SPI Performance Monitoring

MPE Contributions

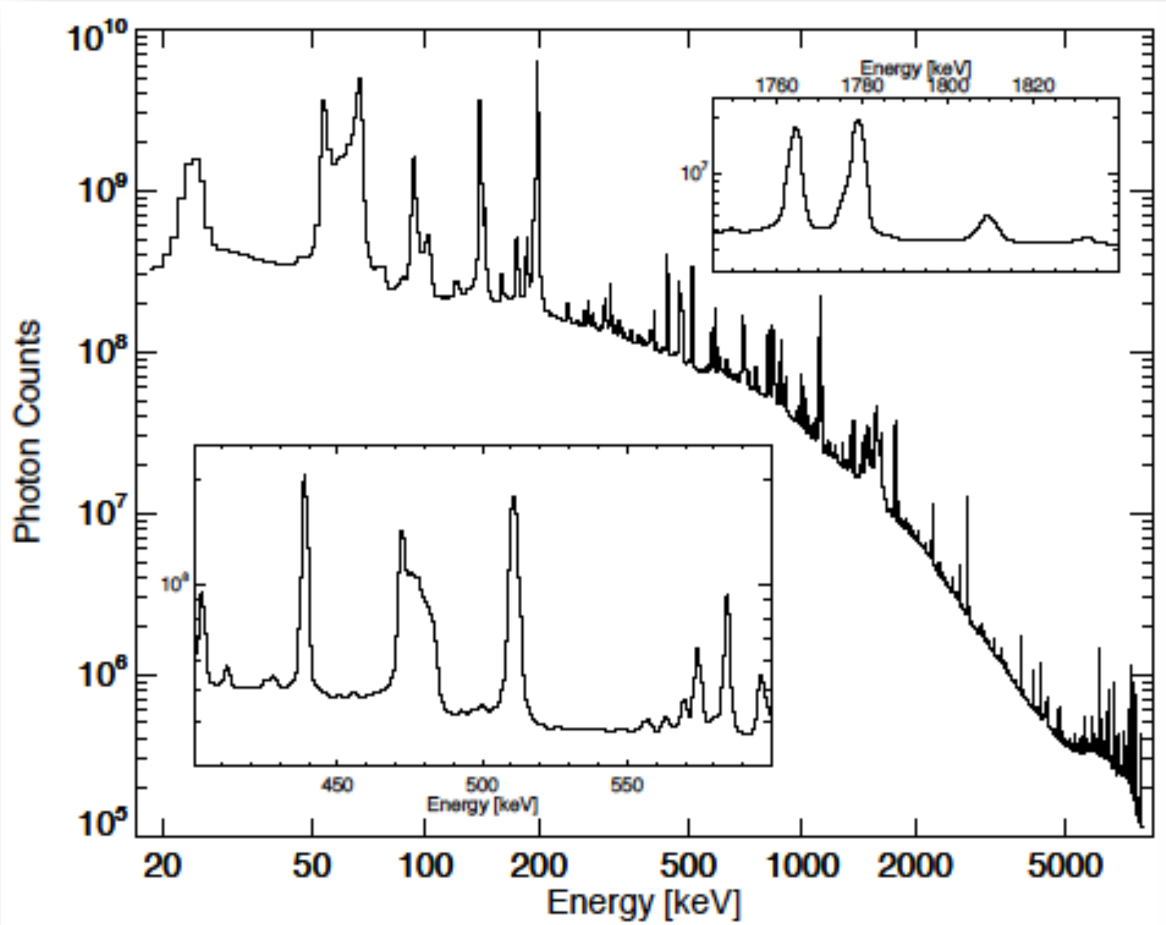
- SPI spectral response
- ACS Status and Calibration

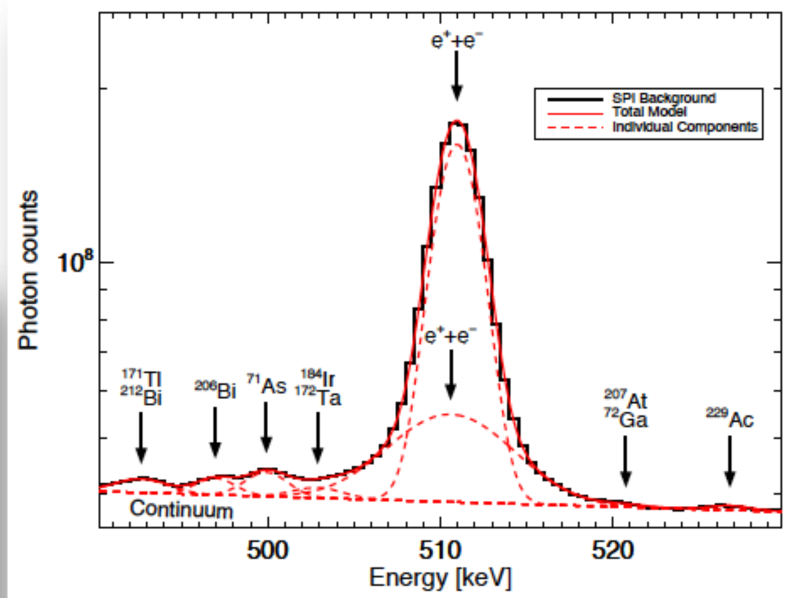
November 2019

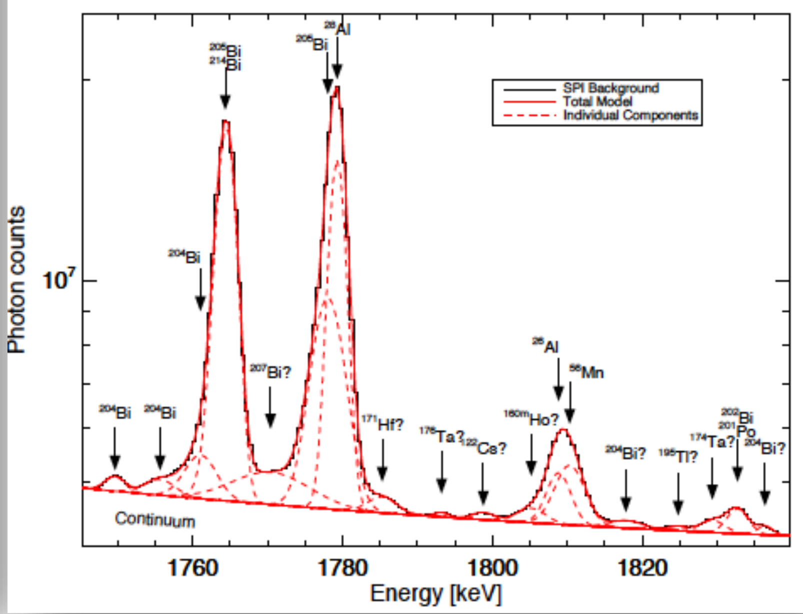
MPE routine monitoring:Spectral Fitting

- Routine decomposition of SPI detector spectra
  - ☆ spectral performance
  - ☆ background situation
  - → SPI response database (www)

  A&A papers Diehl+2018; Siegert+2019

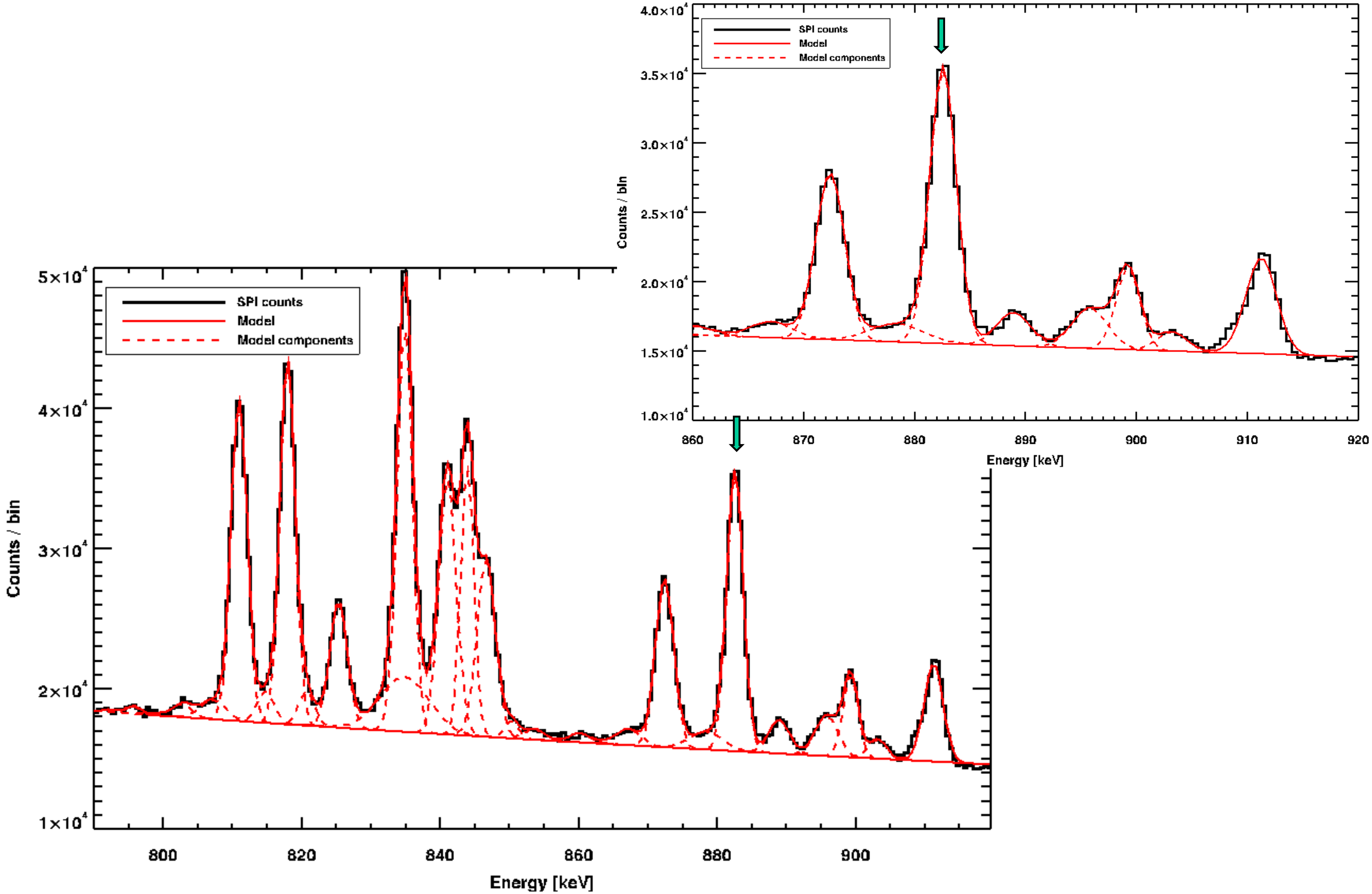






MPE routine monitoring:Spectral Fitting

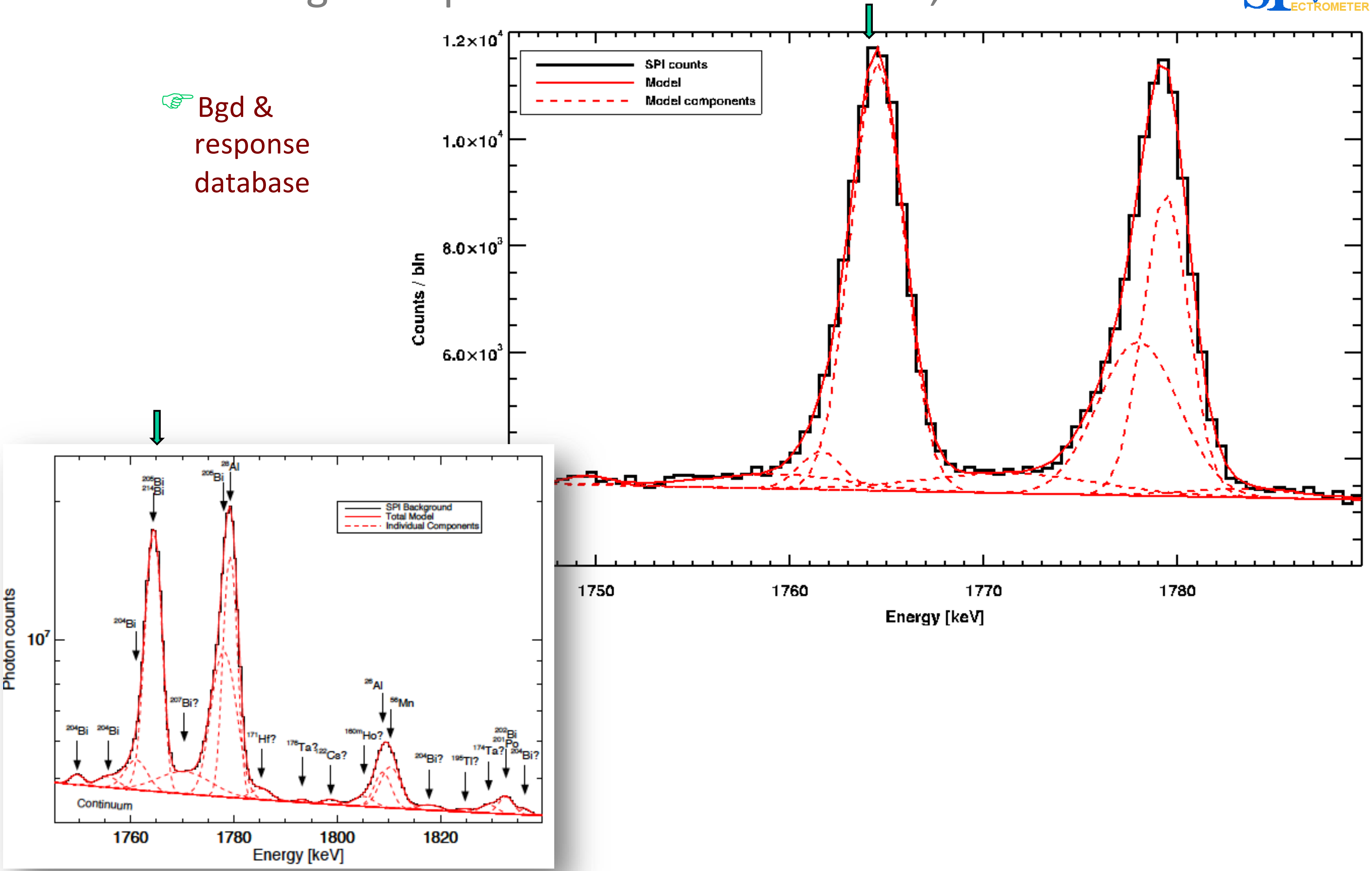
- Recent fitting examples for the 882 keV line, rev 2155



MPE routine monitoring:Spectral Fitting

- Recent fitting examples for the 1764 keV line, rev 2155

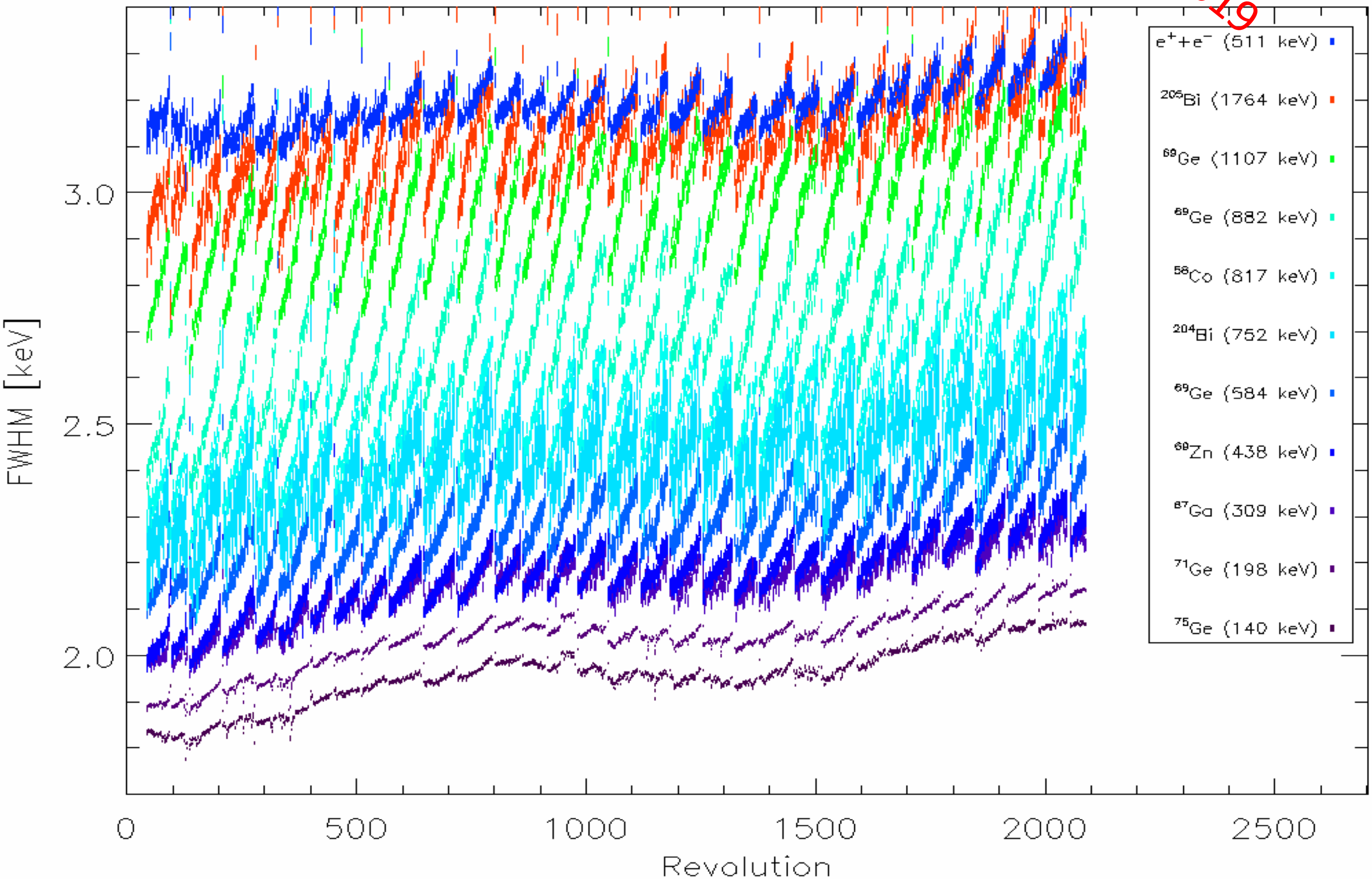
☞ Bgd & response database



SPI Performance Monitoring

- Monitor Energy Resolution in routine fits (rev. 2088)

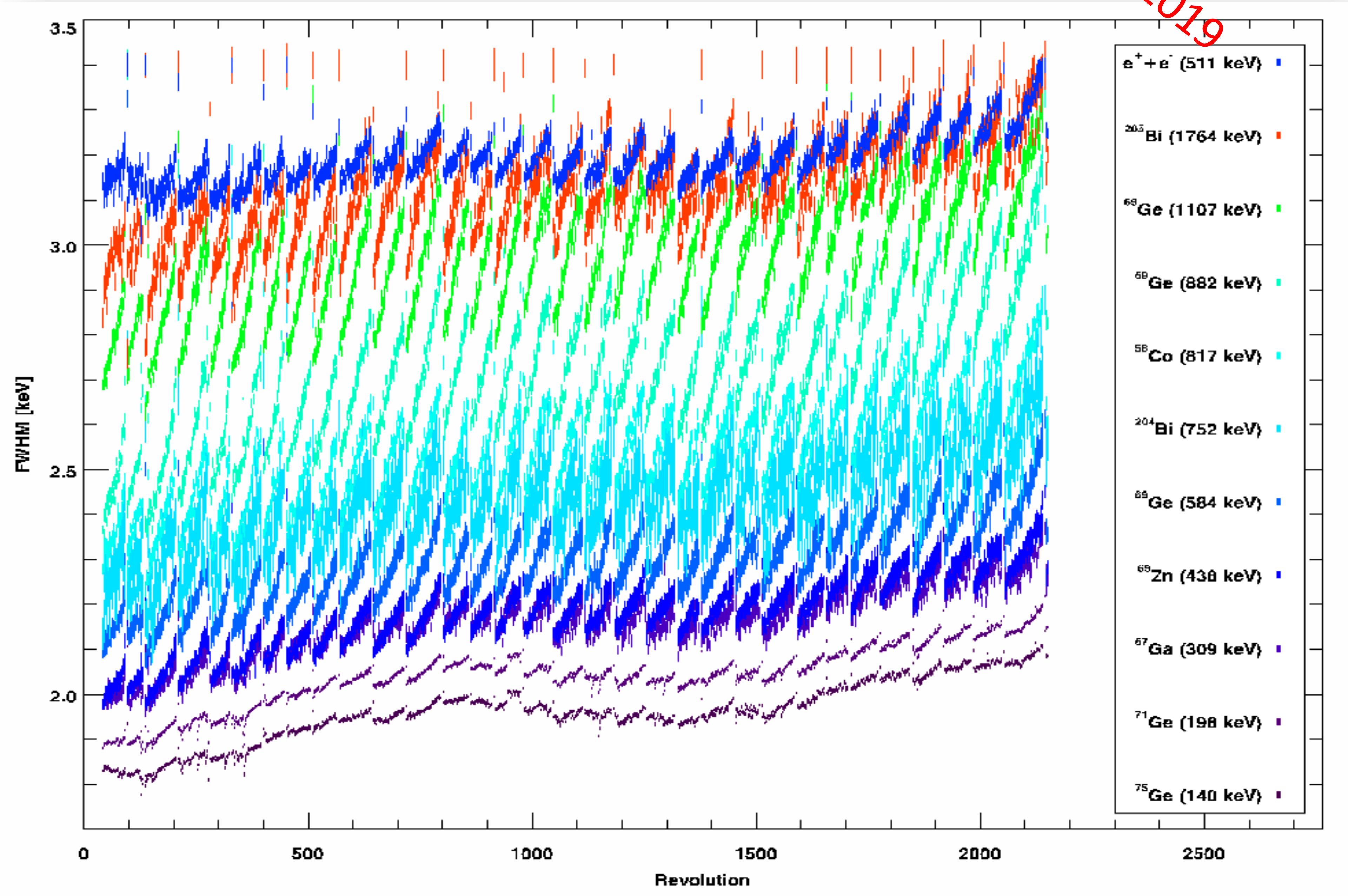
Jun 2019



SPI Performance Monitoring

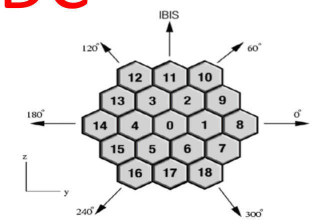
Nov 2019

- Monitor Energy Resolution in routine fits (rev 2155)



SPI Annealing Assessment: 2017 crisis →

→ MPE backup 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

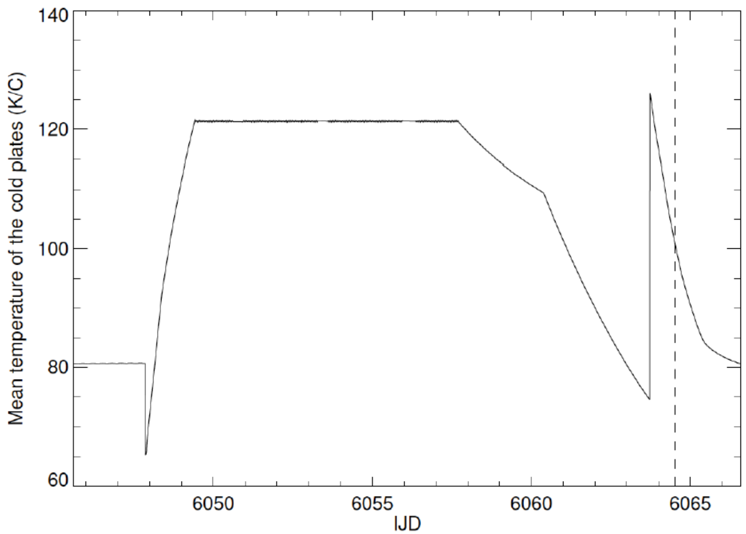


Fig. 1.1a: Annealing overview: Cold plate temperature across the annealing period. Note the units and scaling of temperature change from Kelvin to approximately ~ºC during the heating period. The SPI switch-on time is marked (dashed line).

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

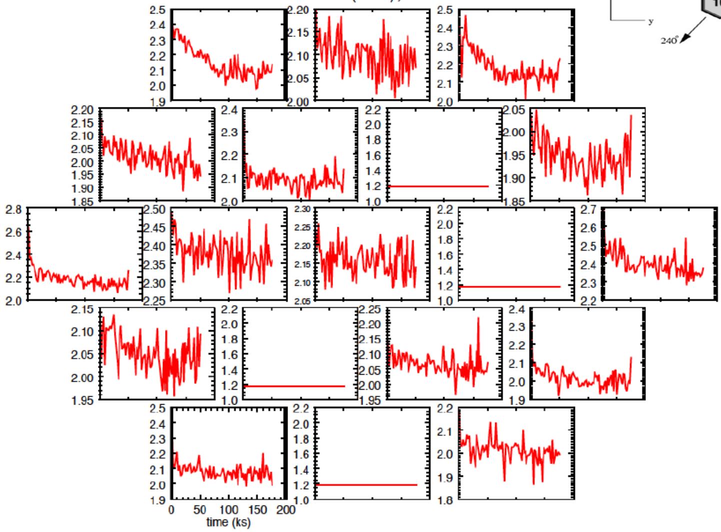


Fig. 1.7a: Instrument response (198 keV line width) after switch-on, as it evolves with scw's during the first orbit

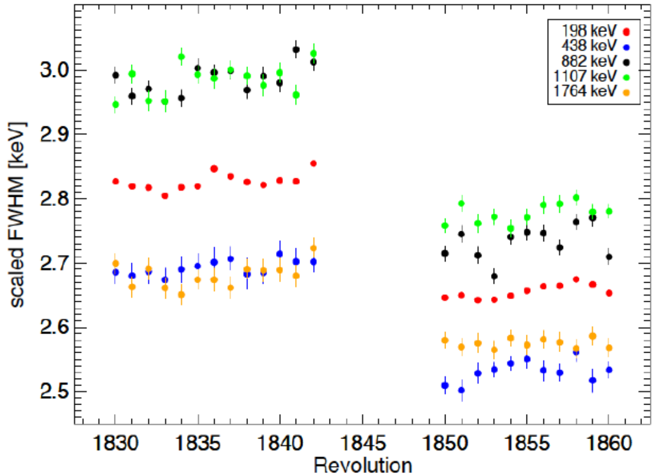
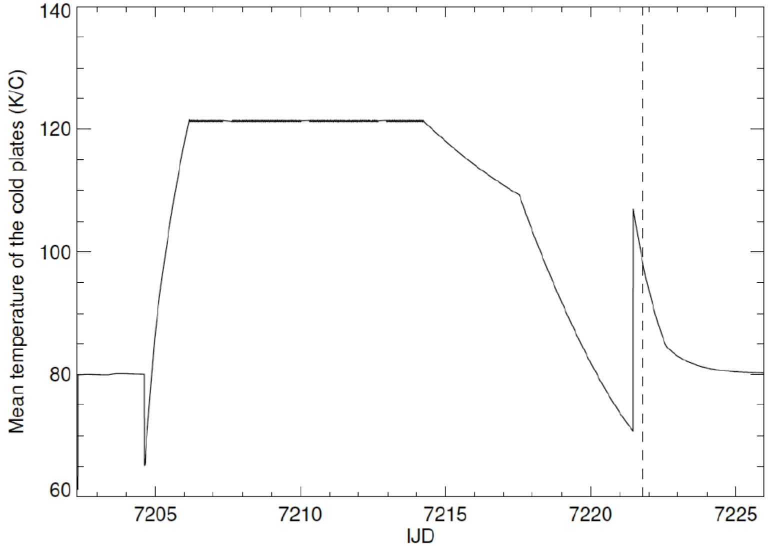


Fig. 2.2: SPI camera spectral resolution around the current annealings, no. 27-29

33^{rd} Annealing

- 33^{rd} annealing details...



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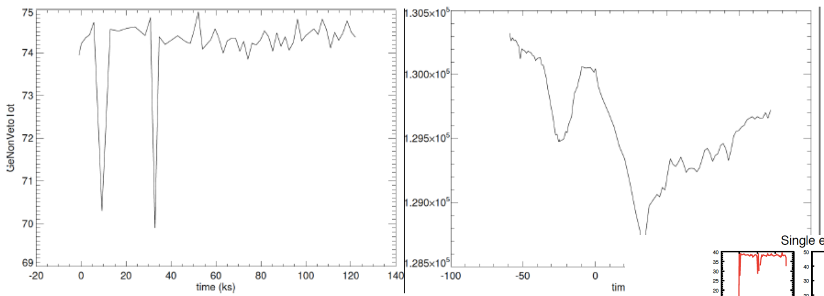


Fig. 1.2: Event rate evolution for the Ge detectors as comp

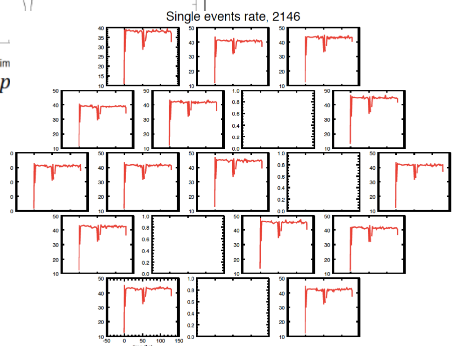


Fig. 1.6: Instrument settling: Ge detector event rates for one orbit, processed events (SE)

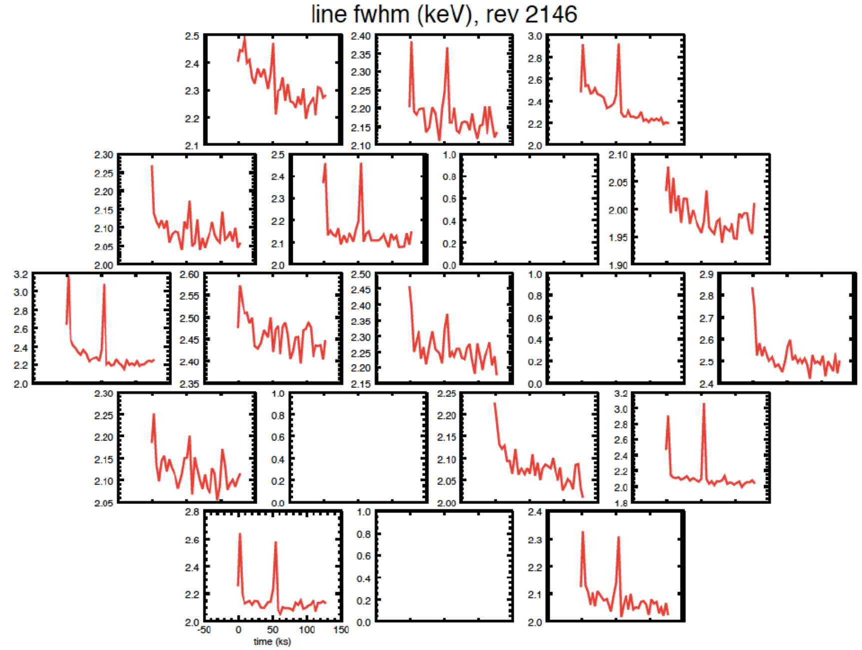


Fig. 1.7: Instrument response (198 keV line width) after switch-on, as it evolves with scw's during the first orbit

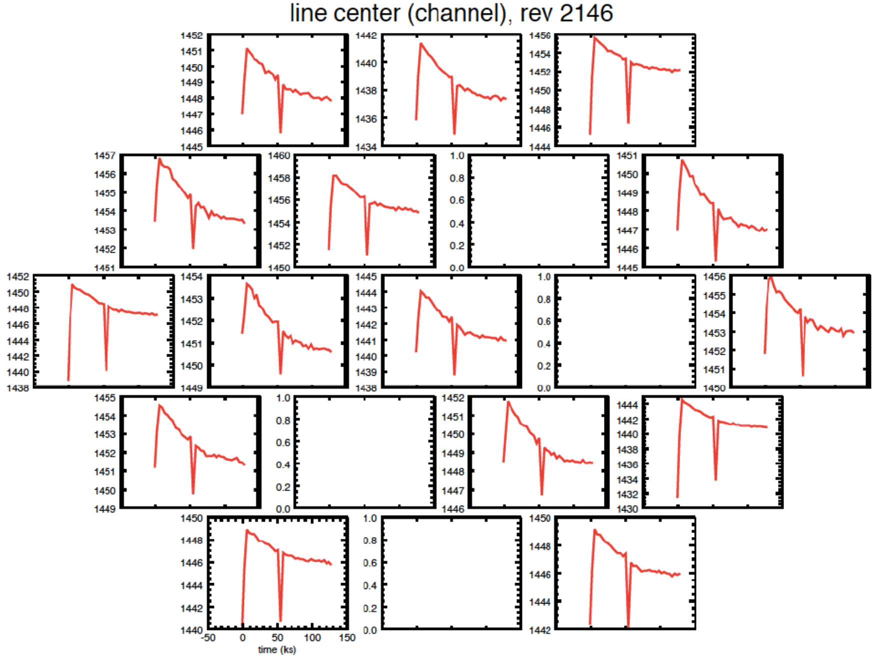


Fig. 1.8: Instrument response (198 keV line centroid, i.e. gain) after switch-on, as it evolves with scw's during the first orbit

33rd Annealing (Rev 2140-2145; 22 Sep – 10 Oct 2019)

- The recovery after 33rd annealing is ~ok

---------------------------------33rd annealing, Revolution 2046: Fitted line width (FWHM, keV)

HV (kV)	1.52	2.03	2.53	3.01	2.03	1.52	2.11
Det							
00	2.35	2.26	2.27	2.26	2.30	2.33	2.24
01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03	2.42	2.20	2.14	2.15	2.16	2.25	2.12
04	2.60	2.54	2.48	2.43	2.36	2.53	2.45
05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
06	2.14	2.11	2.11	2.06	2.04	2.04	2.07
07	2.35	2.07	2.11	2.00	2.12	2.25	2.07
08	2.69	2.60	2.53	2.50	2.53	2.52	2.51
09	2.01	2.03	2.02	1.93	1.88	1.97	2.00
10	2.54	2.44	2.45	2.42	2.28	2.50	2.27
11	2.31	2.16	2.20	2.17	2.28	2.30	2.16
12	2.27	2.44	2.39	2.49	2.21	2.18	2.30
13	2.11	2.09	2.11	2.08	2.09	2.14	2.06
14	2.52	2.45	2.34	2.27	2.27	2.43	2.21
15	2.26	2.19	2.13	2.16	2.11	2.19	2.11
16	2.39	2.15	2.14	2.16	2.21	2.22	2.08
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	2.17	2.07	2.09	2.09	2.05	2.13	2.03

Uncertainty in FWHM is estimated as 0.044 keV

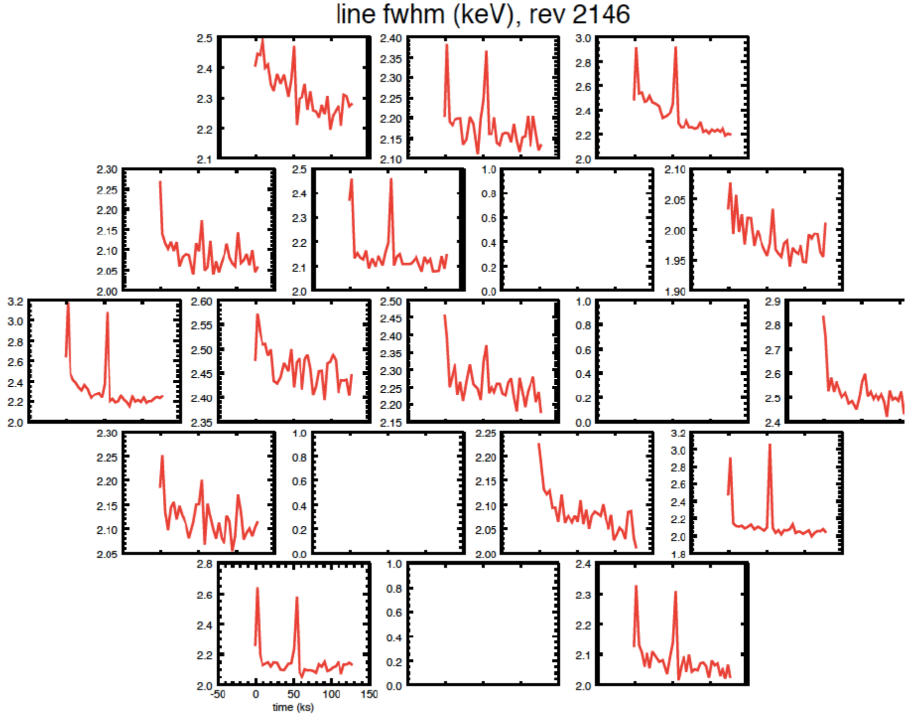


Fig. 1.7: Instrument response (198 keV line width) after switch-on, as it evolves with s
during the first orbit

33rd Annealing (Rev 2140-2145; 22 Sep – 10 Oct 2019)

- The energy calibration after 33rd annealing is ~ok

Fitted line center (channel)

HV (kV)	1.52	2.03	2.53	3.01	2.03	1.52	2.11
Det							
00	1439.8	1443.1	1443.1	1443.3	1440.6	1437.2	1441.8
01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
02	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03	1451.2	1456.8	1457.2	1457.1	1454.4	1448.0	1455.6
04	1450.7	1452.5	1452.7	1452.5	1450.7	1448.7	1451.5
05	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06	1448.2	1450.5	1450.6	1450.5	1448.1	1445.6	1449.2
07	1431.7	1442.1	1443.3	1443.2	1439.6	1428.5	1441.7
08	1452.0	1454.8	1454.9	1455.1	1452.3	1449.2	1453.6
09	1447.2	1449.7	1449.5	1449.1	1446.8	1444.1	1447.9
10	1445.3	1453.5	1454.3	1454.4	1451.1	1442.0	1452.9
11	1436.2	1439.9	1440.0	1439.8	1436.9	1433.1	1438.3
12	1447.0	1449.6	1450.1	1450.3	1447.4	1444.5	1448.7
13	1453.7	1455.8	1455.8	1455.7	1453.3	1450.9	1454.3
14	1438.7	1448.7	1449.7	1449.7	1445.7	1435.1	1448.0
15	1451.2	1453.5	1453.6	1453.5	1451.3	1448.6	1452.3
16	1439.2	1446.9	1448.0	1448.1	1444.7	1437.2	1446.7
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	1442.4	1447.5	1448.1	1448.3	1445.3	1439.4	1446.6

Uncertainty in line center is estimated as 0.1

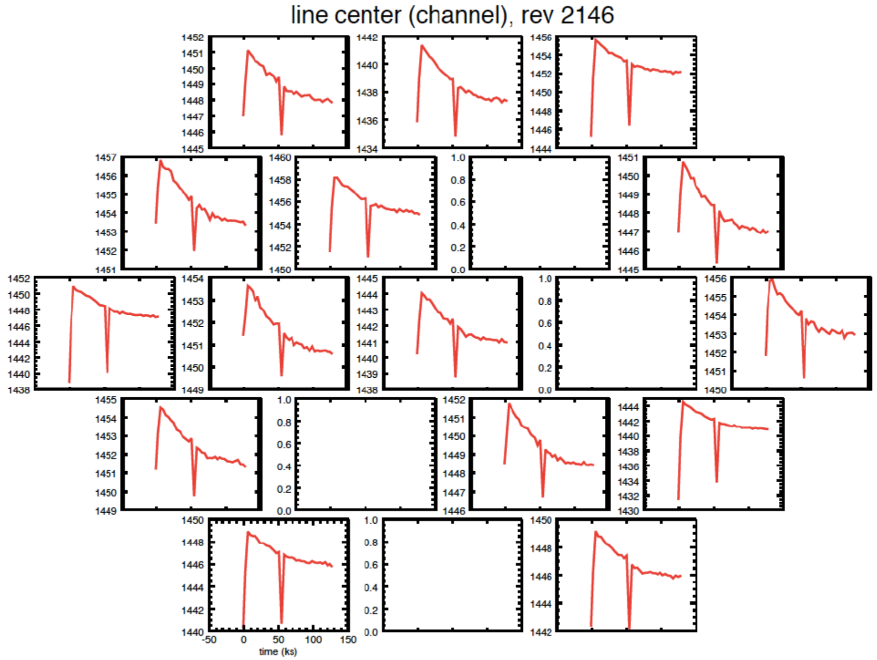
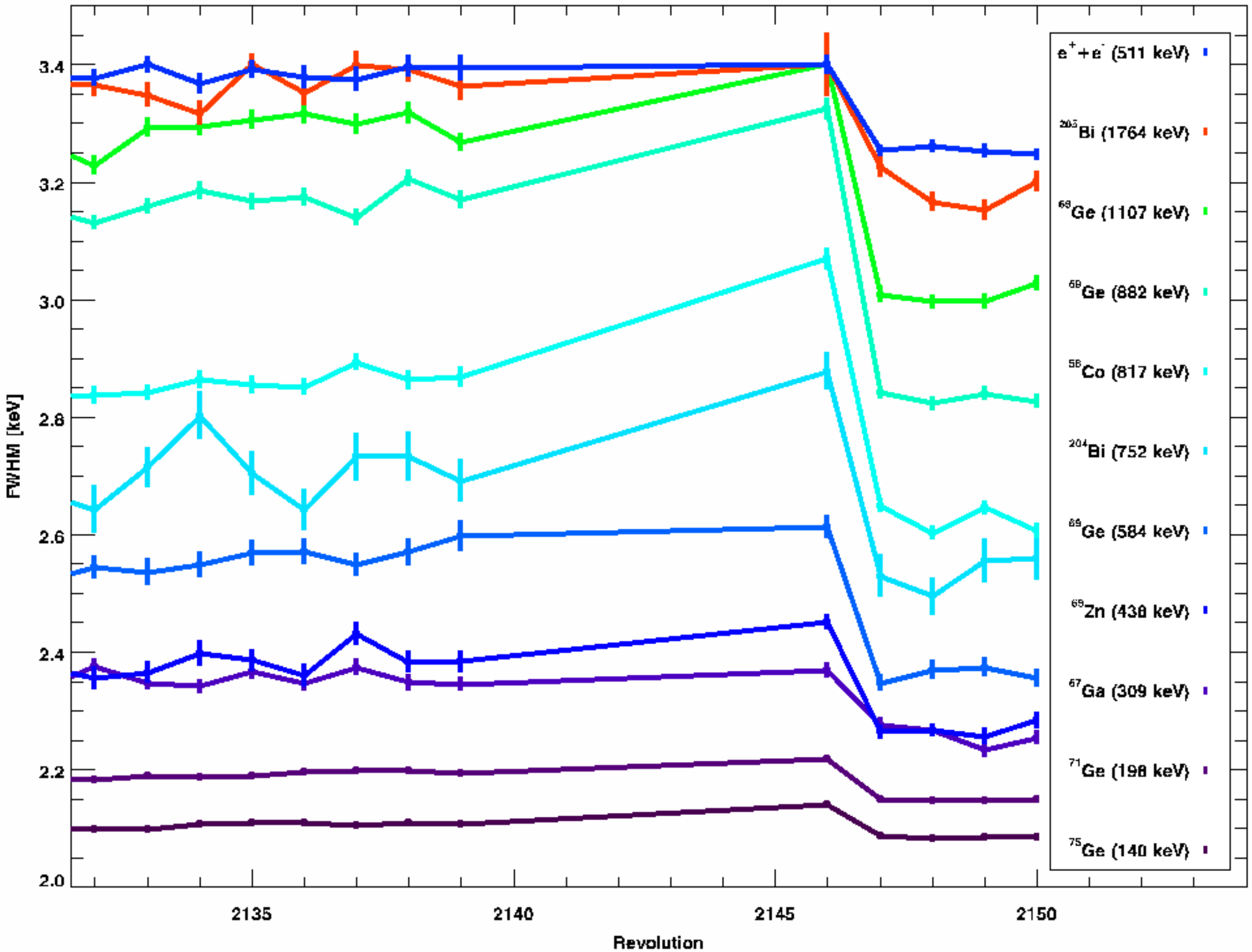


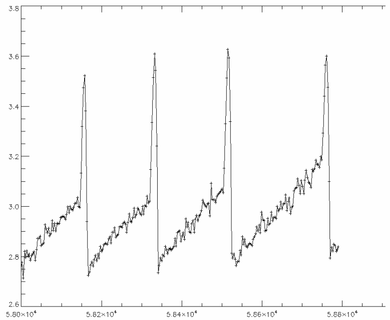
Fig. 1.8: Instrument response (198 keV line centroid, i.e. gain) after switch-on, as it evolves with scw's during the first orbit

33rd Annealing (Rev 2140-2145; 22 Sep – 10 Oct 2019)

- The most-recent evolution of spectral resolution



☆ 882 keV line



Testing Different HV settings (rev 2155)

- HV impact on resolution:
  - Minor improvement at higher HV
  - No need for changes

--------------------HV test, Revolution 2151: Fitted line width (FWHM,

HV (kV)	2.11	1.52	2.03	2.32	3.01	2.23	2.11
Det							
00	2.27	2.23	2.35	2.28	2.29	0.00	2.24
01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03	2.07	2.23	2.14	2.13	2.18	0.00	2.08
04	2.40	2.48	2.36	2.47	2.37	0.00	2.37
05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
06	2.00	2.06	2.04	2.09	2.13	0.00	2.01
07	2.01	2.27	2.09	2.03	2.01	0.00	2.04
08	2.37	2.46	2.49	2.36	2.41	0.00	2.40
09	1.93	1.99	1.97	1.93	1.97	0.00	1.95
10	2.29	2.36	2.17	2.19	2.34	0.00	2.23
11	2.13	2.23	2.14	2.20	2.14	0.00	2.12
12	2.21	2.18	2.20	2.18	2.34	0.00	2.17
13	2.07	2.14	2.07	2.08	2.07	0.00	2.10
14	2.19	2.41	2.15	2.22	2.17	0.00	2.18
15	2.08	2.13	2.17	2.12	2.10	0.00	2.09
16	2.10	2.23	2.16	2.17	2.13	0.00	2.09
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	2.12	2.16	2.12	2.13	2.08	0.00	2.05

Uncertainty in FWHM is estimated as 0.042 keV

Special High-Voltage Variation Test

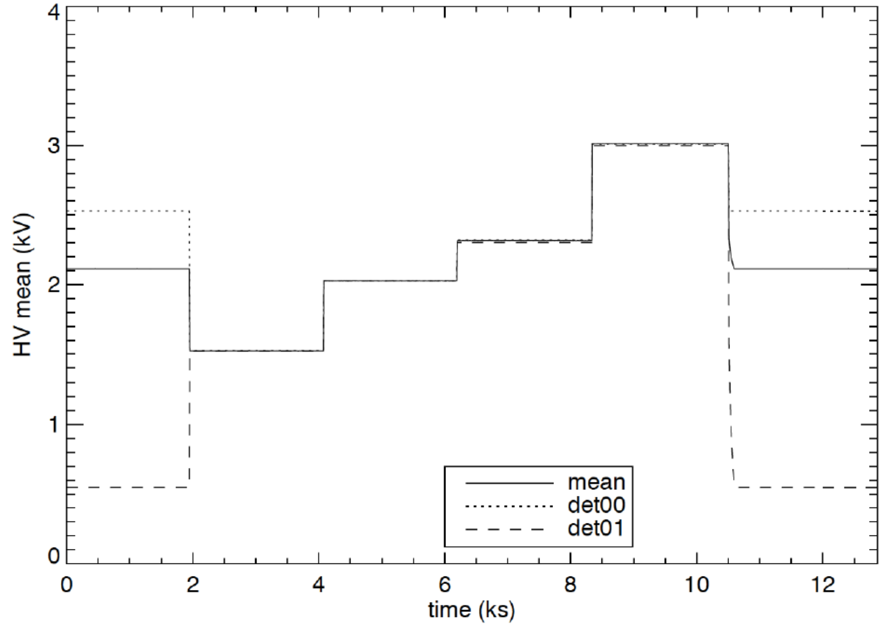


Fig 1.10: HV settings during the detector performance test in rev 2151

HV (nominally 1.5kV, 2.0kV and 2.25kV), see OCR#407

Testing Different HV settings (rev 2155)

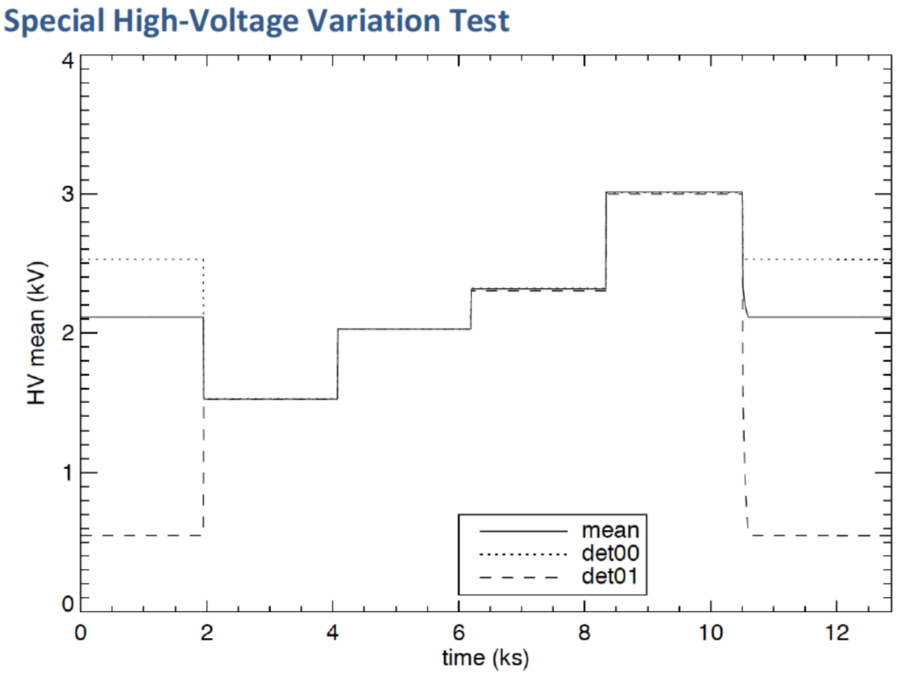


Fig 1.10: HV settings during the detector performance test in rev 2151

HV (nominally 1.5kV, 2.0kV and 2.25kV), see OCR#407

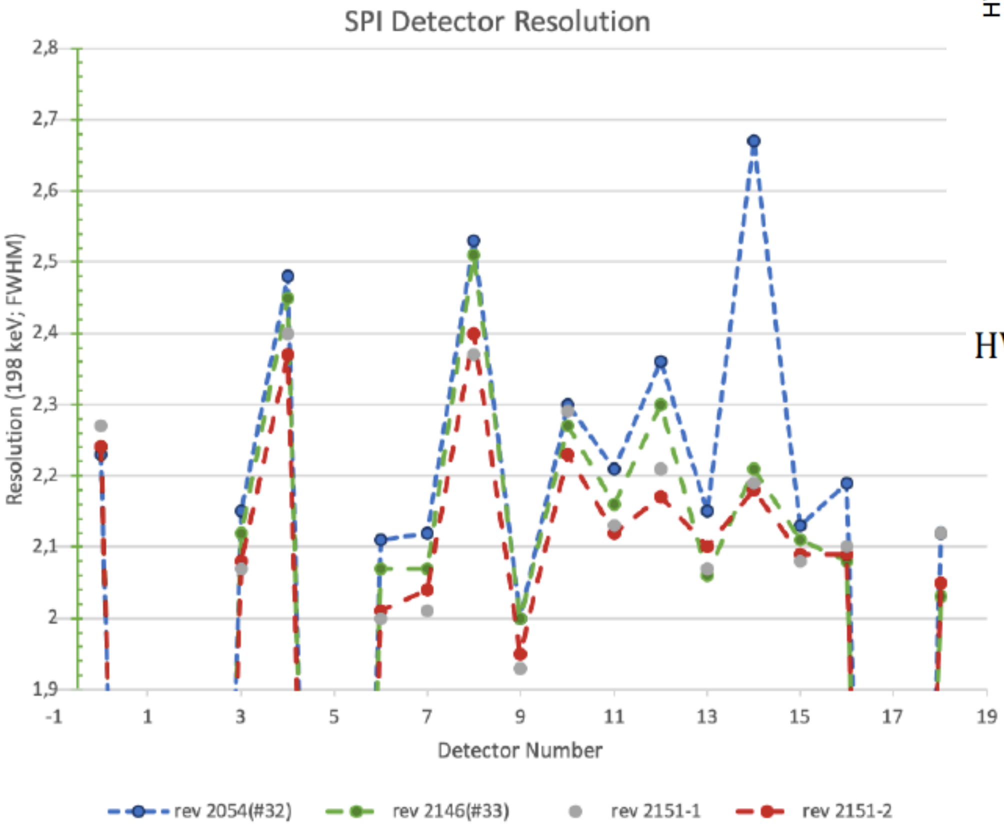


Fig 1.11: Detector resolutions after 33rd annealing versus during HV test at 5 revolutions later

☆ After annealing, resolution settles

The annealings in summary

- Compare resolution recovery for all annealings: :-(

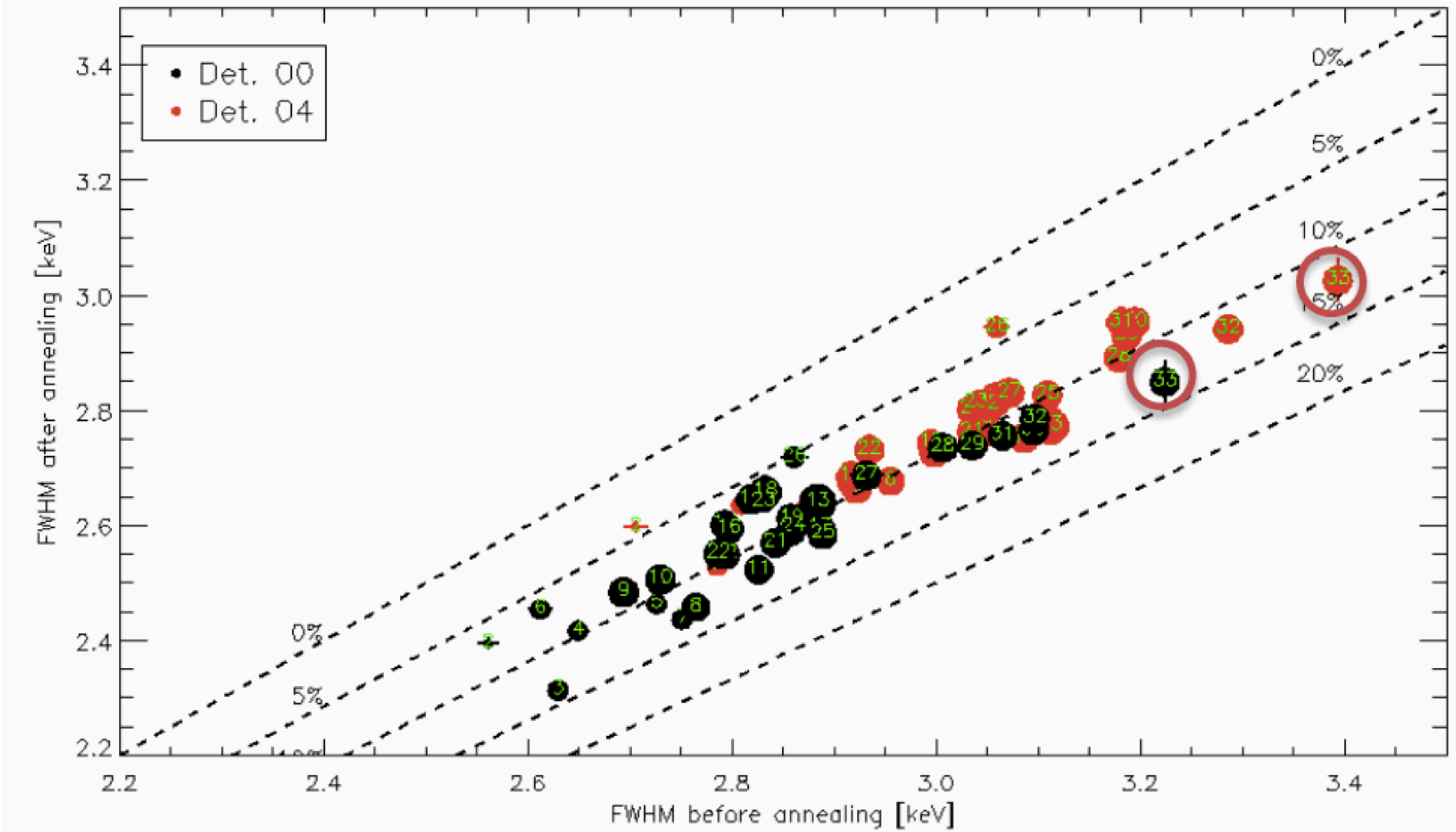
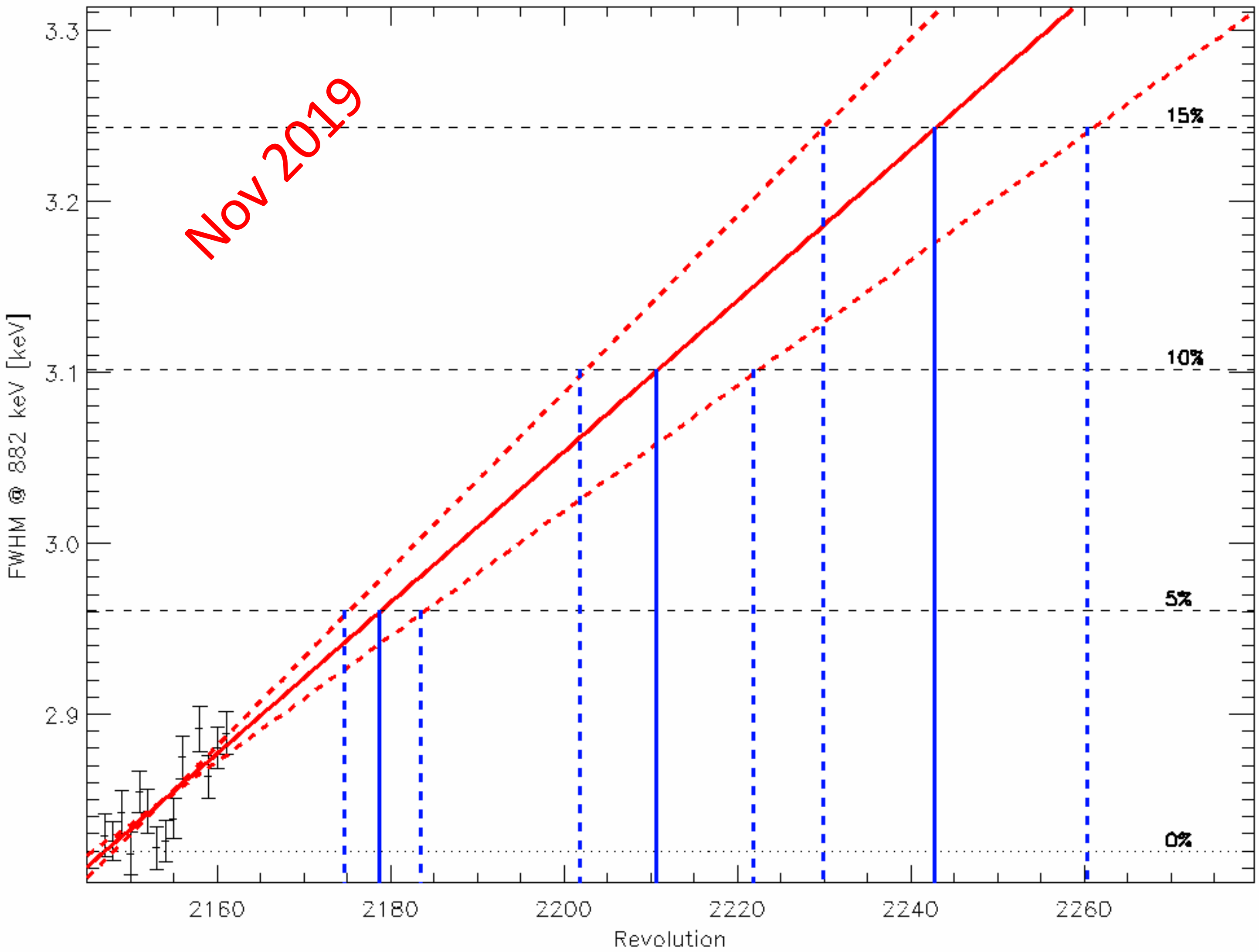


Fig. 3.1: Spectral resolution before/after the current annealing for two detectors, in context, with data marked from the last annealing

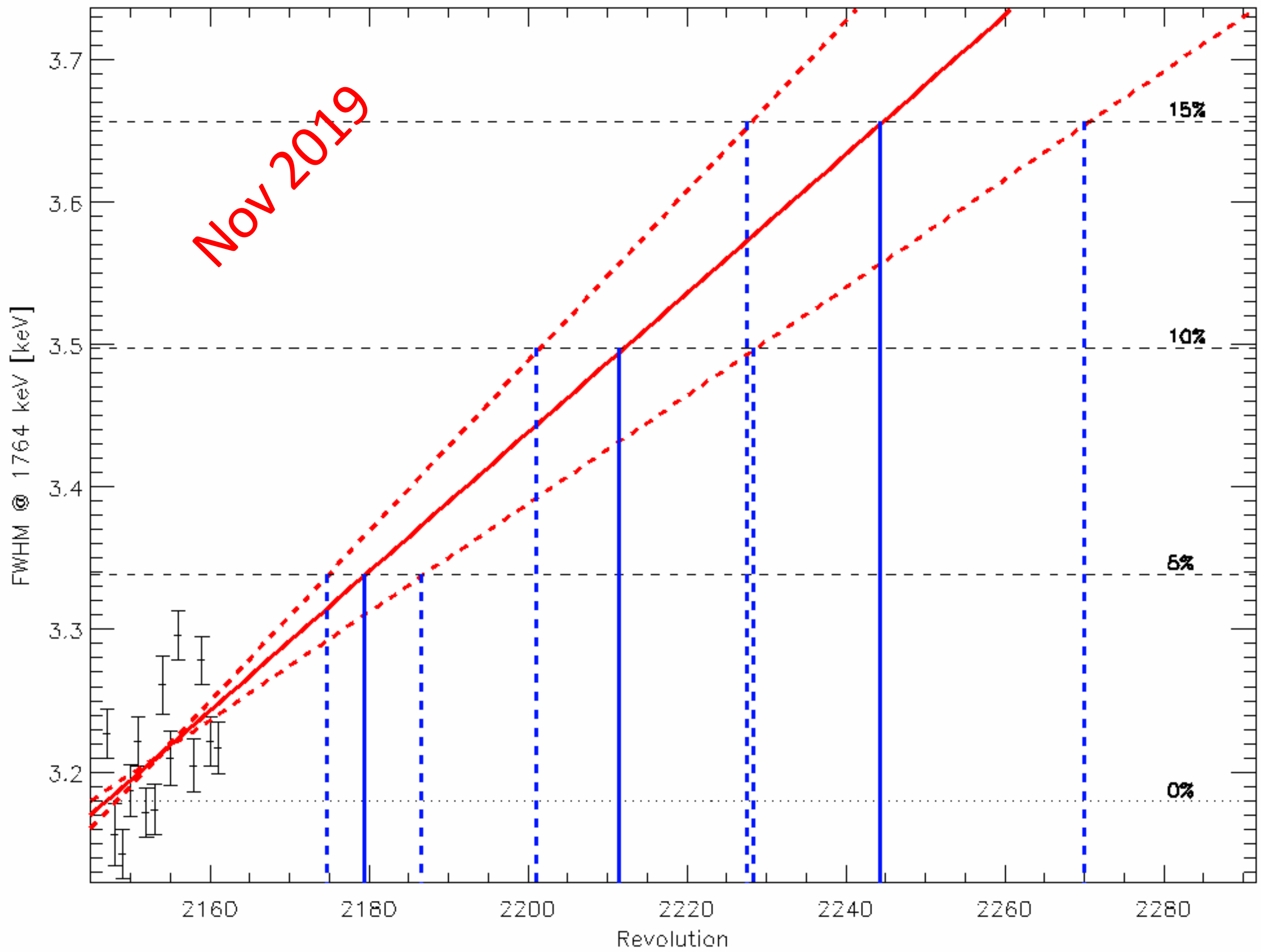
Forecasting the time of the next annealing

- Latest evolution of spectral resolution (rev 2146-2161)
  - ☆ Linear extrapolation of degradation, goal~10%, use uncertainties
    - ➔ Next annealing suggested near revolutions [2202-2222]



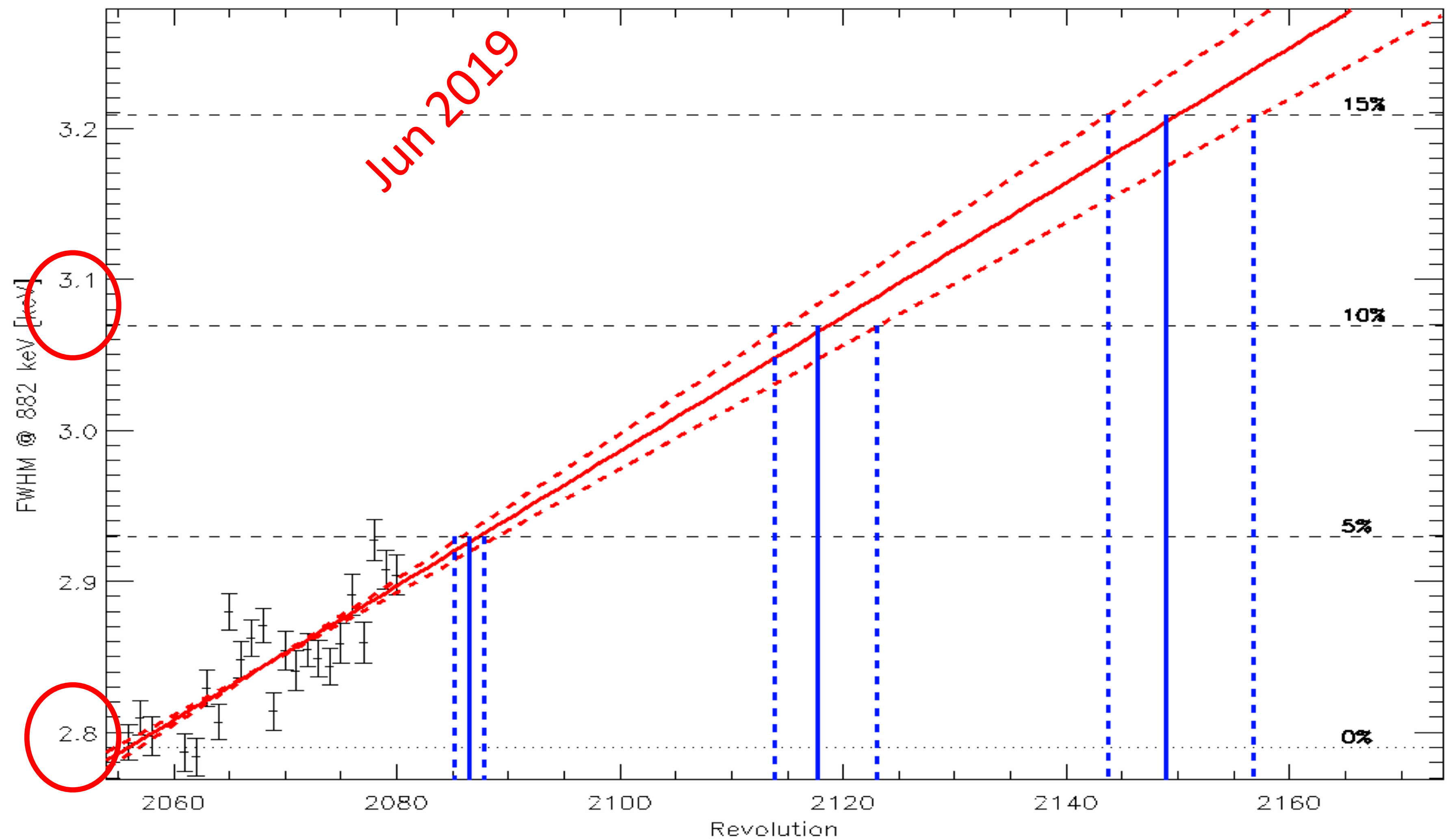
Forecasting the time of the next annealing

- Latest evolution of spectral resolution (rev 2146-2161)
  - ☆ Linear extrapolation of degradation, goal~10%, use uncertainties
    - ➔ Next annealing suggested near revolutions [2201-2228]



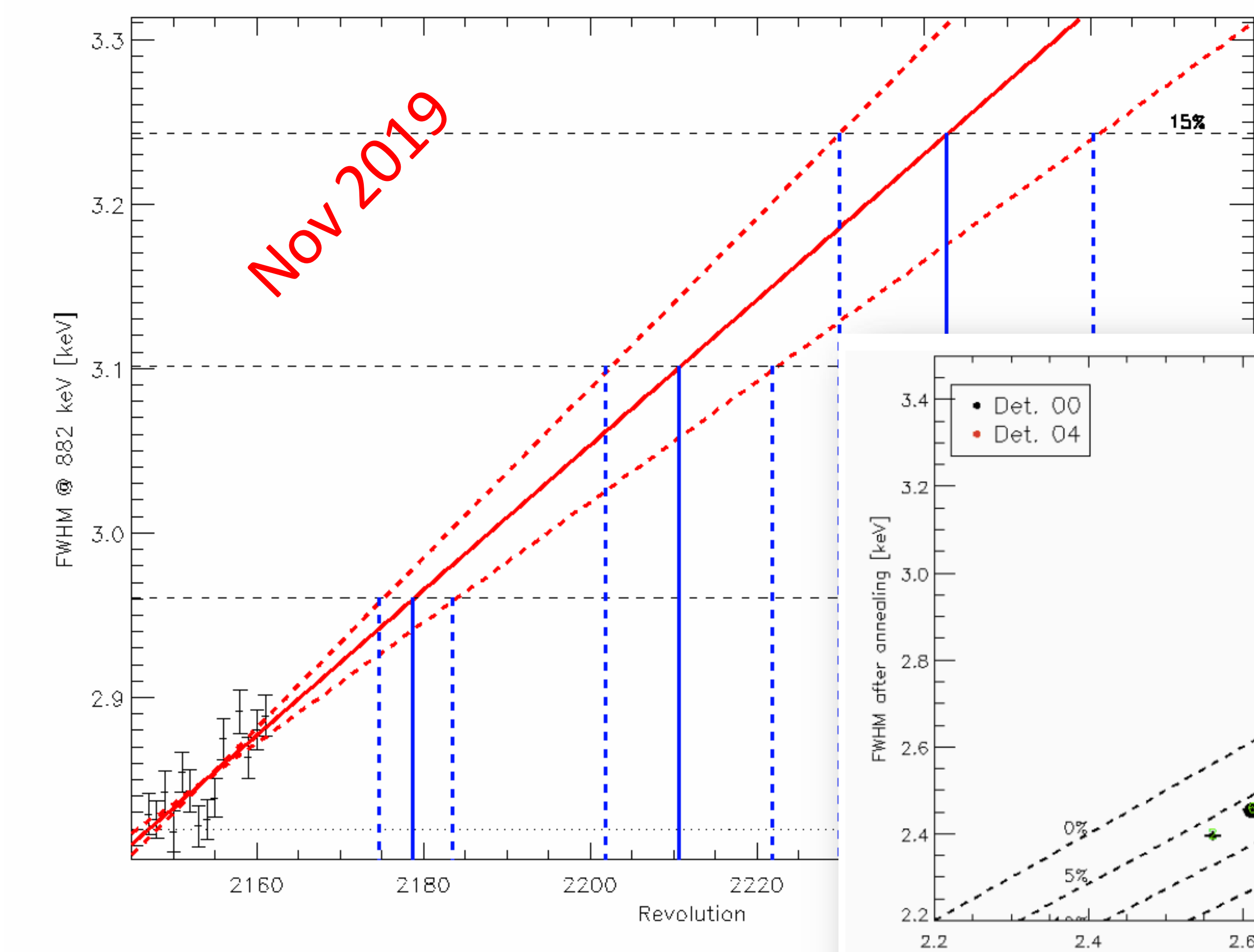
Forecasting the time of the 33rd annealing

- From evolution of spectral resolution rev 2056 to 2080
  - ☆ Linear extrapolation of degradation, goal~10%, use uncertainties
    - ➔ revolutions [2113-2122] ...was 2140!



Forecasting the time of the next annealing

- Latest evolution of spectral resolution (rev 2146-2161)
  - ☆ Linear extrapolation of degradation, goal~10%, use uncertainties
    - ➔ Next annealing suggested no later than revolution ~2220



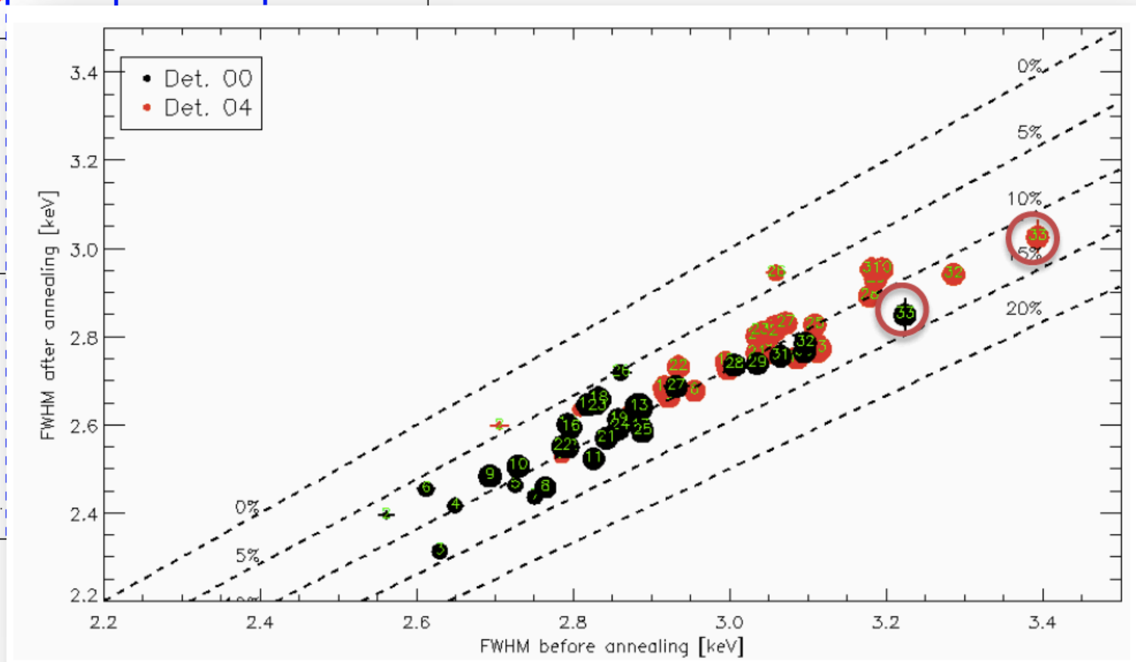
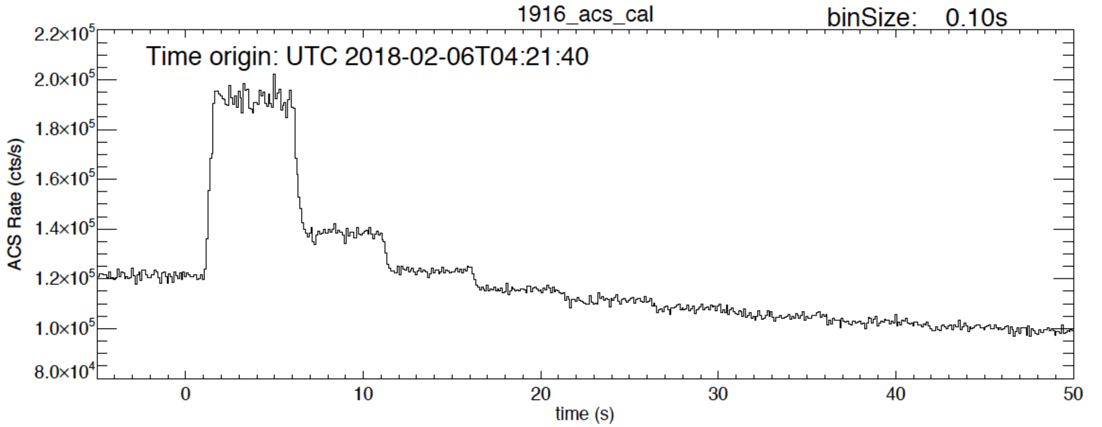
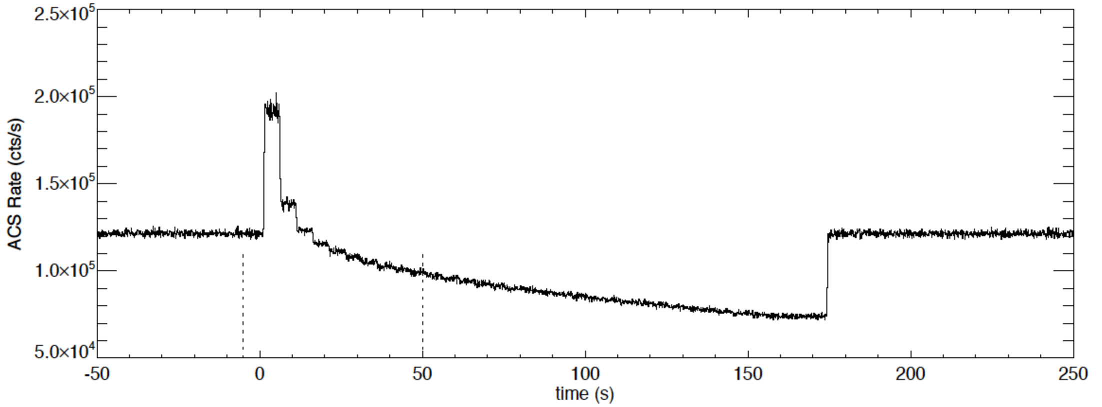


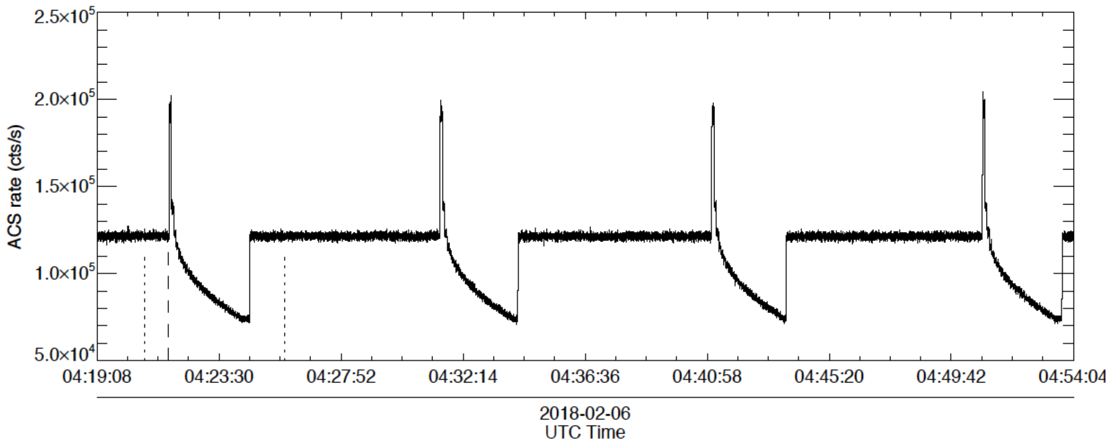
Fig. 3.1: Spectral resolution before/after the current annealing for two detectors, in context, with data marked from the last annealing

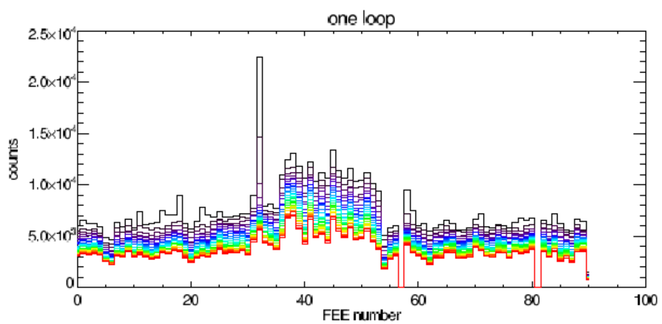
ACS Calibration

- Regular calibrations of ACS system: threshold steps
  - Rate reduction with increasing threshold (32 steps, ~50 loops)
  - Compare performance for remaining 89 of 91 FEE rate outputs among successive calibrations



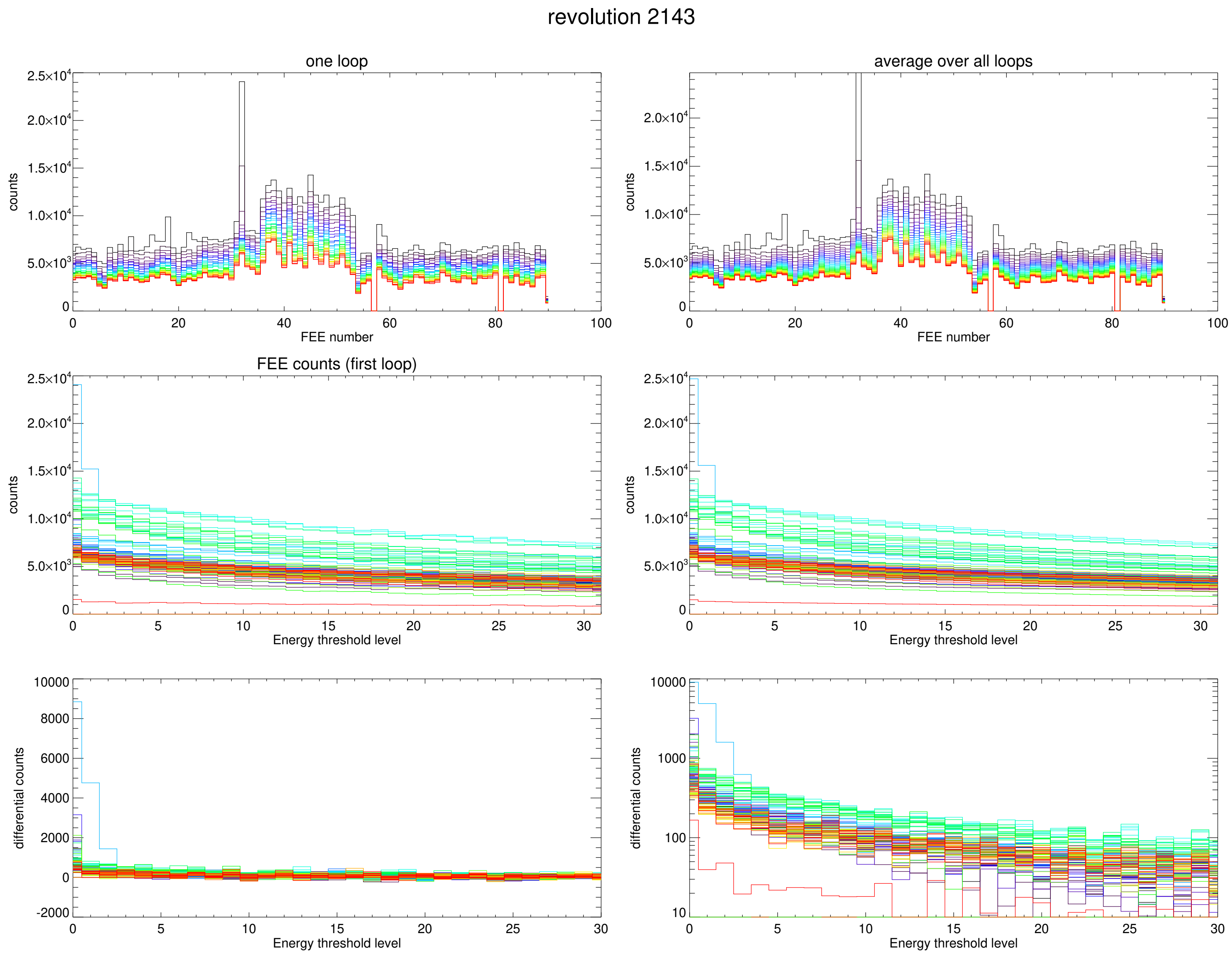






Latest ACS Calibration (rev 2143)

- Rate reduction with increasing threshold (32 steps, ~50 loops)
- Compare performance for remaining 89 of 91 FEE rate outputs among successive calibrations



ACS Calibration: Status 2019

- B.Sc. Thesis Felix Schmuckermaier (11/2018)
  - ☆ Assessement of Issues
    - Missing prelaunch calibrations
    - A straightforward (PL, linearity) model fails to describe data
    - Residuals show significant unexpected behaviour around 200 keV
    - Grouping of FFEs and ACS sub-units possible
    - Degeneracies of calibration-data fits to our model: No clear external constraints
    - A temporal degradation of ACS detectors could explain observed trend (but so could a change in irradiation/bgd environment)
  - → Existing ACS Calibration Data are Insufficient for ACS Response Inflight Calibration

Next: (Jun2019)

- Comparison/Validation on GRB data, ACS and GBM?
  - ☆ Discussions with V. Savchenko et al
  - ☆ Detailed description of ACS Response: cmp. VS's approach with our model

No progress on that...

Late-Mission Activities @ MPE 2019+

- Routine procedures (XZ) (→ automatic; documented)
  - ☆ Data import, routine processing
  - ☆ Quality checking
  - ☆ Spectral fitting → response database
  - ☆ Performance validation (incl annealings)
  - ☆ Software maintenance
- Multi-instrument analysis software "3ML"
  - ☆ Model parameter fitting
  - ☆ Instrumental response and background treatment encapsulated
  - ☆ Start with GBM, SPI, LAT, …
  - ☆ Python based
- Handover of MPE-INTEGRAL activities 2020 to J Greiner
  - ☆ RD retired 2/2019, has 2 PhD students till 2020/21
  - ☆ DLR support MPE and Xiaoling Zhang till 2021
  - ☆ J Greiner Co-PI 2020+ (had been involved in high-energy astrophysics science and in SPI