

SPI ANALYSIS OF THE HIGH ENERGY EMISSION OF CYG X-1

- Data set, Method and parameters
- Validation (Crab observations)
- Results

Data set and Field of view

Angle selection : 13°
More than ~20 scw in the revolution

42 parts of revolutions

Total duration : **4 Ms**

From June 2003 to December 2009

Log of the *INTEGRAL* SPI Observations of Cyg X-1 Used in This Paper

Revolution Number	Start	End	Useful Duration (ks)
79–80 (5×5)	2003 Jun 7 00:59	2003 Jun 12 03:35	293
210–214 (A)	2004 Jul 3 00:01	2004 Jul 17 00:25	709
251–252 (A)	2004 Nov 3 14:23	2004 Nov 7 16:26	176
259 and 261 (H)	2004 Nov 26 12:28	2004 Dec 3 15:43	143
470 (EXO, H)	2006 Aug 19 09:19	2006 Aug 21 16:02	159
486 (EXO, H)	2006 Oct 6 00:11	2006 Oct 8 07:55	160
498–505 (GP)	2006 Nov 11 19:31	2006 Dec 4 06:20	535
628–631 (A)	2007 Dec 4 19:05	2007 Dec 15 21:08	388
673 (A)	2008 Apr 18 17:41	2008 Apr 19 22:09	54
682–684 (A)	2008 May 14 08:13	2008 May 22 19:54	304
739–746 (A)	2008 Nov 1 02:14	2008 Nov 24 05:25	551
803–806 (A)	2009 May 11 08:27	2009 May 22 11:32	371
875(H*) and 877(H)	2009 Dec 12 16:18	2009 Dec 19 20:57	160

Sky Model : Cyg X-1
Cyg X-3
EXO 2023+375
GRS 1915

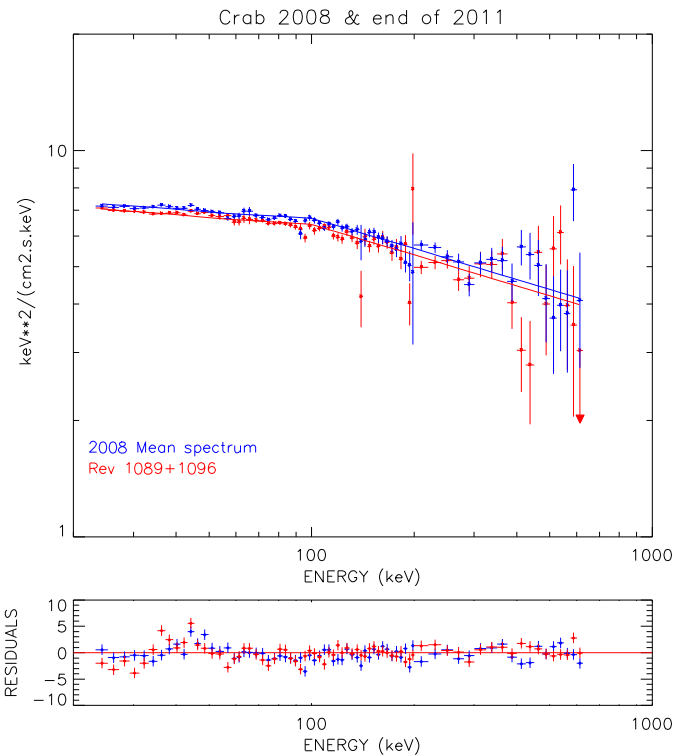
Method and Parameters

Our standard method

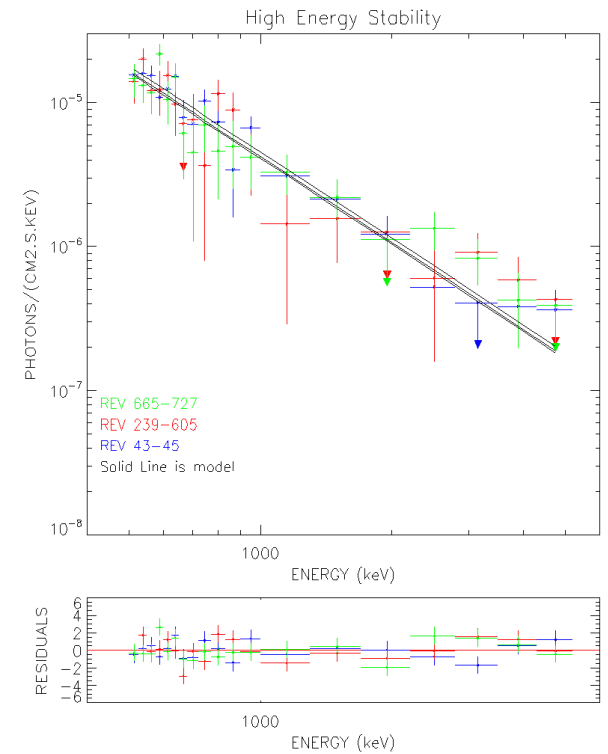
- Background based on flat-field observations
 - 1 pattern per ~ 6 months
 - 1 normalization factor each ~ 10 ks (5 scw)
- All Single events for $E > 650$ keV
PSD events only above
- Sources' flux kept constant per revolution
- Model fitting: choice of all free parameters value through a χ^2 minimization
- Check at the end of the flux extraction that final χ^2 values close to 1 (per energy bin and scw).
- Check in the final spectra that background lines are properly subtracted (139 and 198 keV lines)

Validation of the method

On the Crab observations Between 20 keV and 5 MeV

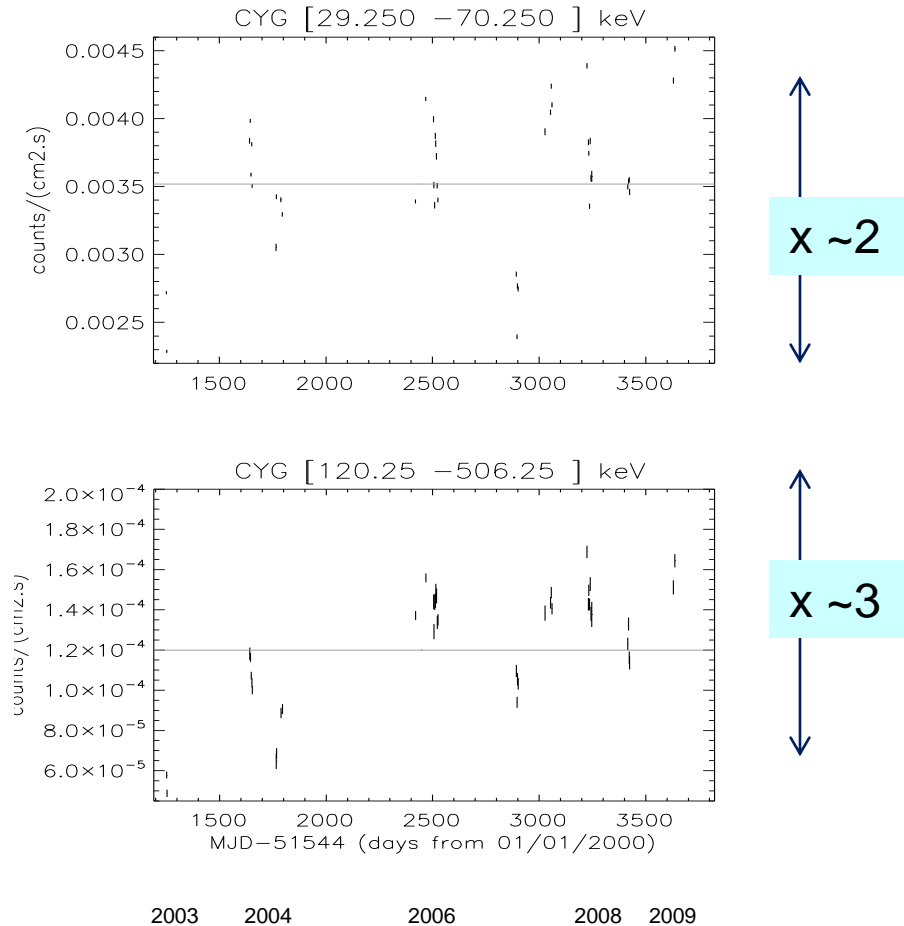


Stability of the
spectral parameters
and flux

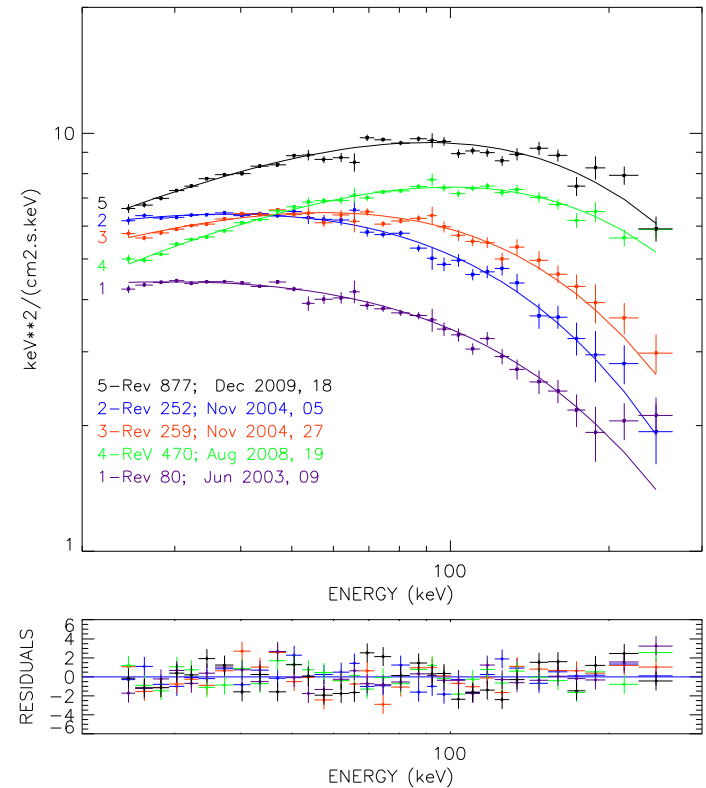


Cyg X-1 results

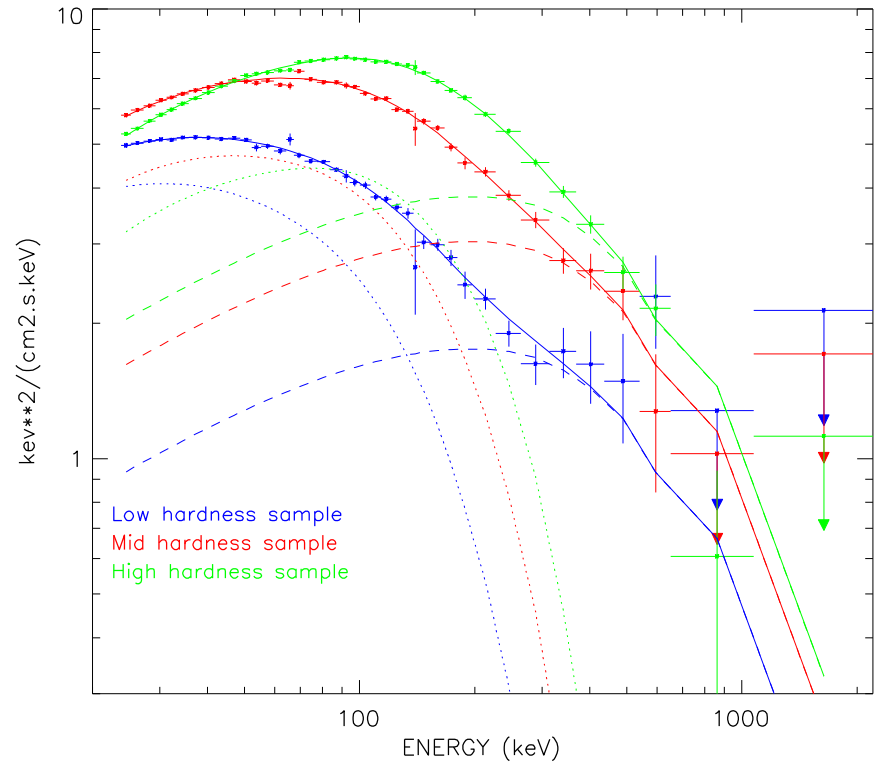
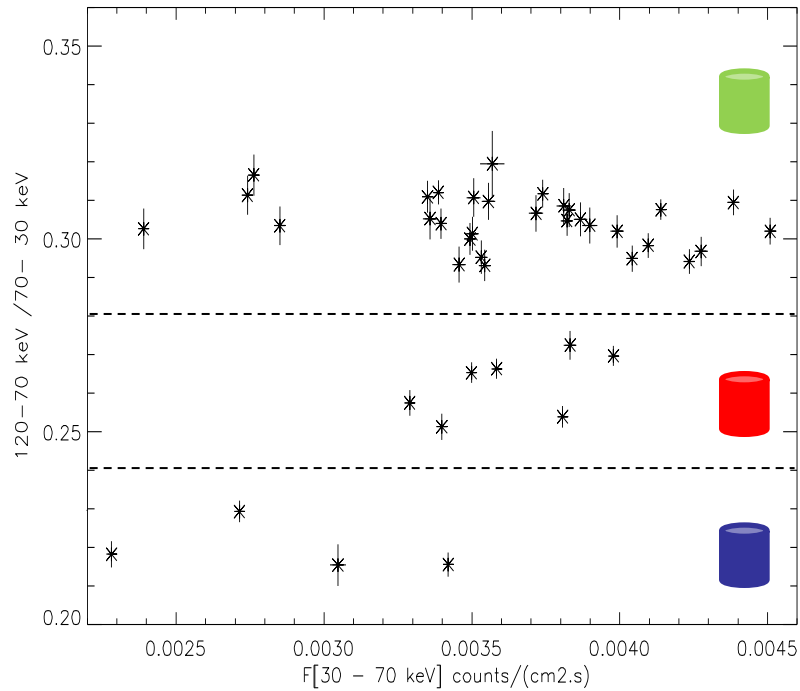
FLUX averaged by revolution



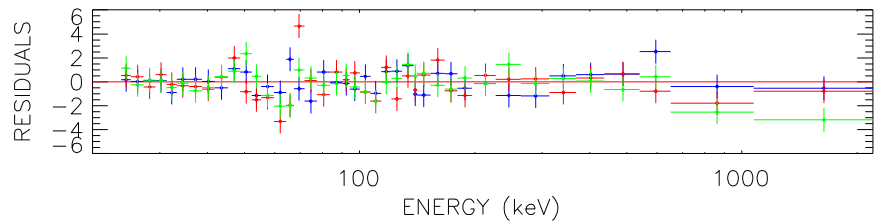
Clear spectral and flux variability



Cyg X-1 results

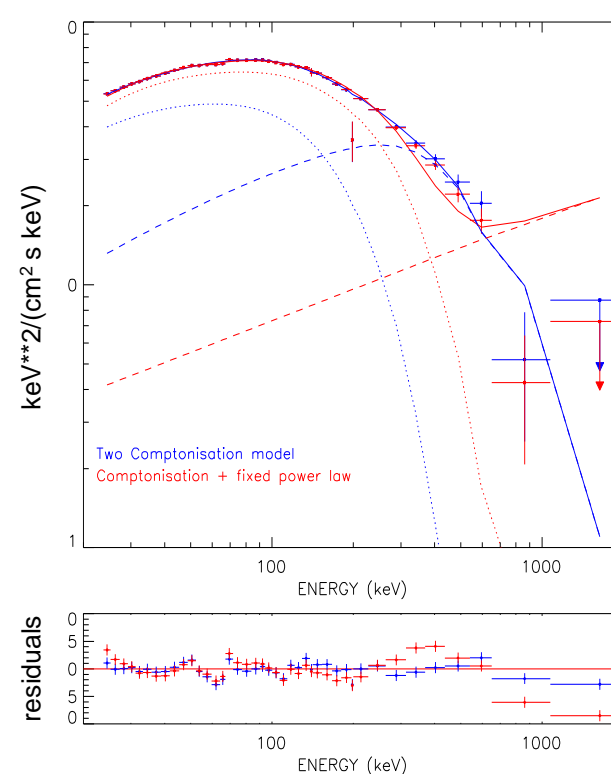
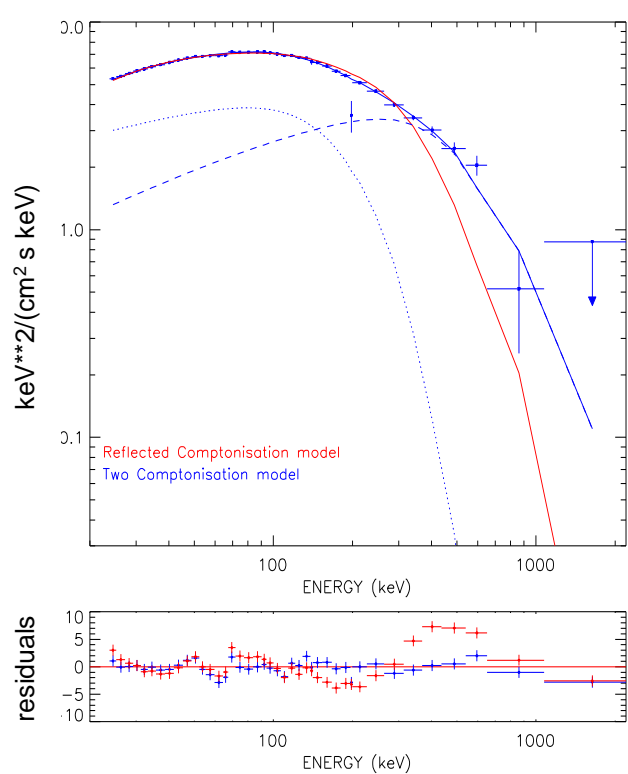


Sample/Model	Ω	kT keV	τ	kT_2 keV	τ_2	χ^2_{red}
Low hardness sample	0.55 ± 0.25	33 ± 3	1.2 ± 0.1	130 (fix)	0.6 (fix)	0.99 (36)
Mid hardness sample	0.73 ± 0.15	36 ± 3	1.4 ± 0.2	130 (fix)	0.6 (fix)	2.13 (36)
High hardness sample	0.68 ± 0.15	40 ± 3	1.6 ± 0.1	130 (fix)	0.6 (fix)	1.4 (36)



- Temperature and optical depth increase
- + same 2nd Comptonisation medium

Cyg X-1 results: Total spectrum

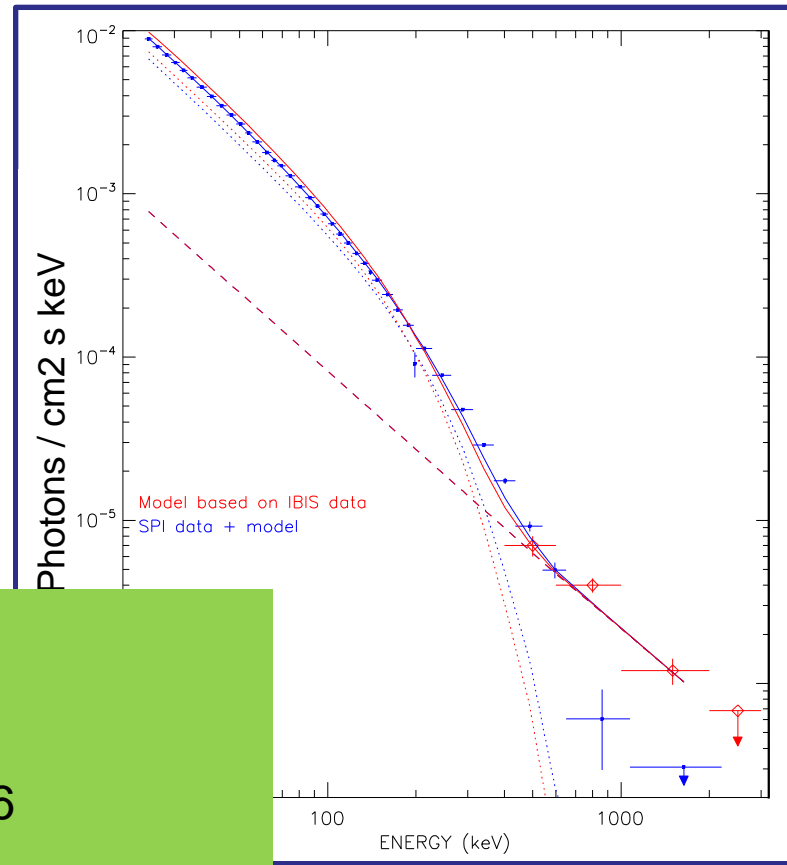


Model	Ω	kT keV	τ	α or kT_2 keV	τ_2	χ^2_{red} (DoF)
Refl*Comptt	0.90 ± 0.3	75.0 ± 3	0.91 ± 0.03			6.0 (37)
Refl*Comptt + power law	0.88 ± 0.3	56 ± 3	1.2 ± 0.1	1.8 ± 0.2		5.1 (35)
Refl*Comptt+Comptt	0.8 (fixed)	38 ± 3	1.6 ± 0.15	123 ± 10	0.5 (fixed)	1.7 (36)

Cyg X-1 results: Comparison with IBIS (1)

IBIS DATA from Laurent et al.,
(2011)

Presentation at CHIA
workshop (Sept 2011)



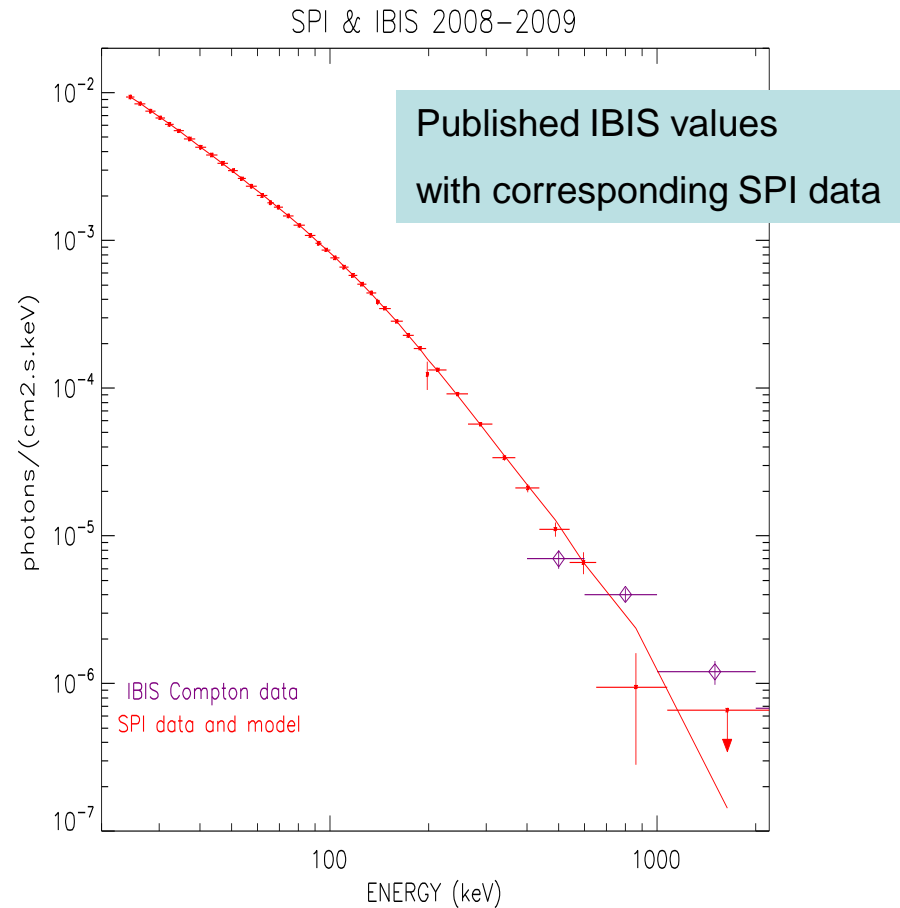
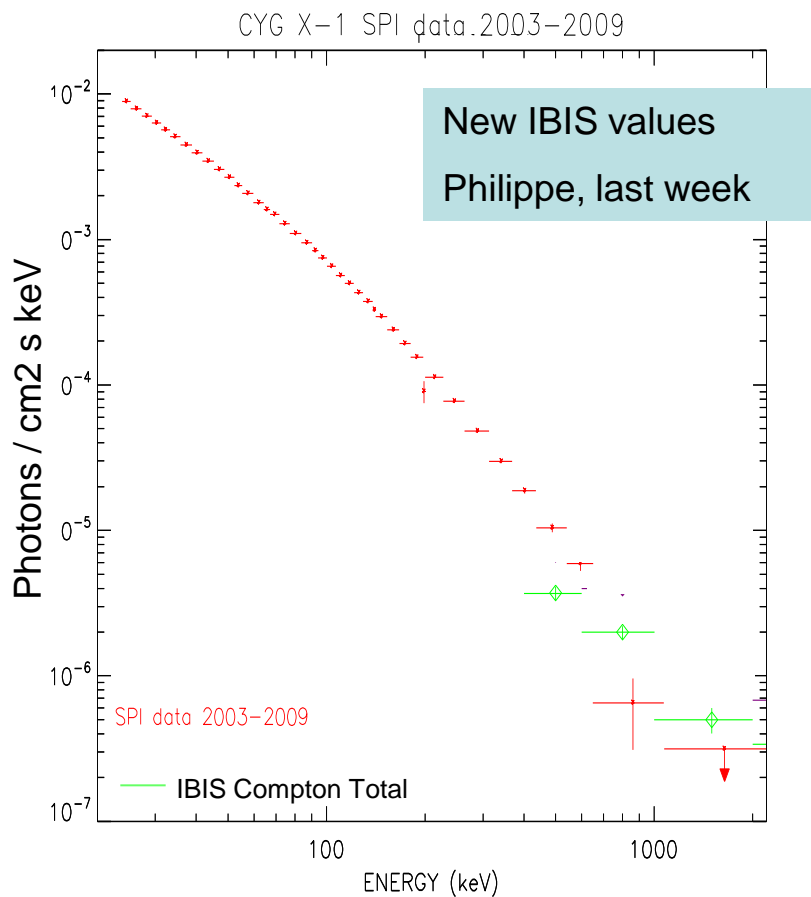
Comptonisation +
The same power law
with photon index = 1.6

Nice agreement up to ~ 600 keV
Clear discrepancy above 600 keV

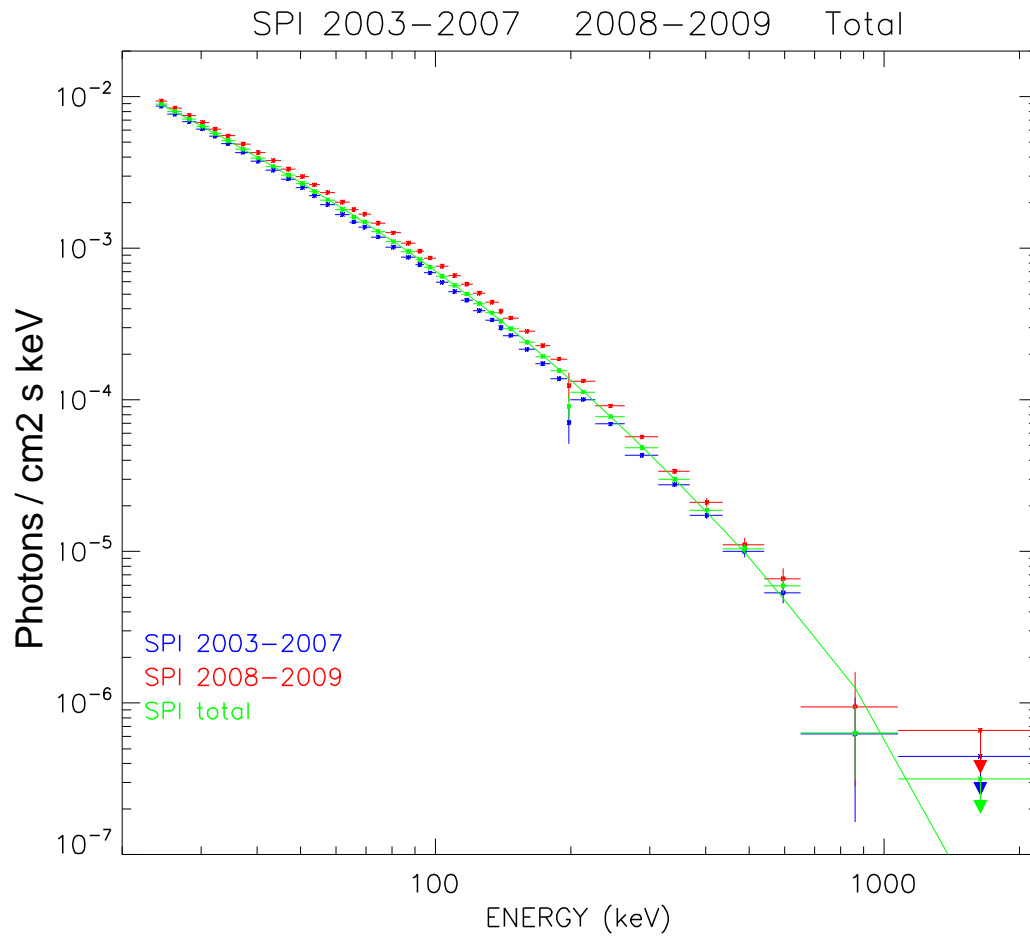
Cyg X-1 results: Comparison with IBIS (2)

Total spectrum

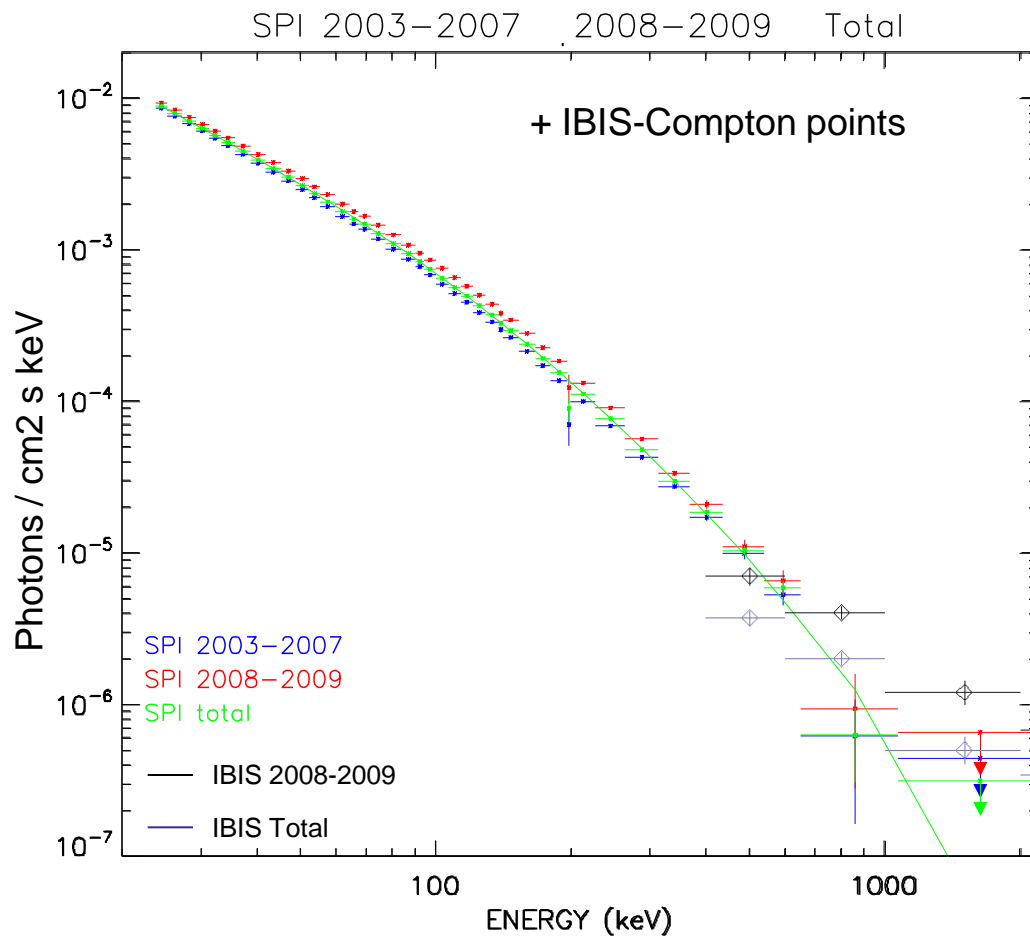
2008-2009 spectrum



All together: Comparison SPI - IBIS



All together: Comparison SPI - IBIS



CONCLUSIONS

- ❑ Hard to reconcile IBIS-COMPTON and SPI results.

What to do ?

- ❑ Comparison with the Crab data
First test gives a factor 2in the bad direction
- ❑ SPI polarization measurements ?
Not so easy to detect (and in any case, < 1 MeV)

High energy results require more time
For calibration and science

Cyg X-1 IUG 18-19/01/2012
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