DE-64 Camera System

exceptional DQE & enormous area for cryo-EM

delivering | bigger | better | faster | cameras for electron microscopy

Direct Electron®

INNOVATION PROPELLING DISCOVERY

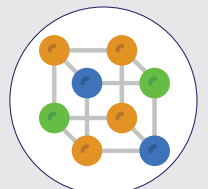## Direct Detection for Transmission Electron Microscopy

- The most advanced direct detection sensors, delivering high speed, extraordinary resolution, and ultra-low noise.

- Superior DQE delivers higher resolution for cryo-EM.

- 8k × 8k (67.1 million) pixels.

- Electron counting with large pixels & CDS for the very best image quality.

- Movie-mode imaging for motion correction, dose filtering, etc.

- Continuous streaming for microED (diffraction) & continuous-tilt tomography.

- High-dynamic range, global shutter readout, & integrating mode for microED.

- The most impactful and cost-effective upgrade to a TEM's capabilities.

Cryo-EM at 2.3 Å resolution structure of lumazine synthase from the DE-64 counting on a JEOL CryoARM300.
Figure courtesy of David Bhella (University of Glasgow, Glasgow, Scotland, UK).
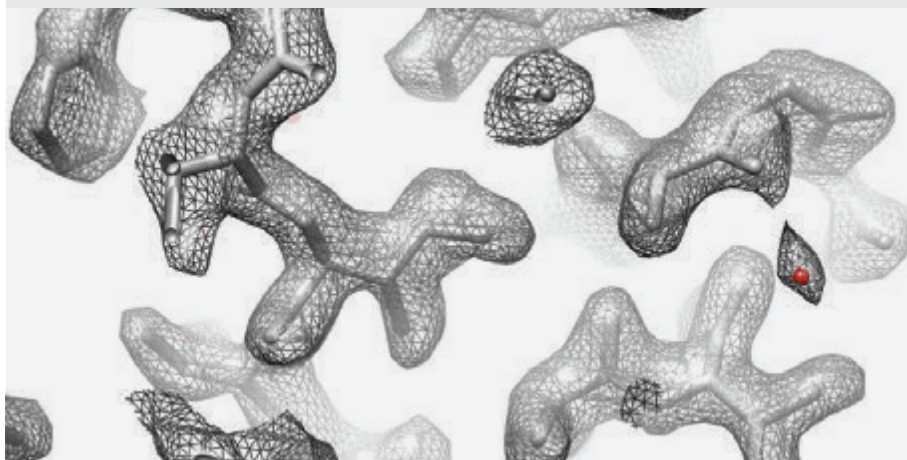
Applications

MATERIALS

BIOLOGY

Optimized for Ultra-High-End Cryo-EM Applications

High-Throughput Automation
ultra-large search mode images without montaging

High-Resolution Single-Particle
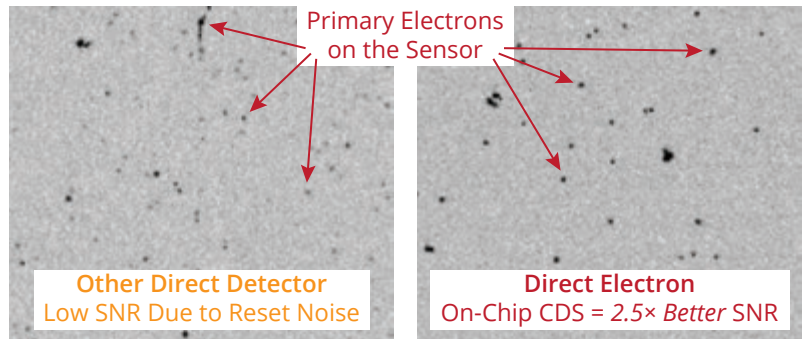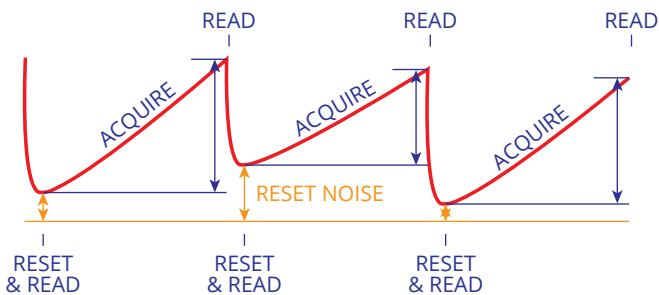counting with large-pixels & CDS maximizes DQE

Continuous-Tilt Tomography
tilt-series acquisition in under 3 minutes

Conventional Cryo-Tomography
enormous area with high resolution

MicroED (Diffraction)
high dynamic range & large area for crystallography

The Most Advanced Direct Detection Sensor Technology

on-chip **correlated double sampling (CDS)**
dramatically improves sensitivity by subtracting reset noise that plagues other CMOS sensors

READ READ READ

ACQUIRE ACQUIRE ACQUIRE

RESET NOISE

RESET & READ RESET & READ RESET & READ

Primary Electrons on the Sensor

Other Direct Detector
Low SNR Due to Reset Noise

Direct Electron
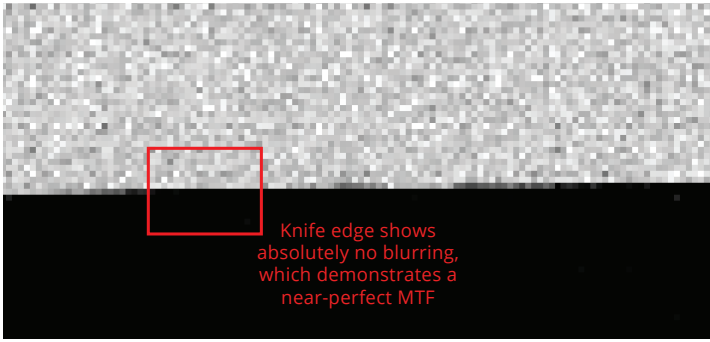On-Chip CDS = *2.5× Better* SNR

Direct Electron's DDD® sensors have ultra-low noise, which is clearly demonstrated by visualizing individual 300 keV electrons. TEM primary electrons clearly stand-out from the background on the Direct Electron sensor, while they are often lost in the background of other sensors. *Figure courtesy of Greg McMullan, (MRC-LMB, Cambridge, UK).*

The DE-64 delivers ultra-high DQE(0) because electron events are easily distinguishable from background. The counting threshold is thus highly effective.

Background: 99.9% below the threshold

Threshold

Electron events: 99.8% above the threshold
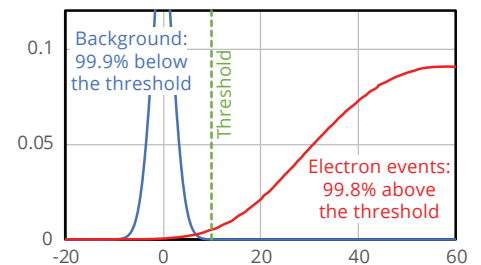
Large-Pixel Electron Counting Delivers Near-Perfect MTF

Knife edge shows absolutely no blurring, which demonstrates a near-perfect MTF

Hardware binning by 2× on the DE-64 delivers two key benefits: (1) it matches the pixel size to the event size of electrons on the sensor, eliminating uncertainty in the location of each incoming electron, and (2) it increases the camera frame rate so that single-particle exposures are approximately 8-12 seconds.
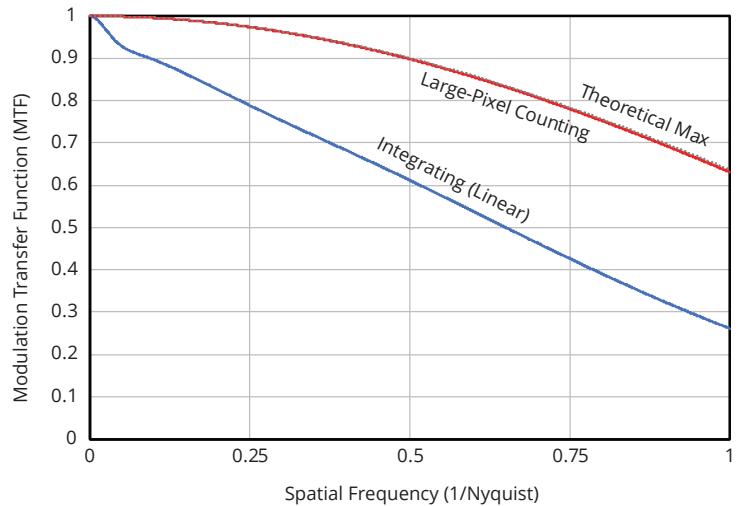
Elegantly-Designed to Maximize Scientific Productivity

integrated Faraday plate
for exposure measurement
with each acquisition
(US Patent 7,952,073)

sensor protection shutter
to protect the direct detection
sensor from undesired exposure
(US Patent 7,952,073)

**high-performance
10th generation
DDD® sensor**
custom-designed
and manufactured
by Direct Electron

**precision-
engineered parts**
that are widely
compatible with
TEMs from many
manufacturers

field-replaceable sensor
to maximize instrument
uptime over the lifetime
of the camera

fully retractable
to enable use of other cameras
and/or an energy filter mounted
under the DE camera

no sliding O-rings
to prevent vacuum "hiccups"
during insertion/retraction
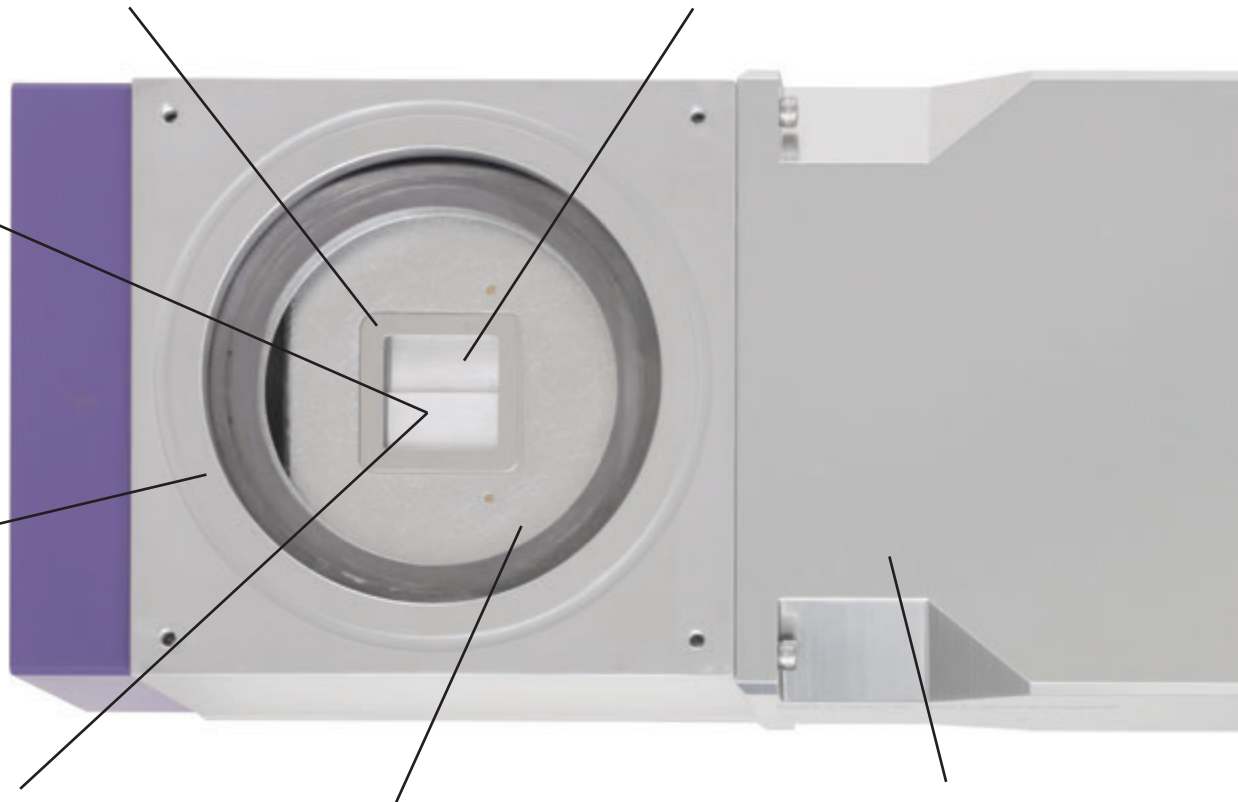
|	
TEM electron energy	sensitive to 80 keV − 1.25 MeV | optimized for 200 & 300 keV
pixel array specification	8192 × 8192 (67.1 million pixels) | 6.5 µm pixel pitch
single electron SNR	~50:1 (300 kV)
sensor design	>3T pixel design with on-chip correlated double sampling (CDS) backthinned | radiation hardened | rolling or global shutter
acquisition frame rate	42 fps max, unbinned full-frame | 141 fps max, binned-2× full-frame, low-noise subarray readout up to 4,512 fps (4096 × 128) | user-selectable hardware frame rate
acquisition modes	integrating mode | counting mode (with optional counting system)
exposure rate	large dynamic range with consistent performance (e.g., >500 e⁻/pixel/s)
mounting position	fully retractable | mounted on-axis TEM bottom port or in JEOL film drawer
exposure measurement	integrated Faraday plate for exposure measurement with each acquisition
sensor protection	integrated sensor protection shutter | TEM blanking/shuttering | failsafe software
computer system	high-performance computer | Windows 10 | NVidia GPU(s) | up to 80 TB storage
image format	non-proprietary to ensure broad compatibility | TIFF, MRC, AVI, MP4, etc.
acquisition software	DE Mission Control software for advanced image/movie acquisition and analysis application specific software modules for 4D-STEM and in situ acquisition (optional)
automation	compatibility: SerialEM | Leginon | EMTools (TVIPS) | JADAS (JEOL) | others customization: software development kit (SDK) for integration with custom software

Integrating (Linear) Mode
best for single particle analysis of viruses and large complexes
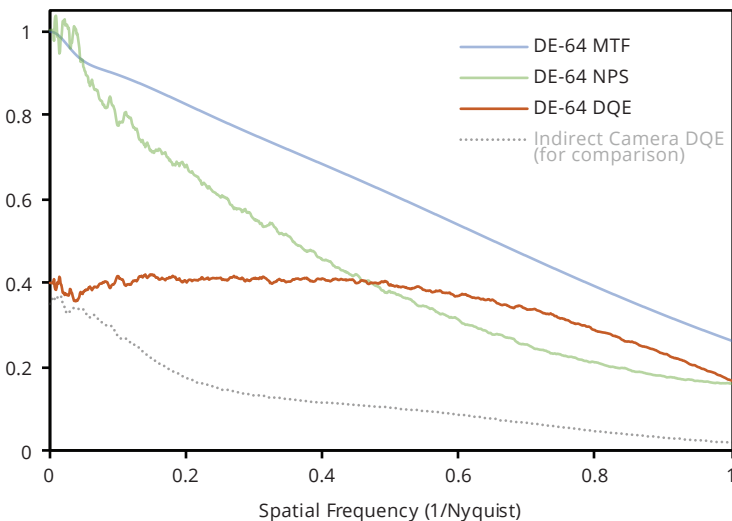
Electron Counting Mode
best for single particle analysis of small and/or challenging proteins
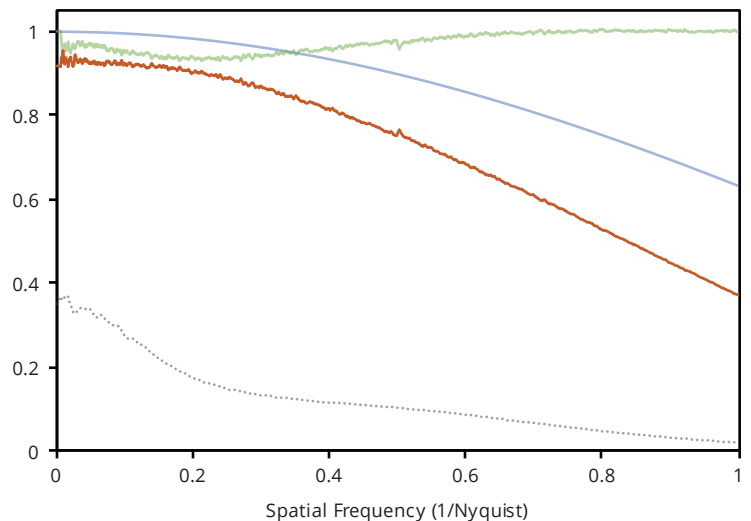
DQE curves are shown for 300 kV electrons | Counting Mode DQE is with 2×-binning and assuming a flat NPS | Specifications and performance are subject to change.
Example images of various camera applications were collected by researchers using one of Direct Electron's cameras (not necessarily the DE-64).