

GCDE point sources catalog with SPI

- Bright X-ray galactic X-ray sources (Neutron stars and black holes) are concentrated towards the Galactic Center region.
- The SIGMA/GRANAT telescope has completed the last survey of the Galactic Center at energies above 40 keV, 8 years ago.
- One of the aim of SPI is to perform high-resolution spectroscopy as well as imaging of astrophysical sources between 20 keV and 8 MeV.
- INTEGRAL with SPI and IBIS are carrying out a new hard X-ray/soft gamma-ray survey with a higher sensitivity.
- Actually, SPI represents the best compromise in terms of angular resolution (imaging), energy resolution (spectroscopy) and sensitivity above 100 keV.

These motivate the present study :

Catalog of sources/ Individual sources study

Data analysis

- Imaging with SPI: The necessity to use dithering to obtain images/spectra results in heavy mathematical methods
- Along with the necessity of the background modeling (variability), source variability must also be introduced (at least for strong sources like 4U 1700-377, Sco X-1, etc..)
 - Systems to be solved has a huge number of unknowns(flux per source and per time window) and increase with data size (science windows)

Results

- Catalogue of sources using SPI at various time scale
 - On short time-scale (per revolution) by correlation of excesses in each images (Munich presentation)
 - But must contains artefacts!
 - Long time-scale (several revolution, GCDE1+2)

Search for sources using no prior information for GCDE 1-

- In order to test the technique the basic analysis was performed without using prior information about known sources. The prior is introduced progressively
- Sky regions
 - 1) whole raw data to build a sum image.
 - 2) raw data are divided in 3 subsets (namely positive, negative and central longitude), that have more or less equal duration, according to the average galactic longitude of each revolution.
- For each data set, we build images in 7 energy bands :20-27, 27-36, 36-49, 49-90, 90-166, 166-300, 300-542 keV
- Finally, we build and analyse 28 sky images
- Correlation in energy : “looks like” spectrum
- Spatial correlation : The field-of-view of these 3 data subsets overlap partially even if the data used are independent. Thus a source can be seen, at the same energy, in several images.
- Finally, we detected 87 excesses/ sources

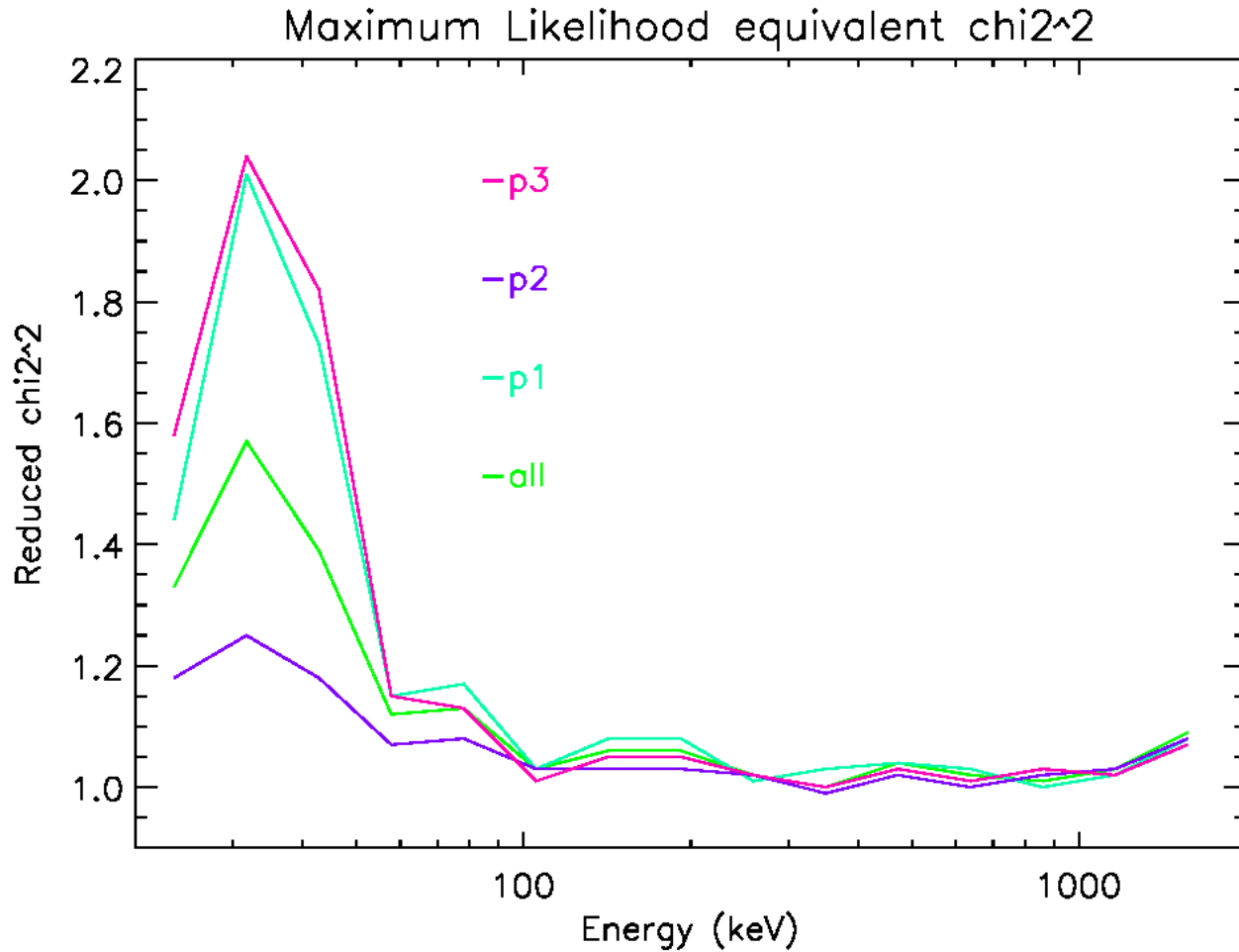
Whole image : sources detected above 7 standard deviation (std)

| Number of sources N detected above 7 std | Associated with a known source | New / artefact |
|--|--------------------------------|----------------|
| N > 20 keV | 65 | 12 |
| N > 27 keV | 62 | 10 |
| N > 36 keV | 48 | 2 |
| N > 49 keV | 19 | 0 |
| N > 99 keV | 11 | 0 |

Energy band : 49-99 keV

| std | P1 | | P2 | | P3 | | WHOLE | |
|-----|------------|---------|------------|---------|------------|---------|------------|---------|
| | Identified | Unknown | Identified | Unknown | Identified | Unknown | Identified | Unknown |
| 4 | 9 | 7 | 7 | 2 | 12 | 10 | 26 | 9 |
| 5 | 8 | 1 | 3 | 0 | 10 | 2 | 17 | 2 |
| 6 | 3 | 1 | 3 | | 9 | 0 | 11 | 0 |
| 7 | 3 | 0 | 3 | | 8 | | 10 | |

MAXIMUM LIKELIHOOD ANALYSIS

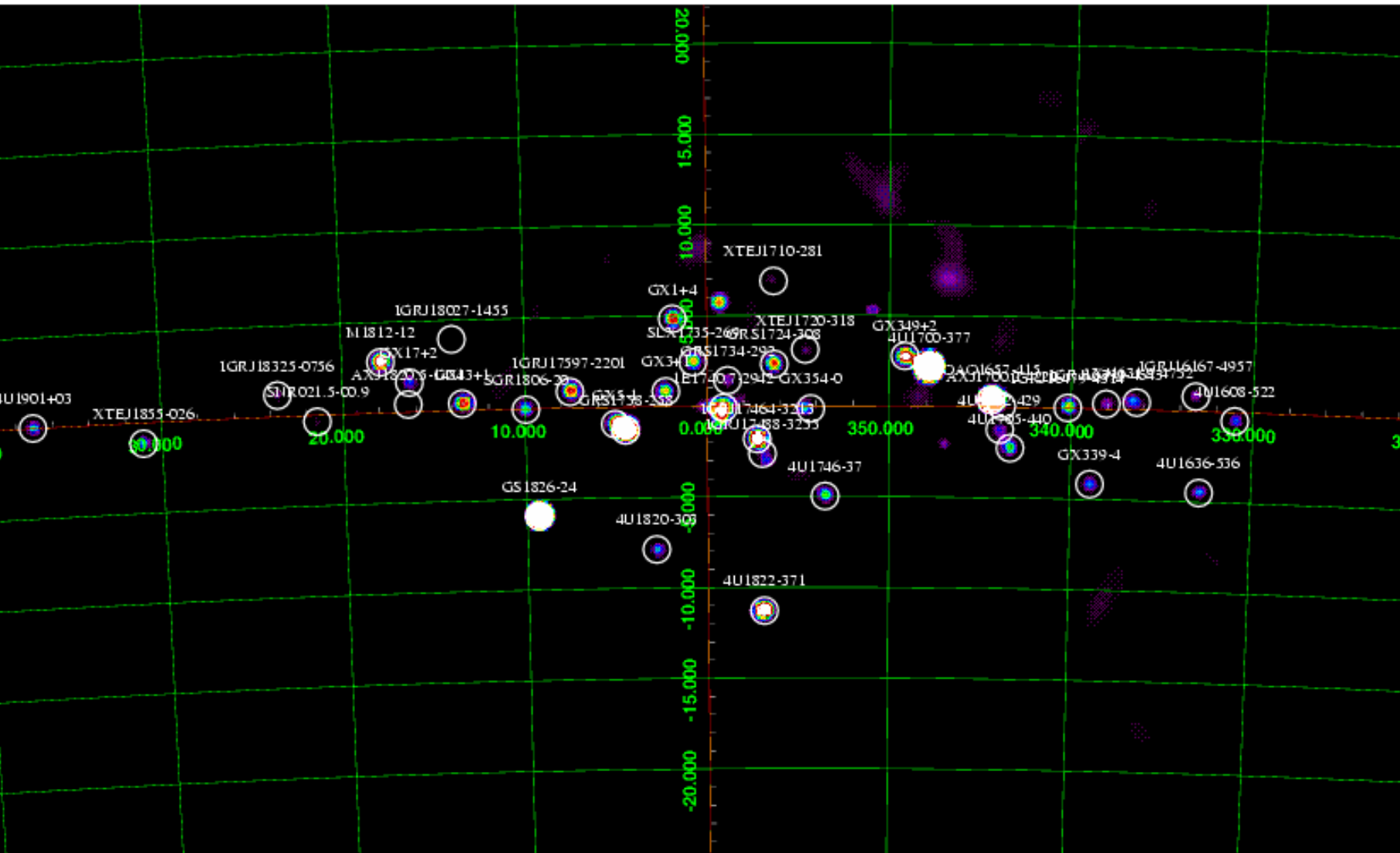


In this analysis, the sources variability is not taken into account,

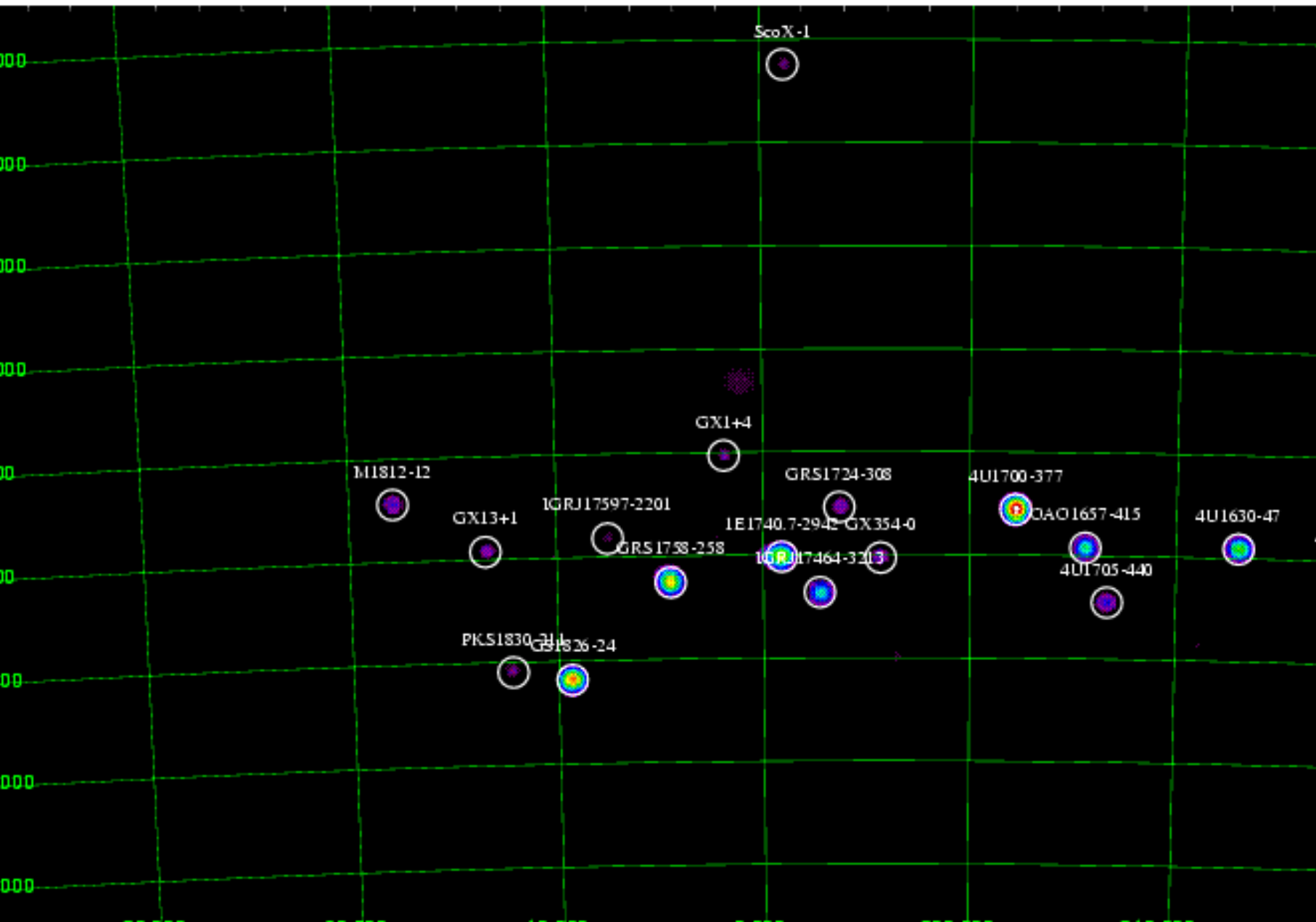
it explained in most part the high χ^2 value at low energy (below ~ 50 keV)

25-50 keV Image (2 Ms)

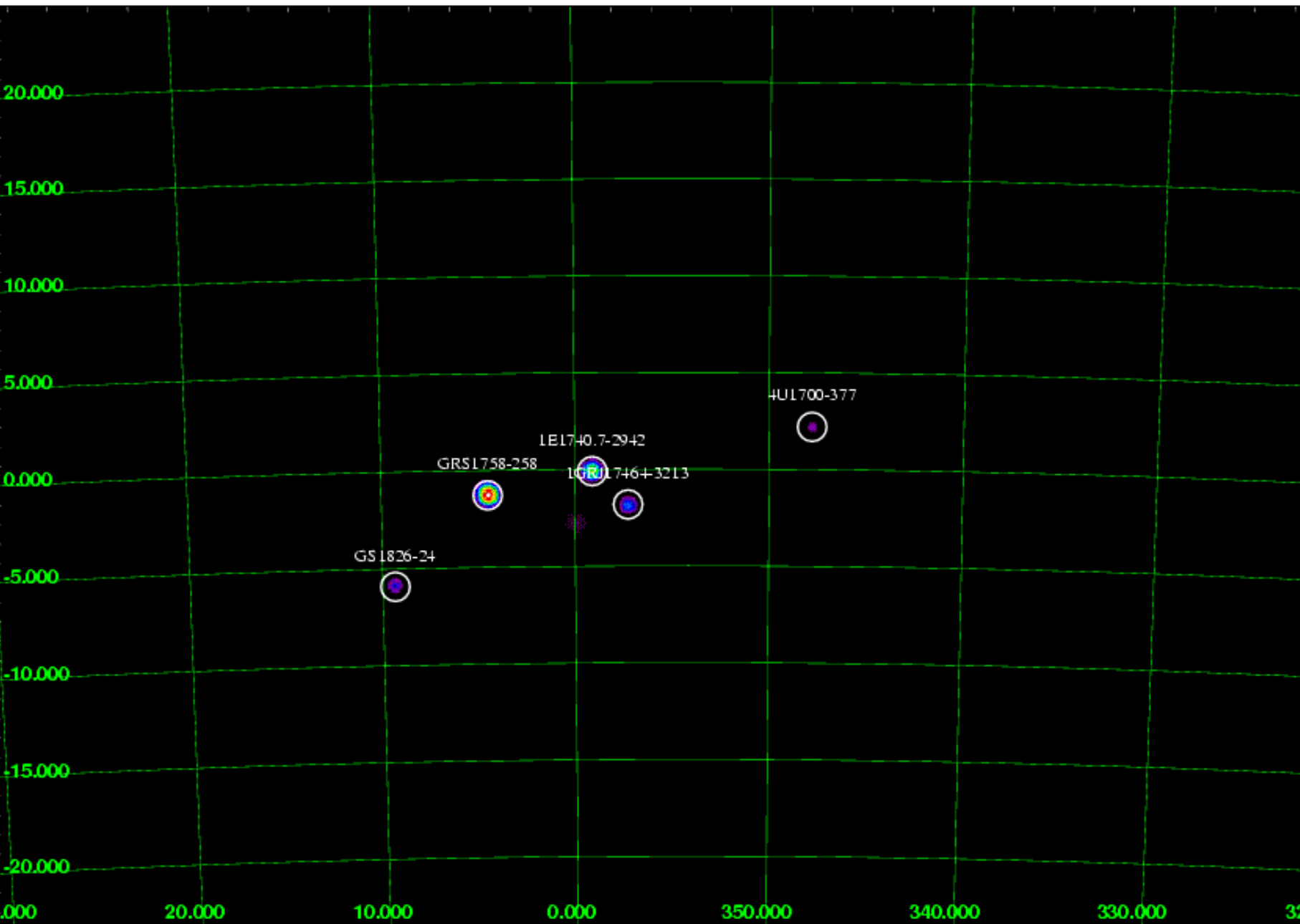
In this new analysis, we add data GCDE 1 + GCDE 2 + public data on GCDE. The sources position is fixed.



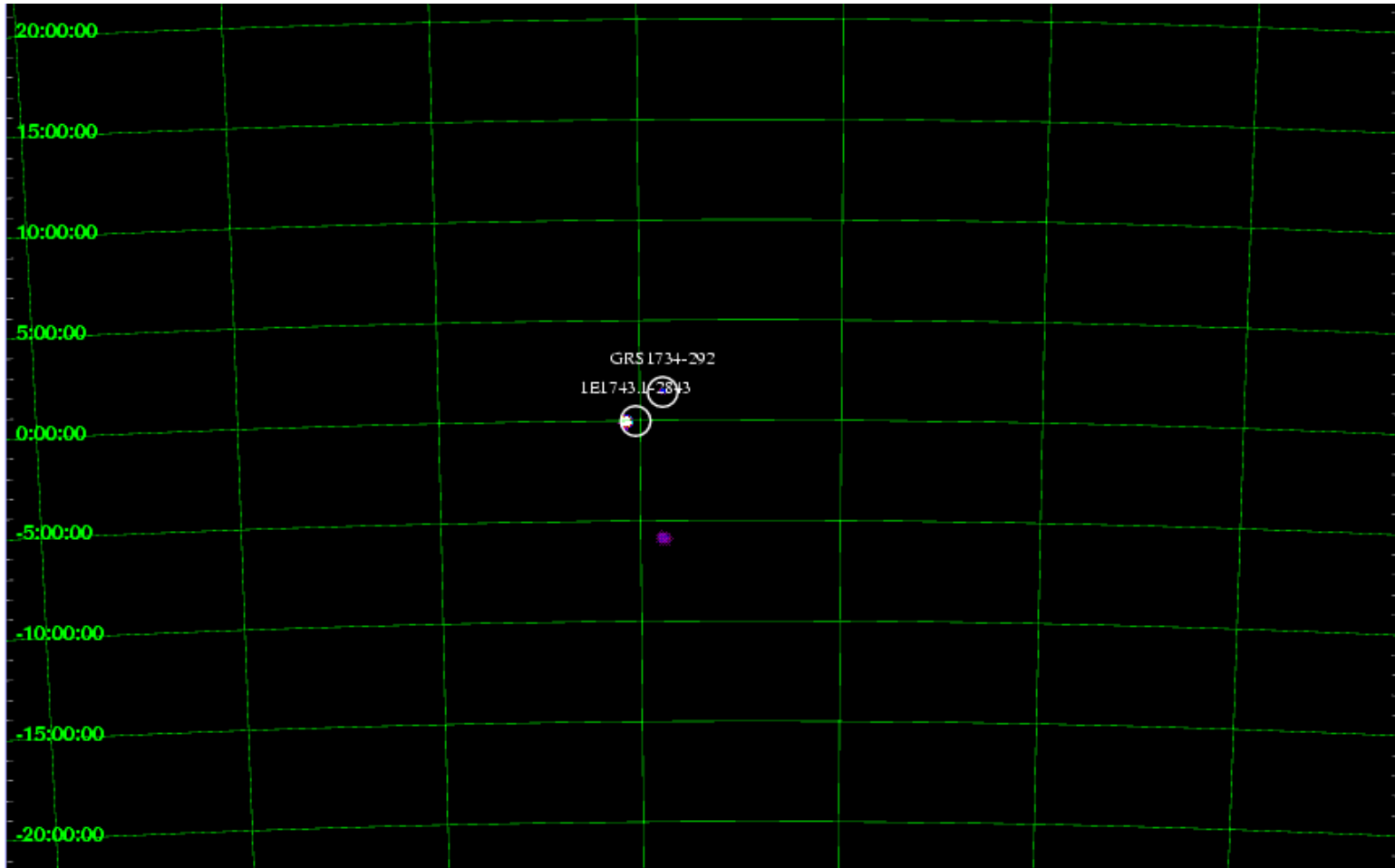
50-150 keV (2 Ms) (std > 5)



150-300 keV (2Ms) (std > 4)



400-600 keV image (2 Ms)



Std > 3.5

- **New analysis**

- Improvement of background modelling and SCWs selection.
- Spectrum of each source and light curve for strongest sources on time scale of pointing, day, revolution

- **Limitations of imaging with SPI**

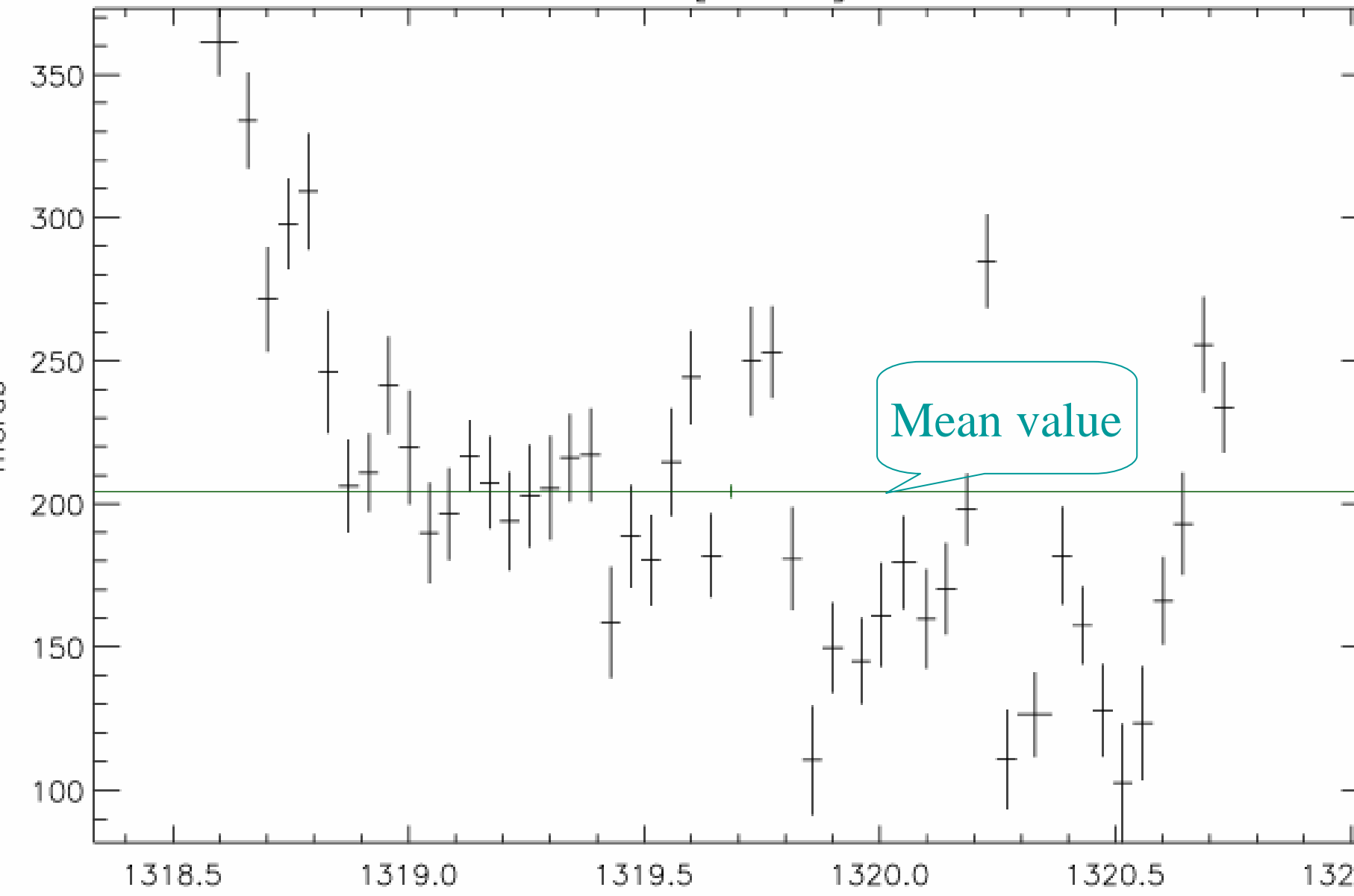
- Sources variability is not incorporated in the imaging process for sources search, this can pose problem for weak sources detection.

- **Light curves and spectra**

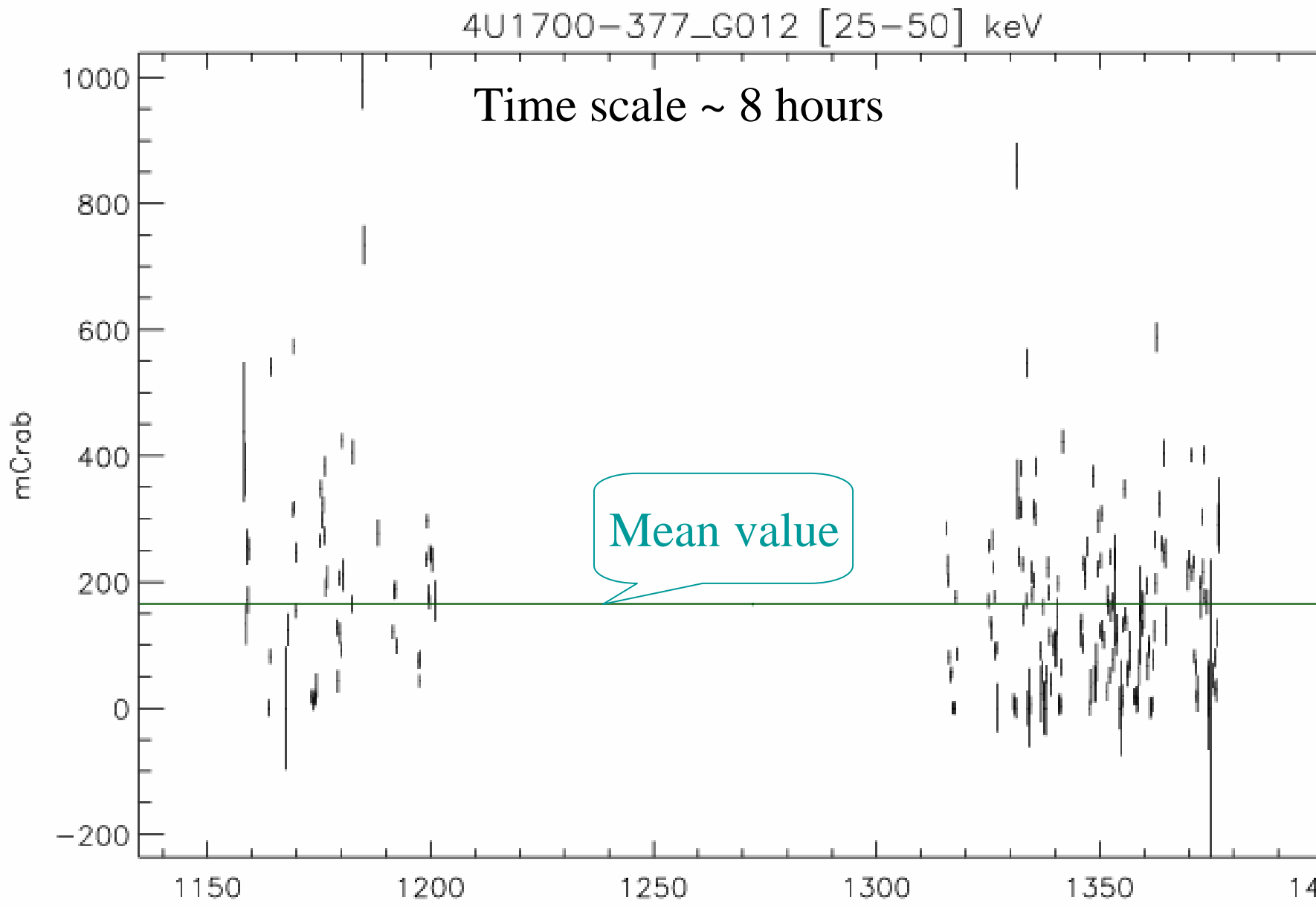
- A sources catalog is used as input (fluxes extraction)
 - Can not include the variability on time scale of a pointing, even for large set of data as the GCDE survey for all the sources

Sco X-1 / Revolution 110

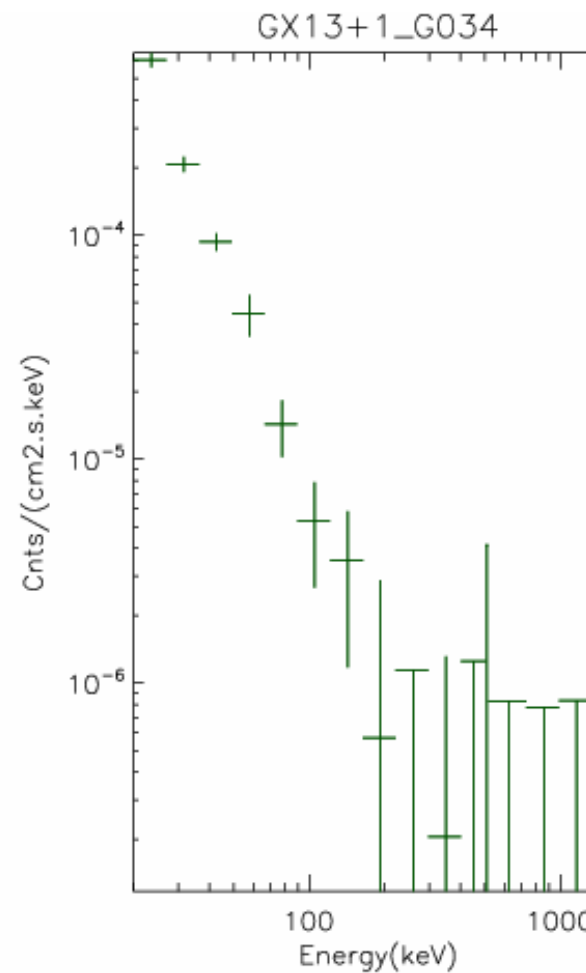
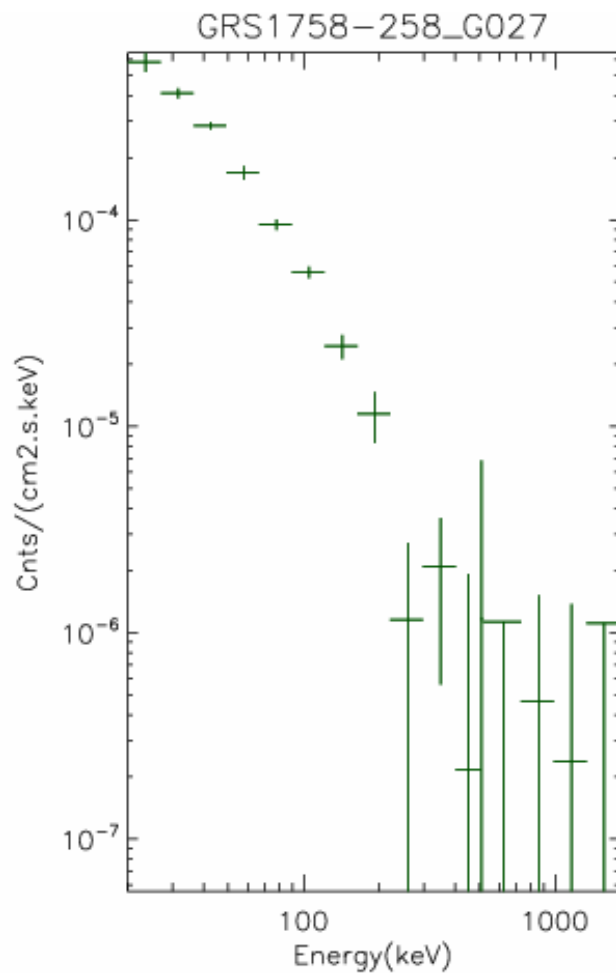
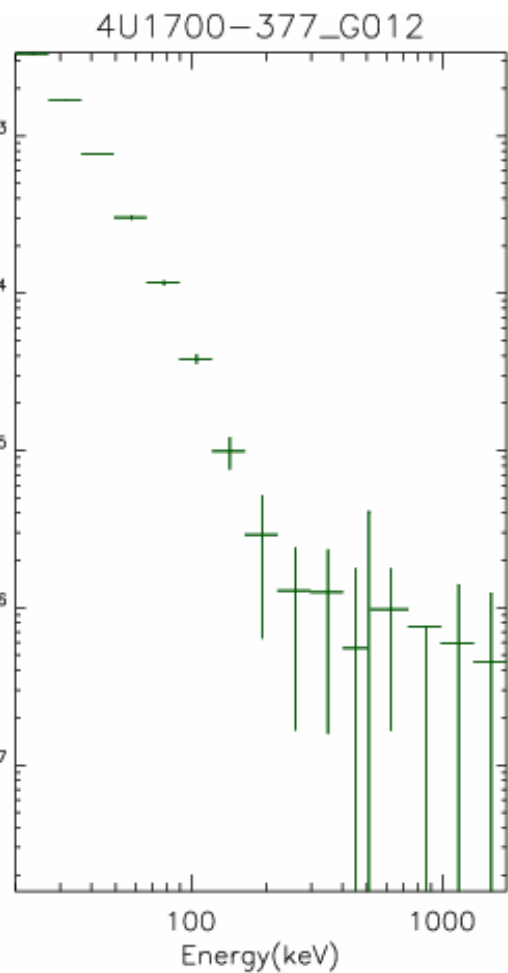
ScoX-1 [25-50] keV



4U 1700-377 / GCDE 1+ GCDE 2 +Public data



4U 1700-377 and SCO X-1 vary on time scale of 8 hours



Perspectives

- Galactic soft gamma-ray total point source continuum (Problem related to diffuse galactic continuum)
- High energy spectra and light curve of each sources
- Sources spectroscopy (not exploited yet)
 - systematic search of absorption/ emission line
- Statistic studies
 - Sources population (LMXBs, HMXBs, Neutrons stars, black holes, etc.)
 - Log N -log S
- Correlation of SPI excesses with MeV sources (EGRET)
 - Same method used between 20 keV and 1 MeV can be used above 1 MeV to build source catalogue