Suzaku Mission Status

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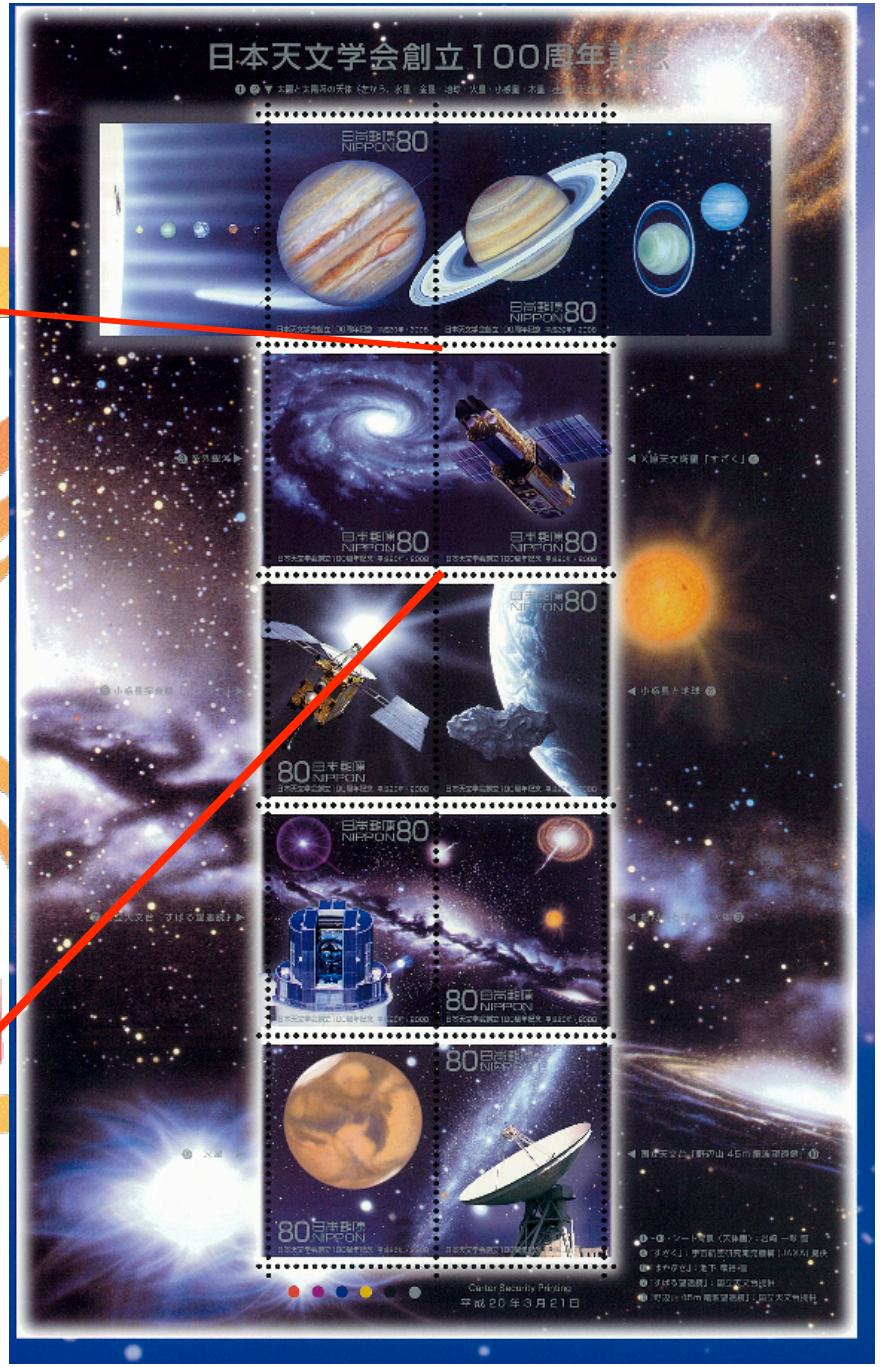
US Suzaku Project Scientist

Postal stamps to celebrate
Centennial Anniversary of
Astronomical Society of Japan



Japan Post printed
one million sheets!

US-Japan collaborative mission
Suzaku and its characteristics

	X-ray Imaging Spectrometer XIS	Hard X-ray Detector HXD
Instrument type	Soft X-ray Telescopes + CCD Cameras (One BI.)	Collimated well type Detectors PIN + GSO
Energy Range	0.2-12 keV	PIN:10-80keV GSO:60-600 keV
Angular resolution	1.8-2.0’	
Field of view	19’x 19’	0.56 ° x0.56°
Energy Resolution	140 eV @ 6 keV	0.35 keV @ 20 keV

1000 days in orbit on April 5, 2008!

Mission Status Summary

1. Revised background models make **HXD** the most sensitive detector in the 10-200 keV band

2. Charge injection keeps the best energy resolution of the **XIS** among CCD instruments

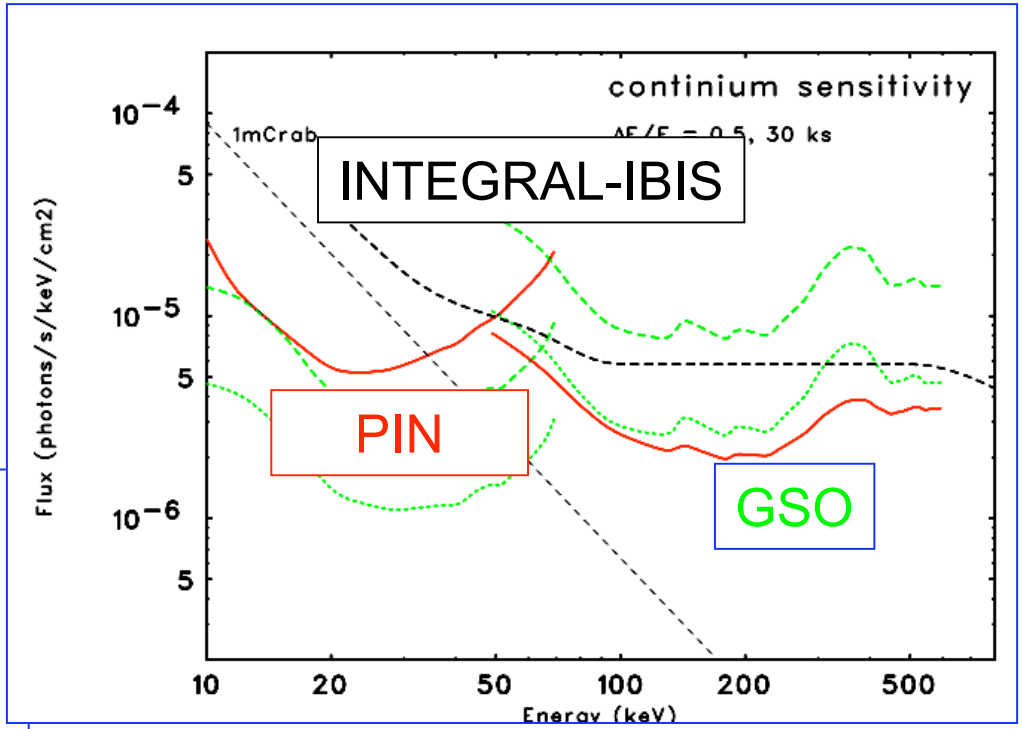
3. XIS filter contamination is understood and stable

Improved HXD BKGD Models

New PIN detector NXB model has ~1 % systematics

New GSO detector NXB model has ~1% systematics

Calculated Sensitivity for a point source (30 ks exp.)



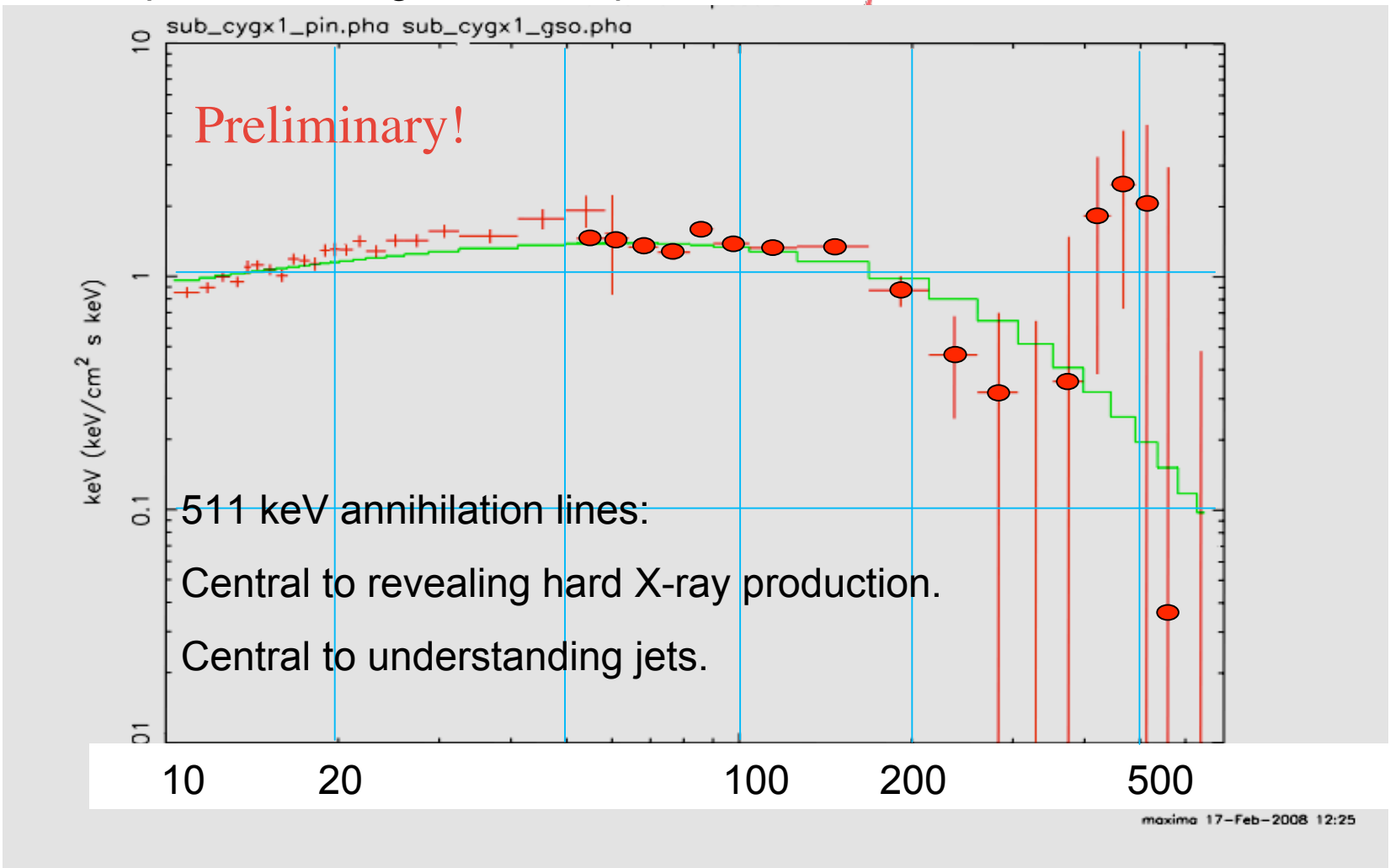
Highest sensitivity

Small fov, guard detectors

Suzaku-HXD is able to detect
Hard X-ray VARIABILITY
of mCrab sources
even with **strong absorption**.

Extreme sensitivity in hard X-rays: Cygnus X-1

Difference spectrum of Cyg X-1 between high state and low state.
No spectral fitting has been performed!



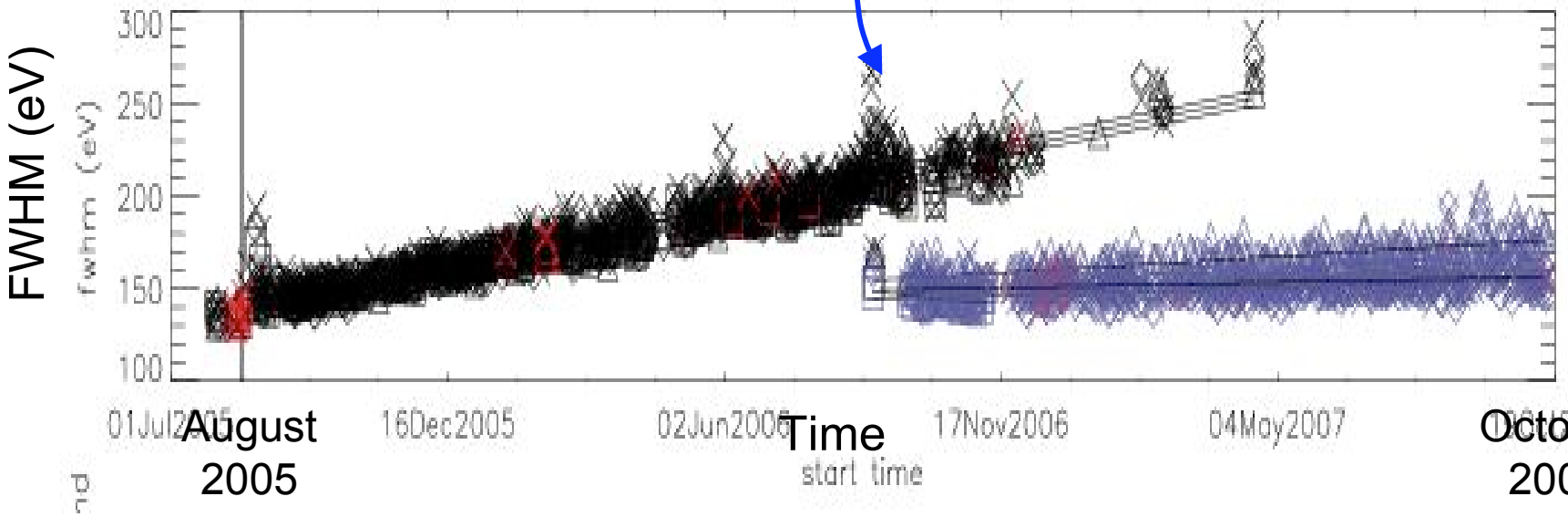
S. Yamada, private communication

Improvements of XIS energy resolution by the charge injection

Monitoring data of ^{55}Fe

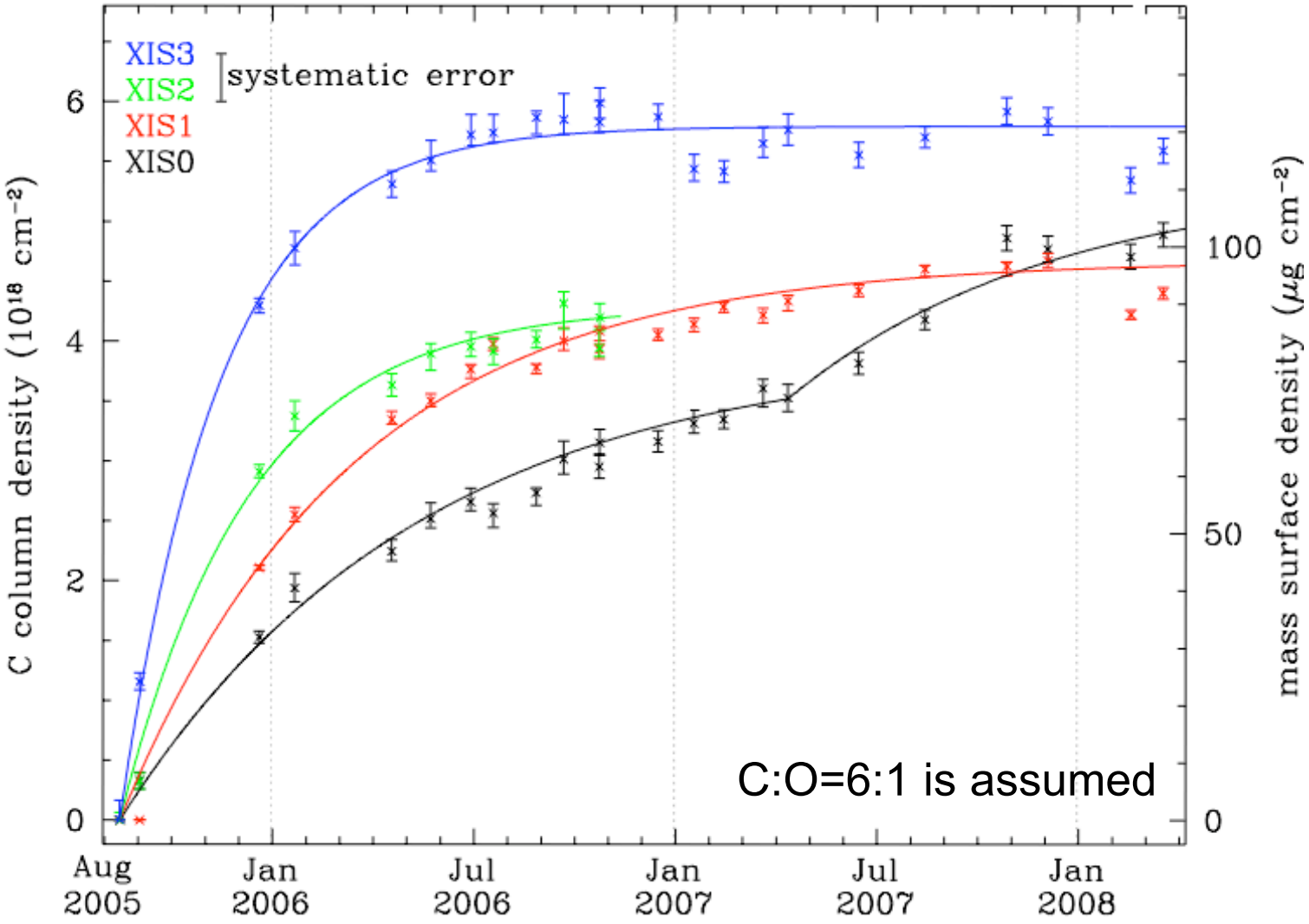
Spaced-row charge injection (SCI) introduced

Energy resolution



XIS has the best spectral resolution of any X-ray CCD detector!

History of contamination layer thickness



Unique Science enabled by Suzaku

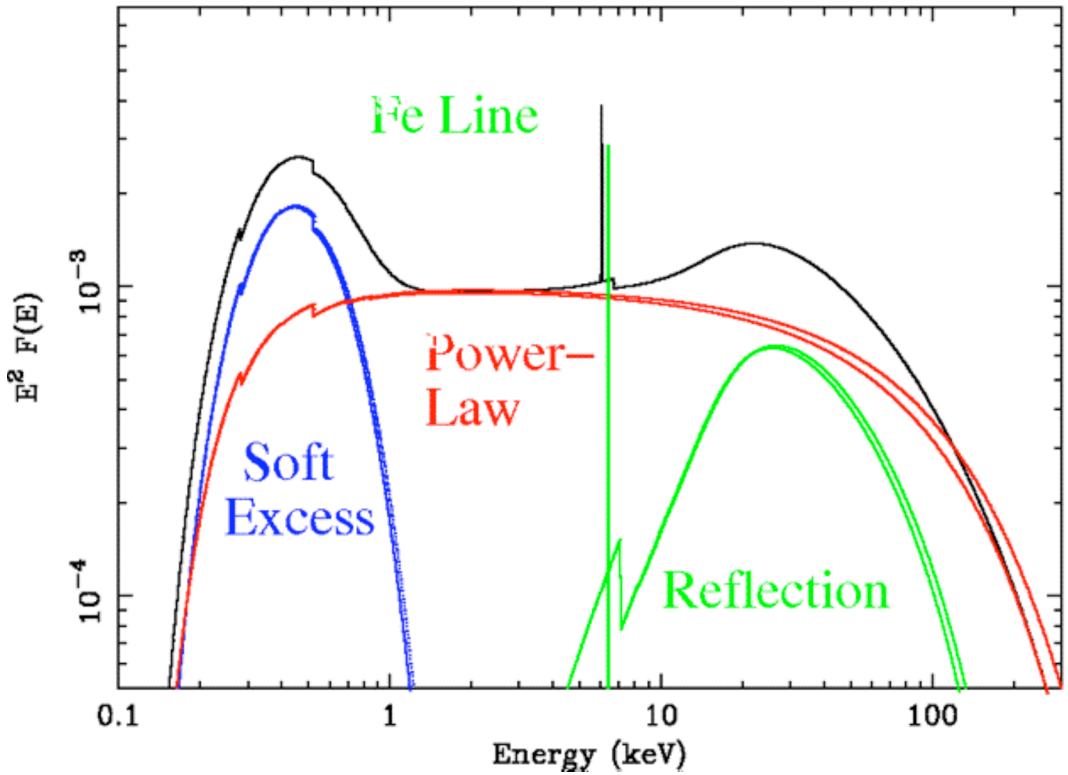
Attribute	Unique Science Enabled (examples)
Simultaneous broad band energy coverage (0.2-600 keV)	Simultaneous measurement of disk emission, warm absorber composition and velocity, reflection hump, and broad Fe lines in X-ray binaries and supermassive black holes
Spectral resolution in the 0.2-10.0 keV band	Measurement of C, N, O abundances in ISM and SNRs Determination of properties of geocoronal and heliospheric soft X-ray charge exchange emission
Spectral resolution and sensitivity in the 6-10 keV band	Detection and separation of Fe band features in cataclysmic variables, X-ray binaries, AGN and the Galactic Plane and Ridge Modeling of relativistic effects in broad Fe lines in neutron star binaries and stellar and supermassive black holes
Low background in the 0.2-10 keV band	Measurement of cluster temperatures and abundances to the virial radius Mapping of low surface brightness sources (e.g., extended HESS Galactic sources)
High sensitivity in the 10-50 keV band	Spectroscopy of **all** AGN detected by Swift -- determination of the contribution of absorbed AGN to the CXRB Measurement of the magnetic field strength in XRBs and AXPs through detection of cyclotron features Search for nonthermal emission from clusters and SNRs

Suzaku Addresses Thematic Questions:

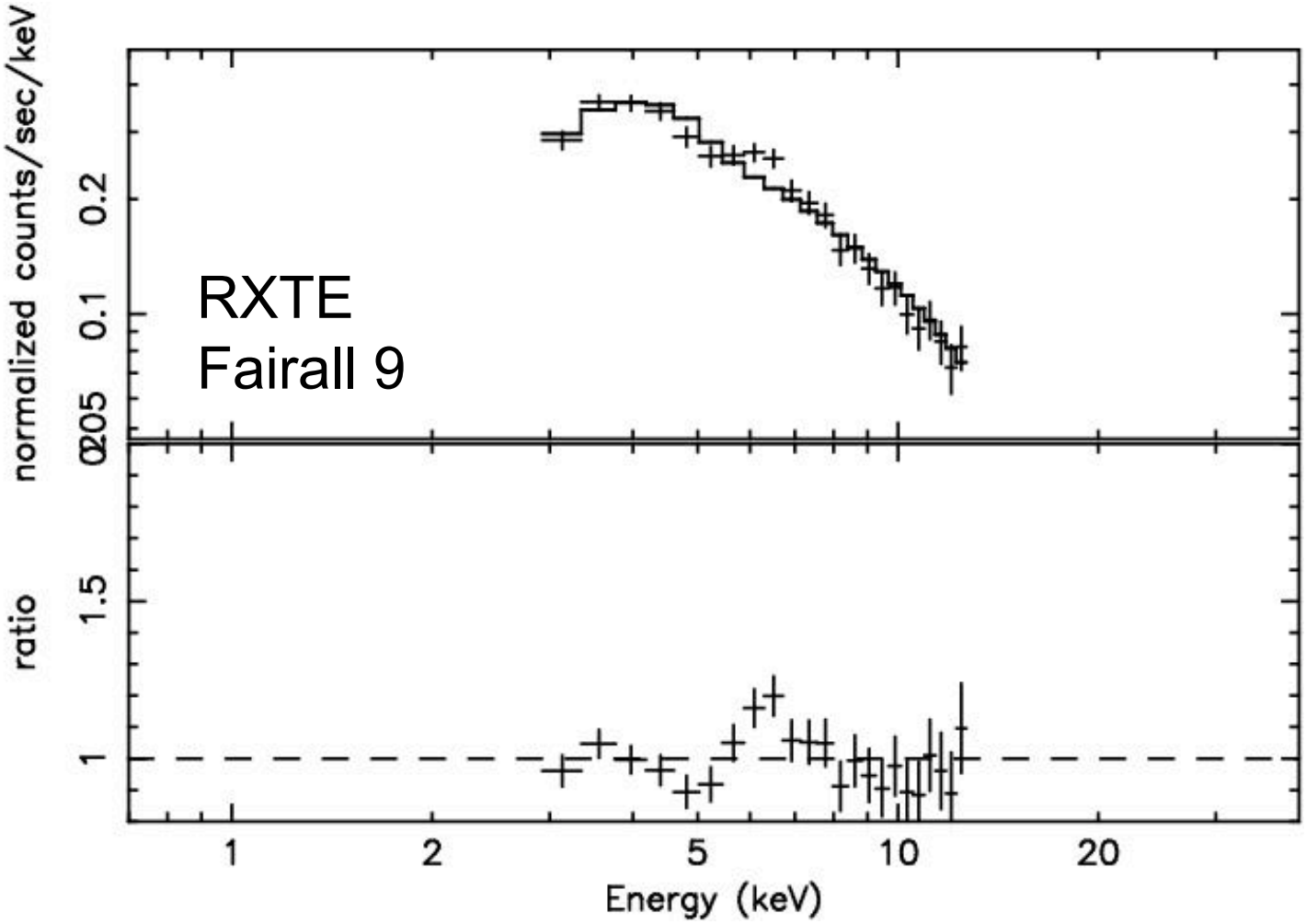
- The nature of space and time near to black holes?
- The nature of dark energy?
- How do cosmic accelerators work?

Understanding accretion in strong gravity --> broad-band spectra of *many* sources.

Only Suzaku can do that.



Suzaku is the *best* observatory for spectroscopy of moderately bright and faint accreting sources.



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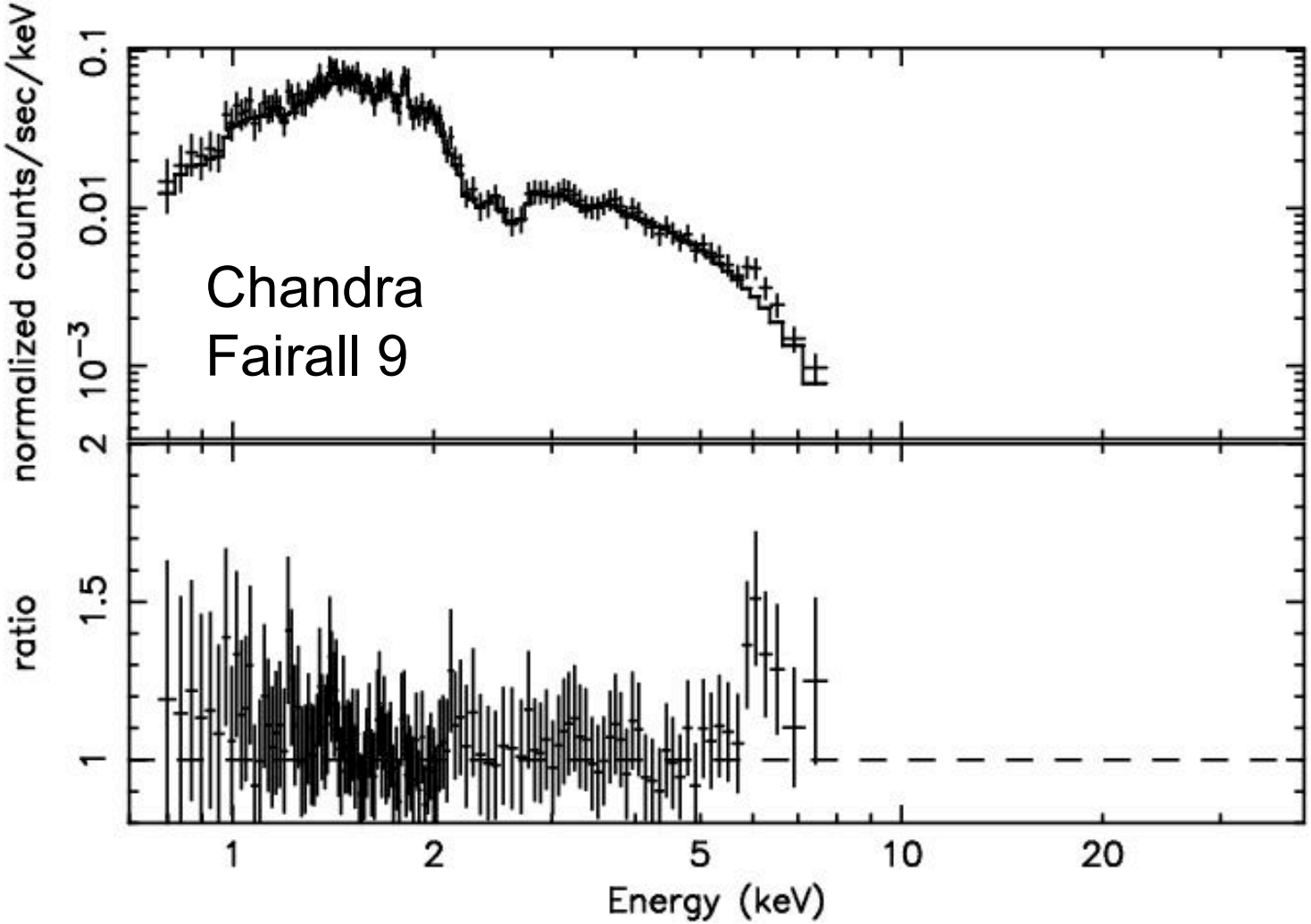

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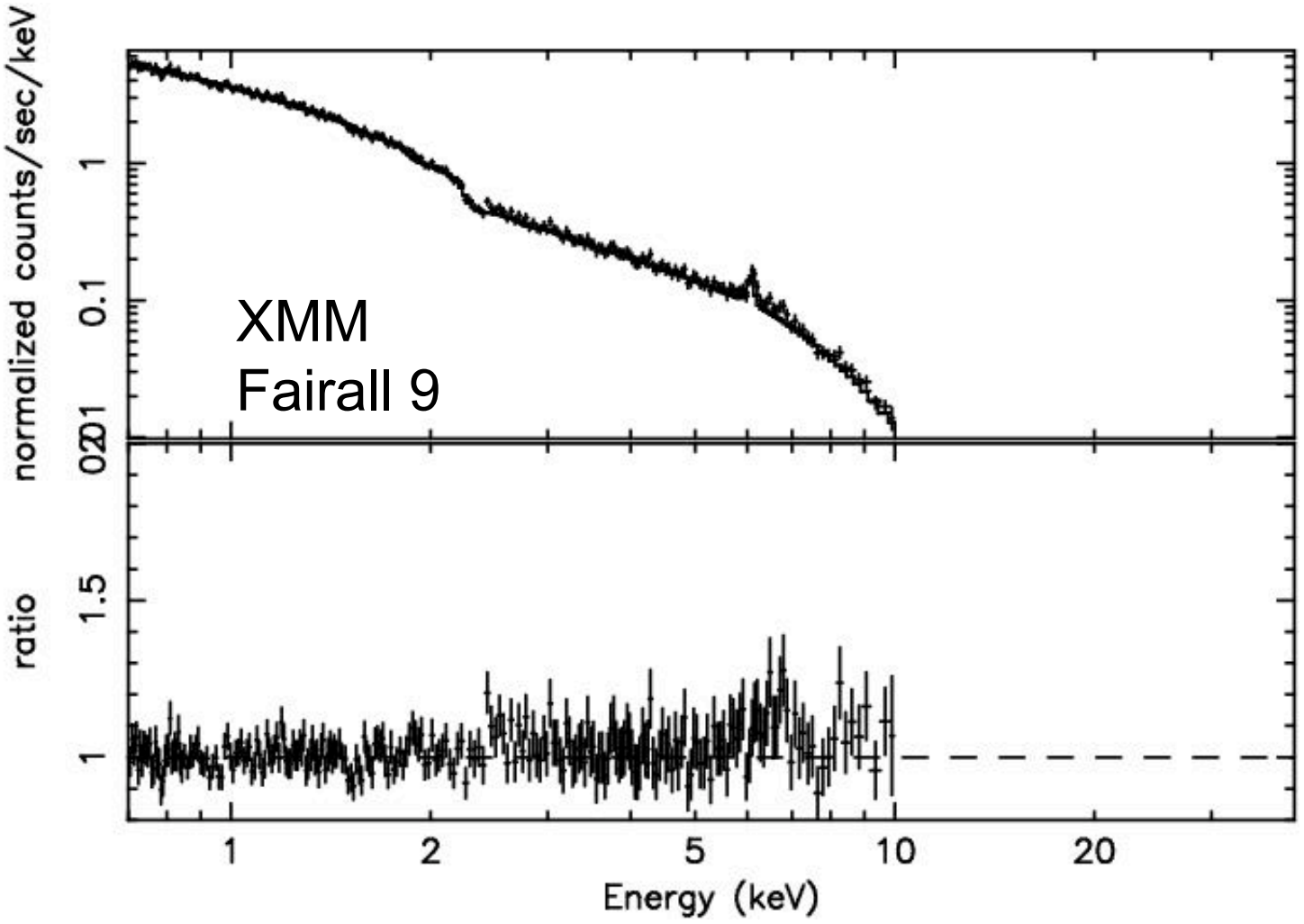

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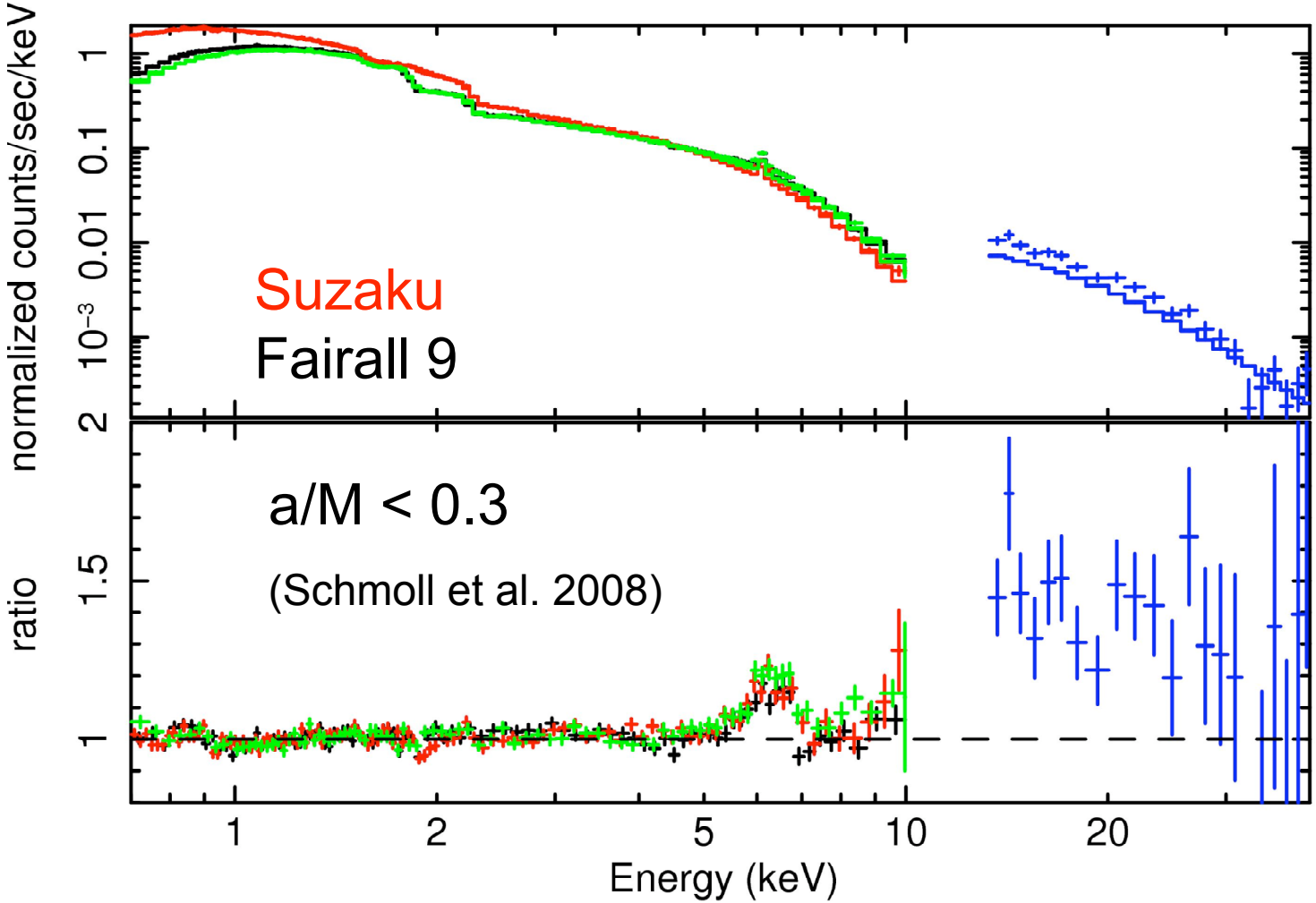
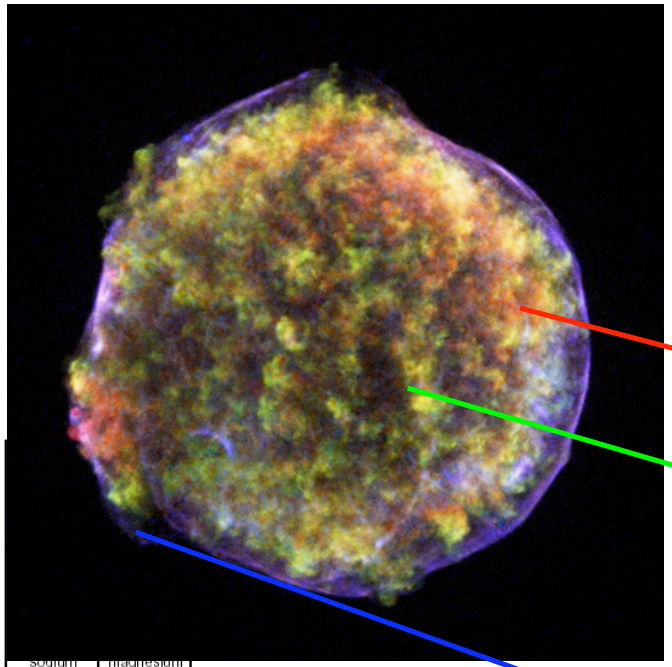


Low abundance metals in Tycho's SNR



Common elements are easily detected in supernova remnants.

But better spectra are needed to fully reveal the explosion.

																	helium 2 He 4.0026
												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
sodium 11 Na 22.990	magnesium 12 Mg 24.305											aluminium 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948
potassium 19 K 39.098	calcium 20 Ca 40.078		scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.846	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selenium 34 Se 78.96	bromine 35 Br 79.904	krypton 36 Kr 83.80
rubidium 37 Rb 85.468	strontium 38 Sr 87.62		yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29
caesium 55 Cs 132.91	barium 56 Ba 137.33	57-70 ✳	lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]

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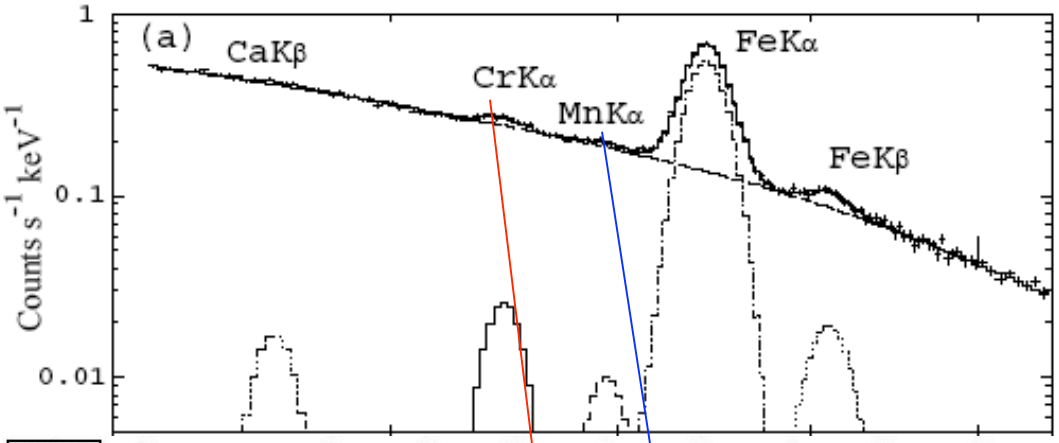

Trace element abundances distinguish exposion models.

Delayed detonation models are favored by Suzaku spectroscopy!

Only Suzaku has detected both Cr, Mn.

hydrogen 1 H 1.0079																	helium 2 He 4.0026
lithium 3 Li 6.941	beryllium 4 Be 9.0122												boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180
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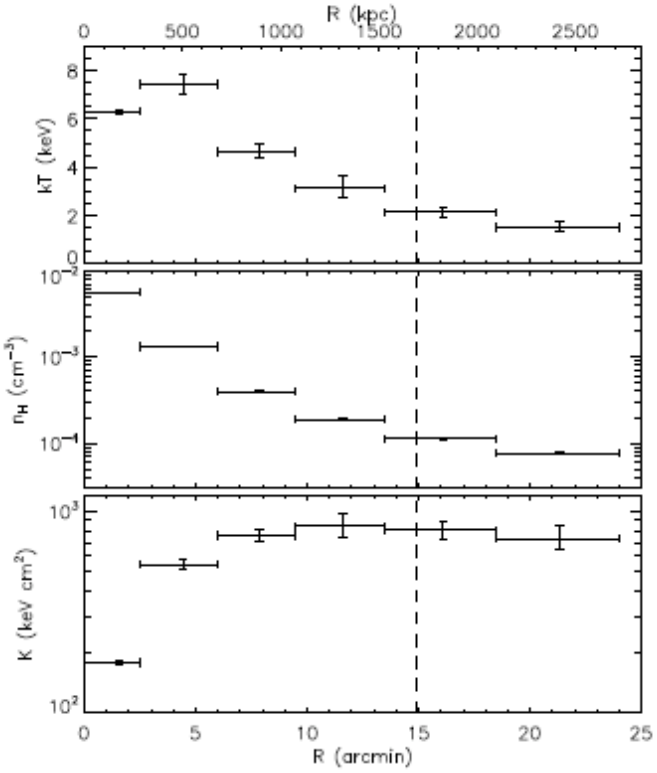
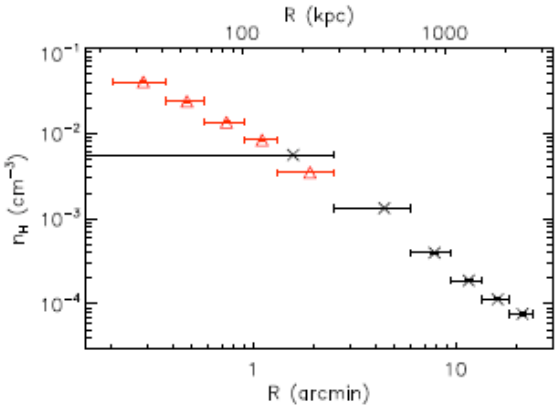
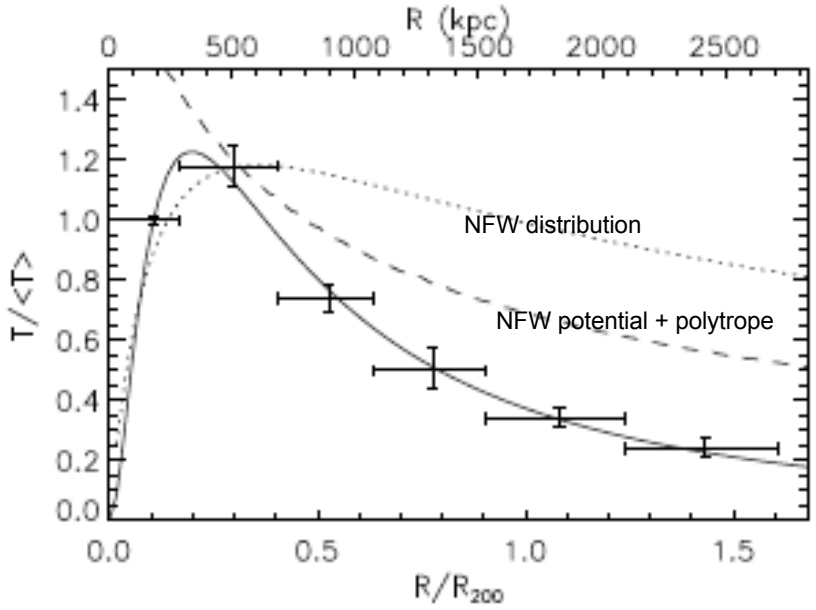
Suzaku is the *best* observatory for low surface brightness studies





Comparison of density profile with Chandra result

Comparison of normalized temperature profile with models shows thermal energy deficit at large radius



First measurement of cluster properties beyond virial radius - PKS0745-191 (George et al. 2008; MNRAS in press)

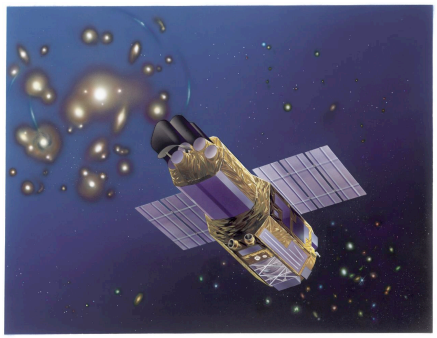
Suzaku Lifetime projection

ASCA	
Launch	Feb. 1993
Loss of control	July 2000
Re-entry	Mar. 2001

ASCA (1993-2001)

Suzaku	
Launch	July 2005
XIS-2 Damage	Nov. 2006
Orbital life	~2015

Suzaku (2005-)



Suzaku is one of a series of US-Japan collaborations, that started with ASCA and will be followed by Astro-H (2013)

AO4 plans

- AO4 released on Monday, September 8
- National time division for AO4 remains 37.5% US, 50% Japan, 12.5% joint
- US Long project time allocation will remain ~1 Ms
- Introducing Key Programs
  - 1-2 at any given time; > 1 Ms per program
  - Time dedicated to answering specific questions uniquely suited for Suzaku
  - Driven by community input

Potential Suzaku Key Projects

- ***Survey of LMXB Lines to Constrain Neutron Star Parameters***
- ***Solving the Mystery of the 30 keV X-ray Background by measuring spectra of absorbed AGN discovered by Swift and INTEGRAL***
- ***Survey of Unidentified Extended Galactic TeV Sources***
- ***Investigating Dark Energy using a snapshot survey of ~500 Clusters of Galaxies***
- ***Galactic SNR survey to identify low Abundance Nucleosynthesis Products***

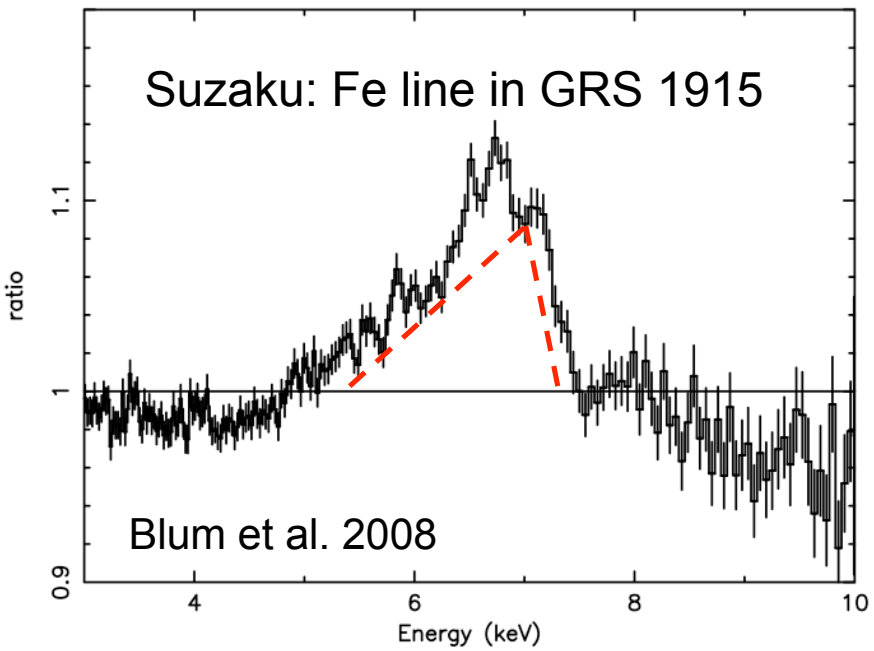
US Project Status

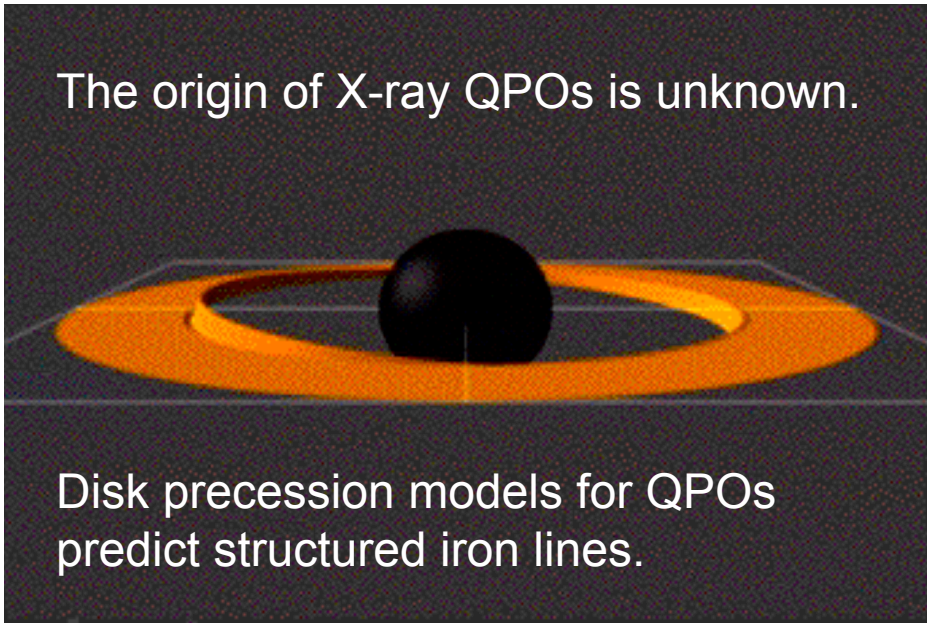
- Ranked 4th of 9 missions in 2008 senior review
  - Supported Key Project concept
  - Recommended closer coordination with Swift, Fermi, etc.
- US program is funded through FY 2010
- GO support funds for AO4+ are modest
  - ~$500k - $700k available for AO4,5
  - We plan to ask NASA HQ for funding augmentation
- JAXA seems inclined to continue data sharing arrangement indefinitely
- For future, coordinated programs with Chandra, Swift, possibly others

Galactic black holes and neutron stars are nearby General Relativity laboratories.

Suzaku is making unique strides.

Combining Spectra and Timing: Microquasar GRS 1915+105





- Bright source figure of merit: *Collecting Area * Livetime*.
- Suzaku opens a discovery space.

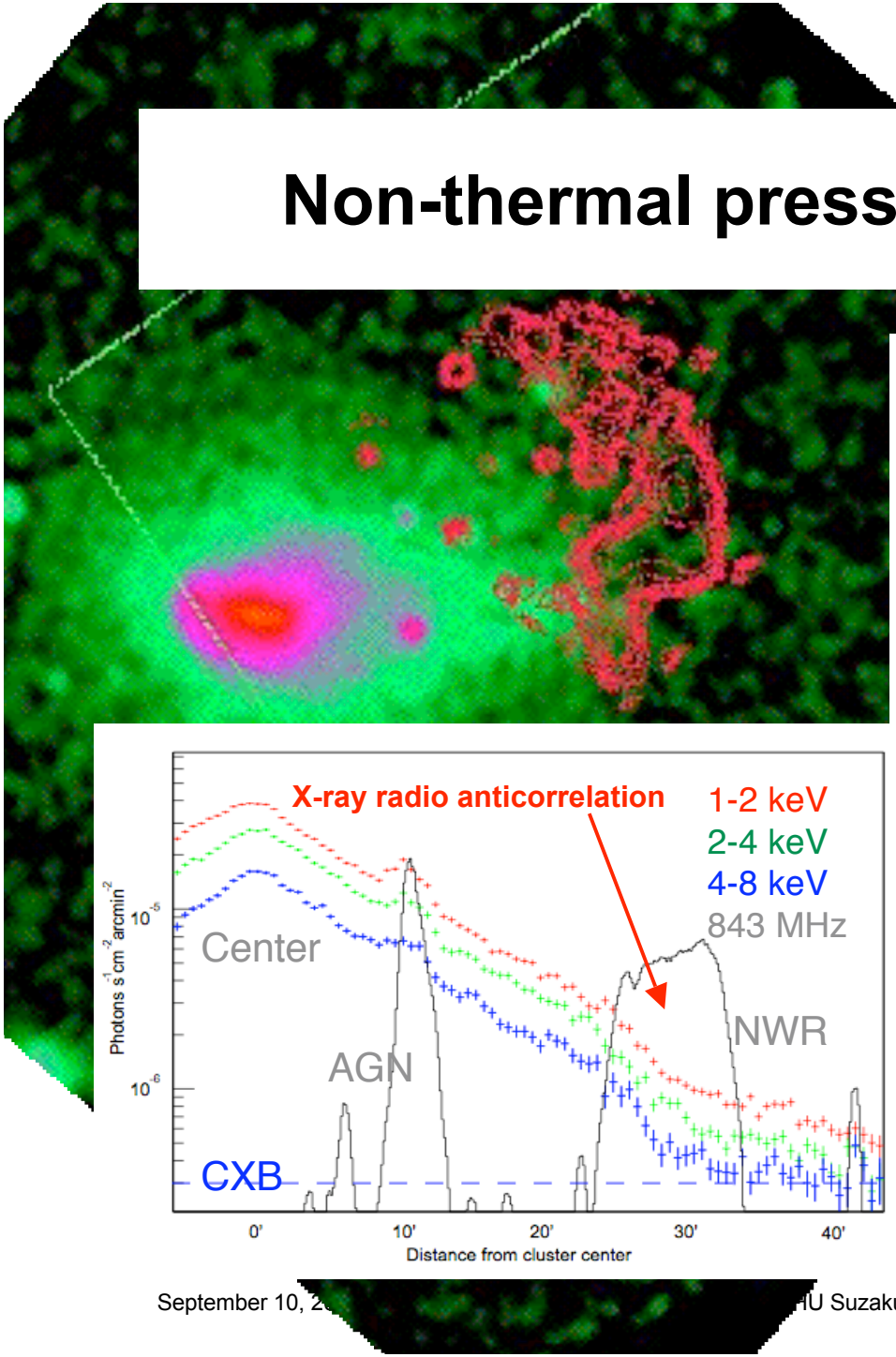
Understanding Type Ia SNe explosions requires the detection of rare elements.

Suzaku is making unique strides.

Hard X-ray emission in clusters can reveal important, elusive physics.

The Suzaku HXD enables new studies.

Non-thermal pressure in clusters



- Stringent upper limits on hard X-ray flux in Coma, A 3667, +++
- Radio + hard X-rays --> B field.
  XIS/HXD on A 3667: B>2.2μG
- *Non-thermal* pressure contribution, out to the virial radius.
- Strong implications for S-Z effect. Need to survey more clusters!
- Low background + sensitivity of XIS, HXD made this possible.
  (Sarazin et al. 08, Wik et al. 08)

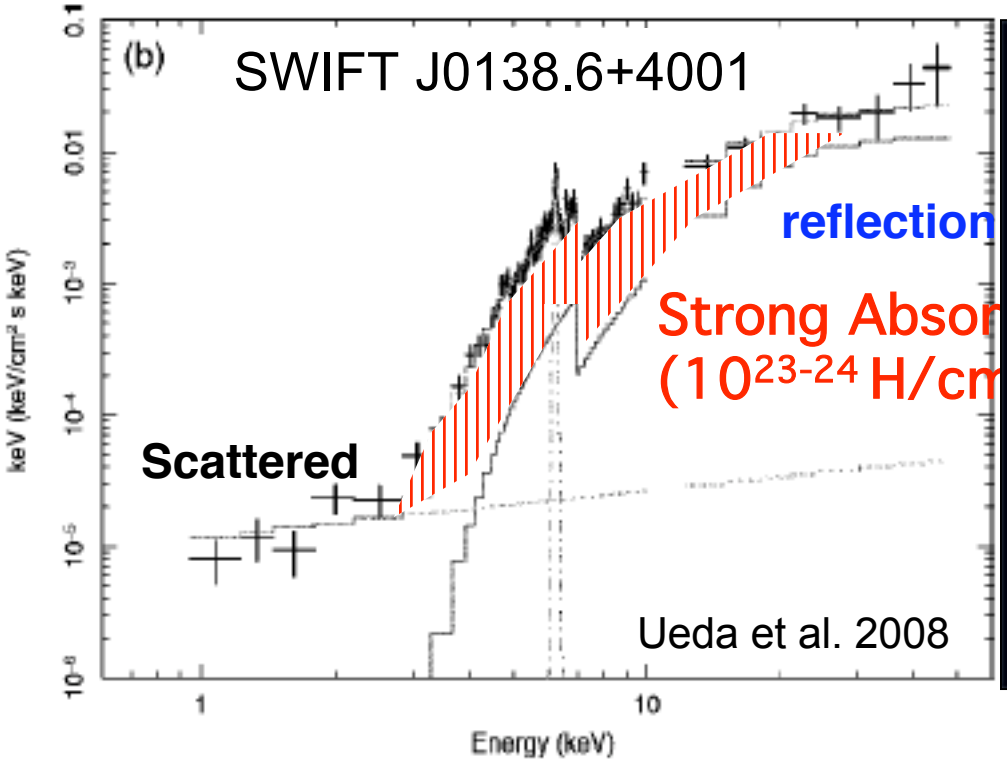
Hard X-ray emission mechanisms remain elusive. So too does jet production.

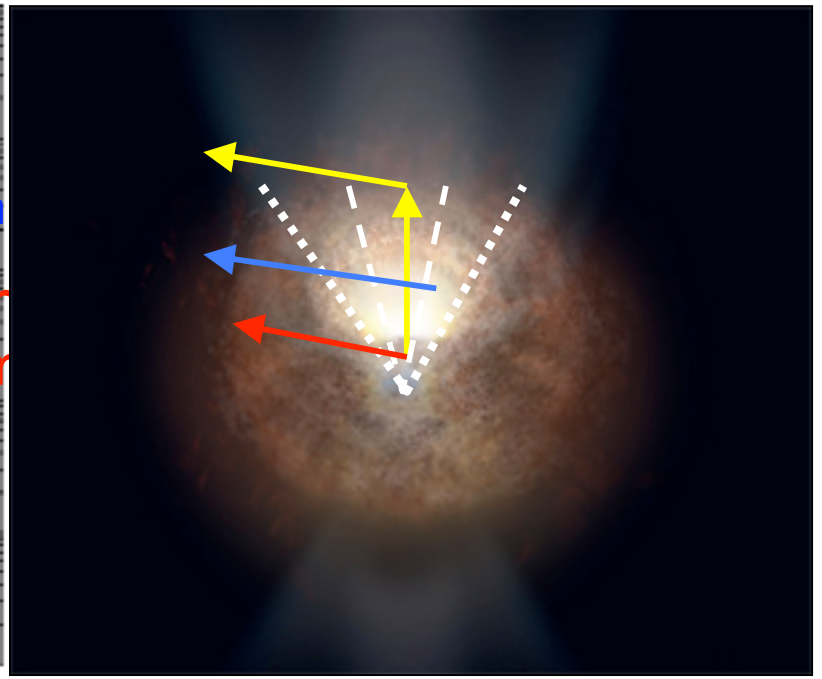
Suzaku is poised to make real progress.

Suzaku spectroscopy of Swift/BAT AGN is changing our picture of AGN

Not seen in soft X-ray, [O III] surveys.
Many more massive black holes!

Very week scatter(<0.5%)
Small cone angle(<20°)

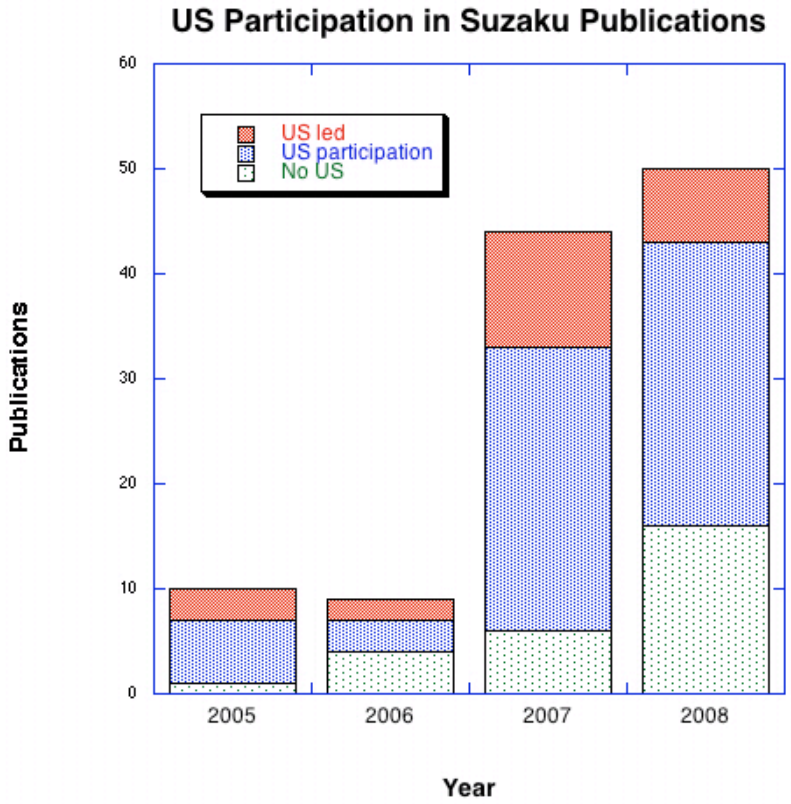




Suzaku publications

- Already more publications in 2008 than in 2007
- Special PASJ editions in 2007, 2008; third special edition being planned

Suzaku publications



- US scientists are involved in the vast majority of Suzaku publications
- Publications by US guest observers just starting to be submitted

US AO3 results

	AO1	AO2	**AO3**
Proposals submitted	164	156	**120**
Total time request (Ms)	24.1	25.6	**21.2**
Oversubscription factor	4.3	4.4	**3.5**
A/B/C proposals accepted	28/23/21	28/18/26	**24/15/20**
Long proposals accepted	-	-	**3/9**
Grant funding	$1.7M	$1.7M	$1.2M-$1.7M

- Interest in Suzaku remains high within US community
- Comparable program oversubscription in Japan
- AO3 grant funding depends on outcome of overguide request

Long Proposals

- 1 Ms each by US and Japan was set aside in AO3 for long proposals (projects requiring > 300 ks)
- US received 9 proposals; time was awarded to 3
  - Search for eclipse of NGC 3227 nucleus by orbiting clouds
  - Study of variability of warm absorber in nearby Seyfert NGC 4051
  - Determination of spatial distribution of low abundance metals in Tycho's SNR
- Long programs will continue in AO4 at approximately the same level

US Suzaku funding

- In guide Suzaku budget is:
  - $2.349k in FY2009
  - $2.428k in FY2010
- This budget funds processing, archiving, guest observer services, proposal review support, E/PO, and guest observer grants
- Amount available for grants is only $500k; reduced from $1.7M for AO1 and AO2
- Suzaku grants for AO1-2 were typically $26k, modest compared with programs of similar power
- The Suzaku project is requesting restoration of grant funding to AO1-2 level, in the form of an overguide request