UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES
Département d'astronomie

ISDC

OSA11.2-beta: ISGRI

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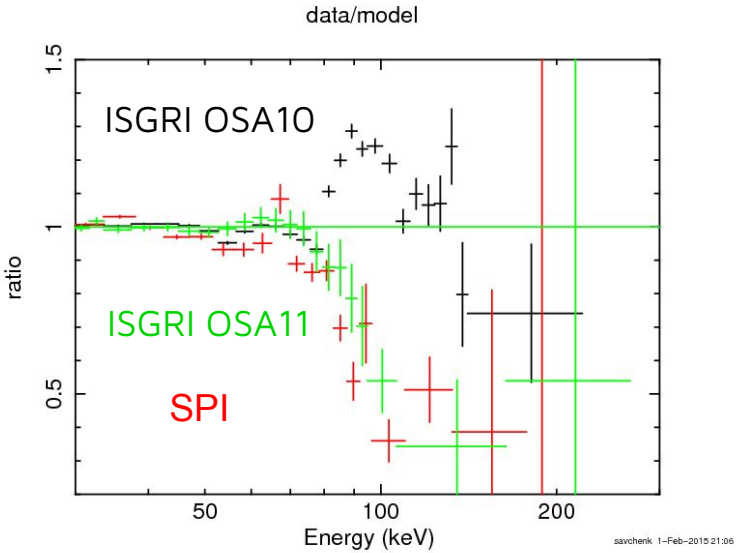
Sardinia, October 14 2021

Issues in OSA10

Critical:

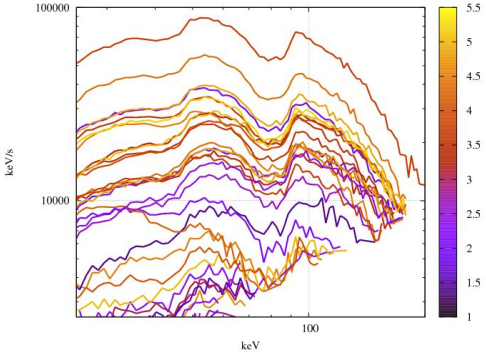
- Spectra of one or two bright sources quite different from Crab are not reconstructed correctly
- Big discrepancies after ~2017, hard or impossible to correct with OSA10 approach (ad-hoc efficiency, fitting ARF)
- Line positions of some cyclotron line sources, Her X-1 sometimes (rarely) mismatch strongly.



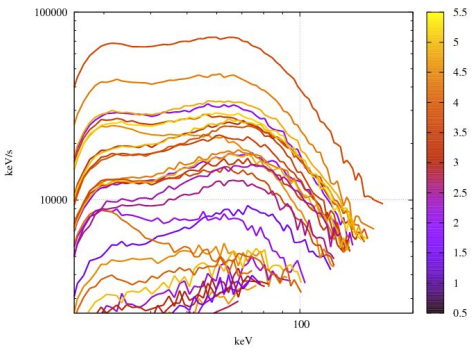
Additional issues (small or no effect on fitted source spectra)

- Presumably, ARF should represent effective area, not electronic issues.
  - ISGRI Efficiency: from **detected events** to **reconstructed rates** (done by OSA internally)
  - RMF+ARF: from **reconstructed rate** to **flux** (done in expect out of OSA)
- Long-term reconstructed rate stability (e.g. Crab)
- Can we understand ISGRI detector, and make physical, continuous model at least for some parts? This should make spectra smoother, predictions more absolute.
- Understand detector polarization, fast (~several hours) and historic

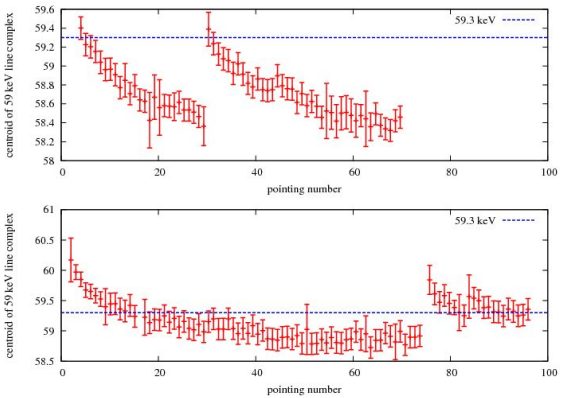
OSA10



OSA11

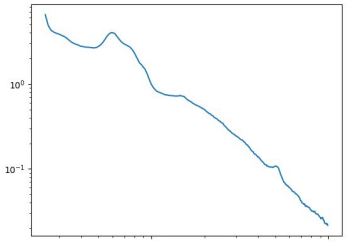


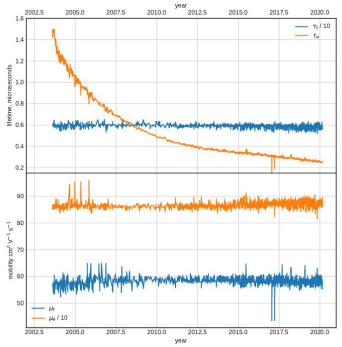
Detector polarization



Calibration

Fit charge loss model to background





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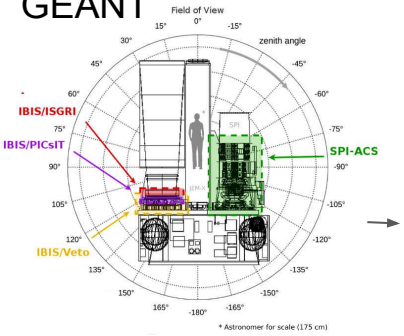


Fit low-energy RMF and efficiency

3ML Multi-Mission Maximum Likelihood Framework

OSA

Reconstruct **deposited "photon" energies**

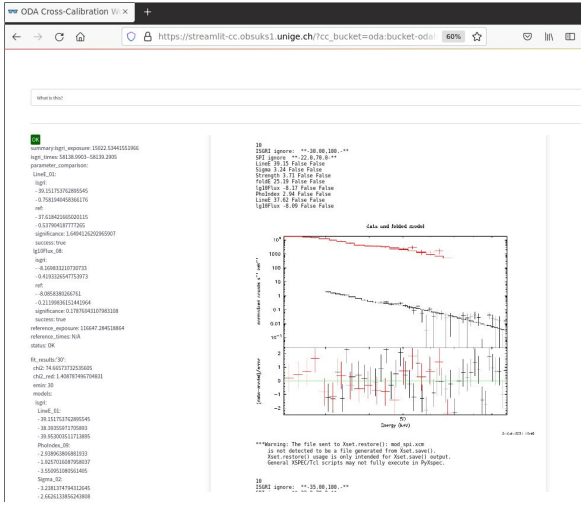
Reconstruct **"equivalent" count rates** dividing by efficiency

Fit detector plane with model shadows

Verification

No ARF fitting
(even if it's not necessarily a bad thing)

Fitting spectra
(xspec)



How to verify?

Previously - a testing campaign, long exchanges with experts about what the fits mean. With limited and diminishing human resources, and also major changes needed to software, it's hard.

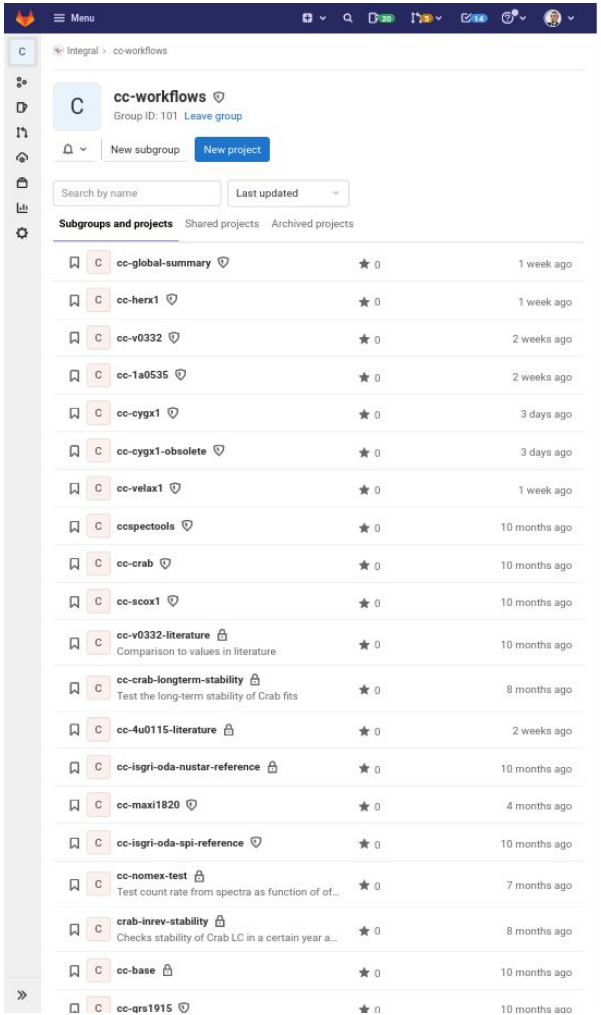
We decided to take software-inspired approach, and define **a collection of reproducible tests** for **ISGRI reconstruction**.

- Reduce, contain, some of the "fitting magic", which may lead to inconsistent hard to reproduce results
- define requirements in advance, learn from any found mismatch in controlled way
- capture some of the expert knowledge for legacy in "live" workflows

We compare spectral properties with **NuSTAR**, **SPI**, or **literature results**. Some of the reference was produced in collaboration with SPI and IBIS teams.

30 distinct source cases, 1-30 observations each, up to 100 SCW per observation.

This is not easy to implement! But several somewhat recent technologies and related developments made it much easier.



Online Analysis: dev environment and user-friendly

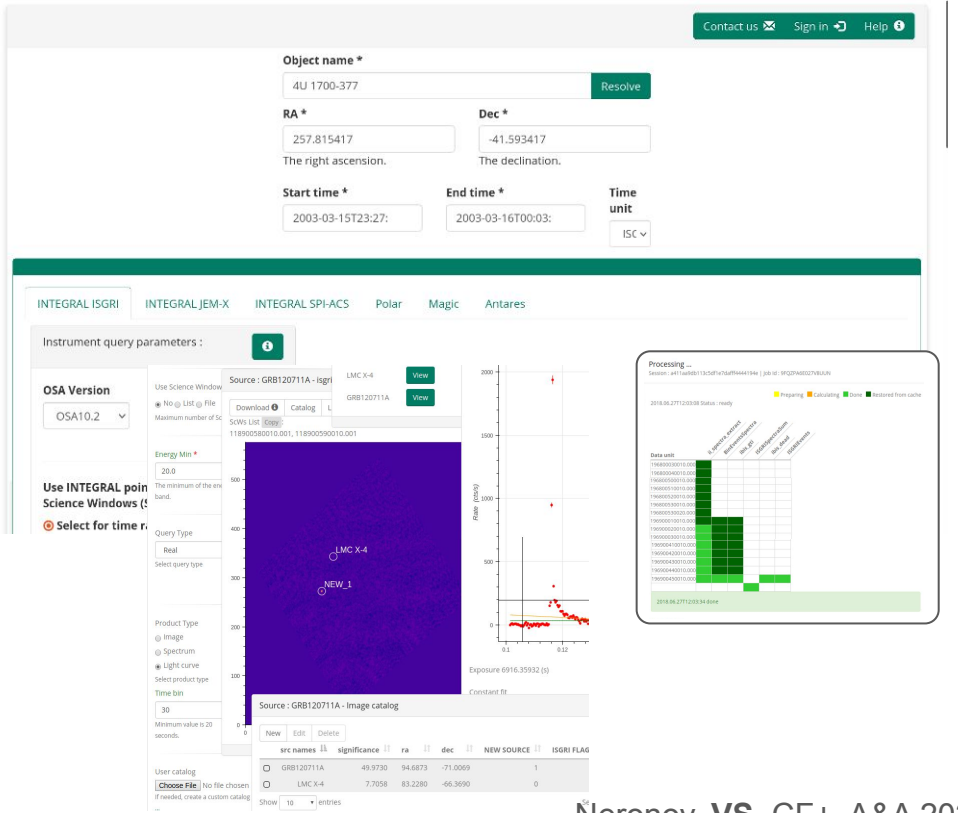
Typical analysis threads, **"scripts" for INTEGRAL OSA analysis**, as a service.

Analysis near the data archive, reduced results traced with provenance graphs and reused by everybody (respecting data rights).

All the recent data. Dev OSA versions.

We also use it to test to notice and solve OSA issues, propagated in traditional OSA builds.

It also makes OSA more available for people who would not normally use it. We support right-to-replicate, and host several instances. SDG



Neronov, **VS**, CF+, A&A 2021

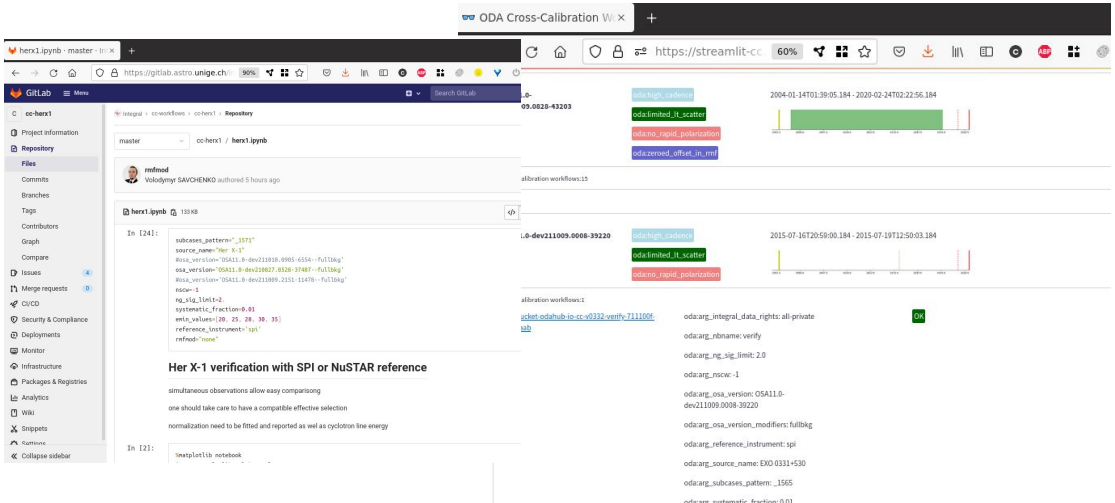
Jupyter notebooks with extra annotations: conventional “modern” technologies, ready to be public. Only concern is data rights for some workflows/results.

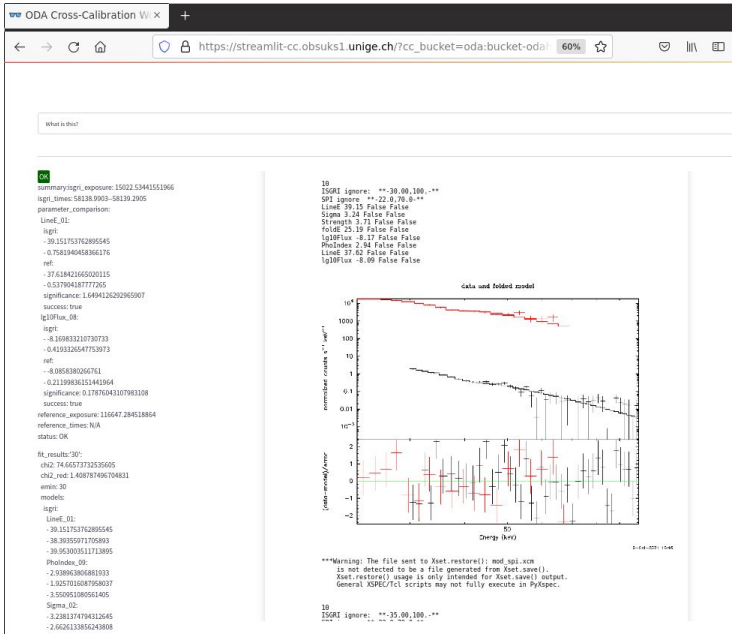
Can be run on one of numerous compatible platforms: **binder**, **googlecollab**, **Renku** (EPFL), **DataLabs** (ESA)

Can also fetch other data sources, especially web-based analysis (INTEGRAL and not).

Pluggable, fetching and fitting parts can be replaced.

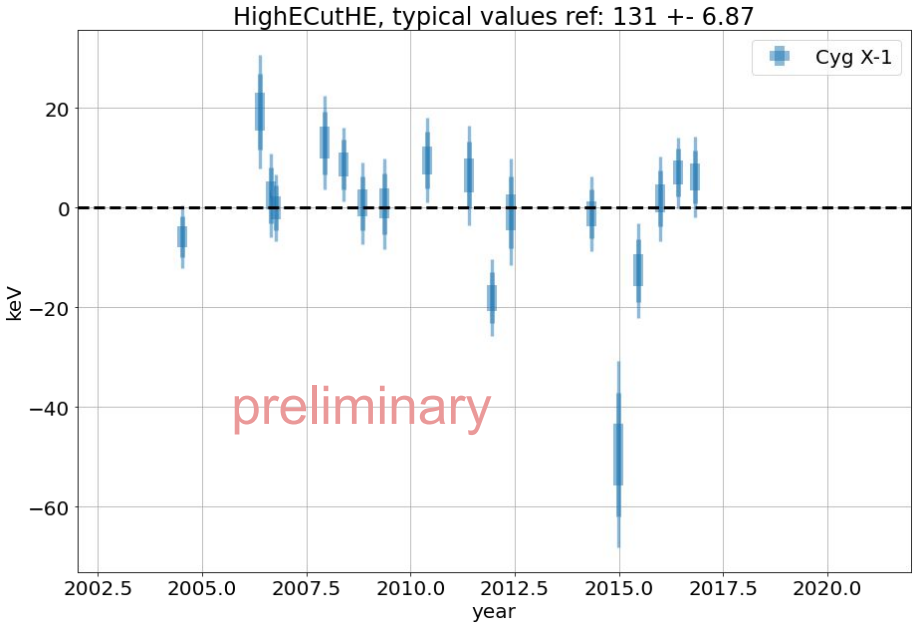
Is run automatically in response to new OSA or data.

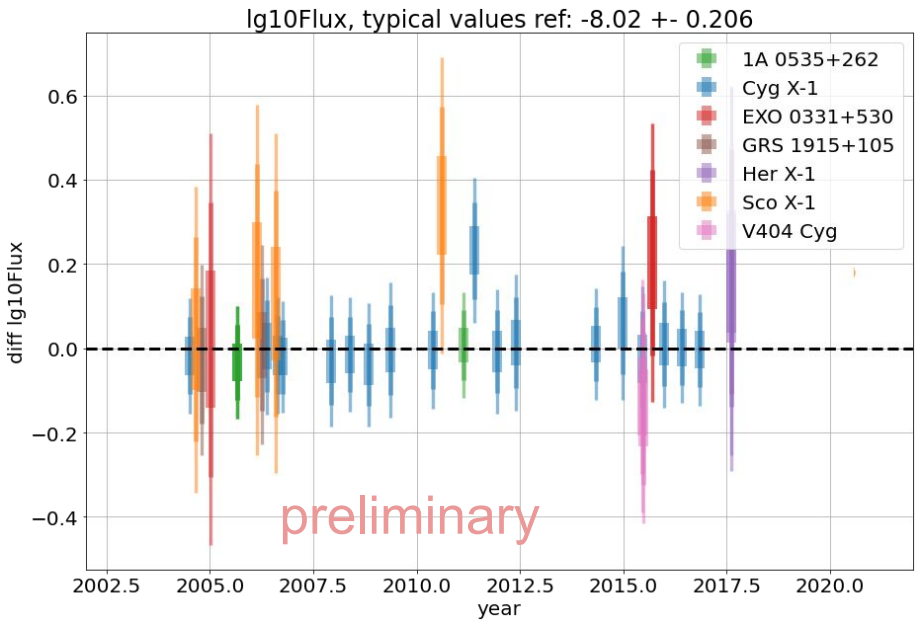




Aggregated results: High-energy reconstruction and flux

Differences in reconstructed parameters between ISGRI and "expectations"

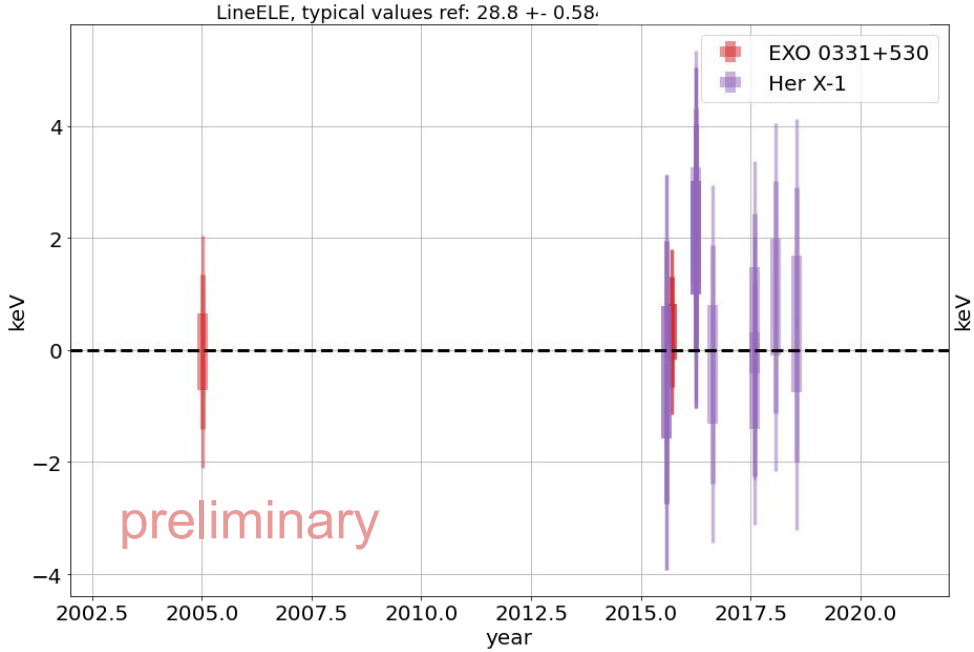


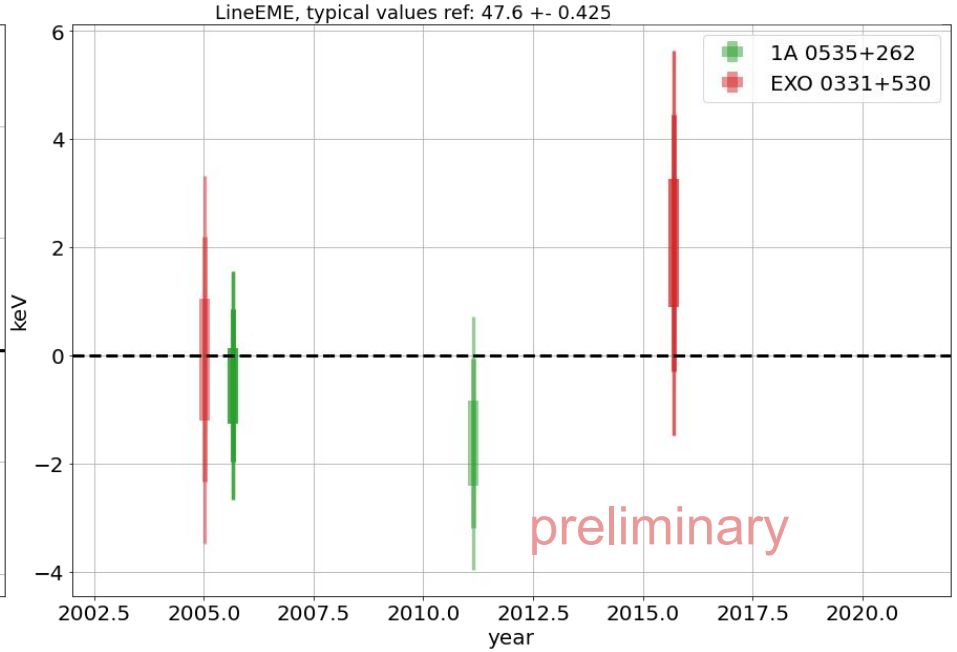


Aggregated results: Cyclotron lines

Major complexity, delicate models, provide feedback for low-energy. Thanks Carlo for help with building the fitting

Entire time range is covered, but more observations exist and may be added.

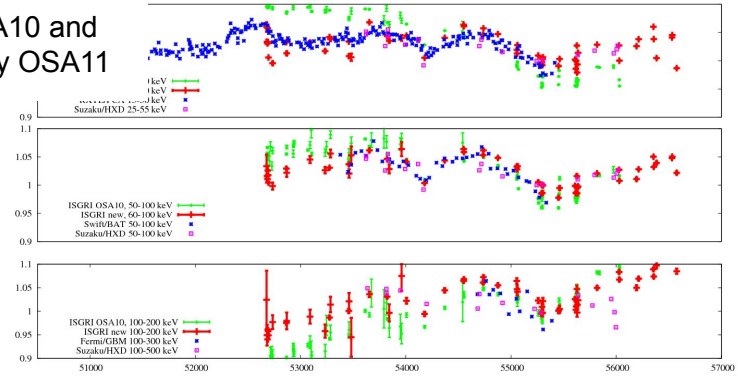


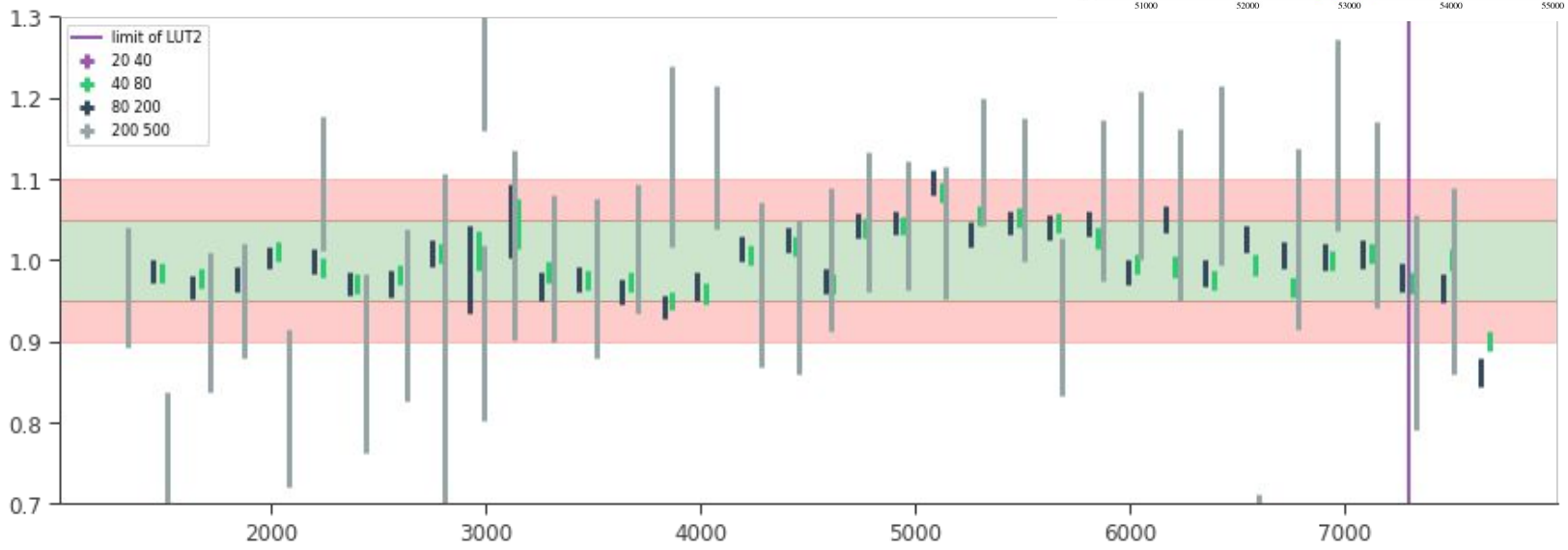


Long-term count rate: Crab

above ~60 keV - "absolute" measurement with detector model. Below - using efficiency instead of ARF.

OSA10 and early OSA11





Selection of Crab data

Ready?

No more anomalous source features (see 1A 0535+105), background spectra look the same **OK**

Cyclotron line sources consistent with reference where available **OK**

High-energy (>60 keV) rates stable from physical detector model **OK**

ARF does not change, efficiency and RMF do **OK**

Internal (to IBIS team) validation beta ready in MMODA and normal IC.

ISGRI still evolving. Need to follow until the end of the mission. **ok for now**

Rapid evolution caused by polarization is implemented, but not available in the beta. **ok for now**

Detector plane background model should be updated. **ok for now**