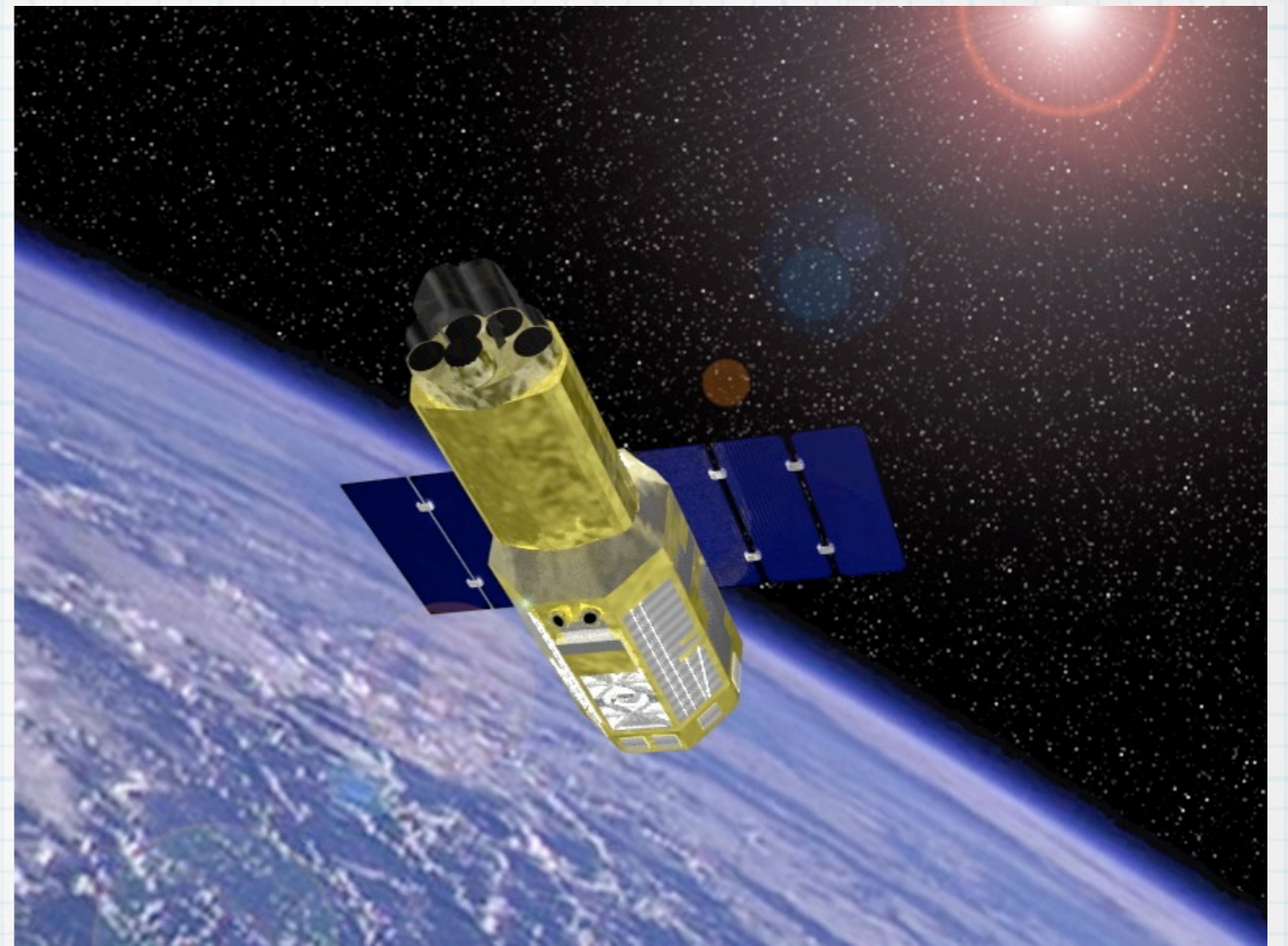


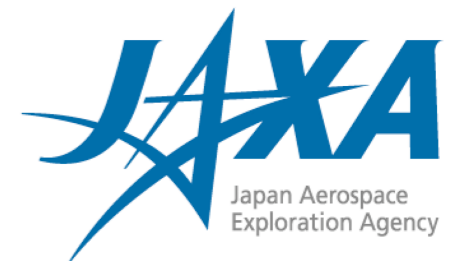
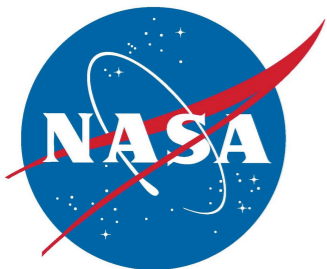
The Suzaku X-Ray Observatory



Richard Kelley, NASA/Goddard

Kazuhisa Mitsuda, ISAS/JAXA

on behalf of the entire Suzaku team



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)



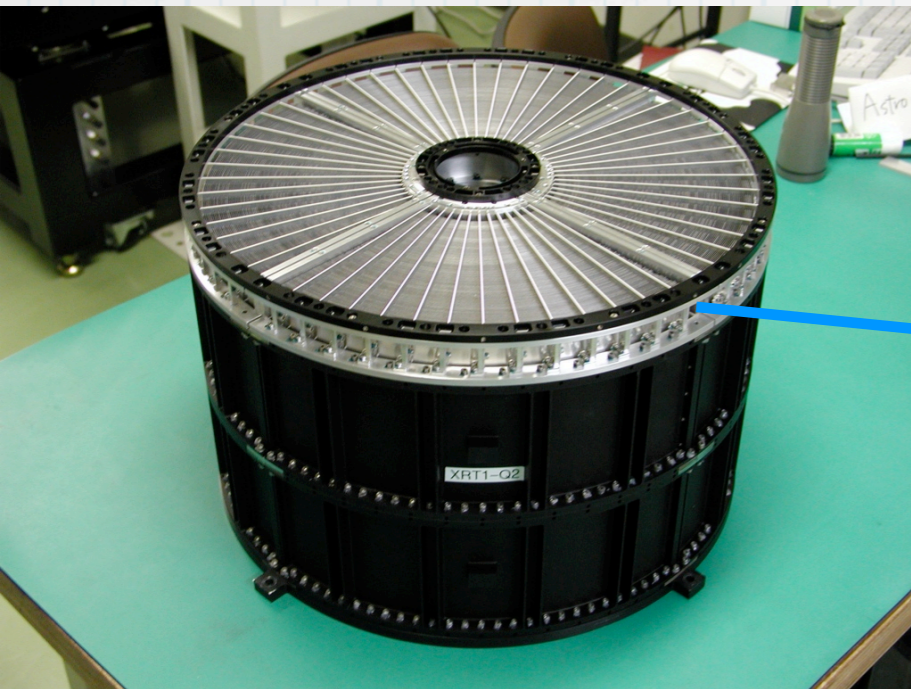
ISAS/JAXA-NASA international collaborations

Scientific instruments:

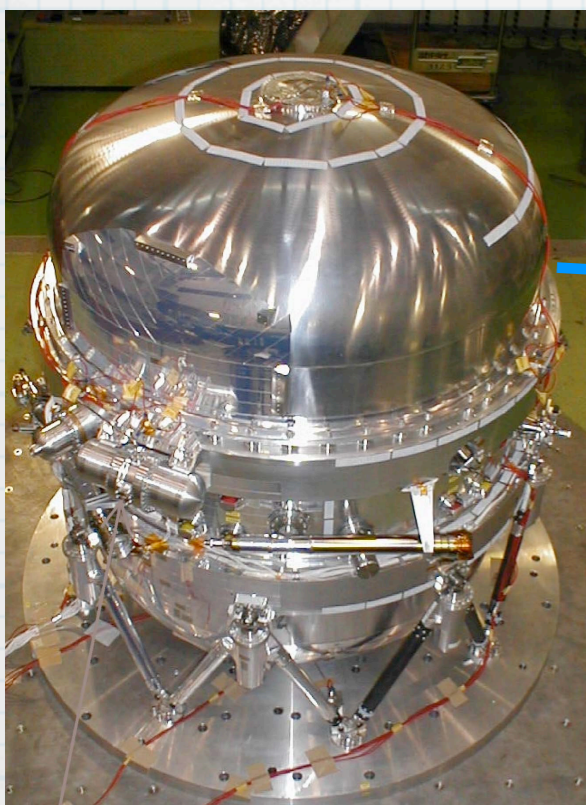
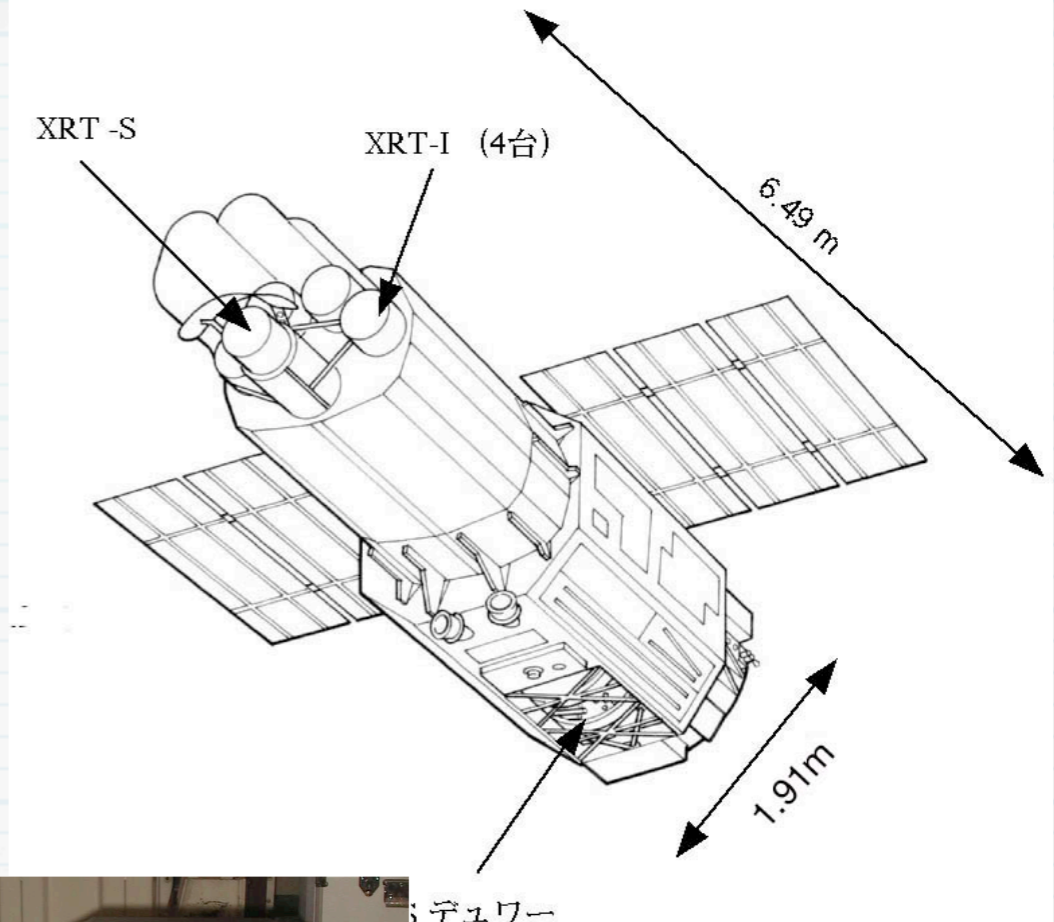
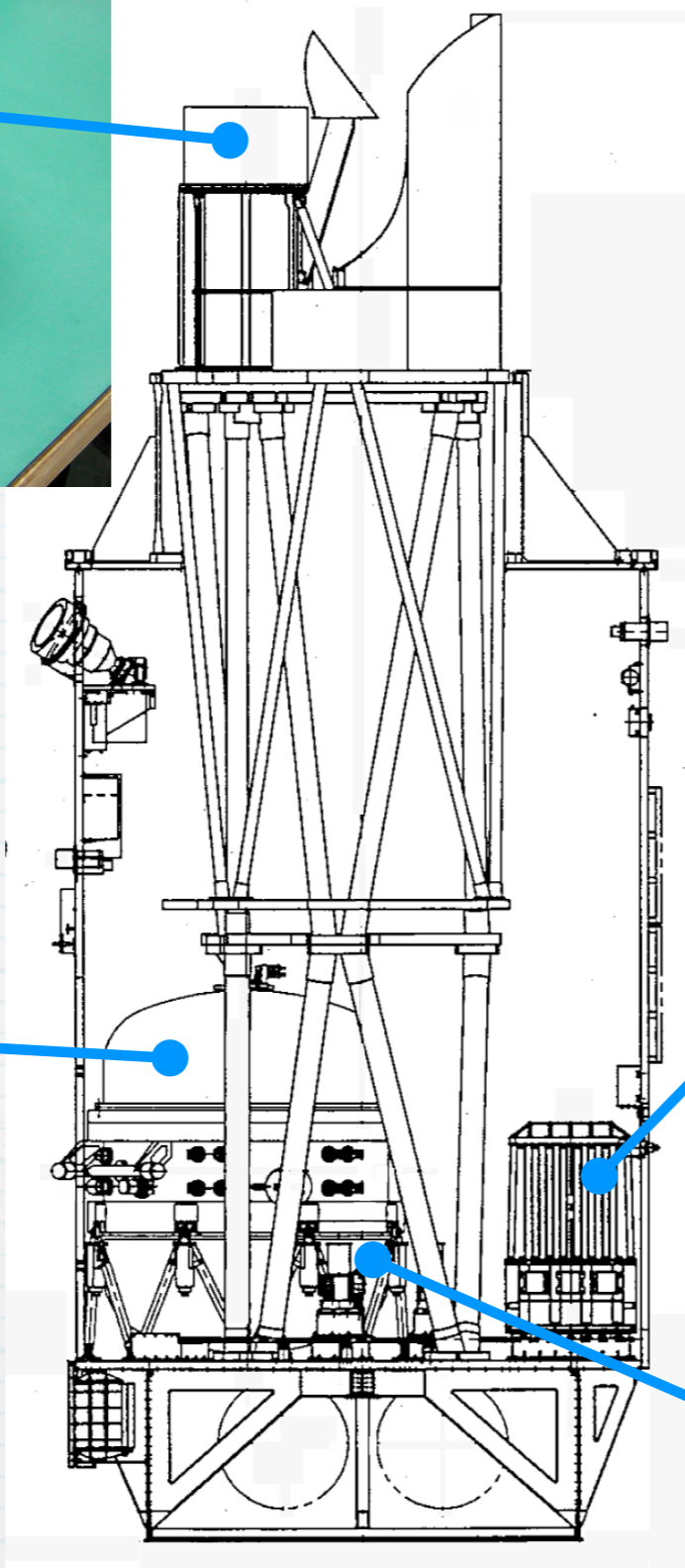
X-ray optics, X-ray spectrometers (e.g., CCDs, microcalorimeters)

Analysis software

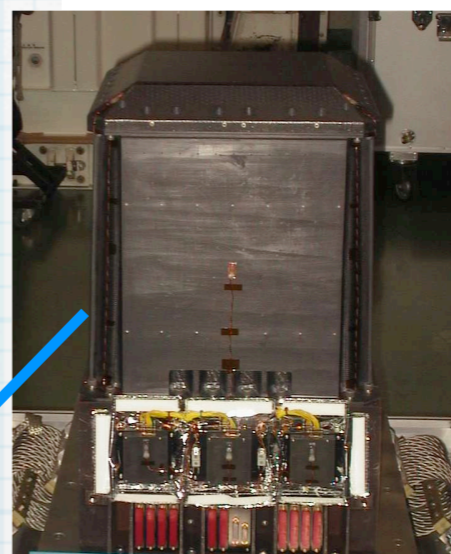
Launched on July 10, 2005 from Uchinoura with M-V launch vehicle.



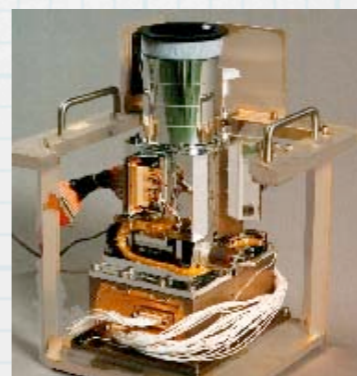
XRT (5 units)
 NASA/GSFC-Nagoya-
 ISAS/JAXA



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

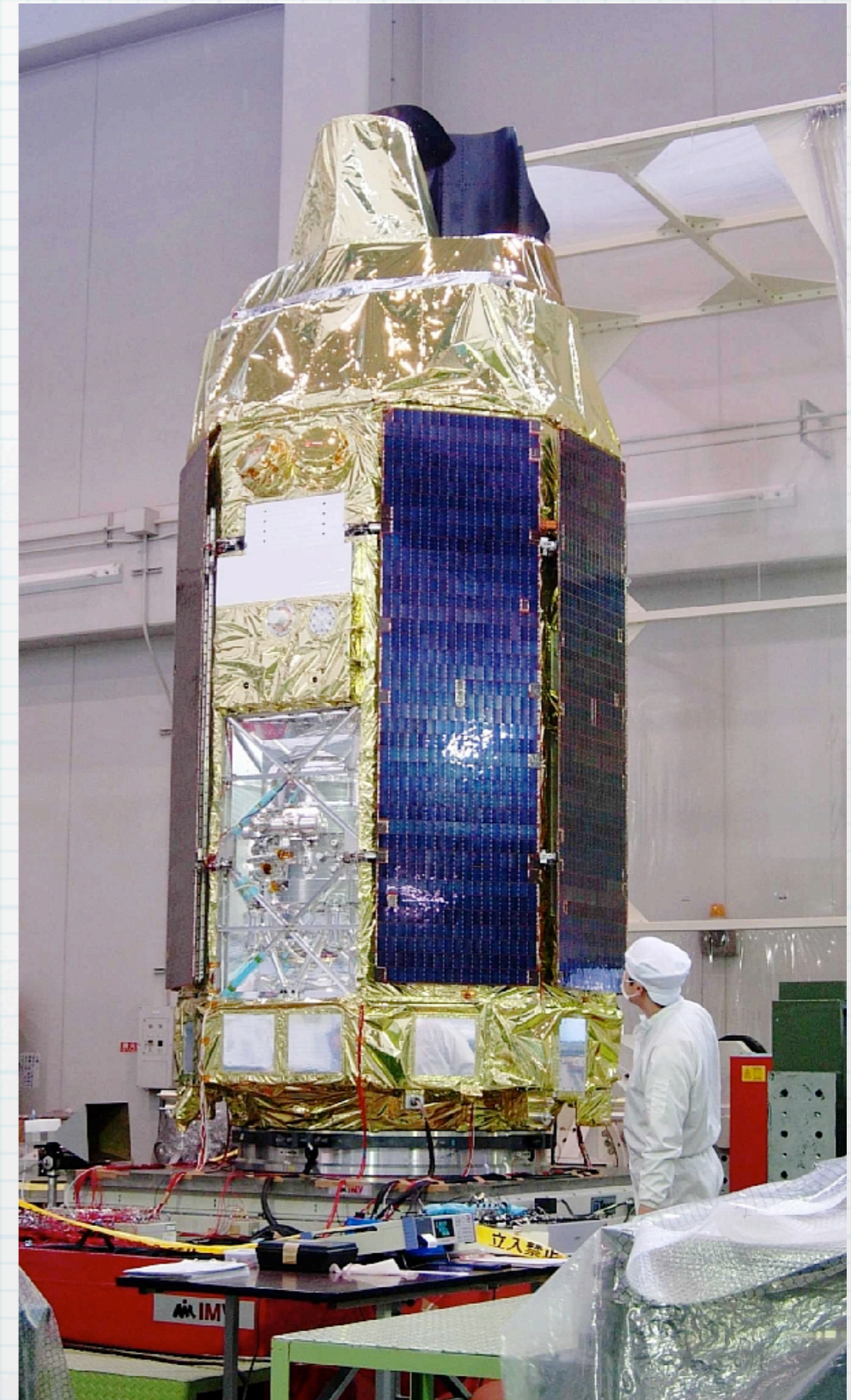
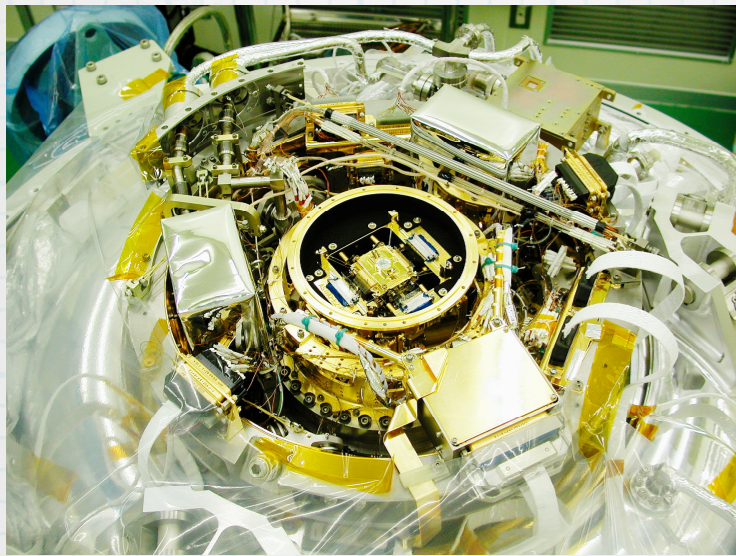


HXD
 Tokyo-ISAS/JAXA-
 Riken-Saitama-
 Hiroshima



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

The high resolution X-Ray Spectrometer (XRS)



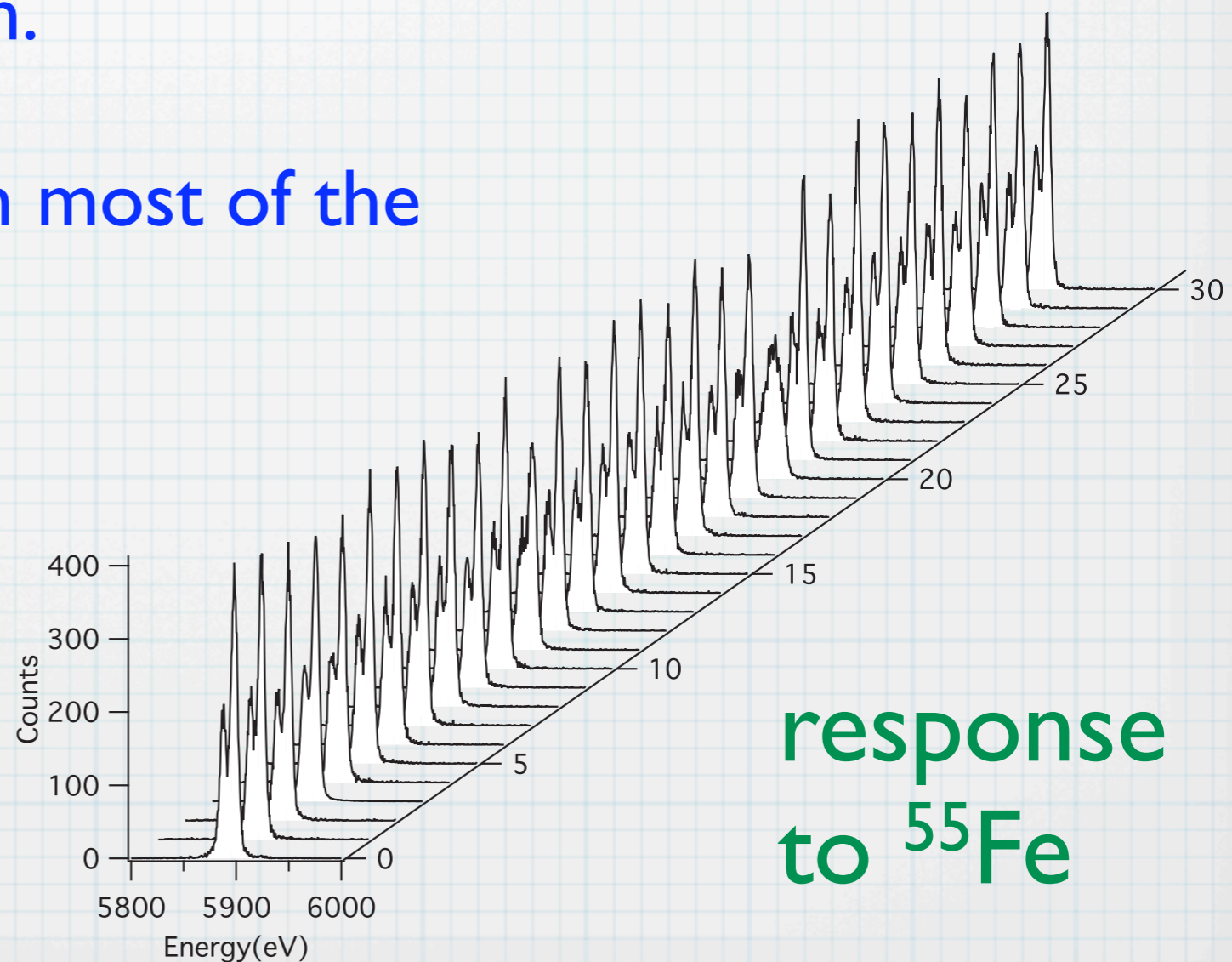
XRS Pre-launch Performance

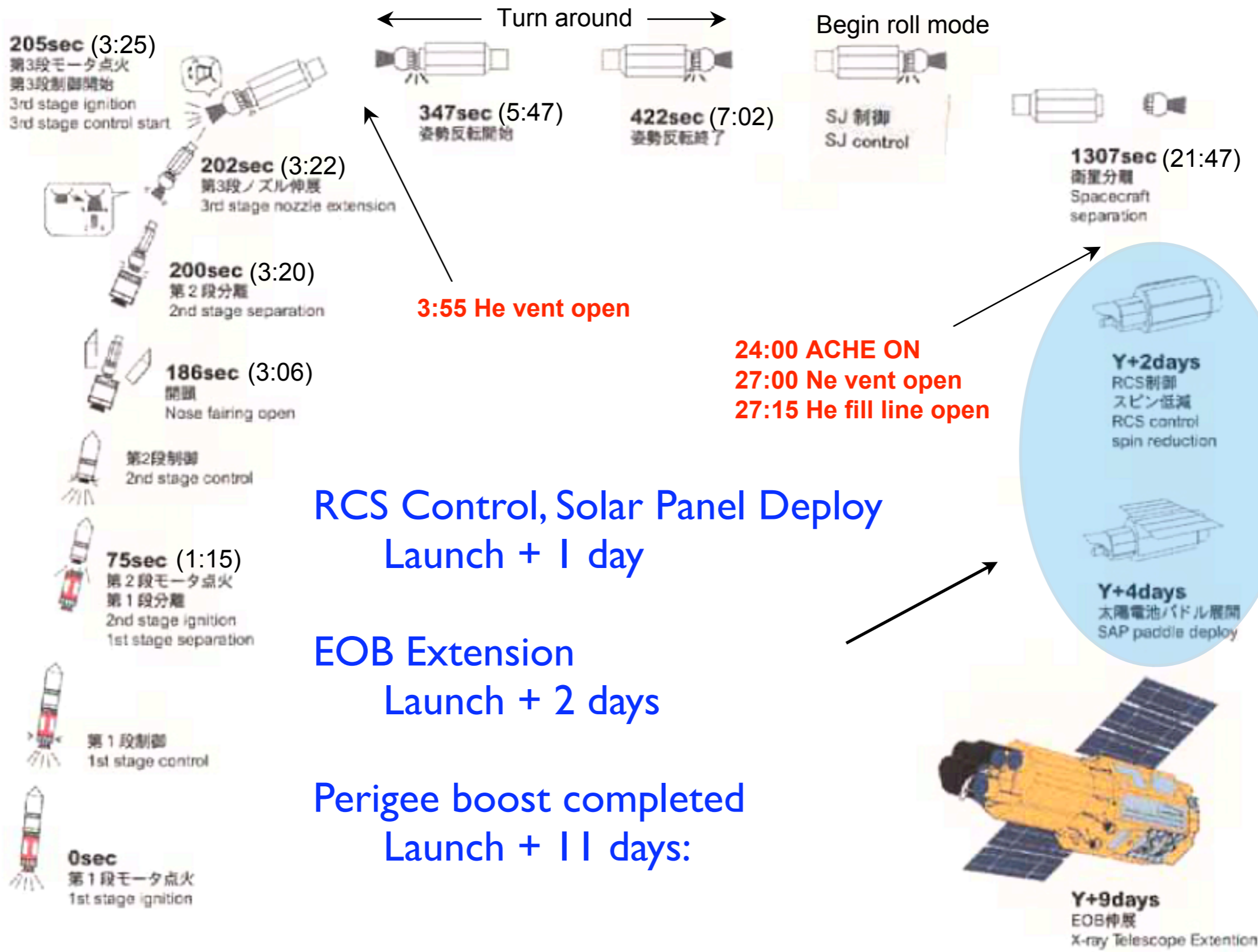
Finished assembly and cooled in July 2004.

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.





3:55 He vent open

24:00 ACHE ON
27:00 Ne vent open
27:15 He fill line open

**RCS Control, Solar Panel Deploy
Launch + 1 day**

**EOB Extension
Launch + 2 days**

**Perigee boost completed
Launch + 11 days:**

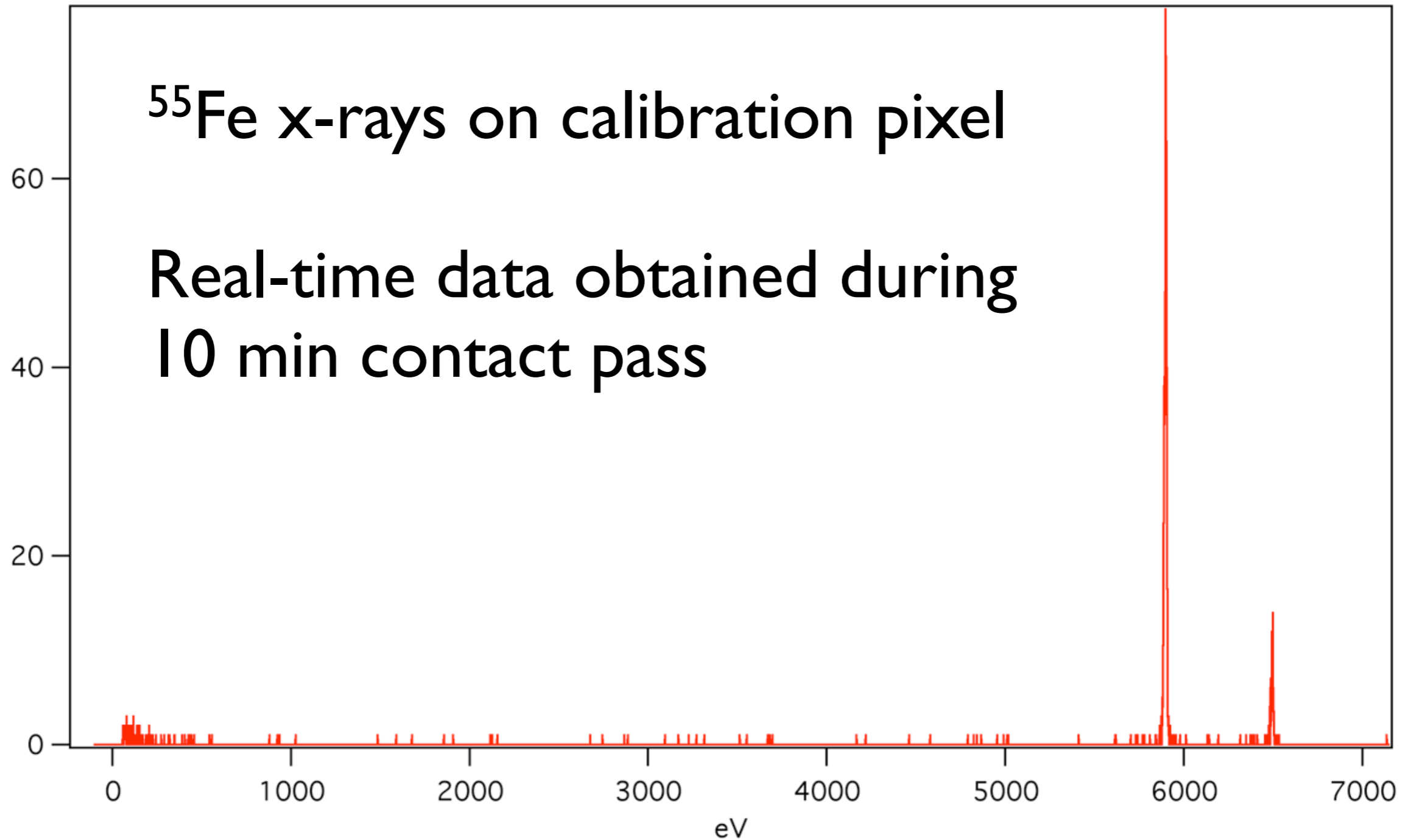
Final orbit: 566 x 569 km, 31 deg

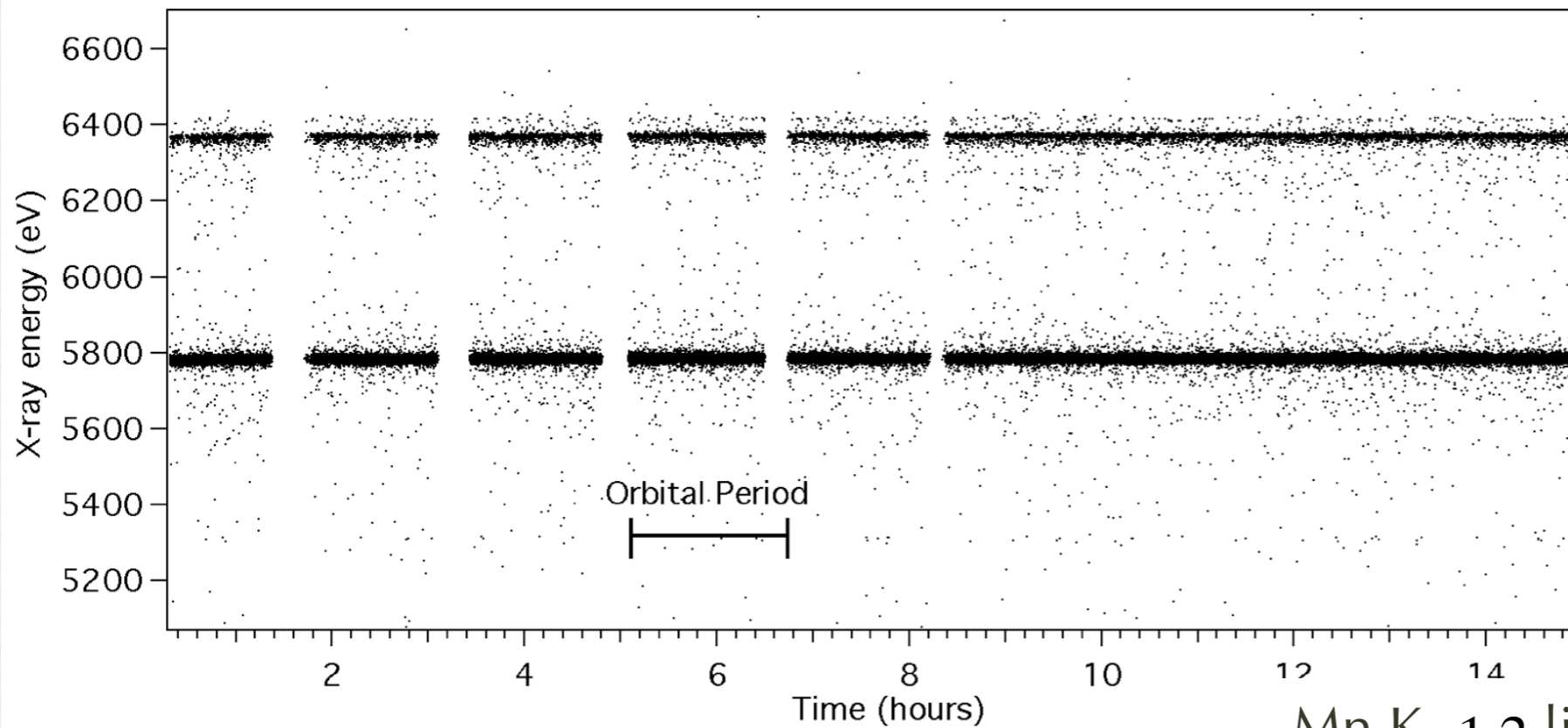
Initial XRS post-launch operations were excellent:

- 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



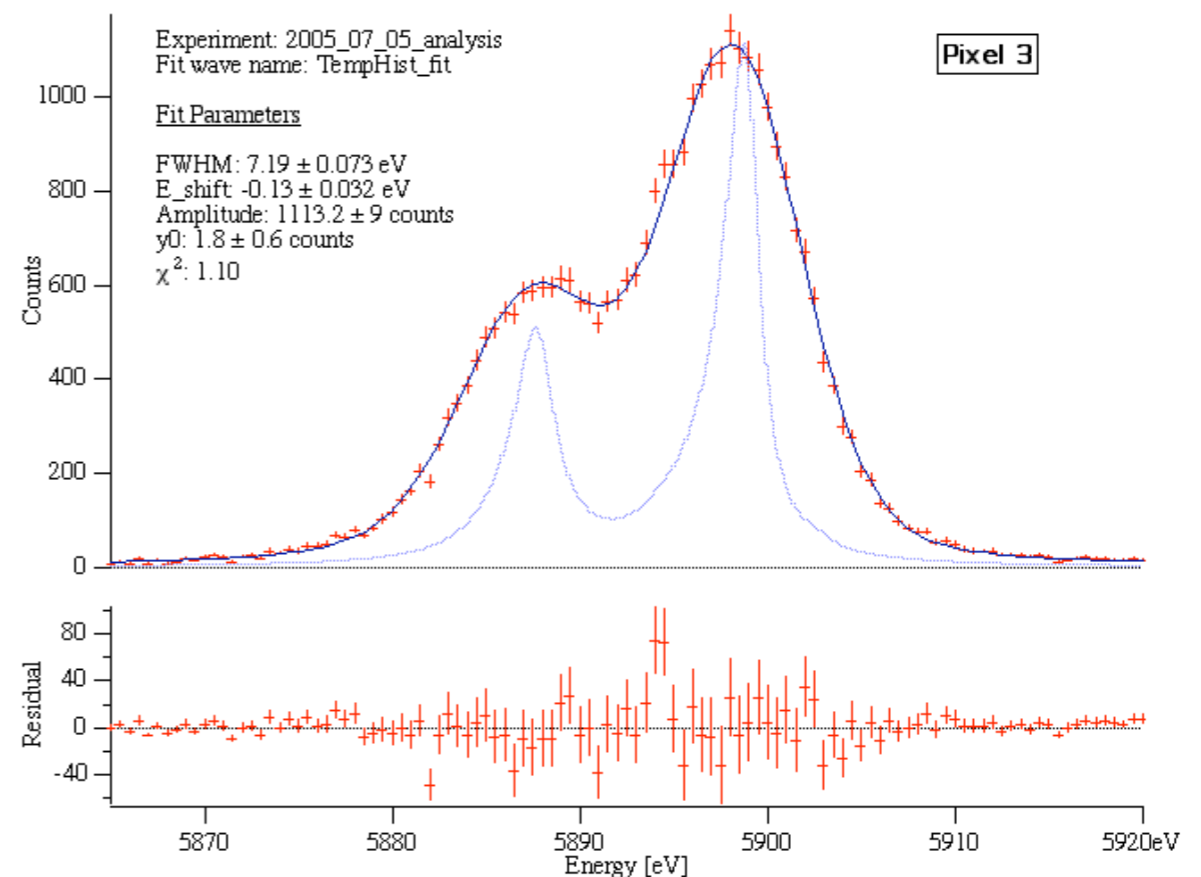


Mn $K_{\alpha 1,2}$ line easily resolved in orbit

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.



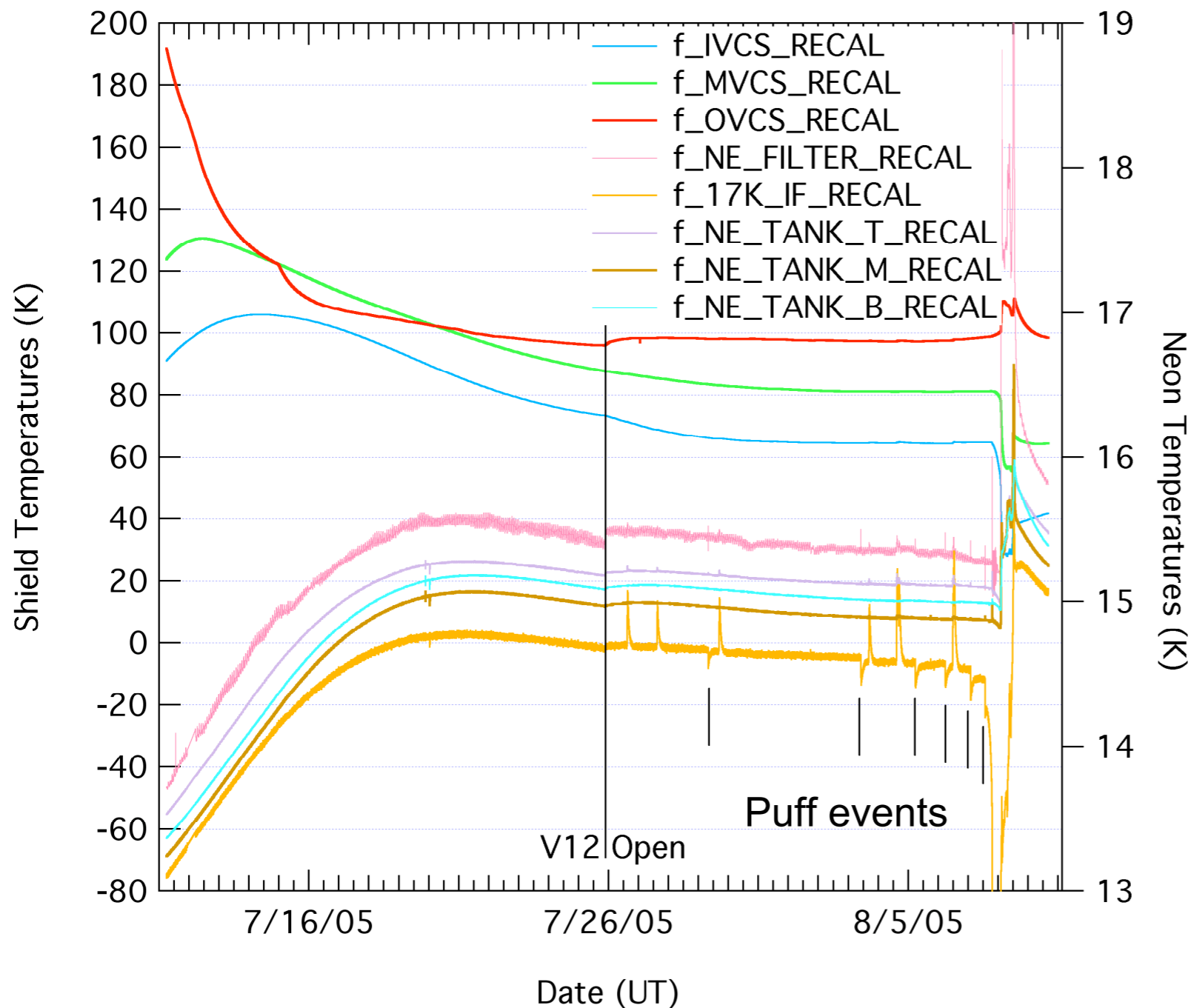
What happened?

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.

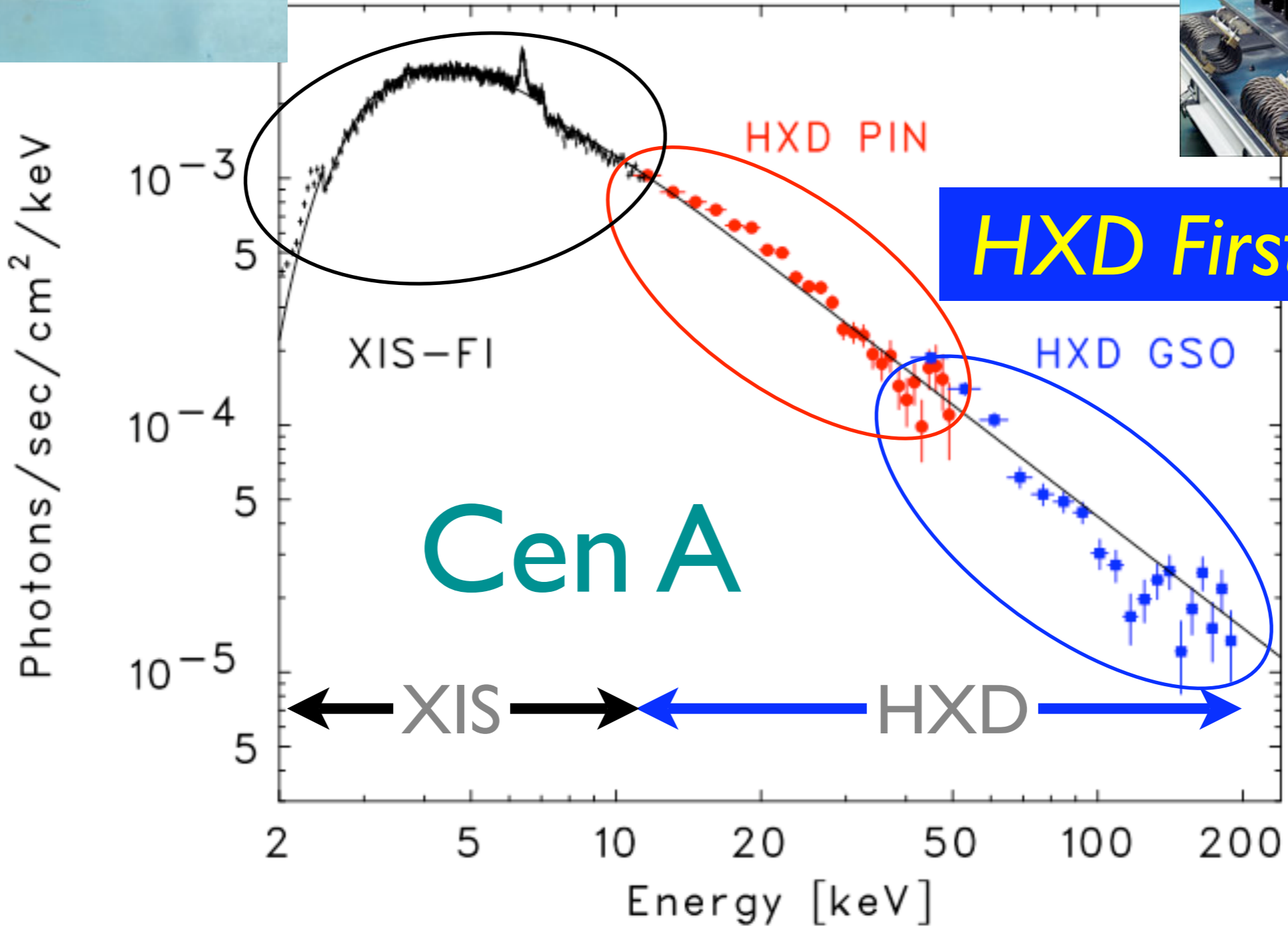
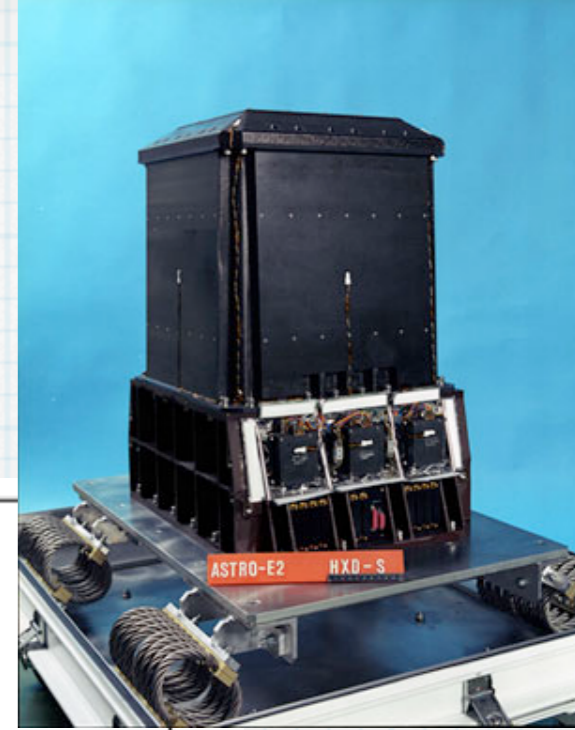
and... there's a lot more to Suzaku!

Suzaku Now

Wide-band X-ray spectroscopy:

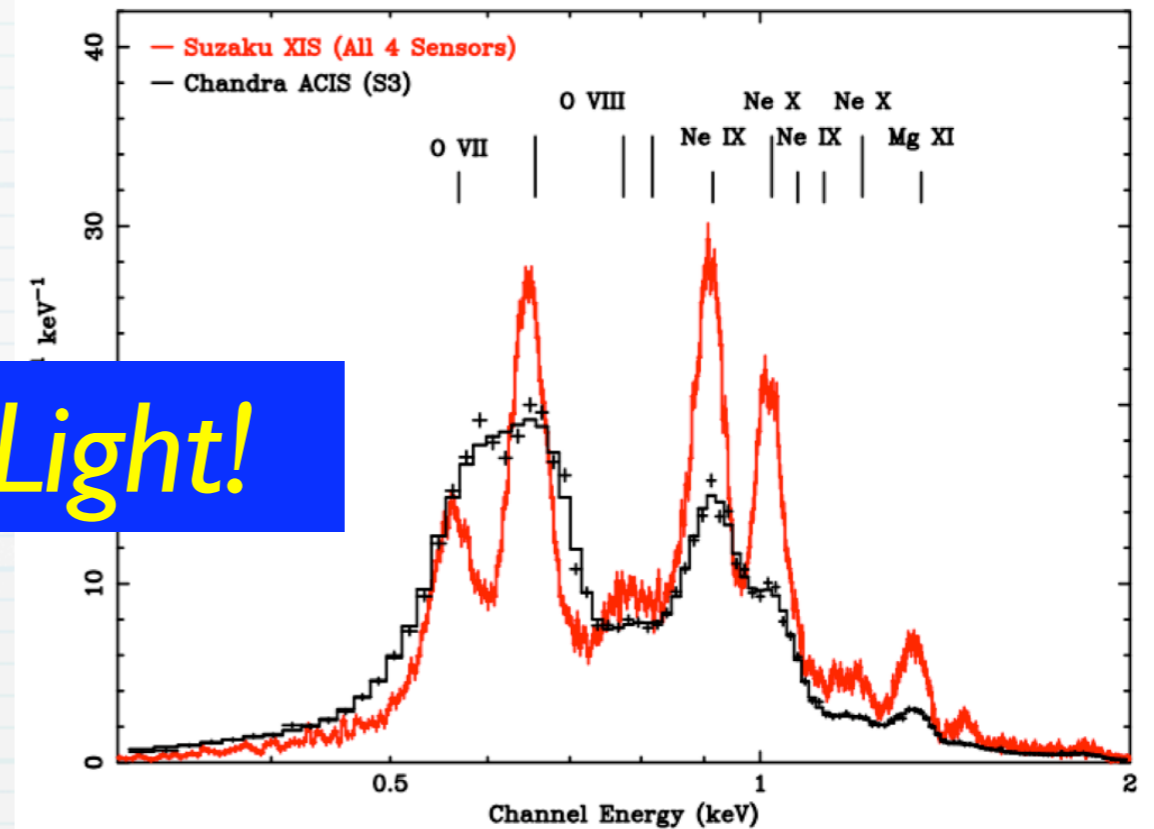
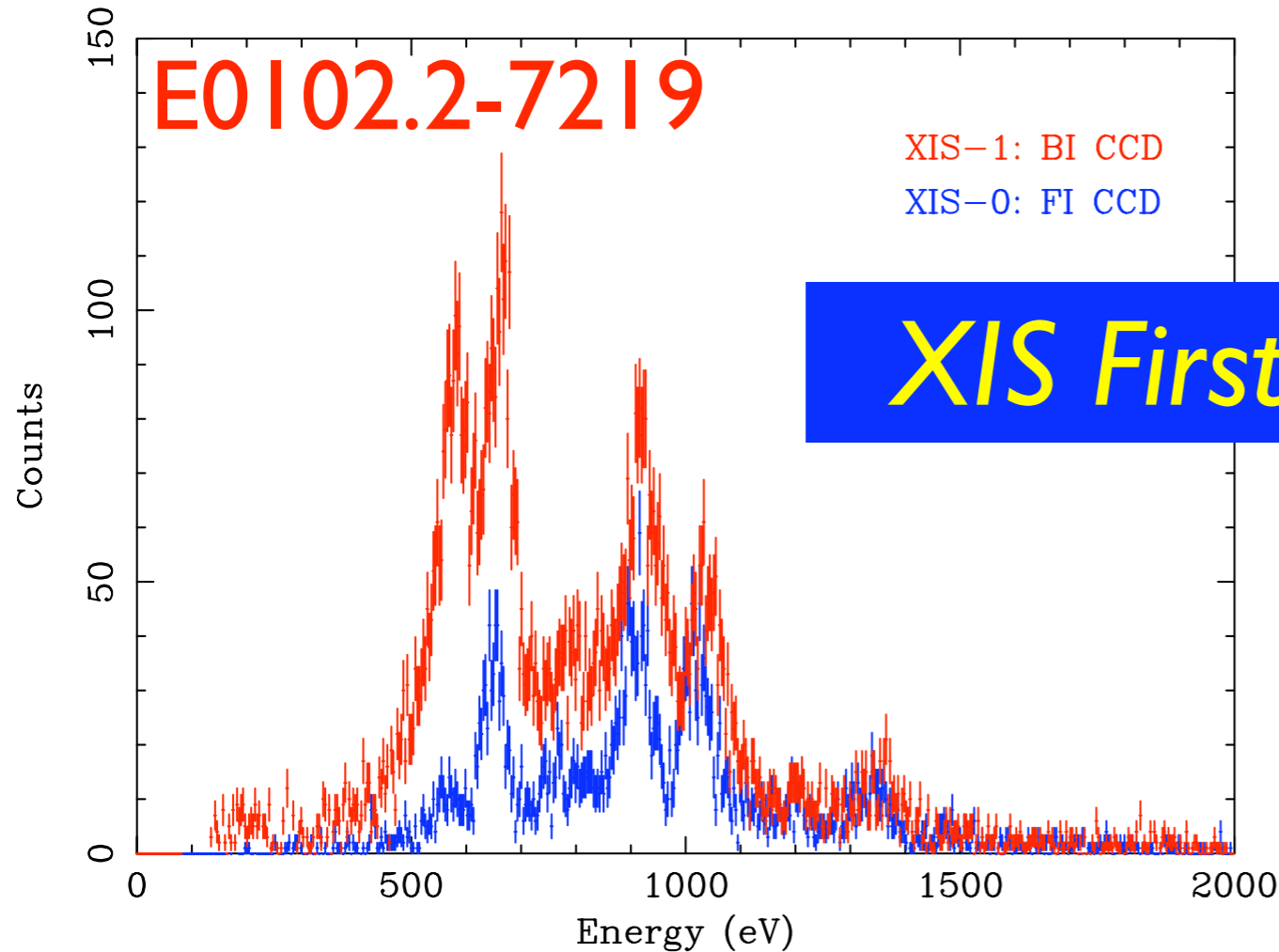
- $\sim 1000 \text{ cm}^2$ effective area 1-6 keV
- Low background
 - Much lower stray light than ASCA mirrors
- Good energy resolution
- Improved line spread function on low energy side, particularly important $< 1 \text{ keV}$

Power of *Suzaku*: very broad-band



New Capabilities Offered by Suzaku/XIS

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



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

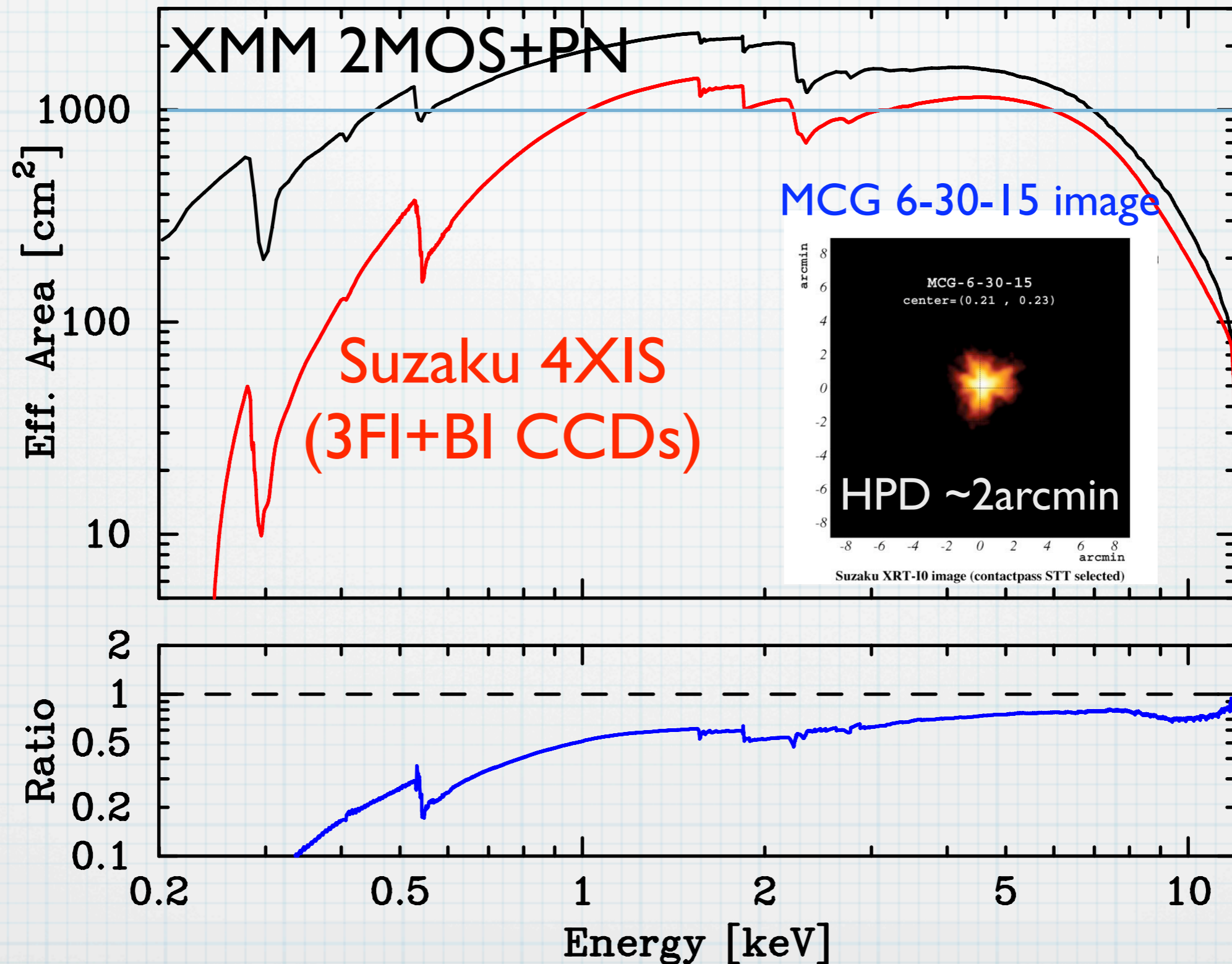
nice job, XIS team!

see Bautz et al. poster

Front and Back-illuminated CCD's

Suzaku Team, preliminary

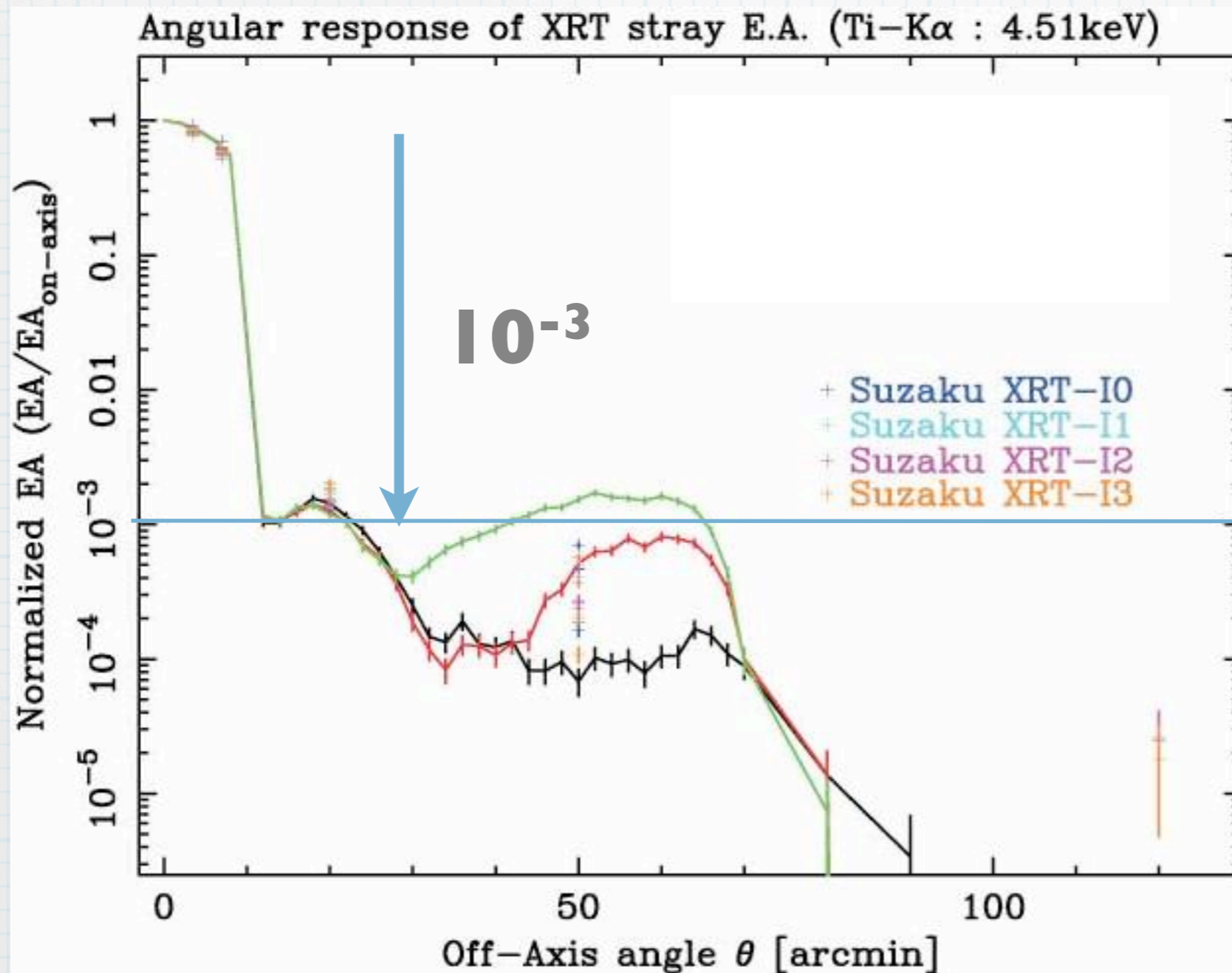
Effective area



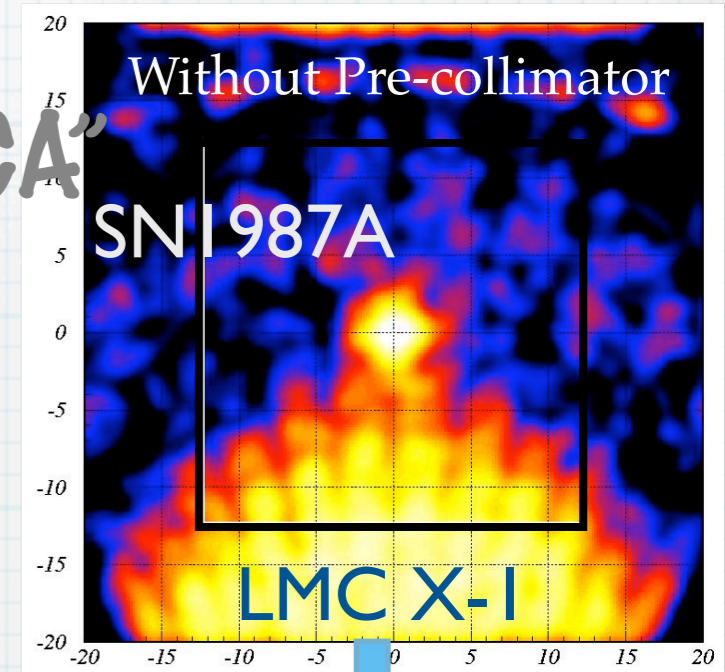
Stray light

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

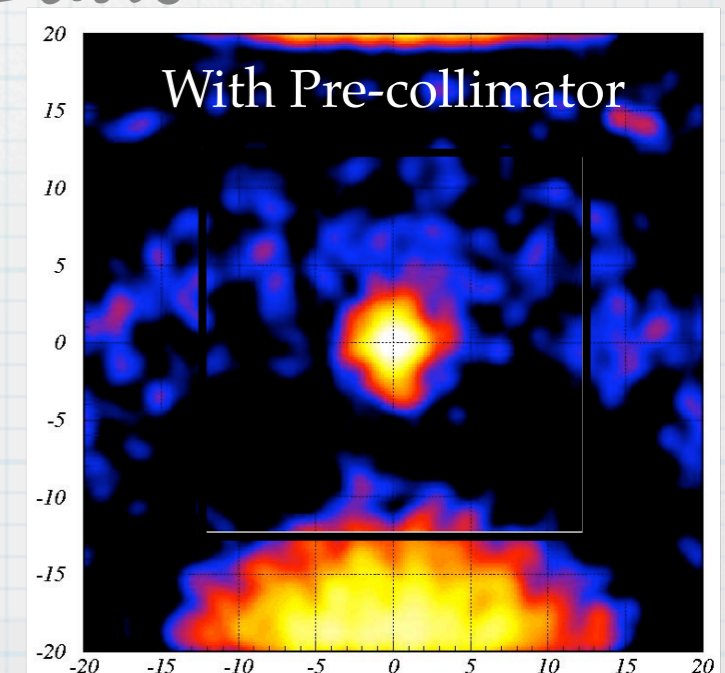
Ray tracing calibrated by ground measurements



“ASCA”

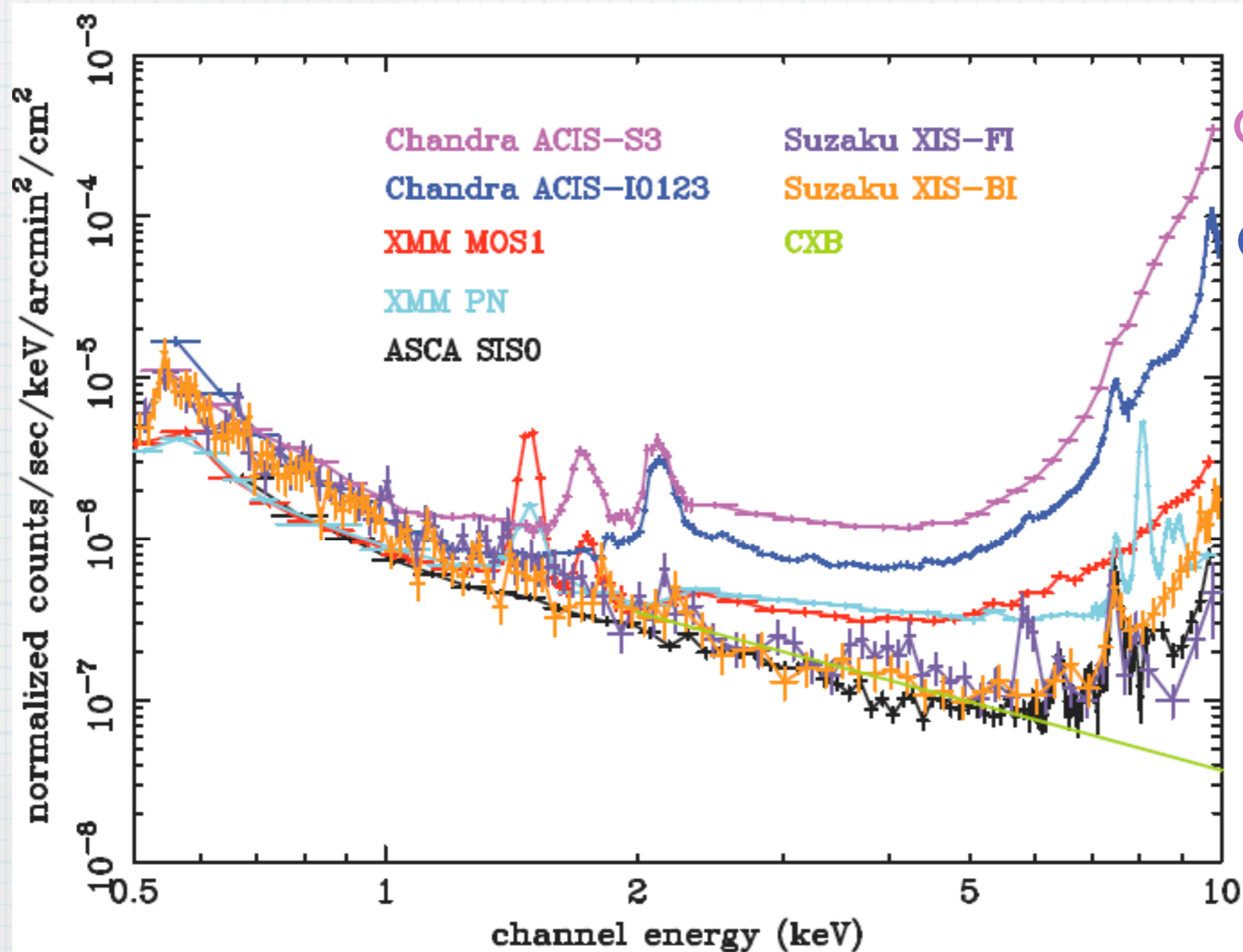


Suzaku



Low XIS background

Background normalized by effective Area and FOV



Chandra ACIS-S3

Chandra ACIS-I0-3

XMM MOSI

XMM PN

Suzaku BI

Suzaku FI

ASCA SIS

Suzaku XIS
background is
comprable to
that of ASCA SIS

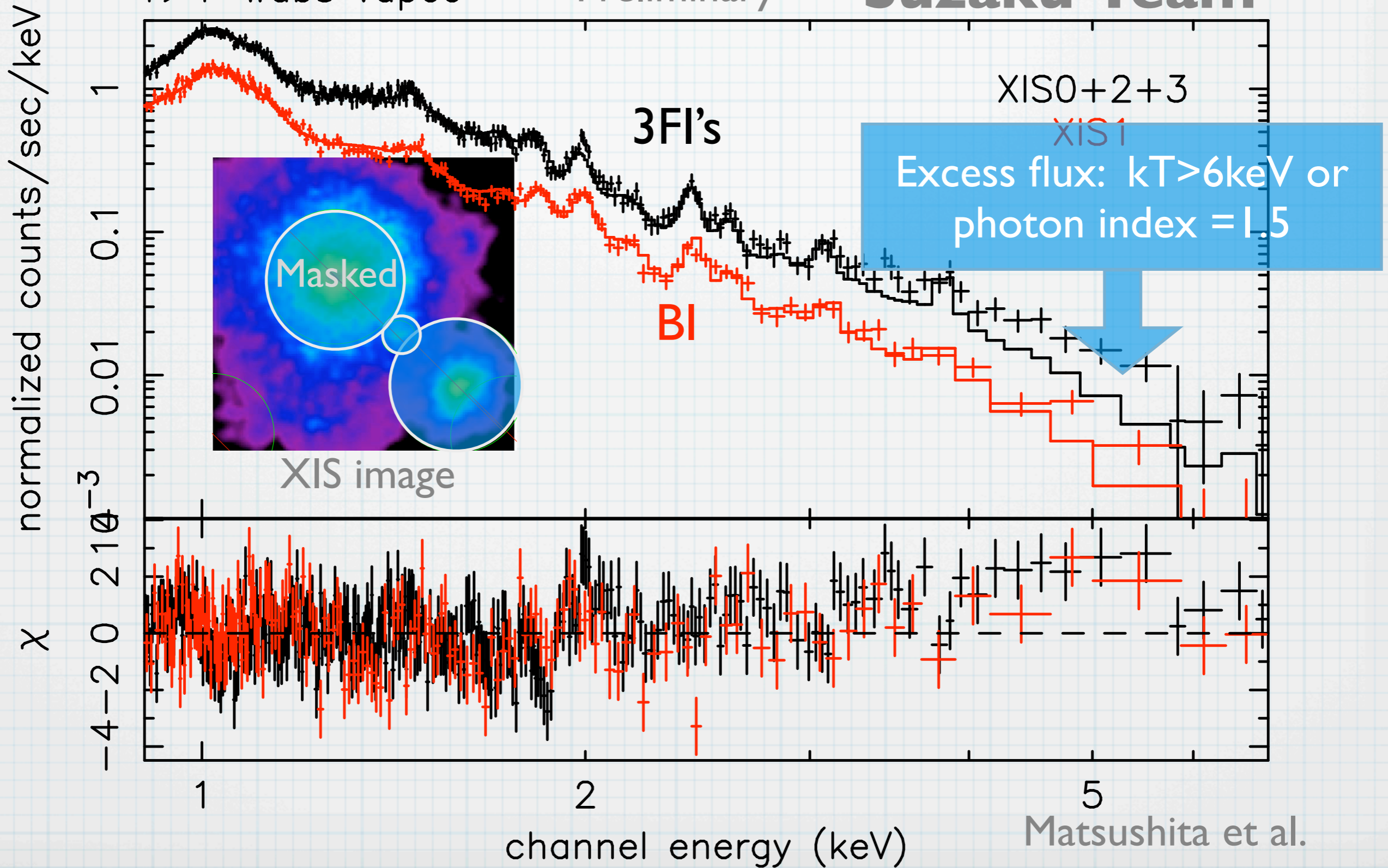
Low surface brightness

Fornax cluster $r > 4'$

$r > 4'$ wabs*vapec

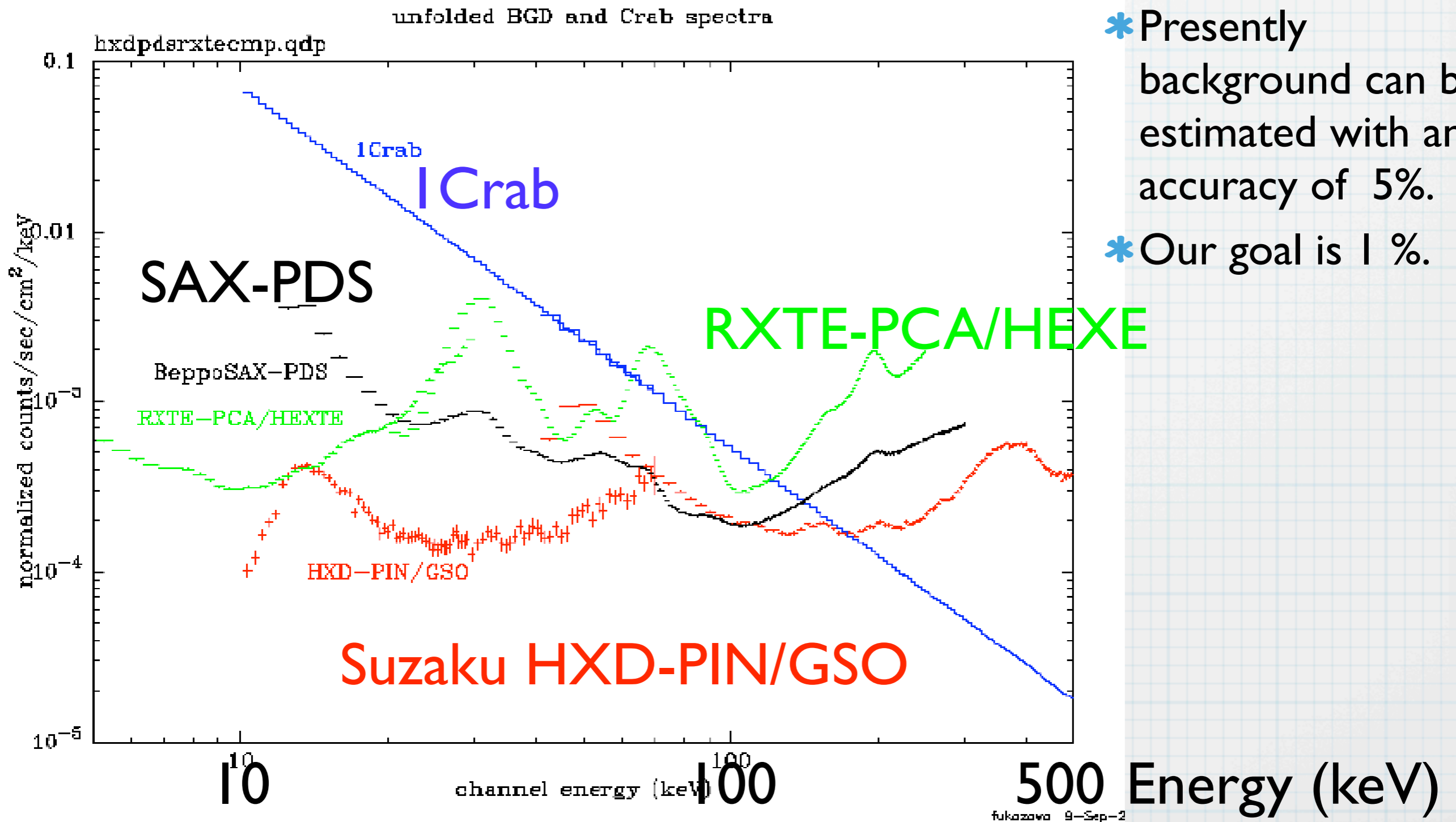
Preliminary

Suzaku Team



Low HXD background

Background normalized by effective Area

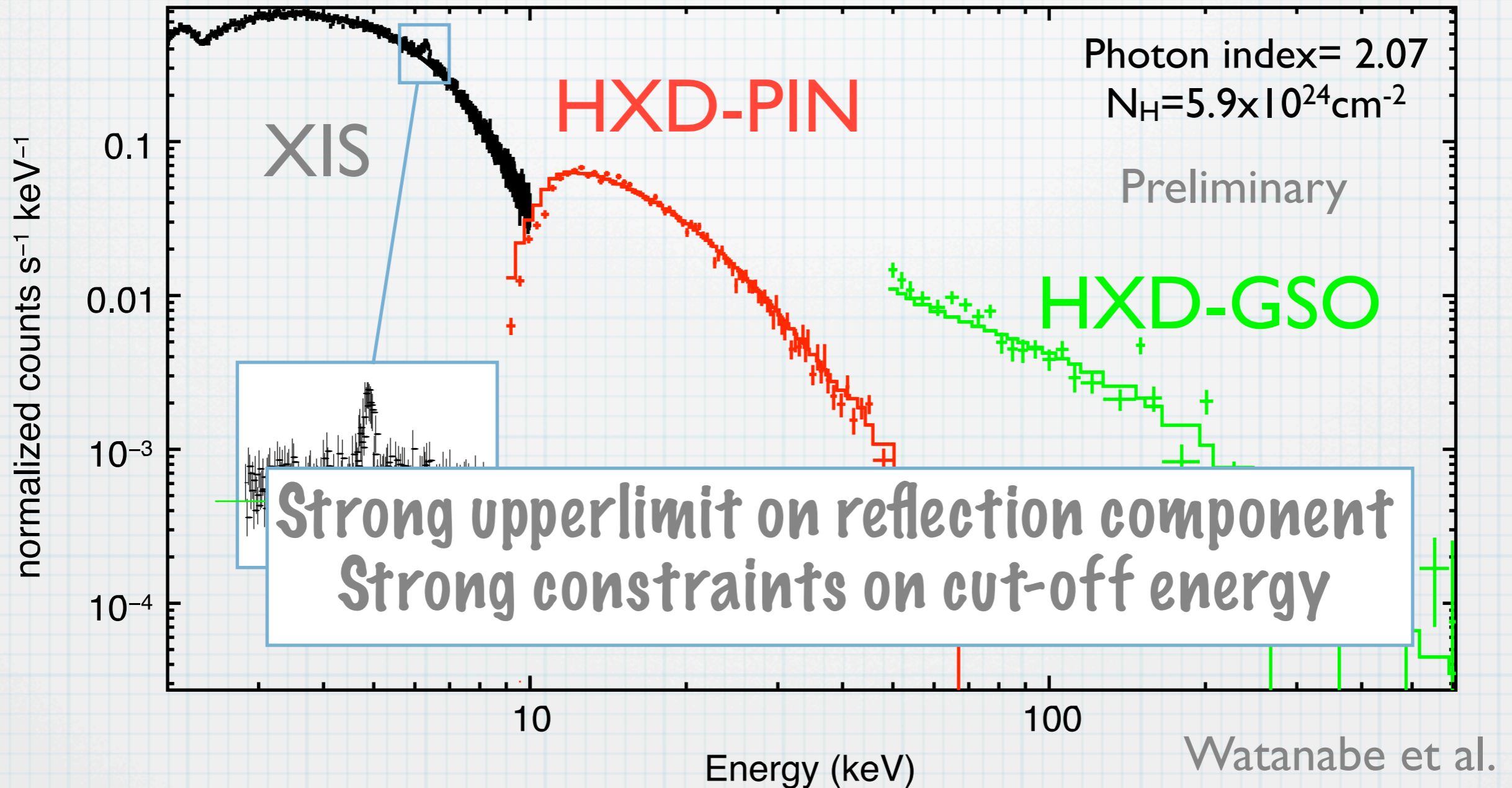


- * Presently background can be estimated with an accuracy of 5%.
- * Our goal is 1 %.

Sy2 Galaxy (NGC2110)

86ks

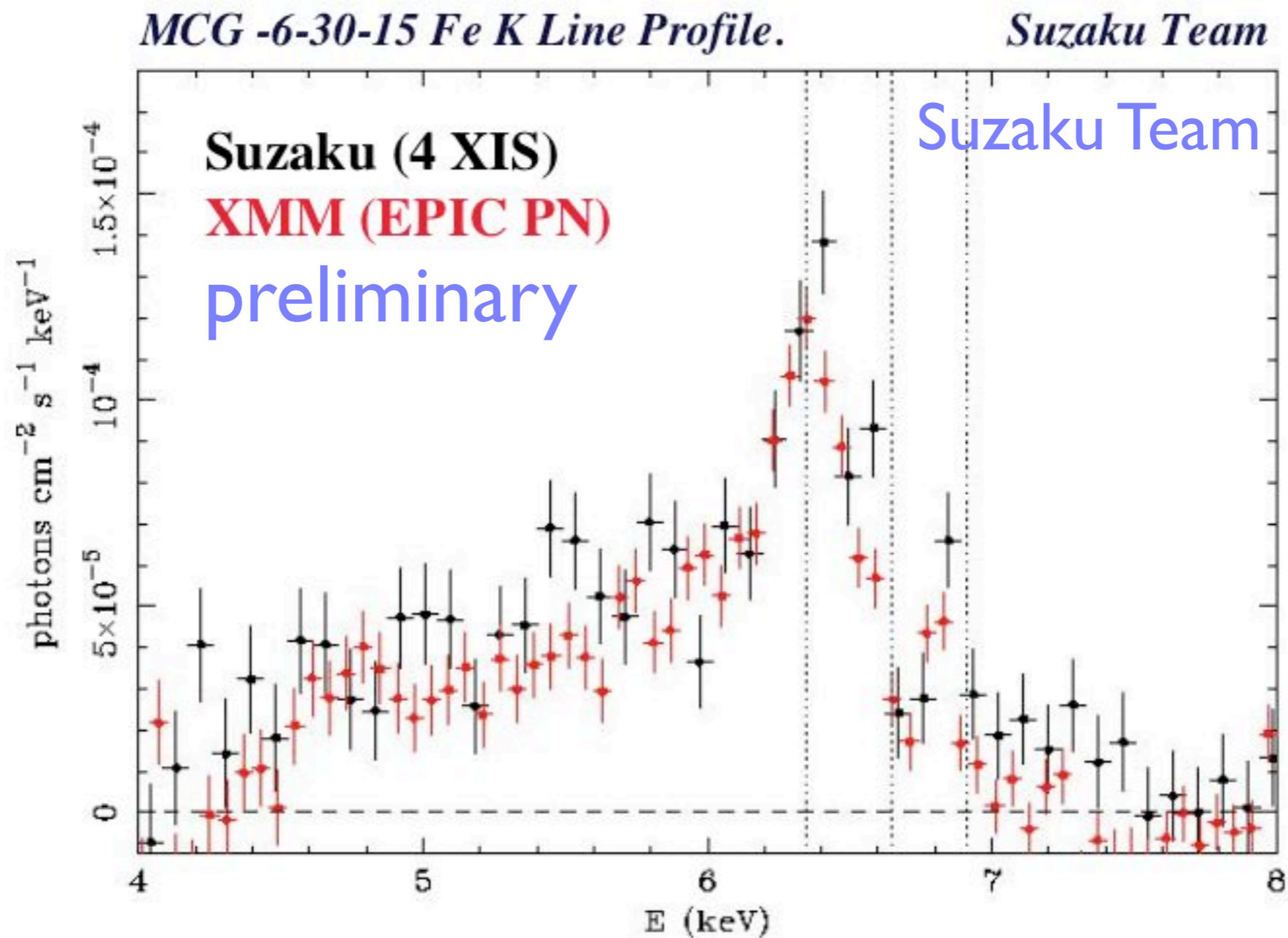
Suzaku Team



GSO is detecting at least up to 200 keV

Spectral structures

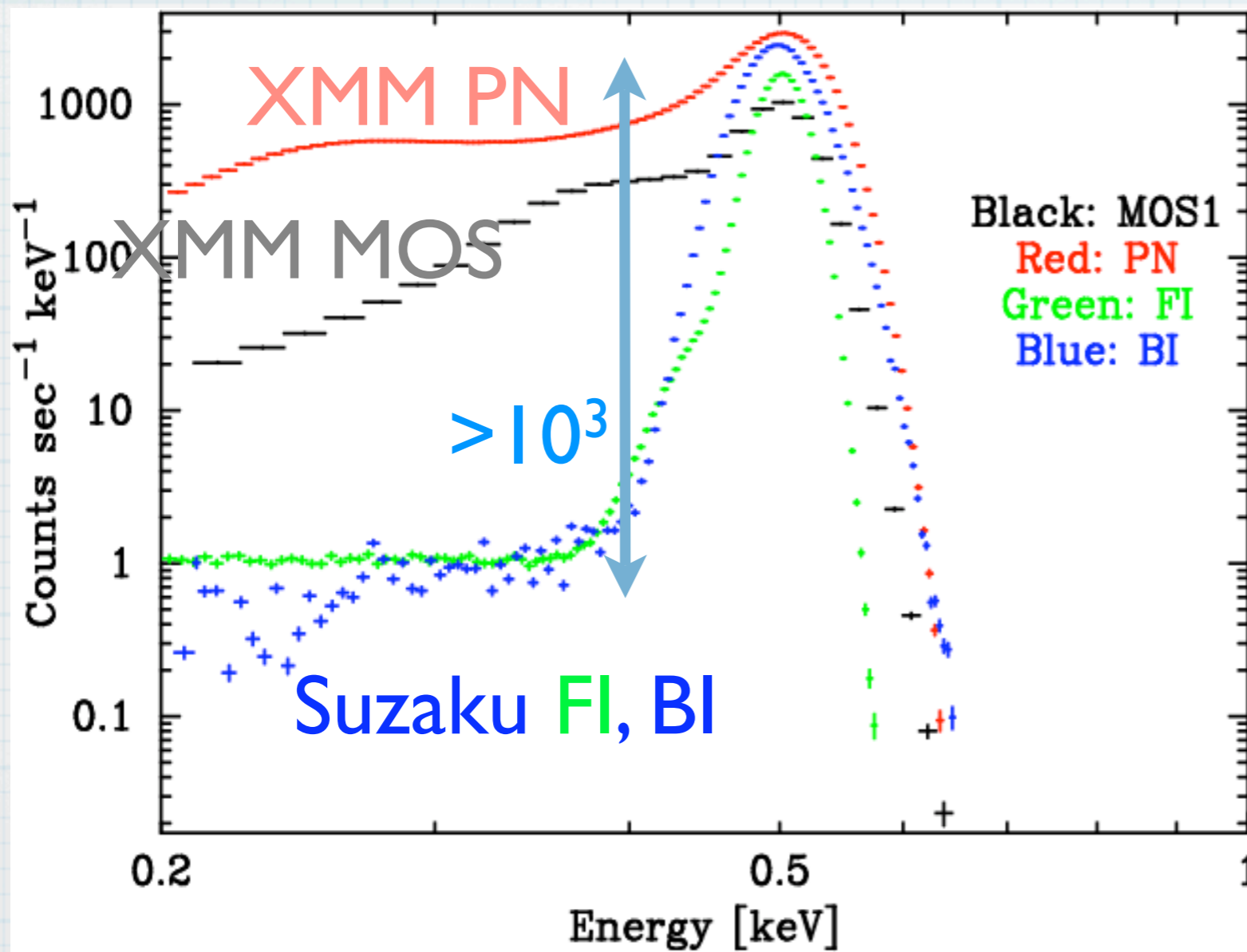
With the wide band coverage, continuum spectra can be constrained well.



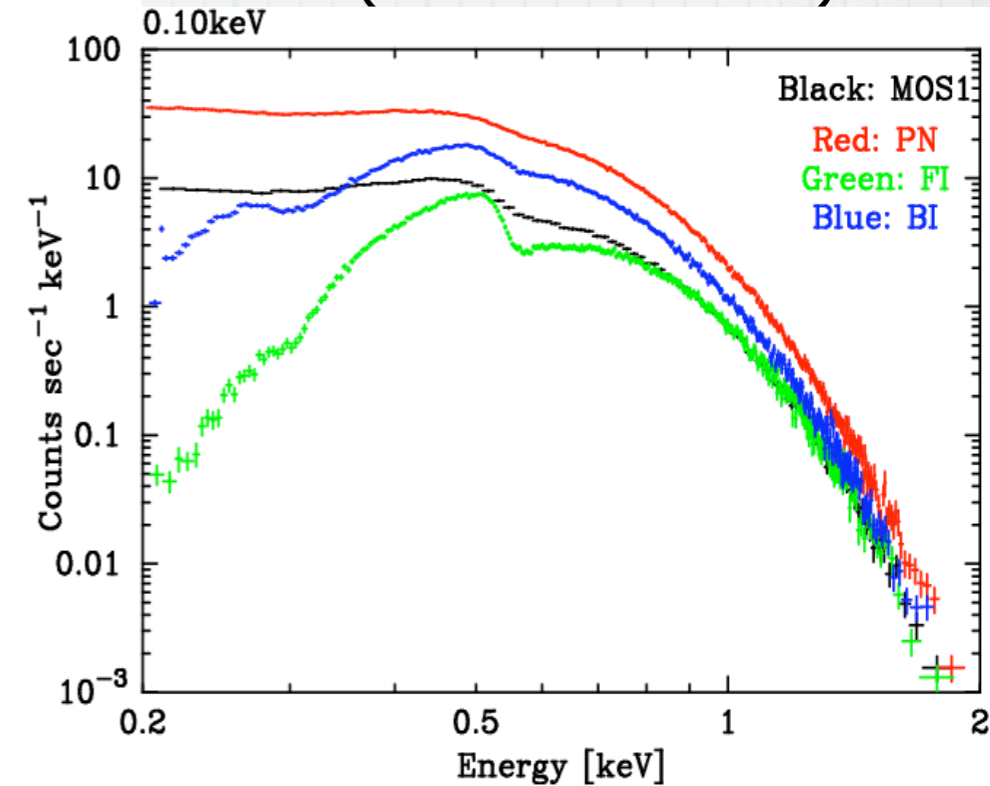
XIS energy response < 1 keV

very low low-pulse-height tail

Thanks to MIT XIS team
Bautz et al. (Poster I90)



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

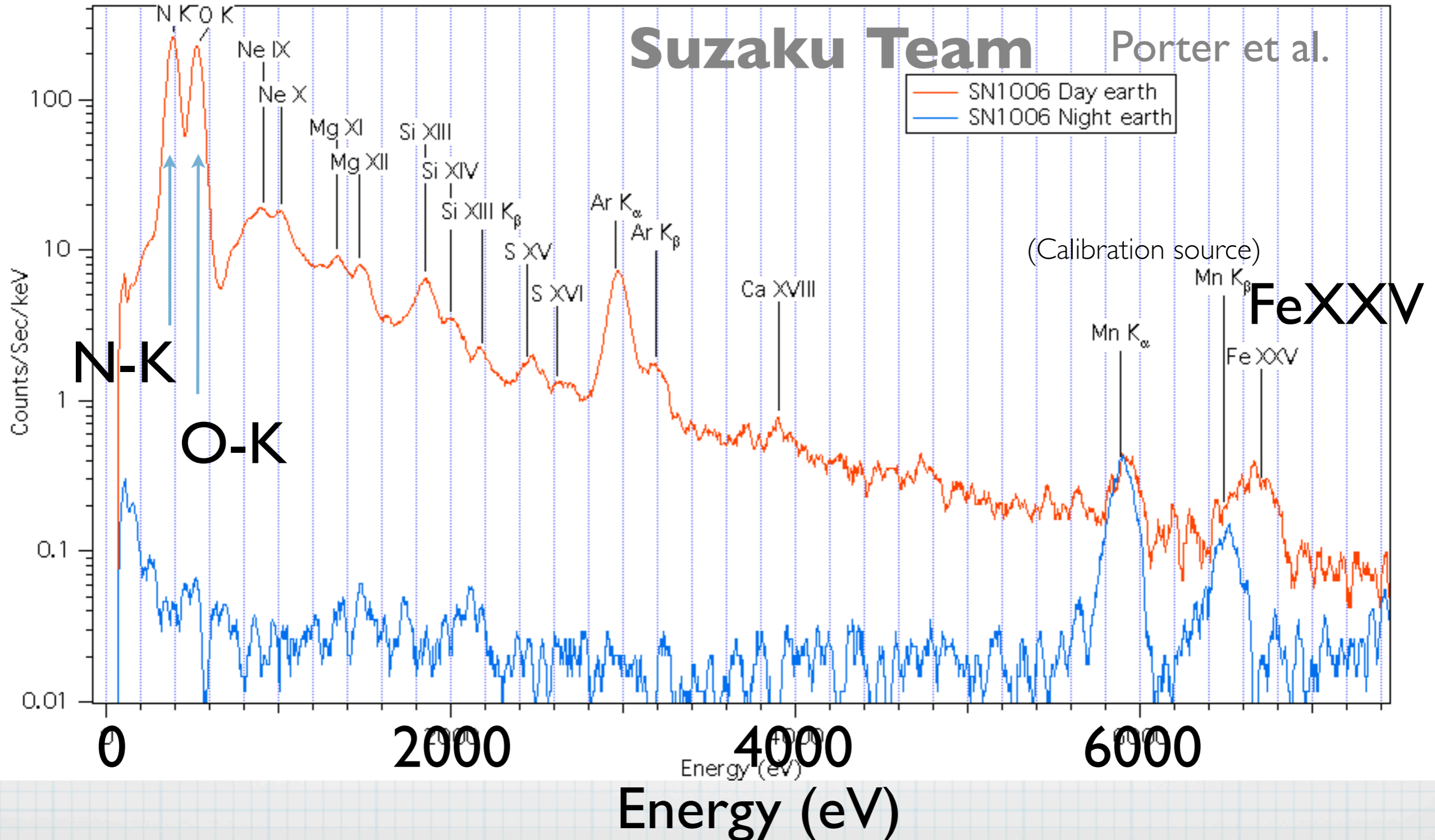


response for 0.5 keV monochromatic X-ray

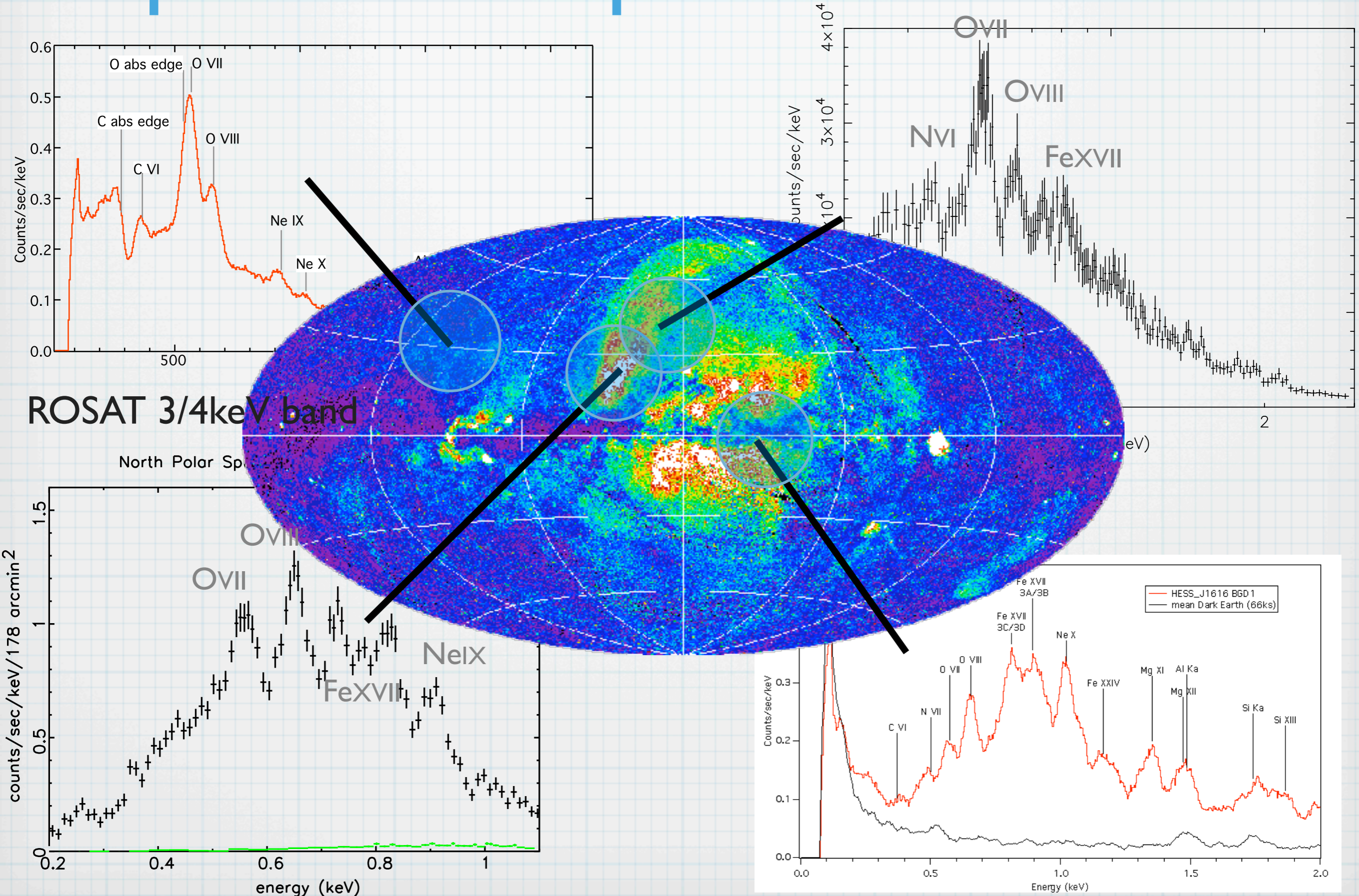
Good spectral response

X-ray emissions from earth atmosphere

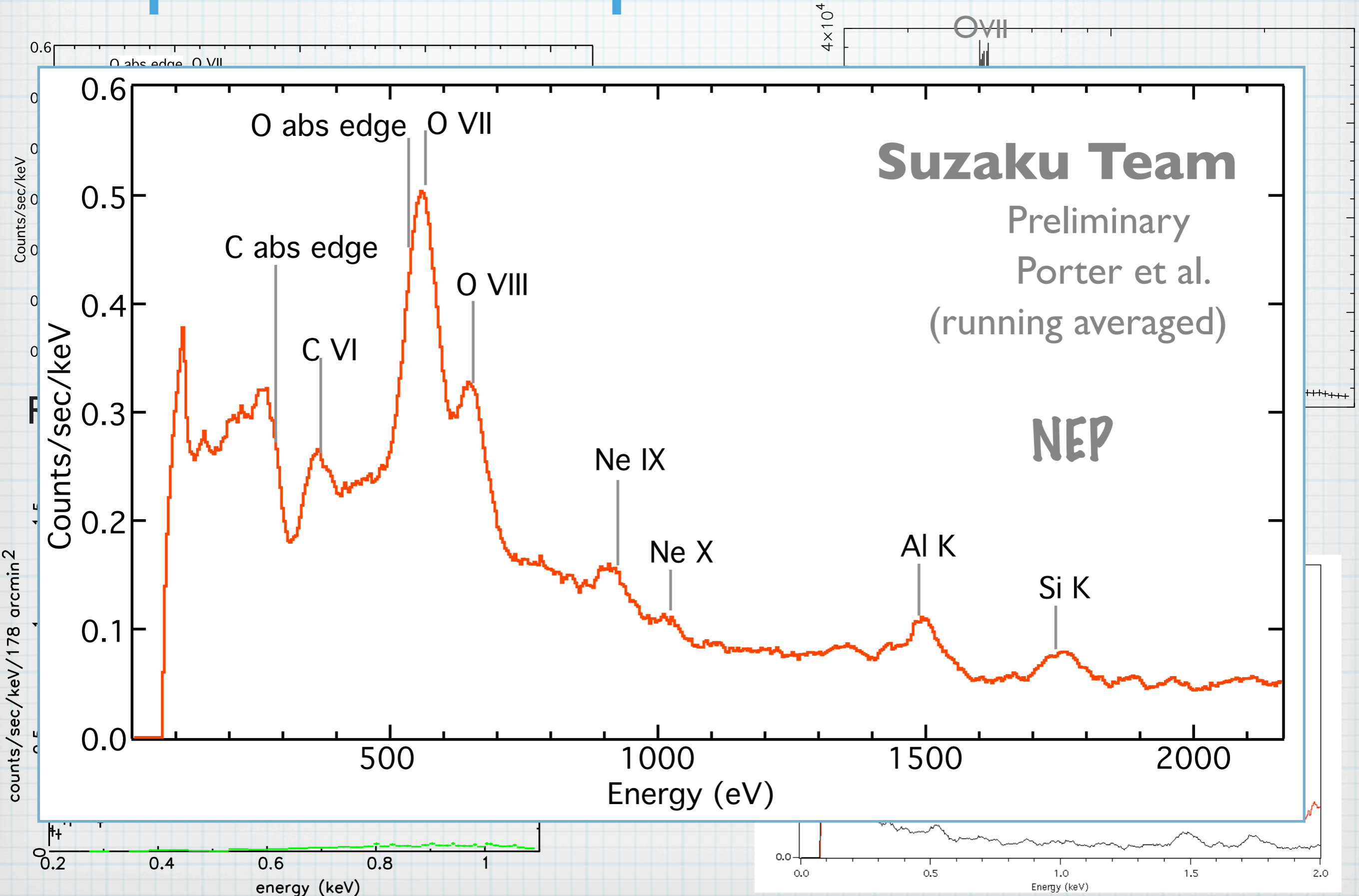
Emission lines, N-K, O-K, NeIX-K to FeXXV, are clearly visible



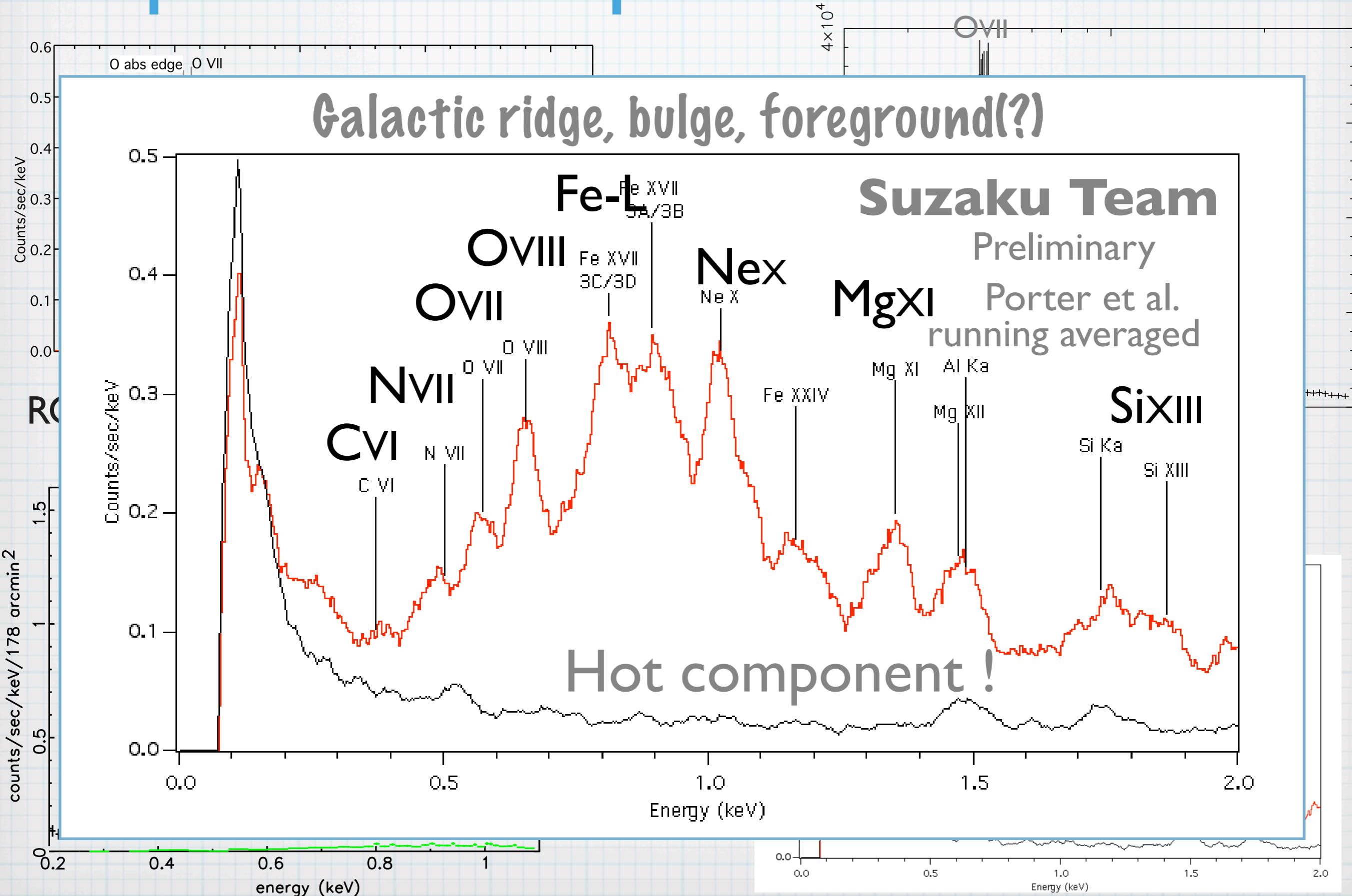
Spectacular spectra of hot ISM



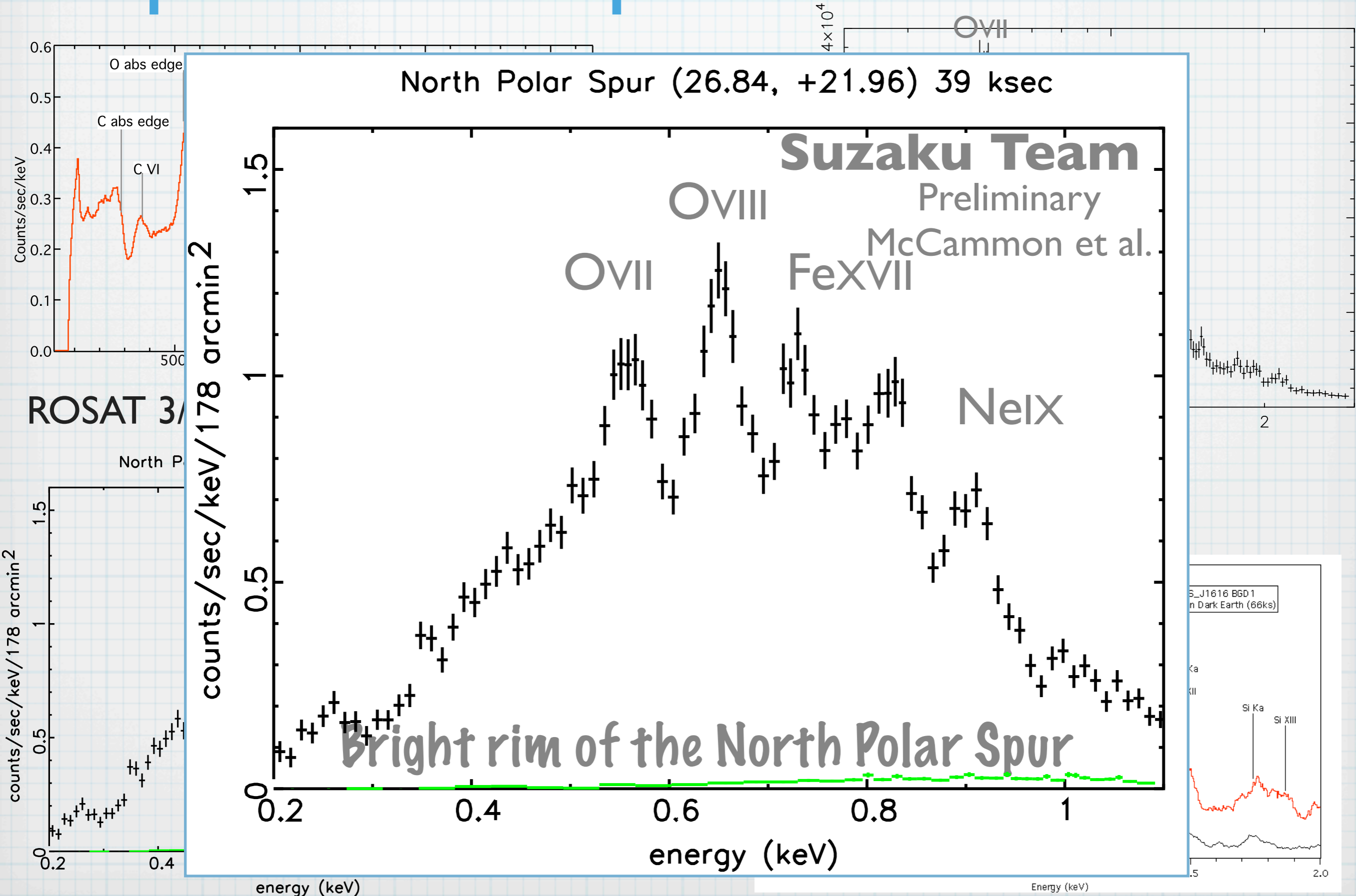
Spectacular spectra of hot ISM



Spectacular spectra of hot ISM



Spectacular spectra of hot ISM

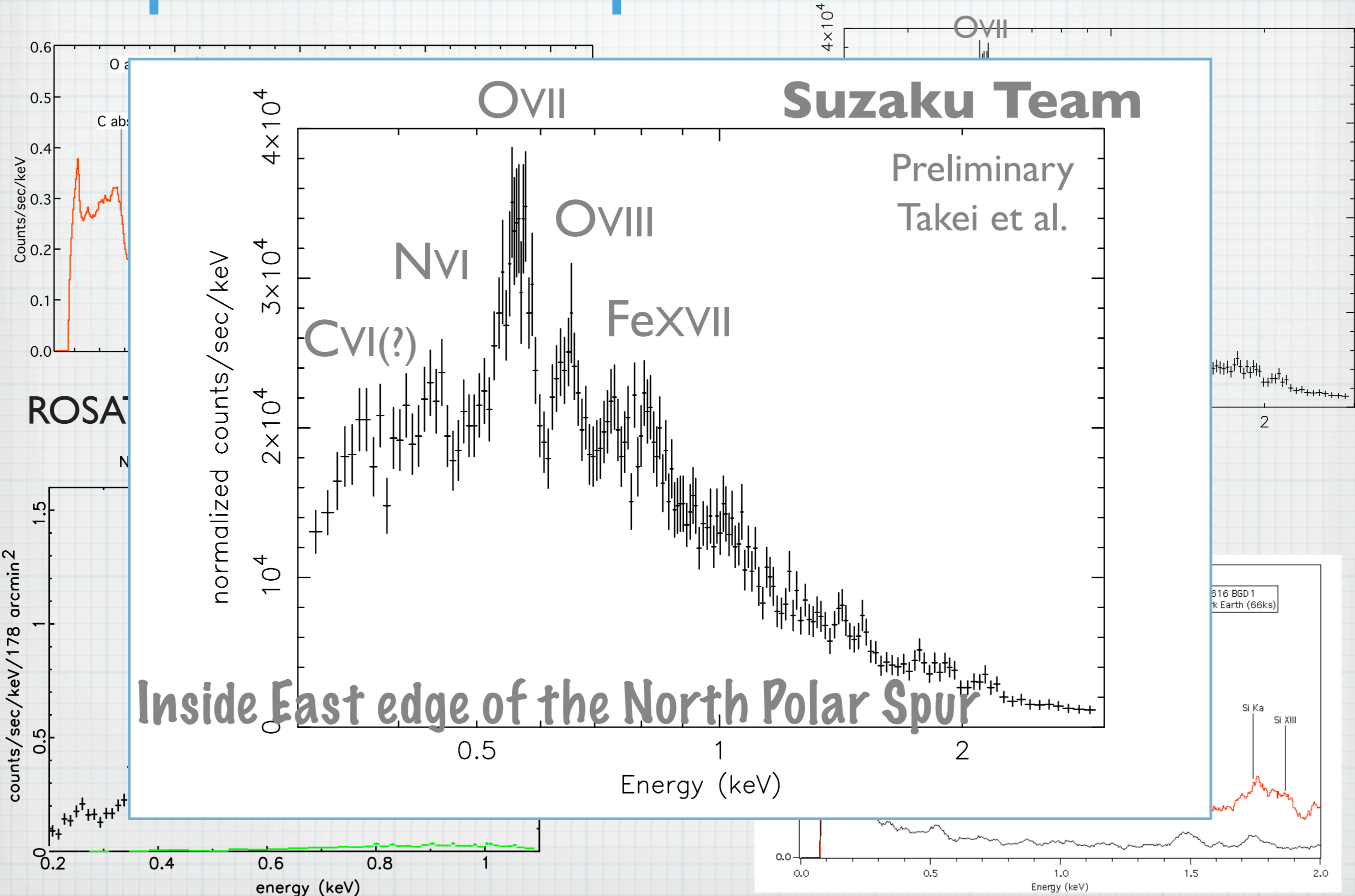


Preliminary spectral fitting

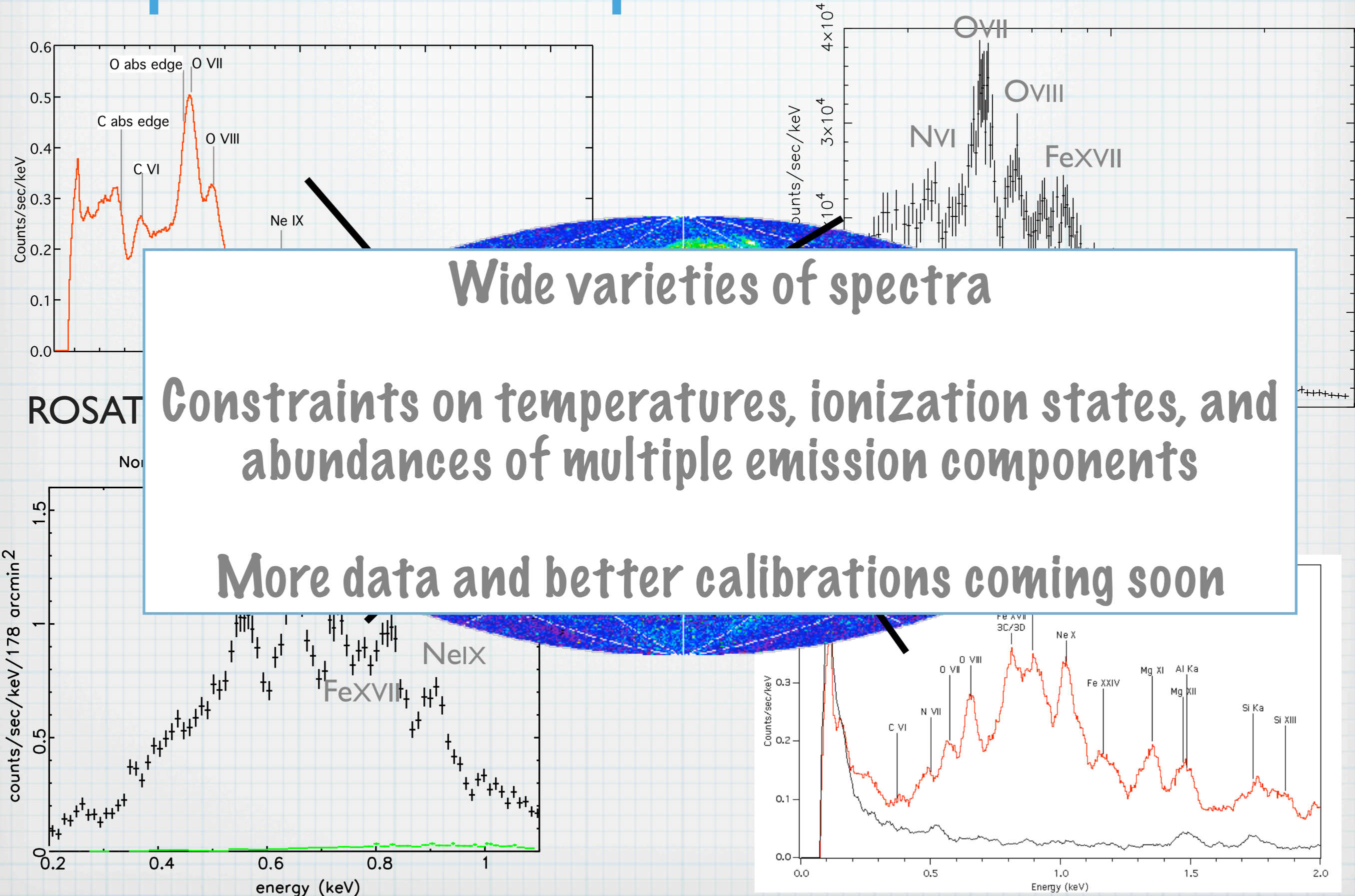


At least multiple temperatures and non-solar abundances are necessary, though the spectrum cannot be fitted well yet. Bad fits are partly due to calibration problem.

Spectacular spectra of hot ISM



Spectacular spectra of hot ISM



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, $< 1\text{keV}$ compared to Chandra and XMM

Very much a unique and powerful observatory

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