

A new type of Active Pixel Sensor (APS) is capable to meet the unprecedented requirements for the central Wide Field Imager (WFI) instrument of ESA's future XEUS mission: simultaneous energy and position resolved detection of X-rays with high quantum efficiency at high count rate on a large format sensor. First prototypes of the APS have been produced and tested in the MPI Semiconductor Laboratory.

The X-ray Evolving-Universe Spectroscopy (XEUS) mission is under study by the European Space Agency ESA as follow-up to the XMM-Newton satellite. XEUS consists of a Mirror Spacecraft (MSC) with an aperture of several m<sup>2</sup> and a Detector Spacecraft (DSC) aligned to a focal length of 50 m. The DSC carries two high-resolution cryogenic Narrow Field Imagers (NFIs) and a Wide Field Imager (WFI). The WFI will perform deep surveys, positioning sources for the NFIs and measuring their broad band spectra. The WFI requirements are high efficiency with moderate energy resolution and large field of view (FOV). They are achieved by the combination of three complementary imaging spectrometers:

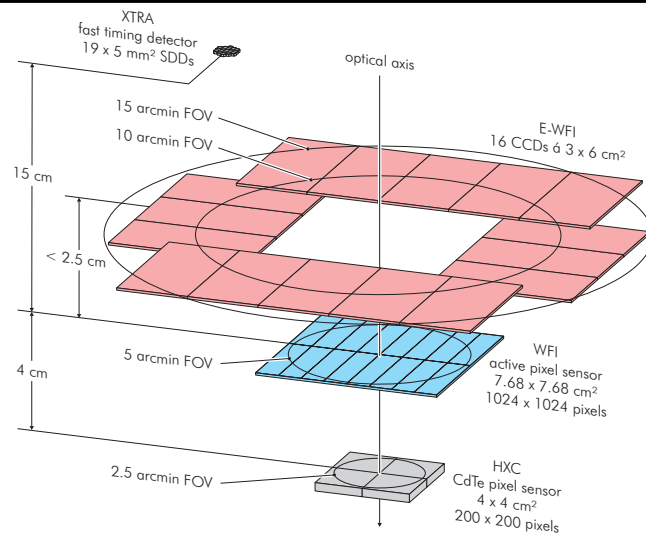


Fig. 1: Layout of the XEUS WFI focal plane. Vertical distances are not to scale.

Because of the high photon throughput, the central region, where pointing targets will be located, requires the use of a fast **Active Pixel Sensor (APS)**. The size of the APS is such as to cover a 5 arcmin section of the FOV. As the XEUS mirror will have a good off-axis performance the FOV is extended to a diameter of almost 15 arcmin by a frame of CCDs around the central APS. This **Extended Wide Field Imager (E-WFI)** area significantly increases the number of scientific objects per deep field observation. The **Hard X-ray Camera (HXC)** consisting of a pixelated CdTe array is placed behind the APS and will detect the high-energy X-rays that penetrate the APS without interaction.

In addition to the imaging spectrometers the WFI includes the **Fast Counting Spectrometer XTRA** to perform studies of time-variable point sources. Figure 1 shows the arrangement of the XEUS WFI instruments.

Two of these systems are under development at the MPI Semiconductor Laboratory:

The central **WFI instrument** is an **Active Pixel Sensor (APS)** based on the integrated amplifier DEPFET. The APS has a format of 1024 x 1024 pixels with a pixel size of 75 x 75 μm<sup>2</sup>. It is made monolithically on 450 μm thick, fully depleted silicon and backside illuminated with a 100% fill factor. The DEPFET principle allows for random accessible pixels with flexible readout modes (full frame, windowing, fast timing). Due to parallel readout the full frame readout time is in the order of few msec. At present 64 x 64 APS prototypes of the first production batch are under test. The measured electronic noise of 5 electrons ENC at an operation temperature of -60°C is already close to the XEUS specifications.

Next to the XEUS primary scientific goals the telescope's large aperture will be used to collect X-rays from time-variable objects with a periodicity in the msec range. To perform timing studies the dedicated **instrument XTRA** (XEUS Timing for Relativistic Astronomy) is integrated in the WFI. As the time-variable objects are among the brightest sources the detection system must be able to handle count rates up to 10<sup>7</sup> per sec with a timing resolution of 10 μsec and a simultaneous energy resolution in the order of 300 eV (FWHM at 6 keV). The detector for XTRA is a monolithic array of 19 **Silicon Drift Detectors (SDDs)**, each 5 mm<sup>2</sup> large. Each SDD cell in combination with high-rate readout electronics is able to operate at an incoming rate of 1 million photons per sec with an energy resolution of 250 eV (FWHM at 6 keV).

**Reference:** X-ray Evolving-Universe Spectroscopy – The XEUS Instruments, ESA-Report SP-1273, Nov. 2003