

Falcon 4 Direct Electron Detector

Enhance productivity with high throughput and the best image quality

The Falcon 4 Detector is the next step in direct electron detection; for the first time a large pixel layout (14 μm), a high signal-to-noise ratio and enhanced speed have been combined for optimized productivity.

The Thermo Scientific™ Falcon™ 4 Direct Electron Detector has an improved (electron counting) detector quantum efficiency (DQE) over the entire spatial frequency range, combined with a 10-times shorter exposure time than its predecessor.

The new optimized chip design is based on the proven large pixel layout of the Falcon product range (14 μm), further improving the unsurpassed low-noise levels while improving electron localization for reduced coincidence noise. Combined with the increased internal framerate (250 fps), this allows collection of the best quality images with a high throughput.

The Falcon 4 Detector is fully integrated in Thermo Scientific EPU and Tomography Software. To further enhance productivity and ease of use, the camera comes with a new data management platform (DMP) which hosts EPU Data Management (powered by Thermo Scientific Athena Software), allowing easy organization of large datasets and streamlined interfacing with your image processing system.

The new optional EPU Quality Monitor is an on-the-fly pre-processing tool (for motion correction and CTF estimation, including derived parameters) for evaluation of the acquired SPA data during the actual acquisition process. This allows users to judge the quality of the acquired data and optimize the data acquisition while it is happening.

With its unique combination of highest image quality, high throughput and a streamlined solution for data management and quality monitoring, the Falcon 4 Detector enables the productivity boost required by today's leading scientific and industrial communities.

Key benefits

Best imaging quality

- Highest DQE over the entire spatial frequency range – ideally suited for small or difficult to detect proteins
- Optional EPU Quality Monitor for on-the-fly quality assessment

High throughput for faster results

- 10 times shorter exposure times than its predecessor
- Next generation controller for minimized offload times
- Optimized for small coincidence loss

Ease of use

- Fully embedded in Thermo Scientific EPU and Tomography Software, guaranteeing smooth daily operation
- Built-in EPU Data Management (powered by Athena Software) offers easy project administration and automated organization of images and metadata for remote and collaborative access, all while maintaining full backward compatibility with existing workflow setups

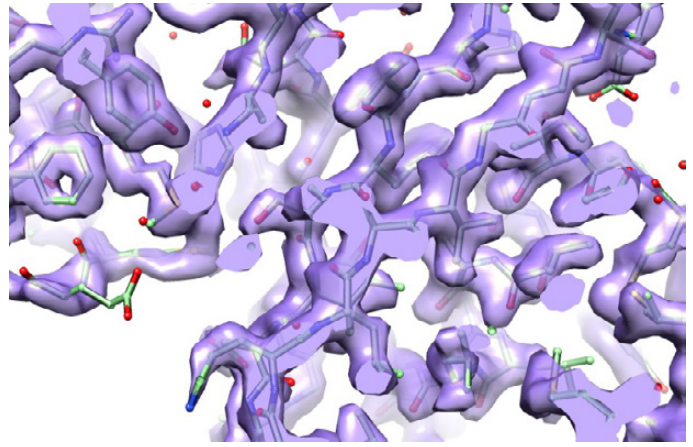
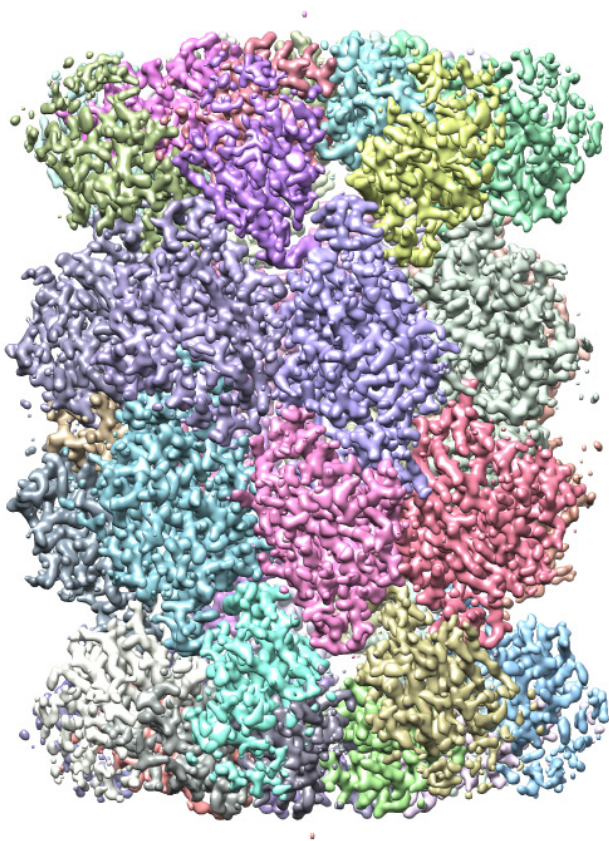


Figure 1. 3D reconstruction of the 20S proteasome from *Thermoplasma acidophilum* at 2.0 Angstrom resolution. Data collected on the Krios G4 Cryo-TEM with Falcon 4 Direct Electron Detector. Image courtesy of Dr. Juergen Plitzko and Dr. Philipp Erdmann, Max Planck Institute for Biochemistry, Martinsried, Germany.

Best image quality

The Falcon 4 Detector is the newest camera on the market, featuring a high signal-to-noise, large-pixel design. The readout speed has been increased to 250 fps while maintaining the extremely low noise levels that the Falcon cameras are known for. Thanks to a sensor redesign, the electron event localization was further improved, resulting in reduced coincidence noise. When combined with the intrinsically low noise level of the detector, incoming electrons are detected with:

- A large detection probability, resulting in an unsurpassed DQE at low spatial frequency (DQE(0) = 0.9)
- A large detection accuracy, providing unsurpassed DQE at higher spatial frequencies (DQE($\frac{1}{2}$ Nq) = 0.75, DQE(1 Nq) = 0.35)

Overall, the DQE over the entire frequency range was improved, making the Falcon 4 Detector ideal for fast, high-resolution reconstructions of a wide range of particle sizes. In particular, the unsurpassed DQE at low frequencies makes it ideally suited for small or difficult to detect proteins.

High throughput for enhanced productivity

The 6x higher internal frame rate, in combination with improved electron event localization, yields exposure times that are reduced up to 10-fold as compared to the previous generation detector. In addition, for each exposure, significant times savings have been realized on overhead (dark image recording, offloading the data from the camera). Overall, this significantly boosts data throughput, leading to faster results and subsequently the need for less microscopy time.

Additionally, the Falcon 4 Detector has a non-interfering, reactive dose-protection mechanism, which avoids the need for repetitive calibrations when changing optical settings. This is enabled by the improved frame rate and improved frame rate (less dose per frame) and improved radiation hardness of the Falcon 4 Detector, causing it to be less prone to damage. Ultimately, the new dose protector concept facilitates an easier and faster experimental set-up.

Ease of use

The Falcon 4 Detector is fully integrated in the EPU and Tomography Software, allowing for smooth daily instrument operation and data acquisition. For single particle analysis, the hardware delivered with the Falcon camera now enables a data management and optional on-the-fly pre-processing solution.

EPU Data Management (powered by Athena Software) comes pre-installed and facilitates the organization, viewing and sharing of single particle cryo-EM data. EPU streams data and metadata directly to a project, which is set up prior to the starting of an experiment. You can easily view all the project data and metadata at the microscope, or remotely through a secure connection, and comment or share it with your collaborators.

Single particle analysis data acquisition can be further augmented with the optional EPU Quality Monitor which processes incoming EPU data on-the-fly. Drift correction and CTF estimation (including derived parameters such as defocus, phase shift, astigmatism, etc.) are visualized, allowing ongoing analysis of incoming image quality. Based on its results, you can optimize acquisition parameters and filter data sets according to quality indicators.

In combination with the Falcon 4 Detector, these solutions help to generate high-quality results quickly, with confidence, and with the same ease of use for which EPU Software is known.

System requirements

The Falcon 4 Detector is available on Krios, Glacios, and Talos platforms (running under Windows® 10) at 200 kV and 300 kV.

Key specifications					
Camera architecture	Direct electron detection				
Sensor size	4,096 × 4,096 pixels ~ 5.7 x 5.7 cm				
Pixel size	14 x 14 μm ²				
Operating voltage	200 kV, 300 kV				
Mounting position	On-axis, bottom mounted, retractable				
Frame rate	250 fps				
Lifetime	5 years in normal use (1.5 Gpe yields <10% DQE degradation)				
Detection modes	EC	Electron counting			
	Linear	Integration mode			
Imaging performance 4k x 4k DQE Pixel size: 0.75 Å; Total dose: 40 e-1/Å ²					
Mode	Dose rate (e/p/s)	Exp time (s)	DQE (0)	DQE (1/2 Nq)	DQE (1 Nq)
EC mode	2	11	0.90	0.75	0.35
EC mode	5	4.5	0.80	0.65	0.30
Linear mode.	20–100	0.2–1.0	0.50	0.40	0.25

