



Stela User Manual

Model 1015

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1 Introduction

The Stela™ camera is a hybrid-pixel electron detector fully integrated into the Gatan Microscopy Suite® software. Stela is optimized for diffraction studies in a transmission electron microscope (TEM) or scanning TEM (STEM). It uses the DECTRIS hybrid-pixel detection technology that allows for electron counting (resulting in a high signal-to-noise ratio) at high dose rates and high-speed, high-dynamic range electron diffraction imaging.

1.1 Configurations

The Stela system includes the camera, detector control unit (DCU), DigitalMicrograph® (DM) PC, and a water chiller.

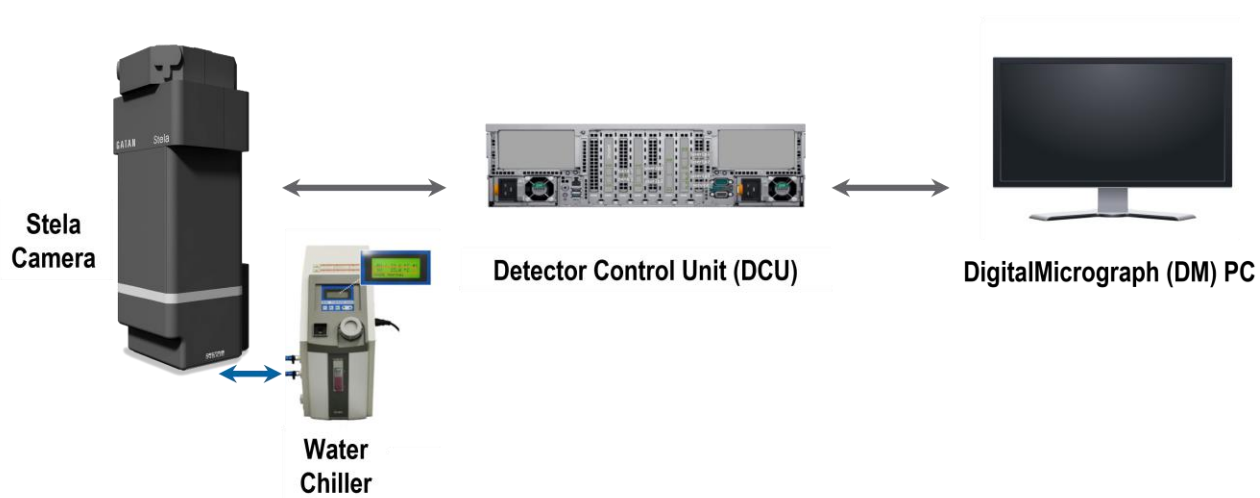


Figure 1: *Stela camera components.*

The Stela camera is available with two different sensor formats, as detailed below.

Table 1: *Stela models and sensor formats.*

Model number	Product name	Sensor format (px)
1015.1	Stela Camera (0.5 MP)	1024 x 512
1015.2	Stela Camera (0.25 MP)	512 x 512

2 Getting started

**WARNING**

Before installing and operating this product, read and review the regulatory pamphlet and follow all safety instructions to avoid the risk of injury and potential hazards.

2.1 Power-up sequence

To start from the power off:

- 1 Turn on power to the DCU using the **power button** at the front of the unit. Allow **10 – 15 min** before attempting to communicate with the DM PC.
- 2 Make sure the water chiller is powered on and running water through the camera (see 2.4).
- 3 Turn on power to the camera using the **touch button** on the camera head.
- 4 Turn on power to the DM PC.
- 5 Log into the DM PC.
- 6 Launch **DM software**.
- 7 Wait for the camera monitor light to turn **green** and **stop flashing**.
- 8 Start **Live** view.

**IMPORTANT**

When ending a DM session, do not quit and immediately restart DM software. DM software requires a few seconds to save data when closed

2.2 Power down sequence

Under normal circumstances, you can leave the Stela camera running. If necessary, you can power down the Stela camera completely.

To completely power down the camera:

- 1 Close the **DM software**.

- 2 Access the DECTRIS web interface by typing **http://169.254.254.1** in the address bar of your web browser and click on **Shutdown** on the bottom left corner of the window.
- 3 Turn off the DM PC using the **Shut Down** option.
- 4 Turn off the camera using the **touch button** on the camera head. You will see either **solid green light** or **fast to slow blink** – slow blink means the camera is off and in standby mode.
- 5 Turn off the power to the water chiller.

2.3 Camera status

Camera **Health Status** can be monitored on the **Camera Monitor** palette. The Health Status light should be **green** for normal operations. You will see a flashing green light at the times when the camera is starting up (do not use the camera before flashing stops) and a red light when the DCU reports that it is in an error state (use **Initialize Camera** button in the **Camera Setup** window to restart the DCU in this case). Camera Setup is available from the setup icon in the **Camera Monitor** palette, as shown in Figure below.

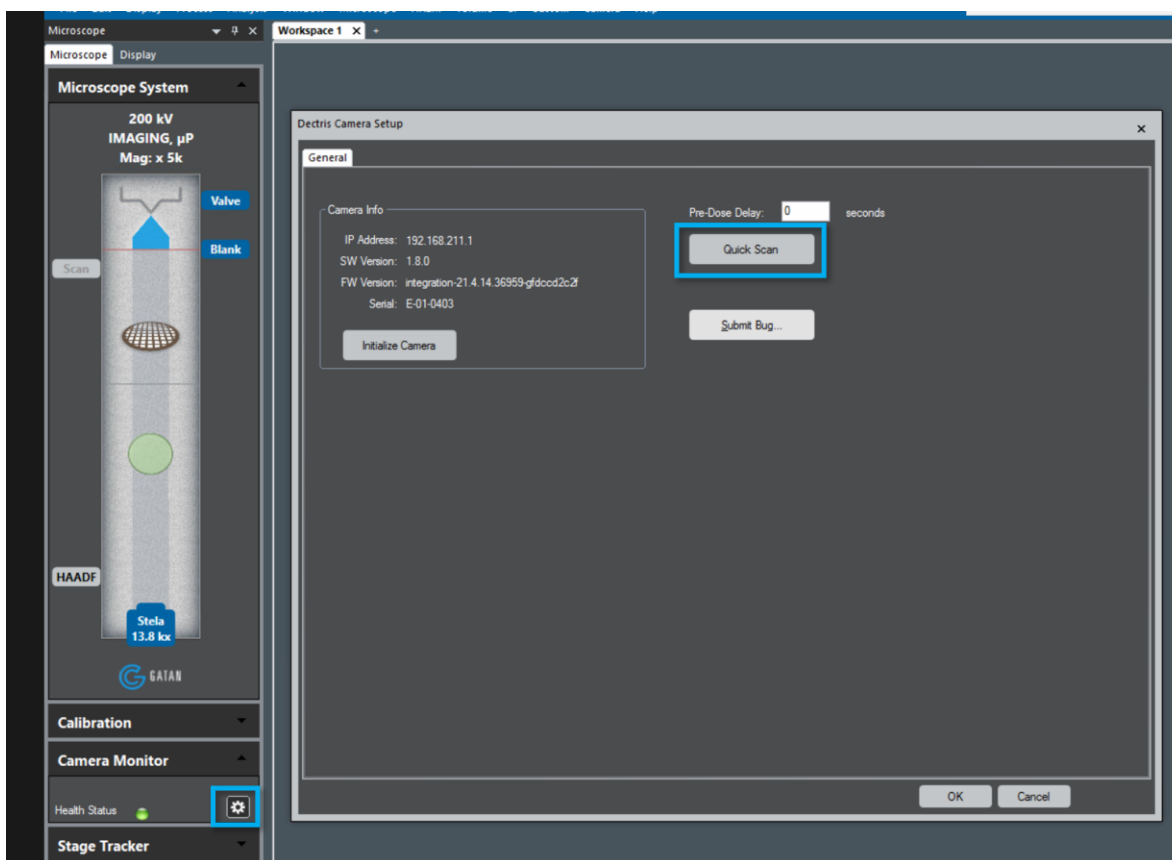


Figure 2: Camera health status.

A Quick Scan feature is also included in the Camera Setup window, and it is used to assess the camera's health. After pressing the **Quick Scan** button, a screen will appear with numerous details showing camera status. When an end-user performs a Quick Scan, a successful result is for all lights to be green.

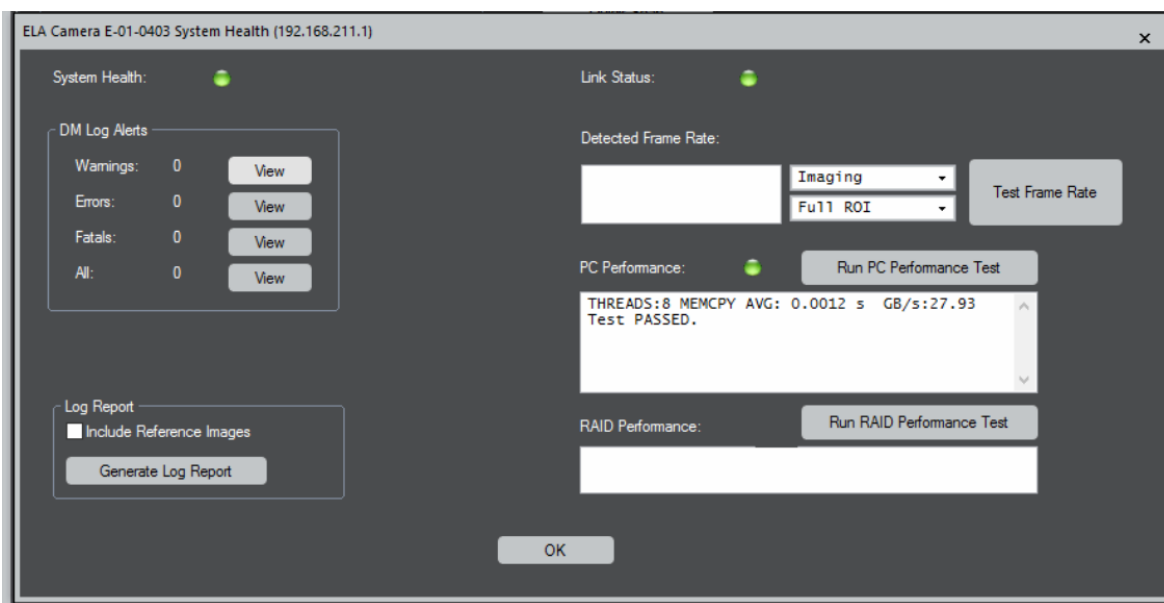


Figure 3: Typical results from Quick Scan showing healthy camera operation (all green lights).

If one or more lights are not green, an error condition exists within the camera system that should be resolved before data acquisition occurs. If problems persist after a full restart of the system, contact your local Gatan service office as listed at www.gatan.com/contact.

2.4 Operating temperature

Stela is water-cooled, and it operates at room temperature (~23 °C). The camera will shut down automatically if it reaches a temperature >35 °C. Check the flow of cooling water periodically. If the display on the chiller shows an error where the set temperature is not at 23 °C and normal mode, make sure the lines are not obstructed and adjust the pressure regulator to bring the flow back to the original level. If the chiller is in an error state, cycle the power after checking for obstructions and water level on the chiller.

2.5 Shutter configuration

The user-mode must be set to **Power User** to access basic shutter configuration settings. Once in Power User mode, the basic shutter configuration is accessed through the **Camera / Configure Camera...** drop-down. Stela camera does not support TEM shuttering (as there is no shutter or override connection from the camera to the microscope).

In supported microscope models, the beam can be set to **Blank** via software control when the camera is idle, and the viewing screen is raised. This default state protects your sample from unnecessary beam exposure/damage while not actively viewing the sample or capturing data. See below:

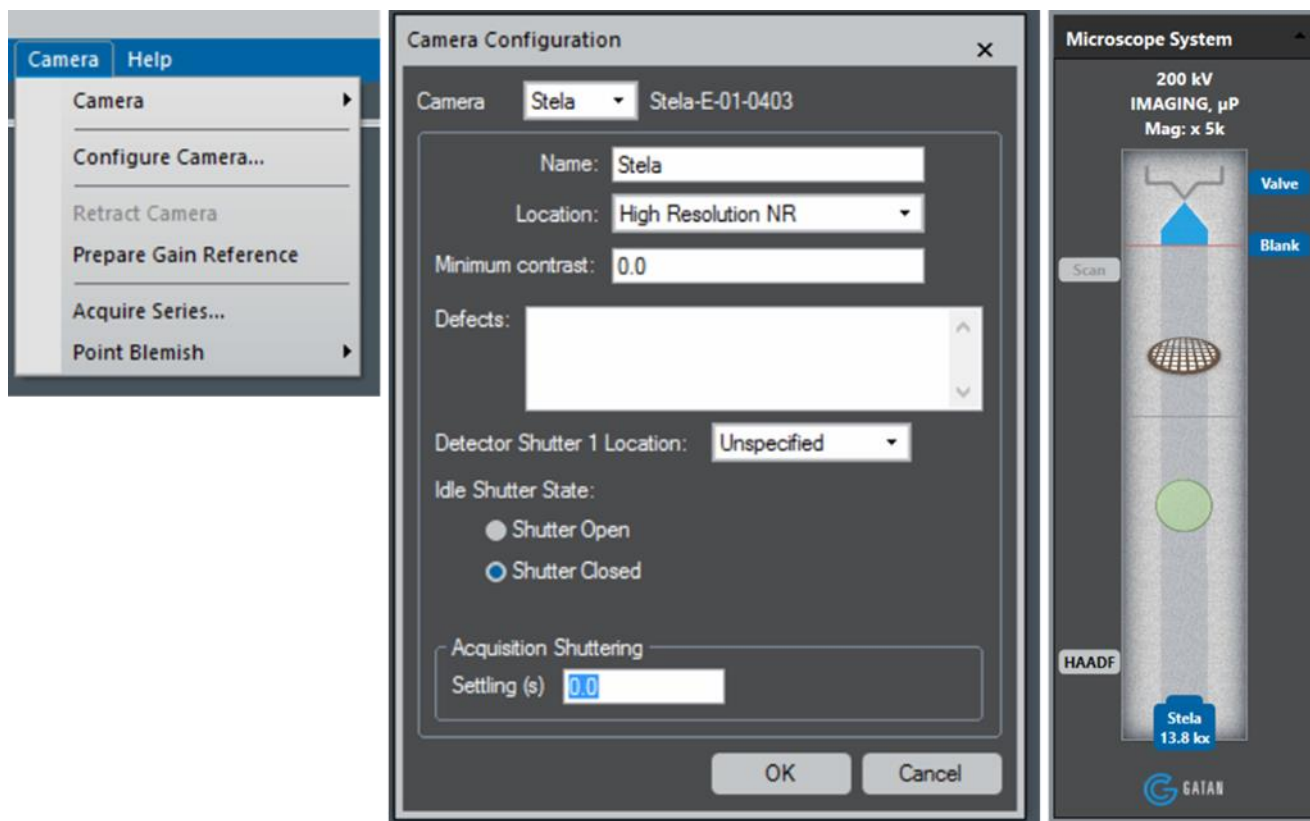


Figure 4: Shutter configuration is accessed via the Configure Camera... menu. Select Shutter Closed for Idle state, so the beam is automatically blanked when camera is idle, and the microscope screen is raised (only for supported microscope models).

2.6 Step-by-step data acquisition

2.6.1 Single images

To acquire a single image:

- 1 Align TEM as you would for any data collection session.
- 2 Start in a sample location where the beam exposure, damage, or contamination is acceptable, not at the best location on the sample.
- 3 Start **DM software** if it is not running.
- 4 Within DM software, check that the **Camera Monitor** is **green**.
- 5 On the TEM, check that the electron beam is on, and the viewing screen is down.
- 6 On the TEM, check that beam intensity on the viewing screen is normal for TEM imaging (beam visible, but not a very small spot).
- 7 Select the **TEM Imaging** technique within the DM software.

- 8 Select **Normal** and **HDR** modes. Set the readout area as desired (Full is recommended as the starting point).
- 9 Start **Live** view.
- 10 Check that the live view exposure time is reasonable (0.001 s is recommended as the starting point).
- 11 Lift the viewing screen by double-clicking on it in DM software.
- 12 Observe the dose rate given in the dose rate monitor in DM software. Check that the dose rate on the sample is not too high for your sample.
- 13 Confirm that the image looks like what you expect to see. If capturing high-resolution images, look at the live FFT in the DM software to adjust focus, objective stigmatism, and magnification.
- 14 Set the capture exposure time to the desired value (if unsure, try 1 s) and set # of frames to the largest value.
- 15 If desired, check the **Save Image** checkbox to save each image to disk as it is captured automatically. If so, check that the save path is set to the desired location in the **Data Set** window, **Capture Autosave** section (always save data to **Raid drive (X:)**).
- 16 If desired, check **Correct Drift** checkbox. If this is selected, drift will be automatically measured and corrected during capture, resulting in a drift corrected image. This will slow down image capture somewhat.
- 17 Move to the desired location on the sample and wait for any sample drift to stop.
- 18 Click the **Capture** button. The resulting image will be displayed in a different workspace and not the live view workspace.
- 19 After capturing several images and deleting any undesired ones, the entire workspace with all its images and their relative positions on the screen can be saved by right-clicking on the **Workspace** tab and selecting **Save workspace as...**, rather than saving individual images one-by-one.

2.6.2 Image stacks

To acquire an image stack, see steps 1 – 13 above

- 1 Set the capture exposure time to the desired total exposure time for the entire stack. Set the **# of Frames** to the desired value. Press **Tab** or **Enter** to allow the software to validate whether this number is possible. The resulting stack will have the number of frames set from this field.
- 2 To capture many image sub-frames, not just a single image, check the **Save Stack** checkbox, and verify that the save path is set to the desired location in **Data Set** window, **Capture Autosave** section (always save data to **Raid drive (X:)**).
- 3 If desired, check **Correct Drift** checkbox. If this is selected, drift will be automatically measured and corrected during capture, resulting in a drift corrected image. This will slow down image capture somewhat.
- 4 Click the **Capture** button. The resulting summed image (not a stack) will be displayed in a different workspace (not the live view workspace). This summed image will only be saved automatically to disk if the save image checkbox is also checked. The individual stack frames have all been saved in a single *.dm4 file in the location specified as the save path. To view the full-stack, right-click somewhere in the workspace and select **Open...** In the dialog box that opens, select the file name that you just captured.

- 5 Drift correction can be applied after data collection if saved as a stack. This is accessed using the process image technique.

2.6.3 Continuous capture

To stream data to disk (e.g., continuous data capture)

See Steps 1 – 13 above, but select the ***In-Situ***, not the Normal mode.

- 1 Set the dataset name and location in **Data Set** window, **Record** section. If this step is skipped, the DM software will warn that the folder location for *in-situ* data has not been configured (always save data to **Raid drive (X:)**).
- 2 Set the view exposure time based on the framerate desired in the streamed dataset. To specify framerate, rather than an exposure time, select **Framerate** from the drop-down menu next to the View button.
- 3 Set the **LookBack duration**. **5 s** is a recommended starting point.
- 4 Start the **Live** view if it is not already running. The LookBack Buffer now begins to fill until it reaches the specified duration.
- 5 Move to the desired location on the sample.
- 6 When the behavior of interest is seen, click the **Record** button to start recording.
- 7 Data can be played back using the *In-Situ* Player. To open a dataset, right-click on the **workspace**, select **Open InSitu Dataset...**, and choose the base folder of the *in-situ* video dataset, which will have a folder named **Hour_00** inside. The most recently collected dataset is pre-selected by default when the dialog opens.

3 Stela camera operation

3.1 Overview

This section describes the modes and configuration options for operating the Stela camera. Several screenshots of DM software are used as references to present and explain the camera features. For more information on setting up DM additional software features, refer to the DigitalMicrograph section.

3.2 Imaging modes

When the Stela camera is selected, two camera modes are available to configure and acquire data. The two modes are labeled Normal and *In-Situ*:

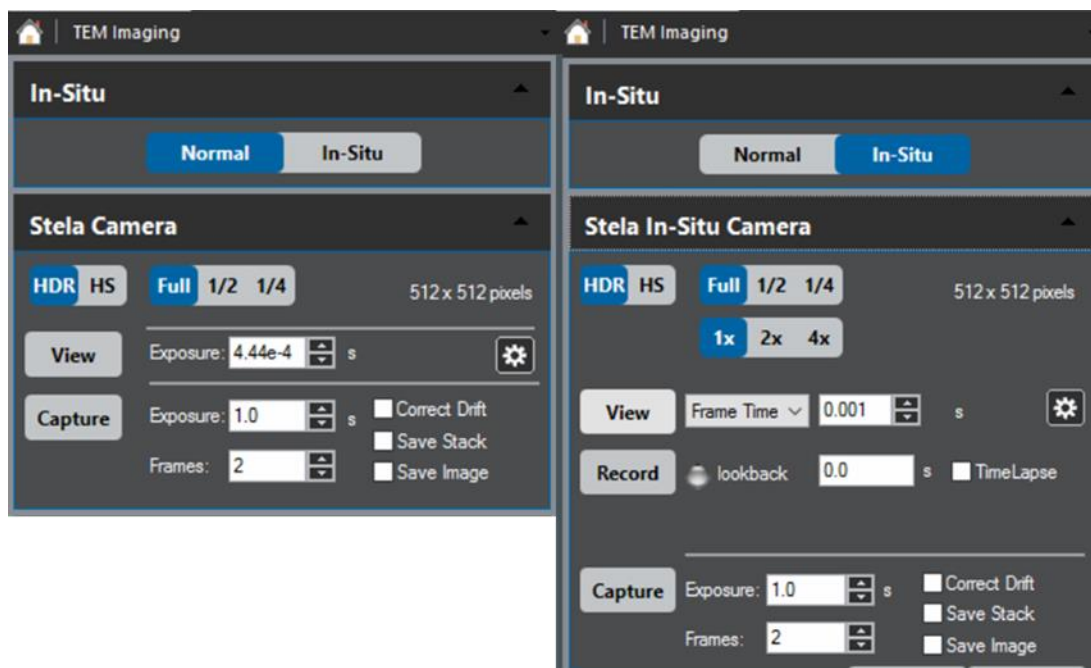


Figure 5: Stela Normal and In-Situ camera palettes.

3.2.1 Stela Camera palette

The Stela Camera palette is used to select parameters for capturing single images or image stacks. The functionality of the controls is labeled and described below:

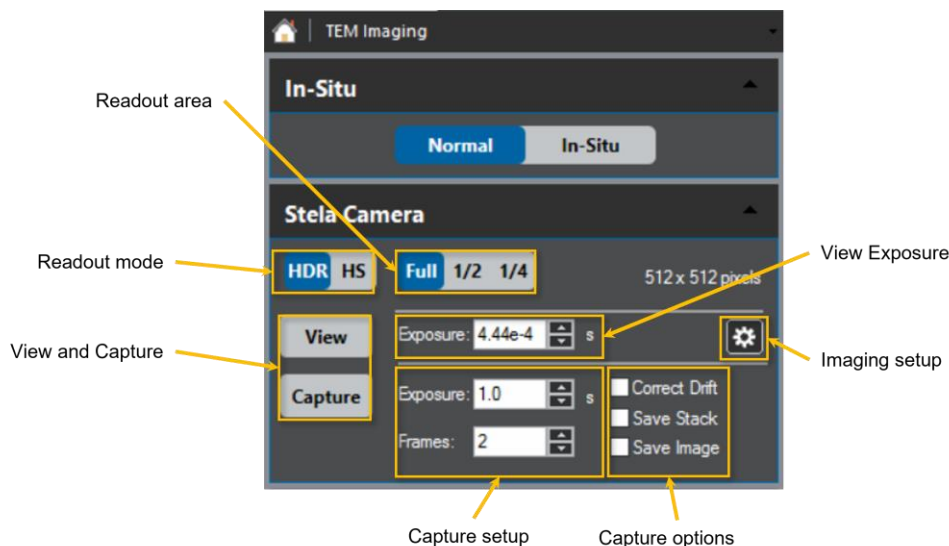


Figure 6: Stela Camera palette used for single or stack image captures.

- **Readout mode:** Selection between HDR (high dynamic range) and HS (high speed) readout modes determines the maximum camera frame rate and the image bit depth (data size); see table below.
- **Readout area:** Selecting a sub-area readout allows image acquisition at faster frame rates (see table below). When a sub-area is selected, the sub-area that is read from the sensor is centered on the physical sensor. The rate that image frames can be stored to disk increases with decreasing readout area.

Table 2: Frame rate and image bit depth for different Stela readouts.

Readout mode	Readout area	Max. frame rate (fps)	Single frame bit depth @ min. frame exposure
HDR	Full	>2000	Unprocessed: 16
	1/2	>4000	Gain normalized: 32
	1/4	>8000	
HS	Full	>4000	Unprocessed: 8
	1/2	>8000	Gain normalized: 16
	1/4	>16000	

- **View button:** Use this to start and stop live view. The View function does not save data to disk but rather simply displays images within DM. If the Exposure is a small number, the rate at which data is updated within DM is limited by the refresh rate of the graphics card in the DM PC. However, if Exposure is set to a large enough value, then the live view will be updated by the time resolution indicated by Exposure.

- **View Exposure:** Set the live view exposure time here. If 0 is entered, DM automatically sets the exposure time to the minimum value allowed for the selected camera readout (mode, area). Use the up and down arrows to increase and decrease the current exposure time by a factor of 2.
- **Imaging Setup:** Drift Correction (Trim Drift Corrected Image), Cropping to Square (only for P/N 1015.1), and Corrections (Unprocessed or Gain Normalized) options are available in this setup window.

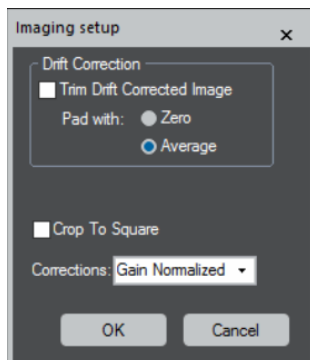


Figure 7: *Imaging setup window.*

- **Capture button:** Use this to capture an image or an image stack
- **Capture options:**
 - **Correct drift:** Check this box if you want to apply live drift correction to the frames as they come in from the camera. Once this box is checked, you will see a drift correction region of interest (ROI) in the camera live view window (blue box); move this box to an area of the sample with enough contrast. DM uses this ROI to measure the drift between camera frames (using cross-correlation). Go to the Imaging Setup window (see Figure above) to select if you want the captured drift corrected image to be trimmed to the maximum common area.
 - **Save stack:** Check this box to capture many image sub-frames, not just a single image. Ensure that the save path is set to the desired location in the Data Set window, Capture Autosave section. The total exposure time for the entire series is set by the Exposure field next to the Capture button, and the number of frames is set by the Frames field next to the Capture button.

Once a stack of frames has been collected, the data can be opened and processed within DM by right-clicking in the main workspace area of DM and selecting Open Series. The frames in an image stack can be viewed independently and used for different options such as frame alignment and drift correction or even with advanced processing such as local drift correction within sub-regions of a single frame.

If Save Stack is not selected, then a stack of frames will not be saved to disk.

- **Save image:** Check this box to save a single frame. Ensure that the save path is set to the desired location in the Data Set window, Capture Autosave section.

If Frames is >1, then the saved image is created from the summed stack of sub-frames specified by Frames. If Save Image is not selected, an image will still be displayed within DM, but an image will not be saved automatically to disk.

3.2.2 Stela *In-Situ* Camera palette

The Stela *In-Situ* Camera palette is used to set conditions for live view and *in-situ* data recording.

- **Readout area:** Selecting a sub-area readout allows image acquisition at faster frame rates (see table above). When a sub-area is selected, the sub-area that is read from the sensor is centered on the physical sensor. The rate at which image frames can be stored to disk increases with decreasing readout area.

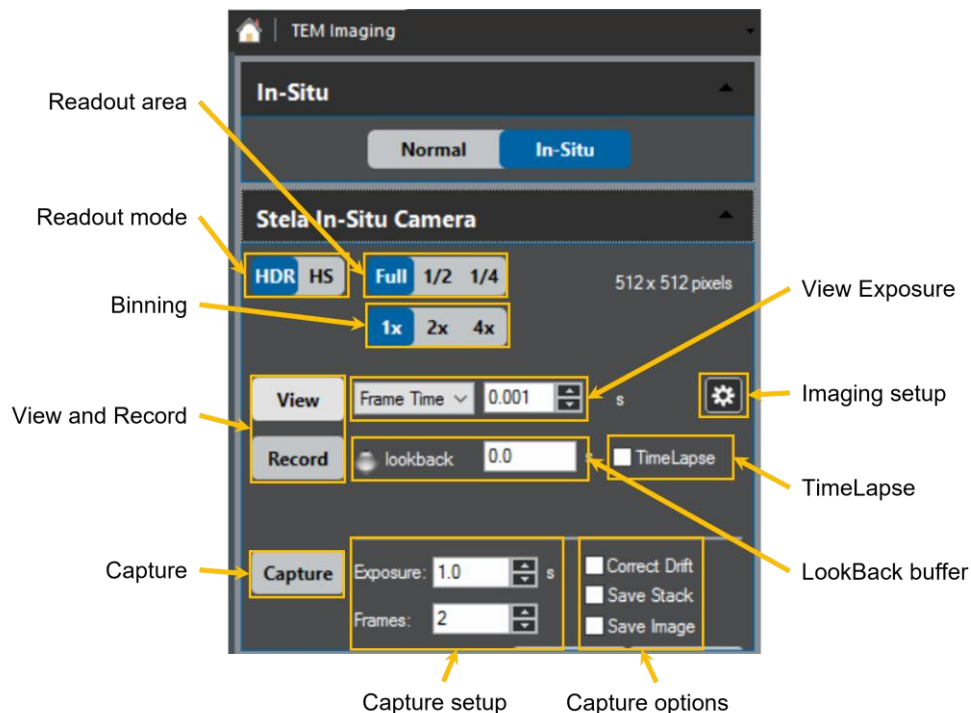


Figure 8: Stela *In-Situ* palette.

- **Readout mode:** Selection between HDR (high dynamic range) and HS (high speed) readout modes determines the maximum camera frame rate and the image bit depth (data size); see table above.
- **Binning:** Binning in the case of Stela camera (x2 and x4) only reduces the image size and does not affect the maximum frame rate allowed for the selected camera mode. A binning of 2x decreases the total data size by a factor of 4. This can save significant hard drive space (e.g., if a bin x1 dataset would have been 40 GB, binning x2 saves 30 GB), as well as significant data transfer and processing time.
- **View button:** use this to start and stop live view. The View function does not save data to disk but simply displays images within DM. If the Exposure is a small number, the rate at which data is updated within DM is limited by the refresh rate of the graphics card in the DM PC. However, if Exposure is set to a large enough value, then the live view will be updated by the time resolution indicated by Exposure.
- **View Exposure:** Here, you have the option to select either the Frame Time or the Frame Rate (inverse frame time). Remember that the exposure time (or frame rate) selected sets the time resolution for images in the live view and *in-situ* data streams acquired with the Record button.

If 0 is entered, DM automatically sets the exposure time (frame rate) to the minimum (maximum) value allowed for the selected camera readout (mode, area, image correction applied). Use the up and down arrows to increase and decrease the current selection by a factor of 2.



IMPORTANT

Note that maximum frame rates allowed for in-situ records depend on the image correction selected in the Imaging Setup window. See the table below for reference.

Table 3: Max. frame in-situ record frame rates for unprocessed and gain normalized images.

Readout mode	Readout area	Max. frame rate	
		Unprocessed	Gain normalized
HDR	Full	>2000	1000
	1/2	>4000	2000
	1/4	>8000	4000
HS	Full	>4000	2000
	1/2	>8000	4000
	1/4	>16000	8000



IMPORTANT

The dataset name and location must be specified through the Data Set palette before the first dataset is recorded; otherwise, DM will warn that the folder location for in situ data has not been configured.

For best performance, in-situ data should be stored on the dedicated solid-state RAID array.

- **Record Button:** Use this to start and stop an *in-situ* data acquisition. Data is saved with a time resolution equal to the Exposure value.

Once a continuous stream of data has been recorded, the data can be opened in DM by right-clicking in the main workspace and selecting **Open InSitu Dataset...** *In-situ* datasets can be processed with the *In-Situ* Player. Numerous tutorial videos and a webinar on the *In-Situ* Player can be found on Gatan's YouTube channel.

- **LookBack:** This feature allows continuous data capture to include a buffer of data that precedes the moment at which the Record button is clicked. Set the duration of the LookBack Buffer in this field (seconds). The LookBack feature is beneficial to prevent missing the start of an *in-situ* reaction and reduce the total data storage needed to capture a reaction.

- **TimeLapse:** Instead of recording every single frame, use TimeLapse to record 1 frame with your desired frequency (seconds or total frames). *In-situ* data recorded using the TimeLapse feature saves a single frame with exposure time equal to the View exposure at the frequency selected by the user.



Figure 9: *TimeLapse for an in-situ record.*

- **Imaging setup:** Drift Correction (not applied to live *in-situ* data stream), Cropping to Square (only for P/N 1015.1 – another tool for data size reduction during *in-situ* data record), and Corrections (Unprocessed or Gain Normalized) option are available in this setup window.

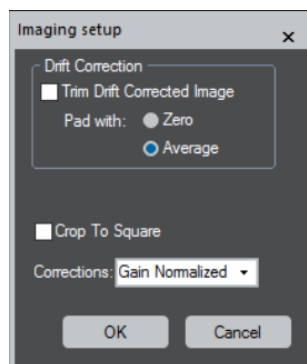


Figure 10: *Imaging setup window.*



IMPORTANT

Recording Gain Normalized in-situ datasets automatically limits the maximum frame rate (min. frame exposure), see table above for more details.

- **Capture button:** Use this to capture an image or an image stack, see more details in section above (Stela Camera palette)

3.2.3 Data Set palette

The Data Set palette allows the user to set the path where images, image stacks, and *in-situ* datasets will be saved.

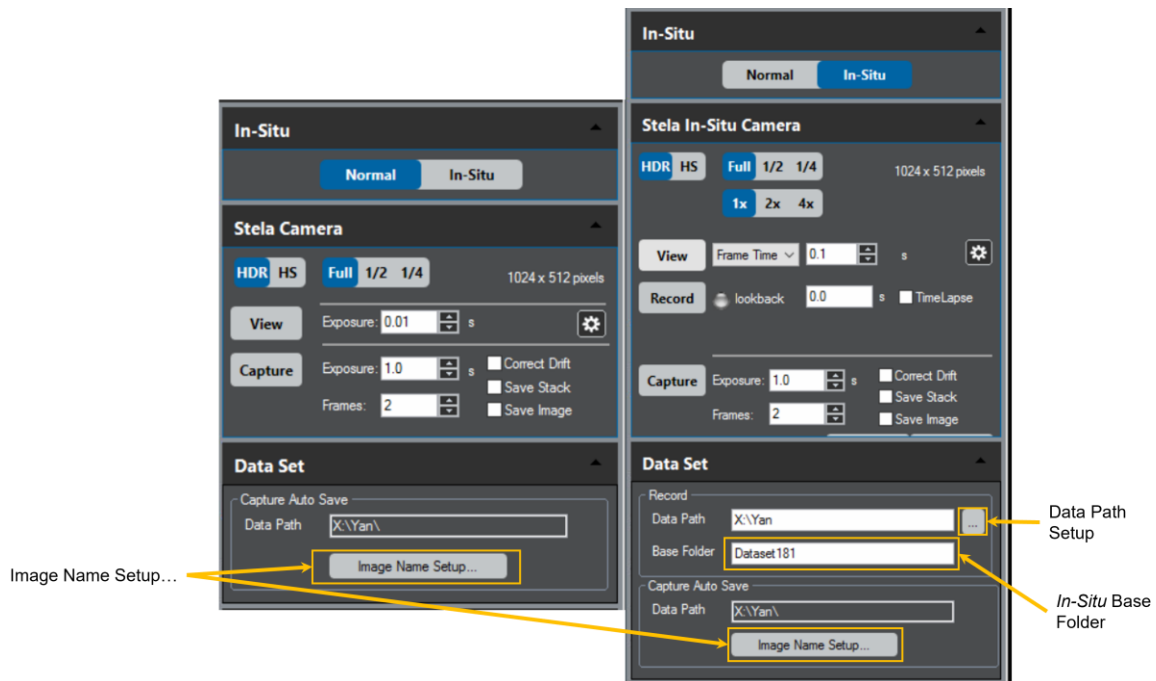


Figure 11: Data Set palette for Normal and In-Situ modes

For image and image stacks, click on **Image Name Setup**:

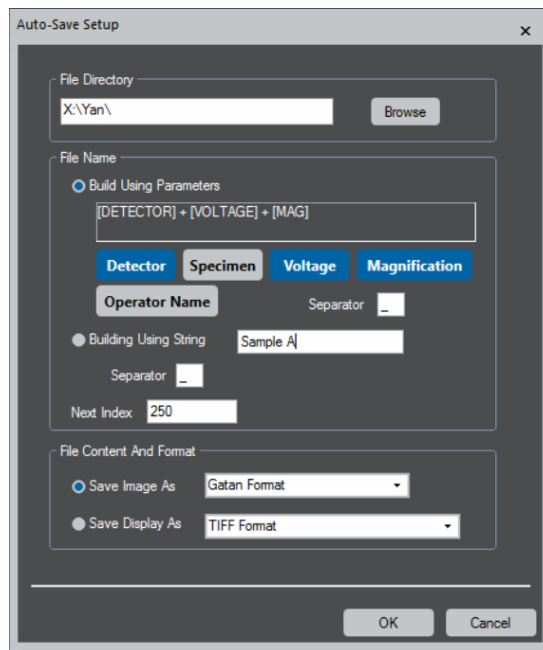


Figure 12: Auto-Save Setup window.

For *in-situ* datasets, click on the **Data Path Setup** button to select the data directory and enter the desired file name in the **Base Folder** box.

3.3 Data acquisition path and image processing

Stela camera data path from the DECTRIS DCU (detector control unit) to the DM PC is shown below:

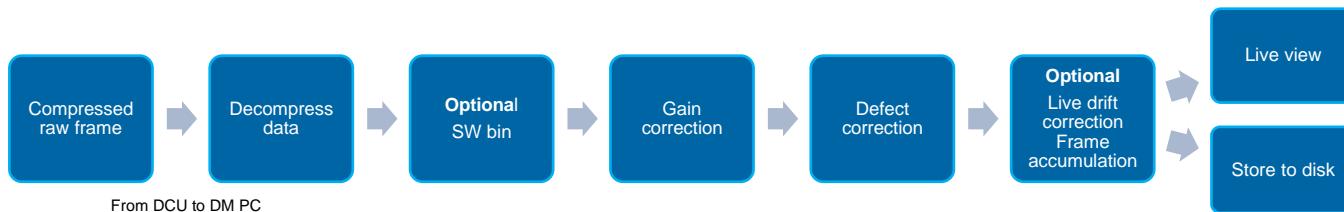


Figure 13: Stela camera data path.

Electron counted compressed raw frames are passed from the DCU to the DM PC, where they are first decompressed. Image bit depth from the DCU varies depending on the imaging mode selected (HDR or HS) and frame exposure time. See the table below for reference:

Readout mode	Frame exposure (ms)	Frame bit depth
HDR	<6.6	16
	>6.6	32
HS	NA	8



IMPORTANT

In certain imaging conditions (especially using the HS mode), data compression above 40% is not possible by the DCU. This results in data flowing into DM PC at a higher than max. rate allowed. In such cases, DM warns the user at the start of live view and asks to reduce the frame rate or the dose rate (effectively reducing data rate into DM PC).

3.3.1 Dark reference

Dark subtraction is unnecessary for the Stela camera since the camera output is nearly perfectly dark (all zeros, except with cosmic events at long exposures) when not exposed to electrons.

3.3.2 Gain correction

Gain correction normalizes the response of each pixel to an electron strike. When collecting gain-normalized data with the Stela camera, the reference images for the camera must exist; so, if the reference image has not yet been acquired, then the user must first collect it.

To acquire reference images, the user mode must be set to **Power User** to make the Camera drop-down menu available. All reference images are stored on the GMS computer at **C:\ProgramData\Gatan\Reference Images**. It is usually sufficient to collect gain reference images once per week.

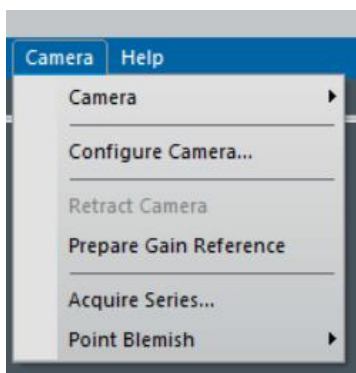


Figure 14: Camera menu is used to start gain reference preparation.

Go to the **Camera** menu and select **Prepare Gain Reference**. The user must adjust the beam conditions to achieve the required beam intensity as part of the gain reference process. Click **Done** once the dose rate and beam conditions have been adjusted per instructions. In the next window, you are asked to enter the desired exposure time. 30 s is the minimum recommended exposure, and it is best to select an exposure time **10 times** longer than the longest desired single-image exposure time.

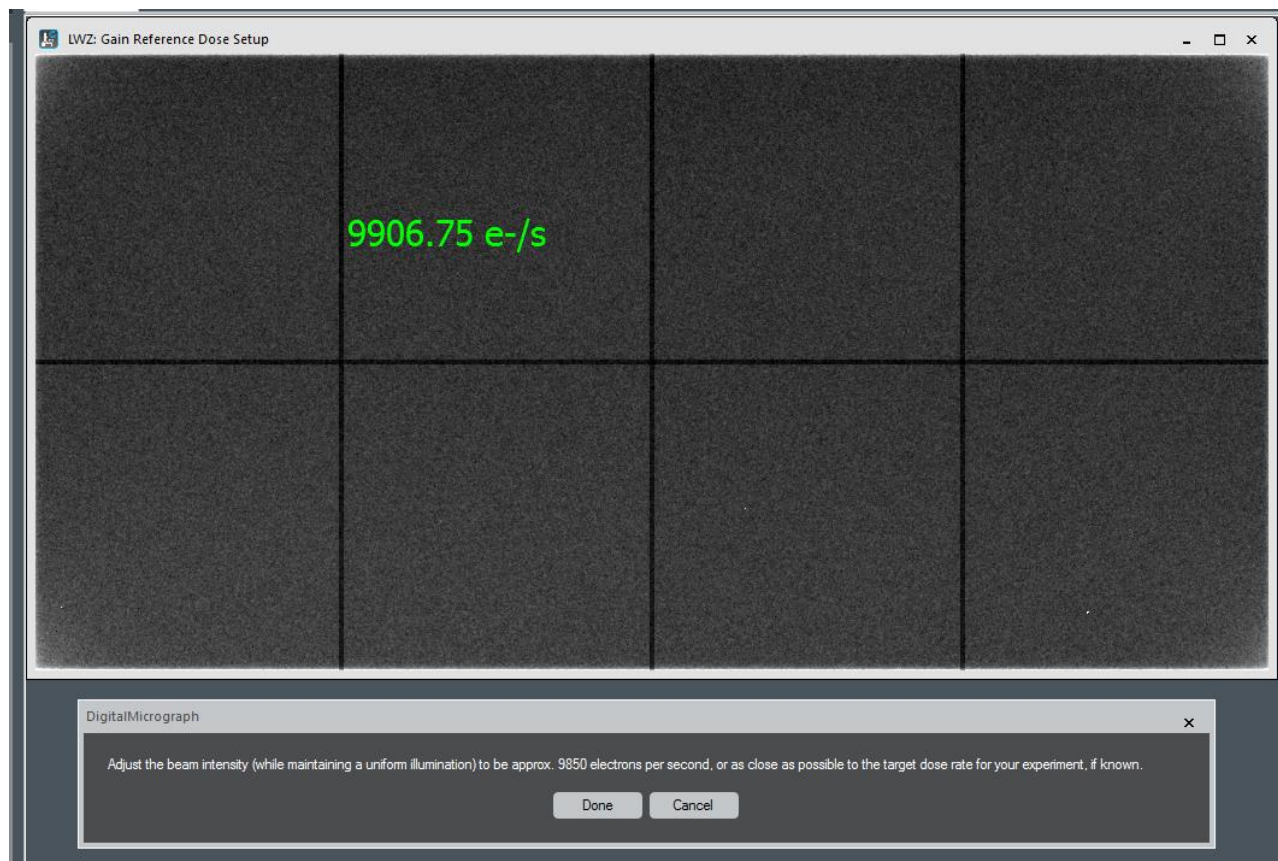


Figure 15: Gain Reference Dose Setup.

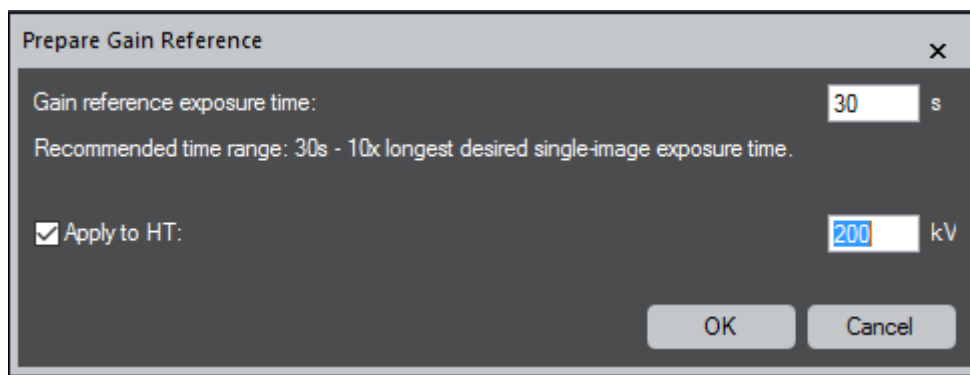


Figure 16: Gain reference preparation options.

Gain reference is dependent on the microscope operating voltage and can be saved for each operating microscope high tension (HT) simply by checking the **Apply to HT** button.

Click **OK** when done, and follow the instructions as shown below:

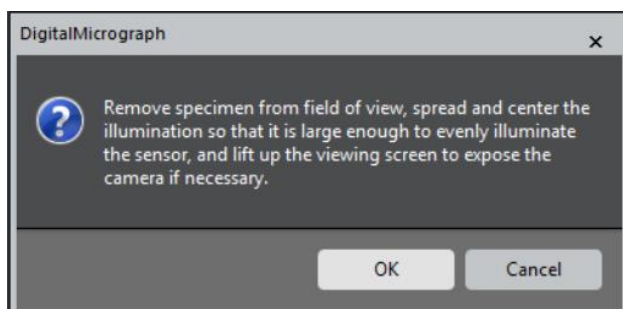


Figure 17: Gain reference preparation instructions.

Click **OK** when ready:

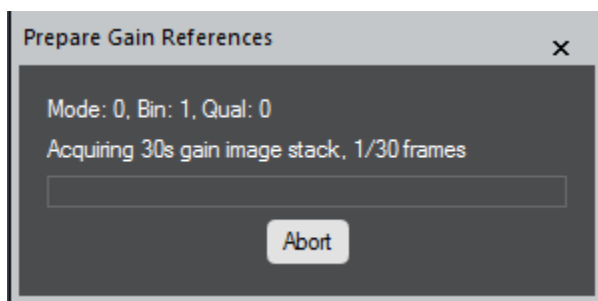


Figure 18: Progress window during gain reference preparation.

The DM software calculates a pixel defect mask to correct for defective pixels during gain reference preparation. Follow the instructions as shown below and click **Done** when ready. We do not recommend you skipping this step.

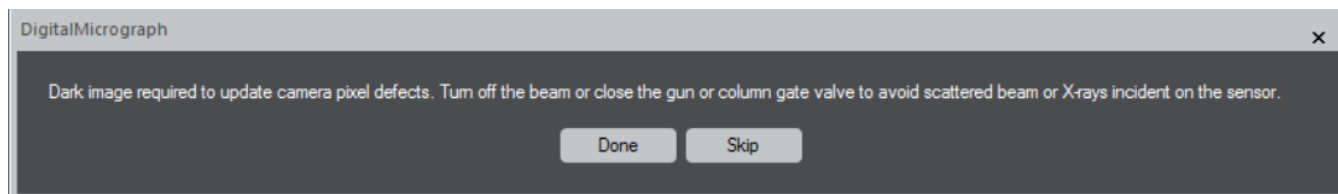


Figure 19: *Pixel defect mask preparation.*

A notification appears once the gain reference acquisition has been completed.

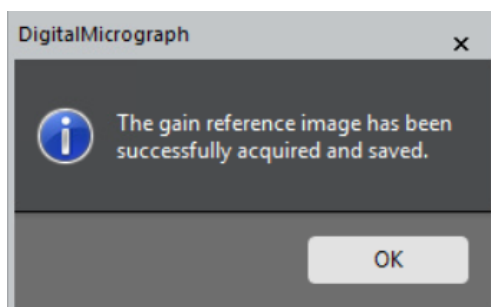


Figure 20: *User is notified once a gain reference image is successfully acquired.*

To check that the gain reference acquisition was successful, after completing reference image acquisition, acquire a flat-field image under dose rate conditions like those used in the reference image process. Then use DM to compute the FFT of this flat field image. A well-corrected image will show uniform intensity with no defects in the FFT.



IMPORTANT

Fixed-point arithmetic is used during the Stela gain correction process, which requires scaling counts by 256x on average and converting HS and HDR raw frames from 8- and 16-bit to 16- and 32-bit, respectively (file type is kept the same). Note that the unprocessed image can be saved without gain correction, allowing for user-defined post-acquisition gain correction.

3.3.3 Defect correction

Defect pixel mapping and removal are performed automatically during the reference acquisition process and do not require specific attention. Regular updating of references allows continued high performance of the camera as the sensor ages.

Defect correction removes poorly performing pixels, which contribute to fixed pattern noise such as hot, dark, or noisy pixels.

There are a couple of ways to perform defect correction with the Stela camera:

- **Pixel defect map:** These maps are images generated during gain reference acquisition and are stored on the DM computer at **C:\ProgramData\Gatan\Reference Images**.

- **User-defined pixel defect map:** A user-generated defect map. To edit this, use the **Defects** text box located in the Camera configuration dialog. This uses the same convention as other Gatan cameras, as indicated in the following examples:
 - 2 row defects: r1000-1001
 - Single column defect: c52
 - 25 column defects: [0,100,2880,124]
 - Cluster(11x21) defect: [200,500,210,520]

3.3.4 Drift correction

The spatial resolution of images of real samples is often degraded due to drift – whether induced from the TEM, sample holder, or sample itself.

Drift correction of a series of frames, followed by summing together the aligned frames, can significantly increase the signal-to-noise of data collected at low dose rates or high frame rates.

There are several ways to correct drift when collecting data with the Stela.

- **Live drift correction:** This only applies to the capture of single images or stacks of images, not to *in-situ* video acquisition.
- **Post-acquisition drift correction of stacks:** Existing free tools in DM enable drift correction of stacks collected with the Stela. Combined with the volume tools, this enables the production of drift-corrected single images. These tools are powerful and flexible, and a full description is beyond the scope of this manual. Documentation for these tools can be found in the DM help files in the Image Alignment and Volume sections.

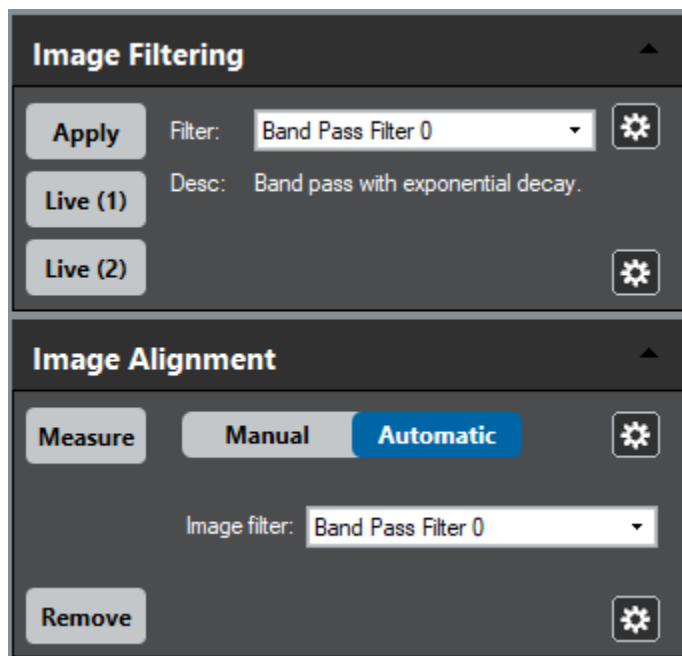


Figure 21: Free image alignment tools for stacks in DM.

- Post-acquisition drift correction of *in-situ* datasets:** DM includes a free *in-situ* player, which has been expanded since version 3.4.1. The *In-Situ* Player and *In-Situ* Editor enable drift correction of *in-situ* video datasets. Alignment can be performed on the full frames. Alternatively, if an ROI is placed on the data, a specific region of interest can be tracked over time. Filters, such as bandpass filters, and edge-detection filters, can be applied to the data during drift correction to improve results. These filters are the same user-adjustable filters that can be applied in the drift correction of stacks. To produce a drift corrected dataset for further processing and analysis, export the data as an *in-situ* dataset.

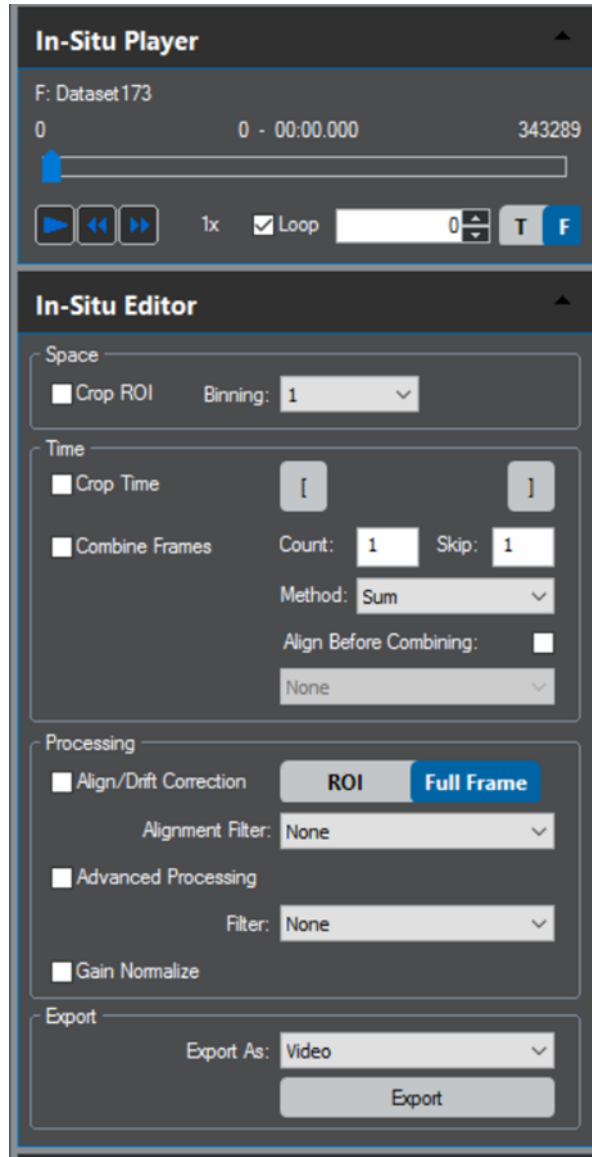


Figure 22: In-Situ Player and Editor



IMPORTANT

A full description of the In-Situ Player and In-Situ Editor is beyond the scope of this manual, but tutorial videos and a webinar on the In-Situ Player can be found on Gatan's YouTube channel.

3.4 Dose rate and saturation

3.4.1 Dose rate monitor

The dose rate monitor provides two measures of the electron beam, the dose rate on the detector, and the total dose at the sample. DM calculates these two values using two important parameters:

- **Detector conversion efficiency (DCE):** The number of counts generated per primary electron and is kV dependent
- **Magnification calibration:** Field of view calibration to determine the pixel size in nm or Å at certain magnification.

It is important to understand the relationship between the dose rate on the camera, dose rate on the sample, and magnification. The parameter linking these two dose rates is the magnification. If the dose rate on the sample is maintained at a constant value, increasing the magnification will result in a lower dose rate on the camera. Conversely, if the dose rate on the camera is actively maintained at a fixed value, increasing the magnification will require increasing the dose rate on the sample.

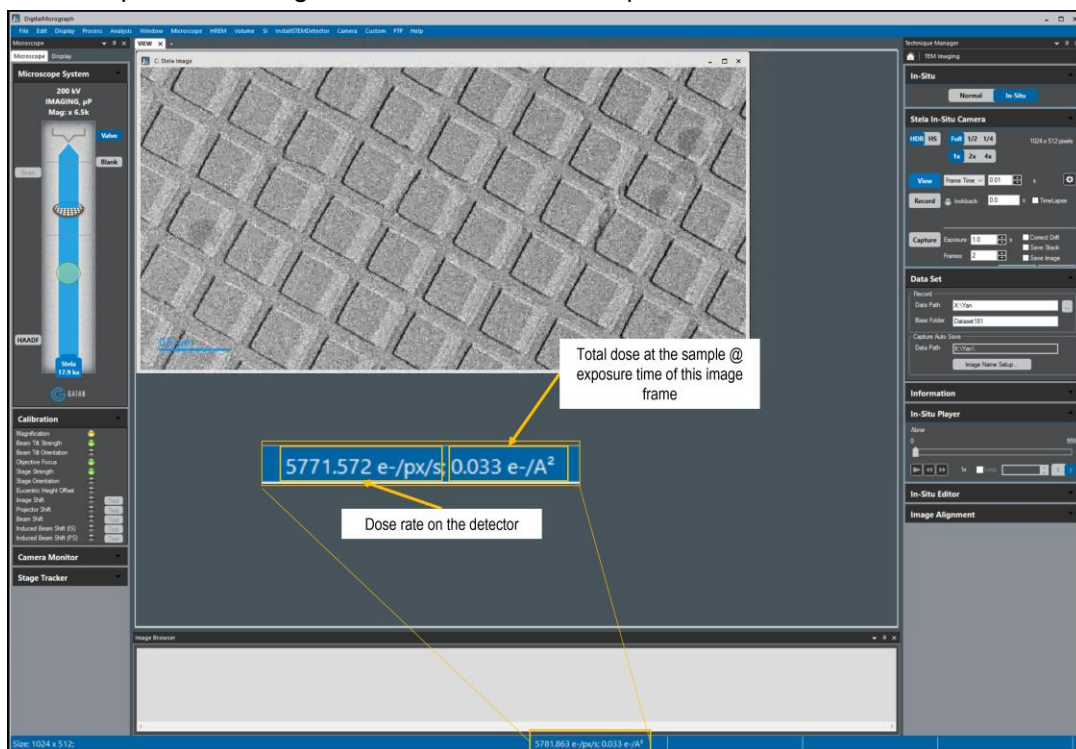


Figure 23: Stela dose rate monitor.

The dose rate monitor calculates its values based on the entire image unless a rectangular ROI is placed on the image. If a rectangular ROI is present, only the pixels inside the ROI are used in the calculation.

The dose rate on the detector is reported per image pixel, not per sensor pixel. The total dose at the sample is reported per exposure. When the active image is the live view or an *in-situ* dataset, this exposure is the view exposure time. When the active image is a captured single frame, the exposure is the capture exposure. To get the most accurate measure of the dose rate incident on the sample, place an ROI in a vacuum region, where the beam does not pass through the sample or support films.

3.4.2 Saturation

There are different types of saturation relevant to the Stela camera. Conventionally at Gatan, Saturation is defined as the deviation from 1% linearity. This is of significant importance when a quantitative measurement of pixel intensities is required for the experiment performed. At 200 kV, the Stela camera maintains linearity in the main sensor field up to 0.2 pA/pixel dose rate (higher values are expected at lower kVs).

In cases where deviation from 1% linearity is not a concern, sensor saturation could occur. At 200 kV, such saturation is expected at dose rates above 0.7 pA/pixel (main sensor field).

The last type of saturation to keep in mind is data format saturation, which depends on the data bit depth. If the data format is saturated in HS mode, try HDR mode. If you still get saturated images, reduce the Exposure for individual frames, increase the magnification, or reduce the beam intensity on the sample. If none of these are viable options and data quality can be reduced, turning off the gain normalization (x256 factor) is a last-resort option to eliminate data format saturation.



IMPORTANT

Saturation values discussed in this section are specified for the main sensor field, and half and quarter values are expected for seams and seam-crossings, respectively.

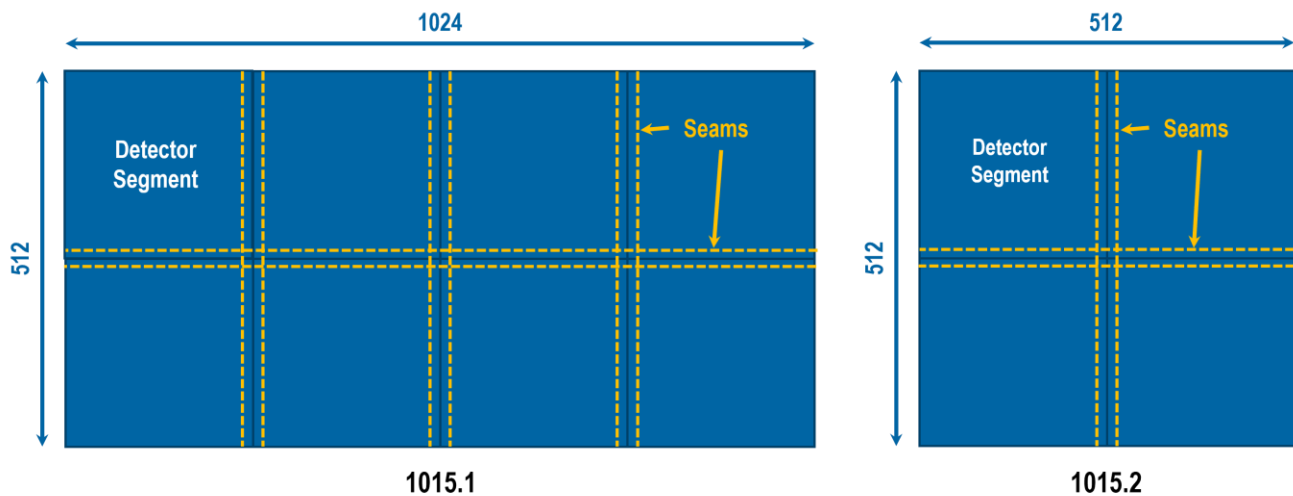


Figure 24: *Stela detector segments are stitched together at seams (figure not to scale.)*

4 DigitalMicrograph software

DigitalMicrograph is an application used for acquiring, visualizing, analyzing, and processing digital image data, primarily within the context of electron microscopy. It is used to control the Stela camera and manage the data collected with the camera.

4.1 Installation

DM software requires valid licenses for instrument control and to enable many analysis features. Installation is a two-step process. First, install DigitalMicrograph licenses using the Gatan license USB or downloaded license files. Installation instructions are included with the licenses. Then, install the DM application software using the DM installer USB or downloaded *.zip file. Installation instructions are included with the USB or can be found on the Gatan website. Make sure the Stela camera is selected in Camera Hardware and TEM.

**WARNING**

Do not add any additional PCI cards to PC.

Do not modify PC configuration.

For optimal performance, do not run anti-virus applications during operation of the camera.

For optimal performance, do not load third-party applications other than those recommended or verified by Gatan.

4.2 Overview

When DM software is launched, you will see five primary areas on the screen

- 1 The Menu Bar at the top contains the File, Edit, Display, Process, Analysis, Window, Microscope, and Help menus. In these menus are all the controls for operating the application.
- 2 The main Workspace area in the middle. This is where images and text windows will be displayed. This area can be separated into multiple workspace tabs, which allow better grouping of data.
- 3 The Microscope System and the image Display panel are on the left side. The Microscope tab shows a diagram of the microscope and can be used to control the microscope system.
- 4 The Image Browser and Output panel on the bottom. The Image Browser window displays thumbnails of all images, which can be used to find and organize data. The Output window is used for displaying text.

- The Techniques Manager is on the right side. This panel will show the different techniques used to acquire and analyze data. The techniques shown will depend on the licenses purchased, so they will be different on different installations. To start acquiring data from a camera, select TEM Imaging.

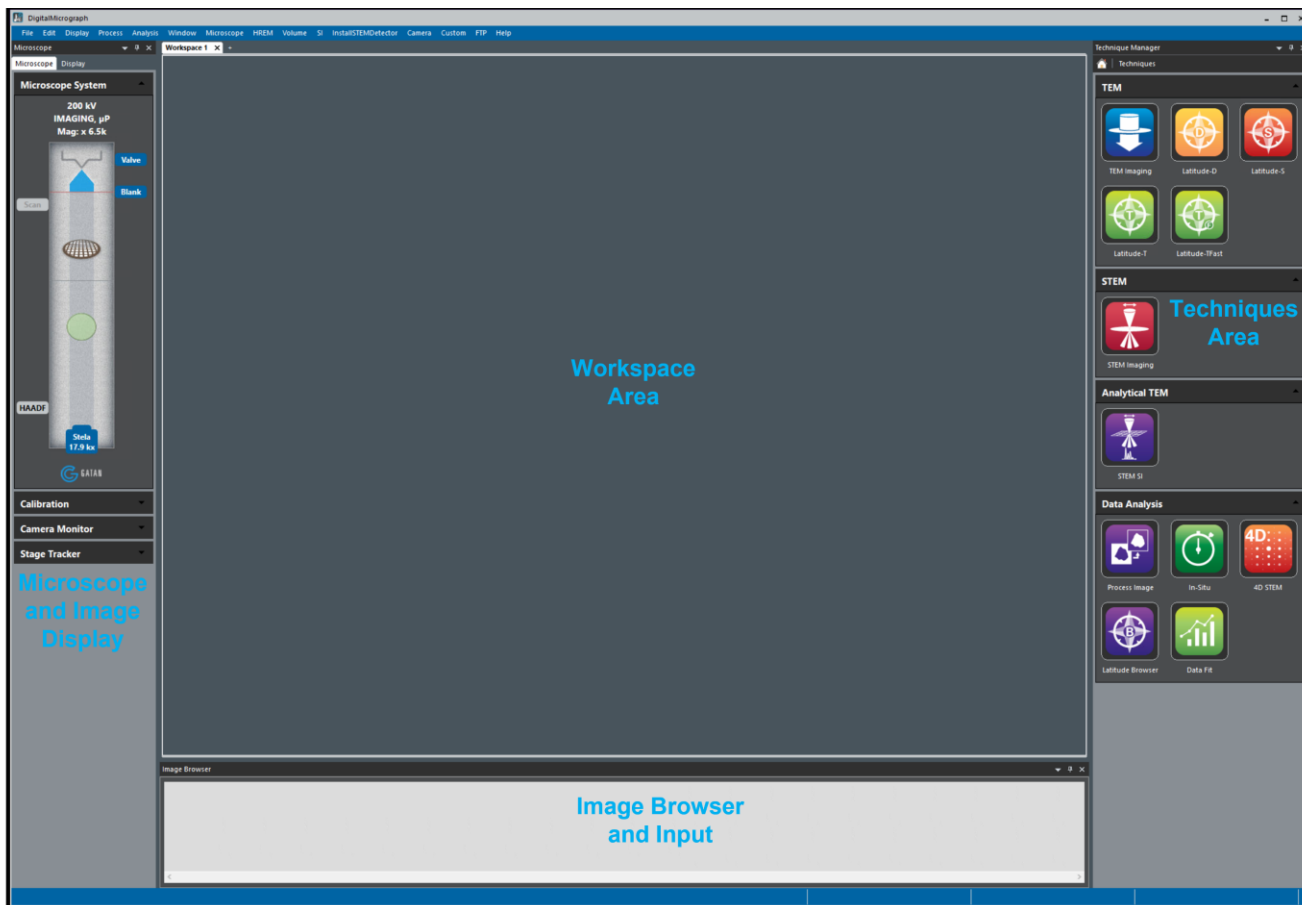


Figure 25: DM user interface.

To configure/choose your palettes, go to Window/Floating Windows. Then select the windows/palettes you would like to display. The checked items are shown in the DM software configuration.

Within the Workspace area, DM software presents all of its information through the use of windows. Each window contains a set of related information.

Image document windows

Image document windows contain a visible representation of a piece of paper. Images can be placed on this page. Other objects such as lines, boxes, and text can also be placed on this page. You can open, save, and print image document windows.

Many aspects of images and objects placed on pages can be controlled using palettes. Palettes are in the control panels (Display Panel and Techniques Panel), which are by default docked on the left and right side of the DM application window.

Text document windows

Text document windows contain text, but their main purpose within DM is to display DM or Python scripts. You can open, save, and print text document windows.

Plugins

DM software can be extended to support acquisition devices using plug-ins. Plug-ins are placed in a folder named PlugIns.

Scripts

DM software can also run simple programs (called scripts) which carry out automated tasks. See Section 6.4 for more information specific to the use of scripts with DigitalMicrograph.

Help

DM includes extensive documentation from the Help menu. Consult the Help files for more information on DM, scripting, and the hardware and analysis features for which licenses are installed.

4.2.1 User modes

DM provides three different user modes: Regular, Power User, and Service. Regular and Power User modes are intended for customer use, and Service mode is reserved for Gatan Service personnel.

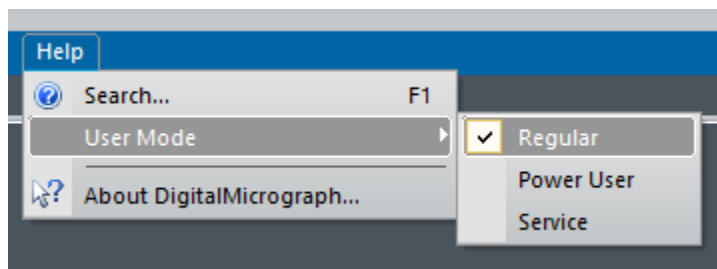


Figure 26: *User Mode selection is available from the DM Help menu.*

The main difference for the Stela between Regular and Power User modes is that the Camera drop-down menu is not available in Regular user mode but is available in Power User mode.

4.2.2 Context-aware tools

The most common commands for working with images are accessible from the image context menu by right-clicking on an image and/or the Workspace area.

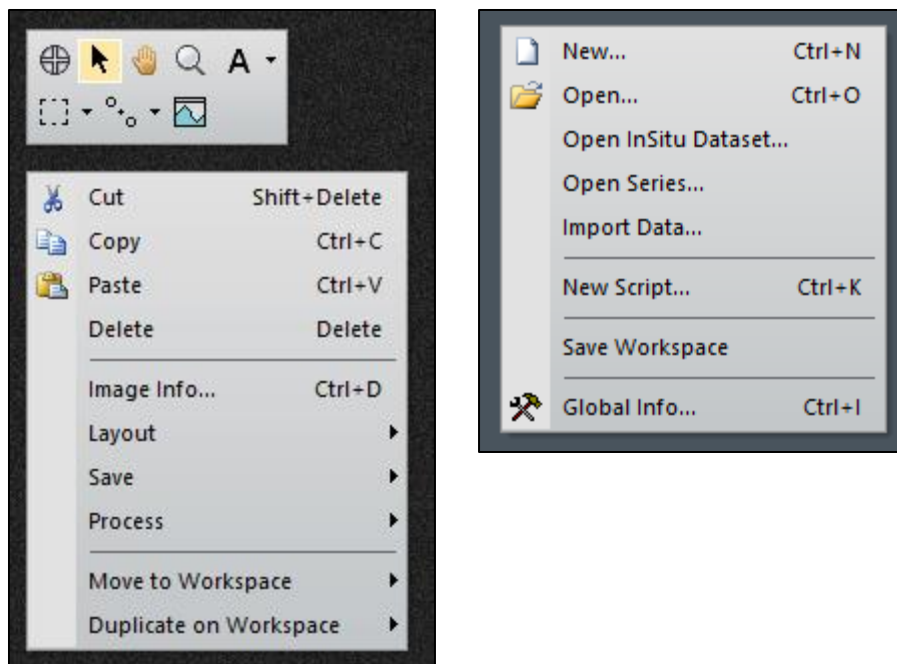


Figure 27: *Image context menus.*

4.3 Magnification correction/calibration

The displayed nominal magnification on most TEMs is for either the viewing screen or photographic film and has 5 – 10% accuracy. The Stela camera is located on a different plane (height-wise) than the film camera. Consequently, the magnification must be calibrated. The calibration is done using reference calibration samples.

At low magnifications:

- Use a cross grating sample or any sample with known spacing

At high magnifications:

- Use graphite or any crystalline samples with known lattice spacing
- Use the **Calibrate Image from Diffractogram** method

It is essential to make sure that the DM software correctly reads the TEM magnification. If the communication between the computer and the TEM is established, the magnification is read automatically. Otherwise, make sure DM is set to prompt the user to enter a value for TEM magnification every time an image is acquired. This can be set by choosing the **Global Microscope Info** window under the **Microscope** menu.

4.3.1 Low magnification

Record an image of a cross-grating replica.

Cross grating sample

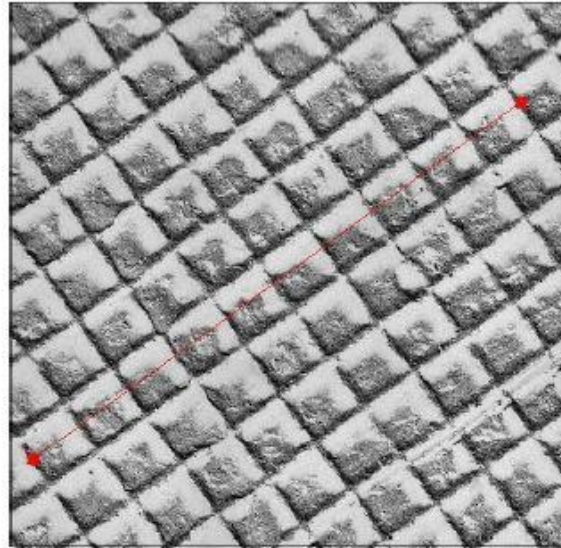


Figure 28: Example of marking a known distance during magnification calibration.

- 1 Choose **Microscope / Calibrate Image**. A red line appears on the image.
- 2 Position it on a feature of known size and follow the instructions on the screen:

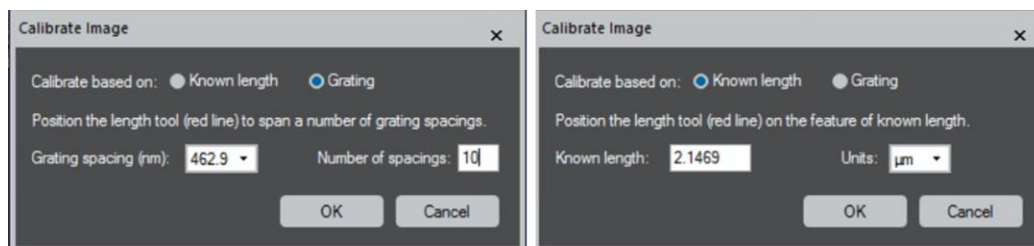


Figure 29: Follow the instructions on Calibrate Image window to complete the calibrations.

- 3 Press **OK** on the Calibrate Image window.

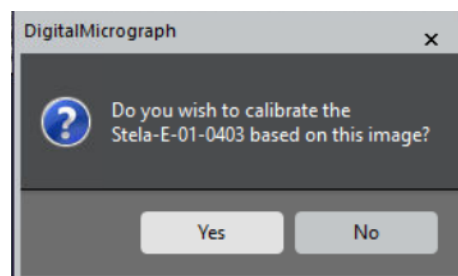


Figure 30: DM asks if you want to use this image calibration to calibrate the Stela camera.

- Click **Yes** to complete the calibration.

4.3.2 High-magnification calibration

Record a lattice image of the crystalline sample.

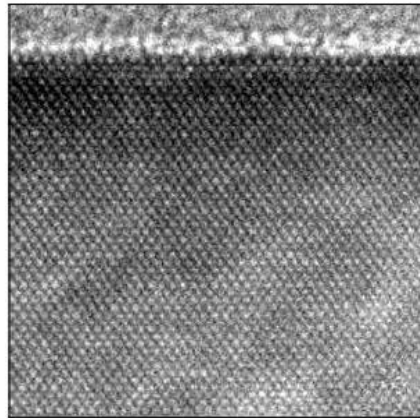


Figure 31: High-resolution image of sample to be used in the magnification calibration.

- Select **Microscope / Calibrate Image from Diffractogram**.
- To calculate the diffractogram, follow the on-screen instructions and click **OK** when done.

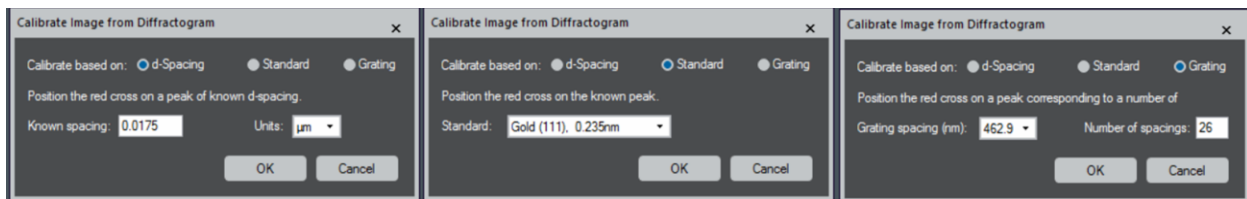


Figure 32: Calibrate Image from Diffractogram

The calibration can be checked on the calibration table containing pairs of values, the nominal microscope magnification, and the calibrated value. To view the magnification table (stored for the current imaging device and microscope operating condition), select **Microscope / Edit Calibrations**.

The microscope calibration dialog shows the table of magnification calibrations stored for the current imaging device and microscope operating condition.

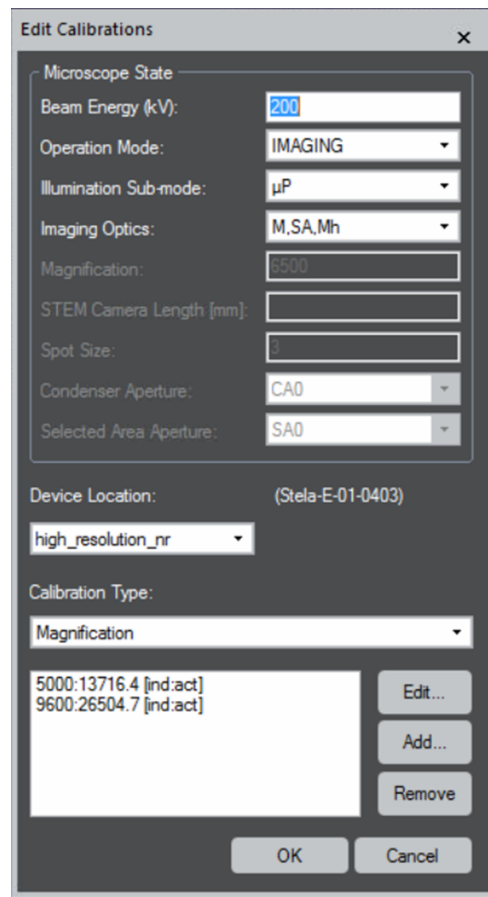


Figure 33: *Microscope / Edit Calibrations*

5 Advanced topics

5.1 STEMx

The STEMx[®] system offers 4D scanning transmission electron microscope (STEM) diffraction data collection through hardware synchronized beam control with Gatan's cameras (Stela, K3 IS, OneView[®] IS, and Rio[™] IS). There are many advantages to collecting 4D STEM data through DM software with the K3 IS camera, including:

- High-speed data acquisition for detail-rich mapping using direct hardware communication and synchronization
- Minimized artifacts associated with specimen damage and system drift - due to the high-speed, shorter duration of each experiment
- All camera functions are still available in addition to the 4D STEM data collection mode
- Simultaneously acquire multiple signals produced in the electron microscope as part of a spectrum image
- Easy to use interface: 4D datasets are collected, stored, and processed in a single application (e.g., DM software)

More information on STEMx can be found on the Gatan website.

5.2 Scripting

Commercial software is great for standard data acquisition and processing techniques, but there is a vast spectrum of techniques and applications which are not all supported equally. Researchers are also constantly developing new methods uniquely tailored to specific experimental designs and the questions they are seeking to answer. Scripting provides nearly infinite flexibility for data acquisition, processing, analysis, and visualization and can be rapidly prototyped and tweaked as needed, and DM software supports two integrated scripting environments.

DM scripting

- Scripting language native to DM
- Supports user-written routines from simple macros to large applications
- Custom syntax (C++ style, Object Oriented Programming)
- Recently added greatly improved editor, debugging, and documentation

See DM Help for more info about DM scripting.

Python

- Embedded within DM as an alternative scripting language
- Includes support for Python libraries, including:
- NumPy, SciPy, and Matplotlib
- Machine Learning and Deep Learning using TensorFlow, Scikit-Learn
- Spectral analysis with HyperSpy...

See DM Help for more info about Python Scripting within DM software.

For the K3 IS camera, scripting can be used to capture still frames. It can also start and stop *in-situ* acquisition using the acquisition parameters currently specified in the user interface. This can be useful for roughly synchronizing the acquisition of data with other actions in the Gatan software and with equipment not controlled directly by DM.

Below is a short example DM script for generating a 2-button userinterface to acquire an *in-situ* video dataset using a Gatan IS camera. Additional scripts and scripting resources can be found on Gatan's website.

```

//$BACKGROUND$
class ISAcquireDialog : UIFrame{
    TagGroup CreateDLGTagGroup( object self ){
        // Dialog building method
        TagGroup DLGtgs, DLGItems
        DLGtgs = DLGCreateDialog( "IS Acquire Dialog", DLGItems )
        TagGroup Button1 = DLGCreatePushButton( "Start", "Act1Meth" )
        TagGroup Button2 = DLGCreatePushButton( "Stop", "Act2Meth" )
        DLGItems.DLGAddElement( Button1 )
        DLGItems.DLGAddElement( Button2 )
        DLGtgs.DLGTableLayout( 2, 1, 0 )
        return DLGtgs
    }
    object LaunchAsModelessDialog( object self ){
        // Main call. Create and display the modeless Dialog
        self.init( self.CreateDLGTagGroup() )
        self.Display( "IS Acquire" )
    }
    // Methods invoked by buttons
    void Act1Meth( object self ){
        Result( "\nStart Recording.\n" )
        CM_InSitu_StartRecord()
    }
    void Act2Meth( object self ){
        Result( "Stop Recording.\n" )
        CM_InSitu_StopRecord()
    }
}
Alloc( ISAcquireDialog ).LaunchAsModelessDialog()

```

6 Troubleshooting

6.1 Software updates

The Stela computer is configured and tested with the DM software installed. Updates to DM are regularly made available to add features and to fix reported bugs. Check the Gatan software website for the latest patches and update the DM software and camera firmware as required.

6.2 Reporting bugs

Users can report bugs found in software by clicking the camera monitor settings button. This button is only visible in power user mode.

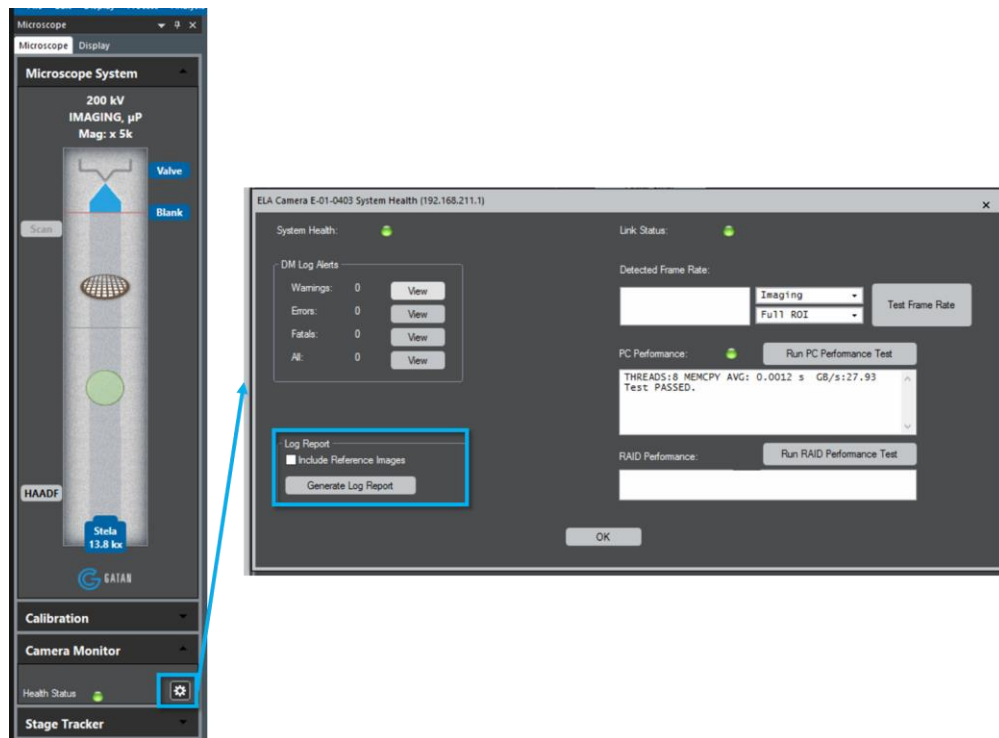


Figure 34: Software bug submission in Camera Monitor Settings.

- Submissions are reviewed weekly by the Gatan software team
- For critical issues that make the camera un-useable, contact the Gatan service team (www.gatan.com/contact)