



# JEM-X

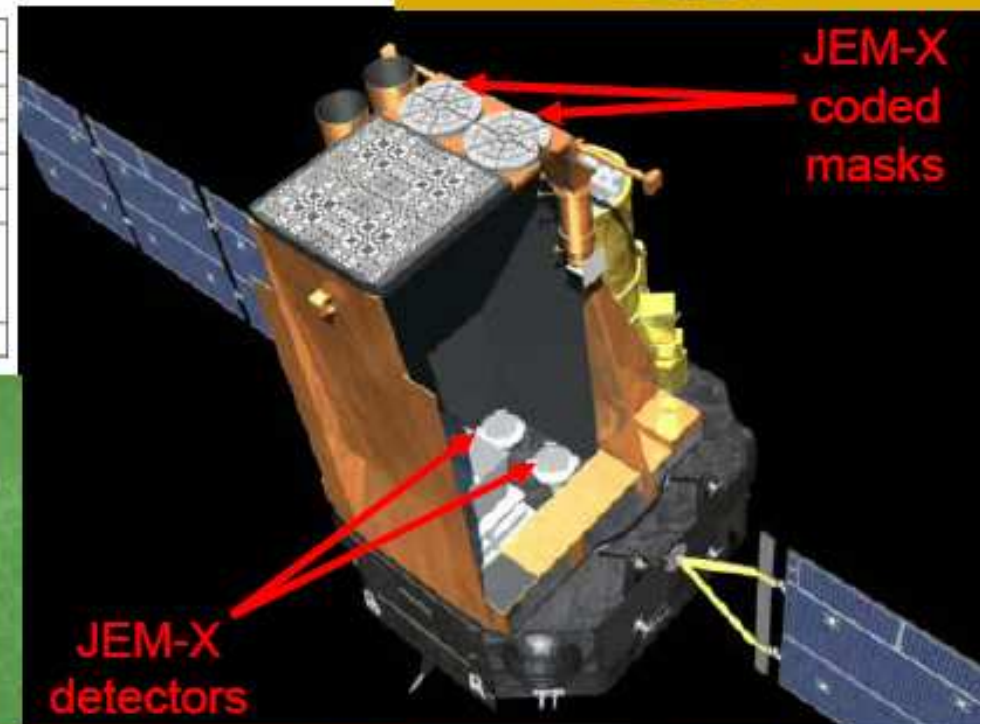
## The INTEGRAL X-Ray monitor

- JEM-X provides coverage in the 3-35 keV energy range
- Gas filled micro-strip detector + coded mask



Table 1. JEM-X specifications

Mask diameter	535 mm
Detector diameter	250 mm
Mask-detector distance	3401 mm
Energy-range	3 – 35 keV Primary range
Energy resolution	$\Delta E/E = 0.40(E[\text{keV}])^{-1/2}$
Angular resolution	3 arcmin
Field of view (diameter)	4.8° Fully coded 7.5° Half response 13.2° Zero response
Point source location	30 arcsec (for a $10\sigma$ source)





## Two approaches used to fit Crab spectrum:

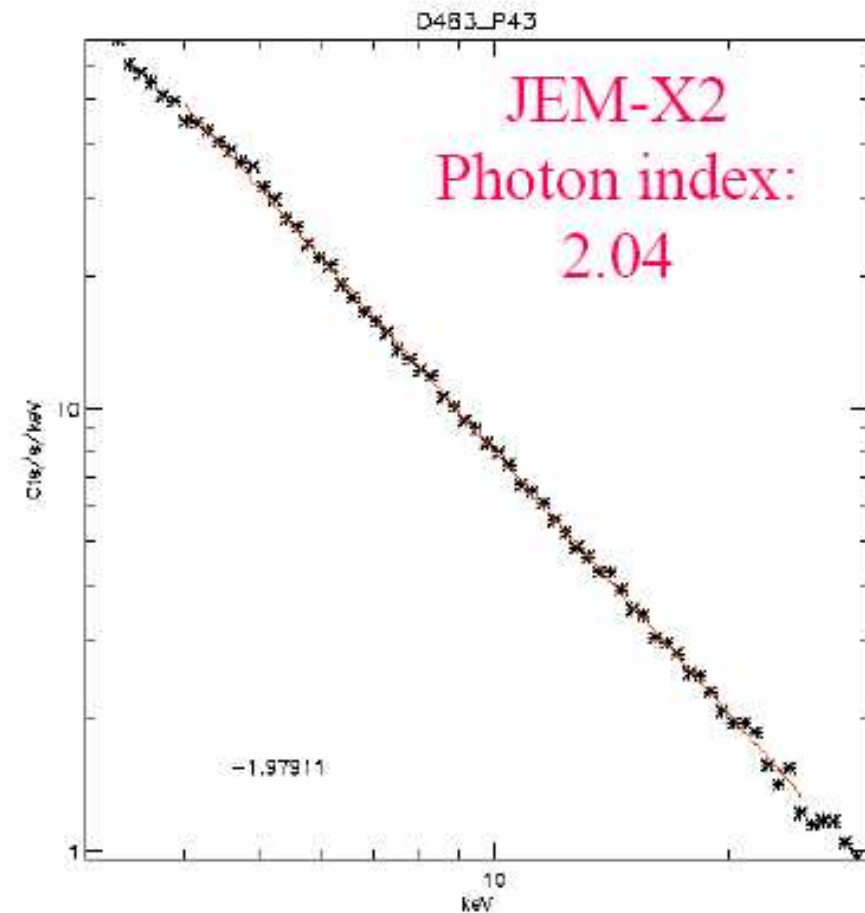
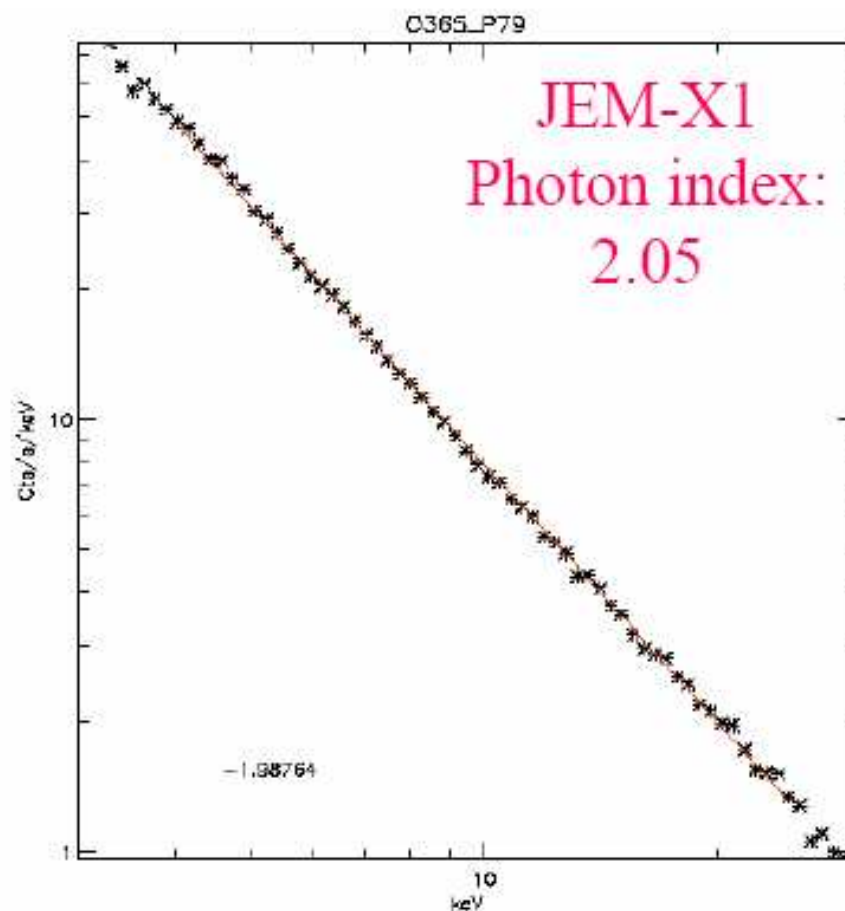
1. Cross-correlation imaging in narrow energy bands and subsequent flux determination from image peak (PSF)
2. Fitting of spectra derived from subtraction of on-off Crab pointings

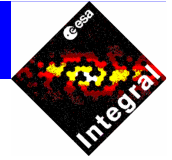
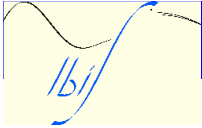
## Challenges:

1. Efficiency as function of photon energy depends on the actual detector gain
2. Vignetting function and detector effective area are difficult to model



## Crab Spectra derived by imaging flux extraction





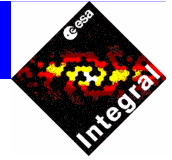
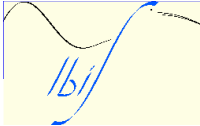
### Status of ISGRI Calibration model [1/3]

#### Main updates OSA 6.0:

- New spectral response taking into account Rise Time of single events.
- New off-axis correction tables

#### Outcome:

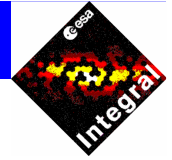
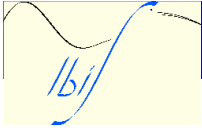
- **better quality of spectra extraction** (lower systematic residuals) due to improved RMF. The accuracy of model fitting with ARF post-facto correction is now ~1%.
- Long-term variability still present (need **time dependent ARFs** to account for)
- Using time dependent efficient area, spectra can be modelled down to a **lower level threshold of ~17 keV** in every observation



### Status of ISGRI Calibration model [2/3]

The **IBIS Mass model** is a code built on GEANT3, with accurate geometric and physical representation of all the active and passive elements of the instrument, including detectors, shield and mask assemblies

- the model is calibrated using **ground data** from module level, instrument level and payload level calibrations (PLGC)
- **in flight data** from on-board calibration source ( $\text{Na}^{22}$ ), Pb and W fluorescence lines are used for continuous gain/offset monitoring
- the MC model is refined with a detailed **simulation of the signal formation in CdTe** (currently under finalization)
- Systematics due to signal formation process makes it necessary to use post-facto **response correction by using Crab in-flight data**)



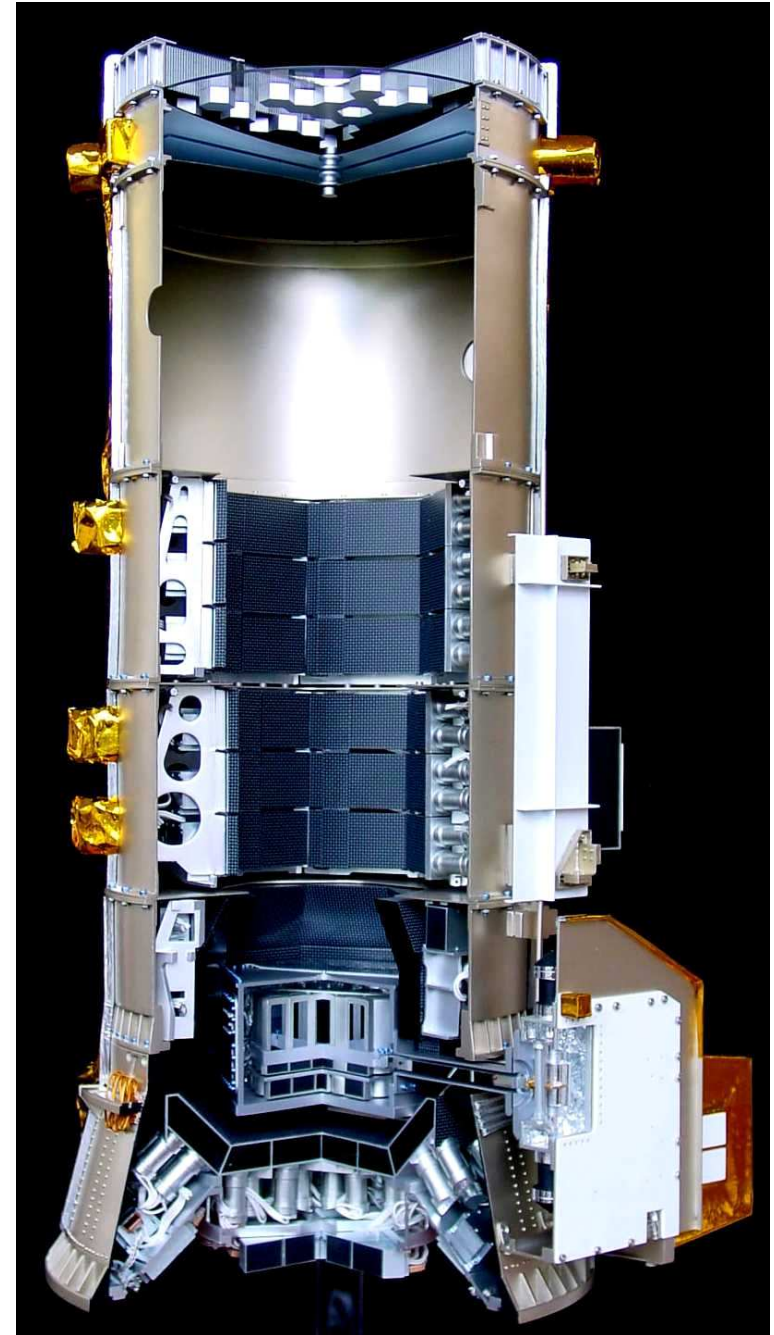
### Status of ISGRI Calibration model [3/3]

#### Crab observations analysis

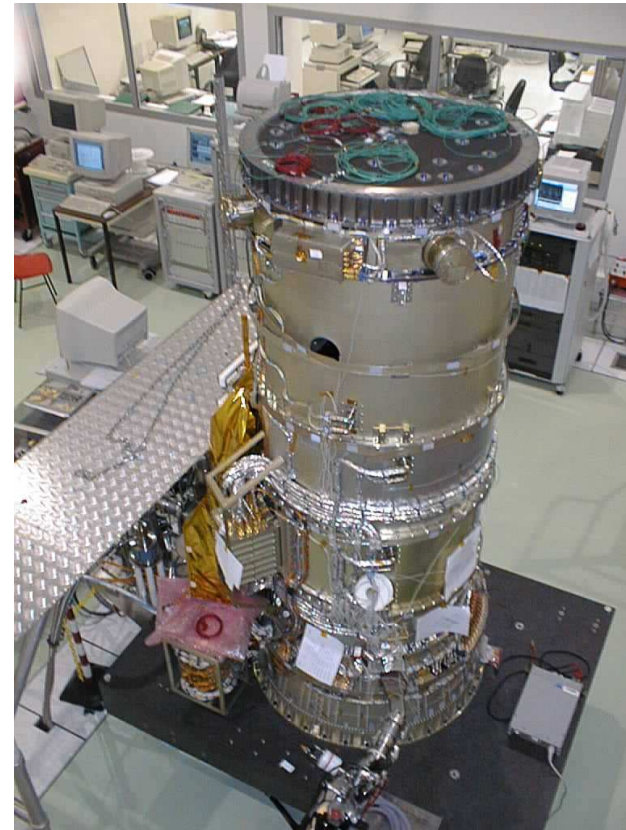
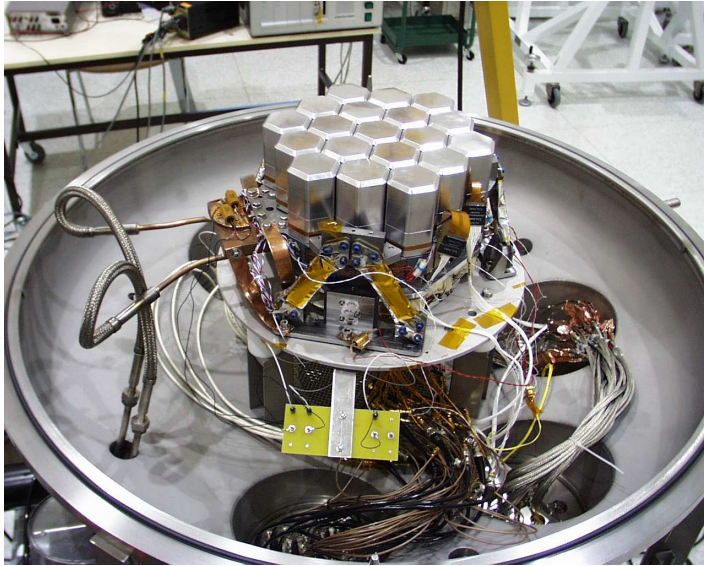
- the current calibration is obtained by assuming power law shape of the Crab (same as OSA-5) and MC model normalization
- Currently, the difference to the SPI data can be described as ~6% lower normalization and slightly steeper spectral shape ( $\Gamma=2.225$  for IBIS)
- The current discrepancy with SPI Crab spectrum is **probably minimized using latest model test results** (flatter shape, higher normalization)
- more consolidated results to come mid Summer

# SPI

Imaging :  $16^\circ$  fully coded FOV  
Angular resolution :  $2.6^\circ$   
Energy range : 20 keV- 8 MeV  
Energy resolution : 0.2 %  
Time resolution : 100 microsec  
Shield : active BGO shield  
Camera : 19 HPGe detectors.  
Active cooling : 85 K



# SPI FM CALIBRATIONS



# SPI CALIBRATION AT BRUYERES LE CHATEL

(May 2001)

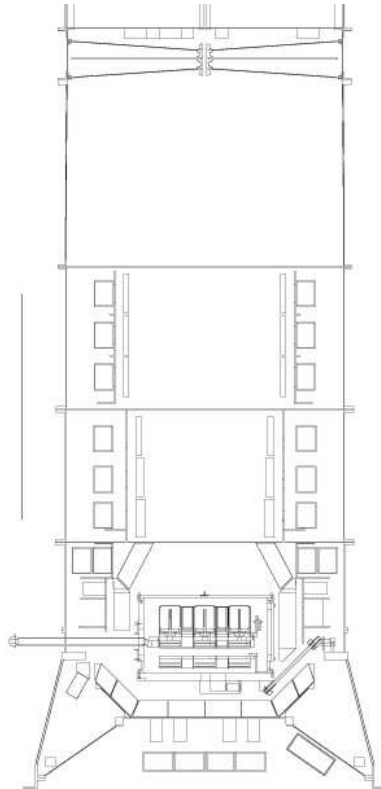


Response matrix generated by  
Monte-Carlo simulation  
Validation and corrections with  
ground calibrations

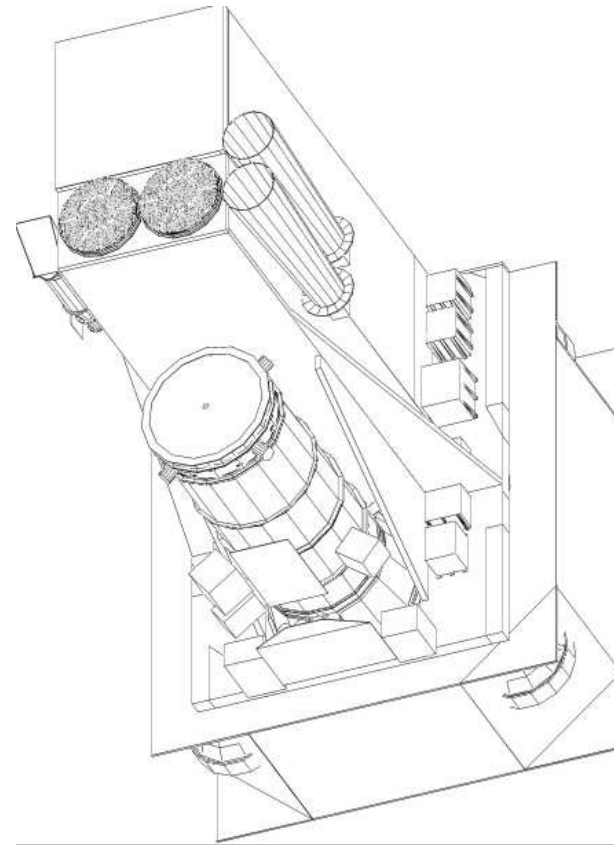
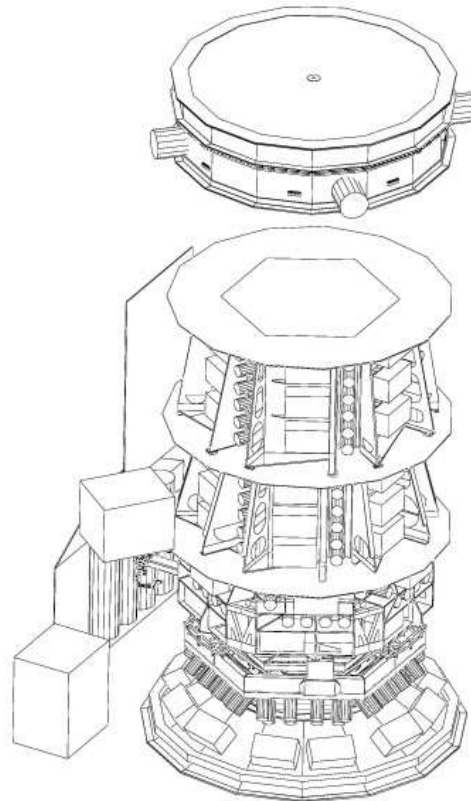
# Instrument Model

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These cutaway views give an idea of the level of detail in the SPI instrument model, which has been integrated with the Southampton “TIMM”.

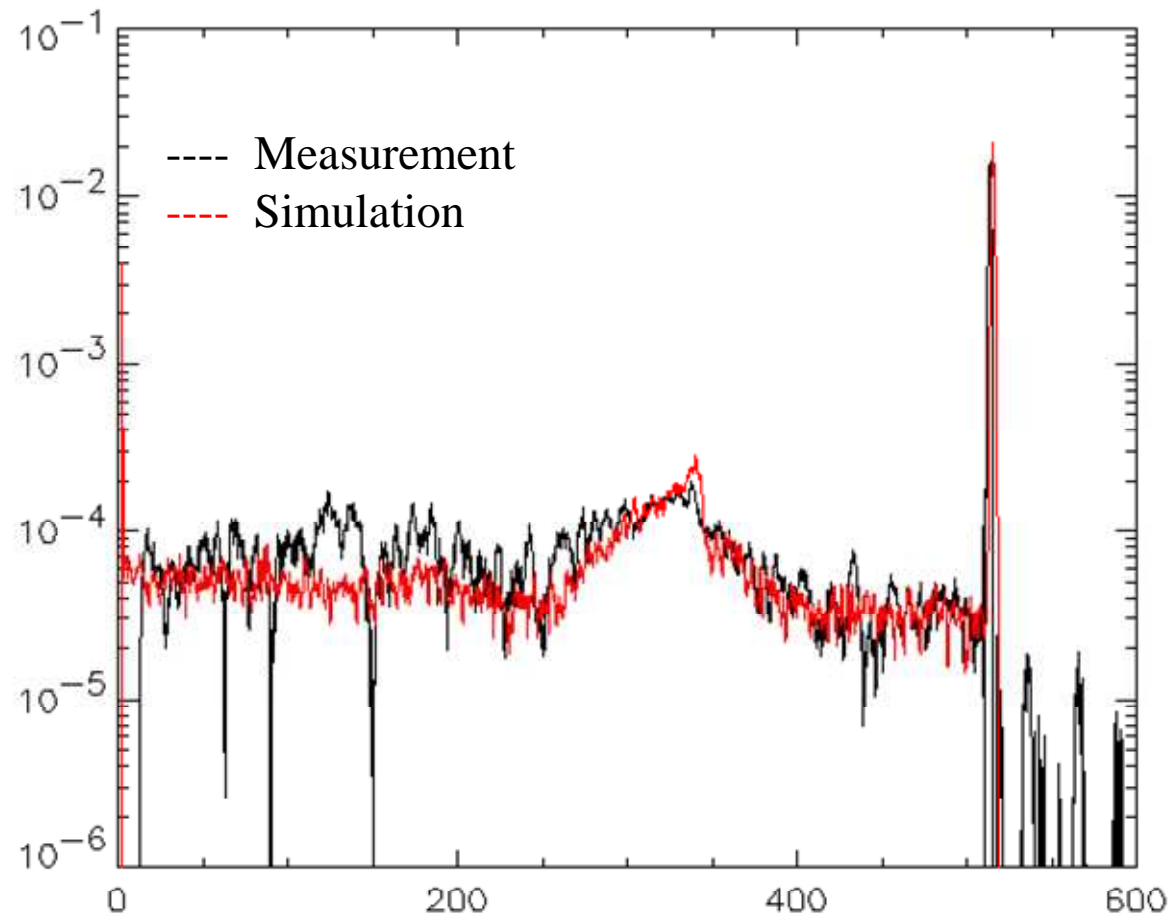


SPI cut-away views



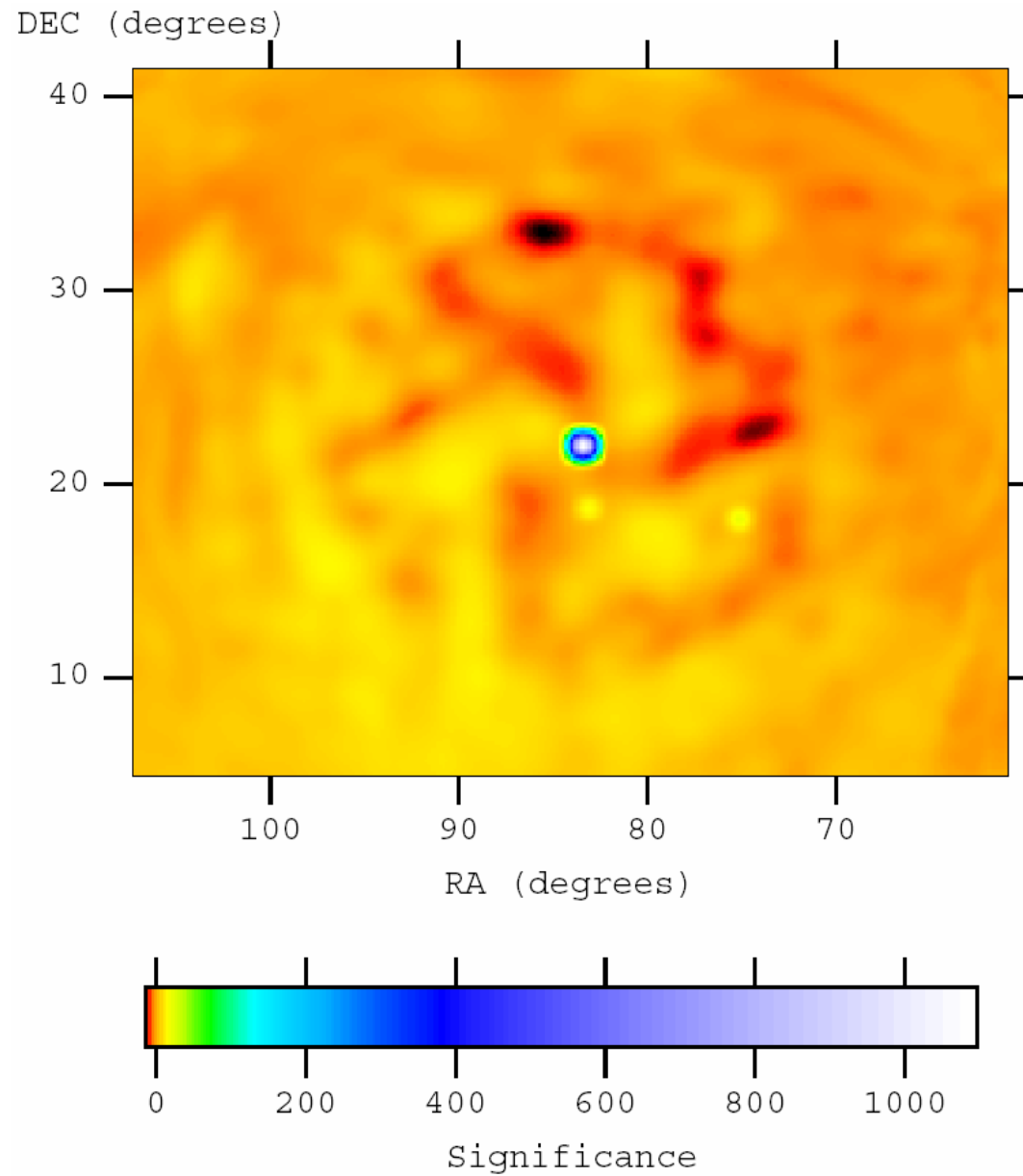
TIMM-3

**Single event spectra simulation and measurement for the central detector. Radioactive source :  $^{85}\text{Sr}$**



# SPI Crab Nebula observations

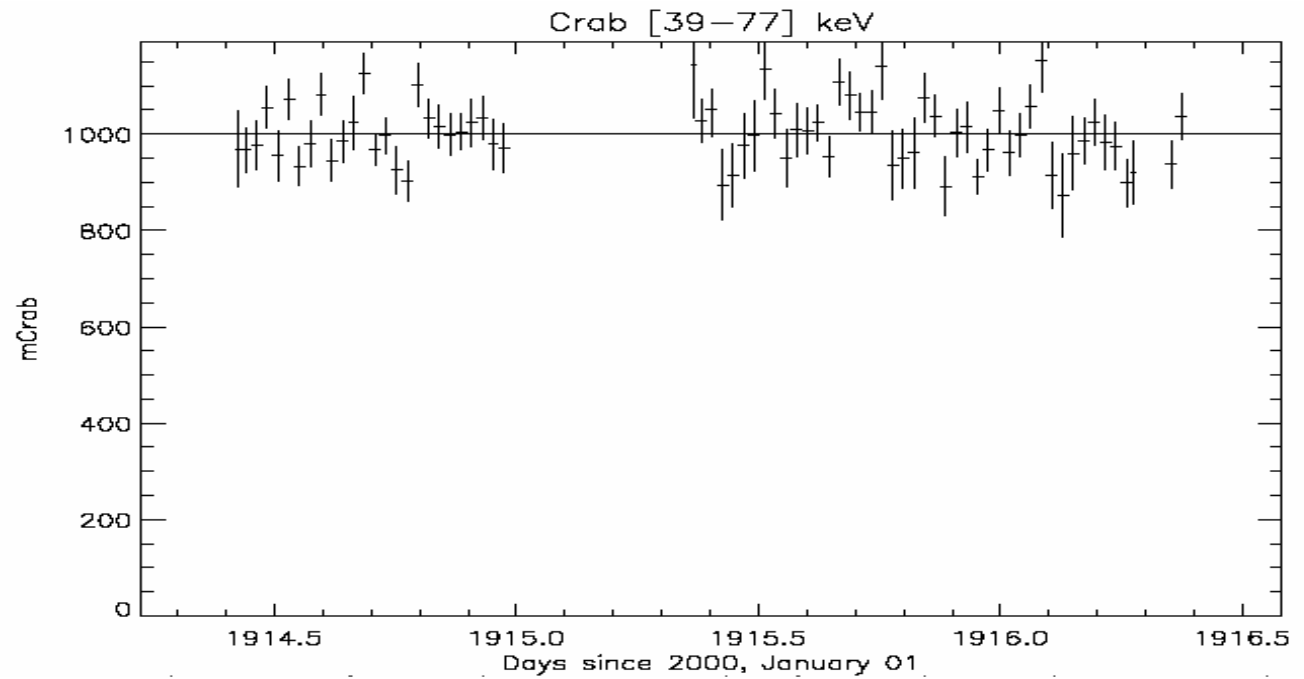
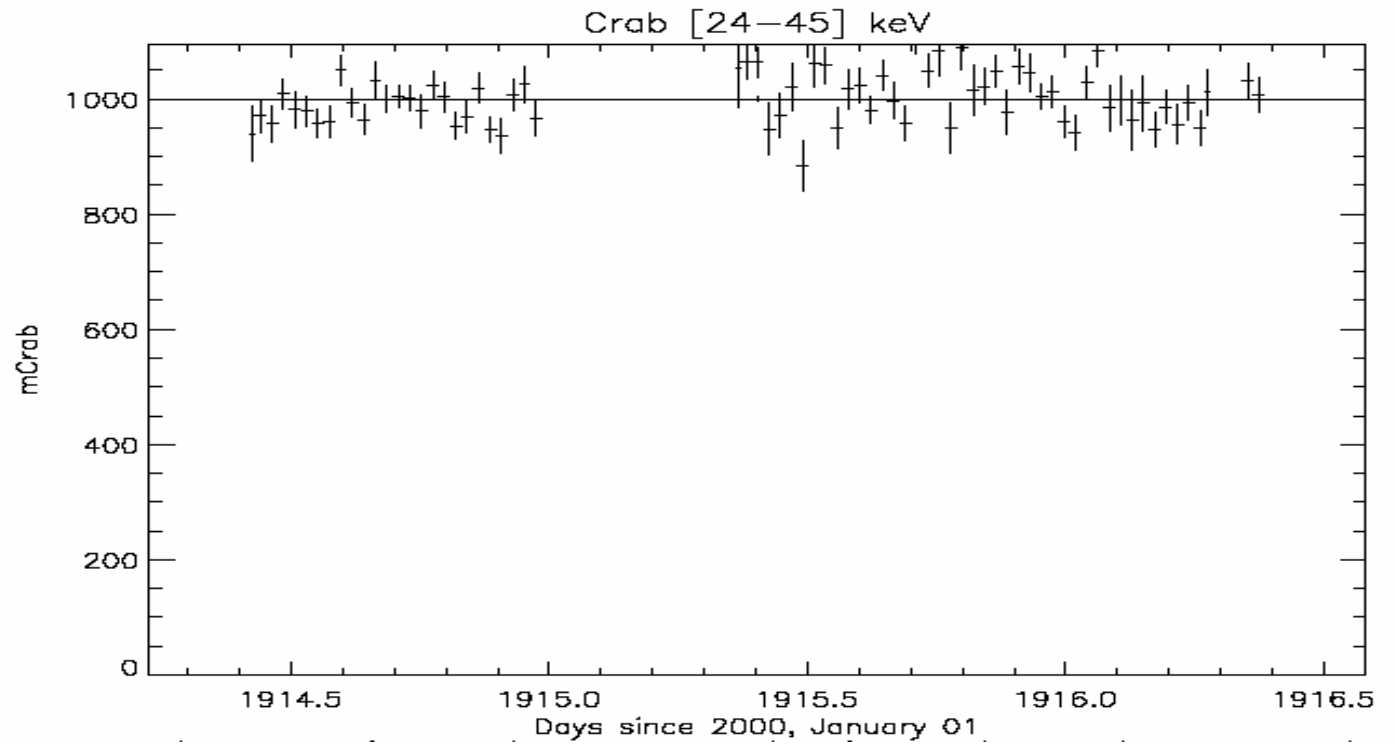
# THE CRAB NEBULA 20-50 keV 567 ks



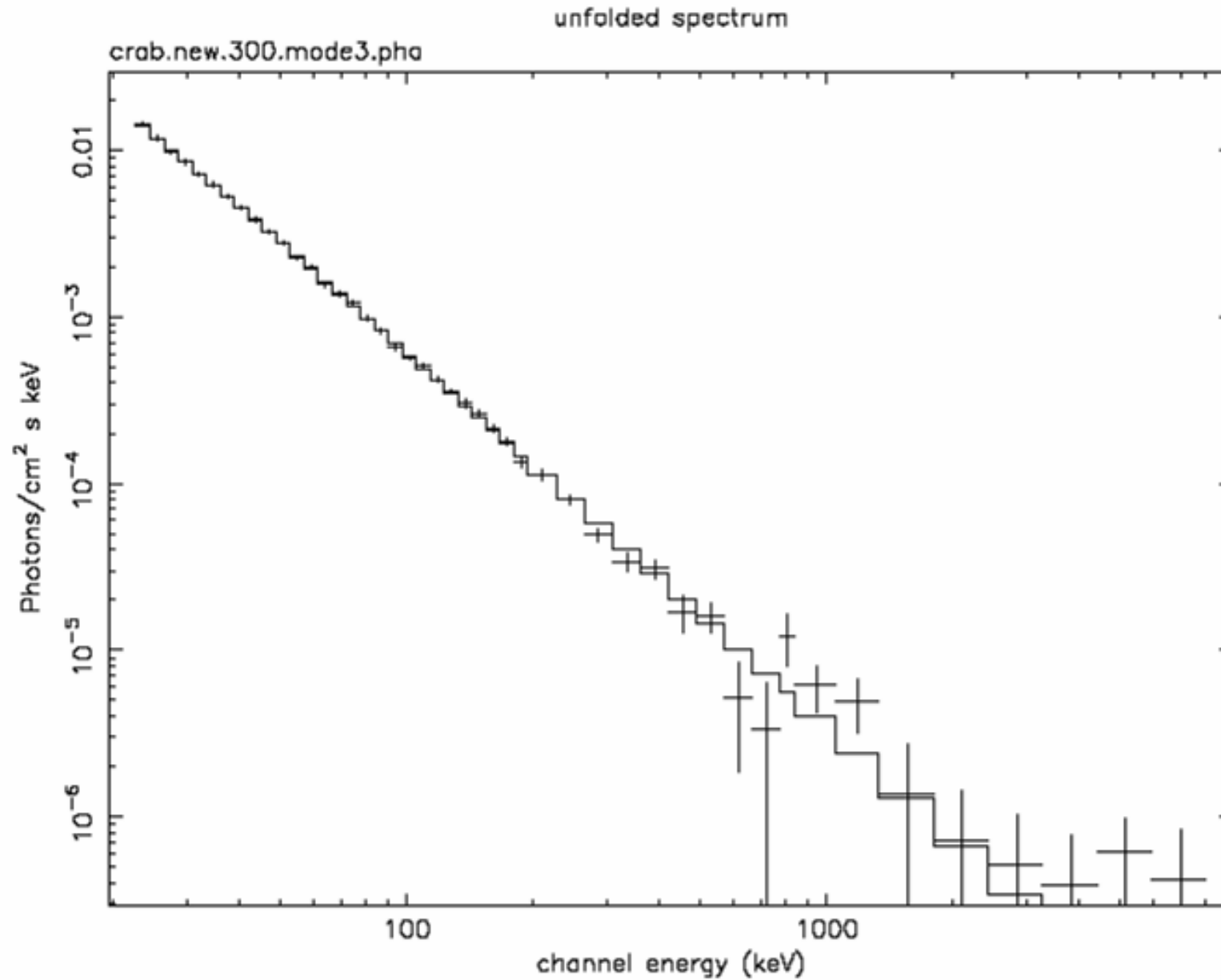
Crab Nebula

Stability in the FOV  
Rev 300

10° circle around  
the axis



# Crab Nebula - Calibration stability – revolutions 300 and 45



# Crab spectral fits

- Energy range 22 keV – 1 MeV
- Use of single events
- No systematics included
- Source and background assumed constant per revolution
- Use of standard response matrices

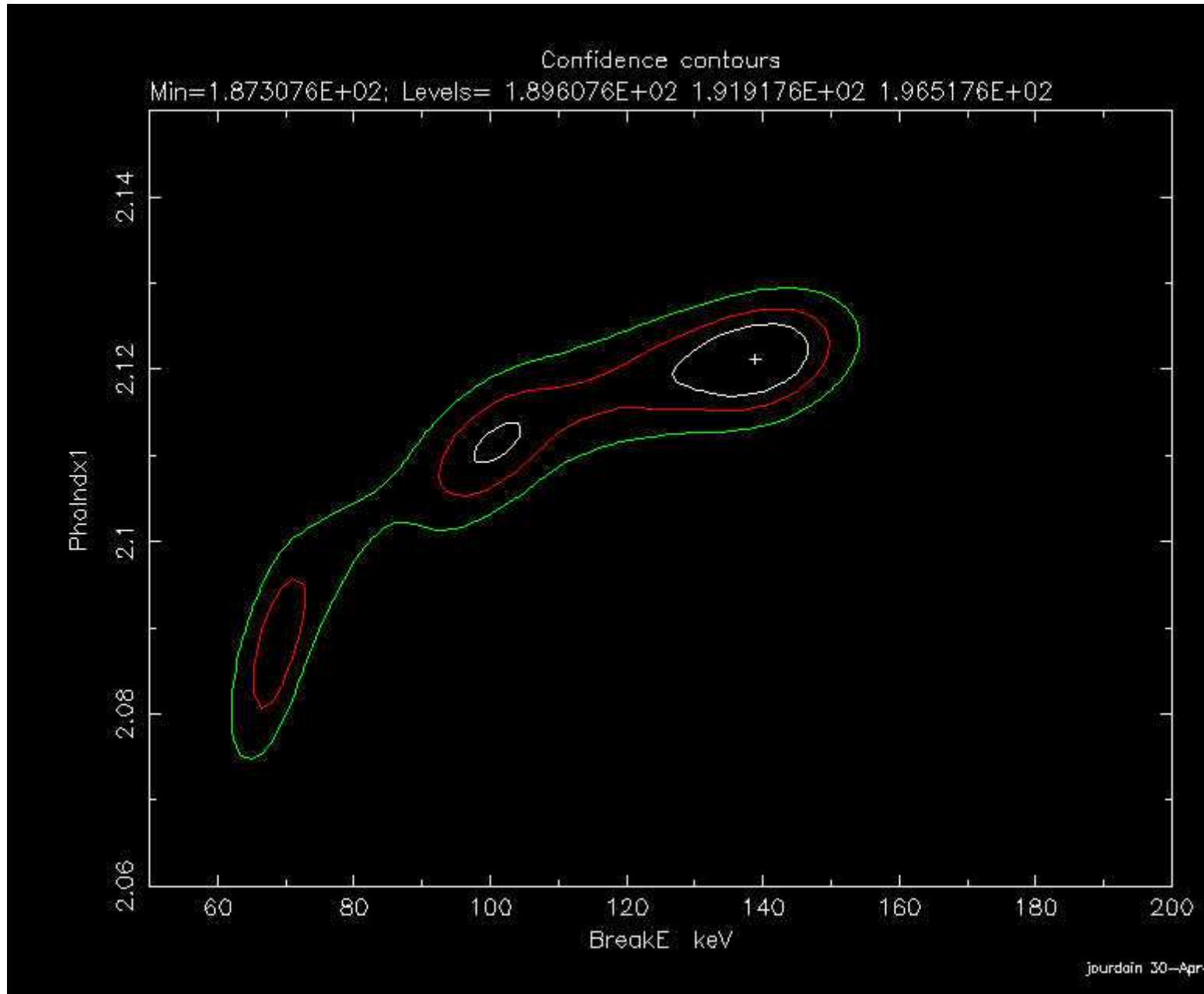
# Rev. 239+300+365+422+483 - 530ks

Rev #	Index 1	Ebreak (keV)	Index 2	Norme @ 100 keV (ph cm <sup>-2</sup> s <sup>-1</sup> )	Red $\chi^2$	Ftest Relat. To powerlaw
Sum	2.14 +/- 2.10 <sup>-2</sup>			6.01 E-04	13.06	
Sum	2.11 +/- 3.10 <sup>-2</sup>	100.0	2.33 +/- 1.10 <sup>-2</sup>	6.18 E-04	5.25	1.2 E-08
sum	2.12 +/- 2.7.10 <sup>-2</sup>	138+/-5	2.47 +/- 3.10 <sup>-2</sup>	6.23 E-04	5.35	6.2 E-08
Sum	2.09 +/- 2.10 <sup>-2</sup>	69 +/- 2	2.25 +/- 2.10 <sup>-2</sup>	5.98 E-04	5.42	7.7 E-08

The power-law is rejected

The broken power law better represents the data (physics behind?)

The broken power law break is not precisely constrained:  
slopes/break dependency



# SUM Rev 239 -- 483

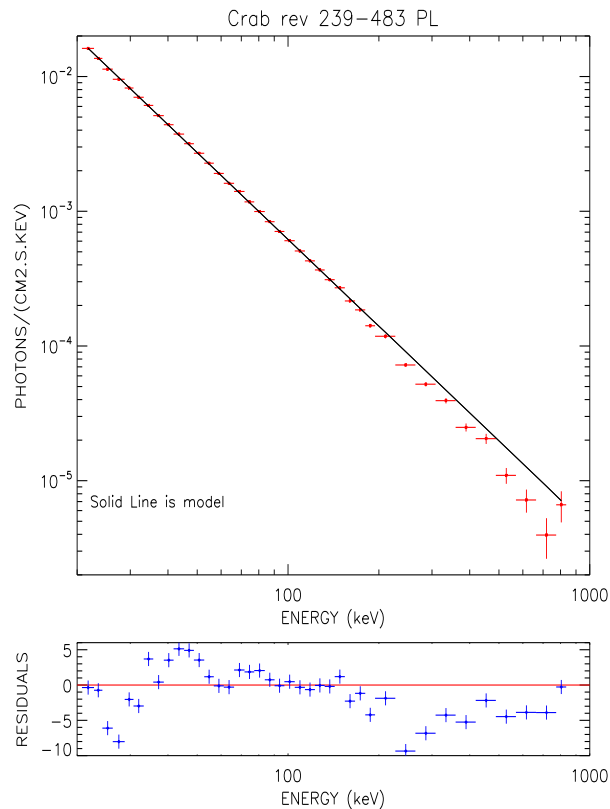
## Model PL

Index 2.14 +/- 2.5E-03

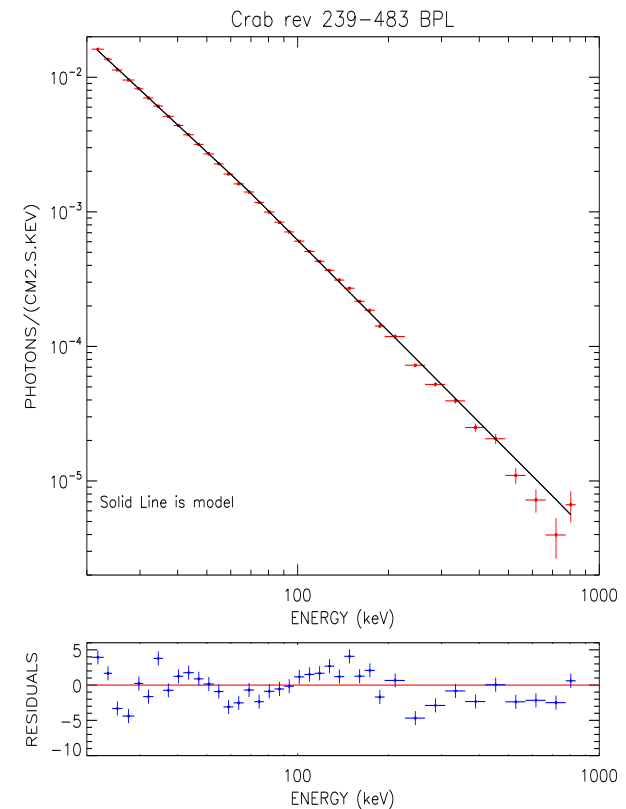
$\chi^2 = 483.4$  using 39 bins.  
Reduced  $\chi^2 = 13.06$  for 37 DoF  
Null hypothesis probability = 0.0

## Model broken PL

Index1 2.08814 +/- 5. E-03  
E Break 68.8701 +/- 2.32937 keV  
Index2 2.25263 +/- 0.1  
 $\chi^2 = 189.7$  using 39 bins.  
Reduced  $\chi^2 = 5.42$  for 35 DoF  
Null hypothesis probability = 3.785E-23



**F- test**  
F statistic value = 27.1  
probability = 7.8 E-08



# SUM Rev 239 -- 483

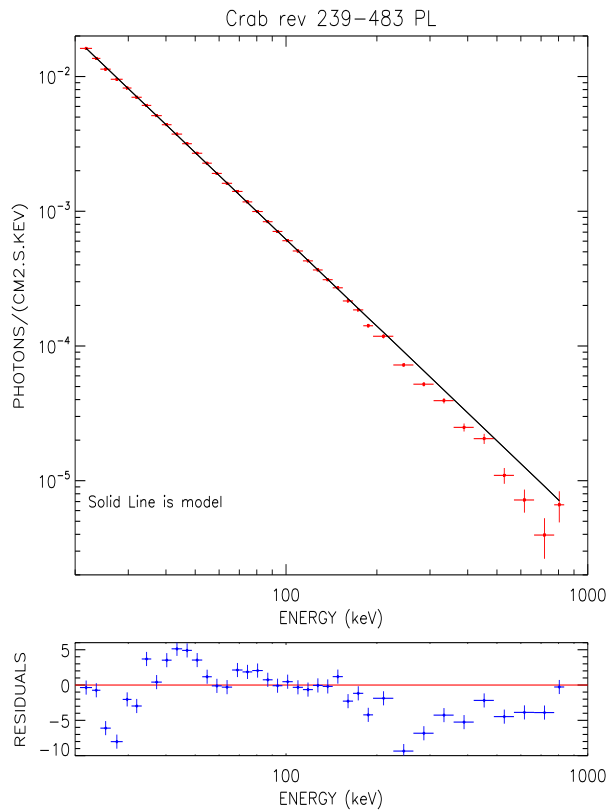
## Model PL

Index 2.14 +/- 2.5E-03

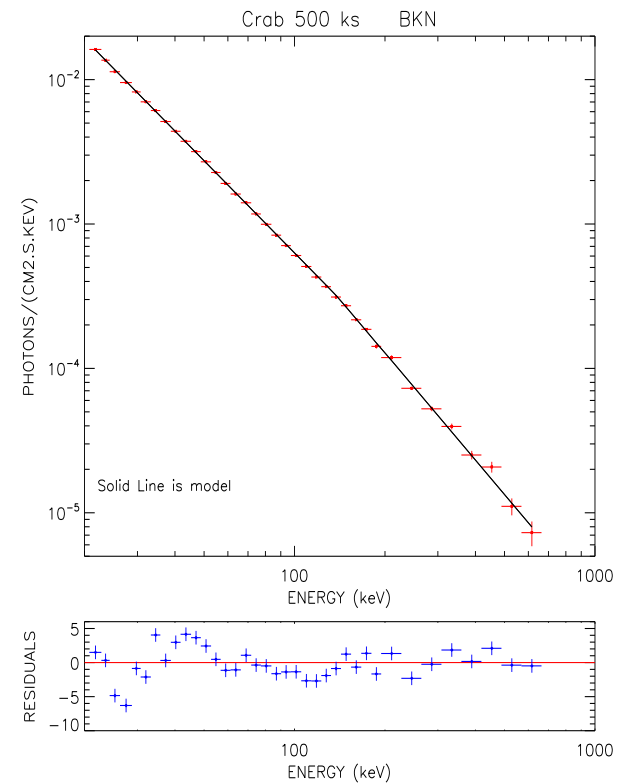
$\chi^2 = 483.4$  using 39 bins.  
 Reduced  $\chi^2 = 13.06$  for 37 DoF  
 Null hypothesis probability = 0.0

## Model broken PL

Index1 2.12105 +/- 0.274  
 E Break 138.297 +/- 5.31 keV  
 Index2 2.46822 +/- 0.311  
 $\chi^2 = 187.3$  using 39 bins.  
 Reduced  $\chi^2 = 5.35$  for 35 DoF  
 Null hypothesis probability = 1.022E-22



**F- test**  
 F statistic value = 27.7  
 probability = 6.21 E-08



# SPI CRAB: Summary

- An absolute calibration
- 22 keV – 1 MeV fit No systematics
- The power law model is rejected
- Probably a gradual spectral softening in hard X-rays
- Compatible with a broken power law:
  - Index1= 2.11 Index2 = 2.33 Ebreak=100 keV
  - Norm =6.18 E-04
- Compatible with PLCO:
  - Index 2.04 Ecut=644 keV

# INTEGRAL CALIBRATION

- SPI absolute and stable since the launch
- IBIS/ISGRI have still instrumental effects to understand and solve.
- Aim to converge towards a common “Integral” Crab ... September 2007 ?!
- Integral “Crab” will look like SPI Crab !