SPI work at MPE

INTEGRAL User Group Meeting #26

1./2. December 2021

Roland Diehl / Jochen Greiner

News

- DLR support for INTEGRAL operation (1 full position) has been extended for the next 3 years (Jan. 2022 – Dec. 2024)
- [redacted]s leaving for Paris
  [redacted]is taking over starting Jan. 1, 2022
- Extension of background model to 2-8 MeV
- PySPI for GRB analysis
- GEANT4 simulations for SPI for higher-resolution response

Routine Activities @ MPE 2020+

Routine procedures (XZ) (→ automatic; documented)

Data import, routine processing

Quality checking

Spectral fitting → response database

Background database

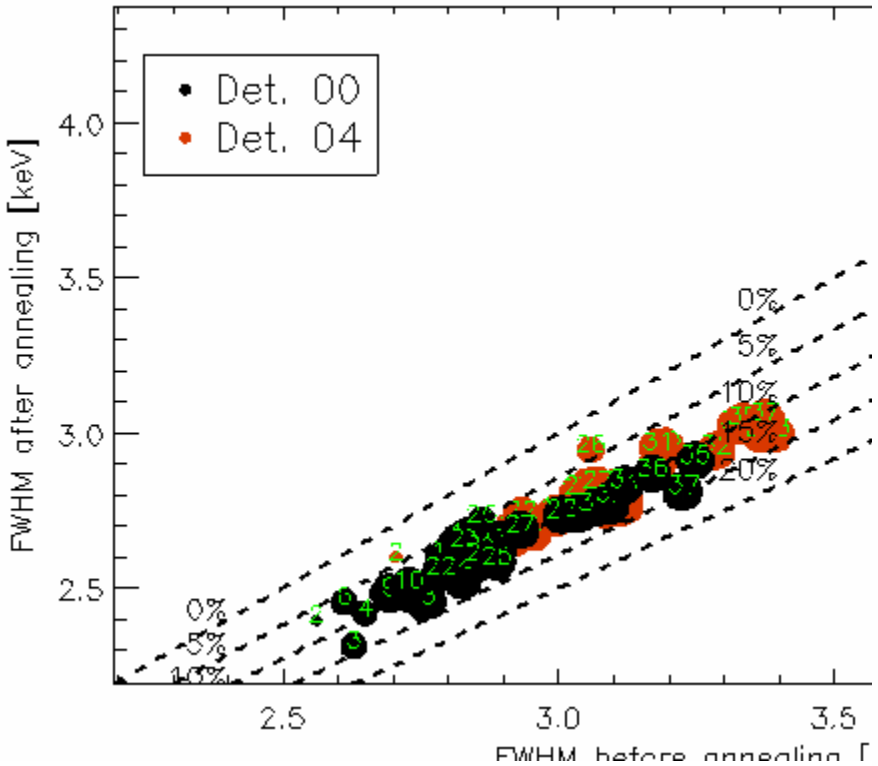
Performance validation (incl. annealings)

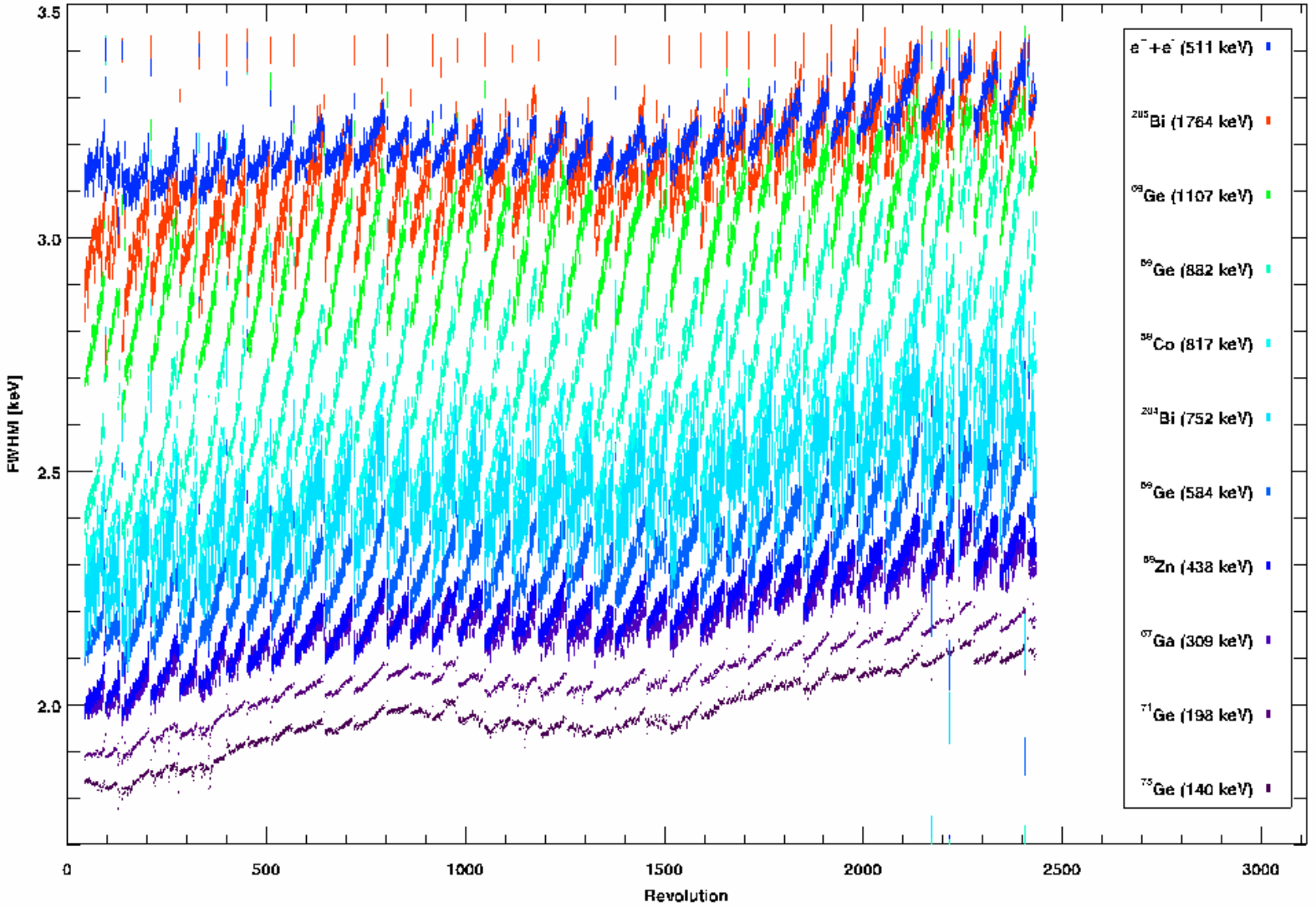
Software maintenance

Interaction with ISDC

Present status

- SPI annealing: OK





Present status

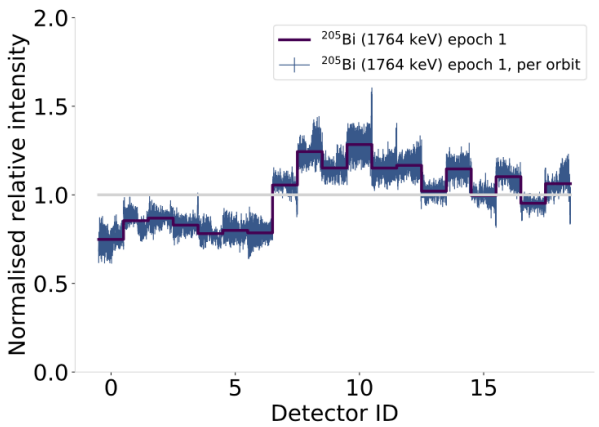
- SPI annealing: OK
- ACS calibration: unchanged since 11/2018 report (Diehl)
- Response database: regularly updated
- Background database: extended to 2-8 MeV

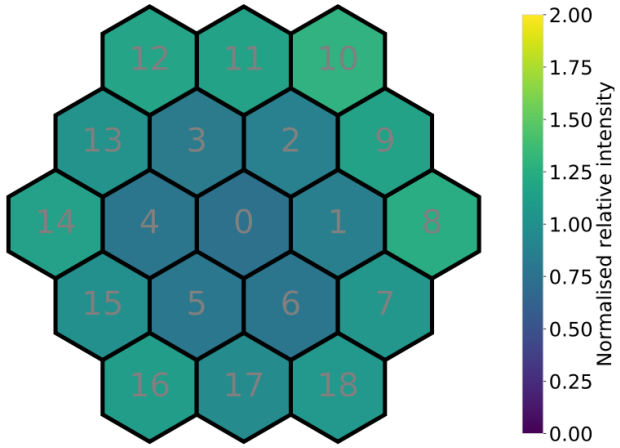
Including double-detector events

Using also multiple-detector events in SPI at energies > 2 MeV

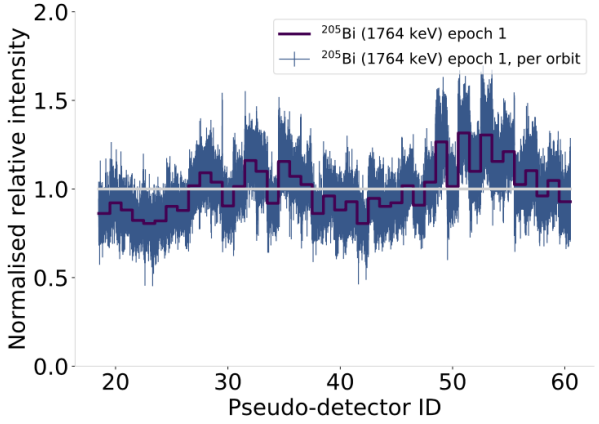
…building a model for instrumental background in detail:

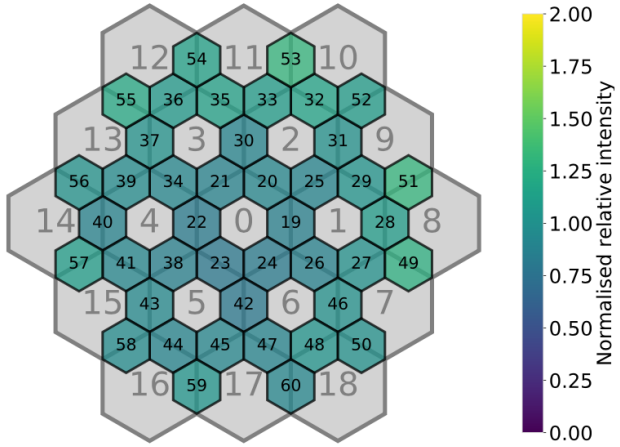
Pleintinger 2020





single events



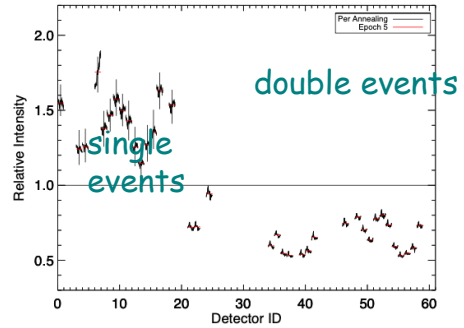


double events

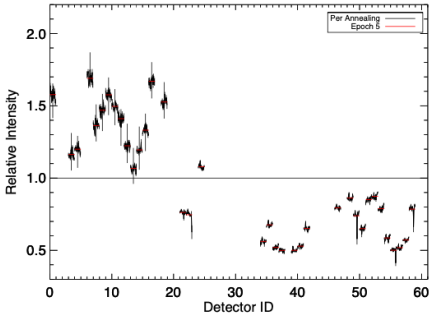
Including double-detector events

building a model for instrumental background in detail:

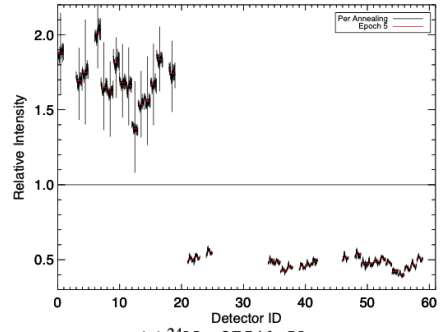
Weinberger 2021



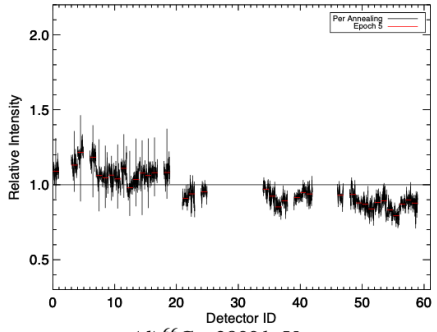
(a) Continuum in the energy range 3500 – 3600 keV



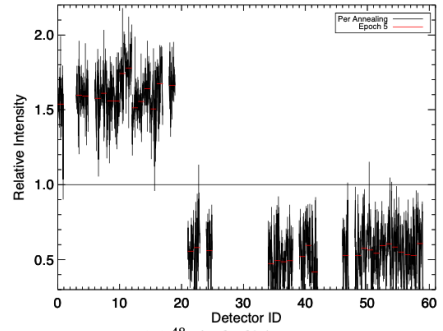
(b) Continuum in the energy range 6450 – 6550 keV



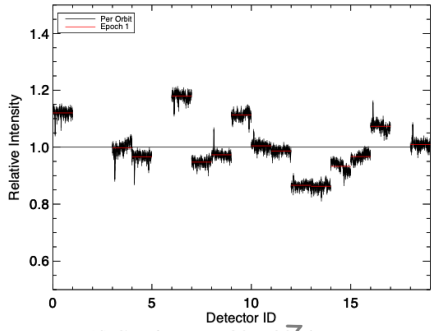
(c) ^{24}Na, 2754 keV



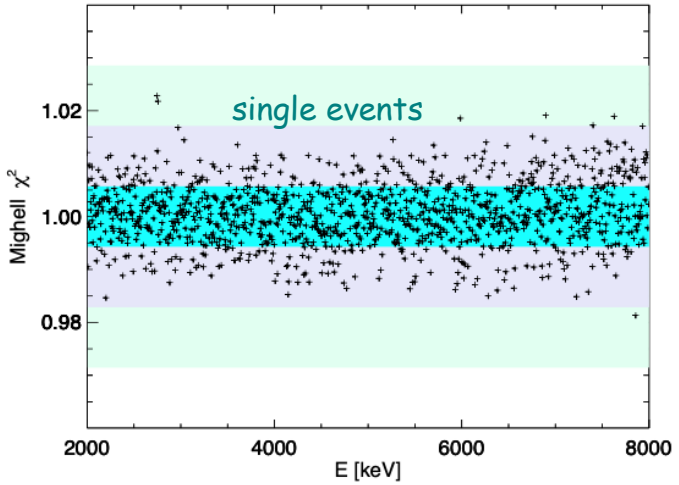
(d) ^{66}Ga, 3800 keV

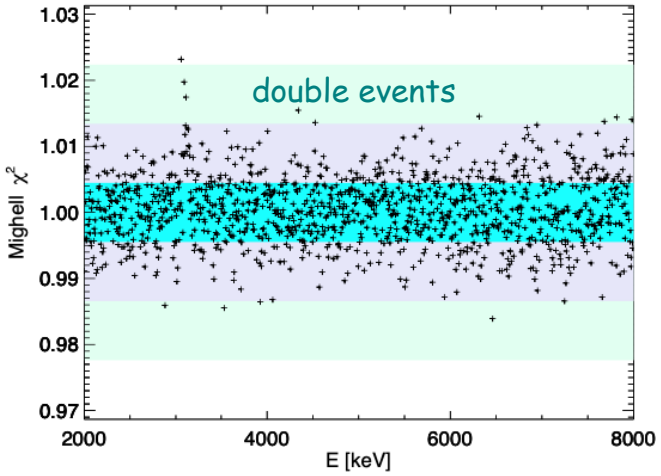


(e) ^{48}Ti, 6760 keV



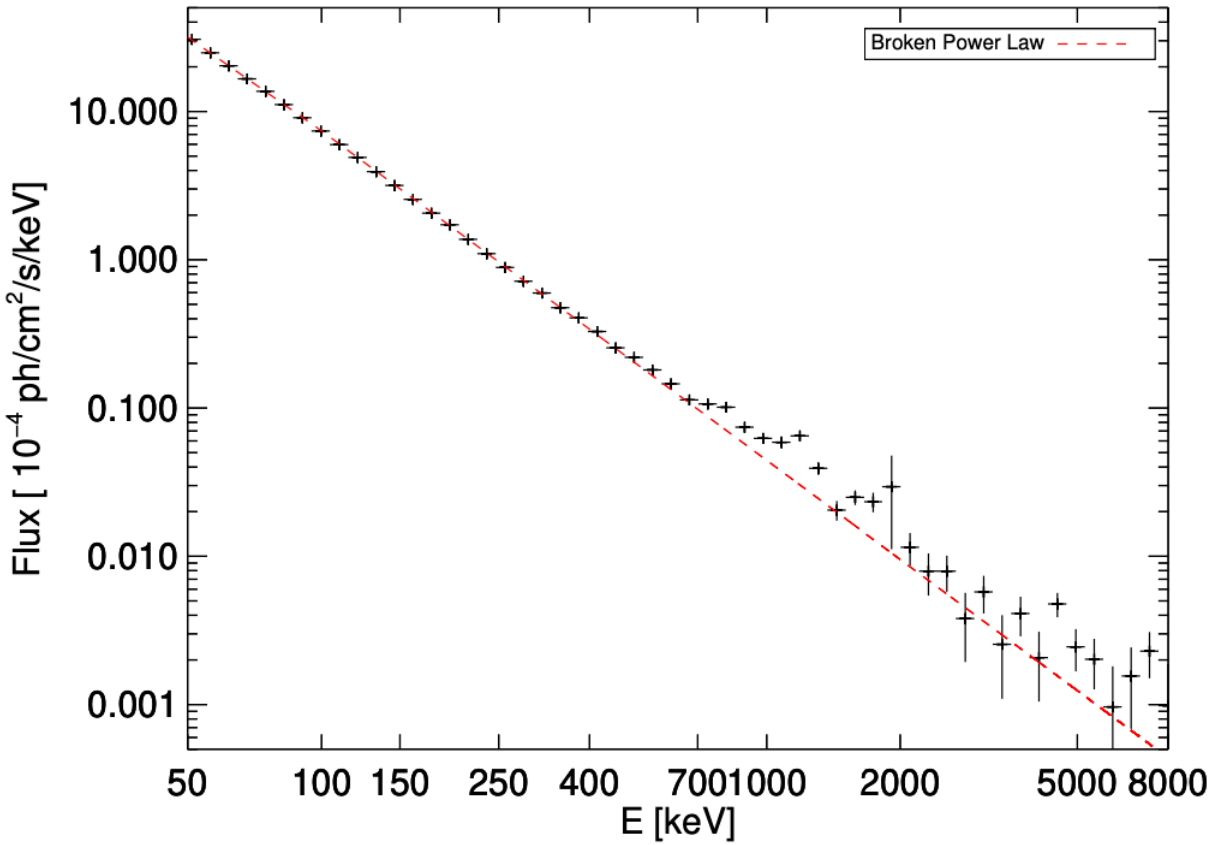
(f) Continuum 780 – 920 keV





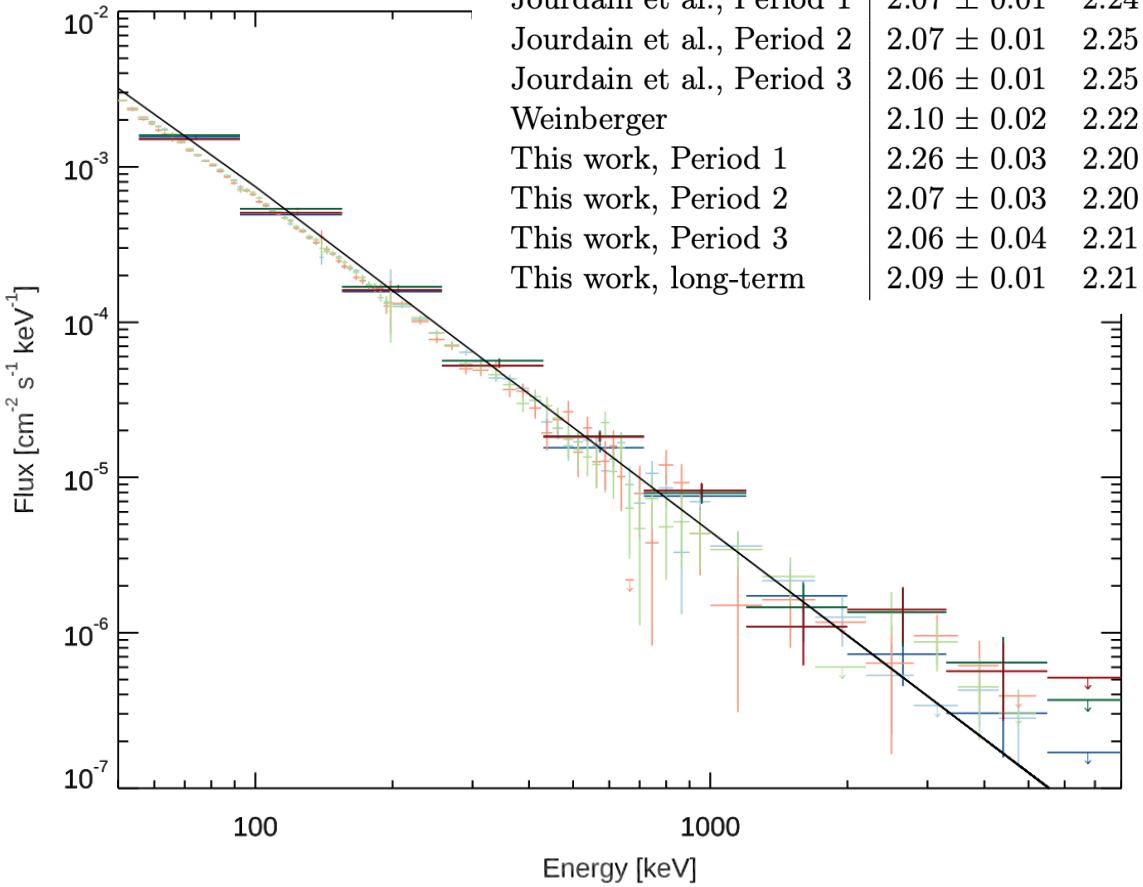
The Crab as a source for method validation

Crab spectrum in fine energy bins up to 8 MeV



Kuhn & Weinberger 2021

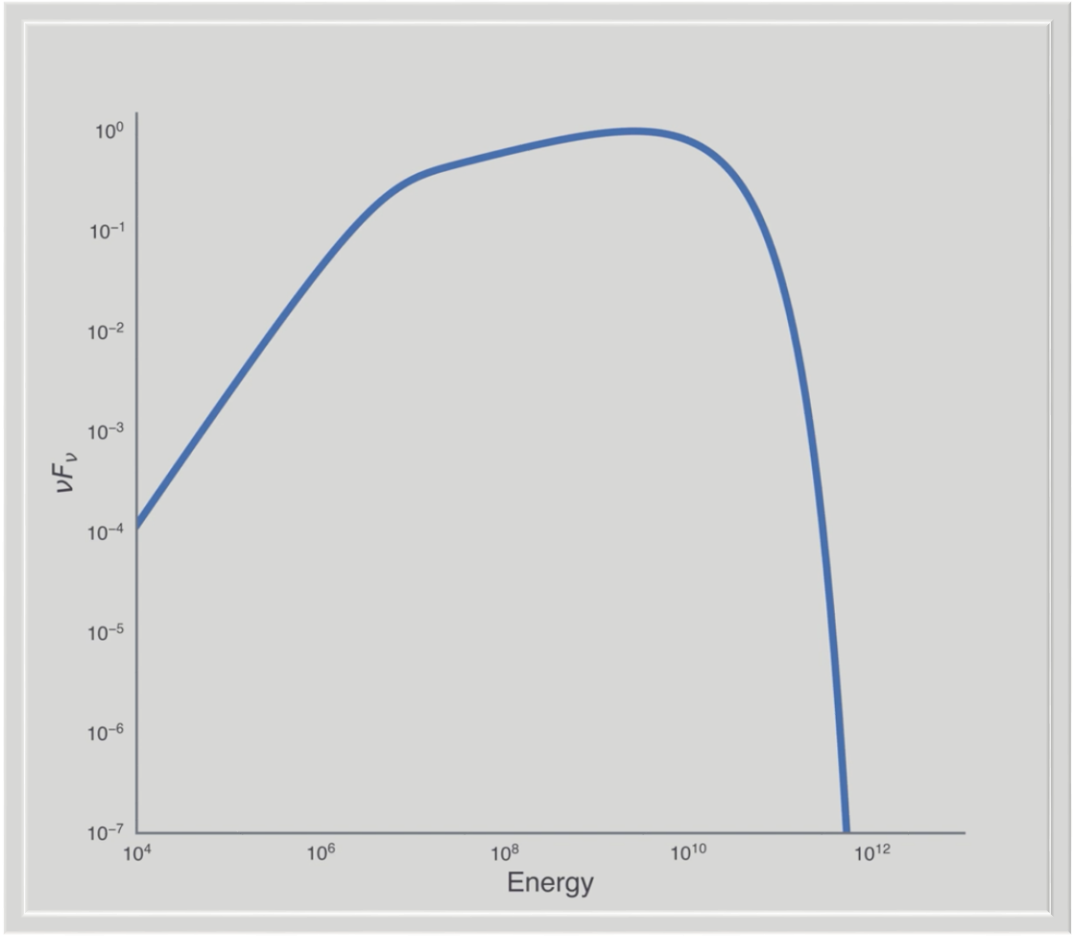
Revolutions	α_1	α_2
Jourdain et al., Period 1	2.07 ± 0.01	2.24 ± 0.02
Jourdain et al., Period 2	2.07 ± 0.01	2.25 ± 0.03
Jourdain et al., Period 3	2.06 ± 0.01	2.25 ± 0.04
Weinberger	2.10 ± 0.02	2.22 ± 0.03
This work, Period 1	2.26 ± 0.03	2.20 ± 0.02
This work, Period 2	2.07 ± 0.03	2.20 ± 0.02
This work, Period 3	2.06 ± 0.04	2.21 ± 0.02
This work, long-term	2.09 ± 0.01	2.21 ± 0.01



→ consistent with other SPI analyses

Why PySPI? -- What can SPI (still) do for GRBs?

- Very good energy resolution: 2.5 keV at 1-2 MeV as compared to 100 keV (Fermi/GBM)
- Energy range covers vFv peak of most GRBs
  - Ideal to precisely measure the curvature around peak
  - Key to distinguish between physical models
- Potential problems:
  - Only photopeak used instead of full response
    ➔ at 1(3) MeV only 68(50)% of photons in photopeak
  - After response correction another fitting per energy bin
  - Inappropriate statistics in low-count regime



Credit: J. Michael Burgess

Analysis Software

GRB analysis with OSA

SPI DATA

SPI POINTING

SPIROS/SPIMODFIT

ONE PHOTO PEAK SPECTRUM

19 Detectors -> one spectrum

RESPONSE MATRIX

XSPEC

GRB SPECTRUM

GRB analysis with PySPI

SPI DATA

SPI POINTING

SPI DEADTIME

Build Timeseries

Construct Response

Deadtime Correction

pyspi

Biltzinger+2021

Provides Plugin

3ML Multi-Mission Maximum Likelihood Framework

Full forward-folding

https://github.com/threeML/threeML

PySPI(GRB) features

- Pure python and easy to install; no dependency on OSA
- Every detector is treated as independent detector
- Full forward folding and correct Likelihood for fits
- Allows for any PSD event selection (can fit the PSD efficiency)
- Makes joint fits with other instruments possible (Bayesian and ML)
- Presently works only for single science windows, due to missing time-dependent background implementation

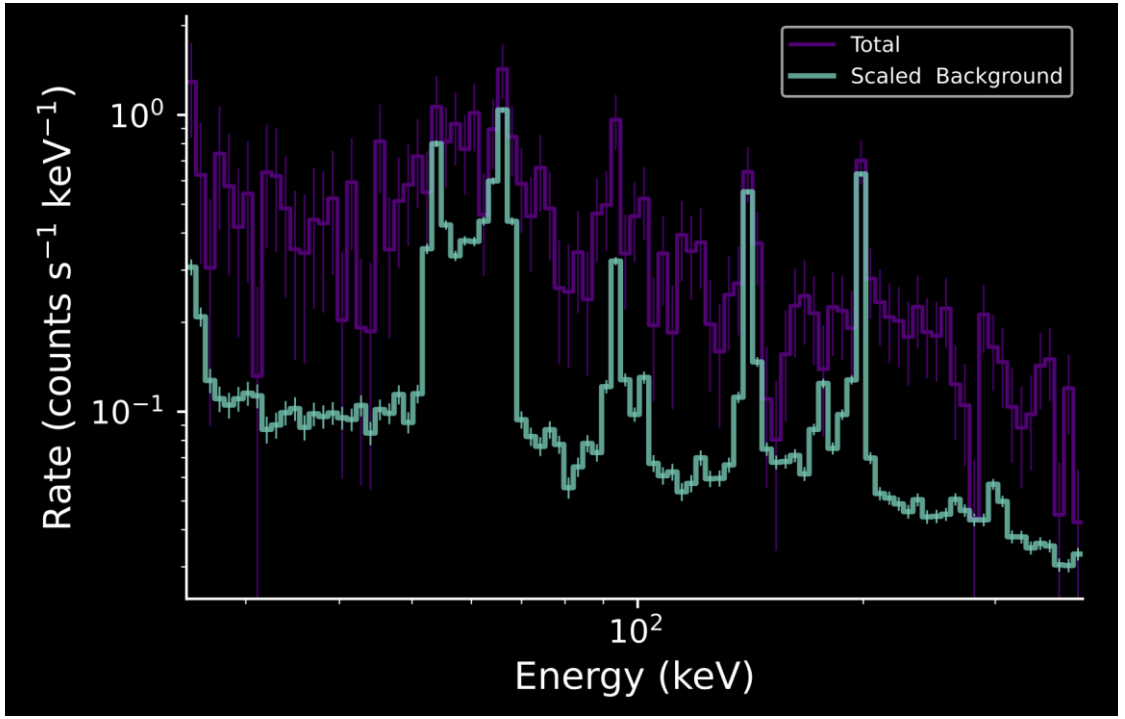
Biltzinger+2021

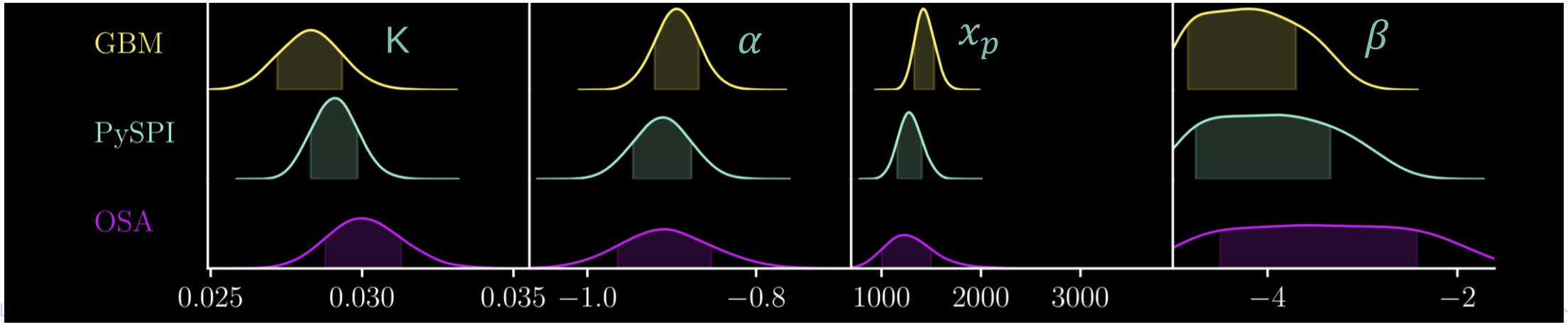
https://github.com/BjoernBiltzinger/pyspi

Results: GRB 120711A

Biltzinger+2021

- Seen by SPI and GBM
- Fit with Band function first
  - Cross-check:
    - GBM and PySPI results match
    - difference between OSA and PySPI

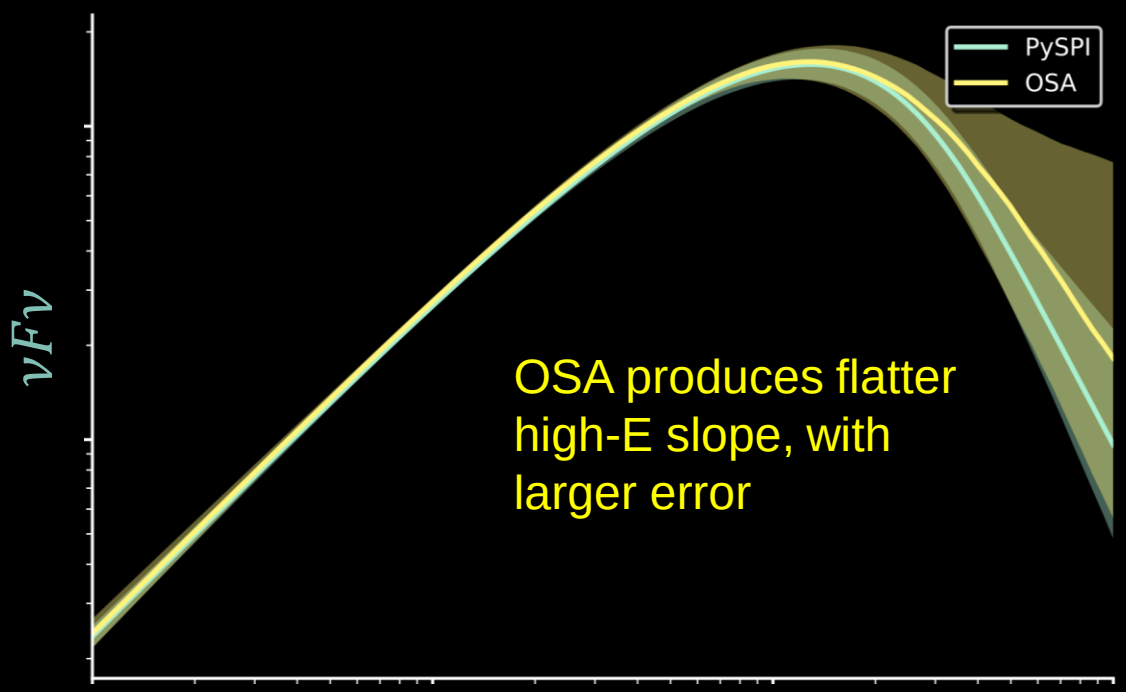




Results: GRB 120711A

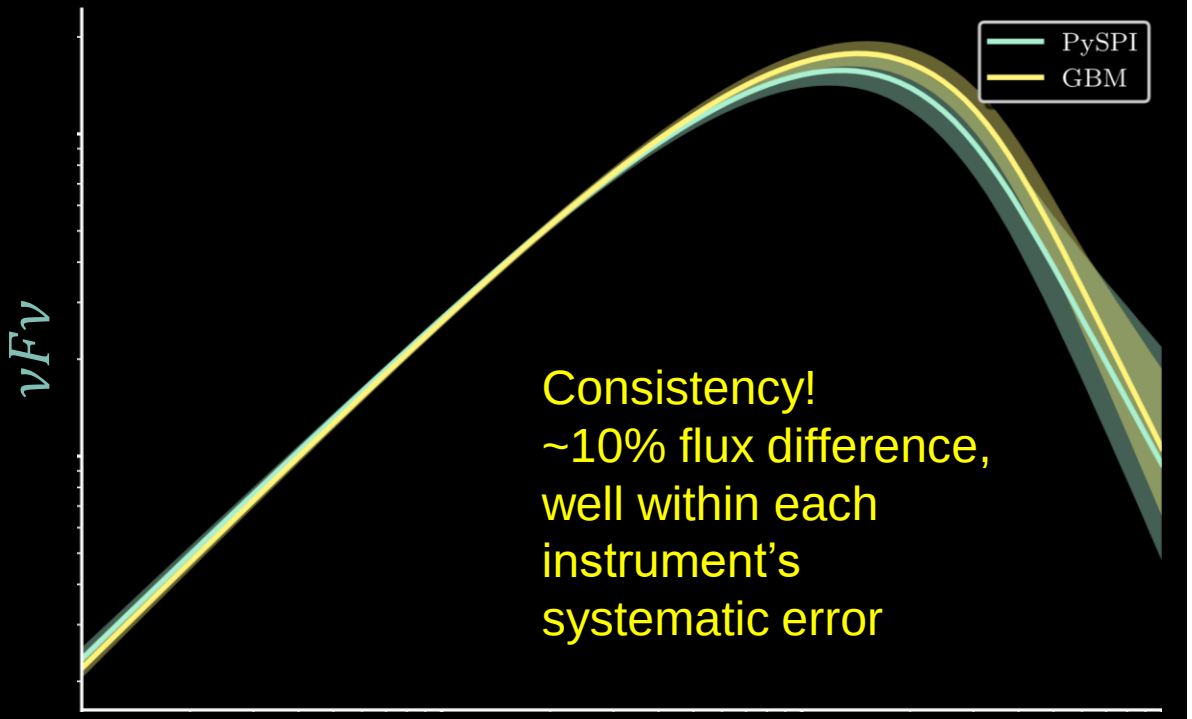
Biltzinger+2021

PySPI vs. OSA



OSA produces flatter high-E slope, with larger error

PySPI vs. GBM



Consistency!
~10% flux difference, well within each instrument's systematic error

Response simulation

- Geant4 simulation:
  Building high(er) spectral resolution response,
  to make use of the very good energy resolution

Credit: Geant4 simulation setup by Maxime Chauvin

Biltzinger+2021