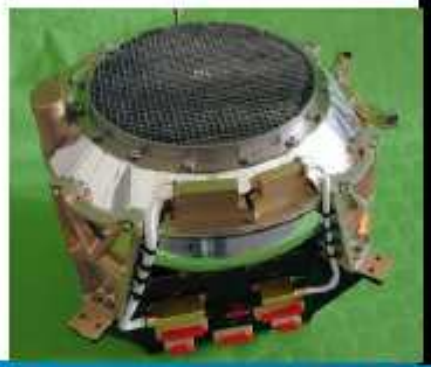
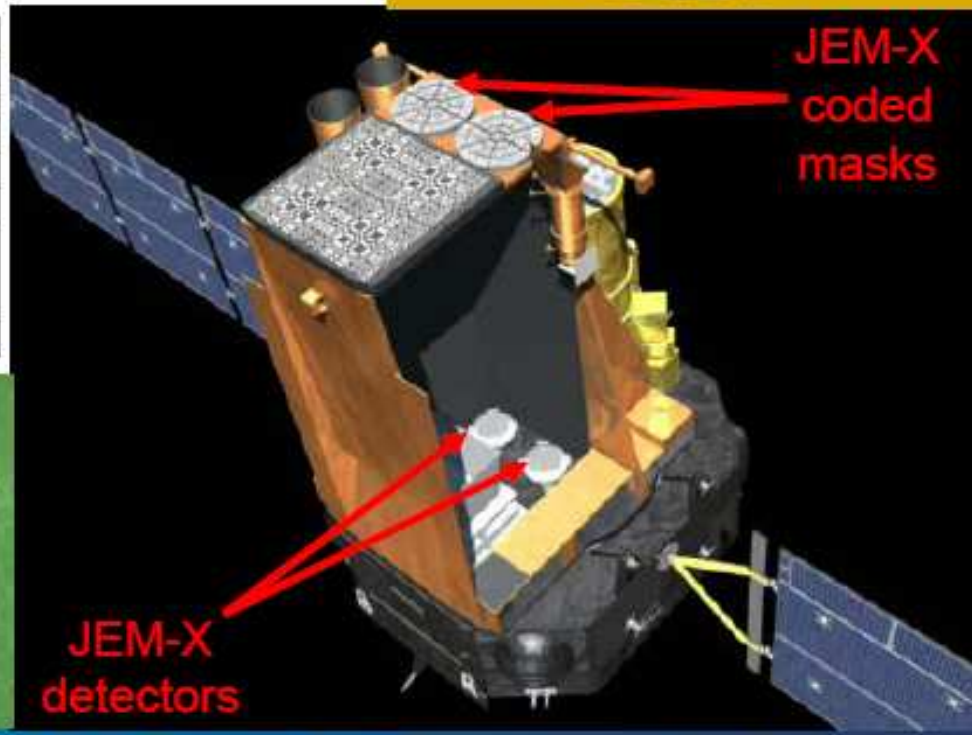
JEM-X
The INTEGRAL X-Ray monitor

- 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	$\Delta E/E = 0.40(E[keV])^{-1/2}$
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 10σ source)





Two approaches used to fit Crab spectrum:

1. Cross-correlation imaging in narrow energy bands and subsequent flux determination from image peak (PSF)

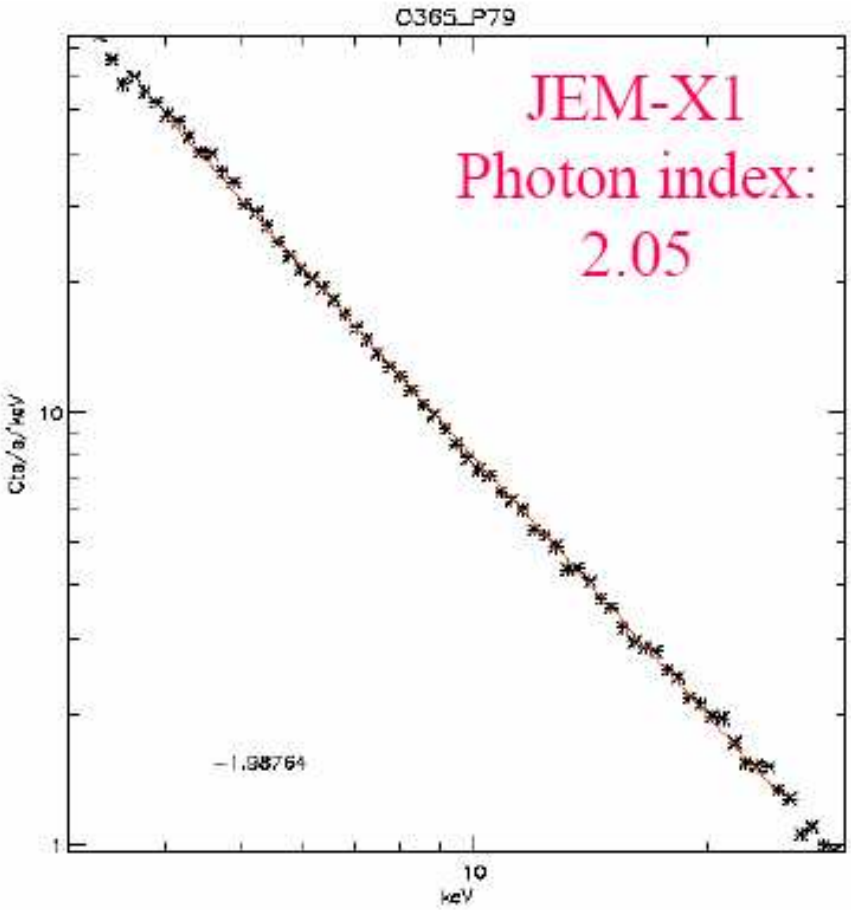
2. Fitting of spectra derived from subtraction of on-off Crab pointings

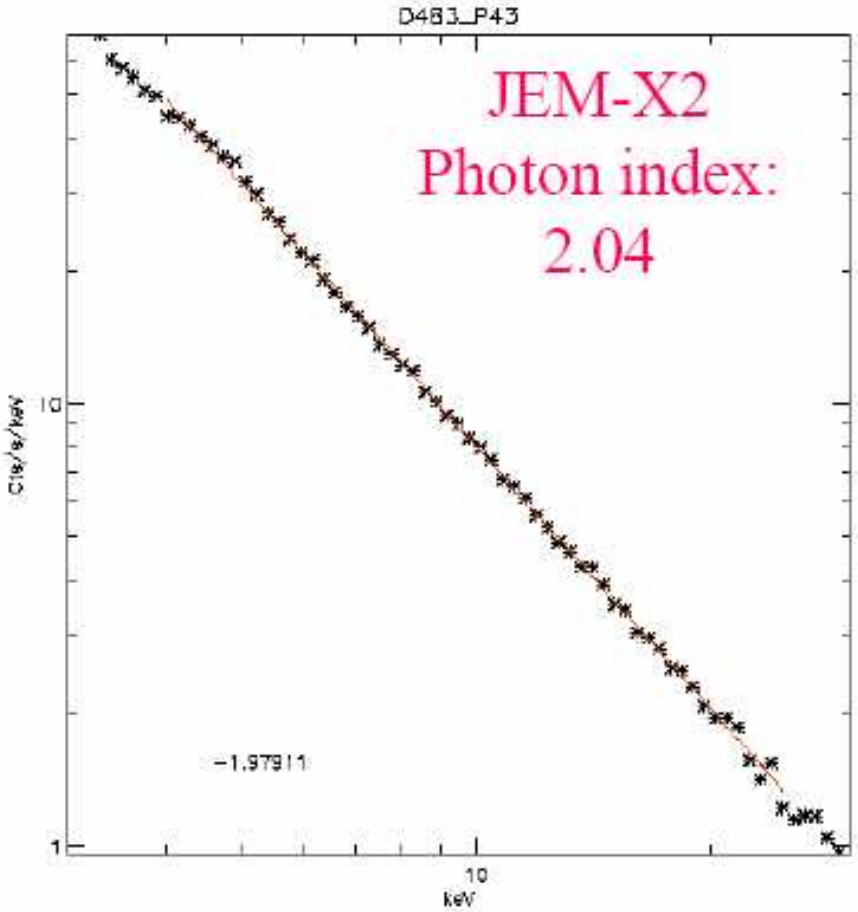
Challenges:

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 (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)

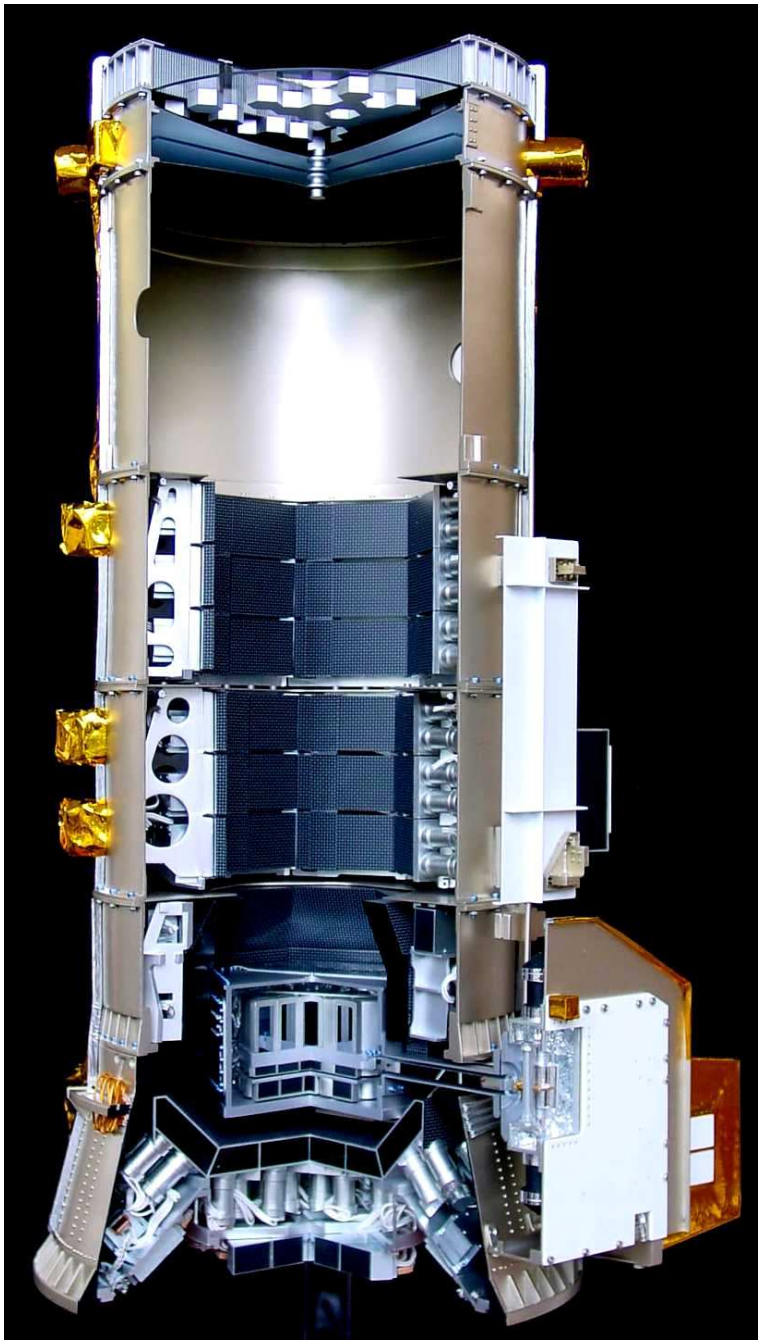
Status of ISGRI Calibration model [3/3]

Crab observations analysis

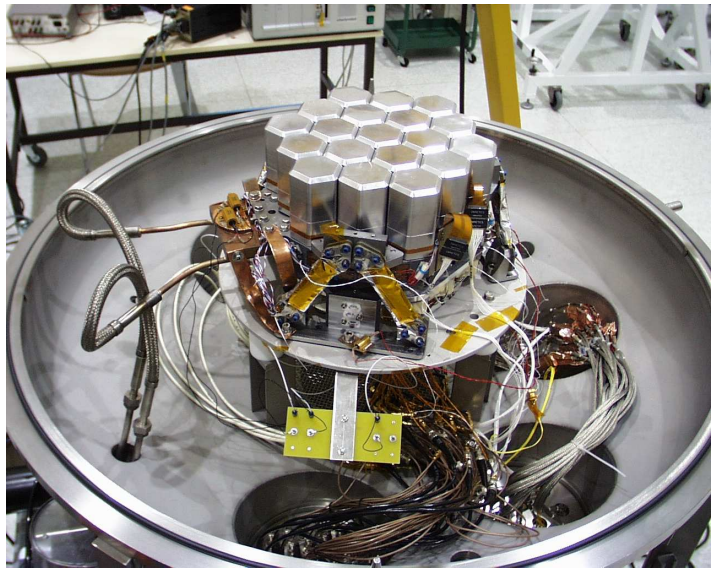
- the current calibration is obtained by assuming power law shape of the Crab (same as OSA-5) and MC model normalization
- Currently, the difference to the SPI data can be described as ~6% lower normalization and slightly steeper spectral shape (Γ=2.225 for IBIS)
- The current discrepancy with SPI Crab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

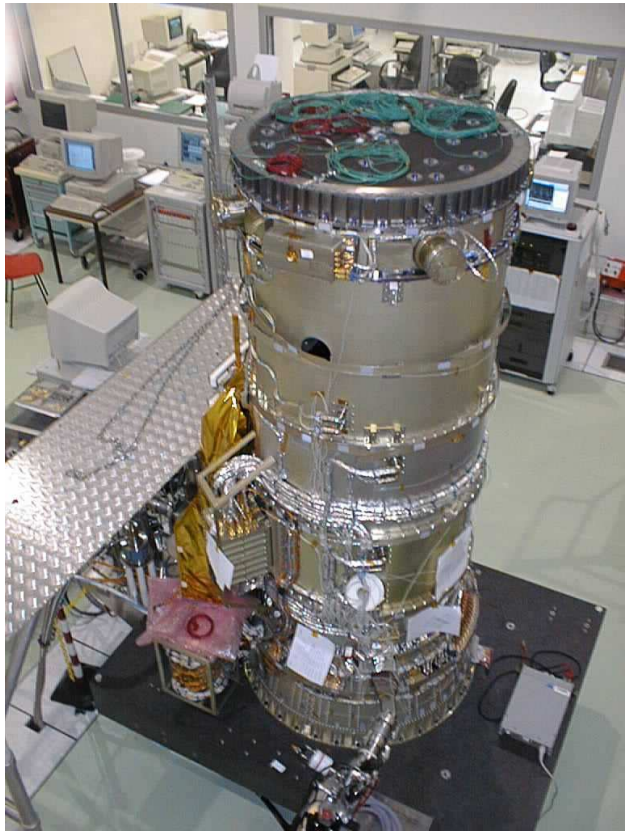
SPI

Imaging : 16°fully coded FOV
Angular resolution : 2.6°
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





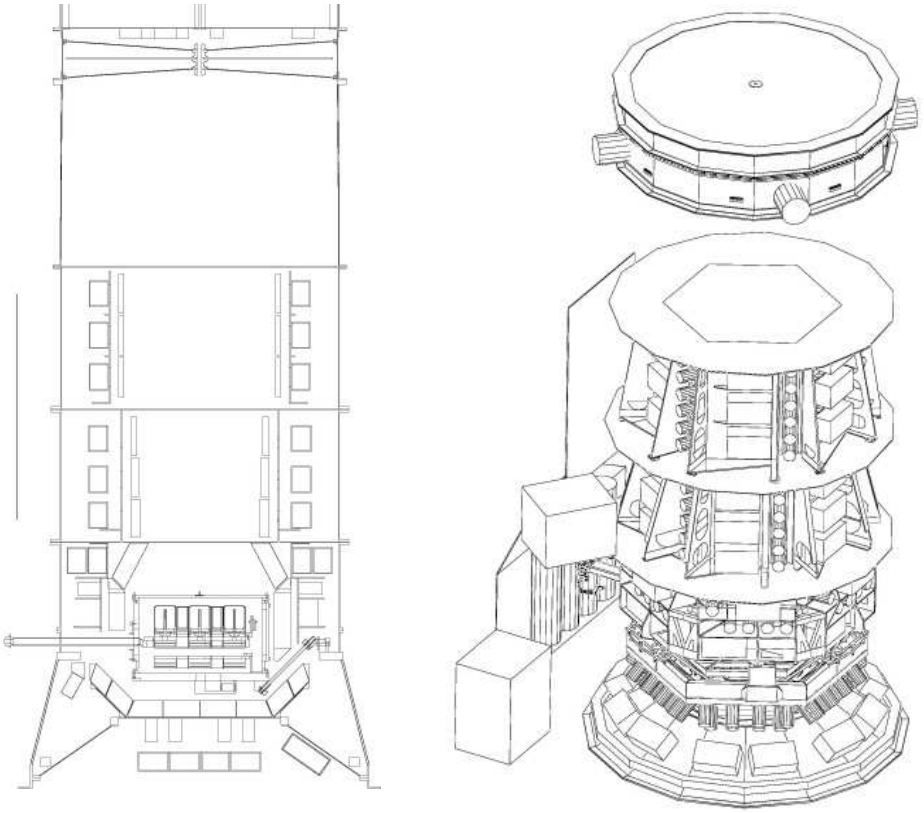
SPI CALIBRATION AT BRUYERES LE CHATEL

(May 2001)

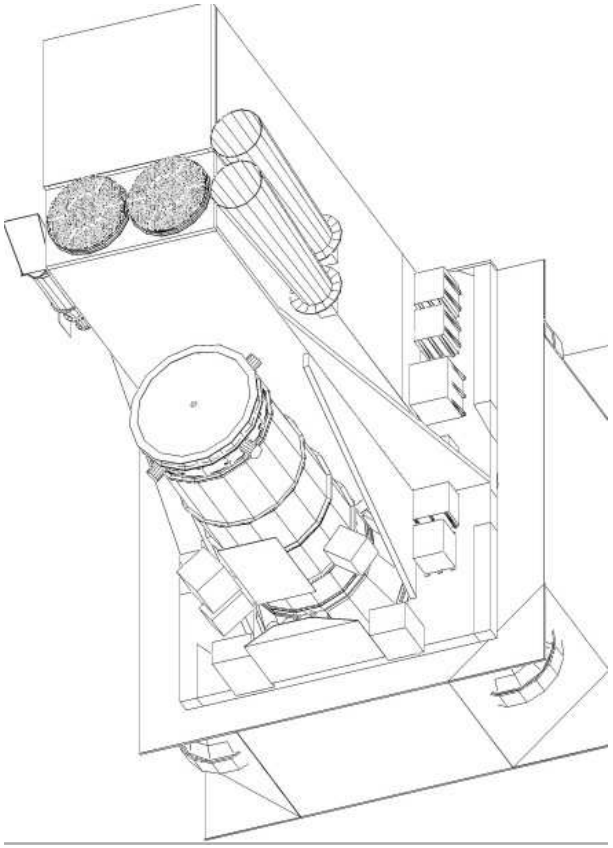
Response matrix generated by Monte-Carlo simulation Validation and corrections with ground calibrations

Instrument Model

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

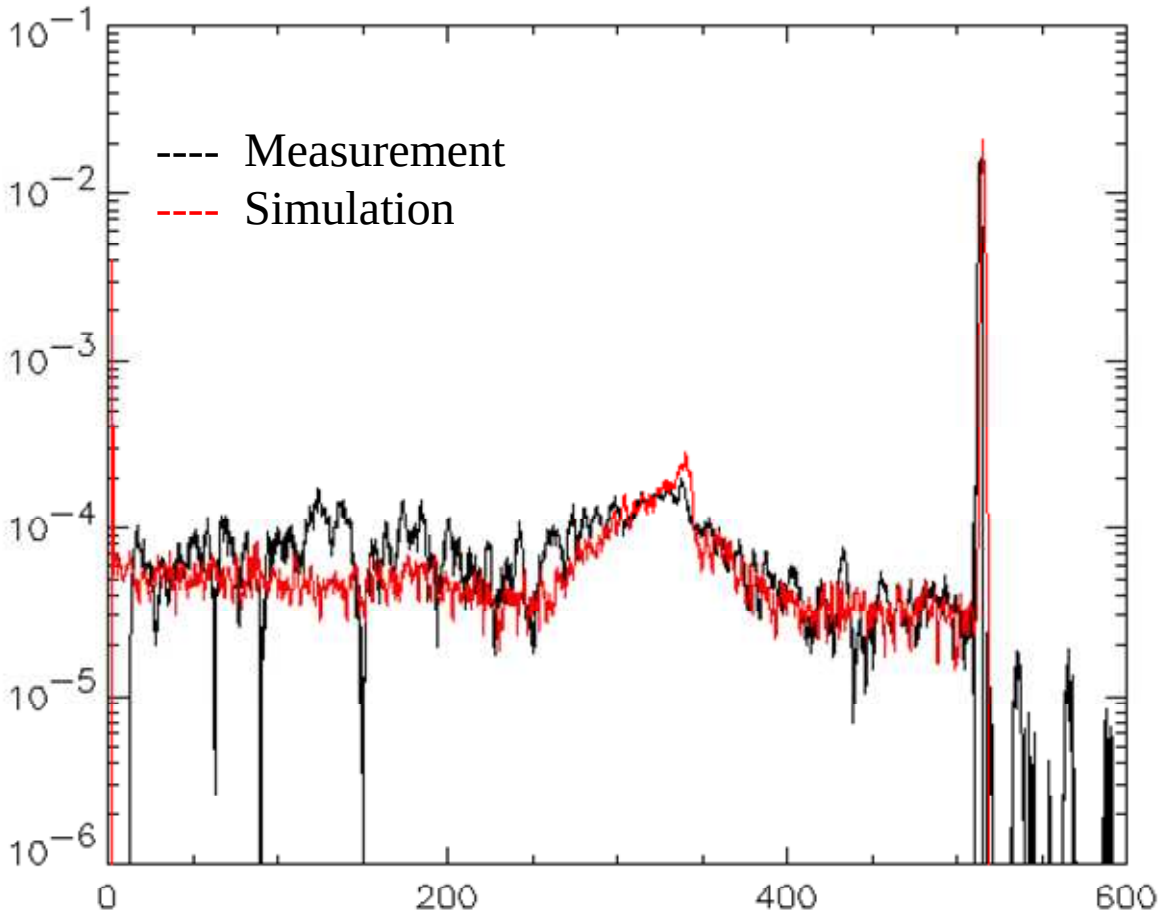


SPI cut-away views



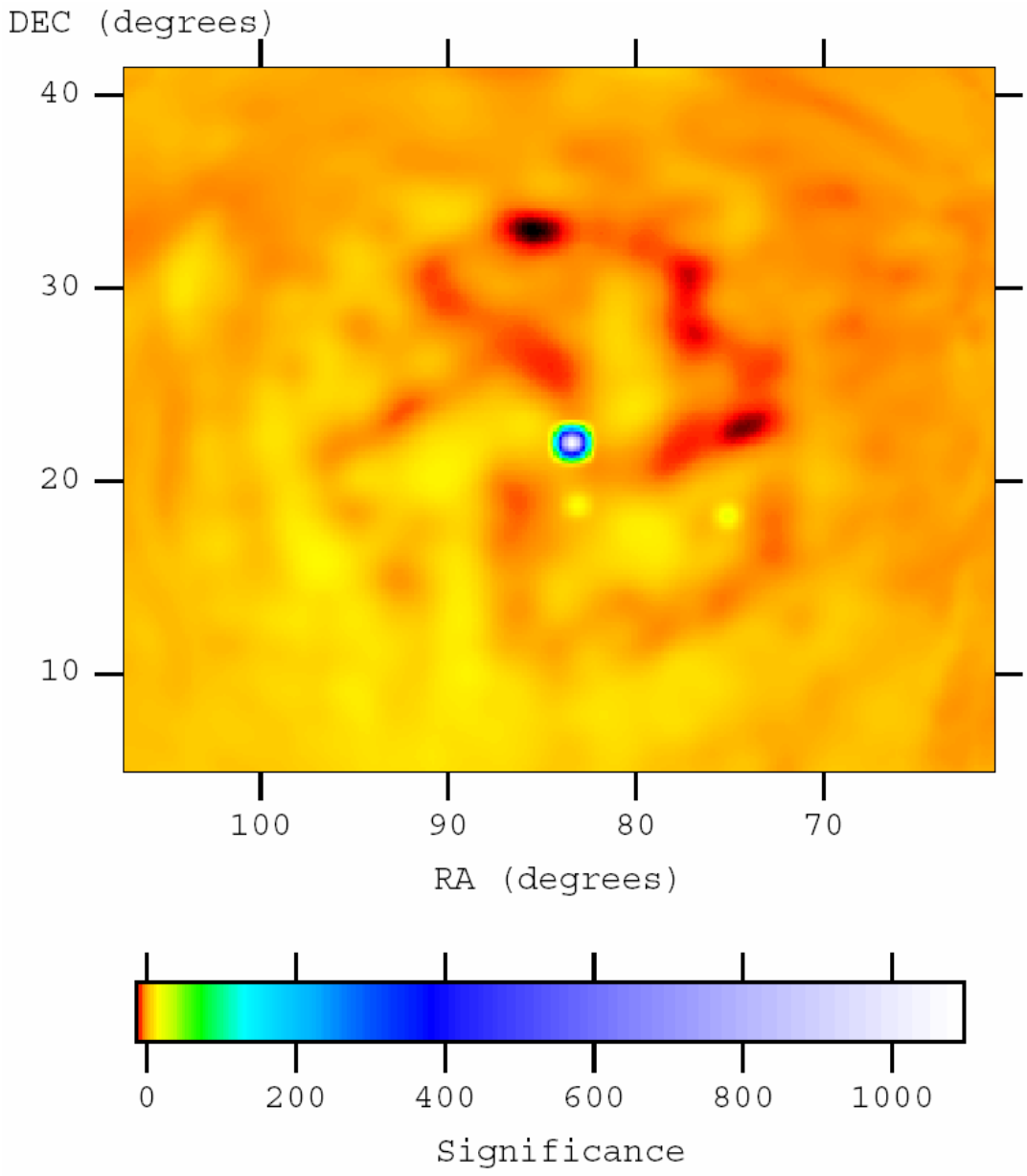
TIMM-3

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



SPI Crab Nebula observations

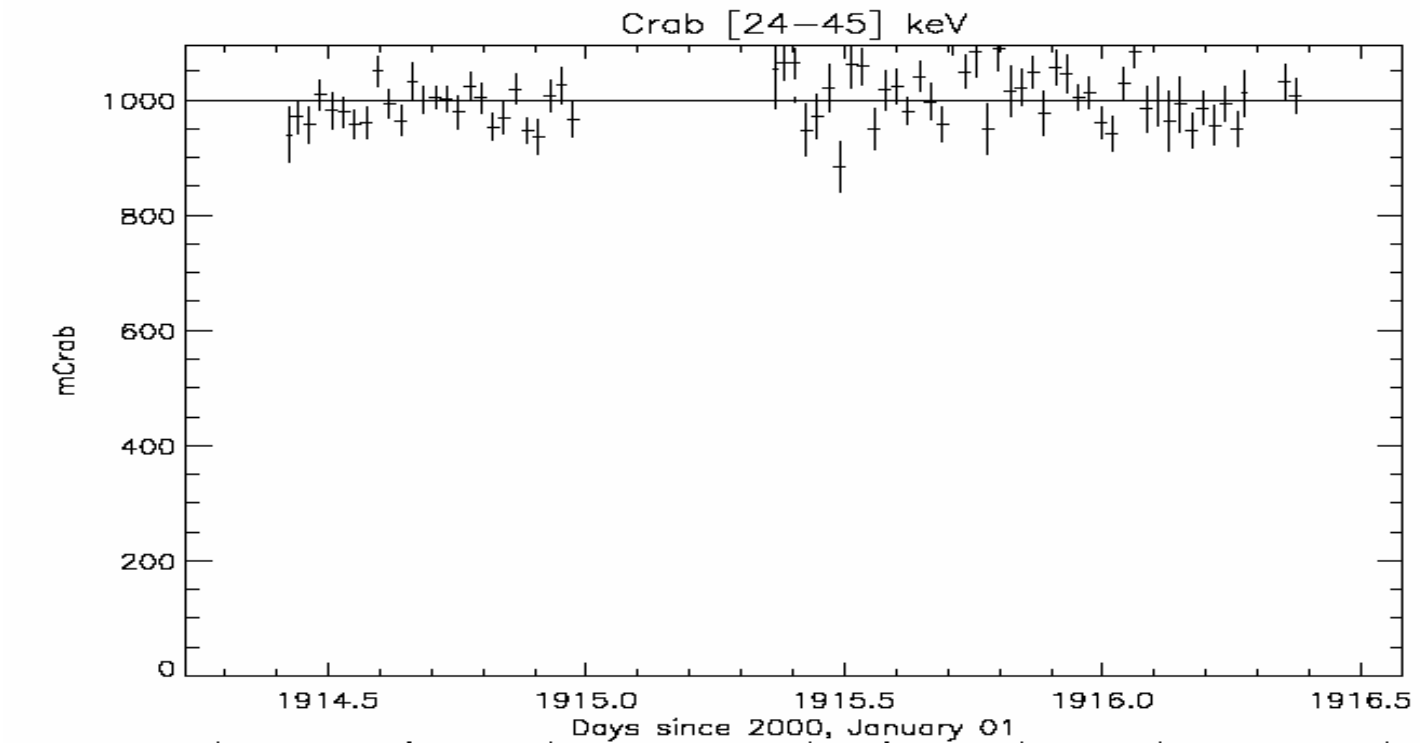
THE CRAB NEBULA 20-50 keV 567 ks

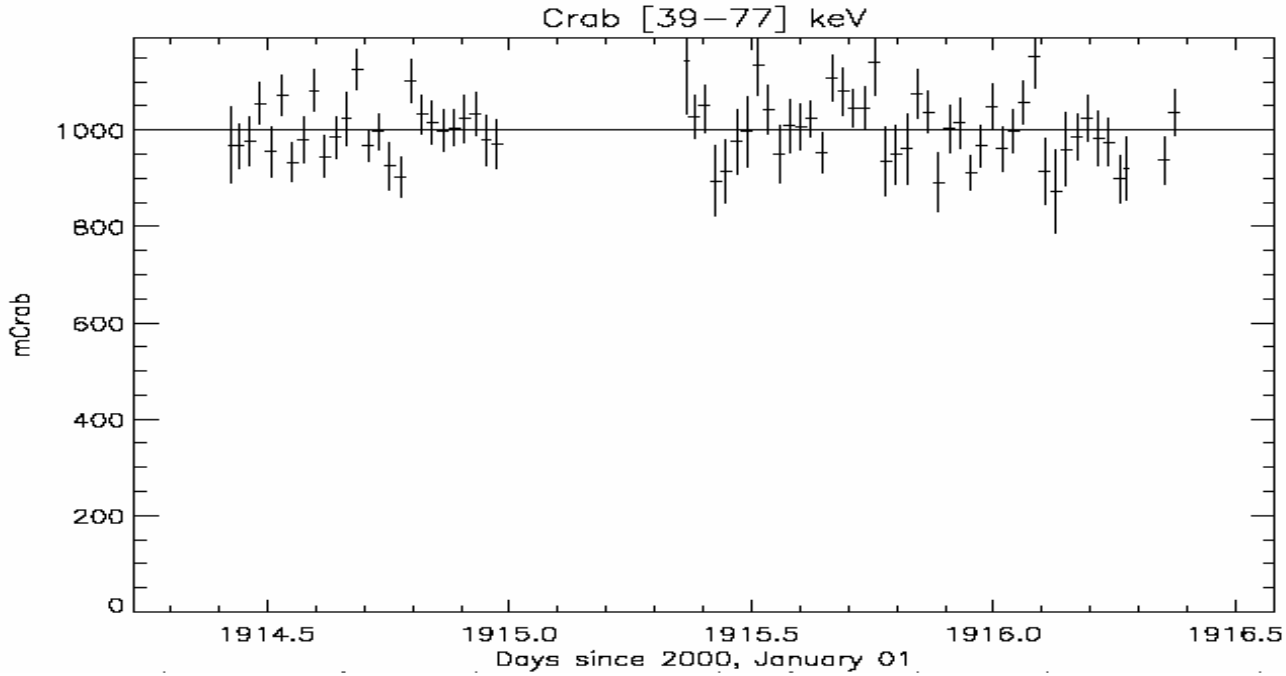


Crab Nebula

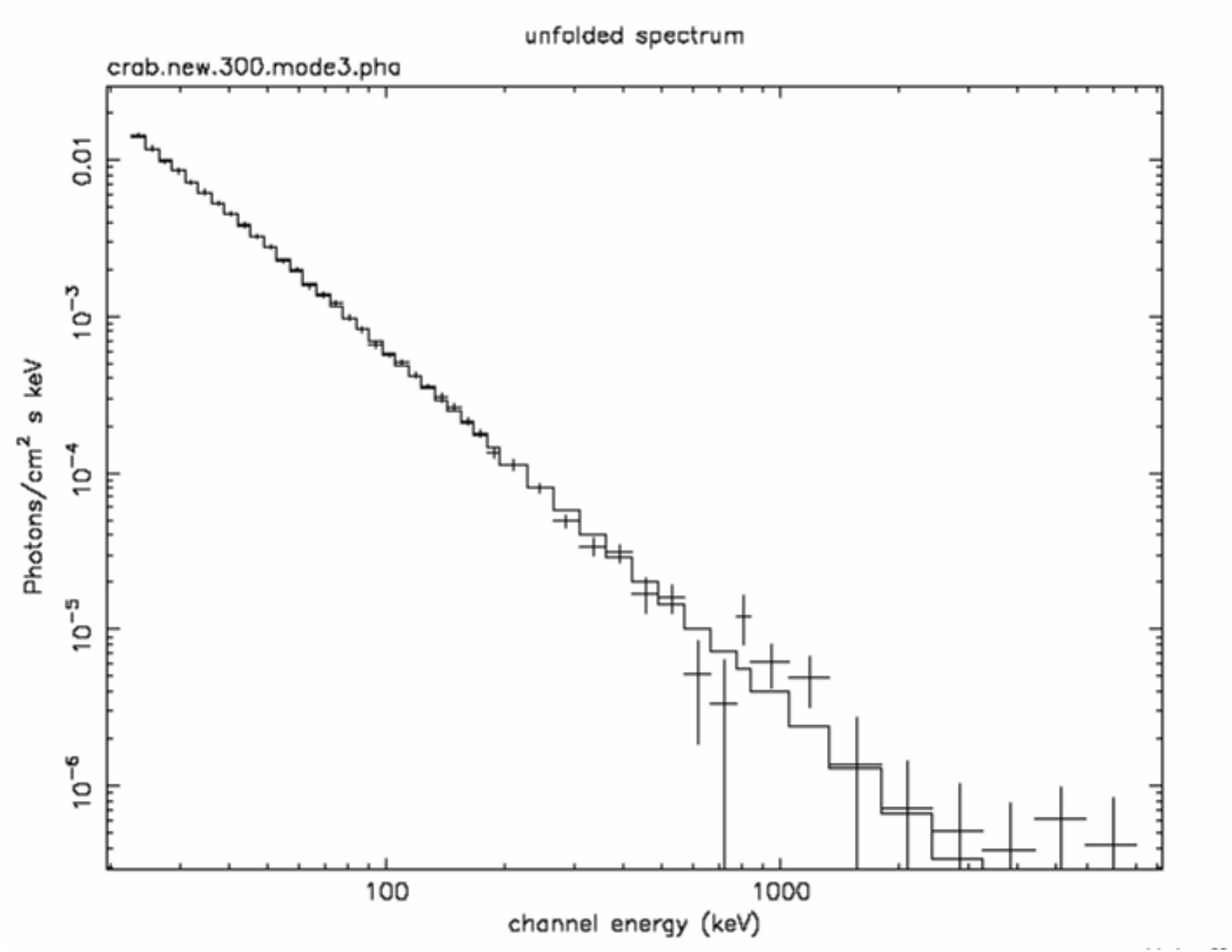
Stability in the FOV
Rev 300

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

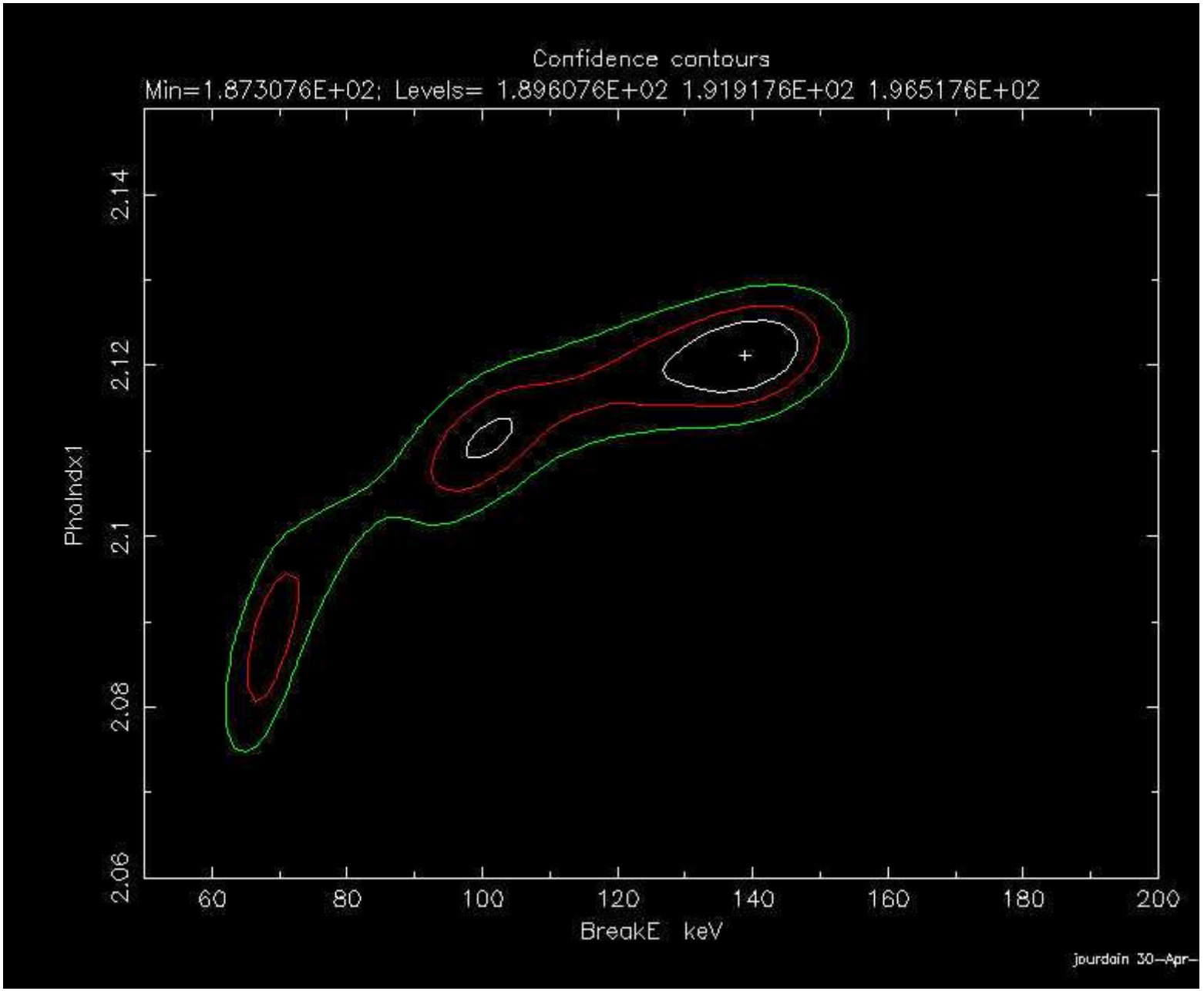
Rev. 239+300+365+422+483 - 530ks

Rev #	Index 1	Ebreak (keV)	Index 2	Norme @ 100 keV (ph cm-2 s-1)	Red χ^2	Ftest Relat. To powerlaw
Sum	2.14 +/-2. 10^{-2}			6.01 E-04	13.06	
Sum	2.11 +/- 3.10^{-2}	100.0	2.33 +/- 1.10^{-2}	6.18 E-04	5.25	1.2 E-08
sum	2.12 +/-2.7.10^{-2}	138+/-5	2.47 +/- 3.10^{-2}	6.23 E-04	5.35	6.2 E-08
Sum	2.09 +/- 2.10^{-2}	69 +/- 2	2.25 +/- 2.10^{-2}	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


Confidence contours
Min=1.873076E+02; Levels= 1.896076E+02 1.919176E+02 1.965176E+02
PhoIndx1
2.14
2.12
2.1
2.08
2.06
60
80
100
120
140
160
180
200
BreakE keV
jourdain 30-Apr-

SUM Rev 239 -- 483

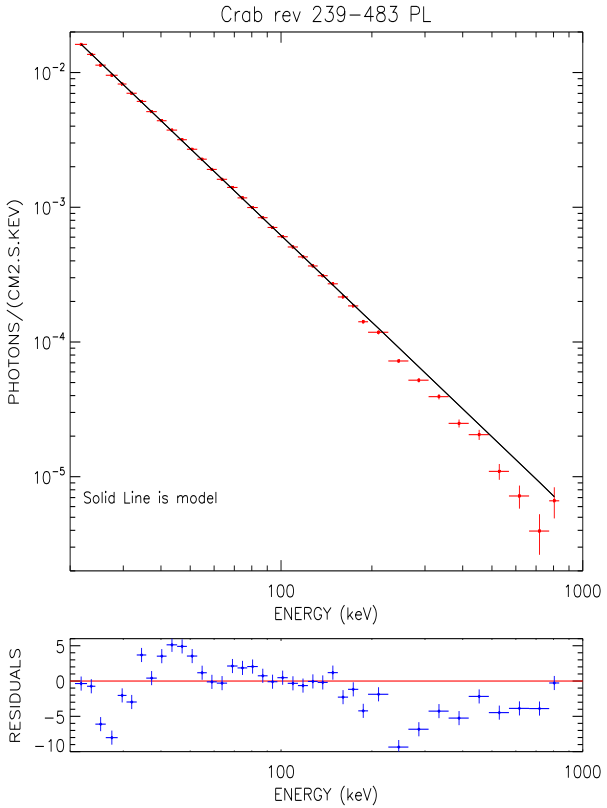
Model PL

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

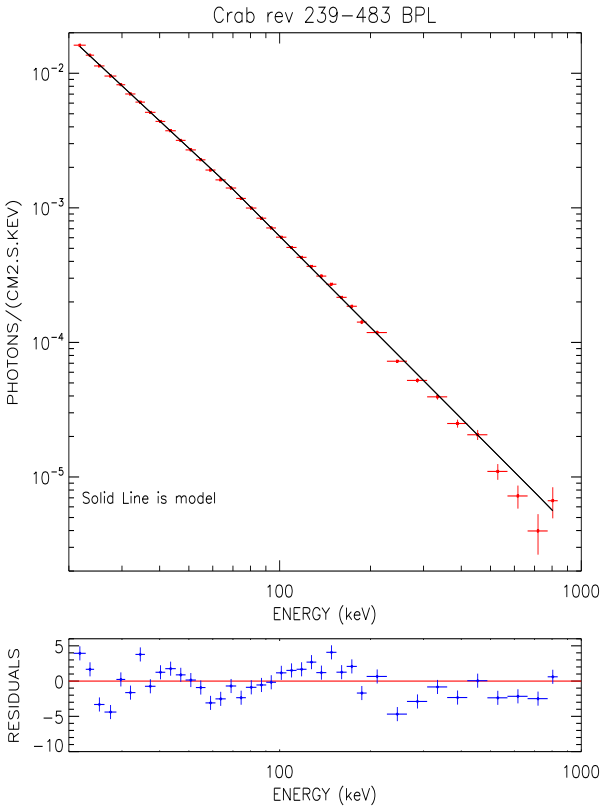
Model broken PL

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

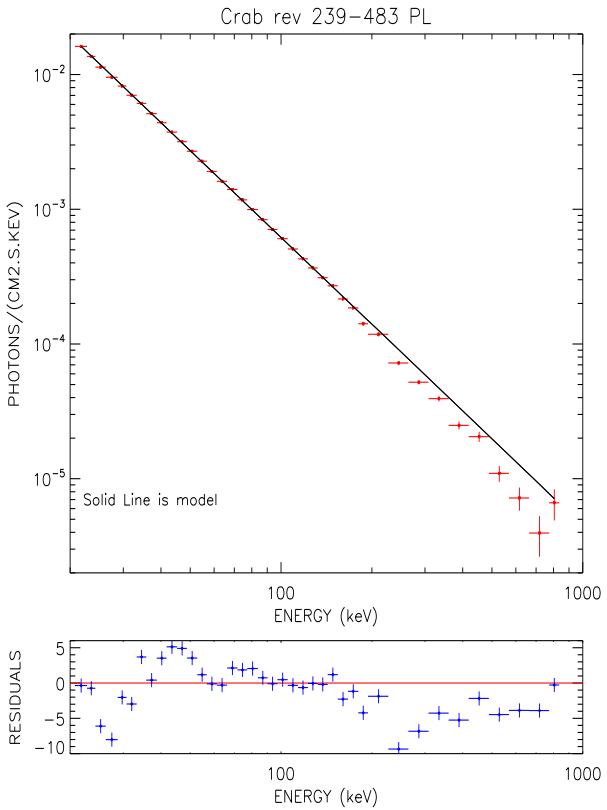


SUM Rev 239 -- 483

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

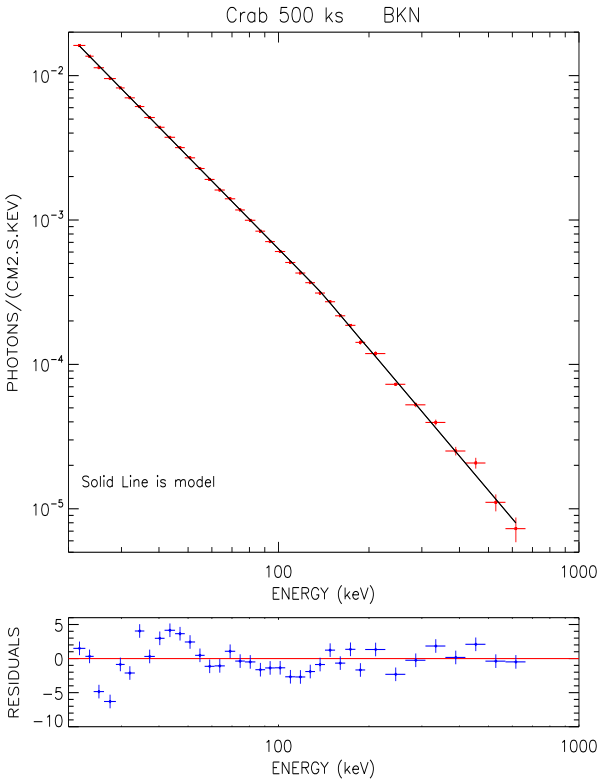


F- test

F statistic value = 27.7
probability = 6.21 E-08

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



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 !