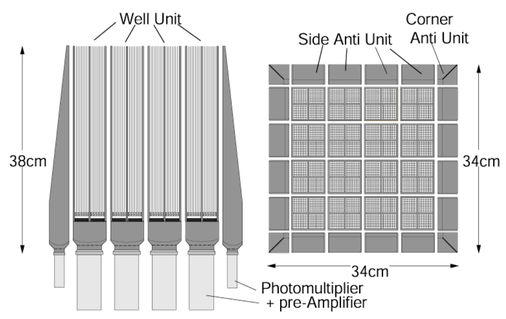
The Current Status of HXD on board Suzaku

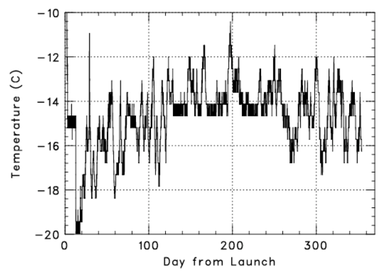
Motohide Kokubun, and the Suzaku HXD team

Department of Physics, University of Tokyo

Introduction & Initial C

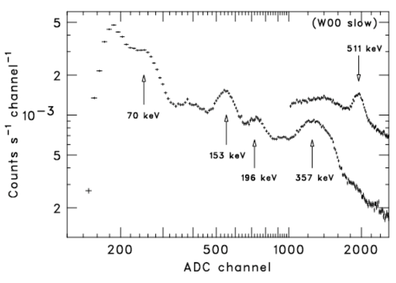


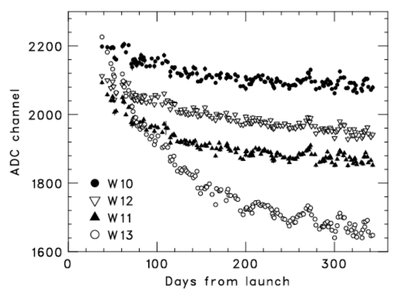
Key concept: Low detector background with:
- Compound-eye configuration of well-type phoswich units.
- Thick active shields surrounding the main detection part.
- Wide energy range (10-600 keV) with PIN-Si + GSO.

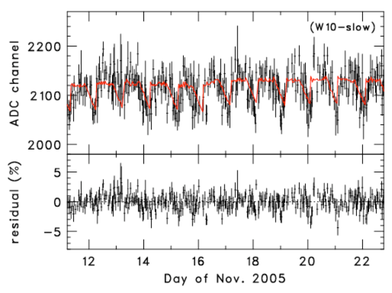


The temperature history of HXD sensor, for about a year from the launch. A few degree scale variation is caused by an incomplete heat transfer of the heat-pipe.

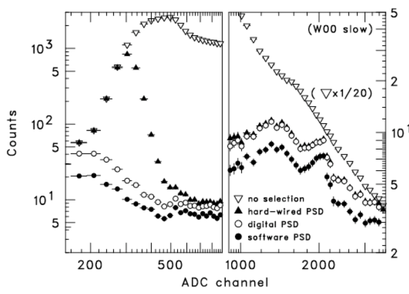
GSO performance

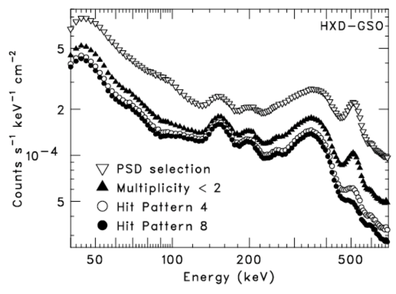


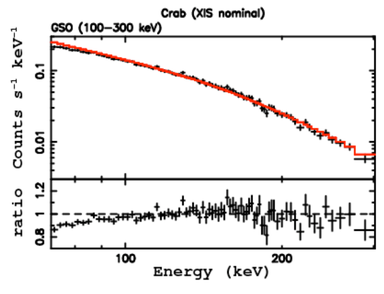




In-orbit energy scale and gain variation of individual phoswich units were measured with the spectral peaks caused by EC-decays of the induced radioactive isotopes. The long-term gain showed at most ~20% decline, in addition, short-term variation was caused by temperature variation and high-voltage reduction during the SAA.

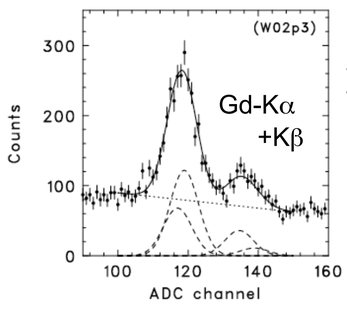


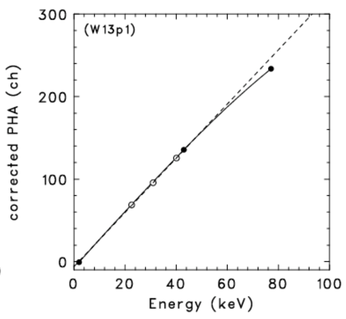




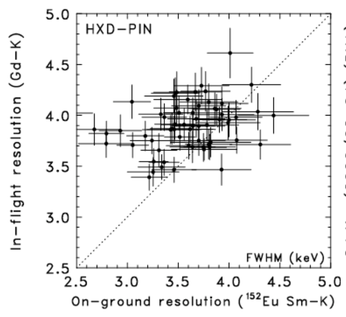
Hard-wired event reduction by the anti-coincidence with the active shields reduced total events by an order of magnitude . In addition, onboard software and ground analysis software further reduced the background down to an order of ~10^{-4} ct s^{-1} keV^{-1} cm^{-2} . The crab spectrum is well reproduced within 10% over a range of 100-300 keV.

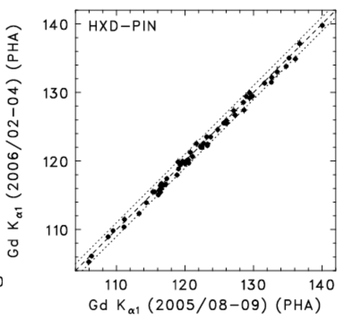
PIN performance



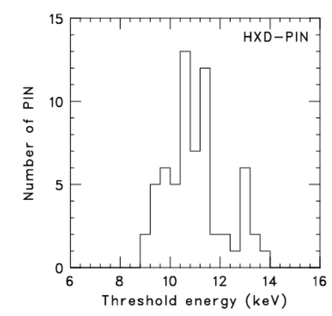


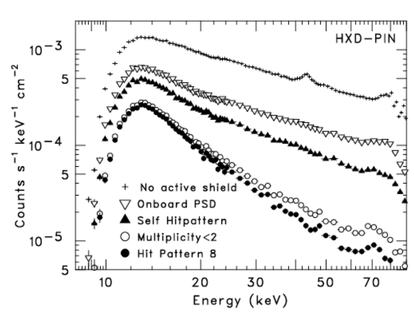
In-orbit energy scale was measured by the fluorescent lines from the GSO and BGO scintillators (Gd-Kα: 43 keV, Bi-Kα: 76 keV). Individual energy scales were determined by a spline curve over 2-76 keV range with an accuracy of 1%.

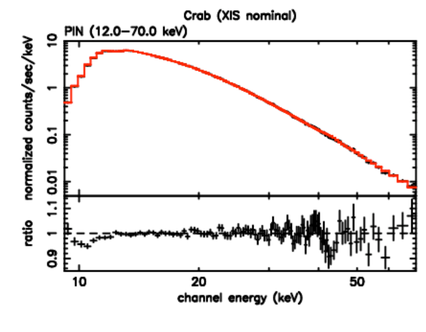




Energy resolution of individual PIN diodes were measured and confirmed to be consistent with those measured at the on-ground calibration (~4 keV FWHM). The PIN gains have stayed constant for half a year.



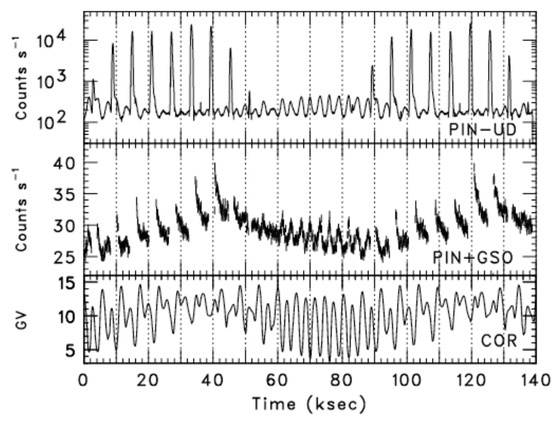


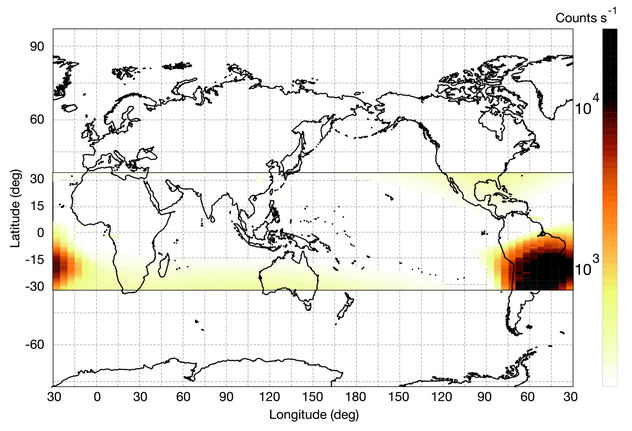


Individual lower energy thresholds were set so as not to be affected by the electrical noises with small pulse heights. They range from 9 to 14 keV, with an average of ~10 keV. In addition to the onboard event screening, several stages of event cuts are applied by the ground analysis software, and the detector background level is successfully reduced down to an order of ~10^{-5} ct s^{-1} keV^{-1} cm^{-2} .

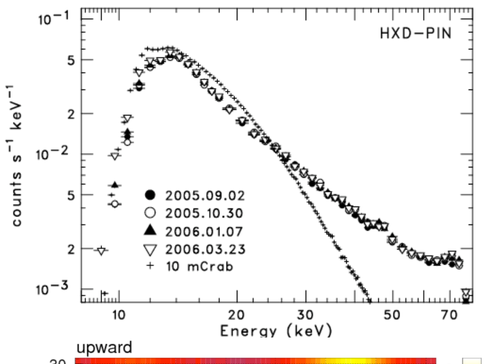
The energy response was constructed by use of the GEANT4 toolkit. The Crab spectrum is well reproduced within a few % over the entire range of 12-70 keV.

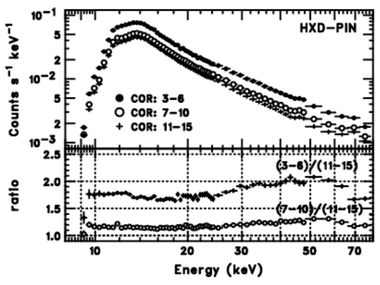
In-orbit background

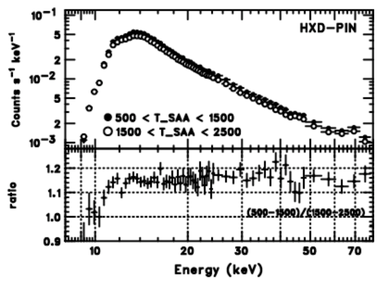


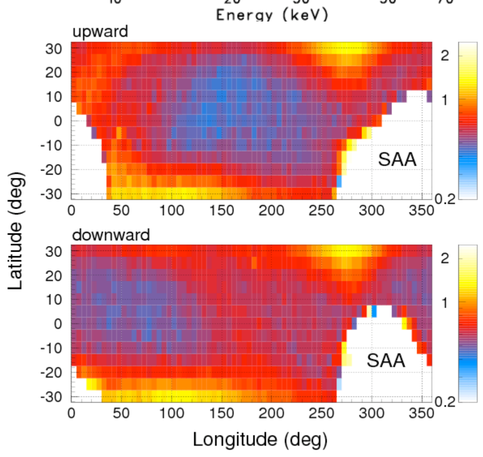


The flux of residual non X-ray background of the HXD is affected by both the SAA activation and primary cosmic-ray particles, which can be monitored by the upper discriminator of PIN (PIN-UD). A flux map can be retrieved by projecting this PIN-UD rate on the geographical coordinates.

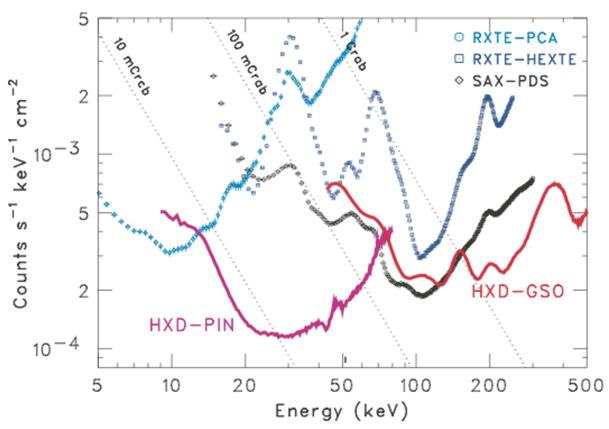




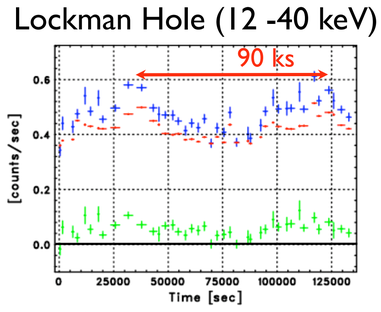




There seems no long-term evolution in the NXB of PIN diodes over a half year. The average level is roughly the same as 10 mCrab intensity at <30 keV. The PIN-NXB level depends on the cut-off energy for the cosmic-ray particles at the satellite position, and shows a variability of factor of ~2. The spectrum keeps a similar shape below ~25 keV, whereas it shows a significant hardning above that energy, at the small cut-off energy regions.

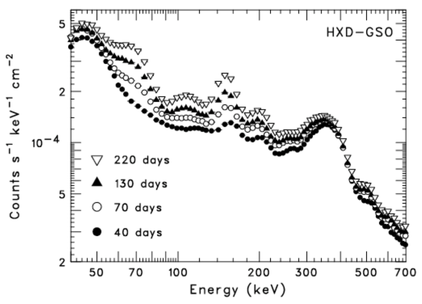


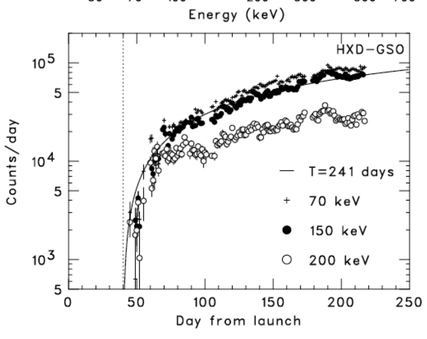
Lockman Hole (12 -40 keV)

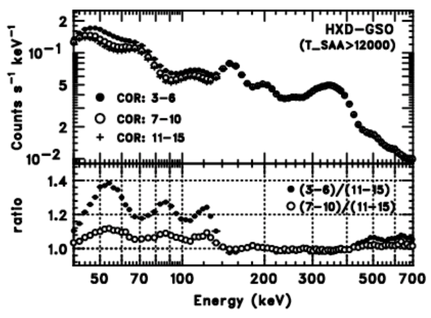


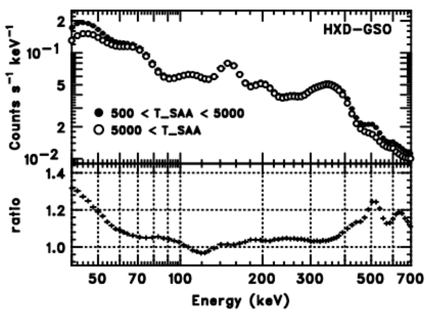
Obs data
NXB model
Data - NXB (=CXB)

The NXB of GSO shows clear evolutions at the peaks of EC-decay isotopes, according to individual half-lives of the decaying nuclei, mainly the products of nuclear interactions between gadolinium and protons. The spectral shape changes, mostly below 150 keV and around 511 keV, with changes of the satellite position in the orbit.









In energy ranges of 15-70 and 150-500 keV, the lowest in-orbit background has been achieved by the HXD, when compared with those of other non-imaging hard X-ray detectors. The actual sensitivity is determined by the accuracy of the background modeling. Currently, the reproducibility of the PIN-NXB model has already confirmed to be 3-5%, except the SAA orbits in which the background increases significantly. Construction of more accurate models, which are applicable to the SAA orbits with an accuracy better than 3% is in progress.

References (contained in Suzaku CD-ROM)

Takahashi, T. *et al.*, PASJ, Suzaku special issuse, 2006

Kokubun, M. *et al.*, PASJ, Suzaku special issuse, 2006