



### INTEGRAL and blazars: energy and sky coverage

INTEGRAL IBIS ISGRI 15 keV – 0.5 MeV, covering upper part of synchrotron peak for HBLs, while in the case of lower-energy blazars this band falls often in the gap between both peaks, with an onset of the second (inverse-Compton) peak in MeV range.

This is why the EGRET sky was dominated by blazars, INTEGRAL sky is not.

Moreover, as the INTEGRAL focus on regions along the galactic plane, extragalactic sources as blazars with generally higher absolute galactic latitude fall in the less exposed regions

Despite of this, ~20 blazars detected so far.

INTEGRAL adds **unique energy range** to multispectral picture of blazars, important for model testing

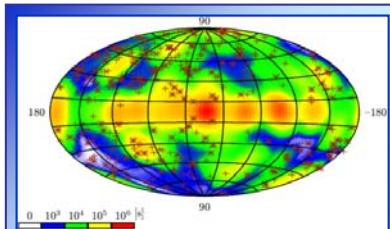


### Searches for faint blazars in IBIS data: procedure developed and tested

Images limited to 60x60 pixels around the source position and fine spectral binning (12 bands between 13 and 520 keV) is combined in just 2 bands – 25-51 keV and 51-250 keV – to reach maximal sensitivity.

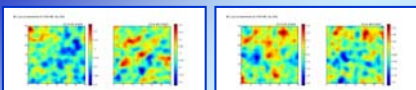
Individual images are combined using varmosaic procedure (by K. Ebisawa) from HEATOOLS (since standard OSA mosaicing tool are not applicable to the cut-outs described).

Final mosaics are centered at the exact catalog position of the source. Total exposure is divided into periods spanning typically less than 2 months and a sub-mosaic is created for each of them. This approach gives better sensitivity to variable sources (that could be averaged out in overall mosaics).



Extragalactic sources as blazars with generally higher absolute galactic latitude fall in the less exposed regions, as shown on the map above (stars show positions of known blazars, crosses are other AGNs from Veron-Cetty catalogue)

### BL Lac, IBIS data



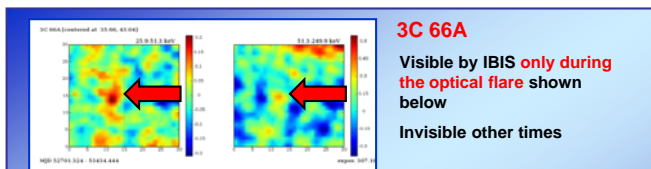
MJD interval 54085.82-54113.01 i.e. 27.19 days size 88x120 [pixels] 0.082x0.082 — exposure 280.888 ksec

15.0-25.0 keV : no peak - upper limit 0.086ct/s  
25.0-40.0 keV : peak 0.193 ± 0.0484ct/s

MJD interval 52985.44-53045.66 i.e. 60.22 days size 88x120 [pixels] 0.082x0.082 — exposure 459.019 ksec

15.0-25.0 keV : peak 0.278 ± 0.0874 ct/s  
25.0-40.0 keV : no peak - upper limit 0.088ct/s

Indications for spectral variability

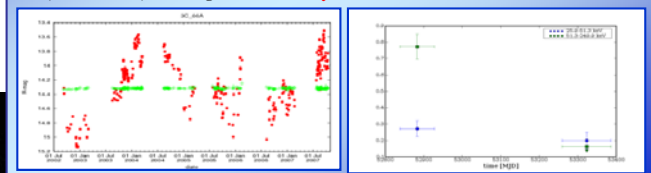


### 3C 66A

Visible by IBIS **only** during the optical flare shown below

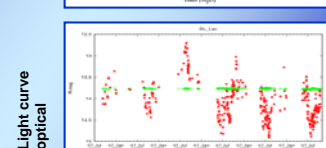
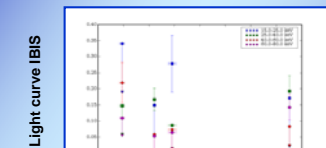
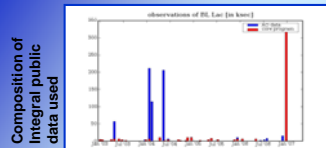
Invisible other times

MJD interval 52701.32-52849.62 i.e. 148.30 days [Mar 2004 - Jul 2004] time mean 1294.368 ± 44.479 size 60x60 [pixels] 0.082x0.082 — exposure 128.563 ksec The flux is (1.66 ± 0.285) 10-11erg/cm2/s **Clearly variable**



# Blazars & ESA INTEGRAL Satellite

### BL Lac cont



### The INTEGRAL AO observation of blazars in outburst

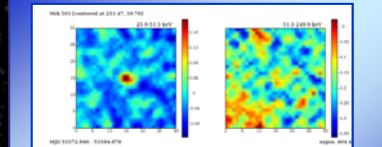
proposal by Pian E. et al. (large collaboration)

So far performed twice

E. Pian, L. Foschini, G. Tagliaferri, P. Bar, V. Berghman, T. Corbelli, A. De Angelis, G. Di Crescenzo, N. Galelli, G. Ghisellini, P. Giommi, P. Grandi, R. Innes, G. Magagnoli, L. Maraschi, A. Marziani, G. Palumbo, M. Perini, T. Perottoni, C. Reuter, T. Saviane, M. Sironi, A. Sillaghi, S. Soldi, L. Tassin, M. Tavecchio, G. Tosti, A. Treves, M. Tziro, E. Vianello, M. Villata, R. Walter

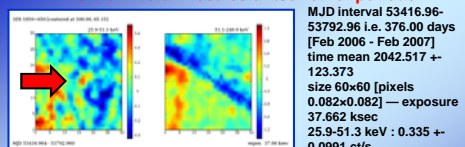
<sup>1,2</sup> René Hudec,  
<sup>3</sup> Elena Pian, <sup>1</sup> Filip Munz,  
<sup>1</sup> Matúš Kocka, <sup>1</sup> Ivana Sujová,  
<sup>1</sup> Věra Hudcová  
<sup>1</sup> Astronomical Institute, Academy of Sciences of the Czech Republic, Ondřejov, Czech Republic  
<sup>2</sup> ISDC, Versoix, Switzerland, <sup>3</sup> INAF Trieste, Italy

### Mrk 501



The most significant result of the procedure described. The flux corresponding to the excess in lower spectral band for Mrk 501 is (1.57 ± 0.24) 10-11erg/cm2/s. The coordinates of the images are given in pixels, one pixel being 4.9 arcmin; mosaics are centered on the catalogue position of the source.

### 1ES 1959+650 variable object visible in 2006 only, invisible in total mosaics and/or other periods

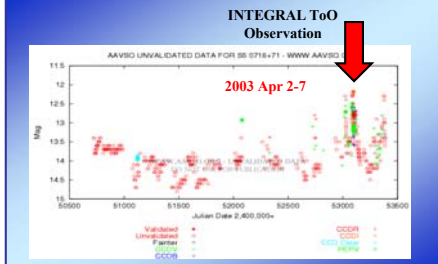


MJD interval 53416.96-53792.96 i.e. 376.00 days [Feb 2006 - Feb 2007] time mean 2042.517 ± 123.373 size 60x60 [pixels] 0.082x0.082 — exposure 37.662 ksec 25.9-51.3 keV : 0.335 ± 0.0991 ct/s

Grants: ESA PECS 98023, GA CR 205/08/1207

### I. Blazar S5 0716+714

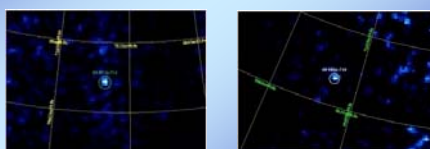
- a BL Lac object
- monitored at radio and optical wavelengths by Whole Earth Blazar Telescope (> 40 telescopes, Villata et al. 2004)
- ToO triggered by optical activity - 2 outbursts up to the extreme level of R =12.1 mag (historical maximum, light increase by 1 mag in 2 weeks and 2 magnitudes in 4 months)
- ToO performed 2003 April 2-7



•INTEGRAL observation: **S5 0716+714** detected only by IBIS ISGRI at 4.5 sigma, 30-60 keV band, for a count rate of 0.11 counts/s (exposure 280 ksec).

•observed at somewhat higher (2x) gamma-ray state when in Oct 2000 (BeppoSAX ToO, Tagliaferri et al., 2003) (R=12.5 versus 12.1)

•**S5 0836+710** (high z blazar of the FSRQ sub-class) observed by chance in the FOV up to 100 keV



S5 0716+714

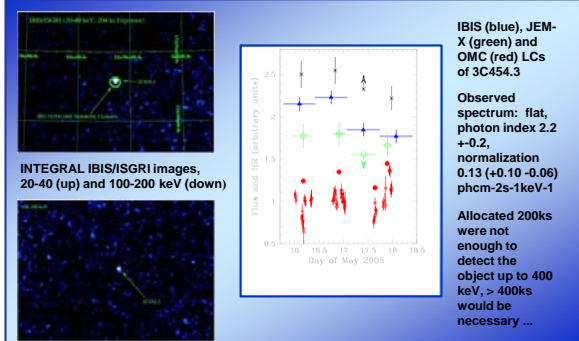
S5 0836+710

### II. INTEGRAL AO-3 ToO observation of 3C454 (z=0.859, Foschini et al. 2005, Pian et al. 2006, PI E. Pian @ large collaboration)

ToO triggered by high optical (T. Balonek, VSNET alert) and X-ray (BAT Swift) activity

INTEGRAL observation started 2005 May 15, at 18:40 UT, exposure 200 ksec

source clearly detected by IBIS/ISGRI in the 20-40 and 40-100 keV energy bands, with a significance of 20 and 15 sigma



INTEGRAL IBIS/ISGRI images, 20-40 (up) and 100-200 keV (down)

IBIS (blue), JEM-X (green) and OMC (red) LCs of 3C454.3

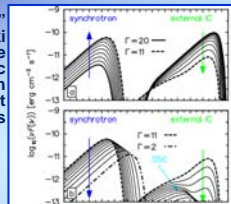
Observed spectrum: flat, photon index 2.2 ± 0.2, normalization 0.13 (+0.10, -0.06) phcm-2s-1keV-1

Allocated 200ks were not enough to detect the object up to 400 keV, > 400ks would be necessary ...

### INTEGRAL & testing blazar models

Testing the "economic" jet model (Katarzynski & Ghisellini 2007): the same bolometric energy budget can produce very different multiwavelength states (Pian et al. 2006).

Blazar multiwavelength spectra as predicted by the "economic" model



### METHOD:

Accurate multiwavelength monitorings of blazars  
3C 454.3: 15-18 May 2005, INTEGRAL, Swift and REM

PKS0537-441: Jan-Feb, July, November 2005: Swift and REM