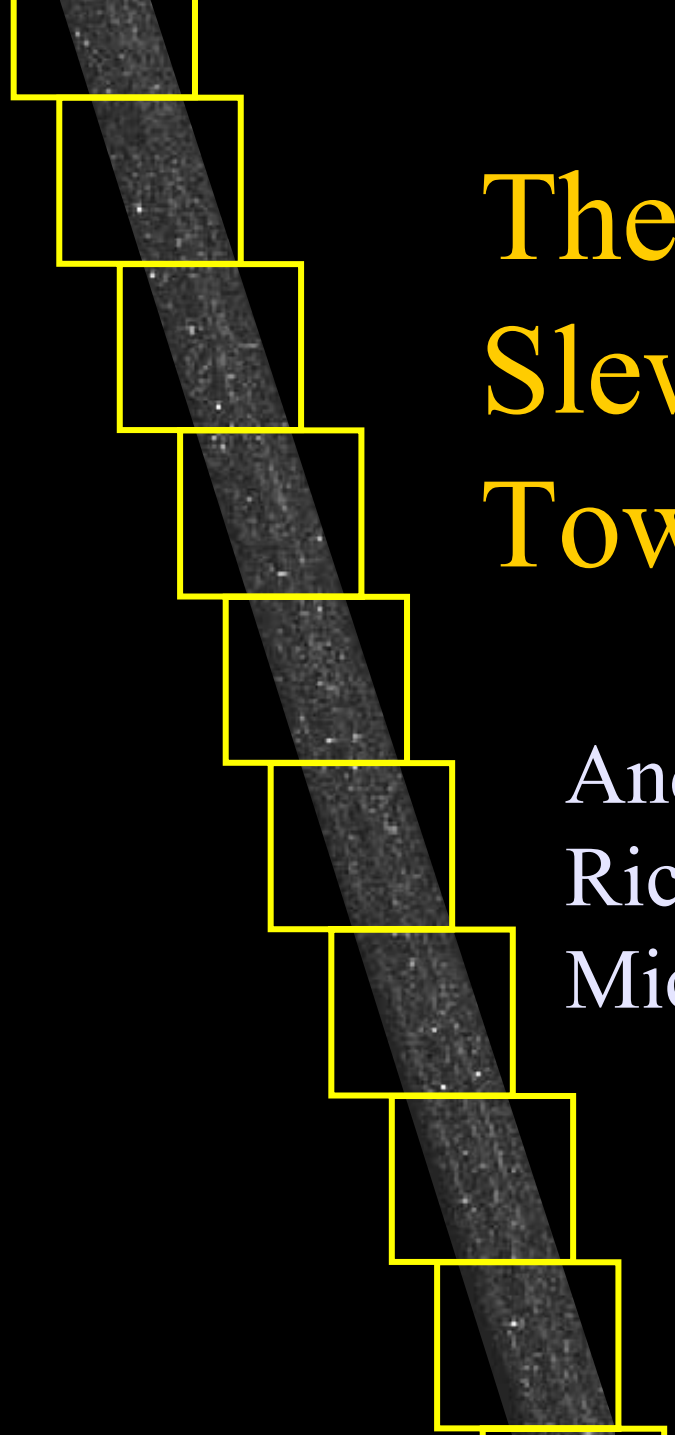
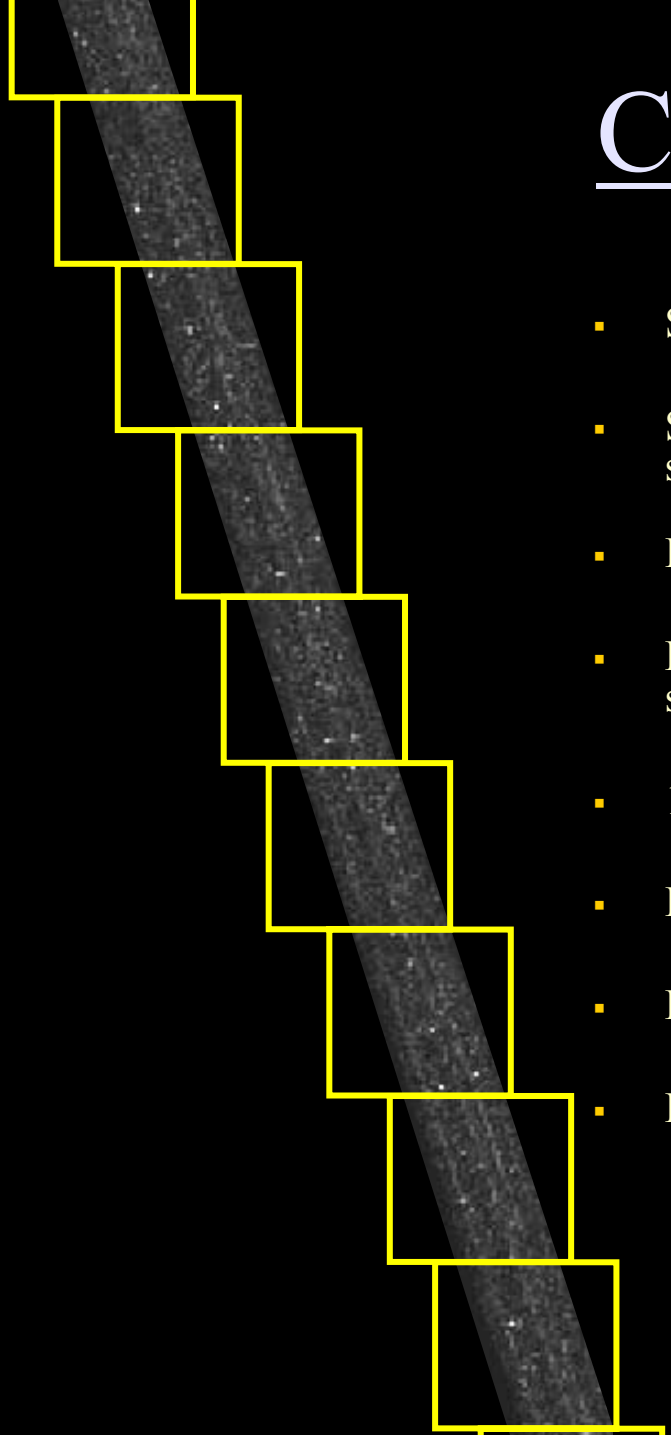


The XMM-Newton Slew Survey: Towards the Whole Sky

Andy Read
Richard Saxton, Pili Esquej
Michael Freyberg, Bruno Altieri

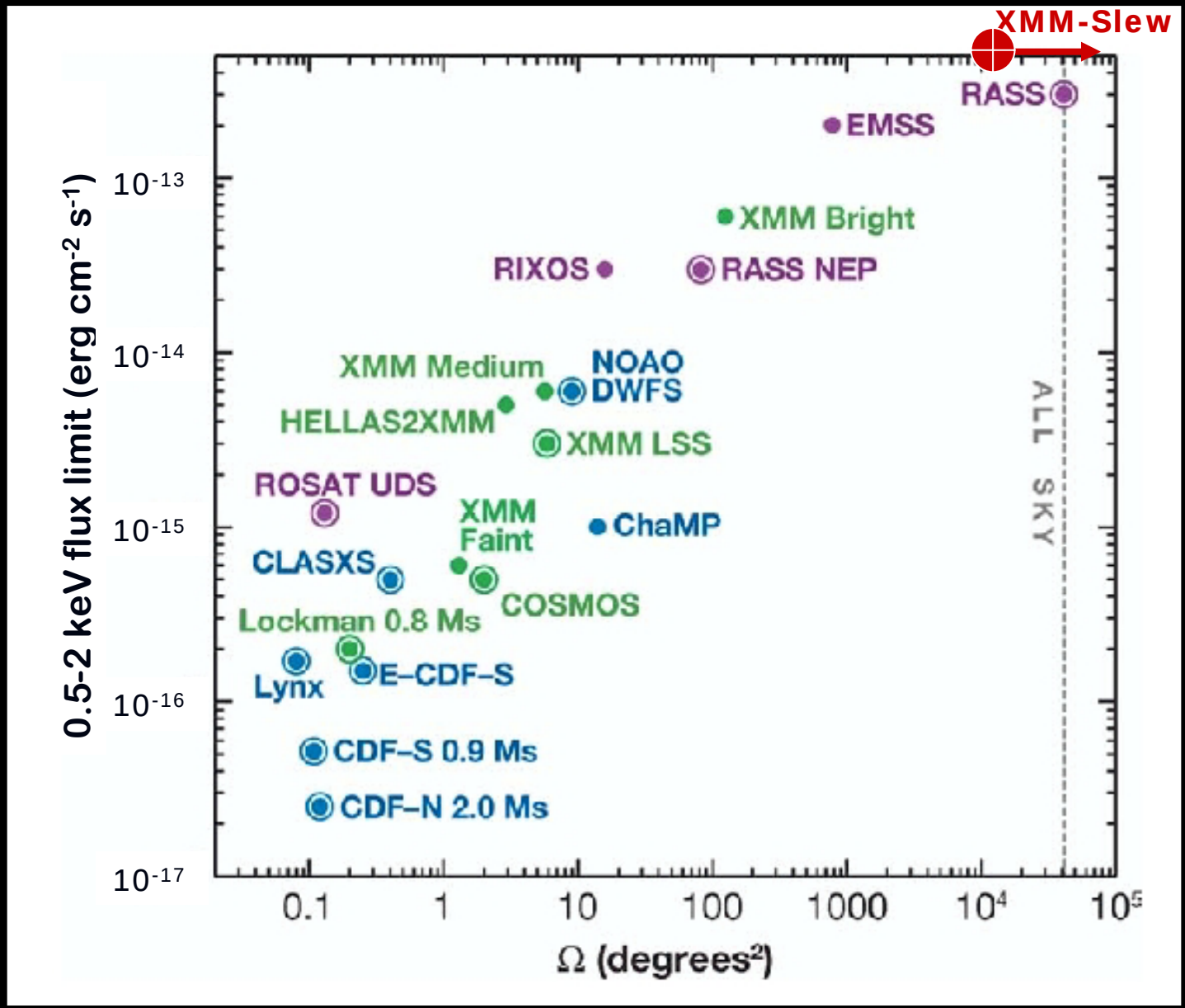


Characteristics

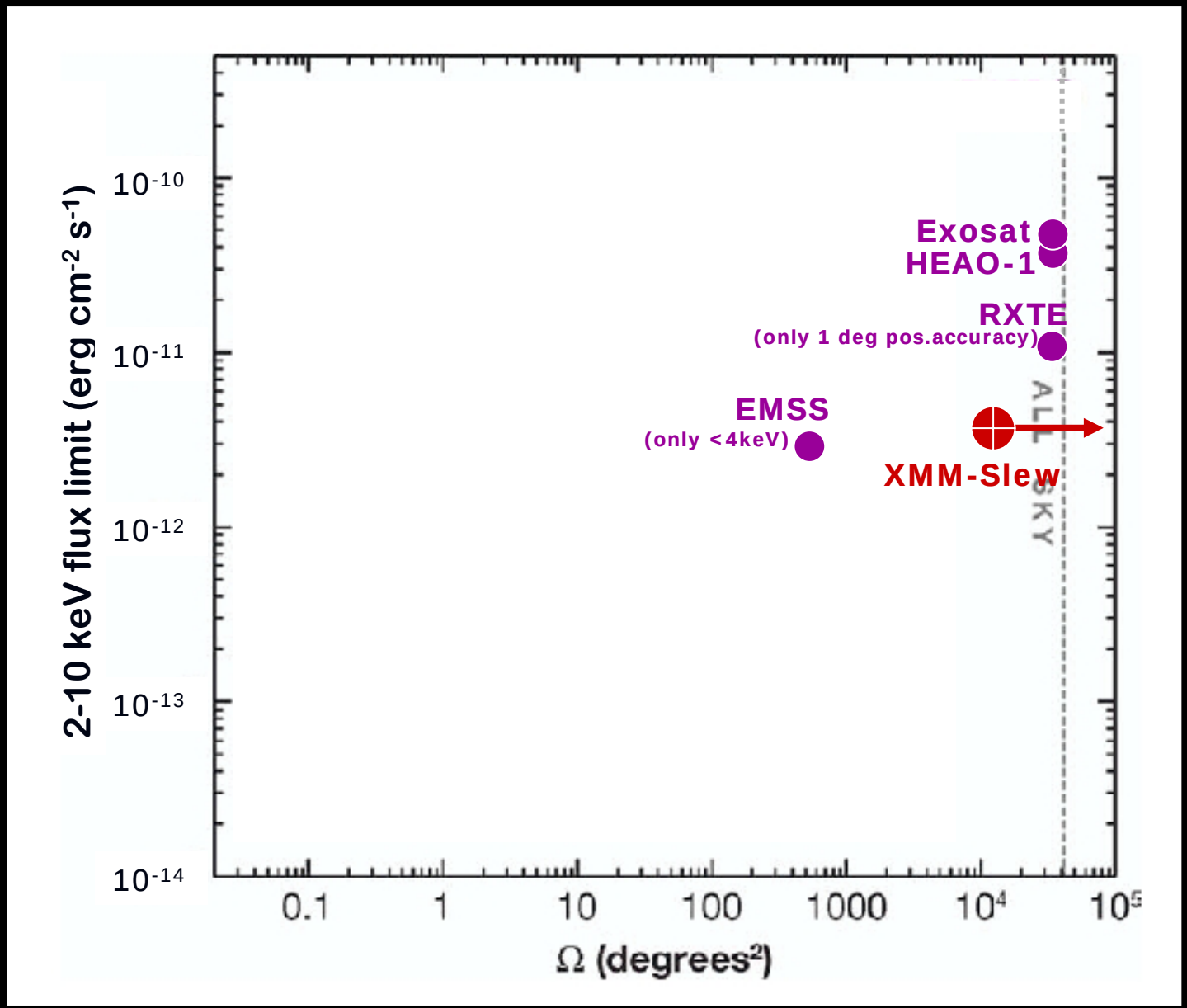
- Slews @90 deg/hr, average 70 deg long, 30 deg^2 area.
- Slews subdivided (~1 deg^2 images) to maintain astrometry, sky positions re-calculated, source-searched
- EPIC-pn (FF, eFF, LW) [MOS frame-time too long]
- PSF similar to pointed observations, slightly extended in slew direction.
- 15 seconds exposure (10 seconds eff. on-axis).
- Low background, typically 0.3c / source box
- Positional accuracy: 8" (1σ)
- Flux limit:
  - **Total band (0.2-12 keV): 1.2×10^{-12}** ergs/s/cm^2
  - **Soft band (0.2-2 keV): 6×10^{-13}** ergs/s/cm^2
  - **Hard band (2-12 keV): 4×10^{-12}** ergs/s/cm^2

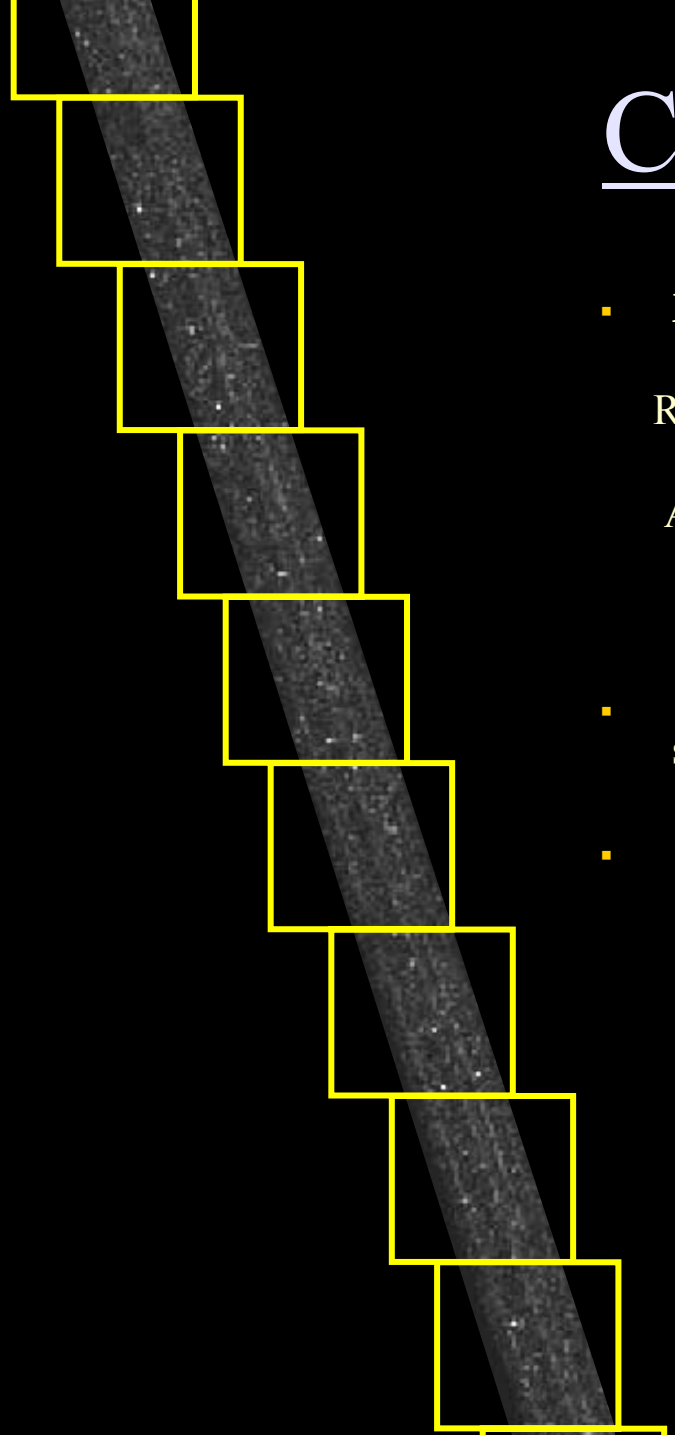
CF: RASS - **3×10^{-13} , HEAO-1 - 3×10^{-11}**

Survey Characteristics – Soft Band



Survey Characteristics – Hard Band





Catalogues

- **XMMSL1**: catalogue of slew sources released May 2006.

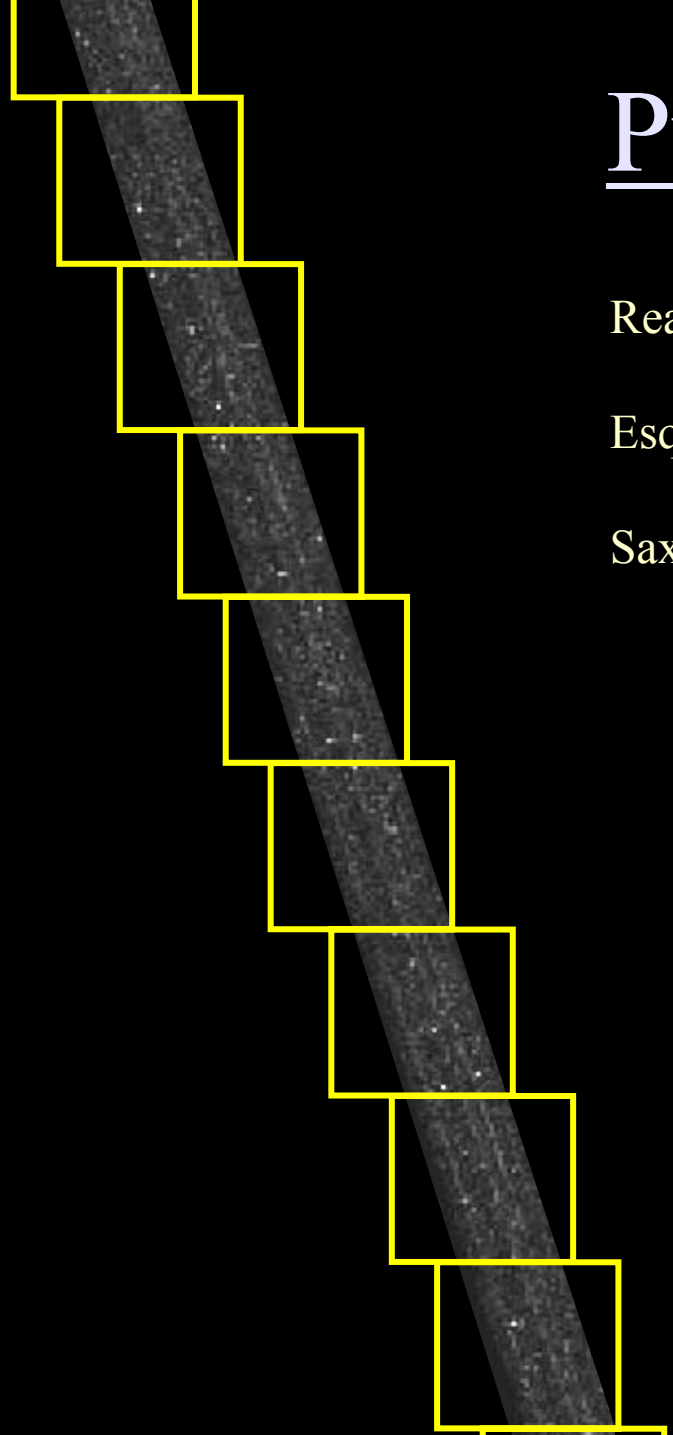
  Revs 314-978, 2700 clean sources (DET_ML>10), 6200 deg^2

  Available from XMM Science Archive:

  http://xmm.vilspa.esa.es/xsa/

- **Delta-1**: To be released ~now, giving total of 4000 clean sources. 10200 deg^2 (25% of sky ignoring overlaps)

- Intention to release further Deltas every 6 months



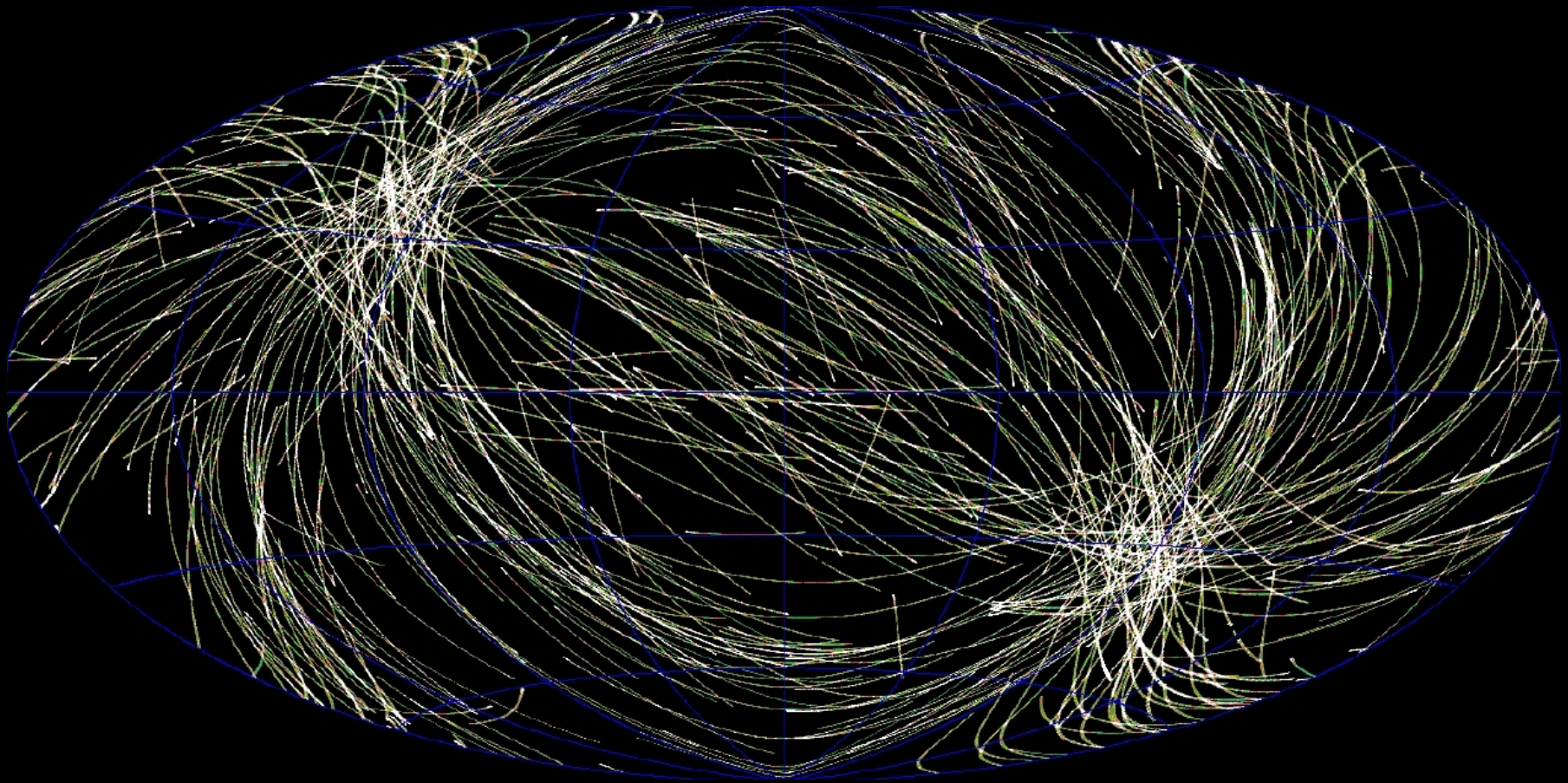
Publications

Read et al, 2006, PASJ - Scientific highlights

Esquej et al, 2007, A&A - High variability galaxies

Saxton et al, 2007, A&A (in prep) - Full description

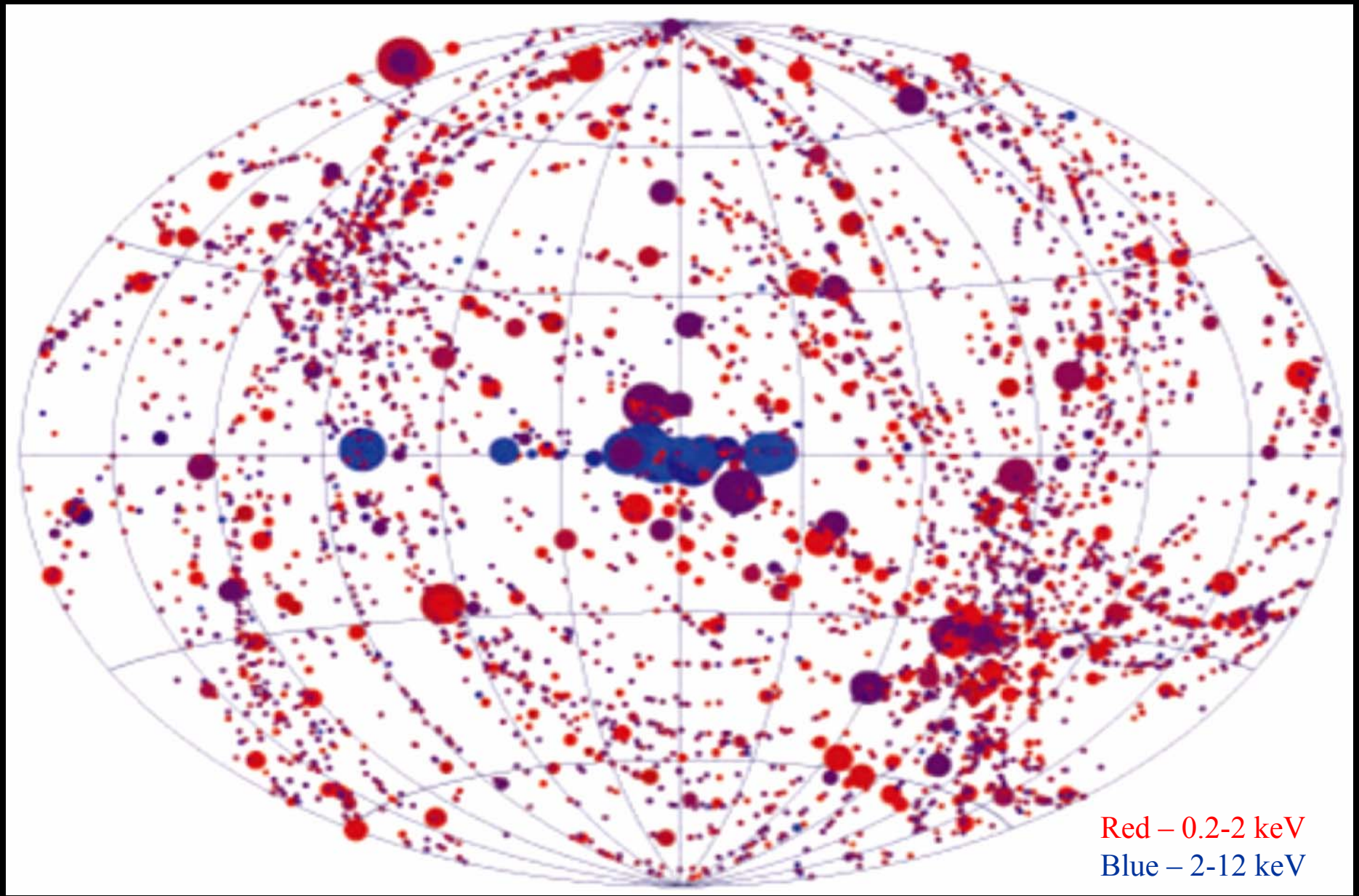
Sky Coverage



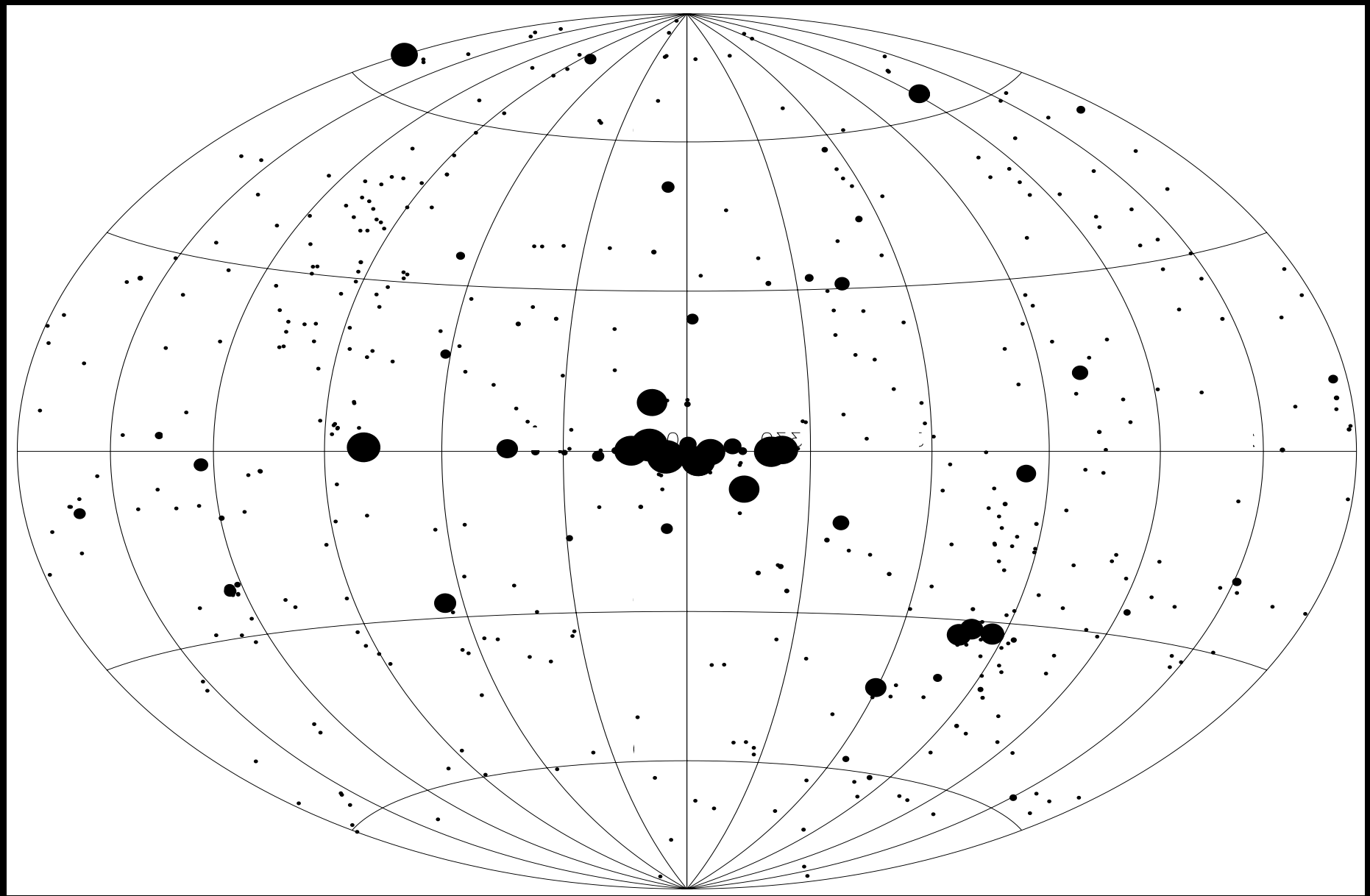
XMMSL1 + Delta-1 (Galactic coords) [~25% of sky : ~20% correcting for overlaps]

+ 150 unsearched slews [total ~30% of sky, correcting for overlaps]

Sources from XMMSL1+Delta-1

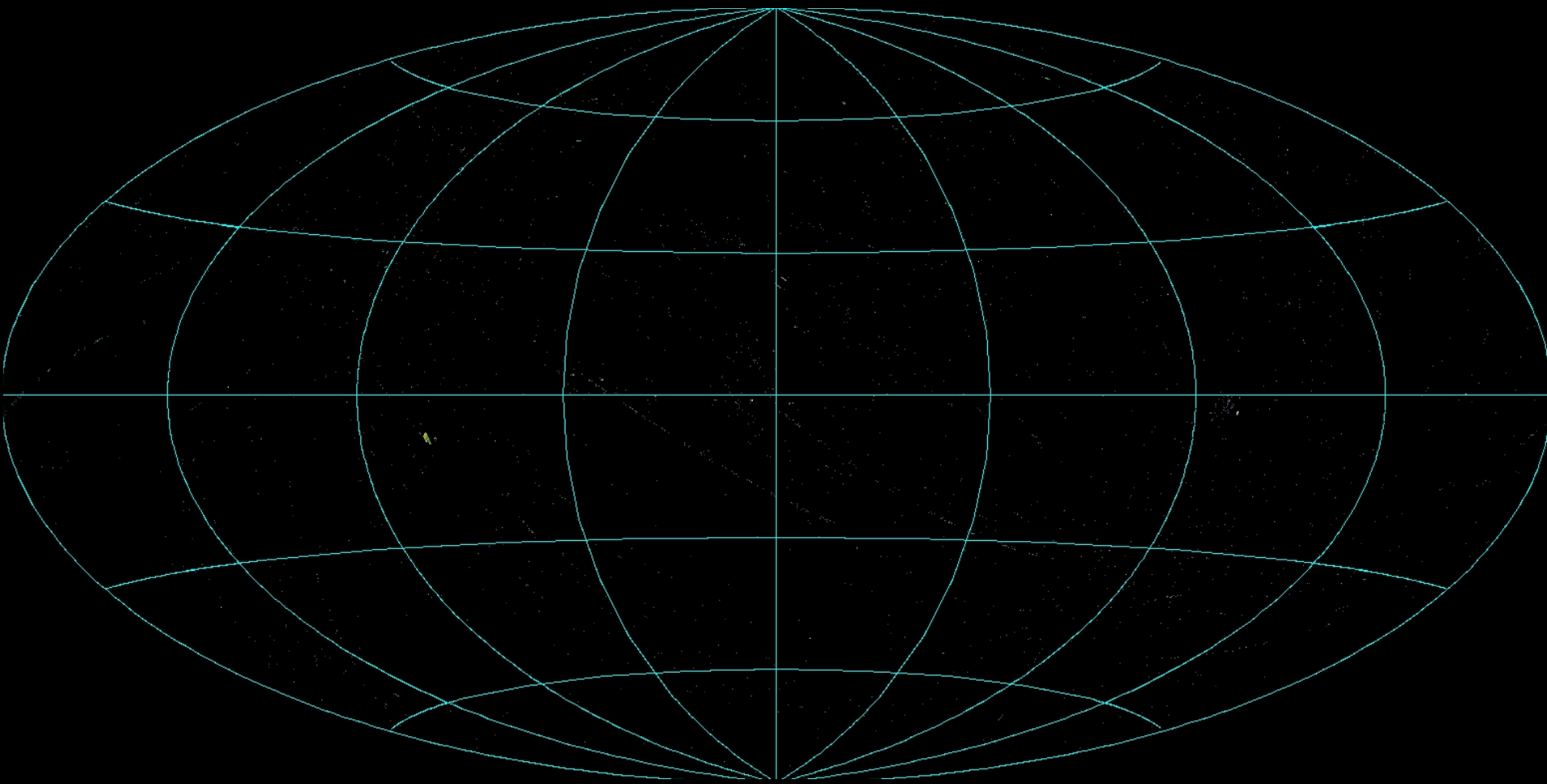


Sources from XMMSL1+Delta-1



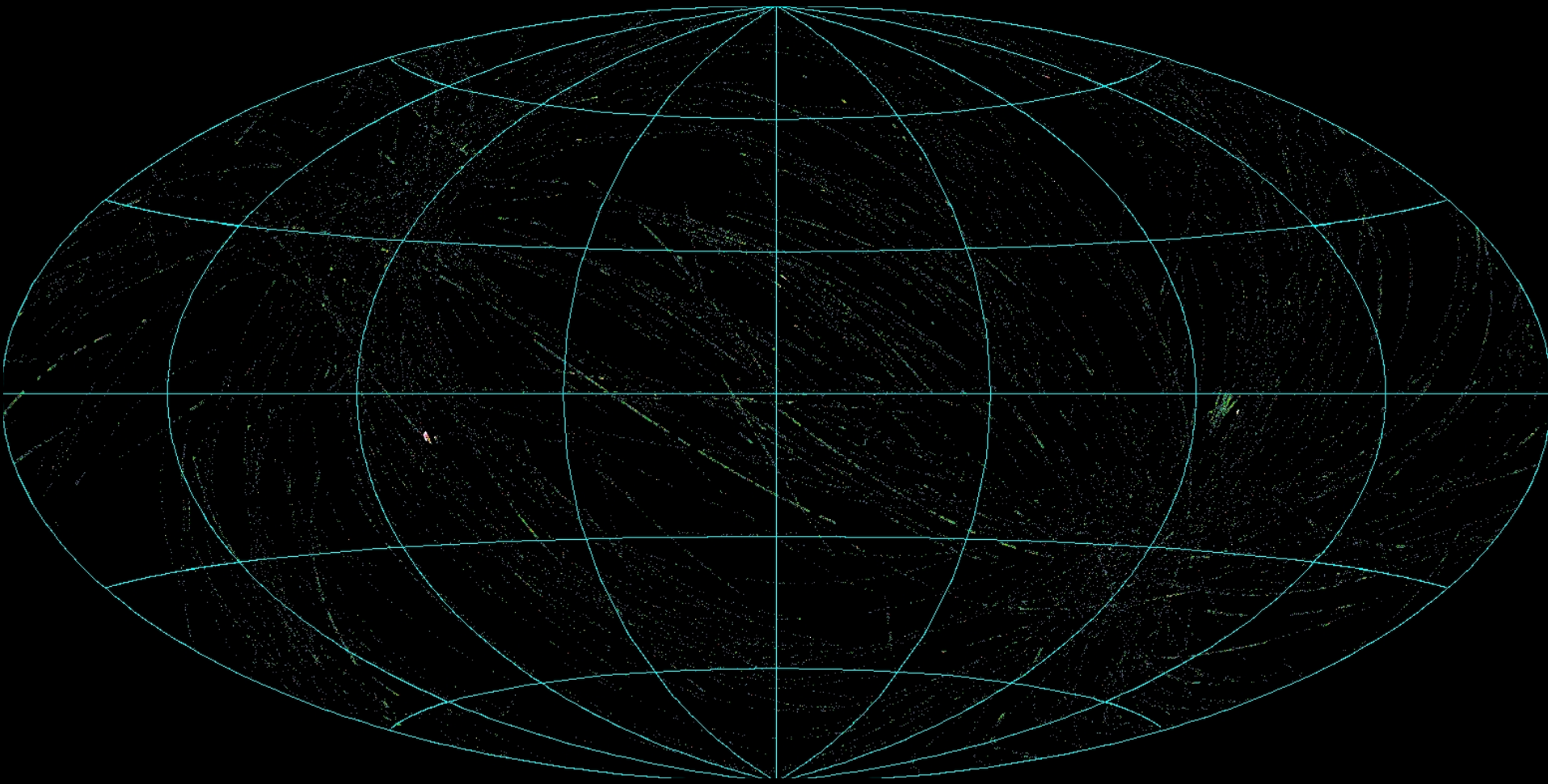
400 hard band sources (2-12keV)

The XMM-Newton Slew Survey : Towards the Whole Sky

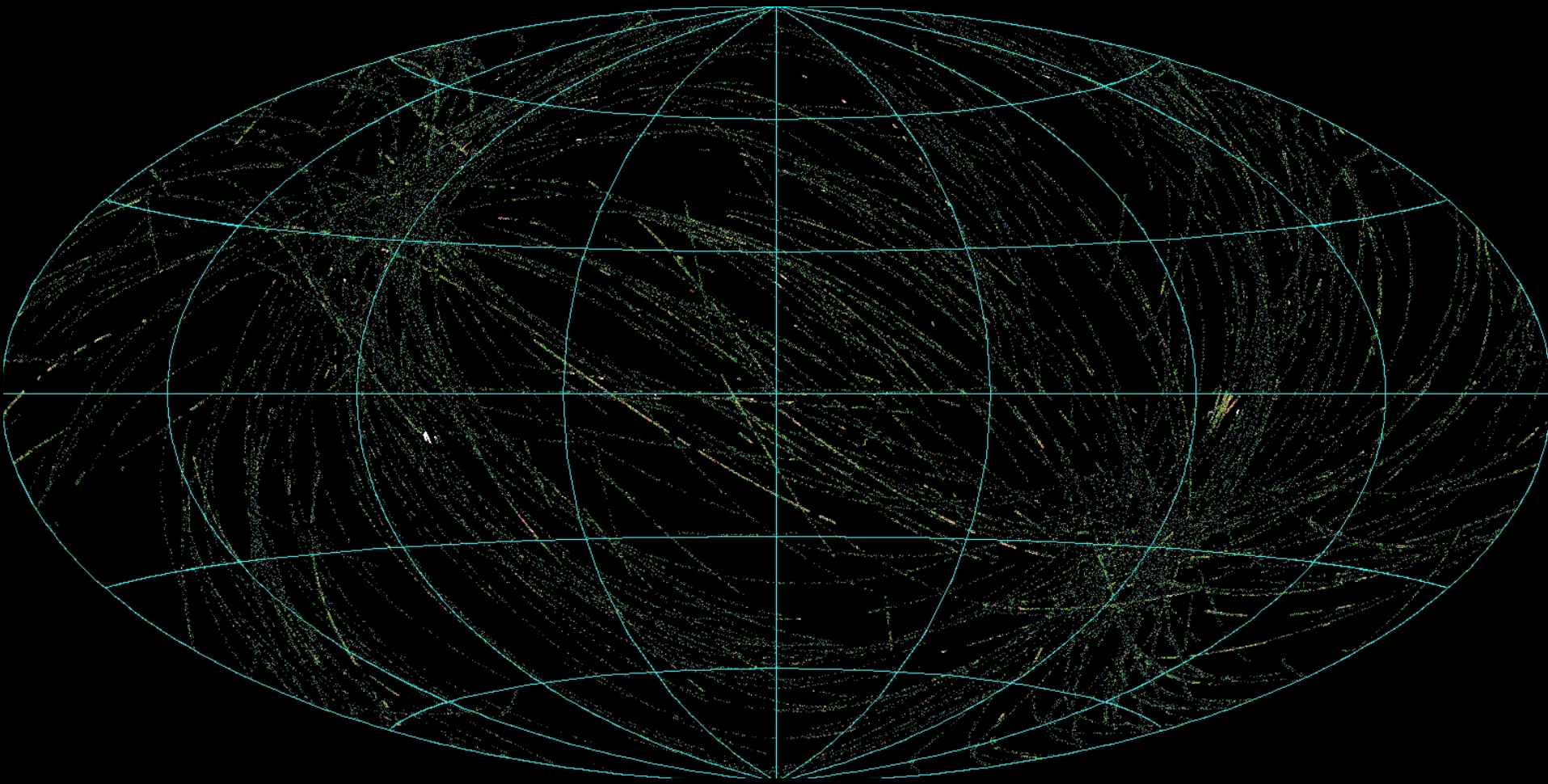


Galactic co-ordinates
Exposure-corrected images
High-BG images removed

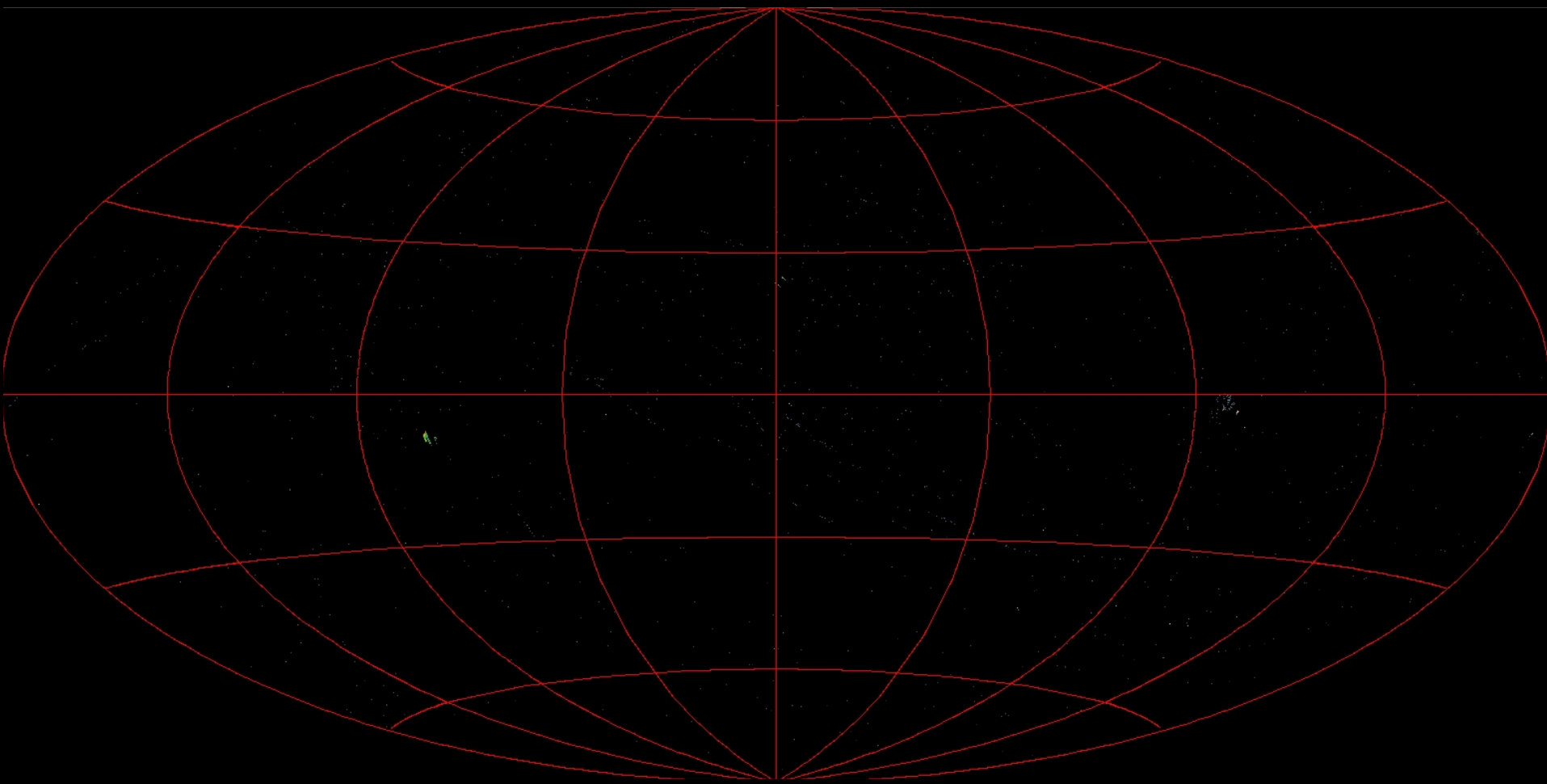
Full band 0.2-12 keV
~ 600 slews
~ 30000 sub-images



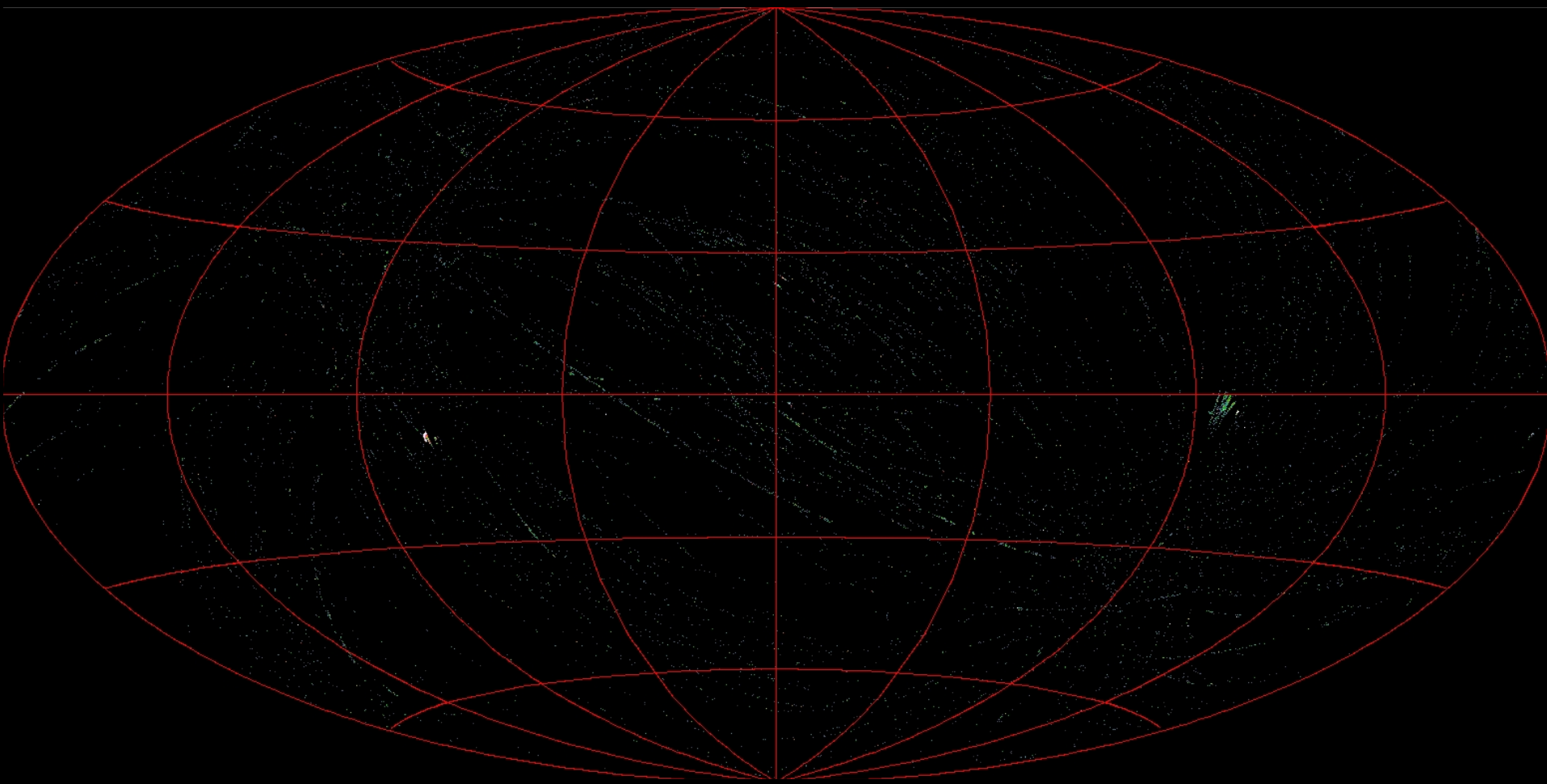
Full band 0.2-12 keV



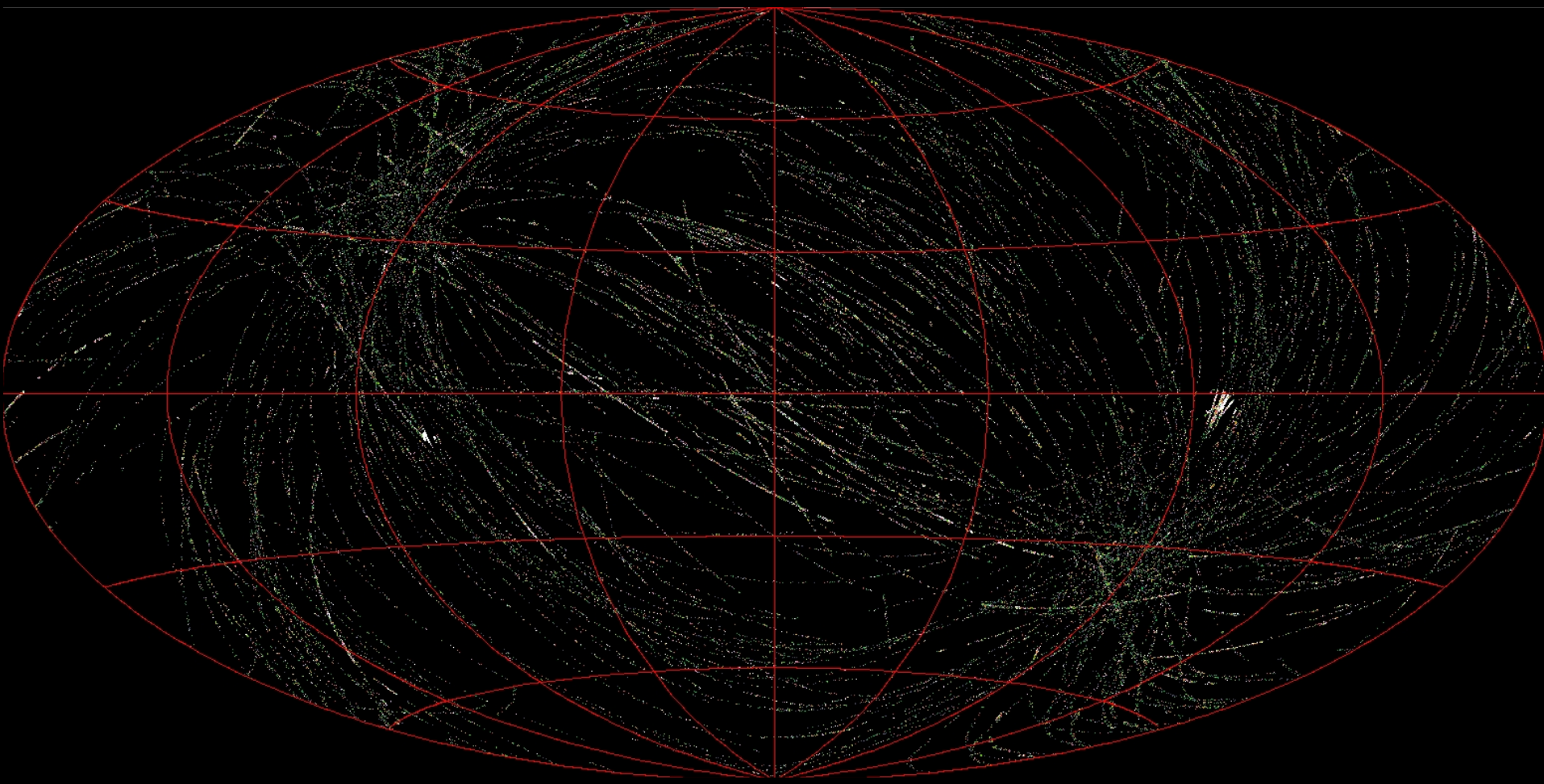
Full band 0.2-12 keV

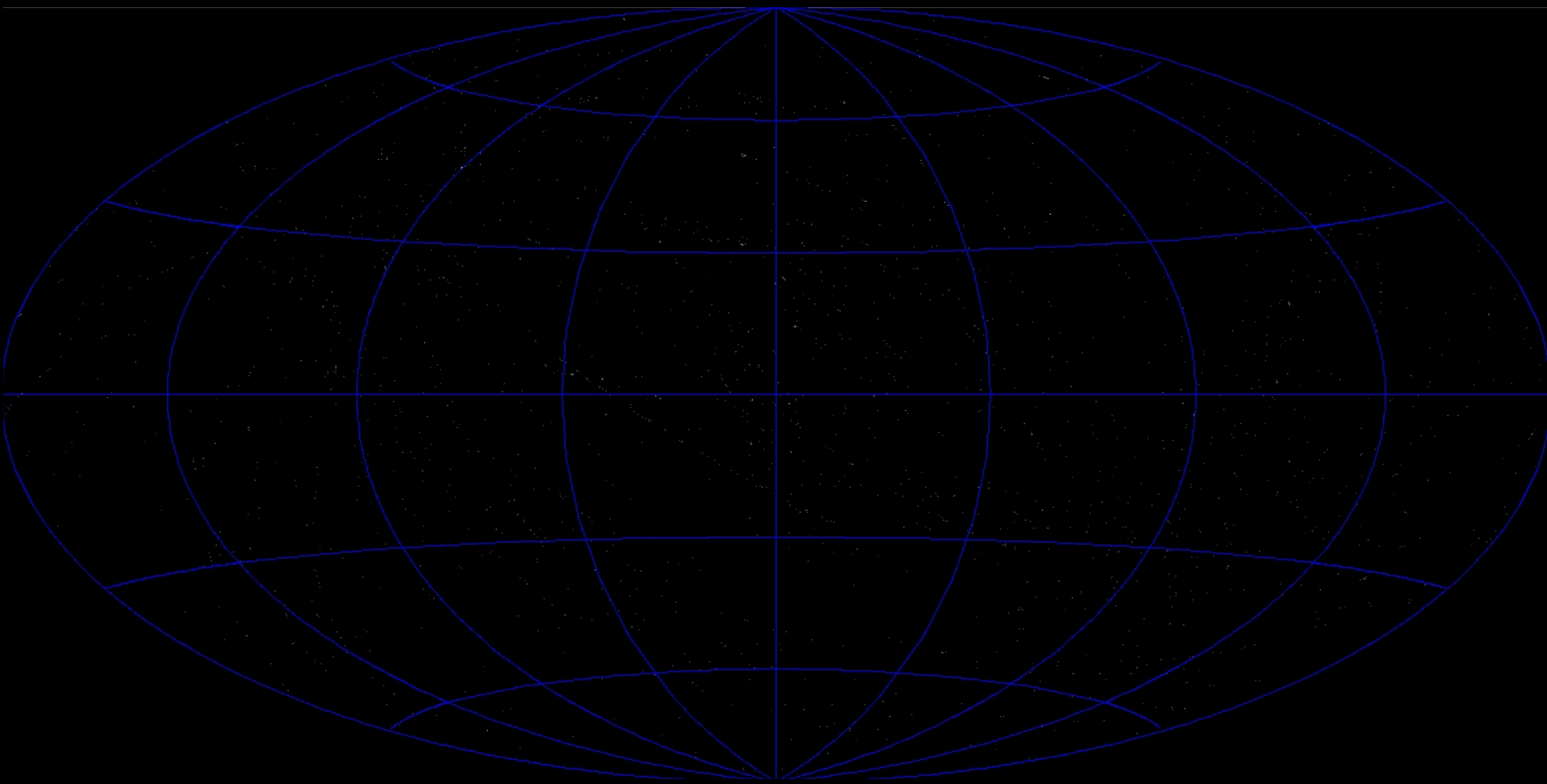


Soft band 0.2-2 keV

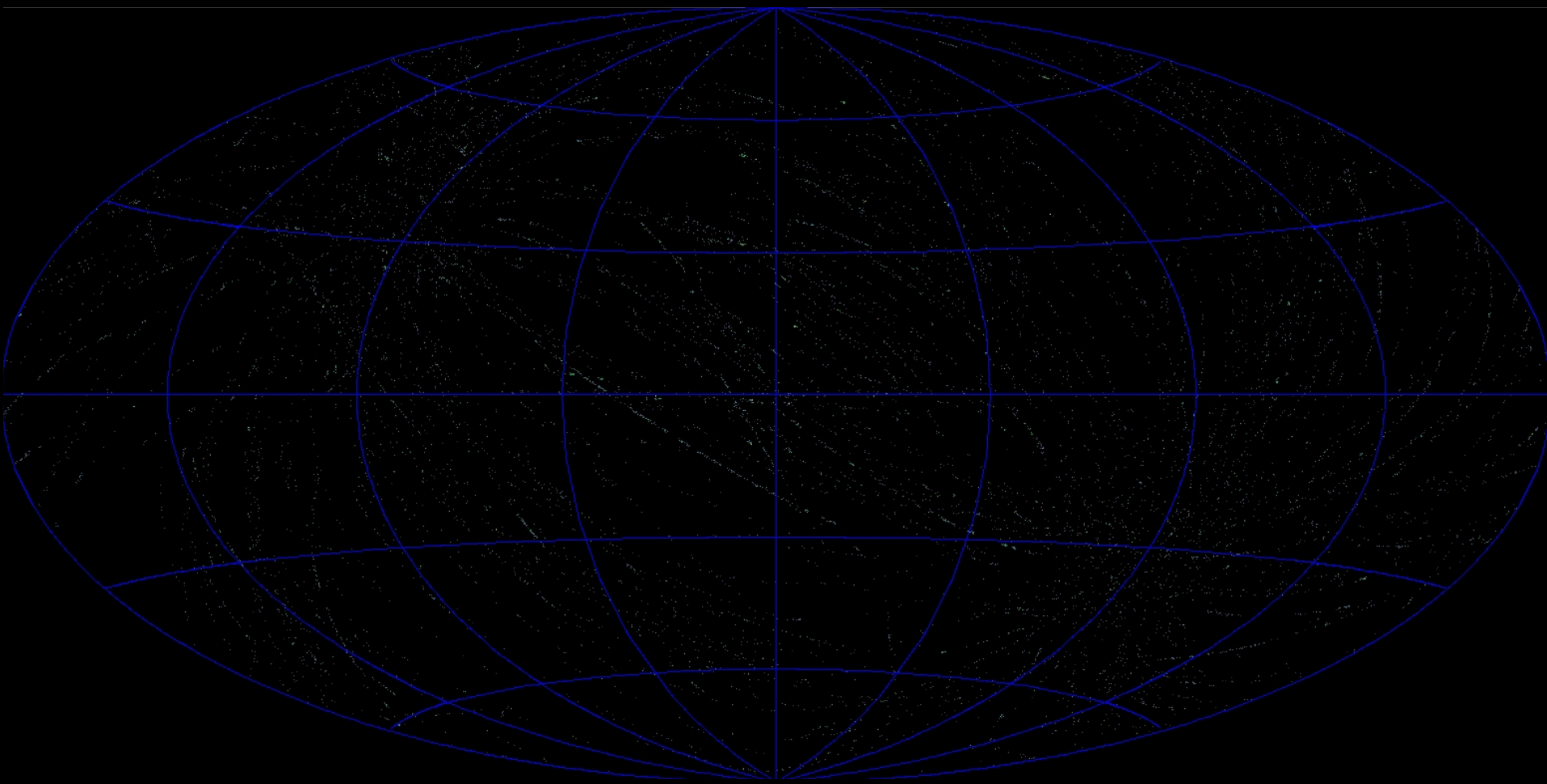


Soft band 0.2-2 keV

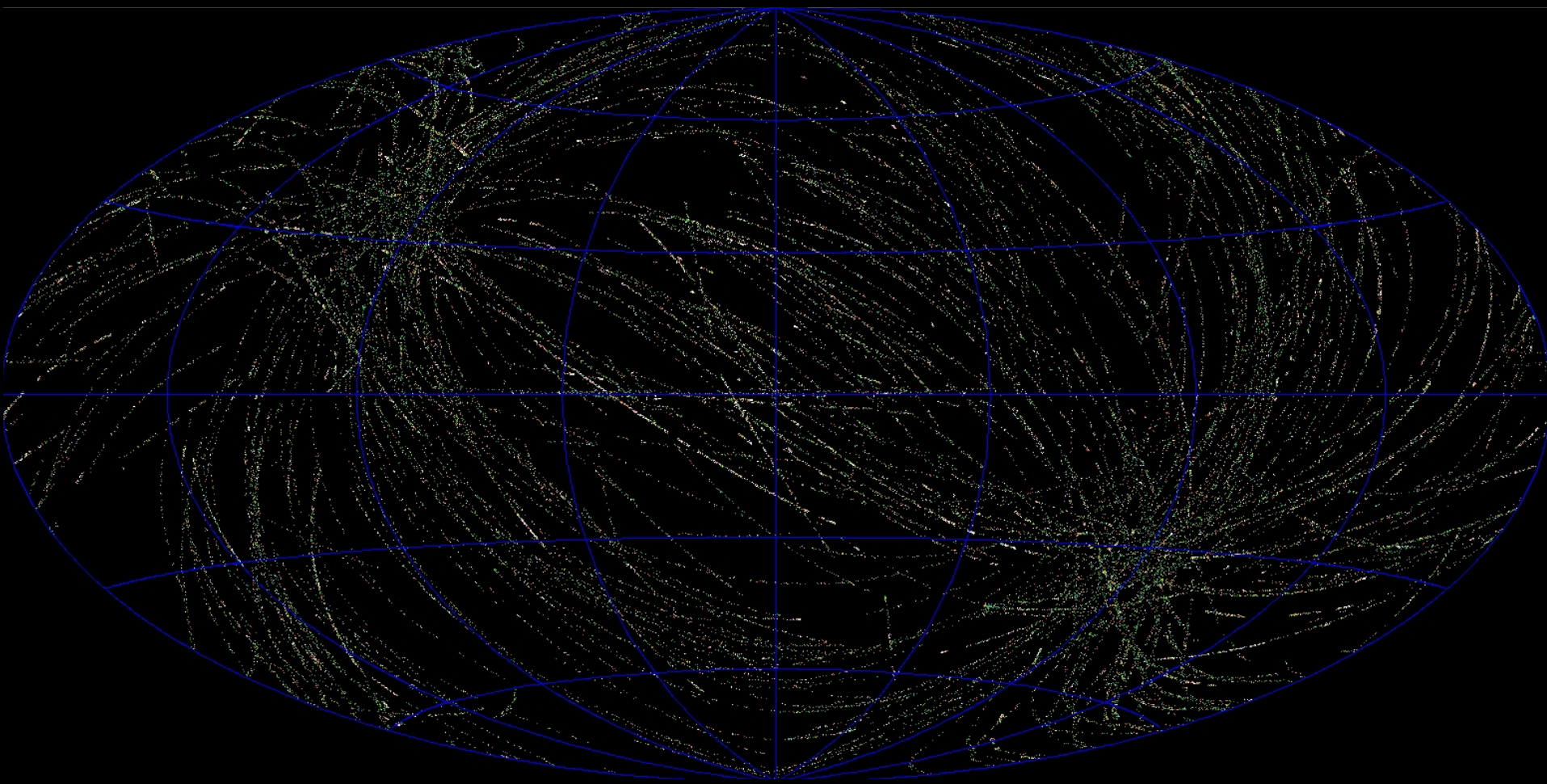

Soft band 0.2-2 keV



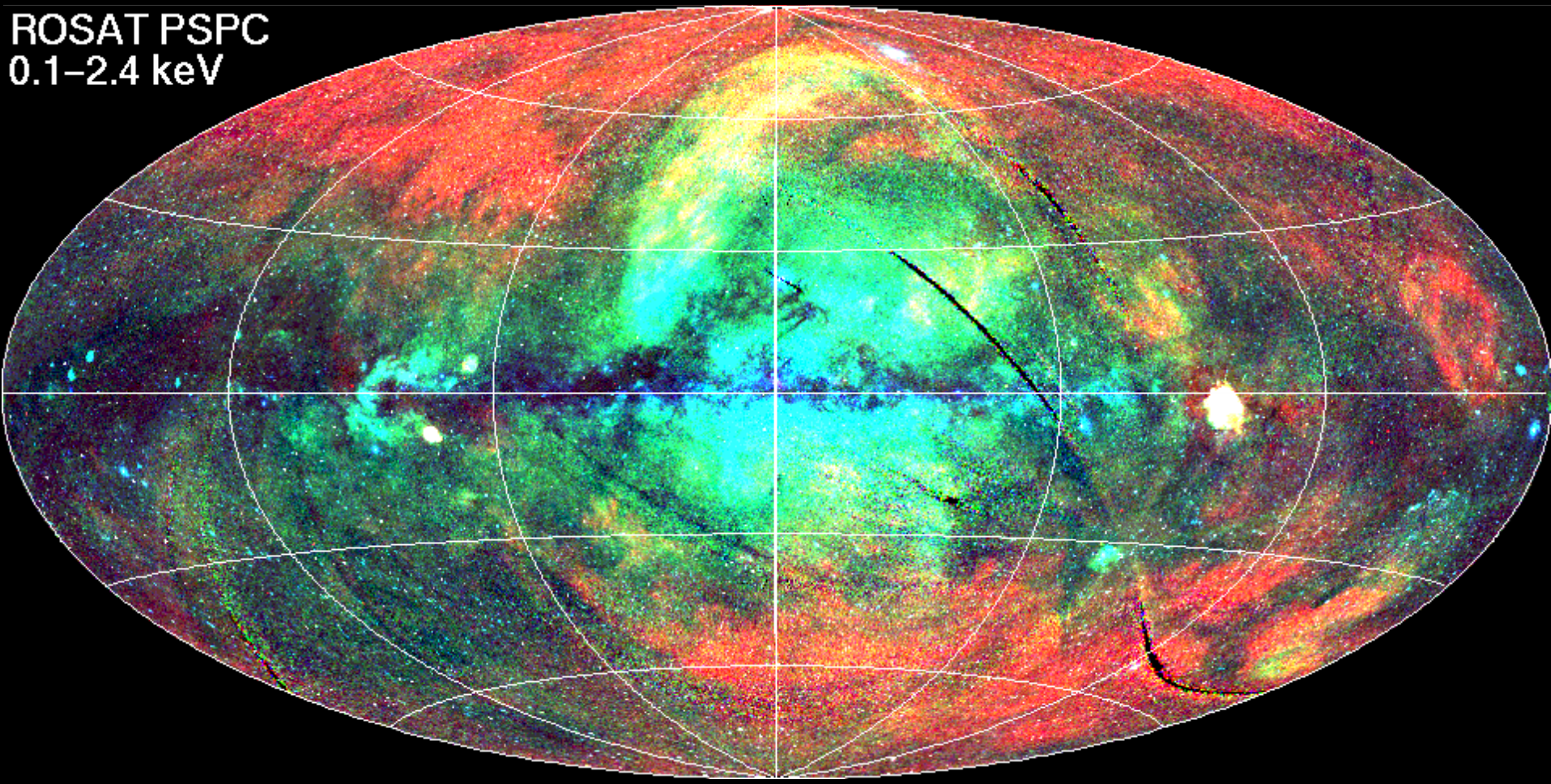
Hard band 2-12 keV



Hard band 2-12 keV

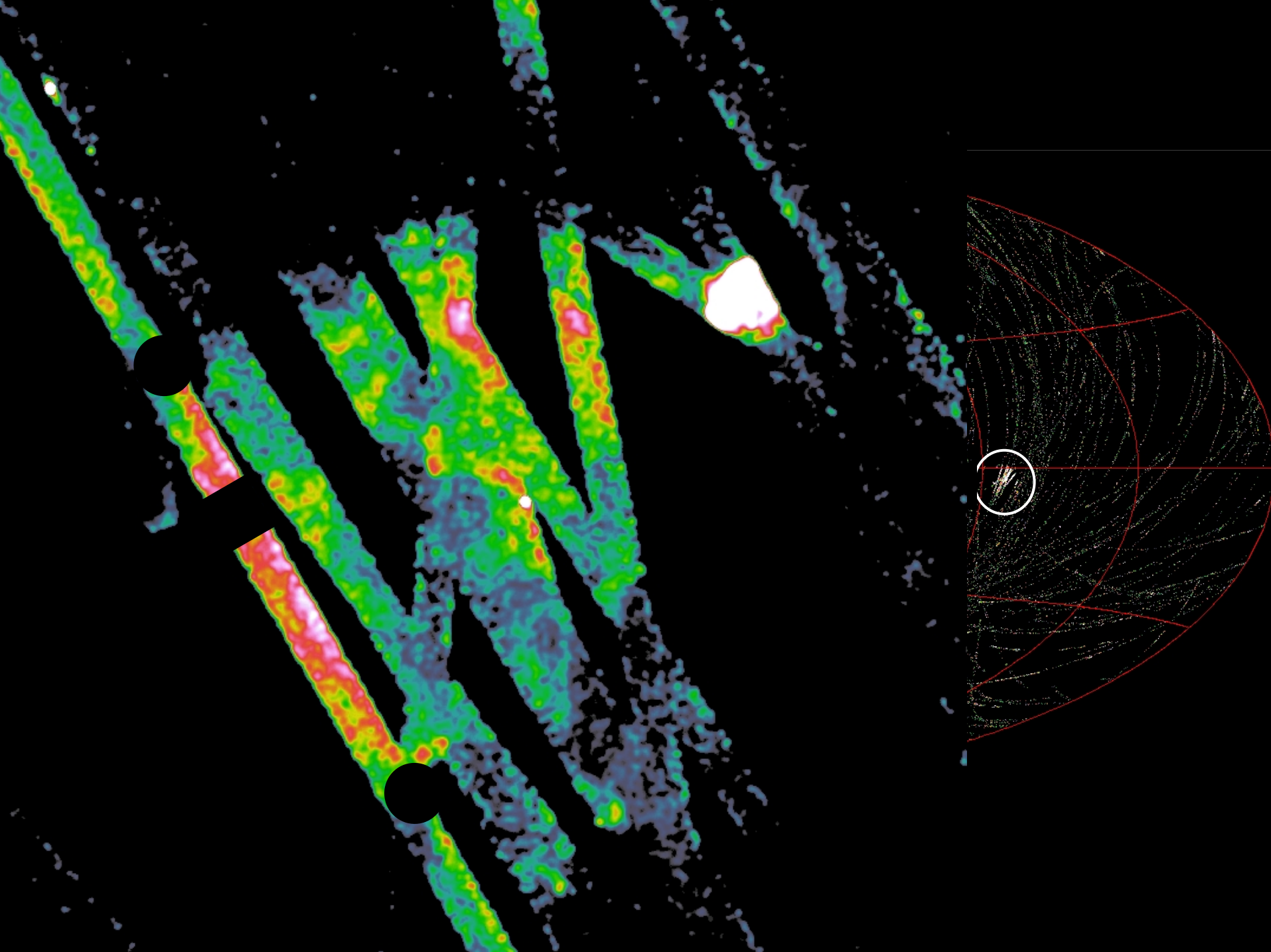


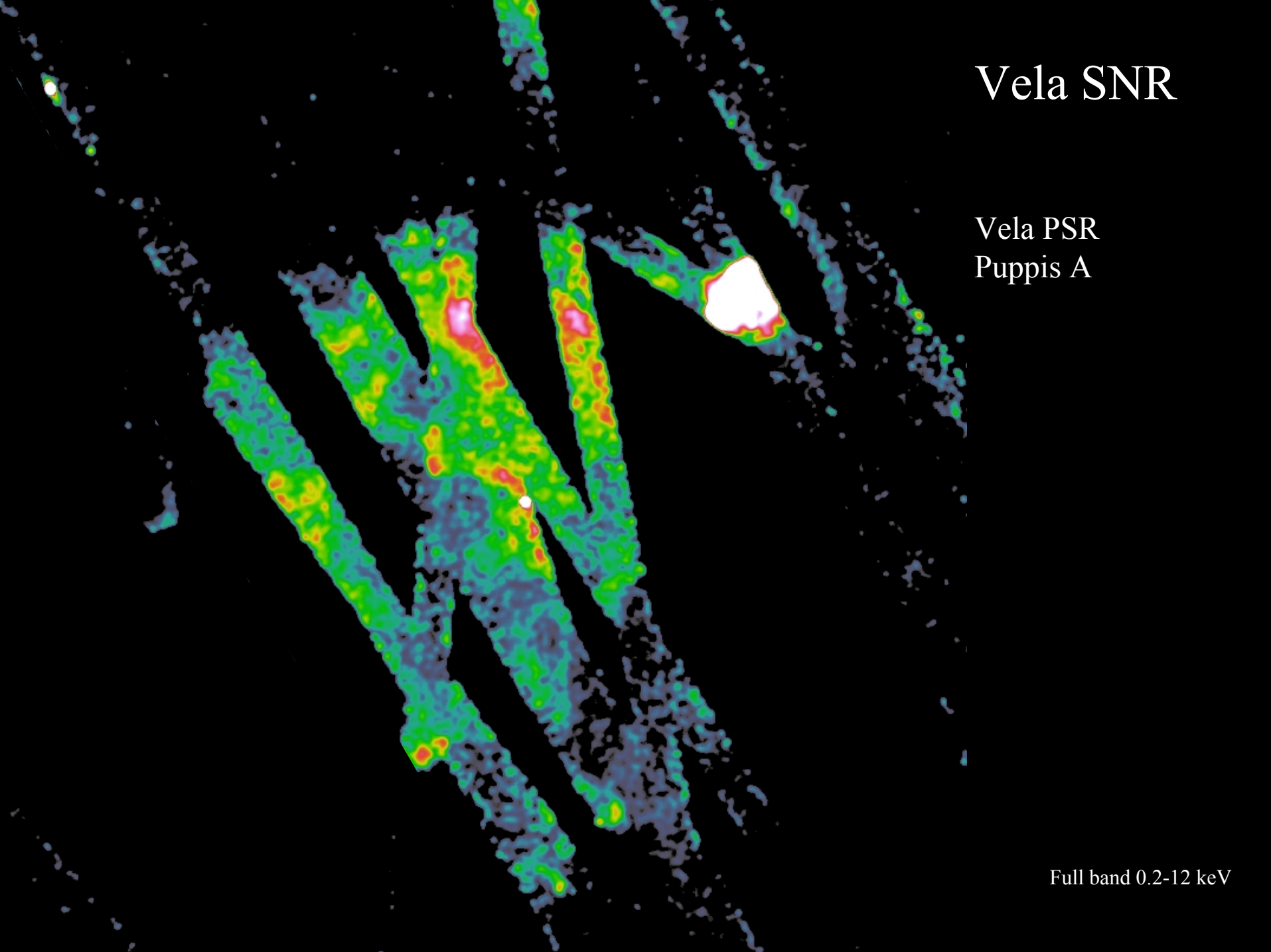
Hard band 2-12 keV



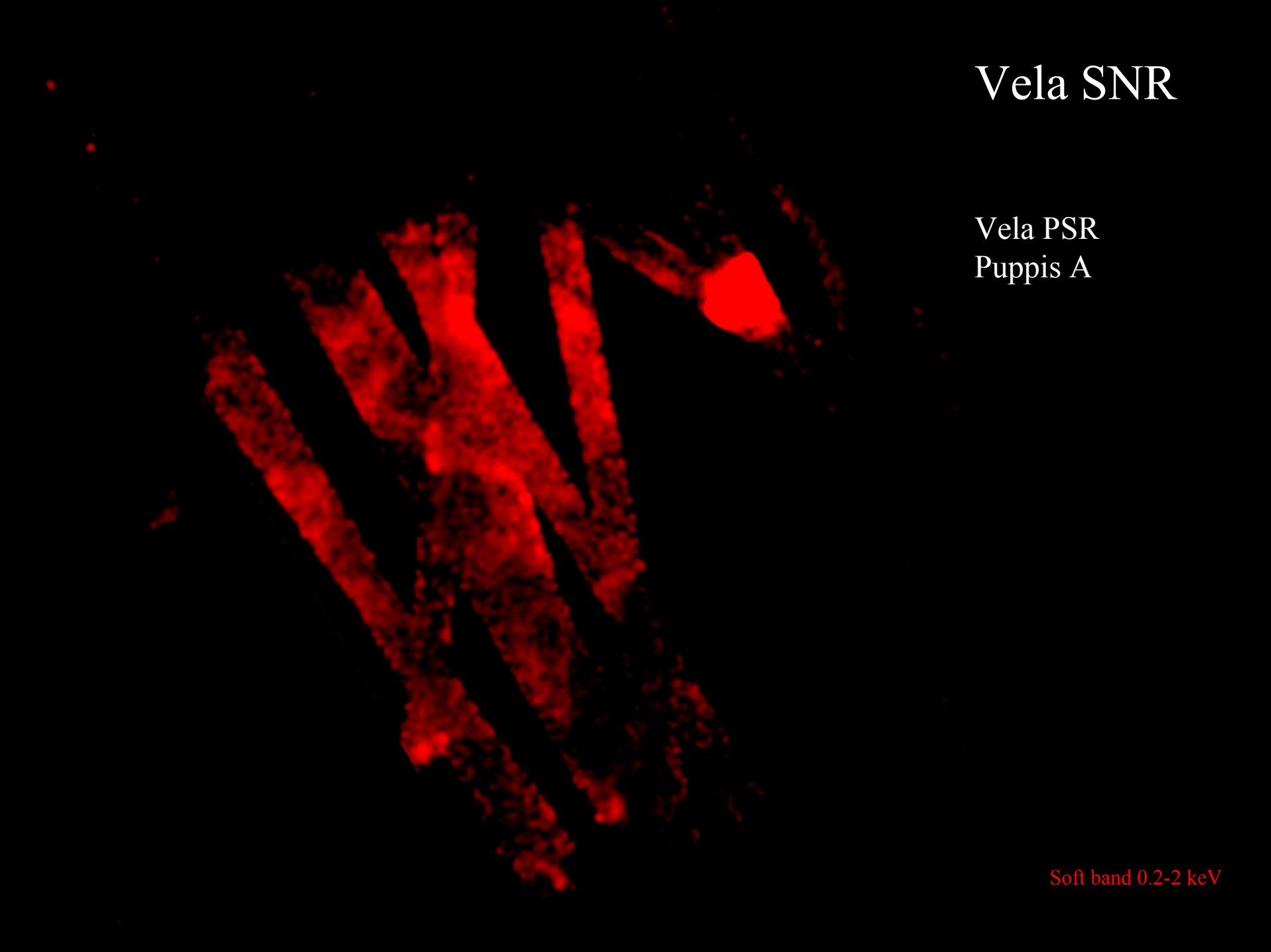
Observation time: ~1 week!

Soft band 0.2-2 keV

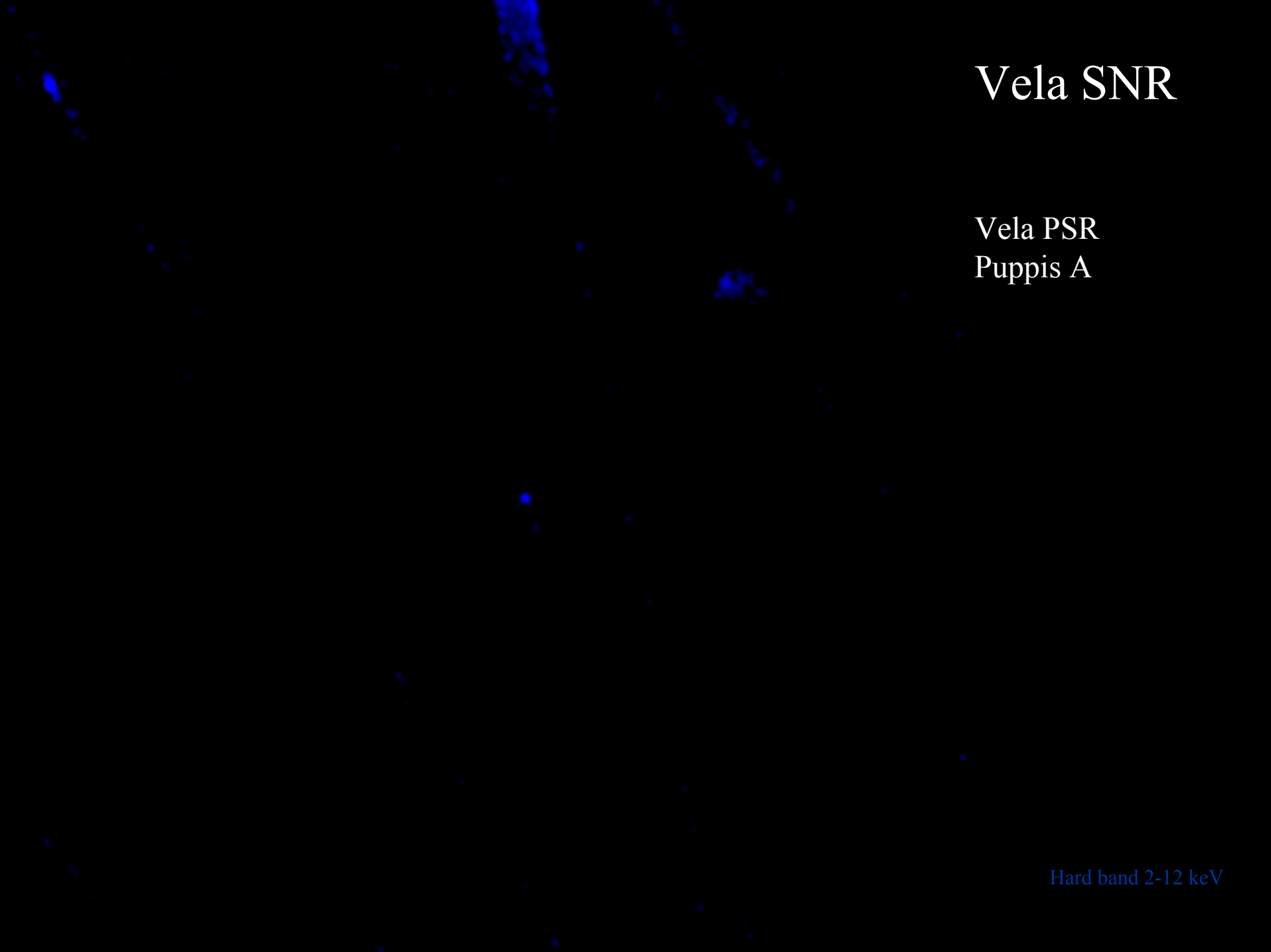


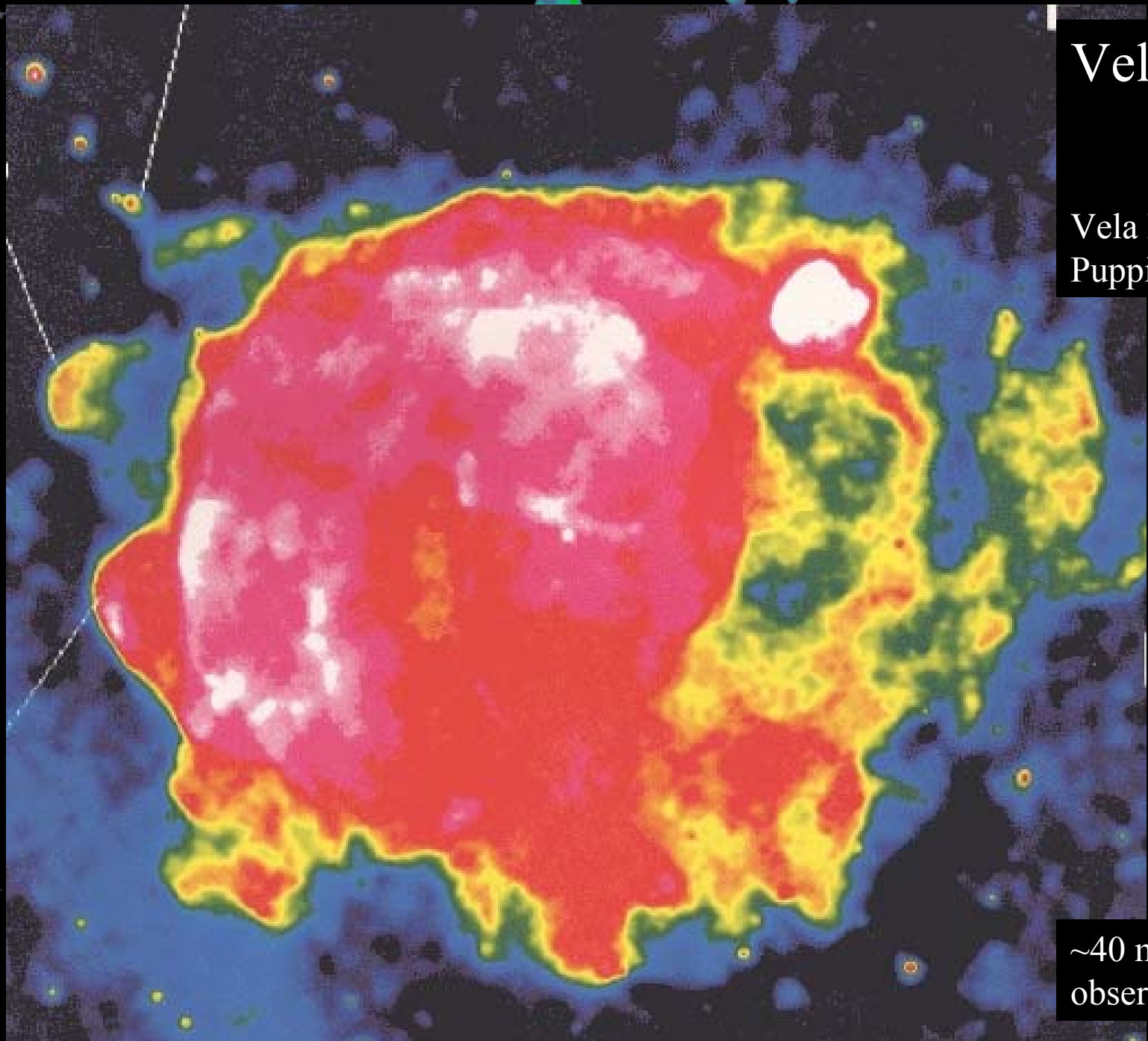

Vela SNR
Vela PSR
Puppis A
Full band 0.2-12 keV

Vela SNR



Vela SNR



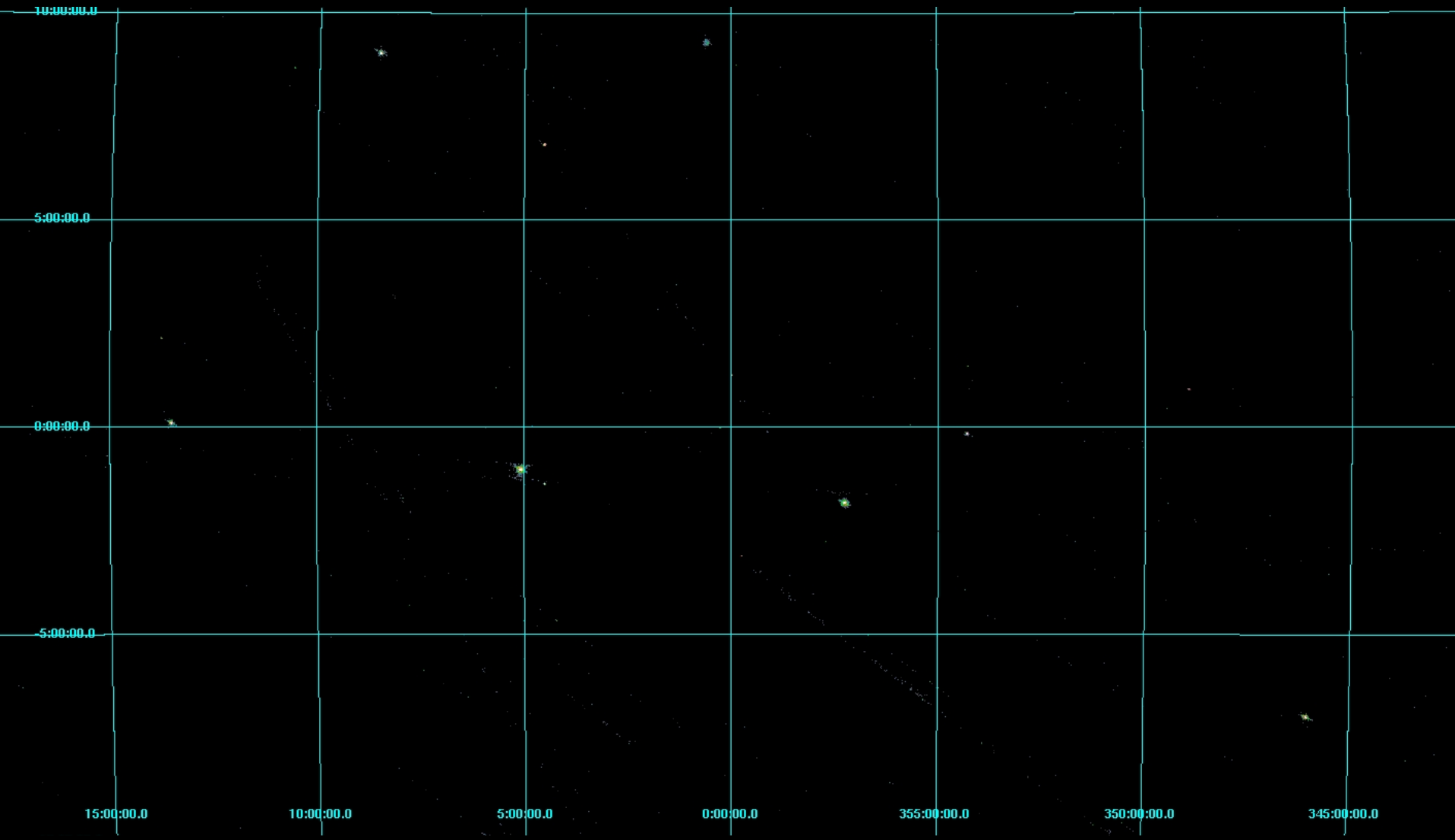


Vela SNR

Vela PSR
Puppis A

~40 minutes
observing time

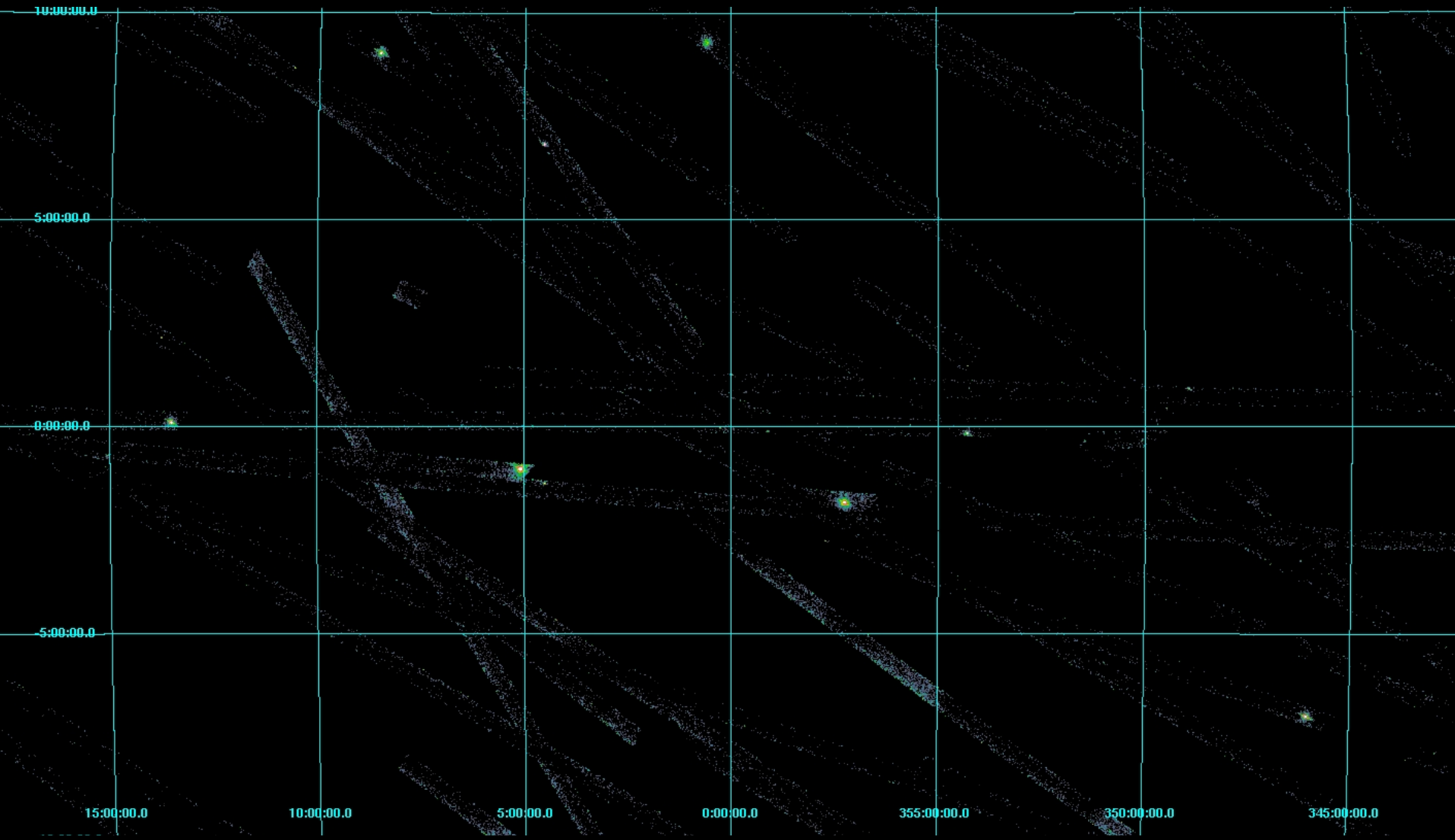
The XMM-Newton Slew Survey : The Galactic Centre



Galactic co-ordinates
Exposure-corrected images
High-BG images removed

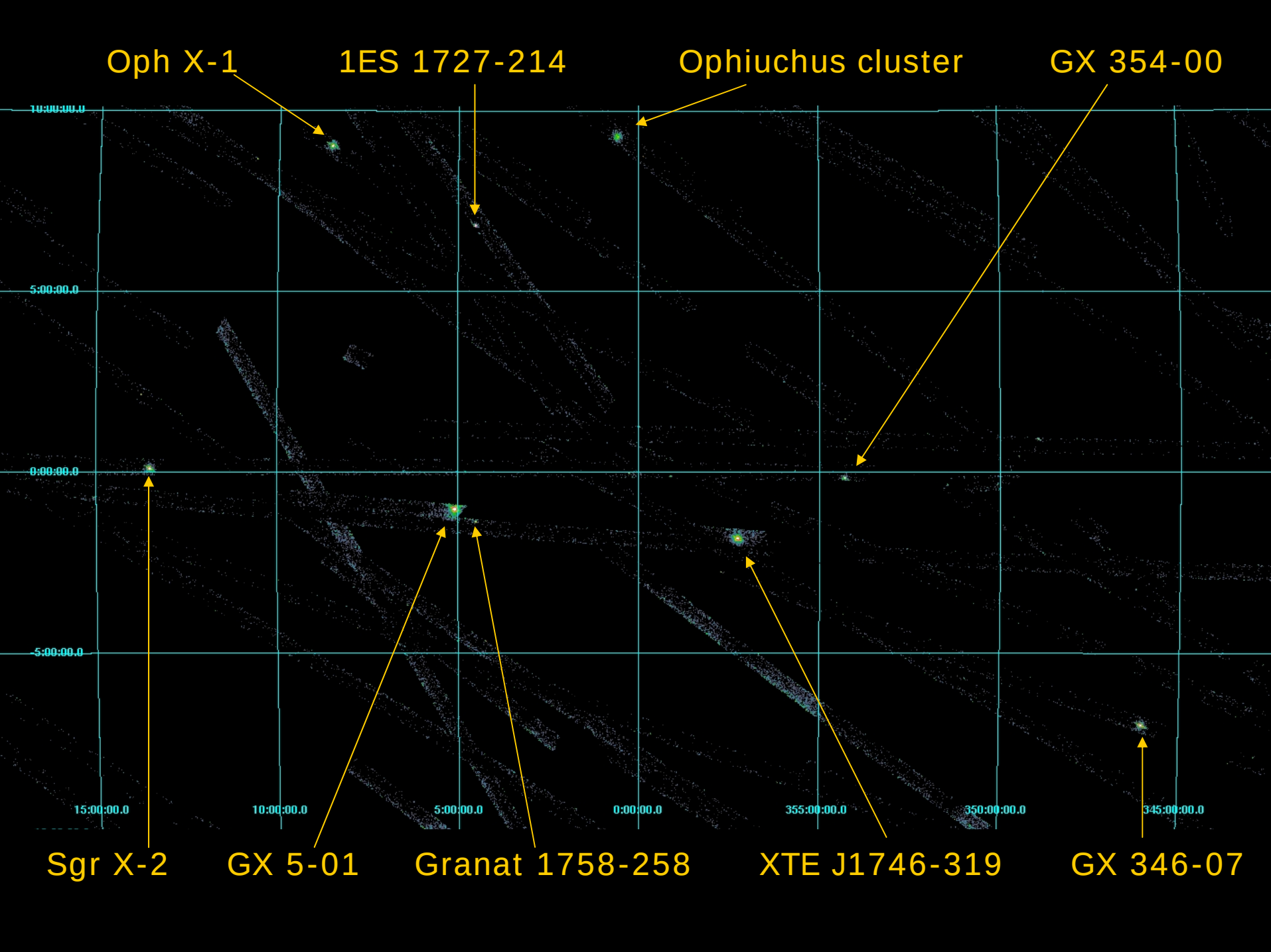
Full band 0.2-12 keV

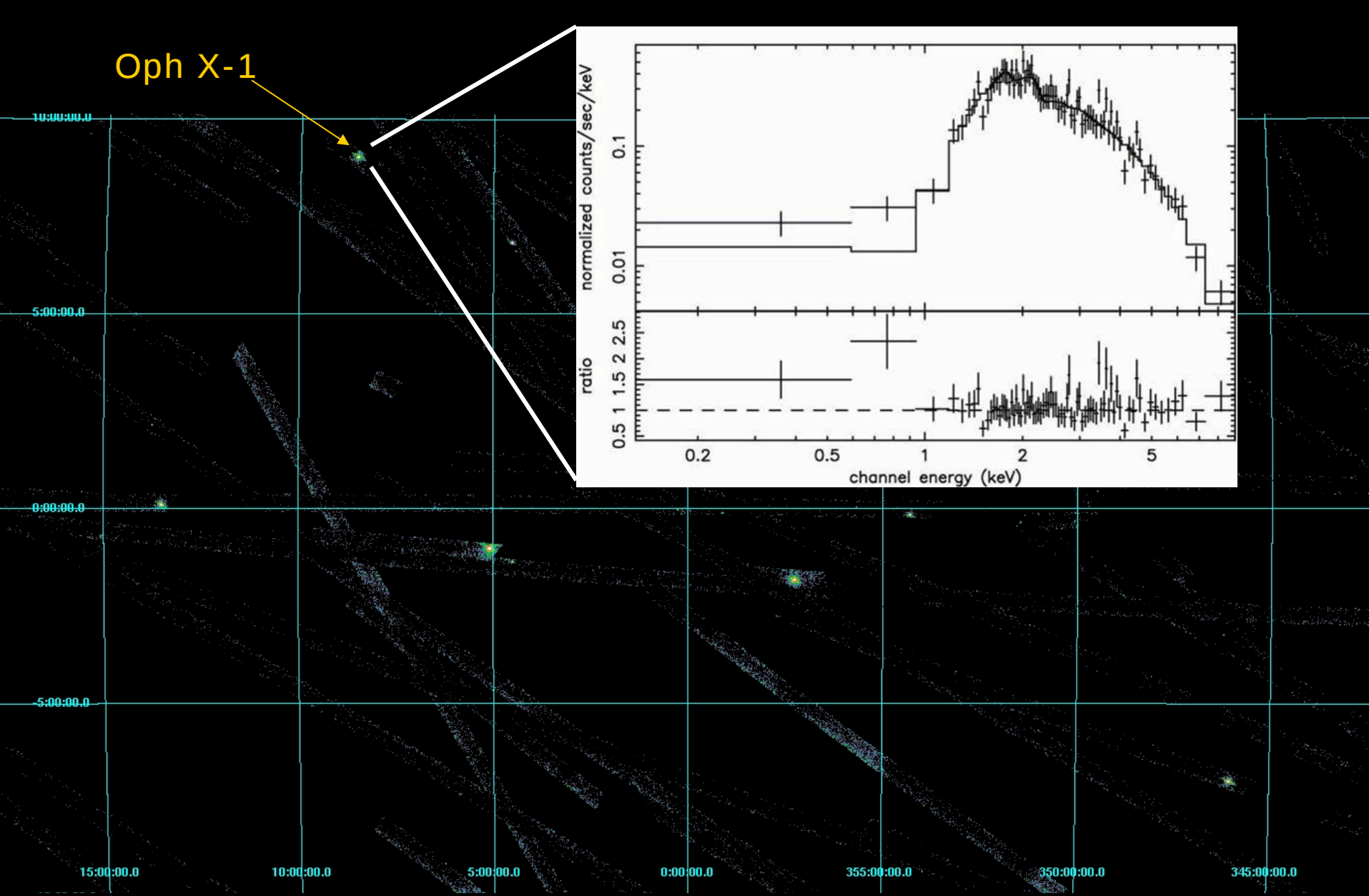
The XMM-Newton Slew Survey : The Galactic Centre

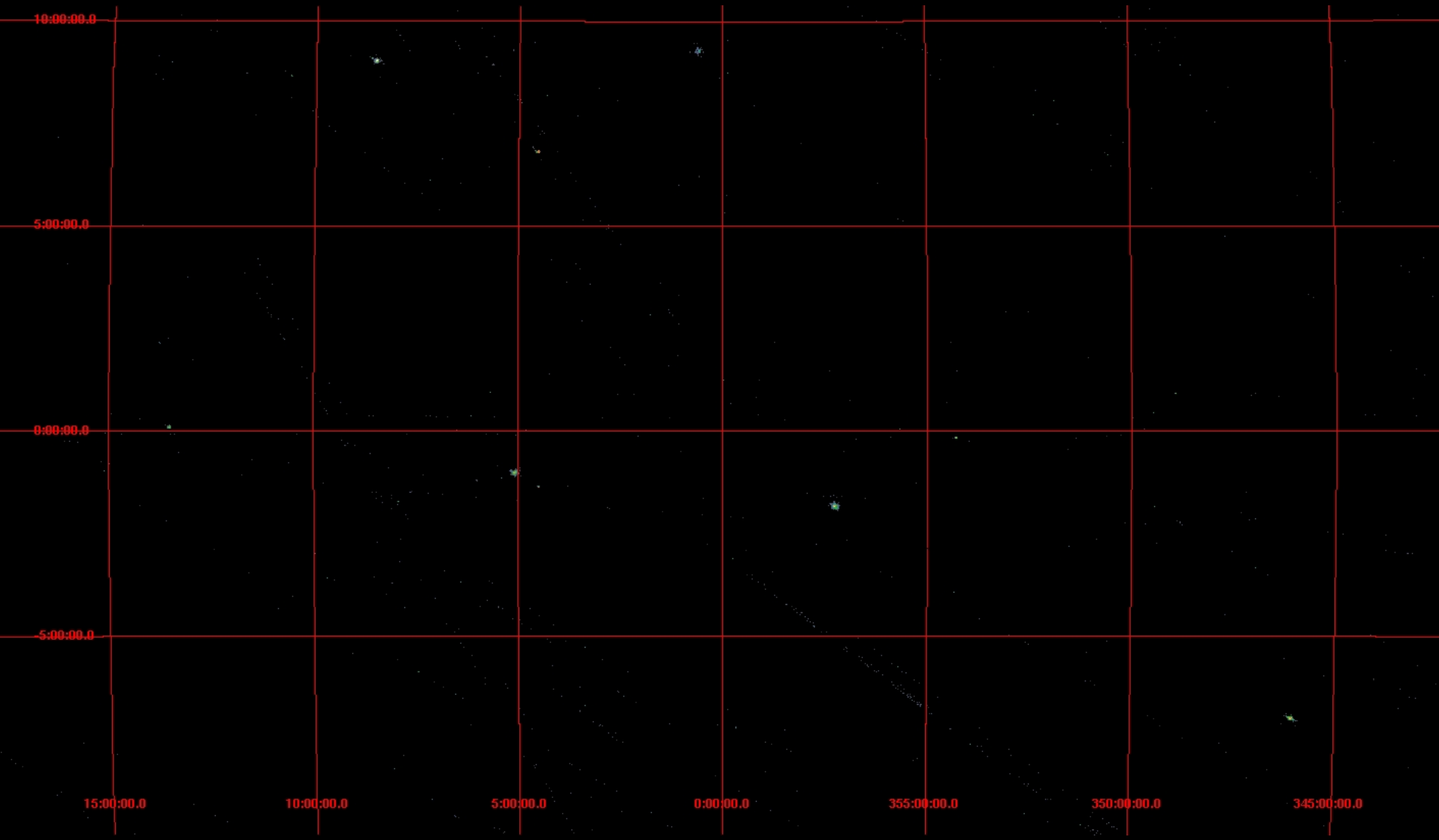


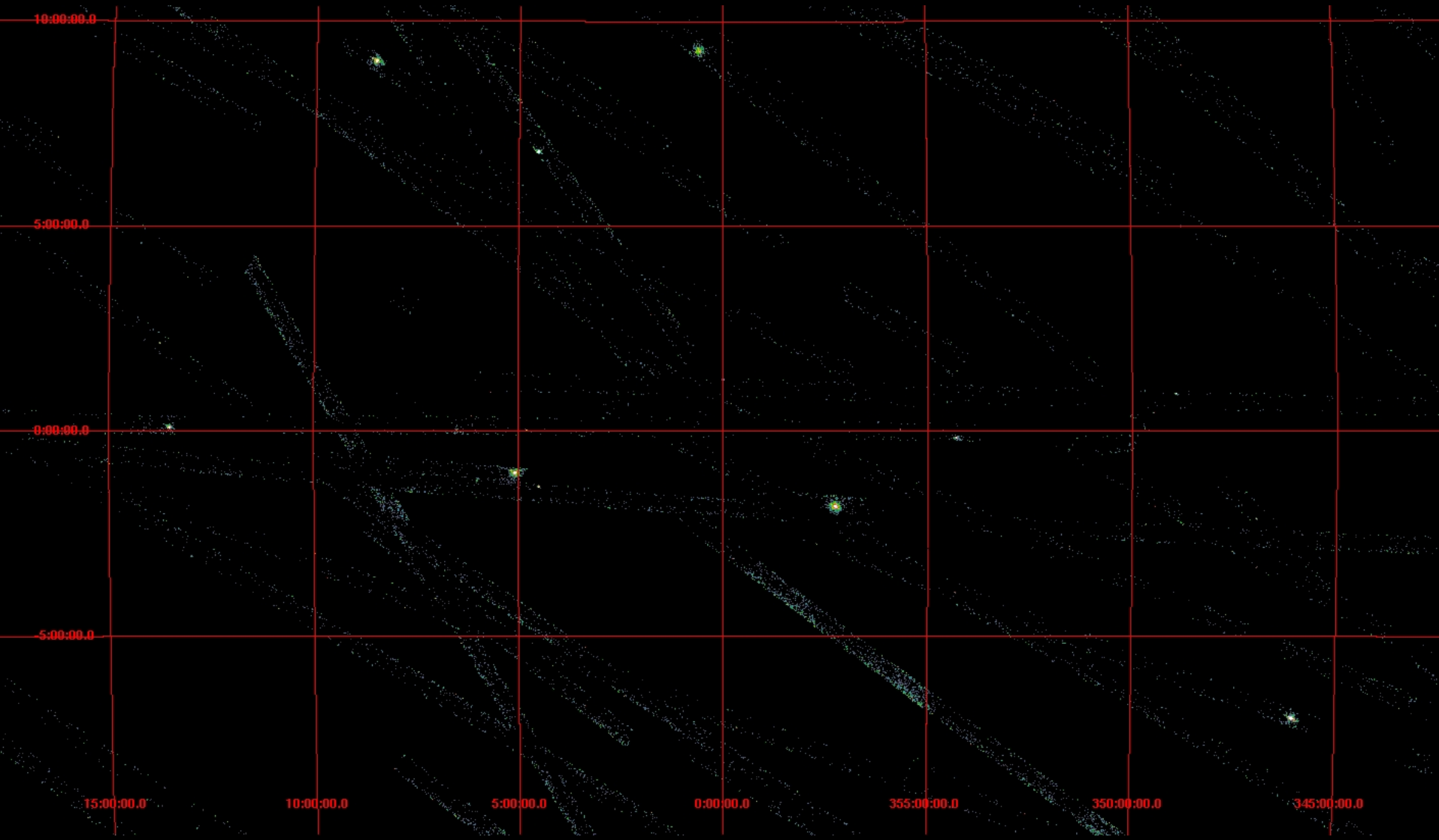
Galactic co-ordinates
Exposure-corrected images
High-BG images removed

Full band 0.2-12 keV

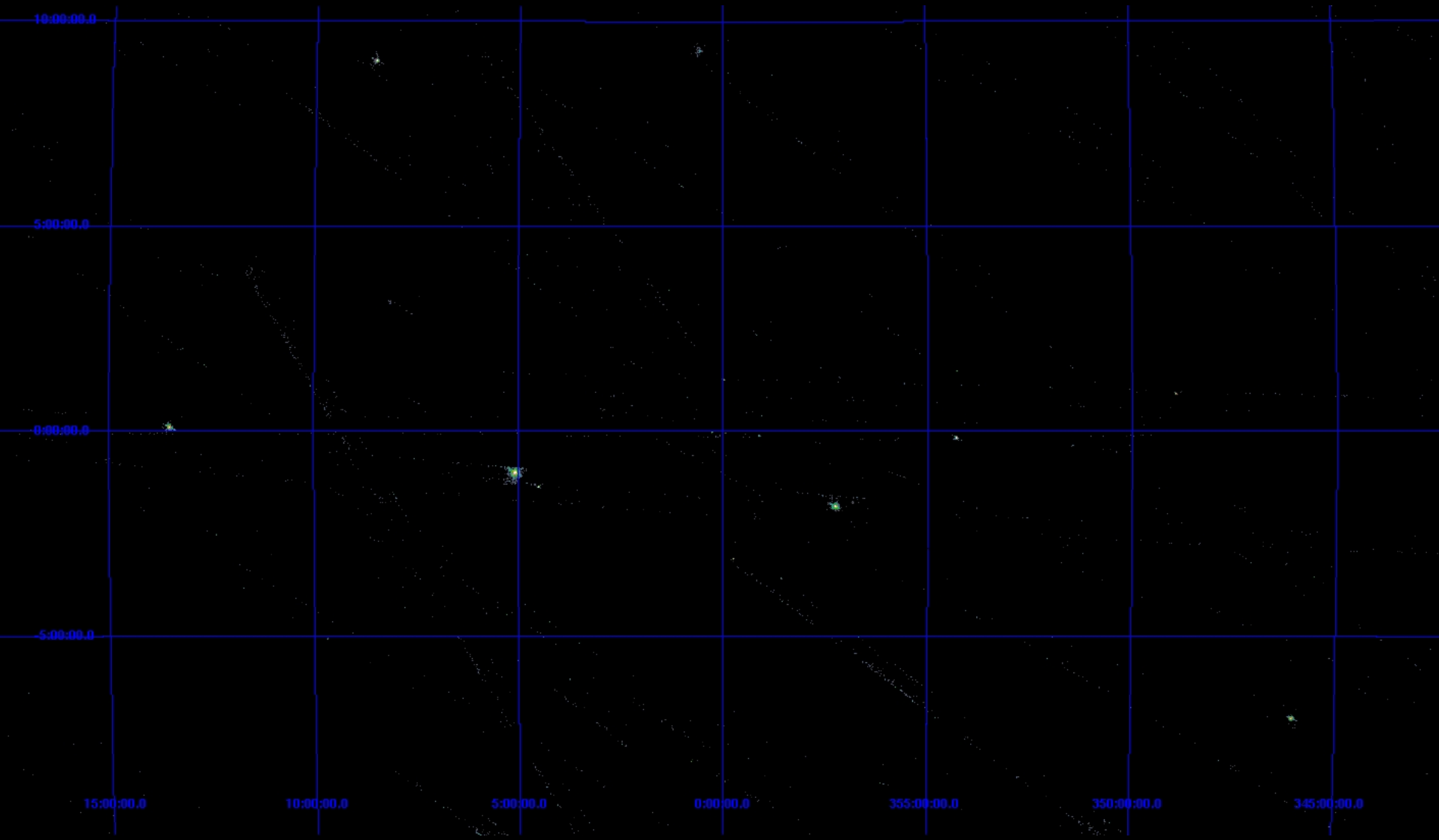

Oph X-1
1ES 1727-214
Ophiuchus cluster
GX 354-00
10:00:00.0
5:00:00.0
0:00:00.0
-5:00:00.0
15:00:00.0
10:00:00.0
5:00:00.0
0:00:00.0
355:00:00.0
350:00:00.0
345:00:00.0
Sgr X-2
GX 5-01
Granat 1758-258
XTE J1746-319
GX 346-07


Oph X-1
10:00:00.0
5:00:00.0
0:00:00.0
-5:00:00.0
15:00:00.0
10:00:00.0
5:00:00.0
0:00:00.0
355:00:00.0
350:00:00.0
345:00:00.0
normalized counts/sec/keV
0.1
0.01
ratio
0.5 1 1.5 2 2.5
0.2
0.5
1
2
5
channel energy (keV)

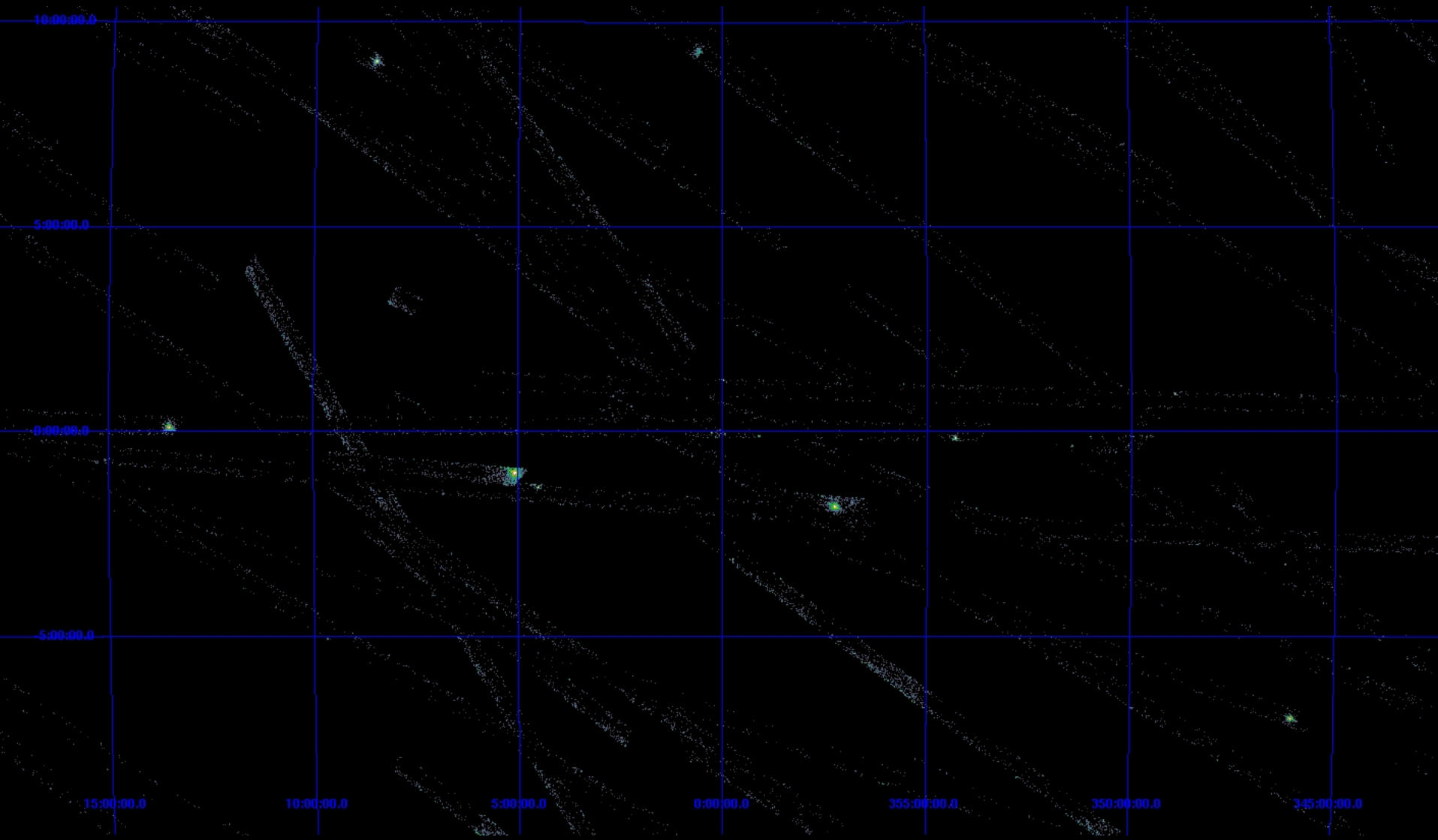

10:00:00.0
5:00:00.0
0:00:00.0
-5:00:00.0
15:00:00.0
10:00:00.0
5:00:00.0
0:00:00.0
355:00:00.0
350:00:00.0
345:00:00.0
Soft band 0.2-2 keV



Soft band 0.2-2 keV



Hard band 2-12 keV



Hard band 2-12 keV

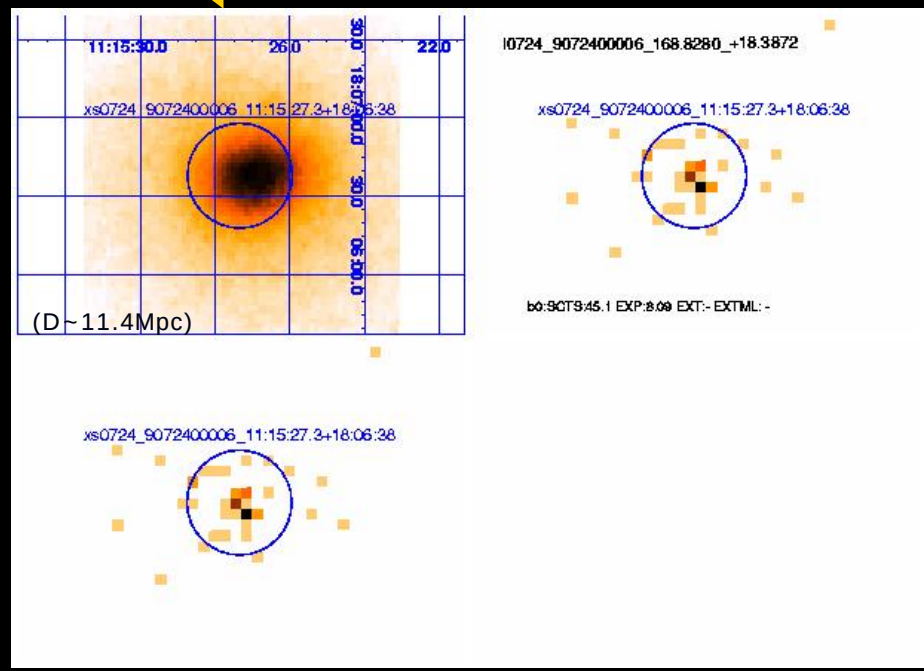
High Variability – soft band sources

Comparing XMM-Newton slew survey sources with RASS:
Looking for extreme variability rare events – only possible with large area survey…

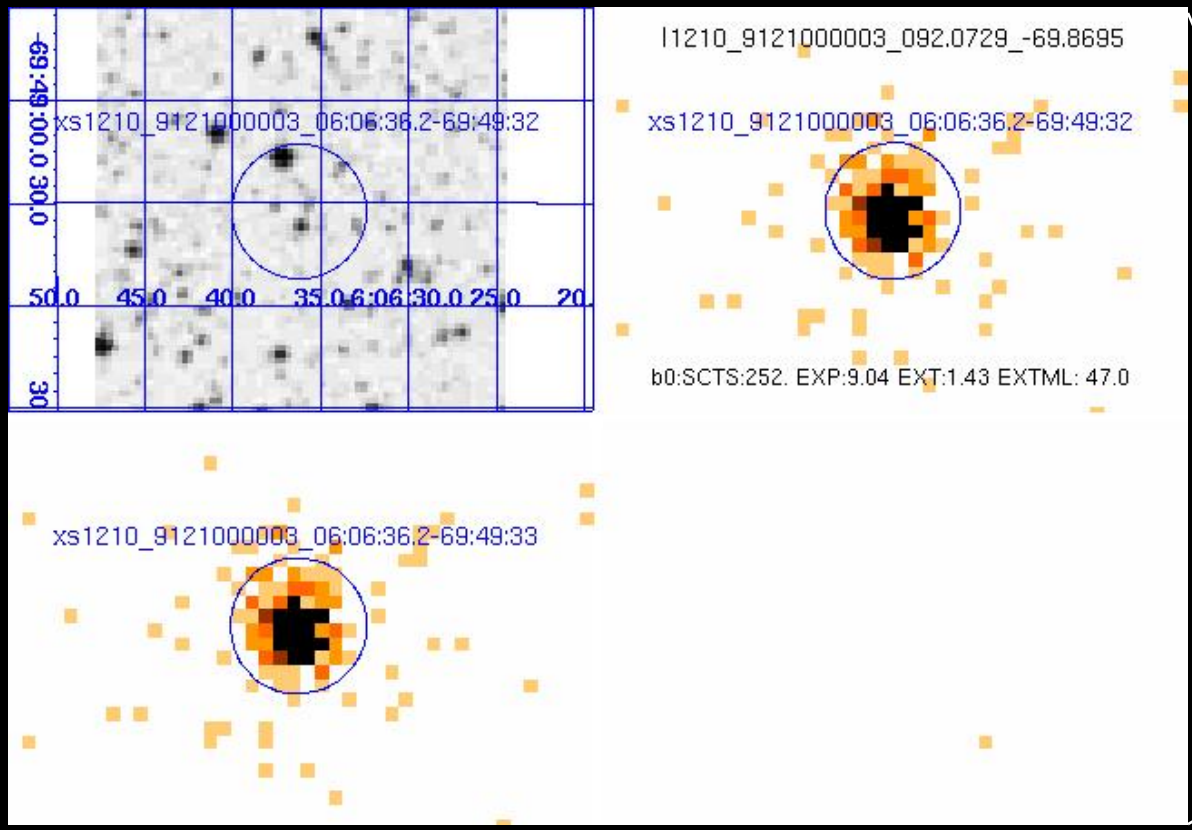
Extreme variability objects include:

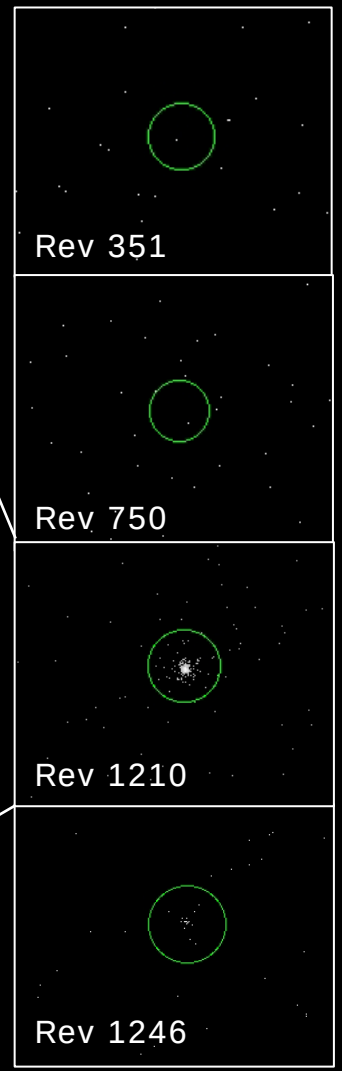
- Flare stars – 1
- Eclipsing binary - 2
- AGN – 4 (QSO, Sy 1.9, Sy 1.5, Sy1)
- Candidate tidal disruption events – 2 (incl NGC 3599 @ 11.4 Mpc)
  (see poster: Pili Esquej et al)
- Dwarf Nova – 1
- Probable new Nova in LMC – 1 …

Same source types as ROSAT found to be highly variable



New Nova in LMC?



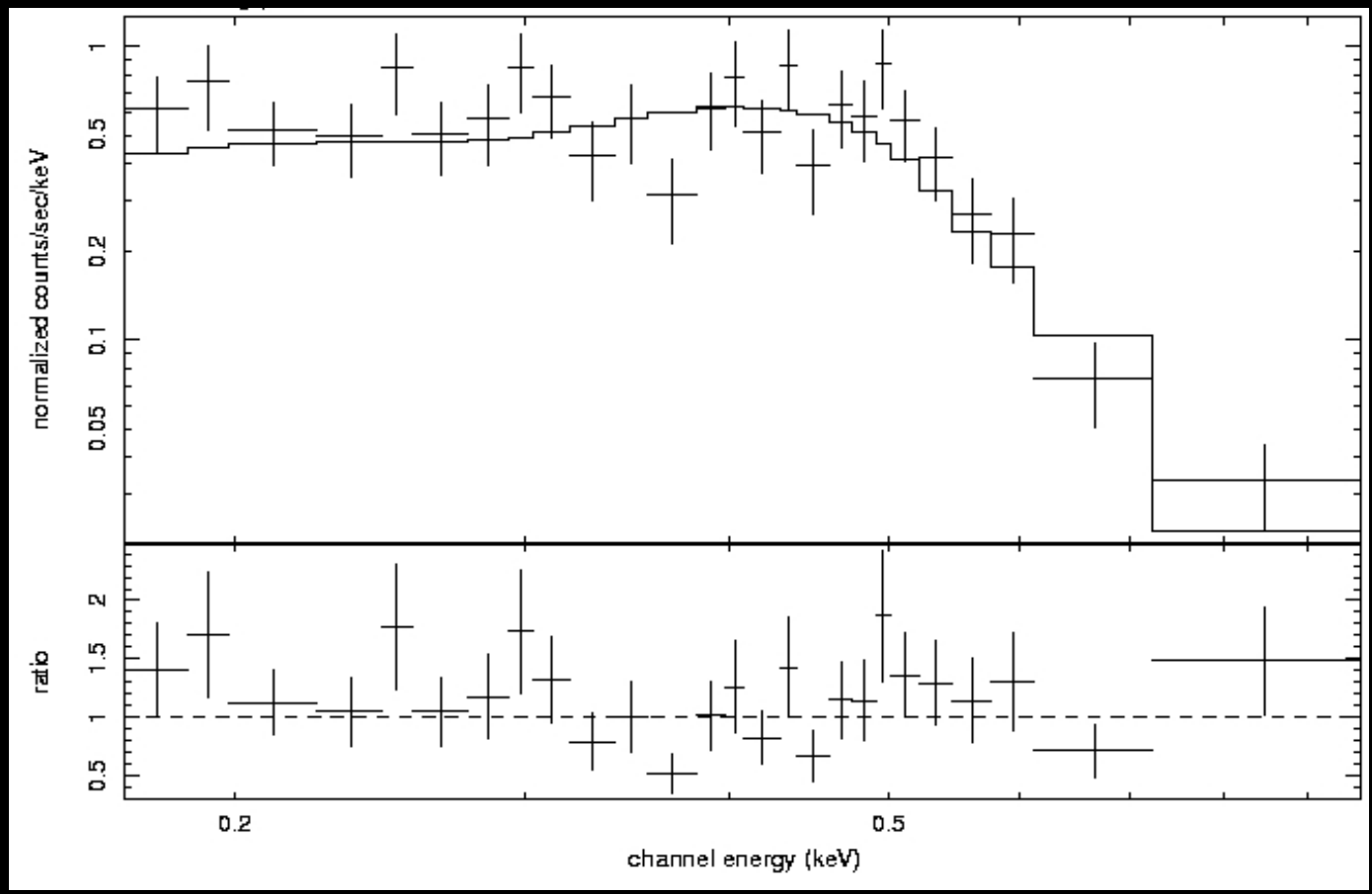


Rev 1210 @ 25 c/s; >200 x brighter than RASS upper limit

Also seen in Rev 1246 @ 4.0 c/s

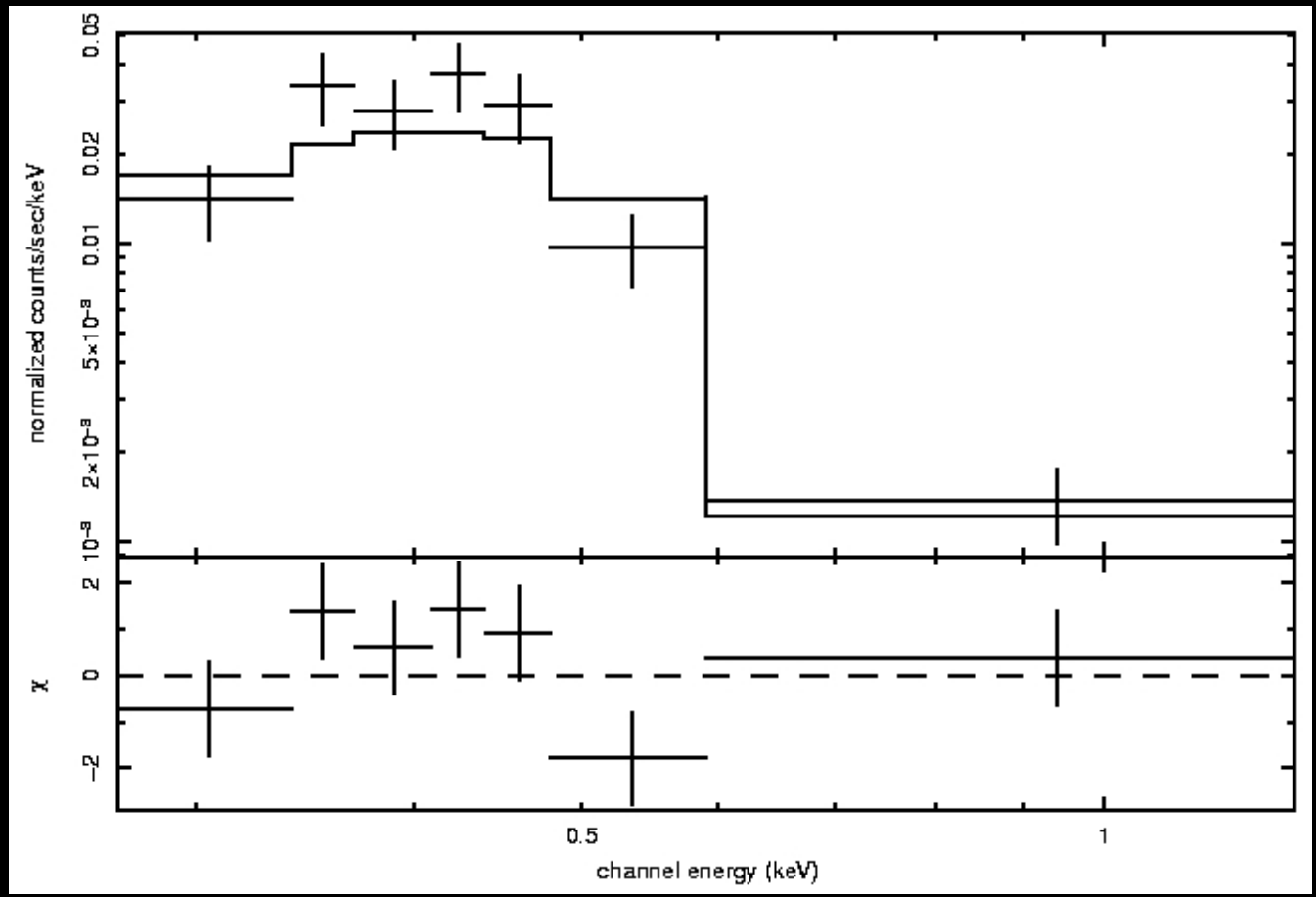
Piled-up, no offset map, moving source, but can do rough spectral work with slew data

New Nova in LMC?



Slew spectrum: Fits to Nh=3.2E20, BBody temp=66 eV
Possibly a Nova on edge of LMC – typical temp=20-80 eV

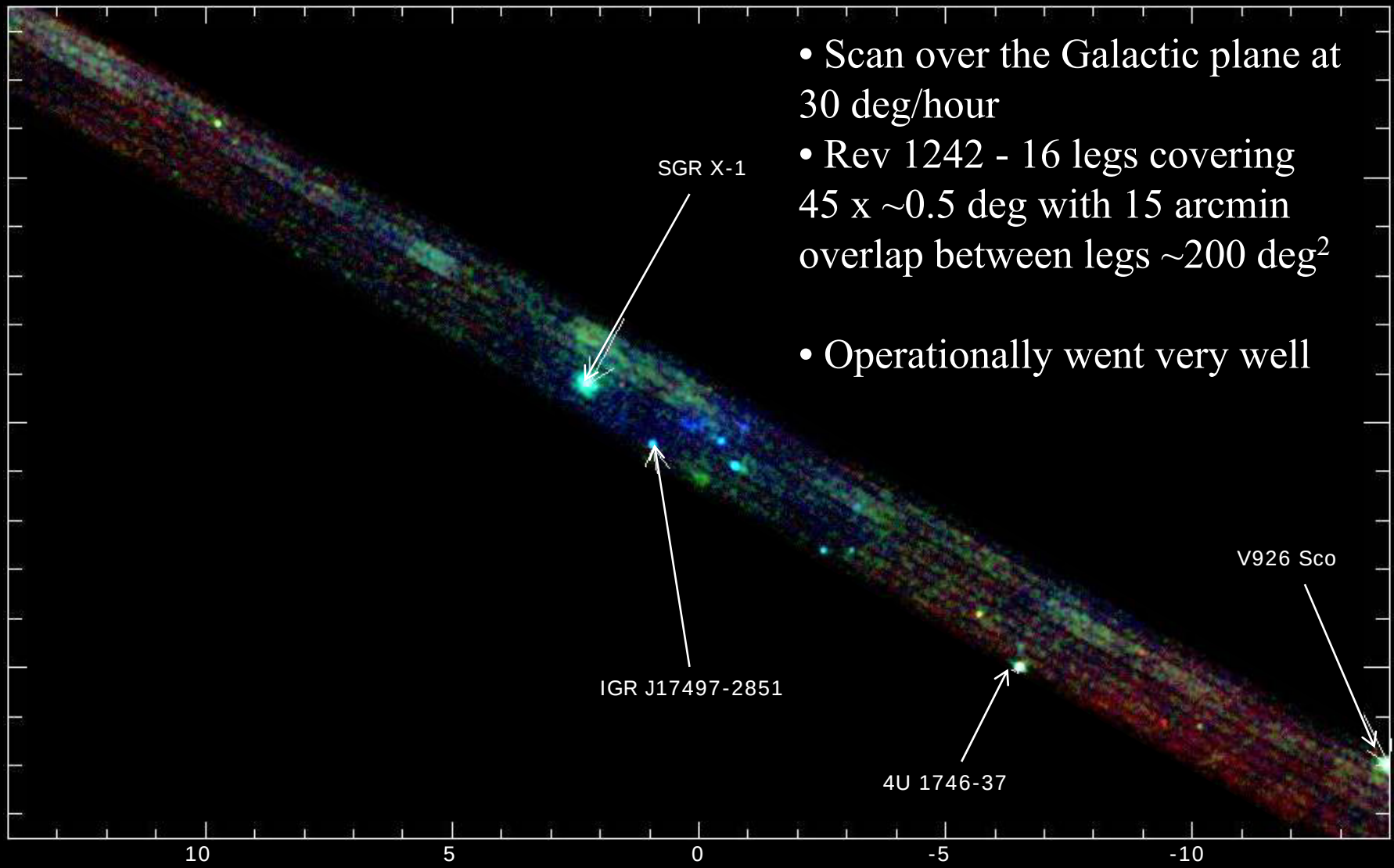
New Nova in LMC?



Read et al
(in prep.)

Swift-XRT spectrum (source faded by factor >100 from Rev 1210):
Fits to Nh=3.2E20, BBody temp=66 eV
No change in spectrum
(Assuming non-spectrally-varying source, then slew spectral analysis is ~sound, even though slew source is moving, is piled-up and we have no offset map)

XMM-Newton EPIC-pn Slow Slew Survey test



- Scan over the Galactic plane at 30 deg/hour
- Rev 1242 - 16 legs covering 45 x ~0.5 deg with 15 arcmin overlap between legs ~200 deg^2

- Operationally went very well

Slow Slew – Developments & Advances

MOS 3x3 mode (frame time 0.4-0.6s) developed and tested (closed CAL, rev 1228, Vela PSR+PWN, rev 1354) – much smaller PSF in slewing modes

10 deg/hr likely achievable without losing too much positional accuracy. In which case:

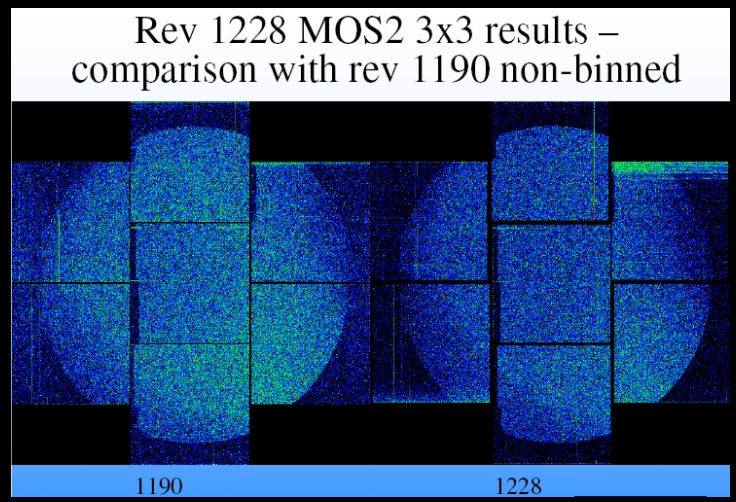
Flux Limits at 10 deg/hr

	0.2-12 keV	0.2-2 keV	2-12 keV
PN+MOS1/2	2.5×10^{-13}	1.0×10^{-13}	8.0×10^{-13}

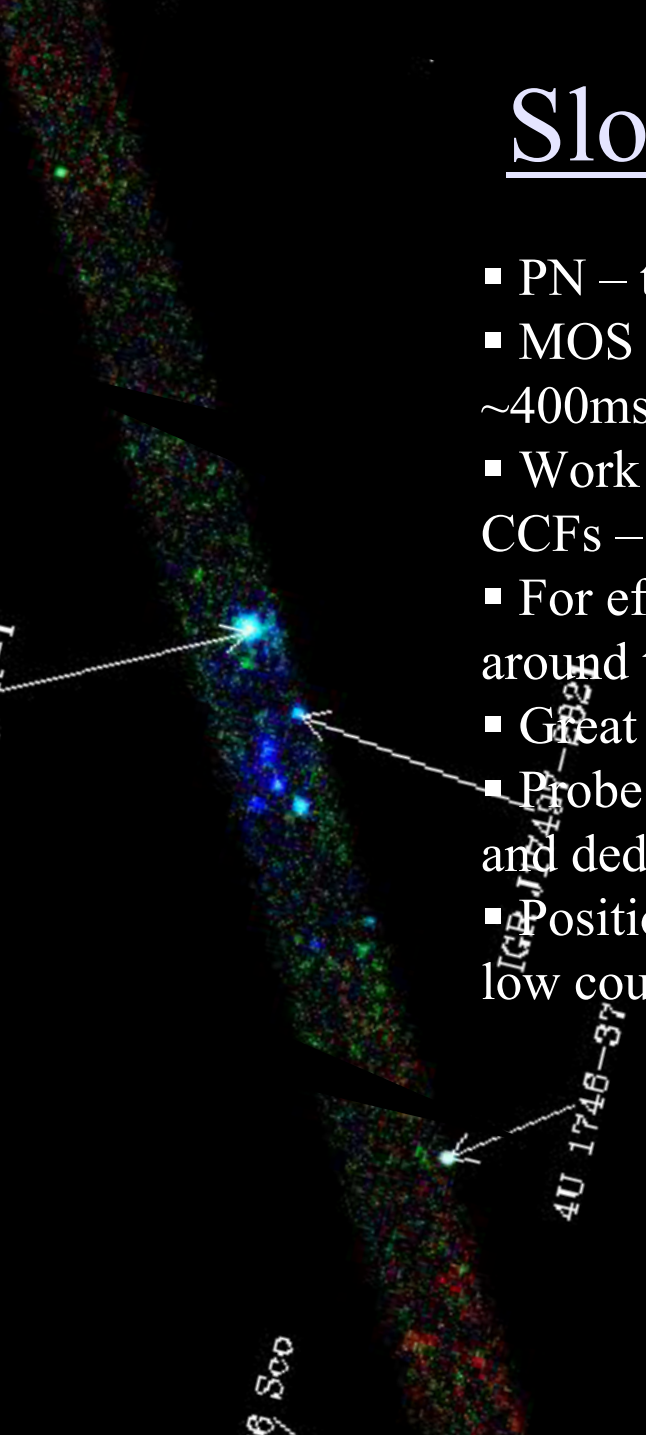
>5x deeper than XMMSL1

10 deg/hr slow slew + combination with MOS 3x3 to be tested

Slower still would go to greater depth (without turnaround overheads), with ~uniform exposure and allow the non-piled up observations of brighter sources.
- Can we go slower? 1 deg/hr? 0.1 deg/hr?

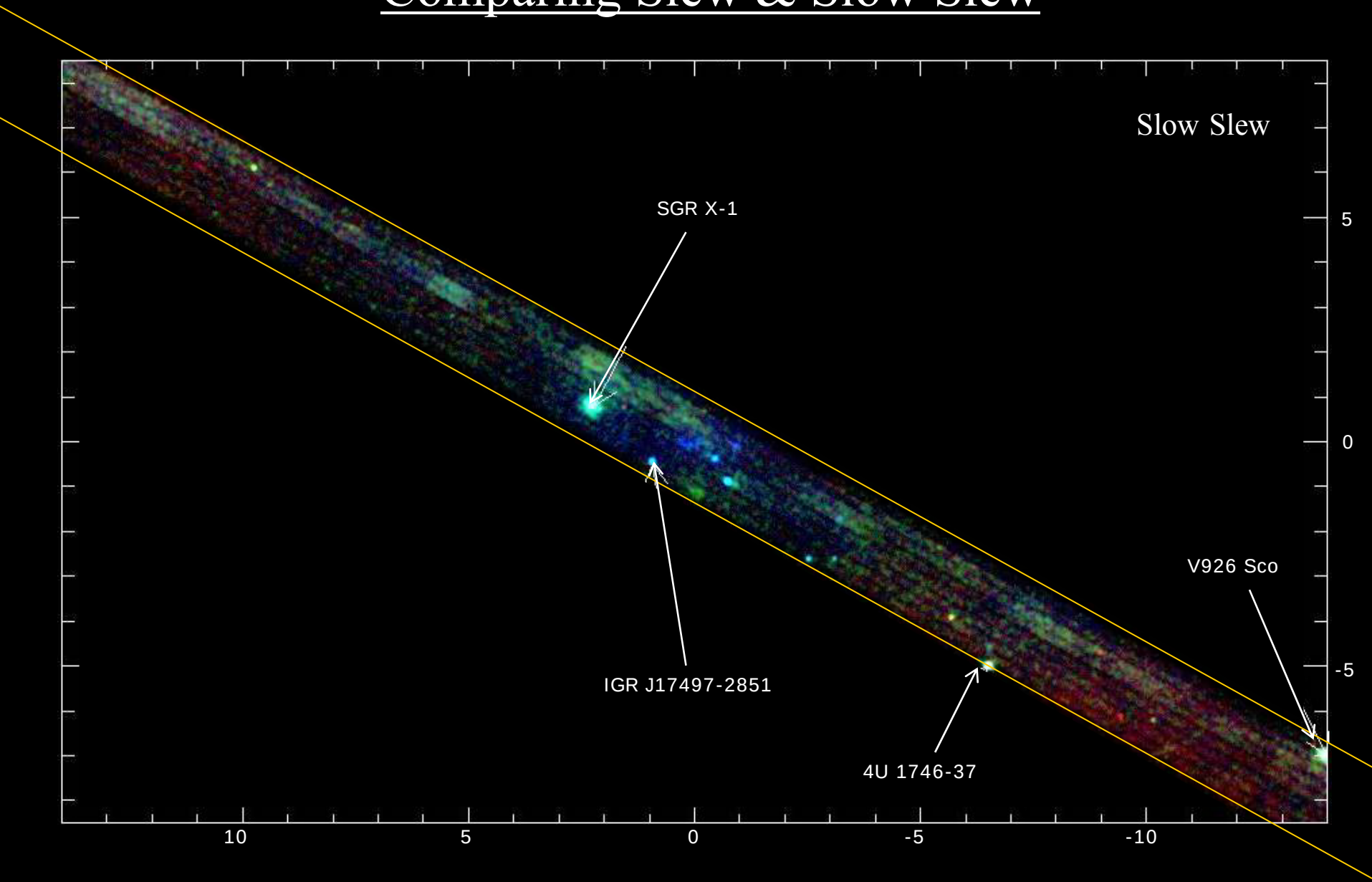


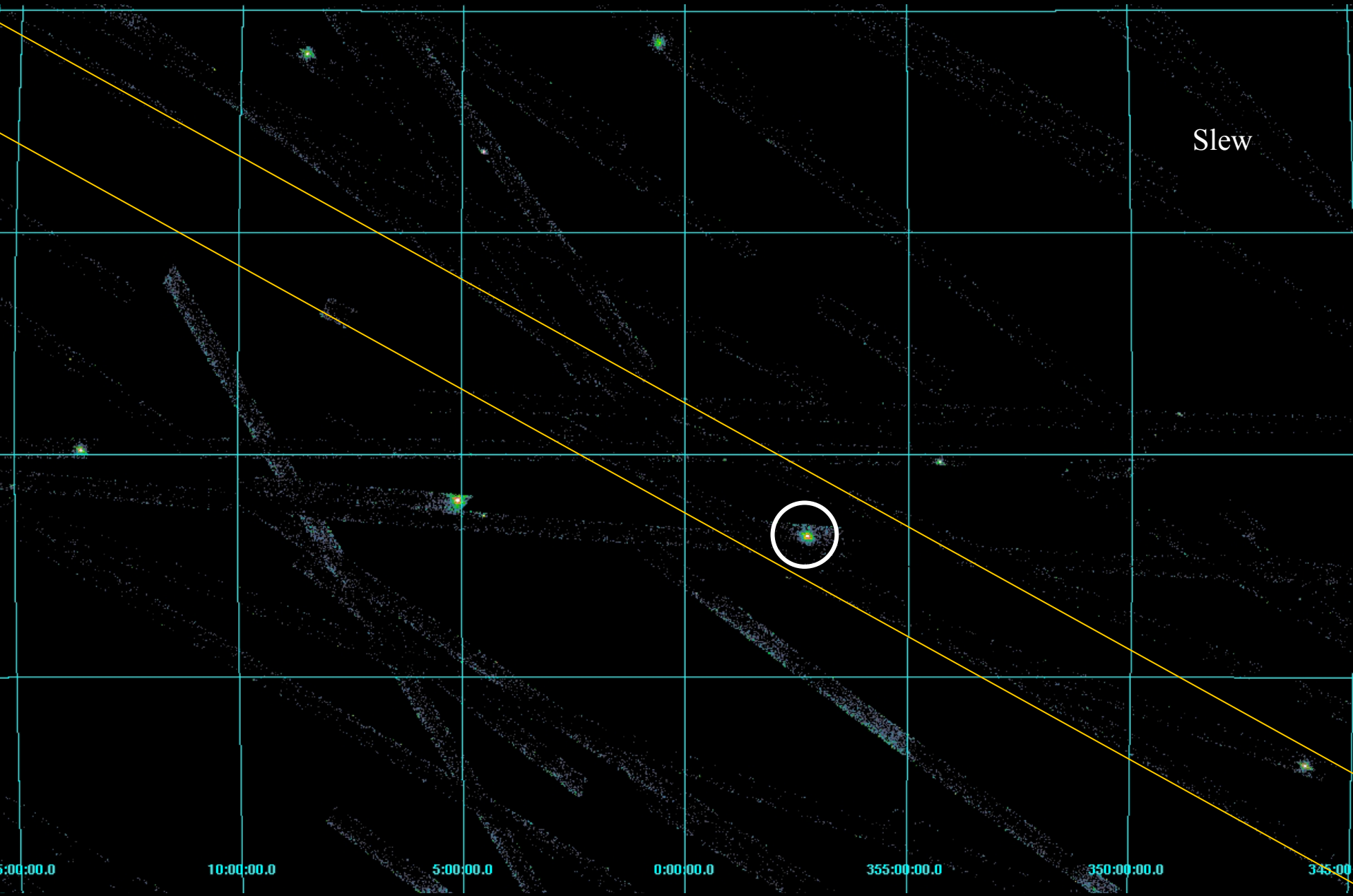
Slow Slew Summary

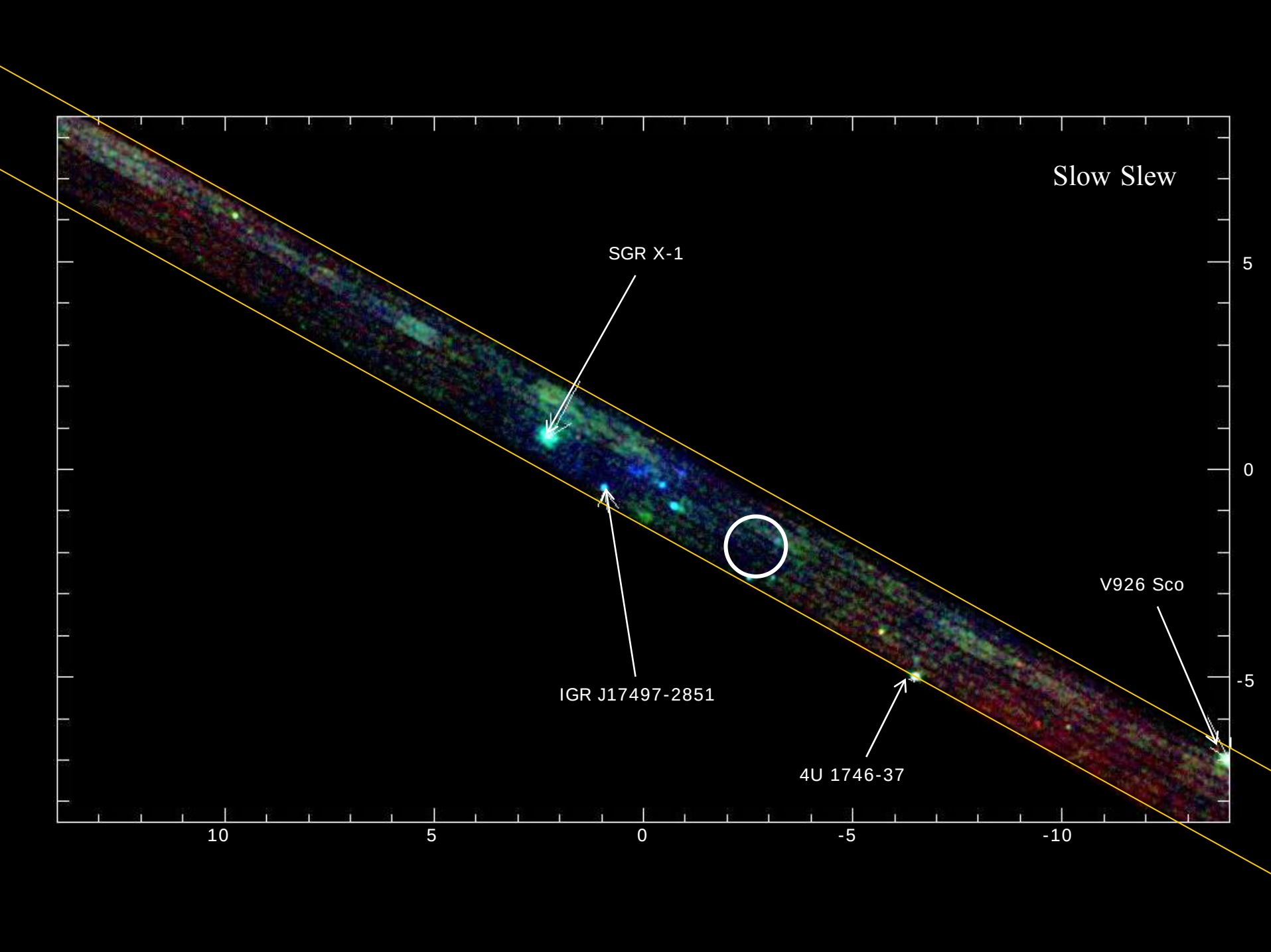


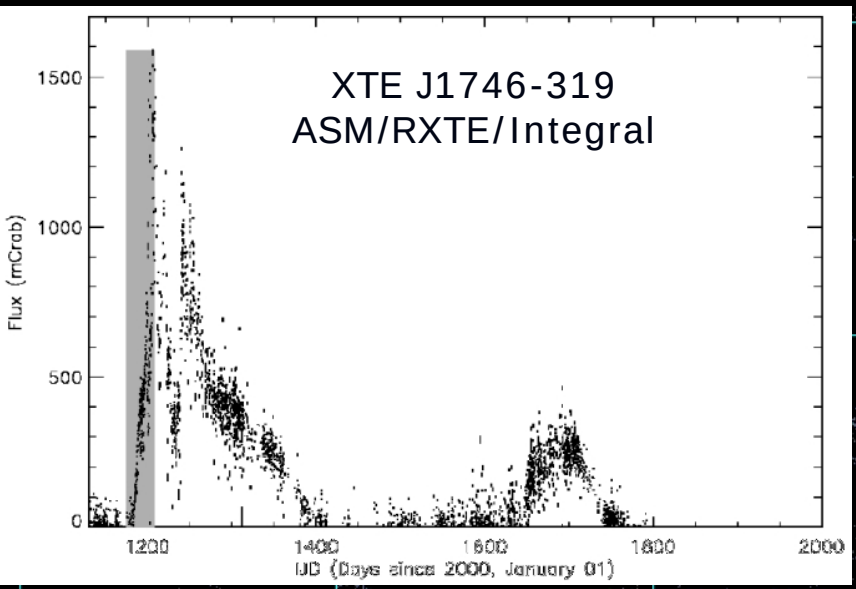
- PN – to run in FF mode, Medium filter
- MOS – intended to run in 3x3 pixel free running mode with ~400ms frame time.
- Work to do with s/w (nearly complete), calibration and CCFs – particularly MOS QE / pattern fractions
- For efficiency need to have legs of at least 1 hour as turn-around time is 17 mins.
- Great for mapping large extended sources
- Probe flux levels intermediate between XMMSL1 and dedicated short pointings, 10^{-13}
- Position error is ~4 arcsecs – similar to pointed obs for low count sources

Comparing Slew & Slow Slew

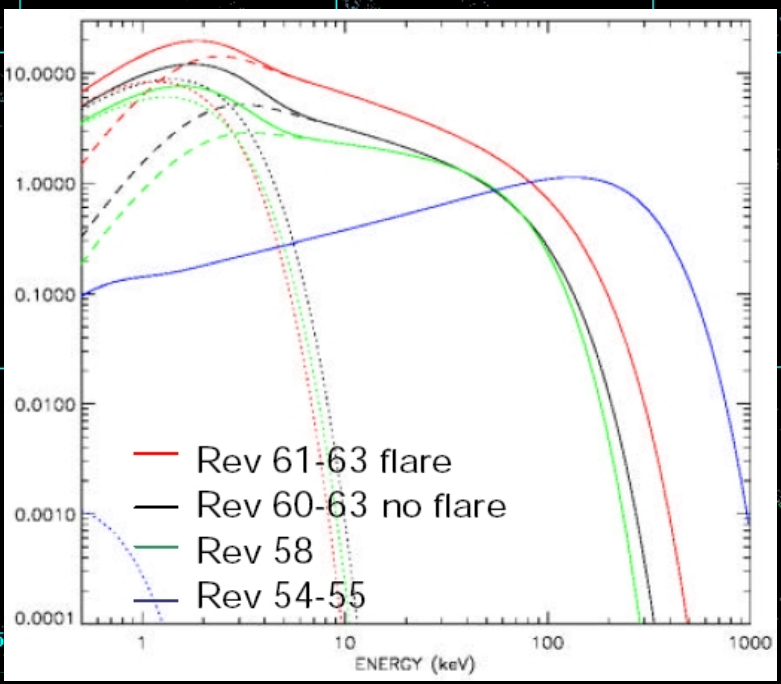



Slew
10:00:00.0
5:00:00.0
0:00:00.0
355:00:00.0
350:00:00.0
345:00


Slow Slew
SGR X-1
IGR J17497-2851
4U 1746-37
V926 Sco
10
5
0
-5
-10
5
0
-5

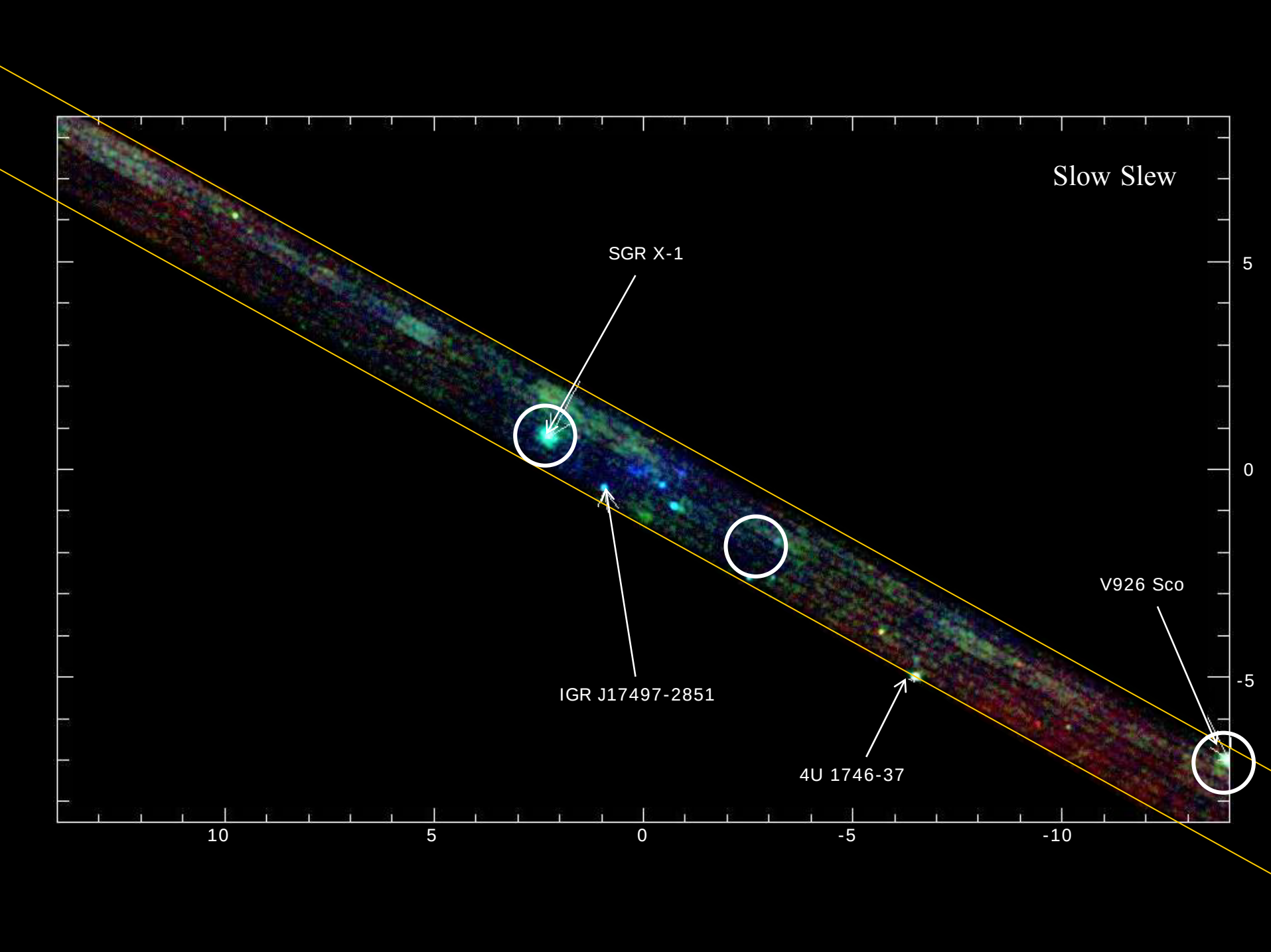


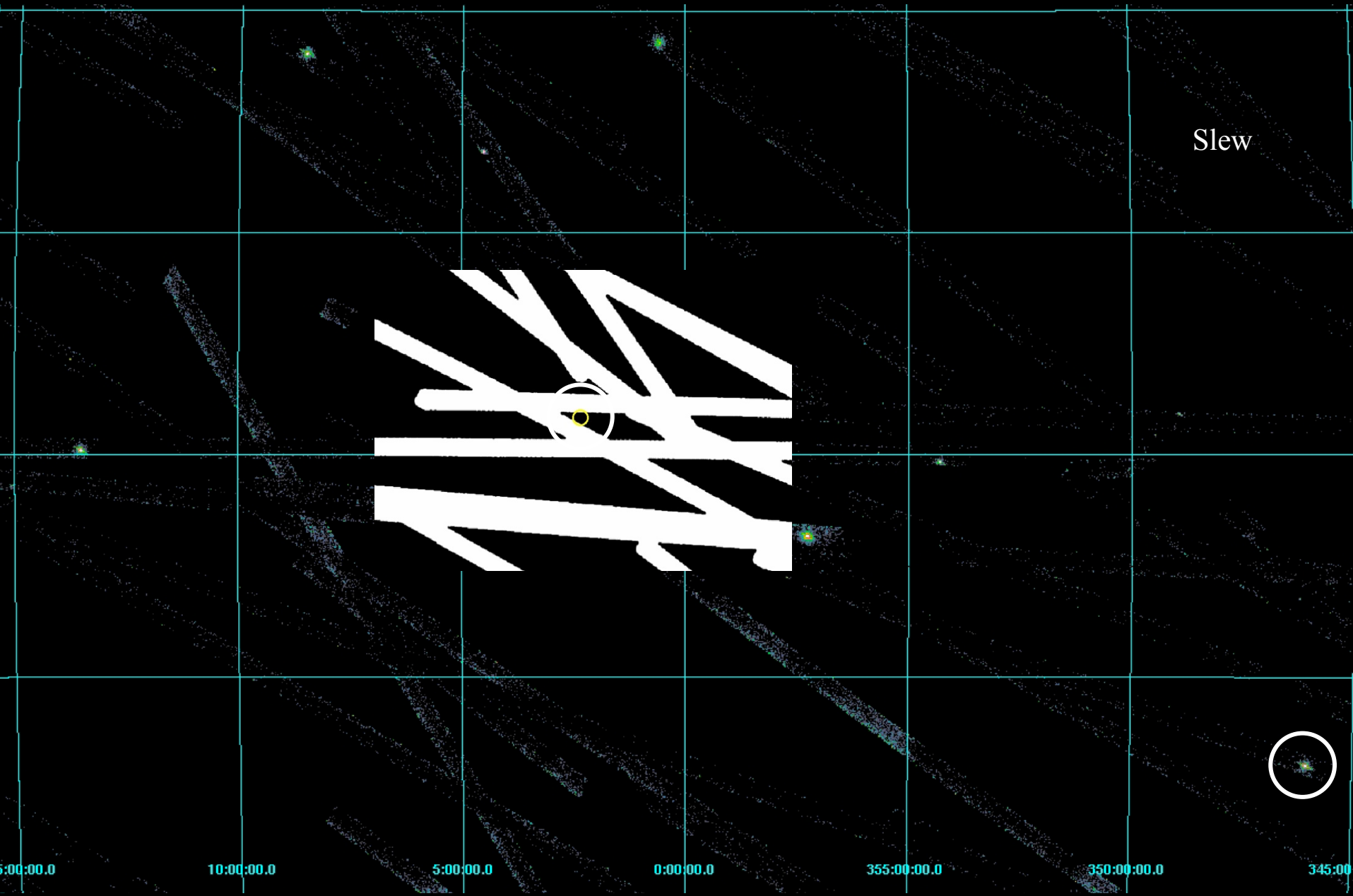
- Black Hole Candidate
- Not seen by ROSAT
- Seen in XMM-Slews in Revs 689 & 690 (at ~constant, very high flux)
- Not seen in Slow Slew test
- Comparing Slew flux with Slow Slew upper limit (P.Rodriguez) : Variability of >x3000!



XTE J1746-319

0:00:00.0 355:00:00.0 350:00:00.0 345:00


Slow Slew
SGR X-1
IGR J17497-2851
4U 1746-37
V926 Sco
10
5
0
-5
-10
5
0
-5


Slew
10:00:00.0
5:00:00.0
0:00:00.0
355:00:00.0
350:00:00.0
345:00

Concluding Remarks

- XMMSL1 Catalogue (full and clean) public (May 06)
- Delta-1 Catalogue public ~now (total ~4000 clean sources, 20% of sky)
  - accessible via XMM XSA (also as FITS files)
- Soft band survey comparable with RASS
- Hard band survey best ever
- ~0.45 clean sources per square degree (~30% of the sky now covered by slews)
- ~55% of the sources have identifications
- Many high-redshift detections
- Extremely interesting ROSAT-XMM variability – Rare events! (Poster – Pili Esquej et al)
- Excellent extended source detection and large area mapping capabilities (Poster – Richard Saxton et al)
- Excellent complementary database, knowledge, expertise for Slow-Slew surveys
- Also:
  - Upper-limits server for slew images as part of XSA
  - Processing of high-BG and problem slews and new slews
  - Whole sky covered in ~few years time, even using present slew operational modes