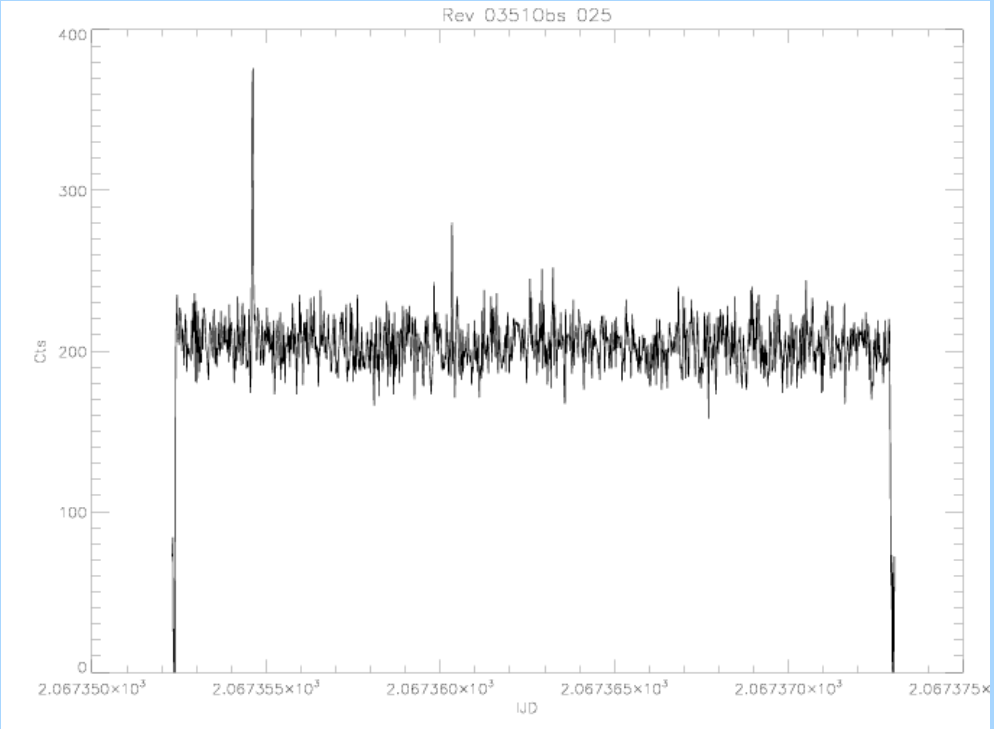
Search for thermonuclear x-ray bursts with Integral



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What ?

- X-ray binaries
- X-ray bursts
- Integral and its instruments

Why ?

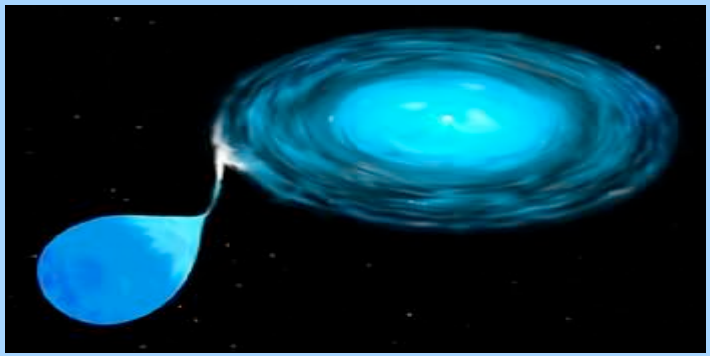
- the Galactic Bulge Monitoring Program
- IBIS and its advantages vs. JEMX

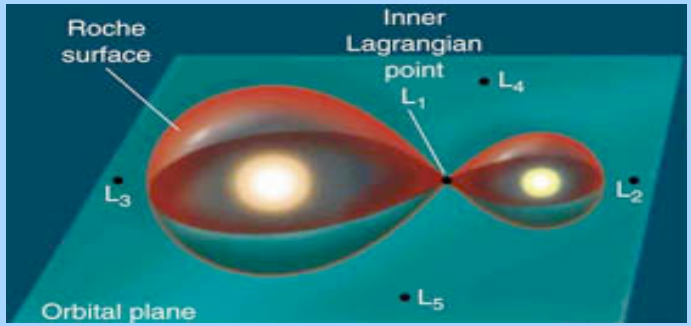
How ?

- Search for bursts in detector lightcurves
- reconstruct a “snapshot” of the burster
- determine the burst properties

Low mass X-ray binaries

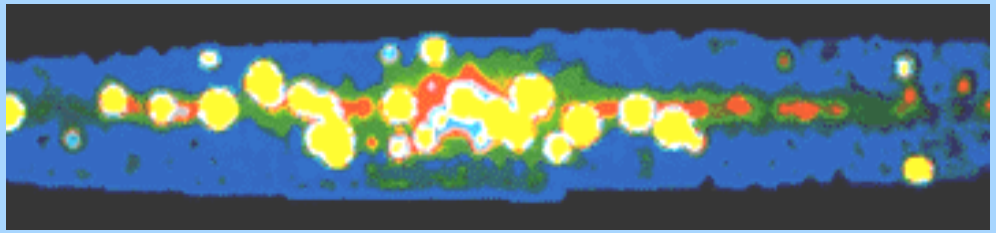
LMXBs consist of a compact object black hole or neutron star, and a low mass companion (old star or white dwarf).





Mass transfer via Roche-lobe overflow → Accretion disk → bright radiation
- heated disk
- matter that hits CO

Properties of LMXBs :
- Luminosity 250 to 25000 L_{sol}
- orbital periods 11 min to 17 d
- soft X-ray spectra (kT ≤ 10 keV)
- ~ 160 known, 130 in Milky Way



Picture of the Galactic Plane in X-rays

Type I X-ray bursts

Thermonuclear burning on the surface of a NS

Accumulation of “fuel” on the NS surface (accretion)

⇩

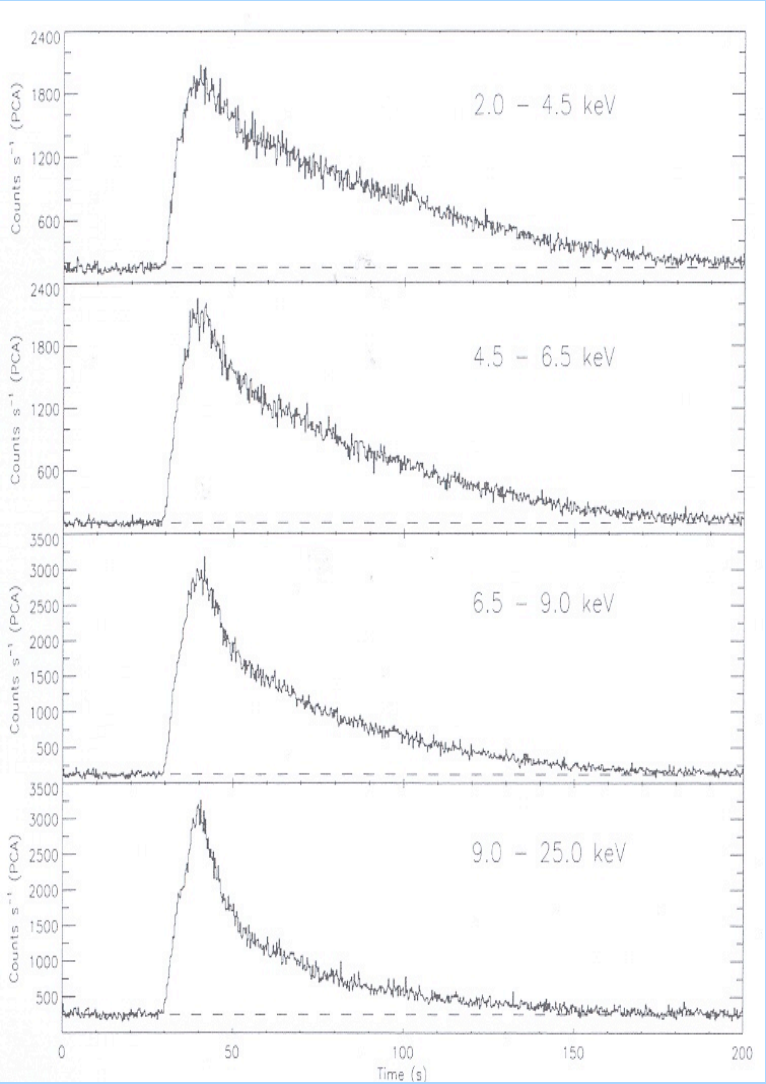
Creation of a thin shell getting denser and hotter

⇩

Thin shell Instability triggers thermo-nuclear runaway

Properties of Type I bursts:

- accumulation for several hours to days
- burst durations ~ 10 – 100 sec (depends on fuel-mix)
- energy release is nuclear, not gravitational
- ~ 70 LMXBs known to be Bursters



Lightcurves of an X-ray burst in different

Integral and on-Board Instruments

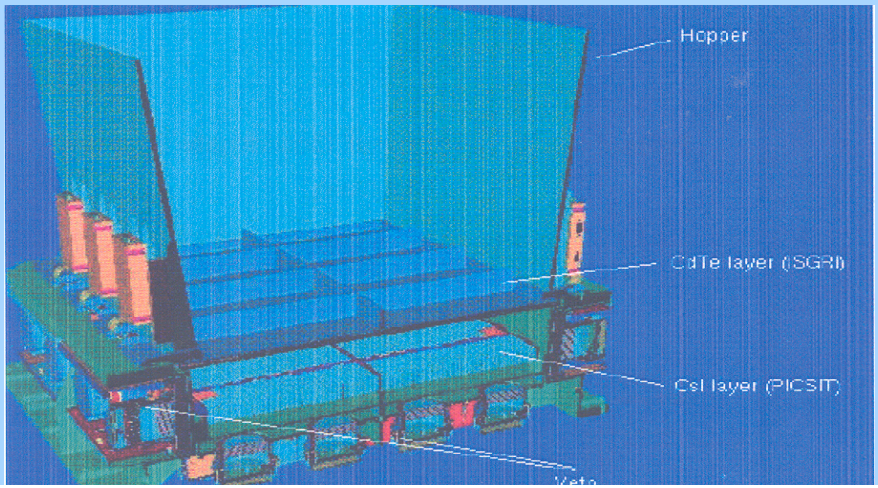
The International Gamma Ray Astrophysics Laboratory

The mission:

Observation of Gamma Ray Phenomena combining fine spectroscopy with imaging and positioning of the sources.

Science goals:

- Compact objects Binaries, Black Hole Candidates,…
- Extragalactic sources AGNs, Seyfert Galaxies,…
- Stellar objects Wolf Rayet Stars, Novae, Supernovae, …
- Observation of Galactic Plane and Center Region
- Detection of Gamma Ray Bursts



The Instruments:

IBIS Imager on Board the Integral Satellite
- high res Images of Gamma-ray objects
- Field of View 9° x 9°
- 12 arcmin angular res

ISGRI Integral soft gamma-ray Imager
- CdTe semiconductor detector
- 15 – 500 keV

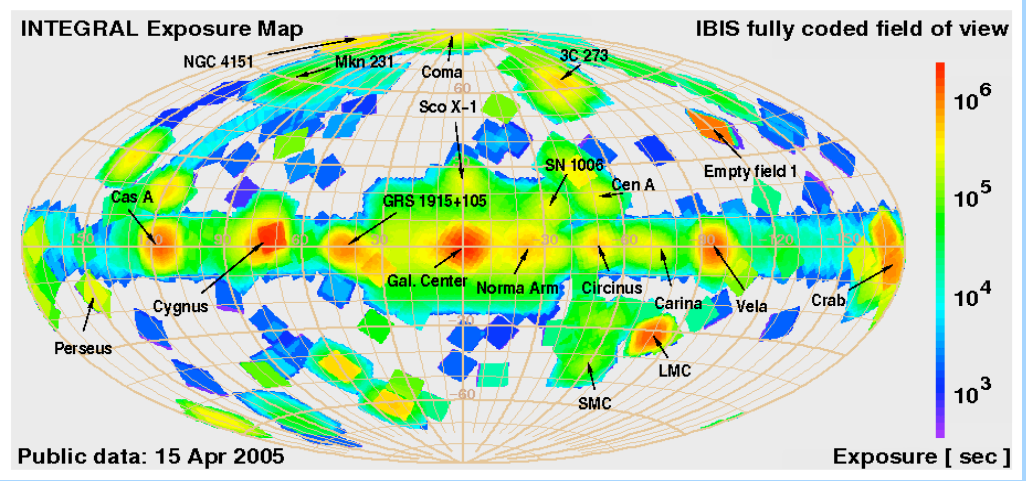
PICsIT Pixellated Imager CsI Telescope
- CsI scintillator crystals
- 200 keV – 10 MeV

JEMX Joint European Monitor for X-rays
- High res Images in the X-ray band
- FOV 4.8° diameter
- 3-35 keV
- 3 arcmin angular res

The Galactic Bulge Monitoring Program

Monitoring of the Galactic Bulge Region with INTEGRAL, it is a rich host of variable X- and Gamma-ray point sources

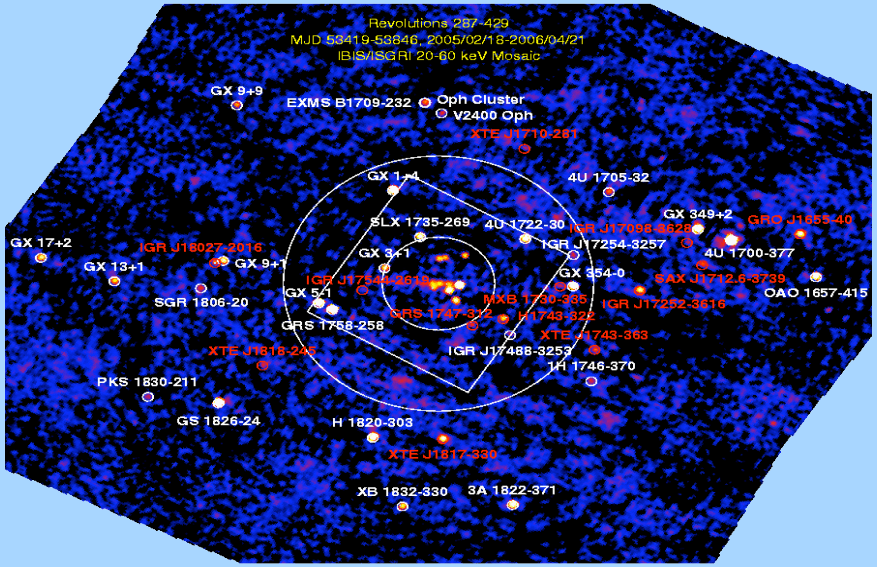
- Observe the region regularly at hard X-rays and Gamma-rays, ~ every 3 days (12.6 ks)
- investigate the source variability and transient activity on short and long time scales



3 Seasons of Observations (Revolutions 288-492)

Total Coverage around the Galactic Center of

- 29° with IBIS/ISGRI
- 6° with JEMX'



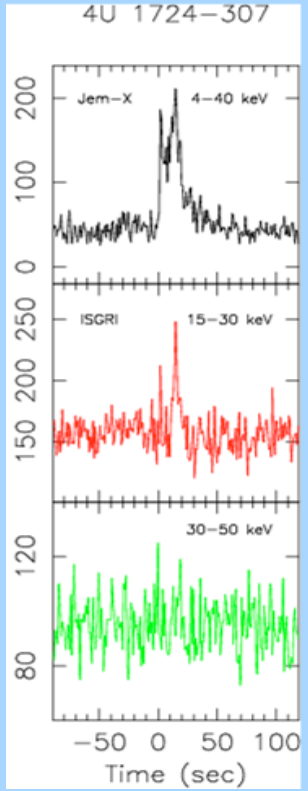
Rev 287-429 IBIS/ISGRI 20-60 keV Mosaic Image

IBIS has a wider FOV than JEMX !

It covers about half of the total X-ray

Burst Detection

Type I bursts are mainly seen in soft X-rays
observed BB temperatures : 1-3 keV → JEMX

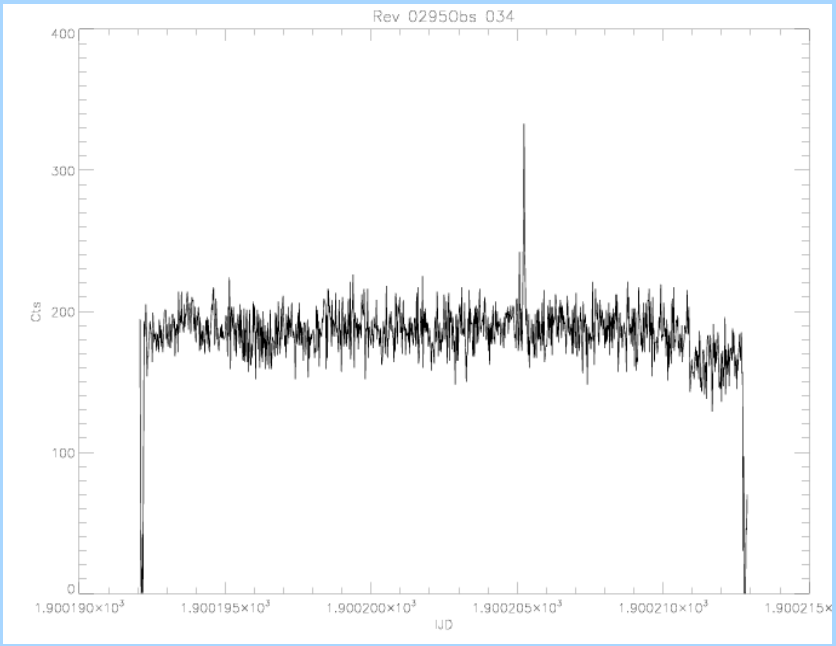


In the 3 seasons of the monitorig program JEMX saw 110 Type I X-ray bursts !

We want to look at them with IBIS !

→ wider FOV

We look at the IBIS/ISGRI Detector Lightcurves of a single observation:

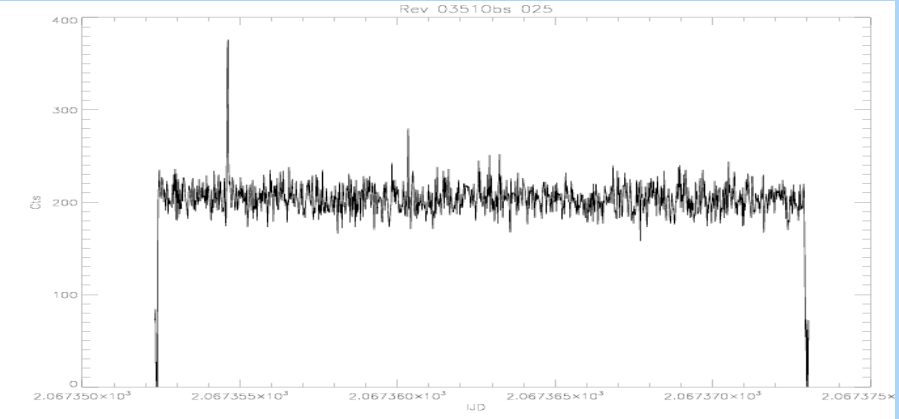


Creation of Histograms bin = 1-2 s → Computation of average count rate $\overline{N}$ and the corresponding standard deviation σ → when condition

$$\frac{N - \overline{N}}{\acute{o}} \geq 6$$

for count rate N in → **Burst !**

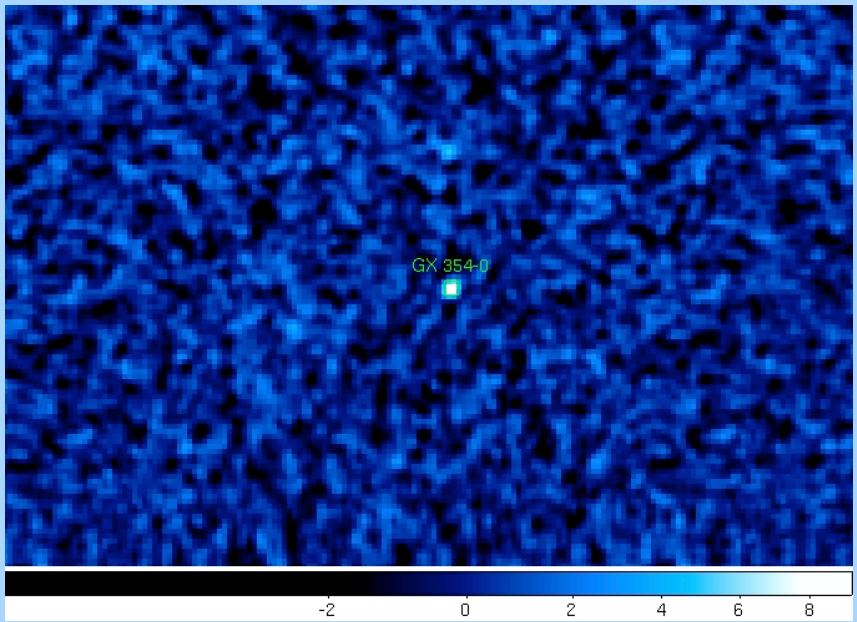
Image Reconstruction

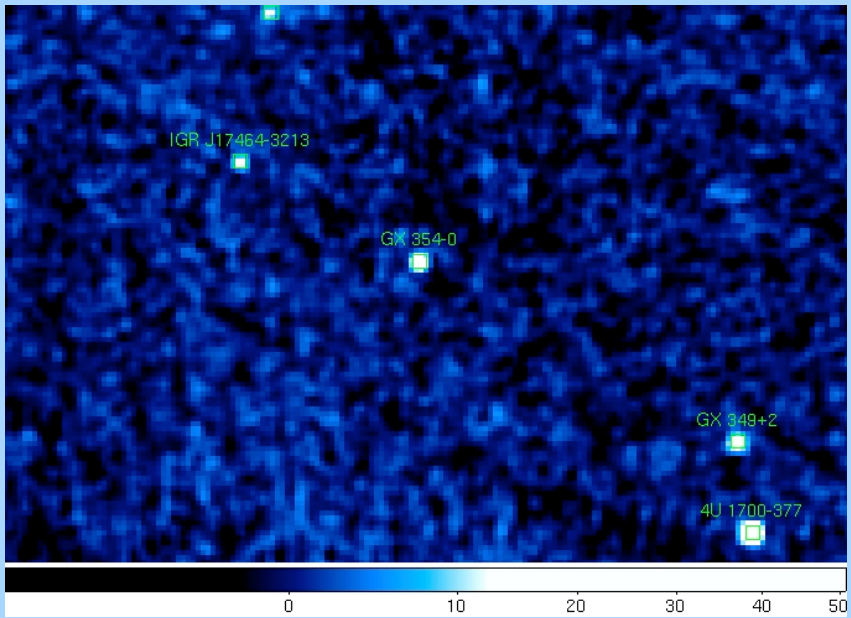


the burst of Rev 351, observation 25 in the histogram

We define a Good Time Interval which includes only the time of the burst

Creation of sky image of the moment of the burst with OSA (Offline Science Analysis Software, V 6.0).





Determining burst properties

The burst shape is given by the following formula :

$$n + h \cdot e^{\frac{-t}{\hat{o}}}$$

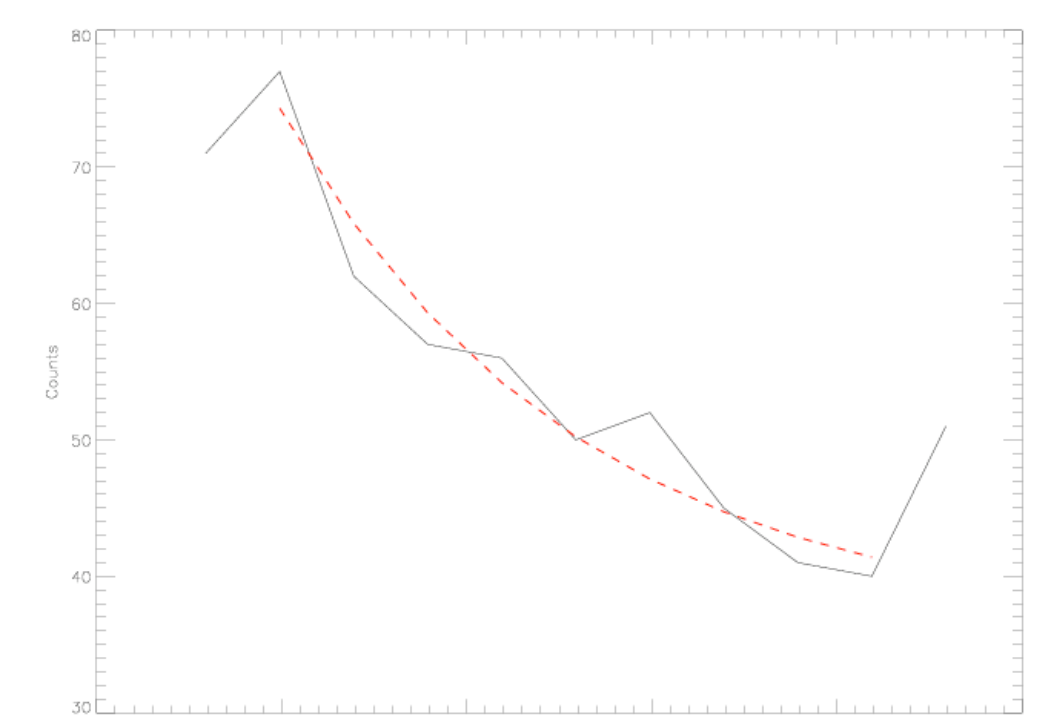
Fast rise with exponential decay

We fit this exponential decay to burst shapes in the histograms:

n ... average count rate

h ... height of the burst above avarage

τ ... mean lifetime



Calculation of the integrated flux E_b of the burst event

Project Status

First Results:

We were able to identify the sources of 56 bursts within the data of 3 seasons (MJD 53419 - 54032) of the GBMP by now:

- The bursts come from 8 different sources
- 35 bursts (62%) come from only one source, GX 354-0
- SGR 1806-20 is a soft Gamma-ray repeater, not a type I X-ray burster

still to do:

OSA didn't find anything, but we have a possible Source

→ identify what OSA left over !

we focused on the high significant bursts (>6) due to image reconstruction.

→ identify as well the fainter ones

→ determine their properties

Source	Rev	ScW	IJD
GX 354-0	288	15	1878.422
1A 1742-294	289	10	1881.199
GX 354-0	293	8	1893.127
GX 354-0	294	7	1896.092
4U 1722-30	295	34	1900.205
GX 354-0	296	40	1902.893
GX 354-0	298	4	1908.001
GX 354-0	299	4	1910.995
GX 354-0	302	8	1920.055
GX 354-0	303	22	1923.422
4U 1722-30	304	2	1925.902
GX 354-0	304	4	1925.941
GX 5-1	305	34	1930.266
SGR 1806-20	347	20	2055.036
SGR 1806-20	348	51	2059.356
GX 354-0	350	9	2063.681
GX 354-0	351	25	2067.355
GX 5-1	359	66	2092.066
GX 354-0	359	69	2092.131
GX 354-0	360	97	2095.855
GX 354-0	361	48	2098.052
GX 354-0	362	6	2099.488
4U 1722-30	364	2	2105.383
GX 354-0	365	69	2109.871
SAX J1747.0-2853	366	7	2111.462
NEW	370	68	2125.705
GX 5-1	370	69	2125.721
GX 354-0	410	3	2242.895
4U 1722-30	411	23	2246.413
4U 1722-30	417	67	2265.463
SAX J1747.0-2853	417	70	2265.529
GX 354-0	420	31	2273.608
GX 354-0	421	4	2275.791
4U 1722-30	428	5	2296.759
GX 354-0	429	104	2302.101
4U 1722-30	469	5	2419.303
GX 354-0	470	1	2422.194
SGR 1806-20	470	3	2422.249
GX 354-0	470	7	2422.329
GX 354-0	472	24	2428.959
GX 354-0	473	2	2431.188
GX 354-0	474	3	2434.202
SGR 1806-20	474	4	2434.209
GX 354-0	475	51	2438.552
GX 354-0	476	14	2440.512
GX 354-0	478	14	2446.473
GX 354-0	480	10	2452.368
GX 354-0	480	16	2452.504

Problems with Image Reconstruction

IBIS is a Coded Mask Instrument → Images of sources have to be reconstructed by The Analysis Software !

Problems with OSA:

- A certain amount of photon counts (exposure time) is necessary so image reconstruction works
- New sources aren't always found by the Software, especially in the partially coded FOV

→ can be found by looking for "ghosts" in the image

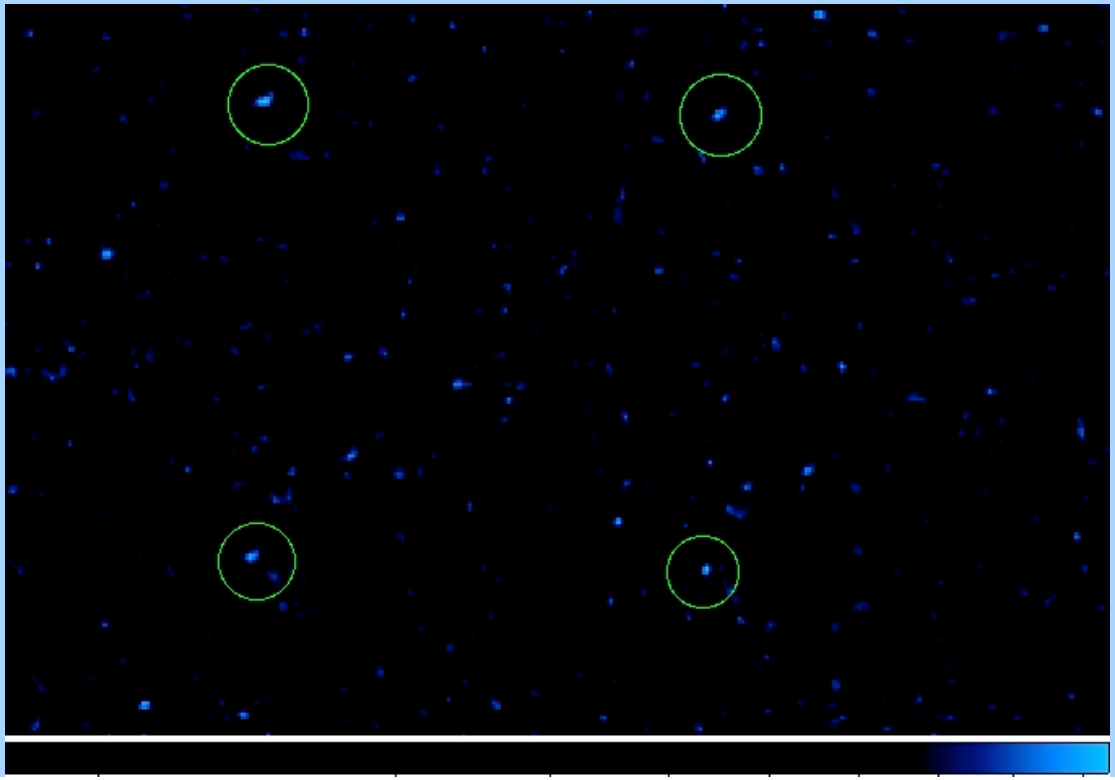


Image of a potential new source not detected By OSA. It's ghosts where not automatically

Thank You !

CODED MASK TECHNIQUE

NO MIRRORS IN GAMMA RAYS

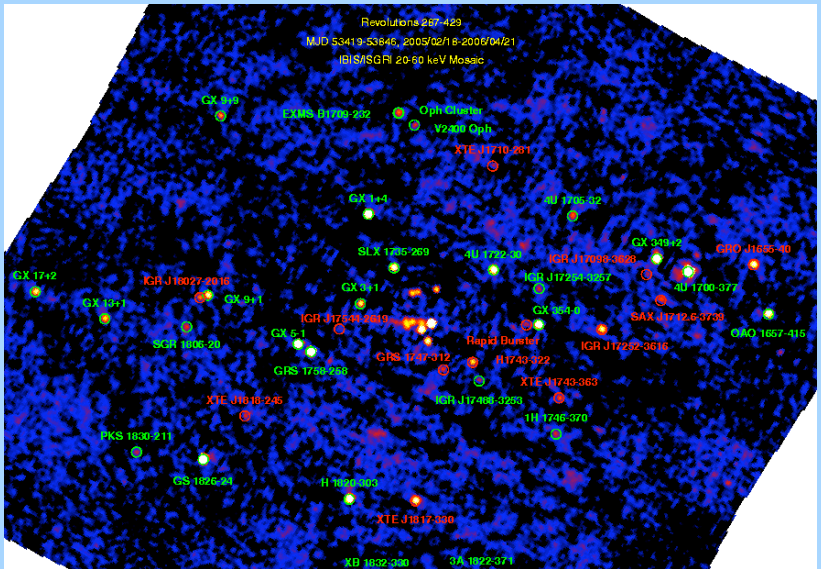
NO OPTICAL IMAGES

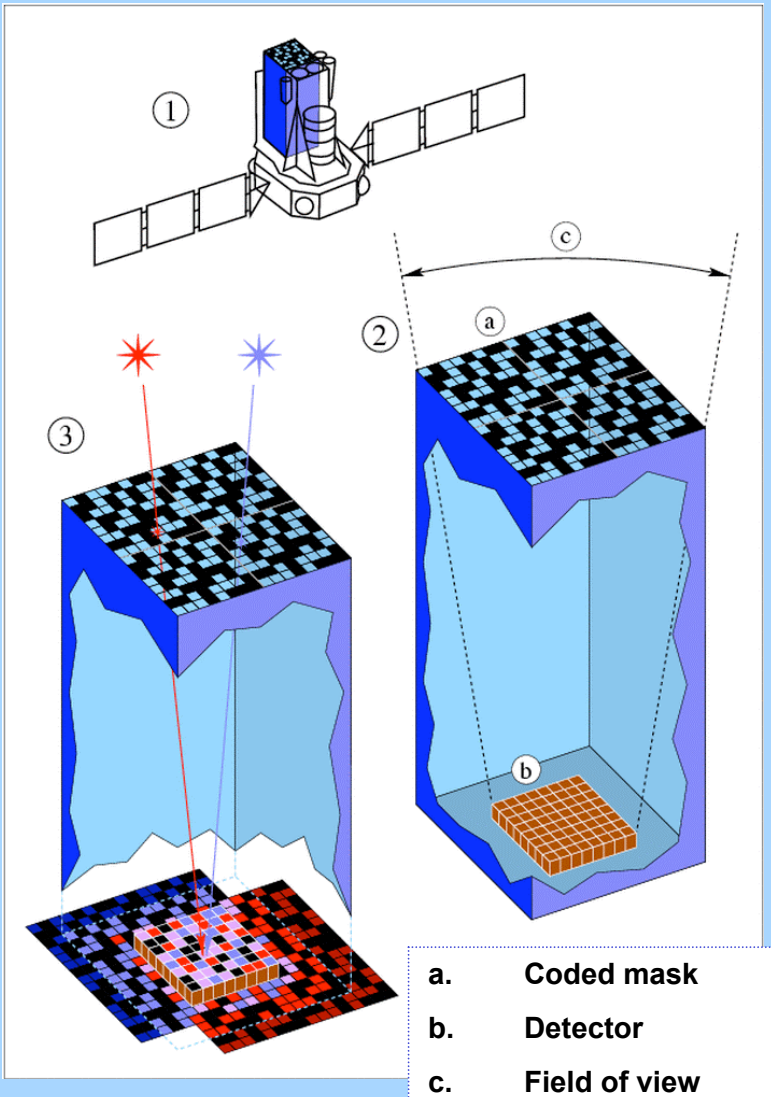
CODED MASK:

- Mask the aperture of the telescope
- Measure its shadow on the detector
- orientation of the satellite & analysis of data from the detector

determine position & intensity of sources

image of the observed sky:





a. Coded mask
b. Detector
c. Field of view

ANTI-COINCIDENCE SYSTEM