

An *INTEGRAL*/IBIS archive at IASF-Mi: overview of HMXB results

A. Paizis (INAF/IASF, Milano)

- *The INTEGRAL/IBIS archive*

Paizis, Mereghetti, Gotz, Fiorini, Gaber, Regni Ponzeveroni, Sidoli, Vercellone, **2013**

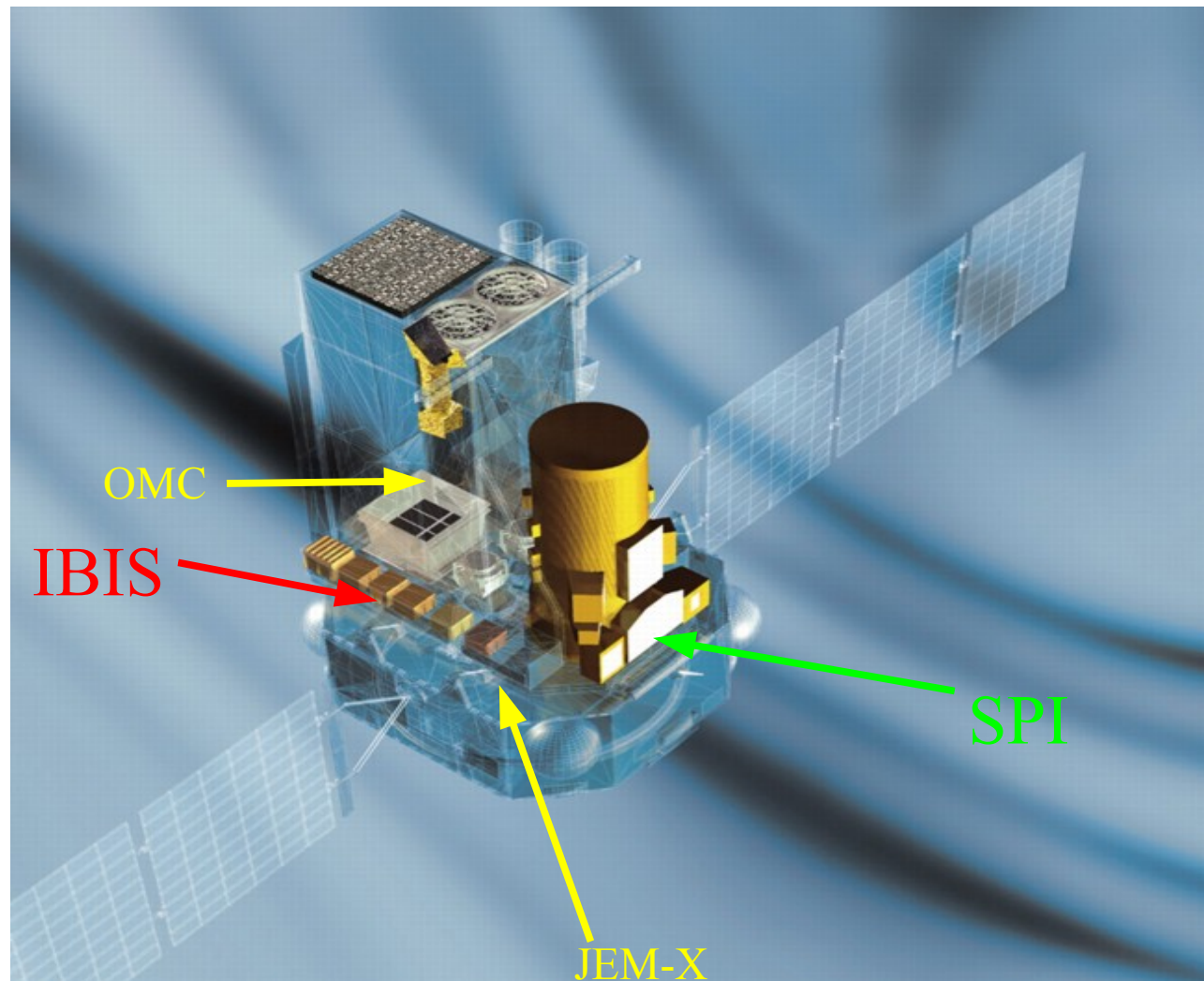
- *HMXB results*

1. SFXTs: Paizis & Sidoli, **2014**; Shakura, Postnov, Sidoli, Paizis **2014**

2. Vela X-1: Sidoli, Paizis, Fürst, Torrejón, Kretschmar, Bozzo, Pottschmidt, **2015**

The *INTEGRAL*/IBIS archive

INTEGRAL



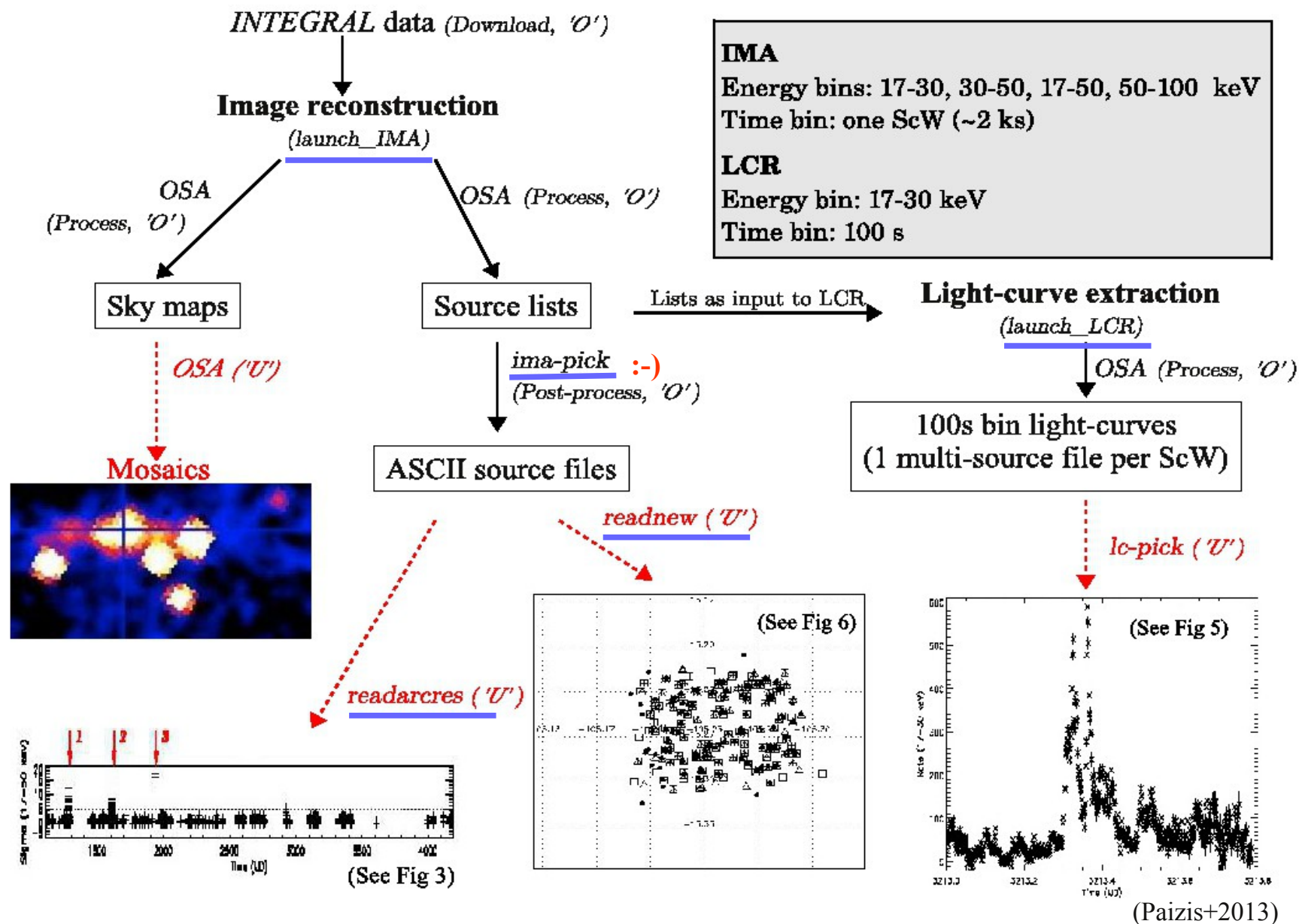
Launched in 2002
(Winkler+2003, 2011)

IBIS: Imager
(15 keV - 10 MeV)

SPI: Spectrometer
(20 keV - 8 MeV)

+ 2 monitoring instr.
JEM-X (4.5 - 35 keV)
OMC : optical camera

Once public,
all data downloaded
@ IASF Milano



INTEGRAL data (Download, 'O')

Image reconstruction

(launch_IMA)

OSA
(Process, 'O')

"IMA"

OSA (Process, 'O')

IMA

Energy bins: 17-30, 30-50, 17-50, 50-100 keV
Time bin: one ScW (~2 ks)

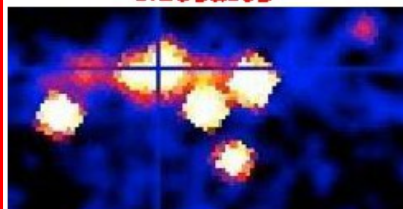
LCR

Energy bin: 17-30 keV
Time bin: 100 s

Sky maps

OSA ('U')

Mosaics



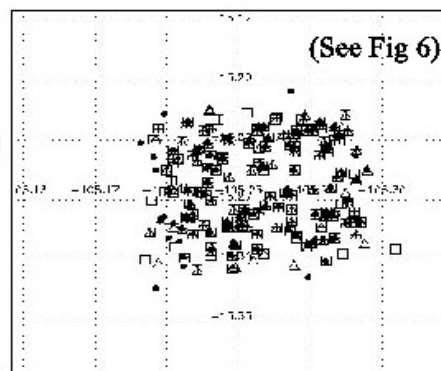
Source lists

Lists as input to LCR

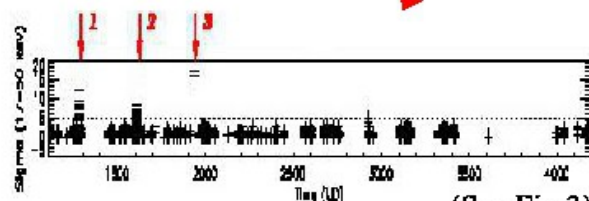
ima-pick :-)
(Post-process, 'O')

ASCII source files

readnew ('U')



readarcs ('U')



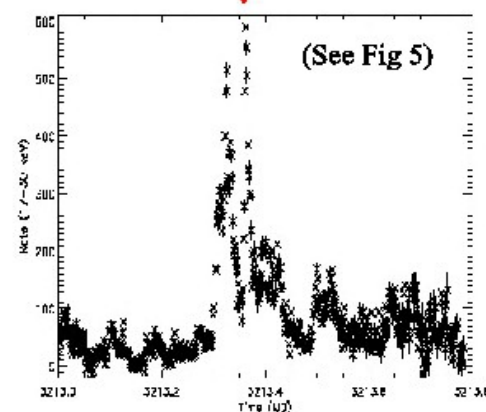
Light-curve extraction

(launch_LCR)

OSA (Process, 'O')

100s bin light-curves
(1 multi-source file per ScW)

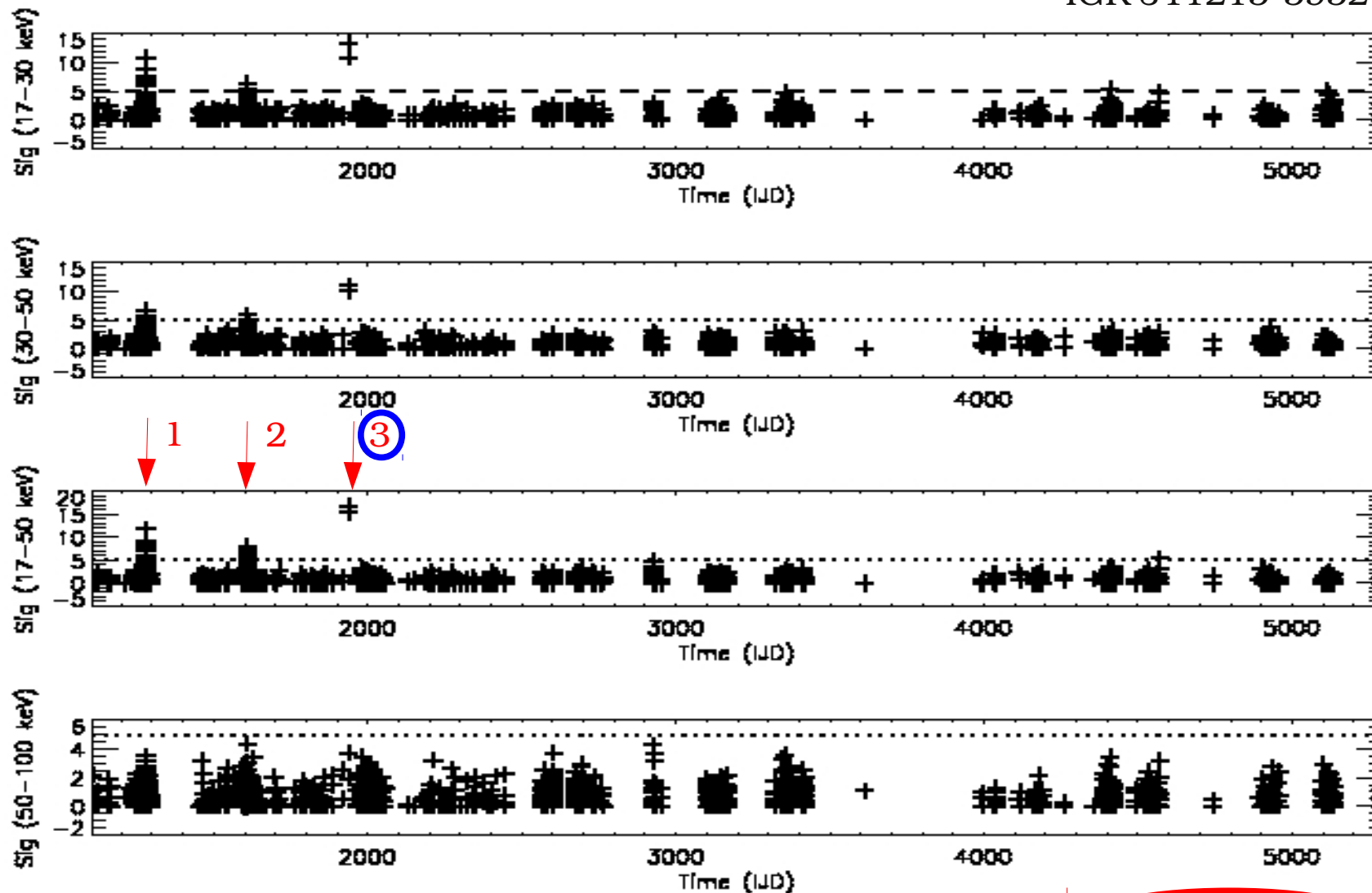
lc-pick ('U')



(Paizis+2013)

Known sources: ~ksec

IGR J11215-5952

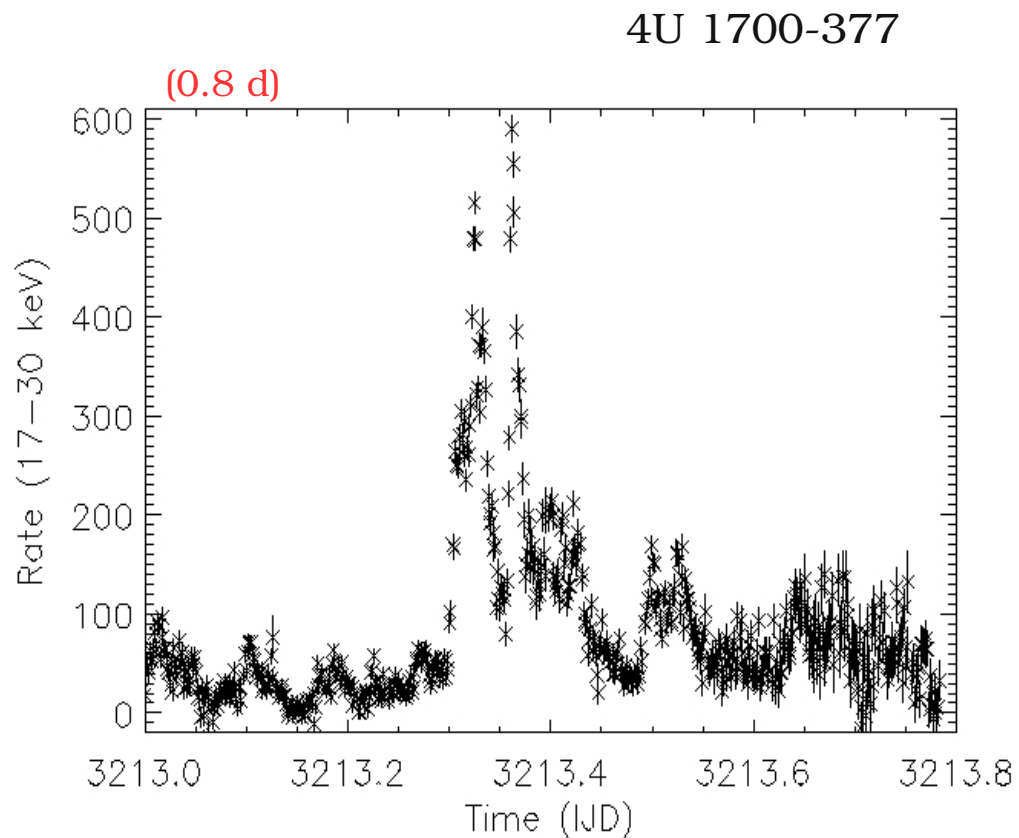
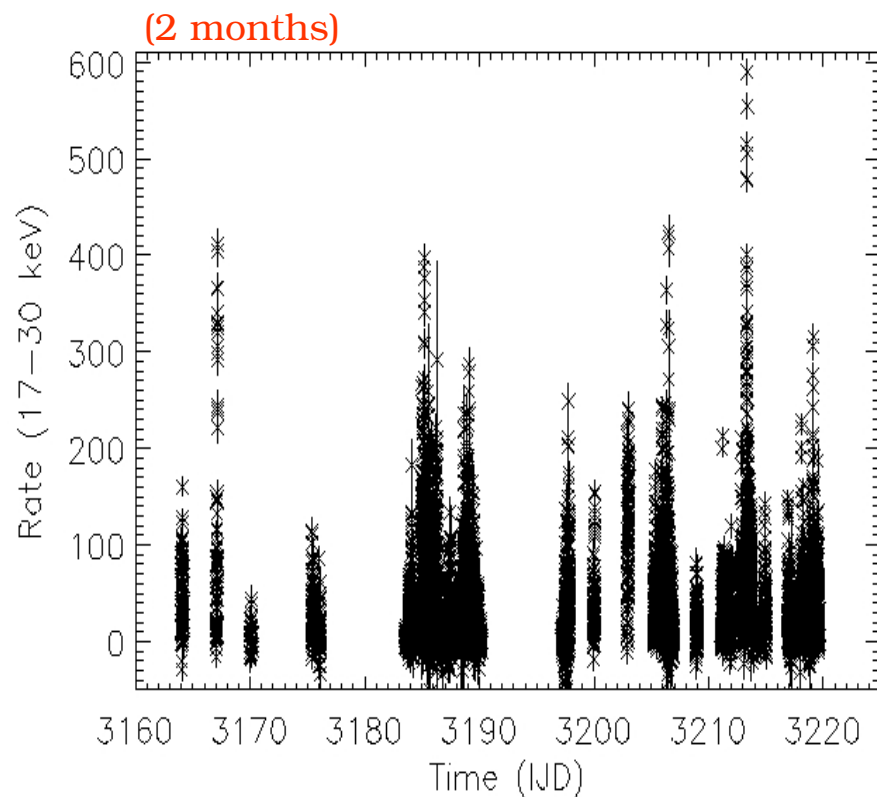


(11.5 years)

No INTEGRAL expertise required!

IMA: SFXT results

Known sources: ~ 100 s



(Paizis+2013)

(1 Crab = 173 cps)

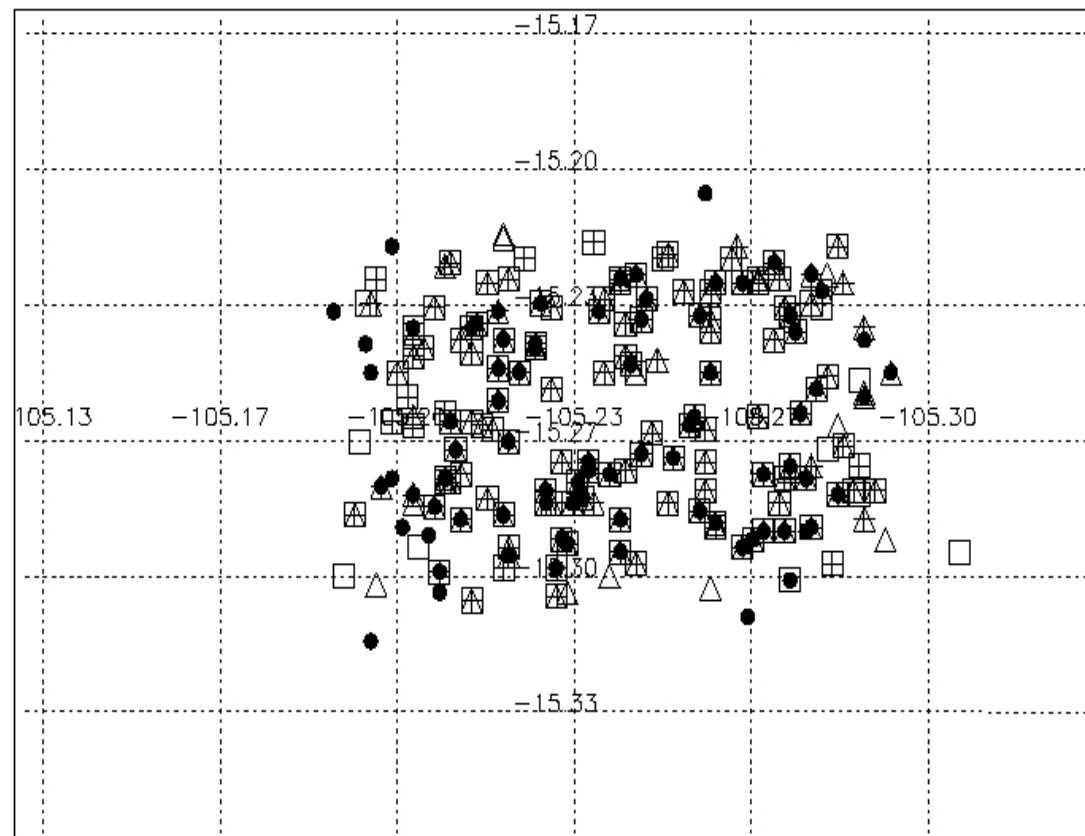
(17-30 keV)

LCR-Vela X-1 results

New sources

```
=====
Where do you want to zoom?
Enter R.A. [degrees]? 254.77
Enter DEC [degrees]? -15.2630
Enter size [degrees]? 0.1
IDL>

=====
Triangles: sources with detsig(17-30keV) > 7
Squares : sources with detsig(30-50keV) > 7
Crosses : sources with detsig(17-50keV) > 7
Circles : sources with detsig(50-100keV) > 7
=====
Select the energy band <1/2/3/4>:
```



(Paizis+2013)

- All the NEW* grouped by position (this is MAXI J1659-152)
- This helps tracing back to see if a new source passed unnoticed in the archive

GOLIA

An *INTEGRAL* archive at INAF-IASF Milano

GOLIA: an INTEGRAL archive at INAF-IASF Milano

A. Paizis, S. Mereghetti, D. Götz, M. Fiorini, M. Gaber, R. Regni Ponzeveroni, L. Sidoli, S. Vercellone
Astronomy and Computing, Volume 1, February 2013, Pages 33-39 ([Link to paper](#))

A. Paizis thanks the [ISDC](#) staff since most of the know-how needed to set-up such an archive was gained during her years at the ISDC (2000-2005).

Abstract

We present the archive of the *INTEGRAL* data developed and maintained at INAF-IASF Milano. The archive comprises all the public data currently available (revolutions 0026-1079, i.e., December 2002 - August 2011). *INTEGRAL* data are downloaded from the ISDC Data Centre for Astrophysics, Geneva, on a regular basis as they become public and a customized analysis using the OSA 9.0 software package is routinely performed on the IBIS/ISGRJ data. The scientific products include individual pointing images and the associated detected source lists in the 17-30, 30-50, 17-50 and 50-100 keV energy bands, as well as light-curves binned over 100 s in the 17-30 keV band for sources of interest. Dedicated scripts to handle such vast datasets and results have been developed. We make the analysis tools to build such an archive publicly available. The whole database (raw data and products) enables an easy access to the hard X-ray long-term behavior of a large sample of sources.

Scripts to build your GOLIA

All the *INTEGRAL* public data can be freely downloaded via the ISDC dedicated [web page](#).
A tar file with the scripts we used to build GOLIA (Process and Post-process phases, i.e. the ones performed by the archive Owner) can be downloaded from this page. These include the Shell scripts *launch_IMA.sh* (and its sub-routine *analysis_IMA.csh*), *launch_LCR.sh* (and its sub-routine *analysis_LCR.csh*), and the PERL script *ima_pick.pl*. Together with OSA, they complete the set of tools we used to build GOLIA. They use freely available interpreters and need no compilation.
Please refer to [Paizis et al. \(2013\)](#) for a description of the archive.

TAR FILE WITH SCRIPTS: [GOLIA_scripts.tar](#) (~41 kb)
SHORT DESCRIPTION: [README](#)

+ **ima_pick!**

If our scripts have been useful to you, please acknowledge us by including the following in your work:
"This research has made use of the scripts provided by the GOLIA group (Paizis et al., 2013, <http://www.iasf-milano.inaf.it/~ada/GOLIA.html>)."
Thank you.

IMA Results SFXTs

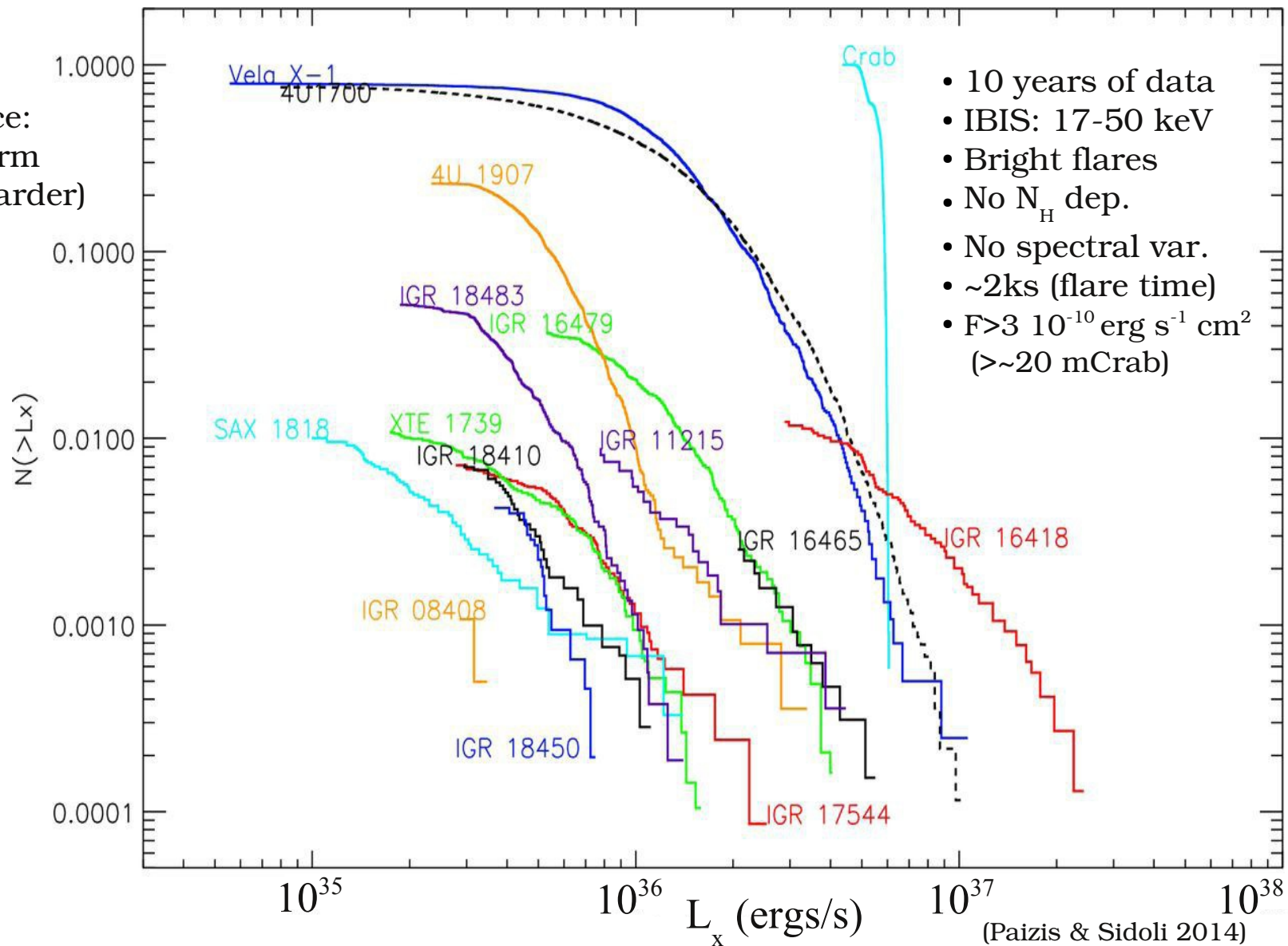
Cumulative distribution functions (11 SFXTs + 3 sgHMXB)

Sources at a glance:

- SgHMXB: log-norm
- SFXT: PL (and harder)

Why a PL?

(see Bozzo+14 for
Swift 2-10 keV,
100s curves)



SOC systems ?

PL-like cumulative curves:

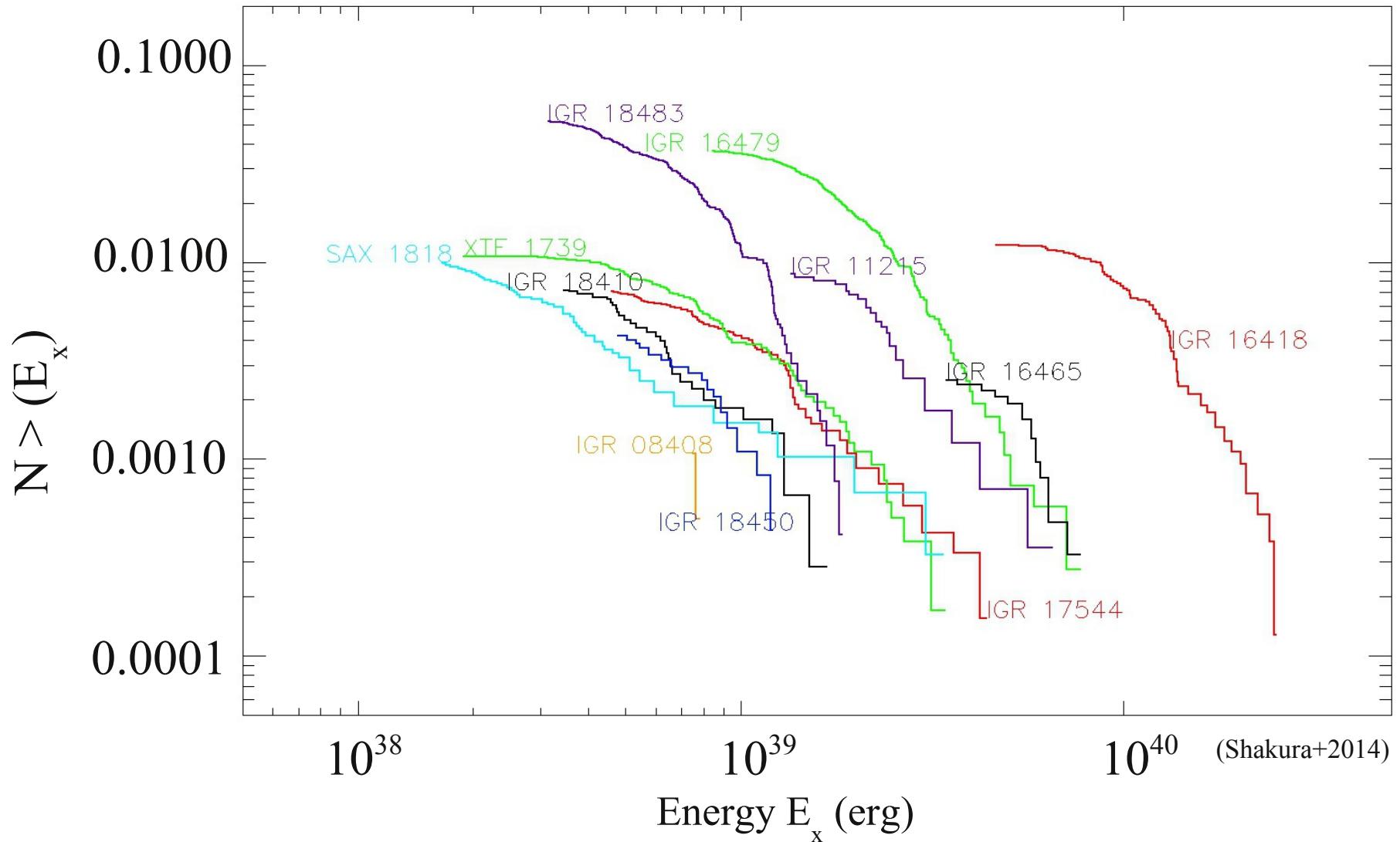
Self-Organized-Criticality (SOC) Systems (Aschwanden 2013)

*“a system which perpetually evolves into a critical state where a minor event can start a chain reaction, leading to a catastrophe”
(sand-pile, earthquakes, solar flares, ecc)*



**There is a physical model that is compatible with *trigger, chain reaction and catastrophe* : subsonic “shell” accretion
(Burnard+1983, Davies & Pringle 1981, Shakura+2012)**

Model: typical mass of shell $\mathbf{M} \sim 10^{19} \text{ g}$ (10^{39} erg)



→ Bright SFXT flares as result of “catastrophe” in a SOC!?

The trigger: magnetic reconnection

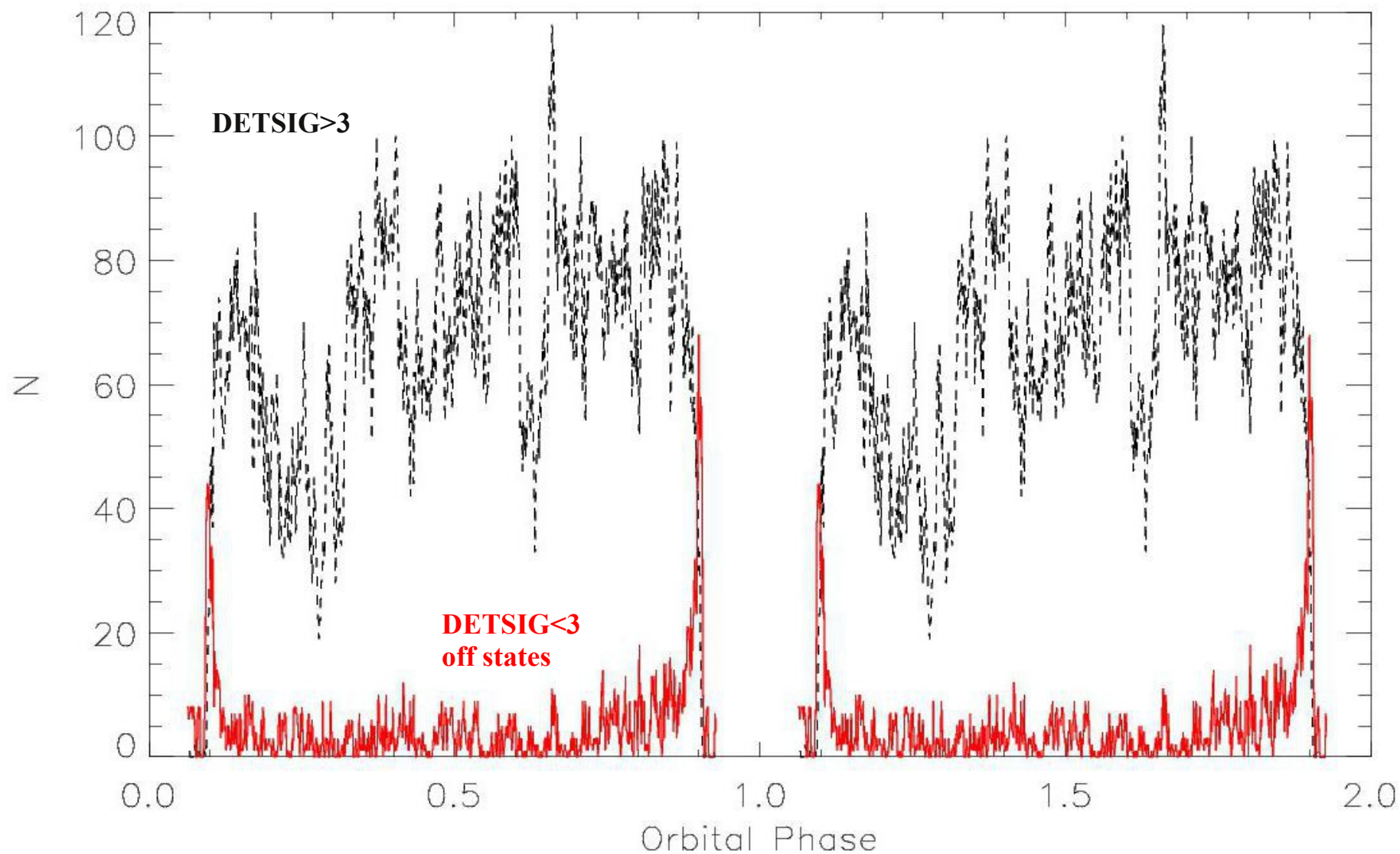
10% sgHMXB have kG

SFXT low state $\longrightarrow$ magnetic reconnection $\longrightarrow$ more matter falls in
 $\longrightarrow$ shell instability $\longrightarrow$ bright flare on $t_{\text{freefall}} \sim 1\text{-}2 \text{ ks}$

(Shakura+2014)

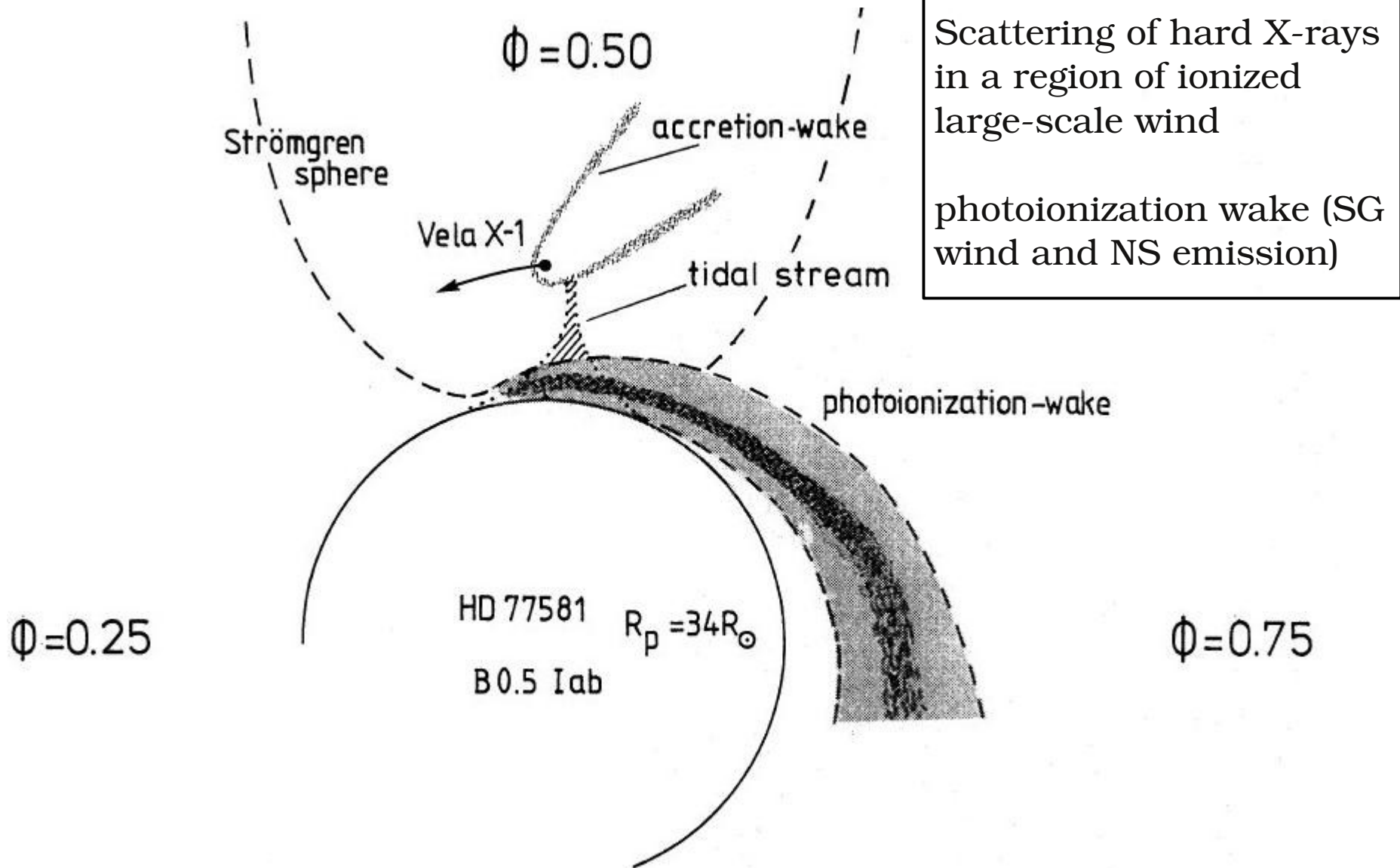
LCR Results
Vela X-1 off-states

Vela X-1

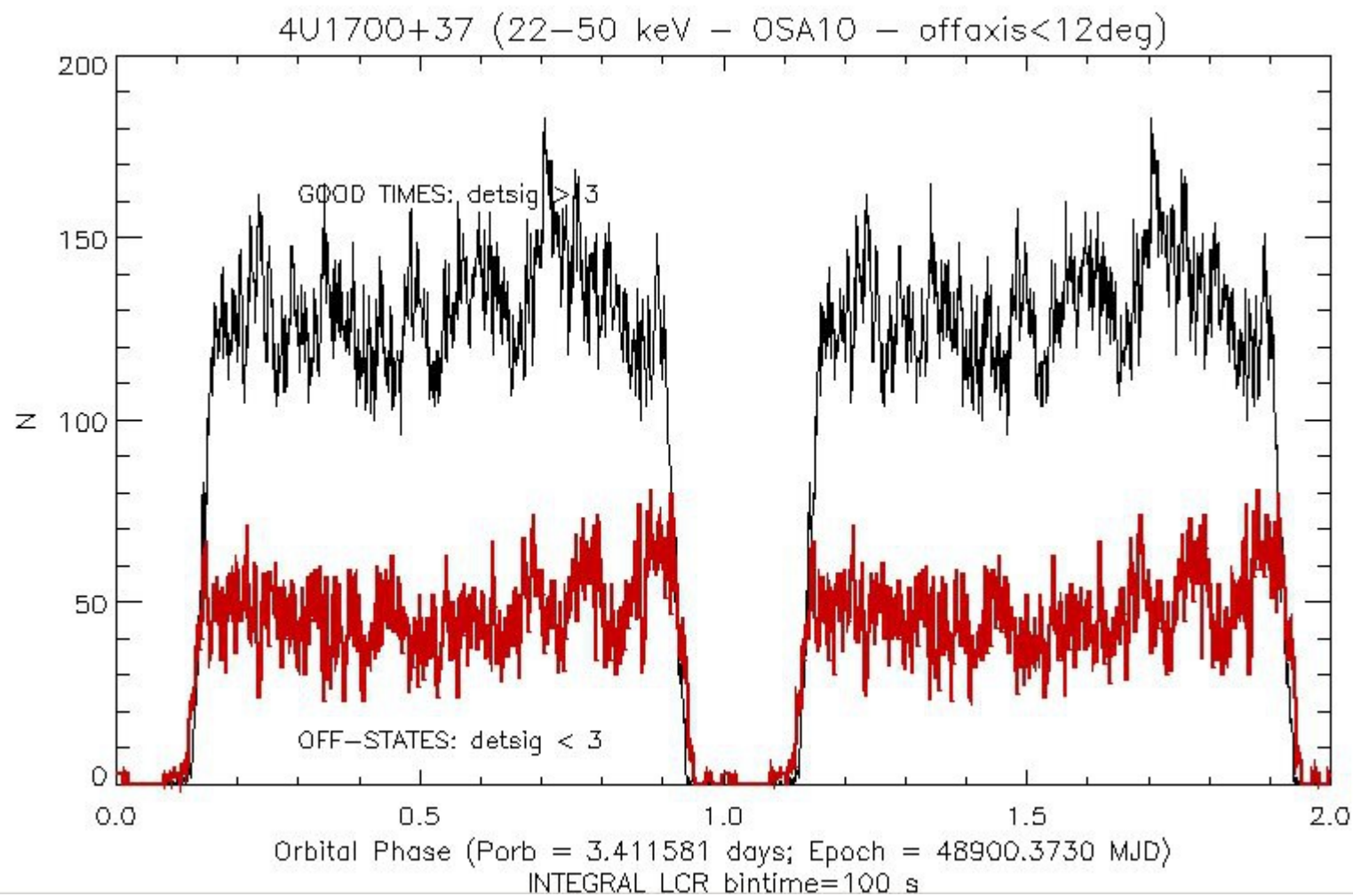


OSA 10.0, 22-50 keV, LCR (100s), 10.2 yrs

(Sidoli+2015)

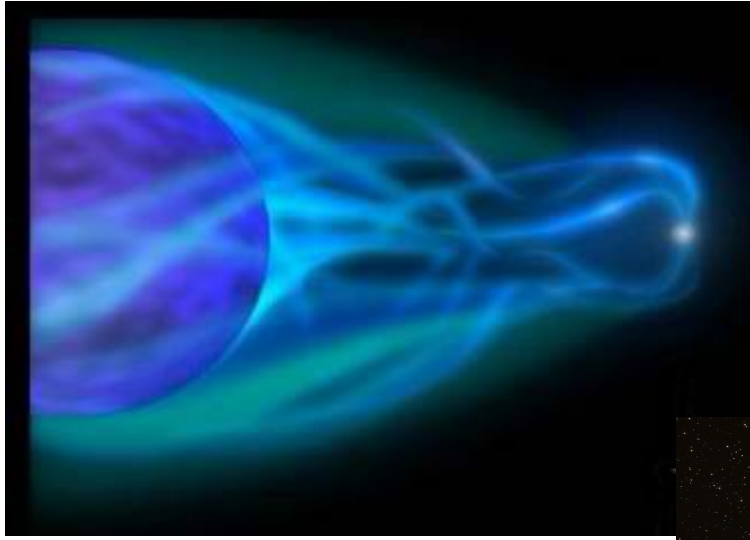


(Kaper+1994)



Conclusions / Future Work

- INTEGRAL offers a wealth of data (sensitivity, FoV and angular resolution): long term studies of classes of sources in a consistent way.
 - Archive on-site triggers ideas/discoveries
 - Want to know your favorite source? Contact me!
 - New archive on its way (s/w and h/w upgrade)
- SFXT cumulative distributions and interpretation (“IMA”)
 - New view of SFXT in hard X-rays
 - Bright flares PL-like : SOC?
 - Subsonic settling accretion model by Shakura et al
 - What can we learn from 100s cumulative curves?
- Vela-X1 off-state distribution (“LCR”)
 - Asymmetric off-state distribution
 - Effect of photoionization wake in hard X-rays
 - Try it on other HMXBs



The
end

Thank

you!

