

A DEPFET detector for Athena's Wide Field Imager (WFI) Instrument



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The WFI instrument onboard of *Athena* will use active pixel sensors of DEPFET (Depleted P-channel field effect transistor) type which combine sensor and amplifier function in each pixel.

A special silicon process technology and transistor design had to be developed for these back-illuminated large sensor arrays with full sensitivity over their 450 μm thickness. The technology allows also depositing an optical blocking filter on the photon entrance window of the sensor chip.

A DEPFET detector consists essentially of the DEPFET sensor pixel array, the so-called Switcher-A ASICs for its control, and the so-called Veritas-2 (VERsatile Readout based on Integrated Trapezoidal Analog Shapers) ASICs, which perform the signal readout. All three key components have been tailored to the WFI instrument.

This detector system offers very fast imaging and excellent spectroscopy of X-ray photons with low-noise performance and high detection efficiency from 0.2 keV to 15 keV, mostly above 90%.

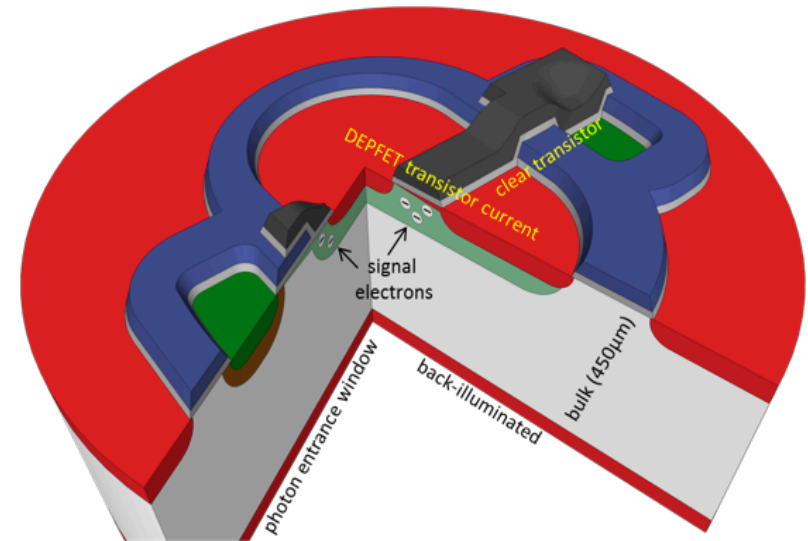
Such a DEPFET detector operated in rolling shutter mode is faster than X-ray CCDs because no charge transfer is needed. The signal is read out directly in the pixel where it has been stored and the readout is performed in parallel for all pixels of a line.

With this detector concept, the scientific and technical requirements of the *Athena* project to the WFI instrument can be met. The focal plane of WFI comprises a Large Detector Array (LDA) with over 1 million DEPFET pixels, subdivided into four quadrants, spanning the 40 arcmin \times 40 arcmin field of view. The pixel size of 130 μm \times 130 μm permits oversampling of the mirror PSF by a factor >2 . The LDA is complemented by a 64 \times 64 pixel Fast Detector (FD), also of DEPFET type, but further optimized for high count rate applications. It enables a pile-up of $<1\%$ and a throughput of $>80\%$ at 1 Crab source intensity.

This is feasible by the extraordinary readout speed of the WFI DEPFET detector, which results for the LDA in a time resolution of 5 ms and for the fast detector in even 80 μs , i.e. a frame rate of 12,500 per second. The time resolution can be even further improved by operation in window mode.

Tests with *Athena* WFI prototype detectors demonstrated in the current technology development phase of the project an excellent performance yielding for example a low read noise of 2-3 electrons rms and an excellent energy resolution (FWHM) of <60 eV at 277 eV line energy and 160 eV at 11 keV.

The detector development is carried out by the Max Planck Institute for Extraterrestrial Physics. The DEPFET sensors are produced at MPG HLL.



Each pixel accommodates a DEPFET transistor in its center whose current is proportional to the number of signal electrons which are generated by an X-ray photon and stored in the so-called internal gate. A second transistor clears the signal electrons and restores the original current level that flows without signal electrons. Credit: WFI Team