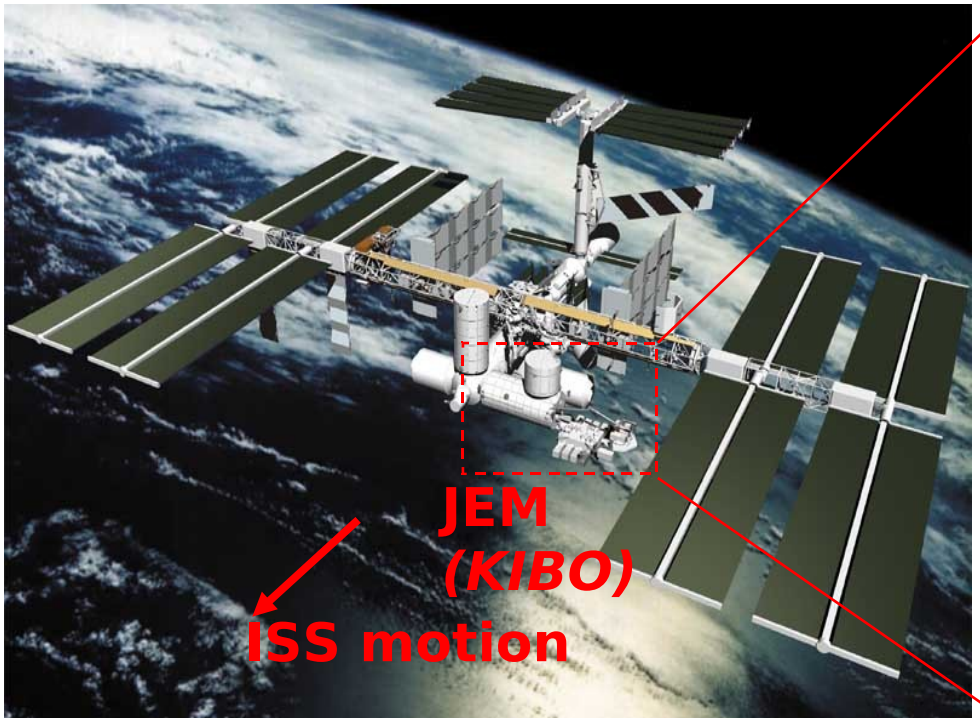
Monitor of All-Sky X-Ray Image
the all-sky mission from the International Space

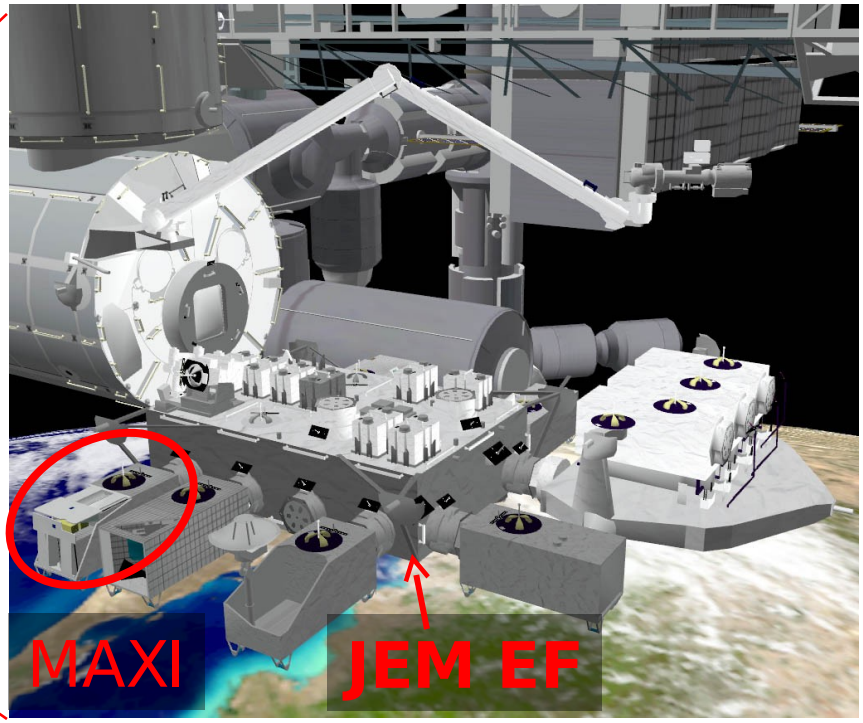
T. Mihara (RIKEN)

On behalf of MAXI Collaboration

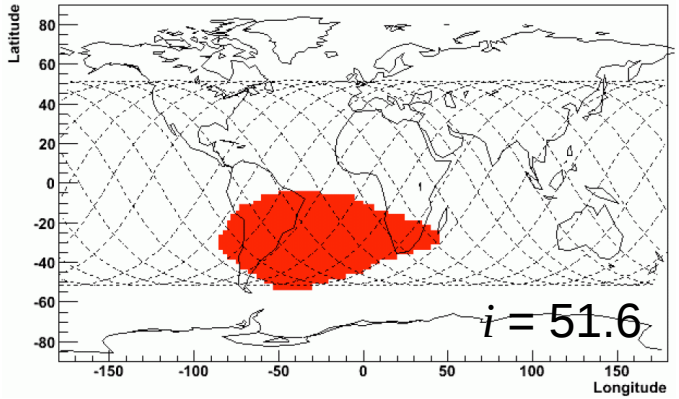
Matsuoka 2009 PASJ submitted. Sugizaki 2009 IEEE submitted.

MAXI mission on ISS

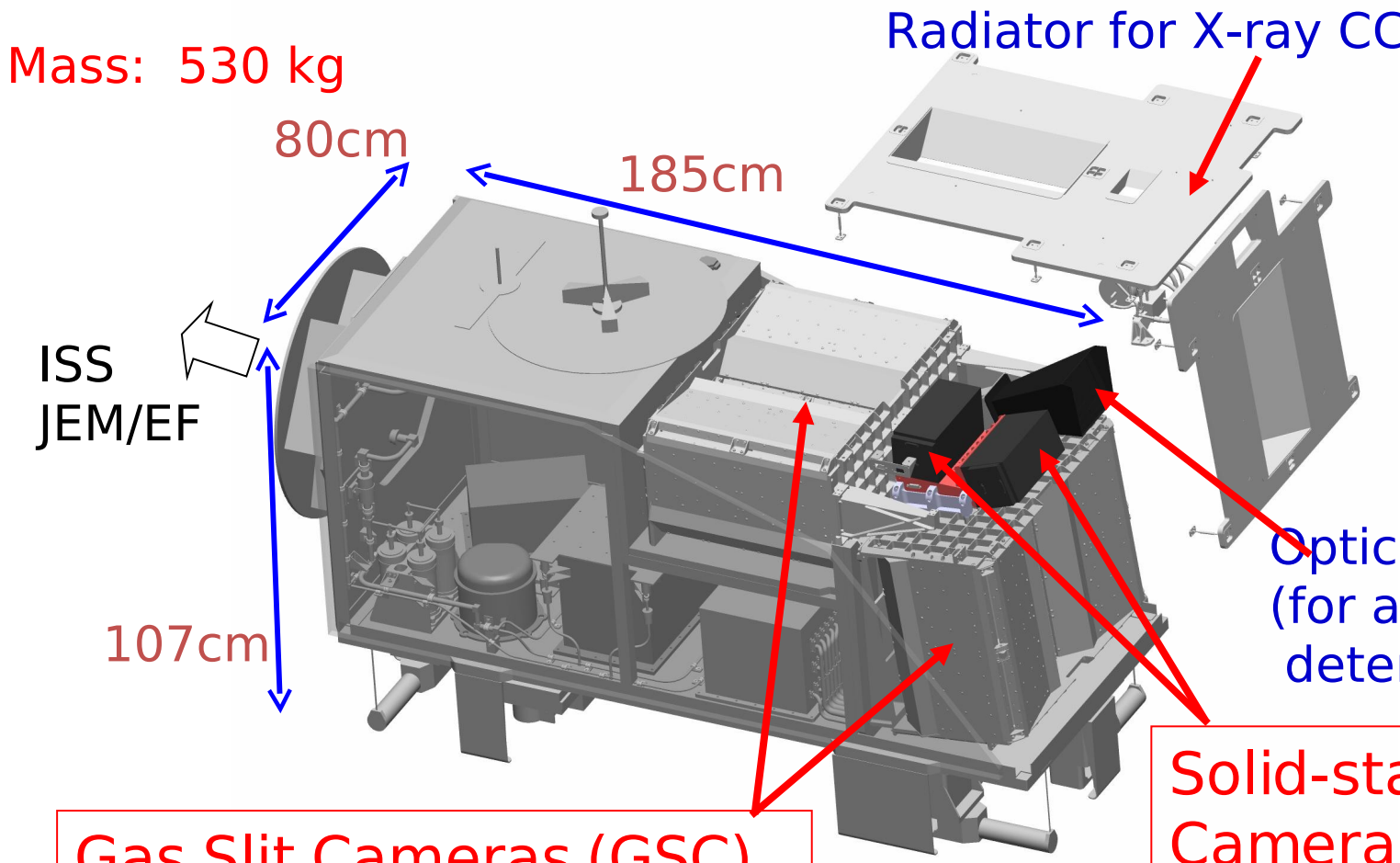




- The first astronomical mission on ISS for all-sky X-ray monitor
- attached on JEM (Japanese Experimental Module, KIBO)
  EF (Exposed Facility)
- launch: Space Shuttle



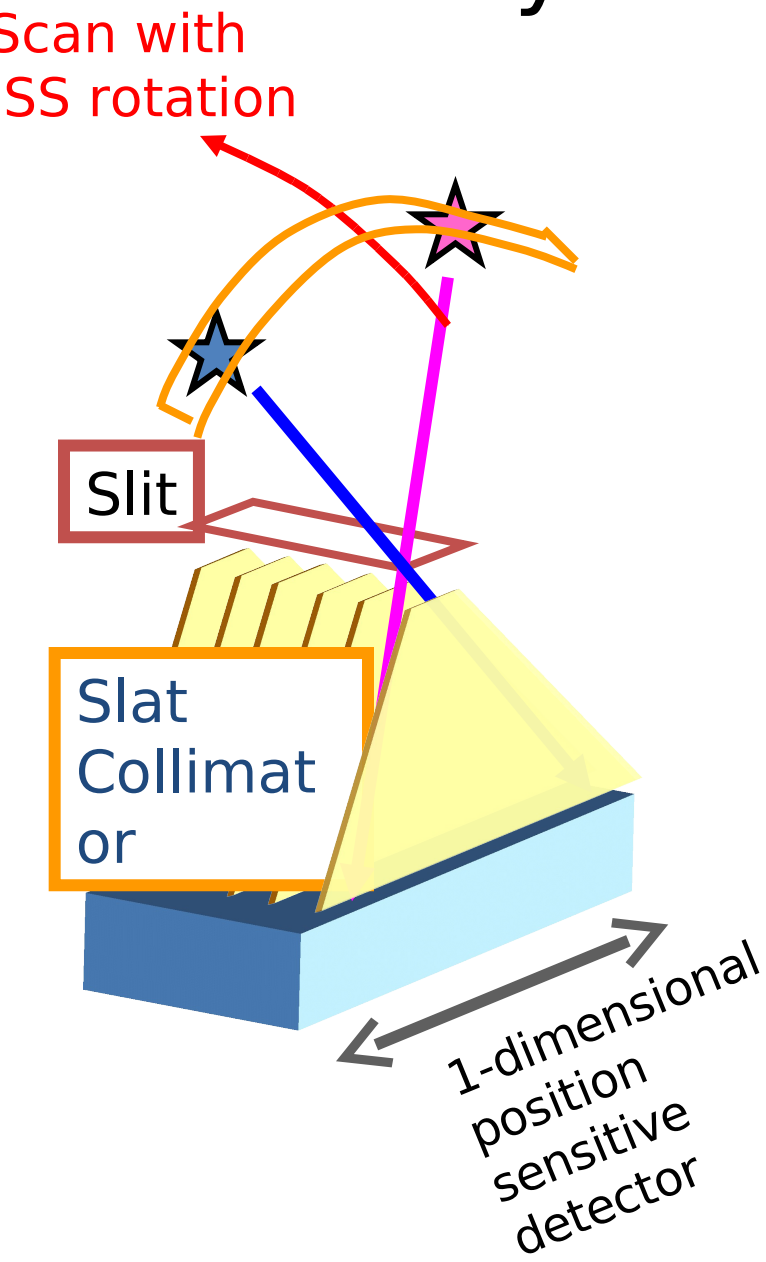
X-ray Slit Cameras on MAXI Payload



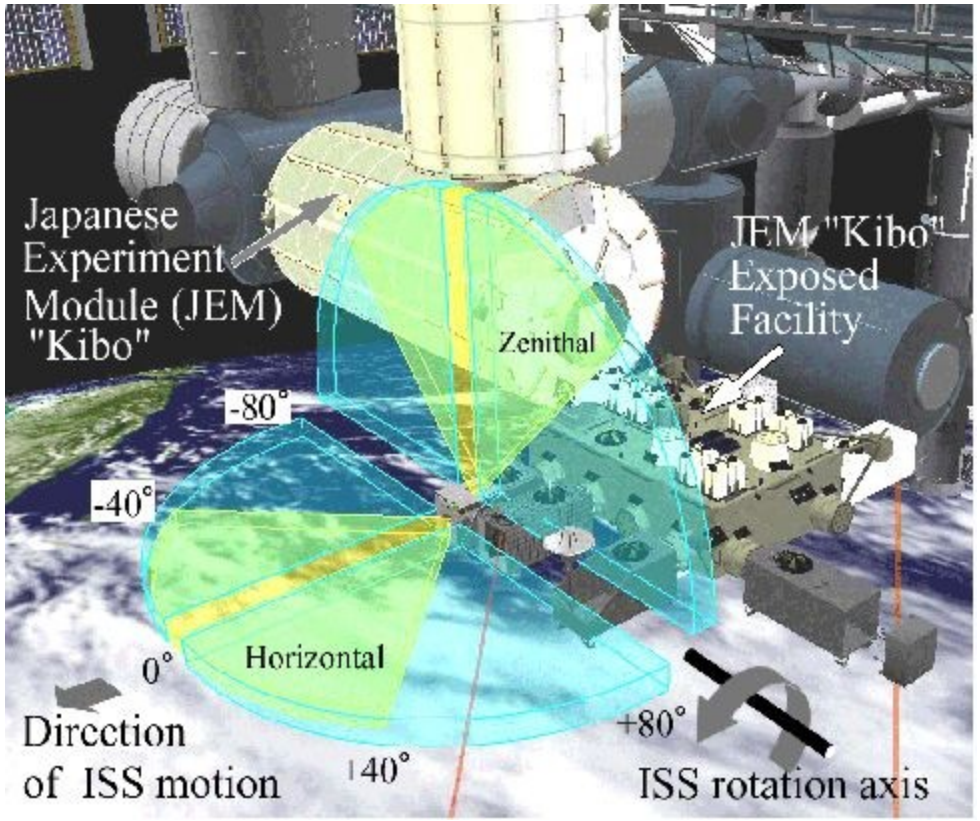
Gas Slit Cameras (GSC)
Xe-filled proportional counter
2—30 keV; 5350 cm²

Solid-state Slit Cameras (SSC)
32 CCD chips
0.5—15 keV; 200 cm²

All-Sky Scan with Slit Cameras

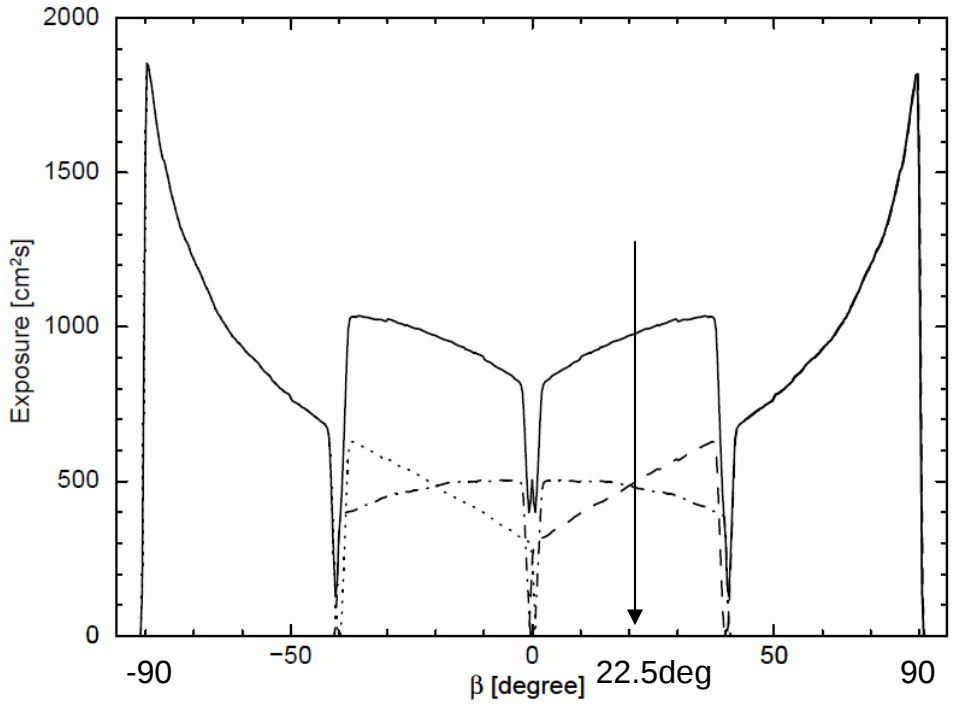


Field of Views



MAXI scans almost the entire (90%) sky twice in every ISS orbital period (~ 90 minutes).

Effective area



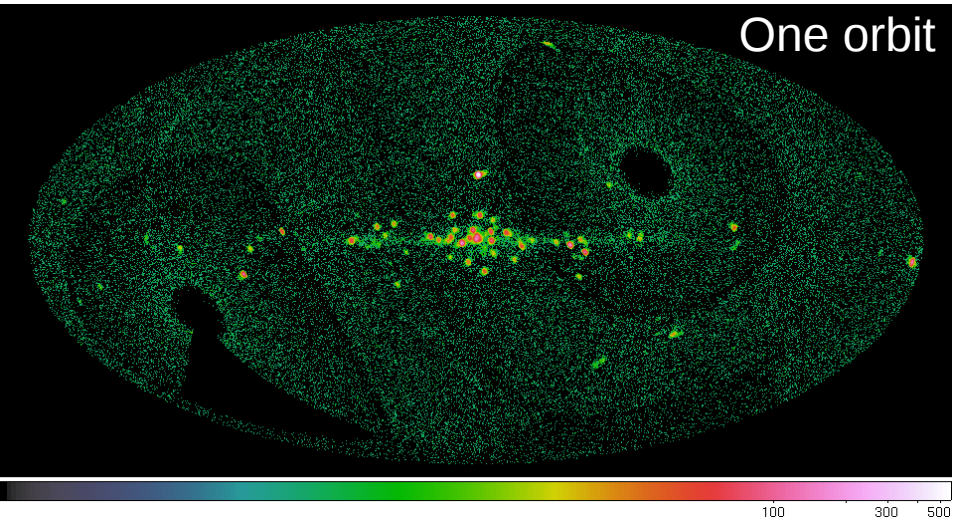
GSC-H and Z added. In one-orbit.

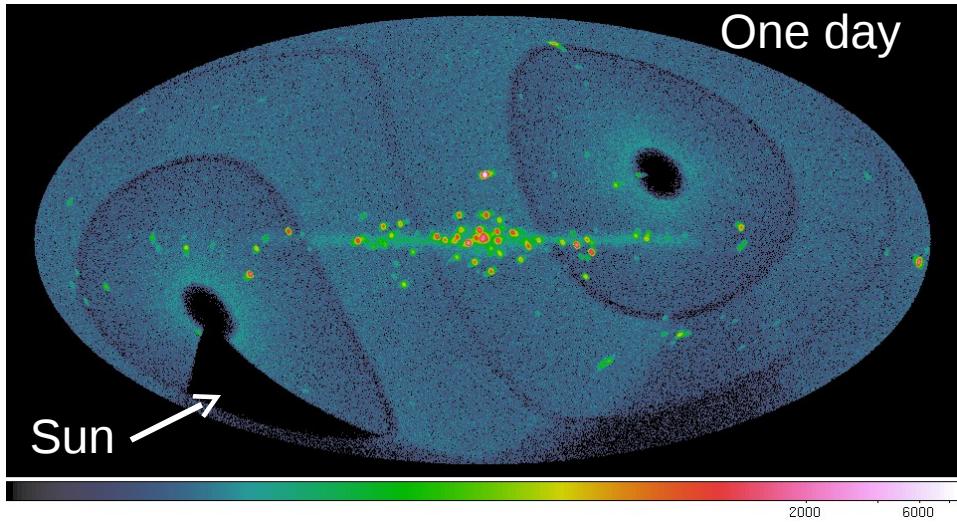
- Effective area 6.17cm²/source/PC
- (2 Hcamera + 2 Zcamera) * 2 FOV * cos22.5 * 0.5 = 22.8cm²/source/orbit
- Dwell time 45s *15orbits *1 yr *0.7 = 3930 cm² ks
- Corresponds to PCA (2400cm²) 1.6 ks

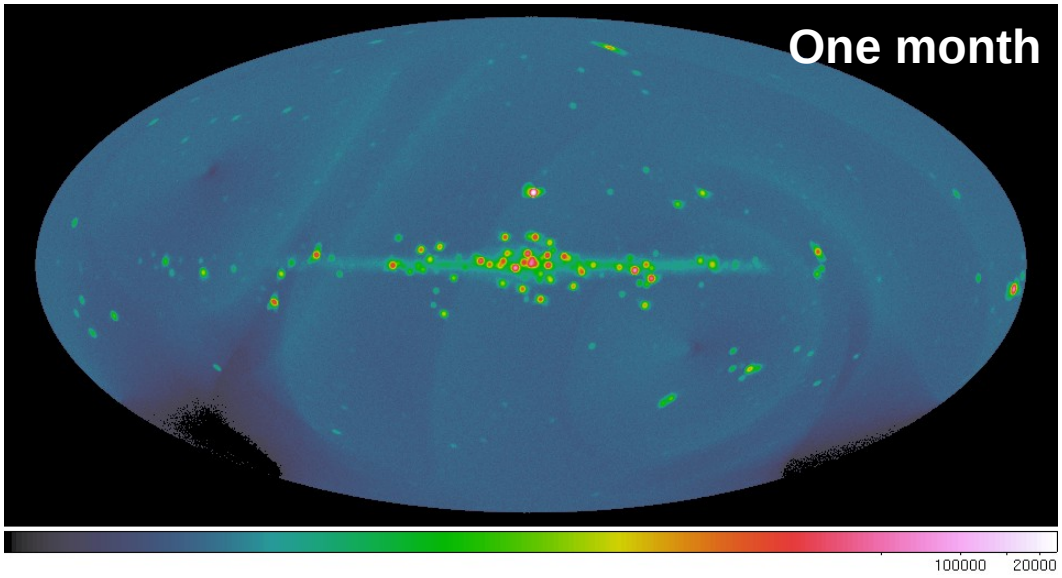
Scientific Objectives

- Detection/monitor of transient X-ray sources in the whole sky
  - Galactic transient
    - X-ray binaries (Novae, QPOs, ..), AXPs, SGRs, flare stars, ...
  - AGNs, GRBs, Supernova breakouts,...
- Rapid nova alerts
  - GRBs, new sources, and outbursts of known sources
- Complete all-sky catalog of X-ray sources
  - 0.5—30 keV, down to 0.2 mCrab in 2 years
  - Census of X-ray sources
- Large scale mapping of diffuse/unresolved X-ray Sky
  - Galactic ridge/loop structures with oxygen (and other) lines
  - Cosmic X-ray background fluctuations and anisotropy

Simulated Sky Images by MAXI



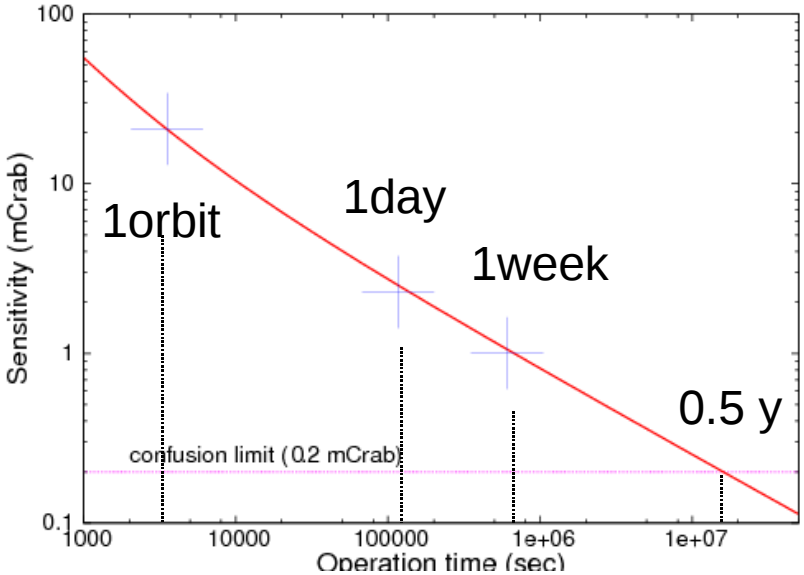




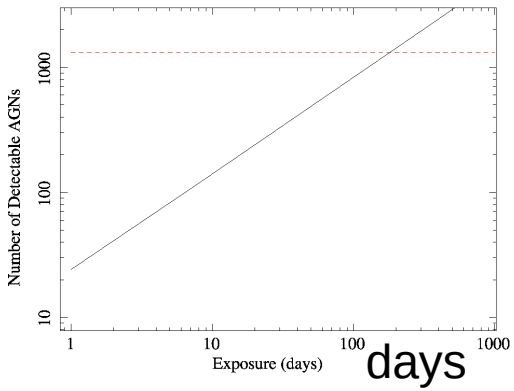
~ 1000 objects and
Diffuse hot sources!

GSC 2-30keV

Detection limit (5σ) of GSC by simulation



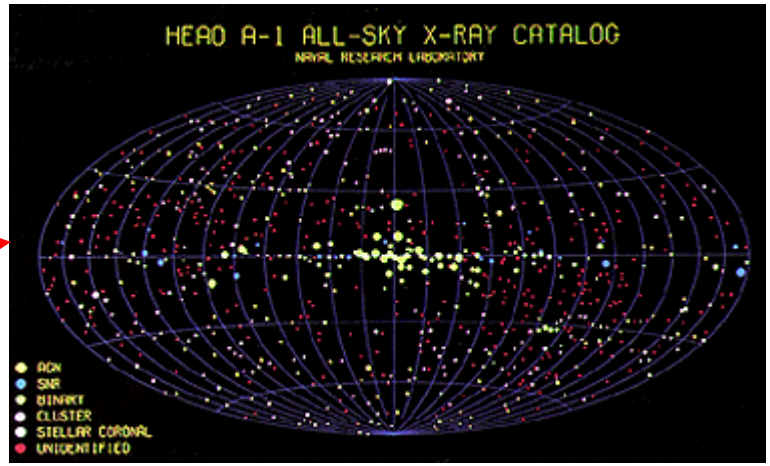
NAGN



|b| > 15

Total number of AGNs by GSC with time.
100 in one week,
1300 in 0.5 year or more (confusion limit).

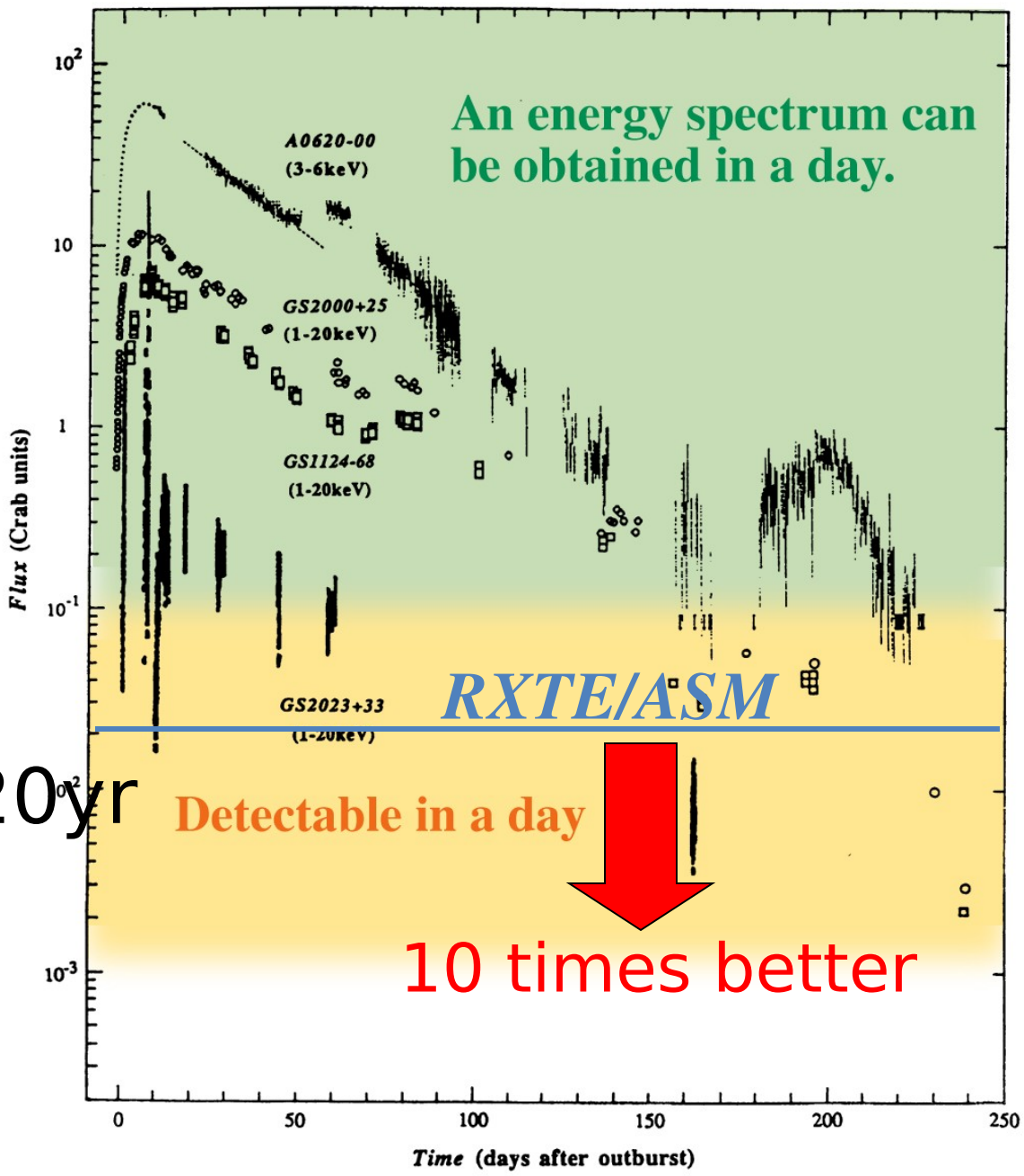
1 orbit	20 mCrab
1 day	5 mCrab
1 week	2 mCrab
1 month	1 mCrab
2 years	0.2 mCrab (Source Confusion Limit)

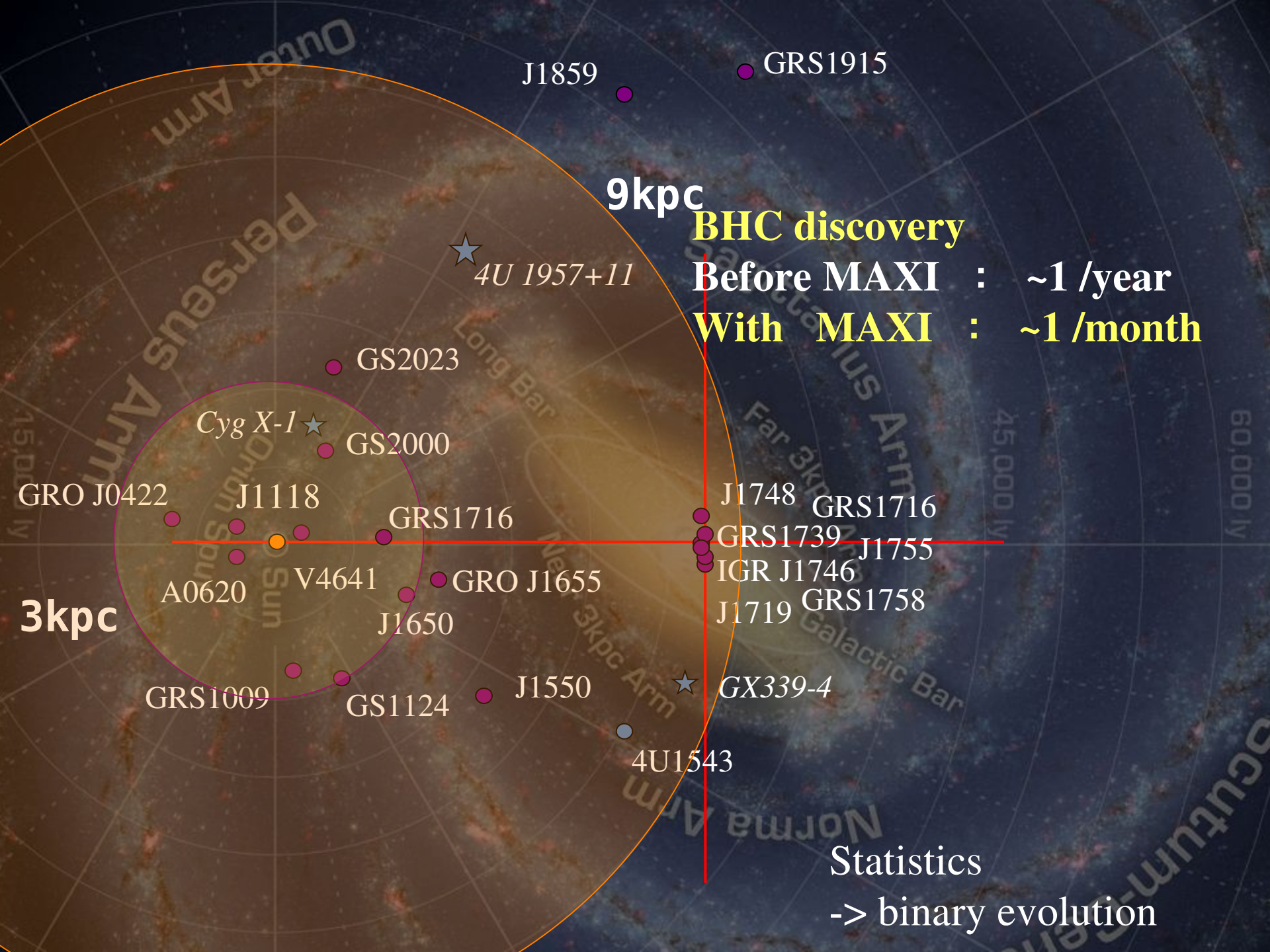


HEAO A-1 equivalent catalog every month!

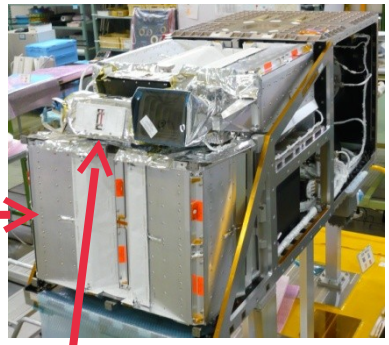
MAXI Capability for Black Hole Transients

- 26 novae in 20yr
- ~1.3 BHC/yr

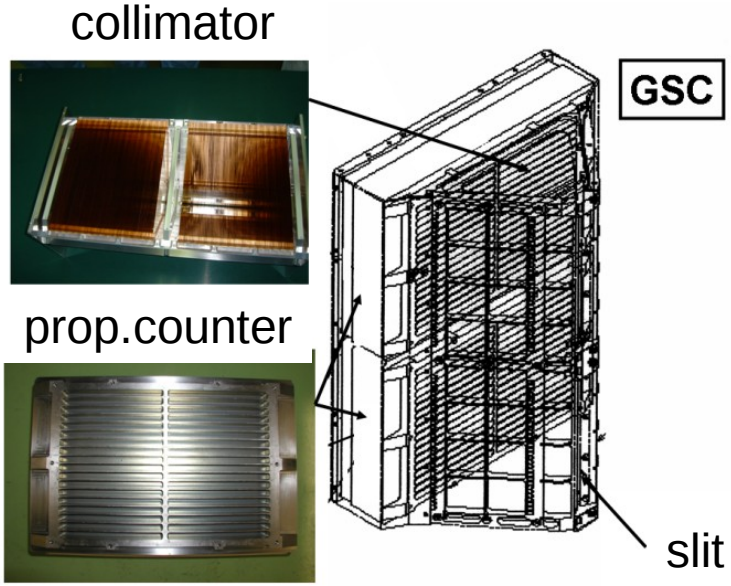



J1859
GRS1915
9kpc
BHC discovery
Before MAXI : ~1 /year
With MAXI : ~1 /month
4U 1957+11
GS2023
Cyg X-1
GS2000
GRO J0422
J1118
GRS1716
J1748
GRS1716
GRS1739
J1755
IGR J1746
A0620
V4641
GRO J1655
J1650
J1719
GRS1758
3kpc
GRS1009
GS1124
J1550
GX339-4
4U1543
Statistics
-> binary evolution
Perseus Arm
Outer Arm
Long Bar
Near 3kpc Arm
Far 3kpc Arm
Galactic Bar
Norma Arm
Sagittarius Arm
Orion Spur
Sun

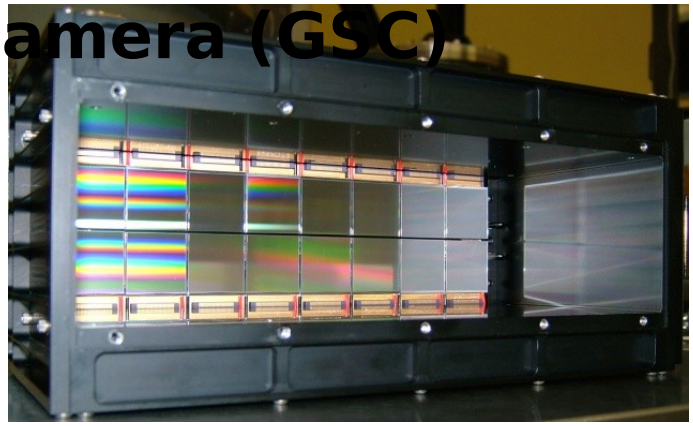
X-ray detectors of MAXI



Gas Slit Camera (GSC)



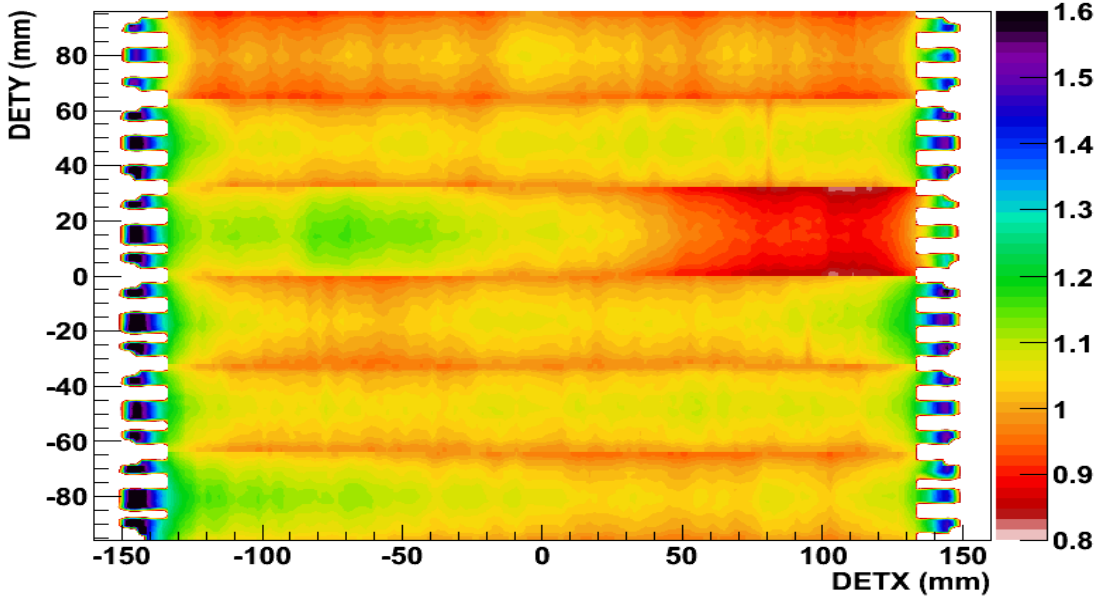
Solid-state Slit Camera (GSC)



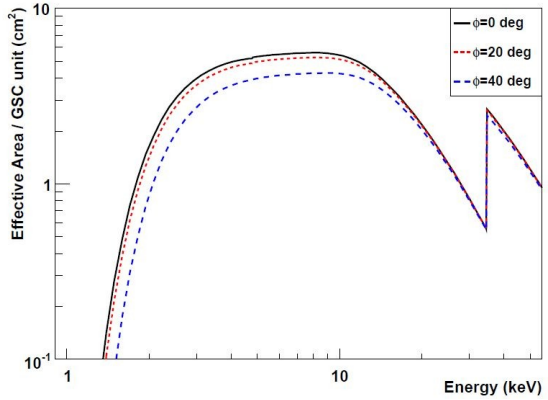
	GSC	SSC
detector	Xe Prop. Counter	CCD 16chips x 2 cameras
Energy Band	12 cam	
Energy resol.	2 - 30 keV	0.5 - 12 keV
Time resol.	15.7% at 8.0 keV	150 eV at 5.9keV
FOV	50 μsec	6 sec
PSF FWHM	1.5 x 160 deg	1.5 x 80 deg
sensitivity	1.5 deg	1.5 deg

Ground cal. : GSC properties

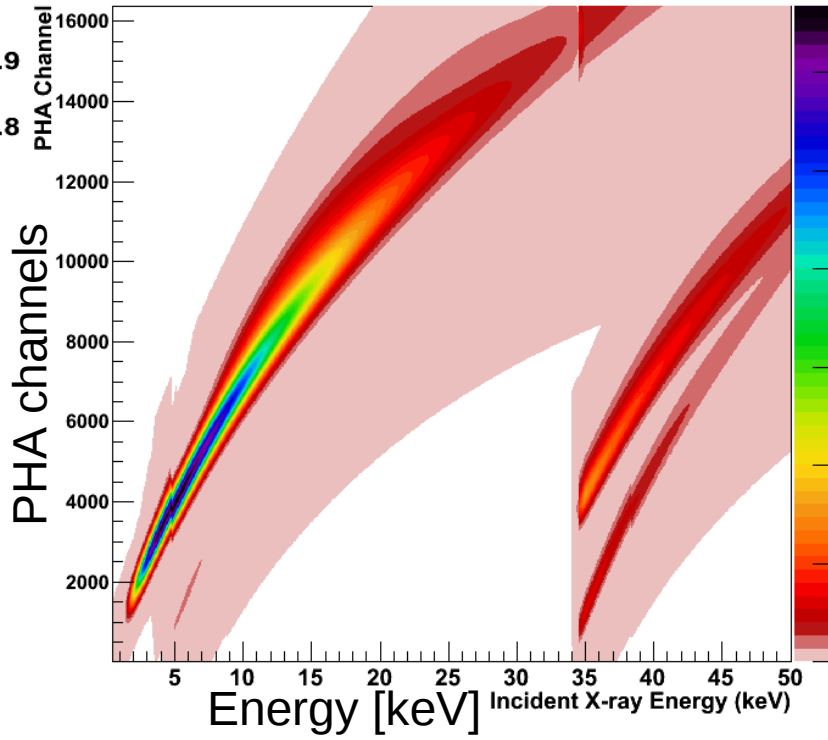
Gain: XY map



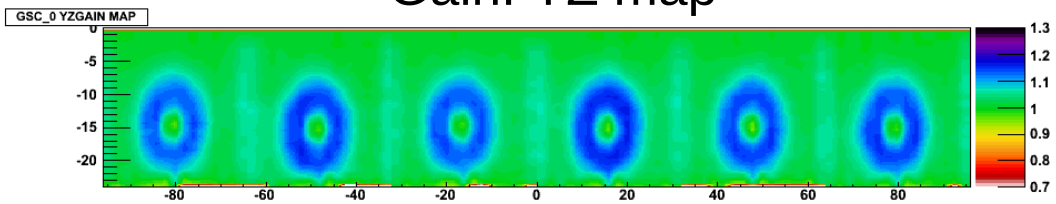
Effective area



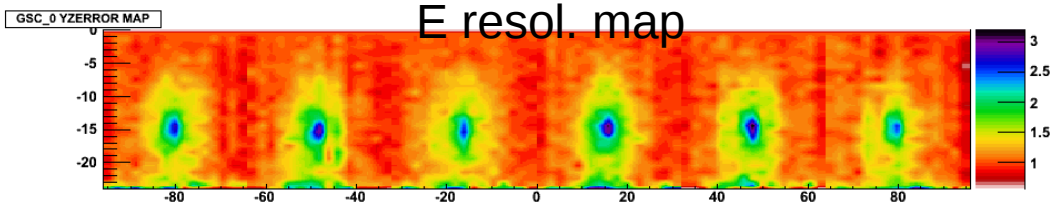
Response matrix in a position



Gain: YZ map

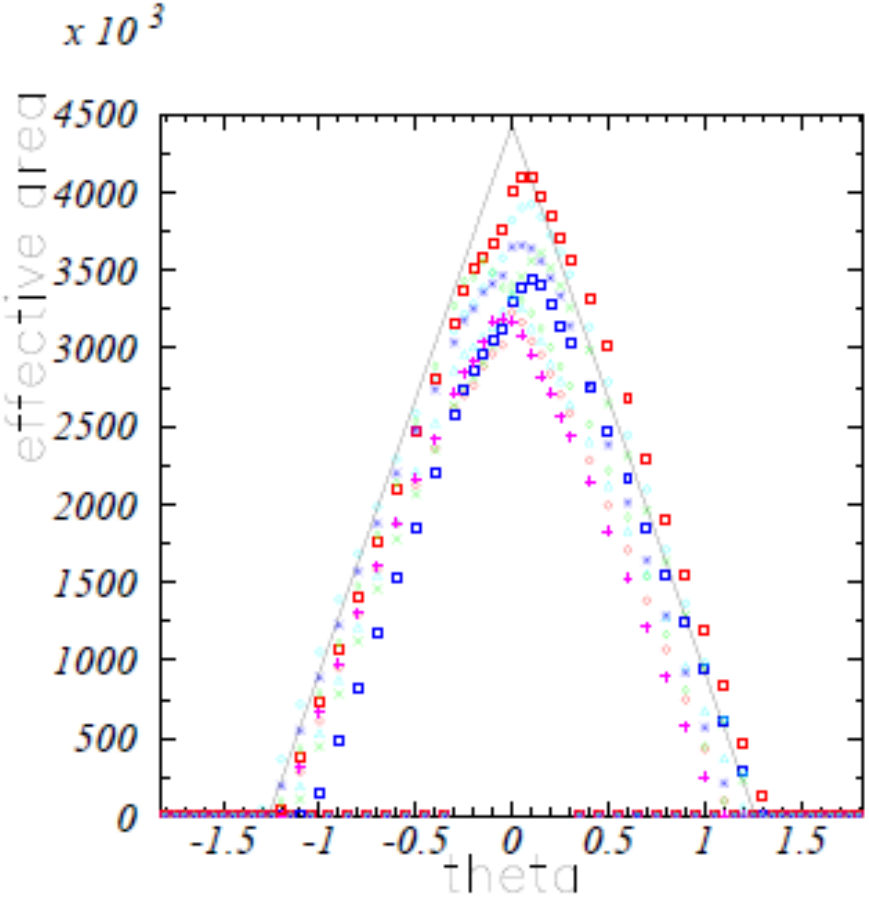


E resol. map



Ground cal : collimator transmission

- Effective area: ~90% of the designed.
- Measured by Cu beam.
- 3 scan paths in FOV.

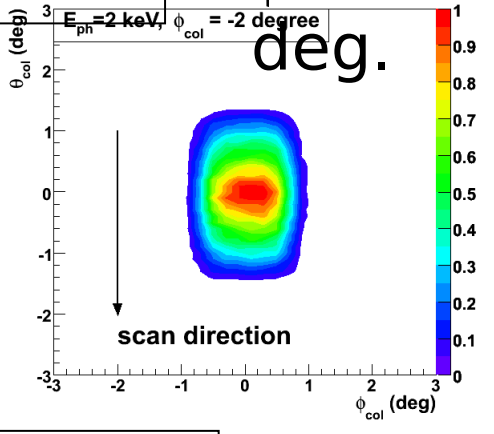


(c) ϕ=30°, CCD=6

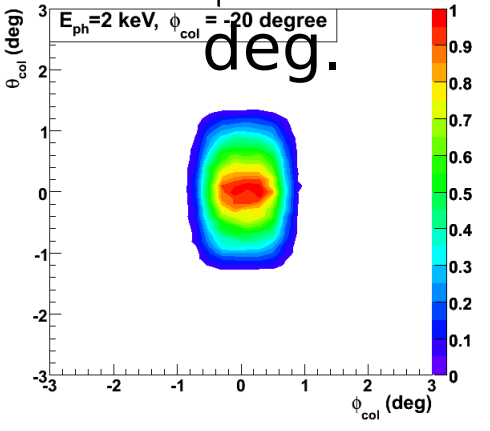
PSF for incident angles

2 keV

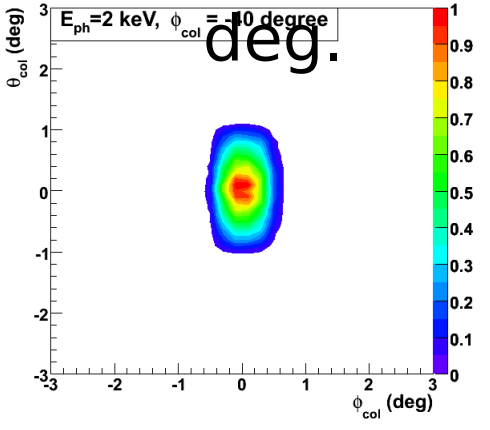
ϕ=2 deg.

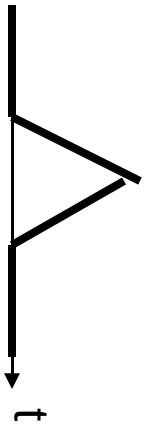


ϕ=20 deg.

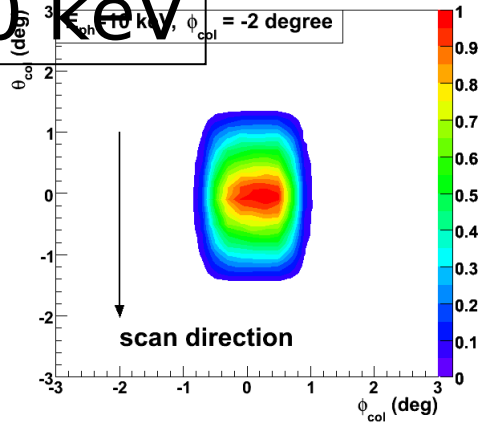


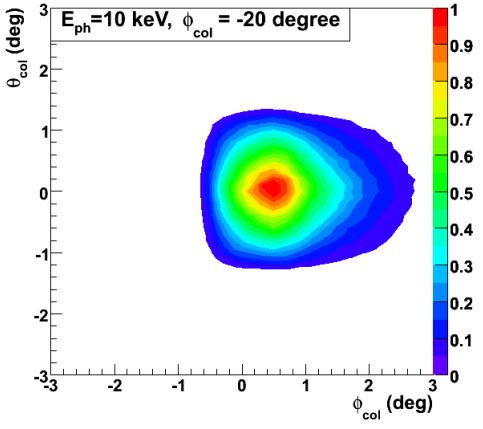
ϕ=40 deg.

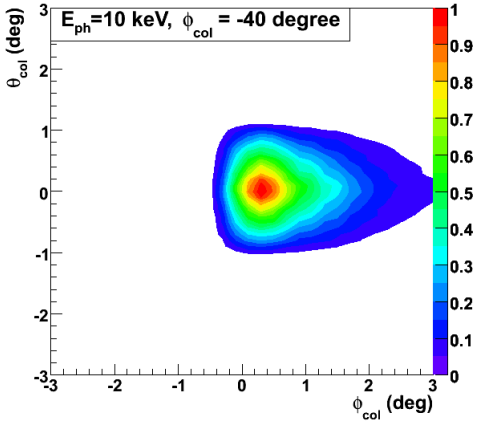


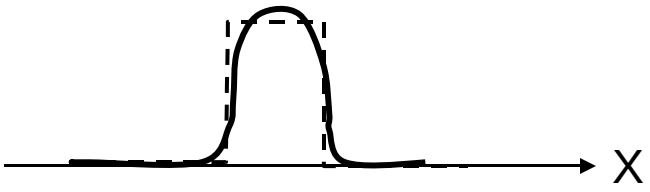


10 keV







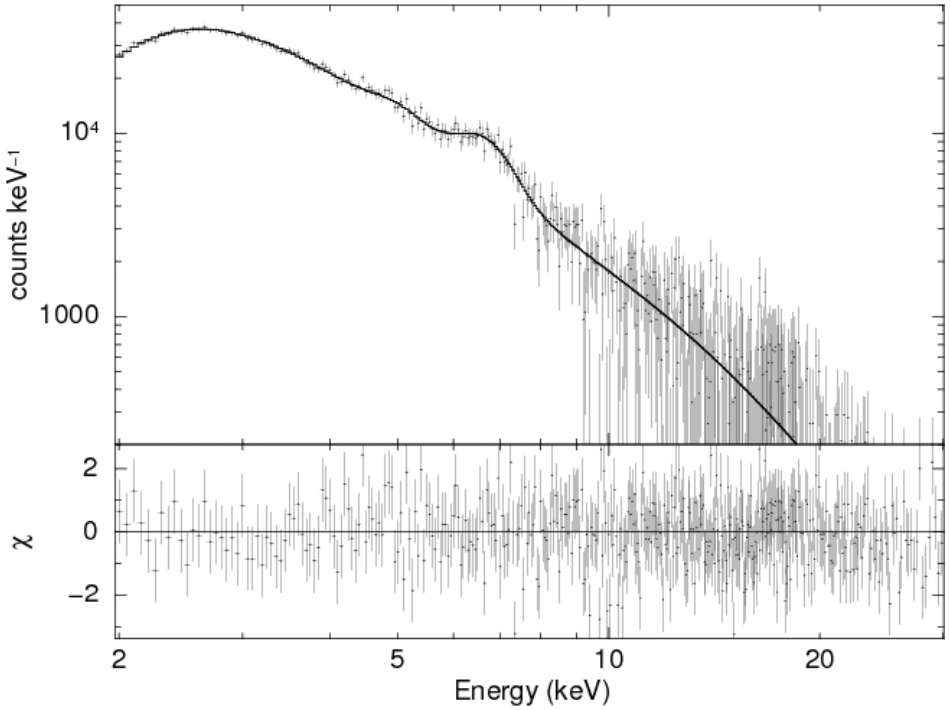


GSC: Energy calibration

Very similar to RXTE/PCA

^{55}Fe isotope: ΔPH/PH~1% in 1 hour -> gain history

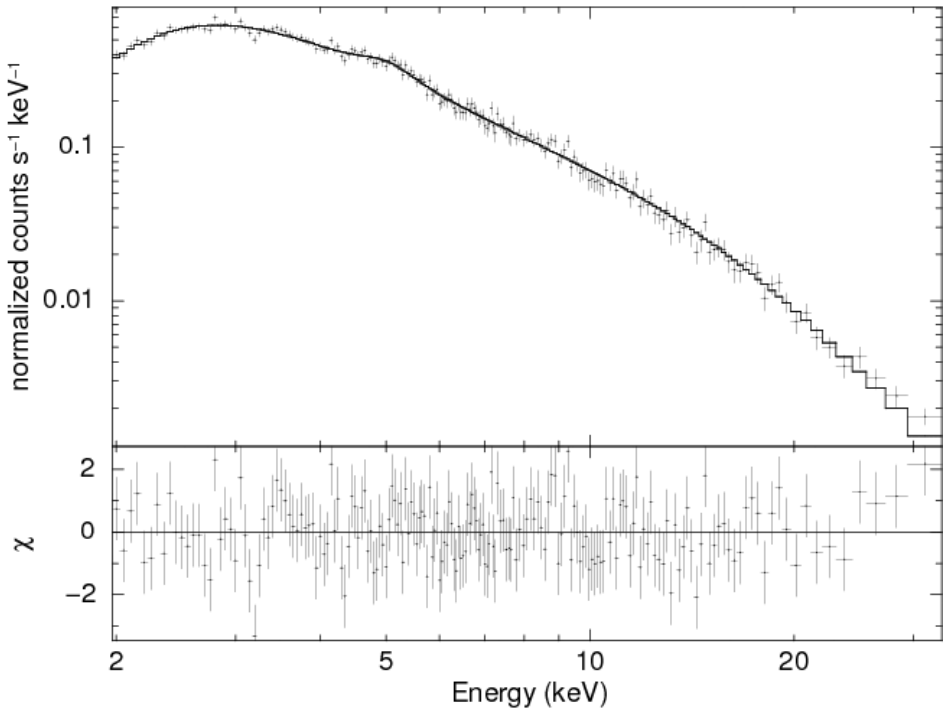
Cas A: 60 days simulation



All anodes and cameras Added.

E = 6.57 ± 0.07 keV

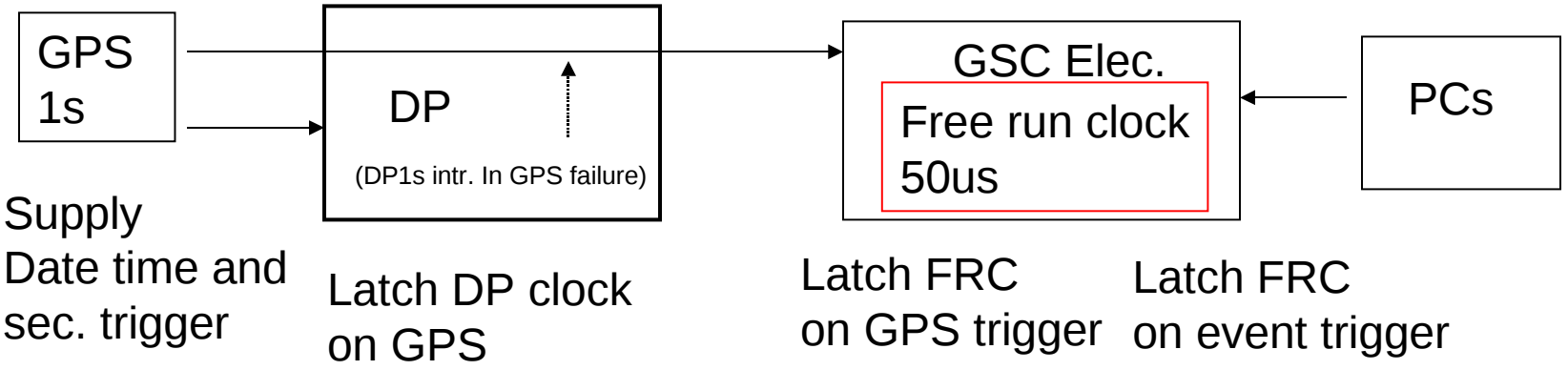
Flux, spectral slope : crab



- 1day simulation
  Γ=2.10, norm=10
- All cameras added
- Γ=2.14±0.03
- Norm=10.5±0.6

Timing of GSC

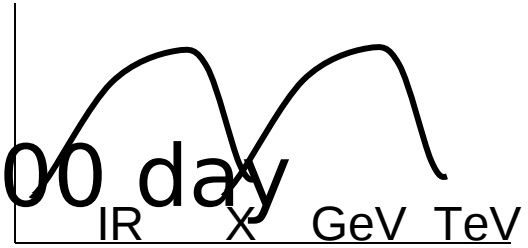
- Timing method

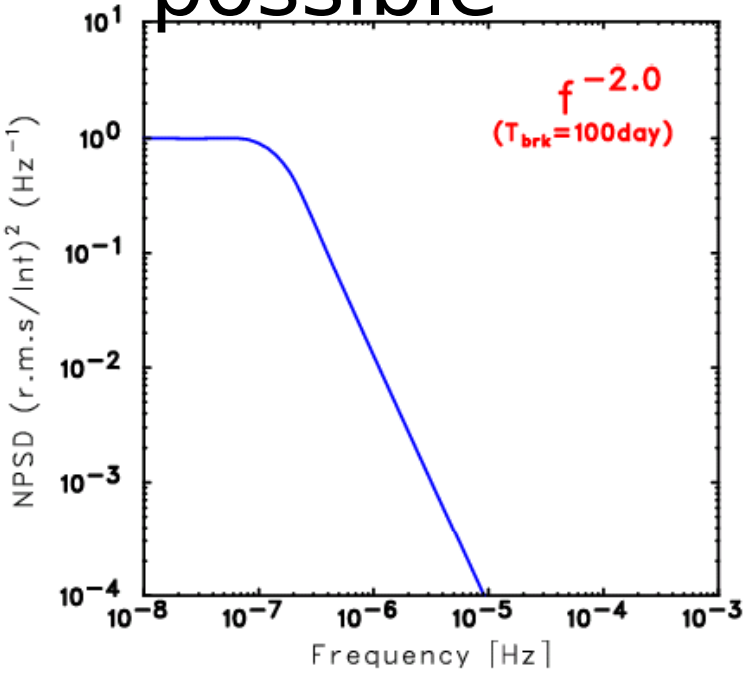


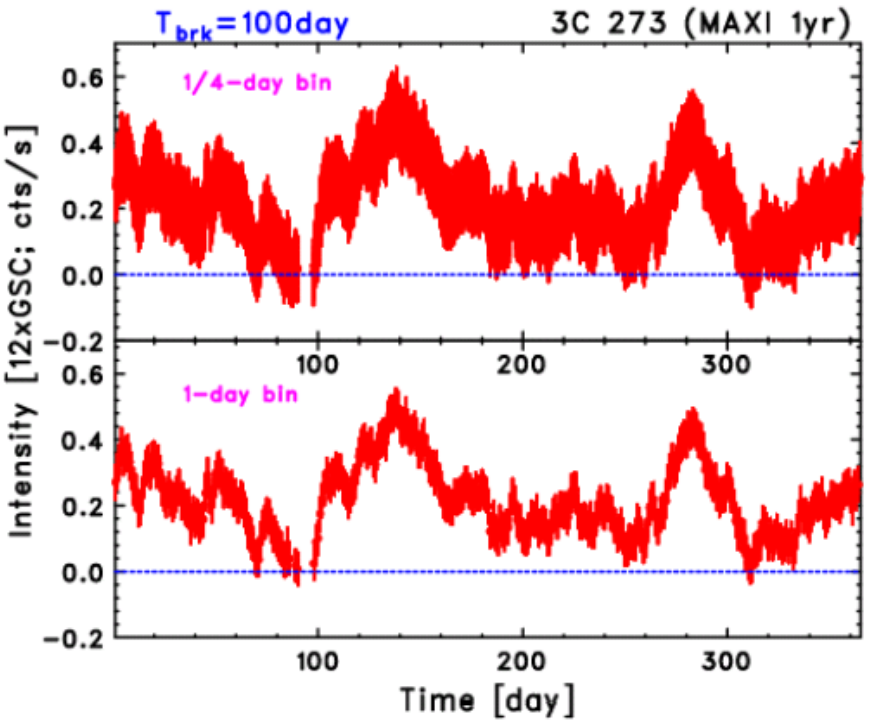
- Timing will be calibrated by Crab pulsar, ms pulsar, binary X-ray pulsars.

Simulation of MAXI-GSC light curve for 3C273

- 5 mCrab variable source
- PSD slope = 2.0, Tbrk = 100 day
- Flux calibration with Blazars possible

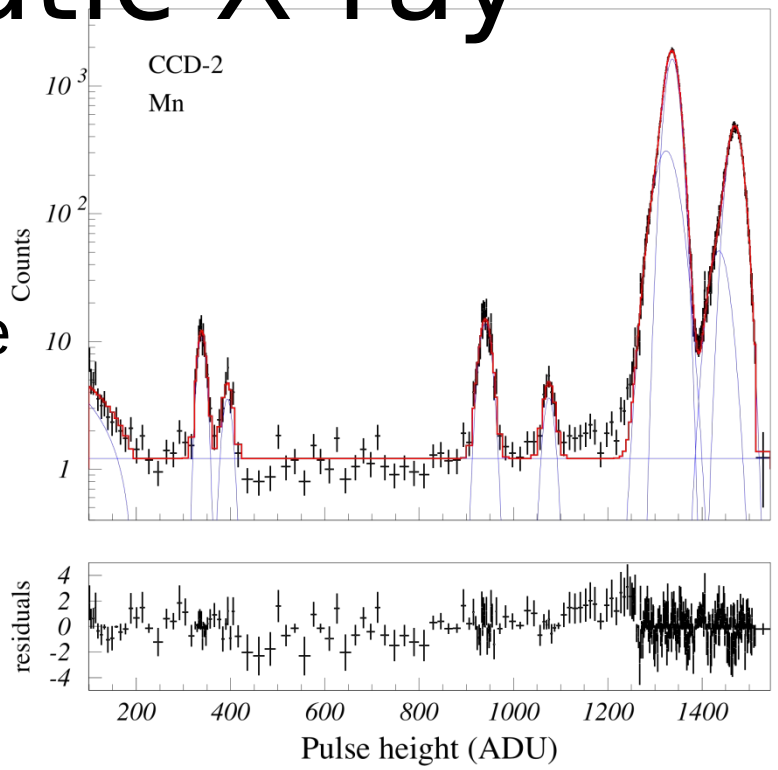


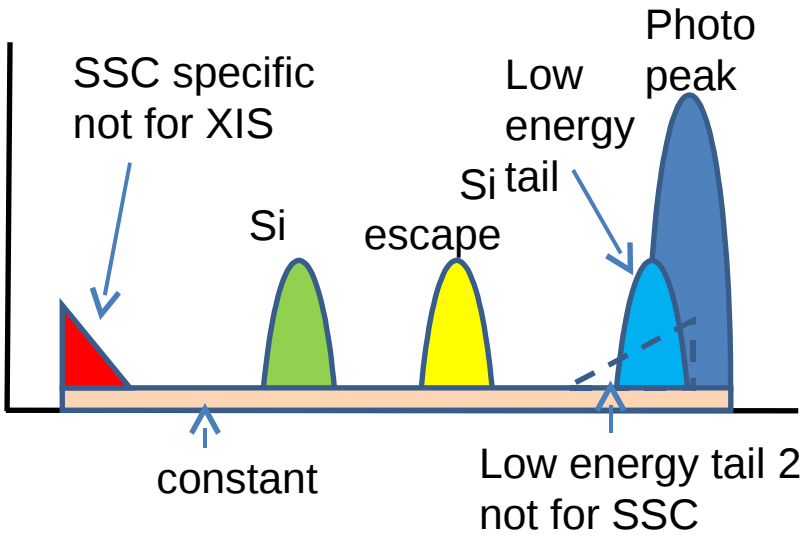




SSC Ground cal: response for monochromatic X-ray

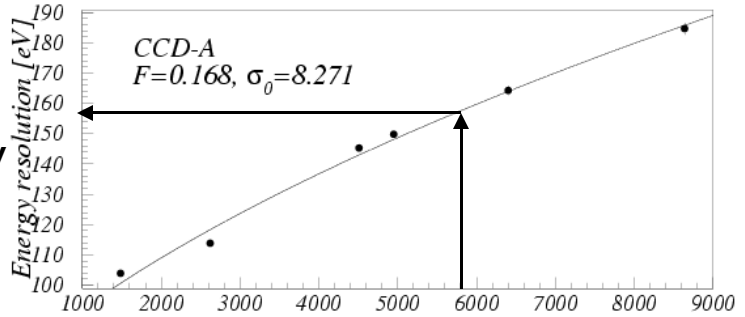
- Fluorescent lines from Al, Si, Cl, Mn, Ti, Fe, Ni, Zn.
- Based on the Suzaku XIS response
- 30 parameters with energy dependence for each CCD.





Energy resolution

~150eV @5.9keV

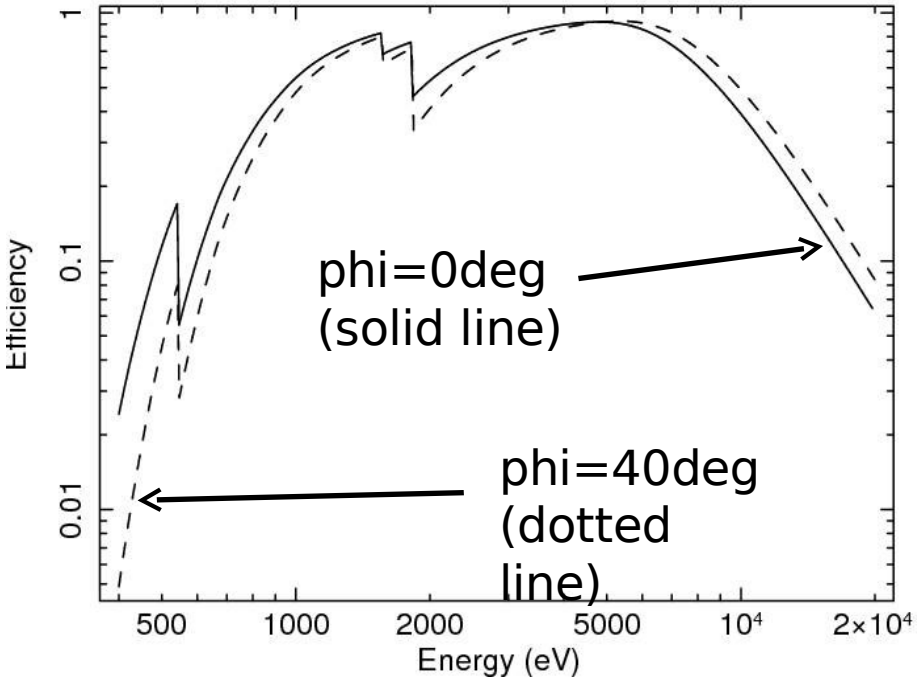


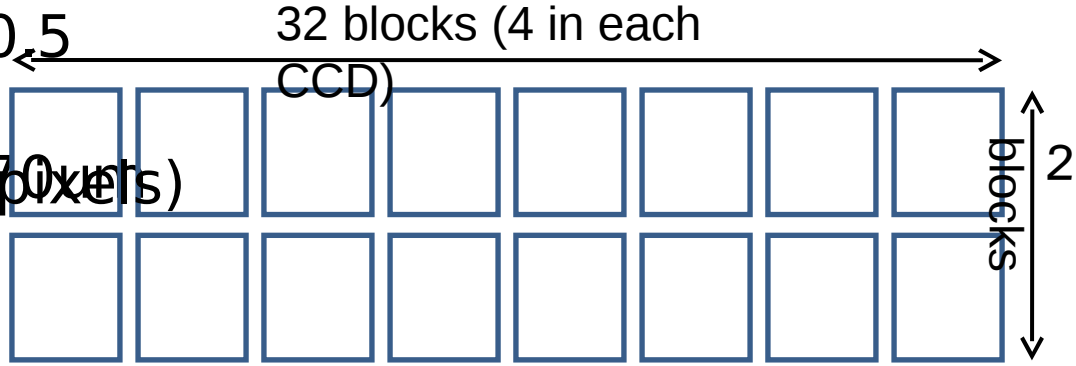
SSC Ground cal: efficiency

- efficiency of CCD: designed values
- depletion layer: measured values

- Al (light blocking): 0.2 um
- Si (electrode) : 0.5 um
- SiO_2(isolation layer) : 0.5 um
- Si (depletion layer) : ~70 um

- Binning is 64 (1024x1024 -> 16x16 pixels)
- Charge injection is ON
- Time resolution is 5.4 s

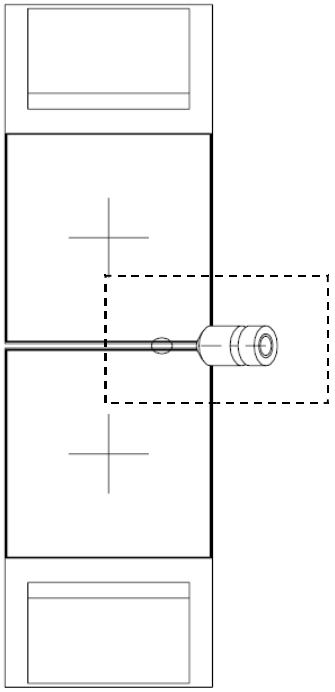


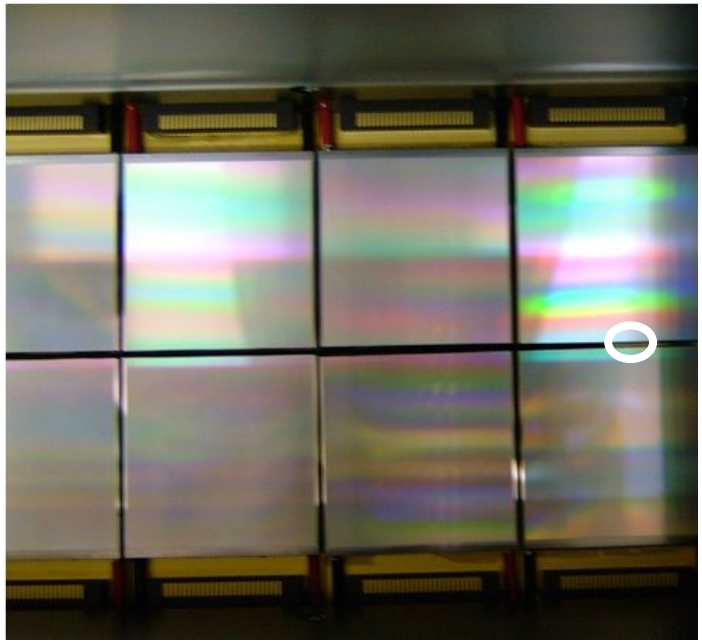


SSC In orbit cal. : isotope

Calibrate CTI by

- Isotopes:
  - ^{55}Fe for 3(4) CC
- X-ray sources:
  - Cas A (Si, S)
  - Cygnus loop (C
- Instrumental:
  - Cu from collimator



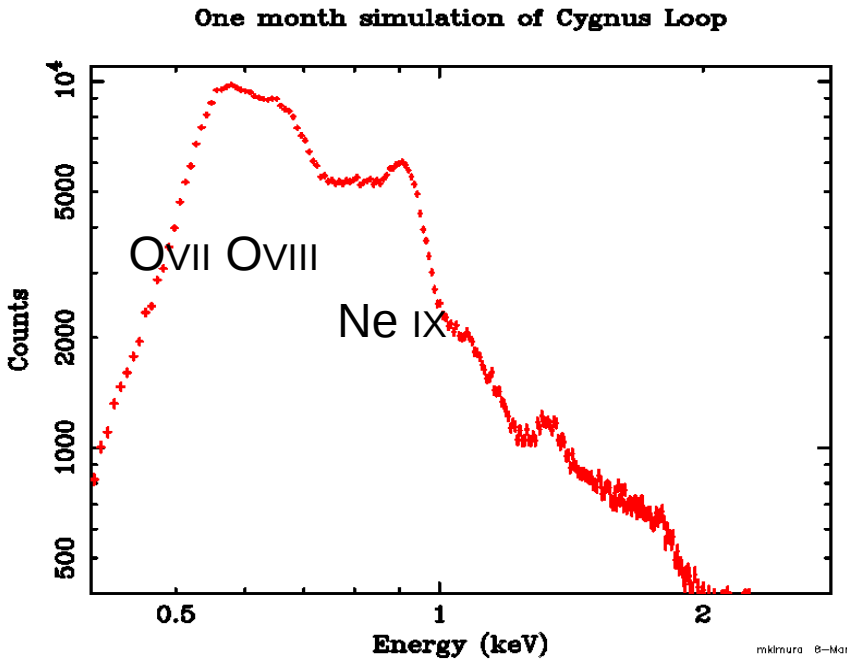


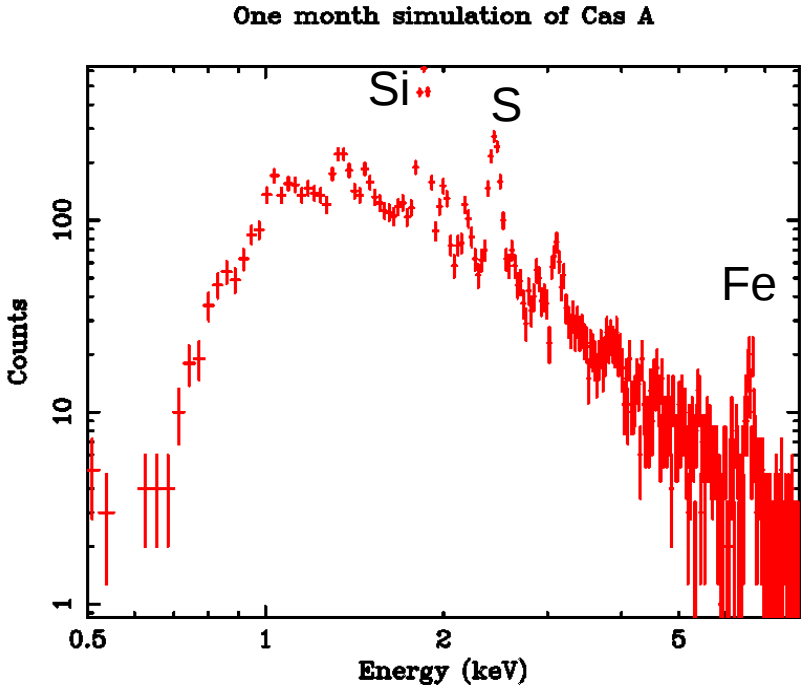
Irradiates 2 of the 16 CCDs

Count rate ~10^4 c/week

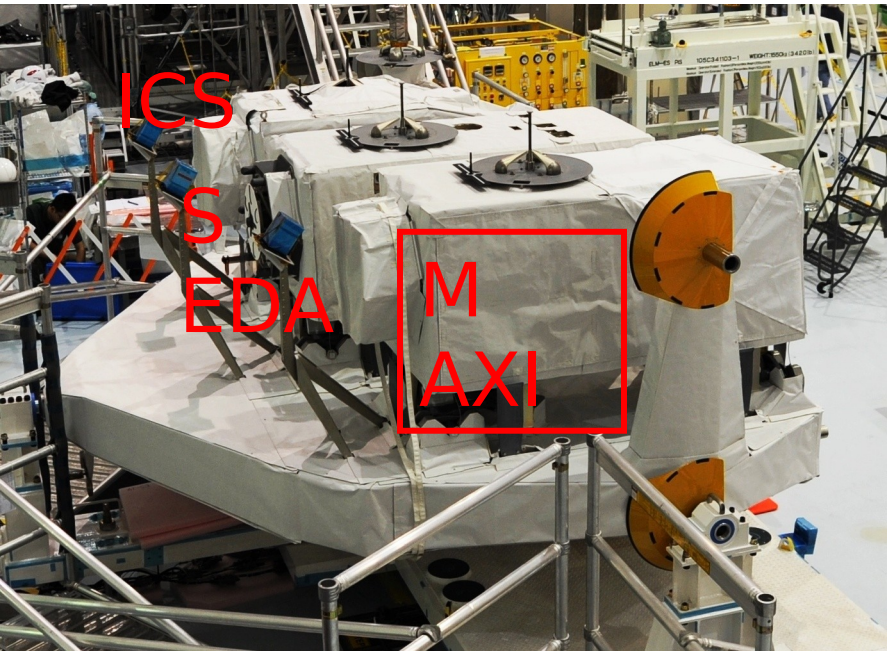
SSC in orbit cal: X-ray sources

- Cygnus Loop
  - diameter : ~3°
  - Strong O, Ne.
  - OVII : 559 ± 4 eV
  - NeIX: 896 ± 1 eV
- Cas A
  - diameter : ~ 6 arcmin
  - Srtong Si, S, Fe lines
  - Well known energies with Suzaku, Chandra, XMM
  - Si-Kα : 1851 ± 3 eV
  - Fe-Kα : 6630 ± 20 eV





Schedule



- ✓ 2007/10 Final integration Completed
- ✓ 2008/9 Final pre-flight tests in Japan
- ✓ 2008/10 Transport to KSC
- ✓ 2008/11 Final pre-flight test at KSC
- ✓ 2009/1 Mounted on Exposed Palette
- ➢ ***2009/6 Launch with Space Shuttle***
  - o Initial Phase, In-orbit calibrations
  - o L+3 months Start releasing

Summary

- MAXI is the first astronomical mission carried on ISS to monitor all-sky X-ray image.
- will be launched in June 13, 2009 by Space Shuttle, Endeavour.
- Effective area is small, but all the sources are observed “all the time”, reaching equivalent to 1ks obs. with PCA in 1 year.
- Any bright sources can be used as cross-calibration.

- After 3 months of the start of the observation of MAXI,
  - Nova alerts will start,
  - Regular science products of pre-selected source will be open

Matsuoka 2009 PASJ submitted. Sugizaki 2009 IEEE submitted.