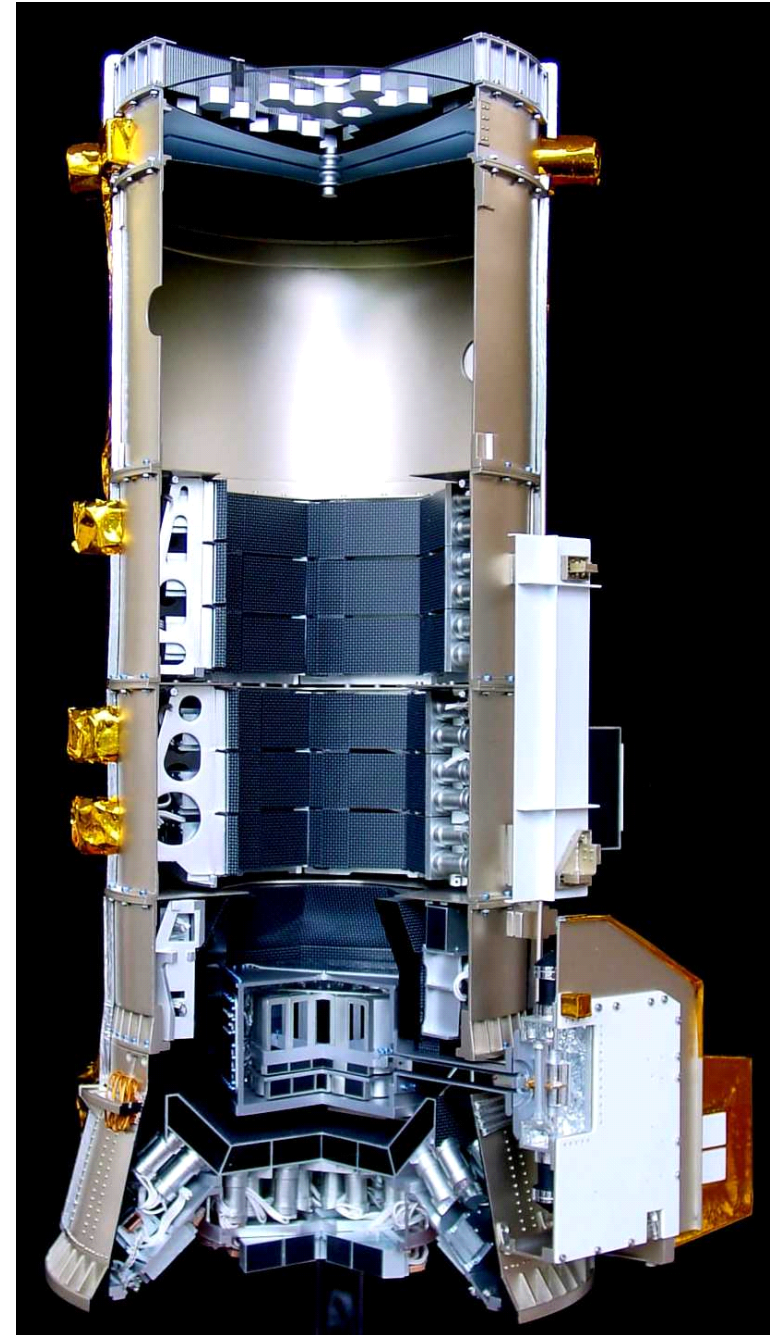
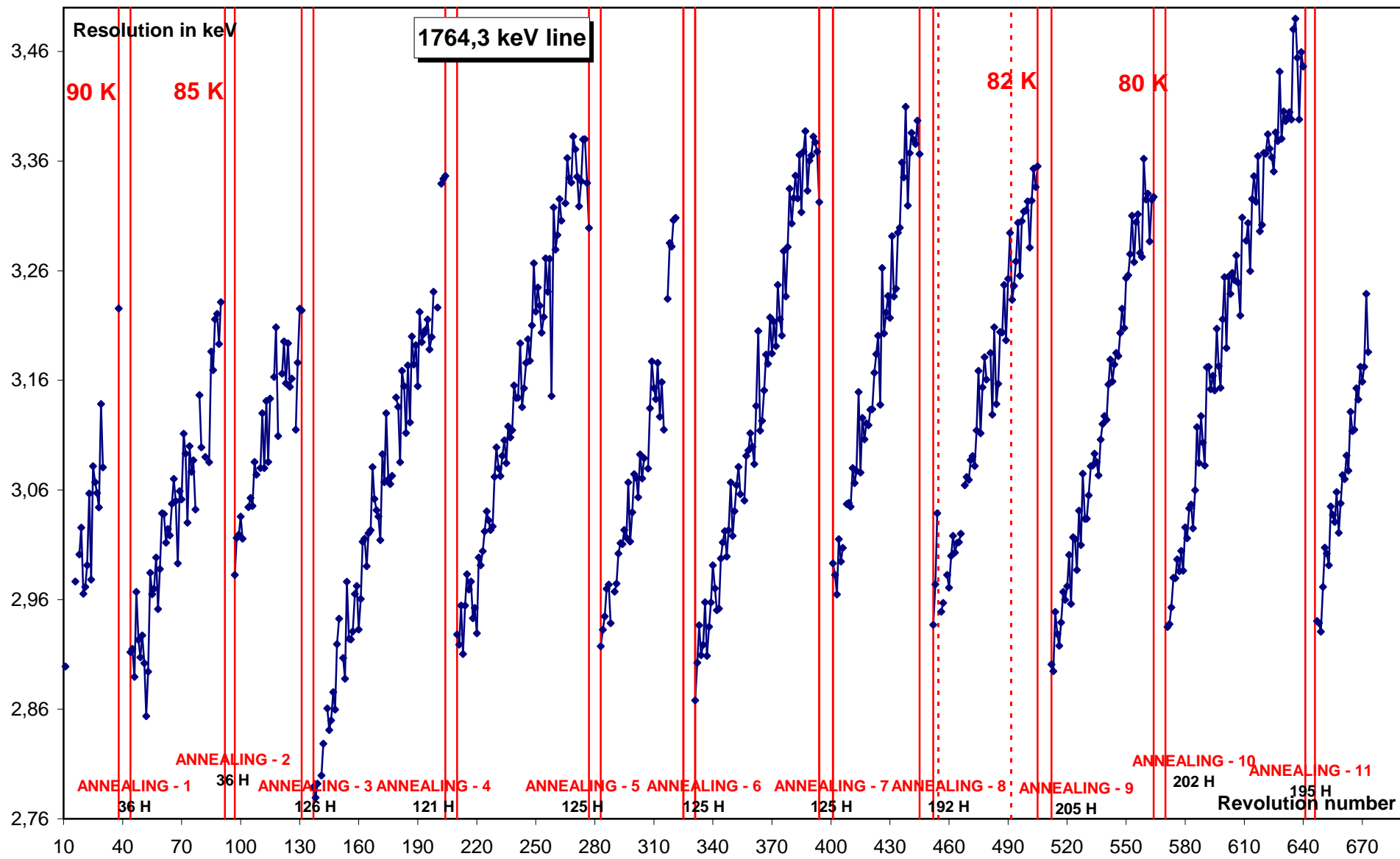


# SPI

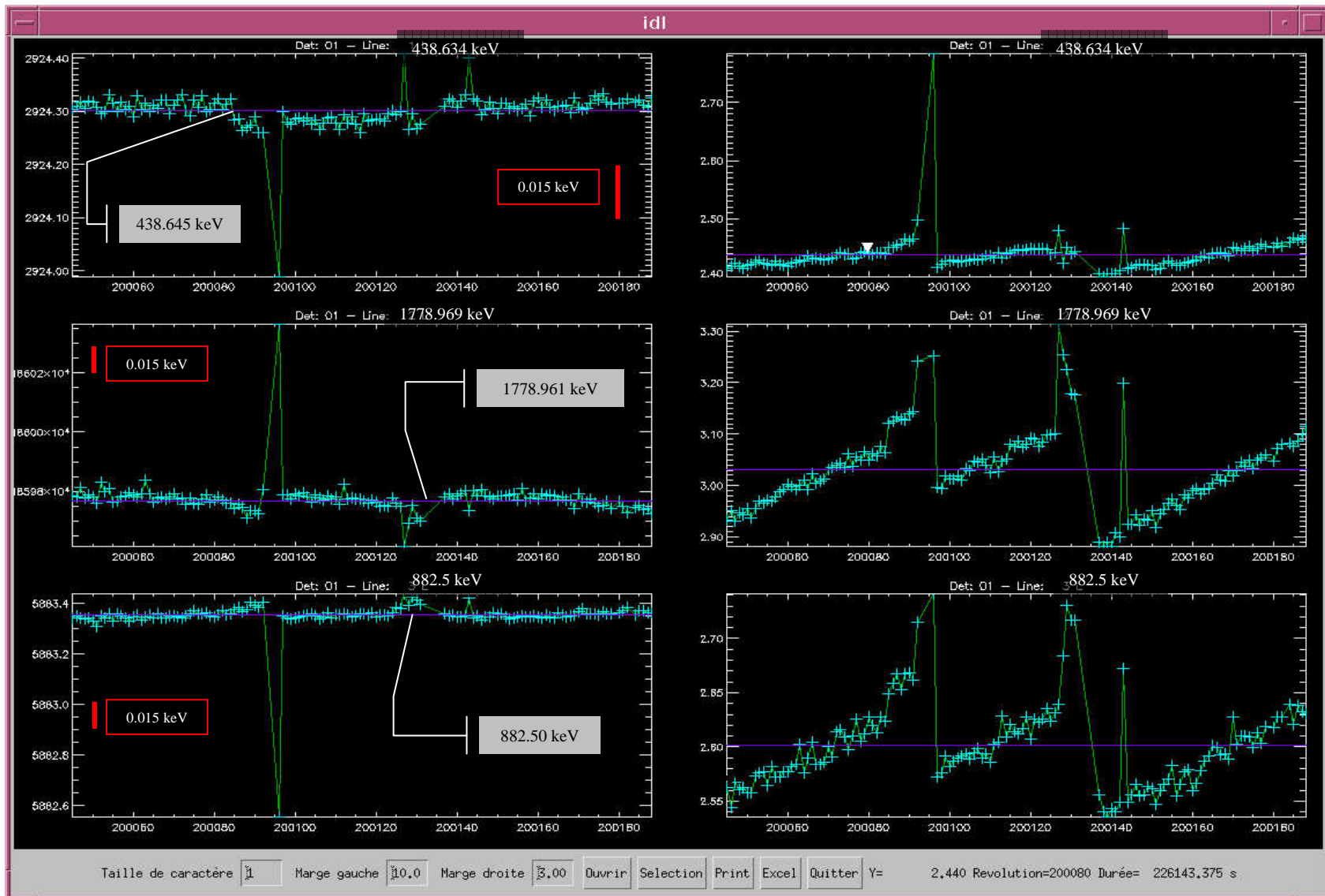
Imaging :  $16^\circ$  fully coded FOV  
Angular resolution :  $2.6^\circ$   
Energy range : 20 keV- 8 MeV  
Energy resolution : 0.2 %  
Time resolution : 100 microsec  
Shield : active BGO shield  
Camera : 19 HPGe detectors.  
Active cooling : 80 K



**ENERGY RESOLUTION  
AND  
GAIN STABILITY**

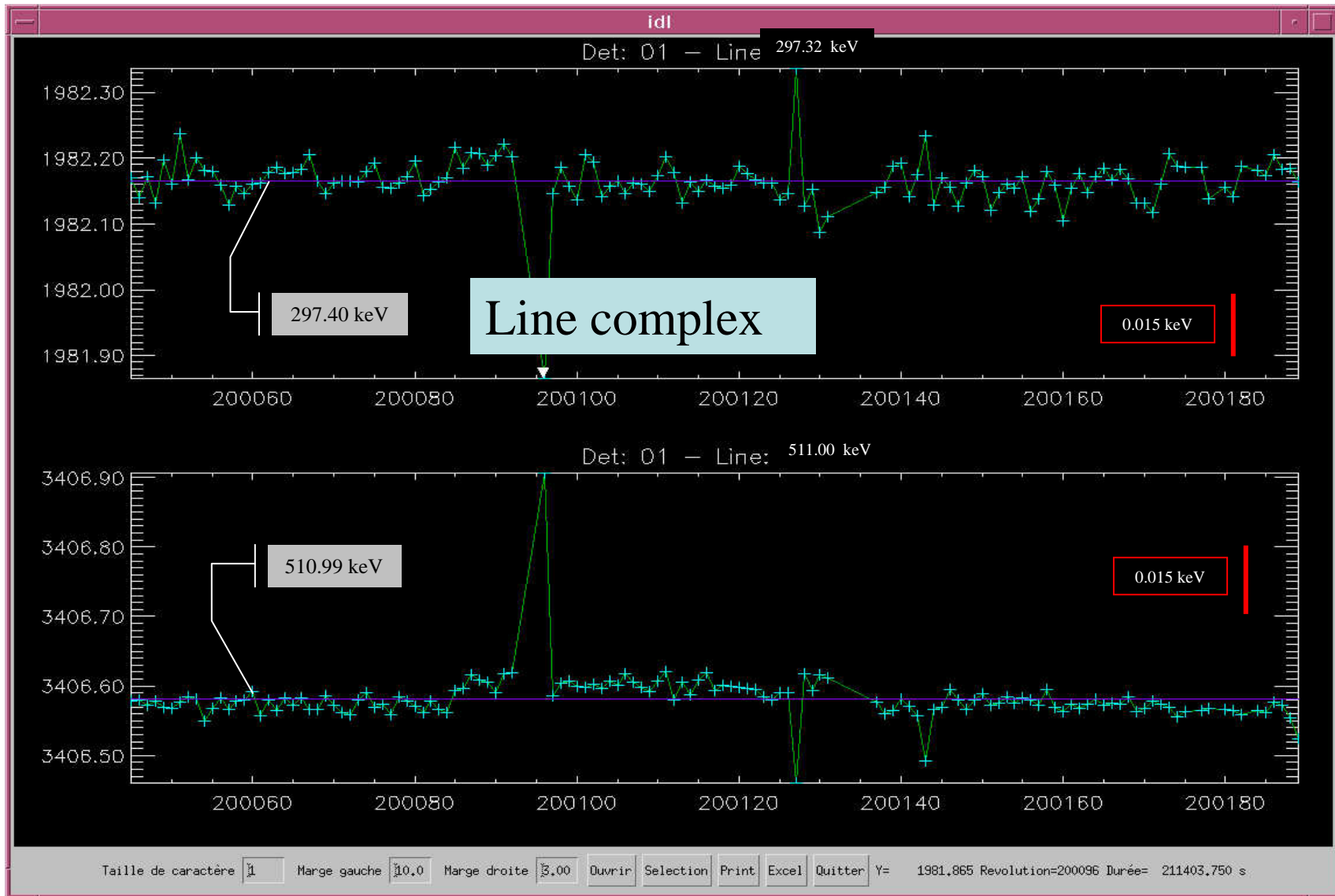


# Whole camera peak positions in keV and energy resolution





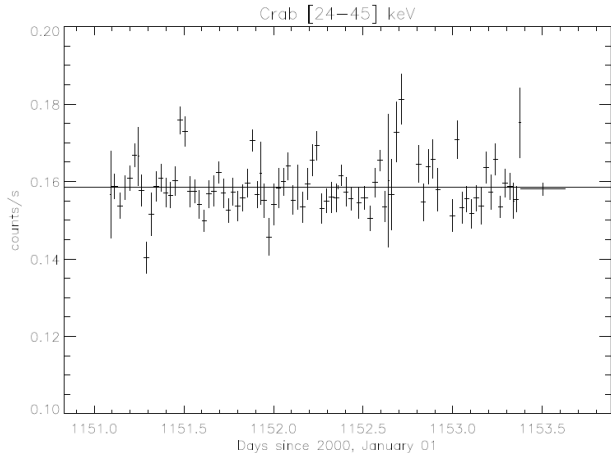
# Peak position in keV for whole camera in ME2-Individual



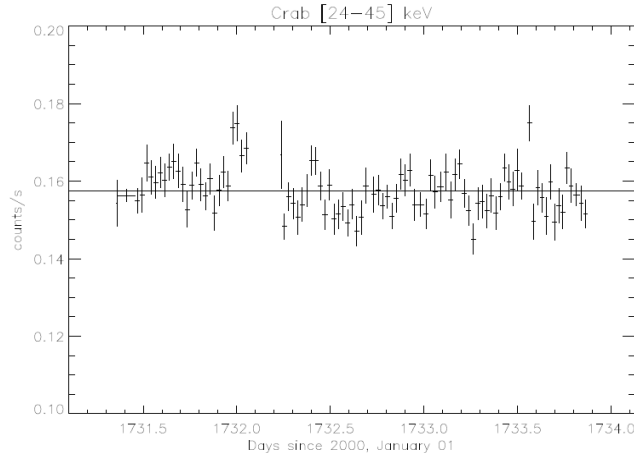
# SPI CALIBRATION WITH CRAB OBSERVATION

# CRAB FLUX by SCW

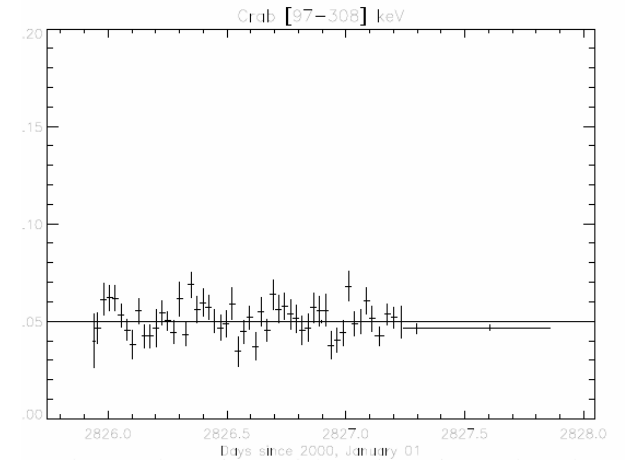
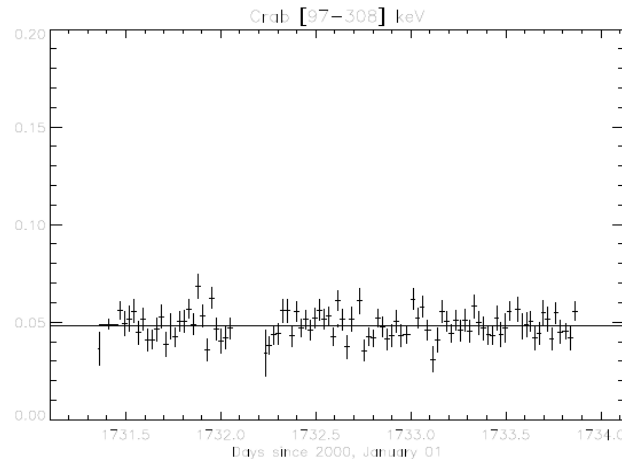
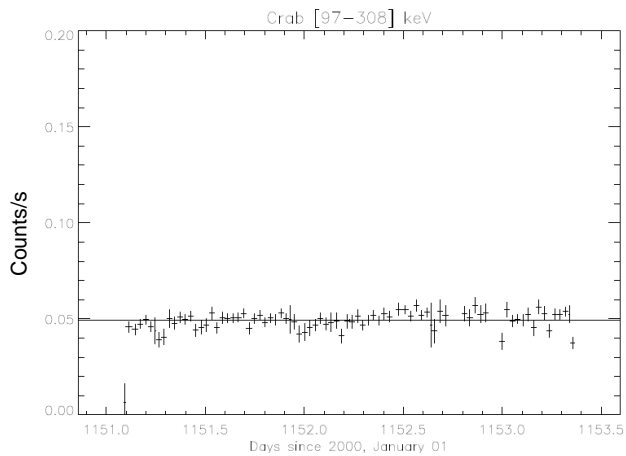
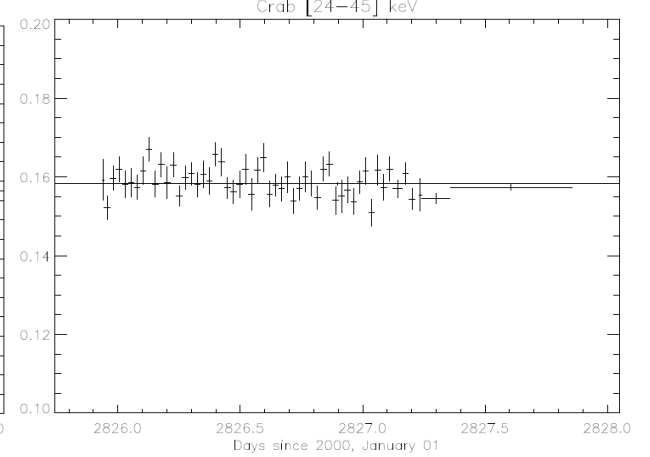
Rev 45



Rev 239



Rev 605



**STABILITY OF EFFICIENCY SINCE THE BEGINNING OF THE MISSION**

# SPI

Total = all revolutions with 17 detectors

**325 ks of useful duration**, distributed over 7 revolutions

From 23. keV to 1 MeV, 0% systematic:

- **Model :**

*a broken power law*

Photon Index 1 : **2.08** +/- 0.01

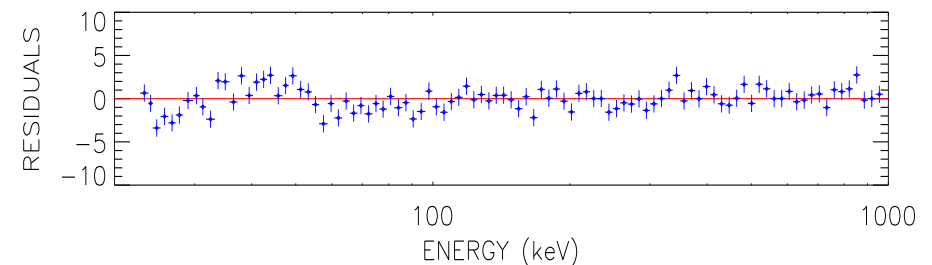
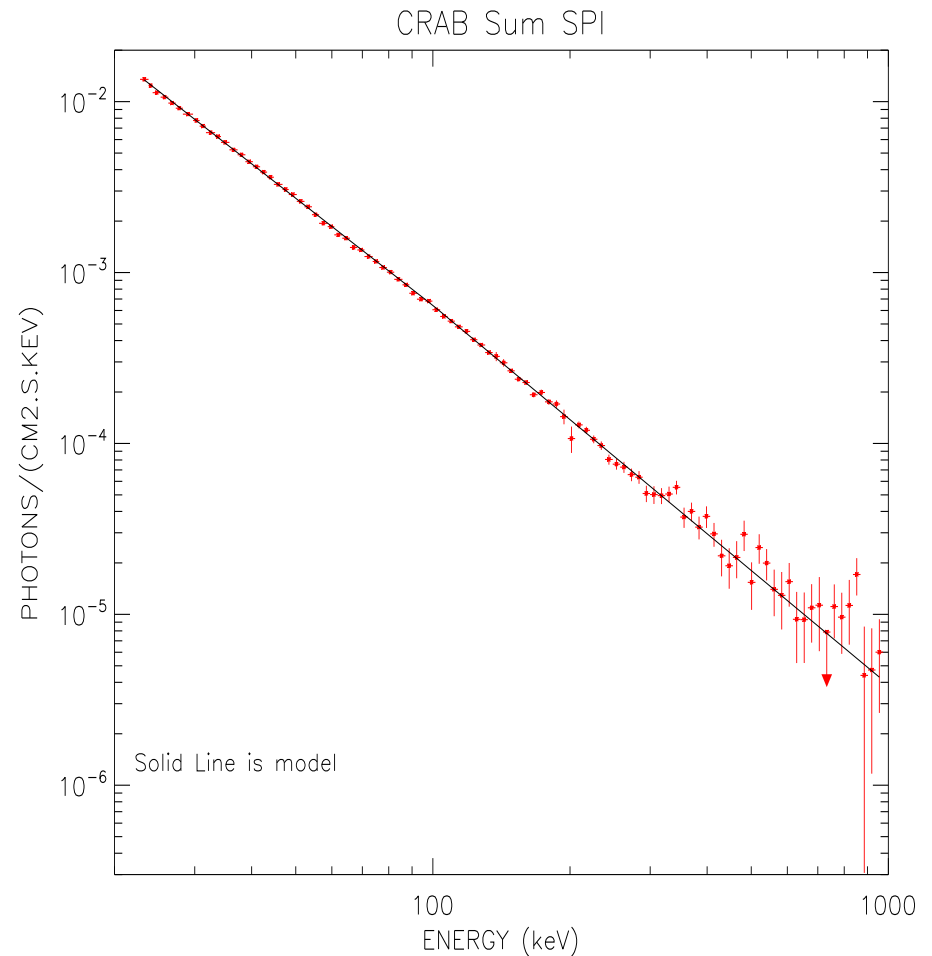
Break Energy (fixed) : **100.000** keV

Photon Index 2 : **2.22** +/- 0.03

Flux @ 100 keV:  **$6.4 \cdot 10^{-4}$**  ph. cm<sup>-2</sup>s<sup>-1</sup>

Extrapol. flux@1 keV : 9.33 ph. cm<sup>-2</sup> s<sup>-1</sup>

Small changes since last meeting due to software correction in the response matrix interpolation



**INTEGRAL Cross-calibration**  
**Status**  
**between 3 keV and 1 MeV**

Answer to IUG action 05-4 by  
Instrument teams

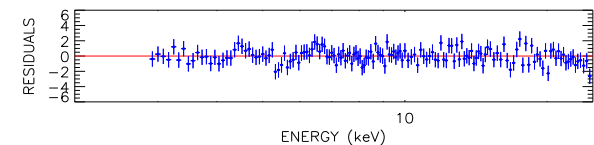
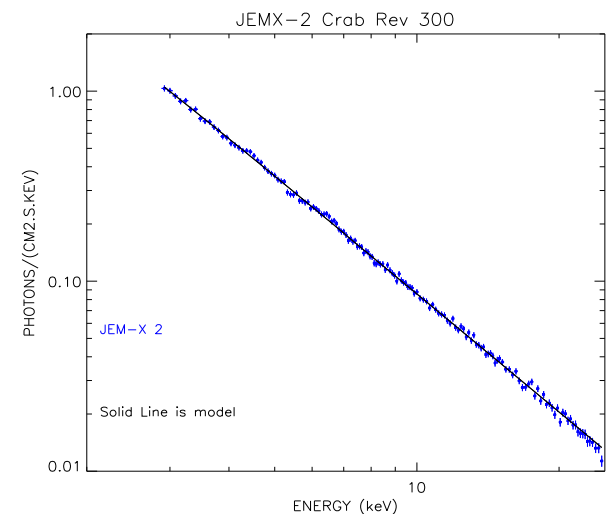
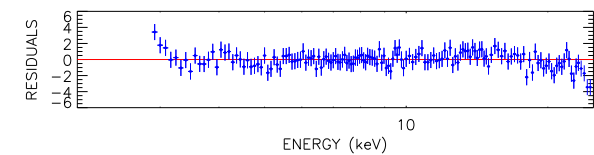
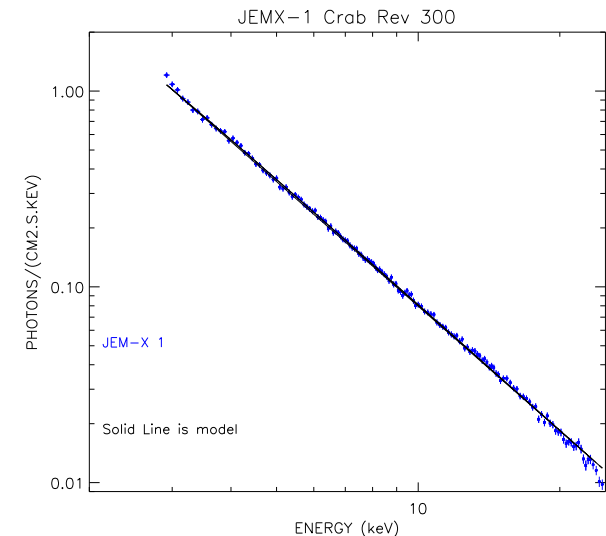
# JEM-X

Orbit 300 data  
(ARF derived from earlier observations):

- JMX1  
Photon Index =  $2.15 \pm 0.05$   
Flux @ 1 keV =  $11.3 \pm 0.1$  ph cm<sup>-2</sup> s<sup>-1</sup> keV<sup>-1</sup>  
NH =  $0.265 \times 10^{22}$  cm<sup>-2</sup> (frozen)

- JMX2  
Photon Index =  $2.07 \pm 0.05$   
Flux @ 1 keV =  $10.2 \pm 0.1$  ph cm<sup>-2</sup> s<sup>-1</sup> keV<sup>-1</sup>,  
NH =  $0.265 \times 10^{22}$  cm<sup>-2</sup> (frozen)

For both instruments the energy flux from  
2 – 10 keV is  $2.28 \times 10^{-8}$  erg cm<sup>-2</sup> s<sup>-1</sup>





# ISGRI

From “absolute” matrix

- Orbit 300 data:

Photon Index =  $2.12 \pm 0.03$

Flux @ 100 keV =  $6.5 \times 10^{-4}$  photons cm<sup>-2</sup> s<sup>-1</sup>

- Orbit 605 data :

Photon Index =  $2.13 \pm 0.03$

Flux @ 100 keV =  $6.2 \times 10^{-4}$  photons cm<sup>-2</sup> s<sup>-1</sup>

- values very similar and compatible at  $\sim 2 \sigma$  level with SPI.
- This proves that below 100 keV ISGRI can give an independent and stable estimate of the Crab spectrum

BUT

some more work is needed to assess the response at high energies and to get rid of the residual systematics (visible with narrow bands) below 100 keV.

That is why the ISGRI response matrices (in particular the ancillary response function, ARF) derived by means of Montecarlo simulations, and based on the current knowledge of the instruments, are corrected “a posteriori” in order to match the SPI Crab spectrum, which is taken as an independent absolute measure.

# SPI

Total = all revolutions with 17 detectors  
5X5 patterns

**325 ks of useful duration**, distributed  
over 7 revolutions

From 23. keV to 1 MeV, 0% systematic:

- **Model :**

*a broken power law*

*with Ebreak fixed to 100 keV*

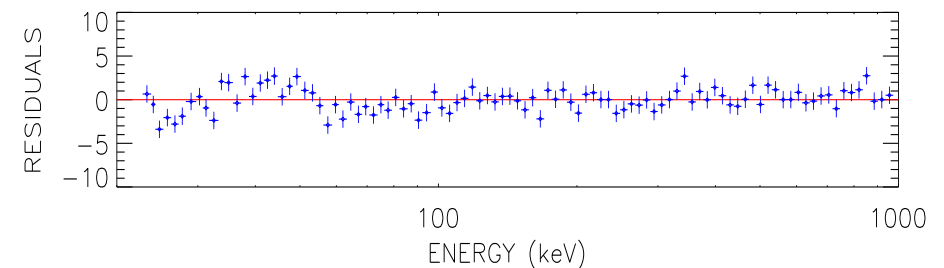
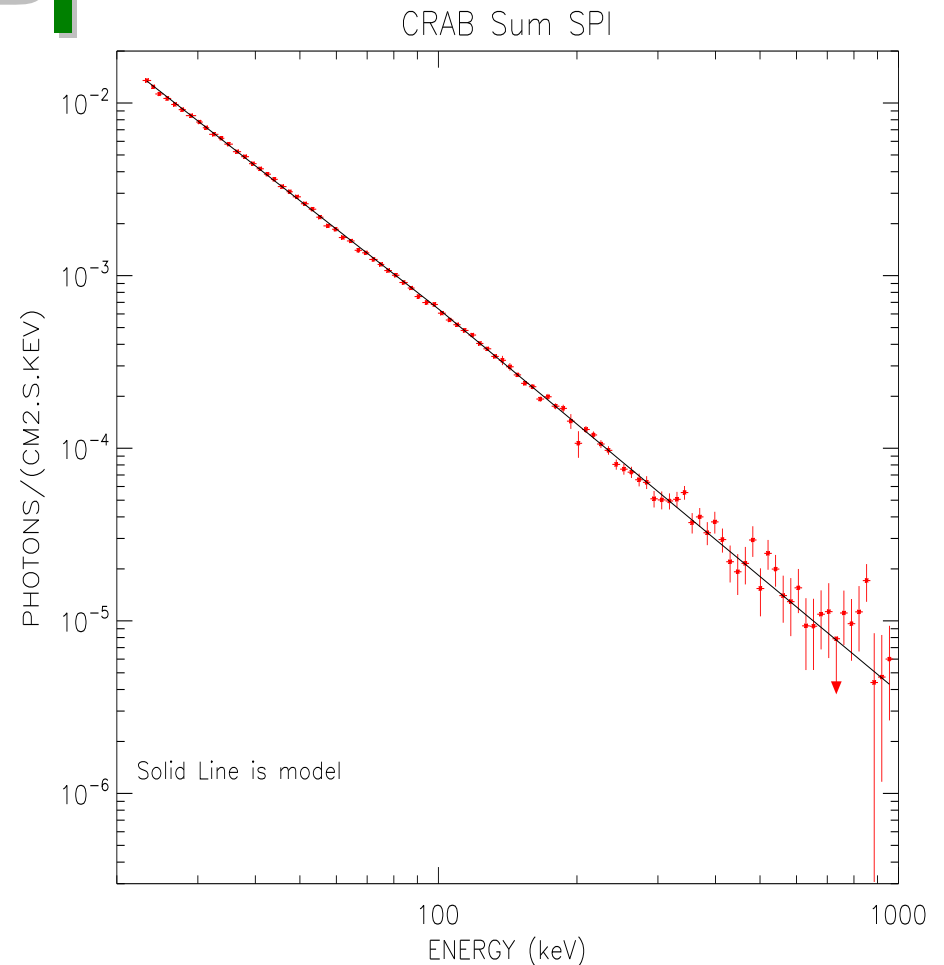
Photon Index 1 : 2.08 +/- 0.01

Break Energy (fr) : 100.000 keV

Photon Index 2 : 2.22 +/- 0.03

Flux @ 100 keV:  $6.4 \cdot 10^{-4}$  ph. cm<sup>-2</sup> s<sup>-1</sup>

Extrapol. flux@1 keV : 9.33 ph. cm<sup>-2</sup> s<sup>-1</sup>



# INTEGRAL CRAB SPECTRUM

- JEM-X 1 and 2 data 3 to 25 keV (15 ks in revolution 300).
- ISGRI data have been used from 14 keV to 1 MeV (revolution 300), as in Section II but with OSA-7 (“corrected”) matrix.
- SPI : As presented above
- Systematics have been added at a level of 3% for JEM X-1 & 2; 1% for ISGRI and SPI

**Model** : a broken power law

with Ebreak fixed to 100 keV

plus an absorption with Nh fixed to  $0.265 \cdot 10^{22} \text{ cm}^{-2}$

Photon Index 1 :  $2.105 \pm 0.3 \cdot 10^{-2}$

Break Energy : 100.000 keV frozen

Photon Index 2 :  $2.22 \pm 0.2 \cdot 10^{-1}$

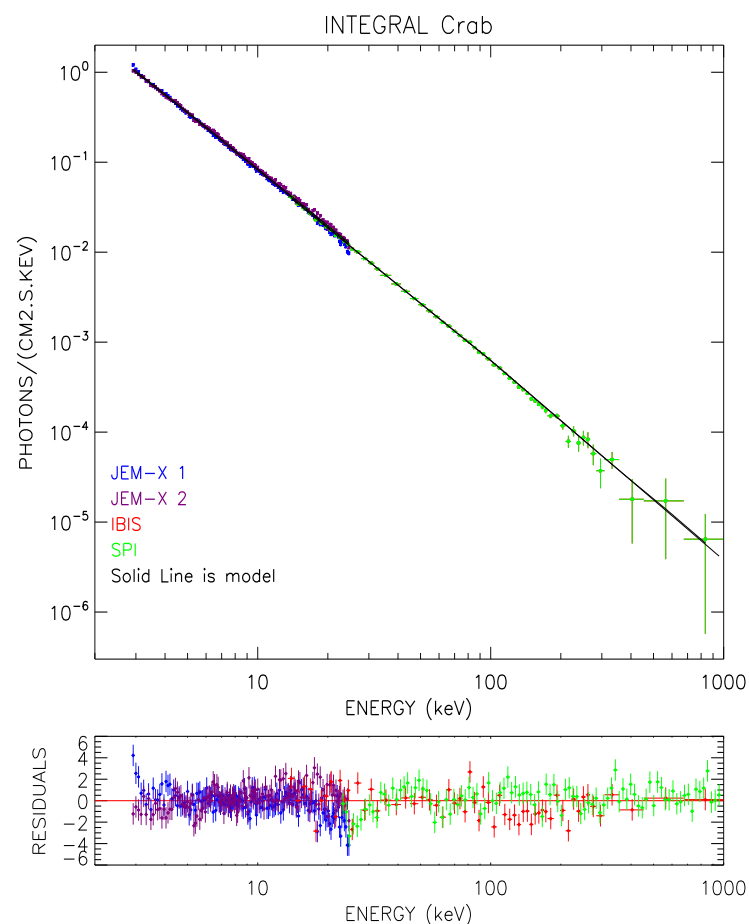
Flux @ 100 keV:  $6.3 \cdot 10^{-4} \text{ photons cm}^{-2} \text{ s}^{-1}$

factor SPI fixed to 1.0

factor ISGRI :  $0.99 \pm 0.2 \cdot 10^{-2}$

factor JEM X-1 :  $1.022 \pm 0.3 \cdot 10^{-2}$

factor JEM X-2 :  $1.06 \pm 0.3 \cdot 10^{-2}$



# Conclusion

- The INTEGRAL instruments give consistent results on the Crab Nebula spectrum, with a global shape in agreement with observations from previous experiments.
- In particular, the cross-normalisation factors between instruments are within reasonable values.

This demonstrates that INTEGRAL can provide reliable spectra over its wide energy range.

**NEXT STEPS**

# SPI : Request for a long 5x5 Crab calibration: 1MS

- The instrument stability at high energy cannot be claimed from low energy results
- After 5 years and 11 annealings, the Lithium drift of the central electrode should have an impact on the efficiency
- Deep Crab observation is mandatory to measure the evolution of SPI efficiency



# Request for a long 5x5 Crab calibration

- The request has been sent to the IUG
- The request has been accepted by the PS
- The last Crab observation lasted 2 Rev.  
(~ 400 ks duration)

# LAST CRAB OBSERVATIONS REV 665 – 666

## MARCH 2008 PRELIMINARY RESULTS

190 scw ~ 2 ks

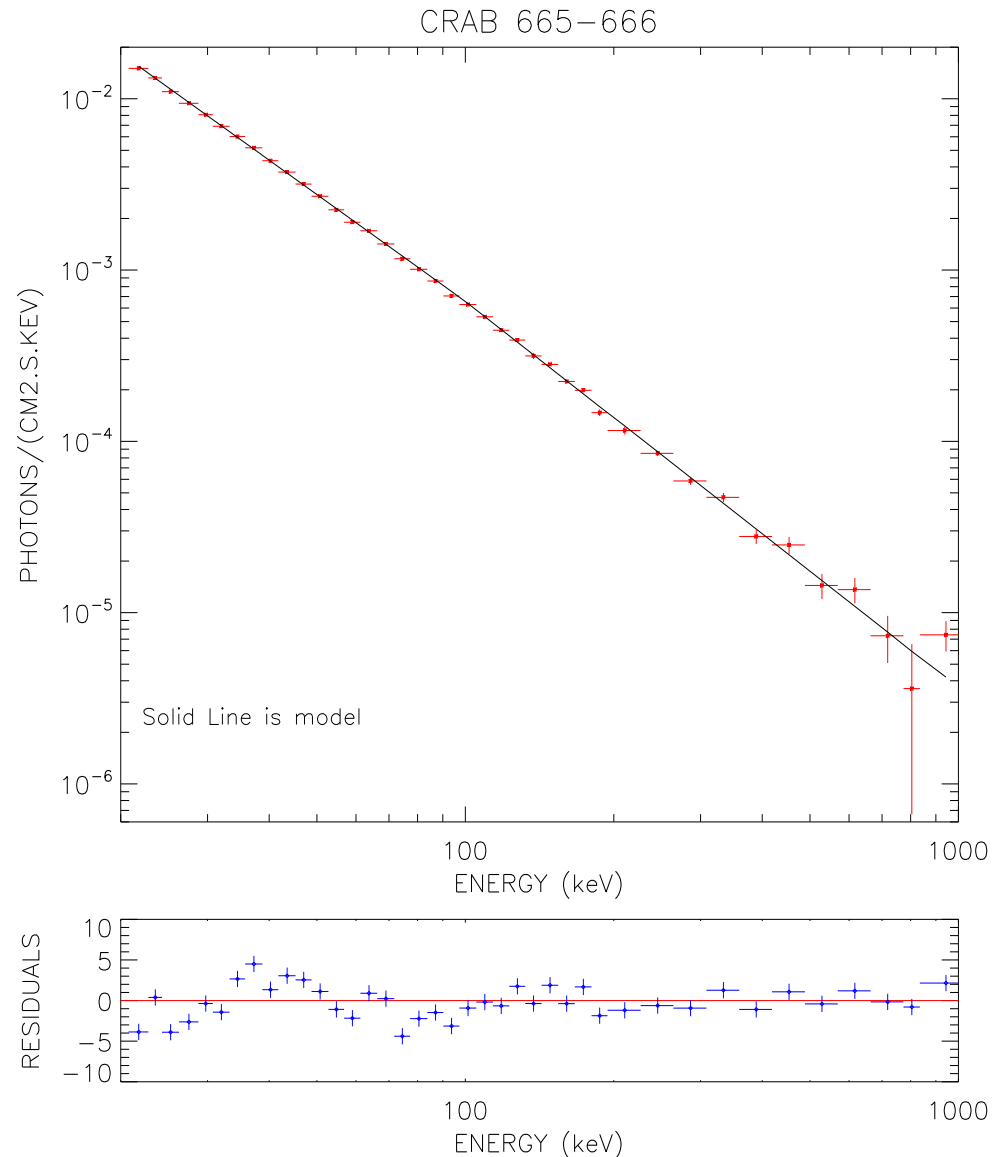
→ ~ 320 ks useful duration

Photon Index : 2.07

Break Energy (fr) : 100.000 keV

Photon Index 2 : 2.25

Flux @ 100 keV:  $6.37 \cdot 10^{-4}$  ph.cm<sup>-2</sup> s<sup>-1</sup>

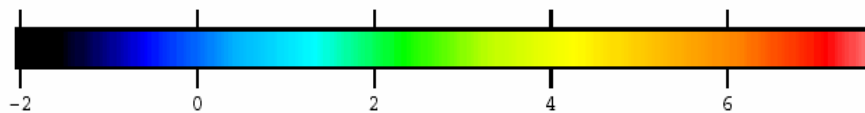
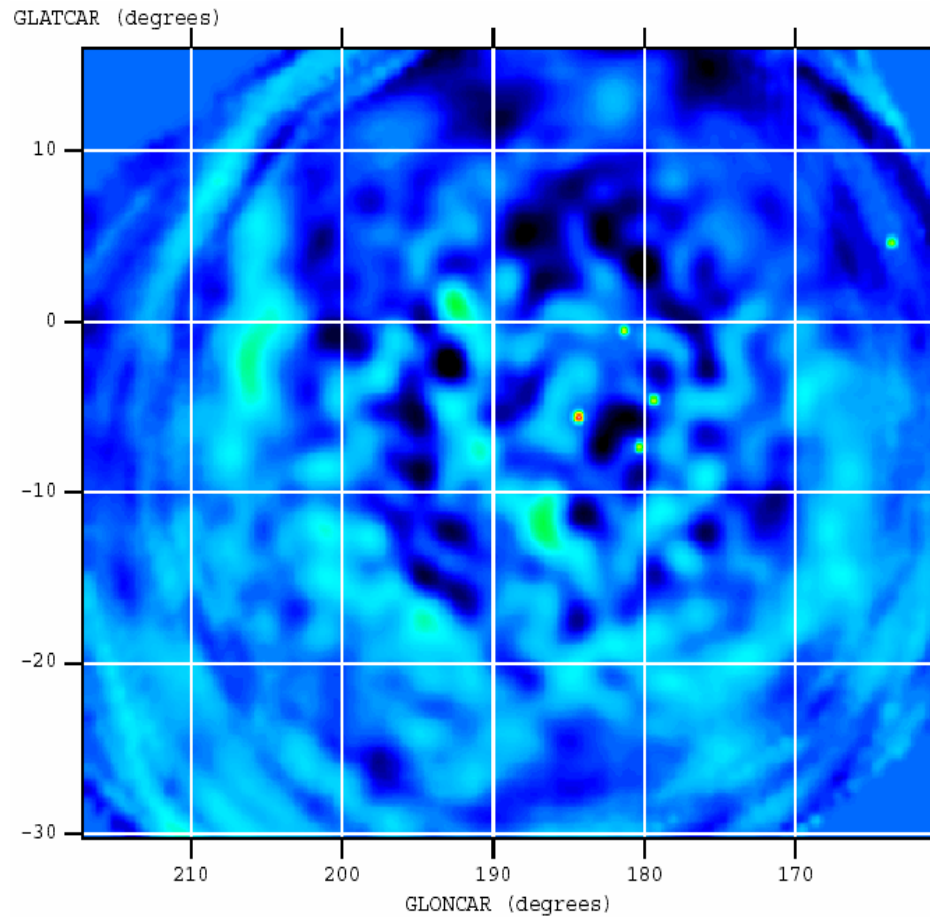


# THE CRAB NEBULAE

2003

625 Ks

## 1.8 – 4 MeV



Significance

