# *Non Thermal SNR Working Group Report 2014*

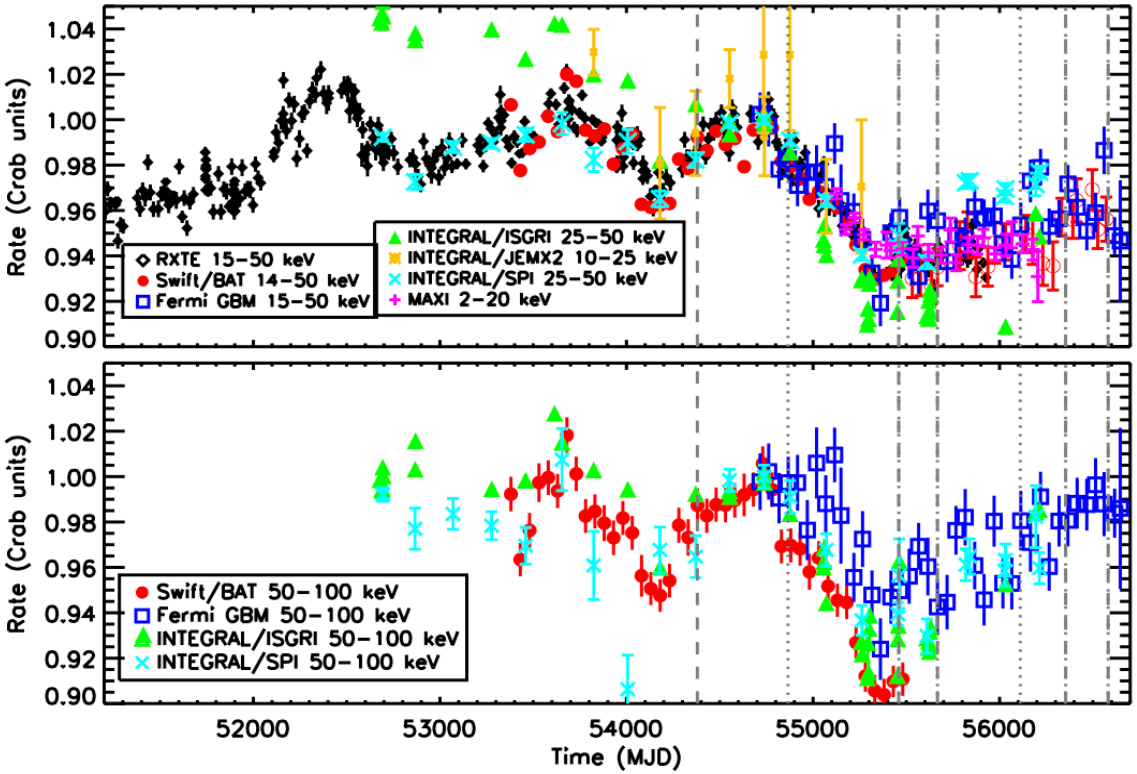
L. Natalucci
on behalf of the Non-thermal SNR WG

Two sessions: Crab; G21.5

# *What the Crab has Been Up to Lately…*

- Light curves for each instrument are normalized to its average rate from MJD 54690-54790.

- GBM – Blue squares
- RXTE/PCU2 – Black Diamonds
- BAT – Red Circles
- ISGRI – Green triangles
- JEM-X – Orange asterisks
- SPI – Cyan X's
- MAXI – Pink plus signs

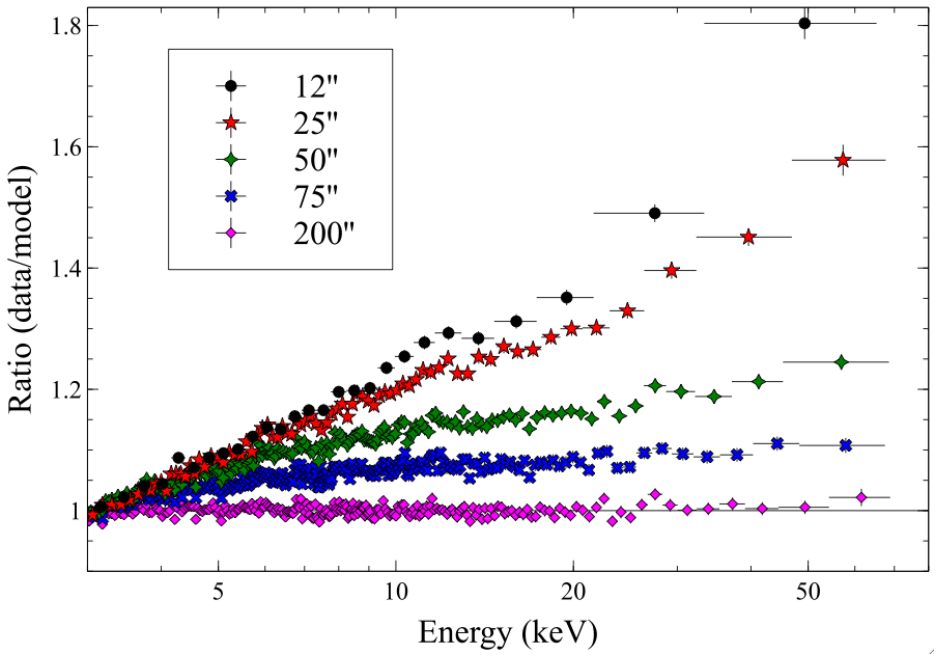


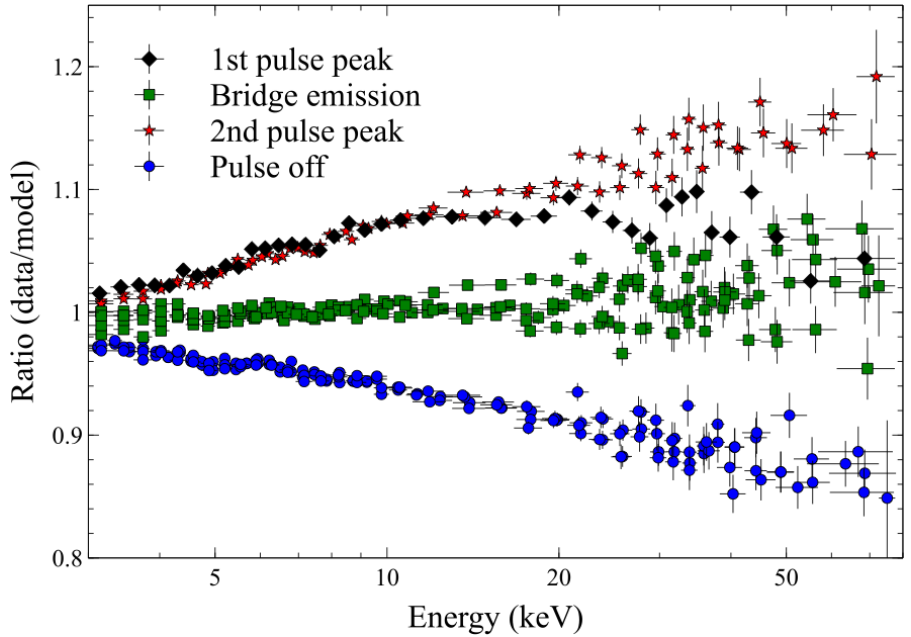

50-100 keV band has nearly recovered to pre-decline level

15-50 keV band has only increased ~30% of the way back to pre-decline level

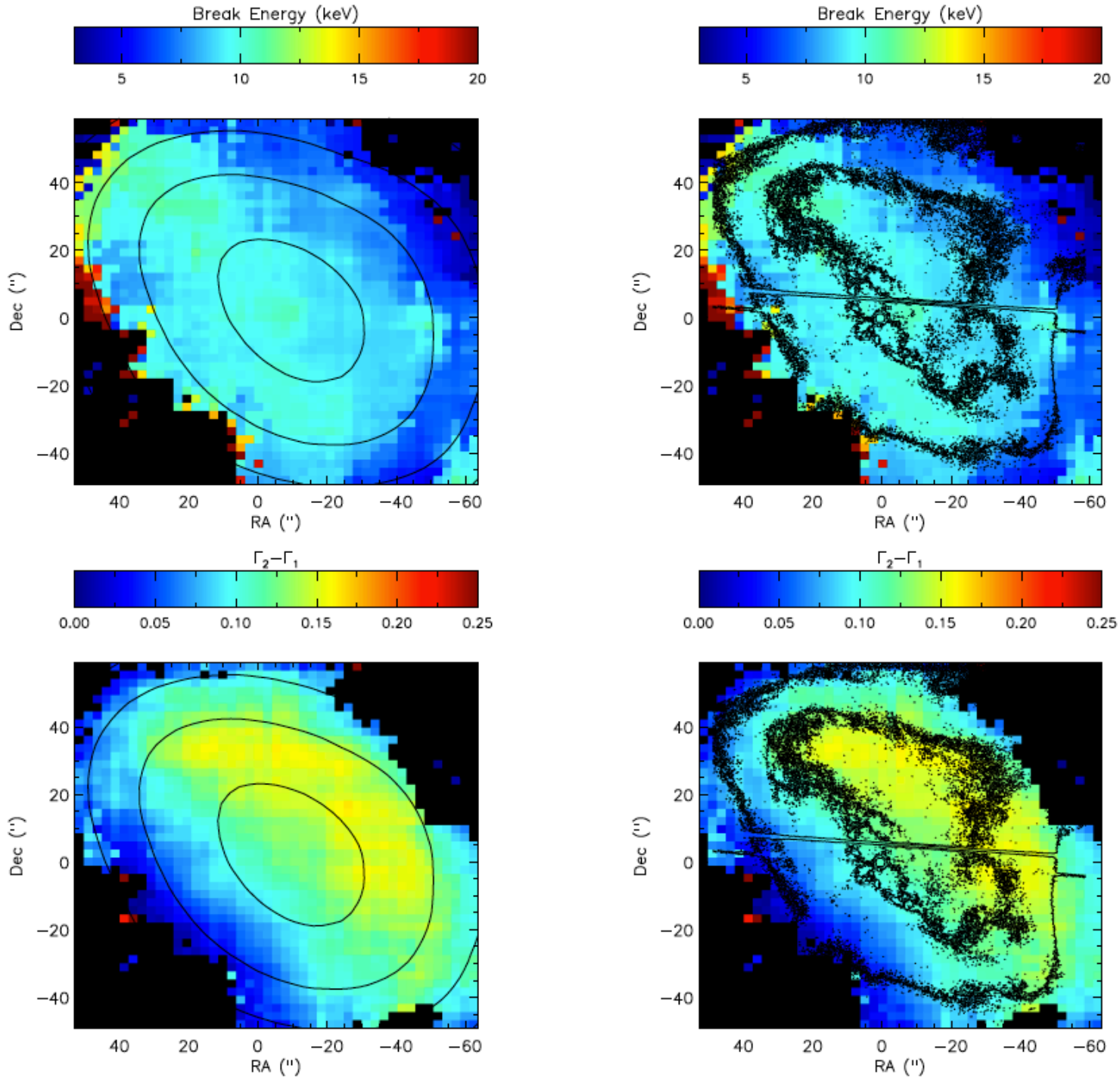
Presented by Gary Case

# *Crab: spatial and phase resolved spectroscopy by Nustar*



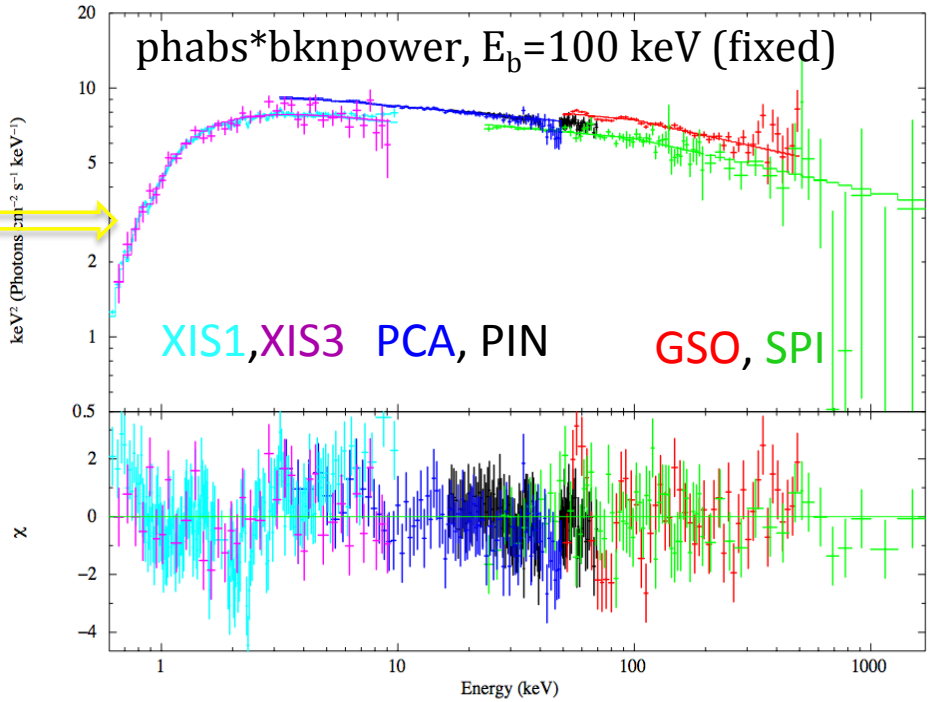




Presented by Kristin Madsen


Break Energy (keV)
5
10
15
20
Dec (")
RA (")
40
20
0
−20
−40
−60
Γ2−Γ1
0.00
0.05
0.10
0.15
0.20
0.25

# Cross-cal of RXTE, Suzaku INTEGRAL: common observation epochs

| 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 |



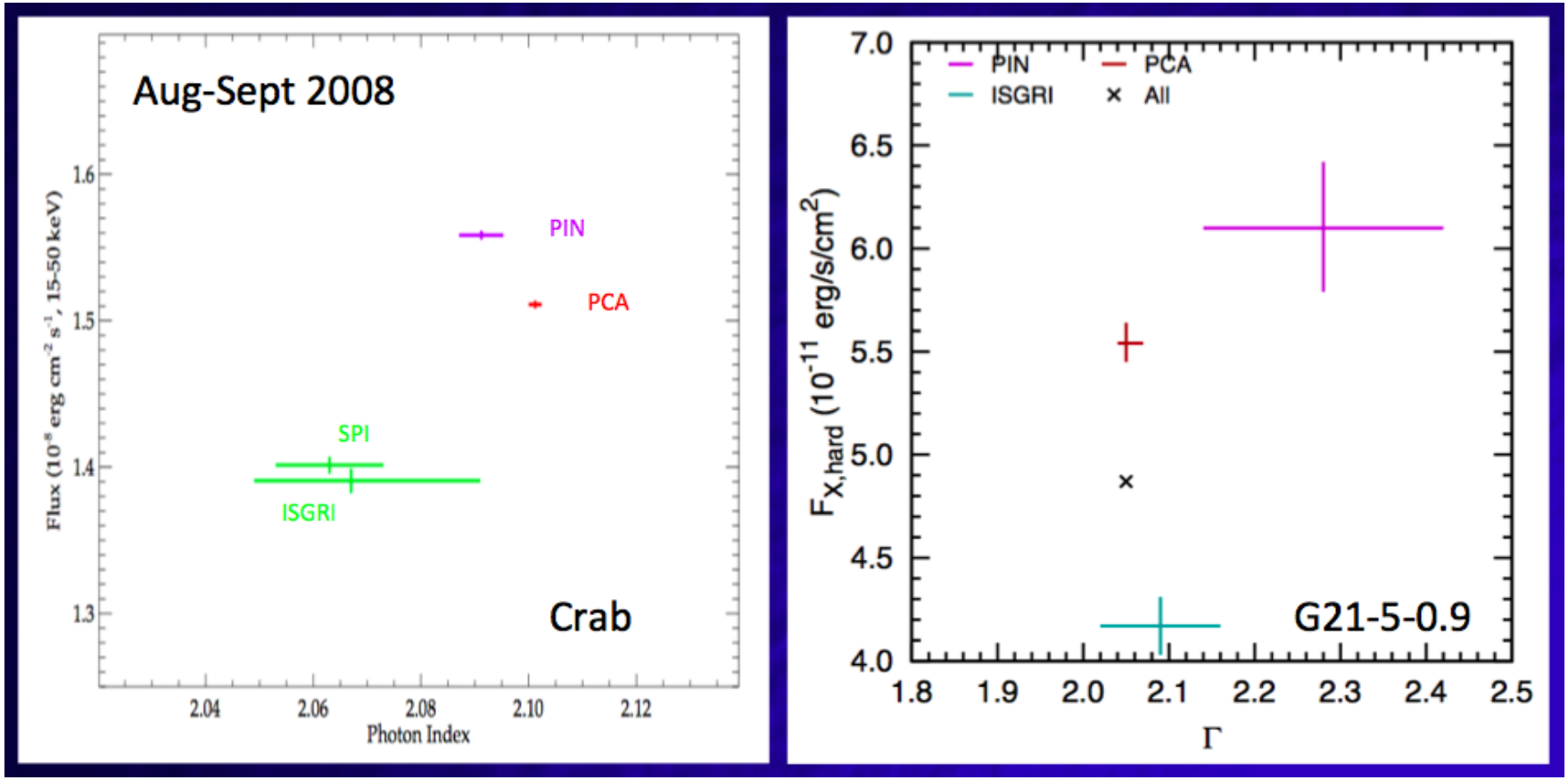

Summary of the fits for nearly simultaneous observations

| Epoch | Γ 1 | Γ 2 | $C_{XTE}$ | $C_{PIN}$ | $C_{GSO}$ | $C_{IBIS}$ | $C_{SPI}$ | $C_{xis1}$ | $C_{xis3}$ | chi/d.o.f. |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 2.096±0.003 | 2.229±0.023 | 1.072±0.009<br>1.071±0.009 | 1.105±0.011 | 1.100±0.011 | 0.982±0.008 | 1.0(f) | | | 440/446 |
| B | 2.102±0.004 | 2.217±0.023 | 1.066±0.011 | 1.104±0.010 | 1.097±0.011 | 0.9784±0.009 | 1.0(f) | | | 405/367 |
| C | 2.085±0.003 | 2.214±0.018 | 1.106±0.008 | 1.102±0.008 | 1.186±0.009 | | 1.0(f) | 0.952±0.010 | 0.960±0.019 | 1098/953 |
| D | 2.071±0.004 | 2.294±0.034 | 1.108±0.009 | | | 1.023±0.007 | 1.0(f) | | | 258/194 |
| E | 2.103±0.002 | 2.233±0.014 | 1.057±0.007<br>1.062±0.007 | 1.093±0.006<br>1.080±0.006 | 1.078±0.007<br>1.087±0.007 | 0.974±0.006 | 1.0(f) | | | 701/612 |
| F | 2.097±0.004 | 2.207±0.042 | 1.108±0.010 | | | | 1.0(f) | | | 148/144 |
| G | 2.121±0.004 | 2.215±0.019 | 1.020±0.011 | 1.126±0.010 | 1.114±0.011 | 0.995±0.009 | 1.0(f) | | | 689/424 |
| H | 2.108±0.004 | 2.184±0.072 | 1.076±0.011 | | | | | | | 120/145 |
| I | 2.114±0.003 | 2.150±0.015 | 1.057±0.007<br>1.061±0.007 | 1.135±0.007 | 1.076±0.008 | 0.975±0.006 | 1.0(f)<br>1.020±0.007 | | | 771/501 |
| | | | 1.075 | 1.110 | 1.109 | 0.987 | 1.0 | 0.952 | | |

Presented by Lorenzo Natalucci

# *Crab vs G21.5 in the hard band*

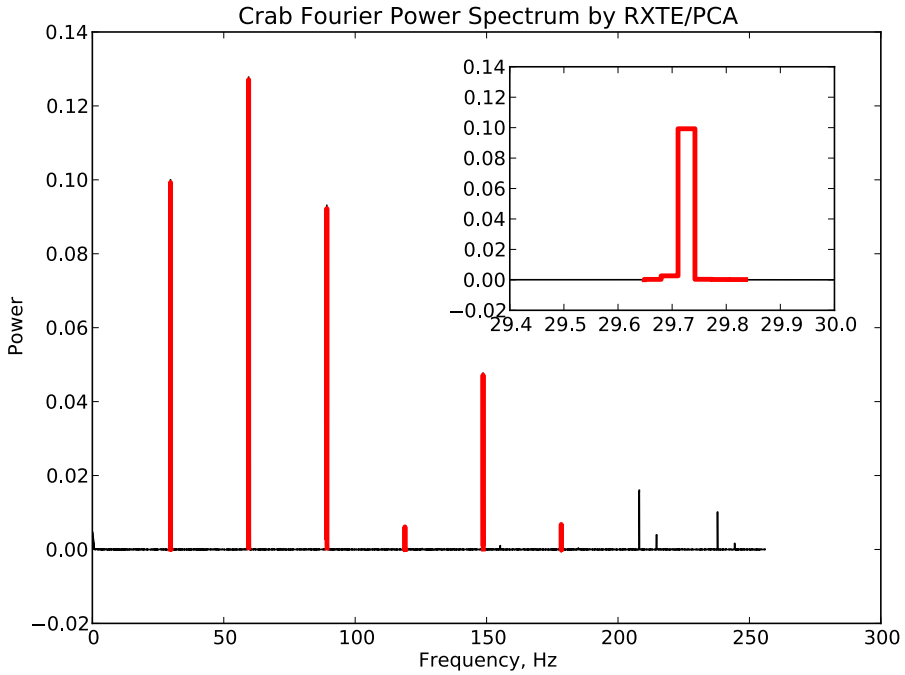
15-50 keV

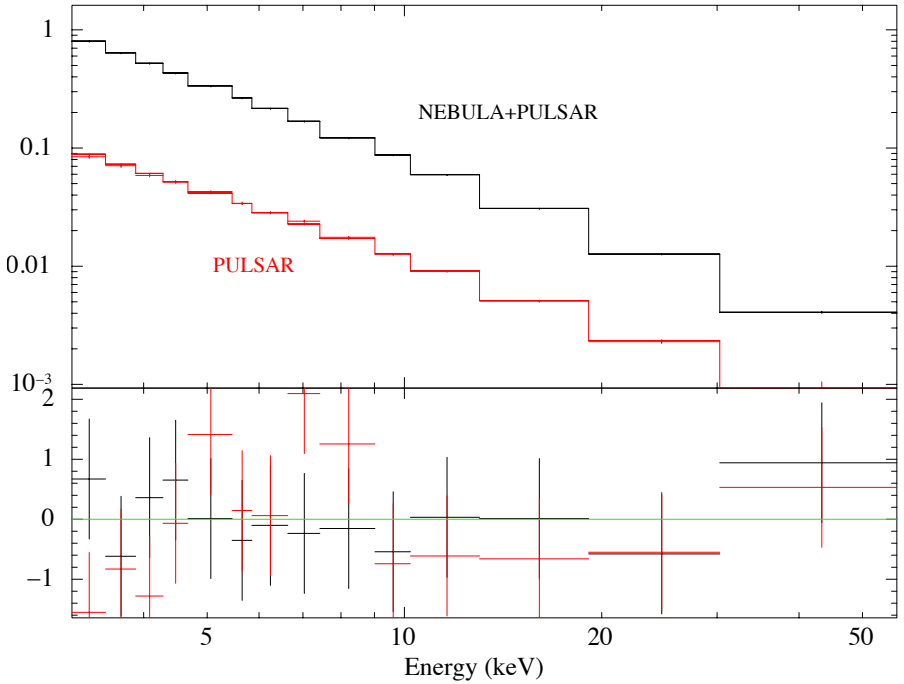



Epoch E

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

# Crab Fourier Resolved Spectroscopy



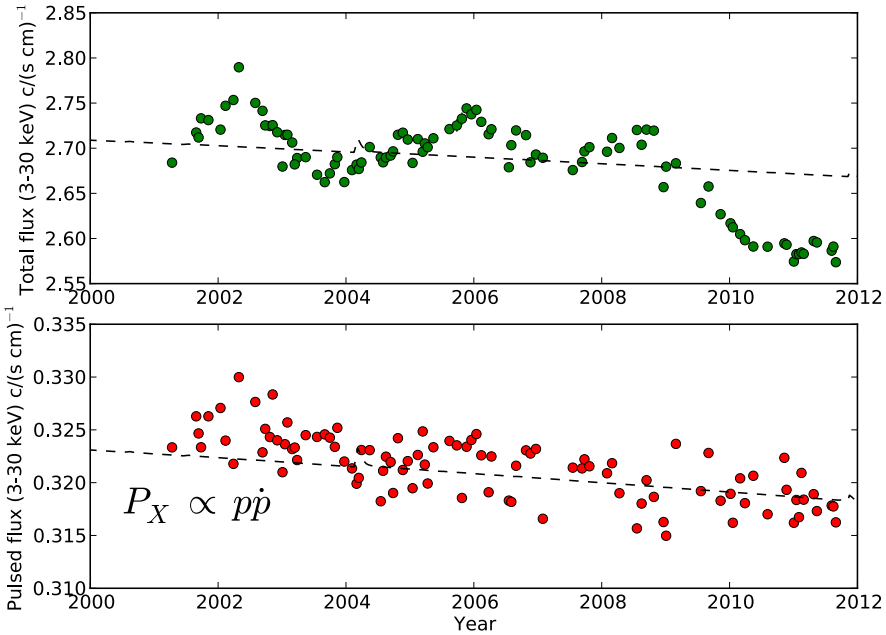



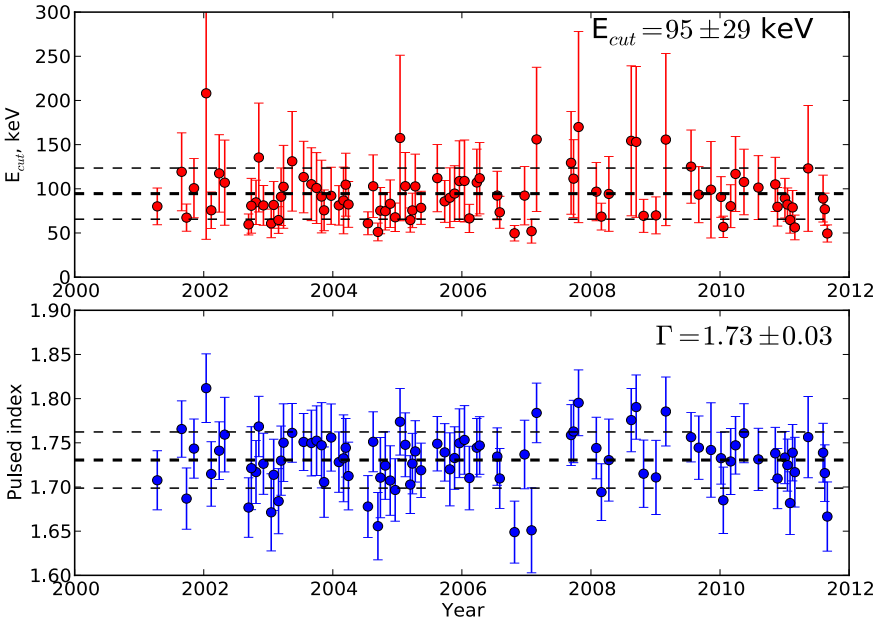

- Fourier Resolved Spectroscopy is used to probe spectrum of quasi-periodic oscillations and broad-band noise in X-ray binaries
- The pulsed fraction is estimated as RMS power for in Fourier harmonics in PDS.
- The pulsed spectrum, calculated by FRS, is background free.
- The Crab Pulsed fraction monotonically increases from 10% at 3 keV to 15% at 30 keV

Presented by Nikolai Shaposhnikov

# *Crab: Total emission vs pulsed*

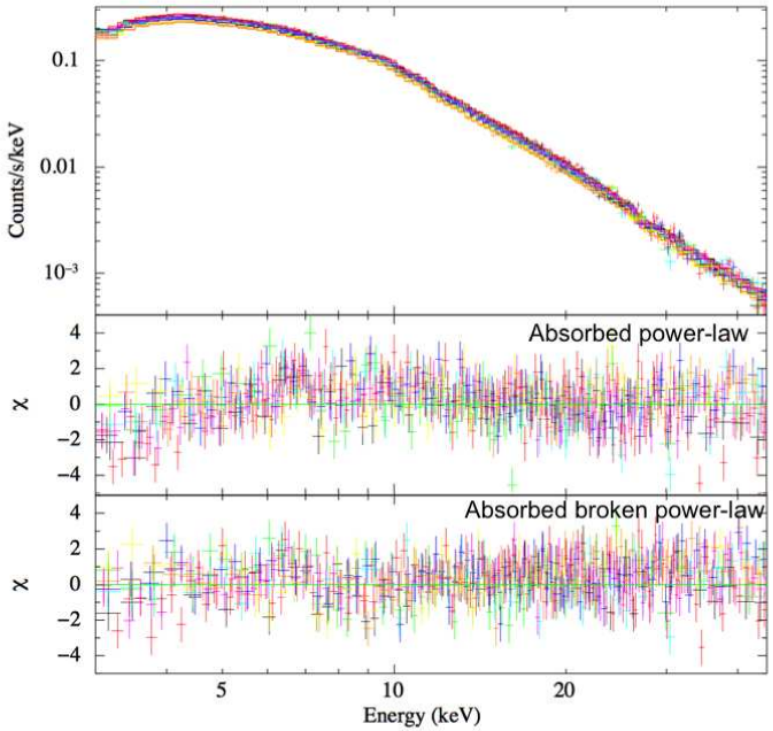
- Analysis covers interval of ~10 years
- Total flux shows long-term variations while the pulsed flux shows uniform decline of about 2% in close agreement with pulsar spindown
- Pulsed flux spectrum : evidence for cutoff at 95 keV
- use Fourier derived energy spectrum for calibration? (advantage: background free)



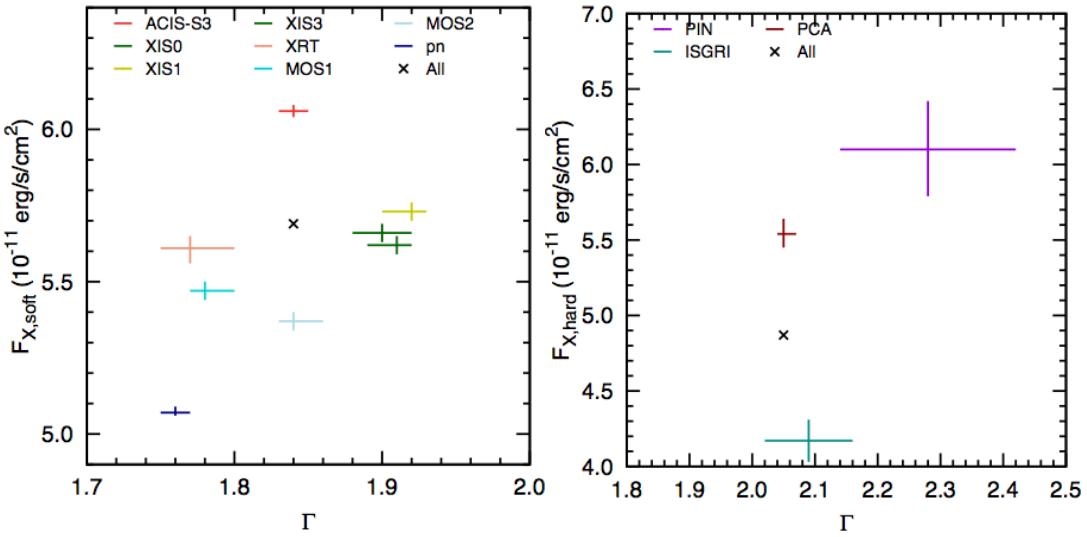
# G21.5 - Nustar

- spatial resolved spectroscopy detects spectral softening with increasing radius, in the <10 keV band (as already observed by Chandra)
- Discovery of a second component with spectral break at ~10 keV
- Break is detected only in the central region (most evident < 30")
- Consistent with IACHEC paper




Nynka et al, ApJ submitted

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

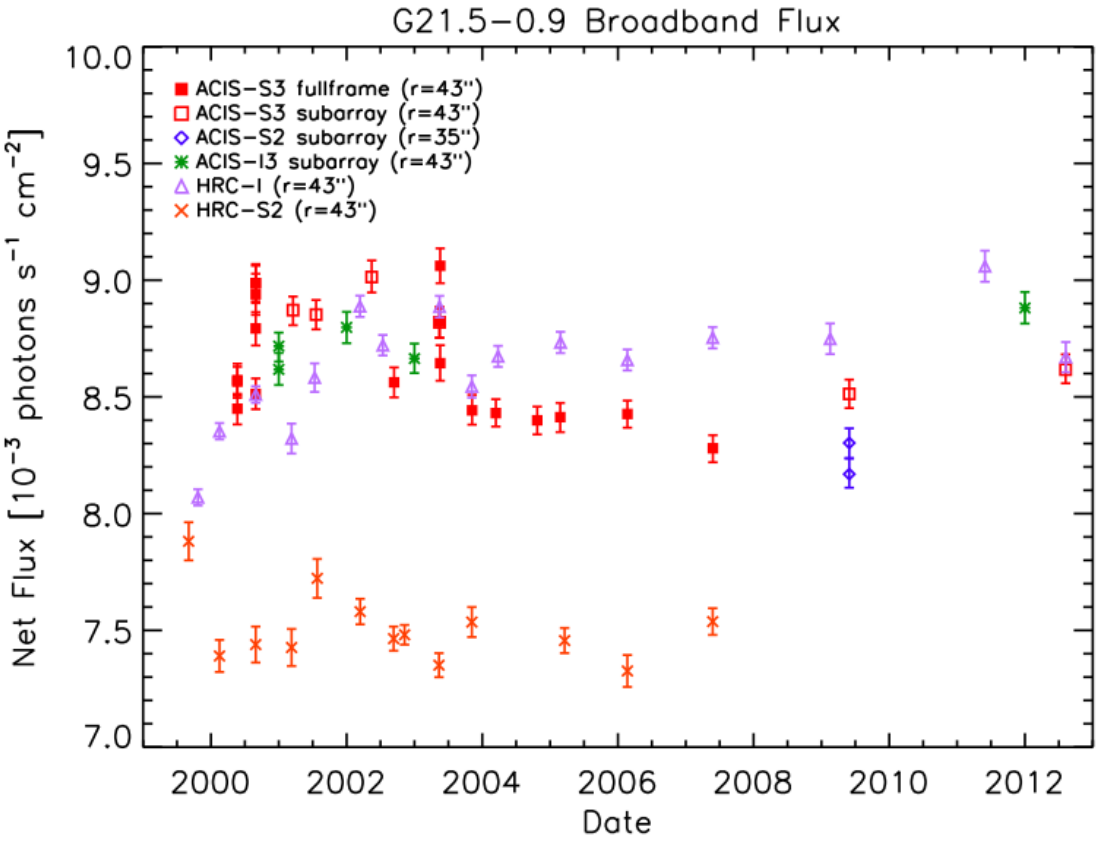



Tsujimoto et al, A&A 2011

Presented by Kristin Madsen

# G21.5 – Chandra lightcurve

- Variability of broadband component (short and long time scale)
- Increasing trend 2000-2002 common to many instruments. Possible concern for XMM EPIC calibration
- More investigation needed




Preliminary (~2 weeks ago)

Presented by Vinaj Kashiap

# *Summary*

## Crab

- Total spectrum: evidence for break near 100 keV: SPI, HXD, possibly GBM
- Pulsed spectrum (RXTE): cutoff near 95 keV; stability
- Crosscal paper:

  possibility of new XMM burst mode calibration ;

  additional data 2005-2011: Swift/BAT, Fermi/GBM? More recent data?

  (**new input data to LN: by mid-September**)
- Organize coordinated observations XMM/NuSTAR in September (possibly, also with Suzaku and INTEGRAL)

## G21

- Evidence for spectral break near 10 keV; mostly detected in inner region
- Soft X-ray spectra flux variability (Chandra): true astrophysical variability?
- IBIS does not see long term variability > 20 keV (<few %)
- New cross-cal paper beyond Masahiro's 2011, Kristin Madsen will lead the effort