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Overview of the X-ray astronomical imaging detectors

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An astronomical X-ray imaging system combining an X-ray mirror and an X-ray imager began with the Einstein observatory launched in 1978. In this satellite, an imaging proportional counter was used as the focal plane detector of the Wolter type I X-ray focusing mirror. Following the Einstein observatory, ROSAT, ASCA and BeppoSAX were equipped with imaging gas counters.
In order to improve the spectral performances, a photon counting type of X-ray CCD camera was developed. ASCA is the first X-ray satellite equipped with an X-ray CCD camera and opened a new era of X-ray astronomy. Along with the progress of the development of X-ray mirrors, X-ray CCDs having a larger formant, a thick depletion layer and backside illumination were developed and used as the formal plane detectors of the Chandra, XMM-Newton, Suzaku and Hitomi satellites. An X-ray CCD is the standard imager of modern X-ray astronomical satellites in orbit.

The weak point of X-ray CCD is its low readout speed. X-ray CCD is unable to observe a bight X-ray source because of the pile-up problem. Therefore, several types of active pixel sensors with fast readout, DEPFET, pnCCD, Hybrid, bulk CMOS, and CCD with CMOS readout, are being developed for future X-ray satellites equipped with X-ray mirrors having large collecting area and high angular resolution.

Non-X-ray background due to cosmic-rays in orbit is the major problem for the imaging spectroscopy in the X-ray energy band above 10 keV, Anti-coincidence with the shield counters is used to reduce the background. This technique requires the imagers to be equipped with a time resolution higher than 10 usec. Thus, the double-sided silicon strip detectors (DSSD) and SOI pixel detectors with the event-driven readout have been developed. The cross-section of photoelectric absorption in silicon is smaller than that of Compton scatter above 50 keV. CdZnTe and CdTe detectors are standard in the energy band. CdZnTe pixel detectors and hybrid detectors of DSSD and CdTe and realized in orbit by NuSTAR and Hitomi, respectively.

Primary author: TSURU, Takeshi (Kyoto University)

Presenter: TSURU, Takeshi (Kyoto University)

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