

# Non Thermal SNR WG meeting Report

## **Attendees:**

Yuan-Hao Wang, Haihui Zhao, Xin Zhou, Dipankar Bhattacharya, Yoshitomo Maeda, Michael Smith, Fangjun Lu, Paul Plucinski, Xi Long, Lorenzo Natalucci, Mingyu Ge, Kristin Madsen (*on skype*)

## **Items discussed:**

- ✓ Crab cross-calibration: status and updates since last year/ path to completion
- ✓ G21.5-0.9: new cross-cal including *NuSTAR* (update of Masahiro's paper?)
- ✓ Crab X-ray timing vs. radio (pres. by Mingyu Ge)

# Crab cross-calibration status

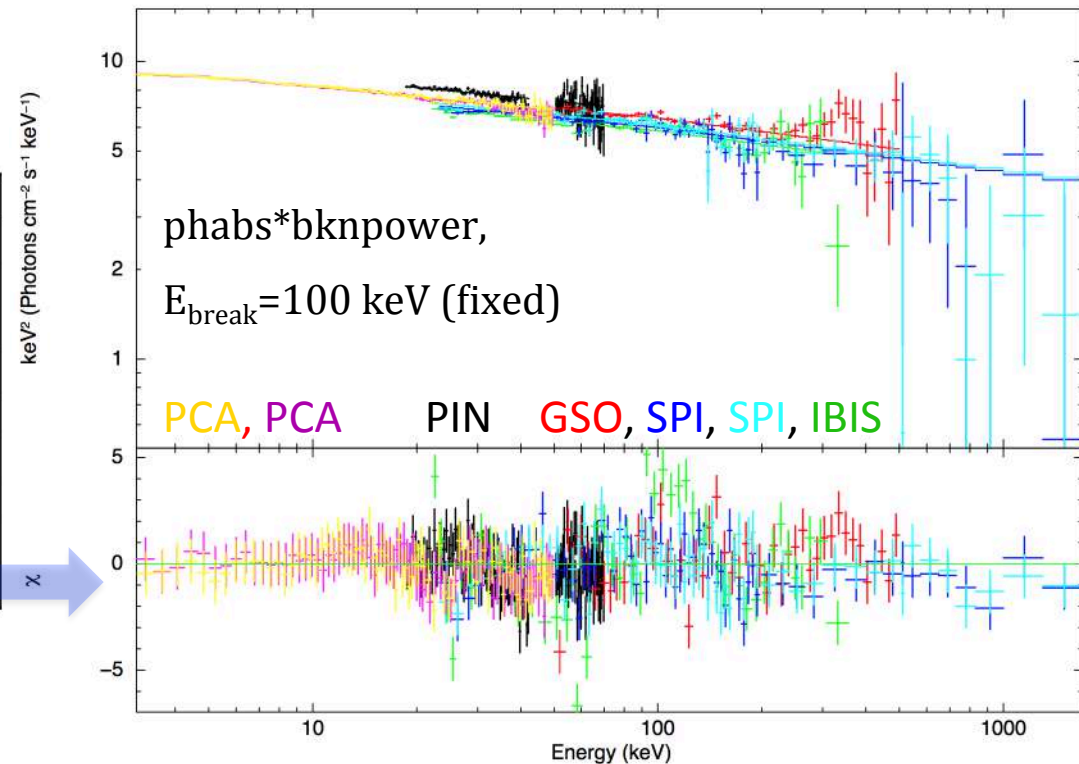
- ✓ Effort based on nearly simultaneous observations of *Suzaku*, *XMM*, *RXTE*, *INTEGRAL*, *NuSTAR*
- ✓ Instruments involved: XIS, HXD(PIN, GSO), EPIC/pn (burst mode), PCA, IBIS, SPI, NuSTAR(FPMA & B)
- ✓ Selection criteria: exposure close enough in time (typically < ~2 weeks)
- ✓ 11 nearly simultaneous epochs up to Nov 2014;

## **Recent updates**

- ✓ *XMM/NuSTAR/INTEGRAL* coordinated, simultaneous observation executed in Nov 2014
- ✓ Observations in September 2012: *NuSTAR*, *Suzaku* & *INTEGRAL*, nearly simultaneous (<5 days)
- ✓ Instrument calibration updates:
  - NuSTAR* calibration paper on astro-ph (K.Madsen, arXiv: 1504.01672)
  - IBIS/ISGRI, calibration issues in OSA 10
  - EPIC-pn burst mode calibration update in 2014

# Nearly simultaneous observations before 2011

Epoch	Date	Instruments
A	Sept-Oct 2005	PCA,HXD,IBIS,SPI
B	Sept 2006	PCA,HXD,IBIS,SPI
C	March 2007	XIS,PCA,HXD,SPI
D	Sept 2007	PCA,IBIS,SPI
E	August-Sept 2008	PCA,HXD,IBIS,SPI
F	August 2009	PCA,SPI
G	March-April 2010	PCA,IBIS,SPI,HXD
H	Sept 2010?	PCA,SPI
I	Feb-Mar 2011	PCA,IBIS,SPI,HXD



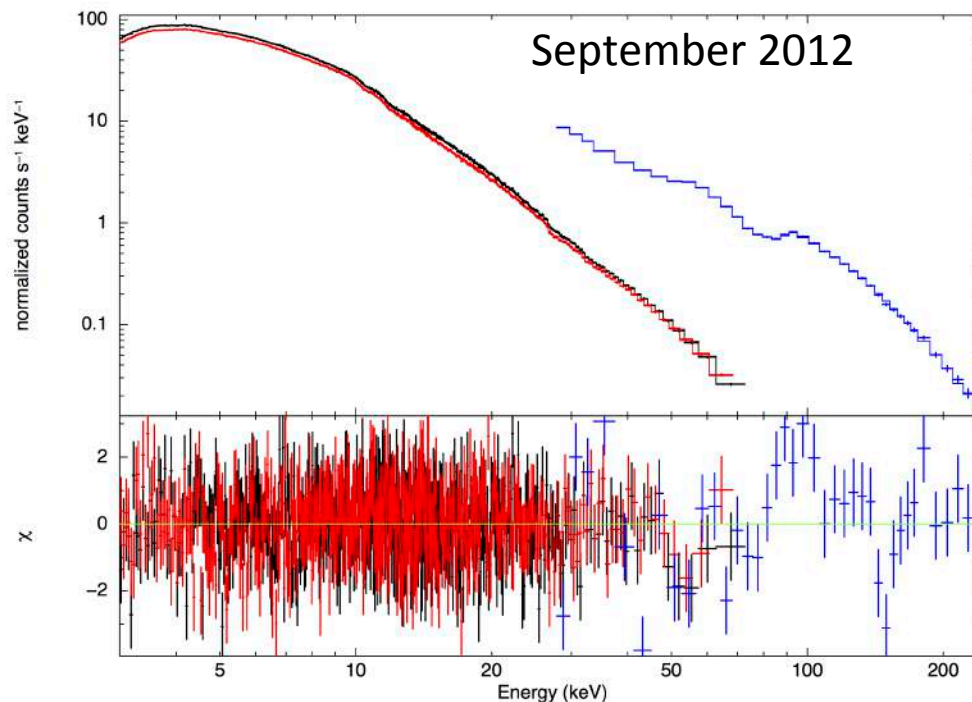
PIN	GSO	IBIS	SPI(1)	SPI(2)	PCA(1)	PCA(2)
1.13	1.08	0.97	1.0	1.02	1.06	1.06

All the fits are performed by imposing a break energy at 100 keV.

Both SPI and HXD/GSO see a spectral break around this energy in the individual spectra.

# Additional data: NuSTAR, INTEGRAL, Suzaku

- ✓ Nearly simultaneous observations: 21-26 September 2012.
- ✓ NuSTAR & IBIS/ISGRI spectra are shown. SPI spectrum is also available, and Yuki Terada has been contacted for HXD



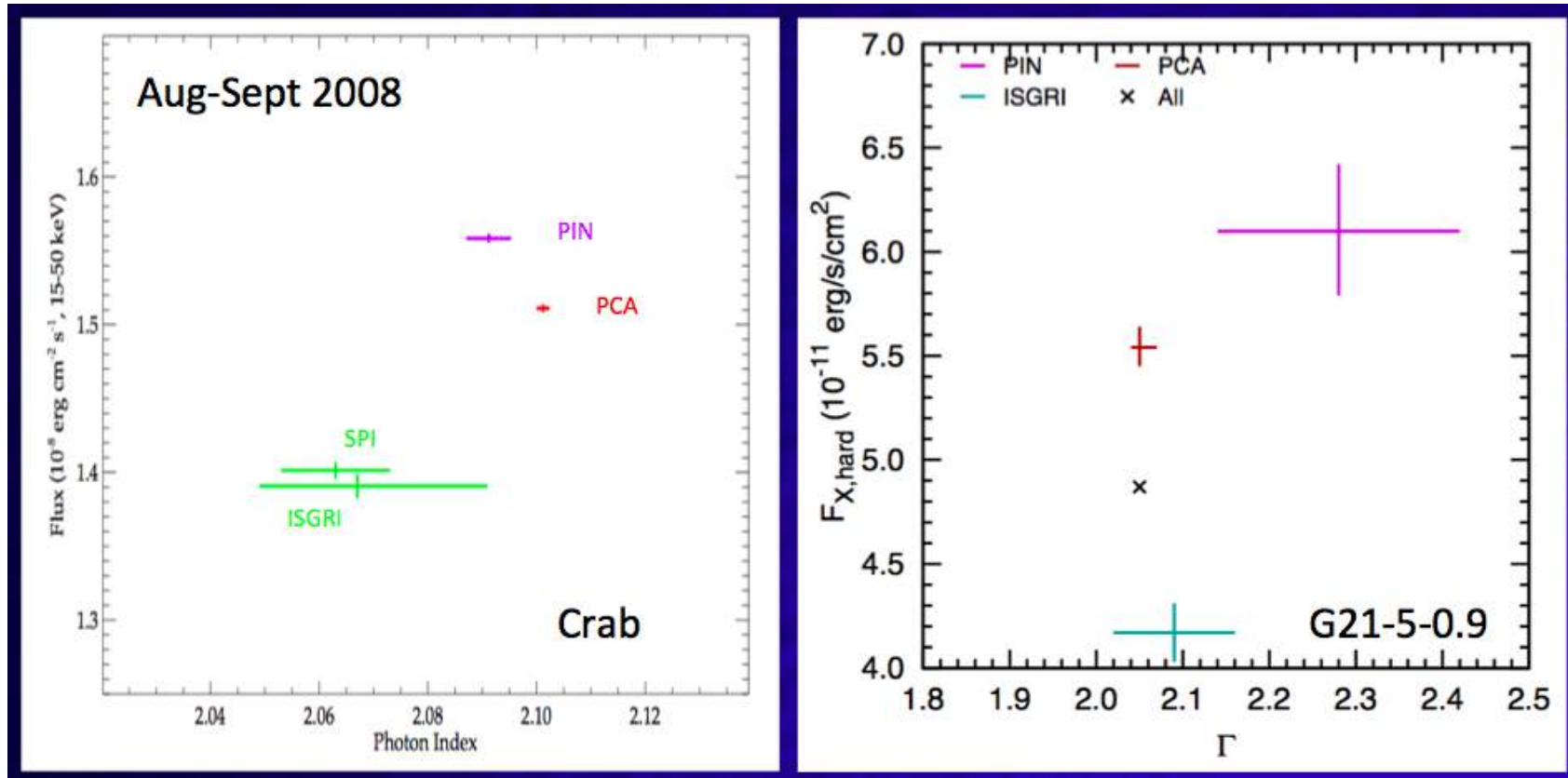
Ratios NuSTAR FPMA & B to ISGRI

constant	factor		0.884390	+/-	1.64107E-03
TBabs	nH	10 <sup>22</sup>	0.318476	+/-	1.83858E-02
bknpower	PhoIndx1		2.09731	+/-	1.07648E-03
bknpower	BreakE	keV	122.176	+/-	6.02187
bknpower	PhoIndx2		2.33956	+/-	5.57559E-02
bknpower	norm		9.76053	+/-	4.05887E-02
Data group: 2					
constant	factor		0.888123	+/-	1.65385E-03
Chi-Squared = 958.24 using 906 PHA bins.					
Reduced chi-squared = 1.0659 for 899 degrees of freedom					
Null hypothesis probability = 8.331972e-02					

- ✓ Nustar spectra extracted using 200" extraction radius
- ✓ Comparing with HXD/PIN will constitute an important test. The PIN/NuSTAR normalization constant is reported as  $\sim 1.13 \pm 0.04$  (Madsen et al, arXiv:1504.01671v1)

# Crab vs G21.5-0.9 in the hard band

15-50 keV

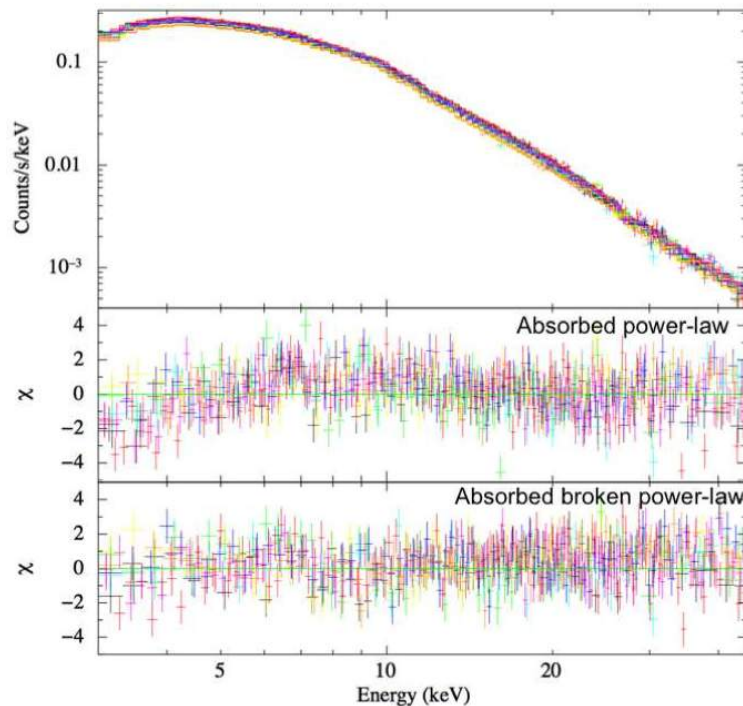


Epoch E

Results are **broadly consistent** with the Tsujimoto et al. 2010 paper

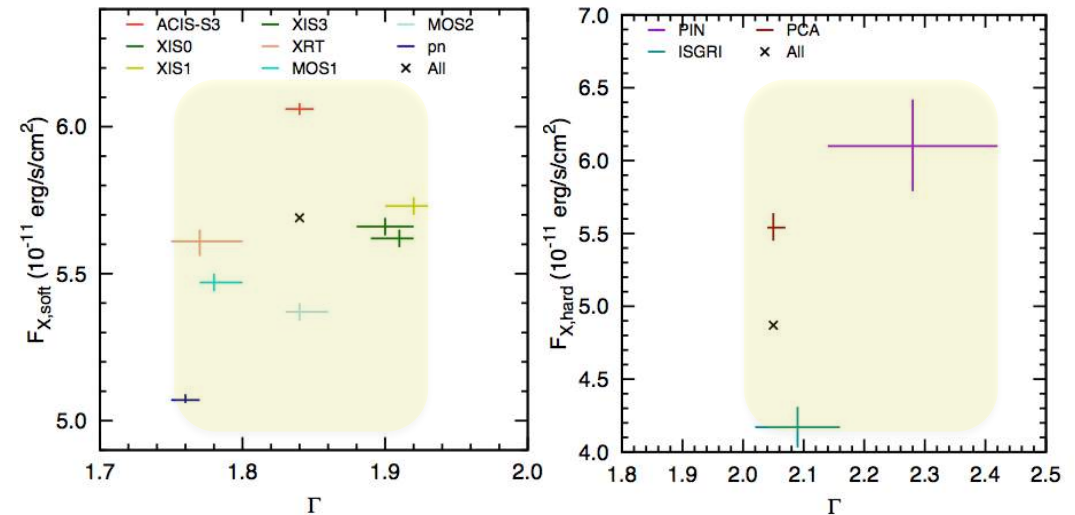
# G21.5 -0.9

- ✓ Spatial resolved spectroscopy detects spectral softening with increasing radius, in the <10 keV band (as already observed by Chandra)
- ✓ Discovery of spectral break at ~9 keV
- ✓ Change of slope also evident in IACHEC paper: not due to instrumental bias
- ✓ G21.5-0.9 is unfit to calibrate medium/hard X-ray instruments on ASTROSAT and HXMT



Nynka et al, ApJ 789,2014

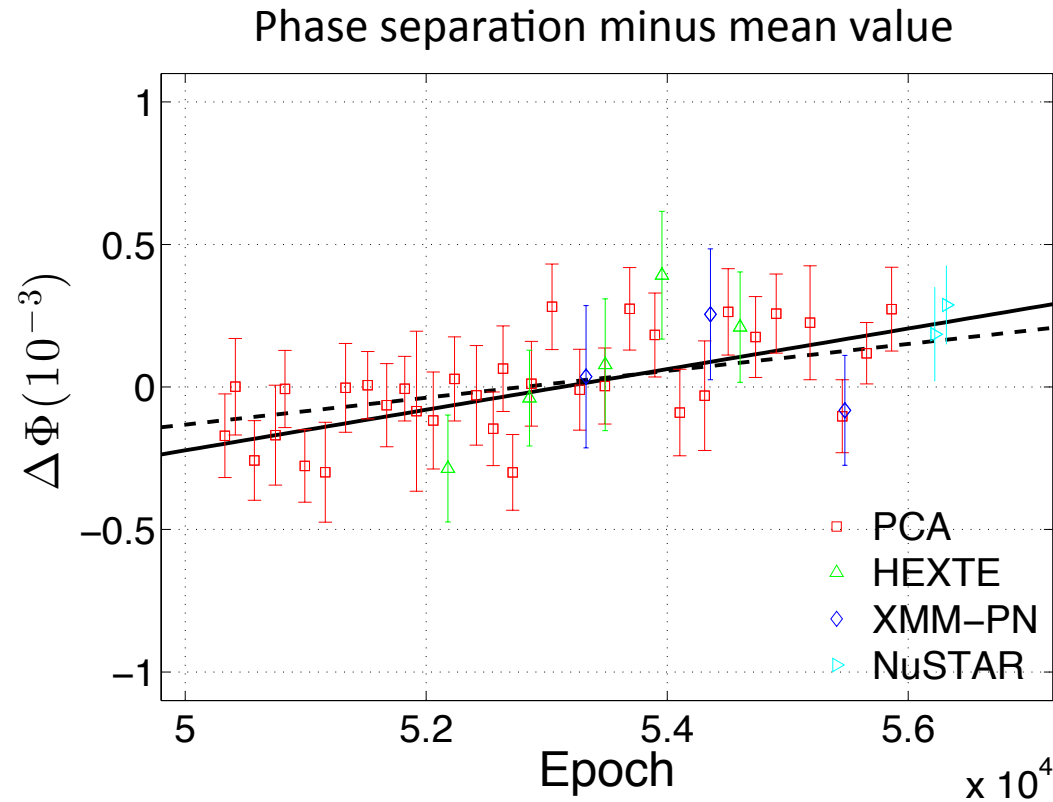
$\Gamma_{hard}$  vs  $\Gamma_{soft}$



Tsujimoto et al, A&A 2011

# Crab timing

- ✓ Evidence for phase lag between X-ray and radio pulses, increasing with time, mostly from PCA data



$$(7.1 \pm 1.3) \times 10^{-8} P \cdot \text{day}^{-1}$$

Credit: Mingyu Ge

**Radio(dashed line):**  $4.7 \times 10^{-8} P \cdot \text{day}^{-1}$

# Summary and actions

## **Crab Paper**

- ✓ Improvement in the cross-calibration dataset (2 more observations including NuSTAR)
- ✓ LN to re-contact Fermi/GBM team
- ✓ Reprocess the IBIS/ISGRI spectra vs new calibration in OSA10.2, ~2 months (will not wait for OSA11)
- ✓ Baseline is not to wait for the Nov 2014 XMM data

## **G21 project**

- ✓ Test new model (Nynka et al paper) against NuSTAR, Chandra, INTEGRAL. Kristin should coordinate the effort after submission of the PKS2155 paper