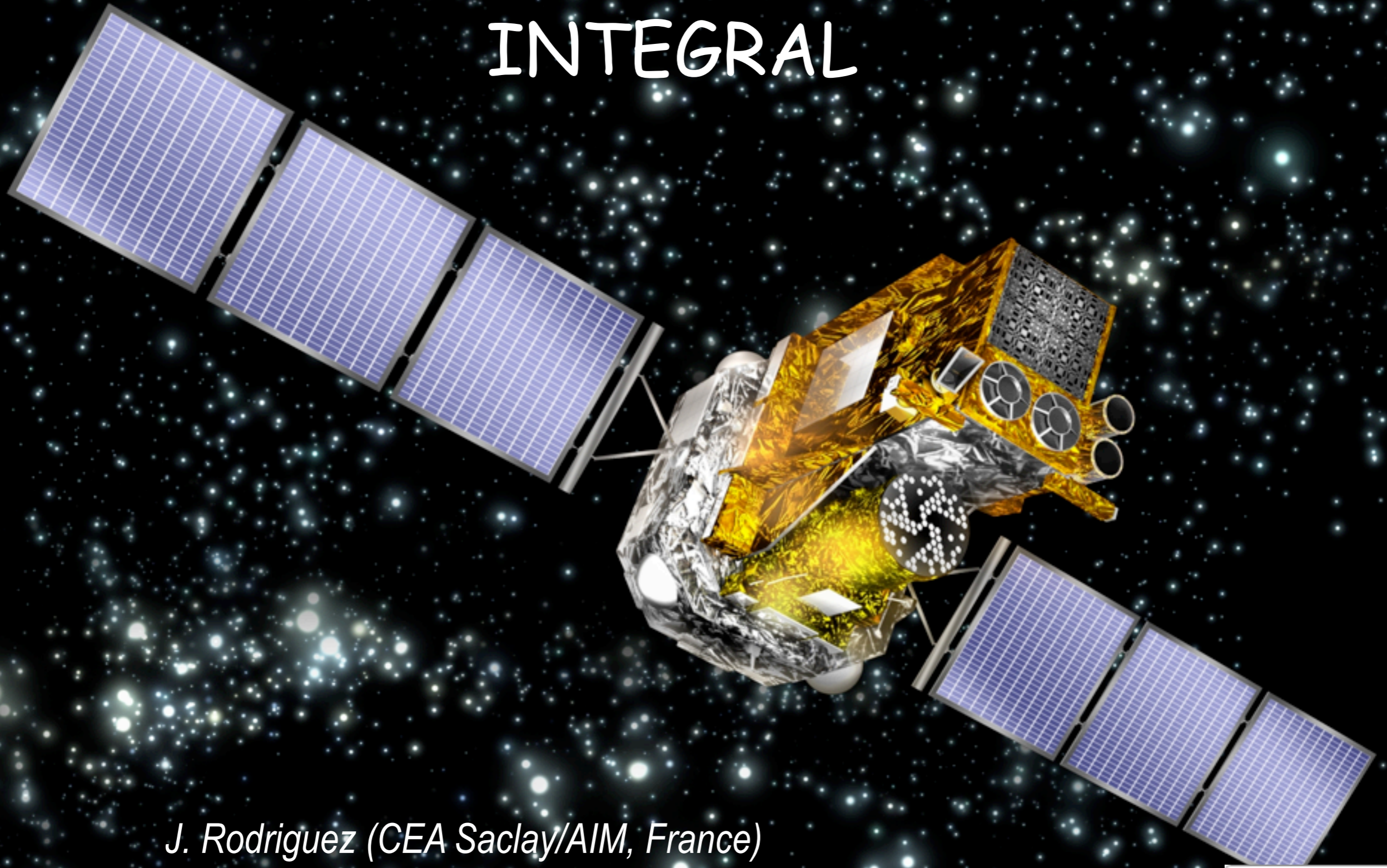


γ -ray polarisation in Cyg X-1 seen with INTEGRAL



J. Rodriguez (CEA Saclay/AIM, France)

*M. Cadolle Bel, V. Grinberg, **P. Laurent**, K. Pottschmidt, J. Wilms*

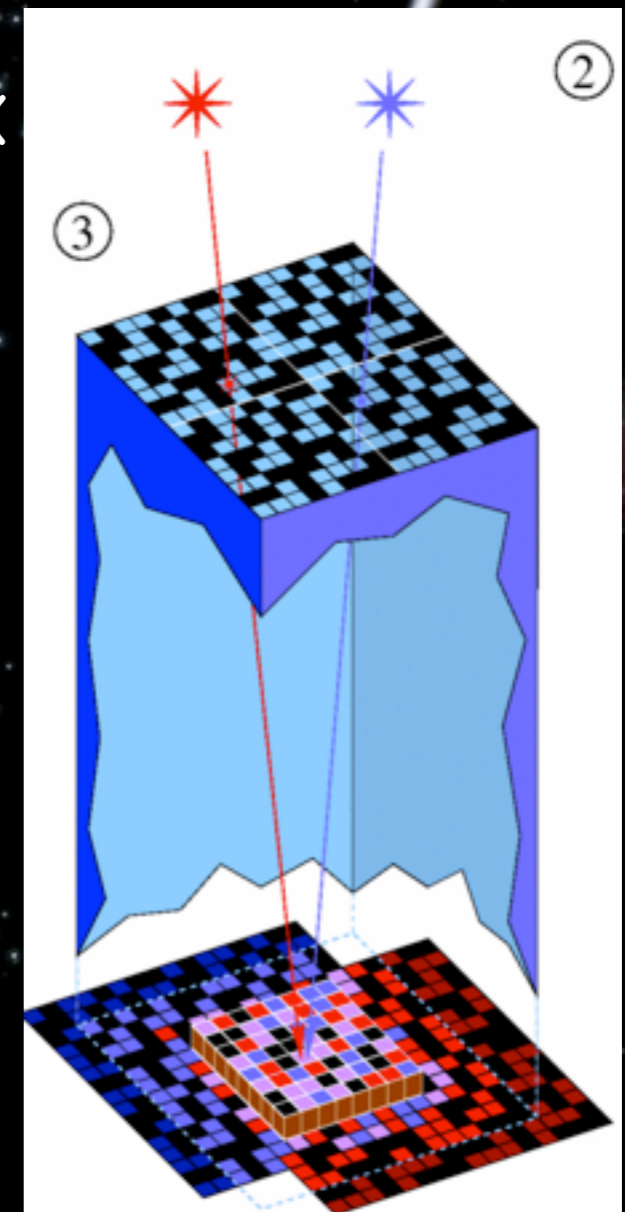
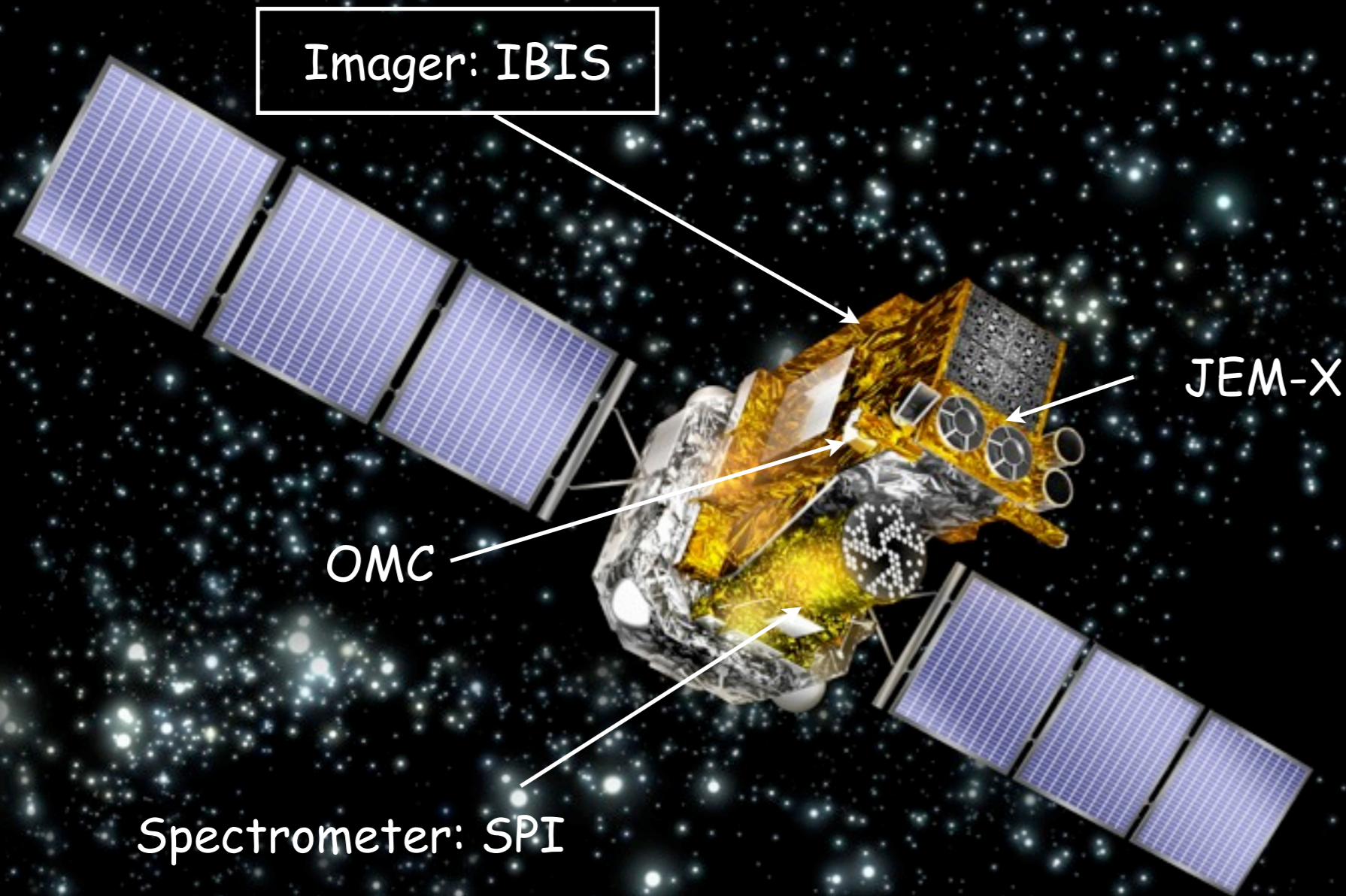
See Laurent et al. 2011, Science, 332, 438



INTEGRAL and the coded mask principle

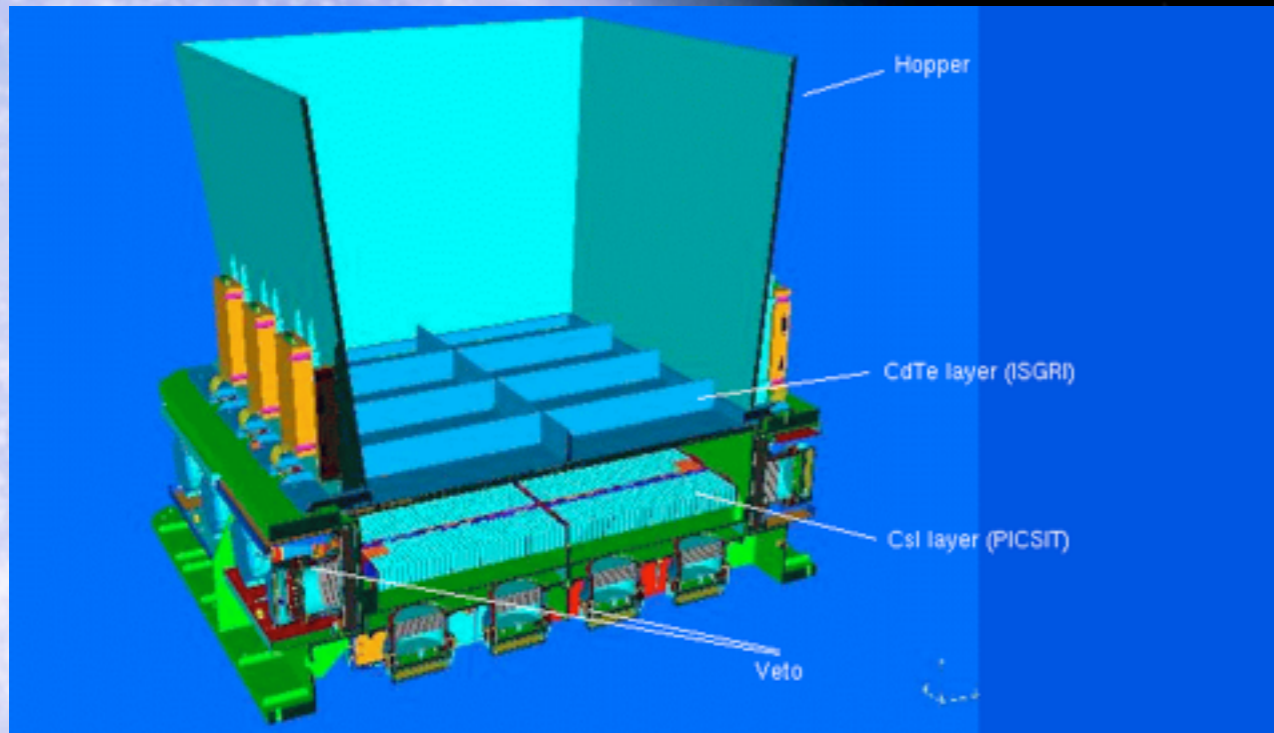


INTEGRAL and the coded mask principle



Detector image = shadowgram
superposition of mask shadows created
by sources in the fov

INTEGRAL / IBIS

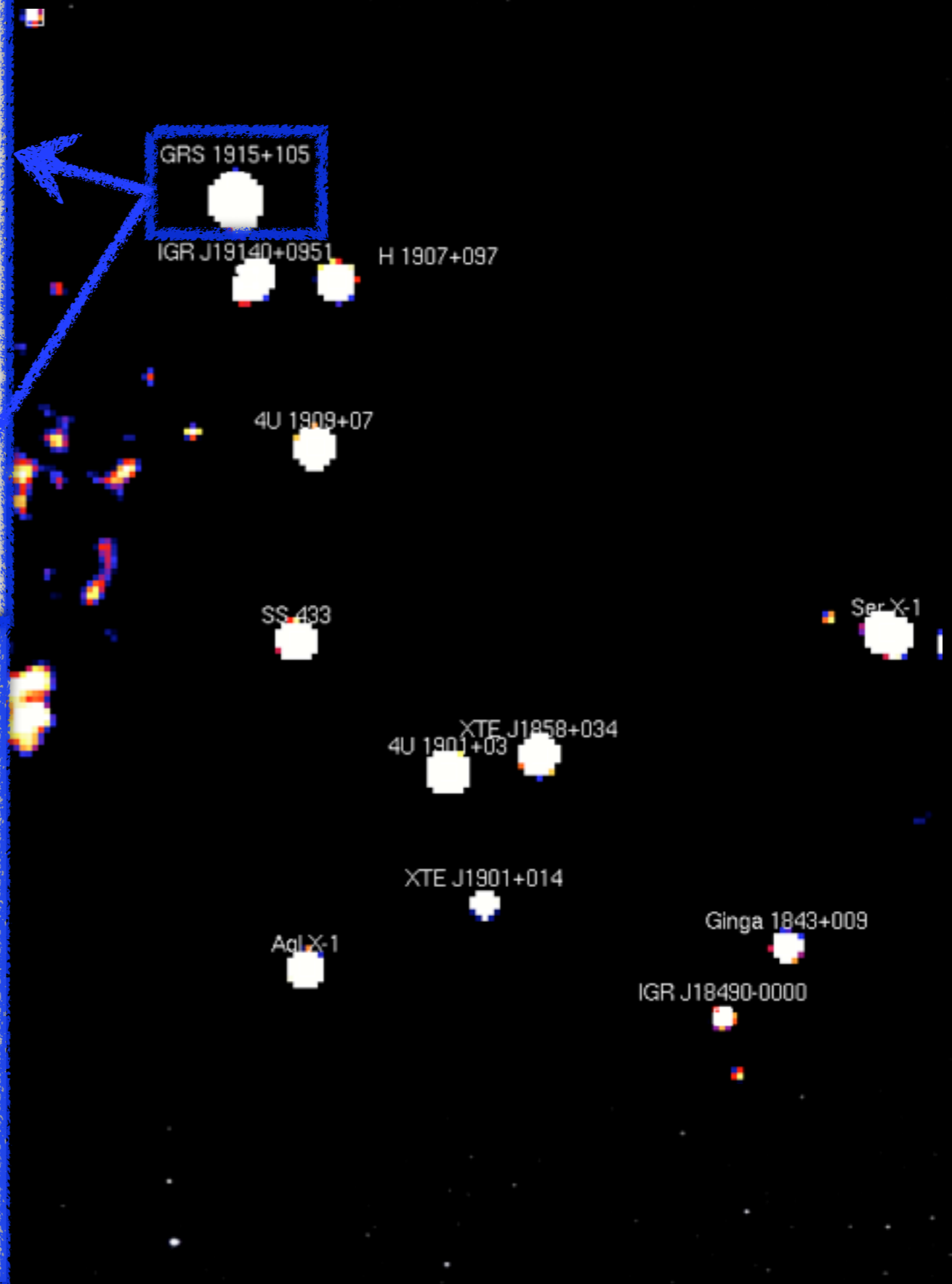
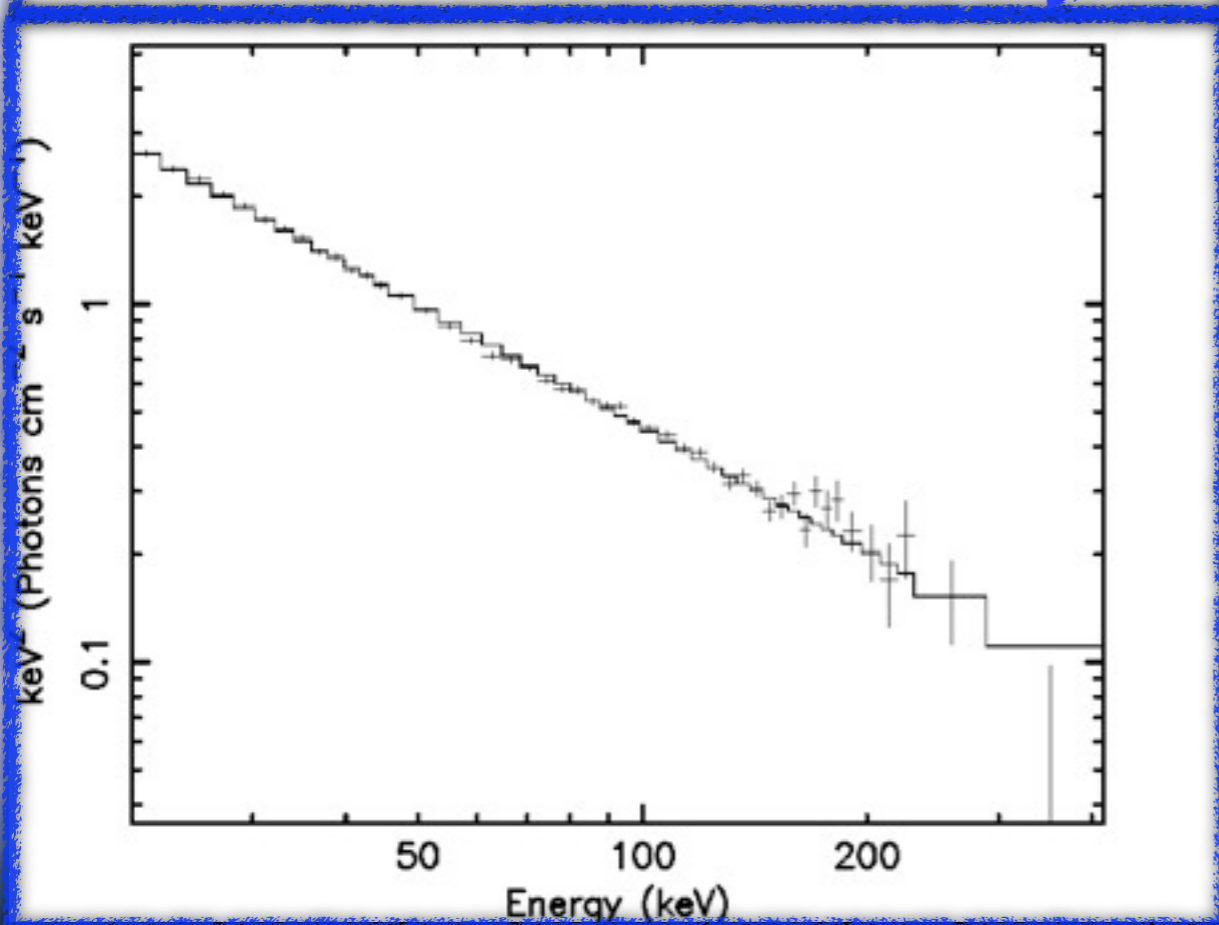
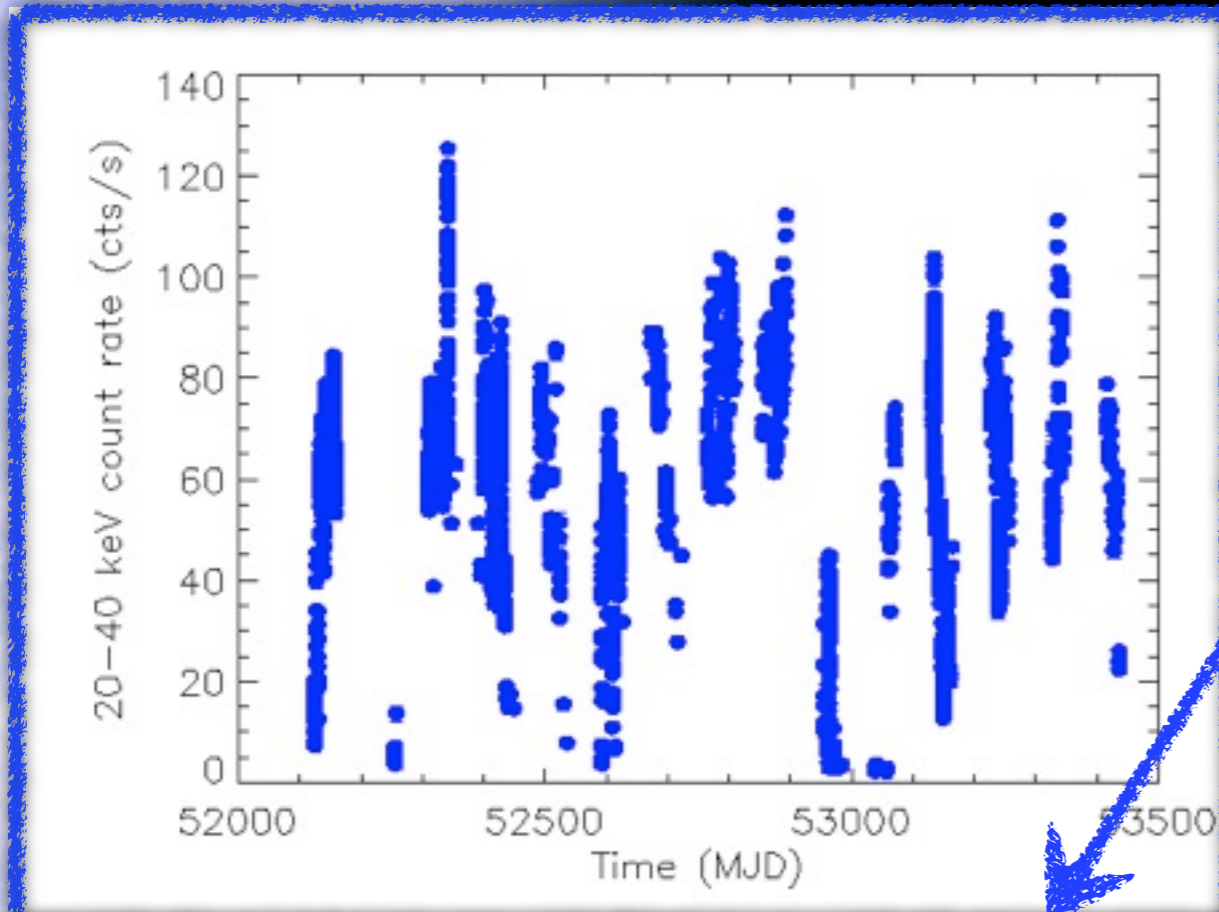


IBIS = 2 layers of detection:
ISGRI: 15~400 keV
PICSIT: 250 ~ 10000 keV

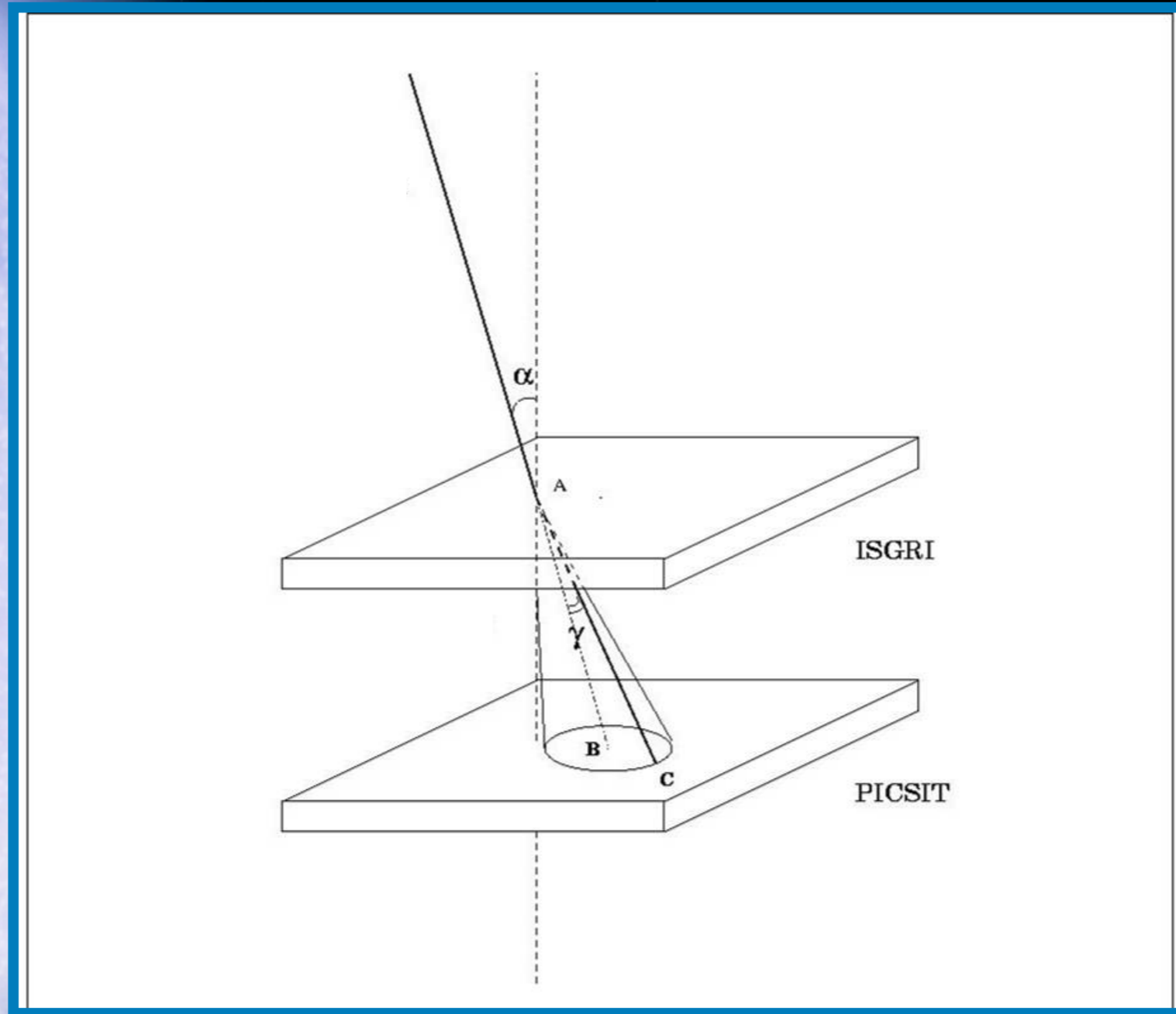


=> Analysis of individual detector products (ISGRI mostly)
=> Photons can interact in both detectors: Compton

ISGRI data products

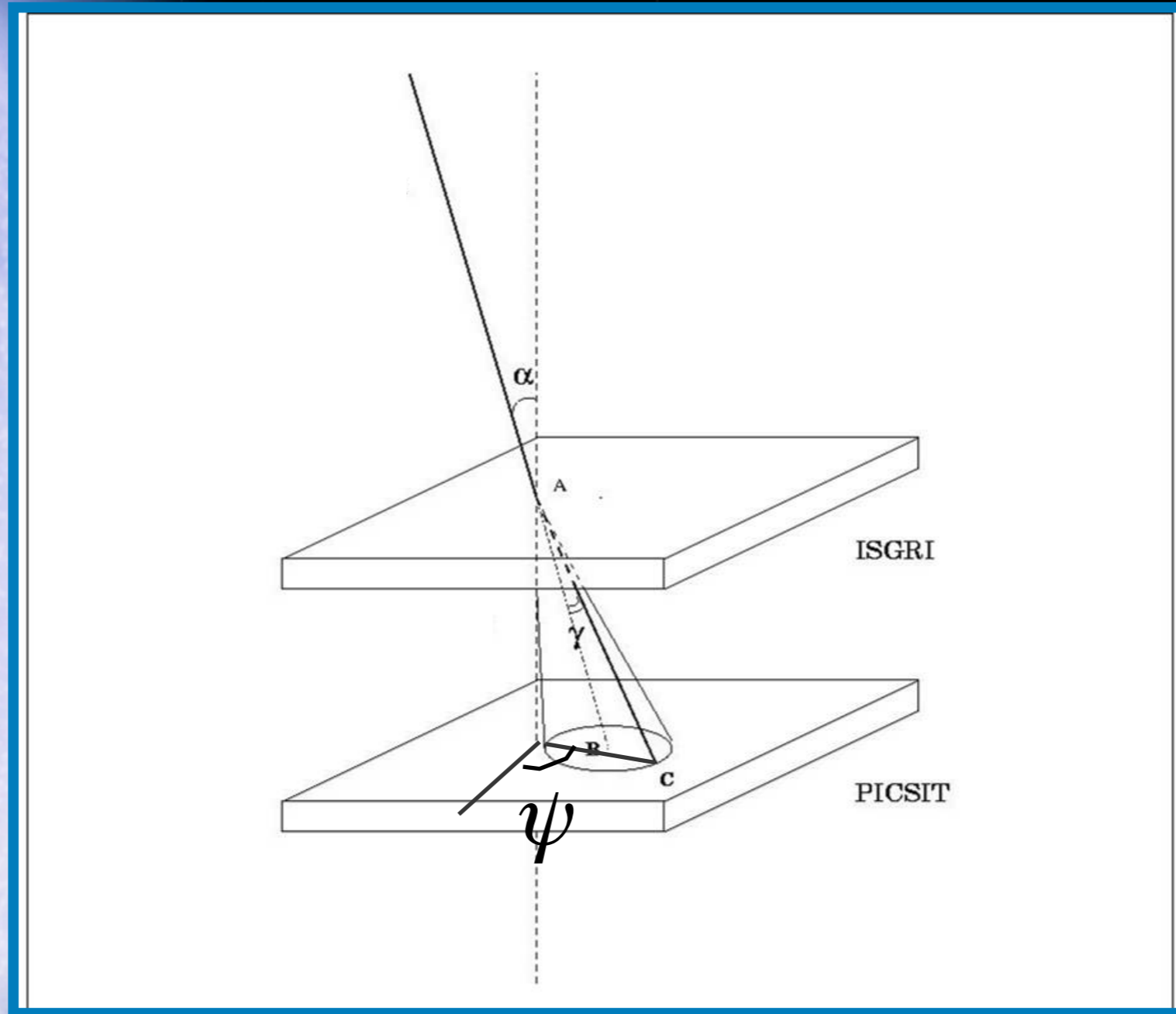


Compton telescope



The Compton mode events uses ISGRI and PICSIT events in temporal coincidence, within a window $\tau_W \sim 3.8 \mu s$.

Compton telescope

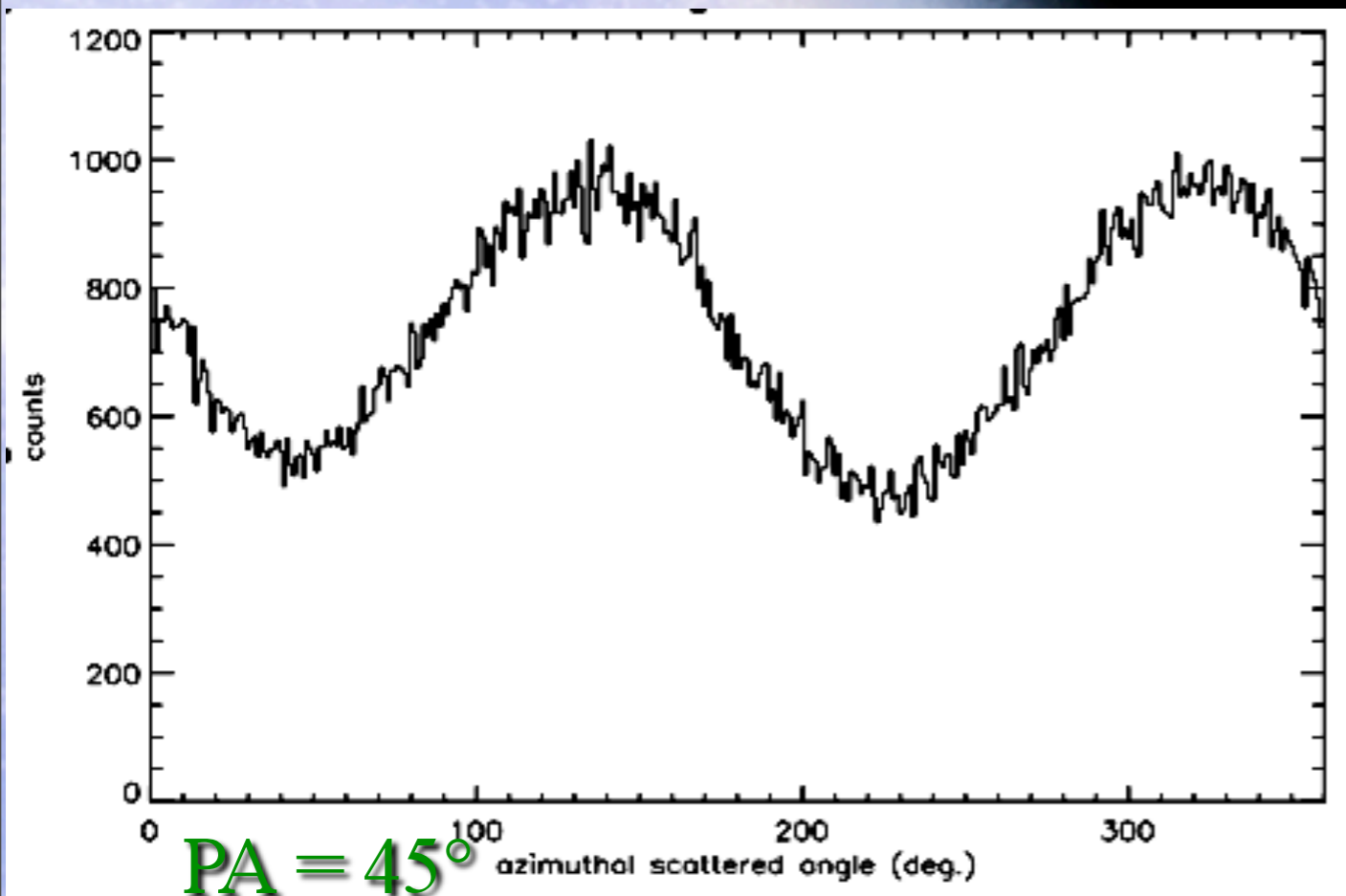


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Compton polarimetry

(Forot et al. '08, Götz et al. '09)

$$N(\psi) = S \{ 1 + a_0 \times \cos(2\psi - 2\psi_0) \}$$



Compton scattering cross section is maximum for photons scattered at right angle to the direction of the incident electric vector => asymmetry in the azimuthal profile of scattered events.

modulation

a_0 = modulation factor

polar. fraction = PF = a_0/a_{100}

a_{100} = modulation for a 100 % polarized source.

polar. angle = PA = $\psi_0 - \pi/2$ [π]

a_{100} needed to estimate the pulse fraction.

a_{100} obtained from simulations (See Forot et al. '08 for all details and Application to the Crab).

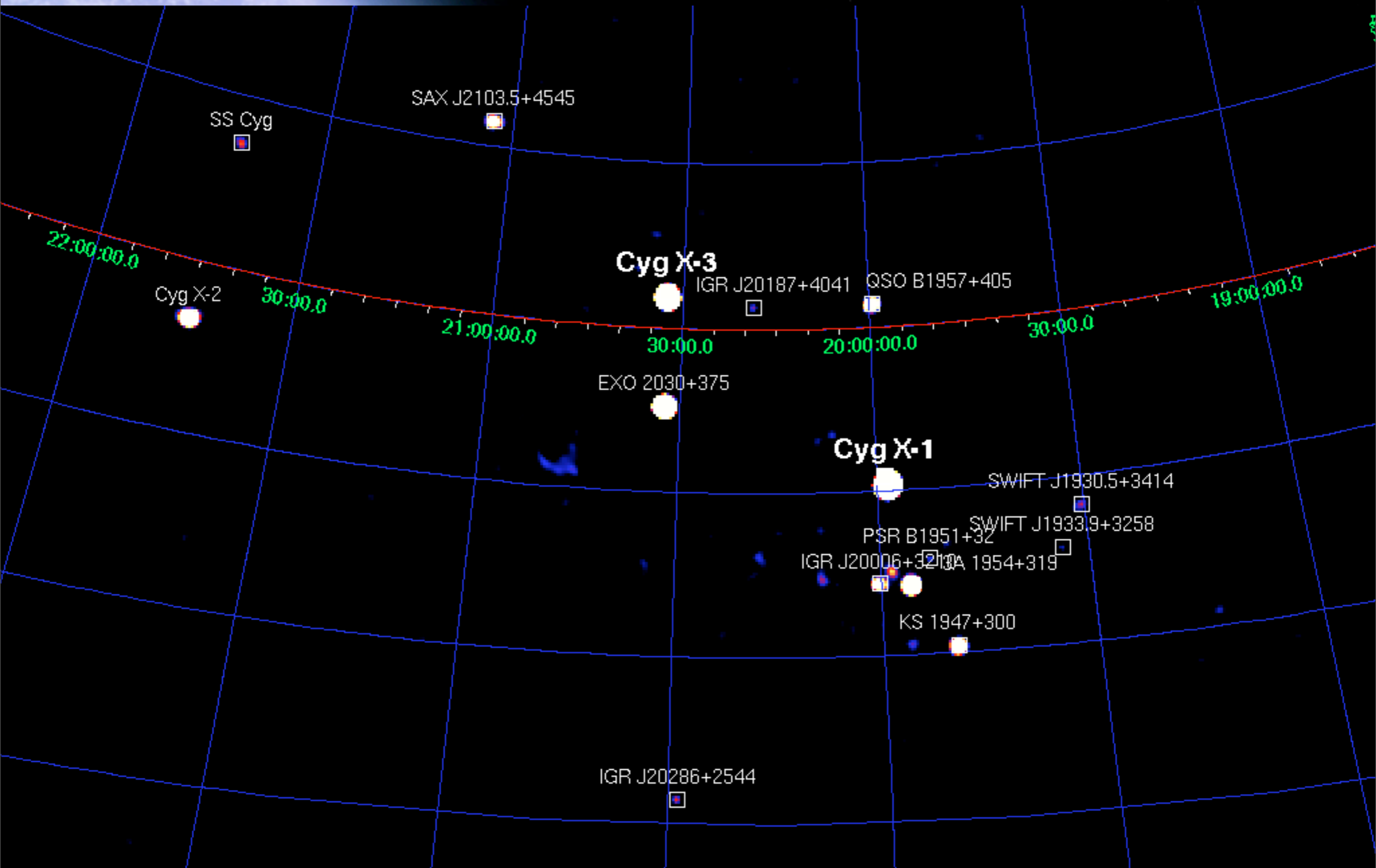
Cygnus X-1: an INTEGRAL view

(See V. Grinberg's Poster)

- ✓ One of the 1st X-ray sources (Giacconi et al. '62)
- ✓ HMXB with BH: HD 226868 (O Sg) + Orb. P \Rightarrow $M_{\text{OC}} \sim 10 M_{\text{sun}}$ (Webster & Murdin '72; Bolton '72)
- ✓ 1st Galactic Black Hole
- ✓ Persistent source
- ✓ «Canonical» Spectral transition
- ✓ Jet source : compact jet (e.g. Stirling et al. '01), discrete ejection @ spec. trans (Wilms et al. '07)
- ✓ «Test» source during INTEGRAL PV phase 10/2002-01/2003
- ✓ See recent review by Nowak et al. 2011 arXiv 1107.2391

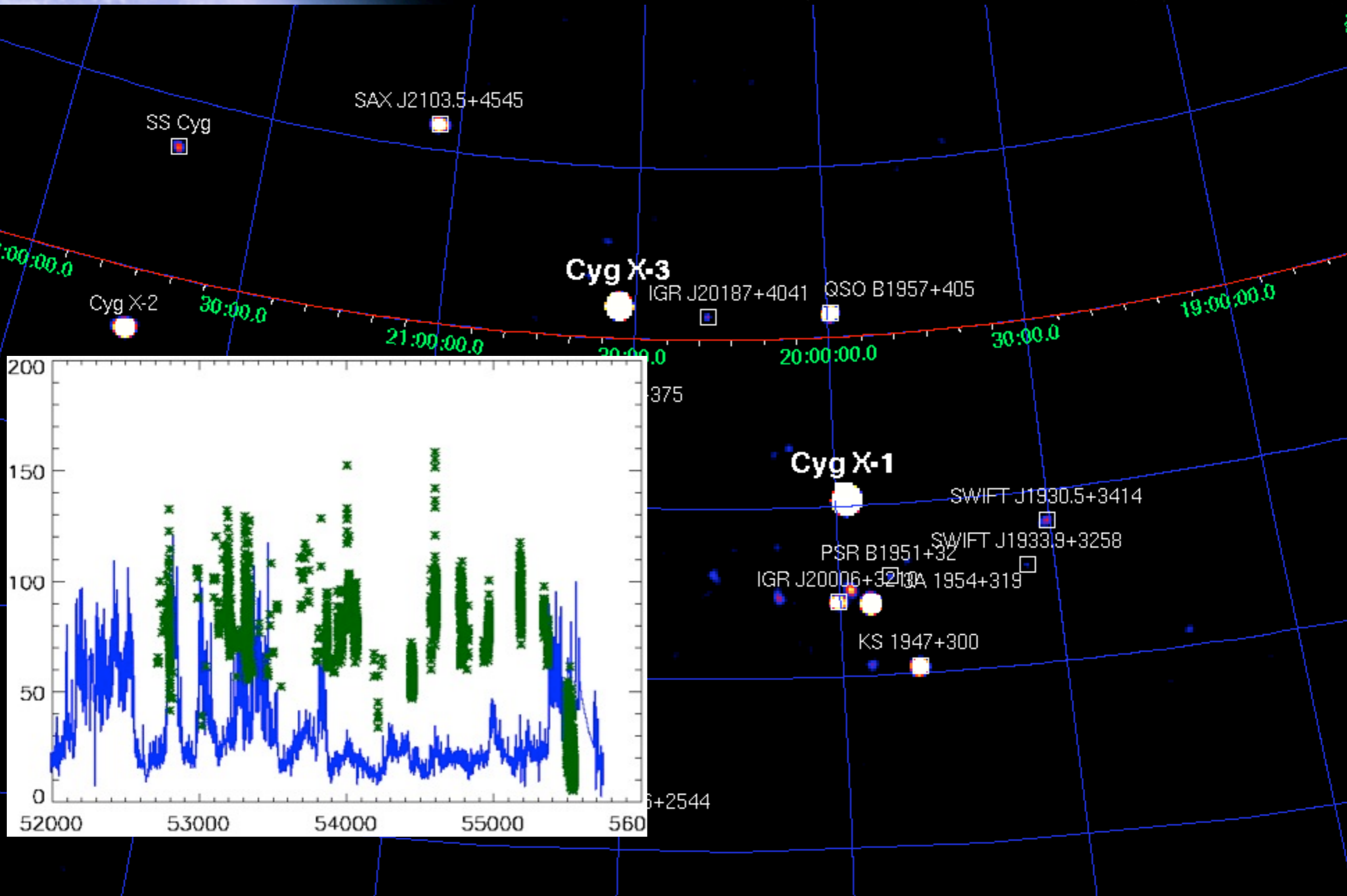
Cygnus X-1: an INTEGRAL view

(See V. Grinberg's Poster)



Cygnus X-1: an INTEGRAL view

(See V. Grinberg's Poster)



Global Spectral Analysis

We have used INTEGRAL data from 2003 to 2010:

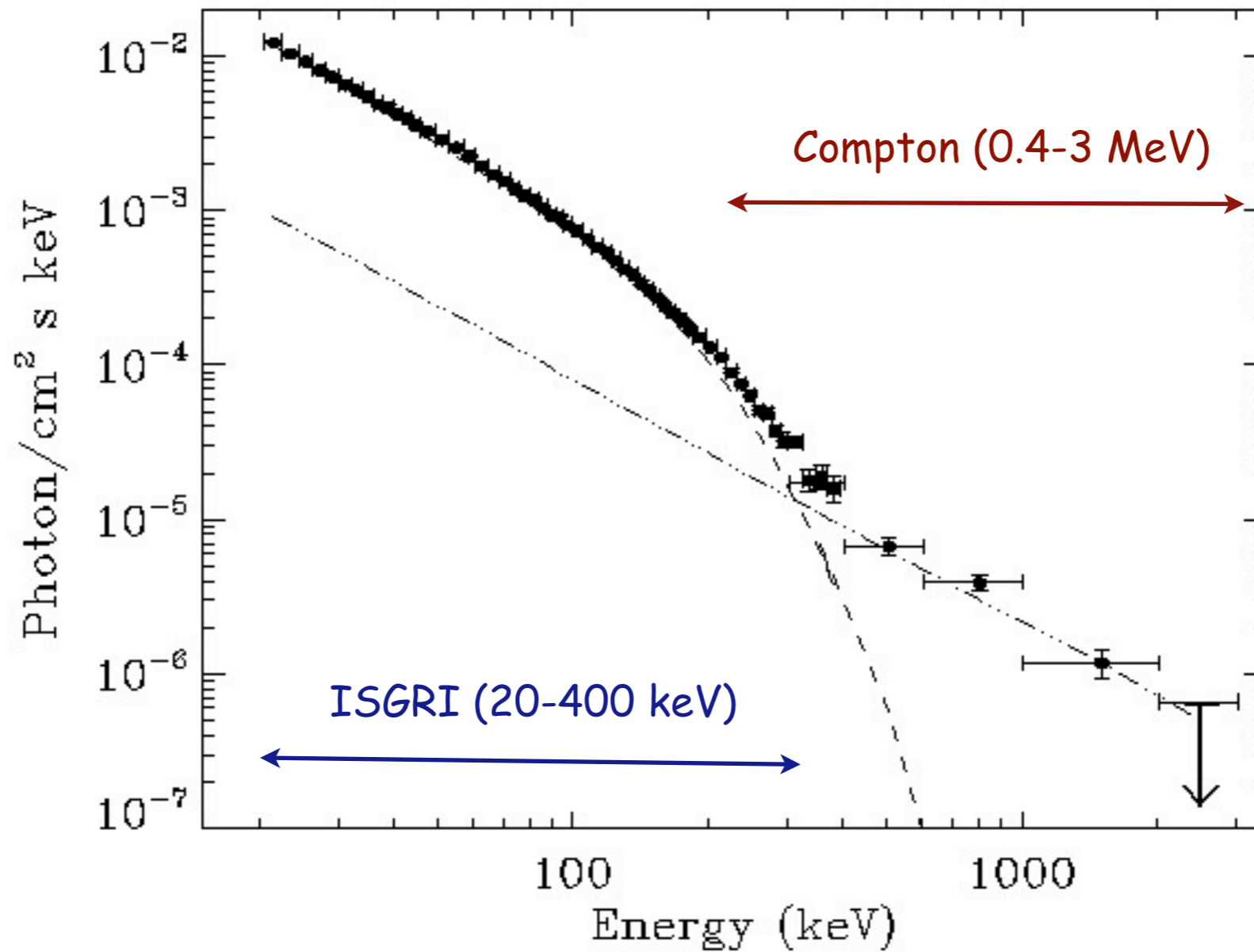
Selection on off-axis angle (Cyg X-1 $< 10^\circ$ off)

Selection on good time (ISGRI, and PICsIT > 10000 s)

=> A total of ~5 Ms of good data

We have summed all IBIS data without discrimination on spectral states => Increase as much as possible the SNR at high energies

We have considered data collected by ISGRI and the Compton mode



Hard (> 500 keV) tail confirmed (e.g. Grove et al. '98, Cadolle Bel et al. '04)

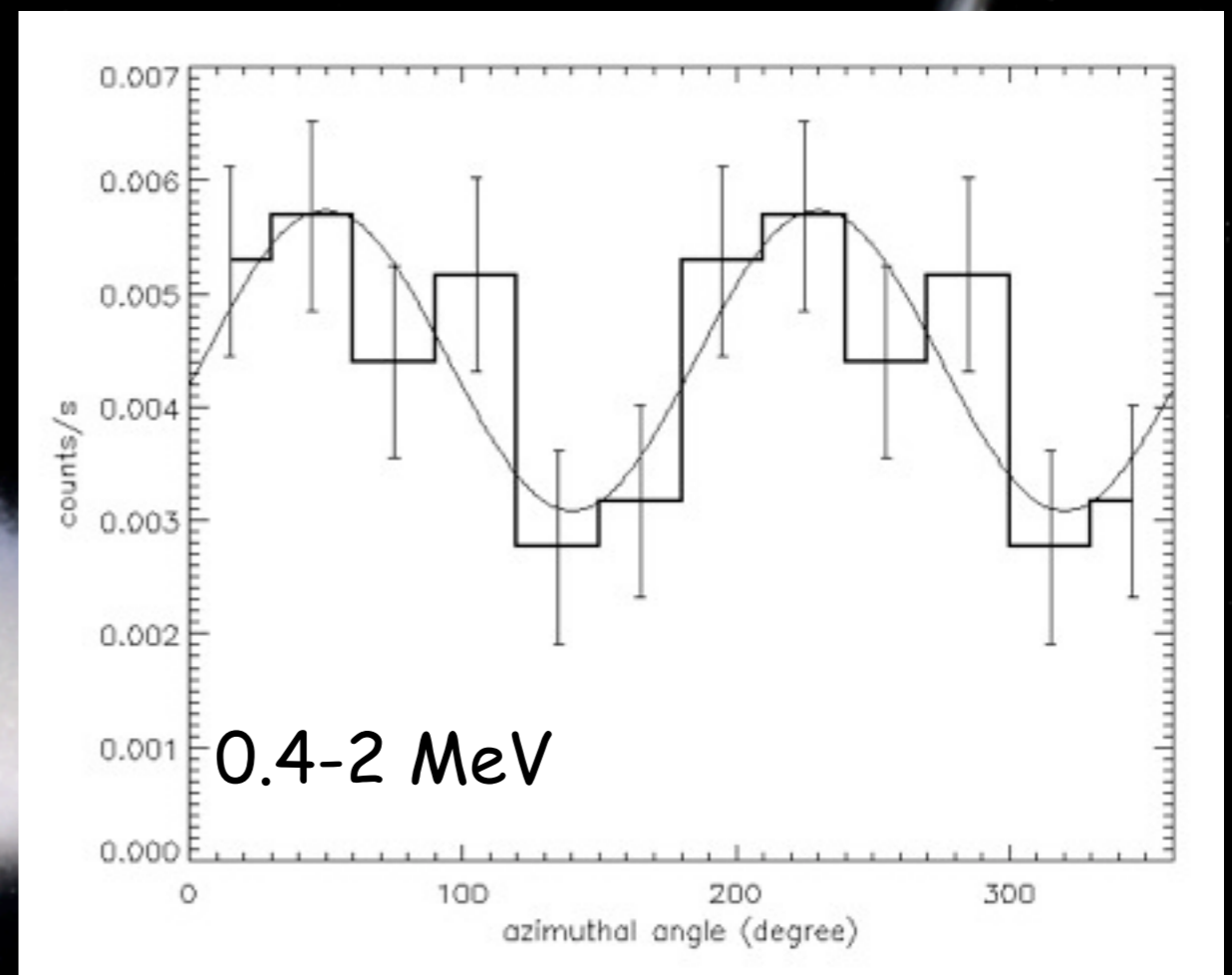
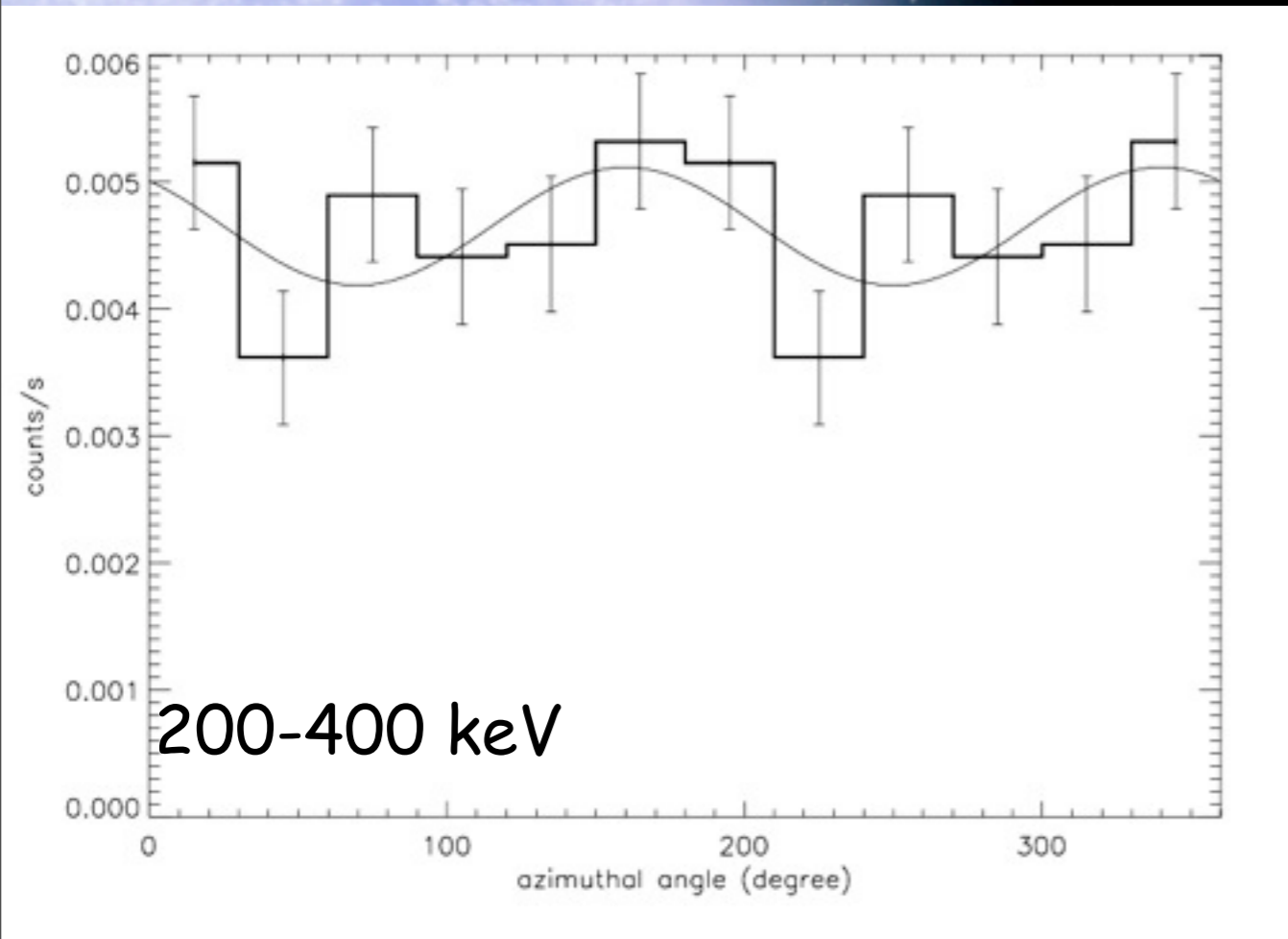
Spectral analysis => 2 Components required:

Thermal Comptonisation $kT \sim 50$ keV

+

Power law above 450 keV $\Gamma = 1.6$

Polarimetry



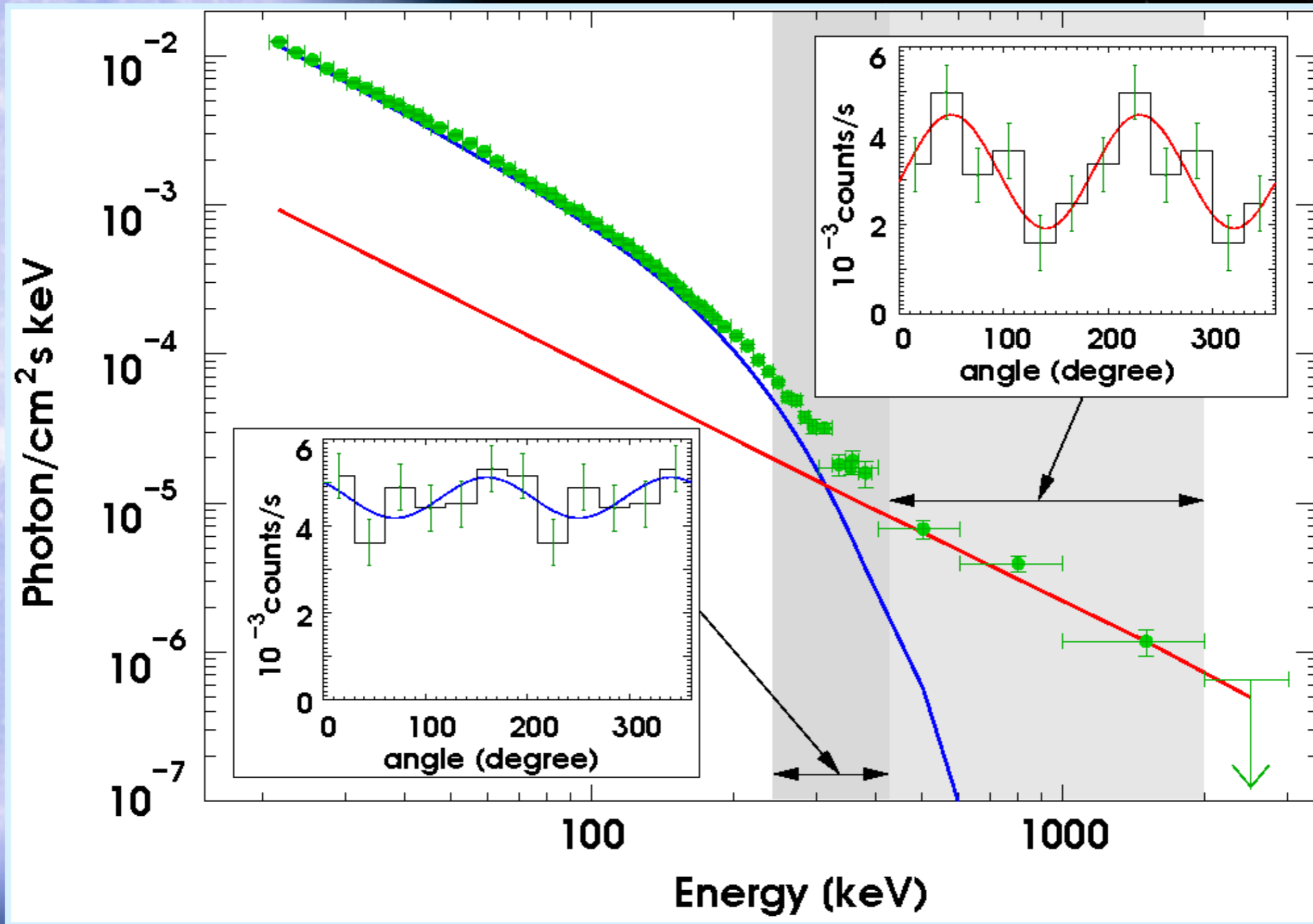
PF < 20%

PF = $67 \pm 30\%$,
PA = $140 \pm 15^\circ$

To summarise

Corona (Compton): not polarised

Hard tail: polarised



Synchrotron from jet?

-Presence of a compact jet in hard state (60% of all scw from HS)

-Hard tail photon index : $N_{ph}(E) \sim E^{-\Gamma}$, $\Gamma = 1.6 \pm 0.2$

Synchrotron emission \Leftrightarrow population of e^- with energy distribution power-law with spectral index $p \Leftrightarrow \Gamma = -(p-1)/2$

Our result $\Rightarrow p = -2.2 \pm 0.4$ close to «canonical» value $p=2$

-PA is 100° away from direction of jet: similar deviations seen in
AGN (Lister & Homan, '05)

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Very likely YES!

Conclusions

Combining 9 years of INTEGRAL data:

=> We have obtained a detection of Cyg X-1 up to 2 MeV

=> The 20-2000 keV spectrum shows 2 components:

Thermal Comptonisation \Leftrightarrow Corona

Power law tail of (a priori) unknown origin

=> First detection of MeV polarisation in an XRB

=> The corona is not polarised

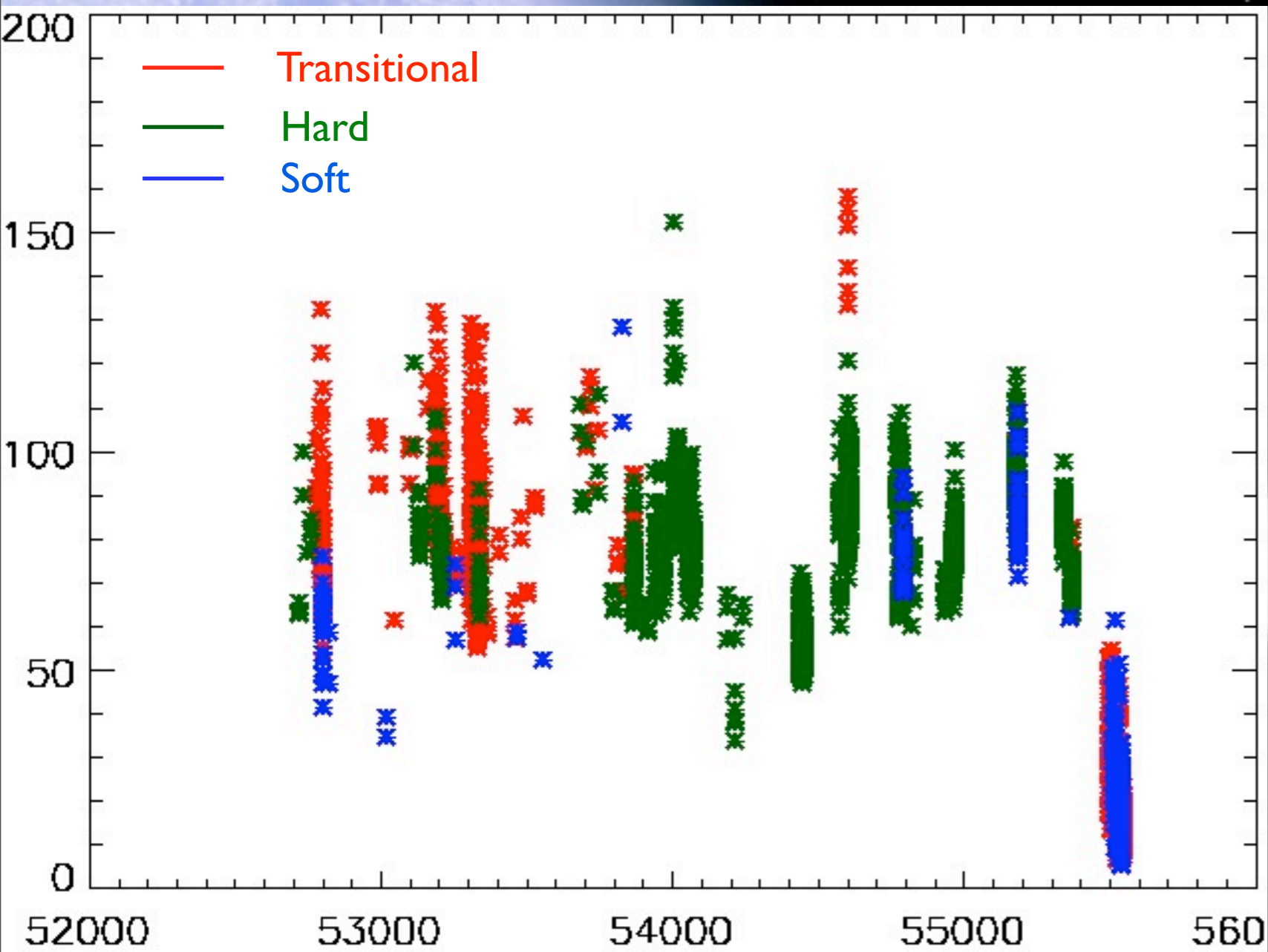
=> The pl tail shows 66 % polarisation with an angle of 140°

=> Pl properties (including polarisation) consistent with synchrotron emission from the jet

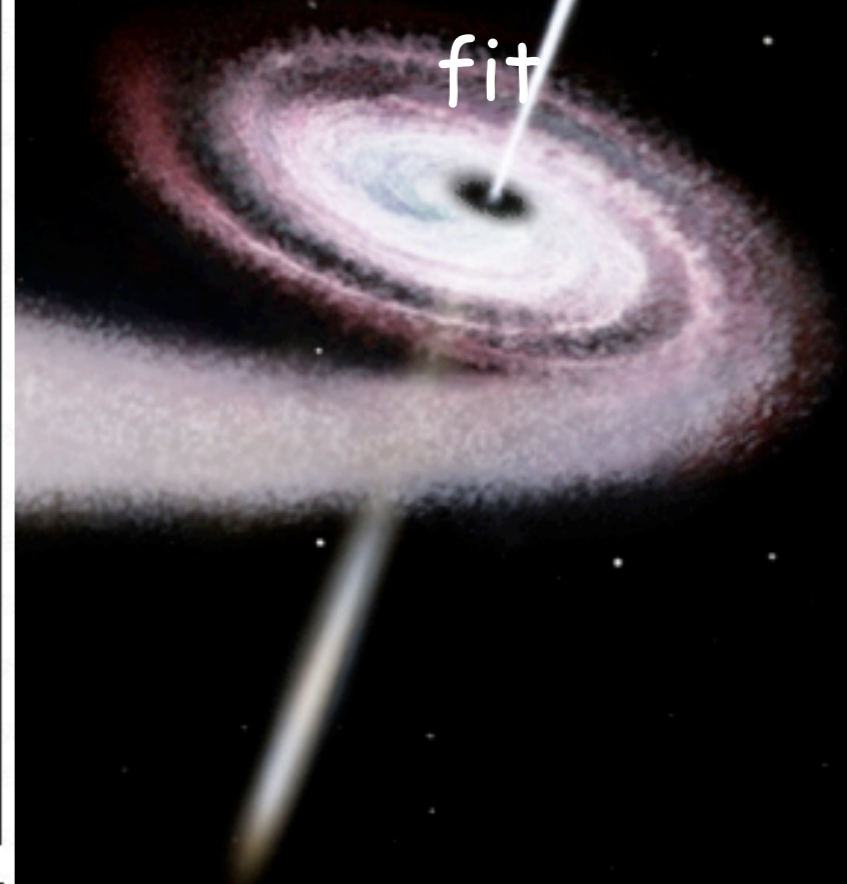
=> First detection of jet emission at MeV energies

Future developments

Separation into states (work on-going) + Soft X-rays



+
Comparison with radio
+
fit



Future developments

Separation into states (work on-going) + Soft X-rays

