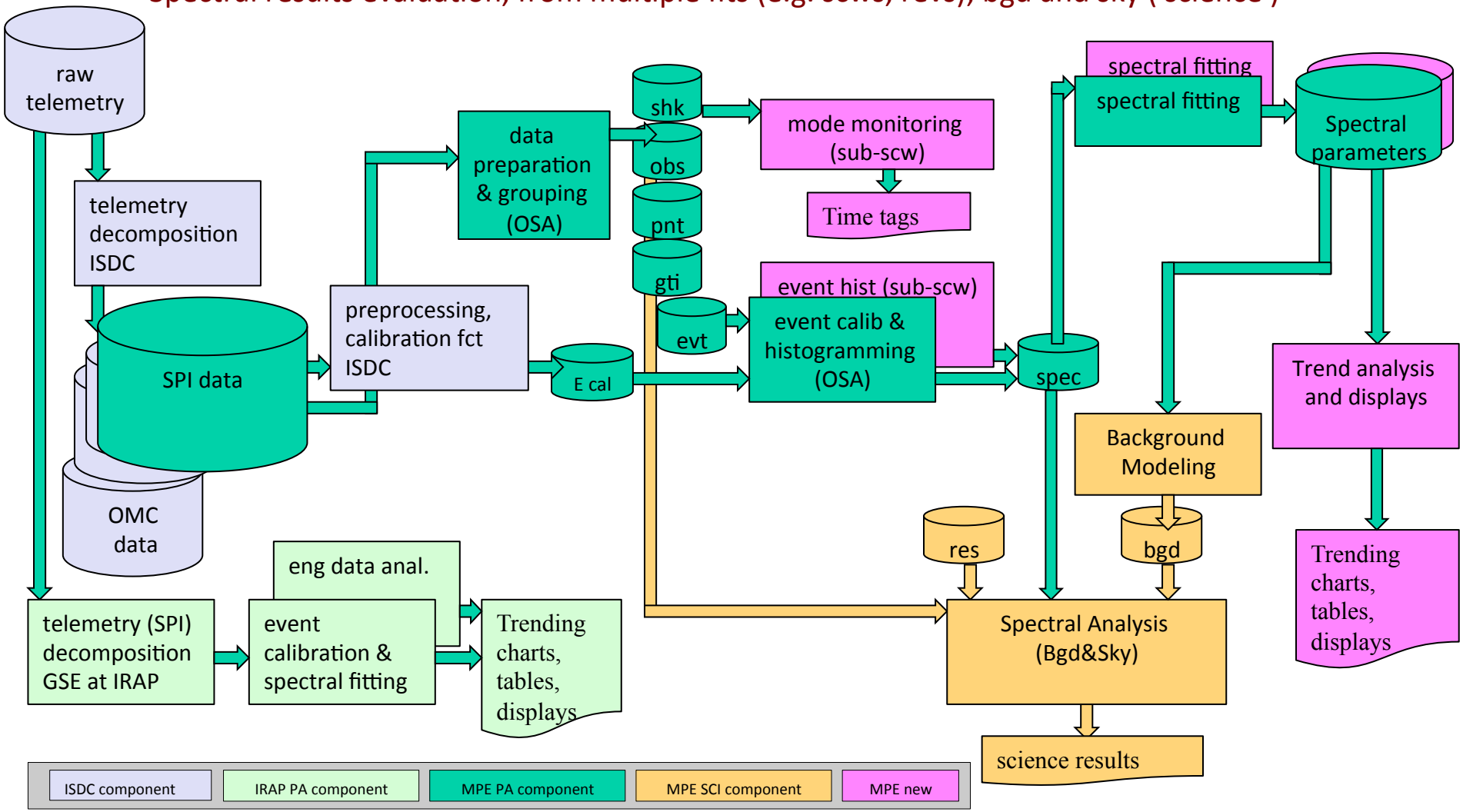
SPI Performance Monitoring

MPE Contributions

February 2018

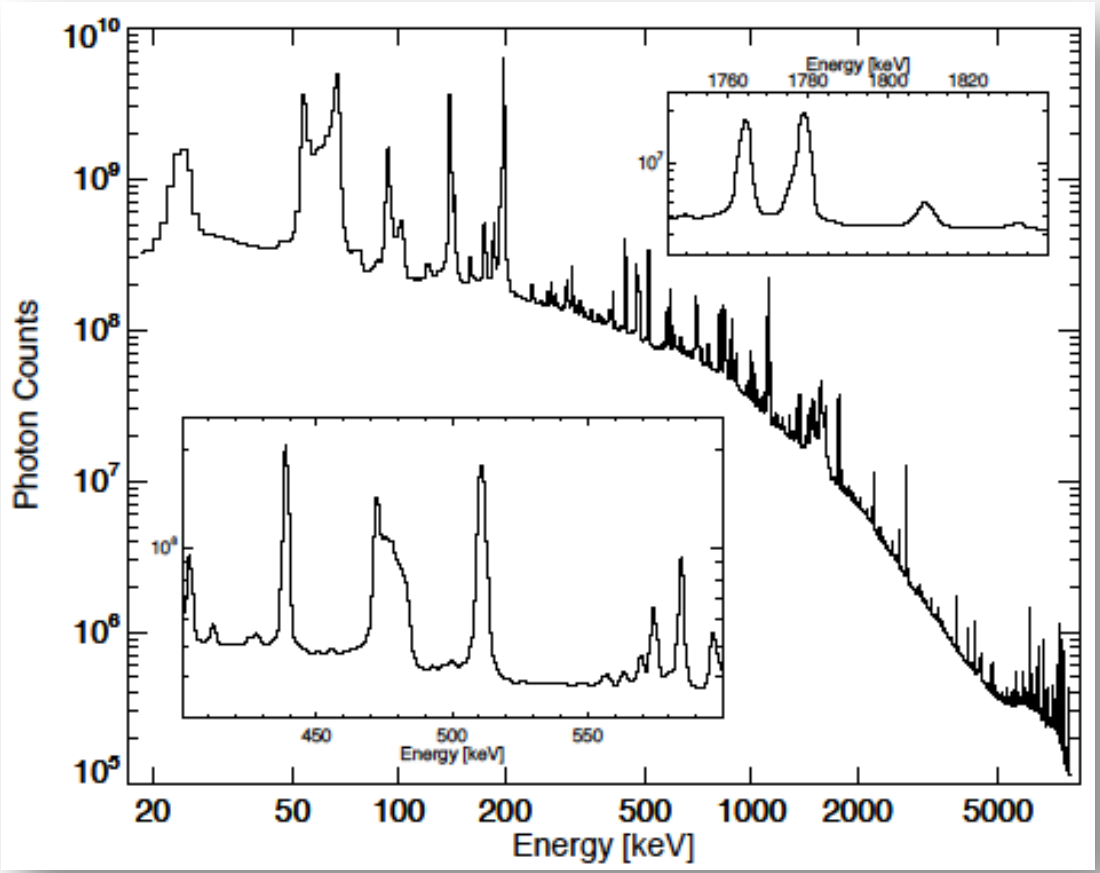
SPI Data Flow: PerfAnalysis and Science

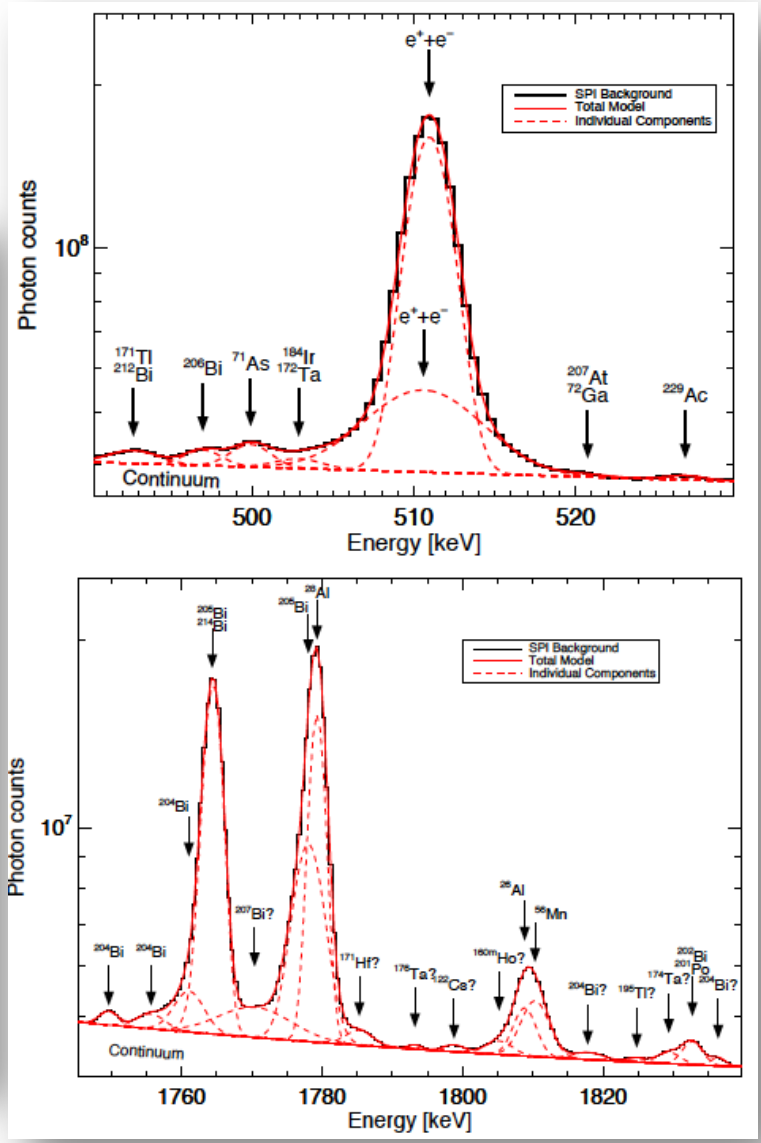
- Telemetry decoding, data extraction and sorting → engineering and science data
- SPI events: raw, calibrated, → histograms; scw's, and other (sub-scw) time intervals
- Spectral fitting: for performance monitoring; for spectral response and background; for science
- Spectral results evaluation, from multiple fits (e.g. scws, revs); bgd and sky ('science')



Spectral Fitting

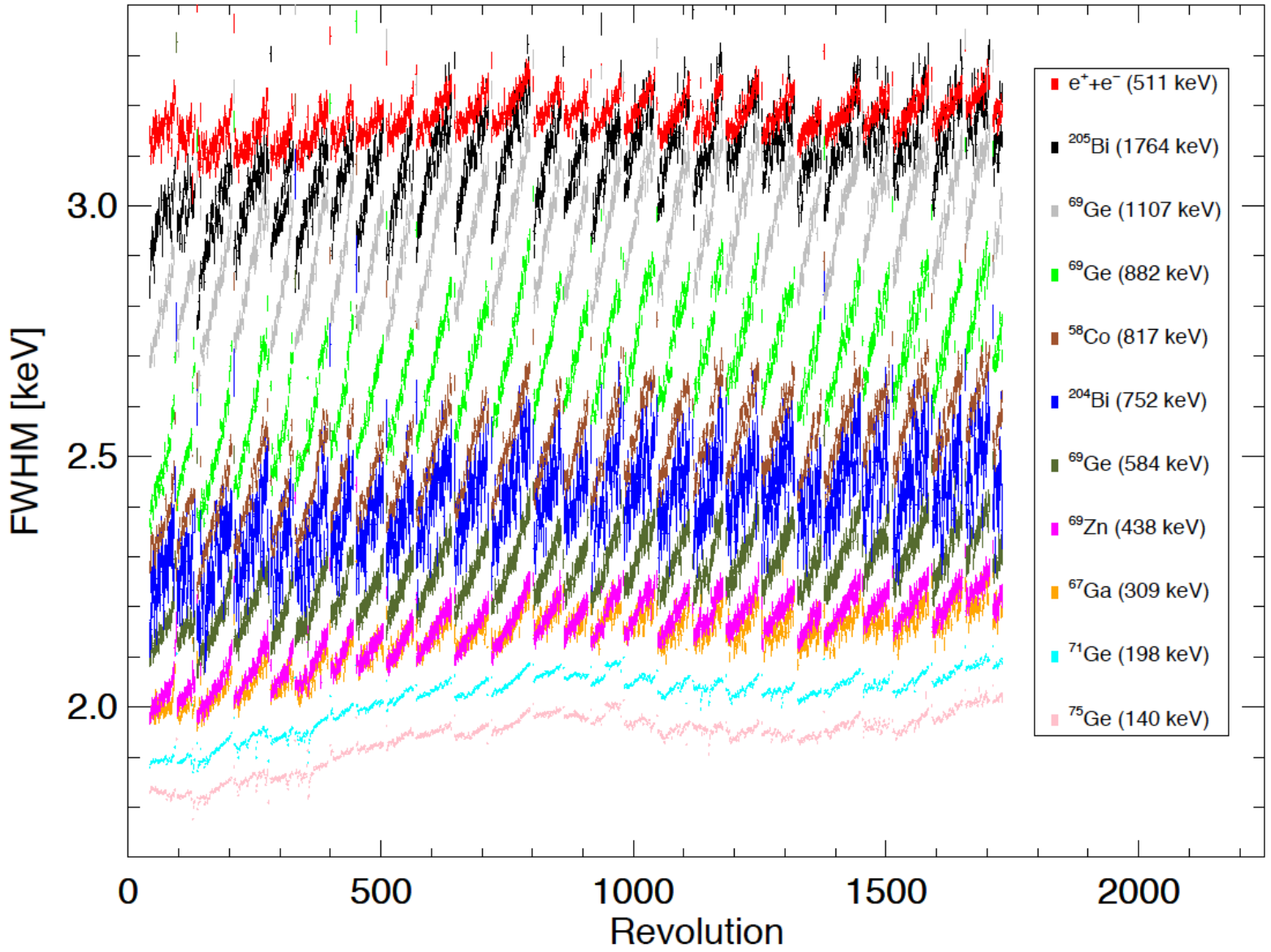
- Routine decomposition of SPI detector spectra
  - ☆ spectral performance
  - ☆ background situation





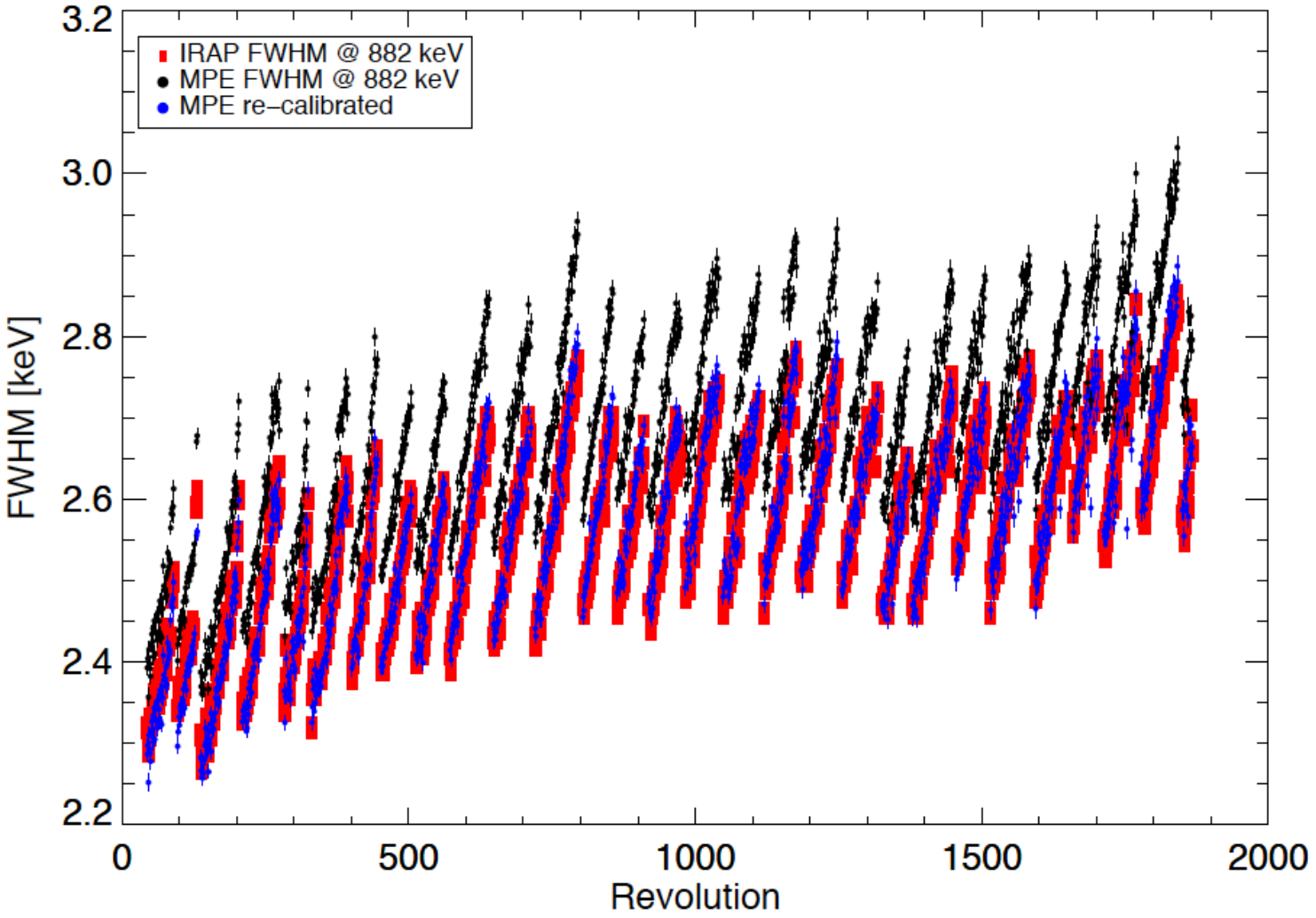
SPI Performance Monitoring

- Monitor Spectral Resolution in Detail



Comparisons SPI Energy Resolution Analyses

- Same general behavior,
  differences in detail from fitting method, underlying bgd, …



… the context at MPE's SPI team…

…A detailed paper describes in-orbit response and background

Astronomy & Astrophysics manuscript no. SPI_bgdResp_astroph
October 27, 2017

INTEGRAL/SPI γ-ray line spectroscopy

Response and background characteristics

Roland Diehl[1]⋆, Thomas Siegert[1], Jochen Greiner[1], Martin Krause[3], Karsten Kretschmer[2], Michael Lang[1], Moritz Pleintinger[1], Andrew W. Strong[1], Christoph Weinberger[1], and Xiaoling Zhang[1]

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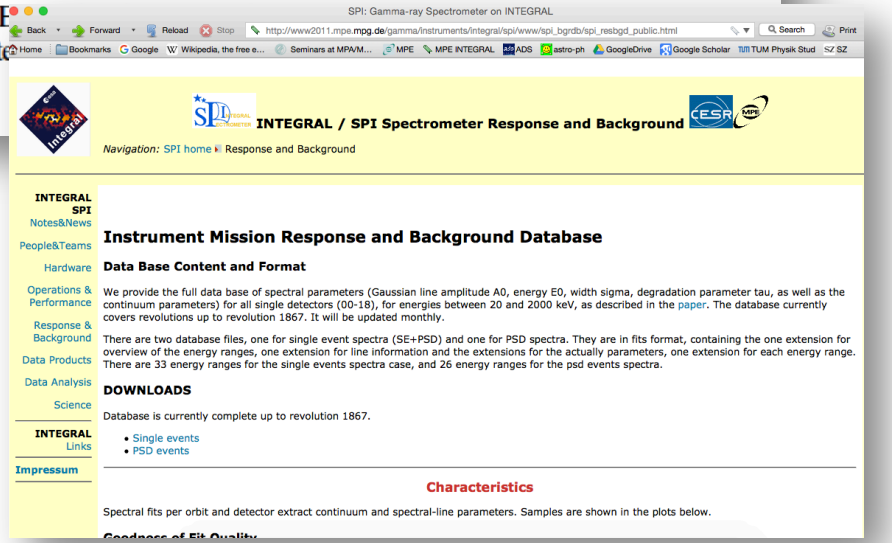
[2] AstroParticule et Cosmologie, Universitè Paris Diderot, CNRS/IN2P3, CE
[3] University of Hertfortshire, School of Physics, Hatfield, AL10 9AB, Unite

Received 22 Aug 2017 / Accepted 24 Oct 2017

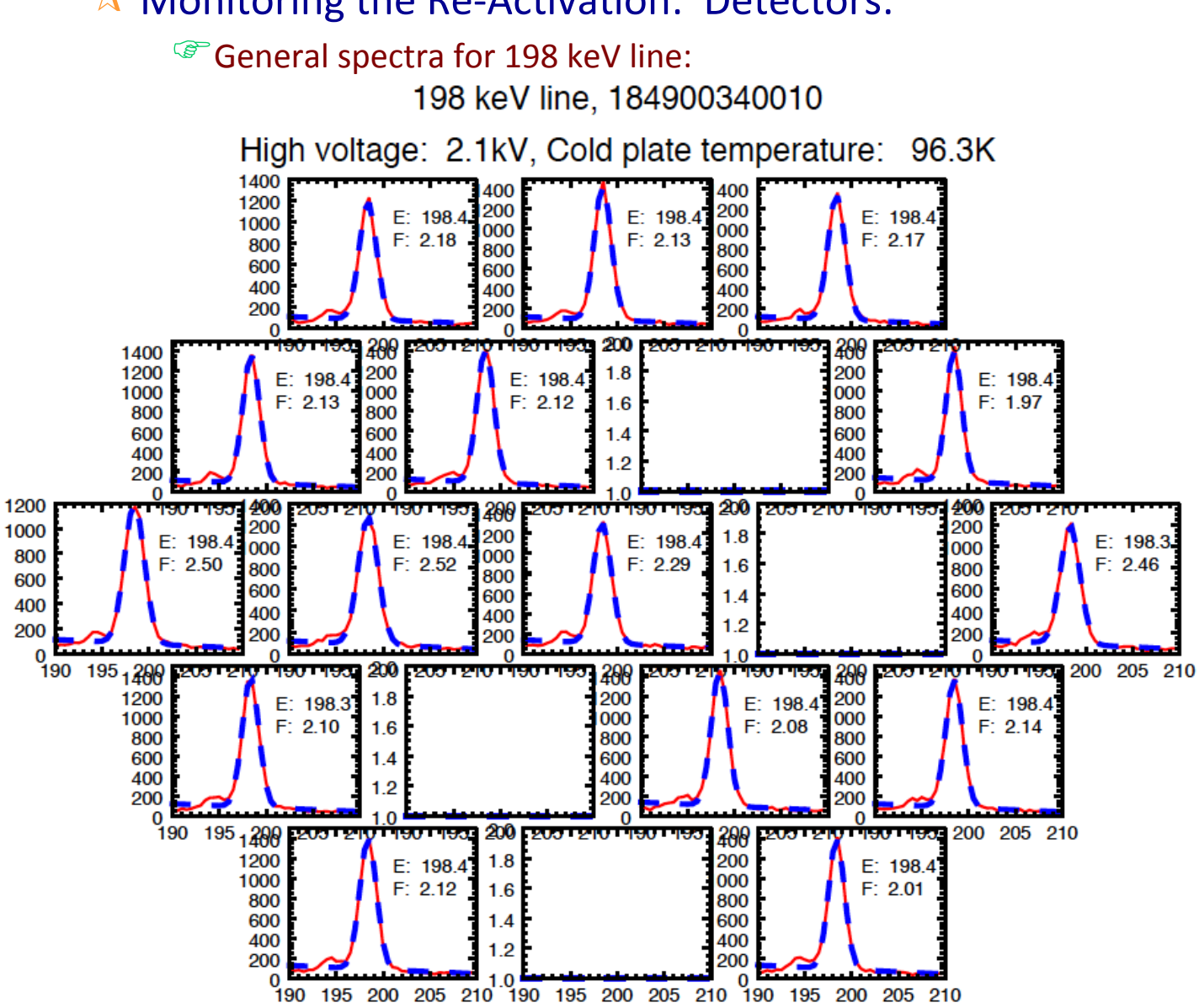


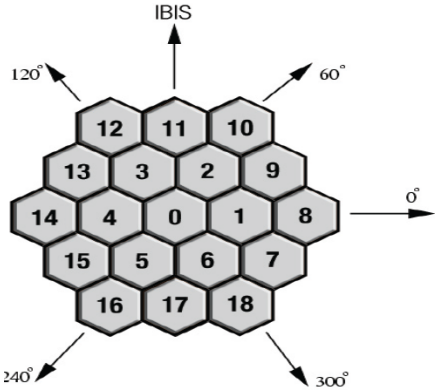
… and the results are on the web

29th Annealing

☆ Monitoring the Re-Activation: Detectors:

☞ General spectra for 198 keV line:





SPI Annealing Assessment

- MPE in standby for monitoring and reporting, through ISDC

SPI Annealing Assessments

SPI Annealings No. 27-29

Issued by: MPE / Roland Diehl, with Thomas Siegert & Xiaoling Zhang

Issue Date: 17 Nov 2017
No. of Pages: 32

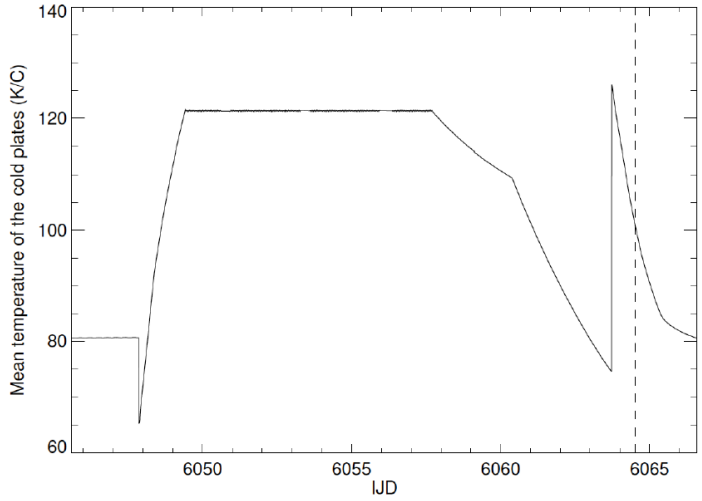


Fig. 1.1a: Annealing overview: Cold plate temperature across the annealing period. Note the units and scaling of temperature change from Kelvin to approximately ~°C during the heating period. The SPI switch-on time is marked (dashed line).

The detector performance, i.e. the resolution and gain:

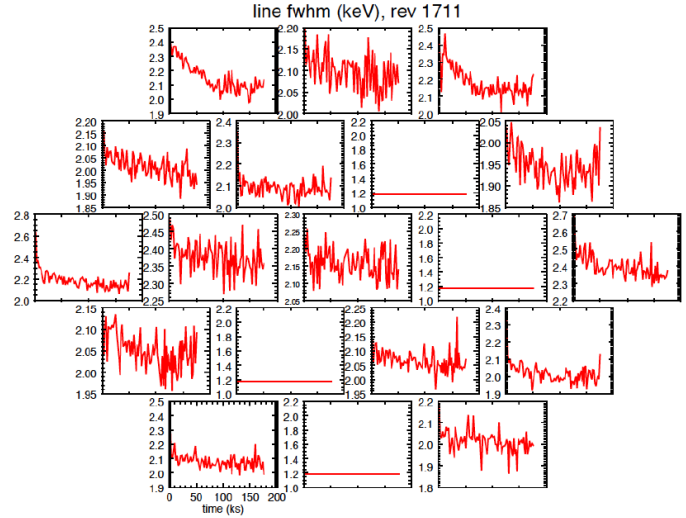


Fig. 1.7a: Instrument response (198 keV line width) after switch-on, as it evolves with scw's during the first orbit

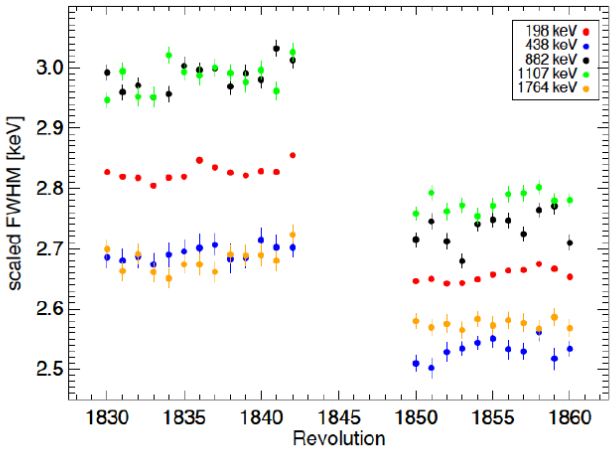
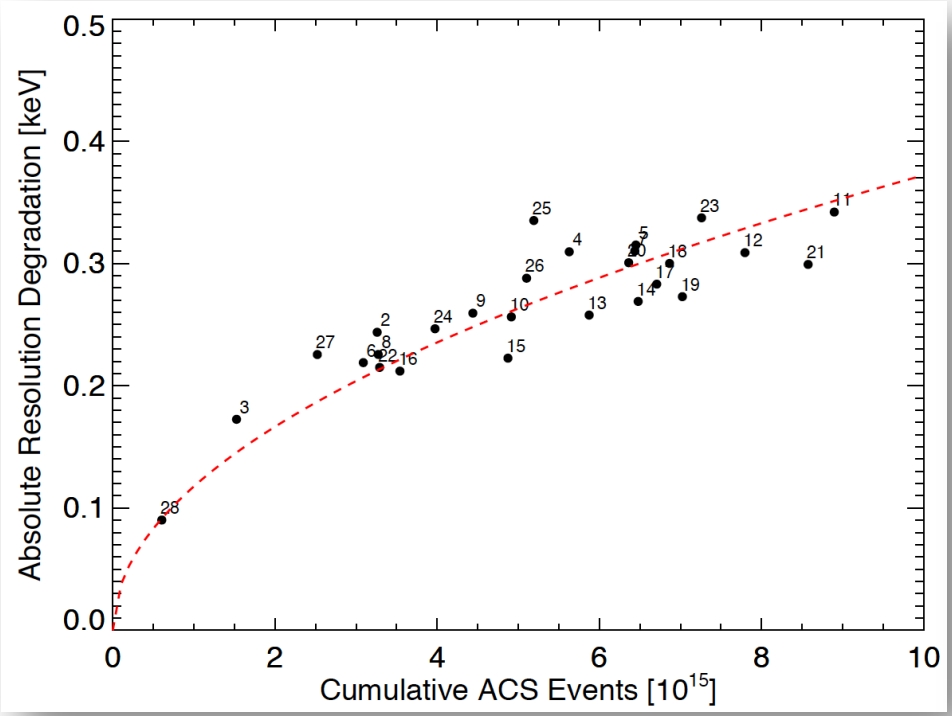
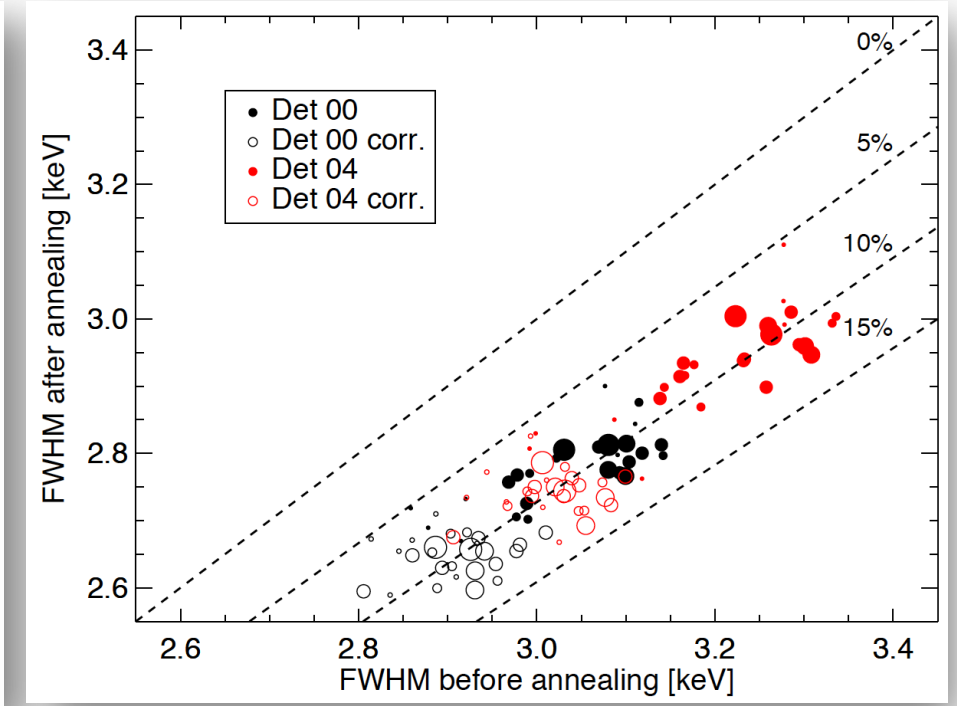


Fig. 2.2: SPI camera spectral resolution around the current annealings, no. 27-29

SPI Annealings

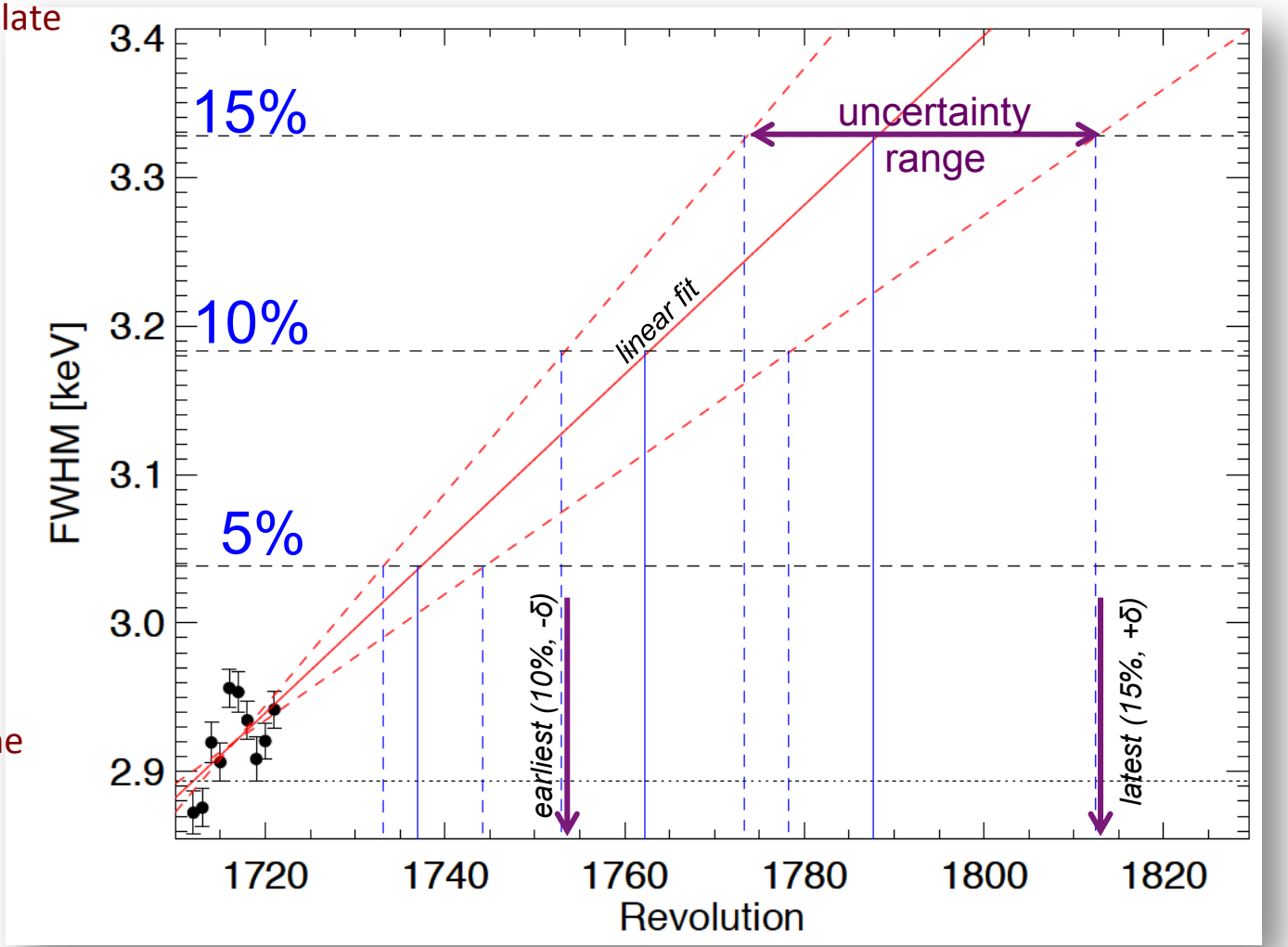
- Monitor Degradation and Recovery





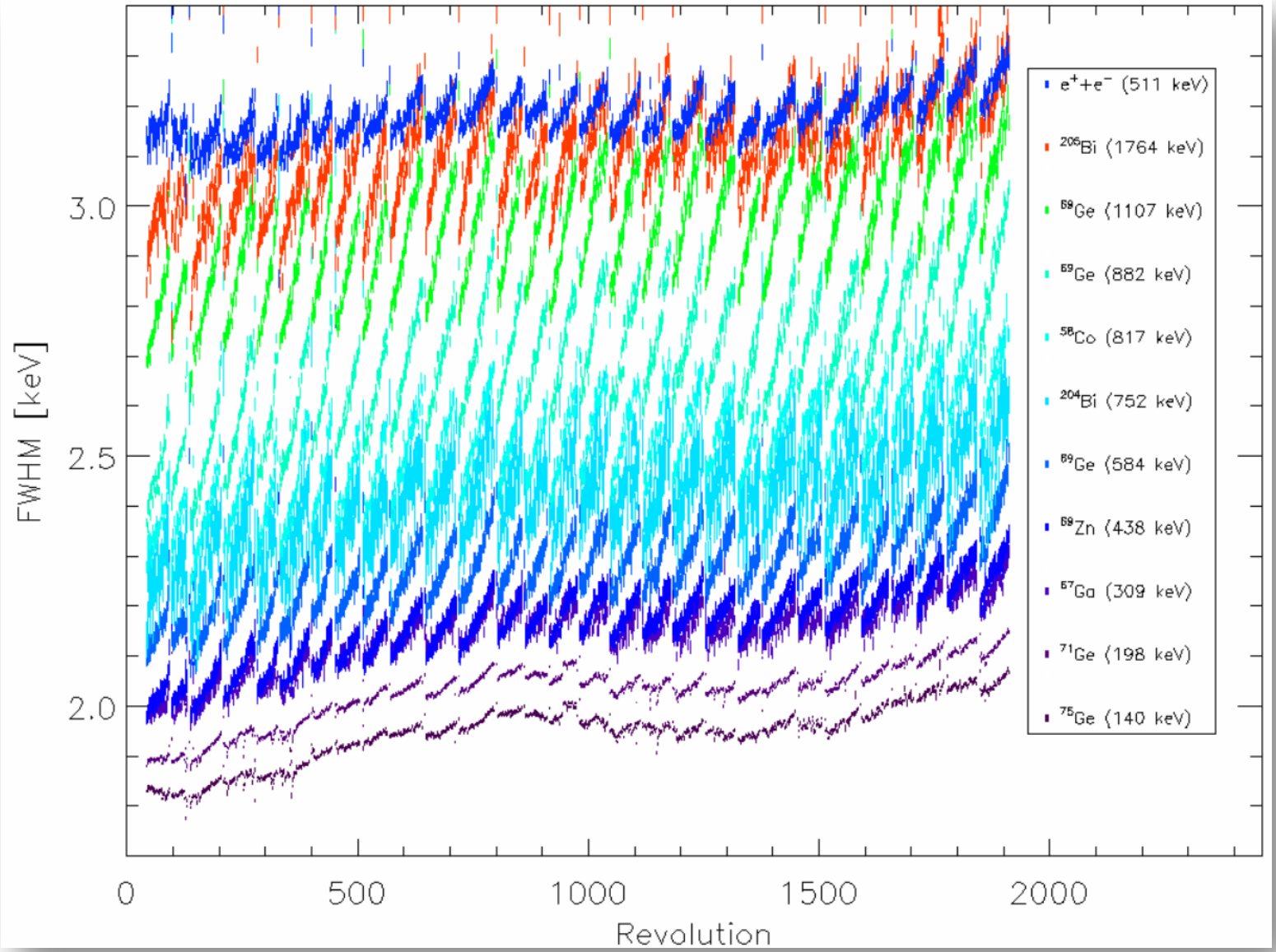
Forecasting the next annealing

- Monitoring the degradation for ~10 revolutions
  - ☞ Derive a gradient, and extrapolate
  - ☞ example, using 1764 keV line



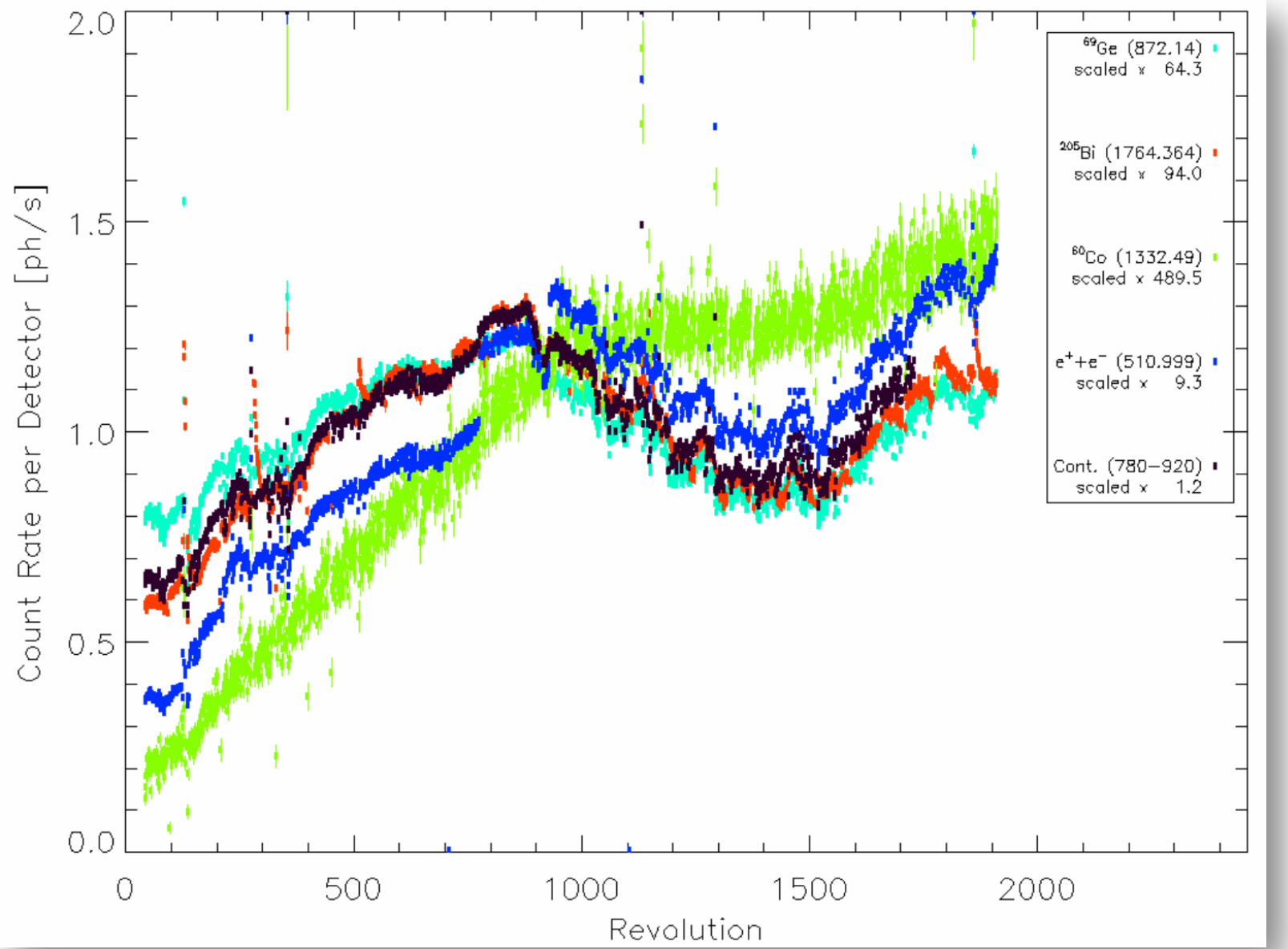
SPI Spectral Resolution Monitoring

- current status (revolution 1911)



SPI Background Monitoring

- current status (revolution 1911)



30th Annealing (Rev 1913-1919; 27 Jan – 12 Feb 2018)

- The recovery after 30th annealing is ~ok

---------- Fitted line width (FWHM,

HV[kV]	1.52	2.03	2.53	2.11
Det				
00	2.32	2.27	2.25	2.30
01	0.00	0.00	0.00	0.00
02	0.00	0.00	0.00	0.00
03	2.36	2.10	2.09	2.12
04	2.54	2.50	2.42	2.42
05	0.00	0.00	0.00	0.00
06	2.14	2.17	2.07	2.05
07	2.40	2.10	2.05	2.03
08	2.70	2.56	2.55	2.54
09	2.06	2.03	2.05	2.02
10	2.50	2.31	2.17	2.22
11	2.32	2.15	2.25	2.12
12	2.47	2.69	2.83	2.74
13	2.17	2.07	2.12	2.13
14	2.78	2.50	2.50	2.47
15	2.22	2.22	2.13	2.13
16	2.38	2.19	2.13	2.10
17	0.00	0.00	0.00	0.00
18	2.16	2.09	2.10	2.08

Uncertainty in FWHM is estimated as 0.045 keV

Table 1.1: Detector settling performance in 198 keV line,

The detector performance, i.e. the resolution and gain:

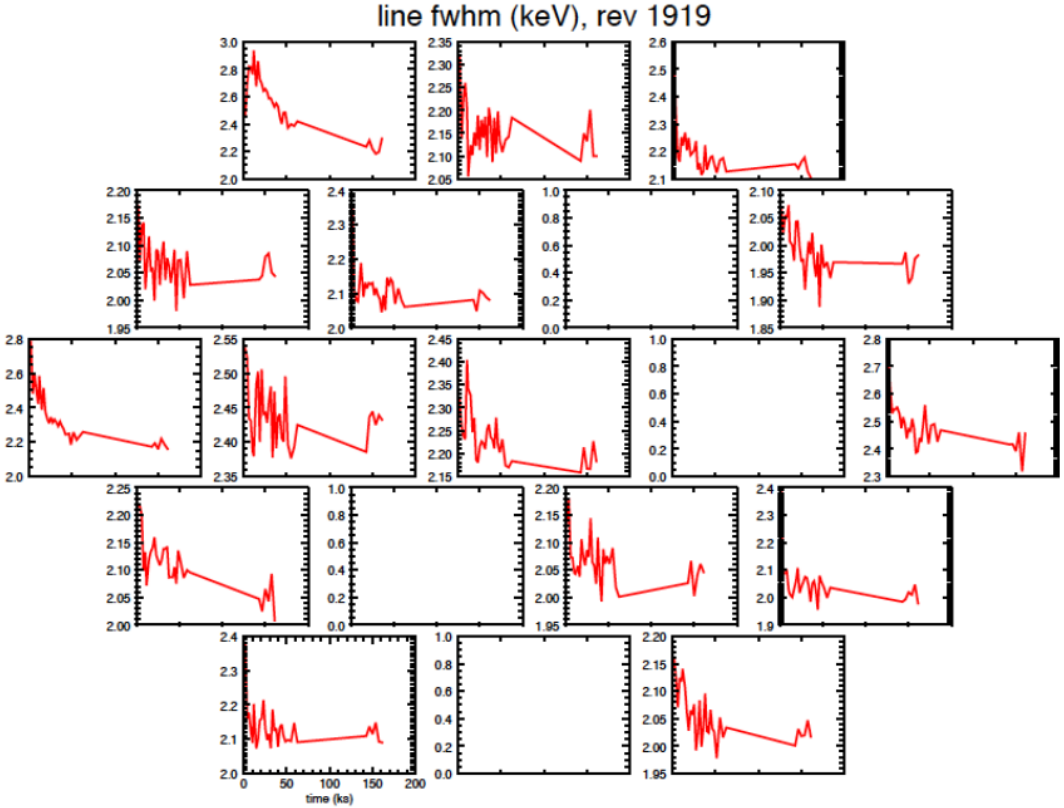


Fig. 1.7: Instrument response (198 keV line width) after switch-on, as it evolves with scw's during the first orbit

30th Annealing (Rev 1913-1919; 27 Jan – 12 Feb 2018)

- The recovery after 30th annealing is ~ok

---------- Fitted line width (FWHM,

HV[kV]	1.52	2.03	2.53	2.11
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03	2.36	2.10	2.09	2.12
04	2.54	2.50	2.42	2.42
05	0.00	0.00	0.00	0.00
06	2.14	2.17	2.07	2.05
07	2.40	2.10	2.05	2.03
08	2.70	2.56	2.55	2.54
09	2.06	2.03	2.05	2.02
10	2.50	2.31	2.17	2.22
11	2.32	2.15	2.25	2.12
12	2.47	2.69	2.83	2.74
13	2.17	2.07	2.12	2.13
14	2.78	2.50	2.50	2.47
15	2.22	2.22	2.13	2.13
16	2.38	2.19	2.13	2.10
17	0.00	0.00	0.00	0.00
18	2.16	2.09	2.10	2.08

29th annealing

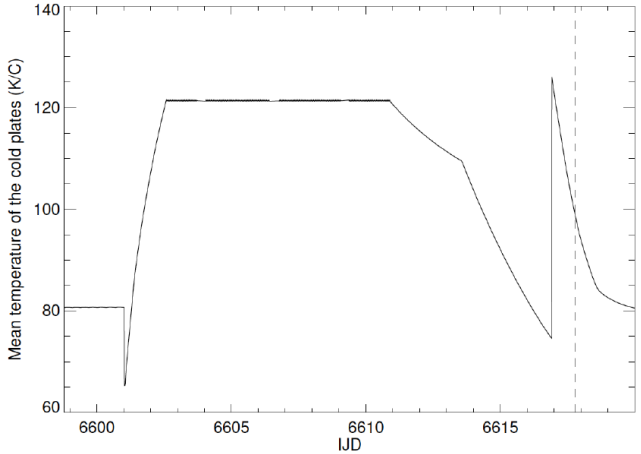
2.3185212	2.2399963	2.2322123	2.258
1.1775000	1.1775000	1.1775000	1.177
1.1775000	1.1775000	1.1775000	1.177
2.3091799	2.1551614	2.1528878	2.118
2.5250806	2.4272715	2.4914614	2.480
1.1775000	1.1775000	1.1775000	1.177
2.1411655	2.1395677	2.0775763	2.068
2.4530045	2.2113502	2.1727338	2.159
2.6665143	2.5455402	2.4929908	2.472
2.1050480	2.0276953	2.0464668	1.986
2.3866897	2.2420027	2.1764666	2.166
2.2887097	2.1815137	2.1664876	2.153
2.2751586	2.2241843	2.1997918	2.193
2.1232990	2.1205218	1.9752331	2.111
2.6245530	2.5375015	2.3803181	2.442
2.1977746	2.1588581	2.0989039	2.109
2.3846485	2.2335174	2.1747495	2.128
1.1775000	1.1775000	1.1775000	1.177
2.2926945	2.0231015	2.0267202	2.059

Uncertainty in FWHM is estimated as 0.045 keV

Table 1.1: Detector settling performance in 198 keV line,

30th Annealing

- 30th annealing showed rate anomalies
  - ☆ threshold changed during switch-on



Tests at different HV settings:

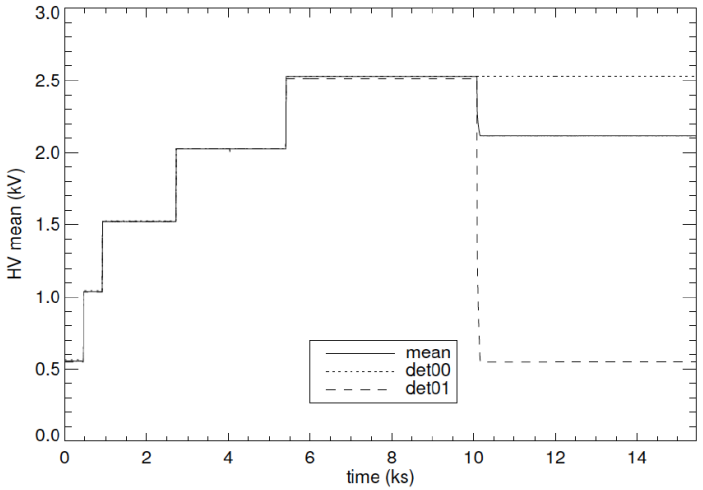


Fig. 1.9: Steps of detector HVs to scan the response as it changes, for mean, working (det-00, dotted), and defunct (det-01, dashed) detectors

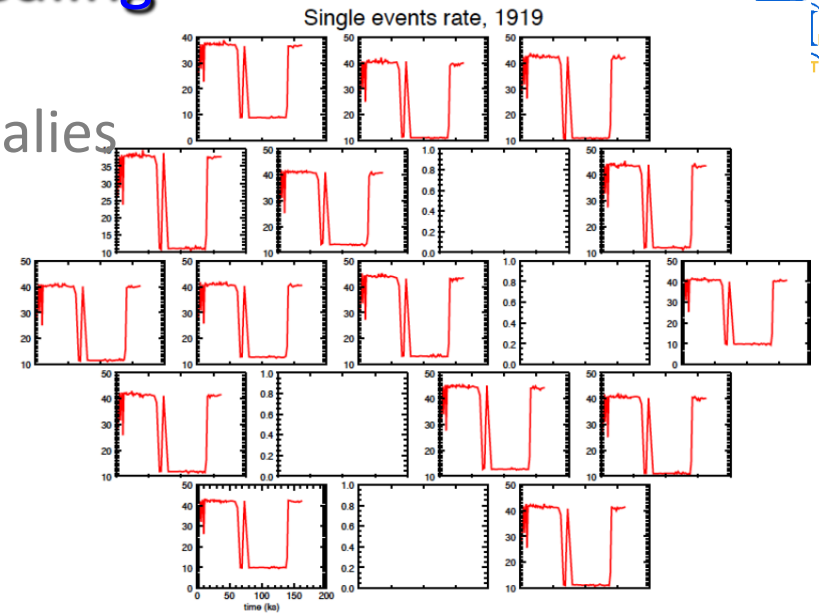


Fig. 1.6: Instrument settling: Ge detector event rates for one orbit, processed events (SE)

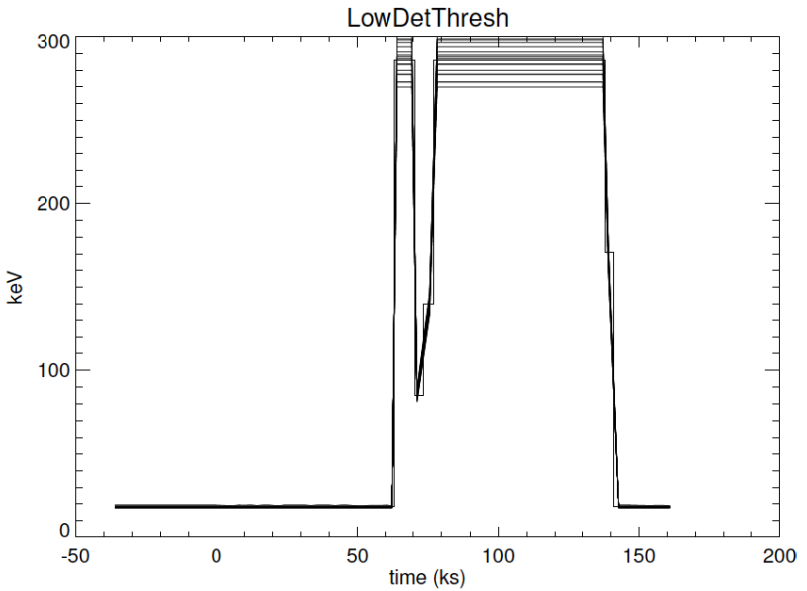
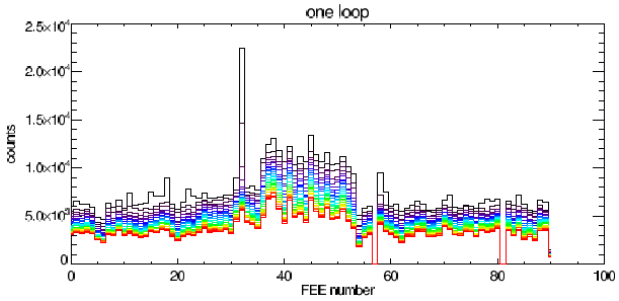


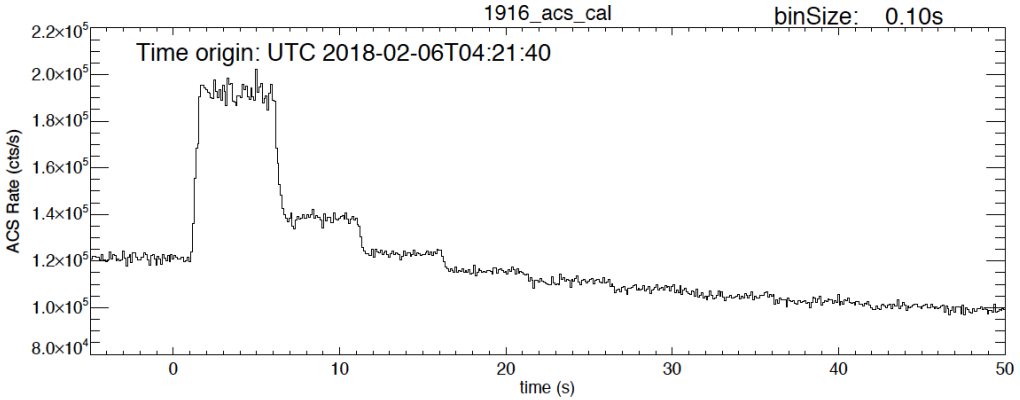
Fig. 2.1: Instrument settling: Revealing the cause for anomalous rate behavior

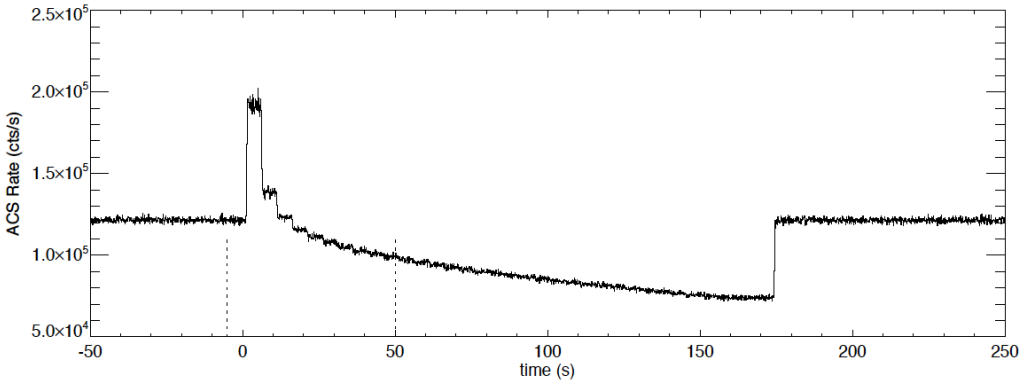
ACS Calibration

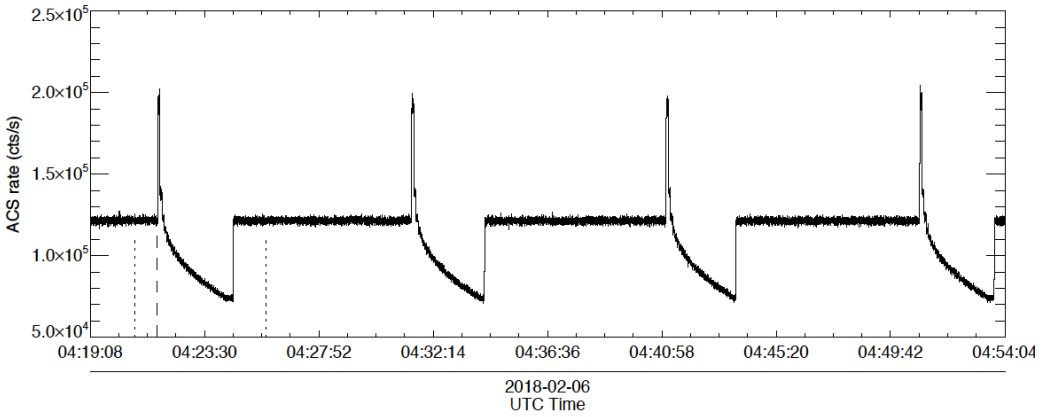
- ☆ ACS provided by MPE
  - ☞ Personnel drain (AvK)

- Regular calibrations of ACS system: threshold steps
  - ☞ Rate reduction with increasing threshold (32 steps)
  - ☞ Compare performance for 91 FEE rate outputs among successive calibrations









ACS In-Flight Calibration

- Inflight performance:
  - ☆ gain tuning early-on →
  - ☆ calibration routine:
    - ☞ measure FEE rates for threshold steps 0.08-4.9 V (0-63)
    - ☞ threshhold set at ~75 keV

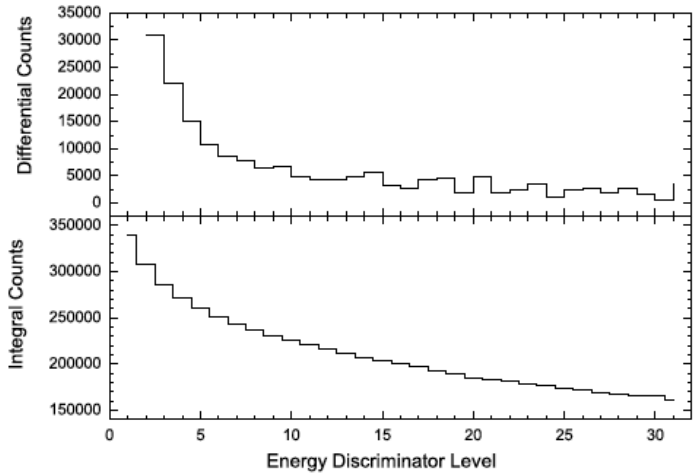


Fig. 7. Integral (bottom) and differential (top) spectra for FEE0. Extracted from ACS calibration.

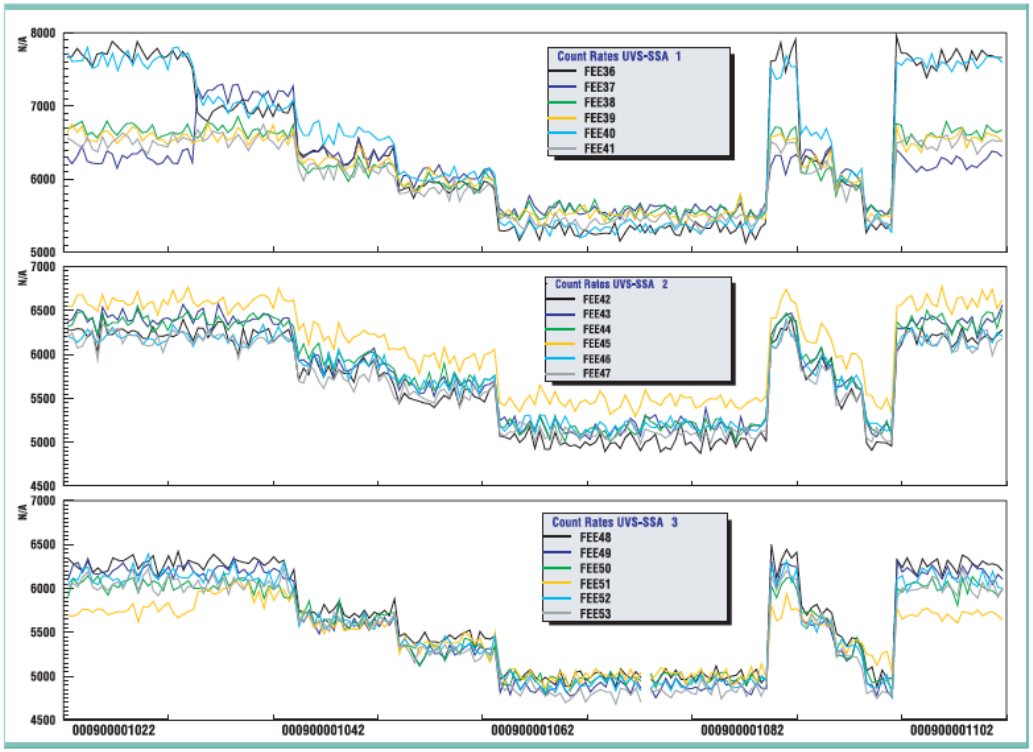
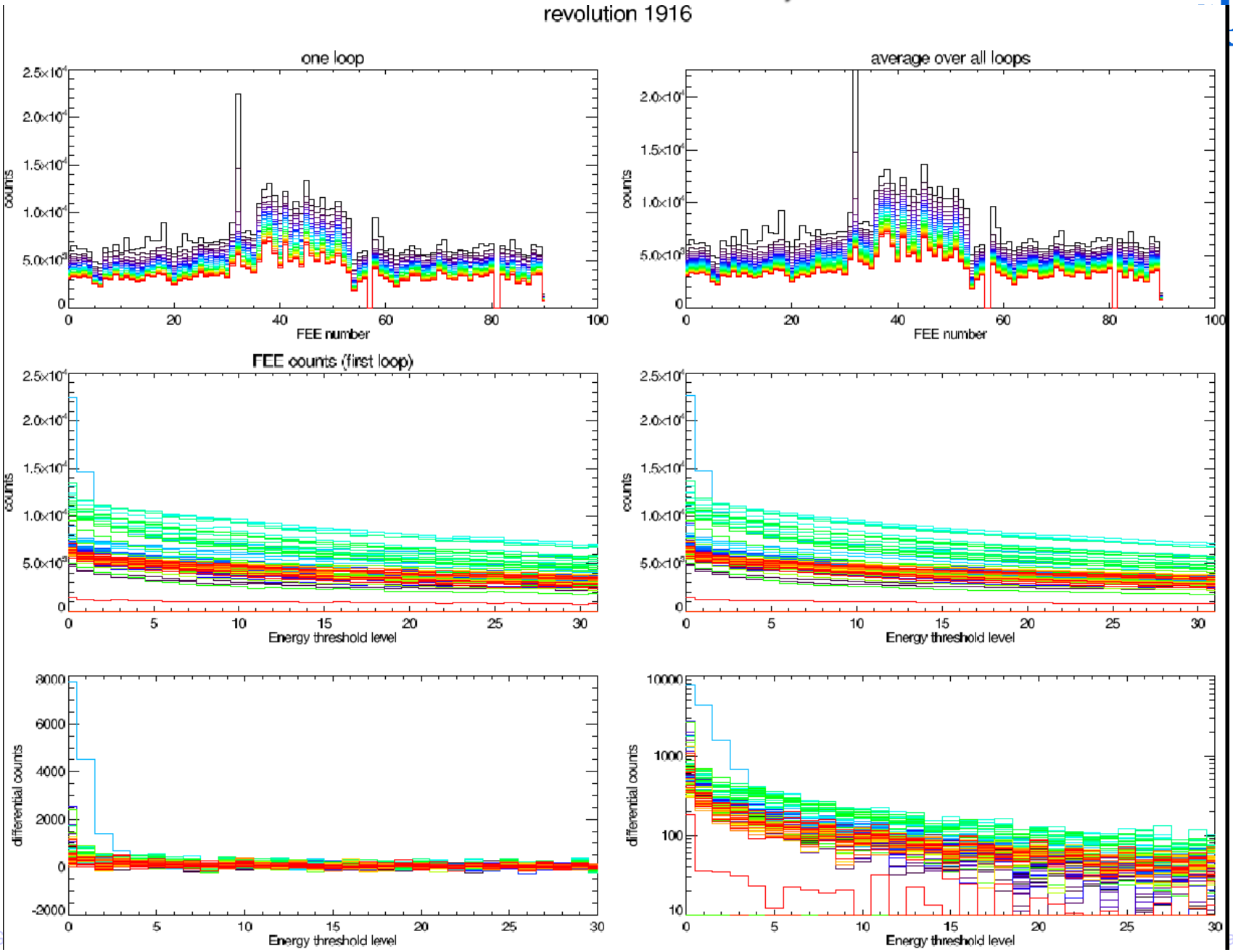


Fig. 8. Tuning of the ACS energy threshold. From left to right: 100 keV untuned, 100 keV tuned, 150 keV tuned, 200 keV tuned, 300 keV tuned. And for comparison again the untuned setting for: 100 keV, 150 keV, 200 keV, 300 keV and 100 keV.

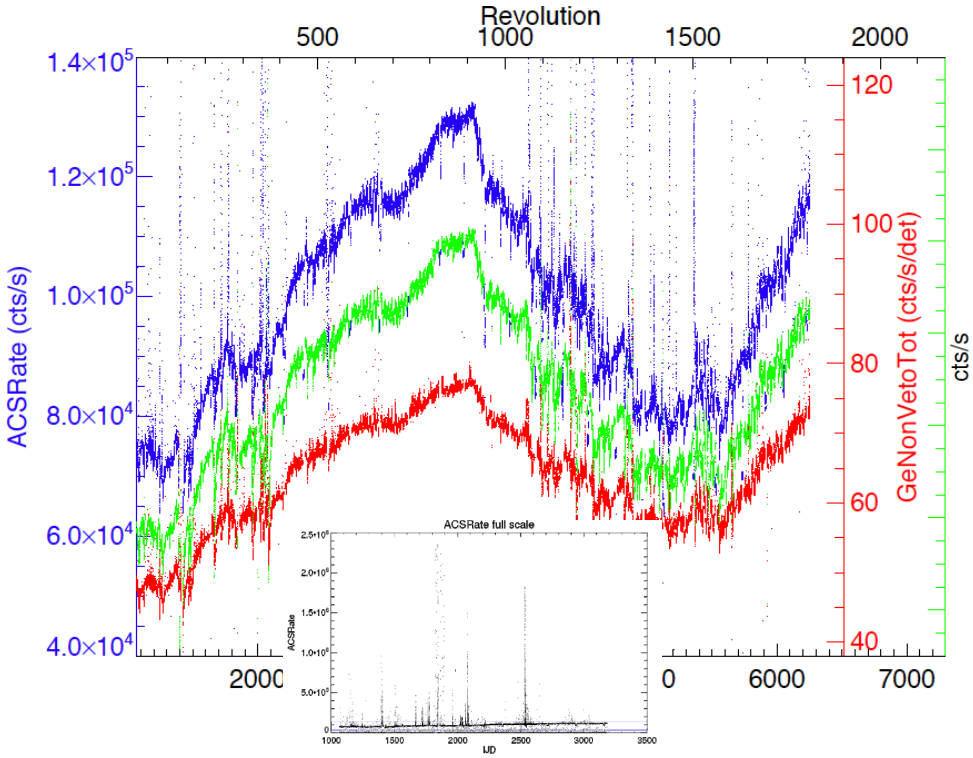
ACS Calibration and Performance

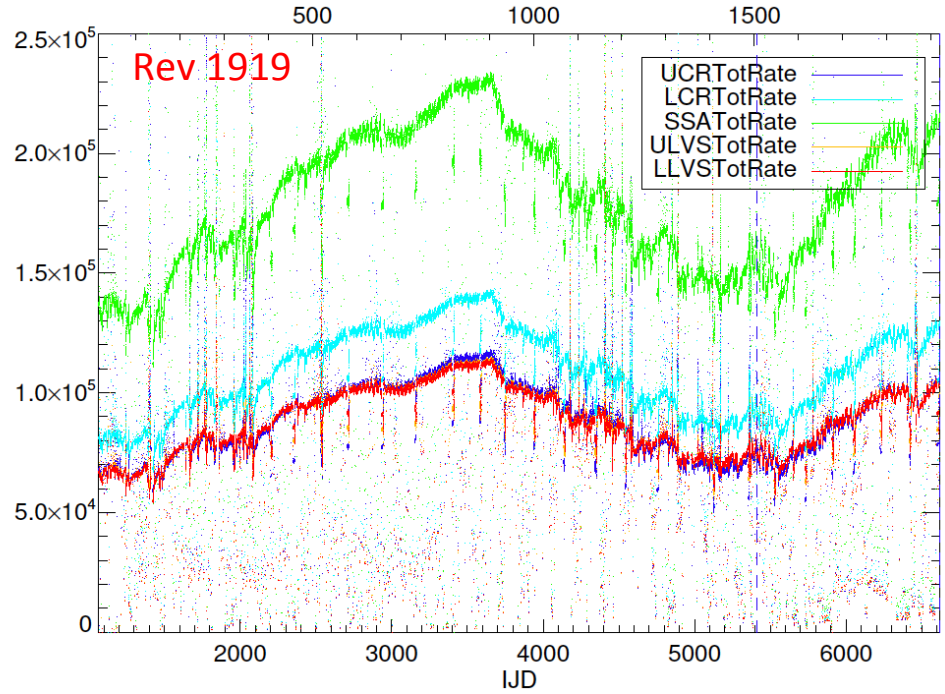
- ACS system performance
  - ☆ Rejection efficiency
    - ☞ Assessed after post-launch verification phase
    - ☞ Ge event rates reduced by ~factor 20 through ACS
    - ☞ Rejection efficiency monitored throughout the mission (functionality; drop-outs)
      - FEE # 57, 82 failed → 2 BGO units with reduced light collection efficiency
      - to be updated with new calibrations, turning off single of the four ACS sub-units
  - ☆ Gamma ray response
    - ☞ Prelaunch calibrations with radioactive source, and single connected PMTs
    - ☞ Evaluation of in-flight threshold calibrations → threshold energies & widths [keV]
    - ☞ Simulations GEANT
    - ☞ Detailed assessment in progress

ACS Calibration: rev 1916, Feb 2018

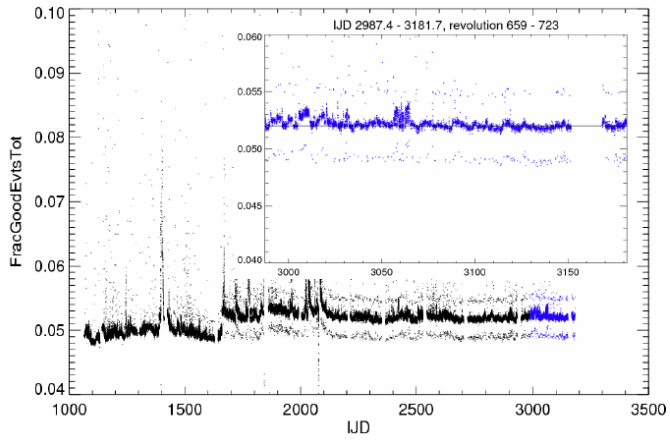


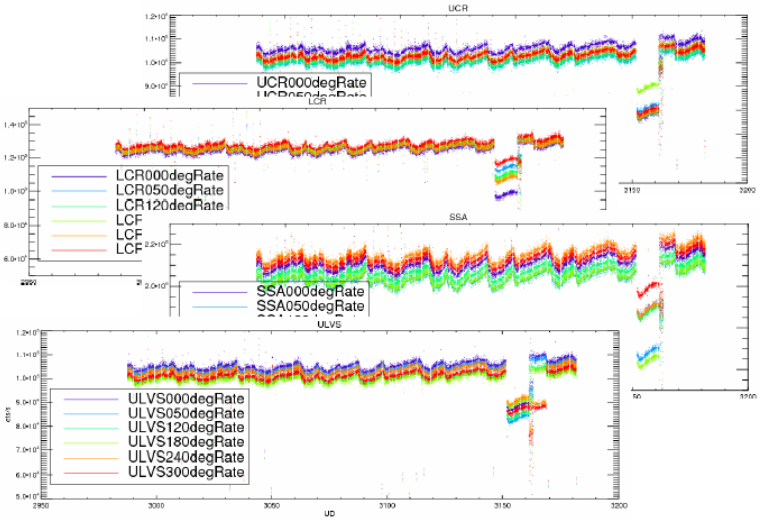
ACS In-flight performance





- 'differential' monitoring
  - any component different from the others?





ACS Performance Assessment: Summary

- ACS Detector & System Performance Assessment
  (in preparation, spring 2018)
  - ☆ Connection of prelaunch calibration to In-flight situation
    - calibration function ch=ch(E)
  - ☆ Establishment of threshold energies
    - ☞ Assumption of an incident particle spectrum, ERF threshold behavior →
      - threshold energy ← rate behavior with threshold settings
  - ☆ Iterative fitting towards a self-consistent description → E response of ACS
  - ☆ Determine shielding efficiency
    - measure Ge rates with partially switched-off ACS (tbd)
  - ☆ Determine ACS gamma-ray response (angular)
    - GEANT simulations
- Work in progress
  - ☆ Establish easily-accessible prelaunch calibrations
    - single pmt calibrations with ^{137}Cs, ^{200}Hg at 662, 279 keV
  - ☆ Analyse 15 years of ACS calibrations *(as described above)*
  - ☆ Prepare "ACS Characteristics and Performance" paper

    (with von Kienlin, Zhang, Savchenko, Siegert, et al.)