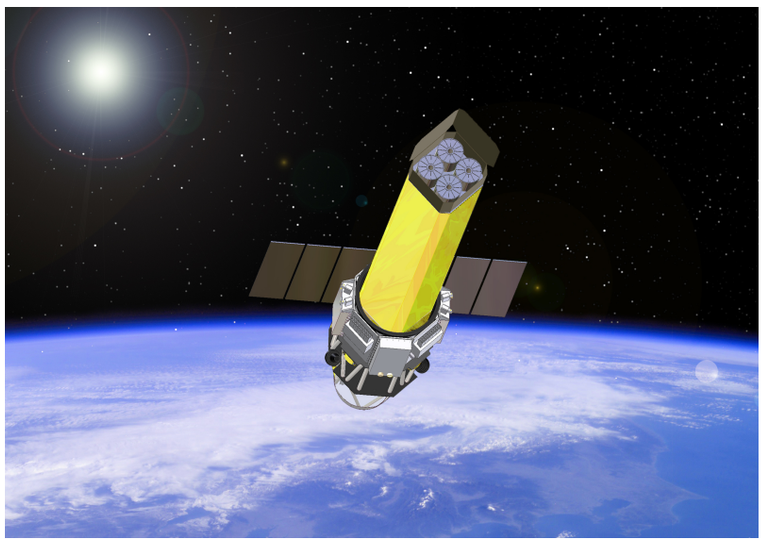
The NeXT X-Ray Mission

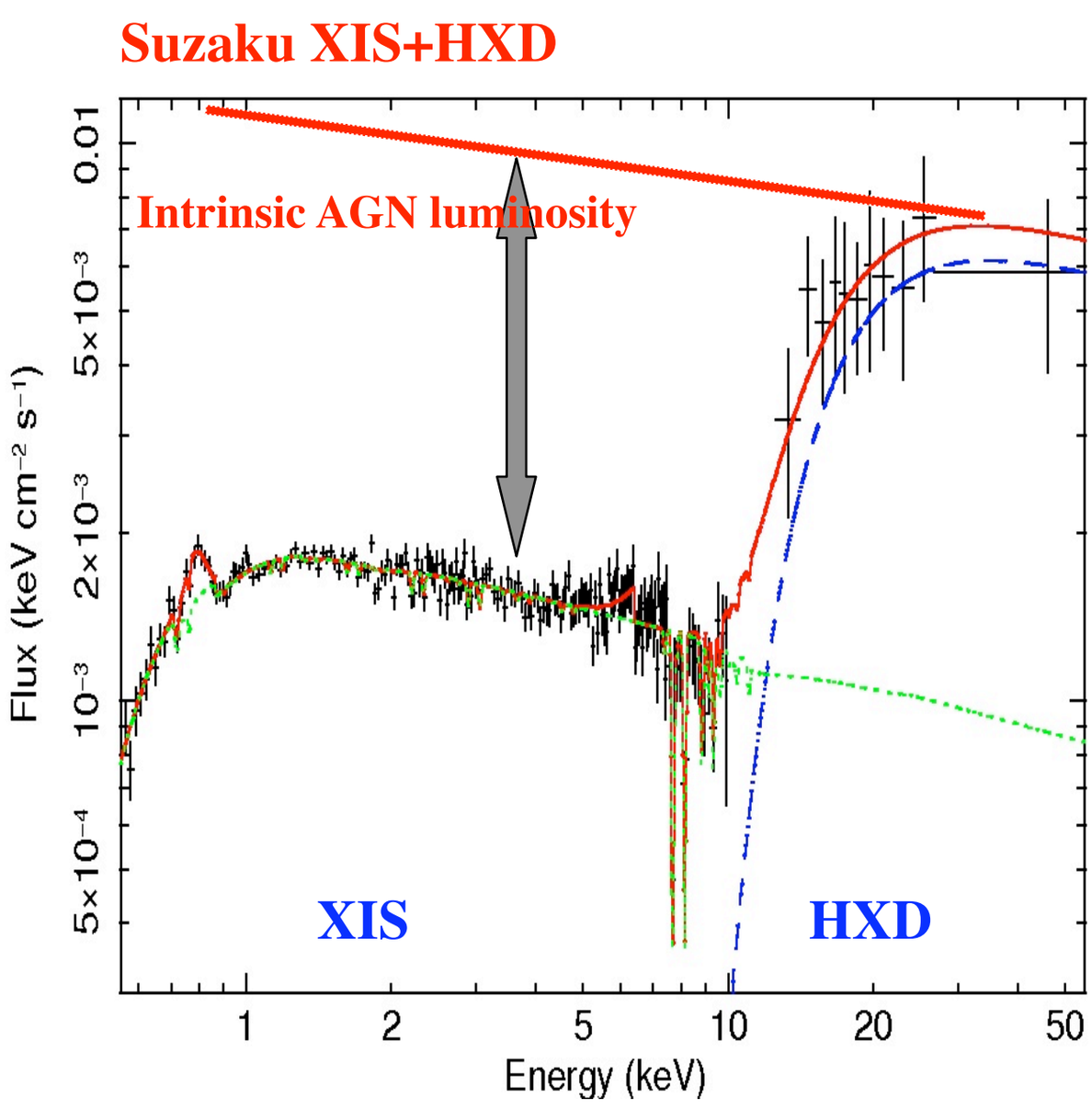
Tadayuki Takahashi
ISAS/JAXA

on behalf of the NeXT team
(Japan/US/Europe)

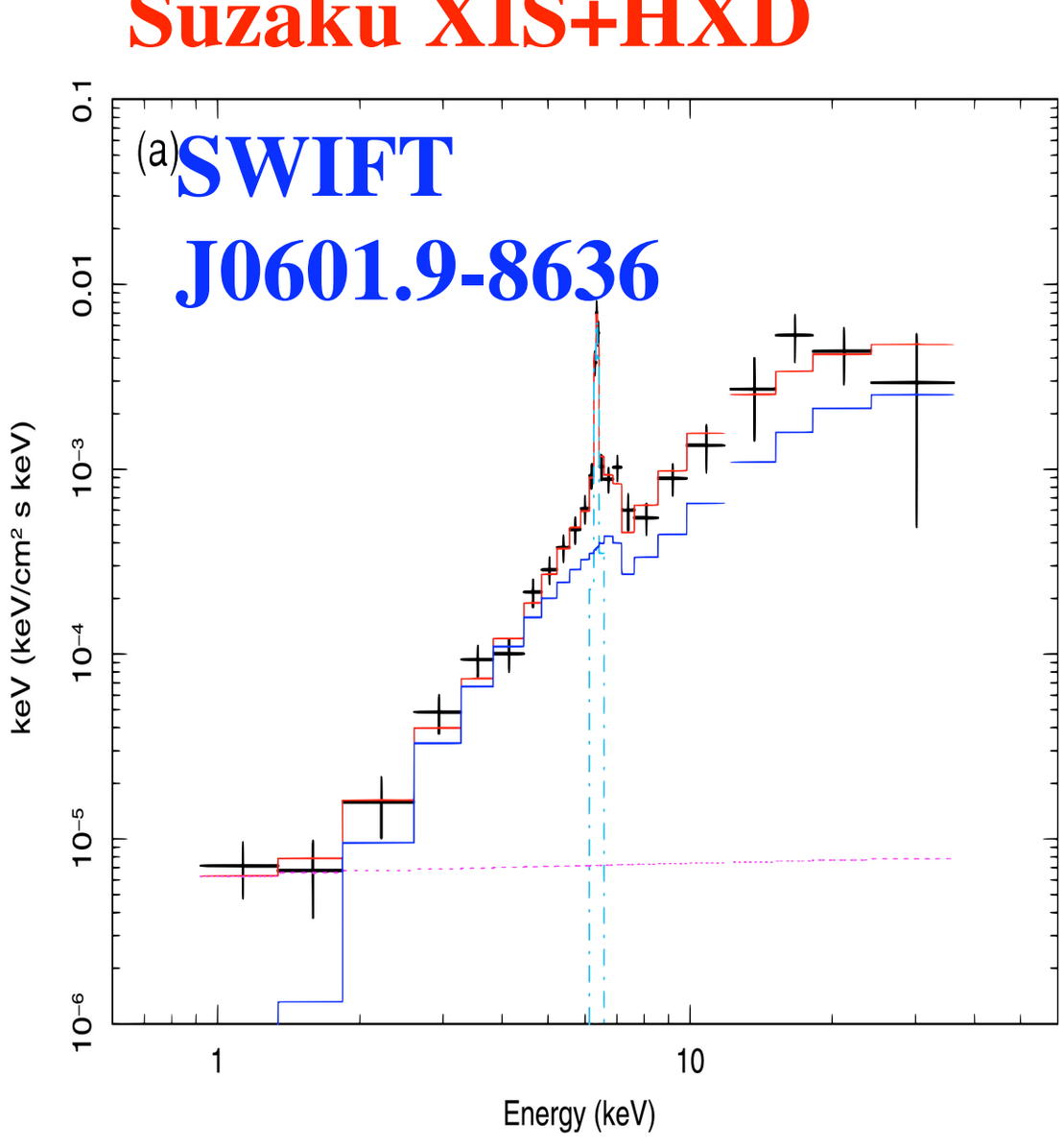


Reasons why we need next generation X-ray observatory

We are now finding more Obscured Power Sources



Reeves, this conf.

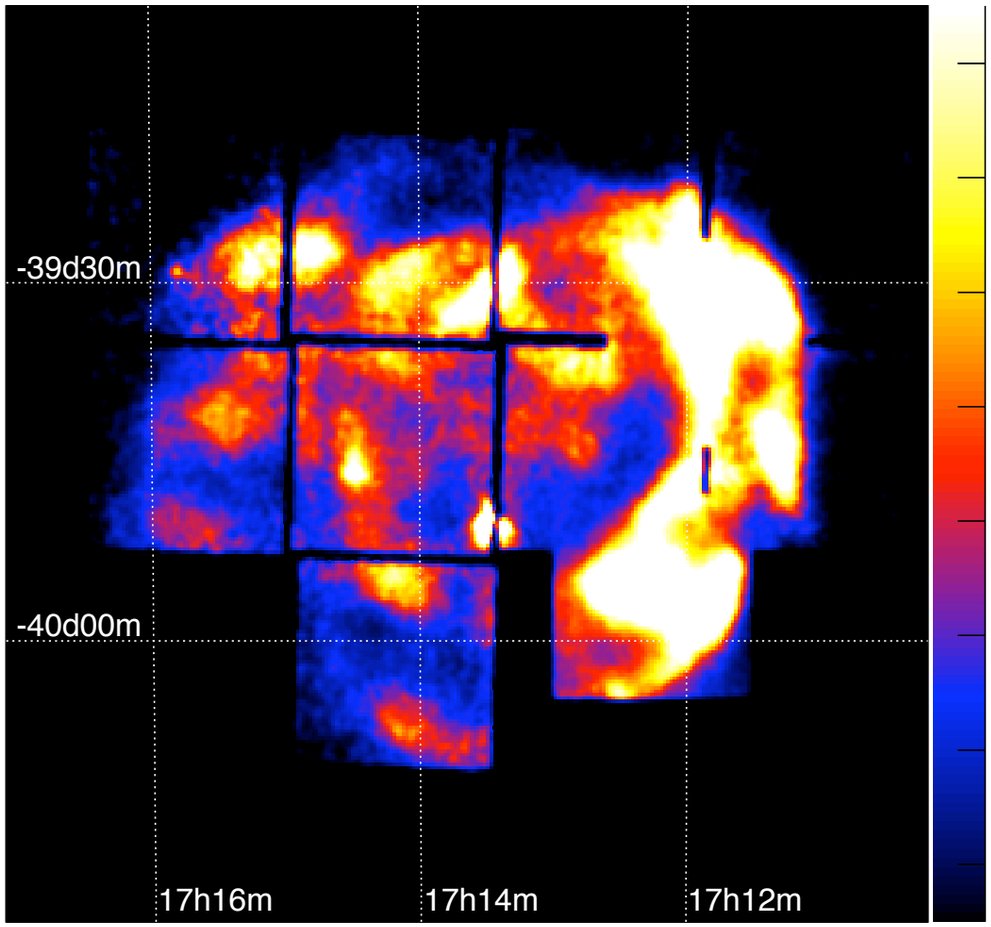


Ueda et al. 2007

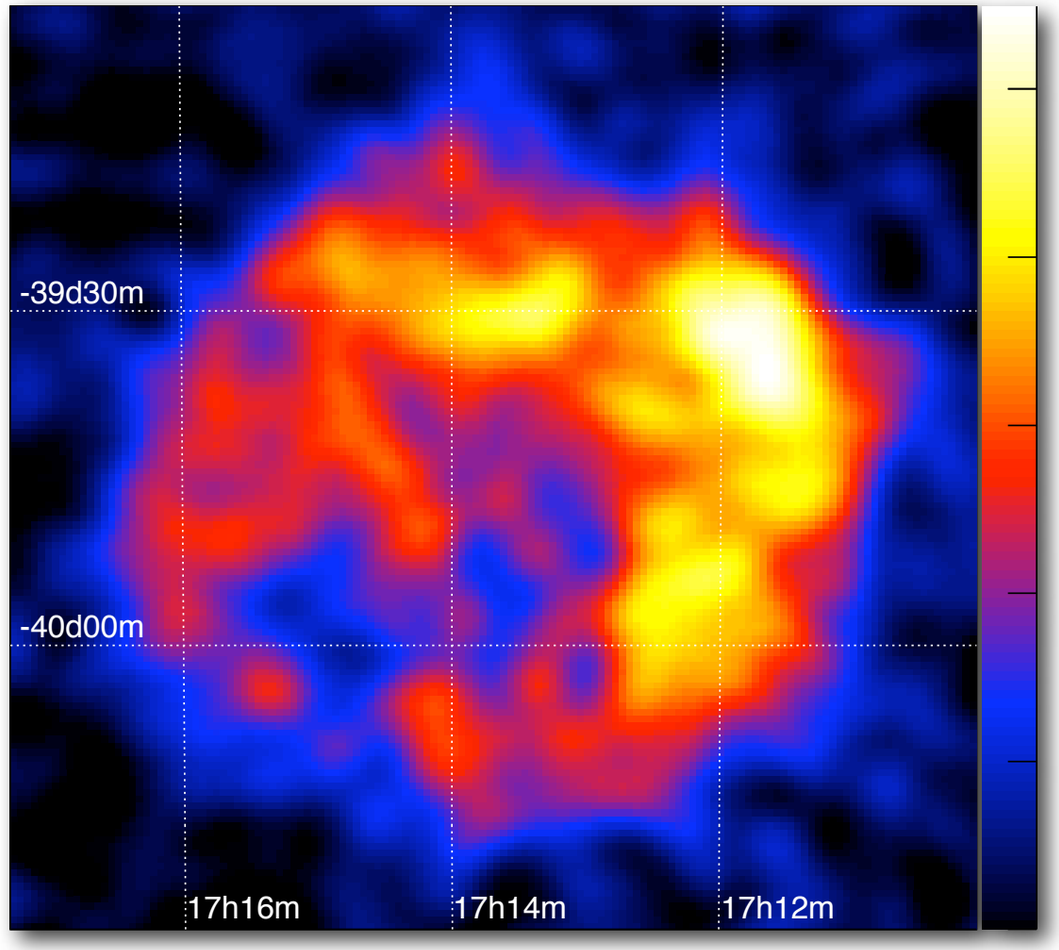
Reasons why we need next generation X-ray observatory

Hard X has a connection with TeV gamma ray from Accelerators

X-ray = 10^{15} eV electron



TeV gamma-ray = 10^{15} eV proton



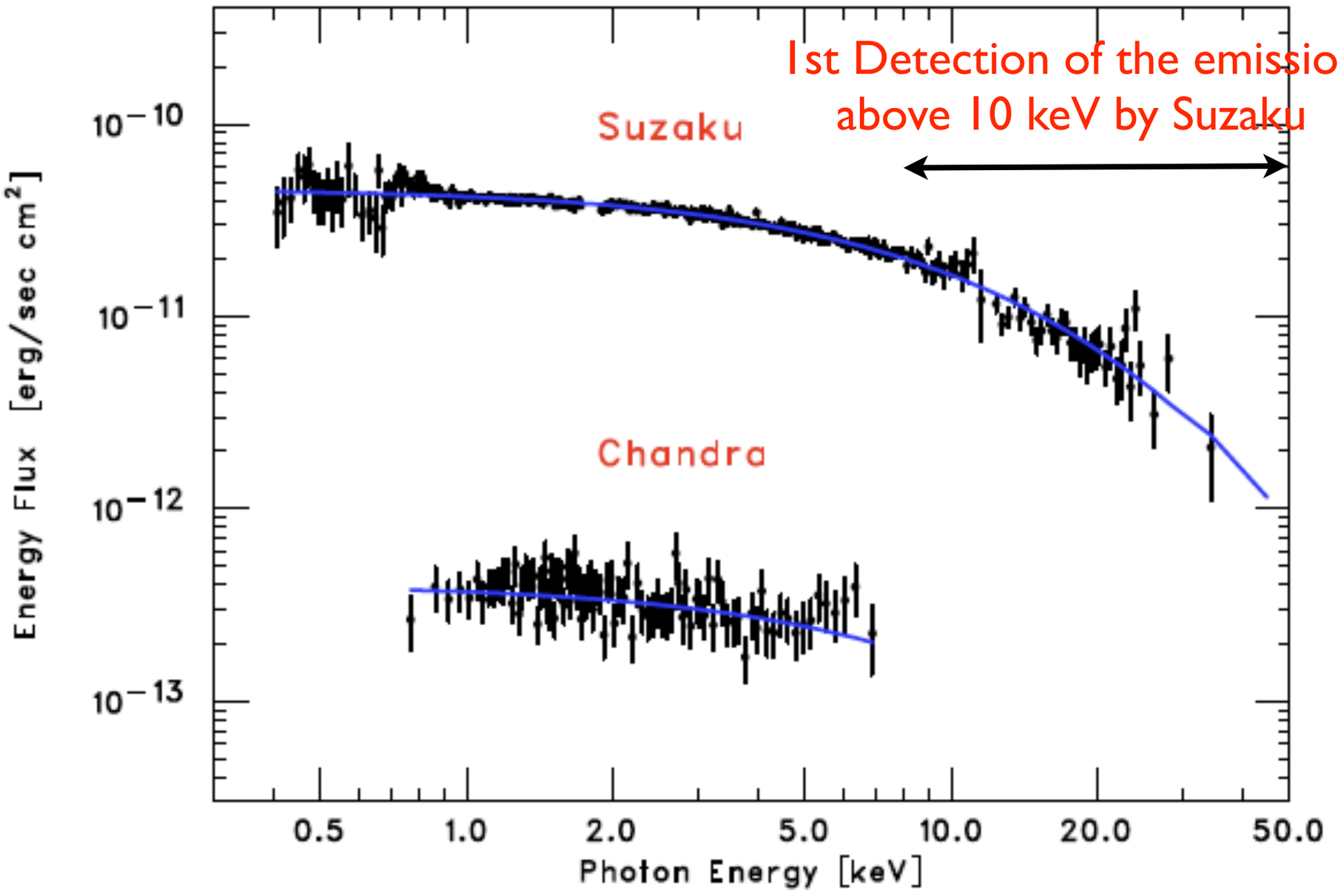
Reasons why we need next generation X-ray observatory

Hard X has a connection with TeV gamma ray from Accelerators

RX J1713.7-3946

X

oton



Uchiyama et al. 2007

Reasons why we need next generation X-ray observatory

Hard X has a connection with TeV gamma ray from Accelerators

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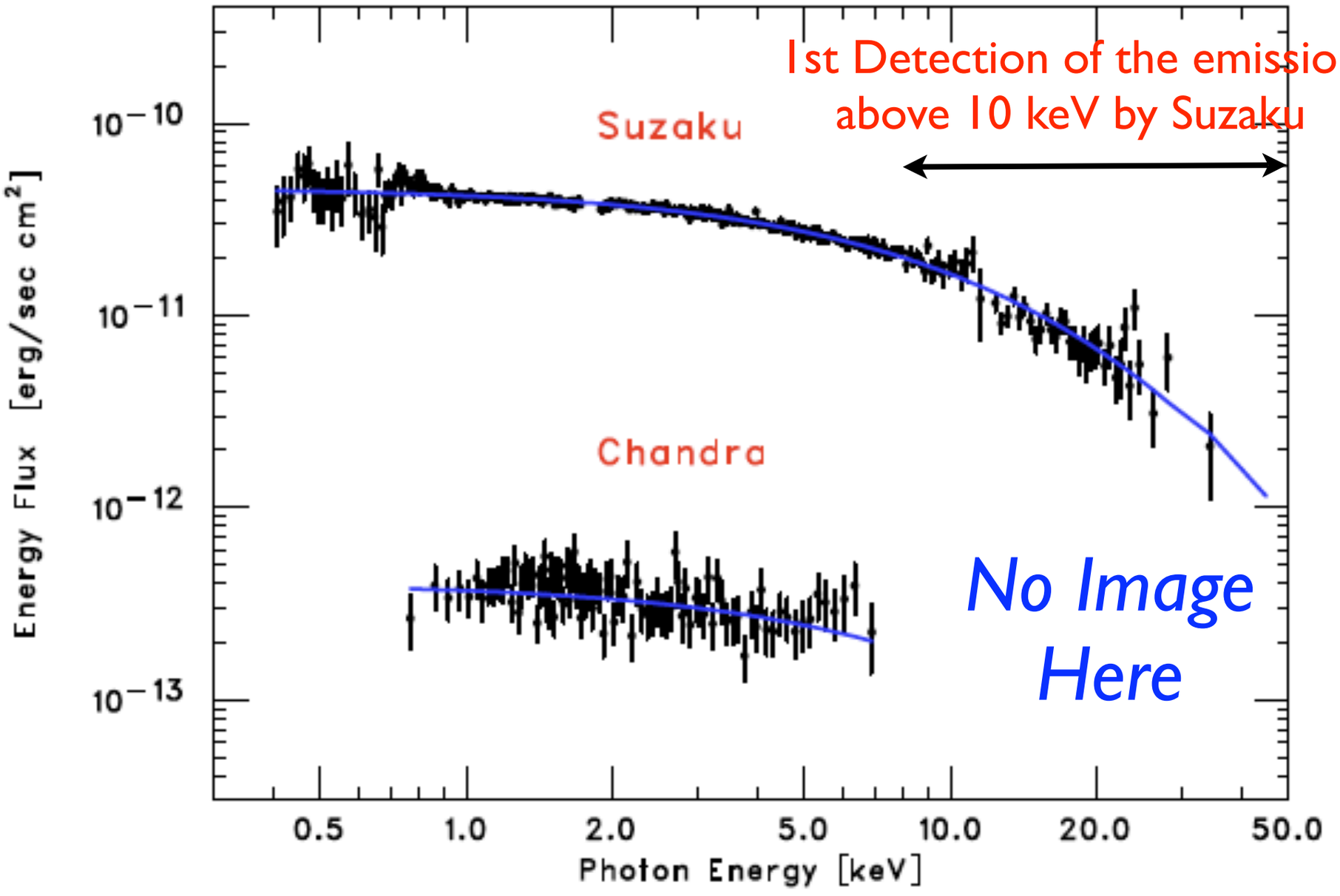
X

oton

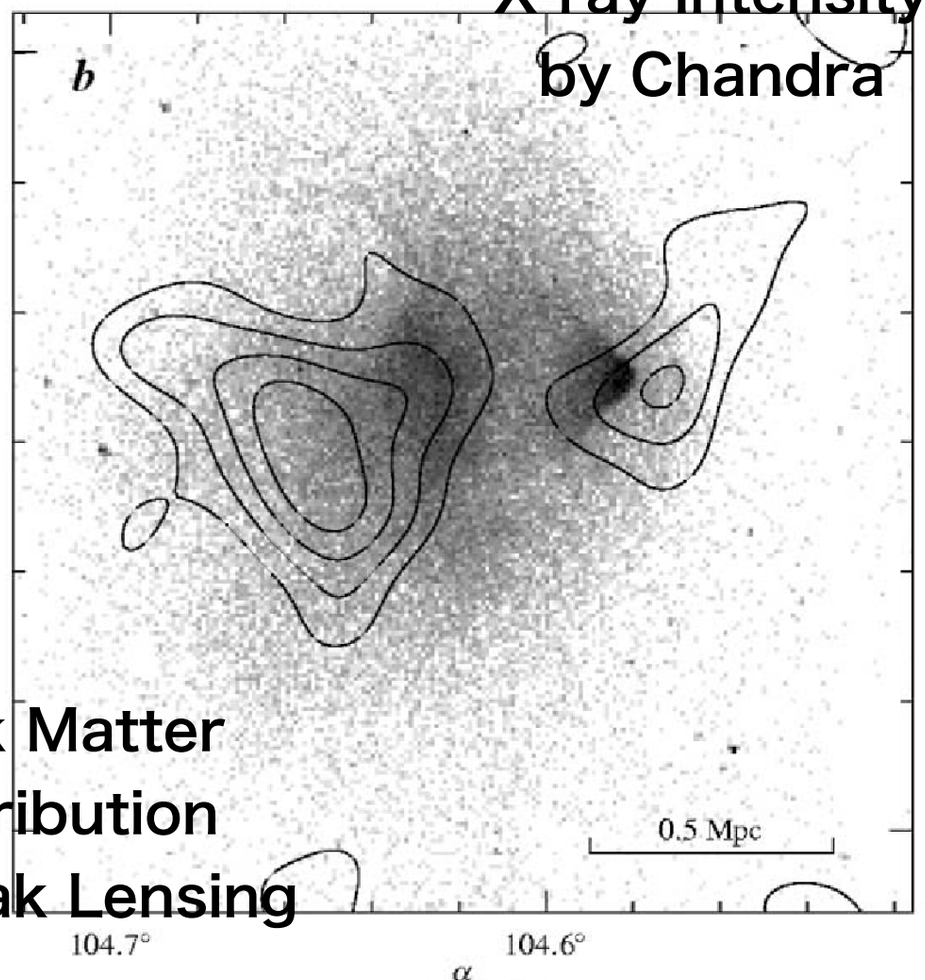


Uchiyama et al. 2007

Non-thermal Process
plays an important role when we study clusters, and then the evolution of large scale structure

Mass of Cluster of Galaxy
= Galaxies + Hot Gas +
+ Bulk Motion (collision/turbulance)
+ Cosmic Rays

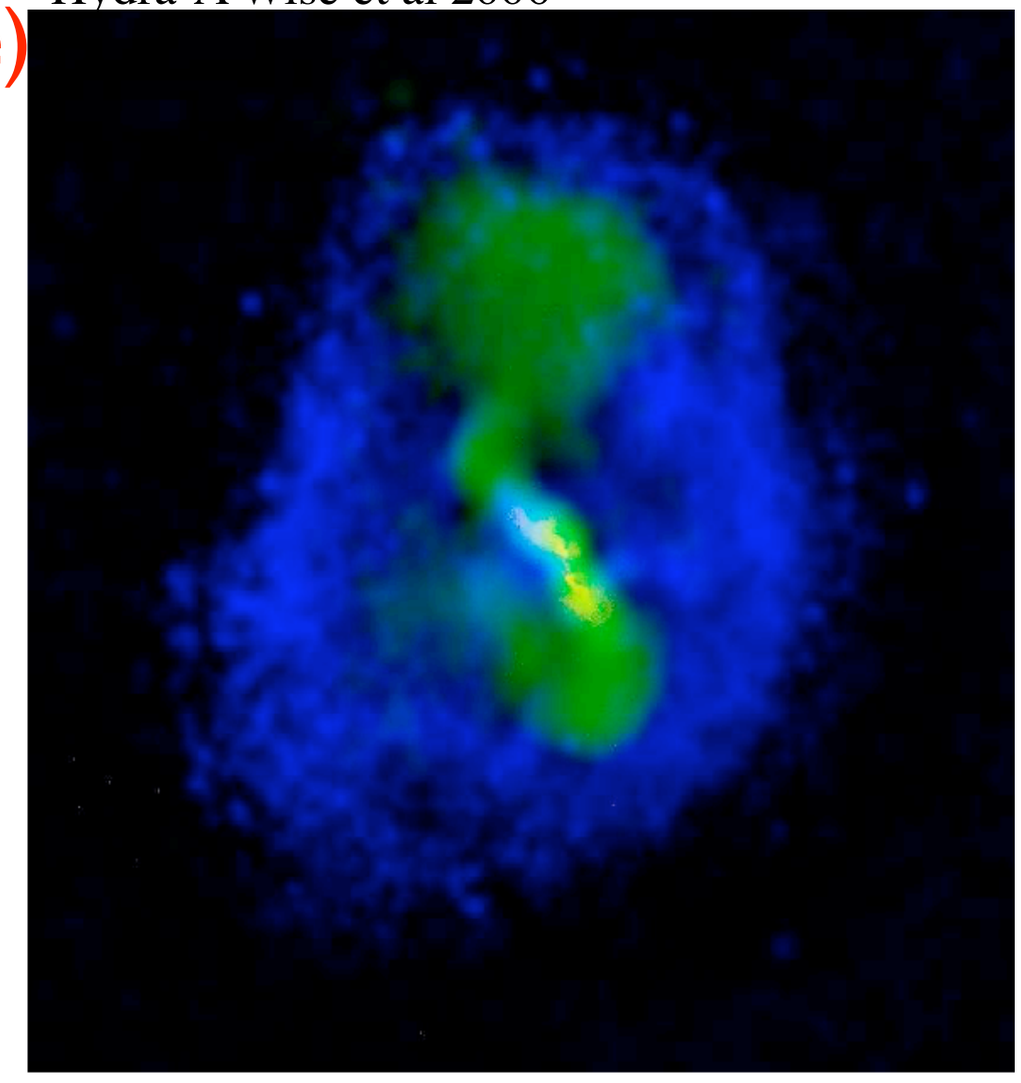
X-ray Intensity
by Chandra



Dark Matter
Distribution
by Weak Lensing

(1E0657-56: Markevitch et al. 04)

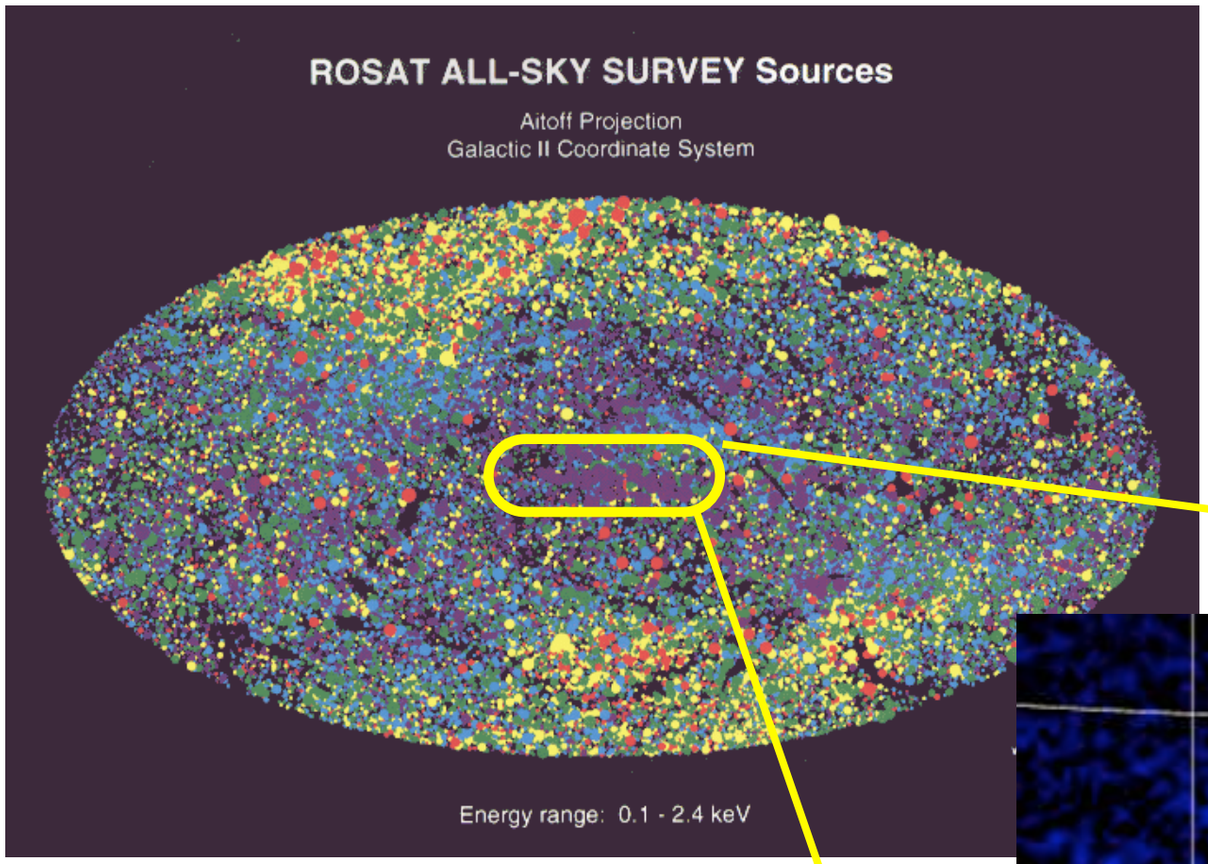
Hydra-A Wise et al 2006



. 3.— Composite color image of Hydra A which illustrates the close connection between the observed, large X-ray cavity system (shown in blue) requency, 330 Mhz radio emission (shown in green). The X-ray emission corresponds to the residual image shown in Figure 2. The 330 Mhz radio Lane et al. (2004). The familiar 1.4 GHz VLA image of Hydra A is also shown in the core in yellow.

expanding cavity, i.e., $P_{jet} = dE_{cav}/dt + pdV_{cav}/dt$. As- though evolution of the cavity and shock is unlikely to l

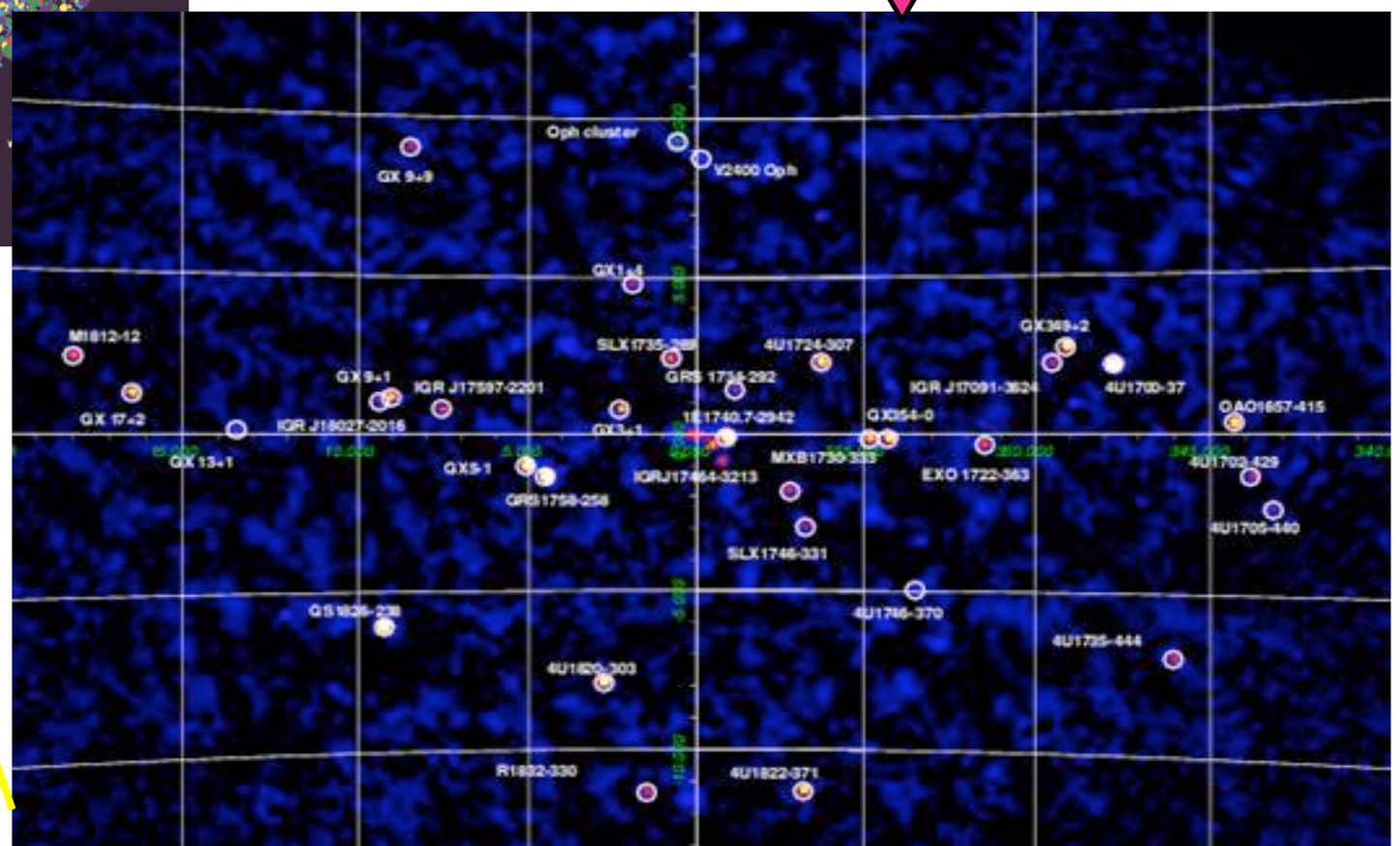
Fact : Hard X-ray Astronomy is far behind the X-ray Astronomy



ROSAT All-sky survey

INTEGRAL ISGRI galactic survey

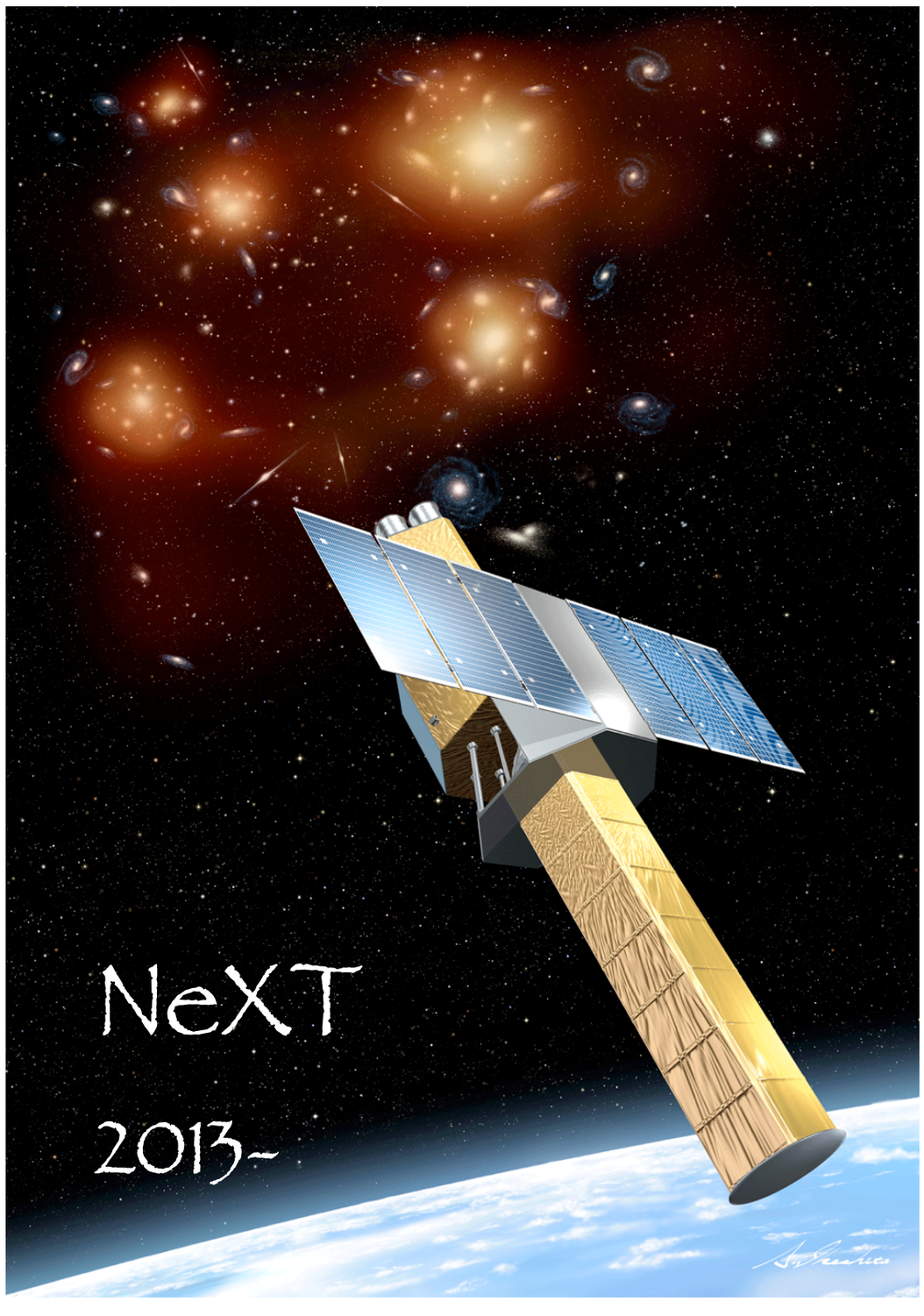
20-40 keV



Current Sensitivity
X-ray : micro Crab
Hard X-ray : m Crab

We have many reasons to have

International X-ray Observatory in 2010's



Phase A since 2007
Target Launch 2013
Launch Vehicle : H2A

- Phase A study has started.
- A review required before we move to Phase B will take place in early 2008 JFY.

NeXT
New Exploration X-ray Telescope

NuStar (2011) / Simbol-X (2013)

Strategy of NeXT

High-energy universe

Strong gavity (BH, DarkMatter)
Collision, Explosion, Jet
Magnetic fields, etc.

High resolution spectroscopy
Energy shift & line broadening

Gas motion

Doppler spectroscopy
Energy shift & line broadenin

Gas heating ↔ Shocks

Trace heavy elements

X-rays

Hard X-ray Imaging

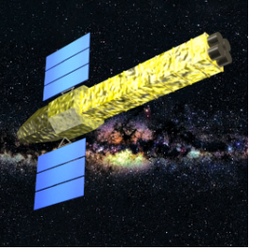
Particle acceleration

Gravitational redshift

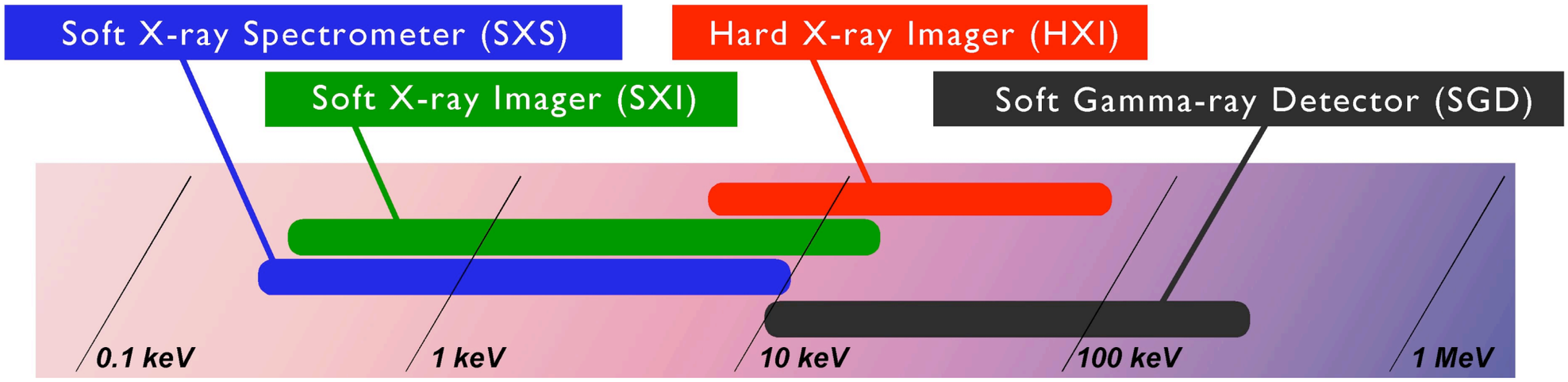
Hard X-rays

Wide band spectroscopy

Search for hidden blackholes



NeXT Baseline Configuration



X-ray micro-calorimeter (small FOV)

SXT-S

SXS

X-ray CCD camera (Large FOV)

SXT-I

SXI

Wide-Band

The first hard X-ray focus imaging

HXT

HXI

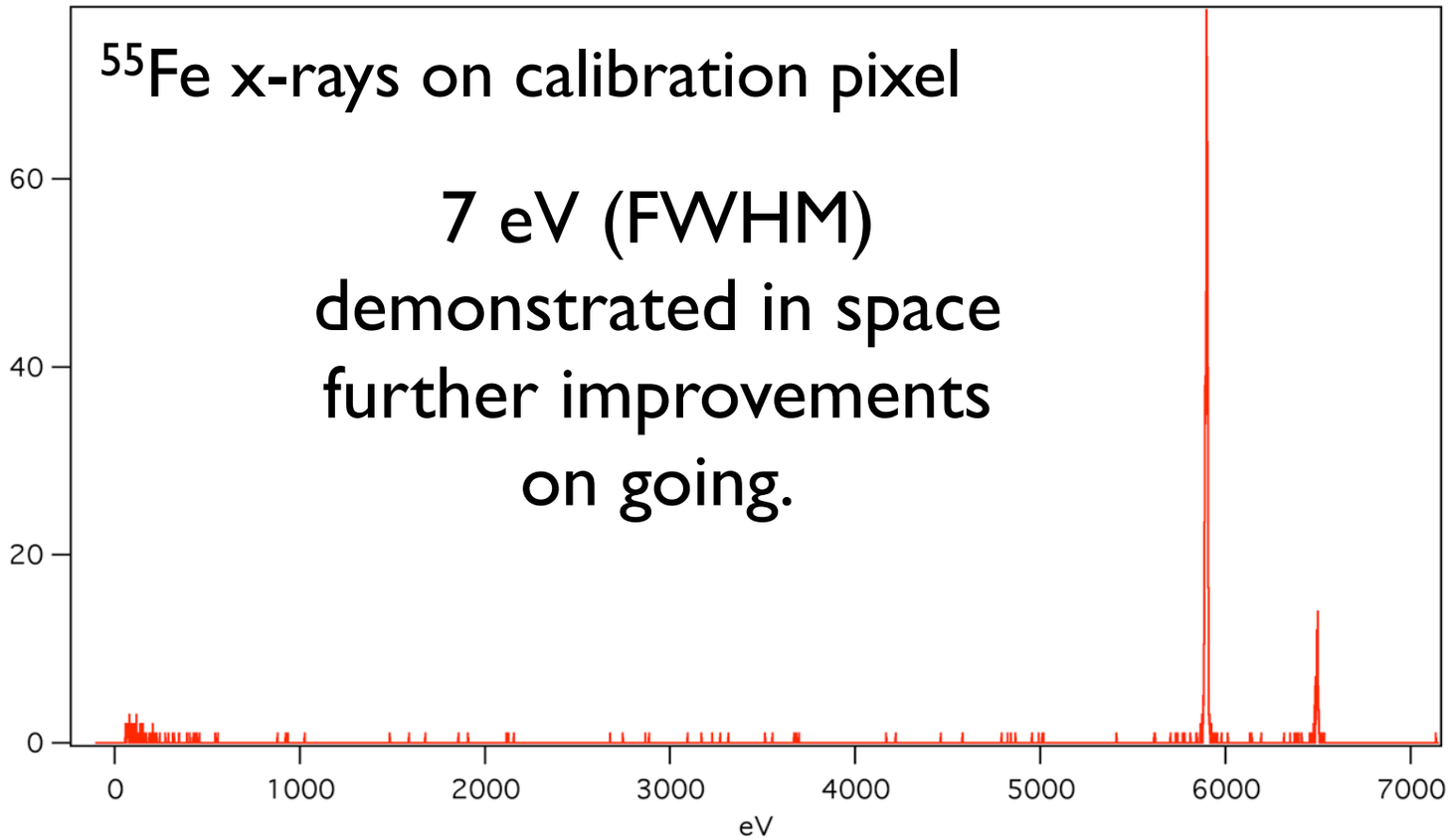
Soft Gamma-ray Detector

SGD

New Technologies

- Micro Calorimeter & Cryogenics
- Hard X-ray Optics (Mirror)
- High Resolution Si strip & pad detectors
- CdTe strip & pad detectors
- Si/CdTe Compton Telescope
- Large-area X-ray CCD

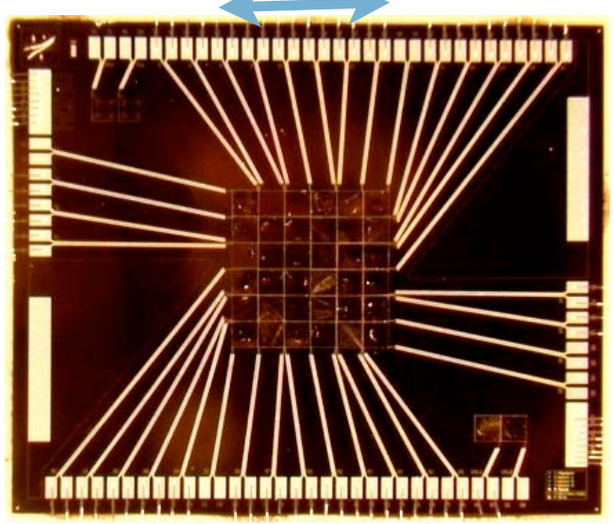
Soft X-ray Spectrometer (SXS)

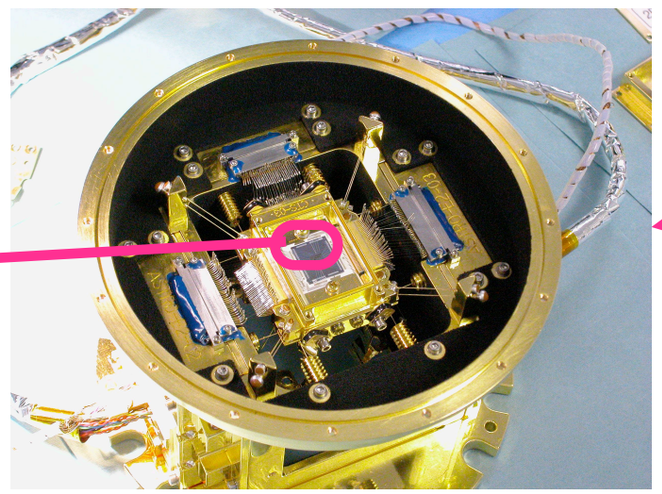


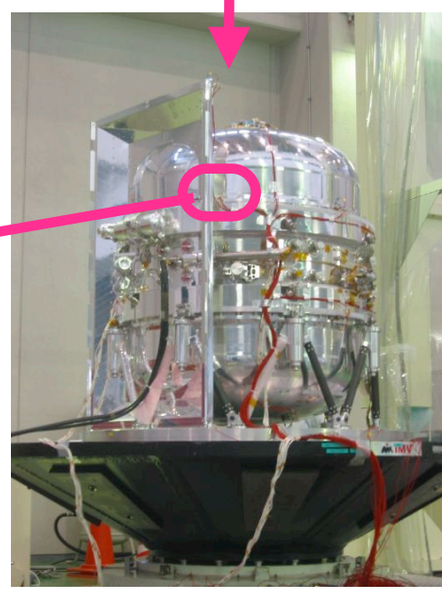
ASTRO-EII (Suzaku)

Recovery of XRS science with improved sensitivity
is the first important goal of NeXT

3.7 mm

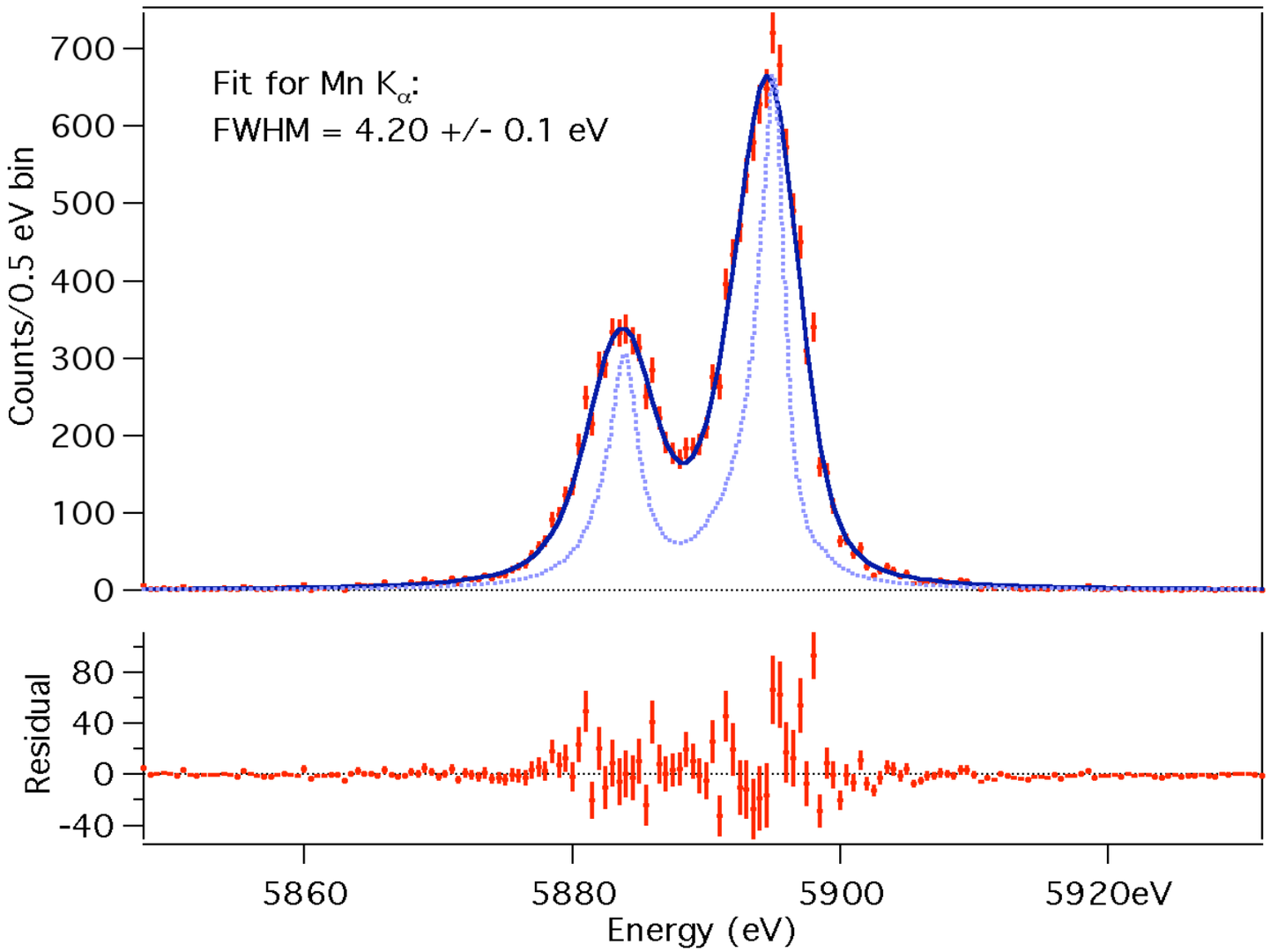


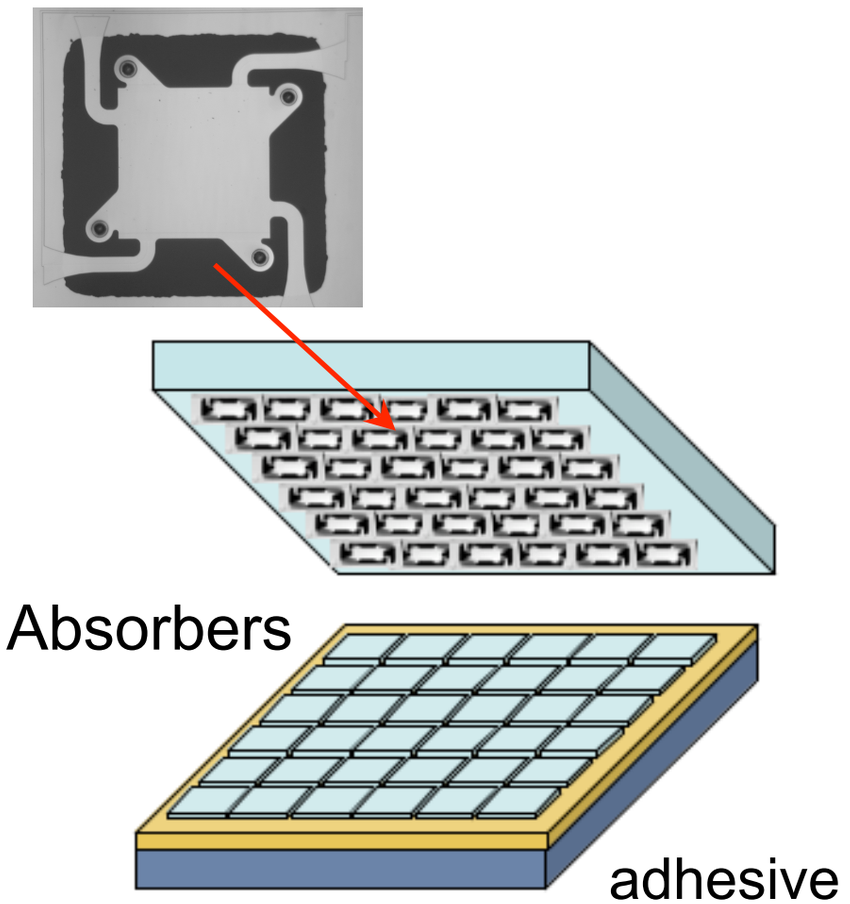




Improved Performance for the NeXT mission

$Hg_{1-x}Cd_xTe$, x = 0.16, 790 × 790 × 6 μm





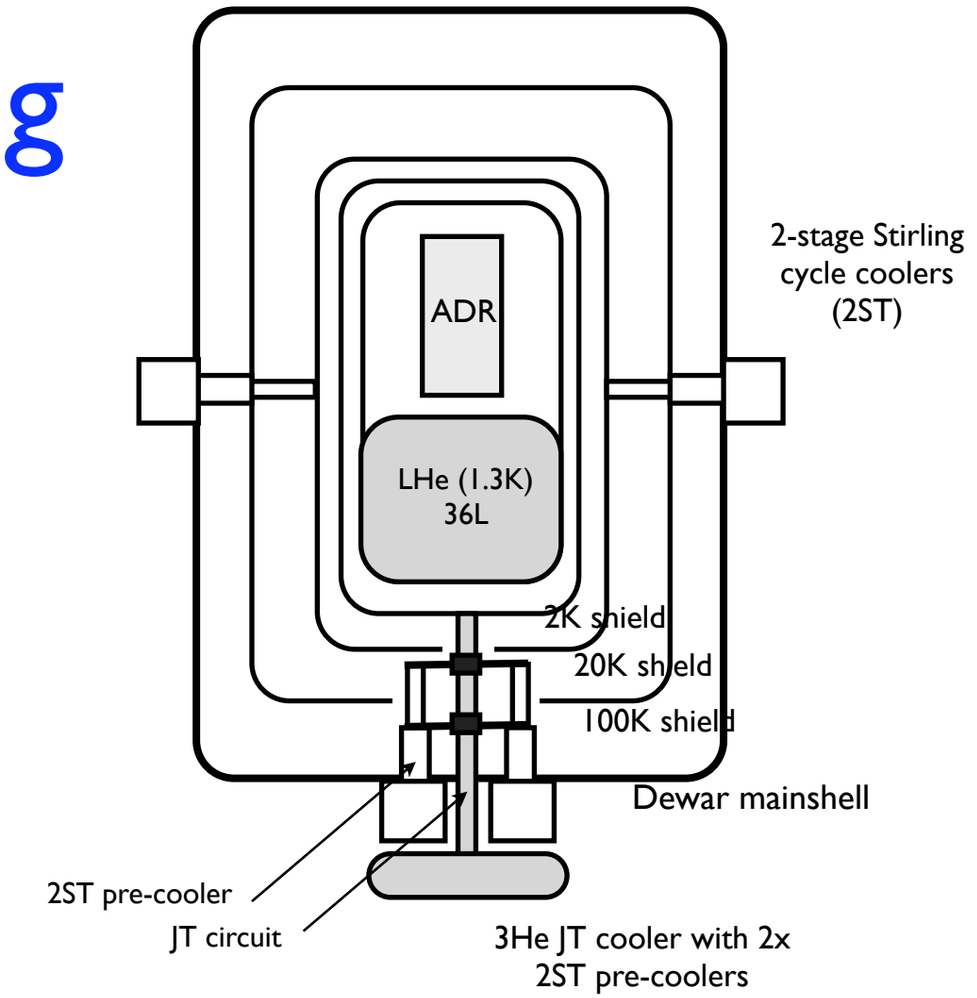
NASA/GSFC

Using the flip-chip bonder, attach absorbers to detectors.

2x 2STs + ^{3}He JT(w/2x 2STs)

To Achieve 50 mK operating temperature in space

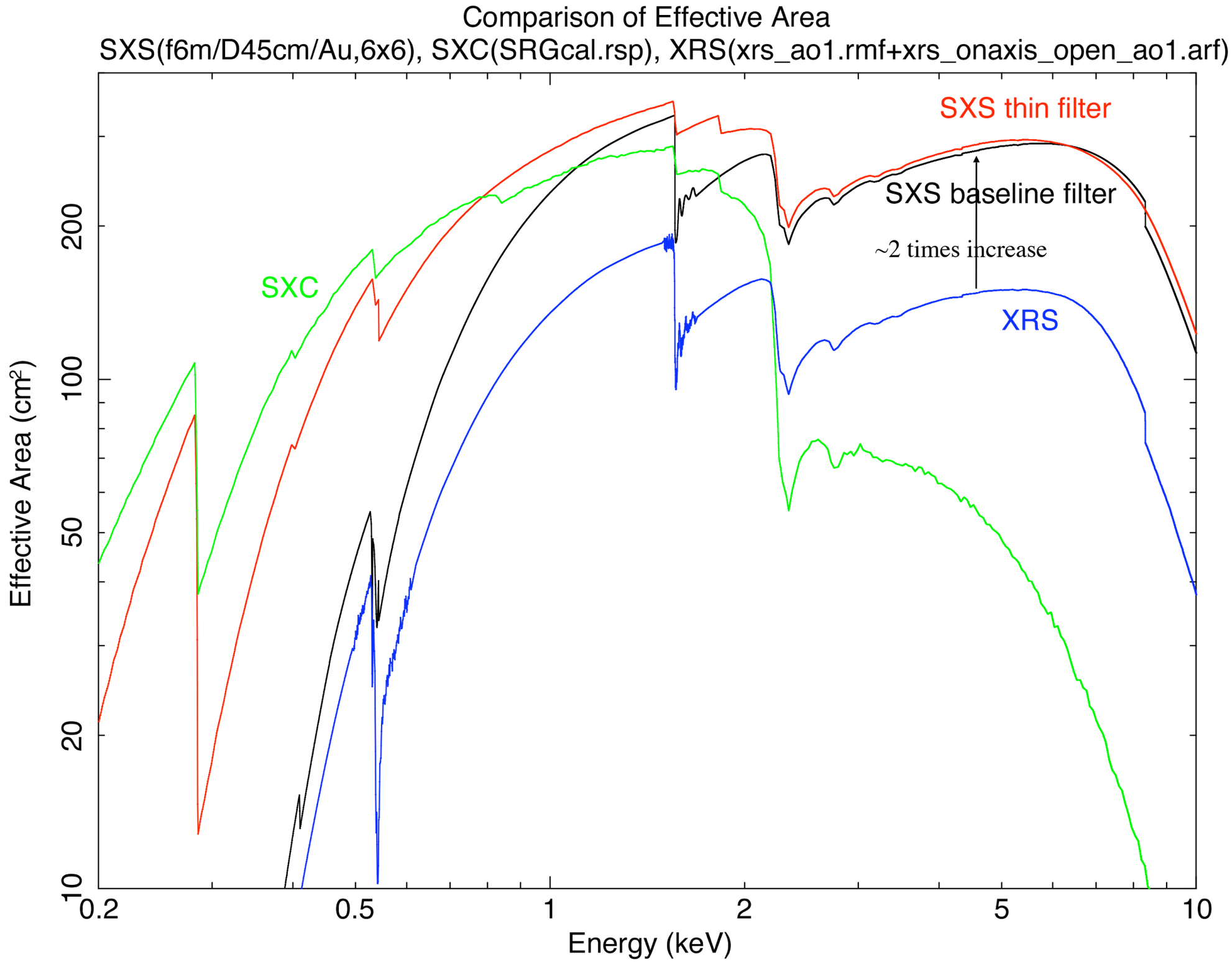
- ADR + Long life-time LHe system with 2-stage Stirling-cycle (2ST) coolers and ^{3}He Joule-Thomson (JT) cooler as thermal shields
- In-orbit life time ≥ 3 years (goal= 5 years)



LHe life: >>5 years as far as JT works

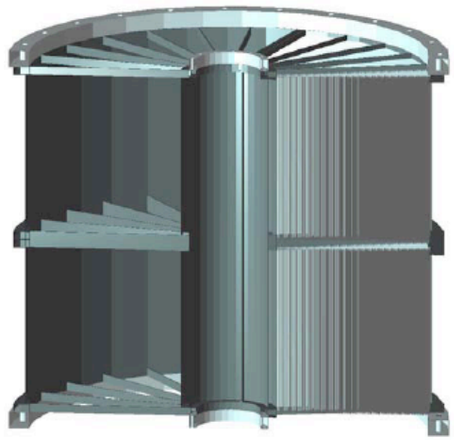
- 840 x 840 μm^2 pixels
- 6x6 array

	6x6
Size	5.015 mm sq.
f=6m	2.87’



Hard X-ray Focusing Telescope

Large Area/Light Weight Mirror



ASCA/Suzaku Style
(Serlemistos type)

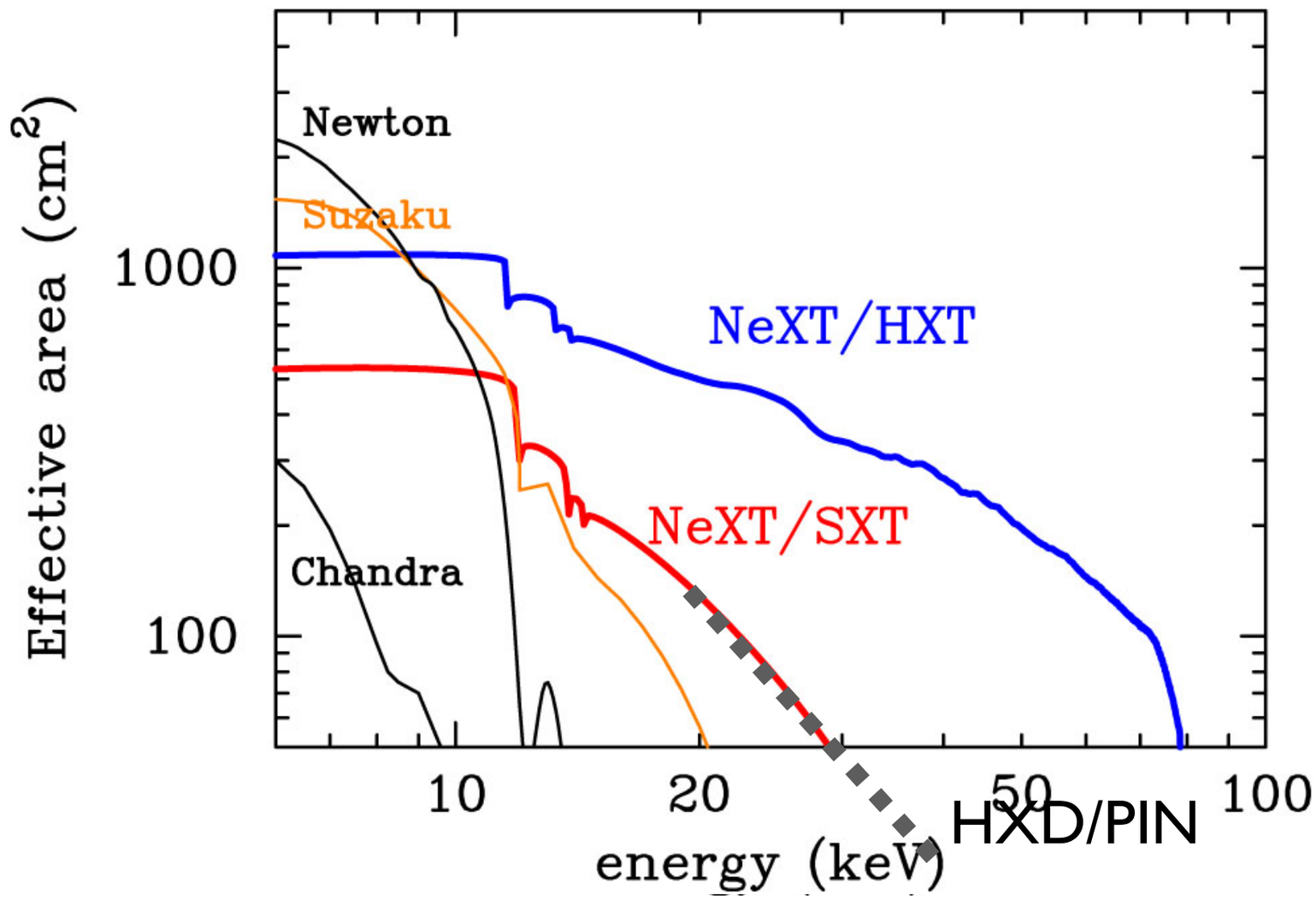
Pt/C multilayer supermirror
(Nagoya U.)

Mirror Weight/telescope

Chandra 1500 kg
XMM 440 kg

Suzaku 20 kg

NeXT HXT 70-80 kg



SUMIT Balloon Experiment
Nagoya/Osaka U.
Hard-Xray Optics Exp. 2006

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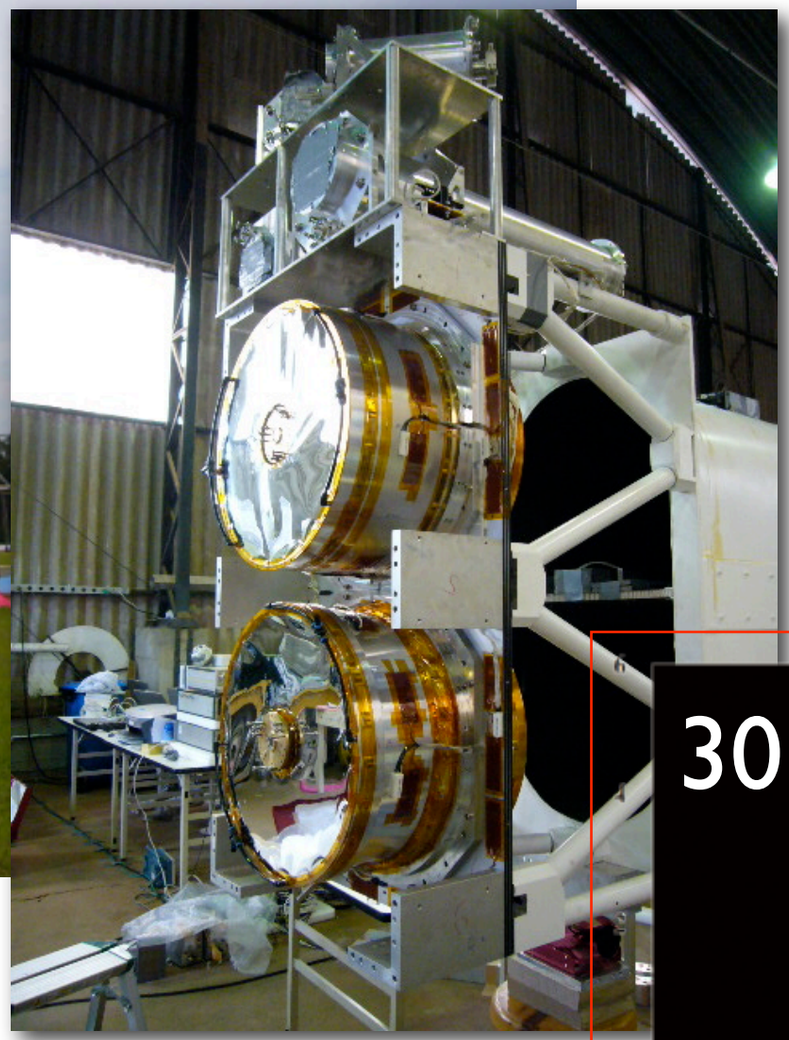
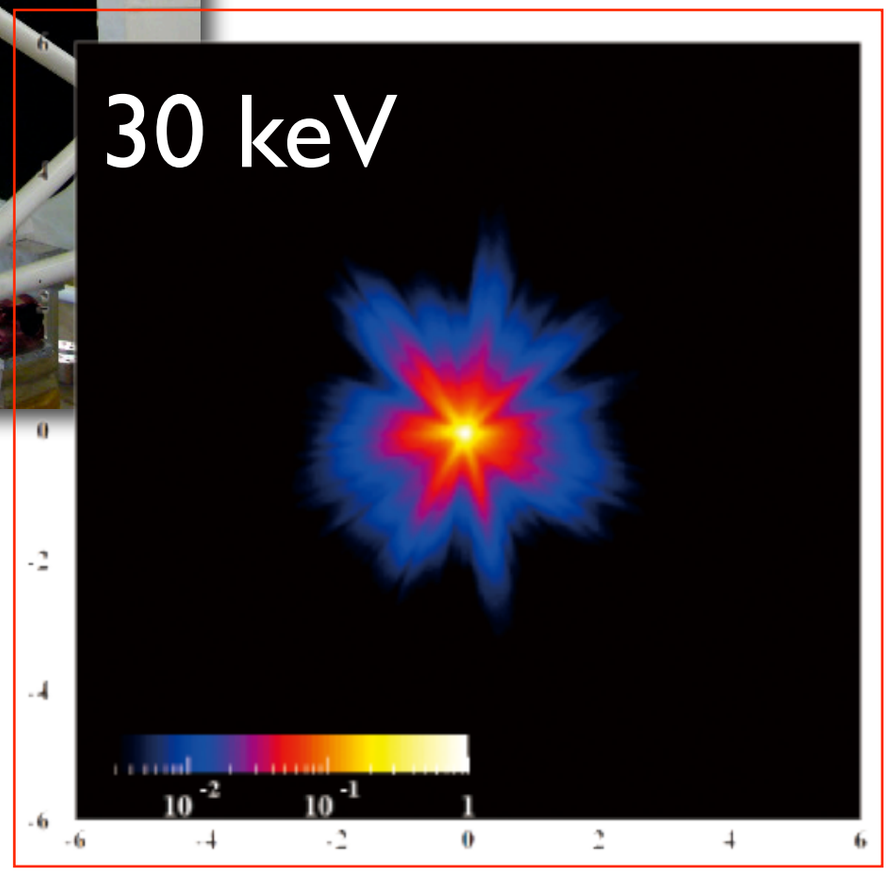
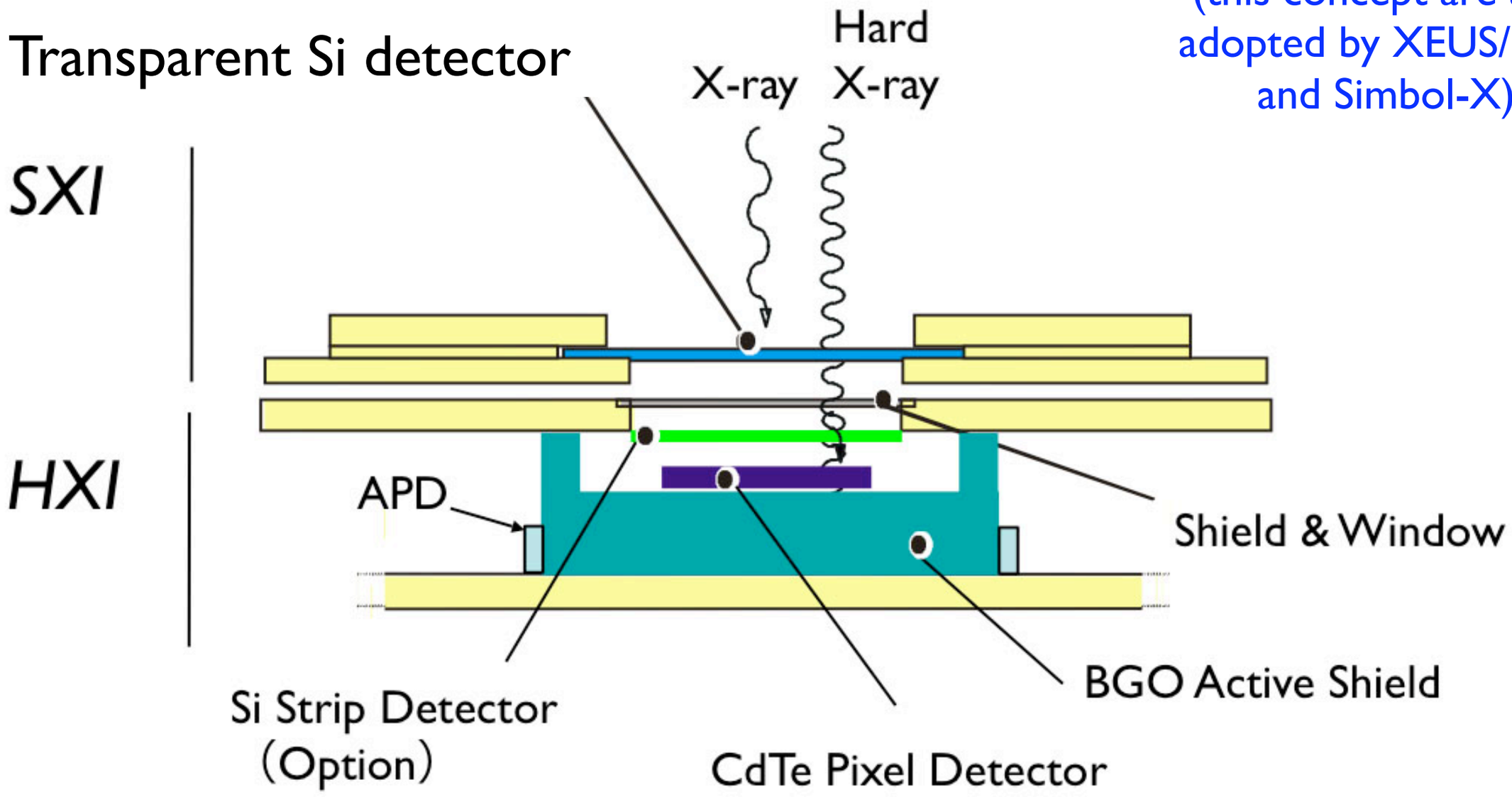




Hard X-ray Imager for Next Generation Hard X-ray Telescopes

Hybrid-type Si+CdTe

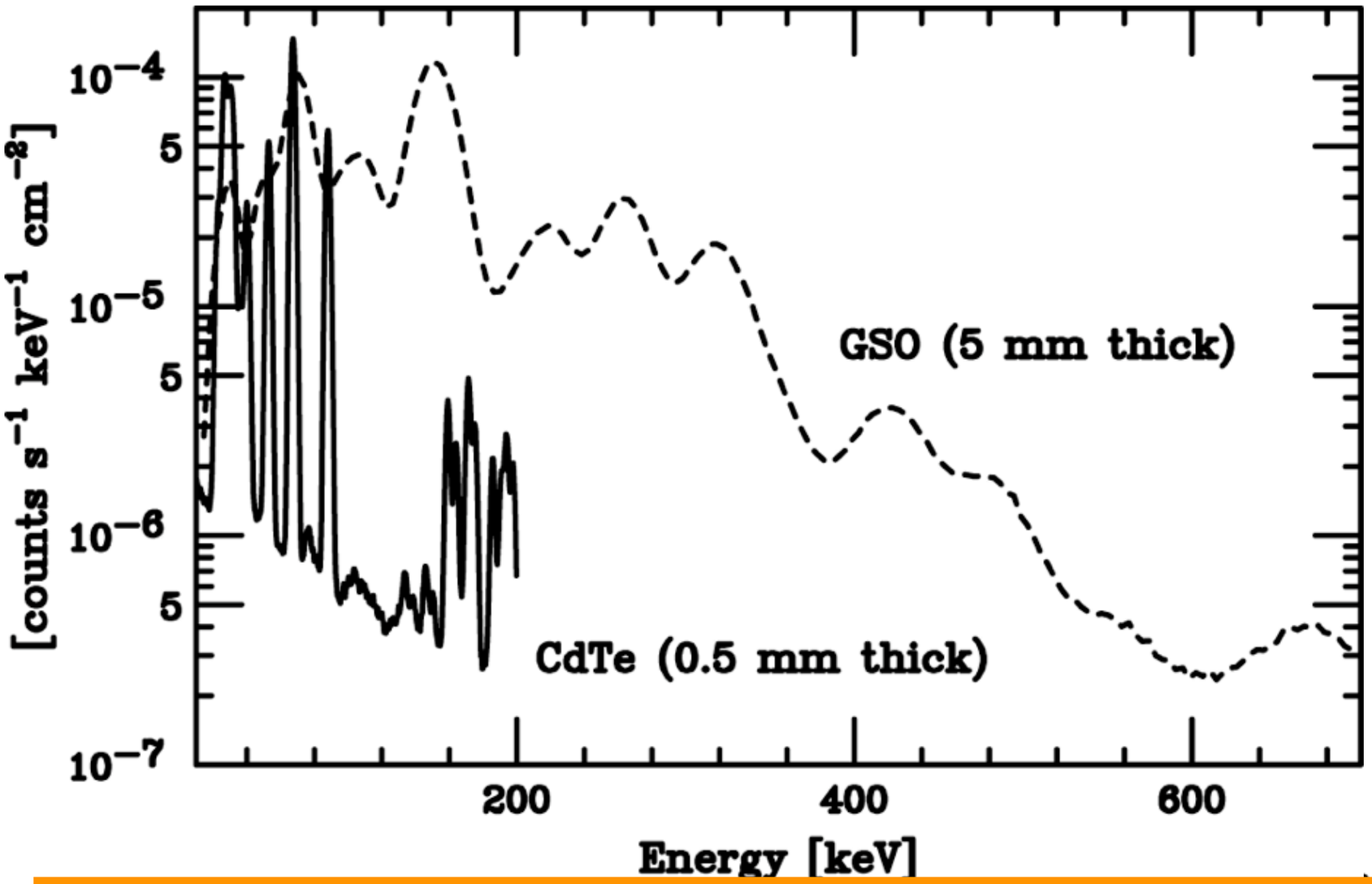
Wide band coverage
by a Hybrid Detector
(this concept are also
adopted by XEUS/HXC
and Simbol-X)



(Concept of the Si+CdTe hybrid
Takahashi et al. NIM A 436, 2000)

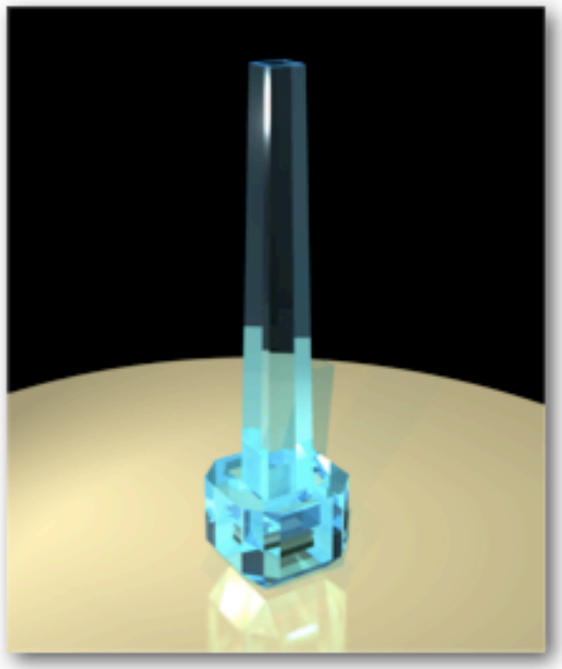
Background Issue

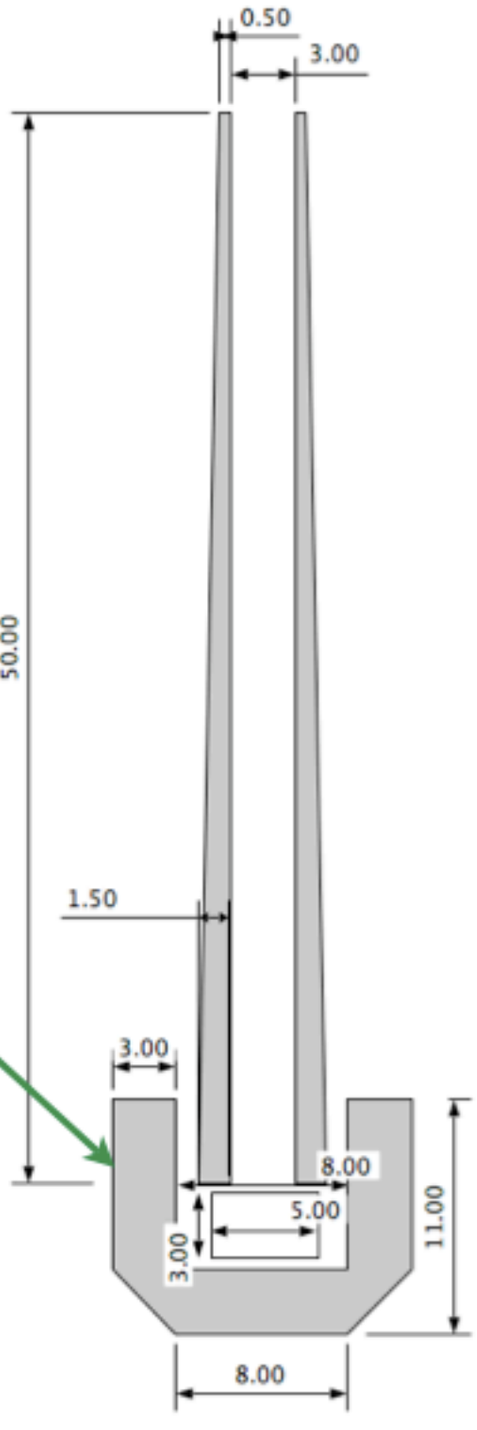
Heavy Material is needed to detect high energy photons, but activation in inevitable.



Very Careful Design is Needed to get High Sensitivity
(Lessons Learned from Suzaku)

NeXT Hard X-ray Imager (HXI)





Low background by Si
< 20-30 keV

Hybrid-type Si+CdTe

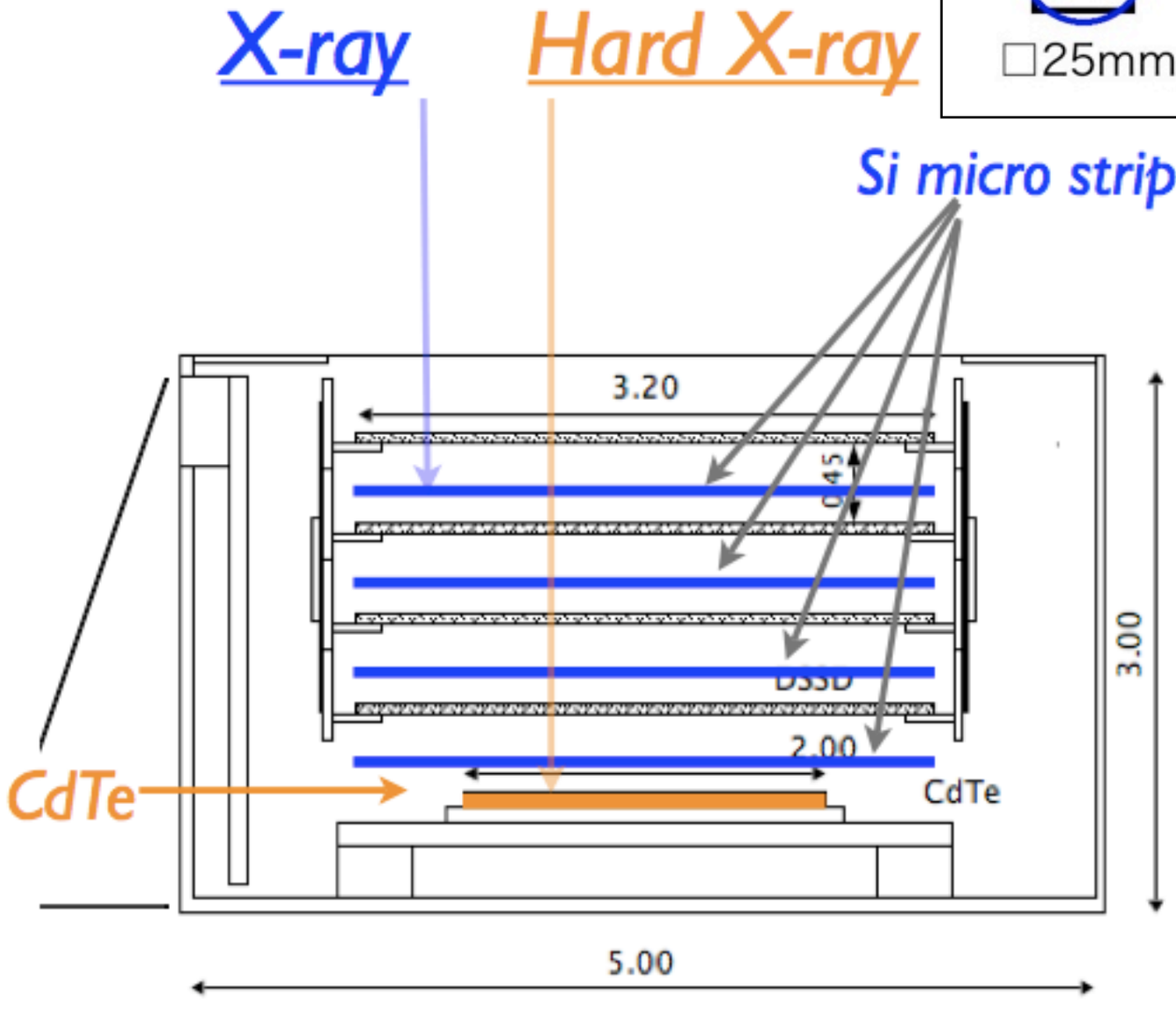
f = 12m

HXI

7.2 arcmin

ϕ9

□25mm



angular resolution 4.3 arcsec - 34 arcsec

Well-type BGO active shield

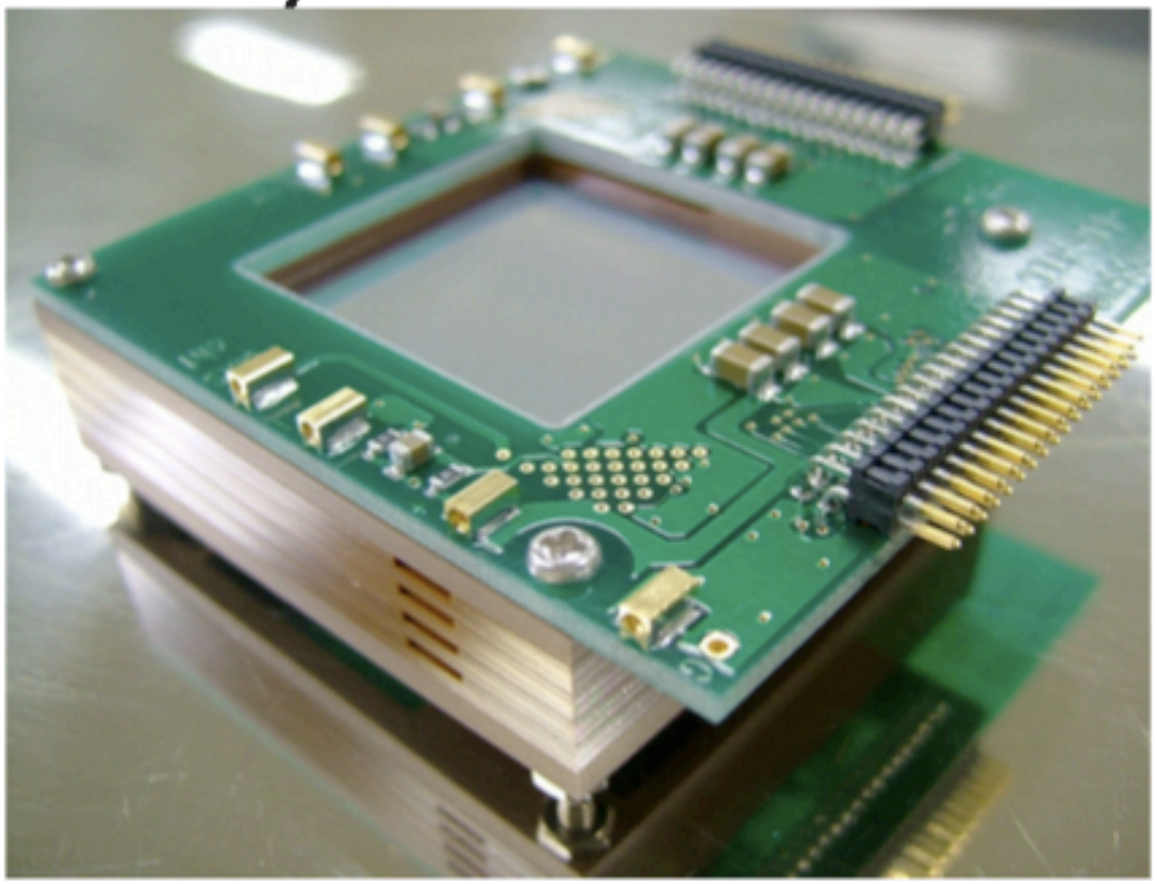
Detector should have sufficient time resolution

Count rate in the shield several 1000 cnts/s

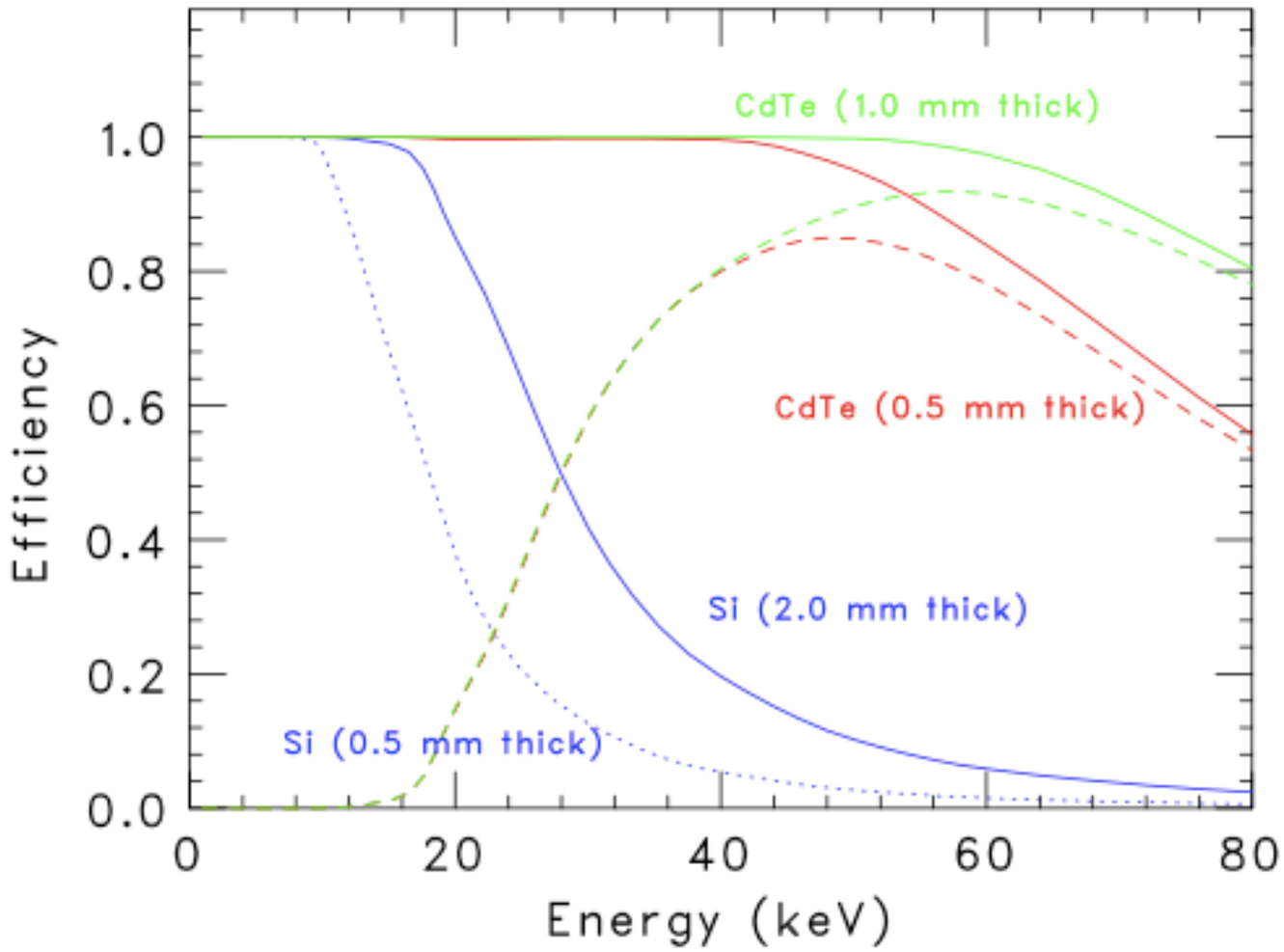
Key Technologies

- Double Sided Si Strip :Fine pitch possible (down to 50 μm).

4 layer stacked DSSD



^{241}Am Gamma-rays



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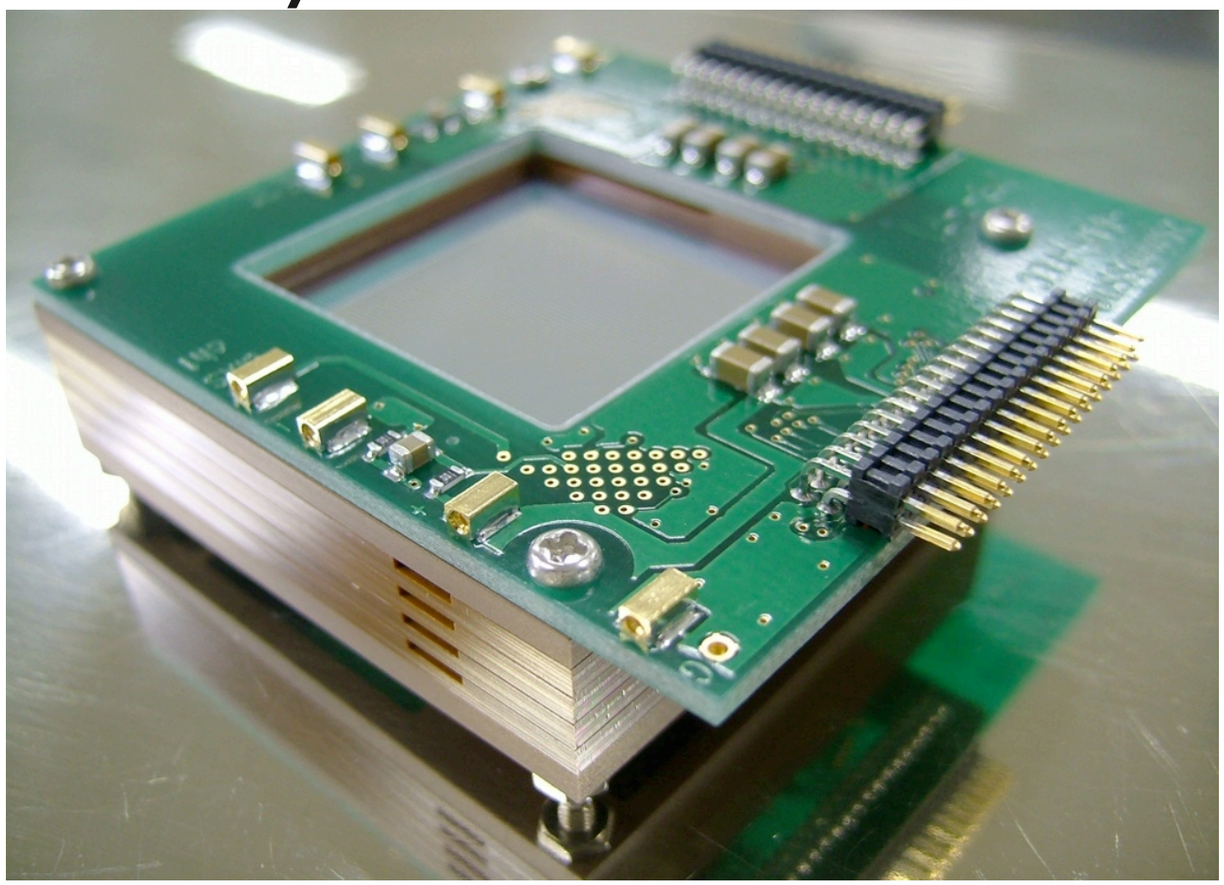
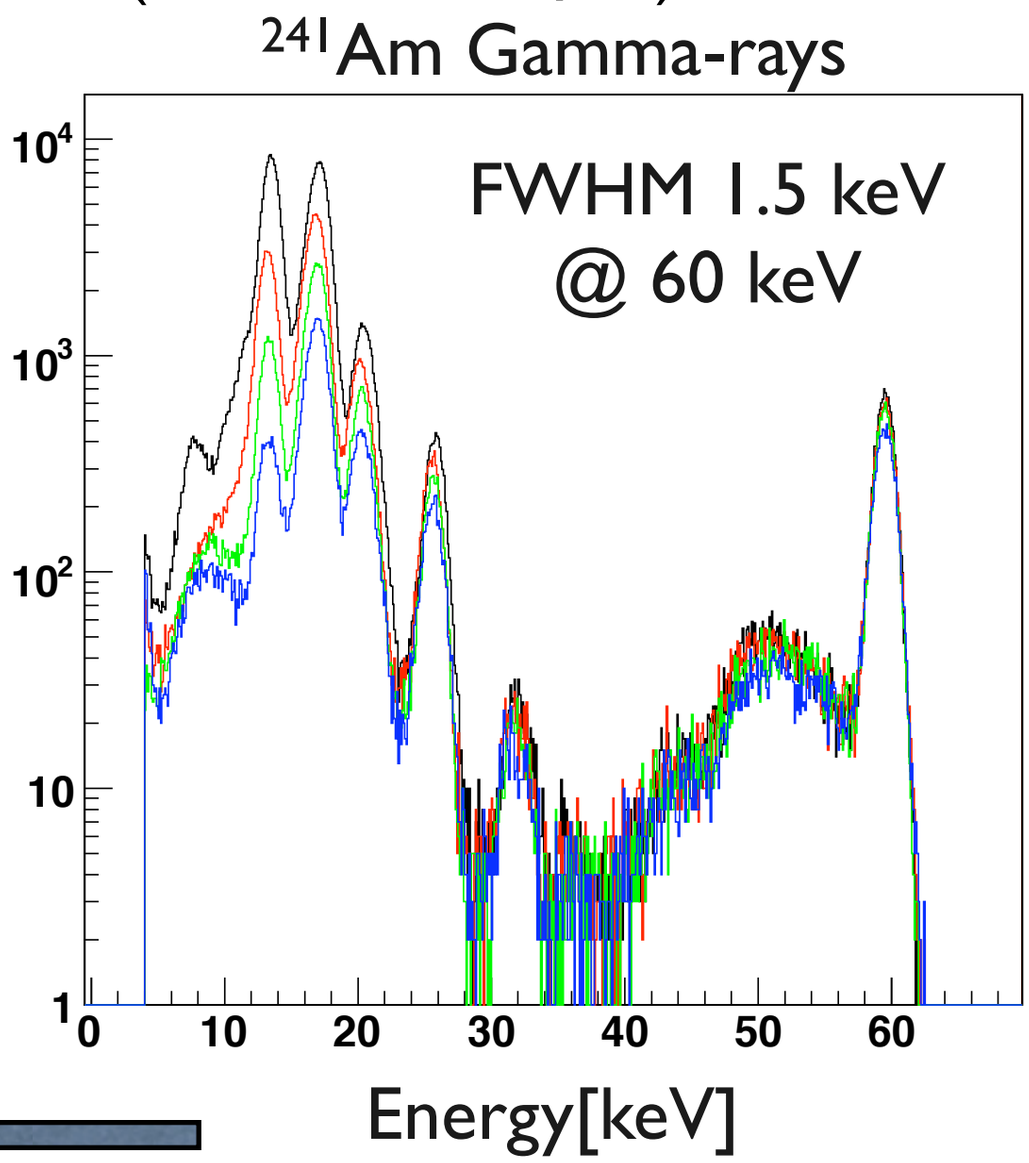
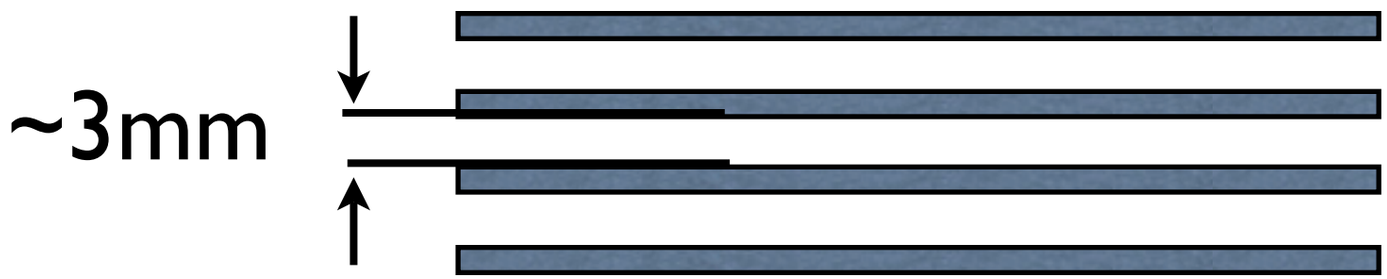
4 layer stacked DSSD







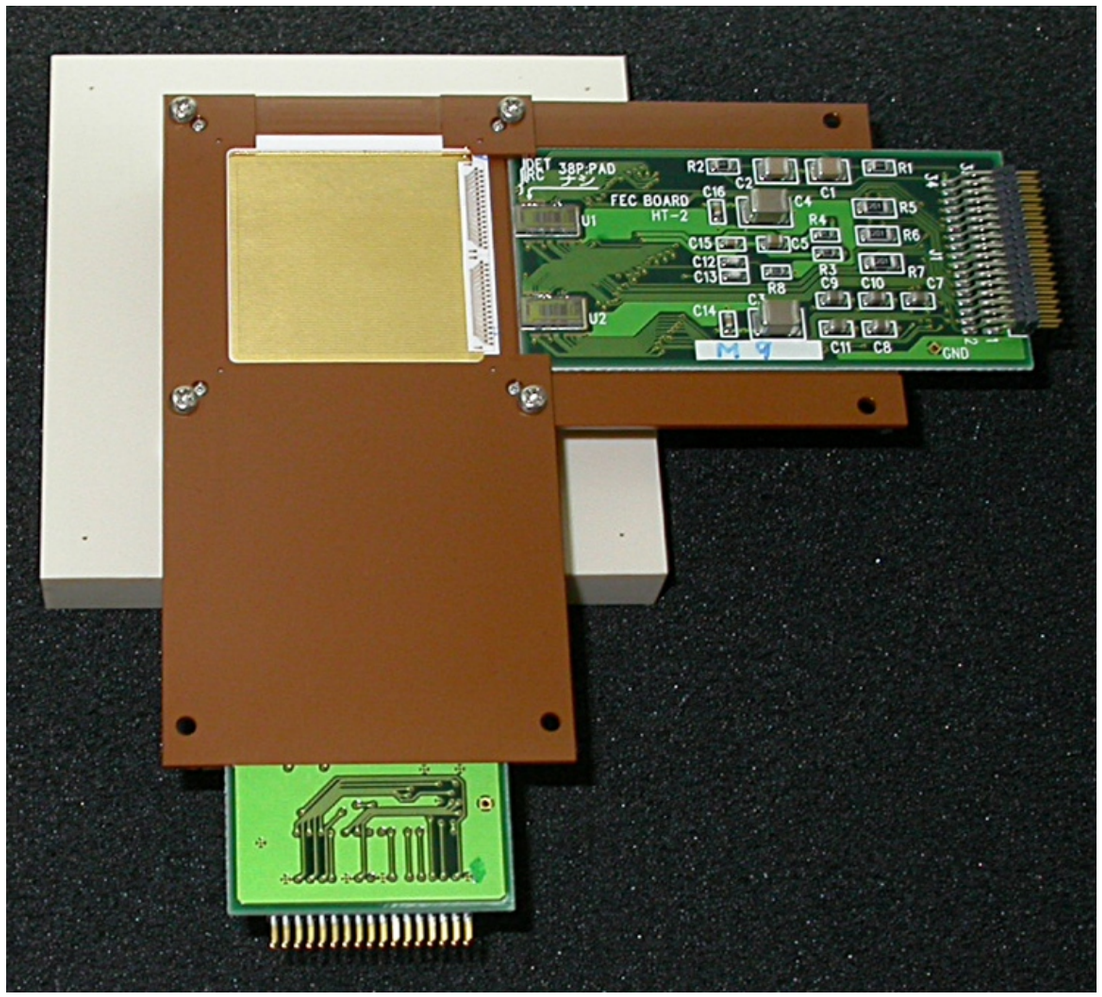
Key Technologies

CdTe Double Side Strip Detector

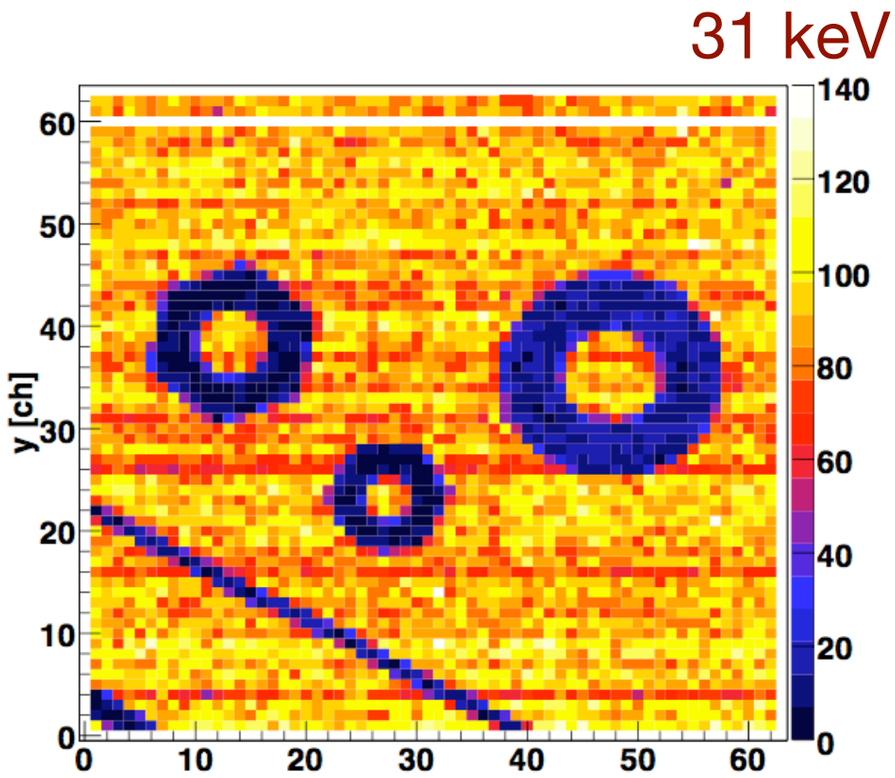
Cross Strip

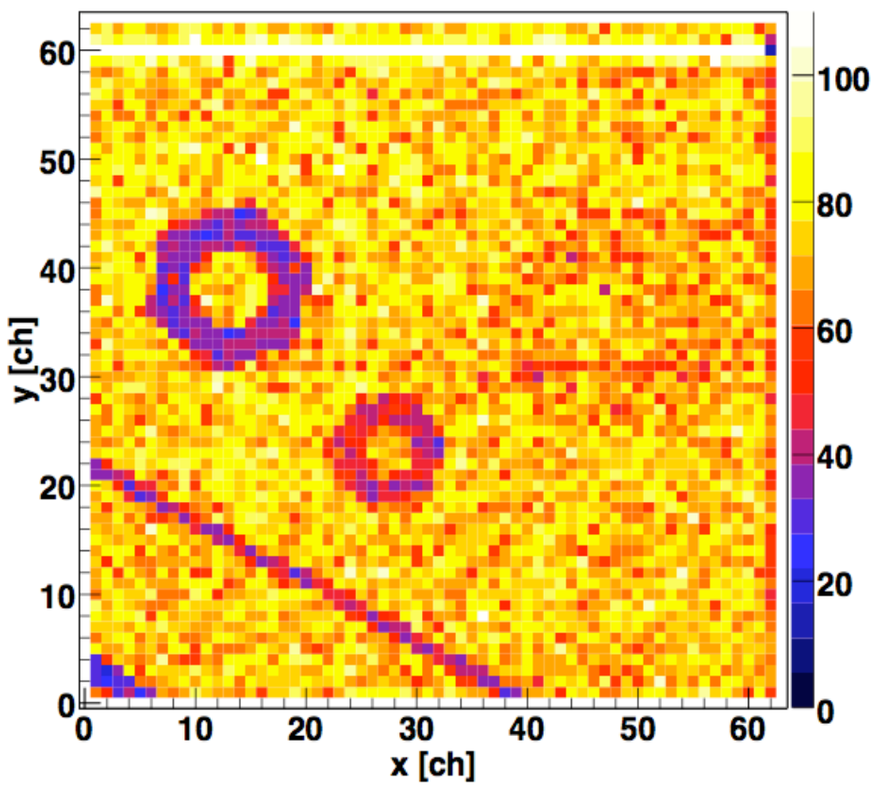
2.5x2.5 cm^2 0.5mm^t

0.4 mm pitch



Takahashi et al. 2007





Key Technologies

Analog VLSI

VA64TA: 64 channel analog ASIC

By ISAS, SLAC & Ideas ASA, Norway

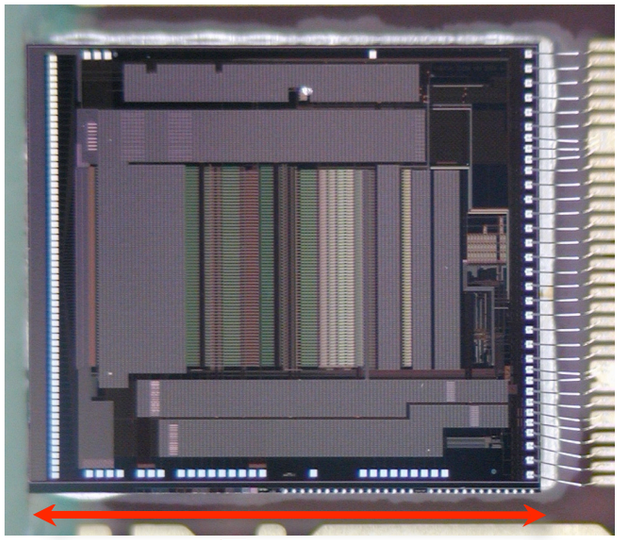
Measured Power Consumption: 0.4 mW/ch

One order lower than VA32TA

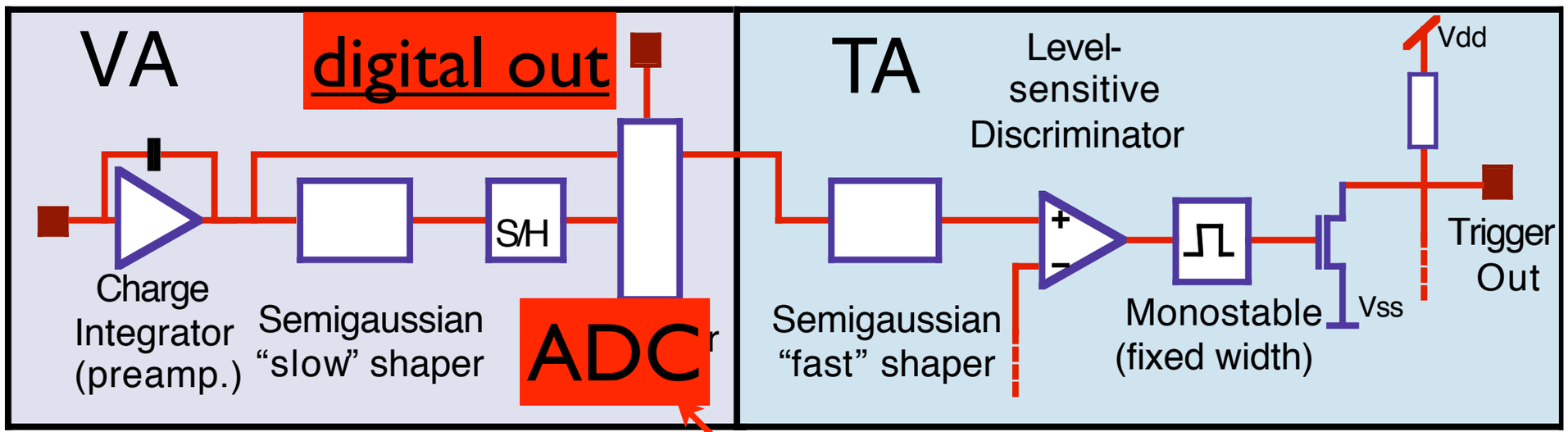
Expected Noise: $(40 + 12 \times C_d)/\sqrt{\tau}\ e^-$(rms)

Majority selector circuit for the tolerance against SEU

2005



7 mm



Peaking Time = 3~5 μs

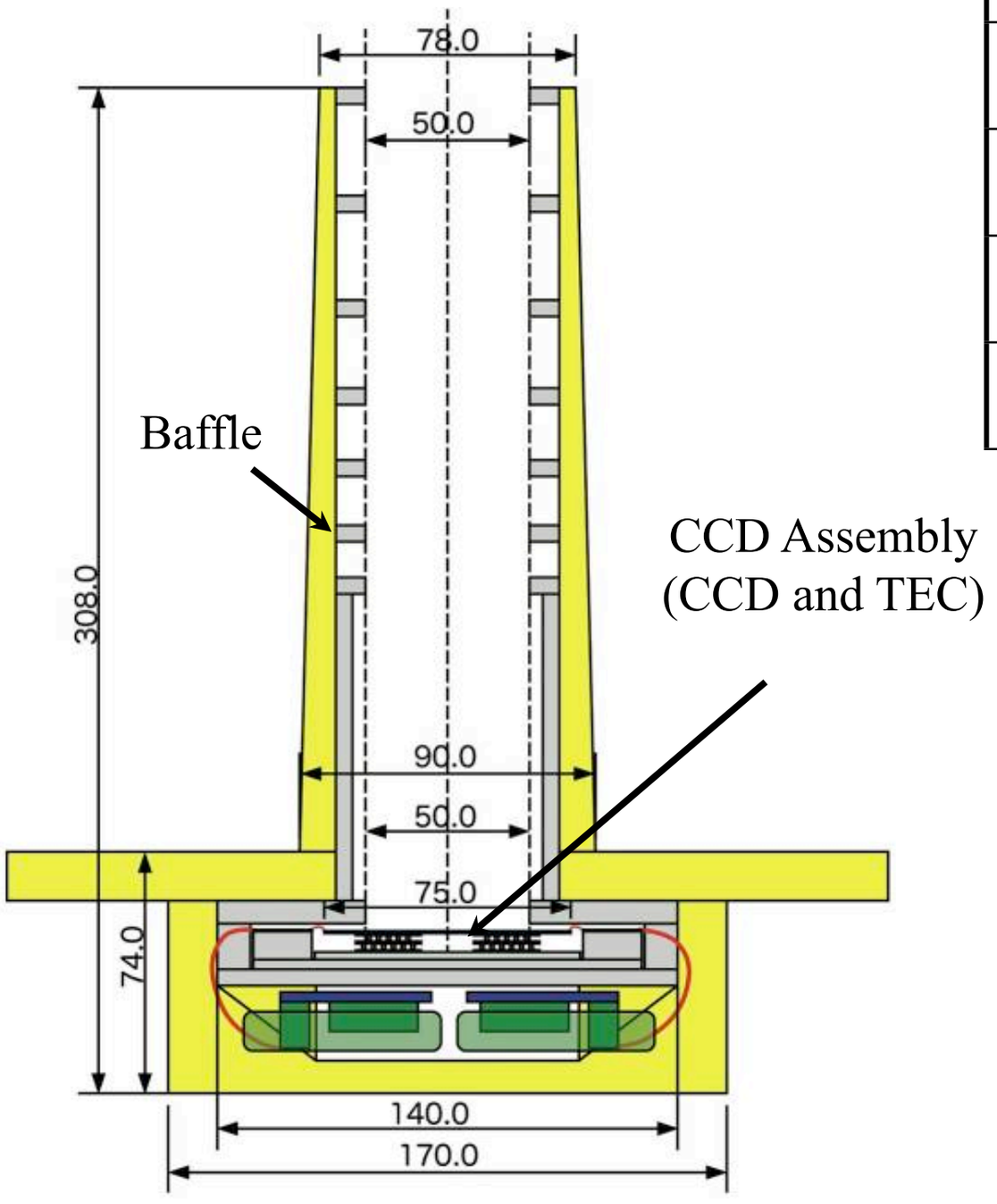
Peaking Time = 0.6 μs

ADC is implemented in the latest version

Soft X-ray Imager (SXI)

Large Area X-ray CCD

Imaging & Spectroscopy



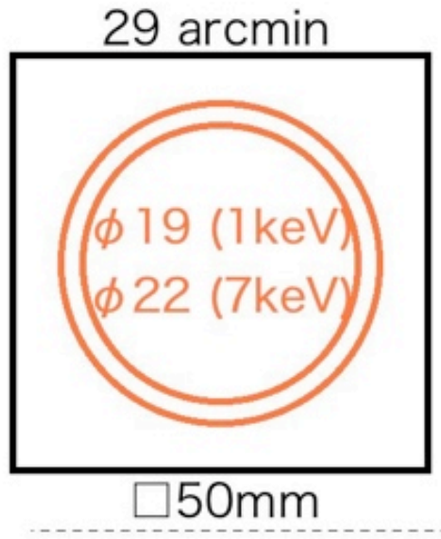
Energy Range	0.5 -12 keV
Detector Size	50 x 50 mm^2
FOV	19 x 19 arcmin^2
Format	2048 x 2048
Read out time	4 sec
Op. Temperature	- 120 degree

Low Operating Temperature

Large FOV

SXI (CCD)

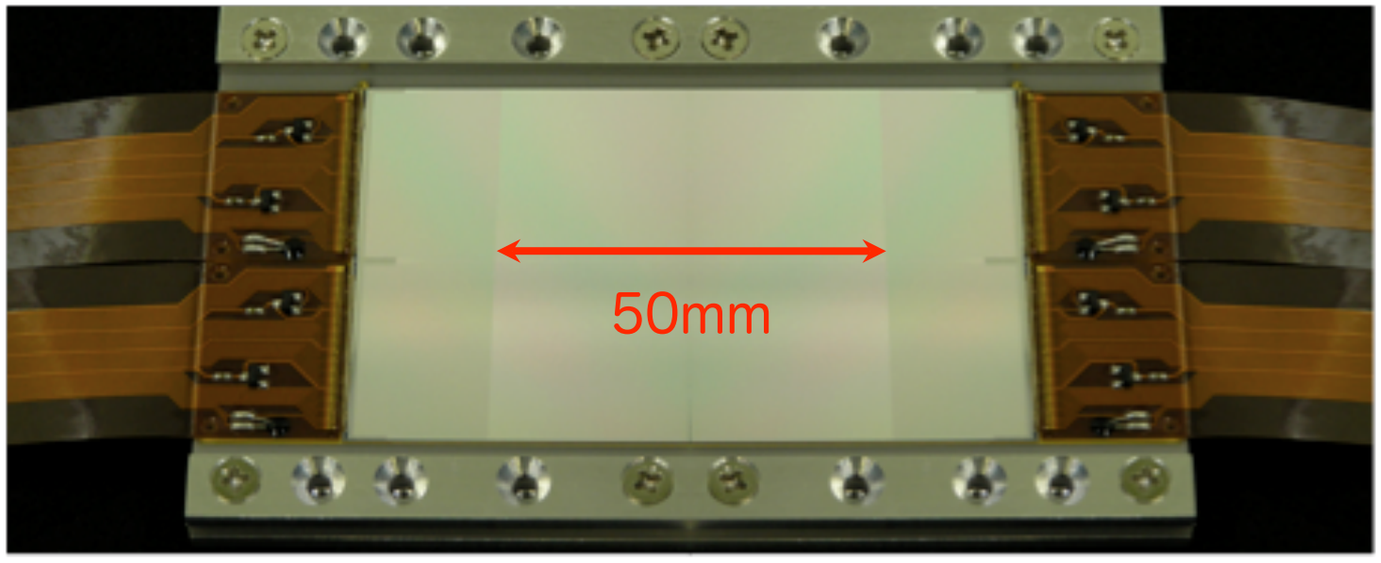
f = 6m



SXS (Calorimeter)

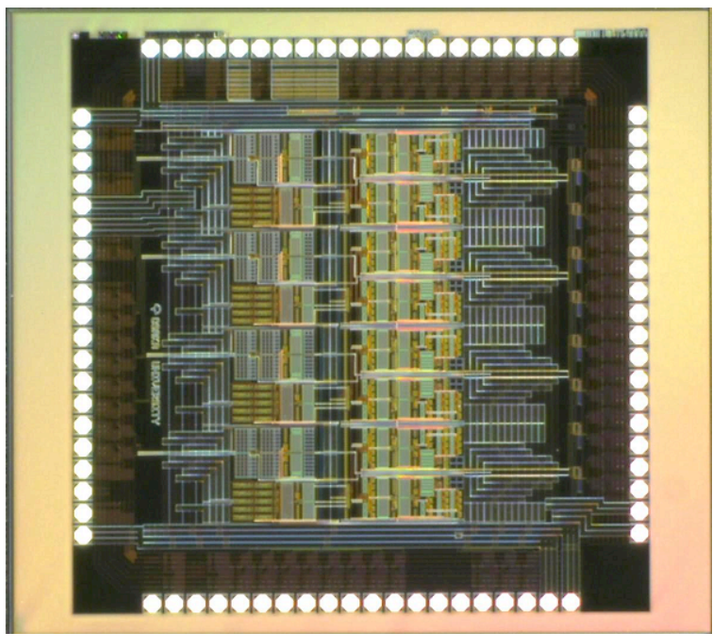
Key Technologies

New CCD

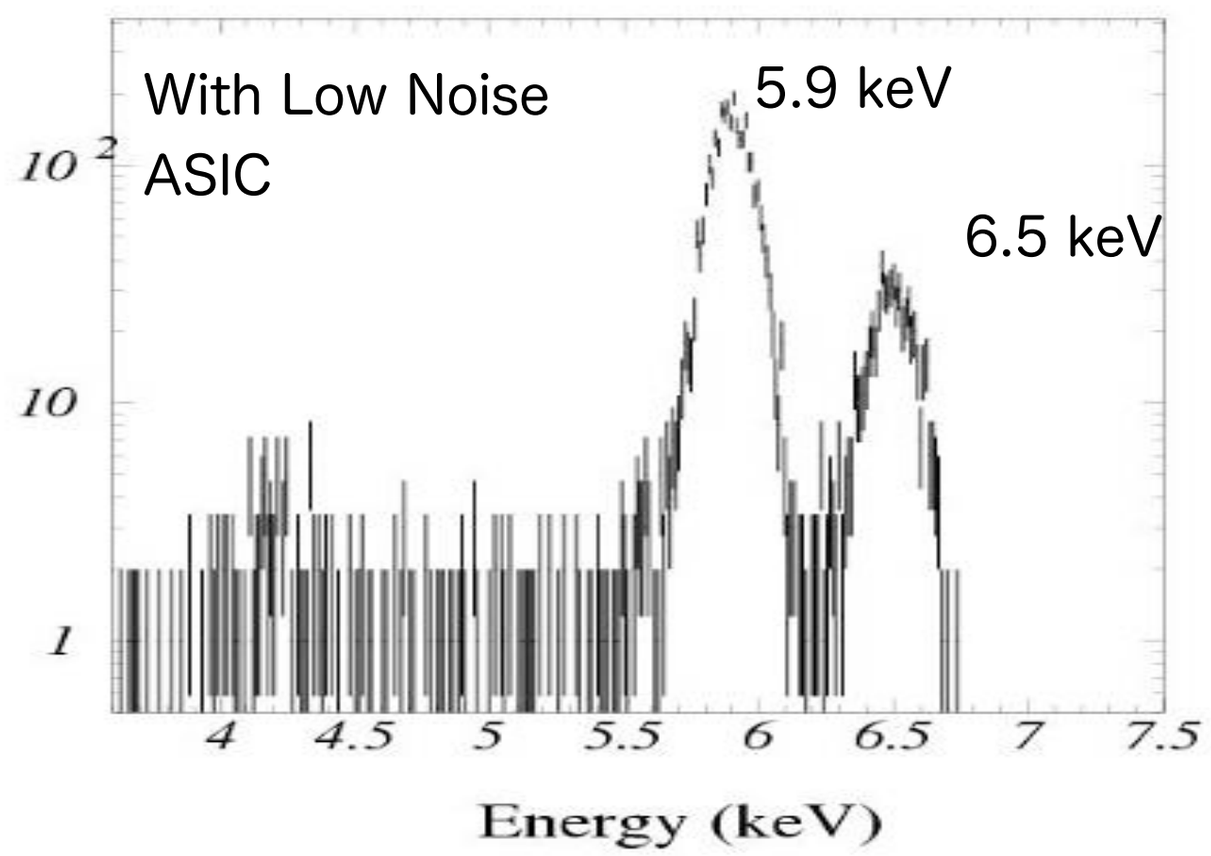


Manufactured by
Hamamatsu
(after long R&D efforts
in Osaka and Kyoto Univ.

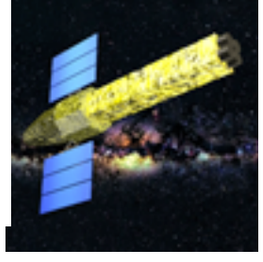
New ASIC (with ΔΣADC)



ΔE=176eV (@6keV)



Soft Gamma-ray Detector(SGD)



SLAC/Stanford Participation

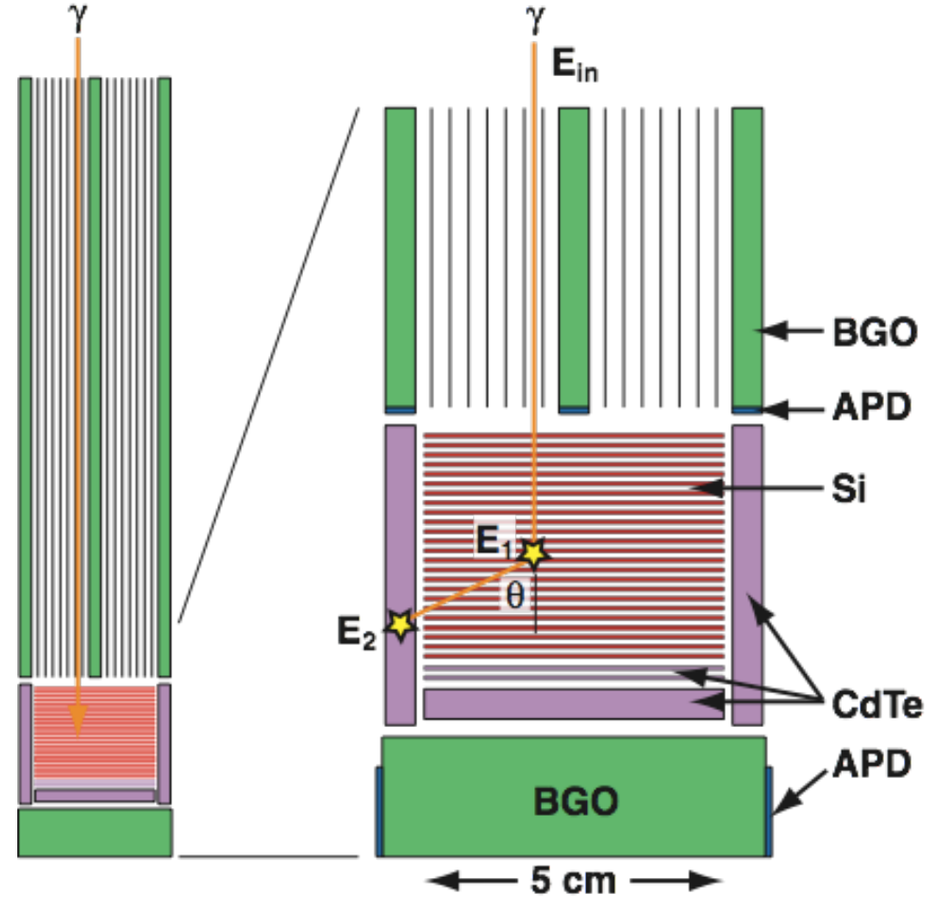
- **Energy band: 10–300 (upto 500) keV.**
- **10 times better sensitivity than HXD @ 100 keV.**
- **Effective area >100cm² @ 100 keV.**
- **Energy resolution < 2 keV @ 40 keV.**
- **FOV < 0.6° for E<150 keV.**

Narrow FOV Compton Telescope

$$\cos\theta = 1 + \frac{m_e c^2}{E_1 + E_2} - \frac{m_e c^2}{E_2}$$

Narrow FOV Compton Telescope

Extremely Low background is achieved by requiring Compton kinematics (~30 cm2) from 60-300 keV with Polarization Sensitivity



Soft Gamma-ray Detector(SGD)

SGD Compton mode can observe down to 1 mCrab with 500 ks observation, with polarization measurement capability

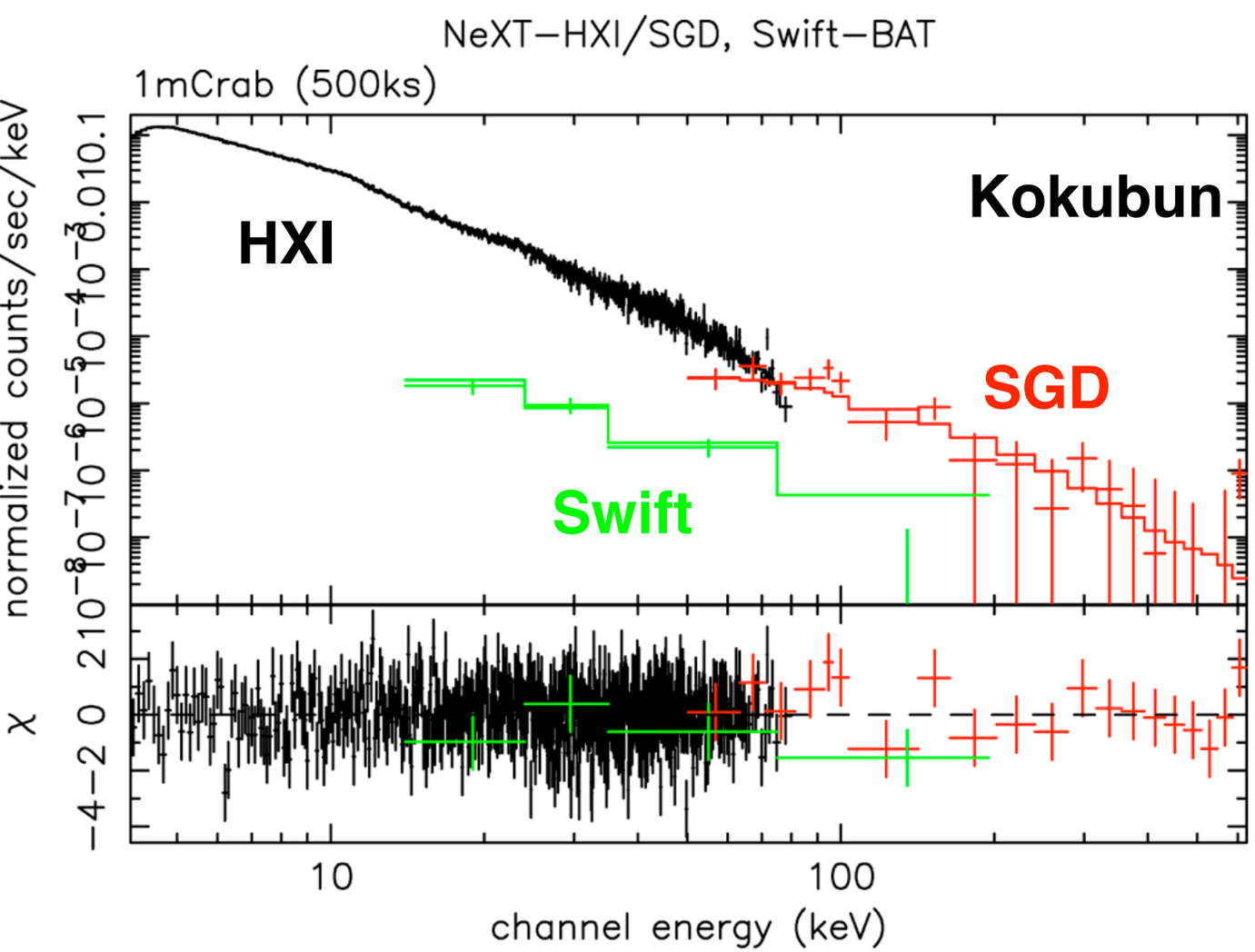
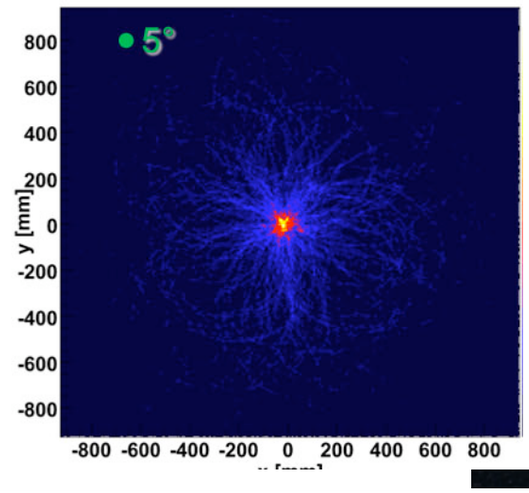
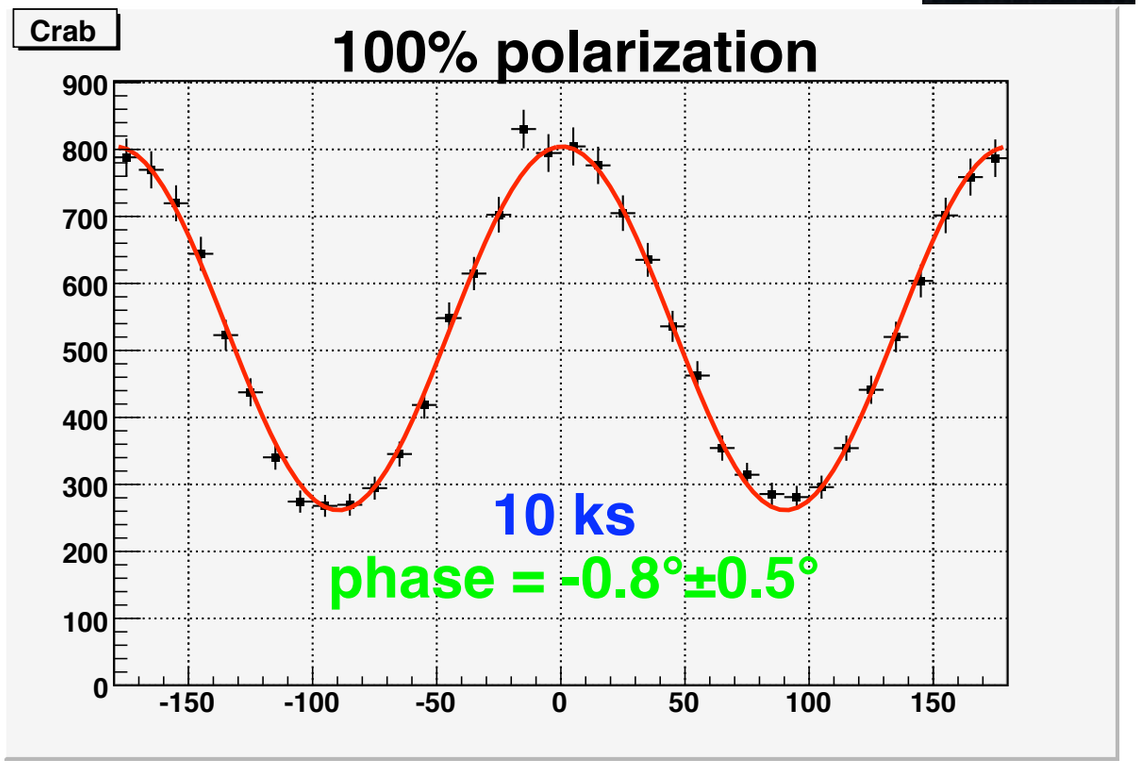


Image taken with 365 keV line



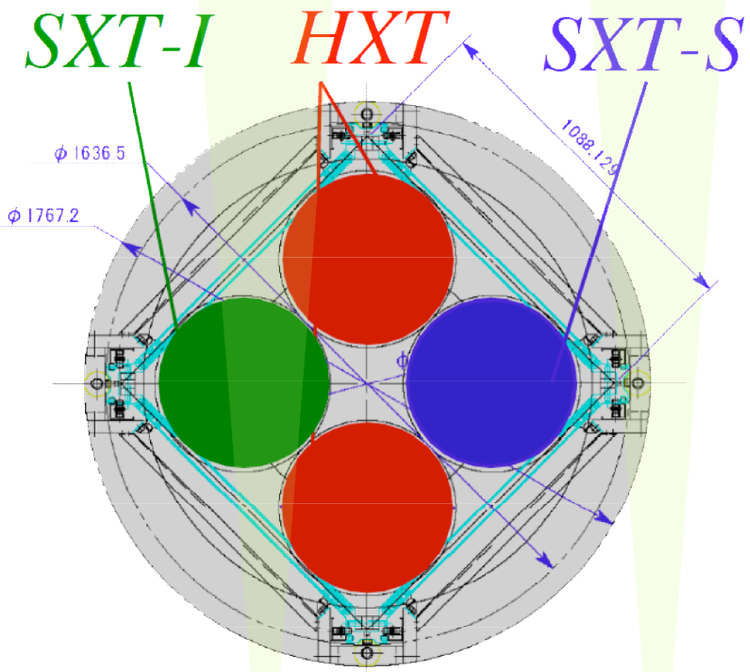


X-rays

Sunshade

Hard X-ray Telescopes
(*HXT*)

Focal Length = 12m

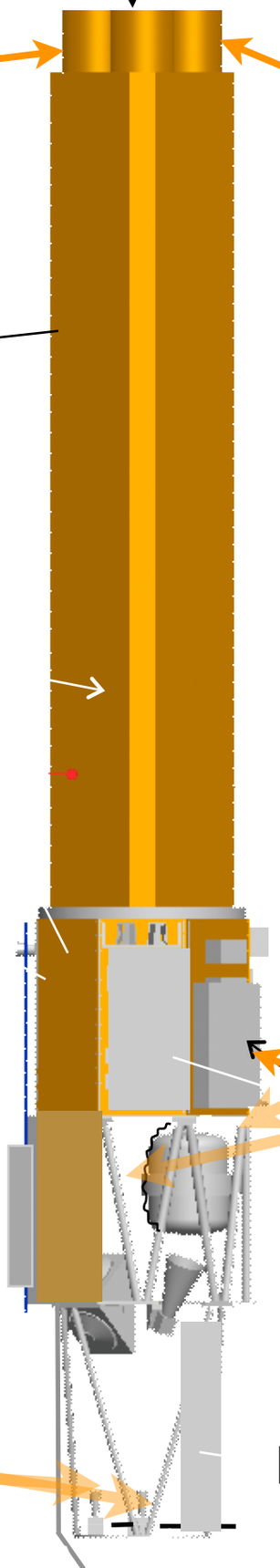


Deployable
Optical
Bench
(EOB)

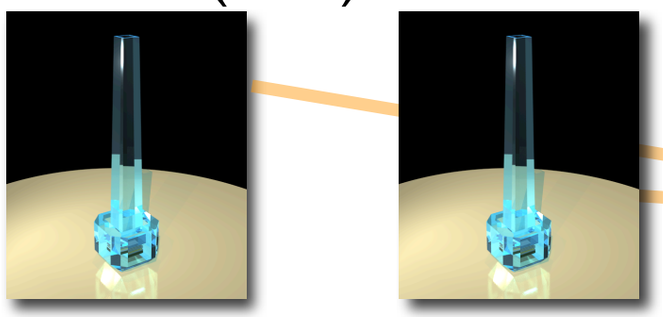
MLI

Radiator

Solar power



Hard X-ray Imagers
(*HXI*)



Sunshade

Soft X-ray Telescopes
(*SXT-S*, *SXT-I*)

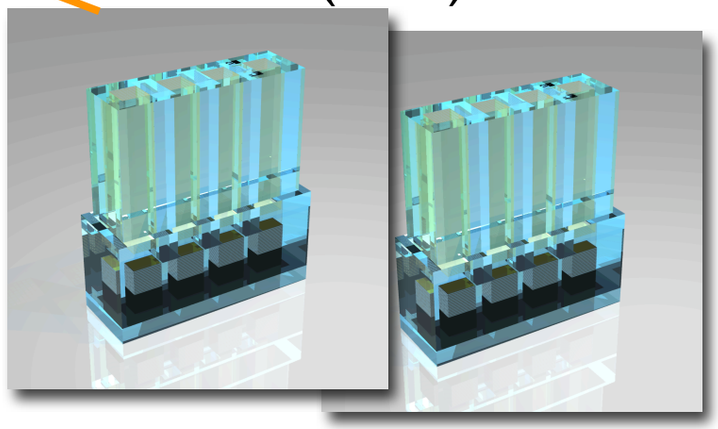
Focal Length = 6m

Microcalorimater
(*SXS*)

X-ray CCD
(*SXI*)

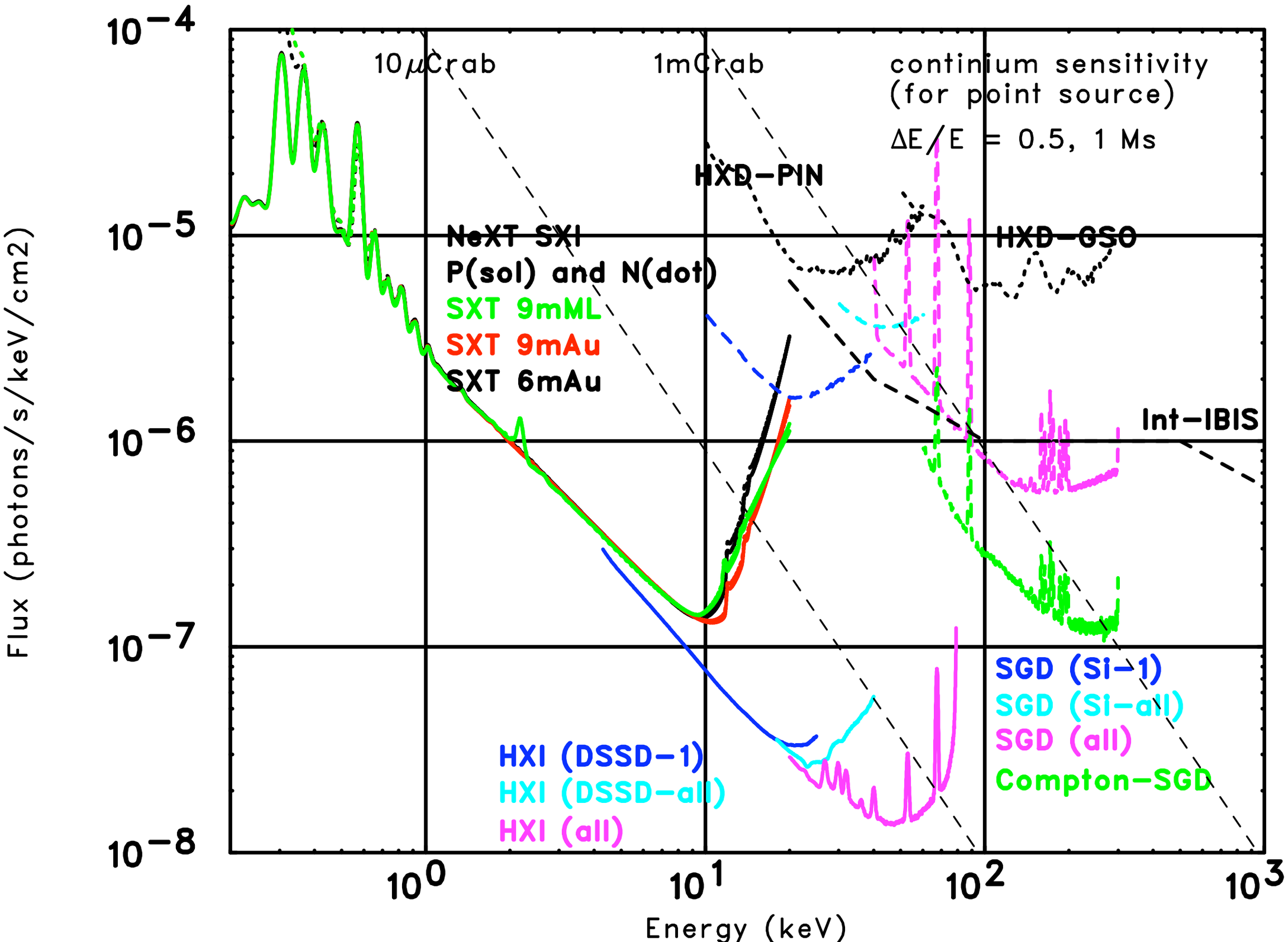
Radiator

Soft γ-ray detectors
(*SGD*)

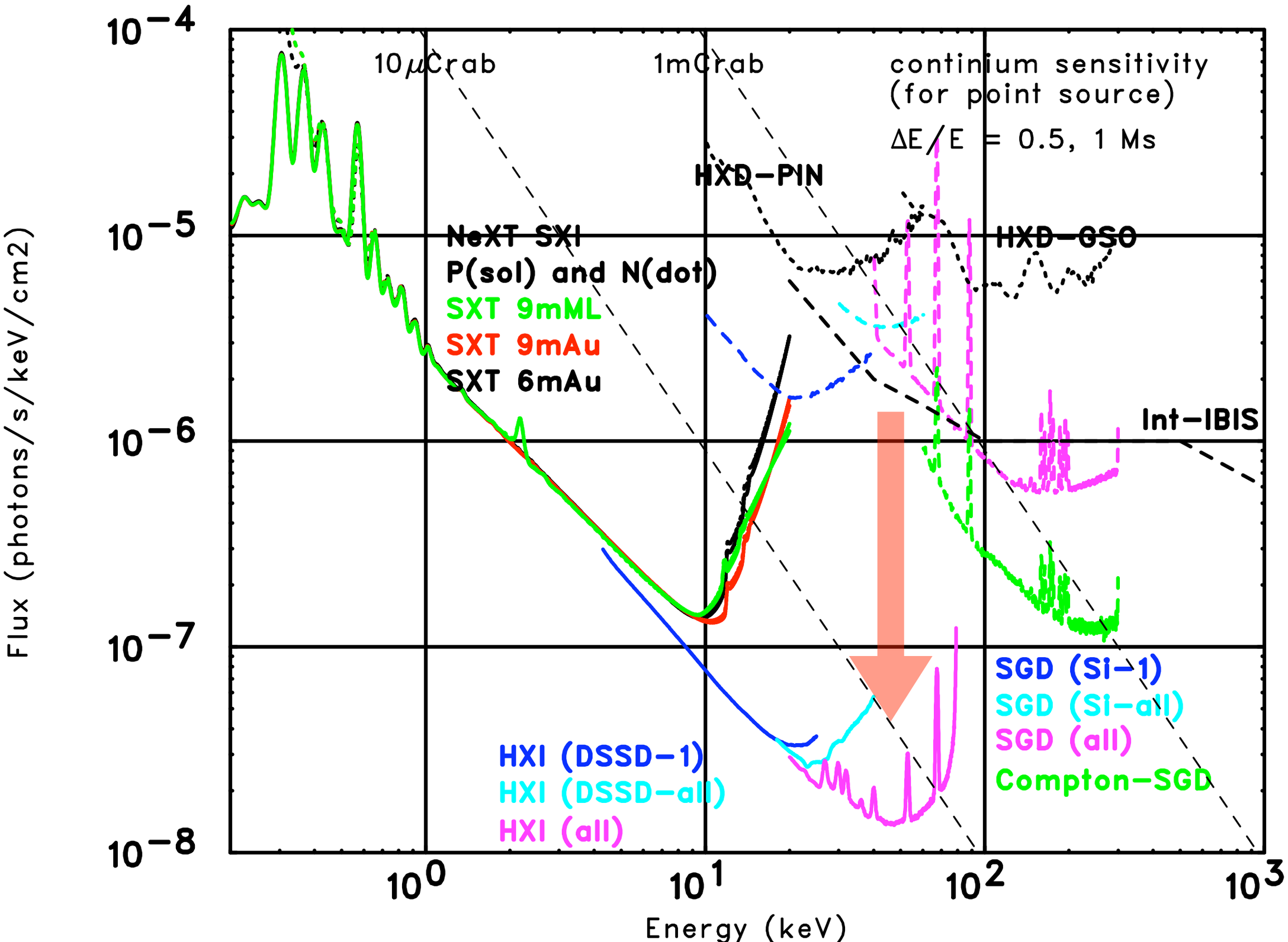


Radiator

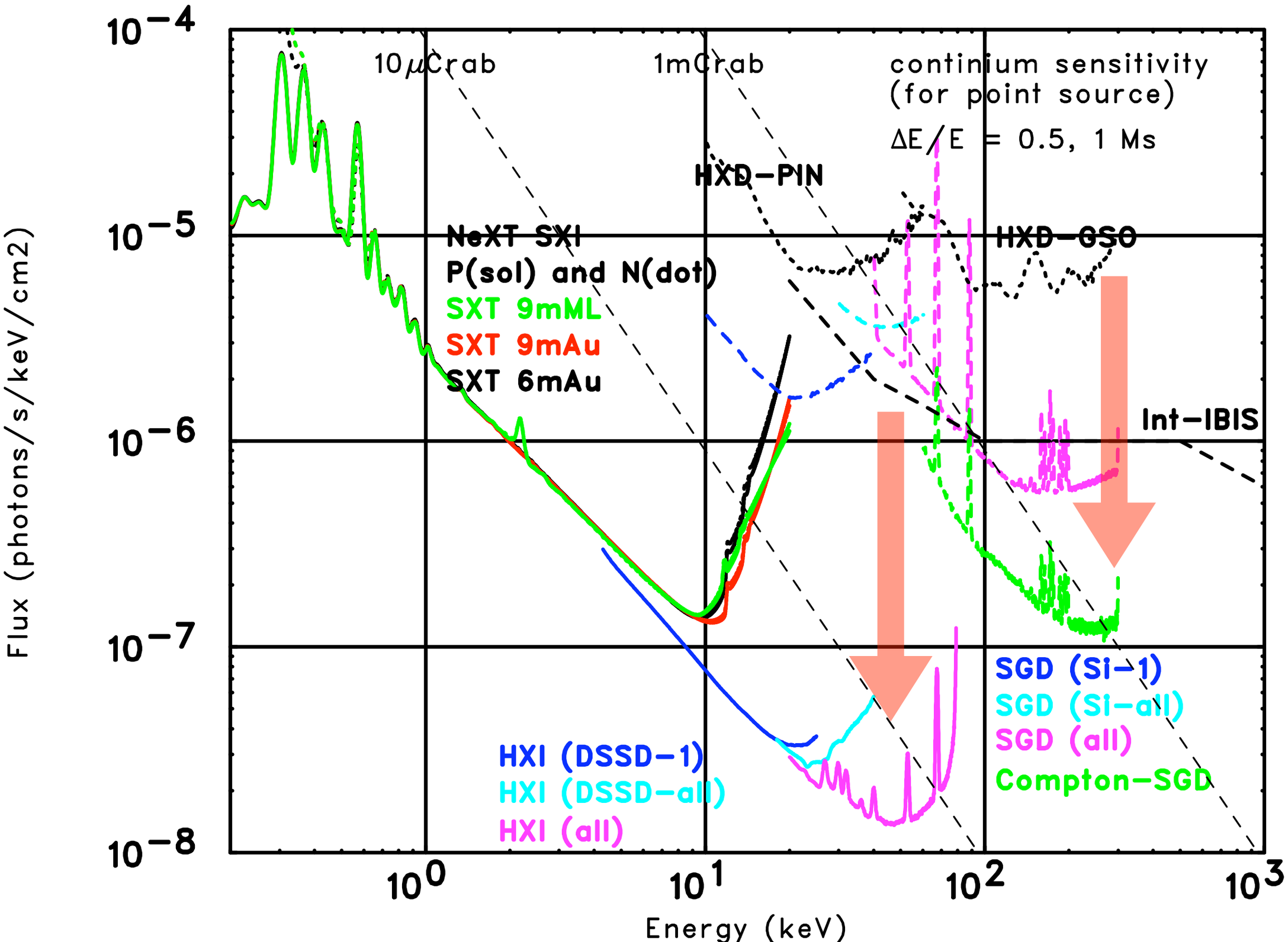
Sensitivity (Based on the current design)



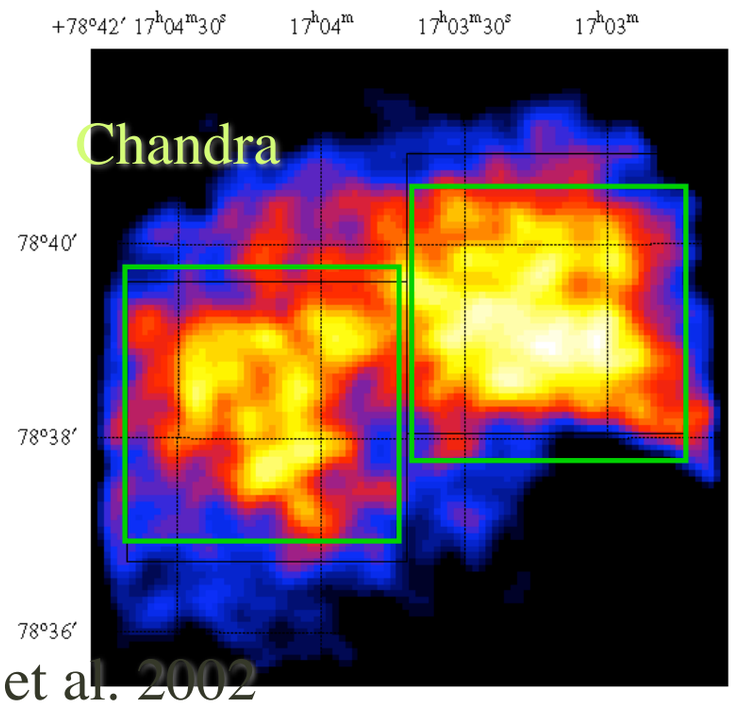
Sensitivity (Based on the current design)



Sensitivity (Based on the current design)

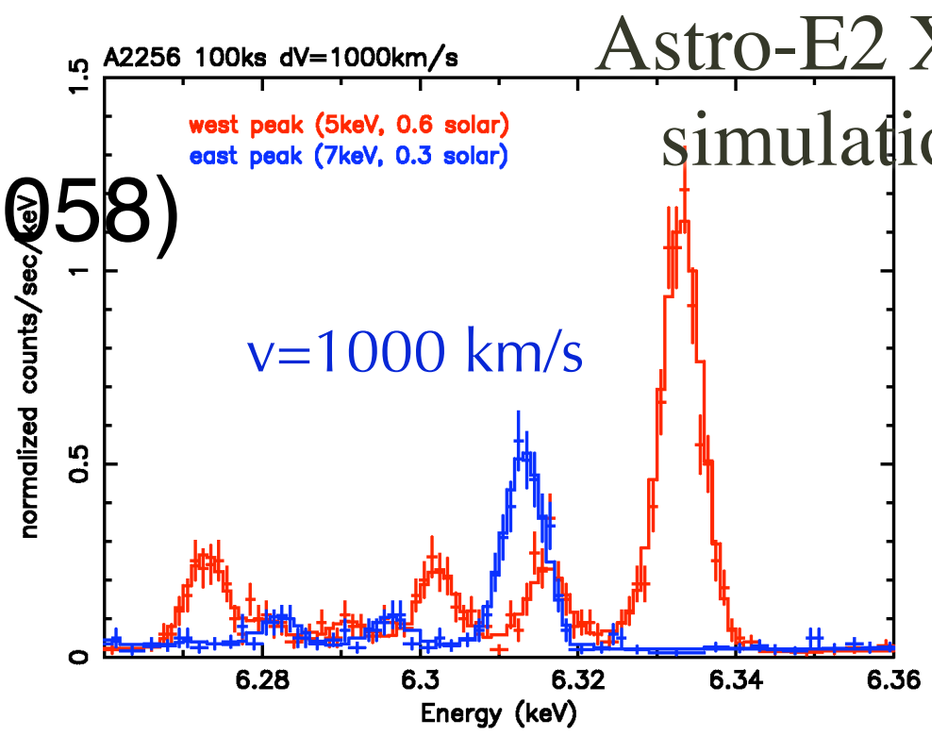


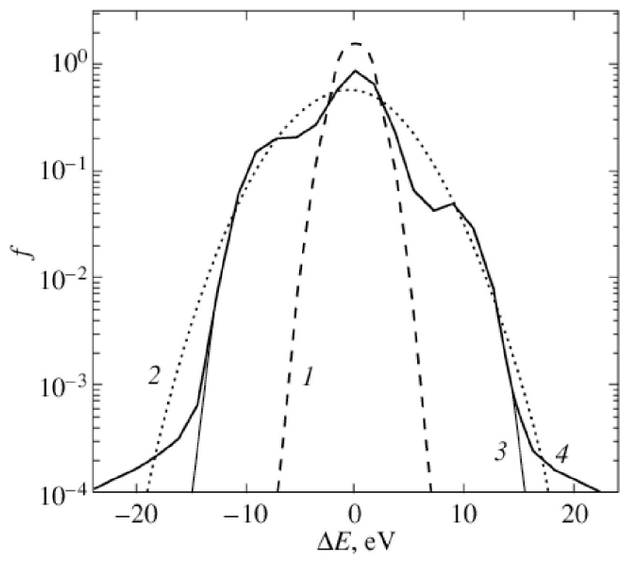
Bulk motion, turbulence & ion temperature



Sun et al. 2002

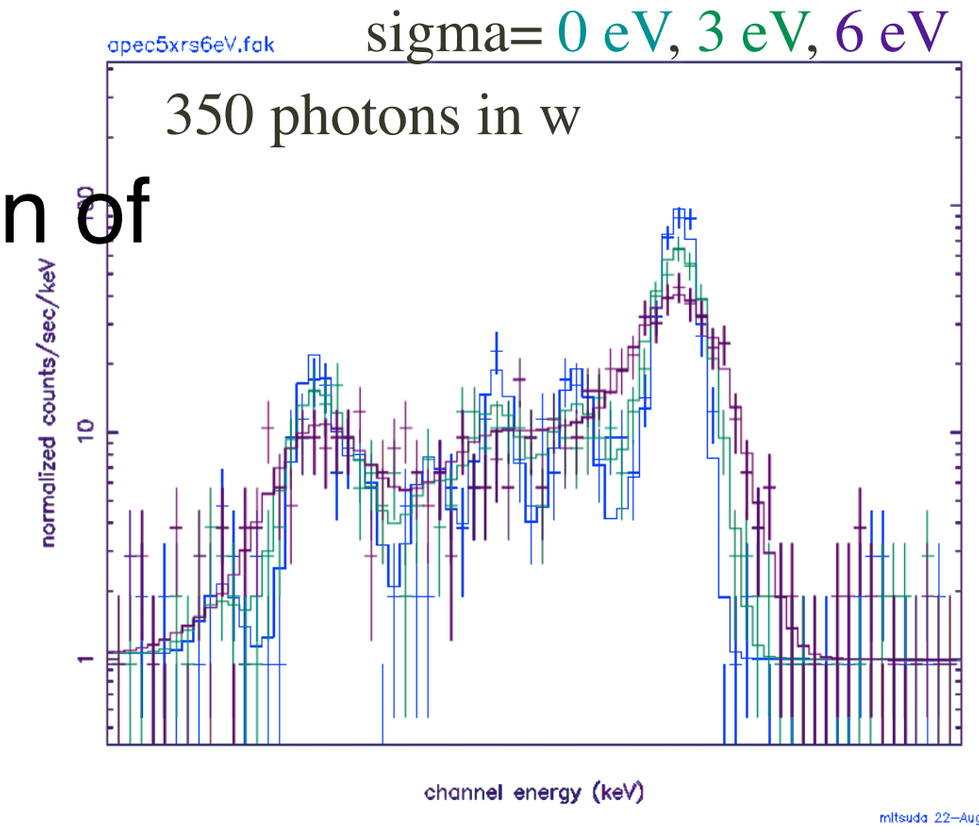
A2256 (z = 0.058)
(PV target)



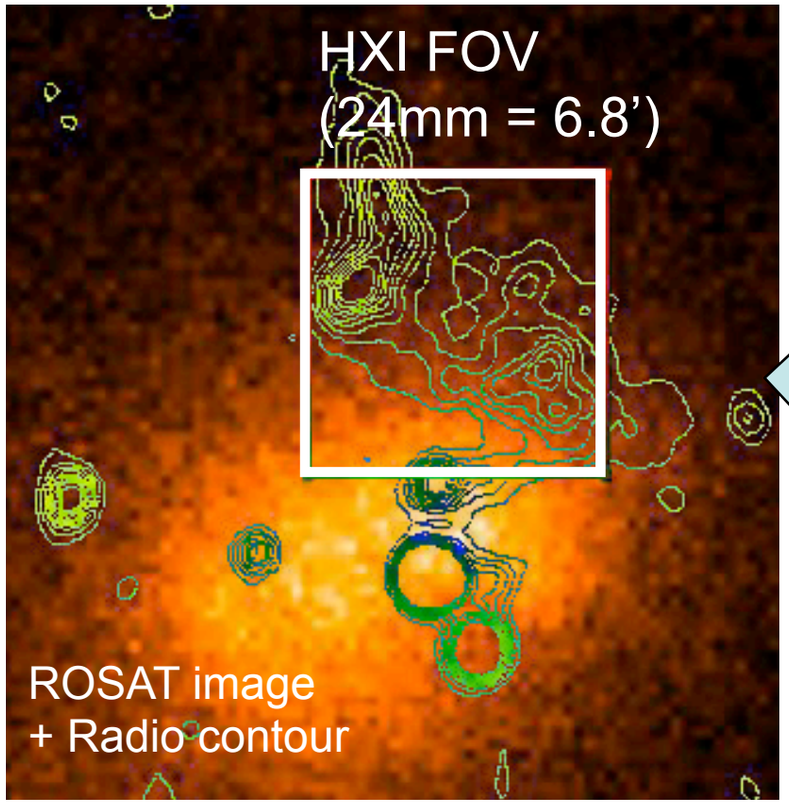


Inogamov and Sunyaev 2003

Turbulence &
Thermal motion of
Fe ion



A2256 hard X-rays claimed by Beppo-SAX

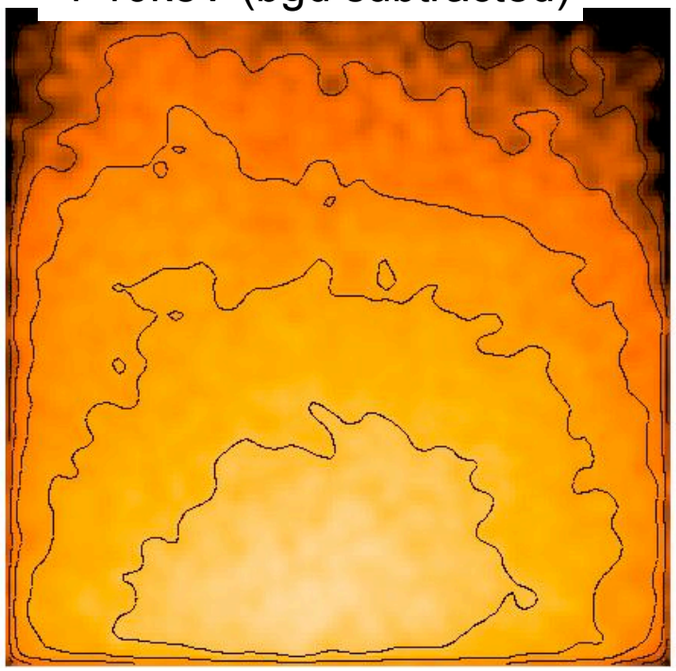


CCD
+ CdTe pixel
+ Gamma-ray Detector

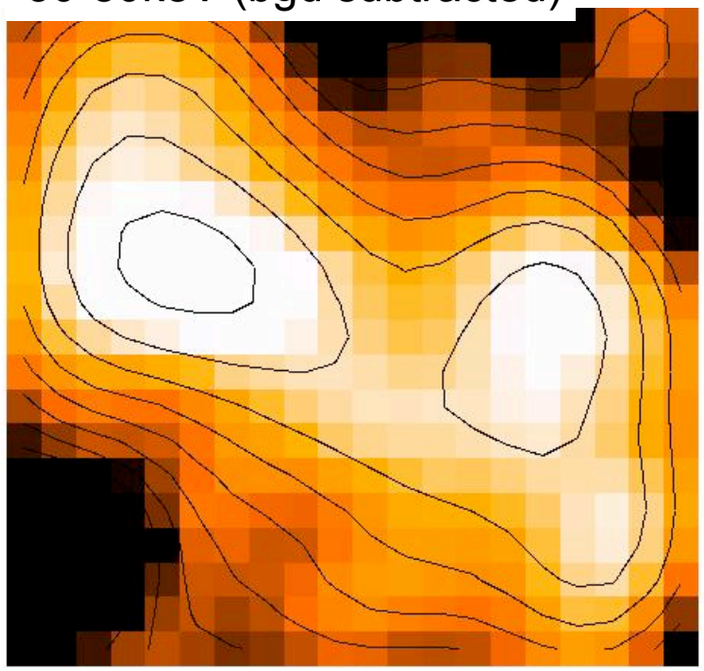
by Furuzawa/Nakazawa

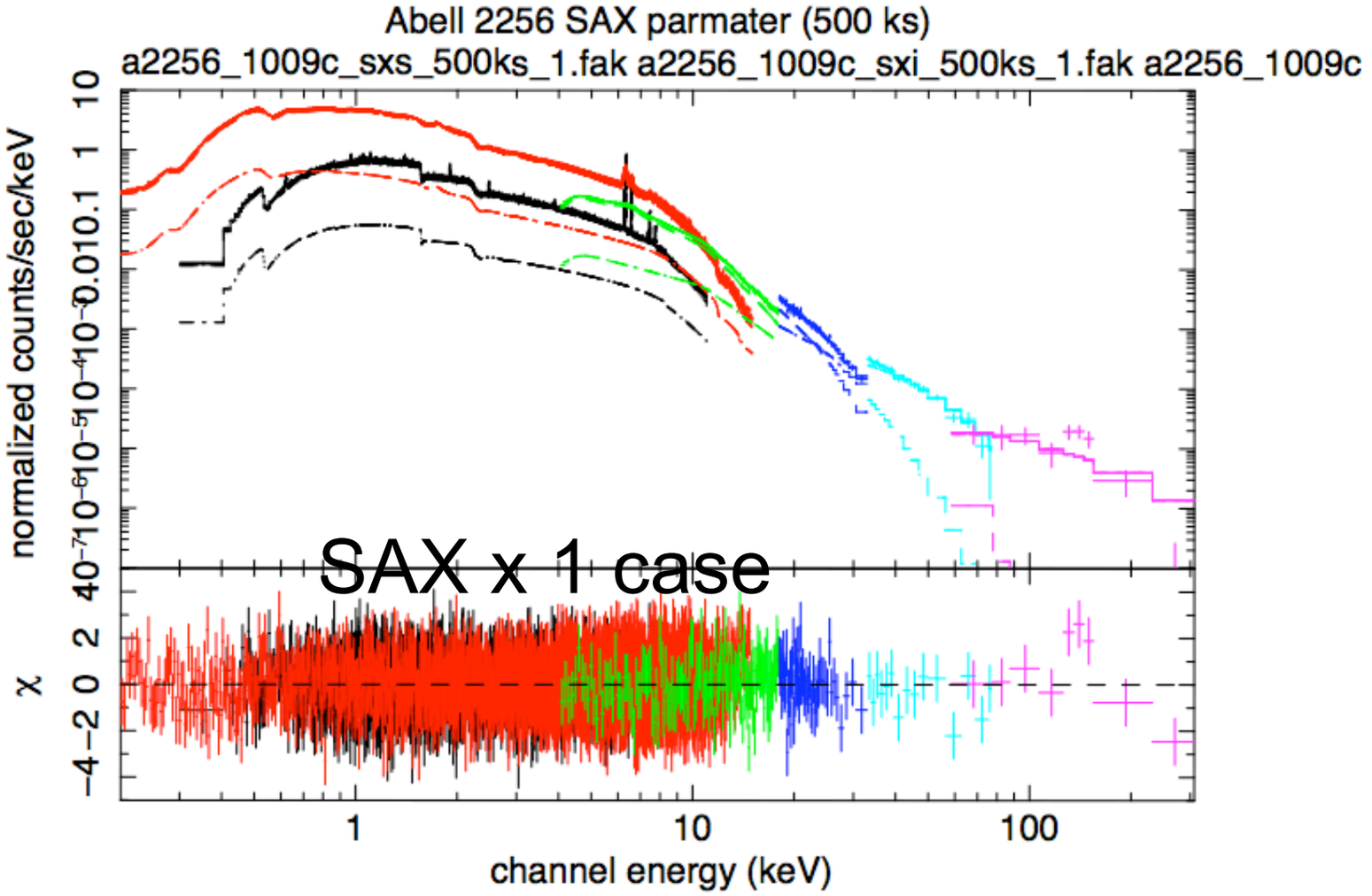
SAX x 1 case (9×10^{-12} cgs 20-80keV)

4-10keV (bgd subtracted)

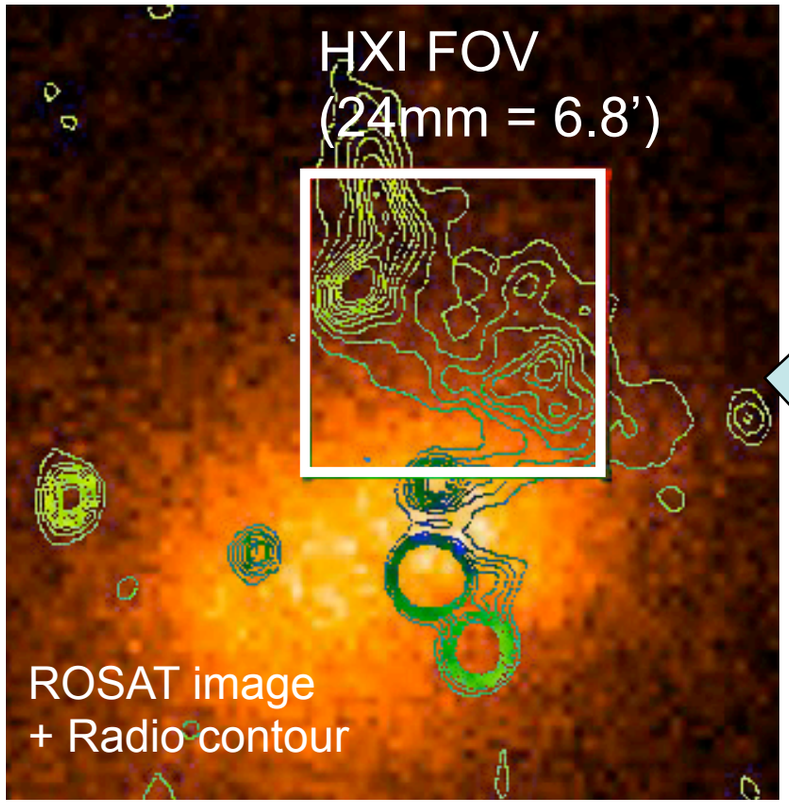


30-80keV (bgd subtracted)





A2256 hard X-rays claimed by Beppo-SAX



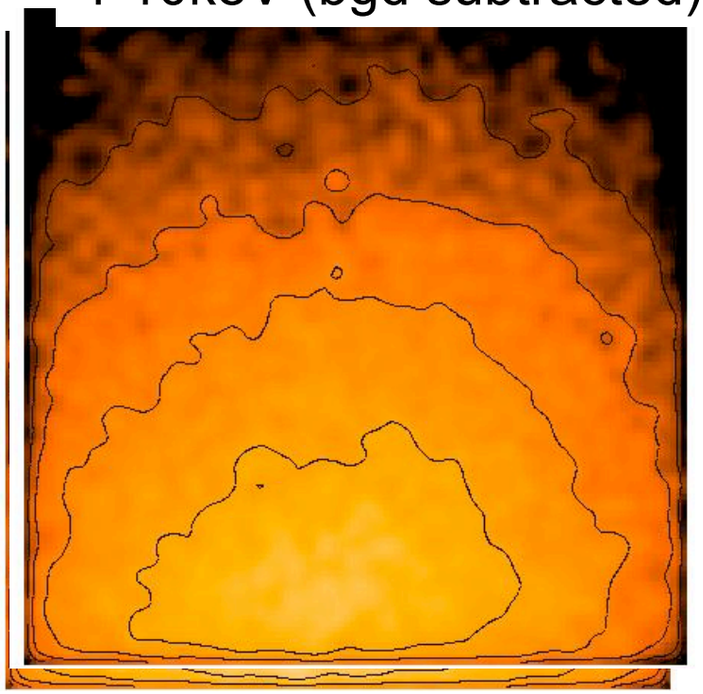
CCD
+ CdTe pixel
+ Gamma-ray Detector

by Furuzawa/Nakazawa

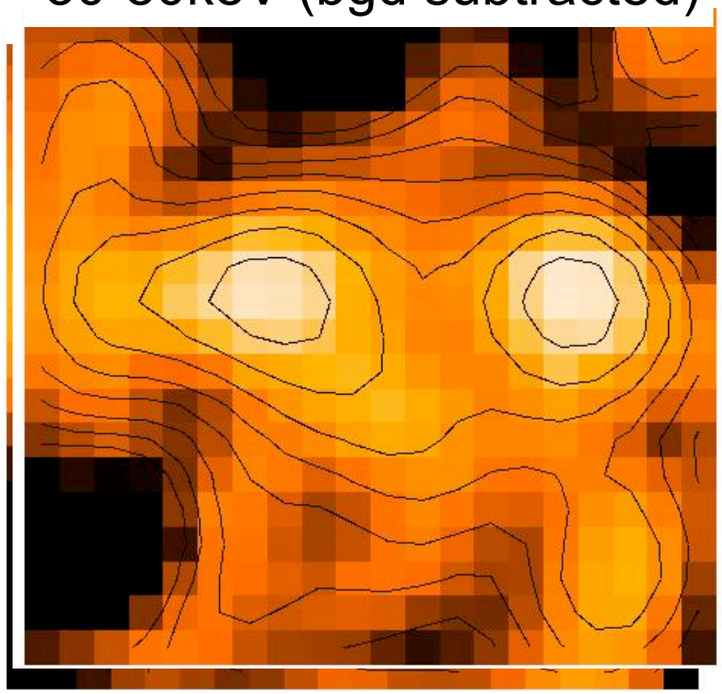
SAX x 0.2 case

cgs 20-80keV)

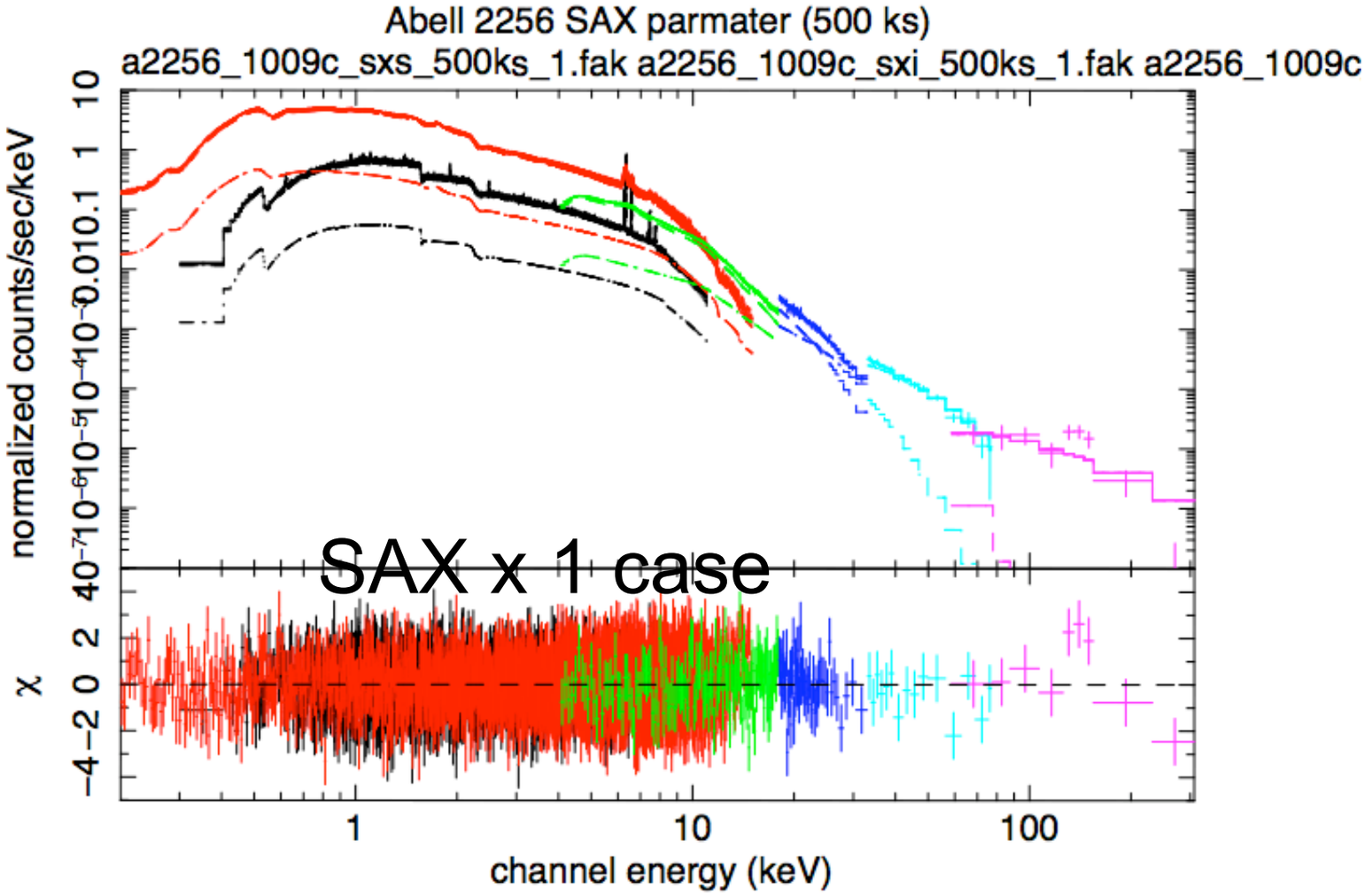
4-10keV (bgd subtracted)

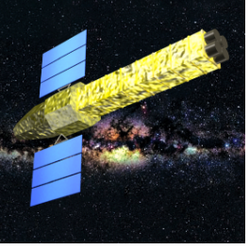


30-80keV (bgd subtracted)



SAX x 1 case





Schedule (Plan)

FY
2007 (H19) | 2008 (H20) | 2009 (H21) | 2010 (H22) | 2011 (H23) | 2012 (H24) | 2013 (H25) | 2014 (H26)

SDR
April

Pre-Phase A

Aug
Phase A

Phase B

April
Phase C

April
Fabrication

August
Integration
Test

August
Launch

Initial Operation
Operation

SDR
PDR
CDR

Summary

- **NeXT has been selected as a mission to go into Phase A.**

  - Baseline instrument configuration defined based on 2005 proposal
  - Pre-project Team defined
  - Phase A study has started. The review required before we move to Phase B (real development) will take place in early 2008 JFY.

- NeXT will carry Leading-Edge instruments to perfrom Cutting-Edge Science in High Energy Astrophysics/ Cosmology.

eV resolution and Wide band Imaging

We are now planning to have a conference entitled "Suzaku, NeXT and beyond" in 2008 or 2009