

Cross-calibration of high energy instruments

Lorenzo Natalucci

Istituto di Astrofisica e Planetologia Spaziali, INAF, Rome, Italy

and

the *IACHEC* Team



<http://web.mit.edu/iachec>

IUG Meeting, ESTEC 27 November 2013

What is IACHEC?

- ◆ The IACHEC is the *International Astronomical Consortium for High-Energy Calibration*
- ◆ Founded in 2006 on impulse by Marcus Kirsch (ESA) and Steve Sembay (University of Leicester). Chaired by Matteo Guainazzi (ESA)
- ◆ It acts as a forum where astronomers involved in calibration of past, present (operational) and future missions work together to improve the cross-calibration among their instruments
 - ◆ Past missions: ASCA, BeppoSAX, ROSAT, RXTE
 - ◆ Operational missions: Chandra, Fermi, Integral, MAXI, Suzaku, Swift, XMM-Newton, NuSTAR
 - ◆ Future missions: Astro-H, eRosita, HXMT, Athena+, LOFT
- ◆ Not directly funded by any Agencies or institutions. Individual projects/missions contribute through the work and mission budget of their calibration teams
- ◆ Strongly endorsed by *XMM-Newton* and *Chandra* User's Group

IUG Meeting, ESTEC 27 November 2013

The IACHEC Team



2006
Nesbud, Iceland

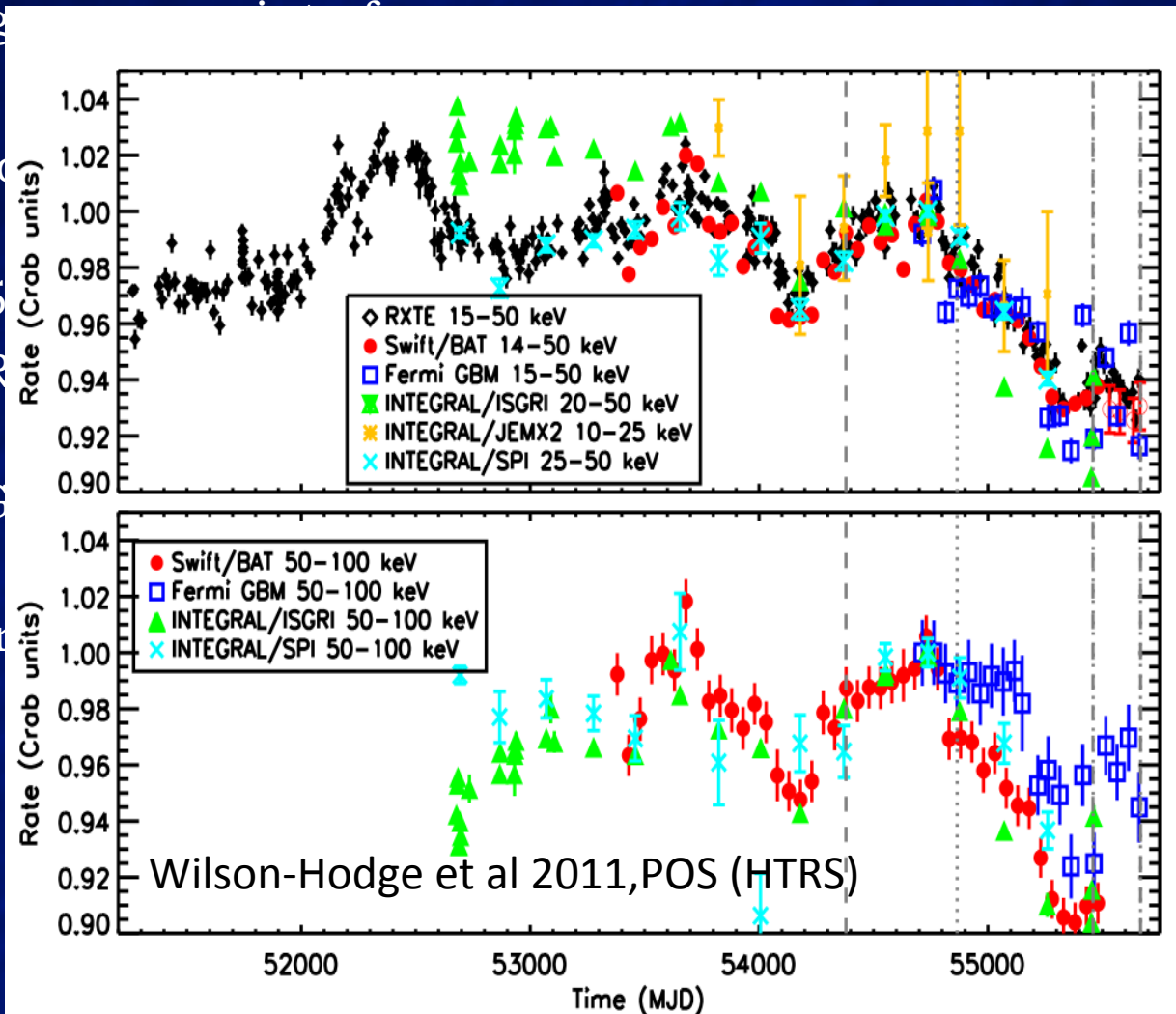


2013
Leicestershire, UK

IUG Meeting, ESTEC 27 November 2013

Standard Candles under study

- ◆ Within the IACHEC, a number of activities is focused on standard candles. The following
- ◆ White Dwarfs: HZ43,
- ◆ Clusters of galaxies (of the HIFLUGCS sample)
- ◆ Isolated NS: RX J185
- ◆ thermal Supernova Remnants (SNRs: Cassiopeia A, SNR 0509-67.5 lines)
- ◆ non-thermal SNRs: Cassiopeia A (area)
- ◆ A standard candle is a source whose luminosity it should be regularly



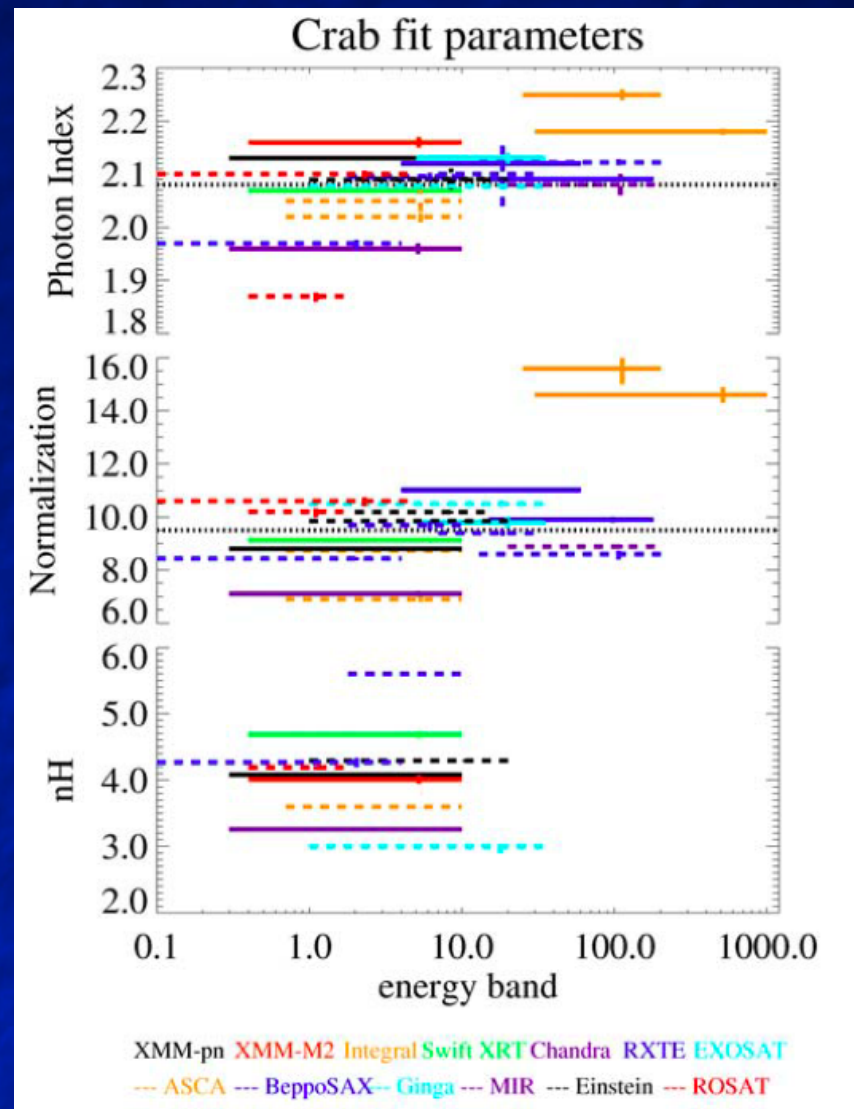
The historical Standard Candle: the Crab

- ◆ For observations before 2005, a reference summary is in the M. Kirsch paper:

ENERGY RANGE IN KEV	$N_H(H)$	Γ	N
0.2-2	4.07	2.02	8.95
2-10	4.5 (f)	2.07	8.26
10-50	4.5 (f)	2.12	9.42
50-1000	4.5 (f)	2.17	10.74
0.1-1000	4.5	2.08	8.97

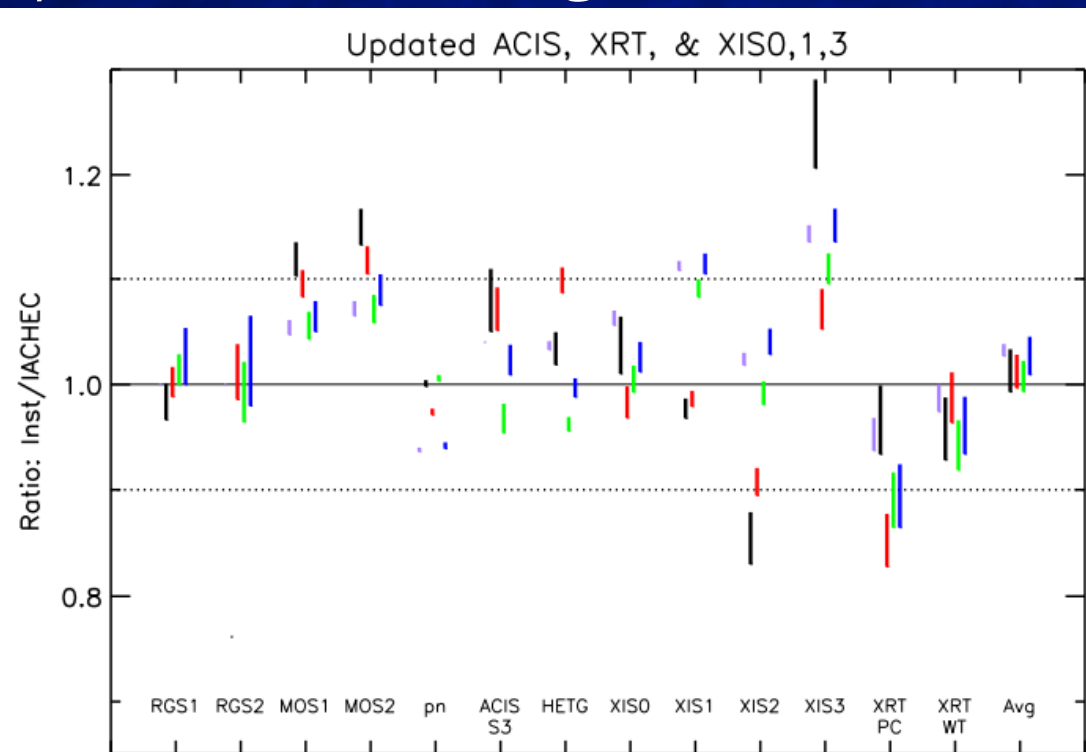
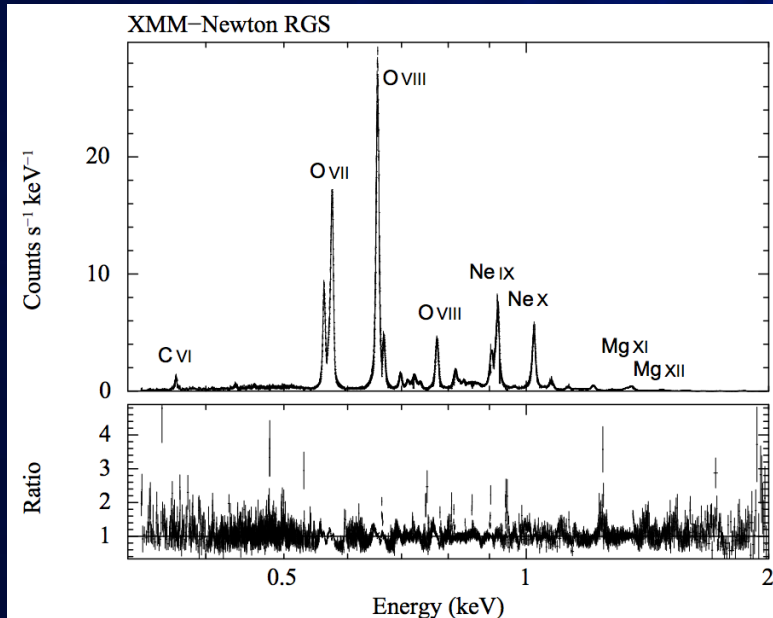
- ◆ Results seem largely inconsistent among different instruments, but this is partly due by the use of a single power law to fit different ranges

(Kirsch et al, SPIE 2005)



Cross-calibrating CCD detectors using 1E 0102.2-7219

- ◆ Cross-calibrating *Chandra*/ACIS, *XMM-Newton*/EPIC, *Suzaku*/XIS and *Swift*/XRT with the brightest SNR in the SMC
- ◆ Model built by XMM-

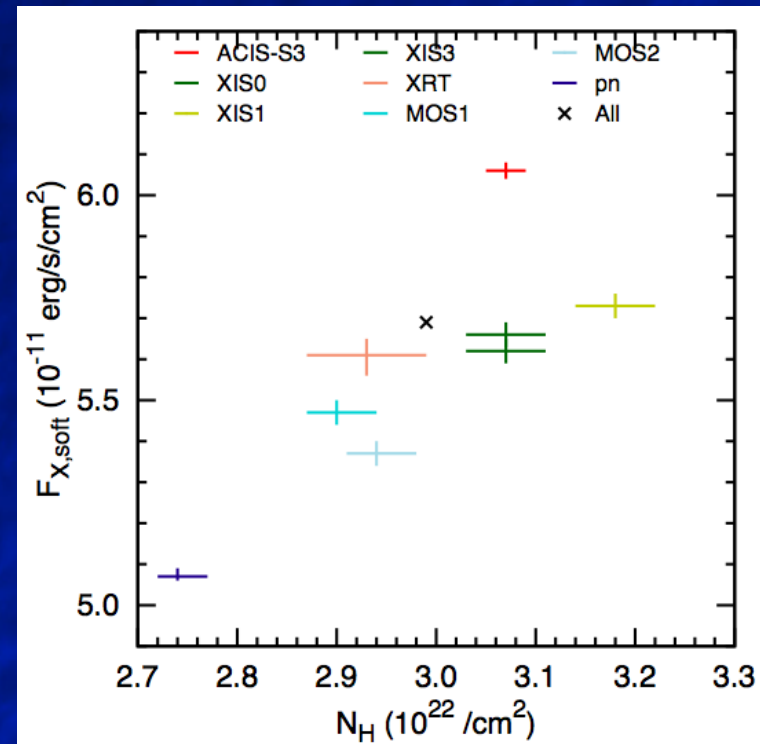
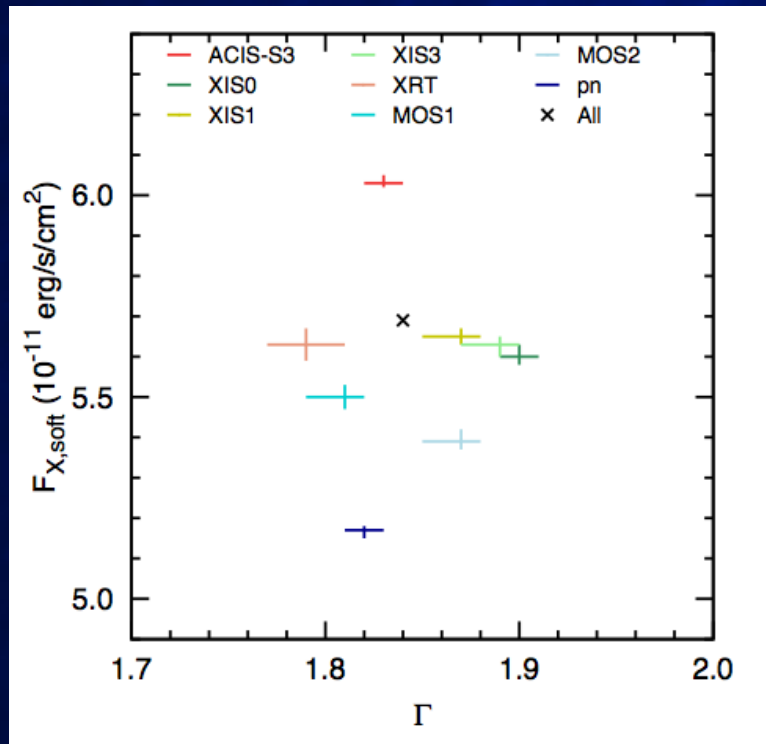


Ratio of the O VII triplet, O VIII Ly α , Ne IX triplet, and Ne X Ly α line normalisations, as well as a global normalisation factor, when the IACHEC model is applied to the E0102 spectra of different missions (Plucinsky et al., SPIE 2012)

IUG Meeting, ESTEC 27 November 2013

Cross calibration in the soft X-rays using G21.5-0.9

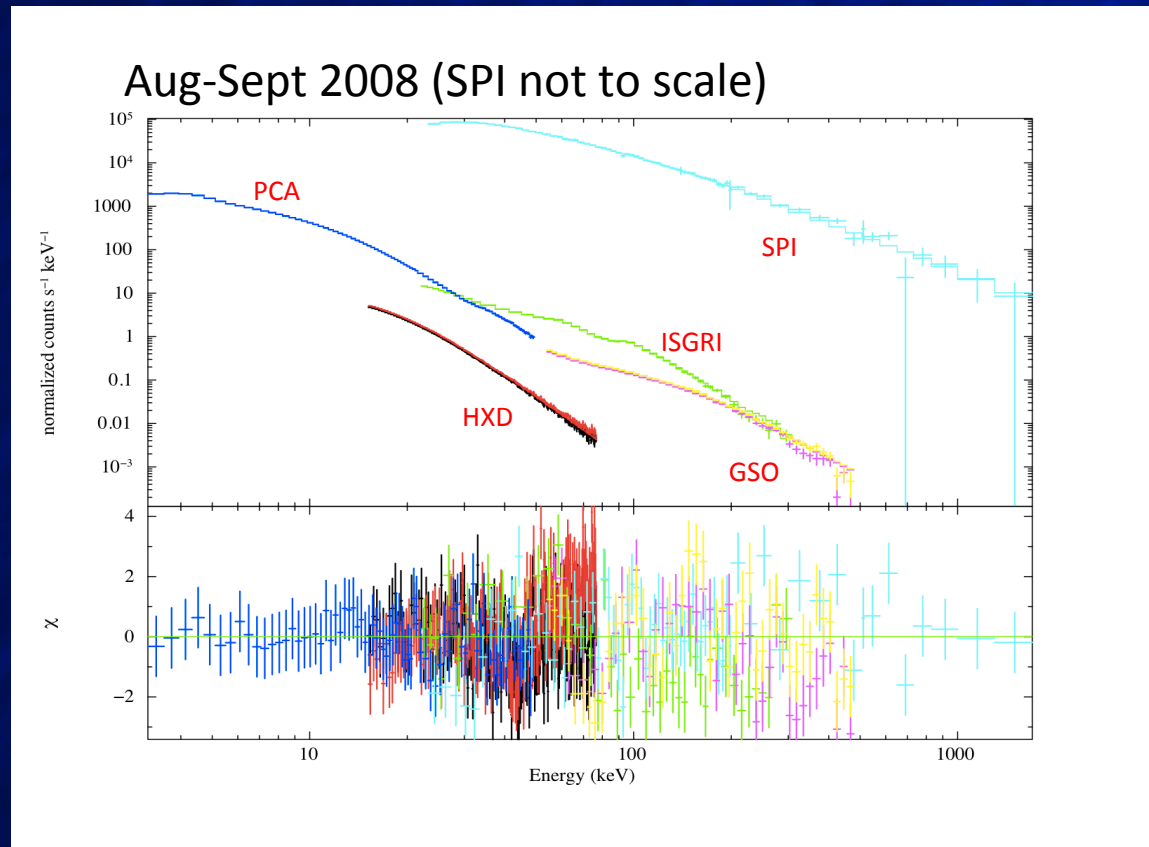
- ◆ The Crab Nebula is both too bright and extended to be an ideal calibration standard in the soft band.
- ◆ the Pulsar Wind Nebula in G21.5-0.9 is used to cross-calibrate both soft and hard band instruments.



Scatter plot of absorbed PL fit parameters for *soft-band* instruments.
(Tsujiimoto et al., A&A 2010)

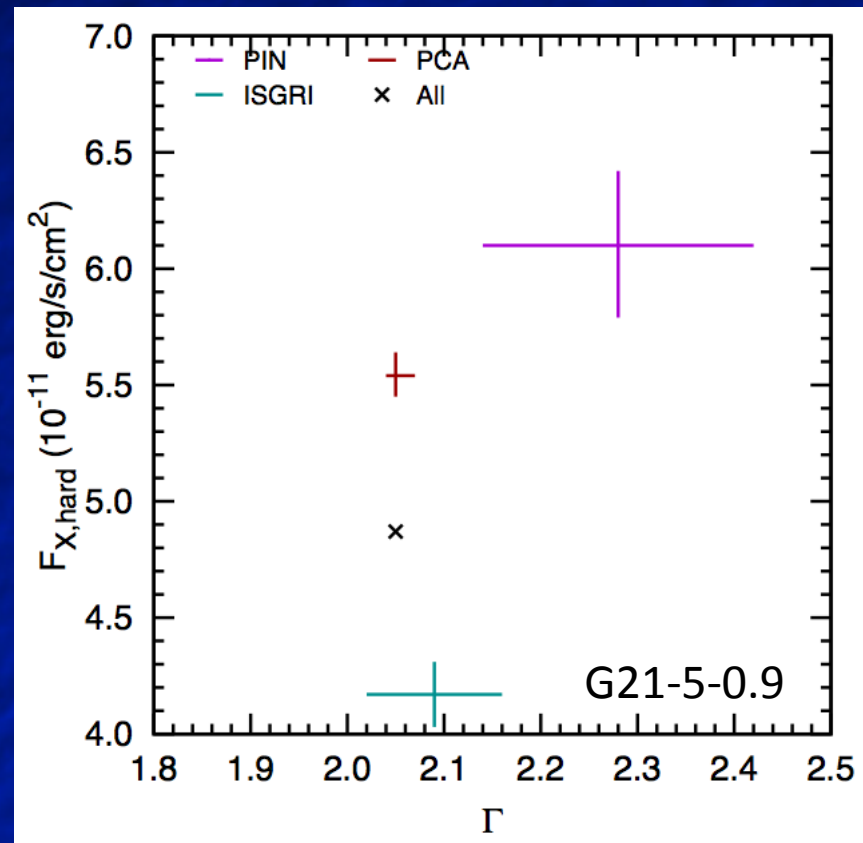
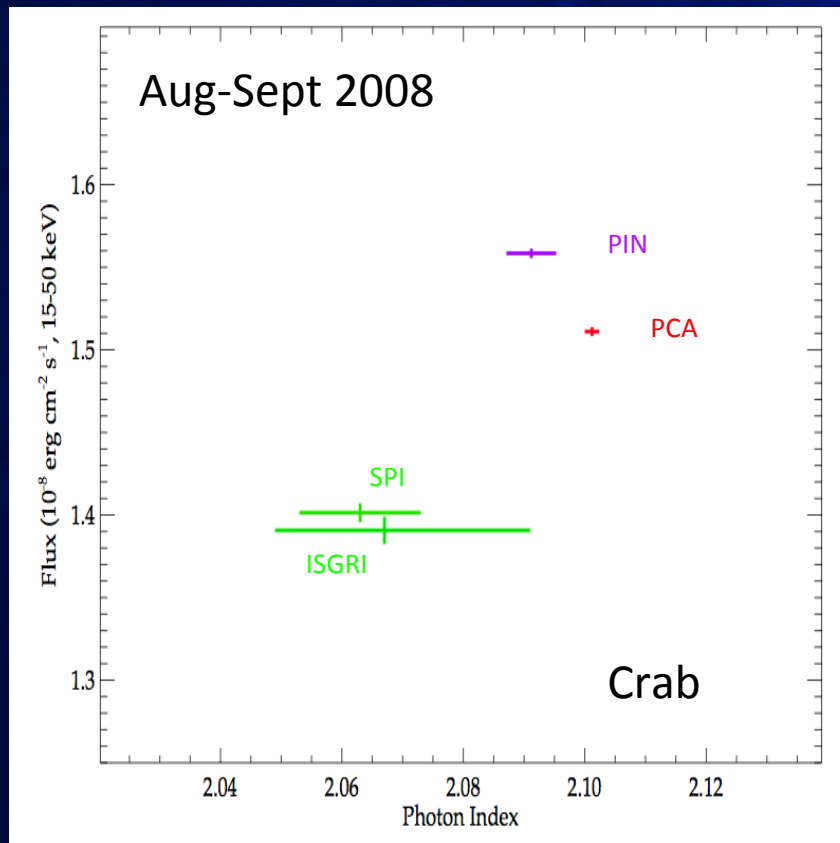
Hard X-rays: Crab

- ◆ Most hard X-ray instruments observe the Crab periodically, roughly at the same epochs.
- ◆ Exploiting a dataset of 10 nearly simultaneous observations (>2005).



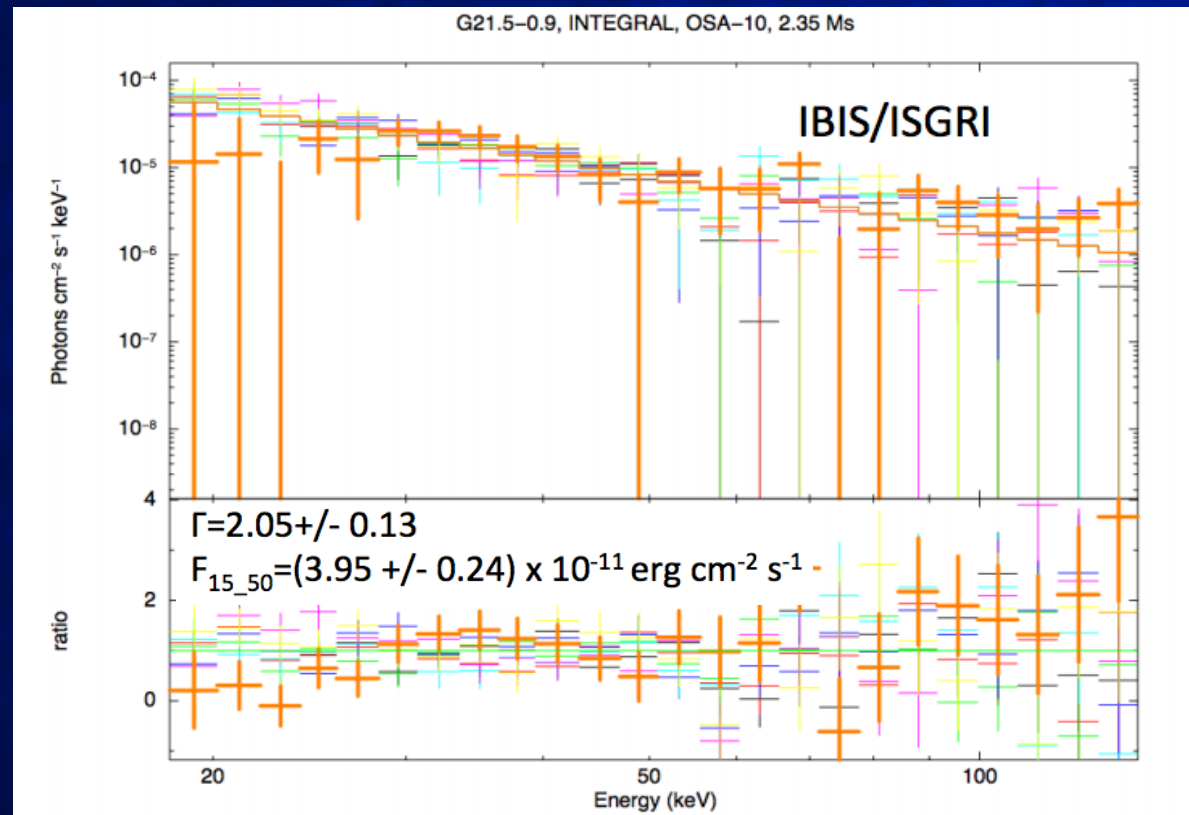
Crab vs G21.5 in the hard band

- ◆ First results are broadly consistent with Tsujimoto et al. (2010)



On-going projects, involving *NuSTAR*

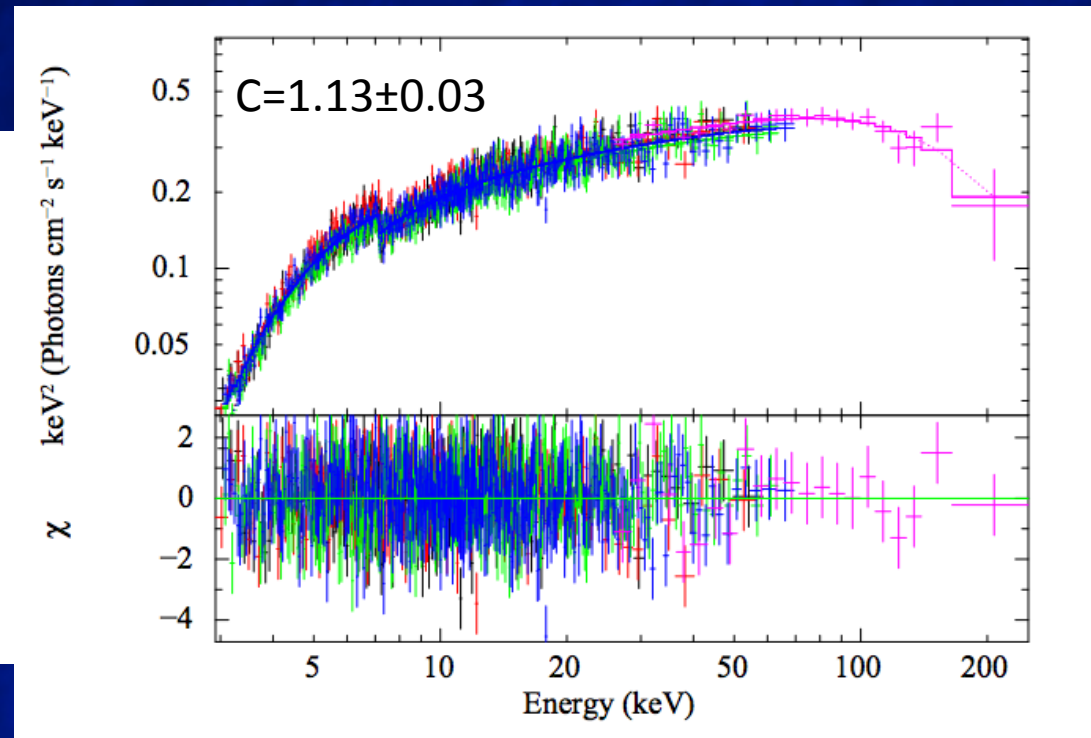
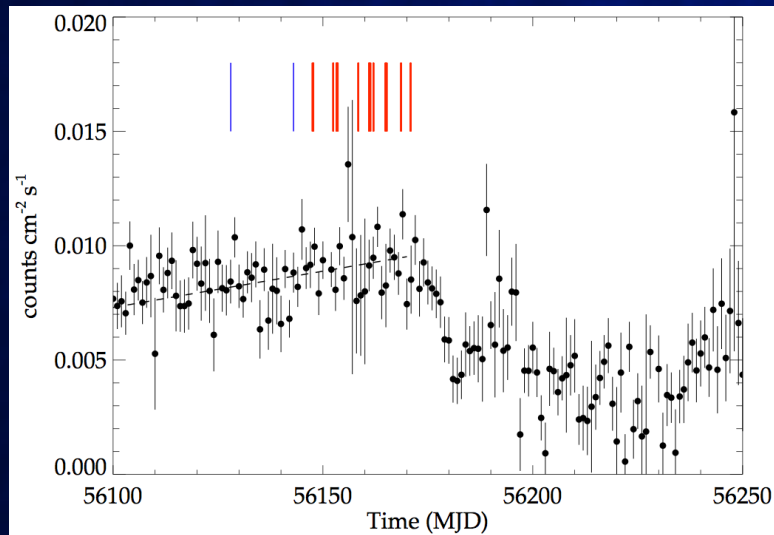
- ◆ Cross-calibration using PKS 2155 (simultaneous observations).
- ◆ G21.5 update with added *NuSTAR*, *Chandra* and more recent data



IUG Meeting, ESTEC 27 November 2013

NuSTAR and IBIS

- ◆ Spectrum of the Great Annihilator shows good agreement between *NuSTAR* and IBIS/ISGRI.



Nearly simultaneous observation of 1E1740.7-2942
(Natalucci et al., ApJ in press)