

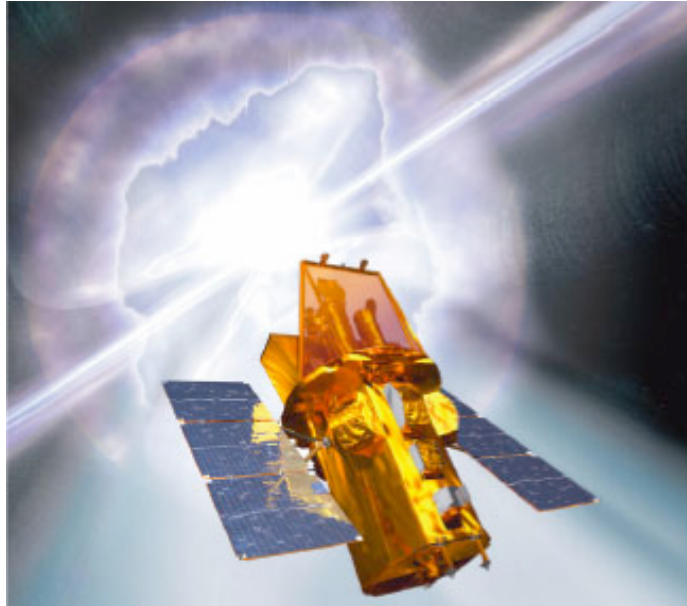
# Swift and Astro-E2

New X/ $\gamma$ -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



# 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

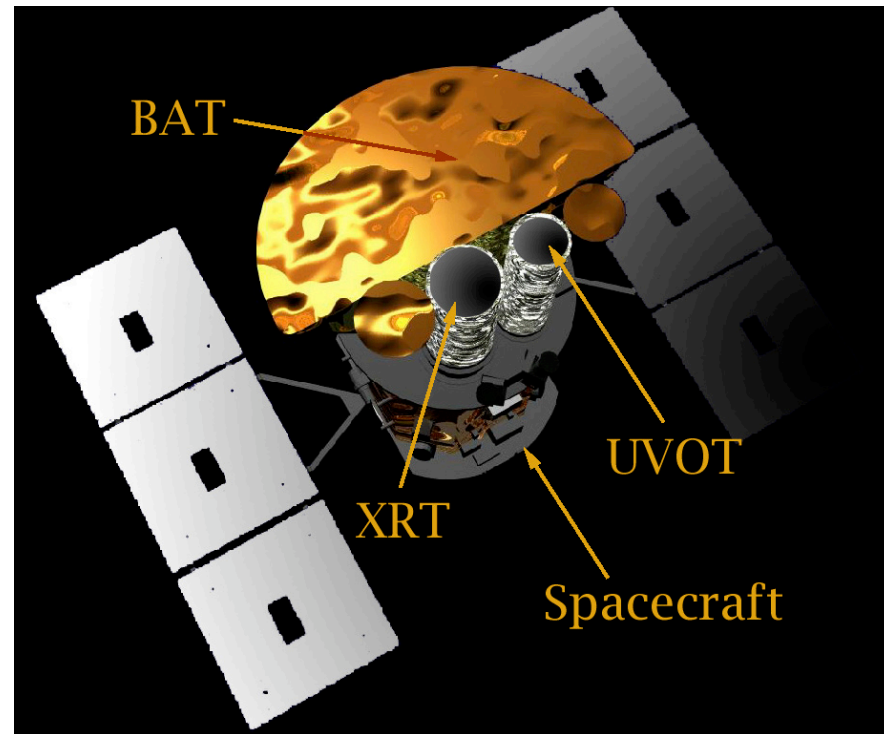
Wide FOV (2 str),  
15-150 keV band imager  
locates BST with 1' accuracy

## X-ray Telescope

Narrow FOV, X-ray imager  
locates BST/afterglow  
with  $\sim 2''$  accuracy

## UV and Optical Telescope

Narrow FOV, UV and Op imager  
locates afterglow with  $\sim 2''$  PSF



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

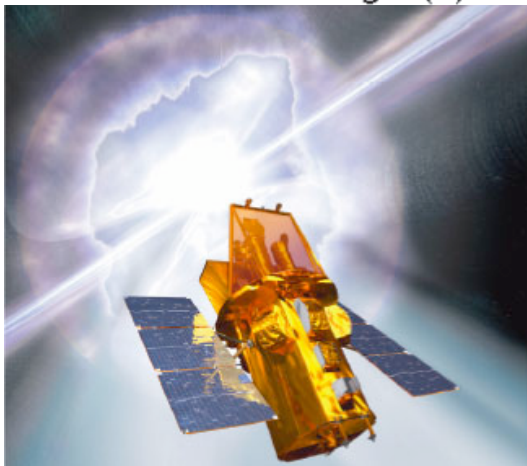
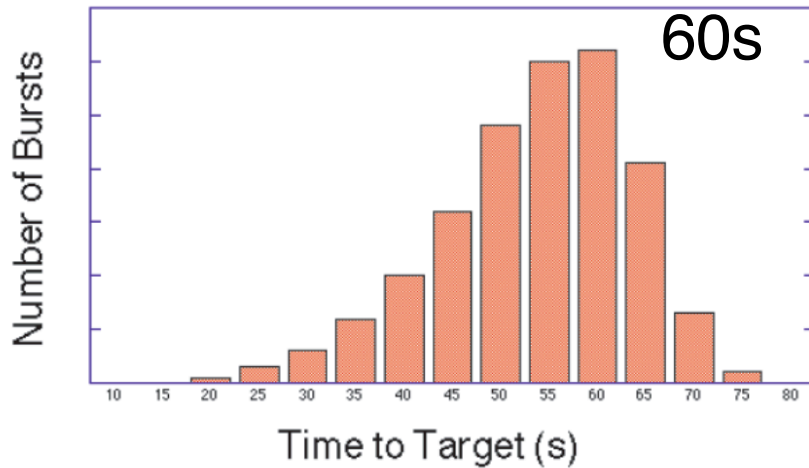
# Key Points of Swift

- 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

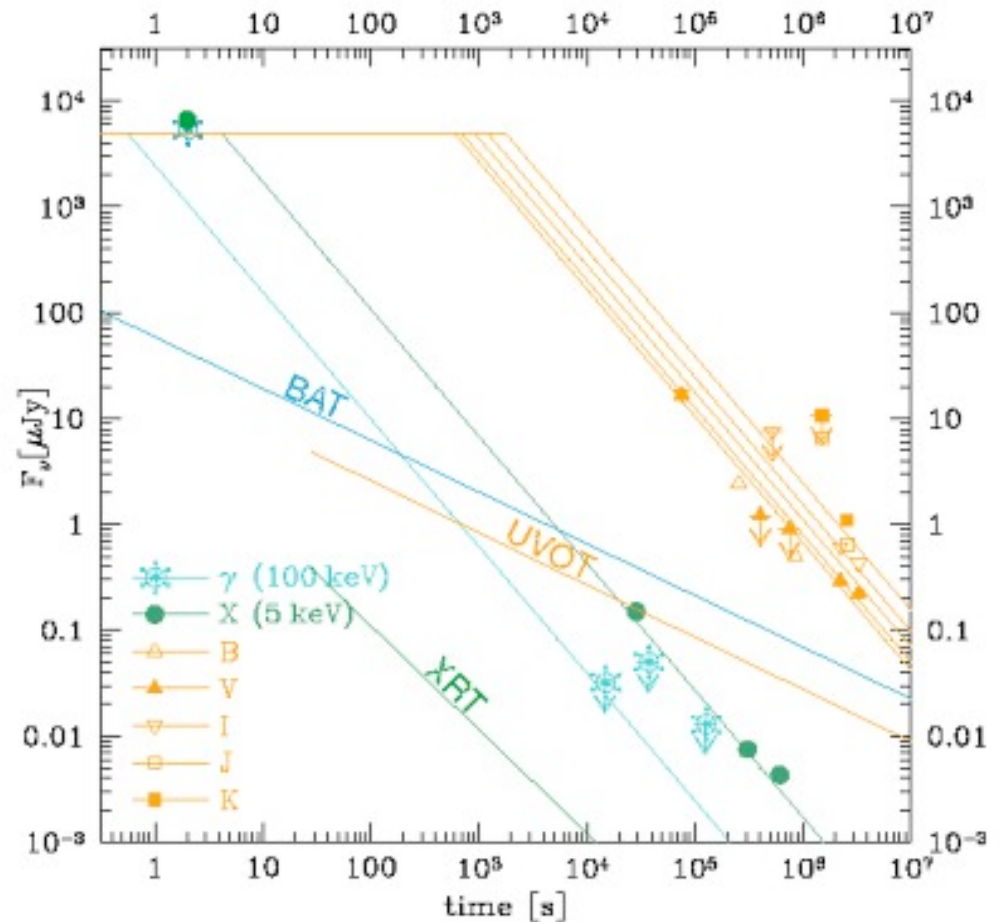
How to track GRB, prompt emission and afterglows

## Time for Slew



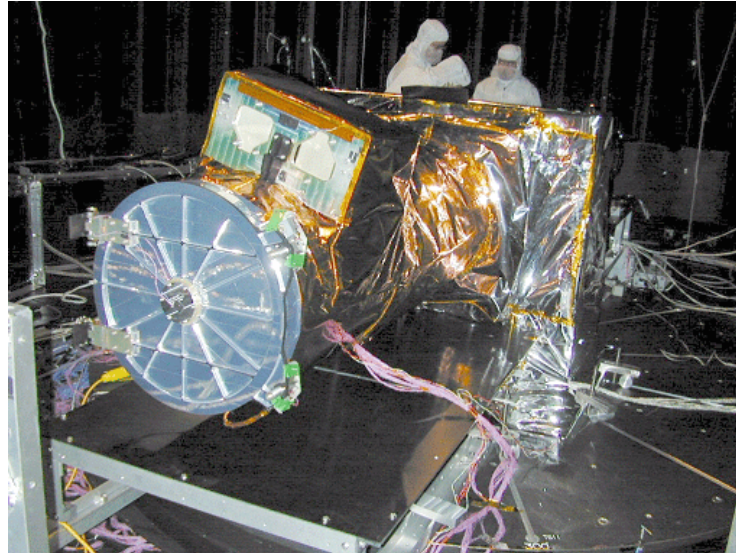
## Afterglow sensitivity

mCrab



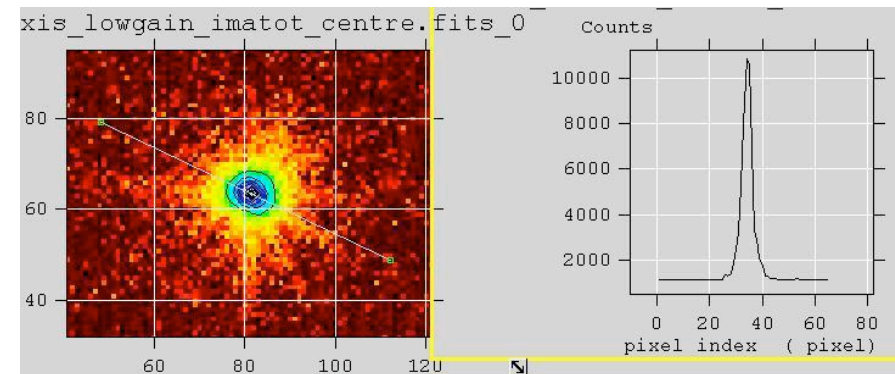
# XRT

## 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**

## Cas-A first light image



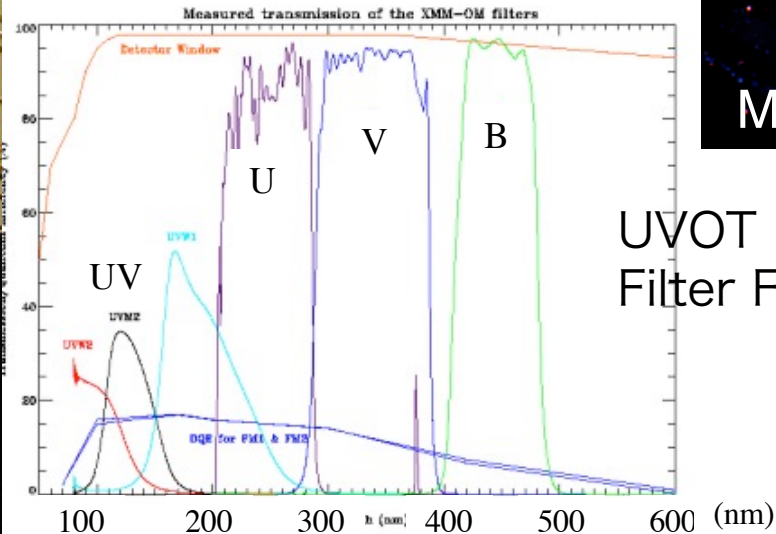


# UVOT



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

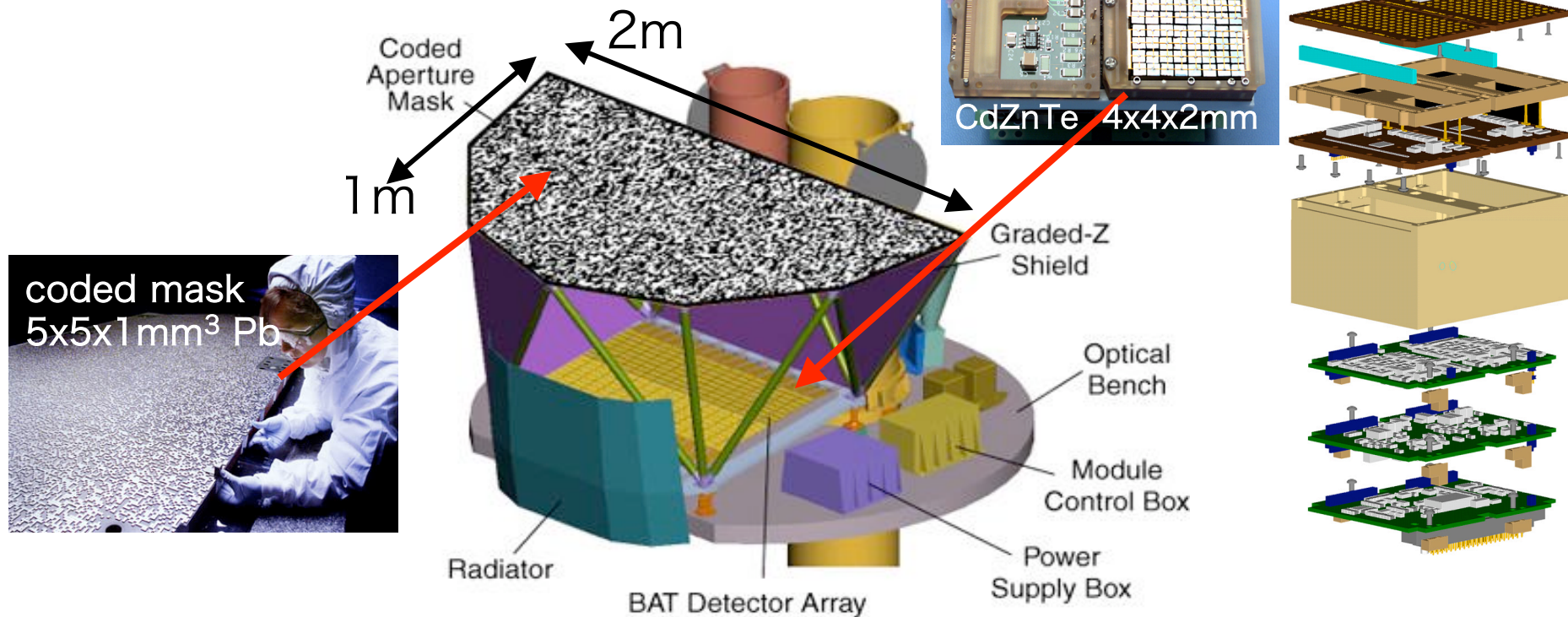
XMM Optical Monitor Backup



Given an  $m_B = 24$  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 cm<sup>2</sup> in total )

➤ 100degx60deg (~2str)

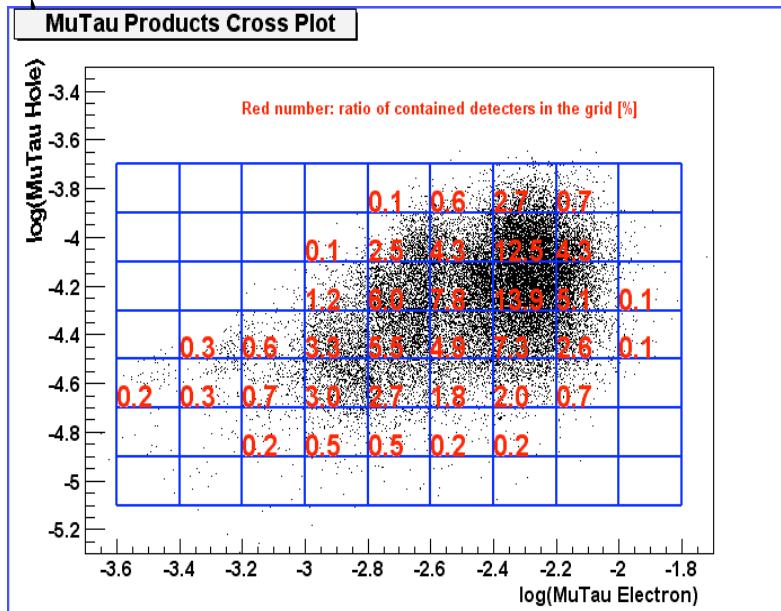
➤ XA-1 chip read out

➤ Ramdum mask with 54,000 Pb plates

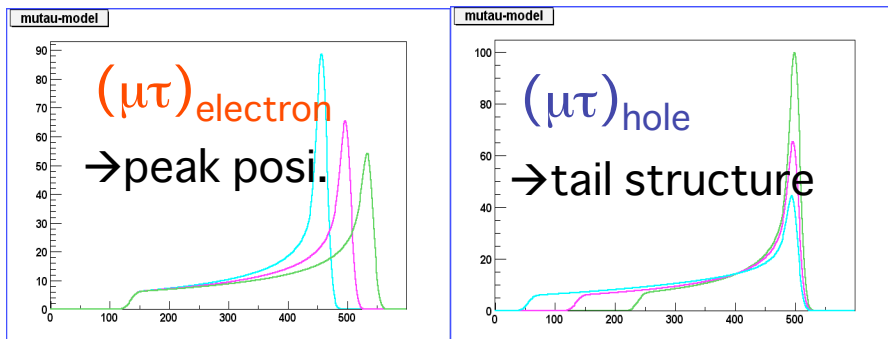
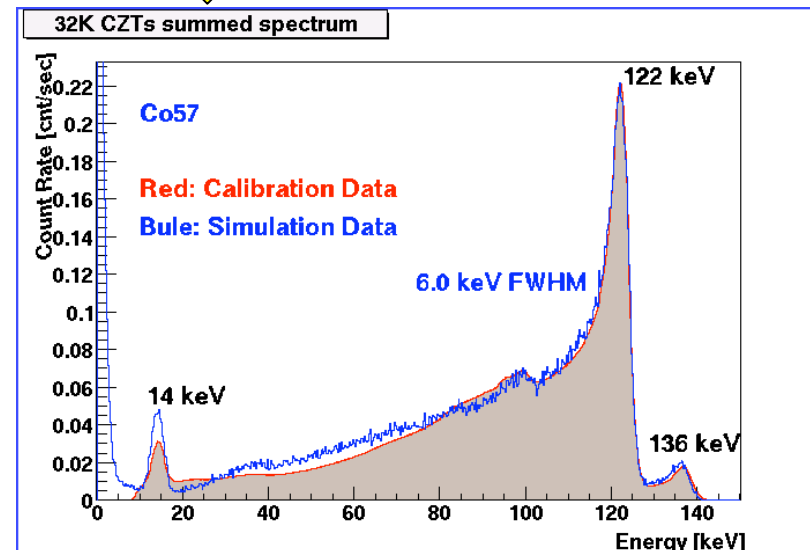
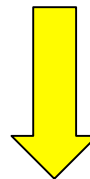
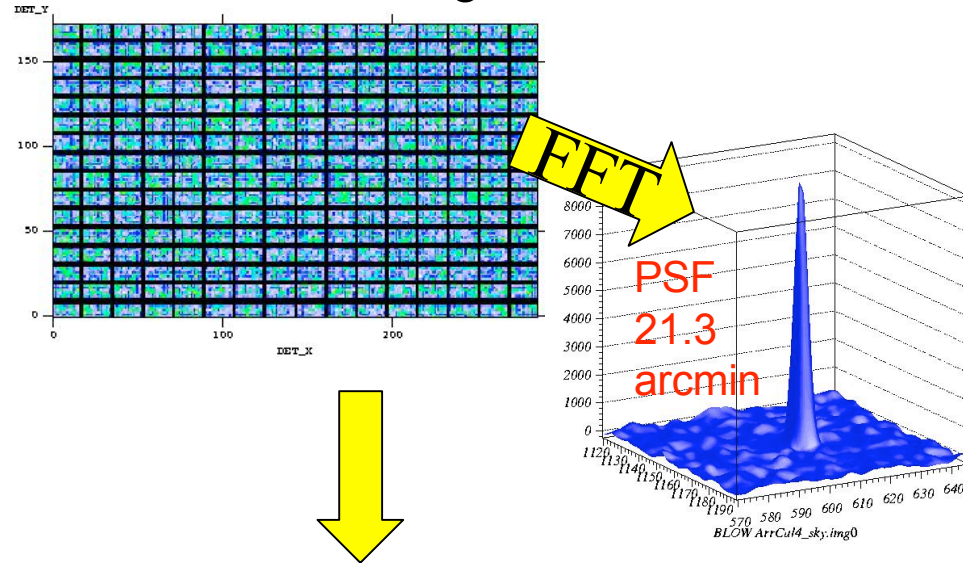
⇒ Japan Swift hardware team is contributing to evaluation and calibration of BAT CZT responses.

# BAT Response generator

32k parameters of  $\mu\tau$  hole and electron



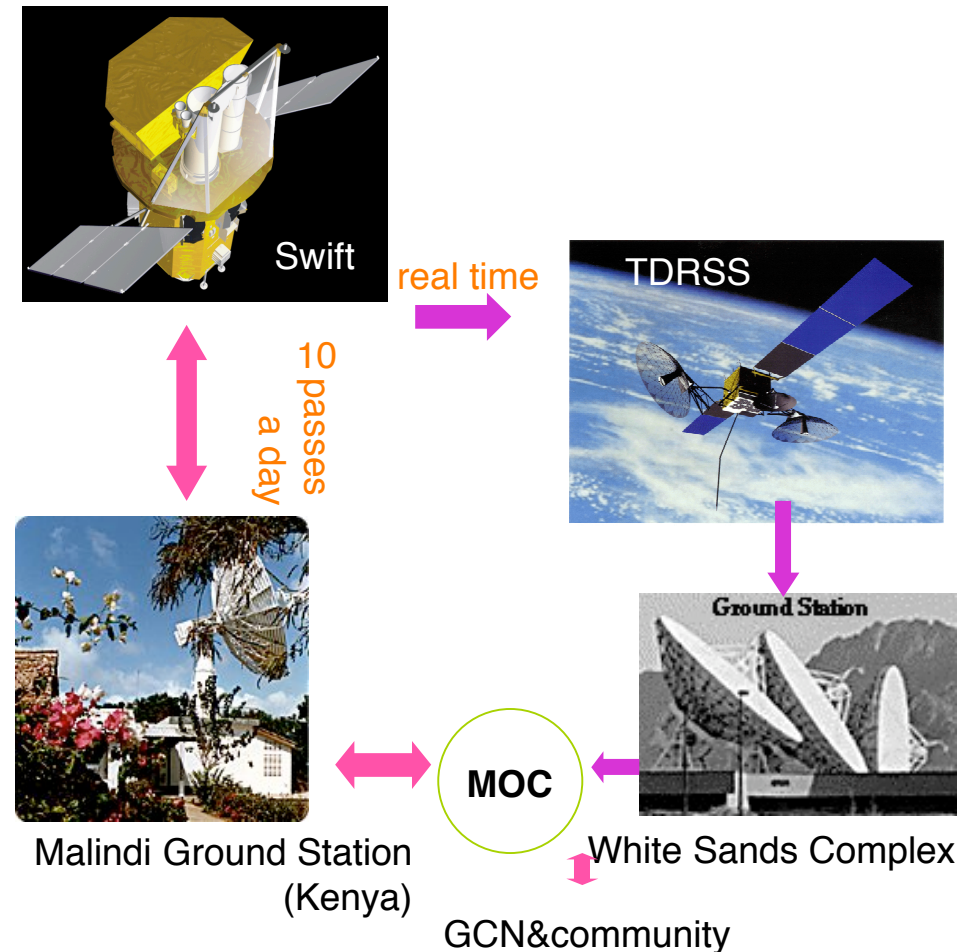
BAT ground Cal data



# 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

HEASARC HOME | SWIFT HOME | ARCHIVE | DATA ANALYSIS | PROPOSALS & TOOLS | EDUCATION & PUBLIC INFO

Swift: Catching Gamma-Ray Bursts on the Fly

ABOUT SWIFT | QUICKLOOK DATA | GCN | SWIFT RESULTS | SCHEDULES & ST

HEASARC HOME | SWIFT HOME | ARCHIVE

**Swift Quick-Look Data**

Fri Sep 3 17:19:23 2004 GMT

Swift: Catching Gamma-Ray Bursts on the Fly

ABOUT SWIFT | QUICKLOOK DATA

Capability to select :

- File
- Directory
- Everything

Download a tar file

**Instructions:**

- Click on a sequence number to access data for that sequence.
- Click on a column header to sort the table by that column.
- Rows with a gray background have been replaced by a more recent reprocessing.
- After one week the data are archived at HEASARC, ISAC, and UKDC and removed from this list.
- The columns are described at the bottom of the table.

Safe Hold - Sequence: 00000000403 Version: 003

[This page contains encrypted data](#)

You have registered the correct password/encryption key

You have the following download options:

- Automatically unpack the data using a Java applet
- Download a tar file.

Select files below, then click this button to download the data:

All Files

aux

- [sw00000000403\\_003\\_job.par](#) ASCII 2 kB (level 1) Job parameter file
- [sw00000000403\\_003\\_process.par](#) ASCII 3 kB (level 1) Processing parameter file
- [sw00000000403\\_input.cat](#) FITS 2 kB FRF input catalog
- [sw00000000403\\_tape.cat](#) FITS 2 kB (level 1) FITS format tape contents
- [sw00000000403pcs.txt](#) ASCII 1 kB (level 1) Site independant checksum file
- [sw00000000403sti.fits](#) FITS 2 kB (level 1) UTC corrections file

log

- [sw00000000403bir.html](#) HTML 1 kB (level 1) HTML exposure report
- [sw00000000403per.html](#) HTML 1 kB (level 1) HTML processing error index
- [sw00000000403pfl.html](#) HTML 1 kB (level 1) HTML file list
- [sw00000000403pin.html](#) HTML 1 kB (level 1) HTML Processing index

Sequence	Version	Object	Observed	Processed	Comments
<a href="#">00000000403</a>	003	Safe Hold	2004-08-28T03:52:58	2004-08-29	new data: moc2004
<a href="#">00000001304</a>	010	Safe Pointing 1	2005-12-19T15:59:05	2004-08-15	new data: moc2004
<a href="#">00000001322</a>	001	Safe Pointing 1	2004-08-26T01:01:08	2004-08-26	new data: moc2004
<a href="#">00000002273</a>	061	Safe Pointing 2	2005-12-19T16:33:27	2004-08-15	new data: moc2004
<a href="#">00000002295</a>	001	Safe Pointing 2	2004-08-25T23:52:27	2004-08-26	new data: moc2004
<a href="#">00000003306</a>	001	Safe Pointing 3	2004-08-26T00:29:58	2004-08-26	new data: moc2004
<a href="#">00000004323</a>	005	Safe Pointing 4	2004-08-25T01:14:36	2004-08-26	new data: moc2004

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

# Swift archive interface

HEASARC HOME SWIFT HOME ARCHIVE DATA ANALYSIS PROPOSALS & TOOLS EDUCATION & PUBLIC INFO

Swift: Catching Gamma-Ray Bursts on the Fly

U.S. site Italian site U.K. site

ABOUT SWIFT QUICKLOOK DATA GCN SWIFT RESULTS SCHEDULES & STATUS RELATED SITES

Browse Home Browse: Swift Mission

GRB Name Coordinate Resolver: All Bursts 1992 Quick Search

GRB Name Coordinate Resolver: All Bursts Select Year Select a Month Quick Search

GRB Name Coordinate Resolver: All Bursts Select Year Select a Month Quick Search

Reset Start Search Query the SWIFT tables using parameters set below

Target id: (e.g. 100001)

Observation Dates: YYYY-MM-DD hh:mm:ss or MJD: DDDDD.ddd

The time portion of the date is optional. Separate multiple dates/ranges with semicolons (;). Range operator is '..' (e.g. 1992-12-31; 48980.5; 1995-01-15 12:00:00; 1997-03-20 .. 2000-10-18)

Object Name Or Coordinates: 160.652, 34.308 J2000

(e.g. Cyg X-1 or '12 00 00, 4 12 6') Use semi-colons (;) to separate multiple object names or coordinate pairs (e.g. Cyg X-2; 12.235, 15.345)

Search Radius: Default arcmin Default uses the optimum radius for each catalog searched.

Select one or more tables below. Click table name to go directly to Table Parameter Search Form

Observation Logs:  Master Log  BAT Log  UVOT Log  XRT Log  TDRSS Log

Source Catalogs:  Swift Gamma-ray Bursts Catalog

Start Search Query the SWIFT tables using parameters set above

NVO Search (coordinate search only)

GRB Name Coordinate Resolver: All Bursts Select Year Select a Month Quick Search

GRB Name Coordinate Resolver: All Bursts Select Year Select a Month Quick Search

Data Inventory Results: Data missing - Instructions Home

National Virtual Observatory. Hosted at the HEASARC

Note: Inventory request completed

RA	Dec	Size
10 42 36.48	+34 18 28.8	0.25

Check All

Images (FITS/GIF)

Optical  DSS1\_SV  DSS1  DSS2  DSS2B  DSS2IR

Infrared  2MASS-H  2MASS-K  2MASS-J  2MASS\_GL(24)

Radio  FIRST  NVSS  WFNSS  NED(2)

X-ray  RASS\_B

Observations (VOTable)

X-ray  ROSAT(1)  ROSPUBLIC(1)

Objects (VOTable)

Surveys  GSC1(38)  GSC2\_2(283)  USNO-A2.0\_CDS(440)

Galaxies  PGC(1)  NBS(1)  RC3(1)  UGC(1)  MCG(1)

Stars  HIP(1)  SAO(2)  AC2000\_2(14)  ASCC-2.5(12)  HD(1)

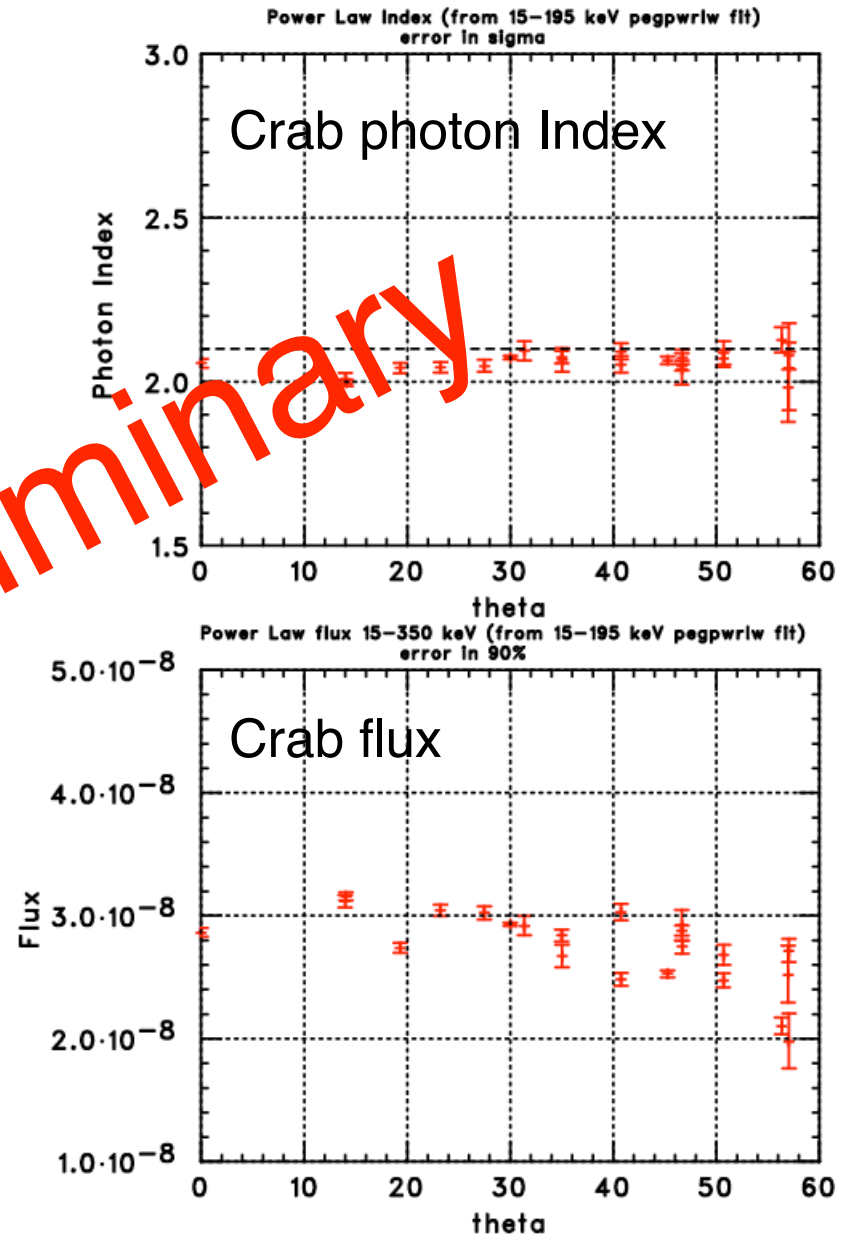
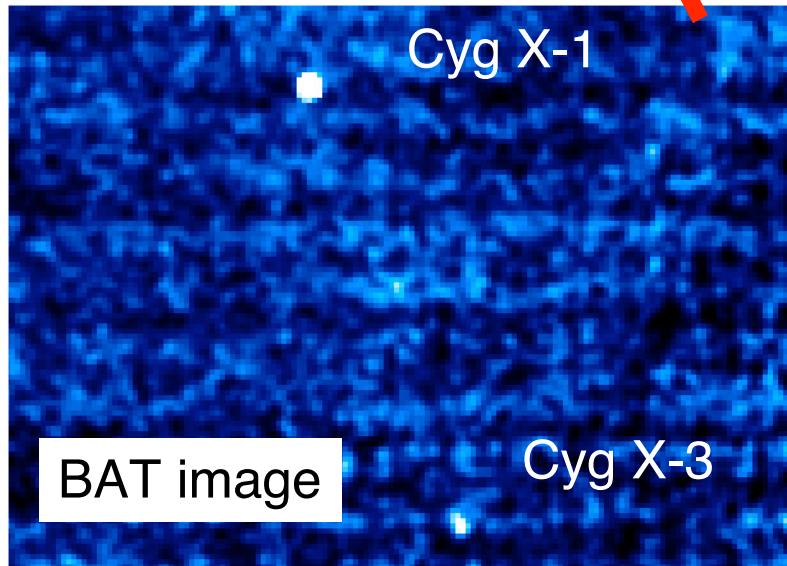
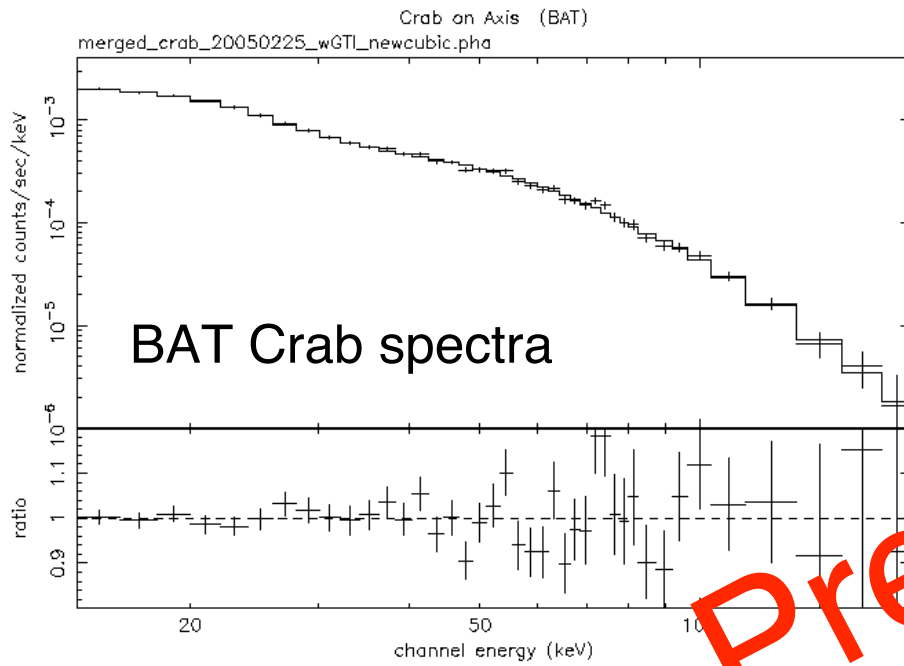
Misc.  RADIOAST(78)  Radio Catalogs(118)  CEDAG(2)  2MASS-PSC(CDS)(245)  TYCHO-2(11)

Analyze data in Aladin

Analyze data in OASIS

Download selected data

# Current BAT calibration status





# GRB 041223 X-ray afterglow

David Borrows et al. ApJL in press

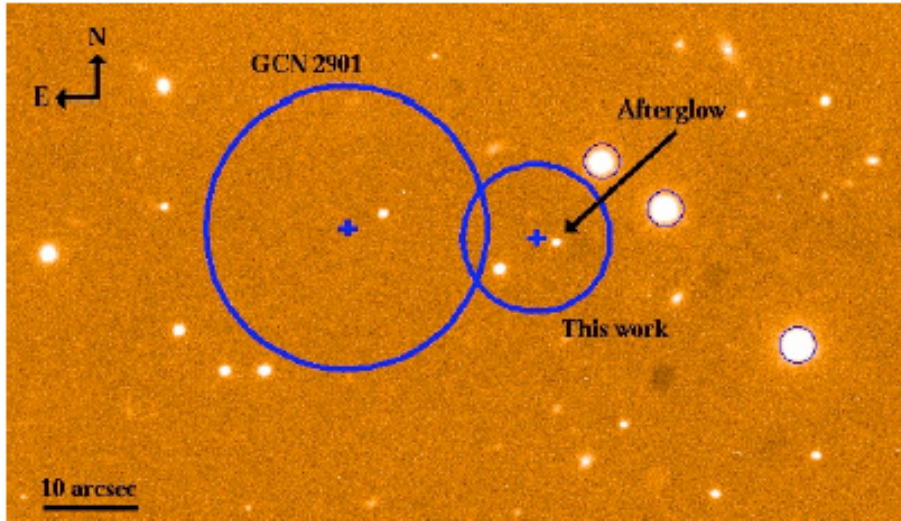
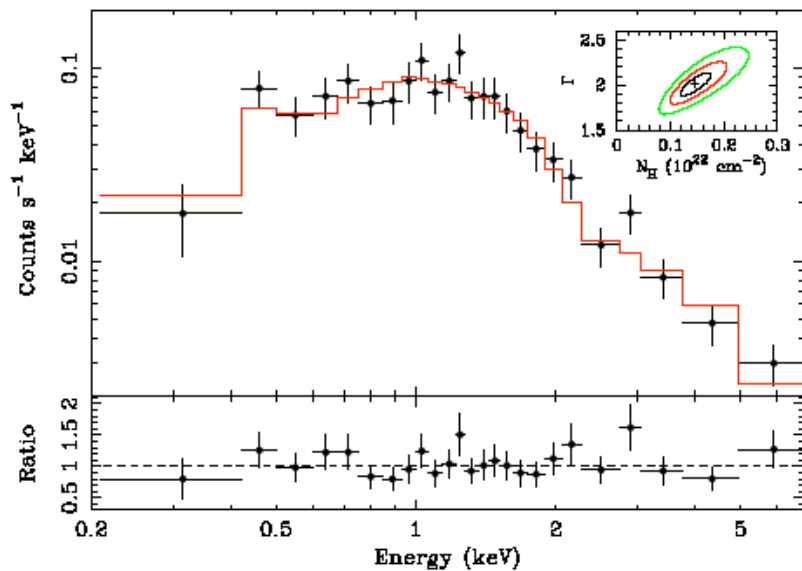
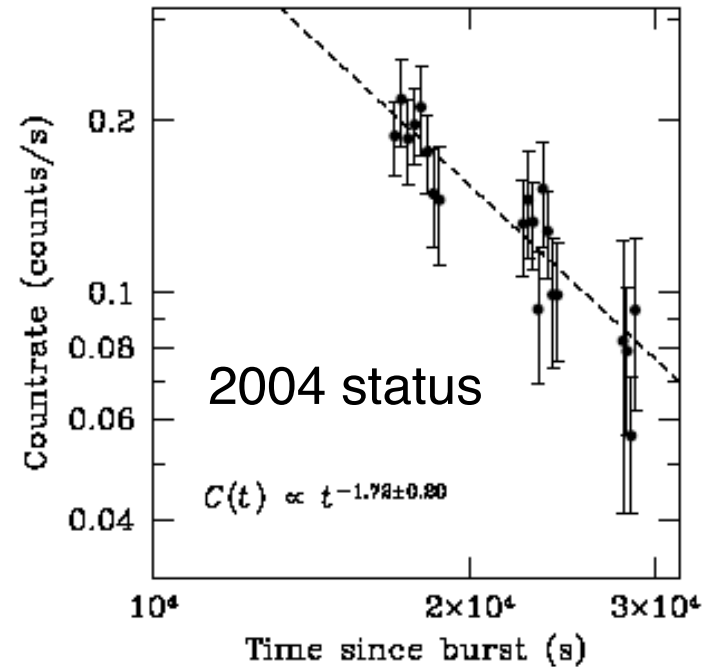


Fig. 2.— *J*-band image of the GRB 041223 afterglow. The error circles from the initial and final XRT positions are indicated. The final X-ray position is 1.1 arcseconds from the NIR afterglow. The three circled stars were used for flux calibration of the *J*-band data.

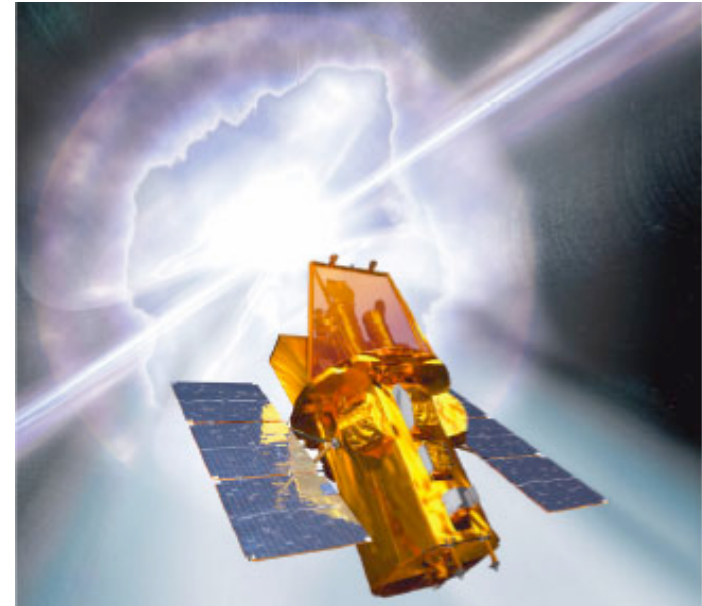


X-ray Spectra



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 marginal detection

**NOT FULLY OPERATIONAL!!**

**HANDLE THIS STATISTICS  
WITH CARE**

**Swift Will be Fully Ready and Open  
by 5th April**

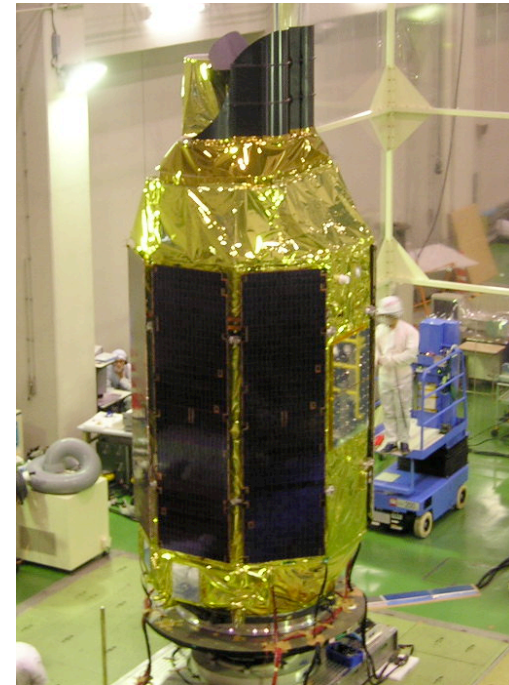
# 2: The Astro-E2 Mission

together with Tae Furusho and Astro-E2 team

# The Astro-E2 Mission

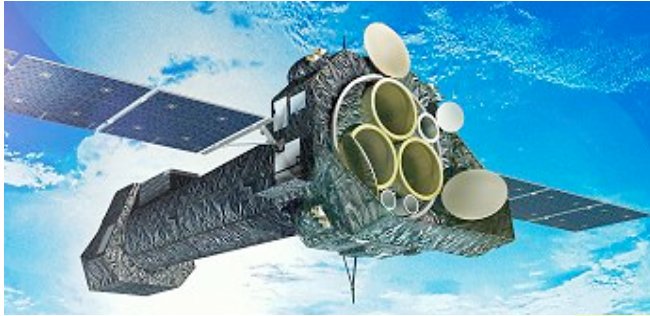
Astro-E2 is a powerful X-ray observatory developed by Japan (ISAS/JAXA) together with US (NASA/GSFC).

- 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



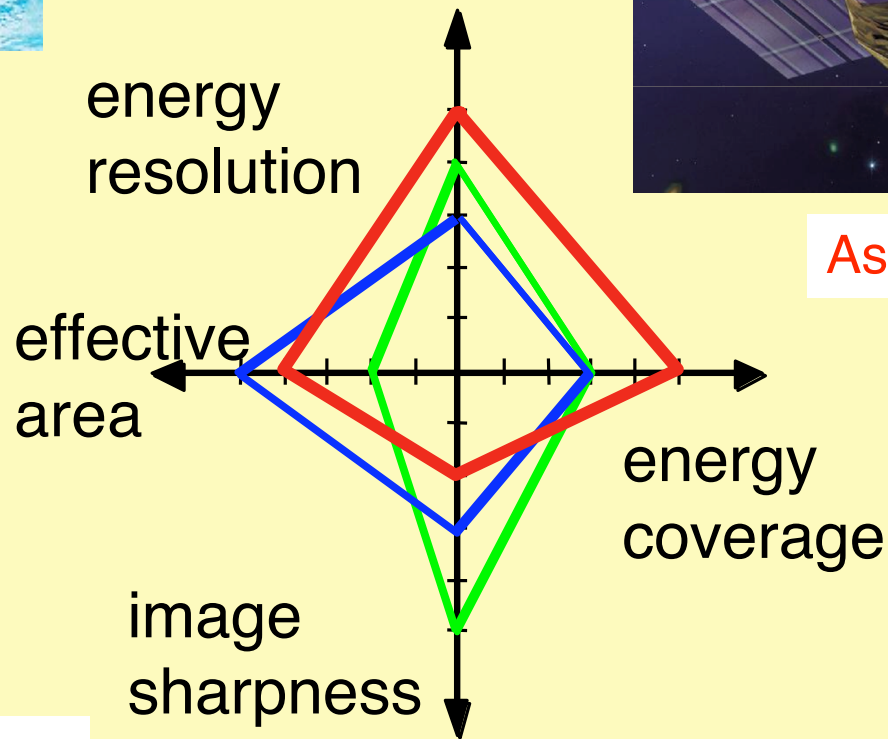
Newton 1999 -



Astro-E2 2005-

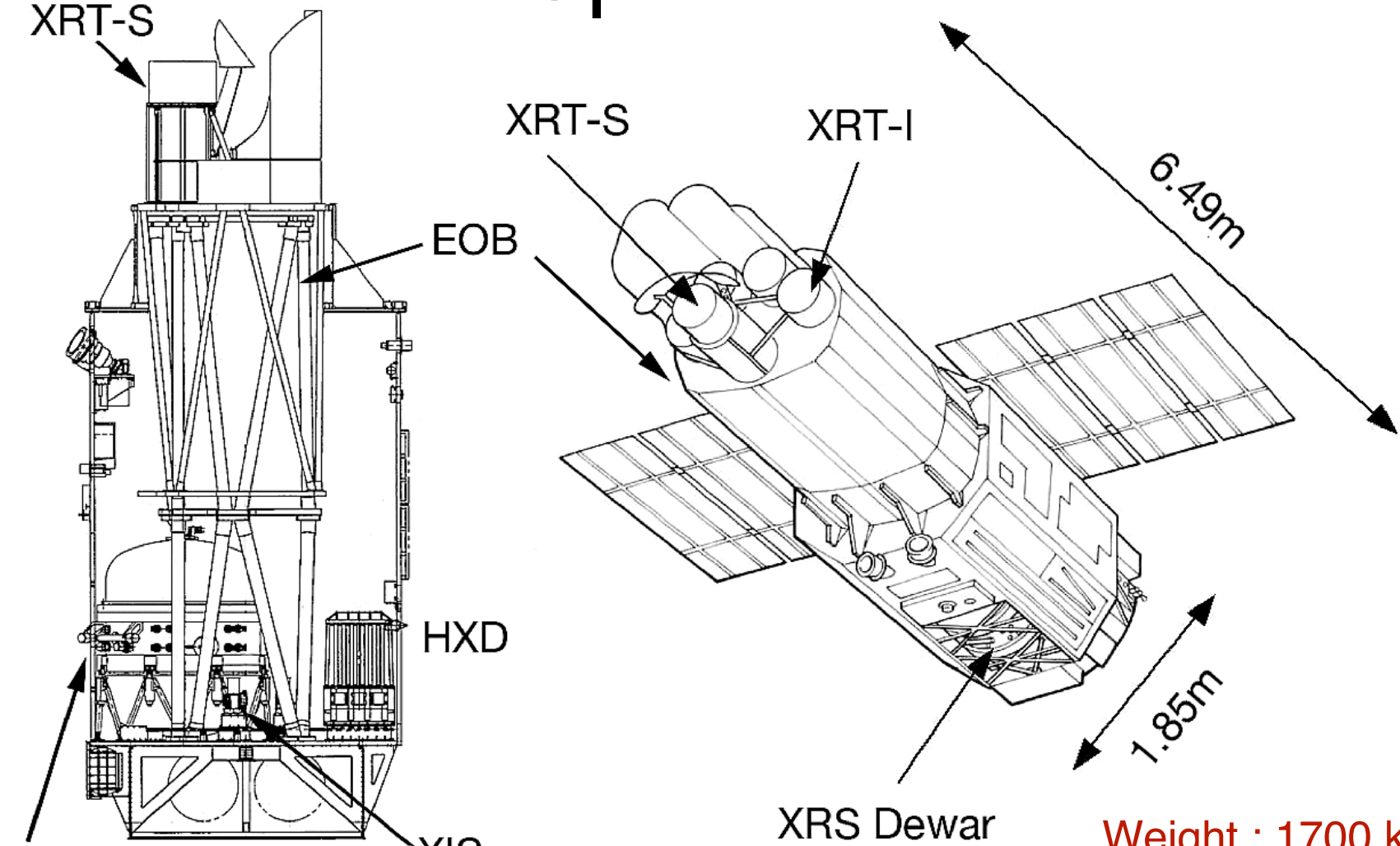


Chandra 1999-





# The Spacecraft



XRS Dewar

XIS

XRS Dewar

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



# Astro-E2 Instruments



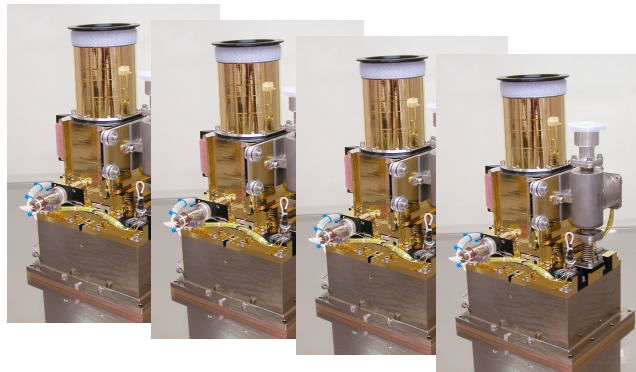
## XRS

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)

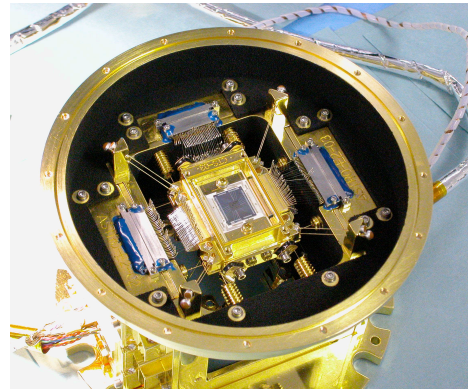
X-Ray Telescopes

Angular resolution ~2 arcmin

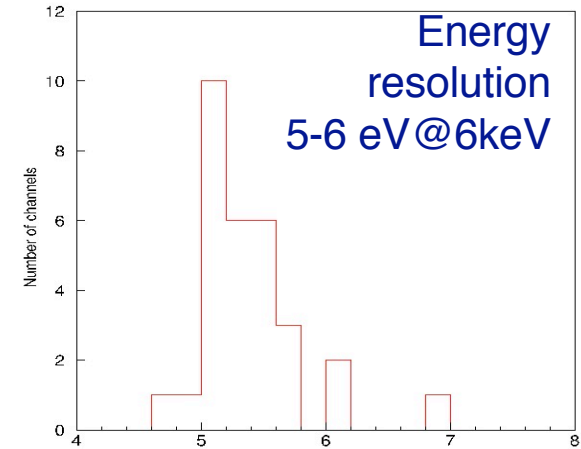
Large Area, Light Weight



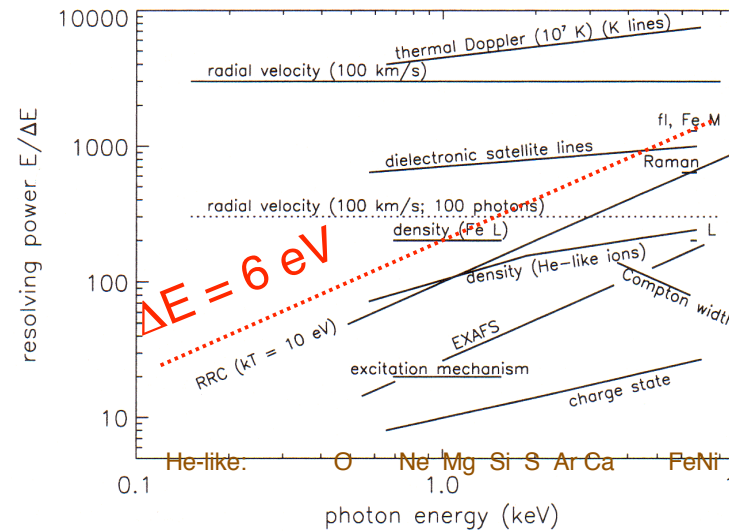
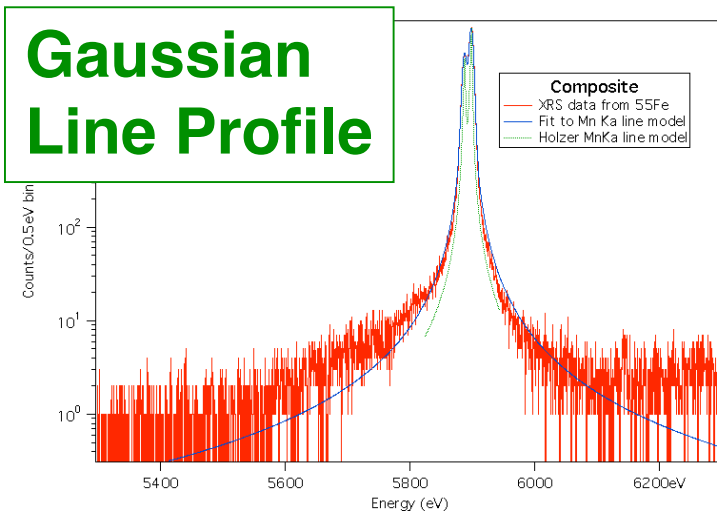
# The XRS



6x6 array with 30 ch  
 Operate at 60 mK  
 Expected lifetime is 2-3 years



**$\Delta E$  improved  
 from 12 eV to 6 eV!**

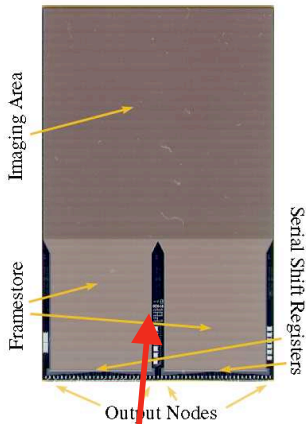


**Highest Resolving Power**

# The XIS and HXD

XIS: X-ray CCD  
imaging spectroscopy

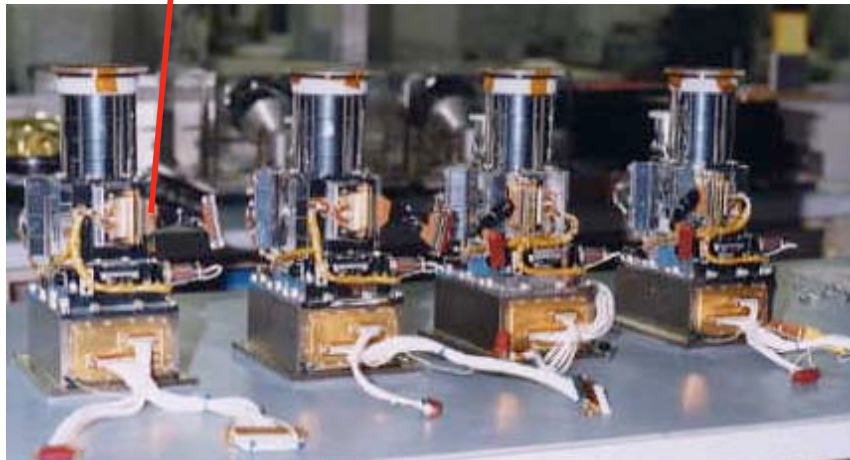
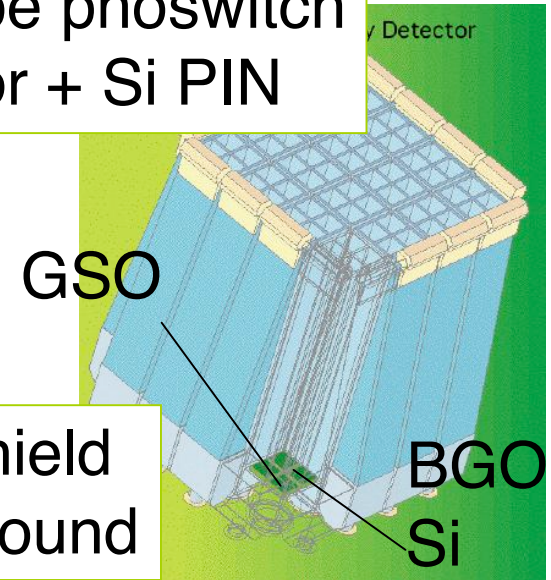
Front Illuminated CCD



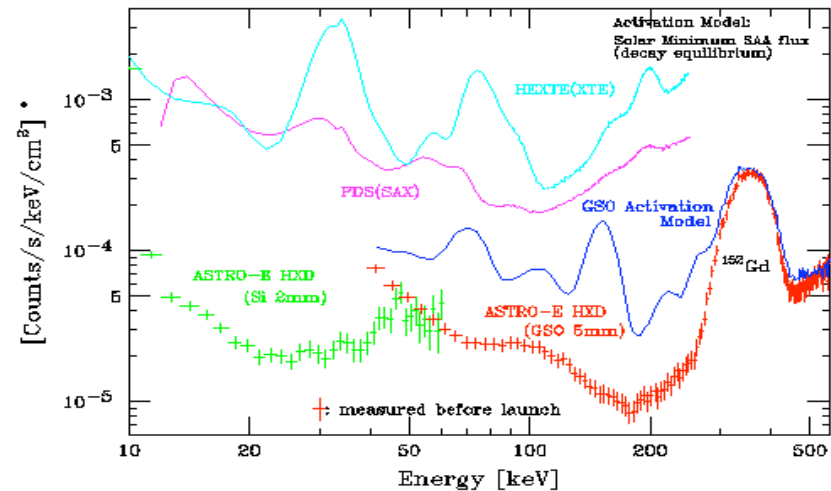
Expecting lowest diffuse BGD among X-ray CCDs on orbit

HXD: Well-type phoswich detector + Si PIN

Deep active shield  
→ Low background



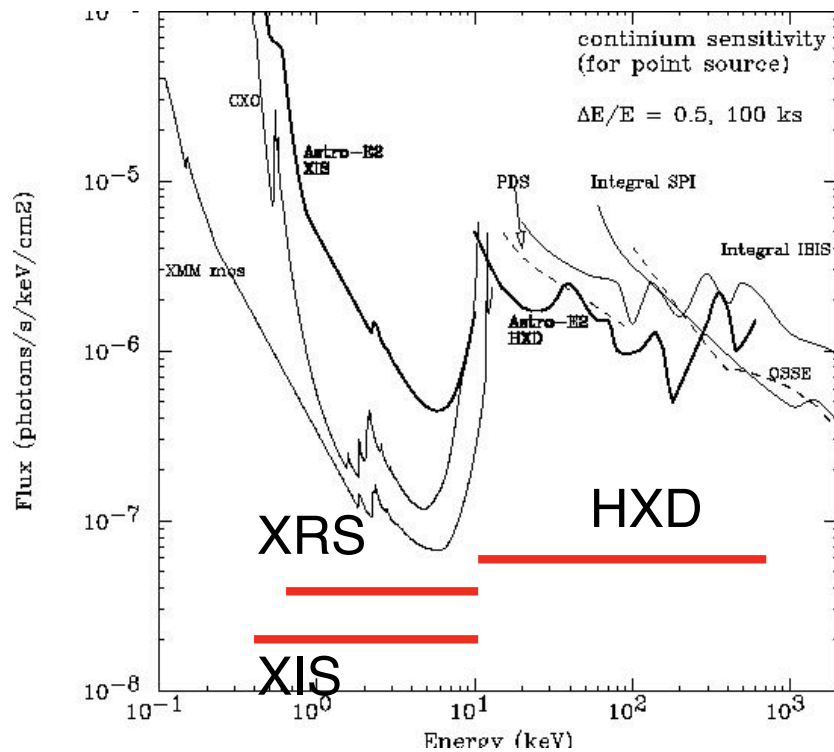
Detector Background Spectra



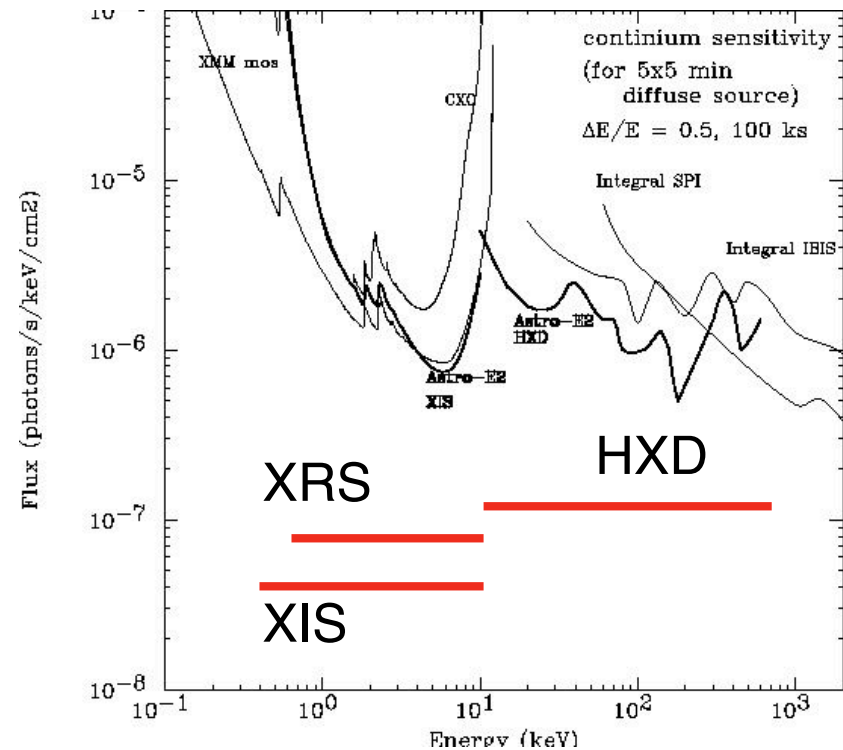


# The Astro-E2 band pass and Sensitivity

## Point source

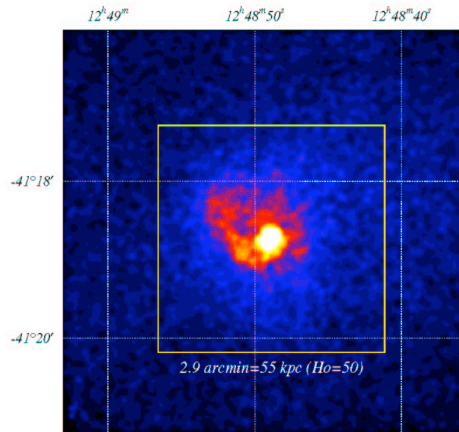


## 5x5 arcmin diffuse source



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

## Abundance/Cooler gas in Galaxy Cluster (Centaurus)

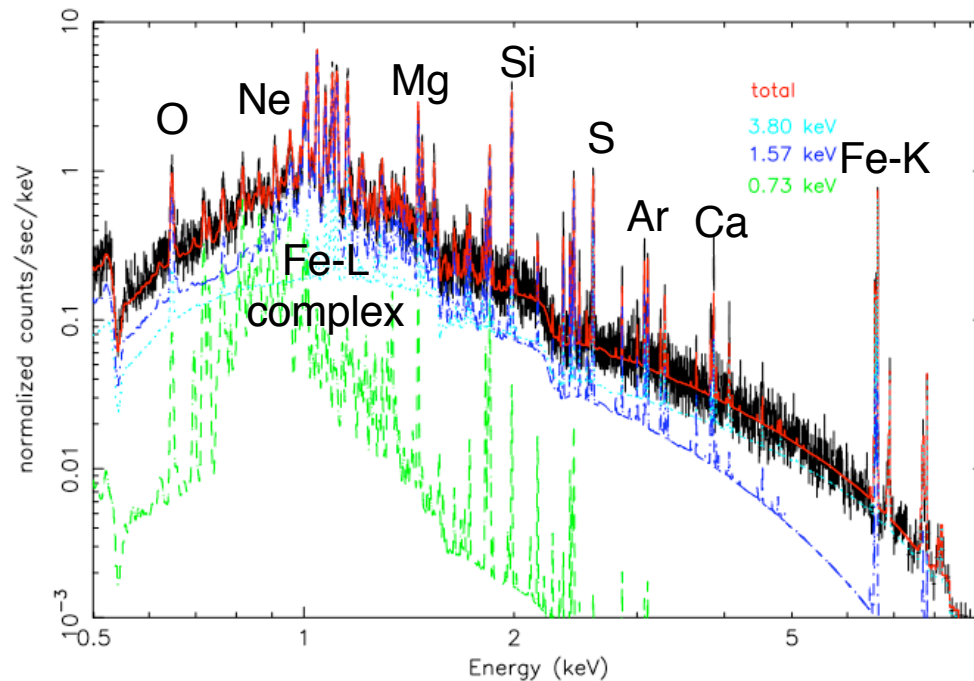


$z=0.011$ ,  $kT=1-3$  keV,  $Z=1-2$  solar

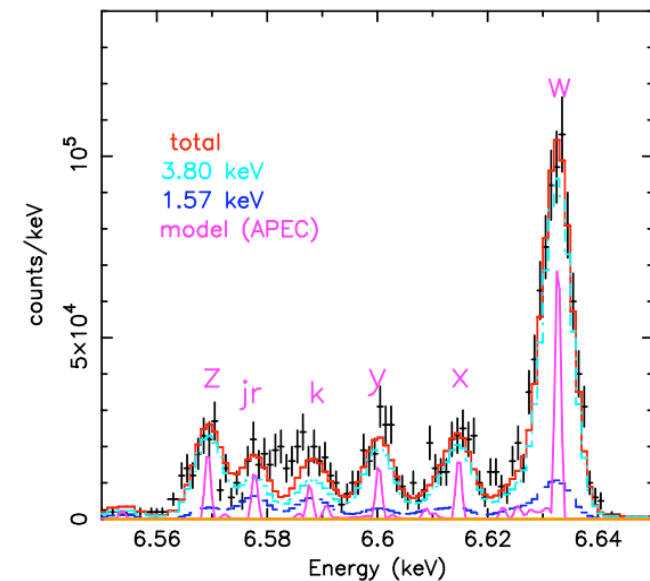
Strong emission lines  $\rightarrow$  **line intensity**

Bright and complex core

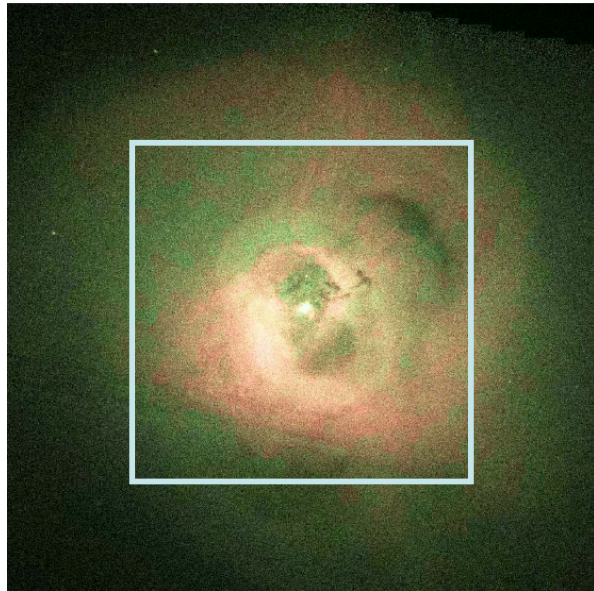
2 or 3 temperature components?



Takahashi et al. In prep



# Dynamics - Cluster Core (Perseus)



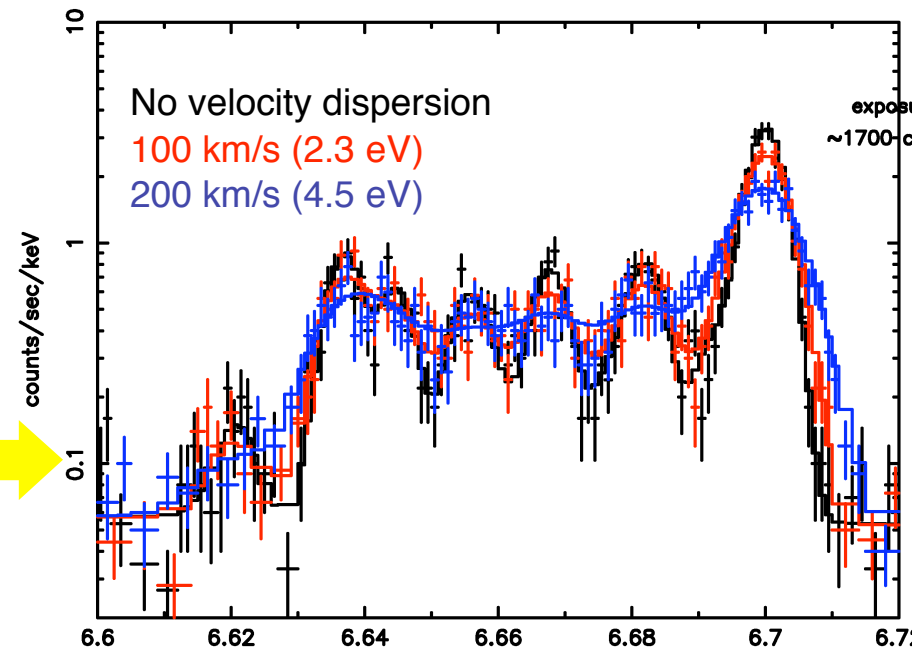
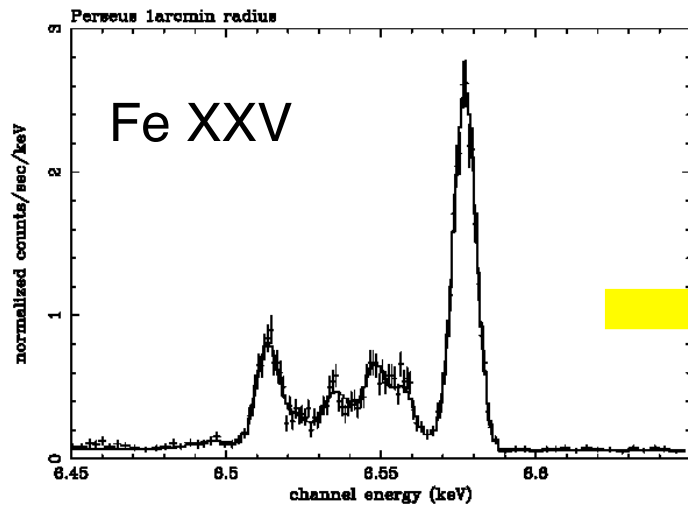
$z=0.018$ ,  $kT=4-6$  keV,  $Z=0.5$  solar

Brightest Fe-K line

Active gas motion → **line broadening**

Resonance scattering

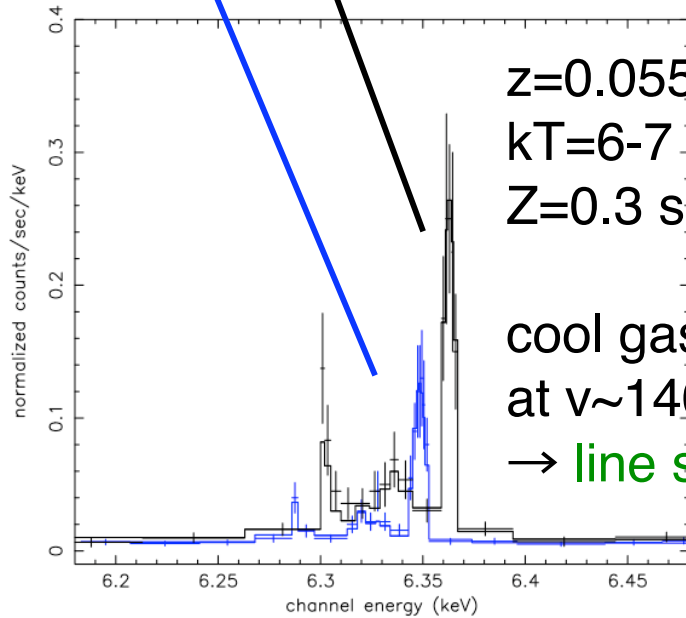
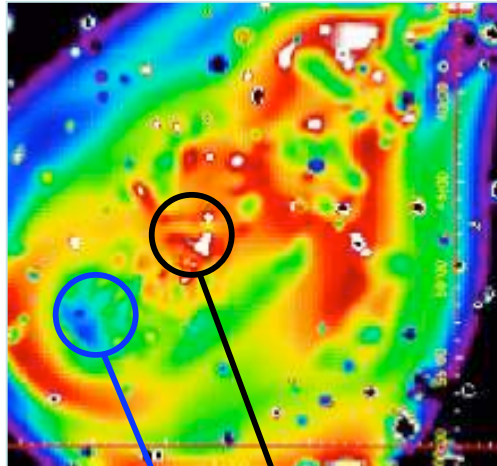
Fabian et al. 2003





# Cluster Merger -- turbulence and possible excess hard

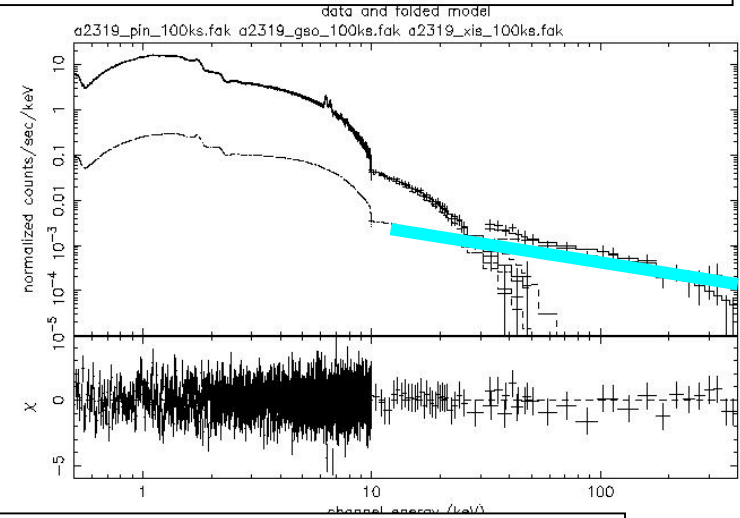
A3667 X-ray



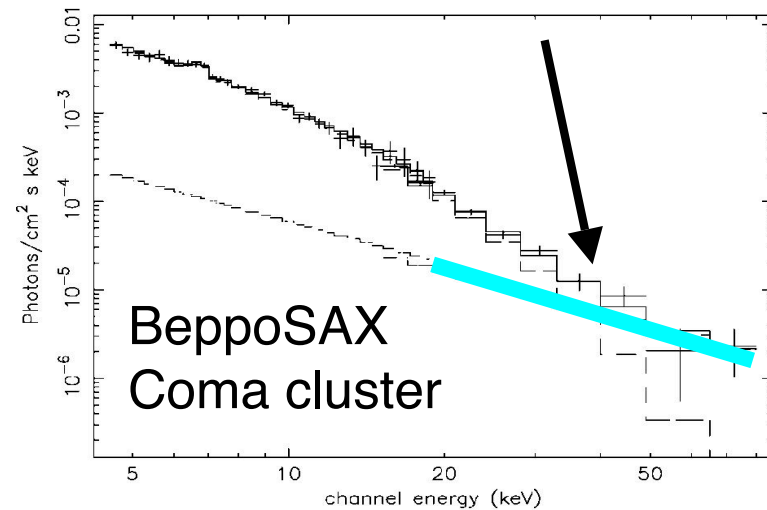
$z=0.055$ ,  
 $kT=6-7$  keV,  
 $Z=0.3$  solar

cool gas cloud moving  
 at  $v \sim 1400$  km/s  
 → line shift

Abell 2319 Astro-E2 Simulation



Coma cluster: **hard excess**

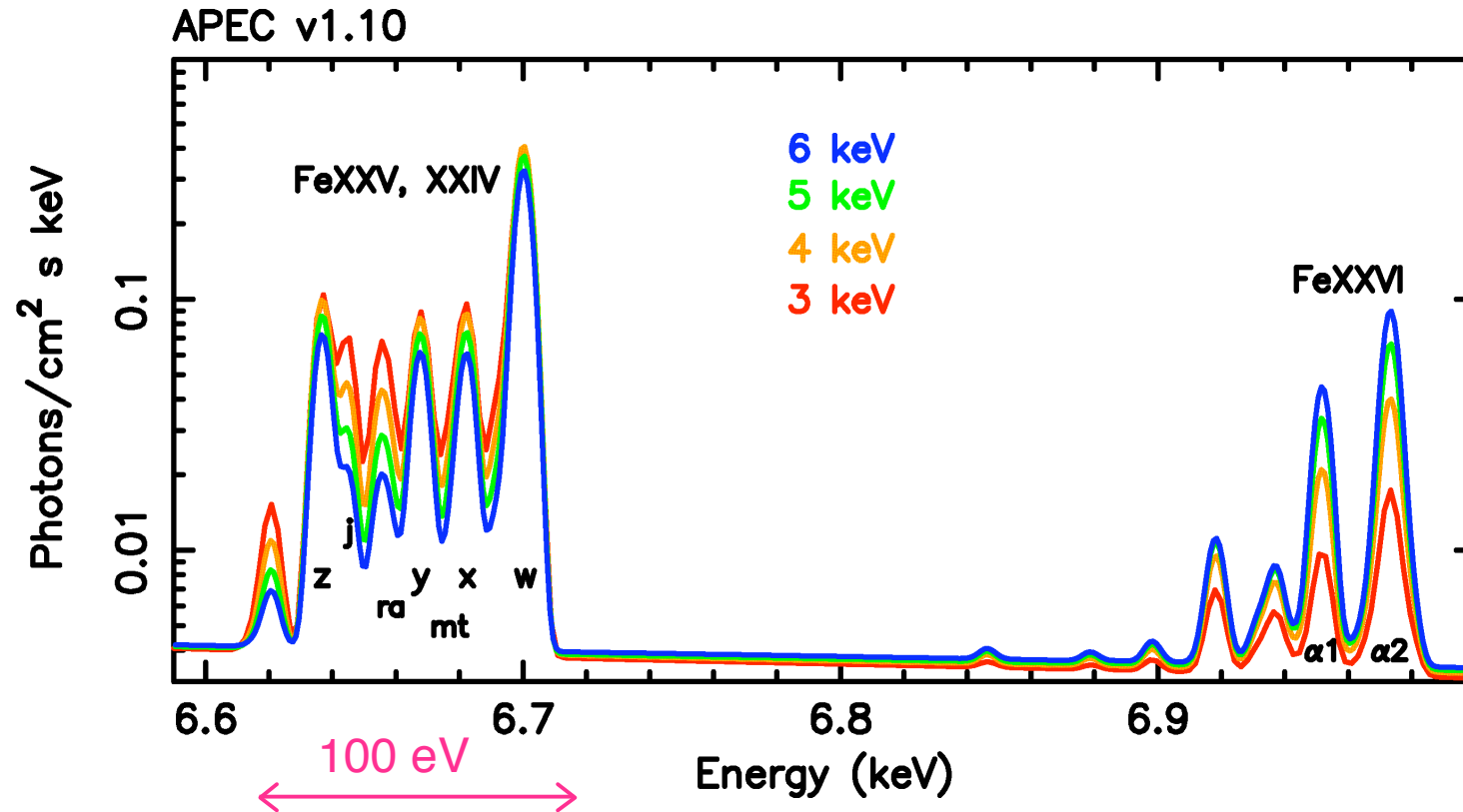


# Plasma Diagnostics

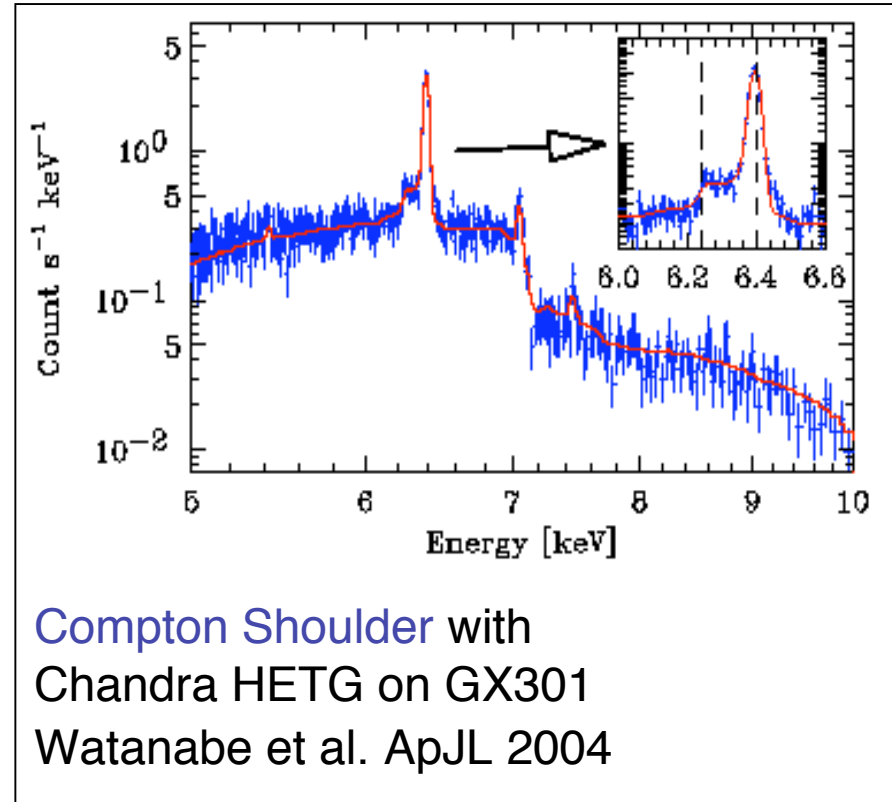
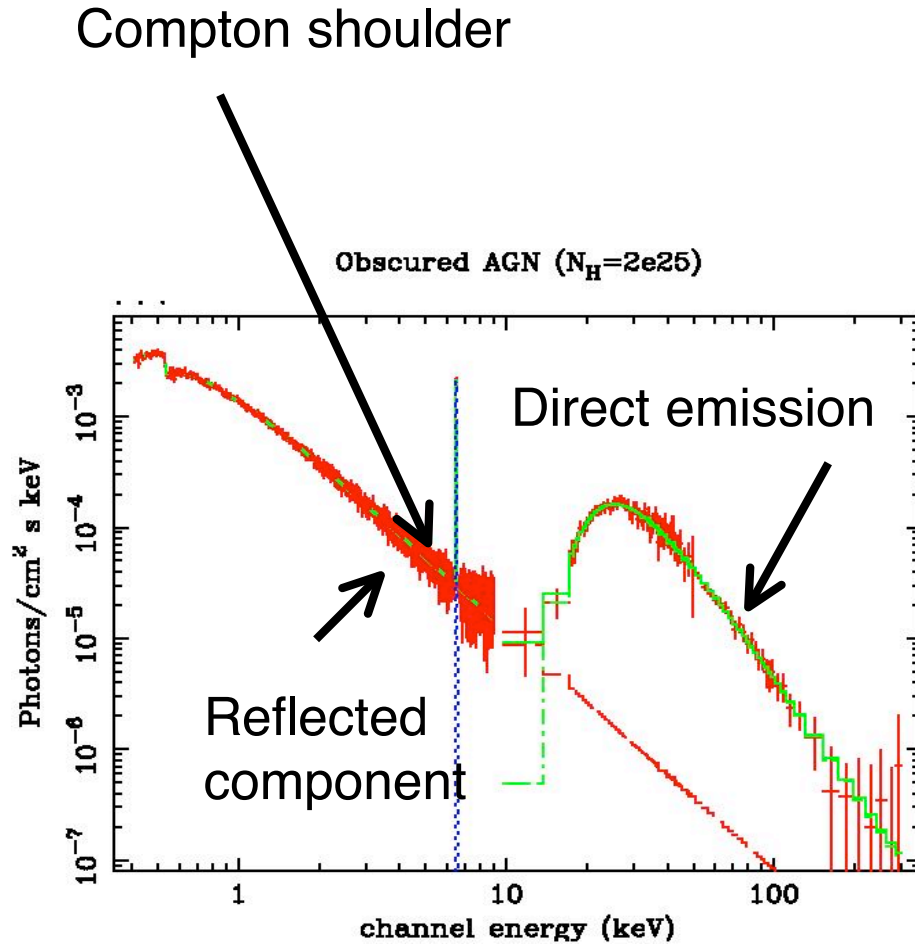
Line ratios give us physical parameters directly!

j/w : electron temperature

z/w: ionization level



# AGN and Compact Sources



Astro-E2 hosts an order of magnitude improved  $\Delta E$  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

2004/11/20 launched



Gamma-ray burst explorer

“Catching GRB on the fly”

## Astro-E2 Mission

2005-summer will be launched



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**