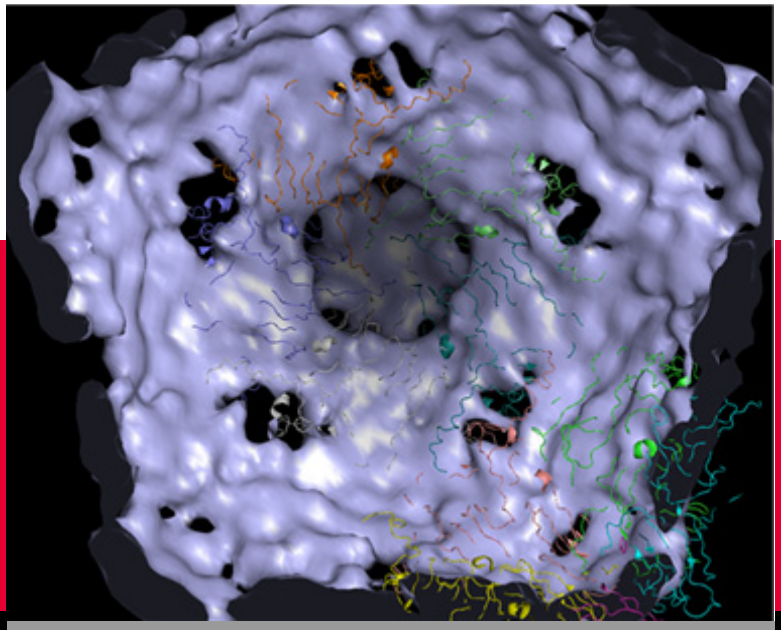
EPU Software User's Guide

PN 1025707-J



Automated Data Collection for
Single Particle 3D Reconstruction

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Trademark Acknowledgments

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Appendix C

FEI MRC Image Format

FEI Applications use the MRC2014 data format. The official format specification can be found at: http://www.ccpem.ac.uk/mrc_format/mrc_format.php.

MRC files have a main header and an extended header. The main header contains generic image information like: the image dimensions and the pixel format (see the MRC2014 format specification). The FEI extended header contains information about the microscope state at acquisition time (e.g., magnification, accelerating voltage, stage position, beam shift, and additional image acquisition information such as binning and exposure). The format of the extended header is described *Table 3*. The size of the extended header is specified by the "NSYMBT" field in the main header.

The image views use the top left corner as zero position. The bottom right corner contains the last pixel. The image data in the MRC2014 files is stored in the same order; the first pixel value (read from the beginning till the end of the file) is from the top left corner and the last pixel value is from the bottom right corner. The pixels are written line by line, starting with the top line (see the image below). Be aware that third-party applications like IMOD and Fiji/ImageJ, can display MRC images in different way. A common discrepancy for example, is the orientation among the central horizontal plane by choosing a different location for the zero-position (top-left or bottom-left corner).

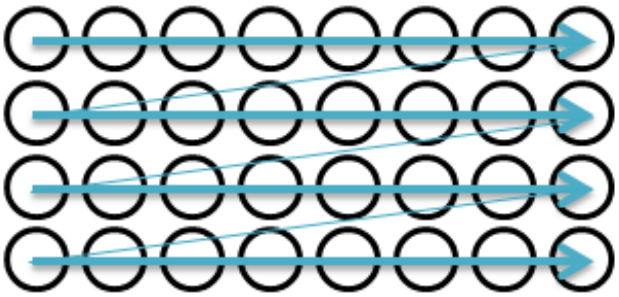

Table 3 Format Extended Header (1 of 7)

Name	Offset (dec)	Offset (hex)	Format	Is present flag	Description
Metadata size	0	0x0000	Int32	NA	Metadata size in bytes
Metadata version	4	0x0004	Int32	NA	Version ID of the metadata format 0 = Initial version which is described here
Bitmask 1	8	0x0008	UInt32	NA	Individual bits indicate which metadata fields are set
Timestamp	12	0x000C	Float64	Bitmask 1 – #0	Time when the image was taken
Microscope type	20	0x0014	16 chars	Bitmask 1 – #1	Identifier for microscope type (Krios, Talos, Titan, Metrios, etc.)
D-Number	36	0x0024	16 chars	Bitmask 1 – #2	Microscope identifier
Application	52	0x0034	16 chars	Bitmask 1 – #3	Application name (e.g. "FEI Tomography")
Application version	68	0x0044	16 chars	Bitmask 1 – #4	
Gun					
HT	84	0x0054	Float64	Bitmask 1 – #5	High tension in Volts
Dose	92	0x005C	Float64	Bitmask 1 – #6	Dose in electrons/m²
Stage					
Alpha tilt	100	0x0064	Float64	Bitmask 1 – #7	Holder Alpha tilt along axis in degrees
Beta tilt	108	0x006C	Float64	Bitmask 1 – #8	Holder Beta tilt along axis in degrees
X-Stage	116	0x0074	Float64	Bitmask 1 – #9	Stage X position in meters
Y-Stage	124	0x007C	Float64	Bitmask 1 – #10	Stage Y position in meters
Z-Stage	132	0x0084	Float64	Bitmask 1 – #11	Stage Z position in meters

Bool = Boolean of 1 byte (0 = false, other value = true)
Int32 = Signed integer of 4 bytes
UInt32 = Unsigned integer of 4 bytes
Float64 = Floating point number of 8 bytes

Table 3 Format Extended Header (2 of 7)

Name	Offset (dec)	Offset (hex)	Format	Is present flag	Description
Tilt axis angle	140	0x008C	Float64	Bitmask 1 – #12	Angle of tilt axis in image in degrees
Dual axis rotation	148	0x0094	Float64	Bitmask 1 – #13	Measured rotation angle after b flip in degrees (Tomography only)
Pixel size X	156	0x009C	Float64	Bitmask 1 – #14	Pixel size X in meters
Pixel size Y	164	0x00A4	Float64	Bitmask 1 – #15	Pixel size Y in meters
Optics					
Defocus	220	0x00DC	Float64	Bitmask 1 – #22	Defocus in meters
STEM Defocus	228	0x00E4	Float64	Bitmask 1 – #23	STEM defocus in meters
Applied defocus	236	0x00EC	Float64	Bitmask 1 – #24	Relative defocus applied by application in meters
Instrument mode	244	0x00F4	Int32	Bitmask 1 – #25	0 = TEM, 1 = STEM
Projection mode	248	0x00F8	Int32	Bitmask 1 – #26	0 = Imaging, 1 = Diffraction
Objective lens mode	252	0x00FC	16 chars	Bitmask 1 – #27	LM, HM, Lorentz
High magnification mode	268	0x010C	16 chars	Bitmask 1 – #28	Mi, SA, Mh
Probe mode	284	0x011C	Int32	Bitmask 1 – #29	0 = micro, 1 = nano
EFTEM On	288	0x0120	Bool	Bitmask 1 – #30	Is true when the magnifications are adapted to the energy filter
Magnification	289	0x0121	Float64	Bitmask 1 – #31	Nominal magnification
Bitmask 2	297	0x0129	UInt32	NA	Individual bits indicate which metadata fields are set
Camera length	301	0x012D	Float64	Bitmask 2 – #0	Nominal camera length in meters
Spot index	309	0x0135	Int32	Bitmask 2 – #1	

Bool = Boolean of 1 byte (0 = false, other value = true)
Int32 = Signed integer of 4 bytes
UInt32 = Unsigned integer of 4 bytes
Float64 = Floating point number of 8 bytes

Table 3 Format Extended Header (3 of 7)

Name	Offset (dec)	Offset (hex)	Format	Is present flag	Description
Illuminated area	313	0x0139	Float64	Bitmask 2 – #2	TEM: beam diameter in meters STEM: not used Undefined on 2 lens condenser systems
Intensity	321	0x0141	Float64	Bitmask 2 – #3	Uncalibrated measure of beam diameter on 2 lens condenser systems
Convergence angle	329	0x0149	Float64	Bitmask 2 – #4	In degrees. Undefined on 2 lens condenser systems
Illumination mode	337	0x0151	16 chars	Bitmask 2 – #5	None, Parallel, Probe, Free Undefined on 2 lens condenser systems
Wide convergence angle range	353	0x0161	Bool	Bitmask 2 – #6	Undefined on 2 lens condenser systems
EFTEM Imaging					
Slit inserted	354	0x0162	Bool	Bitmask 2 – #7	
Slit width	355	0x0163	Float64	Bitmask 2 – #8	Slit width in eV
Acceleration voltage offset	363	0x016B	Float64	Bitmask 2 – #9	in V
Drift tube voltage	371	0x0173	Float64	Bitmask 2 – #10	in V
Energy shift	379	0x017B	Float64	Bitmask 2 – #11	in eV
Shift offset X	387	0x0183	Float64	Bitmask 2 – #12	Corrective image or beam shift relative to exposure preset (in logical units) • TEM: pure image shift • STEM: image-beamshift
Shift offset Y	395	0x018B	Float64	Bitmask 2 – #13	

Bool = Boolean of 1 byte (0 = false, other value = true)
Int32 = Signed integer of 4 bytes
UInt32 = Unsigned integer of 4 bytes
Float64 = Floating point number of 8 bytes

Table 3 Format Extended Header (4 of 7)

Name	Offset (dec)	Offset (hex)	Format	Is present flag	Description
Shift X	403	0x0193	Float64	Bitmask 2 – #14	Applied shift due to optimized position and tracking (in logical units) • TEM: image beam shift • STEM: beam shift
Shift Y	411	0x019B	Float64	Bitmask 2 – #15	
Integration time	419	0x01A3	Float64	Bitmask 2 – #16	Camera or dose fraction exposure time
Binning Width	427	0x01AB	Int32	Bitmask 2 – #17	
Binning Height	431	0x01AF	Int32	Bitmask 2 – #18	
Camera					
Camera name	435	0x01B3	16 chars	Bitmask 2 – #19	TEM: Name of the camera STEM imaging: <empty>
Readout area left	451	0x01C3	Int32	Bitmask 2 – #20	
Readout area top	455	0x01C7	Int32	Bitmask 2 – #21	
Readout area right	459	0x01CB	Int32	Bitmask 2 – #22	
Readout area bottom	463	0x01CF	Int32	Bitmask 2 – #23	
Ceta noise reduction	467	0x01D3	Bool	Bitmask 2 – #24	
Ceta frames summed	468	0x01D4	Int32	Bitmask 2 – #25	Number of frames summed for dynamic range
Direct detector electron counting	472	0x01D8	Bool	Bitmask 2 – #26	
Direct detector align frames	473	0x01D9	Bool	Bitmask 2 – #27	
Camera param reserved 0	474	0x01DA	Int32	Bitmask 2 – #28	

Bool = Boolean of 1 byte (0 = false, other value = true)
Int32 = Signed integer of 4 bytes
UInt32 = Unsigned integer of 4 bytes
Float64 = Floating point number of 8 bytes

Table 3 Format Extended Header (5 of 7)

Name	Offset (dec)	Offset (hex)	Format	Is present flag	Description
Camera param reserved 1	478	0x01DE	Int32	Bitmask 2 – #29	
Camera param reserved 2	482	0x01E2	Int32	Bitmask 2 – #30	
Camera param reserved 3	486	0x01E6	Int32	Bitmask 2 – #31	
Bitmask 3	490	0x01EA	UInt32	NA	Individual bits indicate which metadata fields are set
Camera param reserved 4	494	0x01EE	Int32	Bitmask 3 – #0	
Camera param reserved 5	498	0x01F2	Int32	Bitmask 3 – #1	
Camera param reserved 6	502	0x01F6	Int32	Bitmask 3 – #2	
Camera param reserved 7	506	0x01FA	Int32	Bitmask 3 – #3	
Camera param reserved 8	510	0x01FE	Int32	Bitmask 3 – #4	
Camera param reserved 9	514	0x0202	Int32	Bitmask 3 – #5	
Phase Plate	518	0x0206	Bool	Bitmask 3 – #6	Indicates whether phase plate was used for data acquisition
STEM					
STEM Detector name	519	0x0207	16 chars	Bitmask 3 – #7	
Gain	535	0x0217	Float64	Bitmask 3 – #8	
Offset	543	0x021F	Float64	Bitmask 3 – #9	
STEM param reserved 0	551	0x0227	Int32	Bitmask 3 – #10	

Bool = Boolean of 1 byte (0 = false, other value = true)
Int32 = Signed integer of 4 bytes
UInt32 = Unsigned integer of 4 bytes
Float64 = Floating point number of 8 bytes

Table 3 Format Extended Header (6 of 7)

Name	Offset (dec)	Offset (hex)	Format	Is present flag	Description
STEM param reserved 1	555	0x022B	Int32	Bitmask 3 – #11	
STEM param reserved 2	559	0x022F	Int32	Bitmask 3 – #12	
STEM param reserved 3	563	0x0233	Int32	Bitmask 3 – #13	
STEM param reserved 4	567	0x0237	Int32	Bitmask 3 – #14	
Scan settings					
Dwell time	571	0x023B	Float64	Bitmask 3 – #15	Dwell time per pixel in seconds
Frame time	579	0x0243	Float64	Bitmask 3 – #16	Frame time in seconds (currently it will not be used)
Scan size left	587	0x024B	Int32	Bitmask 3 – #17	
Scan size top	591	0x024F	Int32	Bitmask 3 – #18	
Scan size right	595	0x0253	Int32	Bitmask 3 – #19	
Scan size bottom	599	0x0257	Int32	Bitmask 3 – #20	
Full scan FOV X	603	0x025B	Float64	Bitmask 3 – #21	Field of view in meters
Full scan FOV Y	611	0x0263	Float64	Bitmask 3 – #22	
EDX Elemental maps					
Element	619	0x026B	16 chars	Bitmask 3 – #23	
Energy interval lower	635	0x027B	Float64	Bitmask 3 – #24	
Energy interval higher	643	0x0283	Float64	Bitmask 3 – #25	
Method	651	0x028B	Int32	Bitmask 3 – #26	
Dose fractions					
Is dose fraction	655	0x028F	Bool	Bitmask 3 – #27	

Bool = Boolean of 1 byte (0 = false, other value = true)
Int32 = Signed integer of 4 bytes
UInt32 = Unsigned integer of 4 bytes
Float64 = Floating point number of 8 bytes

Table 3 Format Extended Header (7 of 7)

Name	Offset (dec)	Offset (hex)	Format	Is present flag	Description
Fraction number	656	0x0290	Int32	Bitmask 3 – #28	
Start frame	660	0x0294	Int32	Bitmask 3 – #29	
End frame	664	0x0298	Int32	Bitmask 3 – #30	
Reconstruction					
Input stack filename	668	0x029C	80 chars	Bitmask 3 – #31	
Bitmask 4	748	0x02EC	UInt32	NA	Individual bits indicate which metadata fields are set
Alpha tilt min	752	0x02F0	Float64	Bitmask 4 – #0	
Alpha tilt max	760	0x02F8	Float64	Bitmask 4 – #1	

Bool = Boolean of 1 byte (0 = false, other value = true)
Int32 = Signed integer of 4 bytes
UInt32 = Unsigned integer of 4 bytes
Float64 = Floating point number of 8 bytes