Calibration status of the HXD

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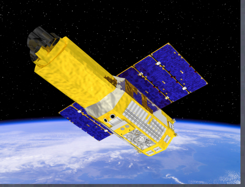
on behalf of the Suzaku HXD team

T.Takahashi et al. (Hardware description)
M.Kokubun et al. (In-orbit calibration)
in the PASJ special issue



Outline

PIN calibration

- Energy scale
- Energy threshold
- Alignment
- Response function

GSO calibration

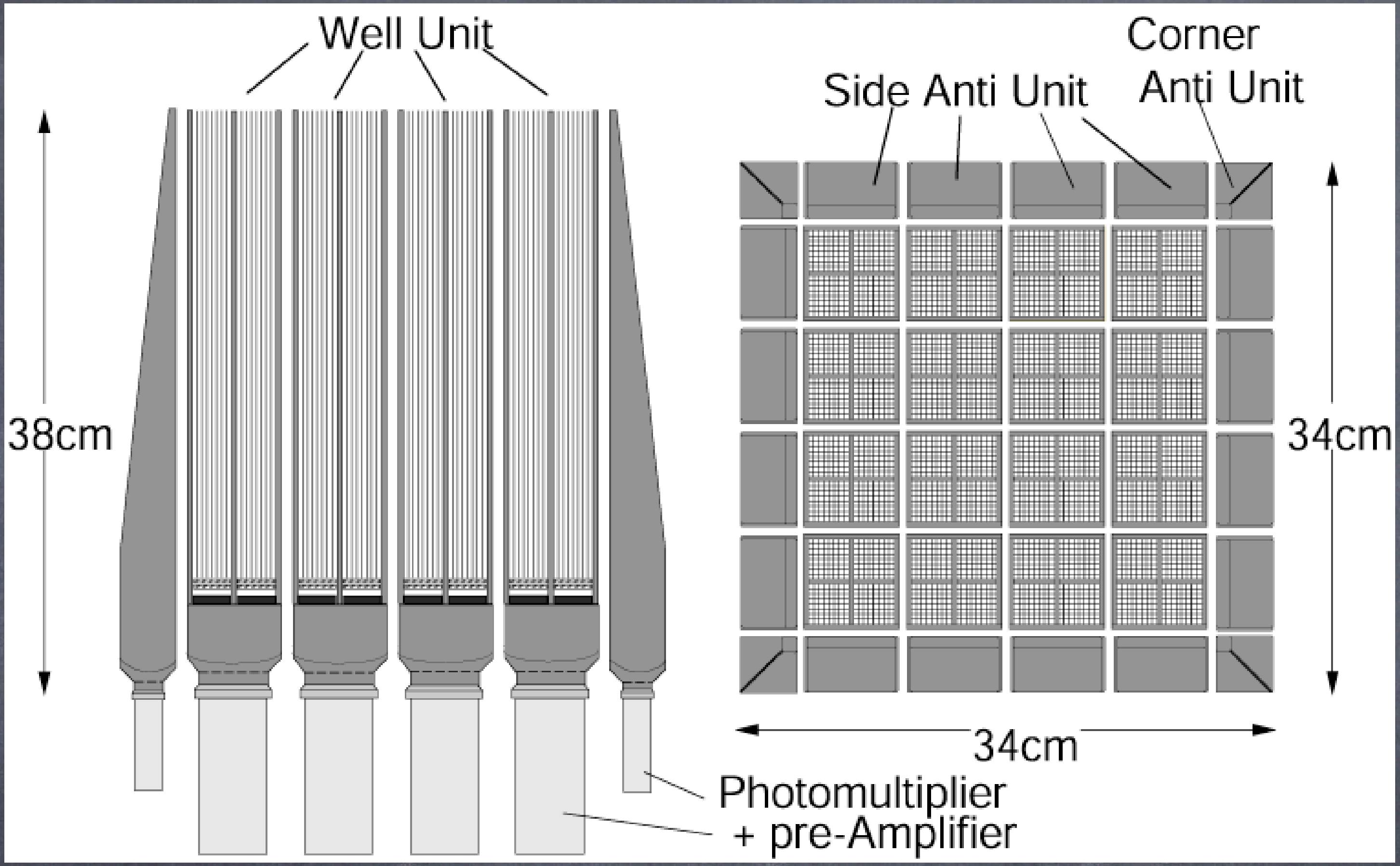
- Energy scale
- Background reduction
- Response function

Common issue

- Temperature
- Dead time
- Timing

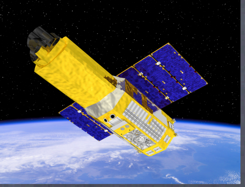
Background : Fukazawa-san's talk

Hard X-ray Detector

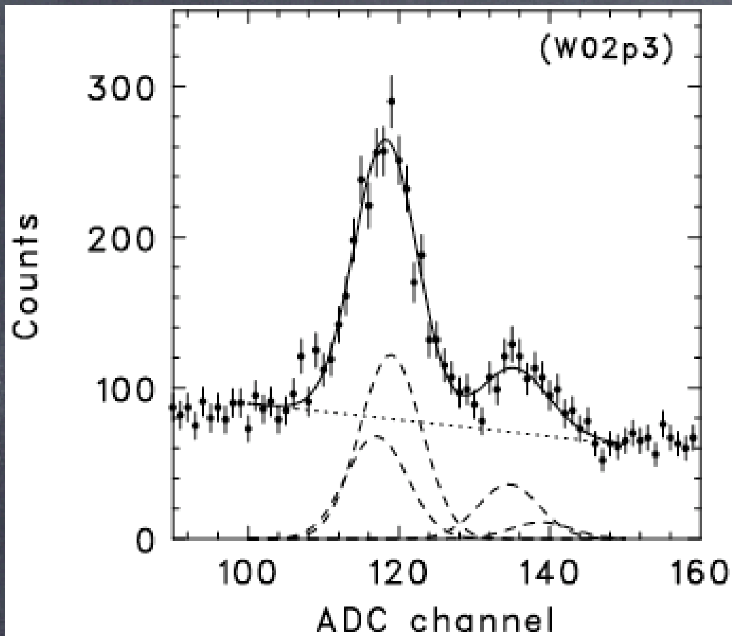


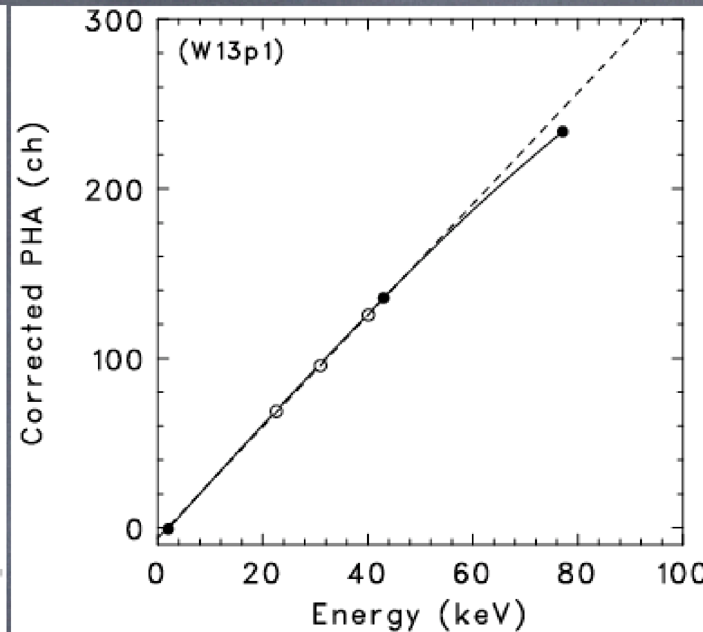
16 well-type phoswich (GSO) + 64 PIN diodes

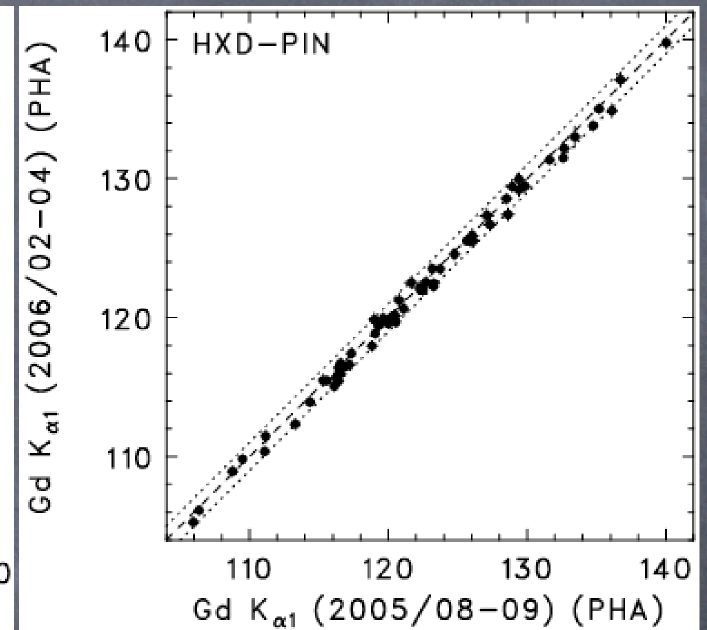
Wide-band All-sky Monitor (WAM) as a GRB detector



Energy scale of PIN





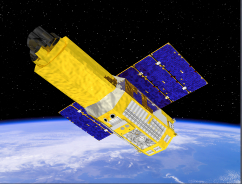


Gd-K fluorescent line in the "rejected event spectrum" can be utilized for cal.

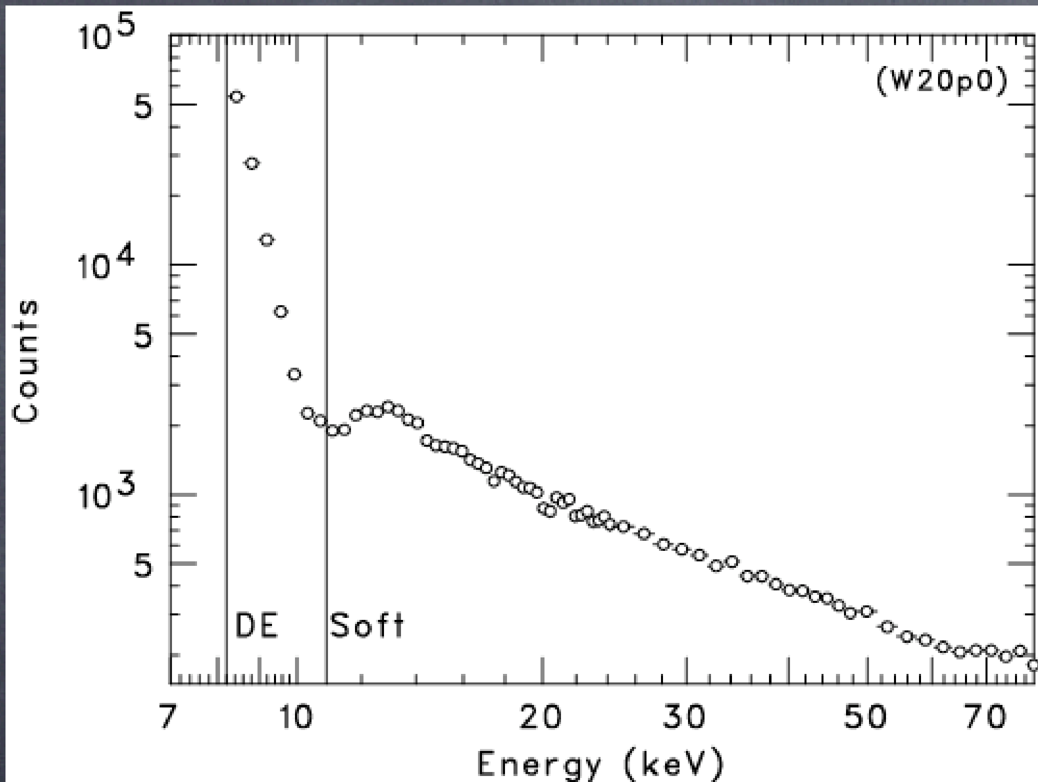
Slight non-linearity at a high energy range (Bi-K from BGO).

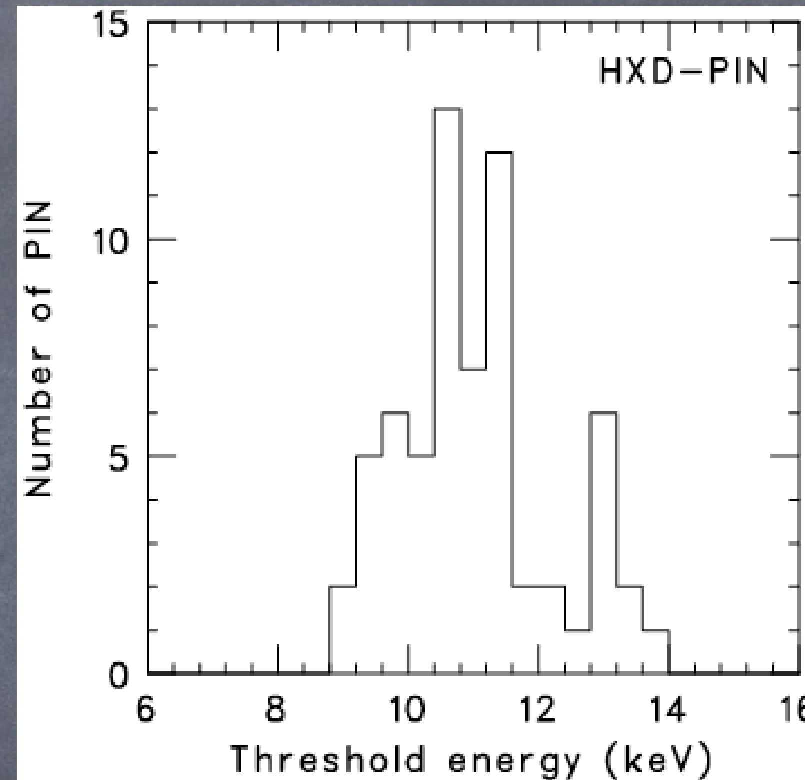
The gain of PIN is stable during a year.

Uncertainties in the PIN energy scale is small as ~1% over the entire energy range of 7-70 keV.

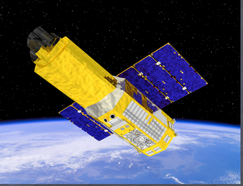


Energy threshold of PIN

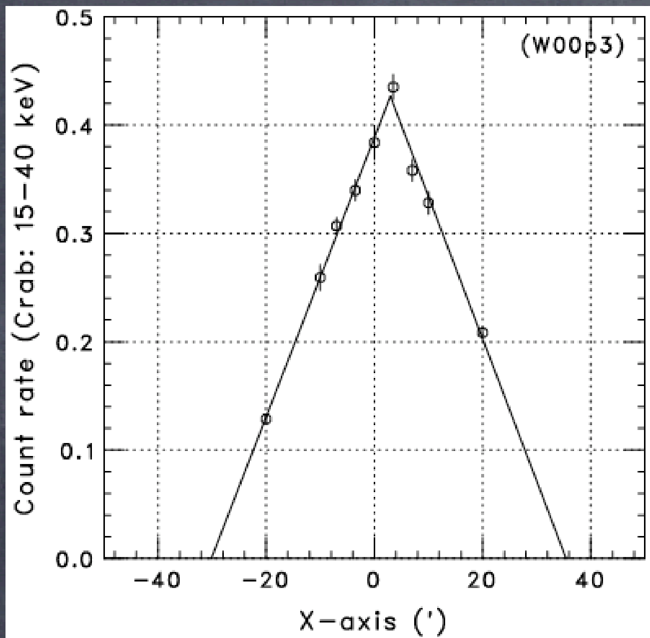


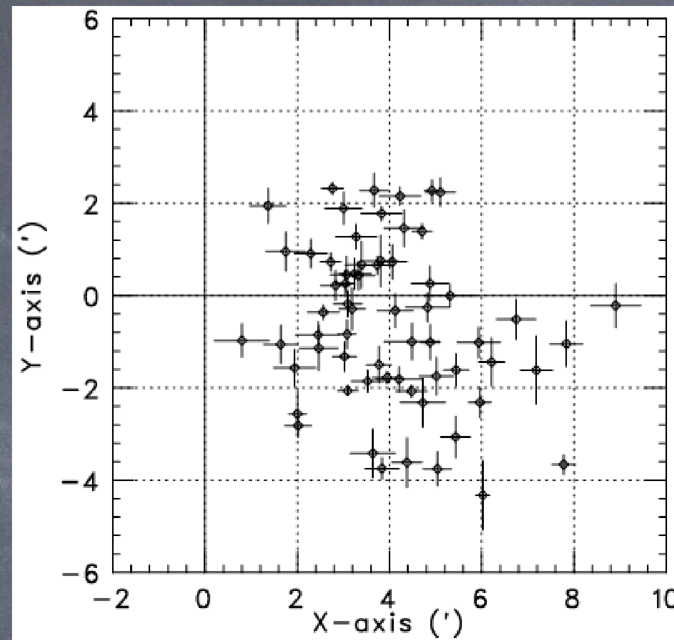


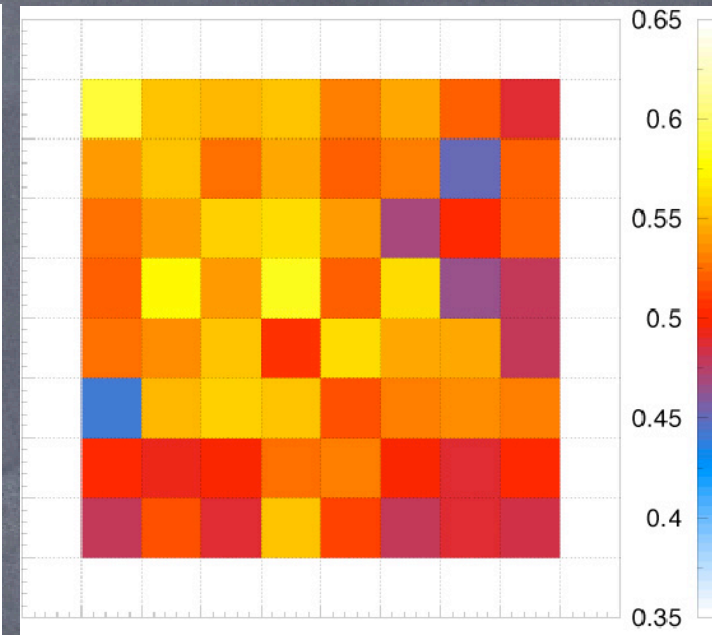
Noise events (thermal and electrical) are rejected by both of onboard and software cuts, which are individually optimized for 64 PIN diodes. Resultant lower threshold energy varies from 9-14 keV.



Alignment of PIN (fine collimator)

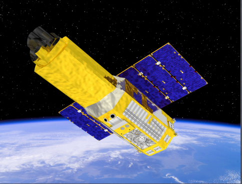




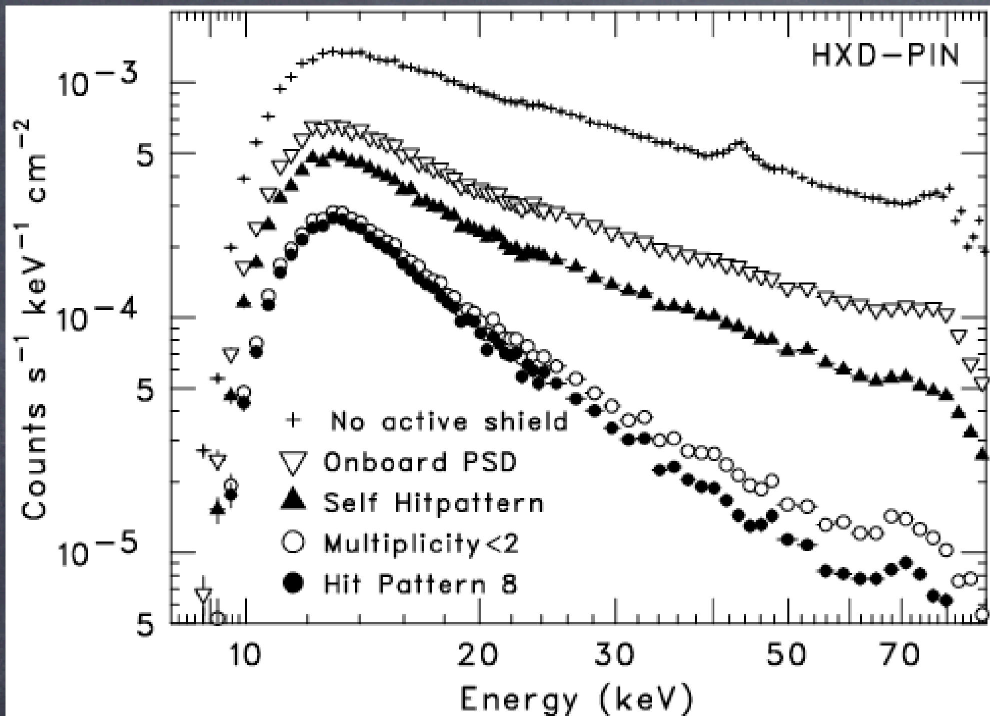


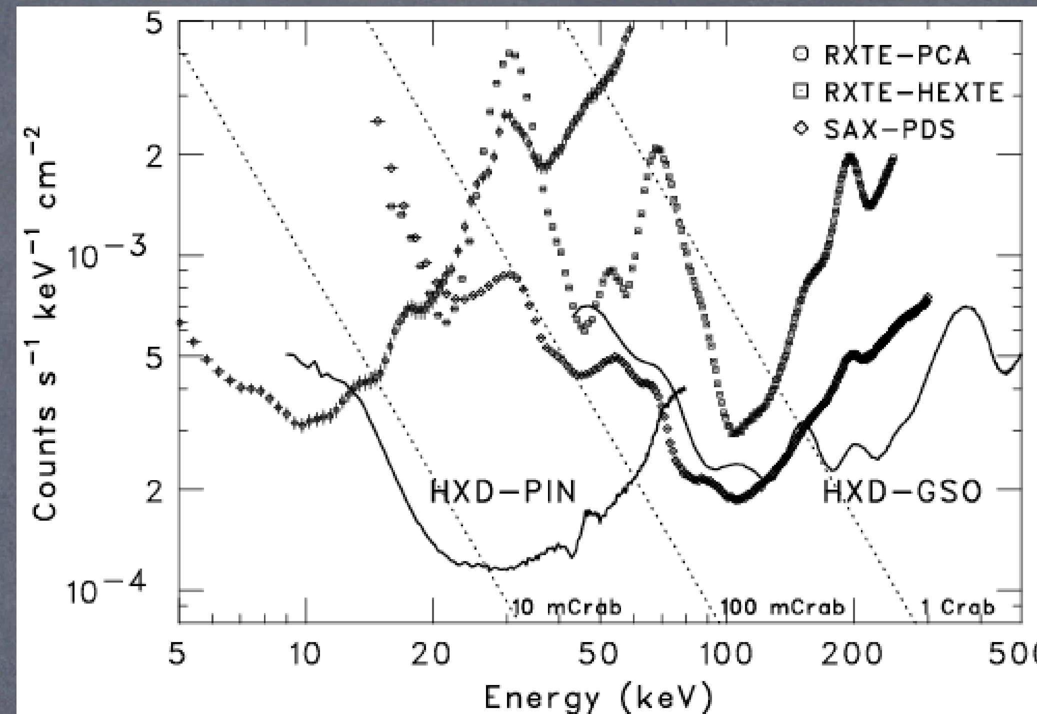
Crab flux map (15-40 keV)

Individual alignments of the 64 fine-collimators were measured with the Crab scanning (9 points for X- and Y-axis). They are aligned within 3.5′ (FWHM), while the weighted mean shows a slight offset by ~4′ in the X-direction.



Background reduction of PIN

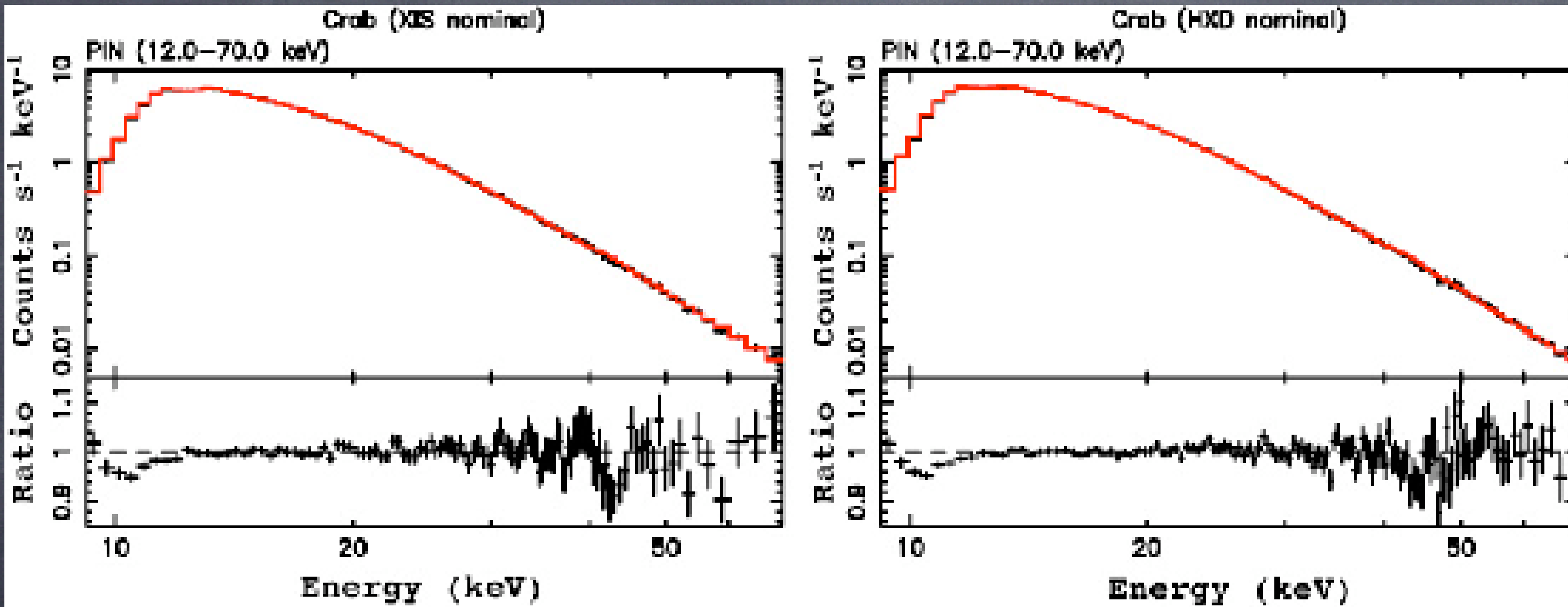




By fully utilizing the anti-coincidence with the active shield, the lowest background level (per the effective area) has been achieved in HXD-PIN.

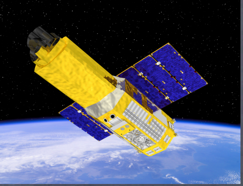
Energy response of PIN

ae_hxd_pinxinom_20060814.fits ae_hxd_pinhxnom_20060814.fits

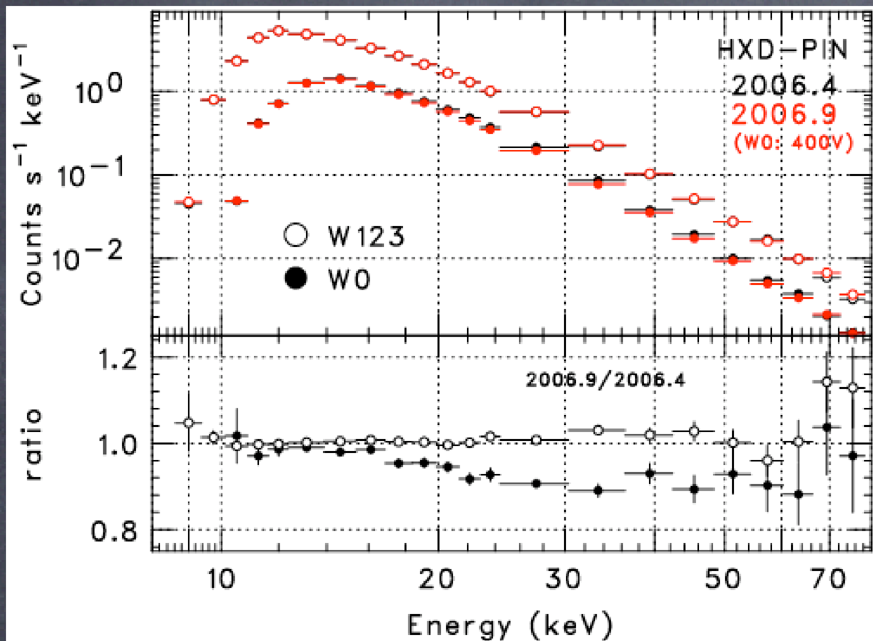


position	XIS nom.	HXD nom.
index	2.12+/-0.01	2.10+/-0.01
norm	11.9+/-0.1	11.1+/-0.1

The residuals of the Crab fitting resides within a few % at the energy range of 12-40 keV, while they become larger (~10%) below 12 keV. The results obtained at the XIS- and HXD-nominal positions give slightly different answers.



Energy response of PIN (400V)



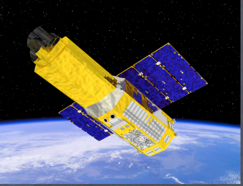
On 2006 May, one of four PIN-HV voltage was reduced down to 400 V.

2006-09-05 : XIS nominal x 40 ks

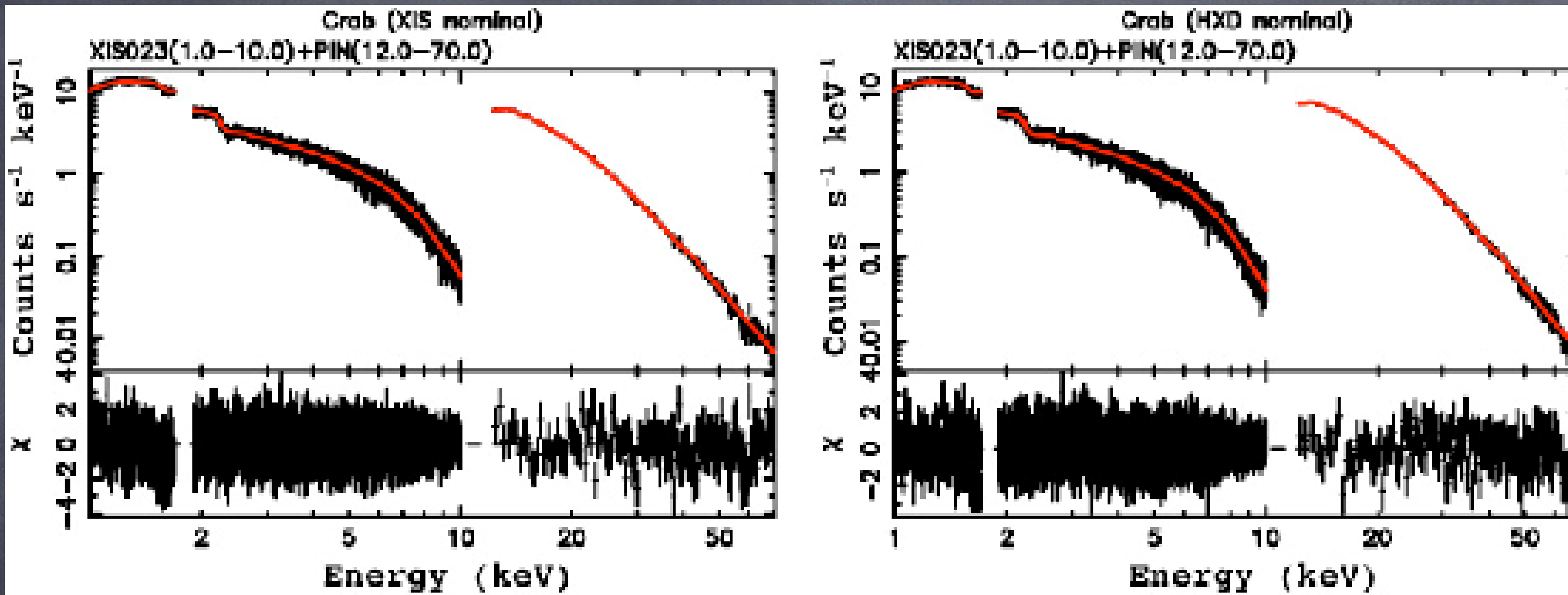
HV-P0: 400V

HV-P1,2,3: 500V

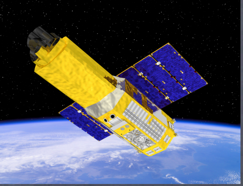
Above 20 keV, the effective area of 16 PIN diodes biased with 400 V decreased ~10% from those with 500 V, which means ~3% loss of the total effective area. The modified response matrices for "W123-only" analysis are available on the Suzaku web.



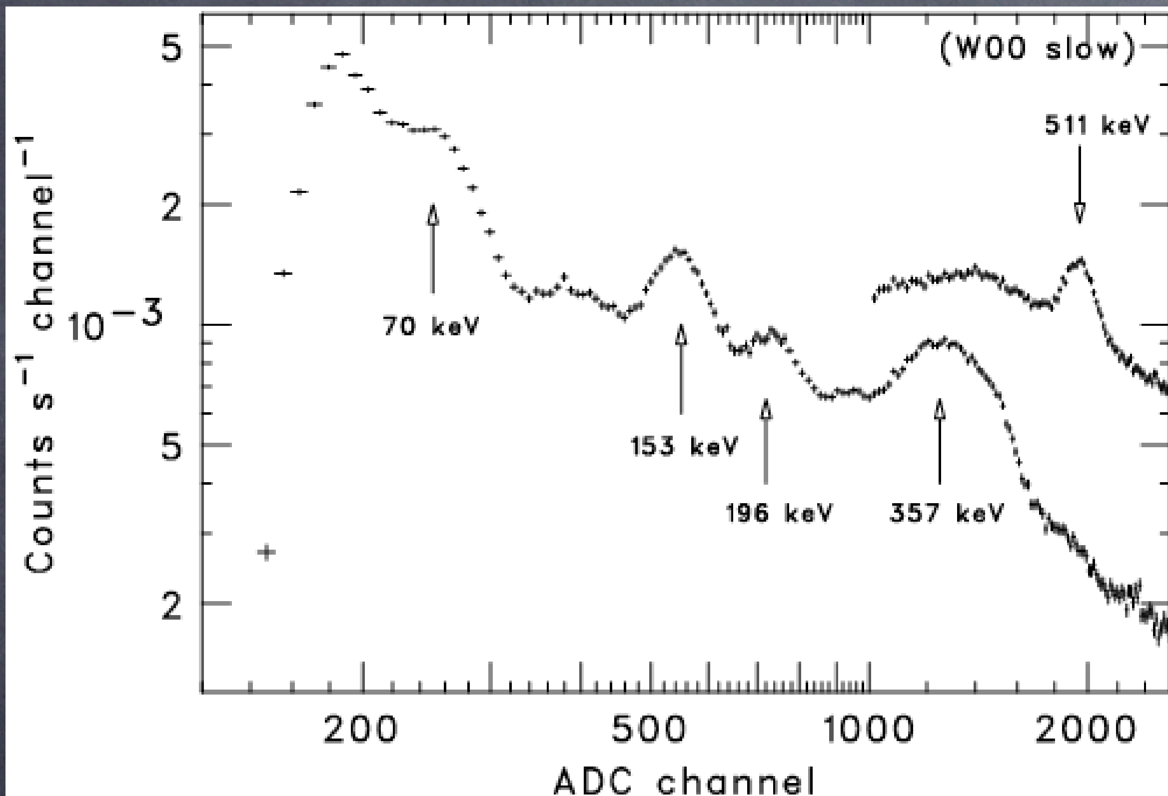
Relative normalization to XIS

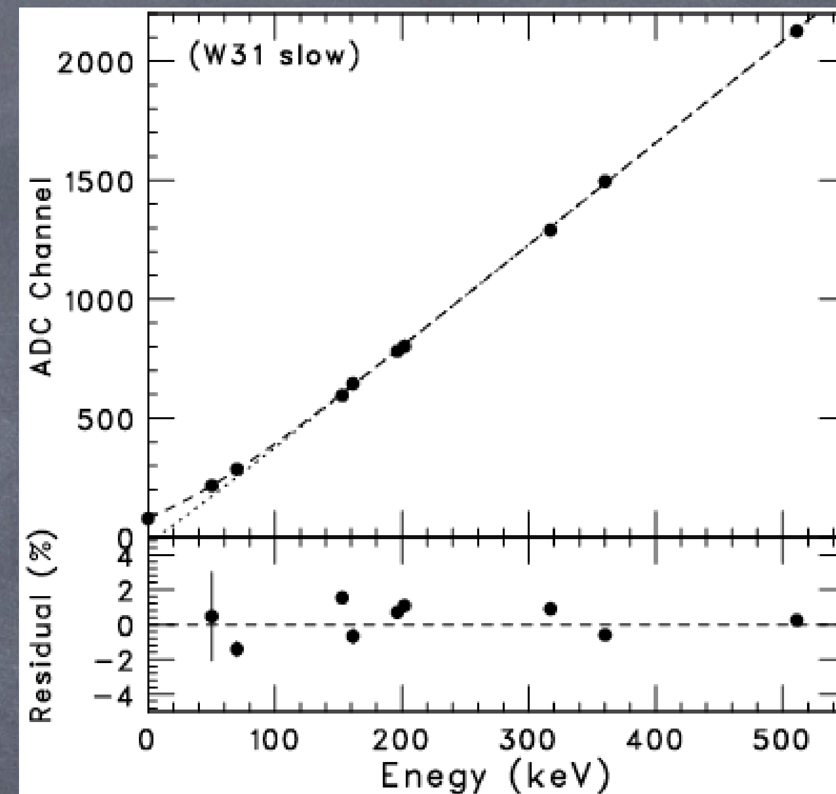


Cross-normalization factor of ~13% at XIS nominal ~15% at HXD nominal are required. The effort to improve the energy response is underway.

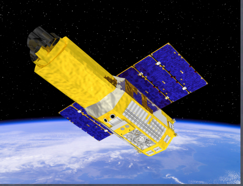


GSO energy scale

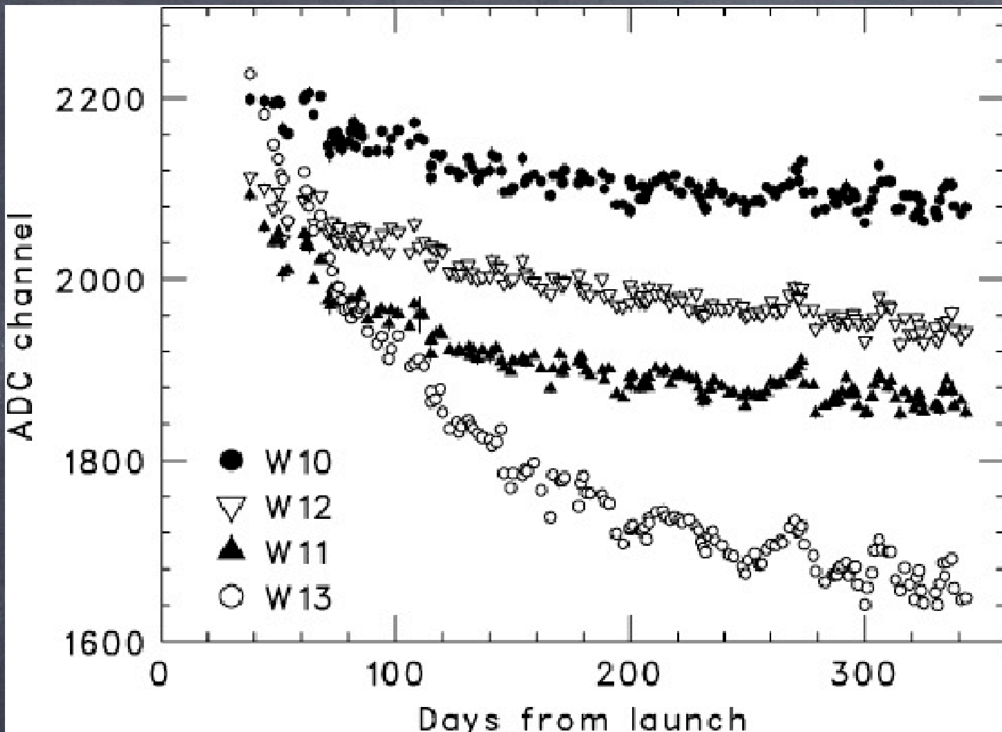


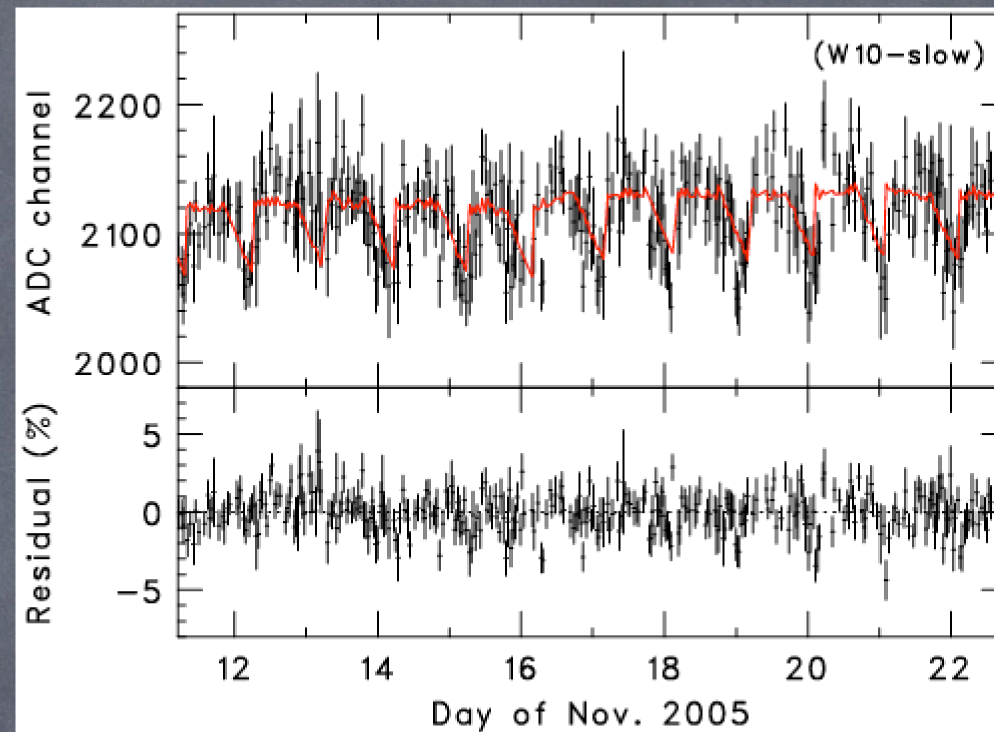


In-orbit GSO energy scale is derived by use of the EC-decay peaks in the background spectrum, together with the 511 keV line. Since a significant non-linearity appears below 100 keV, the uncertainties become larger in this energy range.

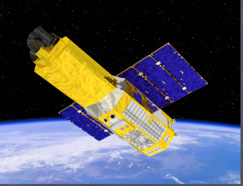


GSO gain variation

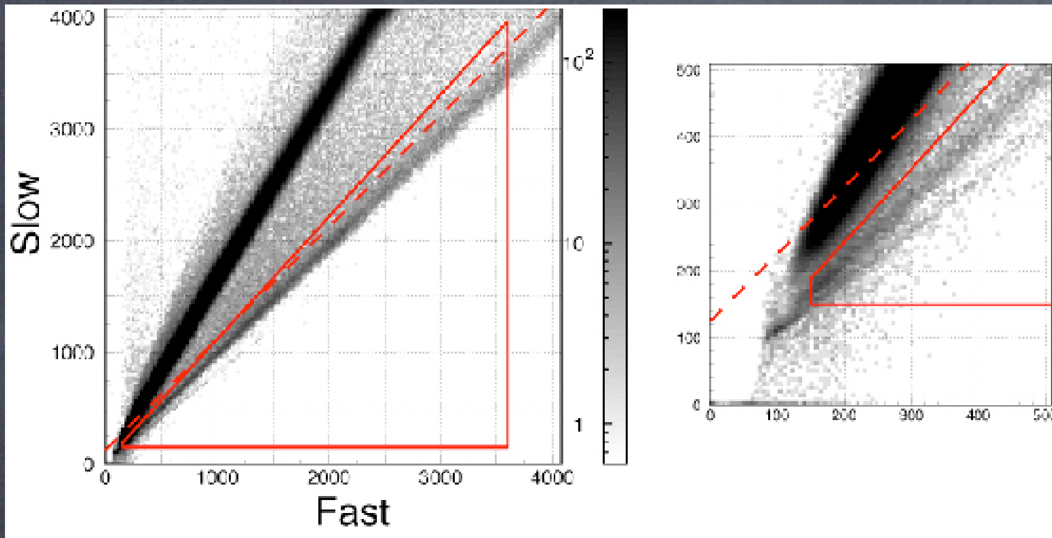




The long-term and short-term gain variations are observed.
The former is caused by the degradation of the PMT gain,
while the latter is due to both of the temperature dependence
of the GSO light-yield and aging effect in PMT gain during the SAA.



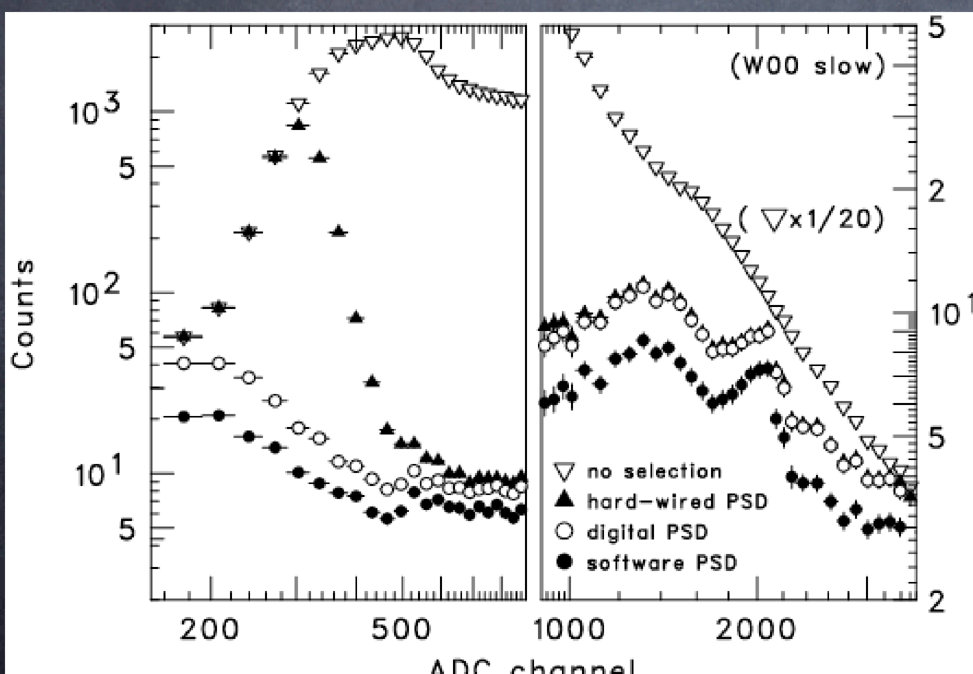
GSO background reduction

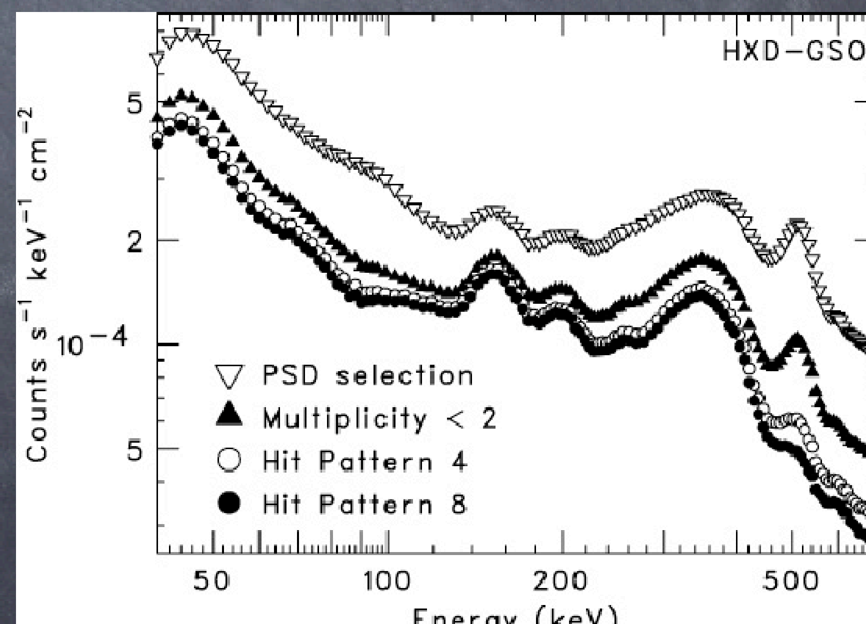


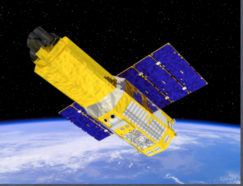
GSO background is reduced with:

- PSD cut on Fast-Slow diagram
- Hit-pattern of 36 active units

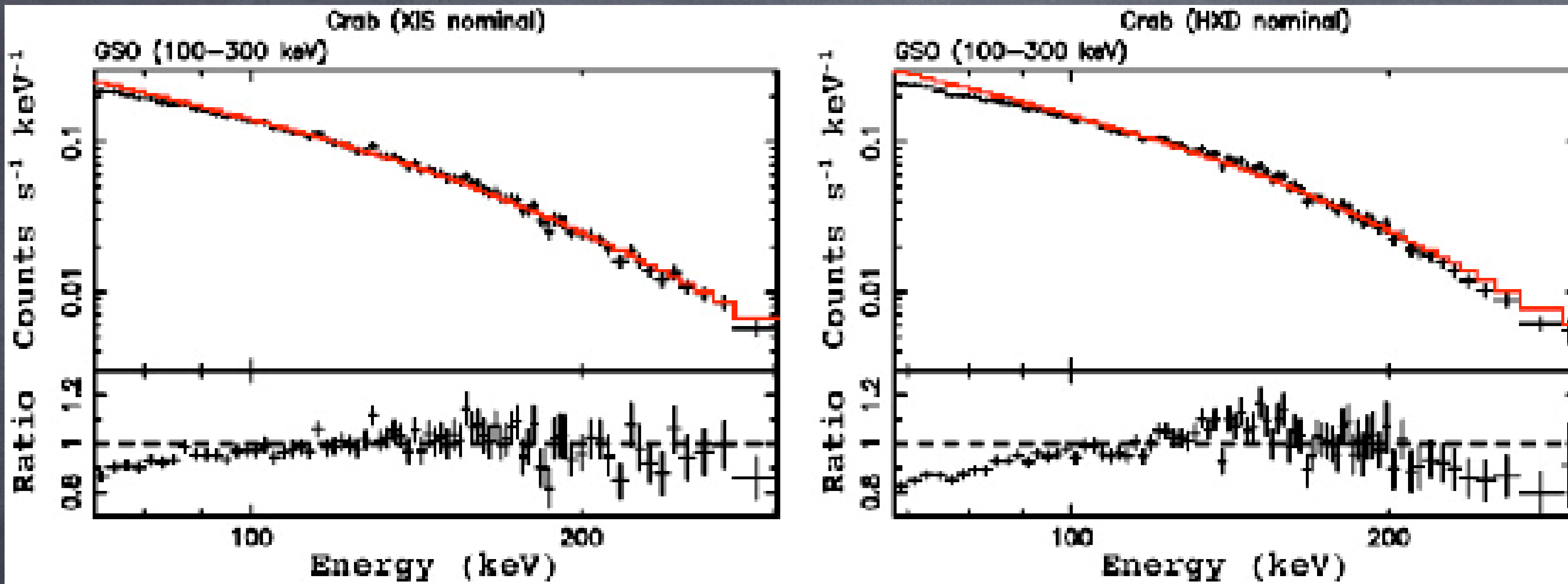
These result in several % of the signal loss, but further reduction of the background.



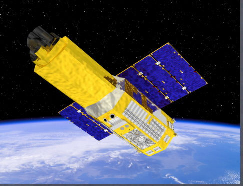




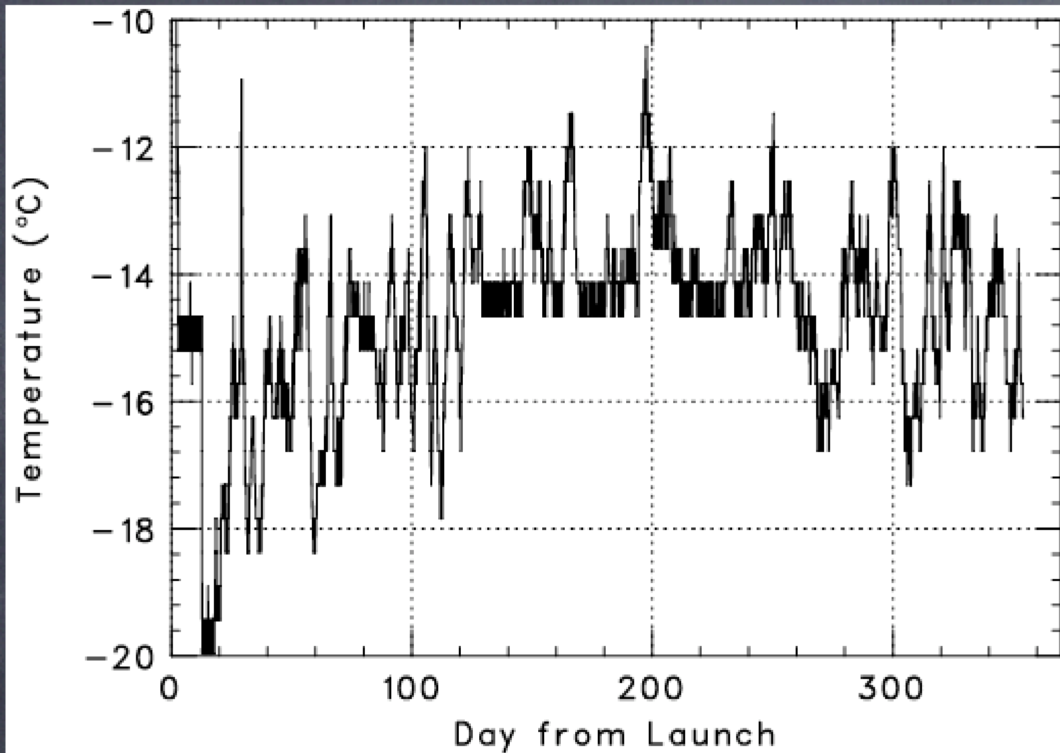
GSO energy response



The residuals of the Crab fitting are less than 10%
at 70-200 keV, but significantly larger outside that energy range.
We are now investigating various parameters in the MC simulation.
We recommend all users to verify your spectrum by creating
"the Crab ratio" before trying to fit the spectrum in XSPEC.



Temperature variation



Design : -20 +/- 1 C

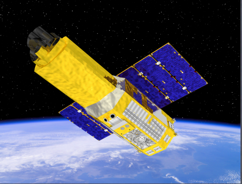
Actually : -15 +/- 3 C

Due to the failure of one of two heat-pipes

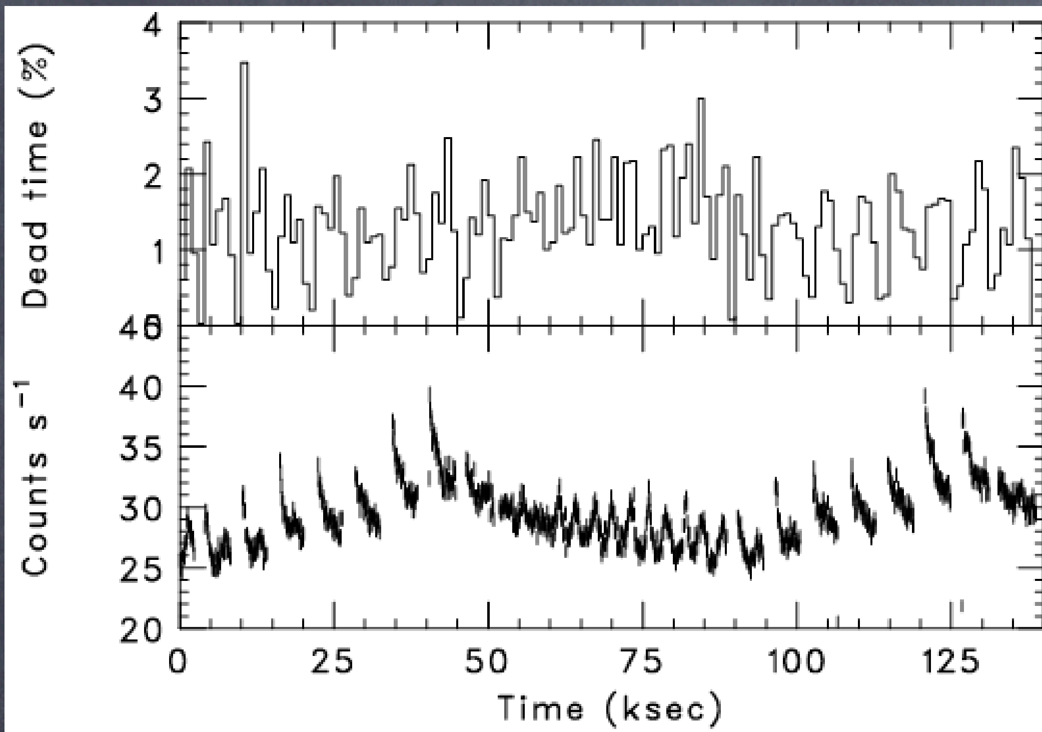
Large XRT-Sun angle (>90) raise the temperature of HXD-S

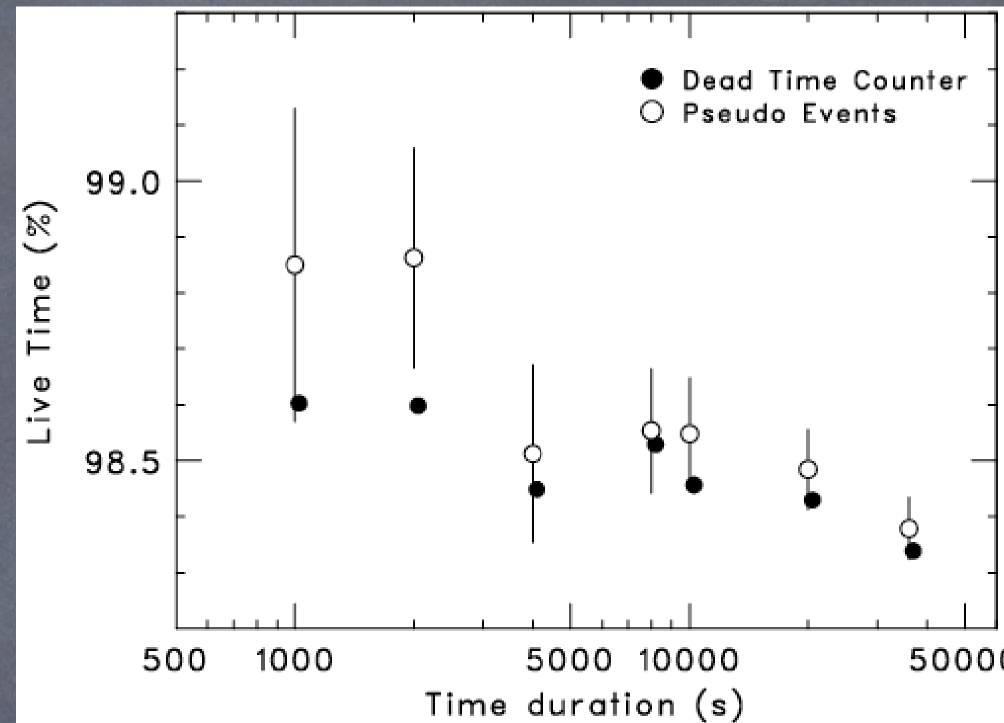
Higher temperature results in

- Higher thermal noise in PIN-Si at lower energy end (<12 keV)
- Smaller light-yield of GSO scintillators and PMT gains

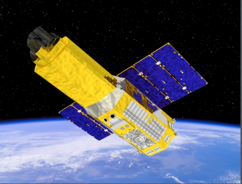


Dead time



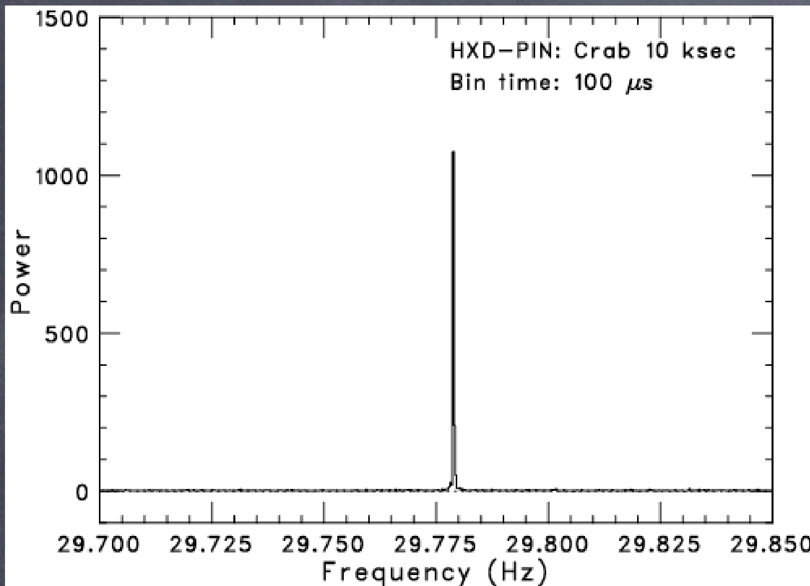


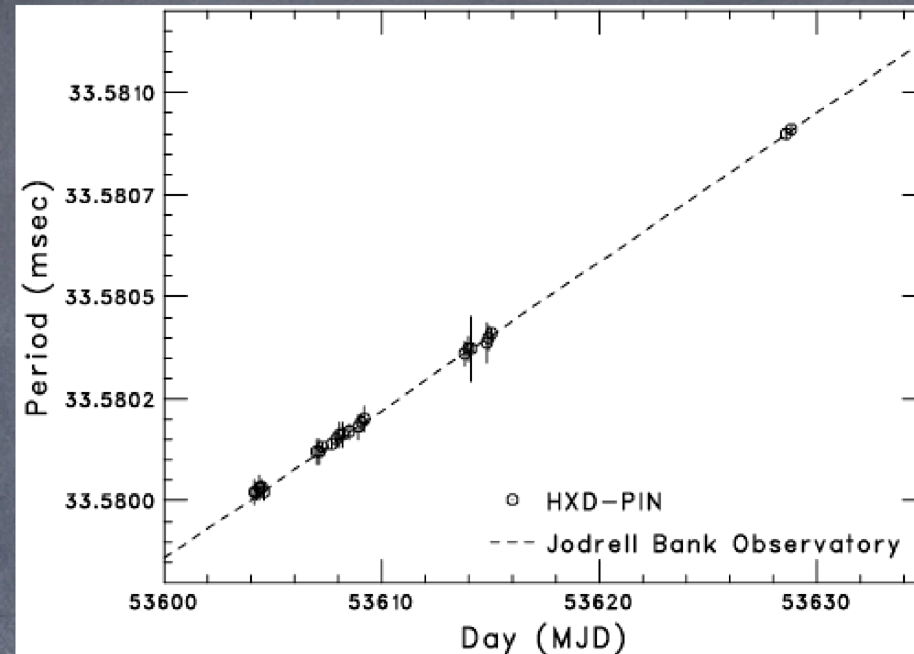
Both the dead-time in the electronics and the signal loss due to the chance coincidence can be corrected by counting "the pseudo events" which are periodically produced in the onboard electronics. The time interval when the telemetry saturation has occurred are already excluded from the GTI of cleaned event files.

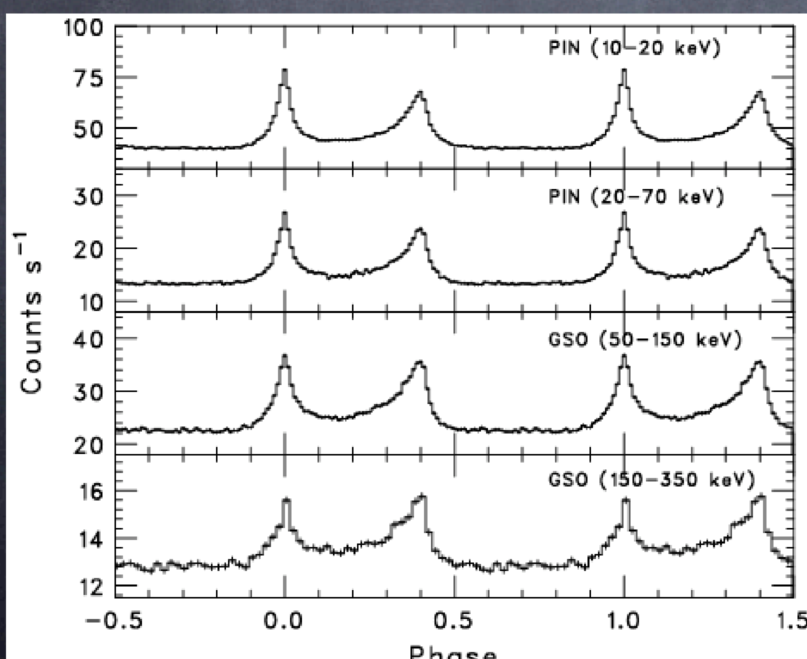


Timing accuracy

Poster #197 (Enoto)







After the correction of

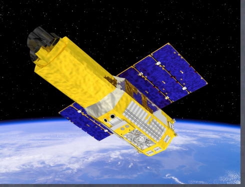
- Temperature drift of the onboard clock
- Barycentric correction

Period

consistent within 10^{-9} sec order

Arrival time

consistent within 200—400 usec



Summary

The in-orbit calibrations of PIN have been almost established, which include the energy scale, alignment, timing accuracy, etc. The in-orbit energy scale has been very stable during a year.

Below 12 keV, there are still remained larger uncertainties mainly due to the variation of thermal/electrical noise and the complicated structure of the depletion layer of PIN-Si.

The uncertainties of GSO calibration are relatively larger than those achieved in PIN, due to the time variation of gain and non-linearities in the energy scale.

We, the HXD team, are and will be working very hard to improve the calibration.