

# Current Status of Suzaku (AstroE-2)

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ISAS/JAXA

on behalf of the entire Suzaku team

# July 10th, 2005

Suzaku



(c) A. Bamba



# Outline of the talk

- Mission Concept
- Report on the X-ray Calorimeter (XRS)
- New Power of Suzaku
  - XRT/X-ray CCD (XIS)/Hard X-ray Detector (HXD)
  - What we can do with Suzaku
- Summary

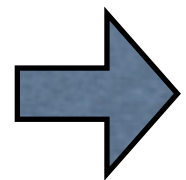
# Astro-E2 (Suzaku)

Study of

- Structure-formation of the universe,
- Very vicinity of Blackholes

with

High-resolution X-ray spectroscopy and  
Wide-band X-ray spectroscopy



Highly complementary to Chandra (US) and XMM-Newton (ESA)

Japan/US international collaboration  
X-ray mirrors, X-ray spectrometer  
X-ray CCD, Analysis software

# Suzaku Payload

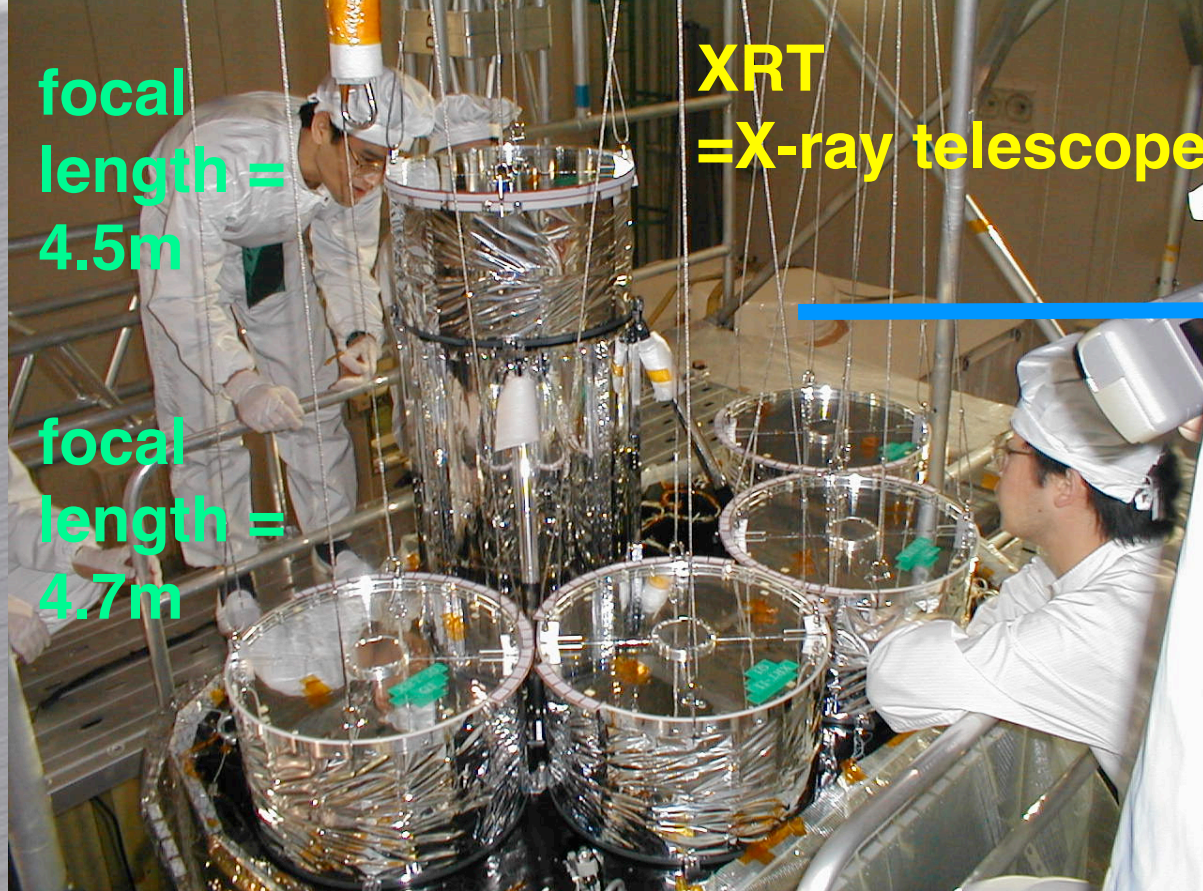
Instrument	XRT-S + XRS	XRT-I + XIS	HXD	
Main role	high-resolution spectroscopy	wide-band spectroscopy		
Energy rage (keV)	0.3 - 10	0.2 - 10	10 - 700	
Effective Area (cm <sup>2</sup> )	150 (@6keV)	1300 (sum of 4 sets)	160 (@2keV)	330 (@100 keV)
Field of View	2.9' x 2.9'	19' x 19'	0.56° x 0.56° ( <b>&lt;80keV</b> )	4.6° x 4.6° ( <b>&gt;100 keV</b> )
HPD of PSF	1.9'	1.7 - 1.9'		
Number of pixels	30	1024 x 1024		
Pixel Size	29'' x 29''	1.1'' x 1.1''		
Energy resolution (FWHM)	6 – 7 eV	120 eV (@6keV)	3 keV (@20keV)	10% @550keV
Time resolution	5 micro s	8ms – 8s	15.3 – 61 micro s	
operating temperature	60 mK	-90° C	-20° C	
mission life	2.4 - 3 years *	as long as possible	as long as possible	



focal  
length =  
4.5m

focal  
length =  
4.7m

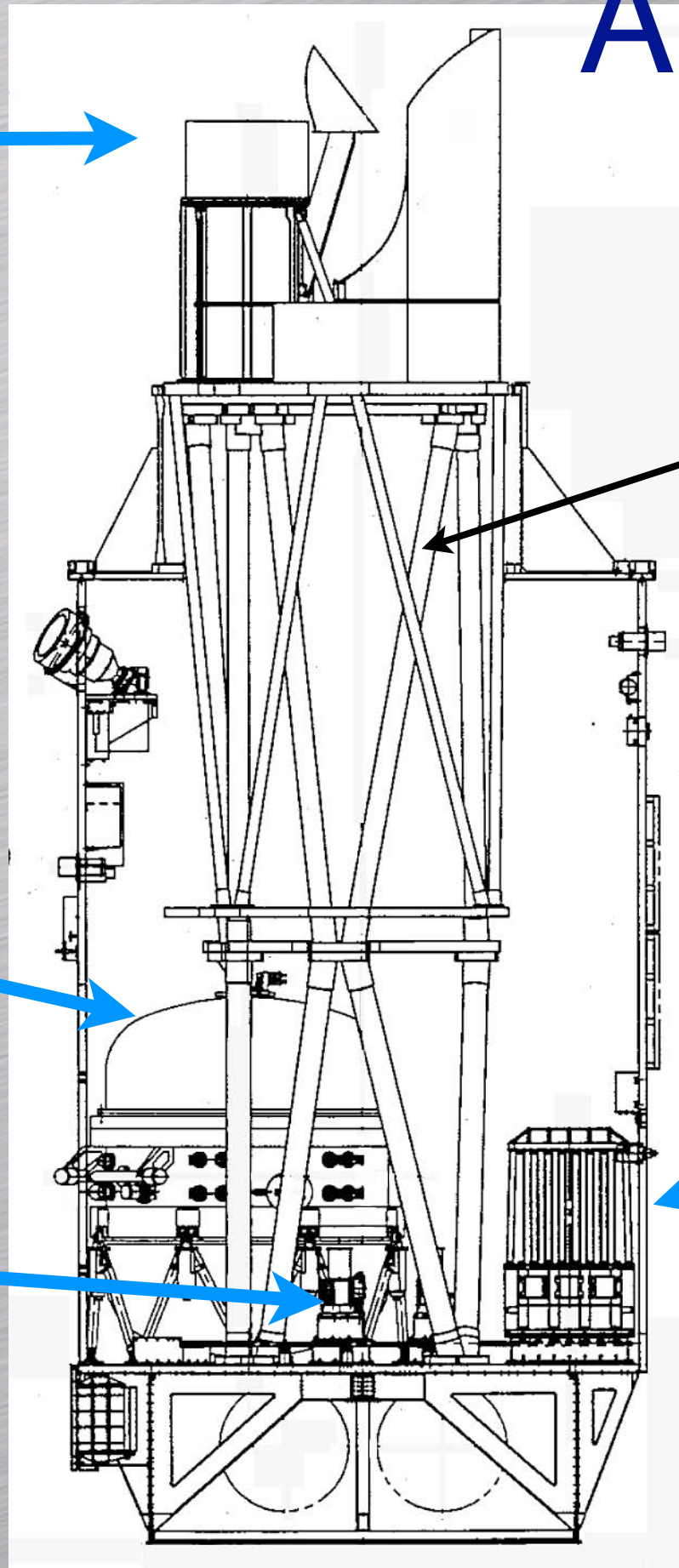
XRT  
=X-ray telescopes



# Astro-E2

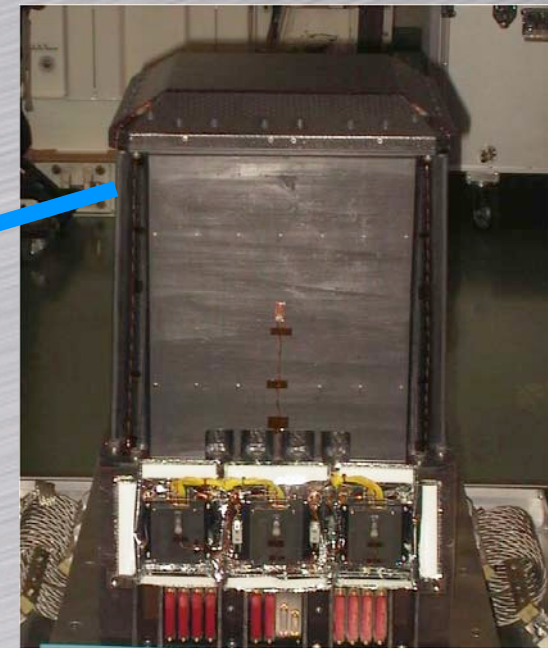
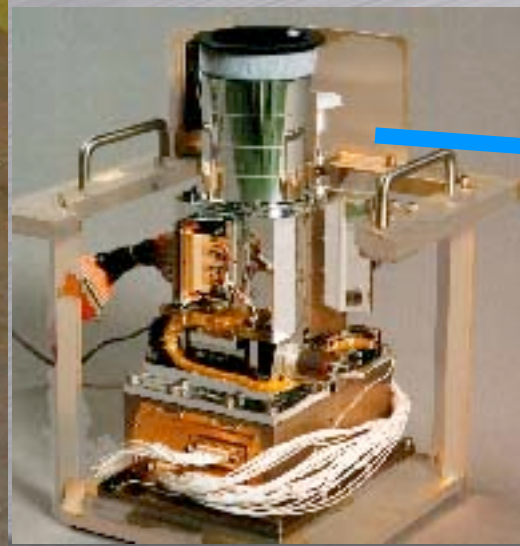
EOB  
=Extensible  
Optical Bench

HXD  
=Hard X-ray  
detector



XRS  
=X-ray microcalorimeter array

XIS  
=X-ray CCD  
cameras





# The team

XRS



HXD



XIS



XRT

And more: International Scientific Advisors, Software/Operation





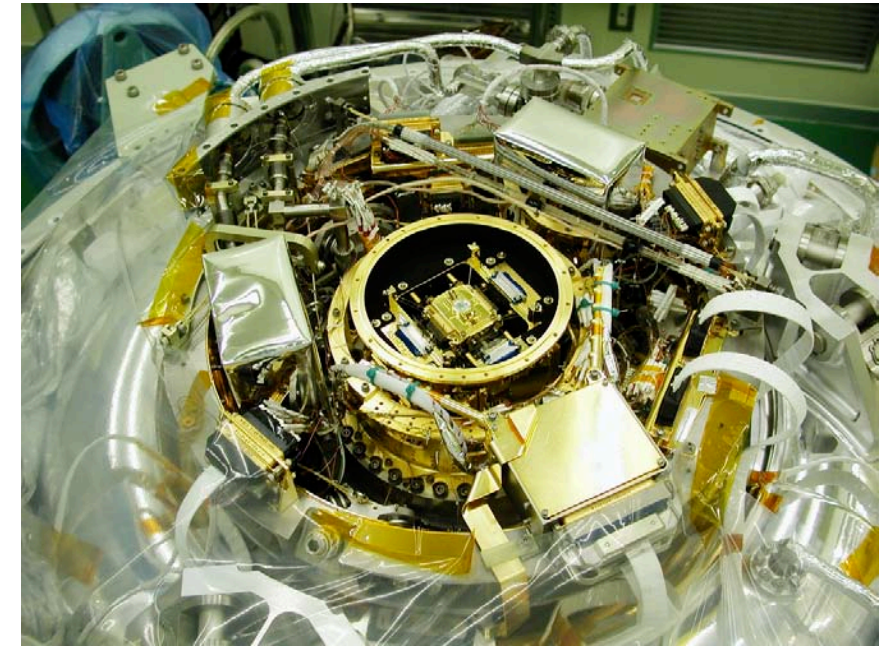
# Lowest temperature and Highest Resolution

July 26: 60 mK was achieved.  
(lowest temperature  
achieved in space)

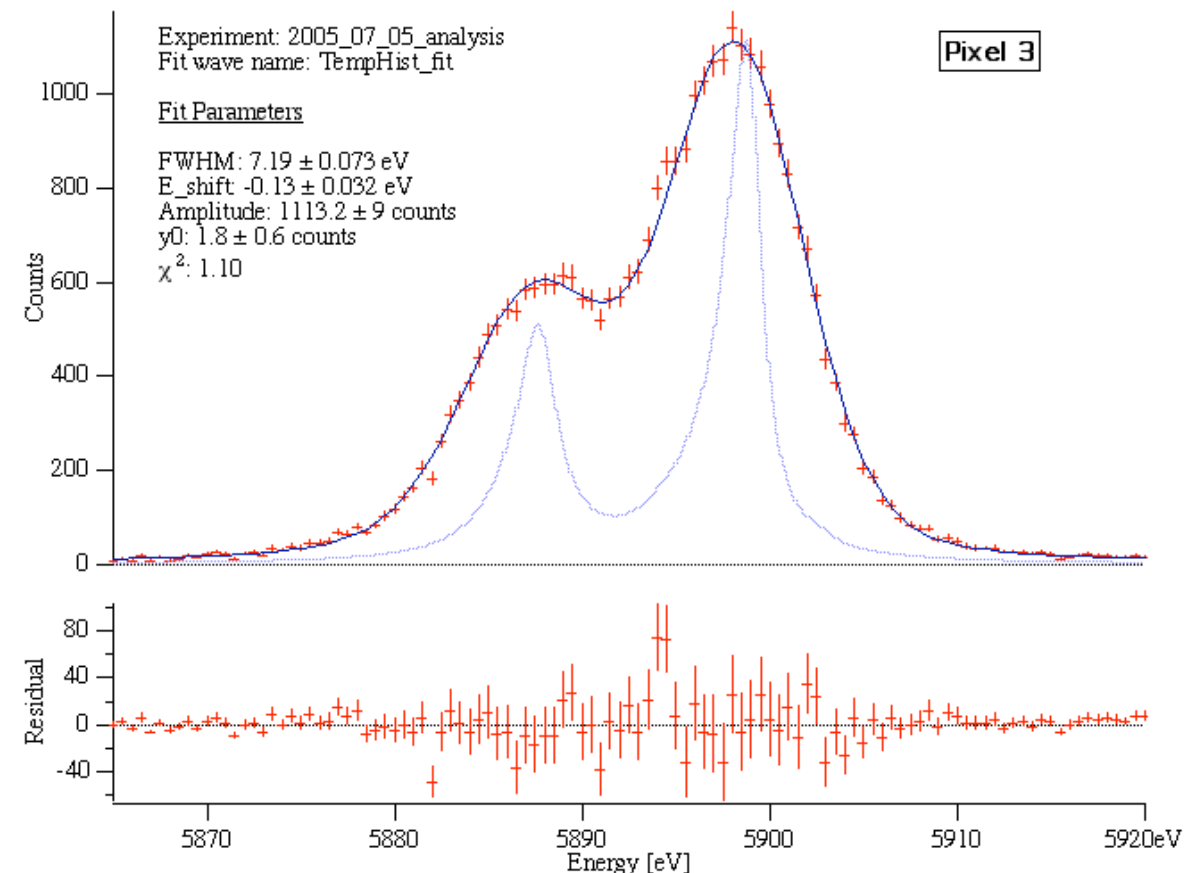
7eV energy resolution was  
obtained for the calibration  
pixel.

Detector was working as expected.  
We expected great  
scientific return for  
**years** of hard work,  
over the next 3 years or  
so.

## XRS



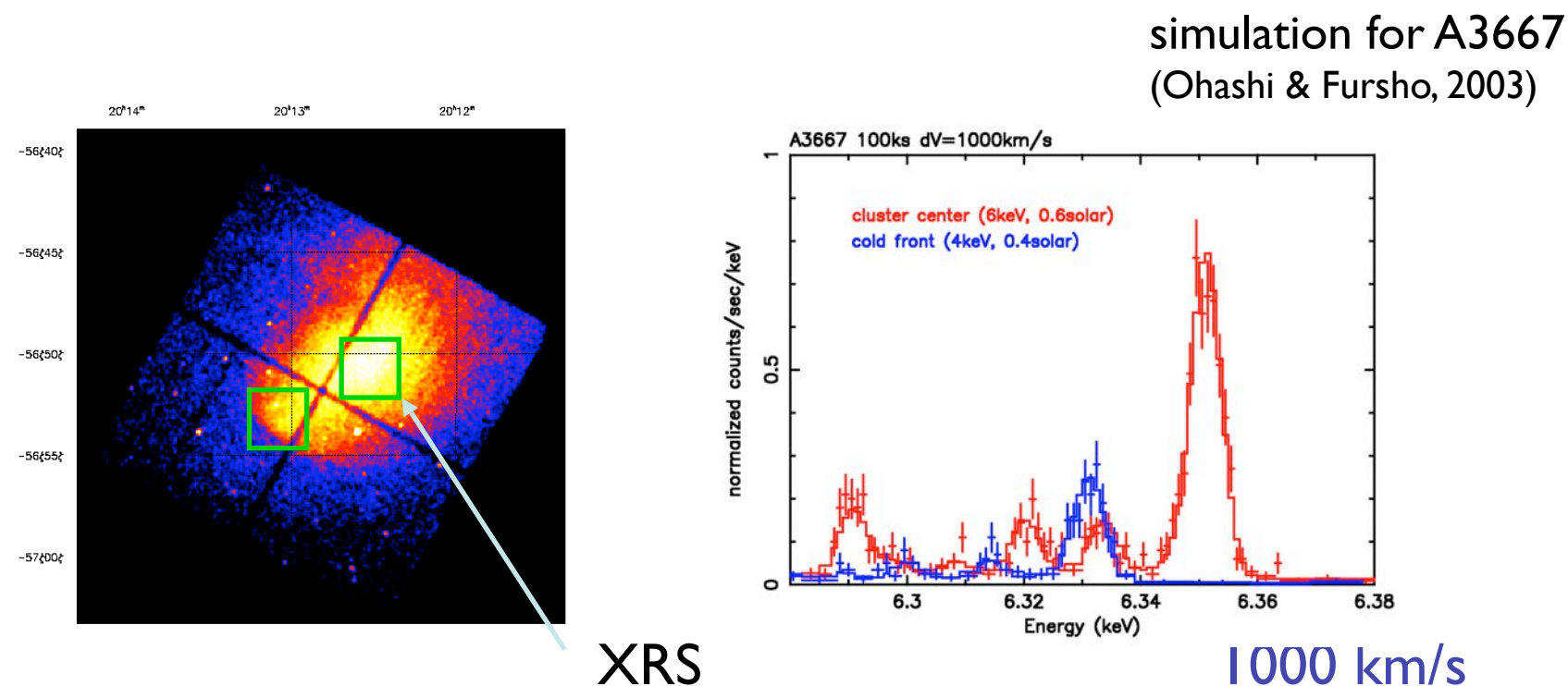
Fine structure of Mn  $K\alpha$  line resolved  
by XRS in orbit





# What we had expected

## Astro-E2 Study of Clusters in merger



Bulk motion of the hot gas associated with a substructure in a cluster of galaxy, if observed, will be the direct evidence of a cluster merger.

The line profile and energy shift ->

The line-of-sight motion of the hot gas associated with the merging sub-cluster ( $v > 1000$  km/s) can be obtained.

# Tragedy

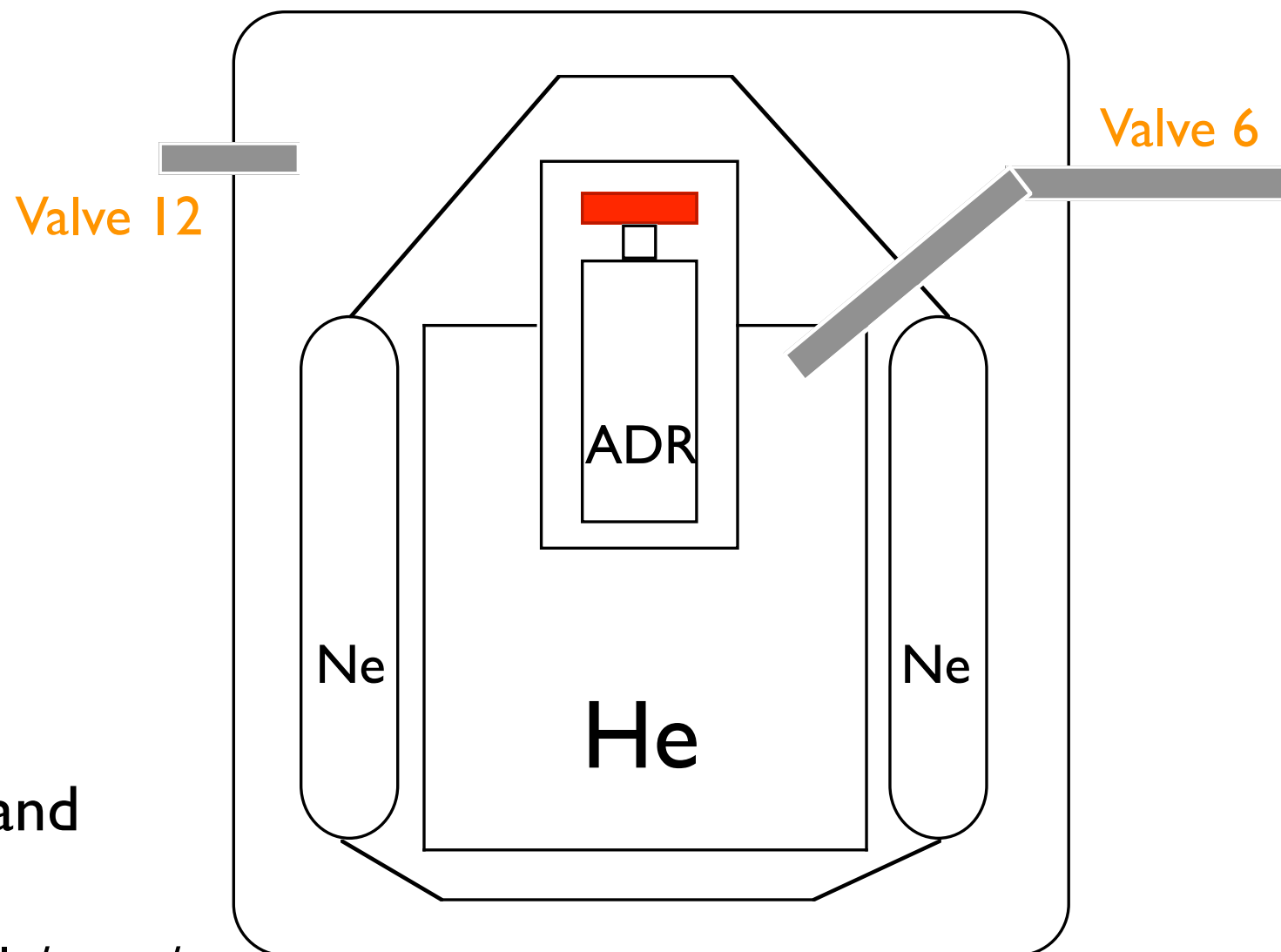
- July 10: Valve 6 (He gas bent) was opened
- July 25: Valve 12 (main shell evacuation valve) was opened
- July 29: First temperature spikes were seen, indicating helium gas (almost certainly vented from the tank) got to parts of the XRS that it shouldn't have gotten into.
- Aug 5: 7 eV resolution confirmed for most of pixels.
- Aug. 8: All Liquid He was lost (during several hours)

Cause of the failure is under investigation by mishap investigation boards of JAXA and NASA.

[http://suzaku.gsfc.nasa.gov/docs/astroe\\_lc/news/xrsend.html](http://suzaku.gsfc.nasa.gov/docs/astroe_lc/news/xrsend.html)



tank





Even without the XRS

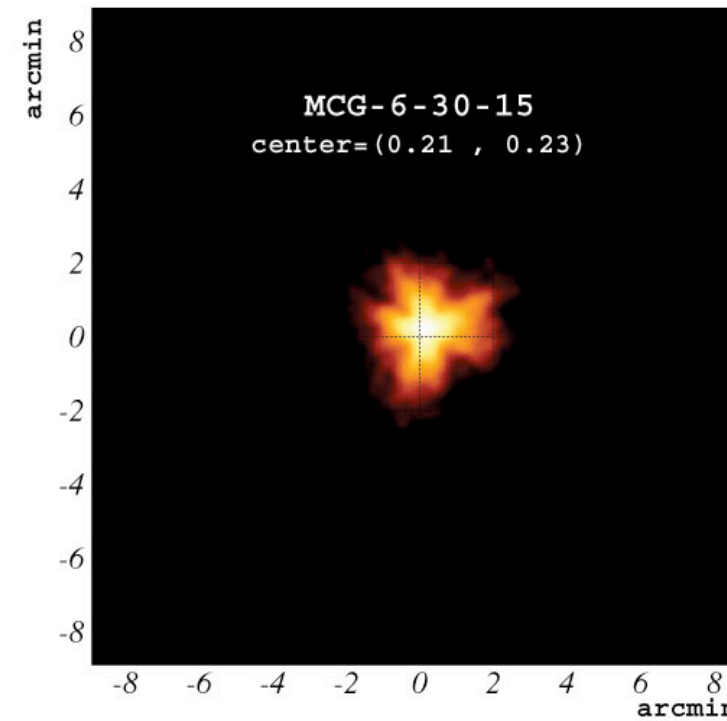
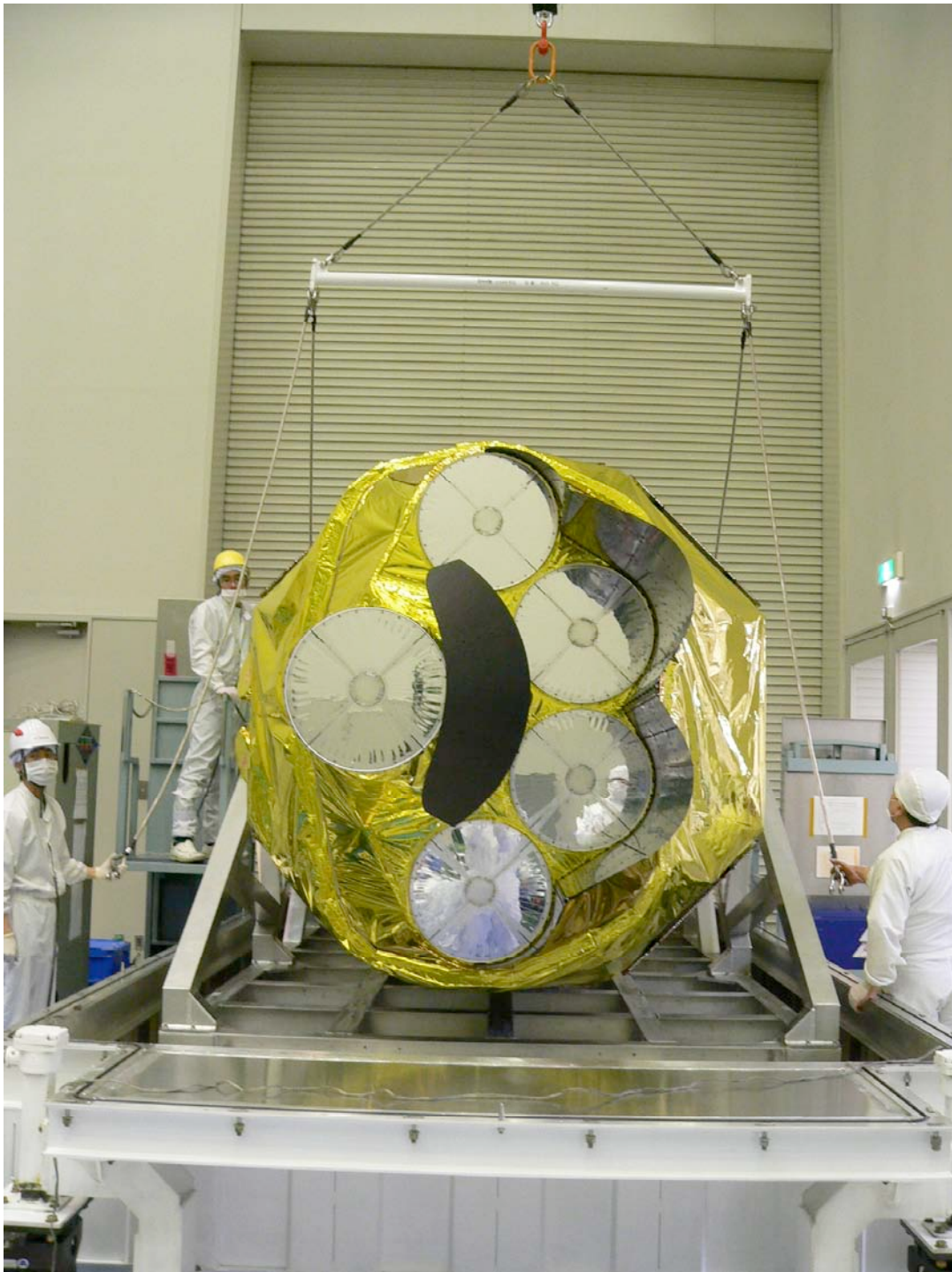
# Suzaku will provide exciting results with

- Large area XRT with pre-collimeter
- Improved X-ray CCD (BI/FI) --- XIS
- Low Background Hard X-ray Detector  
--- HXD



# XRT for the XIS

MCG 6-30-15



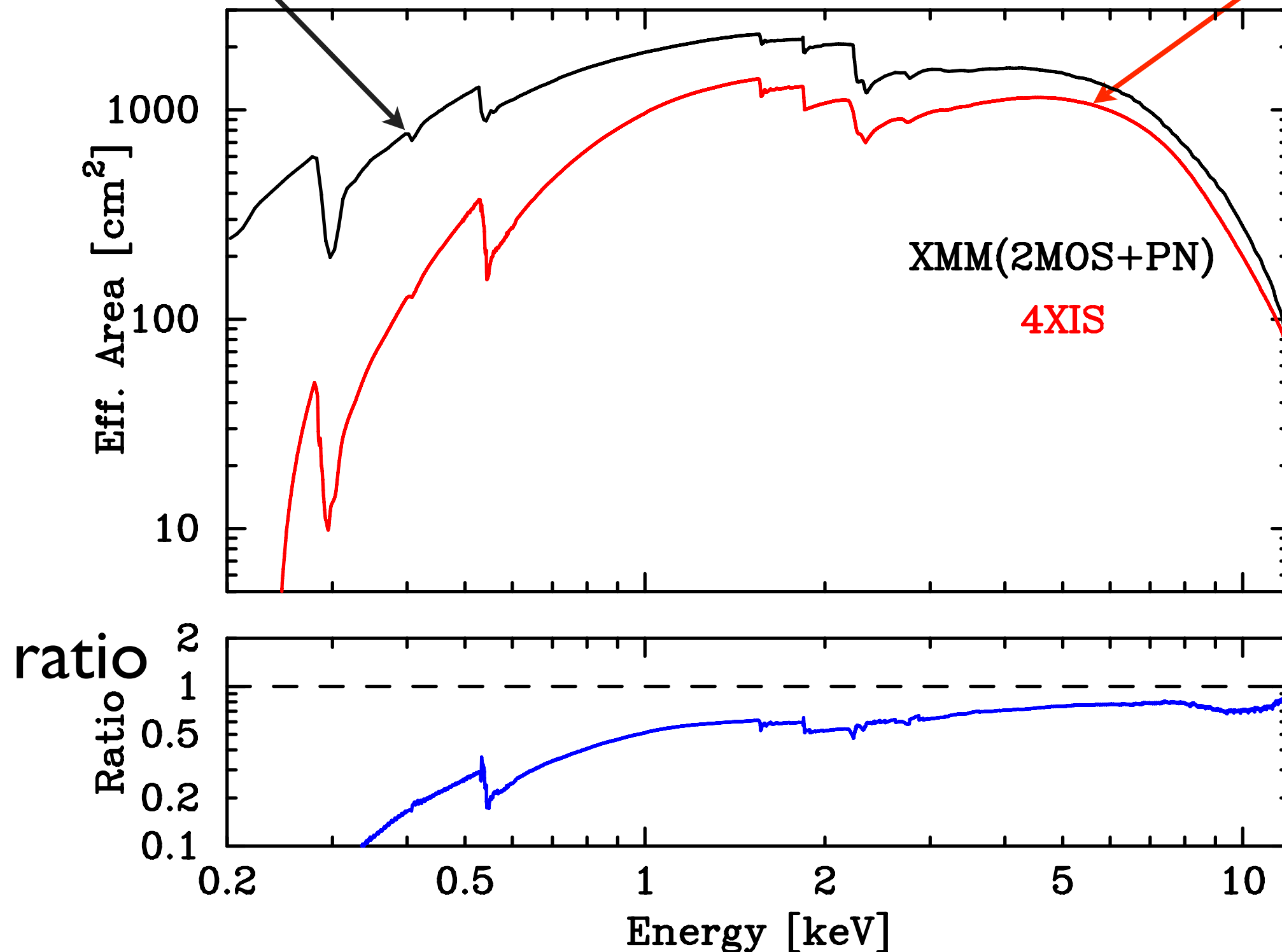
Suzaku XRT-I0 image (contactpass STT selected)

- 4 XRT (1 for BI CCD, 3 for FI CCD)
- angular resolution 0.5 arcmin
- HPD  $\sim 2$  arcmin
- well calibrated

# Effective Area

PN+2MOS/XMM

4 XRT/Suzaku



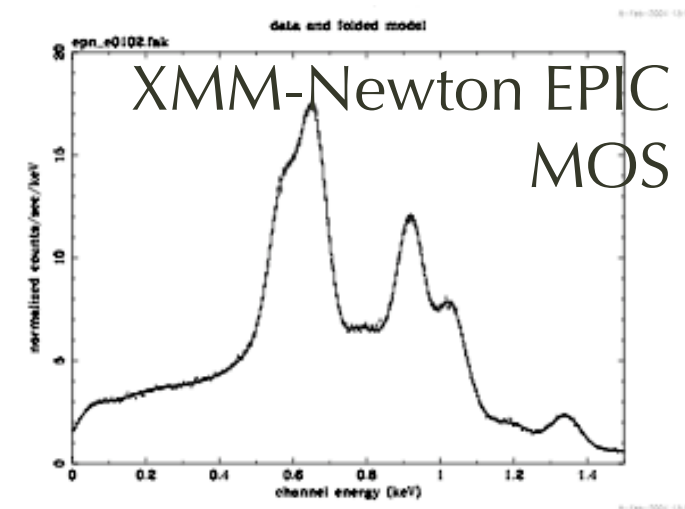
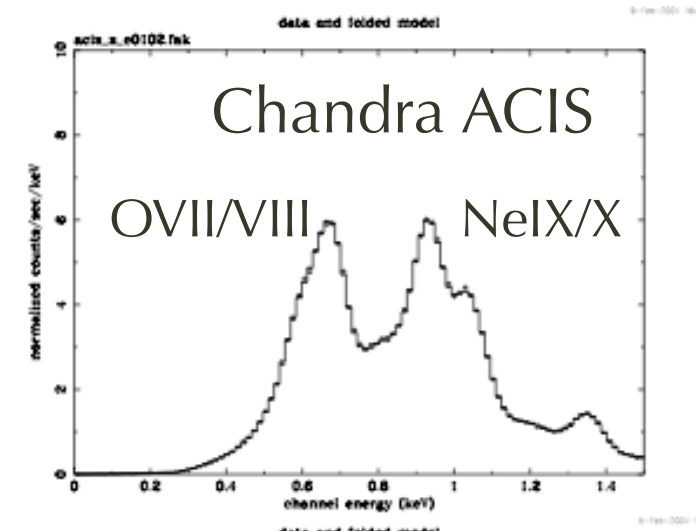
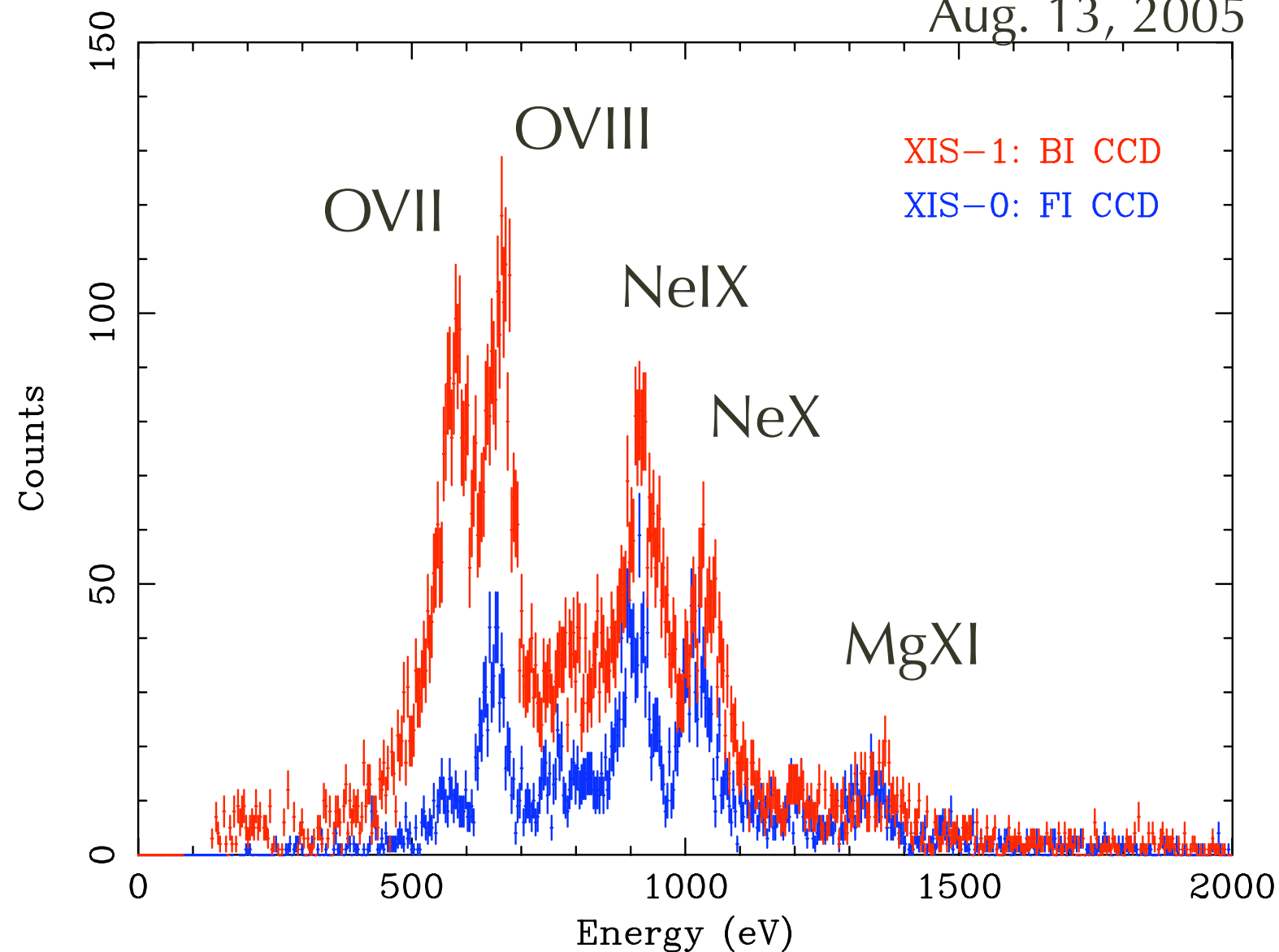
preliminary  
(based on Crab cal)



# Low Energy Spectra with BI/FI-CCD (XIS)

XIS first light – SNR in SMC, E0102.2–7219

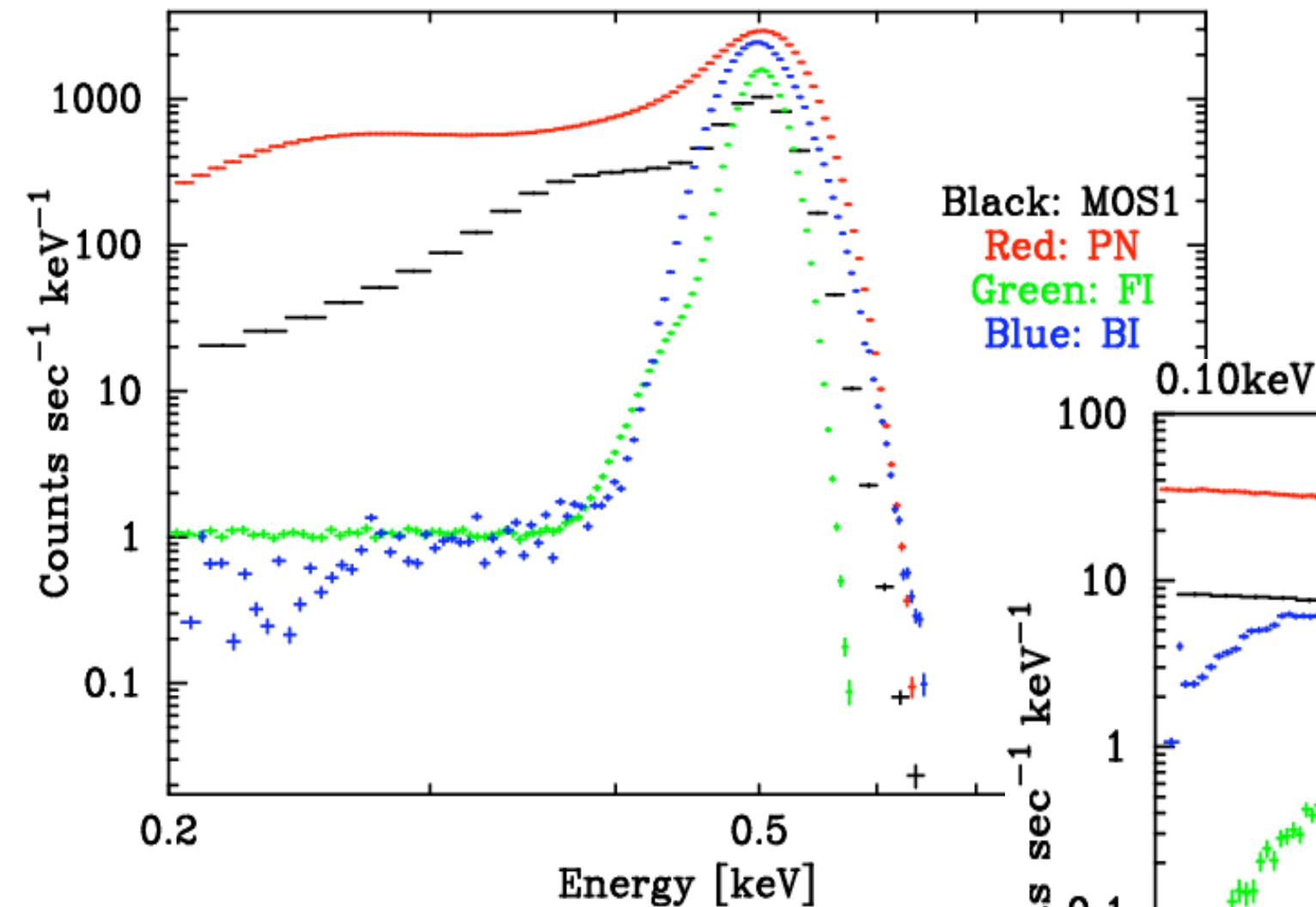
Aug. 13, 2005



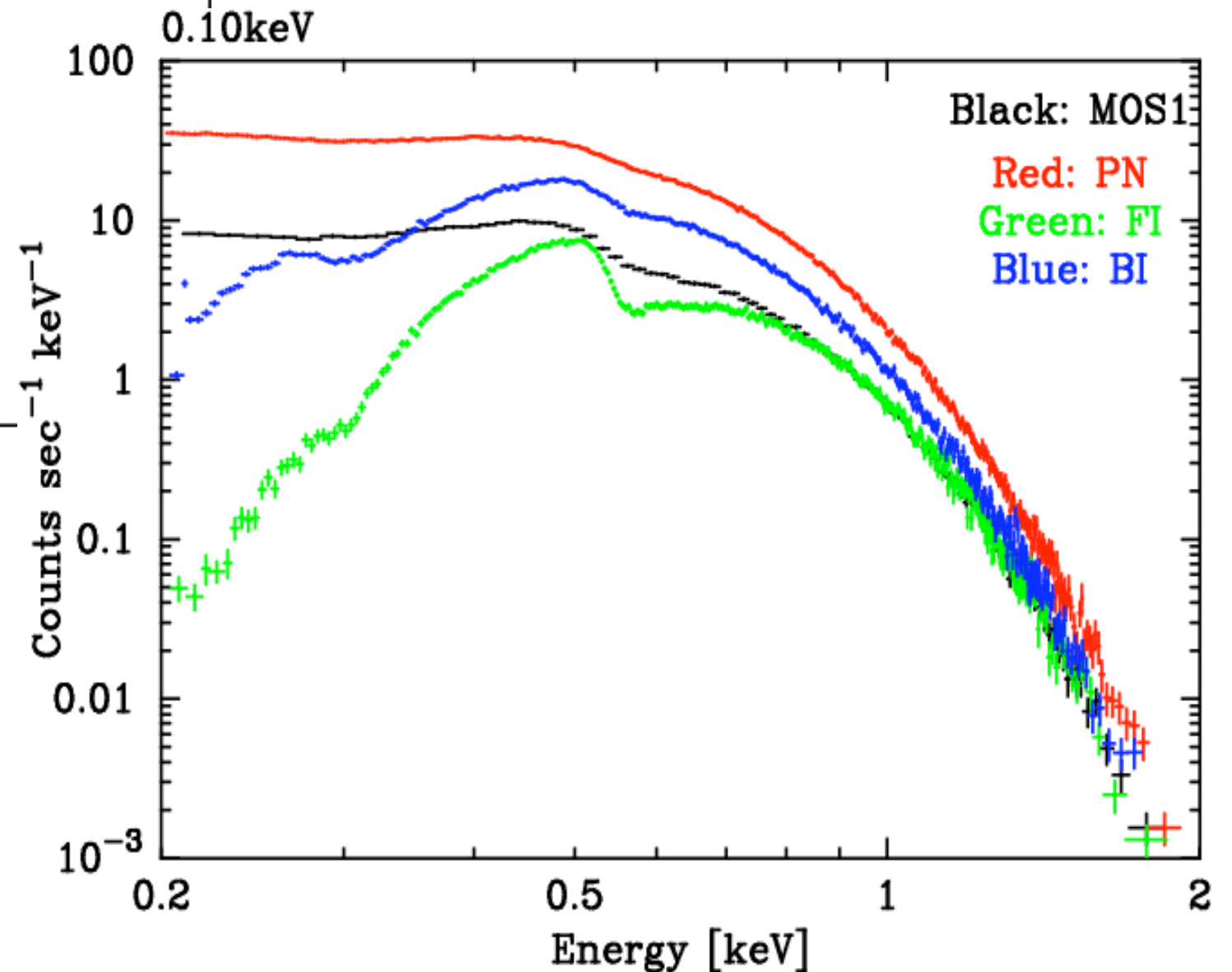
preliminary  
Suzaku Team

# No-tail

response for 0.5 keV monochromatic X-ray



0.1 keV Black body  
( $NH=2 \times 10^{20} \text{ cm}^{-2}$ )





# Low Background : XIS

counts/sec/keV/arcmin<sup>2</sup>/cm<sup>2</sup>

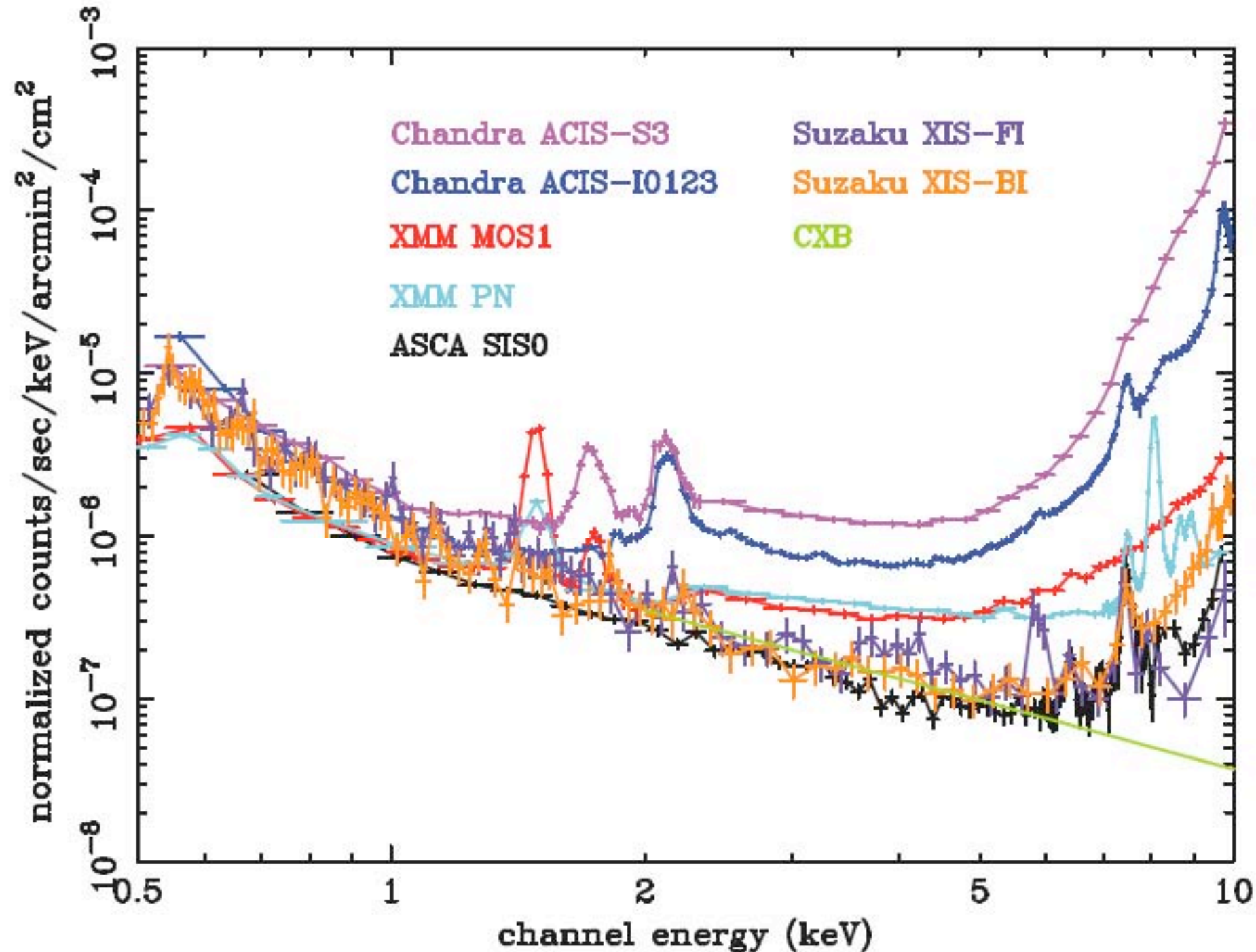


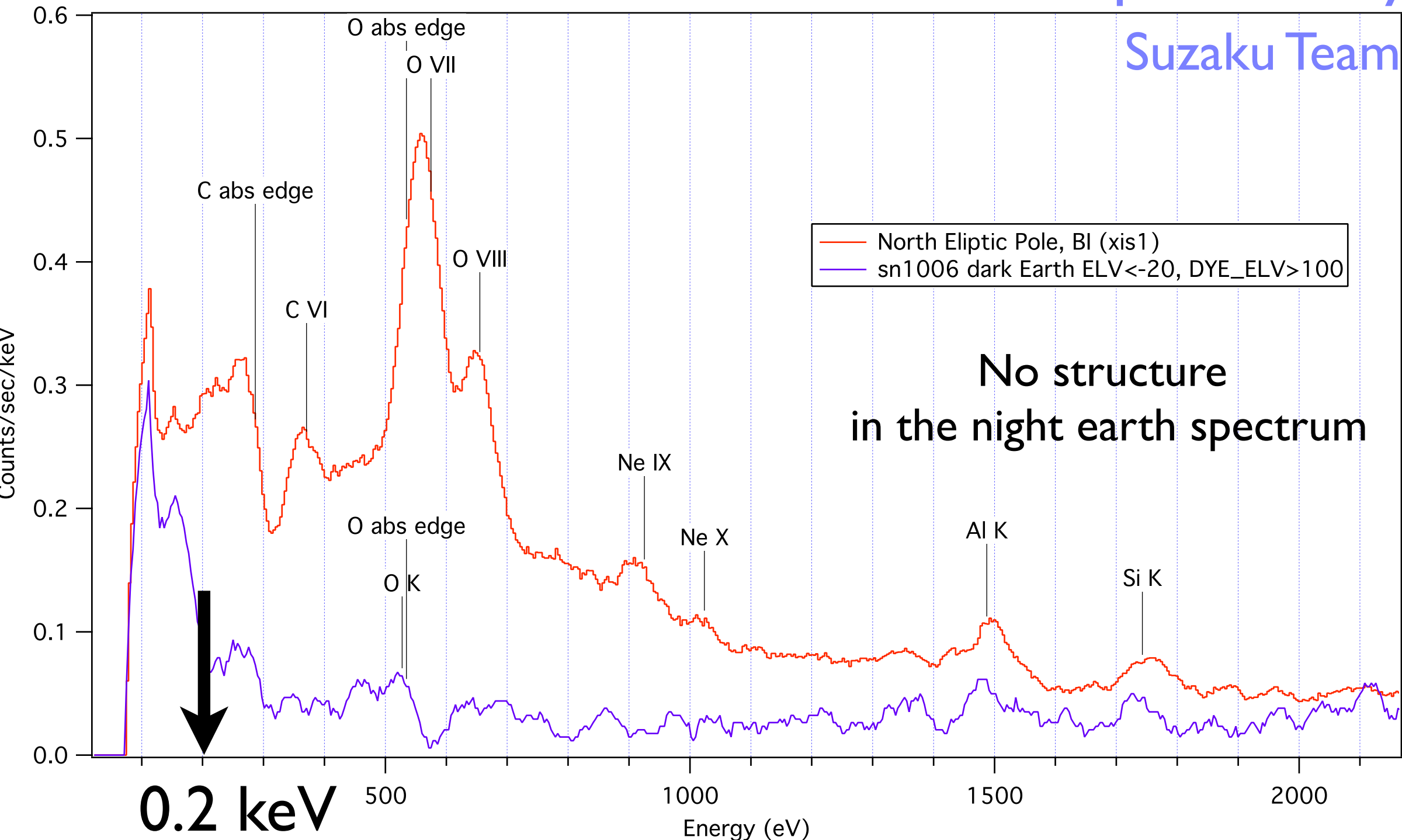
Figure 8: Comparison of the background spectra normalized by the effective area and by the FOV.

# Good Spectrum

- North Eliptic Pole (BI) and the night earth

preliminary

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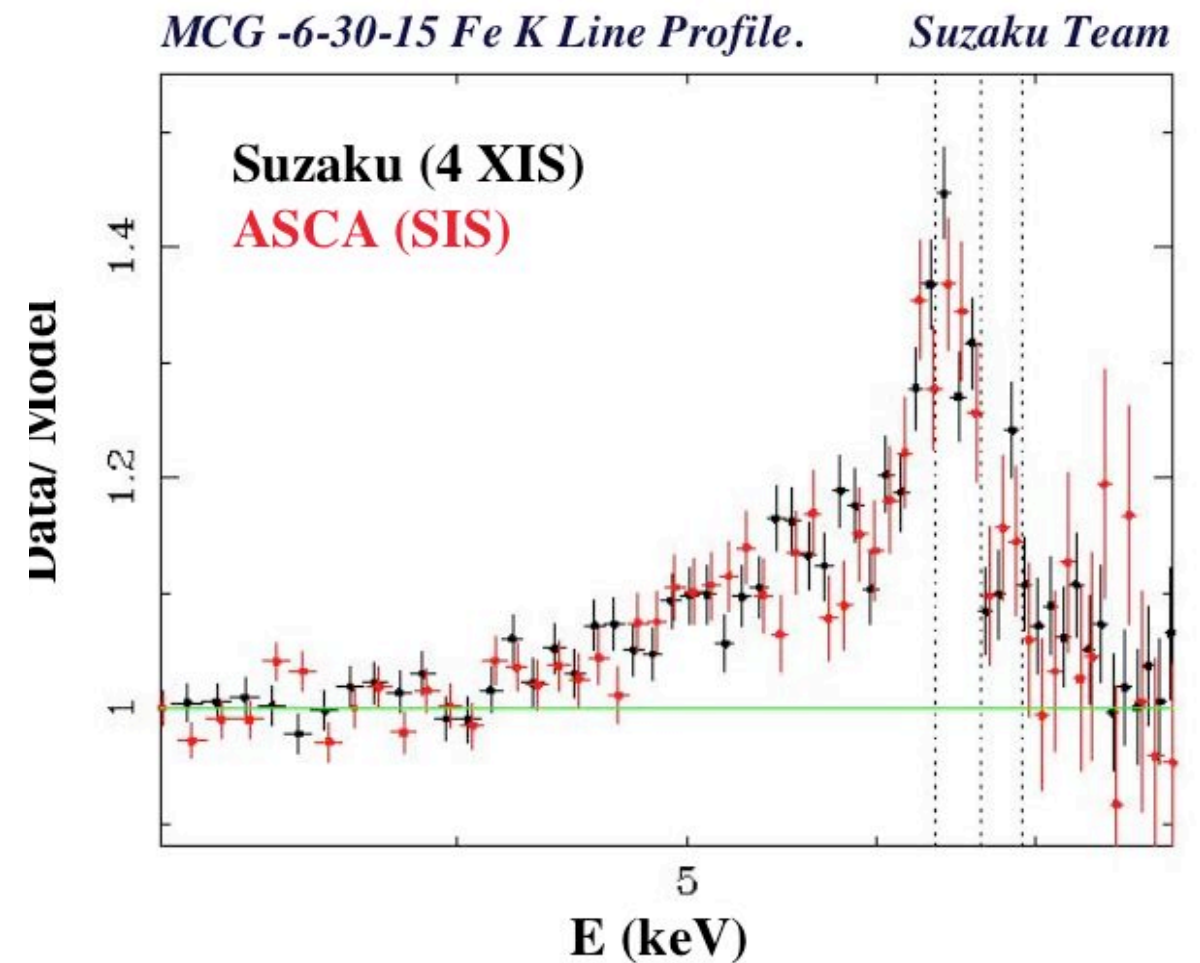
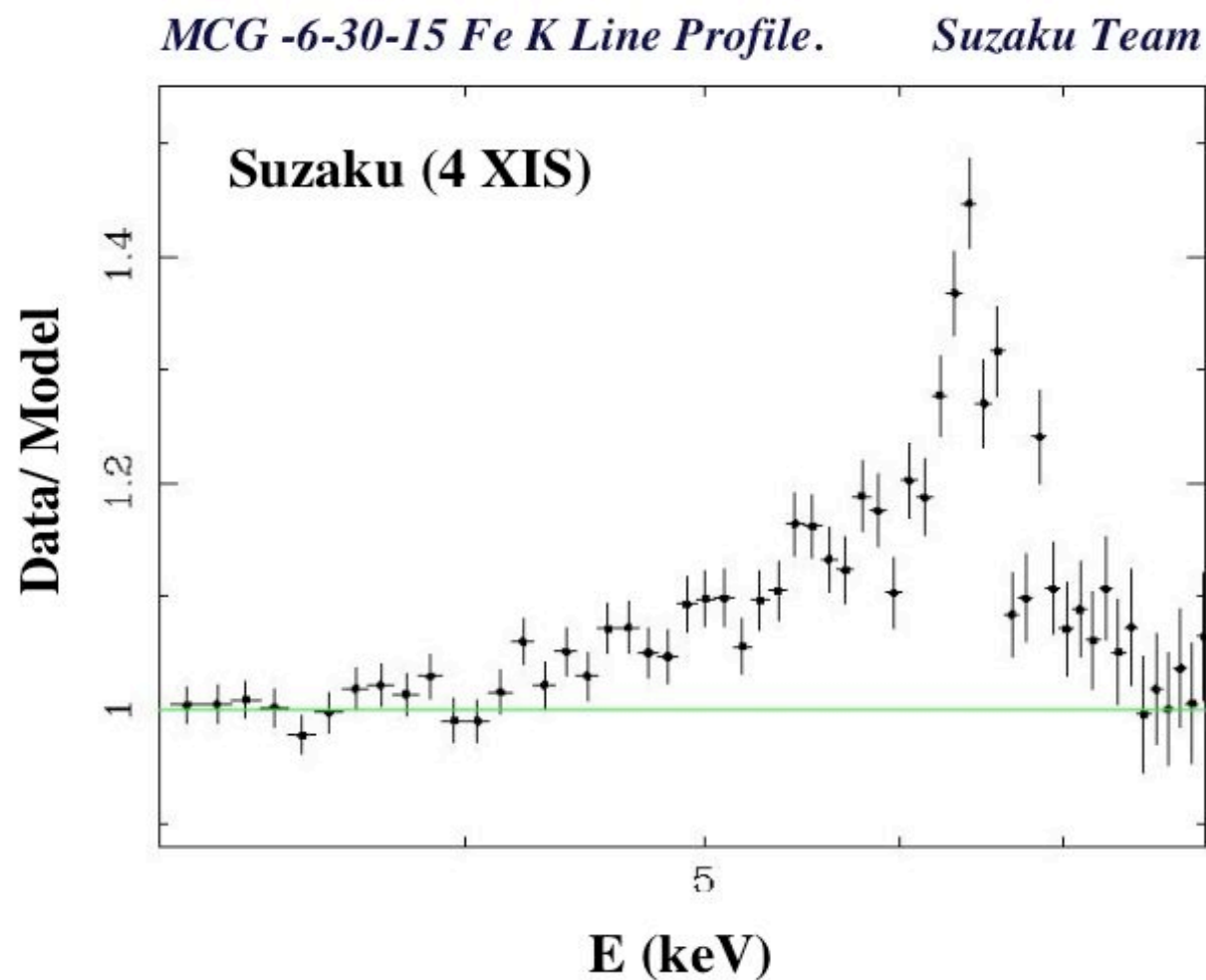




# Broad Iron Line!

- MCG 6-30-15

preliminary  
Suzaku Team



# Hard X-ray Detector

- Japan's answer for the "high sensitivity Gamma-ray" detector.

64 Si PIN diodes  
(4/well unit)

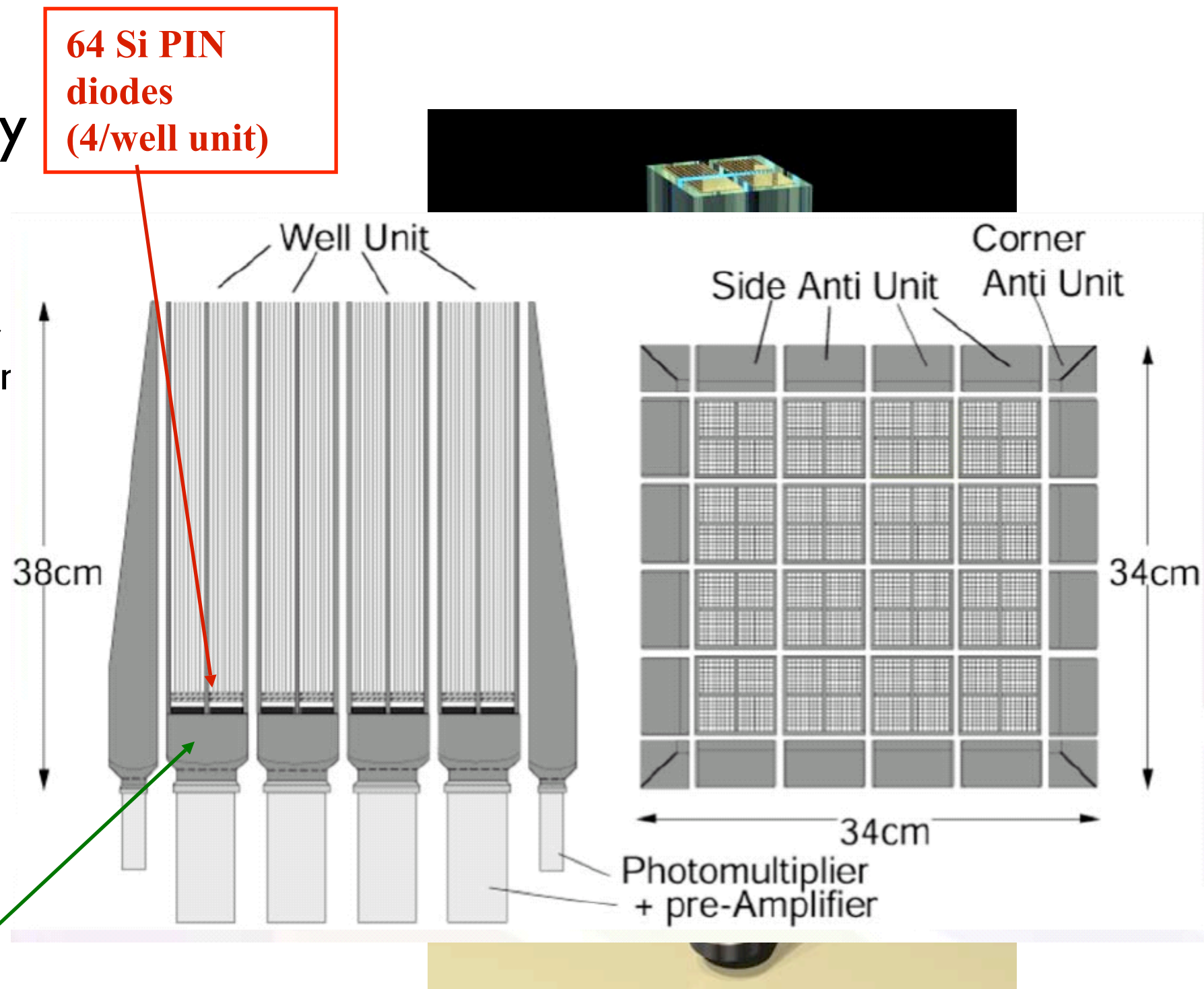
- Low Background (rather than heavy/big) instrumer Well-type Shield

- Si-PIN (8-50 keV)

- GSO Scintillator (50 - 600 keV)

- Thick BGO Shield (av. 4 cm thick)

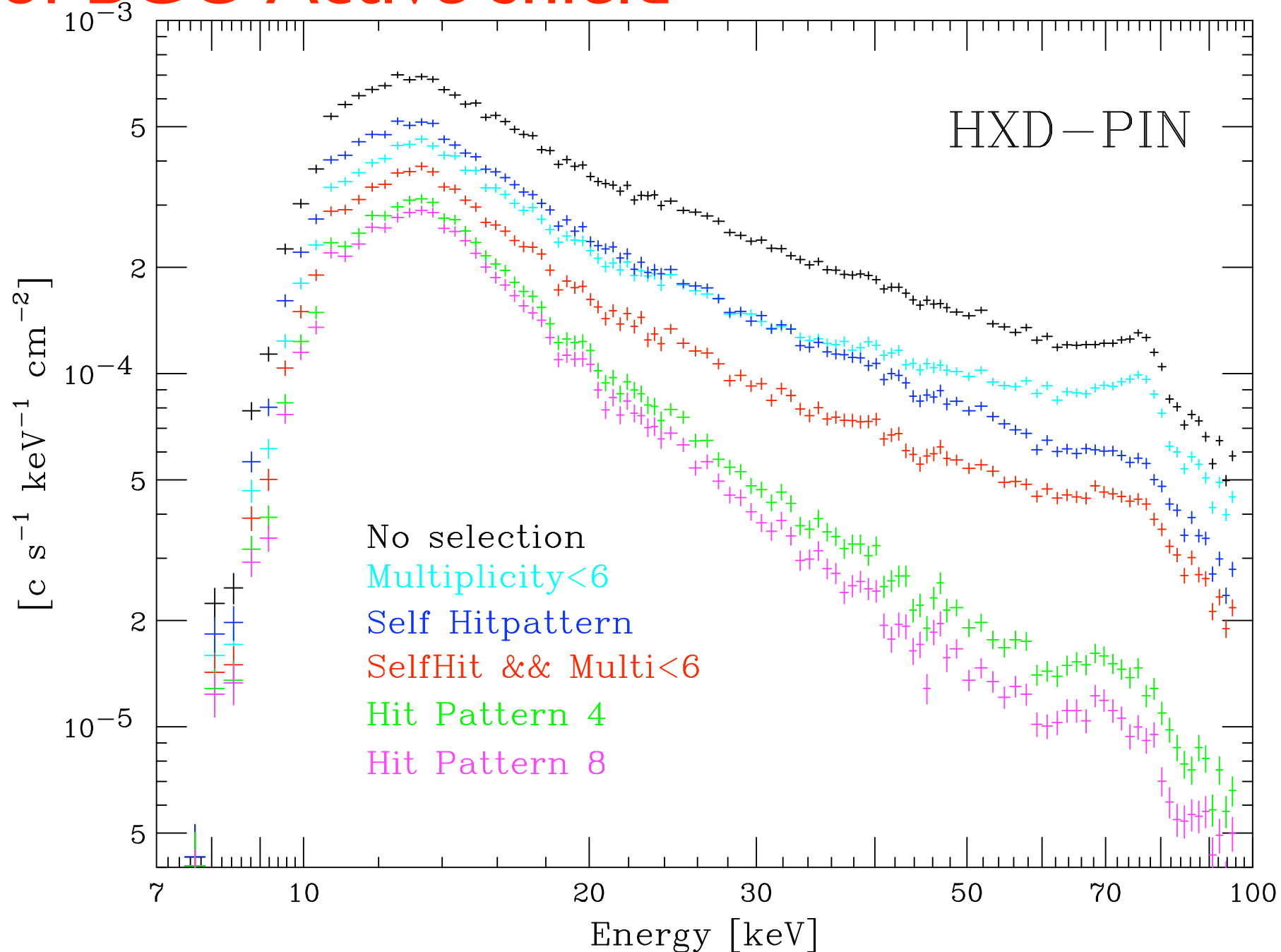
16 GSO/BGO  
phoswich  
counters





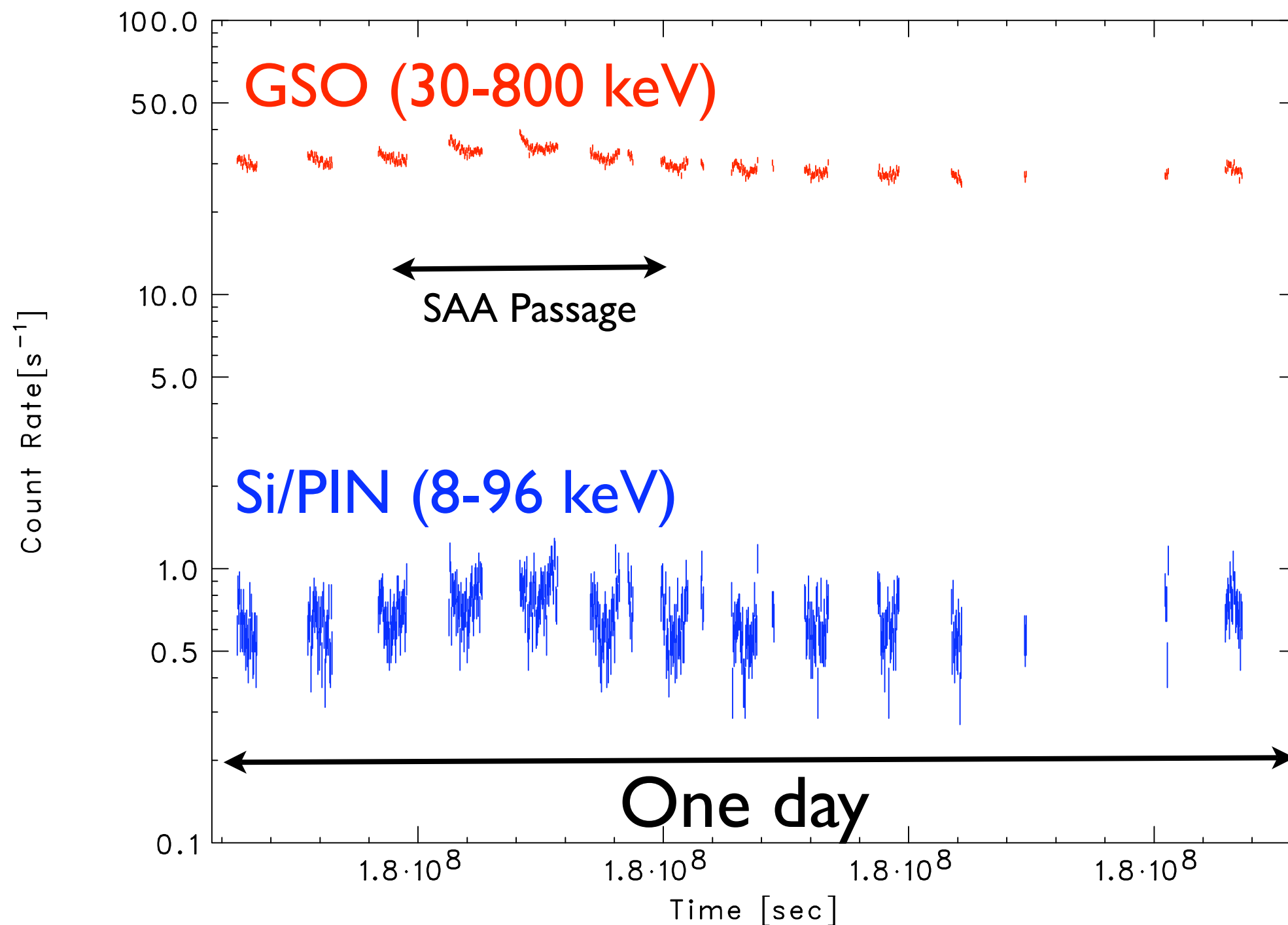
# Background Reduction by “Well-type” BGO Shield

## Effects of BGO Active shield



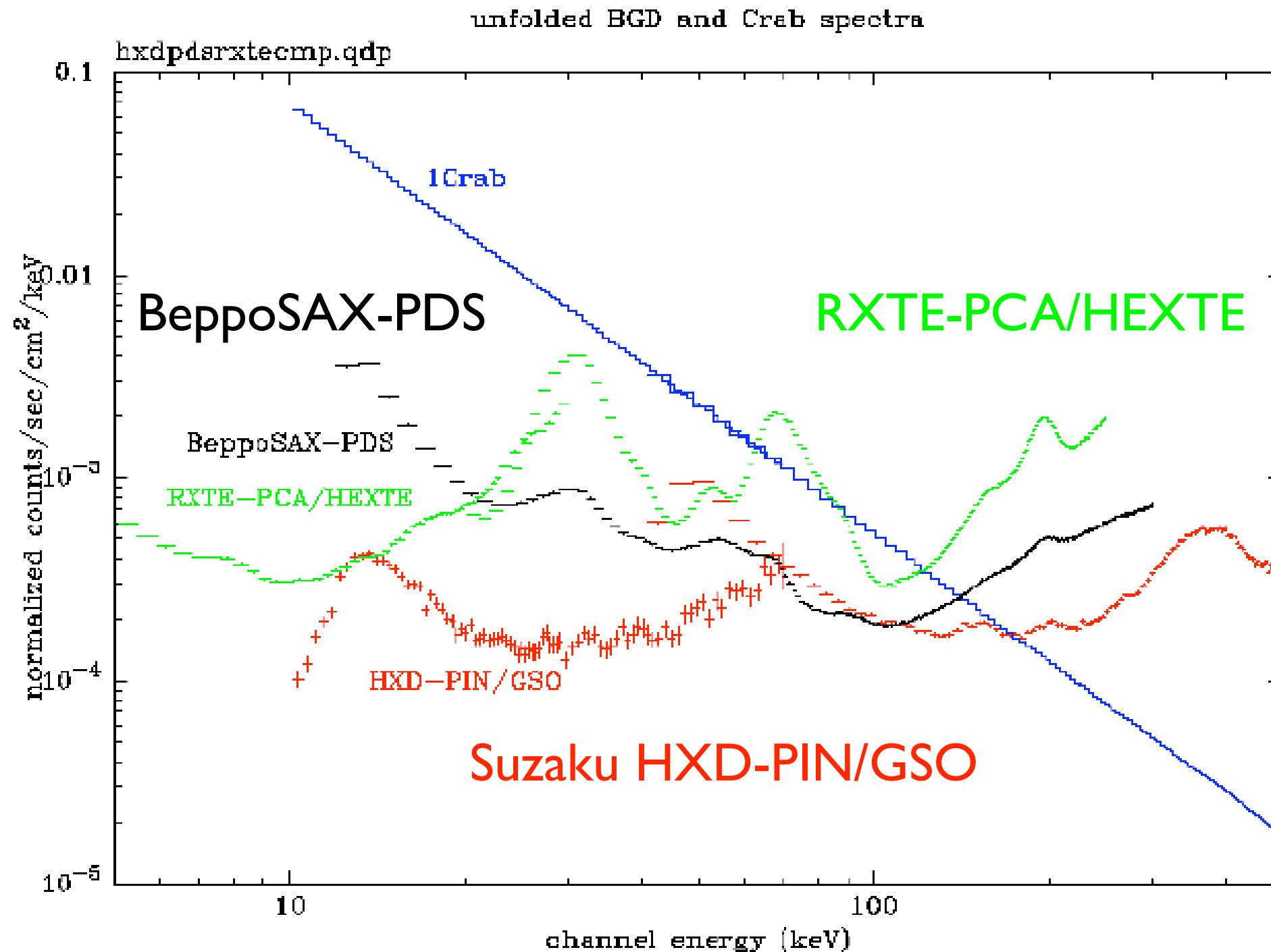
# Background Light Curve

Very stable : even with an inclination angle  
of 36 degrees (with SAA passage)





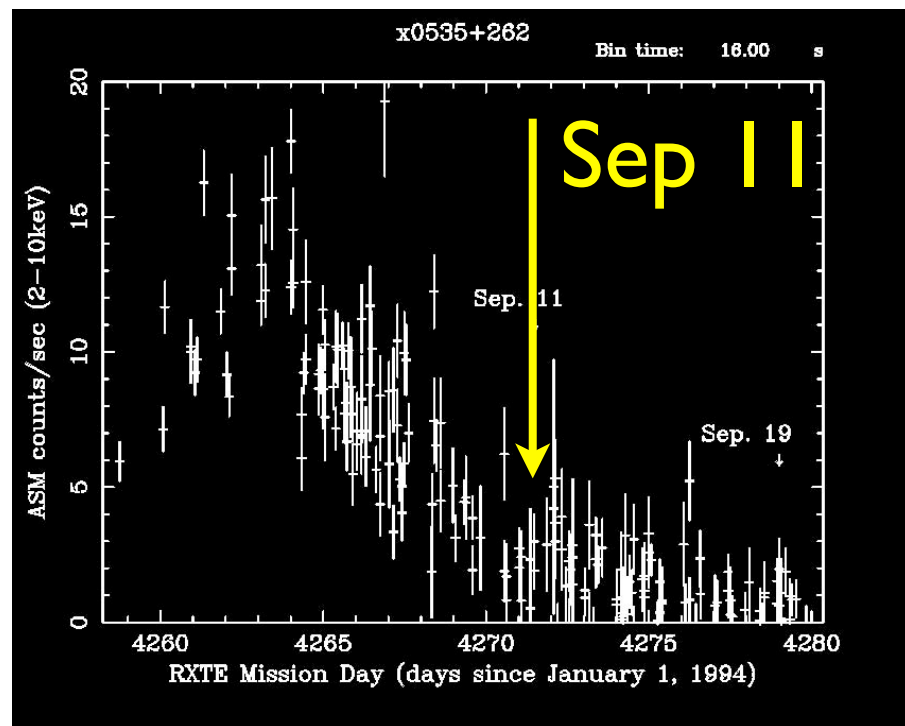
# Background/Sensitivity Comparison with SAX/RXTE



# Detection of cyclotron resonance absorption feature from 3A 0535+262

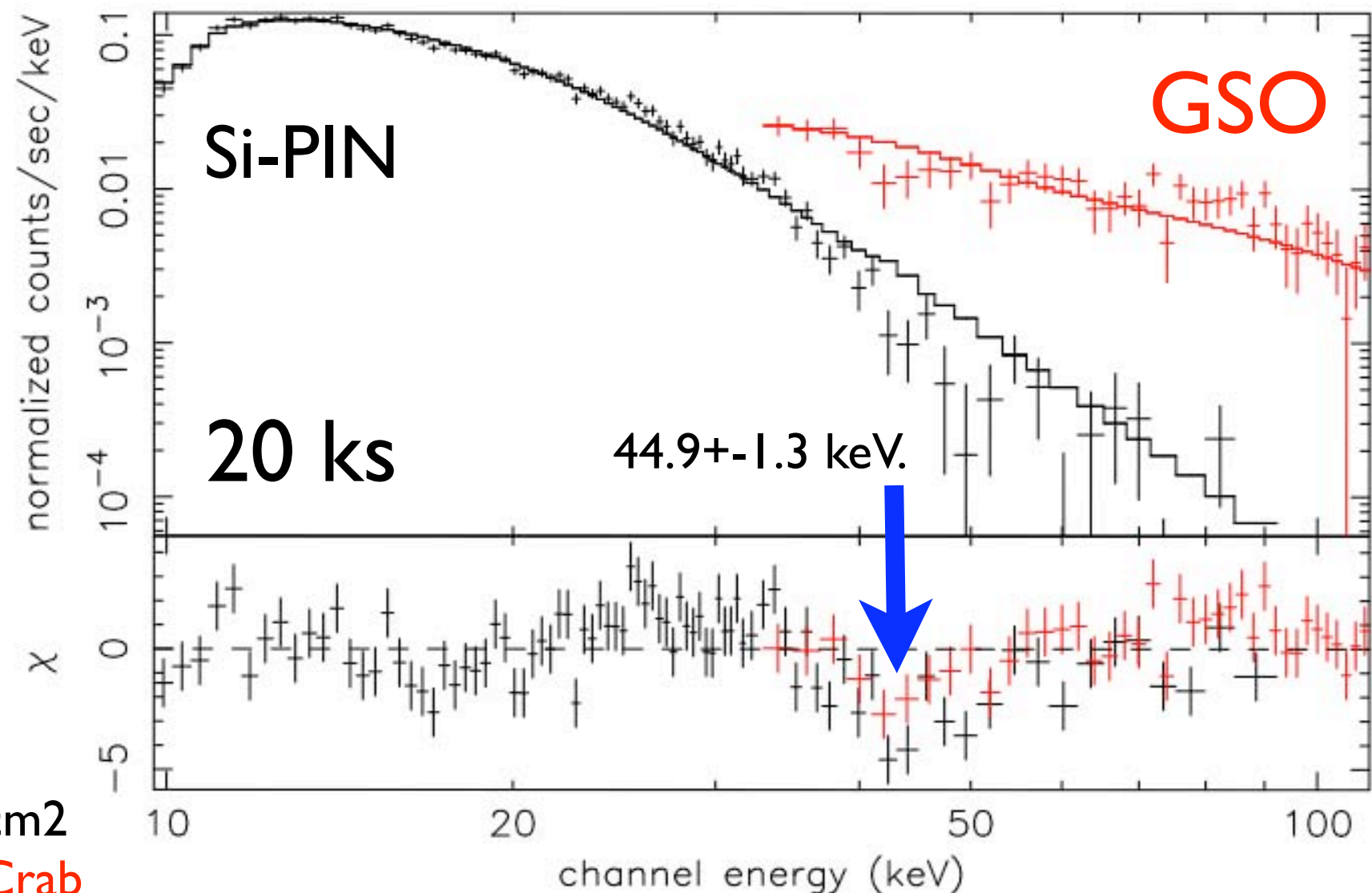
RXTE/ASM

ATEL #613



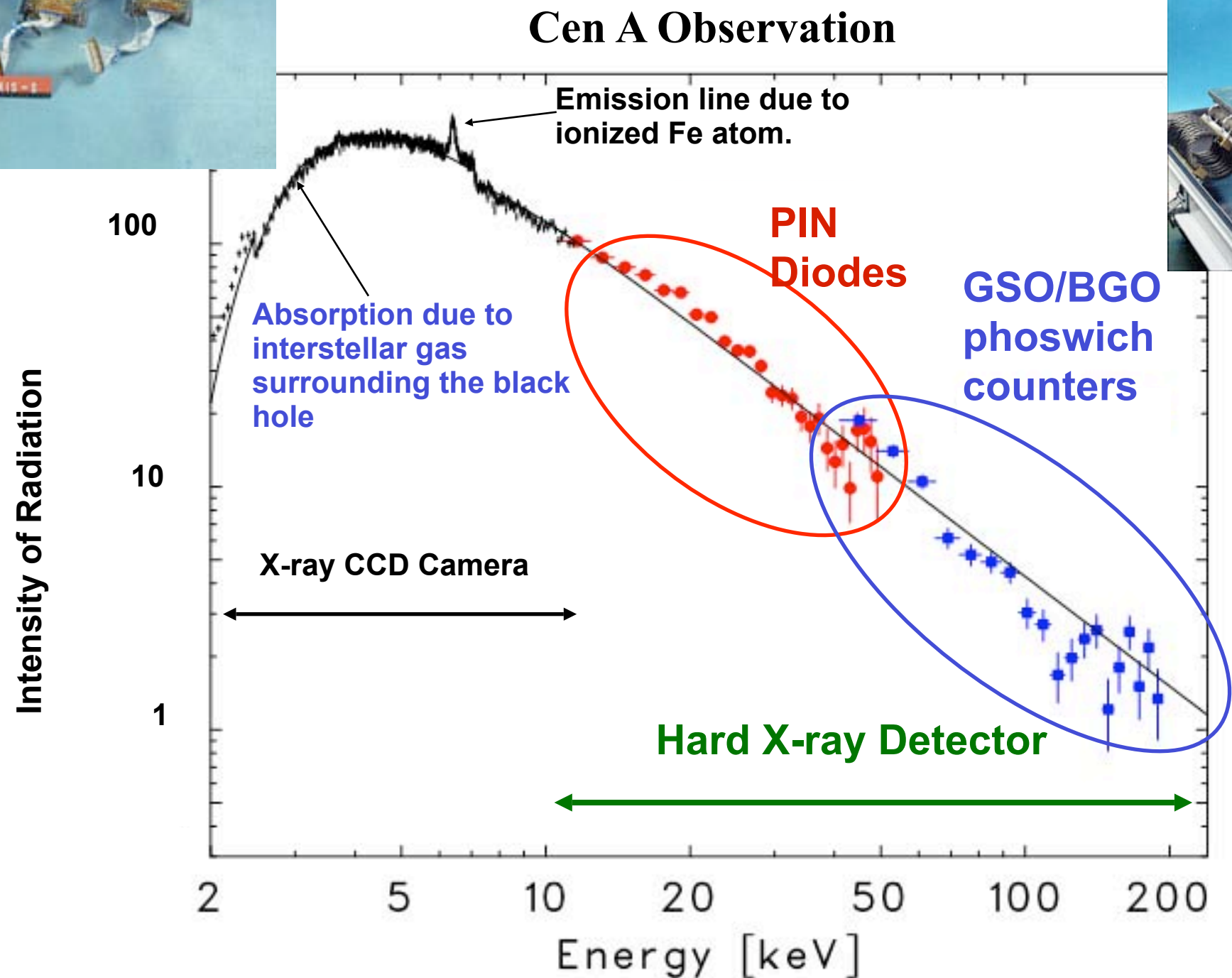
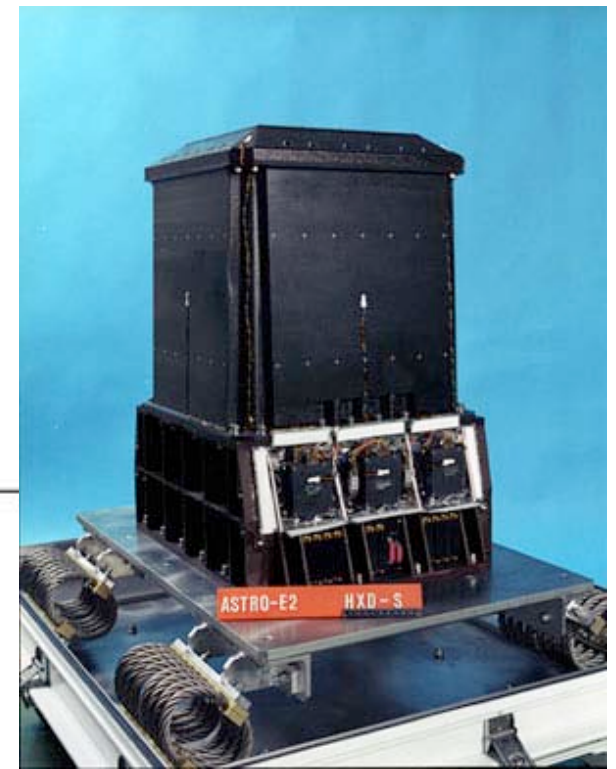
preliminary

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10-100 keV flux of  $8.0 \times 10^{-10}$  ergs/s/cm<sup>2</sup>  
which is equivalent to about 30 mCrab

# Power of Suzaku



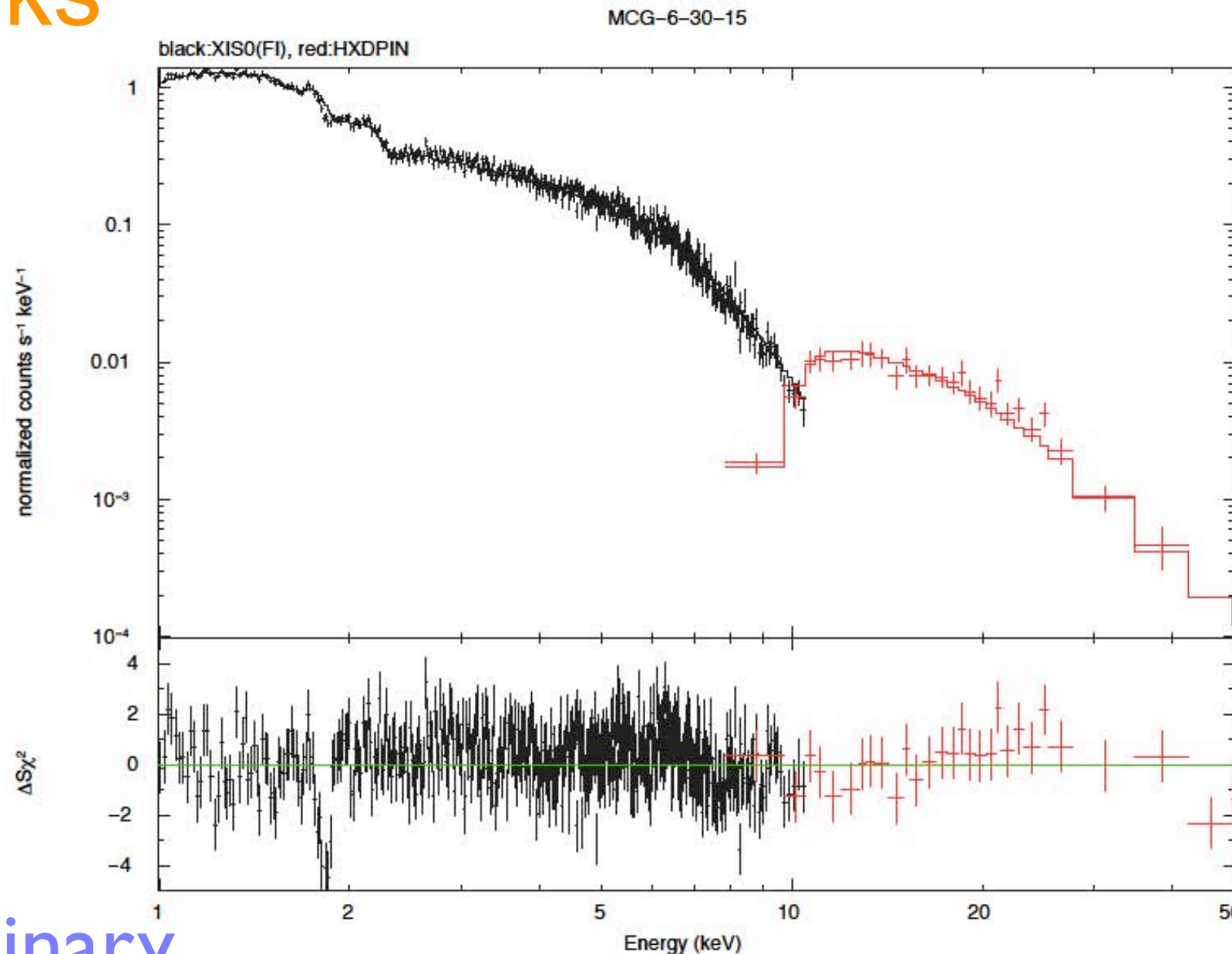
preliminary  
Suzaku Team



# MCG6-30-15 (XIS+HXD)

41 ks

Exposure: 40 ksec(XIS)  
41 ksec(HXD)



Model(wabs x powerlaw)  
NH:  $2.7 \times 10^{21} \text{ cm}^{-2}$   
Photon Index: 1.82  
Norm(@1keV):  $9.3 \times 10^{-3}$

Fitting Region

XIS0:  
1.0--10.0 keV  
(exclude 5.0--7.0 keV)

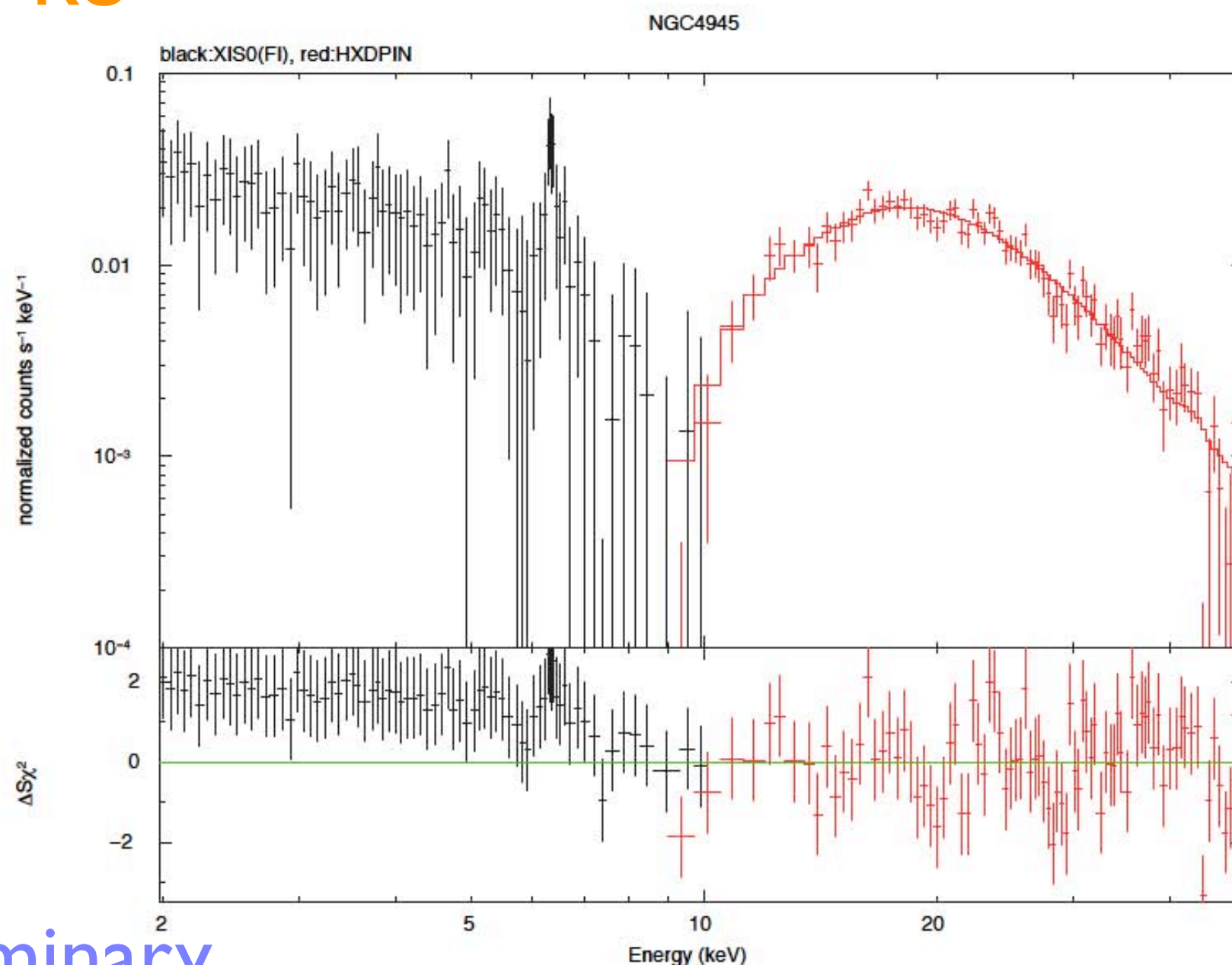
HXD PIN:  
11.0--30.0 keV

- By S. Watanabe (Sep/24/05) and the HXD team

# XIS/HXD NGC4945

23 ks

Exposure: 23 ksec



Model(wabs x powerlaw)  
 $N_H: 5.9 \times 10^{24} \text{ cm}^{-2}$   
Photon Index: 2.07  
Norm(@1keV): 0.15

Fitting Region  
HXD PIN:  
11.0--50.0 keV

- By S. Watanabe (Sep/24/05) and the HXD team

preliminary

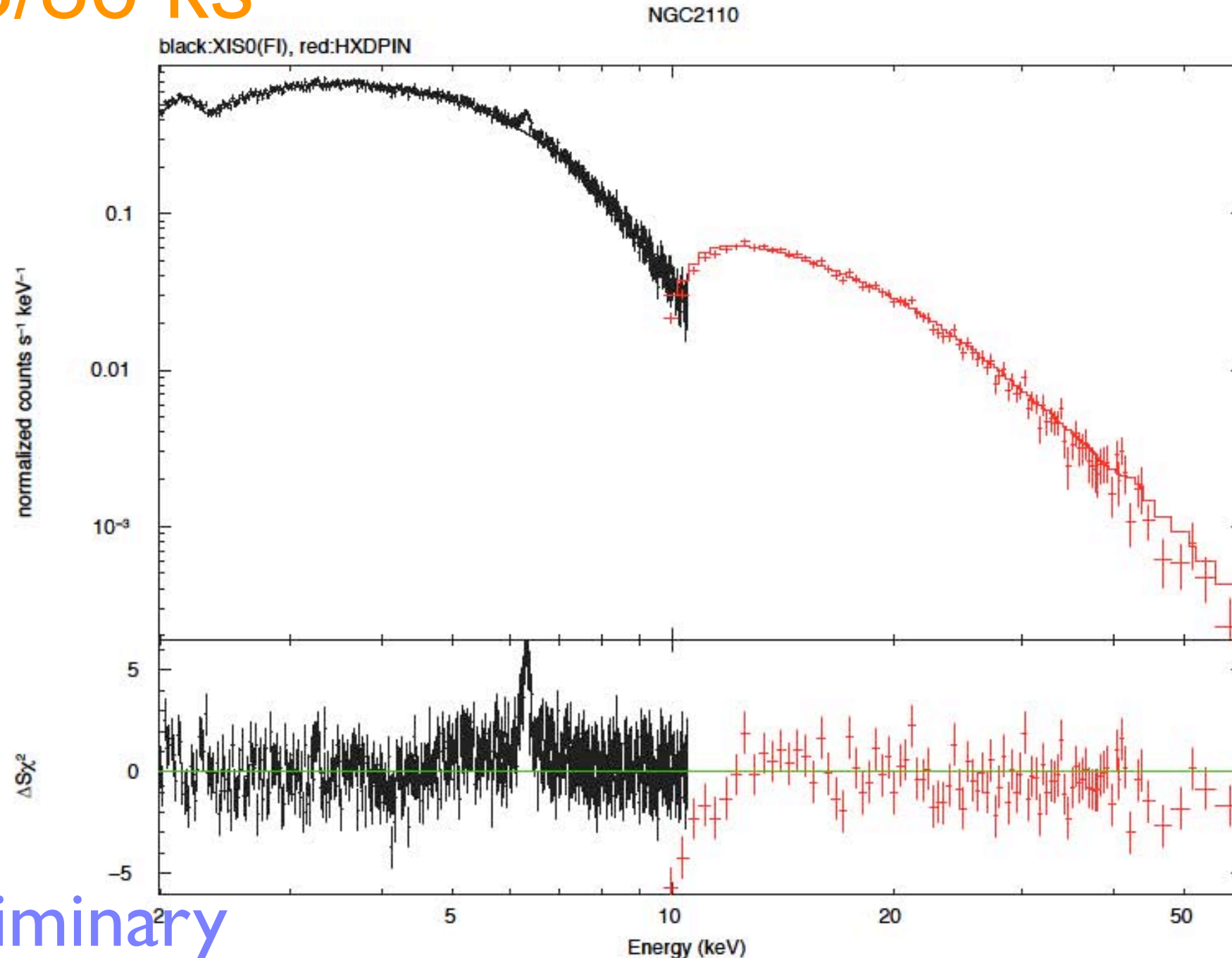
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Detection upto at least 100 keV with GSO

# XIS/HXD NGC2110

73/86 ks

Exposure: 86 ksec(XIS)  
73 ksec(HXD)



Model(wabs x powerlaw)  
 $N_H: 3.8 \times 10^{22} \text{ cm}^{-2}$   
Photon Index: 1.63  
Norm(@1keV):  $2.9 \times 10^{-2}$

Fitting Region  
XIS0:  
2.0--10.0 keV  
(exclude 5.0--7.0 keV)  
HXD PIN:  
11.0--50.0 keV

• By S. Watanabe (Sep/24/05) and  
the HXD team

preliminary

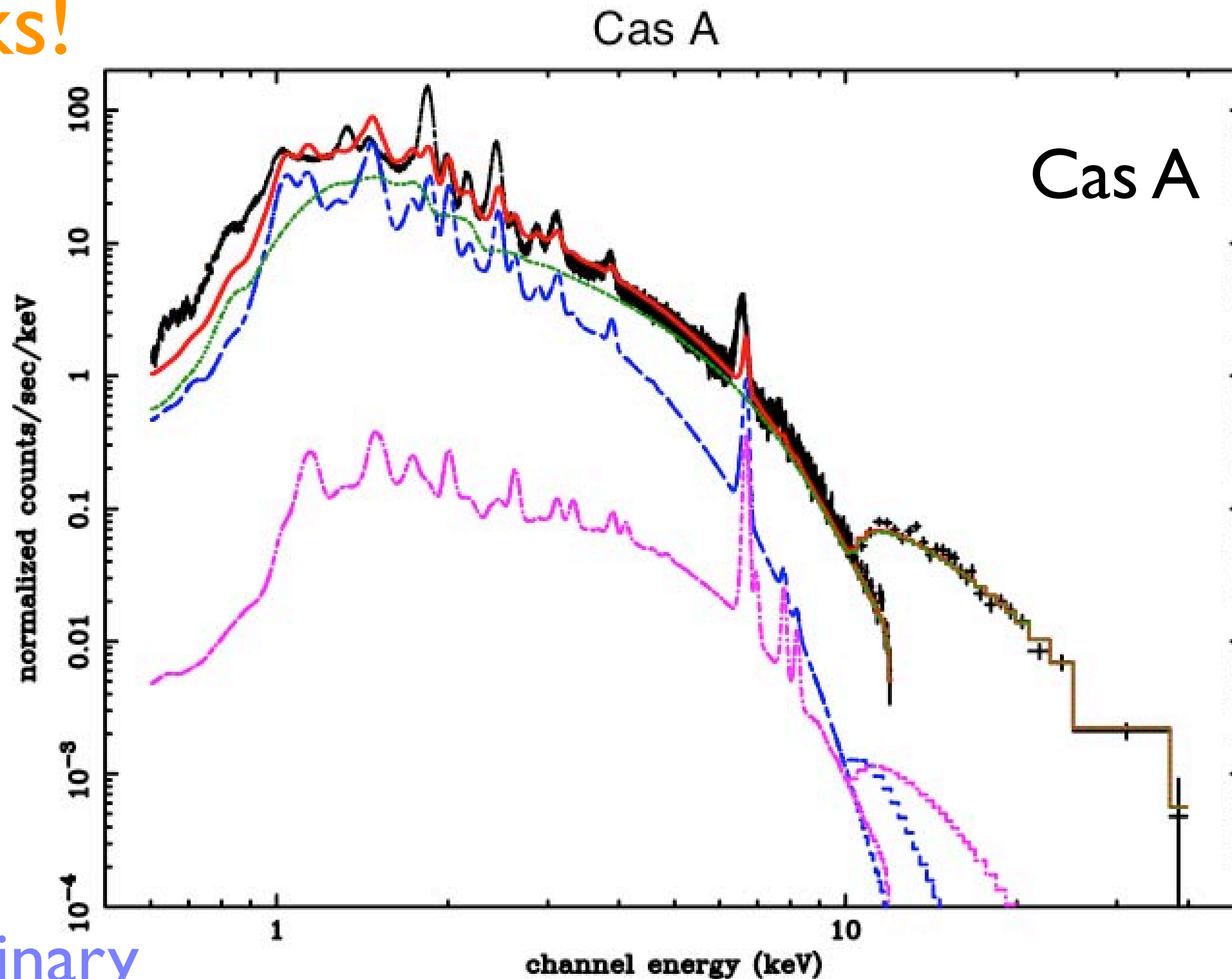
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Detection upto at least 100 keV with GSO



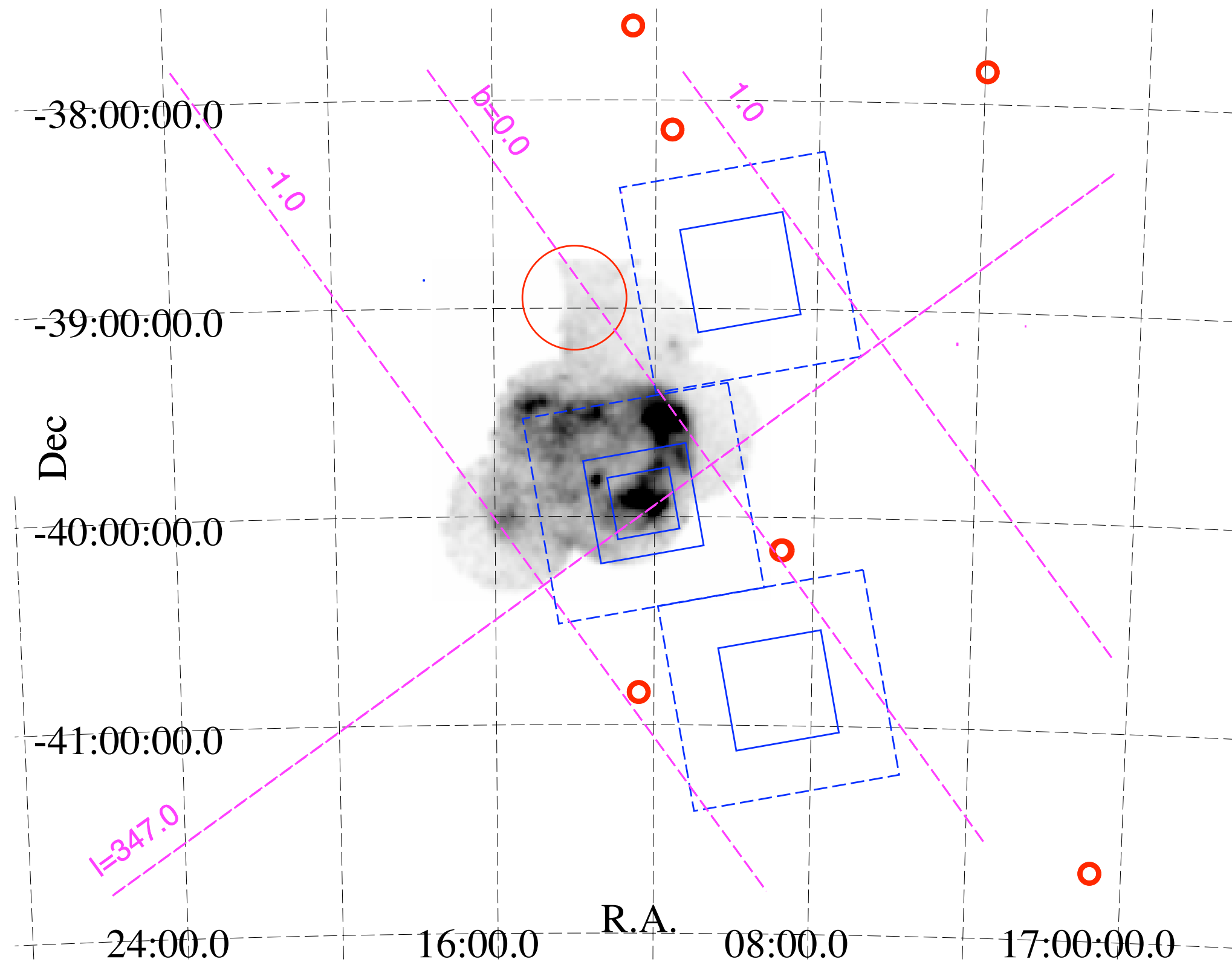
# Supernova Remnants

12 ks!



preliminary  
Suzaku Team

# Narrow FOV of PIN (0.5deg)



# Schedule

- Science Working Group (SWG) observations until Mar. 2006
- Guest Observer (GO) observations start from Apr. 1, 2006
  - All previous AO-I selections are canceled  
(Sorry for those who are waiting for data.).
  - New AO will be released on October 15
    - Due date January 6, 2006
    - Selection by early March
    - Observation from April 1
    - The time sharing of AO-I
      - J(50%), US(37.5%) and J-US(12.5%)
      - J(50%) includes all non-US proposals. In particular, its  $\sim 1/6$ , i.e. 8% of total, will be used for ESA.



# Summary

Successful Launch of Suzaku  
after the failure of the launch of AstroE1.

Loss of the XRS is sad. But we need to know what went wrong so we can do it right the next time. It is important that we DID demonstrate the X-ray calorimeter in space (for 10 days), perfect performance.

I believe a mission with a calorimeter is now regarded as the highest priority in the X-ray community

We have started observations with  
the XIS and the HXD

-- New Power of Suzaku --

Low Background /Wide-band coverage  
New and Exciting data are comming now!

We will do our best to realize the calorimeter  
in VERY-NEAR FUTURE mission.