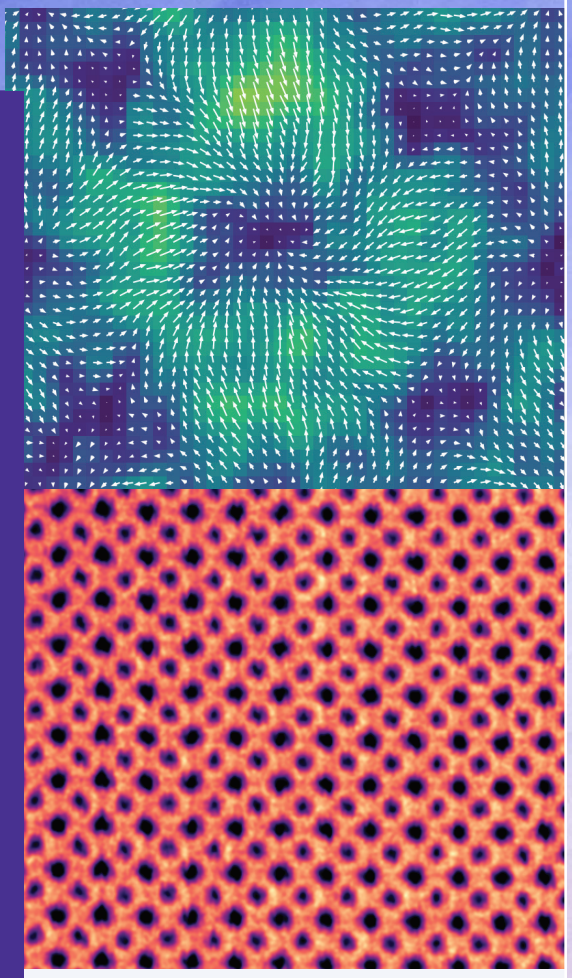
CELERITAS CAMERA

Ultra-Fast 4D STEM and *in situ* TEM

Delivering Bigger | Better | Faster | Cameras For Electron Microscopy

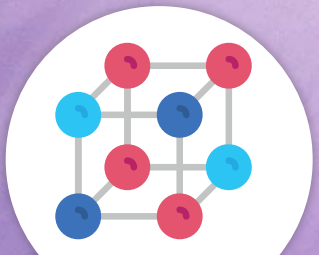
4D STEM AT THE SPEED OF CONVENTIONAL STEM

- Direct detection device (DDD®) delivers ultra-high speed, extraordinary resolution, and ultra-low noise.
- Orders of magnitude faster than other detectors (up to 98,000 fps).
- 1k × 1k (1 million) seamless pixels for a broad range of TEM/STEM methods.
- On-chip CDS minimizes noise.
- Global shutter readout option eliminates rolling artifacts present on other cameras.
- Simultaneous HDR readout delivers more than an order of magnitude higher dynamic range.
- Patented HDR counting automatically performs electron counting in sparse regions while maintaining linearity in bright regions.
- Hardware synchronization with our DE-FreeScan scan generator and other third-party scan generators.
- DE-FreeScan scan generator enables a variety of scan patterns, including conventional raster, serpentine, spiral, subsampled, and custom user-defined scan patterns.



90° rotation symmetry STEM (top) and zoomed-in electric field map of [100] SrTiO3, acquired at 49,000 fps.
Courtesy of Paul Voyles, University of Wisconsin.

DETECTOR APPLICATIONS:



Materials

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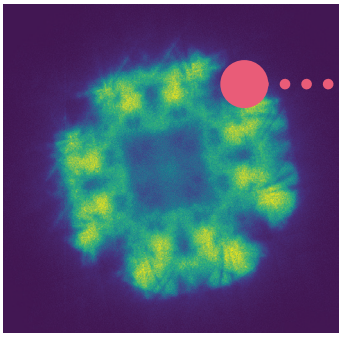
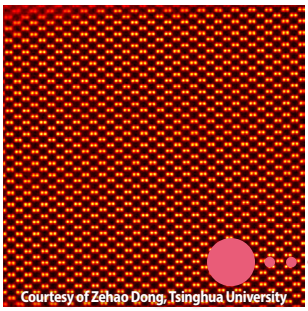
VERSATILE & ULTRA-FAST FOR A WIDE RANGE OF TEM/STEM APPLICATIONS



Position-Averaged CBED (PACBED)

Large number of pixels reveals details unseen with smaller detectors

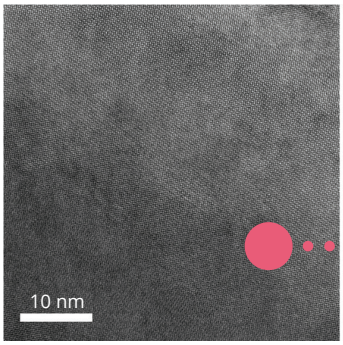


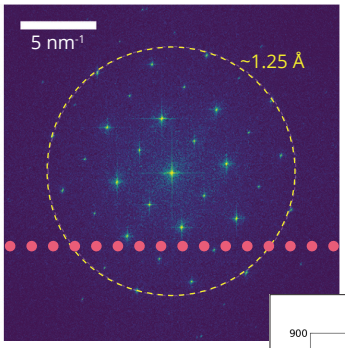
Wide-Range of 4D STEM Techniques

Visualize light elements, electromagnetic fields, etc.

Ptychography

Exceptional single-electron SNR enables low-dose



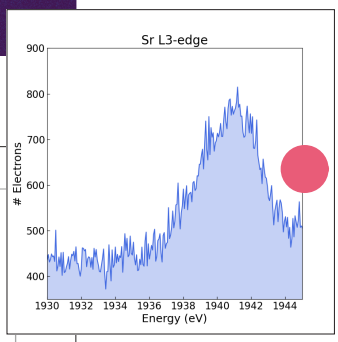


In situ TEM

High speed for visualizing fast specimen dynamics

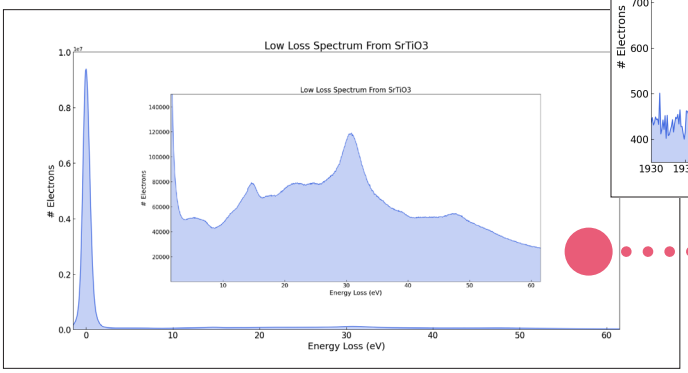
High-Resolution Imaging (HRTEM)

High MTF & sensitivity yields exceptional images



EELS

Ultra high sensitivity for high loss



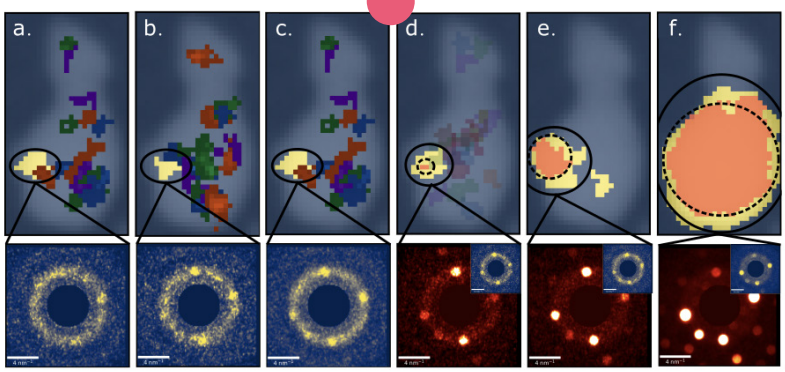
Courtesy of Dr. Mounib Bahir, Liverpool University

EELS

Dyanamic range for low loss

In Situ 4D STEM

Speed + Sensitvity for in situ 4D STEM

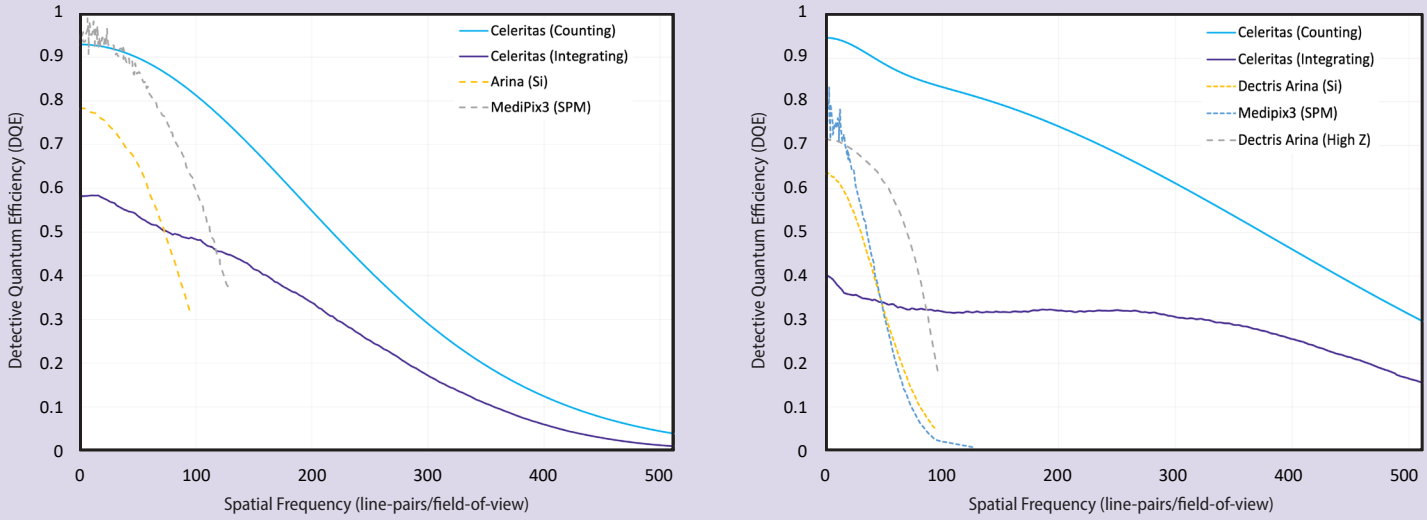


Courtesy of Paul Voyles, University of Wisconsin Madison

In situ 4D STEM at the Speed of in situ TEM

Scan	ROI	Time (sec)
256 x 256	1024 x 1024	28.9
256 x 256	512 x 512	7.6
256 x 256	256 x 256	2.1
256 x 256	128 x 128	1.16
256 x 256	64 x 64	0.667

HIGH PERFORMANCE & LARGE FIELD-OF-VIEW

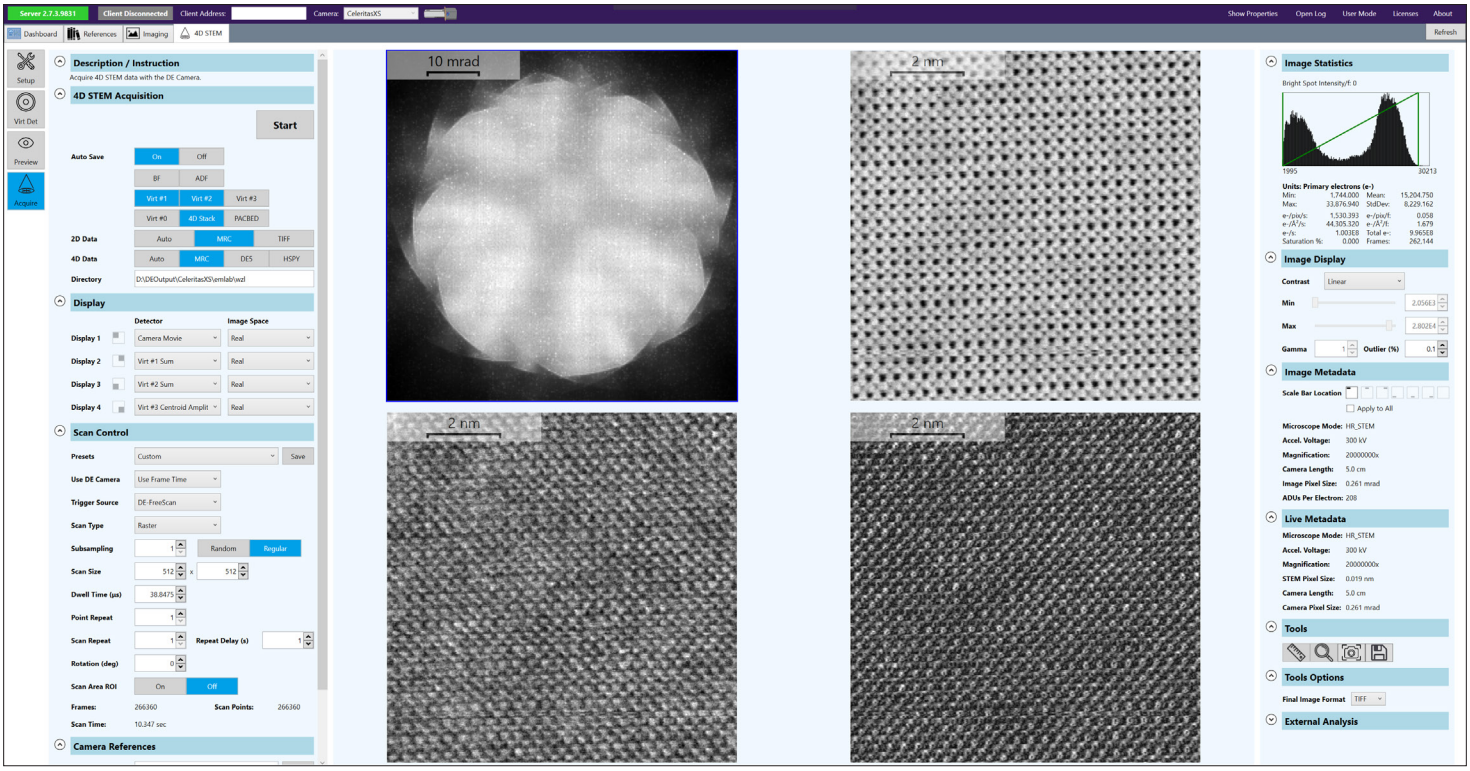


Comparison of the Detector Quantum Efficiency (DQE) for the Celeritas vs other available detectors [1-3]

DIMENSION: POWERFUL, EASY-TO-USE SOFTWARE FOR 4D STEM

DE Mission Control + *Dimension* software includes integrated control of Celeritas and the DE-FreeScan scan generator, real-time virtual image generation, visualization, and data output in formats directly compatible with popular data analysis software. Performing 4D STEM experiments has never been easier.

Plus, DE Mission Control enables imaging experiments, such as HRTEM or dynamic in situ TEM. The software also includes an API for integration with custom software.



[1] P. Zambon et al., Front. Phys. 11 (2023) 1308321. https://doi.org/10.3389/fphy.2023.1308321.
[2] P. Zambon et al. Nuc. Inst. and Methods in Physics Research Section A (2023) 167888. https://doi.org/10.1016/j.nima.2022.167888.
[3] K.A. Paton et al. Ultramicroscopy 227 (2021) 113298. https://doi.org/10.1016/j.ultramic.2021.113298.

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CELERITAS CAMERA

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TEM Electron Energy	Sensitive to 60 keV – 1.25 MeV | optimized for 200 - 300 keV
Pixel Array Specification	1024 × 1024 (1 million pixels) | 15 µm pixel pitch
Single Electron SNR	>50:1 (200 - 300 keV)
Sensor Design	Custom-designed ultra-fast DDD® sensor on-chip correlated double sampling (CDS) | backthinned | radiation hardened
Acquisition Modes	Integrating mode | electron counting mode | HDR counting mode (US patent #11,252,339)
Exposure Rate	Up to 870,000 e-/pixel/second
TEM Compatibility	All major TEM manufacturers & models | DE-FreeScan requires STEM capability
Mounting Position	Fully retractable | compatible with a wide-range of configurations typically in TEM bottom port, pre- or post-energy filter, or in JEOL film drawer
Sensor Protection	Sensor protection shutter | TEM blanking/shuttering | failsafe software
Computer System	High-performance computer | Windows 10 | Nvidia GPU(s) | up to 55 TB storage
Image Format	Non-proprietary | HDF5, MRC, TIFF, or TIFF LZW compatible with Fiji, LiberTEM, Hyperspy, Py4DSTEM, etc.
Automation Software	SerialEM | open API for custom integrations (with Python, C, C++, C#, etc.)
Integrations	CEFID post-column energy filter (CEOS) | precession diffraction (Nanomegas) | Integration with CEOS Panta Rhei
Scan Control	DE-FreeScan scan controller (also includes 4 analog detector inputs) hardware synchronization signal (BNC) | selectable as either input or output

	Celeritas XS		Celeritas
ROI	rolling	global	rolling
1024 x 1024	2,300	2,200	1,000
512 x 512	8,500	8,000	4,000
256 x 256	30,300	25,900	16,000
256 x 128	56,100	42,700	n/a
256 x 64	98,000	63,300	n/a

Frame rates are rounded to three significant digits.
*Optional off-chip CDS and/or simultaneous HDR readout modes operate at reduced frame rate.