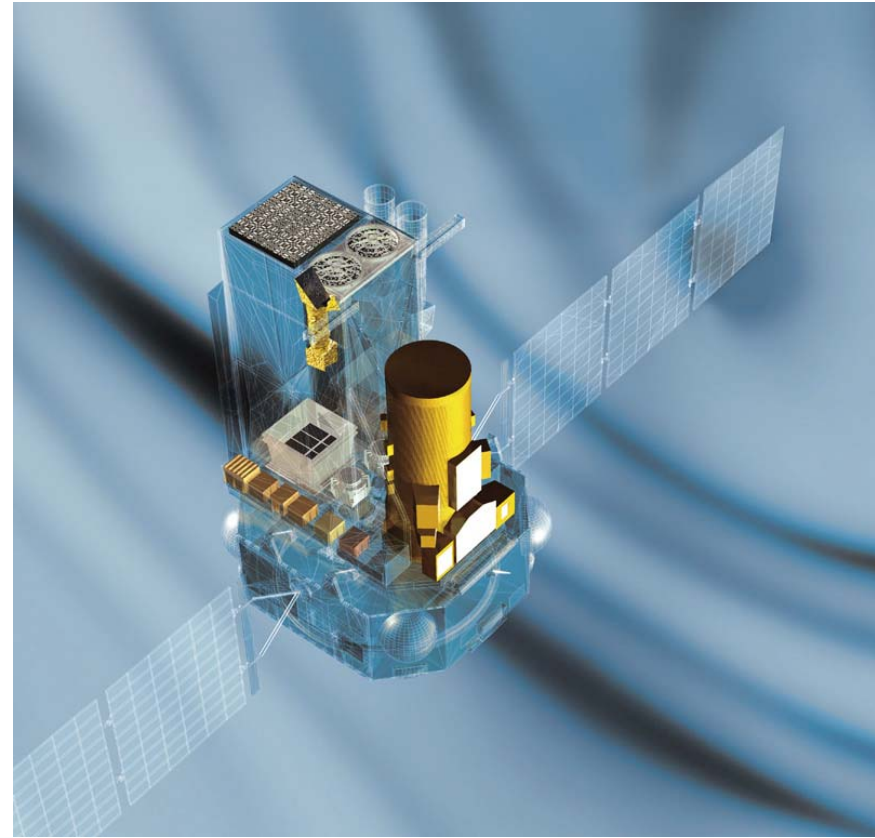


# INTEGRAL: Mission Overview

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- Overview of mission, payload
- Current status, in-orbit performance
- Capabilities for transient monitoring, XRB studies
- AO-1 core & open program plans



# INTEGRAL: Mission Overview

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- Launched successfully, 10/17/02
- Nominal orbit 72 hr, 10,000 km perigee, 150,000 apogee achieved 10/31
- Out gassing, instrument turn on, SPI cooling now complete
- PV Phase begins officially 11/24
  - Cygnus region
- AO-1 starts December 27

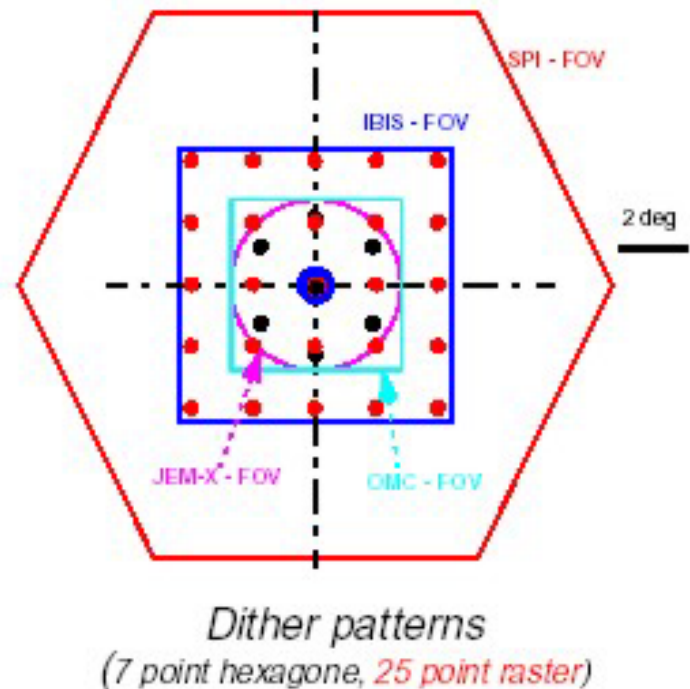


# INTEGRAL Mission

## INTEGRAL SPACECRAFT, LAUNCHER & ORBIT

- Spacecraft = service module (XMM) + payload module, launch mass ~ 4000 kg
- PROTON, launch date: 25 Oct 2001 from Baikonur Cosmodrome
- Mission life: 2 y nominal, 5 y extended
- Orbit: 72 hours,  $51.6^\circ$ , (initial) height of perigee x apogee = 10 000 km x 153 000 km
- Fixed solar arrays: sun (and anti-sun) avoidance cone  $50^\circ$  (2 y,  $60^\circ$ : 3-5 y)
- Science observations > ~ 40000 km (but radiation monitor on-board)

- Datarate: 85.8 kbps (science TLM including instrument housekeeping)
- S/c will perform **dithering** (“off-source-pointings”) manoeuvres during nominal operations

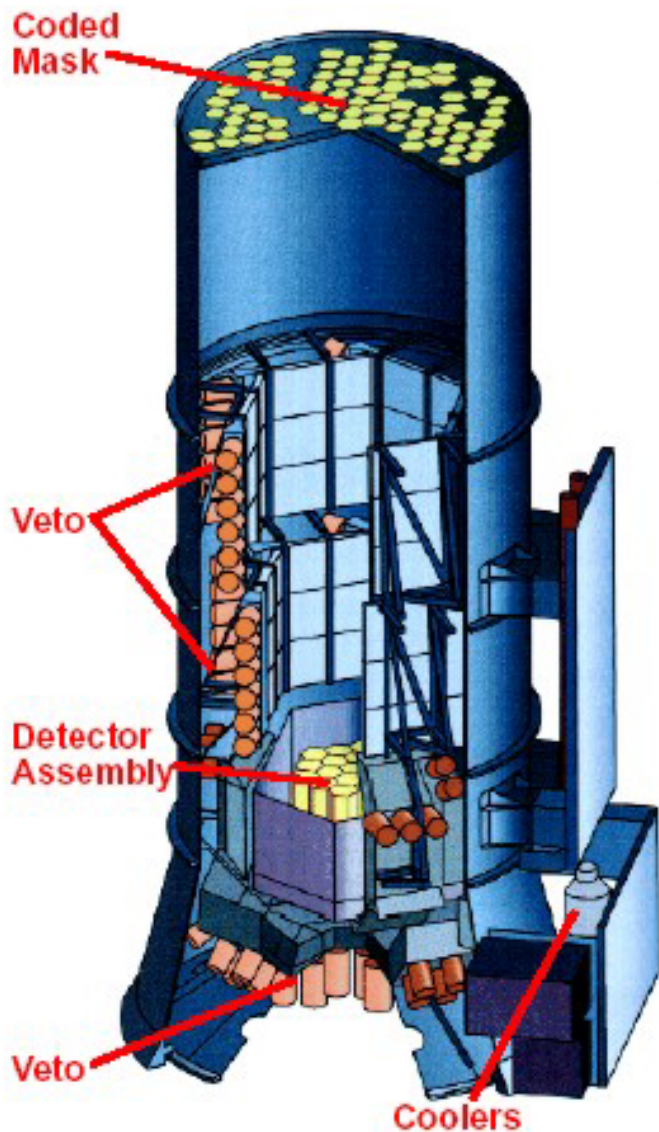


# INTEGRAL Scientific Payload

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- **Instruments, Acronyms & PIs, Lead Institutions:**
  - **SPI** – Spectrometer with cooled Ge detectors, coded mask, active shield
    - PIs( J.-P. Roques, CCSR and V. Schoenfelder, MPE Garching)
  - **IBIS** – Imager with two detector layers (CdTe ,CsI arrays, 16000/4000 pixels), coded mask
    - PIs(P. Ubertini, IAS;F. Lebrun,G. DiCocco, ITESRE).
  - **JEM-X** - X-ray monitor with microstrip proportional counter coded mask
    - PI: (N. Lund, DSRI,)
  - **OMC** -Optical Monitor CCD camera
    - PI: (M. Mas-Hesse, LAEFF-INTA).

# Instruments: SPI



## SPECTROMETER (SPI)

20 keV - 8 MeV

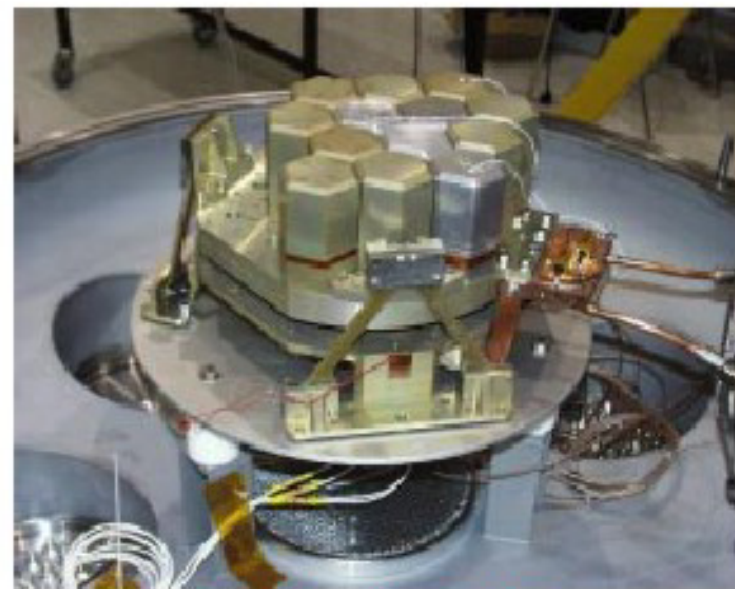
19 Ge detectors (energy resolution: 2 keV @ 1 MeV)

16 deg fully coded FOV

Line sensitivity:  $5 \times 10^{-6}$  ph  $\text{cm}^{-2} \text{s}^{-1}$  @ 1 MeV

1300 kg, 370 W, 20 kbps

PI institutes: CERN Toulouse (F), MPE Garching (D)



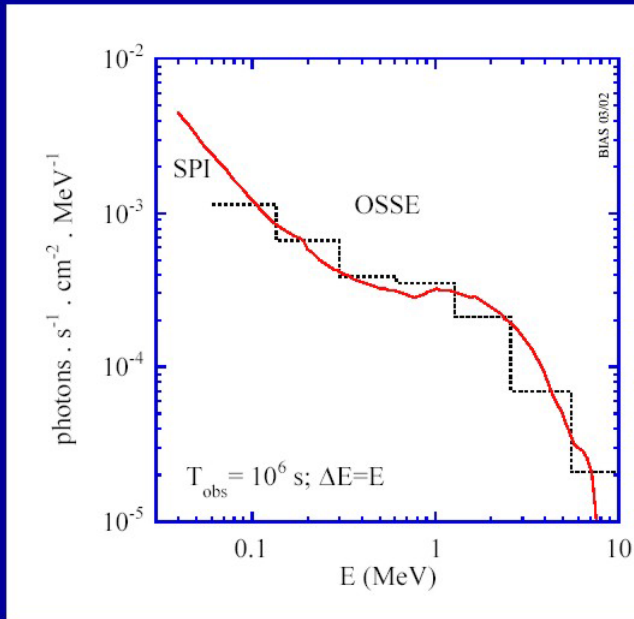
Detector plane (EM)



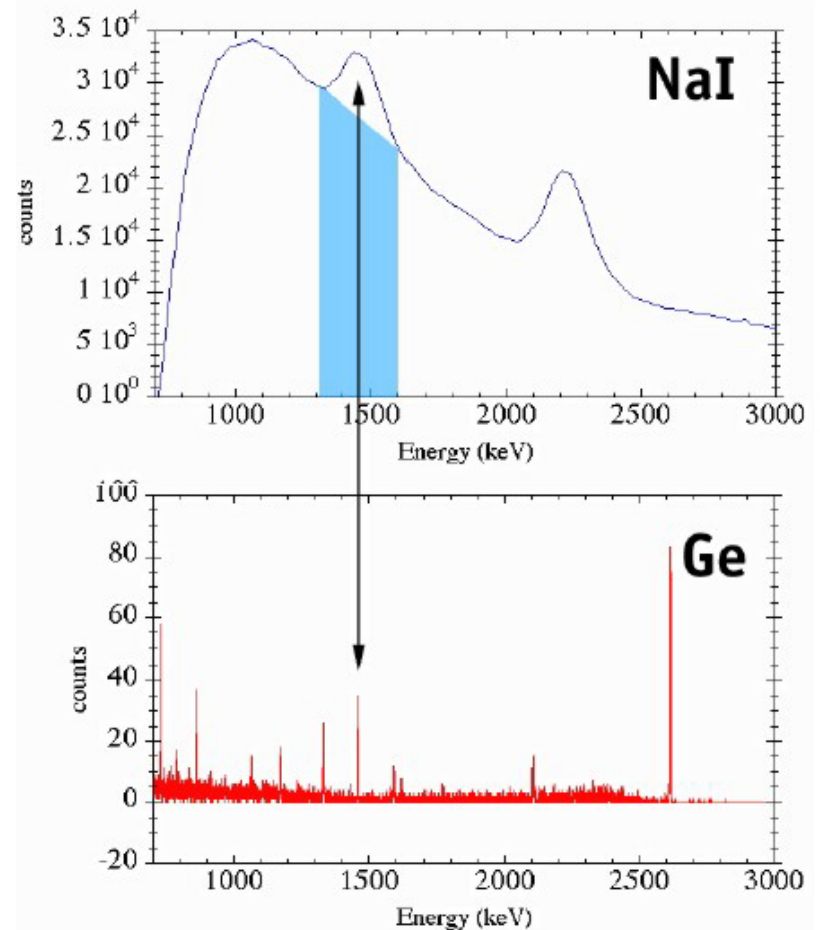
# Instruments: SPI

- Important to note that INTEGRAL's primary advancement from spectral (and spatial) *resolution*.
- 10-20X improvement for lines!

## Updated continuum sensitivity



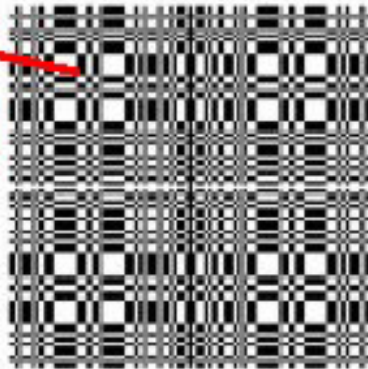
$$\text{sensitivity} \propto \sqrt{N_{bgd} + N_{source}}$$



# Instruments: IBIS

## IMAGER (IBIS)

Coded Mask  
(top view,  
mask @ 3.2 m  
above det plane)



15 keV - 10 MeV

16384 CdTe dets & 4096 CsI dets

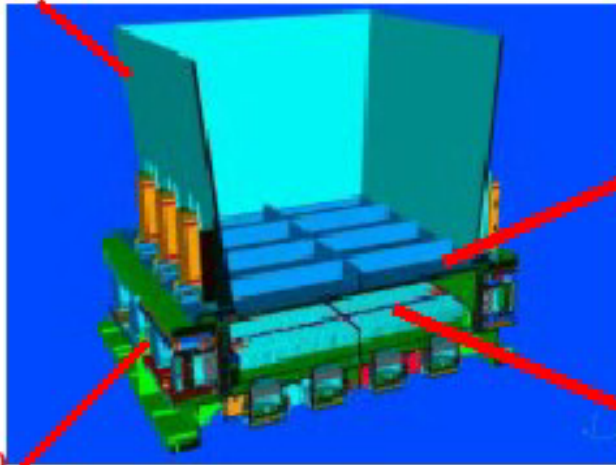
9 x 9 deg fully coded FOV, angular res.: 12 arcmin

Cont sensitivity:  $4 \times 10^{-7}$  ph cm<sup>-2</sup> s<sup>-1</sup> @ 0.1 MeV

630 kg, 275 W, 57 kbps

PI institutes: IAS Rome (I), CEA-Saclay (F),  
ITESRE Bologna (I)

Shield



CdTe

CsI

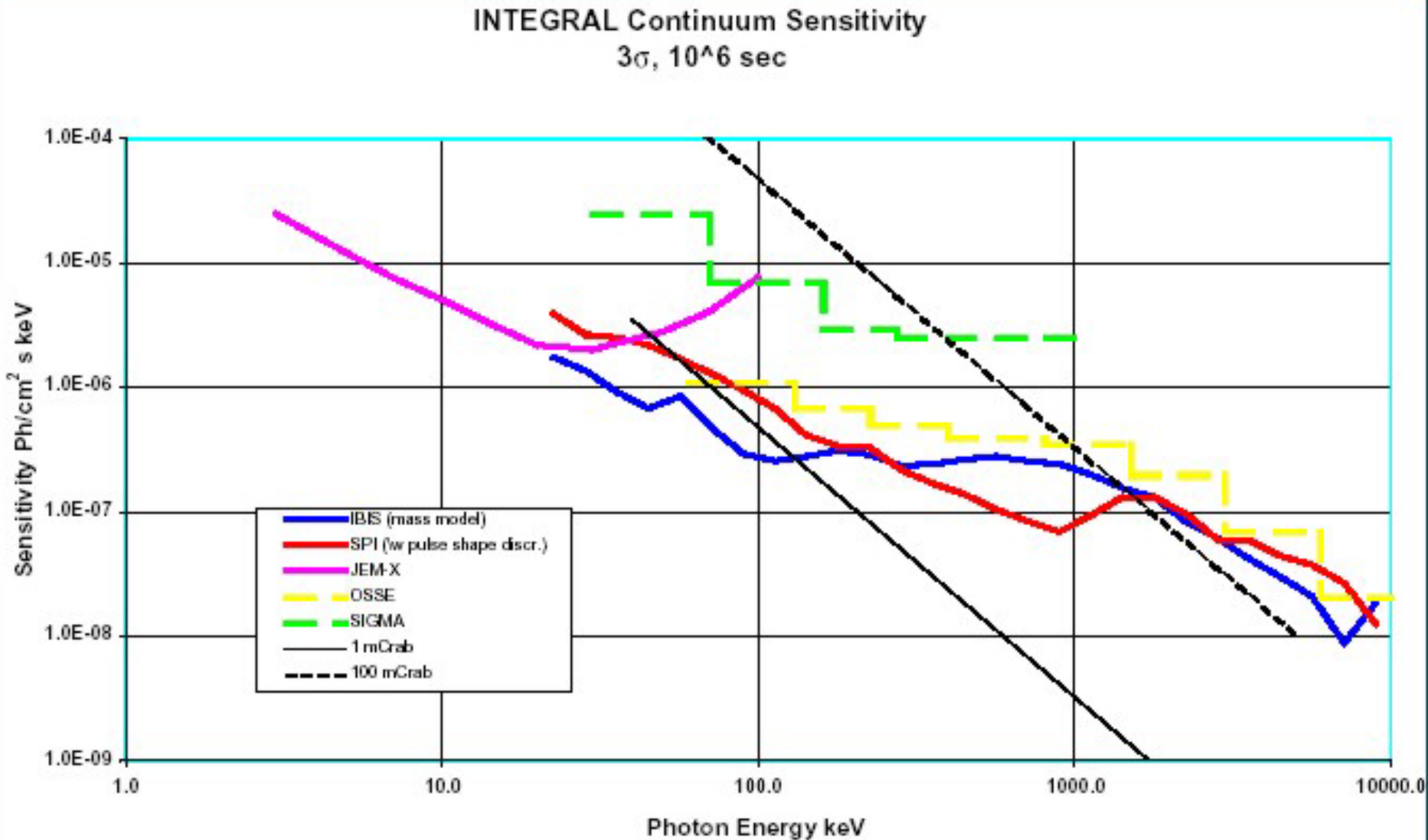
Veto

Detector  
Assembly



Detector assembly (STM)

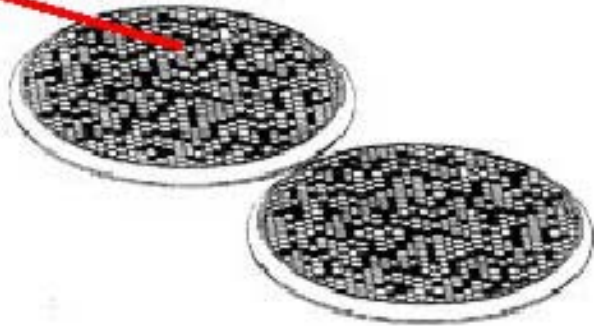
# Instruments: IBIS



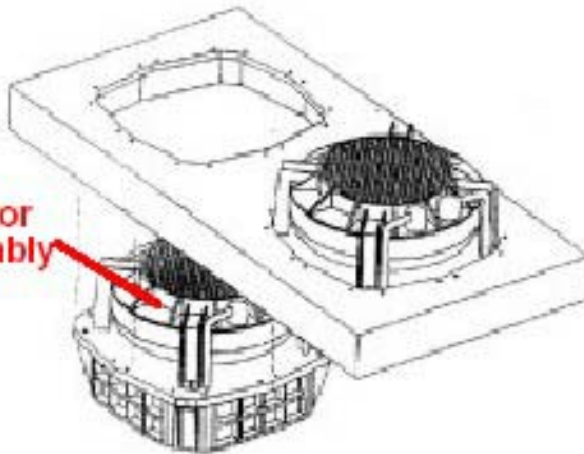


# Instruments: JEM-X

Coded  
Mask  
(3.2 m above det assy)



Detector  
Assembly



## X-RAY MONITOR (JEMX)

3 keV - 35 keV

Microstrip Xe-gas detector

4.8 deg fully coded FOV (angular res.: 3 arcmin)

Cont. sensitivity:  $1 \times 10^{-5}$  ph cm<sup>-2</sup> s<sup>-1</sup> @ 6 keV

65 kg, 55 W, 7 kbps

PI institute: DSRI Copenhagen (DK)



Detector assembly (STM)

# Instruments: OMC

## OPTICAL MONITOR (OMC)

500 nm - 600 nm

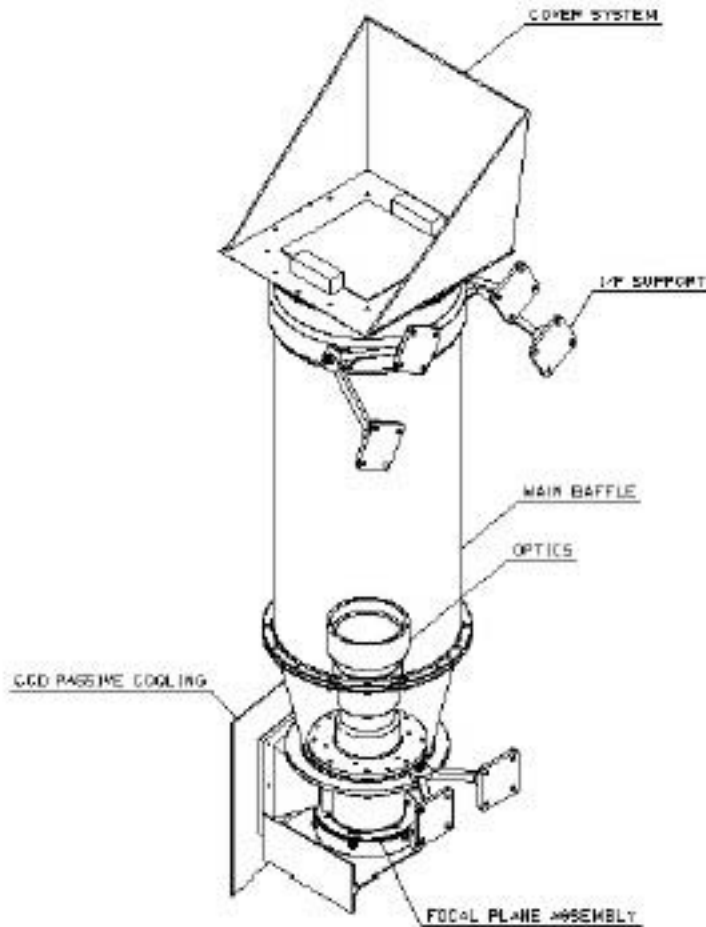
CCD (2048 x 1024 pixels) + V-filter

5 x 5 deg FOV, 17.6"/pixel

Sensitivity: 19.7 mag (V)

17 kg, 18 W, 2 kbps

PI institute: INTA/LAEFF Madrid (E)



# Performance Summary

Table 1: INTEGRAL payload: key parameters

	SPI	IBIS	JEM-X	OMC
Energy range	20 keV - 8 MeV	15 keV - 10 MeV	3 keV - 35 keV	500 nm - 600 nm
Detector/characteristics	19 Ge detectors (each 6 x 7 cm), cooled @ 85K	16384 CdTe dets (each 4 x 4 x 2 mm), 4096 CsI dets (each 9 x 9 x 30 mm)	Microstrip Xe-gas detector (5 bar)	CCD + V-filter
Detector area (cm <sup>2</sup> )	500	2600 (CdTe) 3100 (CsI)	2 x 500	2048 x 1024 pixel
Spectral resolution	2 keV @ 1.3 MeV	7 keV @ 100 keV	1.5 keV @ 10 keV	--
Field of view (fully coded)	16°	9° x 9°	4.8°	5° x 5°
Angular resolution (FWHM)	2°	12'	3'	17.6"/pixel
10 $\sigma$ source location	20'	< 1'	< 30"	< 8"
Continuum sensitivity*	7x10 <sup>-8</sup> @ 1 MeV	4x10 <sup>-7</sup> @ 100 keV	1x10 <sup>-5</sup> @ 6 keV	19.7 m (10 <sup>3</sup> s)
Line sensitivity*	5x10 <sup>-6</sup> @ 1 MeV	1x10 <sup>-5</sup> @ 100 keV	2x10 <sup>-5</sup> @ 6 keV	--
Timing accuracy (3 $\sigma$ )	100 $\mu$ s	67 $\mu$ s - 1000 s	128 $\mu$ s	> 1 s
Mass (kg)	1309	628	65	17
Power (W)	373	275	55	18
Data rate (kbps)	20	57	7	2
*Sensitivities are 3 $\sigma$ in 10 <sup>6</sup> s, units: ph/(cm <sup>2</sup> s keV) [cont.] and ph/(cm <sup>2</sup> s) [line]				

# First Science Result: GRB 021027

- SPI ACS:  
~90 BGO  
crystals
- CR  $\sim 5 \times 10^4$   
cts/sec
- GRB time  
profiles  
– IPN node

## First GRB (GRB 021027) seen by ACS of SPI

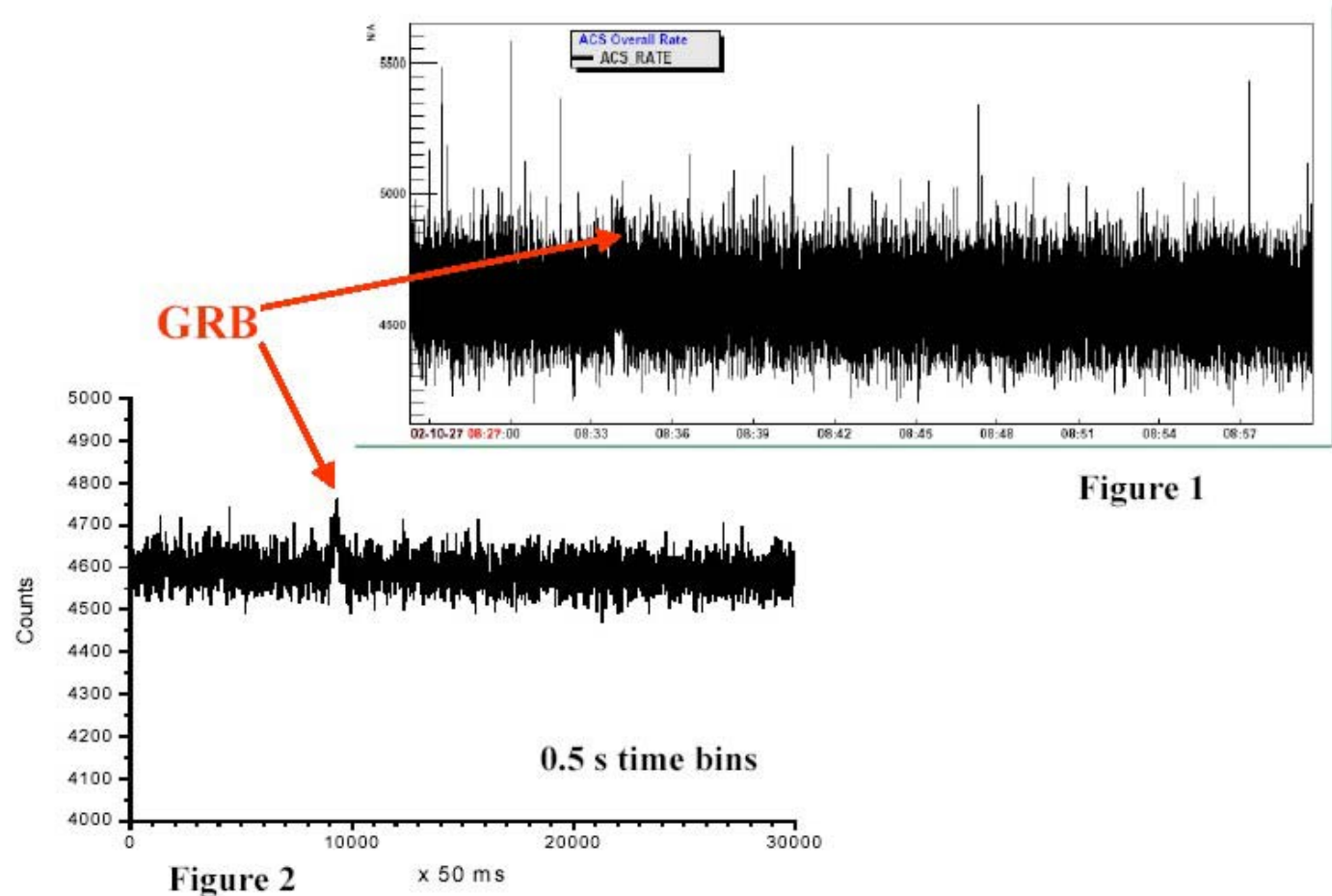


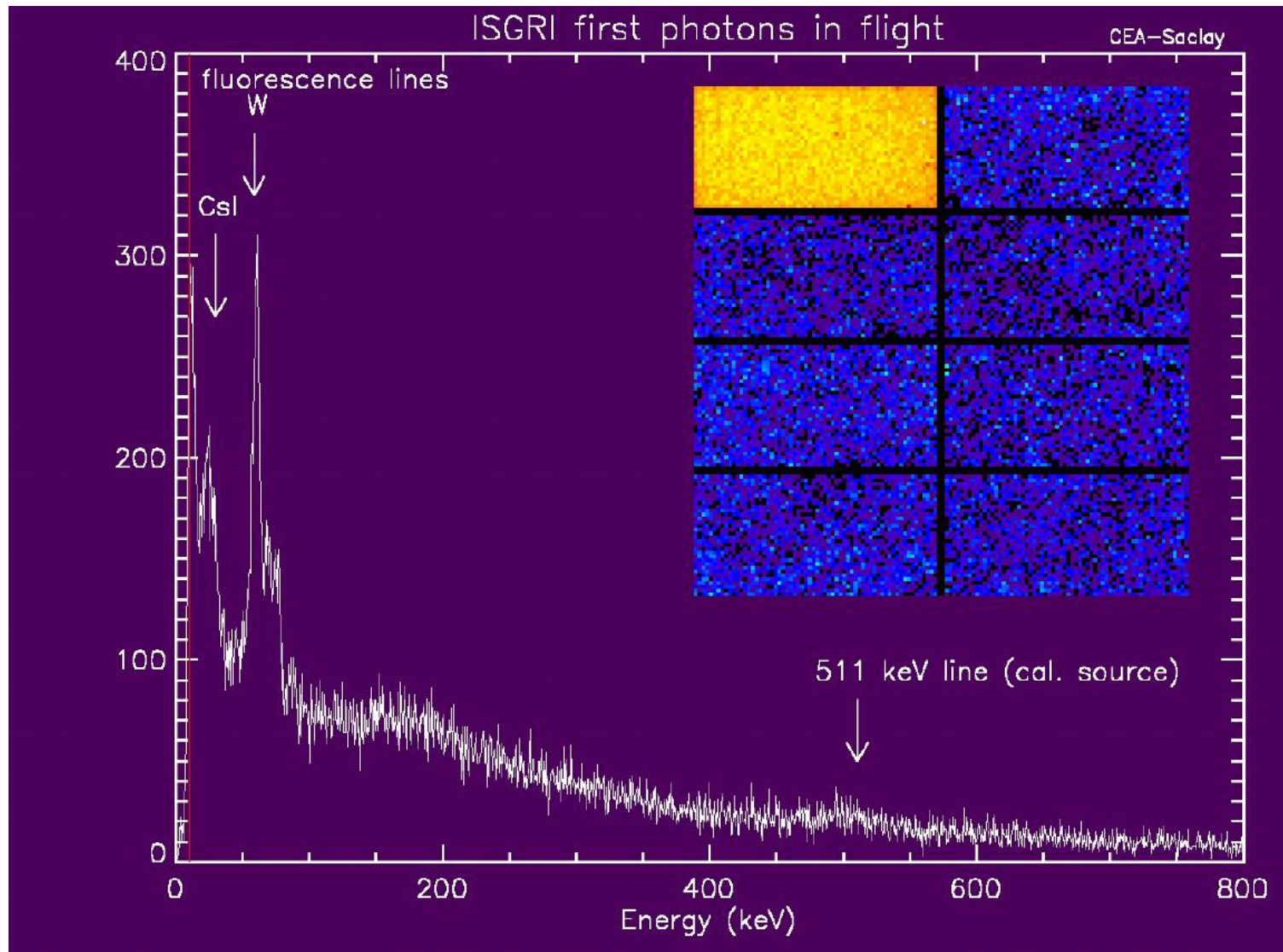
Figure 1

Figure 2



# Early In-flight Performance: IBIS

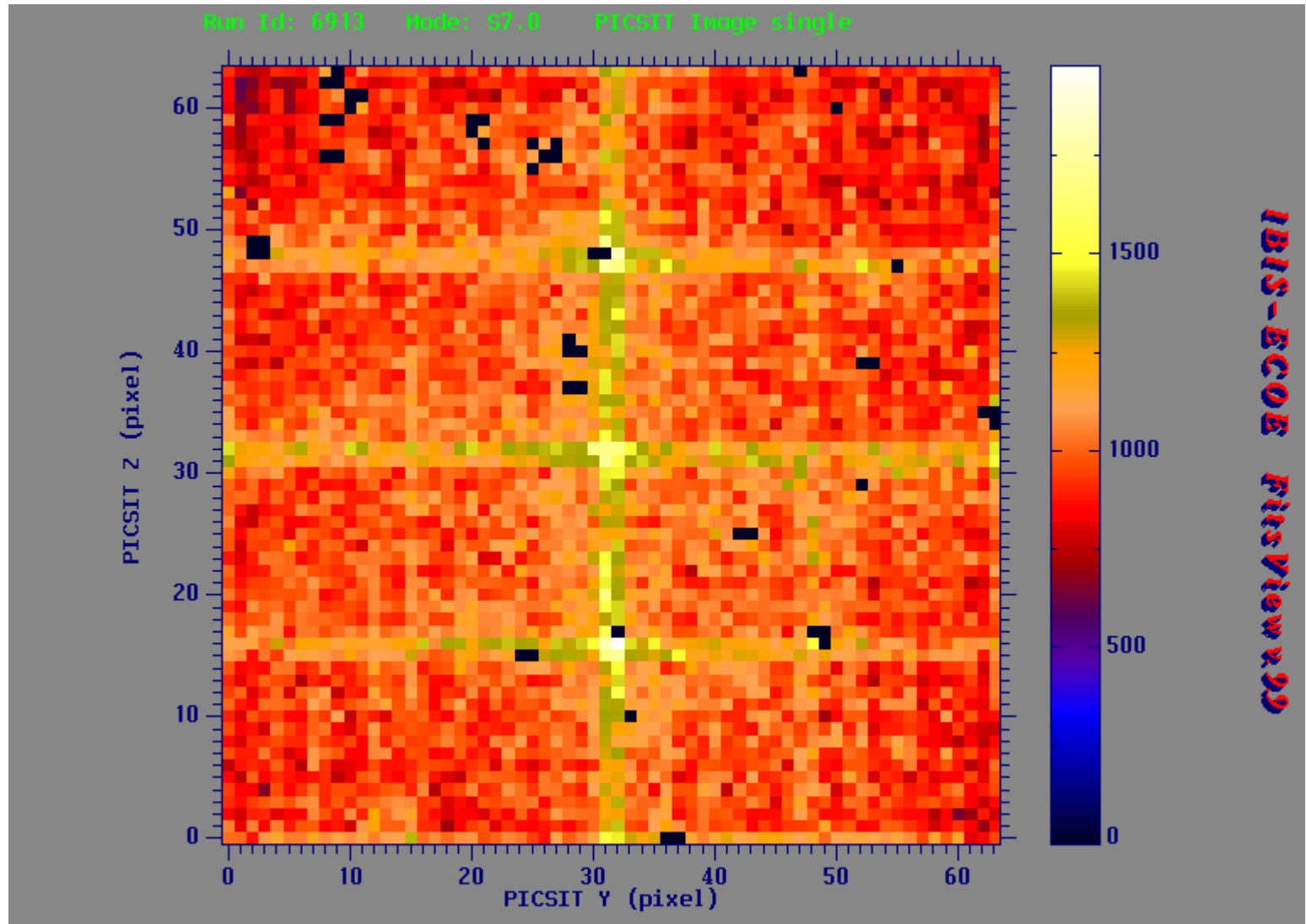
- ISGRI 1st light image (1 subsection active)
- Instrumental & onboard calibration lines measured





# Early In-flight Performance: IBIS

PICSIT  
1st light  
image:  
0.18-5.0  
MeV,  
11/7/02,  
blank sky  
field

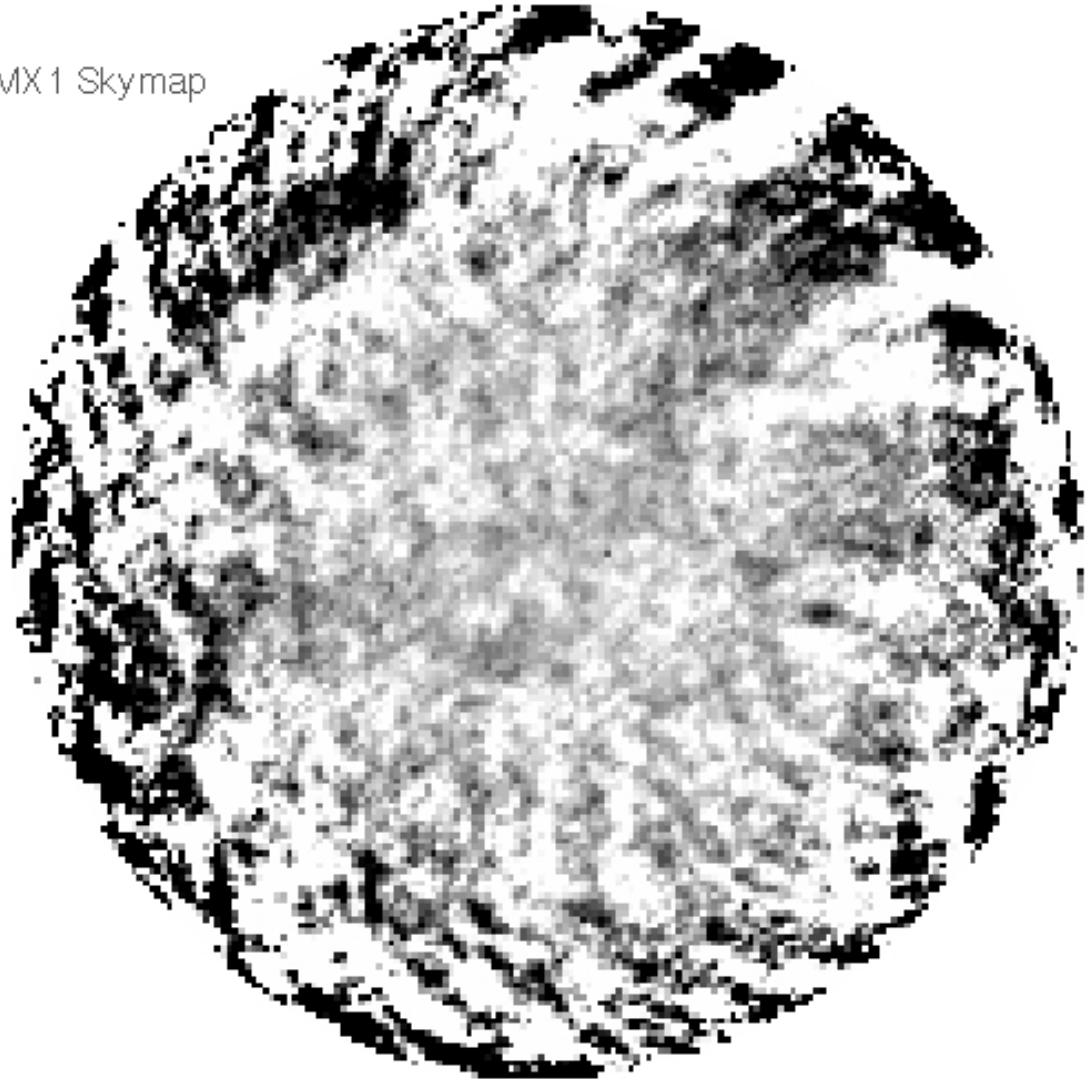


# Early In-flight Performance: JEM-X

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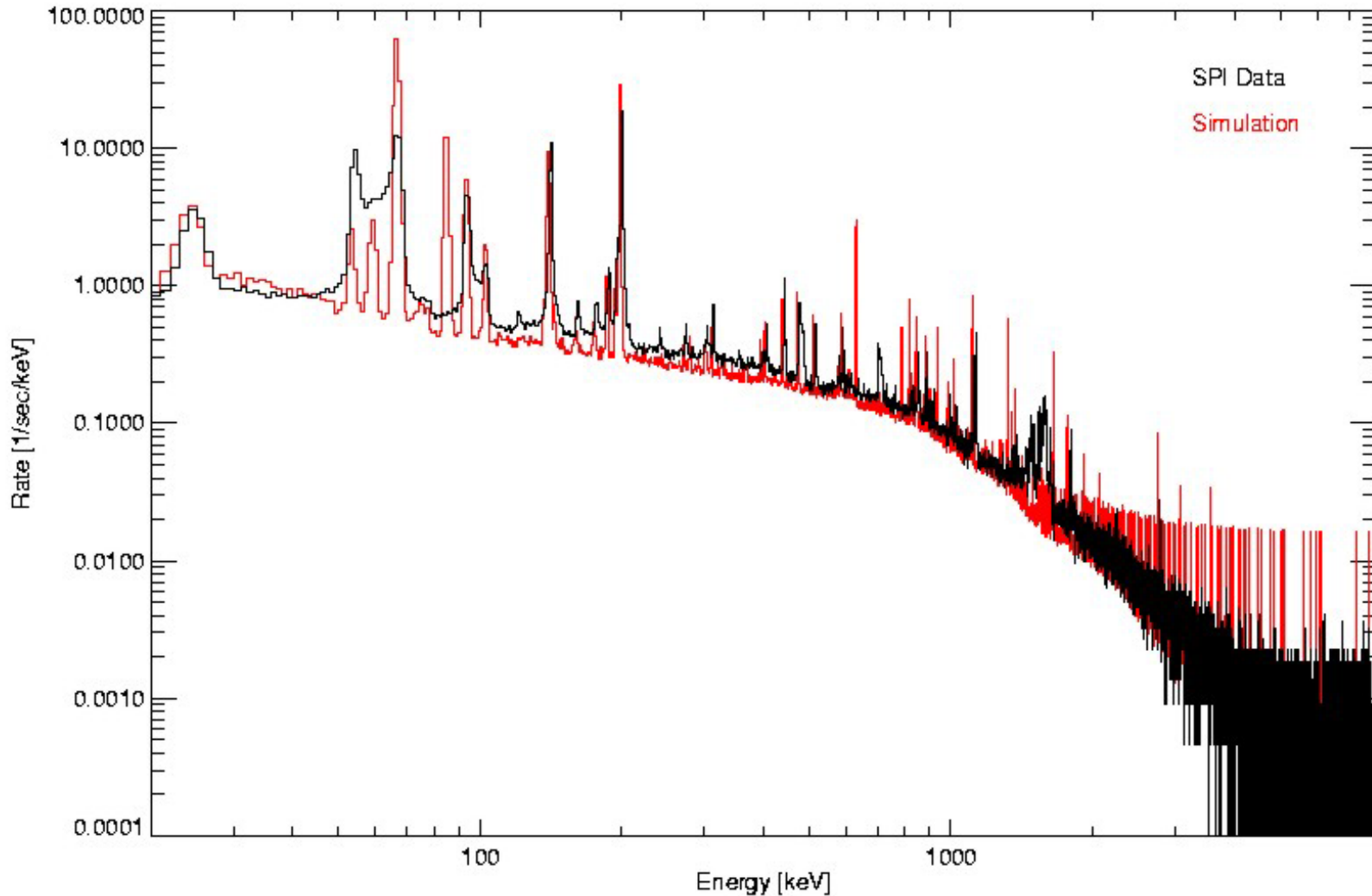
JEMX1 Skymap

JEM-X:  
Image of  
Centaurus  
region;  
Cen X-3 is  
detected  
(central  
bright  
pixel)

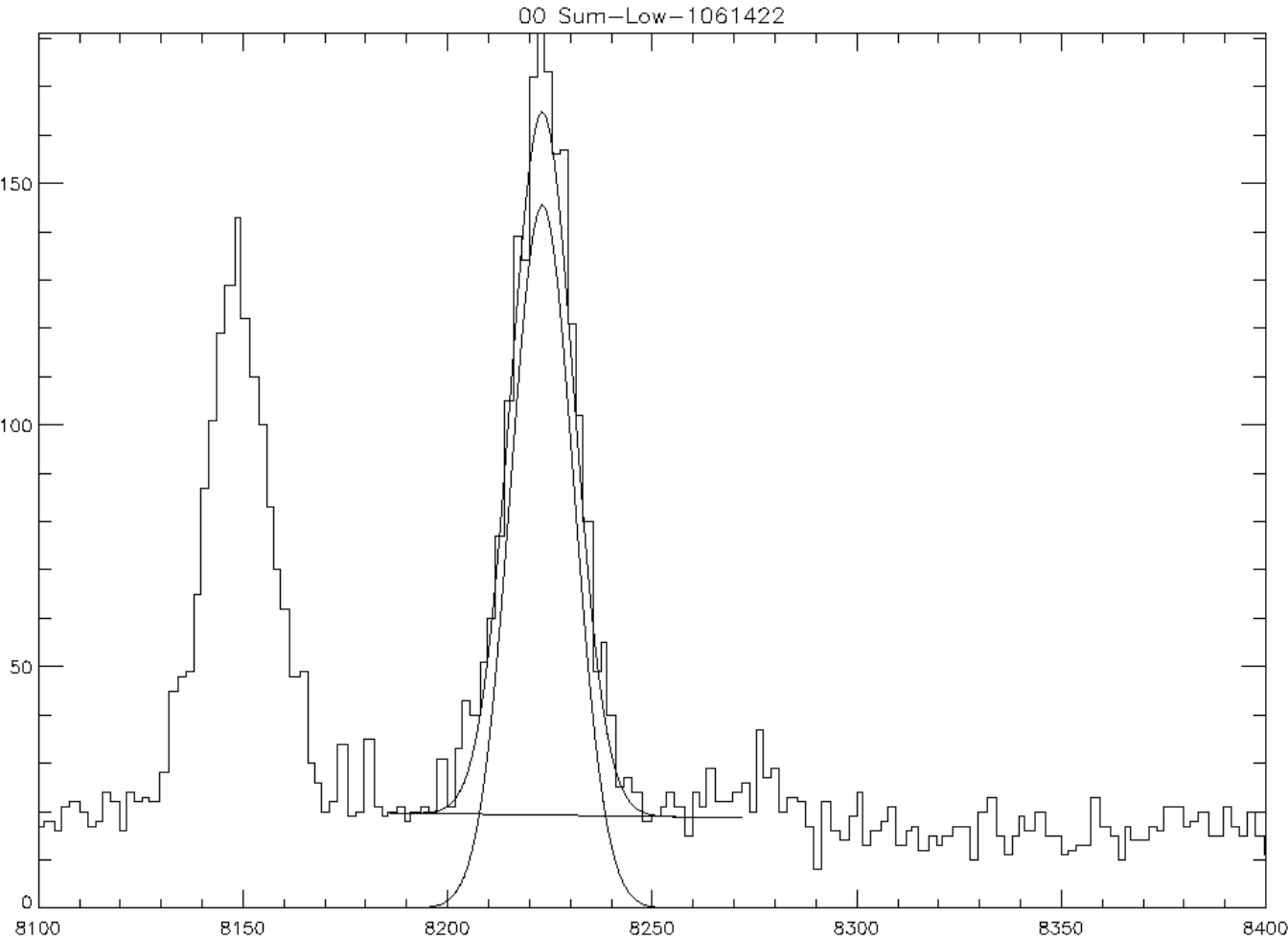


# Early In-flight Performance: SPI

SPI  
background  
spectrum,  
 $T_{ge} \sim 110K$ ,  
 $HV \sim 1000v$   
  
red curve  
is MC  
simulation



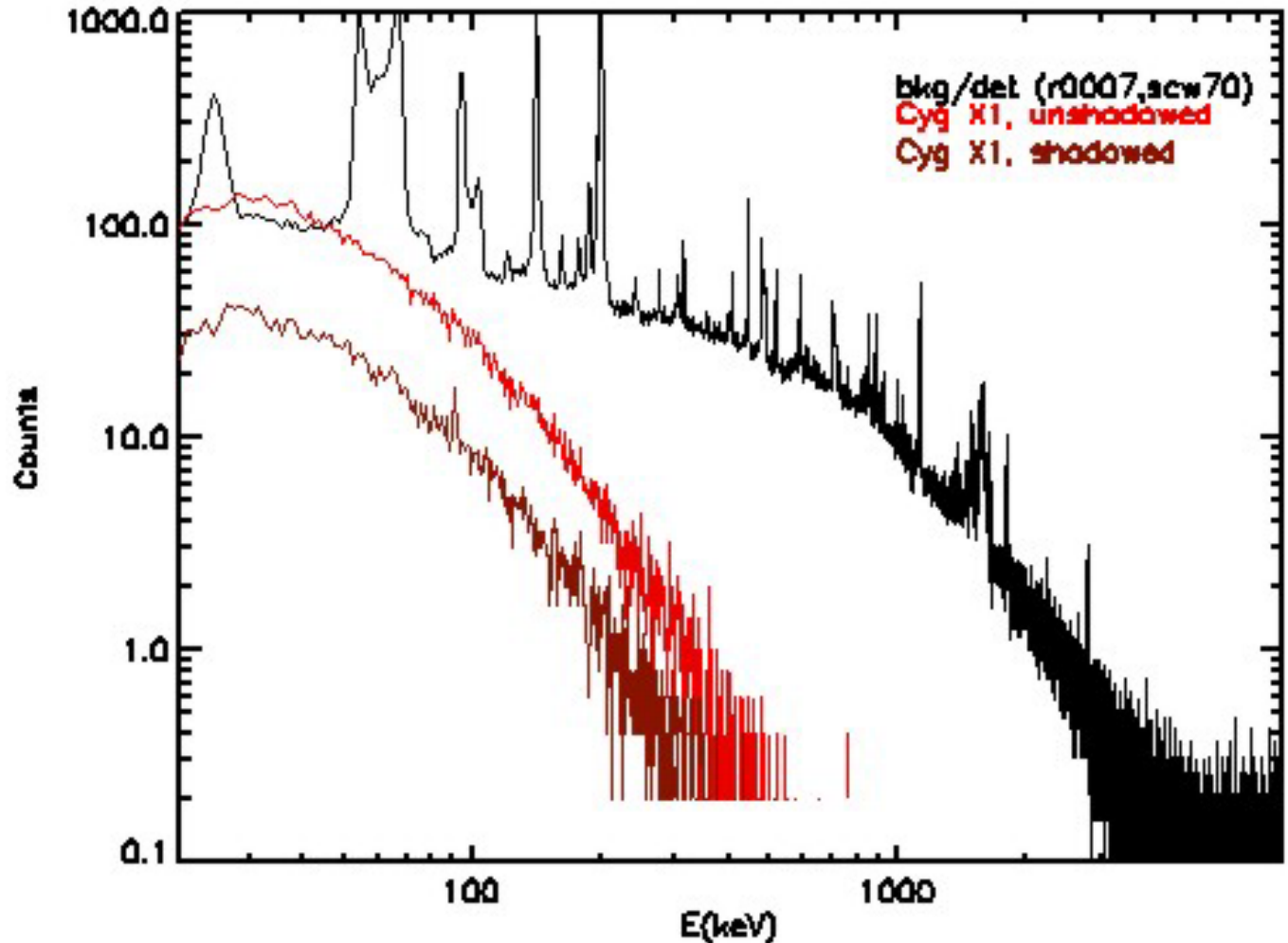
# Early In-Flight Performance: SPI



- 11/11/02:  
 $T_{\text{Ge}} \sim 100\text{K}$ ,  
 $\text{HV} \sim 4000\text{ V}$
- $^{69}\text{Ge}$   
background line  
at 1117.1 keV
- FWHM  $\sim 2.3$   
keV, thus  
within nominal  
spec

# Early In-Flight Performance: SPI

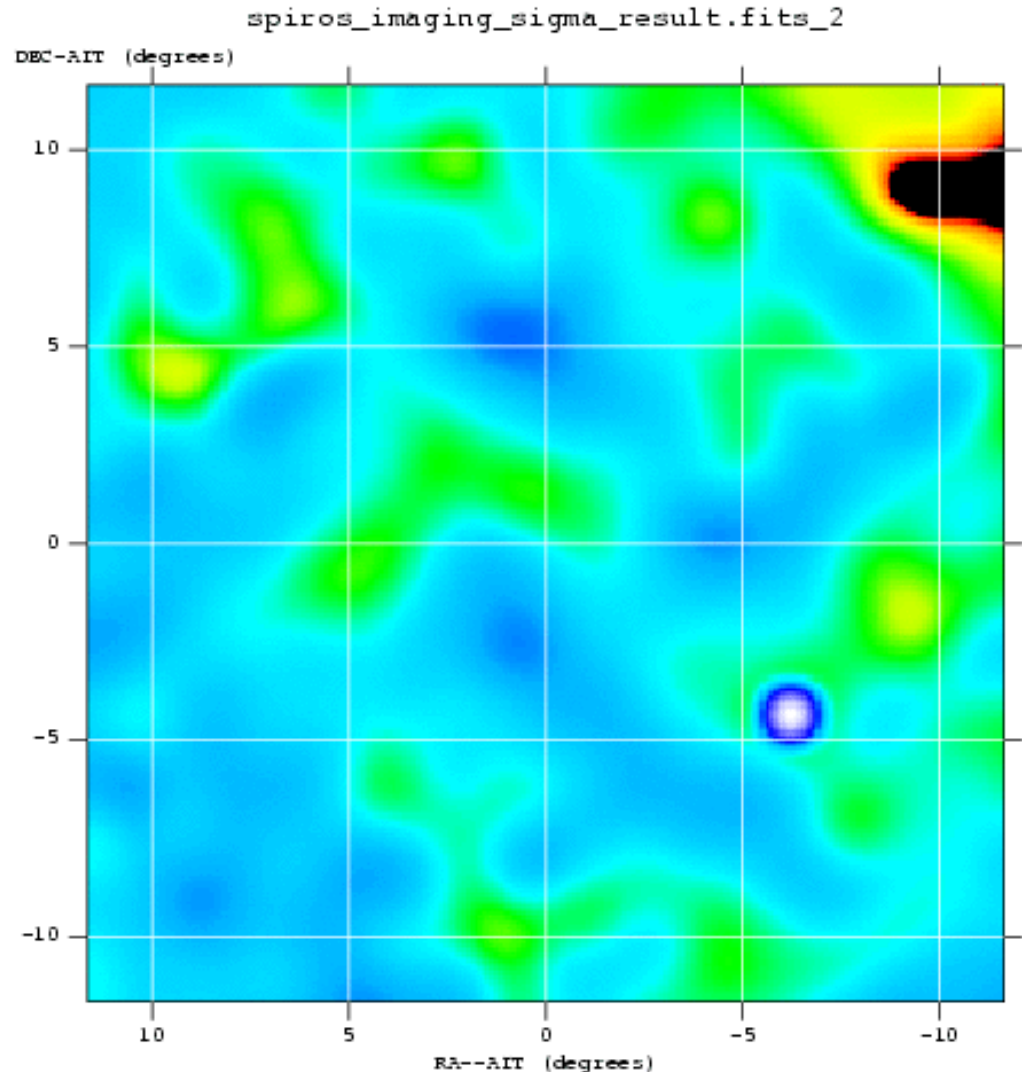
- Rev 0007, scw70 SPI background per detector
- over-plotted; MC simulation Cyg X-1, LHS
- Unshadowed & partially shadowed detectors shown





# Early In-flight Performance: SPI

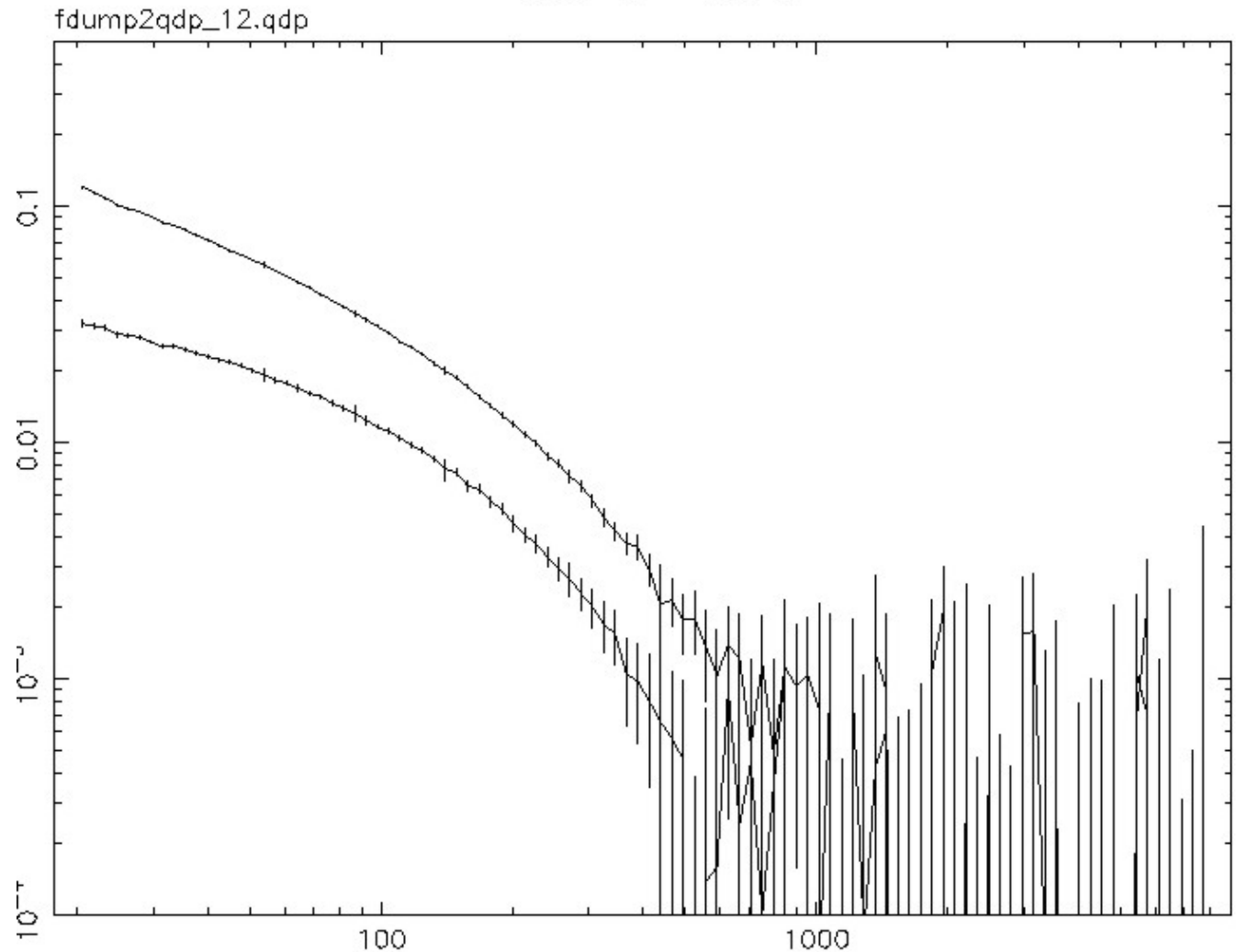
- 1st SPI image, “SPIROS” image reconstruction
- Source in lower rhs apparently spurious(?)
- This type of analysis is part of “standard analysis” pipeline.
  - Transients on a scale of  $\geq 1$ scw
- SPI less sensitive (2-3X, continuum) than IBIS below  $\sim 300$  keV, but wide FoV



# Image Reconstruction, Spectral Extraction

SPIROS solution  
(image  
reconstruction,  
plus source,  
background  
spectral  
extraction) for  
Cygnus region  
bright BHC  
sources (Cyg X-1  
& V404 Cyg)

(Note: errors not  
properly  
represented)



# Problems

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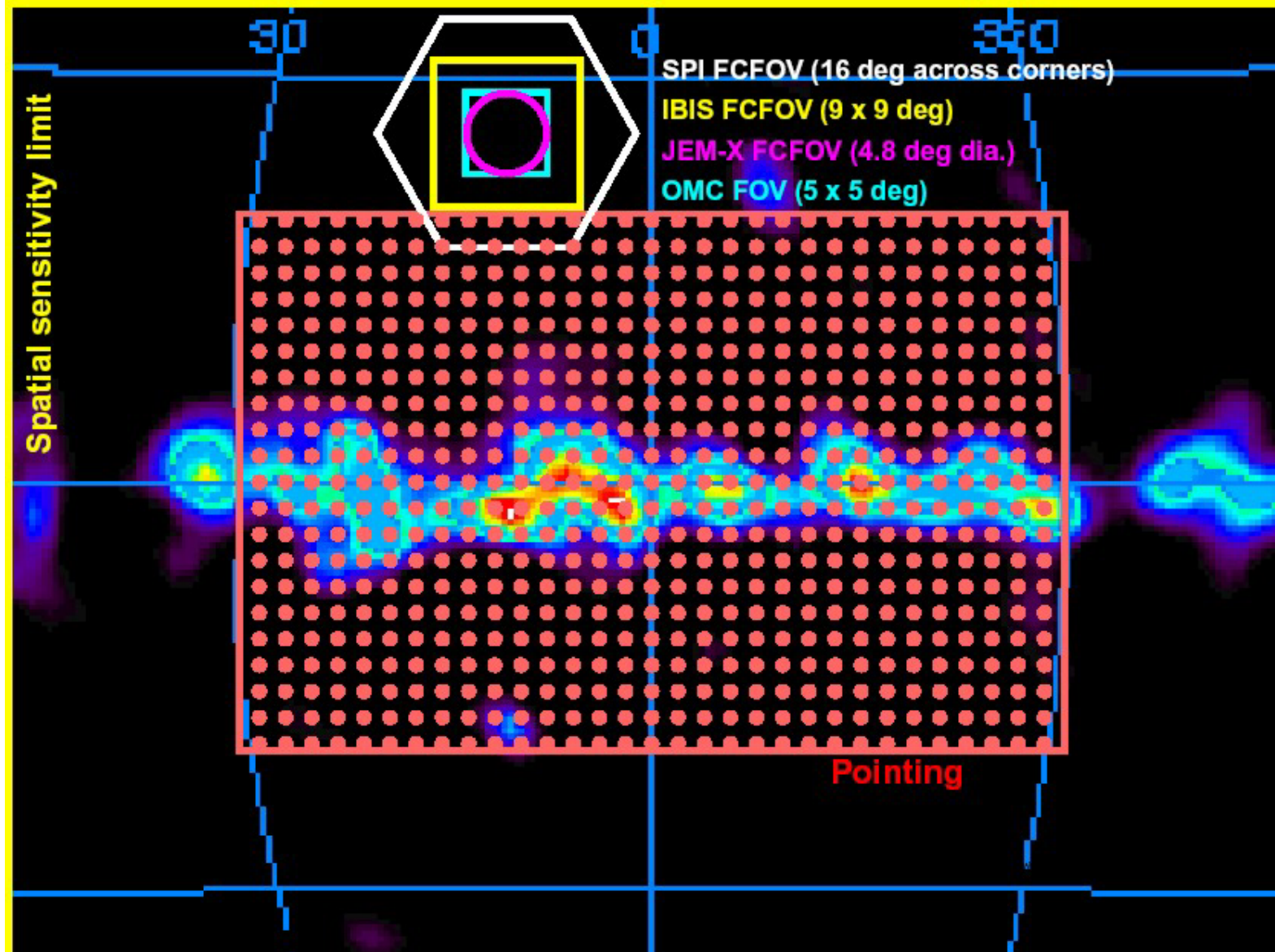
- Background count rates on SPI detectors 2X (or more) higher than expected
  - telemetry saturation problems
  - ISWT will address reapportionment of telemetry, gain change (increase high-energy threshold), or invoke alternate SPI data handling mode
- JEM-X: Put into safe mode Nov. 7
  - possible degradation of some anode strips of the microstrip detectors in both units
  - currently back on at lower operating voltage, **working properly!**
  - problem under study; space environment effects suspected

# AO-1 Observing Program

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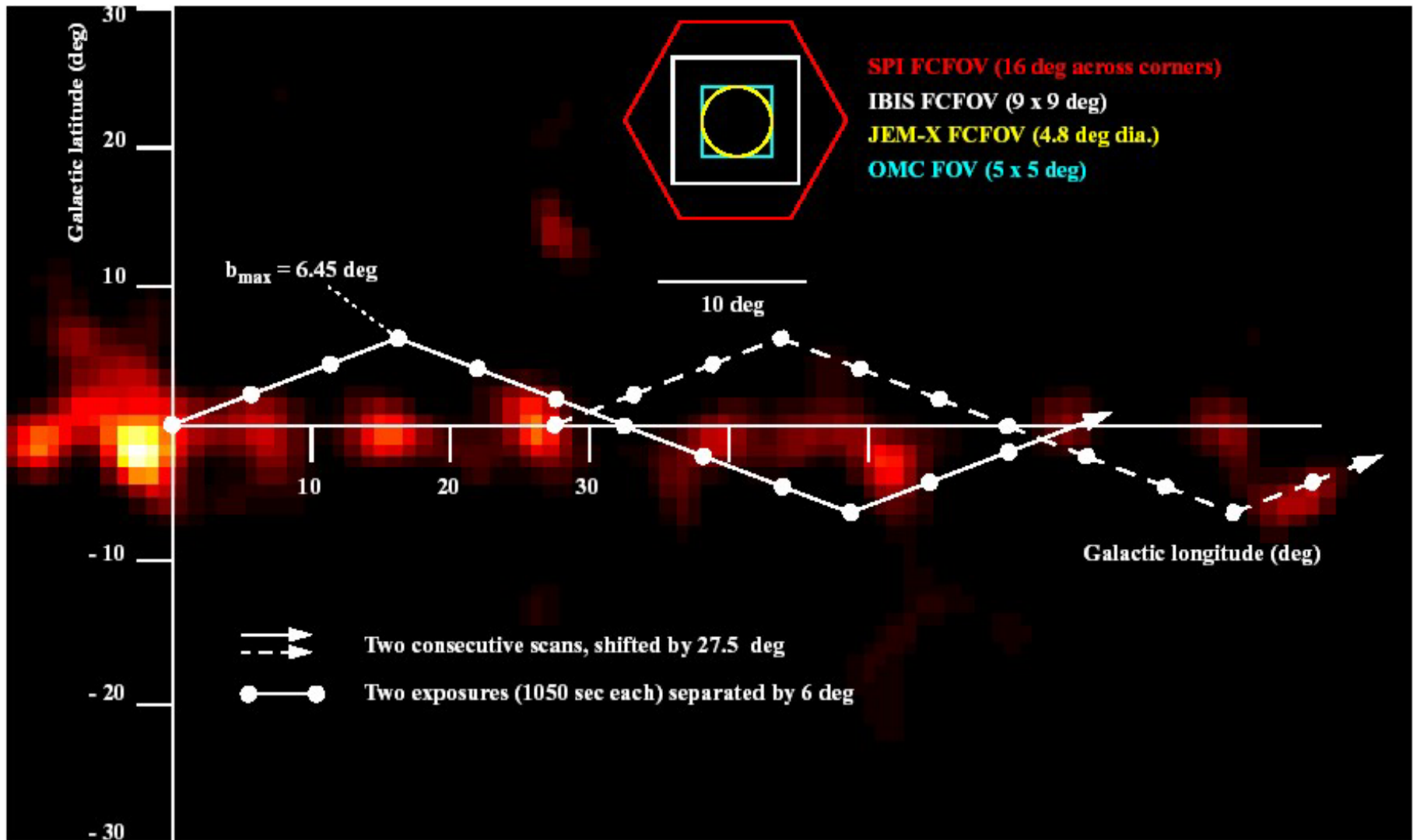
- 35% of ~27 Msec total AO-1 observation time devoted to “core program”
  - Galactic plane scan, ~2.3 Msec
  - Galactic Center deep exposure, 4.3 Msec
  - Vela region, 1 Msec
  - Transients, 1.7 Msec
- Also, ~2 Msec on Cygnus region during PV phase
- Balance of ~17 Msec for open program
- All data become public after 1 year
  - portions of the PV phase will be released promptly

# Observing Program

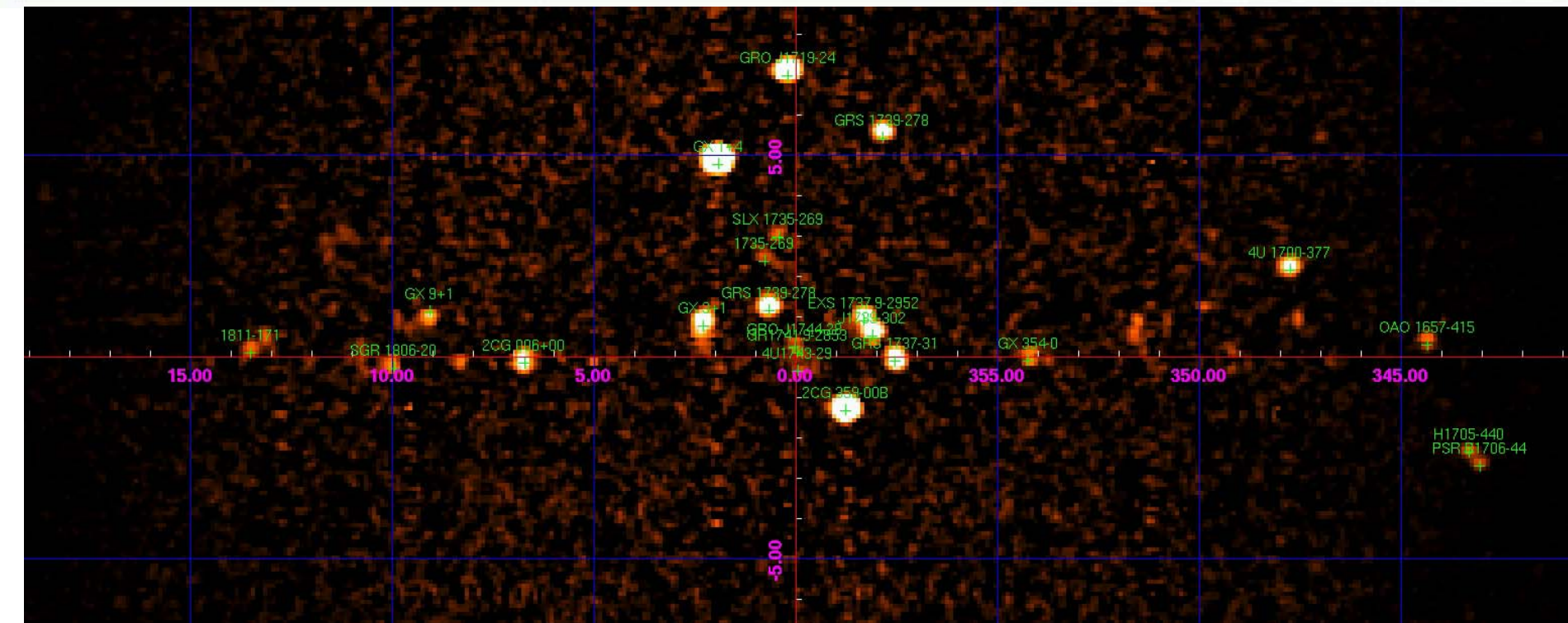
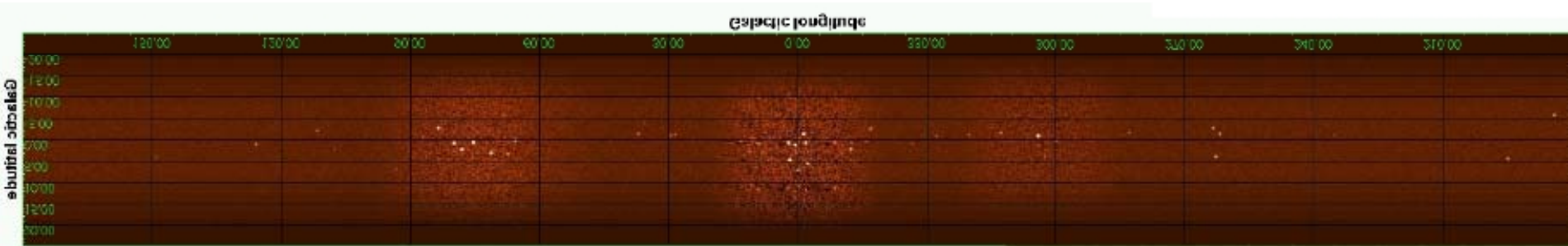




# INTEGRAL galactic plane scans



# Code Program Galactic Plane Monitoring



# AO-1 ToO Planning

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- INTEGRAL ToO capabilities:
  - Fixed solar arrays, 50°-60° solar (anti-solar) ZoA
  - Anticipated response time 20-36 hours
- ~25 (of 119) approved AO-1 programs are for ToO observations
  - totaling  $\sim 9 \times 10^6$  sec, but lots of caveats
  - trigger probabilities vary greatly; many will not be executed
- ~1/2 of these involve X-Ray binaries
- Additionally, core program likely to devote  $\sim 1.7 \times 10^6$  sec to ToOs

# INTEGRAL X-Ray Binary Studies

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- Gamma-ray line emission?
  - A number of reports in literature; need corroboration with much more sensitive instrument
- Accretion driven pulsars (to be covered in detail by J. Wilms)
  - sensitivity to cyclotron absorption features
- Improved characterization of high-energy continuum in BHC & other LMXBs (to be covered by O. Vilhu)
  - unprecedented simultaneous broad-band coverage

# INTEGRAL X-Ray Binary Studies

- Line emission? e.g. Nova Muscae 1991:
  - GRANAT/Sigma (Goldwurm et al 1992)
  - simulation, single SPI detector, 1500 s, binned to  $E/\Delta E \sim 50$

