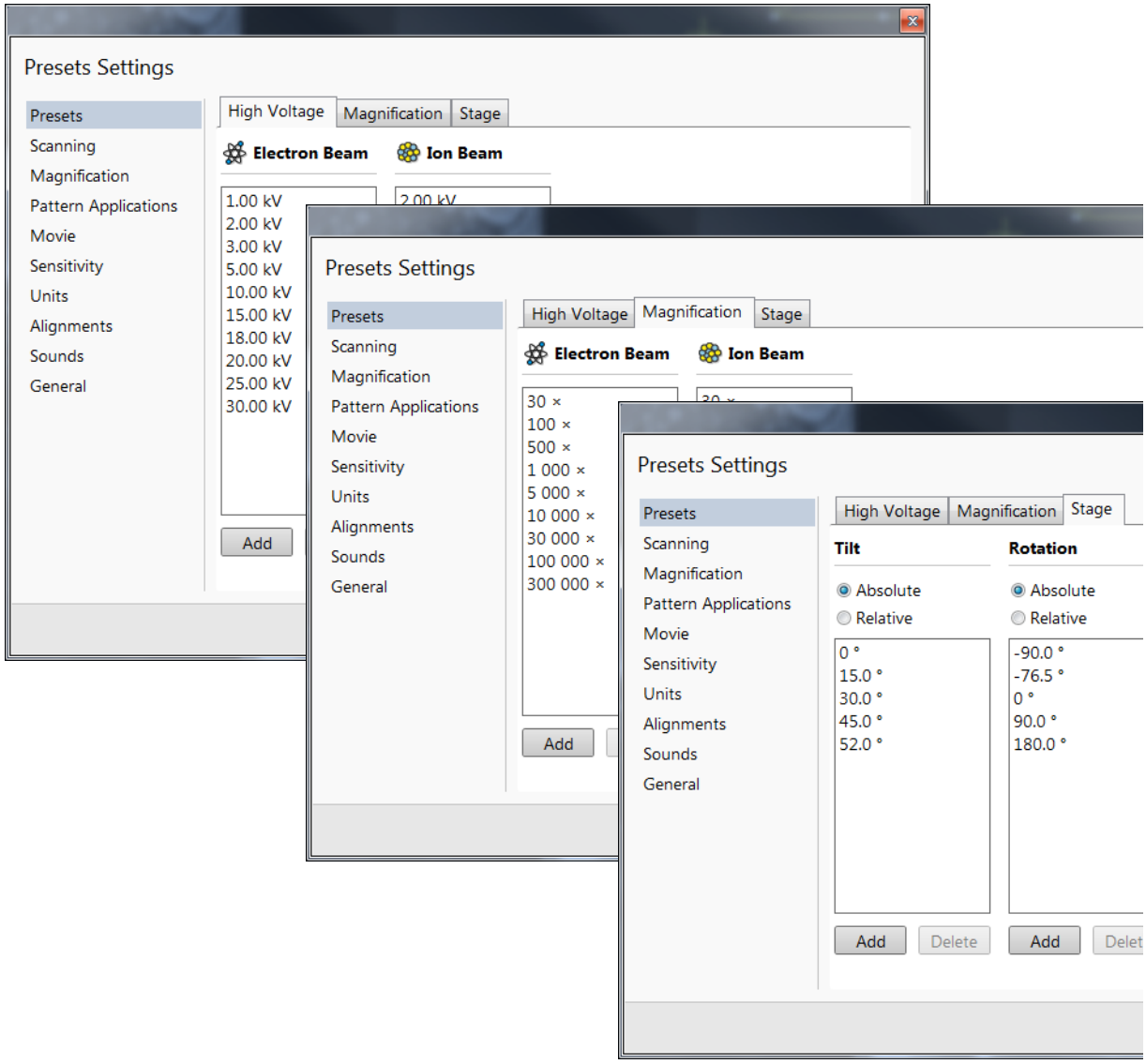


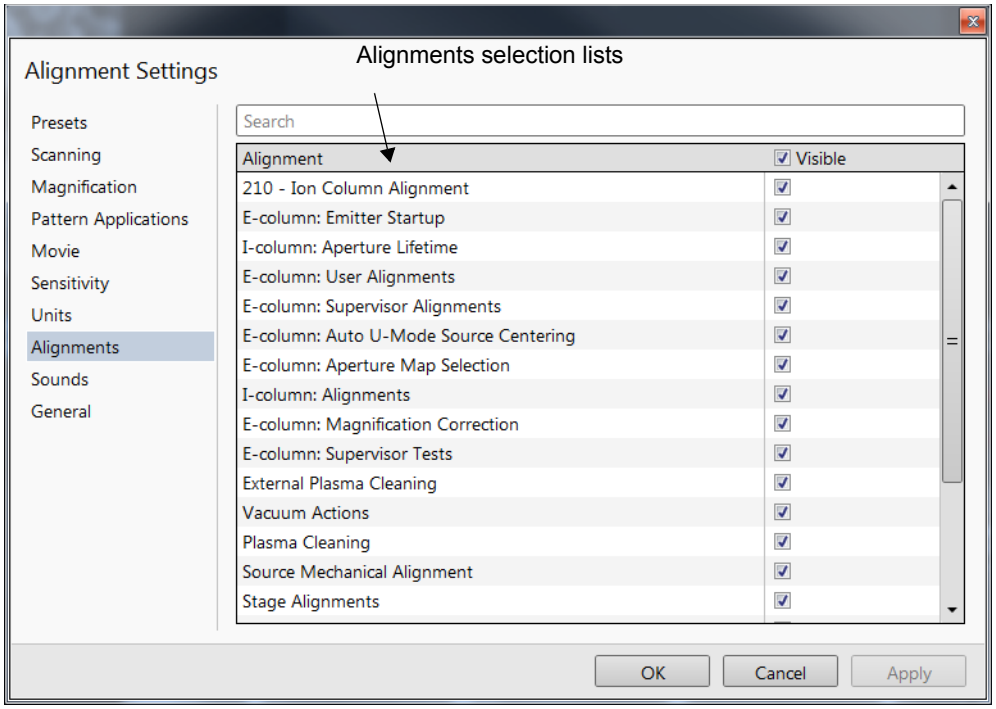
Table 4-1 Presets Settings overview

Interface Item	Description
High Voltage	High voltage values must be entered in kilovolts (0.2 kV = 200 V).
Magnification	The Magnification list can be changed to hold frequently used magnifications. Magnification values that are in the list but do not apply because of the working distance condition will be grayed out in the Magnification menu.
EasyLift	Sets the EasyLift operation preset values: **Jog Speed –** the constant velocity to use in Jog moves **Step Size** – the relative step size to use in Step moves **Rotation Step** – the rotation step size in degrees for Step moves
Stage	Sets the **Tilt** and **Rotation** presets in **Absolute** or **Relative** values.

Alignments section

Use this section to select frequently used alignments from the lists.

Figure 4-35 Alignments Preferences



Magnification section

Use this section to choose setup conditions for screen magnification and for file output and printing. Tick the check box to synchronize the screen (viewing) format with the file/print (output) format.

Figure 4-36 Magnification Preferences

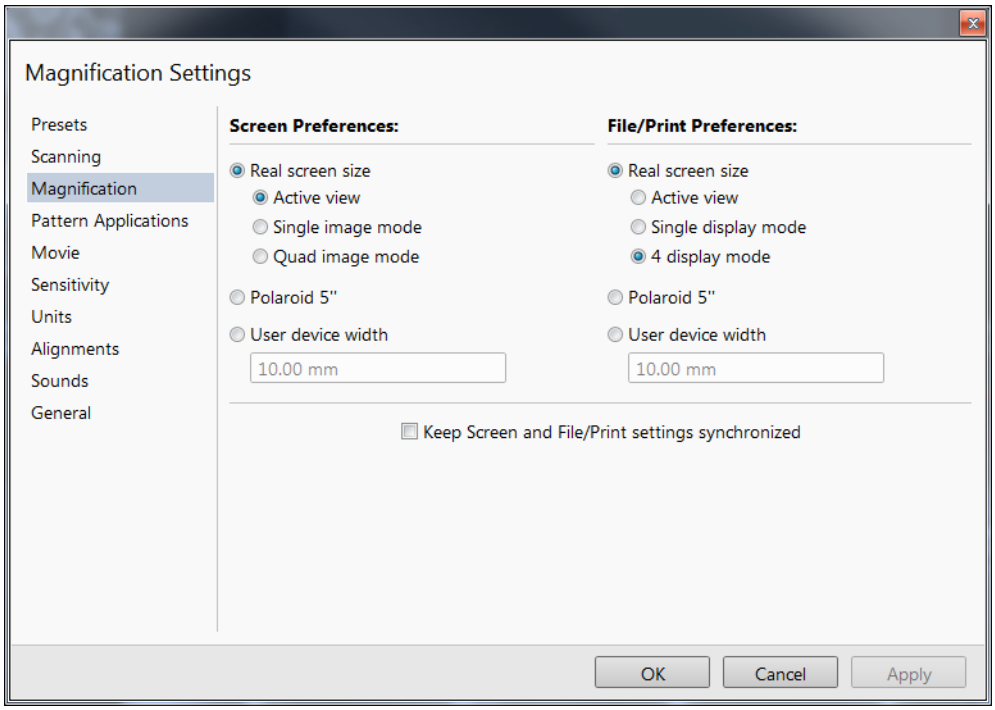


Table 4-1 Magnification Settings overview (1 of 2)

Interface Item	Description
Screen Preferences	Sets the imaging databar magnification show behavior.
File/Print Preferences	Sets the storage/printing databar magnification show behavior
Real screens size:	Handles the imaging pixel width.
Active view	Shows the magnification value for the active imaging mode: either Single or Quad Image mode. It is shown in the databar and stored/printed with an image with an icon representing the Single or Quad Image mode.
Single image mode/ Single display mode	Shows the Single image mode magnification value in the databar and is stored/printed with an image.
Quad image mode/ 4 display mode	Shows the 4-display image mode magnification value in the databar and is stored/printed with an image.

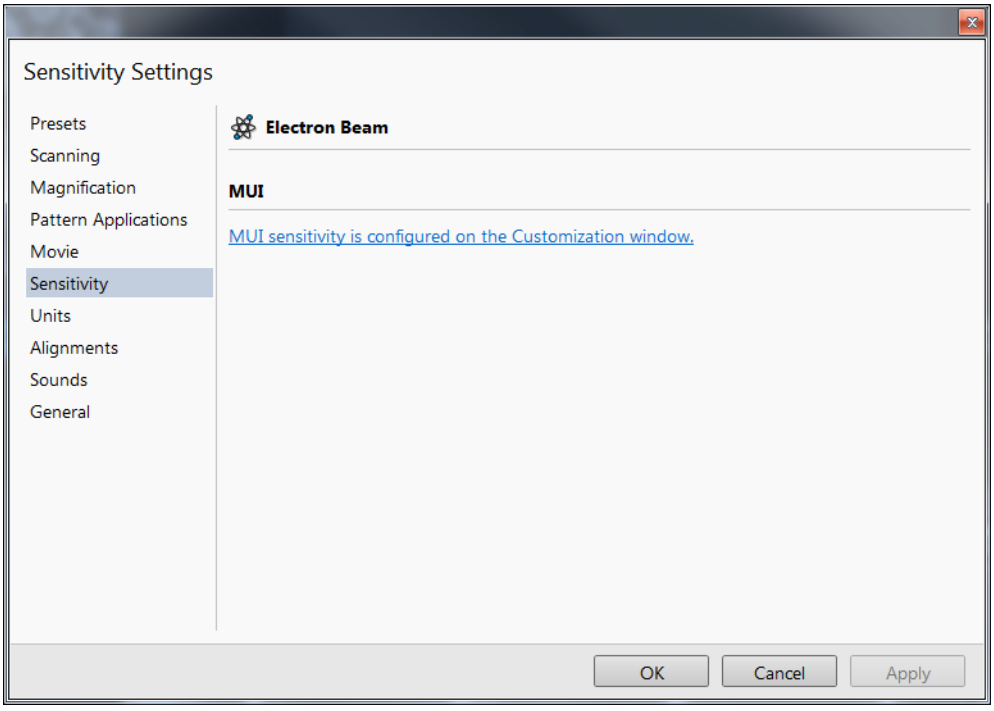
Table 4-1 Magnification Settings overview (2 of 2)

Interface Item	Description
Polaroid 5"	Handles the Polaroid 5" film width. A recalculated magnification value is shown in the databar and stored/printed with an image.
User device width	Handles the User device width (set via the edit box). A recalculated magnification value is shown in the databar and stored / printed with an image.
Keep Screen and File/Print settings synchronized	Keeps both settings identical.

Sensitivity Section

Set the sensitivity of the manual user interface (MUI) knobs separately for the electron and ion beams.

Figure 4-37 Sensitivity Preferences



Scanning Section

Use this section to change the dwell times (scanning speeds) table and to set up the Slow scan / Fast scan / Snapshot / Photo function for the ion and electron beams separately.

Selections can also be made from the Snapshot Grid accessed from the dropdown arrow next to the **Snapshot** toolbar button. See *"Photo / Snapshot" on page 88*.

Figure 4-38 Scanning Preferences

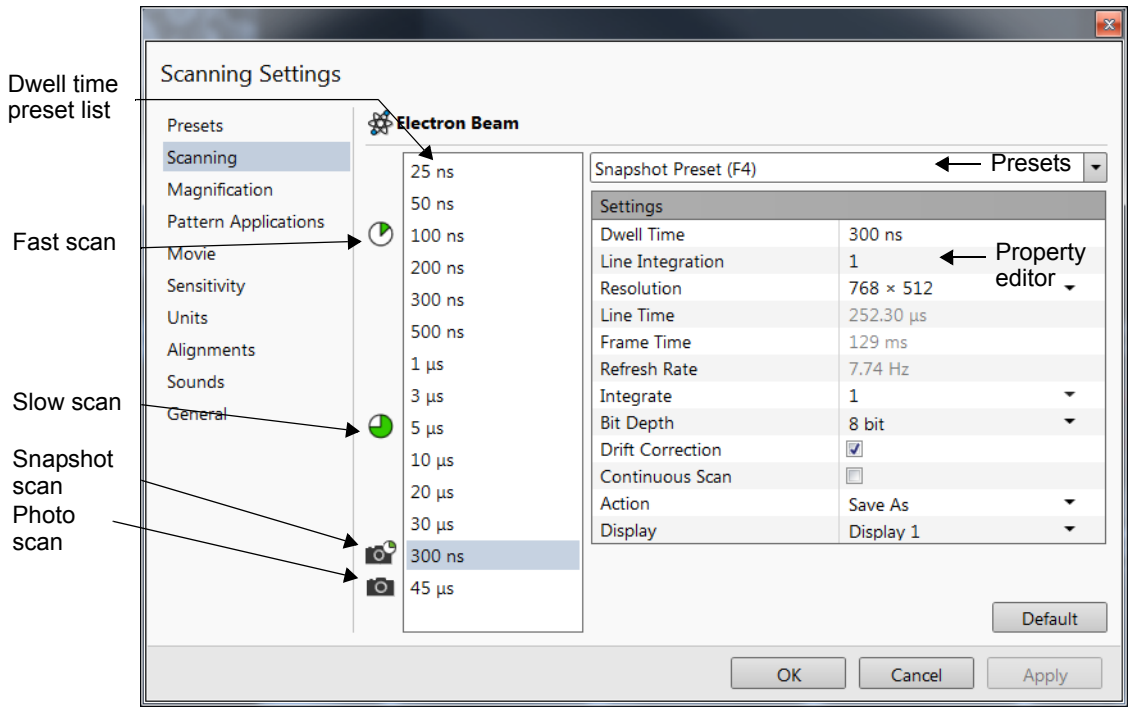


Table 4-1 Scanning Settings overview (1 of 2)

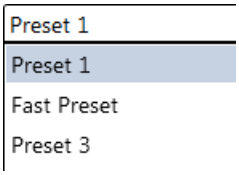
Interface Item	Description
Dwell time preset list	Contains a fixed number of dwell time entries. Change selected preset values in the property editor on the right side of the module. Slow scan, Fast scan, Snapshot, and Photo (different cameras) preset icons indicate the matching dwell time value. To change their values, move the icon up or down by clicking and dragging it to a new preset.
Presets 	Shows a list of selectable scan functions that can be edited in their unique property editor.

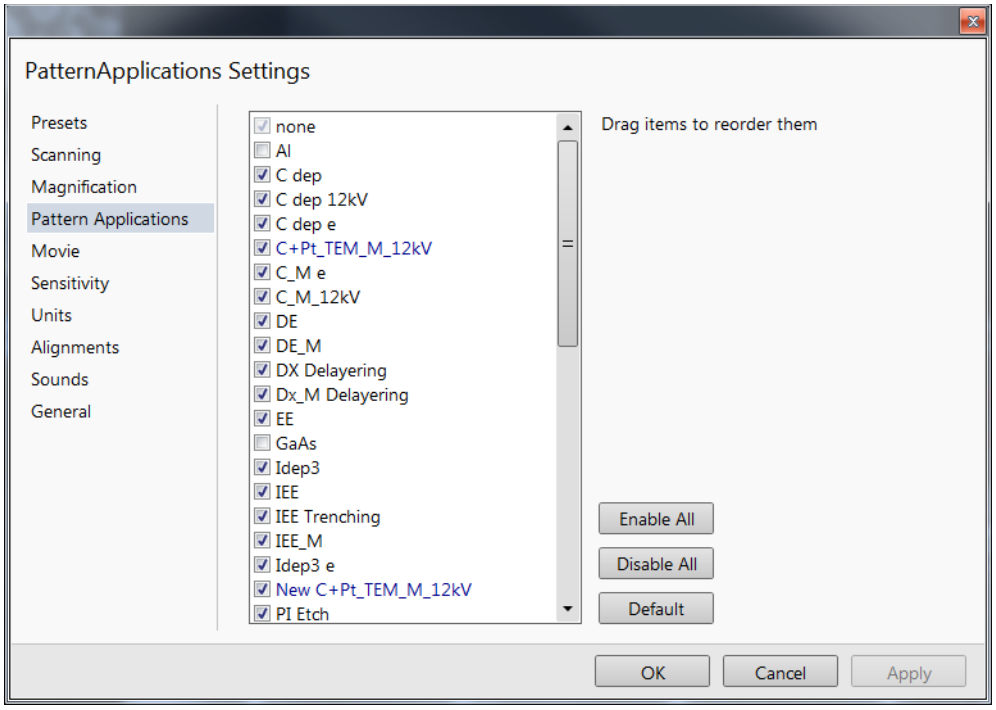
Table 4-1 Scanning Settings overview (2 of 2)

Interface Item	Description
Property editor:	*For different presets not all of following fields are present.*
Dwell Time	The period of time during which the beam remains at the scanned point. The full range of dwell times indicated in the scan selection module (editable field).
Line Integration	Number of line scanning repetitions.
Resolution	Sets the screen resolution.
Line Time	The line scan duration time. Indicates the full range of line times (informative and noneditable).
Frame Time	Indicates the frame time (display scan duration time) as a result of dwell and line time (informative and noneditable).
Refresh Rate	Shows imaging refresh frequency (informative and noneditable).
Integrate	Shows a list of frames from 1 to 512 in steps: 1, 2, 4, 8, 16, 32, 64, 128, 256, 512. This field is only editable for Snapshot and Photo.
Bit Depth	Enables to sets the captured image bit depth (8 bits / 16 bits).
Drift Correction	Enables to correct imaging drifting when integration filter is active. When activated, the text below the blinking pause icon notifies a user.
Continuous Scan	*W*hen set to yes and the Snapshot / Photo function is started during a scanning, this scanning finishes and resulting image is acquired according to the preset. This functionality requires the same scanning conditions for the scan in progress and the Snapshot / Photo preset (Dwell time, Line integration, Resolution, Bit depth…). If they are not, the Application status warning message is shown. The functionality is convenient for charging samples.
Action	Shows a choice of Save, Save As, and None. The selection determines the result of either Snapshot or Photo, and whether the image is saved with a known label to a prelocation (Save) or if the user is prompted for a name and location (Save As). When None is selected, the image just remains onscreen. This field is only editable for Snapshot and Photo.
Display	Enables to sets the display (1, 2, 3, 4) from which the image should be captured.
Default	Restores the default dwell time list and scan functions settings.
OK	Updates the system with any changes to the settings.
Cancel	Returns to the original settings.
Apply	Makes the chosen settings work immediately without updating the old conditions. They will work until the scan is changed or switched off.

Pattern Applications section

Use this section to change the visibility and order of patterning Application Files within the **Properties** module.

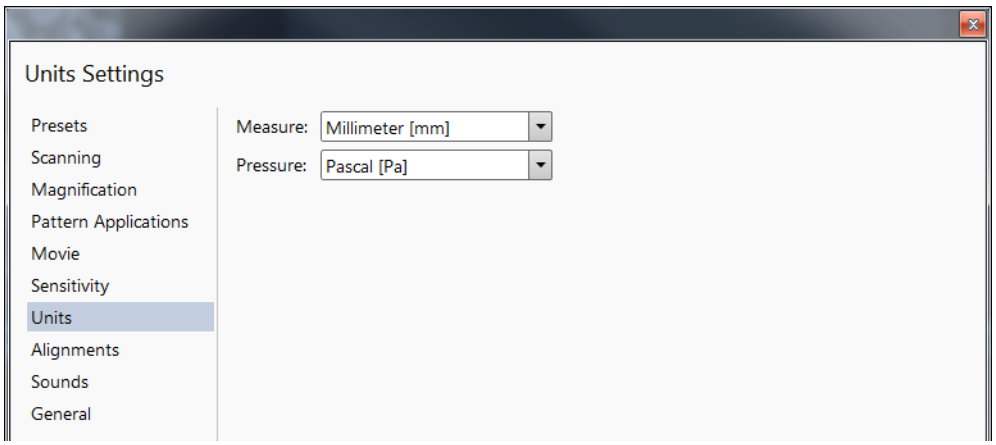
Figure 4-39 Pattern Applications Preferences



Units section

Use the *Units* section to change the units of measure, pressure and temperature. The choices affect the Stage module input boxes, display databar, and status module.

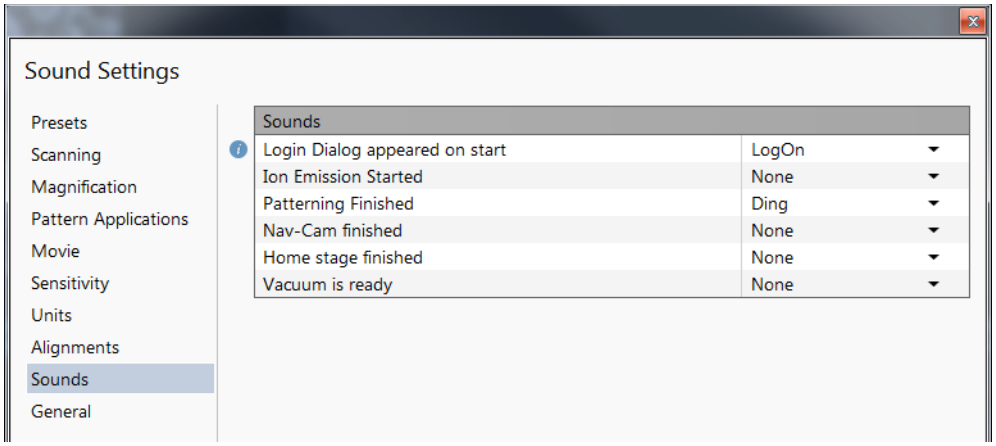
Figure 4-40 Units Preferences



Sounds section

Use the *Sounds* section to set system sound notices for selected tasks.

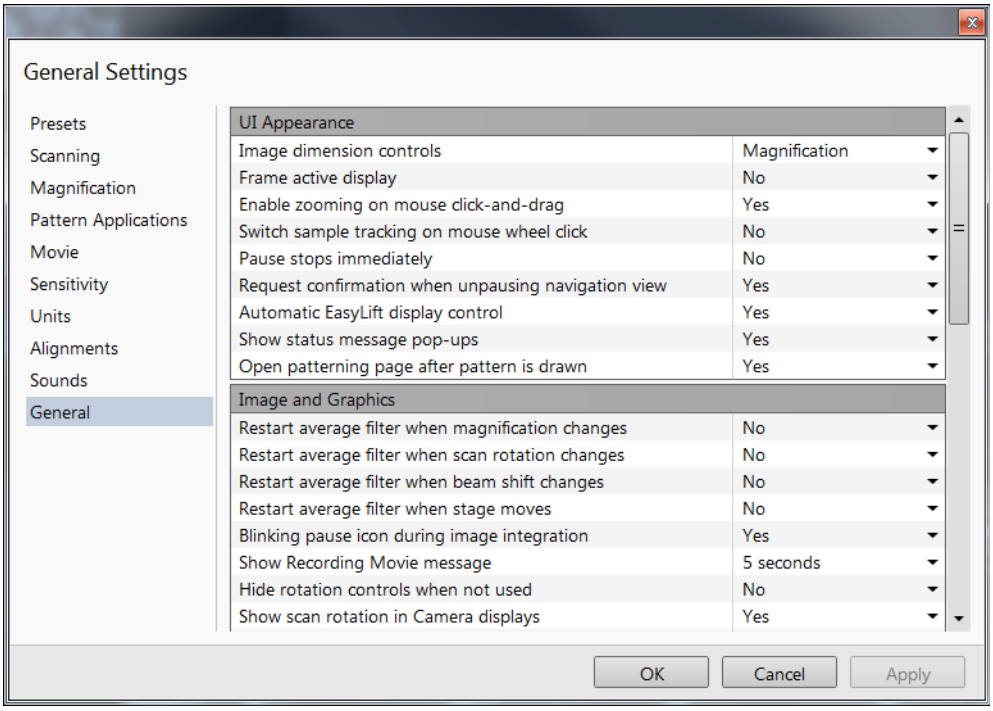
Figure 4-41 Units Preferences



General Section

This section contains a variety of user settings for both UI behavior and microscope operation.

Figure 4-42 General Preferences



NOTE	Some changes become visible after the next UI start.

Table 4-1 General Settings overview (1 of 4)

Interface Item	Description
Category	To make navigation among the number of preferences easier, they are divided into three groups: UI Appearance, Image and Graphics and Microscope Operation. Each item of the selected group is represented by a single line in the property editor. Click on the corresponding Value column to show a drop-down list with the settings available for that item.
UI Appearance	• **Image dimension controls**: Choices are Magnification and HFW. • **Frame active display** (Yes/No): Specifies that the active display have a blue outline. • **Enable zooming on mouse click-and-drag** (Yes/No): Set an option of mouse zooming. • **Switch sample tracking on mouse wheel click** (Yes/No): Switches the tracking movement control linked to the mouse wheel between click-and-move and click-and-drag modes. • **Pause stops immediately** (Yes/No): Causes the Pause function to act instantly or wait for the scan to complete. • **Request confirmation when unpausing navigation** (Yes / No): When releasing (unpausing) navigation imaging, confirmation could be switched on / off. • **Automatic EasyLift display control** (Yes/No): When inserted, causes the overlay to show automatically. • **Show status message pop-ups** (Yes / No): Switches the status messages pop-up on / off. • **Open patterning page after pattern is drawn**: When a pattern shape was created with the use of a toolbar icon and Yes is set, the patterning page activates automatically.

Table 4-1 General Settings overview (2 of 4)

Interface Item	Description
Image and Graphics	• **Restart average filter when magnification changes / scan rotation changes / beam shift changes / stage moves** (Yes/No): Yes is advised. If not, the image can remain with ghost impressions for some time. Restarting the average filter causes the imaging to blink and get noisier; on the other hand, the averaging slows down the imaging response to the changed parameter. • **Blinking pause icon during image integration** (Yes/No): Causes the Pause button to blink when scanning is paused. If Yes is selected, the blinking Pause symbol is shown in displays that are being stopped. Otherwise, the Pause symbol appears only after the image acquisition has actually stopped. • **Show Recording Movie message** (No, 1, 2, 5, or 30 seconds): At the beginning of the movie recording, this message could be shown in the recorded displays for a selected time period. • **Hide Rotation controls when not used** (Yes/No): Hides rotation controls if rotation is not to be used in the application. Specifies if and when the on-image Scan/Compucentric Rotation control should be automatically switched off. • **Show scan rotation in Camera displays** (Yes/No): Shows the saved positions in any navigation image (Nav-Cam, Navigation Montage, Navigation Alignment). • **Show Stage Map in Navigation displays** (Yes/No): Shows the saved positions in any navigation image (Nav-Cam, Navigation Montage, Navigation Alignment). • **Apply AutoLUT after ACB** (Yes/No): • **Apply AutoLUT after grab frame** (Yes/No): These two preferences apply automatically image optimization after said functionality. • **Save digitally zoomed image as** (Entire image / Zoomed area): Saves the digitally zoomed image as the zoomed area or the entire scanned area. • **Show legacy scanning resolution** (Yes/No): Shows old format screen resolutions in the toolbar drop-down list. • **Post Processing** (None / Standard / Custom #): Select an image post processing preset to be applied.

Table 4-1 General Settings overview (3 of 4)

Interface Item	Description
Microscope Operation	• **Interactive Databar** (On/Off): Makes the image databar fields active when possible. • **Scan Rotation Sensitivity** (0.1/0.01): Sets the scan rotation value accuracy. • **E-Beam Working Distance databar precision** (0.1 millimeters / 0.1 micrometers) It is possible to set the precision of the WD setting. • **Lower stage when venting the chamber** (Yes / No): Specifies if the stage should automatically go to a low Z values when venting the chamber. This is a recommended (not default) setting, because it greatly diminishes the chance of hitting the pole piece when closing the chamber doors after mounting a higher specimen. • **Change magnification when pumping** (No /Set to 100× /Set to 200×): Specifies whether the magnification for electron imaging should be automatically set to a low value when the chamber is being pumped (presumably after replacing the specimen). • **Switch off CCD automatically** (No/1 minute/10 minutes/ 30 minutes /1 hour/2 hours/6 hours): Specifies if and when the CCD camera and infrared LED's should be automatically switched off. The countdown starts when resuming the optical display and continues regardless of the operator activity. • **Pause beam display when switching off HV** (Yes/No): Pauses scanning when the beam high voltage is switched off. • **Use measured I-beam current for patterning** (Yes/No): If yes, calculates the total patterning process time based on the actual measured ion beam current no matter what the nominal beam current value is for a selected aperture. This feature should prevent patterning inaccuracies caused by aperture wear. If the measured beam current differs from the nominal value by more than 20%, a dialog box appears to ask if you want to recalculate. • **Allow beam shift in Get mode** (Yes/No): Enables/disables automatic use of Beam shift when a user requires very small point-to-point movements (Get moves at high magnifications). • **Blank E / I -beam during long stage moves** (Yes/No): Blanks the electron / ion beam during long stage moves to prevent sensitive areas of the stage or sample from coming into contact with the beam.

Table 4-1 General Settings overview (4 of 4)

Interface Item	Description
Microscope Operation (cont.)	• **Delete image data when user logs off** (Yes/No): If Yes, any live and/or paused imaging in all displays is deleted when user logs off. • **Reverse joystick movement** (Yes/No): Normally the joystick movement direction corresponds to the stage movement, so the imaging moves in the opposite direction. This setting changes the stage response to the joystick movement direction. • **Auto switch stage measurement system** (Yes/No): Automatically switches the stage measurement systems off when they are not used. This prevents light from "leaking" out of the optical measurement system that may interfere with third party options such as EDS detectors. • **Optimized collection efficiency** (Yes/No): If yes, the inactive (paused) SE detector is prevent from taking the SE signal from the active one. This is not recommended to use while patterning, because it can cause image quality decrease in SPI and iSPI mode. • **Retracted detector will be replaced with a standard detector** (Yes/No): If Yes, retracted detector will be replaced with system standard one, if No, imaging will be replaced with the system message "Detector retracted". • **Chamber illumination** (Yes / No) If Yes and the in-chamber Nav-Cam is installed, inner chamber illumination is on when the chamber is vented. • **Show sample exchange window on pump/vent** (Yes / No) When starting to pump or vent the chamber, the Sample exchange window opens automatically. • **Venting valve opening time** (value): Prolongs the venting time (default value is 300 sec) to eliminate residual vacuum that makes it impossible to open the chamber door or shortens the venting time. • **Default display for Nav-Cam Image** (Display 1/Display 2/Display 3/ Display 4/Active): Sets the default Nav-Cam imaging display. • **EasyLift coordinates depends on bulk stage tilt** (Yes/No): Coordinates of the corresponding stage depends on stage tilting towards the electron / ion beam.

Entering Commands

Enter commands by using the mouse or keyboard. It is possible to configure the shortcuts for the active user account (see *"Keyboard (Shortcuts) customization" on page 51*).

Mouse Button Functions

The mouse buttons control imaging correction, selecting functions, scrolling magnification up/down, and moving the stage in X and Y with Track moves. Mouse buttons are activated by a click, right-click or double-click or in conjunction with a key on the keyboard.

Table 4-2 Mouse Button Functions (1 of 2)

Button	Function
Click	Makes a selection (arrow cursor).
Ctrl + click	Selects a graphical item within an imaging area (adds another one to the selection)
Shift + click	Pauses / releases all displays when clicking the toolbar **Pause** button.
Double-click	• Activates the Get moves to move the selected stage position to the middle of the display (arrow cursor). • Places the 4 mm marker.
Click & drag	• **Zoom In:** Click and drag a selected area from **upper left to lower right** to zoom in magnification to fill the imaging area with the selection (selectable in Preferences). • **Zoom Out**: Click and drag a selected area from l**ower right to upper left** to zoom out magnification to fill the imaging area with the selection (selectable in Preferences).
Ctrl + click & drag left / right	Adjusts contrast.
Ctrl + click & drag up / down	Adjusts brightness.
Shift + click & drag	Activates Beam Shift (hand cursor) while in active display.
Right-click & drag	Focuses image (2-ended arrow cursor). Right-click and move the mouse to the left or right. Release the button to set the focus.
Ctrl + right-click & drag	Activates Lens Alignment (4-ended arrow cursor).
Shift + right-click & drag	Activates stigmator control (4-ended arrow cursor). Shift + right-click & drag the mouse to the left or right (X stigmator), or up or down (Y stigmator) to correct. Release the buttons to finish.
Crtl + wheel-roll up / down	**Coarse Control.** Moving the wheel up increases the magnification; moving it down decreases magnification.
Shift + wheel-roll up / down	**Fine Control**. Moving the wheel up increases the magnification; moving it down decreases magnification.

Table 4-2 Mouse Button Functions (2 of 2)

Button	Function
Crtl + Shift + wheel-roll up / down	Moving the wheel up increases the digital zoom magnification; moving it down decreases digital zoom magnification.
Wheel-click & drag	**Electron/Ion imaging:** activates the Track moves for joystick-like movement over the sample surface. **Optical Imaging in CCD display:** activates the stage Z movement (stage tilt). Moving the mouse up or down moves the stage up or down. This can be seen live in display 4.
Ctrl + wheel-click & drag	**Optical Imaging in CCD display:** activates the stage Z movement (stage tilt). Moving the mouse left increases stage tilt, moving the mouse right decreases stage tilt. This can be seen live in display 4.

Dedicated Windows Keys

Table 4-3 Dedicated Windows Keys (1 of 2)

Key	Function
Enter	Equivalent of **OK** in a dialog box.
Esc	• Equivalent for the **Cancel** button. • Stops the stage motion at that point. • Cancels the drawing mode on Patterning, Measurement & Annotation or Text cursor. This is especially useful when working with EasyLift in control overlay mode. **Note:** *During some procedures (e.g., Home Stage) use the software* **Cancel** *or* **Stop** *button.*
Tab	Steps between entry fields within a dialog box.
(Shift +) Arrows	• In a list box, selects between items in a group. • In an active display, activates Shift moves of the stage approximately 40% (80% without Shift) of the field of view (FOV) in the direction of the keyboard Arrow key.
Ctrl + Arrows	Pan (shift digital zoom area) 80% of view in direction of arrow.
Ctrl + Alt + Arrows	Moves Measurements, Annotations, or Pattern shapes by one screen pixel in the corresponding direction.
Alt (or F10)	Use **Alt** in combination with a character (underlined characters in the menu items) to open the pulldown menu in the active application. For example, pressing **Alt** + **M** at the same time brings up the Magnification pulldown menu.
Alt + Tab (Simultaneously)	Use these keys to show the last used program. Continue to press the **Tab** key (while holding down the **Alt** key) and applications that are resident are shown one by one. When the application you want is shown, release the **Alt** key and it becomes active again.

Table 4-3 Dedicated Windows Keys (2 of 2)

Key	Function
Alt + F4 (Simultaneously)	Exits the active application software or Windows operating system.
Del	Deletes the selected text or items.
Keypad +/-	Changes the magnification of the active display.
Ctrl Keypad +/-	Digital zoom in /zoom out

Function Key Shortcuts

Function keys are located at the top of the keyboard and work either on their own or with **Shift** or **Ctrl** keys.

Table 4-4 Function Key Shortcuts

Key	Function
F1	Shows online documentation.
Shift + F1	Opens the Image Properties window.
F2	Starts (first press) /stops (second press) the Photo scan with the active beam.
Shift + F2	Starts (first press) /stops (second press) the Photo scan with the active beam from all displays with the same beam at once.
Ctrl + F2	Takes an Active Preset Snapshot from all displays with the same beam at once.
F3	Toggles the Videoscope on/off in the selected display.
Ctrl + F3	Toggles the Videoscope on/off in all displays.
Shift + F3	Starts the Home Stage procedure.
F4	Starts (first press) /stops (second press) the electron imaging Snapshot scan from a preset display.
Ctrl + F4	Starts (first press) /stops (second press) the ion imaging Snapshot scan from a preset display.
Shift + F4	Starts/stops the lens alignment procedure.
F5	Toggles between Quad Image or Single Image modes.
Shift + F5	Toggles the Center Cross show on/off.
Ctrl + F5	Toggles Large Image Window mode.
F6	Pauses/activates scanning.
Shift + F6	Toggles the alignment rectangle show on/off.
F7	Toggles between Reduced Area/Full Frame mode.

Table 4-4 Function Key Shortcuts

Key	Function
Shift + F7	When iSPI is On during patterning, electron image is grabbed from the reduced area only.
Ctrl + F7	Applies preset image post processing.
F9	Starts the Auto Contrast and Brightness procedure.
Shift + F9	Starts the Auto Contrast and Brightness procedure in all displays.
F11	Starts the Auto Focus procedure.
Shift + F11	Toggles the Display Saturation function on/off.
F12	Toggles the Compucentric Rotation tool on/off.
Shift + F12	Toggles the Scan Rotation tool on/off.

Specific Keyboard Shortcuts

Table 4-5 Specific Keyboard Shortcuts (1 of 2)

Key	Function
Ctrl + 0 (number)	Moves the stage to X=0, Y=0.
Ctrl + A	Selects all items.
Ctrl + B	Toggles Beam Blank function on/off.
Ctrl + C or Ctrl + Insert	Copies the selected item to the clipboard.
Ctrl + D	Sets Default Parameters.
Ctrl + E	Tilts the stage to 0° (E is for electron beam).
Ctrl + F	Sets FWD to the aligned eucentric point.
Ctrl + G	Resets the Z height based on the Cap-Probe training.
Ctrl + I	Tilts the stage to 52º (I is for ion beam).
Ctrl + J	Shows the EasyLift control in display overlay.
Ctrl + K	Sets Spot mode scanning conditions.
Ctrl + L	starts Link Z to FWD procedure
Ctrl + M	Sets Full Frame scanning conditions.
Ctrl + Shift + M	Shows the movie recording dialog box.
Ctrl + N	Toggles Sample Navigation on/off.
Shift + N	Starts to mill the next pattern line.
Ctrl + Shift + N	Starts to mill the previous pattern line.
Ctrl + O (letter)	Opens the Preferences dialog box.

Table 4-5 Specific Keyboard Shortcuts (2 of 2)

Key	Function
Ctrl + P	Opens the standard Print dialog box.
Shift + P	Moves to the next pattern.
Ctrl + R	Restarts the scan.
Ctrl + S	Saves the image in the active display.
Ctrl + Shift + S	Saves the images from all displays.
Ctrl + T	Toggles between electron and ion beam imaging.
Ctrl + V or Shift + Insert	Pastes the copied content from the clipboard at the cursor position.
Ctrl + X or Shift + Delete	Cuts the selected content to the clipboard (copies and deletes it).
Ctrl + Y	Redoes the last action.
Ctrl + Z	Undoes the last action.
Ctrl + Shift + Z	Starts the Take Nav-Cam Photo procedure.
Tab	Steps among controls.
Ctrl + (Shift +) Tab	Steps (backwards) among displays.
Ctrl + ,	Selects one step slower scan preset.
Ctrl + Shift + ,	Selects the preset slow scan.
Ctrl + .	Selects one step faster scan preset.
Ctrl + Shift + .	Selects the preset fast scan.
Ctrl + Shift + A	Alternates between electron/ion scanning.
Ctrl + Page Up / Down	Steps up / down through the control pages buttons for selection.
Ctrl + 1 / 2 / 3...	Selects the control page by the button number sequence.
Ctrl + +/-	Scales up/down the digital zoom imaging 2×.
+	Increases magnification 2×.
-	Decreases magnification 2×.
*	Rounds off magnification to the nearest whole number.
Ctrl + Arrows	Moves the digital zoom area one screen pixel in the respective direction.
Ctrl + Alt + Arrows	Moves the selected measurements, annotations, or patterns by one screen pixel in the respective direction.
Ctrl + Scanning Preset Button	Takes an electron beam Snapshot of the active display only. **Note**: *The same keystrokes will interrupt the acquisition process.*
Ctrl + Shift + Scanning Preset Button	Takes a snapshot from all available electron or ion beam displays (depending on the active beam) at once. **Note**: *The same keystrokes will interrupt the acquisition process.*

Patterning Keyboard Shortcuts

Table 4-6 Patterning Keyboard Shortcuts

Key	Function
Ctrl + C	Copies the selected pattern.
Ctrl + X	Cuts the selected pattern.
Ctrl + V	Pastes the pattern from the clipboard into the active display.
Ctrl + Alt + any Arrow key	Moves the selected pattern 1 pixel in the direction of the selected arrow (left, right, up, or down). Used for its accurate positioning.
Esc	Deselects the currently selected patterns.
Shift + N	Starts milling the next line.
Shift + P	Selects the next pattern for milling.
Ctrl + Shift + N	Starts to mill the previous line.
(Shift +) any Arrow key	• When in a list box, selects between items in a group. • When in an active display, activates Shift moves of the stage about 40% (80% without Shift) of the FOV in the selected arrow direction.
Pause	Starts/pauses/resumes patterning.
Ctrl + Pause	Resets patterning.

5 Getting Started

This chapter describes the essential parts of the system from an operational point of view. These procedures assume you have read and are familiar with the User Interface chapter, but provide ample cross-references and illustrations for the operator who likes to jump right in.

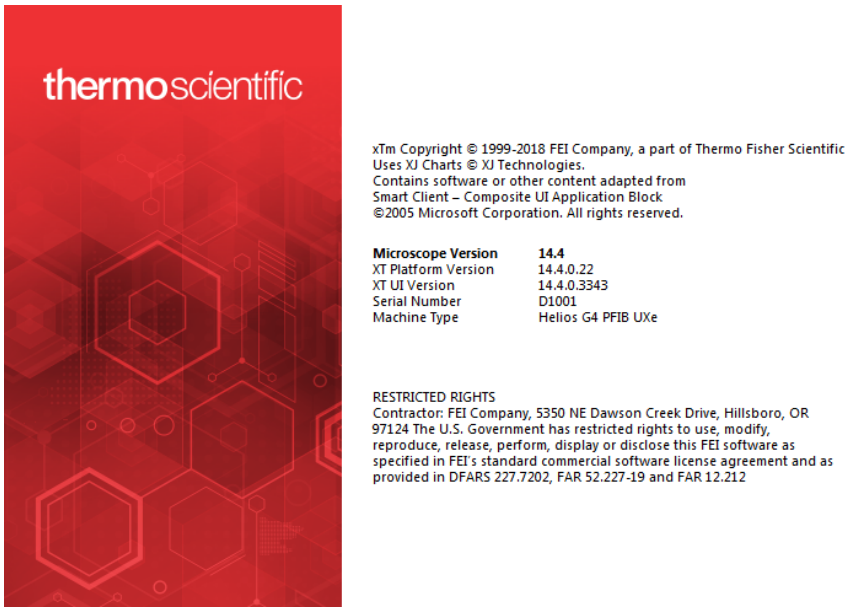
Be sure to take advantage of the cross-references throughout this chapter.

Topics include:

- *"Starting the UI" on page 160*
- *"Guide to System Settings" on page 161*
- *"Beginning Your Session" on page 162*
- *"Preparing the Sample" on page 167*
- *"Obtaining an Image" on page 169*
- *"Working with Detectors" on page 171*
- *"Optimizing the Image" on page 187*
- *"Selecting Beam Conditions" on page 197*
- *"SEM Imaging Modes" on page 200*
- *"Capturing and Handling a Single Image" on page 206*
- *"Recording Movies (Multiple Image Capture)" on page 211*
- *"Importing and Exporting Files" on page 219*
- *"Stage Movement Limits " on page 219*
- *"Moving the Stage" on page 221*
- *"Nav-Cam (In-Chamber Navigation Camera)" on page 232*

Starting the UI

Click **Start UI** in the Server dialog box to start the user interface. The splash screen shows while the software is loading.



After the UI has loaded, log on as a designated user account name. A dialog box for loading your conditions appears and then you can proceed to start the sources and operate the system.

NOTE	Normally this login will be the same as the Windows login. And, If you are using the optional software on the support PC, the logins must match.

Guide to System Settings

Operations Checklist

To ensure correct operation check the following list before continuing. After obtaining a preliminary imaging, you can then experiment with your own settings.

Table 5-1 Setup Conditions

Adjustment	Electron Beam Setting	Ion Beam Setting
Accelerating Voltage	Select voltage relative to specimen type: • Low kV for surface imaging, beam-sensitive samples and slightly charging samples • High voltage for conductors, high resolution, compositional info (BSE, X-ray) For example: • Biological sample HV = (1 – 10) kV Metal sample HV = (10 – 30) kV	• 30 kV for imaging, milling, depositing • 5 kV for cleaning • 5 – 10 kV for large field of view
Beam Current	around 100 pA at 30 kV	around 100 pA at 30 kV
Scan rate	Fast scan (dwell time 0.1 – 0.3 µs)	Fast scan
Working Distance (FWD)	Set the highest specimen point to approximately 4 mm, tilt to 0° (yellow mark in an optical display) and press **Ctrl + F** (set FWD to 4 mm function).	Set the stage to the eucentric position and tilt to 52°.
Eucentric Position	4 mm	13 mm
Magnification	Set to lowest: from 50× to 200×	Set to lowest: from 50× to 200×
Standard Detector	ETD (SE)	ETD (SE)
Filtering	Live	Live
Contrast and Brightness	With contrast at minimum value, adjust brightness to just show a change in intensity to the screen. Increase the contrast to produce a reasonable imaging. Increasing brightness and decreasing contrast produces softer imaging and vice versa.	See Electron beam setting

Beginning Your Session

Usually, the system remains on (with the electron column emitter on) but with the ion column LMIS off. High voltage (HV) is typically off for both columns.

Follow the steps below when beginning the first work session of the day. Throughout the day, the system stays on from session to session.

To begin your session:

1. Enter your name and password in the Login dialog box for Windows 7 accessed at startup. Start the application.
2. Open the **Beam Control** page. Make sure the conditions are set to those recommended above.
3. If a sample is not already in the sample chamber, insert one according to the directions for loading samples.
4. Click **Wake Up** if the System module indicates it is in Sleep mode. This takes up to 10 minutes depending on the previous state of the system.

   This process will start the ion source and high voltages on both columns and open both column isolation valves.
5. The active beam is indicated by the icon in the Column module (in this case electron). Adjust the **High Voltage** slider to that required for the primary electron beam. By switching beams with the toolbar buttons, the Beam Control page will revert to the other beam (in this case ion) for adjustment to be made.

6. Focus the cursor in the active display and click **Unpause** on the toolbar and begin scanning with the electron beam.
7. Focus and stigmate the image using the mouse or MUI. Click the **Link Z-FWD** toolbar button to calibrate the physical position of the sample.

NOTE	Link Z to FWD is very important.

8. Set the eucentric position
   (see *"About Eucentric Position" on page 164*).

   Go to the Navigation page and set the Z value to 4 mm and click **Go To**. The illuminated area of the sample should now be close to the coincident height. To set the eucentric position correctly, locate a recognizable feature under the center cross

of the electron beam in display 1. *(Select **Window > Center Cross** to make it visible.)*

Tilt the stage to 7° if the feature moves away from the screen center after tilting, adjust the stage Z-height to bring the feature back to the center of the screen. Using **Ctrl + I** to tilt the stage to 52°, again bring the feature to the center of the screen if it has moved after tilting. This will set the sample at the eucentric position.

9. Set the coincident point of the electron beam and ion beam. Focus the cursor in another display and click the **Unpause** toolbar button to release that display and begin scanning with the ion beam. Control the contrast and brightness from the Detector module found on most pages. Focus and stigmate the image via the mouse or the MUI. Use the ion beam **Beam Shift** control to bring the same feature to the center of another display. Now the electron beam and ion beam meet in the same point; this is the coincident point.

At this point you will be able to image with the electron beam in one display and the ion beam in another display at the eucentric position, 52° tilt. Use the electron beam for searching the area of interest and the ion beam for milling and deposition.

About Eucentric Position

Establishing the eucentric position is an important part of setting up a sample for observation or modification. Eucentric position should be adjusted after loading any new samples as the load procedure clears all height information.

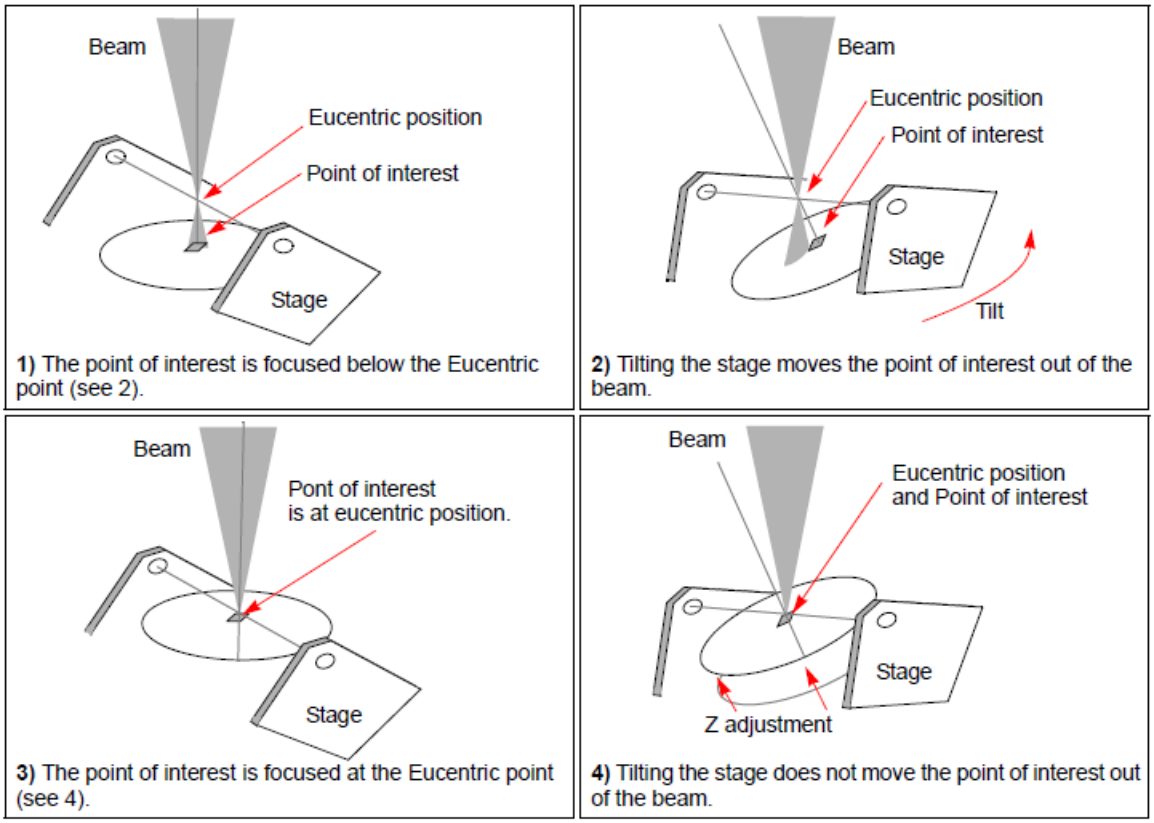
The coincident point is where the stage tilt axis and the ion and electron beam axes intersect. At this point, no matter which direction the stage is tilted or rotated, the feature of interest remains focused and almost no image displacement occurs.

When you have a feature of interest at the coincident point, you will be able to use the different system components, such as the GIS and EDX, in a safe and optimal way.

Finding eucentric position on the system is the process of positioning the sample so it is at the coincident point.

NOTE	The eucentric position adjustment is not necessary for electron imaging of non-tilted samples. However, you still must run the Link Z to FWD procedure.

Figure 5-1 Understanding Eucentric Position



Sample Top Surface Positioning

The distance between the observed sample and the stage rotation head surfaces must be properly set to bring the stage to the eucentric position. This procedure also prevents the specimen to touch the final lens when moving the stage in the Z-axis direction.

With the standard specimen holder it is possible to move the sample (its top surface) along the Z-axis up / down if required (holder movement). This allows a flexibility to load large height specimens onto the stage.

1. Load a specimen onto the specimen holder.
2. Adjust the Z so that the highest specimen point is approximately 4 mm below the lens.
3. Close the chamber and pump it down.
4. Switch on the beam, focus the specimen top surface and run the Link Z to FWD function. The FWD is now recognized by the system as the Stage module, Coordinates tab Z value.

The Z coordinate can now be changed via the software Z control around the eucentric position and further, but not less than 1 mm from the lens for safety reasons.

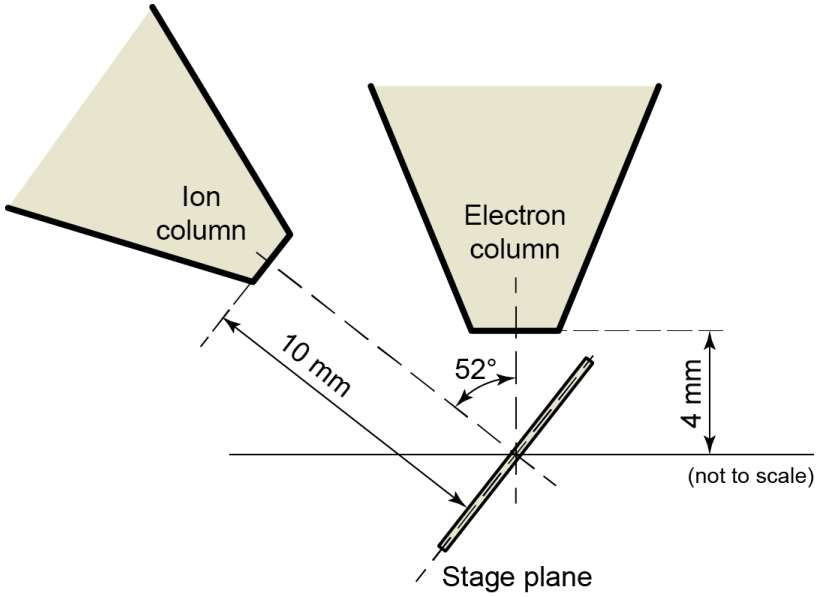
Setting the Eucentric Position

1. Apply the **Stage > Auto Beam Shift Zero** function.
2. Show the **Window > Center Cross** (**Shift + F5**).
3. Focus an image. Link Z to FWD and go to 4 mm WD.
4. Set stage tilt to 0°.
5. Using the Z-control, coarsely focus the image.
6. Set the magnification to 1 000×, find a recognizable feature, and center it under the yellow cross by moving the stage.
7. Watching the feature, change the stage tilt to 10°. Using the Z-control, bring the feature back under the cross.
8. Change the stage tilt to –10°, and bring the same feature back under the cross using the Z-control.
9. Change the tilt to 0°. The feature should not shift significantly. If the shift is > 5 µm, repeat steps from 6 to 9.

Beams coincidence setting procedure

The electron and ion columns are mounted as illustrated in the following figure, which shows the stage tilted to 52°. Beams coincidence occurs ideally at the eucentric position, but in fact it is shifted in the order of tens of µm.

Figure 5-2 Relationship of the Electron vs. Ion columns



NOTE	After aligning the two beams, avoid using beam shift with the ion and electron beams.

The following procedure brings your stage to the beams coincidence; it is assumed that your stage is at eucentric position and that both beams are on:

1. Select the **Electron Beam** from the toolbar Beam selection menu.
2. Tilt the stage to 52°.
3. While imaging with the electron beam, and at 1 000× magnification, find a distinct feature and move it under the center cross by moving the stage.
4. Select the **Ion Beam** from the toolbar Beam selection menu.
5. Using image shift, bring the same feature back under the center cross.

   If you cannot align the two images, recheck the eucentric position with the manual procedure.

Making a Test Pattern

Make a test pattern with a simple pattern using the ion beam and then observing it with the electron beam to see that it has correct beams coincidence.

Ending Your Session

When you are done with your session, log out, leaving the system ready for the next operator (see *"System states" on page 27*)

Preparing the Sample

The sample material must be able to withstand a high vacuum environment without outgassing. It must be clean and conductive. Oil, dust, or other materials may cause sample charging or contaminate the chamber, which could hinder or even prevent evacuation.

CAUTION	Store samples and sample holders in a dry nitrogen storage cabinet. Dust on samples can get drawn into the electron column, degrading imaging and requiring an Thermo Fisher Scientific customer service call to correct the problem.

Needed Tools and Supplies

- Tweezers
- 1.5 mm hex wrench
- Prepared sample
- Specimen stubs and conductive adhesive material
- Class 100 clean room gloves

CAUTION	Always wear lint-free clean room gloves when reaching into the specimen chamber to prevent leaving oils, dust, or other contaminants inside.

Coated Specimen

If the specimen is nonconductive (plastic, fibre, polymer or other substance with an electrical resistance greater than 1010 ohms) the specimen can be coated with a thin conductive layer. This conductive layer reduces beam stir due to sample charging and improves imaging quality.

For successful imaging, rough surfaced specimens must be evenly coated from every direction. Biological, cloth and powder specimens may require carbon or other conductive painting on portions of the specimen that are hard to coat.

Coating reduces beam penetration and makes the imaging sharper. It may mask elements of interest for X-ray analysis (thus the use of carbon for geological and biological specimens).

For more information on specific preparation techniques, see *Scanning Electron Microscopy and X-Ray Microanalysis, 2nd ed.* by Joseph Goldstein et al., Plenum Press, New York, 1992.

Mounting a Specimen on a Holder

Wafers and PGA devices have individual sample-mounting procedures. If you are using a wafer piece or other sample, attach the specimen to the specimen holder using any suitable SEM vacuum-quality adhesive, preferably carbon or silver paint. The specimen must be electrically grounded to the sample holder to minimize specimen charging. If you are using another way to mount a specimen, make sure the specimen is consecutively attached to the holder.

NOTE	The sample holder is not directly grounded to the chamber ground because it is connected to the BNC feed allowing to measure the specimen current.

Obtaining an Image

Principles of SEM Imaging

All scanning microscopes show with the same fundamental technique. The primary beam is scanned across the specimen surface in a regular pattern called a *raster*. Normally, this raster consists of a series of lines in the horizontal (X) axis, shifted slightly from one another in the vertical (Y) axis. The lines are made up of many dwell points and the time of each dwell point can be shortened or prolonged (*dwell time*). The number of points per line can be increased or decreased as well as the number of effective lines (*resolution*). The result is a picture point (*pixel*) array. Low or high resolution imaging can be obtained by changing these factors. The larger the pixel array, the higher the imaging resolution. The image is created pixel-by-pixel in the computer memory and shown on a monitor screen.

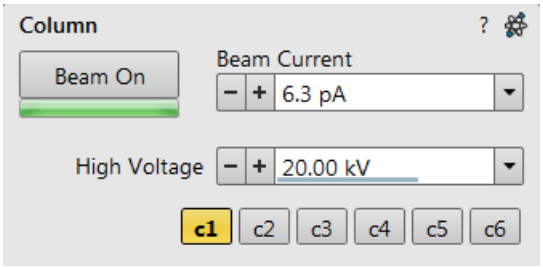
The signal emitted by the specimen surface as it is illuminated with the primary beam is collected by the *detector*, amplified and used to adjust the intensity of the corresponding pixel. Because of this direct correspondence, the pixels shown on the monitor are directly related to the specimen surface properties.

The raster consists of many (typically one million) individual locations (*pixels*) that the beam visits. As the beam is scanned, the signal emitted by the sample at each beam position is measured and stored in the appropriate digital memory location. At any time after the beam scan, the computer can access the data and process it to change its properties, or use it to generate an image.

Setup for Imaging with Either Beam

The following procedure assumes that the source is already on, the sample is at eucentric position, and the two beams are at the coincident point.

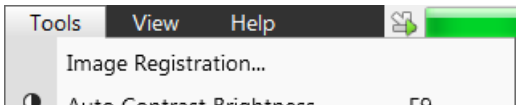
1. On the Beam Control page for the active beam, click **Beam On** in the Column module to ramp up the high voltage.



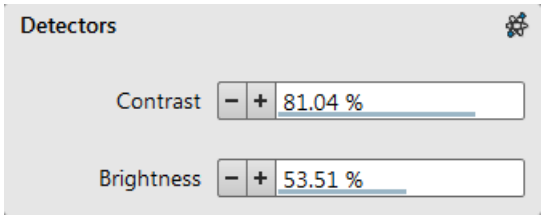
2. Focus the cursor in any display, select **Electron Beam** from the toolbar, and click **Unpause** to begin scanning with the electron beam. An image will appear in the activated display. Focus the image with the mouse or MUI.

3. Click the **Link Z TO FWD** toolbar button.
4. Adjust the contrast and brightness with any of the following ways:

- **Auto Contrast Brightness** toolbar button
- **Tools > Auto Contrast Brightness**
- **F9 / Shift + F9**



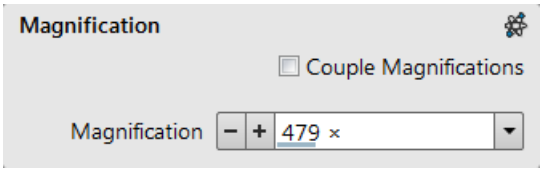
- The separate adjusters on the Detector module on most control pages



- MUI knobs

5. Adjust to a suitable magnification with any of the following ways:

- Magnification list box on the toolbar
- Magnification slider on the Beam Control page

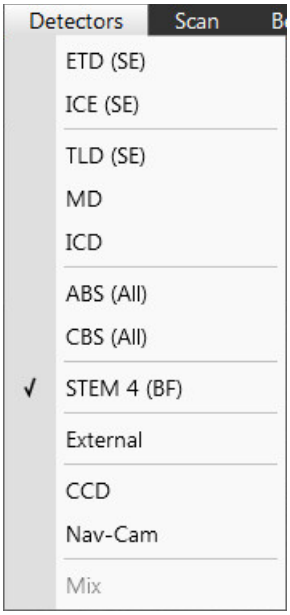


- Keyboard **+** and **–** keys
- MUI knob

6. Correct the focus and astigmatism.

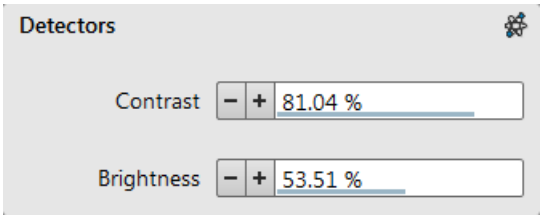
Working with Detectors

The detectors installed on your system appear in the Detectors menu and Detector Settings list box. The accessibility is dependent on the system status.



When a detector mode is selected, its acronym shows to the right of the detector name in the menu. In addition to the standard detectors available, there may be optional ones available for your system type.

Detector selections are tied to the choice of the active beam. The system always reverts to the last detector used for that beam in that display, reverting also the contrast and brightness to the settings last used.



The ion beam has one active mode for milling and imaging. The electron beam has three modes, selected from the toolbar button or **Beam > SEM Mode** (see further).

Table 5-1 Detector Choices by Beam

Detector	Ion Beam	Electron Beam
ETD	yes	yes, in Mode 1
TLD-S	yes	yes, in Mode 1 / 2 / 3
TLD-B, TLD-C, TLD-D	no	yes, preferably in Mode 2 only, with magnifications > 1500×
ICE (optional)	yes	yes, in Mode 1
MD	No	Yes, in Mode 1 / 2 / 3 Mode 2 recommended + Beam Deceleration (better signal : noise ratio), WD ? 4 mm
ICD	No	Yes, in Mode 1 / 2 / 3 Mode 2 recommended + Beam Deceleration (better signal : noise ratio), WD ? 4 mm
DBS (ABS / CBS)	No	Yes, in Mode 1 / 2 / 3
Nav-Cam	no	no
CCD	yes	yes
Mix	yes	yes
STEM (optional)	no	yes, in Mode 1 / 2 / 3

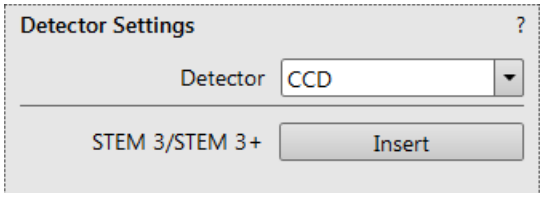
Infrared CCD Camera

Imaging obtained with this camera assists in overall sample and stage orientation by viewing the inner space of the specimen chamber (an optical display).

It protects the objective pole piece and retractable detectors against collision when moving (especially in the Z-direction) or tilting the stage. IR LEDs are used to light the specimen chamber interior.

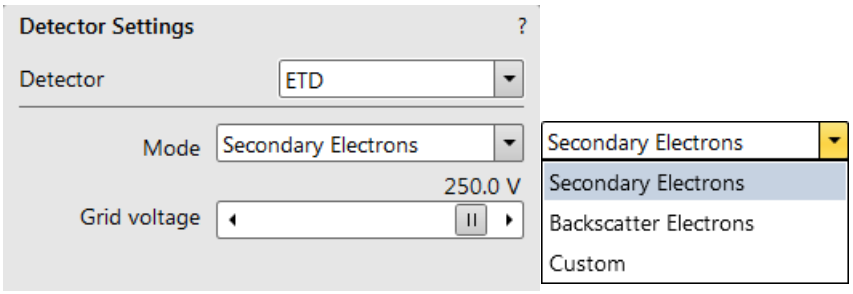
Retractable Detectors Control

When any retractable optional detector is installed on the system, the **Insert/Retract** button is added to the Detector Settings module to enable the equipment control while working in the optical display.



Everhart Thornley Detector

The Everhart Thornley Detector (ETD) is a scintillator photo-multiplier type detector collecting electrons generated by the primary beam interaction with the specimen surface. It is permanently mounted in the chamber over and to one side of the sample.



It works in Modes:

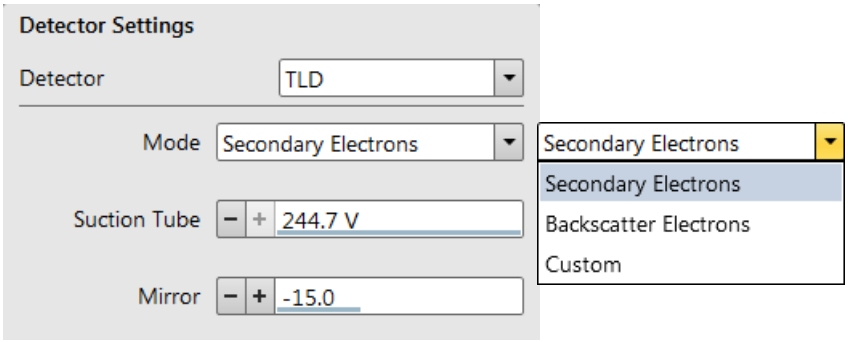
- Secondary Electrons (SE)
- Backscattered Electrons (BSE)
- The Deceleration Mode is available, when it is on
- Custom

ETD Settings

- For **Secondary Electron mode**, set the **Grid Voltage** to +250 V.
- For **Backscatter Electron** mode, set the **Grid Voltage** to –150 V.
- For a **Custom** mode, change the Grid Voltage with the adjuster in a range from –240 V to + 260 V. When the voltage is negative (use a range of –25 V to –240 V), secondary electrons are repelled from the ETD detector and only backscattered electrons are detected.

Through Lens Detector

The Through Lens Detector (TLD) is primarily designated to high resolution imaging in the Mode 2: Immersion (UHR).



It works in Modes:

- Secondary Electrons (SE)
- Backscattered Electrons (BSE)
- Custom

TLD Settings

Suction Tube Voltage

The **Suction Tube Voltage** adjuster modifies electron collection.

- When the voltage is **negative**, low energy secondary electrons are repelled from the TLD detector and only backscattered electrons are detected.
- When the voltage is **positive**, low energy secondary electrons are collected by the TLD detector. The Suction Tube Voltage capability is from –150 V for only backscattered electrons to +150 V for secondary electrons collection.

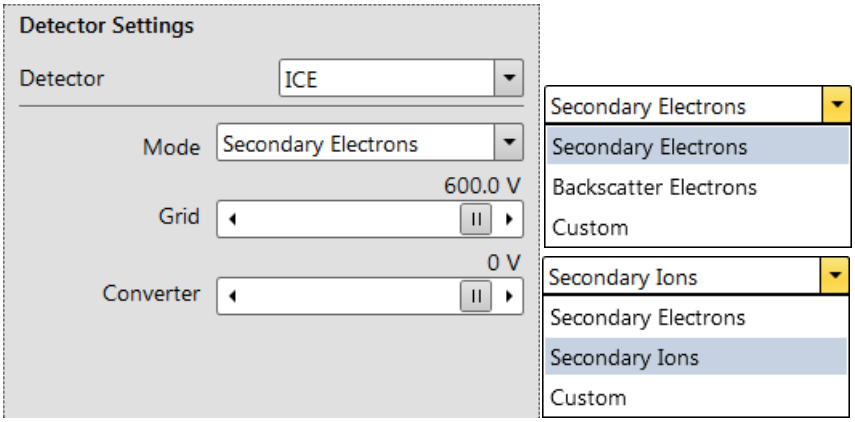
Mirror

The **Mirror** adjuster deflects the acceleration path of the secondary electrons into the detector in Secondary Electrons mode. It can also be used to convert high energy backscattered electrons to secondary electrons in Backscatter Electron mode.

NOTE	When using the FIB Immersion utility, the Custom Mode Suction Tube Voltage for electron imaging is copied to the Custom mode for ion imaging.

ICE Detector

The ICE is a charged particle detector mounted near the end of the ion column. It collects secondary ions (SI) or electrons (SE, BSE) to form an imaging signal.



The Electron beam and Ion beam imaging (distinguished by the beam icon in the module header) have different Modes.

Electron beam modes:

- Secondary Electrons (SE)
- Backscatter Electrons BSE)
- Custom
- Deceleration Mode – available, when the Deceleration Mode is on

Ion beam modes:

- Secondary Electrons (SE)
- Secondary Ions (SI)
- Custom

ICE Detector Settings

- When changing any of the adjusters, the **Custom** mode is activated for any beam, allowing values to be changed.
- The **Grid** continuous adjuster: Positive voltage for SE imaging, negative voltage for BSE and SI imaging.
- The **Converter** continuous adjuster: 0 for SE and BSE imaging, negative for SI imaging.

NOTE	Changing the beam current adjusts the detector contrast automatically.

ICE & ETD Collection Efficiency

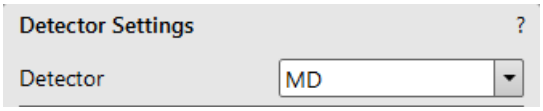
ICE and ETD detectors are both able to collect SE signal. In order to prevent the inactive (paused) SE detector from taking the SE signal, set the **Preferences** dialog **> General** tab **> Optimized collection efficiency** item to **Yes**. This provides more SE signal to the active SE detector. This is advantageous for common imaging but it is not recommended to use while patterning, because image quality decreases in SPI and iSPI mode.

NOTE	Large changes to the custom conditions on biased detectors (such as the ETD and the ICE) could cause beam shift, which in turn affects the beams coincidence. Therefore it is not advisable to change custom conditions while patterning (if beams coincidence is affected, run the Beams coincidence setting procedure (see above) before a patterning starts).

Mirror Detector (MD)

The MD collects BSE signal which energy distribution differs from the BSE signal of TLD. It can work independently on TLD, so simultaneous BSE and SE imaging is possible. With the Beam Deceleration mode ON, the detected signal consists of a mixture of BSE and SE whose characteristic differs according to the microscope settings.

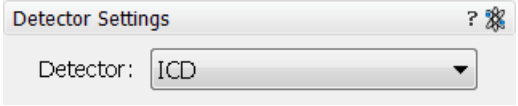
In general MD has better Signal to Noise ratio with longer acquisition time (dwell time > 1 µs) as it is the Solid state detector.



In-Column Detector (ICD)

The ICD detects BSE, which are scattered close to the electron beam axis when the Beam Deceleration mode is off. It provides high Z-contrast signal. With the Beam Deceleration mode ON, the detected signal consists of a mixture of SE and BSE whose characteristic differs according to the microscope settings.

The ICD has better Signal to Noise ratio at WD ? 4mm with longer acquisition time (dwell time > 1µs) as it is the Solid state detector.



Directional Backscattered Detector (DBS) Angular Backscattered Detector (ABS) Concentric Backscattered Detector (CBS)

NOTE	The DBS is an optional detector.

The Directional Backscattered Detector (DBS) uses either angular (ABS) or concentric (CBS) segmentation of the detector diode. The control and settings of the two variations are the same.

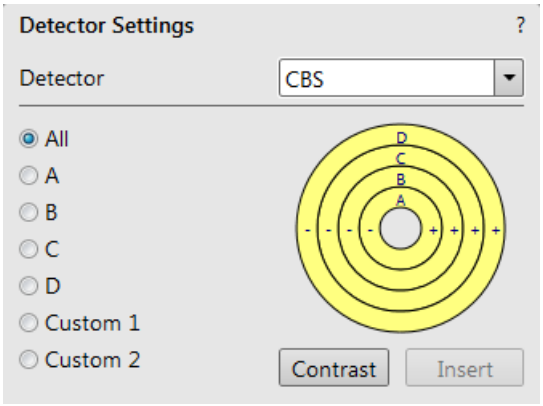
It is mounted on a retractable arm that can be inserted between the lens and the sample and it is parked to the pole piece to reduce vibration.

Figure 5-3 Directional Backscattered Detector

CBS Detector Settings

The CBS distinguishes between BS electrons scattered close to the beam axis – inner segment (preferentially compositional contrast) and electrons scattered far from the beam axis – outer segment (more topography signal).

Click one of the radio buttons to select the required mode: All (all segments), A, B, C, D, or Custom.



Custom mode is used to define the segments to be used for detecting.

- Clicking the **+** over a segment activates it (yellow color).
- Clicking **–** over a segment subtracts its signal (blue color).
- Clicking any sign twice disables the segment (gray color).

The **Contrast** button is accessible only when the CBS detector is selected in several displays. Clicking it sets the brightness and contrast of each display with CBS detector to the same level.

Distribution of electrons collected by detector segments changes with the setting of working distance, lens mode, and Beam Deceleration mode.

It is also possible to set different concentric segments in particular displays and then use the **Enhanced Image** module **> Mix 3** or **Mix 4** tab to mix color coded signals to create color images. (see *"Mix 3 and Mix 4 Tabs" on page 128*).

When the detector is retracted, the information text is shown in each display that uses it.

Inserting and Retracting CBS Detector

The following conditions must be met before inserting the retractable detector:

- Chamber is pumped.
- The stage must be moved to a safe position for inserting the detector. The **Link Z to FWD** feature must be done and the WD must be more than 2.5 mm.
- The GISs (if present) must not be inserted.

If the above conditions are not fulfilled, the **Insert** button is disabled, and a tooltip occurs when the mouse cursor is over a disabled **Insert** button.

The detector will be inserted after the insertion is confirmed and the tilt is locked. The stage X, Y, and R movements have no limitations. The Z-axis movement is limited to 2.5 mm.

Retracting the detector is automatic when the server is stopped or started and when venting the specimen chamber. Otherwise you can use the **Retract** button.

NOTE	Whenever the Quad BSED is selected, the optical display is paused (because the CCD camera infra-red LEDs are switched off not to emit the photons supersaturating the detector diode). The CBS limits the minimum achievable working distance, that is disadvantageous for high resolution imaging.

DBS movement restrictions

Because of the safety reasons the stage movements are strongly restricted when the detector is inserted. For experienced users these restrictions can be loosen by ticking the **No stage restrictions** check box.

This functionality is released on request by the Thermo Fisher Scientific personnel.

WARNING!	From this point on there is no limits when moving the stage. There is a risk of colliding with any hardware equipment within the chamber!

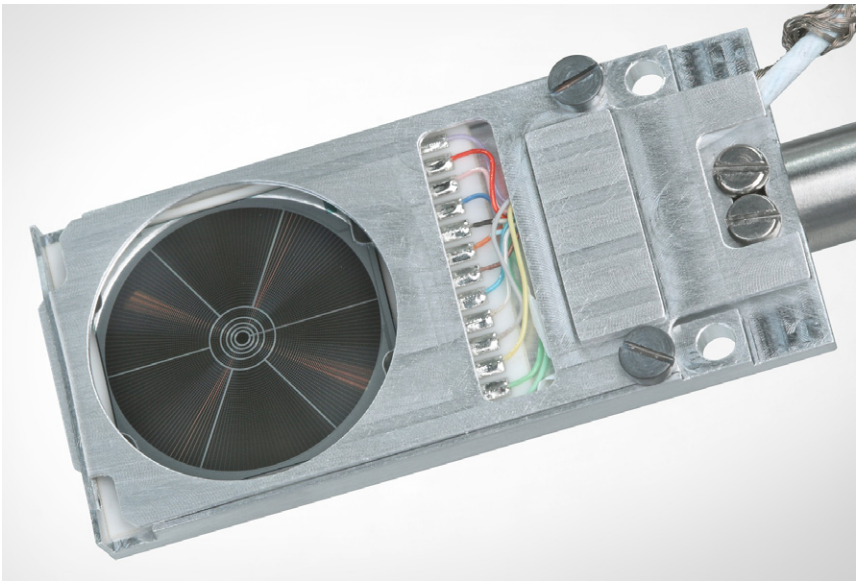
STEM Detector

NOTE	The STEM 3+ detector is an option.

The STEM 3+ (Scanning Transmission Electron Mode) detector is a solid-state design divided into several circular segments. Each segment can be independently selected in the software, allowing imaging under different collection angles. It works best at a slow scan condition.

There are several versions of the STEM detector, differing in geometry and the number of segments. The functionality and control is the same for all of these versions, but the contrast and information obtained can be different.

Figure 5-4 STEM III detector



The STEM 3+ detector is only used with the electron column operation in:

- Mode 1 – used for navigation, with the ETD or TLD.
- Mode 2 – to collect high resolution images once the sample location is found.
- Mode 3 – for collecting XEDS (X-ray Energy Dispersive Spectrometry). To get XEDS mapping, use the STEM BF.

The signals collected by the detector segments are routed through a pre-amplifier, which can process several channels (segments) at once.

The STEM 3+ detector controls are within the Detector Settings module.

The STEM 3+ detector is a retractable device and after insertion remains stationary during stage moves in all axes. The X, Y, Z, and rotation axes of the stage provide sufficient angle of freedom and travel range to position the TEM sample grid at an optimal working distance along the axis of the electron column.

The signals collected by the detector segments are routed through a pre-amplifier mounted on an external wall of the vacuum chamber. The pre-amplifier has one channel dedicated to the Bright Field segment, one channel dedicated to the Dark Field segment, and one channel dedicated to the High Angle Dark Field segments.

Used with a Special Sample Holder

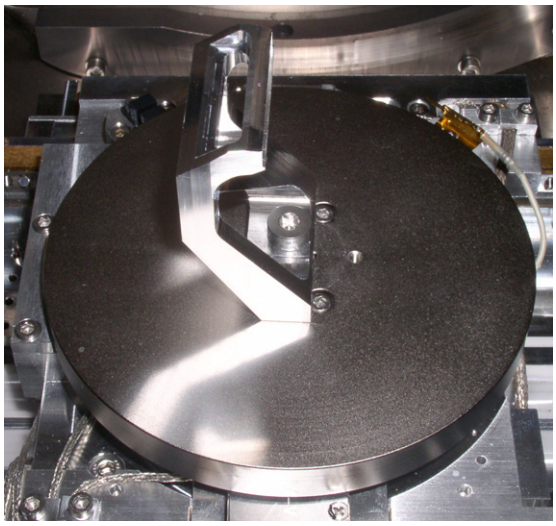
The STEM is mounted on a retractable arm. It must be used only with a special sample holder, oriented in an exact position monitored by the software.

NOTE	When the STEM detector is inserted to the chamber, the stage rotation and the tilt are locked automatically for safety.

Installing the Holder

1. Run the **Home Stage** (**Shift + F3**) procedure.
2. Remove all sample holders from the stage plate.
3. Screw the holder arm to the stage plate.

Figure 5-5 STEM Detector Holder Arm HNL G3 UX



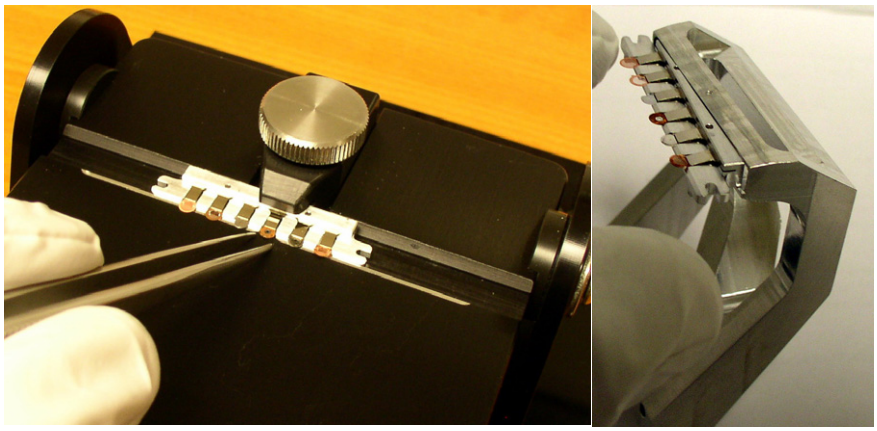
Loading the Sample in a Row Holder

1. Place the row holder on the load base with the load base pin beneath the position you want to load in/out). Tighten the screw knob. The pin lifts up the spring.

   If the pin does not lift up the spring enough to put the sample in, adjust the lifting height by turning the screw.

2. Insert a sample under the row holder spring.
3. Release the screw knob and the entire row holder from the load base.
4. Repeat steps from 1 to 4 to load in/out another sample.
5. Attach the row holder to the arm.

Figure 5-6 Row Holder on Load Base / Row Holder Attachment into Arm

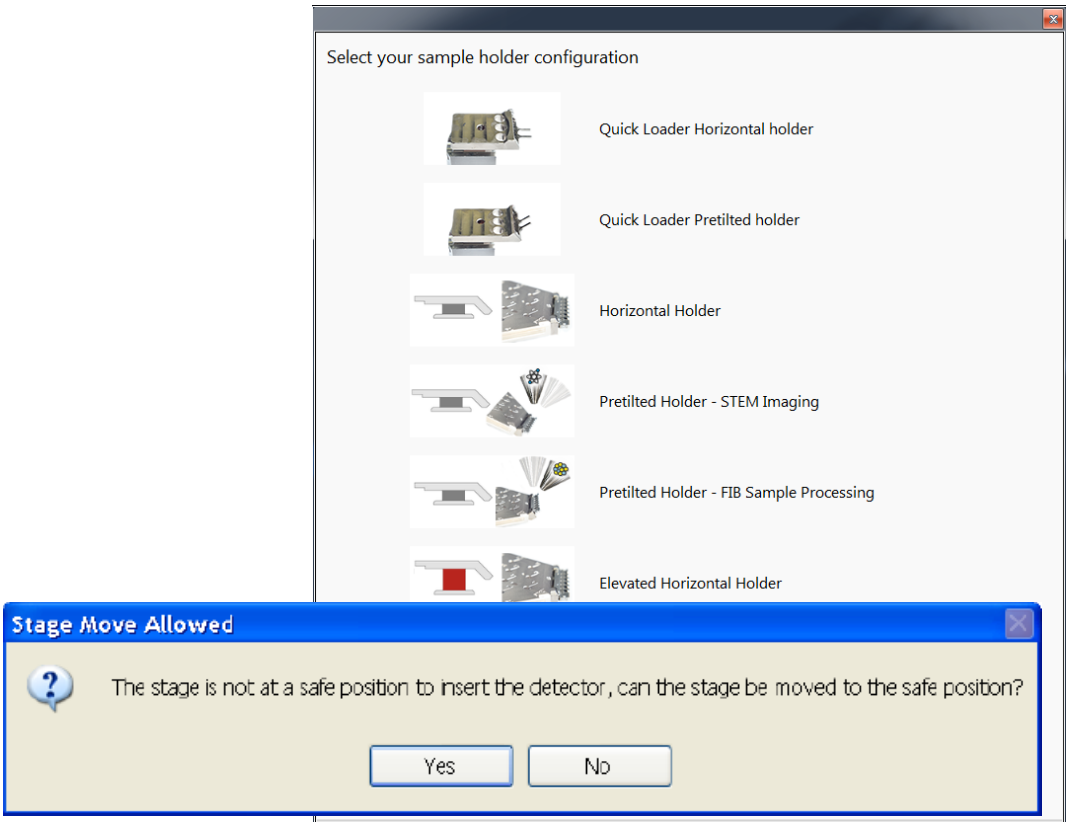


Inserting and Retracting the STEM Detector

CAUTION	Do not perform any stage movement that could cause a collision with the STEM detector and damage it.

Before inserting the retractable STEM detector, the chamber must be pumped, otherwise the **Insert** button on the Detector Settings control is not active (hover the mouse over the button to see a tooltip explaining why the button is inactive).

When clicking **Insert**, a dialog box appears for the correct sample holder selection to enable detector insertion (the dialog appearance depends on the actual system configuration). When the stage is not in a correct position for insertion, another dialog appears requiring a confirmation of moving it to the safe position.



The STEM is automatically retracted when the server is stopped or started or when venting the chamber. Otherwise, click **Retract** to retract it. When the detector is retracted, informational text shows in each display in which it is used.

STEM segmentation

The STEM preset segmentations are available on the **Detector** page / **Detector Settings** module (see *"Detectors Page" on page 122*).

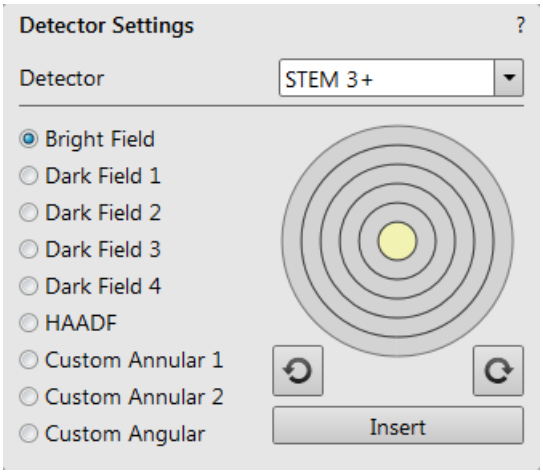
When a preset is selected, the graphic on the module updates and the preset name is appended to STEM on the Detectors menu.

The STEM 4 detector is user configurable by repetitive clicking on any segment, that changes its color with the meaning (for the **Custom** presets):

- **Gray** = disabled
- **Yellow** = enabled
- **Blue** = subtracted (negative) signal: The system takes an image of all of the enabled (yellow) segments and then subtracts the signal acquired from the blue segments.

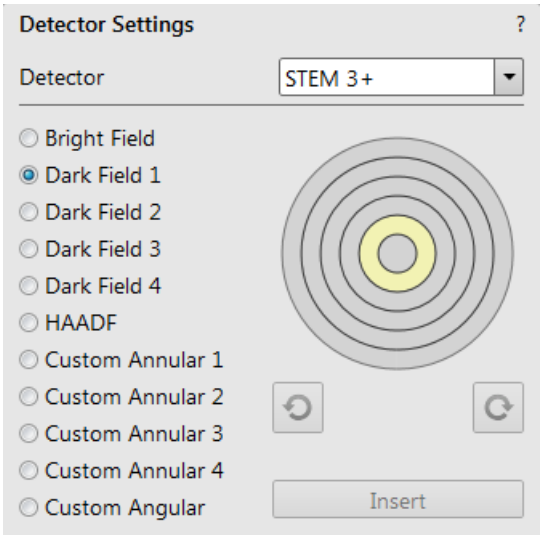
Bright Field Imaging

Bright Field (BF) is a single round segment that collects electrons that exit the sample with the lowest angular range of deflection from the incident electron beam.



Dark Field # imaging

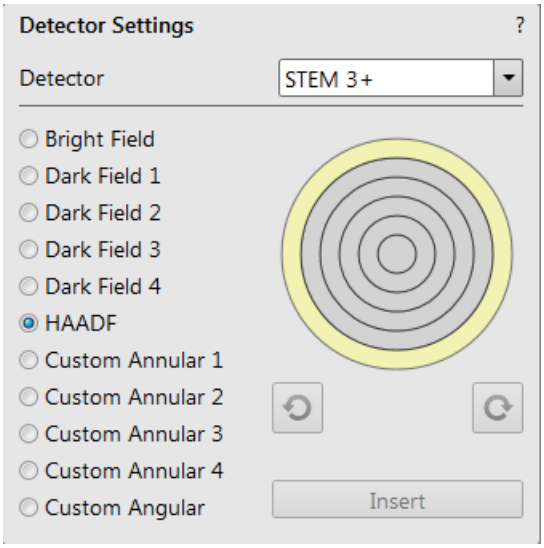
There are four Dark Field (DF) ring-shaped segments, concentric with the Bright Field detector. They collect electrons that exit the sample with a higher angular range of deflection from the incident beam than the Bright Field detector.



High Angle Annular Dark Field

High Angle Annular Dark Field (HAADF) has six segments, represented in the graphic as a single segment. All six segments are turned on and off as a single unit.

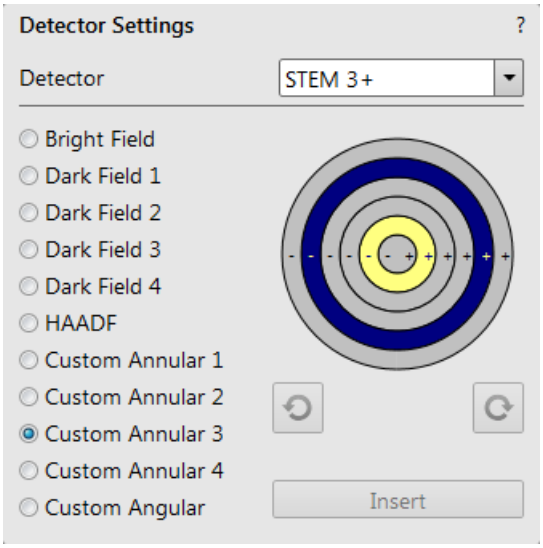
This setting may require higher voltage to create a suitable image as the angle subtended to the detection diode can be wide. Choosing 2× the value used for Bright Field is a good start.



Custom Annular #

Custom Annular # allows you to select any combination of segments to determine the best signal from a specific sample or region of interest within a sample.

- Click the **+** inside a segment on the right side of the circle to enable (yellow) it. Click the enabled (yellow) ring again to disable (gray) it.
- Click the **–** inside an enabled segment on the left side of the circle to subtract (blue) the signal from the image.



Some combinations of pre-defined (BF, DF1..DF4, HAADF) and Custom modes does not allow simultaneous imaging in all four displays.

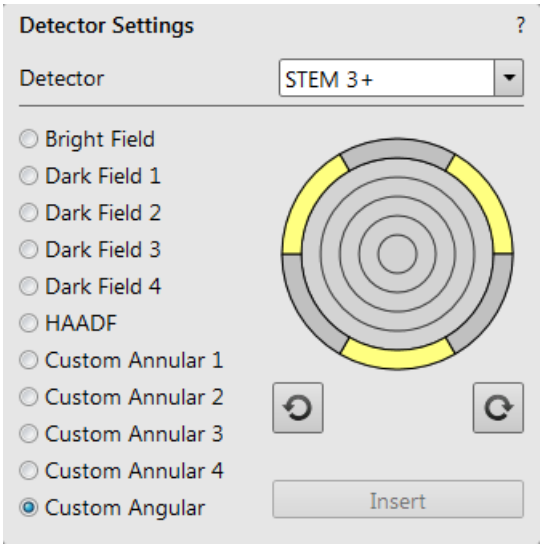
If using more than one STEM signal in multiple displays, the total number of active segments is six. For example, if you are using 4 active segments in display 1, then for simultaneous imaging in the other active displays, you can only select 2 more segments. This is due to the limited number of amplifier channels.

NOTE	Custom Angular was previously called HAADF Partial Imaging.

Custom Angular

Custom Angular allows you to select any combination of the six segments in the outer HAADF ring to determine the best signal from a specific sample or region of interest within a sample.

- Click in a segment to enable / disable / subtract it.
- Click one of the arrow directional buttons to rotate all segments clockwise (CW) or counter clockwise (CCW).



Using the STEM Detector

1. Optimize an imaging using the ETD or TLD detectors (focus, astigmatism correction, an accelerating voltage and a beam current selection, run Link Z to FWD, set contrast and brightness, etc.).
2. Select one of the STEM preset segmentations from the Detector Settings module. See *"STEM segmentation" on page 183*.
3. Insert the STEM and respond to the confirmation dialog box that appears.
4. Select any SEM preset segmentation or set any custom option. Optimize an imaging at low magnification (focus, astigmatism correction, contrast and brightness, etc.).
5. Change the accelerating voltage to suit the contrast necessary through the sample.

   After any accelerating voltage or beam current change repeat steps from 1 to 4.

Optimizing the Image

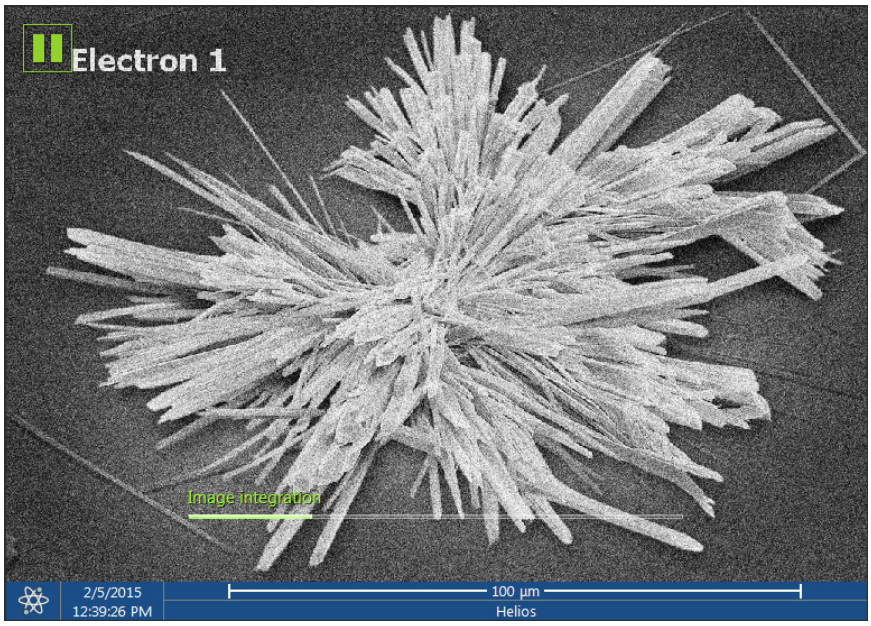
Improve the image by changing scan speeds, contrast/brightness, focusing, stigmating, adjusting beam current, or adjusting magnification.

Scan Speeds and Filtering

To obtain good imaging it is necessary to find a balance between scan speed, charge, sample damage, and signal to noise ratio.

A noisy imaging can be improved by decreasing the scan speed. If charge or sample damage are the limiting factors, it is better to use a faster scan speed in combination with an Average or Integrate filter.

When imaging with integration, the image starts immediately with full grayscale, so you only see a decreasing amount of noise. An acquisition progress bar shows in the active display so you can see the number of frames being integrated.



Contrast and Brightness

The Detector module contains two logarithmic and two linear adjusters that allow you to change contrast and brightness by clicking and dragging the middle slider on the large bar, or the same on the pointer in the small bar.

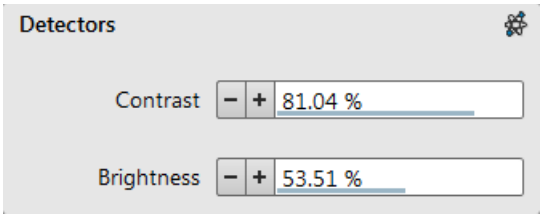


Table 5-1 Contrast and Brightness Operation

Item	Function
Middle slider	For large or small adjustments, depending where you release it. The further from the center that the middle slider is pulled, the larger the change. This is logarithmic.
Gray bar	For larger adjustments, single step increments.
End arrow	For finer adjustments, single step increments.
Small slider	For linear adjustment, continuous.

These adjusters always have a label in the upper left and value in the right corner as a readout value. You can change the Contrast and Brightness by input of the contrast and brightness numbers by double-clicking the readout and typing in the new values.

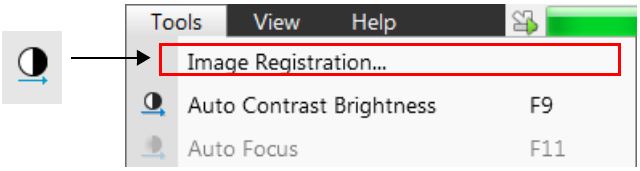
Correcting Contrast and Brightness

The contrast and brightness settings can be set manually either by using the MUI or by adjusting the contrast and brightness controls in the Detector module found on several pages. The following description will work for both methods.

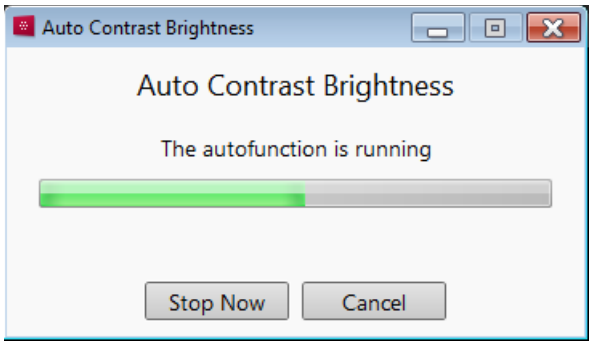
1. Select a medium speed scan in an active display.
2. Reduce the contrast to zero and adjust the brightness to a level so that the last graylevel can be seen, by eye, before the screen goes black.
3. Increase the contrast so that the signal level shows an image.
4. If necessary, adjust the brightness level to improve the image.

Auto Contrast and Brightness

When the beam is unpaused, activate Auto Contrast and Brightness with the toolbar button, from the Tools menu, or click **F9** / **Shift + F9**.



The system will attempt a correction of the contrast and brightness levels to suit the sample so that the majority of graylevels are shown. When activated, a dialog box appears to show the progress of the function.



The function can be interrupted by clicking on the **Stop Now** button. This will leave the image at the stage of progress at stopping. Clicking **Cancel** before the function ends will return the image back to its original status.

Using Videoscope (F3)

The Videoscope shows the video intensity along the currently scanned horizontal line for correcting contrast and brightness. This mode could facilitate contrast and brightness optimization to obtain full grayscale imaging level range.

Three yellow horizontal lines (placed over the display) indicate the following levels:

- White (top line)
- Grey (middle line)
- Black (bottom line)

The oscillogram signal amplitude/central position reflects a contrast/brightness of the just scanned line.

- If the oscillogram is cut by the bottom line, the signal level is clipped in black.
- If the oscillogram is cut by the top line, the signal level is clipped in white.

This should be avoided because the imaging details are lost in the clipped areas.

Tuning the oscillogram exactly between the top and bottom lines for a feature of interest (with the use of the reduced area) results in the full detailed imaging. The signal clipping may be used to obtain harder contrast conditions when more black and white is needed. The signal amplitude lowering decreases the contrast, i.e., the imaging looks softer.

1. Select a slow scan in an active display.
2. Activate the **Videoscope** (**F3** or **Scan > Videoscope**).
3. Reduce the contrast to zero and adjust the brightness level to the lower dashed line (black).
4. Increase the contrast so that the signal level just touches the upper dashed line (white).
5. If necessary, adjust the brightness level once more so that the average signal level is roughly in the middle.
6. The high and low peaks should just touch the dashed lines.

To optimize contrast and brightness, also try using:

- Contrast/Brightness
- Auto Contrast Brightness (**F9** / **Shift + F9**)
- Display Saturation (**Shift + F11**).

Focus

The easiest way to focus is to find a feature of interest on a sample with distinct edges. Use a combination of contrast, brightness, and magnification adjustments to maximize the image quality.

To avoid scanning too long with the ion beam and milling away the sample before you take the final image, move away from the feature of interest with the X and Y stage controls, and focus until the image is sharp on a adjacent area.

Focusing at 2× to 3× the magnification needed for the final result makes the lower magnification sharper. For example, for high resolution output, set the magnification level at 2 000× and focus at 4 000× to 8 000×.

Focusing with the MUI

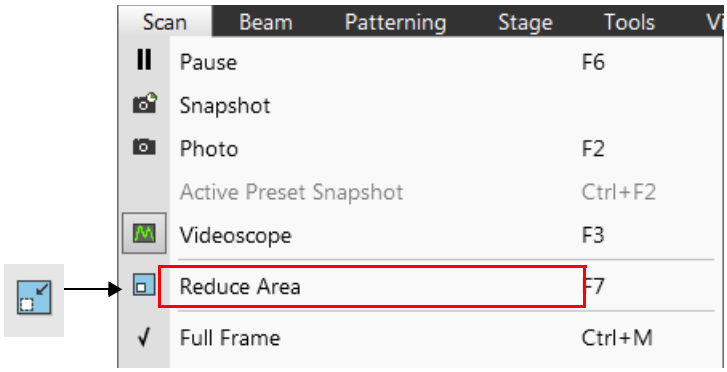
You can also use the MUI **Coarse** and **Fine** focus knobs to focus the image. The image immediately responds to the MUI without a cursor onscreen.

Focusing with the Mouse

1. Hold down the right mouse button while the cursor is in the active display. The 2-ended arrow focus cursor will appear.
2. Move the focus cursor from side-to-side until the image is sharp. When engaged, the focus cursor is active over the whole screen but will not interfere with other controls
3. Move the specimen to a desired area with the X and Y stage controls and refocus until the image is sharp.
4. If this is the first time focusing the new specimen, click the **Z to FWD** toolbar button to confirm focal distance to the Z value on the Navigation page.

Using Reduced Area for Focus

When Reduced Area is chosen, the small green area frame appears in the middle of the screen. This can be used as a focus aid as the scan speed is faster in the smaller area. It can be activated from the Scan menu, the **Reduced Area** toolbar button, or by **F7**.



By default, it will appear in the center of the display or screen.

Moving the Reduced Area

Click and hold the left mouse button in the selected area. The cursor changes to a 4-ended arrow. This will take time, depending on the actual scan speed. Now drag the selected area to the desired position and release the mouse button.

Changing the Size of the Reduced Area

Click and hold the left mouse button at the edge of the selected area. The cursor changes to a 2-ended arrow, either horizontal or vertical. Now drag the selected area out or in to the desired size and release the mouse button.

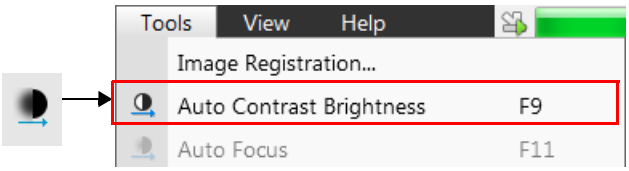
Making a New Reduced Area

Place the cursor outside of the selected area and make sure Get or Track moves are not activated. The cursor should be the normal arrow symbol. Move the cursor to where you want the left upper corner of the selected area to be. Click and drag the cursor until the rectangle onscreen includes the area you want to select. Release the left mouse button.

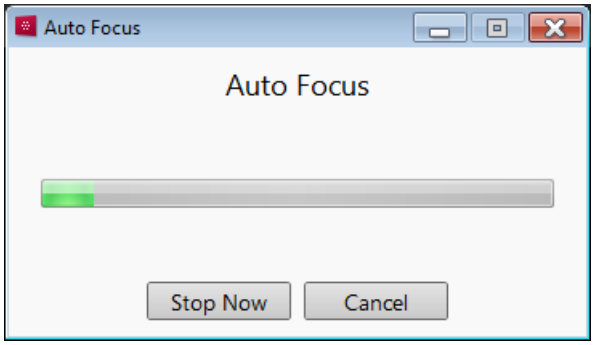
When the Reduced area frame is being manipulated it turns yellow until released, then it reverts to green.

Auto Focus

When the beam is unpaused, activate Auto Focus with the toolbar button, from the Tools menu, or by clicking **F11**.



The system will attempt to correct the focus independent of the working distance or focus set. When activated, a dialog box appears to show the progress of the function.



The function can be interrupted by clicking **Stop Now**. This will leave the image at the stage of progress at stopping. Clicking **Cancel** before the function ends will return the image back to its original status.

Astigmatism

Astigmatism is an optical aberration is caused by different focal lengths for rays of various orientation, resulting in a directional imaging blur (X and Y rays are not focused to the same plane on the edges).

Correct astigmatism whenever you change the imaging conditions.

Stigmating with the Mouse

It is necessary to correct astigmatism of the image (also known as "stigmate") when you change apertures, samples, or working distance. Astigmatism in the image is usually only visible at higher magnifications (3000× or more). If astigmatism is present, the result is a directional distortion change of 90° between the two out-of-focus conditions.

1. Focus the image as well as possible using the mouse.
2. Bring the image just slightly out of focus in one direction to see any astigmatic distortion.
3. Defocus in the other direction to observe a different astigmatic distortion.
4. Bring the focus to the midpoint between the two distortions.

5. Go to the **Stigmator 2D** control on the Beam module of the Beam Control page. **Shift** + **right-click** while in the active display. This will result in a 4-ended arrow cursor appearing at the center of the screen. Still holding the right mouse button down, drag the center of the cross around the screen to achieve astigmatism correction (when the image is at its sharpest).
6. When you are satisfied with the image, release the right mouse button.
7. If astigmatism is severe and the cross is close to the edge of the screen when nearing correction, release the right mouse button, and reposition the cross in the center of the screen.

Repeat this procedure to perform further astigmatism correction.

Stigmating with the MUI

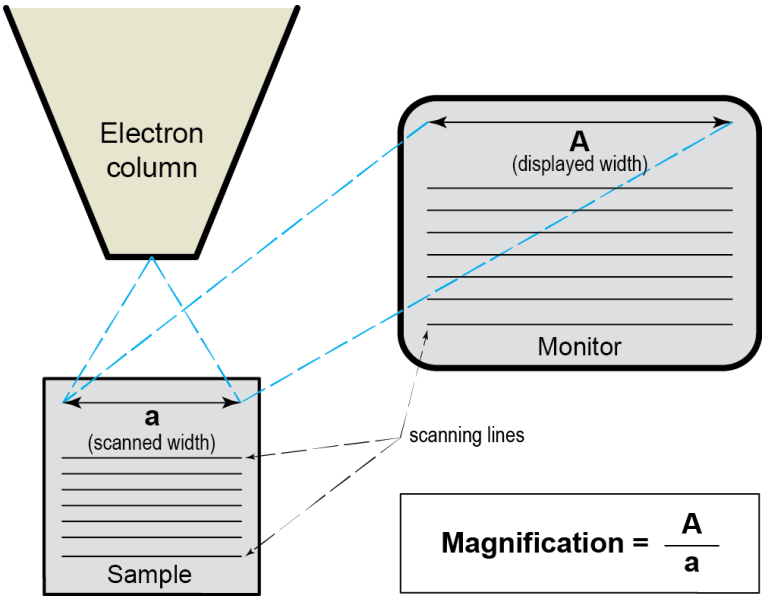
1. Using the MUI **focus** knobs, bring the image just slightly out of focus in one direction to see any astigmatic distortion.
2. Defocus in the other direction to observe a different astigmatic distortion.
3. Bring the focus to the midpoint between the two distortions.

4. Adjust image sharpness with the **Stigmator X** and **Y** knobs until the best image is achieved. The computer beeps when the stigmation limits are reached.
5. Repeat steps 1-4 as necessary.
6. If astigmatism is severe and the cross is close to the edge of the screen when nearing correction, release the mouse and reposition the cross in the center of the screen. Then repeat the procedure above to perform further astigmatism correction. You can use reduced area advantageously.
7. If astigmatism cannot be corrected, there may be some other reason, usually a dirty aperture, the magnification may be too high for the beam spot size, or the sample is charging (apply conductive layer).

Magnification

Magnification is the ratio of the viewing area on the monitor screen to the scanned area on the sample.

Figure 5-7 Magnification definition



If the size of the raster on the sample is made smaller while the raster on the monitor remains constant in size, the magnification of the image increases.

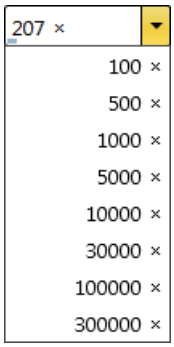
- At low magnification, you see a large field of view.
- At medium magnification, you see a portion of the original scanned area.
- At high magnification, you are zoomed in on only a small portion of the original total scanned area.

Changing Magnification

Toolbar List Box

Use the magnification settings from the toolbar dropdown list box to select from predefined values. If the current value is in the list, it is indicated with a colored background.

1. Click on the toolbar list box to see the list of available magnifications.



2. Click on the required magnification and it appears in the text box, and the dropdown list automatically closes. This can be done while the beam for the column is on, in which case the change is immediate.
3. Enter a magnification value in the text box and then click **Enter** on the keyboard to replace the nearest magnification value in the list with the new one. It also becomes the current magnification value.

Keypad +/- Keys

You can also use the keypad **+/-** keys to change magnification.

- Plus (**+**) increases the magnification 2×,
- Minus (**–**) button decreases the magnification 0.5×.

Selecting a different magnification results in a change of magnification onscreen during live imaging.

Using the Mouse Wheel

You can also use the mouse wheel for changing magnification. Moving the wheel up decreases magnification and moving it down increases magnification. Coarse and fine control can be operated by the **Ctrl** or **Shift** keys.

Table 5-1 Mouse Wheel Magnification

Key	Function
Wheel up + Ctrl	Decreases magnification; coarse control
Wheel up + Shift	Decreases magnification; fine control
Wheel down + Ctrl	Increases magnification; coarse control
Wheel down + Shift	Increases magnification; fine control

Using Selected Area Zoom In/Out

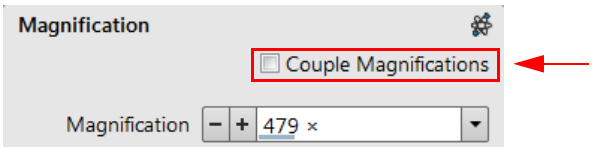
- **Zoom In:** Click and drag a selected area from **upper left to lower right** (the cursor changes to a magnifying glass with a + sign) to zoom in magnification to fill the imaging area with the selection (selectable in Preferences).
- **Zoom Out**: Click and drag a selected area from l**ower right to upper left** (the cursor changes to a magnifying glass with a – sign) to zoom out magnification to fill the imaging area with the selection (selectable in Preferences).
- Click **Escape** to cancel the operation at any time.

Magnification Normalized

The asterisk (*) key on the keyboard can be use to round off the magnification value before storing the image in case the value is odd, e.g., 10 063× would become 10 000×. The condition also takes into account the image size by zooming and the micron bar scaling.

Coupling Magnification

The Magnification module gives access to coupling the magnification of both beams at a particular magnification. The magnification is set with the slider and then locked by ticking the **Couple Magnifications** check box. The active beam icon is shown at the right side of the module.



Direct Adjustments

Use the Direct Adjustments feature for fine-tuning of the beam geometry to achieve the best focus and brightness. It is available from the Direct adjustments page (see *"Direct adjustments page" on page 134*).

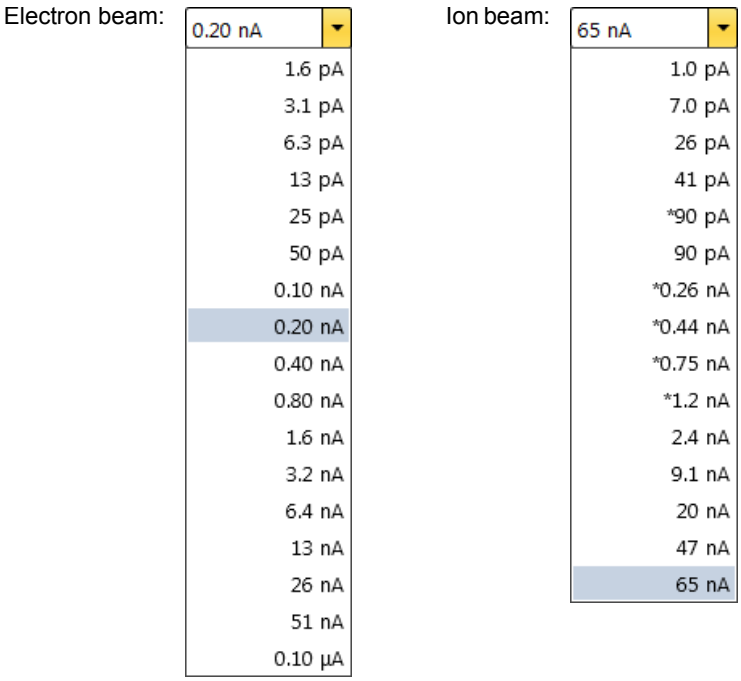
Selecting Beam Conditions

High Voltage and Beam Current

High voltage (HV) and beam current choices are shown for the active beam in the editable dropdown list boxes on the toolbar.

- For the electron beam, high voltage and beam current are independent, so any change of voltage will not result in a change of beam current.
- For the ion beam, the beam current available is dependent on the high voltage, for example at 30 kV the beam current is 100 pA, however, the beam current reduces to 13 pA when the high voltage is set to 2 kV, even when the aperture position is the same.

Figure 5-8 Beam Current Values



Changing High Voltage

Click on the text box to show the list of voltages. Click on the required voltage and it will appear in the text box. The dropdown list will automatically close. If the beam is on, the change will be immediate.

Default values are set within the **Preferences** dialog / **Presets** section (see *"Presets Section" on page 140*). Use the High Voltage slider on the Beam page to select other values.

Changing Beam Current

Click on the dropdown arrow to the right of the text box to show the list of currents. Click on the required current and it will appear in the text box. The dropdown list will automatically close. If the beam is on, the change will be immediate.

- For the electron beam, deciding which beam current is correct for a particular magnification can be determined when you achieve good focus and astigmatism correction easily at the chosen magnification.
- For the ion beam, choosing the correct beam current use is determined by the application.

Ion Beam Apertures

In general, use a smaller aperture for high resolution and a larger one for faster milling.

For a complete alignment procedure for ion beam apertures, refer to *"I-column: Aperture Lifetime" on page 343* and *"I-column: Alignments" on page 344*.

Optimal Ion Beam Currents

Use the following suggestions for choosing optimal ion beam currents.

Table 5-1 General Optimal Ion Beam Currents

Beam Current	Best Use
1.5 – 9.7 pA	High resolution
28 – 48 pA	Standard imaging
>93 pA	Milling

Ion Beam Diameters

The ion beam diameter depends on its current (for the default aperture strip). For more specific applications, see the table below.

Table 5-2 Specific Optimal Ion Beam Currents

Beam Current	Best Use
1.1 pA	• Very high-resolution imaging • High aspect ratio holes • High-resolution imaging • Pt via filling
7.7 pA	• Quick imaging • Fast Pt via filling
24 pA, 40 pA	• Navigation imaging • Milling submicron holes • Final milling on cross sections
80 pA	• Milling micron-sized holes • Intermediate/final milling on cross sections • Short Pt strap deposition
0.23 nA, 0.43 nA	• Milling micron sized holes • Medium Pt strap deposition • Intermediate milling on cross sections
0.79 nA	• Initial milling for small cross sections • Long Pt strap deposition
2.5 nA	• Initial milling for medium cross sections • Longer Pt strap deposition
9.3 nA	• Initial milling for medium-large cross sections • Pt probe pad deposition (40 µm × 40 µm)
21 nA	• Initial milling for large cross sections • Pt bond pad deposition (50 µm × 50 µm)

SEM Imaging Modes

The electron column can be operated in three different final lens modes and in the Beam Deceleration mode.

Final Lens Modes

Use the toolbar buttons or **Beam > SEM Mode** to switch between modes.

Mode 1: Field-Free

This is the default survey mode. This mode is essentially for navigating and reviewing sites at lower magnifications. In Mode 1, the immersion lens is switched off and the default detector is the ETD/TLD in Secondary Electron operation.

For navigation, use the Mode 1 with the TLD detector. Once the sample location is found, switch to Mode 2 to collect final results.

Mode 2: Immersion (UHR)

In this mode the immersion lens is switched on, and the default detector is the TLD in Secondary Electron operation. This mode is used to form ultrahigh resolution electron images of the sample.

Use Mode 2 with the STEM detector in order to obtain high resolution images.

If ion beam imaging is selected in Mode 2, the final lens is switched off to allow ion beam imaging to take place with the last selected ion beam detector.

Selecting Mode 2 also has its own Beam menu presets.

Lens Mode Switching

You can immediately switch from Mode 1 to Mode 2 if other conditions such as stage bias and working distances are within the normal operating range. If the system is at a magnification that is too small, the system will automatically switch to the lowest possible magnification in Mode 2 operation.

Mode 3: EDX

Mode 3 is used for analytical work, such as EDX, where the immersion lens is not so powerful as Mode 2 but can act as a electron trap for backscattered electrons to improve X-ray collection.

Mode 3 is used for collecting XEDS (X-ray energy dispersive spectrometry). To get XEDS mapping, use the STEM BF with Mode 3.

This mode can be used with the ion or electron beam. Selecting Mode 3 also has its own Beam menu presets.

NOTE	If the EDX mode is not accessible (greyed), try to change a magnification so that the HFW < 600 µm.

Electron Source Modes

UC mode is available only for the Helios G4 PFIB UX.

UC On

Select **Beam > UC On** to turn on this mode.

- When UC On is selected: The UC mode maximum HV is 5 kV and maximum beam current is 100 pA. Electrons are supplied with the energy spread less than 0.2 eV, which improves image quality at low HV and low beam currents.
- When UC On is not selected: The Normal mode full system HV and beam current range is available.

UC Auto

Selecting **Beam > UC Auto** switches UC mode on automatically, when HV and beam current values are in the allowed range.

Beam Deceleration Mode

The Beam Deceleration mode (BDM) is an option for some systems.

The Beam Deceleration mode (BDM) is based on a negative voltage stage bias applied to a stage (i.e., a sample). An electrical field between the sample and the nearest surface over (a column bottom or a detector) is formed, acting as the additional electrostatic lens.

Detection Principles

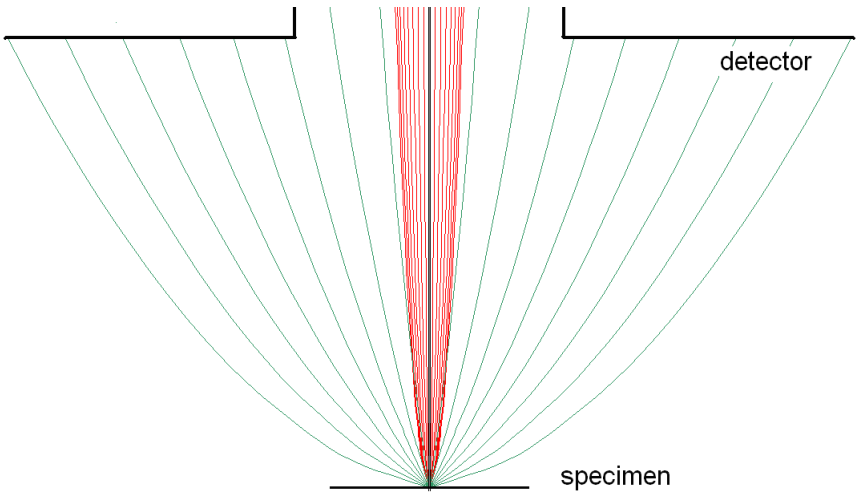
The Beam Deceleration influences both primary and signal electrons. As the sample is at the negative potential according to the ground and detectors, the initial SE and BSE energy (when leaving the surface) is accelerated by the stage bias before the detection. The higher the immersion ratio, the lower the difference between SE and BSE energies when detected. Its power is described by the immersion ratio (imRatio) parameter:

imRatio = (HV + bias) / HV

Signal electrons are accelerated upward and deflected toward the column axis. The SE have a low initial speed and they are usually absorbed into the detector central hole, equally like the BSE heading upright. Conversely, the BSE heading nearly parallel to a surface (which normally cannot be detected) are driven to a detector.

By changing the stage bias, an output angle distribution of electrons leaving a surface could be obtained.

Figure 5-9 Typical Trajectories of Secondary (Red) and Backscattered (Green) Electrons



Detectors most convenient for beam deceleration are BSE types placed closely under or directly inside the column. Their efficiency depends on their active area: the smaller the active area's inner diameter the better. The standard ETD could also be used, but its efficiency is low.

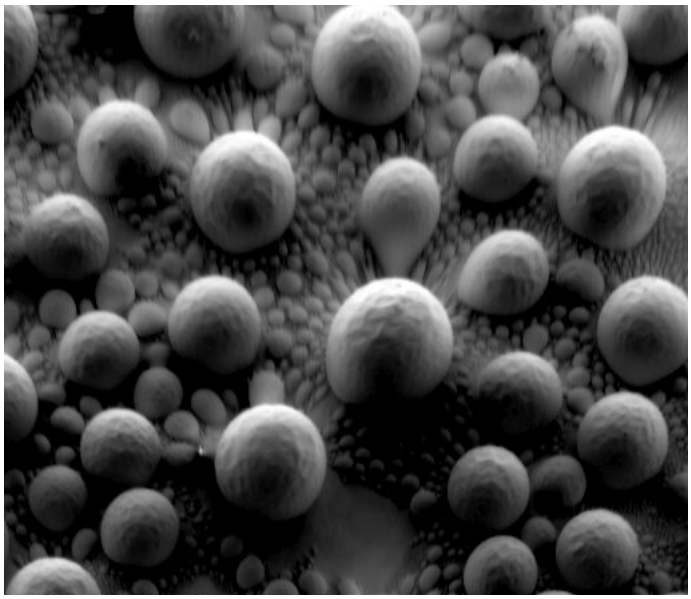
Beam Deceleration Applications

- The BDM enables detection of the BSE when the electron energy is under the detection limit of the detector.
- The BDM expands the electron energy range under the minimum HV limit.
- The BDM improves the microscope resolution at low accelerating voltages. A conventional microscope resolution is limited by a chromatic aberration at low electron energies. The higher is the immersion ratio, the smaller the aberrations, and a loss of resolution at low electron energies is well compensated.
- The BDM enables the detection of electrons heading nearly parallel to a surface which accentuates a surface roughness.

Application Restrictions

Sample tilt causes an electrical field deformation, which adds aberrations (a chromatic aberration and an image distortion) that ar not correctable. An acceptable sample tilt is a few degrees, and less for higher immersion ratios.

Figure 5-10 Signal Distortion and Image Aberrations for Tilted and Rough Sample (Tin Balls) at High Immersion Ratio



Beam deceleration and EasyLift

- If Beam deceleration mode is active (Stage bias turned **On**), EasyLift **can not** be inserted.
- If EasyLift is inserted, Beam deceleration mode (Stage Bias) **can not** be enabled.

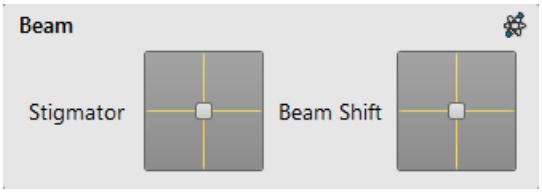
Beam deceleration mode imaging procedure

1. Put the sample into the chamber and pump.

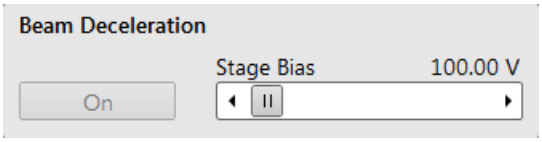
   In the BDM a sample becomes the electrode. Its position, size, tilt, and surface roughness influence an imaging quality. At optimal conditions the sample should be symmetrical, planar, have a size comparable with the detector size, and placed perpendicular to the column axis. In other conditions a distortion, an astigmatism and a blurring caused by the chromatic aberration appear. This is even worse when the immersion ratio is higher.

CAUTION	Because of the proximity of the stage and column, electrical breakdown can occur, resulting in damage to the system and/or the sample.

2. Select the suitable HV and find an area of interest. Set the eucentric position and tune with the **Beam menu > Lens Alignment** and the **Beam Control page > Beam module/Stigmator 2D control** (*"Beam Module" on page 107*).



3. In various displays select the SE and BSE to observe different imaging simultaneously.
4. Click **On** in the Beam Deceleration module (*"Beam Deceleration Module" on page 109*) and gradually raise the stage bias, The SE/BSE image is getting dark/light.



At low magnifications, an ETD image should become dark symmetrically around the window center; in other cases, the sample could be tilted. When a dark area is shifted with a stage bias change, the sample is possibly not parallel with the detector. Use compucentric stage rotation/stage tilt to keep the dark are in the center of the screen.

NOTE	An image shift when changing the stage bias could be caused by imaging near the sample edge or any other edge.

NOTE	When the retractable vCD detector is inserted, stage tilt is restricted via the UI. Override it by manual control to keep the dark rea in the center of the screen.

5. Set the stage bias considering the sample material (charging compensation, material contrast) and to optimize the signal. Set brightness, contrast, and WD according to the requirement.
6. Tune using the **Beam menu > Lens Alignment** and the **Beam Control page > Beam module > Stigmator 2D control** (both of which remember the HV and Stage Bias last used).
7. Repeat steps 4 and 5 to achieve the best result.

Capturing and Handling a Single Image

Good Quality Image Conditions

After obtaining a good quality image, pause or save it using **File > Save** (see *"File Menu" on page 53*).

Conditions for a good quality image:

- Select a Slow scan speed (longer dwell time) of the beam.
- Select a pixel resolution from the drop down list box to suit the detail in the image, i.e., no tearing pixilated edges.
- Increase the magnification at least 2× above the desired value, focus and correct the astigmatism (using the reduced area), then return the magnification back.
- Use the Videoscope to set the Contrast and Brightness accurately, otherwise use the Auto Contrast Brightness procedure.
- Use Pause, Snapshot, Photo, Active Preset Snapshot, or filtering functions.

Image Types

A computer perceives an image as a two-dimensional array of numbers—*bitmap*. Each array element is called a *pixel* and is represented as an integer value. Frequently, the pixel is represented as an unsigned 8-bit integer in the range 0 to 255, with 0 corresponding to black and 255 corresponding to white and shades of gray distributed over the middle values. A 16-bit representation produces up to 65,536 different shades of gray (it is not possible to distinguish on-screen), which may be crucial for obtaining accurate data in analysis.

The raw scanned image is always a grayscale bitmap. You can add colors digitally as a result of particular features. The UI is able to show and save images with a various bit depth:

- The Grayscale 8 bit image offers 256 levels of gray. Live and Integrated images are scanned as 8 bit ones.
- The Grayscale 16 bit image offers 65,536 levels of gray. Averaged and Integrated images are scanned as 16 bit ones.
- For the Mix display images, choose between the 8 or 16 bit mode.
- The Color 24 bit image offers 256 levels of each primary color: red, green, and blue.
  Digital colors coming from the Display Saturation feature in the Image Enhancement module > Color tab, or from the Mix display with color mode, set changes and image bit depth so

there is no way to save it without them. When you want to obtain the image without these color enhancements, you must turn off the respective UI functions.

You can save an image with or without colored digital overlaid graphics (Measurement and Annotation) (see the respective check box in the Save As dialogue). Other types of overlaid graphics over an image are never saved (icons, controls, etc.).

Digital File Formats

The captured image can be saved in various digital formats, depending on the resulting color and bit depth needed. Generally, there is no reason to save an image with a higher bit and color depth than available in an original one. Saving an image with a lower bit and color depth than available leads to the loss of information.

- **TIF 8 or 16 bit**: Grayscale image type
- **TIF Color 24 bit**: Color image type TIF file contains active processing information that could be utilized for a databar setting (see Preferences > Databar section).
- **JPG 8 or 24 bit**: A compressed file format employing a lossy compression algorithm resulting in a small file size with a little loss of information, depending on the particular image appearance and the compression level (factory preset to 80%). The 8 bit depth is automatically selected when saving a grayscale image file. The 24 bit depth is automatically selected when saving a color image file.
- **BMP 8 or 24 bit**: An uncompressed file format. The 8 bit depth is automatically selected when saving a grayscale image file. The 24 bit depth is automatically selected when saving a color image file.

Taking Photo / Snapshot

Click the **Photo / Snapshot** toolbar icon to take a photo / snapshot. The result depends on the selections made in the **Scan** menu / **Preferences** dialog box / **Scanning** section, or from the menu induced by right-clicking above the **Photo / Snapshot** toolbar icon and selecting the **Edit** item.

Slower scan rates are most generally used with the photo image capture method.

Preferences setup

1. Make the destination of the to-be-saved files available to the save routine in the File menu by opening a folder and saving a test file to it.
2. Select **Scan > Preferences > Scanning** item. Select the Photo / Snapshot scan preset from the dropdown list at the top of the property editor (see Chapter 4, Preferences)
3. Select a suitable dwell time by dragging the **Photo / Snapshot** icon to the required value, or by selecting from the Dwell Time property editor of the Scan Presets. If dragging the icon, the new values update in the property editor as soon as the mouse button is released.
4. Select a pixel resolution from the Resolution property editor.
5. Enter the number of frames in the Integrate property editor.
6. Select the Action property for either Save, Save As, or None.

Using Photo / Snapshot

Whenever an image is required, click on **Snapshot** to activate preset scan setting that pauses at the end of the scan time. The result can be just for viewing to verify against the patterning condition, or for saving.

1. Select a display to take a snapshot with the beam that is selected in that display.
2. Set the required magnification.
3. Increase the magnification at least 2×.
4. Focus and correct an astigmatism using Reduced Area.
5. Return the magnification and scan to their original settings.
6. Set contrast and brightness correctly.
7. 
   Click toolbar **Photo** icon or press **F2** to take a preset high quality, high resolution image.
   or
   Click toolbar **Snapshot** icon or **F4** / **Ctrl + F4** for electron / ion beam snapshot.
8. Save the image.
9. 
   Release the scan by clicking once on the **Pause** toolbar icon (or press the **F6** key).

Saving & Opening Single Images

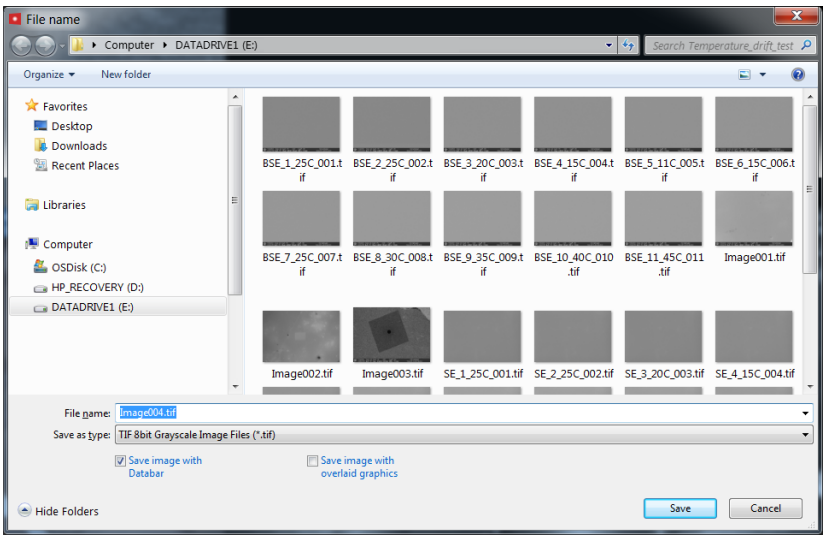
Save

Use the Save function to save and update the original stored image. This is a direct command without confirmation if the label remains the same. This is usually required for a restored image from the archive. Select **File > Save** and the file is saved automatically to its existing label and the original file is overwritten. The function also operates by pressing **Ctrl + S**.

The Save method is also employed by the Snapshot and Photo functions under the Action option, but the image capture routine increments the label and, therefore, adds to the listed images instead of overwriting the last image. The image is given the last known label, including a number that is incremental with successive images, e.g., *Label_001.tif*, *Label_002.tif*, etc.

Save As

Selecting **File > Save As** opens a dialog for saving an image with a new filename and location. The Save As method is also employed by Snapshot and Photo under the Action option, but the image capture routine prompts the Save As dialog.

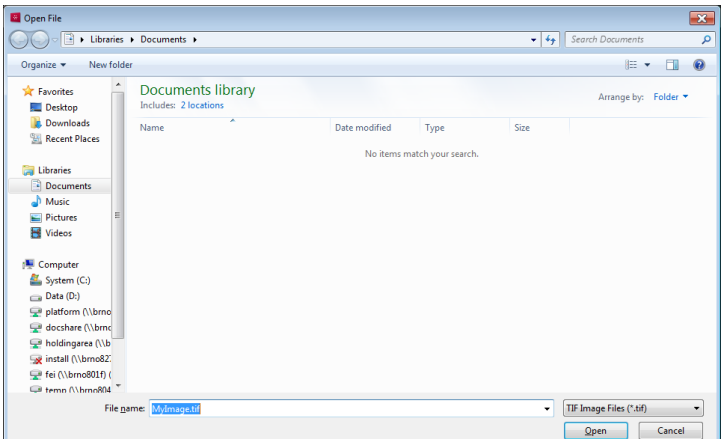


The dialog shows, by default, the location last used to save or open files and the name last used in the current display. You can choose a different location and/or name, select a different image format, and also choose whether to save the image with/without the databar and with/without overlaid graphics by ticking appropriate check boxes. The settings are remembered per display and are used for the subsequent Save actions.

An image can be saved in TIF (8-, 16-, and 24-bit color depth), JPG, or BMP formats. Overlaid graphics can be written into the image either in grayscale (8- or 16-bit) or in color (24-bit).

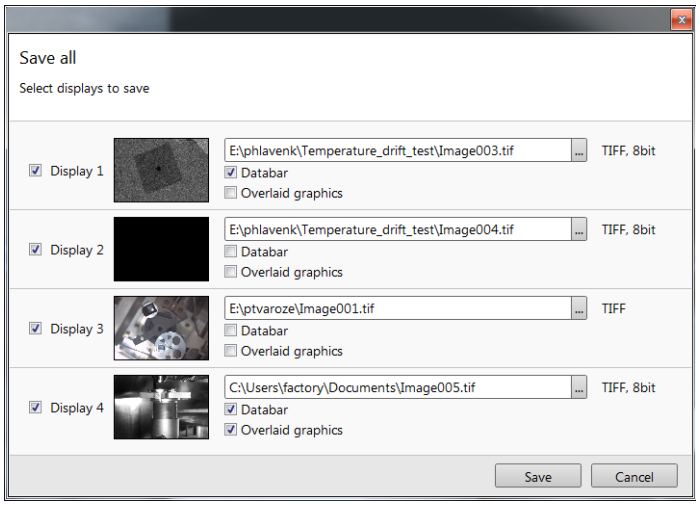
Open

Preselect the display for the image to open in and then select the image from the Open function. Selecting **File > Open** shows a dialog box for opening an image to a particular display. The dialog box shows, by default, the last used location of saved files associated with the imaging function, e.g., the image file location used by Snapshot or Photo. After making your image selection, click **Open** to open the image to the display that has been selected. Images can be opened in any combination of displays.



Saving Multiple Photos

Selecting **File > Save All** opens a dialog box for selecting displays and file names for saving multiple photos.



Tick the check boxes for the images in the displays that you want to save. Browse to a location and choose a name and file format for each image. Click **OK** to save.

Printing an Image

Select **File > Print** to open the Print Setup dialog to select a printer and set up conditions for printing an image or any other printable product from the microscope. Print will only be highlighted when the active display is on Pause.

To print an image:

1. Select a display and optimize the image conditions in that display.
2. Photo the image or open an existing image from memory into the display.
3. Select **File > Print** or press **Ctrl + P**. The Print Setup dialog box appears.
4. Verify the print setup and click **OK.**

NOTE	For higher resolutions, the printer may need a larger memory buffer.

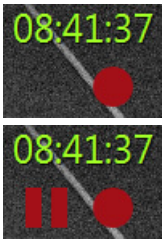
Recording Movies (Multiple Image Capture)

Image Capture with Record Movie

You can make digital video files (AVI) for dynamic experiments performed within the microscope. All displays can be recorded at the same time with synchronized start and the possibility of switching between display and full screen while the video is recording. Record Movie has the following embedded features:

- Resolution at 512 × 422 or 1024 × 884
- Databar image optionally included in the video
- Average or integration changeable during recording
- Scan speed changeable during recording
- Reduced area pauses display for focus or contrast and brightness changes
- Time remaining indicator
- Single frame TIF images recordable during video sequence
- File format compressed AVI (*.*avi*)
- Start, stop, and pause onscreen indicators
- Preferences setup dialog

Display Indicators



A red dot indicates that recording is active in this display. It is shown in the top right hand corner below the timer.

A red ball with the Pause symbol indicates that recording is active, but the data from this display is not stored. It is shown in the top right hand corner below the timer.

An estimation of the time remaining until the end of the video is shown in the upper right corner in the format *hh:mm:ss*. The time is calculated from the average disk space consumption and the free space on the disk.

Understanding Start, Stop, and Pause

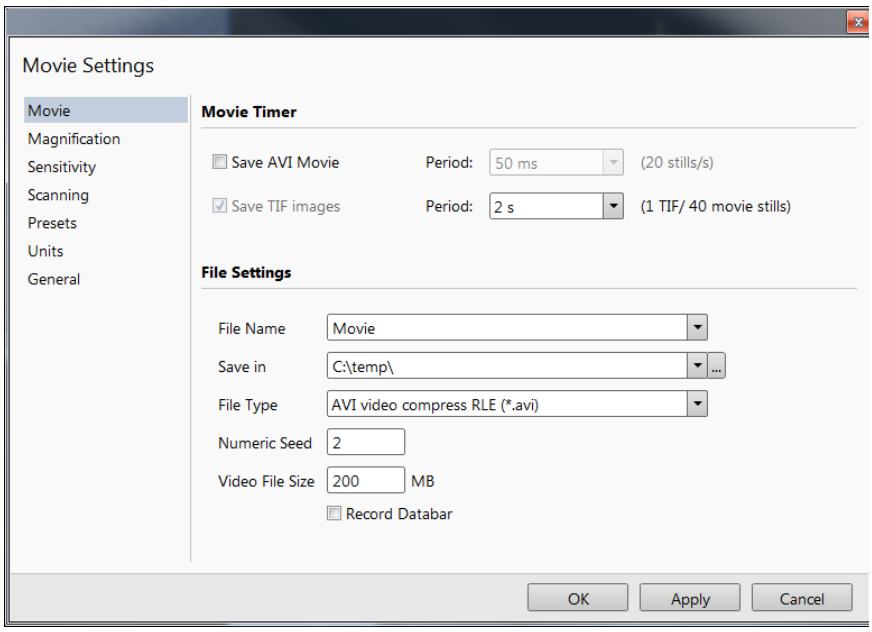
The red dot is the start command button that starts the recording videos, one for each of the image displays at the same moment.

If a display is paused when starting the video, only the first image with a time stamp is stored. When the display is paused during the video recording, storing of the video frames is interrupted, but the video streams keep synchronization for the next unpausing. After reaching the maximum file size, the video is paused, saved, and a new video is started with the same name and incremented numeric seed.

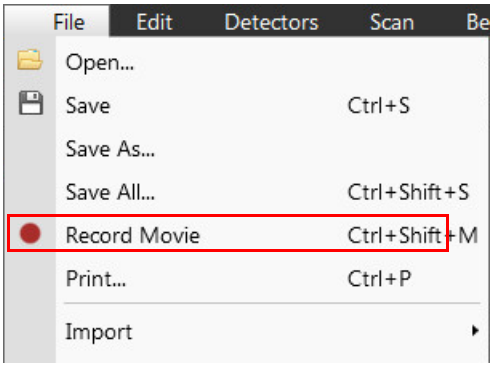
When the red dot, representing Start, is clicked, it turns to a black square, representing Stop. When clicked, the black square then stops the recording of the video of all three displays and closes the files.

Recording a Movie

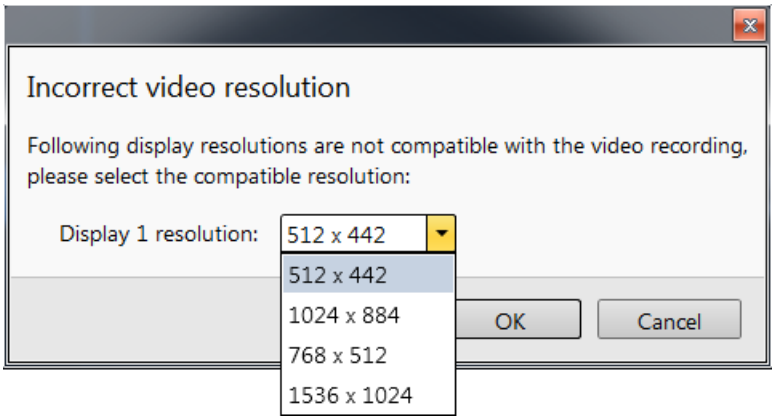
1. Select **Scan > Preferences**. When the Preferences dialog box opens, select the Movie tab.



2. In the **Movie Timer** section, tick the **Save AVI Movie** check box and select the desired time from the **Period** dropdown menu. Tick the **Save TIF images** check box, if required, and then a desired **Period**.
3. In the **File Settings** section, enter the **File Name** and give the **Save in** directory path and the **File Type**. Enter the **Numeric Seed** value and the **Video File Size**. Select the **File Type** and choose whether or not to **Record Databar** by ticking the check box.
4. Click the **Apply** button to temporarily change to the new values or **OK** to permanently fix the values entered. (**Cancel** returns to the original values.)
5. Choose which displays will not be active during recording by selecting the displays and clicking the toolbar **Pause** button. This applies only to displays 1–3.
6. Set up imaging in the live display and select **File > Record Movie** or click the **Record Movie** toolbar button (the button turns into a black square). The first frame with a time stamp on all displays is recorded. The recording then starts; the duration is dependant on the setup in the Preferences dialog.



7. When the video starts and the scan resolution is higher than 1024, the following dialog appears:



8. Choose either of the resolution values and click **OK**. The movie will continue to record at the selected resolution.
9. The movie stops when the black square **Record Movie** button is clicked on the toolbar. The stop command stops recording the video on up to all three displays and closes the files.

Making a Movie with Movie Creator

The Movie Creator is a separate executable software application used to create a movie from a sequence of TIF images.

To activate it, go to *C:\Program Files\fei\exe\Moviecreator2.exe*. The Movie Creator dialog box opens.

File Tab

The File tab contains the setup facilities for creating a movie from a captured sequence of TIF images made while using the Movie function.

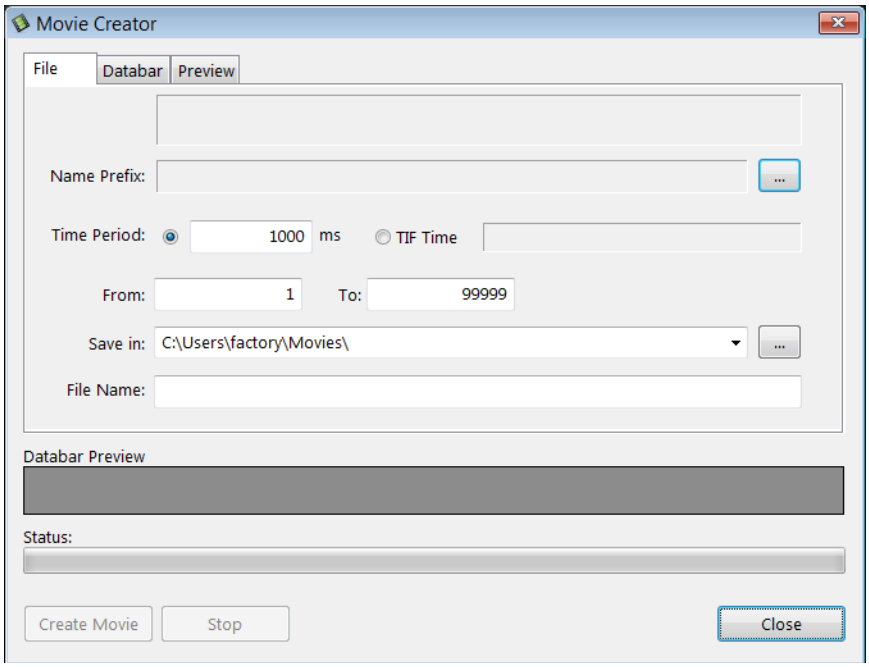


Table 5-1 Movie Creator—File Tab Overview (1 of 2)

Menu Item	Description
Name Prefix	Shows the prefix label for the sequence of TIF images. Click on the dotted button to the right of the dialog box to browse directories and files for the TIF sequence prefix.
Time Period	Provides two choices for selecting a time period: the **millisecond** radio button or the **TIF Time** radio button. To find the best custom timing, you may need to create the movie a few times.
ms	When selected, sets a custom time for playback of the movie.
TIF Time	When selected, sets real time (acquisition = playback)
From/To	Enter the numbers of the starting frame and the ending frame. These represent the sequence beginning to end.

Table 5-1 Movie Creator—File Tab Overview (2 of 2)

Menu Item	Description
Save in	Enter the path where the AVI file should be saved. Click on the dotted button to the right of the dialog box to browse the directories for the path needed.
File Name	Enter the file name for the AVI file to be saved. If this is not filled in, the default prefix (first image) will be used, and is filled automatically.
Databar Preview	Shows the databar chosen from settings made in the Preferences dialog box, Databar tab.
Status	Shows the progress of movie creation.
Create Movie	Starts the creation process of the TIF files to a single AVI file.
Stop	Stops the creation process.
Close	Closes the dialog.

Databar Tab

The Databar tab contains two lists: **Available items** and **Displayed items**. Items in the Available list can be added individually or as a whole to the Displayed list. The Displayed list, when completed, contains all items that will be shown in the databar at the base of the movie display. The order of the items in the Displayed list can be moved up or down due to priority or preference. This, in turn, changes the order of the shown items in the databar. Items can be removed from the Displayed list singularly or in total back to the Available list. This facility does not affect the display and full screen databar and is only dedicated to the Movie Creator.

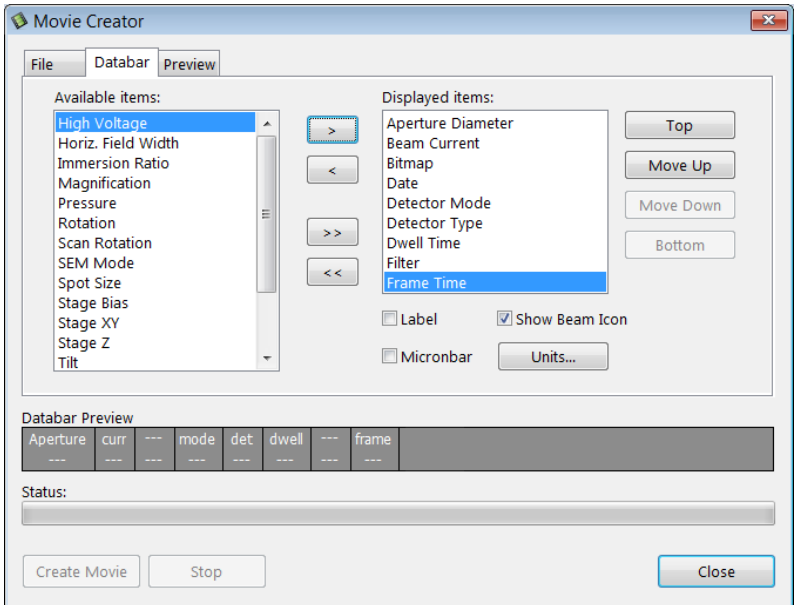


Table 5-2 Movie Creator—Databar Tab Overview

Menu Item	Description
Available items	Shows all items that can be entered in the databar.
Displayed items	Shows the items that will be present in the databar.
>	Adds one item from the Available items to the Displayed items list.
<	Removes one item from the Displayed list to the Available list.
>>	Adds all items from the Available list to the Displayed list.
<<	Removes all items from the Displayed list to the Available list.
Top	Moves an item to the top of the Displayed list.
Move Up	Moves an item up in the Displayed list.
Move Down	Moves an item down in the Displayed list.
Bottom	Moves an item to the bottom of the Displayed list.
Label	Shows the label in the databar.
Micronbar	Shows the micron bar in the databar.
Show Beam Icon	Shows the beam icon in the databar.
Units	Sets the Units of Measure, Pressure, and Temperature used in the movie databar.
Databar Preview	Shows the databar chosen from settings made in the Preferences dialog box, Databar tab.
Status	Shows the progress of movie creation.
Create Movie	Starts the creation process of the TIF files to a single AVI file.
Stop	Stops the creation process.
Close	Closes the dialog.

Preview Tab

Once the movie is created, the Preview tab automatically shows the first image of the movie sequence. By clicking **Play**, the movie starts and the progress slider below the movie proceeds from left to right at a speed depending on the play timing of the movie.

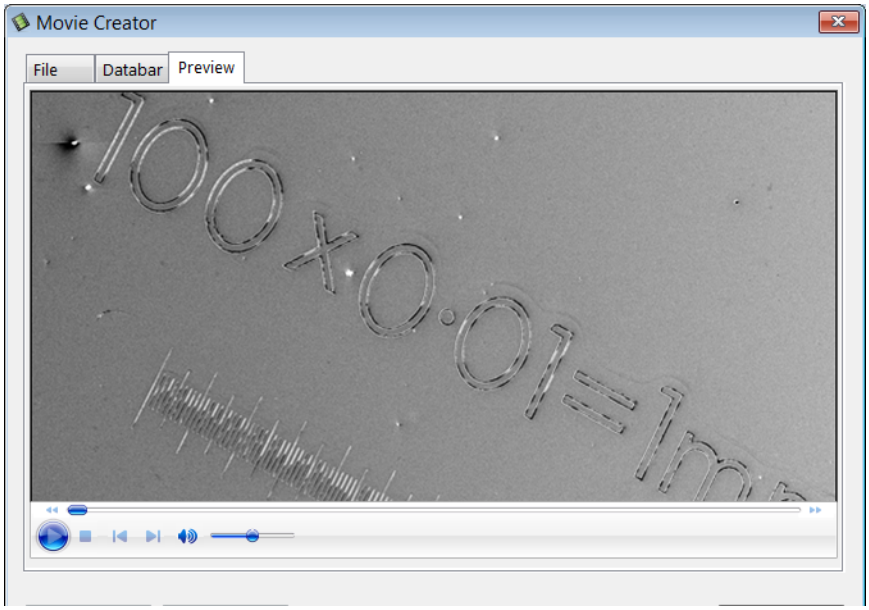


Table 5-3 Movie Creator—Preview Tab Overview

Menu Item	Description
Start/Pause/Stop	Starts, pauses, and stops the movie. Use the slider to run forward and backward through the movie.
Create Movie	Shows the File tab and begins the creation process of the TIF files to a single AVI file.
Close	Closes the dialog.

Playing a Movie

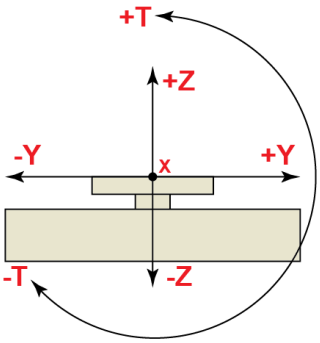
The AVI file movie can be played on the Windows Multimedia player installed on the system or exported to another Windows PC with more advanced movie editing programs. Programs used to play the movie need to recognize the *.*avi* file type.

Stage Movement Limits

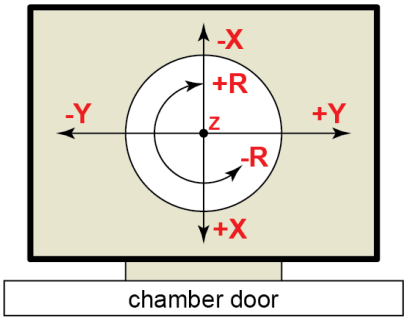
The chamber is equipped with the stage that can be oriented with reference to five axes: **X**, **Y**, **Z**, **Rotation** and **Tilt**. All movements are motorized and software controlled for more advanced location mapping. This includes **Shift**, **Get**, **Track** and the **Stage** module functionality.

NOTE	When moving the stage or tilting the specimen, the magnification may need to be reduced to keep from moving the feature of interest off the screen.

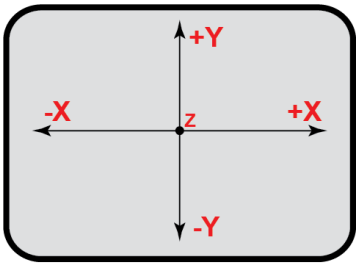
Figure 5-11 Stage Movement Schema



Stage side view
(from chamber door side)



Stage top view



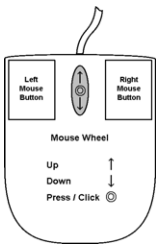
Display view

CAUTION	If the maximum sample size is near to the limit, stage tilt could be limited. Beware of hitting the objective pole piece.

Table 5-1 Stage Features and Limits

Item	UHR stage	150 × 150 mm stage	110 × 110 mm stage	Note
X	from –50 to +80	–75 +75	–55 +55	[mm]
Y	from –50 to +80	–75 +75	–55 +55	[mm]
Z *The positive Z-value direction depends on the Link Z to FWD status*	0 + 20	10 + 20	0 + 66	[mm] holder + stage • **Holder** Z movement means the possibility to manually screw the sample holder in or out. • **Stage** movement means motorized stage movement.
R	360°	360°	360°	continuous
T	–10° to +60°	–38° to +60°	–15° to +90°	
Eucentric Position	Electron: WD = 4 mm Ion: WD = 13 mm			
Clamp	No			
Maximum sample weight	200 g	500 g	2 000 g	For all tilt angles
	1 000 g	1 500 g	5 000 g	At Tilt = 0°

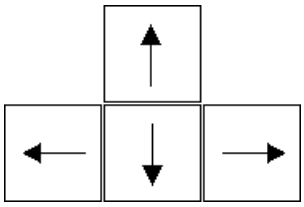
Moving the Stage



The Navigation page contains the essential elements for stage navigation to specific areas (see *"Navigation Page" on page 110*).

Additional software controls for stage movement include three techniques.

Shift moves

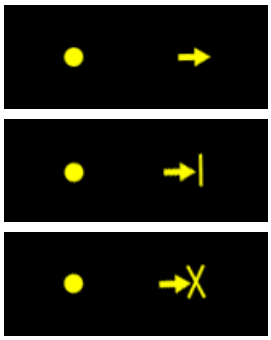


The stage can be moved approximately 80% / 40% of the field of view in any direction by pressing / Shift + pressing on the appropriate **Arrow** key on the keyboard.

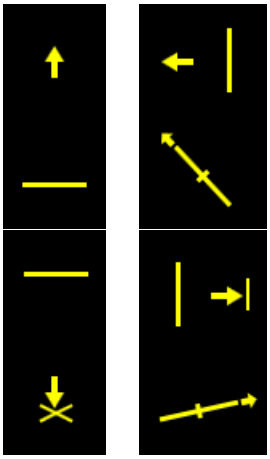
The maximum range for successive frame shift operations equals the range of the stage movement.

Track moves

The Track moves allows continuous directional movement of the stage with variable speed. The speed range is coupled to the magnification and is selectable within certain limits (see the **Preferences** / **General** section / **Switch sample tracking on mouse wheel click** item):



- **Wheel-click & drag** mode – the yellow *dot* appears onscreen in an active display at the mouse cursor point. Move the mouse to the direction intended for an observation – a yellow *arrow* appears onscreen denoting the direction of the stage motion. The motion speed increases with the distance between the arrow and the dot. The direction can be changed by moving the mouse. When you come to the place of interest, release the mouse wheel – the action stops.
- **Wheel-click & move** mode – the mouse wheel does not need to be held; just click on the desired direction to start the Track motion and click again to stop it.



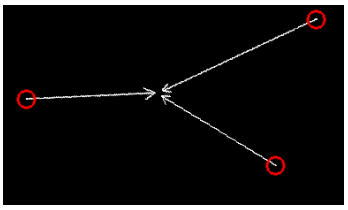
When a yellow line perpendicular to the moving direction appears, the stage approaches the movement limit in that direction; when a yellow cross appears, the limit was reached.

In the optical display, clicking the mouse wheel activates the stage Z movement, which can be seen live.

- **Wheel-clicking & dragging** the mouse up / down – moves the stage up / down (Z-coordinate).
- **Ctrl + Wheel-clicking & dragging** the mouse left / right – tilts the stage left / right.

The direction is indicated by a yellow arrow, either pointing up / down from the horizontal line or left / right from the vertical line.

Get moves



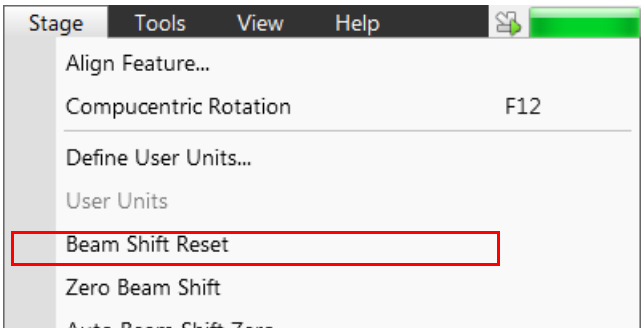
This function brings an image point of interest to the screen's center.

Double-click anywhere within the imaging display; this point is mechanically centered onscreen by moving the stage, which is suitable for lower magnifications. When working at higher magnifications, beam shift can be also employed (see the **Preferences** / **General** section). In this case, the point is electronically centered onscreen by moving the electron beam. When the beam shift comes to a limit in any direction, its value resets, and the necessary stage movement adapts the observed point position.

Electron Beam Shift Reset

When you want to employ the beam shift only (which is suitable for higher magnifications), shift + click on an image point. Drag the *Hand* cursor to move the imaging area in any direction.

When the limit of the beam shift has been reached, either the *Stage* menu / *Auto Beam Shift Zero* or the *Beam Shift Reset* function needs to be applied. In this case, the beam shift is reset, and the observed point position is adapted by the stage movement.



Releasing the mouse button stops the action.

Align Feature

NOTE	For best results, zero scan rotation first.

This feature is designed specifically for long features or when there is need to navigate along a feature that extends off the screen at the magnification required for observation.

When selecting the **Use: Stage Rotation** radio button, the functionality applies de-skew process across the entire length by applying stage moves, bringing the long feature either to the chosen **Orientation: Horizontal** or **Vertical** axis to make it easier to navigate.

When selecting the **Use: Scan Rotation** radio button, the functionality applies de-skew process across the entire length by applying scan rotation.

NOTE	Align Feature can also be used in the Nav-Cam display.

This can be performed at any point within the stage field limits and takes into account the offset for rotation by computer programming of the stage. Point 1 is first located and then point 2. When this occurs, point 2 is not fixed but extends point 1 with an elastic cord until the left mouse button is clicked in the active imaging display. At this position point 2 is located. The longer distance involved results in greater accuracy.

Align Feature is designed to work best at eucentric position. If necessary, follow the procedure outlined in *"About Eucentric Position" on page 164*.

Because the stage makes movements by software control, care should be taken that there are no significantly higher obstacles on the sample plane set at the eucentric position, as these may interfere with equipment under the lens.

To set Align Feature:

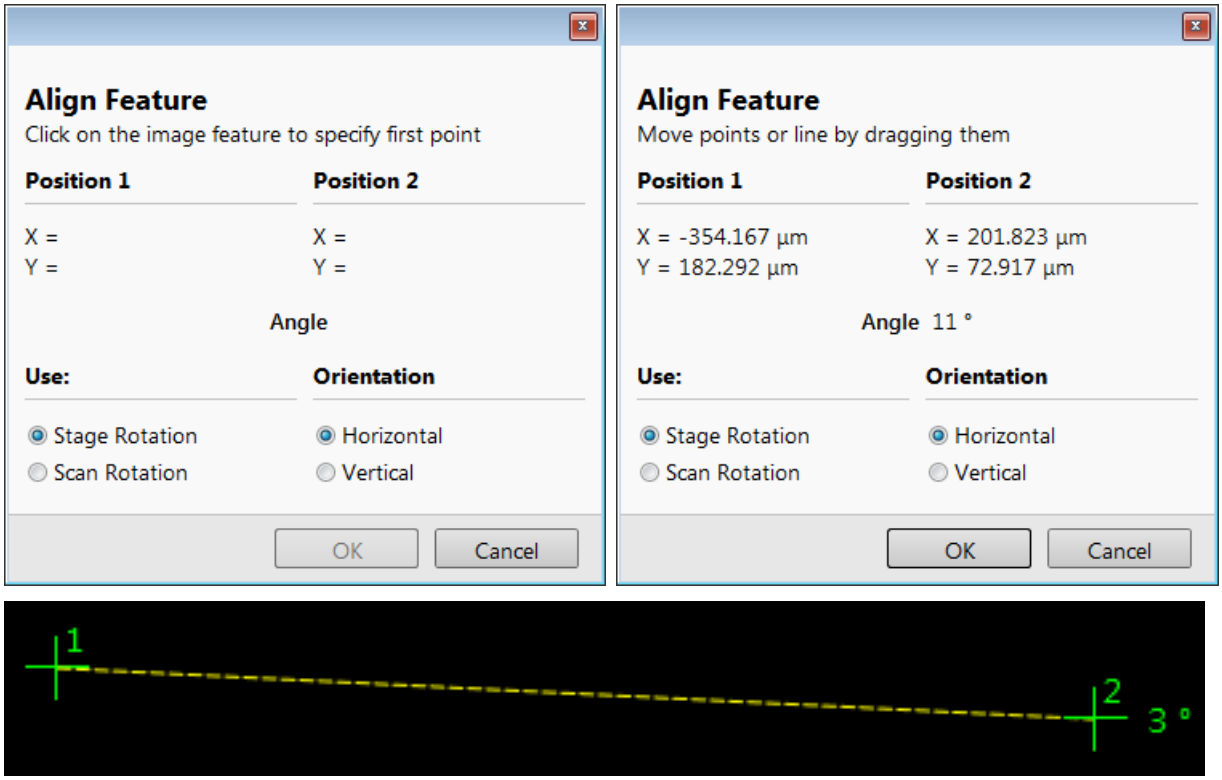
1. Select a long feature of interest on the sample.
2. Click on the **Stage** menu / **Align Feature** or the toolbar icon.

NOTE	It is recommended that you choose your first point on the left of the image and the second point on the right of the image. If you set your first point on the right, the rotation will be offset 180°.

3. Choose **Use:**; choose **Orientation:** either **Horizontal** or **Vertical**, which relates to the desired final orientation of the feature.
4. Click on the first point along the feature, the **Position 1** coordinates update.

5. Moving the mouse updates **Position 2** coordinates continuously, by clicking anywhere along the feature they are stored.

   The **Angle** shows value which is used to correct alignment of the feature along the **Orientation** / **Horizontal** or **Vertical** axis.

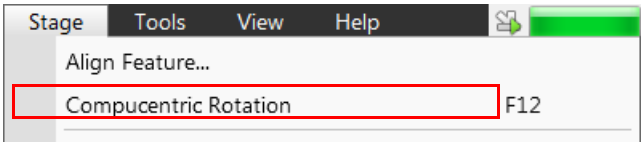


NOTE	This can be corrected at any time by going to the scan rotate settings on the Beam control page and resetting scan rotation to zero.

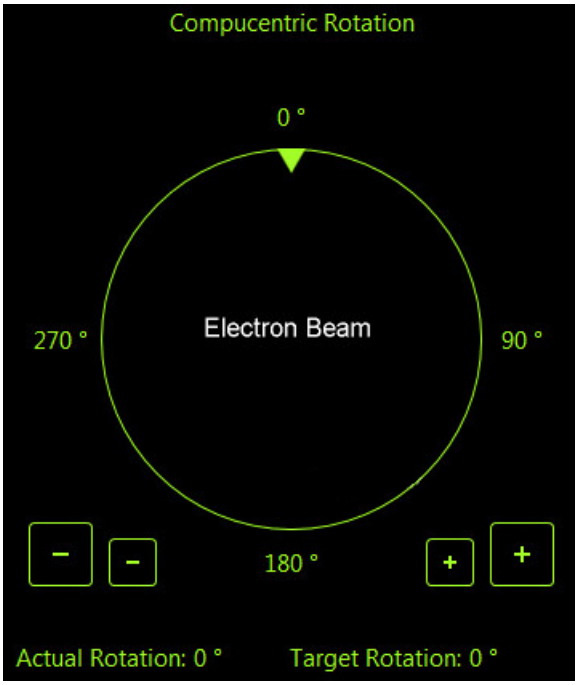
6. Drag any point to change its position, if needed. Right-click on the imaging area (anywhere) to delete points, enabling to define them again.
7. Click on the **OK** button to finish the setting.

Compucentric Rotation

Selecting **Stage > Compucentric Rotation** (or pressing F12 key) places a green circle in the active display.



At a point on the perimeter of the green circle is a green triangle that denotes, by its position, the angle orientation of the sample relative to its original position when placed on the stage, starting at the 12 o'clock position.



By clicking and holding the mouse button down on the green triangle, it can be moved around the circle to chose a new orientation of the sample relative to the detection position. On release of the left mouse button, the computer software updates the position orientation and offset from the mechanical stage center to deliver the same object center, but rotated to the angle selected.

This creates a different direction of illumination for the sample while keeping the object of interest in the center of the imaging area. With the sample at the eucentric position, this can be performed at any position on the sample, irrespective of the mechanical stage center.

Clicking on the numbered angles around the perimeter of the circle causes the stage to drive to that angle and the green triangle updates on screen. Clicking the large / small button with **+** / **–** sign increases / decreases the rotation value about 1° / 0,1°.

The read-out positions shown at the bottom of the display provide information on the **Actual Rotation** (original position in degrees), the **Target Rotation** (the selected position in degrees).

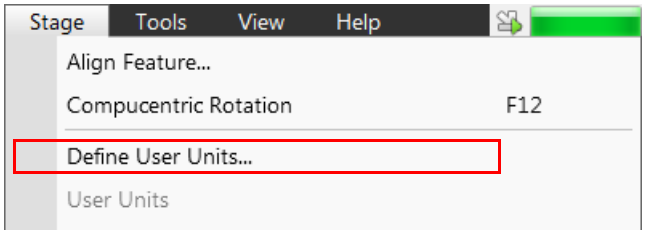
Defining User Units

Define User Units associates stage points with user-defined points to set up a mapping between the stage and user coordinate system. After that, the computer uses these sample coordinates rather than stage coordinates for positioning. For example, a die of an integrated circuit has its own coordinate system. If you choose a 0,0 position, you can drive the stage relative to that position using your own coordinate system. These are expressed in User Unit (UU) coordinates, which may be microns, multiples or fractions of microns, etc. Coordination of the stage can be anchored to either 1, 2, or 3 points, depending on the sample management or application.

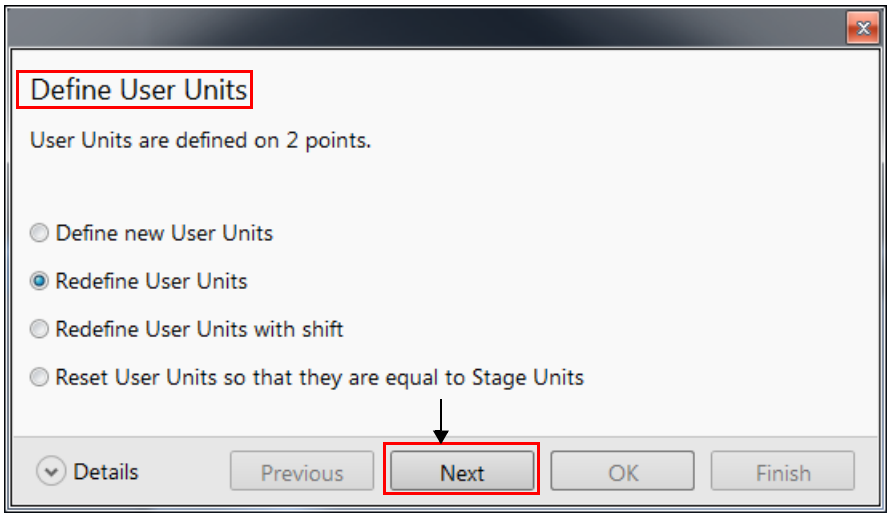
Choose points that are not in a straight line, e.g., at the corners of a die or the edges of an area or wafer. You can align up to three points for the greatest accuracy.

To set up the 1–3-point alignment for any given sample where repeated structures are examined:

1. Click on the sample user point (0,0), its coordinates appear in the **Details** module. Proceed by clicking the **Next** button.
2. Select a feature on the sample surface and bring it into the field of view at a magnification so that it relates to other structures (not too high magnification).
3. Select **Stage > Define User Units**.



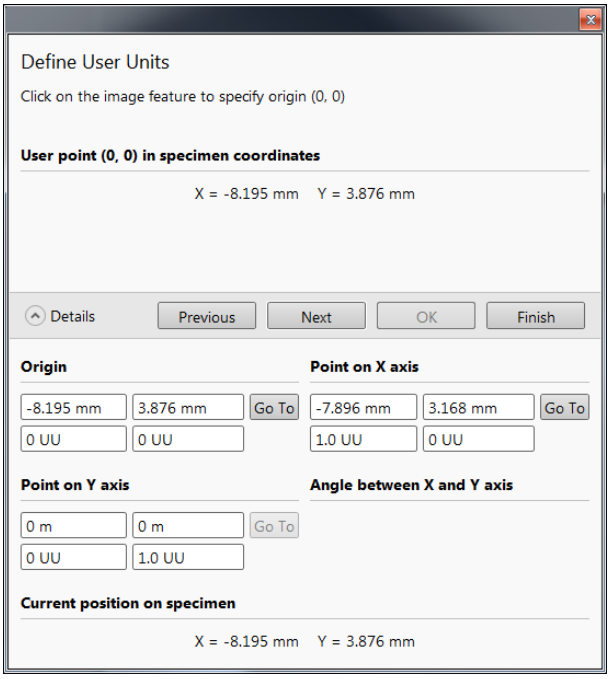
4. In the Define User Units - Start dialog box that appears, select **Define New User Units** and click **Next**.

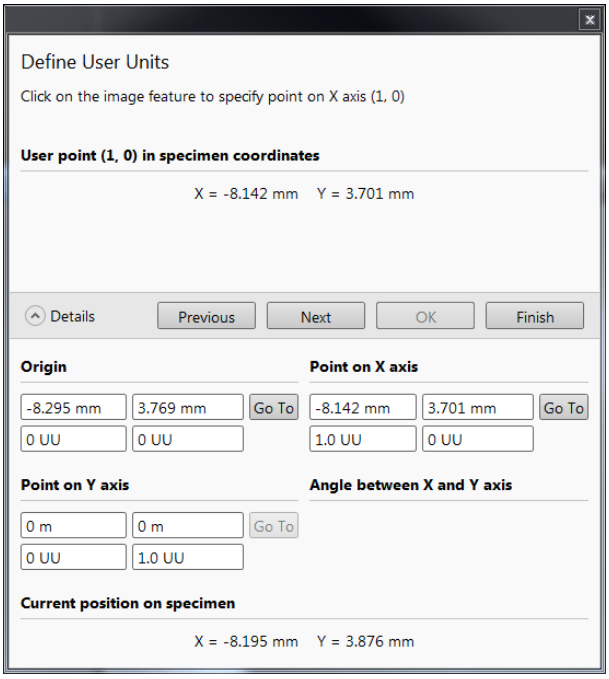


Other possibilities are:

- **Redefine User Units** – changing or updating User Units
- **Redefine User Units with shift** – as above with the use of the Beam Shift
- Reset User Units so that they are equal to the Stage Units

5. The Alignment Point One (0,0) dialog appears.



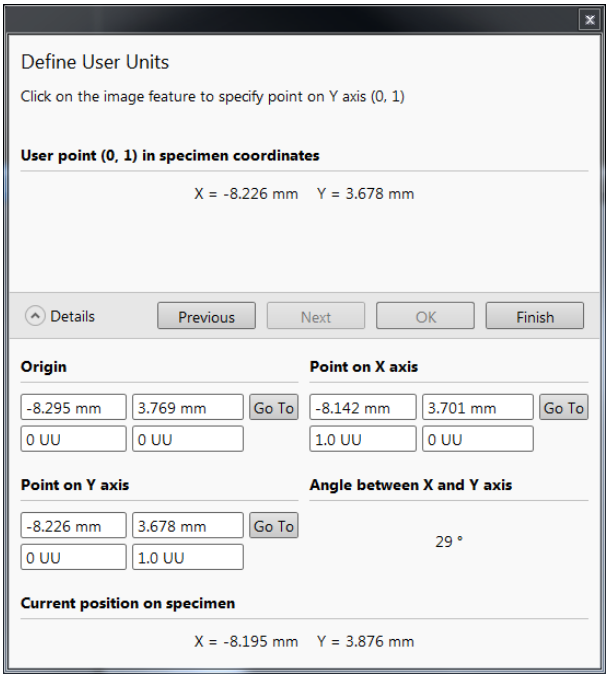


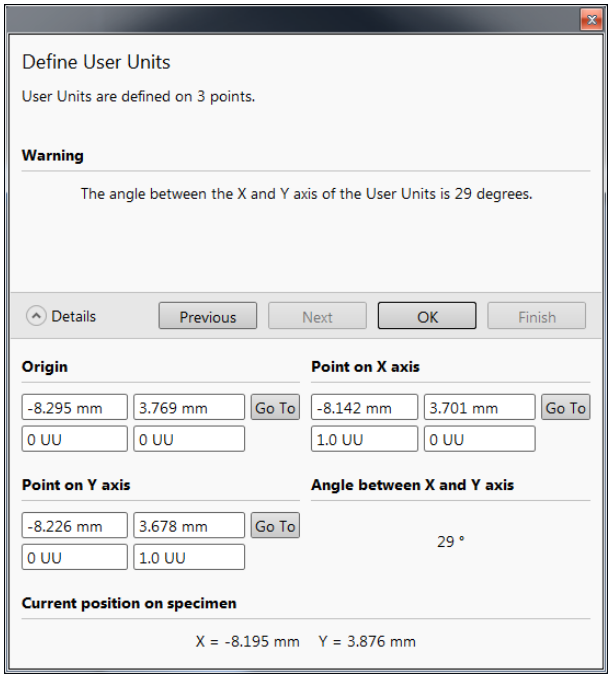
Follow the instructions in the dialog to move to a point and click on it. The coordinates of that point (0,0) appear next to the User X and User Y readout positions in the Details section of the dialog.

6. Click **Next** to continue to two points, or do one of the following:
   - Click **Previous** to return to the previous dialog.
   - Click **Finish** to end the alignment at one point.
   - Click **Cancel** to exit the procedure.
7. After clicking **Next**, the Alignment Point Two (1,0) dialog appears.

   Repeat the procedure, selecting and clicking on a new location point. The read-out positions will show the coordinates for the new Point Two location.

   Choose the next step from the bottom line of buttons as in Step 4. To continue, click **Next**.
8. After clicking **Next**, the Alignment Point Three (0,1) dialog appears. Repeat the process as in Step 5.
9. After clicking **Next**, a confirmation dialog appears.



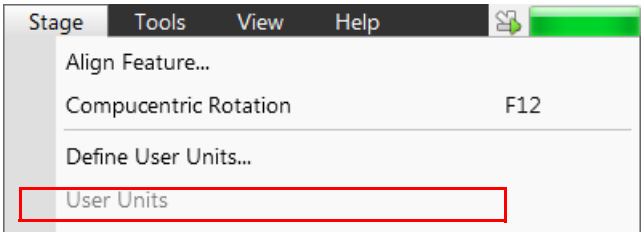


Click **Finish**.

10. Click **Details** at any time to show the resultant coordinates.

User Units

Select **Stage > User Units** to activate User Units as the basis of the stage coordination system.



A tick mark appears next to the label. The stage coordinate system reverts to the last defined user unit configuration for 1-, 2-, or 3-point alignment. From this point on, the stage can operate in Absolute or Relative mode with User Units to perform specific movements.

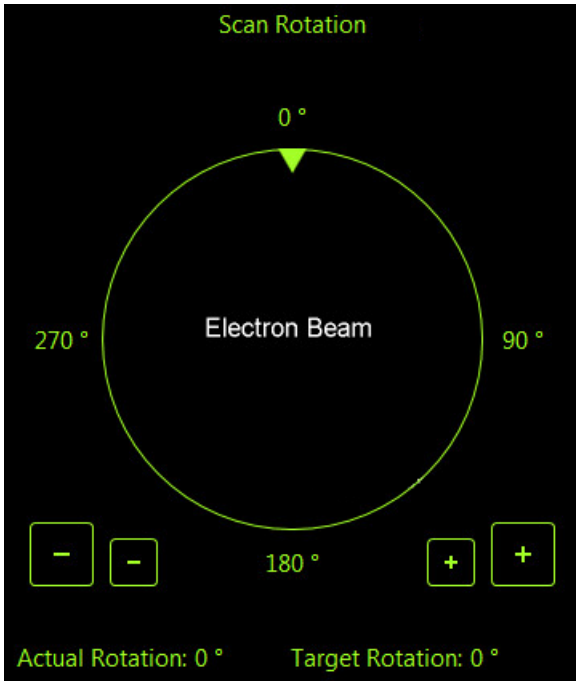
Using 1-, 2-, or 3- Point Alignments

Table 5-2 Alignment Type Differences

Use	1-Point Alignment	2-Point Alignment	3-Point Alignment
Major use	Aligning to a new set of coordinates directly offset from the existing ones.	Aligning the stage axes with the sample X-Y orientation to correct for any skew and overall scale.	Most general alignment. Rescaling to nonstandard units on CAD dies or RAM arrays; correcting for any skew.
Change in scale	None	Scales the axes together.	X can be scaled differently from Y.
Change in orientation	None	Rotates both axes with a fixed 90° angle between axes.	X and Y orientations can be non-orthogonal and can be mirror-imaged.

Scan Rotation

Use the **Beam Control** page > **Scan Rotation** module or use the display overlay control (**Scan** menu > **Scan Rotation** (Shift + F12)), that behaves identically to the Compucentric Rotation (see above).



When patterning is in progress, the scan rotation overlay control is restricted only to the **–** / **+** buttons.

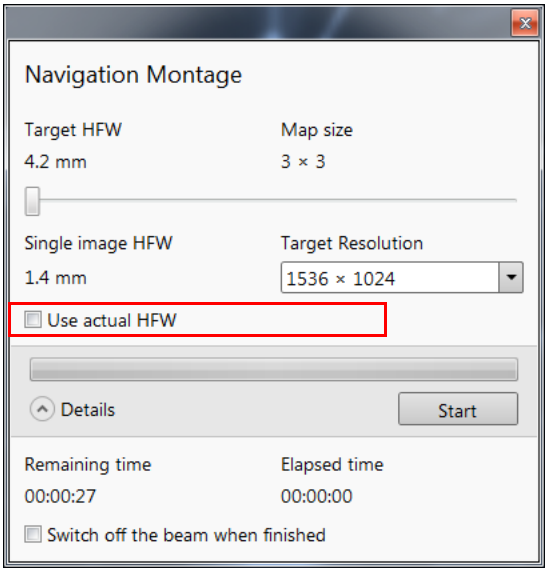
Sample Navigation / Navigation Montage

This software feature enables to navigate along the sample surface when the field of view is smaller than desired (limited by an aperture for instance). For this purpose it is possible to use up to three images which could be changed dynamically (capture, save, or load any time).

For more information, see *See "Navigation Montage..." on page 72.*

Set the Target HFW (horizontal field width) range, which influences the other information fields.

When the **Use Actual HFW** check box is ticked, the system does not automatically use the HFW according to the hardware configuration and sets one for the user. This is convenient when the image corners are rounded and imaging does not cover an entire area.



The **Stage > Sample Navigation** mode is then automatically set. For the selected display, the upper right corner green icon indicates the functionality.

A green rectangle showing the actually selected field of view (in the selected display) appears with the size corresponding to the magnification. In display(s) using Sample Navigation, the Selected Area Zooming and the Get features could be used.

NOTE	The basic condition for correct functionality is an equal stage rotation value for both captured and corresponding live images. In either case, the upper right corner red icon indicates no functionality in the respective display.

Nav-Cam (In-Chamber Navigation Camera)

Beside the **Sample Navigation** and **Navigation Montage** features, this functionality represents a fast method to navigate across a large stage movement area. It gives a fine Navigation image quickly and easily, which is convenient when investigating large area samples or several samples with the use of any multi sample holder. It is also possible to run the **Stage menu > Align Feature** selection with the Navigation image.

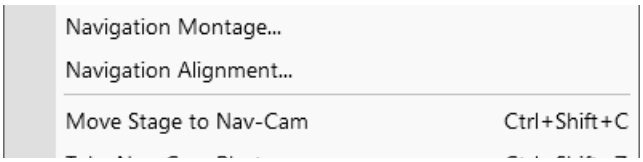
Capturing a Navigation Image

1. Vent the chamber, open the chamber door, insert a sample, and pump the system.

In case you do not want to control the entire procedure, select **Stage > Take Nav-Cam Photo… (Ctrl + Shift + Z)** to automatically run following steps 2, 3 and 4 at once. Click **Cancel** at any time to stop this procedure – the stage remains in the actual position.

Or follow the manual procedure:

2. Select the **Stage > Move Stage to Nav-Cam** item to move the stage to the Nav-Cam position.



At this moment the beam and the detector changes to Nav-Cam and a live image of the navigation camera is obtained in the last used active display (with the resolution of 768 × 512 pixels only).

CAUTION	Retract all retractable detectors to prevent equipment damage.

3. Capture a Navigation image (with high resolution of 3 072 × 2 207 pixels) using the **Snapshot / Photo** function. Save or adjust the image like any other image acquired from the microscope (image enhancement, process, etc.).

NOTE	Wait several seconds for image capturing to finish. If the Navigation image is too dark or faint, set its brightness with the **Brightness** continuous adjuster on the Detectors module when the Nav-Cam display is active before capturing the Navigation image.

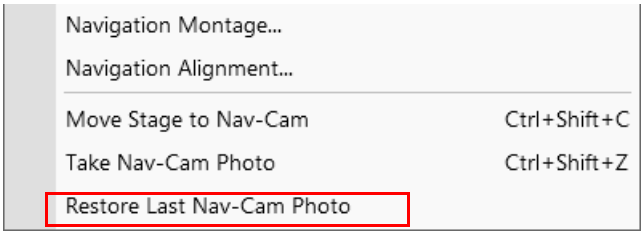
4. Select **Stage > Move Stage to Nav-Cam** again to move the stage to the last used stage position. A green rectangle (or just a cross) represents an observed area.

NOTE	If the Nav-Cam observation takes longer then 10 minutes, software protection switches illumination off for 1 minute to cool down. To proceed the operation, release the display. Nav-Cam usage is not possible to operate (but a navigation is still possible) in the SEM Mode 2 (Immersion/UHR). Nav-Cam usage is restricted for highly shiny and simultaneously planar specimens (Si wafers, mirrors etc.).

Besides a Navigation image, you can also use the **Digital Zoom** module to navigate the stage.

When the **Preferences > General** tab **> Show Stage Map in Navigation display** item is set to **Yes**, stage saved positions are shown in the Nav-Cam photo.

In case a user logs off and the sample and its stage loading position did not change, select **Stage > Restore Last Nav-Cam Photo**.



6 EasyLift NanoManipulator

The EasyLift EX NanoManipulator supports higher yields for TEM sample liftout through an intuitive integrated UI.

The EasyLift is an option feature.

Topics include:

- *"EasyLift Software Control" on page 236*
- *"EasyLift: Needle Exchange/Calibration Alignment" on page 241*
- *"EasyLift Needle Control " on page 246*

About EasyLift

The EasyLift tool allows sample manipulation during an in-situ lift-out process. This process consists of lifting up a piece of material from a bulk and transferring it on a standard grid that can then be loaded into a TEM.

Equipment has these modifications:

- EasyLift EX – full capacity version
- EasyLift – no rotation control
- EasyLift LT – no rotation and lower movement accuracy

EasyLift Software Control

Stage Menu/Active Display Controls

The EasyLift can be controlled with an overlay that automatically pops up when inserted.

NOTE	This display overlay functionality is not available for the EasyLift LT version.

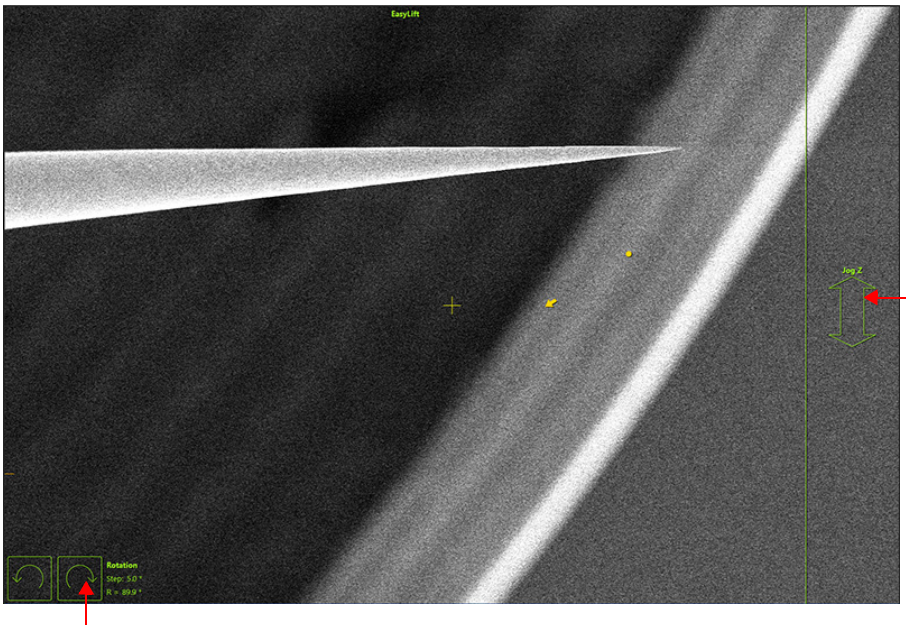
- **To turn the overlay on or off**: Select **Stage > EasyLift** or press **Control + J**. The overlay is shown in the active display (SEM or FIB).

  To cancel active drawing mode of the Patterning, Measurement & Annotation or Text cursor, press the keyboard Escape button.

- **To stop the overlay from popping up automatically**: go to **Tools** menu **> Preferences** item **> General** section **> Automatic EasyLift Display Control,** and select **No**. See *"General Section" on page 147*.

Figure 6-1 EasyLift Active Display Controls

X / Y movements controlled in the area to the left of the green vertical line.
Make Jog and Get moves by clicking and dragging.
The more the mouse cursor is moved away from the starting point, the quicker the needle moves.



Jog arrow corresponds to arrows on EasyLift module

Rotation arrows (CCW and CW) correspond to arrows on EasyLift module

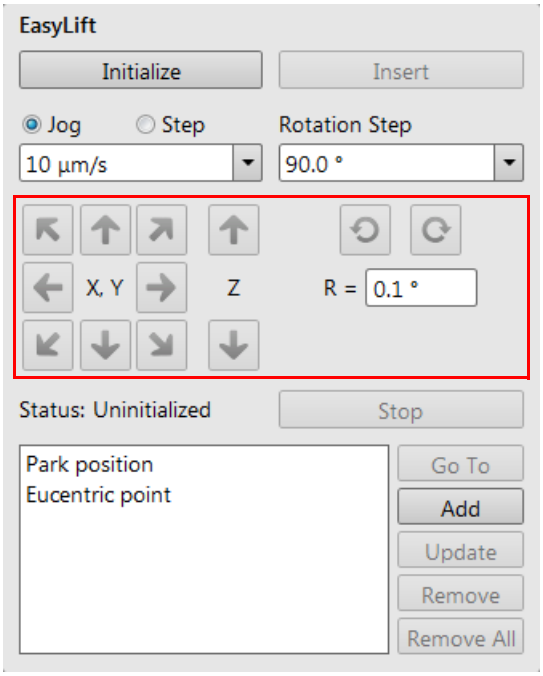
NOTE	When the EasyLift is display controlled and the patterning drawing mode cursor is active (creating a pattern / moving a selected pattern), be aware it has priority over the EasyLift control.

Control Page

The EasyLift is controlled via the EasyLift module on the EasyLift page.

All movement increments are predefined on the **Preferences > EasyLift** section, see *"General Section" on page 147*.

Figure 6-2 EasyLift module



NOTE	Some controls are not included on the EasyLift module on the Patterning and Sample Prep control pages.

Table 6-1 EasyLift Tab Overview (1 of 2)

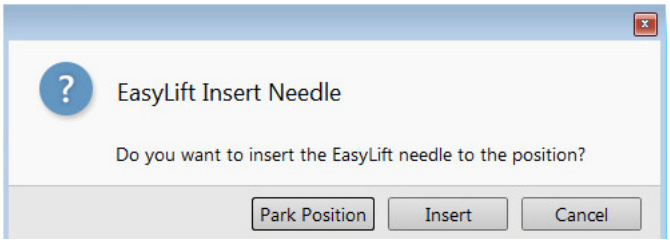
Interface Item	Description
Initialize	When the system is in an unknown state (e.g., after power down), places the EasyLift in the retracted position with all axis at home position.
Insert / Insert To / Retract	Changes its function depending on the state of the EasyLift. Clicking the button calls the confirmation window with posibilities:  • **Park position**: Clicking **it** causes the needle to be inserted at the defined location. In case a user selects any saved position prior clicking the **Insert** button, the button is labelled **Insert To** and the confirmation window looks slightly different. • **Insert:** Clicking **it** causes the needle to insert to a position from which it was retracted. When the needle is inserted, the button is labelled **Retract**: Retracting the EasyLift is always possible. • **Cancel**: Cancels the operation. **Note:** *It's possible to turn the **EasyLift insert needle** message On / Off by setting the **Preferences... / General** tab / **Show EasyLift insert confirmation** item.* **Note:** *Inserting is only possible when the system is linked and at the Eucentric position (WD > 3,7 mm).* **Note:** *EasyLift insertion is automatically restricted when Beam Deceleration mode is on.* ***Note:** Once EasyLift is inserted, you can not use the keyboard arrow keys for stage moves.*
Jog	Specifies Jog moves (constant velocity) to be used for EasyLift control.
Step	Specifies Step moves (relative step size predefined in Rotation Step list box) to be used for EasyLift control.
Rotation Step *Enabled when Step check box is ticked.* 	The needle can only be rotated in steps. This control specifies the step size in degrees. The rotation is executed when clicking the clockwise / counter-clockwise arrow button. **Note:** *The rotation with the manipulator could be performed also in the retracted position.*

Table 6-1 EasyLift Tab Overview (2 of 2)

Interface Item	Description
Arrows	Specifies the direction of EasyLift movement. • In **Jog moves**, as long as the mouse button is held, the EasyLift jogs in the arrow direction. By releasing the mouse button, the movement stops. • In **Step moves**, each mouse click moves the EasyLift with the predefined step size.
R =	Specifies an compucentric rotation value with the 0.2° accuracy.
Status	Shows the status: • **Undetermined**: Run the Initialize procedure • **Retracted/Inserted**: The EasyLift is not /is ready for use ***Note:*** *The Compucentric rotation with the manipulator can also be performed in the retracted position.*
Position	The needle **Park position** is defined by the **EasyLift: Needle Exchange Calibration** (see below). The **Park position** is 200 ?m above the **Eucentric position**. (SEM coordinates). Note, that coordinates used are set within the **Preferences** dialog / **General** / **EasyLift coordinates dependent on bulk stage tilt** setting. **Note:** *When you* **Insert to** the **Park** *position, the rotation angle of the needle is not changed; the current value remains.*
Stop	Stops any manipulator motion.
Go to	Shows when a user-saved position is selected and the needle is already inserted. Clicking **Go to** causes the needle to move to the defined location.
Add	Adds a stored position to the list.
Update	Updates the selected stored value and links the current EasyLift position to the stored position.
Remove	Removes the selected stored position.
Remove all	Removes all stored positions.

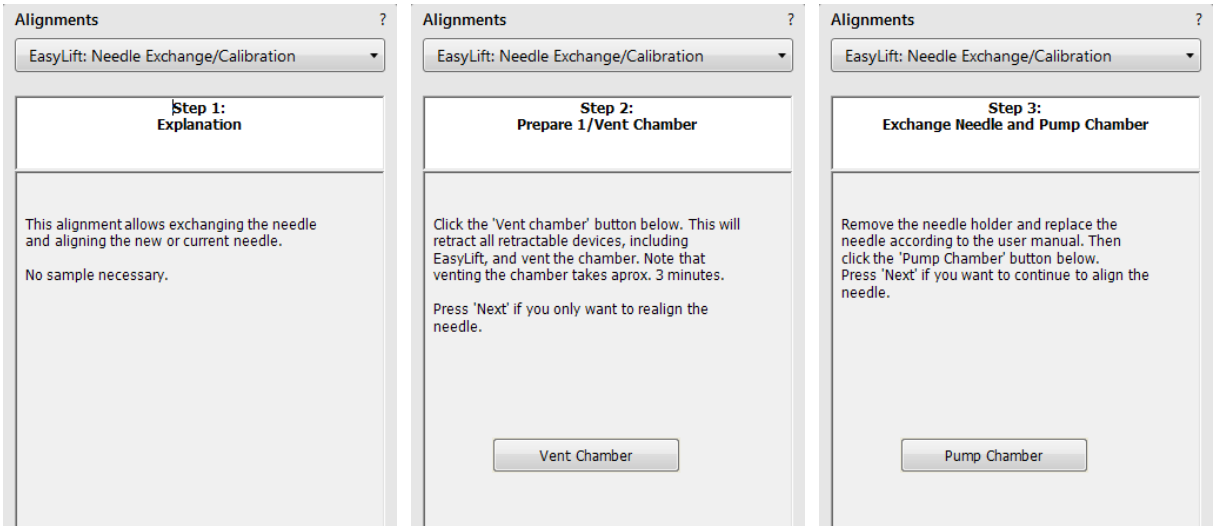
EasyLift: Needle Exchange/Calibration Alignment

Use this alignment to reach the eucentric point with the needle and to compensate for hardware rotational errors of the needle.

Needle Exchange

Folow the instructions within the alignment window.

Figure 6-3 EasyLift: Needle Exchange

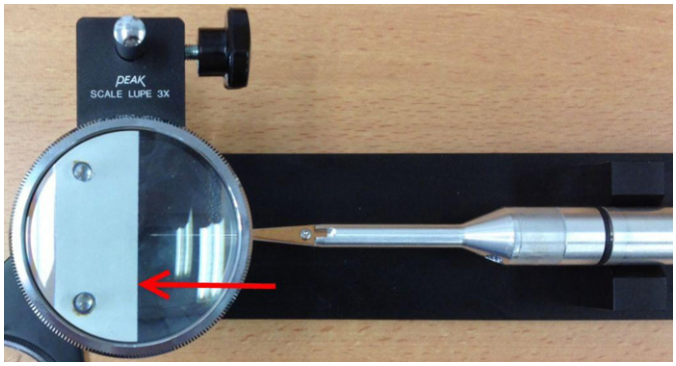


1. **Step 2**: Click the **Vent Chamber** button and wait for the chamber to be vented.
2. Prepare the needle alignment tool – Base holder.
3. Pull the probe shaft radially outward from the EasyLift mechanics with using the removal/insert jig (protecting the needle to touch any mechanical part).
4. Place the probe shaft on the Base holder. Place a little bit of Braycote or Fomblin on shaft O-rings.

5. Push the probe shaft end against the back end of the jig.

6. With tweezers, remove old needle by pulling it directly out.
7. With tweezers, place new needle under the leaf spring.

8. Check by rotating the Probe shaft using the knob at the end if the needle is positioned straight. Reduce the needle tip wobbling (should be within 500 µm).
9. Align the needle to the black/white edge (into /out from the leaf spring). Use the magnifying glass to verify the positional accuracy.



10. Repeat step 3 in the reverse order to put the probe shaft back into the chamber.

CAUTION	Push the manipulator shaft against the manipulator body with adequate force to ensure the shaft is inserted firmly.

11. **Step 3**: Pump the chamber by clicking the **Pump Chamber** button.

Needle Calibration

Folow the instructions for subsequent steps taking care to focus the beams and center the needle as precisely as possible.

Be sure to turn off the jog overlay using **Control + J** and only use the controls given in the Alignments tab. Decrease the step size of the needle under the **Preferences > EasyLift** section and zoom in for more accurate centering.

12. **Step 4**: Click the **Wake Up** button to restore column settings beams and the **Move Stage** button to position the stage.
13. **Step 5**: Align the needle using the procedure described within the alignment window.

Figure 6-4 EasyLift: Needle Calibration

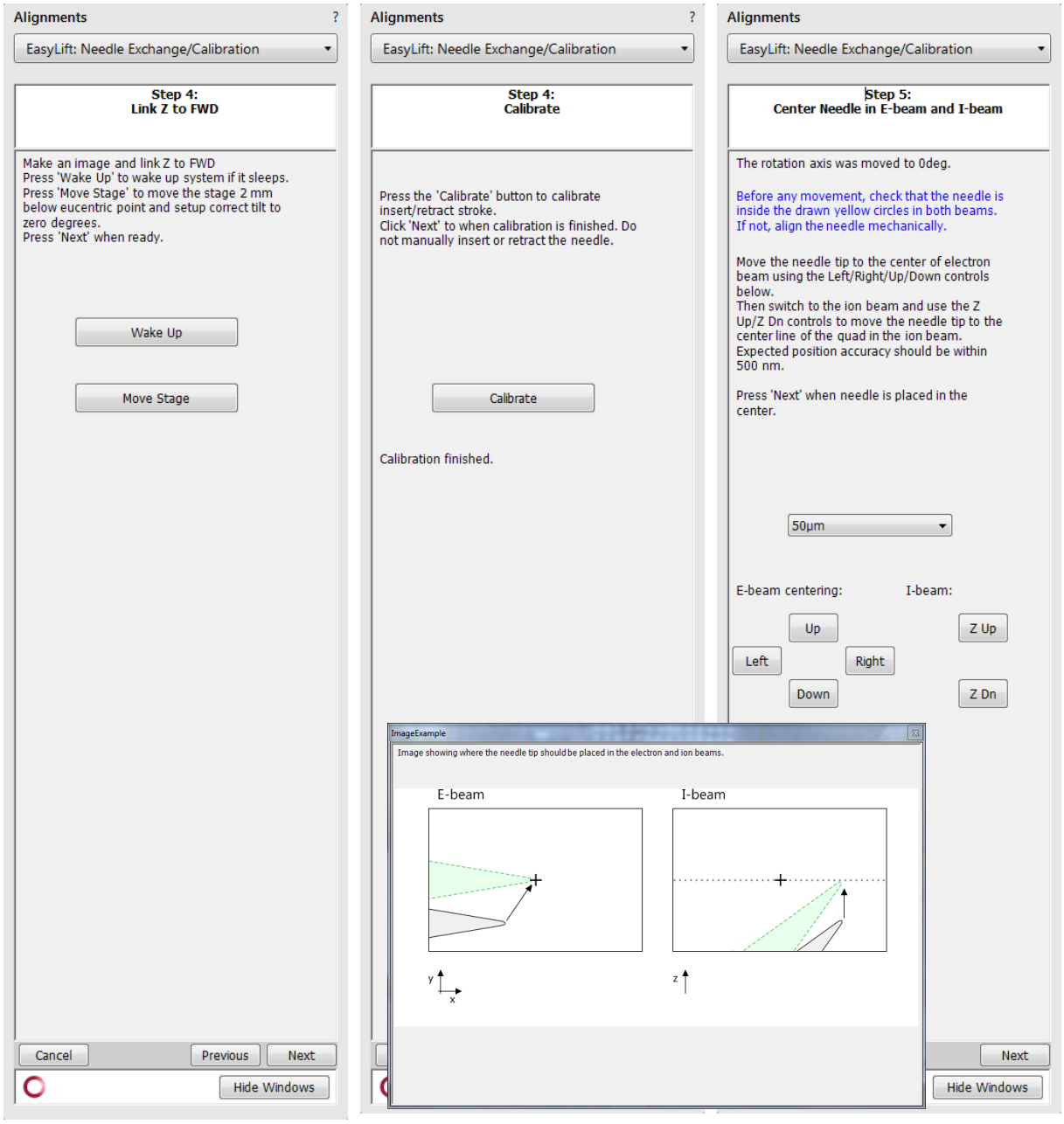
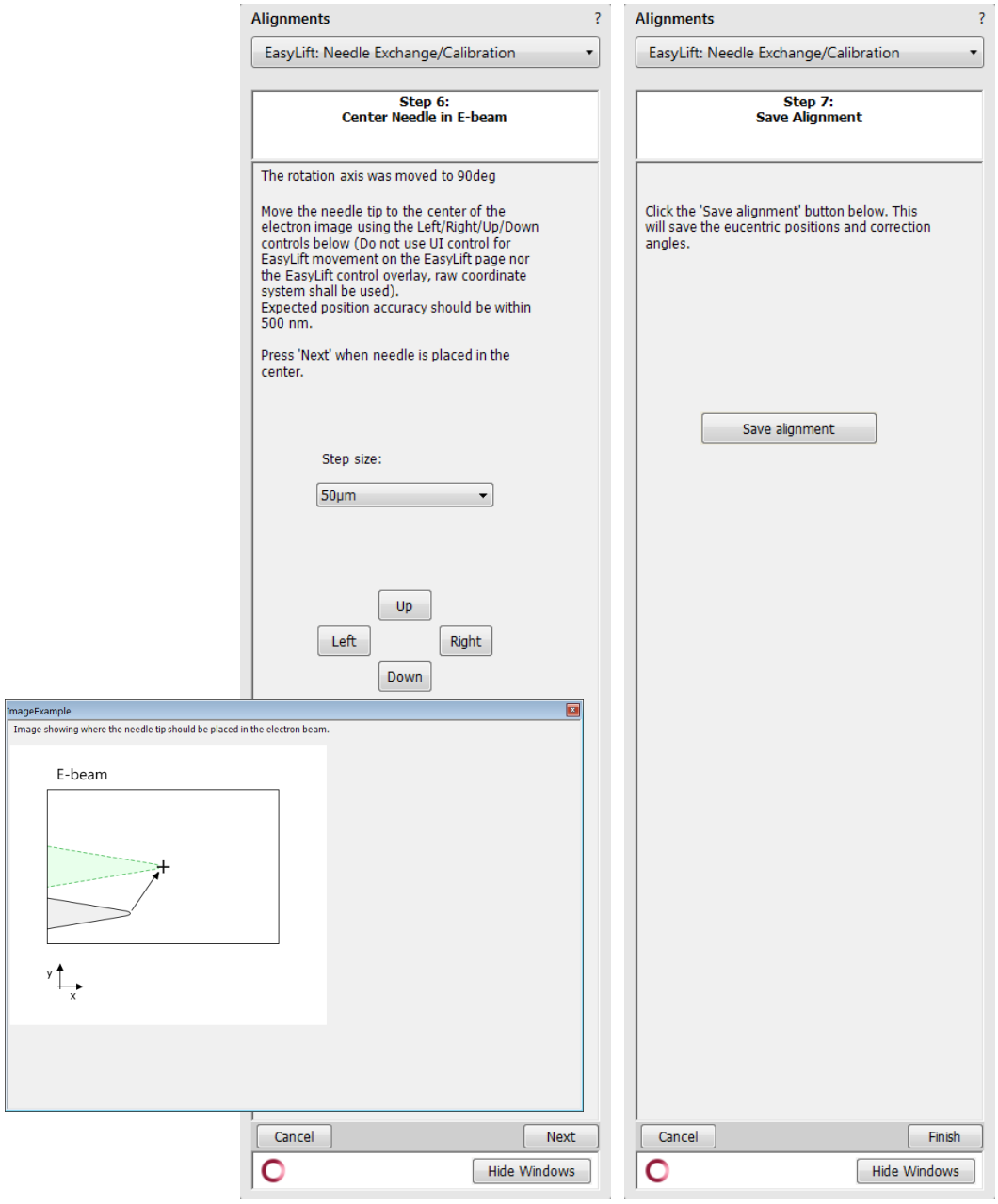


Figure 6-5 EasyLift: Needle Calibration (continuing)

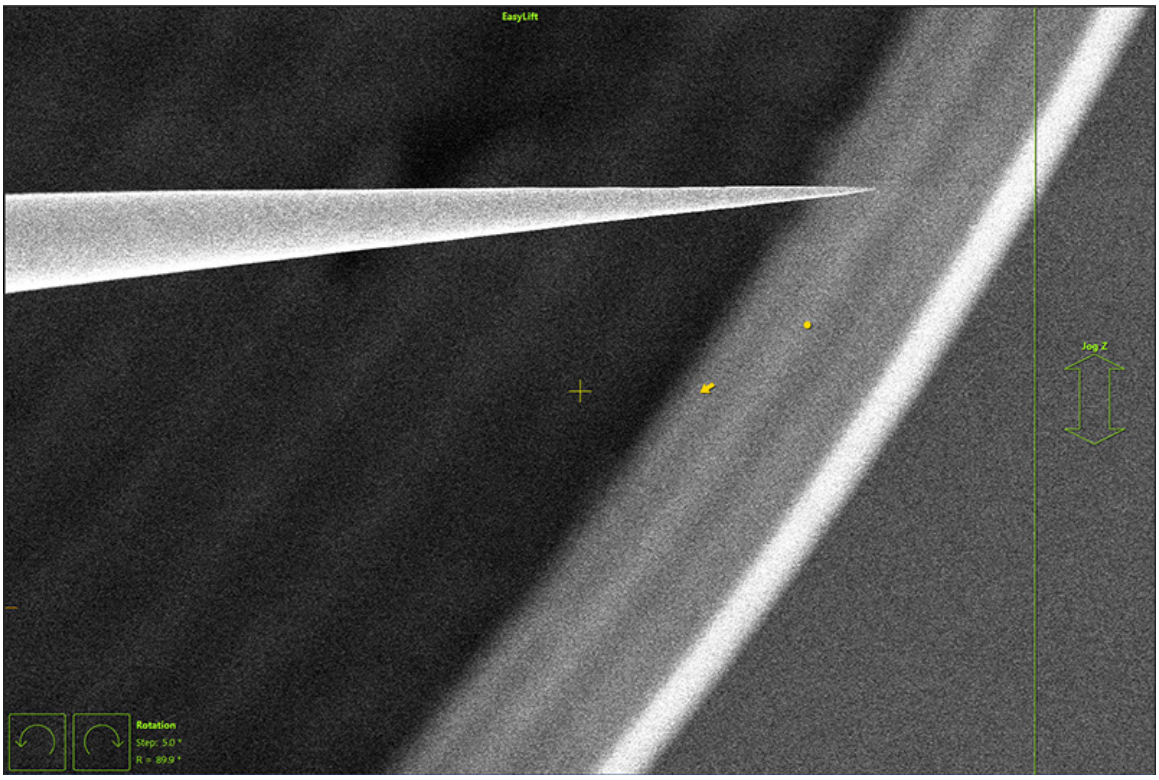


EasyLift Needle Control

CAUTION	When you click **Insert**, the needle will insert to the last place from which it was retracted. To prevent collision, either lower the stage or select a safe user position and click **Insert To**.

NOTE	The display overlay functionality is not available for the EasyLift LT version.

1. Press **Control + J** to turn the motion overlay on and off. The motion overlay comes on automatically when the manipulator is inserted in SW 5.3 and greater.
2. Click inside of the electron beam display and drag the manipulator until it reaches the desired location in X / Y.



3. Click and drag inside of the arrow area on the right side of the display to move the manipulator in z. Look for Z motion in the ion beam.

7 Patterning & Milling

Topics included in this chapter:

- *"Patterning" on page 248*
- *"Patterning Control module" on page 250*
- *"Milling Order of Patterns" on page 256*
- *"Properties Tabbed Module" on page 256*
- *"Patterns Processing" on page 259*
- *"Application files" on page 284*
- *"Milling" on page 288*
- *"Selective Milling" on page 291*
- *"Advanced patterning tabbed modules" on page 264*
- *"Fast iSPI Mode" on page 264*
- *"End Point Monitor (EPM)" on page 266*
- *"Real Time Monitor" on page 270*

Patterning

Patterning is the process of milling, depositing, or etching a pattern onto the sample surface with either electron or ion beam. During patterning, the selected beam unblanks automatically and uses digital beam placement to vector scan over a pattern.

- While patterning can be done with either beam, **the electron beam is generally used for imaging and sometimes for deposition with patterns**.
- The ion beam is used to cut cross sections and tracks, drill vias, and deposit new material.

In general, patterns need to be executed as quickly as possible, while maintaining sufficient edge resolution and preventing potentially damaging charge buildup.

During deposition, the beam is unblanked and a gas injection valve is opened to begin deposition. Multiple gas injection systems (GIS's) or MultiChem may be installed on your system.

Select an application file for a given pattern. A pattern must be defined before an application file can be selected. The given application file then automatically ticks an appropriate GIS / MultiChem check box, calculates the proper dose, and sets the dwell time and overlap appropriate to the beam chemistry.

Selected gas can be changed to fit individual use cases but overlap, and dwell should be set carefully with particular gasses in mind to achieve good results.

Serial milling or deposition will always begin with the first pattern defined in the current image window and continue through subsequent patterns.

In Serial mode, a series of patterns could even be a combination of some to be milled and some to be deposited, but in general this is not recommended (because the GIS / MultiChem remains inserted and may result in possibly depositing instead of milling due to possible residual gas in the chamber).

Control of the patterning processes is via the Patterning menu (see *"Patterning Menu" on page 66*) and/or via the Patterning page (see below).

Patterning page

Use the Patterning page for milling, depositing, and etching a pattern onto the sample surface with a beam and for controlling the gas injection systems (GISs and MultiChem). For operational details, see *"Patterning & Milling" on page 247*.

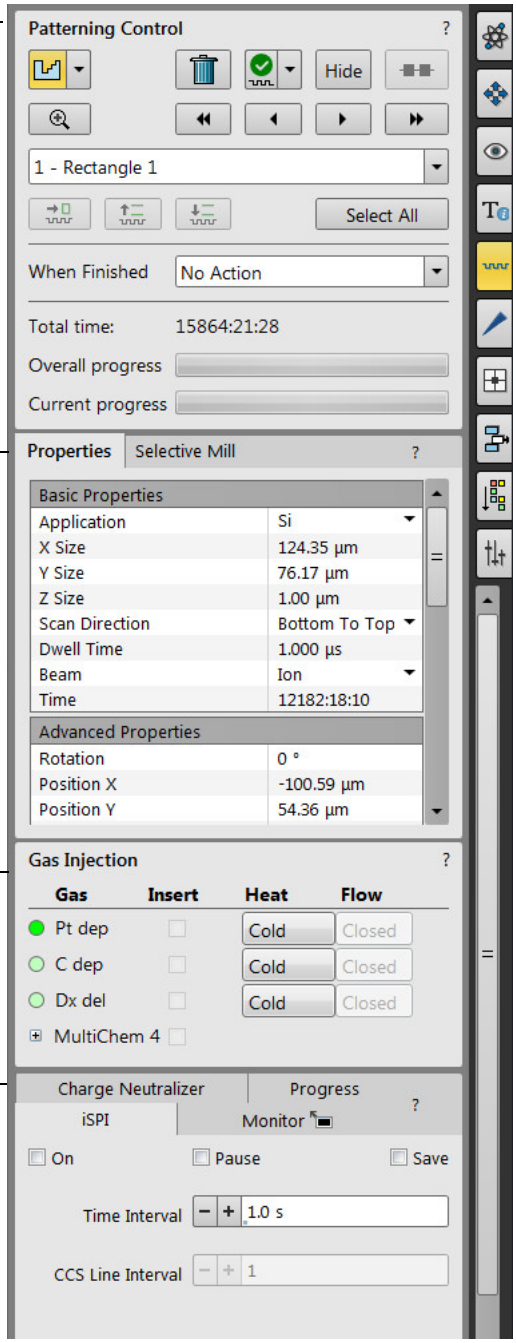
Figure 7-1 Patterning Page

See *"Patterning Control module" on page 250*

See *"Properties Tabbed Module" on page 256*

See *"Gas Injection module" on page 303*

See *"End Point Monitor (EPM)" on page 266*



Patterning Control module

Tools for creating, moving, sizing, and deleting patterns are available at the top of the Patterning Control module.

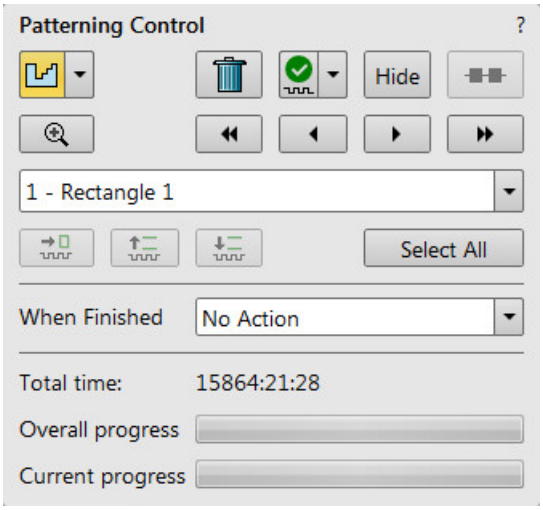


Table 7-1 Patterning Tools Overview (1 of 4)

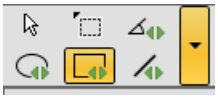
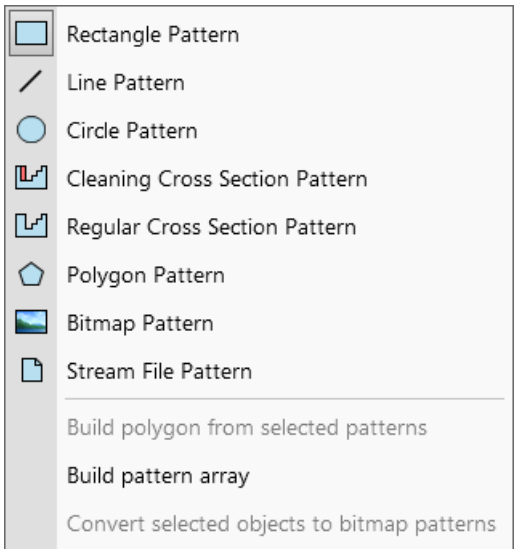
Icon	Pattern
Pattern selector  	Click the down arrow to access the pattern types dropdown list. The selected pattern icon shows to the left of the arrow. It is also possible to use the toolbar icons as well. Gray / Orange background represents inactive / active (shape can be drawn) tool.  The pattern is allocated a number relative to that shape and is shown in the Pattern List. To cancel the drawing mode click the keyboard **Escape** button.

Table 7-1 Patterning Tools Overview (2 of 4)

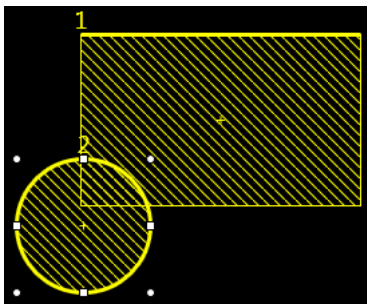
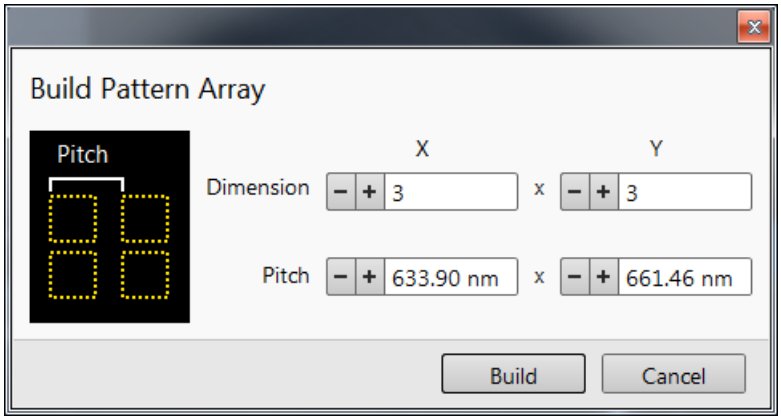
Icon	Pattern
Build Polygon	Joins two overlapping patterns into one pattern. Draw patterns so they overlap. Select / highlight all patterns to include in the polygon, then select **Build Polygon**. 
Build Array	Creates an array of defined patterns.  • **Dimension**: The number of pattern repetitions in the X and Y directions. • **Pitch**: The distance from the left edge of one pattern to the left edge of the next pattern Draw a pattern first, then select **Build Array**. Enter the size and pitch values.
Convert from Annotation	It is possible to convert any selected Annotation or Measurement graphic to a Bitmap type pattern shape with the use of this item.
Trash Can (Delete) 	Deletes the selected pattern.

Table 7-1 Patterning Tools Overview (3 of 4)

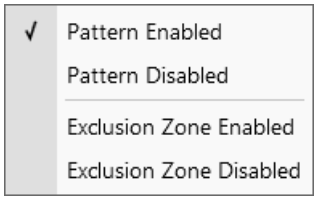
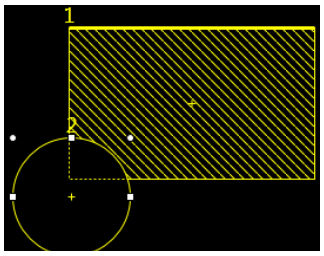
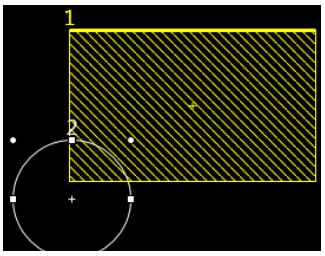
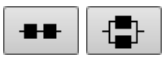
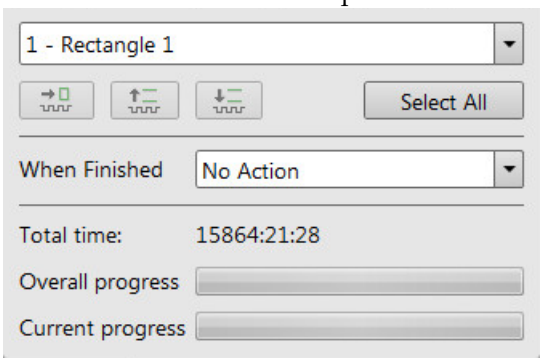
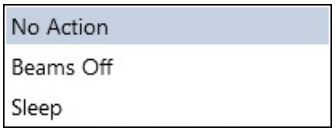
Icon	Pattern
Pattern Enabled / Disabled 	Click the down arrow to see the menu   By default, all patterns when drawn are enabled for patterning. **Button Inoperative** = grayed out. **Pattern E**nabled = green tick mark. **Pattern Disabled** = red circle with slash mark crossed through the green tick mark. Disables the currently selected pattern. The pattern color on the image turns gray to indicate that the pattern will not be processed. **Exclusion Zone Enabled / Disabled**: The overlapping pattern area will be excluded from / included in the processed pattern.   Enabled pattern is yellow, disabled pattern is white.
Hide 	Hides all the patterns in the active display.
Serial / Parallel patterning 	Selects the patterning sequence: • **Serial**: All patterns defined on the screen are milled consecutively; milling is completed on one pattern before moving to the next. Serial patterning is always used with cleaning cross sections as well as regular cross section. • **Parallel**: All patterns defined on the screen are milled concurrently. For example, if three lines are defined as milling patterns, one pass of the beam will be made on one, then the next, then the third, back to the first, and so on until all three lines are milled to the depth selected for the first line. With Parallel patterning, the mill time is recalculated to include all patterns that are shown on the screen. Parallel patterning is typically used to avoid redeposition of material on adjacent areas as well as to save milling time.

Table 7-1 Patterning Tools Overview (4 of 4)

Icon	Pattern
Pattern Zoom 	Brings the drawn pattern in the active display to maximum magnification allowed with the image. The button then turns yellow to indicate zoom is on. When selected during patterning, it always keeps the active pattern digitally zoomed to clearly show the RTM image (see *"End Point Monitor (EPM)" on page 266*).
Sequence controls	Moves the pattern to the beginning, back one, forward one, or to the end of the patterns list.
Pattern list	Corresponds to the pattern shown via the Pattern Selector to the pattern highlighted in the working display.
Activation buttons	The three buttons below the pattern list are fast activation buttons for:  • **Next Pattern**: activated when more than one pattern is present. • **Next / Previous Line**: activated when Cleaning or Regular Cross Section is operative. The same functions can be found in the Patterning menu (see *"Patterning Menu" on page 66*.
Select All button	Selects all pattern shapes within the active display.
When Finished	Select an action to be done after finishing the patterning process from the list:  **Beams Off** – stops both the E- / I-beam sources **Sleep** – applies the **Beam Control** page > **System** module > **Sleep** command
Progress area	Shows the overall and actual progress (over time) of the active patterning. • **Total time** – estimated total patterning time • **Overall progress** – related to the total patterning time of all patterns • **Current progress / CCS line progress** – related to the actual pattern in progress

Pattern Types

Patterns are automatically assigned to one or more particular processes. They are distinguishable by a different cross-hatch.

- The **Rectangle / Line / Circle / Polygon** pattern is dedicated to both milling and deposition.
- The **Cleaning Cross Section** pattern is processed line by line (each line with set number of passes).
- The **Regular Cross Section** pattern has two possibilities selectable in the property editor:

  Scan Method: Multipass – processes entire pattern and starts again (with set number of passes)

  Scan Method: Stairstep – the pattern is created as a compilation of five rectangles with specified overlap between them. Each one is processed with the set number of passes.

Bitmap

Use the bitmap pattern on the Patterning page to import bitmaps as a pattern. A bitmap file must be saved as a 24-bit format, i.e. each pixel consists of red, green, and blue components (RGB):

- The red component is currently not used.
- The green component determines if the beam is blanked.
  Any value other than 0 unblanks the beam.
- The blue component determines the dwell time per pixel.
  If the value is 0, the pixel is skipped.
  If the value is 1 (border), the dwell time of a pixel is the lowest (approx. 100 ns).
  If the value is 255 (border), the dwell time of a pixel is the same as it is set for the pattern.
  The dwell time for the pixels in between the border values is linearly interpolated based on the blue component value.

When drawing a bitmap, it is recommended to use black (0,0,0) for no milling points and green together with blue for milling points (see the following examples).

Table 7-2 Bitmap Color Settings examples

Color	Result
RGB 0 / 0 / 0 — black	The patterning point is not generated and is skipped.
RGB 0 / 1 / 0	A patterning point is generated but it is skipped, dwell time is 0.
RGB 0 / 1 / 1	A patterning point is generated, dwell time is the lowest.
RBG 255 / 255 / 255 —white	A patterning point is generated, dwell time is the same as it is set for the pattern.

To mill a bitmap, see *"Milling a Bitmap" on page 291*.

Stream File Pattern

Stream files cannot be created directly from UI. Use any suitable text processor to create them. There are several stream file types that are recognizable by the first header line (s16 / s16,25ns / s16,DAC or s16,25ns,DAC).

A stream file, created as an ASCII text or binary file that addresses the patterning DAC directly, produces custom pattern files. The advantage of a stream file is that you can make use of the full resolution of the DualBeam microscope. The disadvantage is that generating these files has to be performed outside of the microscope software. Therefore, stream files are for users who write their own programs for specific applications.

Helios DualBeam has a PIA (Patterning-Imaging-Acquisition) with a DAC resolution of 16 bit. Therefore, the addressable points for PIA in X-direction is 65536 pixels, and 56576 in the Y-direction.

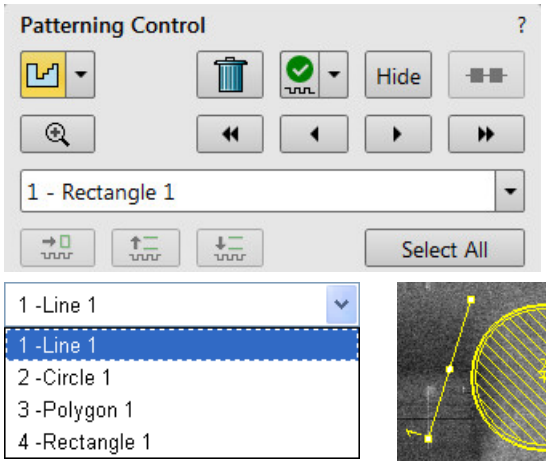
A stream file contains a short header plus data (dwell time, beam position, X, Y). For Helios DualBeam systems, the stream file should start with "s16" to indicate that the DAC is 16 bits. The dwell time on a pixel is in units of 100 ns; you can also introduce the fourth parameter in any addressable point to require beam blanking control. The fourth parameter is optional and it can be added at the end of any individual mill point parameters. If the beam is blanked in the specific point, the fourth parameter in this point is set to 0 and beam is unblanked when the parameter is set to 1.

Below is an example in which 26 points are scanned in a 5 by 5 array, repeating 40 times. The dwell time is 9.6 µs for each point. The file must begin with an "s16," indicating a stream file for DAC 16 bit. The second line defines the number of passes the pattern mills, where one pass has the beam visiting each of the 26 pixels (positions) one time. The third line indicates the total number of X, Y coordinates, in this case 26. The 96 figure represents dwell time in units of 0.1 microseconds. The range of dwell time is 25 ns to 25 ms. The fourth column is set to 0 in the last point to require the beam to stay at the same point and blanked to avoid beam damage outside the pattern area.

s16	96 2867 2867	96 1639 2048	96 2457 1639
40	96 1229 2457	96 2048 2048	96 2867 1639
25	96 1639 2457	96 2457 2048	96 1229 1229
96 1229 2867	96 2048 2457	96 2867 2048	96 1639 1229
96 1639 2867	96 2457 2457	96 1229 1639	96 2048 1229
96 2048 2867	96 2867 2457	96 1639 1639	96 2457 1229
96 2457 2867	96 1229 2048	96 2048 1639	96 2867 1229

Milling Order of Patterns

Patterns are normally milled in the order in which they are created on the screen. Numbers are shown close to / inside the pattern shape and in front of its name to indicate the actual milling order. The milling order can be changed by clicking on the left / right single arrow to move the selected pattern one position up / down and by clicking on the left / right double arrow to move it to the first / last position.



Properties Tabbed Module

A certain pattern can be selected from the list box with many associated parameters which can be set via the **Properties** tabbed module. Properties are set on the **Basic** and **Advanced Properties**, sections, that vary by the selected parameters (pattern type, application file, gas type).

NOTE	If you specify a **Properties** tabbed module > **Advanced Properties** area > **Gas Flow %**, it will override the value set within the MultiChem module. See *"MultiChem" on page 307*.

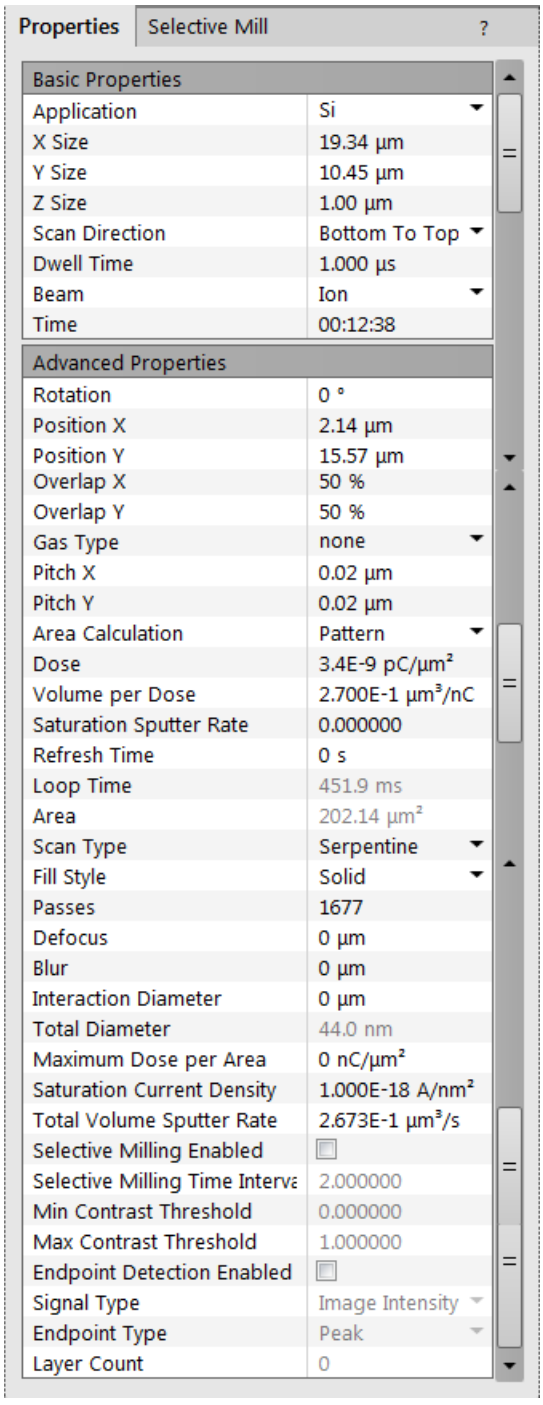

Properties
Selective Mill
?
Basic Properties
Application
Si
X Size
19.34 µm
Y Size
10.45 µm
Z Size
1.00 µm
Scan Direction
Bottom To Top
Dwell Time
1.000 µs
Beam
Ion
Time
00:12:38
Advanced Properties
Rotation
0 °
Position X
2.14 µm
Position Y
15.57 µm
Overlap X
50 %
Overlap Y
50 %
Gas Type
none
Pitch X
0.02 µm
Pitch Y
0.02 µm
Area Calculation
Pattern
Dose
3.4E-9 pC/µm²
Volume per Dose
2.700E-1 µm³/nC
Saturation Sputter Rate
0.000000
Refresh Time
0 s
Loop Time
451.9 ms
Area
202.14 µm²
Scan Type
Serpentine
Fill Style
Solid
Passes
1677
Defocus
0 µm
Blur
0 µm
Interaction Diameter
0 µm
Total Diameter
44.0 nm
Maximum Dose per Area
0 nC/µm²
Saturation Current Density
1.000E-18 A/nm²
Total Volume Sputter Rate
2.673E-1 µm³/s
Selective Milling Enabled
Selective Milling Time Interva
2.000000
Min Contrast Threshold
0.000000
Max Contrast Threshold
1.000000
Endpoint Detection Enabled
Signal Type
Image Intensity
Endpoint Type
Peak
Layer Count
0

Table 7-3 Patterning Properties

Properties	Description
Application	Name of the application file. Clicking the value field produces a dropdown arrow and list of applications. The parameters for the selected application are automatically set for the subsequent properties.
X / Y / Z size	The dimension of the pattern.
Scan Direction	Direction of movement of scan: Bottom to Top / Top to Bottom / Right to Left / Left to Right / Dynamic Top to Bottom / Dynamic Left to Right / Dynamic All Directions
Dwell Time	The time the beam spends on a single pixel per pass (rounded to a multiple of 25 ns).
Beam	The beam (either electron or ion) used for patterning
Time	The time required to process the pattern.
Rotation	Pattern rotation angle. Positive direction is clockwise.
Position X / Y	Position of the pattern relative to the origin (the display center).
Overlap X / Y	Sets the beam diameter overlap. The value of the overlap can be positive or negative depending on a particular application. The overlap parameter influences the **Area Calculation** and the **Dose**.
Gas Type	The name of the gas that must be used to pattern this shape (or None if no gas is to be used).
Pitch X / Y	Sets the pitch between two spots.
Area Calculation	Area calculation is selected as **Pattern** or **Array** for when negative overlaps are required. The system will default to **Pattern** area calculation unless the user changes it.
Dose	Defines the charge dose per area. Be aware of different values depending on the **Area Calculation** setting.
Volume per dose	The volume of material that is removed per charge.
Saturation sputter rate	The maximum linear sputter rate for a given gas. Currently not used.
Refresh Time	The minimum loop time that must at least elapse before the next pass, so that the adsorbed gas can be refreshed.
Loop time	Time required for a single pass.
Area	The surface area of the pattern (read only).
Scan Type	Scanning strategy used while patterning: • **Raster:** The beam scans from left to right, then the beam is blanked and returns to the left starting point • **Serpentine**: The beam proceeds from left to right and back from right to left
Fill Style	For box and circular patterns, choose either to mill a **Solid** or only the **Frame**.
Passes	The number of passes that the beam scans over the pattern.

Table 7-3 Patterning Properties

Properties	Description
Defocus	The defocus of the beam (WD change). Influences the **Total Diameter** and **Area Calculation**. It allows focusing above (negative value) or below (positive value) the sample surface.
Blur	Like Defocus, but specifying the (additional) diameter of the blurred spot.
Interaction diameter	The interaction diameter for an infinitely small beam. Influences the Total diameter.
Total Diameter	The combination of the beam diameter and interaction diameter. This influences the **Overlap X/Y** and **Pitch X/Y** values.
Maximum dose per area	This describes the adsorbed gas layer, allowing a certain dose to be deposited at a higher rate than the saturation current density, allowing a temporary higher rate. (Currently not used).
Saturation current density	The current at which 63% of the saturation sputter rate is reached. (Currently not used).
Total Volume Sputter rate	The speed at which material is removed or deposited. (Currently not used).
Selective Milling Enabled	Corresponds to Enabled check box on the Selective Mill Tab.
Selective Milling Time Interval	Corresponds to the Interval adjuster on the Selective Mill Tab.
Min Contrast Threshold	Corresponds to the left border of the gray level to be processed for the selected pattern on the Selective Mill Tab.
Max Contrast Threshold	Corresponds to the right border of the gray level to be processed for the selected pattern on the Selective Mill Tab.
Endpoint Detection Enabled	
Signal Type	
Endpoint Type	
Layer Count	

Patterns Processing

You must define a pattern and select it before an application file can be selected. Select one of the existing patterns from the Patterning module list or draw a new one.

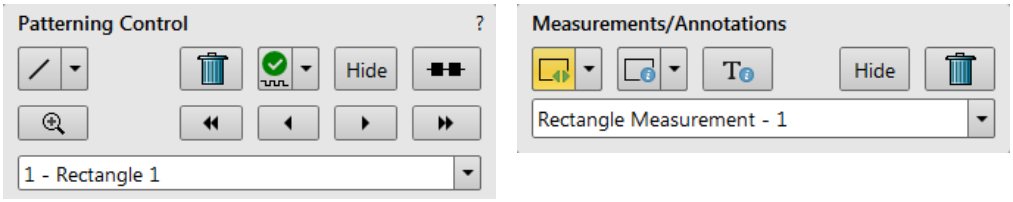
Importing / Exporting Patterns

User created patterns may be imported or exported (saved) via the **File** menu / **Import** or **Export** / **Patterns** item. The saved file (.ptf) contains all parameters found at the patterning Properties module for all patterns drawn in the active display.

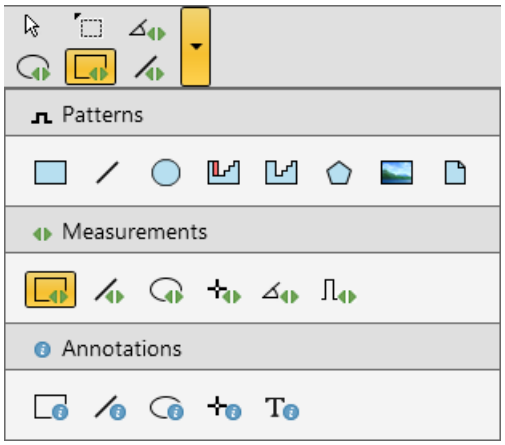
Six (for each beam) toolbar **Pattern Presets** (labeled p#) can be individually assigned to any of these .ptf file. This assignment can be saved or loaded by the **File** menu / **Export** or **Import** / **System Parameters** item.

Patterns / Measurements / Annotations Editing

To create or edit patterns / measurements and/or annotations it is also possible to use the Patterning Control / Measurements/Annotations module with some added controls (see above).



A Pattern, Measurement or Annotation can be drawn and modified (focusing, moving, or resizing) by the toolbar functions in the same way. This gives a user many capabilities to draw pattern shapes, to measure distances, angles, diameters and areas as well as locating and labelling items that are of significant interest on the sample area.



Each tool shows its description as a tooltip.

- **Patterns** – enable to create various pattern objects, which are prepared for subsequent processing.
- **Measurements** graphics – enable to gain dimension information about a specimen feature by overlaying it with a measurement object of different shapes. By changing the magnification these objects resize accordingly.
- **Annotations** graphics – enable to graphically highlight and label items of interest with different shapes.

Shape Creating

Selected tool is shown as the toolbar icon. Clicking on it activates (drawing mode – orange background) / deactivates (white arrow cursor – normal background) the tool. Clicking on the down arrow icon opens the list of available tools, the chosen one is activated from that time on and the object can be drawn onscreen.

To deactivate the drawing mode at any time is possible by pressing the keyboard **Esc** button, or click the toolbar **Arrow** icon.

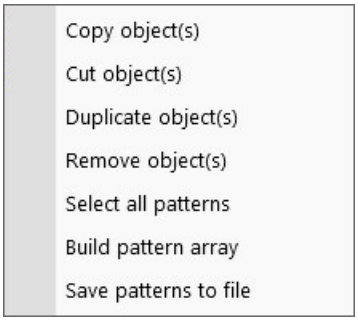
When clicking on an image display in Quad Image mode with the cursor that creates patterns, a slight mouse movement might produce a small unwanted pattern. If you create a small pattern accidentally, delete it by clicking **Delete** while the pattern is active or click the **Trash** button.

1. Choose the suitable **Patterns / Measurements / Annotations** graphic tool.
2. Draw the graphic over the area of interest. This can be done by:
   – clicking on & dragging the cursor in any direction
   – Shift + clicking on & dragging the cursor to any direction – create a shape starting to grow from the point where you have clicked as from the center

To create a text label click the **T** annotation tool, create a rectangle area into which a text should fit and start writing.

Shape Editing

Once a Pattern / Measurement / Annotation object has been drawn, it can be correctly adjusted in size and position over the area of interest by clicking on the Arrow symbol button and bringing the cursor back to the onscreen graphic. A number of appropriate properties are available in the property editor, which can be changed by a selection from a drop down list or by direct precise editing of a text or a value.



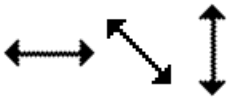
Right-clicking above any shape type shows the corresponding context menu with additional options.

If there are more graphics on screen, use the Arrow cursor to focus on one in particular by clicking on the graphic. Selected object is denoted by the addition of resizing handles (white rounded or square points) to the graphic outline. Moving mouse point cursor in the vicinity of these points forces the cursor to change:

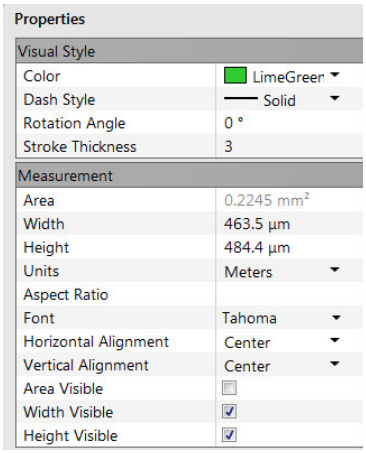
- **Moving** (by mouse): click on inside the boundary of the object and drag it. To move the selected pattern(s) at orthogonal directions hold the **Shift** key when clicking and dragging.
- **Moving** (by keyboard): to move a pattern by one pixel:
  Ctrl + Alt + left arrow = move to the left
  Ctrl + Alt + right arrow = move to the right
  Ctrl + Alt + up arrow = move up
  Ctrl + Alt + down arrow = move down

  If the keys are being held down, the keystrokes are automatically sent from the keyboard until the key is released. After the third keystroke, the counter of keystrokes should be cleared.

The greater pattern placement precision may be accomplished by using the Digital zoom mode.



- **Rotating**: click on the object rotation control (white point in the middle above the graphic) and drag it.
- **Resizing**: click on & drag the resizing handle until the desired size is reached (horizontal / vertical / diagonal resizing cursor). Holding the Ctrl key while dragging forces dimensions to be changed proportionally.
- **Select all objects** (within the selected display):
  click the **Select All** button or press **Ctrl + A**.
  All shape editing functionality are available also for multiple selected shapes.
- **Select multiple objects** (within the selected display):
  Shift + click (while in the Patterning Control module list) to enable continuous selection of patterns.
  Ctrl + click (within the Patterning Control module list or the selected display) to enable adding/removing of actual pattern to/from the selection.
  Press **Esc** to restore the previous selection.
- **Delete selected object(s)**: press the **Delete** key.
- **Copy / Cut / Paste**: Select a pattern and then use the Edit menu or the keyboard shortcuts: **Ctrl + C / Ctrl + X / Ctrl + V**



Using the Properties list

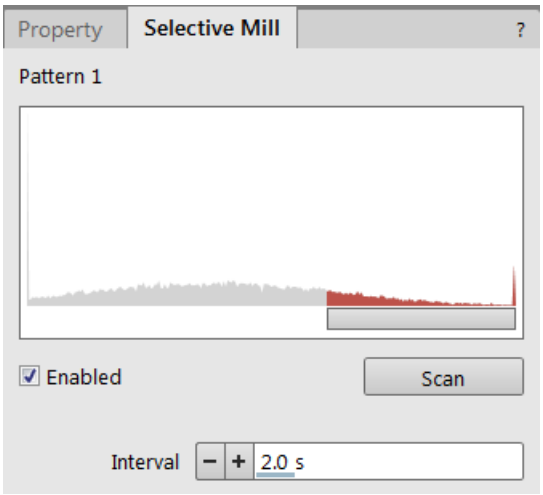
Whether to change a properties of a pattern, measurement or annotation, you can enter the Properties module for the graphic or text you have selected.

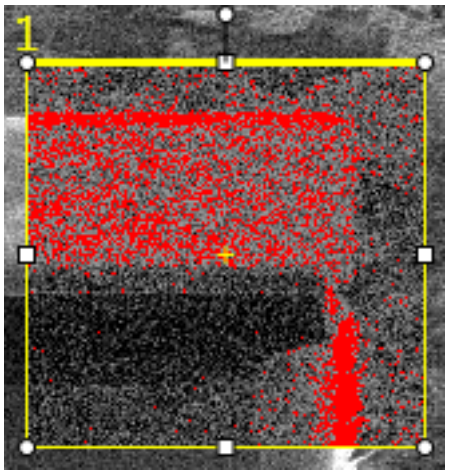
Items such as color, font, line width, measurement type, and text position can be defined. Some properties have a dropdown list, so a choice can be made that will update onscreen for the selected graphic. Numerical values can be entered in text editors, with some properties, to affect the outcome of the graphic onscreen. These will show a text cursor in the edit area when clicked on.

When there is more than one graphic, use the Arrow cursor to gain information from each in turn. The Arrow cursor is only active on screen and changes automatically to the command cursor when over the UI.

Selective Mill tabbed module

Shows selective milling information. It is possible to set a given grey level range to be processed in the extent of the selected pattern area.





- **Enabled** check box: When ticked, enables the selective milling.
- **Scan** button: Enabled for patterns that support selective milling. Clicking it causes the histogram to be shown.
  Move the horizontal grey bar to set a desired grey level range and also move the red rectangle edges to set the grey level extent.
- **Interval** adjuster: Selects the time [s] after which the histogram is actualised.

NOTE During patterning, when you perform a scan and select **Enabled**, the histogram will be updated approximately every second. If you did not perform a scan but selected **Enabled**, adjusted the threshold marker, and started the patterning job, the histogram would remain as it is in the 'Before clicking **Scan**' example.

Advanced patterning tabbed modules

These tabbed modules (iSPI / Monitor / Charge Neutralizer / Progress) give visual feedback on the progress of a milling process. It shows the specimen current (charge absorbed in the specimen) and enables to monitor the specimen current changes as the ion beam interacts with different materials in the sample. For example the differences encountered when milling through some dielectric and striking another one are usually very subtle, but once the beam begins milling into metal, a dramatic difference in absorbed charge can be observed on the Monitor tab / window.

Fast iSPI Mode

iSPI is short for "Intermitted Switching between Patterning and Imaging." Fast iSPI mode is a basic usage toolsetting mode that keeps the beams more coincident, causing faster performance. In the SEM Mode 2 (Immersion/UHR), ion beam shift is used to point the two beams at the same place.

NOTE Changing SEM focus affects the position of the ion beam.

When milling a cross section with the ion beam, users frequently switch to the electron beam to capture SEM images so they can observe the exact position of the current cross section.

Table 7-4 Fast iSPI Mode Selection Differences

FIBI (FIB Immersion) Mode	Do Not Degauss
Can only be used at < 3 kV (the field is too strong above that, causing too much FIB beam shift)	Can be used at all kVs.
No switching time	1 s switching time
Ion Column: FIBI Alignment must be performed before using	
True immersion possible	

Caution!	When performing Intermittent Switching (iSPI) between Ion beam patterning and SEM Imaging/Snapshot in the SEM Mode 2 (Immersion/UHR), be aware of using "Do not Degauss" functionality. It may cause an ion image shift relative to formerly created pattern area (affecting the patterning location!). Allowing of the Degauss functionality prevents this behavior, but extend the switching time between the beams.

1. Define the pattern with the ion beam.
2. Select **FIBI** (**FIB Immersion) mode** icon from the toolbar or **Do Not Degauss** to enter fast iSPI mode.
3. Choose the required Time or CCS Line Interval for the iSPI image:
   - For a Cleaning Cross Section, select a CCS Line Interval to take an electron beam image every "x" number of slices.
   - For all other patterns, select a Time Interval to take an electron beam image every "x" number of seconds.
4. Unpause electron imaging in display 1. You can unpause other electron beam displays with different detectors (e.g., TLD and STEM). Simultaneous images are grabbed in such a case.

NOTE	You can expect to see a shadow mill when running in the SEM Mode 2 (Immersion/UHR). The shadow mill will be equal in width and height to the original mill. The depth is like a surface burn.

Reduced area

Using the Reduced area (**F7**) functionality during patterning with the iSPI mode on within the electron beam display pauses patterning and electron imaging takes place in the Reduced area only to enable tuning of the imaging.

Using the iSPI Reduced area (**Shift + F7**) functionality continues with patterning, and SEM images are grabbed from the reduced area only.

End Point Monitor (EPM)

The End Point Monitor gives visual feedback on the progress of a milling process. This device can be activated to start when patterning starts, stop when patterning is paused, and restart when patterning is continued.

Table 7-5 Advanced Patterning Modules Overview (1 of 2)

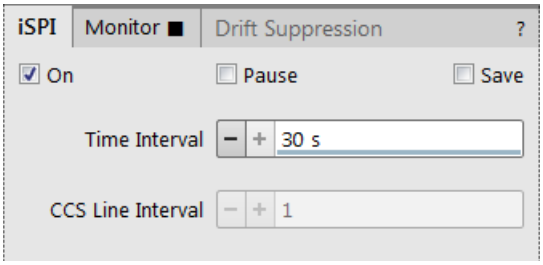
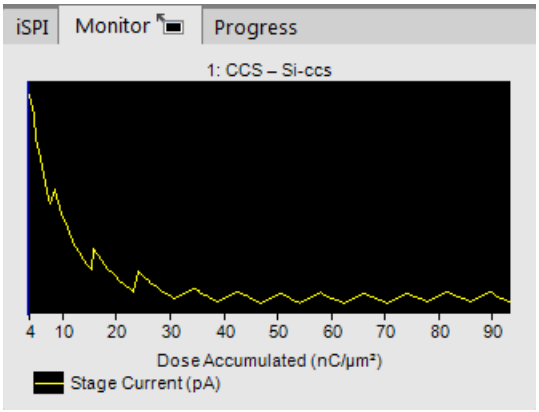
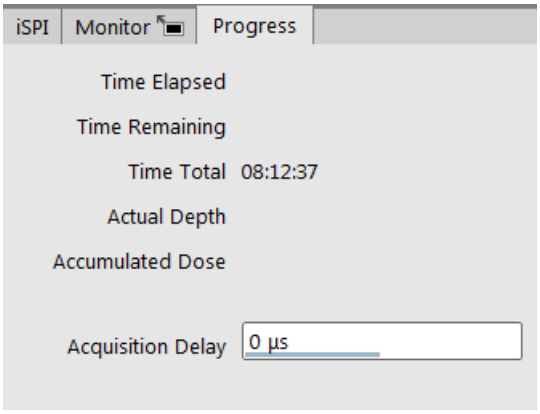
Interface Item	Description
iSPI tab	iSPI (Intermittent Switching between Patterning and Imaging) means that pattern progress can be automatically monitored with electron beam images at selectable intervals. 
On check box	When ticked it starts the iSPI mode, in which the ion beam is paused during electron imaging to minimize the interferences If the **Paterning** menu / **Auto-Start/Stop Electron Acquisition for iSPI** item is ticked the system runs this functionality automatically, otherwise a user must release the electron beam display during patterning in another one. **Note:** *When the* **On** *check box is not ticked, system runs in the SPI mode.*
Pause check box	When ticked it pauses the patterning process after each electron image acquisition according to the **Time Interval** / **CCS Line Interval** slider, which sets the interval after which the system acquires an electron image.
Save check box	When ticked it starts storing of all images acquired during the patterning process (from all live displays). The name, destination and type of stored images are set in the **Preferences** / **Movie** section / **File Settings** area.
Time Interval slider	Selects a time interval (x seconds) to take an electron beam image and pauses the electron imaging. For all patterns except the Cleaning Cross Section.
CCS Line Interval slider	Selects the x number of slices to take an electron beam image and pauses the electron imaging. For the Cleaning Cross Section only.

Table 7-5 Advanced Patterning Modules Overview (2 of 2)

Interface Item	Description
Monitor tab	Shows a reduced view of the **End Point Monitor Plot** window. Click the **black rectangle** next to its label, without regard to be focused on any other module, to access full size Monitor window. The black rectangle changes, clicking on it again closes the Monitor window. See below this table. 
Progress tab	Use the Progress tab to monitor the progress of ongoing processes. 

End Point Monitor Plot Window

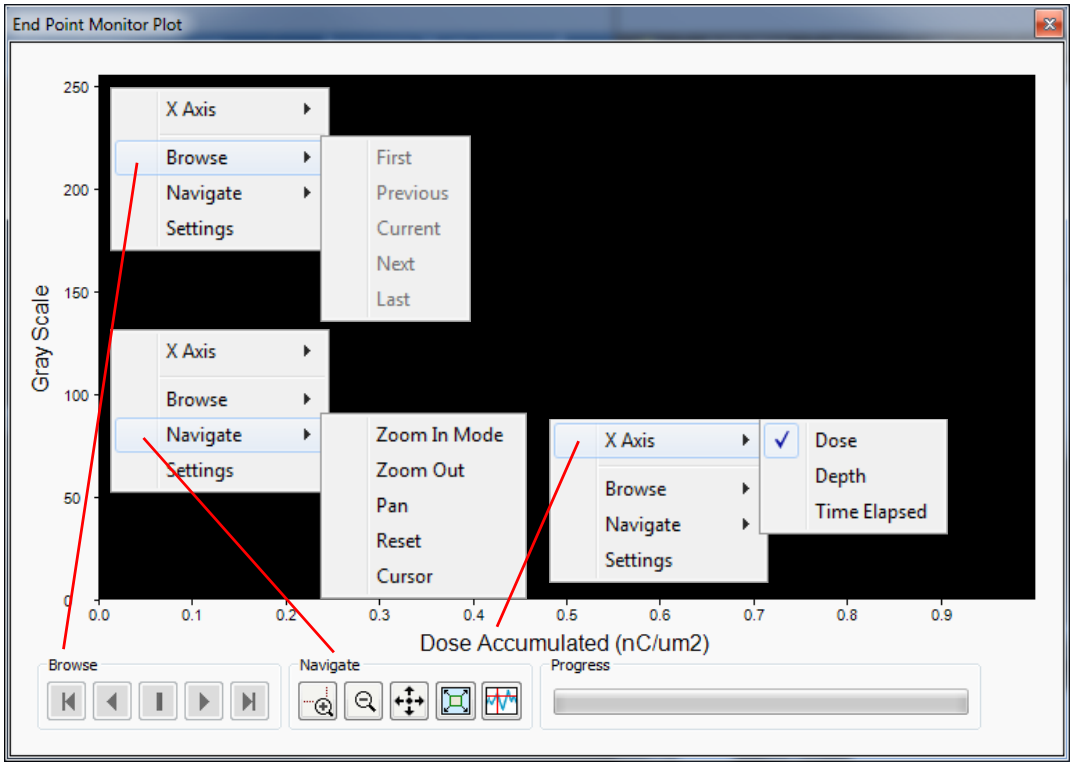
Monitor tab module can be enlarged to the **End Point Monitor Plot window** by clicking the black rectangle next to its label. It illustrates in live time the cutting depth progress monitored by the specimen current. This means the milling progress can be observed as a colored graphics showing the specimen current profile over the progressively milled area.

Each time patterning is started a new graph is started automatically. Pausing / resuming of a patterning stops / continues to plot the graph. When serial patterning mode is set,

there is only one graph, when parallel one is set, there can be more of them.

To configure the window, right-click over the graphical area to access a menu and make a selection or use icons within the correspondingly labeled section.

Figure 7-2 End Point Monitor Plot Window

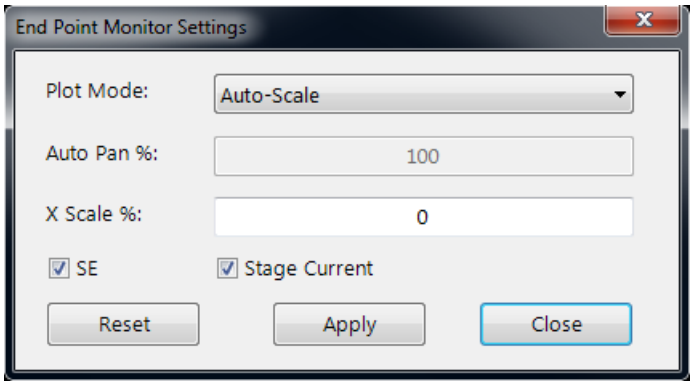


- **Grey Scale** axis shows the average gray value for the iRTM image of the active pattern.
- **X-axis** menu (*Dose / Depth / Time Elapsed*): offers the choice for X-axis description. At least and only one can be selected at a time.
- **Browse** menu (*First / Previous / Current / Next / Last*): offers choices to move from one graph to another.
- **Navigate** menu: it is possible to enter *Zoom In Mode* to enlarge an inspected area or to *Zoom Out* the view. The *Pan* mode enables to scroll around in the enlarged area. The *Reset* choice returns a scale and pan to default. The *Cursor* is used browse to and to explore data points on each plot.
- The **Progress** bar provides visual feedback on the progress of the patterning process.

End Point Monitor Settings dialogue

Clicking the Settings item opens dialogue to set basic plot parameters.

Figure 7-3 End Point Monitor Plot Window



- Initially the graph **Plot Mode** is *Auto-Scale*, meaning that the minimum and maximum of both axes are computed automatically so that the graph is completely visible.

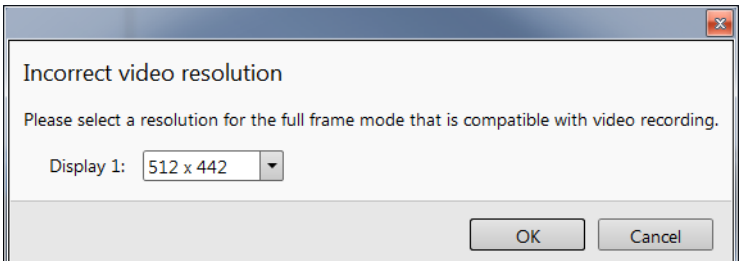
  As points are added during patterning the graph may rescale to achieve this. It is possible to set **X Scale** % to keep graph scale in a fixed level.
- Dragging a rectangle in the graph when in Zoom In Mode zooms in that rectangle and the graph switches to a *Auto-Pan*. In this mode the graph is automatically moved forward according to an **Auto Pan** % value.
- The **SE** (Secondary Electrons) check box switches show of RTM curve in the Monitor graph.
- The **Stage Current** check box switches show of stage (specimen) current in the Monitor graph.
- Switching back to default is possible by clicking the **Reset** button or via the **Navigate** menu / **Reset** item.
- The **Apply** button propagates new settings.

Autosaving Images

The **Save** check box on the iSPI tab is used to save an image at each iSPI iteration.

- Once iSPI is started and Save is enabled, the system will save a new image at each iSPI iteration.
- You can enable/disable the Save functionality while iSPI is running.

- Once the patterning is started, if the Save check box is ticked, the Movie function will start recording and saving the images in the folder as defined in the **Preferences > Movie** menu.
- The AutoSave function will use the same options as set in the **Preferences > Movie** menu with the addition that the save only TIF option is selected. The timer is set to 0.2 seconds. This option will be set to the previous value once the patterning is finished or the **Save** check box is cleared.
- The naming conventions are the same as for the Movie function.
- The limitations are the same as for the Movie function (512 or 1 k image, 0.5 time interval). If the resolution is outside the limits, the same behavior of the Movie function will be used and the following popup window will be shown.



- If the **Save** check box is cleared, the Movie function will be stopped and the TIF option of the Movie function will be set to the previous value.
- If patterning is stopped or finished, the Movie function will be stopped and the TIF option of the Movie function will be set to the previous value.
- If the **iSPI** check box is cleared, the Movie function will be stopped and the TIF option of the Movie function will be set to the previous value.
- If the **Recording** toolbar button is deselected manually by the user (note the **Save** check box is then forcibly cleared).
- If recording is already running (started manually by the **Recording** toolbar button), the **Save** check box is disabled.

Real Time Monitor

The real time monitor (RTM) provides immediate feedback on the patterning process. The patterned area is observed and in case of relatively slow scanning, the scan trajectory can be inspected.

RTM is typically used for an end point detection by observing brightness differences in the detector signal. These result from contrast differences, e.g., when milling through layers of different

composition on a stack of multiple materials or releasing a TEM foil from the EasyLift tip.

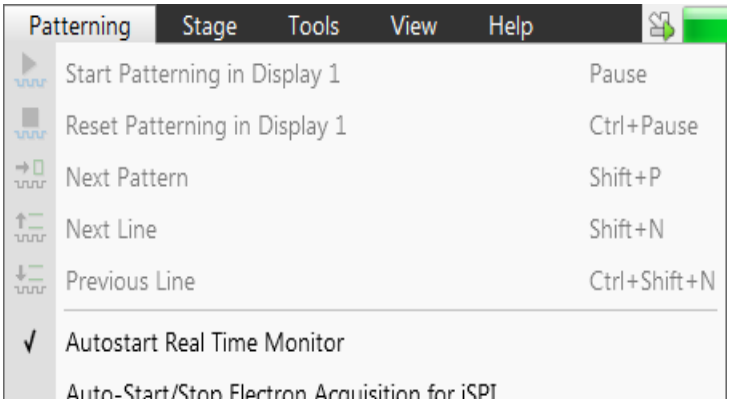
RTM can be used with either beam (SEM and FIB), and with any of the pattern types that are available in the UI.

When starting patterning with the RTM activated, the pattern shape in the UI will be updated with real time image information. The patterned area information is updated based on the detector signal which is shown in synchronization with the beam trajectory. Because the detector signal is synchronized with the scan of the patterning beam (usually FIB), the other beam cannot be used to make a live imaging while patterning (iSPI mode: Simultaneous Imaging and Patterning cannot be used simultaneously with RTM). As an alternative, it is always possible to grab snapshot with the SEM during FIB patterning while using RTM.

Starting and Stopping RTM

The RTM will run if two conditions are met:

- Patterning is active.
- **Patterning** menu **/ Autostart Real Time Monitor** item is activated, or imaging in the ion display with the pattern is unpaused.



These conditions can be realized in two ways:

- Start patterning while the **Autostart Real Time Monitor** item is activated.
- Unpause the imaging in the same display where a patterning task is running.

If the SEM image is live at the moment the RTM is activated, it is automatically frozen. After patterning (or when the RTM is turned off), SEM imaging will not be resumed automatically.

The RTM is automatically stopped:

- Whenever a pattern is reset or finishes because the total patterning has elapsed.
- After a snapshot is taken in the same display where the patterning is active. This is to prevent the RTM information from instantaneously overwriting the snapshot image.
- When SPI mode is activated during patterning.

To force the RTM to stop while patterning continuous, click **Pause** with the FIB-display active. The same can be done to manually start the RTM with the FIB-display active.

RTM and FIB Snapshots

The following procedure assumes that the patterning beam is the ion beam, and the pattern is defined and running in display 2. Similar behavior is valid for other displays or when the SEM is the patterning beam.

In order to have both RTM information and FIB snapshot information available, the latter needs to be taken in a different display, e.g., display 3.

In the following procedure, the display number can be different.

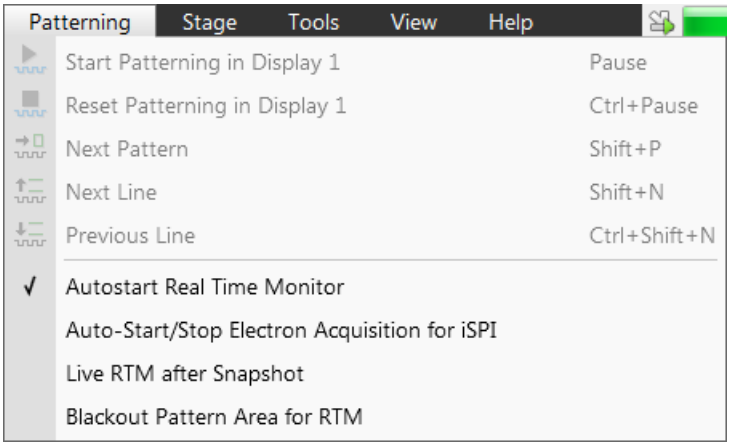
1. Select **Patterning > Autostart Real Time Monitor**.
2. Define the pattern in display 2 (FIB display).
3. Set display 3 to FIB.
4. Start patterning in display 2. This will automatically start the RTM.
5. Click in display 3 to activate it.
6. Take snapshots as required.

Following these steps, display 2 will continuously update with fresh RTM information as the ion beam is executing the pattern. In the mean time, you can take FIB snapshots as often as needed.

As an alternative, the RTM can be restarted manually by clicking on the **Pause** button in the same display, as described above.

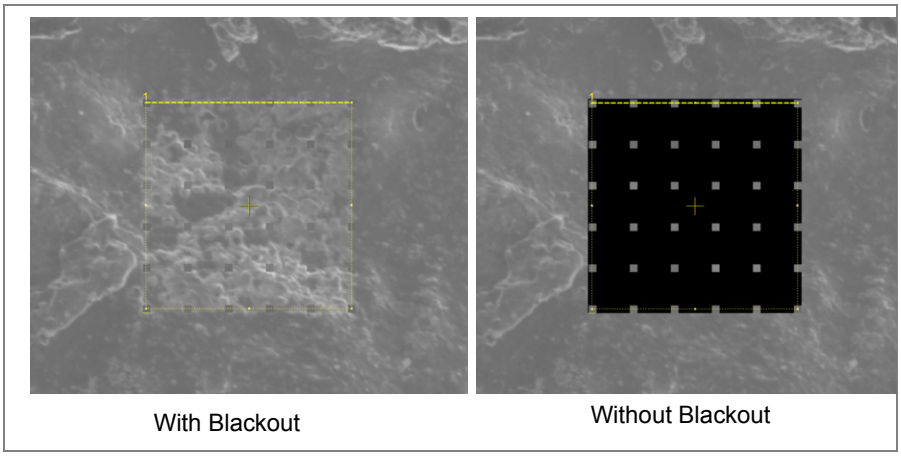
Blackout Pattern Area for RTM

When selected on the Patterning menu, the pattern background where the RTM is shown is made black in order to enhance the visibility of the RTM information. This is especially important for patterns with extremely large pitch or very thin lines.



The images in the following figure illustrate the difference with and without blackout. Note that with the blackout, the visibility of the individual patterning pixels is greatly enhanced.

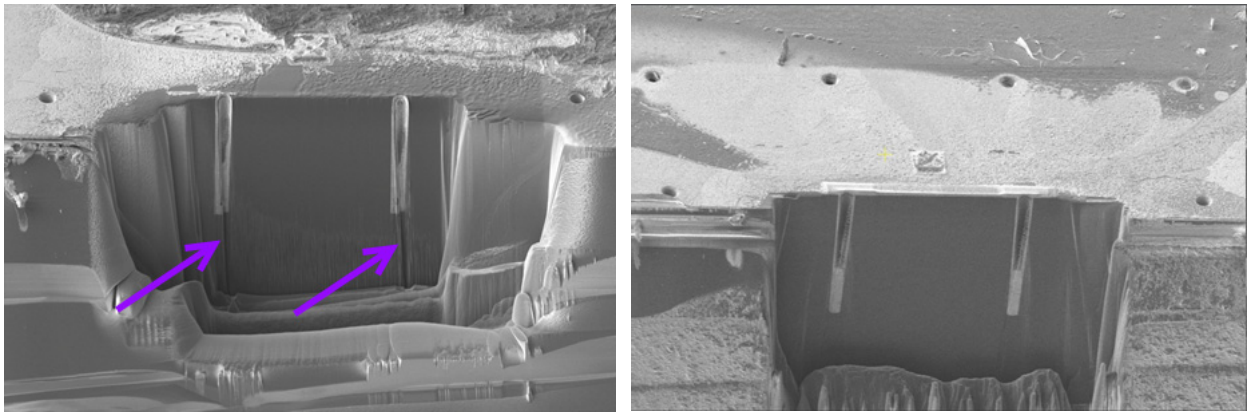
Figure 7-4 With and Without Blackout



Rocking Polish

Rocking polish is a technique used to reduce the effect of curtaining caused by differential milling rates from surface topography or differences in sample materials. This technique is achieved by using two alternating milling angles on the cross-section face during the final polishing step.

Figure 7-5 Cross section: with curtains / Rocking polished



Prerequisites

- Platinum deposition (or your metal of choice) is ready to use.
- Check that the compucentric rotation inaccuracy is less than 50 µm; otherwise run the *Stage Alignments* > *Stage Rotation Center* alignment.
- The *I-column: Alignments* > *Beam Shift Alignment* is done for all the ion beam currents which are going to be used.

Rocking Mill Holder / Carrier installation

Tools needed:

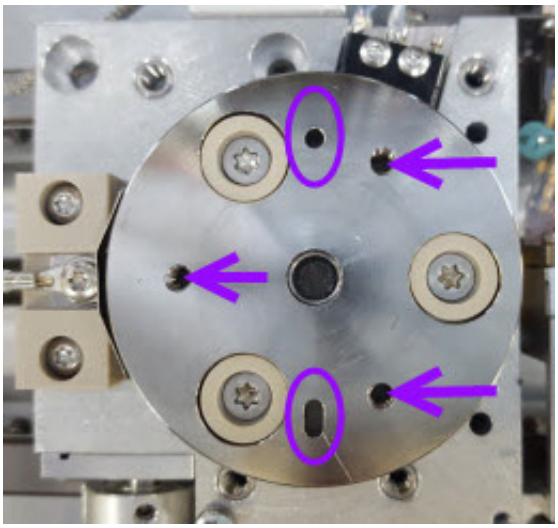
- 2.5 and 1.5 mm hex keys
- Alway use the dust-free gloves appropriate for vacuum usage

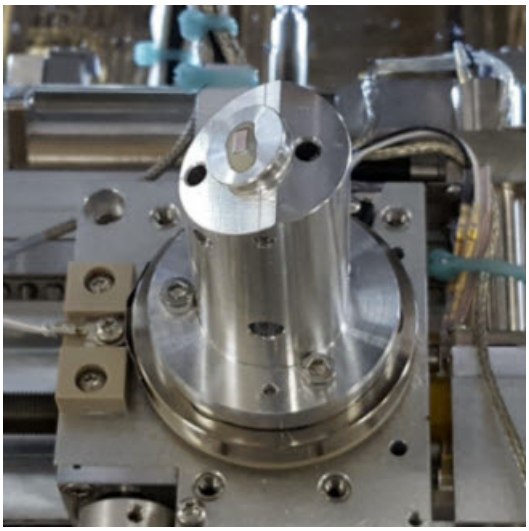
Procedure for UXe / CXe models

1. Click the *Vacuum* module > *Vent* button.
2. Set the *Sample Exchange* > *Holder type* > *Other Accessory*.
3. Set stage rotation to 0°.
4. Remove any sample holder (if present) from the stage.
5. The two keyed-pin holes (purple ovals) and the three screw holes (purple arrows) serve to mount the Rocking Mill holder;

to the stage in only one position (looking from the front): the beveled edge slopes to the left and faces the ion column.

Take care to push the Rocking Mill holder down flat before tightening the screws!





6. Use the 2.5 mm hex key to tighten the three screws. Do not overtighten.

Procedure for HXe model

The sample exchange takes place with use of the Loadlock Rocking Mill carrier.

Sample loading

Prerequisites

The maximum sample dimension is

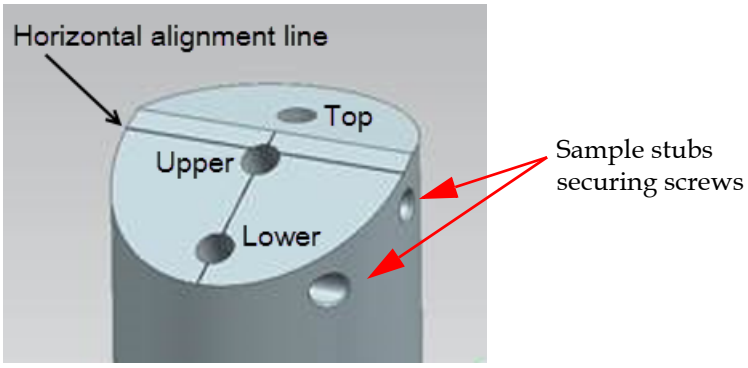
- UXe / CXe: (30 × 30 × 5) mm; the Rocking Mill holder travel range is over the central (25 × 25) mm.
- HXe: (25 × 25) mm; the Rocking Mill carrier can accommodate up to the 25 mm (1") diameter stubs on the 30° pre-tilted position.

Procedure for UXe / CXe models

1. Click the *Vacuum* module > *Vent* button.
2. Set stage rotation to 90°, so that set screws are accessible.
3. Mount the sample on the stub as flat as possible.
4. Load stub onto pre-tilted Rocking Mill holder. There are one horizontal and two tilted positions:

- Level top position can be used for regular applications.
- Upper tilted position for small samples

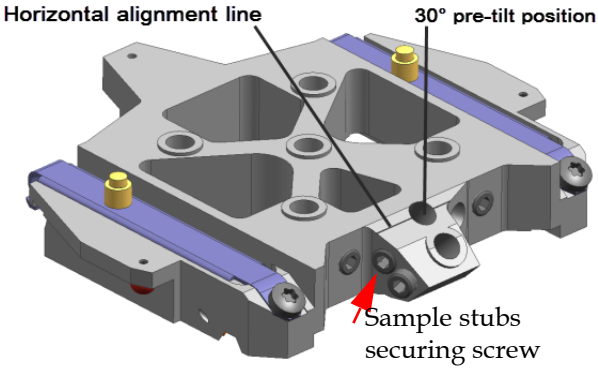
- Lower tilted position for larger samples v
  The goal is to get the region of interest as close to the alignment line as possible.

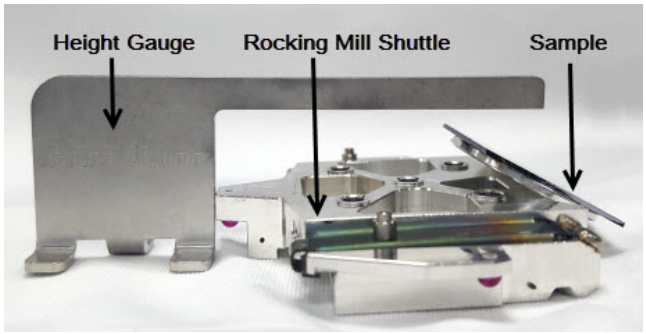


5. Rotate the stub, so that the top of the sample is on the lower side of the slope. Try to rotate it to the desired angle of the sample.
6. Tighten the stub with the 1.5 mm hex key; use the alignment line as a guide to check the sample position.
7. Set stage rotation to 0°.
8. Click the *Vacuum* module > *Pump* button and wake the system.

Procedure for HXe model

1. Mount the sample on the stub as flat as possible.
2. Load stub onto pre-tilted Rocking Mill carrier.
   The identifying feature of the carrier is an upper hole on the 30° pre-tilted surface. Check the carrier with the loaded stub fits under the height gauge.





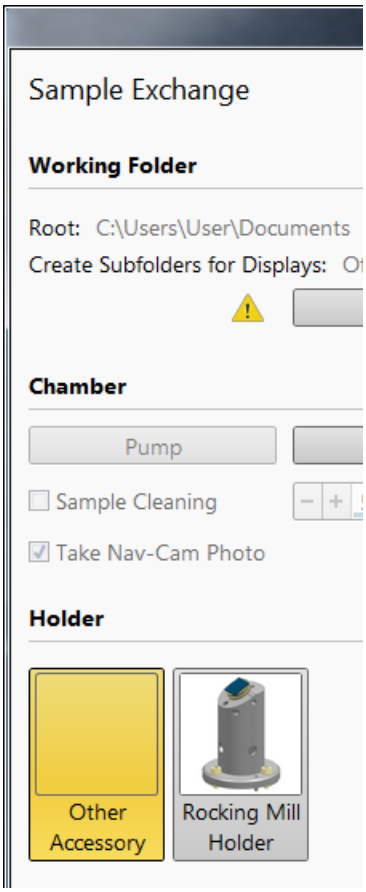
3. Rotate the stub so that the top of the sample is on the lower side of the slope. Try to rotate it to the desired angle of the sample.
4. Tighten the stub with the 1.5 mm hex key; use the alignment line as a guide to check the sample position.

5. Load the Rocking Mill Shuttle into the chamber and wake the system.

System setup

When the sample is loaded to the system, follow with the beams coincidence setup:

6. Set the *Sample Exchange* > *Holder type* > *Other Accessory*.
7. Roughly set the Eucentric position (see Chapter 7).
8. Set the *Sample Exchange* > *Holder* type > *Rocking Mill Holder*.
9. At stage tilt 0°, in the electron imaging, bring a recognizable feature in the center of the screen.
10. In the ion imaging, raise or lower the stage until the same feature is in the center of the screen.
11. Link Z to FWD.
12. Setting the stage tilt to 22°, sets the 30° pre-tilted surface perpendicular to the ion beam.



Related software features

When you select *Rocking Mill Holder / Carrier* along with the ticked *Stage* module > *Z-Y Link* check box, the software tilts the stage allowing the stage to move along multiple axes to keep the working distance consistent.

Within an ion imaging, the working distance is only maintained for *Get moves* (see Chapter 7) or moves in the motion pages. The *Track moves* (such as with the joystick or middle-mouse button) are not supported for keeping the working distance.

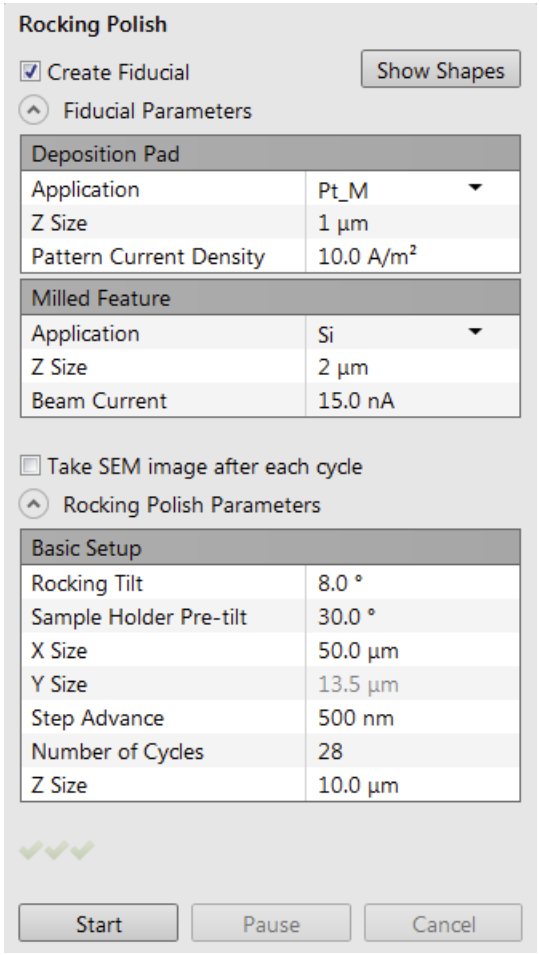
When you tick the *Stage* module > *Compucentric Rotation* check box and the rotation changes, the software calculates new X, Y coordinates to bring the center feature back to the beam.

Some restrictions are placed on stage motion for sample and system safety: Rotation range is limited to ± 90° and only one sample can be used at a time if the rotation is more than 90°.

Rocking Polish module

The module with controls is accessible on the Rocking Polish page (modified Patterning page). Clicking the down / up arrow for the *Fiducial Parameters* and for the *Rocking Polish Parameters* expands / collapse the controls fully.

Figure 7-6 Rocking Polish module



- Ticking the *Create Fiducial* check box creates *Deposition Pad* used as part of the alignment mark with set Fiducial parameters.

Deposition Pad – fiducial parameters for a deposition pad used as part of the alignment mark.

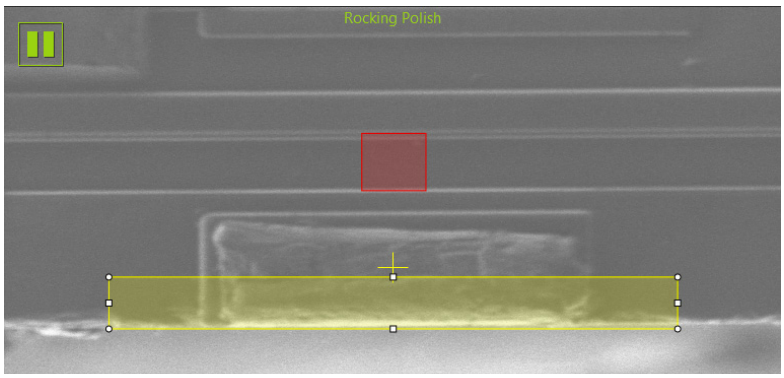
- *Application*: Choose the application file for the deposition material you want to use for the fiducial pad (typically Pt_M). If you do not want or need a deposition, then set the Application file to Si and the Pad Height to 1 nm.
- *Z Size*: Thickness of the fiducial pad, which is typically set to 1 µm. Thicker depositions take more time.
- *Pattern Current density*: Beam current into the pattern area. For Pt, this is typically set to 10 A/m^2 for a time-optimized pad.

Milled Feature – fiducial parameters for a cross-milled section into the deposition pad for an alignment mark.

- *Application*: Application file for milling the fiducial feature in the pad. This is typically set to Si.
- *Z Size*: Depth of the fiducial feature. This is typically set between half and double the pad thickness, but the same as the pad height (1 µm).
- *Beam Current* used for milling the fiducial feature. This depends on the size of the feature, 15 nA works well.
- *Take SEM image after each cycle*: tick this check box to take a SEM picture after each cycle. This is useful for attended milling, but it prolongs the process.

Basic setup – rocking polish parameters

- *Rocking Tilt*: Angle in degrees to rock to the side. It will rock + and – this angle. Use 5–12°.
- *Sample Holder Pre-tilt*: Use 30°.
- *X / Y Size*: Width / Height of the rocking polish mill. Type the value in the field or drag the yellow border.



- *Y Size*: Height of the rocking polish mill. The Type the value by typing in the field or by dragging the yellow box (see image on the next page).
- Step Advance: Type the value, typically from 50–90% of the beam diameter. Higher values are associated with finer polishing, but require more time to process. One option is to draw a cleaning cross section at the beam current you are going to use and refer to the Y pitch size.

Operations

Perform the following tasks to set up the rocking polish technique.

Rocking polish set up

1. On the Navigation page, click Compucentric Rotation and then click Z-Y Link.

2. Use the stage X and Y (or active Nav-Cam) to locate your feature.
3. Once you locate your feature, double check the height by keeping the tilt at 22 degrees while centering your feature in the SEM (double-click or joystick). Then while FIB imaging, raise or lower the stage until the same feature is centered. It should still be centered in the SEM.
4. If needed, use Align Rotate to set the precise rotation of your feature within +/- 10 degrees rotation of the stage.
5. Use normal cross-section methods for a bulk cross section straight down and deposition if desired. Make it 25-50% wider to allow room for the rocking angles.
6. Check the coincidence height by acquiring a SEM and FIB image to confirm that the same feature is centered. Do the following if you need to adjust the height:

   a. Position the feature in the center of the FIB image.

   b. Click the Z-Y Link check box to deselect this software feature.

   c. Start imaging in the SEM. Move Stage Z up or down until the feature is centered in the SEM image.

   d. Click the Z-Y Link check box to select this software feature.
7. Click the Pattern Start button in the vertical toolbar to open the Rocking Polish panel.
8. Click the Create Fiducial check box to select it. You might leave this unchecked if there is already a fiducial that you want to use instead.
9. Click the Show Shapes button.
10. Insert the MultiChem (or GIS) for deposition.
11. Drag the boxes around to where you want them.

- The red/green box is for the fiducial placement. The red/green fiducial box should be at least ~1/8 the size of X Size of the cross section.
- The yellow box is where the rocking polish cleaning cross-section pattern will go.

12. Choose the beam current that you want to use for the FIB cross-sectioning. Set the focus, stigmator, and contrast brightness.
13. Choose the SEM settings you want for the images: horizontal field width (HFW), current, voltage, scan speed, frame size, detector, contrast-brightness, and lens mode.
14. Set the fiducial parameters to the following:

- Deposition Pad: Application = Pt_M; Z Size = 1 µm; Beam Current Density = 10 A/m^2
- Milled Feature: Application = Si; Z Size = 1 µm; Beam Current = 15 nA

15. Confirm that the SEM scan rotation is at 0° if you want to use Dynamic Focus. Set up the scan speed and HFW that you want for the images.
16. Click the Start button on the Rocking Polish page. Do not click the Pattern Start button on the vertical toolbar.

Rocking polish cycles

The following actions are allowed during the rocking polish cycles.

- Observe the progress time remaining for each pattern (first the fiducial deposition, then the fiducial milling, and then the cross section) toward the top of the page.
- Change the SEM settings of contrast, brightness, scan speed, and frame size. The live imaging settings are used for the periodic SEM images.
- If the depth you want is achieved for a slice, then click the next pattern. Monitoring the End Point Monitor can help you decide since this feature speeds up operation.
- Click Cancel if the process is not working correctly or if you are finished. Let the process finish resetting the position before you work with the microscope.
- Grab SEM images during milling by choosing them in the SEM quad and then click Snapshot from the toolbar.
- Watch live milling by choosing the SEM quad and then unpausing the SEM. Secondary electrons from milling will be present, so you will need a beam current that is equal or greater than the FIB to get a decent SEM image (frame averaging helps the image quality). Press F6 to unpause each cycle individually.
- Click the Take SEM image after each cycle check box to deselect this option if the process is proceeding well and if it saves you time. You can select this option later if you want to get an update on the progress.
- You can read the Basic Setup parameters between each cycle and change them during the process. For example, it can be beneficial to start out with a smaller Z size and then increase it over time if needed.

View the sample with the SEM

Perform the following procedure to view the sample top-down with the SEM for locating the region of interest.

1. From the milling view position, click the Add button on the Navigation page to save the position if you want to get back to it.
2. Confirm that the Compucentric Rotation and Z-Y Link are both enabled.
3. Tilt the stage to 0°.
4. Set sample holder to Bulk Holder.
5. Set Rotate Relative to 180°.
6. Set the sample holder to Rocking Mill Holder.
7. Set the Tilt to 30°.
8. Set Scan Rotate to 180°.
9. Start scanning with SEM.
10. Save this position if you want to come back to it later.
11. To go back to milling position, recall your stored location and set the scan rotation back to 0°. If you manually reverse the steps, then you have to set the sample holder to Bulk Holder to rotate the stage. The sample is now ready for you to scan it with the FIB.

Note
In the SEM view, the working distance is maintained by the holder selection and Z-Y Link during joystick use and double clicks. Get stage moves if the stage is rotated to exactly 180 degrees and is closely approximated if the stage is near that rotation value.

Calculate rocking polish mill width (X size)

You need to know how deep you want to mill, generally around 10–25% deeper than the feature. This formula will calculate how much wider you need to make the cross-section pattern to allow the rocked milling to sweep by the bottom of your desired cross section at a given rocking tilt.

Wider [µm] = 2× depth [µm] × tan [°] (rocking angle)

Operational tips

- You can use CAD navigation with the pre-tilted holder using the SEM settings described above and the stage tilt set at 0°. Start with the alignment point that is highest. Do not change stage Z, but refocus at each alignment point and the navigation locations.

- Tilt correction for the scan does not work with scan-rotated images and the rocking polish process uses scan rotation. You can use the annotation measurements. Set the tilt correction for the measurement to the type you want (cross section or surface), set the tilt to manual, and then enter the combined tilt value.

Troubleshoot

Fiducial not found

- If you have set up everything, it has made the fiducial, and during the mill setup you get a "Fiducial Not Found" error, then the process will return to the milling view to wait for your instructions. Check the AutoContrastBrightness, reduce the Rocking Tilt angle, and change the field of view (it should be 2 to 4 times larger than the X size of the pattern). Check the quality of the fiducial mark to confirm that it is clear in the image.
- If the sample is charging during the initial viewing and you get a "Fiducial Not Found"error, first start imaging and then while imaging start the rocking polish process.
- If you get a "Fiducial Not Found" error after the first acquisition, then remember to clear the Create Fiducial check box before restarting the Rocking Mill. With Show Shapes turned on, move the fiducial box to make it red so that it will reacquire the mark. Otherwise, it will reuse the existing acquisition which may not work as expected.

Application files

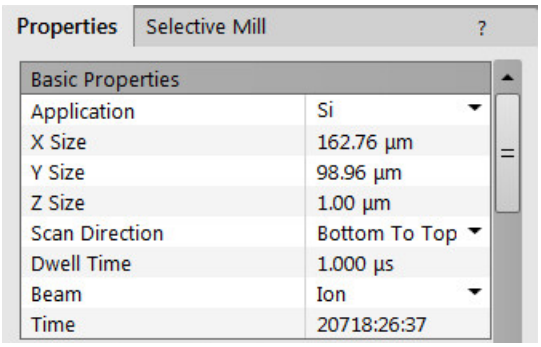
Application files are used with various gas types. With multiple GIS's / MultiChem installed on your system, you can select particular types of patterning by selecting an application file for a given pattern. Milling on specific materials without gas is also more efficiently done with the appropriate scanning conditions using the dedicated application file for that material.

Application files are sorted and shown according to the beam, pattern shape type, and the gas type available within the system. It is possible to set the Application files, that are shown within the UI on the **Preferences** dialog / **Pattern Applications** section.

Setting Application File

Select the required Application file from the **Properties** tab / **Basic Properties** / **Application** item drop-down menu. This is now the active application file for the selected pattern.

The **Gas Type**, **Gas Flow** and **Needle Position** are predefined within the application file and are set automatically. To change any of these parameters, click in the editable value field of a particular item for editing.



Application files are sorted and shown according to the beam, pattern shape type, and the gas type available within the system.

It is possible to set the Application files, that are shown within the UI on the **Preferences** dialog / **Pattern Applications** section.

Silicon Application File (Non-Gas-Assisted)

For the silicon application file, the following patterning properties are defined.

Table 7-1 Silicon Application File (Non-Gas-Assisted)

Property	*.xml	Description
Beam type	ion	
Dwell time	$1.0e^{-6}$ s	The time the beam spends on a single pixel per pass.
Overlap	50%	Sets the beam diameter overlap.
Volume per dose	0,27 $\mu m^3/nC$	Describes the amount of volume of material removed per charge; previously called *sputter rate*.

The parameters above are used for non-gas assisted milling. In this case and if the overlap is positive, the mill time can be calculated based on the volume per dose parameter and beam current.

$$\text{volumneperdose} = \frac{\text{volume}}{\text{charge}} = \frac{\text{cubicmicrons}}{\text{nanocoulombs}} = \frac{\text{cubicmicrons}}{\text{beamcurrent} \times \text{time}}$$

Therefore:

$$\text{milltime} = \frac{\text{cubicmicrons}}{\text{beamcurrent} \times \text{volumeperdose}}$$

For example, create a filled box pattern 5 µm × 5 µm × 2 µm as X, Y, and Z values (the desired volume of material to be milled: 50 cubic µm) and choose 500 pA (0.5 nA), which is 0.5 nano-coulombs per second.

Therefore:

$$\text{milltime} = \frac{50\ \text{cubicmicrons}}{0{,}5\ \text{nanocoulombsper}\,\textit{sec}\text{ond} \times 0{,}15} = 666{,}6\ \textit{sec}\text{onds} = 11\ \text{minutes}6\,\textit{sec}\text{onds}$$

If you change the Z depth from 2 to 4 microns, the desired volume would be twice as large and the milling time would show 22 min. 13 sec. Doubling the beam current cuts milling time in half.

Tungsten Application File (Gas-Assisted)

For the tungsten application file (as an example), the following patterning properties are defined.

Table 7-2 Tungsten Application File (Gas-Assisted)

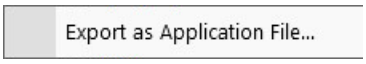
Property	W Dep	Description
Beam type	ion	
Dwell time	250 e^{-9} s	The time the beam spends on a single pixel per pass.
Overlap	–50%	Sets the beam diameter overlap.
Volume per dose	0.025 $\mu m^3/nC$	Describes the amount of volume of material removed per charge; previously called *sputter rate*.
Refresh time	0	Used to add additional waiting time between each pattern pass.
Blur	0	Defocuses the beam to increase deposition for large depositions.
Relative interaction diameter (RID)	150%	Adds additional pitch width to increase deposition rate. A 150% RID results in a pitch of 2.5 times the spot diameter.

The dwell time, volume per dose, and interaction diameter are material- and beam-specific.

Refresh time and blur can be added if required for certain applications, i.e., blur for depositing large areas and refresh time for filling vias.

The relative interaction diameter induces a pitch between two spots. A relative interaction diameter of 0% and 0% overlap results in a pitch of 1 time the beam diameter. A relative interaction diameter of 100% and 0% overlap results in a pitch of twice the beam diameter.

Custom application files



If a patterning use case requires alternative or custom properties configuration, a new application file can be created or the current one can be edited. Right-clicking above the Application file name shows a menu enabling the option to save the changed file as a .xml file.

A list of common volume per dose values (sputter rates) for various materials can be found in the following table. These are all values for 30 kV.

Table 7-3 Material Volume per Dose Rates at 30 kV

Material	Volume per Dose (µm^3/nC)	Material	Volume per Dose (µm^3/nC)
C	0.18	**Au**	1.50
Si	0.27	**MgO**	0.27
Al	0.30	**SiO_2**	0.24
Ti	0.37	**Al_2O_3**	0.08
Cr	0.10	**TiO**	0.15
Fe	0.29	**Si_3N_4**	0.20
Ni	0.14	**TiN**	0.15
Cu	0.25	**Fe_2O_3**	0.25
Mo	0.12	**GaAs**	0.61
Ta	0.32	**Pt**	0.23
W	0.12	**PMMA**	0.40

Milling

When the procedure in *"Beginning Your Session" on page 162* is satisfied, you can begin establishing a pattern to mill on the sample material.

Caution!

When performing Intermittent Switching (iSPI) between Ion beam patterning and SEM Imaging/Snapshot in the SEM Mode 2 (Immersion/UHR), be aware of using "Do not Degauss" functionality. It may cause an ion image shift relative to formerly created pattern area (affecting the patterning location!). The Degauss functionality prevents this behavior, but extends the switching time between the beams.

Process Optimizing

Beam Current / Milling Times

The appropriate beam current value depends on the sample to be milled and your experience with the sample material. Lower beam currents are less destructive and take longer to mill. The beam current and milling times in the following table are guidelines only. Specific parameters depend on your sample material and objectives.

Table 7-4 Beam Current/Milling Times by Application

Application	Suggested Time
Typical cross section (< 20 µm wide)	Try for a total time of 5 – 15 minutes, using 2.4 to 6.5 nA of current. Larger currents cause more damage around the recess and produce vertical walls, such as cut face angle.
Large cross section (very wide or deep)	Expect longer milling times (15 – 20 minutes or more), beware of drifts.
Cleaning cross section	Use a value no less than ¼ – ½ of the main current used for cross sectioning.
Drilling vias or cutting tracks	A drilling time from 1 – 4 minutes is adequate. The main limitations of short drilling times are difficulty in doing endpoint detection and the possibility of damaging the sample.

Magnification and Patterns

If your magnification is too high, milling certain patterns can use too much memory. If it is too low, the pattern corners become round and the edges are jagged. A good rule of thumb is to pick a magnification where your pattern fills 35 – 50% of the screen.

Stopping and Restarting

If at any time during milling or deposition you want to pause, click the **Pause Patterning** icon on the toolbar. When you continue patterning, the software continues the patterning process where it left off. If patterning is reset and restarted after patterns are modified, added, or deleted, it starts from the first pattern, and all patterning completed clocks are reset to zero.

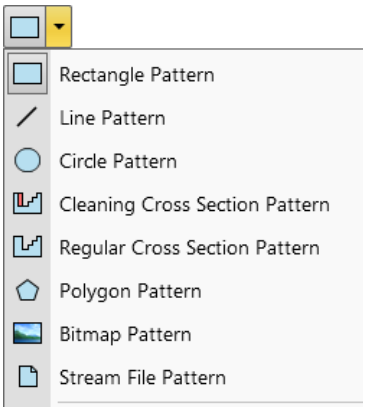
NOTE	When patterning is paused in one display it is possible to start patterning in another one. Similarly when patterning finishes there may still be a paused patterning in another display.

It is possible to acquire an image from the signals generated during patterning. All imaging parameters are dictated by the patterning requirements. Much better images can be acquired by a Snapshot during patterning. In this case patterning is paused, an image is grabbed and patterning resumes.

Fine-Tuning Patterns

Use the MUI **Shift X** and **Y** knobs to fine-tune the image. Beam shifts are used in many applications, such as the low voltage box milling for lamella creation, to give a clean, vertical face to the section. Use Shift also to adjust for drift or charge effects. Grab a frame to monitor the change in mill position.

Milling procedure



1. On the Patterning module or on the toolbar, select a pattern from the Pattern Selector and draw a pattern in the active display. When the selection is made, the blank area shows the relative icon, as shown.
2. Select a beam for patterning from the toolbar.
3. Enter a value in µm as the depth in the property editor.
4. Select the milling aperture.
5. Set the eucentric position and the tool (if aligned) will have the best focused beam.
6. If necessary, use the MUI **Shift X** and **Y** knobs or resize the pattern to correct positioning.
7. Snapshot a single frame to confirm the pattern position.
8. Select **Patterning > Start Patterning** or click **Start Patterning** on the toolbar to begin milling. The endpoint monitor automatically switches on.

9. Select **Patterning > Pause Patterning** or click **Pause Patterning** on the toolbar to pause milling.

10. Select **Patterning > Resume Patterning** or click **Resume Patterning** on the toolbar to resume milling.

11. Selecting **Patterning > Stop Patterning** or clicking **Stop Patterning on the toolbar** during patterning or when patterning is paused resets milling (the button changes to inactive state – gray).

    Using this functionality during an image acquisition (F2 / F4) lets an acquisition to finish and subsequently the patterning is paused (the button changes to active state – black). It is possible to resume or to reset it by clicking an appropriate icon.

    Pressing F2 / F4 (snapshot / photo image acquisition) during patterning pauses the patterning and releases it again after acquisition finishes. Pressing F2 / F4 again or clicking the Resume button during image acquisition resumes the patterning immediately.

Milling in Spot Mode

This procedure is convenient to drill holes with diameter depending on the beam size.

1. Select the **Scan** menu / **Spot** mode. In this mode no scanning takes place.

   The single spot (green cross) cursor appears directly in the center of the screen. If the cursor is not moved the milling process will take place here otherwise click anywhere on the image to move the spot to another position.

2. Move the feature to be drilled to the green cross cursor.
3. Start (or select **Scan > Beam Blank** to unblank) the beam.
4. To acquire an image, click on the **Snapshot** button.
5. Release (unpause) active display to proceed with milling.
6. To exit spot mode, select the **Scan** menu / **Full Frame** item.

Milling a Bitmap

1. On the Patterning module, select a **Bitmap Pattern** from the Pattern Selector dropdown menu.
2. Drag a square on the screen that represents the area of patterning. The position of the square can be changed by dragging.
3. Select **File > Open**. Load the bitmap using the Open dialog box. The bitmap appears in the imaging display.

NOTE	Make sure the BMP is located on the microscope PC and not on the support PC Make sure the pattern is a 24-bit bitmap and not an 8-bit (256 color) bitmap.

4. On the Patterning page, Advanced tab, modify the aspect ratio to **Free** or **Fixed**, depending if stretching the bitmap is required.
5. Optimize other properties such as applications file, depth, leading edge, etc.
6. Start patterning.

Selective Milling

Selective milling selectively scans an area of the sample based on the bright areas in the FIB image. It excludes bright or dark regions from the pattern area with user-adjustable histogram and refresh intervals.

NOTE	Selective milling works only in Serial mode or with one pattern. Patterns are limited to rectangle, circle, line, and polygon.

Sample Setup

1. Load the sample, ensuring it is well grounded.
2. Set the eucentric point and center the area of interest. Use a low beam current to minimize damage to the sample.

Mill Setup

1. Draw a mill box with the dimensions required.
2. Designate this box as a XeF_2_Etch.

NOTE	Selective milling works with the default *Si_Mill* as well as with other gas enchants. XeF_2 is used here for this specific use case.

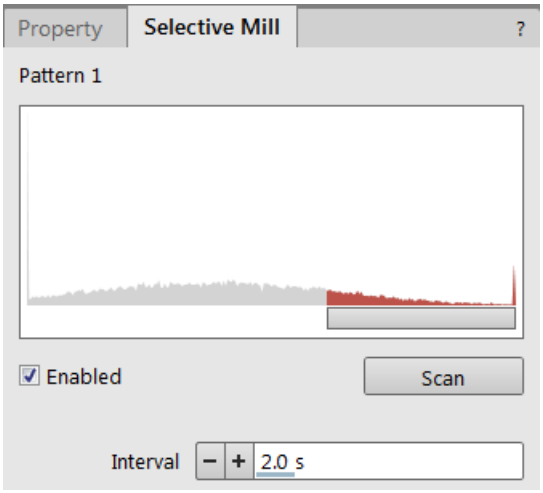
3. Select an appropriate sized beam current.
   - Start by using one that is approximately 30–40 $pA/\mu m^2$.

- If there is too much flashing or ESD events, select a smaller aperture.

4. Go to a sacrificial area on the sample.
5. Insert the GIS nozzles.
6. Start the mill and adjust the brightness and contrast such that you can begin to see the pixels milling in the iRTM. This step is valuable for selective milling.
7. Retract the nozzles and move to the location where you want to remove the oxide.
8. Insert the nozzles once again.
9. Position the mill box correctly over the region of interest.

Selective Mill Parameters

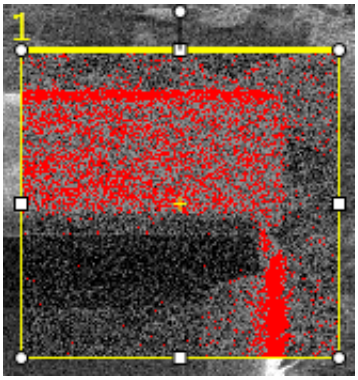
1. On the Patterning page, select the **Selective Mill** tab module.



2. Select **Enable** and then click **Scan**.

   The system will now scan the area of the pattern and evaluate the grayscale levels of the pixels within the pattern.

   A histogram appears below a red bar on the tab. This shows the distribution of the number of pixels with grayscale values between 0 and 255. In this case, all pixels have low grayscale values because it is an oxide.



3. Click and drag the red bar to select the range of grayscale values you want to have milled. The red bar can also be moved by grabbing the black line "pole" under the red bar.

   In this use case, you want only the dark pixels to be milled, so place the red bar as desired.

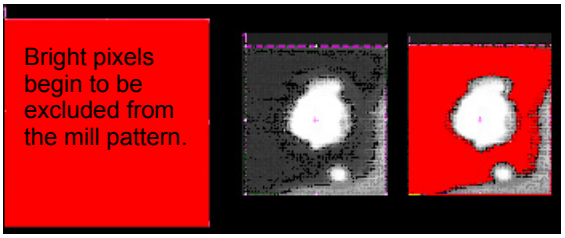
NOTE	If you wanted to mill bright pixels instead of dark pixels, the red bar would be over to the right, indicating only high grayscale values are to be milled. An example of this would be milling through grounded metal to an oxide below.

4. Select the number of seconds in the Interval slider that you want the pattern to be milling before the system rescans the pattern area to reassess the grayscale values.

Start the Mill

1. Enter a high dose value or a long time amount, as this mill should stop automatically when there are no more pixels left with low grayscale values.
2. Select **Patterning > Start Patterning** or click **Start Patterning** on the toolbar to begin milling.
3. As the mill progresses, there will be bright areas (high grayscale values) in the mill pattern, indicating the oxide has been removed and exposing the metal below. As Selective Mill rescans the pattern, it will identify these pixels and omit them from the milling.

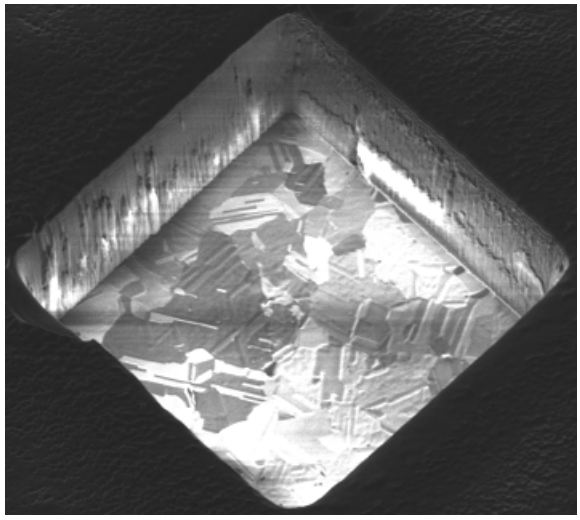
Figure 7-7 Selective Milling Progresses



4. Monitor the bright and dark areas while the pattern is milling by adjusting the selected mill pixel range (red bar) either while it is milling or when it is paused.
5. After the pattern has completed, check to see if the metal is satisfactorily exposed. If not, either repeat this process or simply do a regular XeF_2 mill for a few seconds.

Verifying the Selective Mill

1. When the mill has stopped automatically, there should be no more pixels with low grayscale values left in the mill pattern, and the metal should be cleanly exposed.
2. Tilt the sample to approximately 45° and view the quality of the exposed surface. It should be flat and even with vertical side walls and no holes or spots, as shown below.



3. If there is any oxide left, redo the Selective Mill.
4. If there are any holes in the metal, you may need to start over.

Creating Cross-Sections

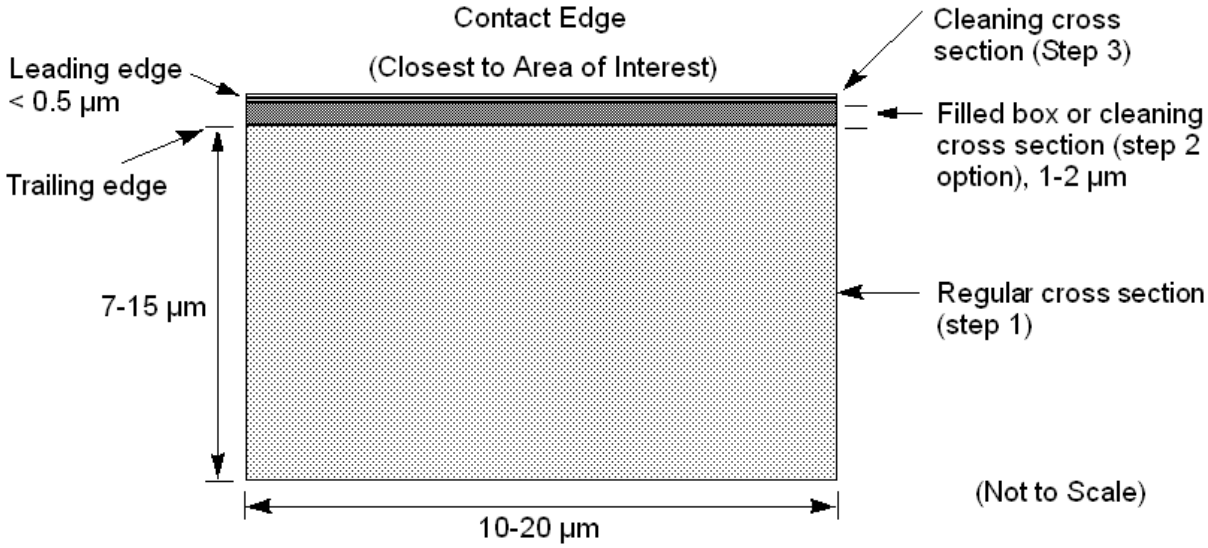
Cross sections are cut in a multipass fashion to allow the exposed layers to be seen when the stage is tilted to 52°.

Mill a typical cross section in two or three stages:

1. The first stage is a regular cross section.
2. For optional second stage use either filled box or cleaning cross section at a reduced current. (If the cross section is large, a second cleaning may be required at a lower current.)
3. For the third stage, use cleaning cross section to make the final cut.

Following image shows the relationship of these pattern areas and their relative size. A typical cross section is 10 – 20 µm wide by 7 – 15 µm tall with the dimensions and depth appropriate to the size of the target area of interest.

Figure 7-8 Typical Cross Section



Be attentive to boxes positioning if you are sectioning a specific point. Use fine milling to expose the exact area of interest. For example, a 2 µm offset should be more than enough at 3 nA of current. Calculate the outline as the height of the box relative to the depth to be milled. If you intend to view at 52° and see details 3 µm from the surface, then the original box should be at least 3 µm tall.

Making the Cross Section

Mill a regular cross section with five superimposed box patterns sharing three common edges.

First Stage

1. Select a ion beam display by clicking in it and begin scanning.
2. Move the stage to where you want to mill the cross section.
3. Find the eucentric position.
4. Tilt the stage to 52°.
5. Save this position in the location list in the Stage module. (This is as far as the instructions take you in *"Beginning Your Session" on page 162*.
6. Align both beams by correcting the beams coincidence (see *"Beams coincidence setting procedure" on page 166*).
7. Optimize the ion beam image if necessary.
8. Restore the stage position you stored in Step 5.
9. From the toolbar, set the ion beam current between 93 pA and 6.5 nA, depending on the size of the cross section (sometimes using the 21 nA is necessary).
10. Image briefly on the area to set the magnification and position.
11. Click **Snapshot** to grab an ion beam frame.

12. Go to the Patterning page and select **Regular Cross Section** from the Pattern Selector menu.
13. Bring the cursor to the image area and draw a rectangular box about 2 µm from the area of interest.
14. While still on the Patterning page, within the property editor set the Application to Si and enter the value for Depth as needed. Click **Enter** to update.
15. Click **Snapshot** to grab an ion beam frame.
16. Click the **Start Patterning** icon on the toolbar.
17. Use **Snapshot** to update your image as desired by grabbing a frame with the ion beam or electron beam.

Second Stage (Optional)

Use the **Cleaning Cross Section** from the Patterning page, Pattern Selector menu, at a reduced current for this step.

1. From the toolbar, set the ion beam current to approximately ¼ of the beam current used for the first cut.
2. Click **Snapshot** to grab an ion beam frame.
3. Click **Cleaning Cross Section**. Bring the cursor to the image area and draw a rectangular box. Adjust its size so that its leading face is approximately 0.2 µm from the target area and the trailing edge extends just beyond the rough cut.

NOTE	Remember to fill in the depth of your cross section in the properties editor on the Patterning page.

4. Snapshot another ion beam frame to verify alignment of the pattern to the feature.
5. Click on the **Start Patterning** icon in the toolbar.
6. Click in a new display, click the **Electron Beam** toolbar button, and begin scanning.
7. Click **Snapshot** to grab a frame to view the electron beam image.

Third Stage

Use the **Cleaning Cross Section** from the Patterning page, Pattern Selector menu, for this final step.

1. If the cut is too rough, change the ion beam current between 0.28 nA and 0.92 nA. Adjust focus as needed.
2. In the patterning display, click **Snapshot** to grab an I-Beam frame.
3. Click **Cleaning Cross Section**. Bring the cursor to the image area and draw a rectangular box. Adjust its size so that its leading face crosses the target area and the trailing edge extends just beyond the rough cut.

NOTE	Remember to fill in the depth of your cross section in the property editor on the Patterning page.

4. Click **Snapshot** to grab an ion beam frame and click the **Start Patterning** toolbar button.
5. Click in a new display, click the **Electron Beam** toolbar button, and begin scanning.
6. Click **Snapshot** to grab a frame to view the electron beam image.

Multipass

The fastest way to do the rough milling part of a cross section at a given beam current is to do the equivalent of two or more cleaning cross-section patterns over the pattern area, i.e., a multipass pattern where one multipass is a set of line patterns that move from bottom to top of the patterned area. Each line mill contains the number of passes needed to reach a fraction of the specified depth where this fraction is equal to the depth divided by the number of multi passes. This is the default mode.

The enhancement in the rate is because the beam is always milling on an edge which enhances the sputtering yield. If only one pass is made then redeposition effects tend to backfill the section. This prevents the SEM from seeing the full section face. By making several passes, typically 2 or 3, then a cleaner removal is achieved enabling the SEM to view into the cross section at the 52^{o} angle.

AutoTEM already makes use of a similar function, where a series of narrow box patterns are used with typically two passes. The use of boxes rather than lines is to minimize the overhead of pattern creation for AutoTEM.

Two parameters are used:

- **Multipass**: Number of passes
- **Scan ratio:** The actual value used is the dose delivered at the first line divided by the dose delivered at the last line of the pattern.

  For example:

  A scan ratio of 0.25 means it will deliver 4 times the dose at the finishing line as it does at the first line and the lines in between are linearly interpolated.

  A scan ratio of 2 means the dose delivered at the first line is 2 times that of the finishing line.

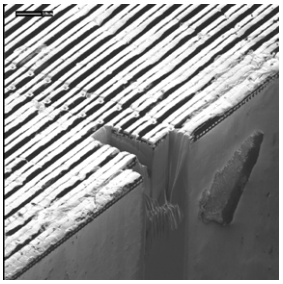
Multipass Pattern Improvements

The multipass pattern has been reworked from the previous version. The scan ratio calculation is now more stable and the scanning methodology has been slightly changed to help pattern efficiency and speed. The “scar” on the left hand side of the pattern and the “bump” at the finishing edge have been eliminated. The multipass pattern is now the default instead of stairstep milling.

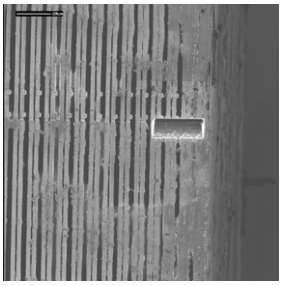
Viewing the Cross Section

After cutting the cross section, switch to SEM imaging and acquire an overview image of the cross section without the need to move the stage. The following figure shows examples of some typical milling views of a cross section.

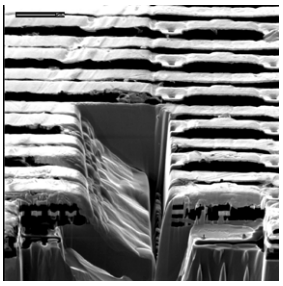
Figure 7-9 Cross Section Views



Perspective view of the cross section milled on the edge of a sample



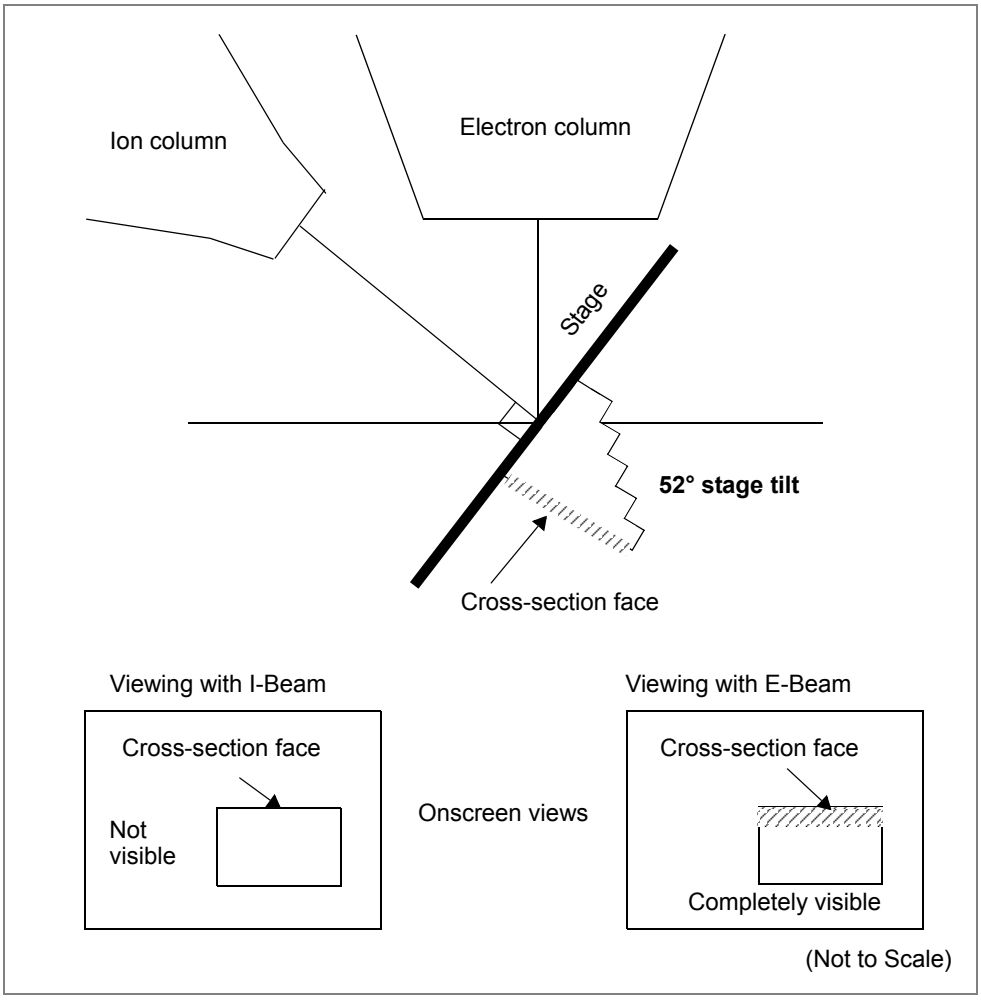
Top view of the cross section



Cross-section view. This view was done to show the geometry of the cross section.

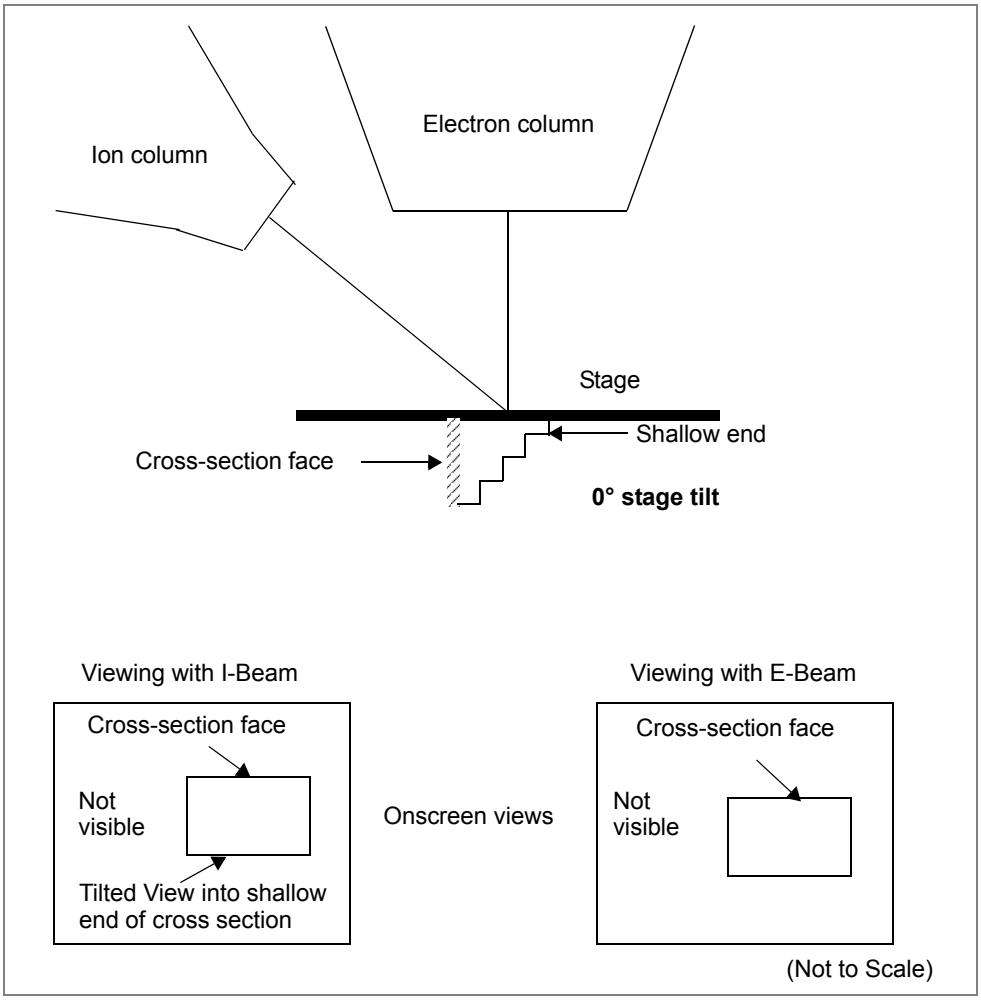
The following image shows the relationship of the columns and stage to the face of the cross section during milling and how this is viewed onscreen, depending on whether you image with the electron or ion beam.

Figure 7-10 Cross Section Viewing During Milling



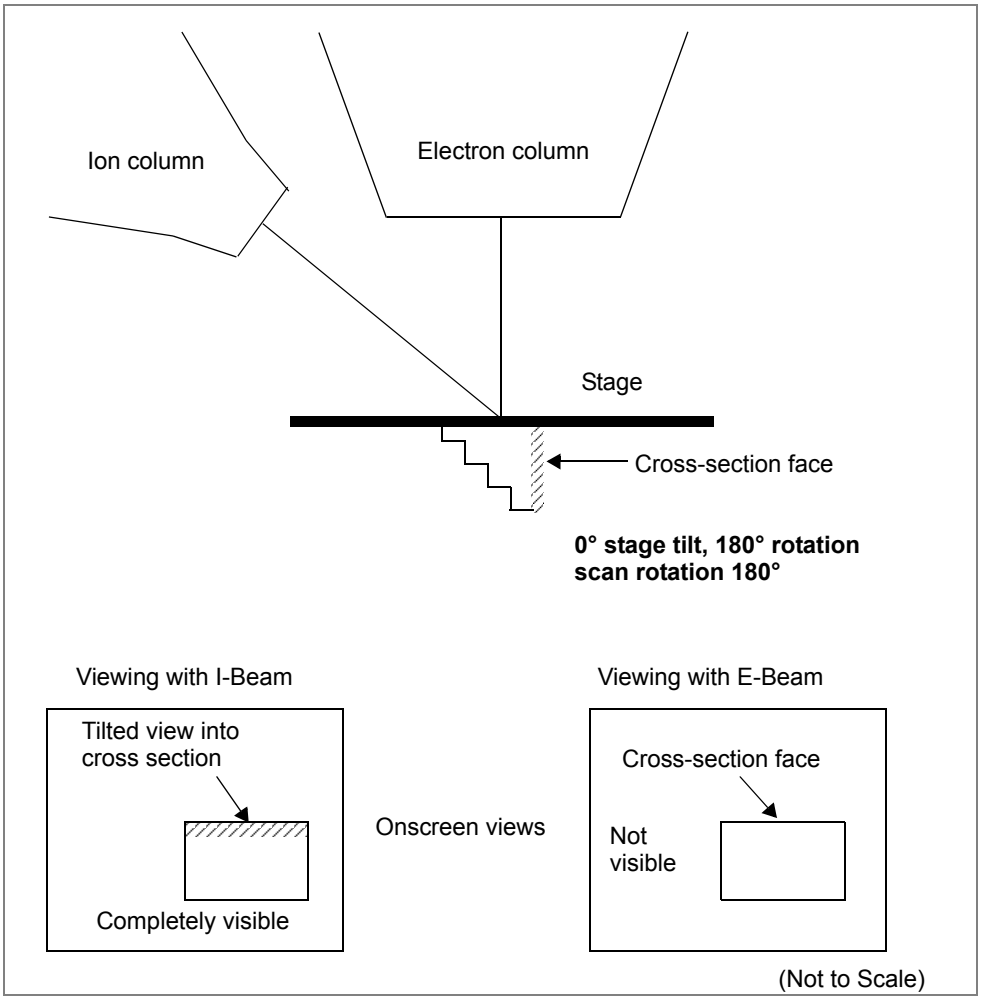
The following image shows the onscreen view with the stage at 0° tilt, with both the electron and ion beam imaging views.

Figure 7-11 Cross Section Viewing at 0° Tilt



The following image shows the onscreen views with the stage still at 0° tilt, but with both stage and scan rotation at 180°.

Figure 7-12 Viewing at 0° Tilt Rotated 180°



8 Gas Injection System & MultiChem

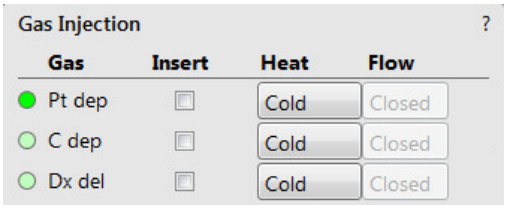
Different gas types are used to deposit on or etch away material surfaces. A gas type is allocated to each gas injector, and up to five gas injectors can be mounted on the system.

If the system has an EasyLift, then only gas injection systems (GIS'es) mounted to the port No. 4 may be used!

WARNING!	GIS & MultiChem chemicals are hazardous! Read the User safety manual before starting GIS operation! In case the Platinum deposition (Pt dep) GIS was used simultaneously with the CryoMAT Loader and/or CryoCleanerEC, always run the decontamination procedure (see the User safety manual "Pt deposition chemical" chapter).

Gas Injection module

The Gas Injection module on the Patterning page enables to select the type of gas deposition or etch material.



For the MultiChem item controls description within the Gas Injection module see below.

Table 8-1 Gas Injection Module Overview

Interface Item	Description
colored circle	Shows the assigned color of all installed gasses.
Gas	Shows the installed gas name. Hover the mouse over a particular gas name to see the tooltip for its Lifetime
Insert check box	Shows the insertion status for each gas: • **Ticked**: inserted • **Cleared**: retracted
Heat	Shows the heat status for each gas.
Flow	Toggles between closed or open. Shows the current set point for the pulsed valve for each chemistry. Double-click on the **Flow** to change the set point

Color and Hatching of Pattern shape

When patterning with the electron / ion beam, the pattern shape is hatched / crosshatched.

When no gas is assigned to a pattern, the shape is in yellow. A disabled pattern is in gray.

When patterning with GIS, entire shape is colored according to gas being used.

When patterning with MultiChem, entire shape is always in orange and the colored circle (corresponding to the color of gas being used) is shown above the pattern. When a mixture of gasses is used, more colored circles are shown.

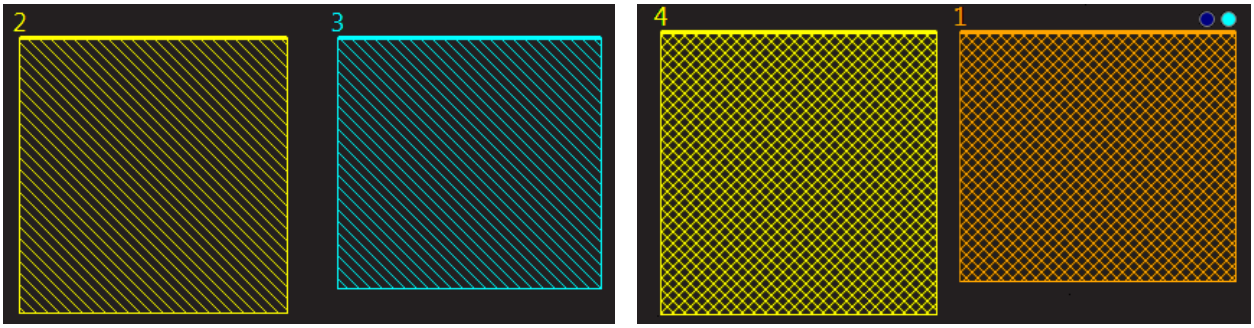


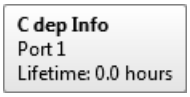
Table 8-2

MultiChem color code		GIS color code	
X C Dep	Tea green	C dep	Tea Green
Enhanced Etch	Red	Del Etch	Light Purple
Au dep	Melrose	Dx Del	Light Green
IDEP2 (w/H2O)	Aqua	Enh Etch	Blue
IEE	Fuchsia	IEE	Fuchsia
X Pt dep	Lime	Ins Dep	Yellow
SCE	Navy blue	Pt Dep	Lime
X W dep	Green	SCE	Dark Red
O2	Malibu	W Dep	Green
CF4	Blush pink		
Dx Delayering	Yellow		
DE	Navy blue		

Setting up the GIS

Set up the GIS to be used before patterning is started. It can be held heated and inserted, but not opened, until it is ready to use.

When not in use, the GIS should be closed, cold, and retracted. Leaving it closed, heated, and retracted is also an option if it is to be used over several patterns so that reheating is not necessary.

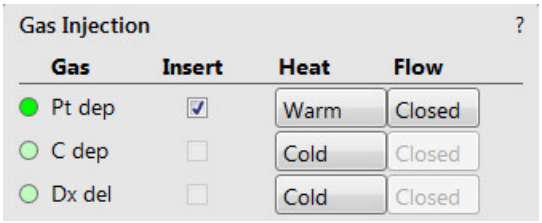


A tool tip info is given about the selected GIS line:

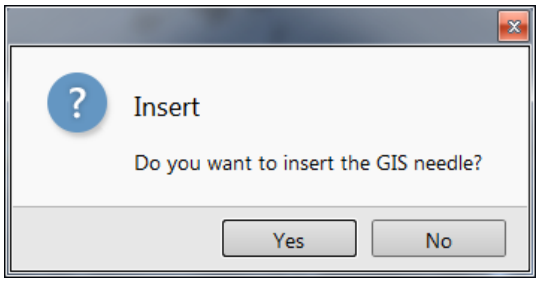
- **Port #** – GIS connection position
- **Lifetime** – time of GIS employment

Before the patterning with the GIS starts, the gas reservoir must be heated by clicking the **Heat** column / **Cold** status button.
The **Cold** status is replaced by a progress bar, which in turn is replaced by the **Warm** status when the GIS is fully heated. To cool down a reservoir, proceed in reverse order.

To insert the GIS needle manually tick the **Insert** check box.
A confirmation dialog appears. Ticking the **Insert** check box again retracts (cleared box) the GIS.

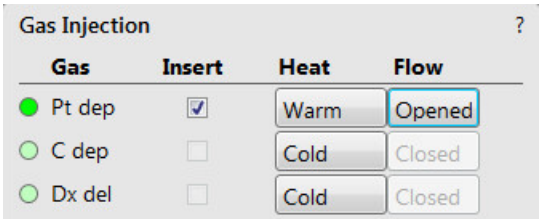


In the confirmation dialog box that appears, click **Yes** if you know there is nothing obstructing the GIS needle travel. While the GIS needle is inserted, the stage can be moved slightly using Get or Track moves (see the *"Stage Movement Limits " on page 219*).



CAUTION	Beware of stage moves while GIS is inserted! The GIS needle can be damaged by incautious stage movements!

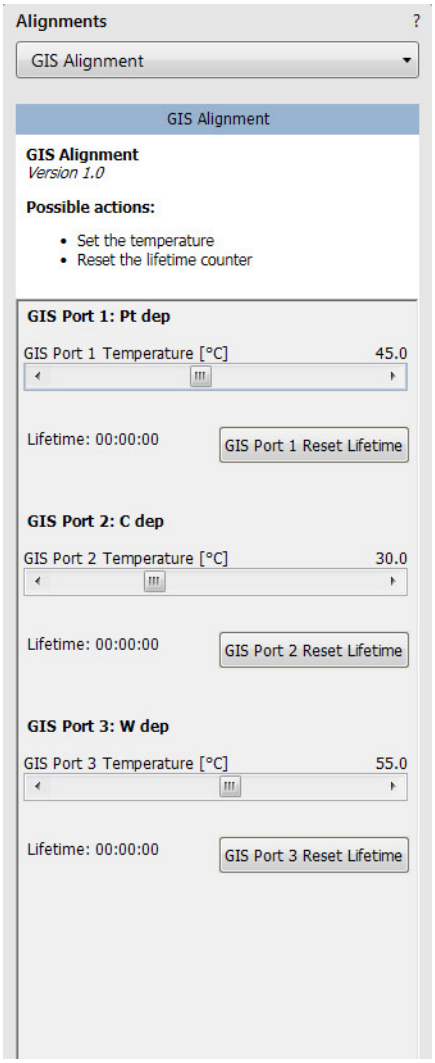
To open / close the GIS valve click on the **Flow** column / **Closed** / **Open** status. This will not be possible until the Heat column / Warm status is reached.



In normal operation, the GIS opens automatically when patterning is started if an application file with a gas type is selected.

The GIS is now in operation and is either depositing or etching, depending on the chosen gas type.

GIS Alignment



MultiChem

The MultiChem sub-atmospheric gas delivery system is intended for use on Thermo Fisher Scientific microscopes as an improvement to the standard single Gas Injection System (GIS). It is capable of delivering gasses to a sample surface to perform beam chemistry processes under vacuum.

The MultiChem allows up to six chemistries to be installed in a single port, mixing of supported combinations of gasses, and fine flow control, particularly for etching chemistries such as SCE and IEE.

The gas heaters are turned off when the system is put into Sleep mode and restarted when the system is restarted with the Wake Up routine (see *"System states" on page 27*).

Port Installation

MultiChem can only be installed in Port 1 or Port 4 for Helios G4 PFIB systems.

Be aware of MultiChem/GiS port configuration: For TEM lamella preparation via. Lift-Out technique, Multichem/GiS can only be installed in Port 4 to avoid collision with EasyLift!

Features

- MultiChem will use the standard GIS needle.
- Six Chemicals in One Port
- Two gas ports have water-cooled Peltier heaters/coolers that can cool to < 10° C.
- Up to two gas ports can be used for external gasses: O_2 is currently supported, leaving one for future use.

  External gas lines are NOT double contained and MUST NOT be used for hazardous gasses.
- Any number of gasses may be mixed in the mixing chamber prior to entering the needle. Compatibility is determined at setup and only compatible gasses are allowed to flow together.

Pulse Width Modulated Valves for Gas Flow Control

- Fixed frequency of 4 Hz with Flow (duty cycle) variable between 0.01% and 100%.
- Each gas port has a pulse width modulated (PWM) valve and an on/off delivery valve.

Motorized Needle Positioning

- 15 mm Insert/Retract motion is pneumatic.
- Two radial axes of motion (X-Y) with approximately –1 mm range.
- One axial axis of motion (Z) with +0 to –1.5 mm range from the eucentric position.
- Two stored positions: 0° /* 0° and 52° / 90° stage tilt.

Integrated into UI

- Similar look and feel to the existing GIS controls in the same space.
- Same insert / retract behavior as existing GIS.

MultiChem Module

The MultiChem is controlled via the **Gas Injection** module and the **Property** tab module on the **Patterning** and **Sample Preparation** control pages. It is used to control the installed gasses. Up to six gasses may be installed per MultiChem.

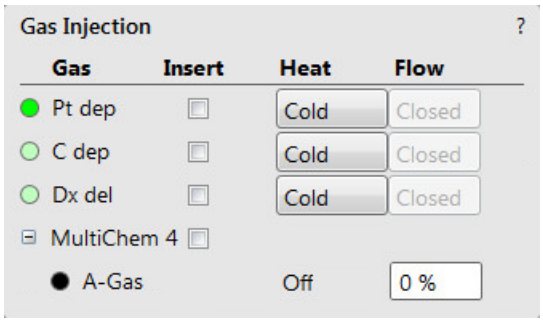


Table 8-3 MultiChem Module overview (1 of 3)

Interface Item	Description
(colored circle)	Shows the assigned color for the gas.
Gas / Multichem	Shows the installed gas name. Hover the mouse over a particular gas name to see the tooltip for its Lifetime. **W dep Info** Port 2 Lifetime: 0.0 hours

Table 8-3 MultiChem Module overview (2 of 3)

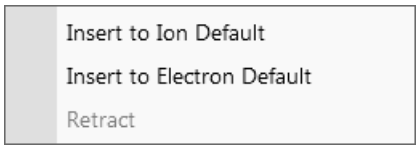
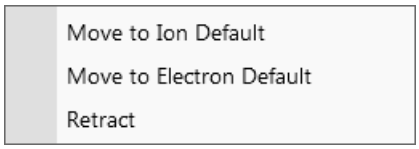
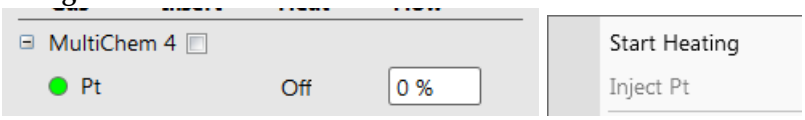
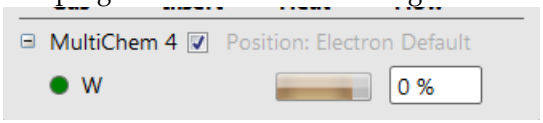
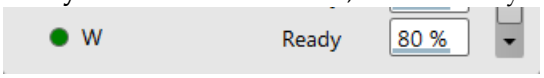
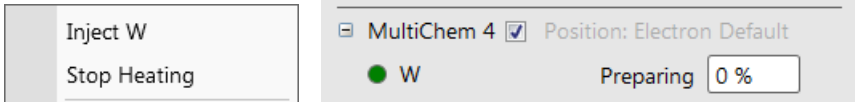
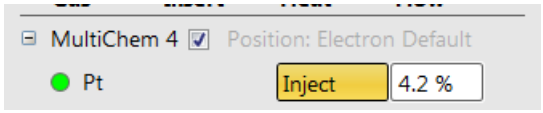
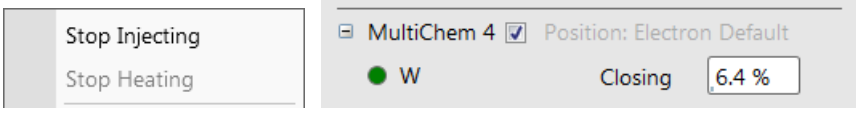
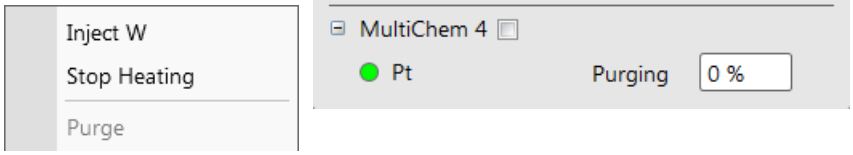
Interface Item	Description
Insert check box	Shows the insertion status for the MultiChem nozzle. Ticking the check box has the same functionality as selecting **Insert to Ion / Electron Default** from the menu (right-click above the Gas name): inserts the nozzle according to the stage tilt angle – 0° / 52° electron / ion default position. When inserted, it is possible to **Move** the nozzle **to Ion / Electron Default** position or to **Retract** the nozzle by selecting a desired menu item. Clearing the check box has the same functionality as **Retract** item.   **Note:** *Any custom insert needle positions that were defined in the* **MultiChem Supervisor Alignment - Needle Alignment** *will also appear in the right-click menu.* Retracting the MultiChem nozzle is enabled even while patterning is in progress; the valve is immediately closed and the nozzle is retracted at the same time. This is desirable for working with etching gas.
Heat	Shows the heat status for each chemistry: • **Off**: The crucible is not heated. Click the **Start Heating** item from the **right-click menu.**  The progress bar shows the heating status.  • **Ready**: The crucible is heated, the chemistry is ready for injection. 

Table 8-3 MultiChem Module overview (3 of 3)

Interface Item	Description
Flow edit box	If the nozzle is inserted, select **Inject #** item from the right-click menu or click the **Ready** button, the **Preparing** status appears. It is also possible to **Stop Heating** at this moment or to inject any allowed combination of gasses including that gas.  Injecting is indicated by the **Inject** status and the highlighted background; click & right / left drag inside the box with the % value (cursor changes to the horizontal 2-ended arrow) to increase / decrease a **Flow** rate or double-click the value to enter it.  The value can be set from 0.01% to 100% with a higher percentage corresponding to a higher gas flow. A user can effectively change the level of gas Flow during the patterning process. The Flow can be limited for particular chemistries if the vapor pressure for that chemistry is too high to safely flow into the specimen chamber without compromising the vacuum. This limit is configured when installing a chemistry. If a pattern is started that specifies a **Flow** [%], then the flow will be set to the value defined in the pattern. To use a custom flow for a pattern, set the **Gas Flow** in the Advanced Patterning tab (see *"Starting a Manual Single Gas Flow" on page 312*) or select a pattern that does not specify a gas and manually start and stop the gas injection. **Note:** *If you specify a* **Gas Flow** *% in the Advanced Properties, it will override the value set in the MultiChem module.* **To Stop Injecting select the appropriate right-click menu item or click the Inject button,** the **Closing** status appears. 

Purging

With the nozzle retracted, the only option is to **Purge** the gas, which will flow the chemistry into the fore line directly, bypassing the specimen chamber. The Purge option can be used if there is some suspicion that the crucible pressure is too high, but this should not be necessary in normal operation.



The maximum Purge value can reach up to the **Maximum allowed gas flow** value set in the **Chemical Maintenance Alignment** (specific for each gas).

For the older Multichem version (model # 117135-0 – see the equipment label) the Purge function is not available for conductive material depositions, because its excessive use causes premature failure of components in the MultiChem. Use the following procedure to manually purge the gas into the specimen chamber:

1. Insert the MultiChem nozzle.
2. Turn off the SEM and FIB High Voltage (the MultiChem nozzle should remain inserted, but the beams will be isolated in the event of a pressure burst).
3. Double-click on the Flow [%] field for the chemistry to be purged.
4. Change the Flow to 0.25%.
5. Prepare to monitor the Specimen Chamber pressure.
6. Begin flowing of the chemistry to be purged.
7. Monitor the Specimen Chamber pressure.
   a) If the Specimen Chamber pressure rises above 8 e^{-5} mbar, then close the valve, decrease the Flow and go back to Step 6.

   b) Wait until the Specimen Chamber pressure falls below 2 e^{-5} mbar, then double the Flow (up to a maximum of 100%) and go back to Step 7.
8. Once the Flow has reached 100%, continue to monitor the Specimen Chamber pressure until it has stabilized.
9. Stop the gas Flow.
10. Retract the MultiChem nozzle.

Basic Processes

CAUTION Insert the nozzle only when the sample is at eucentric position. Use caution when making stage moves while the nozzle is inserted to prevent damage to the nozzle.

1. To insert the nozzle, right-click on the appropriate gas type and select **Insert** from the menu that appears.
2. Collect an image.
3. Place a pattern.
4. On the Basic tab, select an Application file for the defined given pattern. It automatically sets the appropriate gas, the dwell and overlap, and calculates the proper dose appropriate to the beam chemistry.
5. (optional) To set a custom flow (% of mixture), double-click **Gas Flow** and enter a value between 0.01% – 100%.
6. Start patterning (the gas flow will start automatically).

Starting a Manual Single Gas Flow

1. Insert the nozzle.
2. Set the Flow.
3. Double-click **Ready.**

Starting a Manual Mixed Gas Flow

1. Insert the nozzle.
2. Set the Flow for all gasses.
3. Right-click on one of the gasses in the mixture to access a menu and select the desired gas mixture.

Crucible Exchange

This procedure is used when empty crucible(s) is/are exchanged.

CAUTION It is possible to change any crucible when it is empty for the new one of the same type only. To change for any other gas type crucible it is necessary to call the Thermo Fisher Scientific service.
For any crucible exchange it is necessary to use the external optional Fumex, otherwise this procedure is not allowed for users and it is necessary to call the Thermo Fisher Scientific service.

CAUTION Do not perform any operation without proper safety training.
Chemical exposure is not expected, but as a precaution use gloves when handling MultiChem parts.
Crucibles are heated and may still be hot when removing. Take caution to allow the crucible time to cool before handling.

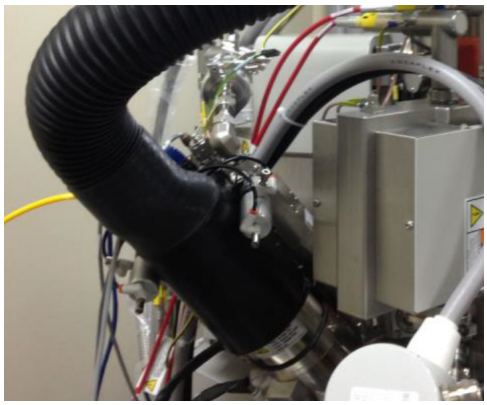
Vent MultiChem

CAUTION Fumex filters must be replaced every 12 months.
Air velocity meter must be calibrated every 12 months (calibration of the air flow meter is the customer's responsibility via a third party vendor).
If either of these conditions are not met then MultiChem cannot be vented for crucible maintenance!

CAUTION Fumex must be attached and running at all times when MultiChem chamber is open.

1. Move the Fumex to within 6 feet of the MultiChem and connect the AC power cord to a wall socket near the system. Do not use system power for the Fumex unit!
2. Attach the Fumex hose to the top of the double walled MultiChem cover.

3. Turn on the Fumex to full fan output.

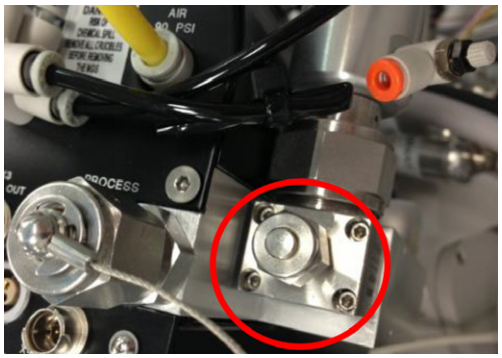


4. Using air velocity meter provided, verify the velocity in the center of the closed lid is > 3 m/s [600 ft./min]. If air flow does not meet specification **do not** continue with this work instruction.

CAUTION

Consult Fumex manual for airflow remedy steps to correct airflow issue. If unable to resolve airflow issue, Contact Thermo Fisher Scientific to schedule a FSE to visit to replace the chemistry.

5. Loosen the MultiChem vent valve cap.



6. Open MultiChem Supervisor Alignments (see below) and select **Vacuum Actions (**deselect other alignment listings).
7. Click **Run Selection**.
8. From the drop down menu, select the port that matches the MultiChem which requires vacuum action.
9. Click **Next**.
10. Switch off E and I beam, so that they are isolated.
11. Click **Vent MChem**.

MultiChem Crucible Exchange

Unpack new crucible

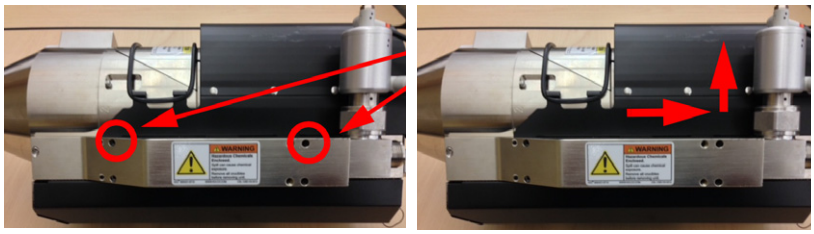
CAUTION

MultiChem crucibles are single-use only and are not to be opened or refilled. Do not attempt to open crucibles or intentionally liberate contents by defeating safety protections.
Keep all packaging when performing a crucible replacement. The old crucible being removed from the MultiChem will be placed in this packaging.

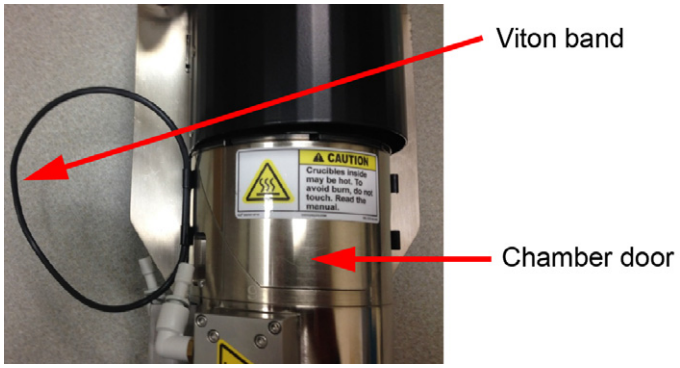
12. Open the shipping box.
13. Remove the crucible container and open it with a blade screwdriver.
14. Remove the new crucible from the Mylar bag.
15. Remove the crucible shipping screw from the bottom. **Keep the shipping screw as this is required to be installed in the removed crucible.**
16. Place the crucible on a clean cloth or wipe in the upright position for 10 minutes before installing in the MultiChem. This allows for the chemical to settle inside crucible.

Remove empty crucible(s) from Multichem

17. Remove the top / bottom cover:
    Loosen 4 upper securing screws, slide the cover towards the back of the MultiChem and pull out.

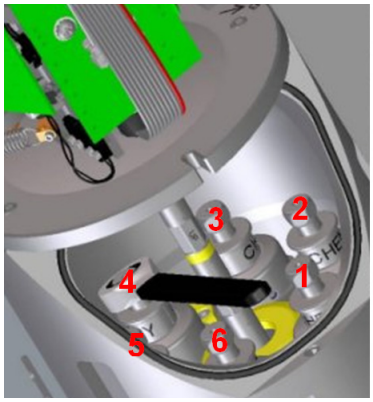


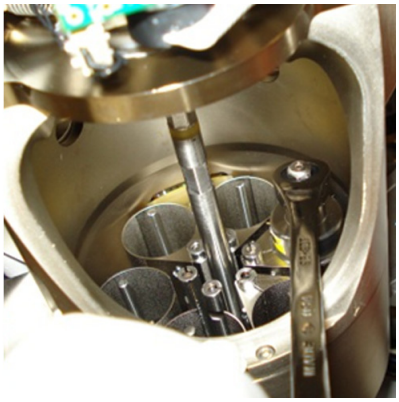
18. Release the Viton band from the chamber door and remove the MultiChem chamber cover.



19. Identify which numbered MultiChem heater slot location will be replaced. The heater slots are numbered from 1-6 going counter clockwise. Slot numbers are machined on the side of the MultiChem.

20. If the slot is already occupied, use the 7 mm wrench from the tool kit to remove the crucible. Turn the crucible (counterclockwise) 3 full turns until it is disengaged from the threads.





When using the crucible ratchet to install / remove crucibles, place the ratchet end over the hex portion of the crucible and tilt the ratchet up. This will wedge the ratchet to the crucible and keep the wrench from sliding off.

21. Using the long tweezers, remove the empty crucible from the chamber.

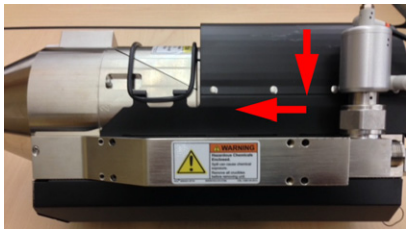
CAUTION	Use caution when handling the crucibles since they still may be hot.

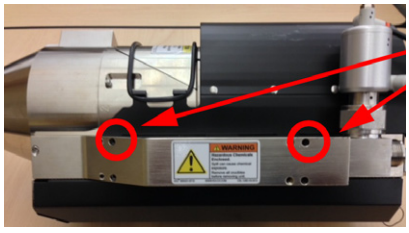
22. Install the crucible shipping screw that was removed from the new crucible (*see step 15*) to the crucible just removed. Set this crucible to the side on a clean dry wipe, as it will need to be packaged for disposal.
23. If replacing more crucibles, set each crucible on a clean dry wipe. Make note of the slot from which each crucible was removed as they will need to be installed in the identical slot of the new MultiChem. If the crucibles will not be placed back into the MultiChem, then install shipping screws into each crucible.

Installing new crucible(s) into the MultiChem

24. Using long tweezers, place crucible in the port from which the old crucible was removed *(see step 21)*.
25. Reach in and thread the crucible in as far as you can by hand.
26. Tighten the crucible using the 7 mm wrench. **Do not over tighten** (*see step 20*).
27. Mount the Multichem top cover:

    Push the top cover into the MultiChem slots, slide toward the front of the MultiChem and tighten 4 upper securing screws.





Packing the removed crucible(s)

28. Verify a crucible shipping screw has been installed in the crucible bottom (*see step 15*).

29. Place the crucible into the Mylar bag, subsequently into the chemical container, and into the shipping box, all with appropriate chemical labels. It is the customer's responsibility to dispose of used chemistry.

Pump MultiChem and disconnect Fumex

Repeat steps No. 6. / 7. / 8 / 9.

30. Click **Pump MChem** to pump down the Multichem. When complete, click **Finish**.

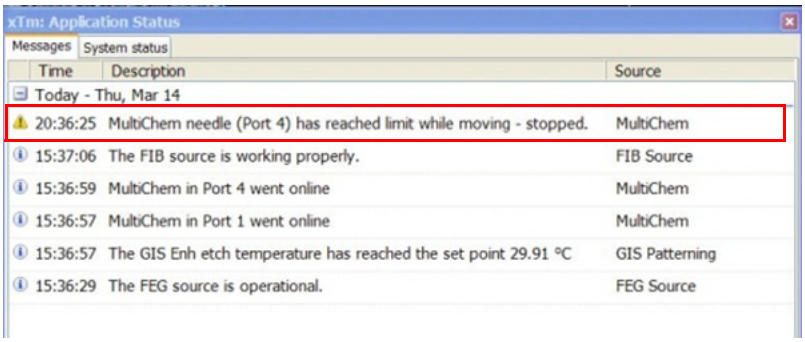
31. Tighten the vent cap.

32. Disengage Fumex from MultiChem, turn it off and disconnect power. Store it per customer instruction.

Precautions

CAUTION Insert the nozzle only when the sample is at eucentric position. Use caution when making stage moves while the nozzle is inserted to prevent damage to the nozzle.

- Logging off an actual user, closing or restarting the xT microscope Server / Microscope Control software does not change conditions of the MultiChem. It could be inserted or injecting under some circumstances. The system provides tooltips relevant to the actual state.
- When not in use, the injection should be stopped (to save lifetime), and the nozzle retracted.
- The safety switch inside the MultiChem disallows valve usage at pressure > 0.5 atm. This prevents users from getting exposed to high temperatures within the enclosure. Messages are shown in the Application Status window.
- If the X or Y axis gets out of the allowed ± 0.5 mm range, the needle jog moves will automatically stop, but the other axis will continue to move. A message shows in the Application status window.



- Given the advanced capabilities of the MultiChem unit, it is possible to operate the unit in a manner whereby one material may appear in adjoining layers; this is referred to as *cross contamination*.

  This behavior is most commonly seen with platinum gas, as its physical composition allows itself to adhere to parts of the MultiChem mechanism. If you need advice, contact your local Thermo Fisher Scientific office and ask about the applications support services that we offer. Applications support is not covered by service contracts or warranties.

MultiChem Gas Names

The MultiChem gas names will be a simplified and shortened version of the chemistry name. The individual chemistries may be used in more than one gas chemistry application, and that some chemistry applications are composed of more than one gas.

For example, IDEP2 is TEOS and water vapor:

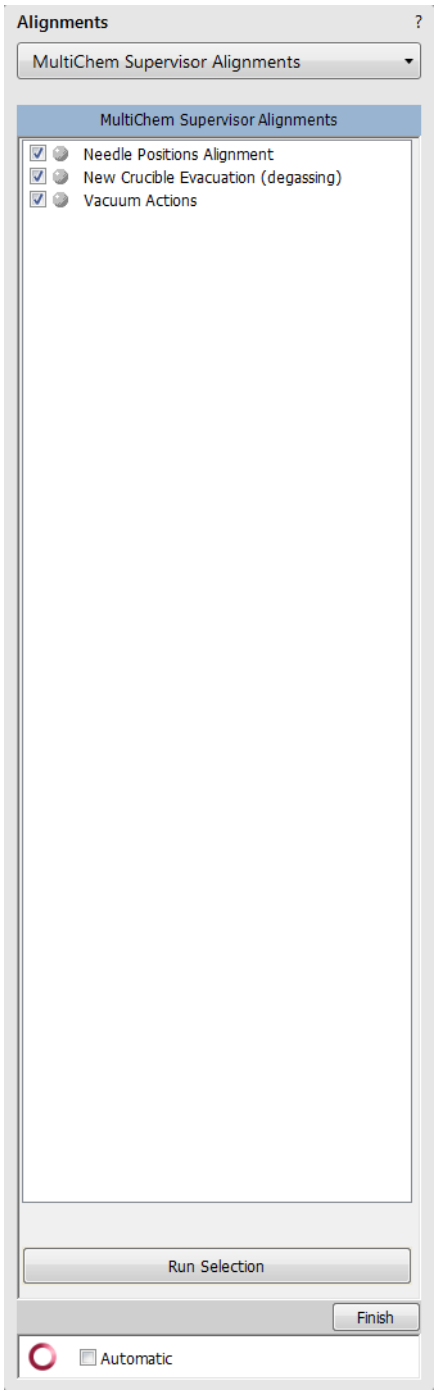
- TEOS by itself is not IDEP2, so it is misleading to name the TEOS port IDEP2
- Water vapor is used by itself as SCM, but it is also used in IDEP2

MultiChem Pattern Application Files

The Pattern Application File names will be with an "_M" appended to the end to denote, that it is a MultiChem application file.

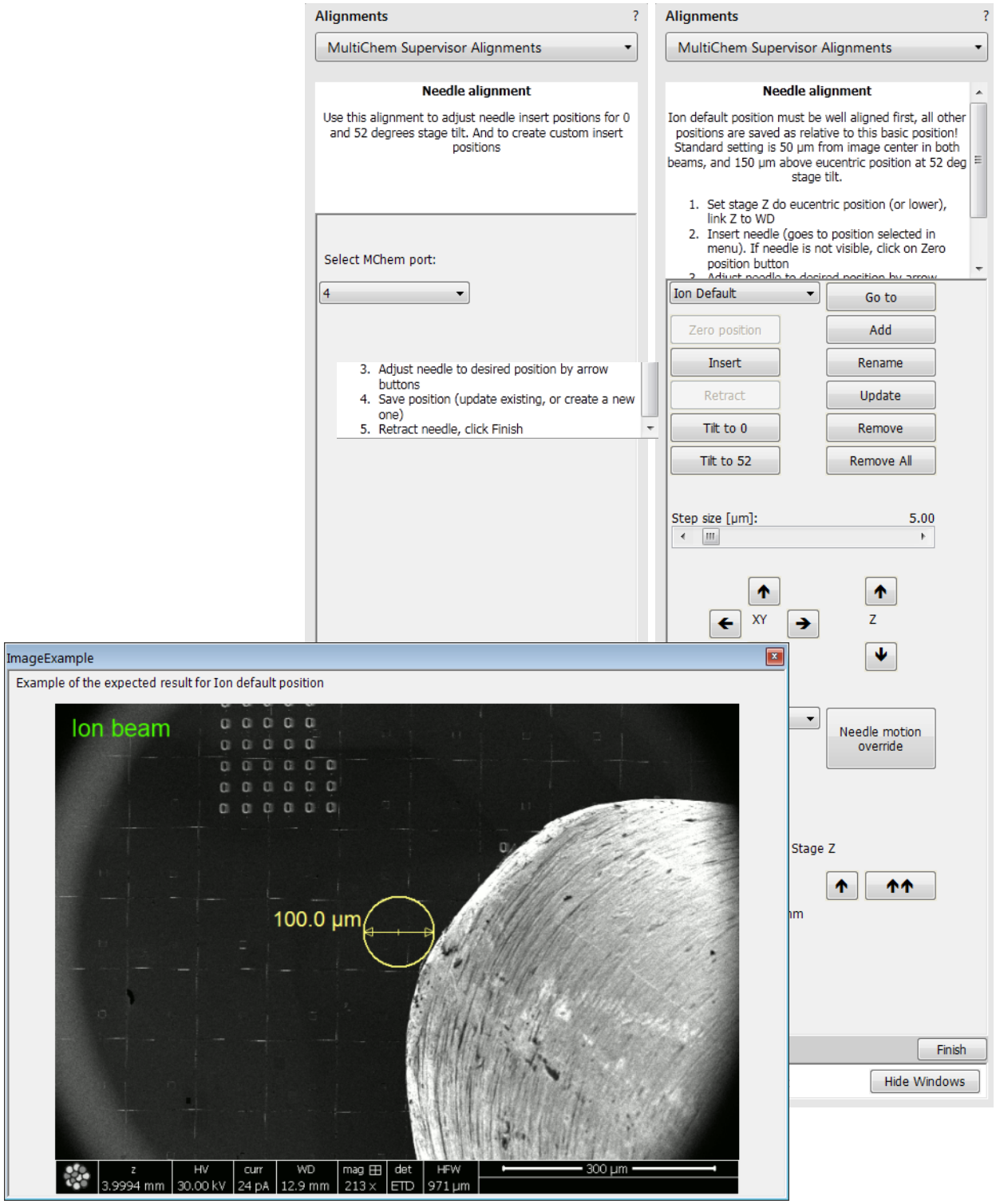
MultiChem Supervisor Alignments

Select one of the four supervisor alignments and click **Run Selection**.



Needle Positions Alignment

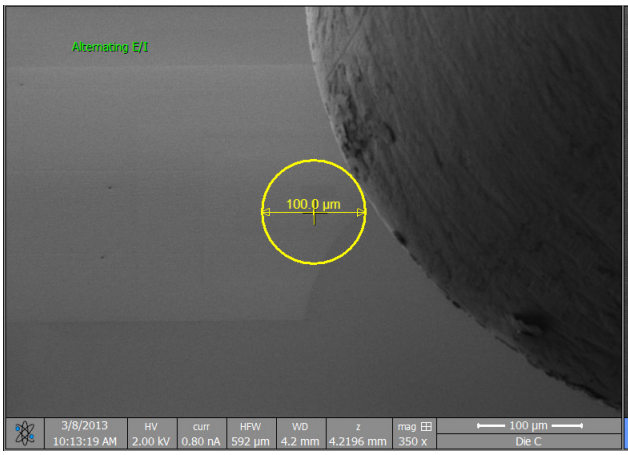
Follow the guided instructions.



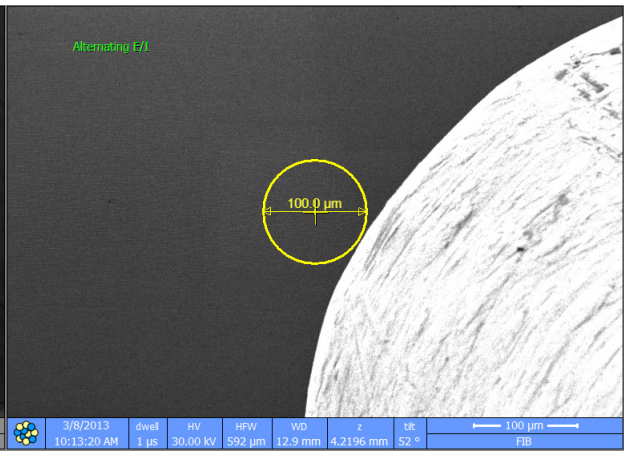
Needle Placement Using a Circle Measurement Tool

1. Define a circle measurement tool with a 100 µm diameter on the SEM and FIB images and place the center of the circle at the center of the image.
2. Position the nozzle so the edge of the nozzle is within a couple microns of the edge of the circle when viewed with either beam. This will place the needle at the 50 µm distance from the image center, as required for the alignment procedure.

SEM Image



FIB Image



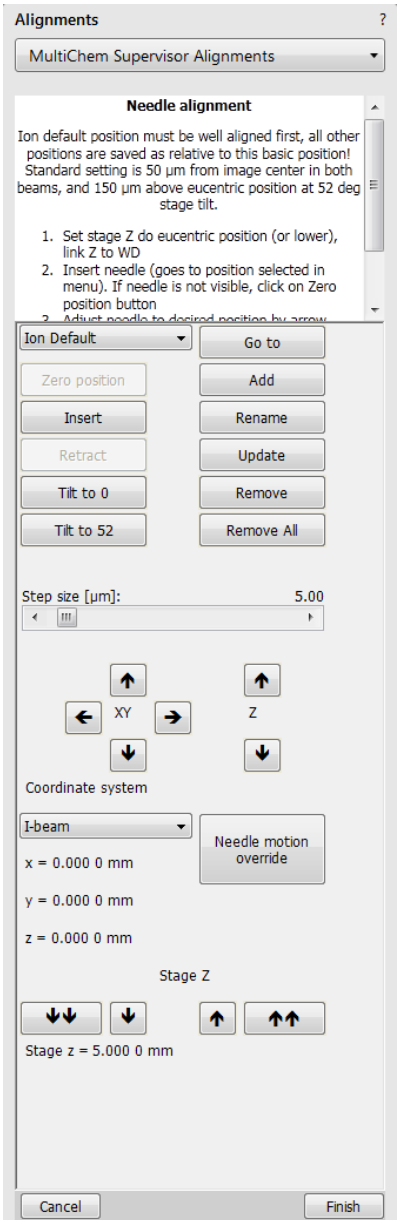
3. Note the stage Z-axis value at the working height (usually eucentric or coincident point). While live imaging, slowly and carefully raise the stage until the sample touches the nozzle and a touch alarm is generated OR the nozzle deflects.

   If the nozzle begins deflecting immediately upon raising the stage, then the nozzle was touching at the working height: in this case lower the stage until the nozzle is no longer touching and repeat the step 2.

   Determine the distance of the nozzle from the working height by subtracting the z-axis value at working height from the value at which the sample touched the nozzle. If the nozzle is not 150 µm ± 15 µm above the working height, then raise or lower the nozzle as necessary and repeat the step 2.
4. Once the nozzle position is correct, update the nozzle position prior to retracting the nozzle (retracting prior to saving will cause the nozzle position to go back to the previously stored position). Re-insert the nozzle and verify that it goes back to the correct position.

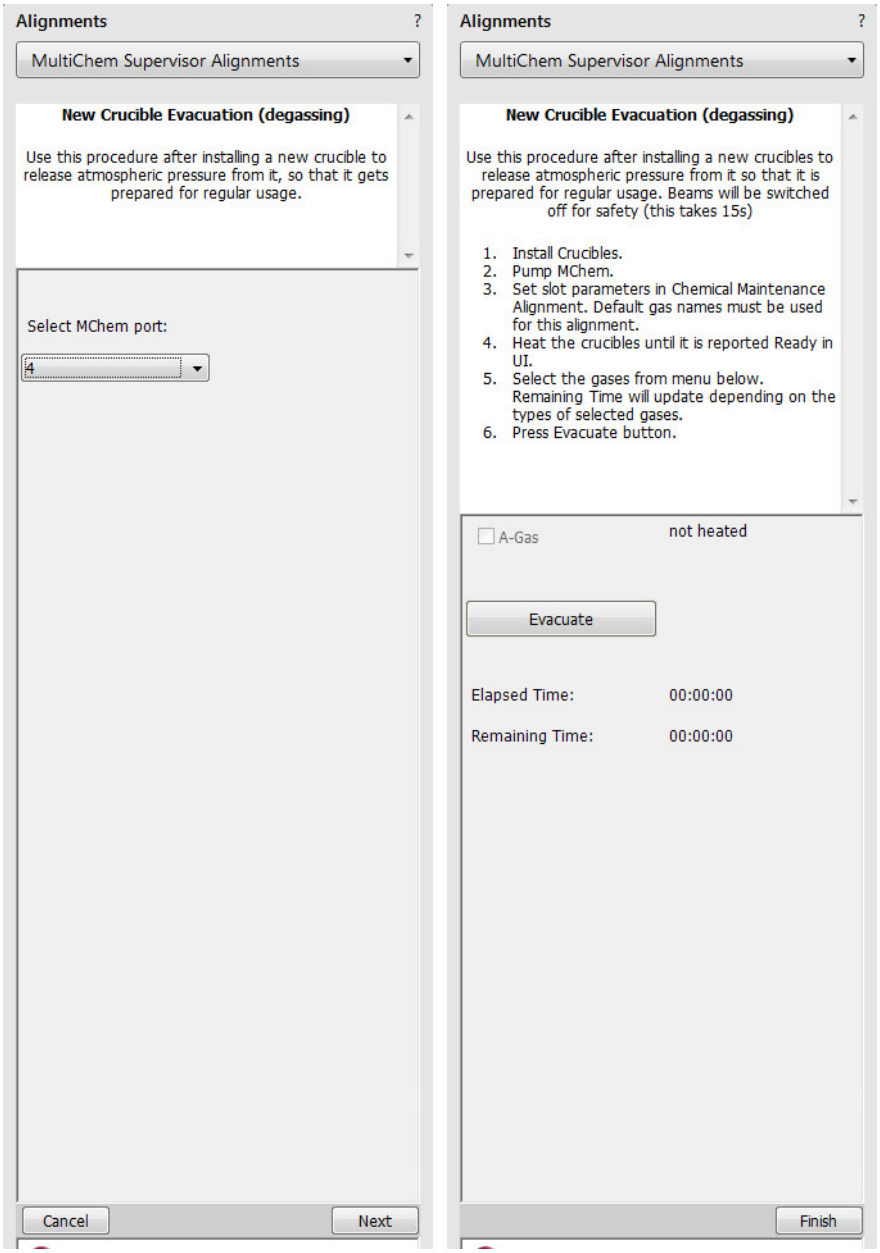
Creating a Custom User Position

1. Move the nozzle to the desired position.
2. Click **Add** to create a new User Position entry in the position dropdown list.
3. Verify that the newly-created position is selected and click **Rename**.
4. Enter the desired name for the new position and click **Finish.**
5. Verify that the name has changed and that the newly-created position is selected and then click **Update** to store the position.



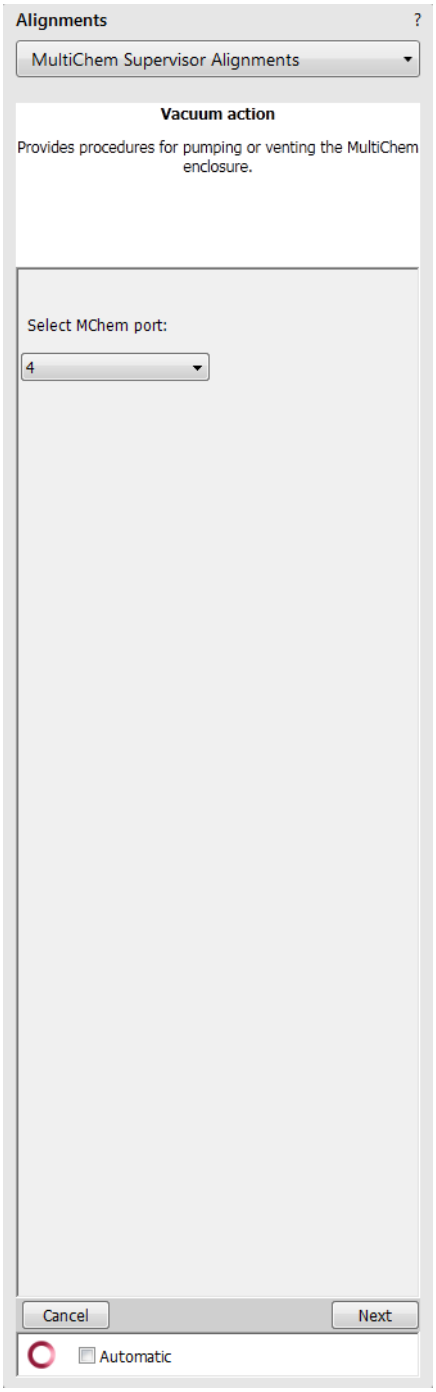
New Crucible Evacuation (degassing)

Follow the guided instructions. This alignment should evacuate all selected crucibles one at a time. This will save time when installing more crucibles at once.



Vacuum Actions

Follow the guided instructions.



9 Alignments

CAUTION	Read this entire chapter before attempting any alignment corrections.

This chapter describes procedures for aligning the electron and ion columns for Thermo Fisher Scientific trained users and users. All alignment procedures take place on the Alignments page.

Topics include:

- *"About Alignments" on page 328*
- *"General Description and Structure" on page 331*
- *"Alignment List" on page 333*
- *"E-column: Emitter Startup" on page 335*
- *"E-Column: User Alignments" on page 336*
- *"E-Column: Supervisor Alignments" on page 337*
- *"E-Column: Auto U-Mode Source Centering" on page 338*
- *"E-Column: Aperture Map Selection" on page 339*
- *"E-Column: Magnification Correction" on page 340*
- *"E-Column: Supervisor tests" on page 341*
- *"I-column: Aperture Lifetime" on page 343*
- *"I-column: Alignments" on page 344*
- *"Stage Alignments" on page 346*
- *"External Plasma Cleaning / Plasma Cleaning" on page 347*
- *"Vacuum Actions" on page 349*
- *"Automatic Alignments" on page 351*

About Alignments

When all necessary alignments are performed properly, the beam moves through the column with maximum transmission, with minimum beam aberrations, the image will stay in focus, its rotation will be corrected, and it will not show a substantial image displacement when voltage and/or beam current are changed. Further more, the ion beam and electron beam should be in coincidence and report the same sample location accurate for milling/imaging purposes.

During electronic alignment, image motion is minimized and correcting beam astigmatism and focus are adjusted for each of the ion beam apertures. Additionally, image shift is corrected as necessary.

Ion column alignment procedures for the Phoenix and Tomahawk columns consist of mechanical and electronic beam manipulations to correct asymmetries. These corrections are made to give the best beam performance over a full range of operations.

NOTE	Ion column electronic alignment is VERY important for the successful performance of automatic scripts, e.g., AutoTEM™ and AutoFIB™.

During alignment procedures, you are allowed to change magnification and scanning speed, to use reduced area, and to optimize image brightness and contrast. If it is not prohibited for a particular alignment, you can also stigmate and focus the image. However, you cannot manually change the mode or high voltage or use the beam shift during an alignment procedure.

NOTE	Do not use Beam Shift at any time during the adjustment procedures, other than where specified, as this may be set to zero value at each section, and extra movement can offset the zero condition. All movement of the specimen can be made using the stage, either mechanical or motor driven, where appropriate.

Recommendation

To maintain your system in a good condition it is recommended to run specific alignments periodically, as stated in the following table:

Table 9-1 Periodical alignments

Alignment group	Alignment	Period [day]	Model
E-column: Supervisor alignments	Source Centering U-Mode	2	UX
	Source Tilt & Shift N-Mode	7	UX
	Source Tilt & Shift U-Mode	7	UX
	Stigmator HR	14	UX / CX
	Source Tilt & Shift	7	CX
	Lens Align & Stigmator UHR	7	UX / CX
I-column: Alignments	Beam Alignments	7	UX / CX
	Beam Shift Alignments	7	UX / CX

The Alignment Monitor (see further) arranges necessary alignments to be executed within the set period of time automatically.

Preliminary Conditions

- It is assumed that the Thermo Fisher Scientific trained service engineer's mechanical alignment of the column is correct before the user can properly perform the software user alignment.
- Before starting the alignment, the sample should be at eucentric position, and the ion beam shift on the Beam Control page should be set to zero.
- Before aligning the electron column, be sure that the final lens aperture is clean and properly centred.

Common Rules

- Alignments should be performed in display 1 to ensure the correct functionality of the Contrast, Brightness, and Auto functions used on the Alignments pages.
- During adjustment procedures, you can change the magnification, the scanning speed, use reduced area, and optimize image contrast / brightness. You can also correct astigmatism and focus an image (although for a particular alignment this is not allowed).
- During adjustment procedures, do not change a Spot size or a High Voltage. Do not use the Beam Shift at any time during the adjustment procedures, as this is set to the zero value at each alignment section. All specimen movements can be made using the stage where appropriate.

Service Alignments

Only Thermo Fisher Scientific Service engineers with password access can enter the Service Alignments page.

General Description and Structure

Common Elements

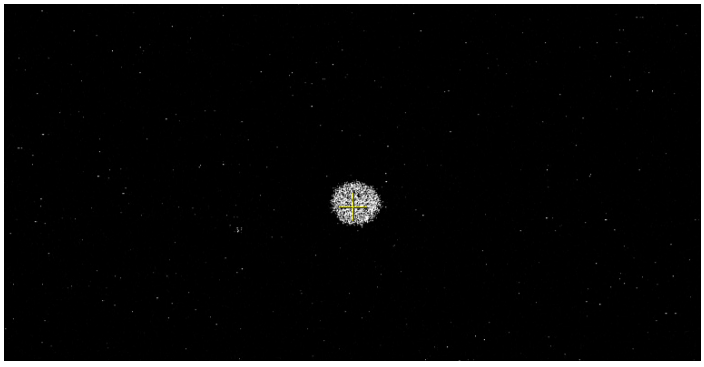
All software alignments (except Aperture) have the same page form and common elements:

- An outline of the function
- Alignment commands
- Step-by-step instructions - Follow the instructions given in the **Instructions** module. The **Step** shows the present control step number and the total number of steps.

Buttons and Control Elements

The following particular buttons and control elements have the same behaviors for all alignment procedures, when available:

- The **Start** button starts the procedure and proceeds with following dialogues.
- The **End** button moves a user to the last step (by clicking the **Next** button) to be able to finish the alignment procedure.
- The **Contrast / Brightness** adjusters enable to optimize the image quality during alignment.
- The **Auto** button executes the appropriate alignment action automatically for a particular voltage / spot / direction (whatever suitable) with the use of the **Image Recognition** software. If this utility does not recognize image features well, the procedure is aborted and Warning message appears onscreen. In this case change the imaging conditions (better focus, slower scanning, or lower magnification) and try again.
- The **Crossover** button activates the Crossover mode, where the onscreen image shows the electron source tip instead of the sample.



Alignment Commands

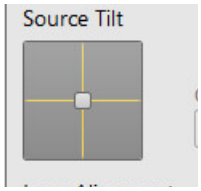
Table 9-2 Alignment Commands

Button	Description
Start	Starts the alignment procedure.
Next	Moves you to the following page after all the necessary settings have been selected.
Previous	Takes you to the previous page if the previous setting needs to be changed.
Finish	Completes the procedure and saves the new settings.
Save	Saves the actual settings at that point.
Cancel	Returns to the start without changing the original settings or the settings saved the last time SAVE was clicked.

Click **Start** and proceed with the next set of instructions.

Tips for X and Y Corrective Movement

Alignments may require some corrective movements in X anY direction at the same time. This is simplified by X and Y being represented as a 2D X-Y control (graphical adjuster).

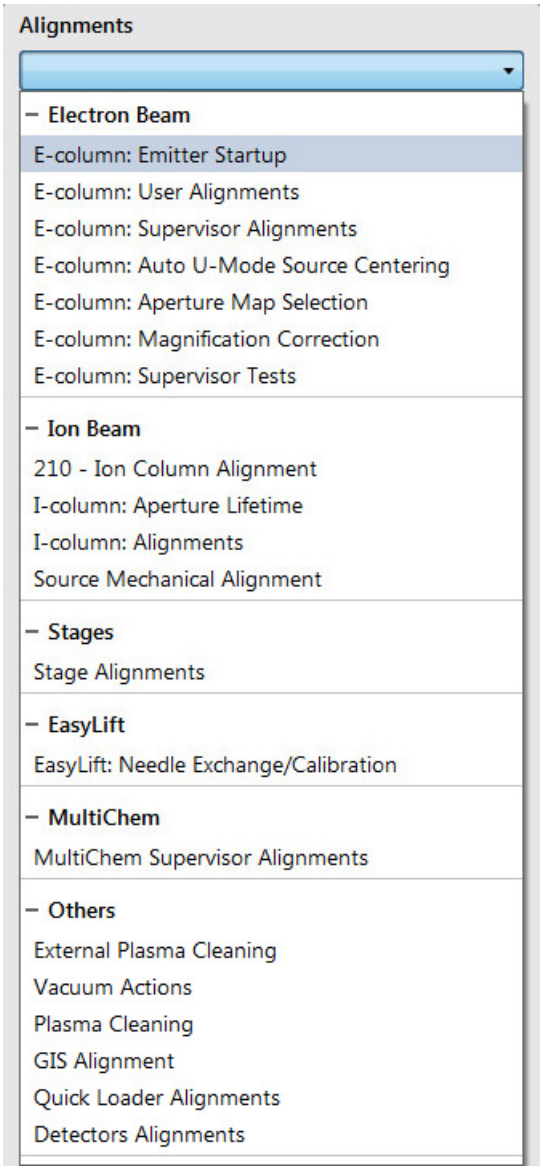


Click on the 2D box and hold down the left mouse button; a cross-hair shows onscreen with a small 4-ended arrow cursor located in the center. By moving the mouse, the cross-hairs move and affect the image as required. Due to the fact that the probe rotation correction is switched off automatically in some alignment procedures, the X and Y movements may not always appear to be in the same directions.

Alignment List

On the Alignments page, open the list box and then choose the Alignment needed.

Figure 9-1 Helios G4 PFIB HXe



Electron Beam

- **Emitter Startup**: Enables IGP's and electron gun - Emitter switching On / Off.
- **E-column: User Alignments**: Set of User level electron beam adjustment procedures

- **E-column: Supervisor Alignments**: Set of electron beam adjustment procedures
- **E-column: Auto U-Mode Source Centering UC+**: Automatic alignment centers the beam through U-mode aperture.
- **E-column: Aperture Map Selection**: Enables to set a second set of final lens apertures in case the image quality deteriorates (one or more actually used apertures are worn out).
- **E-column: Magnification Correction**: User magnification calibration (see Beam menu item).
- **E-column: Supervisor tests**: Set of system test procedures

Ion Beam

- **210 - Ion Column Alignment**
- **I-column: Aperture Lifetime**
- **I-column: Alignments**
- **Source Mechanical Alignment**

Stages

- **Stage Alignments** (set of utilities):
  Stage Rotation Center – sets the stage rotation centre for the compucentric rotation.

EasyLift

- **EasyLift: Needle Exchange/Calibration**: Option – see *"EasyLift: Needle Exchange/Calibration Alignment" on page 241*.

MultiChem

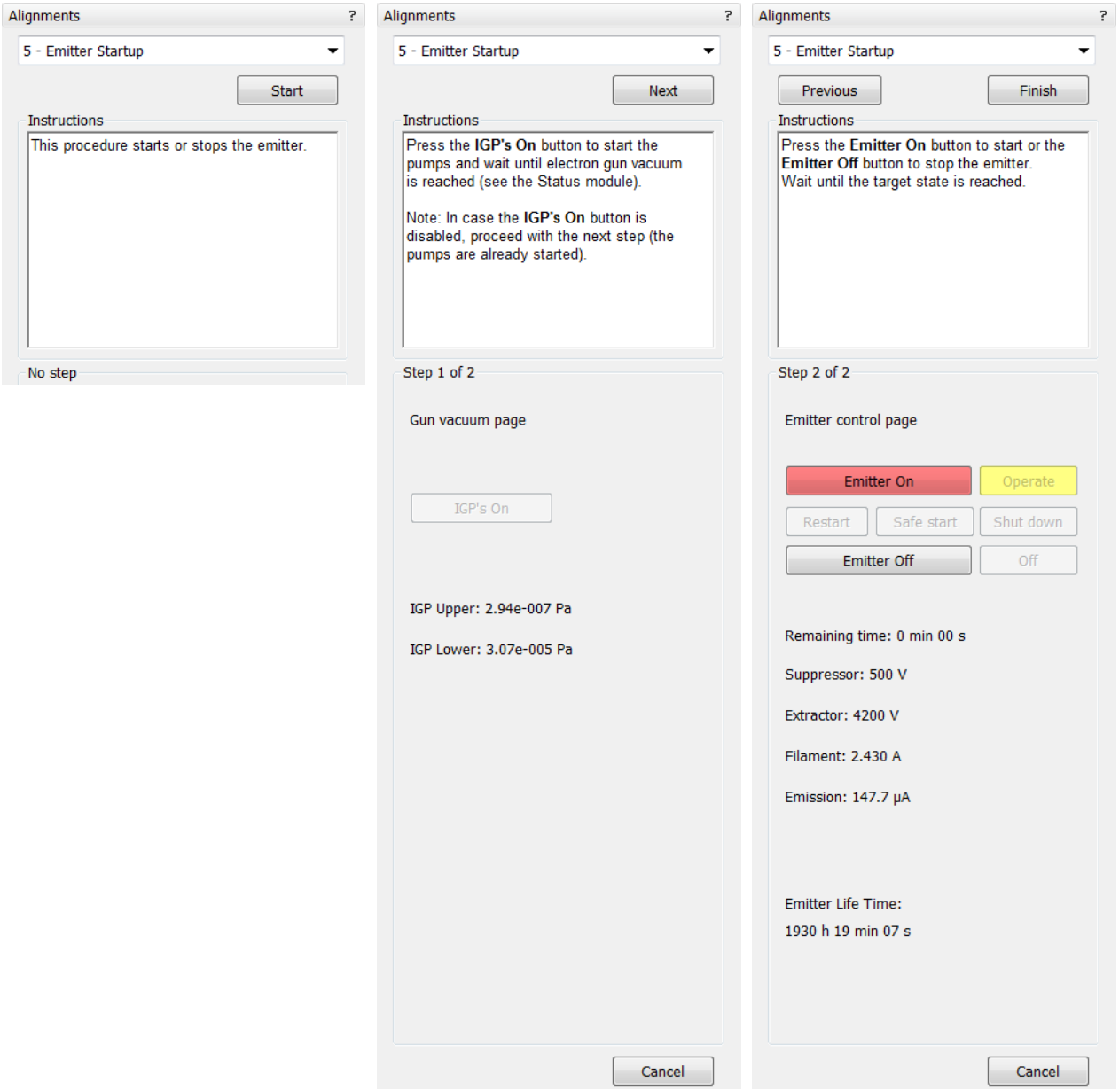
- **MultiChem Supervisor Alignments**: Option – see *"MultiChem Supervisor Alignments" on page 321*.

Others

- **External Plasma Cleaning / Plasma Cleaning**: Enables the chamber plasma cleaning and sets time of specimen plasma cleaning
- **Vacuum Actions**: Set of vacuum utilities not available from the UI.
- **GIS Alignment**: Option – see *"GIS Alignment" on page 306*.
- **Quick Loader Alignment**: Option – see *"Quick Loader Alignment" on page 391*.
- **Detectors Alignments**: Set of MD, ICD and ABS detectors calibration.

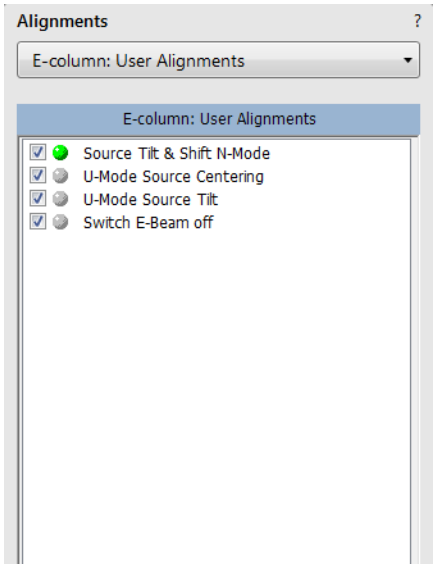
E-column: Emitter Startup

This procedure enables IGP's (Ion Getter Pumps) and electron source switching On/Off in cases of emergency shut down or if the microscope mains switches off.



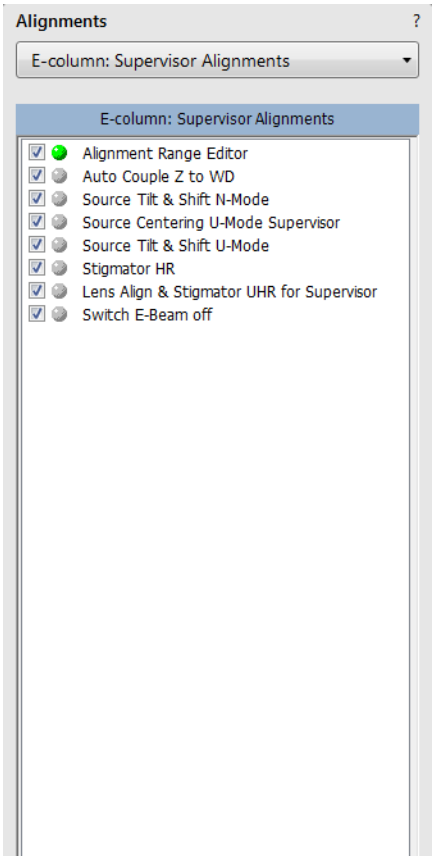
NOTE	If the Emitter **On** button is disabled and the IGP´s are running, restart the xT microscope Server and try again.

E-Column: User Alignments



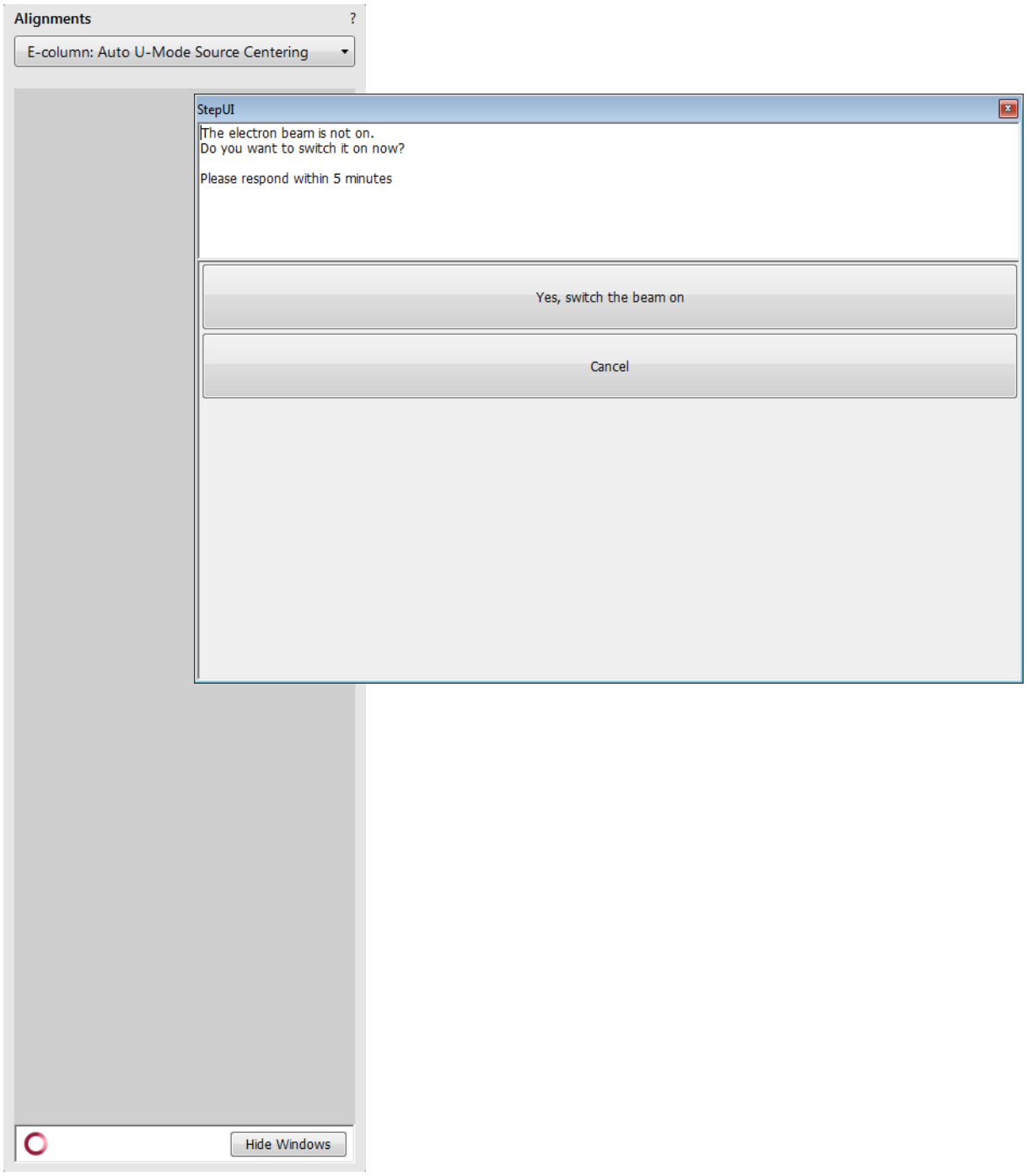
- **Source Tilt And Shift N-Mode**: Centers the electron source tilt and shift.
- **U-Mode Source Centering**: Centers the UC beam through U-mode slits.
- **U-Mode Source Tilt**: Sets up the Source Tilt values to get the beam through the EBA (Electron Beam Aperture) for different HV and UI probe values, and the source Shift values to direct the beam through the center of the HR lens.
- **Switch E-Beam off**:

E-Column: Supervisor Alignments



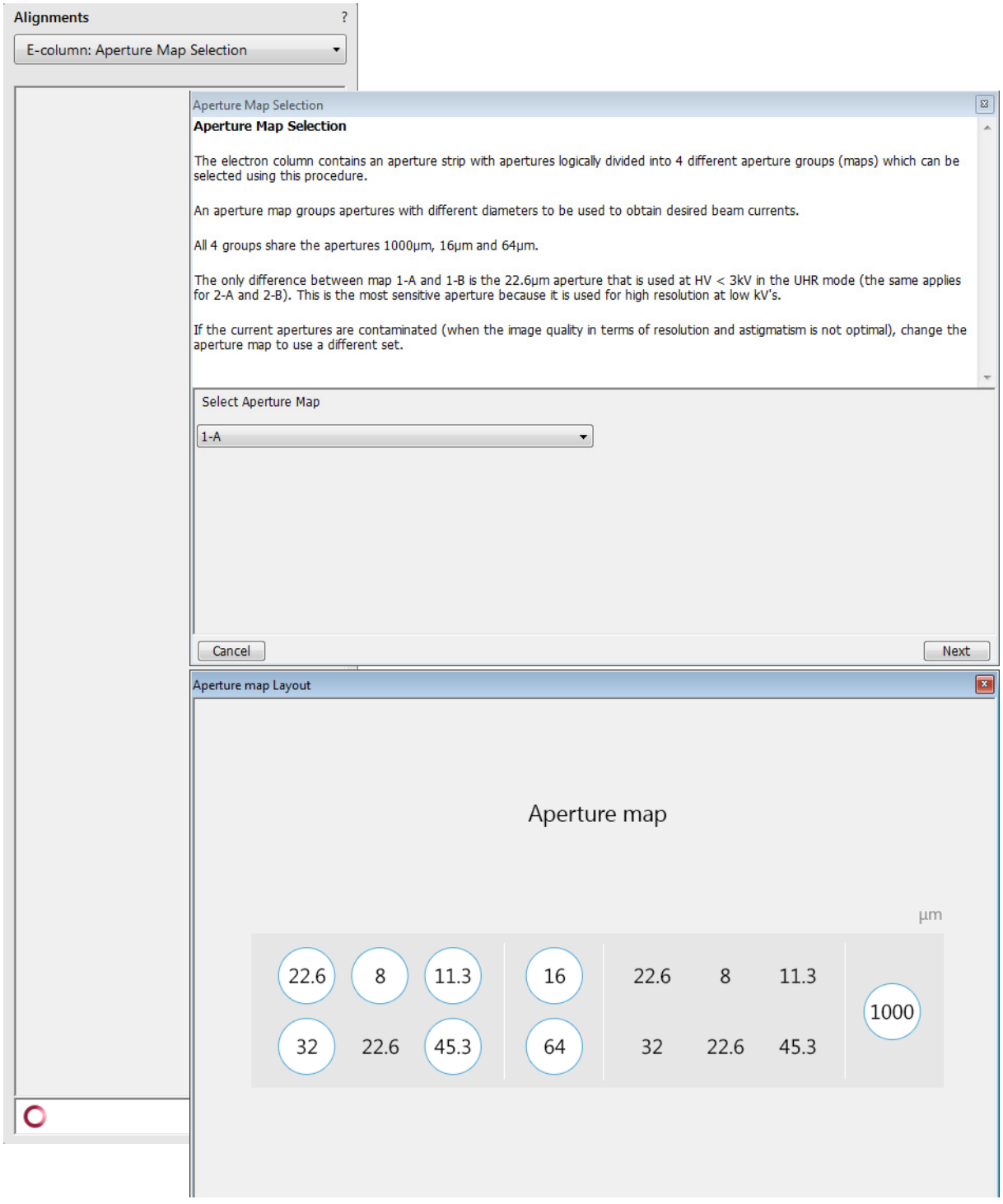
- **Alignment Range Editor**
- **Auto Couple Z to WD**
- **Source Tilt and Shift N-Mode / U-Mode**: Sets up the Source Tilt values to get the beam through the EBA (Electron Beam Limiting Aperture) for different HV and UI probe values, and the source Shift values to direct the beam through the center of the HR lens.
- **Source Centering U-Mode Supervisor**:
- **Stigmator HR**: Sets up the table values for different HV of the Stigmator balance and astigmatism correction in HR mode.
- **Lens Align & Stigmator UHR for Supervisor**: Sets up the table values for different HV on the Lens Alignment, Stigmator balance and astigmatism correction in Mode 2 (Immersion/UHR). Eliminates image shift during focusing and/or normal astigmatism correction in Mode 2.
- **Switch E Beam Off**

E-Column: Auto U-Mode Source Centering



E-Column: Aperture Map Selection

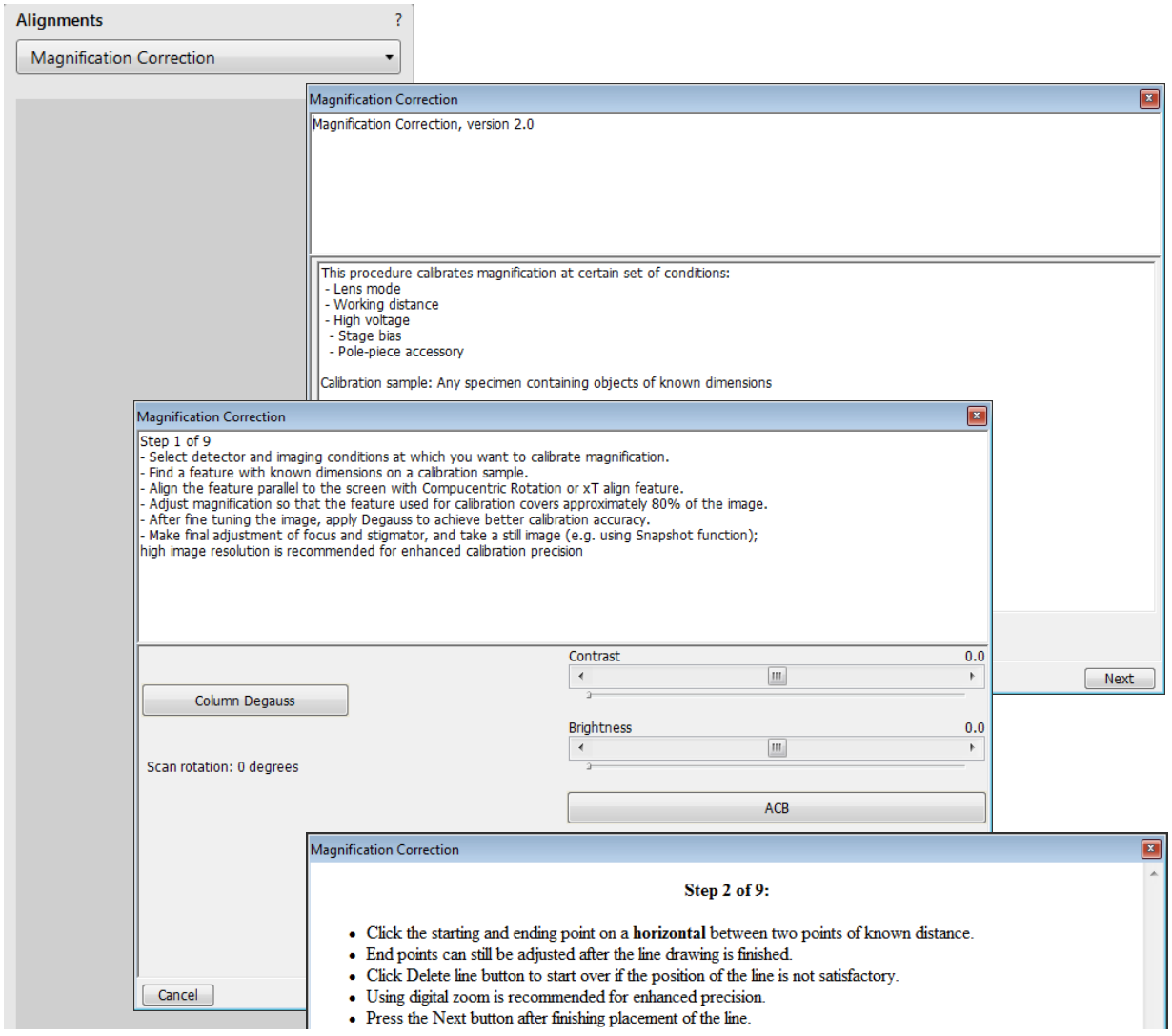
Try to change the aperture map when imaging is poor or the astigmatism can not be corrected.



E-Column: Magnification Correction

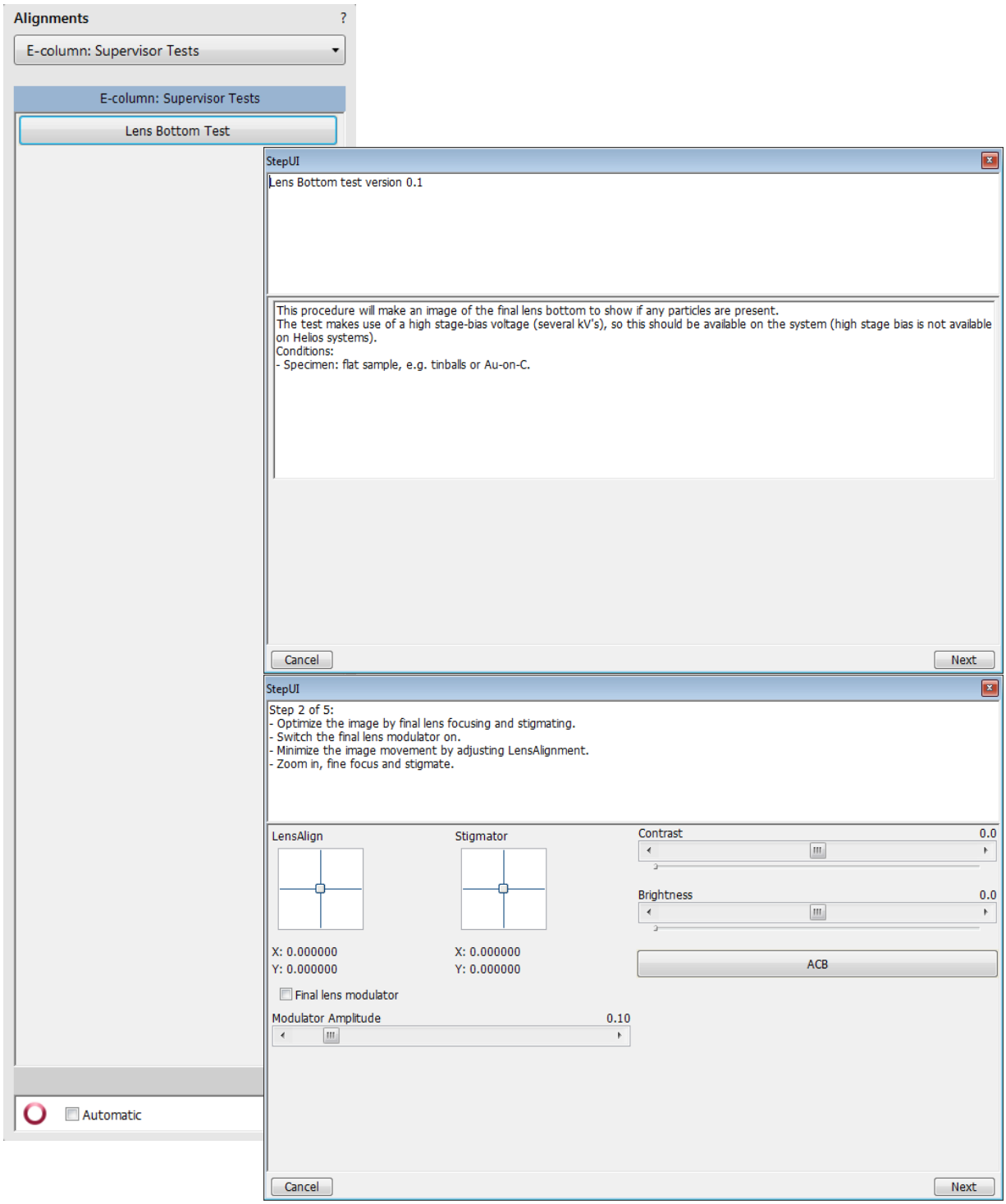
This utility is intended to enhance factory calibration accuracy under particular, user selectable conditions:

- Lens mode
- Working distance
- High voltage
- Stage bias
- Pole-piece accessory.



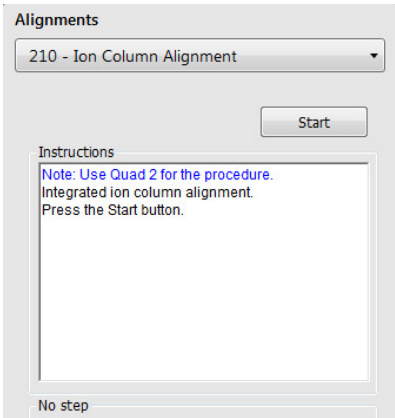
NOTE	Select **Beam > Magnification Correction** only for calibrated conditions, otherwise it could worsen magnification accuracy.

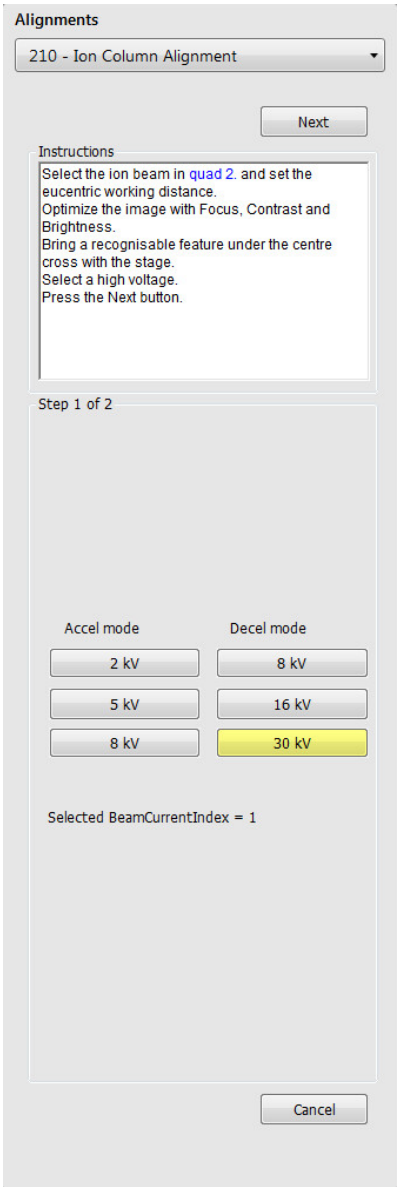
E-Column: Supervisor tests

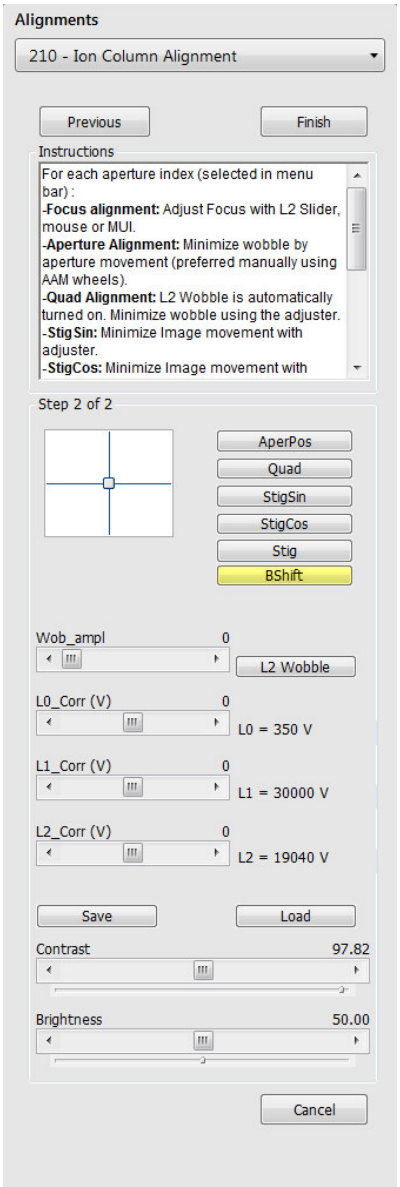


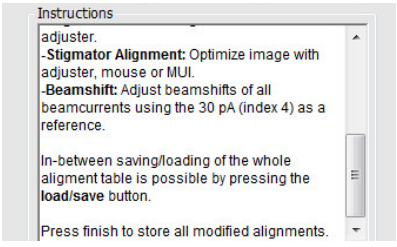
■ **Lens Bottom test**

210 - Ion Column Alignment

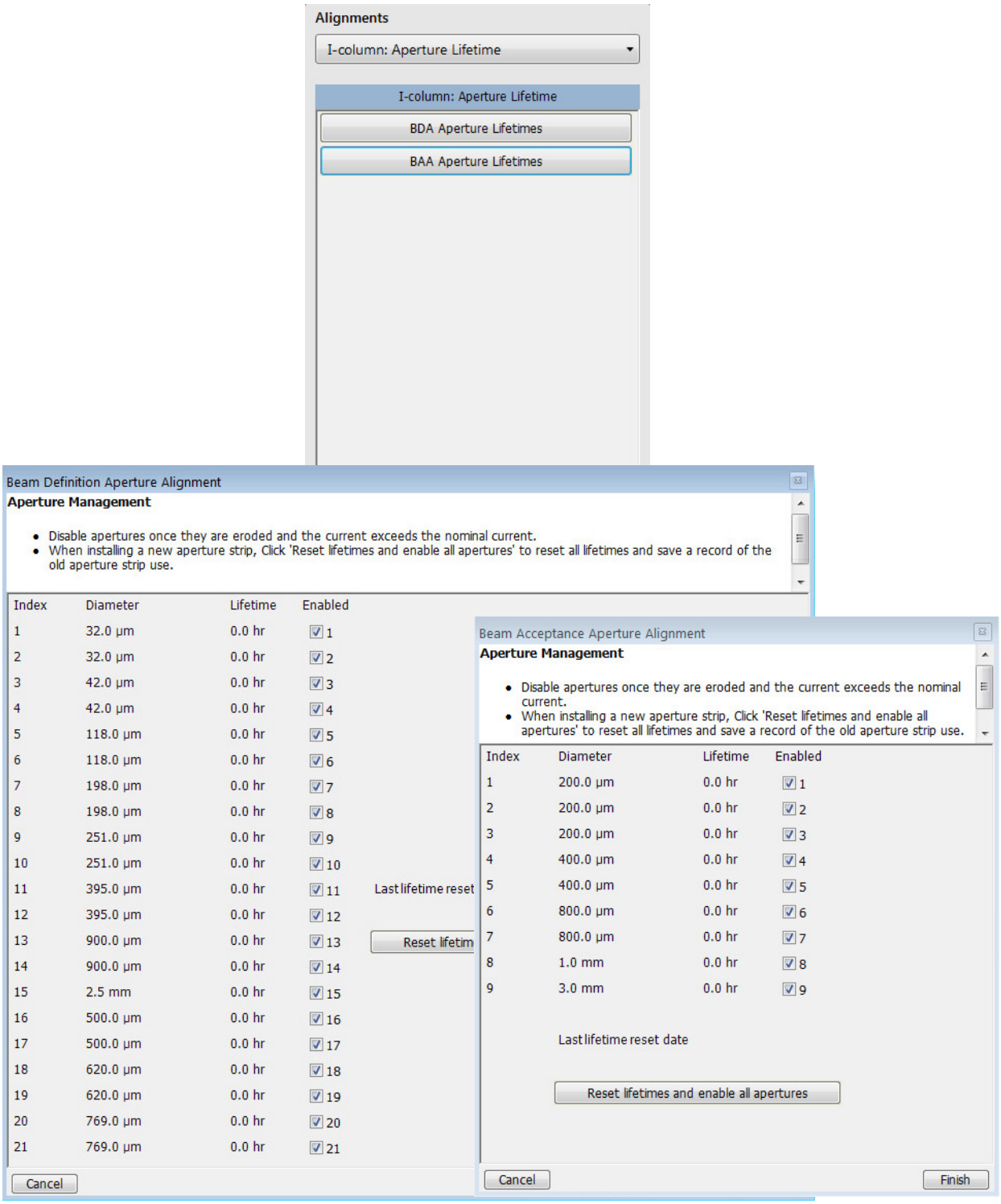




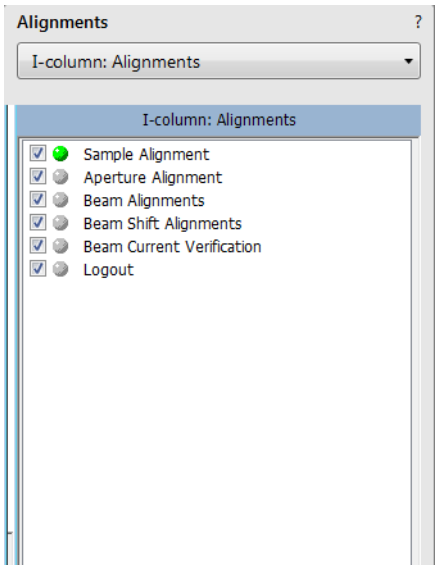




I-column: Aperture Lifetime

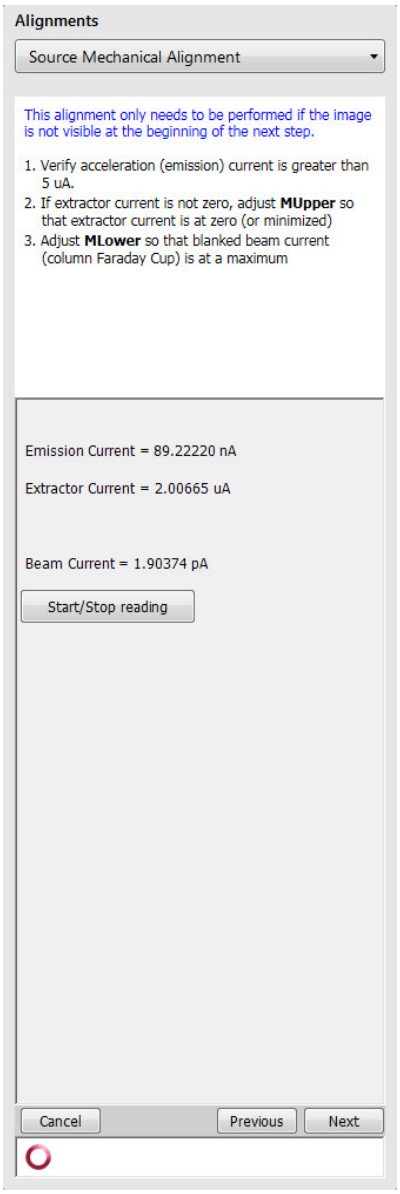


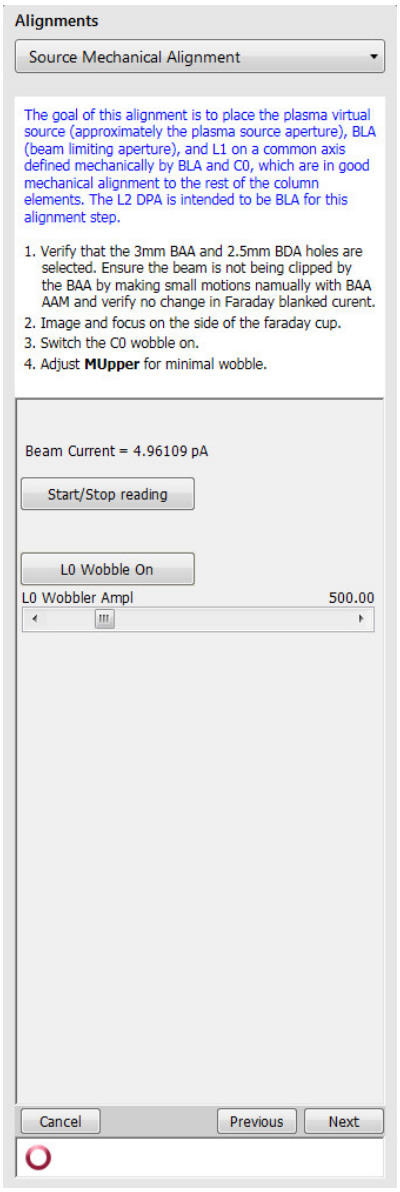
I-column: Alignments

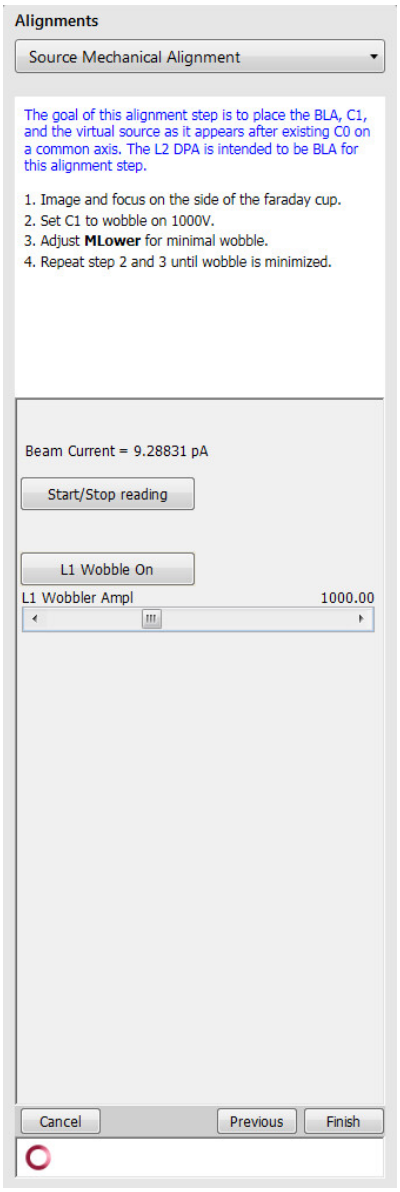


- **Sample Alignment**:
- **Aperture Alignment**:
- **Beam Alignment**:
- **Beam Shift Alignment**:
- **Beam Current Verification**:
- **Logout**:

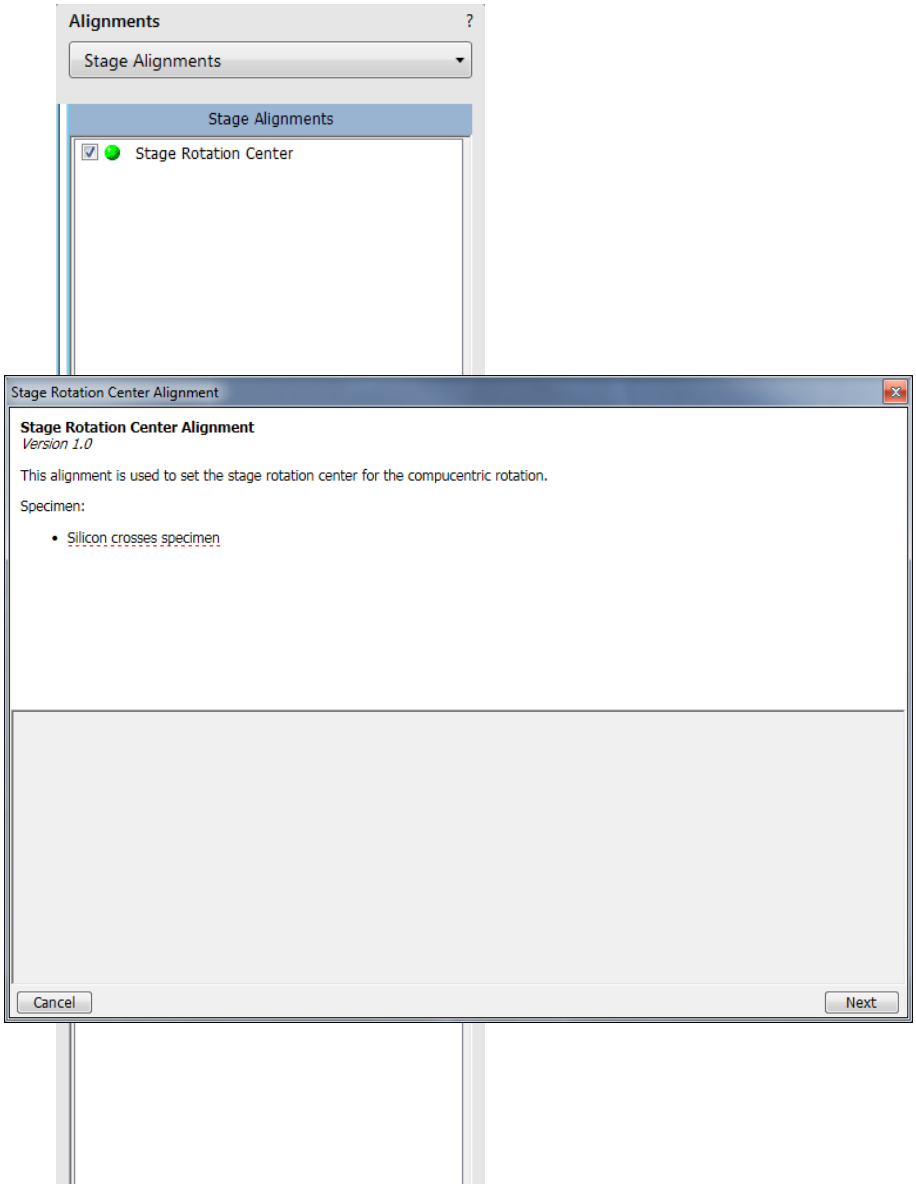
Source Mechanical Alignment







Stage Alignments



- **Stage Rotation Centre**: The stage rotation has a mechanical center and it can be controlled by changing the Stage module / R value. The stage moves around its mechanical center. In some cases this is not desired because a rotation around the field of view center would be more useful.

  Make sure the stage tilt is zero during alignment. The magnification should be from 500× to 2 000× and the sample should have a well recognizable feature at least 10 mm from the center to improve accuracy.

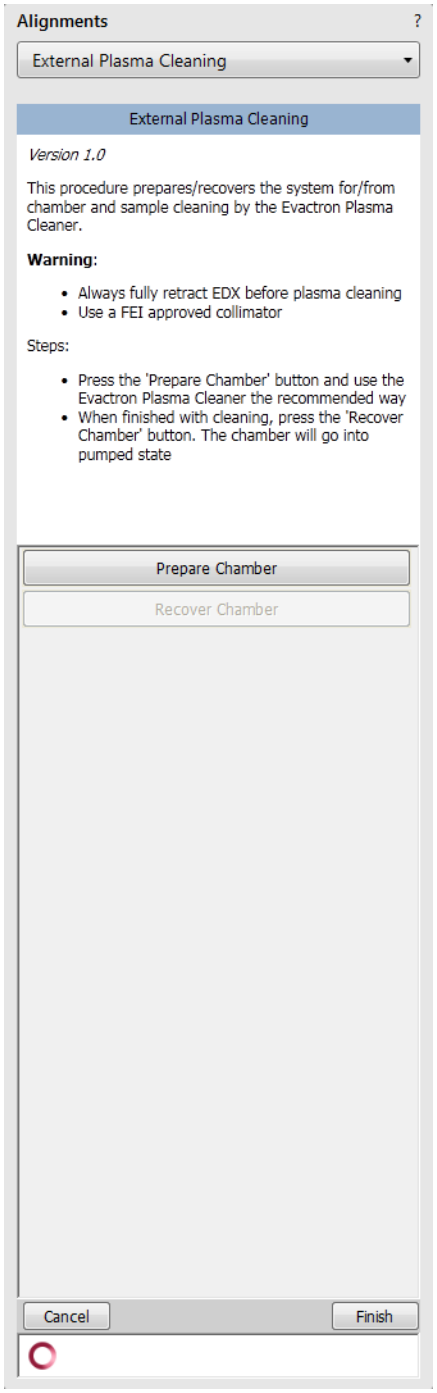
External Plasma Cleaning / Plasma Cleaning

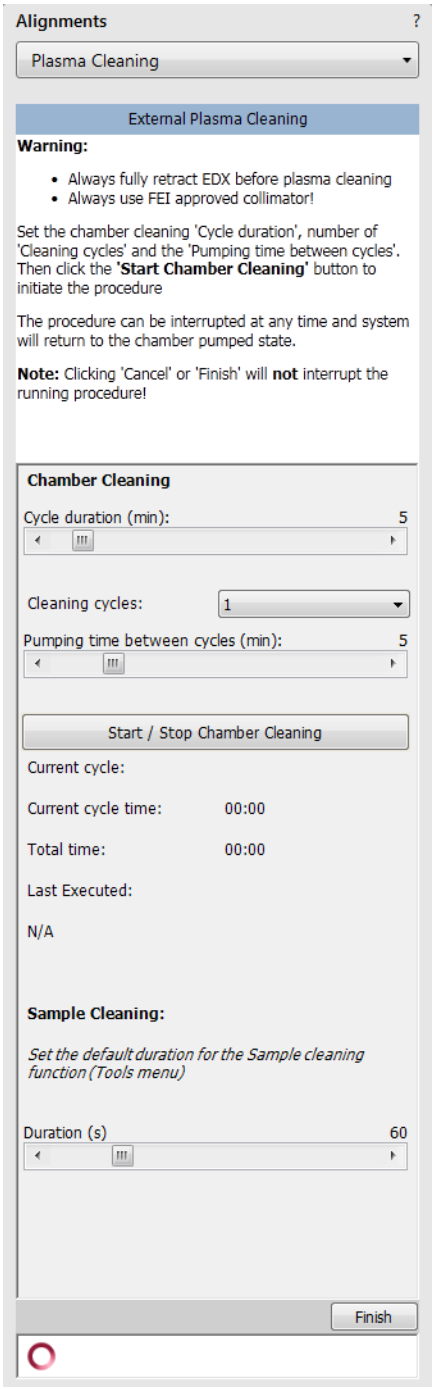
CAUTION	Always retract EDS / WDS / EBSD detector before plasma cleaning procedure! Do not leave sensitive samples (including Au-C resolution test samples) in the chamber during Chamber Cleaning (it may be damaged).

When a repeated **Sample Cleaning** procedure is not effective (see *"Sample Cleaning" on page 77*), click the **Start / Stop Chamber Cleaning** button, its **Duration** could be much longer.

If longer plasma cleaning time is needed it is recommended to use several shorter plasma cleaning cycles separated by pumping the chamber down to HiVac mode. Residuals created during plasma cleaning are pumped away and following plasma cleaning is more effective. Adjust the Cycle duration, Clean cycles and Pumping time between cycles.

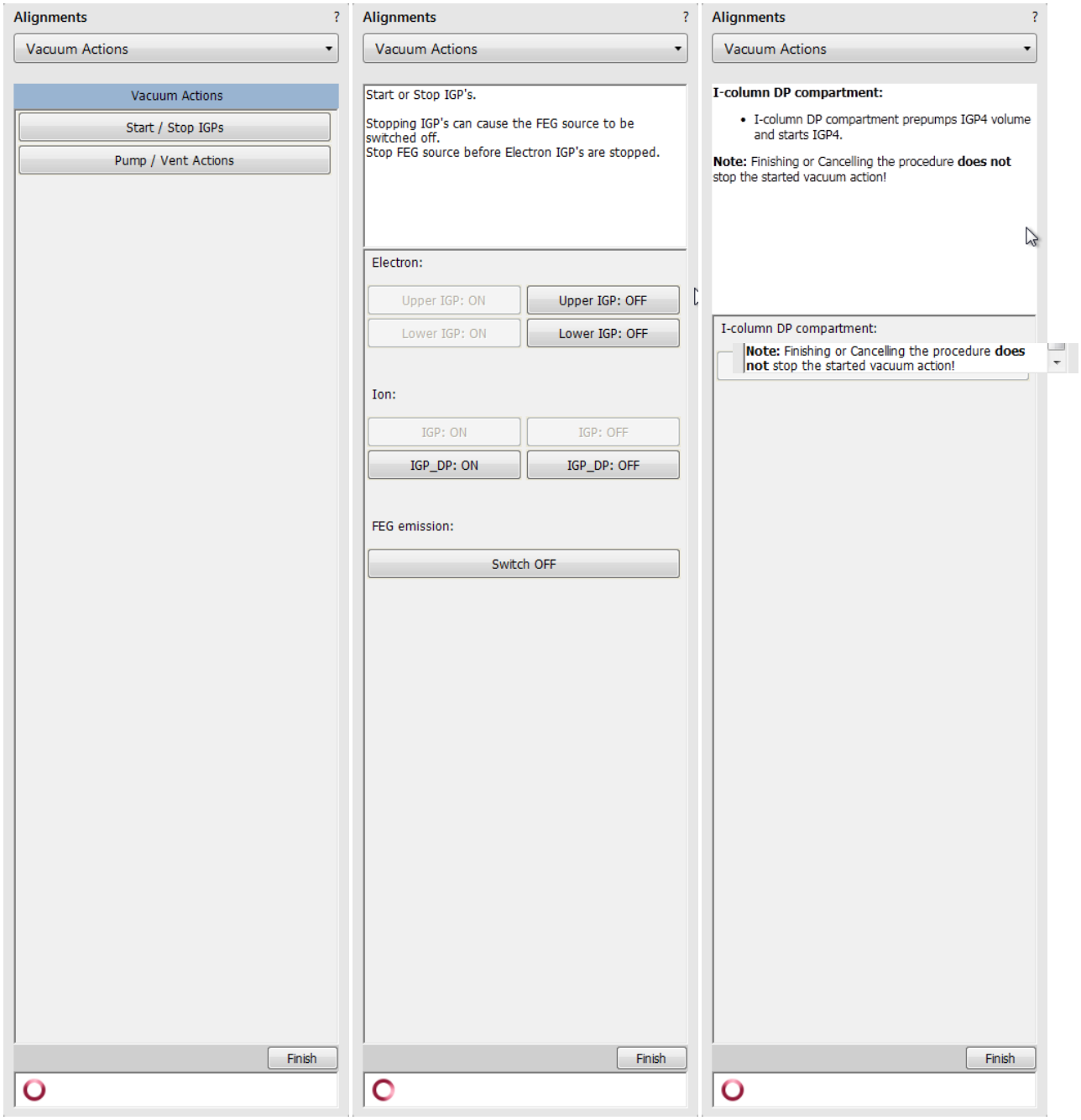
NOTE	If there is an external Evactron plasma cleaner, follow the External Plasma Cleaning alignment instruction and the Evactron user manual!


Alignments
?
External Plasma Cleaning
External Plasma Cleaning
Version 1.0
This procedure prepares/recovers the system for/from chamber and sample cleaning by the Evactron Plasma Cleaner.
Warning:
Always fully retract EDX before plasma cleaning
Use a FEI approved collimator
Steps:
Press the 'Prepare Chamber' button and use the Evactron Plasma Cleaner the recommended way
When finished with cleaning, press the 'Recover Chamber' button. The chamber will go into pumped state
Prepare Chamber
Recover Chamber
Cancel
Finish

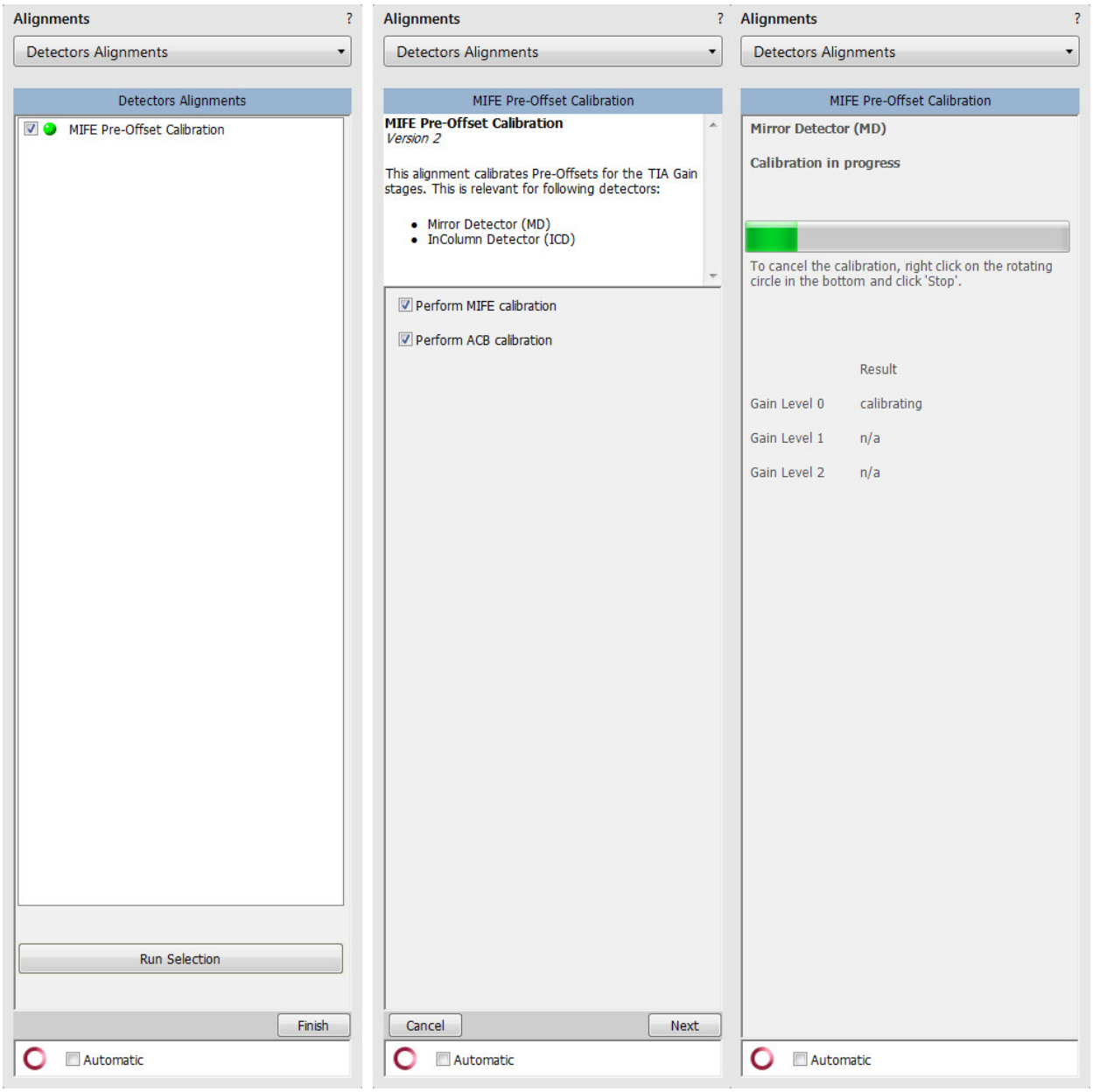

Alignments
?
Plasma Cleaning
External Plasma Cleaning
Warning:
Always fully retract EDX before plasma cleaning
Always use FEI approved collimator!
Set the chamber cleaning 'Cycle duration', number of 'Cleaning cycles' and the 'Pumping time between cycles'. Then click the 'Start Chamber Cleaning' button to initiate the procedure
The procedure can be interrupted at any time and system will return to the chamber pumped state.
Note: Clicking 'Cancel' or 'Finish' will not interrupt the running procedure!
Chamber Cleaning
Cycle duration (min): 5
Cleaning cycles: 1
Pumping time between cycles (min): 5
Start / Stop Chamber Cleaning
Current cycle:
Current cycle time: 00:00
Total time: 00:00
Last Executed:
N/A
Sample Cleaning:
Set the default duration for the Sample cleaning function (Tools menu)
Duration (s) 60
Finish

Vacuum Actions

- Start / Stop IGP's – enables to start / stop vacuum pumps in case of power failure / emergency or service actions
- Pump / Vent Action – enables to pump / vent particular vacuum system sections

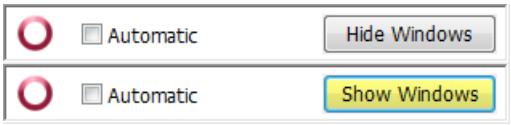


Detectors Alignments



Automatic Alignments

Some of Alignments are not numbered and run in a different environment; they are actually the set of alignments. Most of the procedures could run automatically by ticking the **Automatic** check box placed next to the red star.

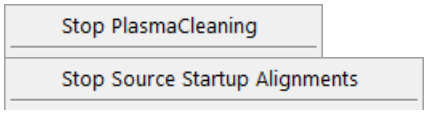


During the procedure, informational windows can be turned on / off by the **Show/Hide Window** button. **Cancel** the alignment sequence or continue by the **Next** button.

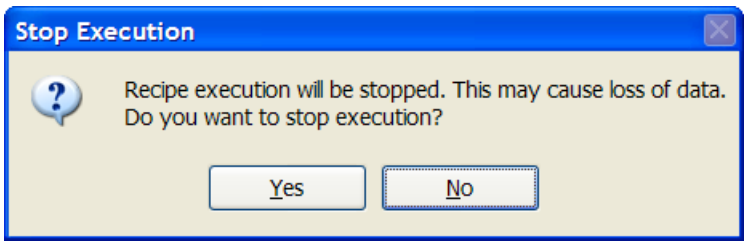
CAUTION	Read carefully the instructions provided by the system before proceeding with any alignment.

If you have selected any e-beam alignment procedure and you want to select any other one, you must **Finish** or **Cancel** an opened procedure first. To start alignment procedure or to stop one in progress, right-click over the red star and select the required action (**Start/Stop**). A confirmation dialog is shown.

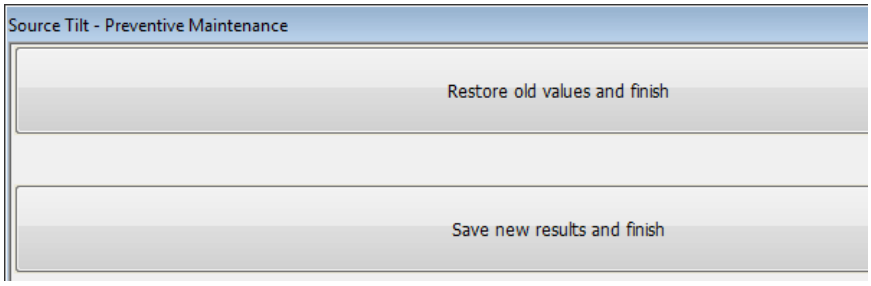
By clicking the **Cancel** button, by selecting the **Stop** item in the menu (see below) or by closing the UI, nothing is saved (see Restore old results below).



In all cases, the alignment windows over the displays disappear and the **Stop Execution** dialog appears.



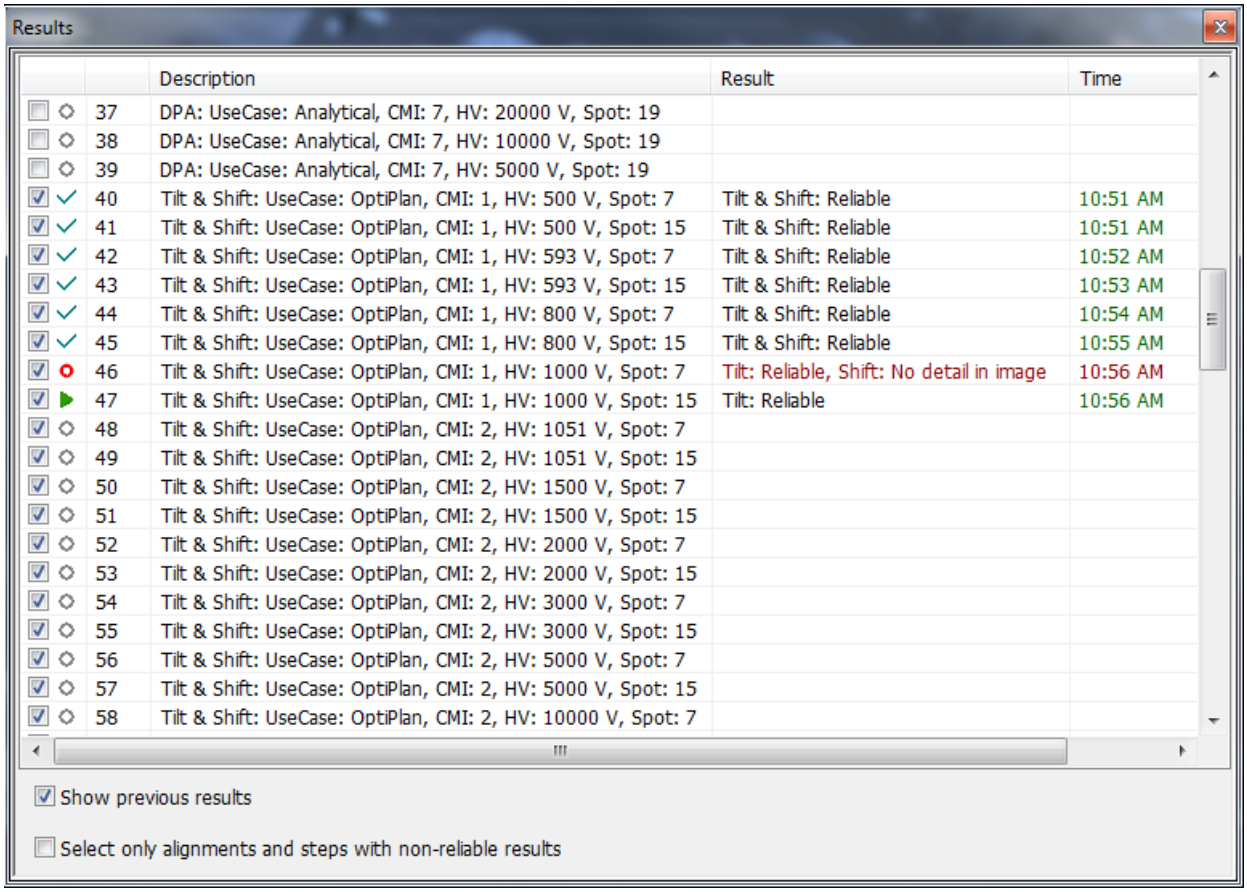
The last page of every alignment offers one or more of the following possibilities:



- **Restore old values and finish**: Undoes the adjustments, nothing will be saved.
- **Save new results and finish**: Keeps new adjustment values and saves them. Also creates a new **Restore Point**.

Results

The result of every step is shown by means of an icon in the result list when performing alignment steps.



- **Unavailable**: The result has never been obtained, at least not by this procedure. This may mean that it has never run, or that it failed to do anything meaningful (the difference between these two is not important).

- **Reliable**: The result is trusted by the automatic procedure OR a user has passed the alignment step manually (i.e., we trust that a user actually performed the alignment step).

- **Unreliable**: The automatic procedure has done meaningful work, but could not decide whether the obtained result can be trusted. This suggests you should review the result manually.

- **Out of range**: The automatic procedure trusts that the optimal outcome is outside the range of the variable to be aligned. A value is set that is near the border of the range.

10 Applications

There are several software applications accessible via the menu bar **thermoscientific** drop down menu:

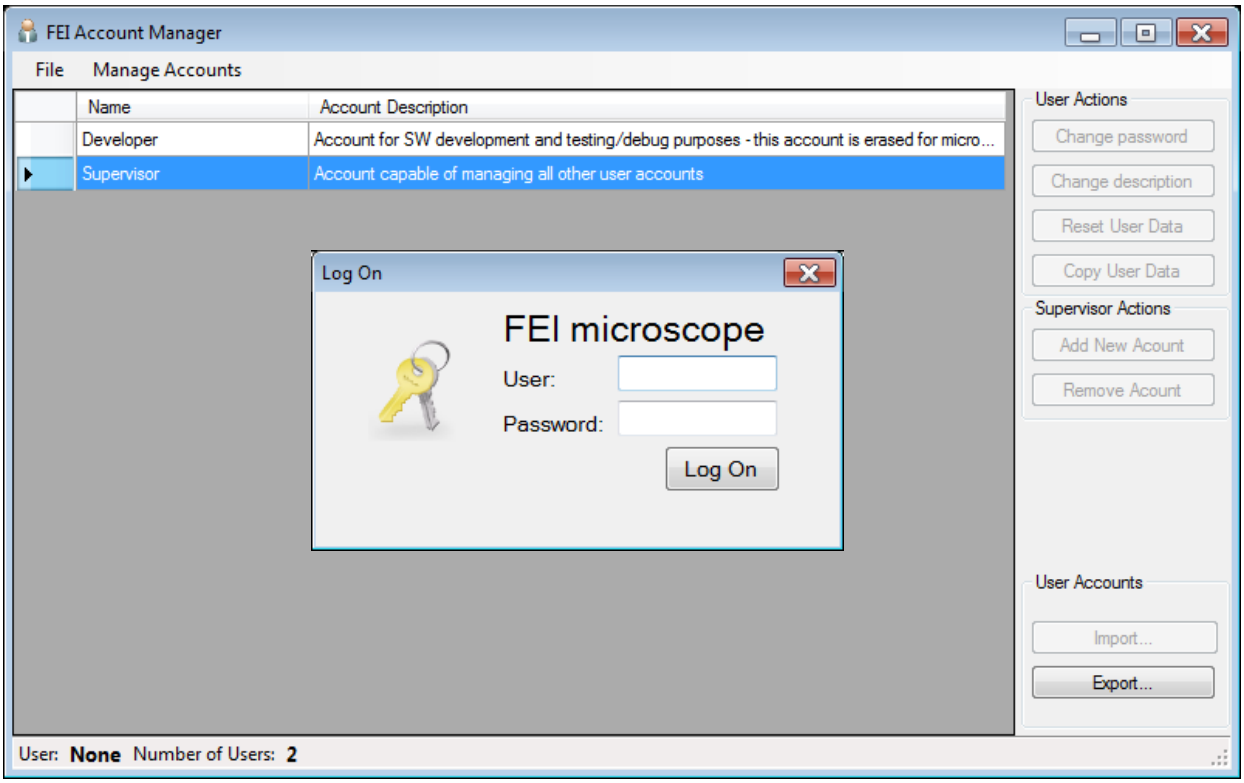
- **Account Management –** allows to organize users and accounts (see *"Account Manager Application" on page 356*).
- **Data BackUp –** allows to backup all system settings according to the account (see *"Data BackUp Application" on page 361*).
- **Auto Report –** when requiring a service intervention this utility enables to send the demand and the Report about the microscope system states (see *"Diagnostic Auto Report Application" on page 362*).

Account Manager Application

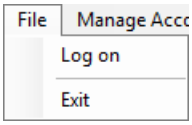
Within this application it is possible to organize microscope user accounts: creation and removal of user accounts, setting of user account name, description and password as well as copying and removal of user data.

Account administration

Start the software by clicking the menu bar **thermoscientific** drop down list / **Account Manager** icon or by clicking the **xT Microscope Server** window / **Service tools** button / **Account Manager** icon.



File menu

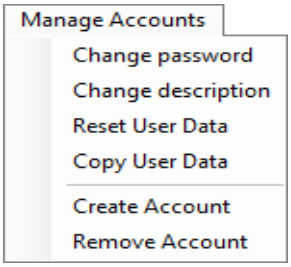


To manage accounts it is necessary to **Log on** at first. Active **User** is indicated in the bottom left corner of the application window together with a total **Number of Users** (accounts). First the application starts with just one **User** account, default credentials for the **Log On** dialog are:

- **User:** Supervisor
- **Password:** Supervisor

To exit the application click the **Exit** item.

Manage Accounts menu / User Actions area / Supervisor Actions area



Items within this menu have the same functionality as buttons within the **User** and **Supervisor Actions** areas placed on the right side of the main application window.

Table 10-1 Manage Accounts menu Overview (1 of 2)

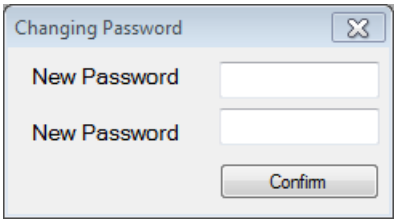
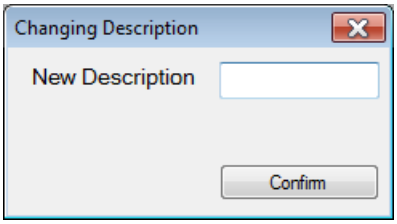
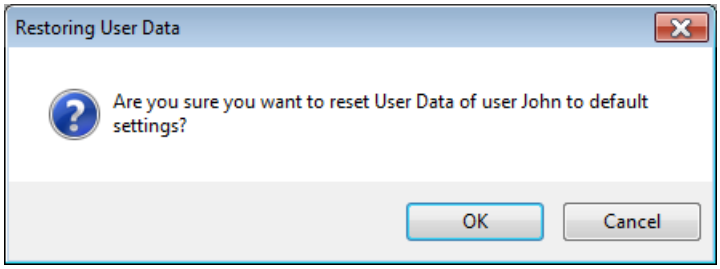
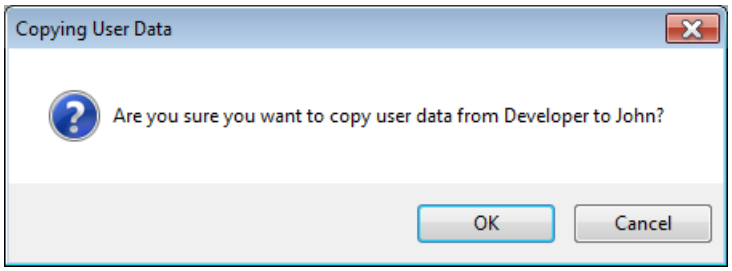
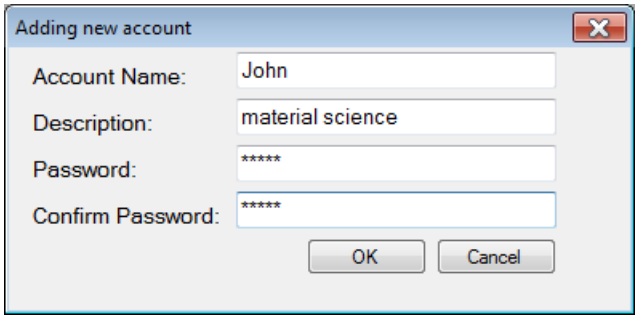
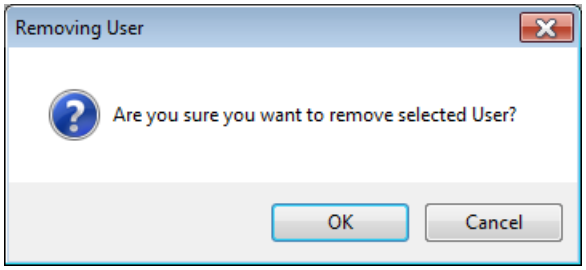
Menu Selection	Description
Change password	Changes a password of an active account. For the Supervisor level account it is advisable to change the password after the first log on.  A Supervisor can change the password for any user level account. The password has to be confirmed.
Change Description	Changes Account Description of an active account. After entering new description confirmation dialog appears.  A Supervisor can change description for any user level account.
Reset User Data	Resets user data of an active account to default settings.  A Supervisor can reset user data for any user level account.

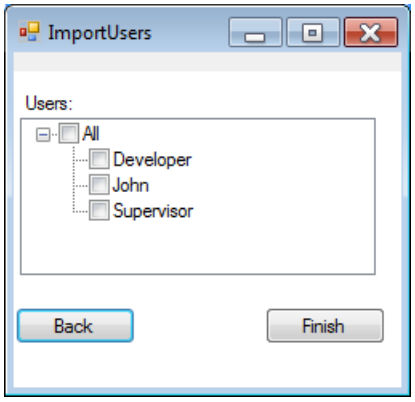
Table 10-1 Manage Accounts menu Overview (2 of 2)

Menu Selection	Description
Copy Userdata	Copies user data from a selected user account to the active user account. 
Create Account	Adds a new user account.  Only Supervisor can create new user level account.
Remove Account	Deletes a selected account and its user data.  Only Supervisor can delete any user level account.

User Accounts area

Any user can export accounts settings to the .reg file by clicking the **Export…** button.

Only a Supervisor can **Import…** user accounts exported to the .reg file by ticking the appropriate check box(es).



User Logins and Account Settings

Each user login account stores a variety of preference and configuration data in the registry. These values are then restored when that user logs back into the system.

Two main sets of data that are stored:

- Overall Layout and Settings for the UI,
- Preference Dialog Settings.

When a new user account is created the system database (Windows registry) is not populated with every possible setting. Rather what happens is that some values are only stored as the user changes them. For example, the MUI sensitivity settings are saved to the registry only once a user makes a change to one or more of the settings. Before that point the values the user will see when logging in are inherited from the Supervisor user account. This has the benefit of allowing all new user accounts to default to the same values that the Supervisor has already been using.

If the Supervisor makes a change to a parameter which other users have never adjusted, other users will inherit the change from the Supervisor user when they log in (as they have no settings of their own).

As soon as the user makes any preference setting, then they will be creating registry entries and will see their own adjusted settings each time they log in, independent of what the Supervisor does. This issue mainly applies to some setting in the preference dialog

(e.g., MUI, scan settings) and to some other specific UI items like end-point detection settings.

The Account Manager application software also allows the administrator to copy settings between user accounts. For example, if the Supervisor settings were applied to other accounts then the next time these other accounts login they will have the same preference settings as the Supervisor. In this case subsequent changes of the Supervisor's MUI values (for example) would not be inherited by the other user accounts even if they do not make any MUI changes themselves as they now have their own registry values for these parameters.

Overall Layout and Settings for the UI

Overall stored settings:

- Electron and ion beam settings (HV, current, HFW)
- Dwell, resolution, position for each beam in full frame, reduced area, line, and spot modes
- Detector settings (bias voltages, etc.)

Stored settings for each display:

- Active beam (electron, ion, optical)
- Image save file path
- Image save settings (databar or overlays included)

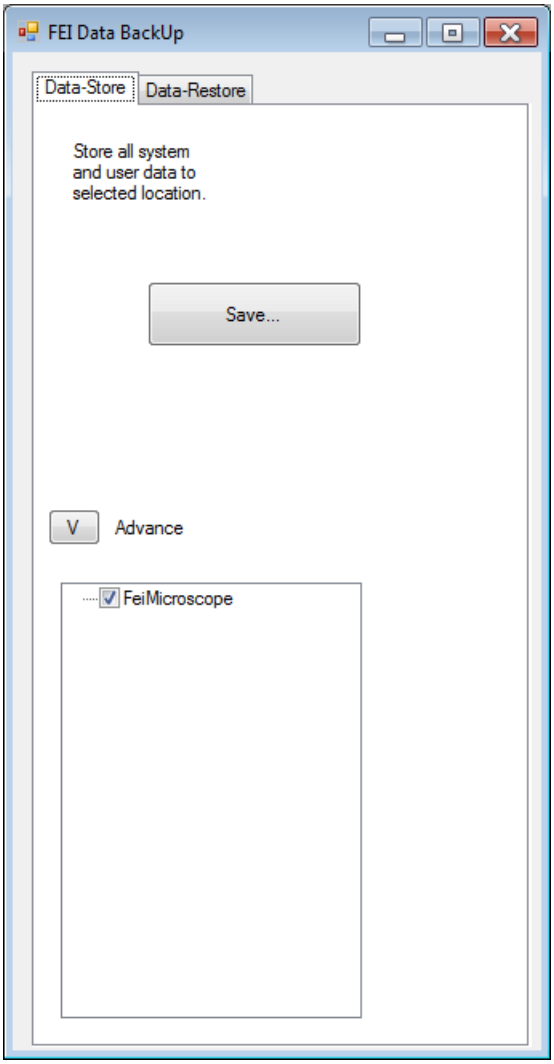
Stored settings for each beam in each display:

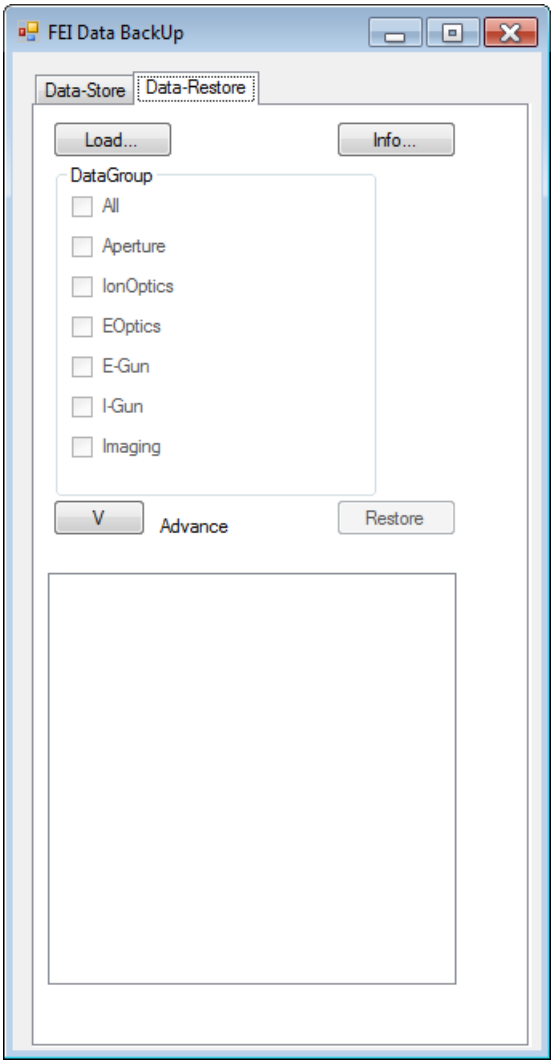
- Active detector
- Detector subsettings for all detectors (is CDEM in SE or SI mode)
- Detector mixing settings
- Digital brightness/contrast/gamma settings
- Databar text
- Zoom and pan (shift) values for digital zoom mode

Other parameters, such as the end point detection area settings are also stored per user.

Data BackUp Application

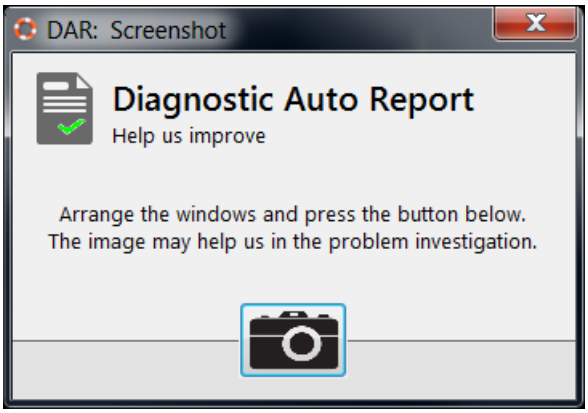
This application allows to store / restore all system and user data.

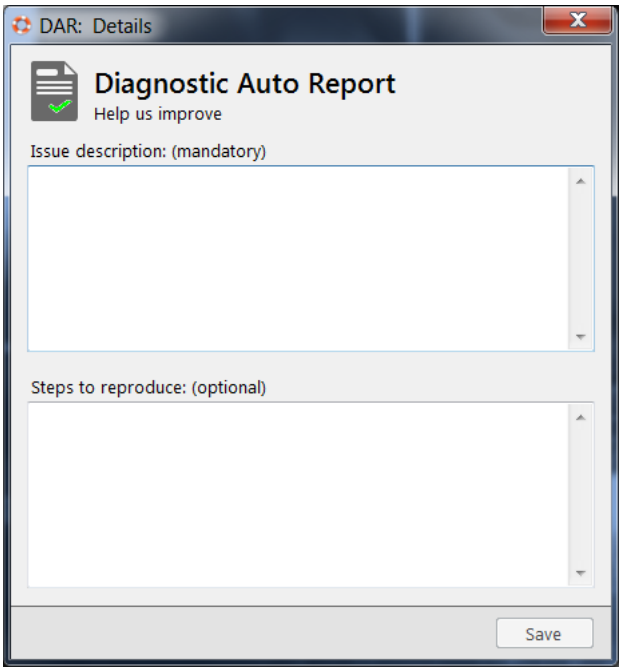


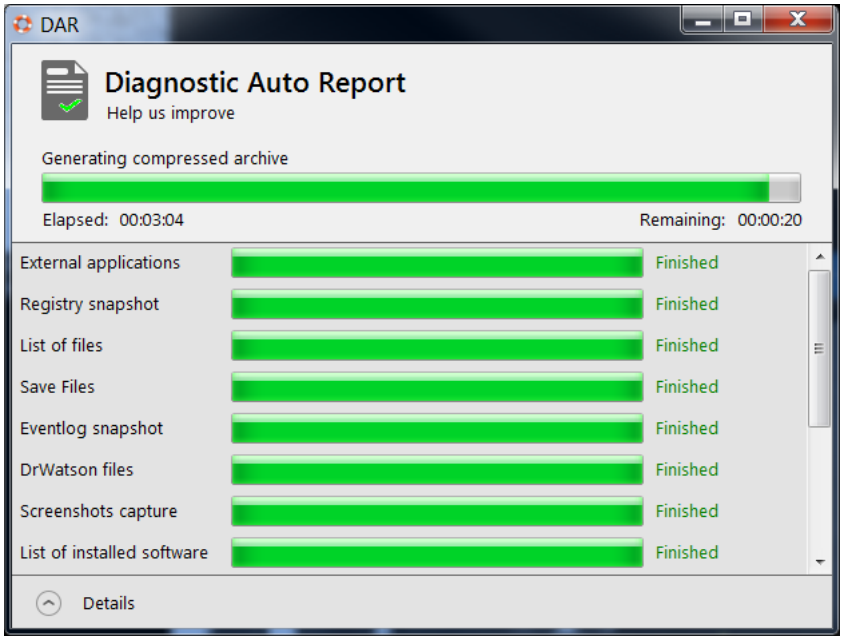


Diagnostic Auto Report Application

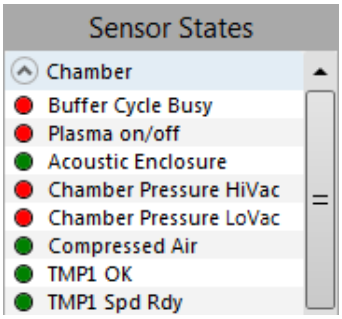
This application enables to create the report when requiring the service intervention.







11 Maintenance



This section describes necessary microscope maintenance procedures that can be carried out by the user. Topics include:

- *"Cleaning Procedures Overview" on page 364*
- *"Stage Maintenance" on page 366*

CAUTION	Before any maintenance action, check the vacuum interlock status in the Sample exchange window / Vacuum tab / Sensor States area. The circle in the *Chamber Pressure HiVac* and *Chamber Pressure LoVac* lines must be red!

User maintenance is at a minimum due to gun and column design providing a long uptime. Therefore, a complicated maintenance is normally a part of a service contract to be performed by a qualified service engineer.

At the user level, the first approach to clean the system is to use the **Tools** menu / **Sample cleaning…** (see *"Sample Cleaning" on page 77*). When this is not satisfactory, try to clean polluted column parts (see bellow).

CAUTION	Parts that operate in vacuum should be handled carefully using clean powder-free gloves. Parts not in use should be stored in suitable containers or packed in aluminium foil. The EDX window (option) is very fragile and must be protected from large pressure oscillations. It is also recommended to remove the detector before major cleaning activities. Be aware of removing the chamber door locking screw(s), used during an instrument transportation (labeled REMOVE)! If these are installed, an overpressure over 20 kPa (150 Torr, 0.2 bar) can arise inside the chamber during the vent procedure (N2), which is harmful to the EDX window, if installed.

NOTE	Gas back fill (N2) should be maintained while the specimen chamber is at ambient pressure. However, to avoid gas waste it is recommended the chamber should be left vented no longer than necessary.

Cleaning Procedures Overview

Frequency of cleaning is, in most cases, determined by necessity due to poor image quality or gross astigmatism level. Recommended cleaning procedures are given below for parts which operate in vacuum and are subject to possible contamination.

List Of Applied Cleaners

- De-ionized or distilled water – H_2O
- Ethanol – C_2H_5OH
- Ethanol p/a (Pro Analysis: 99.8% pure) – C_2H_5OH
- Isopropanol
- Neutral pH cleaning fluid (soap solution)
- CIF* or SOFT SCRUB (fine abrasive household cleaner) or 0.05 ìm aluminous powder

Table 11-1 Household Cleaners

Country	Name
Austria	CIF
Australia	CIF
Finland	CIF
France	CIF
Germany	CIF
Italy	CIF
Japan	CIF
Netherlands	CIF
Switzerland	CIF
UK	CIF
USA	Soft Scrub

WARNING! The cleaning solvents ethanol and isopropanol are highly flammable! Do not use open flames and do not smoke while cleaning. Ventilate the room properly.

Cleaning Column Parts

All column parts are polished before the instrument is delivered. For this reason only occasional light polishing is required to remove contamination that may build up on components in the specimen chamber as part of normal operation. Any part that is exposed to the electron beam should be highly polished, and free of contamination and/or scratches that can charge and thus degrade the image.

CAUTION	Gold plated parts should not be polished with abrasive.

Materials and Technique

To polish components, place a lint-free cloth on a flat surface (a glass block is ideal) and apply a small amount of Soft Scrub or CIF and distilled water to the cloth.

Place the part to be cleaned on the polish and rub with a circular motion until all contamination has been removed. For inner surfaces, use a cotton swab or wooden dowel as an applicator. A toothpick can be used for small holes.

Lint-free nylon (not cotton) or latex surgical gloves should be worn while handling parts to avoid contaminating just-cleaned surfaces. Tweezers should be used to hold small parts.

After the part has been polished, remove the Soft Scrub/CIF cleaner by washing in hot water. Inspect the part under a stereo microscope at 20× magnification to ensure that there is no remaining contamination or polish residue. Wash the part in de-ionized or distilled water in a beaker with an ultrasonic cleaner for several minutes. Transfer the part to a clean beaker with alcohol or isopropanol and clean ultrasonically again for several minutes.

When the components are dry (a compressed air 'duster' can speed drying), reassemble and return to the column. If a part is stained, heat it with hot water and immediately rinse with alcohol and dry using compressed air.

Cleaning Tips

Parts exposed to the electron beam require periodic polishing. This will ensure maximum performance of the instrument for many years.

Do not use metal polishes such as POL or WENOL to clean parts as these can leave outgassing material. Be aware that threaded surfaces should not be polished as these do not have contact to the beam and are a source of outgassing if polish is trapped. Wash threads with alcohol or isopropanol, if absolutely necessary.

After cleaning, inspect all parts for residue and stains using a light microscope.

Stage Maintenance

Stage Mechanics

Checking the condition of the stage should be a weekly exercise as many different samples may be exchanged in this time period. Some samples may be powders or composite materials that inadvertently drop particles on or in the stage. If a silicon wafer breaks in the chamber it can shatter into hundreds of pieces. In this case the stage should be thoroughly cleaned before attempting movement again.

Cleaning Stage Parts

Abrasive and solvents must not be used on the moving stage parts. Cleaning by a suction is the ideal method. If not available, cleaning should be done by using dry nitrogen gas bursts around the stage mechanics to blow out any foreign materials. Make sure the final lens and detectors are protected from the turbulence. Do not use sharp metal objects to scrape away debris. A fine pair of plastic tweezers can be used to pick up difficult particles. Spillage on the stage should be wiped up using a lint-free cloth, followed by suction or blowing with clean gaseous nitrogen.

Specimen Holders

Recommended cleaning procedures are given below for parts that operate in vacuum and are subject to possible contamination. Frequency of cleaning is, in most cases, determined by necessity (image quality or astigmatism level).

Cleaning

1. Clean these parts using a lint free cloth and a mild abrasive domestic cleaner.
2. Rinse in tap water.
3. Clean in an ultrasonic cleaner for 5 minutes using distilled water.
4. Clean in an ultrasonic cleaner for 5 minutes using alcohol p/a or isopropanol.

CAUTION	Do not place parts together in the beakers. Wash separately as damage can occur to the metal surfaces.

5. Rinse in alcohol p/a.
6. First blow dry with a compressed air canister, then dry thoroughly under an infra-red lamp (15 min to 1 hr) at a temperature of between 80 °C and 100 °C. Do not bake in an oven!

12 System Options

This chapter covers hardware and software that is an option either integrated in, or accessory to the system.

Topics include:

- *"External Current Measurement (Keithley Picoamper Meter)" on page 375*
- *"Fast Beam Blanker" on page 376*
- *"Multi Stub Holder" on page 376*
- *"I-Beam Charge Neutralizer" on page 377*
- *"CryoCleanerEC" on page 380*
- *"Quick Loader" on page 386*

Contact your Thermo Fisher Scientific sales representative for more up-to-date information on system options.

For information on other options, see:

- *"Nav-Cam (In-Chamber Navigation Camera)" on page 232*
- *"Directional Backscattered Detector (DBS) Angular Backscattered Detector (ABS) Concentric Backscattered Detector (CBS)" on page 177*
- *"STEM Detector" on page 179*
- *"MultiChem" on page 307*

Manual User Interface

The manual user interface (MUI) provides an ergonomic interface with rotary knobs to perform functions that can also be performed with the software.

- **Imaging**: contrast and brightness control
- **Stigmator**: X and Y control
- **Magnification**: continuous magnification control up / down
- **Shift**: X and Y image shift control
- **Focus**: coarse and fine control

MUI Software Equivalents

Table 12-1 MUI Software Control Equivalents

MUI	Software Equivalent
Image Contrast Brightness	Contrast and brightness adjusters on pages or **Auto Contrast and Brightness** buttons on the toolbar.
Stigmator	**Shift +** right mouse button
Magnification	**+/-** keys on numeric keypad. **Shift +** mouse wheel-click for fine control. **Ctrl +** mouse wheel-click for coarse control. **Additional operation combinations:** **Ctrl +** Magnification wheel for increase/decrease digital zoom.
Beam Shift	**Shift +** click **Additional operation combinations:** **Ctrl +** beam shift: clockwise moves viewport to left (shift X) and down (shift Y). Sensitivity depends on sensitivity set in Preferences.
Focus	Right-click mouse button

Customization

Sensitivity can be adjusted for all controls except Magnification by presetting the various sliders via the Preferences dialog / Sensitivity section (see *"Sensitivity Section" on page 143*).

Manual User Interface GC

The extended manual user interface (MUI GC) provides an ergonomic interface with rotary knobs and 6 programmable shortcut buttons to control Thermo Fisher Scientific Dual and Single beam scope.

1 – Rotary controls (Knobs)

2 – Programmable buttons for shortcuts with displays

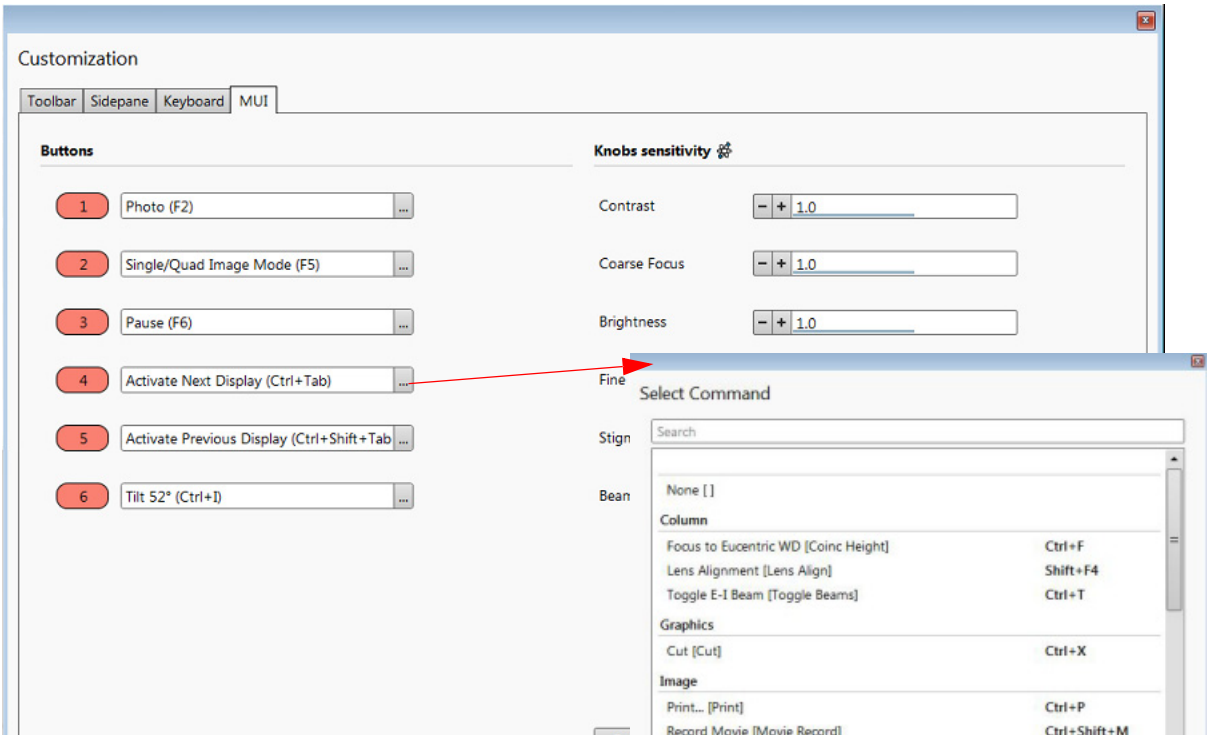
3 – Keyboard

4 – E-beam Snapshot (in display 1)

Customization

The MUI GC Knobs sensitivity (1) can be adjusted for all controls except Magnification. It can be set separately for the electron and ion beams:

1. Click on the display that has the desired beam and change the slider in the MUI customization tab to the desired value.
2. Click the OK button to save changes.
3. Programmable Buttons (2) functionality can be set by clicking any … button and selection of a desired command.



Joystick

The Joystick provides controls to perform stage functions that can also be performed by the software. It is connected to a USB connector located on the Microscope computer.

NOTE	Your joystick may look slightly different than the one shown in the figure.

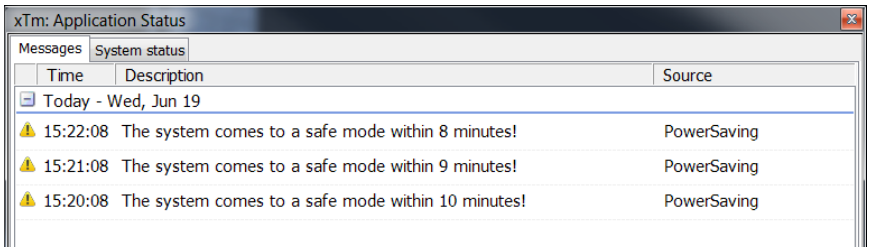
- Button *1* – not used
- Lever (3) operating:
  – Up / Down moves the stage in the Y axis direction
  – Left / Right moves the stage in the X axis direction
  – Clockwise / Counterclockwise rotates the stage clockwise / counterclockwise
- Button *2* pressed while operating the Lever:
  – Up / Down moves the stage up / down (regardless of the Link Z to FWD status)
  – Left / Right tilts the stage
- Button *3* speeds up the stage motion:
  – 10× in X / Y axis
  – 5× in Z axis
  – 2× in R / T axis

NOTE	The joystick is automatically disabled during milling when the axes are locked.

Uninterruptible Power Supply (UPS)

If the power failures occur occasionally it is recommended to use the microscope UPS, which maintains the vacuum in the electron source section.

In case the microscope system is powered by the UPS and a mains power failure happens, the system starts 10 minutes countdown to switch to the safe mode. User is informed about the countdown progress in the application status window. If the mains power is recovered within this time, the countdown is cancelled and nothing happens.

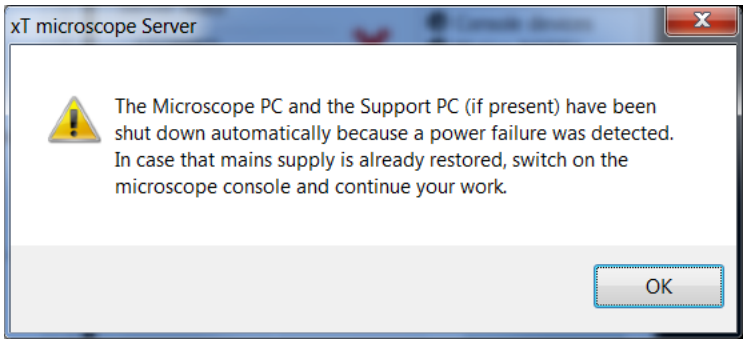


After 10 minutes of continuous power off a shutdown to the safe mode with following actions is activated:

- FEG emission is gently switched off
- Ion emission is gently switched off
- Chamber is vented
- UI is stopped
- xT microscope Server is stopped
- Microscope console is switched to the Standby mode
- Microscope controller and the support computer (if present) are switched off

WARNING!	Because the Emitter IGP's are supported by the UPS, some parts of the microscope are still under power.

To return the system to an operation follow the startup procedure (see Chapter 2). When the xT microscope Server is launched the first time from the safe mode, a dialog is shown to inform a user.

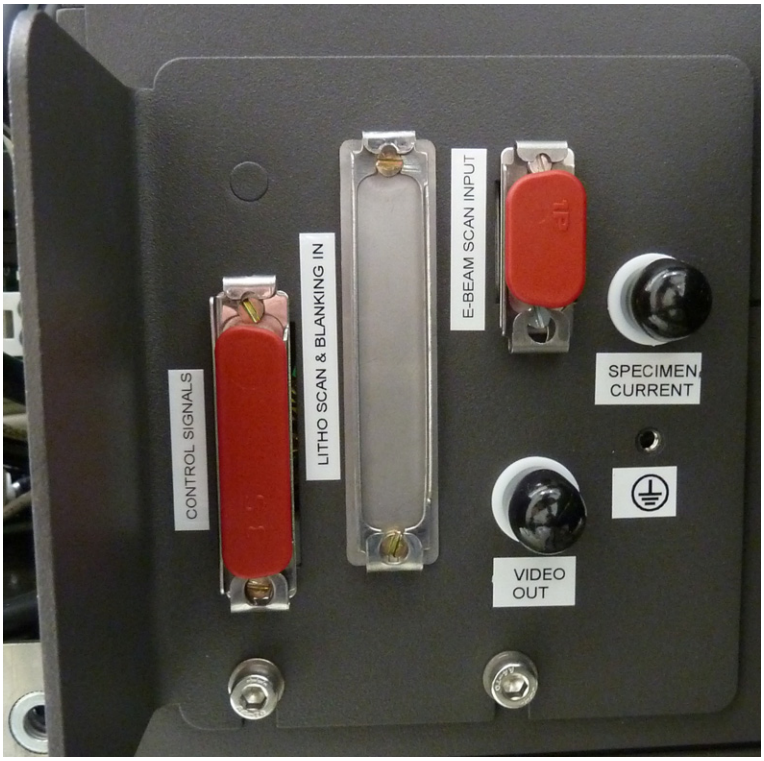


NOTE	A Thermo Fisher Scientific trained user must restart the system after a longer power failure. If the Startup procedure fails, contact an Thermo Fisher Scientific service engineer.

External Current Measurement (Keithley Picoamper Meter)

When **Stage > External Current Measurement** is selected, it is expected to have a Keithley picoamper meter connected to the External Connectors panel / Specimen Current connector, located on the back side of the microscope console.

Figure 12-1 External Connectors Panel



In this case, the Status bar / Specimen current value is **Ext** and the meter readout shows actual specimen current.

NOTE	When the Stage menu / External Current Measurement is not selected, switch the picoamper meter off or disconnect it.

Fast Beam Blanker

This equipment is used to protect sensitive samples from the electron beam. The beam is blanked while moving the beam to the starting point of a new line, frame, or pattern.

NOTE	When the Fast Beam Blanker is used, electron current measurement may be lower than actual value. This inaccuracy is higher at fast scanning times. To obtain an exact electron current value use the Spot mode at a sample area, which is not sensitive or important.

Multi Stub Holder

This is an option for some systems.

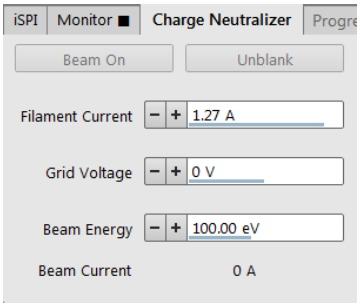
The Multi-stub Holder with 7-stub holding disc is provided with the microscope as an option.

It has a spring clip fitting and the threaded shaft which screws into the stage rotation head center and can be securely attached to the stage by means of the conical locking piece.

Torx Drivers

Within the kit are two Torx drivers to complete the fitting of the interfacing parts. All screws for interfacing connections are Torx. All screws for clamping sample stubs are of the Hex-key type. The appropriate Hex-key tool is standard with the system and not found in this kit.

I-Beam Charge Neutralizer



The I-Beam Charge Neutralizer uses a low energy electron beam to control charging induced by the ion beam. This allows imaging and patterning of nonconductive materials and reduces electrostatic discharge-related sample damage (by spreading electrons on the sample).

All controls are available from the Charge Neutralizer tabbed module on the Patterning page.

Values could be adjusted even while the beam is off in the ranges:

- **Filament current**: from 0 to 1.43 [A]
- **Grid voltage**: from –5 to +5 [V]
- **Beam energy**: from 28 to 200 [eV]

1. Verify whether the correct detector mode is selected to enable the Charge Neutralizer usage:
   - The ETD is recommended to use with negative Grid Voltage values (Custom mode). Positive Grid Voltage values are enabled, but detector can be saturated.
   - The TLD can be used only with negative Suction Tube Voltage values in Custom mode.
   - The ICE detector is recommended to use in Secondary Ion mode / with negative Grid Voltage values (Custom mode). Positive Grid Voltage values are enabled, but detector can be saturated.
2. Click the **Beam On** button to switch on the Filament current (the filament starts to generate electrons and is heated).
3. Start the charge neutralizer by clicking the **Unblank** button. The Grid voltage (as indicated on the slider) is now applied to the grid and (in case of a positive voltage), electrons will be spread via the grid on to the sample.
4. Optimize imaging by adjusting the values.
5. Click the **Beam off** button to turn off the Charge Neutralizer.

   The software waits for the filament to cool before the chamber can be vented (the progress bar shows the cooling progress, which takes about 7 minutes).

Finding the Optimal Operation Range

- Before adjusting the filament current or beam energy settings, adjust the Grid voltage until the sample is no longer charging (no drift or flash):

  Start with the grid voltage at –5 V, then slowly increase the value until the image stabilizes.
- The Initial value of beam energy should be about –100 eV.
- The Initial value of filament current should be about 1.15 A.

NOTE	Filament adjustment should be kept to a minimum as this will decrease the lifetime of the electron gun.

If neutralization cannot be reached at these values, first increase the beam energy, then adjust the filament current if necessary.

It is advisable to adjust settings after changing:

- Samples
- System magnification
- Scan conditions
- Ion beam current

Otherwise, if conditions and sample types remain constant, you should only have to fine-tune your initial successful settings.

The last settings are stored and can be recalled when switching the Charge Neutralization off / on and also after exiting UI software.

Balancing Electron and Ion Beam Currents

If your image is still too white and lacking details after you have started the charge neutralizer and slightly reduced the contrast, you probably have too much electron beam current compared to ion beam current. The electron beam is desorbing ions from the surface, which masks the gallium ion-induced signal (the electron-stimulated desorption). To rectify the problem, try the following suggestions:

- Reduce the grid voltage to reduce the beam current. The details should become visible as you achieve the balance between ion and electron currents.
- Fine-tune the grid voltage settings to a level appropriate for your application; the exact value is sample-dependent.

- If you continue to reduce the grid voltage you will reach a switch point where there are just not enough electrons to compensate the charging anymore. If you have gone below this point, slightly increase the grid voltage again until the charging disappears. Now you have reached the optimum working condition with the best possible contrast of your charge compensated secondary ion imaging.

If you are still unsatisfied with the image, adjust the beam energy (50 V, for example) and check the results.

In case the filament does not start slowly, increase the filament current.

Remarks

- Verify that the Charge Neutralizer is functioning by using a glass sample (Thermo Fisher Scientific company part number 22805 Rev A).
- When patterning is paused, the Charge Neutralizer stays on.
- When a Snapshot or Photo is taken with the ion-beam while patterning with the ion-beam is active, the Charge Neutralizer should stay unblanked.
- When a Snapshot or Photo is taken with the E-beam while the ion-beam patterning and Charge Neutralizer are active, the Charge Neutralizer is automatically blanked and unblanked. This will enable the use of E-beam grab frame during patterning.
- When an E-beam grab frame is performed during ion beam imaging, the Charge Neutralizer will blank and automatically unblank when switching back to ion beam imaging.
- The Charge Neutralizer can not be used in iSPI mode. When working in iSPI mode, the detector interlock is not OK because the electron beam is imaging.

CryoCleanerEC

Use the CryoCleanerEC to decrease the contamination level in the system. It can be efficient to approximately 24 hours.

The kit consists of:

- Vacuum vessel, including o-rings, screws
- Vacuum vessel lid
- Nitrogen vessel (Dewar) with cap, including proper warning labels
- Nitrogen vessel stand
- Nitrogen vessel safety pliers
- Manual

WARNING! This option uses liquid nitrogen (LN2), which may cause serious cold burns.
In case the Platinum deposition (Pt dep) GIS was used simultaneously with the CryoCleanerEC, always run the decontamination procedure (see the User safety manual “Pt deposition chemical” chapter).

Parts and Accessories

The CryoCleanerEC consists of a nitrogen vessel that is surrounded by an outer container—the Vacuum vessel, which is connected to one of the specimen chamber ports by a vacuum seal. The space between is then pumped by the microscope vacuum system.

Figure 12-2 Nitrogen and Vacuum Vessels with Accessories

When the specimen chamber (together with the CryoCleaner) is pumped, liquid nitrogen is introduced to the nitrogen vessel. Its outside cold surface absorbs contaminating products from the

specimen chamber. The vacuum in the specimen chamber improves over a short period and contamination is now reduced.

When LN2 runs out, a pressure burst inside the chamber could cause the system to vent and to be at atmosphere for long periods of time if unattended. In this case, the system switches the beams off, but it is protected from venting (about 30 min). After this period, an automatic vacuum recovery procedure tries to pump to HiVac. The system is vented if only if it is not successful.

Flanges

The Vacuum vessel has special flanges enabling it to mount to different chamber ports with the use of interlink with a desired shape (depending on the port to be used and the vicinity).

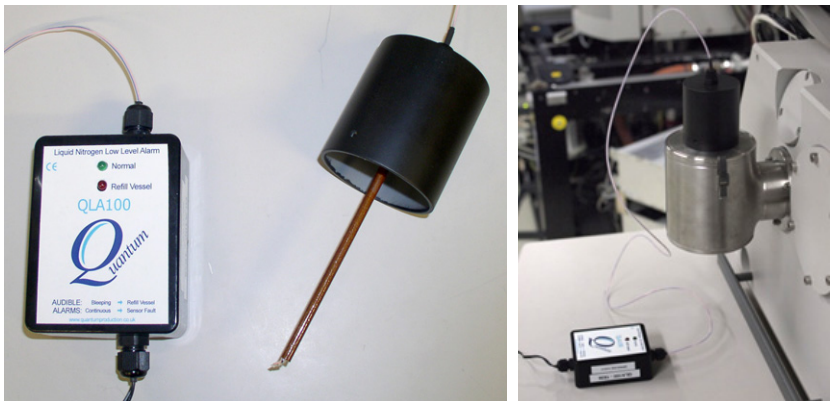
Figure 12-3 CryoCleaner Flanges

The interlink flanges can be mounted on by means of the 3 screw-hole fittings on the perimeter of the vacuum flange. Care must be taken that the 'O' ring held in the end of the flange is secure, free of dirt, and is not crimped when mounting.

Liquid nitrogen probe

A probe is immersed in the Cryocleaner to monitor the level of liquid nitrogen.

Figure 12-4 Liquid nitrogen probe



Information about the liquid nitrogen level shows in the Application status window if that feature is enabled on the General tab in the Preferences dialog box. See *"General Section" on page 147*.

Cryocleaner Operation

Once mounted, the nitrogen vessel can be placed in the Vacuum vessel. Secure the two components by fixing the clips to the top of the nitrogen vessel and locking the clips down. Take care that the 'O' ring seal on the Vacuum vessel is secure when joining the two components together.

Dewar Vessel Refilling

WARNING!

The handling of LN2 should be performed wearing face and hand protection in the form of a face visor and a pair of thermal protective gloves.
Users must not touch the cold surfaces of the Dewar as this could result in burns. Use the Safety Pliers provided, when handling the nitrogen Vessel.

1. Pump the specimen chamber; the Vacuum vessel is pumped along with it.
2. When the specimen chamber vacuum is ready (Pumped status), partially fill the Dewar with the use of a funnel (the plastic cap upside down), and wait until boiling stops.
3. Then fill the Dewar and place the plastic cap on top of the CryoCleaner. The volume of liquid nitrogen needed is approximately 500 ml.

NOTE	The LN2 stops boiling very quickly so that no vibration is seen from this device. If the CryoCleaner needs to be used for longer periods, it can be refilled with LN2.

NOTE	Before re-filling, perform the Baking procedure on *"Baking the nitrogen vessel" on page 384*.

Figure 12-5 Plastic Cap Refilling Position

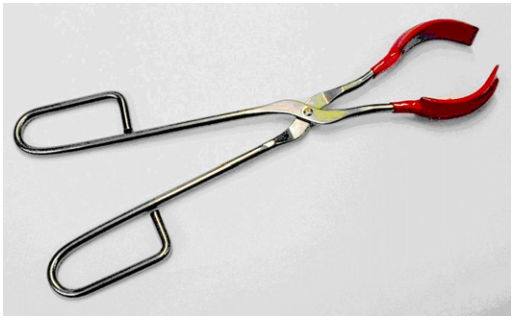
Removing the nitrogen vessel

WARNING!	Use the Safety pliers provided when handling the nitrogen vessel.

Removing the nitrogen vessel depends on the level of contamination found in the specimen chamber. If the level is unusually high, then the CryoCleaner could work continuously until improvement is seen, otherwise the nitrogen vessel can normally be removed after approximately 2 to 3 hours.

NOTE	It is not recommended to leave it inside the vacuum vessel after all nitrogen evaporates, because contamination evaporates back to the chamber.

1. Vent the specimen chamber (the excess LN2 starts to boil).
2. Unclip the nitrogen vessel from the Vacuum vessel. Lift the nitrogen vessel out of the Vacuum vessel by the Safety pliers placed under the ring on the neck of the Dewar cylinder.



3. Place the Lid over the Vacuum vessel to seal it from the atmosphere (fix the clips). Pump the specimen chamber again, however the microscope vacuum remains cleaner than before and sample contamination is still reduced.
4. Remove the cap from the nitrogen vessel and pour out the excess LN2 into a suitable container.

WARNING!	When the LN2 is removed from the nitrogen vessel, the bottle still remains at a very low temperature.

5. Place the nitrogen vessel onto the Stand ready for baking.

Baking the nitrogen vessel

1. Place the nitrogen vessel Stand on a suitable heat resistant surface.
2. Place the nitrogen vessel onto the stand and use an Infra-red lamp to bake the base of the bottle. Baking should take place for approximately 2 hours.

   Alternatively, the nitrogen vessel can be baked in an oven at 90° C for 2 hours.

Regenerating the Dewar by heat allows removal of condensed contamination and subsequent reuse of the vessel.

NOTE	The oven that is used must have a venting system to extract any harmful fumes. Alternatively it should be baked in a fume cupboard using an infra-red lamp.

Replacing the nitrogen vessel

1. Vent the specimen chamber. Allow the nitrogen vessel to cool down before handling.
2. Unlock the two clips holding the Vacuum vessel Lid. Remove the Lid from the Vacuum vessel.
3. Place the nitrogen vessel in the Vacuum vessel, taking care that the 'O' ring seal on the Vacuum vessel is secure when joining the two components together. Secure the two components by fixing the clips to the top of the nitrogen vessel and locking the clips down.
4. Pump the specimen chamber. The Vacuum vessel is pumped along with the specimen chamber.

Maintenance

- Keep the 'O' rings clean of dust and fibre particles by inspecting the Vacuum vessel main 'O' ring on a regular basis. If the Vacuum vessel is removed frequently from the specimen chamber, inspect the specimen chamber 'O' ring seal each time.
- Keep the sealing surfaces of the nitrogen vessel and the Vacuum vessel Lid clean and free of dust and fibre particles.
- Do not use any kind of vacuum grease on the 'O' rings.
- Wipe the outsides of the stainless steel parts with a lint free cloth dampened with pH neutral soap solution to remove finger stains.

Spare Vessel

You can obtain a secondary nitrogen vessel kit, which contains:

- Nitrogen vessel
- Vessel stand
- Vessel plug

Quick Loader

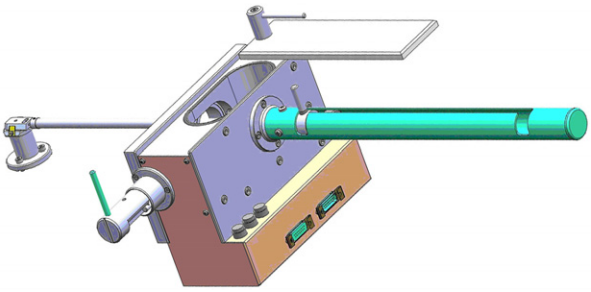
The Quick Loader is only available for the Helios HXe PFIB model. It was designed for:

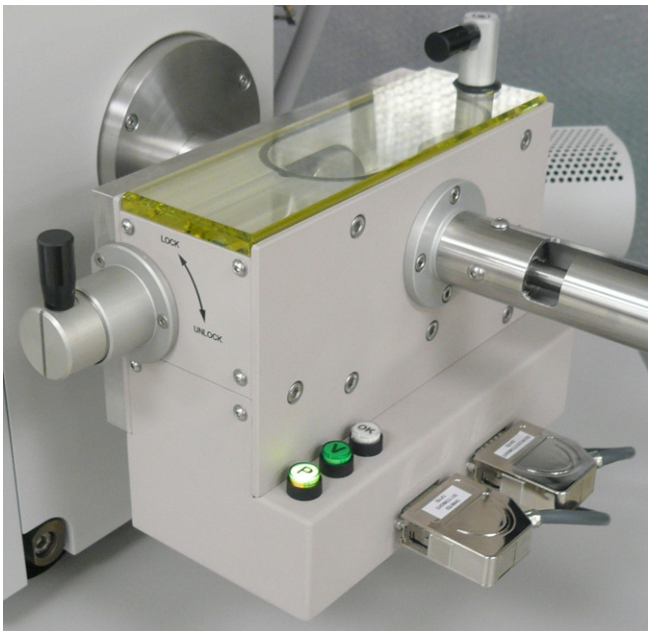
- Easy Sample transfer
- Faster sample through-put
- Contamination free chamber environment
- Materials applications

Caution!	Minimize a Quick Loader usage with the CryoCleaner (see below) filled with LN2! This is because each Load cycle adds small layer of gas and ice onto the nitrogen vessel surface, thus decreasing the CryoCleaner efficiency and increasing the amount of gas released into the specimen chamber in case the LN2 dries out.

General description

The loader can manually load and unload small samples into the SDB / SEM. The loader is connected to the specimen chamber of the SDB / SEM and also integrated into the main vacuum system hardware and software.



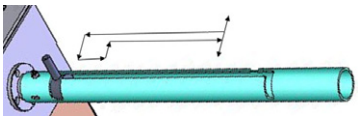


The loader consists of a loading rod with set slide and parking position, a vacuum chamber for loading and unloading the sample carrier (with sample) onto a bayonet fitting located at the end of the rod. A gate valve seals the vacuum of the SDB / SEM specimen

chamber and can only be opened when the vacuum of the loader chamber is correct, this being indicated by a 'OK' labeled LED prompted by an electrical and mechanical interlock.

The sample carrier can be entered into the main SDB / SEM specimen chamber by way of the rod and released by the rotating motion of the rod at a predetermined position on the stage adapter.

Loading rod



The loading rod has a pre-machined slot to move in to load or unload a sample. At each end there is a side slot. There are 2 side slots at the further end from the vacuum chamber. One is for loading and unloading the sample carrier in the loader chamber and the other is a parking position (prevents the rod to be sucked in by the vacuum).

Caution!	Do not unload the sample carrier with gate valve opened! The sample carrier could drop down from the rod.

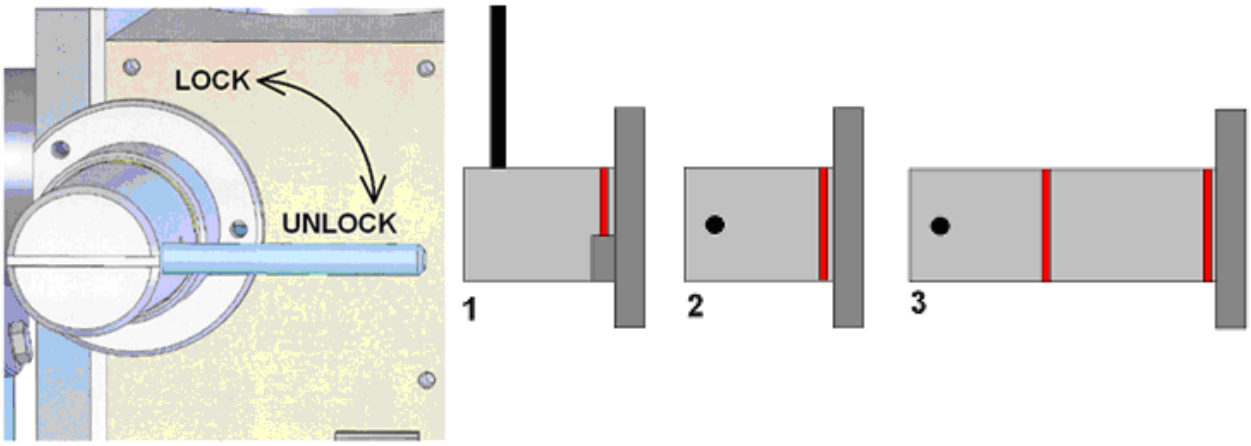
At the end of the rod closest to the loader chamber is a large slot for coupling and de-coupling the bayonet into or out of the sample carrier when positioned on the carrier adapter.

The bayonet is designed to make a positive and secure connection to the sample carrier so that it remains horizontal and in a straight line to connect with the carrier adapter within the specimen chamber.

Gate valve

The Gate Valve has positions that are defined by the following status:

- rotated position of the Gate Valve Lever: LOCK / UNLOCK
  The position has to be turned from LOCK to UNLOCK to be able to move the loading rod IN and OUT
- colored strips on the side of the exposed barrel axis:
  one / two when IN / OUT



- Position 1 - IN and LOCK
- Position 2 - IN and UNLOCK
- Position 3 - OUT

The Gate Valve has a two safety movements.

- it can be placed over the entry hole on the slide
- it can be locked in place by a turn of the connecting knob (securing the closure of the valve)

A system interlock takes care of correct conditions (system vacuum, accelerating voltage) for loading and unloading cycles (movement of the gate valve).

Controls

There are 2 buttons (while in operation) and 1 indicator lamp:

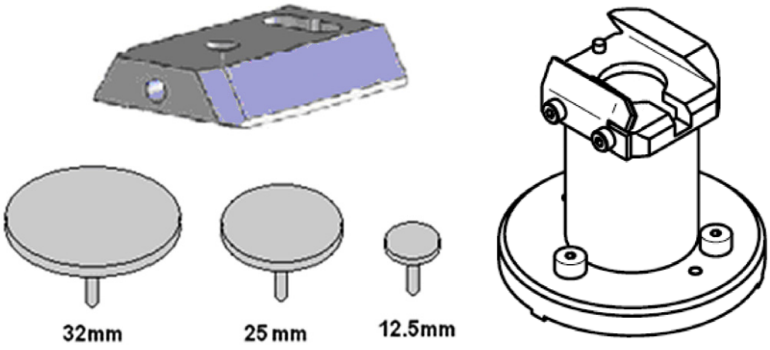
- The **P** (pump) labeled button is pressed to pump the loader chamber to the required vacuum, the stage moves to a loading position at the same time. If the system reaches appropriate vacuum level, the lever interlock is released and the gate valve can be opened. The pump cycle is automatically terminated when the required vacuum is reached.
- The **V** (vent) labeled button is pressed once to vent the loader chamber. The vent cycle continues till the **P** button is pressed or it is terminated by time-out. If the microscope chamber as well as loader is vented then pressing the **V** button release lever interlock and gate valve can be opened.
- The indicator lamp labeled **OK** lights up when vacuum is reached after pumping. When it goes out this means the wait time has been exceeded and the appropriate vacuum for a

transfer has been lost. Pressing the **P** button again will bring the system to vacuum **OK** status.

Control buttons are not shining when the system is recovering from vacuum status transition (e.g. immediately after the load/unload sample, during venting the system...). After finishing the state transition the control buttons will be in operation again.

Sample Carrier, Sample Gauge and Stage Adapter

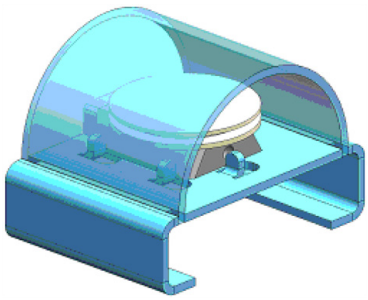
A sample carriers (2 pcs.) are used to hold and transport the sample from the loader to the specimen stage of the SDB / SEM. The carrier sits in the stage adapter with a dovetail joint. It is fixed to the loading rod via a bayonet coupling. The loading rod is de-coupled at the bayonet coupling when the sample carrier is located in the adapter and withdrawn leaving the sample carrier ready for sample observation.



The Stage Adapter is connected to the rotation base of the stage by 3 hexagonal headed screws. The base of the adapter has 3 high points for a firm 3-point contact to the rotation base to prevent vibration transmission.

The height of the stage adapter is distinct to the SDB /SEM system it is used with. The top of the adapter has a dovetail slot for the acceptance of the sample carrier from the rod loading mechanism.

Sample Height

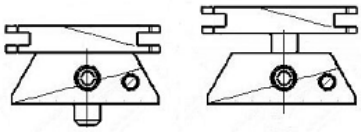


Before mounting the Stage Adapter the stage must be homed with the chamber door opened.

Only samples that fit the Sample Gauge can be loaded. One sample stub of diameter up to 32 mm (1 1/4 ") can be used, although standard sizes of 25 mm and 12.5 mm can also be used. Height can be no greater than 9 mm.

The shuttle clamps with a spring in the dovetail shaped slot of the adapter. It is fixed to the loader arm via a bayonet coupling. The maximum pin length of the stubs that can be used is 11 mm (most

common commercial Thermo Fisher Scientific type stubs have a pin length no greater than 8 mm).



The sample transfer position Ztr is not 0, but in practice from 0.5 to 1.0 mm. The achievable Working Distance could be calculated:

- WDmax = 11.9 mm - H (sample height) + Ztr
- WDmin = 1.9 mm - H (sample height) + Ztr

Consequently the minimum working distance in case of a sample with minimum thickness could be as much as WDmin = 2.9 mm. This is too much for proper HiRes imaging. However by simply mounting the stub into the shuttle in an elevated position, as in the drawing, the sample can be brought up to a minimum working distance of zero.

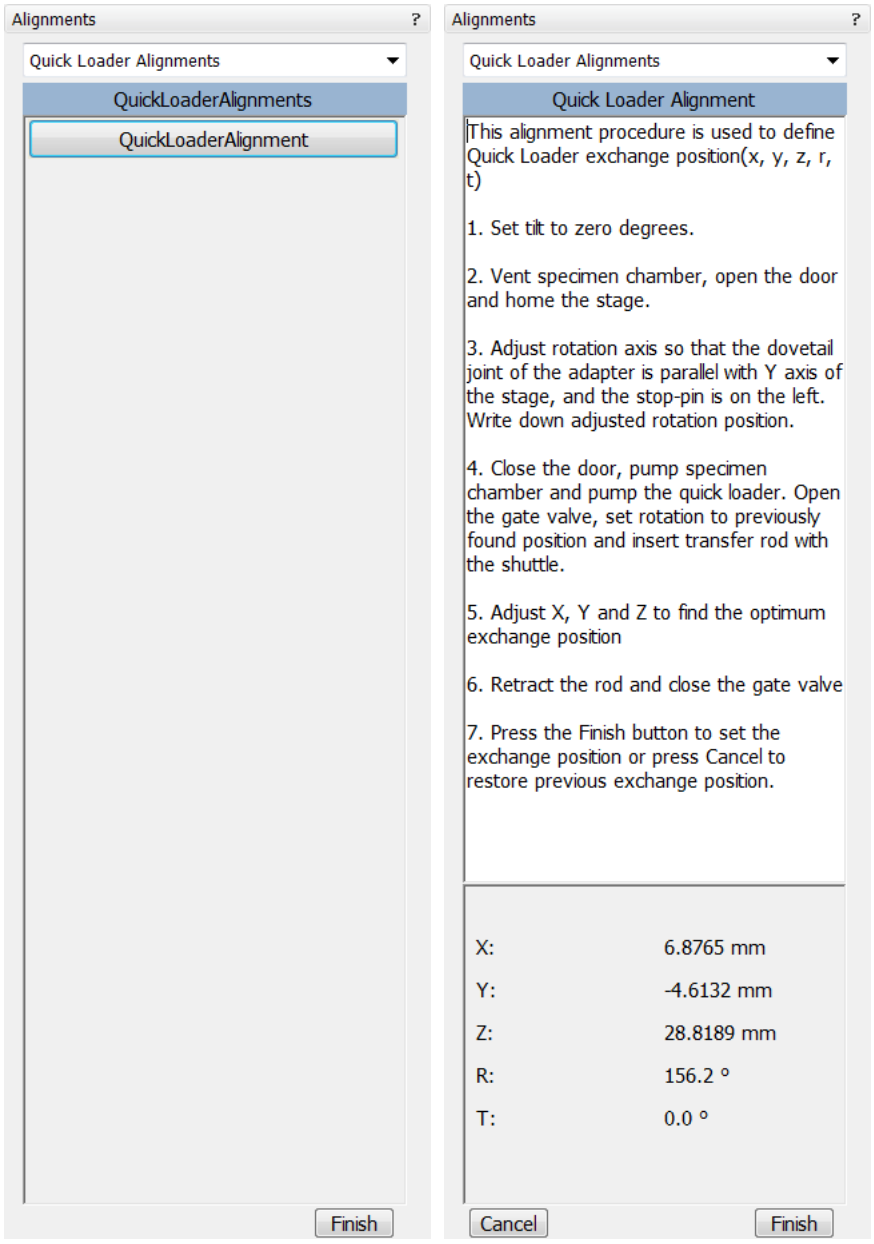
Installation

The Quick loader is pre-installed in the factory. No special adjustment is needed only the loading rod was removed for transport.

1. Unpack the lead glass lid.
2. Remove four screws holding the cover of the loading rod feed-through.
3. Use the same screws to attach the loading rod to the loader chamber.

Quick Loader Alignment

The load / unload position is preset from factory. If a calibration is needed, run the **Quick Loader Alignment** at first.



Operations

Loading a sample

1. Mount the sample with fast drying adhesive medium onto the stub. Allow to dry.
2. Check the sample satisfies the sample limits imposed by placing the top of the mounting tool over the base mount.

Caution!	If the sample proves to be too large this has to be addressed before the sample and carrier should be allowed into the loader chamber.

3. If the sample satisfies the limits, the sample loaded carrier can be loaded into the loader chamber. A user can either remove from or place a mounted carrier in the loader chamber by using tweezers for stubs which will fit around the stub rim.

NOTE	Loading samples this way is an easier and safer than trying to mount the sample directly into the sample carrier while in the loader chamber.

Rod Loading Sequence

1. While holding the sample carrier on the loading table in the loader chamber move the rod out of the Parking position to the far left, to the back of the slot and forward to engage the bayonet into the sample carrier. Place the rod back into the Parking position after coupling to prevent the rod slowly creeping forwards.
2. Switch OFF the electron and ion beam accelerating voltage. Retract the GIS or STEM modules (if present) to a safe state (can not be used in combination with loader).
3. Close the loader chamber lid. After the lid is properly closed the **P** button starts to shine.
4. Press the **P** button, the button stops to shine and the pumping cycle starts, the stage moves to the loading position at the same time. When the vacuum in the loader chamber is correct the pump light starts to shine and the **OK** button lights up indicating operation can continue. The gate valve lever interlock is released.
5. Turn the Gate Valve knob lever from LOCK to UNLOCK position. Then carefully pull the knob bar fully out from the

first mark on the knob drum to the second mark. Turn the knob bar to (counterclockwise) to the LOCK position.

6. Move the loading rod from the Parking position into the chamber while still holding the rod bar. The Sample Carrier will engage with the Stage Adapter at the end of the rod travel.
7. Turn the rod bar to the left (counterclockwise) to the base of the slot; pull back on the rod bar so it travels along the base of the slot, then turn to the right (clockwise) so that the rod bar is vertical and withdraw it back to the PARK slot at the far end of the rod guide.
8. Close the Gate Valve by turning the knob bar to the UNLOCK position and press the knob in to engage the valve over the opening, this can be seen through the lead glass lid, then turn the knob bar to the LOCK position to secure the valve. Good practice is to leave the loader chamber under vacuum.

Unloading a sample

1. If there is a sample carrier in the loader chamber attached to the bayonet, remove it (the chamber needs to be vented and the carrier removed).
2. Switch OFF the electron and ion beam accelerating voltage. Retract the GIS or STEM modules (if present) to a safe state (can not be used in combination with loader).
3. Close the loader chamber lid. After the lid is properly closed the **P** button starts to shine.
4. Press the **P** button, the button stop to shine and the pumping cycle starts, the stage moves to the loading position at the same time. When the vacuum in the loader chamber is correct the pump light starts to shine and the **OK** button lights up indicating operation can continue. The gate valve lever interlock is released.
5. Turn the Gate Valve knob lever from LOCK to UNLOCK position. Then carefully pull the knob bar fully out from the first mark on the knob drum to the second mark. Turn the knob bar to (counterclockwise) to the LOCK position.
6. Move the unloading rod from the Parking position into the chamber while still holding the rod bar. When resistance is found turn the rod bar to the left (counterclockwise) to enter the bayonet. Push forward and turn the rod to the right (clockwise) and the bayonet will engage with the Sample Carrier on the Stage Adapter close to the end of the rod travel.
7. Withdraw the rod back to the far end of the rod guide and place in the Parking position. The rod, bayonet and sample

carrier are now out of the chamber and sit in the Loader chamber.

8. Close the Gate Valve by turning the knob bar to the UNLOCK position and press the knob in to engage the valve over the opening. This can be seen through the lead glass lid, then turn the knob bar to the LOCK position to secure the valve.
9. Press **V** button once. The chamber will be vented and the lid can be opened. The sample carrier can be released by turning the rod bar to the far left and pulled back then returned to the parking position. Remove the sample carrier.
10. Close the loader chamber lid.
11. Press **P** button to evacuate the loader chamber.

NOTE	In case the sample carrier falls from the loading rod, vent the chamber with gate valve opened, put the carrier back to a correct position and close the gate valve. Proceed from the step No. 1.

Loading/Unloading – vented microscope chamber

If the microscope chamber is vented and Loader chamber is evacuated, press **V** to vent the loader chamber. After the chamber is vented, you can:

- press **P** button to pump the chamber again if needed (store sample under vacuum condition)
- press **V** button to release the mechanical interlock of the gate valve lever. Then you can open gate valve.

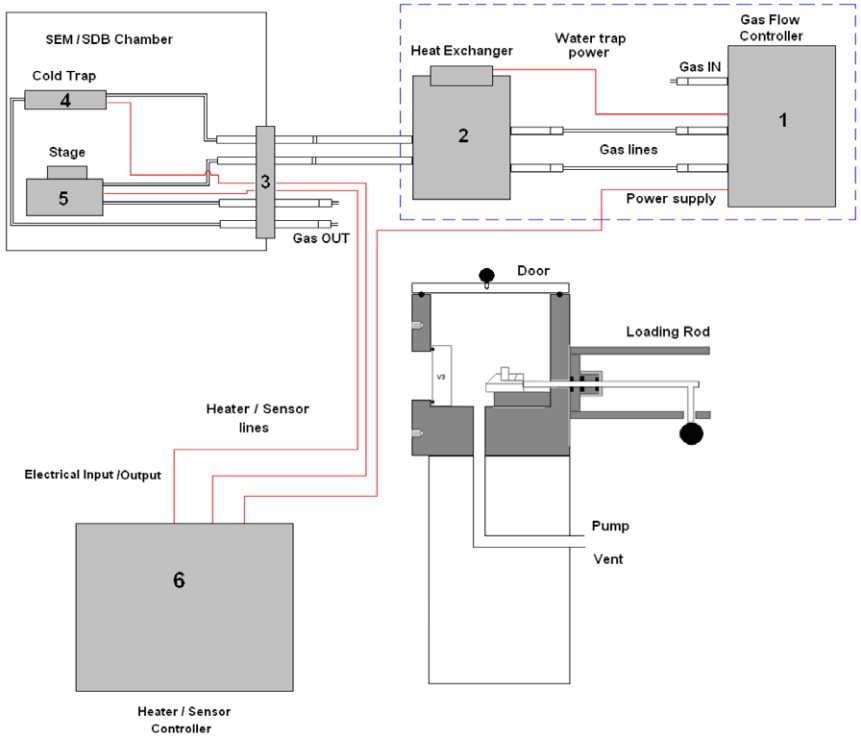
Close the gate valve before microscope chamber pumping.

CryoMAT Loader

The CryoMAT Loader is in fact the Quick Loader (see above) with the addition of the Cryo option, which technically can be added after Quick Loader installation. It is therefore important to become familiar with the Quick Loader operation prior to using the CryoMAT option.

The CryoMAT Loader is designed for dehydrated sample transfer, cryogenic cooling, and temperature control within a SEM or DualBeam instrument. It has single stage transfer, a preset sample temperature control, and is integrated into the existing SEM or DB vacuum system. The result is a simpler system to use for less experienced and experienced Cryo users alike. It is also designed to be used for more demanding delicate IC sample TEM prep where ambient temperature or beam conditions cause problems.

Figure 12-6 CryoMAT Loader Block Diagram



- 1. The **Gas flow controller** (on a trolley mount) controls the N2 pressure and flow through the cryo components.
- 2. The **Heat exchanger** cools down the flowing N2 to cryogenic temperatures. A **water trap** captures water from the N2.
- 3. The **Gas and electrical interface flange** introduces the gas pipes and electrical cables through the chamber wall.

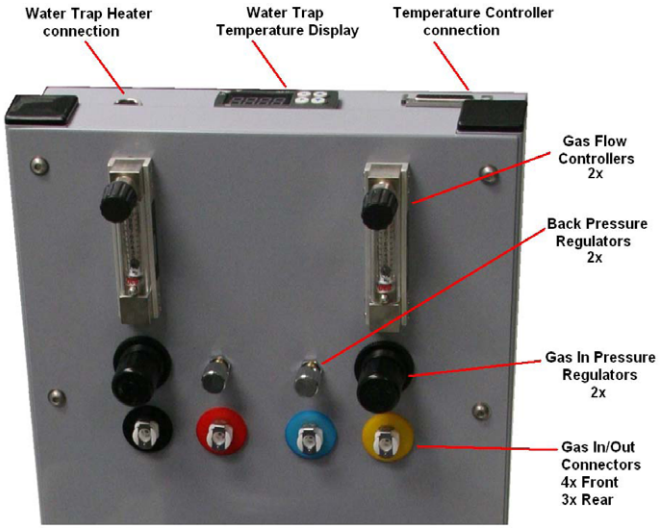
- 4. The **Cold trap** creates the coldest position in the chamber to trap condensing water vapor molecules.
- 5. The **Cryo stage** Holds the sample at cryogenic temperature.
- 6. The **Cryo heater** & **sensor controller** allows temperature changes to the sample, gives temperature feedback to a visual show for the cold trap and cryo stage.

1. Gas Flow Controller

The gas flow console panel is housed on the top part of the heat exchanger trolley to control the N2 flowing through the LN2 heat exchanger for cooling the cold trap and the cryo-stage.

Primary function of this unit is to regulate the gas flow independently to the cryo-stage and cold trap via the heat exchanger. The N2 pressure is regulated from the original supply to this unit at 1.5 bar (21.75 PSI) and 5 liters / minute flow rate.

Figure 12-7 Gas Flow Control Panel



Trolley panel components

- 2× pressure valves for regulation of the incoming gas pressure
- 2× gas flow regulators 10 l/m scale
- 2× back pressure end valves with nonclosing action
- 7× gas connections with interconnective piping
- Water trap heater temperature read out display with preset controls
- Power supply to drive the temperature control, display and N2 water heater
- Output socket to N2 water heater + cable
- Temperature controller connection + cable

2. Heat Exchanger and LN2 Dewar

The Dewar volume is 12 liters and will be filled with LN2. It accommodates a central pipe core of four pipes (two in and two out). Gas flows from the gas flow control to the two incoming pipes and further into the heat exchanger. At the end of the central core the pipes end as two coils which sit at the base of the Dewar to create cooling transferred by conduction from the LN2 to the N2 gas flowing in the pipes.

Figure 12-8 Heat Exchanger and Dewar

Heat Exchanger components

- Stainless steel or aluminium vacuum container (Dewar)
- Water trap with heater and cable
- Central pipe core with heat exchange coils at base
- Insulated cold N2 pipes out of the central core
- Non-insulated warm N2 pipes in to the central core
- Power supply (housed in trolley)

The insulated pipes coming out of the central core then proceed to the gas flow and electrical interface flange situated on a chamber port.

The cooled gas feeds the cold trap and cryo stage independently before returning to the interface flange. The return pipes with gas flowing back from the cryo stage and the cold trap also enter the insulation (neoprene) so that ice does not form at the port. These continue to the trolley entering gas connections through the two back pressure valves and then to atmosphere.

Water Trap

To prevent water entering the cooling system via the N2 gas, a water trap is designed into the top of the central core of the heat exchanger. The water trap chamber volume is heated to evaporate the unwanted water condensing into the trap. An independent power supply house in the trolley panel drives the heater.

WARVING!

Whenever handling LN2 (the 12 liter nitrogen Dewar and the Heat Exchanger), wear face and hand protection (face visor and a pair of thermal protective gloves). Do not touch cold surfaces as this could result in burns!

Lowering the Heat Exchanger into the Dewar

1. Allow the LN2 to stabilize from boiling after filling before transporting the Dewar and before lowering the heat exchanger into the Dewar.
2. Lower the heat exchanger into the Dewar slowly and with caution as the LN2 will boil due to the warm heat exchanger components.

Removing the Heat Exchanger from the Dewar

Caution! Remove the heat exchanger from the Dewar slowly and with caution as the core components remains at cold LN2 temperature for some time.

1. Place the cold heat exchanger core at the side of the Dewar to warm up. Do not touch the heat exchanger until the ice condensation on it has completely thawed.
2. Close the lid to the 12 liter Dewar.

4. Cold Trap

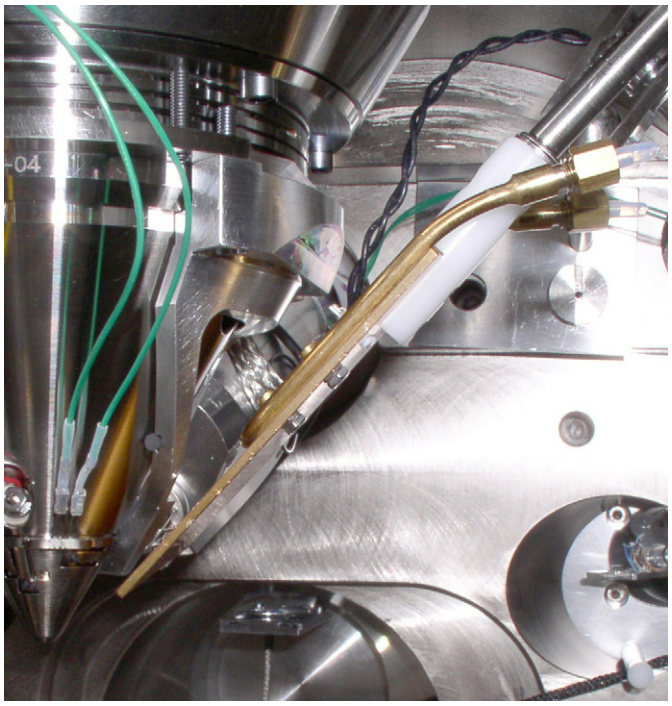
The cold trap protects the sample from water vapor condensing on its surface while at low temperature. It is suspended by a bracket from the back of the chamber to one side of the lens cone.

The extension plate can be used (in addition) for even more effective anti-contamination of the sample. This encircles some of the lens diameter but is above the GIS needle input level.

Cold Trap components

- Cold trap plate
- Mounting rod and insulator
- Sensor element
- Ground connector
- Swivel bracket
- Extension Plate

Figure 12-9 Cold Trap



5. Cryo Stage

Caution!	The cryo stage can be rotated (because of the connections of pipes and wires) maximum ± 20°! With the cryo stage installed do not use the **Home Stage** procedure!

The cryo stage is a complex construction allowing samples to be cooled down to cryogenic temperatures. The supporting components are insulated from the low temperature by a double ceramic minimized contact method. The cold part of the stage can be heated so temperature can be regulated with feedback via a thermal sensor. This allows the cold temperature of the sample to be carefully chosen.

The sample can be tilted with the cryo stage to 52° tilt for milling in a Small Dual Beam instrument.

The thermal insulation is constructed to prevent temperature exchange from the main stage to the sample and so that constant temperature can be maintained.

The base plate is constructed in two parts so that the cryo stage can be removed quickly and conveniently without having to break connections or cut pipes.

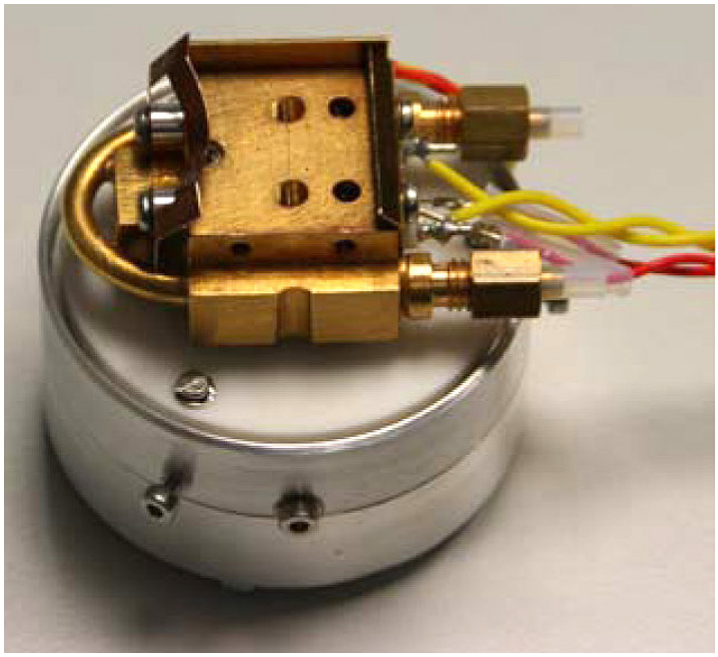
The base has three point contact onto the Thermo Fisher Scientific stage to eliminate vibration and a location pin that connects into the stage table. In this way, the load position alignment remains valid when remounting the cryo stage.

The X, Y and Z axes movements are not limited. Tilt is able to go to maximum but will only be restricted by the presence of the cold trap at approximately 56° tilt.

NOTE	Moving the sample away from the protection of the cold trap (above the sample) can cause ice to condense on the sample by water molecules released from warmer surfaces.

The cryo stage can be removed easily and quickly.

Figure 12-10Cryo Stage Construction



Cryo stage components

- Mounting base plate
- Thermally insulated stage mount
- Heater element to 100°C
- Sensor element
- Ground connector

Cryo Sample Carrier and Cryo Stubs

The cryo sample carrier connects to the loading rod bayonet with the same mechanism as the ambient sample carrier. Release and re-connection to the rod is also using the same mechanism as the Quick Loader.

The cryo sample carrier connects onto the cryo stage within the SEM/SDB with a "dovetail" device that is spring loaded on the cryo stage.

The sample stub hole is further along the carrier to a depth of 5.0 mm and of a diameter to accept with close fit a 10.0 mm diameter stub. The stub hole is terminated before penetration to the lower side of the sample carrier. A further 3.0 mm hole is drilled into the center of the base of the 10.0 mm stub hole for vacuum pumping purposes.

A small hex screw secures the stub through a threaded hole at the far end of the sample carrier.

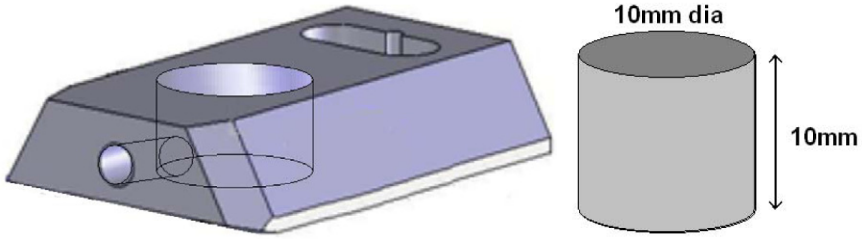
Standard Cryo Stubs

A plain stub type (10.0 mm length × 10.0 mm diameter) is supplied with the cryo option as this can then be simply engineered with holes or slots when necessary. It is commercially available as a consumable product from many SEM accessory suppliers.

Samples are secured by conductive paint on/in:

- a plain stub for mounting regular or irregular samples,
- a slot in the stub can facilitate thin samples or sheet material,
- a drilled hole in the stub can accept viscous liquids, pastes or strips of material.

Figure 12-11 Cryo Sample Carrier with Standard Stub



6. Cryo Heater & Sensor Controller

Temperature Controller

The controller shows actual (red numbers) **Cold Trap / Cryo Stage Temperature**. Required (green number) **Set Temperature** of the cryo stage could be set by buttons under the display.

The **3 way Temperature Switch** position determines a function:

- at **Up** position the high temperature is preset (**SET 2 Warm**) for sample exchange or removing (up to +50° C, default +20° C),
- at **Down** position the low temperature is preset (**SET 1 Cold**) for sample cooling,
- at **Center** position a temperature control is not in operation.

The cold trap temperature relies on the N2 flow and should be adjusted from the gas flow controller (–150° C to –190° C). It must always be at a lower temperature to the sample, approximately 10° C to 30° C difference.

Figure 12-12 Temperature Controller Display

Temperature controller components

- Free standing box.
- Temperature readout from Cold Trap.
- Temperature controller/readout from Cryo stage.
- 3 way temperature switch (High/Neutral/Low) for Cryo stage.
- Control interface cable
- Power cable

Operating the CryoMAT Loader

WARNING!	In case the Platinum deposition (Pt dep) GIS was used simultaneously with the CryoMAT Loader always run the decontamination procedure (see the User safety manual “Pt deposition chemical” chapter).

NOTE	Follow the sample loading / unloading instructions for the Quick Loader (see above) and become familiar with the process before operating the CryoMAT Loader.

Mounting the Sample

1. Mount a stub into the sample carrier and secure it by tightening the hex screw.
2. Mount the sample with strong adhesive medium such as Carbon or Silver paint onto the stub. Do not use carbon adhesive pads (Tabs) because their adhesive can become ineffective at low temperature and may cause the sample to fall off the stub.

Cooling Down the Sample (First Time Operation in Session)

3. With the Heat exchanger removed from the Dewar, fill the 12 liter Dewar with LN2.
4. Switch on the water heater at the back of the Gas flow controller trolley. Open the pressure regulators and flow meters fully. The back pressure regulators should always be open and are only used to create temporary extreme low temperatures not normally in use. They have built-in safe none closing valves to prevent a closed circuit.
5. Turn on the dry N2 gas at its source and regulate the pressure to 1.5 Bar pressure to the Gas flow controller trolley.
6. Allow 10 minutes to flush the system of any condensed water. Adjust the pressure regulators to show 5 L/M on the flow meters. Make sure that the heat exchanger rod is completely dry and void of trapped water. Carefully immerse the heat exchanger rod into the 12 liter Dewar. Watch the temperature controller read-outs for the lowering of temperature.

Balancing the Flow Rate Versus Temperature

This is a procedure using the default temperature settings. Other temperatures can be used but the cold trap should always be at a lower temperature (at least 20°C but no greater than 40°C).

7. Wait for the boiling effect to subside before adjusting, this will be seen as bouncing balls in the flow meter tubes.
8. The Cold trap will reach a lower temperature first because it is a shorter circuit, the cryo stage will follow. Therefore first regulate the flow meter to slow down and stop the cold trap at approximately -160°C. This will probably be between 4 and 5 l/min.
9. Immediately regulate the cryo stage gas flow so that it just over shoots -130°C. This will probably be between 3 and 4.5 l/min.
10. Switch the 3 Way Temperature switch down to SET 1 Cold preset temperature and wait for the system to reach the required temperature (-130° C, usually after 10 minutes). The cold trap flow rate may need a small final adjustment and can now be set so that it stabilizes at a temperature of ~-160° C).
11. The read-outs on the controller box will indicate the temperature stability at the cryo stage and cold trap. Do not switch on the beams till the sample is at the necessary low temperature. Once this is stable viewing or milling can begin on the sample.

Sample Exchange / Removing

12. When the sample needs to be warmed up to ambient temperature before being exchanged or removed, bring the stage to a non-tilt condition and switch off the HV.
13. Switch the 3 Way Temperature switch up to SET 2 Warm preset temperature and wait for the system to reach the require temperature (usually after 20 minutes).
14. During sample exchange keep the cryo stage at the SET 2 Warm temperature.
15. Follow from the step No. 10 on to proceed with observation.

Finishing CryoMAT Loader Operation

Daytime Use

This operation should only take approximately 15 minutes.

1. Bring the stage to a zero tilt condition and switch off the HV.
2. Switch the 3 Way Temperature switch up to SET 2 Warm preset temperature and wait for the system to reach the require temperature (usually after 20 minutes).
3. Switch the 3 Way Temperature switch to center position (Off).
4. Remove the sample carrier from the SEM/SDB, vent the loader chamber and remove it from the loader with tweezers.
5. Turn off the N2 gas supply to the 12 liter Dewar unit and wait for the supply pipes to the chamber interface to become flexible (approximately 15 minutes).
6. Carefully remove the heat exchanger from the 12 liter Dewar and cap off the 12 liter Dewar to save LN2.
7. Turn on the N2 gas supply to the 12 liter Dewar unit and warm the coils at the end of the core with a hair dryer of at least 1000 Watt.
8. When the temperatures on the controller box show ambient temperatures, stop heating the coils and turn off the N2 gas supply. Switch off the water trap heater on the trolley panel.

Overnight

Follow the procedure for Daytime Use and skip steps No. 7. and 8.

9. Allow the system to warm up over night.

Mirror Detector Protective Shutter

This device protects MD from ion residues, that gradually degrade detector functionality: contrast, calibration etc.

Ion residues (pollutions) accumulated dose is dependent on ion current used, exposure time and gas chemical type (Pt and W). To maintain good detector functionality we recommend to use the Protective shutter.

UI Control

The device can be controlled manually via the toolbar icon, that has several variations:

- Icon is not accessible when:
  - Retractable DBS is inserted
  - Link Z to FWD procedure has not been done
  - Z-axis coordinate is too close to final lens pole and the stage is tilted more than 2° (each direction)
  - patterning is in progress

NOTE	Consequently when the Shutter is inserted, some devices cannot be inserted / used.

- Shutter is **retracted and not needed**
- Shutter is **retracted but needed**
  icon blinks between the retracted / inserted states

- Shutter is **inserted and needed**
  normal shutter functionality

- Shutter is **inserted but not needed**
  there is no danger of pollutions, it is possible to retract the shutter

According to actual state each icon variation and has its corresponding tooltip.

When patterning parameters are set, calculation takes place and recommendation appears (blinking toolbar icon) to insert the shutter before patterning starts if the calculated ion residues dose is exceeded.

Short time period before estimated loss of detector functionality the Application status message appears with recommendation to insert the Shutter.

When the shutter is going to be inserted and any GIS, Multichem and/or EasyLift is inserted, system retracts the appropriate device automatically to enable shutter insertion, and returns the device to the original position.

NOTE	When the EasyLift is going to be automatically retracted, the confirmation dialog appears in order not to destroy possible sample attached to its needle.

Stage Move Limitation

When Shutter is inserted:

- The stage cannot move to Z-axis < 2 mm.
- When the stage Z-axis < (Eucentric position – 300 µm), the stage can be tilted in the ±2° range. When the stage is tilted more, it cannot be moved to Z-axis < (Eucentric position - 300 µm).
- When Link Z to FWD is lost, the Application status warning message appears: Z is not linked to FWD, when moving the stage beware of hitting MD Protective Shutter!