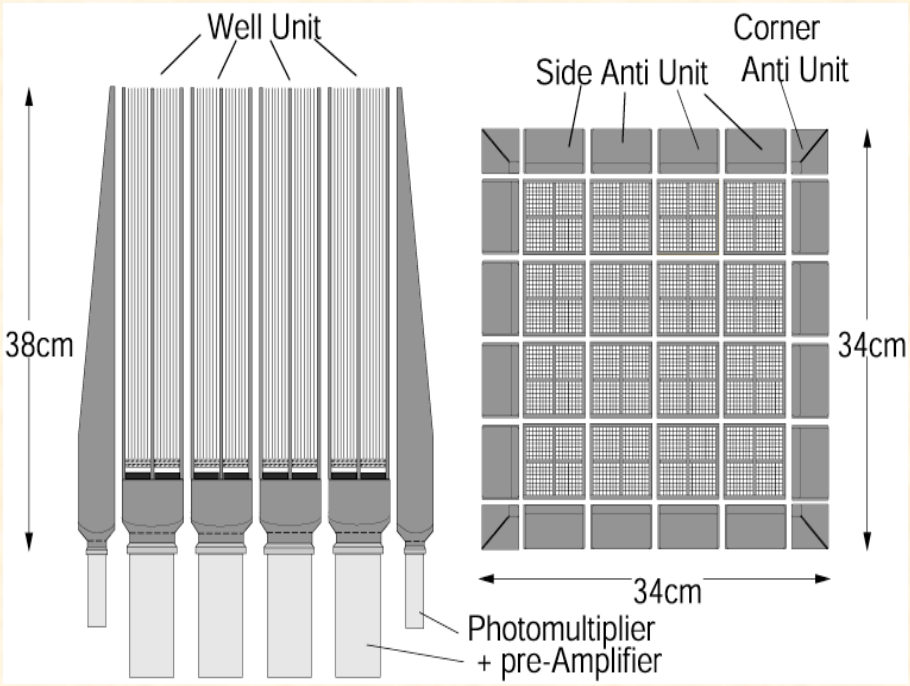
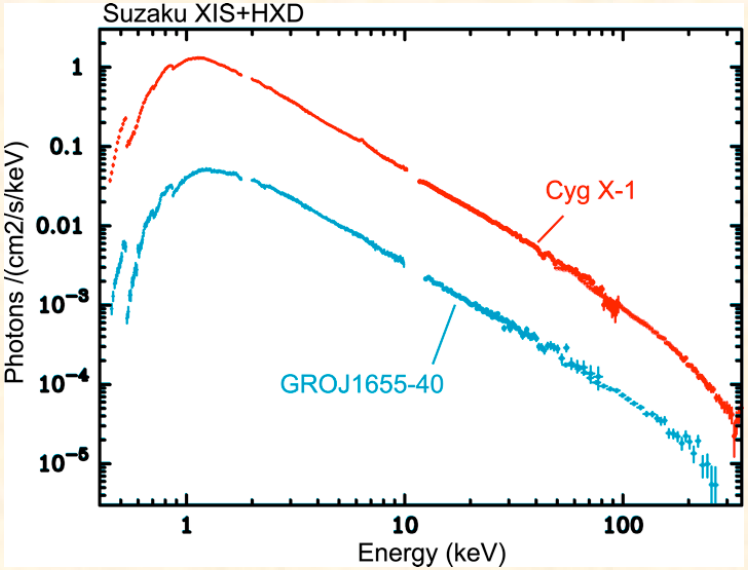
HXD Status/performance and Calibration plan

Y.Terada
on behalf of the Suzaku-HXD team

Hard X-ray Detector





64 PIN-Si diodes : 10-70 keV, dE~4keV(FWHM)

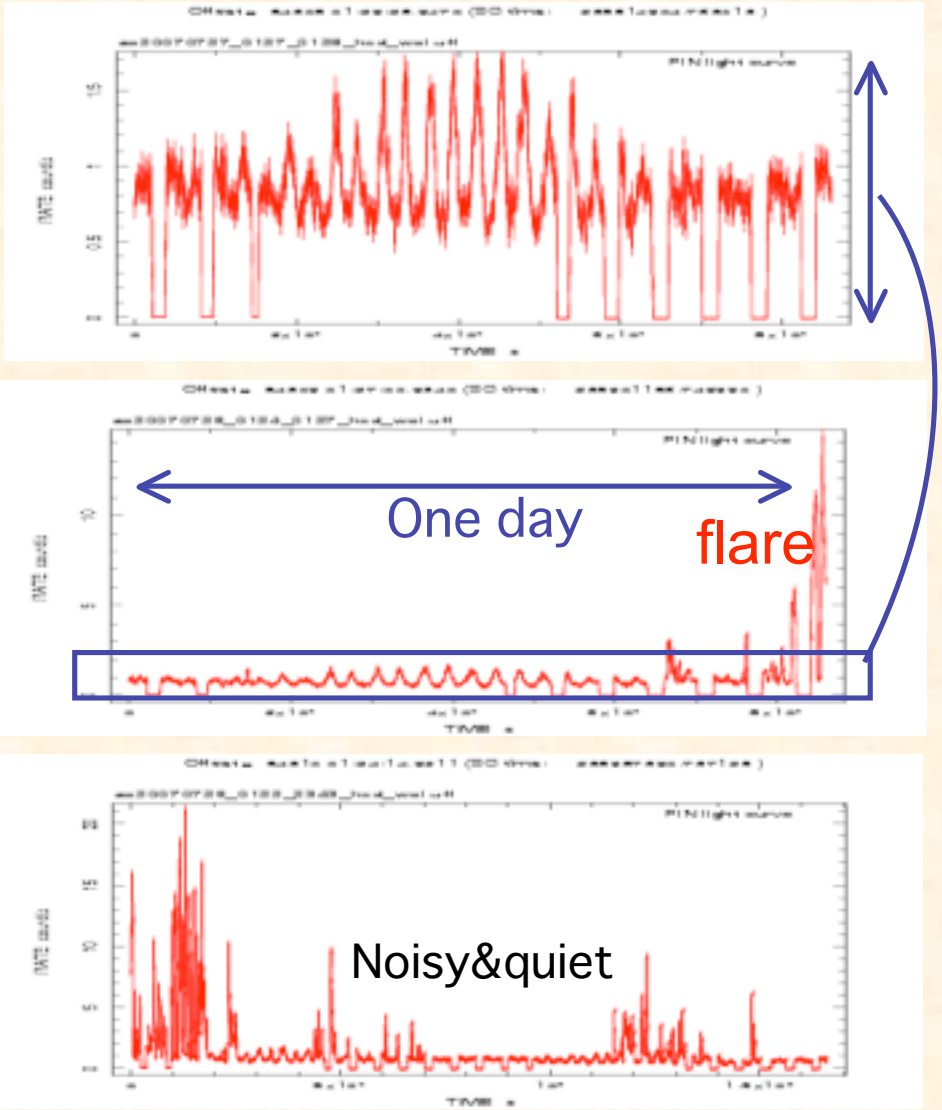
16 well-type phoswich (GSO) : 40-600 keV

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

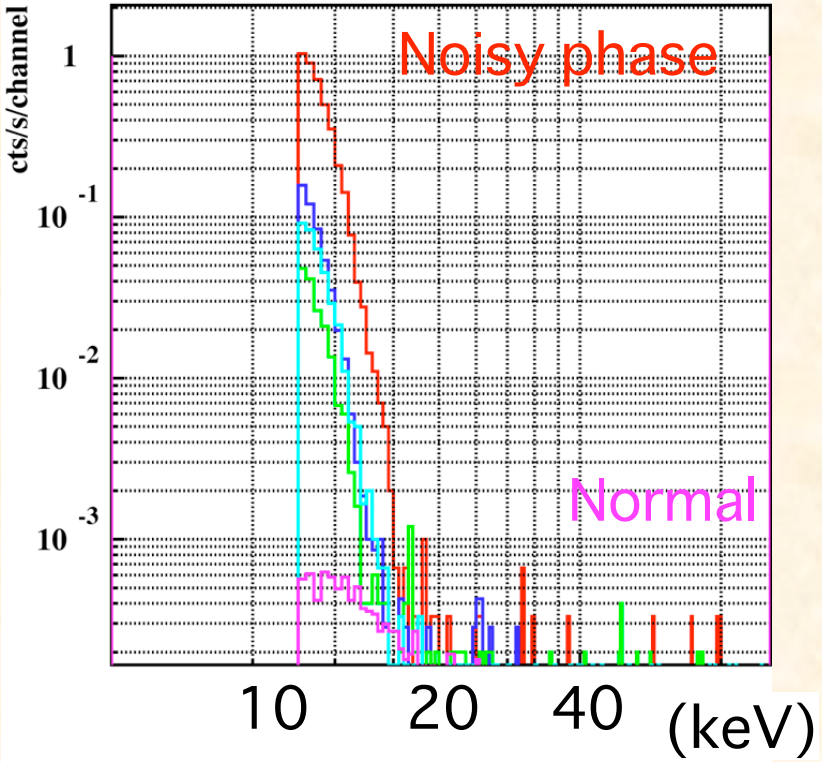
1. In-orbit Operation (2007)

~1.1 PIN HV operation~

Flare-like event on 28 Jul, 2007



PIN Spectra of W10 PIN-0



- Low energy noise around LD
- HV (W1) 400V → 0V
  → 300V → 400V
- Now it is quiet

~ PIN HV summary ~

Date	W0/	W1/	W2/	W3
2005/08/17	500V/	500V/	500V/	500V
2006/05/25	400V/	500V/	500V/	500V
2006/10/03	400V/	400V/	500V/	500V
Now	400V/	400V/	500V/	500V

Please check
http://www.astro.isas.jaxa.jp/suzaku/log/hxd/

In-orbit Operation (2007)
~1.2 GSO UD operation~

HXD sub system

Spacecraft

AE-DE transfer limitation
1k events x 4 line

Telemetry limitation
32/16kbps
(Data Rate-H/M)

In condition of sun angle, temperature of cold plate of the HXD, charging the battery, etc…

If saturated,

dead time increase

data gap / skip

In-orbit Operation (2007)
~1.2 GSO UD operation~

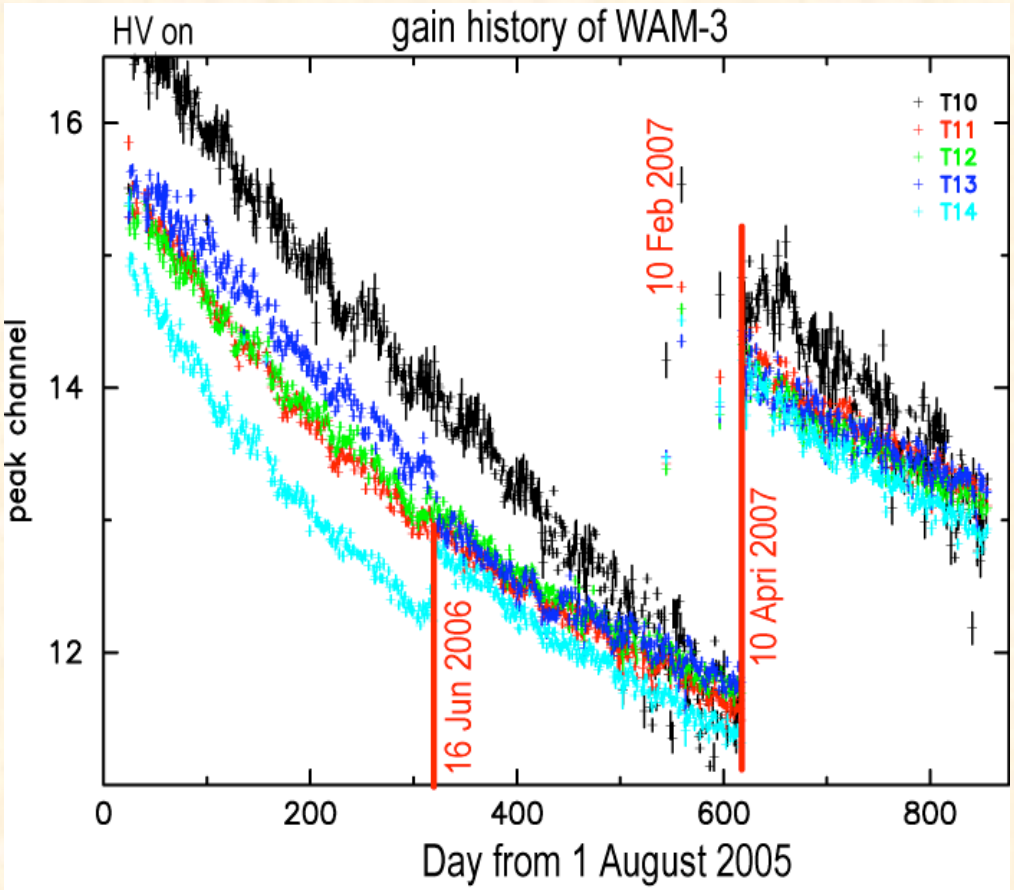
To avoid the saturation between AE-DE, we checked the setting parameters of the HXD-AE; on 11/Aug/2007, we changed the upper discrimination level of GSO (>1000 keV → ~800 keV)

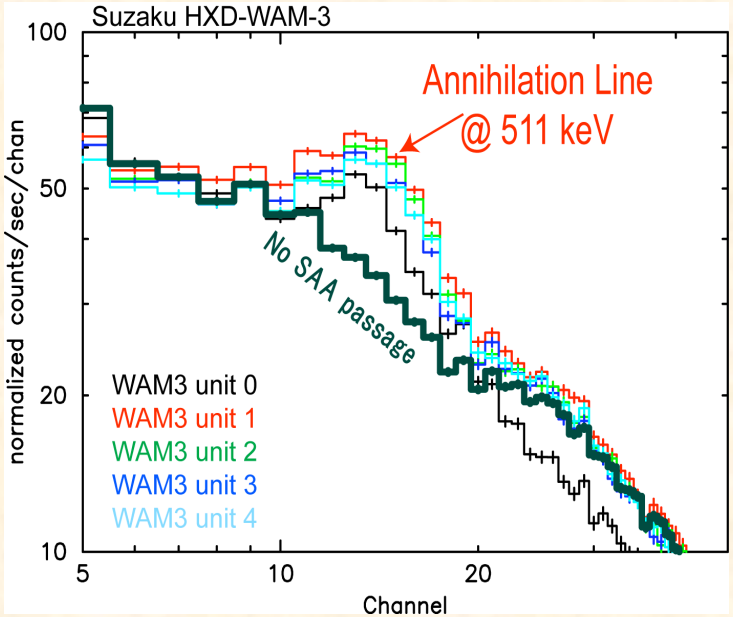
- Average rate decreased by ~15% as estimated.
- AE-DE rate saturate at low COR regions even after the UD operation (excluded from the cleaned event).
- In the low COR region, lower energy events than GSO UD dominate the rate.
- No further operations are planned. (Final setting of HXD-AE)

Successfully made the margin of the saturation of the data transfer between the HXD-AE and HXD-DE

In-orbit Operation (2007)
~1.3 WAM gain changed~

We check the PMT gain of WAM 20 units, every day using annihilation line feature after the SAA passage.





· Change AMP gain at 10 April 2007,
after the mode check on 10 Feb ’07.

2. Software Updates (V1.x → V2.x)

2.1 Format Changed

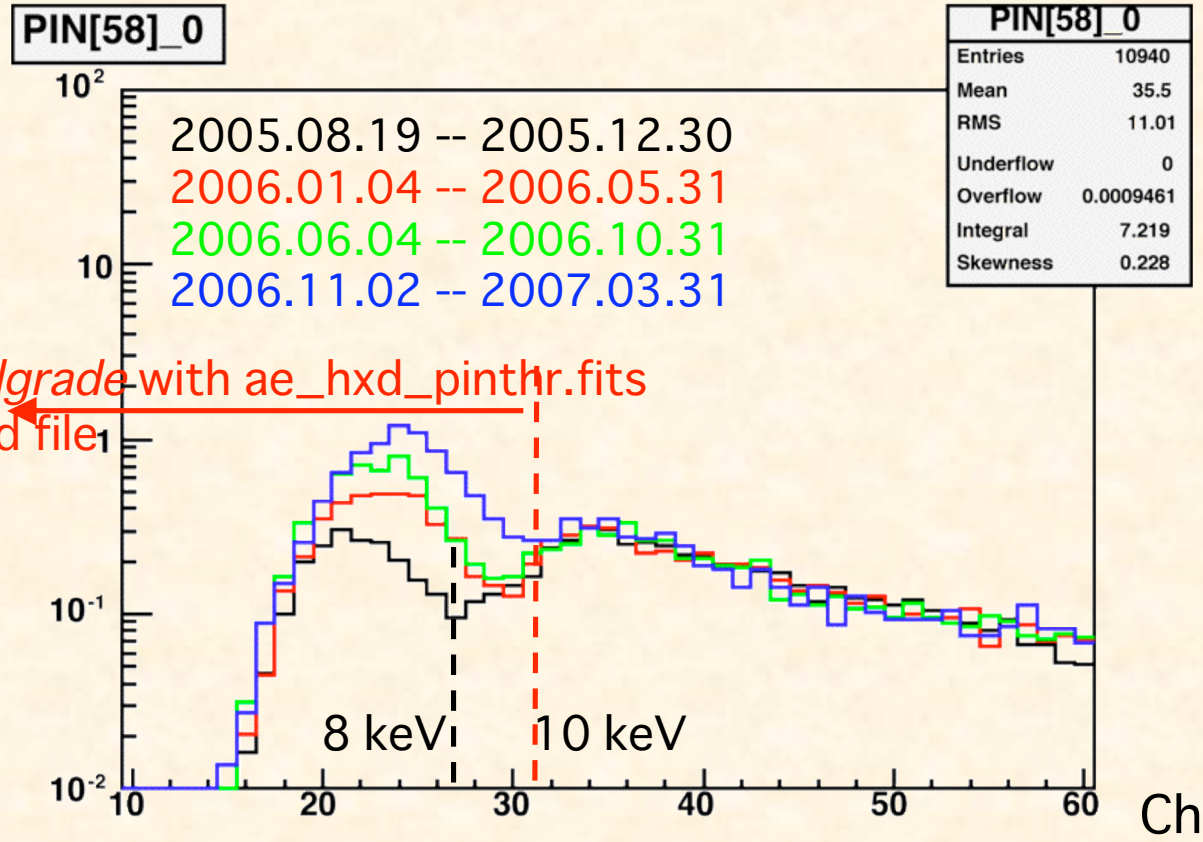
- Format of WEL event fits file was changed.
- HXD ftools in HEADAS 6.3-6.4; **no** backward compatibility to V1.x format files.

- If you need to analyze ver 1.x products, please use format conversion script provided via
  http://suzaku.gsfc.nasa.gov/docs/suzaku/analysis/v2soft.html,
  and use new ftools.
- The HXD team strongly suggest to use the ver2.x products with new ftools and CALDB.

2.2 GTI Changed

- v1.x GTI includes the time when HXD-AE to –DE transfer is saturated
- v2.0 The epochs when AE to DE transfer is saturated are excluded in the
  GTI to make cleaned event list.
- If you want to ignore AE-DE saturation, please make a GTI file by yourself with *hxdgtigen* in fifo_full=no mode, and make cleaned events with the GTI from UFF

2.3 PIN (Software) Threshold changed



discarded by *hxdgrade* with ae_hxd_pinthr.fits
in making cleaned file

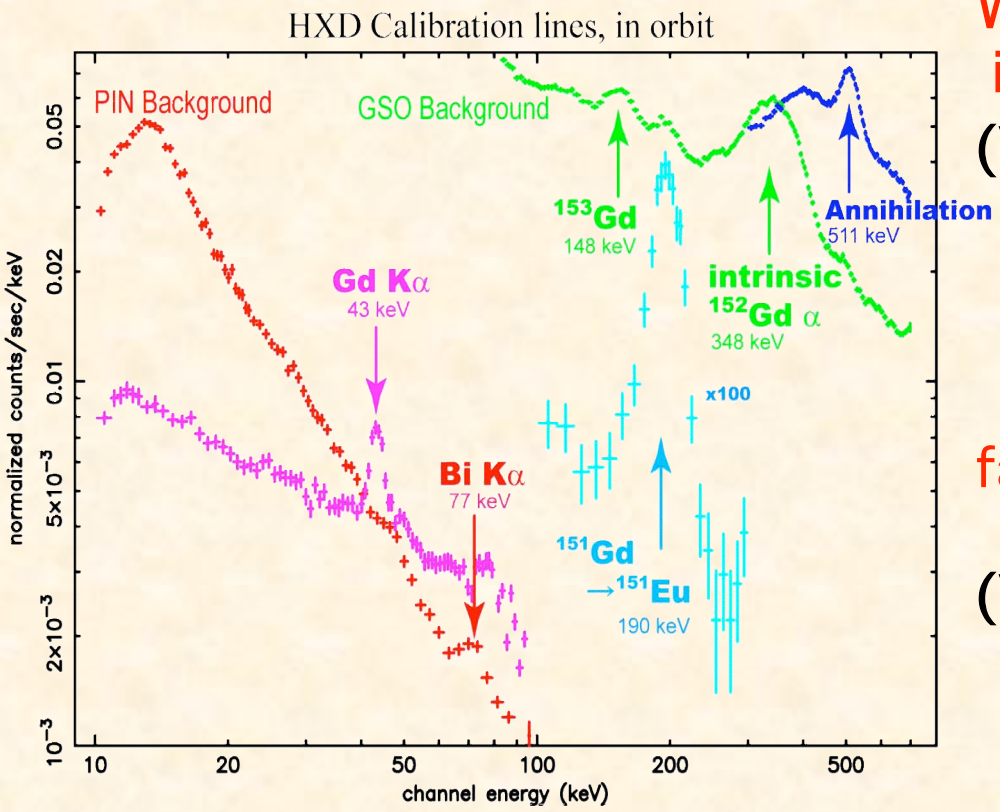
4 sets of ae_hxd_pinthr_YYYYMMDD.fits in CALDB.

epoch 1) 2005-08-17 11:00
epoch 2) 2006-05-25 13:25
epoch 3) 2006-10-03 23:35
eopch 4) 2007-07-28 02:00

← automatically selected by *hxdpi*

2.4 GSO gain history

Energy scale calibration with the annihilation line, activation lines, intrinsic



We changed the GSO gain history fil in CALDB after ver 2.0.

(V1.x) GSO Gain History File:

ae_hxd_gsoghf_YYYYMMDD.fits

- list of PHA channel of lines
- one column per 1 day
- sometimes pipe-line proc failed.
- no maintenance now

(V2.x) GSO Gain History Table:

ae_hxd_gsoght_YYYYMMDD.fits

- products from gsoghf, stable
- list of parameters of gain trend
- drifts by the temperature, short

term trend after HV OFF/ON

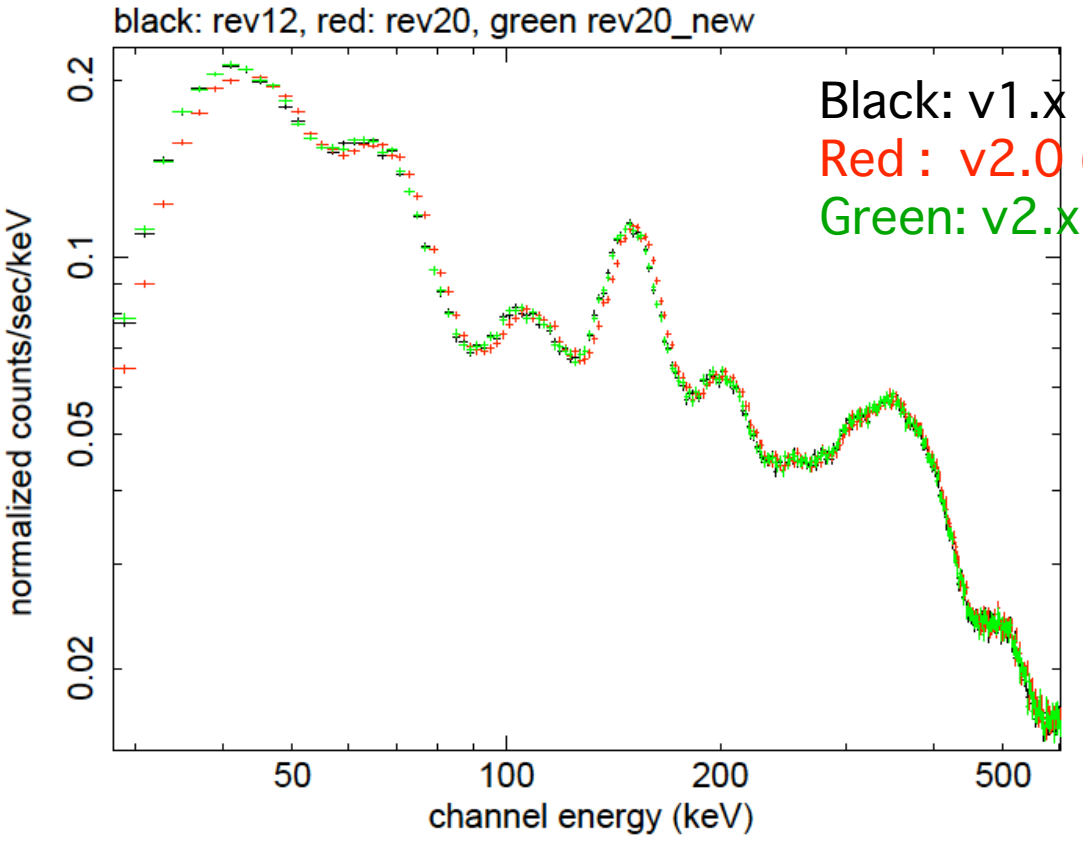
Important notes:

-Gain determined in the pipe line process is a tentative value.

-Final gain values will appear in CALDB area, (every month).

→ Please reprocess gso events file by yourself.

-There's a known bug in *hxdpi* in HEADAS 6.3.x, which is fixed in the latest release HEADAS 6.4 last week (Dec 2007)



Black: v1.x

Red : v2.0 (HEADAS 6.3)

Green: v2.x (HEADAS 6.4)

・No difference between v1 and v2 products

・Bug in hxdpi for v2.0,v2.1,v2.2 products (which is fixed in the latest release, 6.4)

3. Calibration Updates (2007)

3.1 Current status

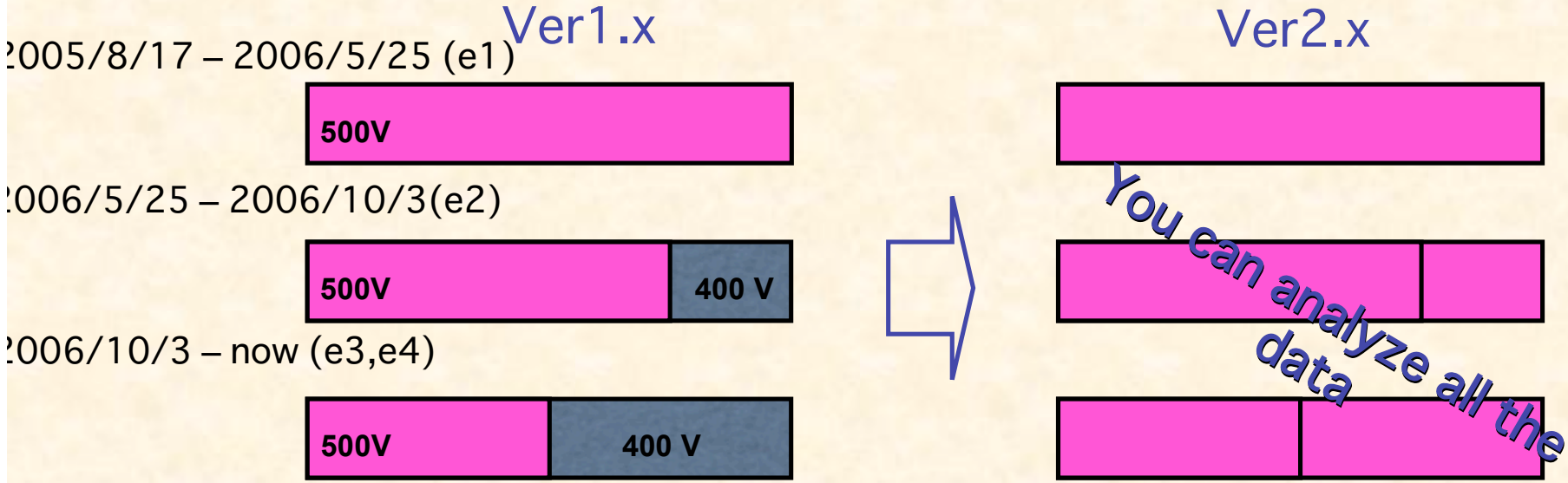
http://www.astro.isas.jaxa.jp/suzaku/process/caveats/

Table: Error Budgets of Scientific Instrument Calibrations

Instrument	Calibration Item	Present Uncertainties (July 2007)	Requirement	Goal
HXD	Absolute effective area	20%	20%	5%
	Relative effective area	15%	10%	5%
	Angular response	5%	10%	5%
	Background modeling (PIN)	5~10%	10%	5%
	Background modeling (GSO)	3%	10%	3%
	Energy scale	1% (PIN)	**%	**%
	Absolute timing	360 mu s	300 mu s	100 mu s
	Relative timing	1.9×10^{-9}	10^{-8}	10^{-10}
HXD-WAM	GRB absolute timing	2 ms	1 ms	1 ms
	Absolute effective area	10~40%, depending on the incident angle	20%	20%

3.2 PIN HV=400V data

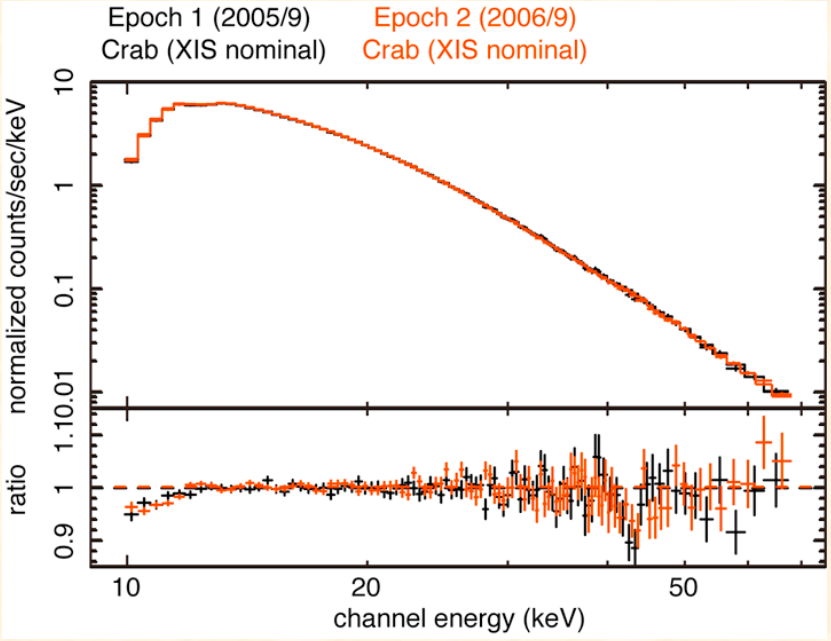
In version 2, we can analyze all the PIN data including HV=400V datasets

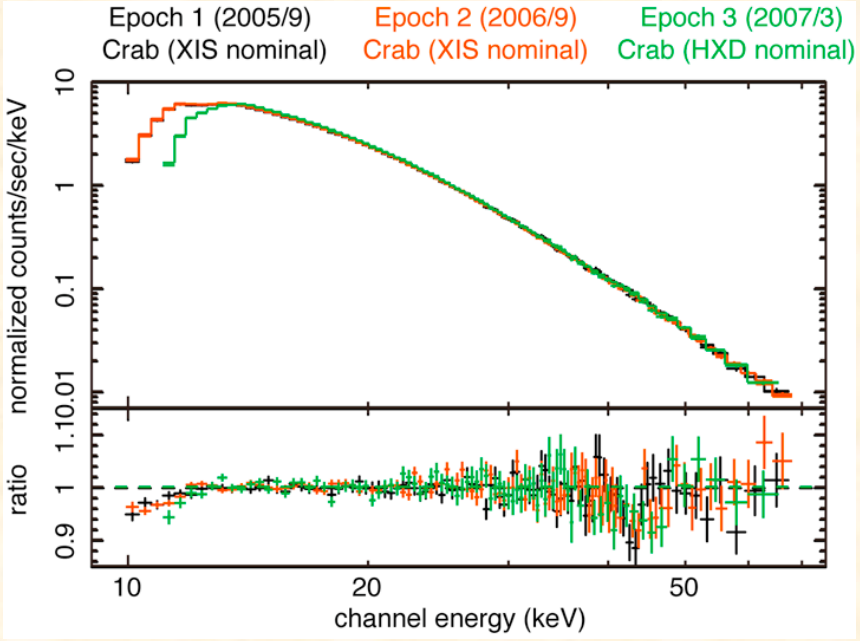


- Response files for epochs
  - ae_hxd_pinxinome1_20070914.rsp
  - ae_hxd_pinxinome2_20070914.rsp
  - ae_hxd_pinxinome3_20070914.rsp
  - ae_hxd_pinxinome4_20070914.rsp
- NXB models
  - estimation for selected WEL units (v1.x) → each Unit and HV settings (v2

Crab spectra

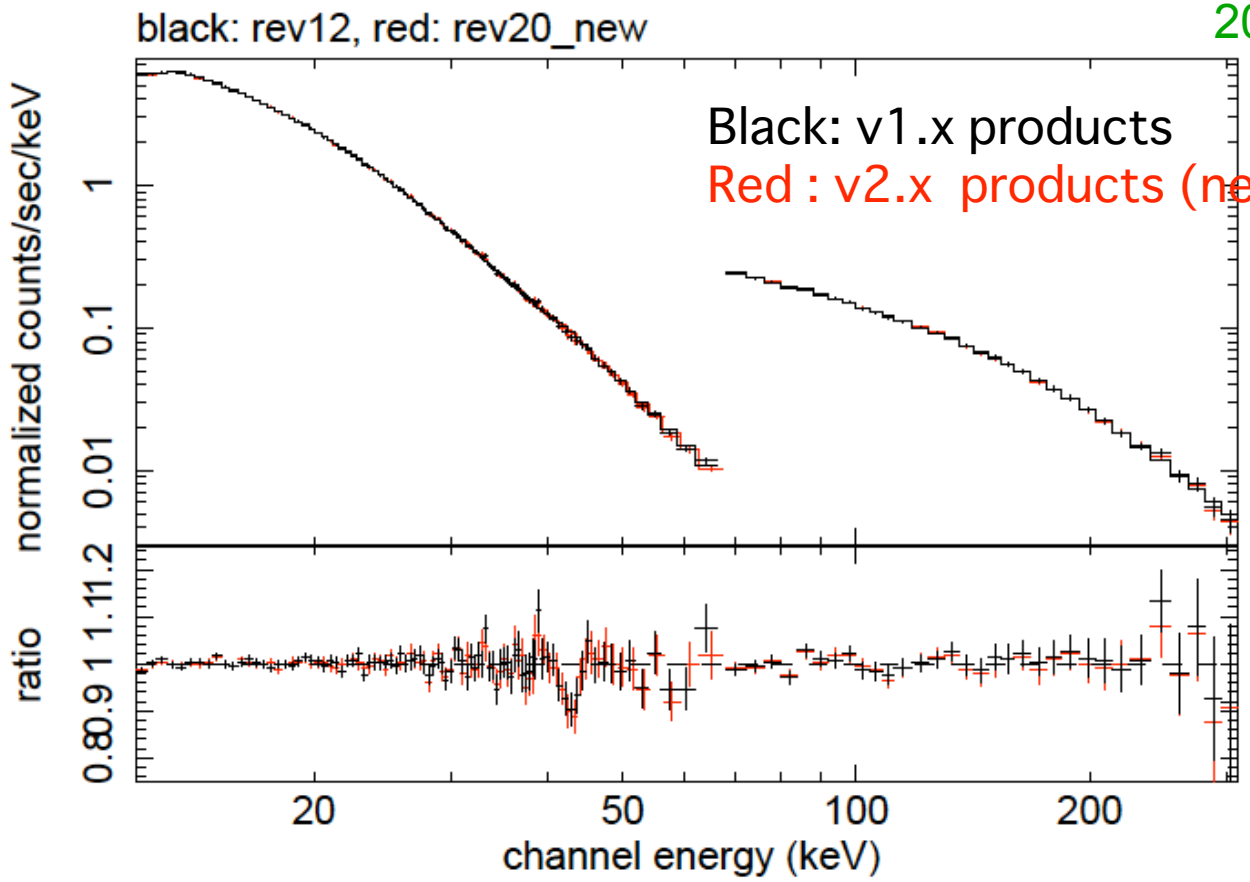
Epoch 1. 2005.8.17 -- 2006.5.13
Epoch 2. 2006.5.13 -- 2006.10.2
Epoch 3. 2006.10.2 -- 2007.7.28
Epoch 4. 2007.7.28 -- **





Epoch	Nominal	gamma	norm (@ 1 keV)	chi2/dof
	constant factor%			
1	XIS	2.11 (±0.01)	11.6 (+0.2,-0.3)	79.6/89
1.16 (±0.01)				
1	HXD	2.09 (±0.01)	10.9 (+0.3,-0.2)	63.6/83
1.15 (±0.01)				
2	XIS	2.11 (±0.01)	11.4 (±0.2)	99.3/94
1.15 (±0.01)				

3.3 Energy response of PIN & GSO



2005/09/15 XIS nominal Crab

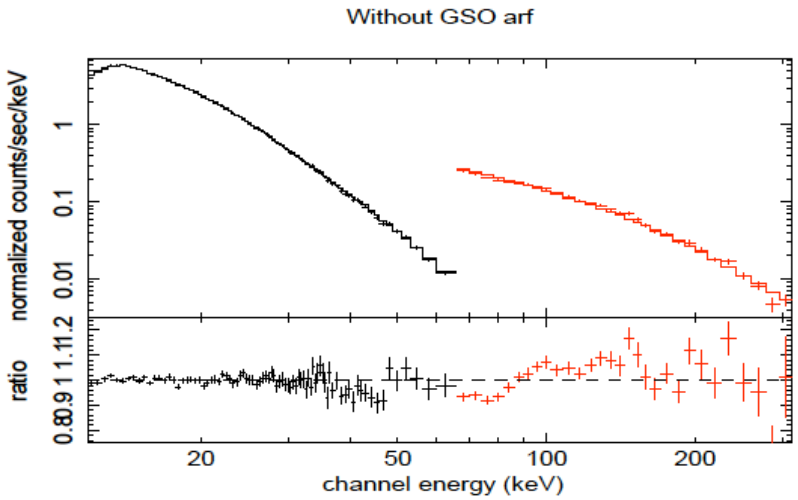
Black: v1.x products

Red : v2.x products (new hxdpi, with GSO arf)

- No difference between the v1 and v2 response matrix
- Please use the v2 rsp for the v2 products.

3.4 GSO response

Nominal GSO response (v2.x)



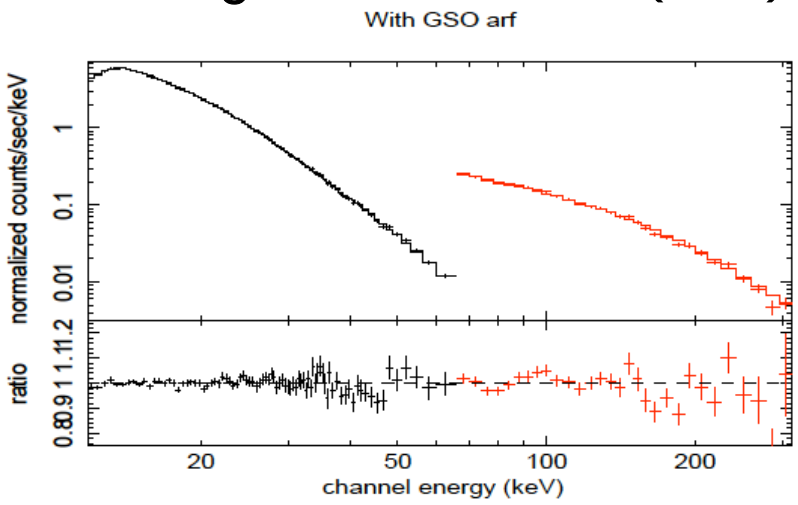
2007/03/20 HXD nominal, Crab Spectra

- Cross normalization PIN : GSO = 1: 0.80
- Residual ±10% in GSO band

χ^2/dof ~ 2.5

- We need further studies on GSO response

With fudge arf file of GSO (v2.x) ← For convenience to use GSO data



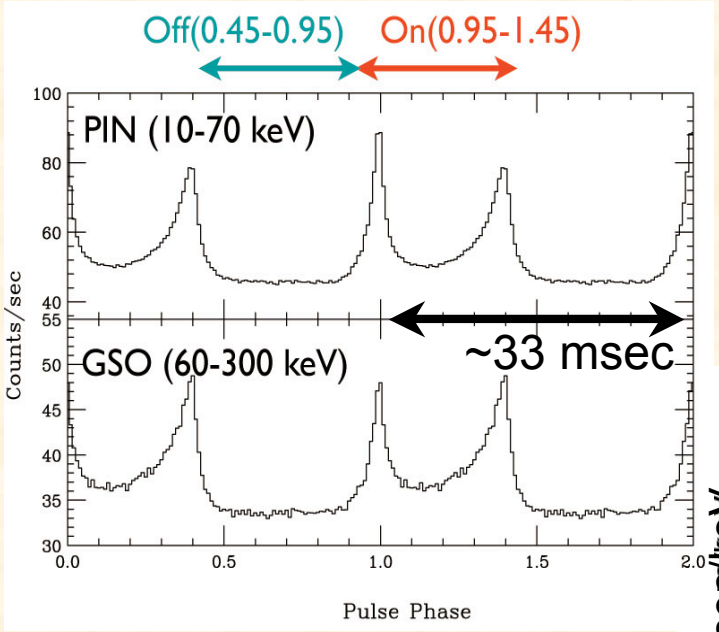
- We prepared fudge GSO arf file, which is just adjuste the Crab spectra

χ^2/dof ~ 1.5

- Cross normalization
  PIN :GSO = 1: 1.00 for the dataset of 15 Sep 200
  PIN :GSO = 1: 0.96 for 20 March 2007 Crab
  (caused by the angular response, roll angle)

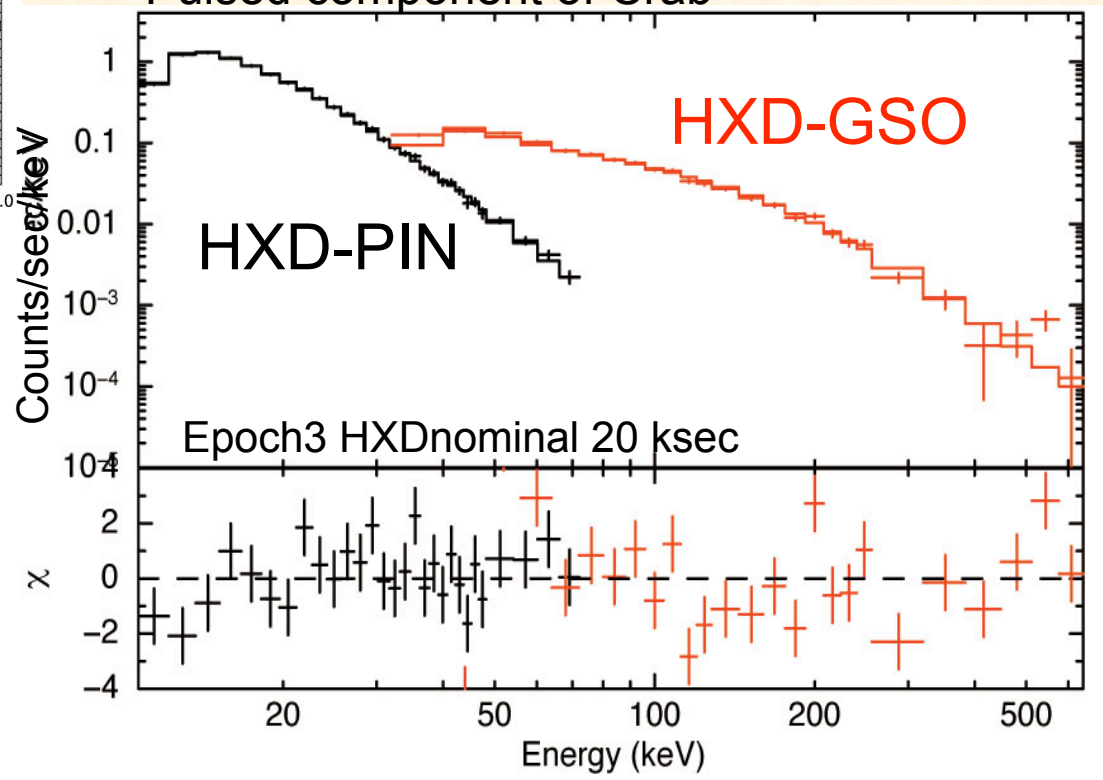
- Need more checks on this fudge factor!! Please be ca

Another photon index (1) Crab Pulse On-Off spectrum

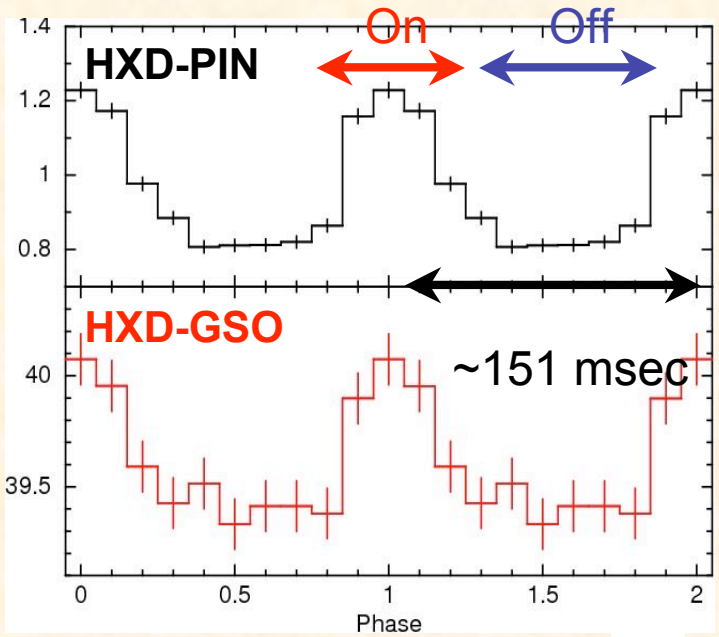


Crab On-Off spectra which can be fitted with a single power law (Γ =1.5, cross normalization PIN:GSO = 1:1)

Pulsed component of Crab

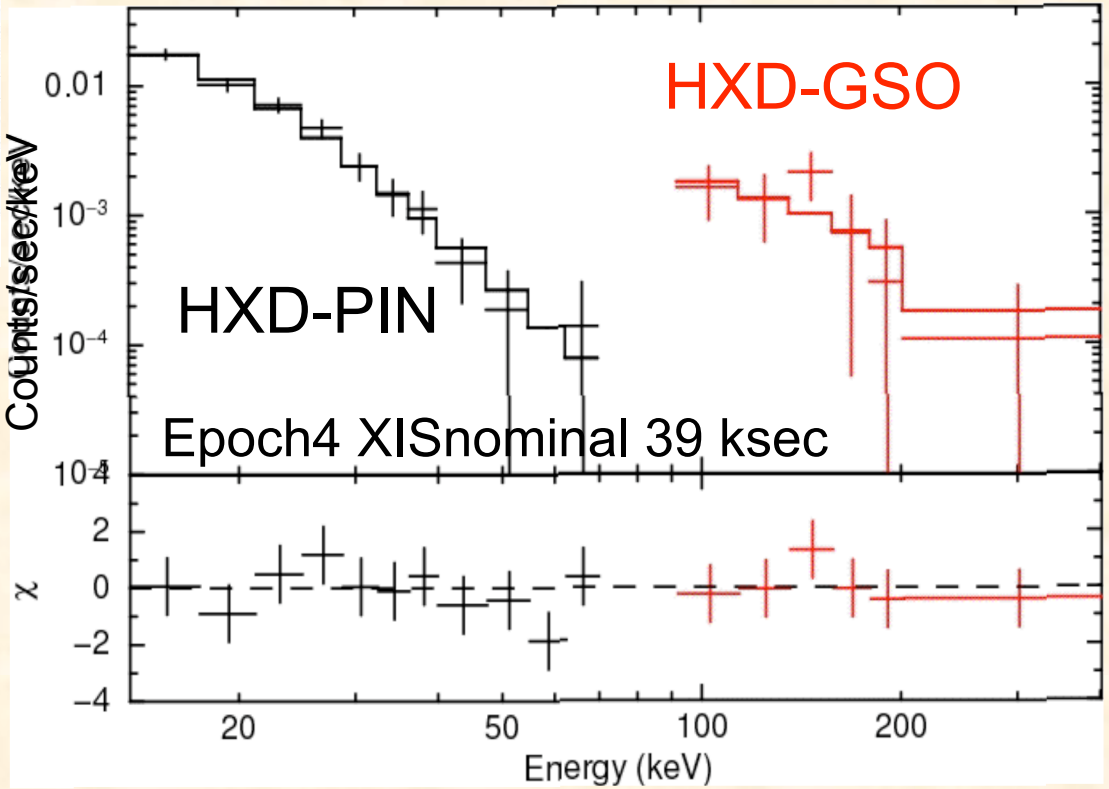


Another photon index (2) PSR B1509-58 Pulse On-Off spect

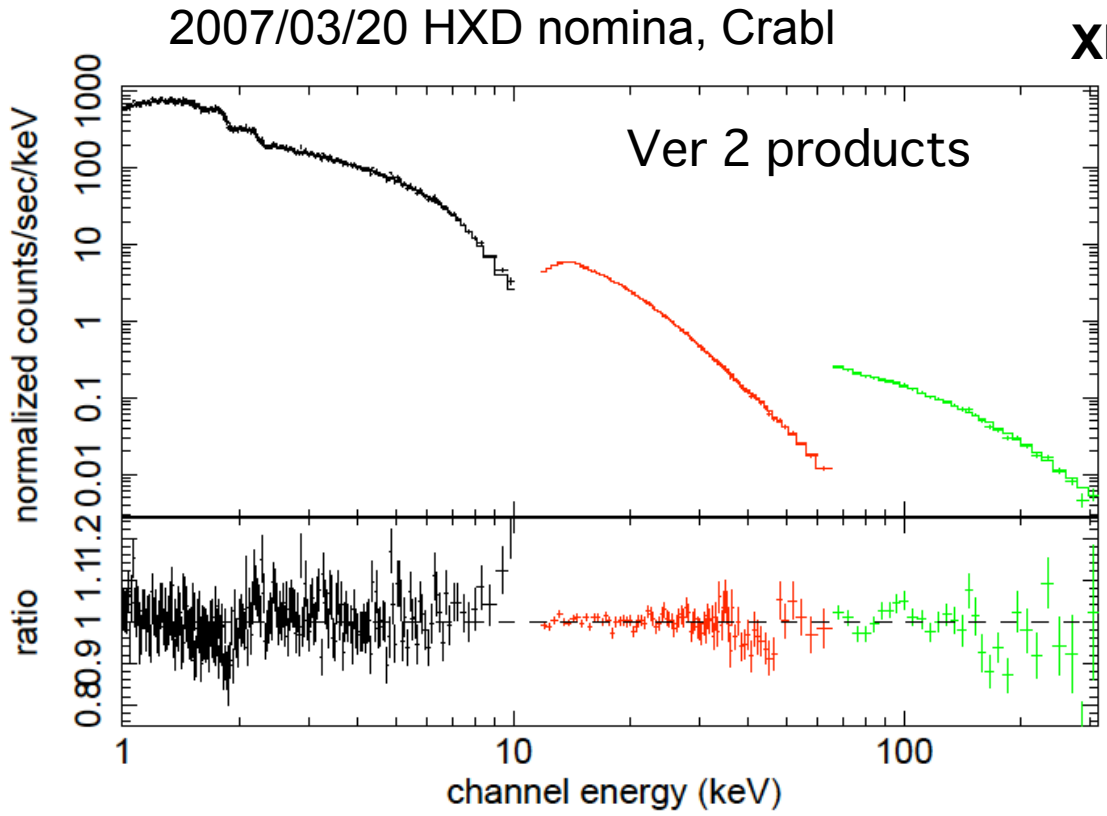


PSR1509-58 On-Off spectra which can be fitted with a single power law (Γ =1.92, cross normalization PIN:GSO = 1:1)

Pulsed component spectra of PSR1509-58



3.5 cross normalization between the XIS and the HXD



XIS0: PIN: GSO = 1 : 1.12 : 1.07

※ Same results on NGC2110 (XIS nominal),
XIS:PIN=1:1.13
※ PIN: GSO = 1: 0.96 for this data

$N_H = 0.33 \times 10^{22}$
$\Gamma = 2.10$
Norm = 9.54
χ ^2/dof ~ 1.2

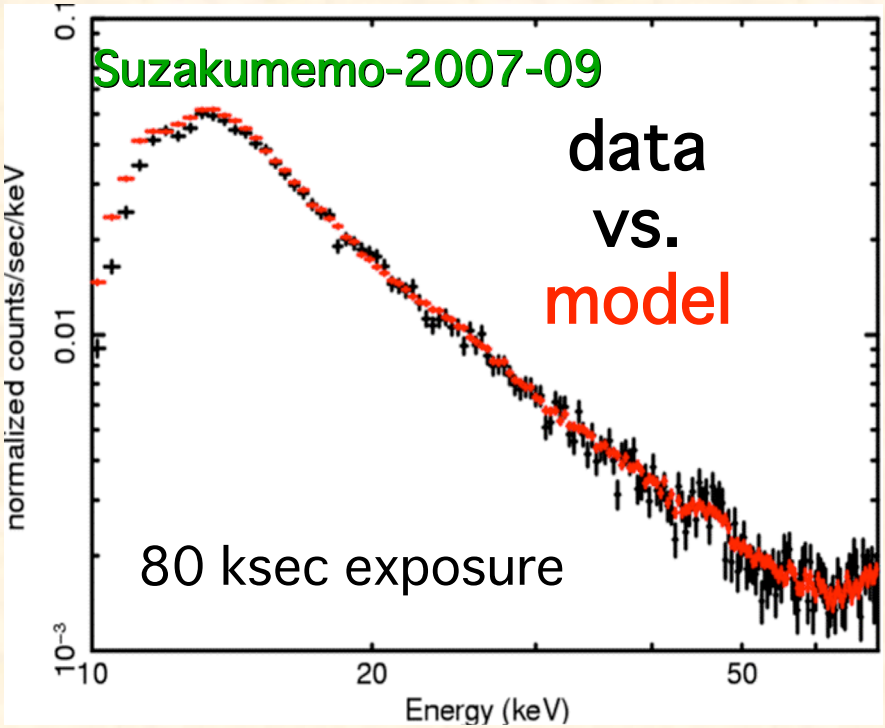
cross normalization (XIS: PIN = 1 : 1.12~1.15) the same as v1.x

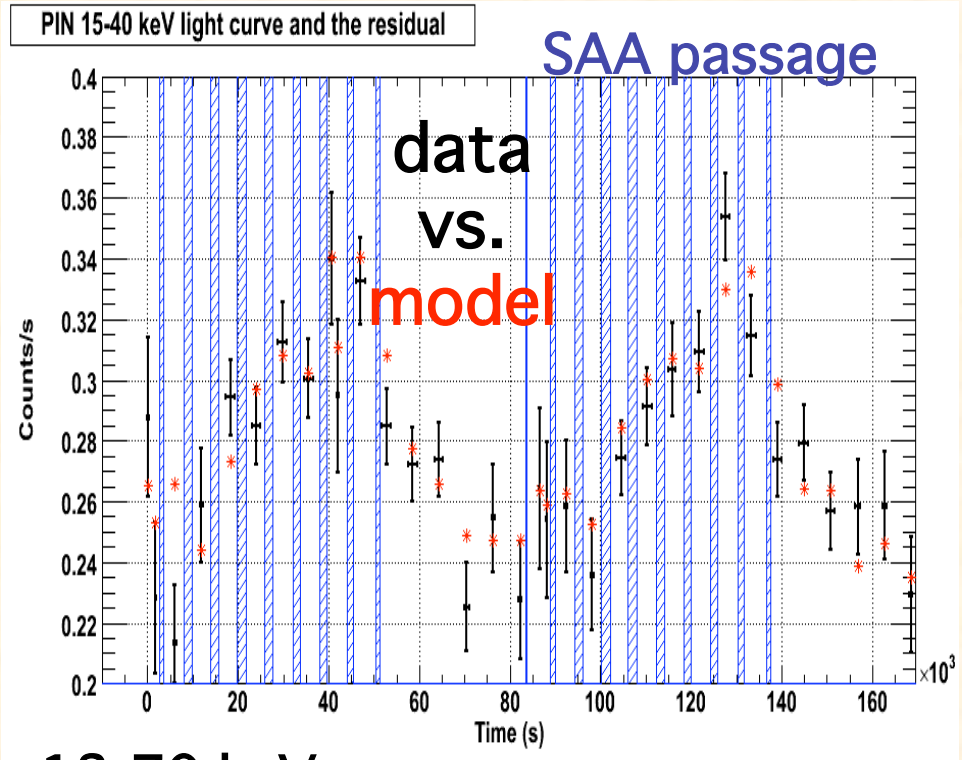
3.6 PIN NXB model, updated

Tuned up several parameters on PIN NXB model
Provided via WWW (ISAS & GOF), as an archive data.

http://www.astro.isas.jaxa.jp/suzaku/analysis/hxd/pinnxb/
ftp://legacy.gsfc.nasa.gov/suzaku/data/background/pinnxb_ver2.0

・Typical NXB spectrum and LC of a long "Earth" observation (MCG-6-30-1

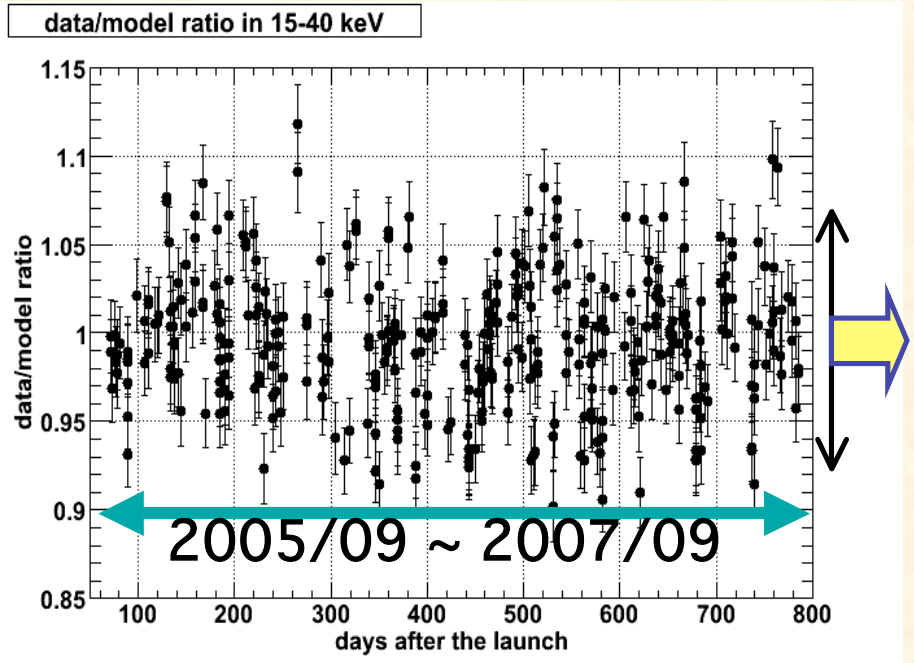


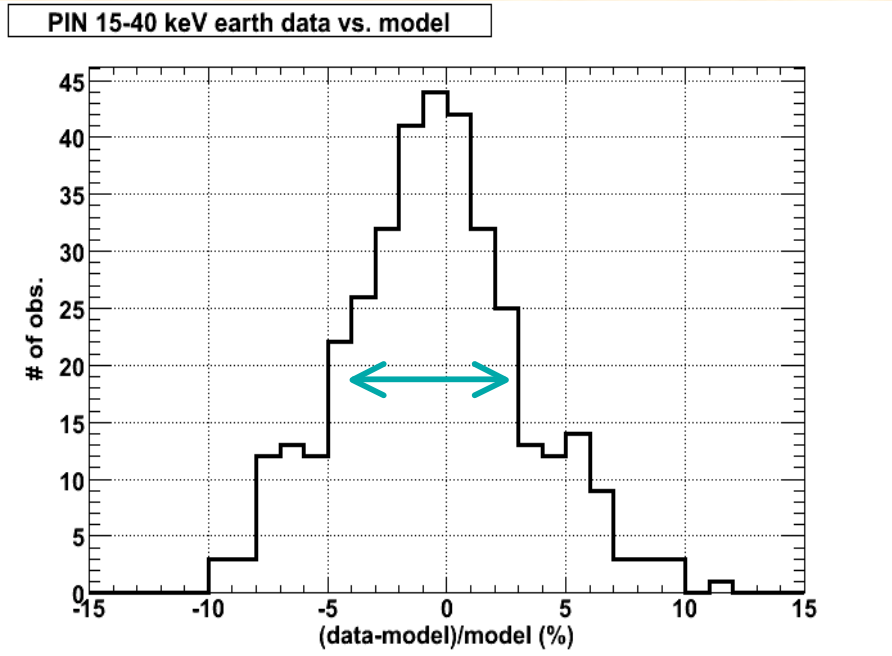


_good agreement in 12-70 keV
_NXBs in SAA path and non-SAA path are well modeled

・We checked the reproducibility of all available earth data.

Suzakumemo-2007-09





_ No long-term trend

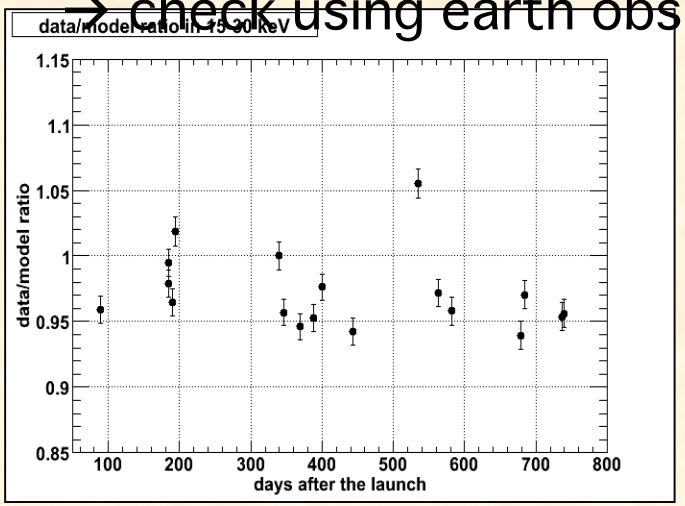
_ s=3.8%, s_{stat}=2.0% → s_{sys}= 3.2% (15-40keV, 10ks exposure e

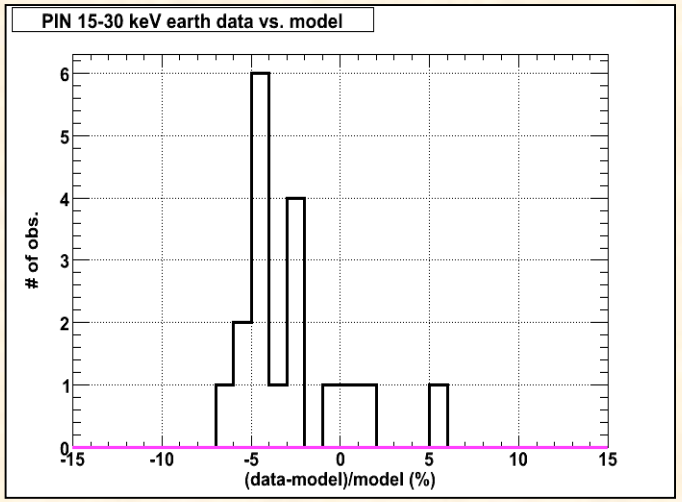
Comment: reproducibility after renormalization

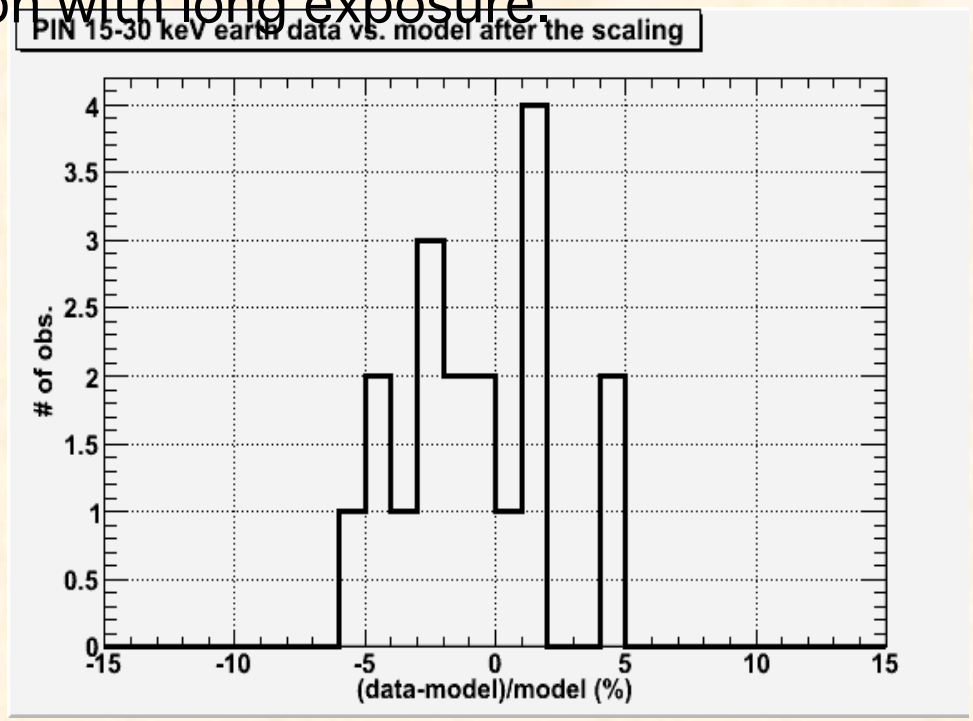
・Renormalization of the spectrum using a higher band is proposed for a better NXB estimation. (suzakumemo-2007-10)

・The improvement could be canceled by statistical errors in high energy band.

→ check using earth observation with long exposure.



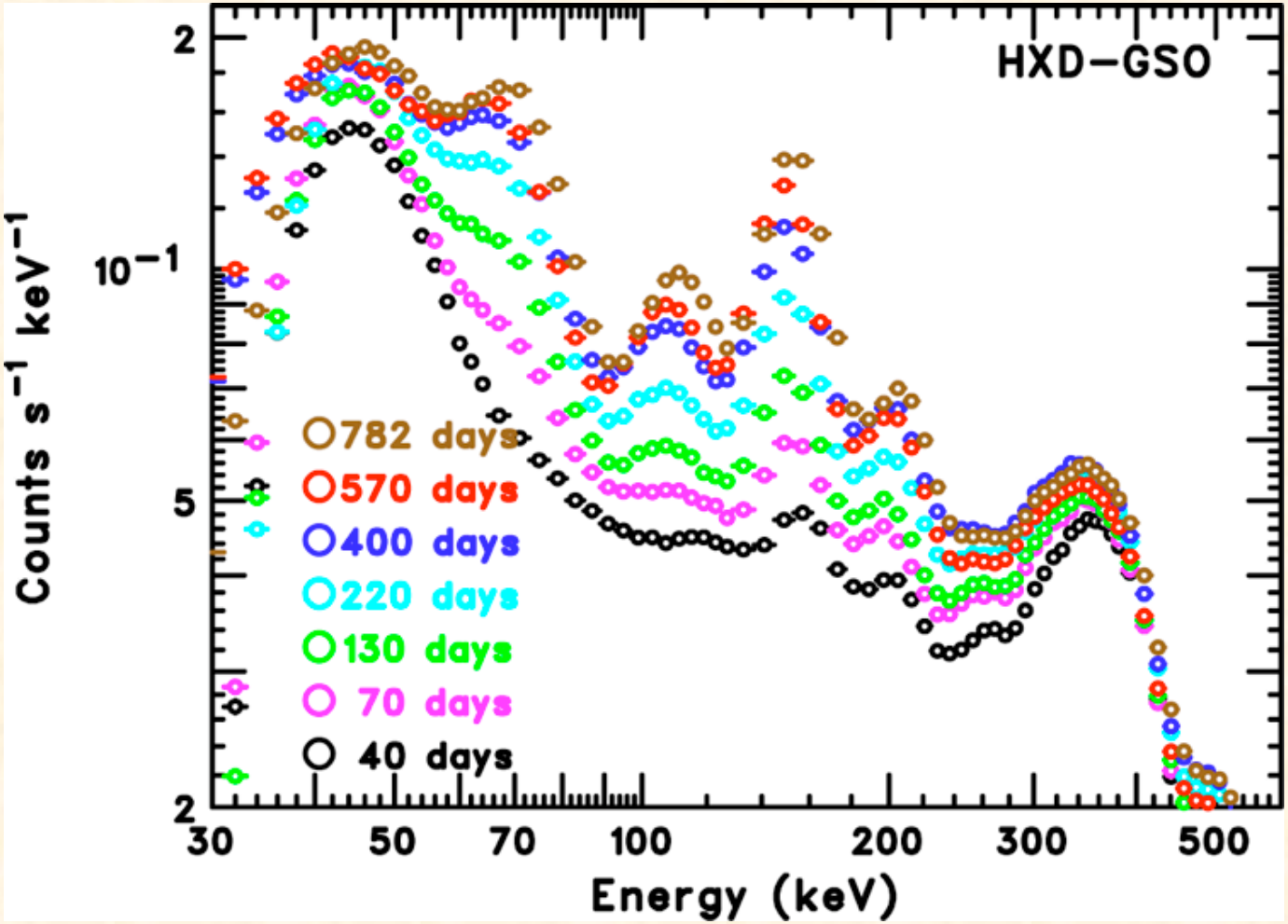




・No significant improvement.
(probably due to statistical error)

・peak-to-peak of the residual is ~5%
for earth obs. with exposures >40 ks.

3.7 GSO background



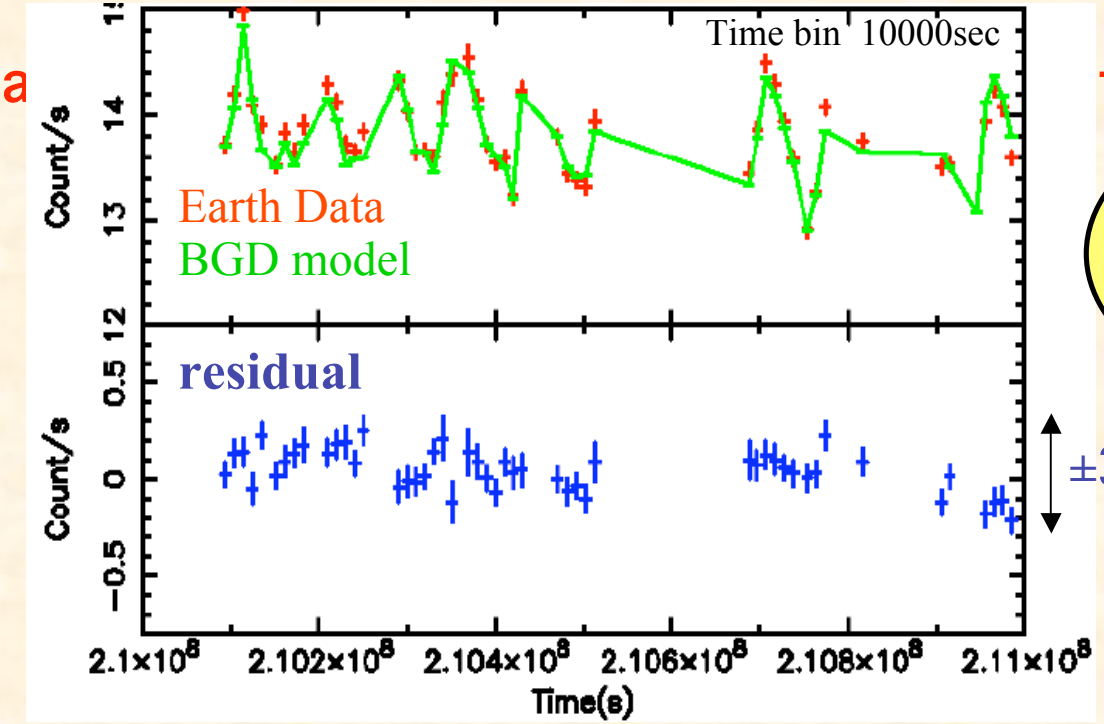
Background level is almost saturated, as expected

GSO background for ver 2.x products

The model is obtained by fitting the light curve of BGD, by an appropriate formula indicated by the properties of the BGD. (This technique is also available for the PIN background, and a part of released PIN BGD is prepared by this model.) The model parameters are determined for each 32 energy band. From 1.2 to 2.0, some minor improvement will be done.

Soon, it is available! (End of December 2007)

- after the PMT gain is determined. → normally takes 1.5 months
- dela t f a moment

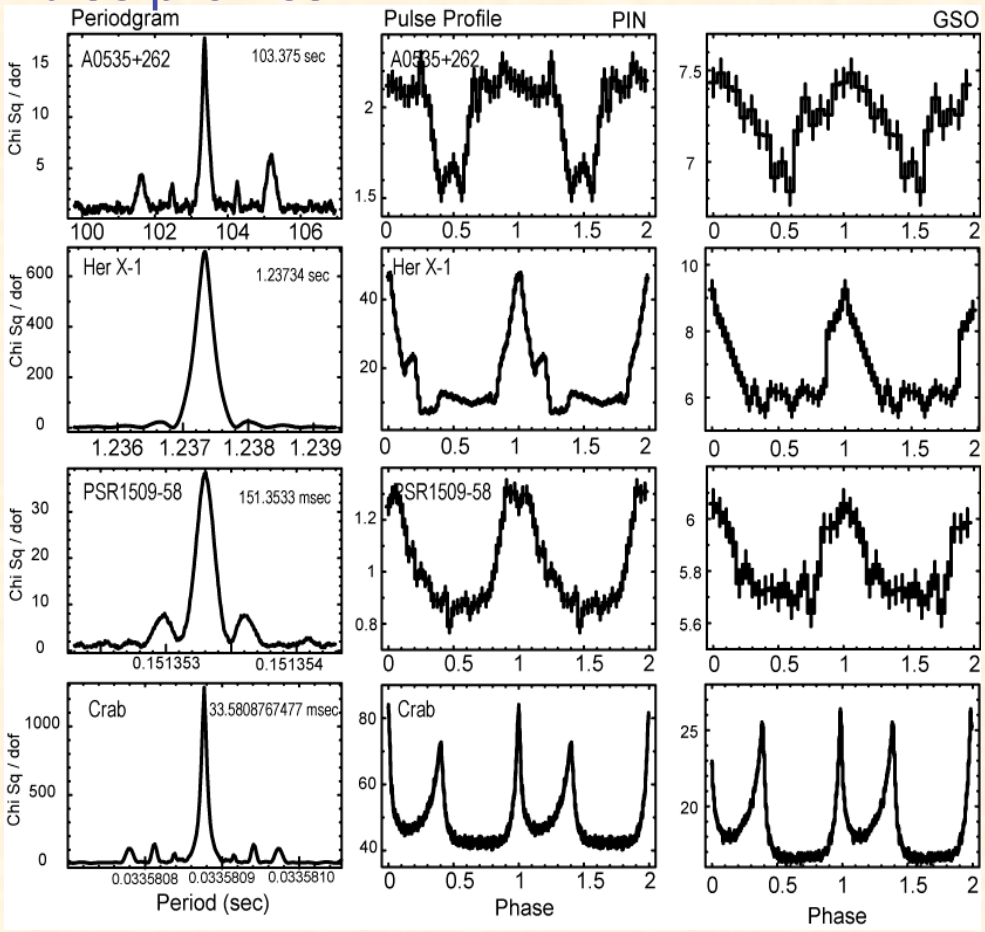


Now checking in the HXD team

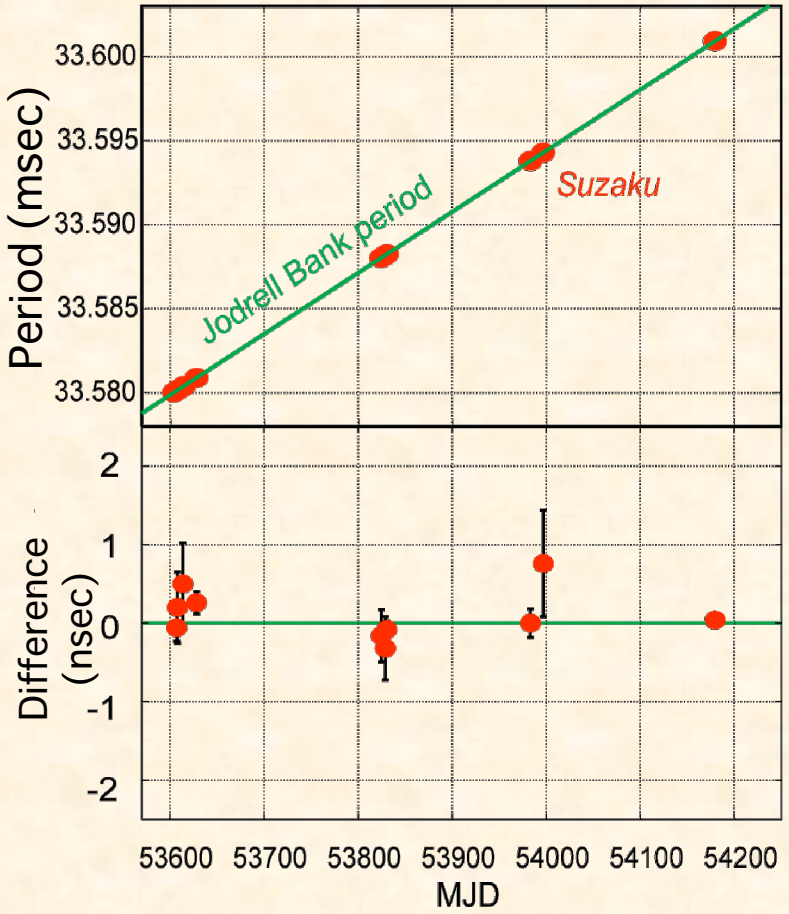
3.8 Timing capability of the HXD

Y.Terada etal 2008 PASJ in press

Pulse profiles



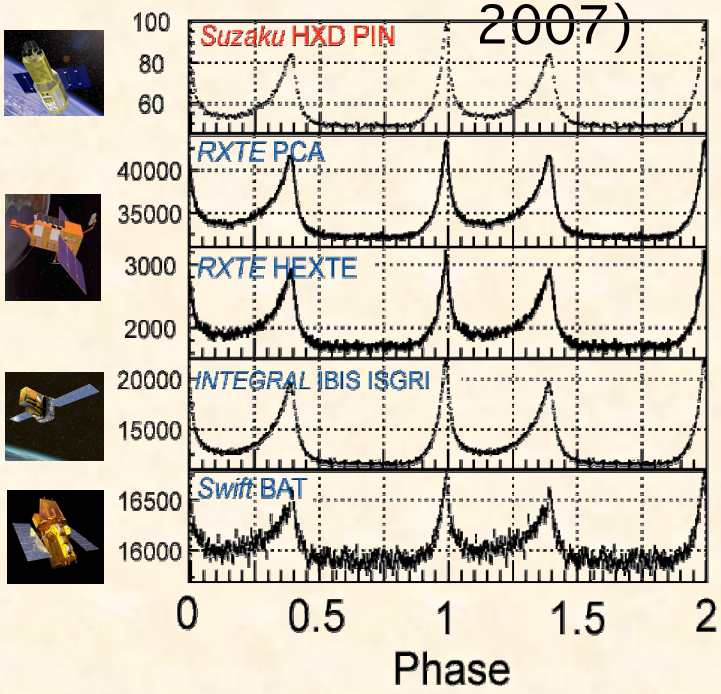
History of Period of Crab pulsar

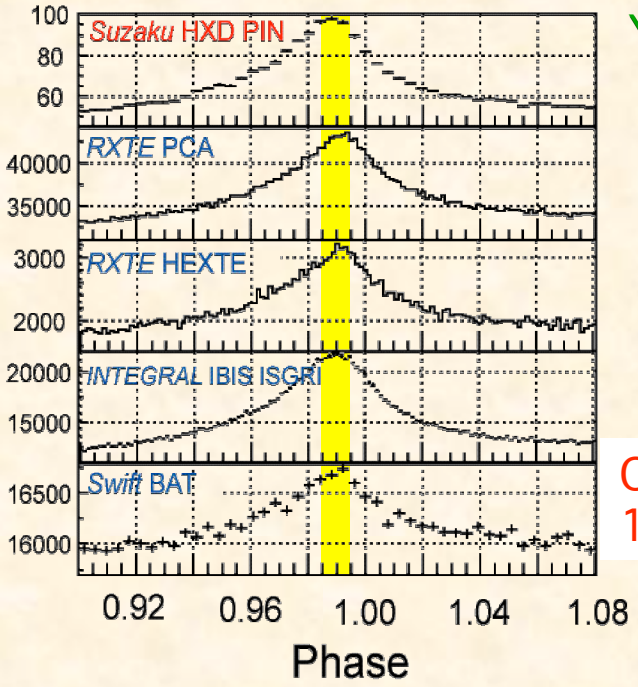


→ No problem at 33msec – 103 sec

P and P_dot (~4.12×10^{13} s s^{-1}
consistent with Radio result

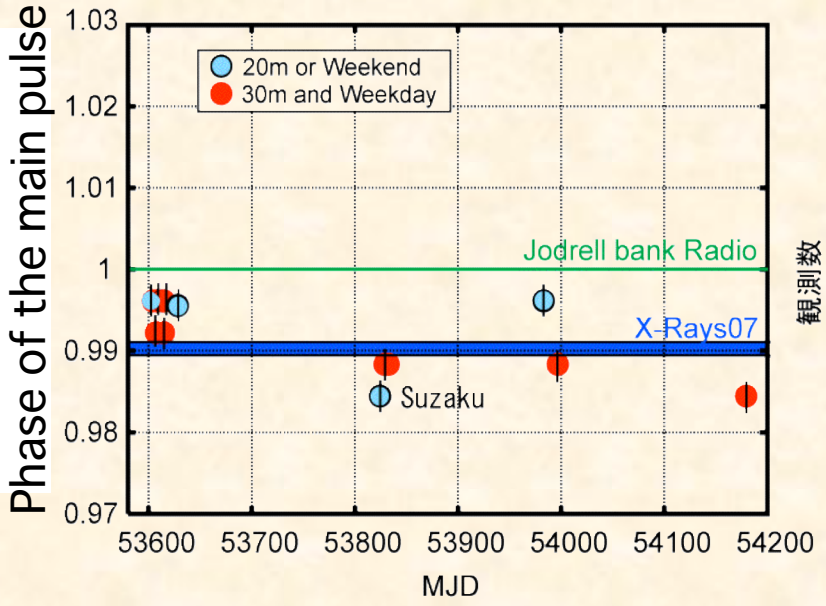
Simultaneous observation of Crab pulsar (20 March 2007)

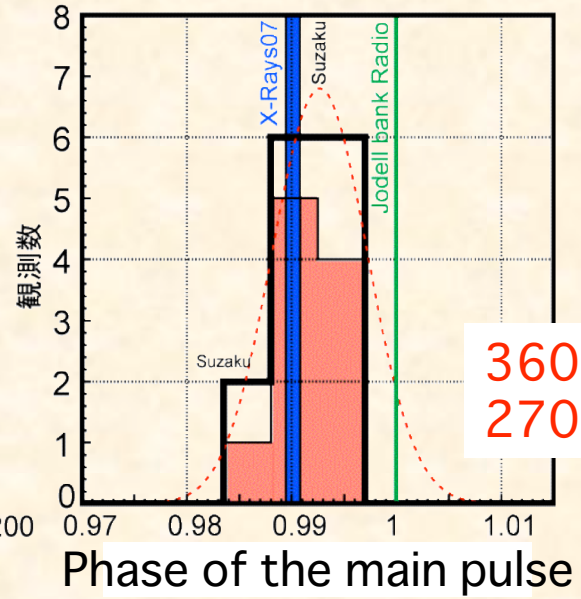




Y.Terada+ 200
PASJ in press

Consistent with
100 μ sec

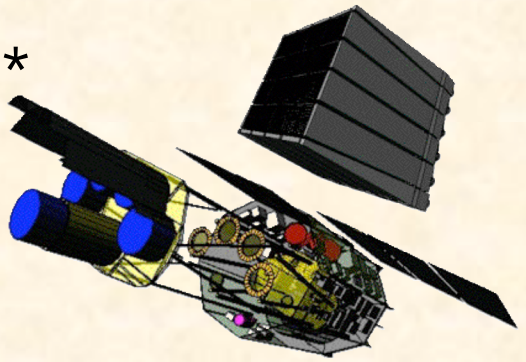




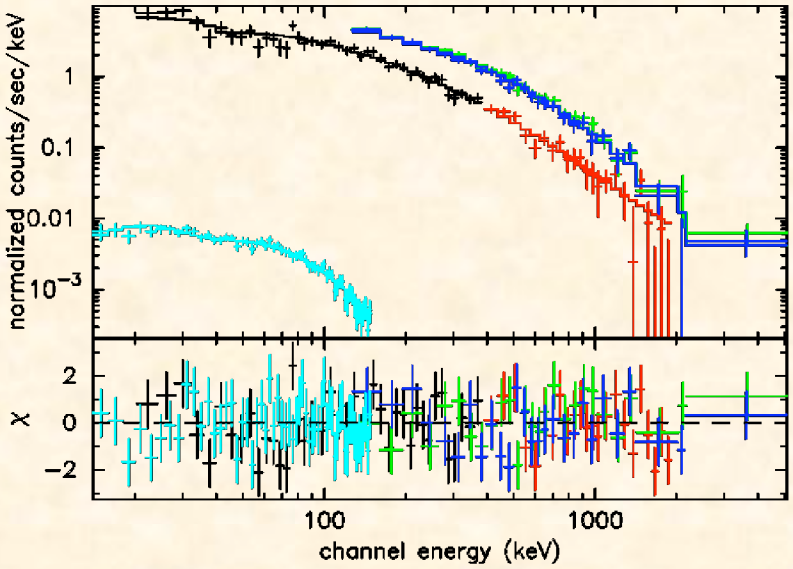
360±150 μ sec or
270±130 μ sec (in conditic

4. WAM status

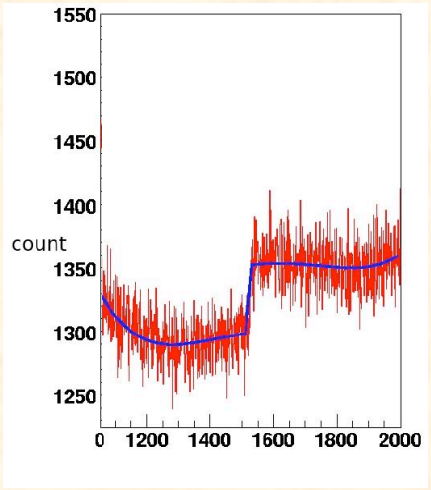
*** Summary (2005 Ag. -- 2007 Oct.) ***	
confirmed GRB	317 (194)
possible GRB	223 (97)
SGR	68 (6)
Solar flare	166 (28)

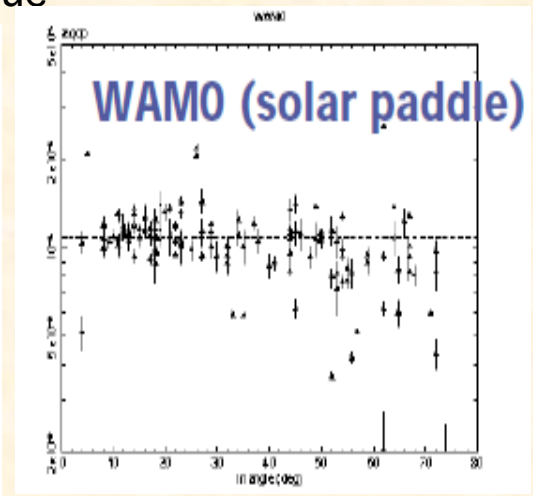


Cross calibration with Konus/Wind, RHESSI, Swift BAT
using GRB events and Solar flares



Calibration with Crab spectra by the Earth
Occultation technique





Please visit the WAM WWW page (http://www.astro.isas.ac.jp/suzaku/research/HXD-WAM/WAM-GRB/)

5. Future prospects

PIN low energy spectra (<13 keV → <10 keV)

Due to thermal noise around LD channel (heat pipe problem)
→Try to "model" the time variable noise shape (looking for coincidence param

PIN effective area

PIN-XIS cross normalization ~13%
_ Tune up parameters in making response matrix via Geant4 Mass Mod
_ Ground experiments with fright spare PIN diodes

GSO response (without fudge factor)

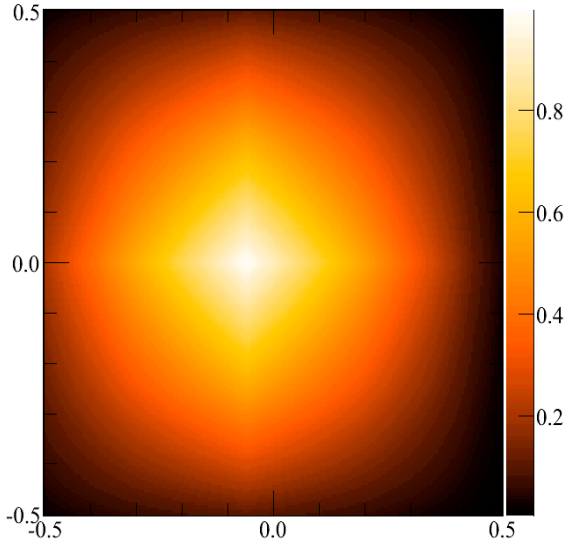
-Energy scale: re-calibration of electronics of HXD-AE
-Tune up parameters in Geant4 Mass Model

Reproducibility of NXB model(s)

- Many efforts on modeling empirically
- Study the origin of NXB events by the full simulations of activation events with MGGPOD

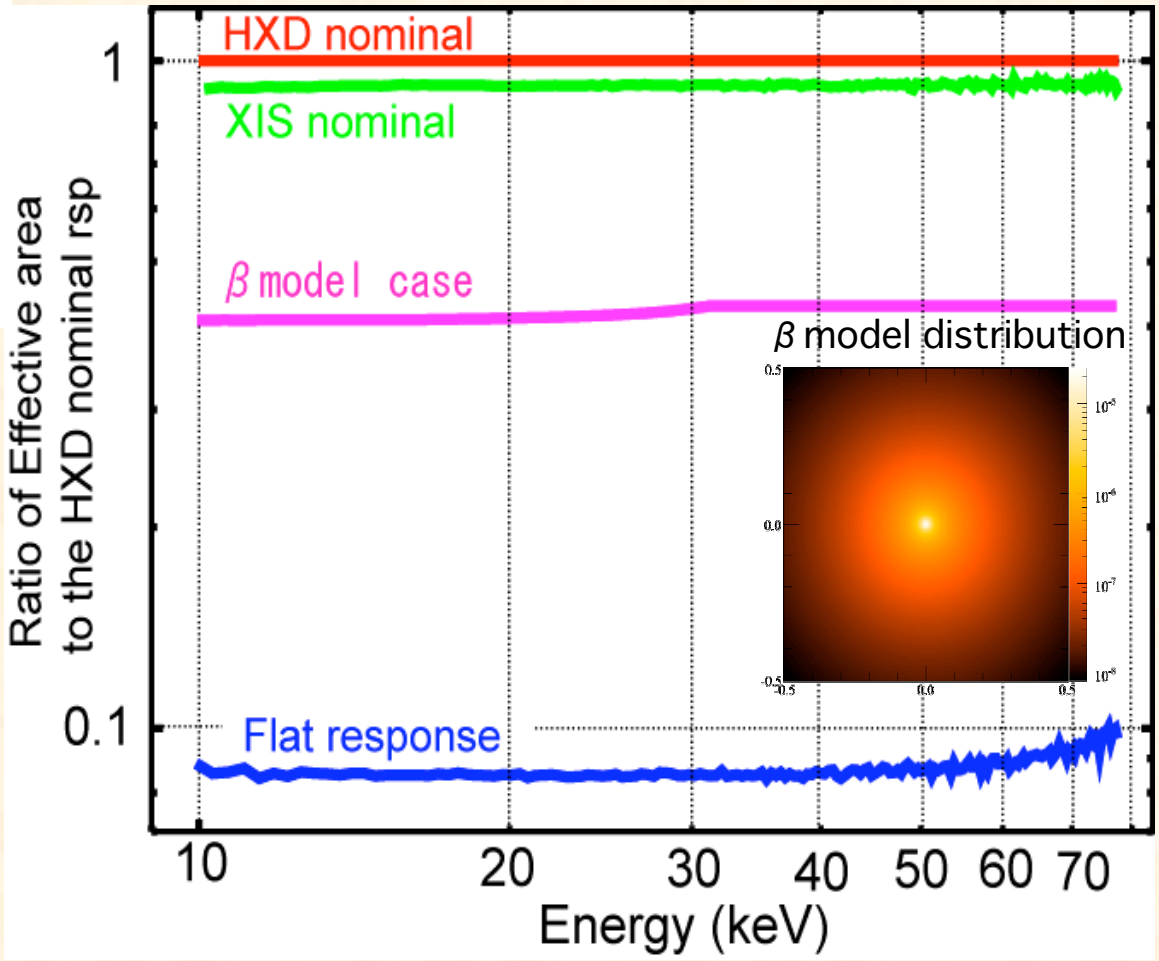
Comments: analyses for diffuse sources

Angular response of PIN



HXD arf: correction factor to the HXD nominal rsp
Produced by ***hxdarfgen***
Not support an image input → Please add arfs by yourself
Or wait for the next release

diffuse arf(PI) = Σ (arf(PI) x model) / Σ model



Summary

Table: Error Budgets of Scientific Instrument Calibrations

Instrument	Calibration Item	Present Uncertainties (July 2007)	Requirement	Goal
HXD	Absolute effective area	20%	20%	5%
	Relative effective area	15%	10%	5%
	Angular response	5%	10%	5%
	Background modeling (PIN)	5~10%	10%	5%
	Background modeling (GSO)	3%	10%	3%
	Energy scale	1% (PIN)	**%	**%
	Absolute timing	360 mu s	300 mu s	100 mu s
	Relative timing	1.9×10^{-9}	10^{-8}	10^{-10}
HXD-WAM	GRB absolute timing	2 ms	1 ms	1 ms
	Absolute effective area	10~40%, depending on the incident angle	20%	20%