TIA – An update on functionality in Tecnai 2.1.8/3.0

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1 Introduction

In TIA (TEM Imaging and Analysis) for Tecnai version 2.1.8/3.0 (Windows 2000 and Windows XP, respectively) very substantial changes have been made. This manual gives an overview of those areas in TIA that have been affected most. The main areas where major changes have been made are in the display of data, experiments and processing.

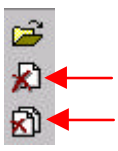
2 Display windows

Previous versions of TIA suffered from the fact that additional acquisitions often overwrote data acquired just before, which could cause loss of data. The new way of acquisition works as follows:

- In imaging (CCD or STEM), Search and Preview will acquire their images in dedicated Search and Preview display windows (multiple display windows are now shown as tabs at the bottom). CCD and STEM will have their own Search and Preview windows. These windows are automatically selected (brought to front) as needed. Search and Preview are re-used (so you will at most have four, CCD Search, CCD Preview, Scanning Search, Scanning Preview).
- In spectroscopy (EDX and EELS) the situation is similar except that here there is only a single mode View additional to Acquire.
- All acquisitions through Acquire will result in new display windows. The name of the display window reflects the time of acquisition plus the name of the technique involved (time is time of day, as e.g. in 15.42.50 CCD Acquire which is a CCD image acquired at 15 hours, 42 minutes and 50 seconds). Generally you cannot read much more than the time as the tabs are too short. The full name will be visible in TIA Analysis mode in the TIA title bar, or the windows listed at the bottom of the Windows menu. If you do not see the tabs in TIA Analysis mode, switch on Workbook mode in the Windows menu (the menu item should be checked). You can also see the contents of the Window menu in Analysis mode by clicking on the Window button  of the toolbar. The name will also be the default file name suggested for saving.
- To these rules there is one exception: Any acquisitions of other detectors (CCD, EDX, EELS) in STEM mode are always inserted into separate panes in themost recent STEM display window. The rationale here is that such data in STEM bear a relation to the STEM image itself, in that the data have been recorded at the beam position in the STEM image.

Hints:

- To **remove panes** in windows with multiple panes, right-click with the mouse on the pane and select Delete pane in the popup menu. The Delete pane item will no longer be present if there is only one pane left in the display window. You can then only delete the pane contents.
- To **delete all display windows**, click on the Close all button (third from the top) of the toolbar in TIA Acquisition mode. You will be asked to confirm this. To **delete the current display window**, click on the Close button (second from the top). Again you will be asked for confirmation.

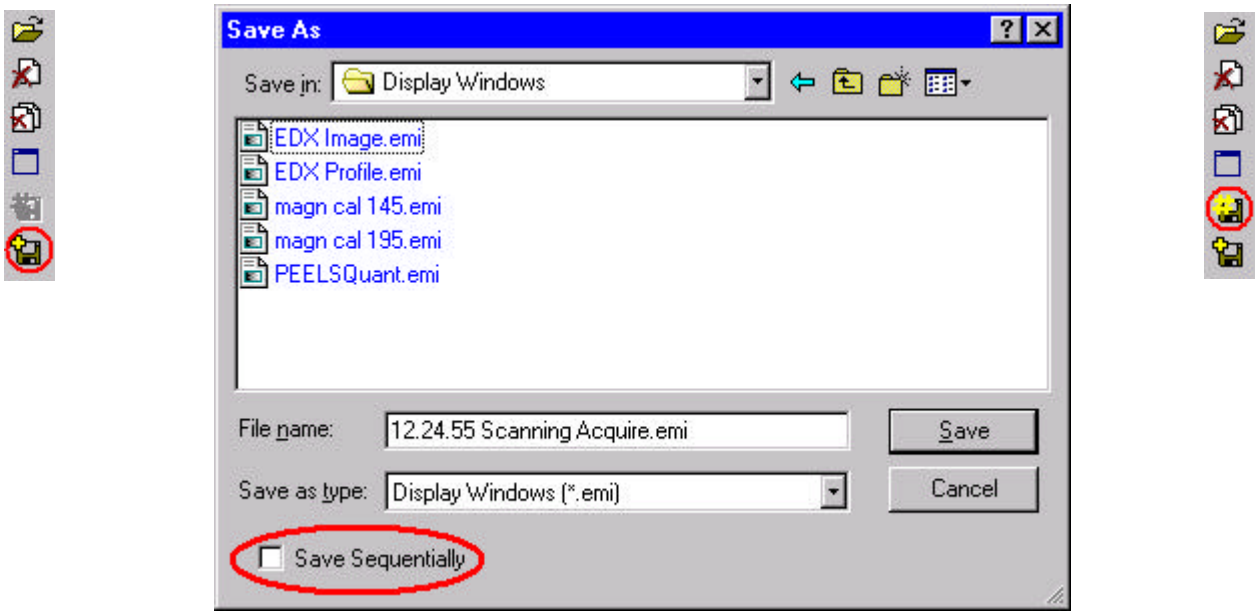


- To switch between TIA acquisition and analysis modes, you use the lay-out definition of the TEM user interface. At the bottom right 

there is a button that changes from  to 

  where the  indicates the acquisition mode and the  the analysis mode.
- There is an option in the application selection dialog (accessible throught the blue-square button to the left of the  or  buttons) to keep TIA in analysis mode if it is displayed on the second monitor.

- There is an easy saving feature called “Save sequentially”. This allows you to define a filename. All files can then be saved with increasing serial number by a single press on a toolbar button. To use Save sequentially, select the first display window to be saved and press the Save As button (circled in red in the left-hand picture below). In the Save As dialog (center picture), check the “Save Sequentially” checkbox and define your choice of filename. The Save Sequential toolbar button (circled in red in the right-hand picture below) will become enabled. Each time you press this button the currently selected display window will be saved under your choice of filename followed by an underscore and a serial number.



3 Experiments

There are two major changes in the way experiments are run.

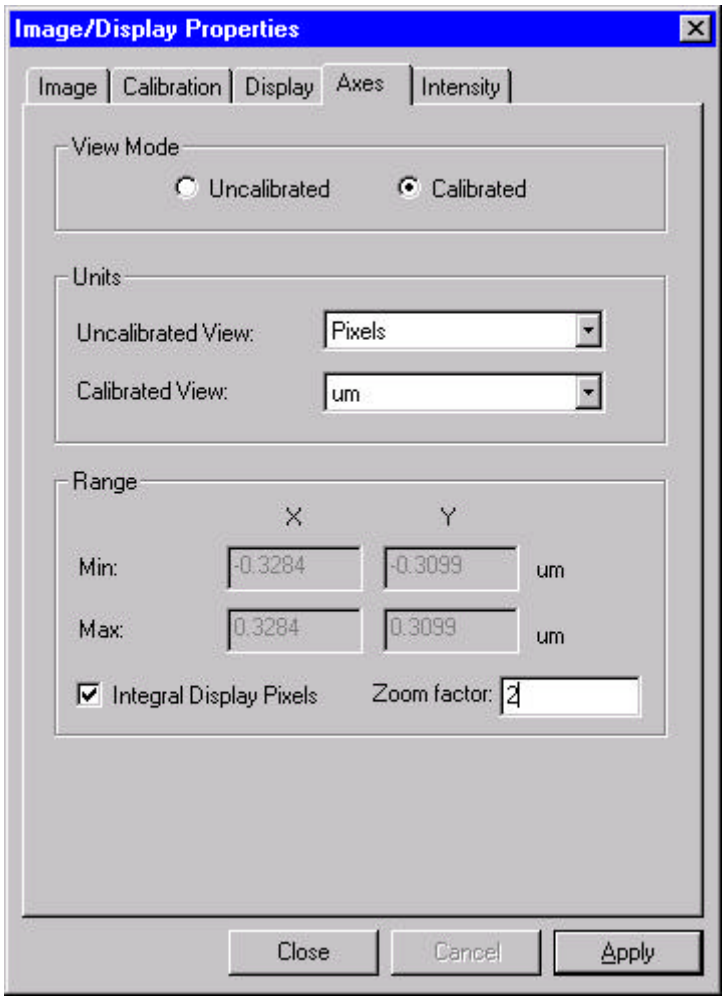
First of all, it is no longer necessary that you make sure all proper displays and markers are present before an experiment will work. Previously, if you wanted to do EDX mapping or profiling, you had to make sure there was an EDX spectrum display present in the window with the STEM image. You also had to make sure the image selection or line marker was present and selected. This is all no longer necessary. Simply make sure you have appropriate STEM image acquired and select the experiment. The relevant marker(s) will be inserted and selected, move the marker to where they should be, and start. The required displays will be added automatically.

The second change is that you cannot simply change settings to an experiment that has already been started. If you interrupt an experiment and move for example the image selection marker and then restart, the experiment will still use the previously defined position. You have to start a new experiment by acquiring a new STEM image and then select the particular experiment.

4 Image display

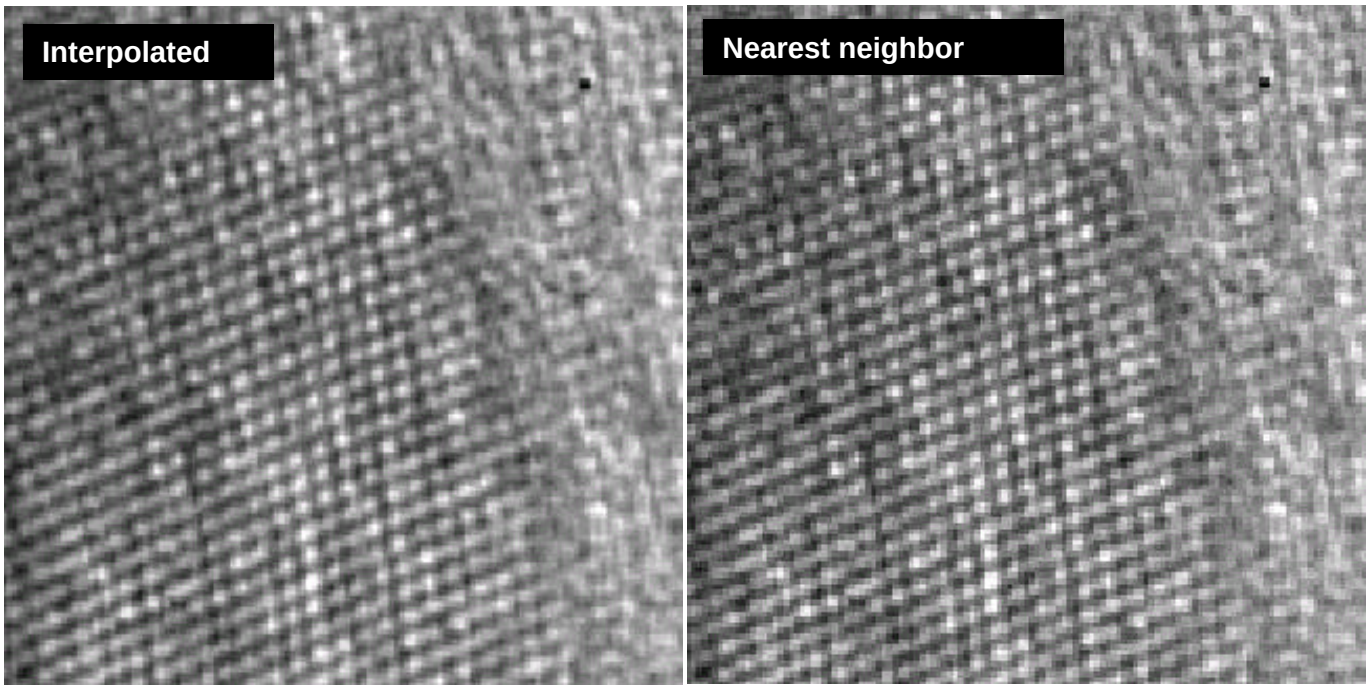
4.1 Zoom factor

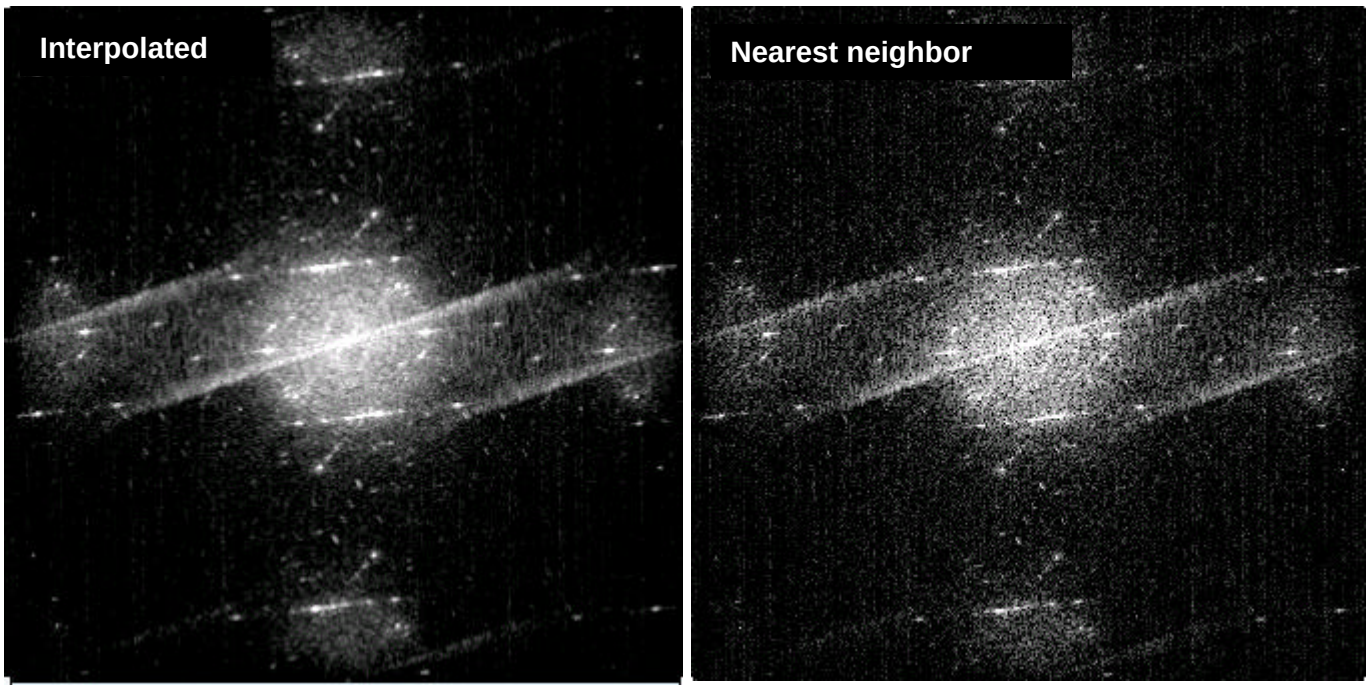
Generally TIA displays images (and other data) such that it uses the available space in the optimum way. That can mean that one screen pixel does not correspond to one individual image pixel (or a binned variant thereof, such as 2x2). You can fix the zoom factor by opening the Image/Display Properties dialog (double-click on the image or the background around it). Under Axes you can select Integral Display Pixels as well as a Zoom factor.



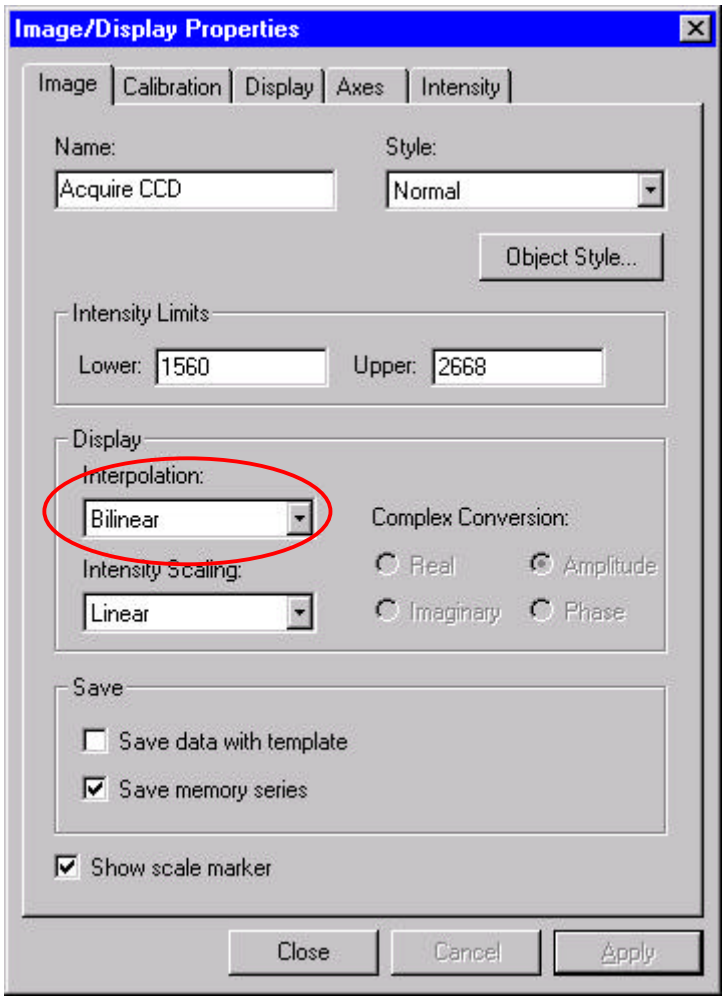
4.2 Bilinear / nearest neighbor display

TIA has two image display modes, bilinear and nearest neighbor. In the former all pixels contribute to the image display and results in a smoother, less noisy image. In the latter, only the image pixel closest to the screen pixel is used. The former is the default for acquired images. Especially on FFTs the difference can be substantial. Examples are shown below.





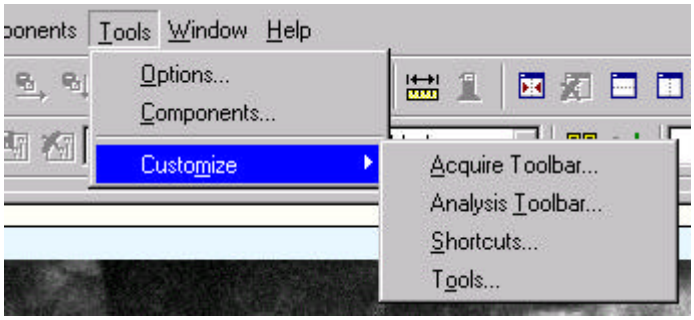
To change, open the Image/Display Properties dialog (double-click on the image or the background around it). Modify the interpolation setting.



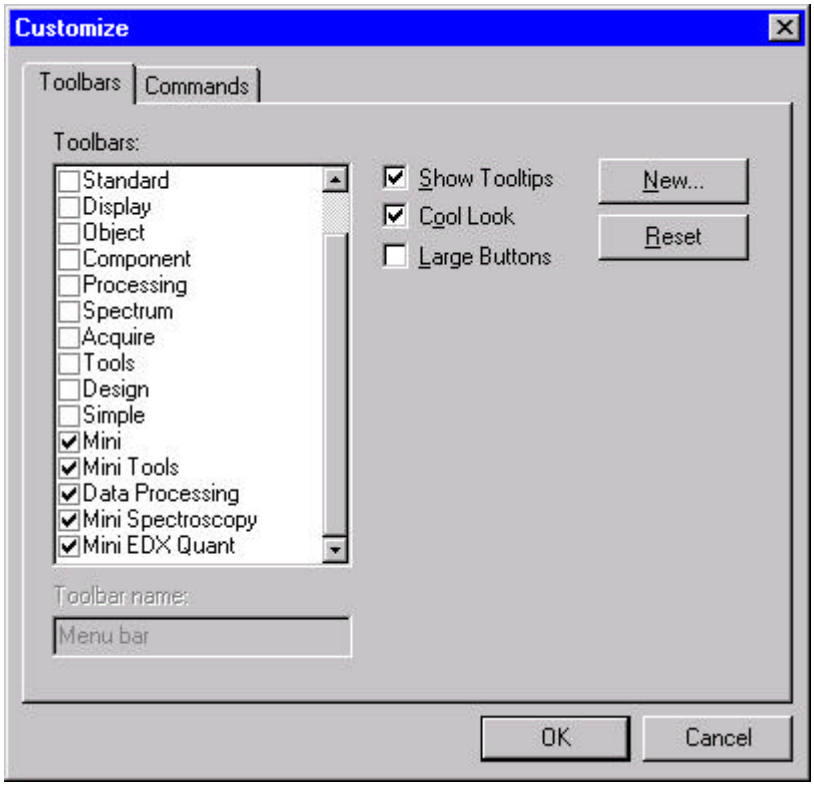
5 TIA user interface elements and customization

5.1 Toolbars

The basic TIA user interface can be customized. The UI editor can be found in the Tools / Customize menu (Analysis mode), and then users can select either to customize the tool bars and commands in analysis mode or in acquisition mode.



The dialog below shows the commonly set toolbar for the analysis mode (assuming an EDX detector is present).



Initially the toolbars will most likely look as shown on the extreme right.
You can customize this by grabbing a toolbar by the handle (the ribbons at the top) and dragging it underneath another toolbar.
If you need to re-arrange the toolbars and there is not enough room (the toolbar area is not wide enough), drag one toolbar to the right until you are just still inside the toolbar area, then release it. The toolbar area will become wider.

This is a more suitable lay-out.

Note: To keep the setting of the toolbars as defined after closing and re-opening TIA, switch to analysis mode and back to acquisition mode once. This forces TIA to store the setting.

5.2 Explanation of acquisition toolbars

5.2.1 Mini

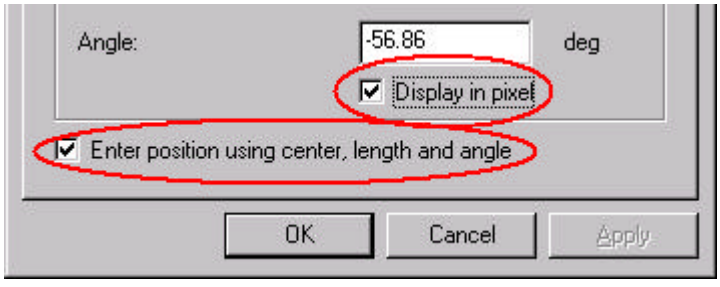
Open	Open an existing file
Close	Close the currently selected display
Close All	Close all display windows
Window	Gives the Window menu
Save Sequential	Save currently selected display window with next serial number
Save As	Save currently selected display window
Print	Print currently selected display window
Show/Hide Control Panels	Shows or hides the control panels, see section 6
Show/Hide Output Window	Shows or hides the Output window
Autoscale	Autoscale currently selected object (image, spectrum) vertically and horizontally
Lock Object	Lock object (fixes object position, cannot be changed until unlocked)
Components	Access to processing functions, see section 7

5.2.2 Mini Tools

Note: The selection of the tools other than the arrow tool is generally for a single action. If you want to use another tool repeatedly, press the Shift key while selecting the particular tool. To go back to using the arrow tool, press Shift and click on the arrow tool.

Arrow Tool	Default cursor to select objects
Move Tool	Click and drag to move an image around
Zoom Tool	Click on the image and zoom by a factor 2 (with Shift key = zoom out)
Specimen Center Tool	Use the click-center feature functionality
Image Position Marker Tool	Insertion of a position selection marker into an image
Beam Position Marker Tool	Insertion of a beam position into an image
Line Marker Tool	Insertion of a line into an image
Image Selection Tool	Insertion of a rectangle for selection of part of an image
Oval Marker Tool	Insertion of a circle or ellipse in images
Text Marker Tool	Allows you to insert text annotation

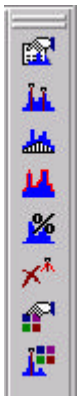
Note: you can edit the settings of markers in various ways by double-clicking on them or right-clicking with the mouse. Generally you can define starting and ending values, or center and size. Both you can do in real or in pixel units.



5.2.3 Data Processing

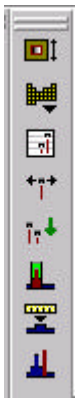
Image Selection	Copies part of an image, see section 7.1
Intensity Profile	Extracts intensity profile from an image, see section 7.2
FFT	Calculates FFT from 2- or 1-dimensional data, see section 7.4
Inverse FFT	Calculates inverse FFT from FFT, see section 7.5
Autocorrelate	Calculates auto-correlation of an image, see section 7.8
Flip Horizontally	Flips image horizontally, see section 7.11
Flip Vertically	Flips image vertically, see section 7.11
Rotate	Rotates image, see section 7.11
Add	Adds data or constant to data, see section 7.12
Subtract	Subtracts data or constant from data, see section 7.12
Multiply	Multiplies data with data or constant, see section 7.12
Divide	Divides data by data or constant, see section 7.12
Log	Makes log of data, see section 7.13
Correct Background	
Data Processing Setup	Leads to dialog with settings, see section 7.15

5.2.4 Mini Spectroscopy



EDX Quant Setup
EDX Peak ID
EDX Background Correction
EDX Peak Fit
EDX Quantify
EDX Clear Quant
Setup EDX Auto Map
EDX Generate Maps/Profiles

5.2.5 Mini EDX Quant

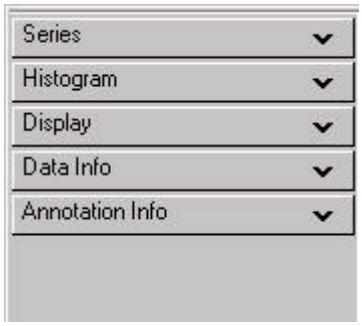


Vertical Autoscale
Periodic Table
KLM Setup
KLM Labels
Clear All
Energy Window Tool
Calibration Shift Tool
Marker Tool

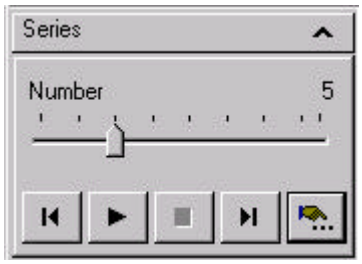
6 Control panels

TIA control panels are designed to browse through data series (Series panel), set the display image's dynamic range via the histogram (Histogram panel), set the display image's brightness and contrast (Display panel), display data information (Data info panel), and annotation information (Annotation info panel) on the selected annotation.
Five control panels are provided. The control panels occur in a bar that can be floating or fixed to the TIA window. If the panel is floating and you want it fixed, drag it by the top until it slots into place (left- or right-hand side of the TIA window).

The control panels can be flipped open or close (up/down) by the small arrow button at the right-hand top of each control panel title bar. Here all panels are closed.

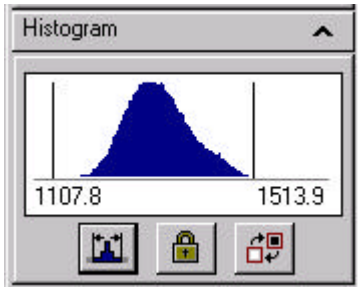


Note: To keep the position of the control panel bar as defined after closing and re-opening TIA, switch to analysis mode and back to acquisition mode once. This forces TIA to store the setting.

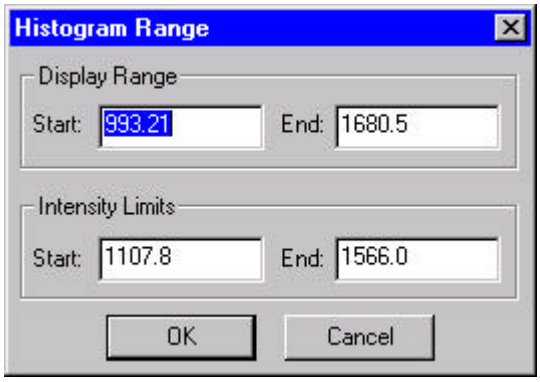


Data from a specific detector can be stored in series, with only one item visible at any time. This can apply for example to the EDX spectra from a line profile or map. To browse through the data, you use the "Series" Control Panel (sometimes you can also use linked markers, for example in line profiles or maps by dragging the marker).
Select the data containing the series by clicking on the data. The Number in the Series control panel will give the currently visible data. You can scroll through the data with the scroller. You also play the data as a "movie" by the buttons underneath (from left to right, back, play, stop, forward, play settings – the latter brings up a dialog in which you define how the movie will be played).

Note: If you want a series of images displayed with the same fixed intensity limits (see below), you have to lock the display range, otherwise scrolling through the series will revert to the automatic display range selection.



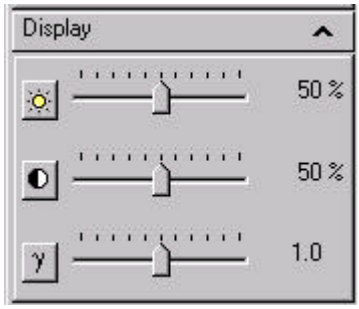
The histogram control panel contains various items that define how the image is displayed. The dark blue area shown is the histogram, the frequency distribution of the intensity levels in the image. The range of the horizontal axis is determined by the minimum and maximum intensity levels in the image. The values shown – which correspond to the vertical lines – are the intensity levels TIA uses for displaying the image – called the intensity limits.
You can change the intensity limits by dragging the vertical lines. You can change the horizontal axis scale as well as the intensity limits by double-clicking below the histogram itself (so on the "axis area"). This will bring up the following dialog.



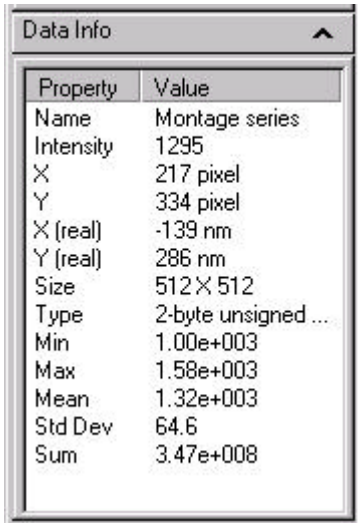
You can edit the individual values. The intensity limits can also be set by double-clicking on an image and changing the Intensity limits values. The Display Range controls the intensity range that is displayed on the histogram; the Intensity Limits control the display of the image.

The three buttons underneath the histogram have the following functionality:

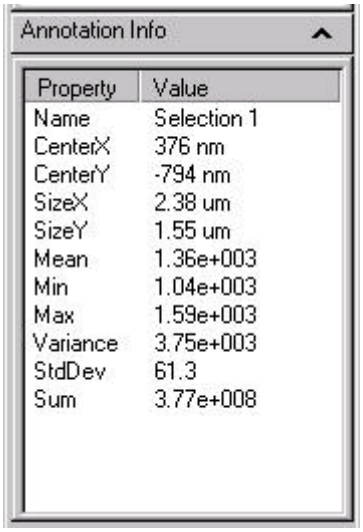
- Autoscale the intensity limits.
- Lock the intensity limits.
- Invert the image (goes to its negative).



The display control panel allows you change the way the image is displayed (brightness, contrast and gamma). You can reset the values by clicking on the relevant buttons. 



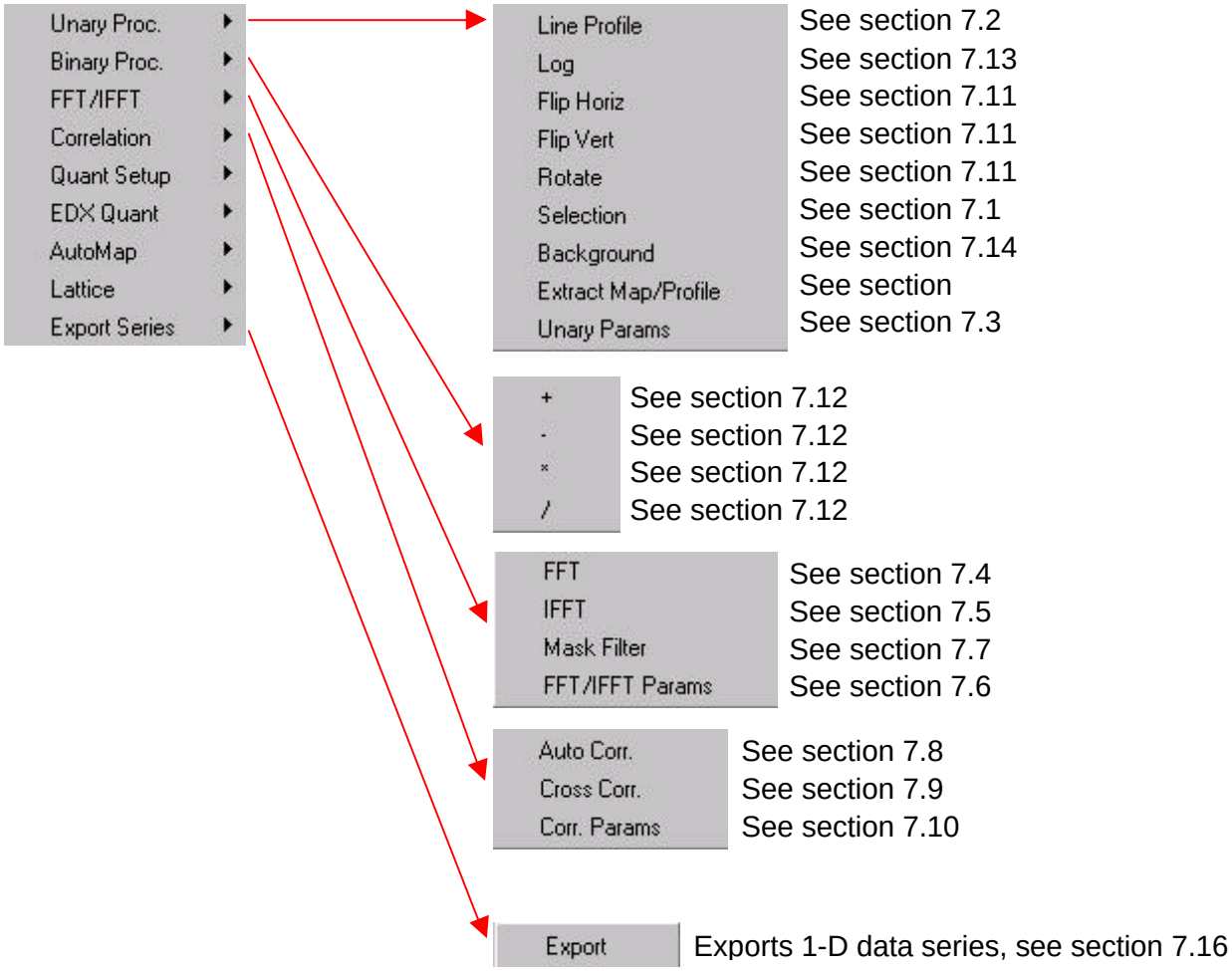
The data info control panel contains various information about the data that has been selected.
The Intensity, X and Y values will update as you move the cursor over the data. The remaining values apply to the data as a whole.



The annotation info contains information about the selected annotation. This can be any of the marker or text annotation. Any relevant information the annotation conveys is also shown. For example an image position marker will give the image intensity in addition to the X,Y position. An image selection marker (example shown to the left) will show information about the marker as well of the data (mean, minimum, maximum, etc).

7 Processing

The Components toolbar button gives access to the following menu structure (EDX Quantification items not covered). Some of these functions are also preset in the form of dedicated toolbar buttons.



Notes:

- All processing creates a processed copy of the original data.
- You can track what has been done to generate data by inspecting the data name. It will reflect the processing stages. For example IFFT(FFT(Acquire HAADF)) is the inverse FFT of the FFT of “Acquire HAADF”.
- During processing TIA will often generate temporary empty panes. This is necessary to keep an even and controlled pane distribution.

7.1 Image Selection

This processing tool provides a digital zoom ability to help users resolve image details from a high resolution image or to copy part of an image. To execute the function:

- Acquire an image.
- Place an image selection marker to mark the region of interest (ROI).
- Select Image Selection to create a digital-zoomed image.

Hint:

- Drag/move the marker will update the digital-zoomed image. If you do not want the image selection to update, right-click on the digital-zoomed image and uncheck Link processing; or make a copy of it into another pane.

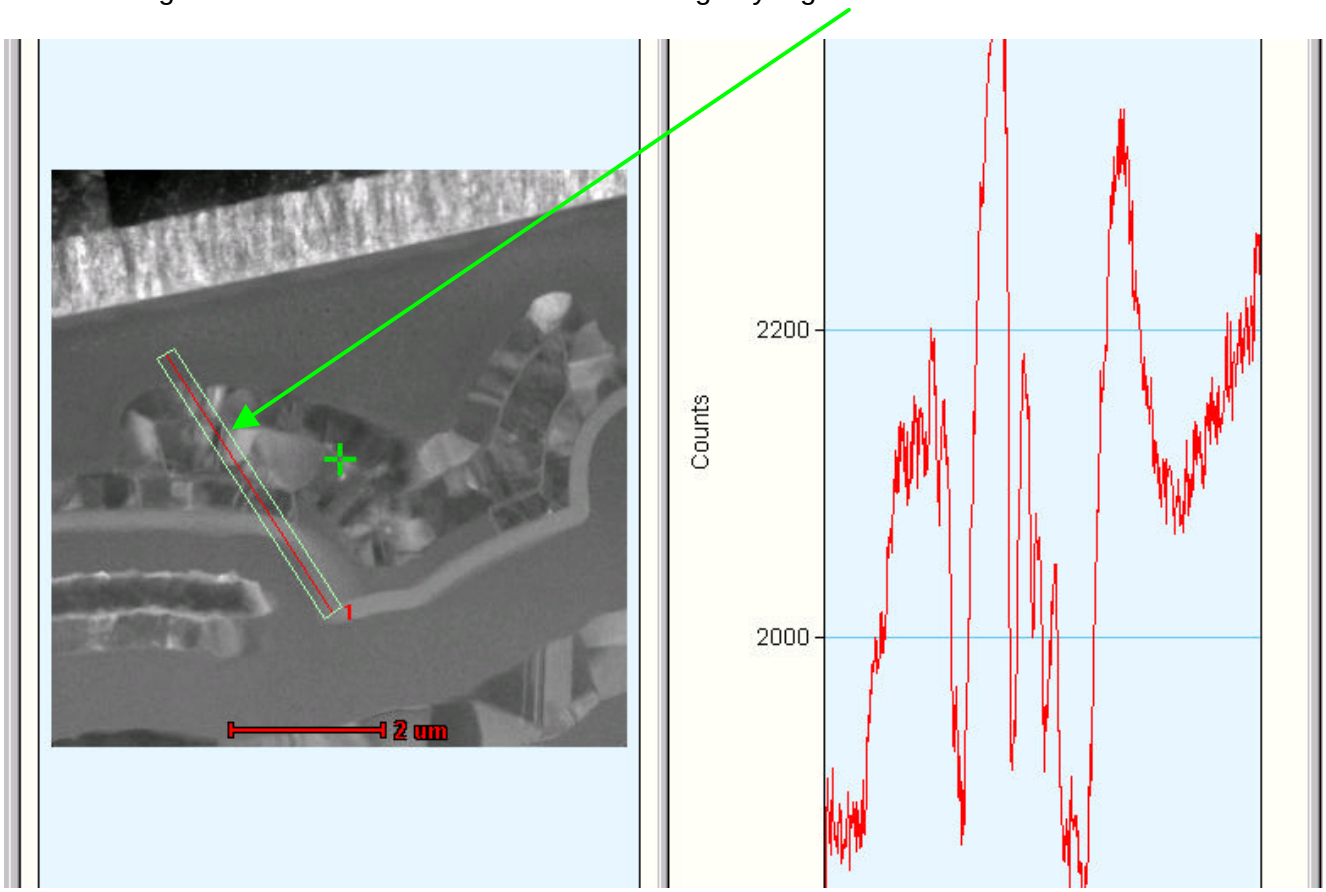
7.2 Intensity Profile

This processing tool provides a quick way of retrieving an image intensity profile from a selected area. To execute the function:

- Acquire an image.
- Place a line marker to mark the region of interest (ROI).
- Select Intensity Profile to retrieve the image intensity profile.

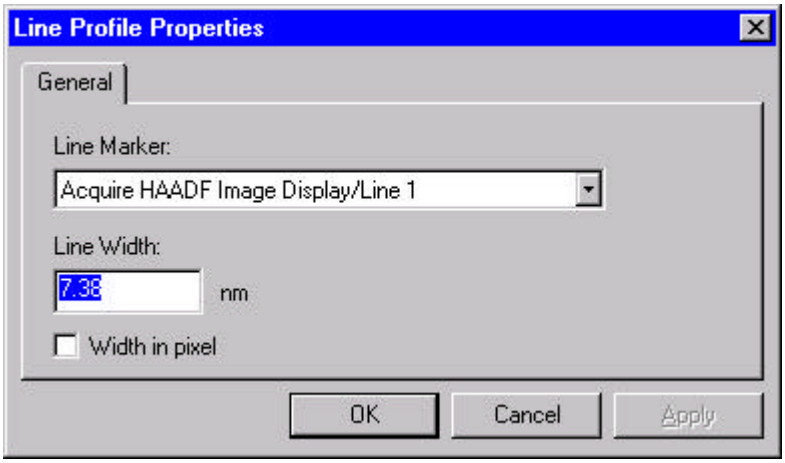
Hints:

- Drag/move the marker will update the intensity profile from the new ROI.
- The intensity profile can be average over the width perpendicular to the line marker.
- The integrated area is indicated in the source image by a green outline.



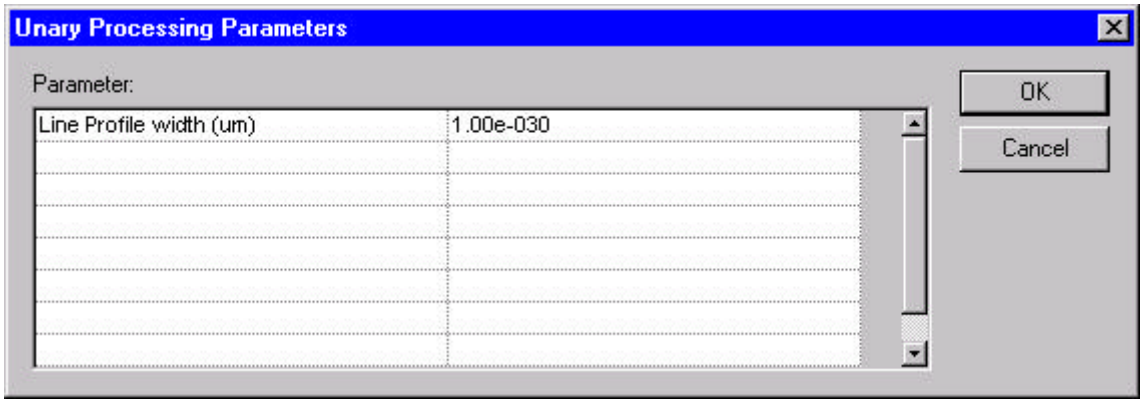
There are two ways to define the integration width of the profile:

- Right-click on the extracted profile and select Edit Line Profile… from the pop-up menu. The line width (in pixels or calibrated units) can be changed in the dialog.



- Define the width in micrometers in the unary parameter dialog (see below).

7.3 Unary parameters



The line profile width can be defined in real units in the unary parameters dialog.

7.4 FFT

This processing tool provides a way to analyze high resolution images or images with periodic features. A quick example shows how to measure d-spacings and angles from a high resolution image.

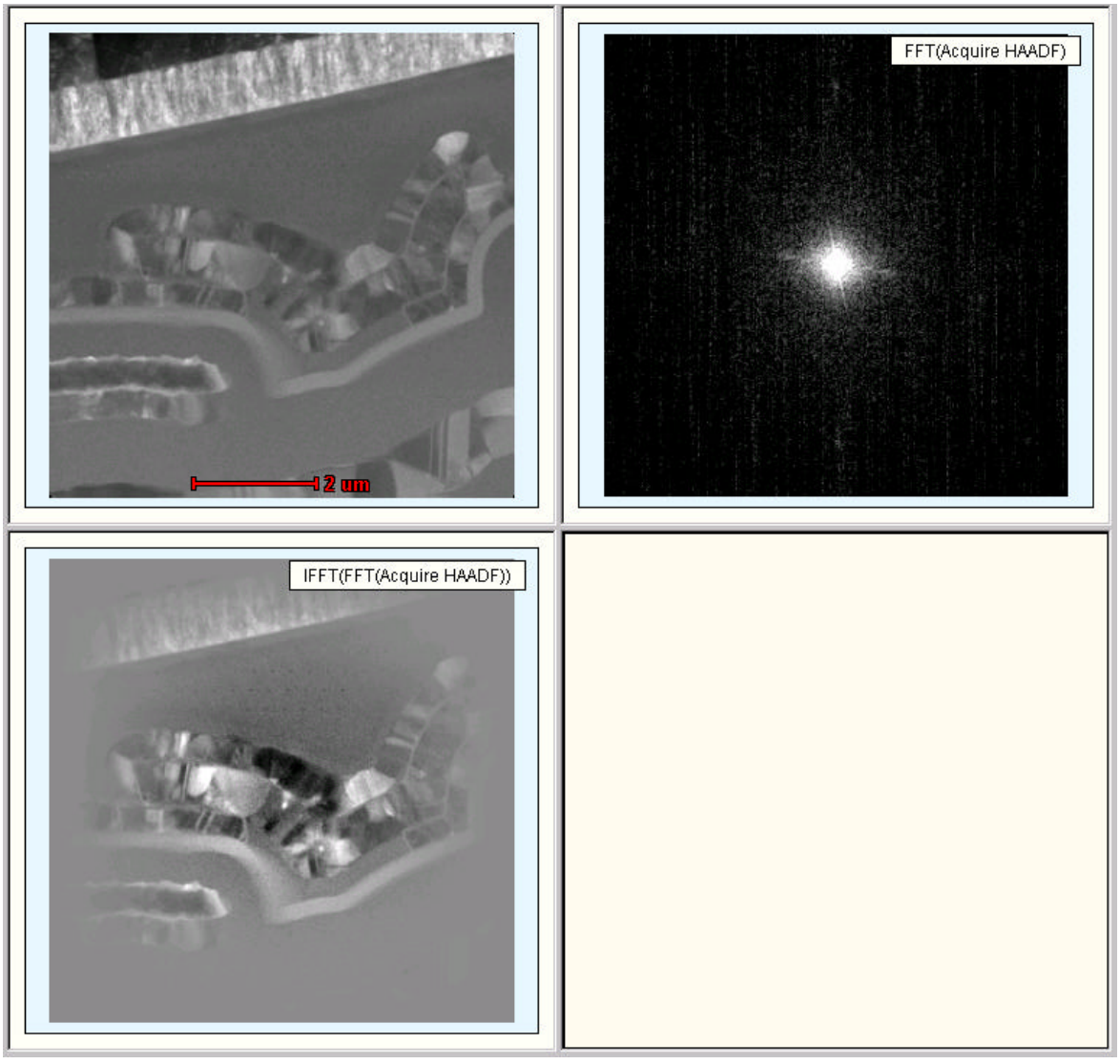
- Select a suitable image or select a sub-area of an image with the Image Selection marker.
- Select FFT on the tool bar to generate a Fourier transform of the image.
- Place an image position marker on one of the diffraction spots using the Image Position Marker Tool.
- Select Add Spacing function of the Lattice component to measure the d-spacing from the original HREM image. The measured result will be displayed in the output measurement window.
- You can measure angles between two diffraction spots using the Add Angle function of the Lattice component. Place and select two markers (using mouse selection while holding down the Shift key), then apply the processing.

Hints:

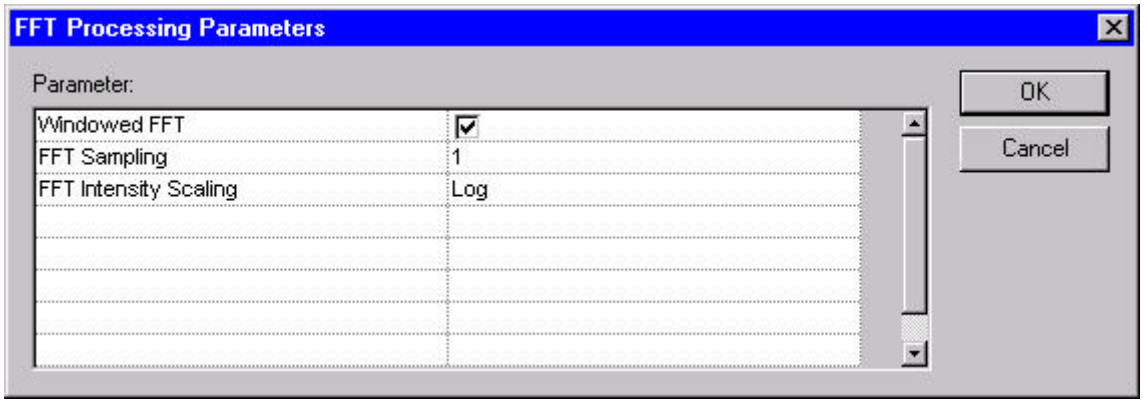
- It is not necessary that images or sub-area selections of images used for FFT are square or in power-of-two sizes. TIA automatically pads the data to power-of-two before creating the FFT.
- To reduce the computation time of calculating FFT/IFFTs on large images (for example, a 2048x2048 image), a digital-binning or reduced FFT can be used. Right-click on the FFT image and select Edit FFT… from the pop-up menu, and select a different Sampling Interval value. Alternatively use the FFT/IFFT parameters dialog.
- To caluclate the FFT from a sub-area of an image, place a suitably sized and position Image selection marker in the image, make sure it is selected (the white-square handles are visible) and do the FFT.
- To improve the FFT image quality, a filtered FFT image can be generated. In TIA, a Hanning window will be applied if this option had been selected from the Edit FFT… dialog. Alternatively use the FFT/IFFT parameters dialog.

7.5 Inverse FFT

The inverse FFT inverts a Fourier transform. As input it requires a reciprocal-space image. Generally the IFFT of the FFT of an image will reproduce the image. But the effect of various parameters can be seen by an IFFT of an FFT. In the example below you can see the effect of the Hanning window used for creating the FFT: the images edges are softened.



7.6 FFT / IFFT Parameters



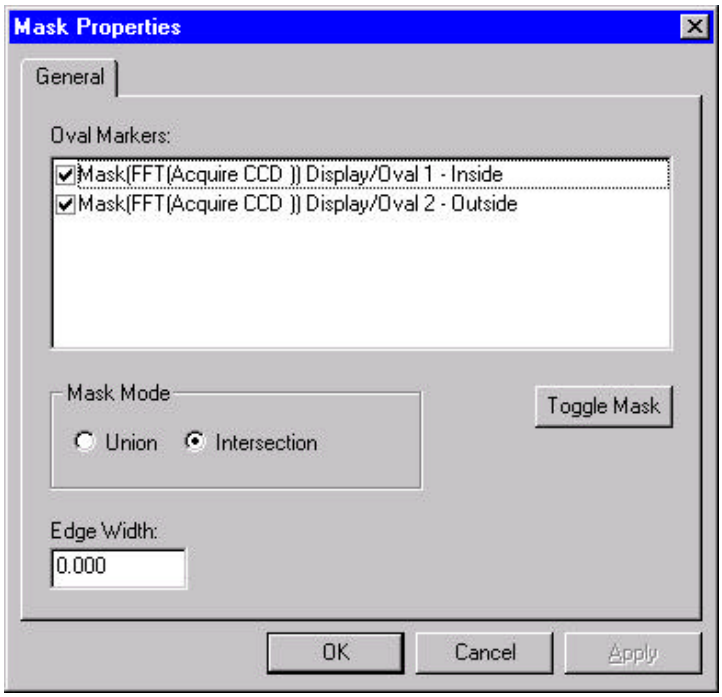
The FFT Processing Parameters dialog provides access to the Windowed FFT option (generally this should be on, otherwise the hard edges of the image may give artefacts in the FFT), the FFT sampling (a bit similar to binning; a sampling interval of 2, 4, 8, etc results in an FFT sampling fewer pixels) and the intensity scaling of the FFT (generally log units gives the best results because of the large dynamic range in FFTs).
By default, the right half of the histogram of FFTs is displayed. This suppresses the noisy background of the FFT. If needed this can be adjusted by changing the FFT display style:

- Double-click on the FFT to open the Image/Display properties dialog.
- On the Image tab press Object Style…
- In the Autoscale Mode select Entire Histogram.
- To activate the new setting, autoscale the Intensity Limits on the histogram control panel (see section 6).

7.7 Mask / filter

This process tool provides a way to improve the image signal/noise ratio by filtering out the image noise in reciprocal space. This is a very useful procedure on any given HREM image or images containing periodic structures. A circular band filter will be used as an example in this instruction.

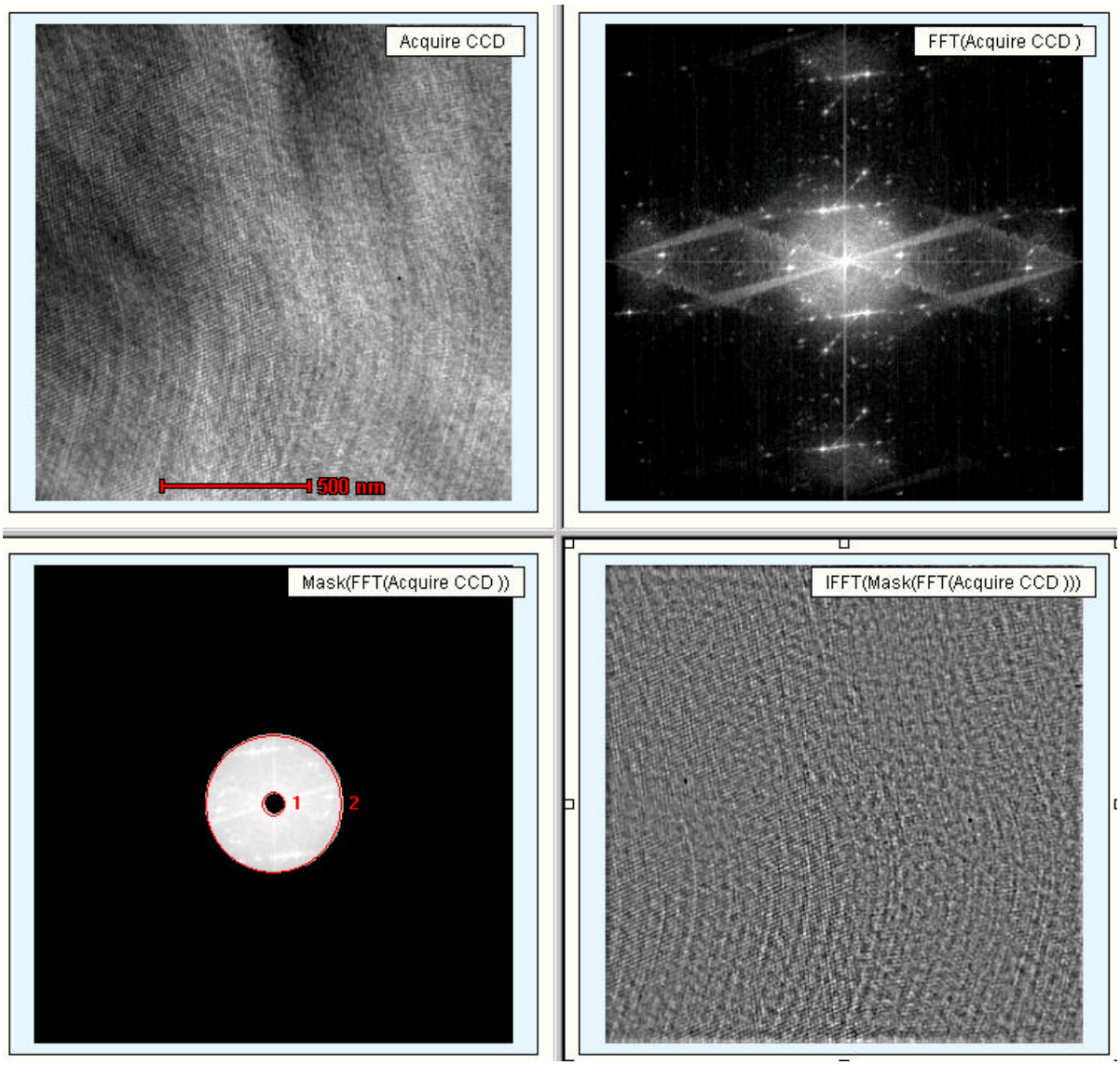
- Open or acquire a HREM image.
- Create the diffractogram (FFT).
- Apply Mask Filter processing on the FFT. A copy of the FFT will be generated.
- Place two circular markers on the FFT image using the Oval Marker Tool to mark the ROI (inner and outer boundaries) used for filtering. Use the marker properties dialogs to center the markers and make them circular (Center values to 0, Size values equal).
- Right-click on the FFT image marked as Mask and select Edit Mask… from the pop-up menu, a Mask Properties dialog is displayed. Use it to control the mask filtering process.
- Select/enable both markers to use for the filtering process.
- Single click on the first marker text to select it. If it is the smaller of the two, click Toggle



Mask to toggle its masking area from inside changed to outside. Otherwise do this for the second marker.

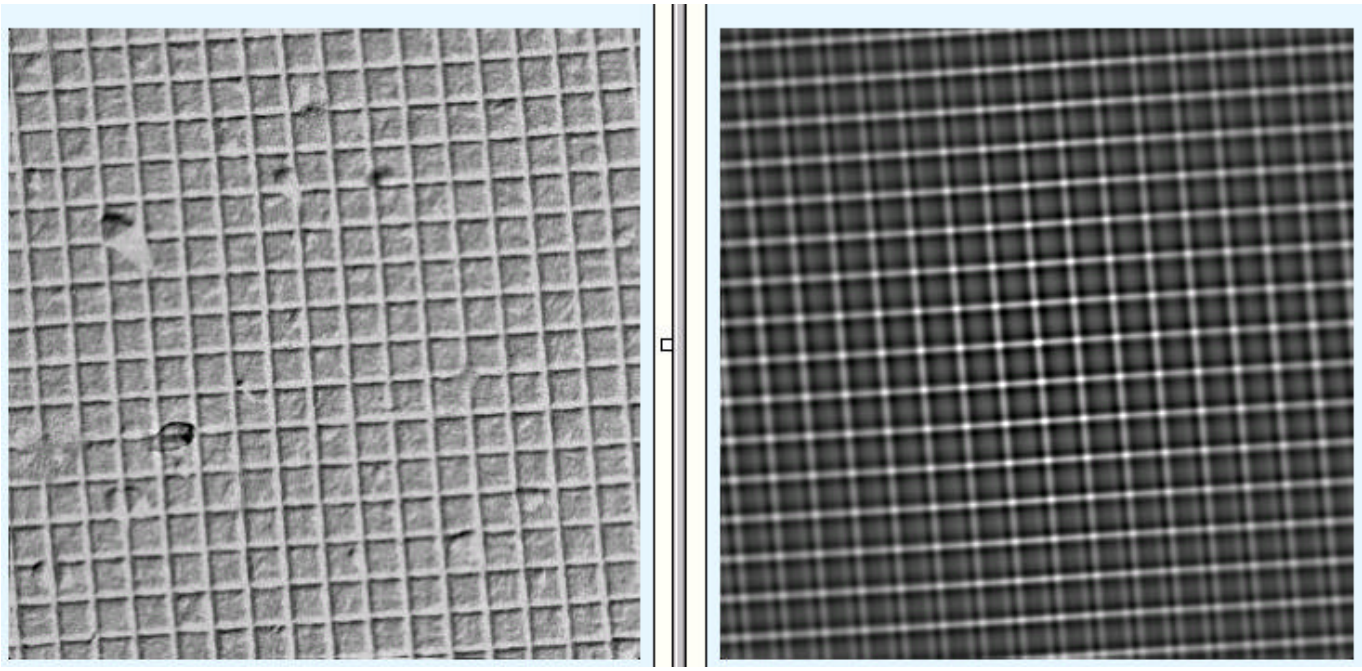
- Change the Mask Mode from Union to Intersection.
- Click OK to apply the changes (you can click on Apply with the dialog open to see what happens).
- Select filtered FFT image and apply the “IFFT ” process tool to generate the filtered real space image which has better signal to noise ratio compared with the original image.

Hint: You can change the mask markers and the mask as well and the IFFT will be updated automatically.



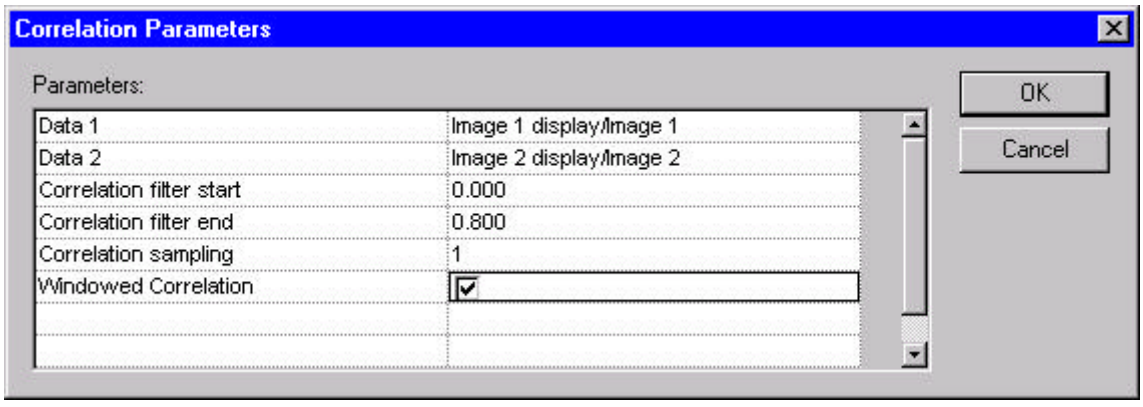
7.8 Autocorrelate

This process tool calculates the autocorrelation function of the image. In essence the autocorrelation shows how an image is similar to itself. If the image has repeating features as in the cross-grating (left) shown below, you see the repeat pattern in the autocorrelation (right). Otherwise it can be used for example as a (rough) measure of the resolution of a CCD camera. If each pixel is totally independent of its neighbors, the autocorrelation of a noise image will be a spike. In practice there is a broader peak which reflects the fact that the CCD is only imperfectly able to resolve each incoming electron.



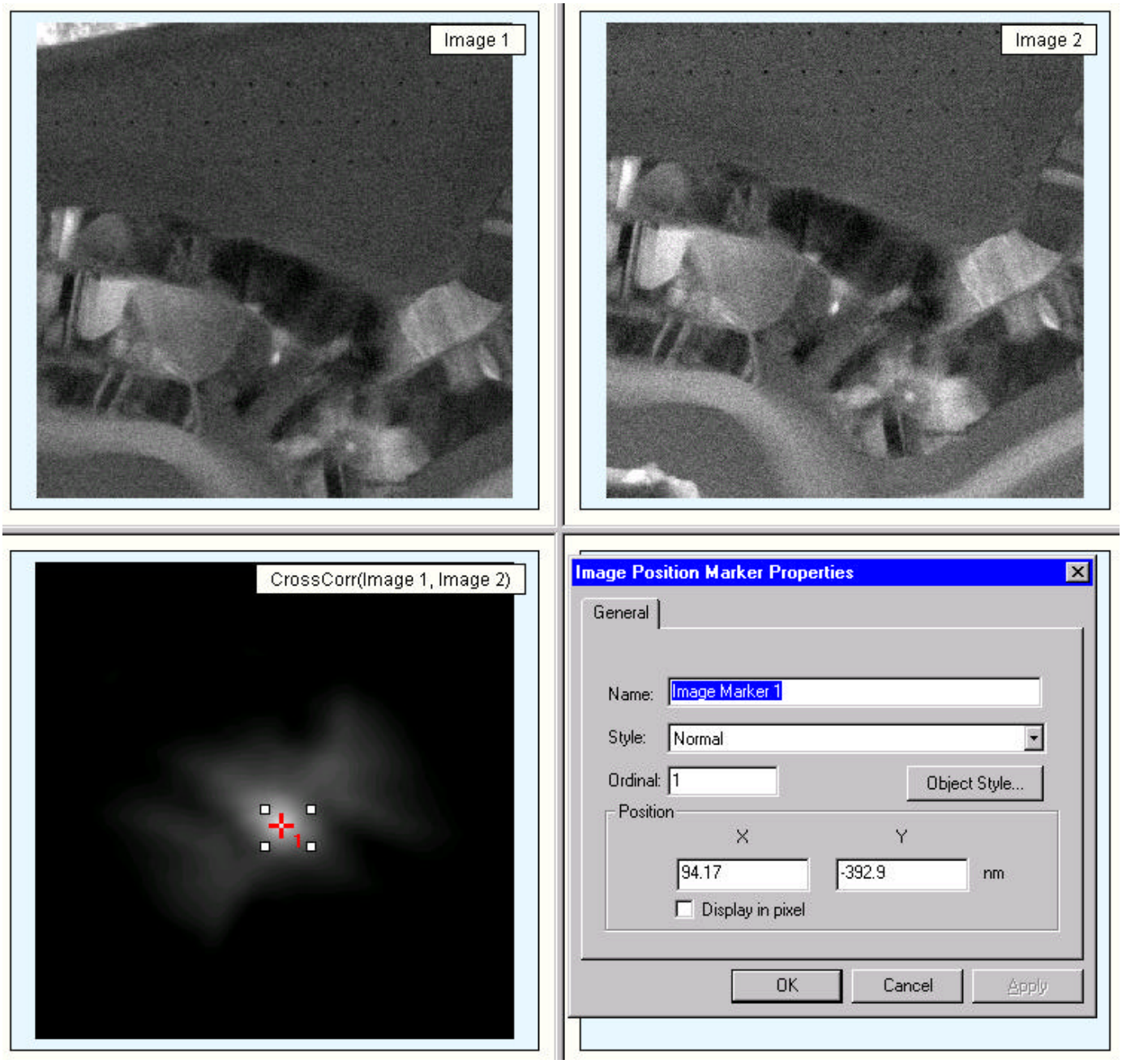
7.9 Cross-correlate

The cross-correlation requires two images in a single document. The cross-correlation is useful to determine shifts between images. When you use cross-correlate, the following dialog is displayed.

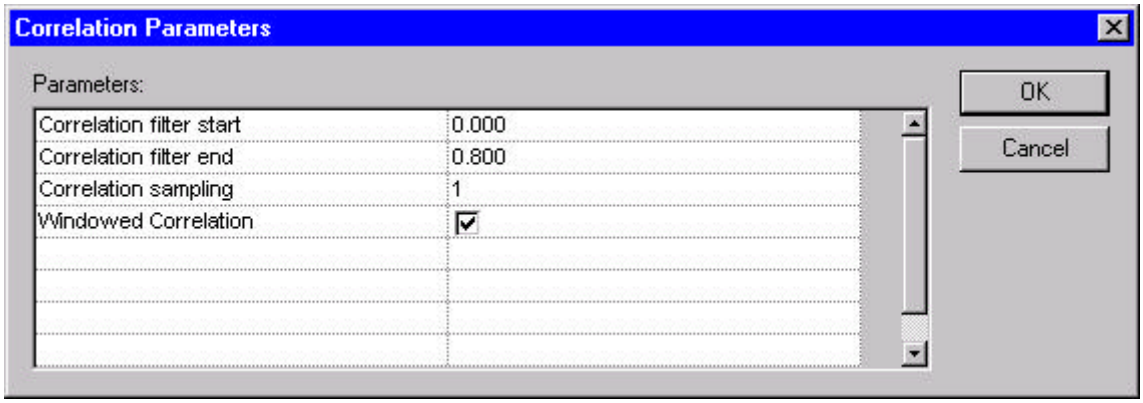


Select the two images required under Data 1 and Data 2.

The marker in the cross-correlation shown below has been placed at the maximum. The marker position demonstrates a shift of 94, -329 nanometers.



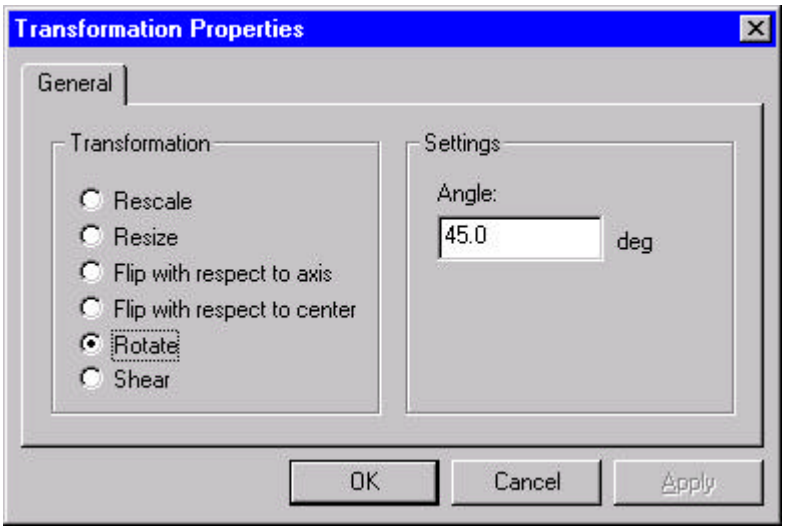
7.10 Correlation parameters



You can select filter parameters for the correlation. Be very careful with the filter start value, because an improper selection can cause severe ringing in the correlations. The sampling and windowing are as for FFTs.

7.11 Image transformations

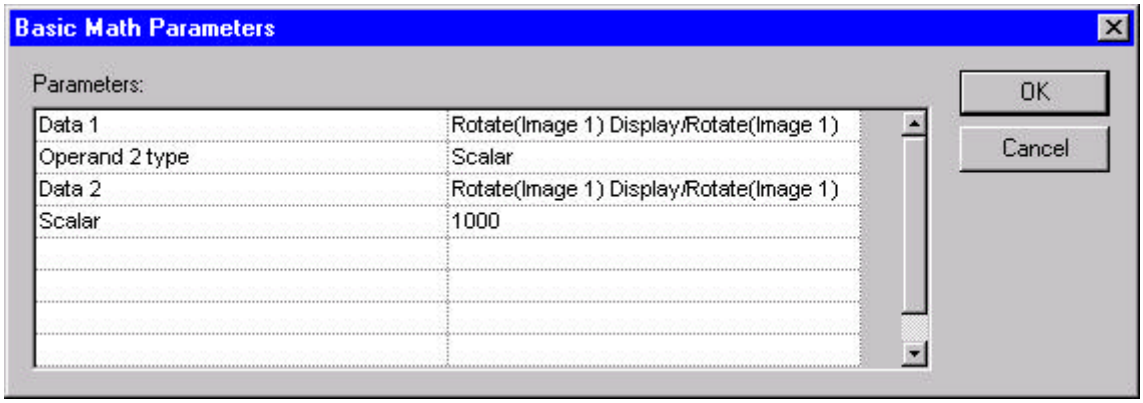
This processing tool provides a quick way to align the image to a certain orientation via flipping or rotation. Flipping provides a quick way to flip image vertically or horizontally, and rotation can rotate images at any given angle.
Acquire an Image, select Flip Horizontally, Flip Vertically, or Rotate to process the image. To change the rotation parameters, right-click on the result image and select Edit transformation. There you will find a number of additional transformations such as rescale, resize and shear.



7.12 Simple math

This processing tool provides a quick way to add, subtract, multiply and divide either a (scalar) constant or data with an image. For processing two images mathematically, both images have to be in the same document. Here, a simple adding process will be used as an example.

- Open a file (or emi document) containing two images
- Select Add and the Basic Math Parameters dialog will be opened.



- To add two images, select image name 1 for the Data 1 drop-down list and image name 2 for the Data 2 list. Use Data as the Operand 2 Type to process the image.
- A processed image will be created.

Note: When image data are used, make sure that the images have the same calibrations (which means they have been recorded at the same magnification). If the calibrations are not the same, TIA will adjust one of the images to make it match the other, which can lead to a lot of memory being required. To make calibrations equal, double-click on one of the images, inspect the calibrations. And copy those over to the other image.

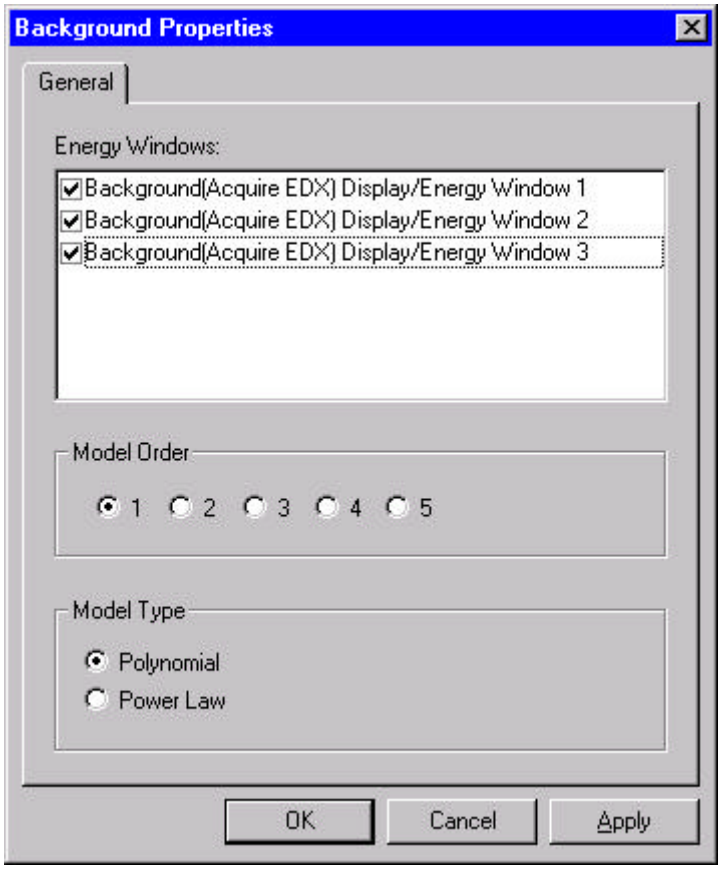
7.13 Log

This processing tool provides the log (natural log, not base 10) of the image.

7.14 Correct Background

This tool allows the user to perform a background correction on an EDX or EELS spectrum using one or more user-defined energy windows. Follow these steps to correct background on a spectrum:

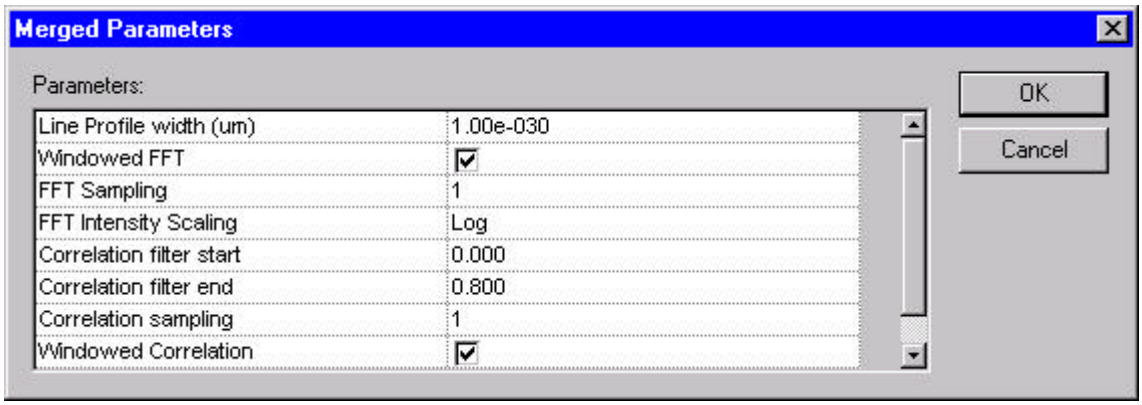
- Acquire a spectrum or open a file containing a spectrum.
- Click on the spectrum to select it and press the Correct Background button in the Data Processing toolbar.
- A new display will be added to the Display Window containing the spectrum with the option to perform background correction.
- Use the Energy Window tool to create one or more energy windows over an appropriate background region(s) of the spectrum.
- Right-click over the new spectrum and select Edit Background…. The Background Properties dialog will be shown:



- Check the checkbox next to the desired energy window(s) in the list to be used for correction.
- Choose the Model Order and Model Type, then Press “OK” to apply the correction.

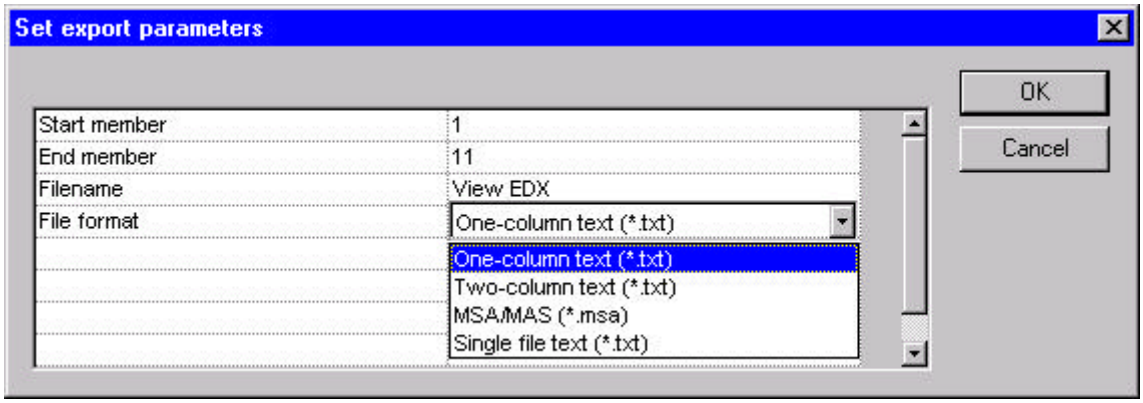
7.15 Data Processing Setup

Data processing setup produces a dialog with all processing parameters (Unary, see section 7.3; FFT, see section 7.6; and Correlate, see section 7.10).



7.16 Export data series

Export data series exports 1-D series data (spectra) into various kinds of formats. Select the visible spectrum from a data series and select Export series / Export. The following dialog will become visible:



Start and end member define the start and end data from the series that will be exported. You can specify a filename and a file format. The data will be exported to the folder Exported Data as defined for the current user in the TIA Administrator.