



IBIS/ISGRI: calibration status, and cross-calibration with SPI

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on behalf of the IBIS Team

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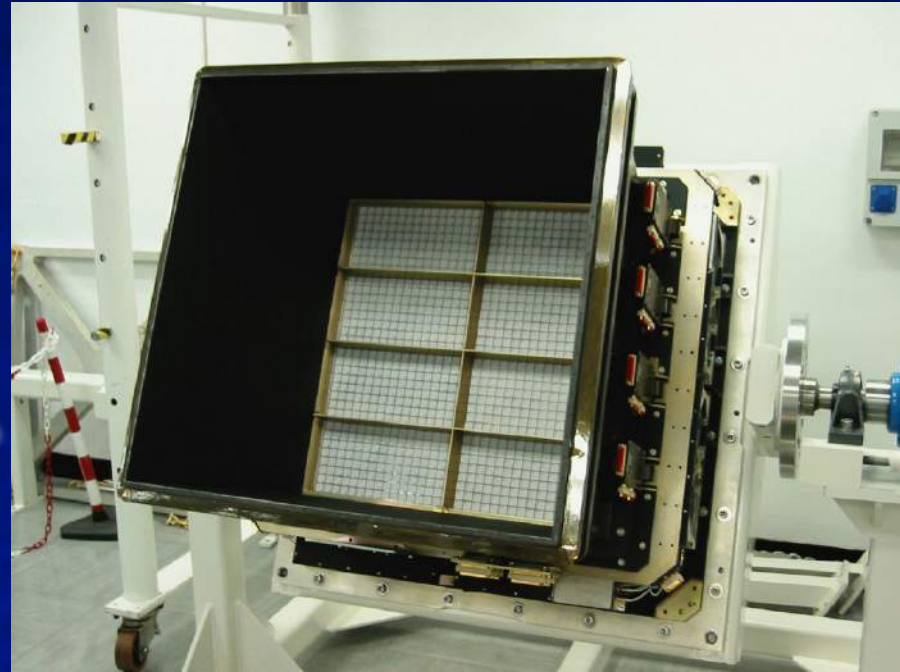
³APC, Paris

⁴CNRS/IRAP, Toulouse

The ISGRI detection plane



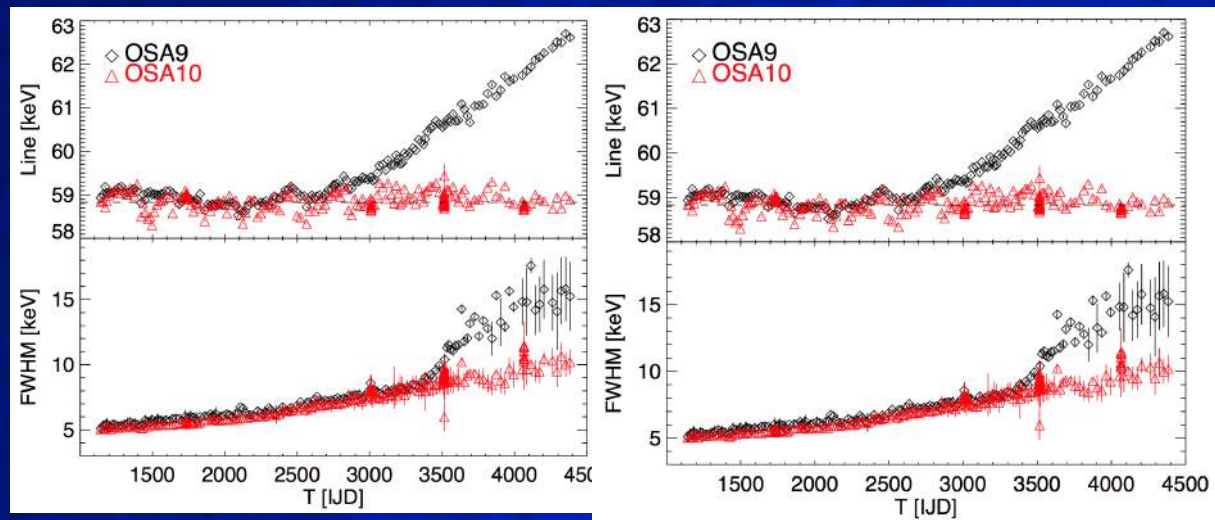
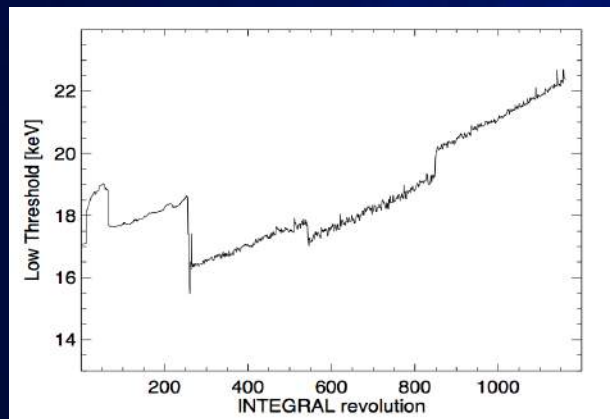
3.2 m



ISGRI: 2mm thick CdTe, 8 modules, total of 16348 pixels with 4 mm resolution, energy range 15-1000 keV, sensitive area 2600cm² (Lebrun et al. 2003)

OSA10 implementation of calibration

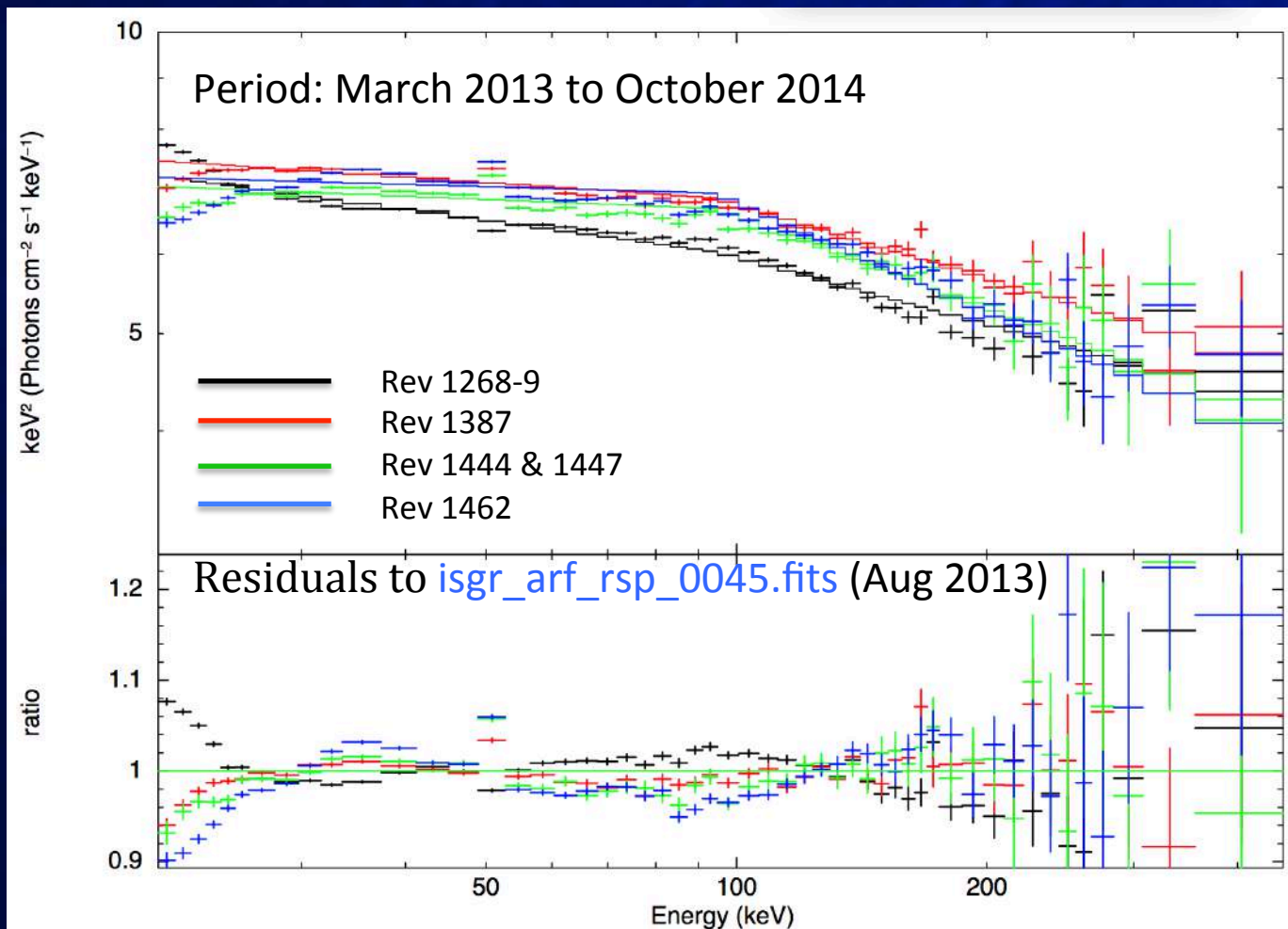
- ✓ Current S/W version: OSA10.1
- ✓ Changes to OSA9: Improved calibration of gain and energy correction (with more accurate model of temperature dependence), improved modeling of low thresholds
- ✓ Gain/offset vs time keep the positions of the background lines at ~ 60 keV and 511 keV



Caballero et al (POS, Proc. INTEGRAL Conf 2012)

Crab spectra against model

- ✓ OSA10 energy correction S/W is not robust against response evolution
- ✓ Spectra are corrected using time dependent ARFs



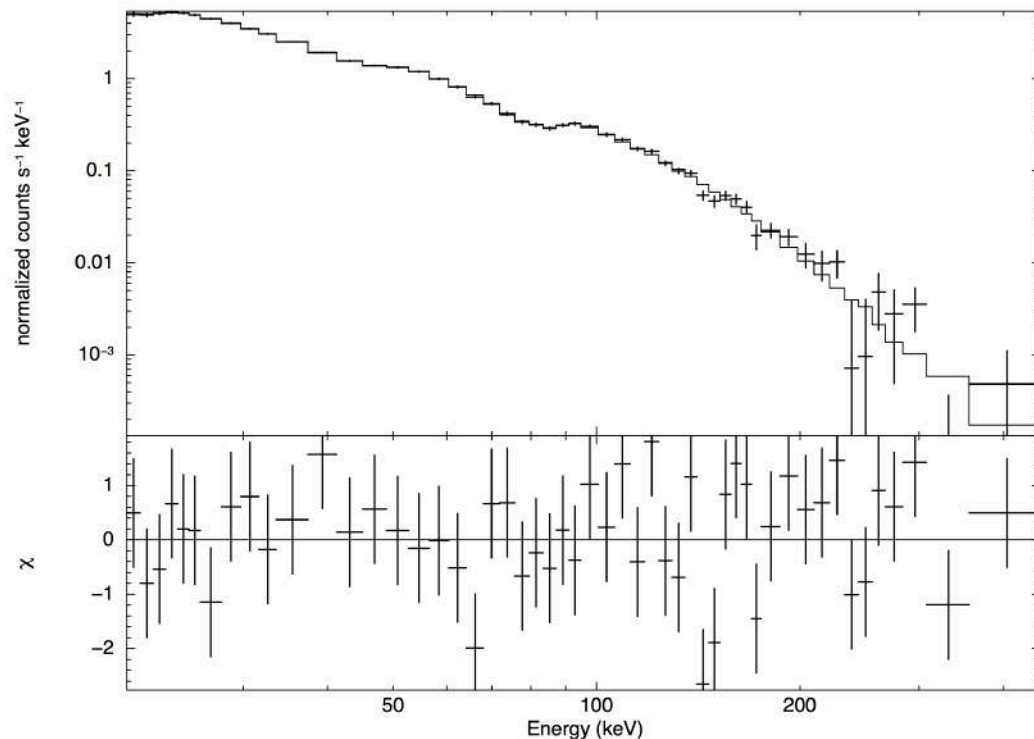
Recent Crab observations used for calibration

Revolution	Date	Remarks
1221	13-15 Oct 2012	100ks custom pointings, 10ks staring, 100ks 5x5wide isgr_arf_rsp_0043.fits in OSA10.1
1268-1269	2-7 March 2013	200 ks/orbit, 5x5wide, includes 10ks staring isgr_arf_rsp_0044.fits in OSA10.1
1278	1-2 Apr 2013	50ks 5x5seq, 50ks custom
1327-1328	25-31 Aug 2013	200ks/orbit, 5x5seq, includes 10ks staring isgr_arf_rsp_0045.fits in OSA10.1
1342	9-10 Oct 2013	50ks custom
1387	21-22 Feb 2014	200 ks 5x5seq, include 10ks staring
1444, 1447, 1452, 1456	Aug-Sep 2014	45ks/orbit, 5x5seq
1461	30 Sep—3 Oct 2014	50ks custom, 35ks staring, 123ks 5x5 seq
1462	3-6 Oct 2014	200ks 5x5seq (to be delivered soon)
1466,1468	17-22 Oct 2014	45ks/orbit, 5x5seq

Testing October 2014 ARF with recent GPS data

- ✓ New ARF produced using Crab calibration in rev. 1462

Cygnus X-1, revs. 1488 to 1490 (26.5ks); fit to cutoffpl



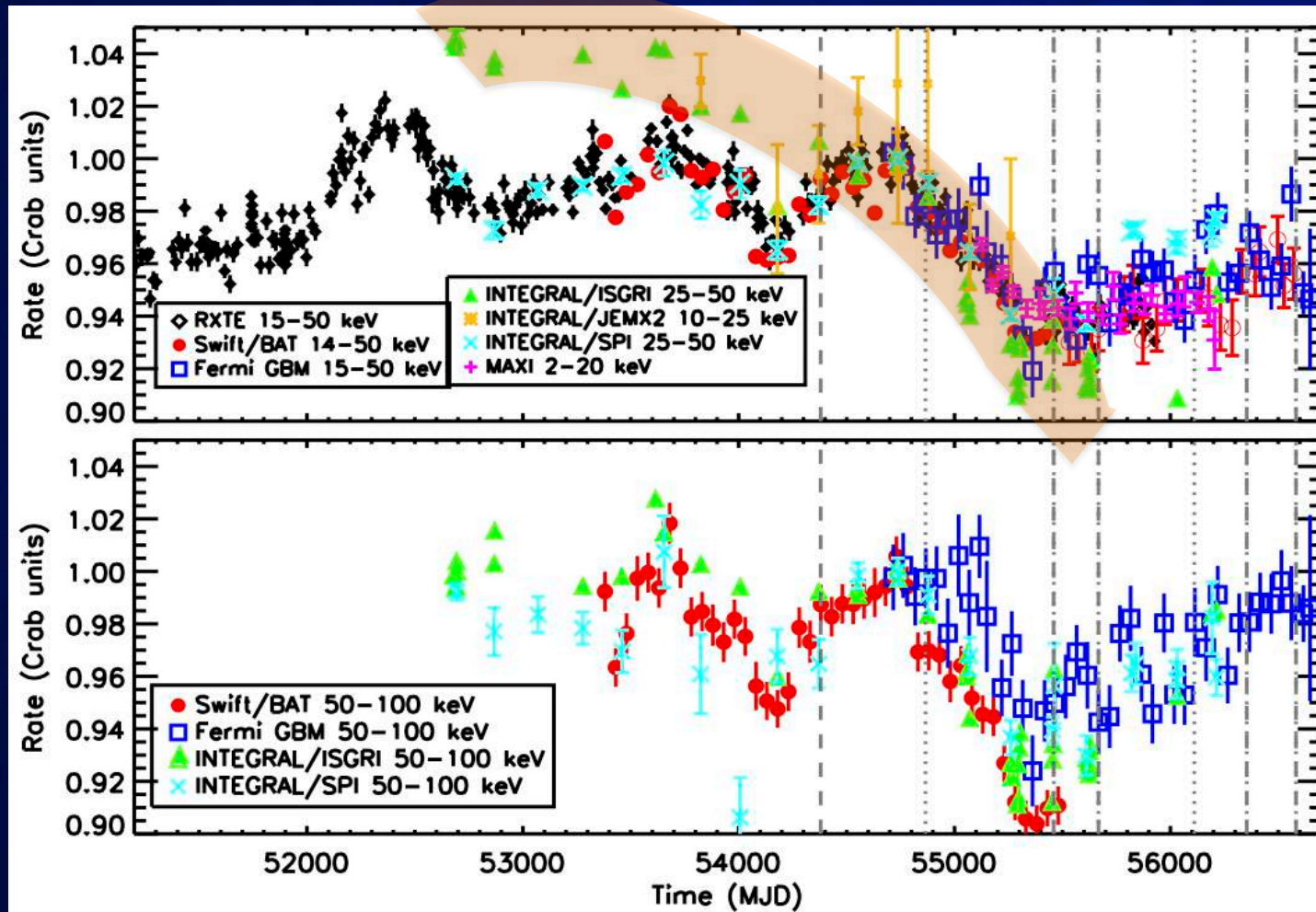
$$\Gamma = 1.927 \pm 0.050$$

$$E_{\text{cut}} = 184 (-26, +35) \text{ keV}$$

$$\chi^2 = 48.20/49$$

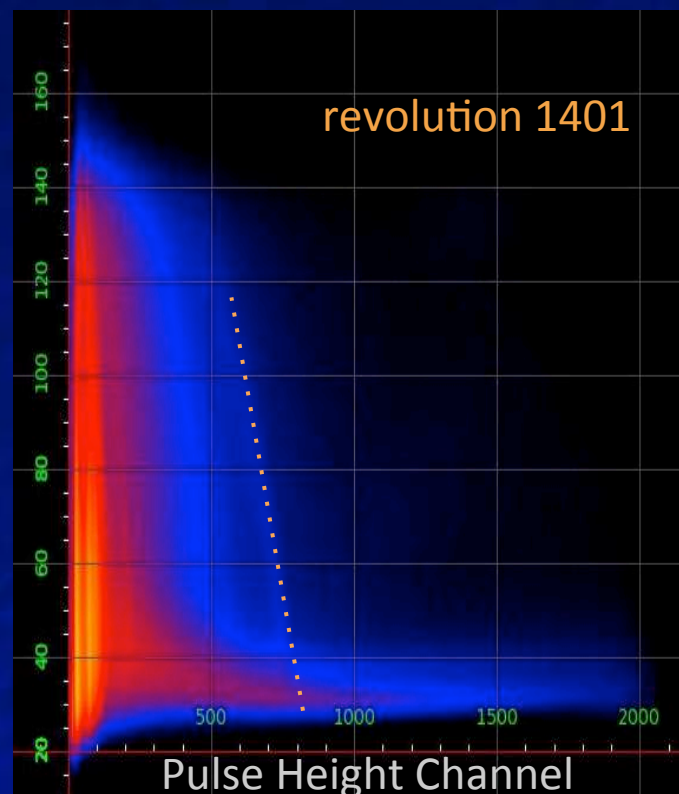
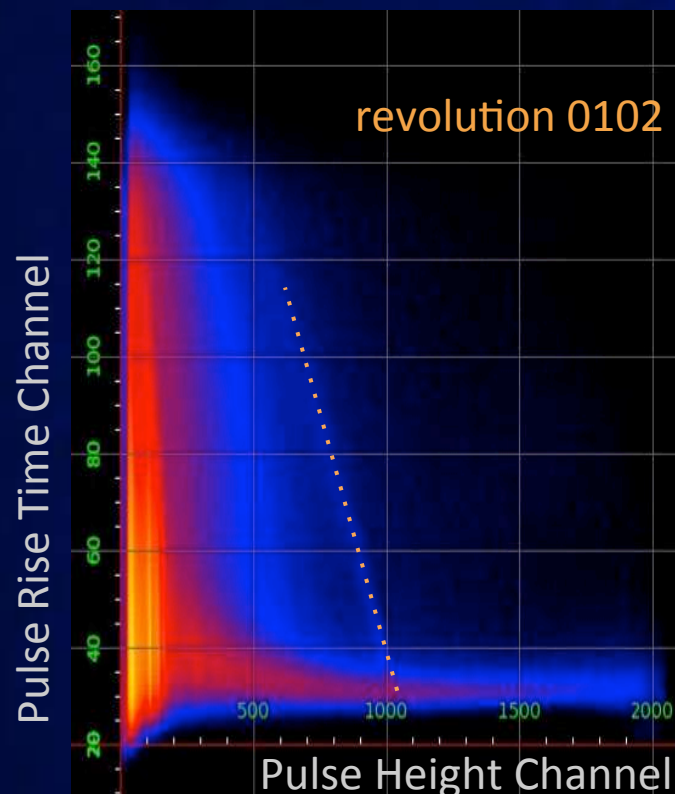
Average flux (20-100 keV):
 $7.4 \times 10^{-9} \text{ erg cm}^{-2} \text{ s}^{-1}$

Effects on counts rates



Light Curve presented by G. Case (9 th IACHEC Conf., 2014)

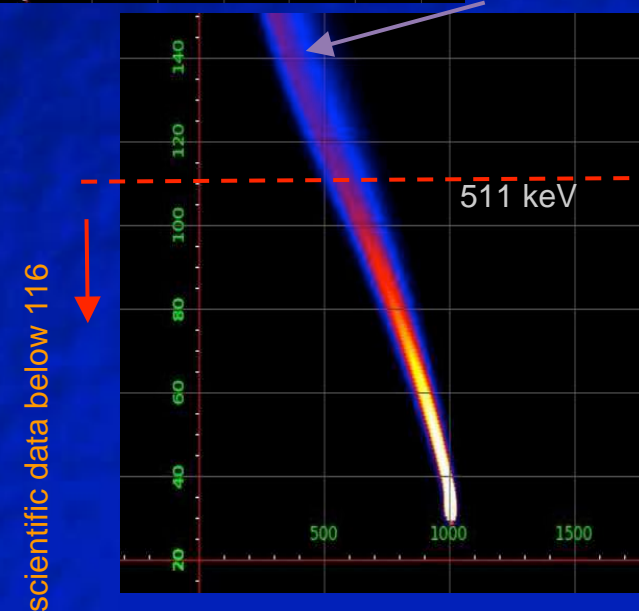
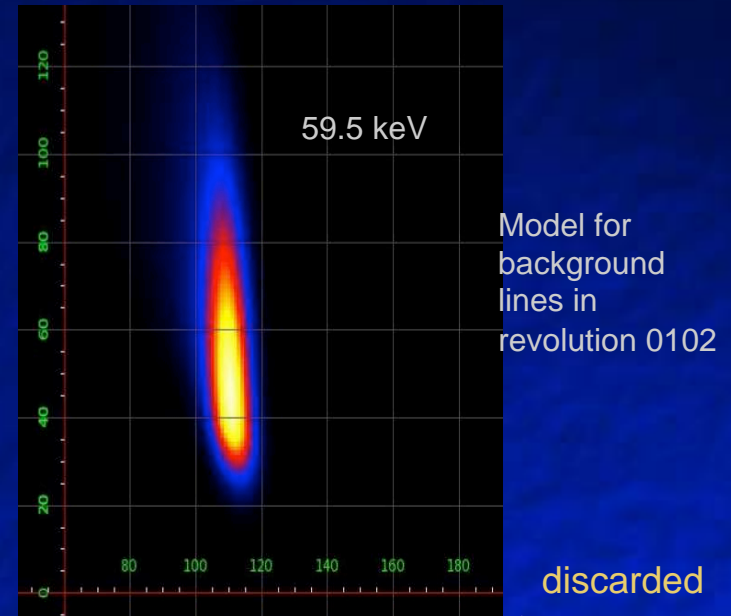
ISGRI energy calibration evolution



- ✓ Losses due to trapping (limited charge carrier lifetime) and ballistic losses decrease pulse height of long pulses
- ✓ Irradiation of detector changes lifetime of charge carriers, decreasing pulse height, causing pulse height drift
- ✓ The reconstruction must be time-dependent

Charge loss model

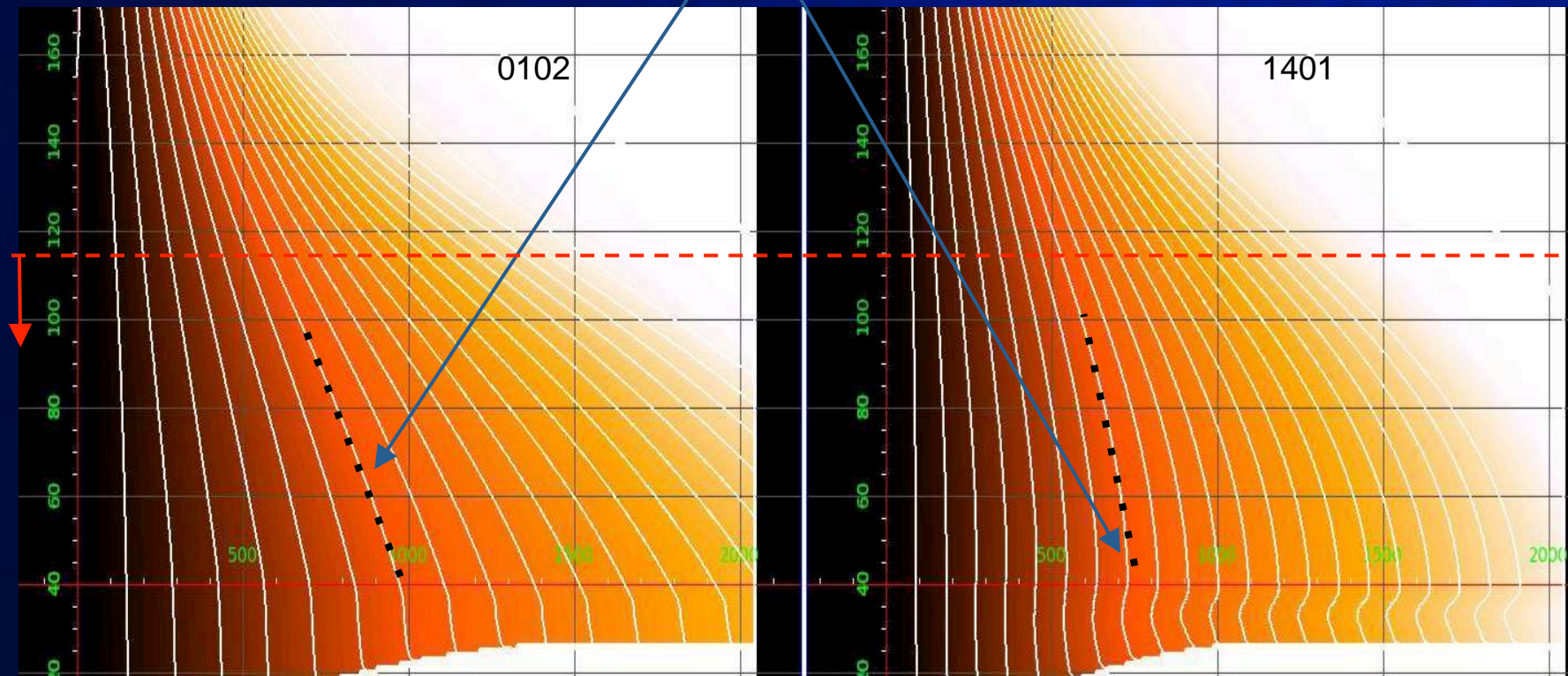
- ✓ Charge loss model due to limited charge carrier lifetime: 4 parameters fitted in each revolution.
- ✓ Ballistic losses model related to low charge carrier mobility: Fitted to ground calibration. In S1 data range set by 2 fixed parameters.
- ✓ Model of electronics: charge to PH conversion with resolution, fixed for each rise time - pulse height pair. Many (~15) parameters are selected.
- ✓ Offset and width are fitted in a revolution, to account for possible incompleteness of the model.



Model of LUT2 evolution

Energy contours in LUT2

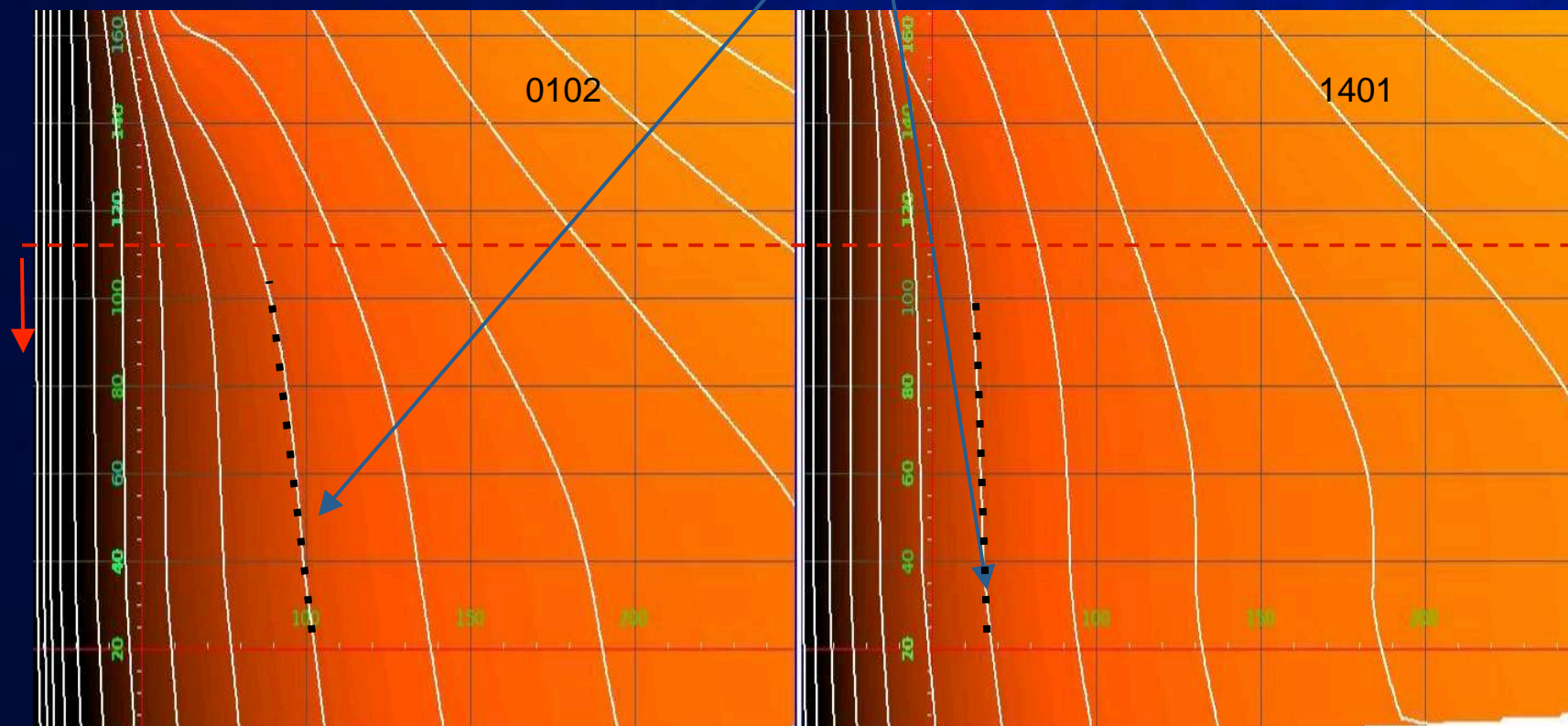
511 keV



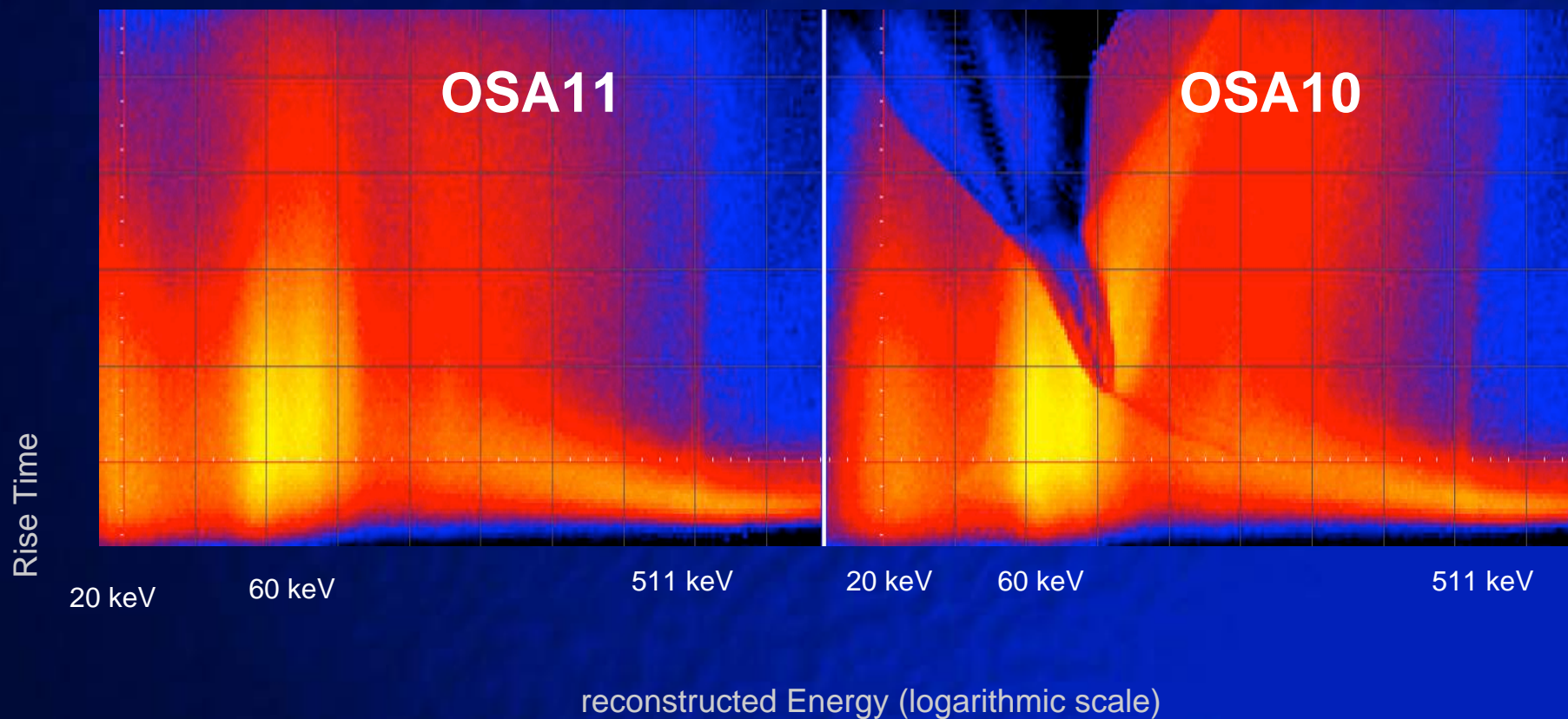
Model of LUT2 evolution

Energy contours in LUT2, focus on low energy

50 keV



OSA11 vs OSA10



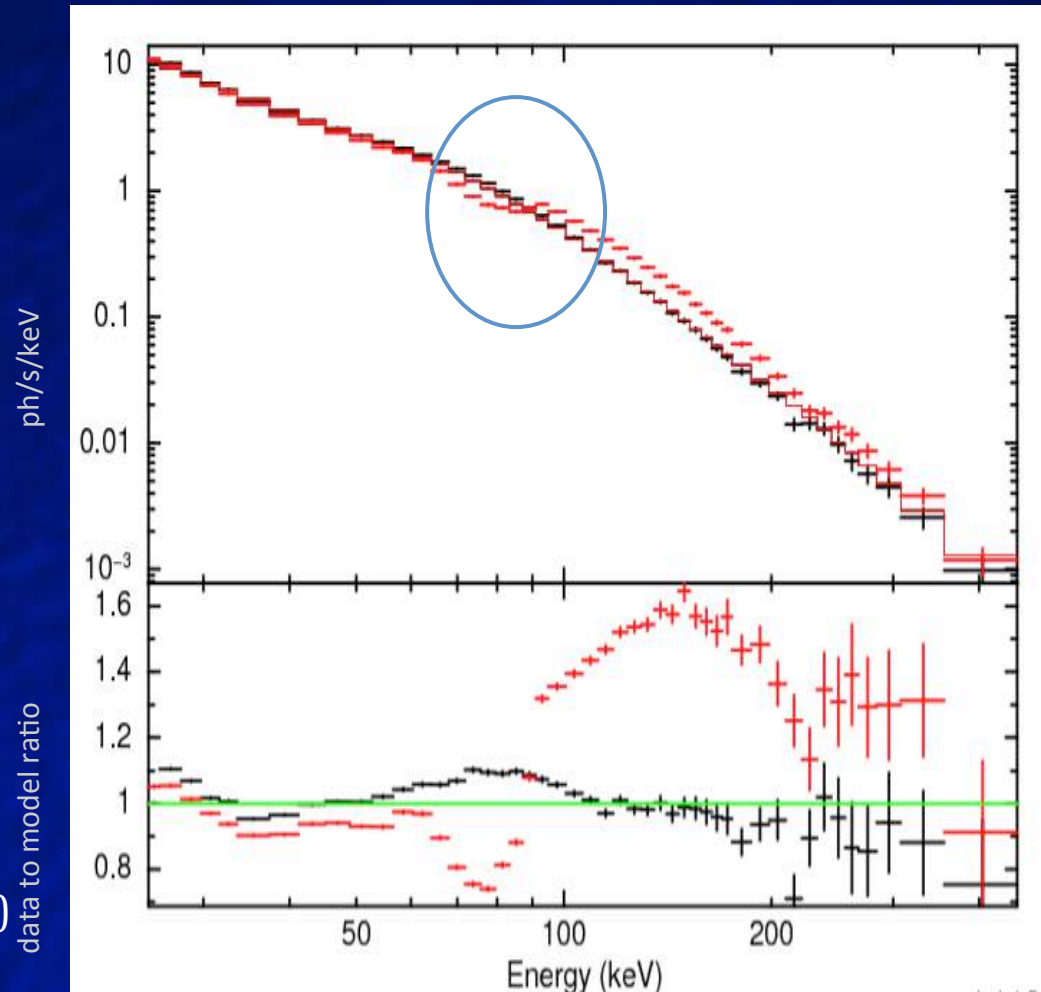
revolution 1401

Savchenko et al 2014 (Proc. INTEGRAL Conf.)

Testing on Crab spectrum

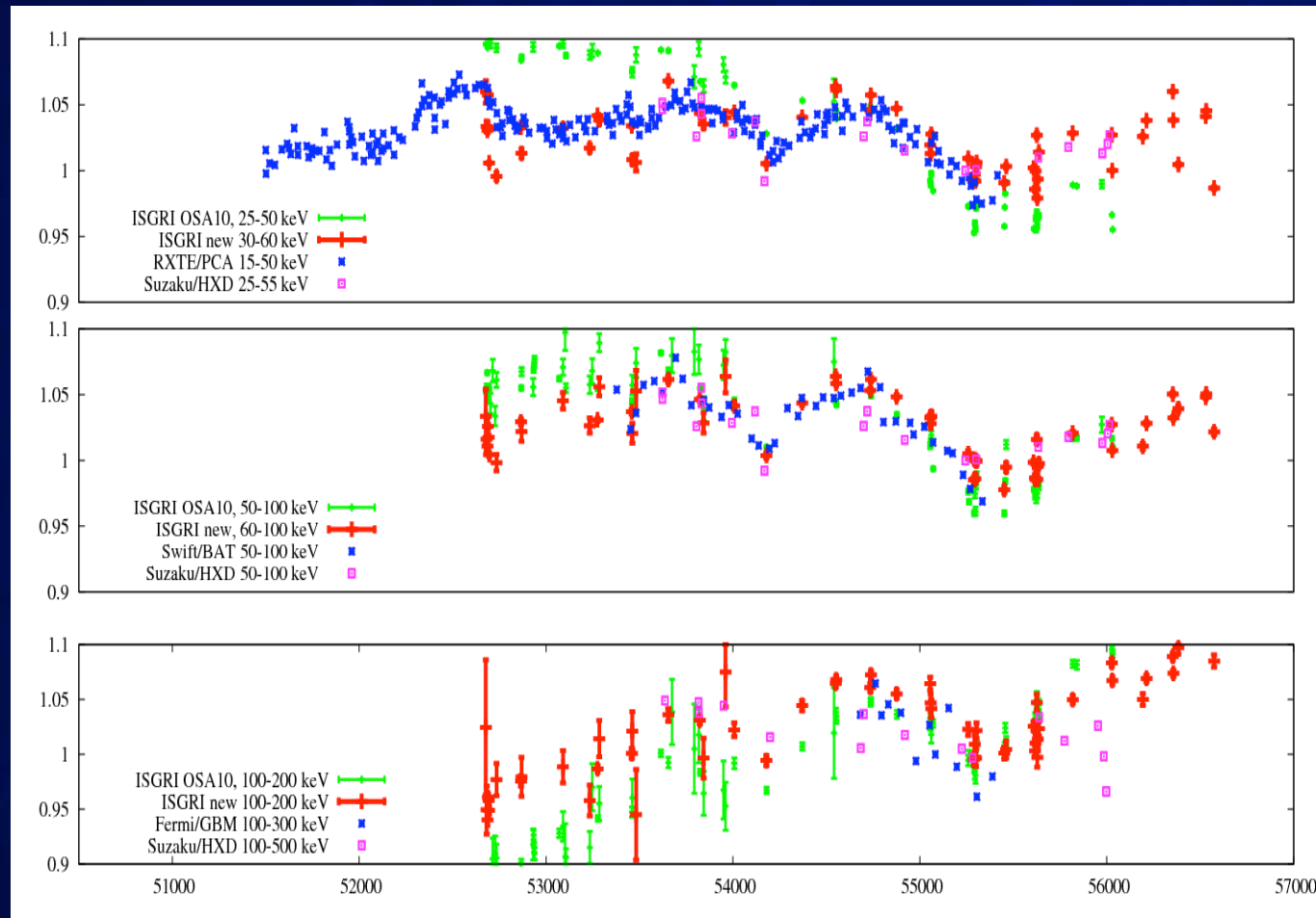
- ✓ Wave structure in 70-100 keV range is gone.
- ✓ For Crab, about 50% decrease of count rate above 100 keV.
- ✓ Remaining difference between model and prediction will be dealt with by better treatment of LE threshold

Savchenko et al 2014 (Proc. INTEGRAL Conf.)



broken powerlaw, only normalization fitted to OSA11, break at 100 keV, LE slope 2.1 (SPI), HE slope 2.21 (all-mission fit ISGRI). Revolution 839 of Crab calibration

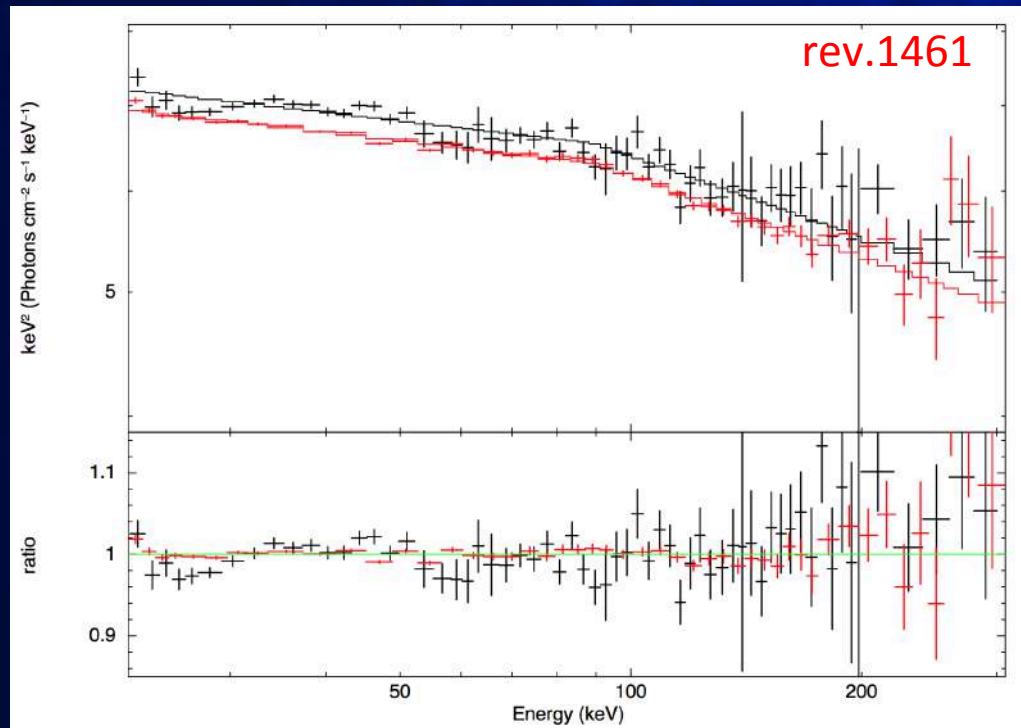
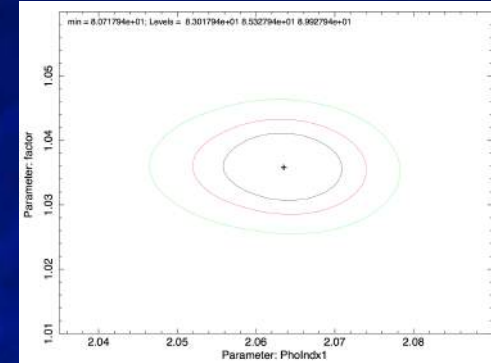
Final Crab evolution



Savchenko et al 2014 (Proc. INTEGRAL Conf.)

IBIS/ISGRI vs SPI, October 2014

- ✓ Modelled by broken PL
- ✓ For ISGRI, the response is calibrated on the Crab using the same model
- ✓ Normalization difference is $\sim 3\%$ for this observation (maybe explained by secular Crab variation)



$$\Gamma_1 = 2.063 \pm 0.008$$

$$E_{\text{br}} = 83 \pm 7 \text{ keV}$$

$$\Gamma_2 = 2.19 \pm 0.02$$

$$\chi^2 = 81/104$$

$$\text{Flux (SPI, 20-100 keV): } 1.75 \times 10^{-8} \text{ erg cm}^{-2} \text{ s}^{-1}$$

Conclusions

- ✓ The energy correction S/W in OSA10 does not correctly describe the shape of the detector effective area and its time evolution
- ✓ This bias is still corrected by periodic Crab calibrations
- ✓ New OSA11 model is expected to solve many of the problems related to the energy correction
- ✓ IBIS-SPI cross-calibration is within expected range