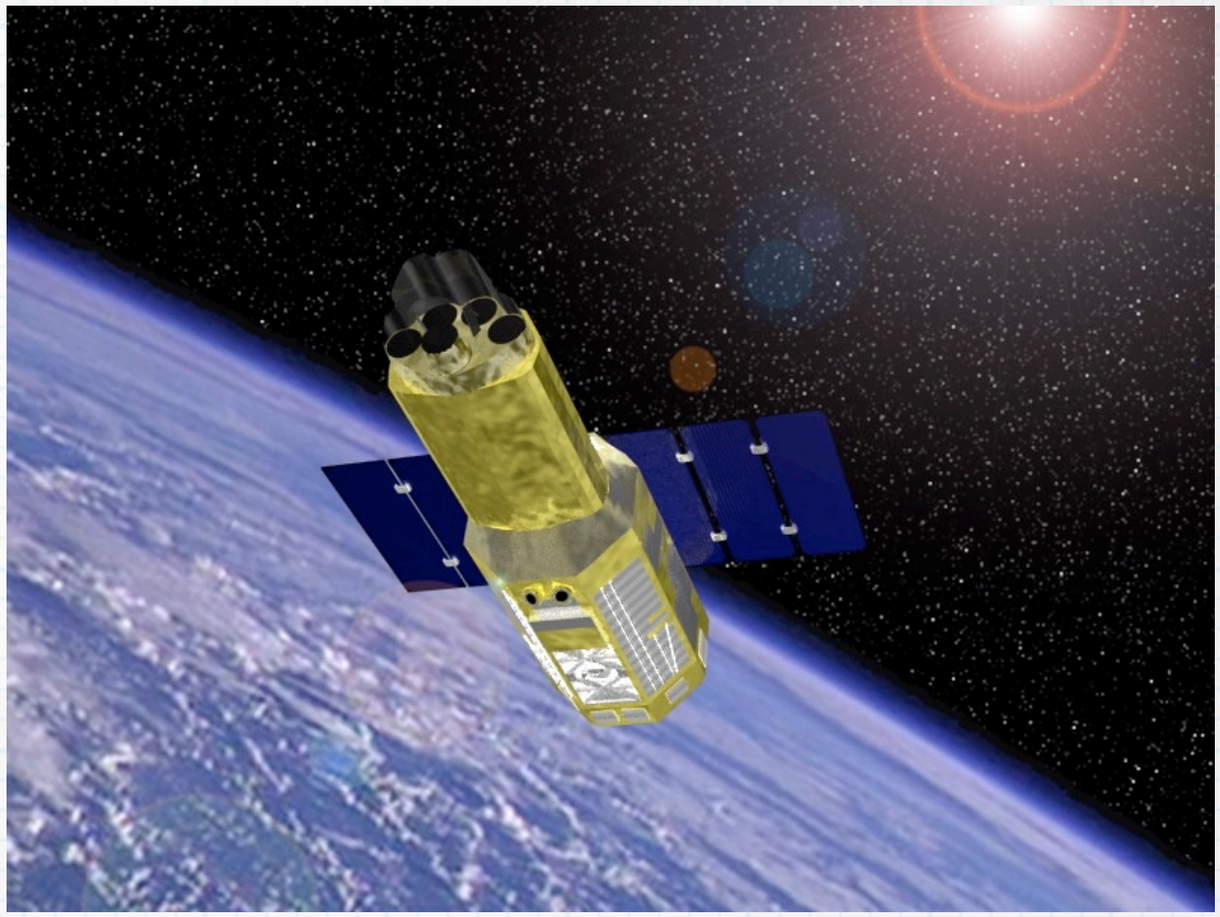
The Suzaku
X-Ray Observatory



Richard Kelley, NASA/Goddard

Kazuhisa Mitsuda, ISAS/JAXA

on behalf of the entire Suzaku team

NASA ISAS JAXA Japan Aerospace Exploration Agency

Launch of Astro-E2

Suzaku

from Asian mythology

Outline

Mission Concept

Report on XRS

Suzaku Capabilities and Performance

- XRT/X-ray CCD (XIS)
- Hard X-ray Detector (HXD)
- What you can do with *Suzaku*

Summary

Suzaku

Investigations of

- Structure-formation of the universe
- Environment very close to blackholes

using

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

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

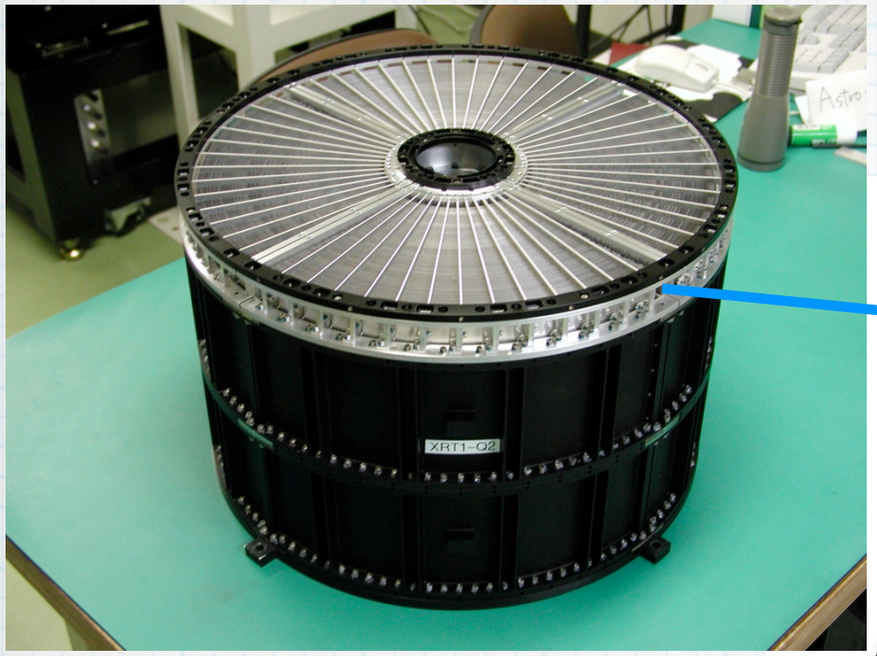
ISAS/JAXA-NASA international collaborations

Scientific instruments:

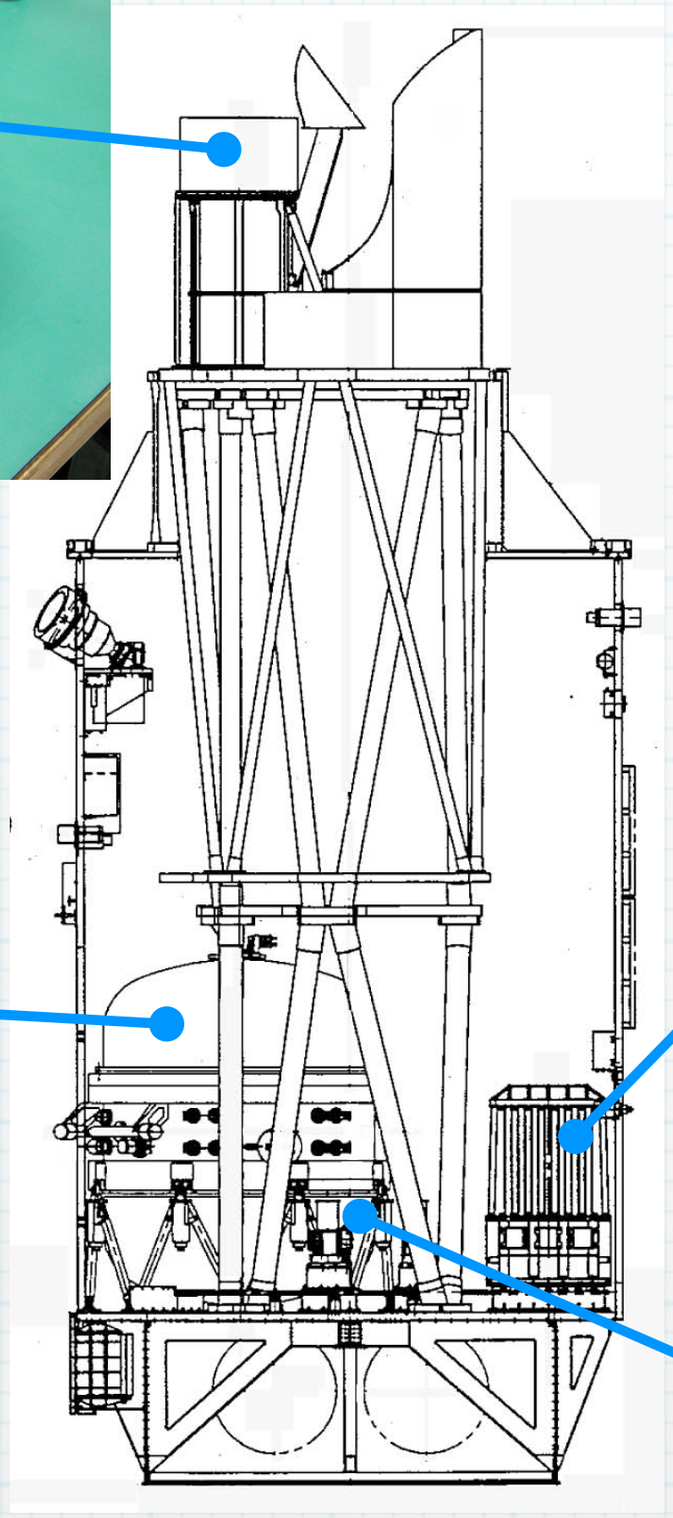
X-ray optics, X-ray spectrometers (e.g., CCDs, microcalorimeters)

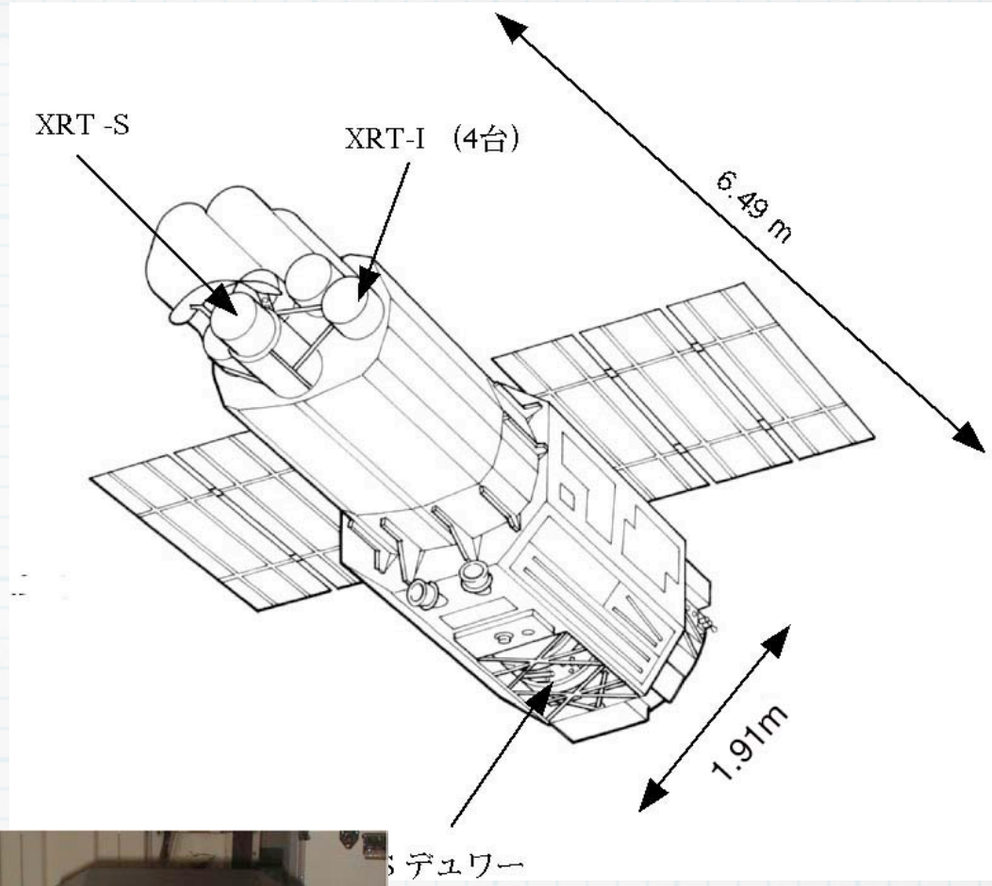
Analysis software

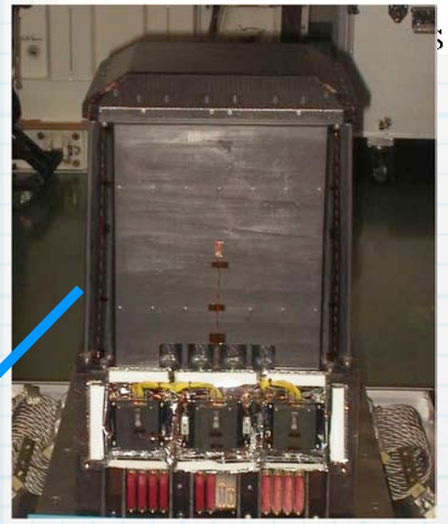
Launched on July 10, 2005 from Uchinoura with M-V launch vehicle.



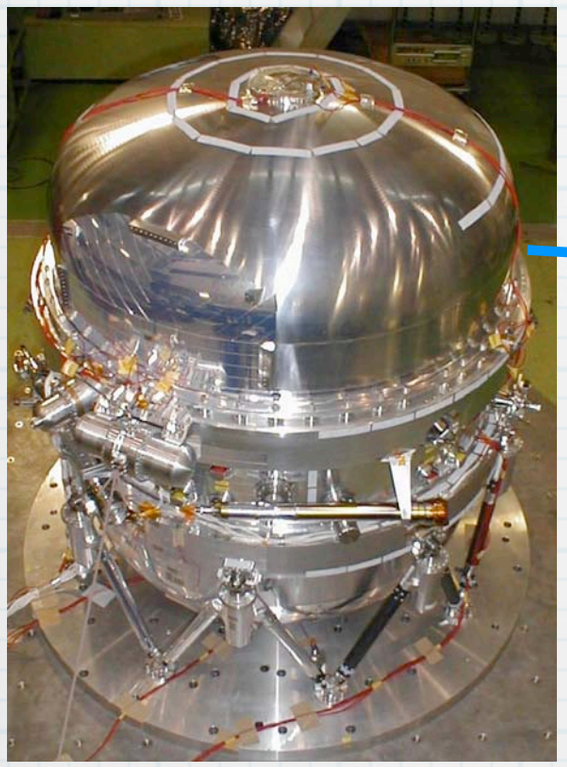
XRT (5 units)
NASA/GSFC-Nagoya-
ISAS/JAXA







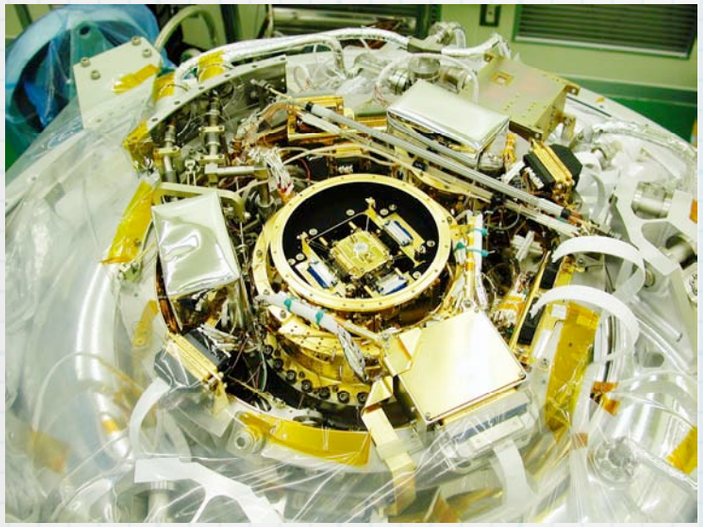
HXD
Tokyo-ISAS/JAXA-
Riken-Saitama-
Hiroshima

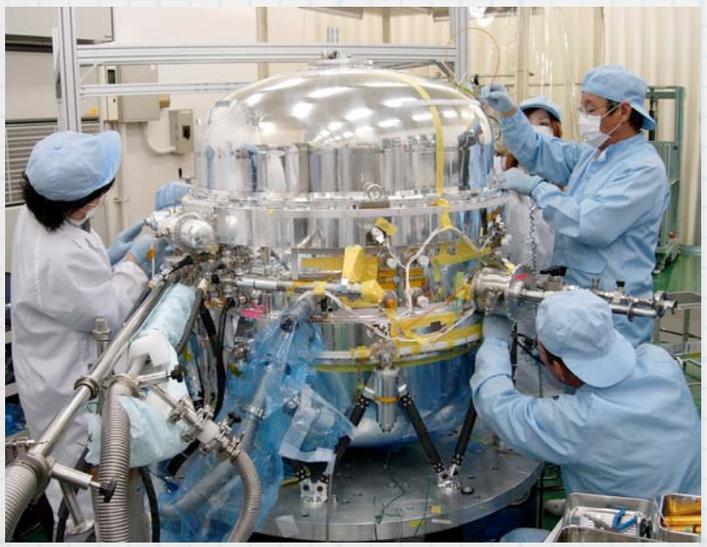


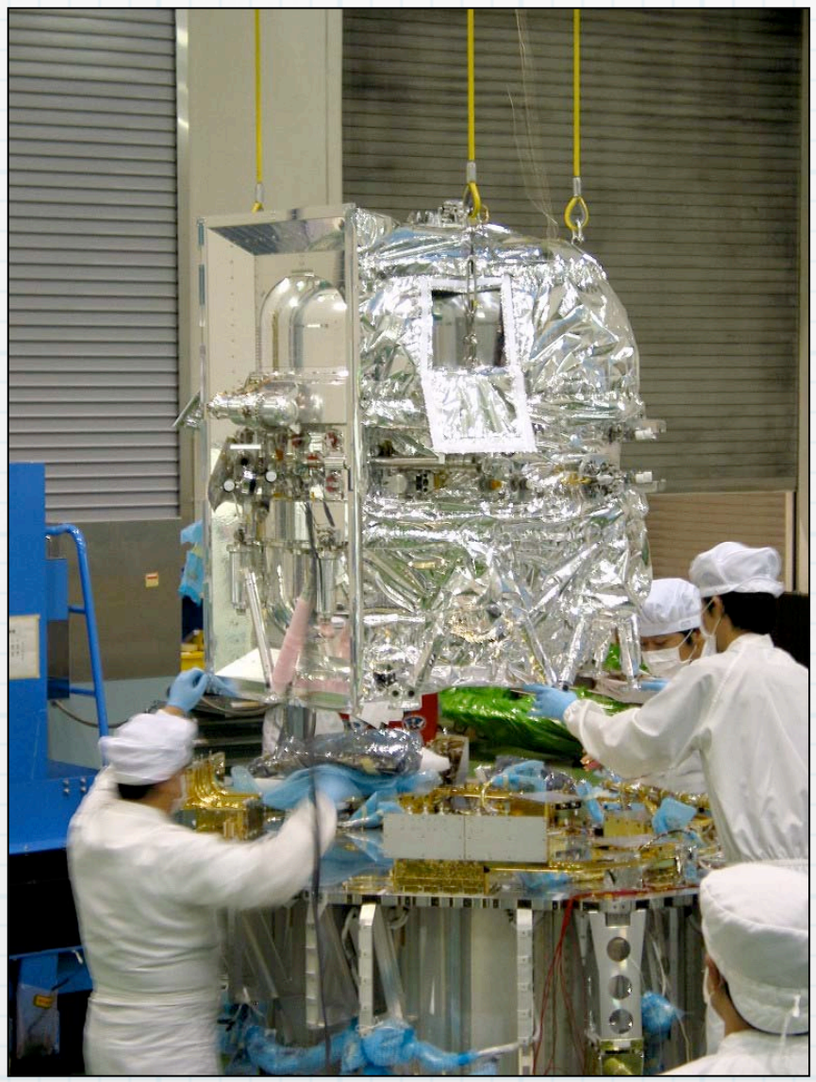
XRS
NASA/GSFC-Wisconsin
-ISAS/JAXA-TMU

XIS (4 units)
MIT-Kyoto-Osaka -
ISAS/JAXA

The high resolution X-Ray Spectrometer (XRS)







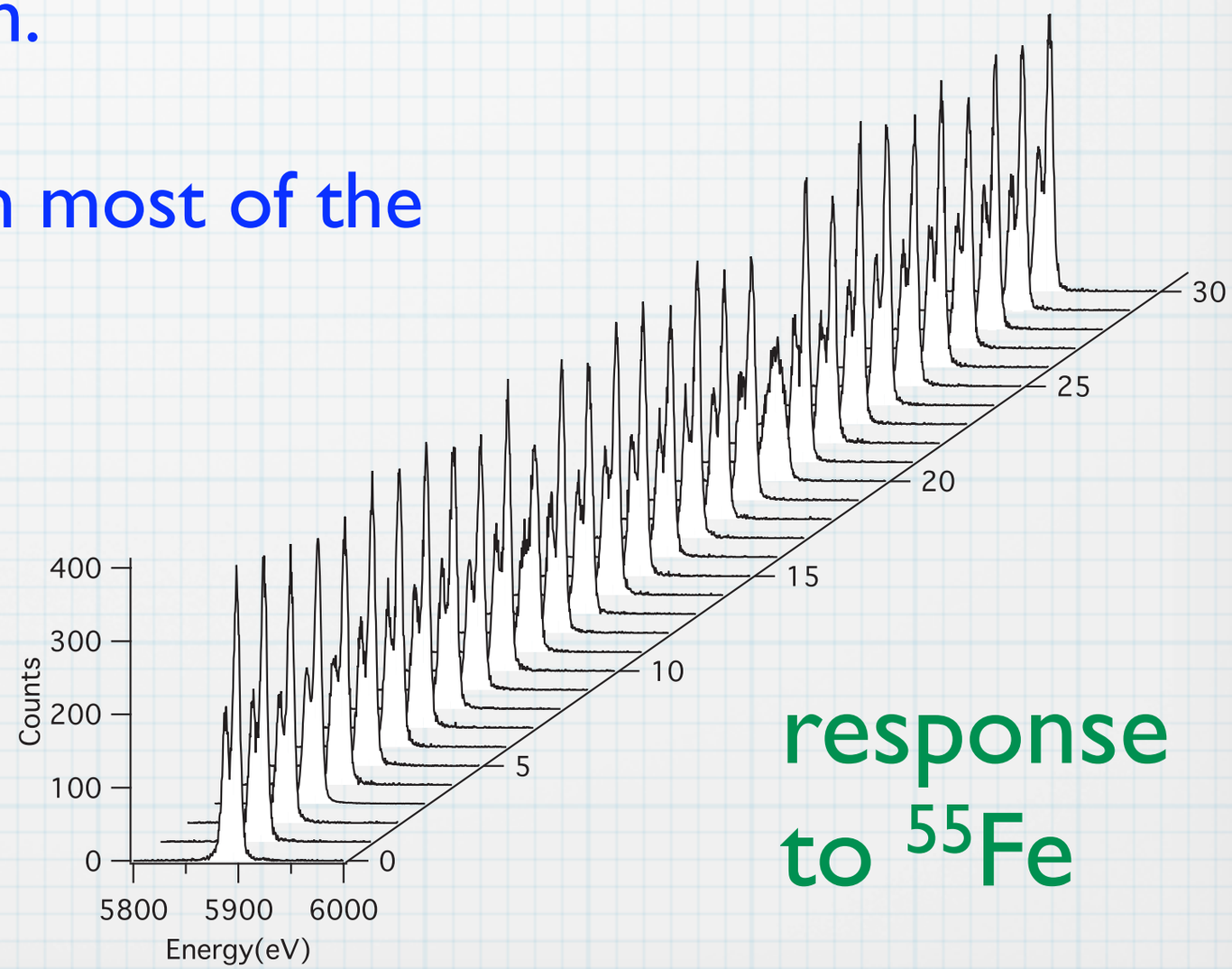
XRS Pre-launch Performance

Finished assembly and cooled in July 2004.

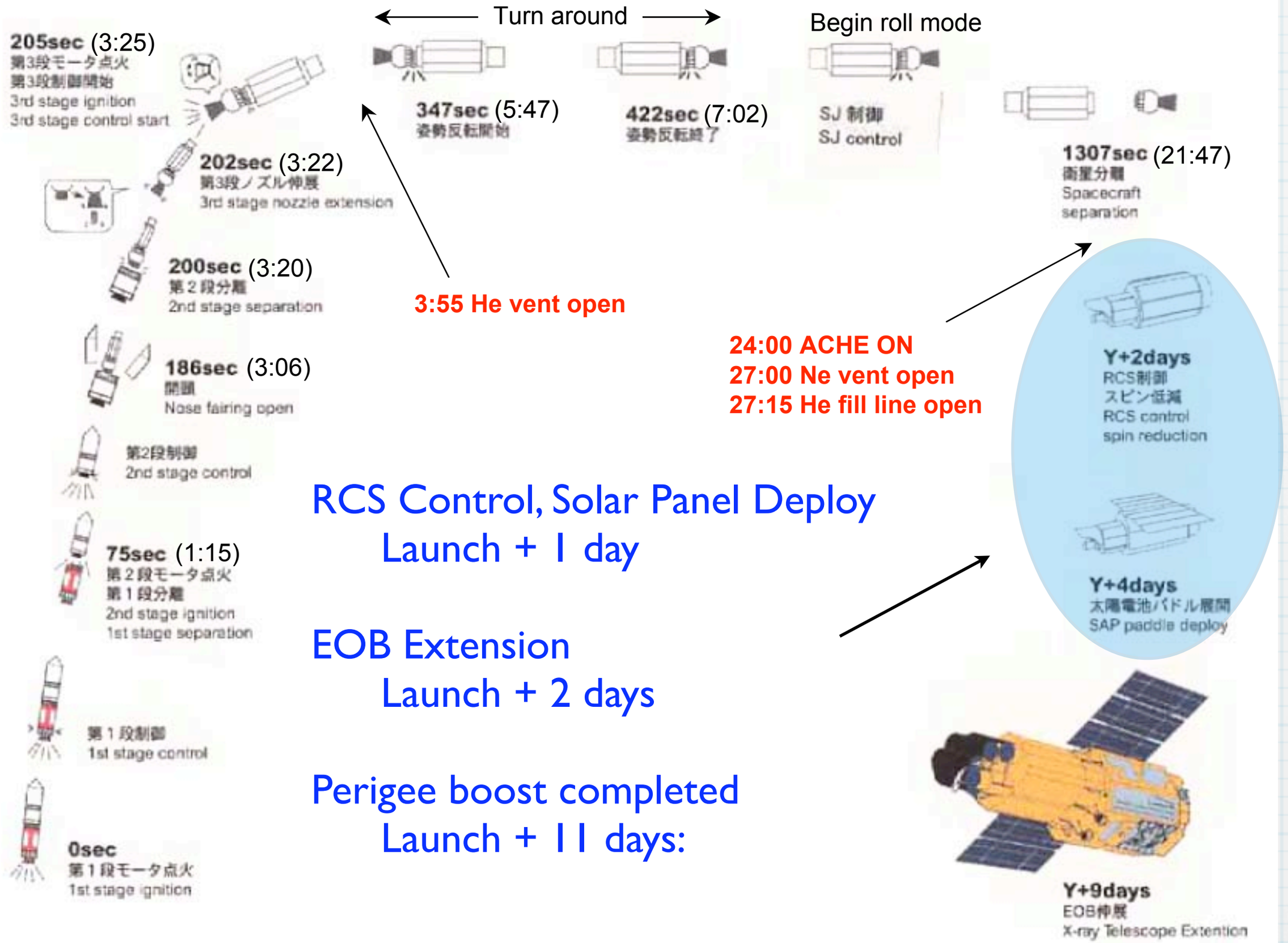
Calibrated, tested, and excellent operation for about one year prior to launch.

~ 6 eV (FWHM) resolution on most of the array.

He and Ne heat loads were such that > 3 year lifetime was expected.



response to ^{55}Fe



RCS Control, Solar Panel Deploy
Launch + 1 day

EOB Extension
Launch + 2 days

Perigee boost completed
Launch + 11 days:

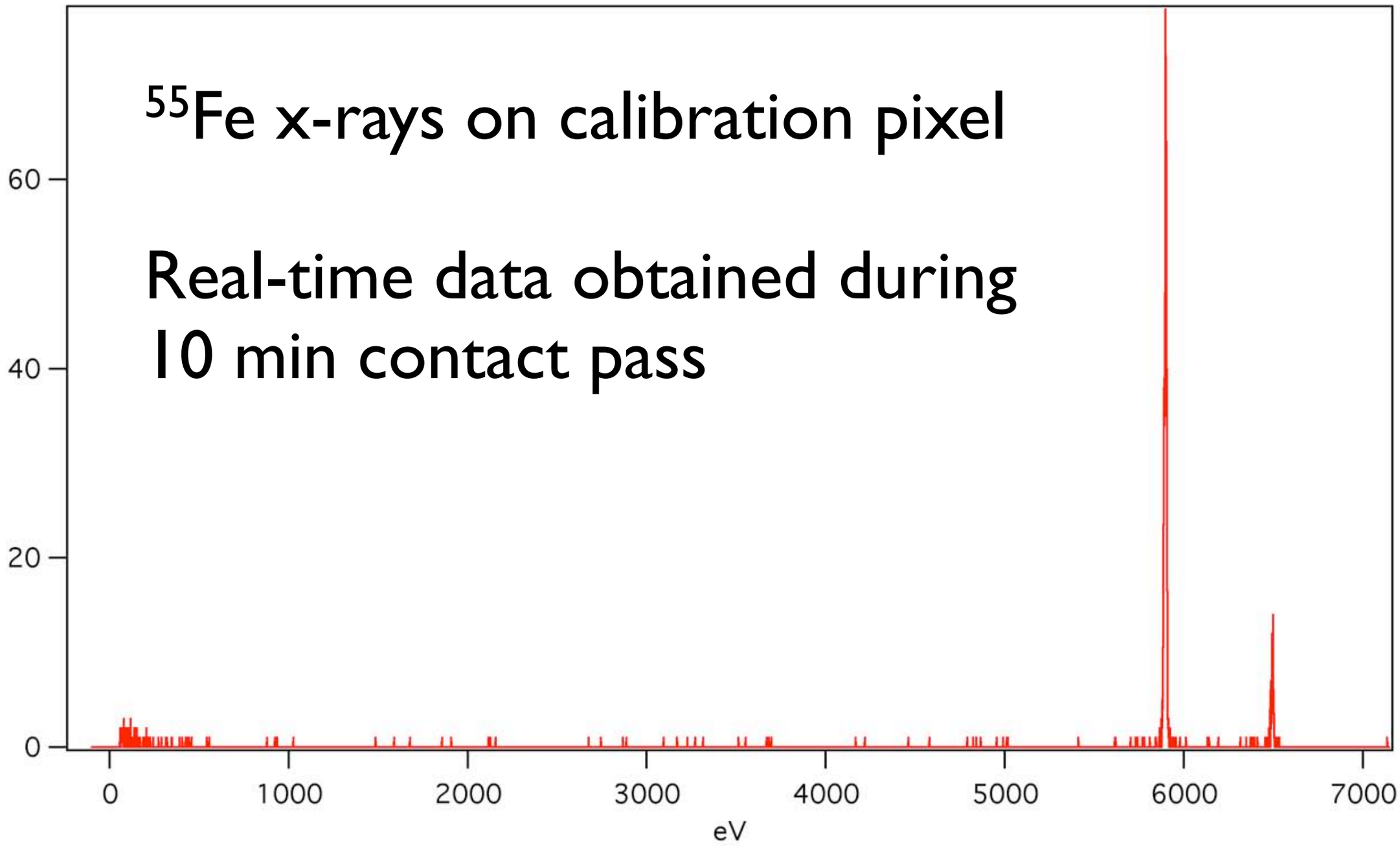
Final orbit: 566 x 569 km, 31 deg

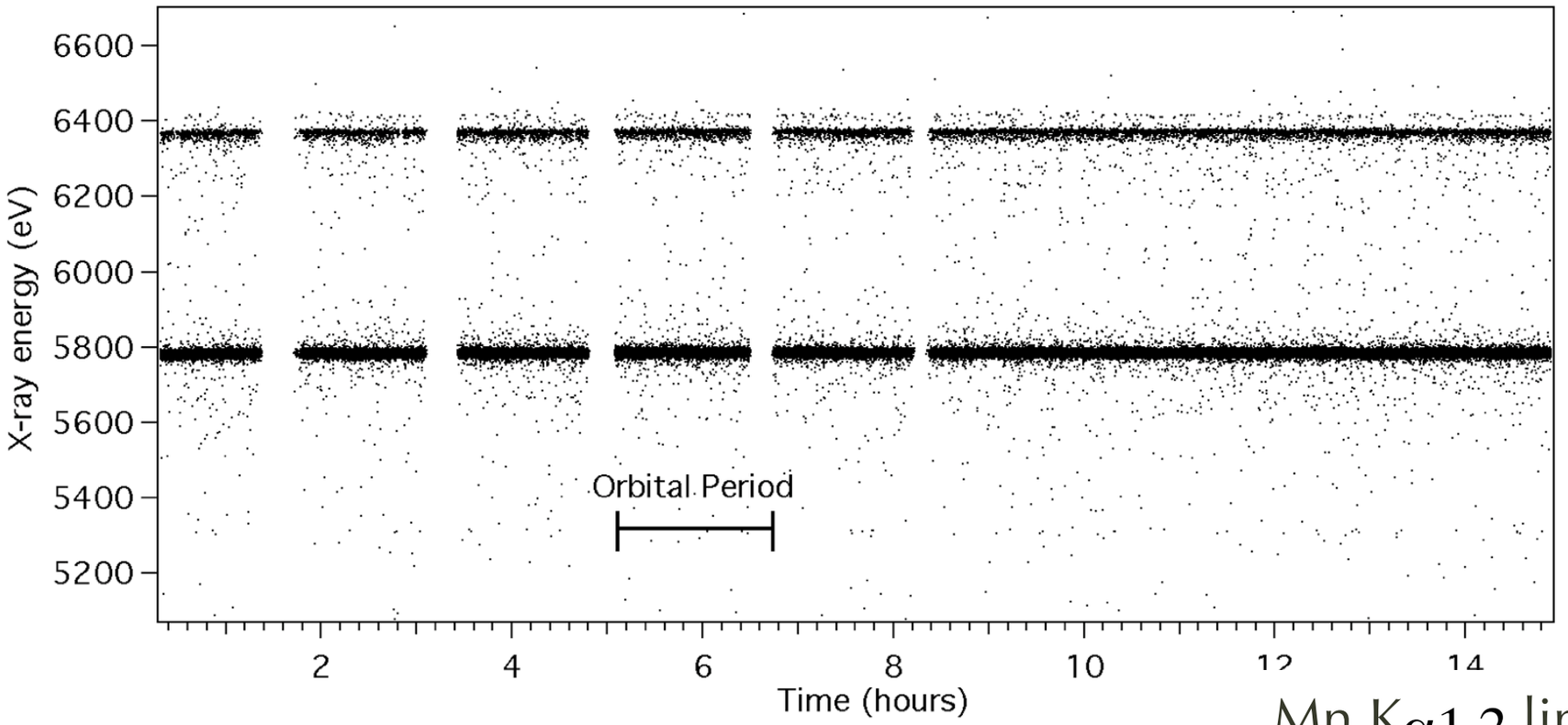
Initial XRS post-launch operations were excellent:

- Heat load on He tank was as expected, so > 3 years
- Stirling-cycle mechanical cooler is working well
- anticoincidence detector is working well
- ADR cooled to 0.060 K; 38 hours hold time, 50 min recharge time (97.8% duty cycle.)
- microcalorimeter array performance was nominal

^{55}Fe x-rays on calibration pixel

Real-time data obtained during
10 min contact pass



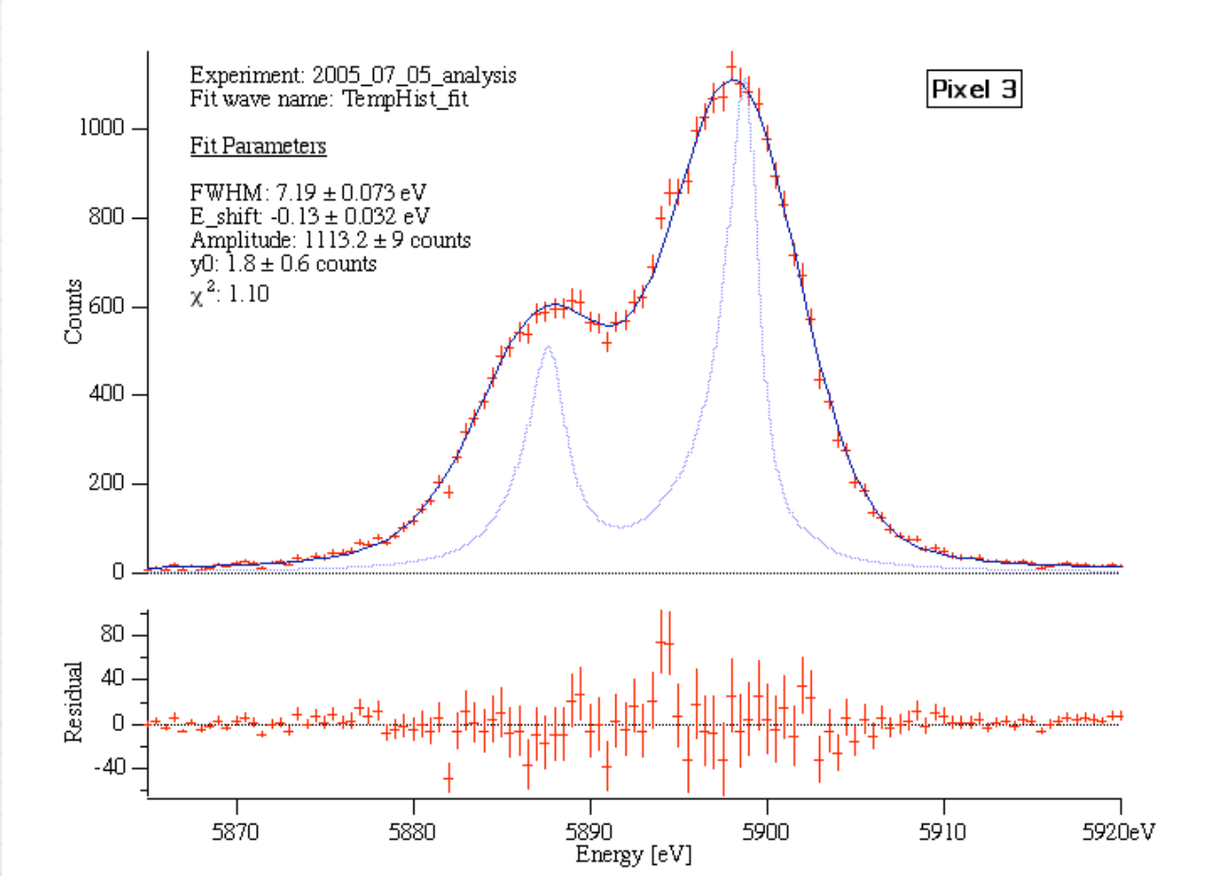


Mn Kα1,2 line easily resolved in orbit

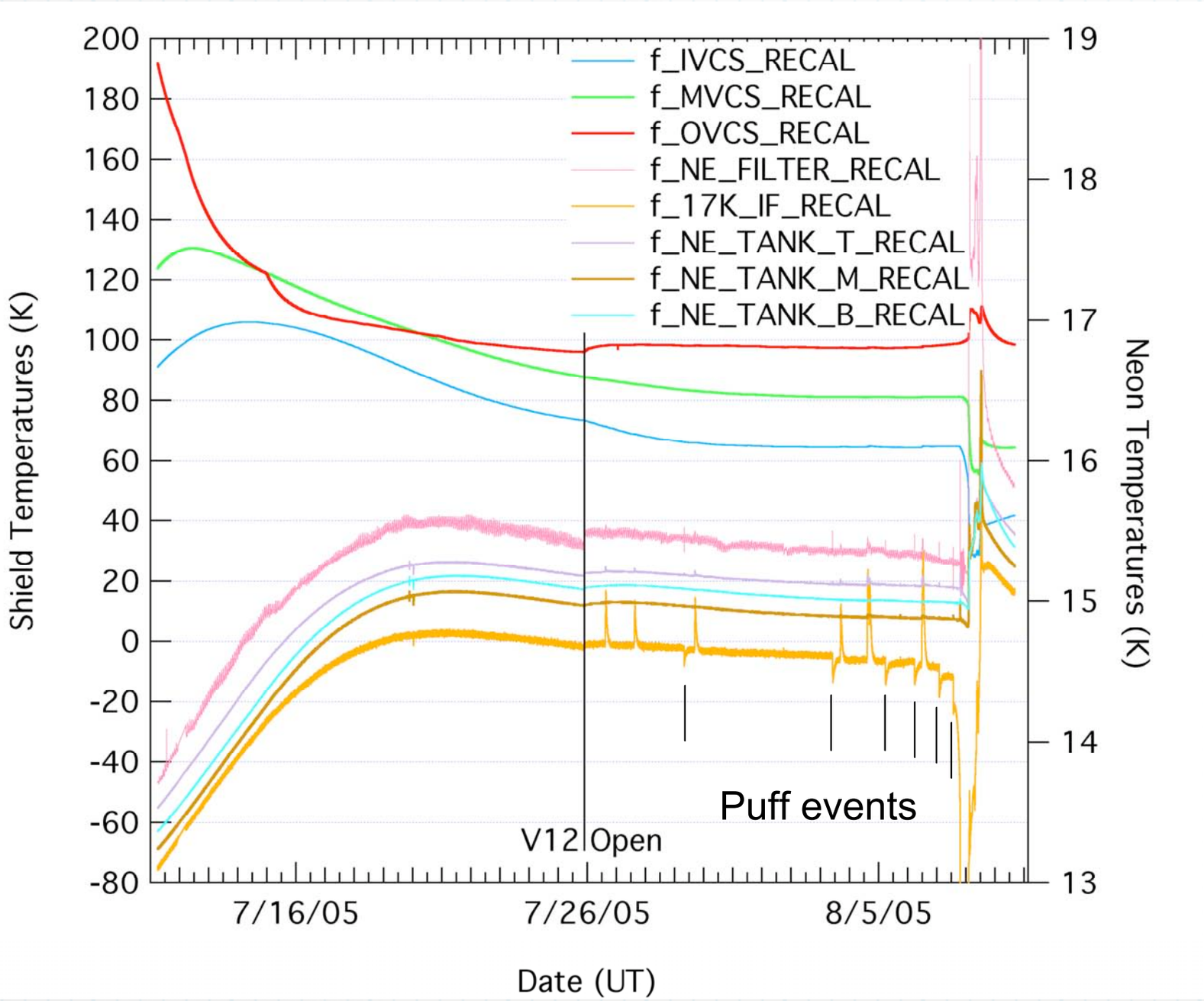
Gain is very stable

- ☑ No heating from SAA passage or day/night effects
- ☑ No particle activation

Energy resolution of 7 eV (FWHM) achieved. Other pixels gave same performance using Filter Wheel cal source.



What happened?



After ~ 16 days in orbit, dewar vacuum vent valve was opened, as planned.

A few days later, He dewar experienced periodic heat load spikes that became more frequent. Eventually lost He on August 8.

Appears that there was a problem with venting of the He and Ne cryostats to space. Dewar vacuum compromised.

NASA and JAXA investigations underway.

Unfortunately, no science with the XRS, but...

New technology proven in space:

X-ray microcalorimeter energy resolution performance demonstrated.

New type of anticoincidence detector worked perfectly, and in fact still is.

No cumulative radiation effects observed on microcalorimeter array or JFETs.

Gain drift was small and easily correctable.

Low temperature technology (adiabatic magnetic refrigerator) cooled array to 60 mK and worked perfectly. Carried out 6 ADR cycles. Mechanical cooler is operating properly.

Prior to opening dewar vent, estimated cryogen lifetime was well over 3 years.

We at least have a strong engineering success, vital for future microcalorimeter missions.

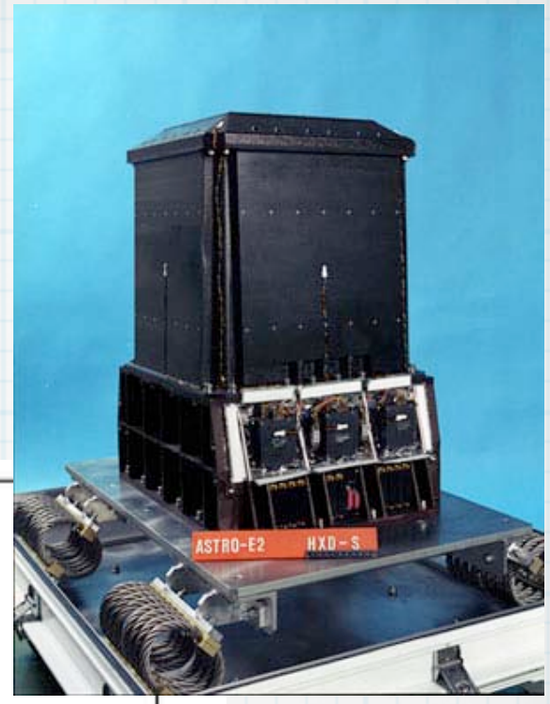
and... there's a lot more to Suzaku!

Suzaku Now

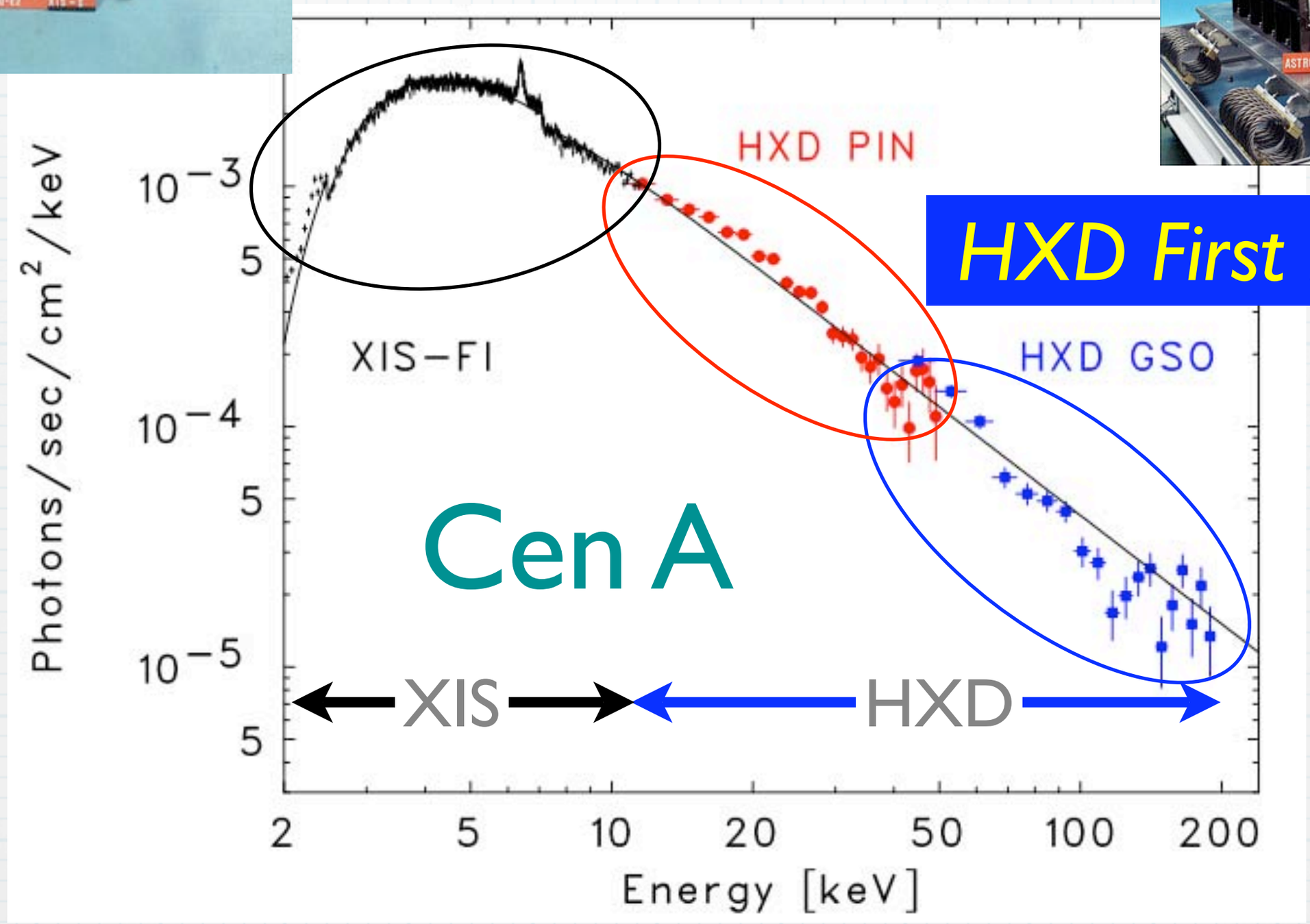
Wide-band X-ray spectroscopy:

- ~1000 cm^2 effective area 1-6 keV
- Low background
  - Much lower stray light than ASCA mirrors
- Good energy resolution
- Improved line spread function on low energy side, particularly important <1 keV

Power of *Suzaku*: very broad-band

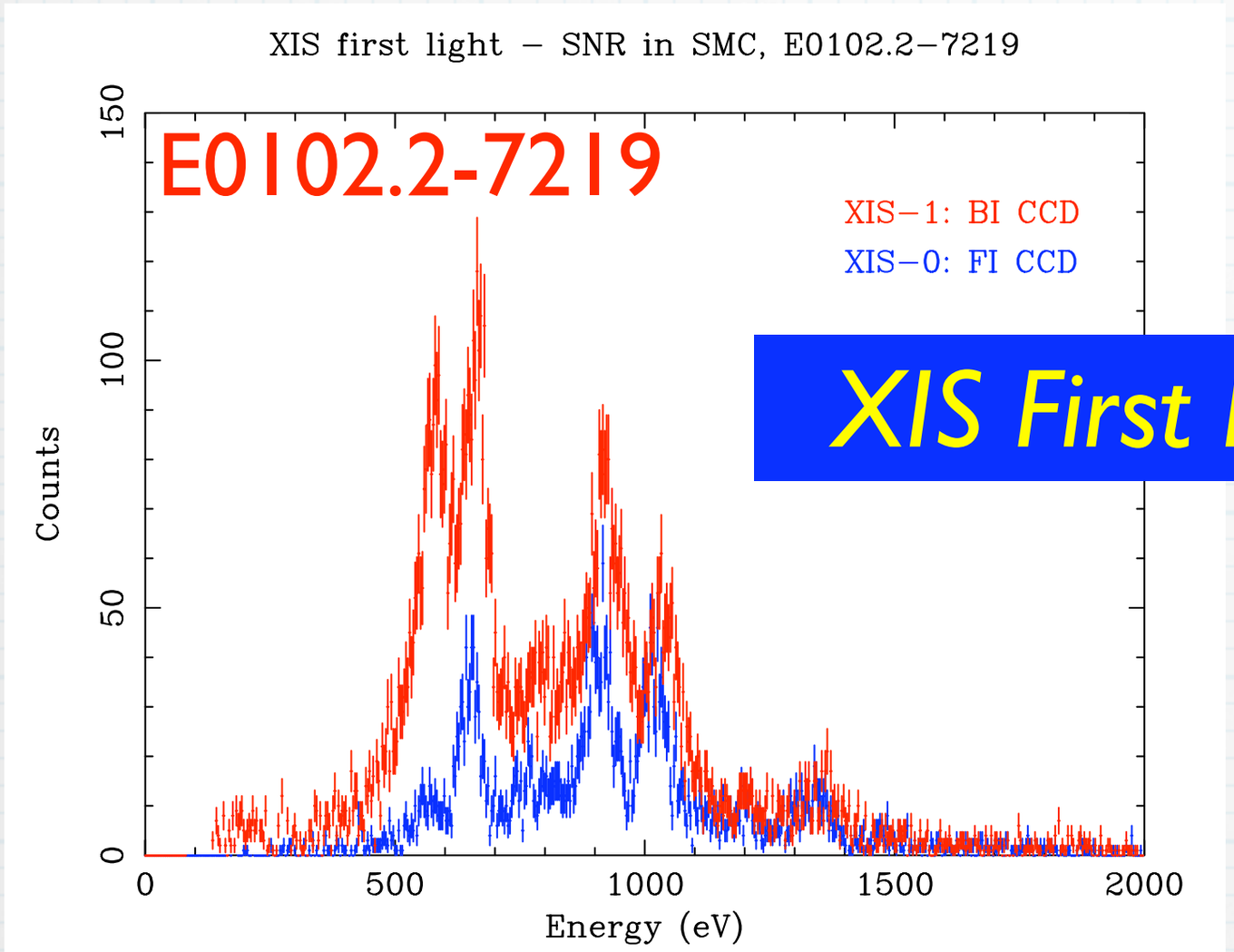


HXD First Light!

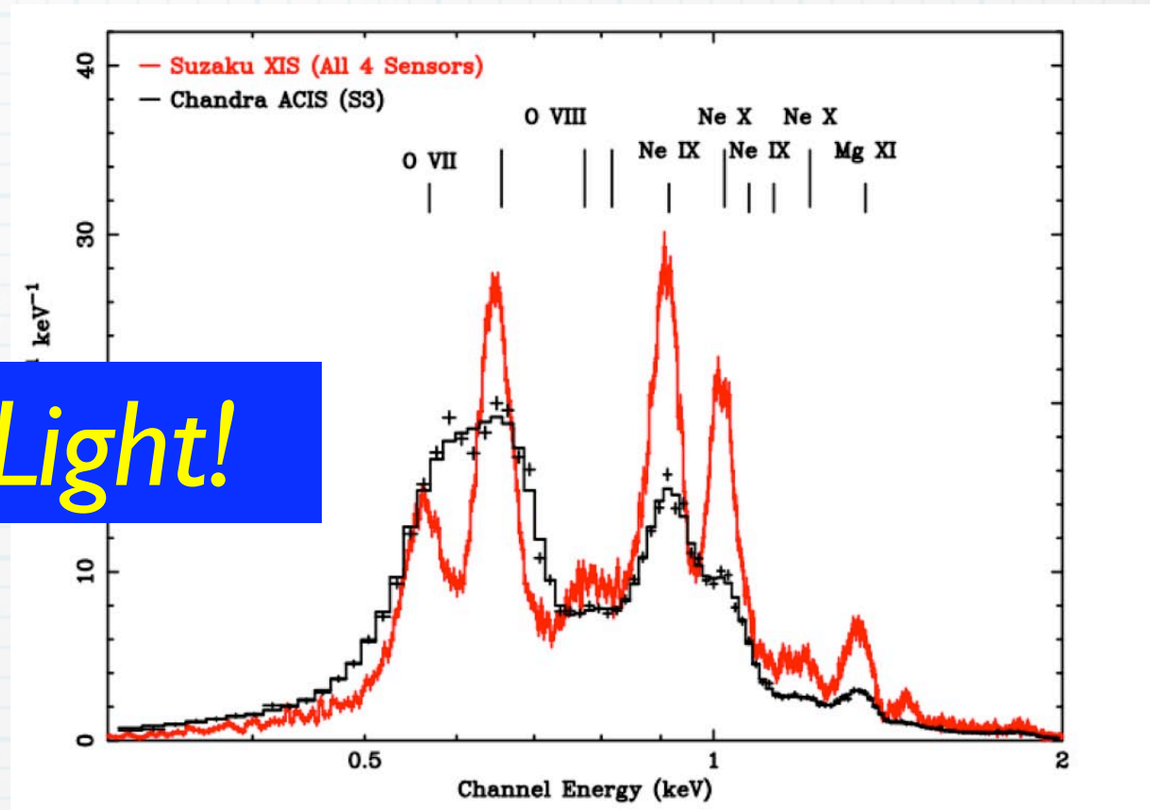


Suzaku Team, preliminary

New Capabilities Offered by Suzaku/XIS



XIS First Light!



Front and Back-illuminated CCD's

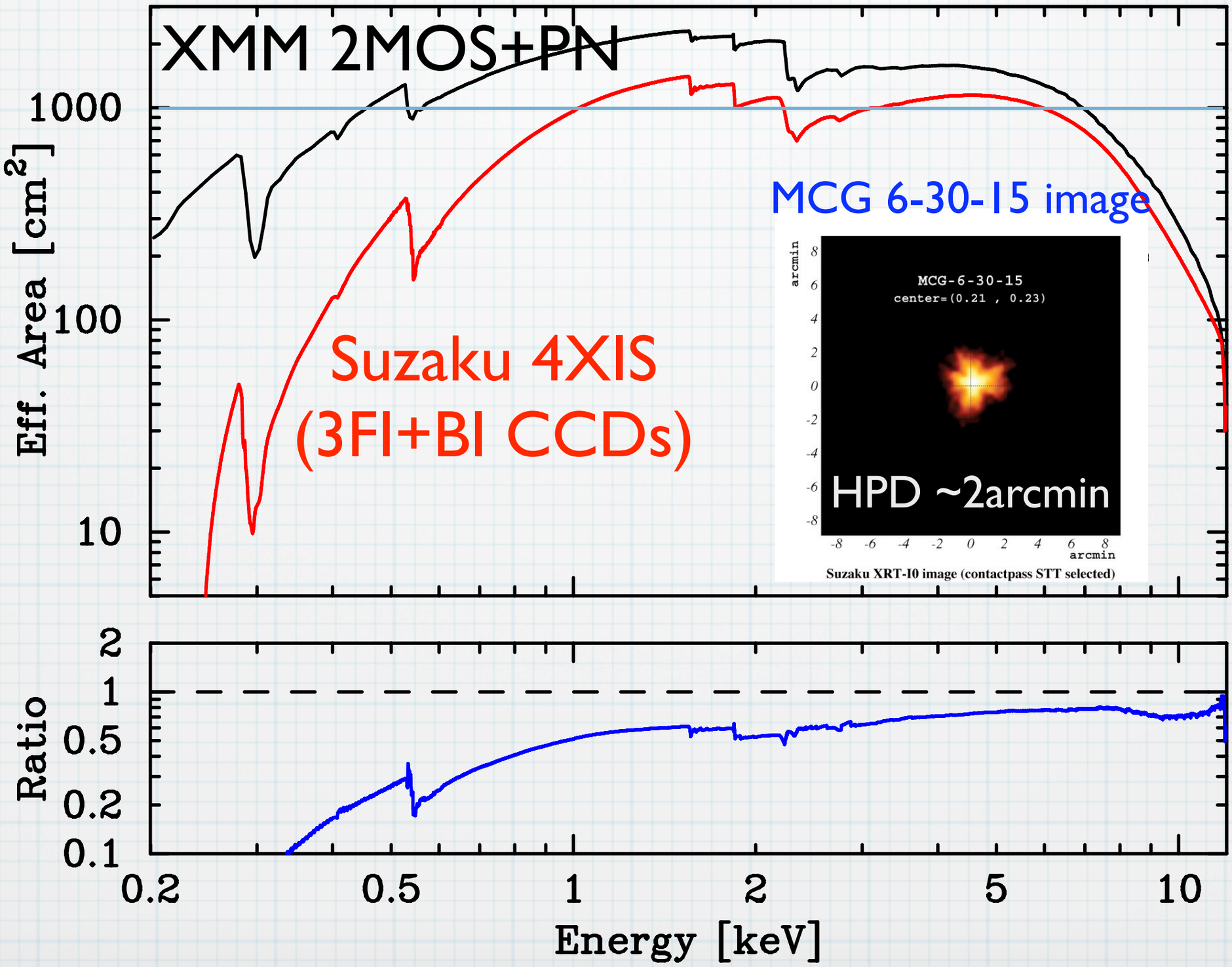
Suzaku Team, preliminary

Comparison of *Suzaku* (all 4 sensors) with Chandra/ACIS (S3)

nice job, XIS team!

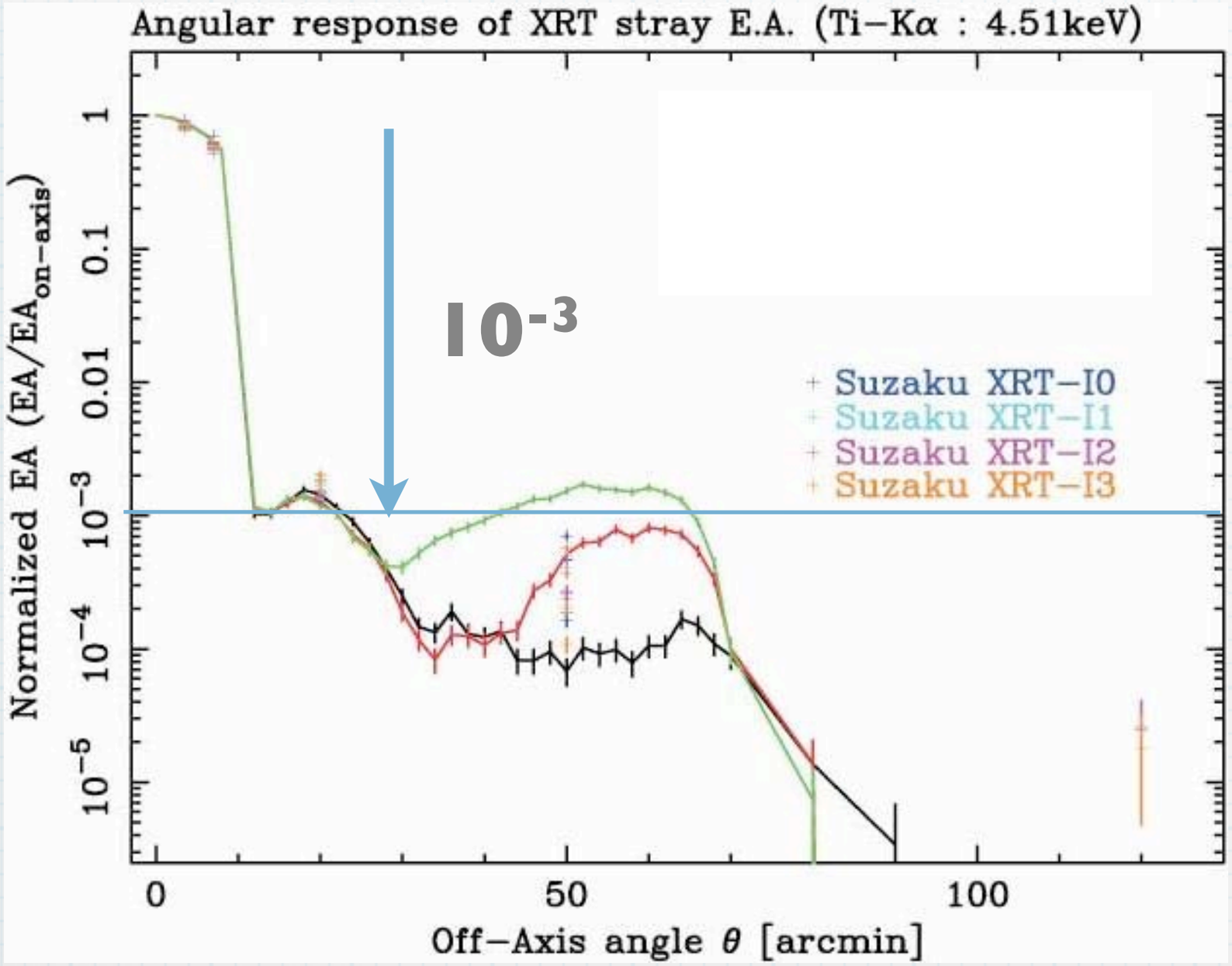
see Bautz et al. poster

Effective area



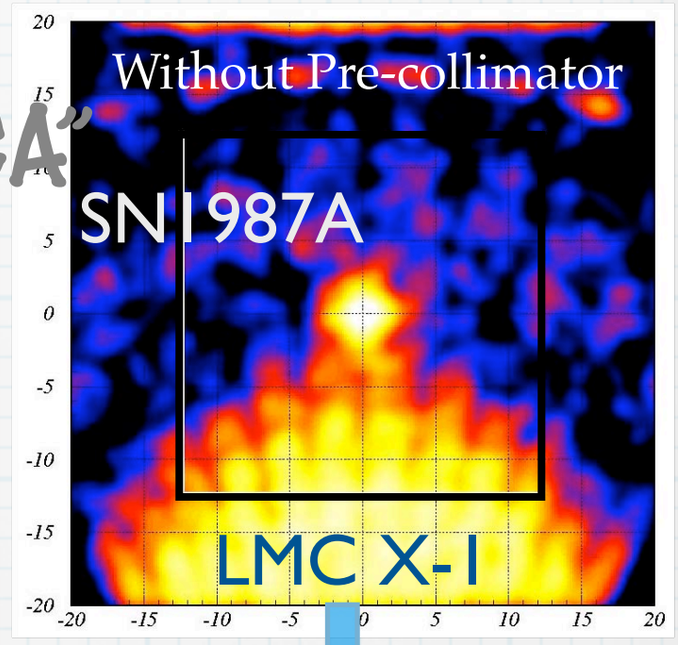
Stray light

* Much smaller stray light than that of ASCA by pre-collimators

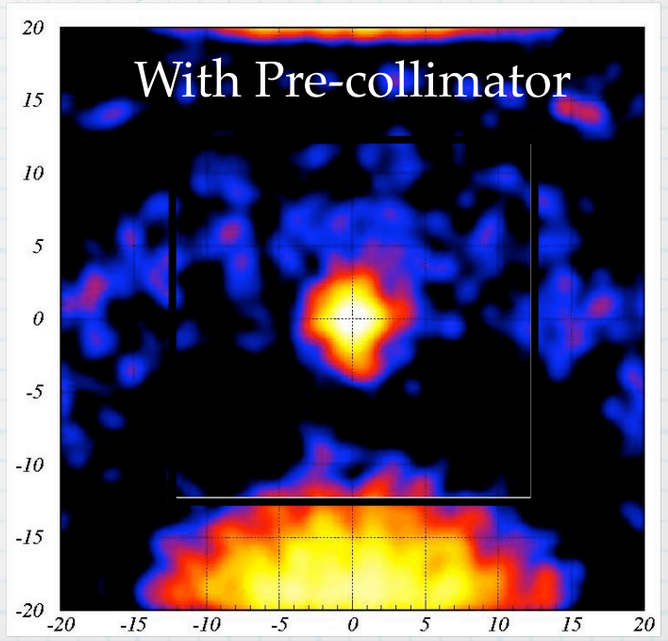


Ray tracing calibrated by ground measurements

"ASCA"

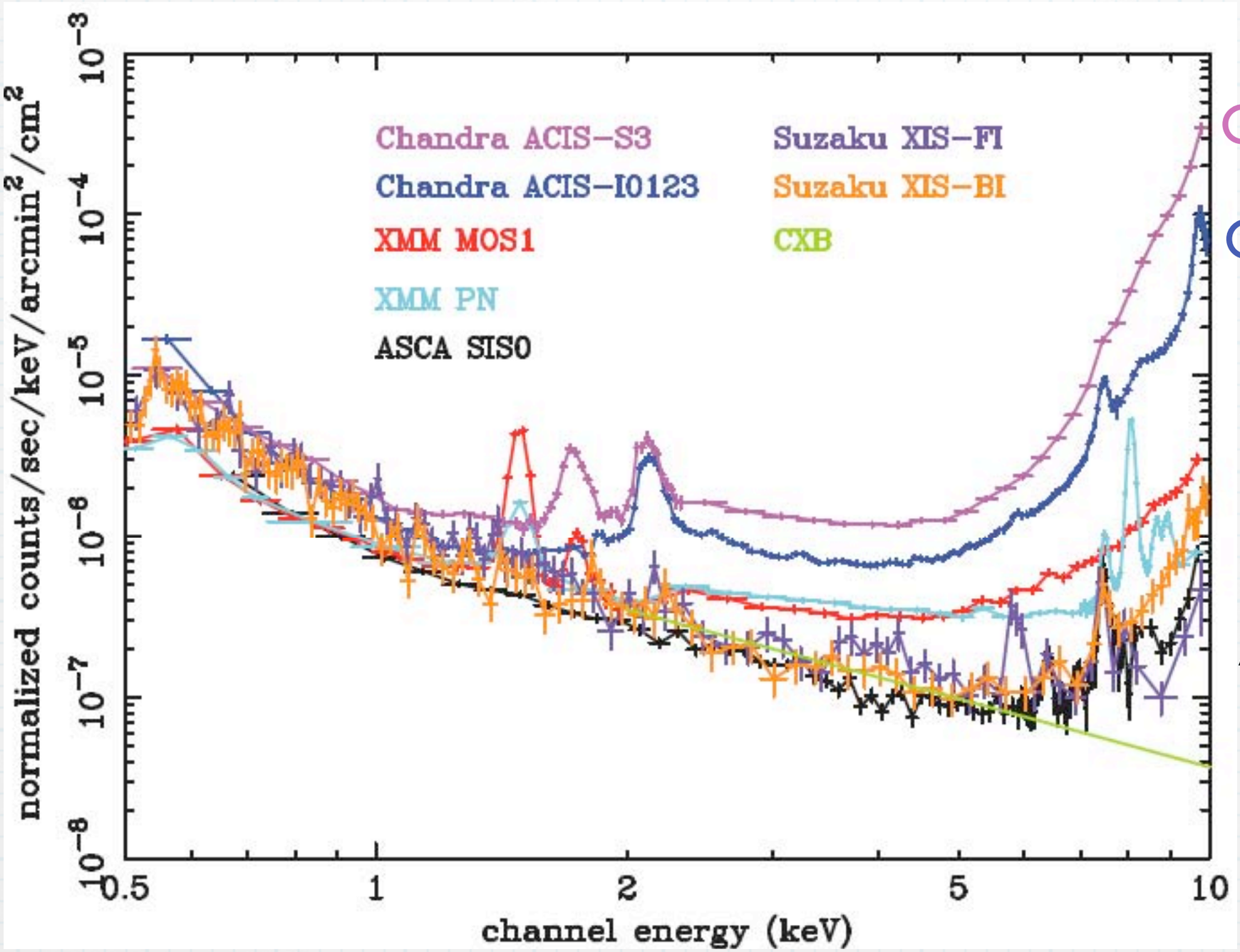


Suzaku



Low XIS background

Background normalized by effective Area and FOV



Chandra ACIS-S3

Chandra ACIS-I0-3

XMM MOS1

XMM PN

Suzaku BI

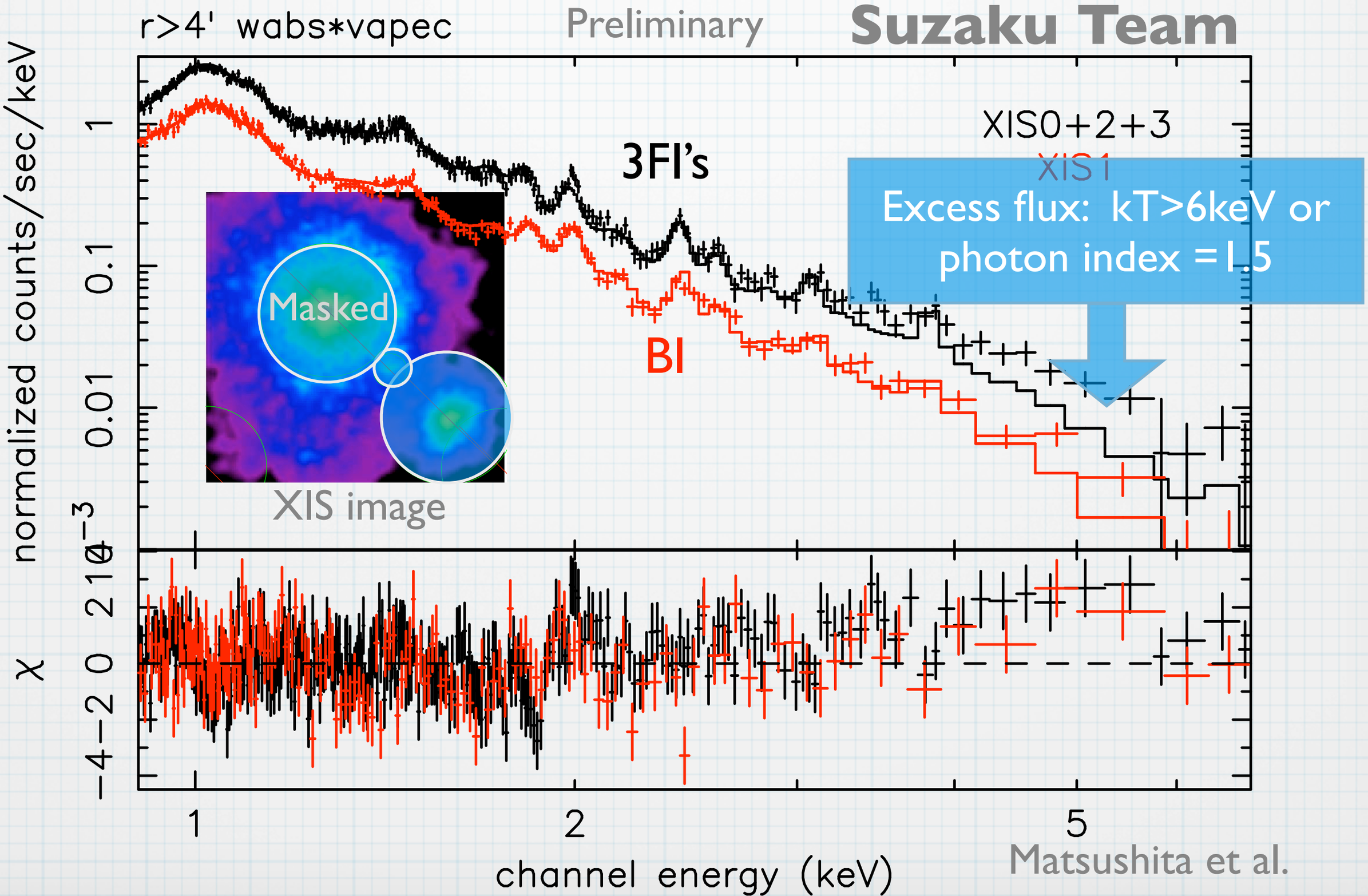
Suzaku FI

ASCA SIS

Suzaku XIS background is comprable to that of ASCA SIS

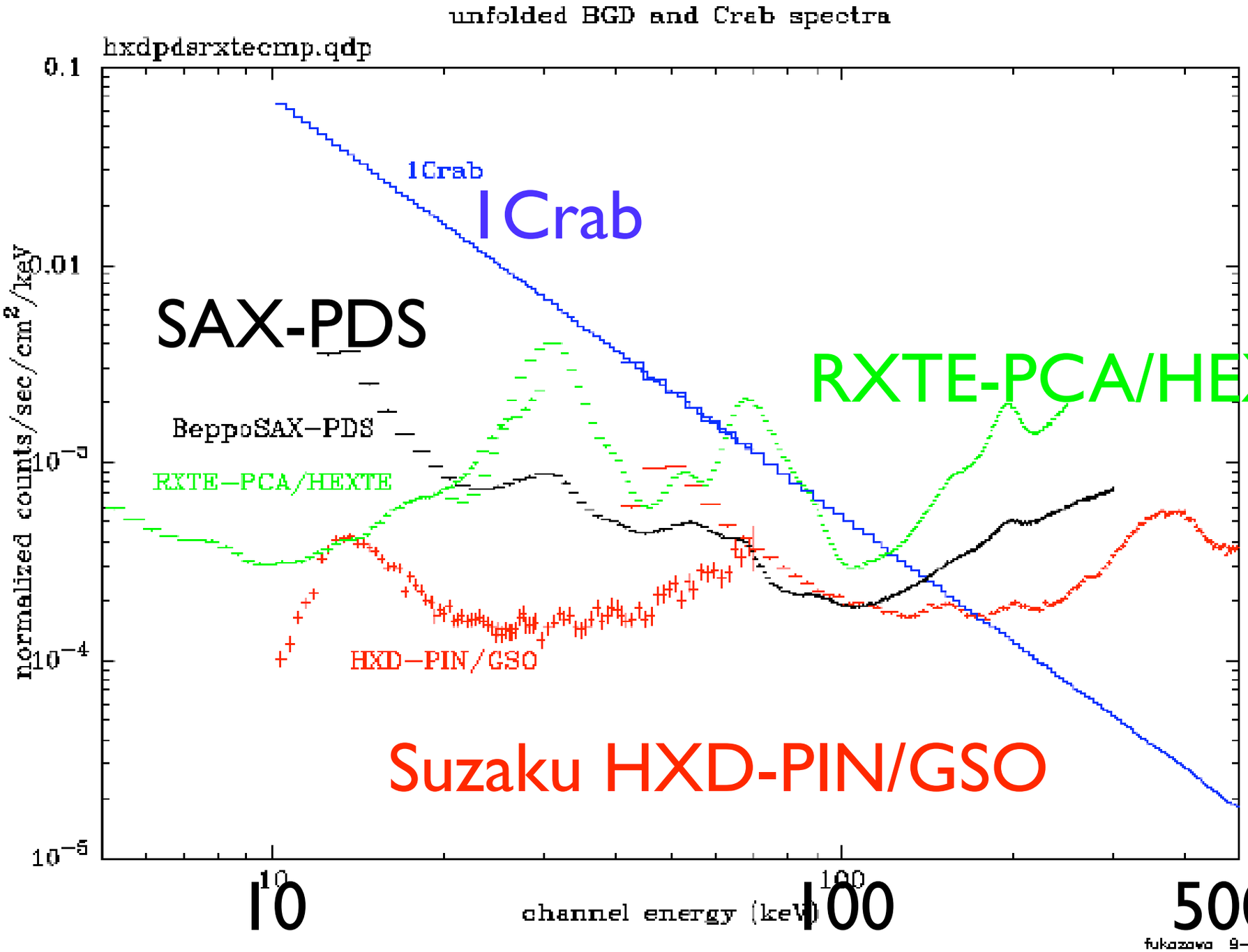
Low surface brightness

Fornax cluster r>4'



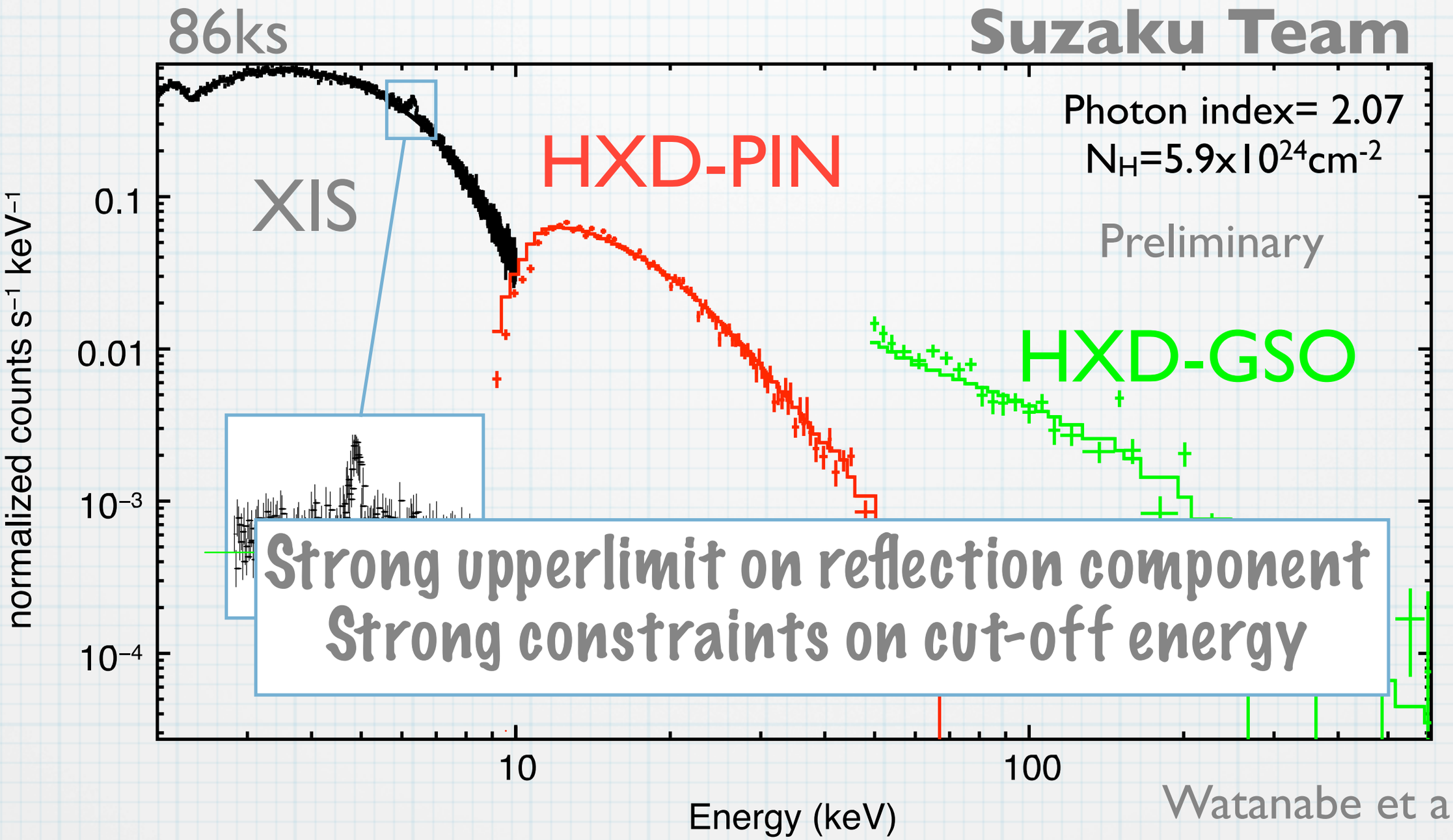
Low HXD background

Background normalized by effective Area



- Presently background can be estimated with an accuracy of 5%.
- Our goal is 1 %.

Sy2 Galaxy (NGC2110)

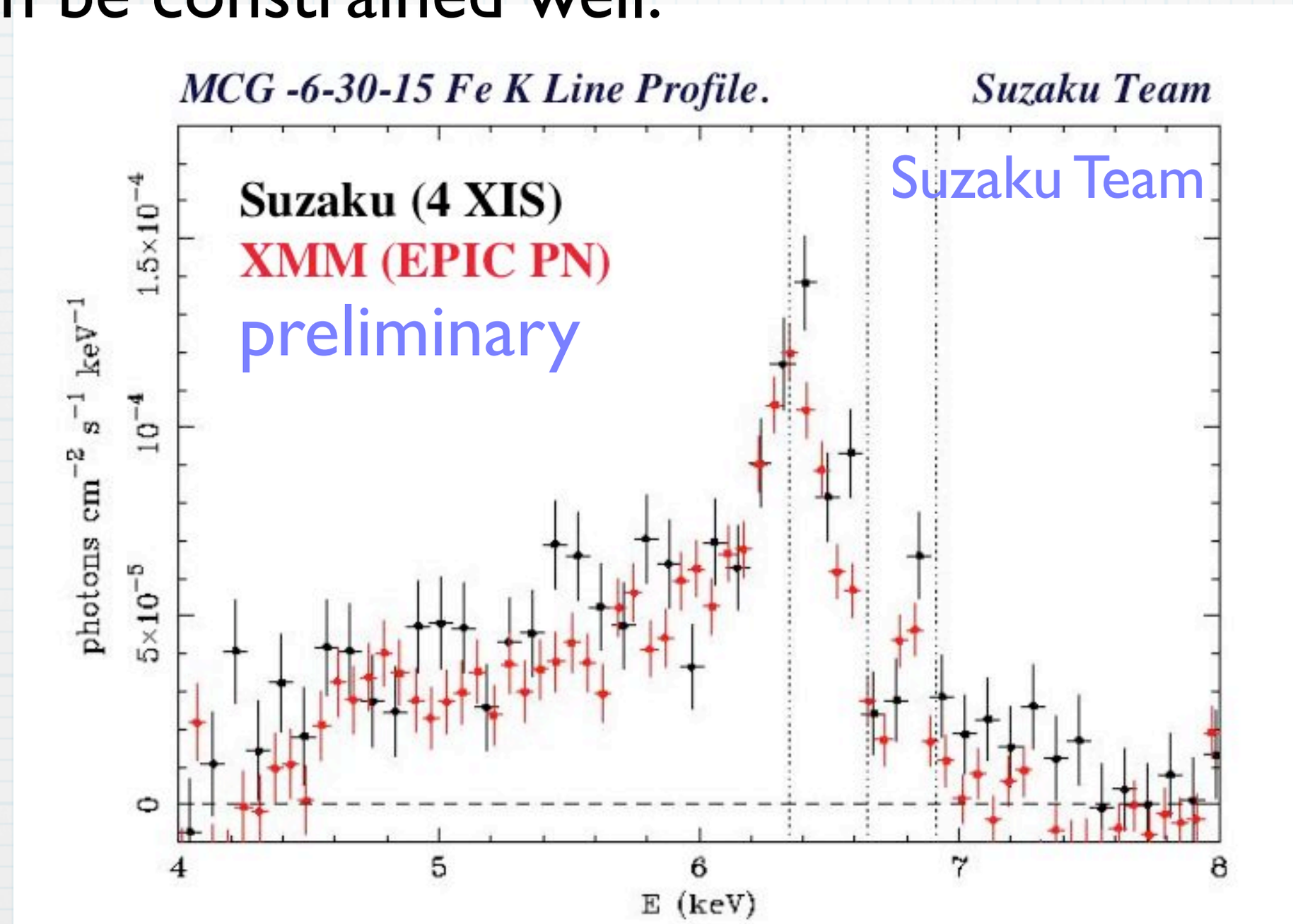


Watanabe et al.

GSO is detecting at least up to 200 keV

Spectral structures

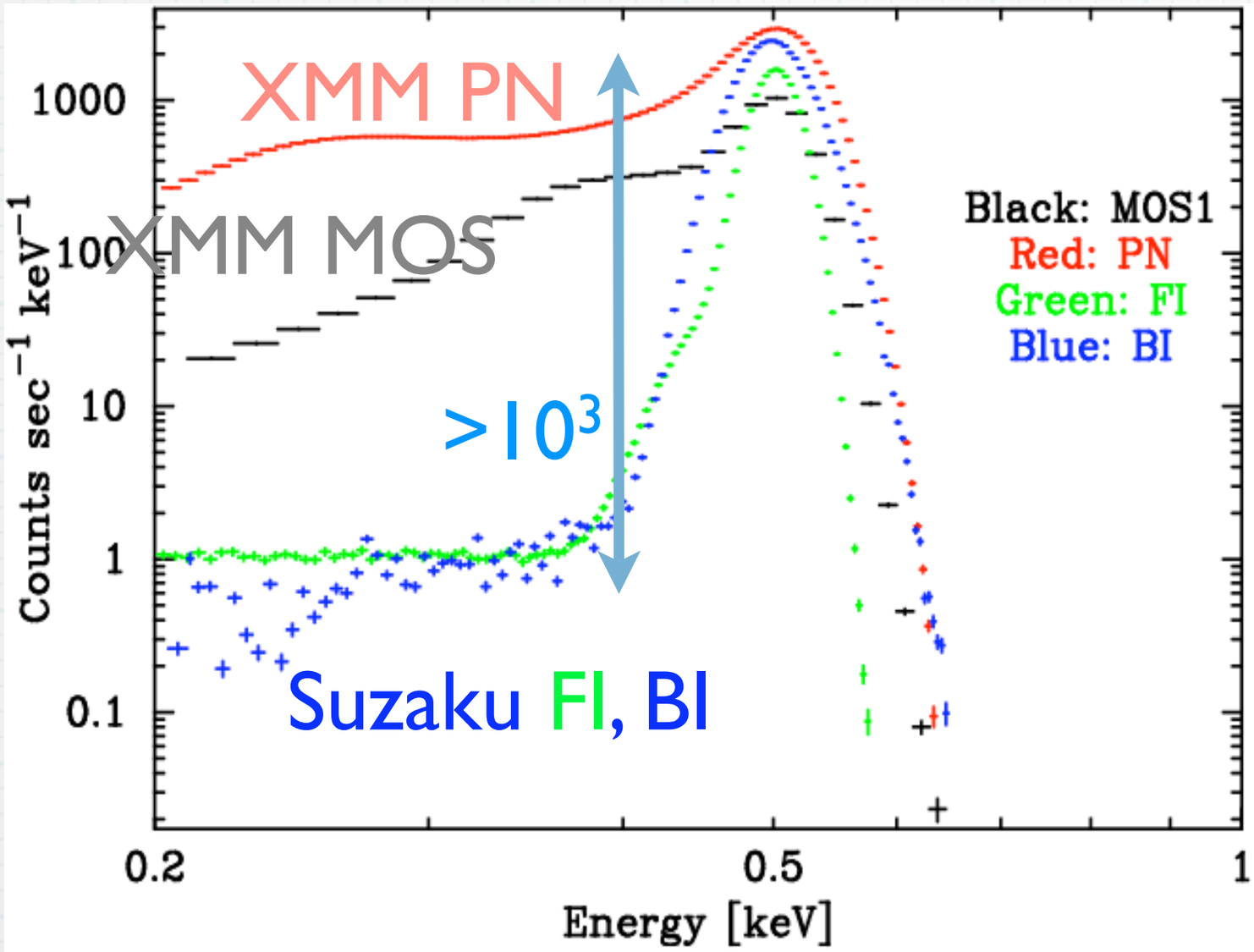
With the wide band coverage, continuum spectra can be constrained well.



XIS energy response < 1keV
very low low-pulse-height tail

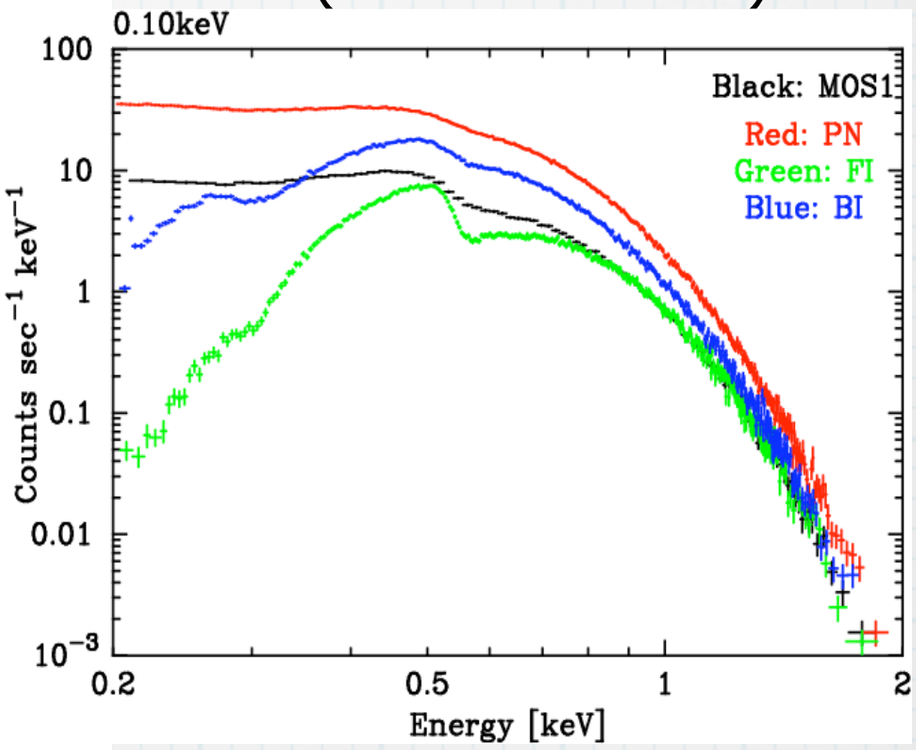
Thanks to MIT XIS team

Bautz et al. (Poster 190)



0.1 keV Black body

(NH=2×10^{20}cm^{-2})

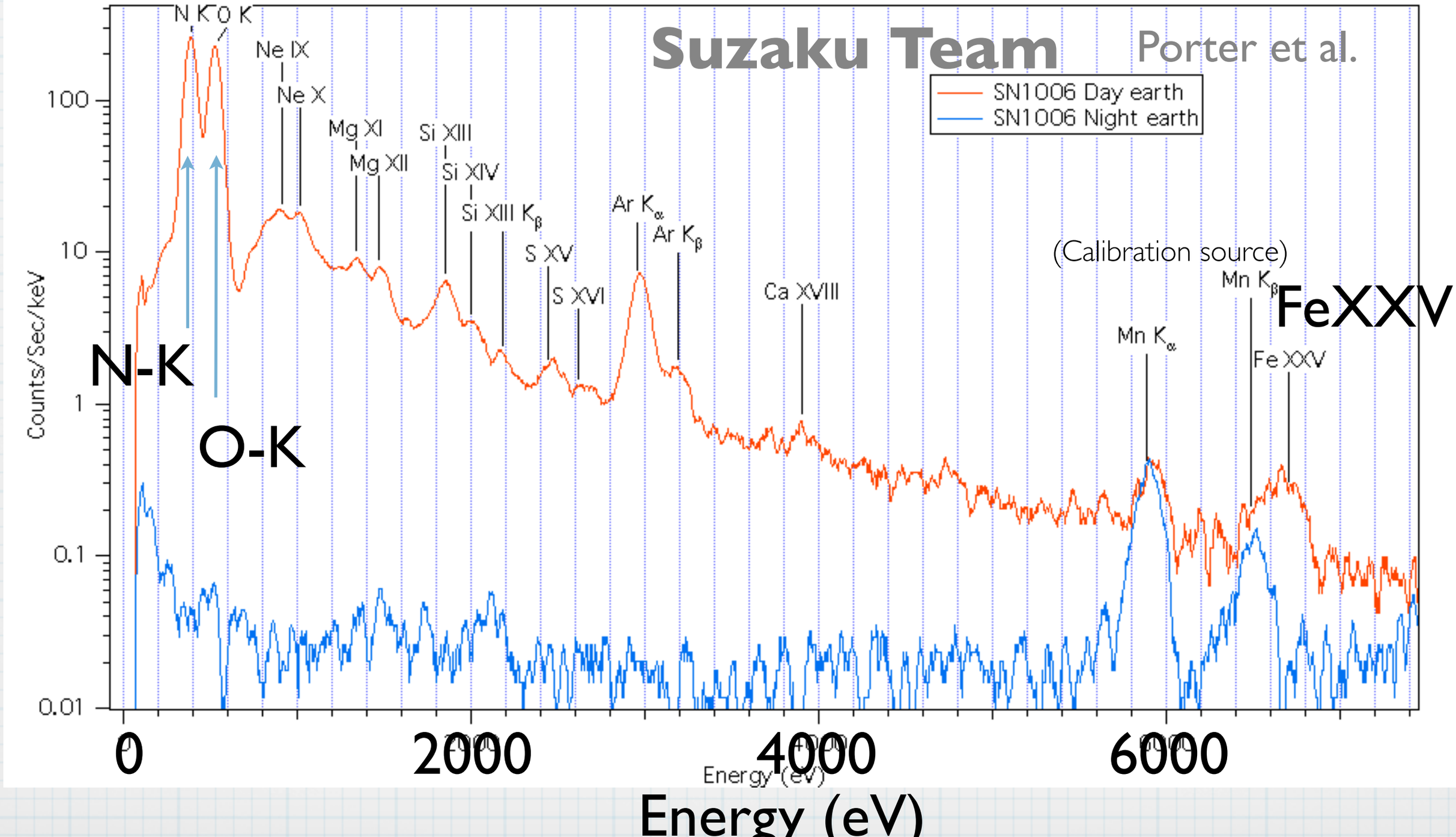


response for 0.5 keV monochromatic X-ray

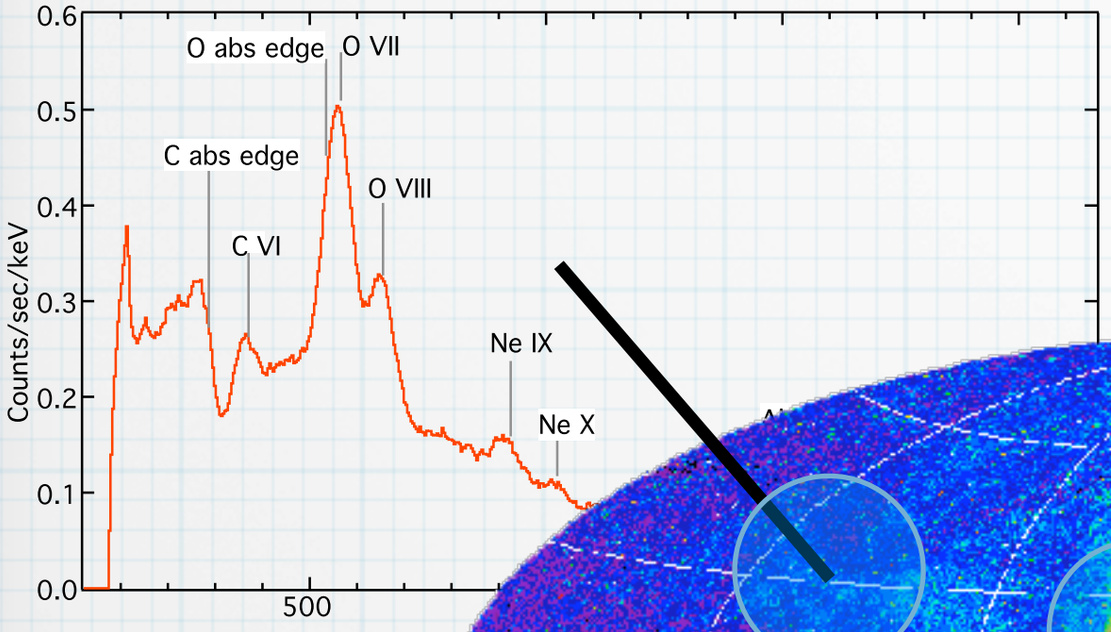
Good spectral response

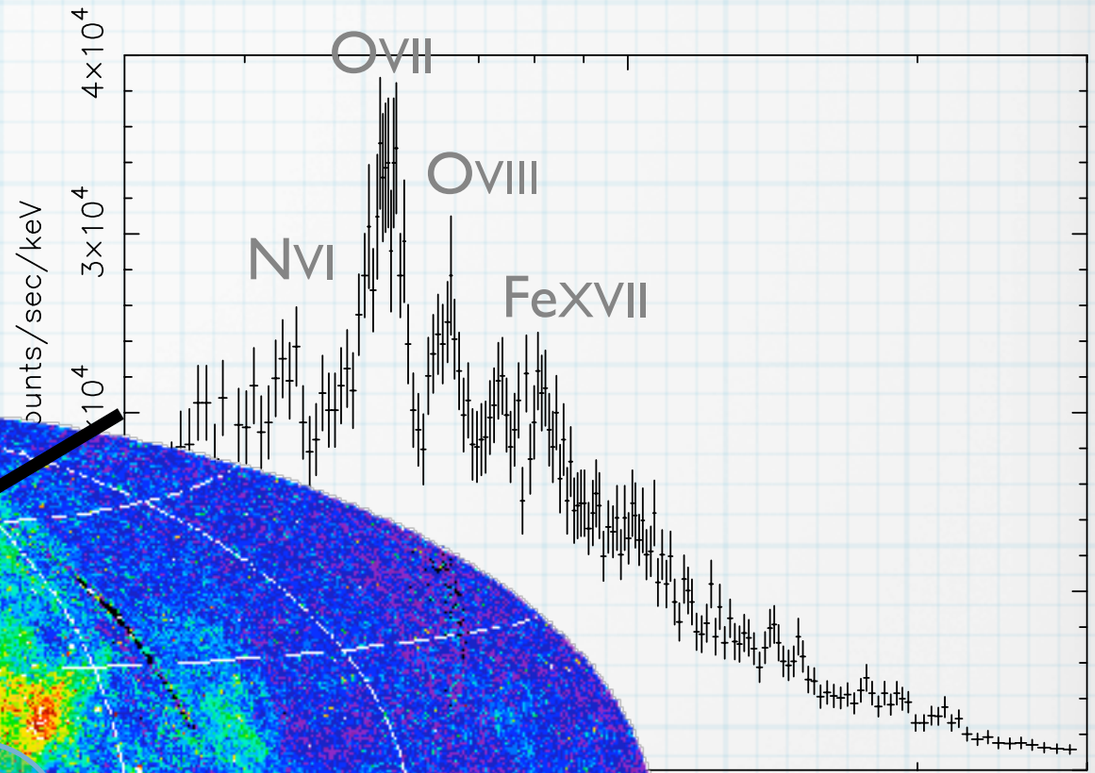
X-ray emissions from earth atmosphere

Emission lines, N-K, O-K, NeIX-K to FeXXV, are clearly visible

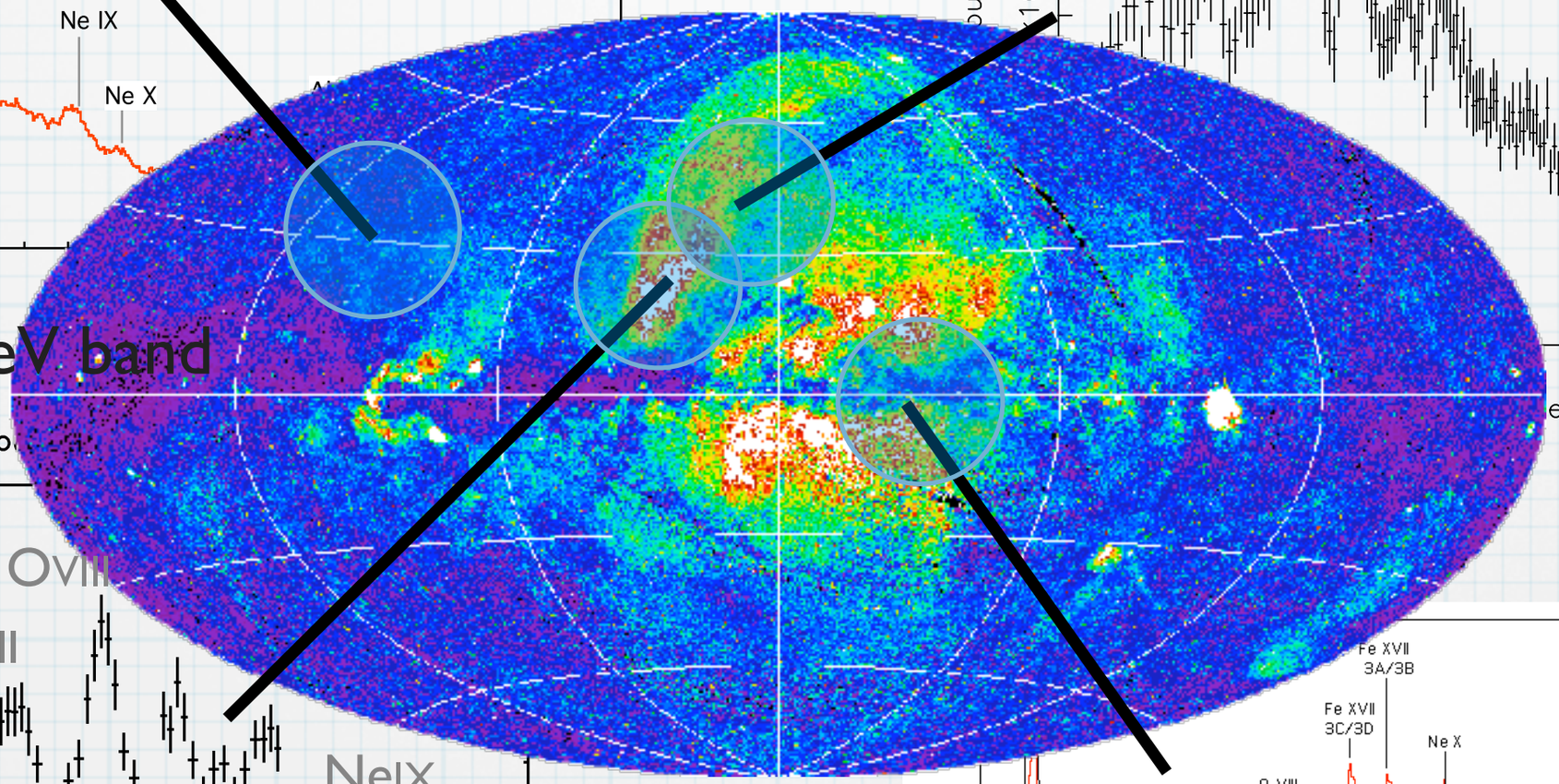


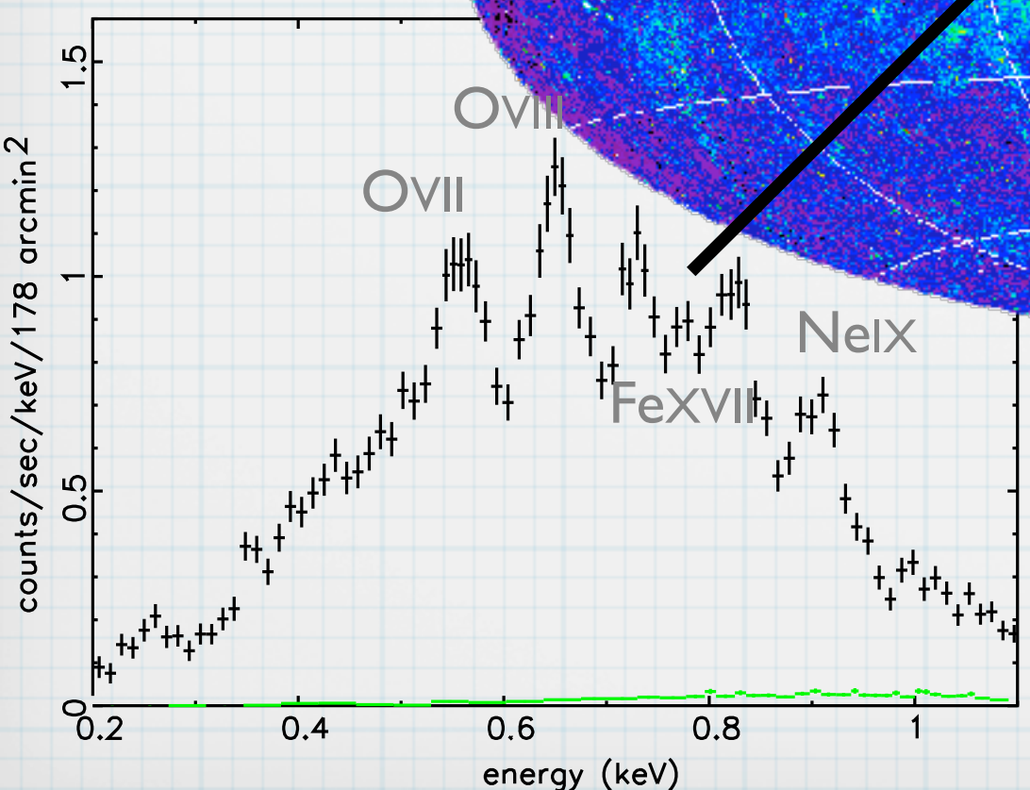
Spectacular spectra of hot ISM

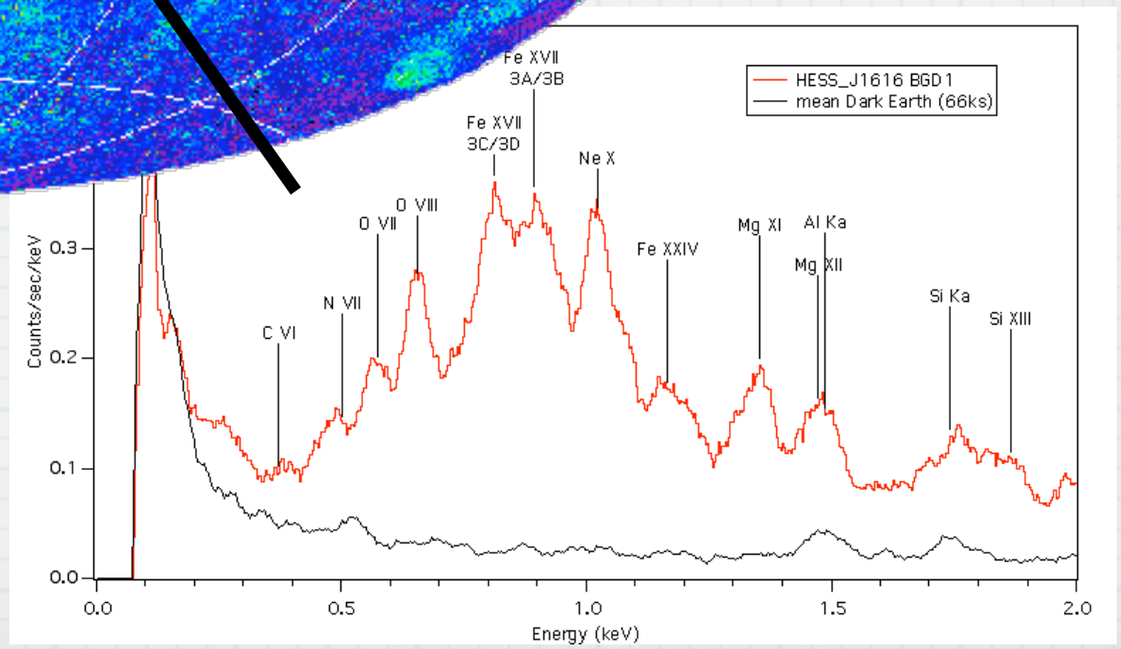




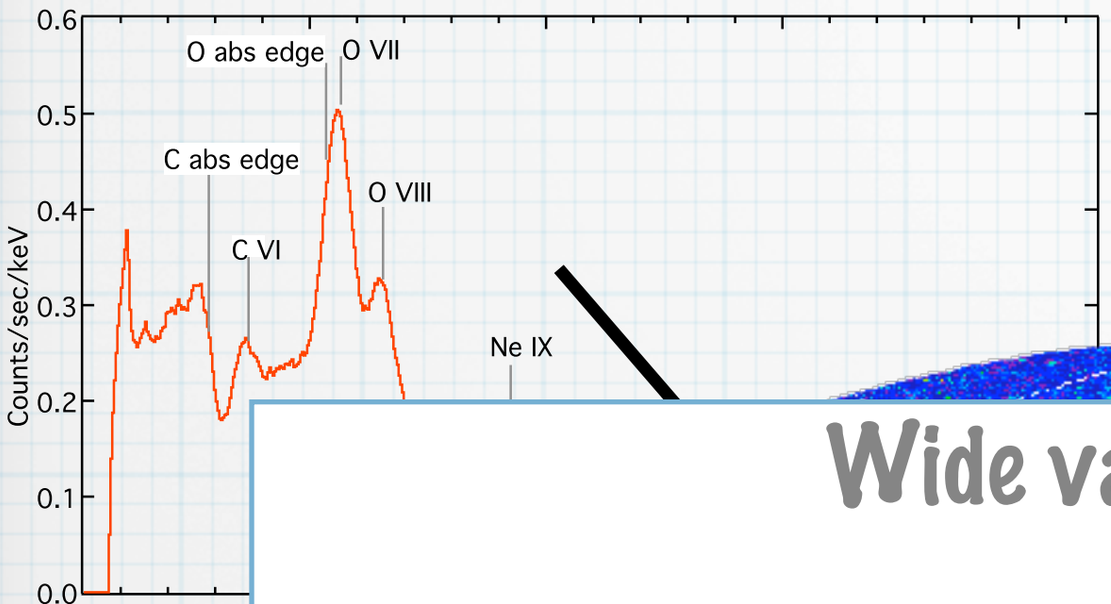
ROSAT 3/4keV band

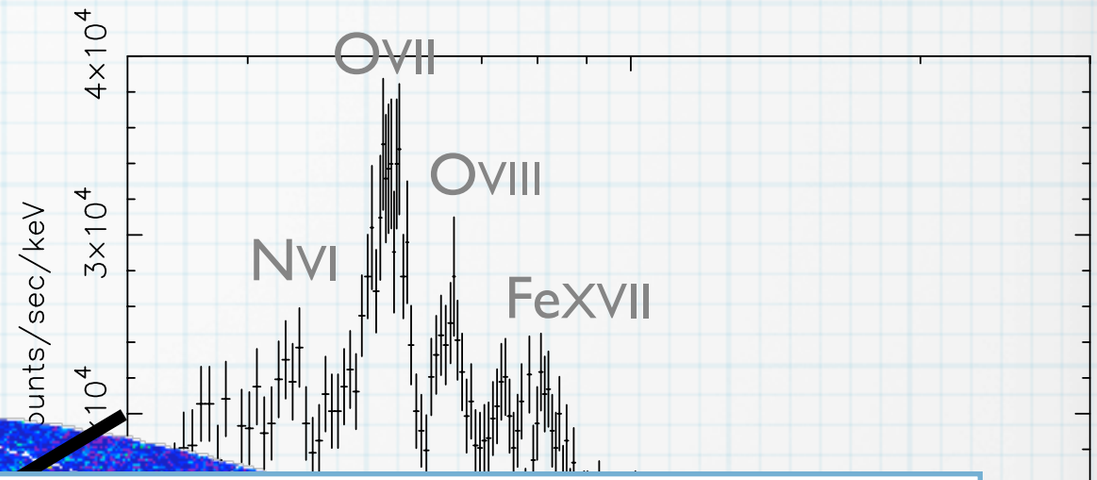






Spectacular spectra of hot ISM





Wide varieties of spectra

Constraints on temperatures, ionization states, and abundances of multiple emission components

More data and better calibrations coming soon

ROSAT

Guest Observer Plan

Science Working Group (SWG) observations until March 2006

SWG target list to be released this a week.

International time allocation:

Japan - 50%, US - 37.5% and Japan/US - 12.5%

Japan allocation includes all non-US proposals (8% of total, will be used for ESA.)

Guest Observer (GO) observations will start April 1, 2006

New AO was released October 15

Due date is January 6, 2006

Planning to release data from ~ 8 representative targets by end of November.

Summary

Suzaku is a new high energy astrophysics observatory available to the astronomical community.

Wide-band spectroscopy all in one observatory

- Low background over a very wide X-ray band
- Improved mirror performance from ASCA
- Good energy resolution with greatly improved line spread function, in particular, < 1keV compared to Chandra and XMM

Very much a unique and powerful observatory

Cluster of galaxies, SNRs, Accreting BHs, ISM, IGM, ...