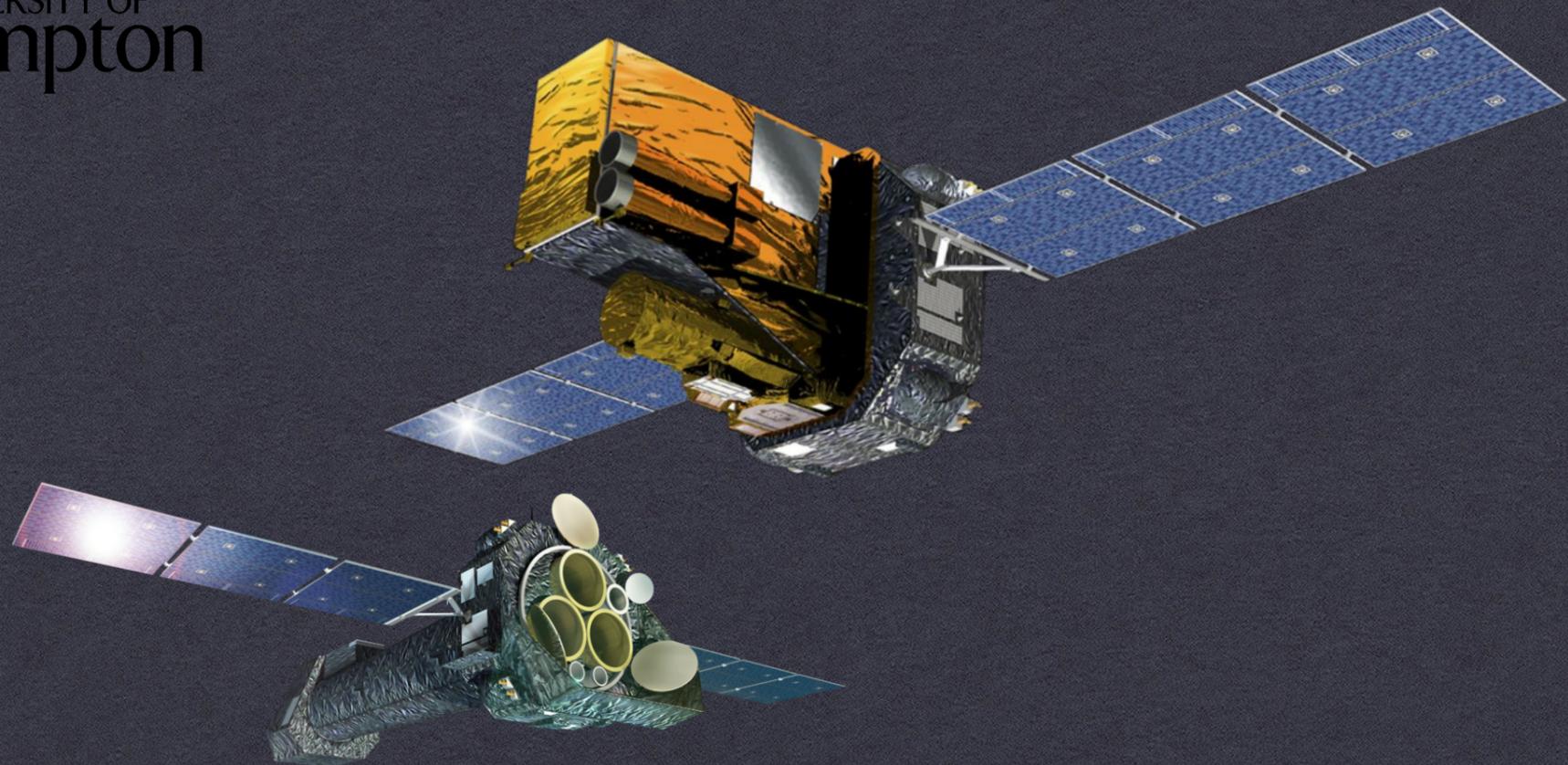




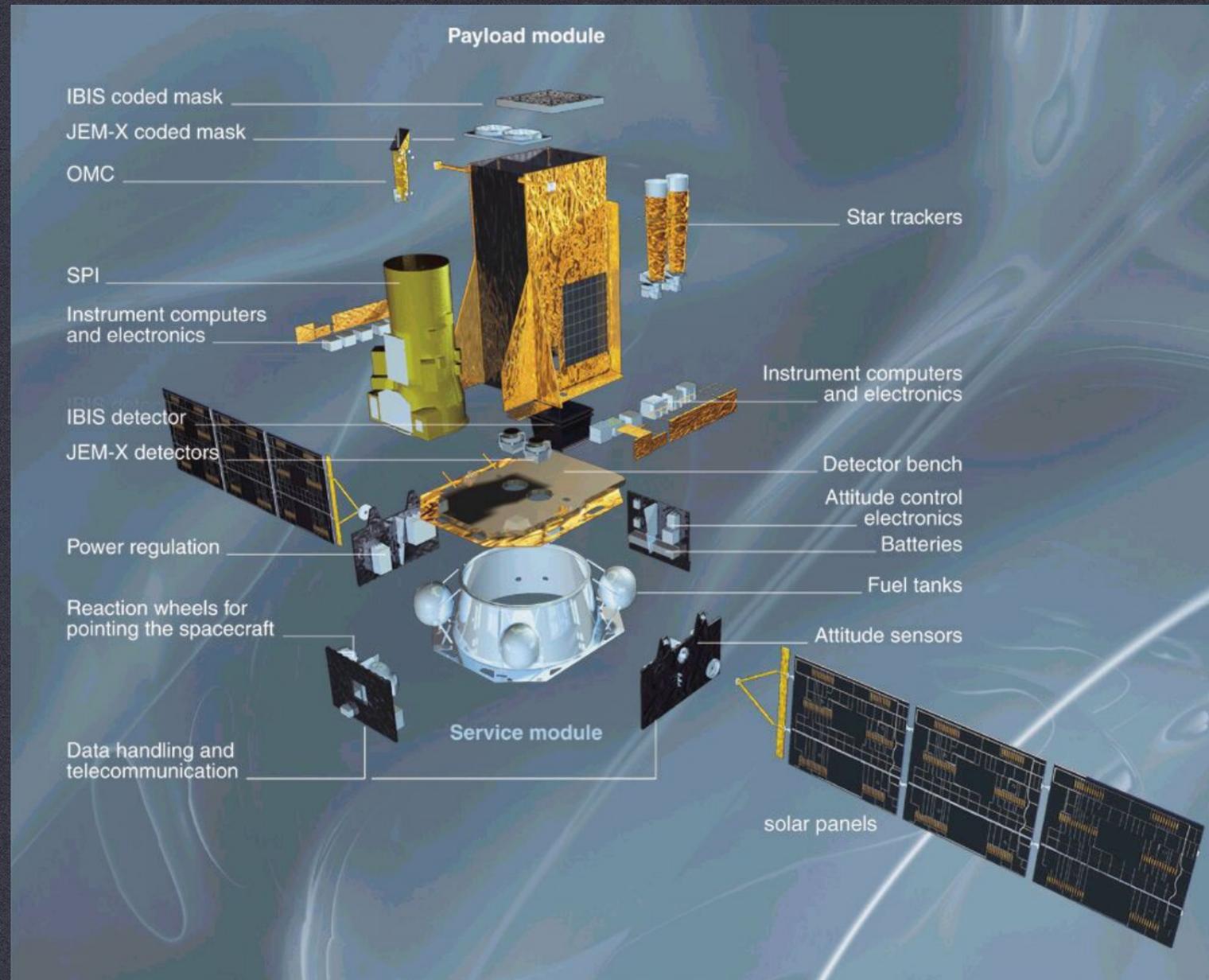
UNIVERSITY OF
Southampton



THE VIEW FROM (JUST) ABOVE XMM

A J BIRD, SOUTHAMPTON UNIVERSITY

TREASURES HIDDEN IN HIGH ENERGY CATALOGUES, TOULOUSE, MAY 2018



PROJECT

INTEGRAL

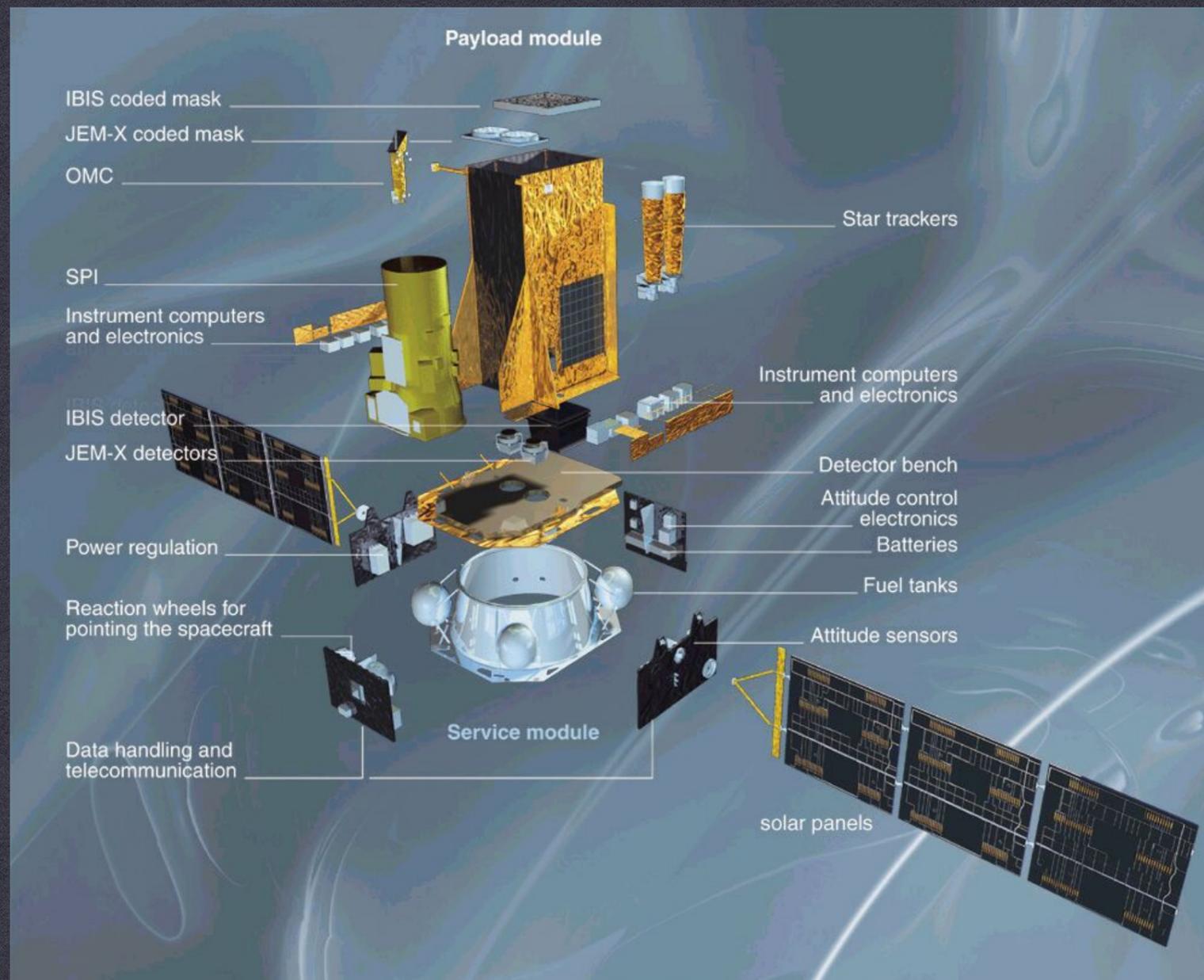
HARD X-RAY / SOFT GAMMA-RAY TELESCOPE

DATE

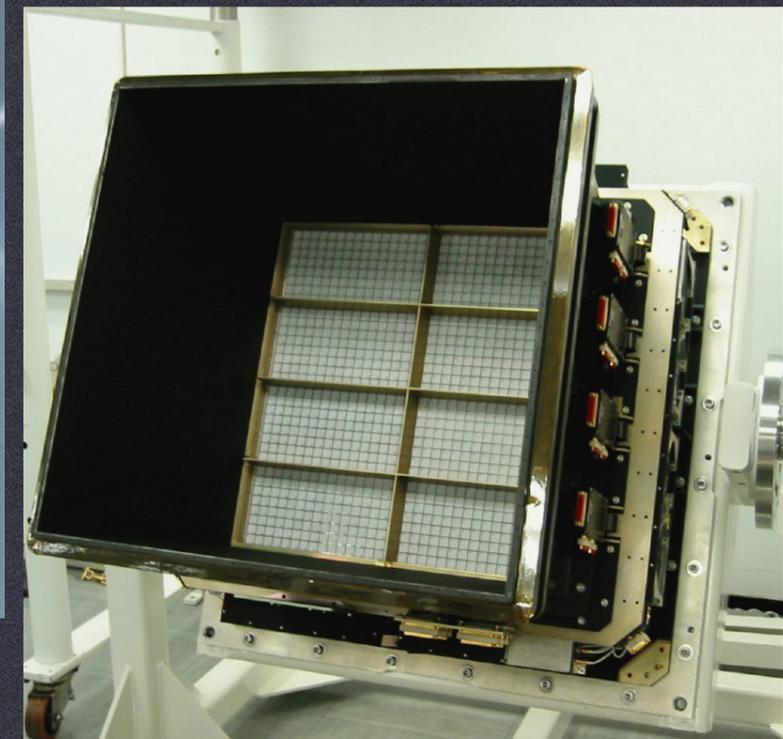
2002-

CLIENT

ESA



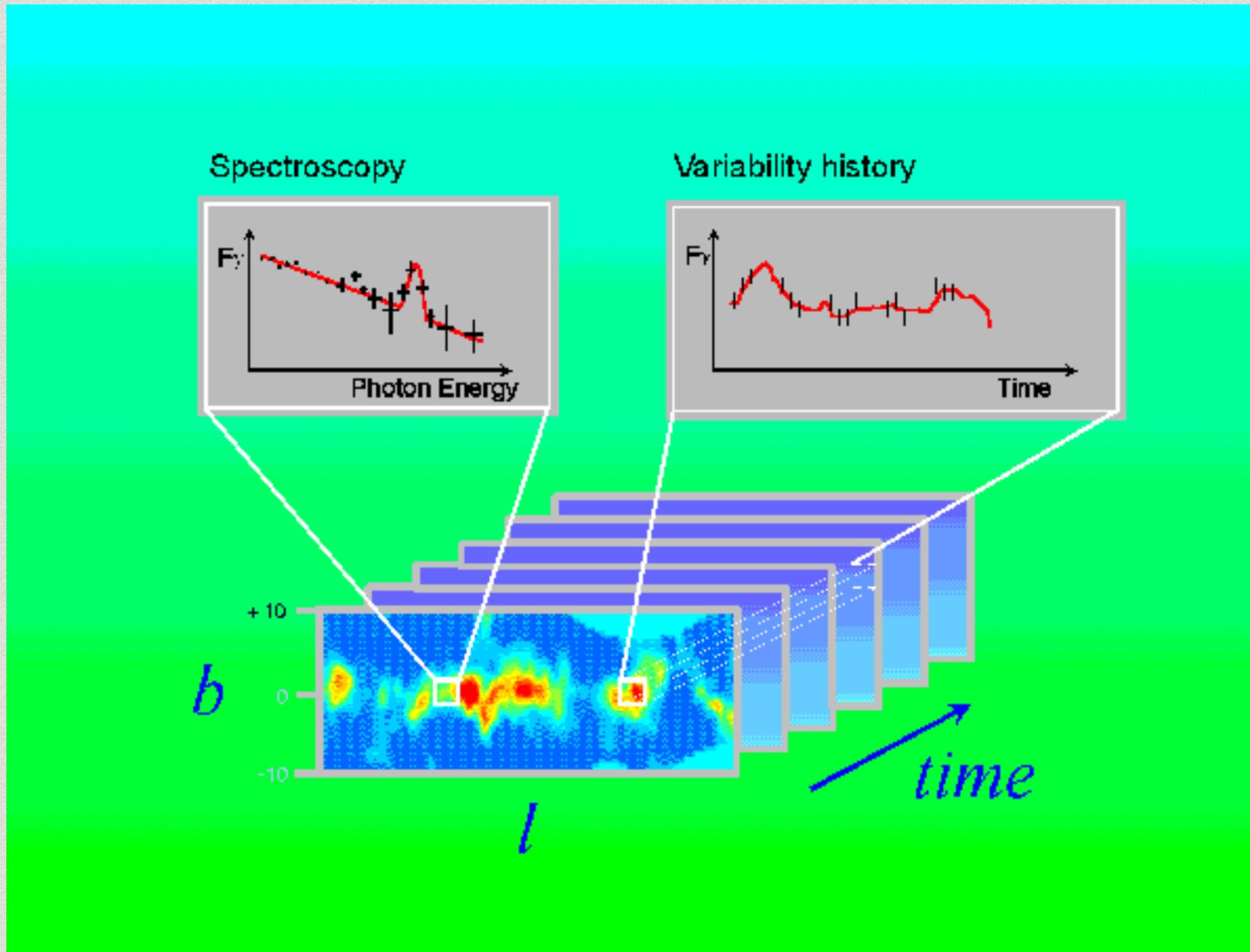
- 18-300keV
- Coded aperture imager
- 30deg FOV
- 12' FWHM PSF
- ~1' positions
- ~20mCrab in 2000s



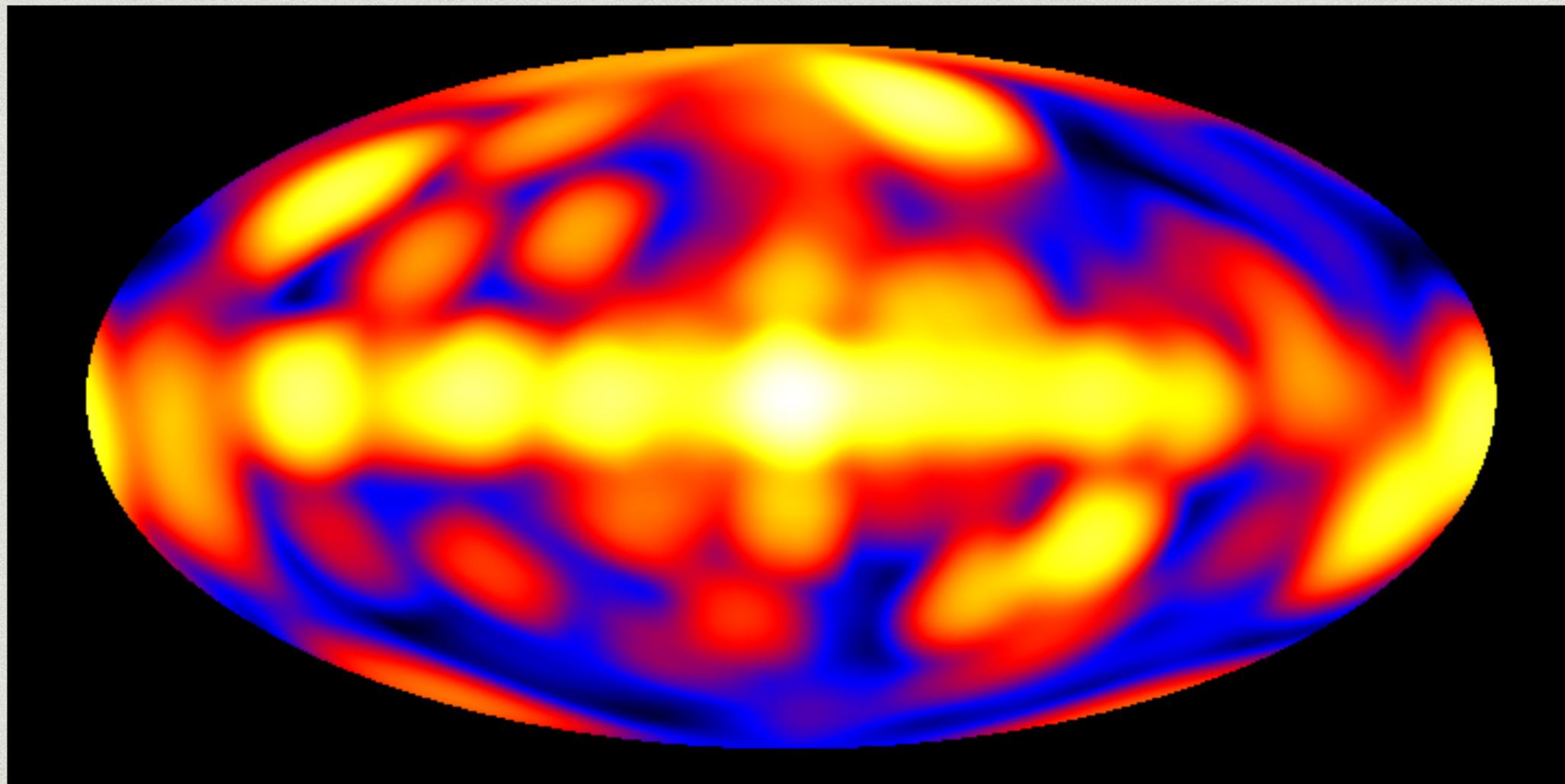
IBIS TELESCOPE

MAIN SURVEY INSTRUMENT - CONSISTS OF ISGRI AND PICSIT DETECTORS , VETO SHIELD AND MASK

A little history ...

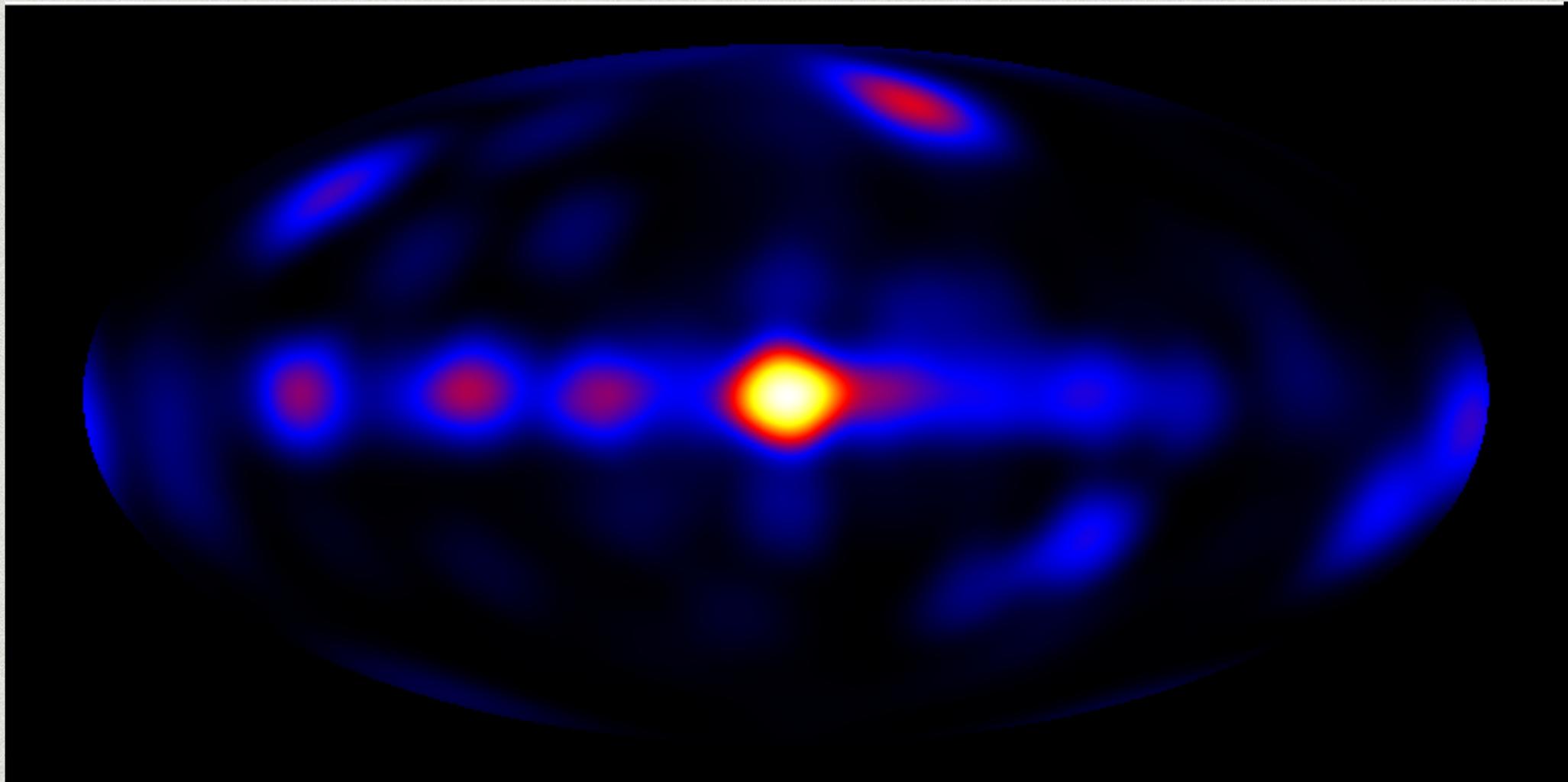


Current exposure



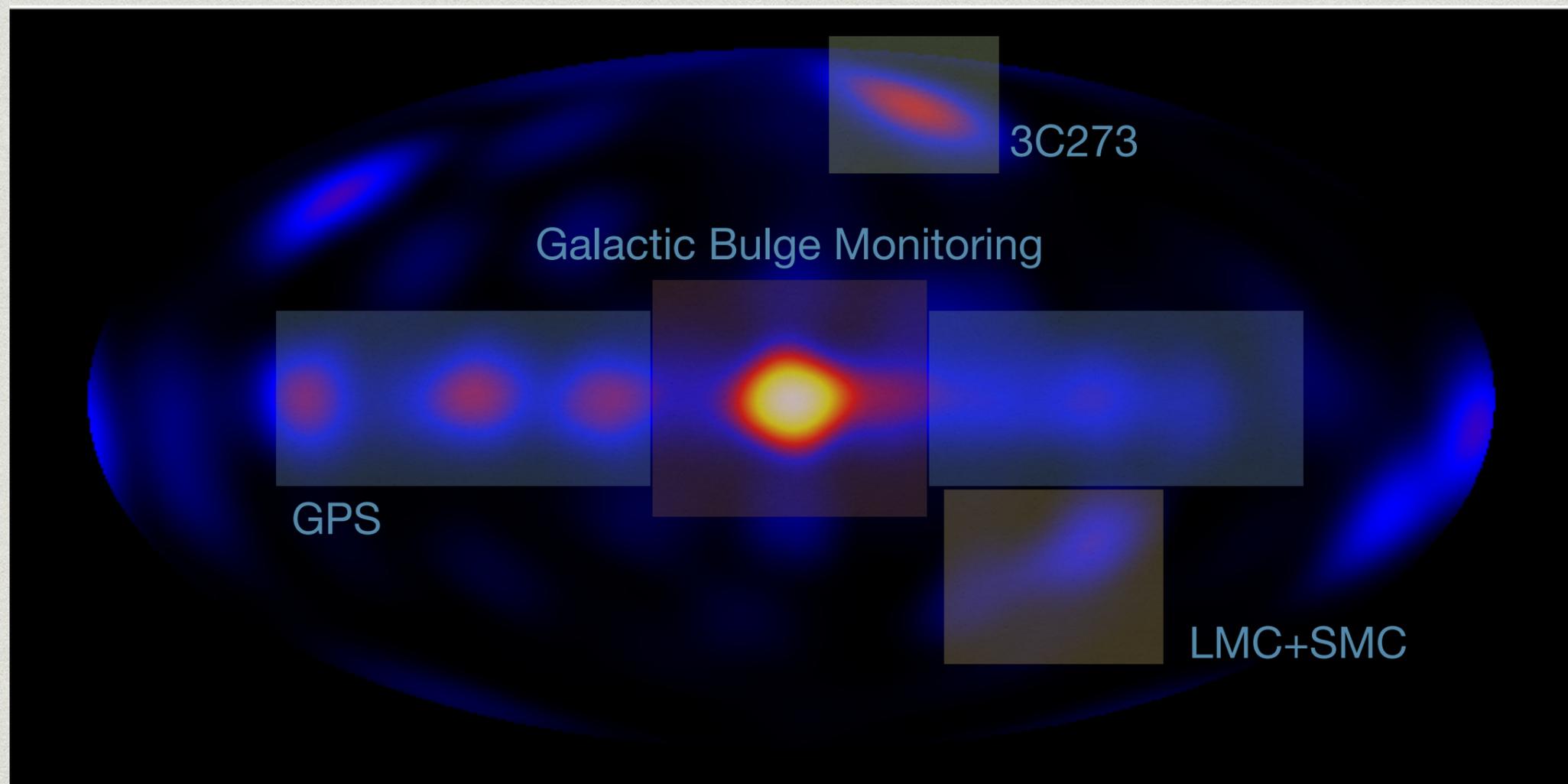
Pre-AO16 (up to 2018) - exposure map

Current exposure



Pre-AO16 (up to 2018) - exposure map, linear scaling

Major programmes



Pre-AO16 (up to 2018) - exposure map, linear scaling

GRO J1750-57

IGR J17473-2721

GC

4U1730-335

GX 354-0

IGR J17252-3616

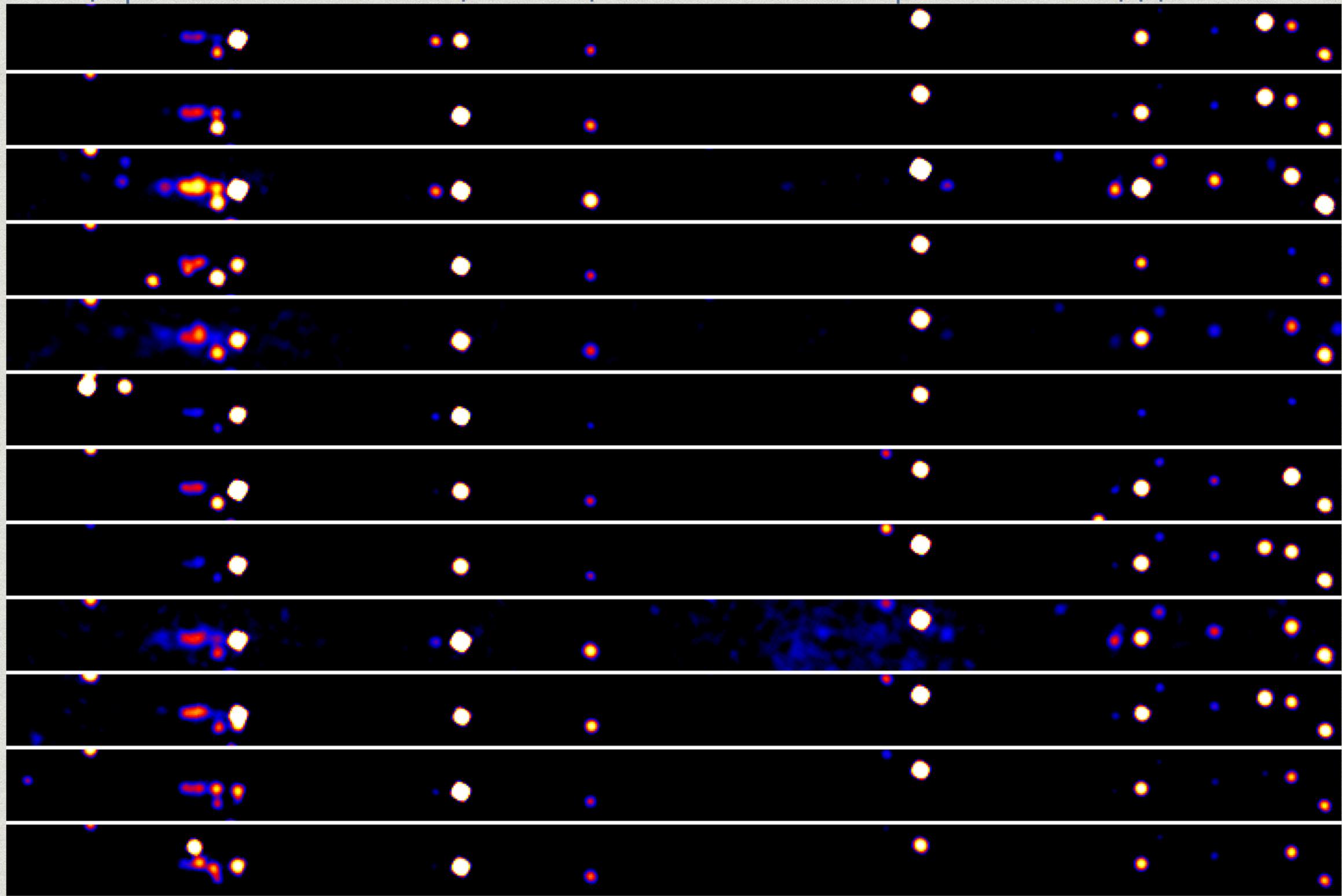
4U 1701-407

OA0 1657-41

IGR J16479-4514

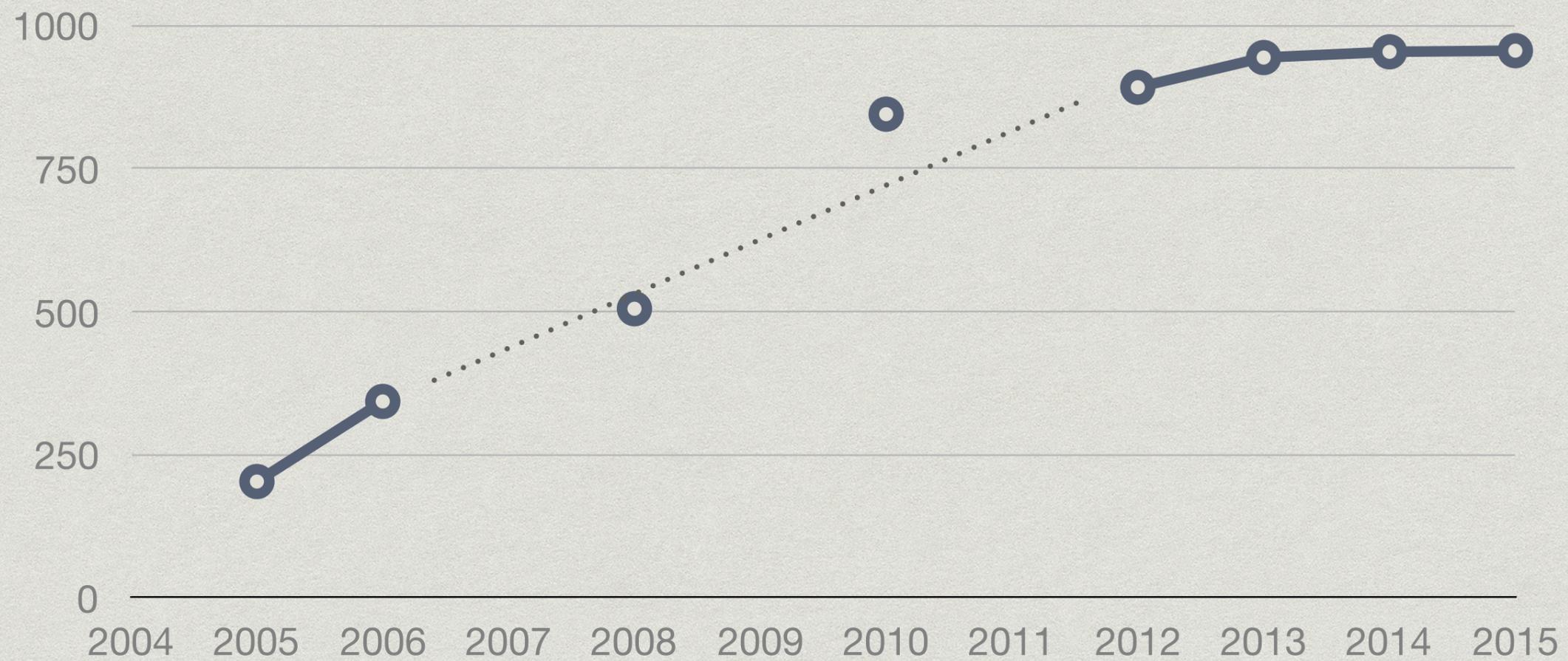
GX 340+0

IGR J16418-4532



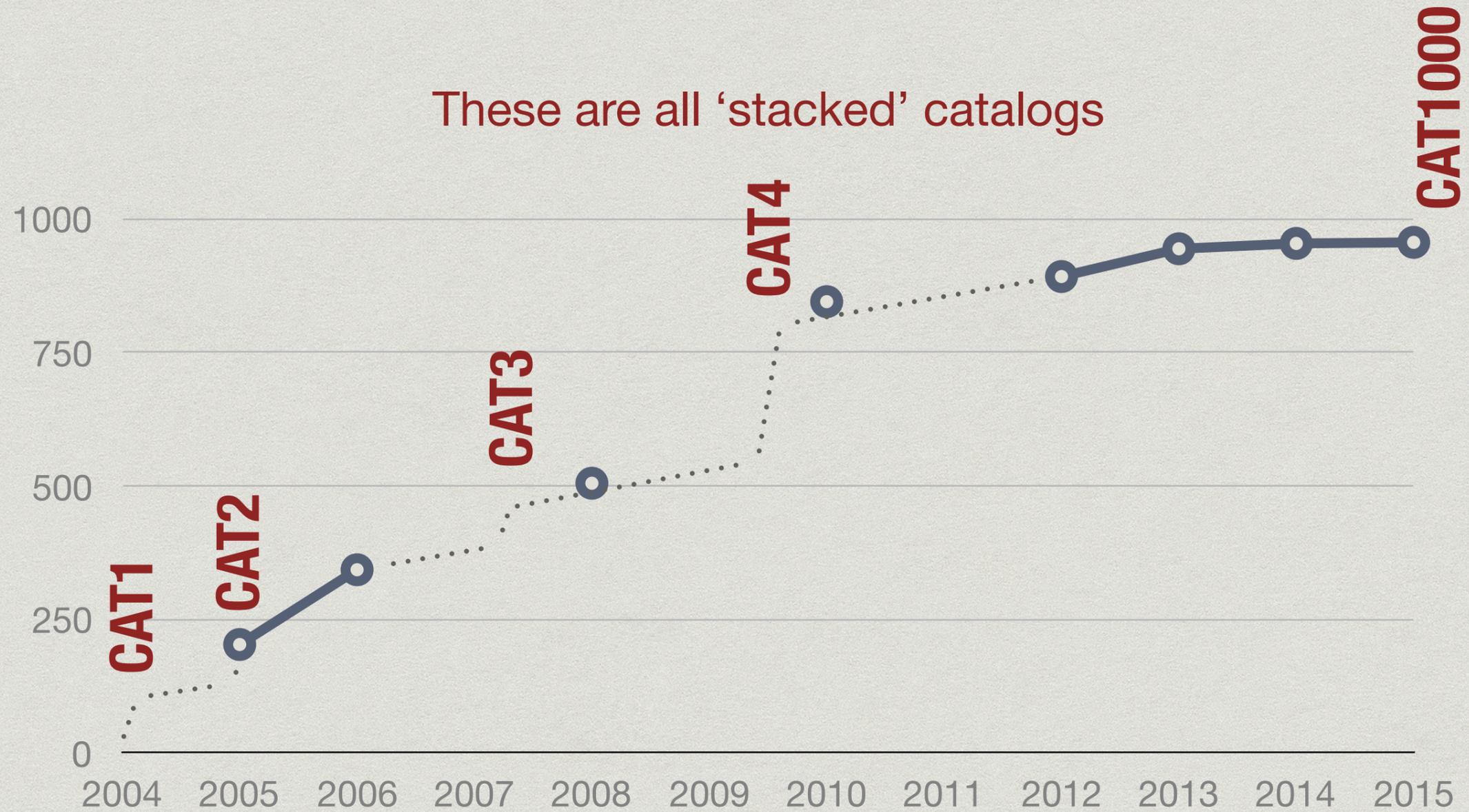
Source discovery

Based on INTEGRAL 'reference catalog' - number of IBIS-detected sources

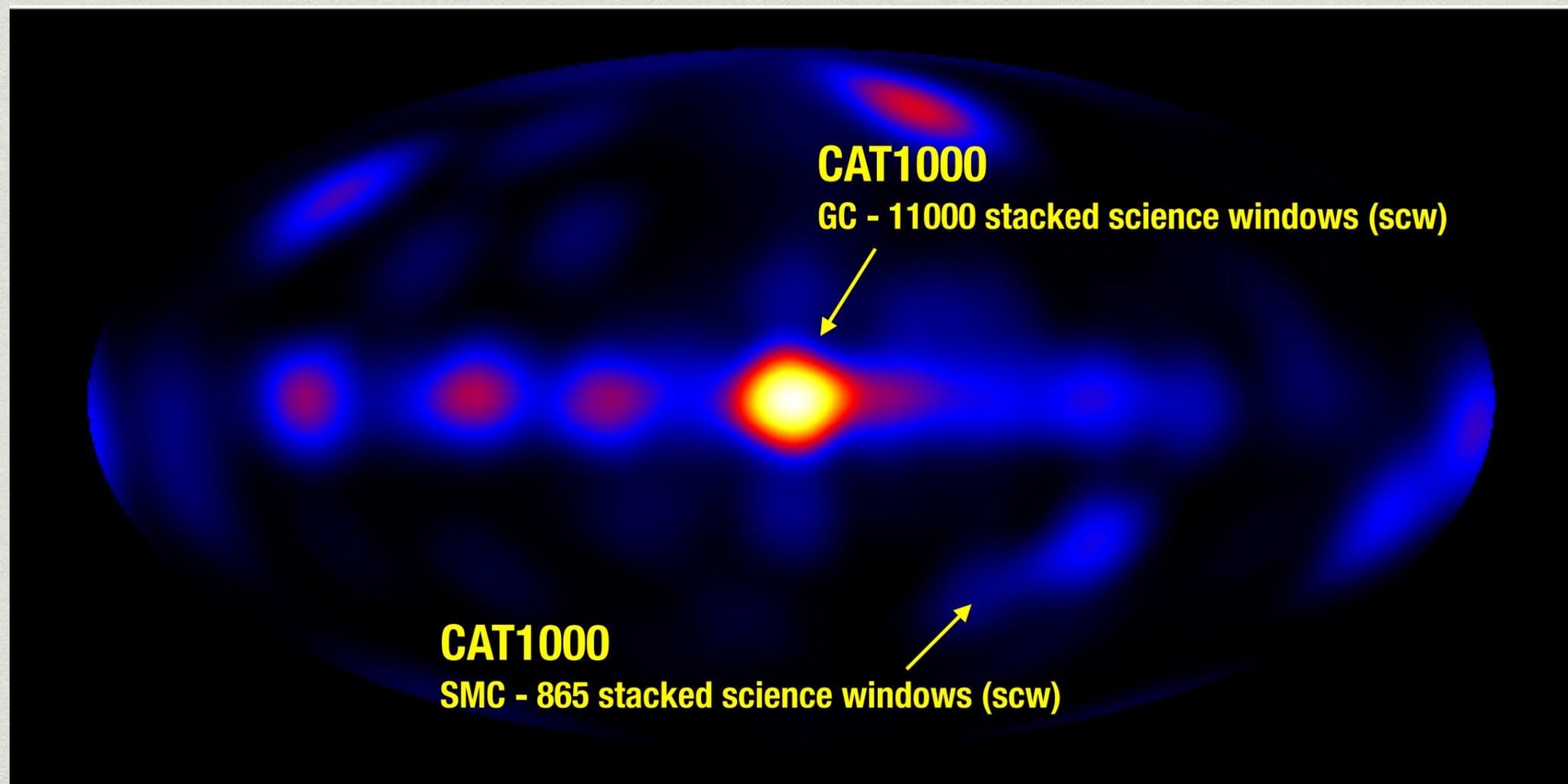


Source discovery

These are all 'stacked' catalogs



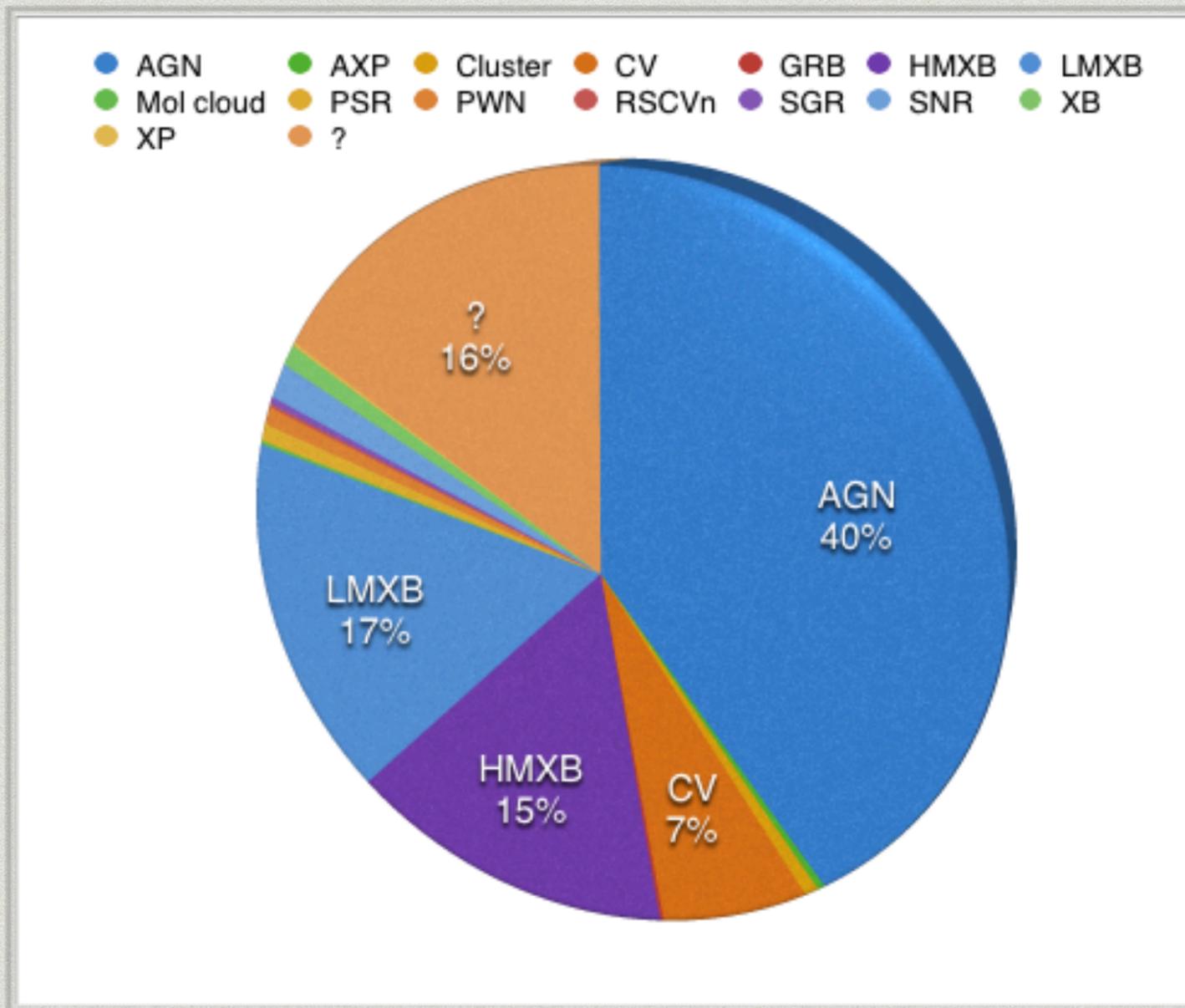
Current exposure



Pre-AO16 (up to 2018) - exposure map, linear scaling

What are they?

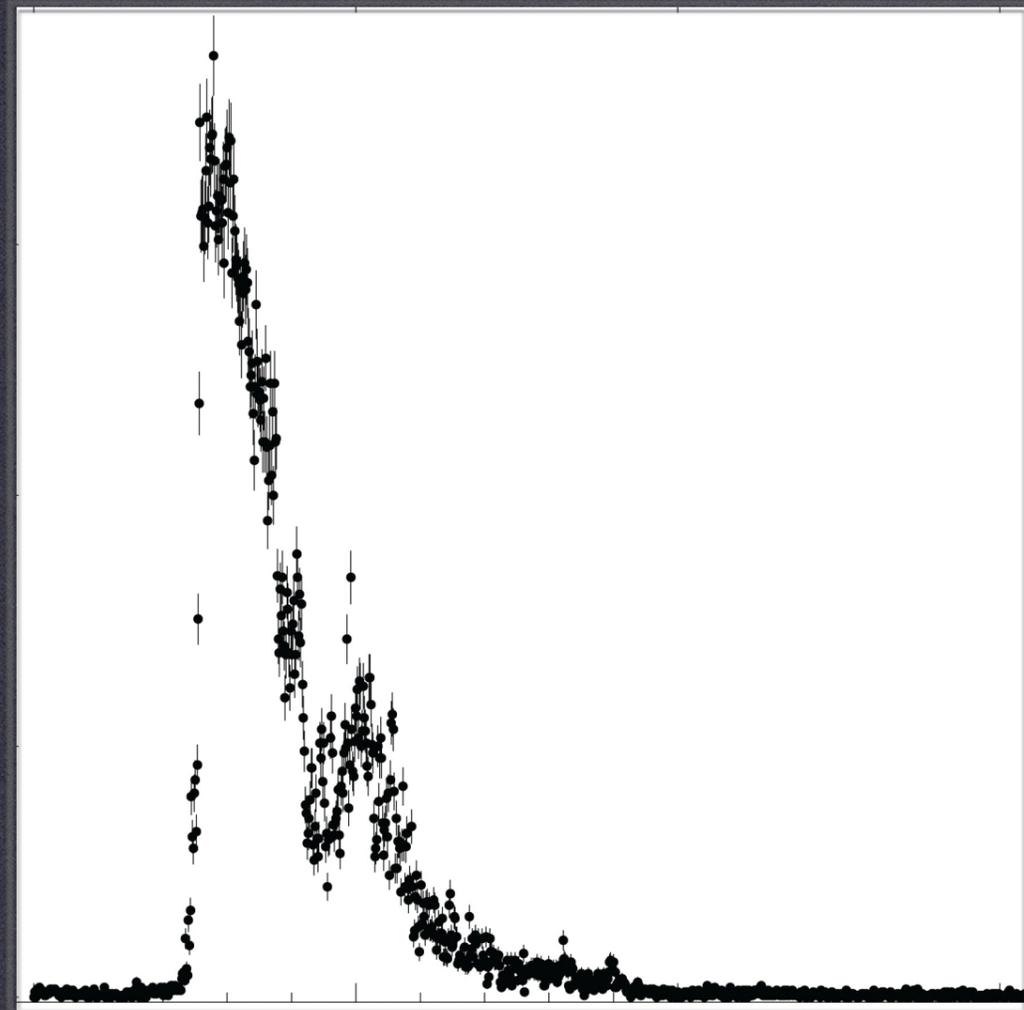
- * Indicative of the approach, which targets persistent all-sky source and transient objects
- * AGN and CV (isotropic populations) responsible for half
- * All the catalogs have contained a substantial fraction of '?' new sources



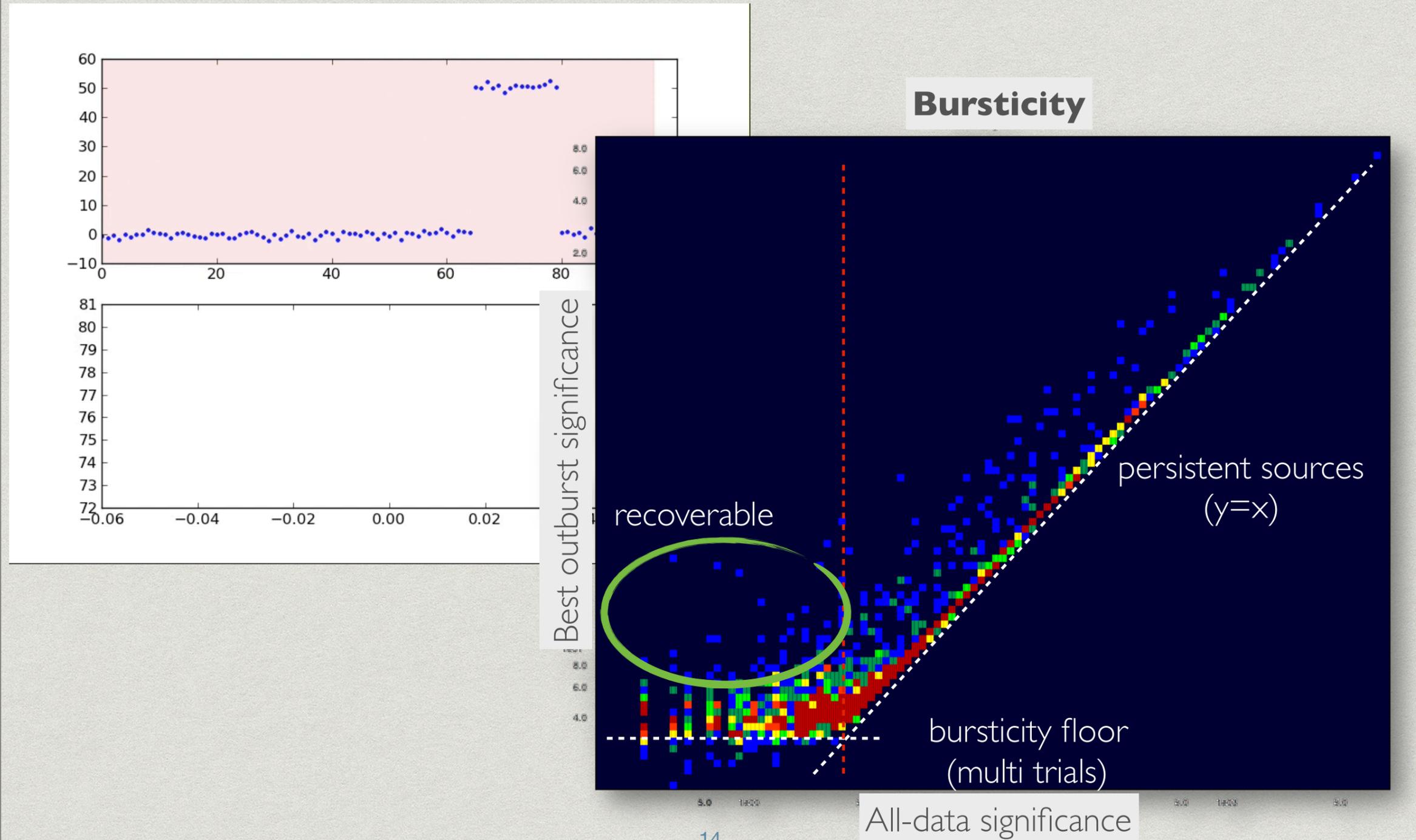
'CAT4' Bird+ 2010 ... updated for 'CAT1000'

HIDDEN IN TIME

THE TRANSIENT POPULATIONS

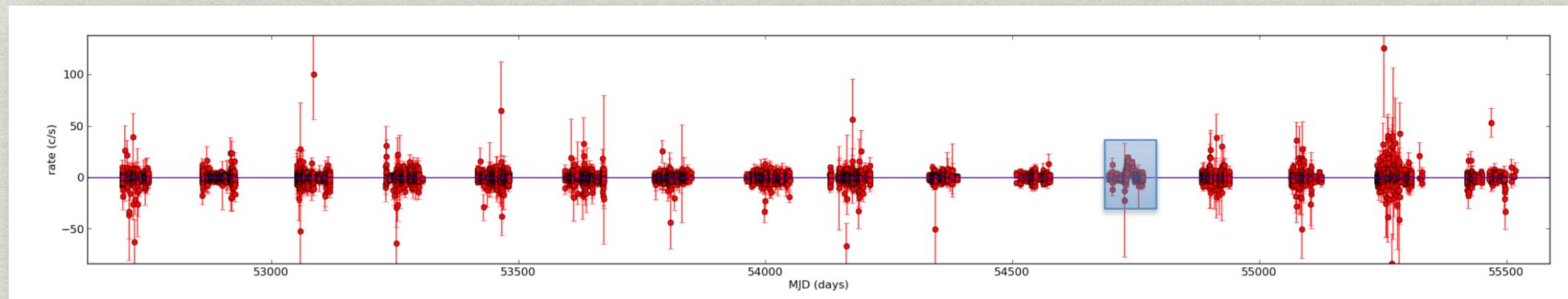


Hunting transient sources



A bursticity example

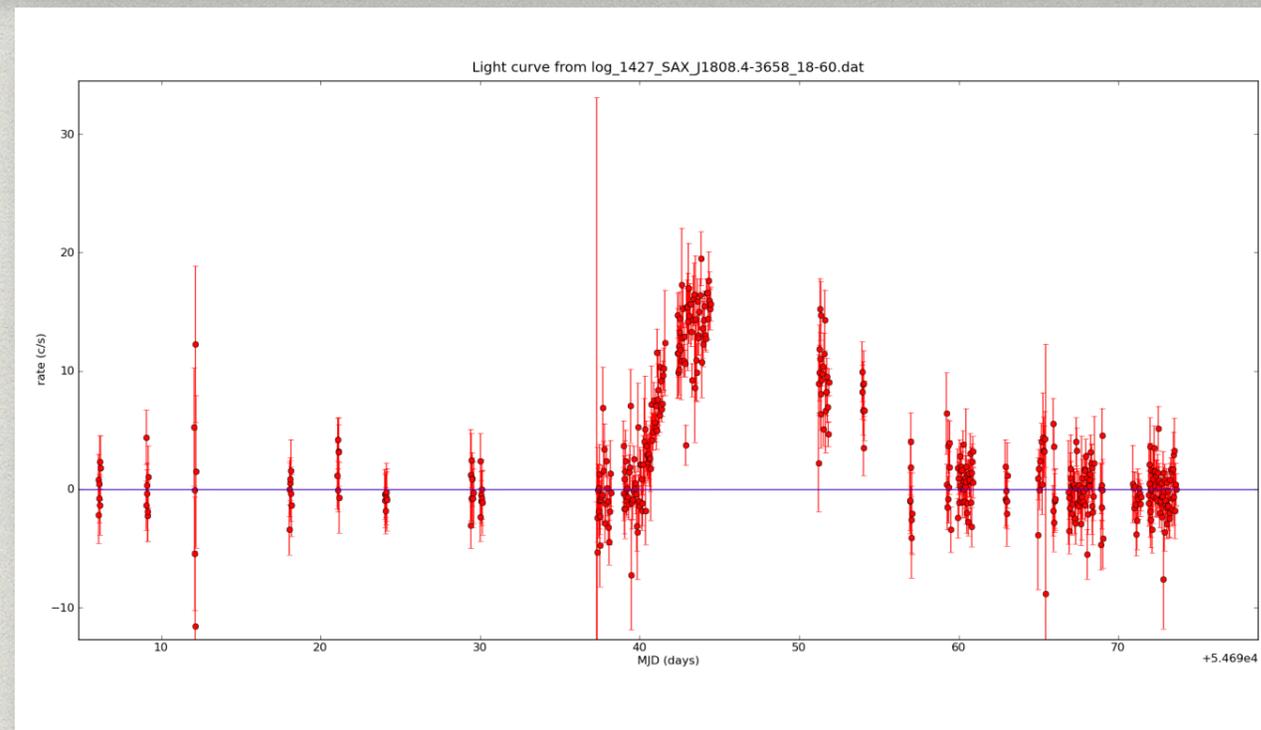
SAX J1808.4-3658 (accreting MSP)

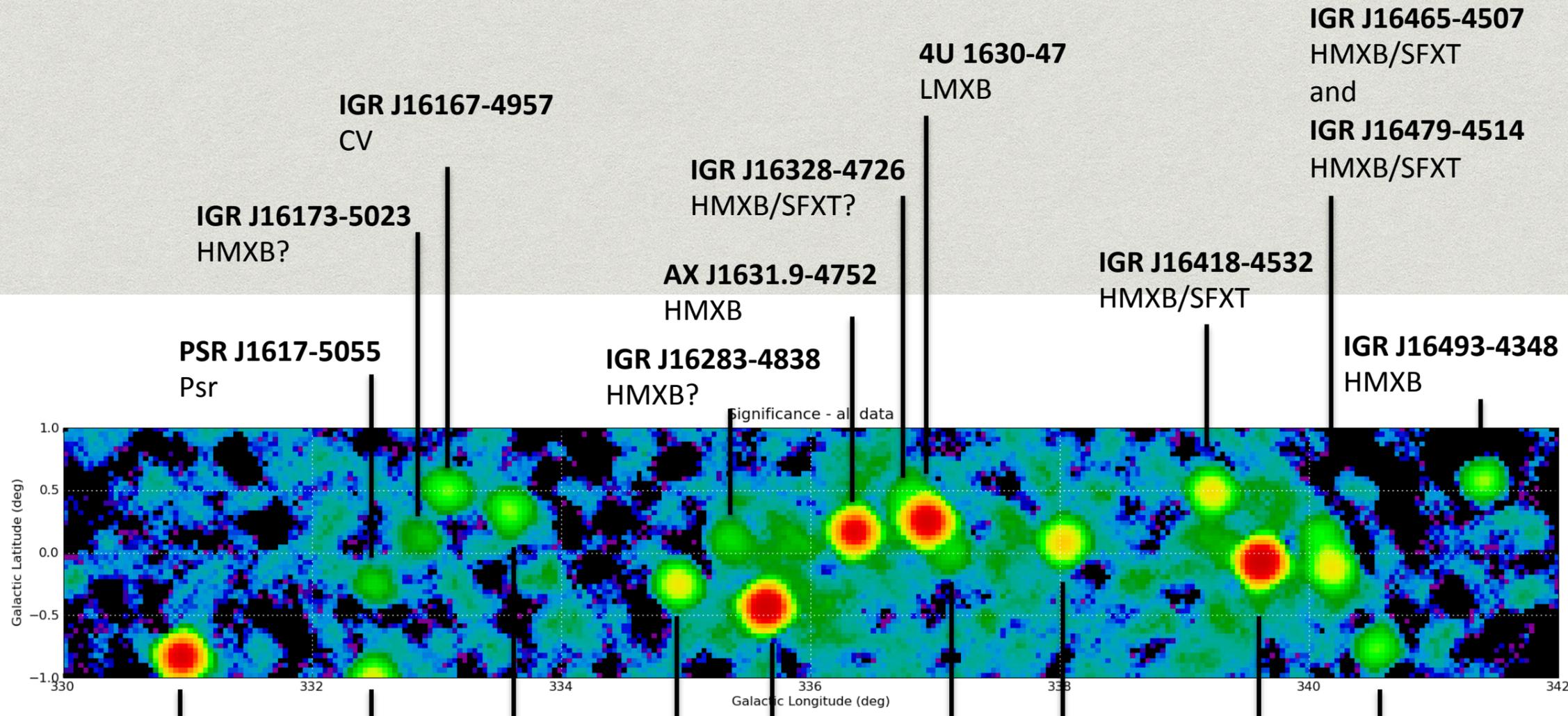


3.4 sigma

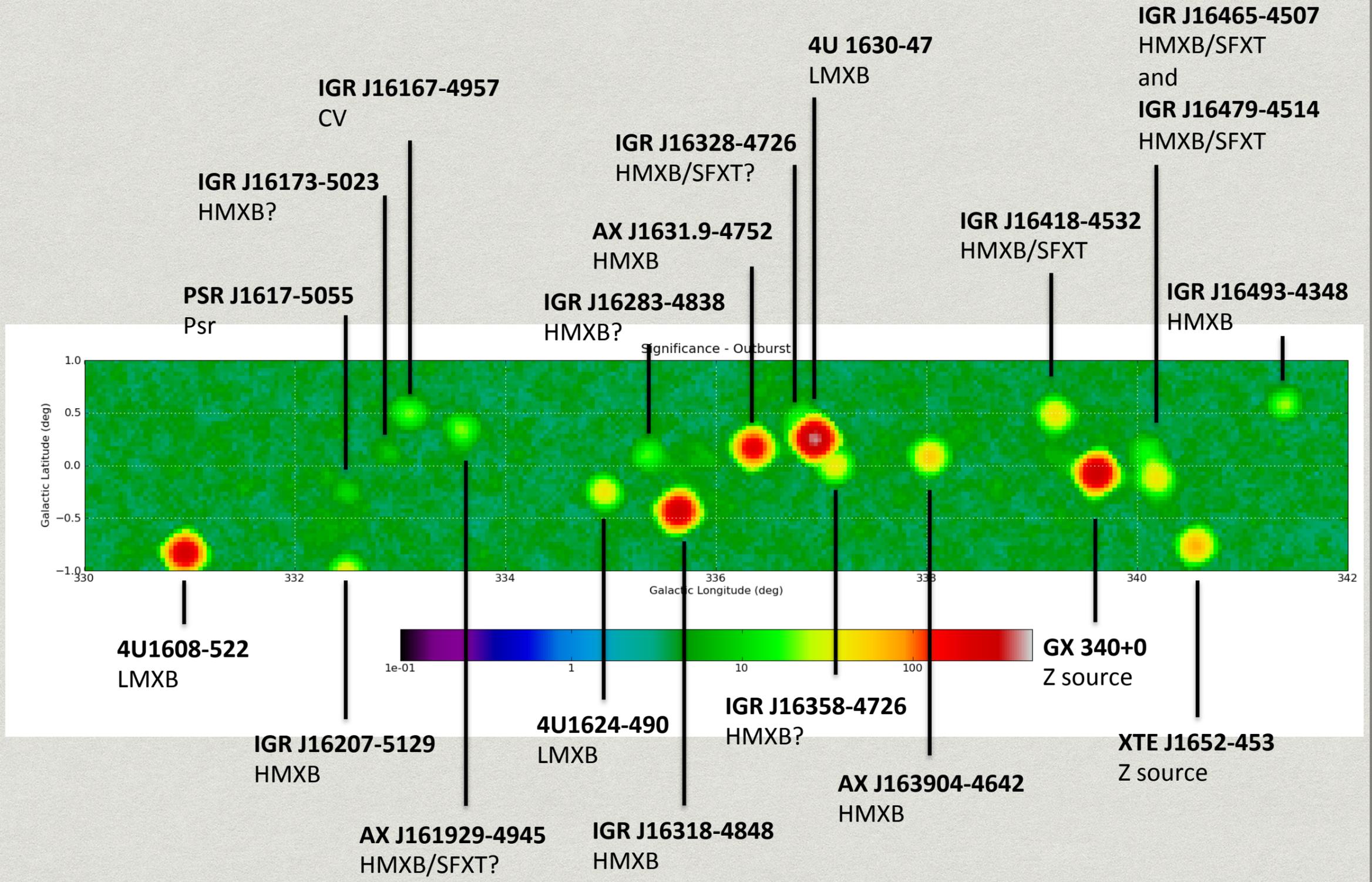
x16.7

58 sigma





- IGR J16167-4957
CV
- IGR J16173-5023
HMXB?
- PSR J1617-5055
Psr
- 4U1608-522
LMXB
- IGR J16207-5129
HMXB
- AX J161929-4945
HMXB/SFXT?
- IGR J16283-4838
HMXB?
- 4U1624-490
LMXB
- IGR J16318-4848
HMXB
- IGR J16328-4726
HMXB/SFXT?
- AX J1631.9-4752
HMXB
- 4U 1630-47
LMXB
- IGR J16358-4726
HMXB?
- AX J163904-4642
HMXB
- IGR J16418-4532
HMXB/SFXT
- IGR J16465-4507
HMXB/SFXT
and
IGR J16479-4514
HMXB/SFXT
- GX 340+0
Z source
- XTE J1652-453
Z source
- IGR J16493-4348
HMXB



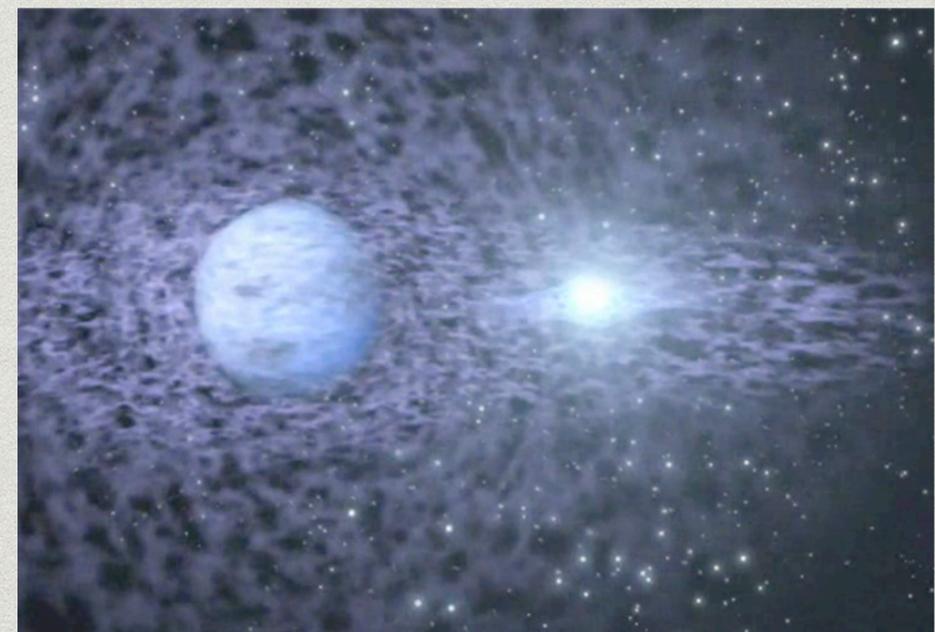
HIDDEN IN ENERGY

THE OBSCURED POPULATIONS



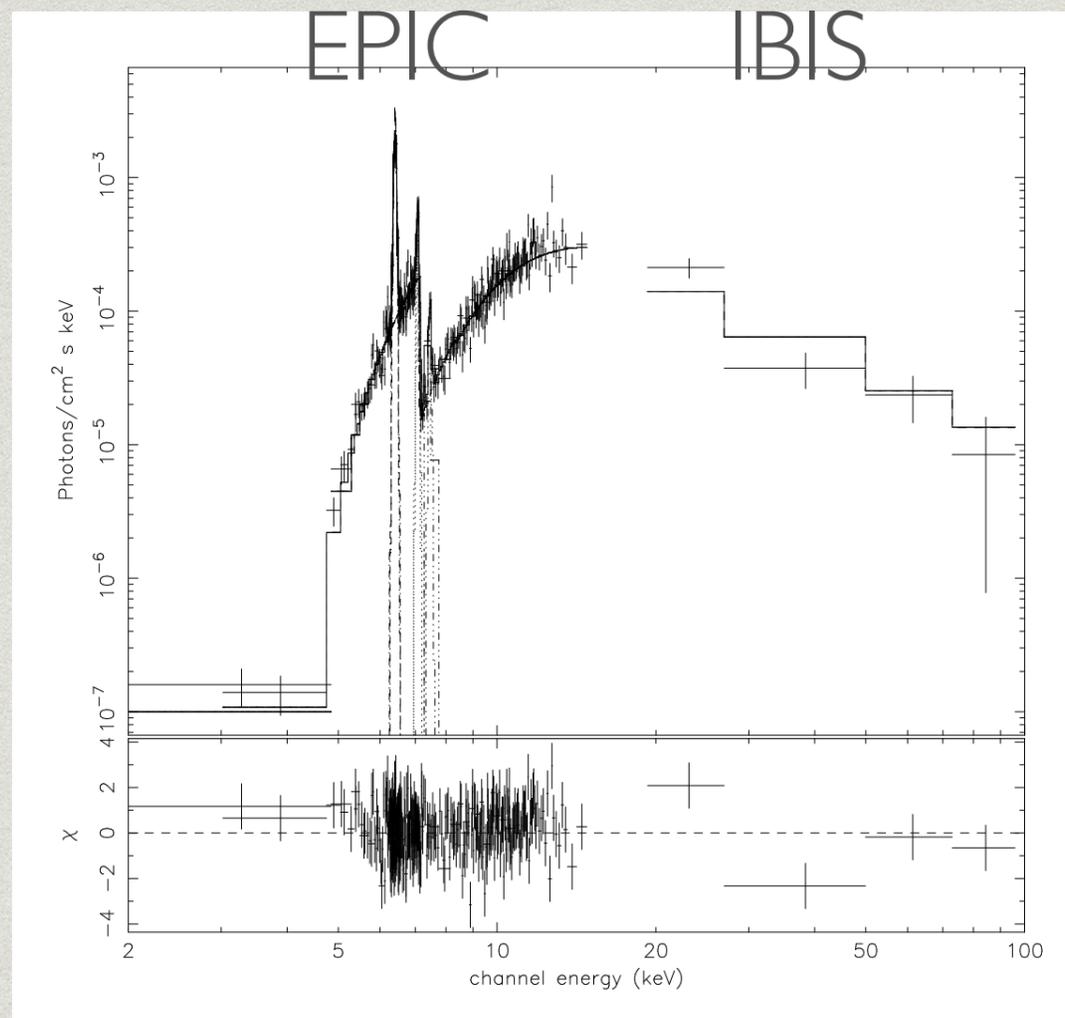
Highly obscured sources

- * Highly obscured HMXBs seen mostly in spiral arm tangents
- * Emitter is hidden in dense environment surrounding the donor star
- * Early-type supergiants
- * Typically short (<10d) orbits
- * High intrinsic $N_H > 10^{23}$



Credit: ESA/S.Chaty

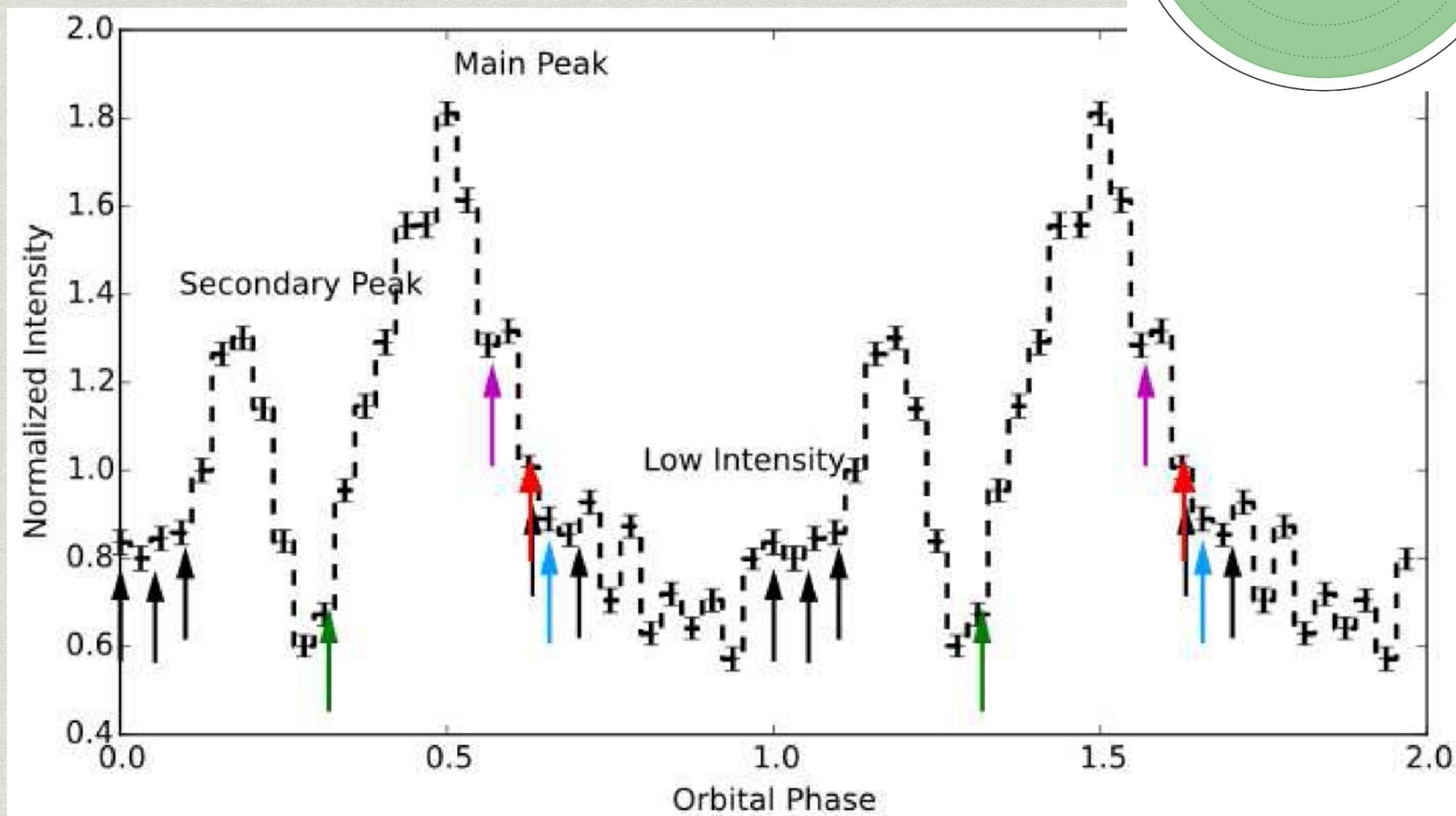
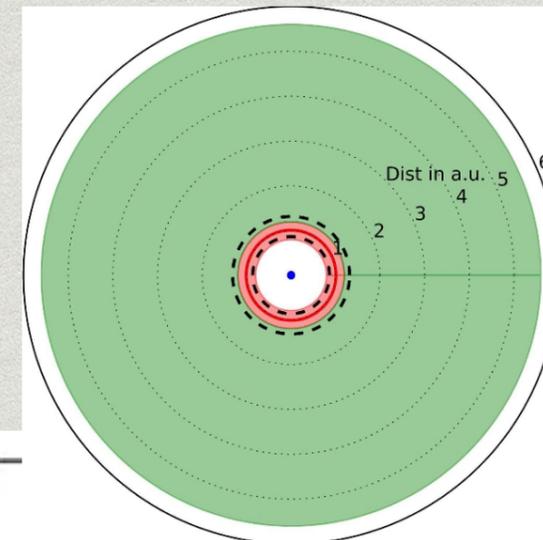
IGR J16318-4848



Walter+ 2003

- * First source detected by INTEGRAL (29 Jan 2003)
- * NS orbiting a sgB[e] star within a dense envelope of dust and cold gas
- * $N_H \sim 4 \times 10^{24}$, so virtually undetectable below 5 keV; still the record N_H .
- * Persistent, but highly variable source. Outbursts (~ 300 mCrab) seen on multiples of 80.2d P_{orb}
- * Non-spherical (disk?) warm and hot circumstellar dust components

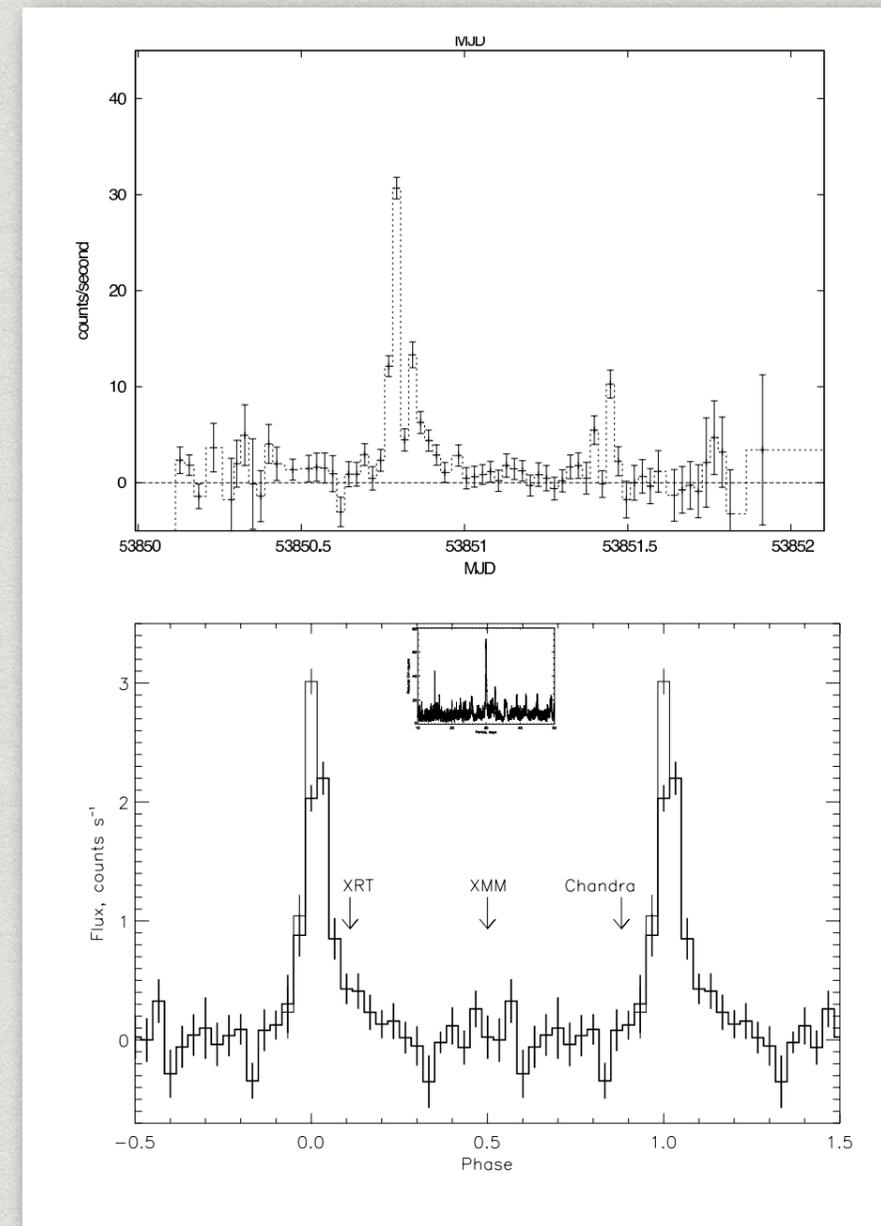
IGR J16318-4848



Iyer & Paul, 2017

SFXTS

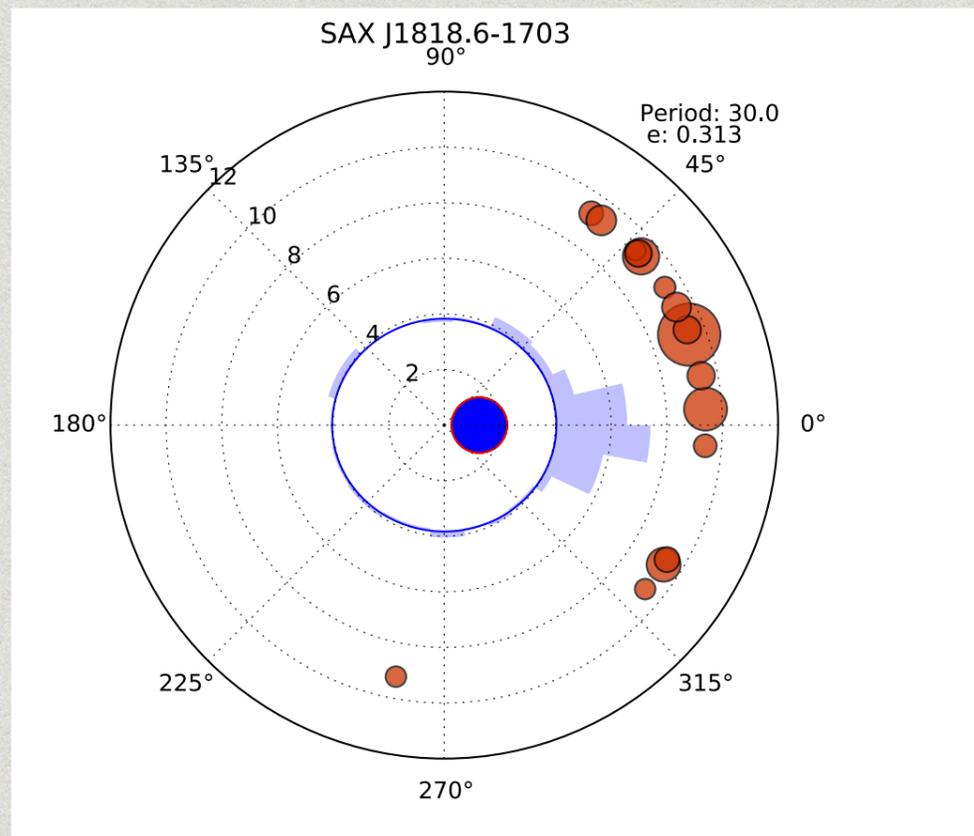
- * Supergiant Fast X-ray Transients
- * A largely phenomenological class
 - * High dynamic range (x1000)
 - * Short (<hour) flares
- * Binary orbits from ~4d to ~160d
- * Accretion onto NS from an inhomogeneous supergiant wind
- * Rapid changes / switches in accretion rate



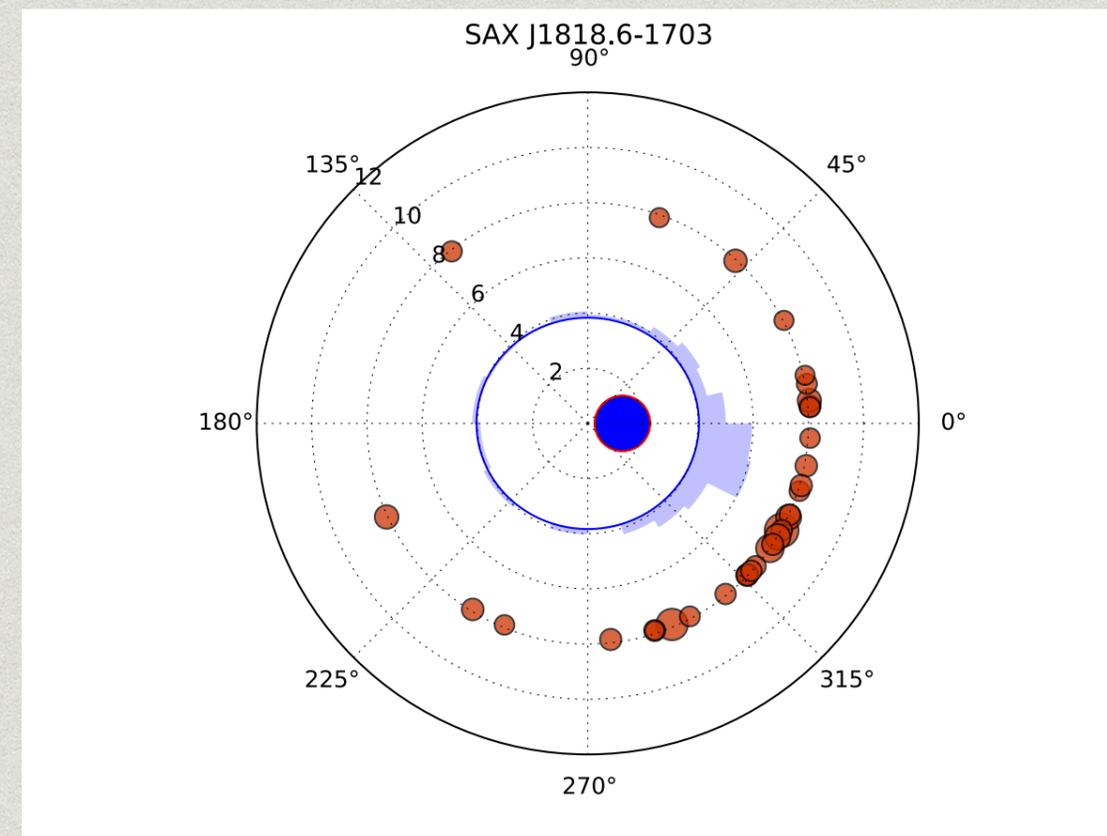
SFXTs - a long term strategy

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

Goossens+

CURIOUS?

FIND THEM YOURSELF



Has INTEGRAL seen my favourite source?

	Name	Author	Focus	Band	Sources	Exposure
2004	Cat1	Bird+	Plane	17-100keV	123	5Ms
2004	GCCat	Revnivtsev+	GC	18-60keV	60	
2005	Cat2	Bird+	All-sky	17-100keV	203	10Ms
2005	SPIACS1	Rau+	GRBs	>80keV	388	
2006	HE1	Bazzano+	High energy	>100keV	49	10Ms
2007	4-years	Krivonos+	All-sky	17-80keV	403	33Ms
2007	Cat3	Bird+	All-sky	17-100keV	421	40Ms
2008	SPI-4year	Bouchet+	All-sky	25-300keV	173	51Ms
2009	JEM-X cat	Westergaard+	All-sky	5-15 keV	209	
2009	AGNCat	Beckmann+	AGN	>20keV	199	
2010	Cat4	Bird+	All-sky	17-100keV	724	70Ms
2010	7-years	Krivonos+	All-sky	17-80keV	521	
2012	9-year	Krivonos+	Plane	17-80keV	402	
2012	SIX	Bottacini+	NEP	>15keV	113	
2012	AGNCat1	Malizia+	AGN	17-100keV	272	
2012	OMC1	Alfonso-Garzon+	All-sky	Optical	6071	
2015	HE2	Krivonos+	High energy	>100keV	132	
2016	Cat1000	Bird+	All-sky	17-100keV	939	110Ms
2017	AGNCat2	Malizia+	AGN	17-100keV	363	

Or check the latest ISDC reference catalog at <https://www.isdc.unige.ch/integral/catalog/latest/catalog.html>

Hints, tips & gotchas

- * If you've never tried analysing INTEGRAL data, have a go! It's fun...
- * The instruments have been running for 15+ years, and responses have evolved. Spectroscopic low energy threshold is now ~22 keV.
- * Always remember that you get correlation images - don't do aperture photometry!
- * Light curves can have resolution down to ms resolution if you're brave and your source is bright.
- * More realistically, science window (~1500s) light curves are what you'll use. They'll have big, and probably regular, gaps. Beware of aliasing etc.
- * If in doubt, make an light curve of the off-axis angle, and repeat your analysis.
- * Spectra are good, but be aware of 2 different methods for bright and faint sources - and making a spectrum for 15 years of data from an evolving instrument is tricky.

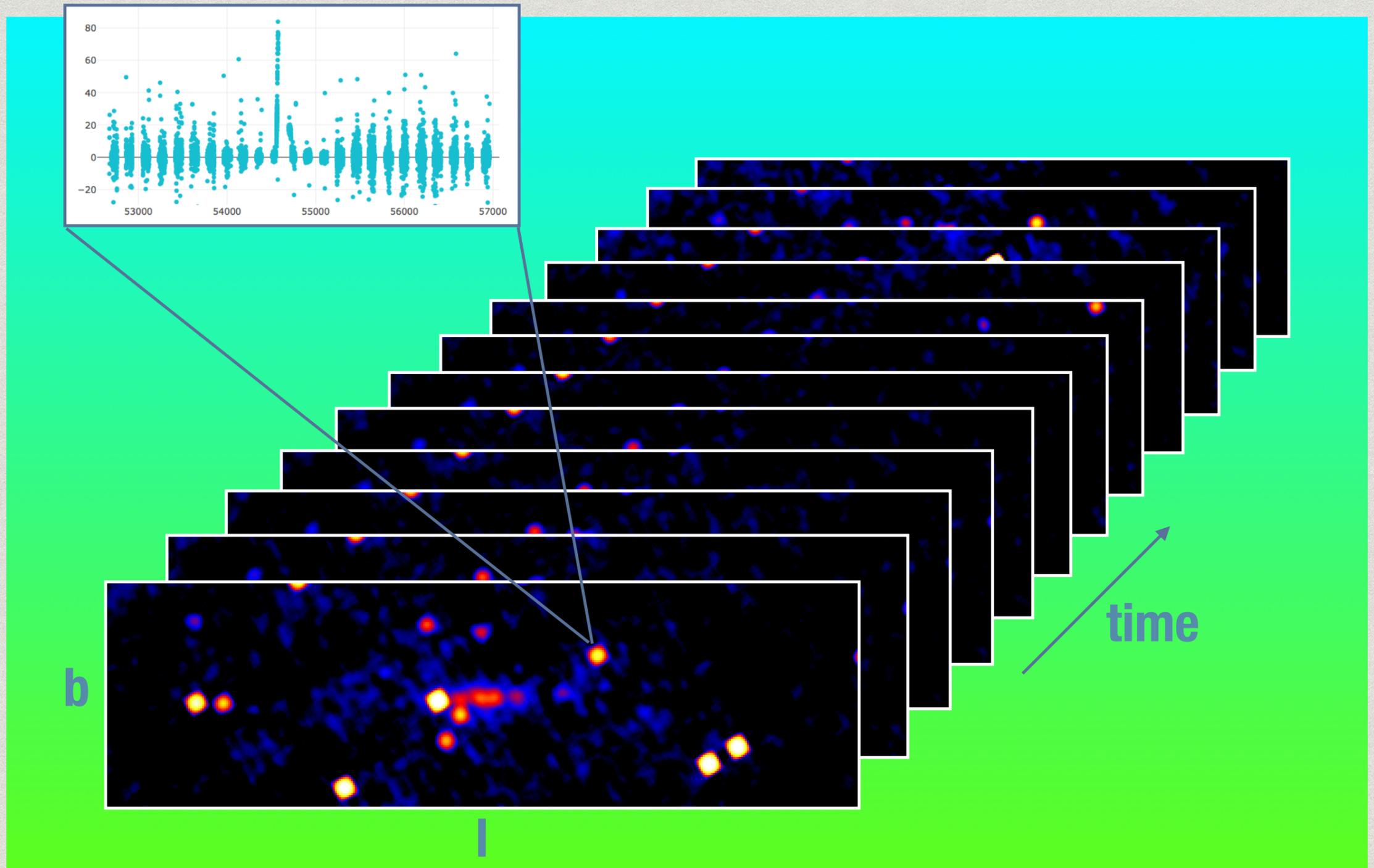
Online Data Products

- * INTEGRAL Science Data Centre - on demand data products
 - * <https://www.isdc.unige.ch/heavens/>
- * IBIS survey at Southampton - catalogs and data products
 - * http://www.integral.soton.ac.uk/projects/ibis_survey/IBISsurvey.php
- * Galactic Plane Scans - images & light curves
 - * <http://gpsiasf.iasf-roma.inaf.it> (near real-time during campaigns)
- * Galactic Bulge Monitoring - images & light curves
 - * <http://integral.esac.esa.int/BULGE/> (near real-time during campaigns)

In the future...?

- * The job gets bigger, the people get fewer
- * OSA11 is imminent, will `encourage' a full re-analysis
- * Switch to full 4D approach (light curve grid)
- * Machine learning for
 - * source detection
 - * detection merging
 - * light curve outlier detection
 - * meta-data tagging (quality flags etc)
- * Incorporating slew survey (GPU-based analysis)
- * End-of-mission survey products

History ... Brought up to date...



Thanks to:

The IBIS survey team

The Galactic Plan Scans team

The INTEGRAL Bulge Monitoring team

ISDC

ISOC

Any questions?