(Cross) calibration report to the IUG

IACHEC activities
IBIS/ISGRI Crab calibration observations

L. Natalucci

INAF-IAPS, Rome

INTEGRAL USERS GROUP MEETING #23, ESA/ESTEC, 26-27 NOV 2019

IACHEC news

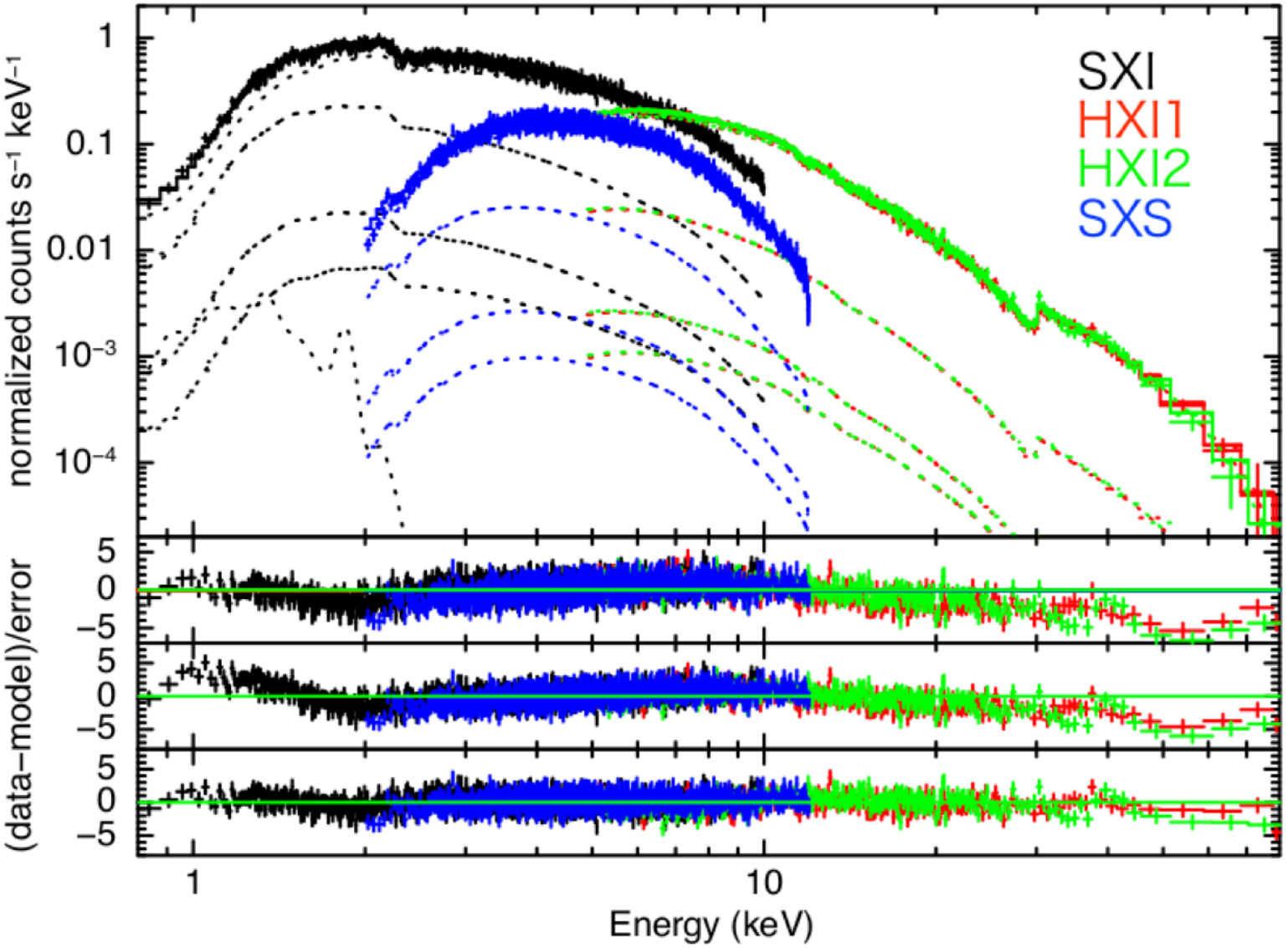
- Consortium has grown since last meetings. 60 scientists met at Shonan Village (Kanagawa, Japan) in May 2019
- Kristin Madsen appointed as new IACHEC Chairman since 2018.
- More emphasis and structured activity on coordinated observations: *Chandra, XMM-Newton, Swift, INTEGRAL, Astrosat, NuSTAR, NICER, Insight-HXMT*
- Improved studies on methodologies for new missions: *XRISM, IXPE* and *Athena*
- Prototype of cross-calibration database at IAPS
- New IACHEC website: www.iachec.org
- Next meeting will be in USA in April 2020

Some recently discussed topics

- Modelling high resolution data: need to improve atomic physics codes– relevant to *Hitomi, XRISM* and *Athena*
- Impact of calibration uncertainties on modeling astrophysical effects
- New effort for cross-calibration using the SNR G21.5-0.9 with *Chandra,XMM,NuSTAR,Hitomi,INTEGRAL,Swift:* defining a calibration standard model for the spectral shape of this source.
- *XRT/Nustar* coordinated observations
- NuSTAR measurements of the Crab in straylight mode and nominal mode
- Joint analysis of *Nustar & INTEGRAL* data (e.g. MAXI J1820+70, 3C273)
- Crab multi-year analysis by SPI team: report of small-scale variability compatible with the other instruments
- Use of Band model to analyse Crab spectra

(2) G21.5 : Hitomi data

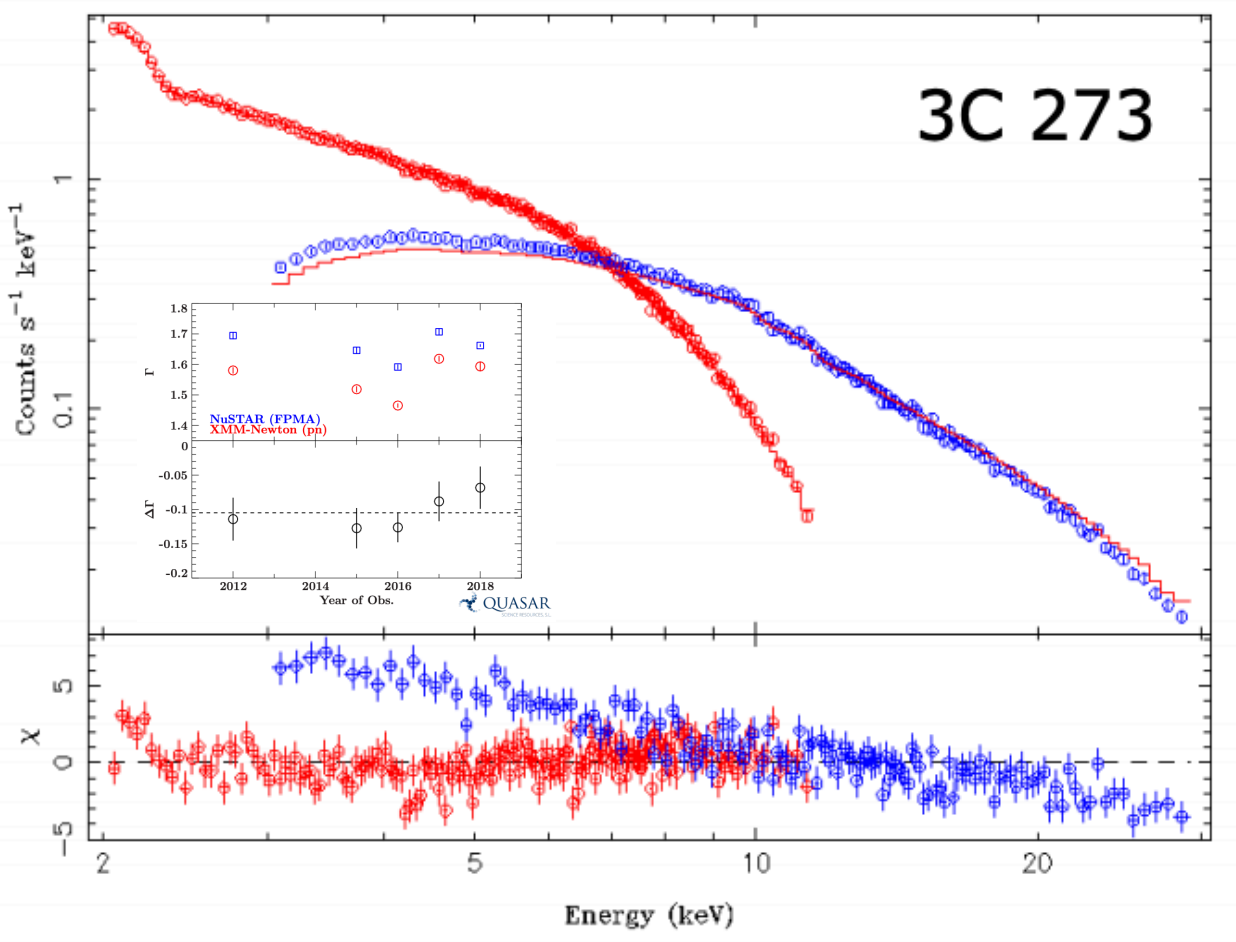
Credit: M. Tsujimoto, IACHEC 2018



$E_{break} = 7.1 \pm 0.3$ keV, $\Gamma_{soft} = 1.74 \pm 0.02$, $\Gamma_{hard} = 2.14 \pm 0.01$

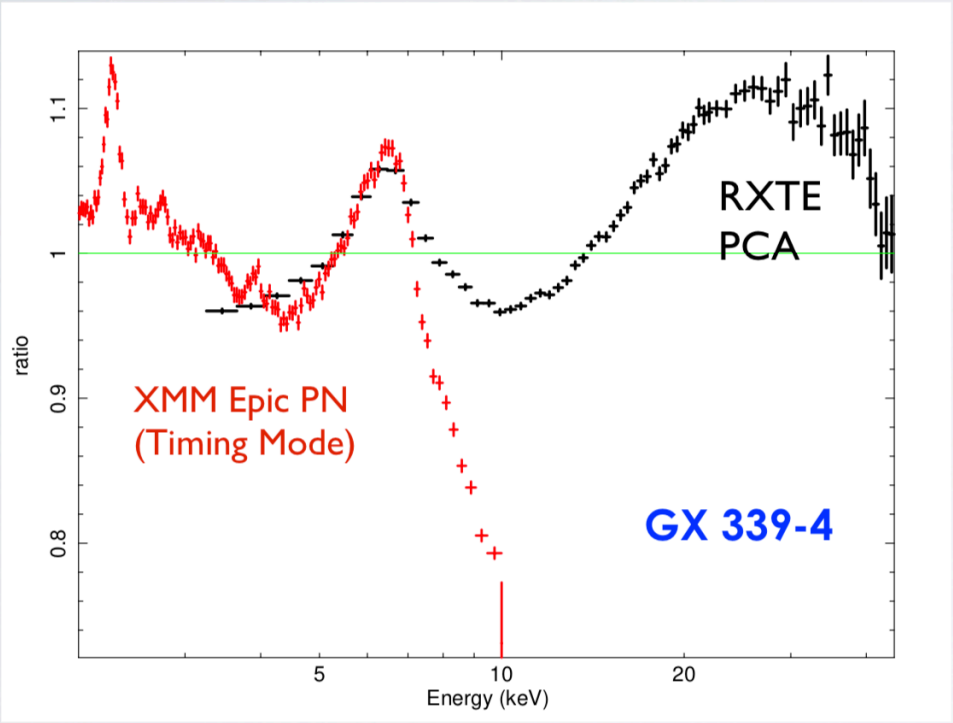
Coordinated observations

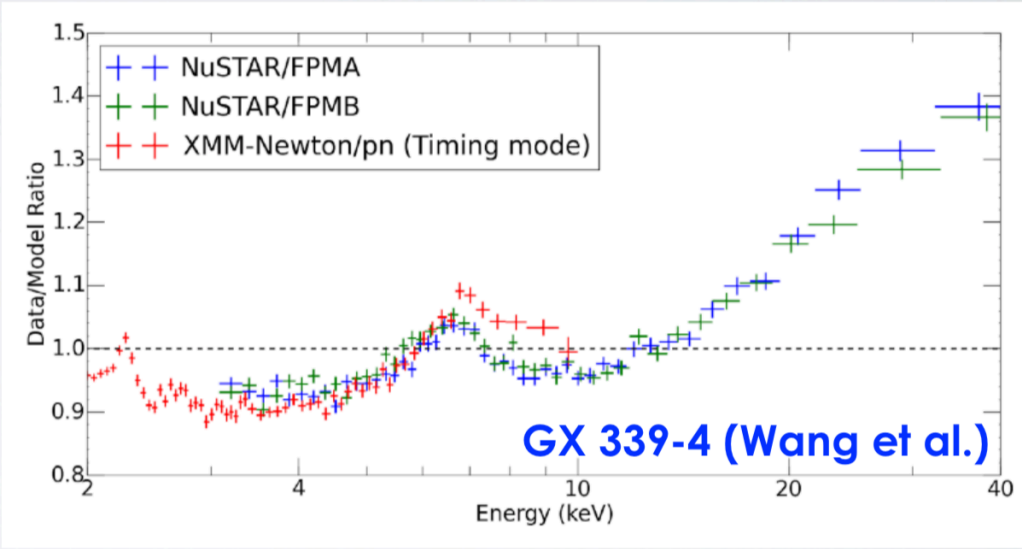
- ➢ *Swift/XRT* (WT mode) and *NuSTAR* observations of bright Galactic binaries
- Good agreement for Her X-1 and MAXI J1820+070 low state
- Issues on XRT spectral extraction for sources with high flux & column densities sources
- Possible ~5% calibration issue in NuSTAR at low energies
- ➢ *NuSTAR* vs *epic-PN* comparison for AGNs/Blazars
- Indication for ~15% higher flux and softer slope ($\Delta\Gamma$~0.1) in NuSTAR spectra
- ➢ Continuing cross-calibration campaign on 3C273



Credit: F.Fuerst, IACHEC 2019

Epic-PN vs NuSTAR





XMM (TM) vs. RXTE

- 2009 Outburst: High count rate
- Very different Fe K line profile: XMM looks narrower

XMM (TM) vs. NuSTAR

- 2015 Outburst: lower count rate
- Significantly different continuum slope
- But good agreement between NuSTAR and Swift XRT

Credit: J. Garcia, IACHEC 2019

3C273 - Update on Cross-calibration of INTEGRAL with NuSTAR

Lorenzo Natalucci ([1]), Manuela Molina ([2]), Angela Malizia ([2])

(1) INAF/Institute for Space Astrophysics and Planetology, Rome
(2) INAF/Institute for Space Astrophysics, Bologna, Italy

Campaigns on 3C273

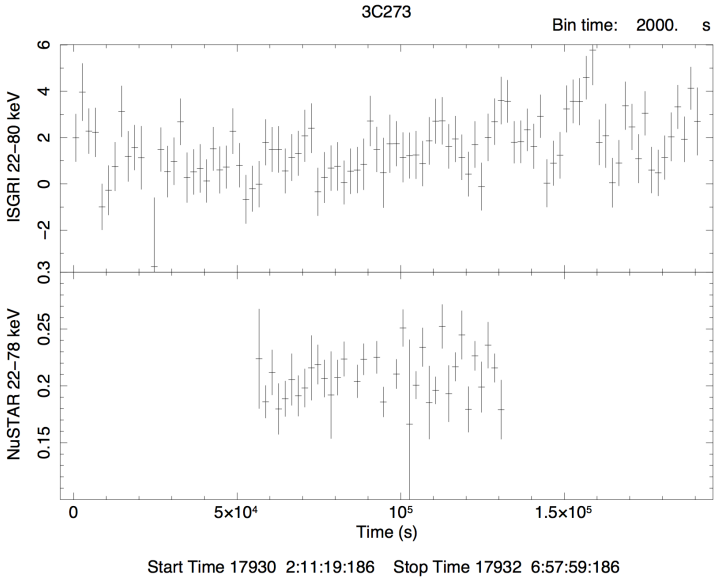
- Results with IACHEC campaigns in 2012, 2015, 2016,2017
- Instruments on Chandra, NuSTAR, Suzaku, XMM and INTEGRAL

Published results

- Previous results of 3C273 with INTEGRAL and NusTAR joint fits published by Madsen et al 2016 (ApJ 812,14)
- Previous results in the soft band (<10 keV) published in Madsen+16 (arXiv: 1609.0903)
- Madsen et al., NuSTAR calibration paper

3C273 - NuSTAR vs IBIS/ISGRI

- Last observation analysed: 2017



Exposure times 2017:
INTEGRAL ~2 days
NuSTAR: 35ks

SW & cal versions:
nustardas_06Jul17_v1.8.0 &
CALDB version : 20180126
IBIS OSA10.2

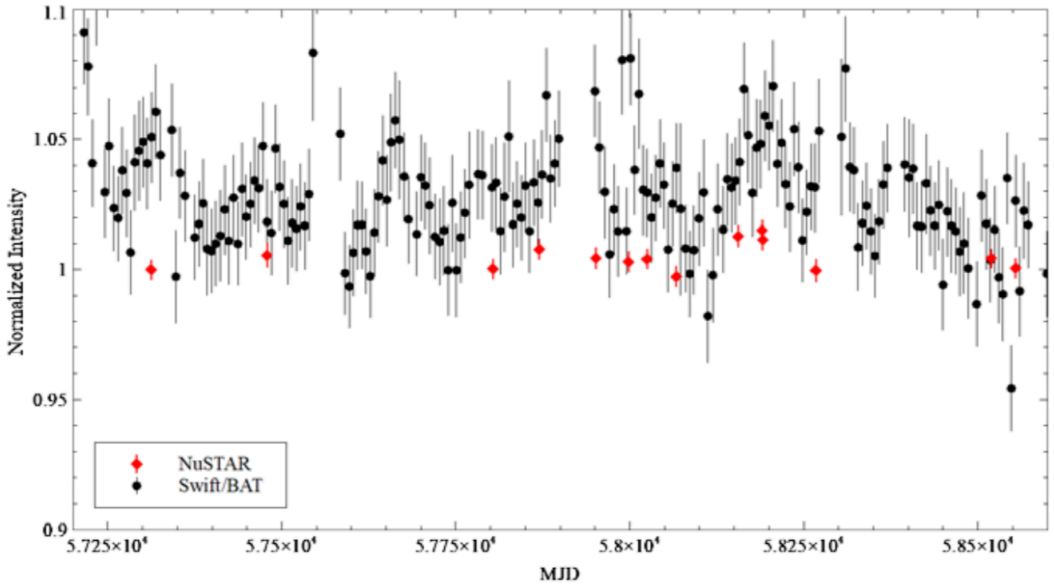
- The joint fits for the 4 epochs show good agreement within <10%

model: const*wa$_g$*po							
Year	Γ	$C_{FPMA/ISGRI}$	$C_{FPMB/ISGRI}$	$F^{ISGRI}_{20-40keV}$ (10^{-11}erg cm^{-2}s^{-1})	$F^{FPMA}_{20-40keV}$ (10^{-11}erg cm^{-2}s^{-1})	$F^{FPMB}_{20-40keV}$ (10^{-11}erg cm^{-2}s^{-1})	$\Delta\chi^2$
2012	1.669±0.003	$0.995^{+0.07}_{-0.06}$	$1.024^{+0.07}_{-0.06}$	6.49	6.46	6.65	0.994
2015	1.739±0.012	$1.196^{+0.411}_{-0.244}$	$1.211^{+0.416}_{-0.247}$	3.74	4.47	4.53	1.012
2016	1.608±0.005	1.069±0.06	1.087±0.06	11.73	12.54	12.75	1.094
2017	1.677±0.007	$0.861^{+0.09}_{-0.07}$	$0.88^{+0.09}_{-0.08}$	6.62	5.70	5.84	1.055

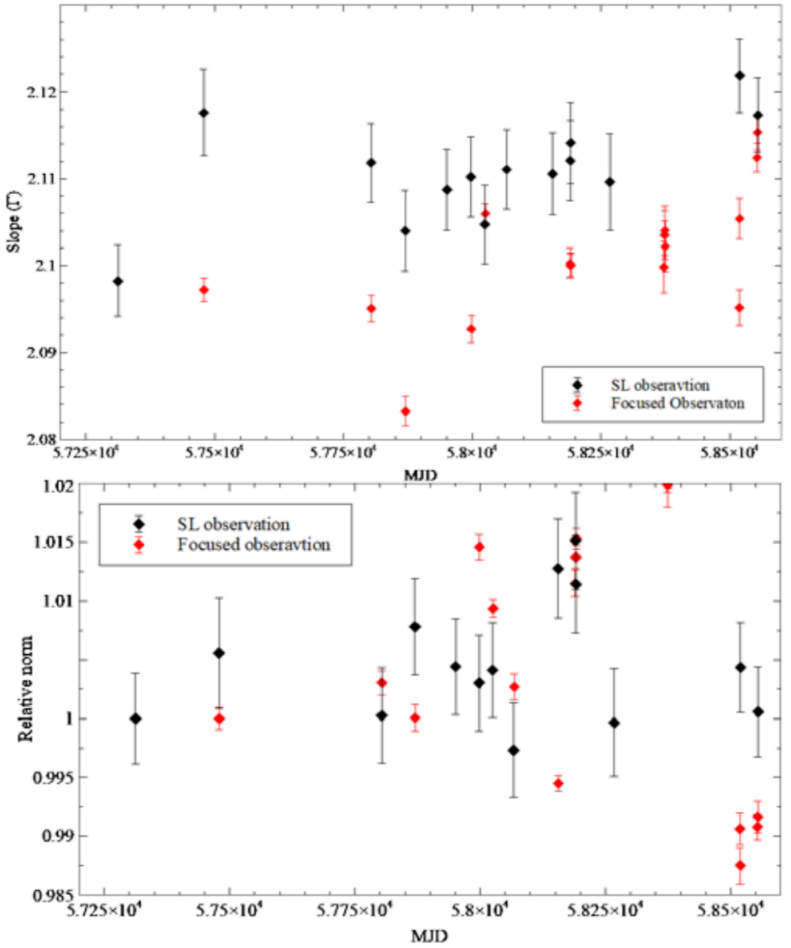
Presented at 13th IACHEC Meeting, 2018

NuSTAR Crab monitoring campaign

NuSTAR - Crab



Credit: K. Madsen, IACHEC 2019



Crab Nebula - IACHEC Multi-mission Project

- Results exclusively based on the analysis of nearly simultaneous periods
- Emphasis on the hard band (>10 keV)
- Instruments on board: XIS, PIN, GSO, PCA, IBIS/ISGRI, SPI, NuSTAR, (EPIC-pn), GBM, BAT
- Total of 14 nearly simultaneous epochs (2005-2016).
- Broken power law model, with E_{br} ~100 keV
- Broad band spectral fitting
- Yet unpublished – preliminary results of multi-mission analysis are available at:

https://iachec.org/wp-content/presentations/2018/

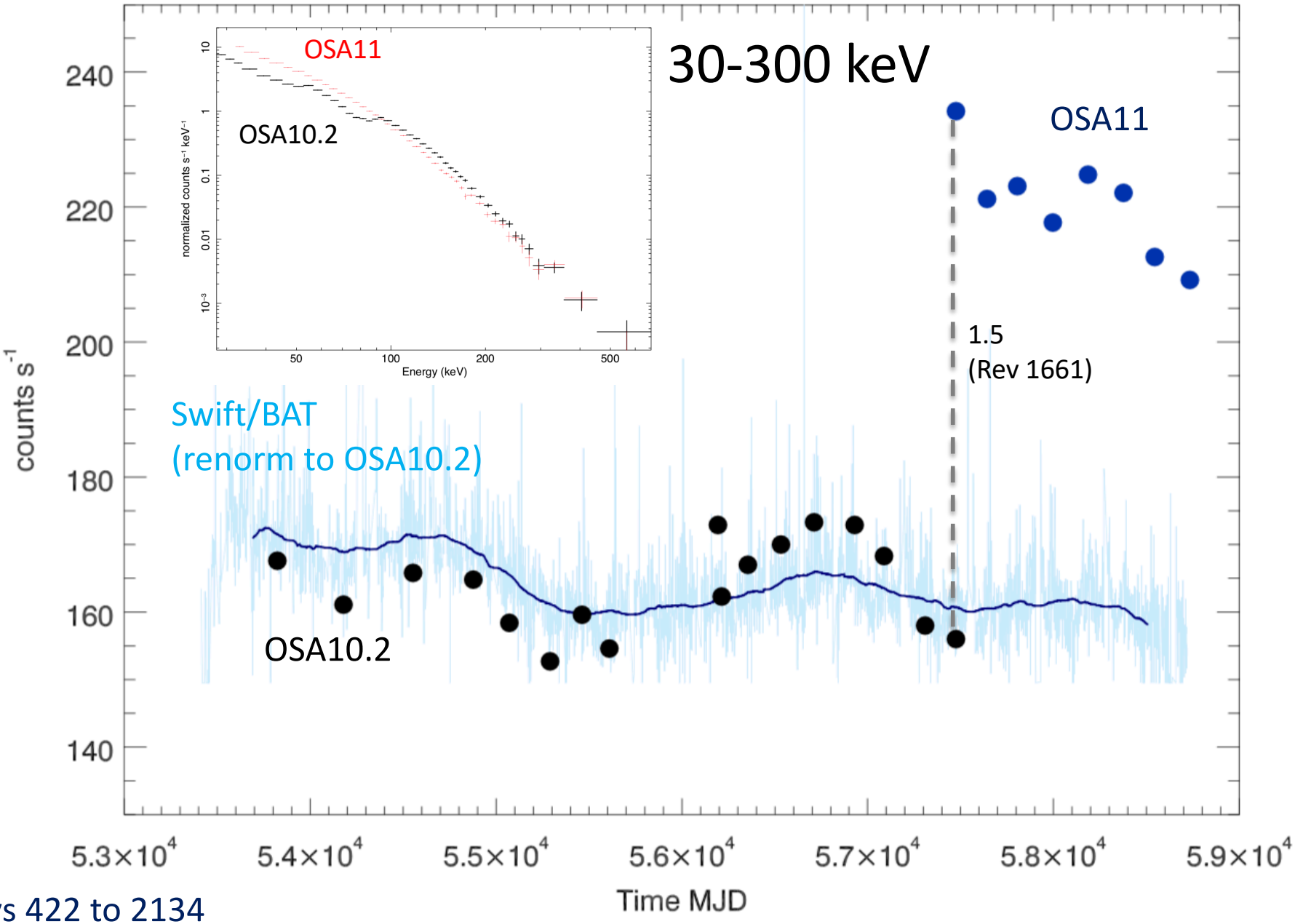
(Non-Thermal SNR WG report)

Energy bands

Instr.	Energy Bands (keV)			
XIS	3–10			
PIN		10–25,	25–80	
GSO			25–80^	100–300
PCA	3–10,	10–25,	25–80	
IBIS			25–80,	100–300
SPI			25–80,	100–300
NuSTAR	3–10,	10–25,	25–80	
EPIC	3–10			
GBM			(25–80),	100–300
BAT			25–80	

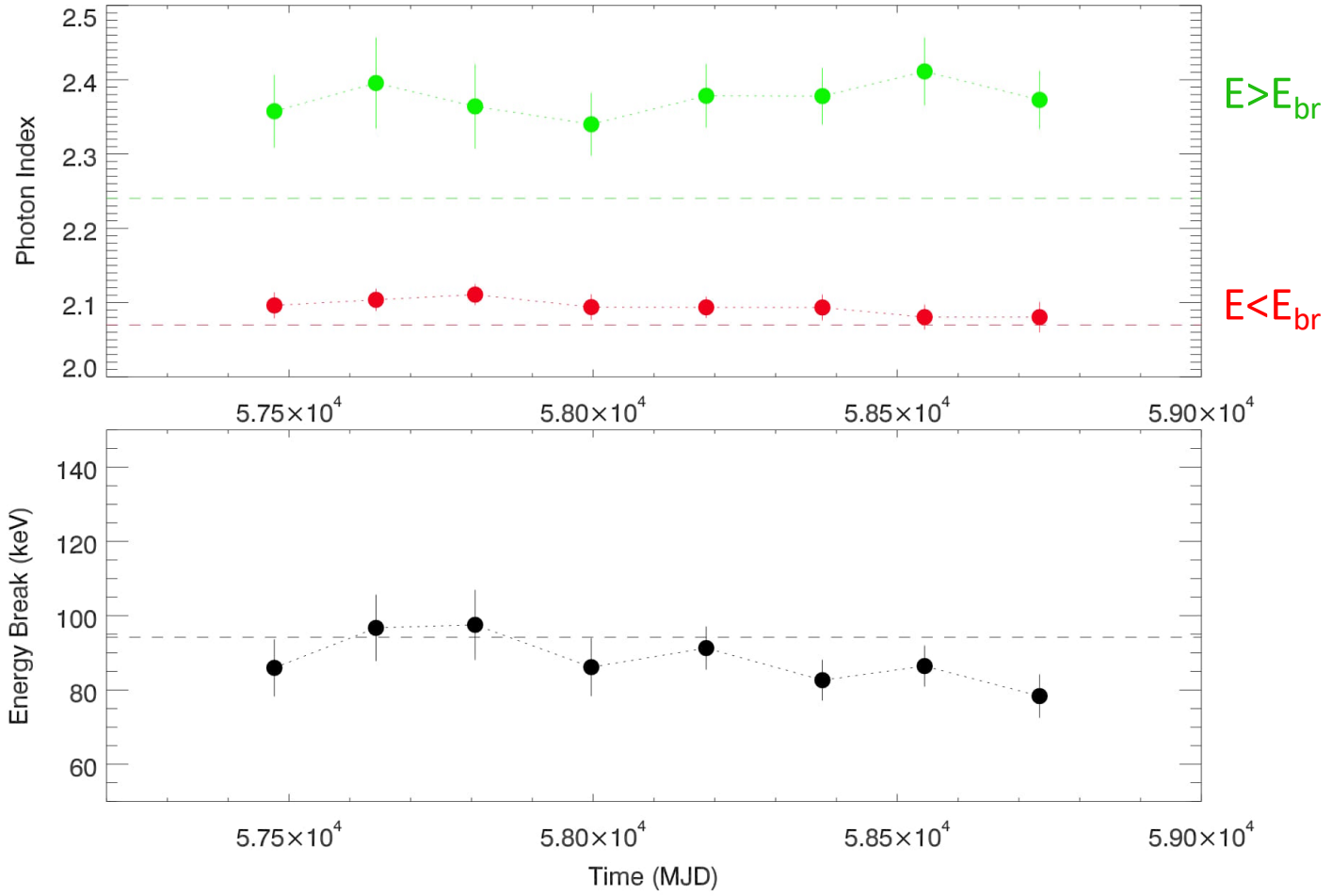
^for GSO, E >40 keV

Crab Nebula - IBIS/ISGRI 2006-2019

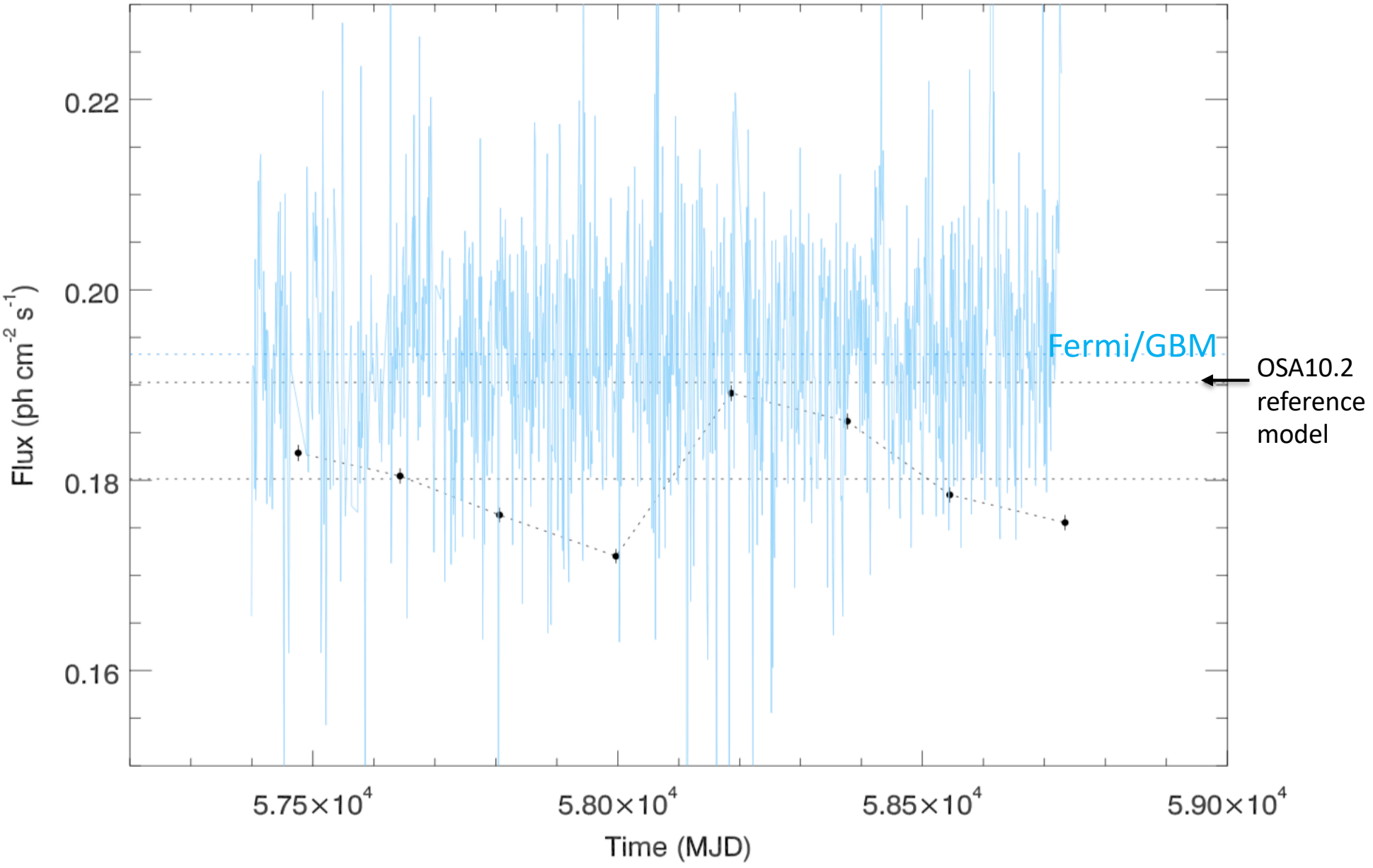


Revs 422 to 2134

OSA11 – Crab Spectral Fitting with Broken Power Law



OSA11 Flux 30-300 keV



Revs 1661 to 2134

Summary

- Crab matrix from multi-mission project is basically available to the team: goal is to publish results
- *IBIS/ISGRI* analysis to be provided for G21.5 observations
- Exploit observations for 3C273 campaign during 2018, 2019. Goal: publication (contact K.Madsen)
- Fully characterise spectral variability in multi-year Crab spectra of IBIS/ISGRI (spanning OSA 10.2 & OSA11)
- Plans for OSA11 and future calibration releases with application to full mission data