# MSA plugin for Gatan DigitalMicrograph Help

Version 1.6

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## **Quick Reference Guide**

- Welcome to MSA
- Import functions
- Utilities
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- Release notes

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### Welcome to MSA

Welcome to MSA, the multivariate statistical analysis (MSA) plugin package for Gatan DigitalMicrograph.

The current package version is **1.6**, which consists of following functions:

- <u>Import</u>
  - EMSA spectrum series import
  - XED-SI data import
  - EFTEM image series import
- <u>Utilities</u>
  - Bin SI
  - Spatial sub SI
  - Spectral sub SI
- <u>MSA</u>
  - Weighted-PCA
- Release notes

These plugins should work in GMS version 1.7.1 or higher.

Information of the package version and available functions can be seen by selecting MSA>About MSA

About MSA	
I FHICH	MSA: MSA plugin for Gatan Digital Micrograph
O LEINON AREM	Copyright: (2007-2014)
Microscopy Read in.	Masashi Watanabe / Lehigh University
School 7.7	HREM Research / www.hremresearch.com
_ Details	
Version: 1.6	
Available plug-ins:	
* Import - EMSA spectrum serie: - XED-SI data import: in - EFTEM series import:	s import: import a series of EMSA spectra nport an X-ray SI data file import a series of EFTEM images
* Utilities - Bin SI: apply spatial/s - Spatial-sub SI: extract - Spectral-sub SI: extract	pectral binning on SI spatially partial SI data ct spectrally partial SI data
* MSA - Weighted-PCA: apply	weighted principal componenet analysis to SI

The detailed description of each function can be also found by clicking the above link.

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### **Import Functions**

Three import functions are available in this plugin package. These functions import a series of spectra/images and s spectrum image obtained from different software or acquisition systems, and convert them as a single spectrum image in the dm3 format. Currently available functions are as follows:

- EMSA spectrum series import
- XED-SI data import
- EFTEM image series import



### **MSA>Import>EMSA spectrum file series**

### Current Function Version: 1.1 (Sep./18/'11)

### **Brief Description**

This function imports a series of EMSA formatted X-ray spectra (i.e. a line profile) into Gatan DigitalMicrograph as a 2D spectrum image..

### <u>Usage</u>

Select **MSA>Import>EMSA spectrum file series** from the menu bar. Then, a dialog appears.

then click the OK button.	files are sto	ired and input para	meters,
Select folder			
File parameters			
Root filename		Extension	
File numbers			-
Step scale 1.0	Ste	p unit nm	

First, you should select a folder, where a series of EMSA formatted X-ray spectra is saved, by clicking the Select folder button.

Second, input the rootfile name and extension name into the fields. Note that the EMSA formatted files must be named as

### foojjj.ext

where **foo** is the rootfile name, **jjj** is an index number of the series and **ext** is the extension name. For example, **Linescan4.emsa** or **Spectrum10.txt**. If there is a space between the rootfile name and an index number (e.g. default output name from Oxford INCA system), add a spece after the root name in the Root filename box.

Third, input list of index numbers in the file numbers field, e.g. case 1: 1-100 (if you want to import 100 spectra (#1 - #100) continuously) or case 2: 1-8, 10, 12, 14, 15-48, 51-78, 80 (if you want to skip spectrum #9, #11, #13, #49, #50 and #79). You can set the range of spectra to be imported just as setting of page range in the general print dialog.

Then, input the Step scale nad Step Unit in the fields. For example, input 5.0 and nm into the fields respectively if you measured the line profile with 5 nm

step.

Finally, click the Import button.

Here is an example of the dialog just before clicking the Import button. Example for case 1:

then click th	e OK button.	es are stored ar	nd input parai	meters,
Select folder	C:¥data¥NewZe	ta¥SRM-data¥	Sep-07-2007	¥series1¥
File parameters			1010	
Root filename	Spectrum		Extension	bt
File numbers	1-100			
Ste	ep scale 1.0	Step unit	nm	

Example for case 2:

Select a fold then click the	er where EMSA files e OK button.	are stored and	input parar	meters,
Select folder	C:¥data¥NewZeta	¥SRM-data¥Se	ep-07-2007	¥series 1¥
File parameters				
Root filename	Spectrum		Extension	bd
File numbers	1-8, 10, 12, 14-48,	51-78, 80		
Ste	p scale 1.0	Step unit	nm	
Version:	1.2 (Oct./11/'11) Ma	asashi Watana	be (2006-20	011)
			or I	C

The imported file can be treated as a 2D spectrum image. So, individual

spectra can be displayed via SpectrumPicker tool  $\overset{\textcircled{}}{D}$  in the tool bar (after DigitalMicrograph version 3.11.1) or in the BasicTools window (before version 3.11.1).



### **Acknowledgements**

Thanks to Bernhard Schaffer (FELMI/ZFE, Graz University of Technology) for providing me the request to skip spectra.

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### MSA>Import>XED-SI data

### Current Function Version: 1.4 (Sep./18/'11)

### **Brief Description**

This function imports an X-ray energy dispersive spectrum-image (XED-SI) saved in a binary format from your software for X-ray acquisition/analysis. Currently, this routine can load "foo.raw" files from Oxford INCA system, "foo.spd" files from EDAX Genesis system and "foo.raw" files from Bruker (where "foo" means the spectrum image file name). In addition, any "uncompressed" binary 3D data can be loaded if you can figure out the file format. You may need to consult the original software manual or manufacture whether you can save X-ray spectrum images as a regular binary file.

### <u>Usage</u>

Select **MSA>Import>XED-SI data** from the menu bar. Then, a dialog appears.

select Generic and input all the	ır system is not listed, e parameters.
System System type Generic Coxford INCA EDAX Genesis C Bruker	File configurations         Offset         Byte size         4         Swap data byte         Vector-wise format
SI size X pixels 0 Y pixels	0 Channels 0
Calibration	
Advis. Scale [1,0] Oh	gin ju.u Unit jnm
raxis: Scale 1.0 Un	gin ju.u Unit jnm
Eaxis: Scale 1.0 Orio	gin 0.0 Unit keV

First, should select your system for X-ray analysis by clicking the radio button.

Sele and sele	ect the XEDS syste click the OK butto ct Generic and inp	em used to acquire a spectrum image on. If your system is not listed, out all the parameters.
- SI siz	System System type Generic Oxford INC/ EDAX Gene Bruker e	A esis 0 Channels 2048
- Calibr	ation	
X axis	s: Scale 1.0	Origin 0.0 Unit nm
14000	s: Scale 1.0	Origin 0.0 Unit mm
Y axis		

Case 1: if you select Oxford INCA, several fields become gray out.

You do not fill the gray fields since this function will obtain the parameters from "foo.rpl" file, which is saved with "foo.raw" file in INCA software (so, you must locate the "foo.rpl" file with the "foo.raw" file in the same folder). Now, the most important thing is to input the E-axis scale, which is the value of channel/keV. This is essential. If you leave this E-axis scale field as 0.0, you will see an error message. Then, click the Import SI button and select a desired "foo.raw" file.

🖶 Open						×
Look in:	Paul-map			•	🗈 💣 🎫	•
C.	Name	Date taken	Tags	Size	Rating	
Recent Places		A				
Desktop	map.raw	map.rpl				
Masashi						
Computer						
L 🖉						
Network		-				
	File name:	map.raw			<b>_</b>	Open
	Files of type:	All Files (*.*)	)		•	Cancel
		Open as	read-only			

Case 2: if you select EDAX Genesis, again several fields are gray out.

Sele	ect the XE	DS systen	n used to acquire a spectrum image
and sele	click the ( ct Generic	OK button and inpu	n. If your system is not listed, ut all the parameters.
	System System t C Ger C Oxfo ED/ C Bruk	ype neric ord INCA AX Genes ker	File configurations Offset 0 Byte size 4 Swap data byte Vector-wise format
SI siz X pixe	e els 0	— Ypi	ixels 0 Channels 2048
- SI siz X pixe Calibr	e els 0 ation	Ypi	ixels 0 Channels 2048
- SI siz X pixe Calibr X axis	e els 0 ation s: Scale	Y pi	ixels 0 Channels 2048 Origin 0.0 Unit nm
- SI siz X pixe Calibr X axis Y axis	e els 0 ation	Y pi	ixels 0 Channels 2048 Origin 0.0 Unit nm Origin 0.0 Unit nm
SI siz X pixe Calibr X axis Y axis E axis	e els 0 ation s: Scale s: Scale s: Scale	Y pi	ixels 0 Channels 2048 Origin 0.0 Unit nm Origin 0.0 Unit nm Origin 0.0 Unit keV

To obtain the parameters for a Genesis spectrum image, this function looks for "foo\_SE1.txt" file. When X-ray spectrum image was acquired in EDAX genesis system, an electron image (such as bright-field STEM, annular dark-field STEM, or secondary electron image etc.), you should save the image as a tiff file. The "foo\_SE1.txt" file is automatically saved when you save the image as tiff. You must put this "foo\_SE1.txt" file into the same folder, where the corresponding "foo.spd" file is saved. Then, click the Import SI button and select a desired "foo.spd" file.

**Case 3:** if you select **Bruker**, several fields become gray out.

Sele	ct the XE	DS syster DK buttor	used to acquire a spectro If your system is not listed	um image I,
sele	ct Generic	and inpu	t all the parameters.	
- SIsiz X pixe	System System to Ger COxfo CED/ CED/ Bruk	ype beric ord INCA AX Genes cer Y p	File configuration Offset 0 Byte size 4 Swap data by Vector-wise for cels 0 Channels	s te rrmat
Calibr	ation			
X axis	: Scale	1.0	Origin 0.0 Uni	t nm
Yaxis	: Scale	1.0	Origin 0.0 Uni	t nm
E axis	: Scale	0.01	Origin 50.0 Uni	t keV

You do not fill the gray fields since this function will obtain the parameters from "foo.rpl" file, which is saved with "foo.raw" file in Bruker software (so, you must locate the "foo.rpl" file with the "foo.raw" file in the same folder). Now, the most important thing is to input the E-axis scale, which is the value of channel/keV. This is essential. If you leave this E-axis scale field as 0.0, you will see an error message. Then, click the Import SI button and select a desired "foo.raw" file.

**Case 4:** if you do not have parameter files (**"foo.rpl"** file for **Oxford INCA** or **"foo\_SE1.txt"** file for **EDAX Genesis**), you can still import your **"uncompressed"** binary spectrum-image data by filling all the required parameters. Here is an example for **EDAX Genesis "foo.spd"** file.

Select the XEDS syst and click the OK butt select Generic and in	tem used to acquire a spectrum image ton. If your system is not listed, nout all the parameters.
System System System System System System type Generic Coxford INC EDAX Gen Bruker	CA nesis
Calibration	pixels [100 Channels [2048
Xavis: Scale 10	Origin 0.0 Unit nm
Addis. Sedie 11.0	and the second
Yaxis: Scale 1.0	Origin 0.0 Unit nm

Once you successfully import a binary spectrum-image data, you can treat it as a regular 3D spectrum image.



## MSA>Import>EFTEM image series

### Current Function Version: 1.1 (Sep./18/'11)

### **Brief Description**

This function imports a series of EFTEM images acquired by the **Acquire Filtered Series** function in Gatan DigitalMicrograph as a spectrum image (data cube). .

### <u>Usage</u>

Select **MSA>Import>EFTEM image series** from the menu bar. Then, a dialog appears.

Select input t	initial and final EFTEM images taken as ne energy step. Then, click the OK butt	s a series and on.
	File parameters	
	Initial image	
	Final image	
	Energy step: eV	
/omion: 1	) (Oct /11/11) Convright: Maeaehi Wat	anabe (2005-2012)

First, you should select the initial and final EFTEM images from a series of acquisition by clicking the Initial image and Final image buttons. Second, input the energy step value in eV. Then, click the Convert button.

Here is an example the dialog just before clicking the Convert button.

input th	initial and final EFTEM images taken as ie energy step. Then, click the OK butto	a senes and n.
	File parameters	
	Initial image [test3 [12eV]	
	Final image [test3 [17eV]	
	Energy step: 0.1 eV	
	(Oct. /11./11). Conversiont: Macazahi Wata	nabo (2000-2011

Note that the EFTEM image series must be named as

### foo [jjjeV].dm3

where foo is the rootfile name, jjj is an energy-loss value of the particular image. For example, test 3 [12.4eV].dm3.

The imported file can be treated as a regular 3D spectrum image.



## Utilities

These functions in Utilities add additional capabilities to process spectrum images, e.g. pixel/channel binning (which are available in newer version of DM as well) and spatial/spectral data extraction. Details are as follows:

- Bin SI
- Spatial sub SI
- Spectral sub SI

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## MSA>Utilities>Bin SI

### Current Function Version: 1.5 (July/10/'12)

### **Brief Description**

This function applies spatial (x- and/or y-axis) and/or spectral (energy-axis) data binning to an existing 2D or 3D spectrum image. Note that this function is available in recent version of DMS (ver. 1.7.1 or higher). This function is only for users who still use previous versions of DMS.

### <u>Usage</u>

Open a 2D or 3D spectrum image, first. Make sure that the spectrum image is the front image, and select **MSA>Utilities>Bin SI** from the menu bar. Then, following dialog appears.

ե Bi	nSI	×
	Usage Select binning pa and click the "OK	rameters (" button
	Spatial 1 Spectral 1	•
Versio Copyr	on: 1.5 (July/10/'12) ight: Masashi Watar	nabe (2005-2012)
	ОК	Cancel

Select binning 2 or 4 in the spatial and/or spectral popup fields.

parameters OK'' button
2 💌
4
/11/'11) be (2007-2011)
Cancel

Then, click the Binning button. The binned spectrum image will appear shortly.



Detailed information of this processing via the Bin SI plugin can be found in Binning tag under the Processing Tag of the binned SI file, available through Image Display Info.



### MSA>Utilities>Spatial sub SI

### Current Function Version: 1.2 (July/10/'12)

#### **Brief Description**

This function extracts a selected area from an existing 2D or 3D spectrum image and shows the selected sub area as a new spectrum image.

#### <u>Usage</u>

#### Case 1: 2D spectrum image

Open a 2D spectrum image and select a sub area to be extracted using the LineROI tool  $\checkmark$ . (note: you do not have to draw a perfectly perpendicular line)



Then, select **MSA>Utilities>Spatial sub SI** from the menu bar. A new 2D spectrum image appears.



#### Case 2: 3D spectrum image

Open a 3D spectrum image and select a sub area using the RectangleROI tool



Then, select **MSA>Utilities>Spatial sub SI** from the menu bar. A new 3D spectrum image appears.



Detailed information of this

processing via the Spatial sub SI plugin can be found in Spatial sub tag under the Processing Tag of the extracted SI file, available through Image Display Info.



### MSA>Utilities>Spectral sub SI

### Current Function Version: 1.2 (July/10/'12)

#### **Brief Description**

This function extracts a selected energy region from an existing 2D or 3D spectrum image and shows a new spectrum image with the selected energy region.

#### <u>Usage</u>

Open a 2D or 3D spectrum image and show a spectrum from the spectrum image using the SpectrumPicker tool in the tool bar. Next, select a energy range you want to extract from the existing spectrum image.



Then, select **MSA>Utilities>Spectral sub SI** from the menu bar. A new spectrum image with the selected energy range appears.



Detailed information of this processing via the Spectral sub SI plugin can be found in Spectral sub tag under the Processing Tag of the extracted SI file, available through Image Display Info.



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## MSA

This is the core function of this plugin package, which applies one of multivaliate statistical analyses to spectrum-image data.

Weighted-PCA

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### MSA>MSA>Weighted PCA

#### Current Function Version: 1.6 (Sep./11/'13)

#### Brief Description

This function performs principal component analysis (PCA) to a 2D or 3D spectrum image (SI) with proper weighting based on Poisson statistics. Since this function creates many result files from a single SI file, it would be better to create a dedicated folder before you apply this function. After decomposing the SI file, you can extract each component: a pair of a loading spectrum (spectral feature) and a score image (spatial amplitude). Then, you can reconstruct a noise-free (or noise-reduced) dataset from the original SI. In addition, you can also check the PCA application from a residual data (difference between the original and reconstructed SIs).

#### Usage

As mentioned above, you should create a dedicated folder before you apply PCA to your SI. This technique requires a lot of memory. So, it is strongly recommended to close all files in DigitalMicrograph. This function tries to use only available physical memory. Even if the available physical memory is limited or smaller than the targeting SI, you can still complete PCA as long as the SI can be opened in DigitalMicrograph. However, if the available physical memory is smaller, it would take much longer for processing.

After closing all the opened files, select **MSA>MSA>Weighted PCA** from the menu bar. Then, the following dialog appears.



The numbers in the blue boxes indicate the step you should follow in order to apply PCA. Namely,

- 1. Select a 2D or 3D spectrum image in the Gatan DM3 format
- 2. Apply matrix decomposition to the SI
- 3. Evaluate componenets
- 4. Reconstruct the noise-reduced spectrum image

Each step is explained as follows:

1. First, click the Select SI button in the region 1 of the dialog, then the dialog for file open appears.

🛗 Open	-					×
Look in:	🔒 latestResu	ılts		- + (	ti 💣 💷 🔹	
œ.	Name	Date taken	Tags	Size	Rating	
Recent Places	🔽 🛃 area15	i.dm3				
Desktop						
Masashi						
Computer						
Network						
	File name:	area 15.dm3	5		-	Open
	Files of type:	All Files (*.*)	)		•	Cancel
		C Open as	read-only			

You can select the desired SI file and click the Open button. The selected file name appears in the string filed with the absolute path.

Select SI C:¥data¥MSA¥area15¥latestResults¥area15.dm3

2. Once the data is selected, the Decompose SI button is activated in the region 2.



Then, click the Decompose SI button. This process would take a few seconds to a few minutes depending on your CPU speed and the data size. As long as the progress window displays the following message, your PC is NOT frozen.



Just wait until the scree plot is displayed.



Note that the scree plot is logarithm of the eigenvalues graphically plotted against the index of component. A number of principal components is usually evaluated based on the scree plot. In the above example, a number of the principal components distinguished from the noise components can be 6 or 7 from the primary principle component.

Detailed information of this Weighted PCA process can be found in MSA tag under the Processing Tag of the Scree Plot, available through Image Display Info.

□ Display Line Plot Options Placement □ Info Tags Calibration □ Object Tags	Processing Operation: MSA Operation: MSA Operation: MSA Operation: MSA Original SI Original SI Original SI Operprocess: spectral-spatial weighting Routine: 32 bit Spatial binning: 1 x 1 Time: 7/10/2012 10:46 AM
	Update Global Info OK Cancel Save Defaults

3. After the data is decomposed, the Display components button is activated in the region 3.



It is essential to evaluate each component in terms of a pair of a loading spectrum (spectral feature) and a score image (spatial amplitude) in order to distinguish the principal components from noise. To view components, input the component range you want to evaluate in the Initial and Final boxes and click the Display components button. Then, selected components are displayed. It should be noted that the page mode is now default to display components.

![](_page_31_Figure_2.jpeg)

In the above example, a spectral feature (loading) and spatial amplitude (score) of component 1 are displayed in one page. In order to other extracted components, you can use the slice tool, which is used to manipulate 3D data cubes such as spectrum images.

![](_page_31_Picture_4.jpeg)

By sliding the index of component in the slice-tool dialog, a desired component can be displayed.

![](_page_32_Figure_2.jpeg)

To extract the displayed component, select **MSA>Extract Component** (s)>Current Component from the menu bar. Then, the displayed component (both the loading spectrum and score image) is extracted.

![](_page_32_Figure_4.jpeg)

If you want to extract all the components currently contained in the page mode file, select **MSA>Extract Component(s)>Extract All** from the menu bar.

Centrel     Slice	1 C: Score 01-04(01)	to D: Loading_01-04(01)	
Low: 1 score High: 2 score	The second second	0.5	
Width: 1 score I Display Center I Show Range	1-1-2-1 1 //	88	
	particle in p	0.5	
		0.4	
		0.8	
		02	
		000 2 4 6 8 10 12 14 16 keV	18 20

The loading spectrum and score image are displayed separately. Again, using the slice tool, individual components can be seen (coresponding to a selected component, both a loading spectrum and score image are simultaneously loaded).

![](_page_33_Figure_4.jpeg)

In order to extract individual or all components, select MSA>Extract Component(s)>Current Component or MSA>Extract Component(s) >Extract All from the menu bar.

It is very important to evaluate individual components and to distinguish statistically significant ones from noise. The function of displaying components is one of main features of this plugin.

Again, detailed information of the individual components including this weighted PCA process can be found in MSA tag under the Processing Tag of the Loading spectra and Score images, available through Image Display Info.

mage Display Info	
<ul> <li>Display</li> <li>Line Plot</li> <li>Options</li> <li>Placement</li> <li>Image</li> <li>Info</li> <li>Tags</li> <li>Calibration</li> <li>Spectrometer Info</li> <li>Object</li> <li>Tags</li> </ul>	<ul> <li>Meta Data</li> <li>Processing</li> <li>IO</li> <li>Operation: MSA</li> <li>Parameters</li> <li>Component</li> <li>Eigenvalue: 1.0</li> <li>Index: 1</li> <li>Information (%): 89.9233</li> <li>Trace: 1.11206</li> <li>Determined number of components: 134</li> <li>MSA type: Weighted PCA</li> <li>Original SI</li> <li>Preprocess: spectral-spatial weighting</li> <li>Routine: 32 bit</li> <li>Spatial binning: 1 x 1</li> <li>Time: 7/10/2012 10:47 AM</li> </ul>
	OK Cancel Save Defaults

It should be noted that the information (%) tag under the Component tag indicate the fraction of information that this particular component (index 3 in the above example) contains in this SI data.

4. After the data is decomposed, the Reconstruct SI button is also activated in the region 4.

![](_page_34_Picture_5.jpeg)

By evaluating of individual components, principal components can be distinguished from noise components and it is possible to reconstruct the spectrum image data with reduced noise. Input the last index of principal component in the box and click the Reconstruct SI button. Then, data reconstruction process starts. This process could take longer depending on the using PC and data size. However, if the following message appears in the progress window, the process is progressing.

![](_page_34_Picture_7.jpeg)

After the reconstruction process is completed, the reconstructed spectrum image is displayed.

![](_page_34_Figure_9.jpeg)

Detailed information of the reconstruction process can also be found in in

E- Display	Processing	
Orbitay     Contrast     Oisplay     Color     Display     Otor     Placement     Image     Otor     Calibration     Sectrometer Info     Session Info     Object     Tags     Captions     Captions     Captions	Processing     Processing     Processing     Processing     Processing     Processing     Processing     Processing     Preprocess: spectral-spatial weighting     Preprocess: spectral-spatial weighting     Preprocess: spectral-spatial weighting     Preprocess: spectral-spatial weighting     Preconstruction     Information (%): 99.4566     Number of component: 4     Trace: 1.11206     Routine: 32 bit     Spatial binning: 1 x 1     Time: 7/10/2012 10:48 AM	· ·
	Update Global Info OK Cancel Save Defaults	

MSA > Reconstruction tag under the Processing Tag of the Reconstructed SI file, available through Image Display Info.

The fraction of information contained in the reconstructed SI file over the original SI file can be found in Information (%) tag under the Reconstruction tag.

Now, the Show Residual SI button is finally activated in the region 5.

![](_page_35_Picture_6.jpeg)

The residual SI is the difference between the original and reconstructed SIs. Therefore, the validity of reconstruction can be confirmed by comparing the residual SI with the original and reconstructed SIs.

Detailed information of the reconstruction process can also be found in in MSA > Reconstruction tag under the Processing Tag of the Reconstructed SI file, available through Image Display Info.

- Display	- Processing	
Contrast		
Display		
Color	- Operation: MSA	
Placement	- Parameters	
- Image	- Determined number of components: 134	
Info	MSA type: Weighted PCA	
Tags	Original SI	
Calibration		
Spectrometer Info	Reconstruction	
Microscope Info	Information (%): 99.4566	=
Session Info	Information in residual (%): 0.543437	
- Object	Number of component: 4	
Tags	Trace: 1.11206	
- Captions	Routine: 32 bit	
Captions	Spatial binning: 1 x 1	
	Time: 7/10/2012 10:54 AM	
	Update Global Info	

The fraction of information contained in the residual SI file over the original SI file can be found in Information in residual (%) tag under the Reconstruction tag.

Note that you can reset the paramters in this dialog by clicking the  $\ensuremath{\mathsf{Reset}}$  button

![](_page_36_Picture_5.jpeg)

The summary of each step descrived above can be seen in the Result window.

![](_page_36_Picture_7.jpeg)

#### **Output files**

Many output files are generated from a single spectrum image by this PCA plugin. Here is the summary:

![](_page_37_Picture_2.jpeg)

If a spectrum image file in the dm3 format named foo.dm3 is processed, following files are generated:

- foo-org.raw: original data converted from the original dm3 file (8 byte real, binary)
- foo-result.txt: summary of eigenvalues for scree plot (ascii)

#	C:¥data¥MSA¥ar	rea15¥latestR	esults¥area15-result.txt: Results of eigen analysis↓	
#	Preprocessing:	0 (Spatial	and spectral scalings)↓	
#	Spatial binnir	ng: 3 (Spatia	.lly 4 × 4)↓	
#	Routine: 64 bi	it↓		
#	dimensions of	original spe	ctrum image↓	
#	nPixelX: 256		land a second	
#	# nPixelY: 256↓			
#	nChannel: 102	241		
#	dimensions of	result vecto	rs by eigen decpmposition↓	
#	Score: 65536>	<102↓		
#	# Loading: 1024x1024			
#	Eigenvalue: 1	021		
#	trace = 1.395	50591J		
#	eigenvalue	C ratio	absolute eigenvalue↓	
1000	1 1.00000000	0.71681553	4194304.00000000↓	
	2 0.10515268	0.79219060	441042.30608604↓	
	3 0.01474060	0.80275689	61826.54907351↓	
	4 0.00401008	0.80563138	16819.48802894↓	
	5 0.00110764	0.80642535	4645.77184136↓	
	6 0.00064896	0.80689054	2721.949334664	
	7 0.00060927	0.80732727	2555.47619955↓	
	8 0.00060500	0.80776094	2537.53892223↓	
_				

- foo-eigen.raw: full eigenvalues (8 byte real, binary)
- foo-loading.raw: limited loading matrix (8 byte real, binary)
- foo-score.raw: limited score matrix (8 byte real, binary)
- foo-reconstructed.raw: reconstructed data matrix (4 byte real, binary)
- foo-residual.raw: area15-residual.raw: difference between original and
- reconstructed data matrices (4 byte, binary)
- foo-reconstruction.log: summary of reconstruction (ascii)

# C:¥data¥MSA¥area15¥latestResults¥area15-reconstruction.log: detail information of data reconstruction via MSA↓ # dimensions of original spectrum image↓ nPixelX: 256↓ nPixelY: 256↓ # nChannel: 1024↓ dimensions of result vectors by eigen decomposition↓ Score: 65536x102↓ Loading: 1024×102↓ Eigenvalue: 102↓ number of components selected for data reconstruction: 74 number of non-zero data: 6792197↓ chi square value between original and reconstructed SIs: 0.751857↓ # # result file names↓ # - area15-org.raw: original data (8 byte real, binary)↓ - area15-loading.raw: limited loading matrix (8 byte real, binary)↓ # - area15-score.raw: limited score matrix (8 byte real, binary)↓ # # - area15-eigen.raw: full eigenvalues (8 byte real, binary)↓ - area15-result.txt: summary of eigenvalues <mark>for</mark> scree plot (ascii)↓ - area15-reconstructed.raw: reconstructed data matrix (4 byte real, binary) $\downarrow$ # - area15-residual.raw: difference between original and reconstructed data matrices (4 byte, binary)↓ 1

#### Advanced Setting

Several parameters for preprocessing/processing can be choosed in this plugin. If you prefer to change those settings, click Advanced Setting button.

Show Original SI
Advanced Setting
Reset

Then, a sub dialog appears.

Scaling © Spectral-Spatial © Spectral © Spatial © Non	Spatial binning
Use 64-bit n	outine
ок	Cancel

### Caution: If you do not have any idea, DO NOT CHANGE THESE PARAMETERS (KEEP THE DEFAULT SETTING)!

Scaling: selection of scaling is extremely important for proper PCA applications. The detail can be seen in literature (R.N. Cochran & F.H. Home, "Statistically weighted principal component analysis of rapid scanning wavelength kinetics experiments", *Anal. Chem.*, **49** (1977) 846-853; M.R. Keenan, P.G. Kotula, "Accounting for Poisson noise in the multivariate analysis of ToF-SIMS spectrum images", *Surf. Interface Anal.*, **36** (2004) 203-212). Binning: you can apply spatial binning to enhance your spectral features from a spectrum image with many pixels. If the spectrum image has many pixels, you may apply spatial binning of 2 or 4. However, this preprocess does not degrade spatial resolution in the final decomposed data. Use **64-bit routine (only available in the MSA plug-in package for GMS 1.x**): if you use DigitalMicrograph (GMS 1.x) under 64-bit Windows (XP x64, 64 bit Vista and maybe 64-bit Windows Servers), this check box is automatically activated. If this option is checked, this plugin calls an

independent 64-bit command-line routine via system call. Since DigitalMicrograph (GMS 1.x) is currently 32-bit program, it is impossible to integrate such 64-bit routine under any 32-bit program. However, the major limit of the 32-bit program is memory size to allocate contineouly (about 2GB). This 64-bit routine can expand the limitation up to whatever your PC has (now 4GB is just a standard in any 64-bit system). Other than that, this 64-bit routine works exactly same as this plugin. If data size is larger than 2 GB, this 64 bit routine can process much faster than the 32-bit routine. If data size is larger than 8 GB, this 64-bit routine is only way to process the data in this plugin. In the MSA package for GMS 2.x, this option is no longer necessary because 64-bit GMS is available!

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![](_page_39_Picture_23.jpeg)

### Acknowledgements

All the tools required to develop this package have been supported by

![](_page_40_Picture_5.jpeg)

## **Release Notes**

- Version 1.6: Adjusted to GMS 2.3 Improved a display style for components as a 3D data stack (Jan./16/'14)
- Version 1.5: Modified tag structure (July/10/'12)
- Version 1.4: Modified dialog formats (Oct./11/'11)
- Version 1.3: Adjusted to GMS 2.x and added Tags in resultant files processed by Bin SI, Spatial Sub SI, Spectral Sub SI and Weighted PCA (Sep./18/'11)
- Version 1.2: Added an import option for Bruker system in XED-SI import (Dec./14/'09)
   Version 1.1:
- Minor bug fix (June/9/'09)
- Version 1.0: First official release version (Oct./30/'08)

![](_page_40_Figure_14.jpeg)