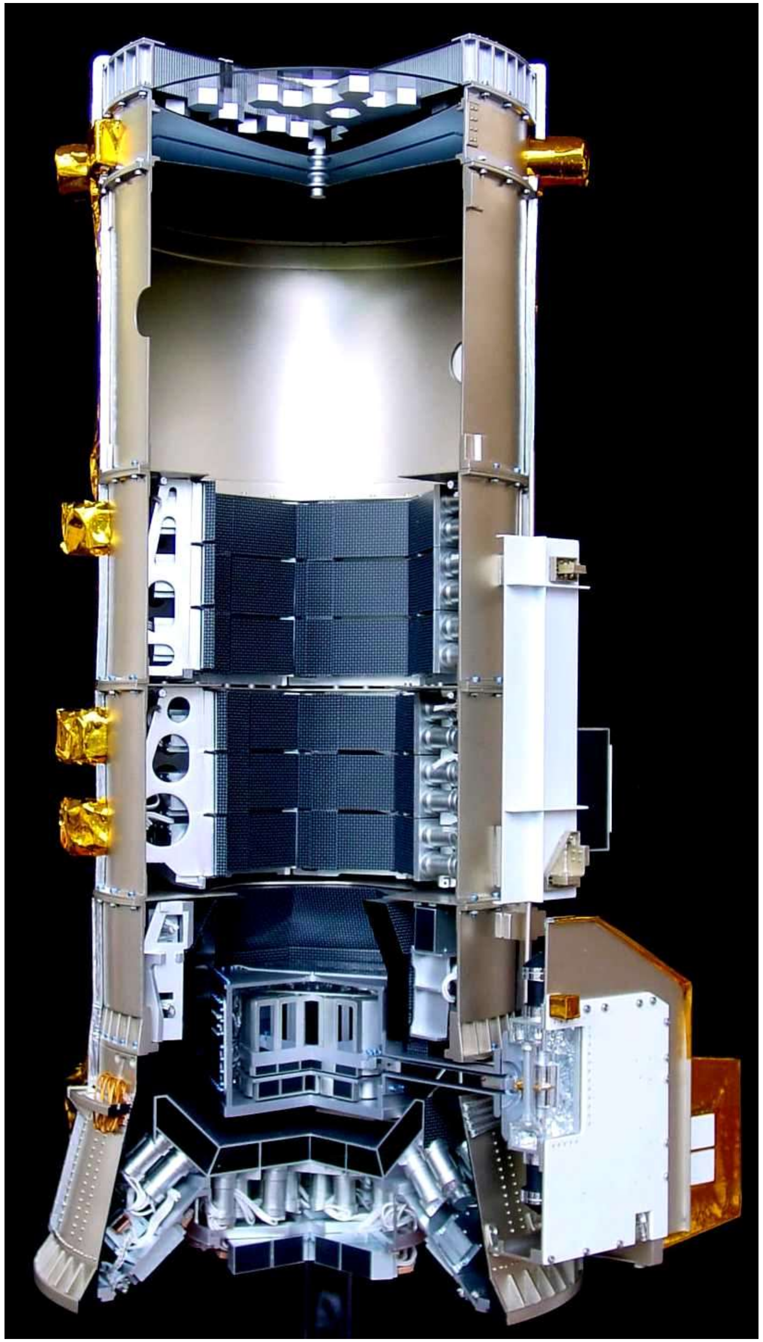
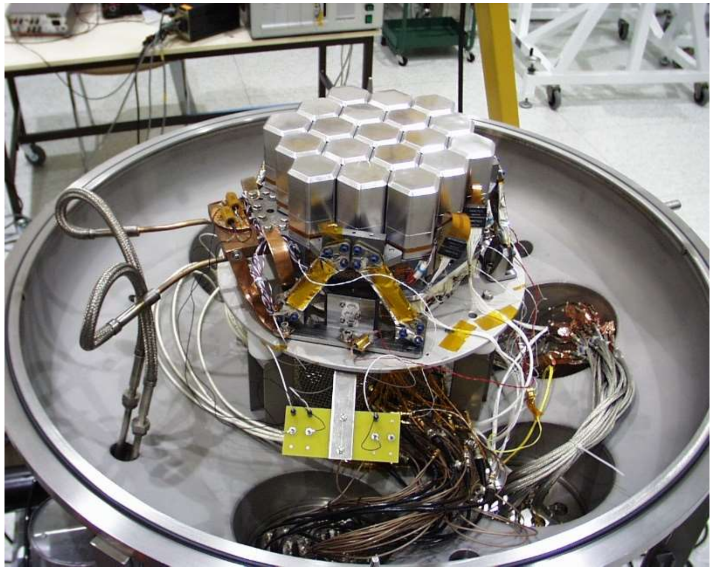
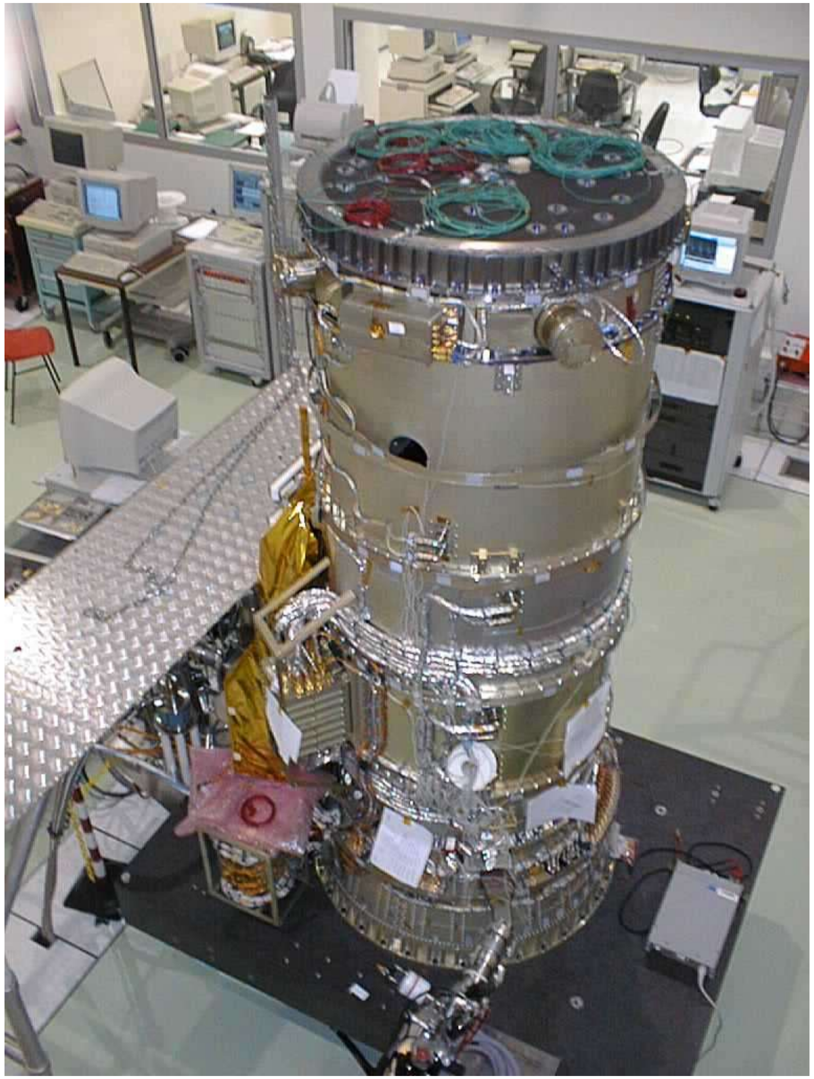
SPI

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 : 80 K



SPI FM CALIBRATIONS





SPI CALIBRATIONS

4 STEPS :

- **CAMERA CALIBRATION** :

After camera integration (Sept 2000)

- **SPI CALIBRATION AT CNES**

After SPI integration (Dec 2000)

- **SPI AT THERMAL TEST**

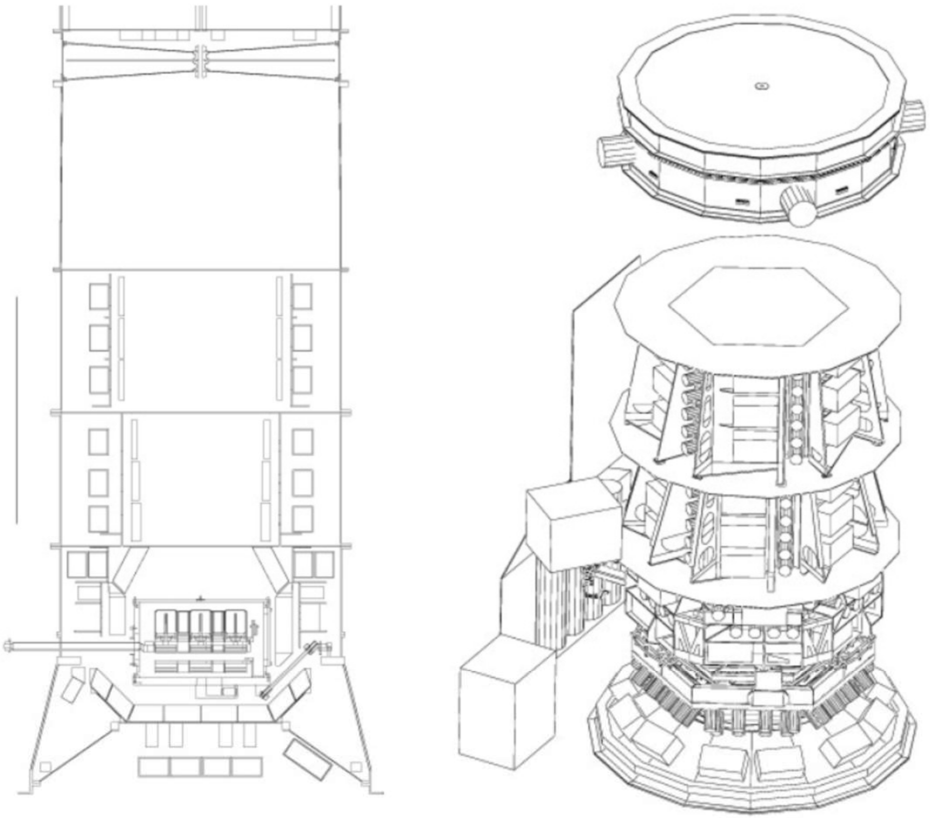
SPI in representative thermal conditions(March - April 2001)

- **SPI CALIBRATION AT BRUYERES LE CHATEL**

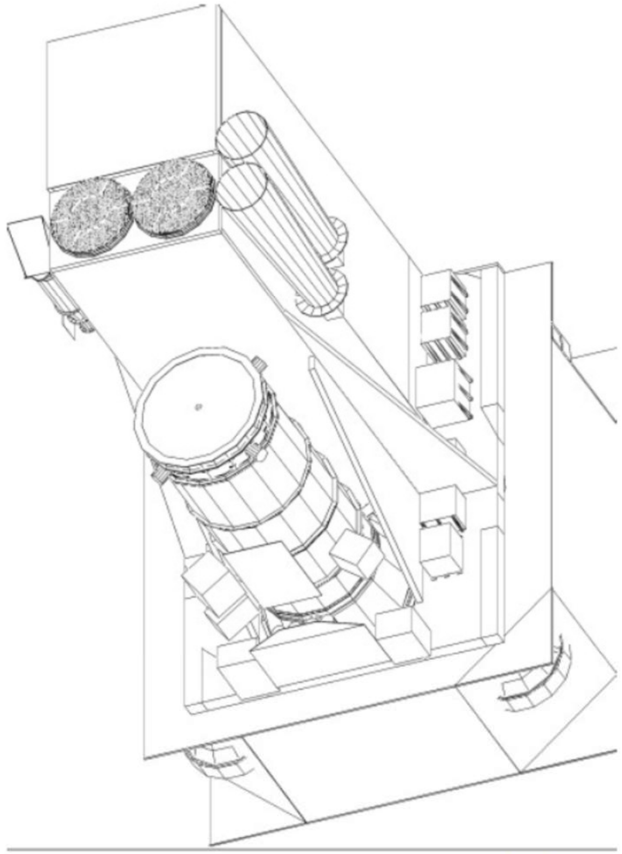
Latest calibration before SPI delivery at ESA (April - May 2001)

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”.

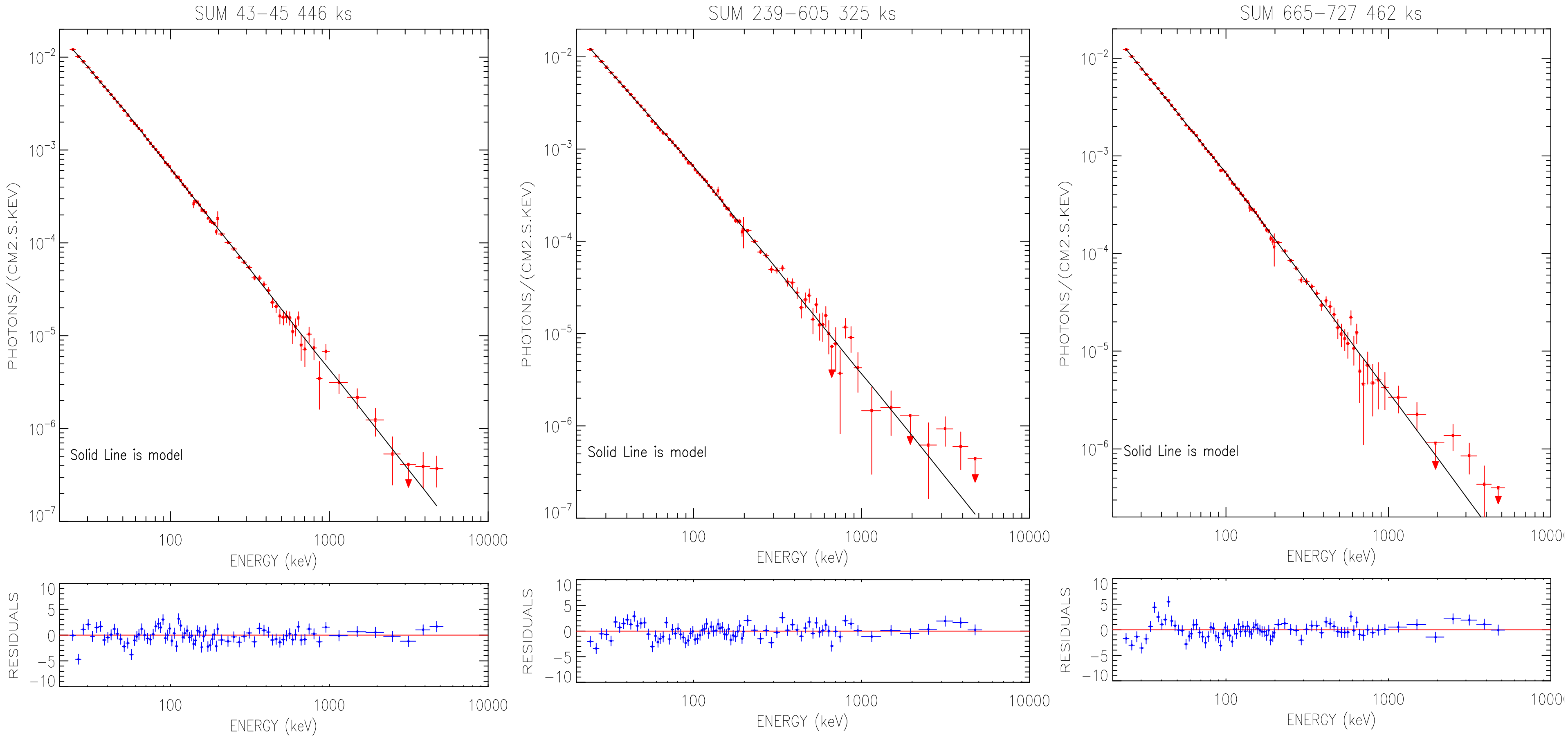


SPI cut-away views



TIMM-3

SUM for 3 periods
5X5 patterns



Fit with a broken power law ; Ebreak = 100 keV; index1=2.07 ; index2=2.25

This was shown here in 2009 ! After 10 years more the results on Crab are similar.

See E. Jourdain talk in the Crab session for the last refinements.

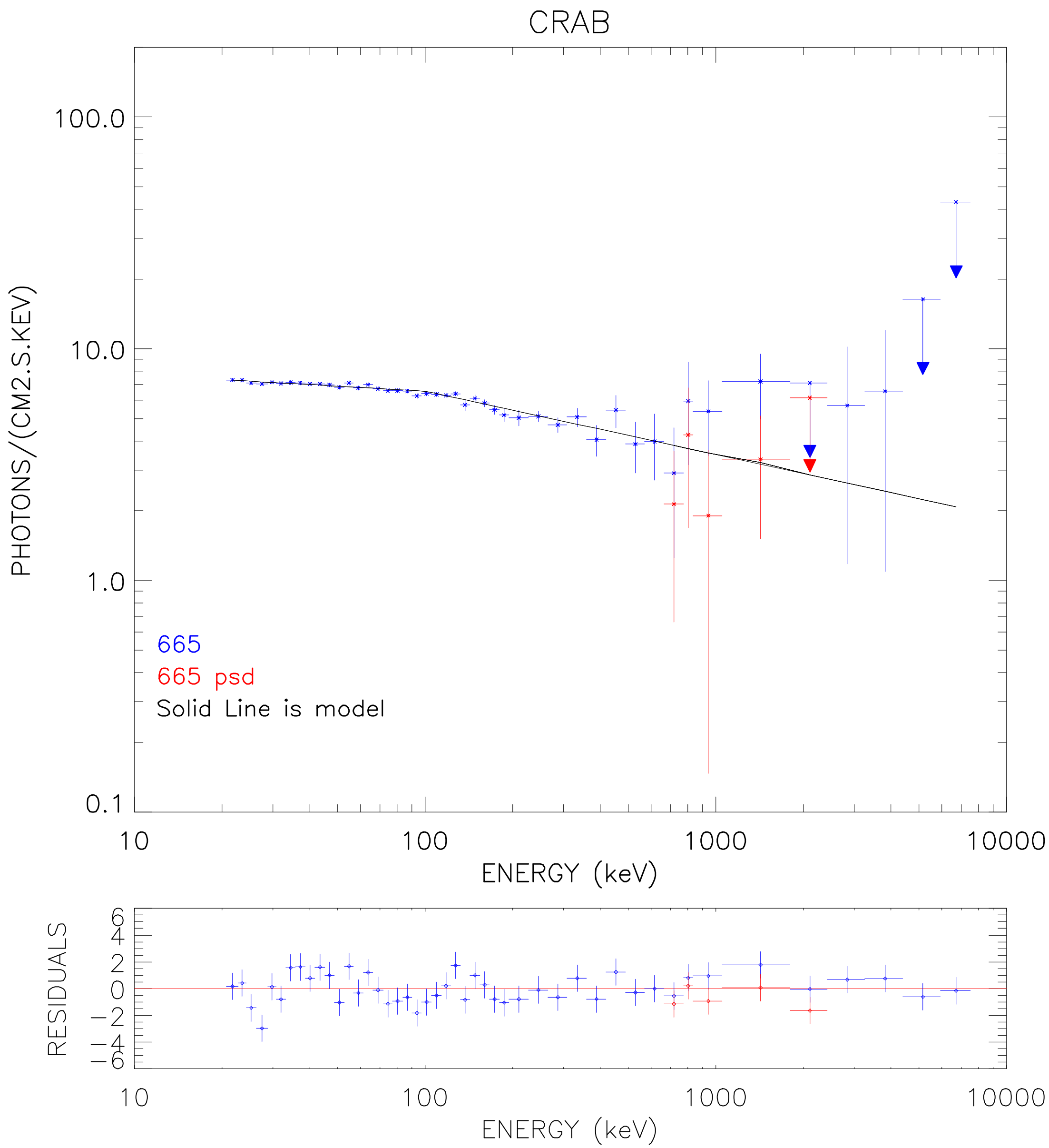
IACHEC 2009 and Jourdain & Roques 2009

-Spectra pollution by electronic noise 700keV-1.7 MeV

-- The “noise” is unstable

-- in the 650-2200 keV range PSD electronics supply a second trigger.

-- use of this trigger to confirm the event.



On the high-energy emissions of compact objects observed with *INTEGRAL* SPI: Event selection impact on source spectra and scientific results for the bright sources Crab Nebula, GS2023+338 and MAXI J1820+070*

JEAN-PIERRE ROQUES[1] AND ELISABETH JOURDAIN[1]

[1] *CNRS; IRAP; 9 Av. colonel Roche, BP 44346, F-31028 Toulouse cedex 4, France*
Université de Toulouse; UPS-OMP; IRAP; Toulouse, France

(Received October , 2018; Revised November , 2018; Accepted)

ABSTRACT

The *INTEGRAL* SPI instrument observes the hard X-ray sky from 20 keV up to a few MeV since more than 15 years. In this energy domain, the main emitters are compact objects for which SPI provides spectral information of prime interest. Recently, two transient sources reached very unusual flux levels and have been detected up to a few hundreds of keV with a high significance level. A drastic reduction of the systematic errors is thus required to obtain reliable spectra. This objective is achieved through an analysis including a detailed understanding of the instrument behavior. This paper presents both aspects of the data analysis: we first give a basic description of the instrumental issues, then we present the solution to be implemented in the SPI data analysis (at the event selection stage) and illustrate with a few examples the reliability of the SPI results in the high-energy domain when the data analysis is performed properly. We take benefit from this refined analysis procedure to propose an updated model of the hard X-ray spectral shape of the Crab Nebula. We revisit the high-energy emission observed in GS2023+338 spectra during its 2015 outburst and present the first results from the SPI observations dedicated to the recently discovered transient MAXI J1820+070.

SPI: Event processing

x 19

GeD's + preamplifiers — Two outputs:

- Image of the current flowing in the Germanium. (For pulse shape analysis). Fast ~no integration
- Standard, charge integrated output. For energy measurement. Slow, 500us time constant.

PSD electronics

- Pulse shape analysis(non longer used)
- Trigger between LLD and ULD for each GeD
- Produces a Time Tag.
- Multiple events anticoincidence

AFEE electronics

- ULD and LLD
- PSA-PHA
- Provides Energy
- Provides Time-Tag
- 26us dead time for analysed events, 100 us dead time for saturating events

ACS

Time tags

DFEE electronics

- Time Tag processing – delay alignments – time tags windows generation and association.
- events classification

Event association and classification

- For each Time Tag: creation of concidence time windows and check for:
  - Association for events in different GeD   >> ME (Multiple Event)
  - Association of AFEE TT and PSD TT   >> PE Event
  - Association Event and ACS TT, then creation of vetoed/non-vetoed events
- Then the events are classified as:
  - Events in coincidence with an ACS TT are dropped.
  - SE = non-vetoed events, non-coincident with anything else
  - ME = two or more non-vetoed events in the same time windows.
  - PE = non-vetoed event coincident with a PSD Time Tag. Thus one AFEE trigger AND one PSD trigger

SE : unique AFEE Time Tag. No other coincidence

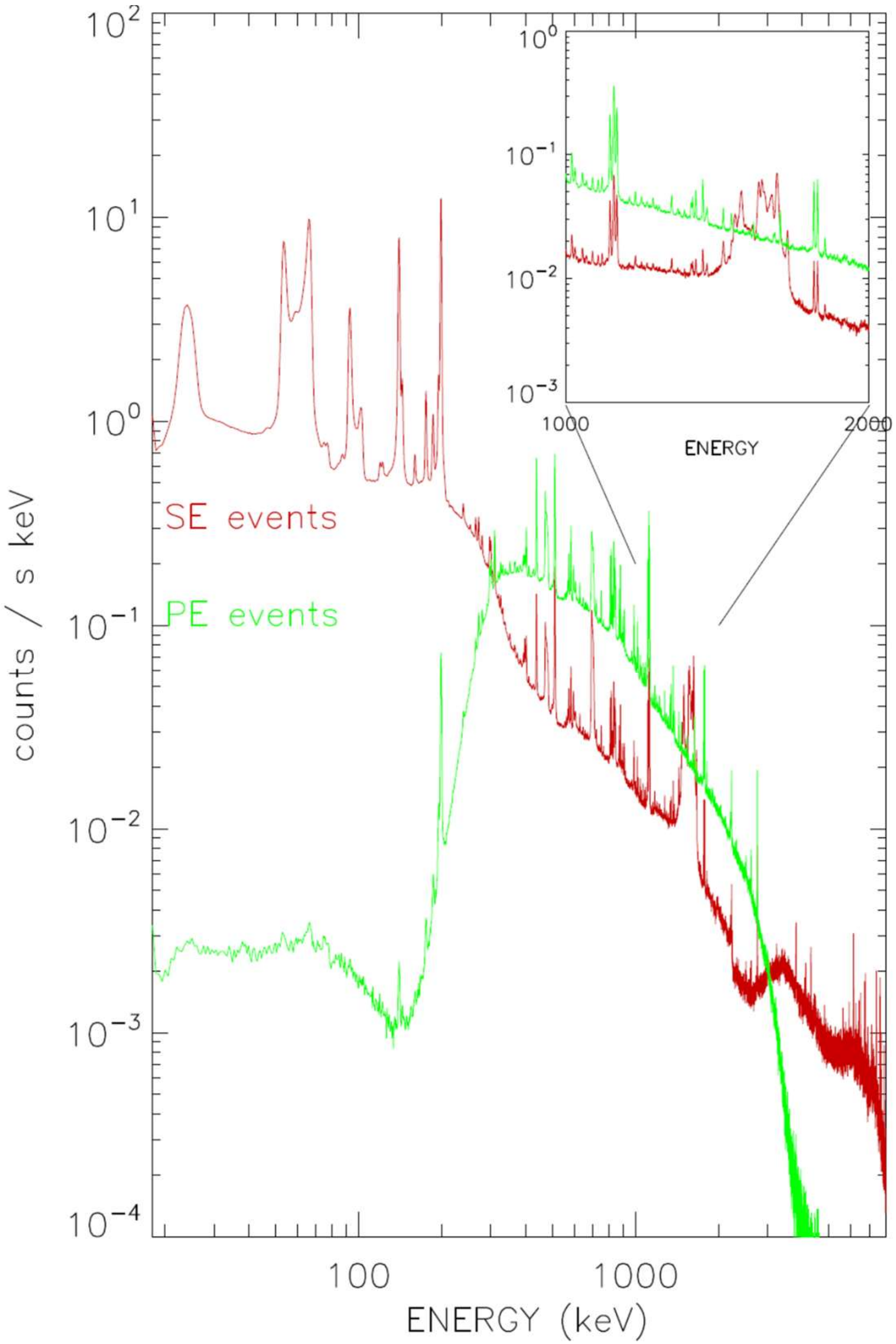
AFEE LLD=18 keV

PE: AFEE Time Tag + PSD Time Tag

PSD LLD = 400 - 650keV
PSD ULD = 2.2MeV - 2.7 MeV

SE events are affected by spurious artefacts, obvious in the MeV region.

PSD efficiency:
The PSD electronics has its own dead time which can be measured precisely with background lines. This efficiency defined by PE/(SE+PE) is around 85%.
See Roques & Jourdain for details



The orign of spurious events

- From ground tests, we know that these events are linked to huge energy deposits.
  - AFEE saturates and the recovery is long.
  - Energy of events falling during the recovery is wrong and pushed towards high energy (similar to pile-up)
- PSD is not affected thanks to the short integration time of the signal (30ns).
- Then when PSD issues a TT, the event is really in the LLD-ULD range.
- The use of the PSD TT allows a confirmation of the event energy range and ensures that it is not a low energy event shifted at higher energy.

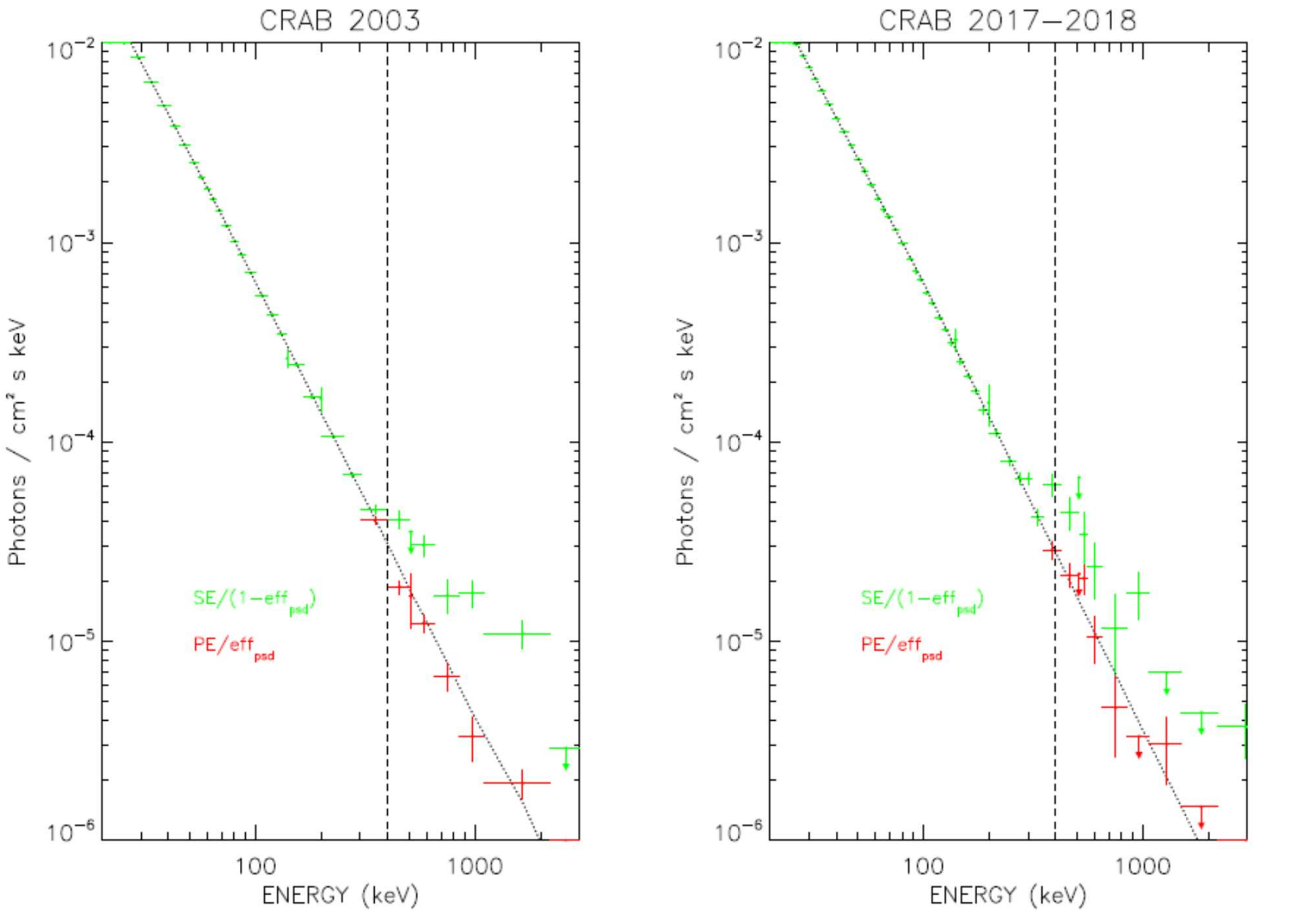
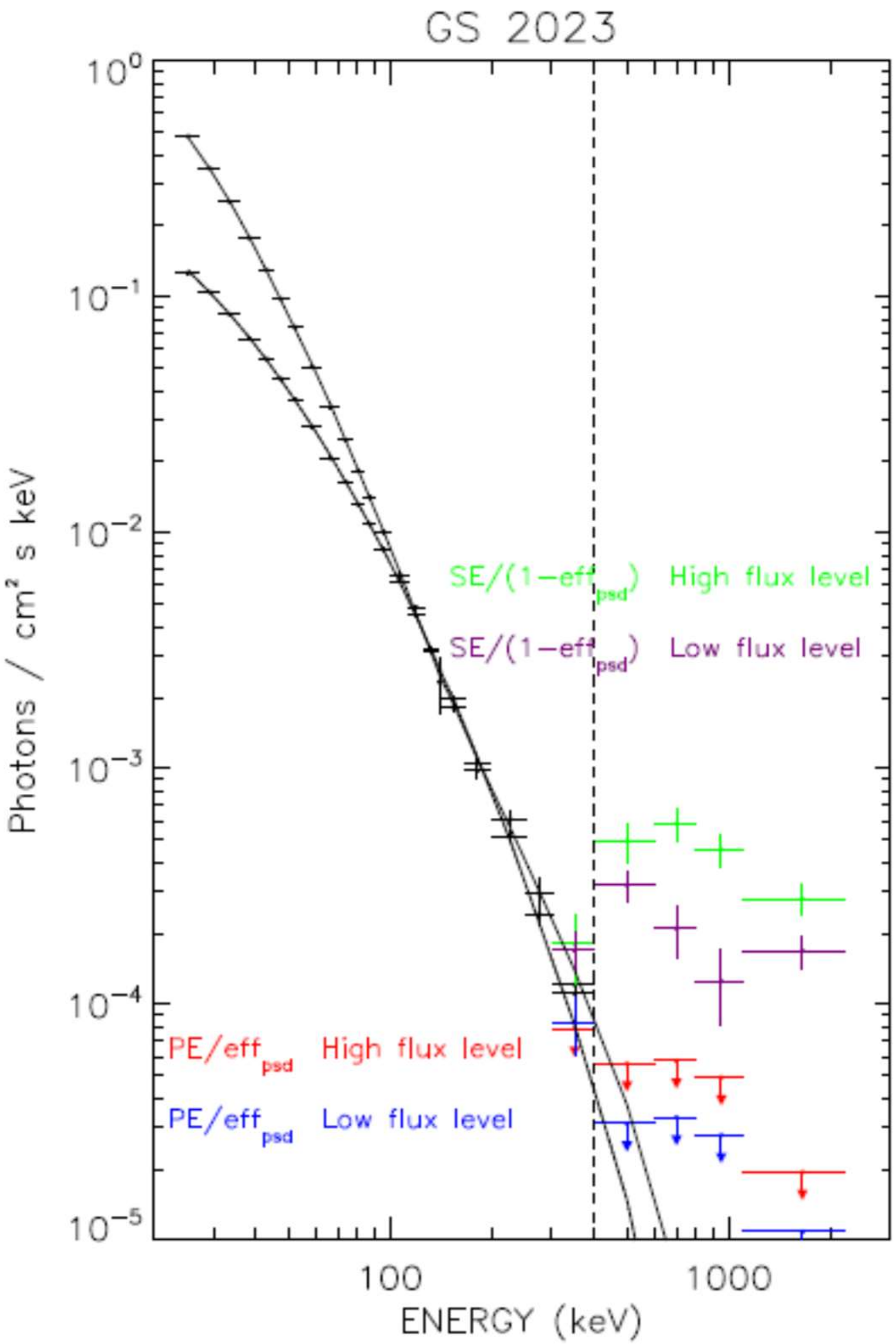


Figure 2. Crab Nebula spectra obtained with SE and PE datasets for 2003 (left panel) and 2017-2018 (right panel) observations.

Spurious events clearly depend on the low energy flux!

We determined that the flux of false SE (350-2000keV) is 0.12% - 0.20% of the 60keV flux (in ph/cm2/s/keV)

Claim of annihilation line detection in V404 is wrong and is easily explained…



SUMMARY

- Generation of spurious events by the analog front end electronics is discussed.
- We establish that a tiny fraction of low energy photons are displaced towards high energy during the recovery time of the electronics after saturating events.
- Thanks to the capabilities of SPI triggering scheme, we show that the PE events are immune to this problem.
- We demonstrate that these spurious events have a dramatic effect on the spectra of intense sources (>= Crab) leading to some « false » discoveries!