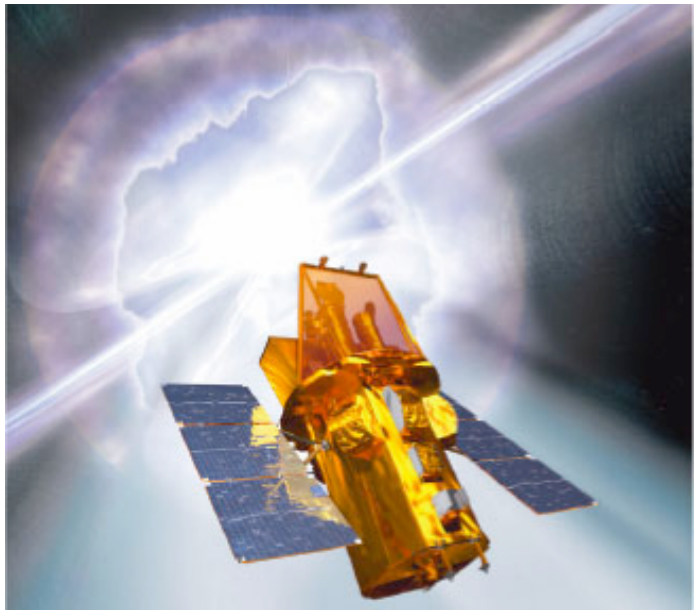
Swift and Astro-E2

New X/γ-ray Astrophysical Satellites to Start Observations in 2005

Kazuhiro Nakazawa (ISAS/JAXA)
on behalf of Swift-team and Astro-E2 team

Swift Mission

2004/11/20 launched



weight 1.5t

NASA-international

Gamma-ray burst explorer

"Catching GRB on the fly"

Astro-E2 Mission

2005-summer to be launched

weight 1.7t

ISAS/JAXA-international

X-ray Observatory

Wide-band and finest spectrometer for X-ray astronomy

Both will start operation in 2005

K. Nakazawa Kashiwa 8 Mar. 2005

1: The Swift Mission

together with Tad.Takahashi, M.Tashiro, M.Kokubun,
G.Sato, M.Suzuki, T.Mitani, H.Takahashi, Y.Okada, H.Ozawa,
S.Watanabe, M.Sugiho
and Swift-team members

The Swift Mission

Revolution in GRB observation

Bust Alert Telescope

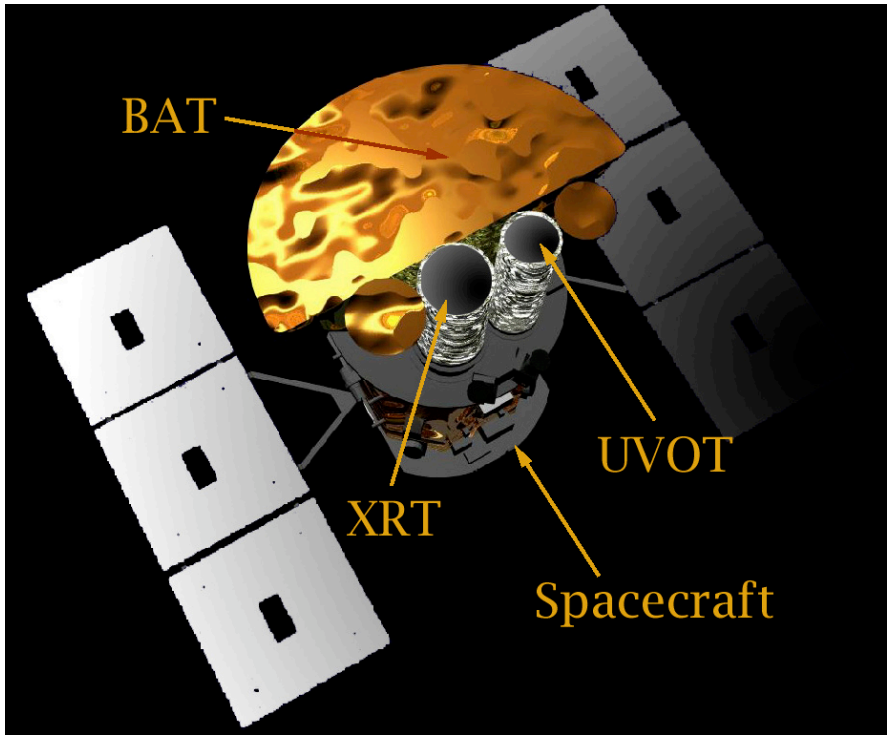
Wide FOV (2 str),
15-150 keV band imager
locates BST with 1' accuracy

X-ray Telescope

Narrow FOV, X-ray imager
locates BST/afterglow
with ~2" accuracy

UV and Optical Telescope

Narrow FOV, UV and Op imager
locates afterglow with ~2" PSF



Swift automatically maneuvers itself to the BST within ~100 s. ALL data is public immediately to invoke best followups

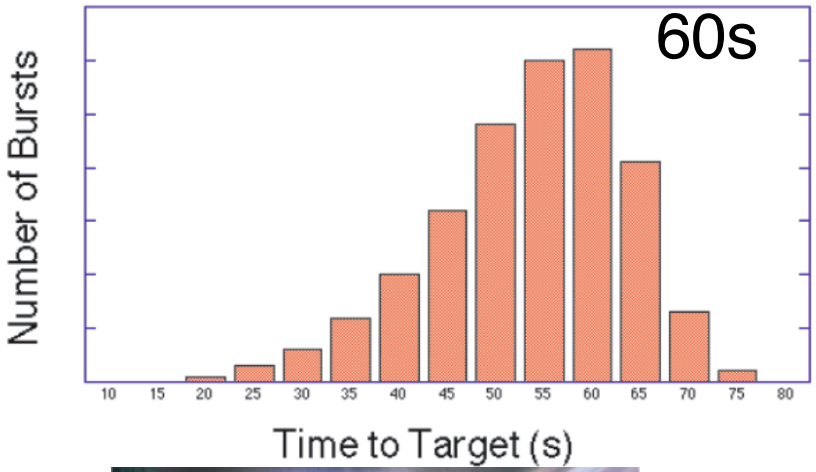
Key Points of Swift

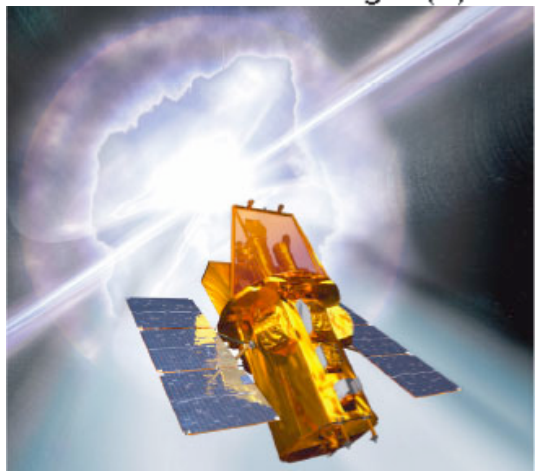
- High sensitivity and wide field of view to locate as much as 100 GRB/yr (currently 20 GRBs / 90 days = 82 GRBs/yr)
- Not only locate, but also carries out automatic follow-up observations for GRB
- Broad-band follow up
  - BAT: 15-200 keV
  - XRT: 0.5-10 keV
  - UV and Optical
- All data is open to anyone, immediately
- Rapid GRB notifications via GCN
- In addition, a (nearly) all -sky hard X-ray image will be obtained (~1 mCrab sensitivity)

Swift Performance

How to track GRB, prompt emission and afterglows

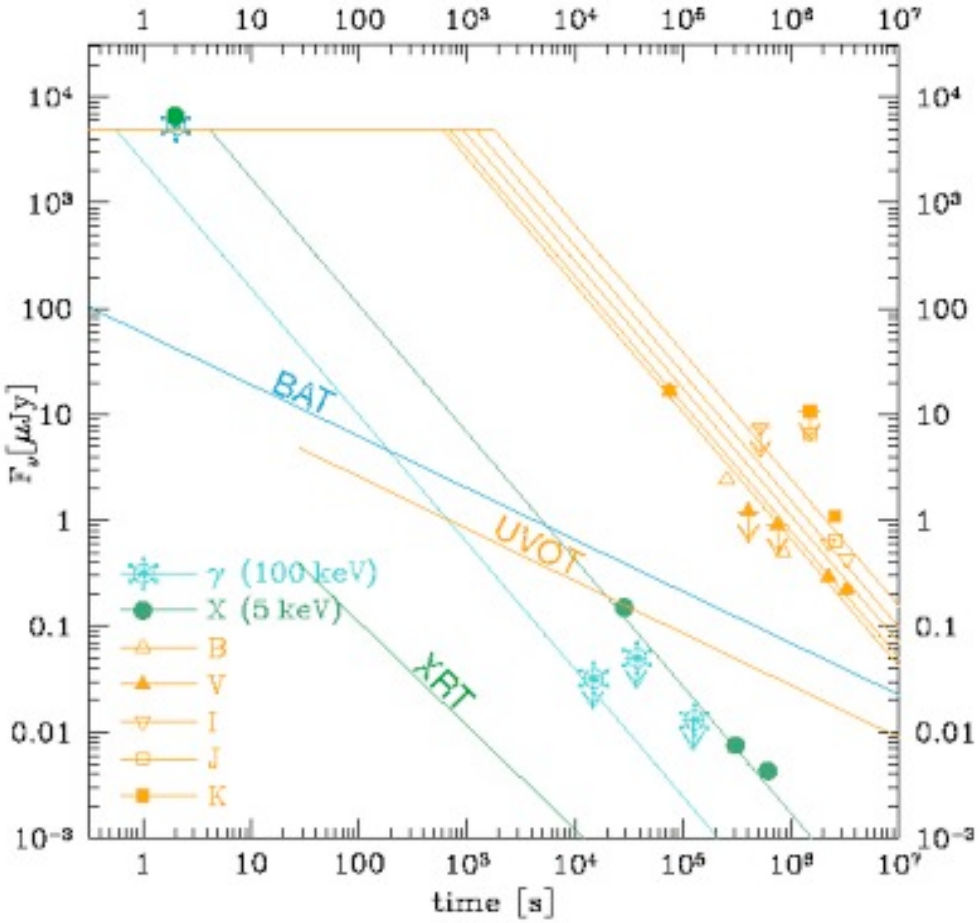
Time for Slew





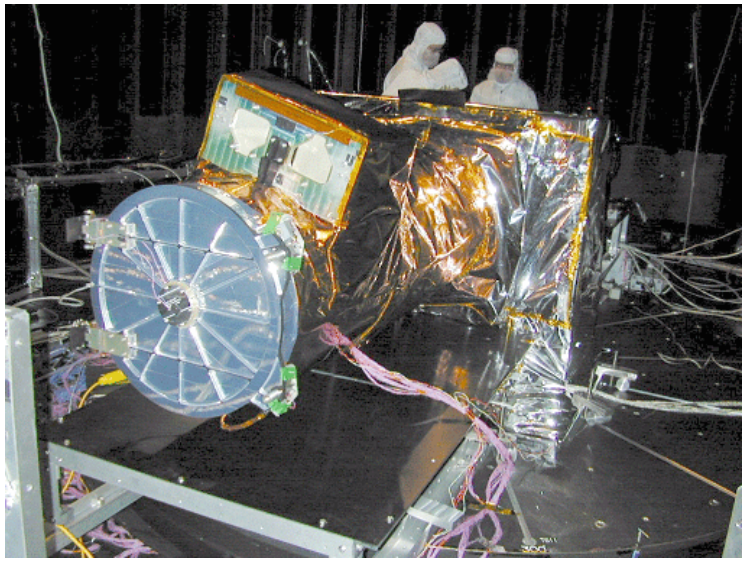
Afterglow sensitivity

mCrab



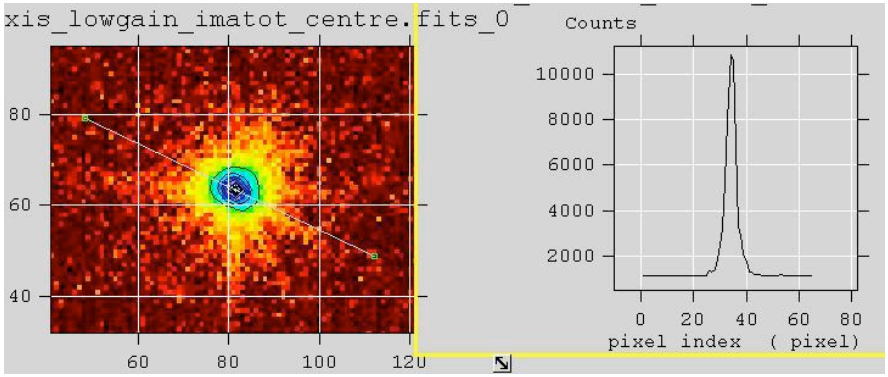
XRT

XRT in Thermal-Vacuum Test



Telescope	3.5 Wolter I, 12 shells
Telescope PSF	18 arcsec FWHM @ 1.5 keV
Position Accuracy	2.5 arcseconds (2 sigma)
Field of View	23.6 x 23.6 arcminutes

JET-X mirror and XMM-Mos CCD



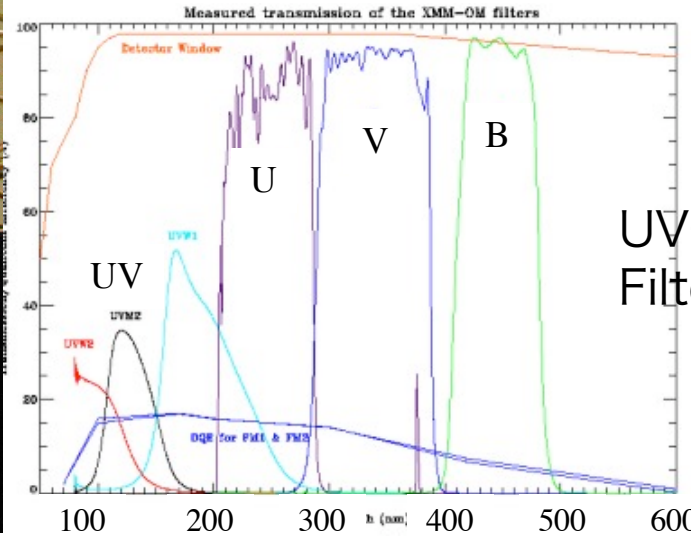
- Location accuracy is ~2”
- TEC power was lost
  shortly after launch
    currently by passive cooling
    -70 ~ -50 C, depending on
    satellite attitude and mode
- Below -50 C, CCD works well

UVOT

NASA

Telescope	30 cm Ritchie-Cretien
Telescope PSF	2 arcsec FWHM @ 350 nm
Position Accuracy	0.3 arcseconds (2 sigma)
Field of View	17 x 17 arcminutes

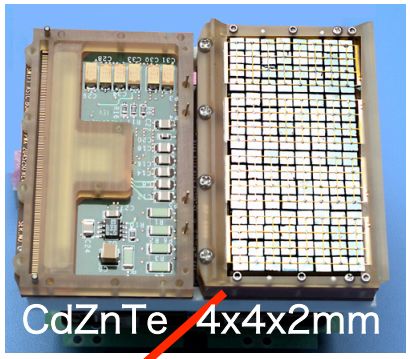
XMM Optical Monitor
Backup

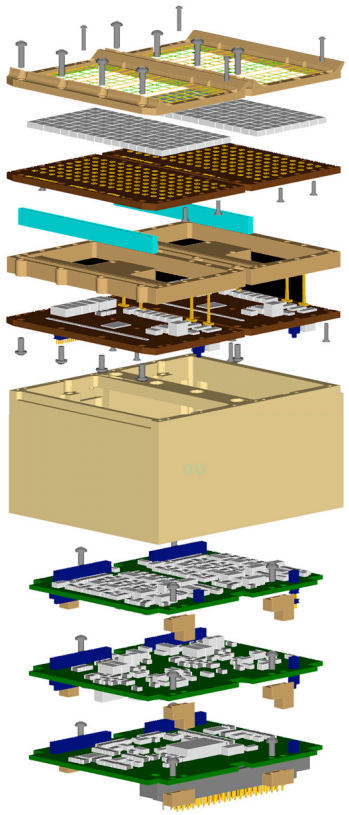


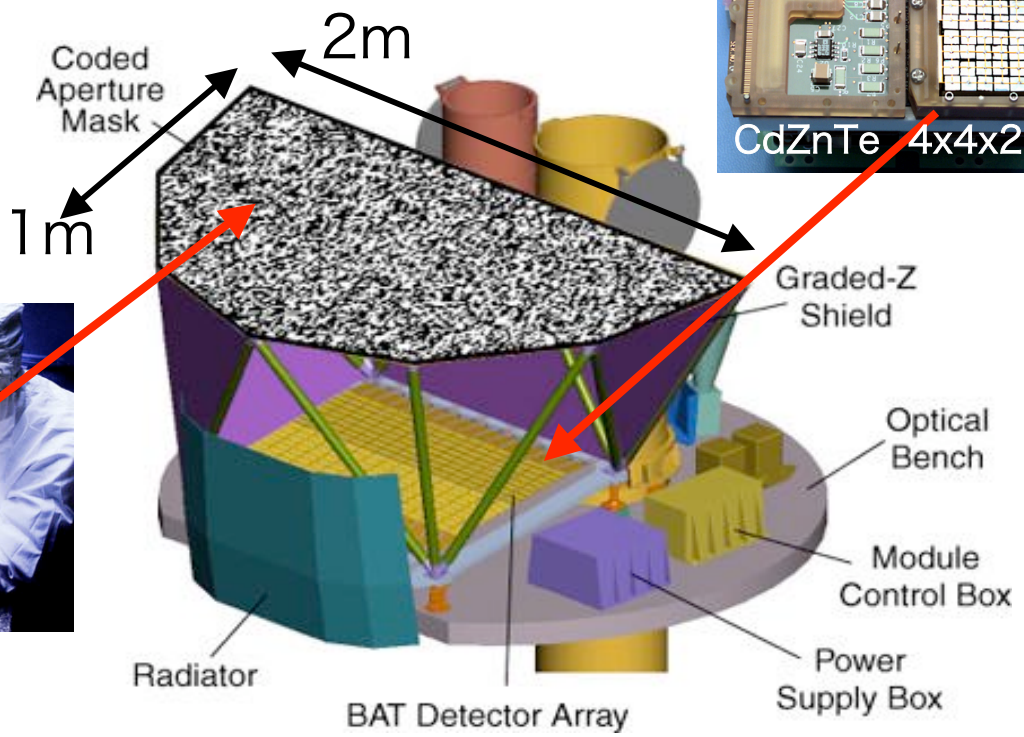
UVOT
Filter Function

Given an mB = 24 source with a spectrum like an A0 star,
the signal-to-noise ratio is 4.3 in 1000 s.

Burst Alert Telescope (BAT)







- CZT detectors x 32,768
  (5200 cm² in total)
- 100degx60deg (~2str)
- XA-1 chip read out
- Ramdum mask with 54,000 Pb plates

⇒ Japan Swift hardware team is contributing to evaluation and calibration of BAT CZT responses.

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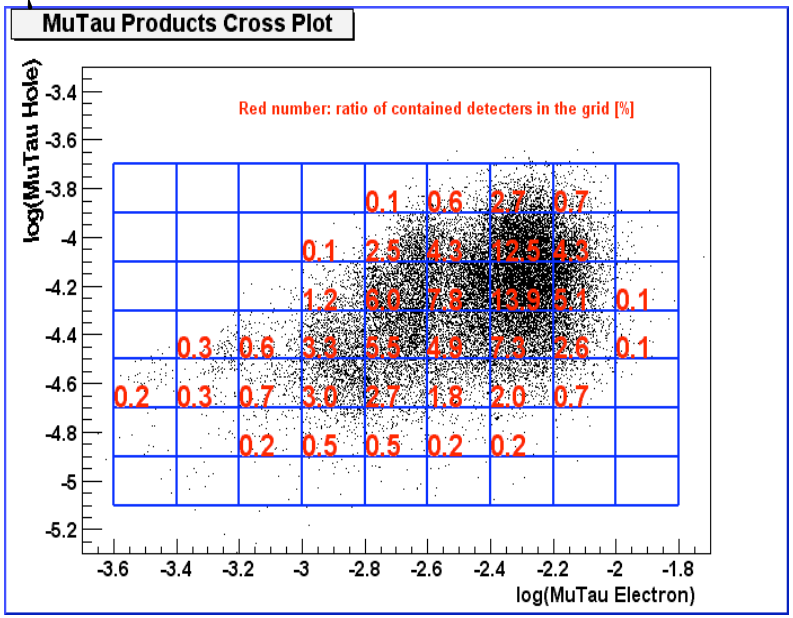
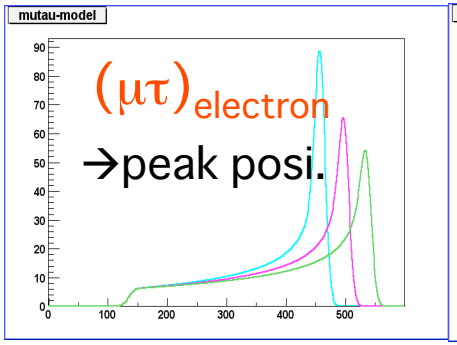
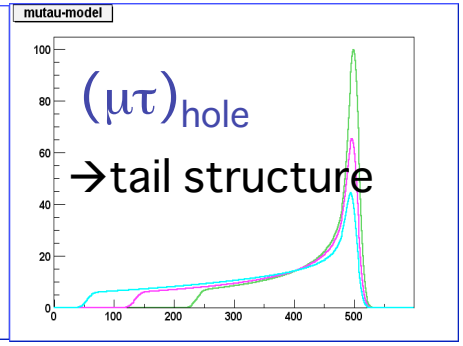
BAT Response generator

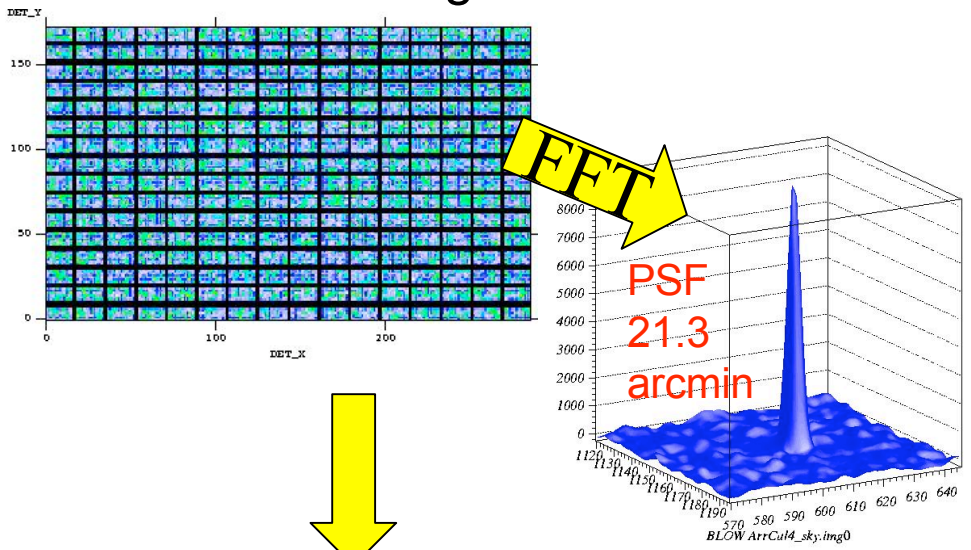
32k parameters of μτ hole and electron

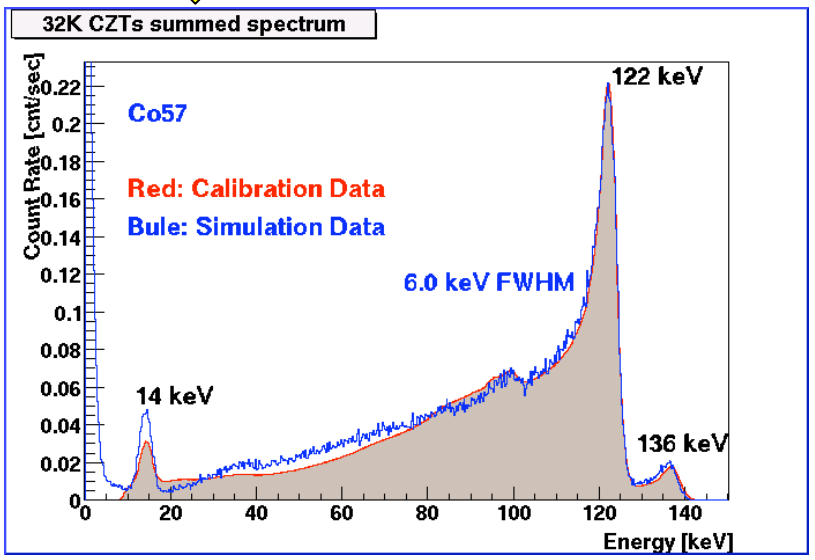






BAT ground Cal data





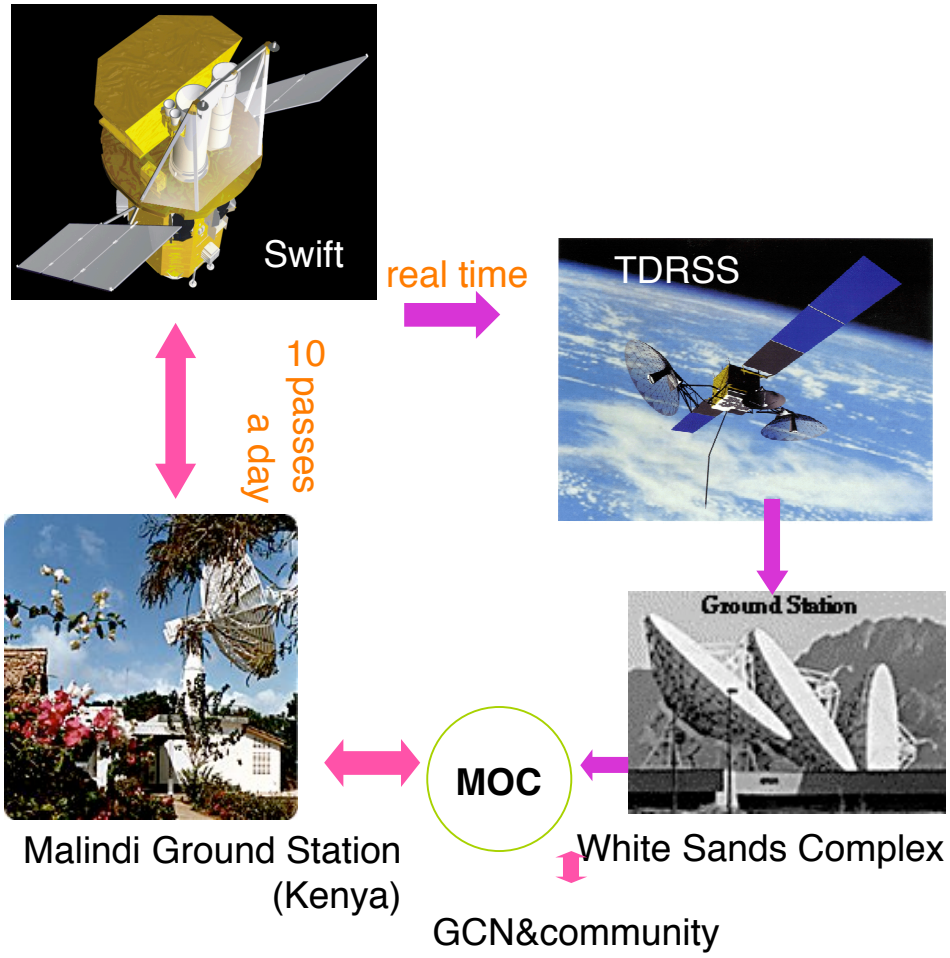
GRB Detection and Notice Scheme

After GRB detection

- ~20s
  - BAT GRB location (~2 arcmin)

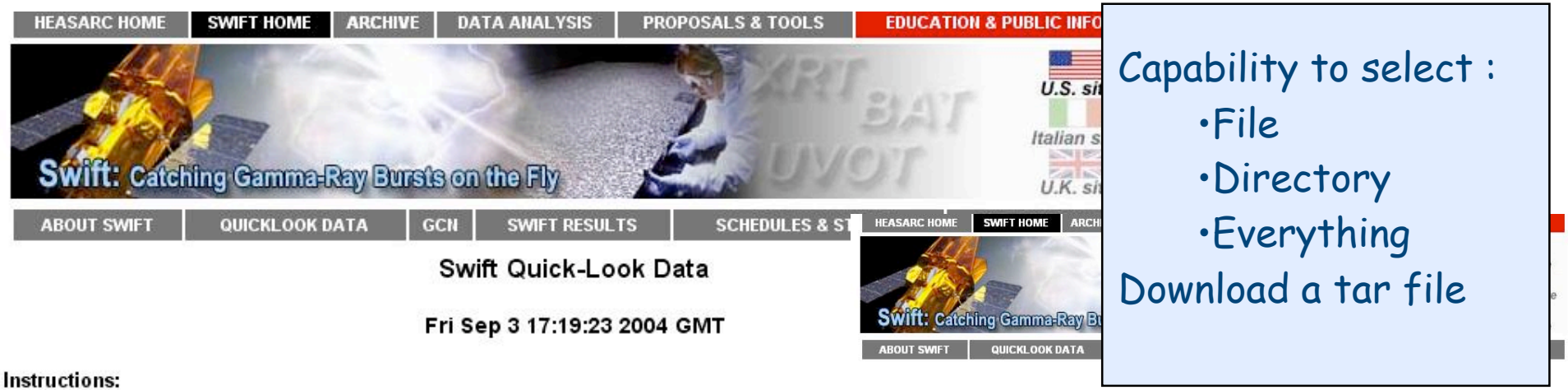
  →TDRSS→operation center →GCN

  Satellite Slew →GRB Pointing
- ~70s
  - XRT imaging and locating (~2 arcmin)
- ~140s
  - GRB spec, image, light curve to ground
- ~240s
  - UVOT image (~0.3 arcsec)
- ~1,200s
  - XRT spectrum
- ~10,000s
  - All data down link to Malindi station and archive



Follow up observation starts immediately
-Swift follow-up team coordinated by Kevin Hurley
-All the other is encouraged to join

Swift Quick-look interface



Capability to select :

- File
- Directory
- Everything

Download a tar file

http://swift.gsfc.nasa.gov/cgi-bin/sdc/ql?

BA Training documents

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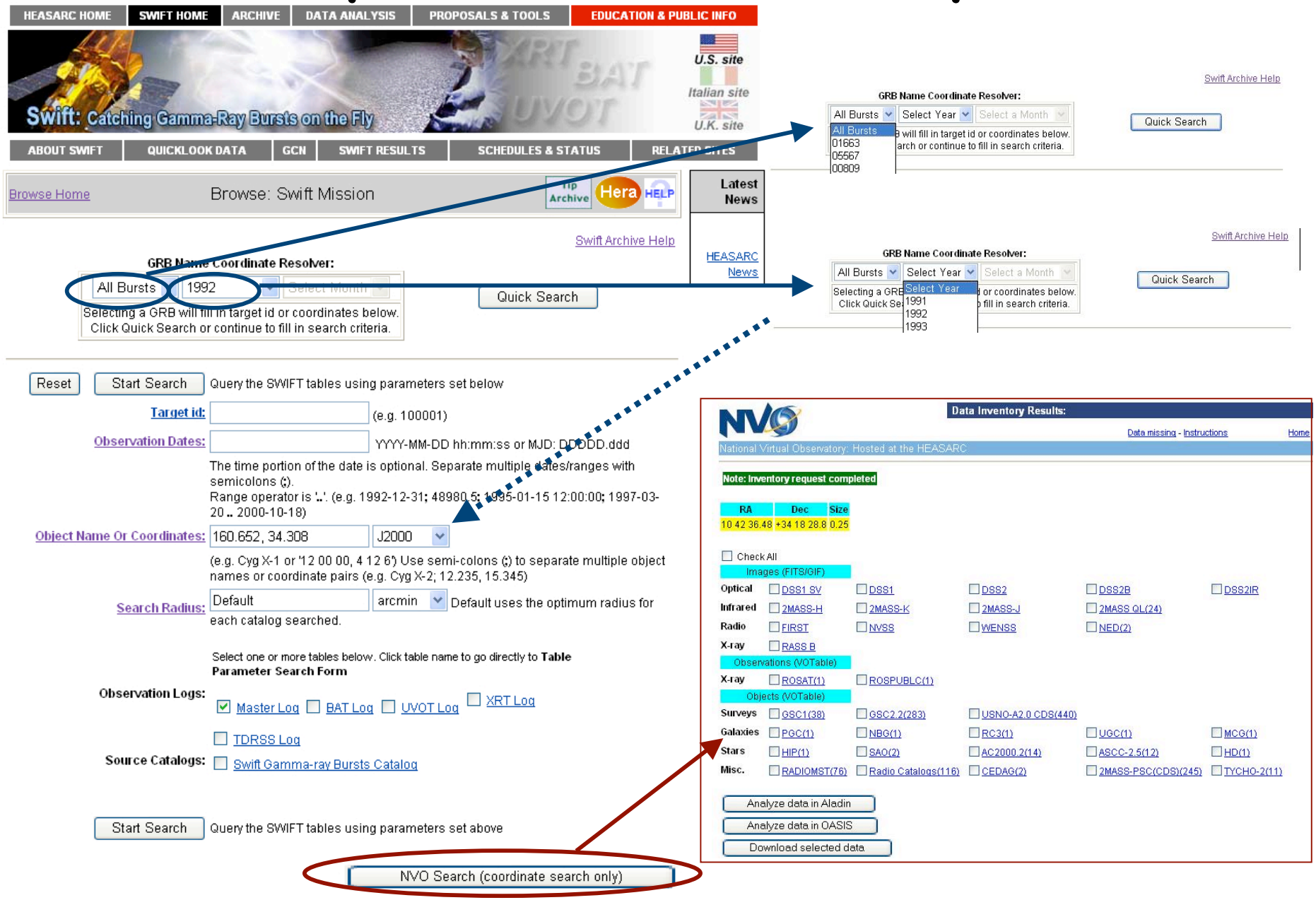
Swift archive interface



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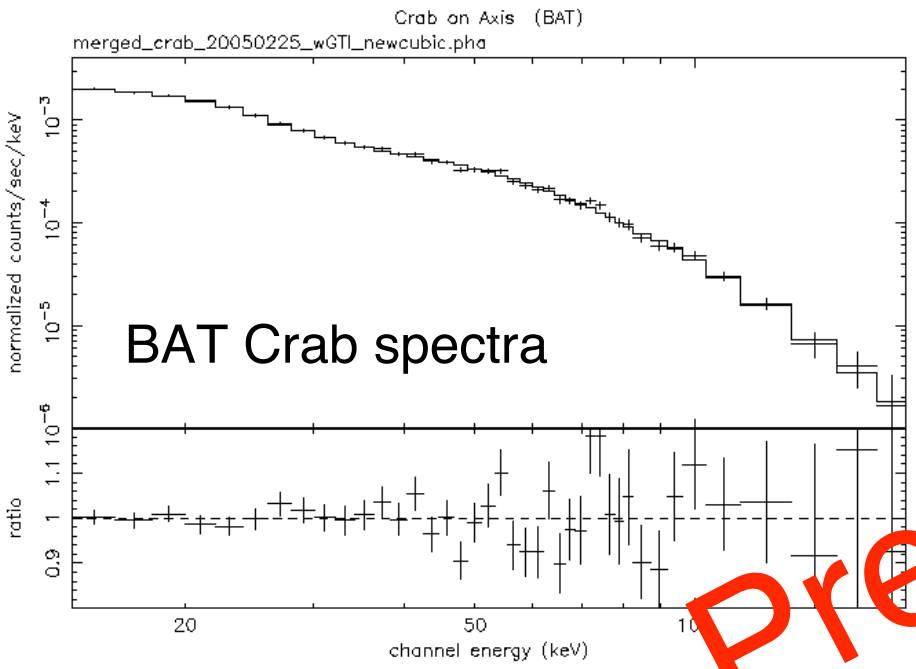
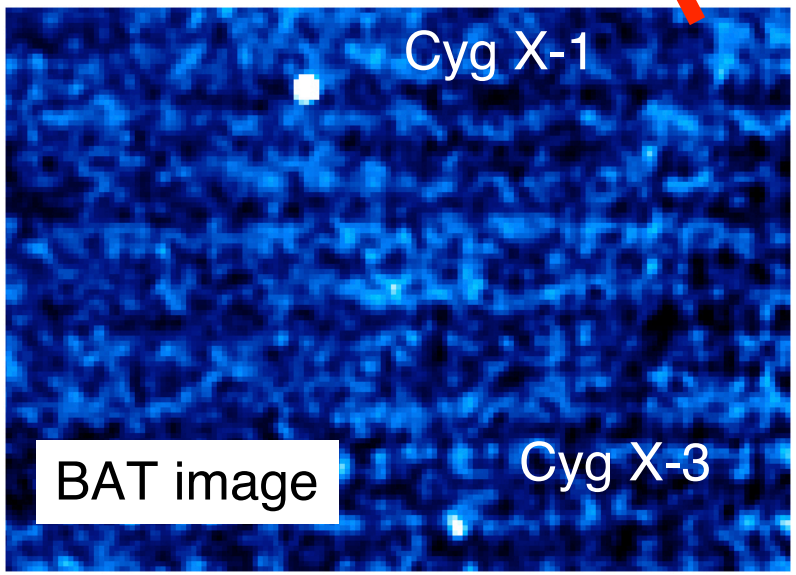
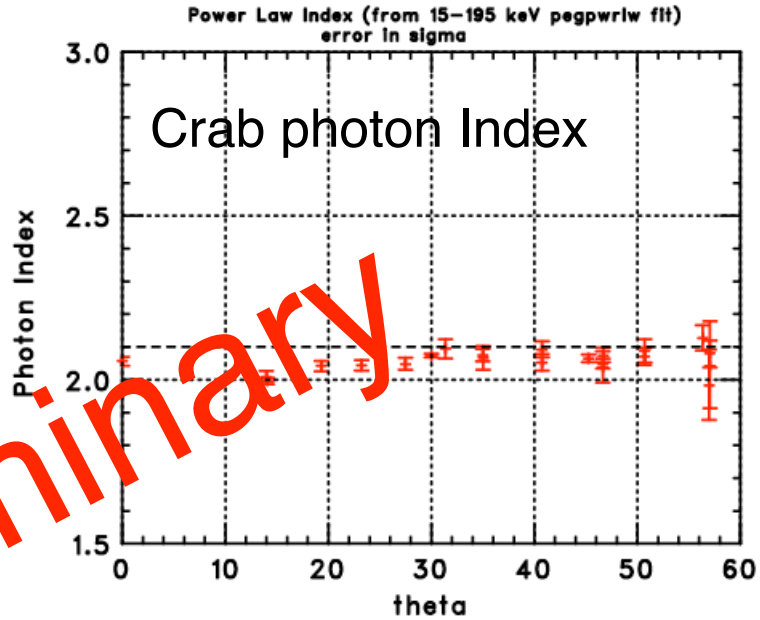
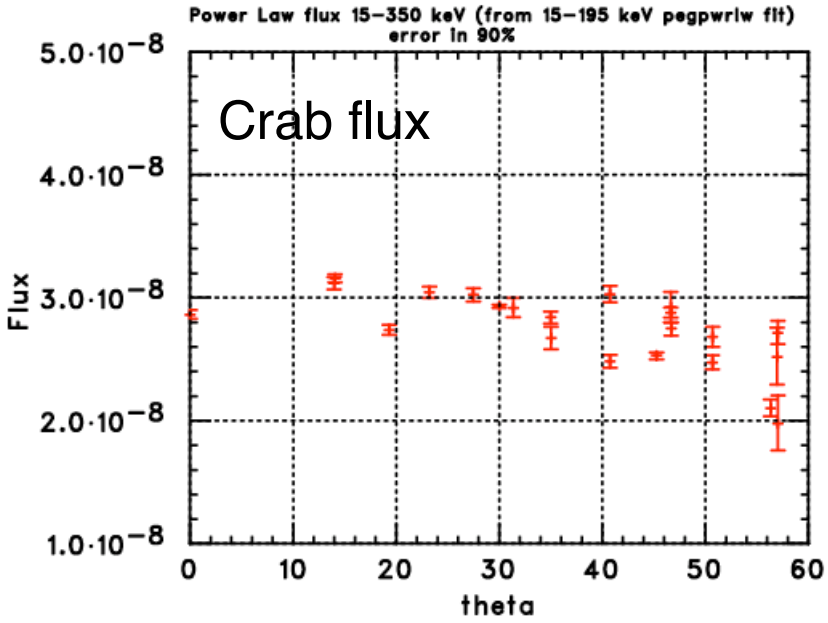
Current BAT calibration status









Preliminary

GRB 041223 X-ray afterglow

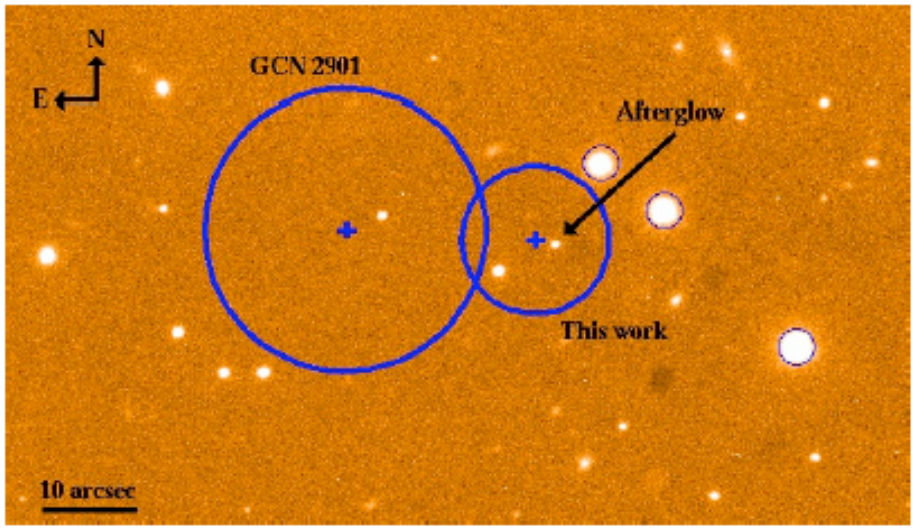
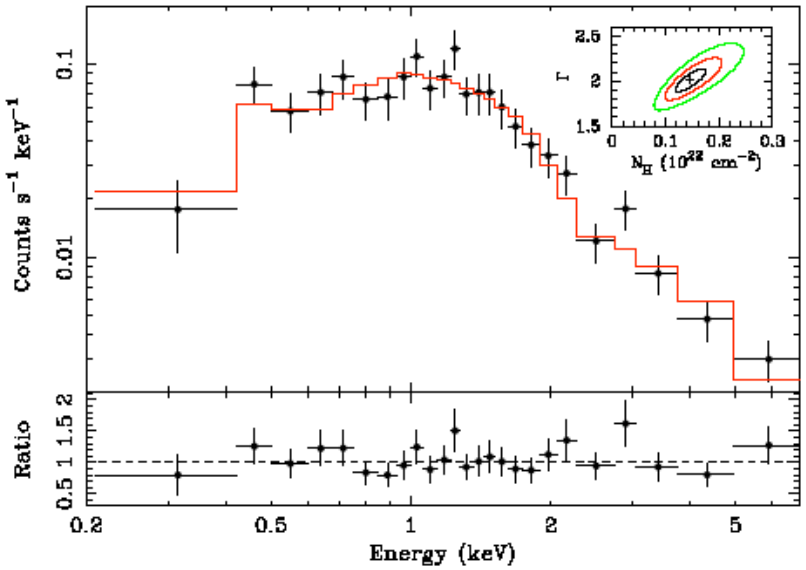
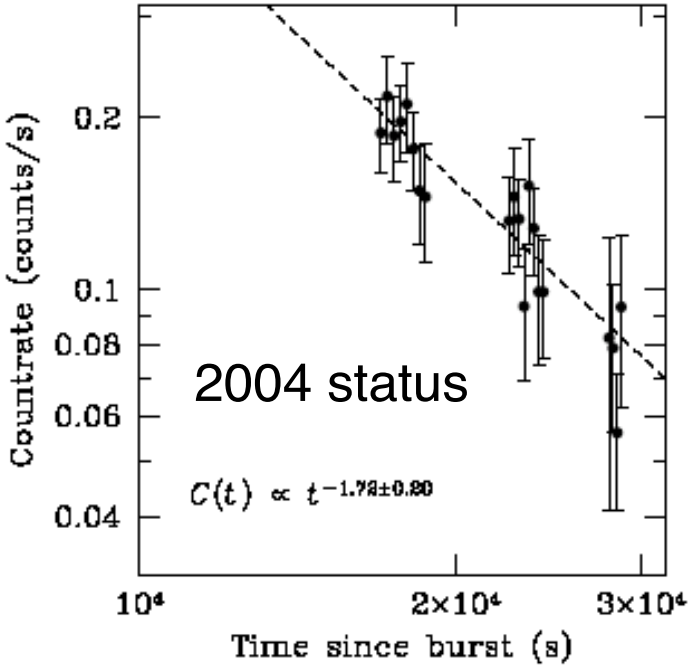


Fig. 2.— J-band image of the GRB 041223 afterglow. The error circles from the initial and final XRT positions are indicated. The final X-ray position is 1.1 arcseconds from the NIR afterglow. The three circled stars were used for flux calibration of the J-band data.



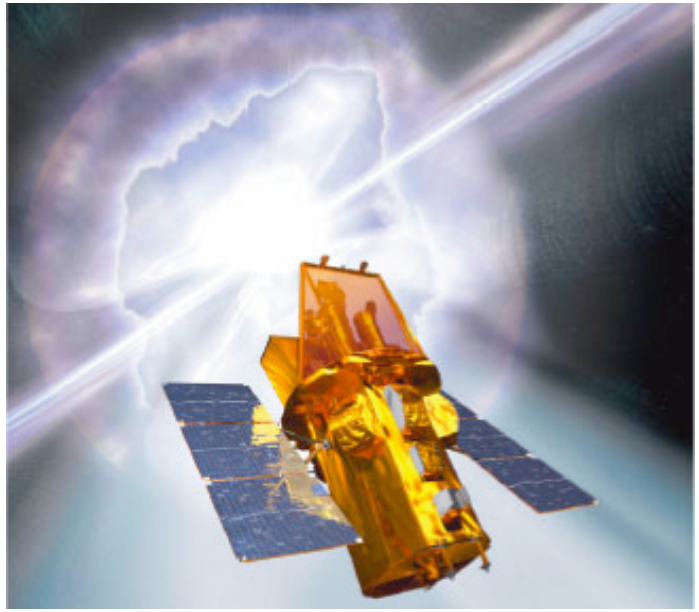
X-ray Spectra

David Borrows et al. ApJL in press



In 2005 Jan, early afterglow just 100s after the first symptom of GRB is obtained, in some case even prompt emission

Swift is currently in Calibration phase
The telescopes are NOT FULLY operational (except BAT)



BAT:
Currently 20 GRBs with BAT locations
1 short burst, 19 long burst

XRT:
9 slews, 6 detections

UVOT:
6 slews, 1 merginal detection

NOT FULLY OPERATIONAL!!

HANDLE THIS STATISTICS WITH CARE

Swift Will be Fully Ready and Open by 5th April

K. Nakazawa Kashiwa 8 Mar. 2005

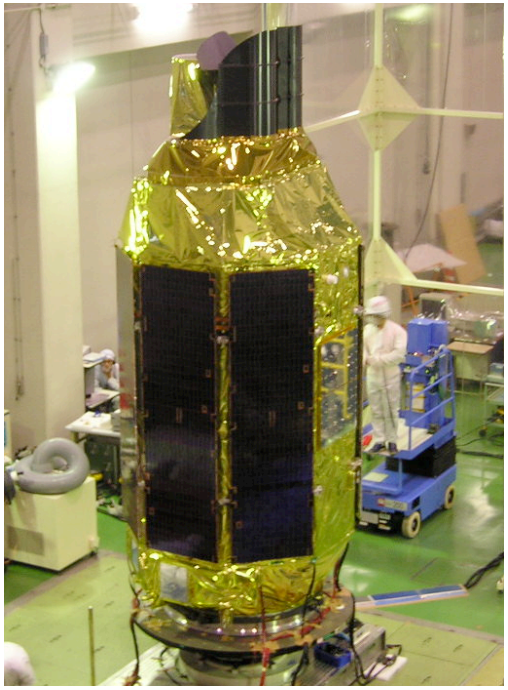
2: The Astro-E2 Mission

together with Tae Furusho and Astro-E2 team

The Astro-E2 Mission

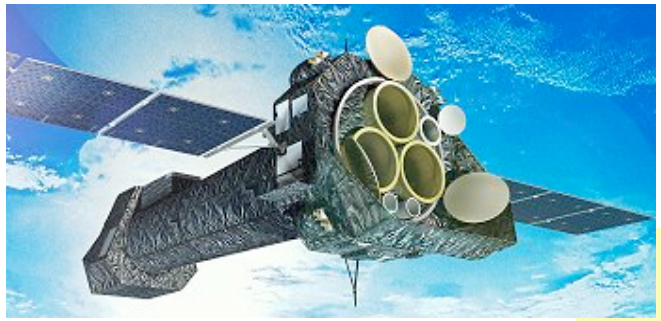
Astro-E2 is a powerful X-ray observatory developed by Japan (ISAS/JAXA) together with US (NASA/GSFC).

- High X-ray spectral resolution at 0.5-10 keV, where bulk of the lines from abundant elements exist (O - Ni)
- Non-dispersive spectrometers enable imaging spectroscopy of extended sources
- Large collecting area for high sensitivity
- Very large bandwidth to enable disentangling complex, multi-component spectra



Introducing New Physics in high energy astrophysics

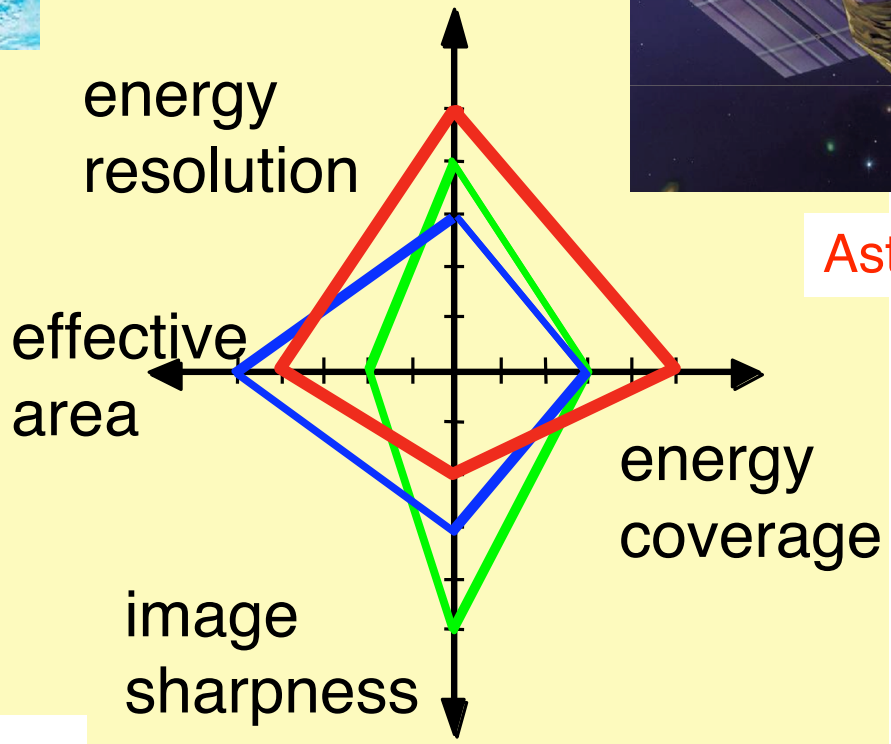
The Astro-E2 Mission



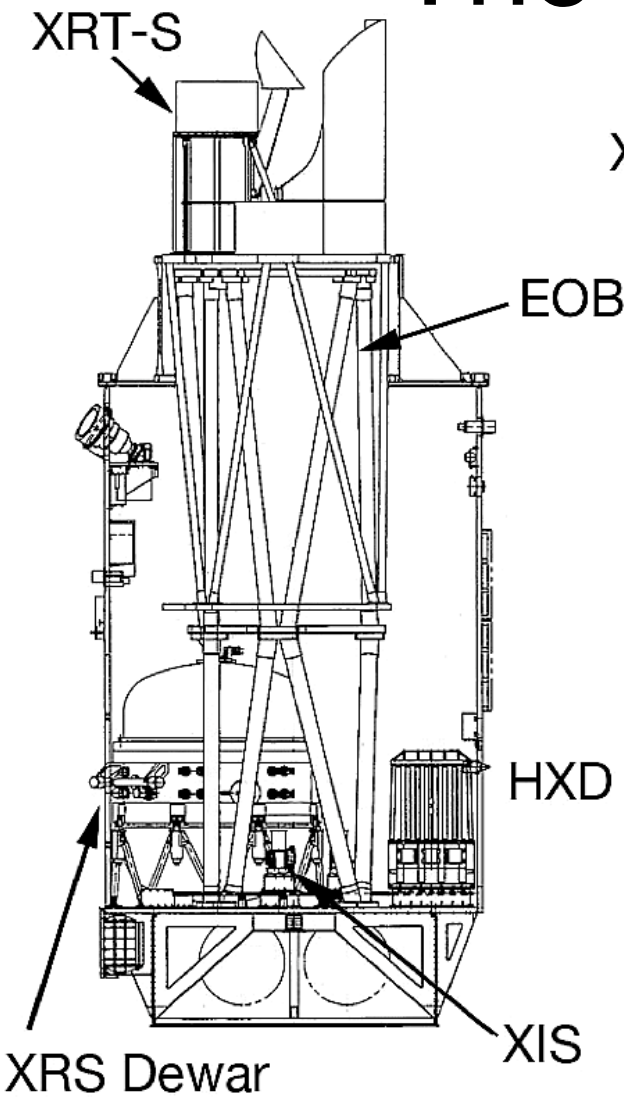
Newton 1999 -

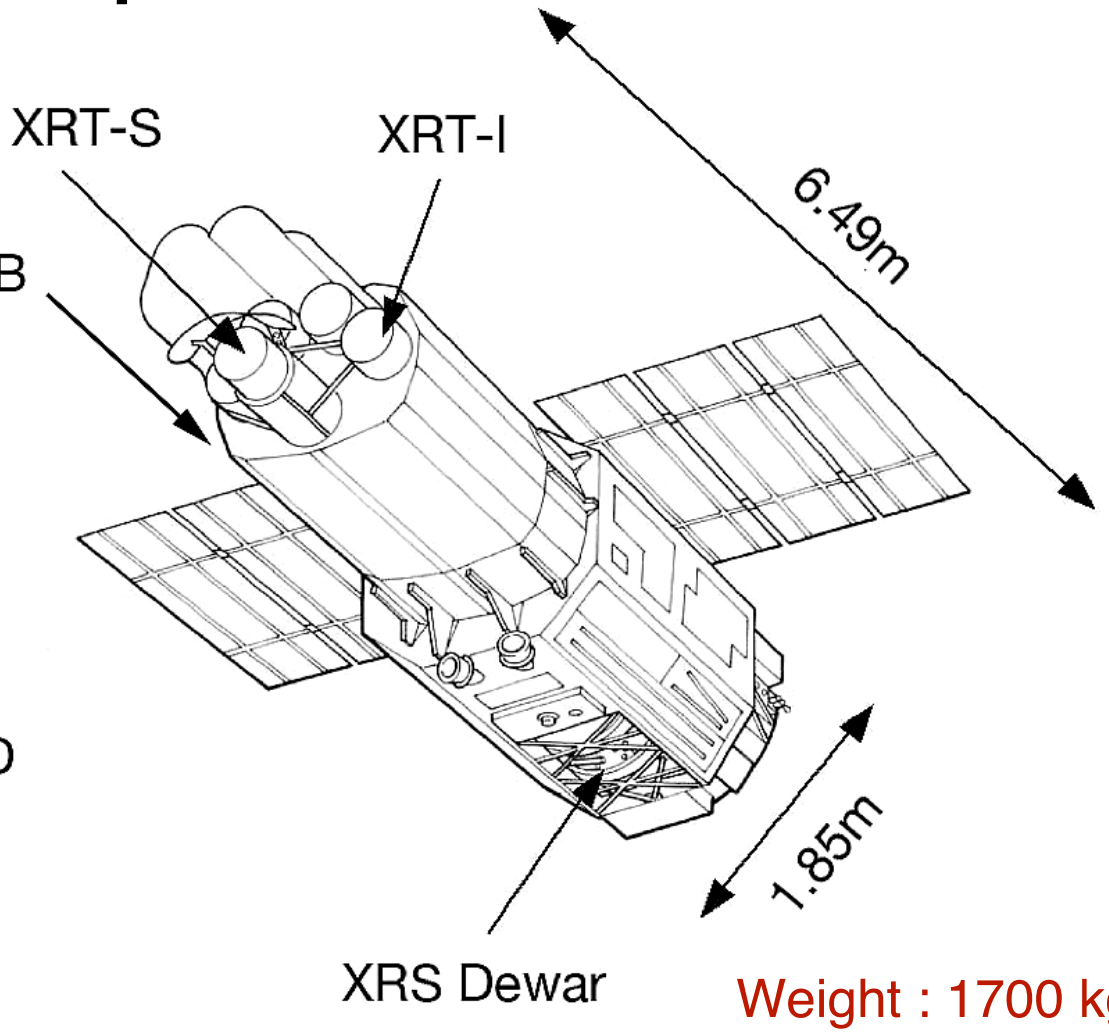
Astro-E2 2005-

Chandra 1999-



The Spacecraft





Weight : 1700 kg
Orbit altitude : 550 km
Orbital period : 96 min

Astro-E2 Instruments

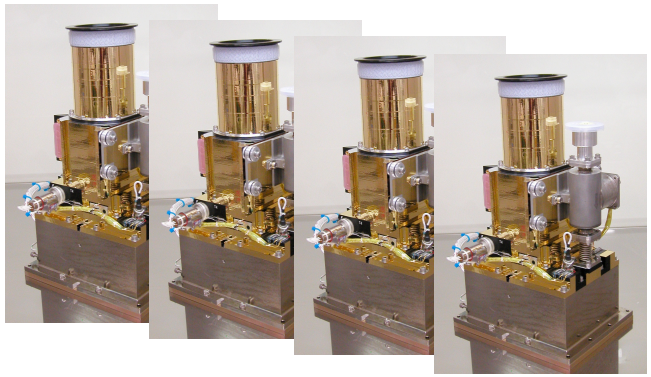
XRS

X-Ray Spectrometer

X-ray calorimeter

Band: 0.3 - 12 keV

FOV: 2.9' x 2.9'



XIS (x4)

X-ray Imaging Spectrometers

X-ray CCD cameras

0.2 - 12 keV

18' x 18'

HXD

Hard X-ray Detector

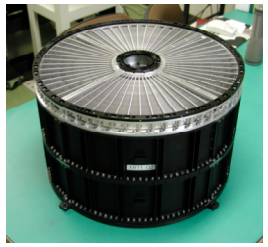
Si PIN + GSO Scintillator

10-40/30-600 keV

34'x34'/4.5°x4.5°

with XRT (x5)

X-Ray Telescopes



Angular resolution ~2 arcmin

Large Area, Light Weight

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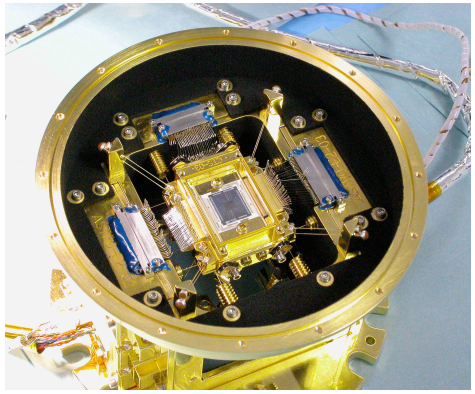
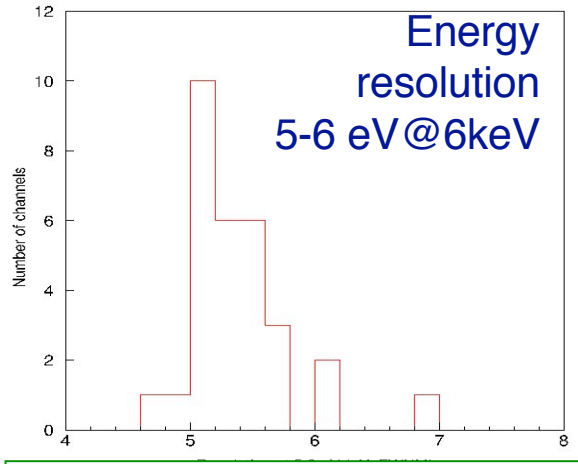
The XRS



6x6 array with 30 ch

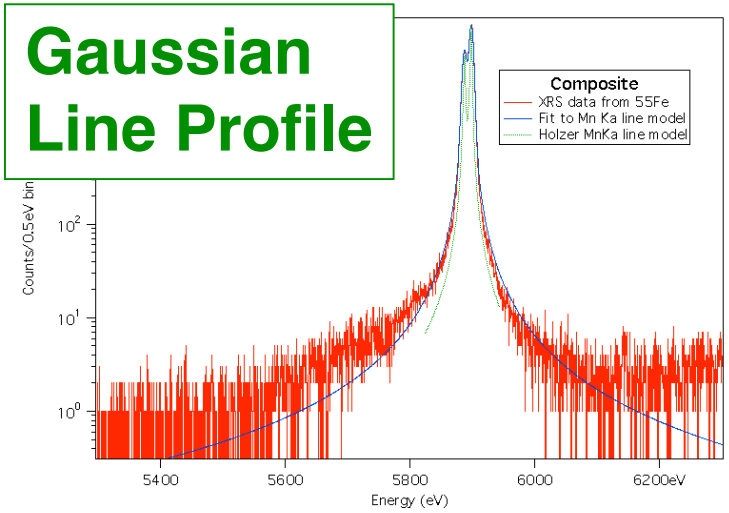
Operate at 60 mK

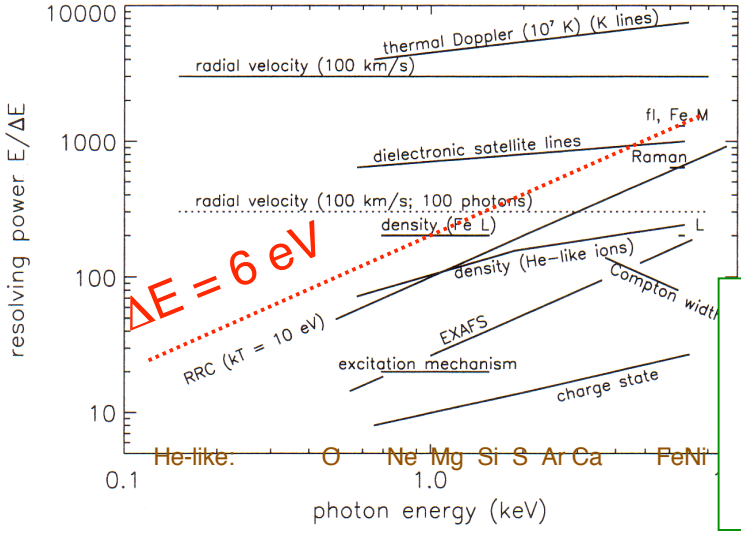
Expected lifetime is 2-3 years



ΔE improved from 12 eV to 6 eV!

Gaussian Line Profile



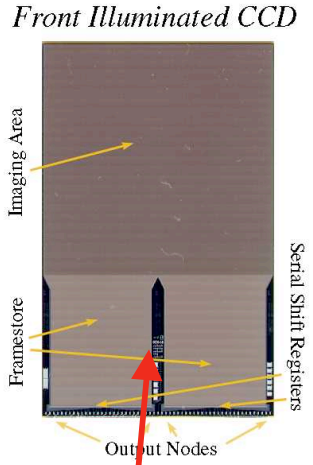


Highest Resolving Power

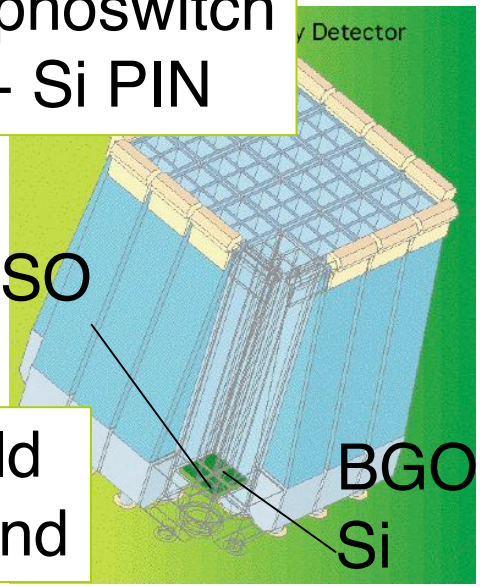
The XIS and HXD

XIS: X-ray CCD
imaging spectroscopy

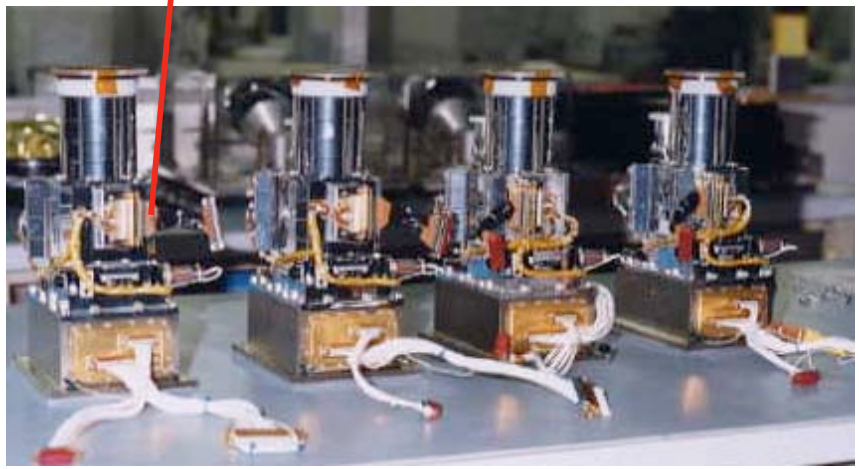
HXD: Well-type phoswitch
detector + Si PIN

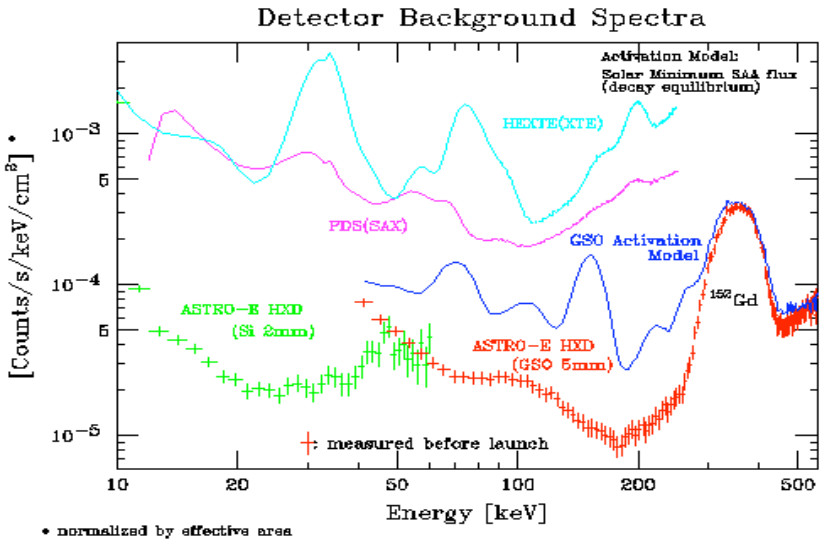


Expecting lowest
diffuse BGD among
X-ray CCDs on orbit



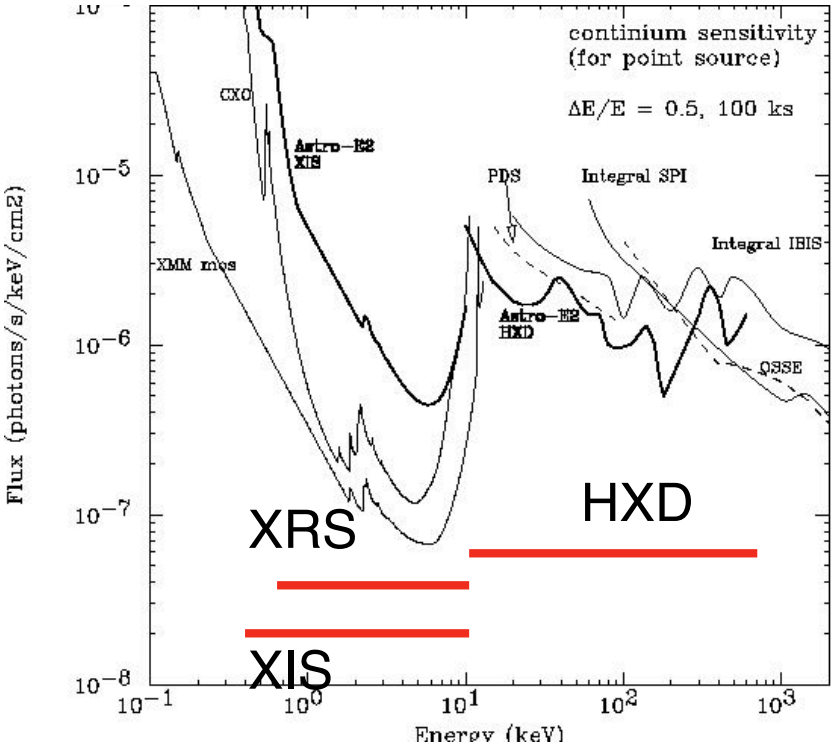
Deep active shield
→ Low background



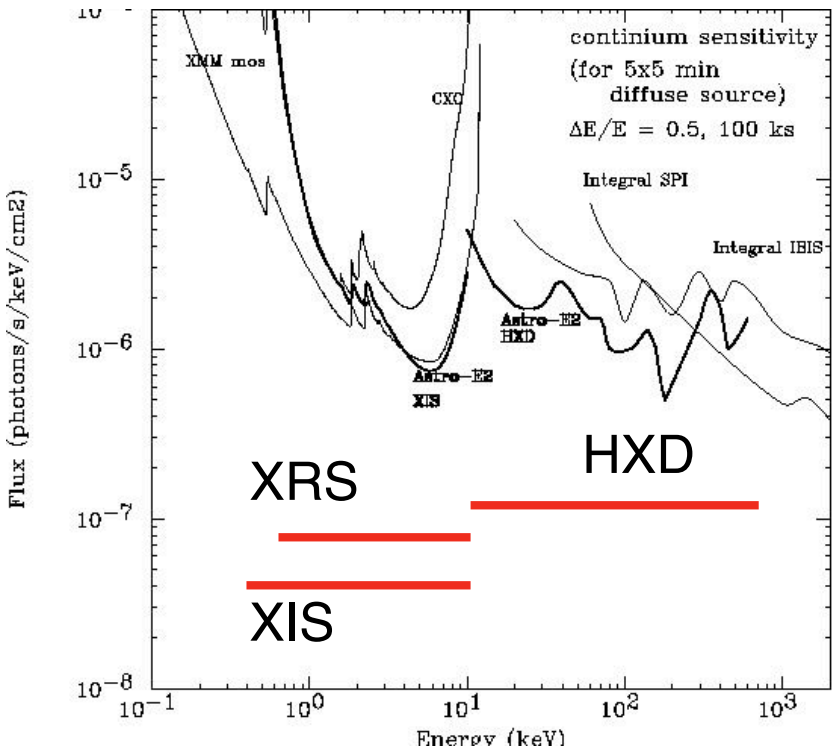


The Astro-E2 band pass and Sensitivity

Point source



5x5 arcmin diffuse source



Wide-band, good hard X-ray sensitivity,
and superior energy resolution with good area

Astro-E2 Science

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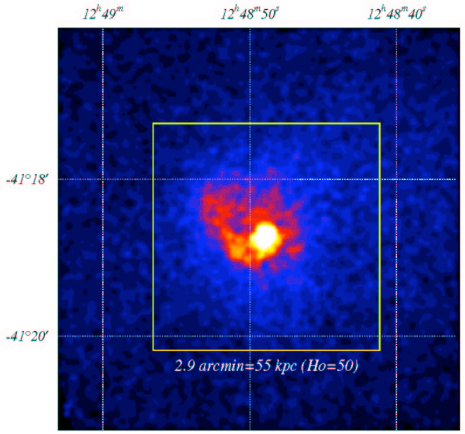
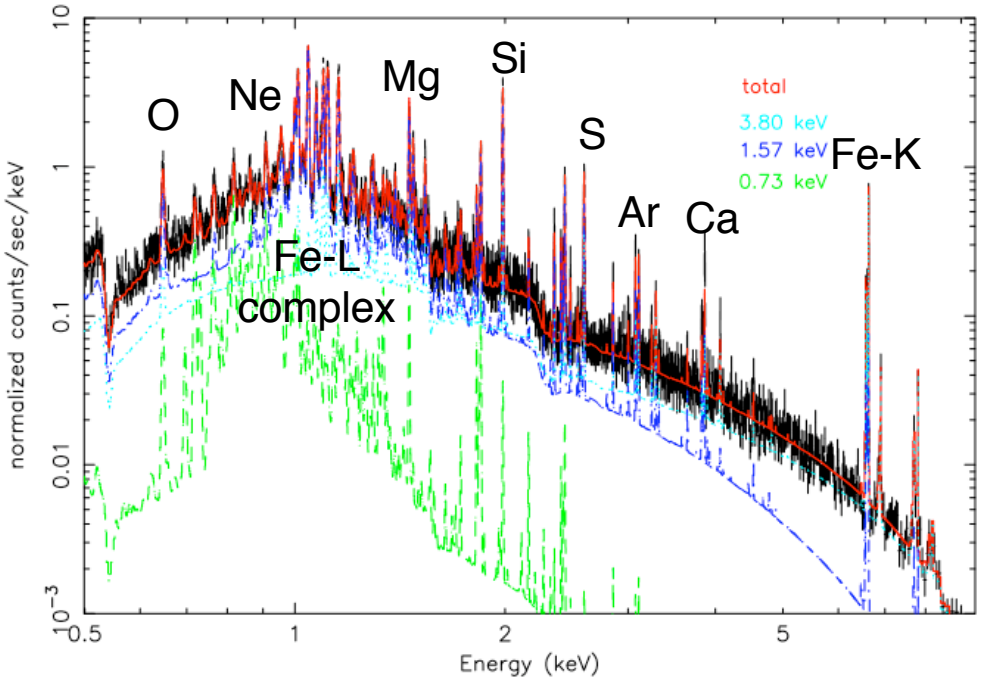
Abundance/Coolest gas in Galaxy Cluster (Centaurus)

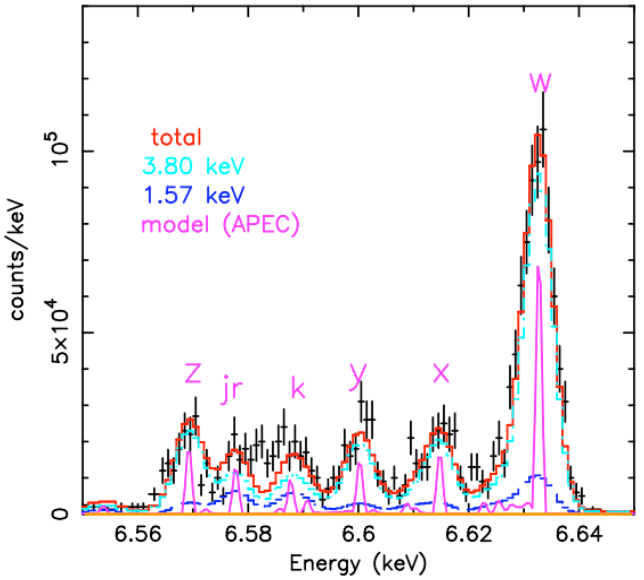


z=0.011, kT=1-3 keV, Z=1-2 solar

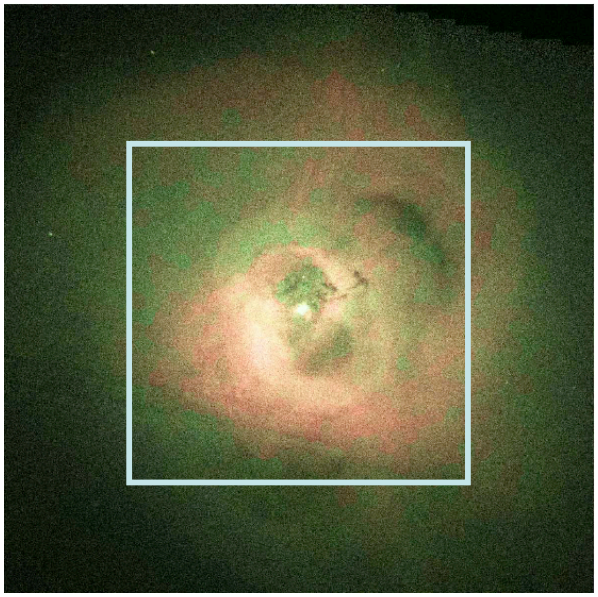
Strong emission lines→ line intensity
Bright and complex core
2 or 3 temperature components?



Takahashi et al. In prep



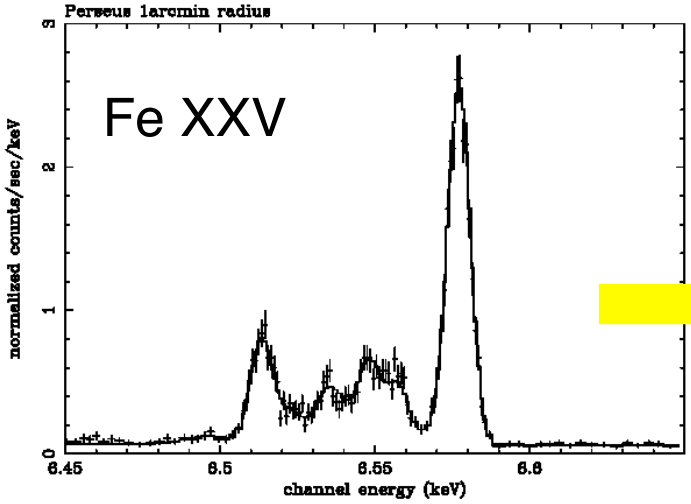
Dynamics - Cluster Core (Perseus)

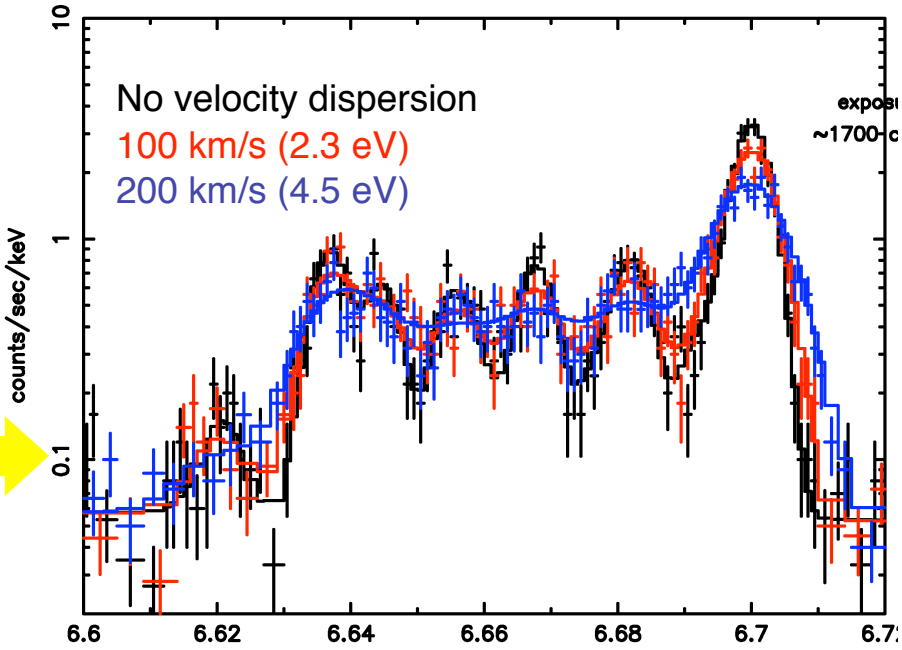


Fabian et al. 2003

z=0.018, kT=4-6 keV, Z=0.5 solar

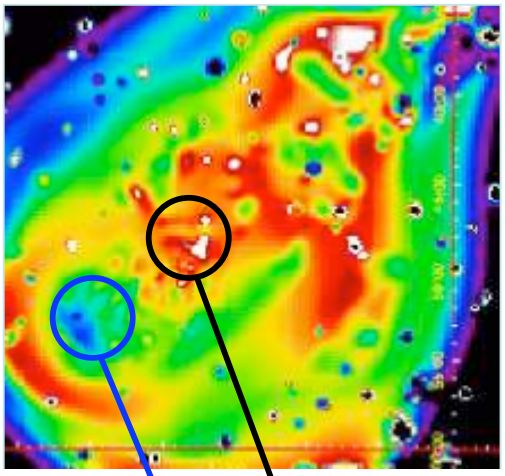
Brightest Fe-K line
Active gas motion → line broadening
Resonance scattering

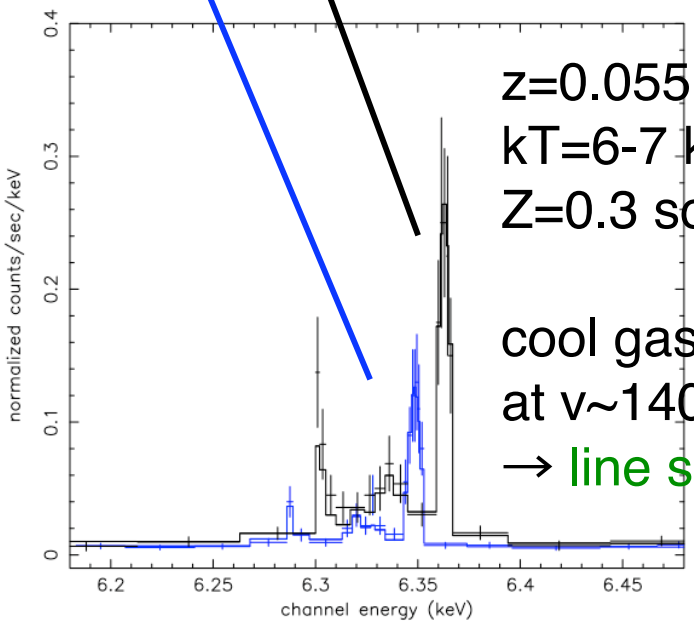




Cluster Merger -- turbulence and possible excess hard

A3667 X-ray

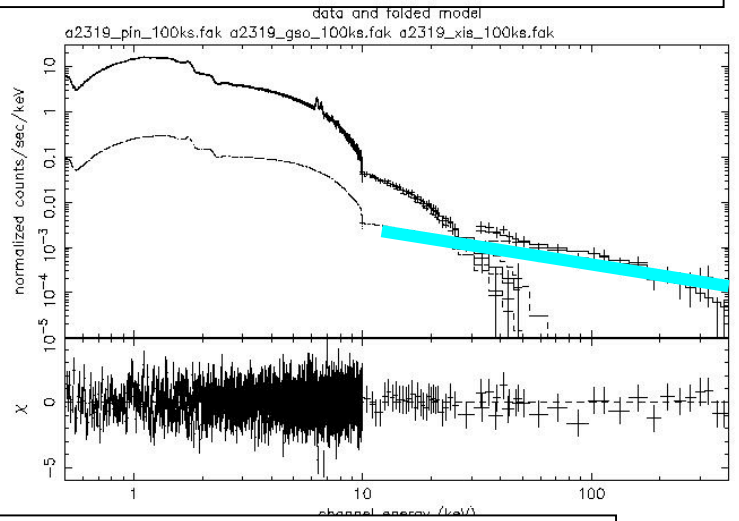




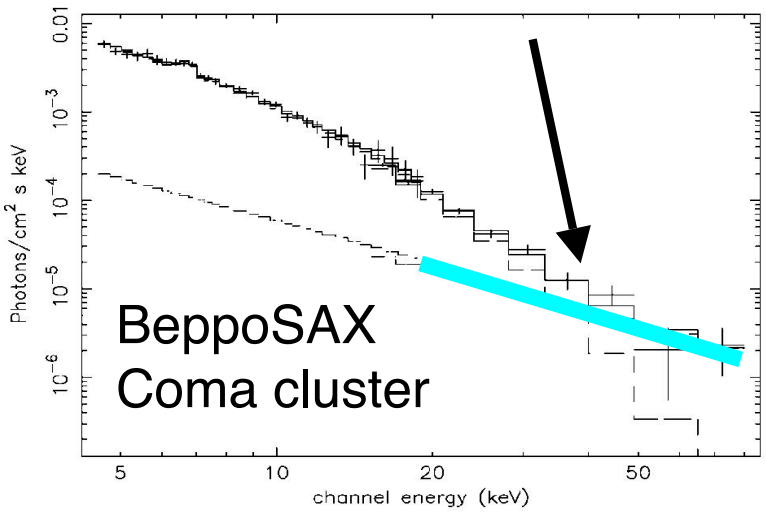
z=0.055,
kT=6-7 keV,
Z=0.3 solar

cool gas cloud moving
at v~1400 km/s
→ line shift

Abell 2319 Astro-E2 Simulation



Coma cluster: hard excess

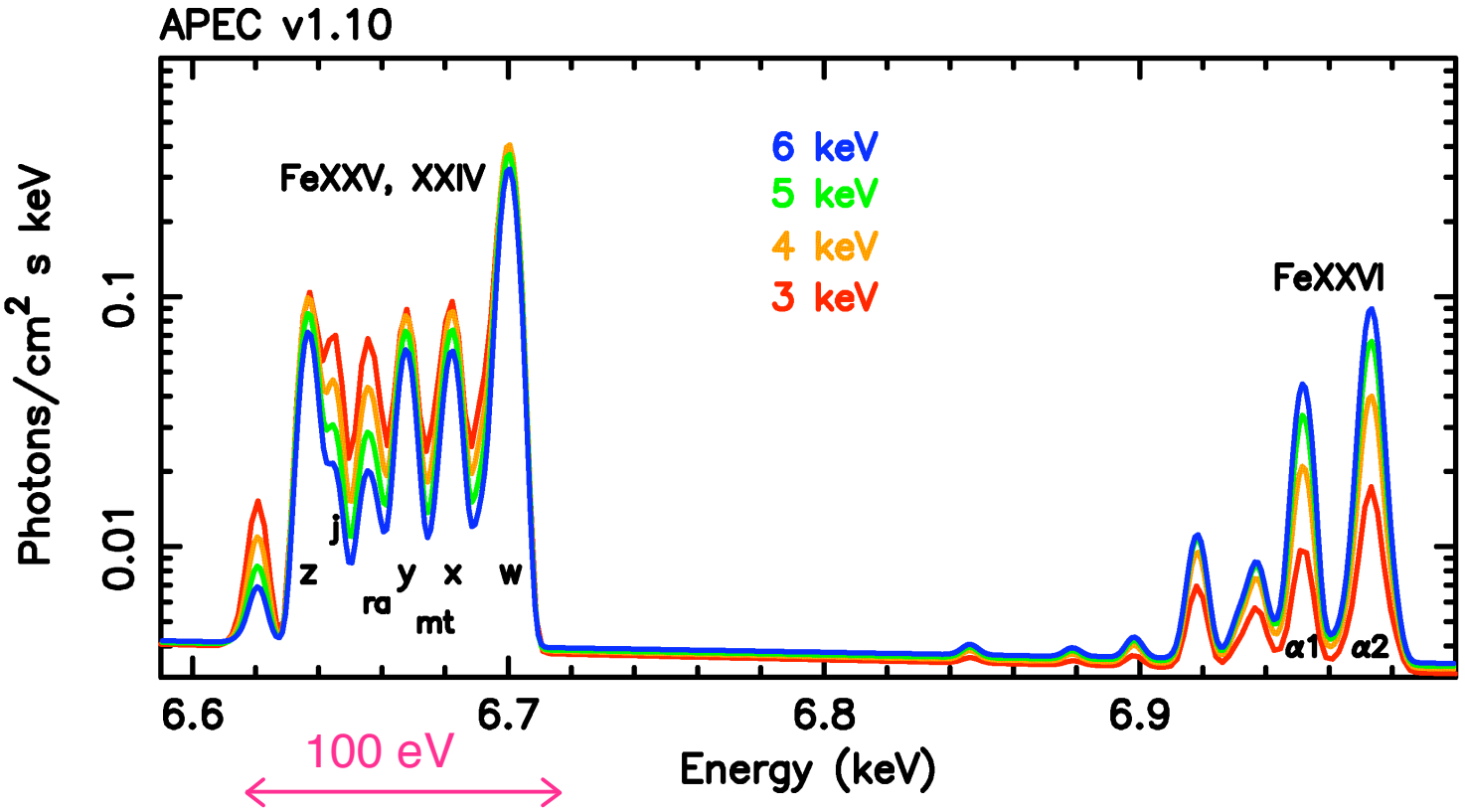


Plasma Diagnostics

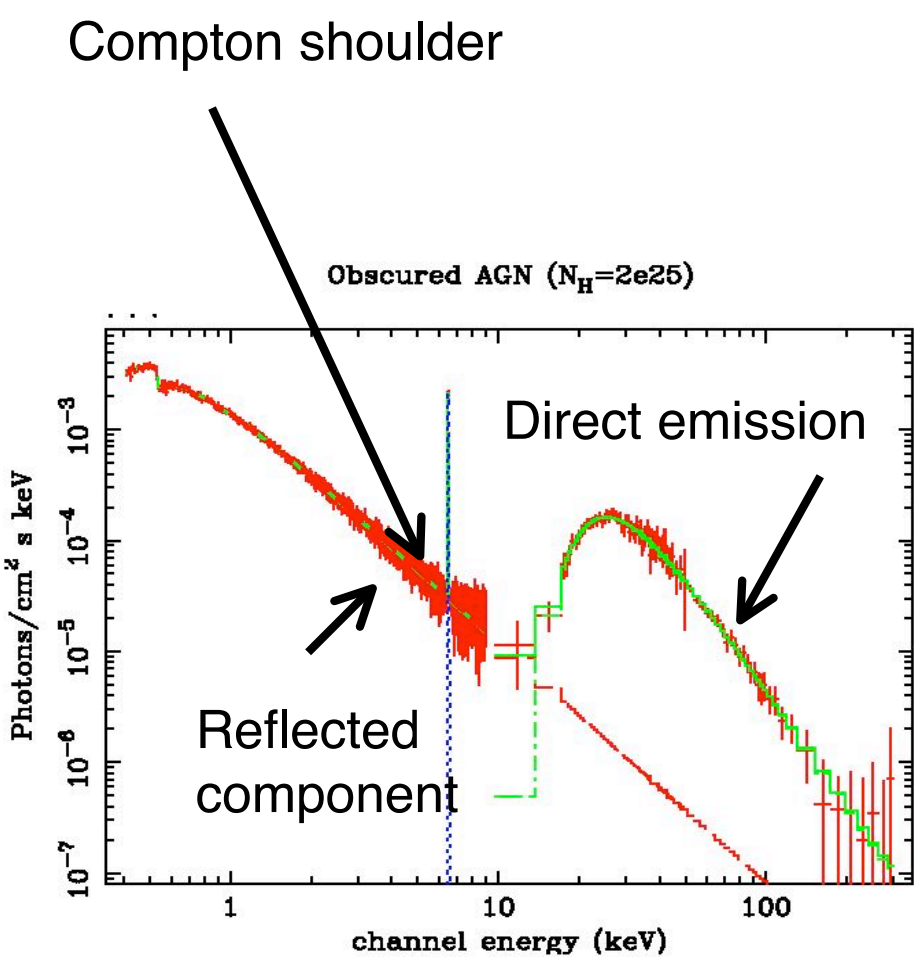
Line ratios give us physical parameters directly!

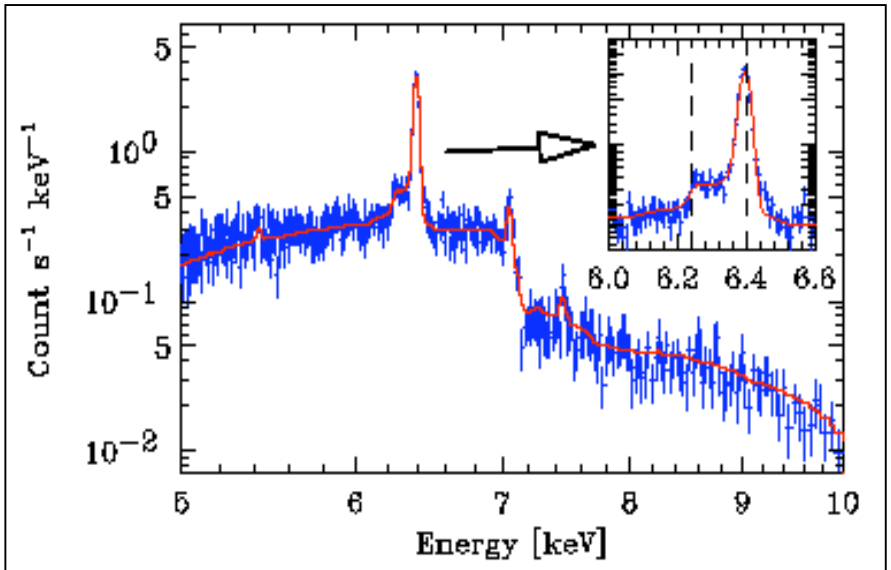
j/w : electron temperature

z/w: ionization level



AGN and Compact Sources





Compton Shoulder with Chandra HETG on GX301 Watanabe et al. ApJL 2004

Astro-E2 hosts an order of magnitude improved ΔE with larger effective area around ~6 keV

The Astro-E2 is in store, ready for launch to be scheduled around this summer

Astro-E2 is a powerful X-ray spectrometer

-high resolving power of 1000
-wide band pass of 0.2-600 keV
-less BGD compared to other X-ray missions for spectroscopy

Astro-E2 PV phase continues for 6 month, and then AO starts. AO-2 will be announced after the PV phase so that everyone can have a look in to the Astro-E2 unprecedented data

Summary

Swift Mission

Gamma-ray burst explorer

"Catching GRB on the fly"

Astro-E2 Mission

X-ray Observatory

Wide-band and finest spectrometer for X-ray astronomy

Active Years for X/Gamma-ray Astronomy is coming!!
Please join us, both are open to public