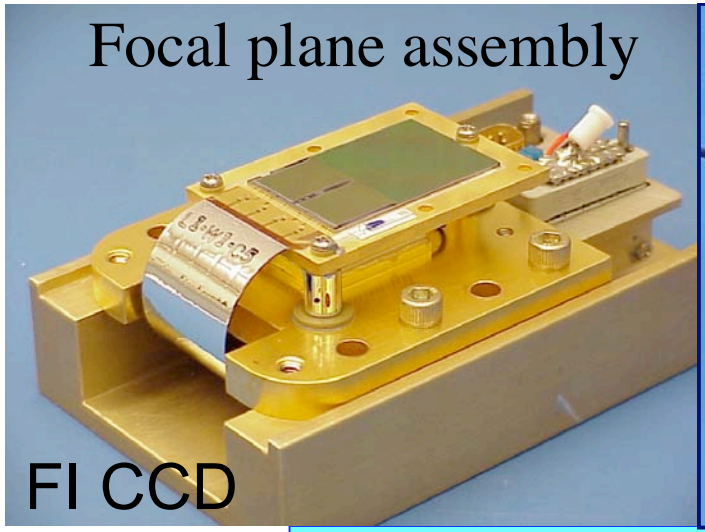
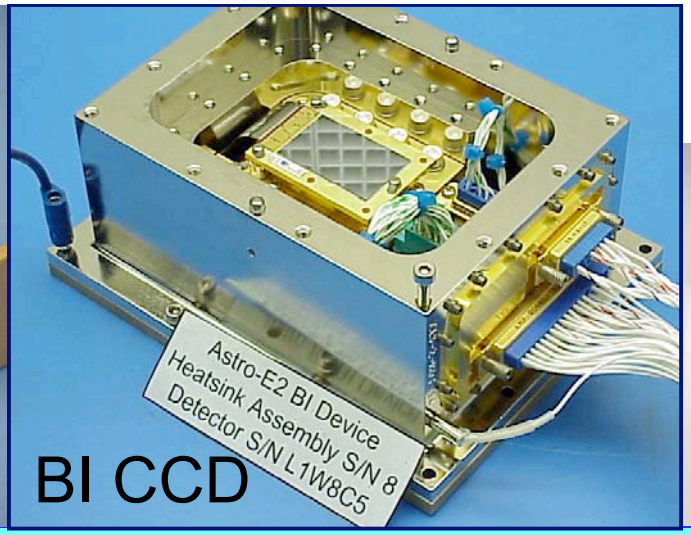




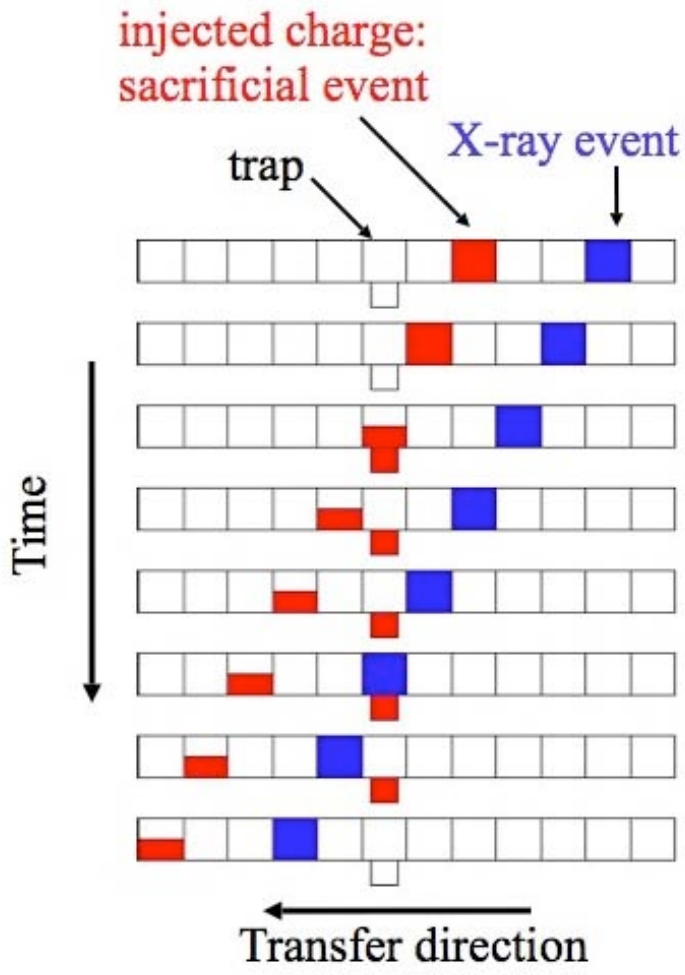
XIS calibration status

T. Dotani
(ISAS/JAXA)
and the
Suzaku XIS team

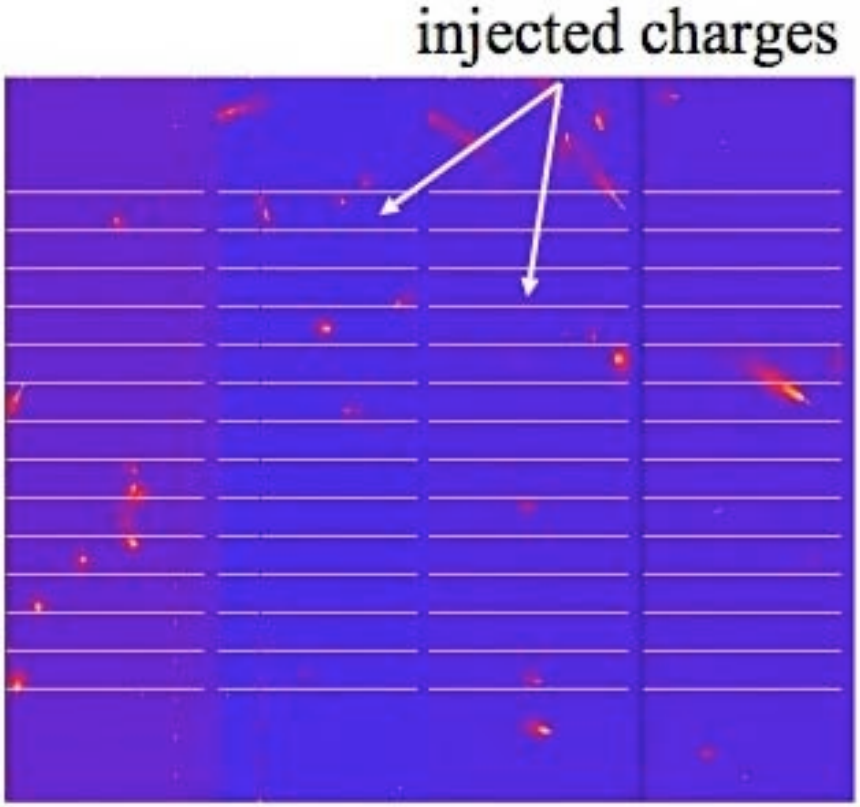
Calibration of the data with spaced-row charge injection (SCI)

Spaced-row Charge Injection

Injected charge will fill the traps to improve the charge transfer efficiency.



Sample image of XIS with SCI

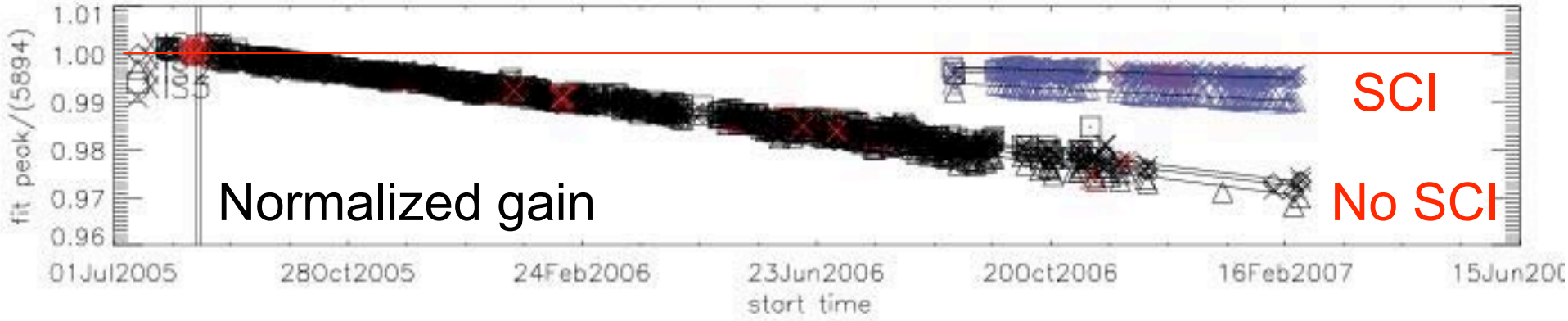


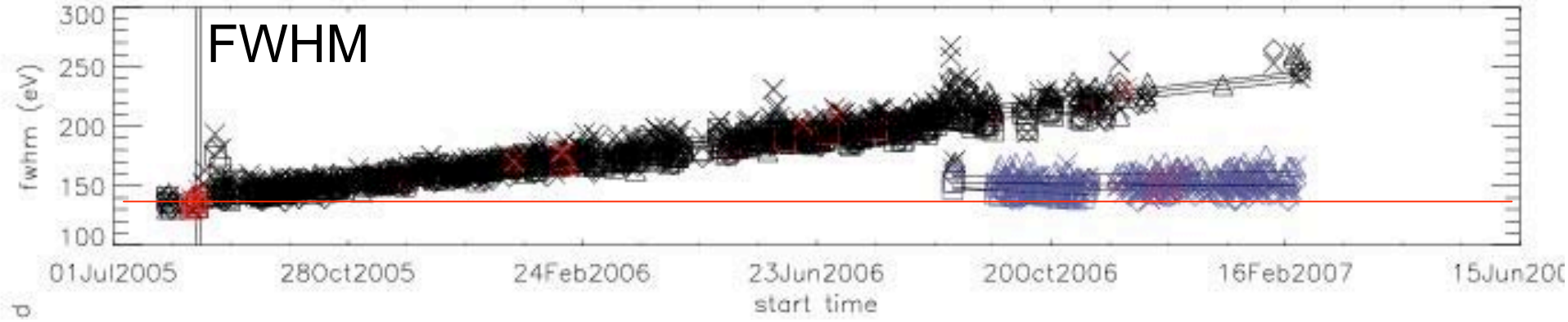
Injected charge will not be read out in normal operation.

SCI: QL analysis

Long-term histories of gain and resolution

Calibration sources: Mn Kα, no CTI correction





Analysis/calibration of the SCI data

- SCI changes the gain, energy resolution, and the effective area of XIS.
- Because the re-calibration of XIS data with SCI takes time, we take 2 steps to release the analysis tools and calibration files.
  - Provisional analysis method (ver. 1.2; Applicable only to the FI sensors)
  - Full analysis of the SCI data, which becomes possible with ver 2.0 software.

Provisional analysis method of the SCI data

(http://www.astro.isas.jaxa.jp/suzaku/analysis/xis/)

Ver.1.2

Applicable only to the FI sensors

1. Recalculate PI values with CTI=0.

   Energy scale is correct with systematic errors of <30 eV (@6 keV).

2. Create the RMF with a time stamp of 2005-8-13.

   Energy resolutions improve from 200-220 eV to 140-150 eV, which is close to those just after the launch. Excess line width of <20eV (@6keV) may be obtained.

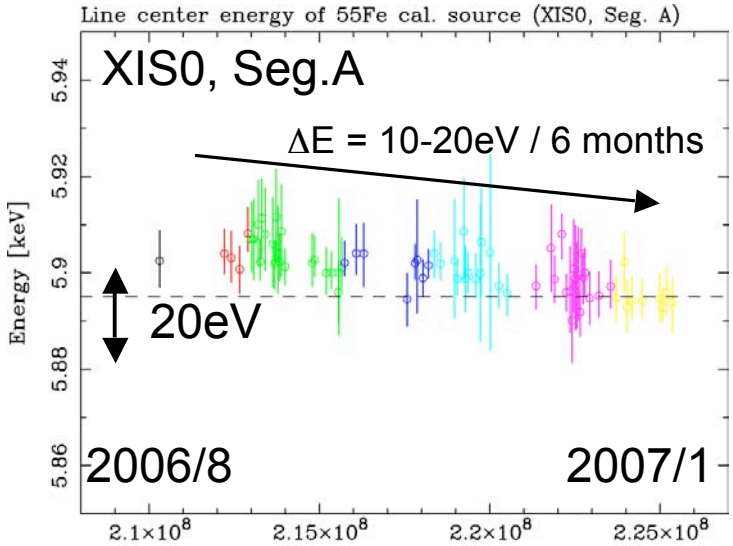
3. Create the ARF incorporating the deadlines due to the SCI.

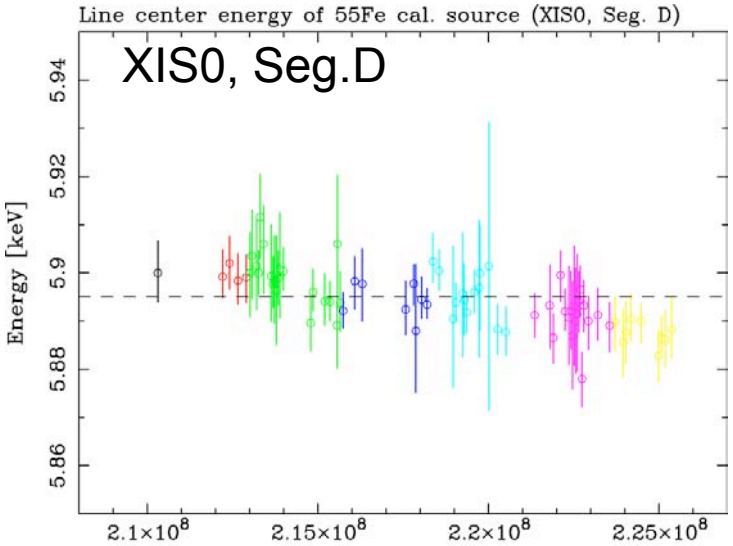
   SCI produces dead lines, whose total area is about 6% and is slightly position dependent.

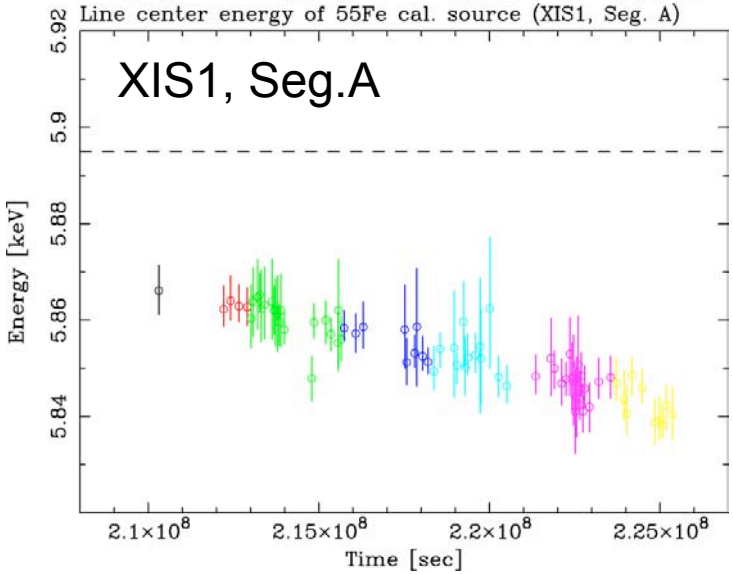
Line center energies of ^{55}Fe

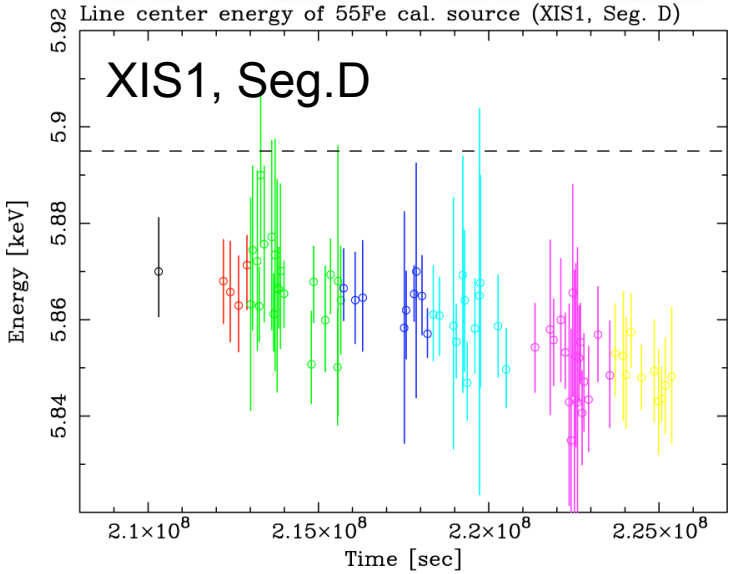
Data: SCI-on, CTI correction: CTI=0

Provisional

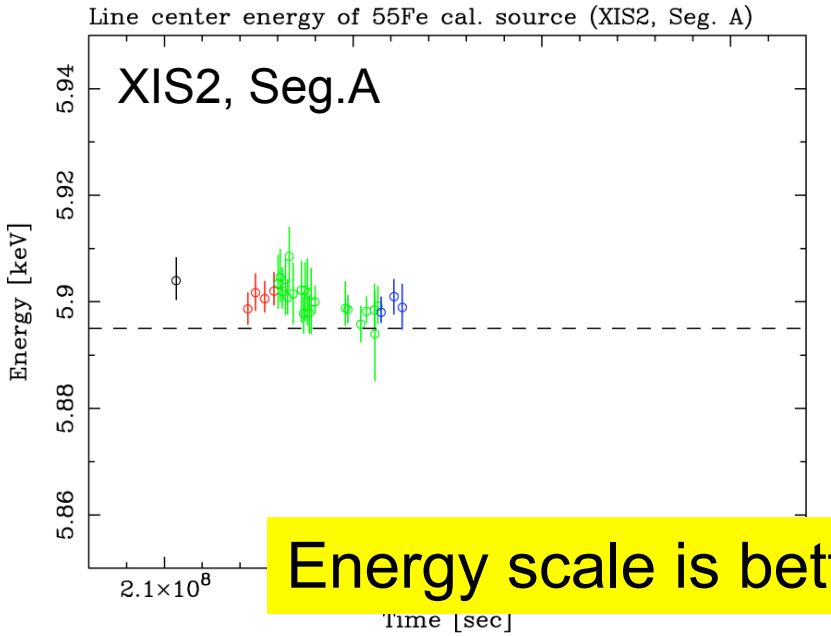


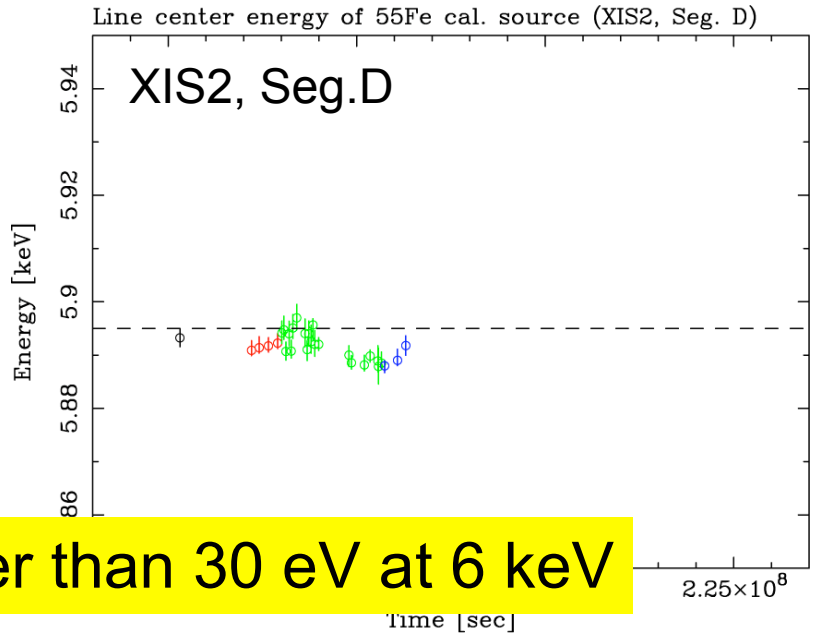




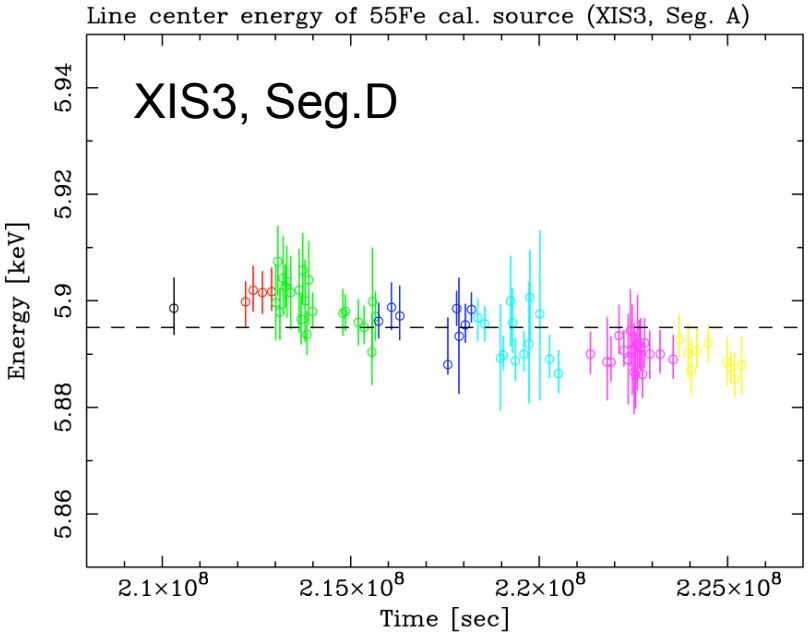


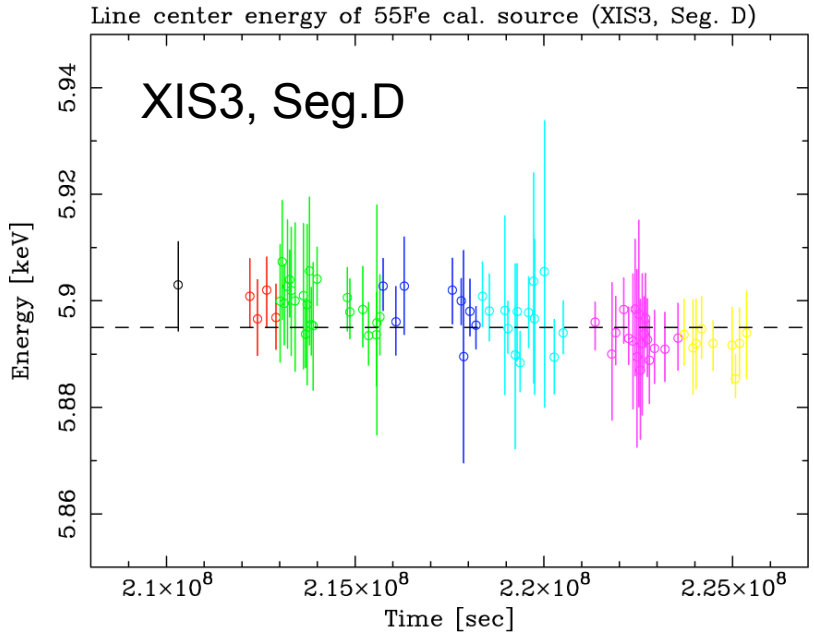
Line center energies of ^{55}Fe





Energy scale is better than 30 eV at 6 keV

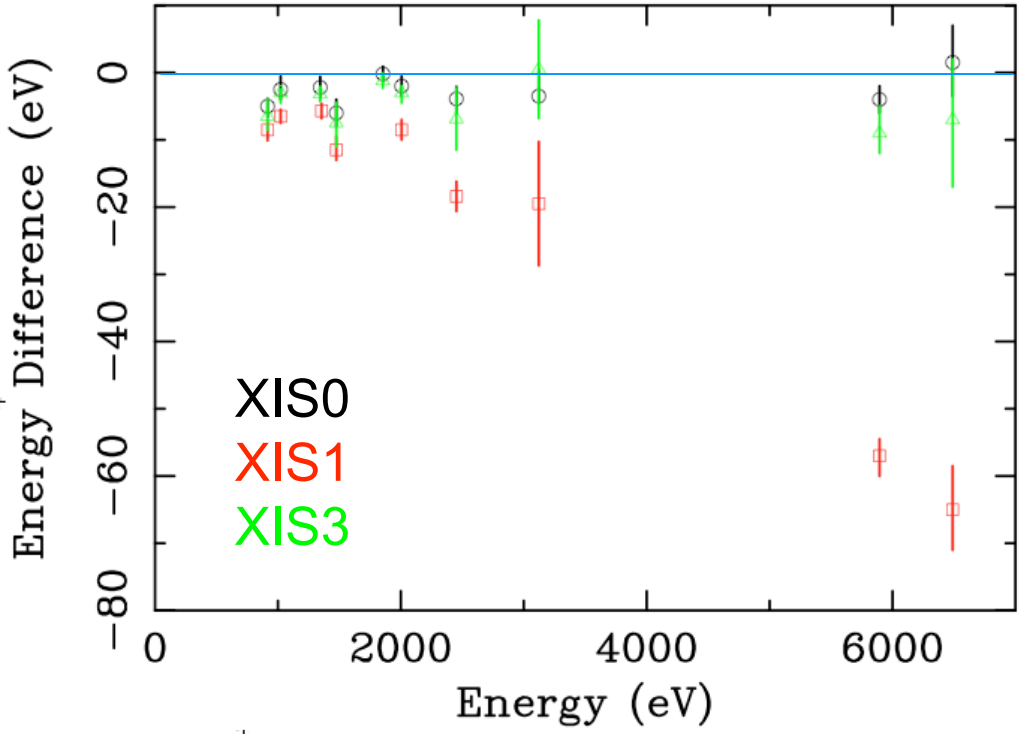


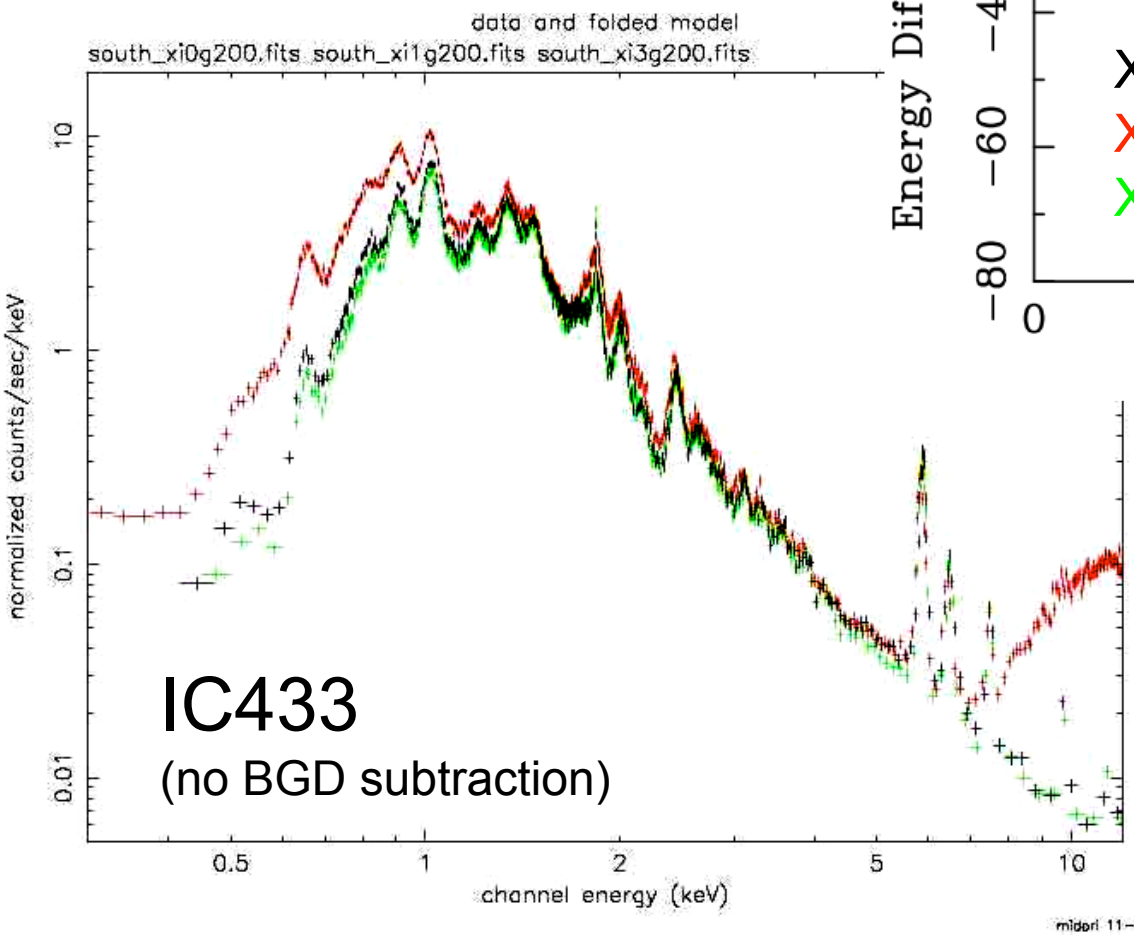


Low-energy gain: IC443

Provisional

Obs: March 2007, SCI-on
Analysis: CTI=0





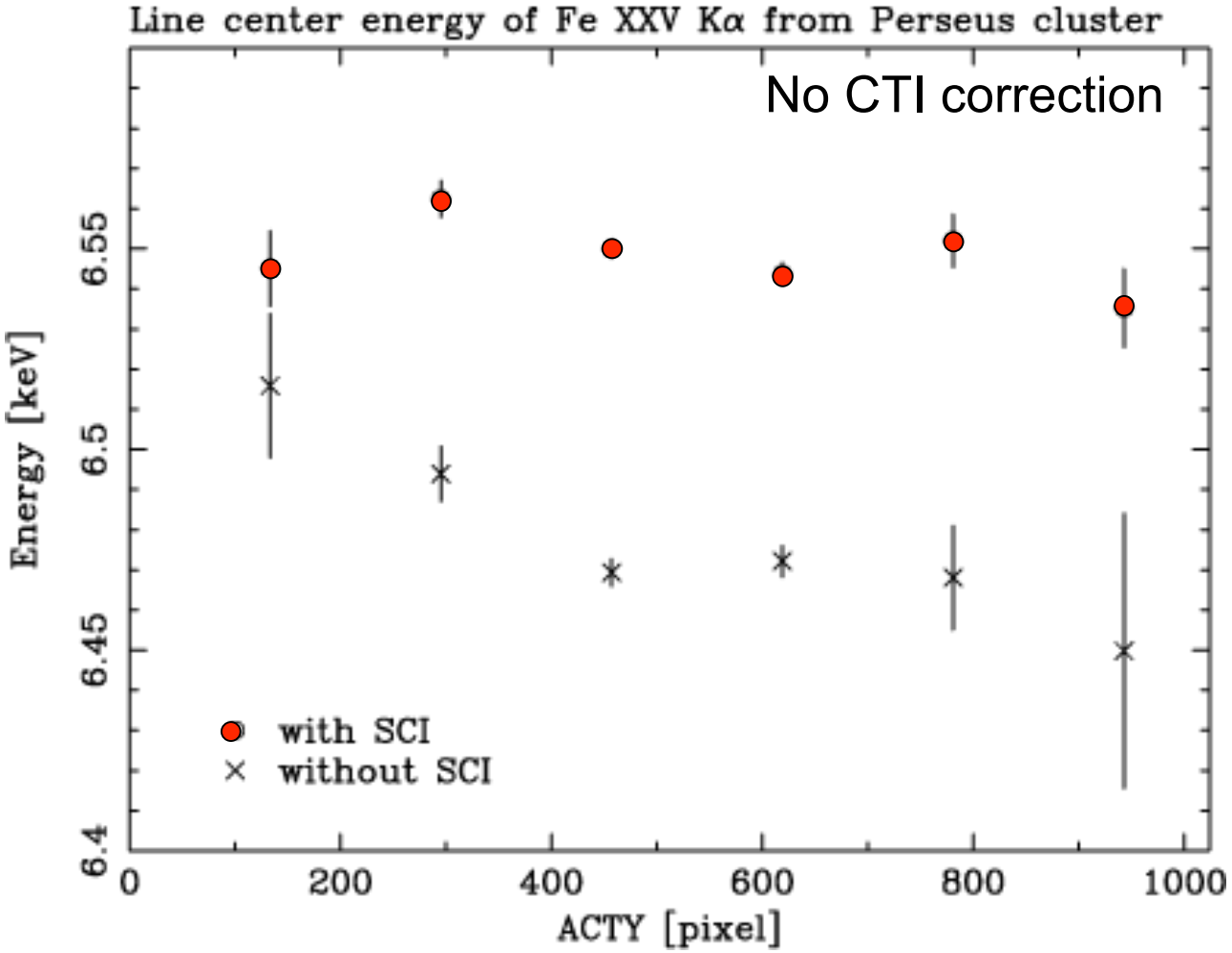
IC433
(no BGD subtraction)

ΔE<10 eV at 1-2 keV
(XIS0,3)

Uniformity of the gain

Provisional

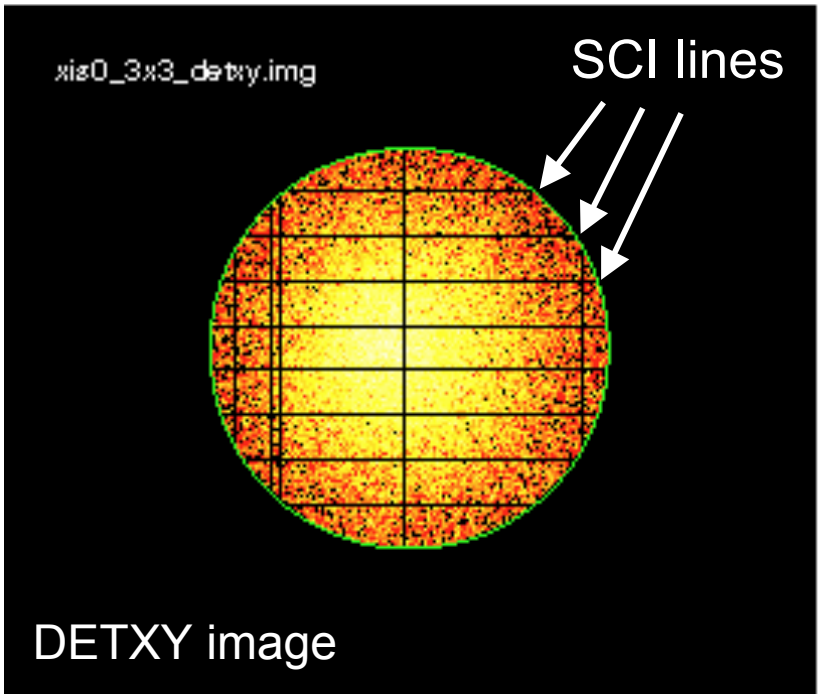
Perseus cluster: August, 2006 with/without SCI



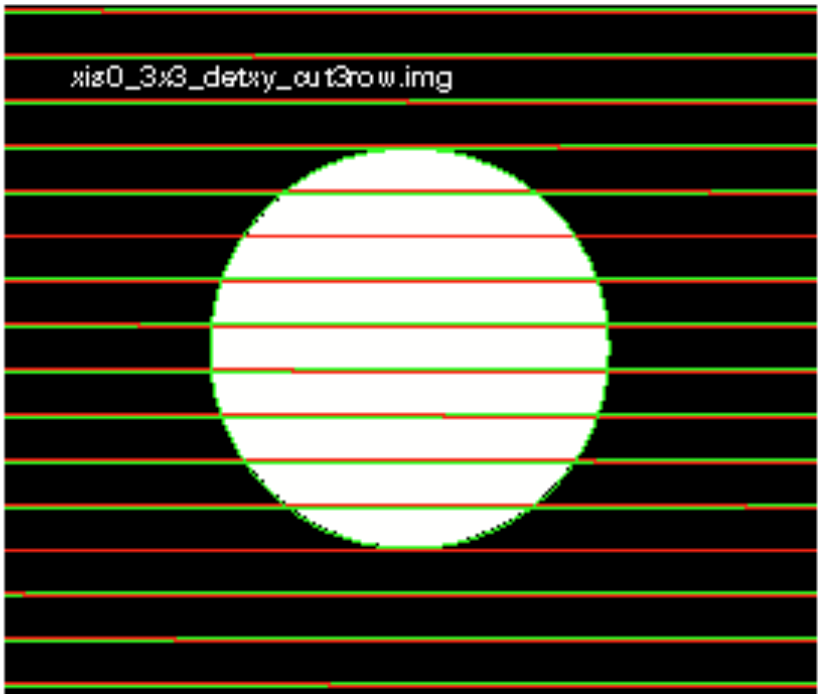
Calculation of ARF

•Reduction of the effective area needs to be incorporated in the ARF file.
•The ARF can be created by running “xissimarfgen” with an appropriate mask image.

Example of an image with SCI



Example of the mask image



New calibration results
to be released for
ver 2.0 processing

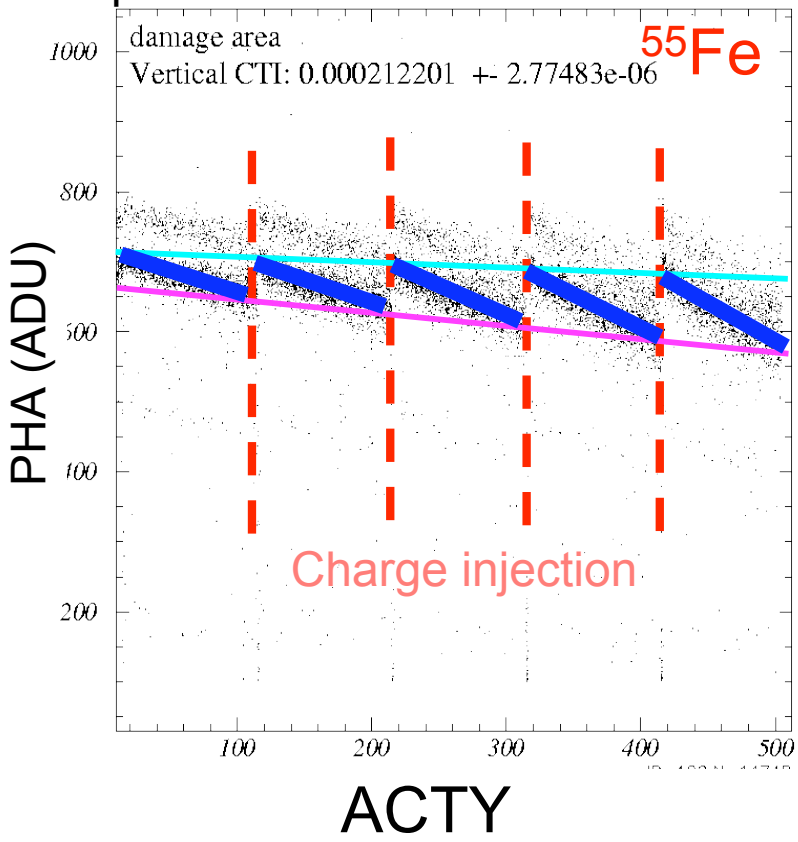
Full analysis of the SCI data

Ver.2.0

1. CTI correction

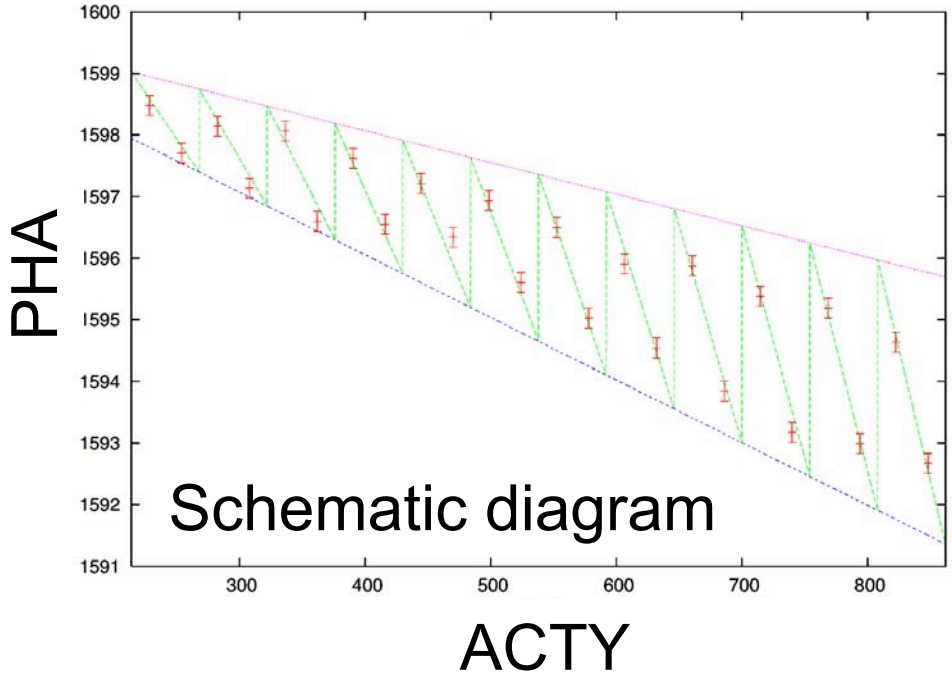
Ground data

Proton-damaged CCD (not XIS) operated with SCI.



Charge loss due to the CTI shows:

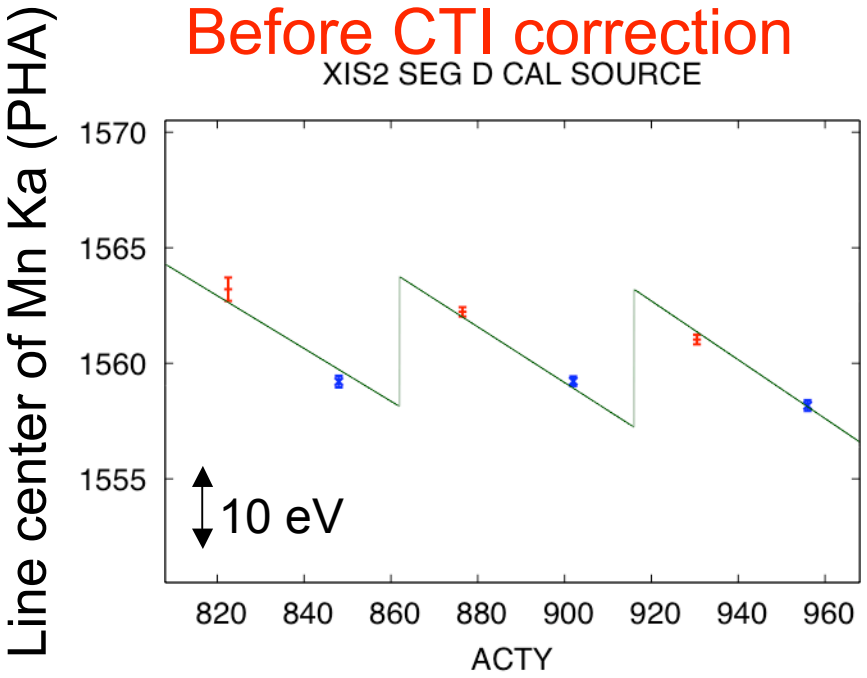
- Saw-like shape
- Overall linear trend with ACTY



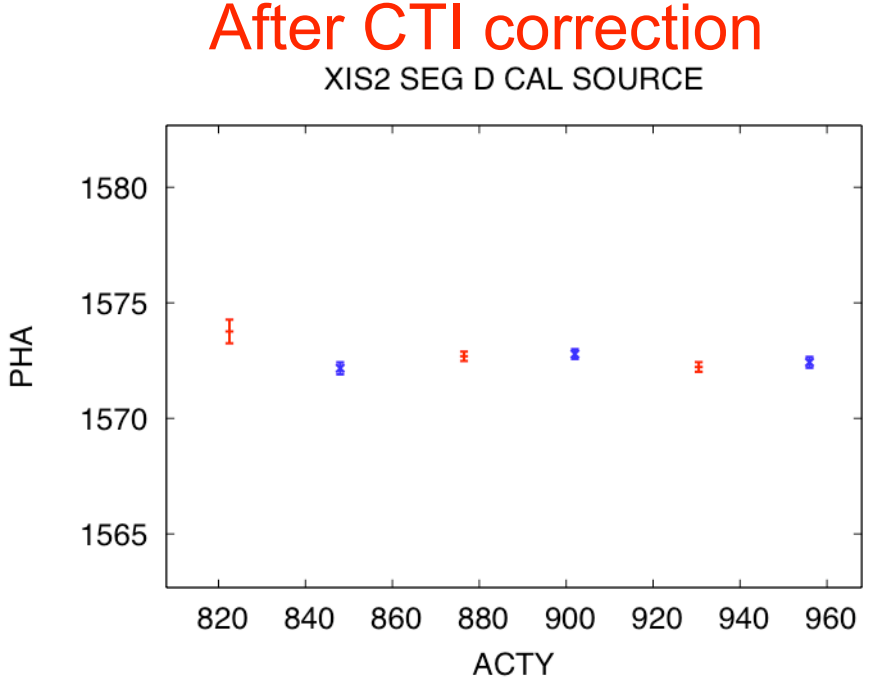
Example of the CTI correction for the SCI data

450 ks of ^{55}Fe data were accumulated.

Before CTI correction



After CTI correction

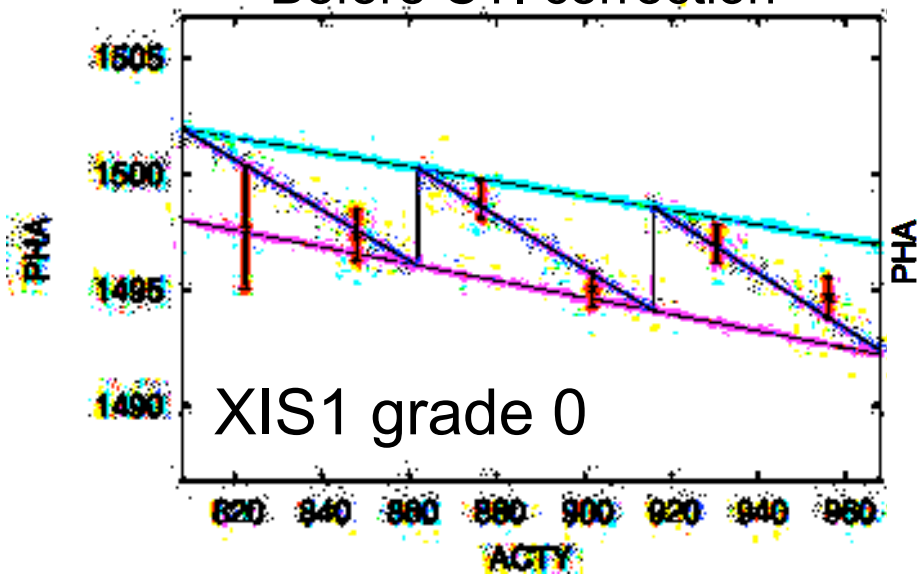


Saw-shape CTI correction works fine.

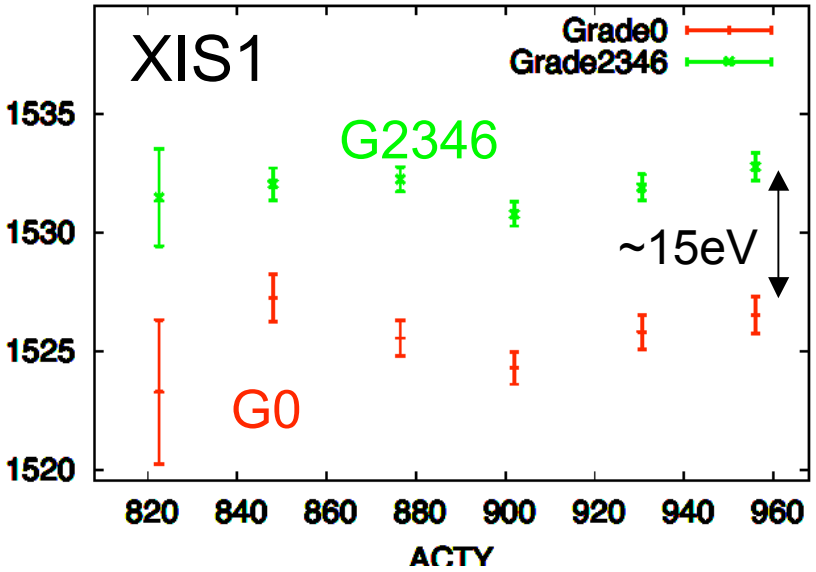
This saw-shape PHA-ACTY relation is not observable even for the brightest class of sources.

Grade dependence of the saw-shape CTI correction

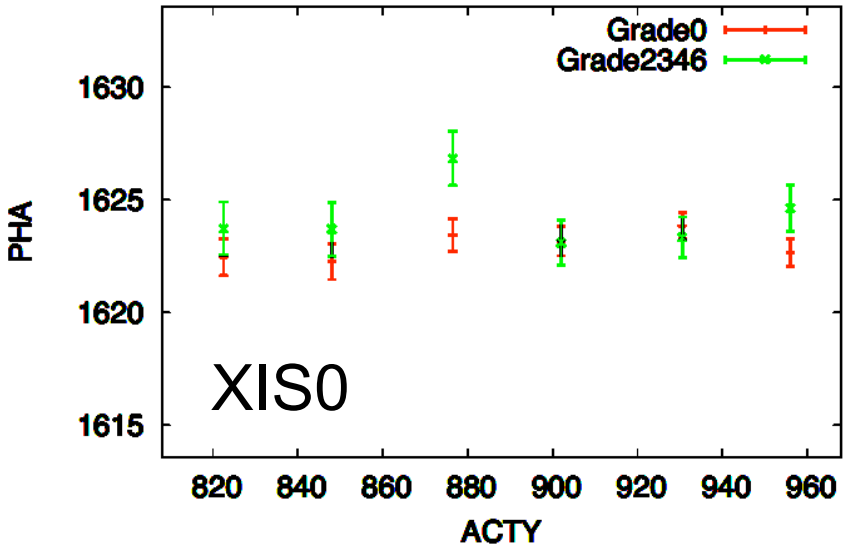
Before CTI correction



After CTI correction



XIS0 SEG0 CAL SOURCE G0 vs G2346



XIS1

Difference of the line center energy after the CTI correction.

PHA dependence of CTI needs to be adjusted.

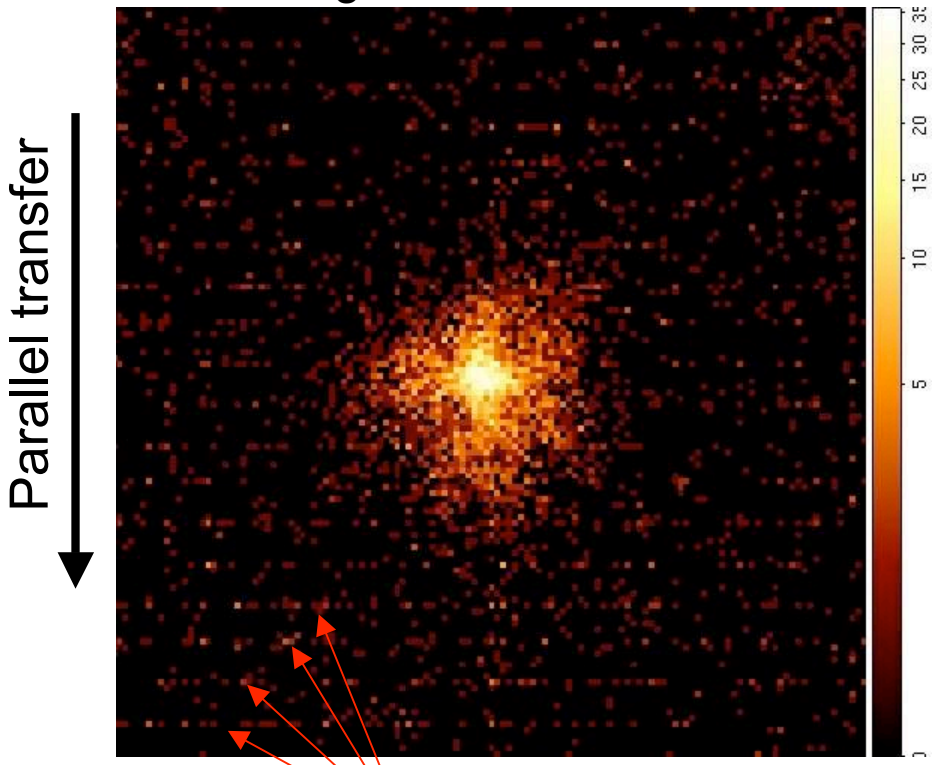
$$\mathrm{CTI} \propto \mathrm{PHA}^{-\gamma}$$

Dead lines due to the SCI

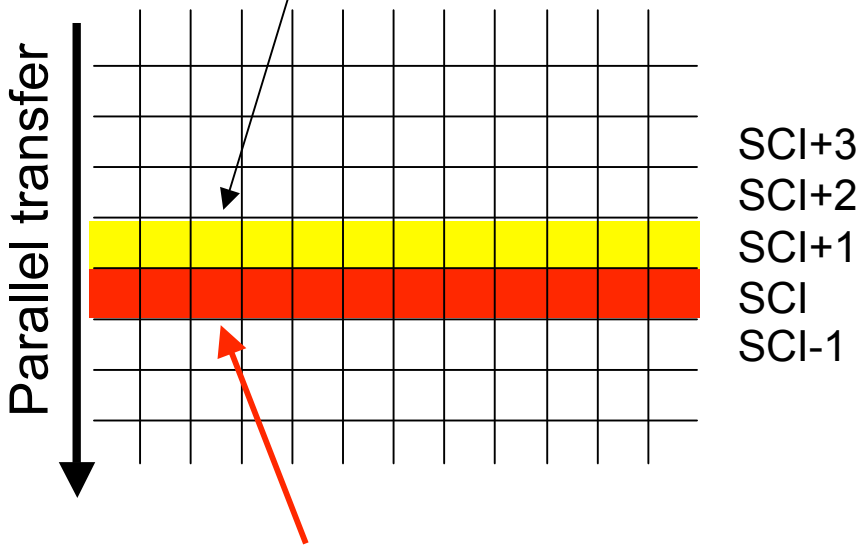
Ver.2.0

E0102 data with SCI

XIS1 Aug 25, 2006 0 - 8 keV

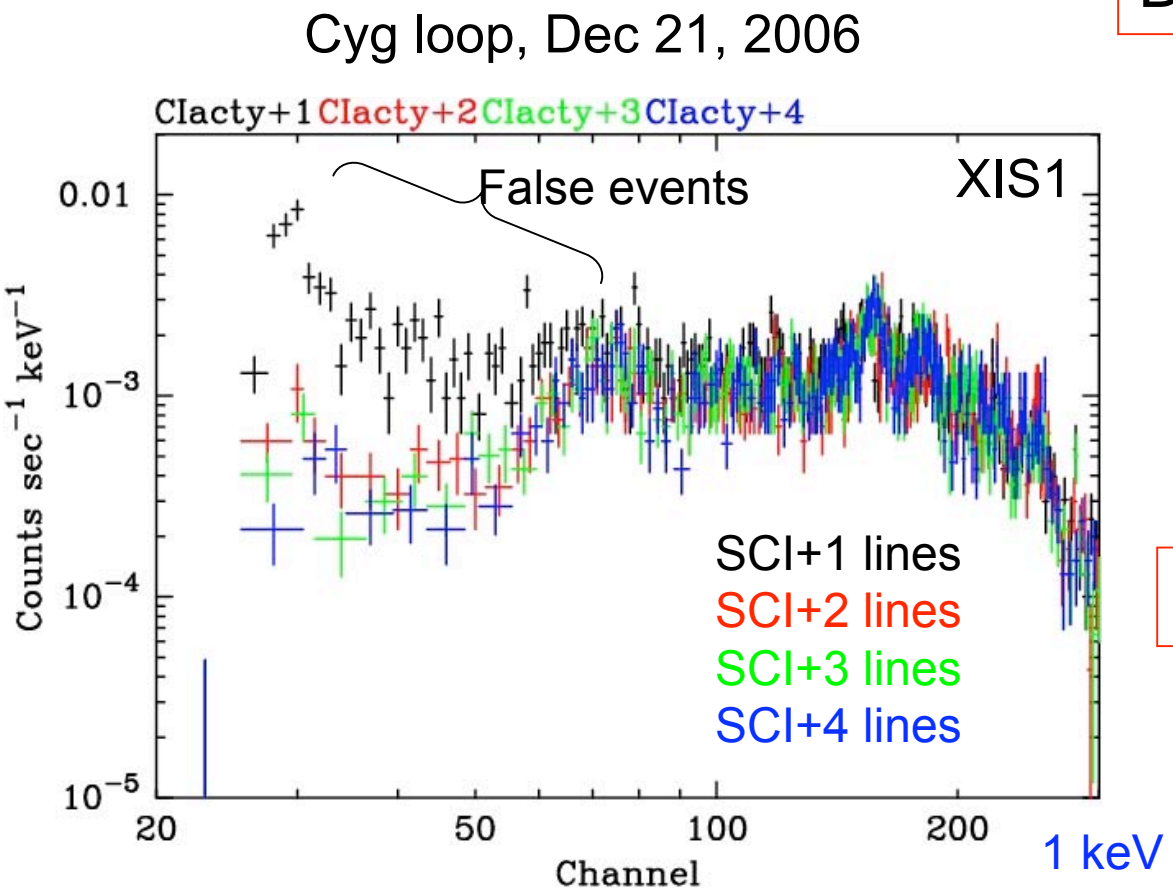


Trail of the injected charge. This produces false events, which should be removed on ground.



Injected charge. This charge is discarded on the chip and empty pixels are inserted.

Comparison of the spectra behind the SCI lines



Dead lines

At least the SCI and SCI+1 lines must be removed. We found that SCI-1 line also needs to be removed. They become dead areas. This will be done automatically in ver 2.0 processing.

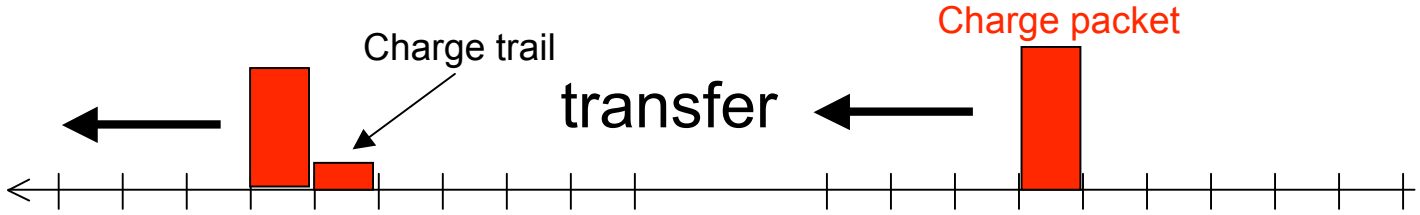
Arf files

Dead areas are taken into account when ruining “xissimarfgen” for the SCI data.

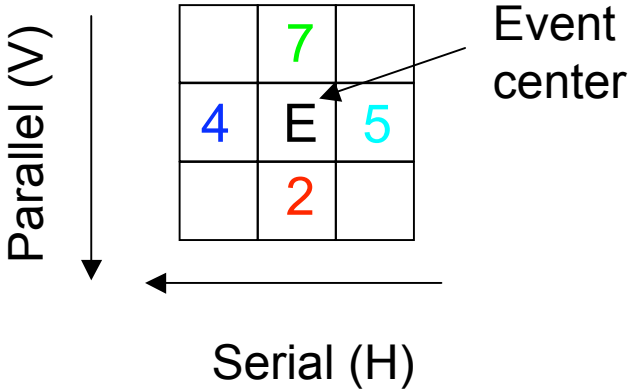
Time evolution of the charge trail

Charge traps with a short detrapping time scale produces a tail in the charge packet during the charge transfer.

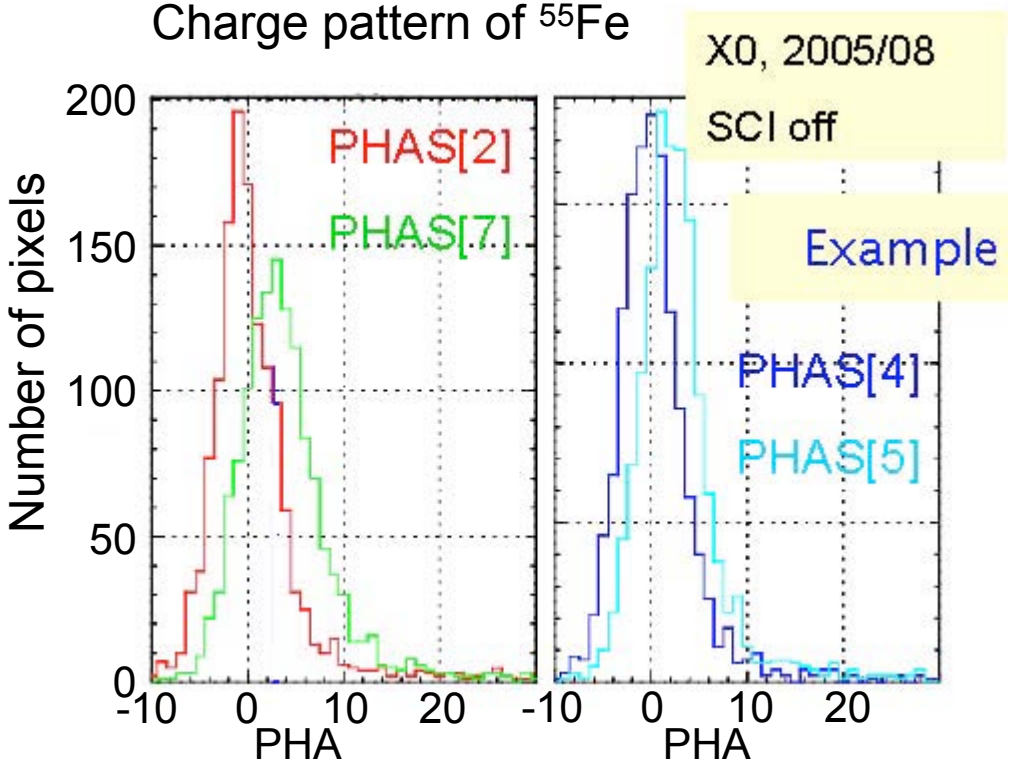
Ver.2.0



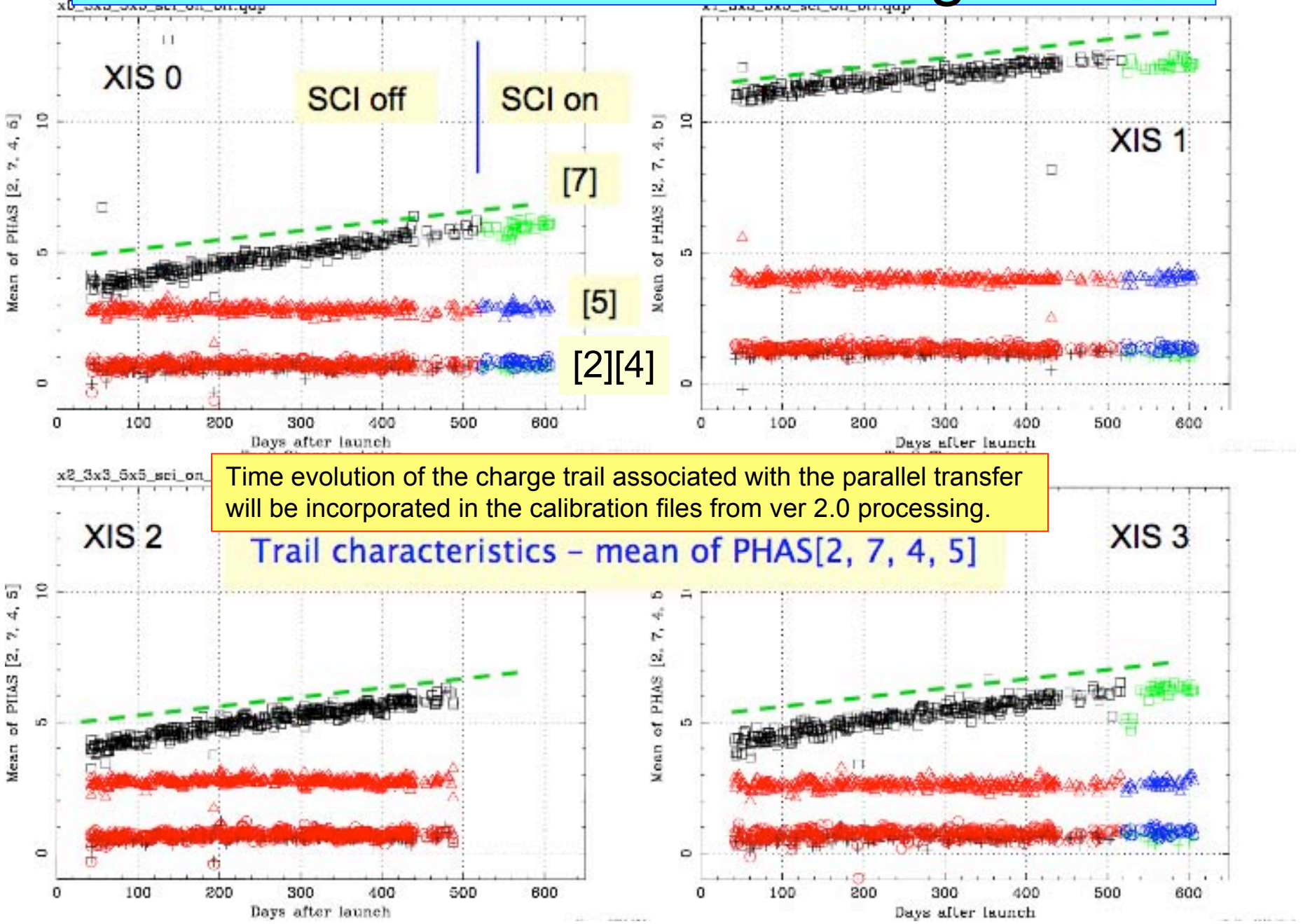
Charge pattern in an event



Charge pattern of ^{55}Fe



Time evolution of the charge trail



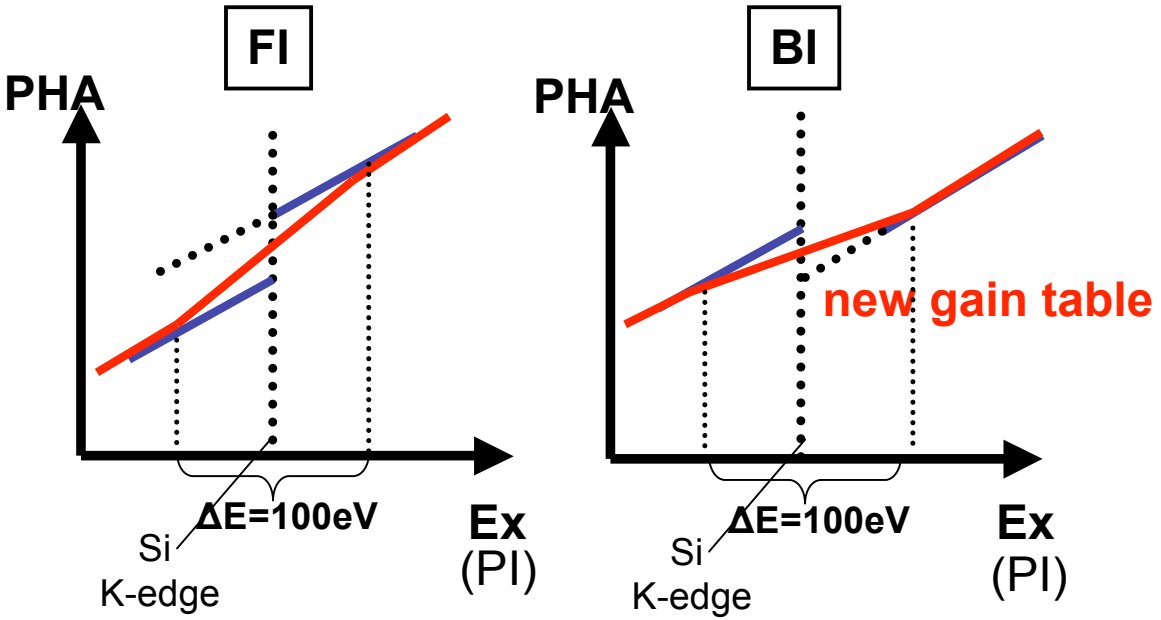
Time evolution of the charge trail associated with the parallel transfer will be incorporated in the calibration files from ver 2.0 processing.

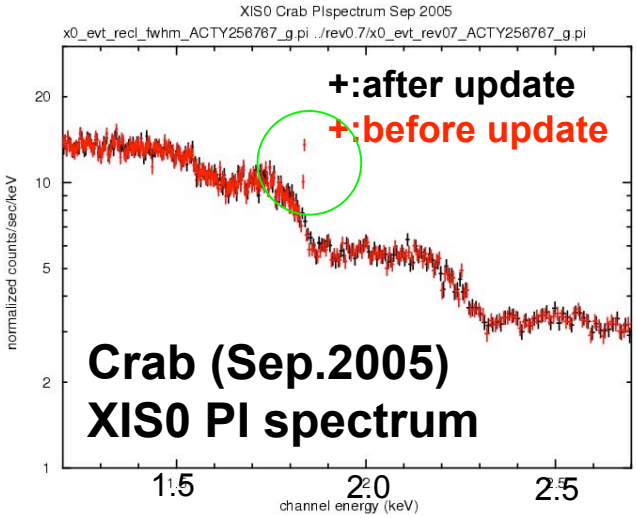
Trail characteristics – mean of PHAS[2, 7, 4, 5]

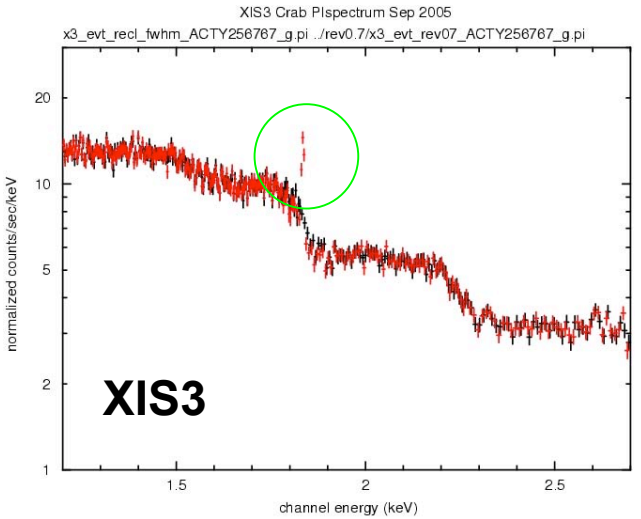
Jumps of data points near the Si edge

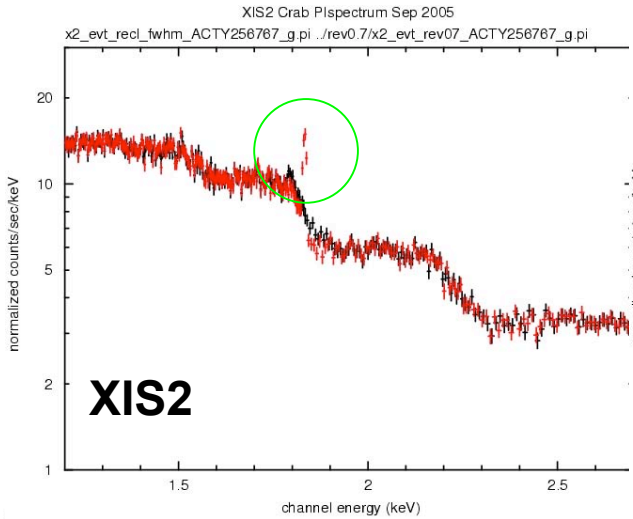
PHA-PI relation was redefined to be continuous.

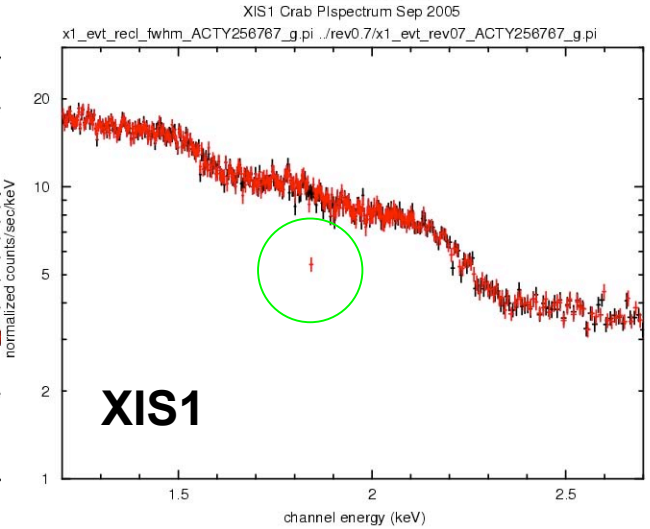
Ver.2.0







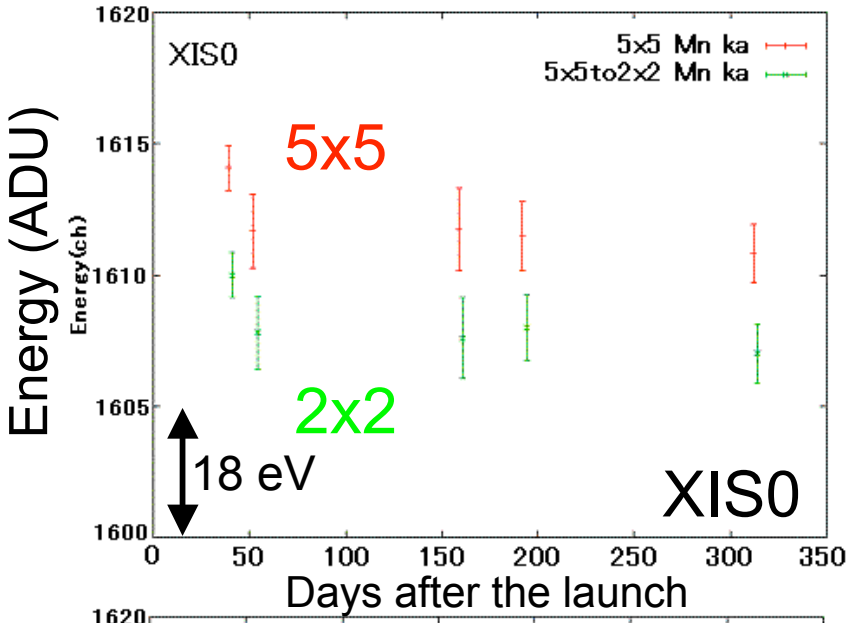


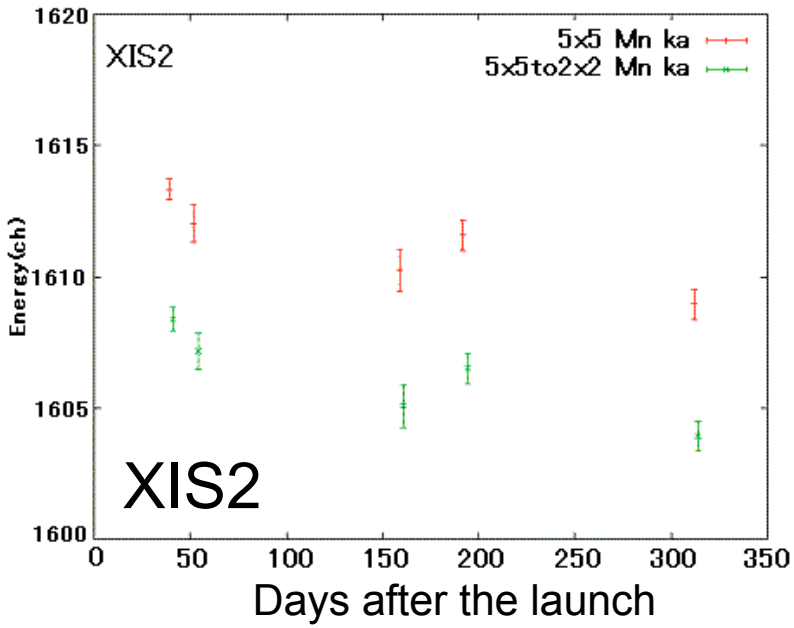


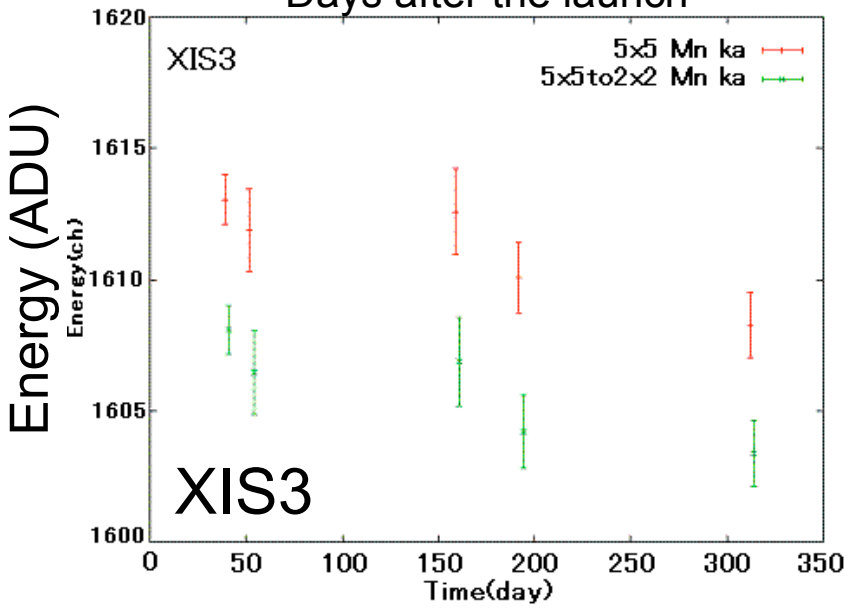
Calibration of 2x2 mode : Gain

Ver.2.0

Comparison of the line energies of ^{55}Fe calibration source.



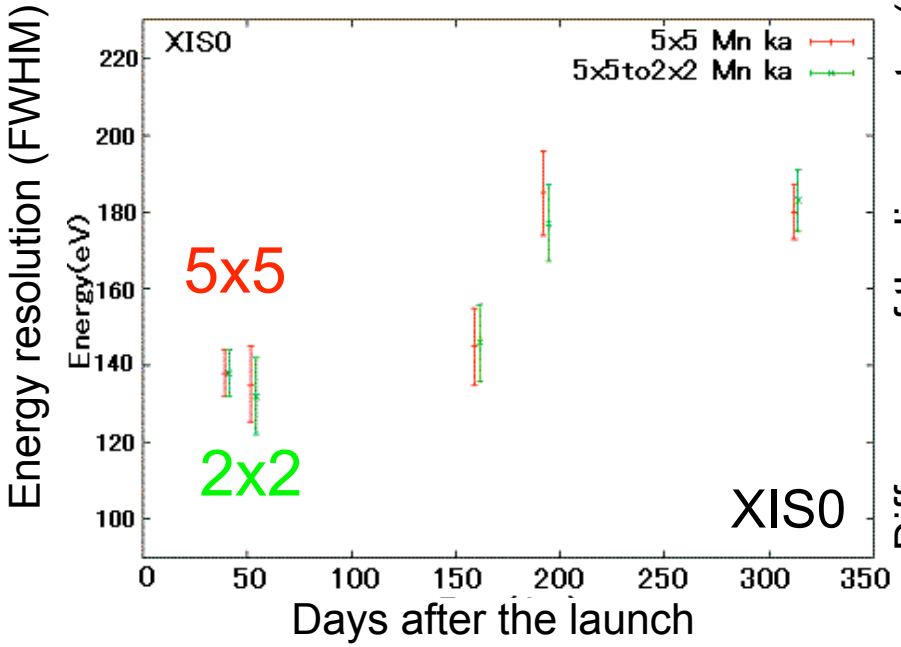




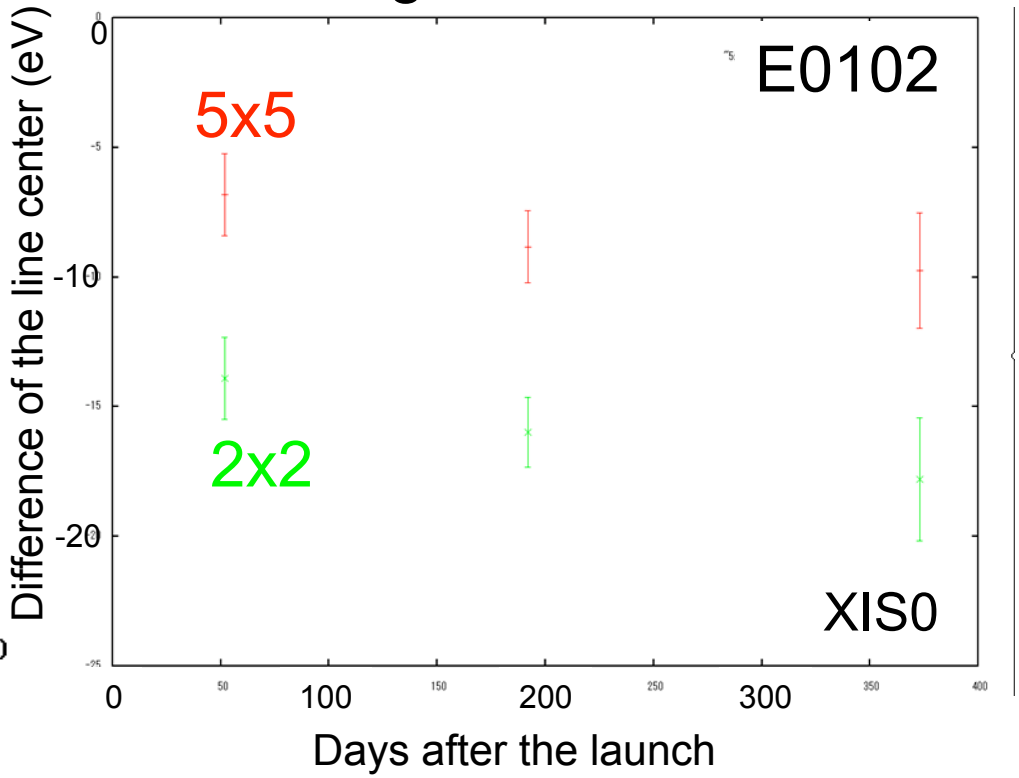
- 2x2 mode has lower gain because the charge trail cannot be corrected.
- 2x2 mode has a constant offset of ~18 eV (@6 keV) compared to 5x5 mode.

2x2 mode : Low energy gain & energy resolution

Line width of ^{55}Fe



Center energies of the Ne IX line



Energy resolution is same for 5x5 and 2x2 (@6 keV).

Constant gain offset of 2x2 mode (compared to 5x5 mode) is about 8 eV at ~1 keV.

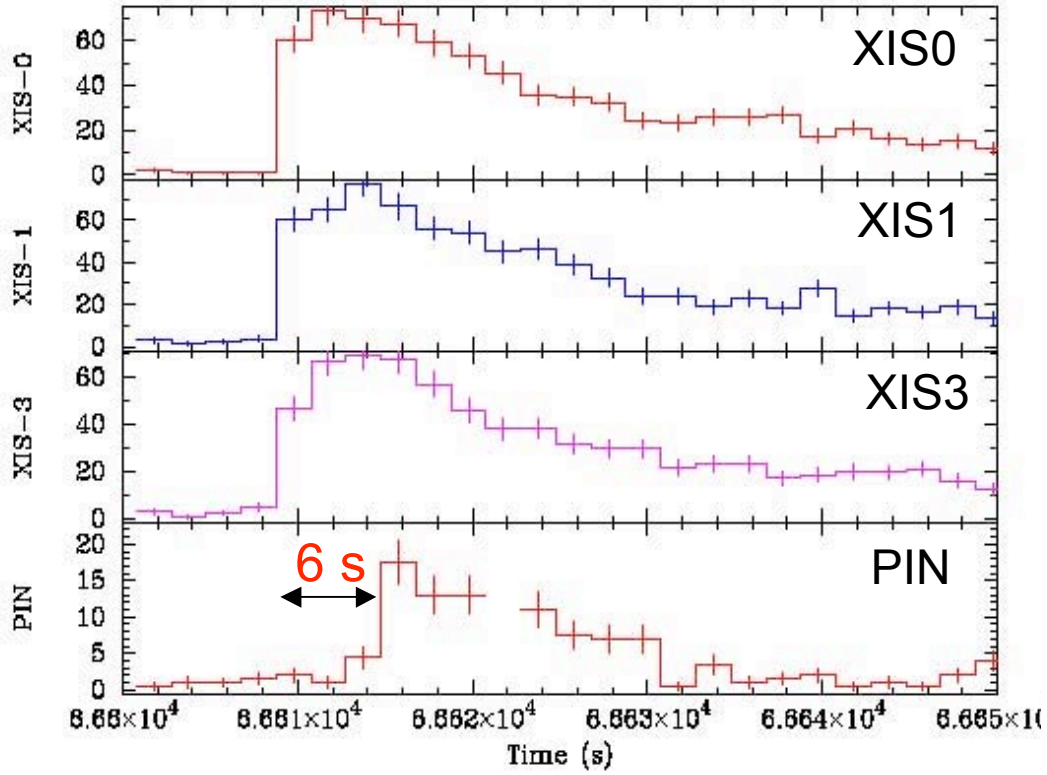
Time assignment error of XIS

http://www.astro.isas.jaxa.jp/suzaku/analysis/xis/

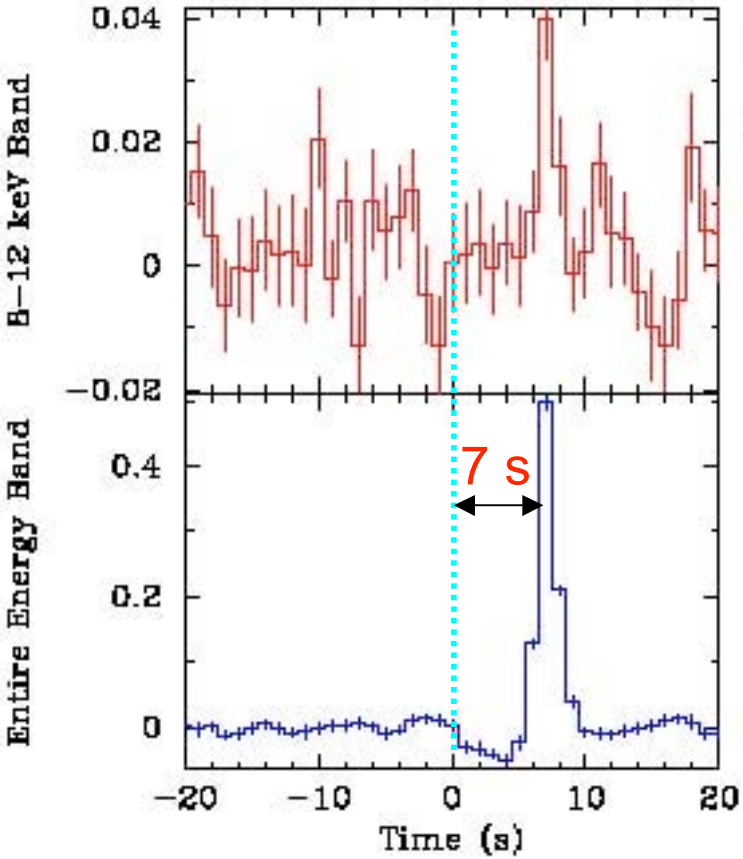
Ver.2.0

XIS time assignment (ver 1.2/1.3) has an offset of 7sec (1/8 window) and 6 sec (1/4 window) compared to HXD PIN. This will be solved in ver 2.0 processing.

XB1323-619 (1/4 window)



XIS2/PIN cross-correlation
Cyg X-1 (1/8 window)



Improvement of the attitude solution

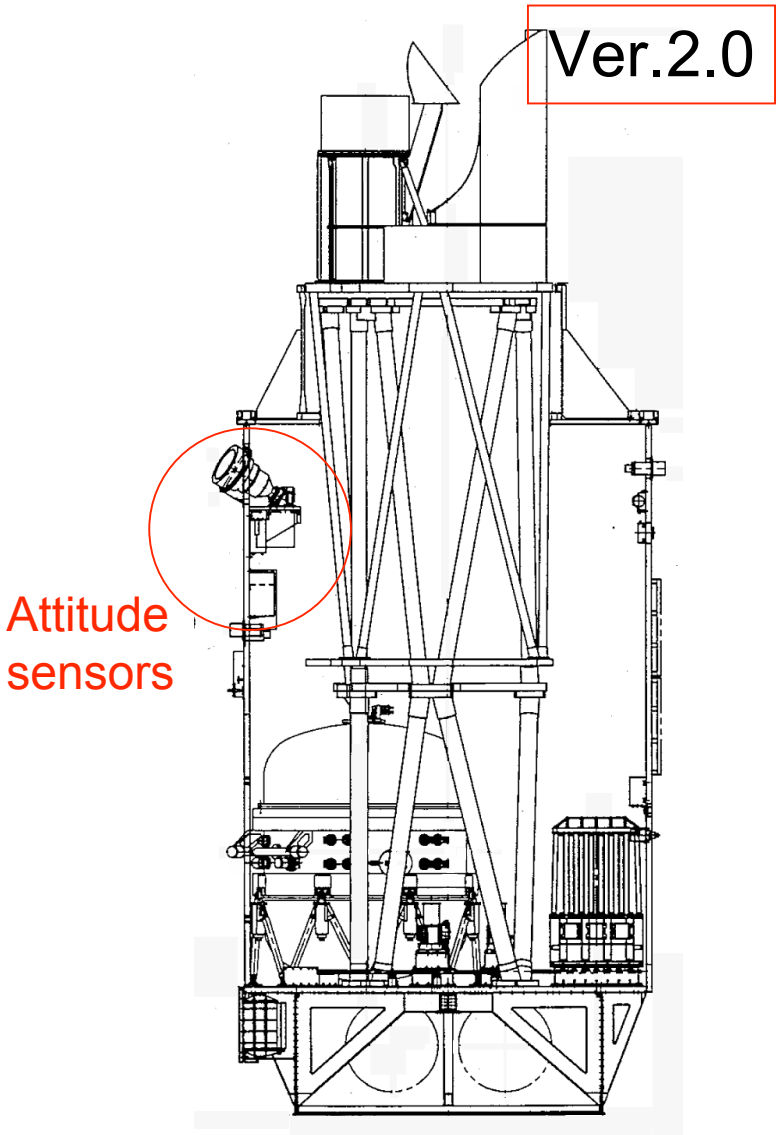
Thermal distortion of the satellite causes the wobbling of the source image of <50 arcsec.

We developed a new FTOOL, “aeattcor” to calculate a wobbling corrected attitude for each event.

(DETX, DETY)

aeattcor ← HK orbit data

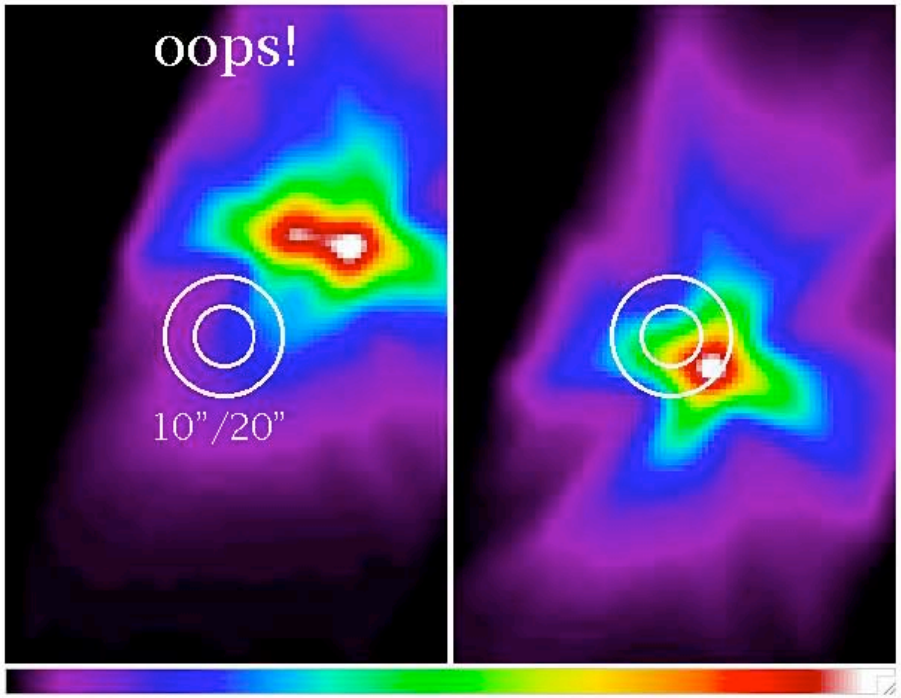
$(X,Y)_{corrected}$



Example of attitude correction with “aeattcor”

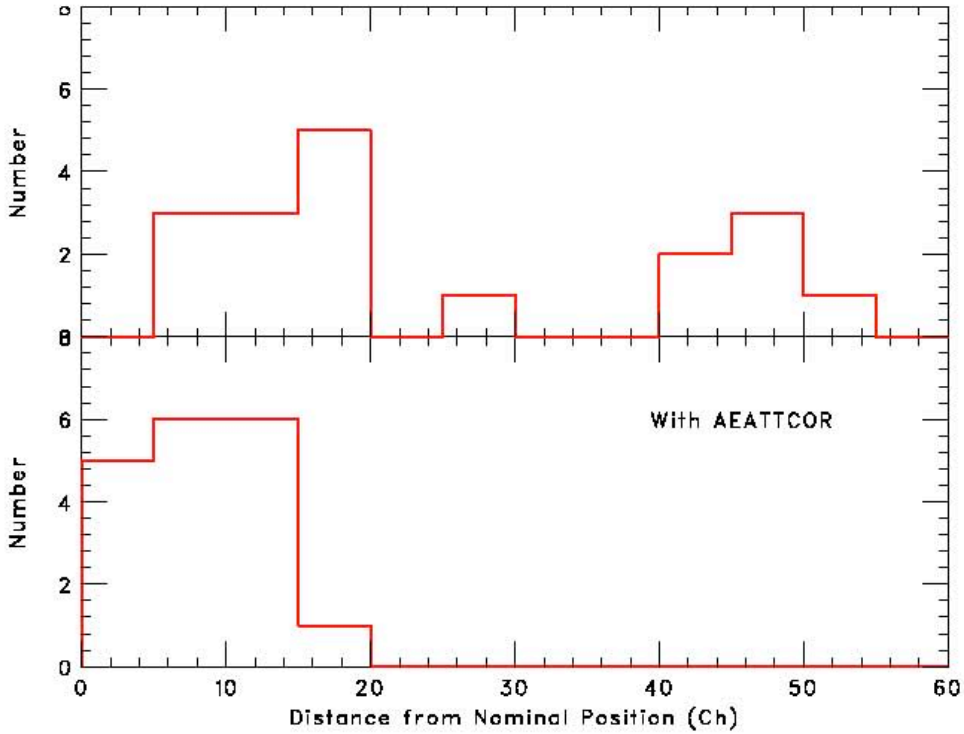
Ver.2.0

uncorrected corrected



Using FTOOLS `aeattcor`,
(1) absolute positions improved
(2) PSF shapes improved

Distribution of Offset Position
18 SWG targets



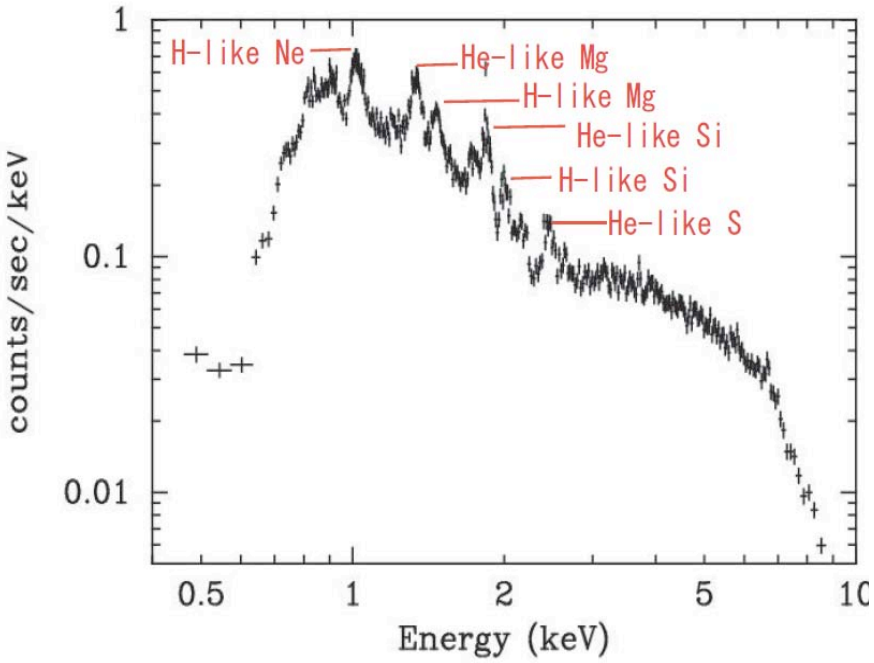
Position error < 20”

On-going calibration, etc.

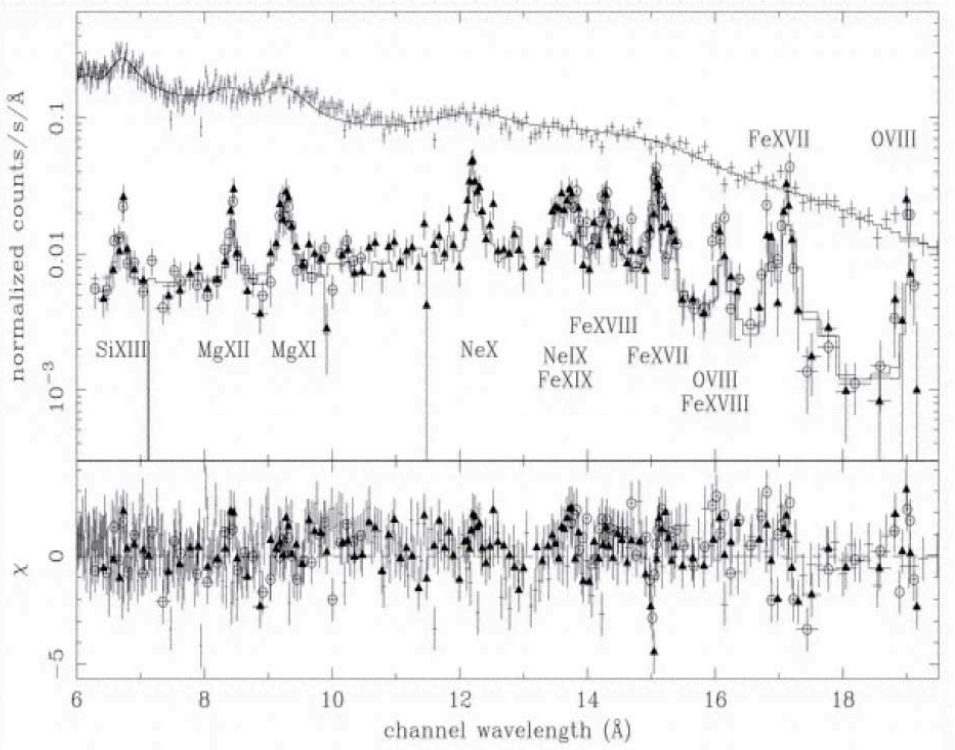
(to be released after ver 2.0)

Gain and resolution at low energies

(1) M82

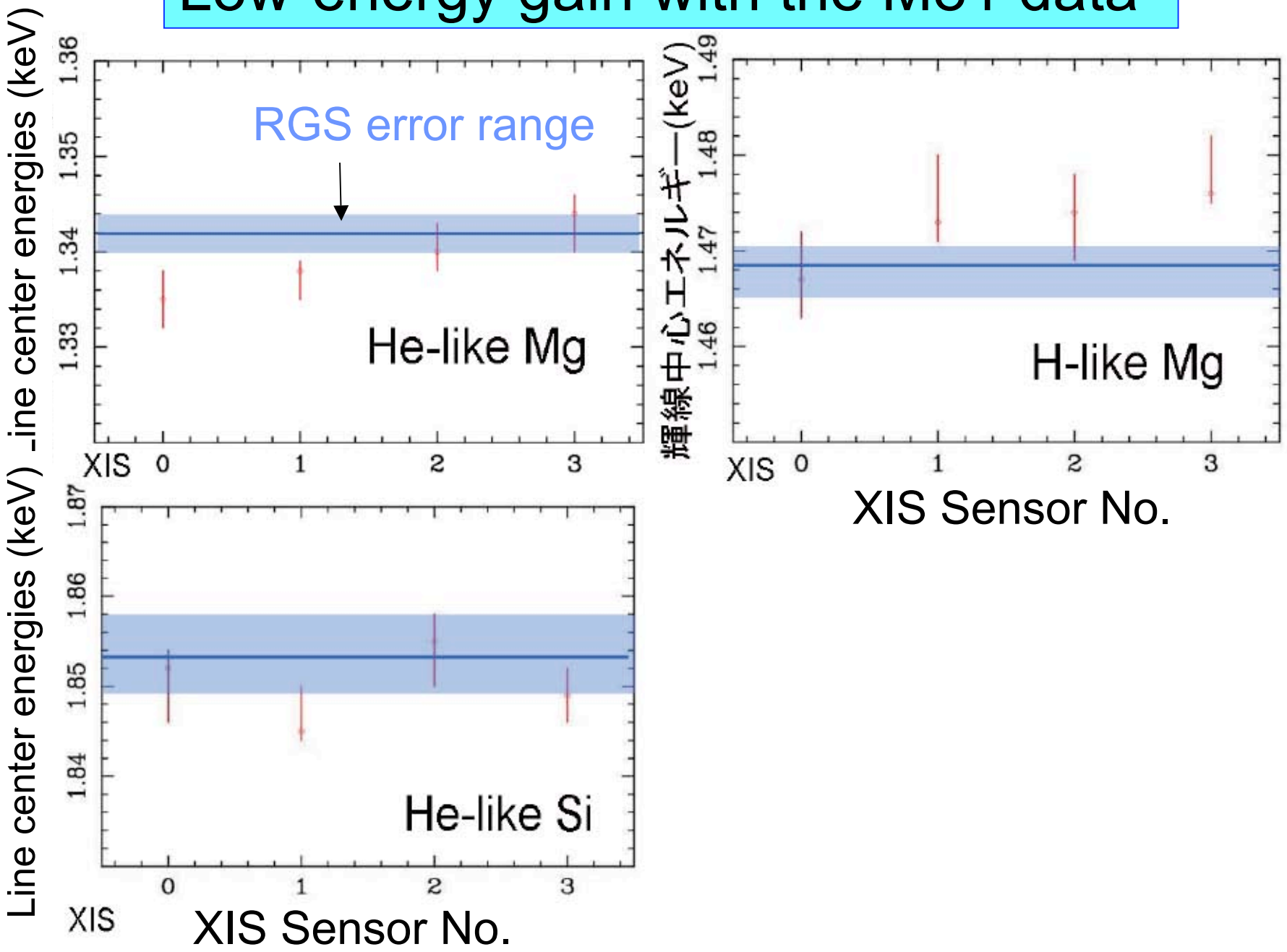


Suzaku
(Oct 2005, no-SCI)

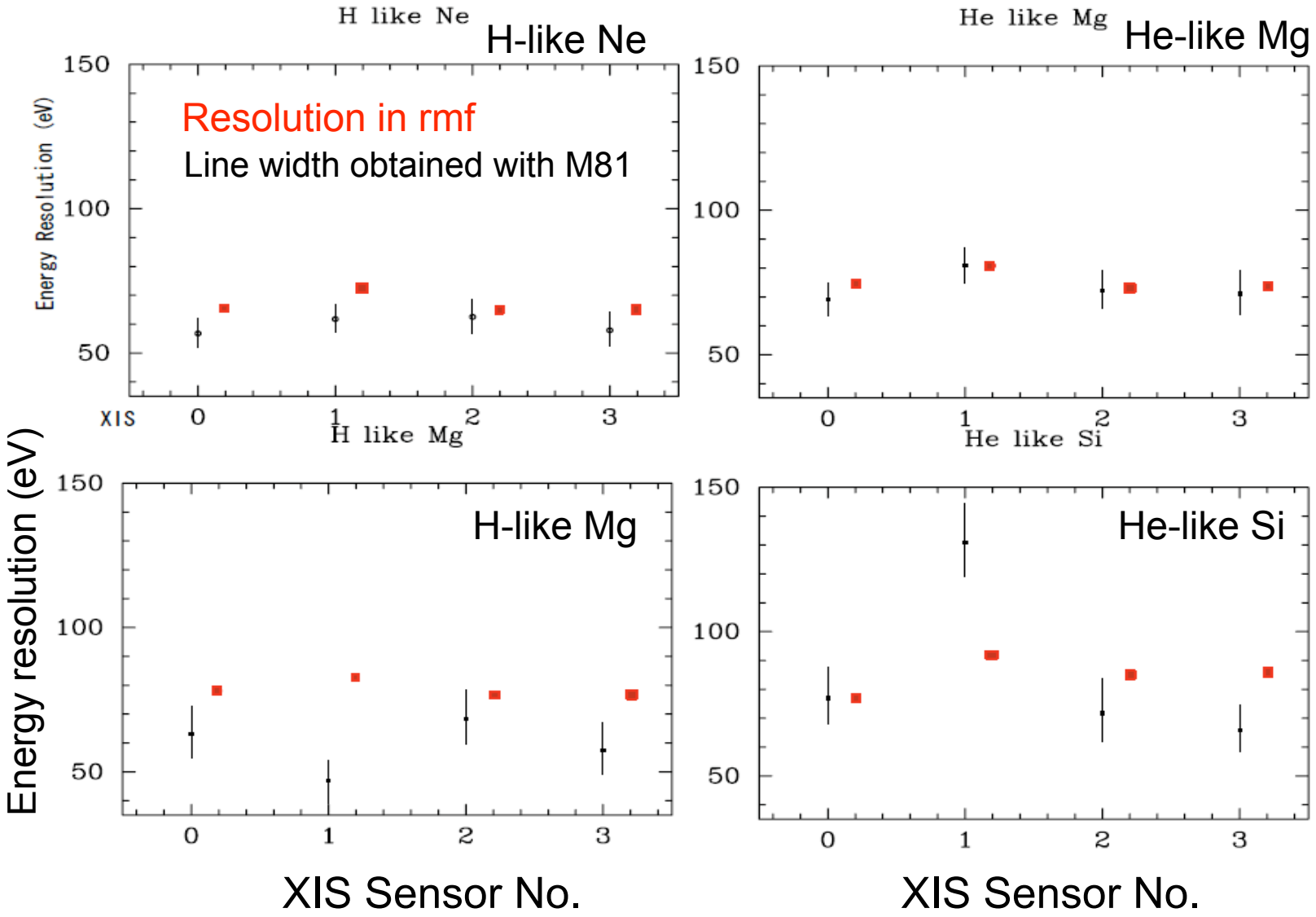


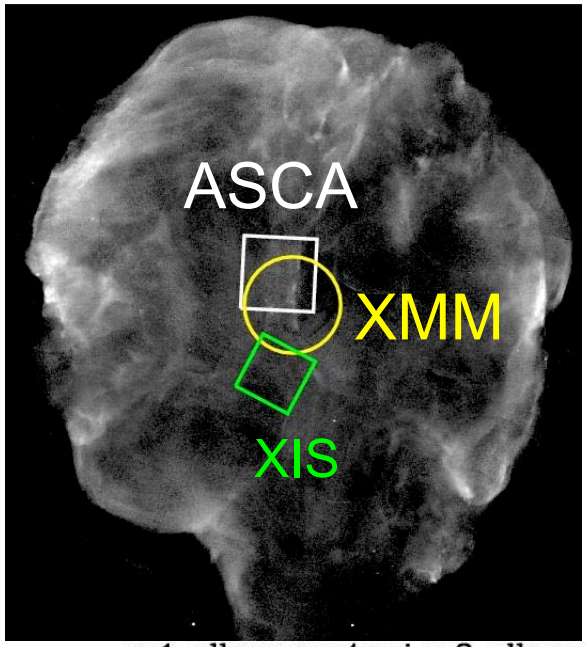
XMM-Newton RGS

Low-energy gain with the M81 data



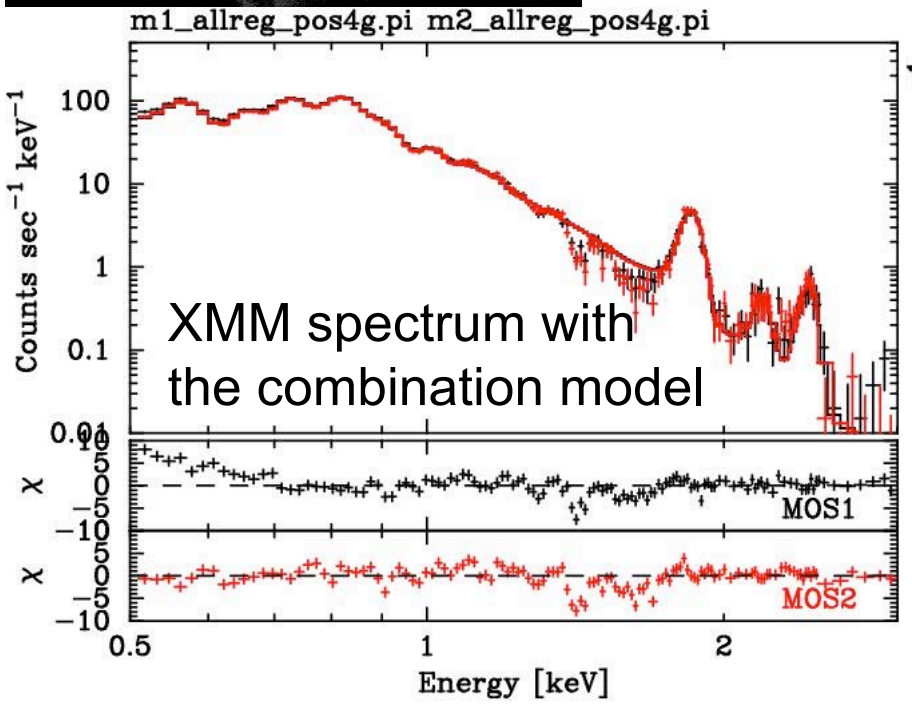
Energy resolution with the M81 data



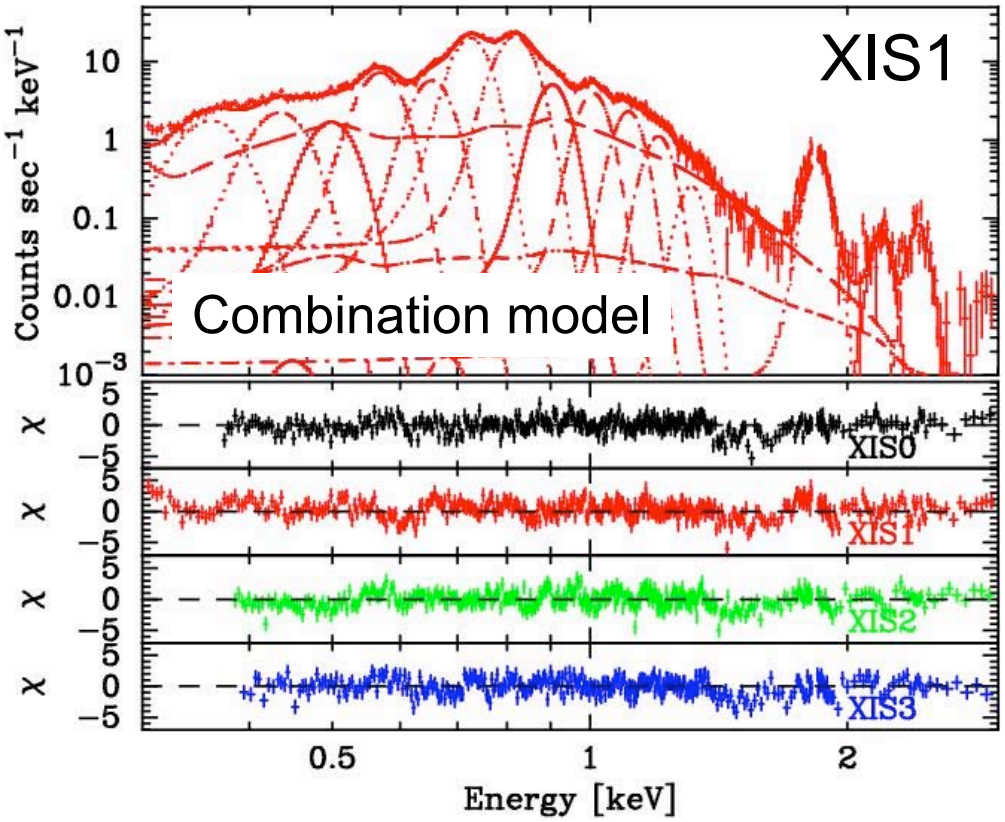


3. Cyg loop (May 2006)

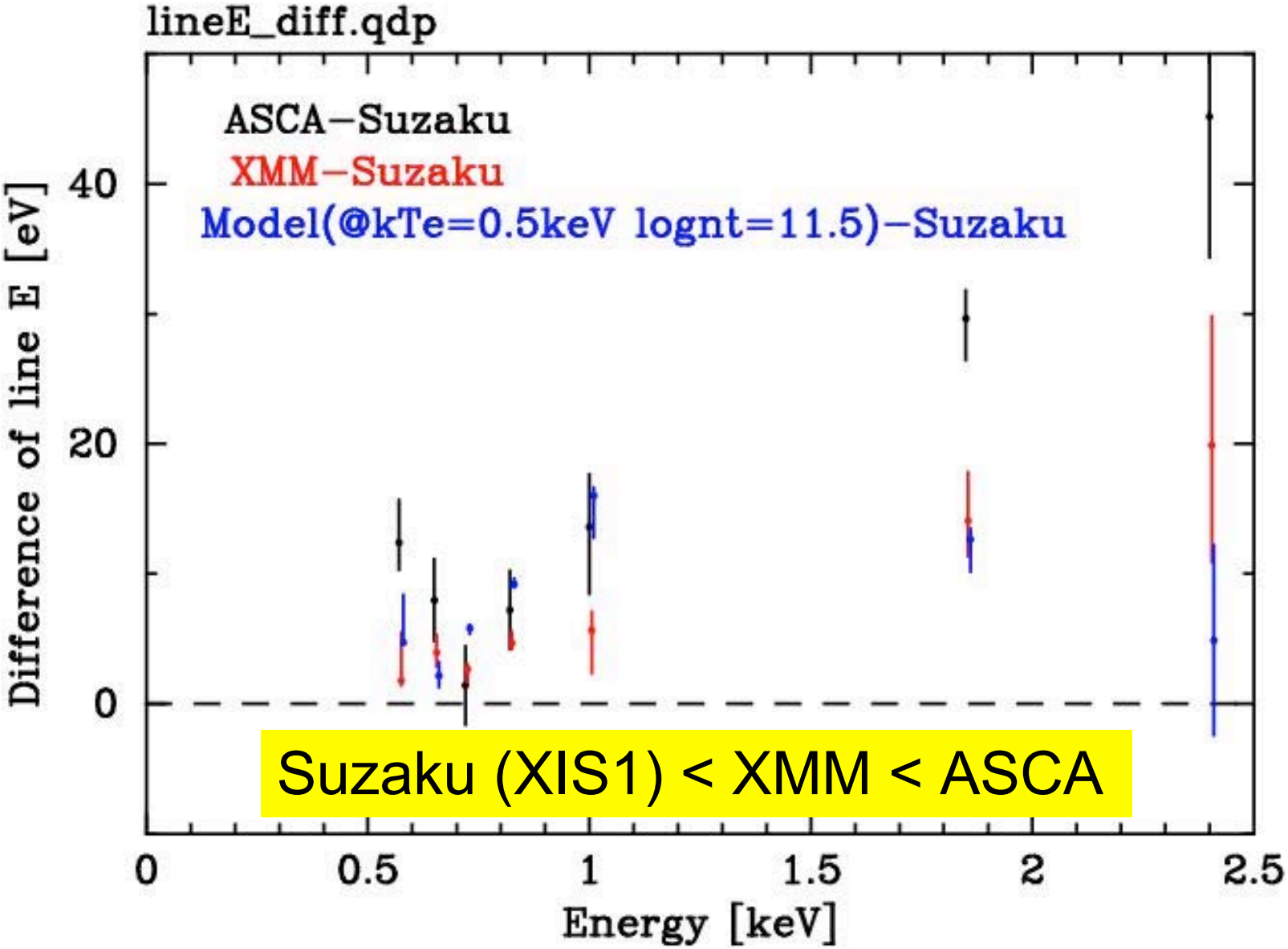
Comparison of the line center energies among Suzaku, XMM-Newton, and ASCA



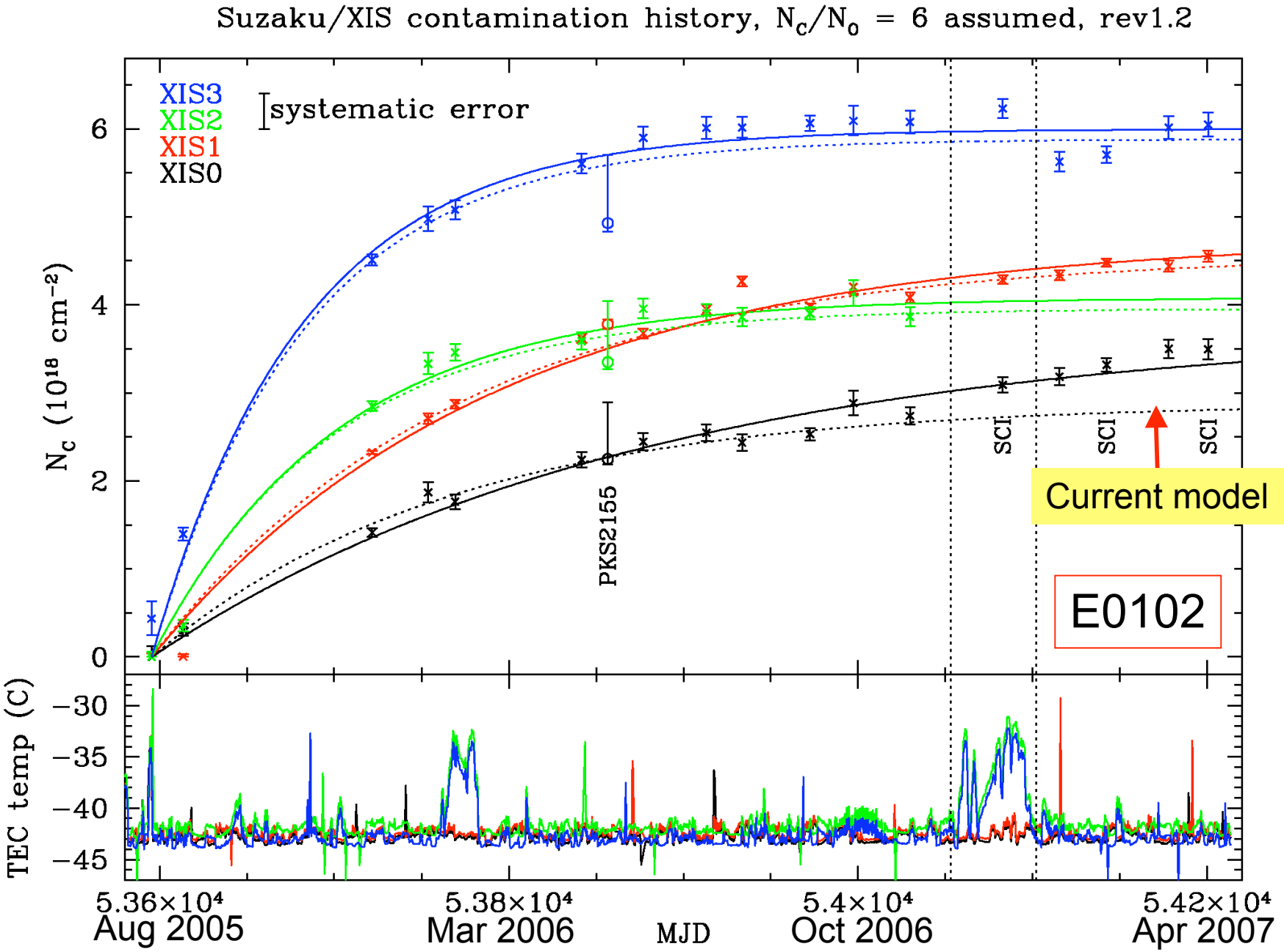
Suzaku XIS



Differences of the line center energies



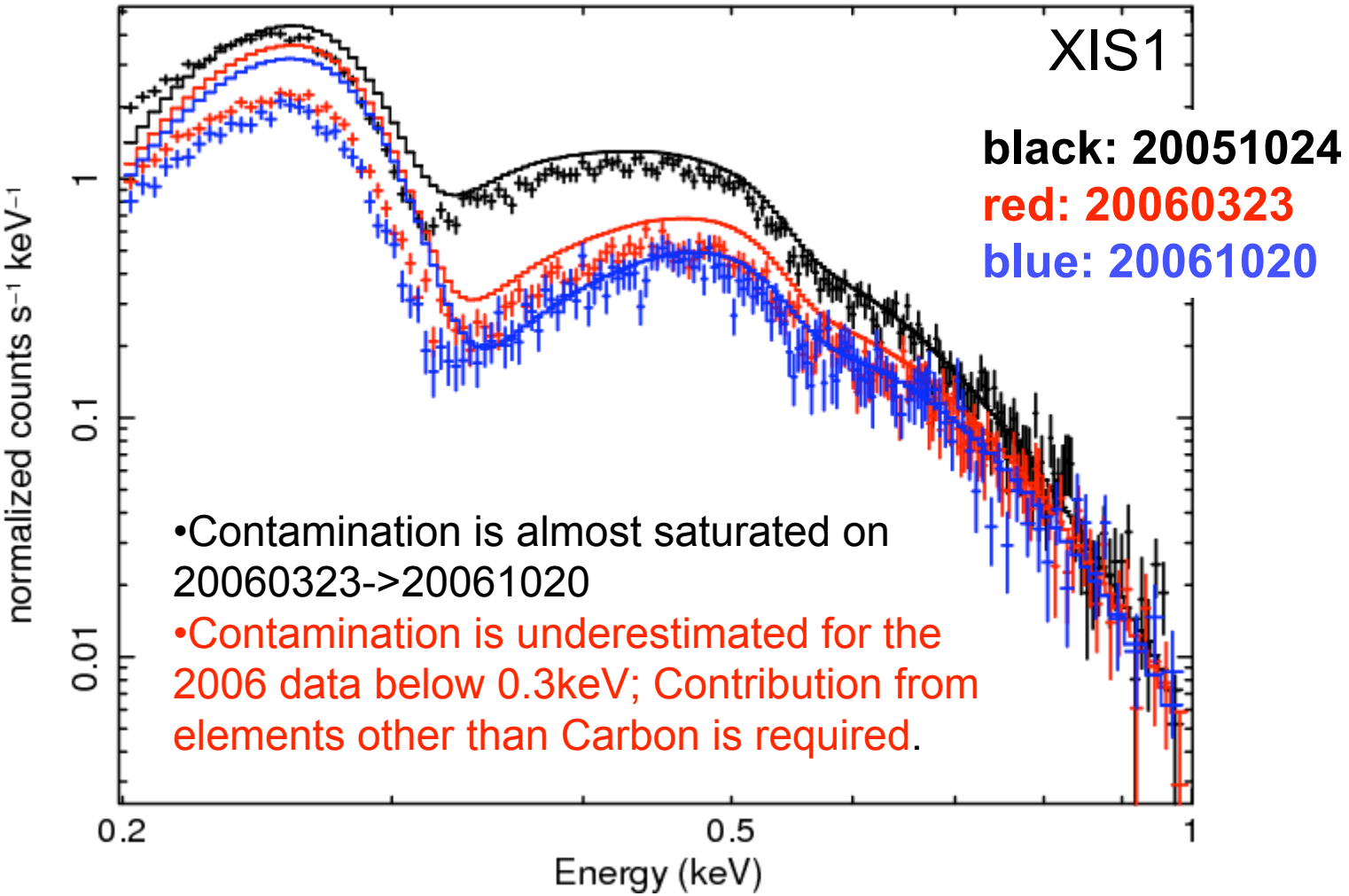
Time evolution of the contamination

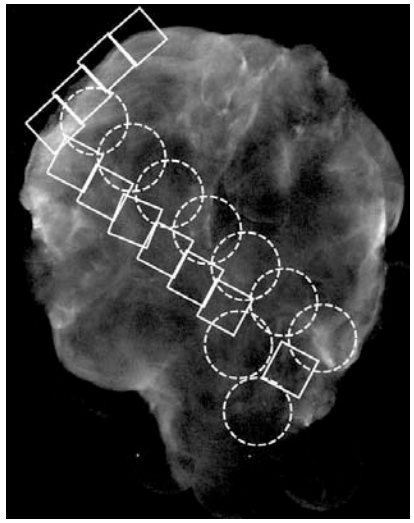


Composition of the contamination: RXJ1856 data

- Ver1.2,ver1.3 processing data from DARTS
- src=circle (3mm radius), bgd=annulus(6-9mm radius)
- rmfile =xisrmfgen, arf=xissimarfgen in heasoft ver6.2 with CALDB latest on 20070425
- Fixed RXJ1856 emission Model=based on Chandra LETG (Burwits et al., 2003)

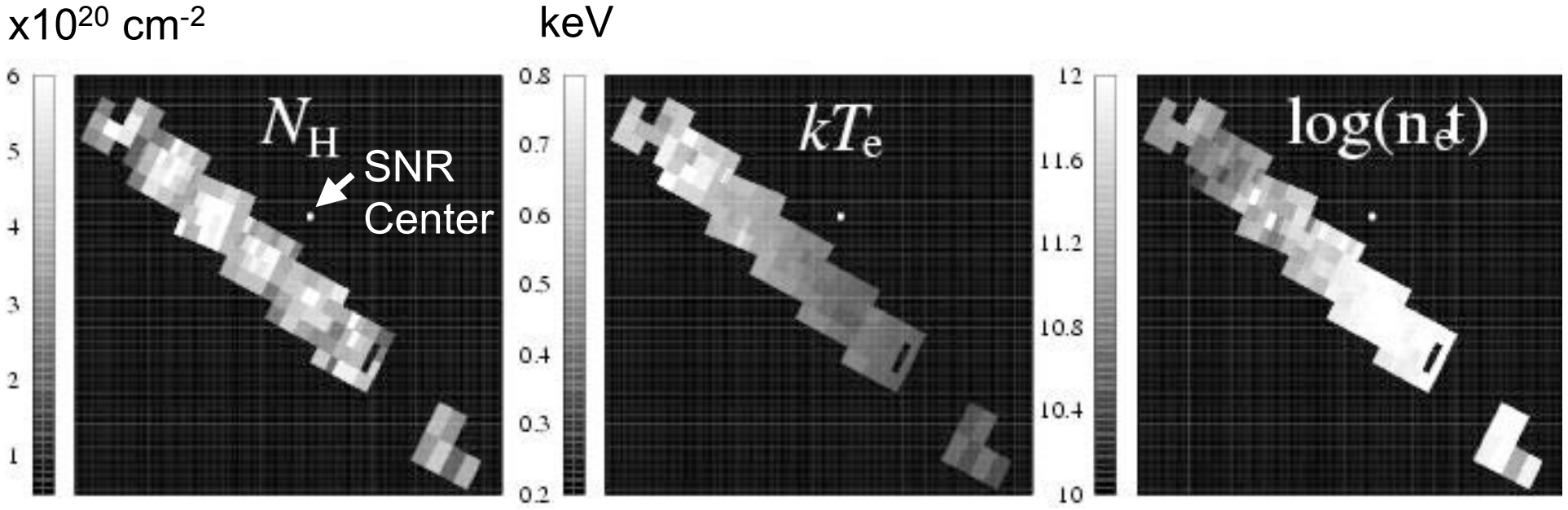
NH=9.5e19cm–2 kT=63.5eV N_bbodyrad=1.344e+5





Spatial distribution of the contamination Cyg loop (May 2006)

XIS fov was subdivided to determine the spectral parameters in each subsection. Non-uniformity of the contamination is taken into account in the analysis.



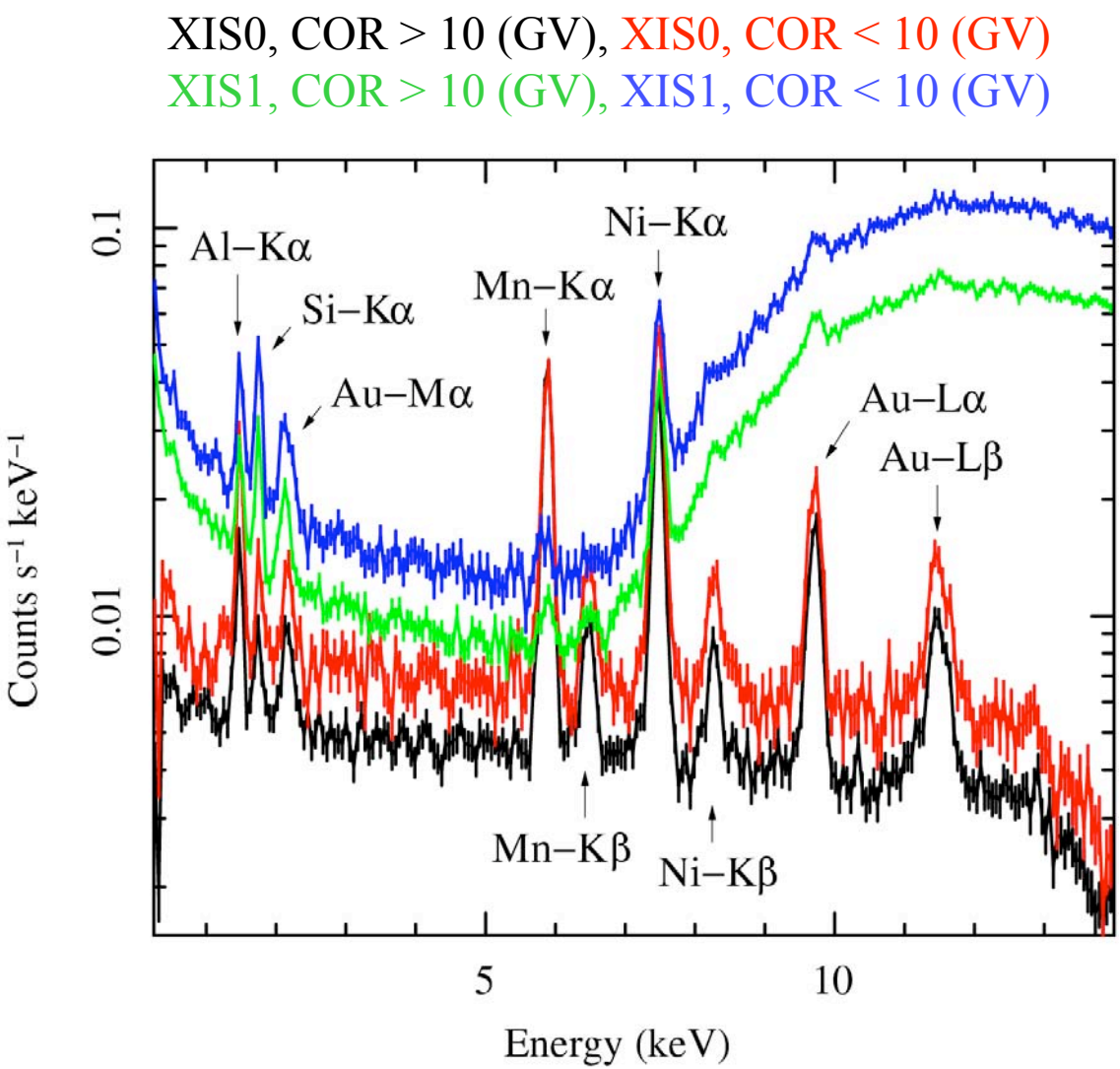
N_H tends to become higher at the center of the FOV.

Database of the non-X-ray background

http://www.astro.isas.jaxa.jp/suzaku/analysis/xis/nte/

- XIS team has released a COR-sorted database of the non-X-ray background based on the ver 0.7 products.

- XIS team has no plan to update the database before the ver 2.0 products become available, because ver 1.2/1.3 are same as ver 0.7 at least for the XIS data.

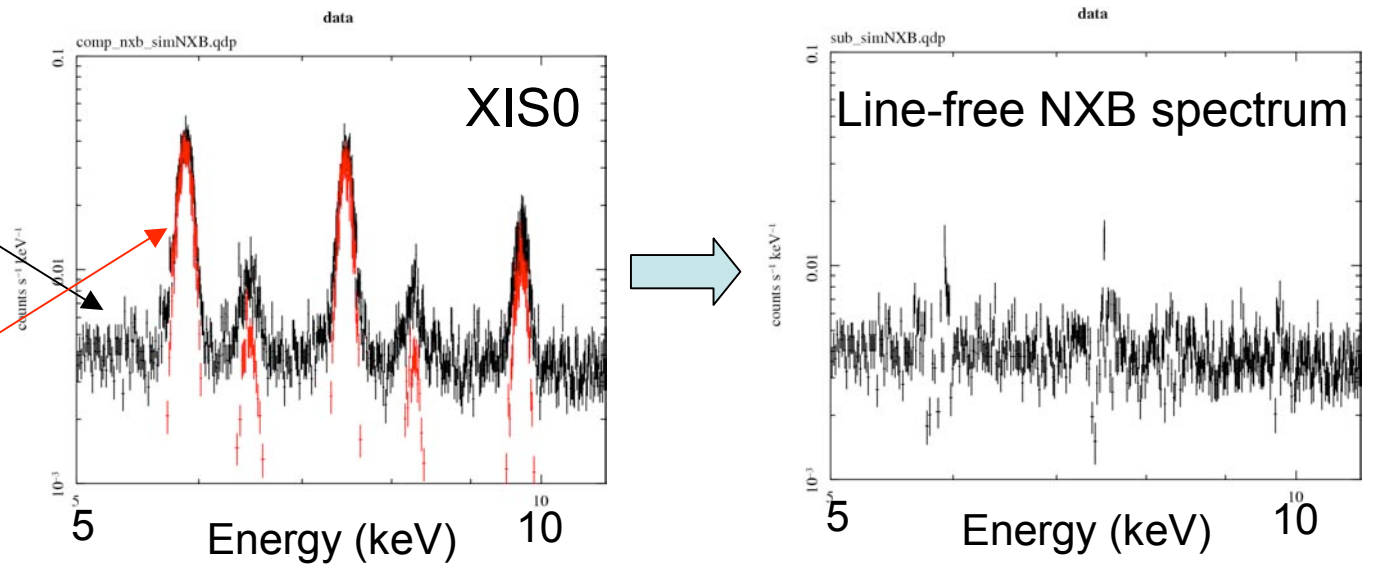


Recipe to adapt the time evolution of the line profiles in the NXB database

- Lines in NXB become broader (and weaker) due to the degradation of the XIS performance.
- Because the NXB database were created using data before May, 2006, systematic differences are found in the line profiles for the recent data.
- This problem can be solved by subtracting line components from the NXB spectrum. XIS team is going to release a recipe for the method.

NXB spectrum

Simulated emission lines based on the best-fit gaussian model.



Other calibration items

- Gain and energy resolution of the data with the window option.
- Overall performance of the timing mode.
- Quantum detection efficiency above 10 keV.

Summary

- SCI data
  - Provisional analysis method (rev 1.2/1.3)
    - Energy scale, effective area
- Calibration for ver 2.0
  - Full analysis of the SCI data
    - Saw-shape CTI correction, PHA dependence of CTI, dead lines due to SCI
  - Time evolution of the charge trail
  - Jumps of data points at Si edge
  - Calibration of the 2x2 data
  - Correction of the time assignment error
  - Correction of the attitude wobbling
- On-going calibration (after ver 2.0)
  - Gain and energy resolution at lower energies
  - Contamination
    - Time evolution, composition, spatial distribution
  - NXB database
  - Calibration of the window data, and the timing mode data
  - Calibration above 10 keV