



# DE-64 Camera System

exceptional DQE & enormous area for cryo-EM

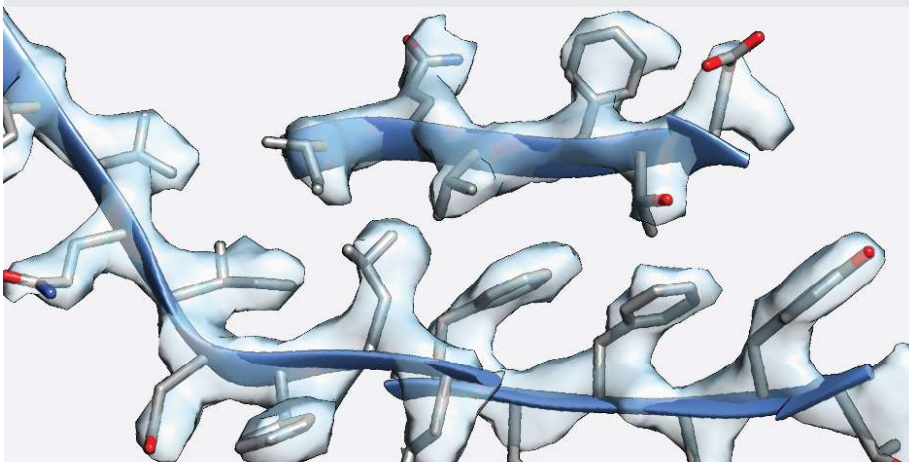
delivering | bigger | better | faster | cameras for electron microscopy

## Direct Detection for Transmission Electron Microscopy

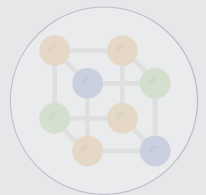
- Direct detection device (DDD<sup>®</sup>) delivers ultra-high speed, extraordinary resolution, and ultra-low noise.
- The most advanced direct detection sensor technology available for cryo-EM.
- 8k × 8k (67.1 million) pixels.
- Exceptional image quality plus movie-mode imaging for motion correction, dose filtering, etc.
- Electron counting for the very best signal-to-noise.
- Unrivaled features, with an integrated survey sensor and Faraday plate.
- High-dynamic range and ultra-large area for tomography.
- The most impactful and cost-effective upgrade to a TEM's capabilities.



Cryo-EM at 2.8 Å resolution (~87% Nyquist, from a DE camera in integrating mode) of chimeric AAV-DJ with a Heparanoid Pentasaccharide.  
*Figure courtesy of Scott Stagg, (Florida State University, Tallahassee, FL, USA).*



Applications



MATERIALS



BIOLOGY

Direct Electron<sup>®</sup>  
INNOVATION PROPELLING DISCOVERY

# Optimized for Ultra-High-End Cryo-EM Applications

## High-Throughput Automation

ultra-large search mode images without montaging

## Electron Counting

large-pixel technology with CDS maximizes DQE

## High-Throughput Single-Particle

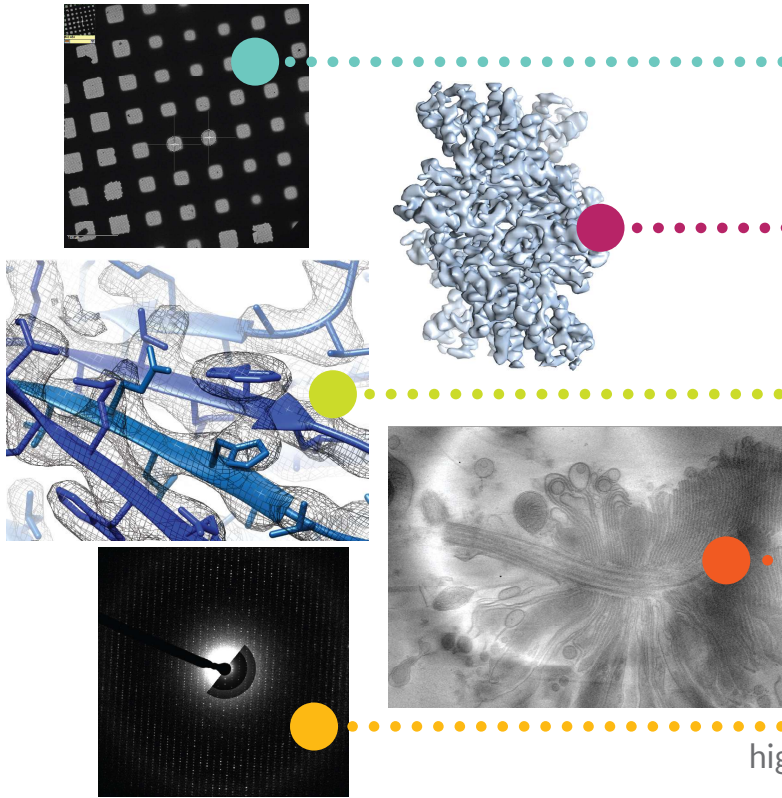
8k x 8k images = 4x more particles per image

## Cellular Tomography

enormous area with high resolution

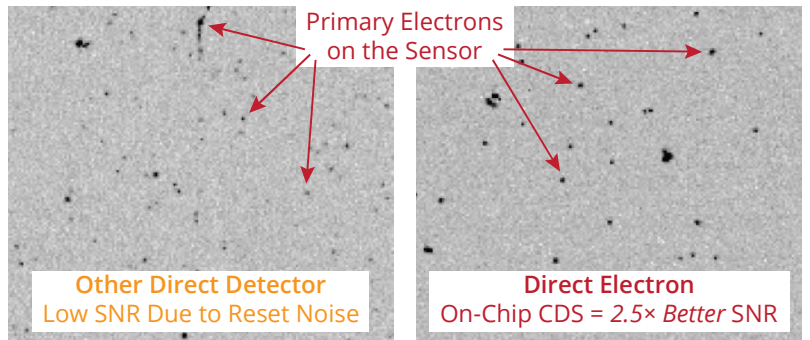
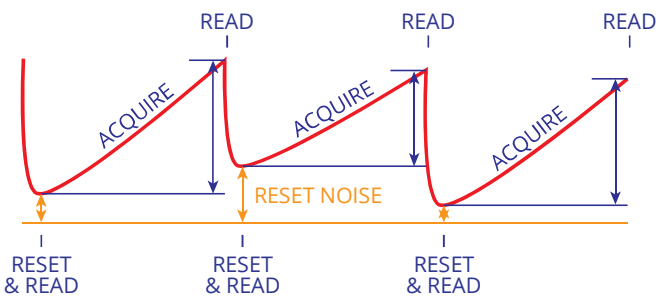
## MicroED (Diffraction)

high dynamic range and large area for crystallography



# The Most Advanced Direct Detection Sensor Technology

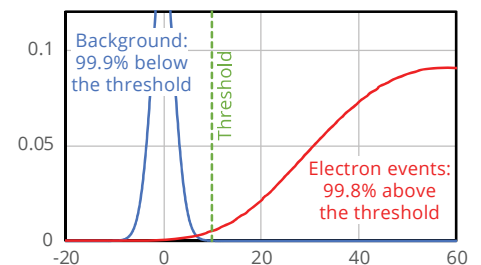
*on-chip* correlated double sampling (CDS) dramatically improves sensitivity by subtracting reset noise that plagues other CMOS sensors



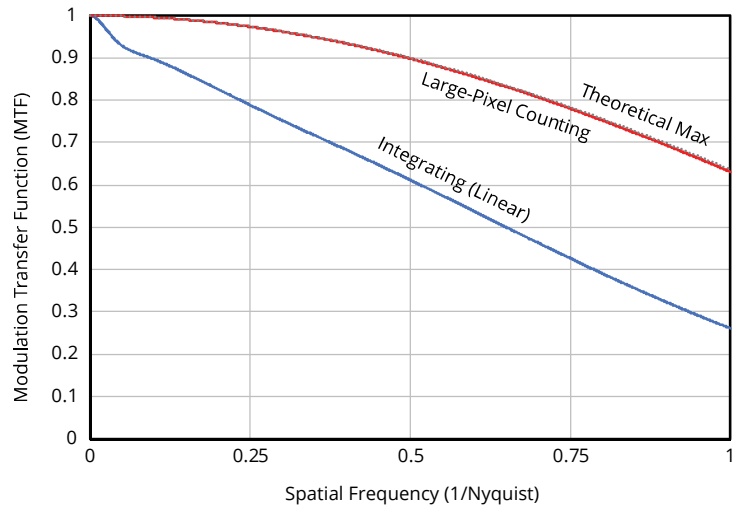
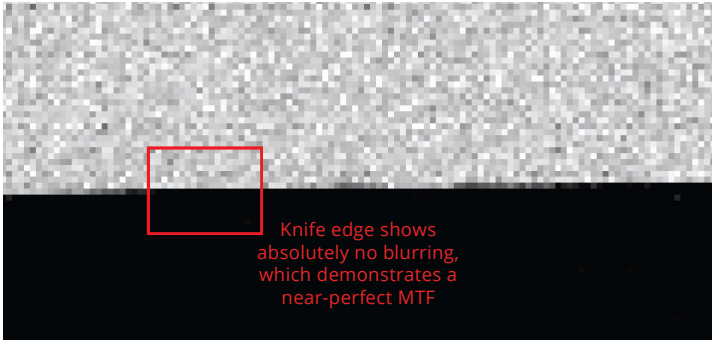
Direct Electron's DDD<sup>®</sup> sensors have ultra-low noise, which is clearly demonstrated by visualizing individual 300 keV electrons. TEM primary electrons clearly stand-out from the background on the Direct Electron sensor, while they are often lost in the background of other sensors. *Figure courtesy 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.



# Large-Pixel Electron Counting Delivers Near-Perfect MTF



Hardware binning by 2x 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

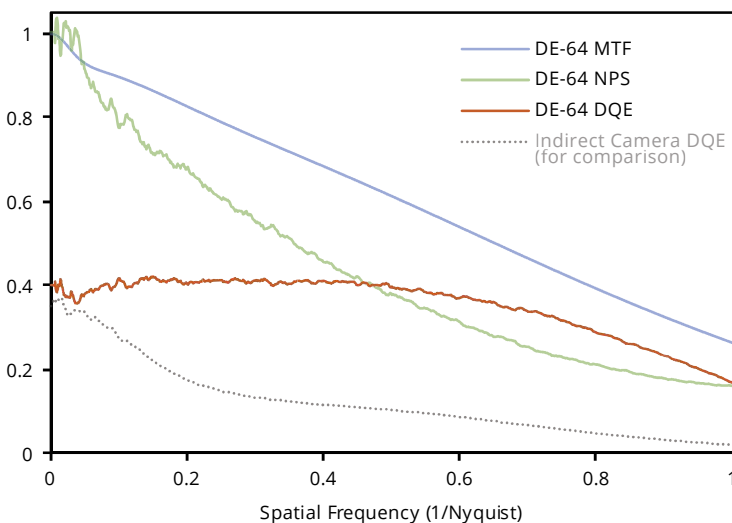
- integrated Faraday plate** for exposure measurement with each acquisition  
*(US Patent 7,952,073)*
- sensor protection shutter** to protect the direct detection sensor from undesired exposure  
*(US Patent 7,952,073)*
- indirect survey sensor** for ancillary imaging operations (e.g., alignment, search, focus)  
*(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

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<b>TEM electron energy</b>	sensitive to 80 keV – 1.25 MeV   optimized for 200 & 300 keV
<b>pixel array specification</b>	8192 × 8192 (67.1 million pixels)   6.5 μm pixel pitch
<b>single electron SNR</b>	~50:1 (300 kV)
<b>sensor design</b>	>3T pixel design with on-chip correlated double sampling (CDS) backthinned   radiation hardened
<b>acquisition frame rate</b>	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
<b>acquisition modes</b>	integrating mode   counting mode (with optional counting system)
<b>exposure rate</b>	large dynamic range with consistent performance (e.g., >500 e <sup>-</sup> /pixel/s)
<b>mounting position</b>	fully retractable   mounted on-axis TEM bottom port or in JEOL film drawer
<b>"buddy" camera</b>	integrated near-axis 2048 × 2048 scintillator-coupled survey sensor
<b>exposure measurement</b>	integrated Faraday plate for exposure measurement with each acquisition
<b>sensor protection</b>	integrated sensor protection shutter   TEM blanking/shuttering   failsafe software
<b>computer system</b>	high-performance computer   Windows 10   NVidia GPU(s)   up to 58 TB storage
<b>image format</b>	non-proprietary to ensure broad compatibility   TIFF, MRC, AVI, MP4, etc.
<b>acquisition software</b>	image acquisition: DE-IM (full-featured, modern GUI)   ImageJ / μManager streaming acquisition: DE-StreamPix (realtime, continuous display and recording) automation: SerialEM   Leginon   EMTtools (TVIPS)   JADAS (JEOL)   others customization: software development kit (SDK) for integration with custom software

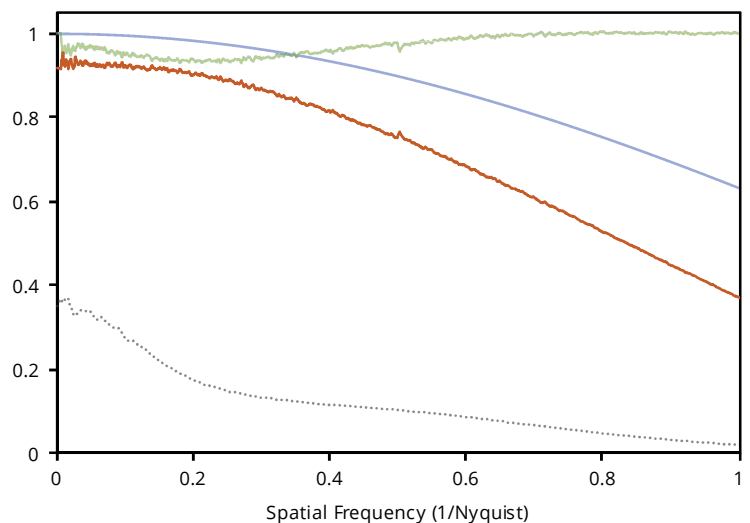
## Integrating (Linear) Mode

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).