XTRA – XEUS Timing for Relativistic Astronomy

The XTRA (XEUS Timing for Relativistic Astronomy) instrument aboard ESA's projected XEUS mission is designed to measure count rates up to 10 million X–ray photons per sec with a time resolution of 10 µsec and an energy resolution in the order of 300 eV FWHM for a 6 keV line. This detector, an array of Silicon Drift Detectors, is developed at the MPI Semiconductor Laboratory.

The X-rays generated in the inner accretion flows around black holes and neutron stars carry information about regions of the strongly curved space-time in the vicinity of these objects. This is a regime in which important predictions of the theory of general relativity are still to be tested. Both high resolution X-ray spectroscopy and fast timing studies can be used to diagnose the orbital motion of the accreting matter in the immediate vicinity of the collapsed star, where the effects of strong gravity become important.

Due to its unprecedented collecting area in the order of 10 m², the XEUS telescope will enable timing studies with extremely good photon statistics. The detector for the XTRA instrument is a monolithic array of 19 Silicon Drift Detectors (SDDs) developed at the MPI Semiconductor Laboratory (figure 1). Each detector cell has a sensitive area of 5 mm² and the front-end transistor of the amplifying electronics is integrated on the detector. A single SDD cell in combination with high-rate readout electronics is able to provide an energy resolution of 250 eV (FWHM at 6 keV) at an incoming rate of 10^6 photons per sec (figure 2). SDDs have demonstrated to be radiation hard with respect to hard X-rays up to an integrated dose of 10^{13} absorbed photons (18 keV), corresponding to 3 years of continuous operation with a constant rate of 10^5 per sec. SDD arrays of this type exist and are used in various X- and γ-ray spectroscopy systems.

The enormous flux of photons will be distributed over the full detector area by placing the detector 15 cm out of the focal plane, either by mechanical construction or by displacement of the detector spacecraft. To extend the XEUS fast timing capability to higher energies it is considered to place a high-Z semiconductor detector, e.g. CdTe or CZT, underneath the SDD array.

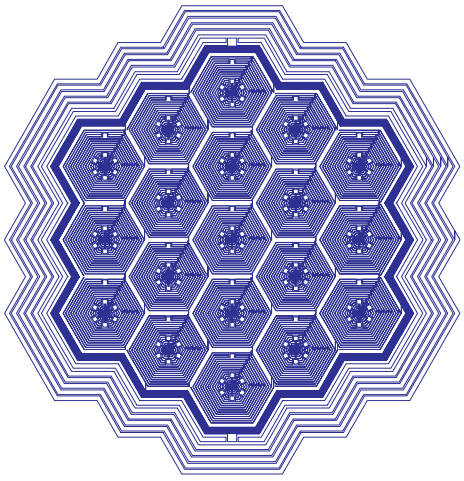

Fig. 1: Layout plot of a 19 cell SDD. Each detector cell has a sensitive area of 5 mm². The first stage of the amplifying electronics is integrated in the hexogonal cells' centers.

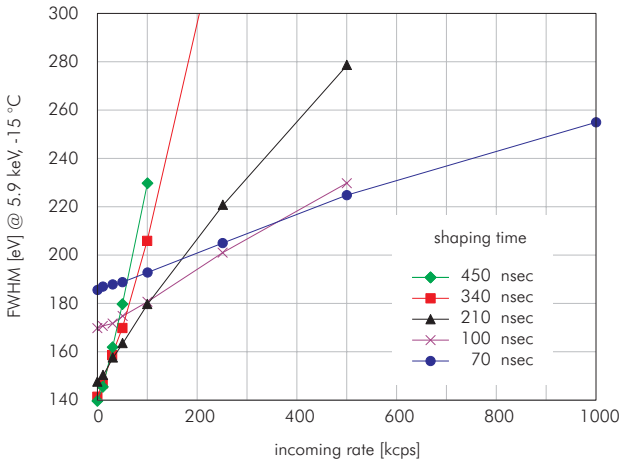

Fig. 2: Measured count rate capability of a SDD. For the extremely short pulse shaping time of 70 nsec the energy resolution is still 250 eV (FWHM @ 5.9 keV) at an incoming photon rate of 10^6 per sec.

References:

- X-ray Evolving-Universe Spectroscopy – The XEUS Instruments, ESA-Bulletin SP-1273, Nov. 2003
- L. Strüder, D. Barret, C. Fiorini, E. Kendziorra, P. Lechner, Fast Timing on XEUS, Proc. of the SPIE vol. 5165 no. 1 (2004), pp. 19-25

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