ISGRI calibration status

Philippe Laurent
(on behalf of François Lebrun)

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ISGRI energy calibration

Volodymyr Savchenko, François Lebrun, Philippe Laurent

ISGRI energy calibration

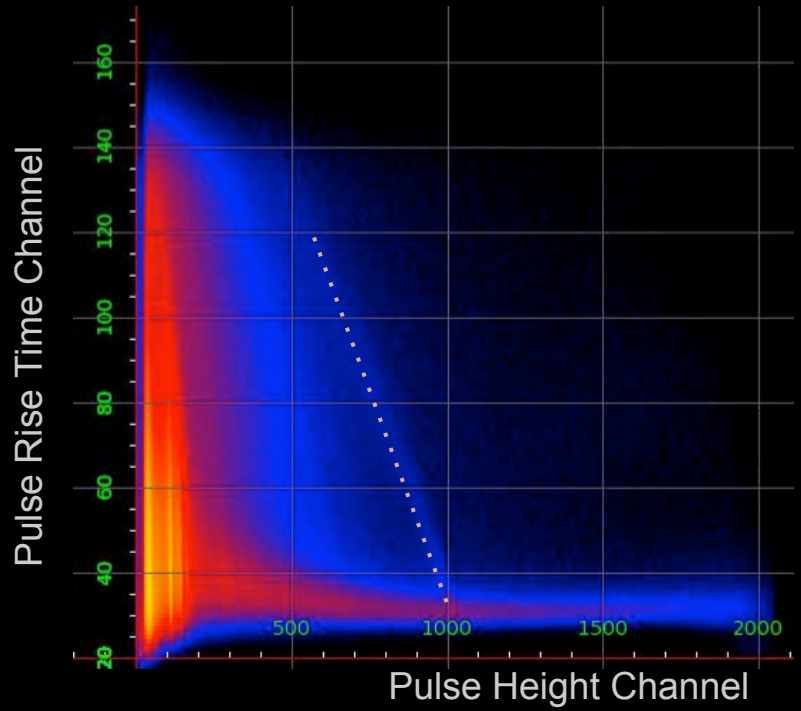
ISGRI consists of CdTe detectors, characterized by low mobility of charge carriers

Photons interacting at large depth produce long pulses (up to 5 μs)

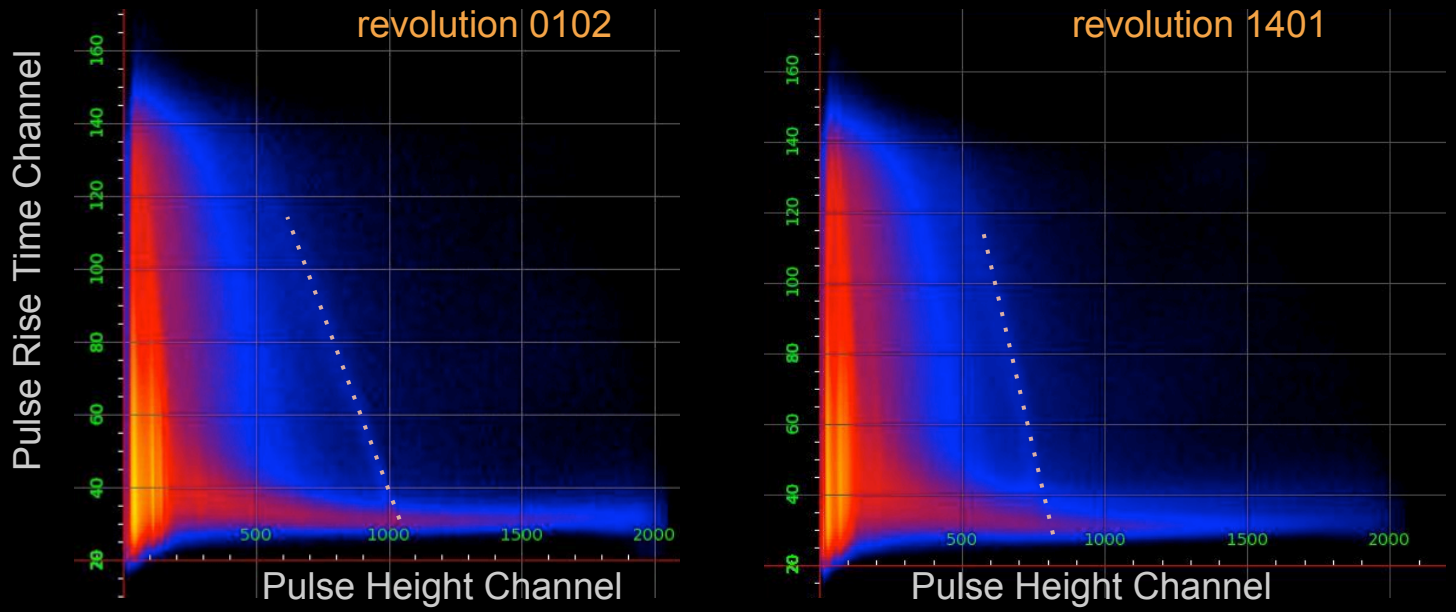
Losses due trapping (limited charge carrier lifetime) and ballistic losses decrease pulse height of long pulses

ISGRI records Rise Time as well as Pulse Height for each event

1D Energy spectrum must be reconstructed from 2D PH-RT spectrum

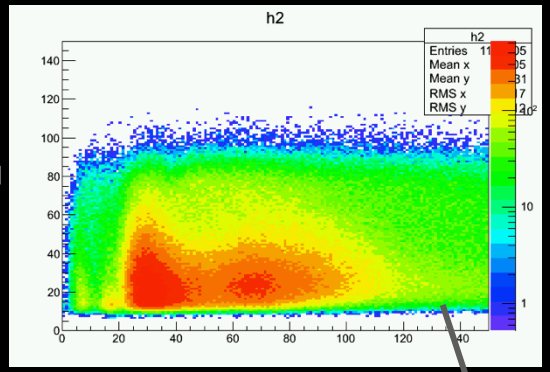


ISGRI energy calibration evolution



Irradiation of detector changes lifetime of charge carriers, decreasing pulse height, causing pulse height drift
The reconstruction must be time-dependent

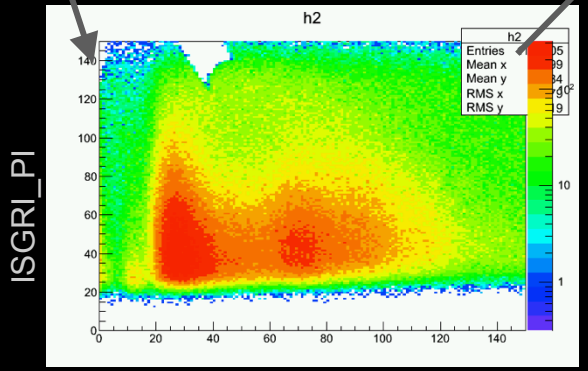
OSA10 energy calibration



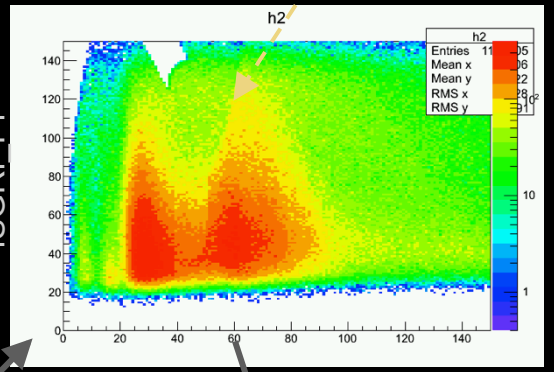
LUT1 uniformity, temperature-dependent per MDU (since OSA 10).

revolution 1401

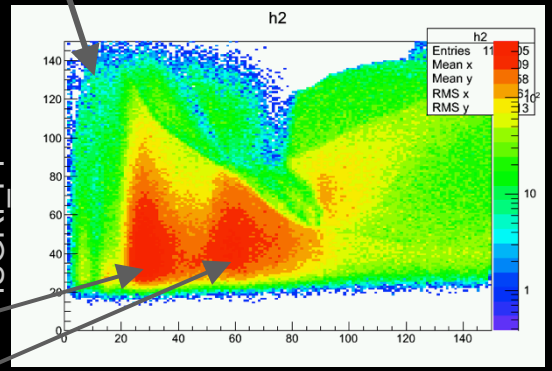
2D drift correction, tabulated for each rise time



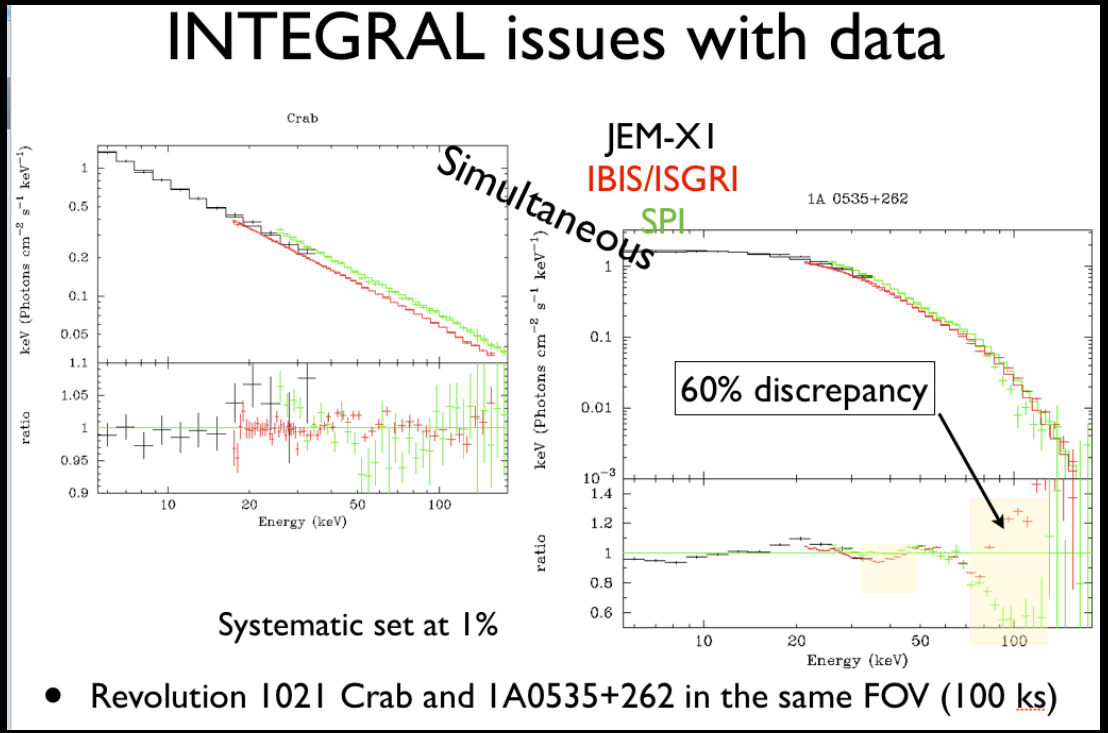
two drift laws



LUT2 (charge loss)



Issues with OSA 10 energy calibration



pointed out by Carlo at IUG 2014

Approach in OSA11

Keep the LUT1 with MDU-dependent temperature correction.

ISGRI_PHA, ISGRI_RT→ISGRI_PHA1, ISGRI_PI

Fit the data of each revolution with time-dependent 2D charge loss model,
Generate LUT2 regularly together with the response

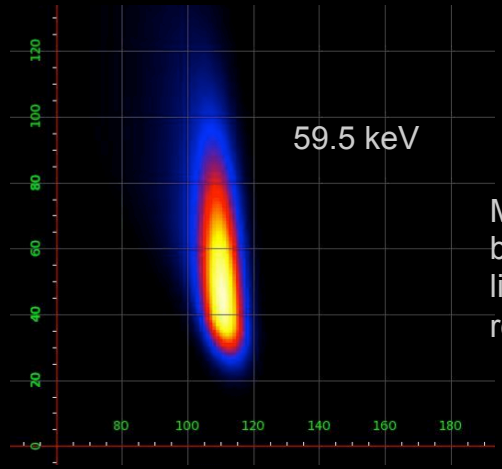
ISGRI_PHA1, ISGRI_PI→ISGRI_ENERGY

Charge loss model

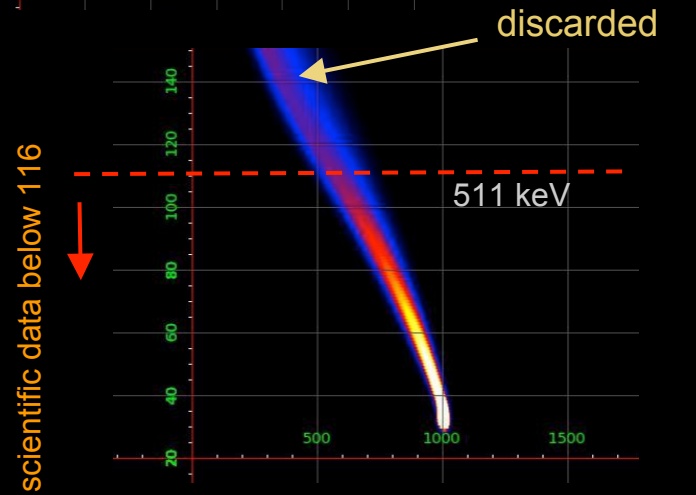
Charge loss model due to limited charge carrier lifetime: 4 parameters fitted in each revolution.

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.

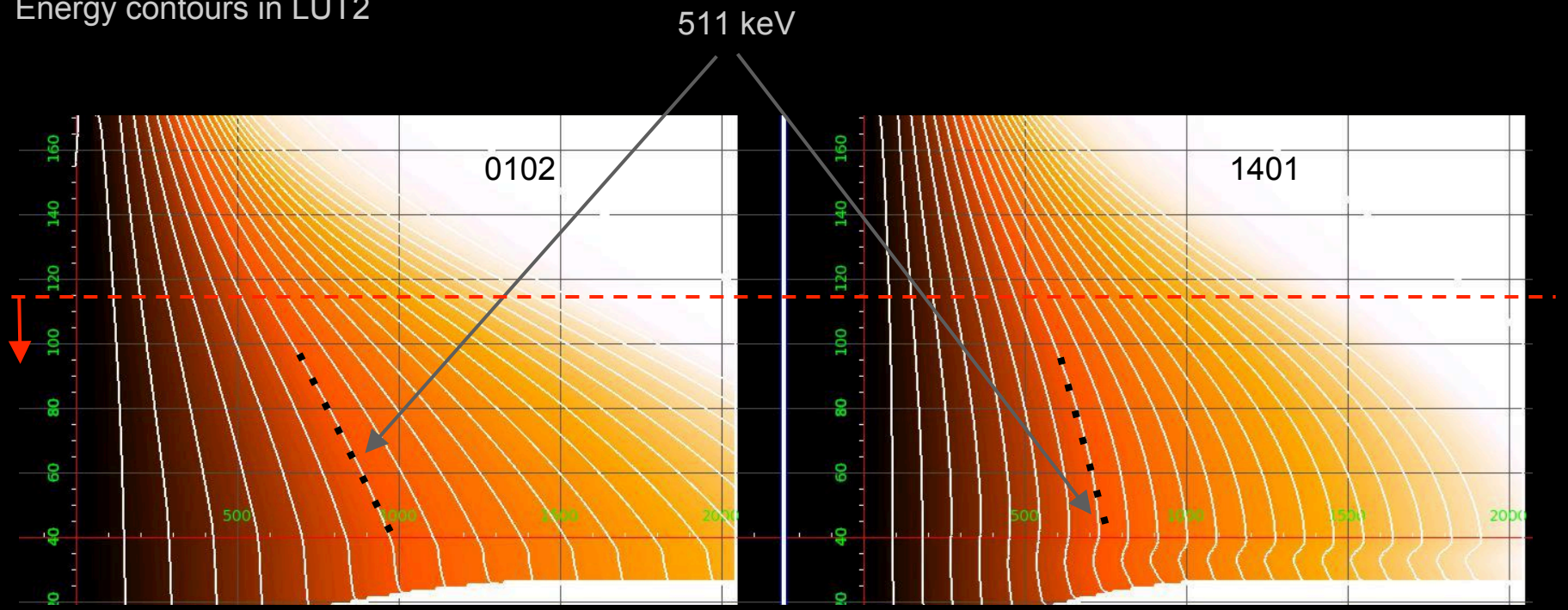


Model for background lines in revolution 0102



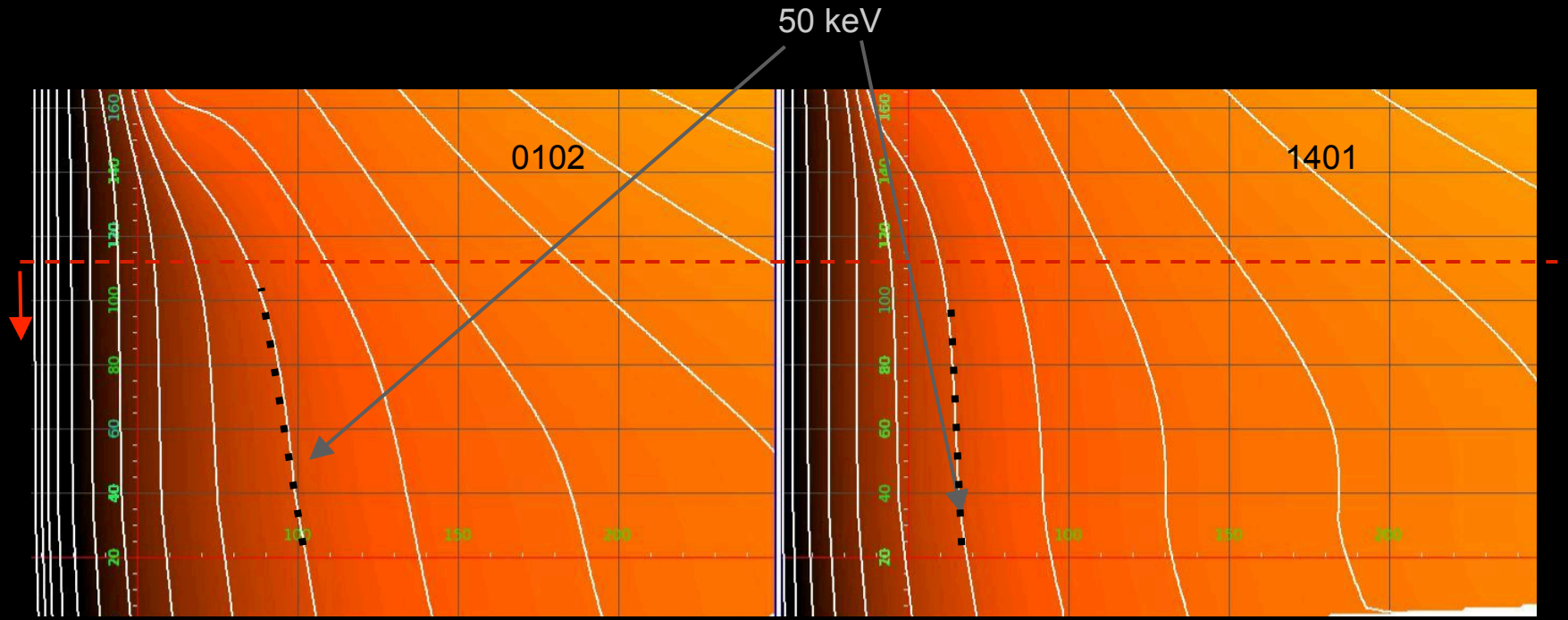
Model of LUT2 evolution

Energy contours in LUT2



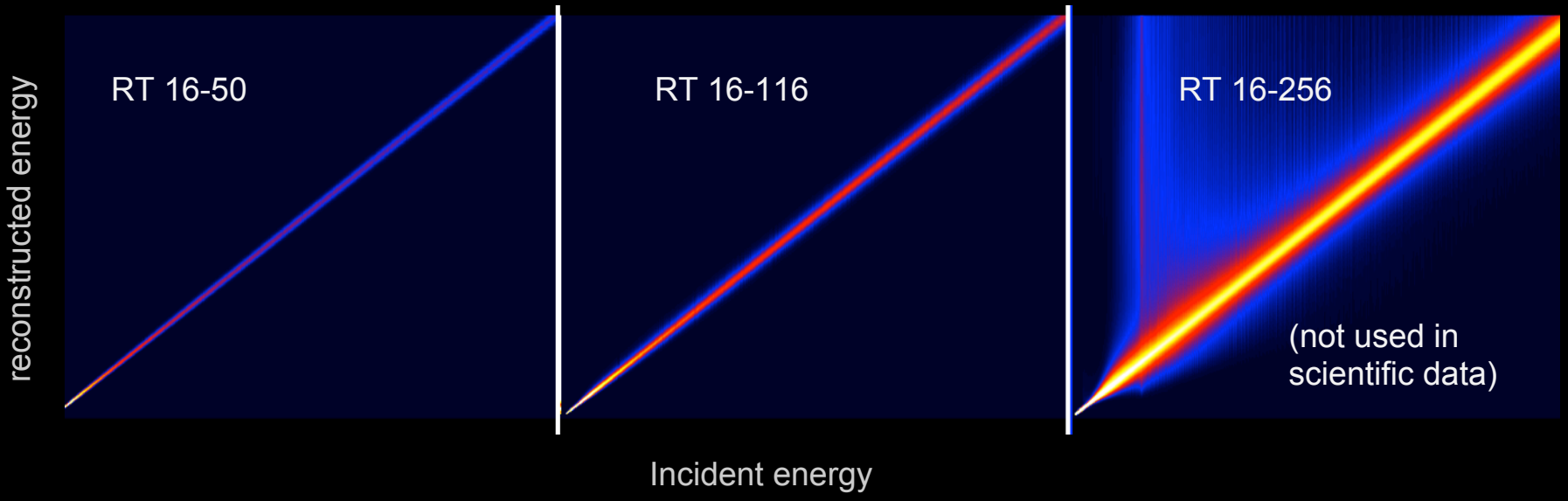
Model of LUT2 evolution

Energy contours in LUT2, focus on low energy

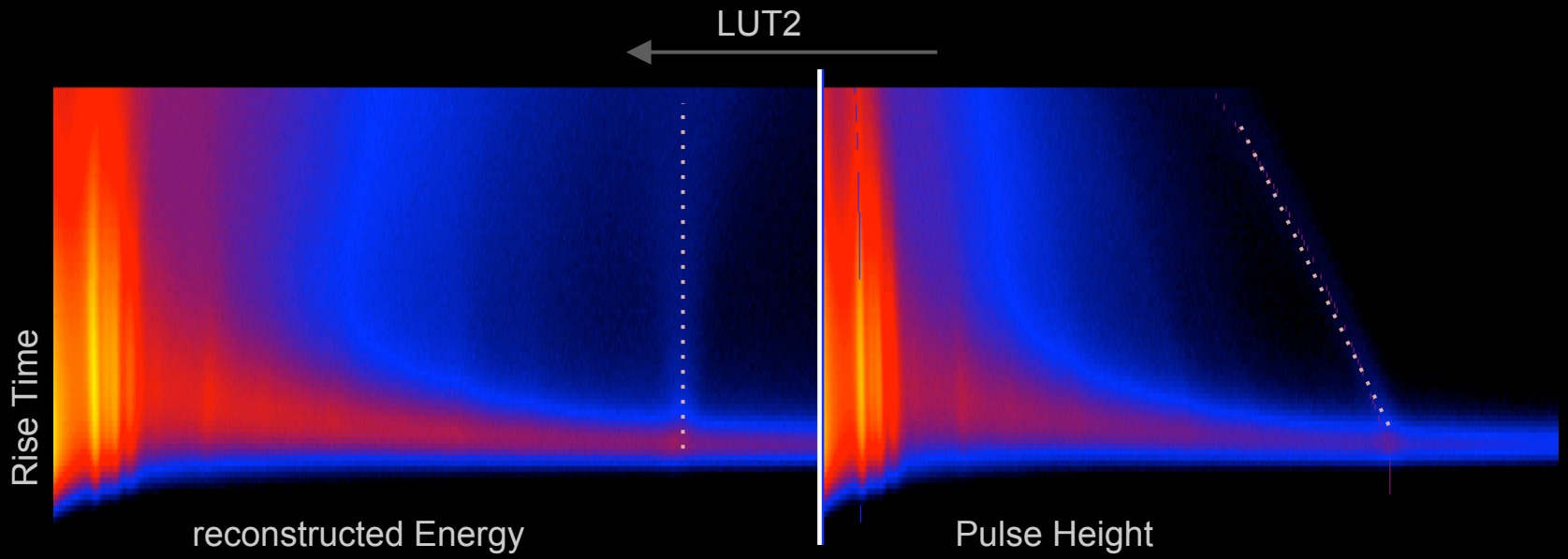


Effect of overlapping energy tracks

After discarding rise time, resolution of reconstructed energy is a combination of resolutions at different rise times, and depends on the rise time used.
Limiting rise time also reduces efficiency.

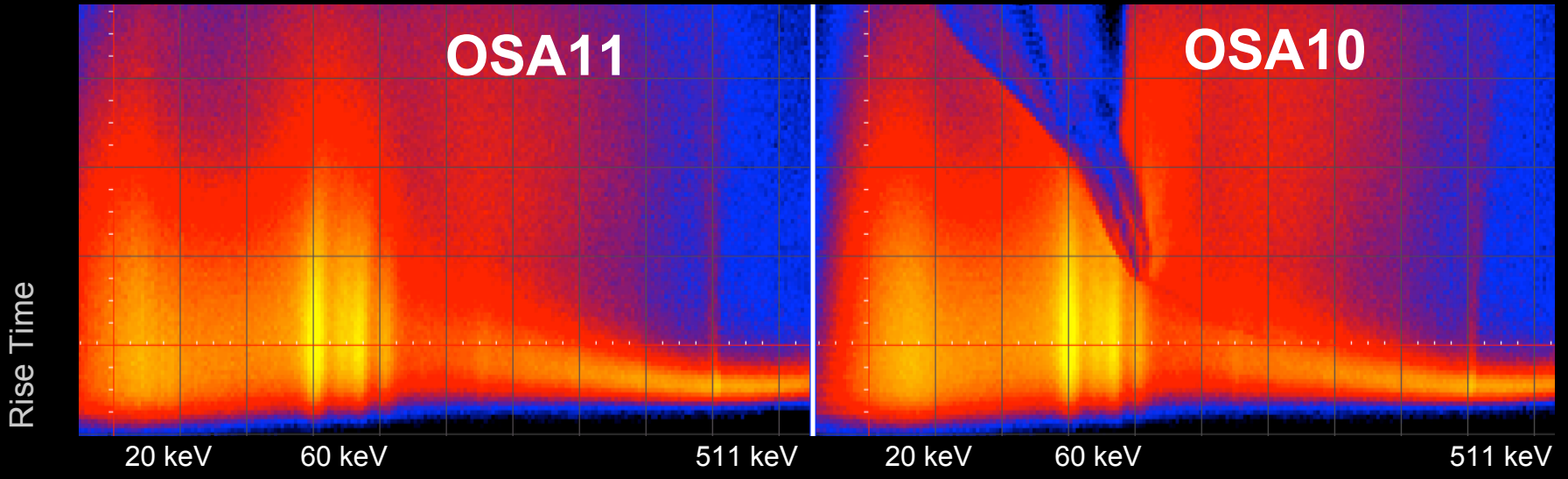


OSA11 reconstruction



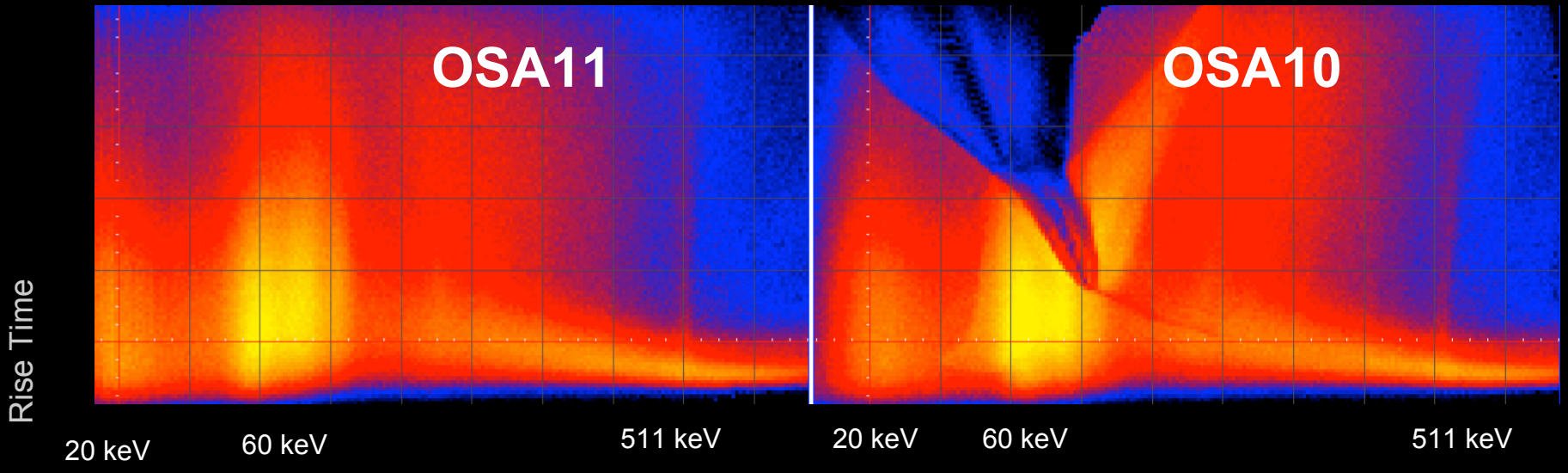
revolution 0102

OSA11 vs OSA10



revolution 0102

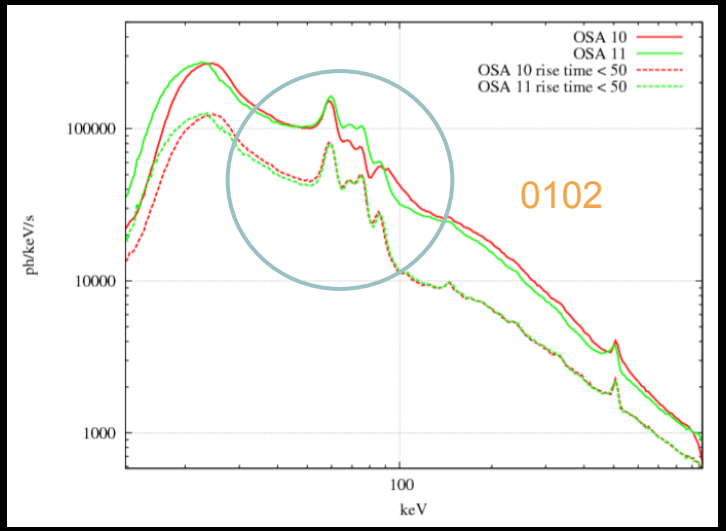
OSA11 vs OSA10

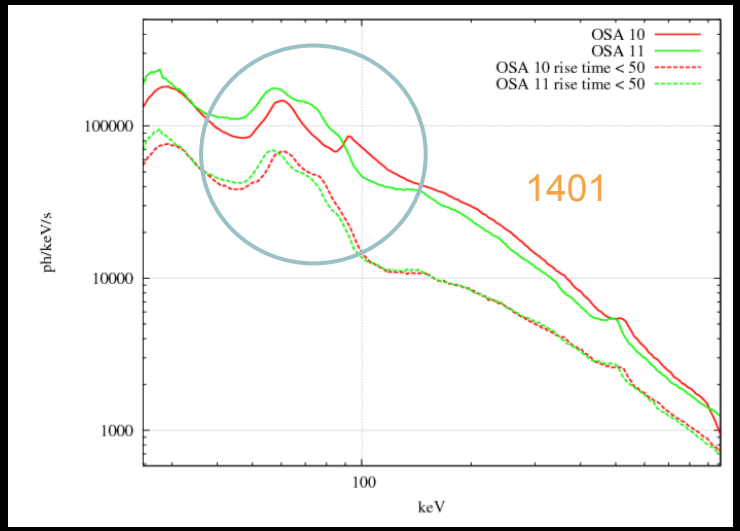


revolution 1401

Effect on the background spectra

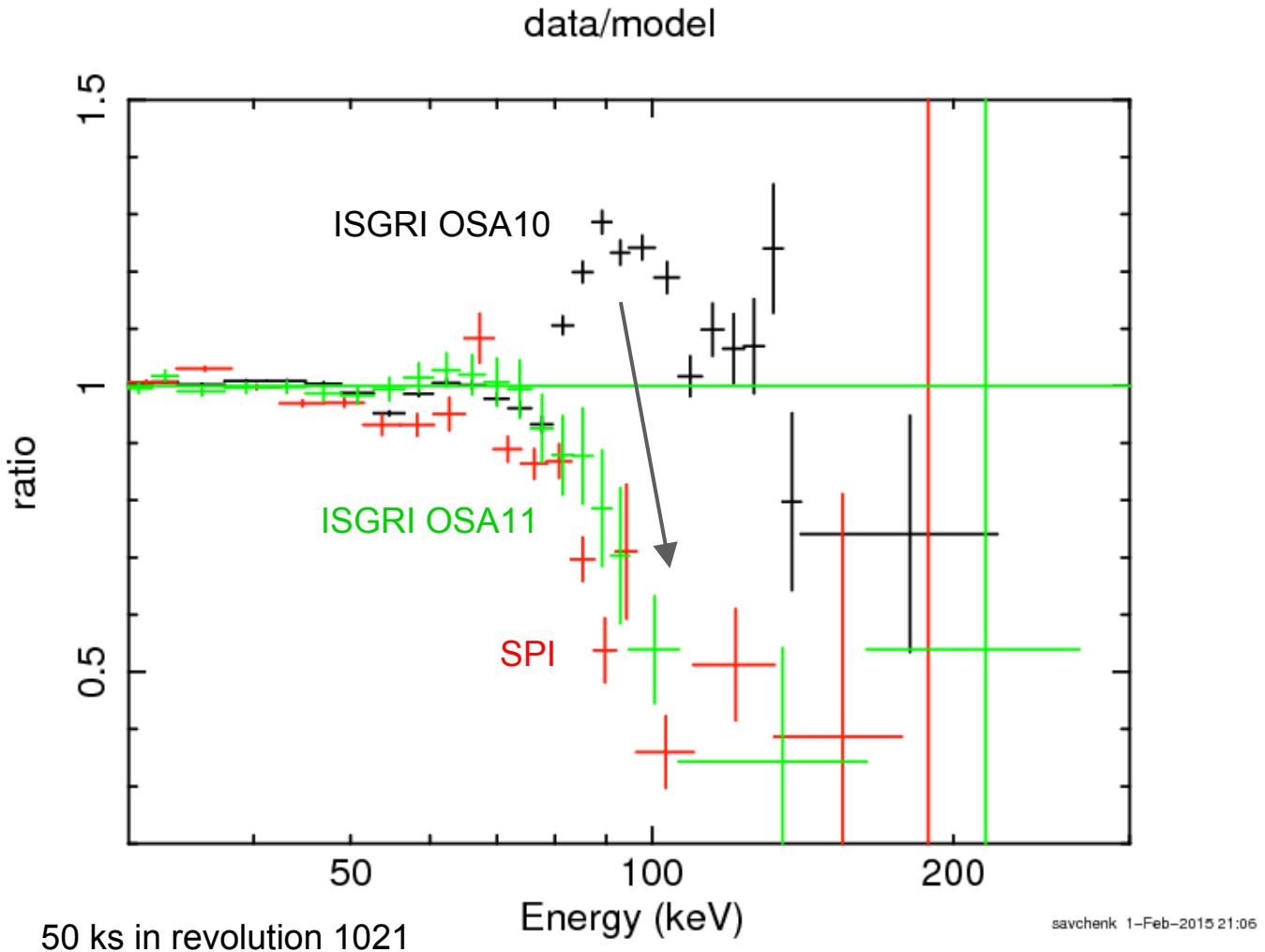
behavior at low threshold is somewhat different, compensated by appropriate correction





for most of the mission low rise time spectra above 30 keV are not affected
drift law of OSA10 is not valid for late revolutions

Spectra of 1A 0535+262



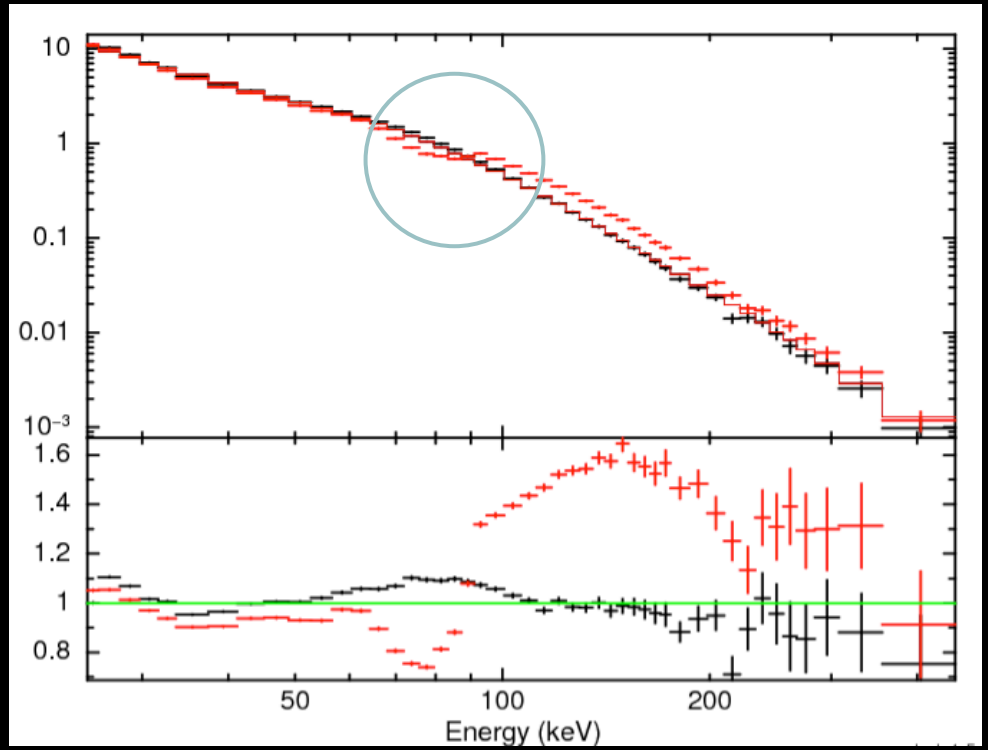
50 ks in revolution 1021

Source spectra: Crab

Wave structure in 70-100 keV range is gone.

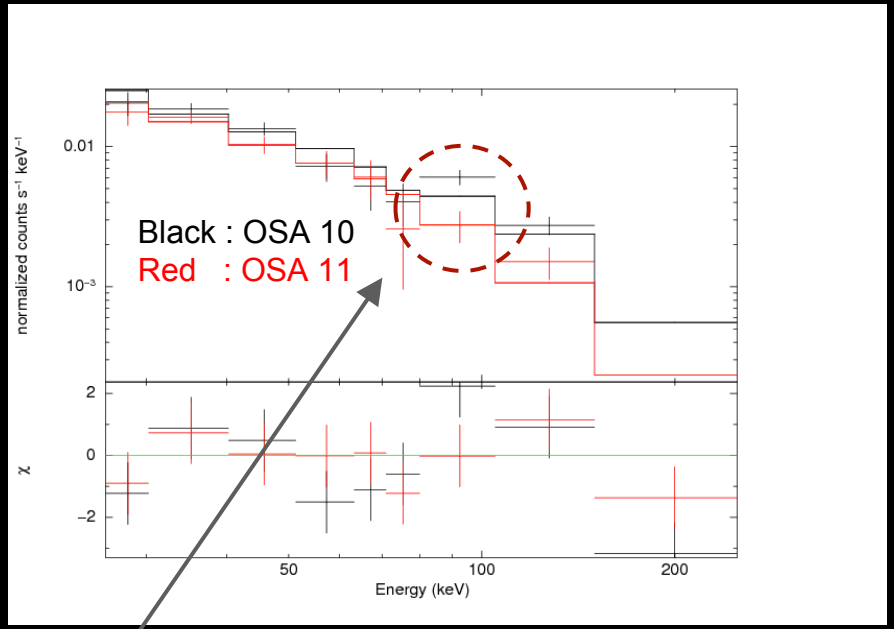
For Crab, about 50% decrease of count rate above 100 keV.

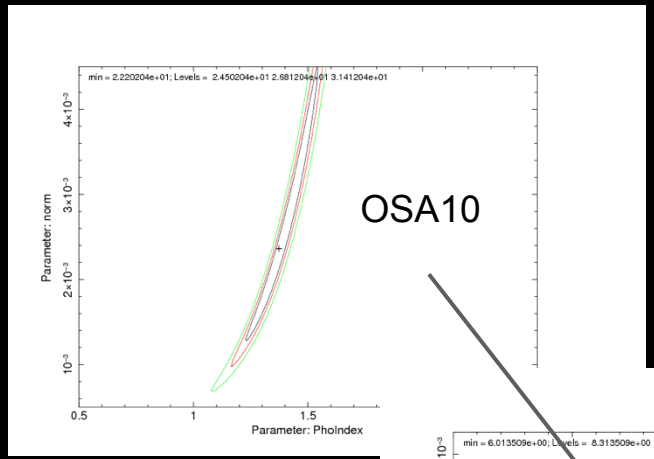
Remaining difference between model and prediction will be dealt with by better treatment of LE threshold

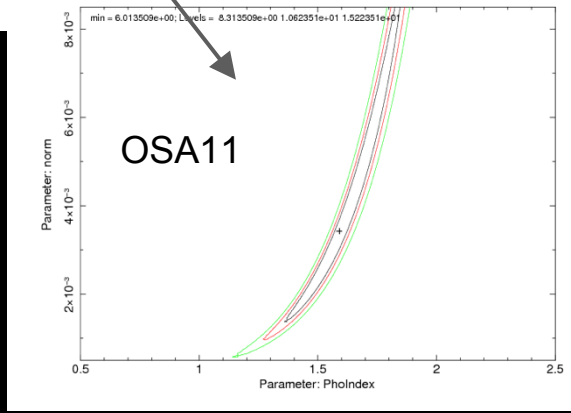


broken powerlaw, only normalization fitted to OSA11, break at 100 keV, LE slope 2.1 (SPI), HE slope 2.21 (all-mission fit ISGRI). Revolution 839 of Crab calibration

Source spectra: weaker sources

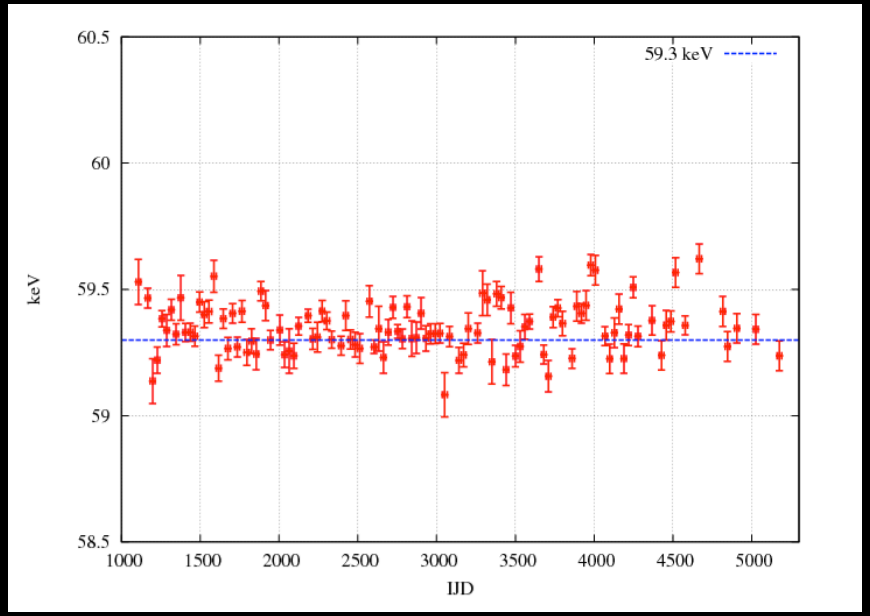


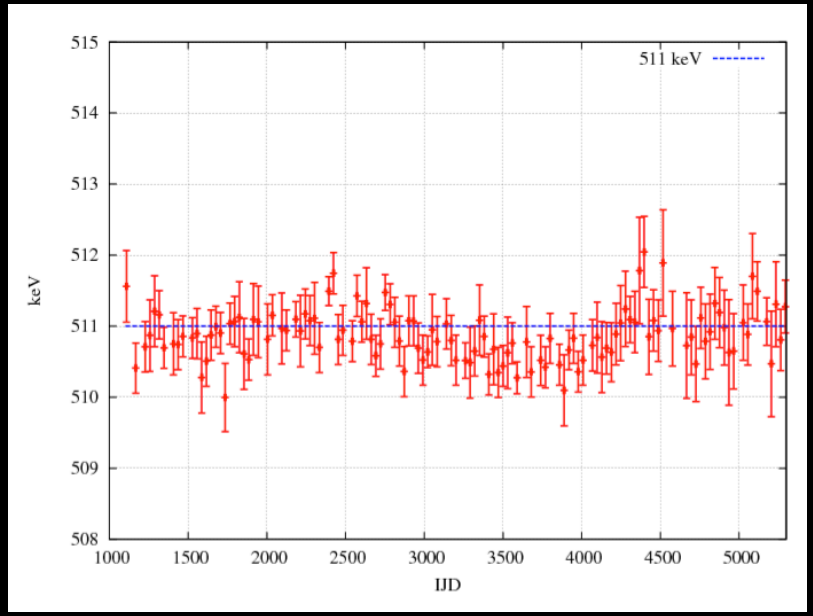




excess at 100 keV was mildly significant, but strongly affected slope!
spectrum of a magnetar provided Lin Lin, 2 Ms observations.

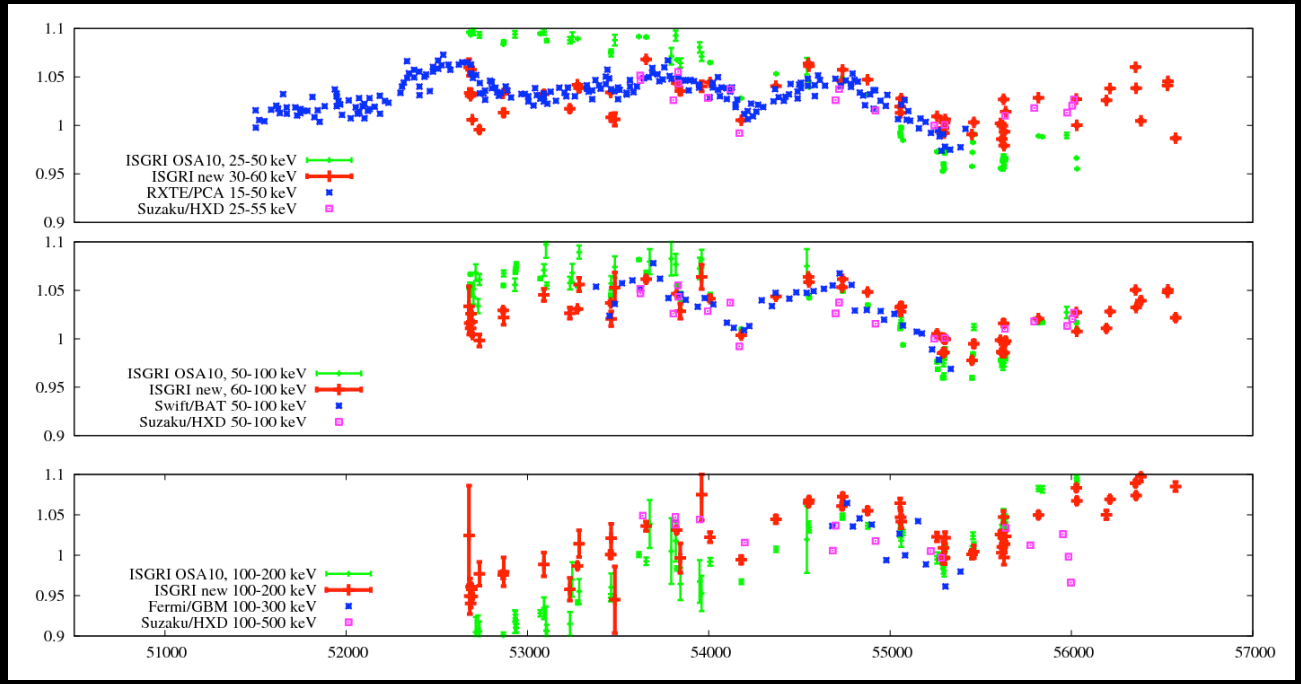
Evolution of the background lines





Line positions fitted in the OSA11 background spectra, averaged over one month. Unstable fit removed.

Final Crab evolution



Remaining issues

Simulated response does not correctly predict counts in 50-100 keV range. This is connected to the structure between absorption edges and the ARF peak.

Increase of the resolution at early time is compatible with assumptions that the resolution is non-evolving in PH-RT plane.
But at later time, the resolution is broader.

Orbital evolution of energy calibration, decrease of gain during the revolution, or after IREM crash. The evolution is connected to IBIS standby, perhaps long-term polarization of detectors.

Changes in OSA11

software

ibis_isgr_energy: disable drift correction (very small change)

ii_shadow_build: to compute LE efficiency, will read current gain information from LUT2, read resolution from current RMF

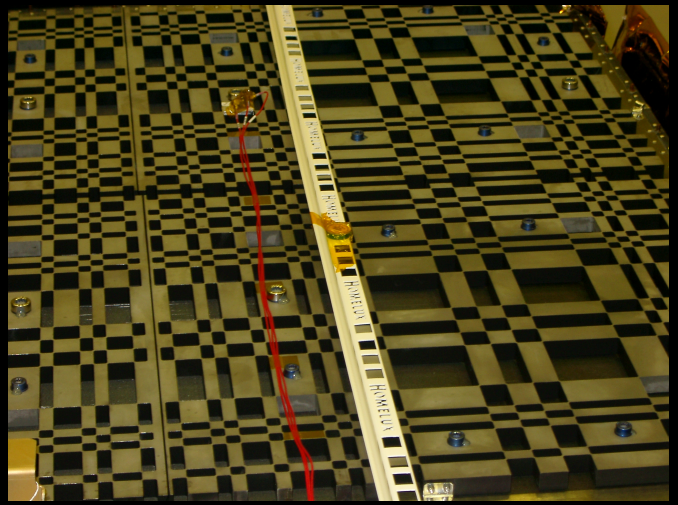
IC tree

LUT2, ARF, RMF every month. delivered together, produced at first by Paris, later at ISDC. Extrapolations will work for limited time, has to be reproduced regularly

ISGRI imaging activities

On-going studies

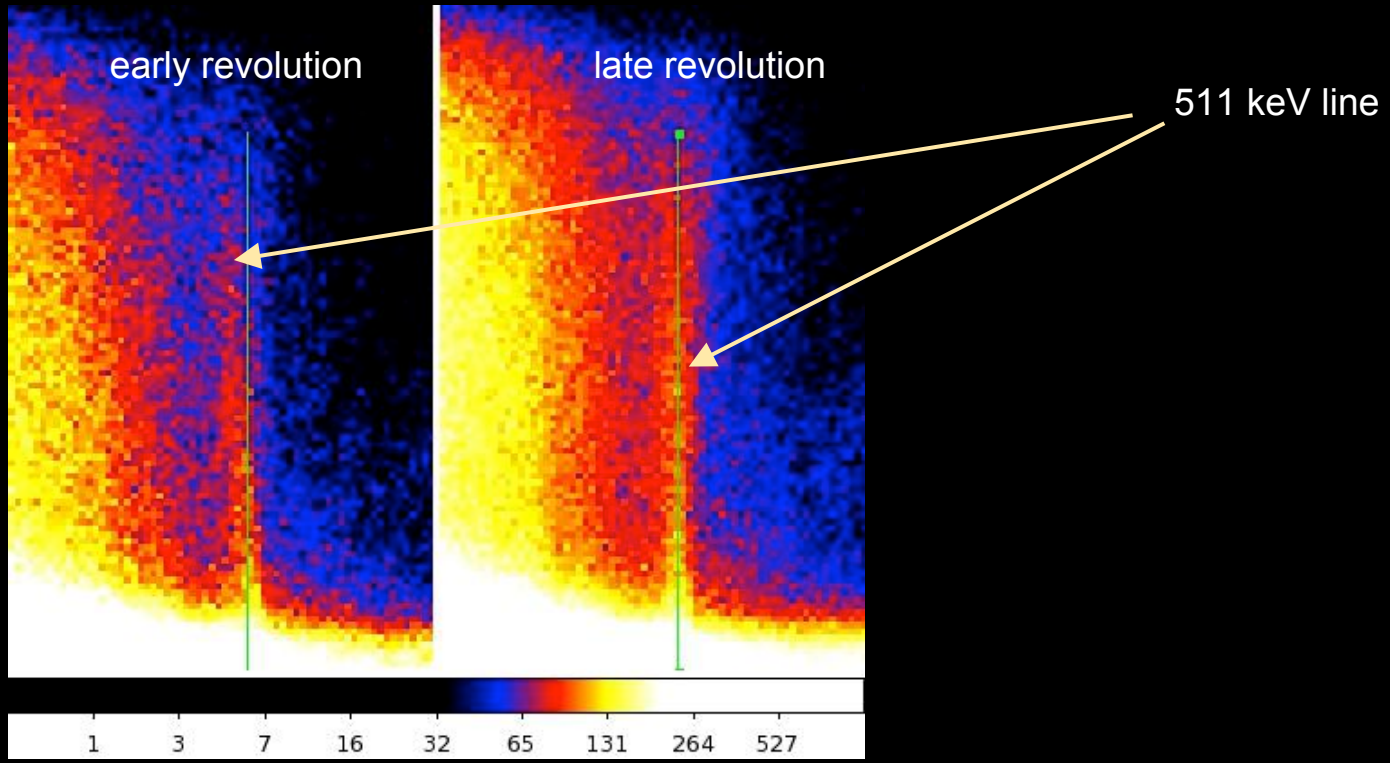
- Point Source Localization Accuracy (PSLA) improvement.
- Improving ghost buster by taking into account bolts into the mask.
- Influence of pixels thickness.
- Uniformity maps.
- Background estimates.



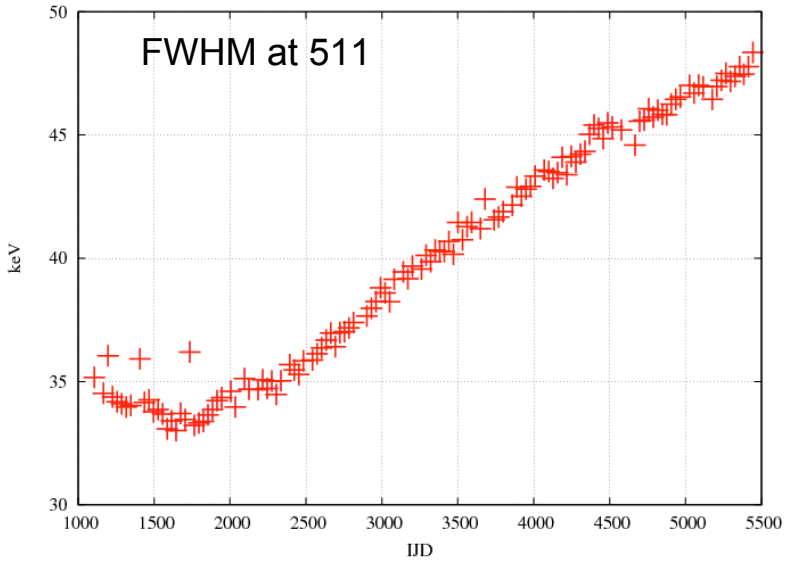
Thank you !

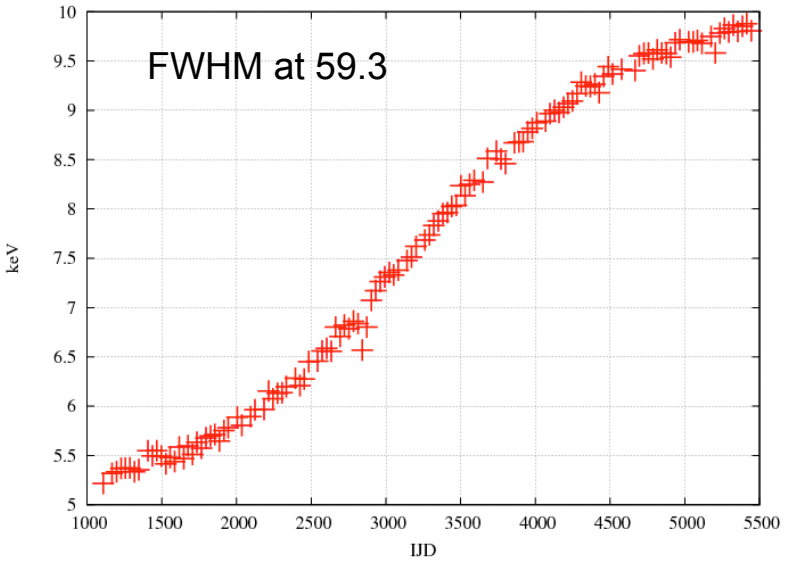
backup slides

backup slides: polarization drift



width


FWHM at 511
keV
IJD
50
45
40
35
30
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500


FWHM at 59.3
keV
IJD
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
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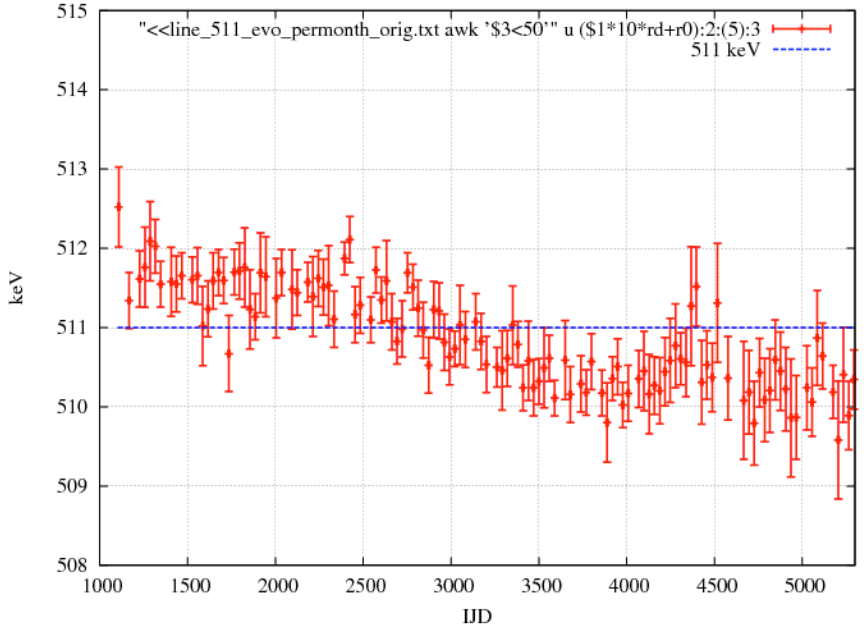
1500
2000
2500
3000
3500
4000
4500
5000
5500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511 keV
keV
IJD
515
514
513
512
511
510
509
508
1000
1500
2000
2500
3000
3500
4000
4500
5000