Gamma-ray bursts observed by INTEGRAL

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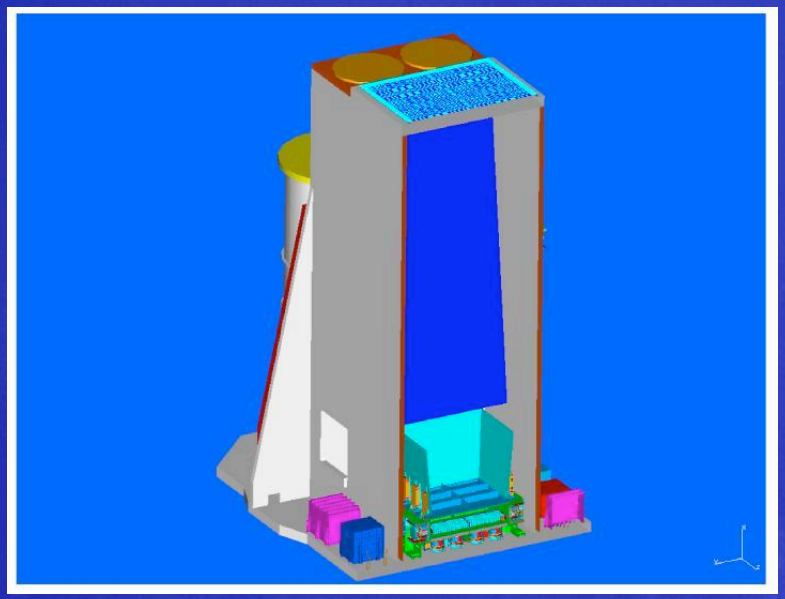
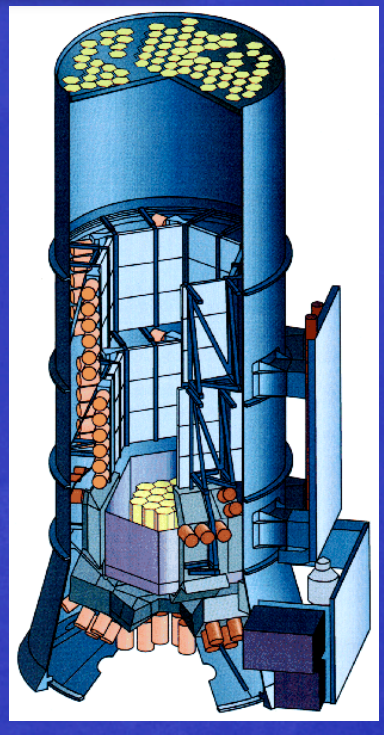
Overview

- INTEGRAL detected 46 GRBs since 2002 - July 2007
- Spectral, spatial, temporal lag properties
- Polarisation measurement with SPI and IBIS at this meeting

GRB Triggers





IBIS-FoV GRBs

1 GRB/month to 3 arcmin

Positions distributed via GCN

http://ibas.mi.iasf.cnr.it

IBAS: Mereghetti

46 GRBs to date

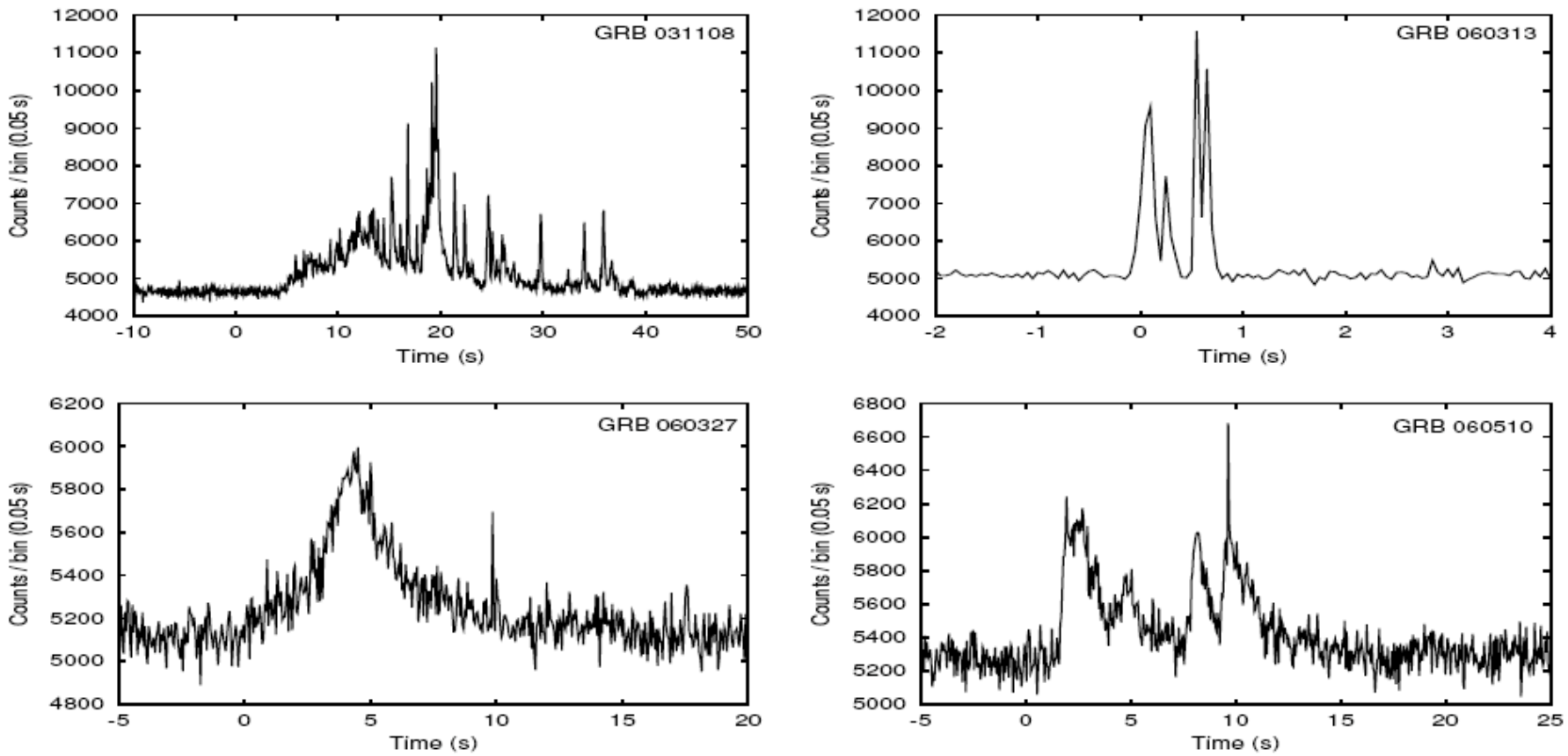
SPI: GRBs in ACS

1 GRB/2-3 days

Light curves public

>80 keV

SPI-ACS



A selection of GRB lightcurves detected by the Anti-Coincidence Shield at photon energies > 80 keV (von Kienlin et al (2003), Rau et al (2005).
See K. Hurley's talk in this session.

INTEGRAL v Swift

- High elliptical orbit 3 days 10,000-150,000 km

- ~80% of time outside radiation belts

- Continuous data downlink & GRB search on ground

- 12 GRBs/yr in the FoV

- 15 keV – 8 MeV => covers peak in GRB νF_ν

-Low Earth orbit 95 min 600 km i=22°

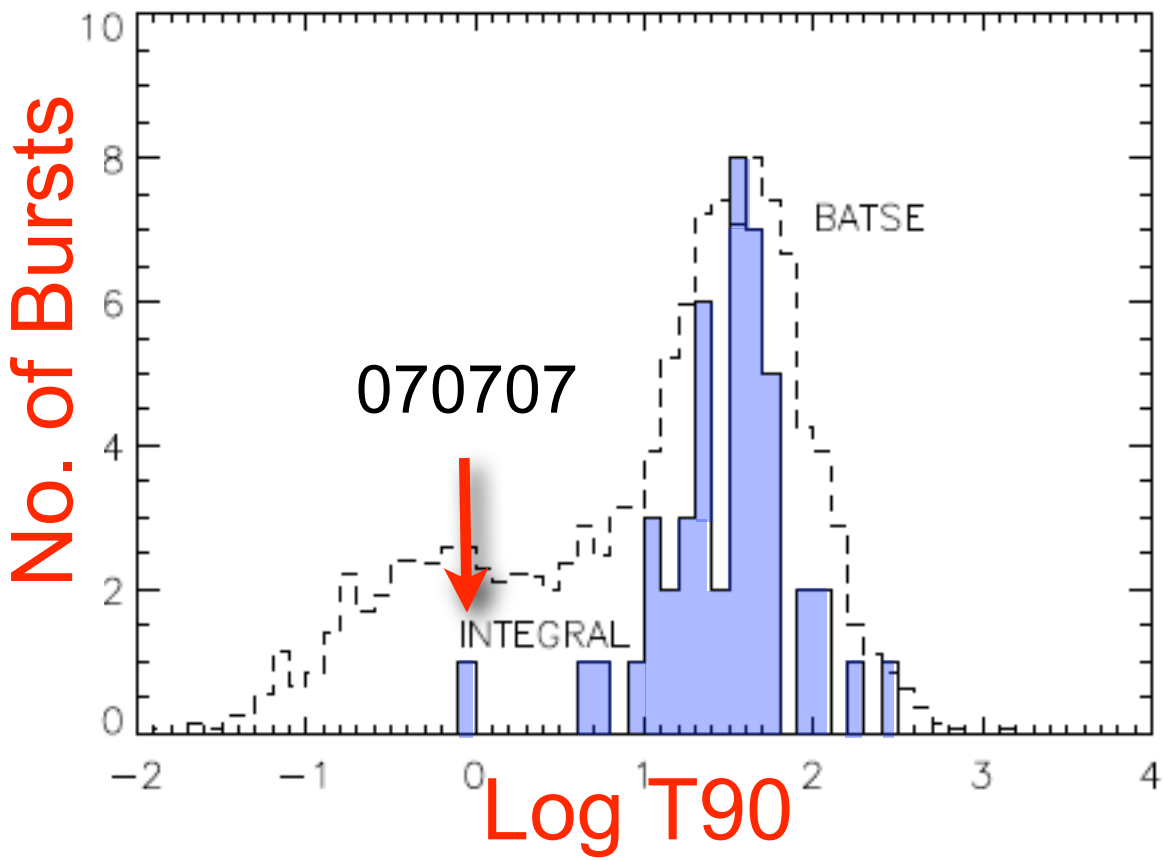
-SAA passages

-GRB search on board

-100 GRBs/yr

-15-150 keV BAT energy range

Duration Distribution

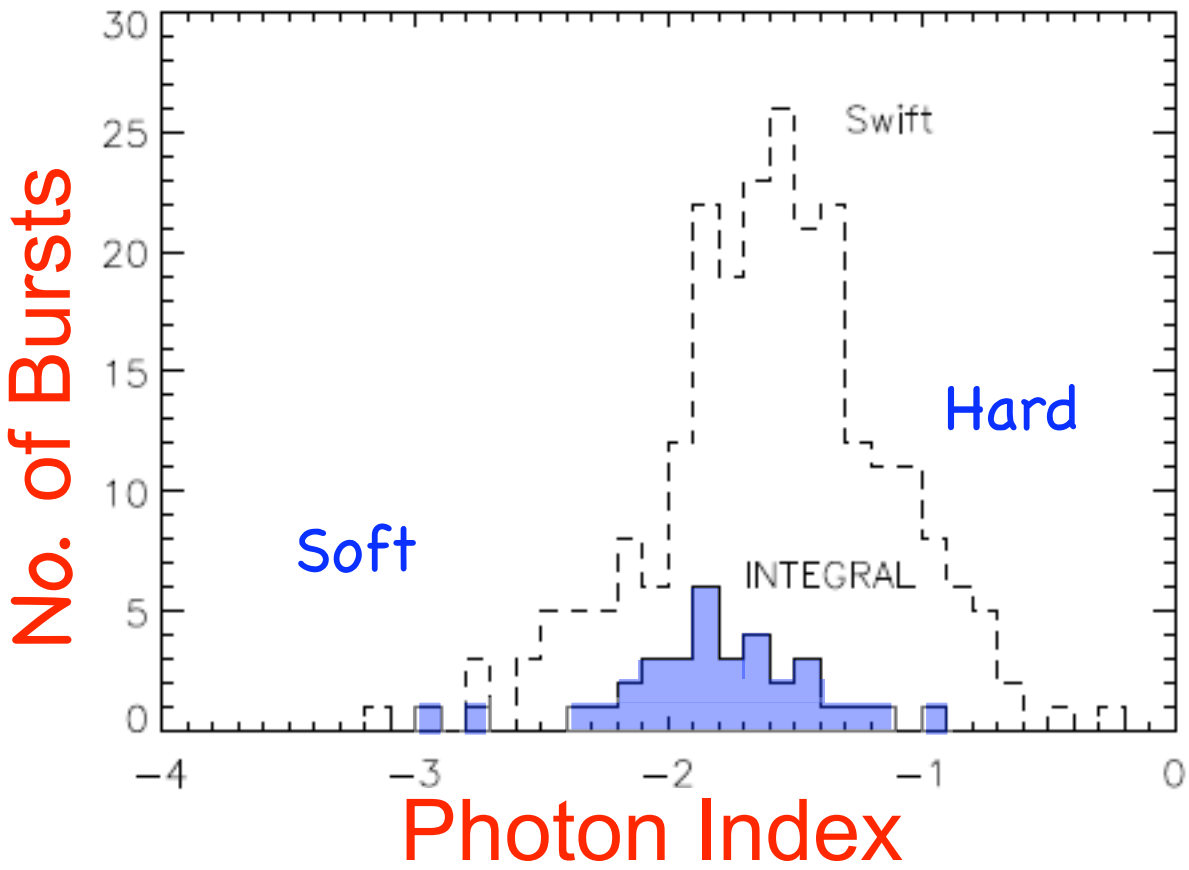


T90 distribution of INTEGRAL GRBs in comparison to that of BATSE (Kouvelitou). The BATSE distribution is normalised to the peak of the INTEGRAL distribution for clarity. The BATSE data for 2041 GRBs is taken from the Current Catalog.

INTEGRAL GRBs

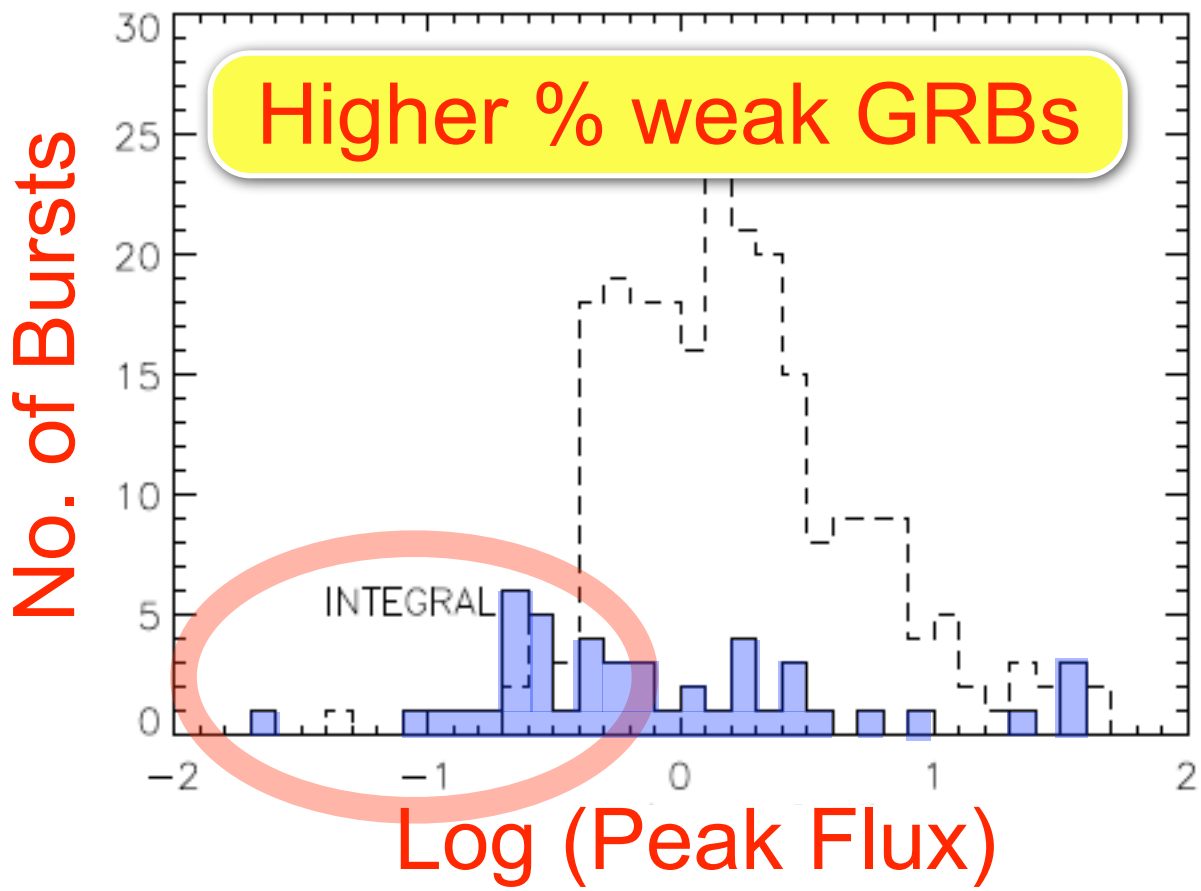
- GRB spectra are generally fit by broken power law with low energy index α and high energy index β. E_0 is the break energy (Band spectrum).
- Often the Break cannot be measured and in these cases regular power laws are used.
- A combination of black body and power law spectra can also be used to get curvature.

Spectral Distribution



Photon index distribution for INTEGRAL GRBs and Swift GRBs in the 20-200 keV and 15-150 keV respectively. The Swift data for 238 GRBs from GRB Lookup table.

Peak Flux



Peak flux distribution for GRBs detected by INTEGRAL (20-200 keV, solid line) and Swift (15-150 keV, dashed line). The Swift data for 237 GRBs is taken from GRB Lookup table.

Spectral Lags

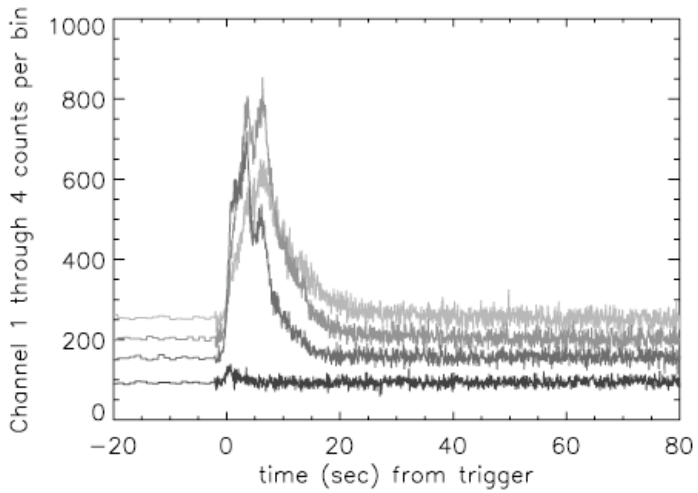
- Time delay (τ) between arrival of high and low energy photons in many GRBs; $0.003 < \tau < 0.4$ s & hard leads soft
- Cross-correlation analysis used to determine τ (eg Band (1997);Norris (2000))
- Peak of cross-correlation function (CCF) corresponds to spectral lag of the GRB
- Lag-luminosity relationship for GRBs (Norris)

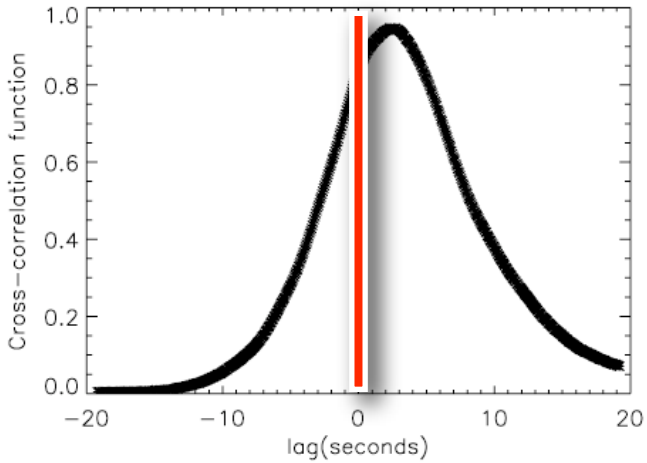
$$L_{pk,iso} \sim 1.3 \times 10^{53} (\tau/0.01)^{-1.14} \text{ erg/sec}$$

- Can (in principle) use spectral lag as GRB distance indicator

Shortest lags => fastest spectral evolution (Kocevski & Liang, ApJ, 2003)

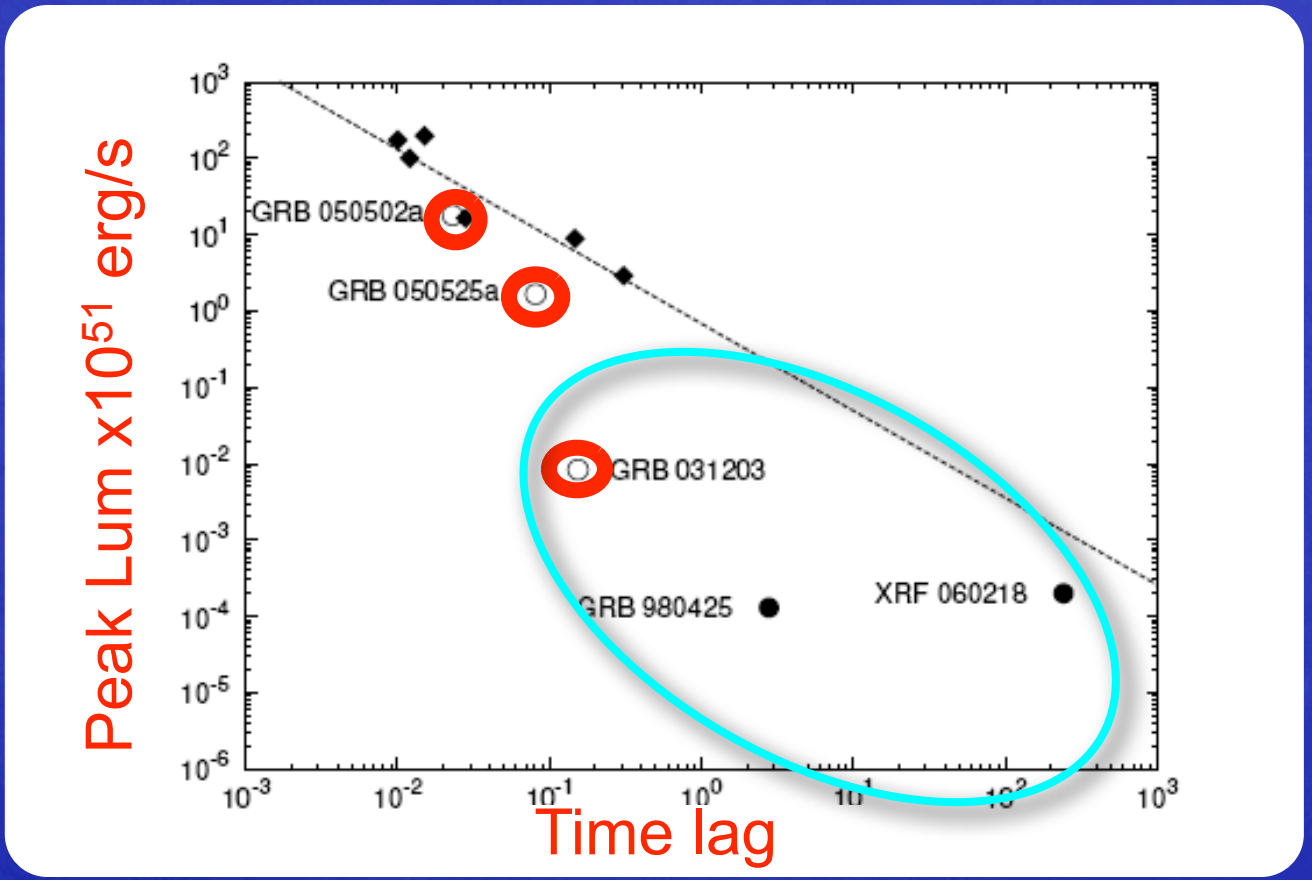
Spectral Lags





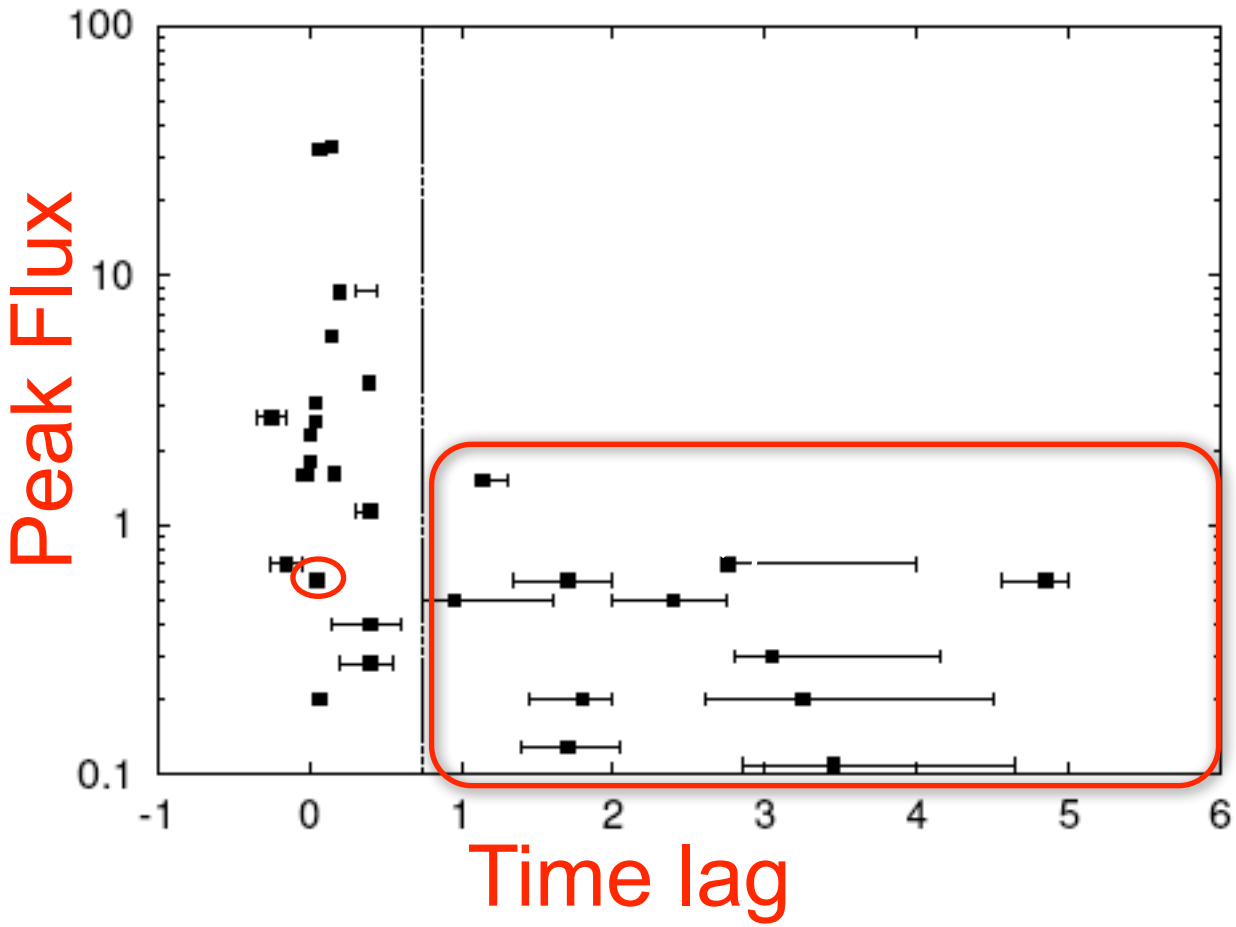
- Cross correlation functions and polynomial τs giving a lag of ~2.5 s
- dashed represents a lag of 0 s.
- Positive lag means hard leads soft emission.
- Red line represents a lag of 0 s.
- Positive lag means hard leads soft emission.

Luminosity-Lag Diagram



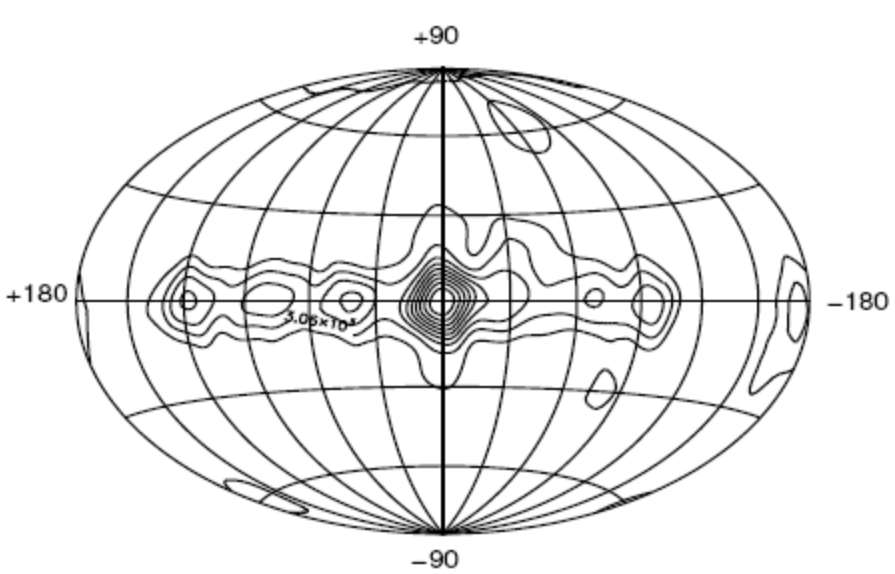
Isotropic peak luminosity as a function of spectral lag measured between 25-50 keV and 100-300 keV for the 3 INTEGRAL GRBs with measured redshifts and the low luminosity SN bursts GRB980425 and XRF060218. The dashed line is the anti-correlation obtained by Norris et al. (2000) using 6 bursts with known redshift.

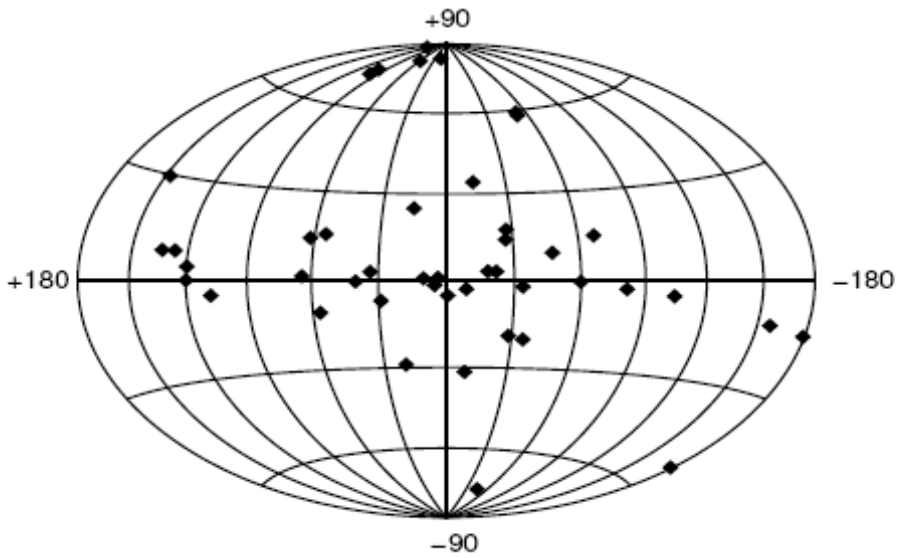
Peak Flux - Lag



Spectral lag distribution of INTEGRAL GRBs as a function of peak flux. GRBs with the longest lags tend to have low peak fluxes, whereas GRBs with short lags have both low and high peak fluxes.
XRF040812 Talk by G. Stratta

Spatial Distribution

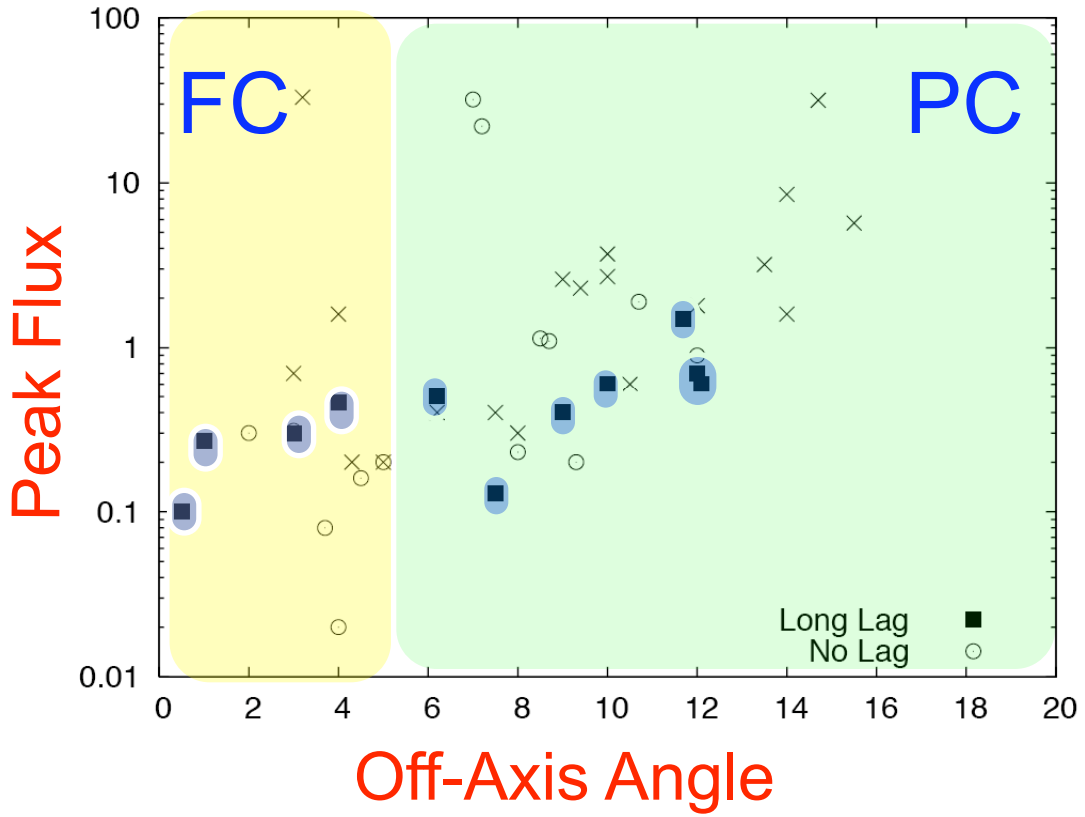




INTEGRAL exposure map in galactic co-ordinates from October 2002 up to July 2007, showing the concentration of exposure in the direction of the galactic plane (courtesy of Erik Kuulkers, private comm).

Spatial distribution of 46 INTEGRAL GRBs detected between October 2002 and July 2007 in galactic co-ordinates.

FC-PC Field of View



Off-axis angle distribution of the 46 GRBs detected by INTEGRAL as a function of peak flux. It can be seen that GRBs detected outside the FCFoV of IBIS, higher off-axis angle rare preferentially brighter with larger peak flux values.

Rates from INTEGRAL

- FCFOV - 81 sq deg ->1/500th of the sky
- 12 in 4 years in FCFoV -> ~1500 per year (BATSE ~600 per year)
- Long lag GRBs about 4/12-> ~500 per year

Interpretation

- Low luminosities are implied by the lag-luminosity, Amati and long, slow pulses
- Low-luminosity eg GRB980425
- Many have E_0 below 20 keV (Amati et al 2002)
- Local population or high redshift ?

Next 5 years

- More exposure out of Galactic Plane (get more redshifts)
- Lower threshold even if some triggers are insecure (Swift plans to lower BAT threshold in December)
- What follows INTEGRAL ?