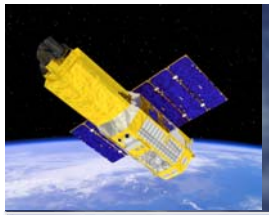
Calibration Status of

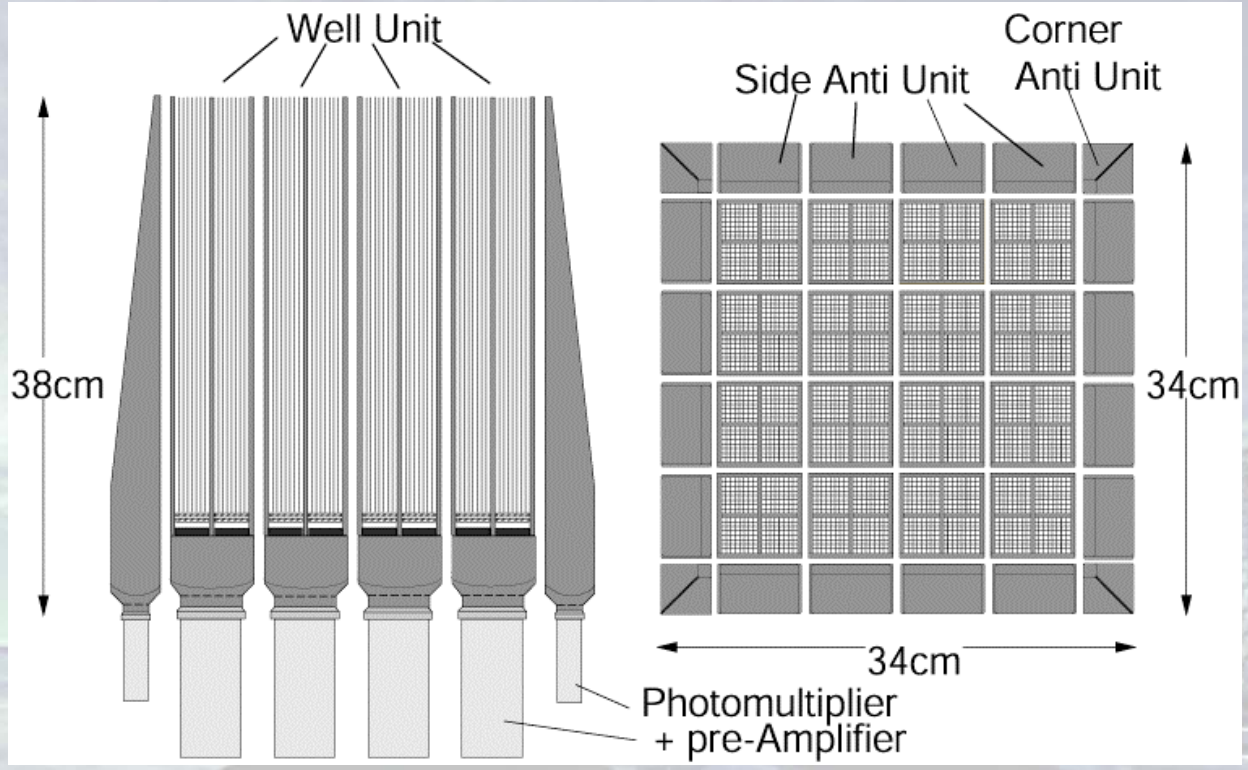
Suzaku Hard X-ray Detector (HXD)

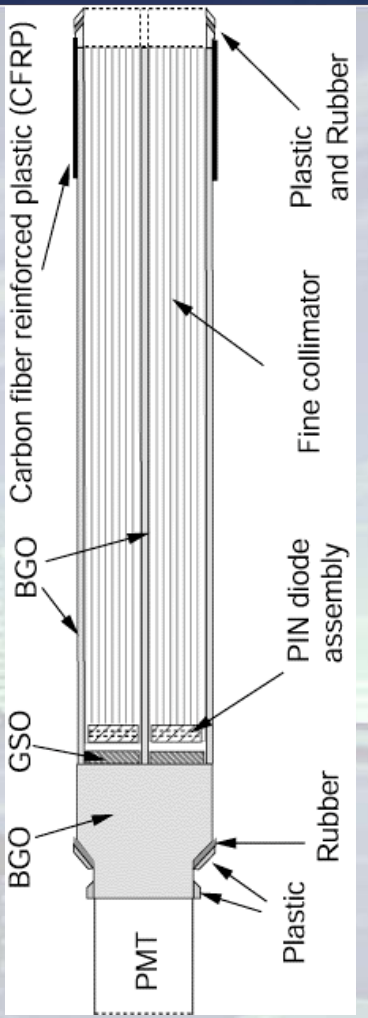
by the HXD team

Univ. of Tokyo, ISAS/JAXA, RIKEN,
Hiroshima Univ., Saitama Univ., Aoyama Gakuin Univ.,
Kanazawa Univ., Osaka Univ., and SLAC



Calibration of HXD (GSO)

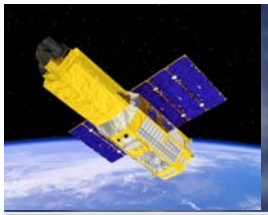




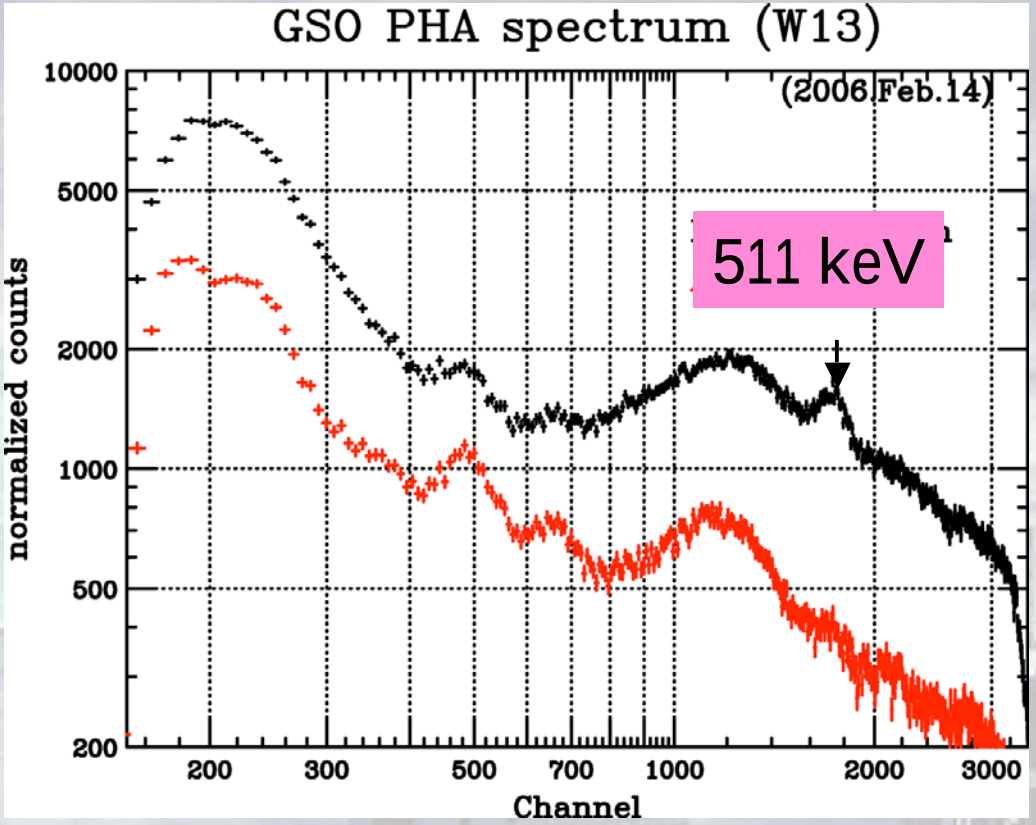
Well-type phoswich of Gd_2SiO_5:Ce (GSO) + BGO

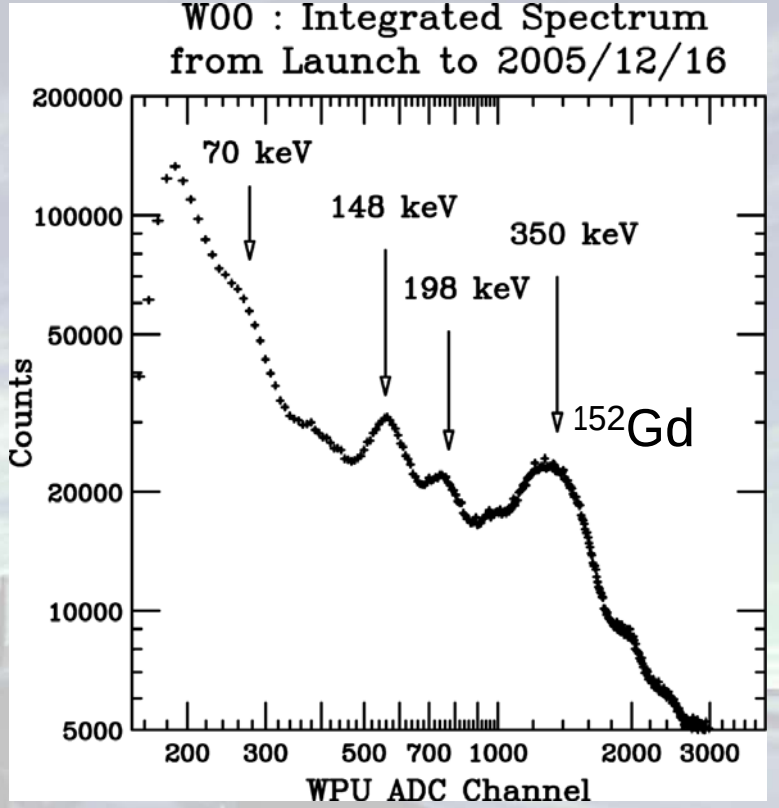
- Large stopping power (Z=64), Fast timing (τ=60ns)
- Energy range : 30-700 keV, FOV=4.5deg(FWHM)
- Geometrical Area : 370cm^2 , ΔE = 10%@662keV

BGO active shield also acts as the Wideband All-sky Monitor (WAM)

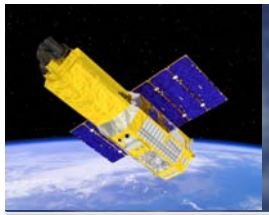


Energy Scale

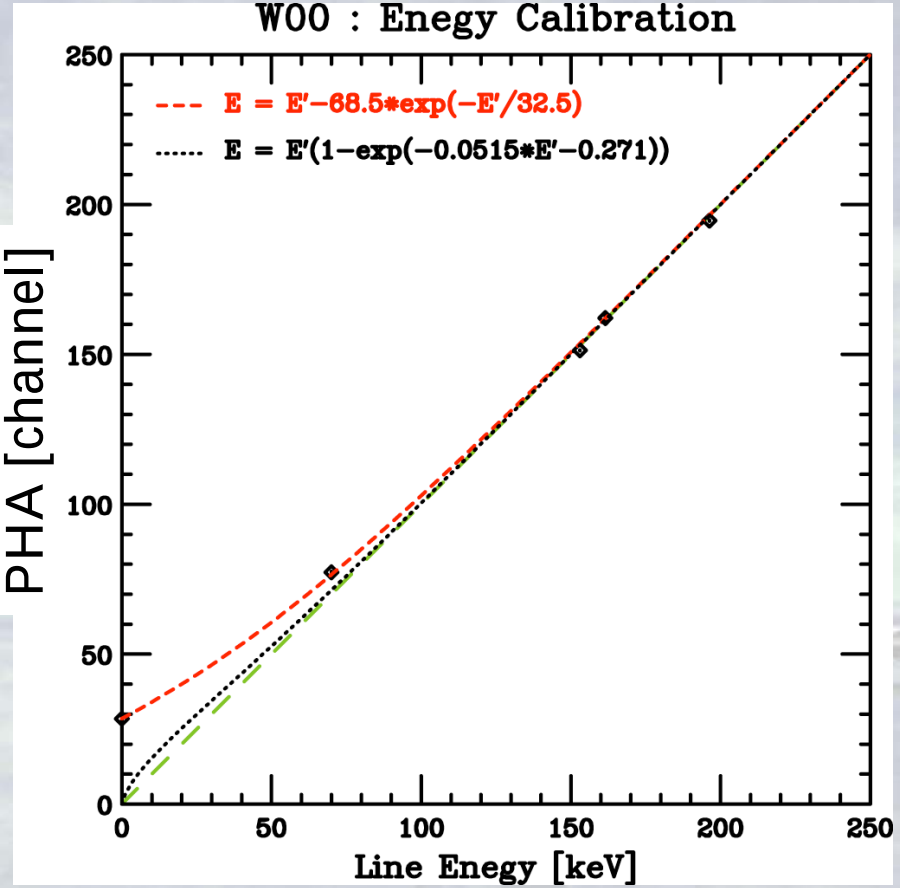




For the gain correction of each unit, prominent lines caused by the in-orbit activation seen in the background spectra are used. The annihilation line is also utilized, which can be seen in the *unscreened* spectrum before applying the anti-coincidence between adjacent units.

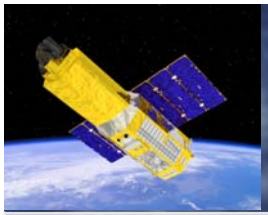


GSO: Non-linearity

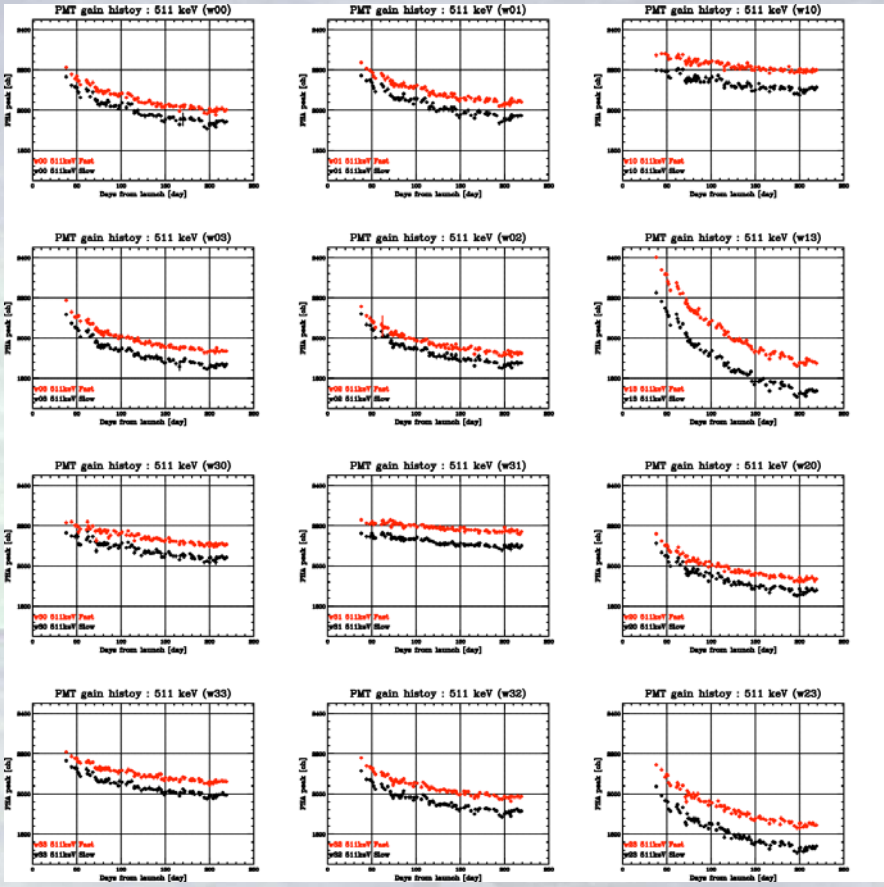


Besides the non-linearity of the electronics and GSO itself, we have found that we need additional non-linearity effect below 70 keV, which was not observed at the on-ground calibration.

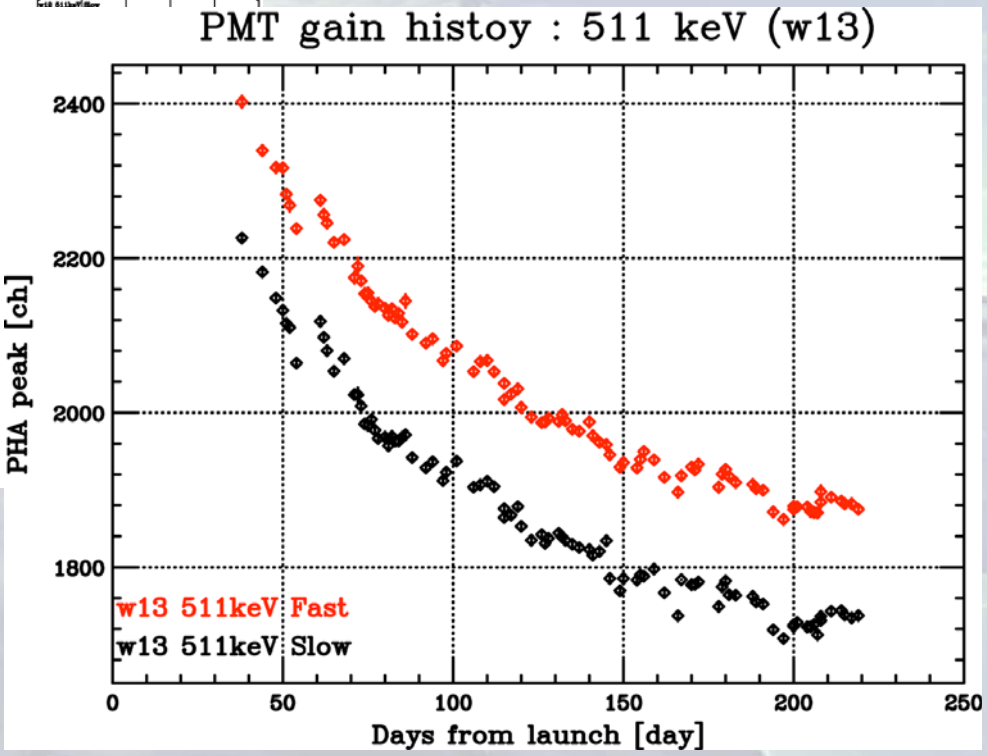
Since there is no calibration line below 50 keV (Gd-K), we assumed the ADC pedestal as the zero-energy point.



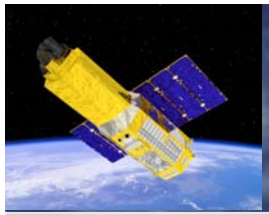
GSO : Gain variation



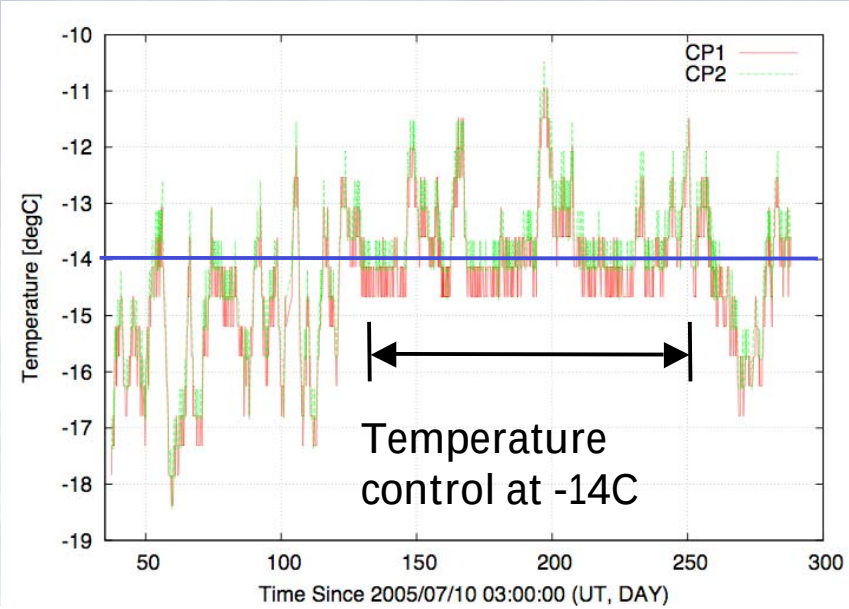
All units show a long-term decrease in gains of 5-20 %. Mainly caused by the aging effects of PMT.

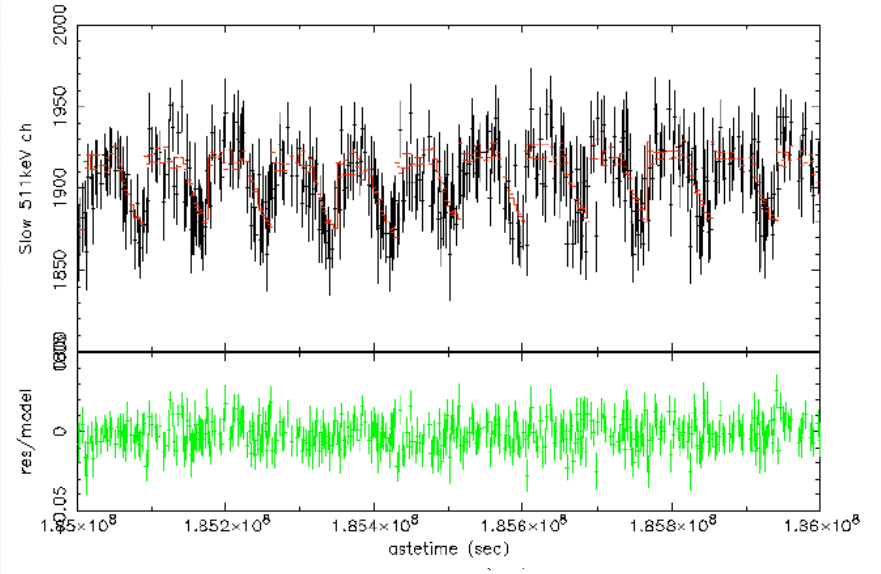


Besides the long-term drift, some short-term variations are seen.



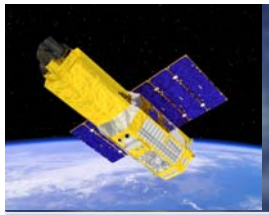
HXD-S TEMPERATURE VARIATION





Due to the failure of one of heat-pipe system, the temperature of HXD-S varies a few degree when the XRT-Sun angle is larger than 90.

Since high-voltages of PMT are reduced in every SAA, this operation also brings ~5% gain drift.



Calibration observations

Crab : Response, Fine-Collimator alignment, Timing cal

5 ks exposure x 24 points

PSR B1509-58 : Response (Pulse On/Off spectrum), Timing cal

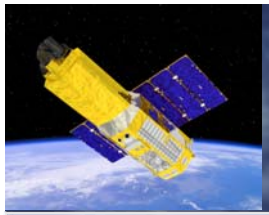
80 ks exposure

NEP, LockmanHole : Background

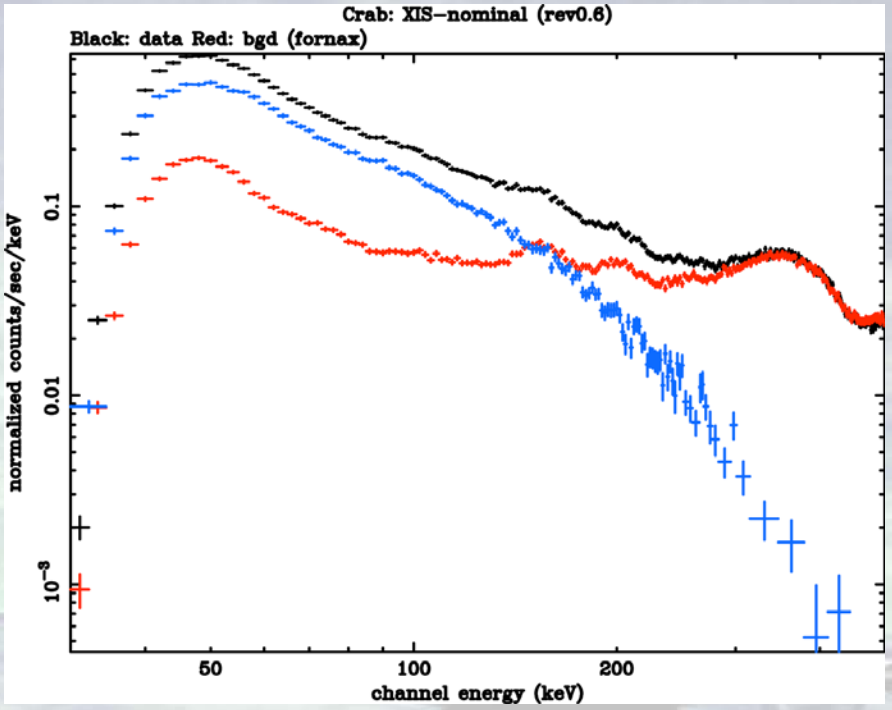
80~100 ks exposure each

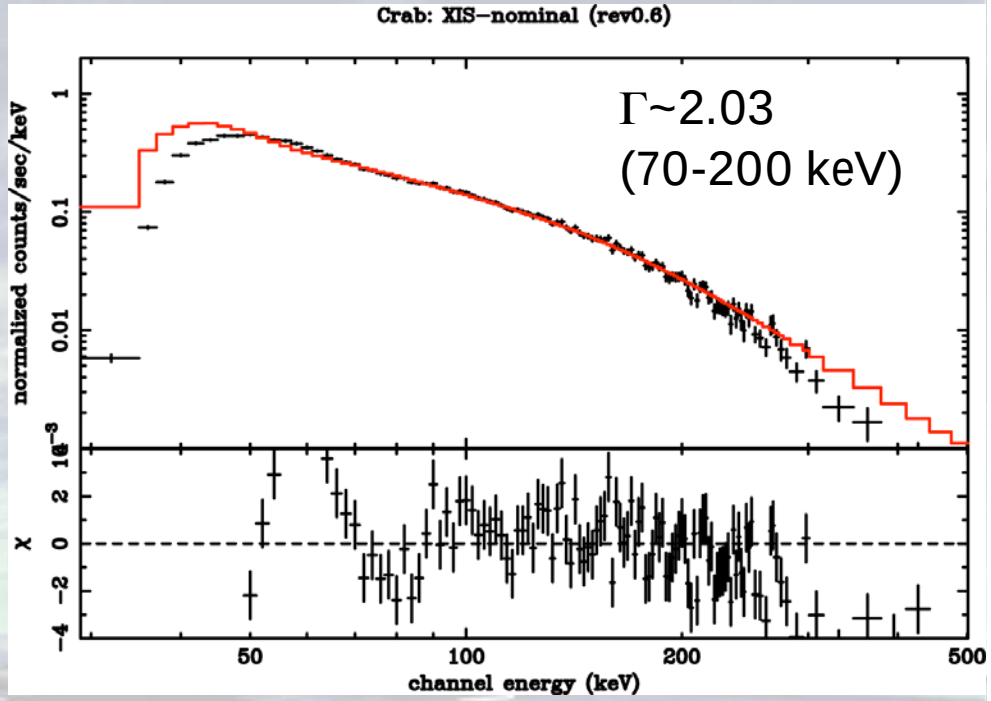
Her X-1 : Energy scale, cross-cal PIN/GSO

40 ks exposure x 2

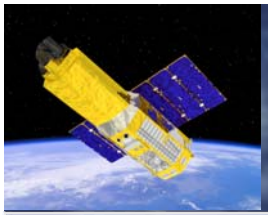


Response of GSO - Crab



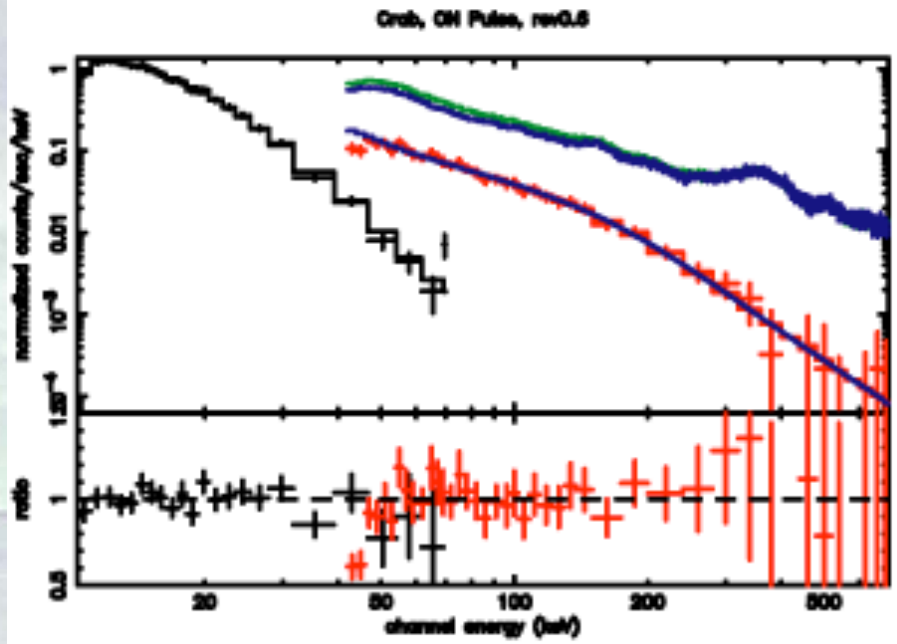


The current version of the GSO response is not yet fully adjusted with in-orbit data. This causes a harder spectrum in GSO than PIN, and also the discrepancy in normalization of ~ 10%.

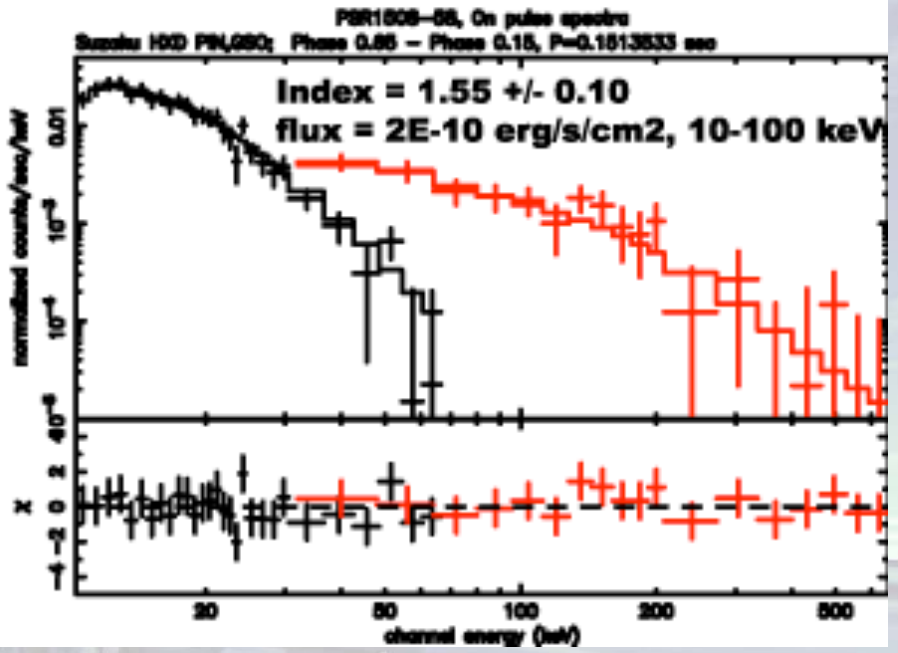


Crab/PSR B1509 On pulse

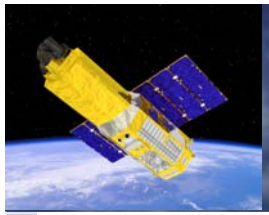
Crab On-pulse



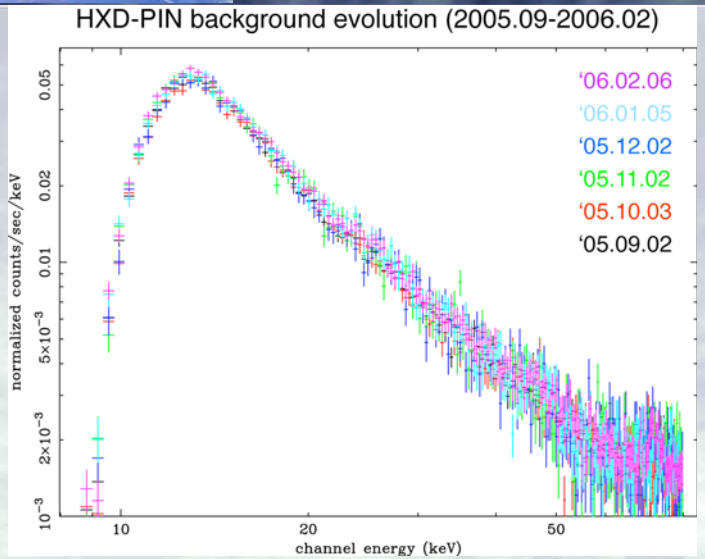
PSR1509 On pulse

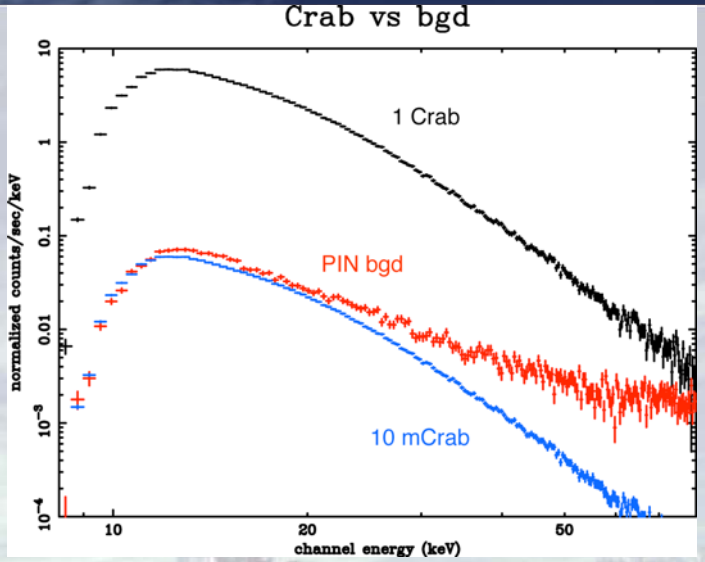


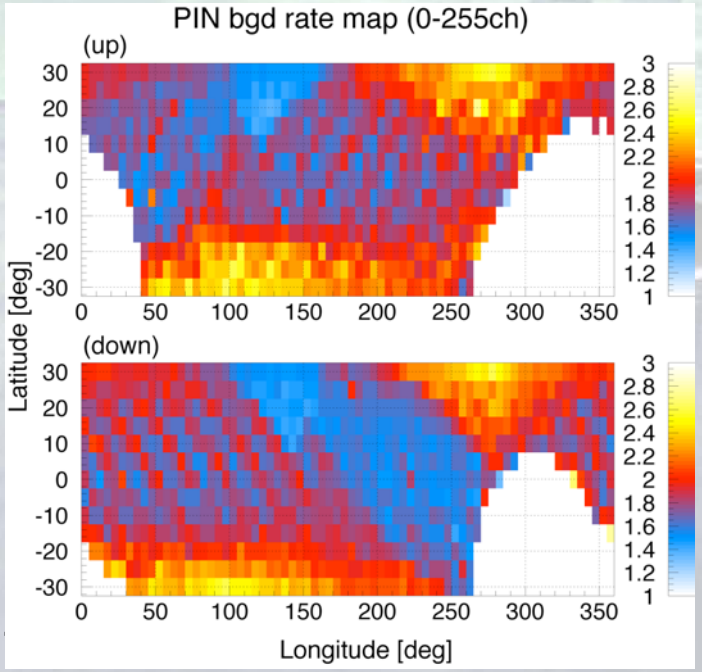
By use of the “On-pulse” spectra of pulsars, the response can be evaluated without the systematic uncertainties of the bgd subtraction.



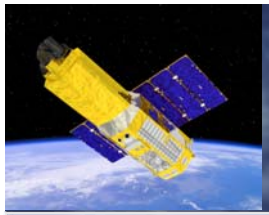
PIN Background



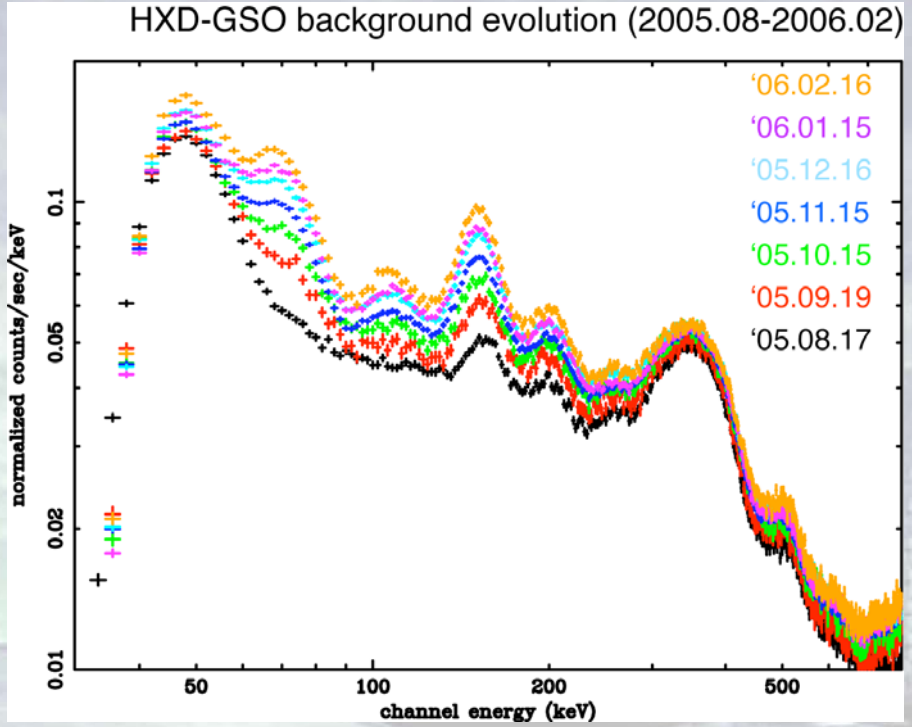


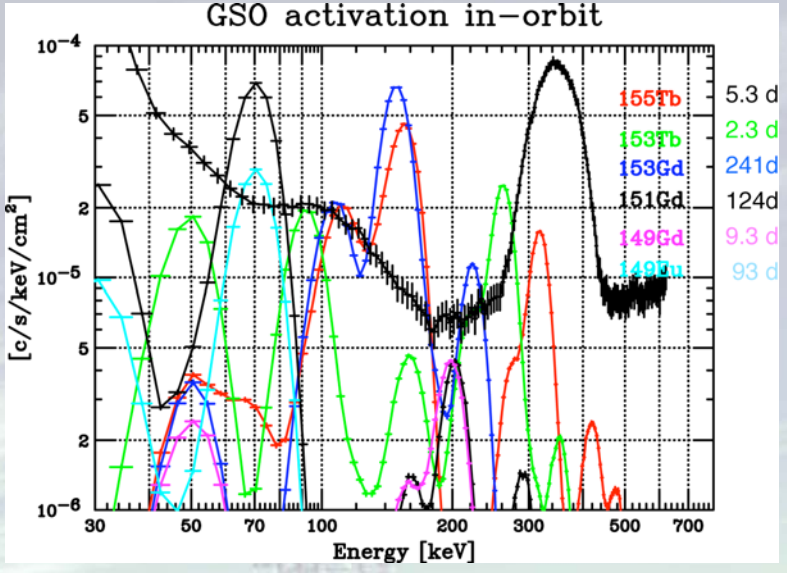


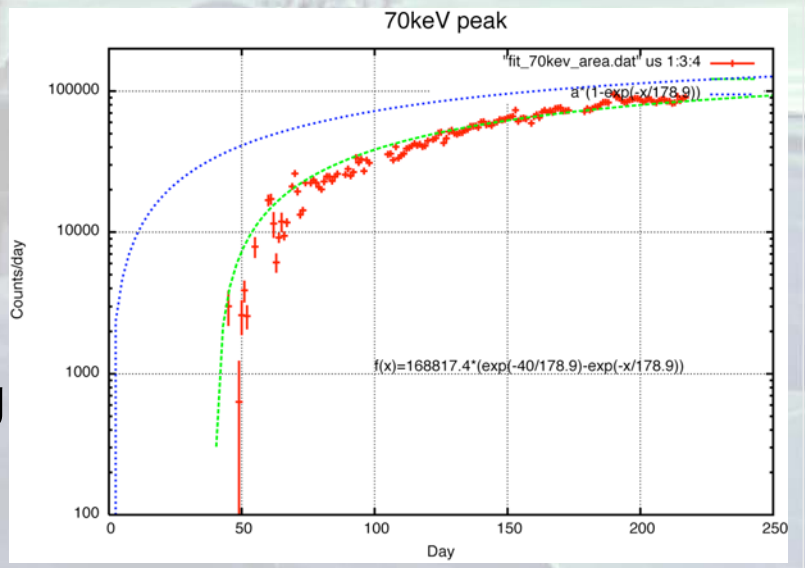
No difference during five months with a systematic error less than 5%. The background level of PIN is ~10 mCrab at 10-25 keV.
A sensitivity of 0.5 mCrab can be achieved with 5 % accuracy of bgd model.
We are accumulating the background database.



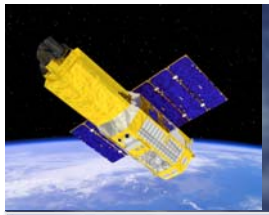
GSO BACKGROUND



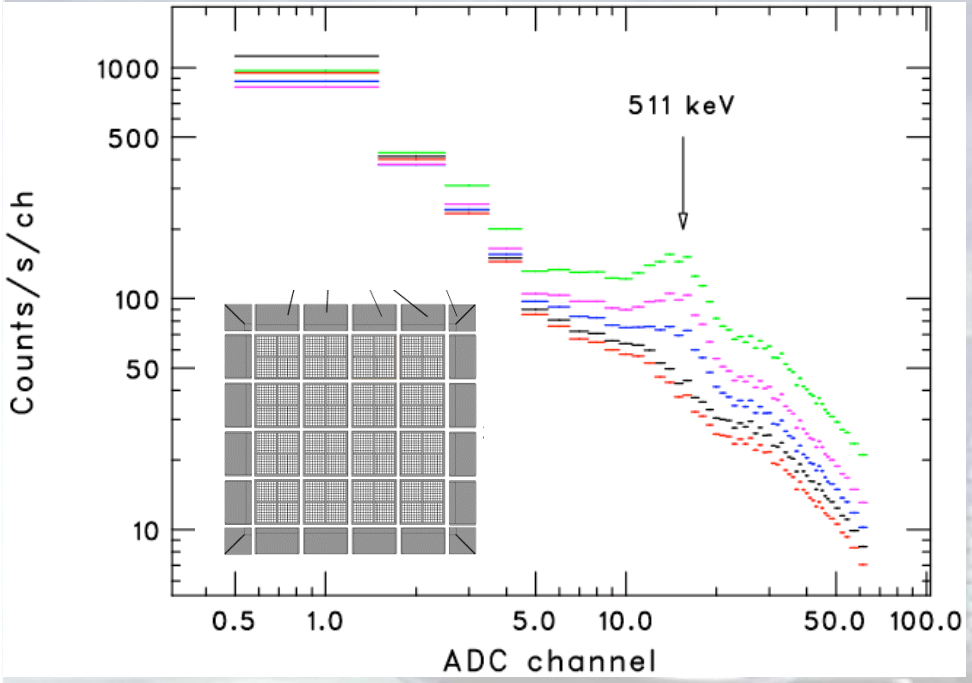


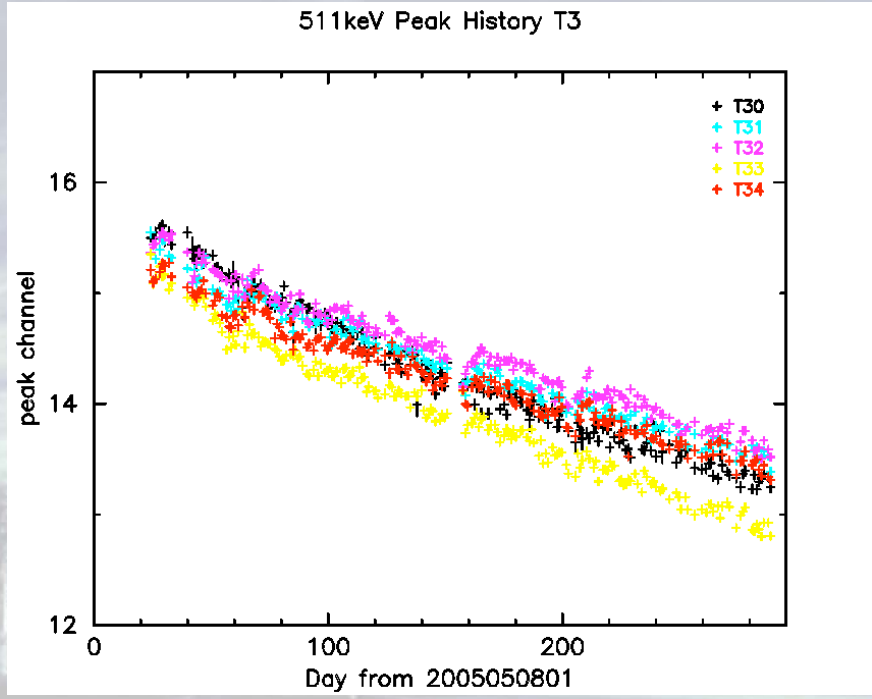


Most of prominent line features can be explained by the activation model developed before the launch. The build-up of individual RI components are fit with the corresponding half-lives.

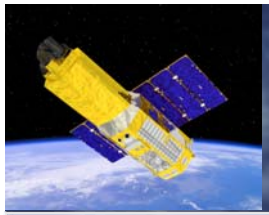


WAM calibration : Gain

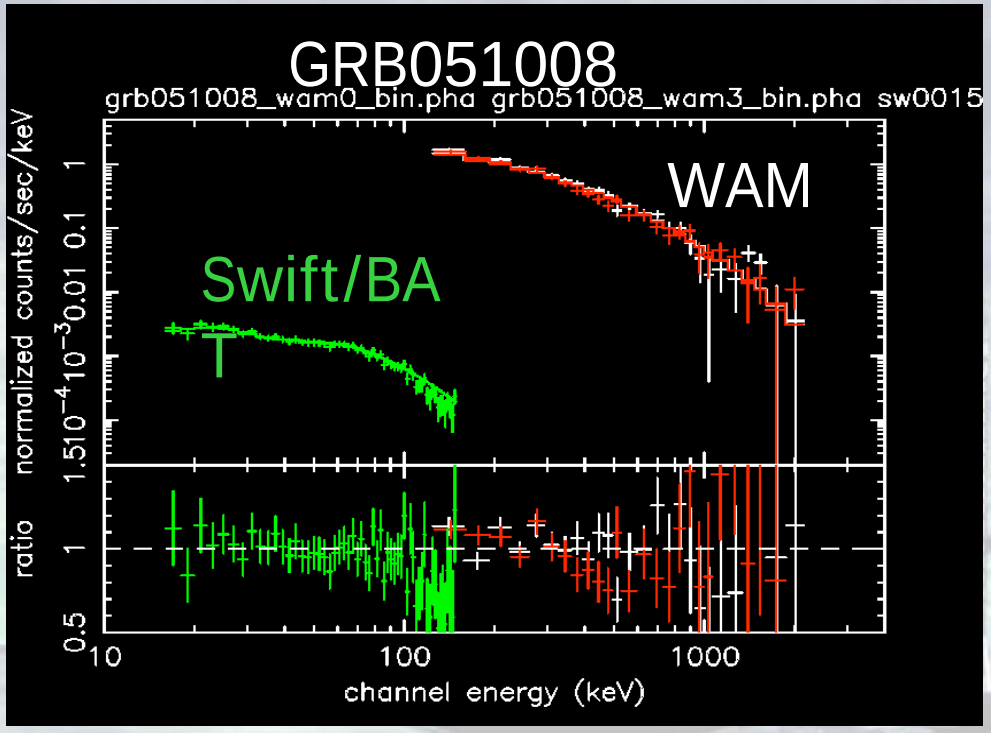


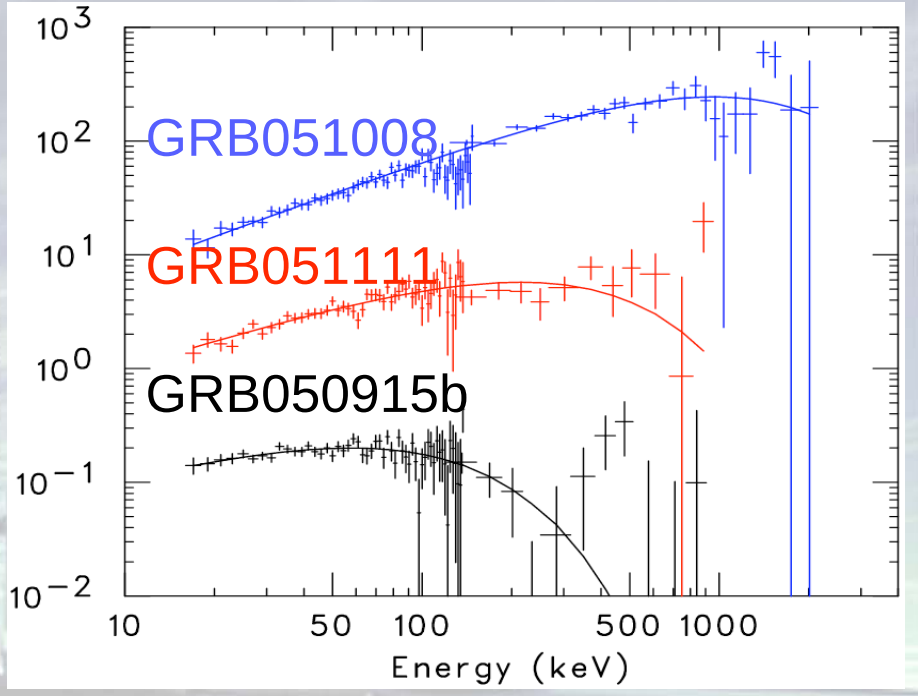


Each face of WAM consists of 4 shield units (the corner unit is excluded). The gain of individual units can be monitored with the annihilation line. A similar long-term gain decrease as that of well-type phoswich units are also observed.



WAM CALIBRATION : RESPONSE

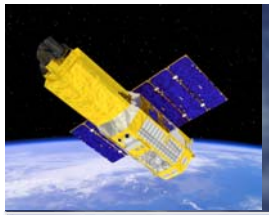




Response matrices are calculated by use of the mass model based on the GEANT4 Monte-Carlo simulation toolkit. A careful calibration is needed since the response depends on the incident angle of GRB.

We have calibrated the absolute flux based on several GRBs which are simultaneously detected with other satellites (Swift and Konus-wind).

Flux uncertainty is currently ~20% in 100-2000 keV.



Summary

We are still extensively calibrating the energy scale, non-linearity, gain variation, energy response, and the background modeling of PIN/GSO, and WAM.

In case of PIN, the gain is very stable, and the calibration are already close to the design goal. On the contrary, the scintillators show complex time variations which is different from unit to unit, and we still need some improvements by utilizing the in-orbit calibration data.