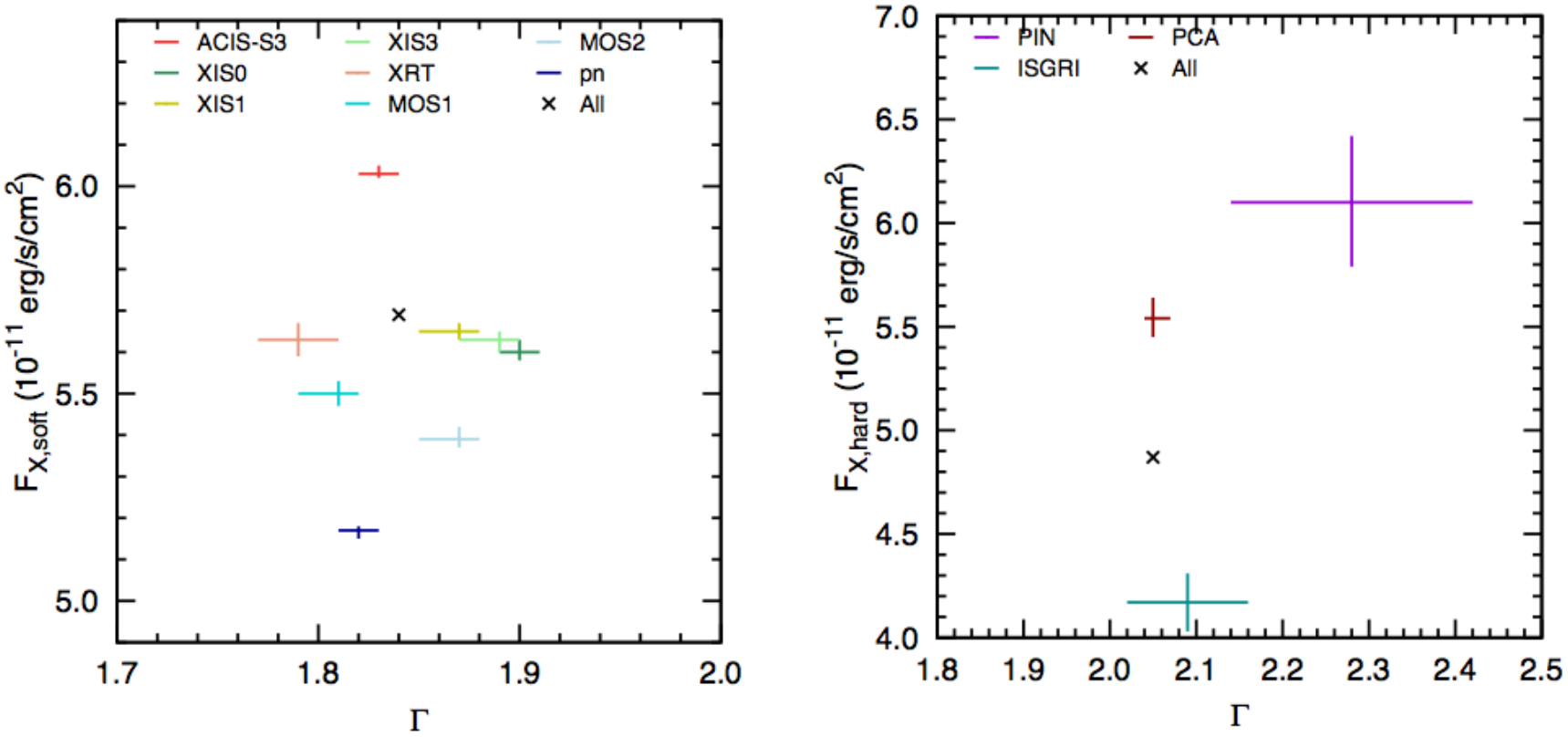
NON THERMAL SNR WG – SESSION 1

Agenda for today:

- ✓ Crab project status/actions
- ✓ Update on G21 and new cross-cal activities

Cross calibration in soft & hard bands: G21.5-0.9



Scatter plot of PL fit parameters for *soft-band* and *hard-band* instruments
Finalized: Tsujimoto et al., A&A 2010

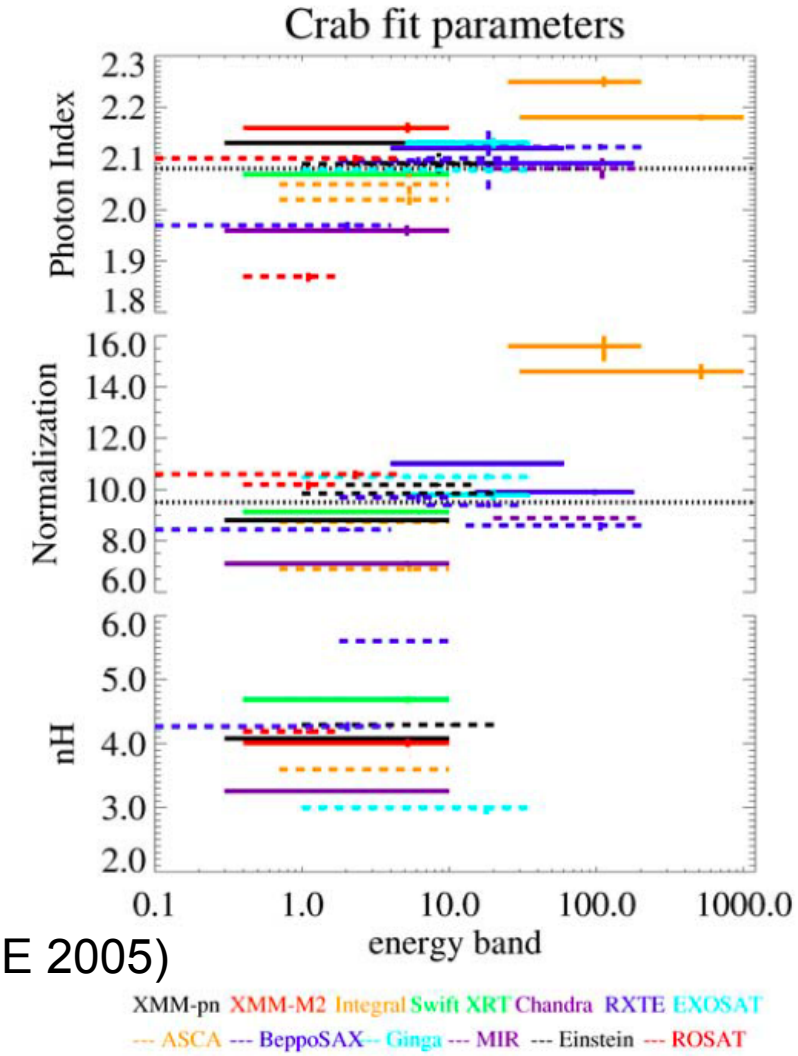
CRAB - BEFORE 2005

A reference summary is in the M. Kirsch paper:

- Results of the fits with a single PL

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



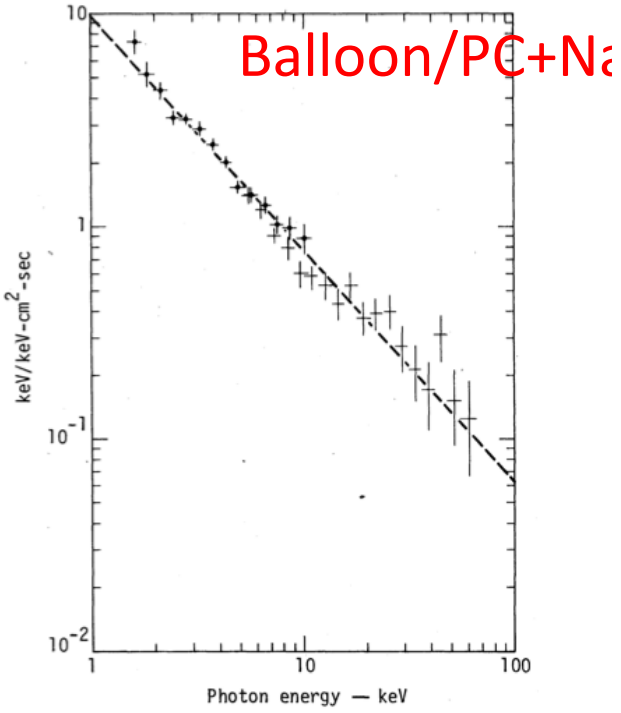
(Kirsch et al, SPIE 2005)

ABSOLUTE FLUX MEASUREMENTS

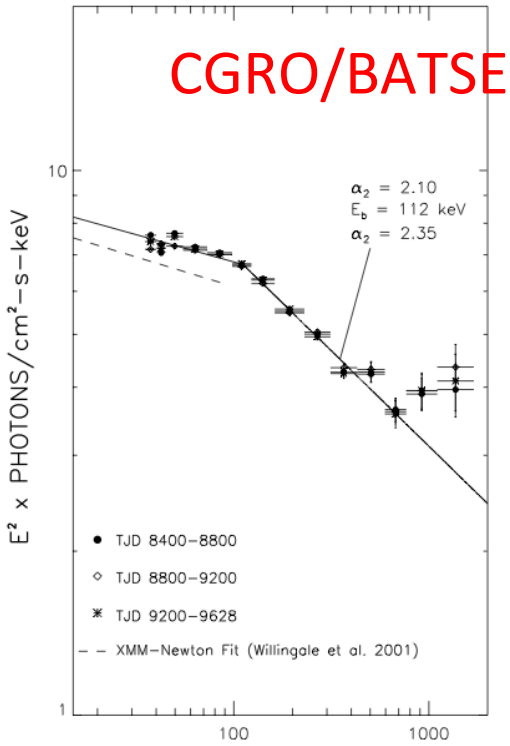
Hard band

Many balloon borne observations

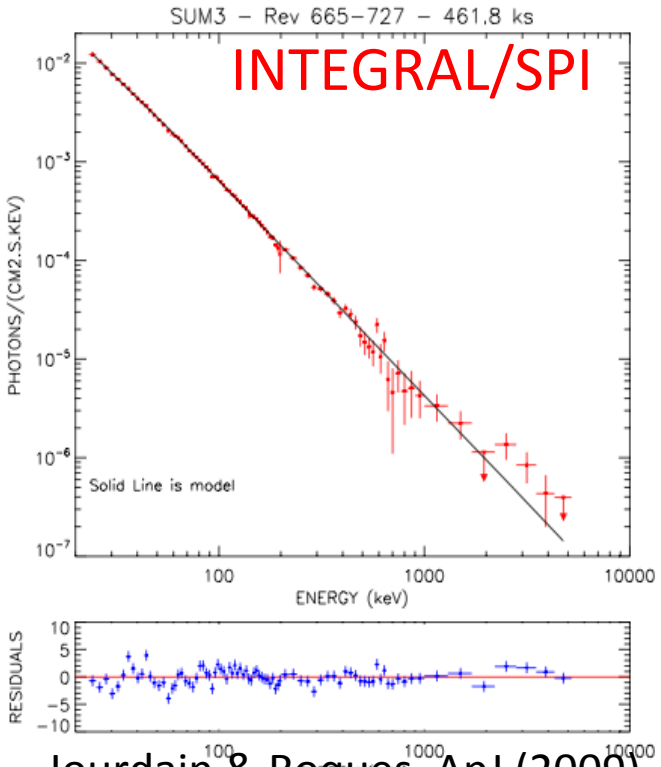
- ❑ BATSE, COMPTEL & SPI: PL with break at ~100 keV
- ❑ A high energy component (> 700 keV) is seen by BATSE, not seen by SPI



Toor & Seward, AJ (1974)



Ling & Wheaton (2003)



Jourdain & Roques, ApJ (2009)

IACHEC/CRAB: STATUS

Data availability:

- XMM (EPIC-pn), Suzaku (XIS, HXD), RXTE (PCA), INTEGRAL(IBIS, SPI)

Facts since last years:

- New IBIS/ISGRI calibration, new OSA software (v10). Updated spectrum
- Nikolai's paper on PCA calibration, Martin's papers on Crab morphology and phase resolved spectra

Actions open: **provide missing info for paper**: see below

- Provide a description of the instrument calibration, on ground and in-flight. Clarify on the use of the Crab and/or other standard candles for response calibration
- Provide the relevant information on data selection and analysis (include information on the Data Processing and Software version), and details of the observations.
- Provide information about the background subtraction process and on possible contaminating sources.
- Provide info on any special treatment needed for Crab spectral extraction.

Status: **first draft ready (will be discussed)**

Observatory	Instrument	ObsID	Epoch[a]	Date[b]	t_{exp}[c] (ks)	Band[d] (keV)	C_{src}[e]
INTEGRAL	IBIS/ISGRI	8860082,8860083	A	2005-10-11T02:18–2005-10-11T21:05	26.698	22–350	361.5 ± 0.3
		0399824		2006-08-13T05:02–2006-08-13T05:40	2.160	22–350	
		8860114	B	2006-09-28T17:03–2006-09-29T16:31	51.806	22–350	
		8860139		2007-09-27T03:54–2007-09-29T13:27		22–350	
		8860149		2008-03-24T15:35–2008-03-26T20:31		22–350	
		8860165	C	2008-09-26T02:10–2008-10-01T10:51		22–350	
		0620037	D	2009-08-12T01:19–2009-08-18T13:09		22–350	
		8860194	E	2010-03-03T11:19–2010-03-04T15:52		22–350	
		0740013/0061	E	2010-04-03T21:31–2010-04-04T21:52		22–350	
		0740013/0064	E	2010-04-08T12:27–2010-04-17T21:00		22–350	
		8860215,8860214		2010-09-12T10:20–2010-09-13T08:23		22–350	
		0770003	F	2011-02-17T19:07–2011-02-19T04:50		22–350	
		8860227 to 8860229	F	2011-02-17T19:07–2011-02-19T04:50		22–350	
		0840017	F	2011-02-23T21:27–2011-03-17T13:27		22–350	
INTEGRAL	SPI	rev365	A	2005-10-11T08:37	30.51	20–2000	8.36×10^5
		rev541		2007-03-11T12:50	71.34	20–2000	1.85×10^6
		rev839	D	2009-08-26T23:15	163.9	20–2000	4.03×10^6
		?avgspec?		**need obs (rev) list for avg spec**		20–2000	
RXTE	PCA	91802-02-05-00	A	2005-09-09T02:01:47	0.478	3–60	8,972 ± 4
		91802-02-06-00		2005-09-23T18:37:45	0.800	3–60	9,146 ± 3
		91802-02-07-00		2005-10-07T19:07:08	0.985	3–60	6,785 ± 3
		92802-01-02-00		2006-03-24T12:34:55	0.817	3–60	8,390 ± 3
		92018-01-01-00		2006-05-10T14:51:44	0.798	3–60	8,272 ± 3
		92802-01-05-00		2006-05-13T15:10:11	0.447	3–60	2,287 ± 2
		92802-02-06-00	B	2006-09-24T18:08:27	0.785	3–60	2,275 ± 3
		92802-01-18-00		2007-03-12T16:41:11	0.570	3–60	4,536 ± 3
		93802-02-01-00		2007-09-22T13:30:54	0.893	3–60	4,366 ± 2
		93802-02-14-00		2008-03-26T05:57:57	0.708	3–60	6,712 ± 3
		93802-02-22-00	C	2008-09-10T19:08:51	0.877	3–60	9,237 ± 3
		93802-02-23-00	C	2008-09-24T20:44:39	0.879	3–60	9,267 ± 3
		94802-01-14-00	D	2009-08-14T23:48:19	0.355	3–60	9,439 ± 3
		95802-01-05-00	E	2010-02-27T06:47:13	0.740	3–60	8,871 ± 3
		95802-01-08-00	E	2010-04-09T17:58:05	0.155	3–60	10,990 ± 8
		95802-01-16-00		2010-09-25T17:30:10	0.865	3–60	9,229 ± 3
		96802-01-04-00	F	2011-02-12T11:17:50	0.895	3–60	9,176 ± 3
		96802-01-07-00	F	2011-03-27T09:40:35	0.848	3–60	6,665 ± 3
Suzaku	HXD/PIN	100023020	A	2005-09-15T19:50:46	12.445	15–70	32.17 ± 0.05
	HXD/GSO				12.445	50–600	18.74 ± 0.07
	HXD/PIN	101004010		2006-03-30T15:39:49	9.095	15–70	32.50 ± 0.06
	HXD/GSO				9.095	50–600	18.56 ± 0.09
	HXD/PIN	101004020		2006-04-04T03:06:43	12.518	15–70	32.18 ± 0.05
	HXD/GSO			2006-04-04T03:06:43	12.518	50–600	18.68 ± 0.07
	HXD/PIN	101003010		2006-04-05T13:06:44	29.083	15–70	34.28 ± 0.03
	HXD/GSO			2006-04-05T13:06:44	29.083	50–600	18.68 ± 0.07
	HXD/PIN	101010010	B	2006-09-05T05:20:45	18.257	15–70	31.38 ± 0.04
	HXD/GSO			2006-09-05T05:20:45	18.257	50–600	18.51 ± 0.06
	HXD/PIN	102019010		2007-03-20T10:41:52	40.525	15–70	32.50 ± 0.03
	HXD/GSO			2007-03-20T10:41:52	40.525	50–600	19.60 ± 0.04
	HXD/PIN	103007010	C	2008-08-27T08:32:51	30.320	15–70	30.93 ± 0.03
	HXD/GSO			2008-08-27T08:32:51	30.320	50–600	18.22 ± 0.05
	HXD/PIN	103008010	C	2008-09-01T09:13:37	31.555	15–70	33.16 ± 0.03
	HXD/GSO			2008-09-01T09:13:37	31.555	50–600	20.01 ± 0.05
	HXD/PIN	104001010		2009-04-02T01:47:37	31.336	15–70	32.80 ± 0.03
	HXD/GSO			2009-04-02T01:47:37	31.336	50–600	19.62 ± 0.05
	HXD/PIN	104001070	E	2010-02-23T01:01:31	15.145	15–70	30.03 ± 0.05
	HXD/GSO			2010-02-23T01:01:31	15.145	50–600	17.63 ± 0.07
	HXD/PIN	105002010	E	2010-04-05T12:37:15	31.341	15–70	30.16 ± 0.03
	HXD/GSO			2010-04-05T12:37:15	31.333	50–600	17.62 ± 0.05
	HXD/PIN	105029010	F	2011-03-21T19:30:59	34.147	15–70	29.78 ± 0.03
	HXD/GSO			2011-03-21T19:30:59	34.147	50–600	17.32 ± 0.05
Suzaku	XIS0	102019010		2007-03-20T10:41:52	0.023	0.6–10	1151 ± 13
	XIS1				0.580	0.6–10	1410 ± 2
	XIS3				0.023	0.6–10	1382 ± 14
XMM	EPIC-pn	0160960401		2004-09-16T02:21:51	439	1–10	4,226 ± 4
		0160960601		2004-09-17T13:44:33	118	1–10	4,227 ± 8

Observations

- Period: Fall 2005 Spring 2011
- 5.5 years
- Many common epochs, mostly during Spring/Fall
- 6 epochs (A-F) for nearly simultaneous spectra

Table 2. Spectral model fits to the emission spectrum of the Crab for the different instruments. All quoted errors are 90% confidence. The energy range given is the one used in the spectral fitting.
Parameters description and units: N_H, Absorption column in units of 10^{21} cm^{-2}; fluxes are *erg cm*$^{-2}$ *s*$^{-1}$ in the specified band (keV); Fl_{3-10} is the unabsorbed flux.

IBIS/ISGRI Model Fit	N_H (10^{21} cm^{-2})	Parameter values and errors	χ^2_ν[dof]
Broken Power Law	0.3-fixed	$\Gamma_1 = 2.071 \pm 0.005, \Gamma_2 = 2.23 \pm 0.02, E_{br} = 88 \pm 5$ $Fl_{20-100} = 1.703 \times 10^{-8}, Fl_{100-300} = 0.958 \times 10^{-8}$	1.09[45][a]
SPI Model Fit	N_H (10^{21} cm^{-2})	Parameter values and errors	χ^2_ν[dof]
Broken Power Law	0.3-fixed	$\Gamma_1 = 2.08 \pm 0.02, \Gamma_2 = 2.23 \pm 0.05, E_{br} = 97 \pm 25$ $Fl_{20-100} = 1.759 \times 10^{-8}, Fl_{100-300} = 0.999 \times 10^{-8}$	1.30[81]
PCA Model Fit	N_H (10^{21} cm^{-2})	Parameter values and errors	χ^2_ν[dof]
Power Law	0.3-fixed	$\Gamma = 2.101 \pm 0.001$, $Fl_{3-10} = 1.740 \times 10^{-8}, Fl_{20-100} = 1.889 \times 10^{-8}$	1.12[1583]
HXD Model Fit	N_H (10^{21} cm^{-2})	Parameter values and errors	χ^2_ν[dof]
Broken Power Law	0.3-fixed	$\Gamma_1 = 2.109 \pm 0.005, \Gamma_2 = 2.234 \pm 0.025, E_{br} = 129 \pm 13$ $Fl_{20-100} = 1.897 \times 10^{-8}, Fl_{100-300} = 1.087 \times 10^{-8}$	1.30[81]
XIS Model Fit	N_H (10^{22} cm^{-2})	Parameter values and errors	χ^2_ν[dof]
Power Law	0.279±0.003	$\Gamma = 2.063 \pm 0.006$ $Fl_{3-10} = 1.509 \times 10^{-8}$	1.15[669]
EPIC-pn Model Fit	N_H (10^{22} cm^{-2})	Parameter values and errors	χ^2_ν[dof]
Power Law	0.246±0.006	$\Gamma = 2.095 \pm 0.007$ $Fl_{3-10} = 1.475 \times 10^{-8}$	1.09[337]

Notes. [(a)] assuming syst=0.005.

SINGLE INSTRUMENT FITS

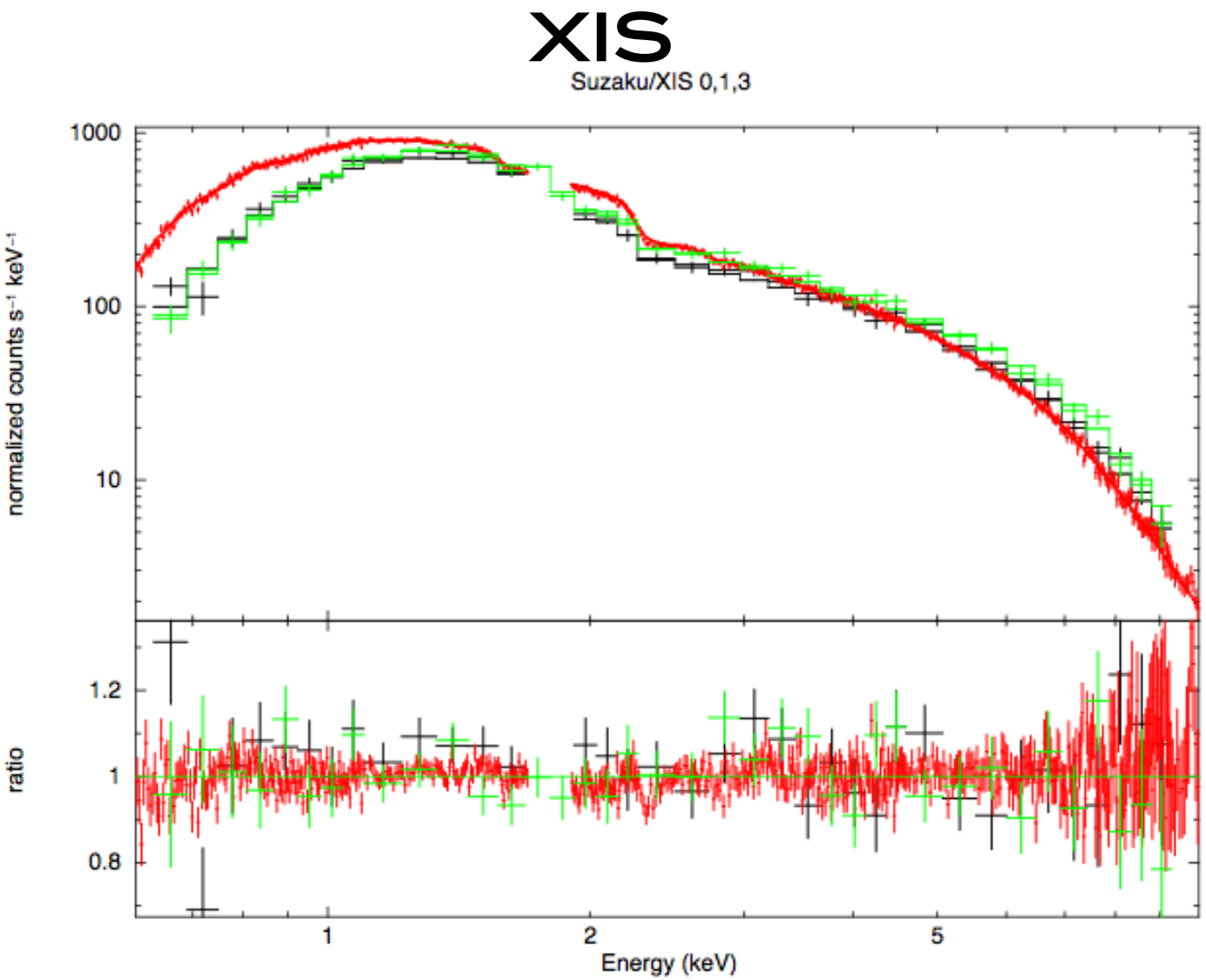


Fig. 5. Crab spectra of Suzaku/XIS detectors n.0,1,3 acquired in Feb 2010.

EPIC-PN: BURST MODE

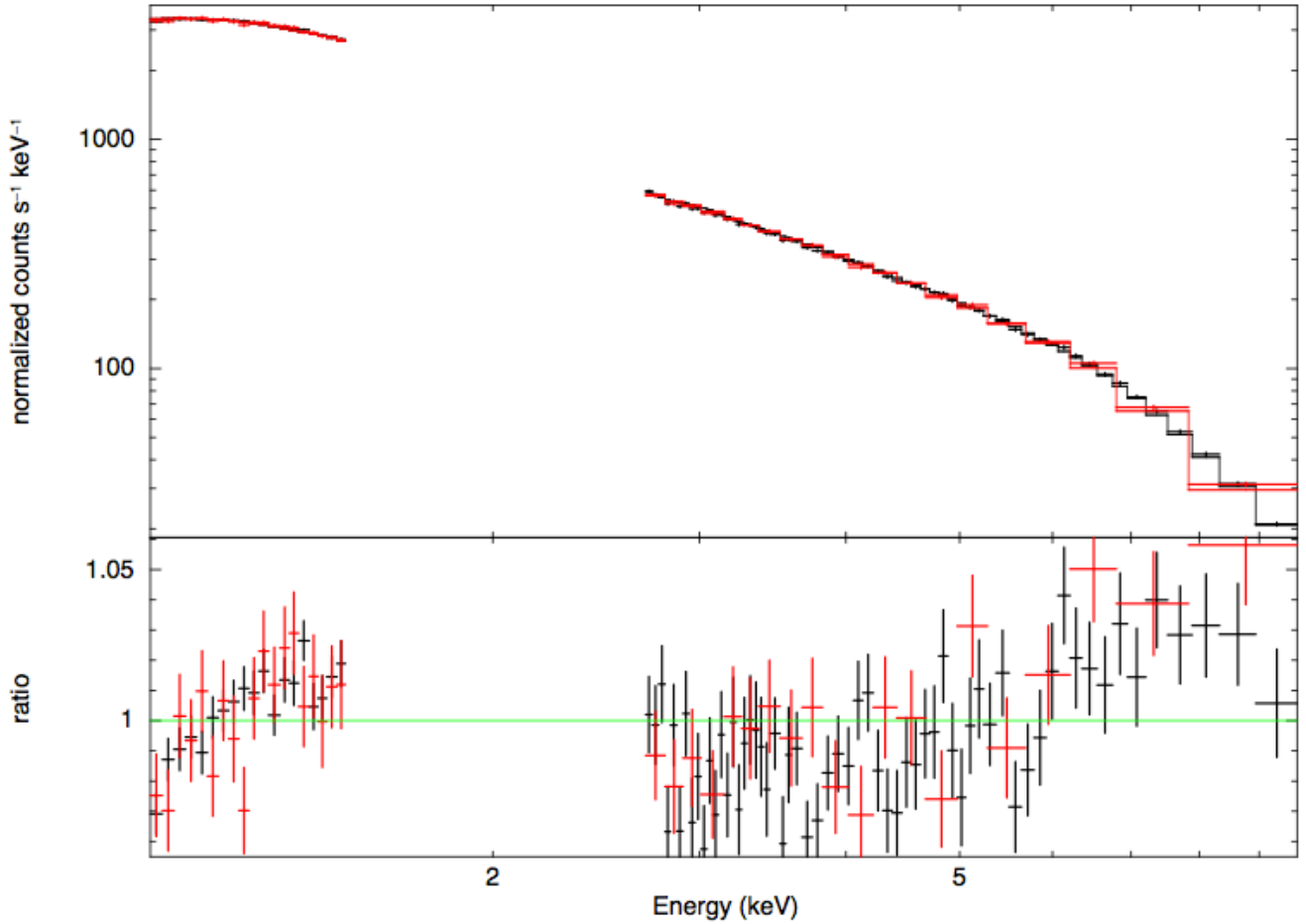
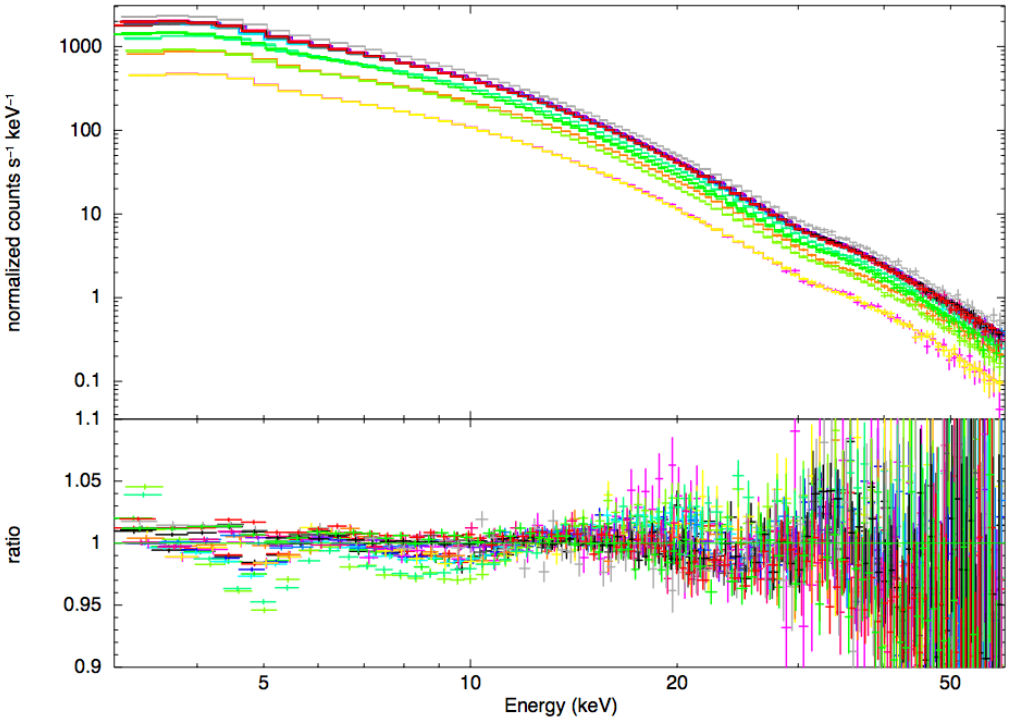


Fig. 7. The XMM/EPIC-pn spectrum measured during an observation of the Crab performed 9 September 2004. The model spectrum is an absorbed power law.

PCA



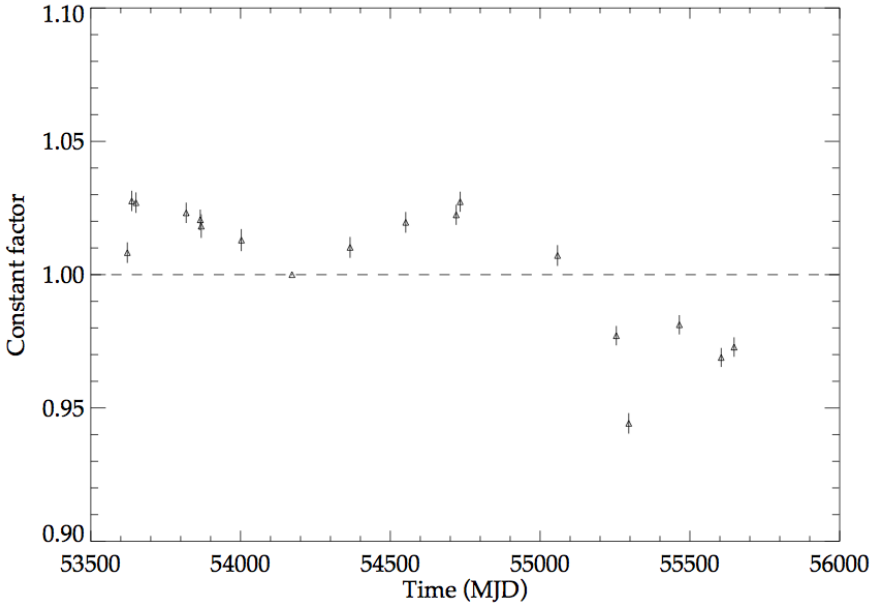


Fig. 4. Time evolution of the normalization constant for the PCA instrument, relative to the observation taken during Spring 2007 (ObsID: 92802-01-18-00).

Shown are the 18 spectra listed in obs. table

HXD (PIN,GSO)

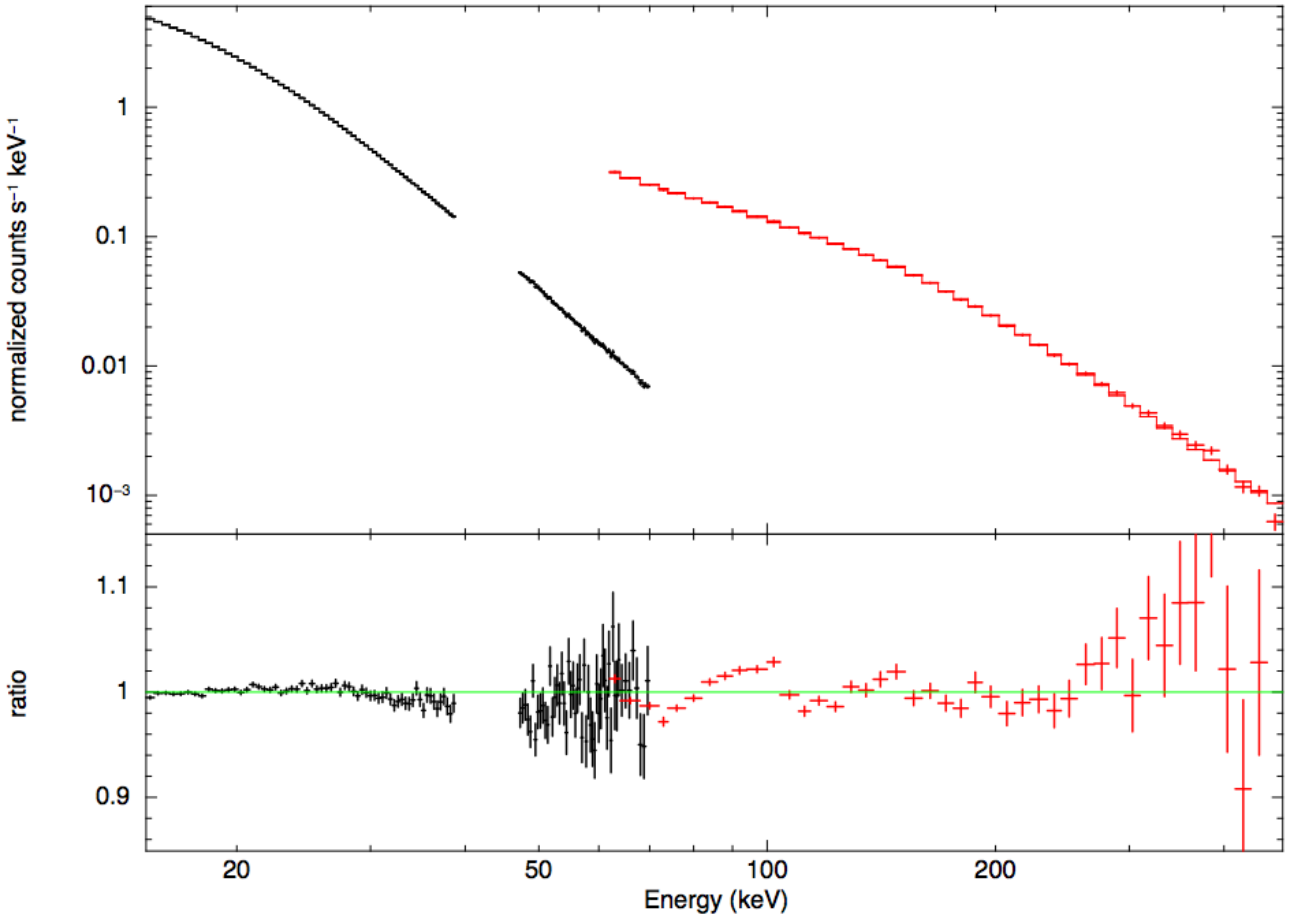
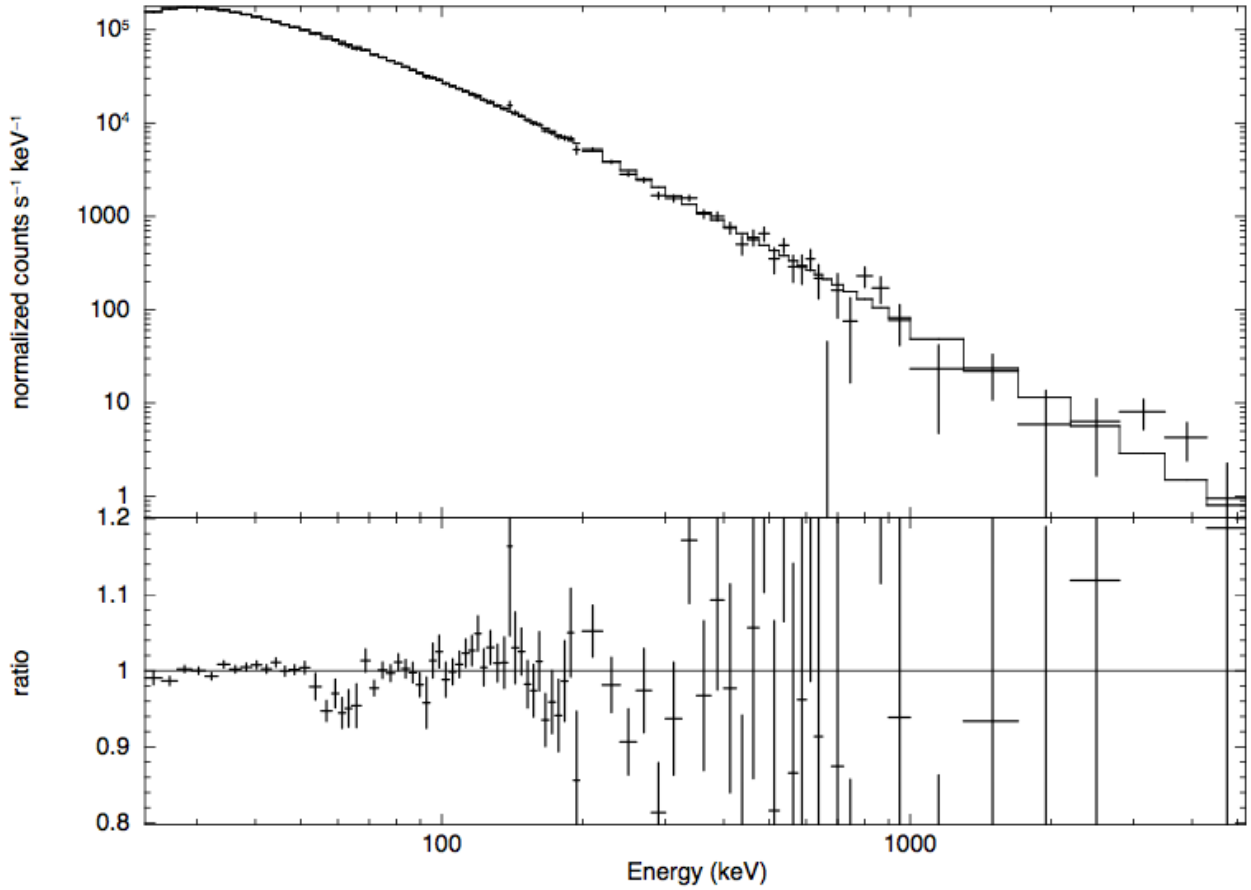
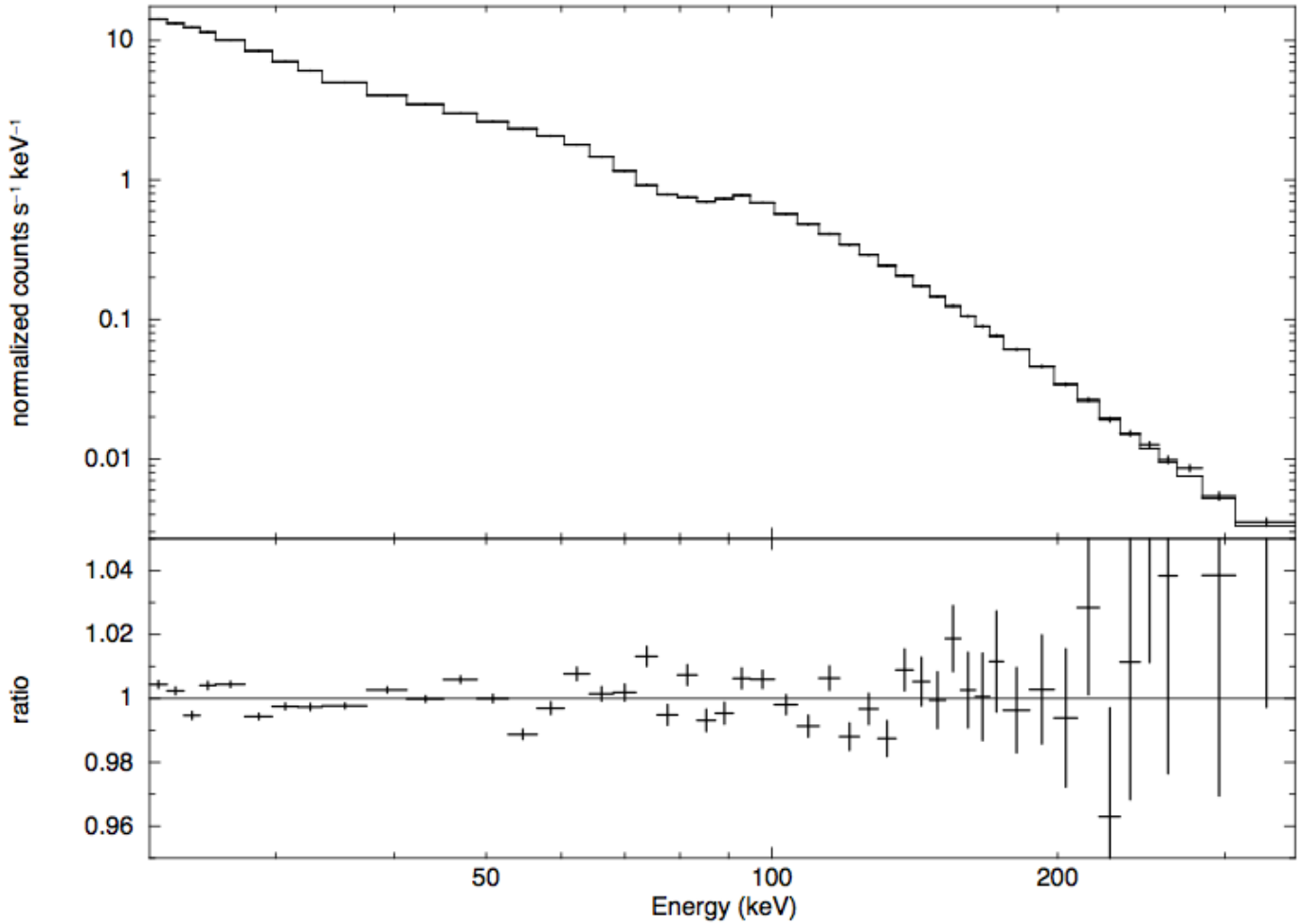


Fig. 6. The average broadband spectrum measured by the Suzaku/HXD in the reference period. The model spectrum is a broken power law.

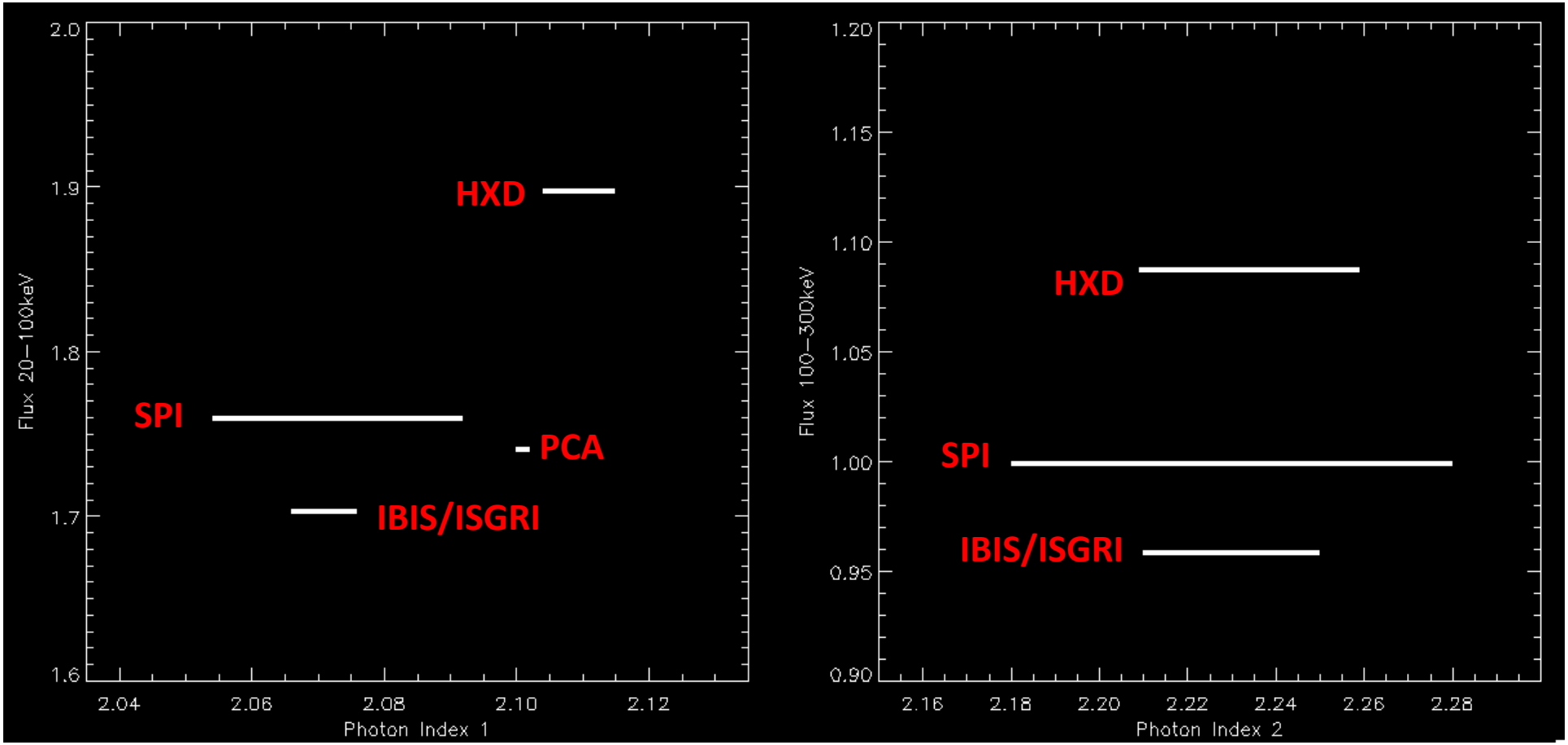
SPI


normalized counts s⁻¹ keV⁻¹
10⁵
10⁴
1000
100
10
1
ratio
1.2
1.1
1
0.9
0.8
100
1000
Energy (keV)

IBIS/ISGRI


normalized counts s⁻¹ keV⁻¹
10
1
0.1
0.01
ratio
1.04
1.02
1
0.98
0.96
50
100
200
Energy (keV)

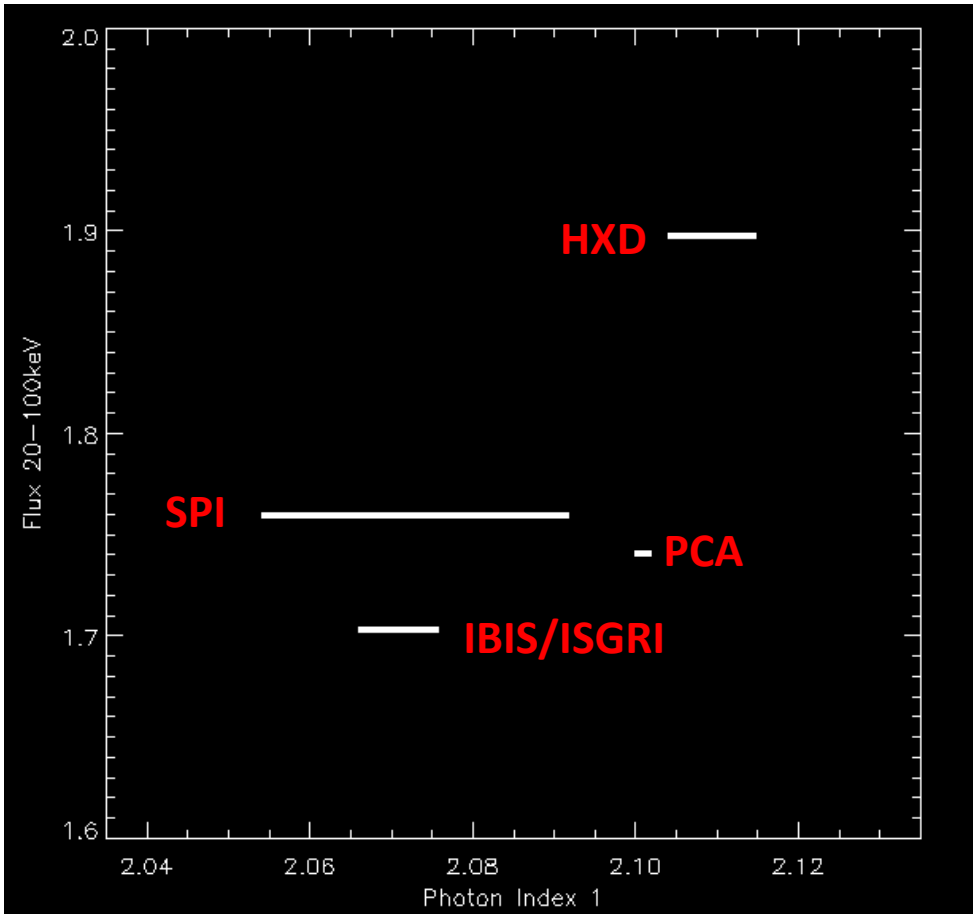
SINGLE INSTRUM FITS, BROKEN PL



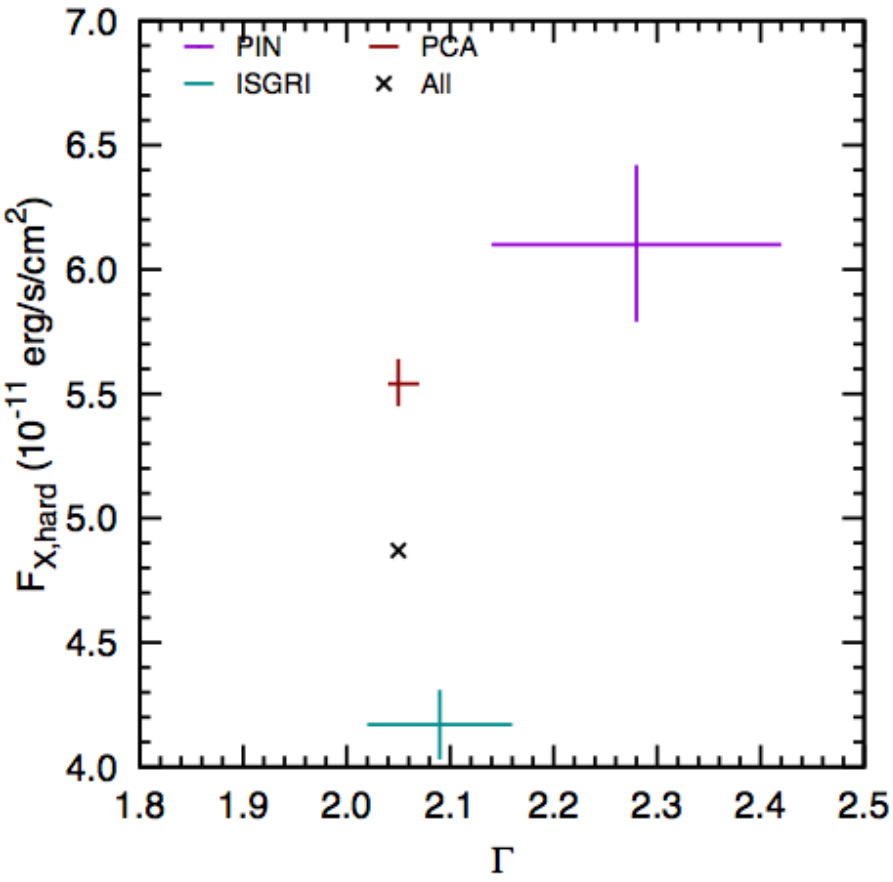
Fluxes: units of 10^{-8} erg cm^{-2} s^{-1}

- PCA fluxes are those one measured during Spring 2007 (ObsID 92802-01-18-00).
- Others are average spectra in the reference period.
- Using syst>0 may affect the parameters

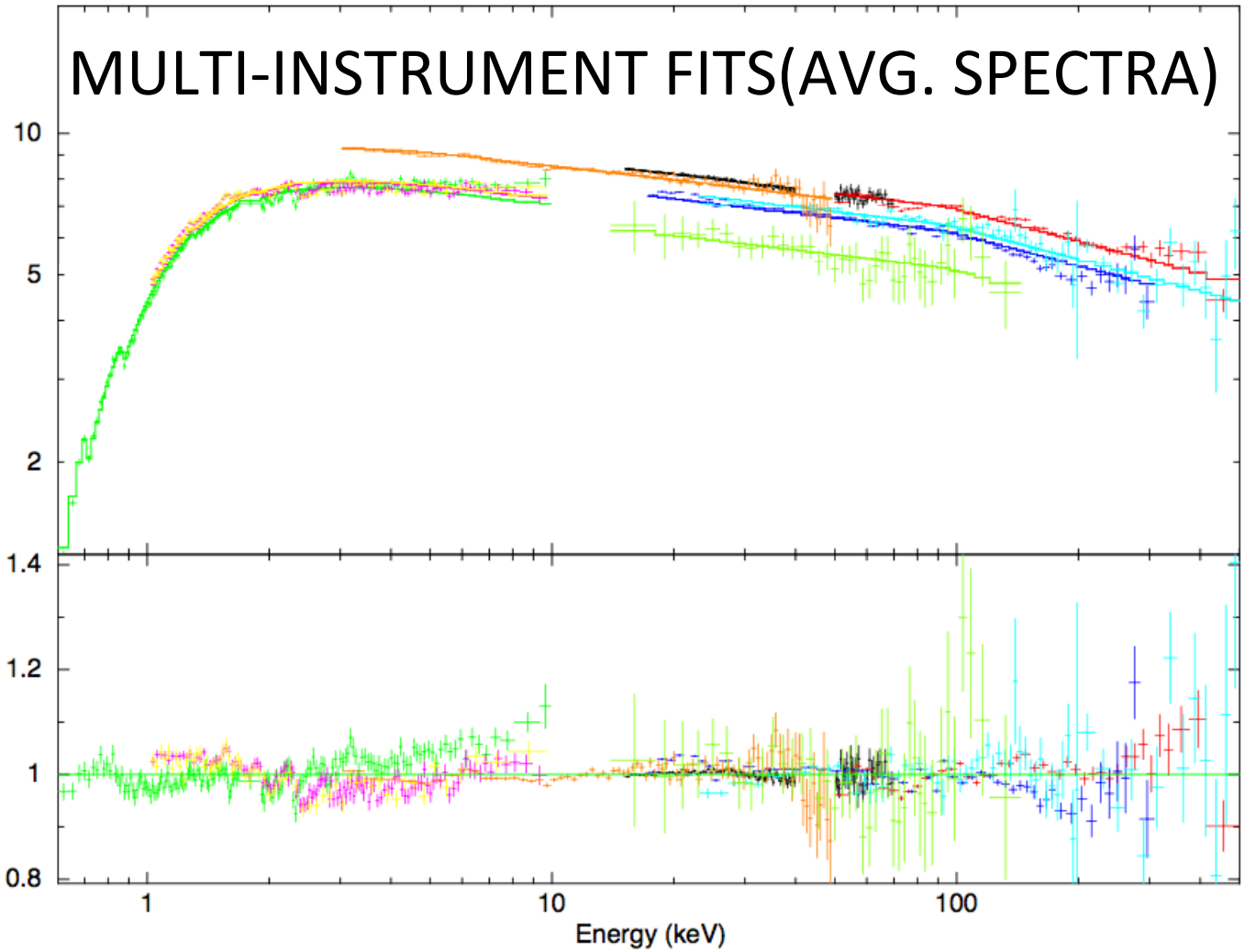
CRAB vs G21.5-0.9



Flux 15-50 keV



MULTI-INSTRUMENT FITS(AVG. SPECTRA)

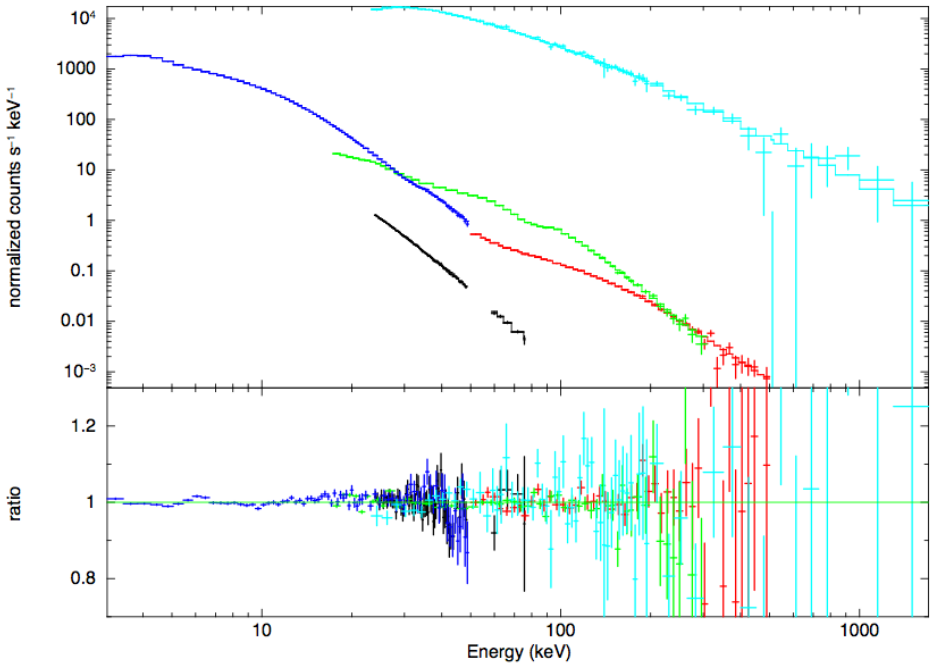


(still to be updated for more recent IBIS spec)

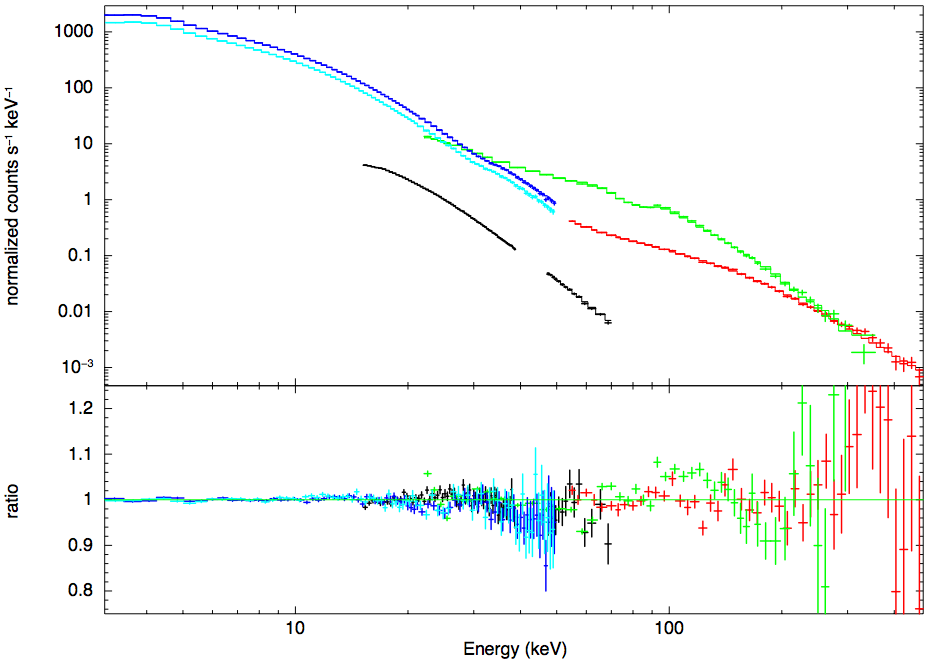
Parameter	HXD/PIN	HXD/GSO	XIS1	IBIS	SPI	EPIC-pn1	EPIC-pn 2	PCA	BAT
C_f	1.093 ± 0.005	1.092 ± 0.006	0.879 ± 0.007	0.969 ± 0.005	1.0	0.904 ± 0.007	0.909 ± 0.07	1.063 ± 0.006	0.809 ± 0.015
Fl_{2-10}			19.24 ± 0.03			19.79 ± 0.02	19.88 ± 0.06	23.265 ± 0.012	
Fl_{20-100}	19.03 ± 0.09	19.45 ± 0.15		17.26 ± 0.05	17.66 ± 0.04			16.49 ± 0.05	14.41 ± 0.21

Constant factors and fluxes (x10^{-9} erg cm-2 s-1) relative to the PCA.

NEARLY SIMULTANEOUS OBSERVATIONS

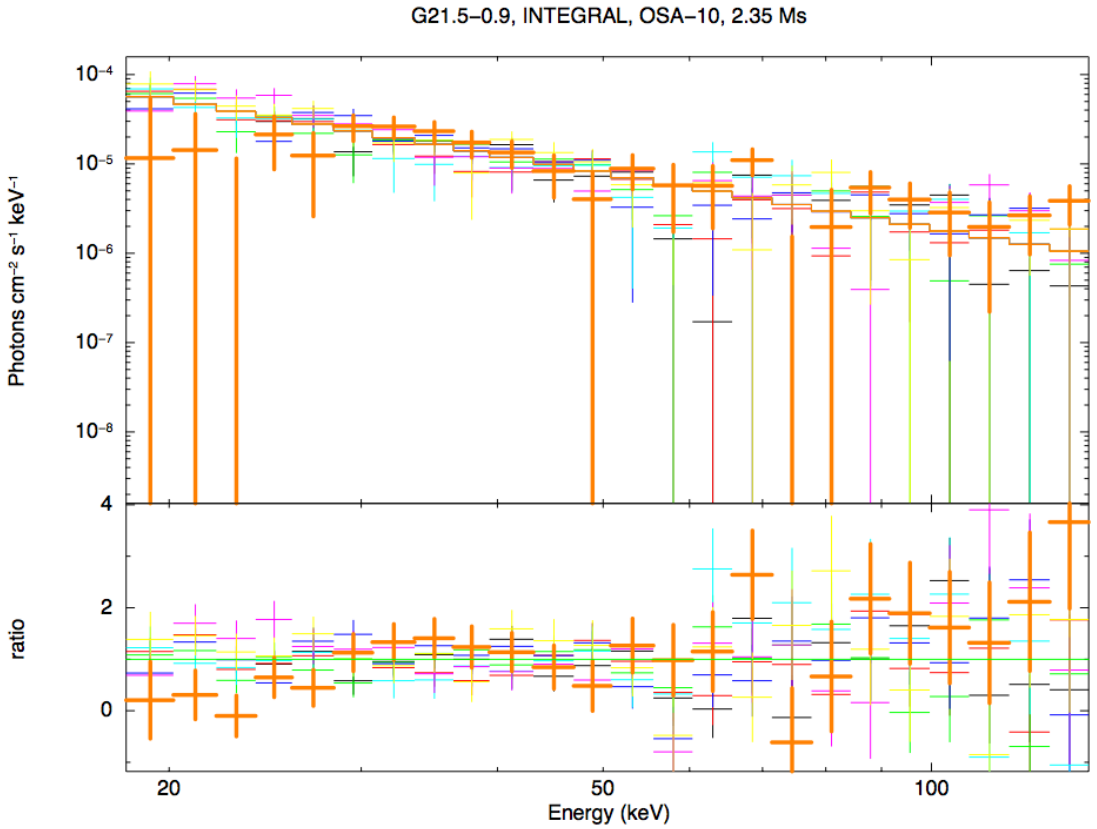


Epoch A (Fall 2005)



Epoch F (Spring 2011)

G21.5-0.9 UPDATE? WITH NuSTAR AND MORE RECENT DATA



Γ=2.05+/- 0.13

F_{15_50}=(3.95 +/- 0.24) x 10^{-11} erg cm^{-2} s^{-1}