The Soft Gamma-Ray Repeater SGR 1806-20 as seen by INTEGRAL

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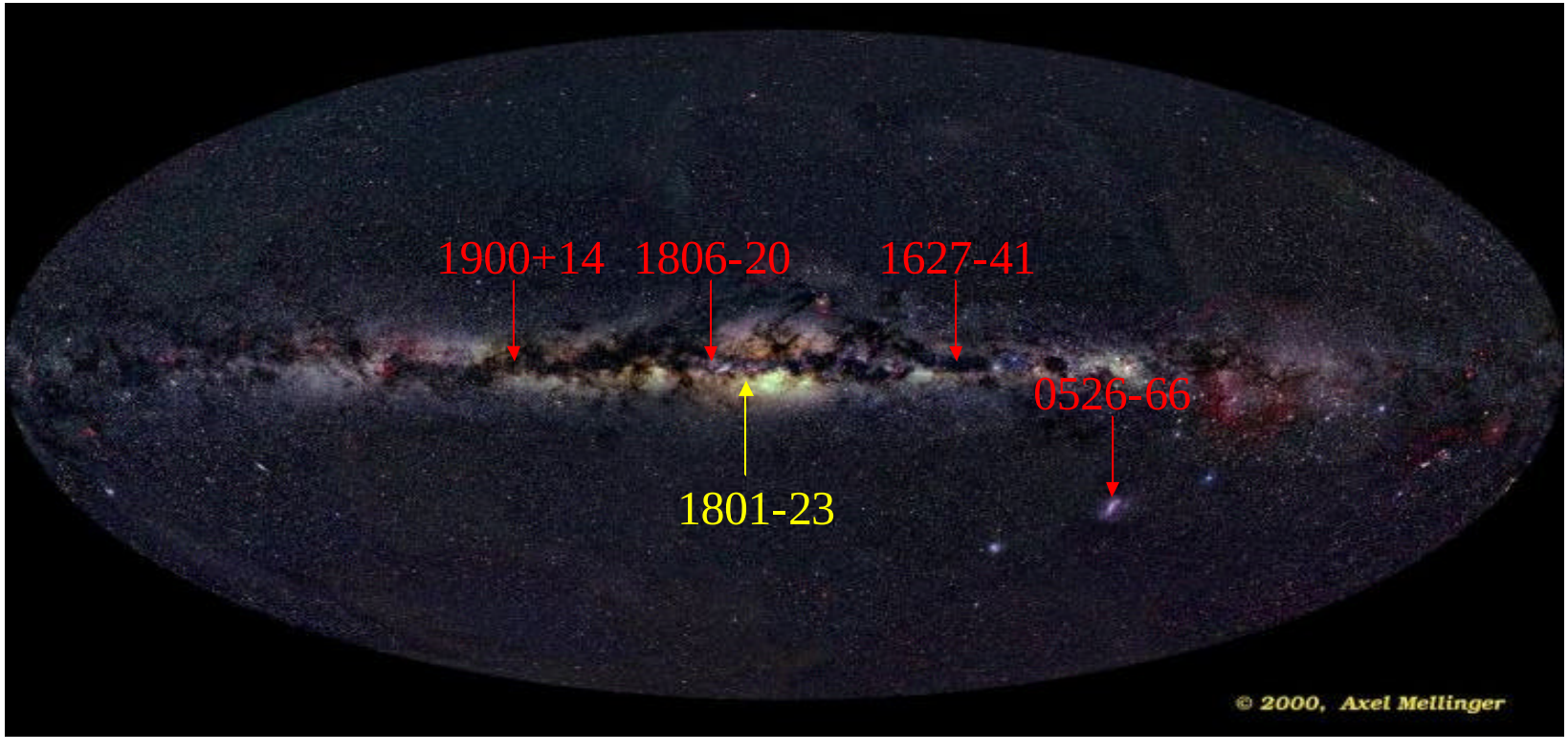
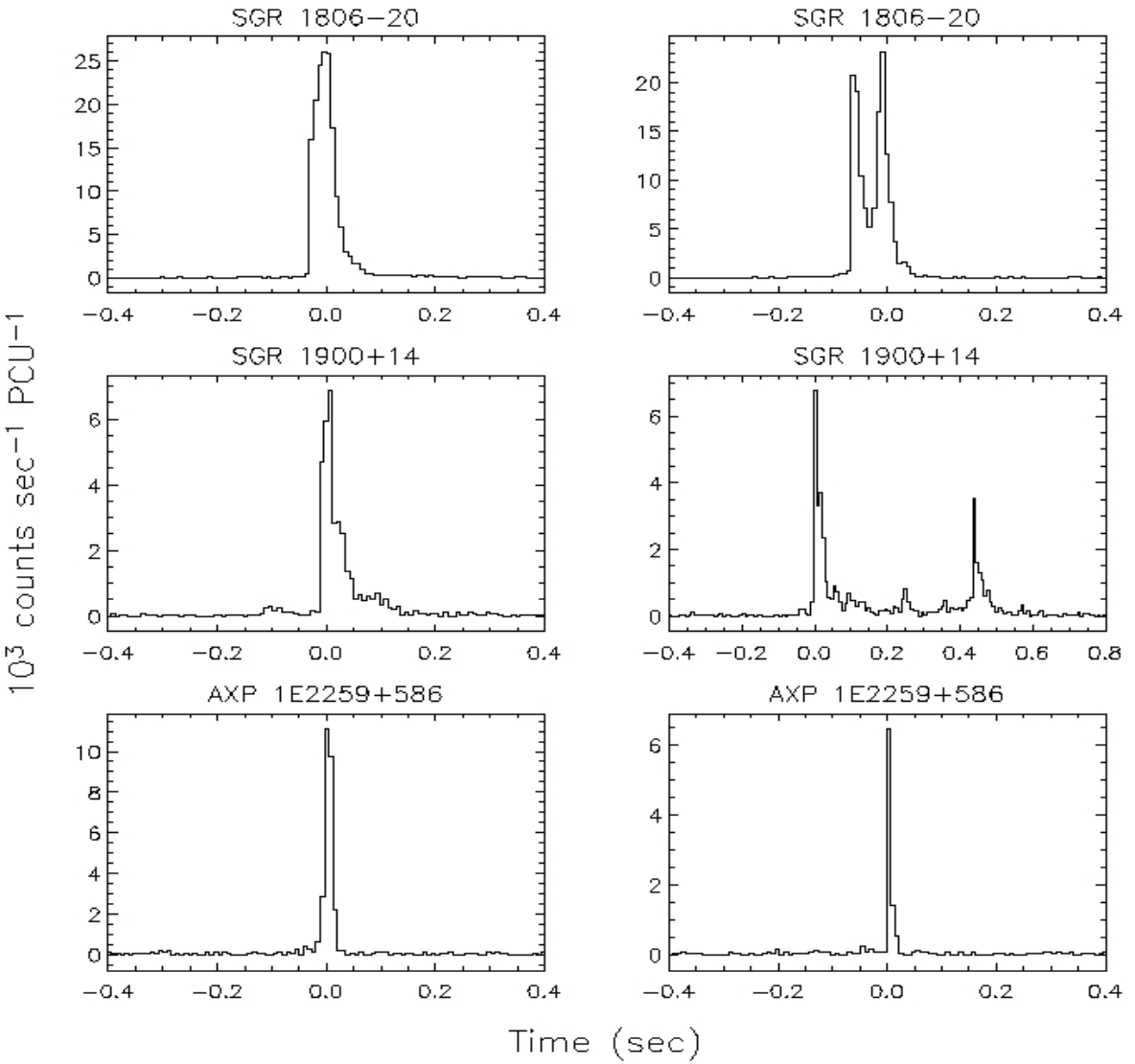
Outline

- Short Bursts
- Persistent Emission
- The 27 December 2004 Giant Flare

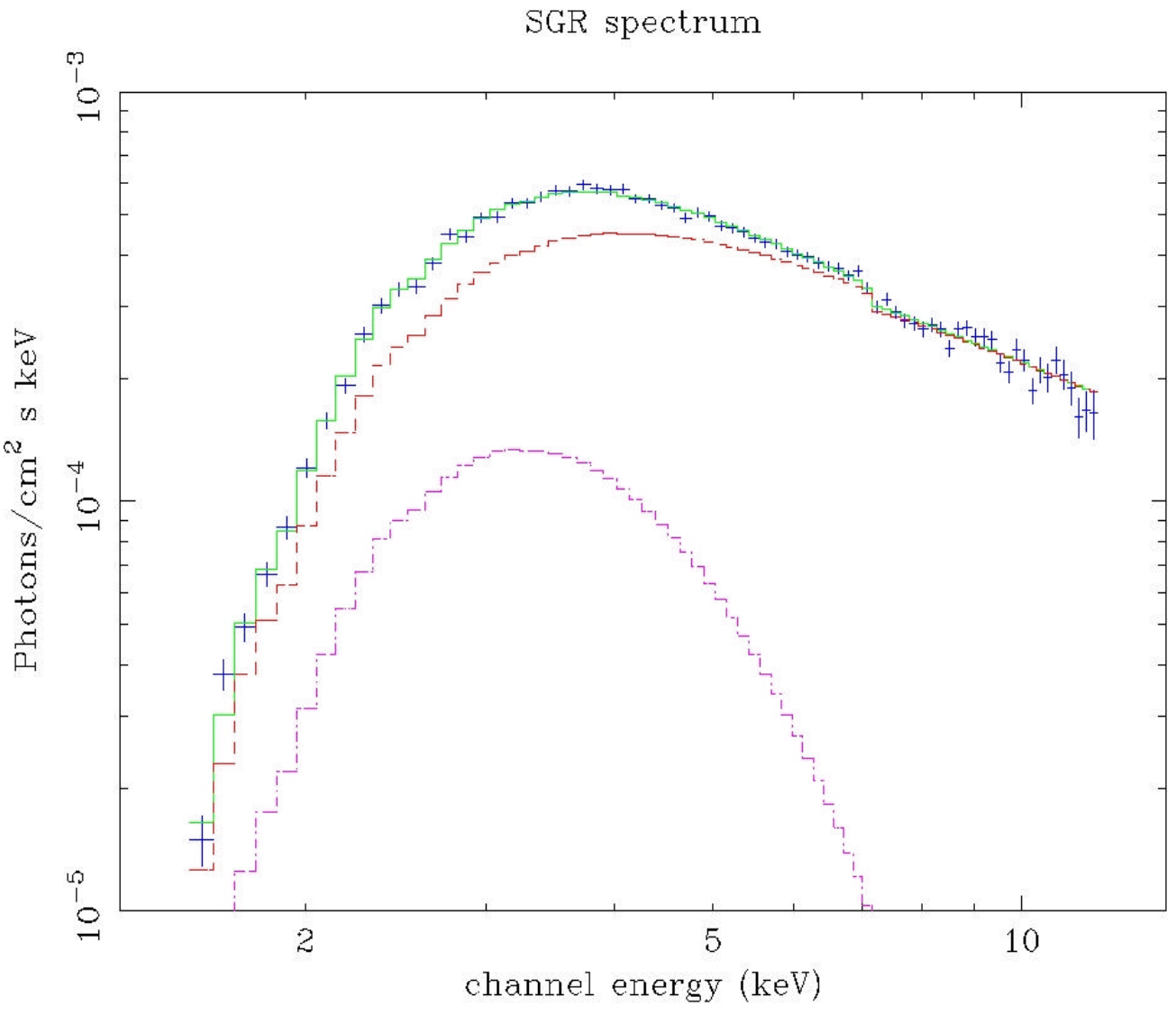
- Soft Gamma-ray Repeaters (SGRs) are a class of peculiar high-energ sources discovered through their recurrent emission of soft ?-ray burst (4.5±0.5 sources)



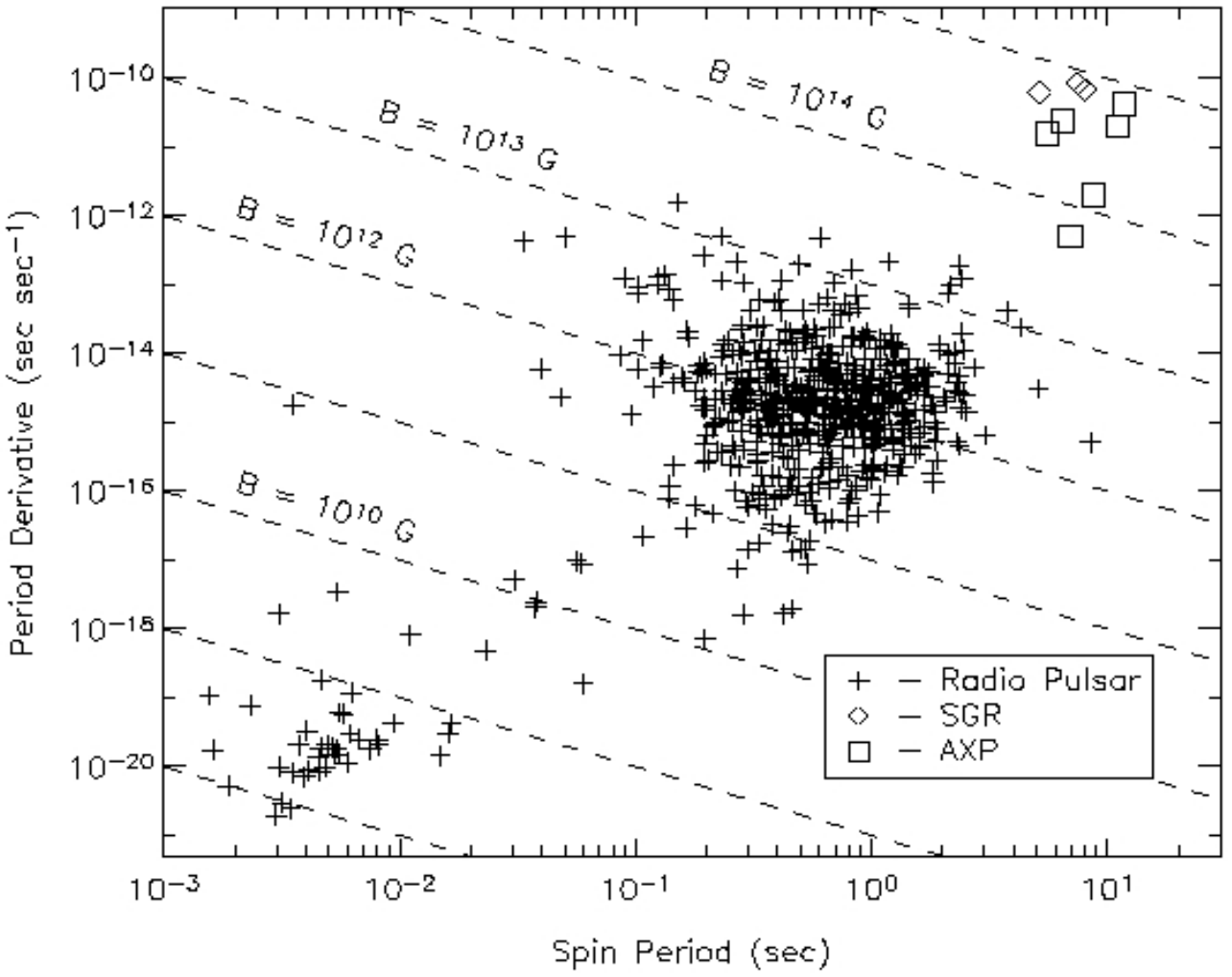
- SGR bursts have typical durations of ~0.1 s and luminosities in the range 10^{39}-10^{42} ergs s^{-1}



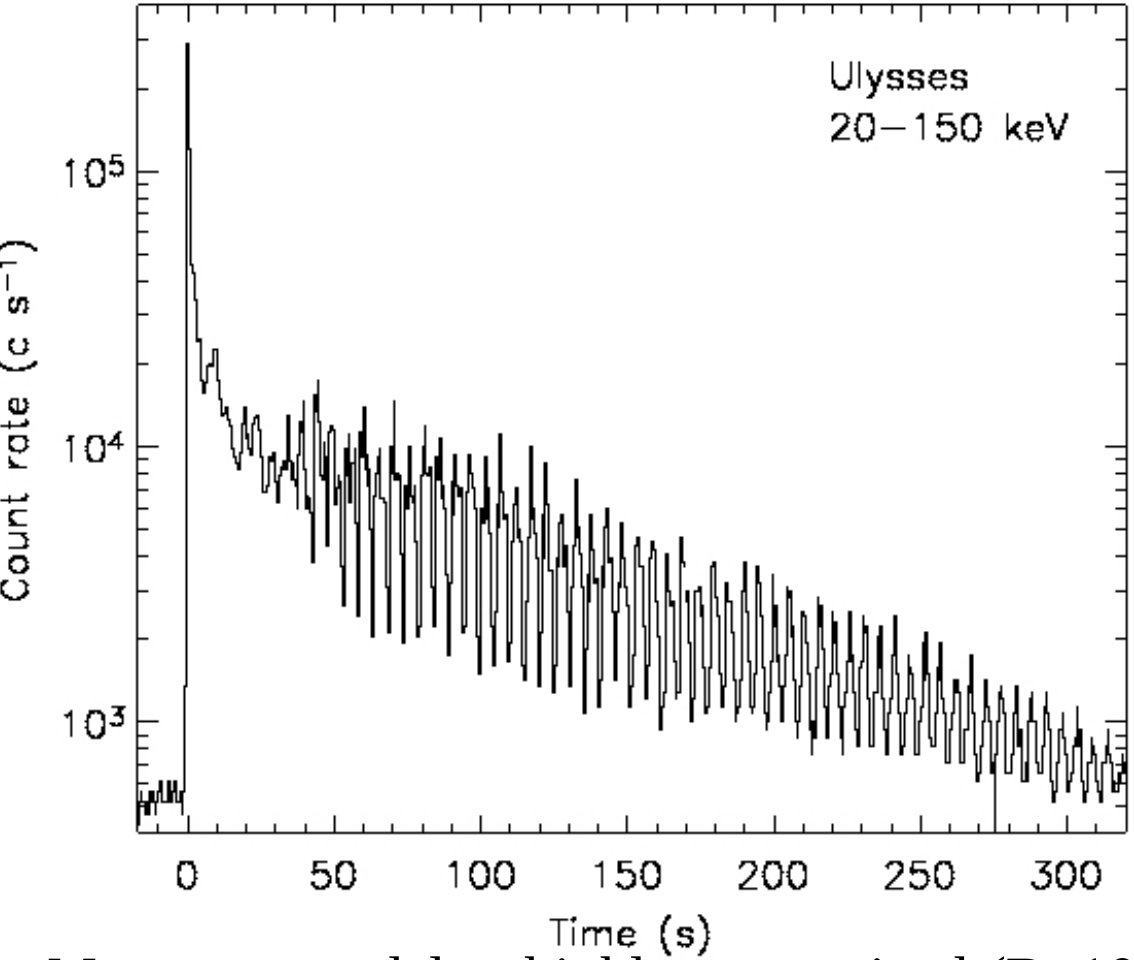
- Persistent emission is observed in the ~0.5-10 keV energy range (ASCA, SAX, XMM, AXAF).



- The spin period and its derivative are measured.



- Occasionally (once every 25-50 years!), SGRs also emit giant bursts that last up to a few hundred seconds and exhibit remarkable pulsations that reveal their spin periods



- 5 March 1979
  0525-66
  Mazets et al. (1979)
- SGR 1900+14
  27 August 1998
  Hurley et. al (1999)

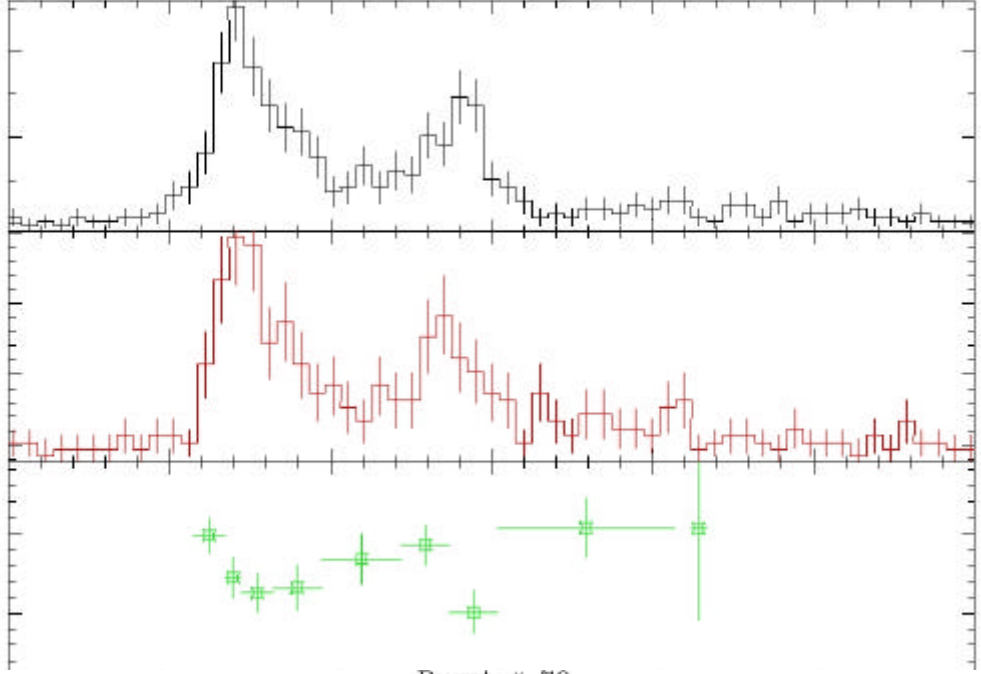
- *Magnetar* model: a highly magnetized ($B \sim 10^{15}$ G) slowly rotating (P~ 5-8 s) neutron star. (Duncan & Thompson 1992)

- **SGR 1806-20 entered a new period of activity in July 2003**
- **More than 100 bursts have been detected by IBAS since then**
- **77 of them have been analyzed**
- **Thanks to the good sensitivity of IBIS they have been studied in detail**

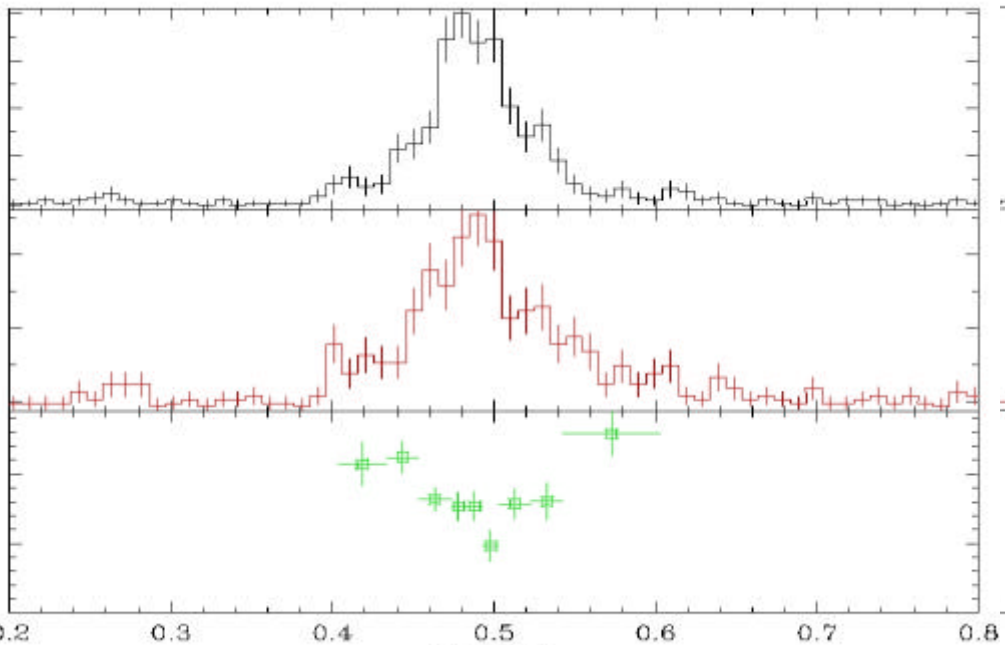
  Spectral Evolution and Hardness-Intensity Correlation

  (See 5Th INTEGRAL Workshop, first 24 bursts)
- **The persistent emission of the source has been detected at energies > 10 keV for the first time**
- **High activity culminating in the Giant Flare of Dec 27th 2004**

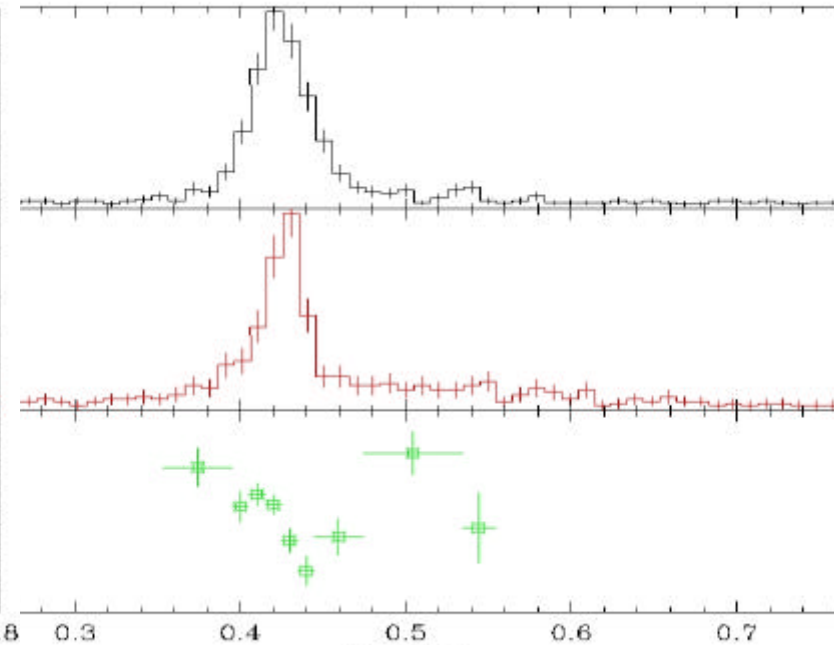
Spectral Evolution



Burst # 70

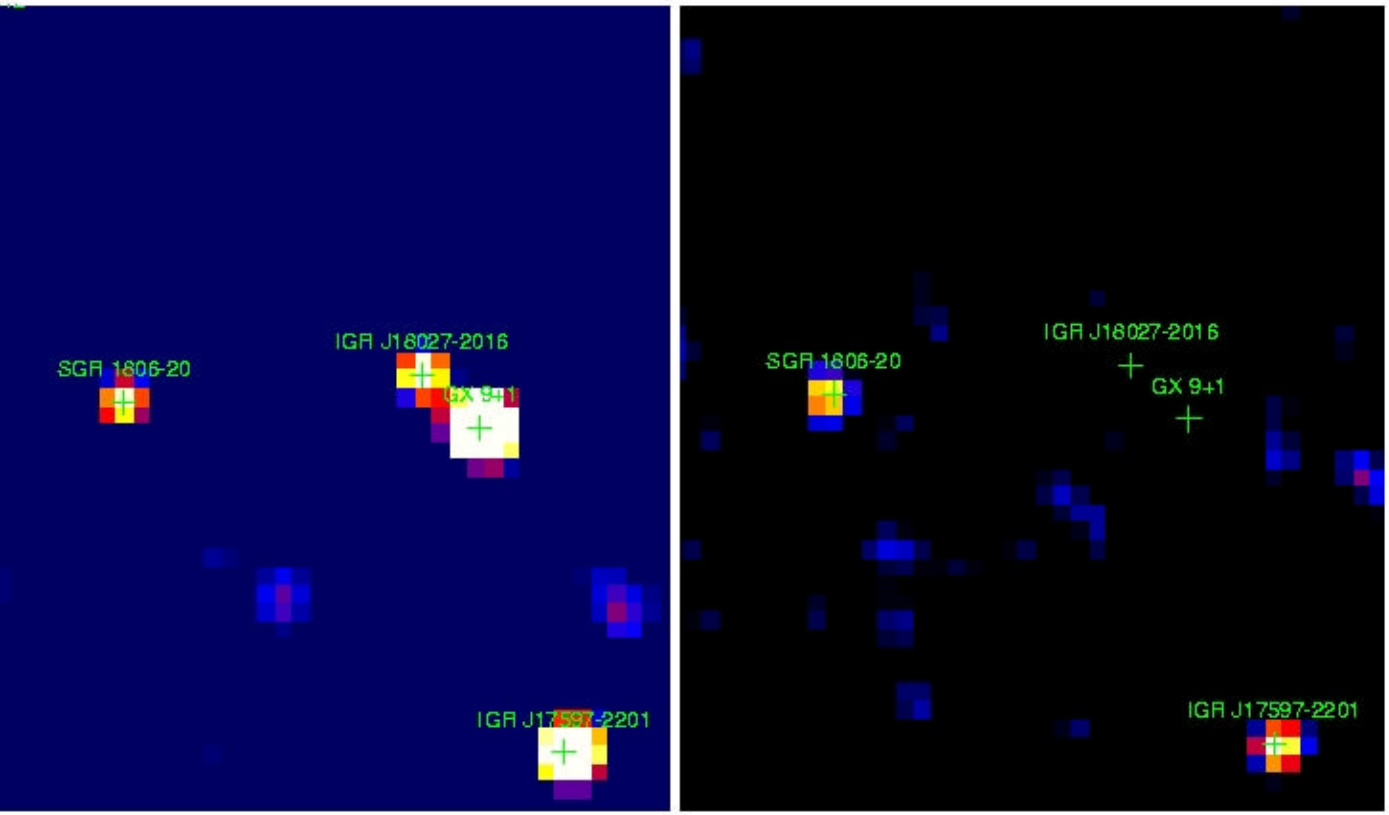


Burst # 53



Persistent Emission I

Mereghetti, Götz, Mirabel & Hurley, A&A, astro-ph/0411695



Total Exposure Time ~ 1 Msec

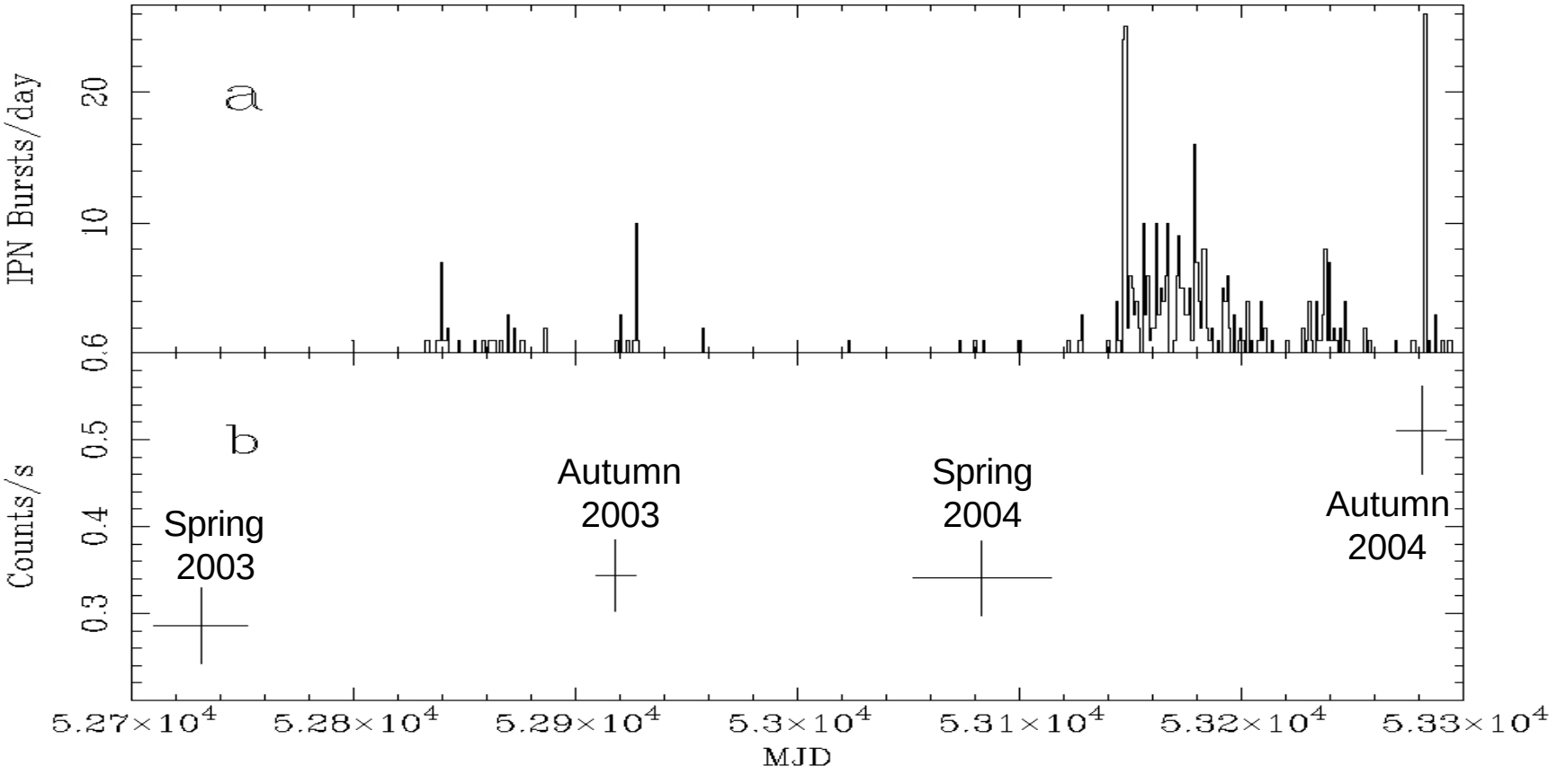
IBIS/ISGRI 20-60 keV 60-100 keV

First detection of emission above 10 keV from an SGR counterpart

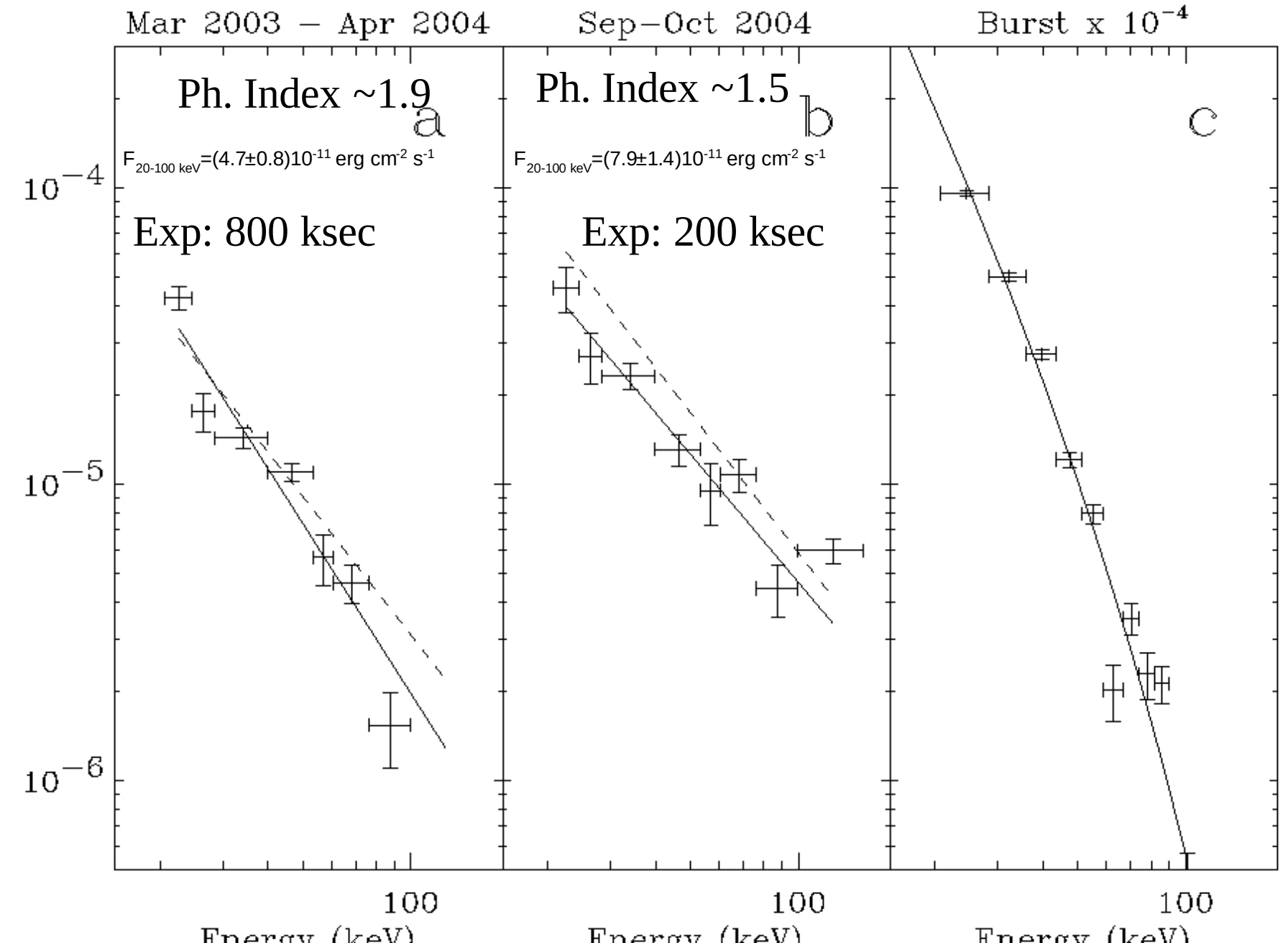
=> Non thermal processes in the Magnetosphere

Persistent Emission II

Mosaicking contiguous observations: Time variability

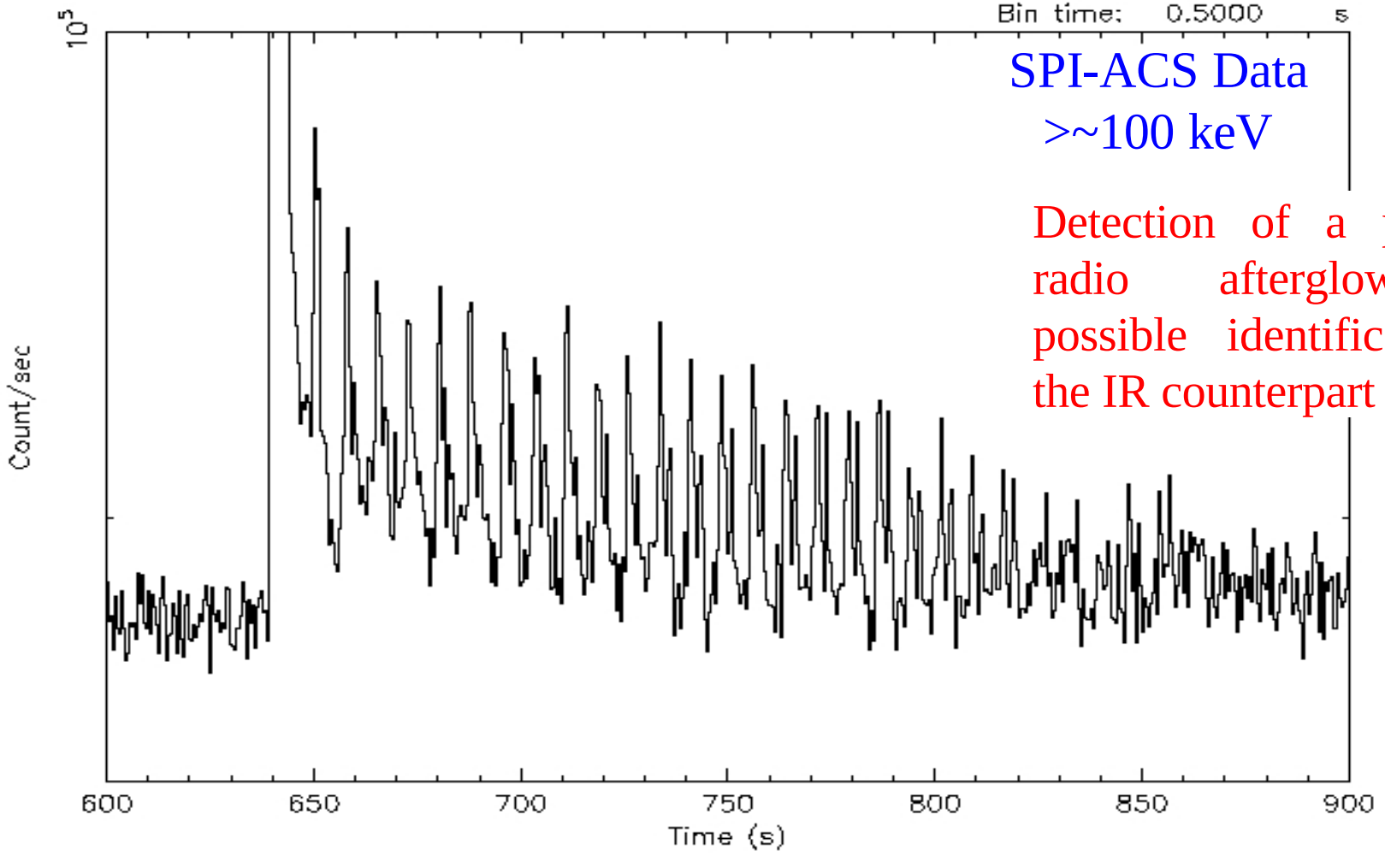


Persistent Emission: Spectra



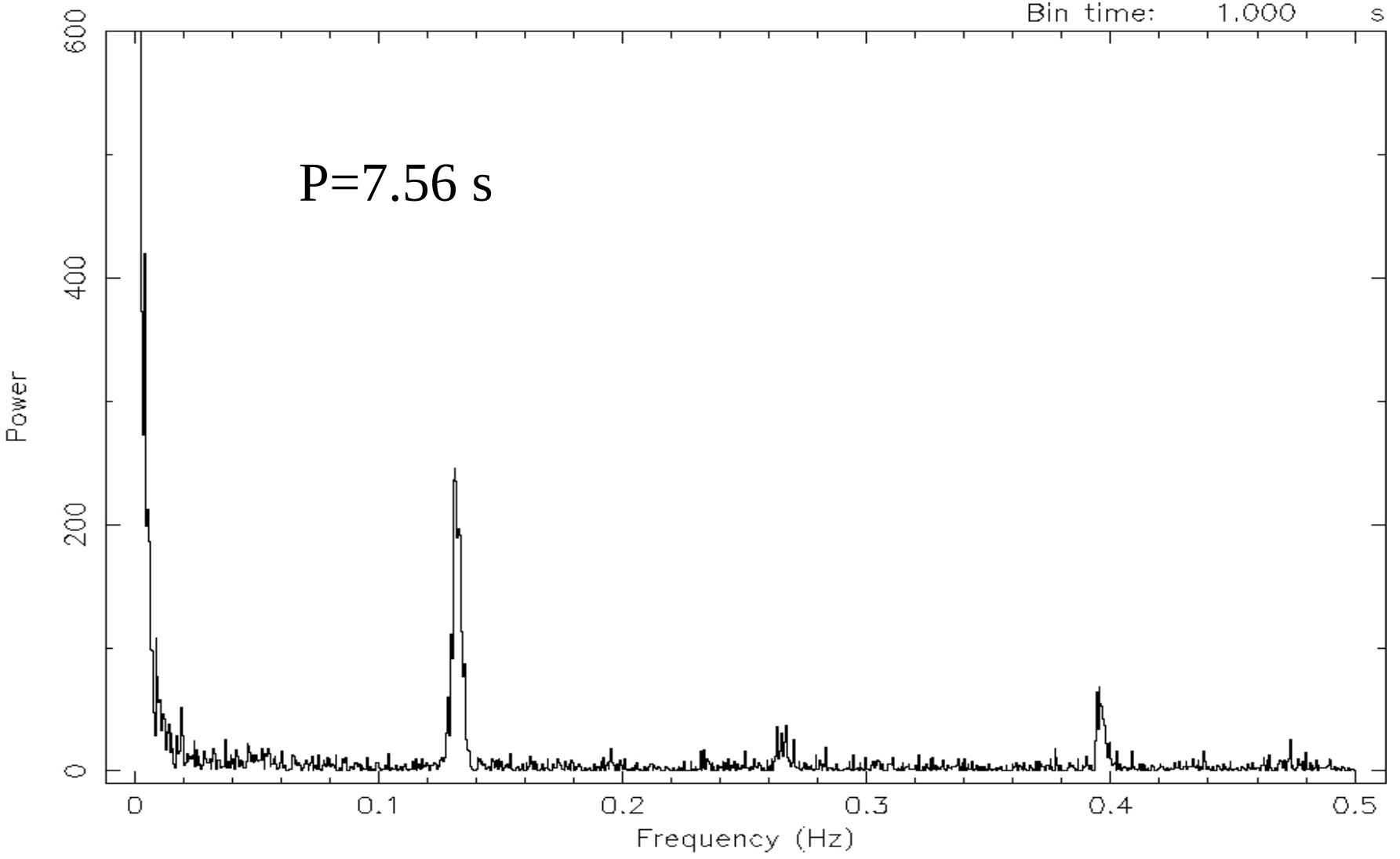
27 December 2004 Giant Flare

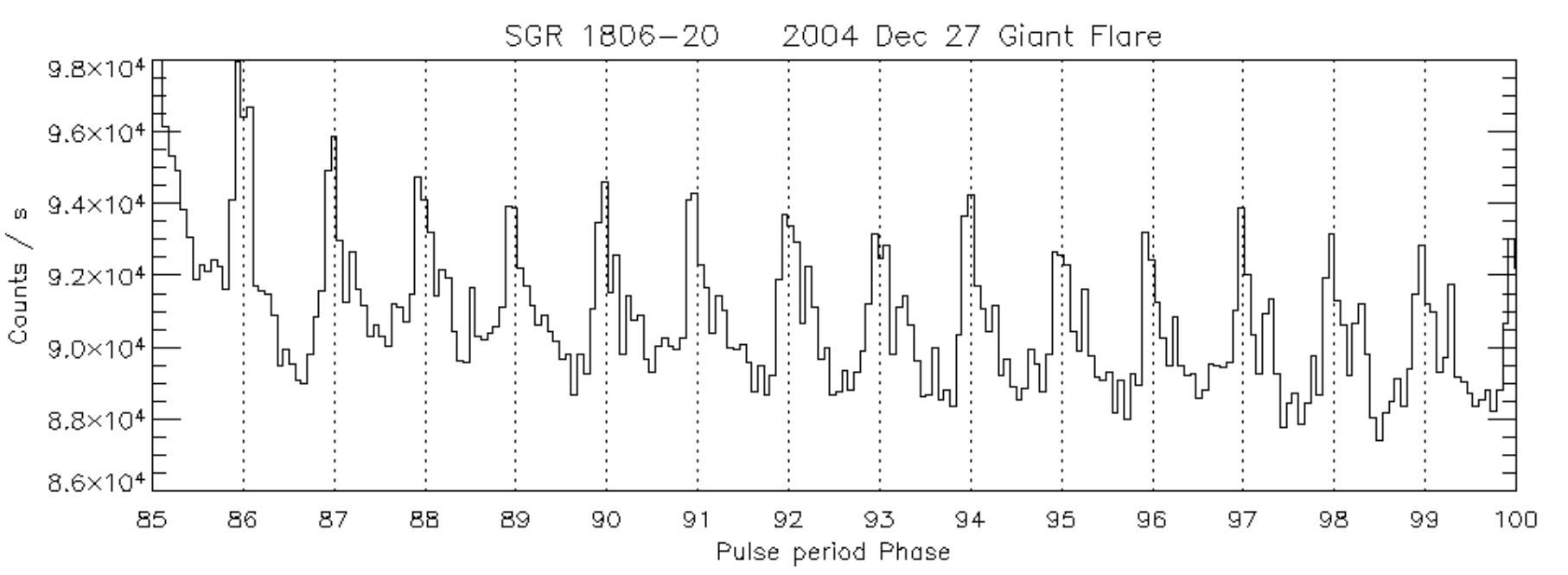
Borkowski, Götz, Mereghetti et al., 2004, GCN 2920

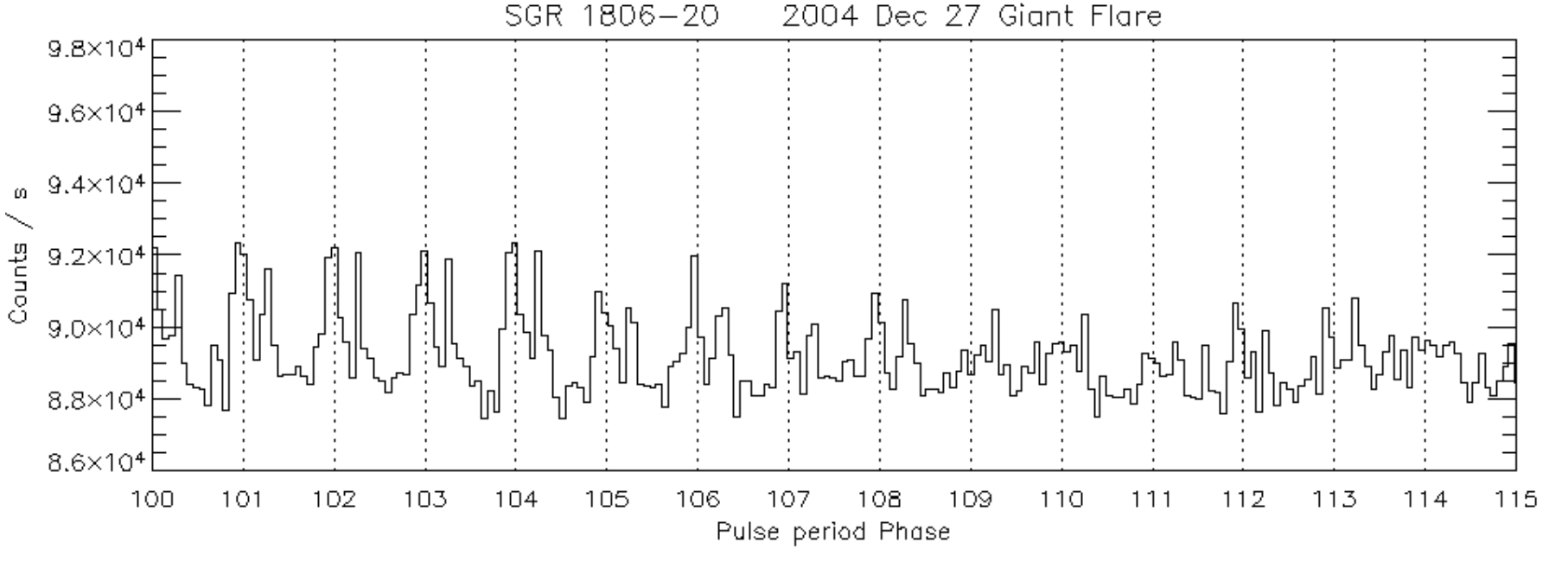


SPI-ACS Data
>~100 keV

Detection of a polarized radio afterglow and possible identification of the IR counterpart


Bin time: 1.000 s
P=7.56 s
Power
0
200
400
600
0
0.1
0.2
0.3
0.4
0.5
Frequency (Hz)
Start Time 11544 0:00:00:000
Stop Time 11544 0:29:59:000


SGR 1806−20 2004 Dec 27 Giant Flare
Counts / s
9.8×10⁴
9.6×10⁴
9.4×10⁴
9.2×10⁴
9.0×10⁴
8.8×10⁴
8.6×10⁴
85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100
Pulse period Phase


SGR 1806−20 2004 Dec 27 Giant Flare
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9.8×10⁴
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9.4×10⁴
9.2×10⁴
9.0×10⁴
8.8×10⁴
8.6×10⁴
100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115
Pulse period Phase

Summary of the *INTEGRAL* 1806 Results

- For the first time good evidence of spectral evolution within weak SGR bursts is presented

- The Data indicate a hardness-intensity anti-correlation

- Discovery of the persistent emission of SGR 1806-20 at energies above 10 keV correlated with the source activity

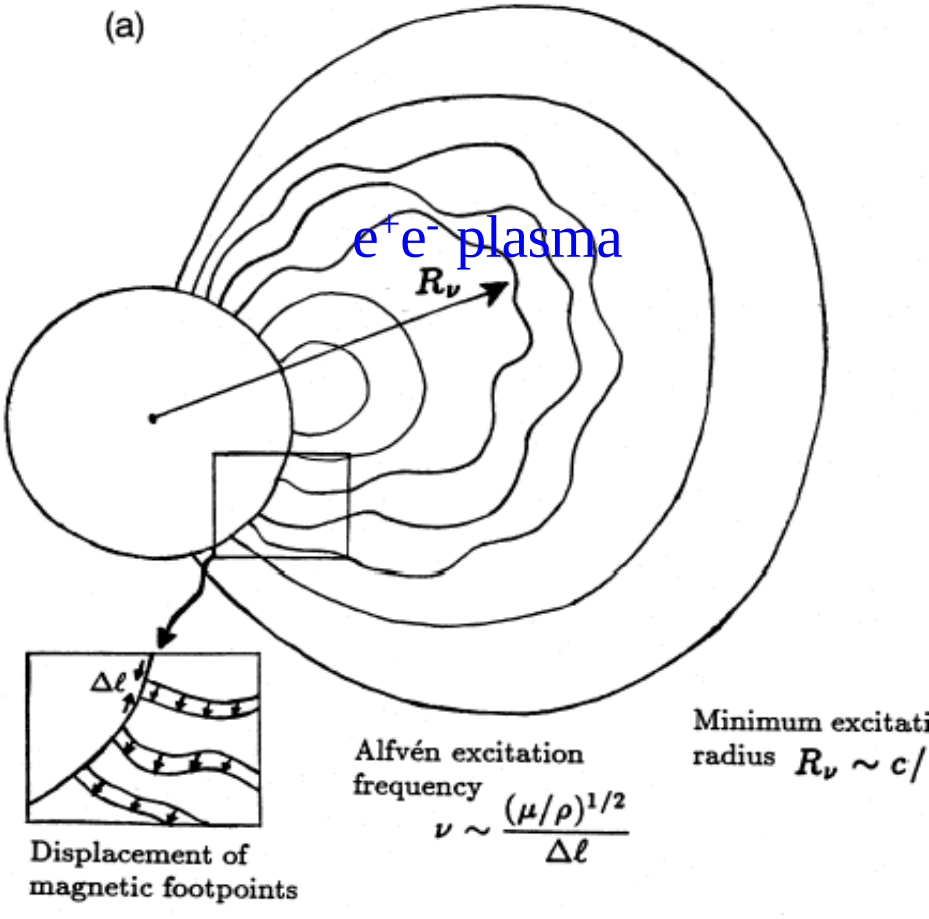
- Giant Flare Analysis is on going….

The *MAGNETAR* model predictions

Highly magnetized (B~10^{15} G), lowly rotating (P~ 5-8 s) neutron tars

Bursts are triggered by a sudden hift in the magnetospheric ootpoints driven by a fracture in he neutron star crust

The radiation originates from he cooling of an optically thick air-photon plasma



Thompson & Duncan (1995)

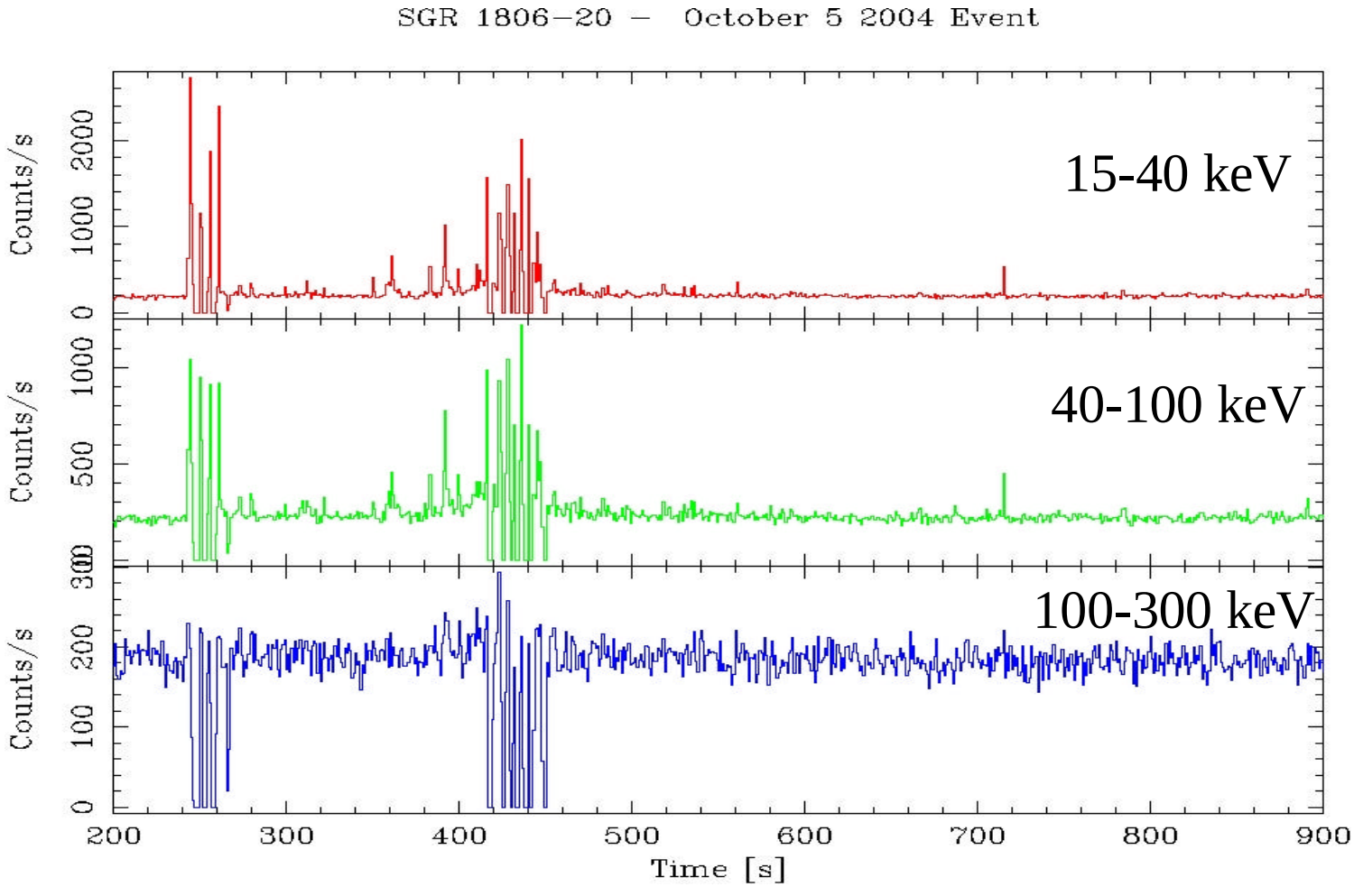
- Soft Gamma-ray Repeaters (SGRs) are a class of peculiar high-energy sources discovered through their recurrent emission of soft ?-ray bursts (4.5±0.5 sources)

- These bursts have typical durations of ~0.1 s and luminosities in the range 10^{39}-10^{42} ergs s^{-1}

- Occasionally, SGRs also emit giant bursts (E~10^{44} erg) that last up to a few hundred seconds and exhibit remarkable pulsations that reveal their spin periods

- The bursting activity and the persistent emission observed in the ~0.5-10 keV energy range are generally explained in the framework of the *Magnetar* model as caused by a highly magnetized (B~10^{15} G) slowly rotating (P~ 5-8 s) neutron star.

- The source activity has been growing until the October 5th 2004 Huge Outburst (GCN 2763)



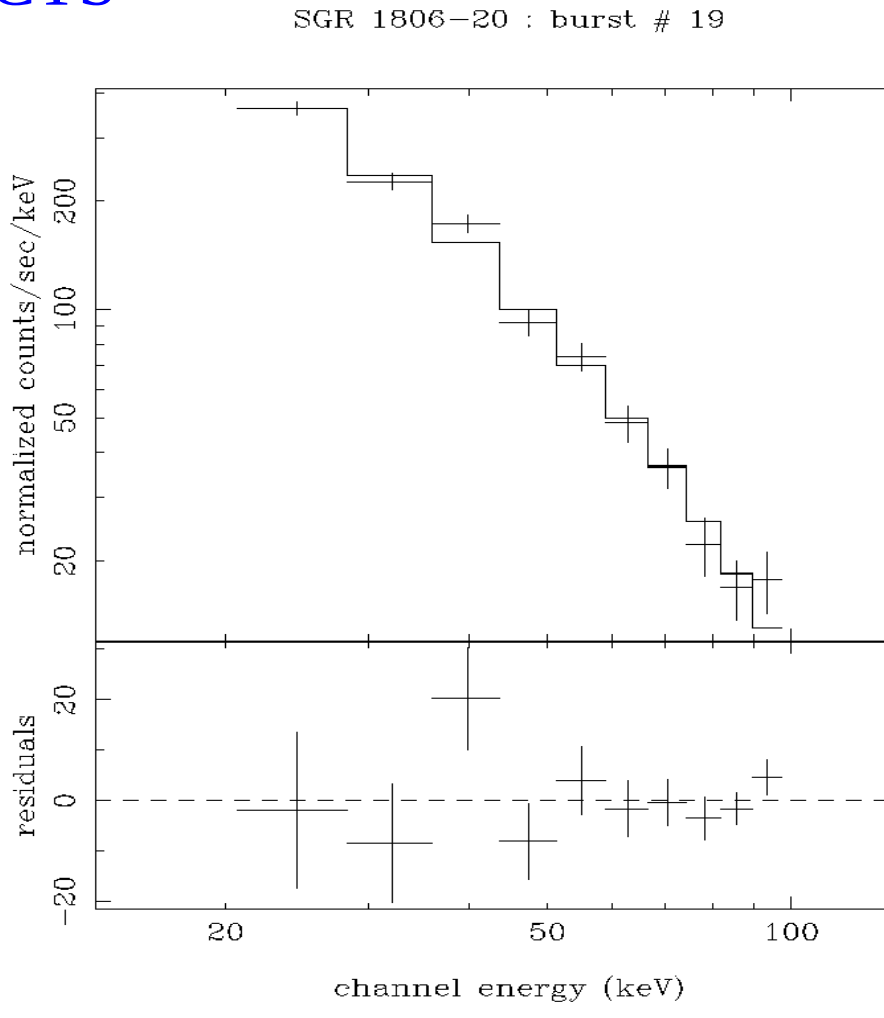
- Culminating in the exceptional Giant Flare of Decmeber 27th 2004 (GCN 2920) never observed from 1806 before

THE SGR BURSTS OBSERVED BY IBIS ARE NORMAL IN MOST RESPECTS

- Durations, energy spectra are typical (OTTB with kT 20-40 keV).

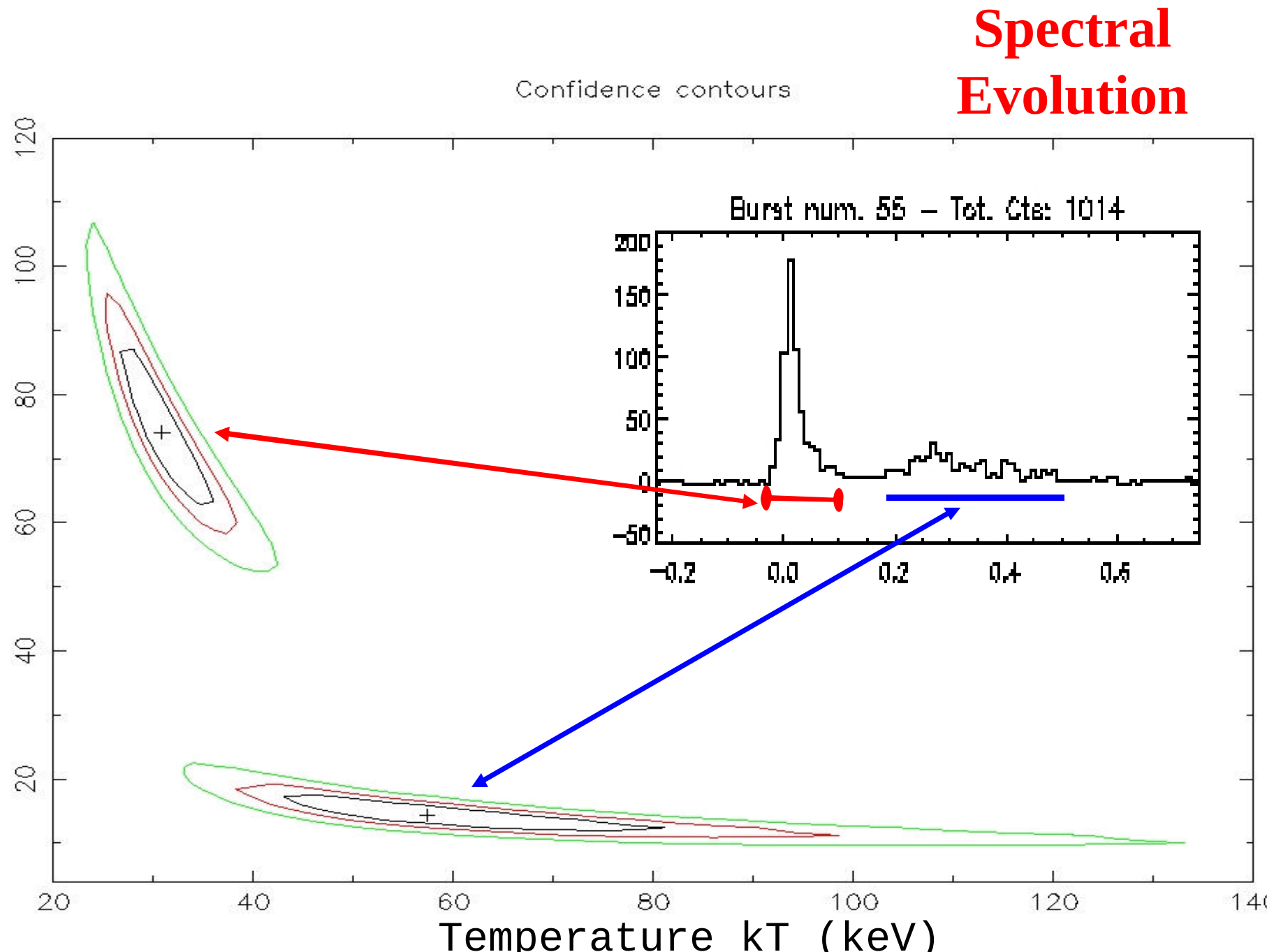
The more complicated models needed at lower energies (<15 keV e.g. Feroci et al. (2004) for 1900+14 bursts) are statistically not requested.

- However, the fluences are very low, ~1.5×10^{-8} erg/cm^2, 25-100 keV

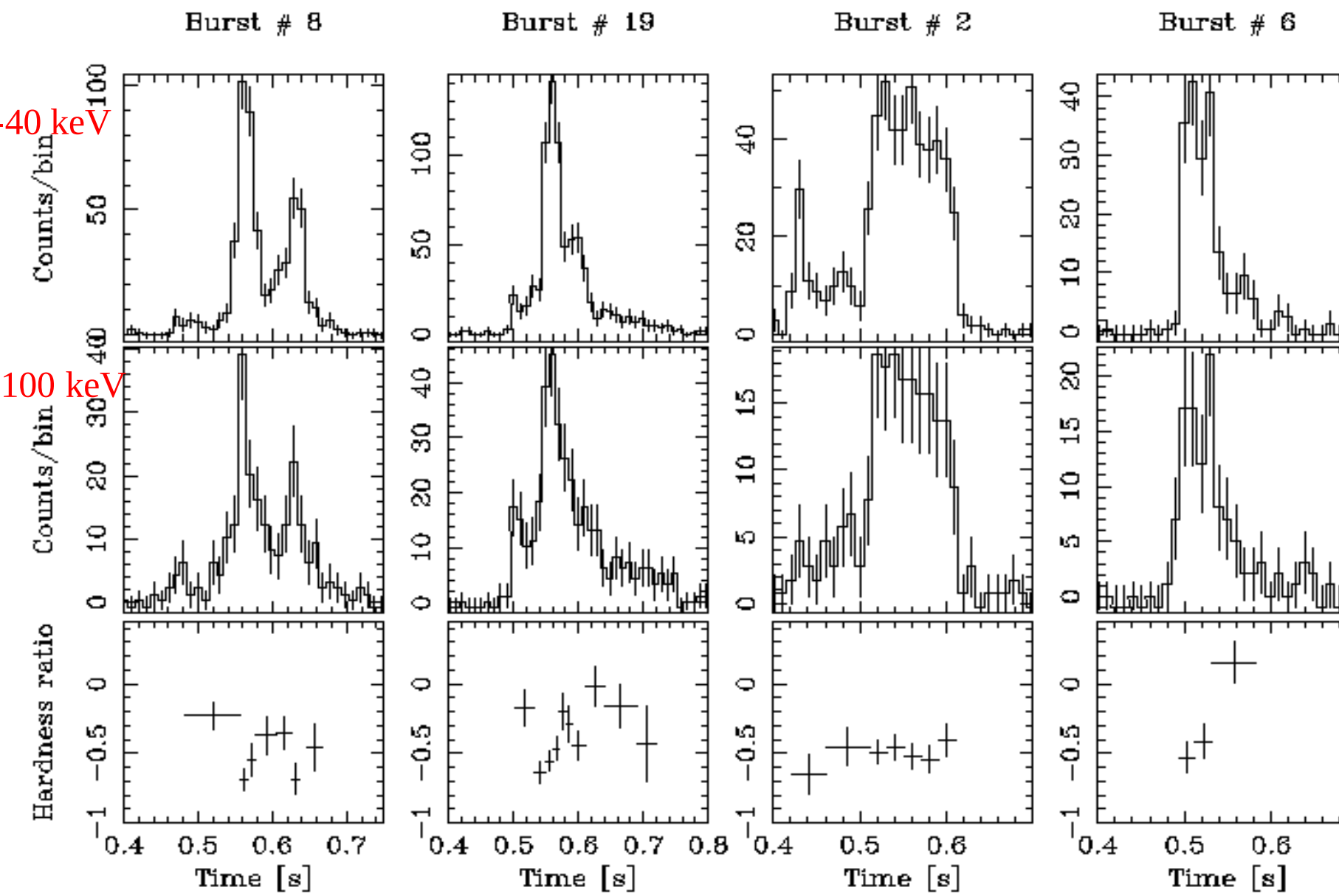


- These are the among the weakest bursts seen from this SGR; thanks to imaging, we are certain that the source is indeed SGR1806-20

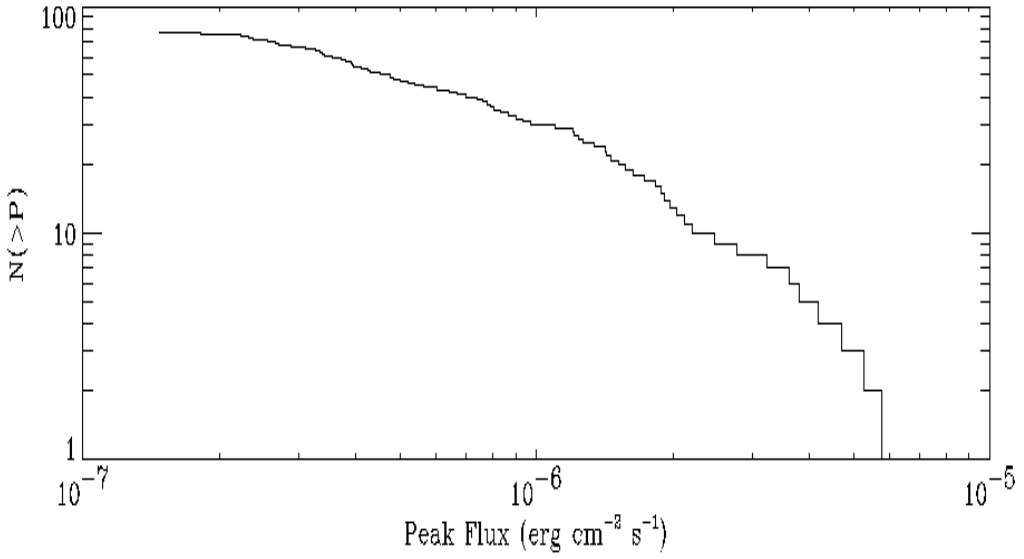
Spectral Evolution



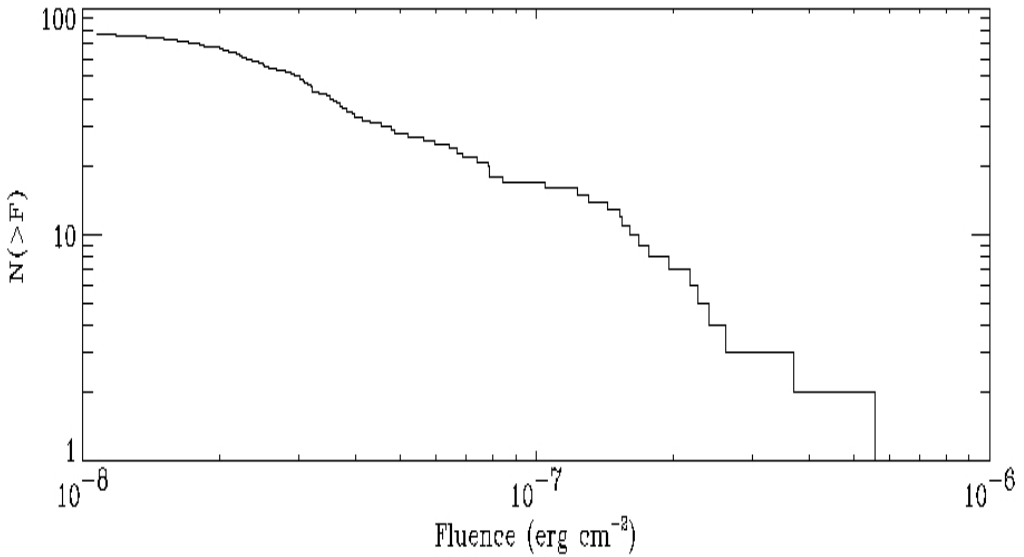
Spectral Evolution of weak bursts with INTEGRAL



Götz et al., 2004, A&A, 417, L45



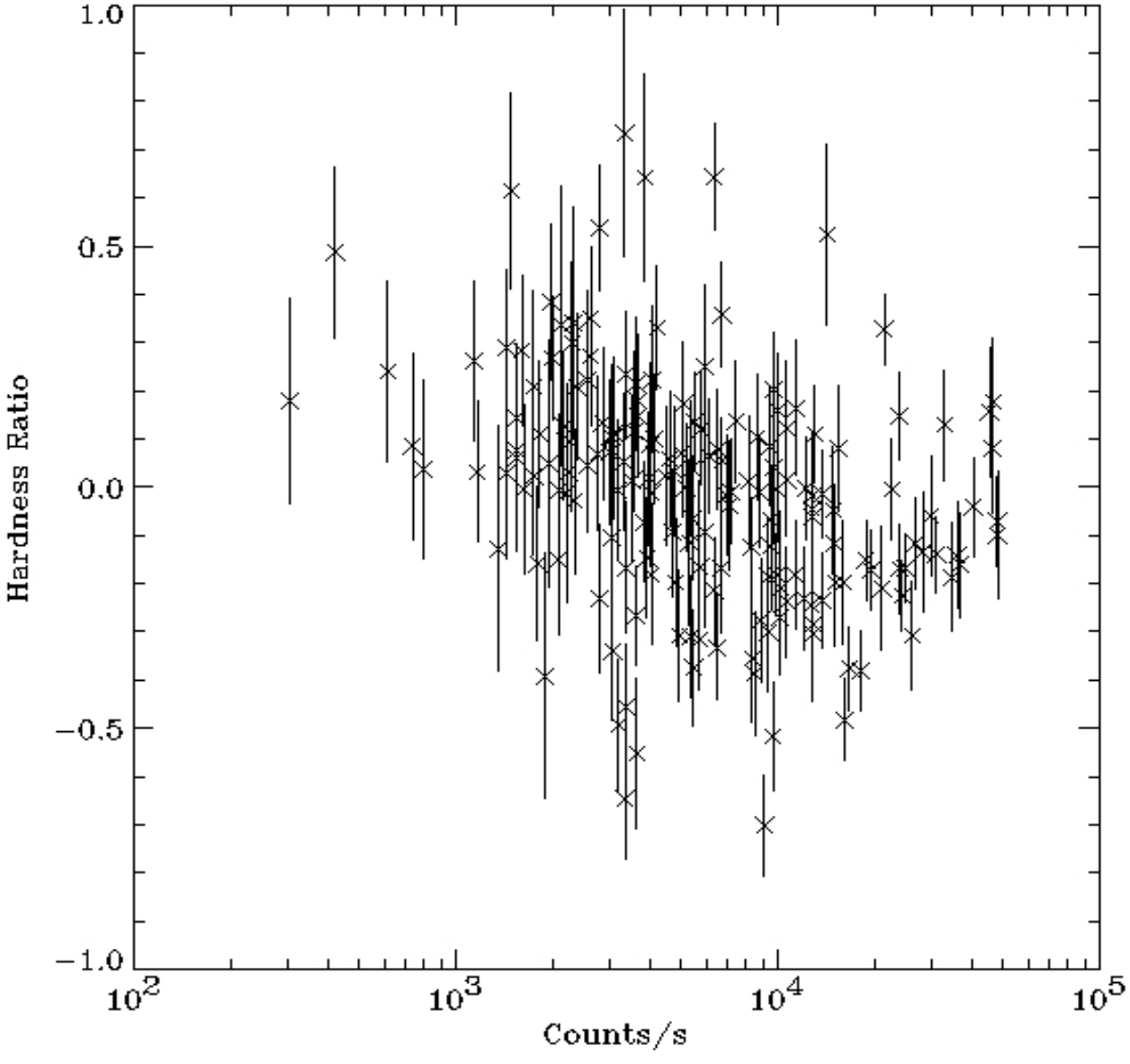
INTEGRAL Log N- Log P
(Peak Flux distribution)



INTEGRAL Log N- Log S
(Fluence distribution)

Index -0.85±0.04

2003 and 2004 bursts



P~1.6×10