MerlinEM

Technical Datasheet

MerlinEM is a fast pixelated detector for electron microscopes. MerlinEM's versatile technology allows for acquisition speeds greater than 21,000 frames per second (@ 1 bit mode) and comes with a workstation computer. MerlinEM is a particle counting detector - each pixel has complex analog and digital circuitry to discriminate single particle events. Noise free, zero dead time readout is possible due to the hybrid design of the detector.

MerlinEM uses threshold discriminators to separate incident electrons from a background signal. It is ideally suited for 4D STEM and dynamical TEM imaging. The detector can be triggered by external events - enabling pump-probe and in-situ type of experiments. Near ideal detector performance (in terms of DQE and MTF) can be reached for electron energy decreasing towards 60 keV[1].

Key applications

4D STEM, time resolved TEM, Ptychography, strain imaging, Lorentz microscopy, electron diffraction imaging, CBED.

Key features

Direct detection
Noise-less readout of single electron events.

Dynamic range
24-bit maximum counting depth (1:16.7 million intensity range in a single image), 12-bit counting depth with no dead time.

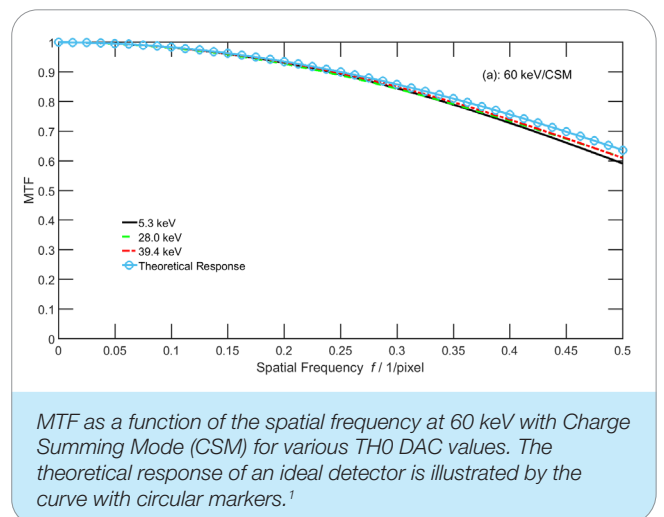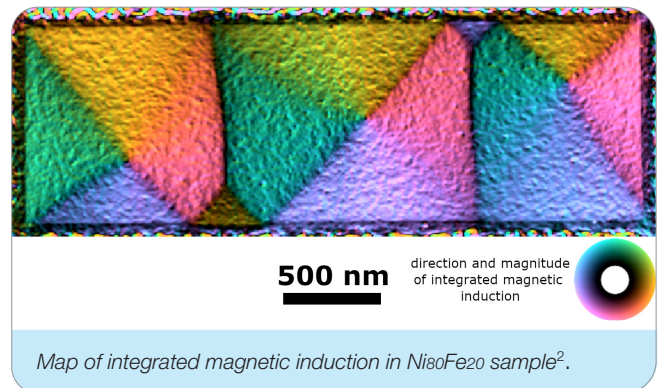**Rapid and versatile readout**
Several bit depth modes allow for varying readouts speeds, including up to 1825 Hz in typical 12-bit mode, and up to 21,000 Hz in binary mode (1-bit). Additionally, the shutter speed can be opened for as low as 200 ns for pump-probe experiments.

Wide energy range and radiation tolerance
30 keV - 300 keV operating range - suitable for low and high energy experiments.

Size and Mount
256 x 256 pixels with retractable and static mounts - fits most microscopes.

500 nm

direction and magnitude of integrated magnetic induction

Map of integrated magnetic induction in $Ni_{80}Fe_{20}$ sample[2].

MTF as a function of the spatial frequency at 60 keV with Charge Summing Mode (CSM) for various TH0 DAC values. The theoretical response of an ideal detector is illustrated by the curve with circular markers.[1]

1 J.A. Mir, R. Clough, R. MacInnes, C. Gough, R. Plackett, I. Shipsey, H. Sawada, I. MacLaren, R. Ballabriga, D. Maneuski, V. O'Shea, D. McGrouther, A.I.Kirkland: "Medipix3 Demonstration and understanding of near ideal detector performance for 60 & 80 keV electrons", Ultramicroscopy Volume 182, November 2017, Pages 44-53

2. In preparation for publication, M Krajnak, DM Paganin, K Fallon, L Clark, S McVitie, J Etheridge, University of Glasgow, University of Monash. A rectangular pattern (3 x 1 μm) was sputtered by focused ion beam and 4D-STEM dataset was acquired by MerlinEM detector in field free scanning transmission electron microscope. Dataset consisted of 510 x 180 images of central diffraction disk in STEM (raw data size 11GB). The contrast value of each probe position is determined by phase correlation method. Ni80Fe20 sample provided by A Sinan and D Atkinson, University of Durham.

Merlin

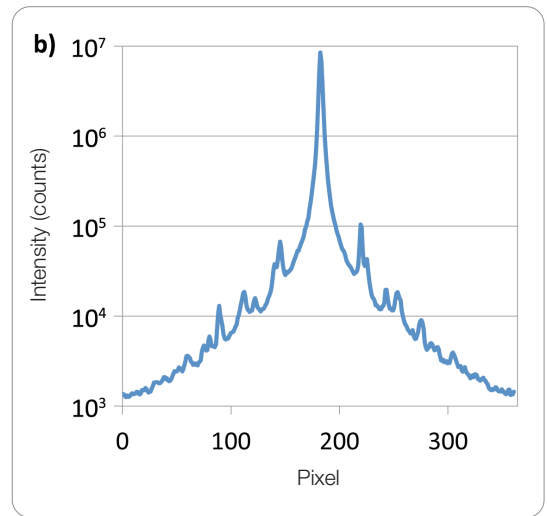*Logarithmic colour scale*

b)
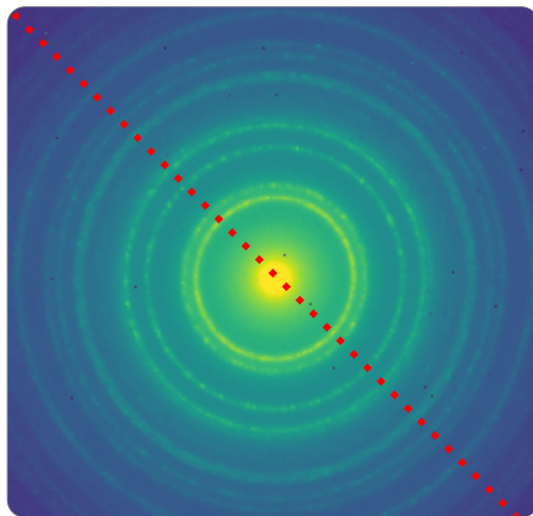
Figure illustrating Merlin's dynamic range capabilities - 24-bit depth acquisition of a diffraction pattern. (a) Acquired diffraction pattern with logarithmic colour scale making visible diffraction features across the full intensity range. (b) Single-line profile along the pattern diagonal highlighting the dynamic range of the information contained in the pattern.[1]

Technical specifications

Sensor:	Silicon 500 µm
Sensor Type:	Reverse biased hybrid silicon diode array
Pixel size:	55 x 55 µm
Active area:	14 mm x 14 mm, or 28 mm x 28 mm
Pixels:	256 x 256 (single) or 512 x 512 (Quad)
Readout noise:	Zero with thresholds set
DQE at 60 keV:	1 at Zero frequency 0.45 at Nyquist[1]
MTF at 60 keV:	>0.62 at Nyquist (depends on mode)[1]
Max frame rate (continuous):	1825 Hz (12-bit)
Gap time (continuous):	0 µs
Maximum dynamic range:	24 bit - up to 16,777,216 counts per pixel.
Trigger:	3.3 / 5 V TTL pulse or within software
Communication:	up to 10 m VHDCI cable; TCP/IP protocol
Energy range:	30 keV – 300 keV
Software:	Labview and TCP/IP protocol
Mount:	Static and retractable available

About

Merlin, developed by Diamond Light Source, is a robust and versatile system built around the Medipix3 ASIC. It is designed with the high performance and reliability standards required by synchrotron beamlines and other industrial and large scale scientific applications.

MerlinEM is an adaptation of the Merlin for electron microscopy use, developed in conjunction with the University of Glasgow.