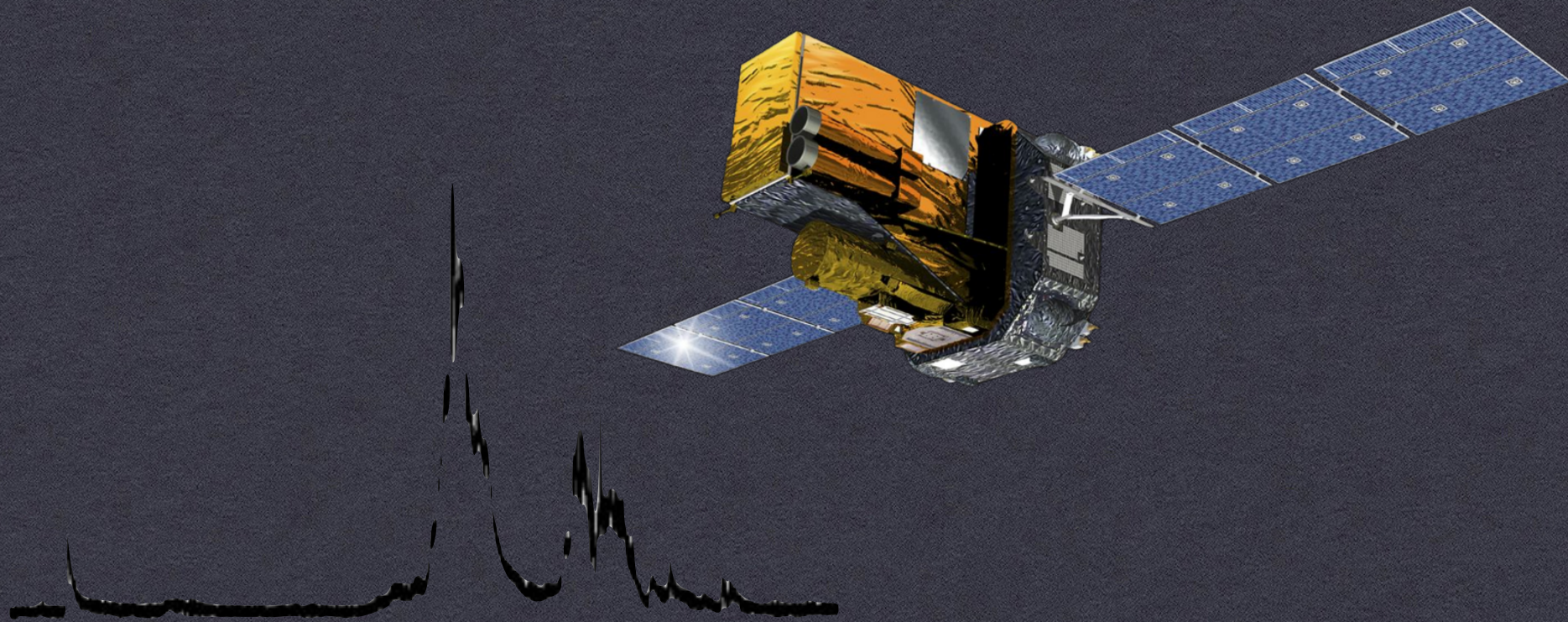


UNIVERSITY OF
Southampton



TRANSIENTS IN THE IBIS SURVEYS

A J BIRD, SOUTHAMPTON UNIVERSITY

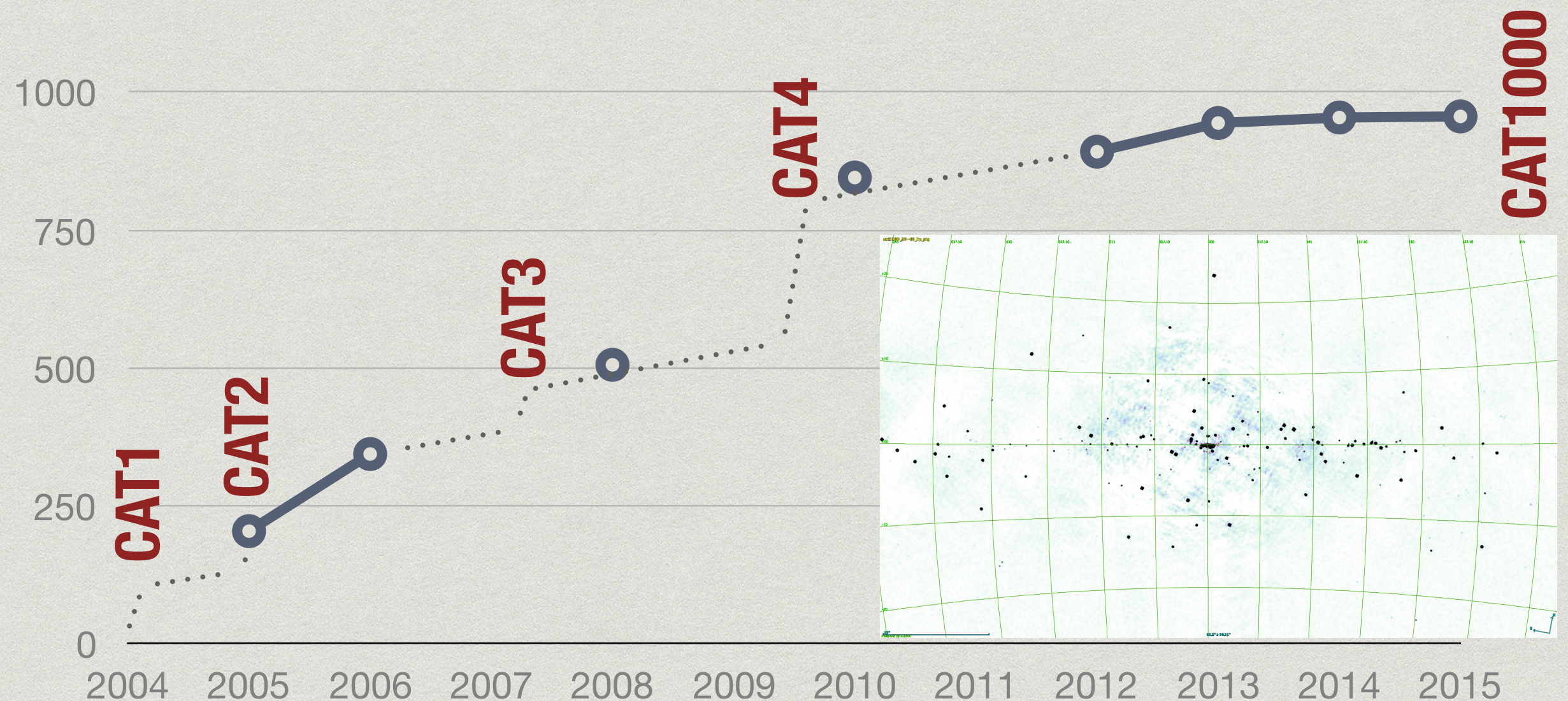
*INTEGRAL LOOKS AHEAD TO MULTI-MESSENGER ASTROPHYSICS
GENEVA, 11-15 FEB 2019*

Outline

- * Why we do surveys and catalogs
- * Why we care about transients in the survey analysis
- * How we search for transients
- * Some highlights so far
- * Future prospects

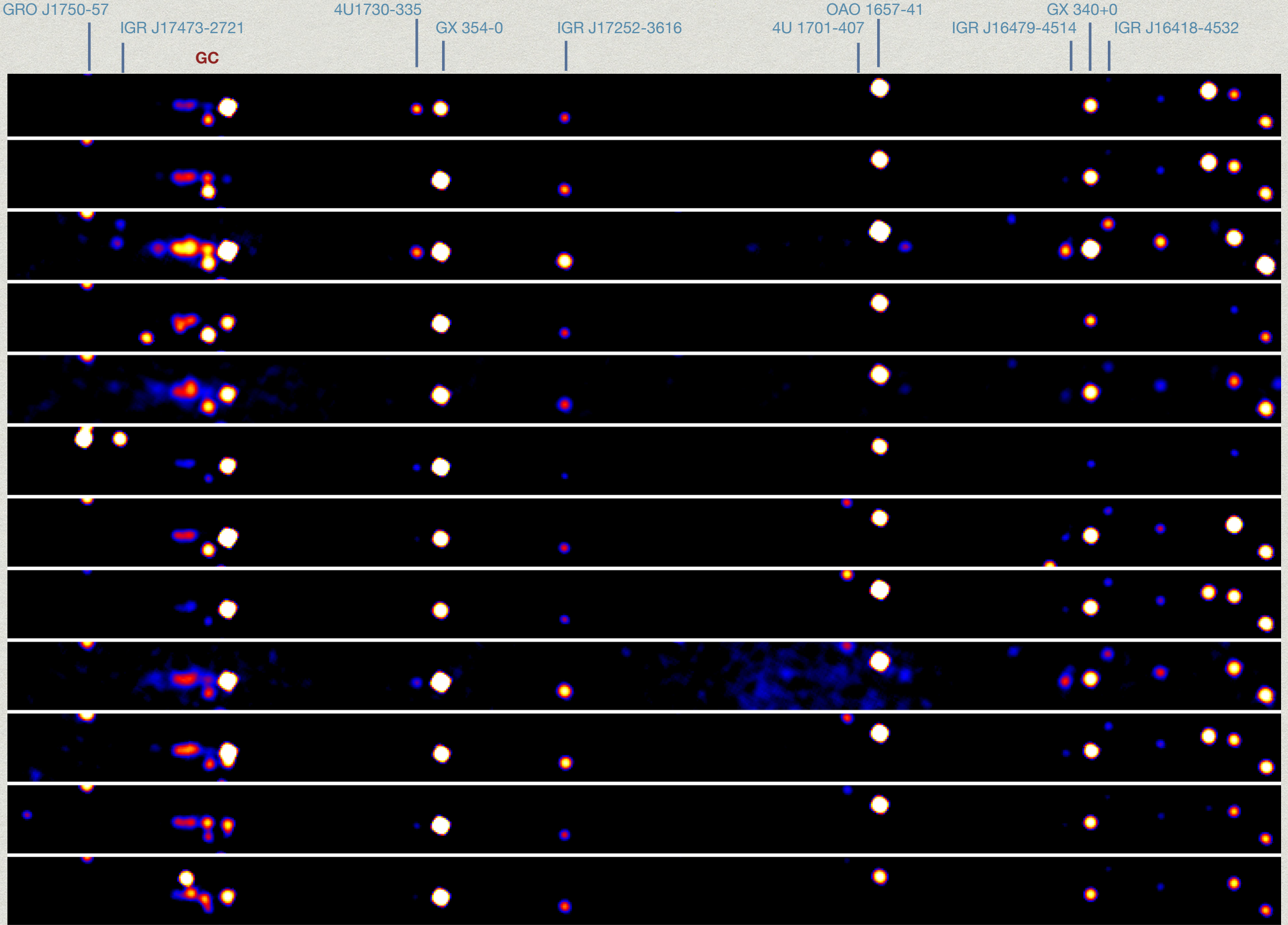
Source discovery

Each survey is a self-consistent analysis, producing a deeper stack of observations, aimed at improving the sensitivity to faint persistent sources...



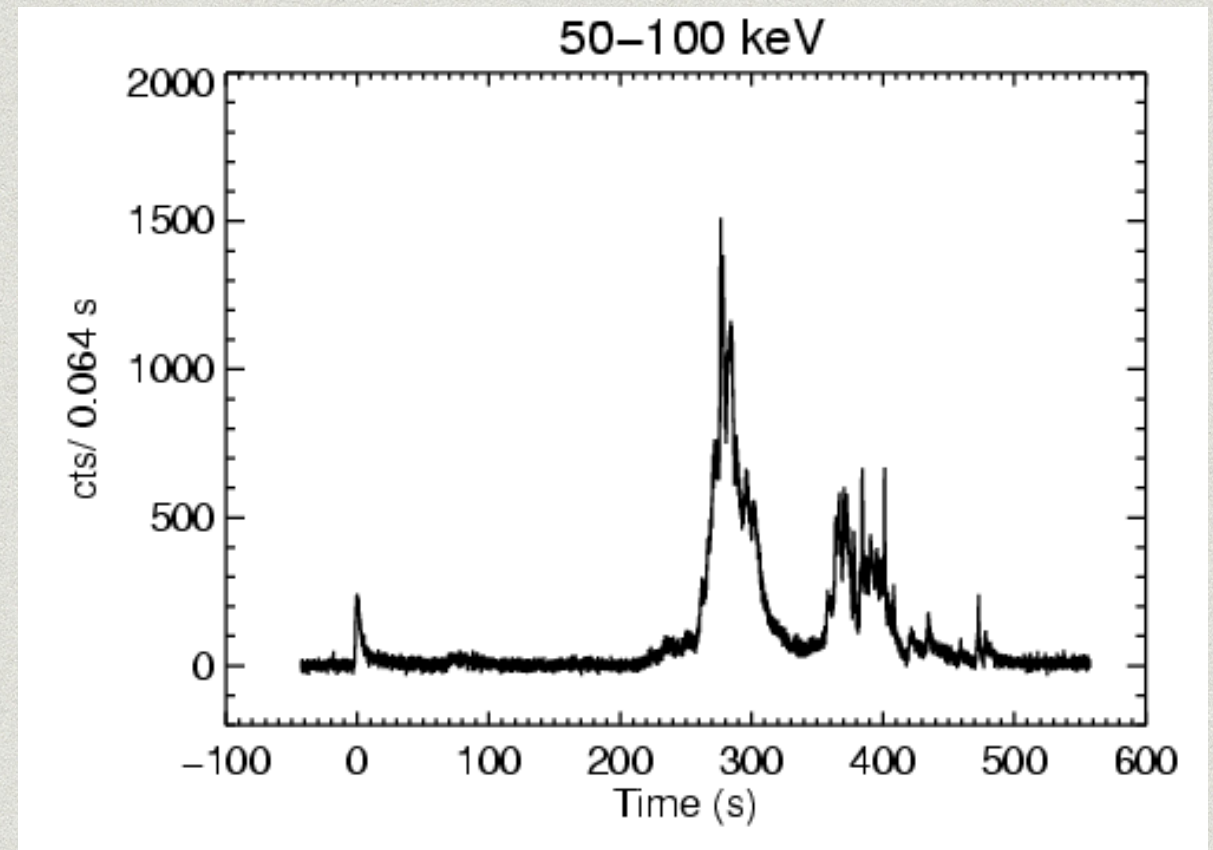
Transients

- * My definition: “Sources we don’t see all the time”
- * Can be recurrent or ‘one-shot’
- * Could be an intrinsically transient source, or a result of variability combined with limited sensitivity - so a transient for one telescope may be a persistent source when viewed by another
- * Timescales from a few seconds to months
- * Can be found in real time (alongside other missions), or **by deep inspection of archival data**



GRB 041219A - our test-case

- * GRB detected end of 2004
- * IGR J00245+6251 in 3rd IBIS/ISGRI catalog
- * Massively bright - lasted few 100s - saturated the s/c data transmission
- * 41.6 sigma in the science window...
- * ... but listed at only 11.5 sigma because cat3 relied on searching revolution (3d timescale) maps



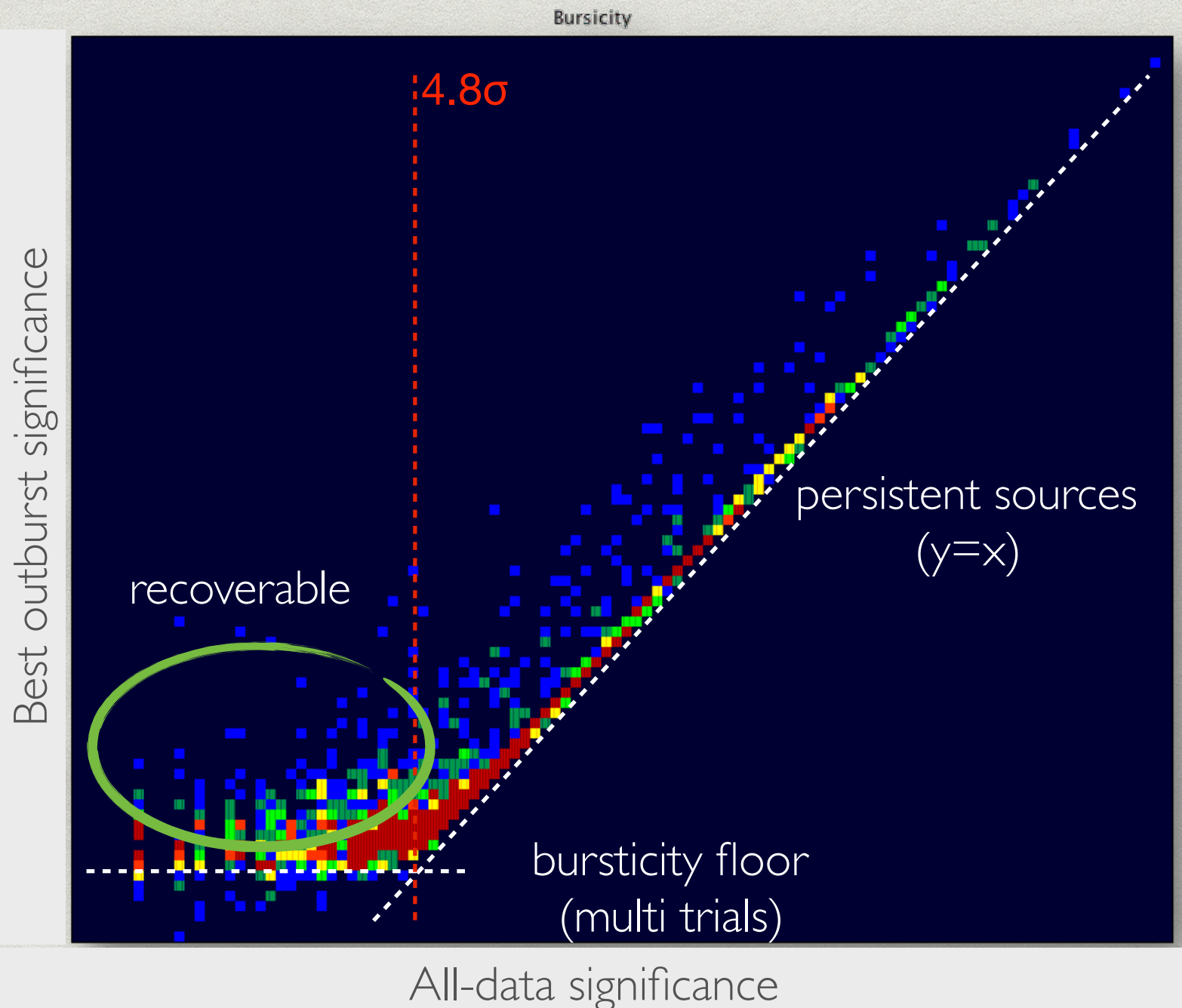
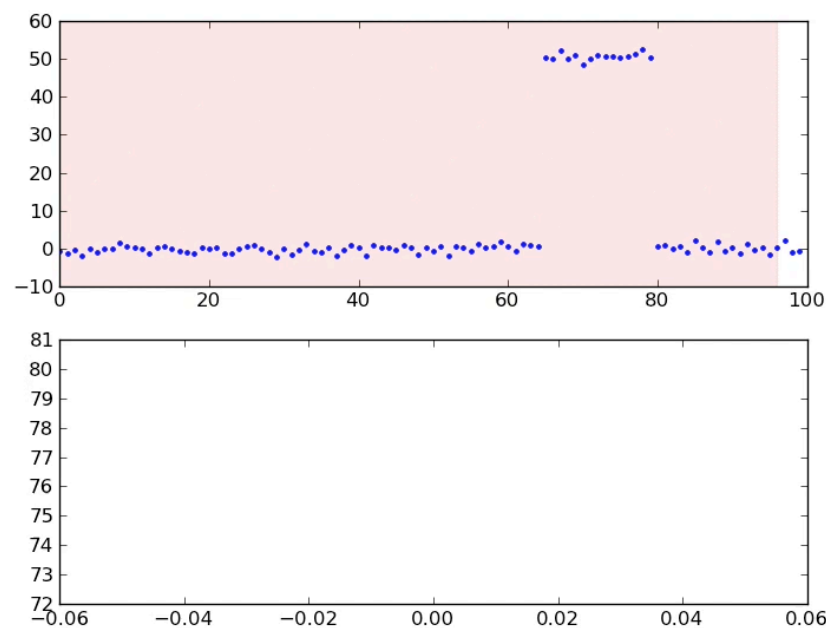
Searching on the right timescales - cat3

- * Searches performed on:
 - * Revolutions (3 day)
 - * Revolution sequences (~10 revolutions, 1 month)
 - * All data
- * But this is all very arbitrary, and depends on the observation strategy, not the way the sources behave
- * But then, all sources behave differently, so what do you do?

Searching on the right timescales - cat4

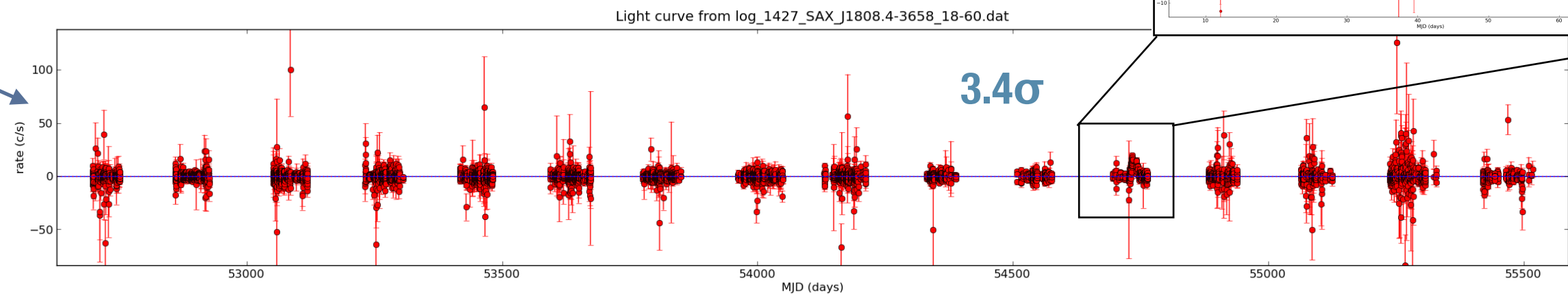
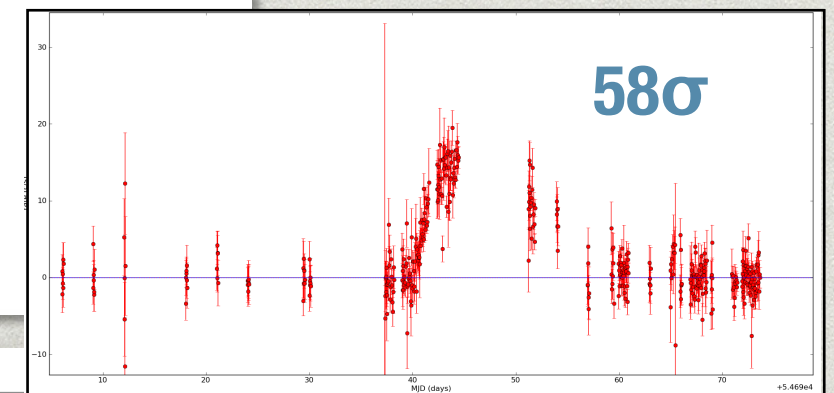
Bursticity:

Sliding window search looking for the time interval that optimises source significance



Top 10 of bursticity

Source	Sig	Sig'	B'icity	Length	MJD range	Notes
SAX J1808.4-3658	3.4	57.5	16.70	14.25d	54730.80 - 54745.05	Sept 2008 outburst of accreting MSP
IGR J17480-2446	3.0	42.9	14.13	20.38d	55477.45 - 55497.82	Oct 2010 outburst of LMXB/Pulsar in Terzan 5
SWIFT J1842.5-1124	3.8	37.2	9.88	17.03d	54717.56 - 54734.59	July 2008 outburst of ?? (galactic transient)
IGR J18539+0727	0.3	34.5	109.86	14.22d	52745.39 - 52759.62	April 2003 outburst of LMXB candidate
XTE J1807-294	2.7	32.0	11.86	35.37d	52698.17 - 52733.54	MSP, discovered Feb 2003
IGR J00245+6251	0.8	27.7	36.91	0.27d	53357.91 - 53358.18	GRB - detectable in revolution (just)
XTE J1751-305	3.6	21.9	6.08	1.60d	54193.30 - 54194.91	April 2007 outburst of accretion-driven MSP
H 1745-203	5.1	20.8	4.07	2.74d	52919.69 - 52922.43	LMXB in GC
??	1.1	19.6	17.92	11.85d	54730.64 - 54742.48	(ra,dec) = (272.367, -26.441)
HR 4492/ GT Mus	4.7	19.1	4.03	0.76d	52824.21 - 52824.97	Flare star in active binary (RS CVn)
IGR J11215-5952	3.4	17.9	5.30	2.72d	53151.90 - 53154.62	long-orbit SFXT

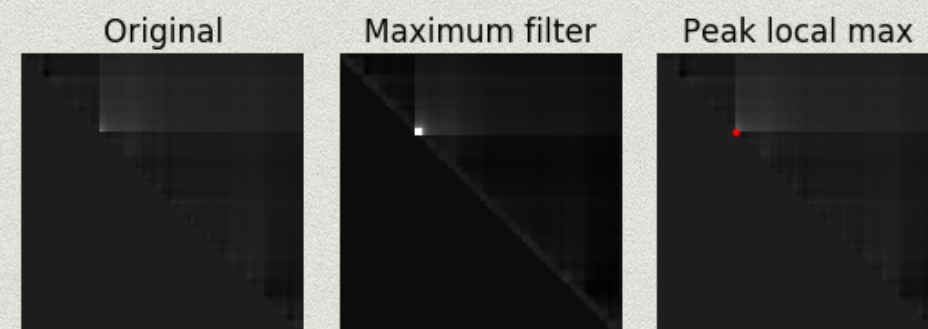
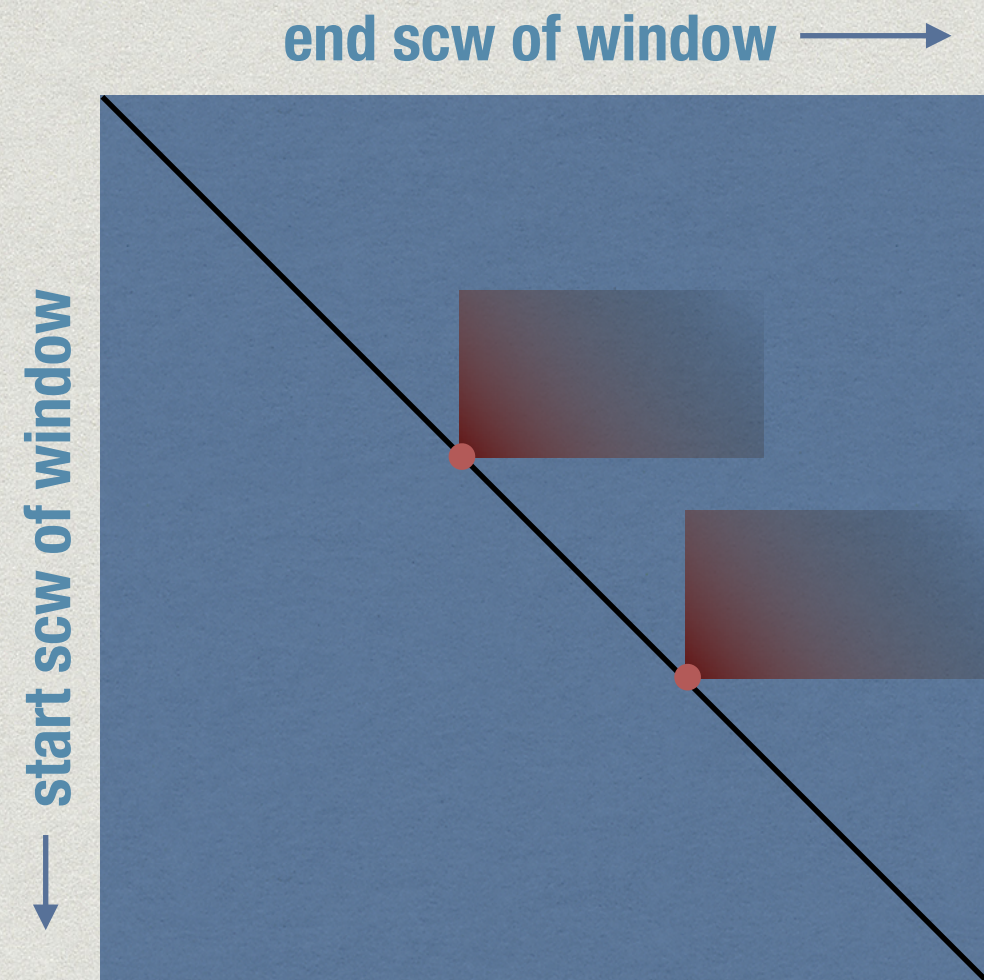
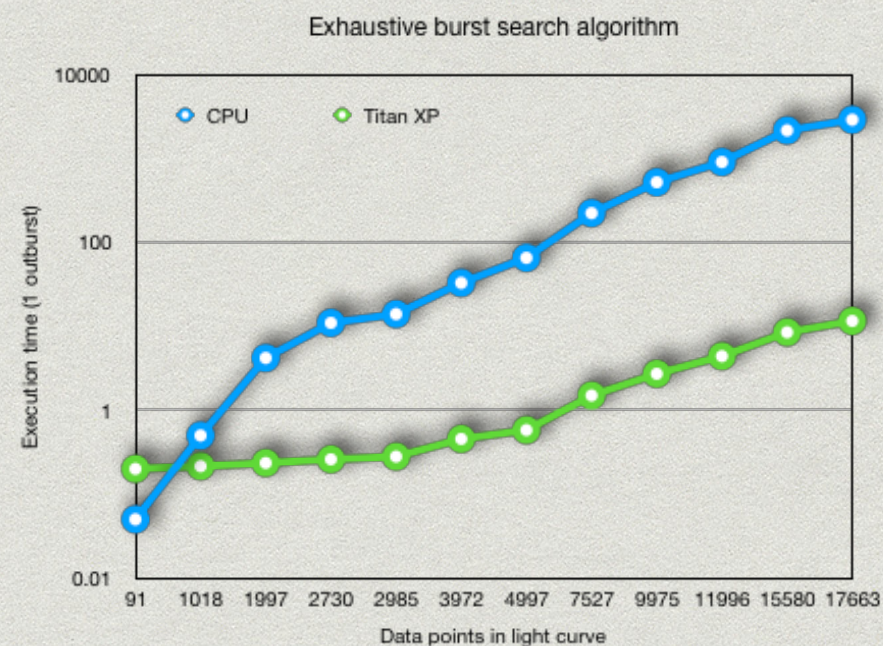


The problems with bursticity

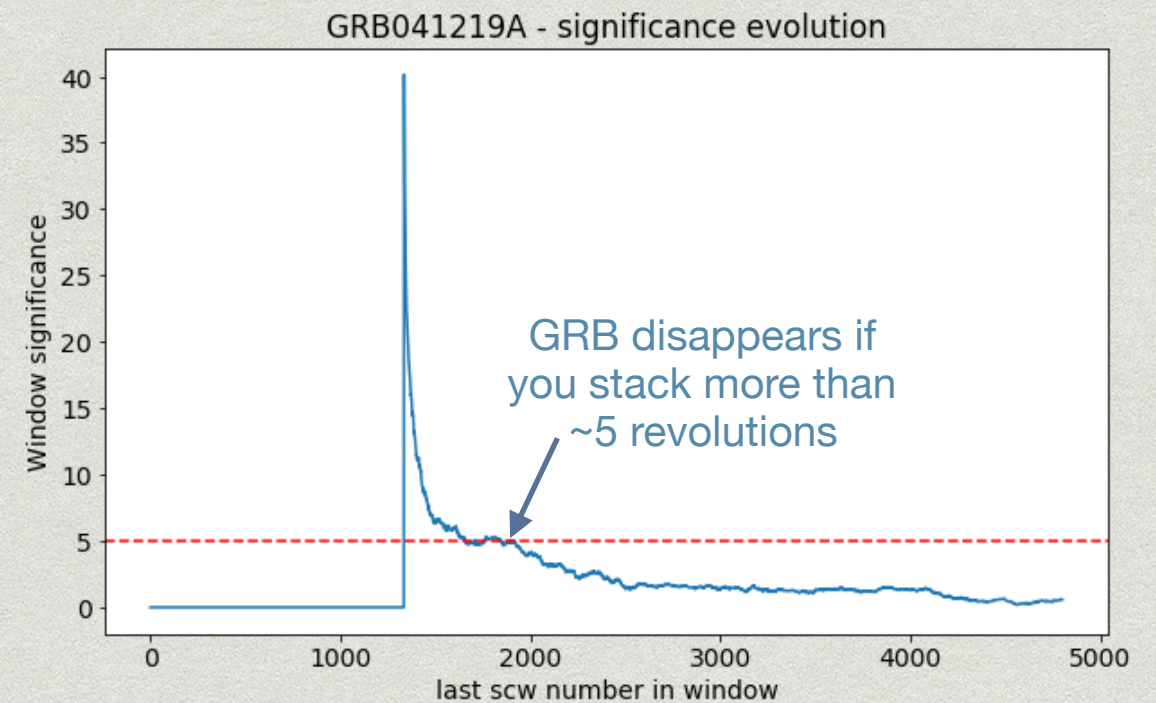
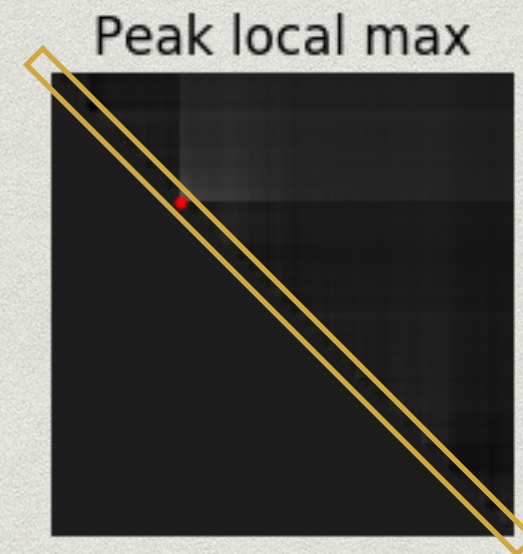
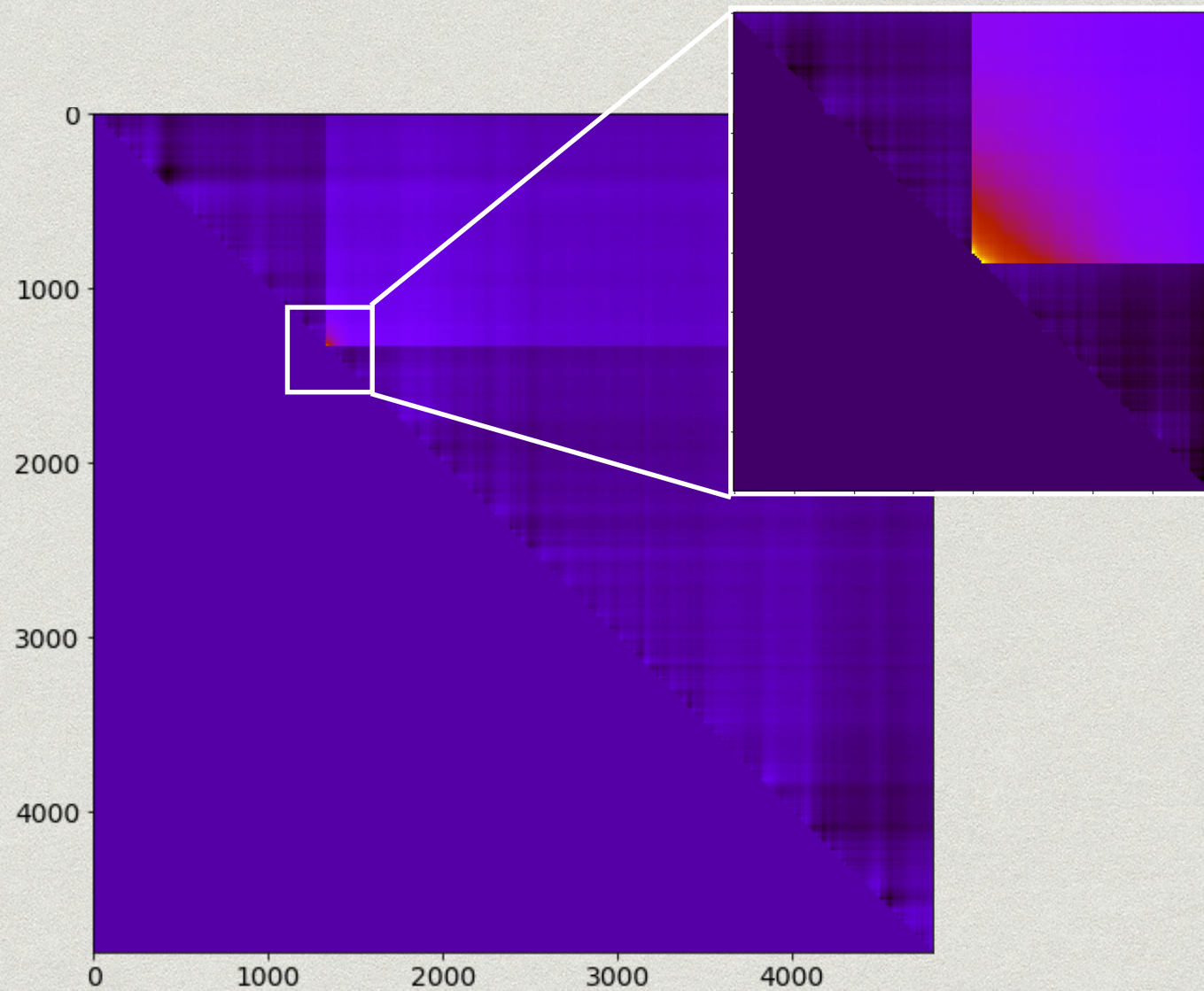
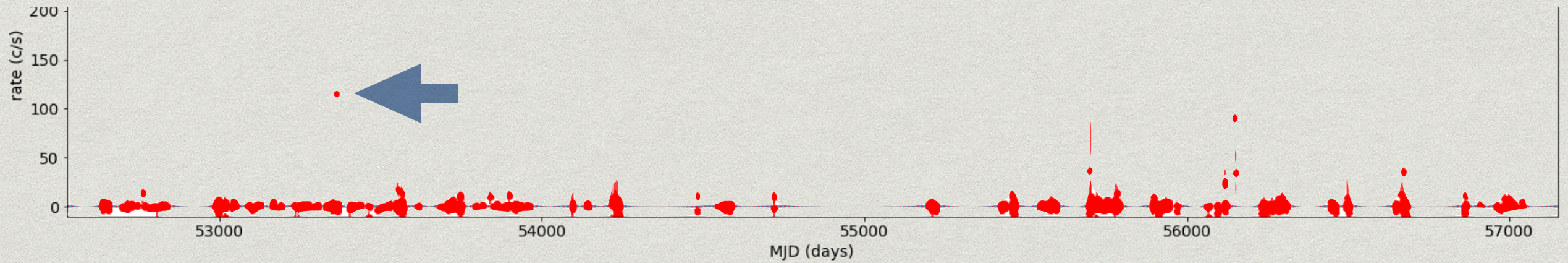
- * Each search performs a lot of trials (risk of false positive detections)
- * Very slow, so there is a temptation to restrict search ranges (introduces bias)
- * Only finds the largest outburst - there could be a lot more info in the light curve
- * Gets prohibitively slow for longer light curves, especially if you run it many times...
 - * ... and many (1000s) runs are needed to properly establish detection limits

Bursticity2

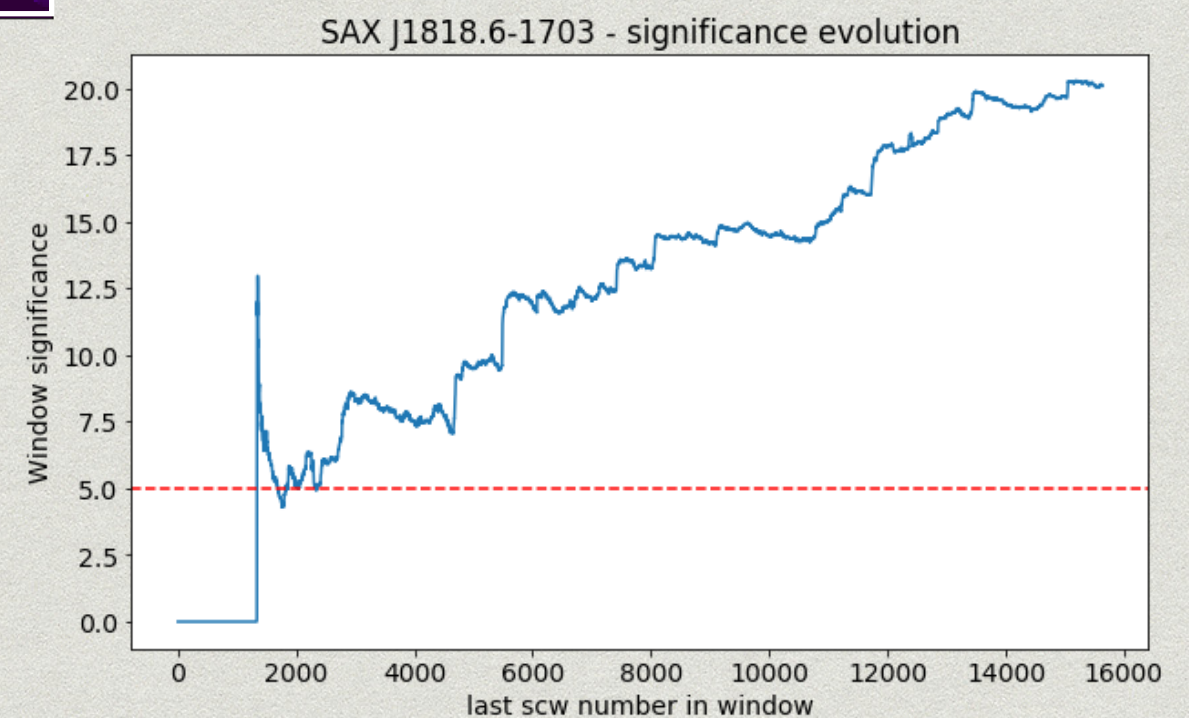
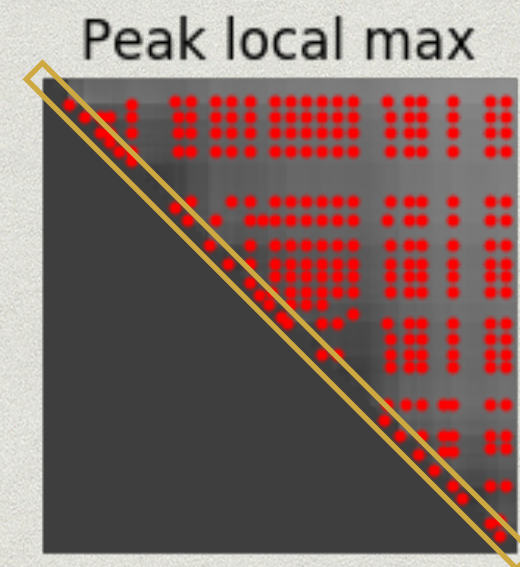
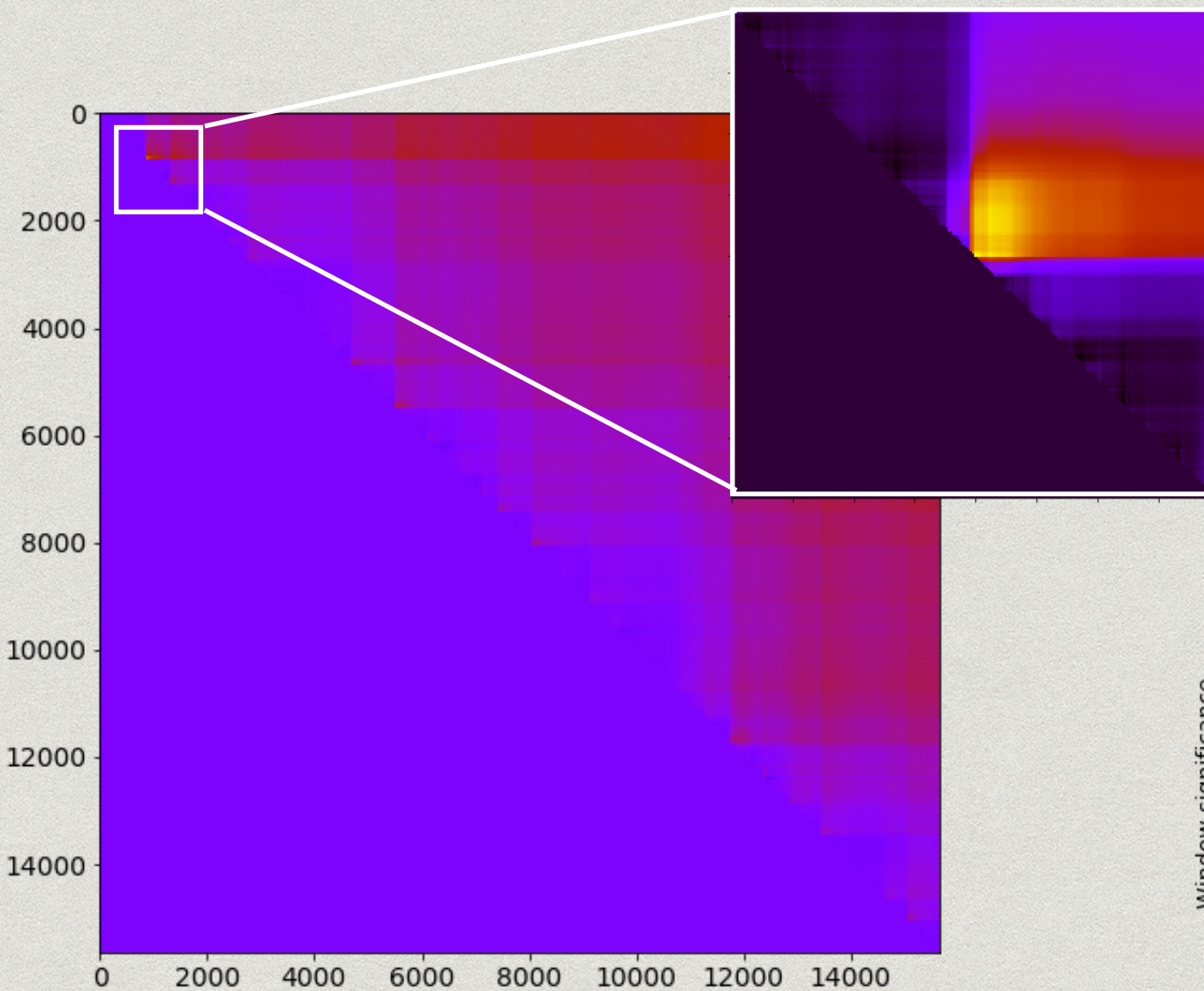
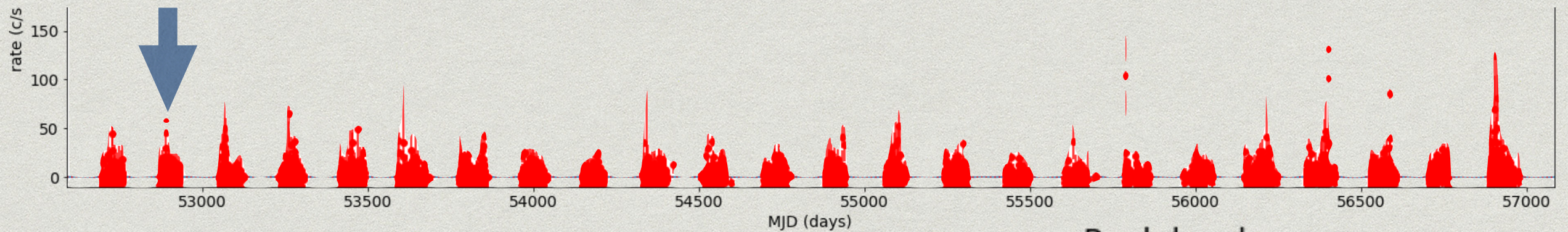
- * Exhaustive search (no biases)
- * Searches every pair of start/end science windows.
- * Enabled by GPU algorithm - 250x faster
- * Finds all bursts in a light curve



GRB041219A - one-shot transient (GRB)



SAX J1818.6-1703 - recurrent transient (SFXT)



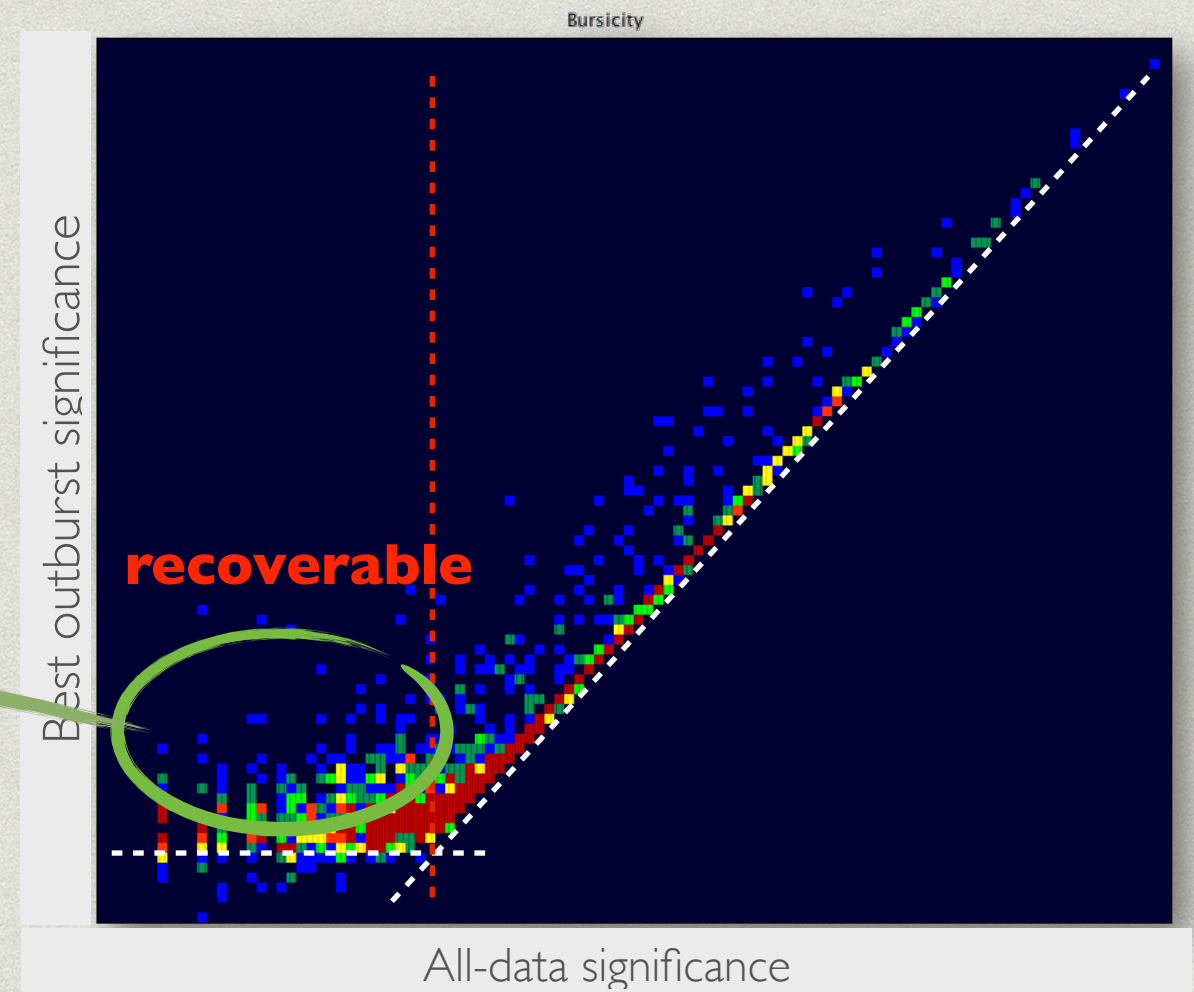
Some stats

What does bursticity find...?

In cat1000, there are about 110 recoverable transient sources above a 5 sigma bursticity floor, which reduces to 53 with a safer 6 sigma floor (about 1/2 are not IGR sources)

Dominated by Galactic sources

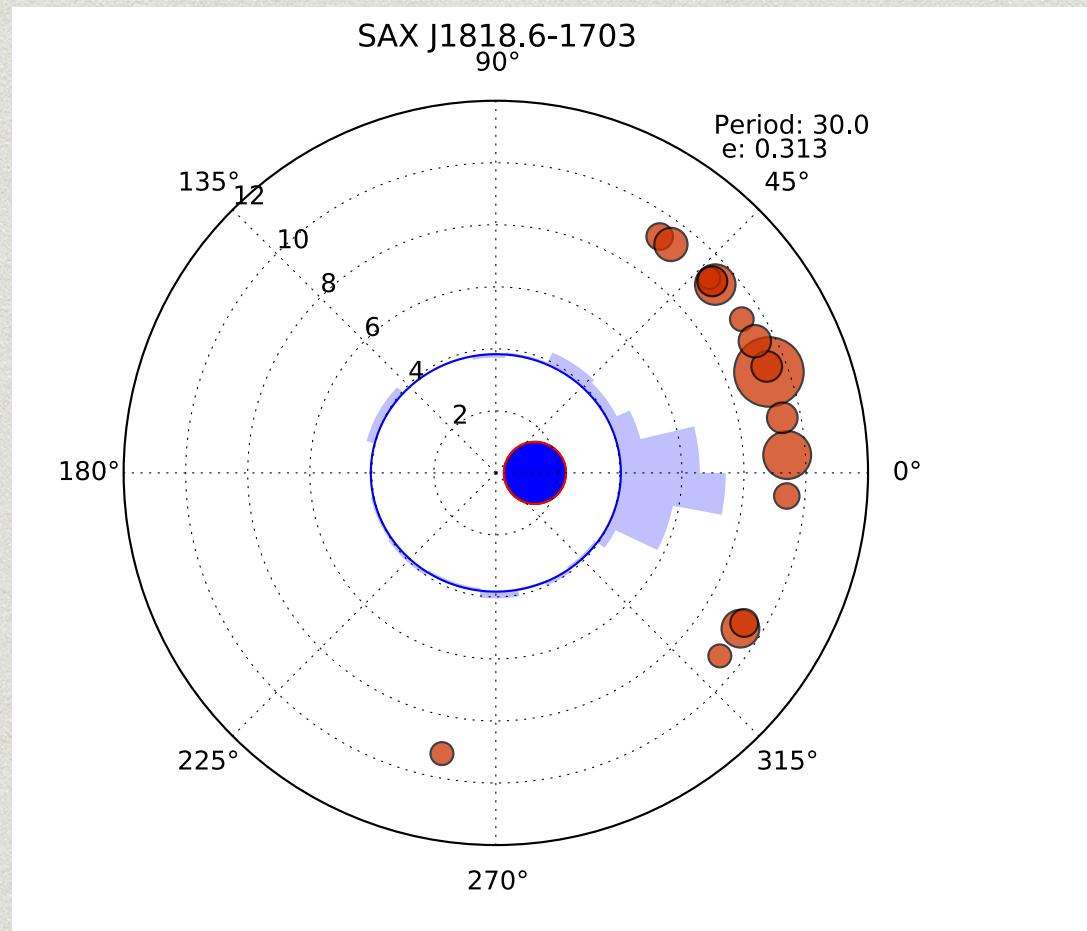
- * 8 LMXB/BHC
- * 6 LMXB
- * 9 HMXB/BeX
- * 4 HMXB/SFXT
- * 2 GRBs
- * 1 AXP?



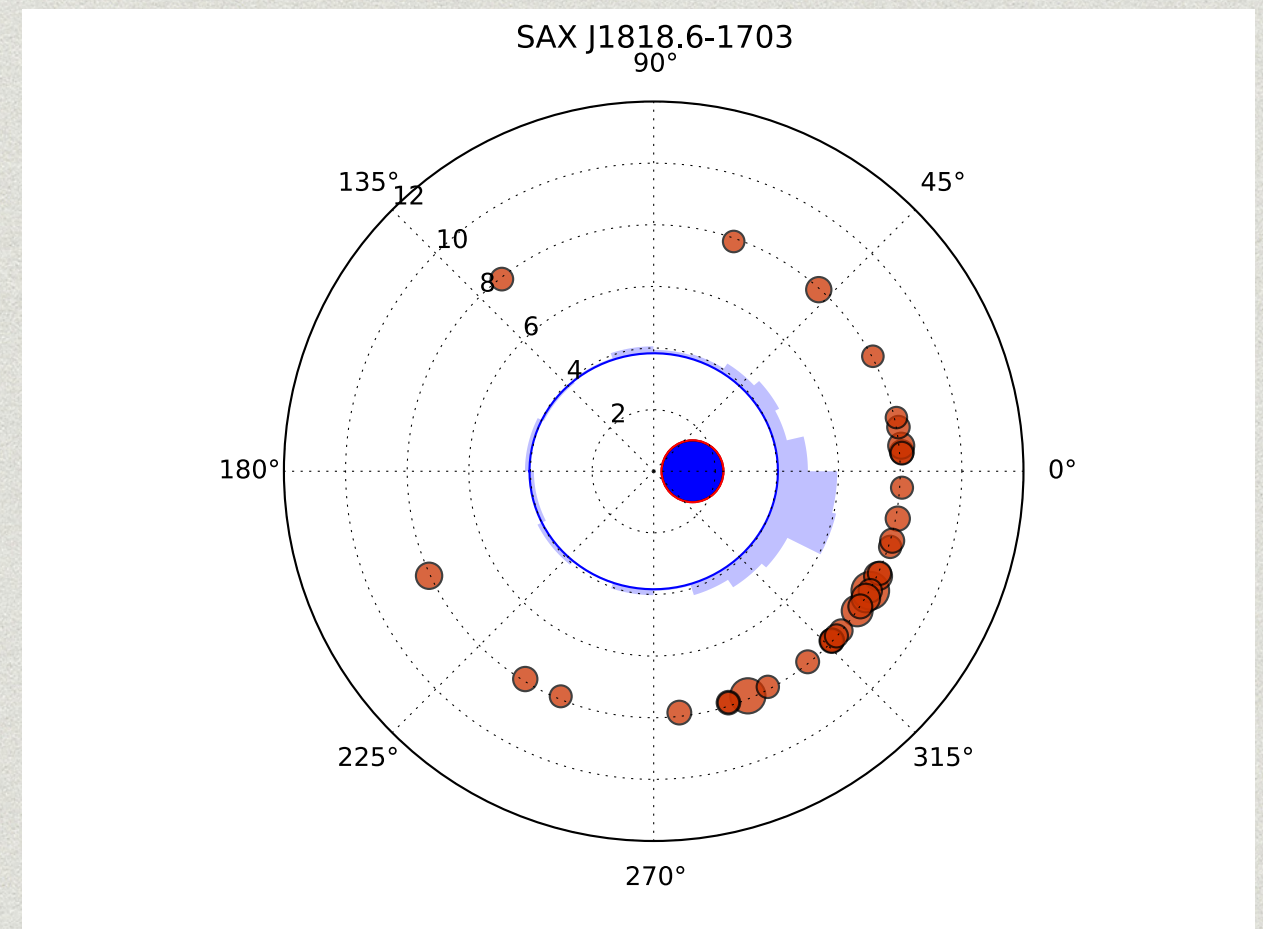
Multiple bursts as science tools

Spectral studies, even targeted around periastron, simultaneous with XMM, and catching outbursts, have failed to find the 'smoking gun' of correlated spectral change with flux

Can timing studies (and statistical surveys) tell us more - on the circumstellar environments?

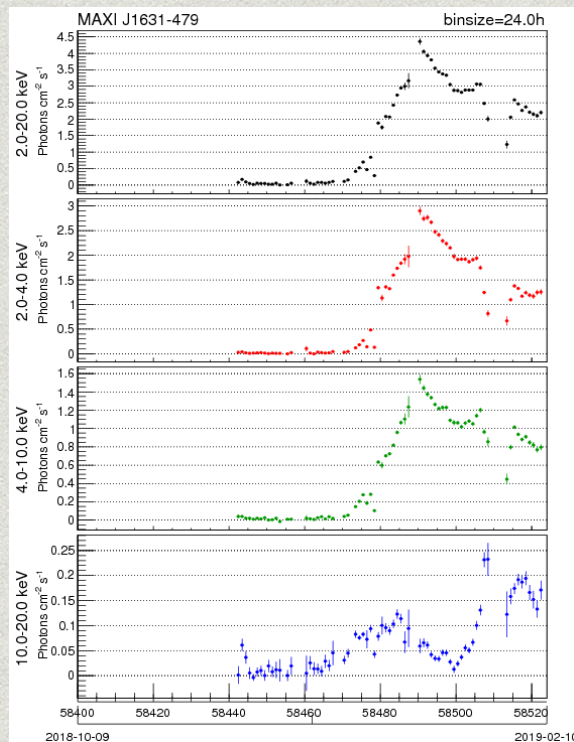
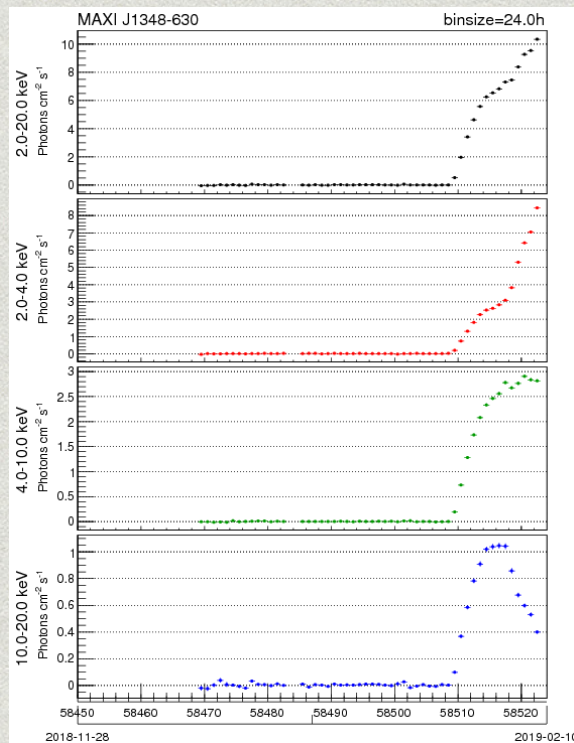


INTEGRAL/IBIS

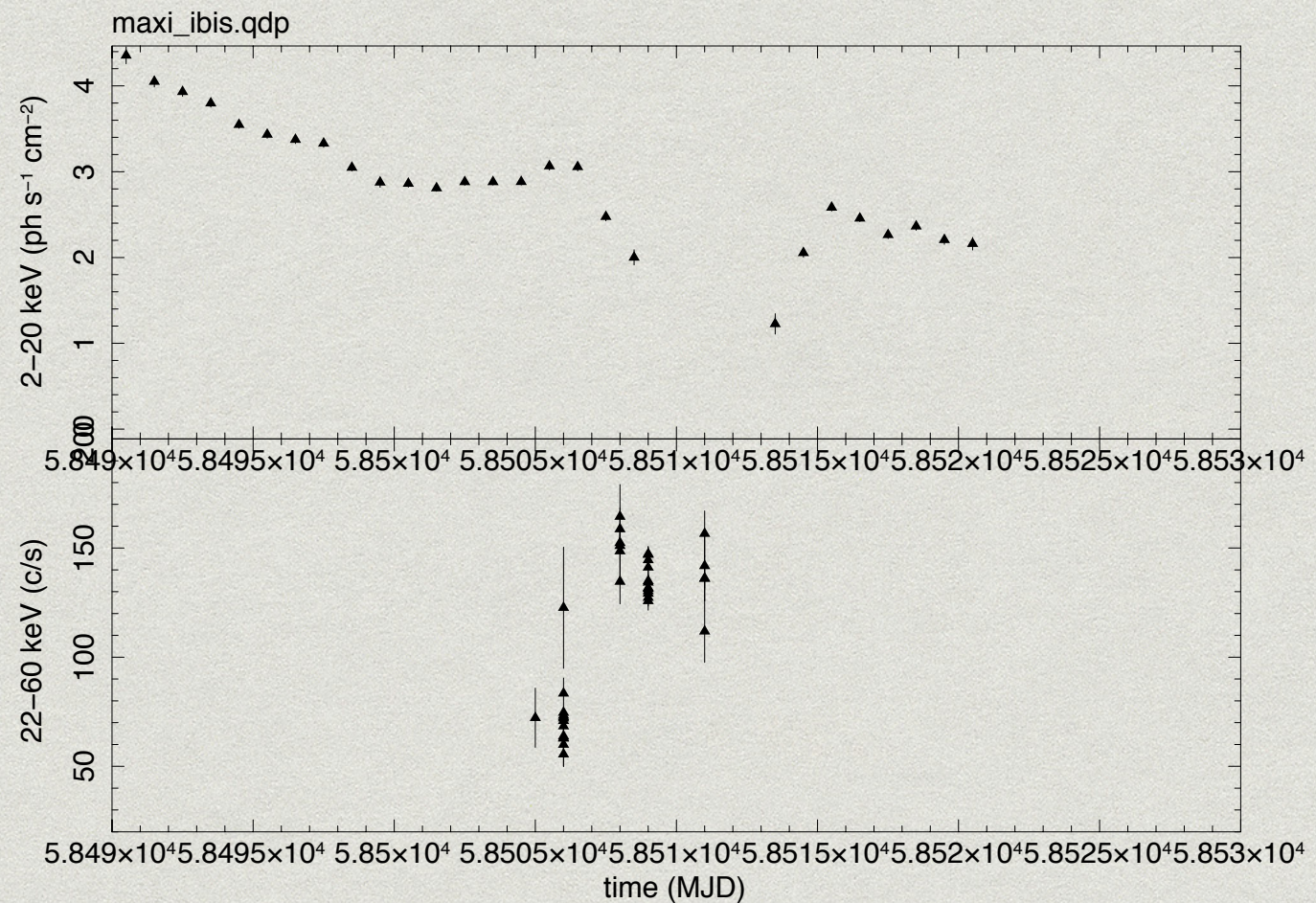


Swift/BAT

Some very recent transients



INTEGRAL Galactic Plane Scans continue, and detect and monitor new transient systems



Start Time 58505 23:40:52:578 Stop Time 58511 15:47:32:578

Even these very bright sources will only be marginally visible in stacks of the whole archive.

In the future...?

- * The task for any archival search gets bigger
- * Are we ready to a switch to a full 4D approach (light curve grid) to address *the elephant in the room*?
- * Healpix representation of sky at full resolution contains $\sim 1\text{Mpix}$
- * Can we look for correlated outbursts in both spatial and time axes?
- * We have not yet started to looked for correlated activity across instruments - a way to lower the floor?

Thanks to:

The IBIS survey team

The Galactic Plane Scans team

The AHEAD project

Any questions?