Suzaku XIS Contamination Status

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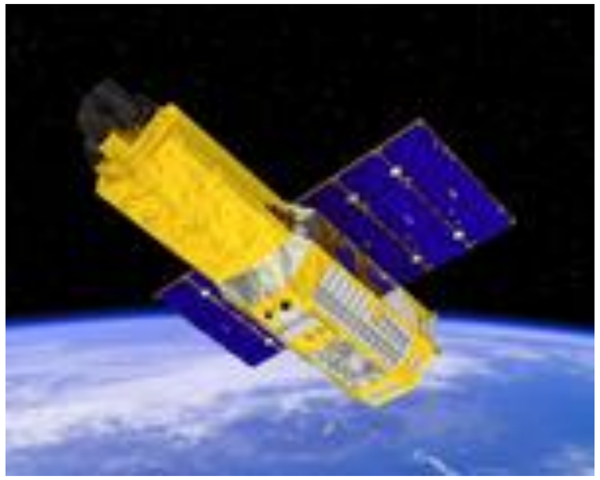
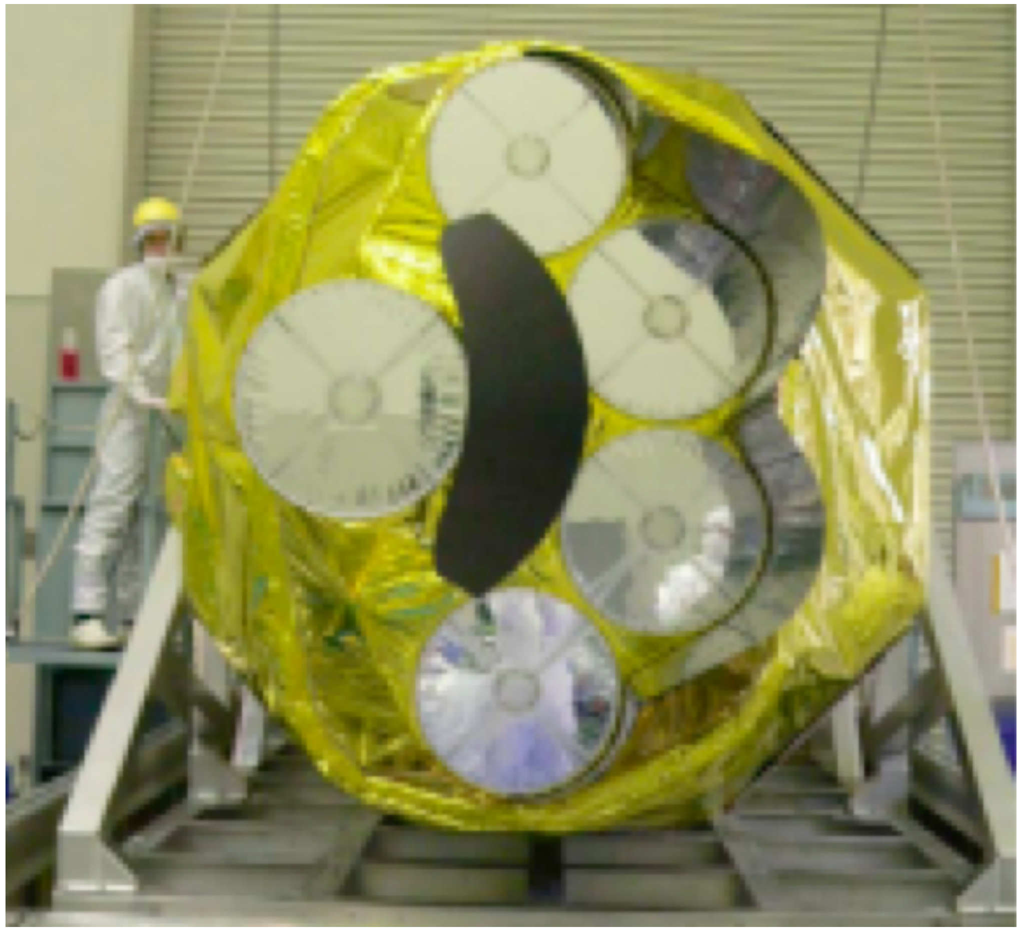
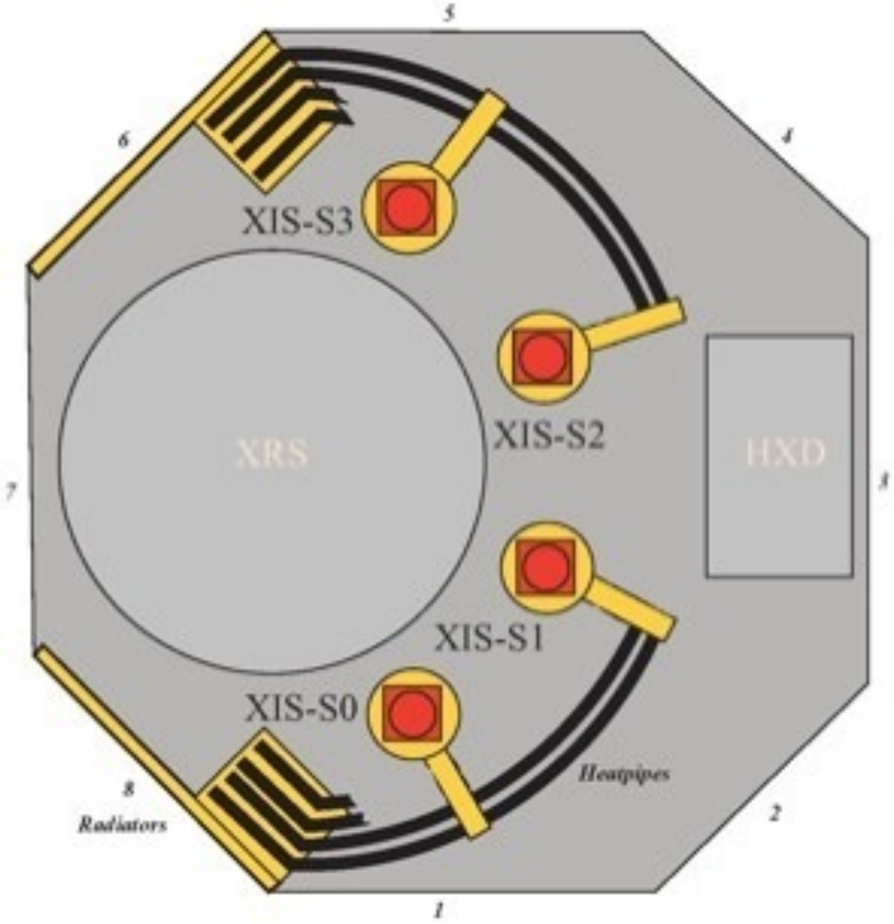
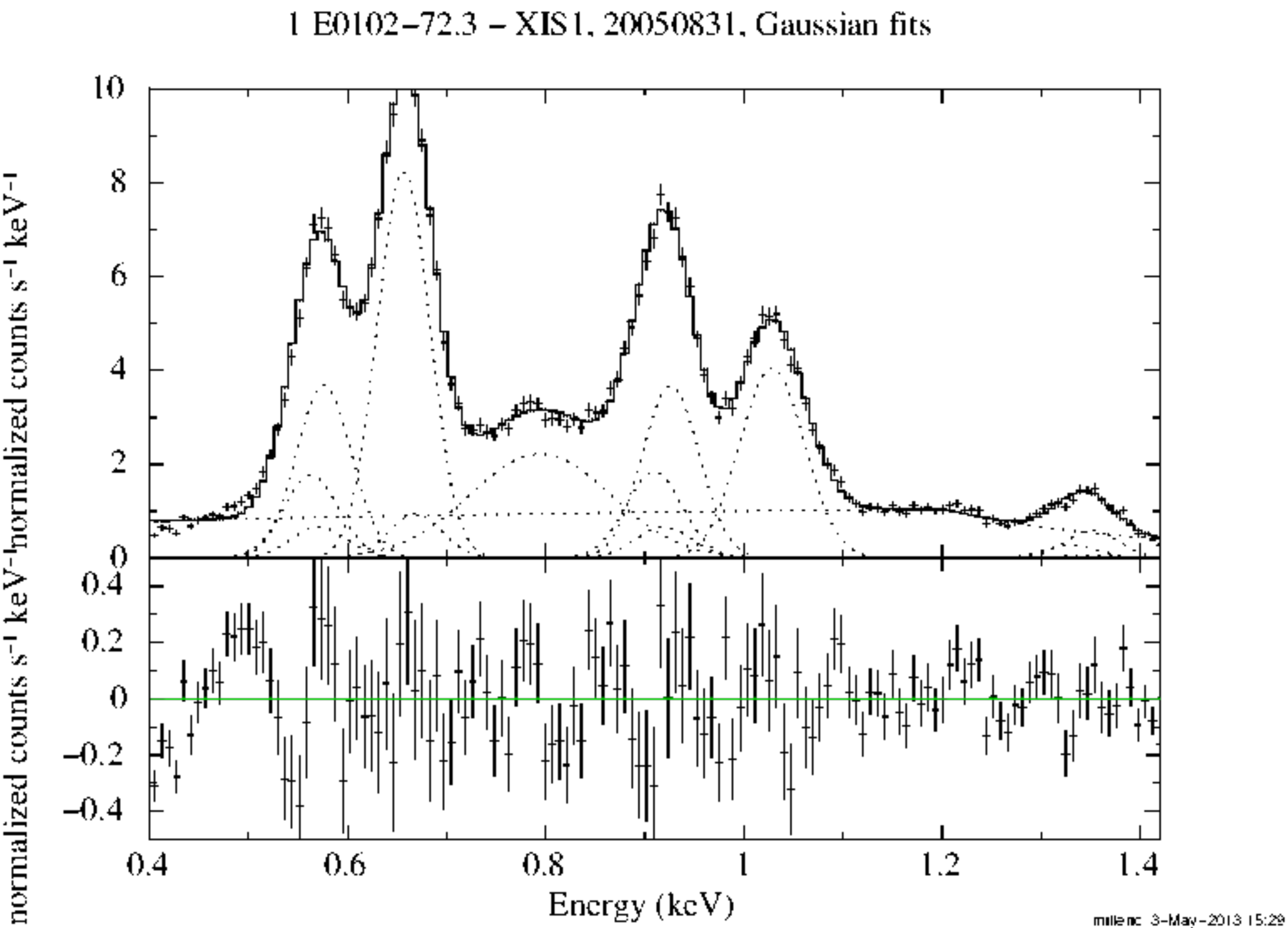
IACHEC 2014

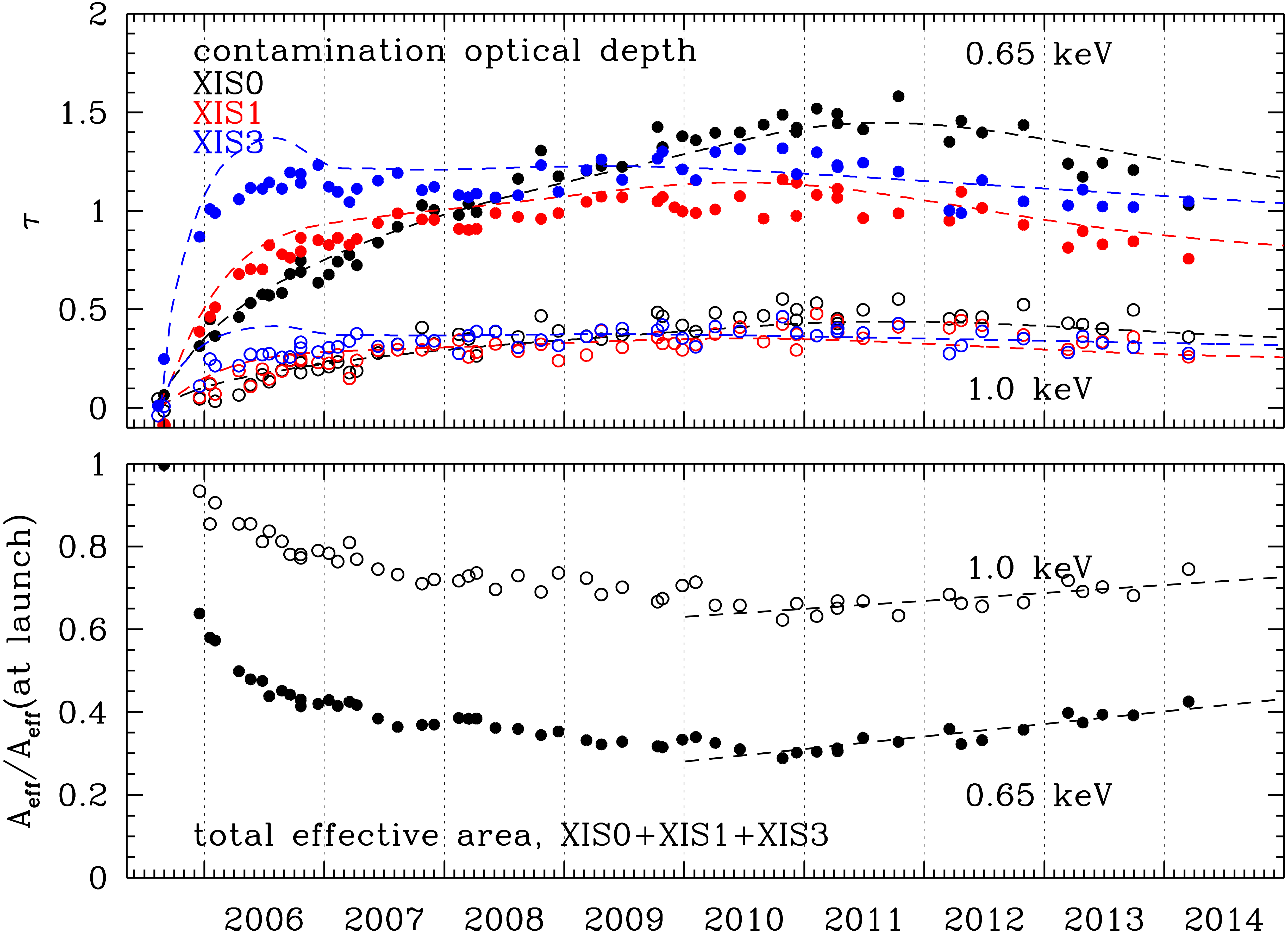
http://space.mit.edu/XIS/monitor/contam

Outline

- contamination history independent of model
- method for determining composition, time dependence, spatial dependence
- interpretation from 2006 XIS "Bakeout Review" possible source


1 E0102−72.3 − XIS1, 20050831, Gaussian fits
normalized counts s⁻¹ keV⁻¹
normalized counts s⁻¹ keV⁻¹
Energy (keV)
0.4
0.6
0.8
1
1.2
1.4
10
8
6
4
2
0
0.4
0.2
0
−0.2
−0.4
millenc 3−May−2013 15:29



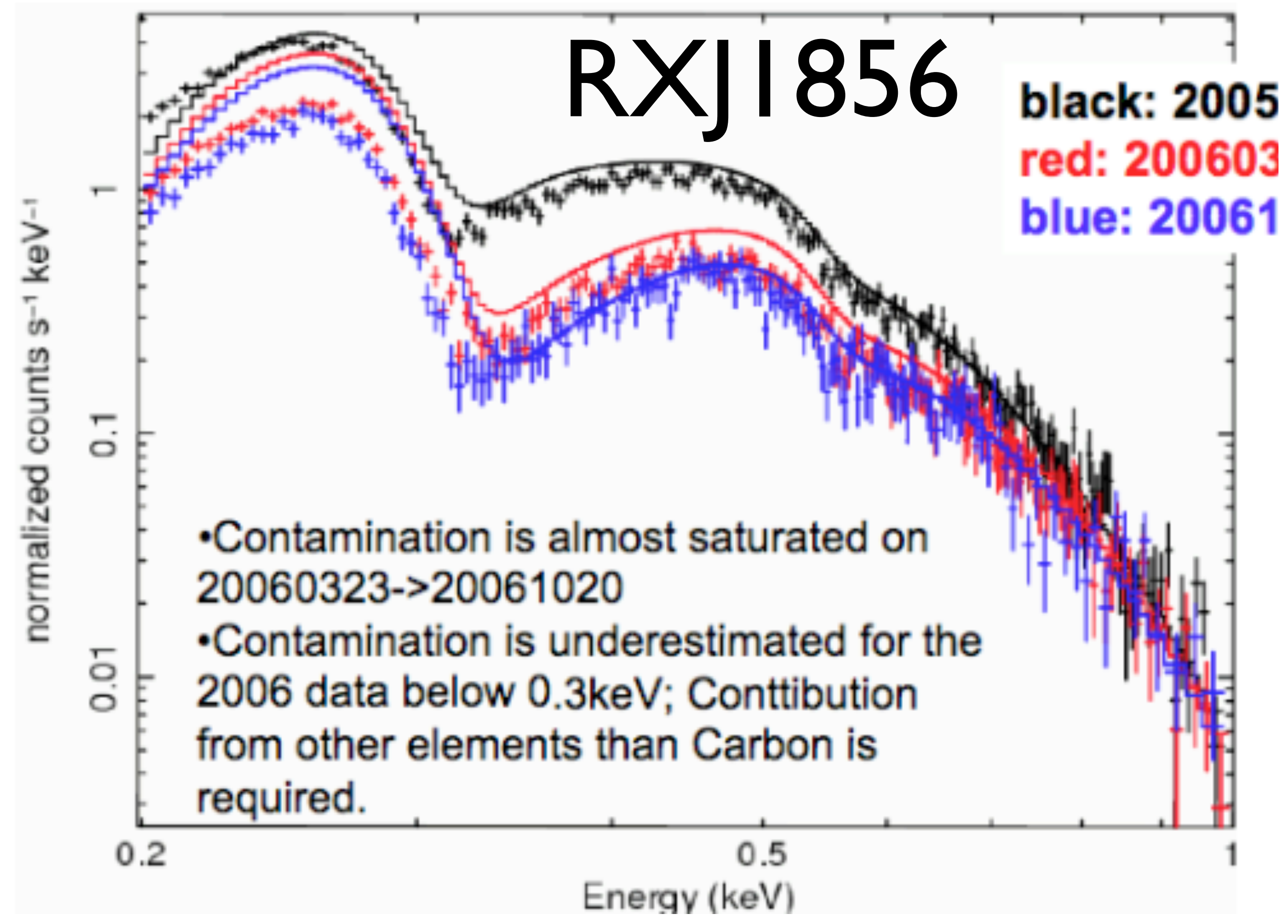
contamination optical depth
XIS0
XIS1
XIS3
0.65 keV
1.0 keV
τ
2
1.5
1
0.5
0
A_{eff}/A_{eff}(at launch)
1
0.8
0.6
0.4
0.2
0
1.0 keV
0.65 keV
total effective area, XIS0+XIS1+XIS3
2006
2007
2008
2009
2010
2011
2012
2013
2014

Key Objects

	Stable (Incident Spectrum known)	Extended over FOV	Always Observable ?	Energy Range	Target of the contaminant study
RXJ1856	Yes (maybe)	No	No	0.2-1keV	Composition
E0102	Yes	No	Yes	0.4-3keV	Evolution
Cygnus Loop	Yes at somelevel	Yes	No	0.2-3keV	Uniformity
PK2155	No but Smooth	No	No	0.2-12keV	Composition
Atmospheric F.L.	No	Yes	Yes	0.39keV 0.52keV	Uniformity Evolution

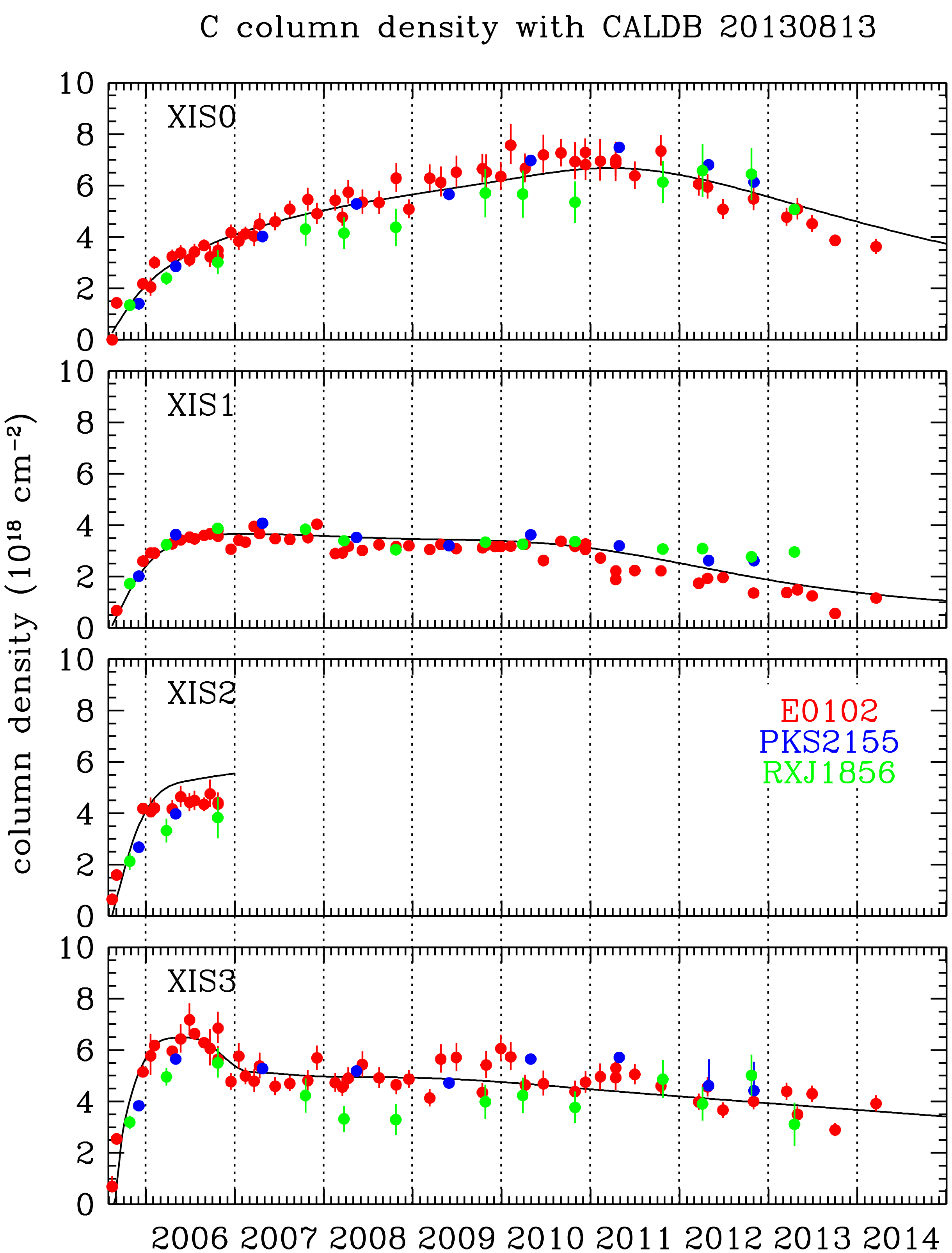
Step 1 – Composition

- fit central contamination
  - RXJ1856, PKS2155
    fit H,C,N,O absorption
    - H is proxy for changes below
      C edge (maybe He?)
      N only allowed for BI
  - E0102
    freeze H,N to previous fit trends

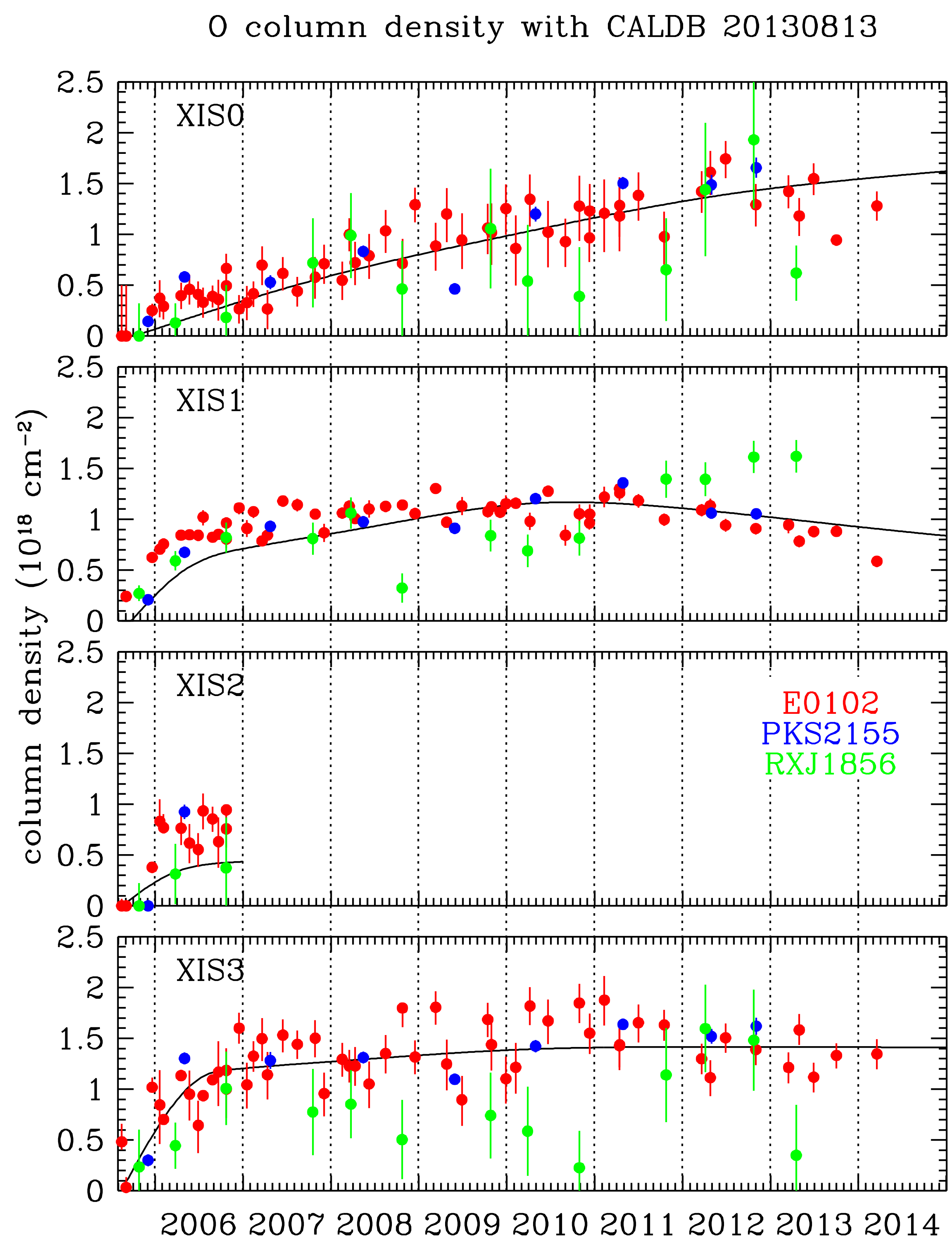


- absorption model
  - *hcnofcol* XSPEC model
    parameters are column densities of H,C,N,O,F
    uses Verner et al. (1996) cross-sections
    no XAFS, just XSPEC

Carbon

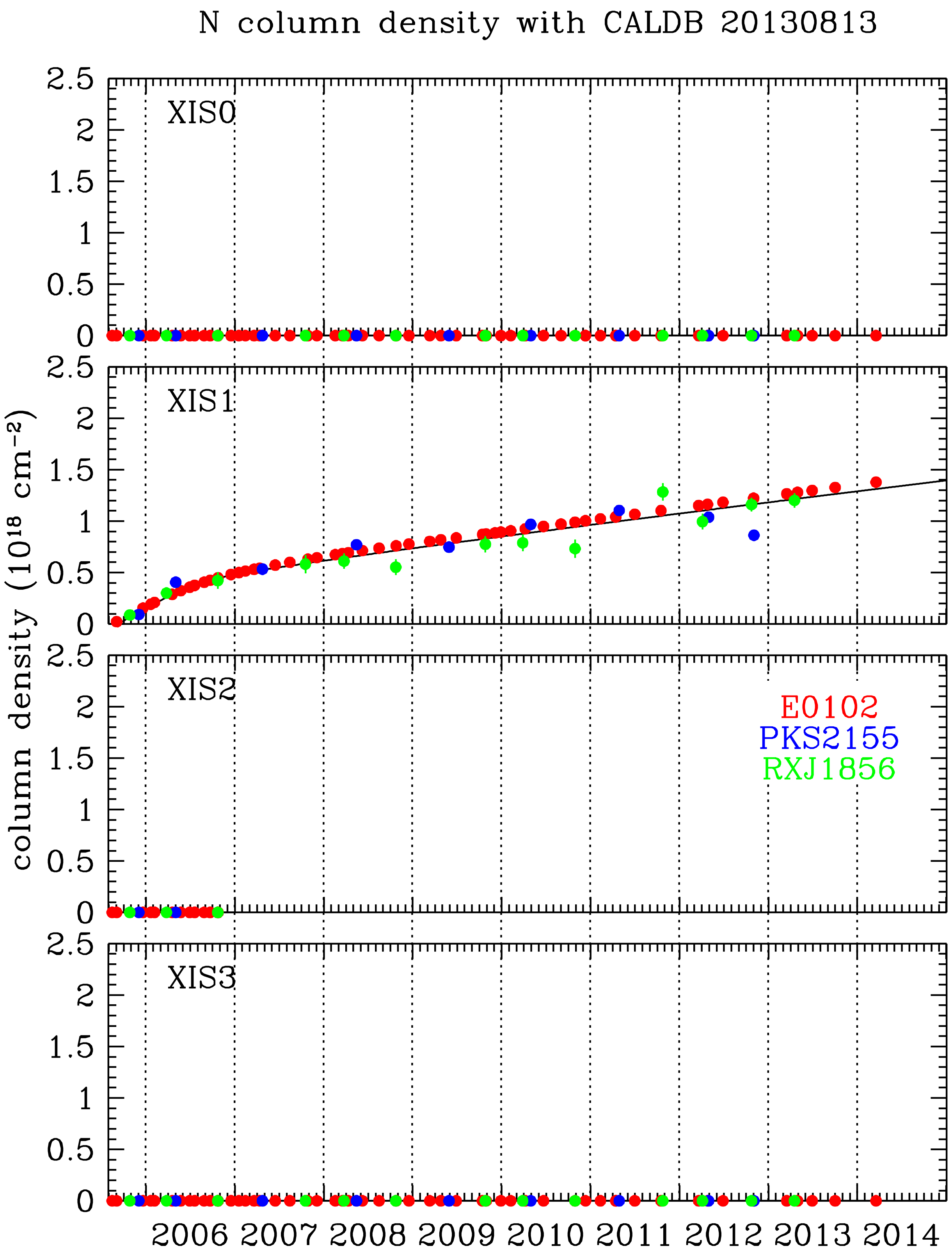


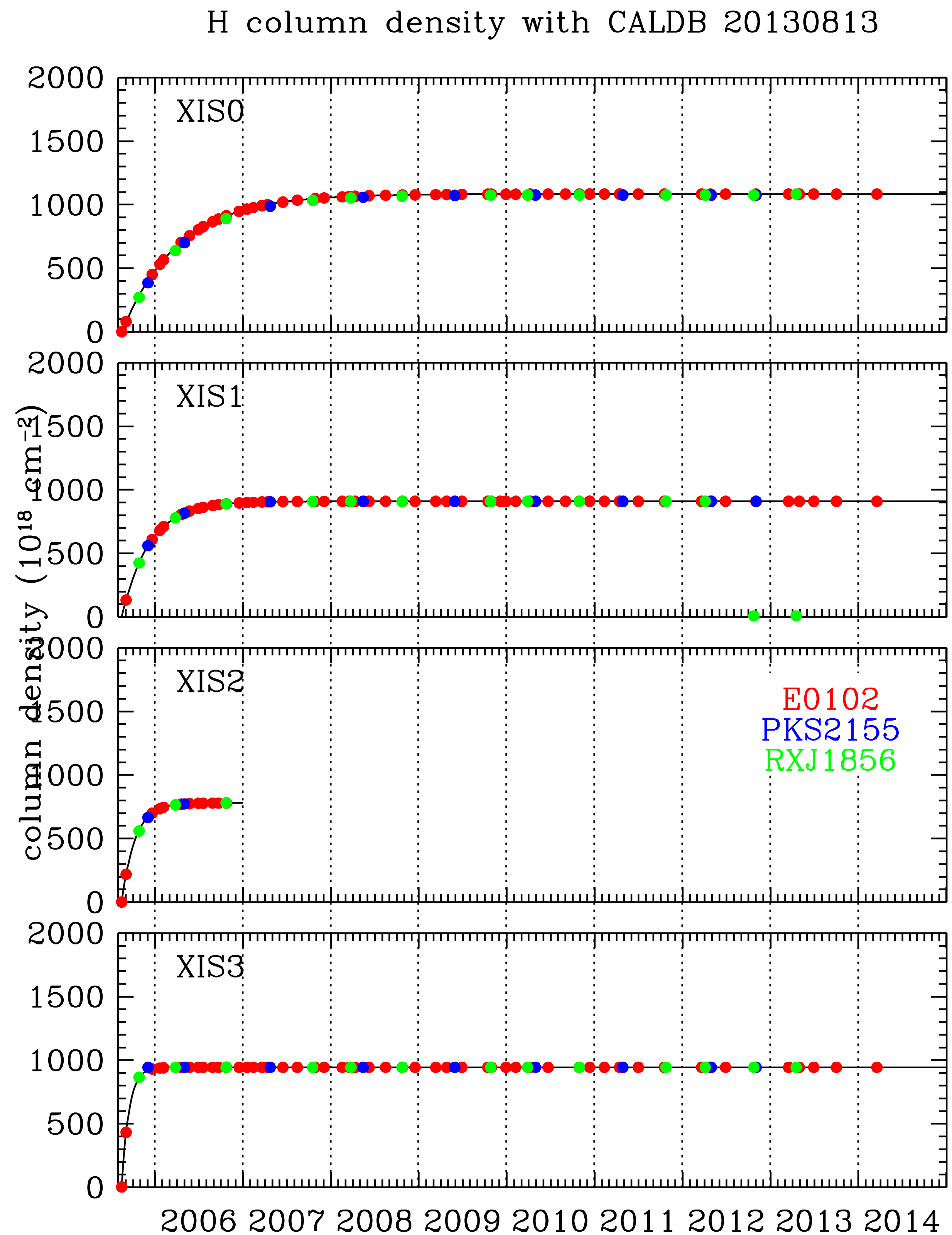
Oxygen



Nitrogen

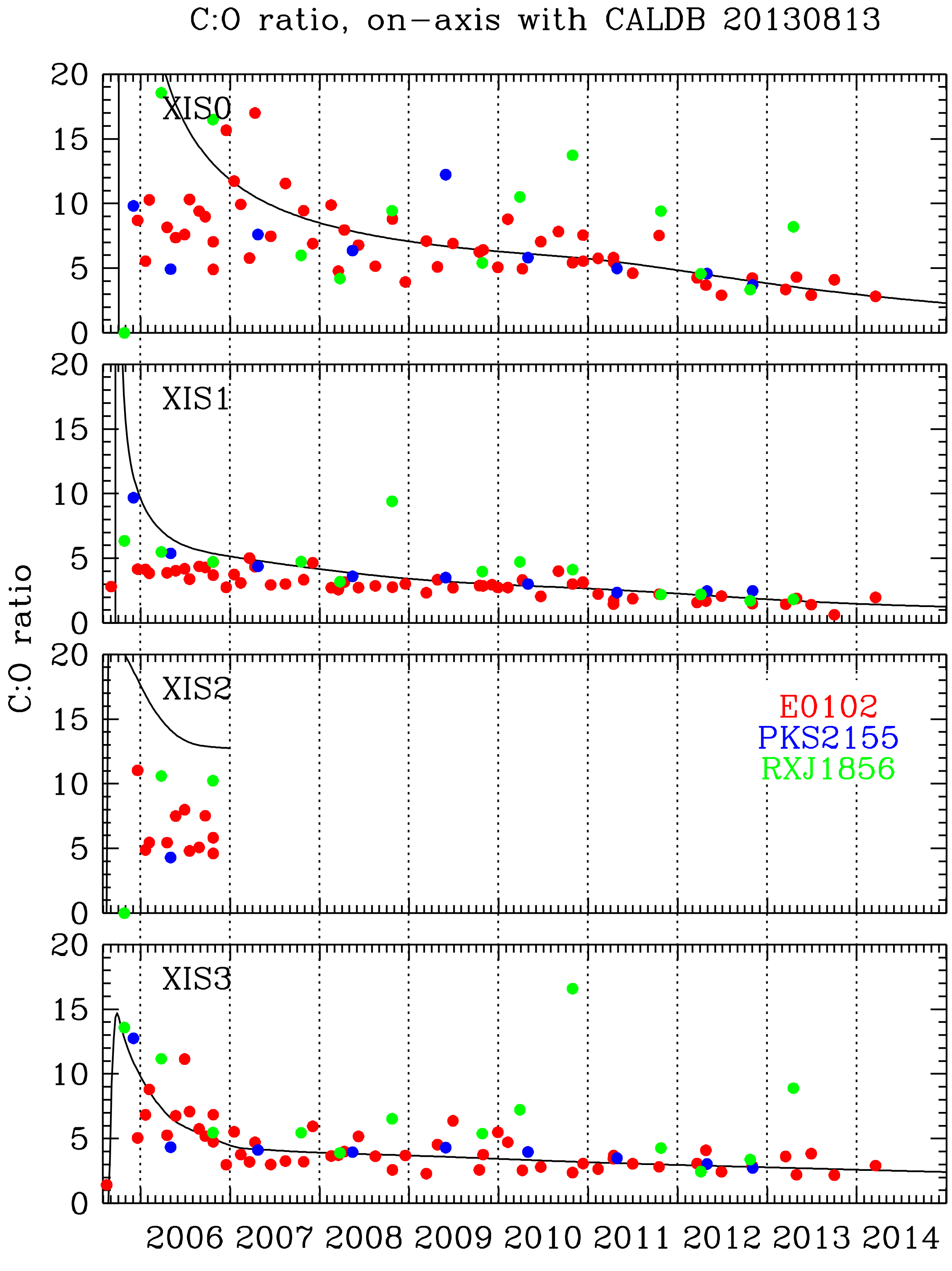
Hydrogen*



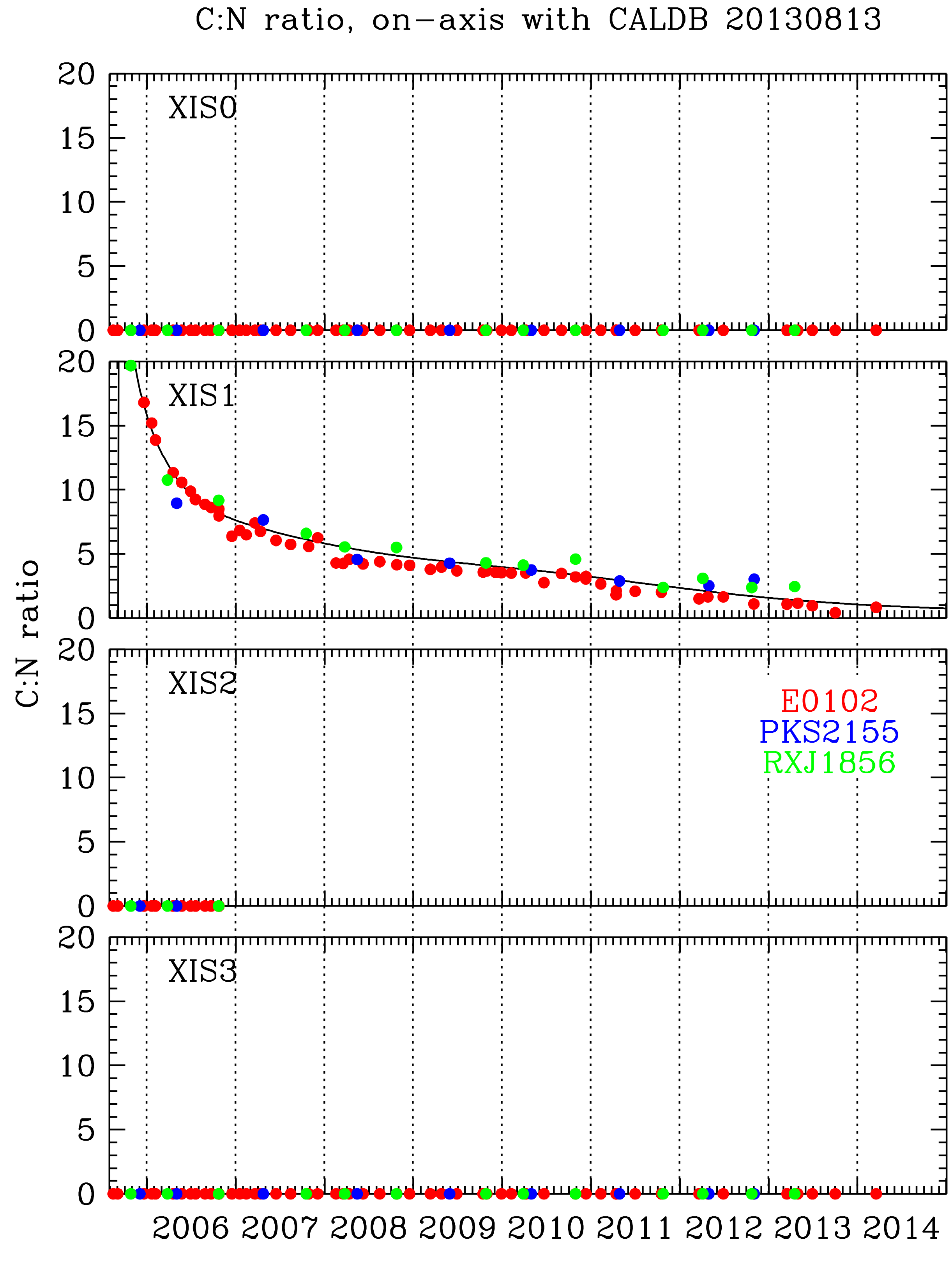


*not really

C : O Ratio

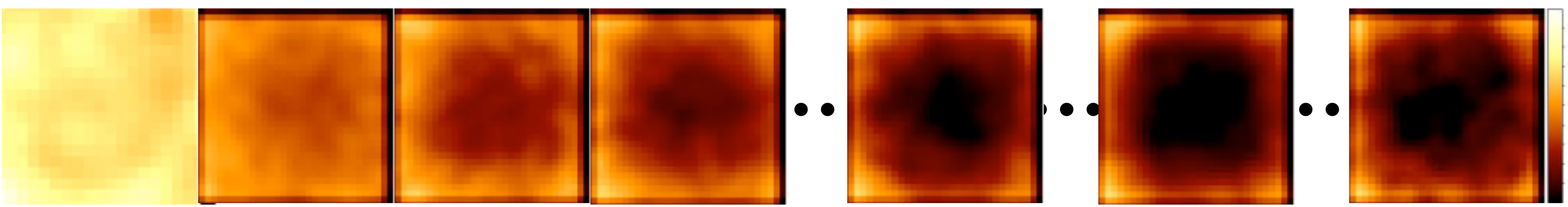


C : N Ratio

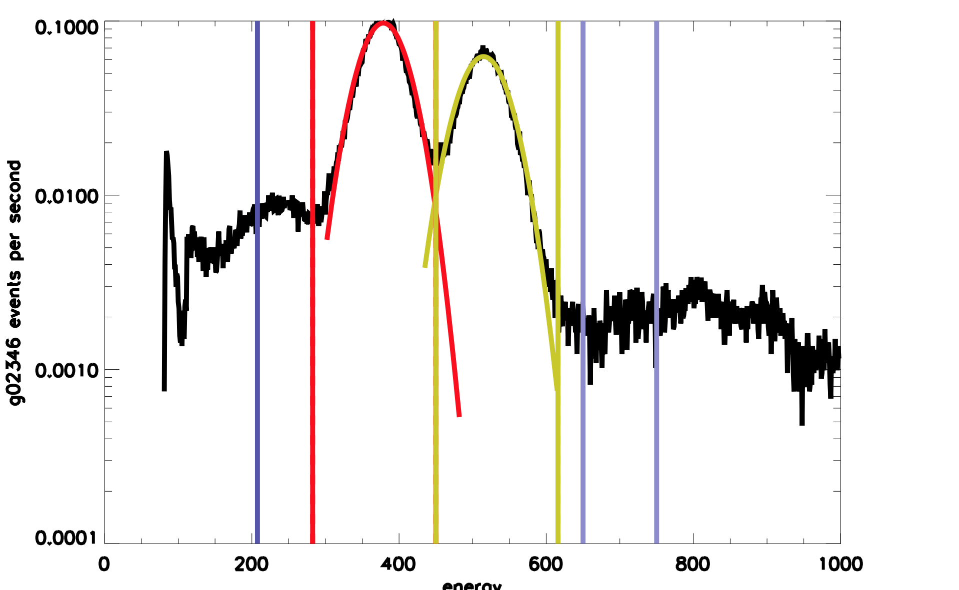


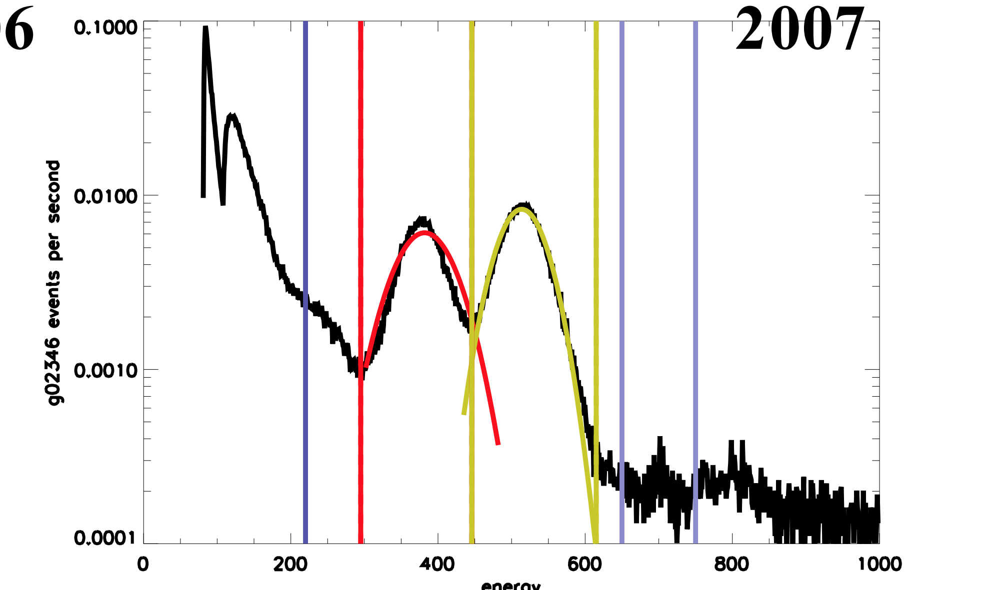
Step 2 – Spatial Dependence

- assume central composition and time dependence
- bright Earth data
  - measure NI K / OI K vs. *R* (assume *flat field*)
- confirm with Cygnus Loop, clusters

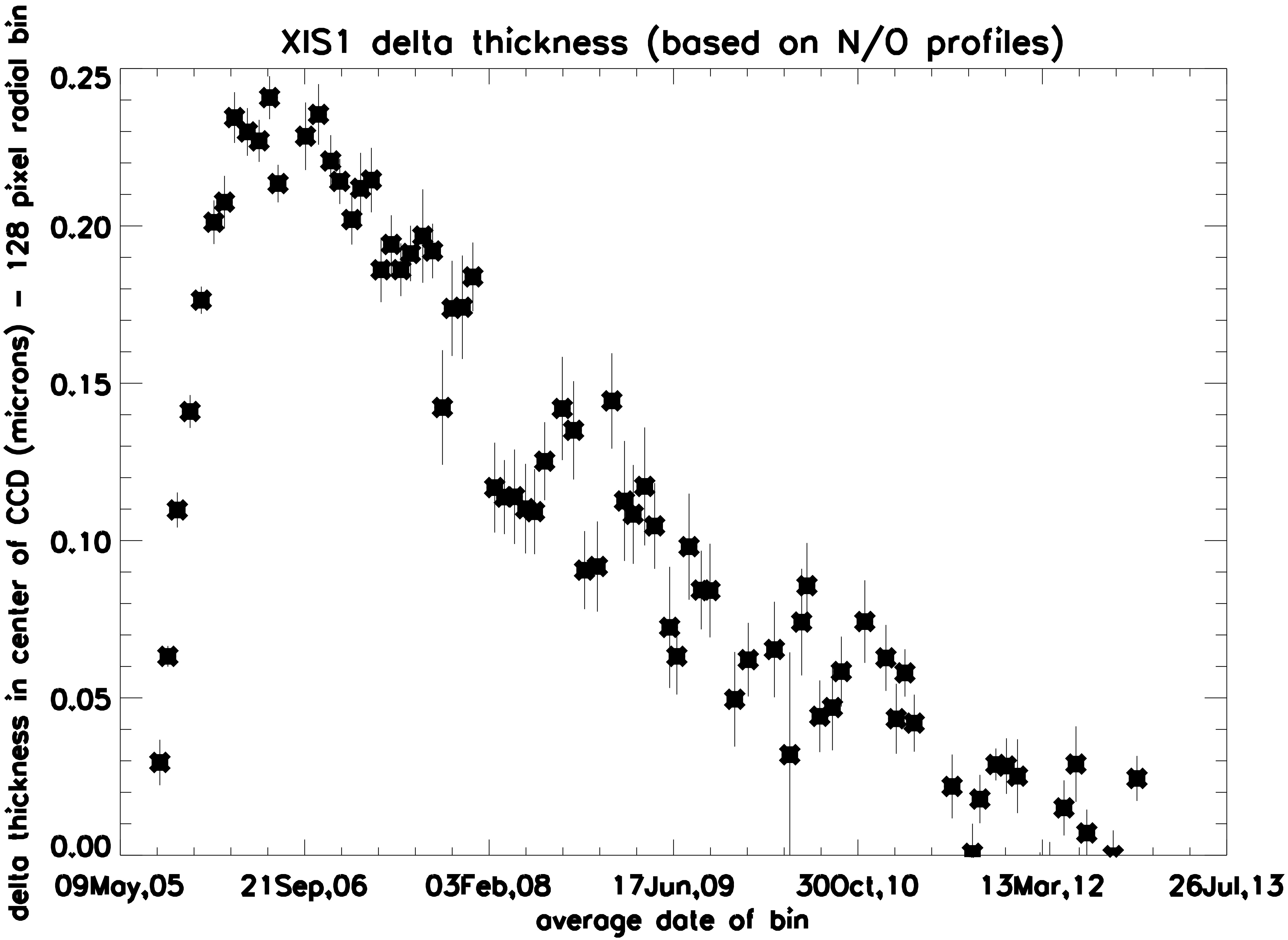


Aug 2005 | Sep | Oct | Nov | Jan 2006 | May | Mar 2007

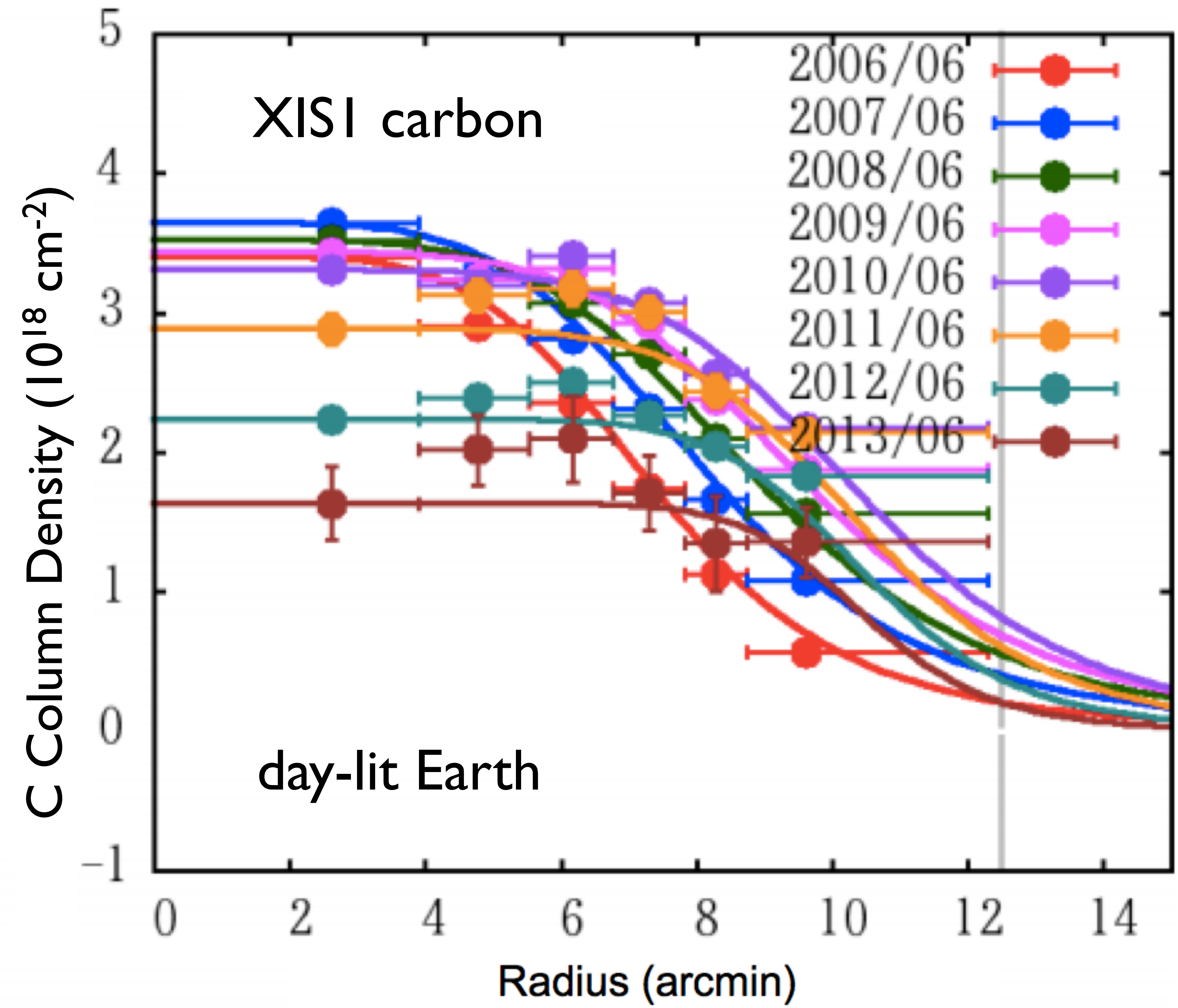




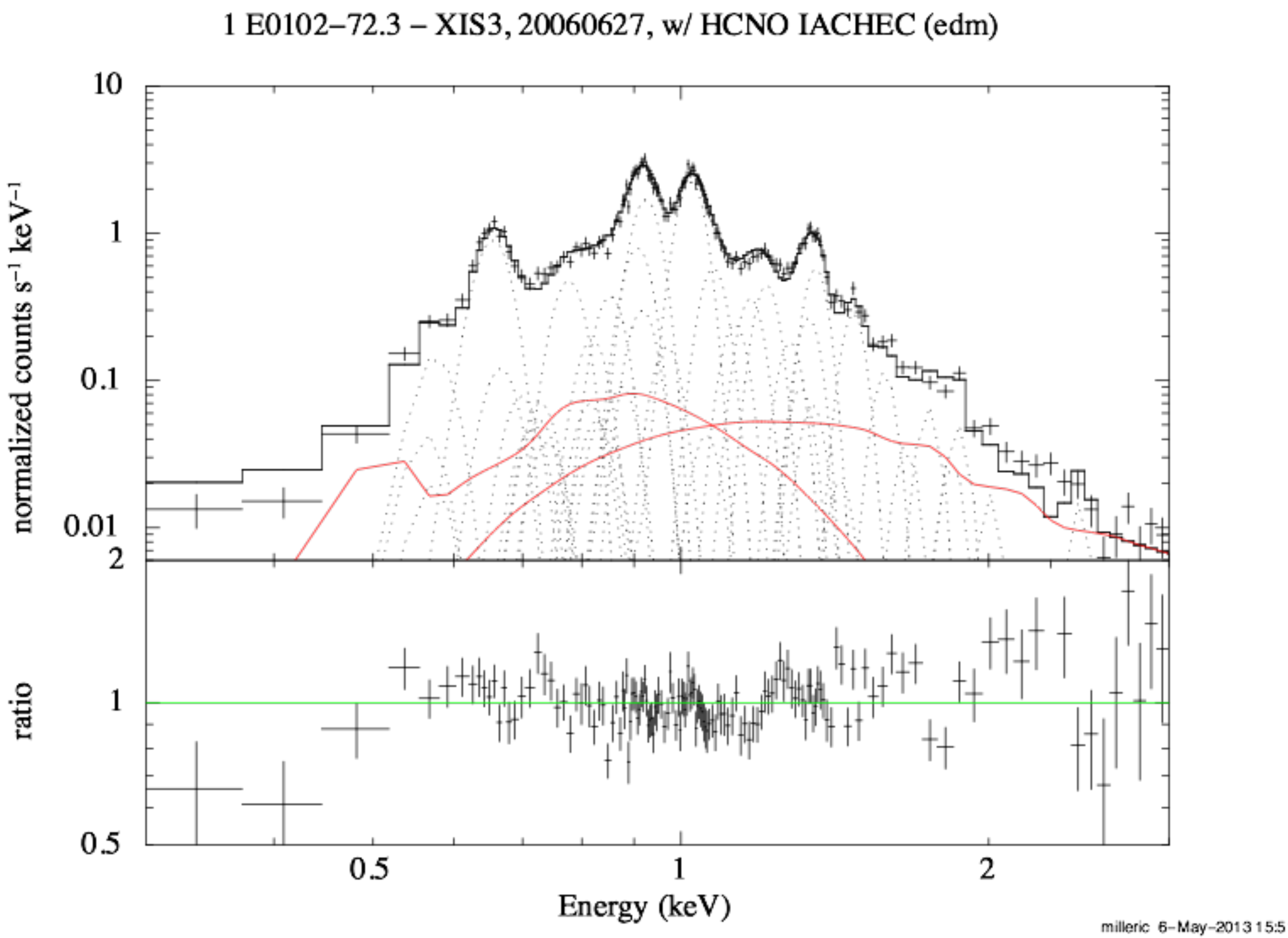
Spatial Dependence



Spatial Dependence

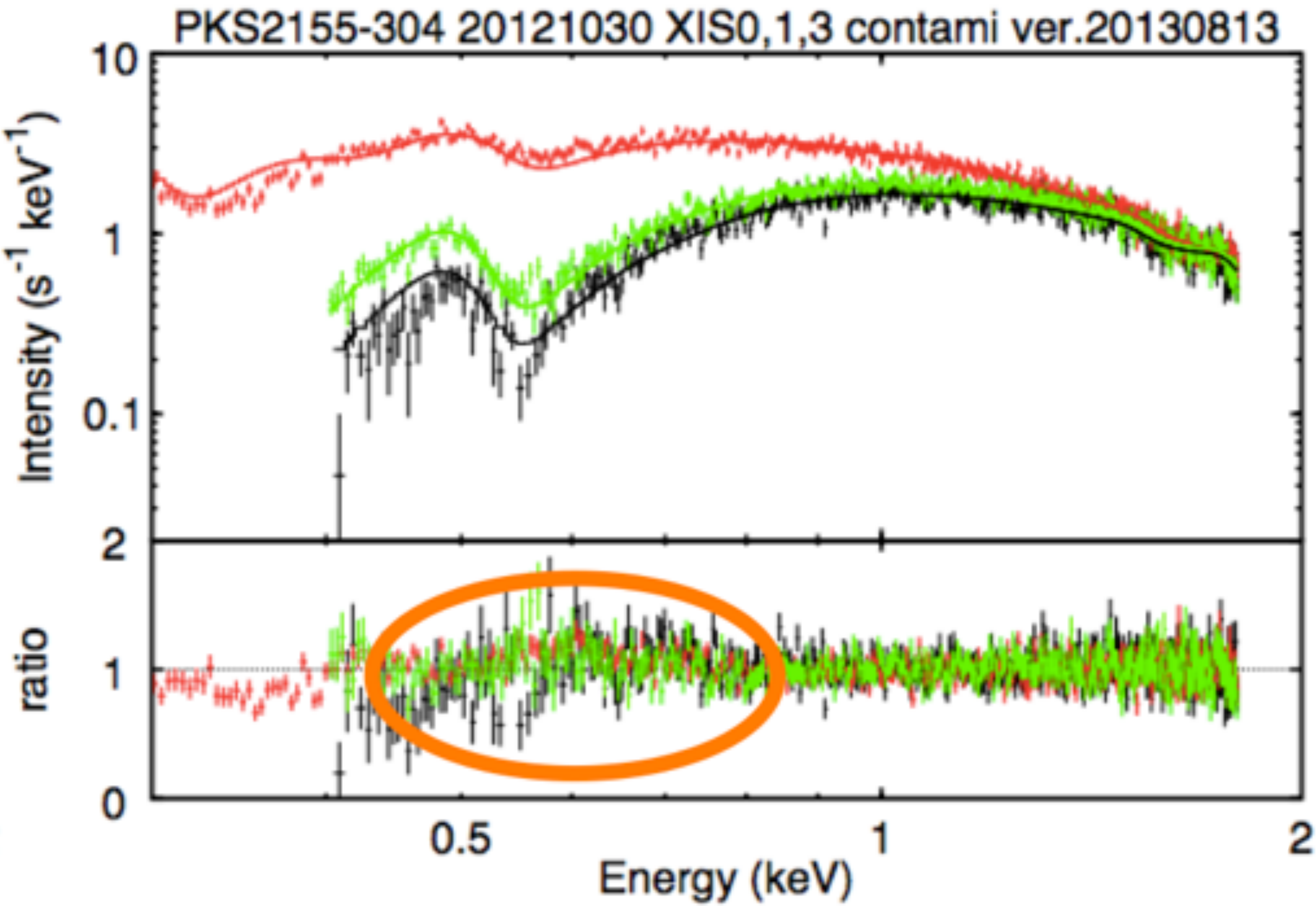


How Well Do We Do?

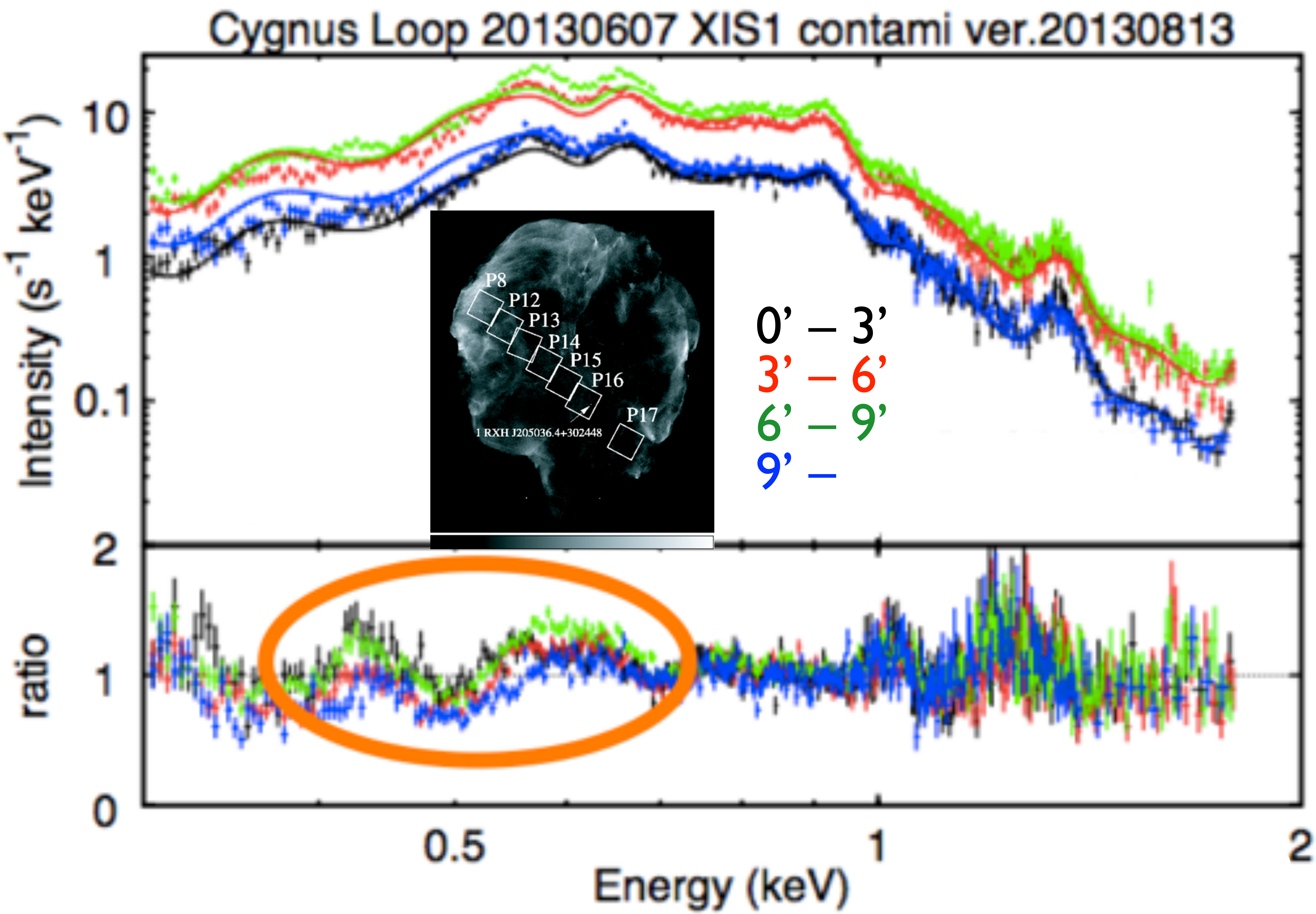


1 E0102−72.3 − XIS3, 20060627, w/ HCNO IACHEC (edm)
normalized counts s⁻¹ keV⁻¹
10
1
0.1
0.01
2
ratio
1
0.5
0.5
1
2
Energy (keV)
milleric 6−May−2013 15:51

Model Quality – On Axis



Model Quality – Off Axis

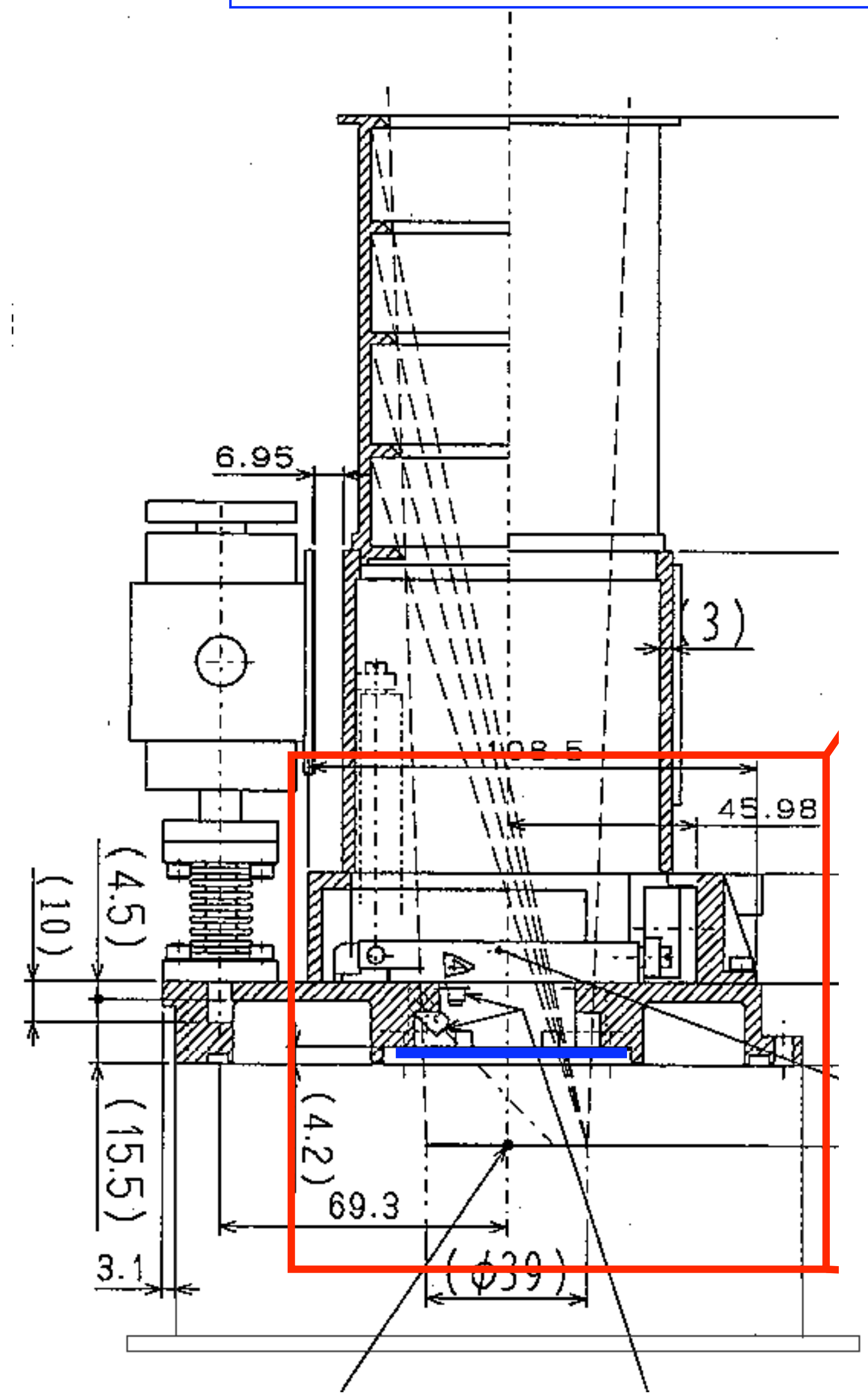


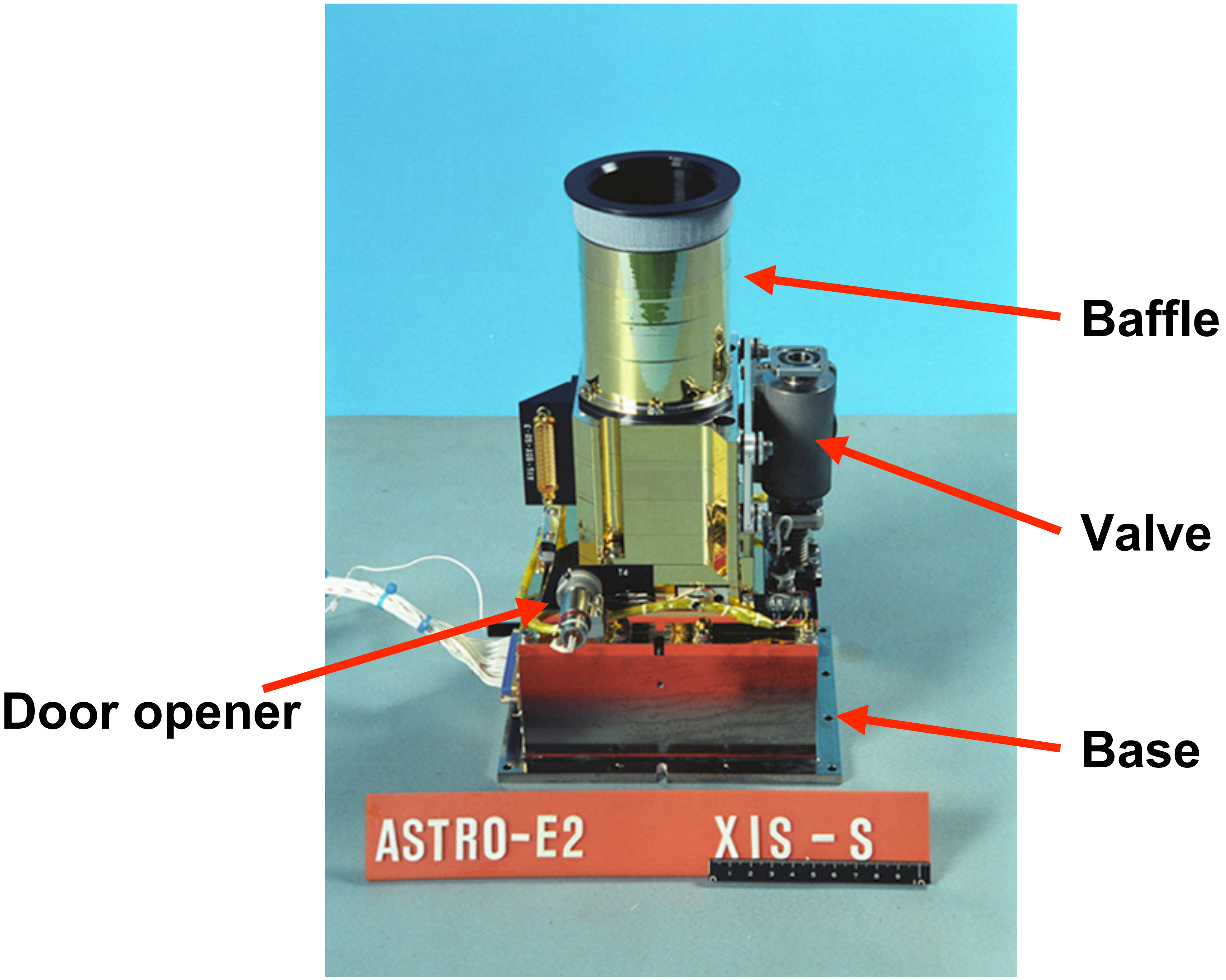
Interpretation

from March 2006 XIS Bakeout Review

Non-uniformity of the contamination

Location of the OBF





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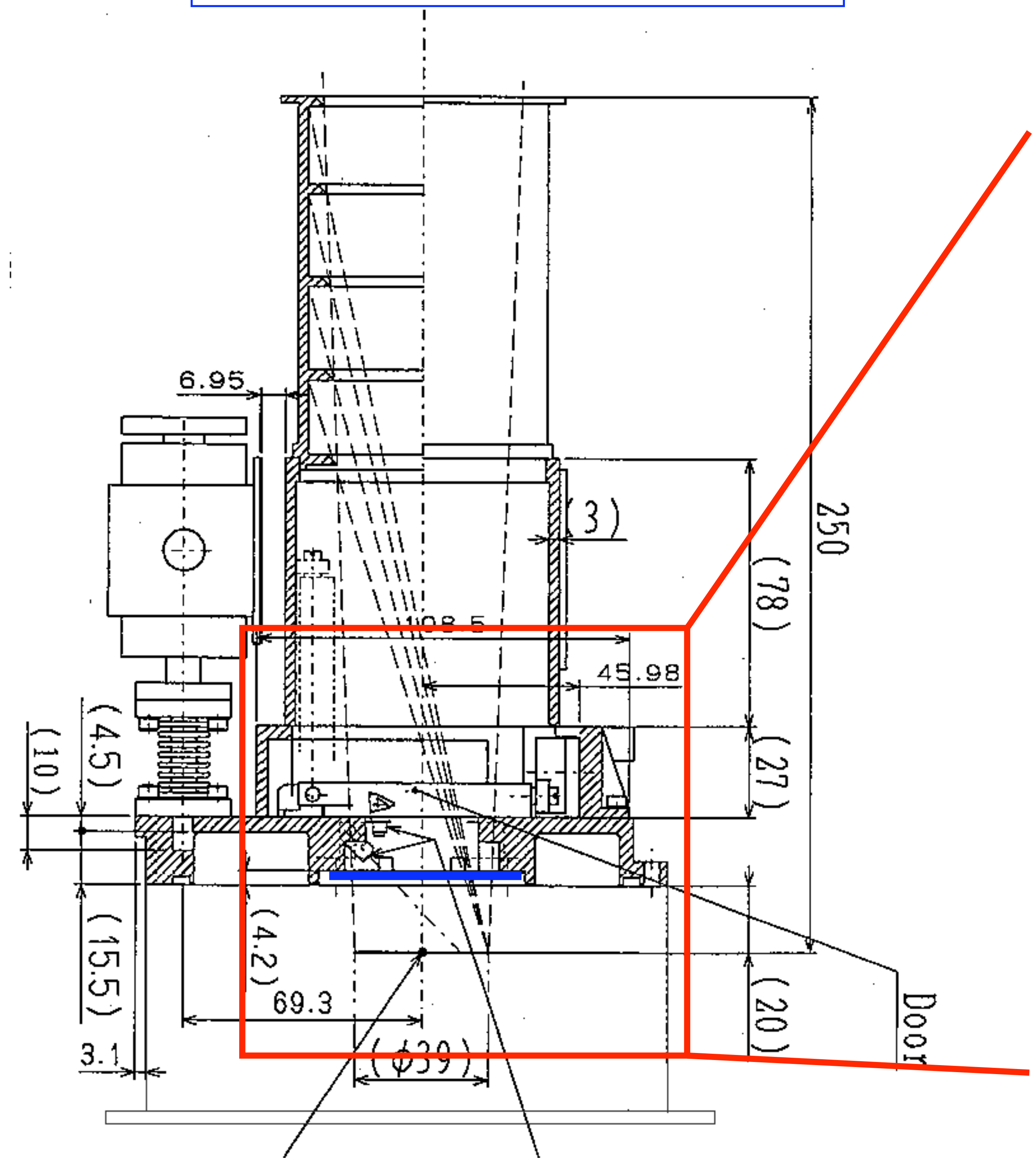
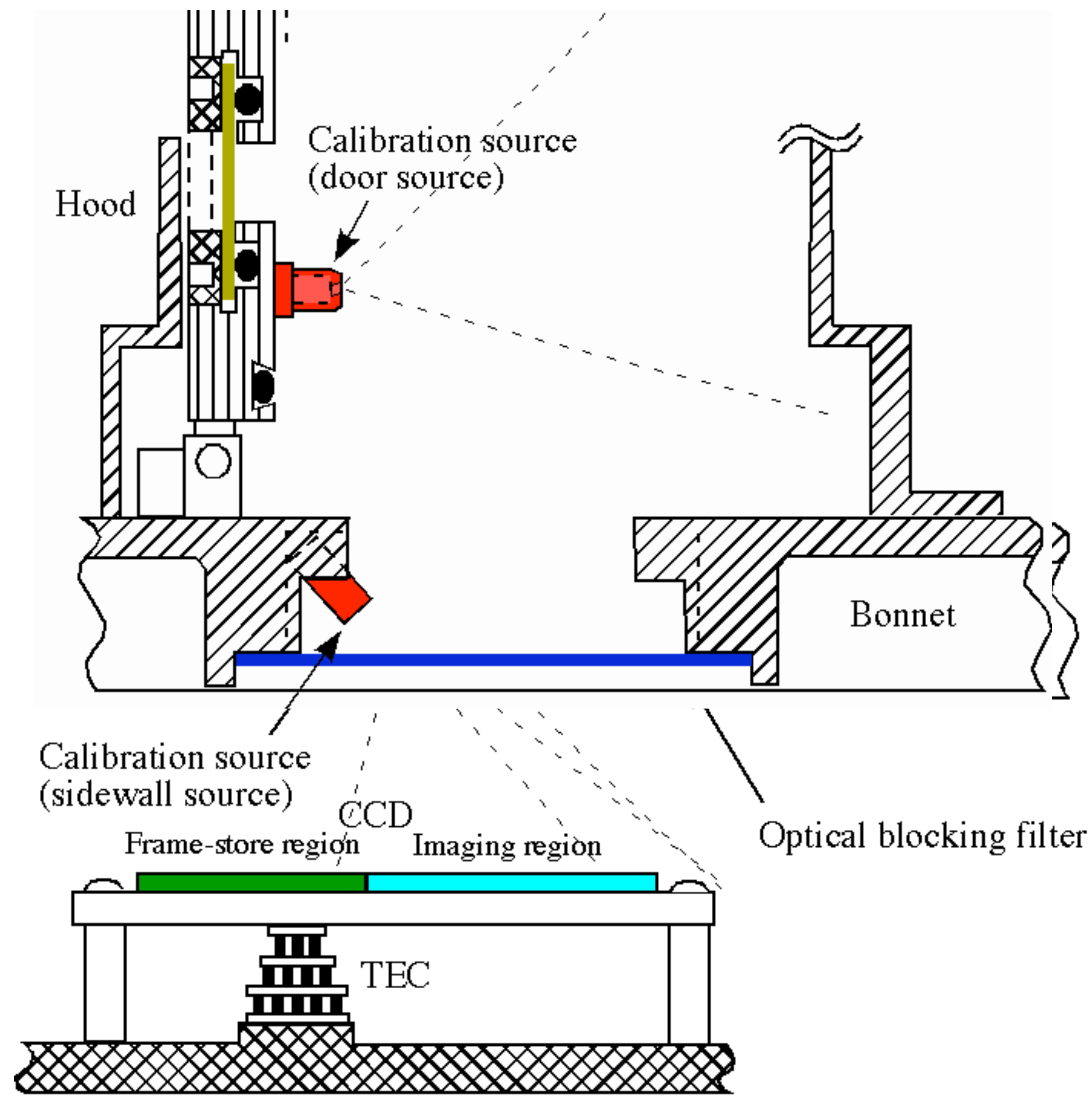
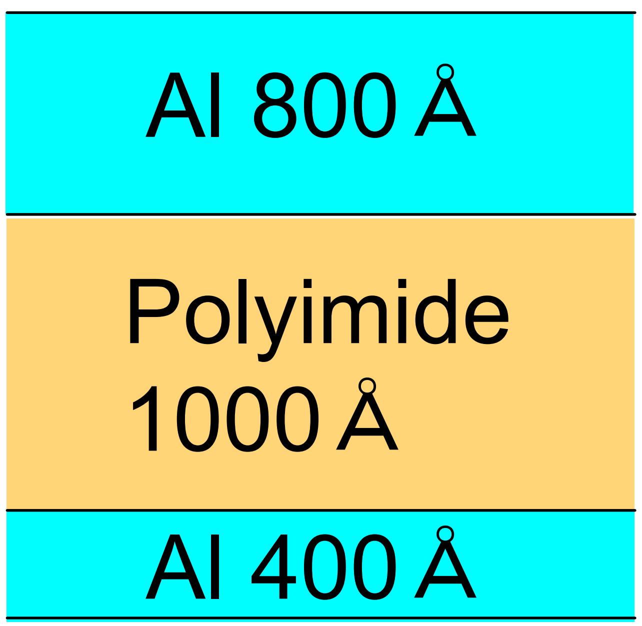
Location of the OBF





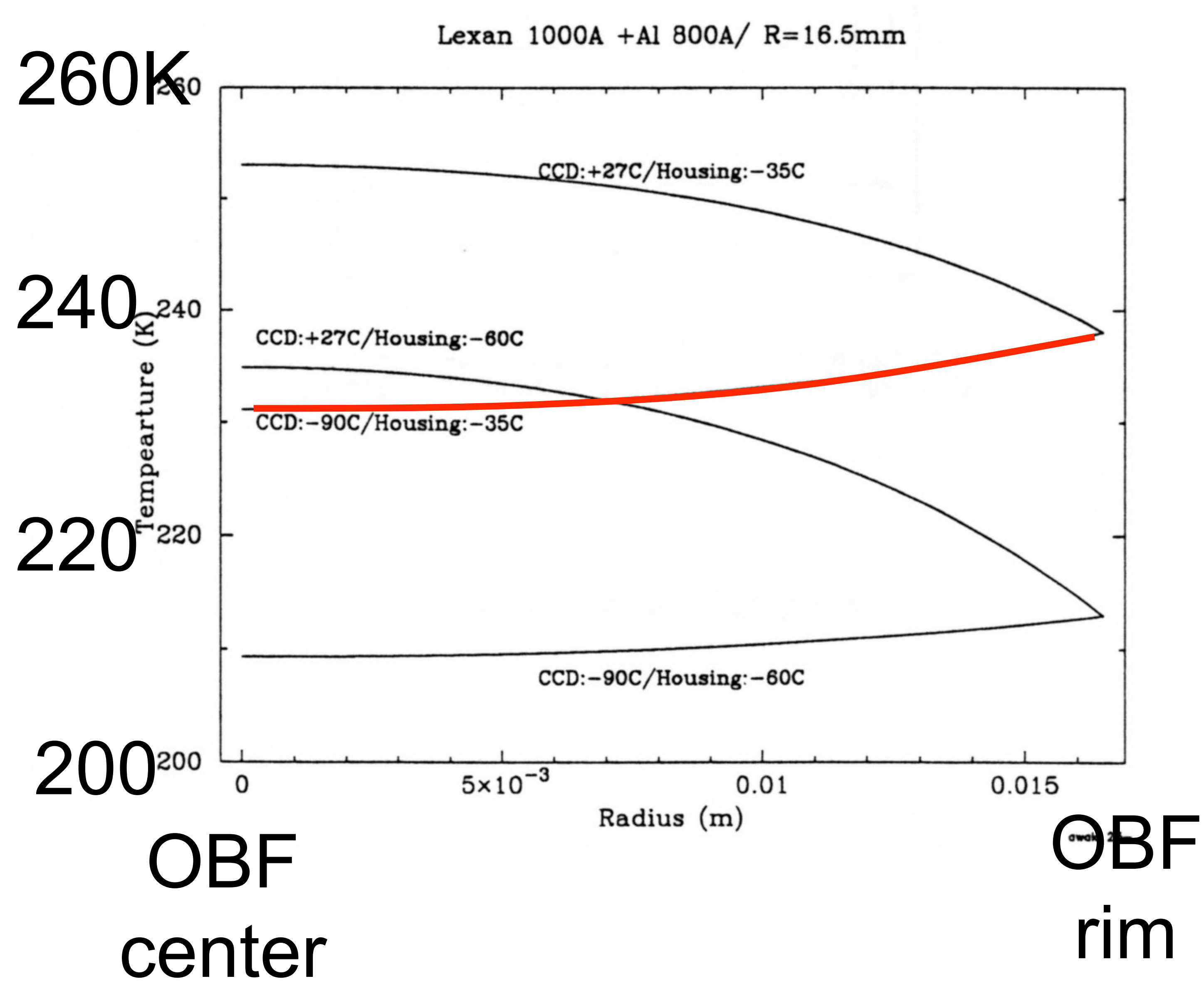
OBF structure and temp profile

OBF



Cross-section

Temperature difference ~ 7−8℃



Results of baking

- Total CVCM of the satellite was ~31g before the baking.
- Total outgas removed during the baking was estimated roughly as ~70g.
- Major fraction of the condensable material was removed by baking.
- Upper limit to the OBF contamination was estimated as ~0.5$\mu g/cm^2$.

Observed XIS contamination is 2 orders of magnitude larger than the estimation based on the satellite baking.

CVCM = Collected Volatile Condensable Mass

Possible difference from the satellite baking

1. Some components did not join the satellite baking.

   XRT, XRS-CDP/CAP/ACHE, Dewar, XRS-FW, XIS-S/AE, HXD-S/AE, HXD-PSU, SAP, BAT, SBR, AOCU, STT-AE/DE, NSAS, WHNS(extra)

1. Operation temperature of some component is higher than the baking temperature.

   IRU: operation temp of 60°C

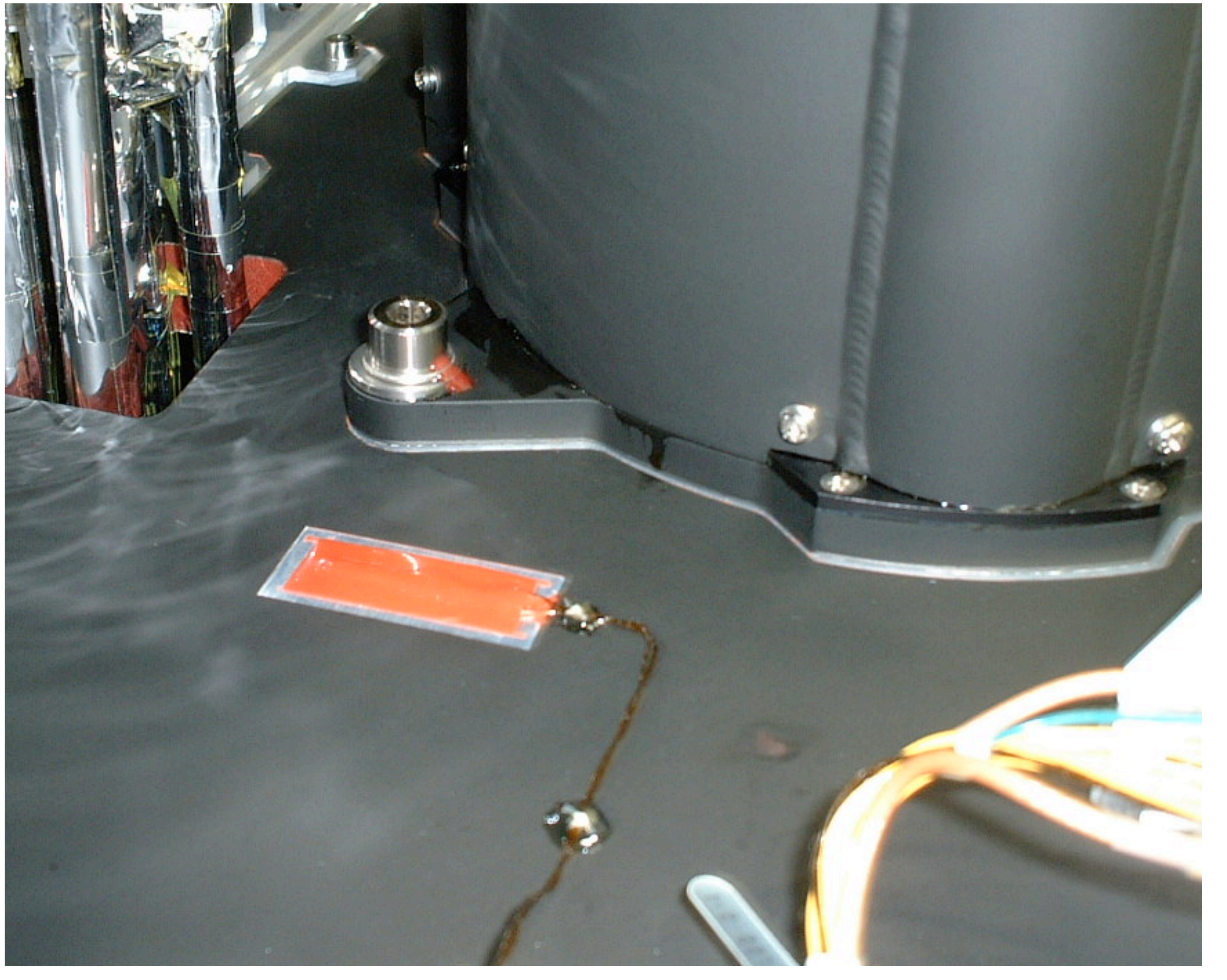
2. Unexpected failure?

IRU: inertia reference unit

- Two units are mounted
  - SA (4 axis) and SB (1 aixs)
- Operation temperature: 60℃
- Tar-like material was found on the housing after the TV test of Astro-F
  - IR analysis: phthalic ester (DEHP etc)
  - Most likely produced from the shock absorber in the IRU.
  - Component test show large mass loss (40g --> 37.3g in 2 months in vacuum)

Leak of tar-like material at IRU-SA

- A leak of tar-like material was found to leak at the mount point of IRU-SA on Oct. 26, 2005, after the thermal vacuum test of Astro-F (akari).



DEHP (a common form of phthalic ester)

$$E = 1.3 \times 10^4 \, \mathrm{K} \qquad P_0 = 7.1 \times 10^{14} \, \mathrm{Pa}$$

One of the most common outgas in the satellite.

DEHP = diethylhexyl phthalate $C_{24}H_{38}O_4$

Summary of interpretation

1. If the contaminant fills inside the satellite uniformly…
   1. Total amount of outgas escaped from the satellite would be very large, 6−33 g.
   2. The vapor pressure becomes probably higher than the saturated vapor pressure of DEHP at satellite temperature.
   3. It cannot explain the difference of contamination among XIS-0,1,2,3.
2. Outgas may reach OBF almost directly from the source.

Summary

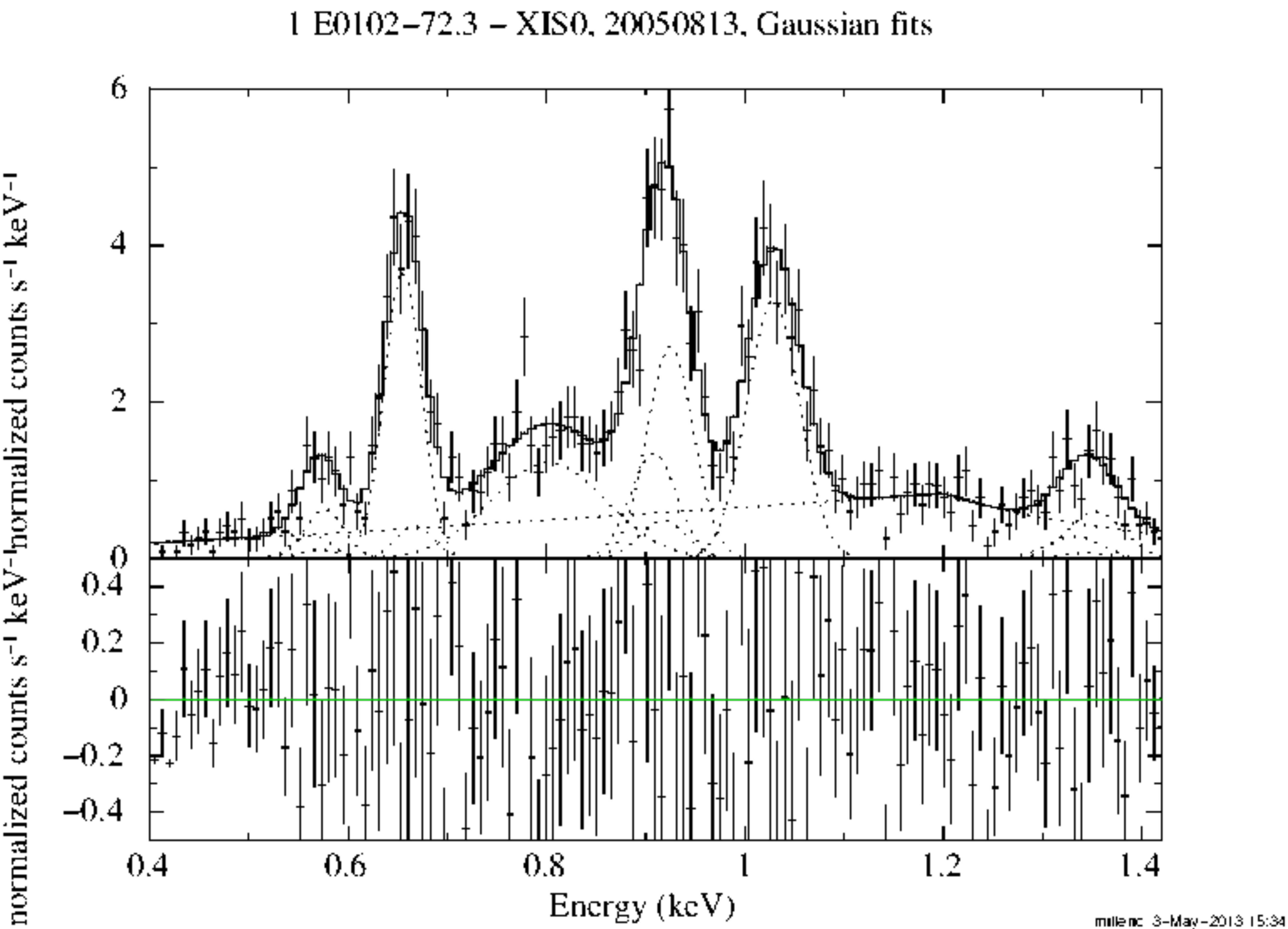
- contamination level increased quickly
  (XIS after 3 months ~ ACIS after 6 years)
  now decreasing at 10% per year
- C:N:O changes with time
  started out C:O ~ 6 ~ DEHP, but not now
- decrease below C-edge: H? He? something else?
- A_{eff} (E > 0.7 keV) is good to ~5%
  A_{eff} (E < 0.7 keV) is (not) good to 10-50%, especially near edges

Contamination WG Plan (1/2)

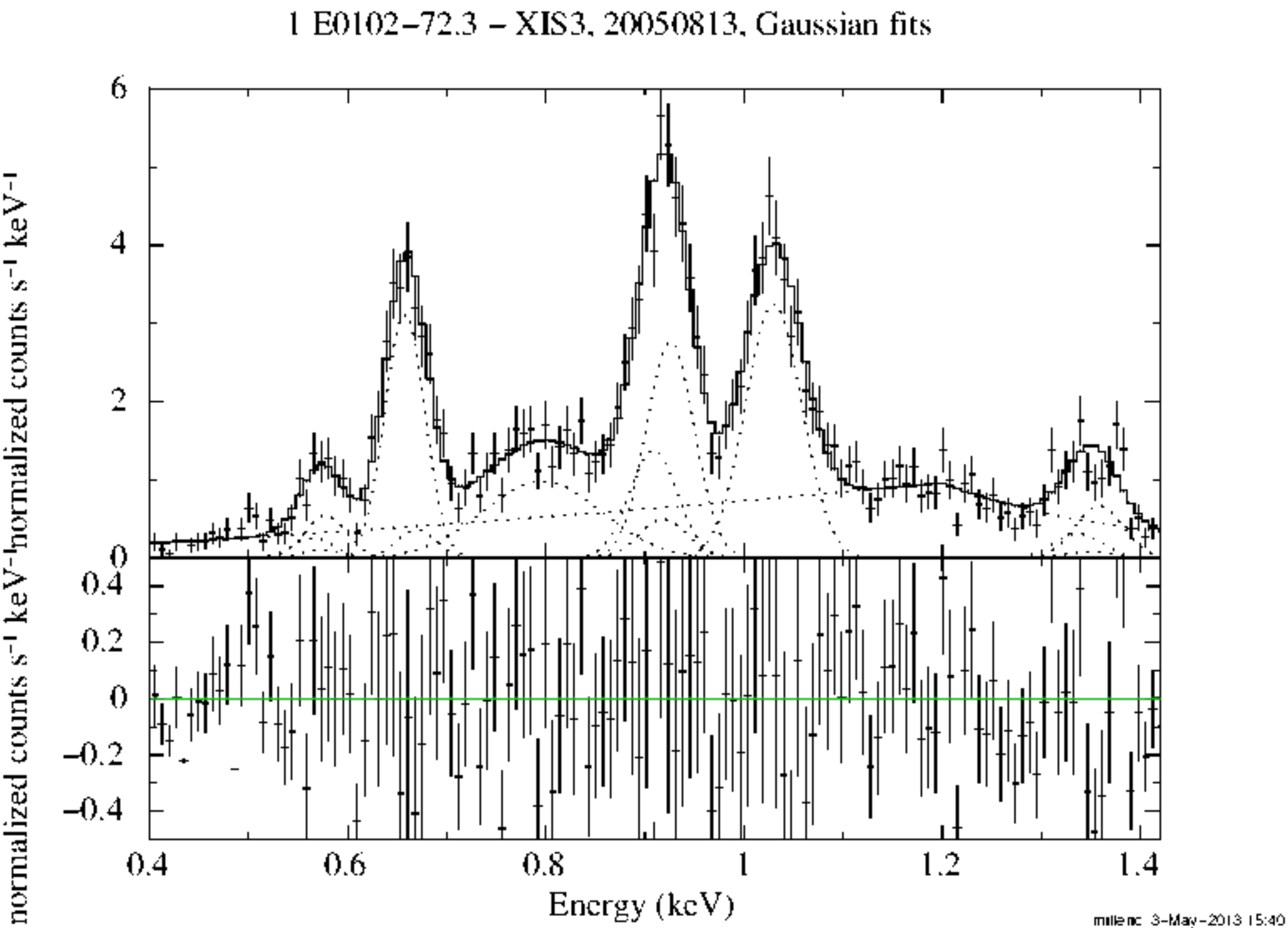
- standardize how we tabulate contamination
  - C,N,O,F, etc. in column density units (10^{18} cm^{-2})
    - useful for composition modeling
  - optical depth τ at some energy
    - C, O edges are useful for comparison
    - OVIII and other bright lines are practical
    - ~ contamination model independent
    - τ converts directly into Aeff, useful for observers

Contamination WG Plan (2/2)

- A/I for all instruments
  - estimates of C,N,O,F, etc. columns (multiple epochs are fine)
  - estimates of τ @ C edge, O edge, 1 keV
- ACIS: Herman
- XMM EPIC MOS: Steve
- XMM EPIC pn: Steve?
- XMM EPIC RGS: Steve?
- Suzaku XIS: Eric
- Swift XRT: Andy B.



1 E0102-72.3 - XIS0, 20050813, Gaussian fits
normalized counts s⁻¹ keV⁻¹
normalized counts s⁻¹ keV⁻¹
Energy (keV)
0.4
0.6
0.8
1
1.2
1.4
6
4
2
0
0.4
0.2
0
−0.2
−0.4
millenc 3-May-2013 15:34


1 E0102−72.3 − XIS3, 20050813, Gaussian fits
normalized counts s⁻¹ keV⁻¹
normalized counts s⁻¹ keV⁻¹
Energy (keV)
0
2
4
6
0.4
0.2
0
−0.2
−0.4
0.4
0.6
0.8
1
1.2
1.4
millenc 3-May-2013 15:40

DEHP pressure

Two estimations

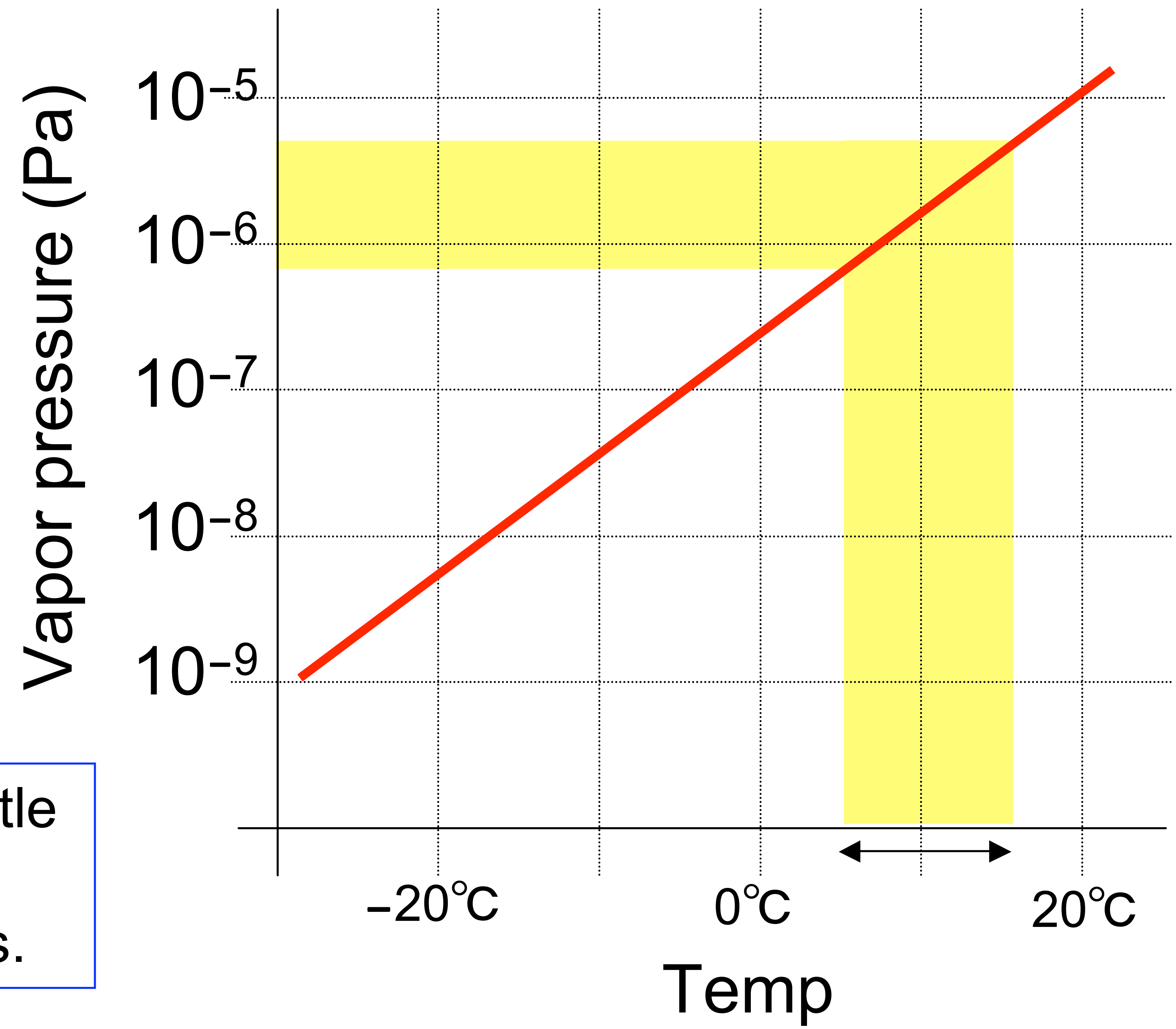
- 8.3E-7 Pa
- 5.2E-6 Pa

DEHP

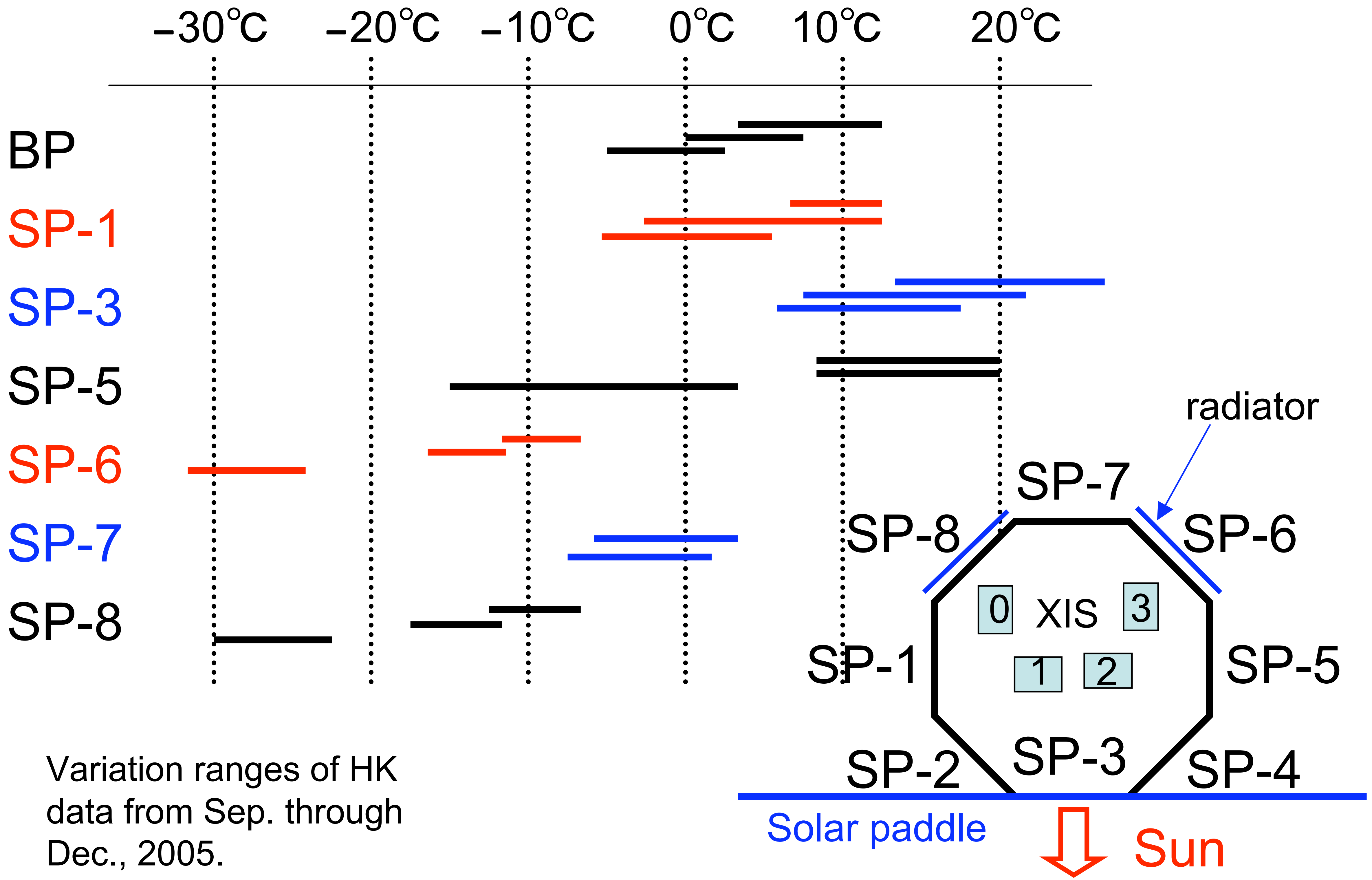
5–16℃

(Temperature in the satellite)

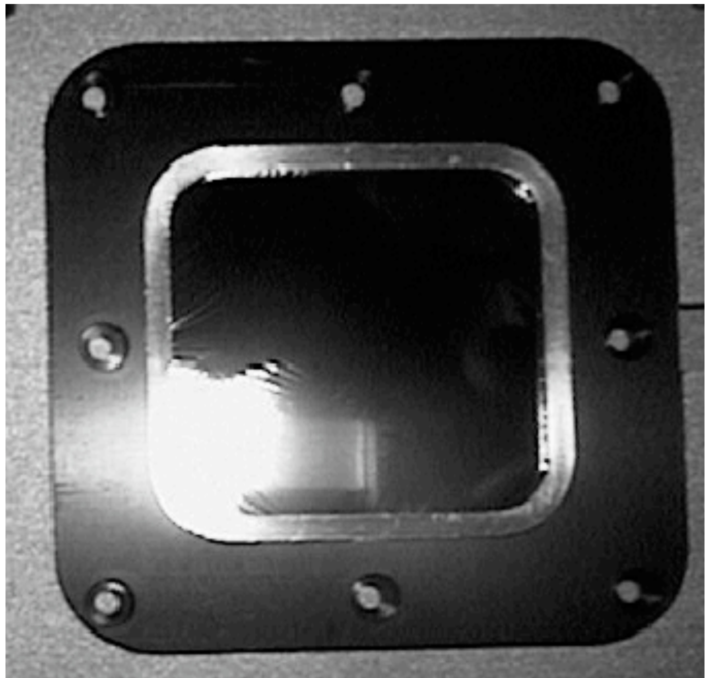
This temperature is a little high compared to the measured temperatures.

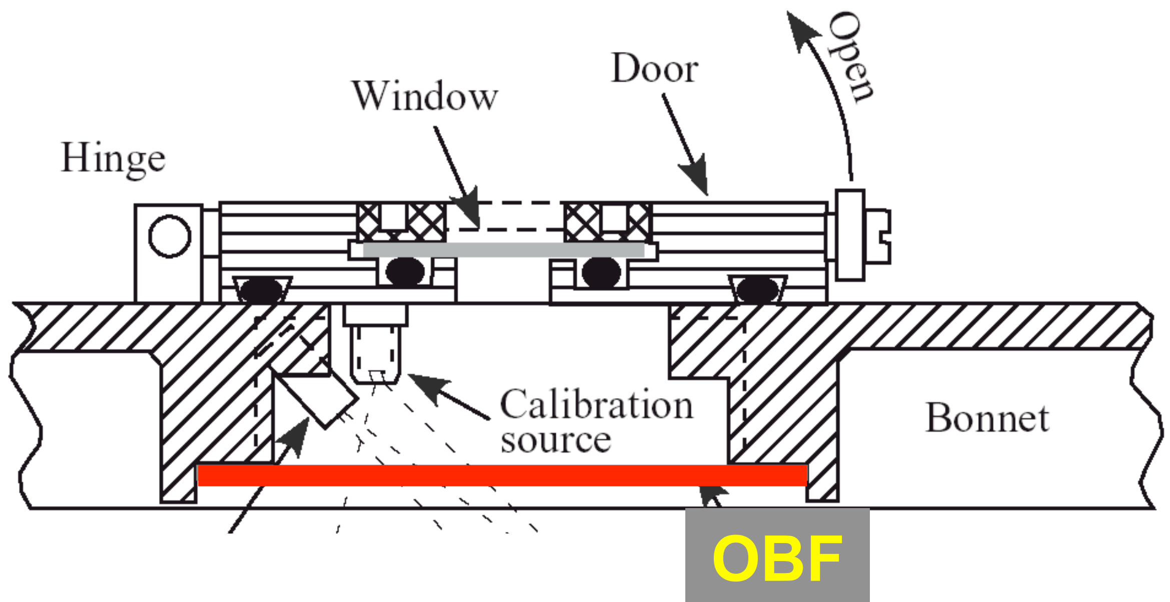


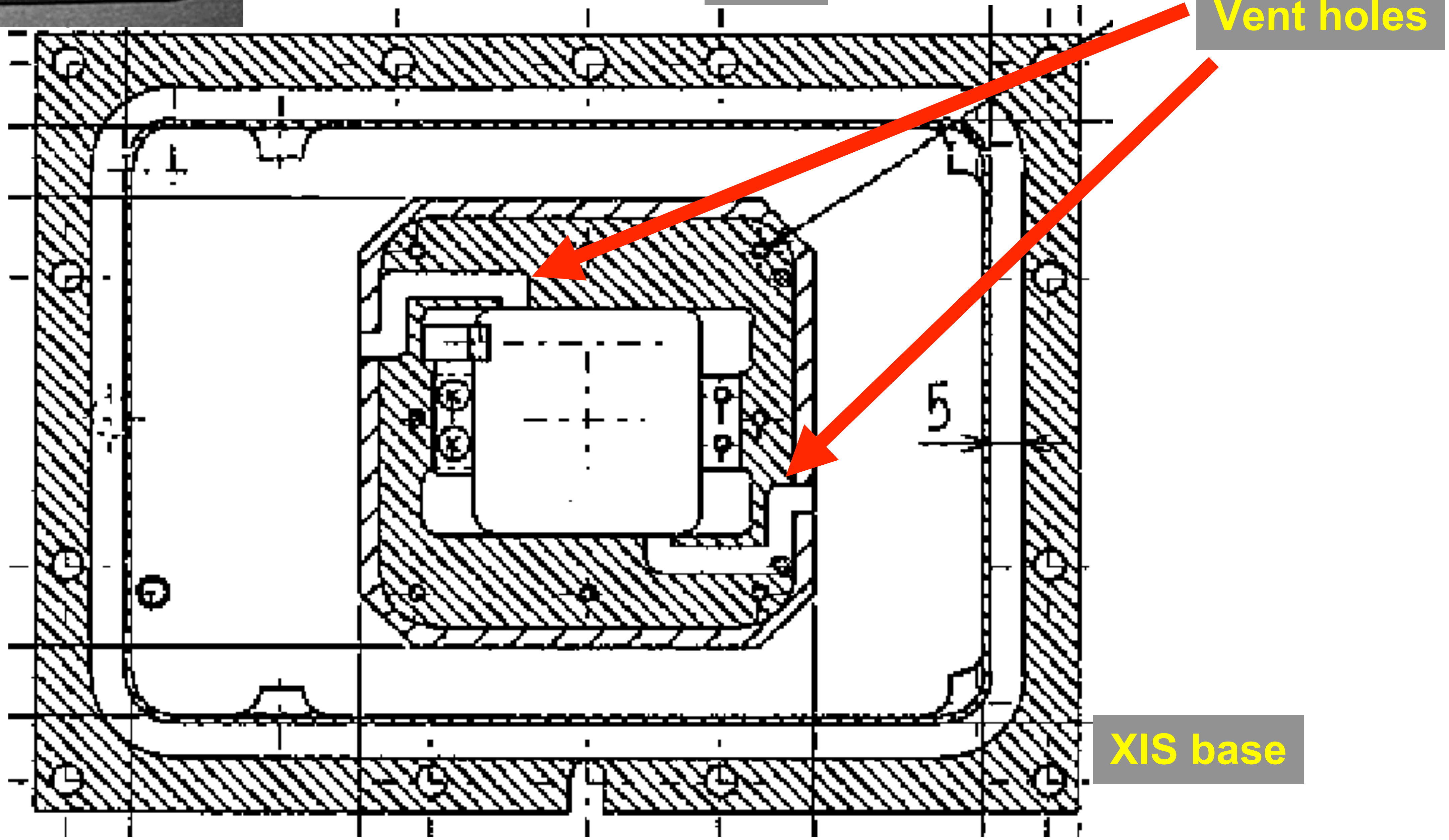
Satellite temperatures
– side panels and base plate –



Variation ranges of HK data from Sep. through Dec., 2005.

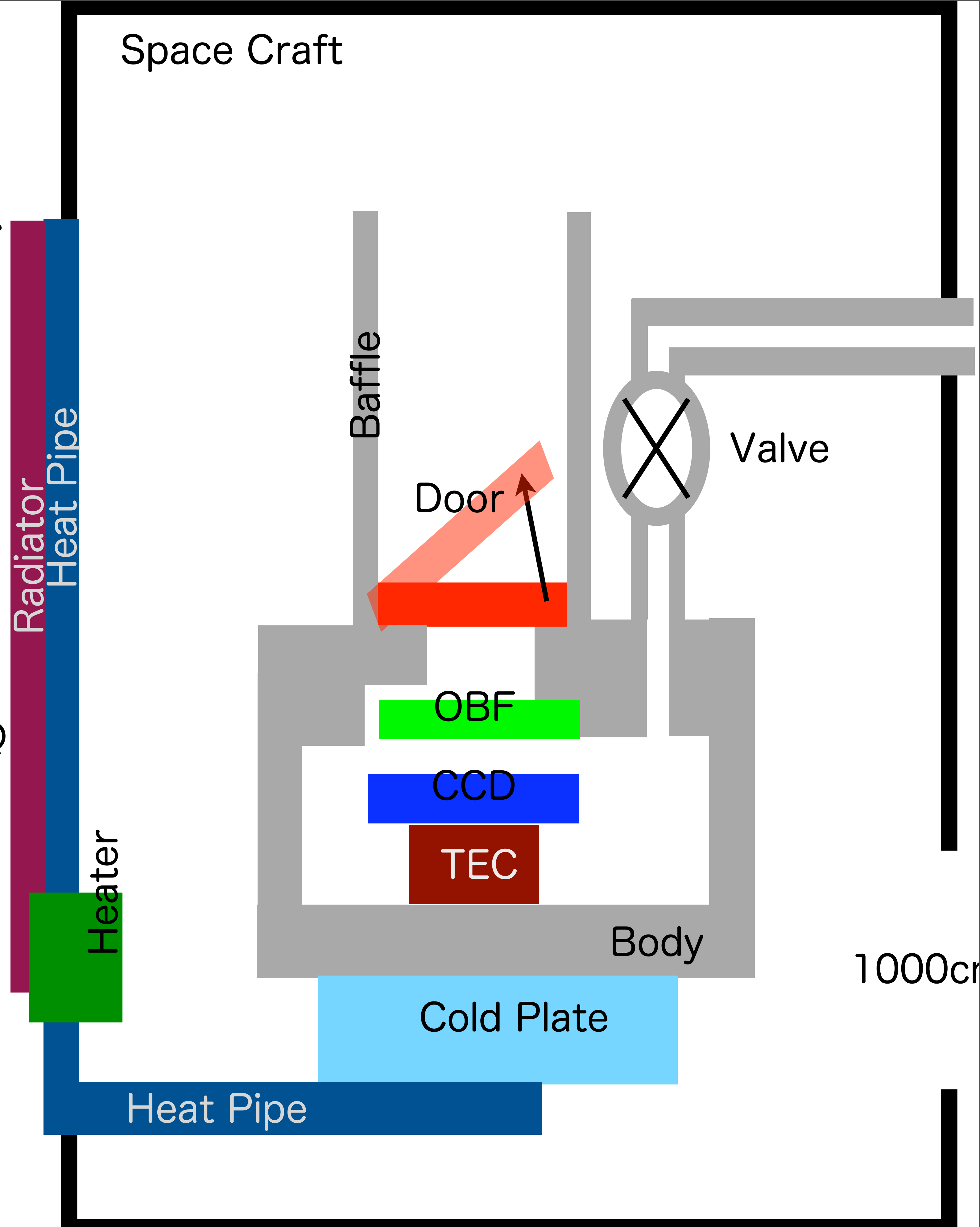



Hinge
Window
Door
Open
Calibration source
Bonnet
OBF


Vent holes
5
XIS base

Sequence

- Launch : valve (close)
- Just after the launce: open. Close, before 1st ΔV.
- BDY-T & CCD-T : +25C → -40C in one day
- After the end of sequence of ΔV, valve open.
- XIS-ON & Parameter Setting
- CCD daq. starts. (CCD-T @ -40C), observe door cal. source.
- CCD-T : -40C → -90C
- Parameter Tuning
- Door open
- Start observing X-ray objects.



Caveats for *Suzaku* from 2007

- **above 0.6 keV**
  - contamination well-modeled for XIS1,2,3, ~10% sys. error
  - contamination on XIS0 is underestimated for mid-2006 onward, fixed in June 2007 CALDB release
- **between 0.3-0.6 keV**
  - C/O ratio is not well constrained (C/O > 6?)
  - changes A_{eff} from the C edge (0.28 keV) to just above the O edge (0.53 keV)
  - could introduce spurious features near the O edge
- **below 0.3 keV (the "C-band")**
  - decrease in A_{eff} with time is seen in some soft sources, e.g. RXJ1856 (shown)
  - C+O insufficient, additional elements required
  - composition may be time dependent
  - C-band calibration is uncertain at this stage
- **extended sources**
  - spatial distribution is modeled from BI chip only
  - FI chips might have different distributions