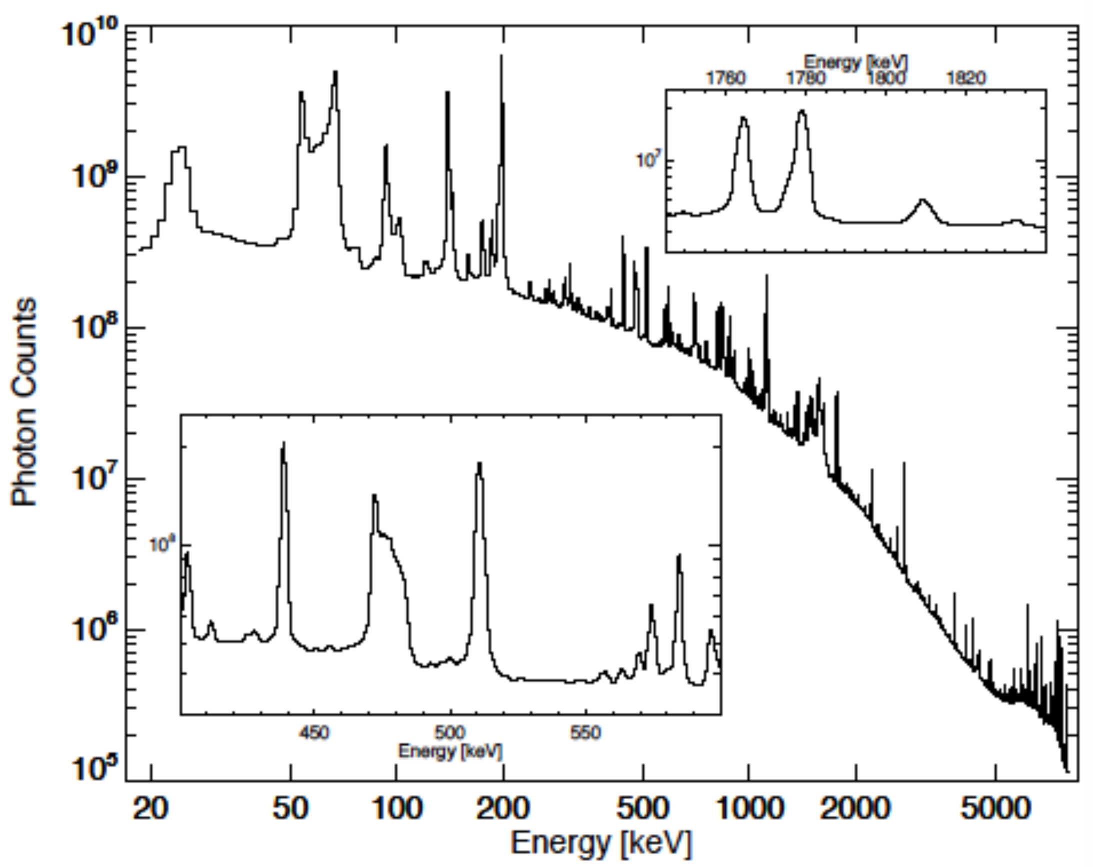
SPI Performance Monitoring

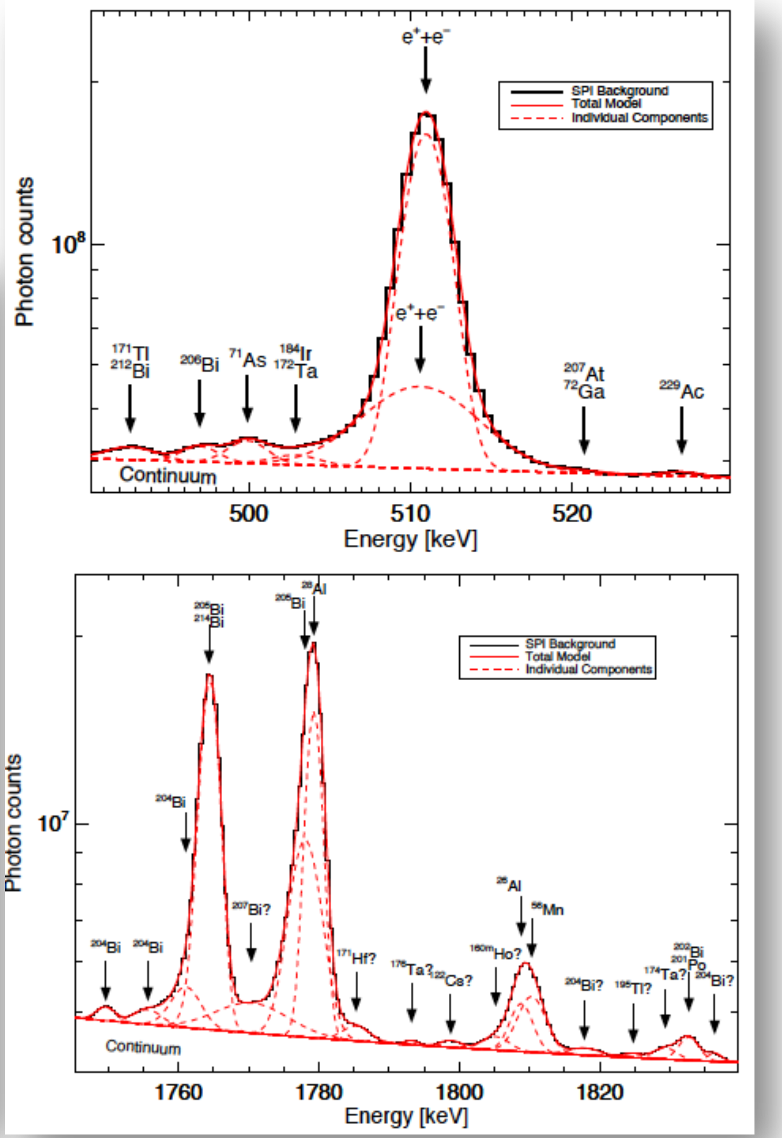
MPE Contributions

November 2018

MPE routine monitoring:Spectral Fitting

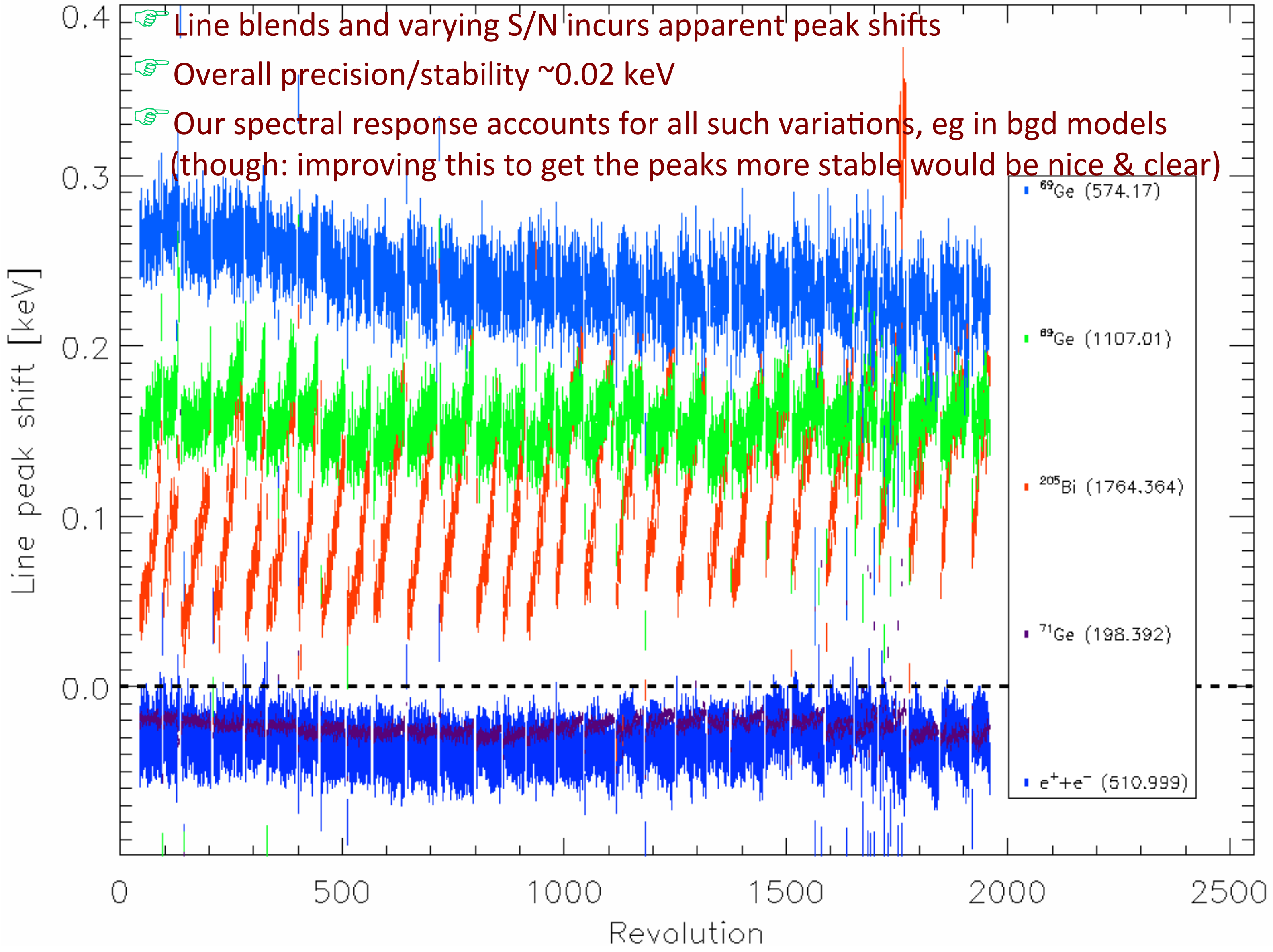
- Routine decomposition of SPI detector spectra
  - ☆ spectral performance
  - ☆ background situation
  - → SPI response database (www)





SPI Performance Monitoring

- Monitor Energy Calibration in routine fits



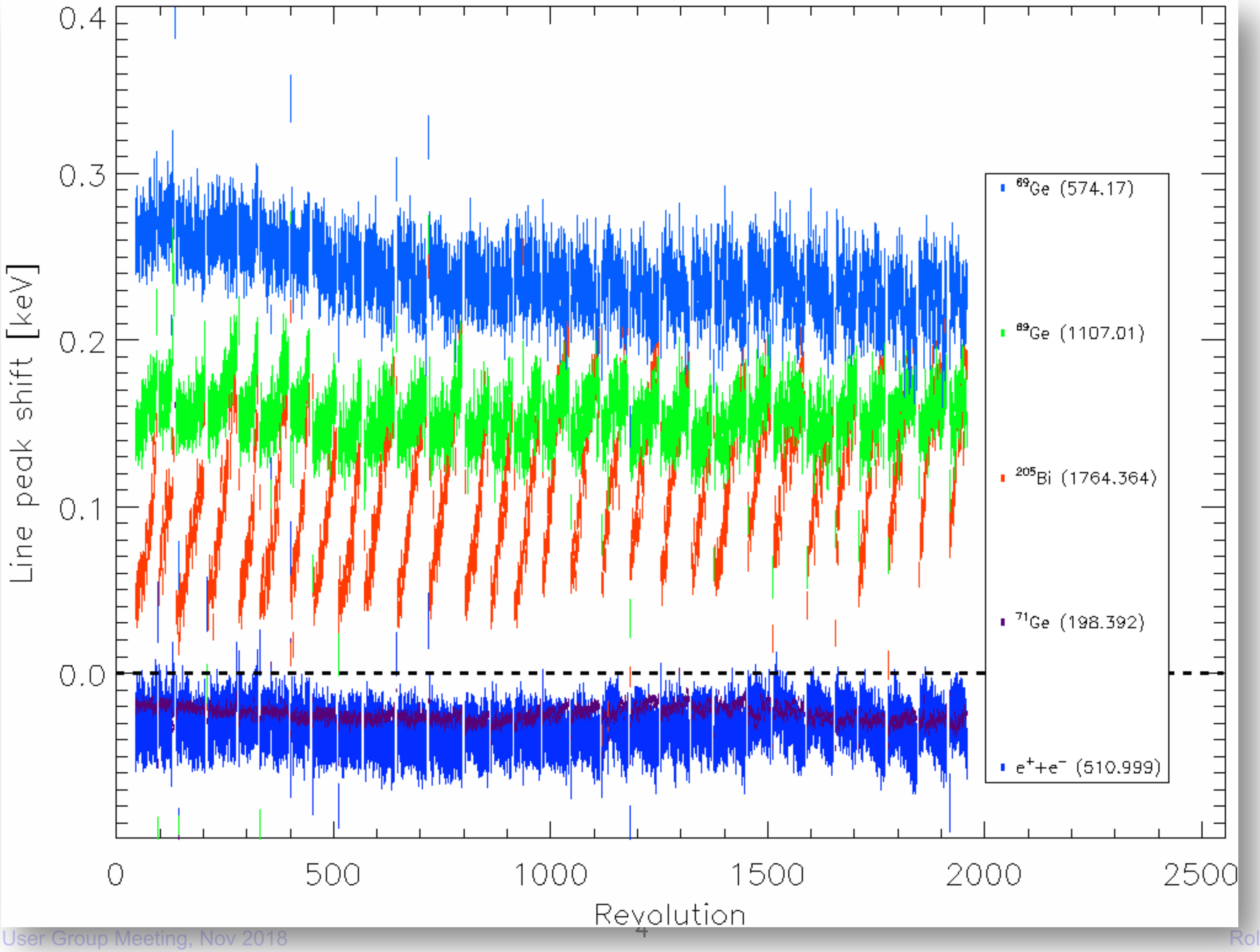
☞ Line blends and varying S/N incurs apparent peak shifts

☞ Overall precision/stability ~0.02 keV

☞ Our spectral response accounts for all such variations, eg in bgd models (though: improving this to get the peaks more stable would be nice & clear)

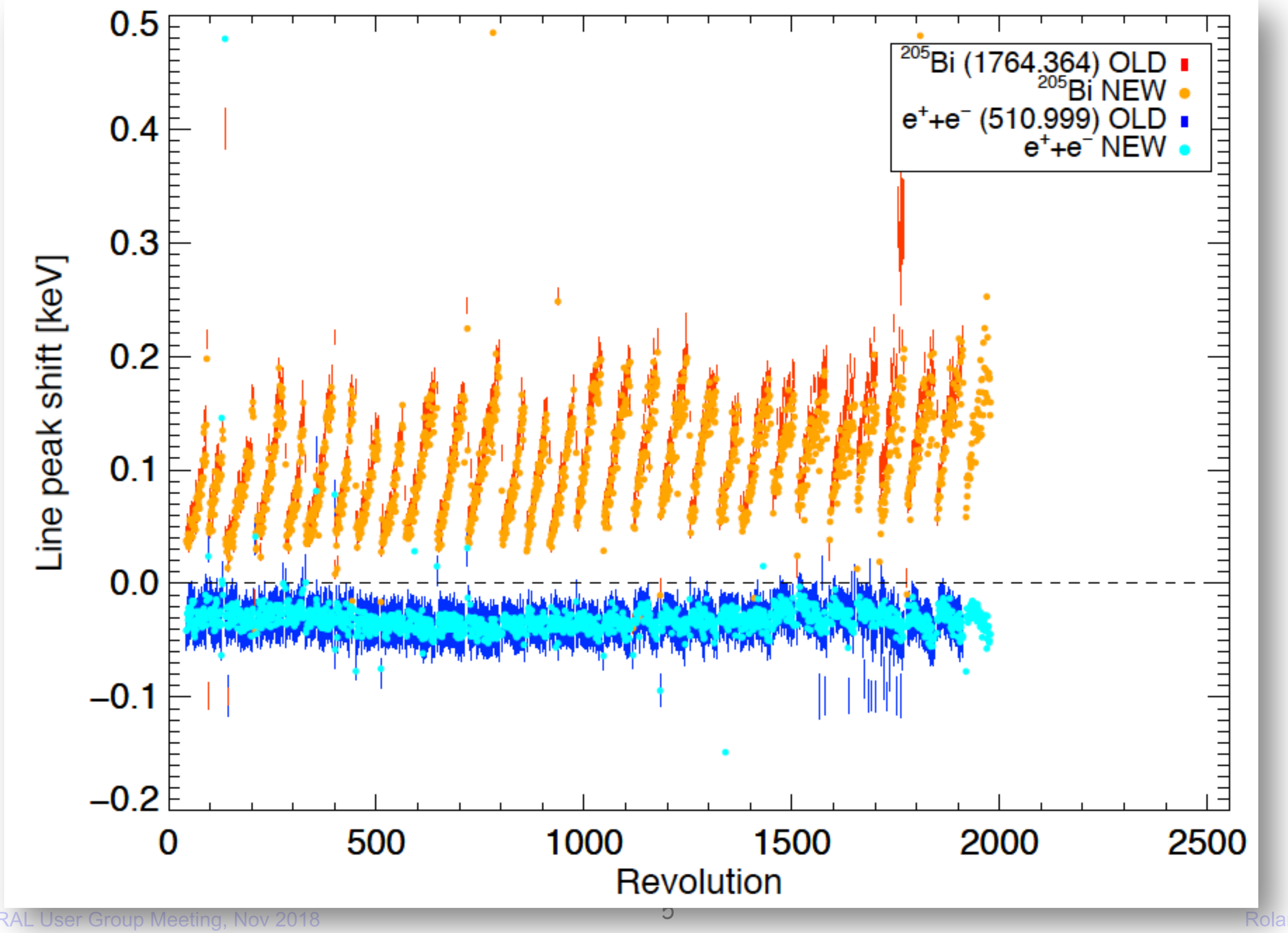
SPI Performance Monitoring

- Re-do Energy Calibration in routine fits



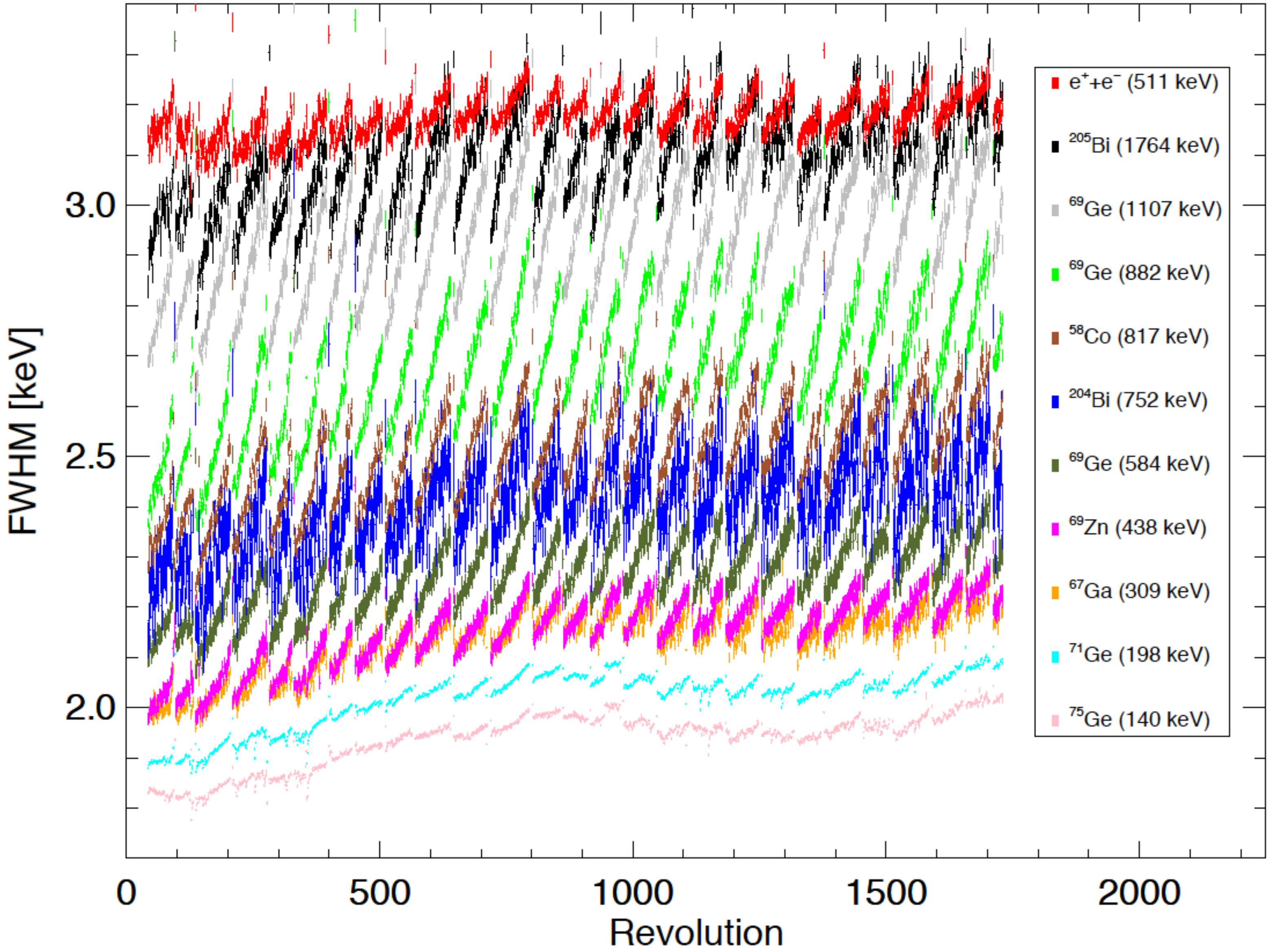
SPI Performance Monitoring

- Re-do Energy Calibration in routine fits



SPI Performance Monitoring

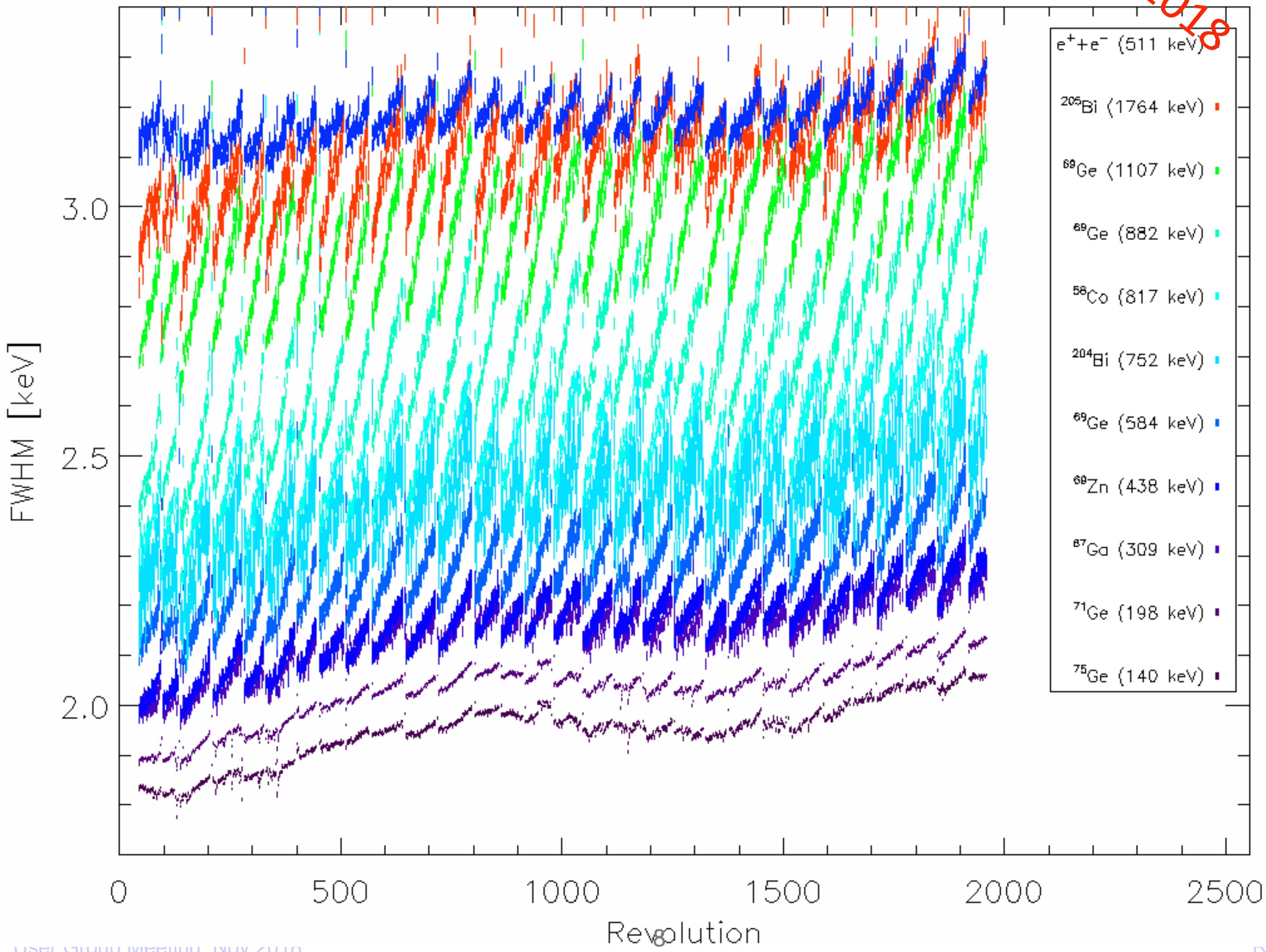
- Monitor Spectral Resolution in Detail (as published A&A 2018)



SPI Performance Monitoring

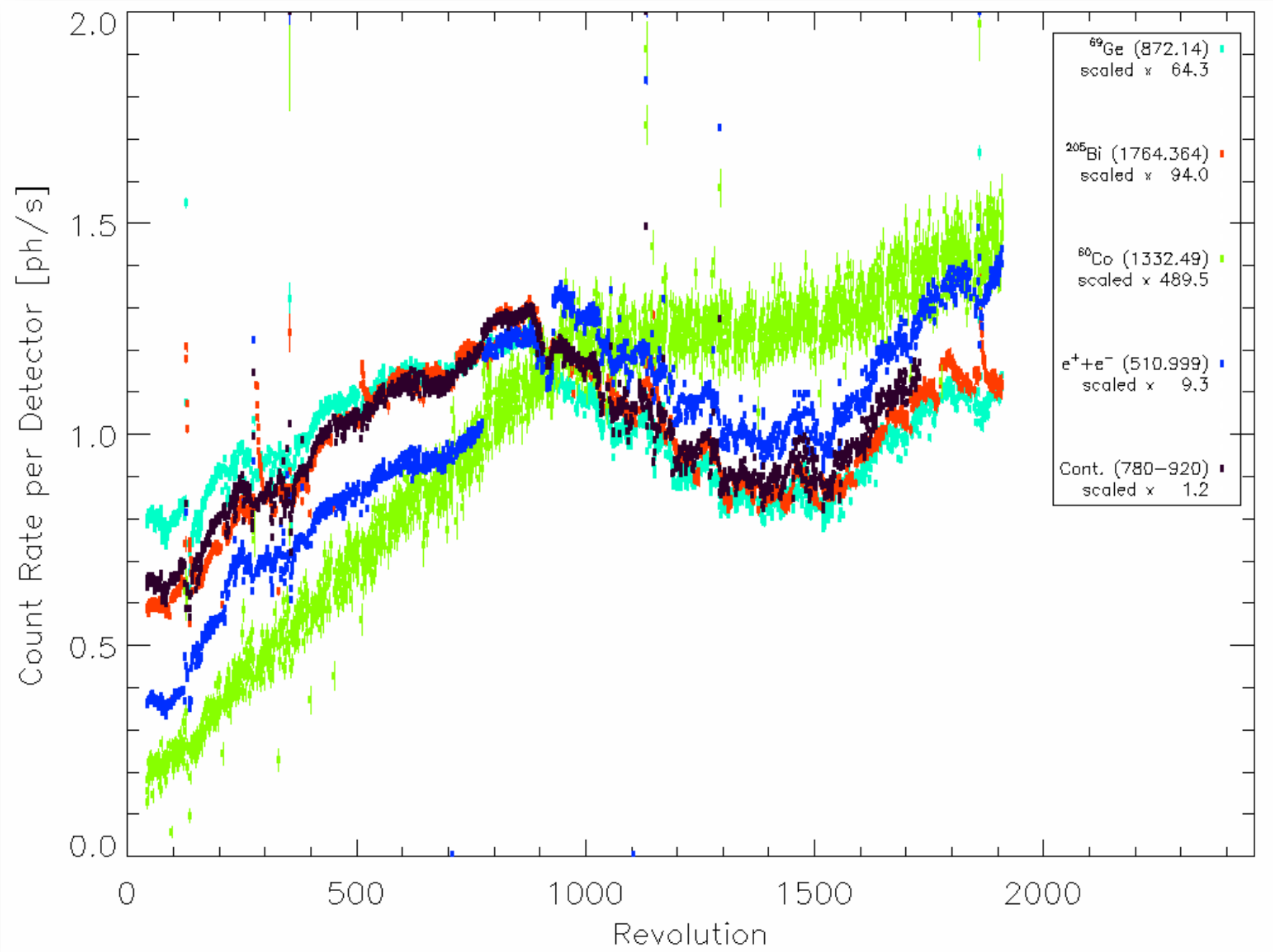
- Status Nov 2018 (rev. 1978; before 31th annealing)

Nov 2018



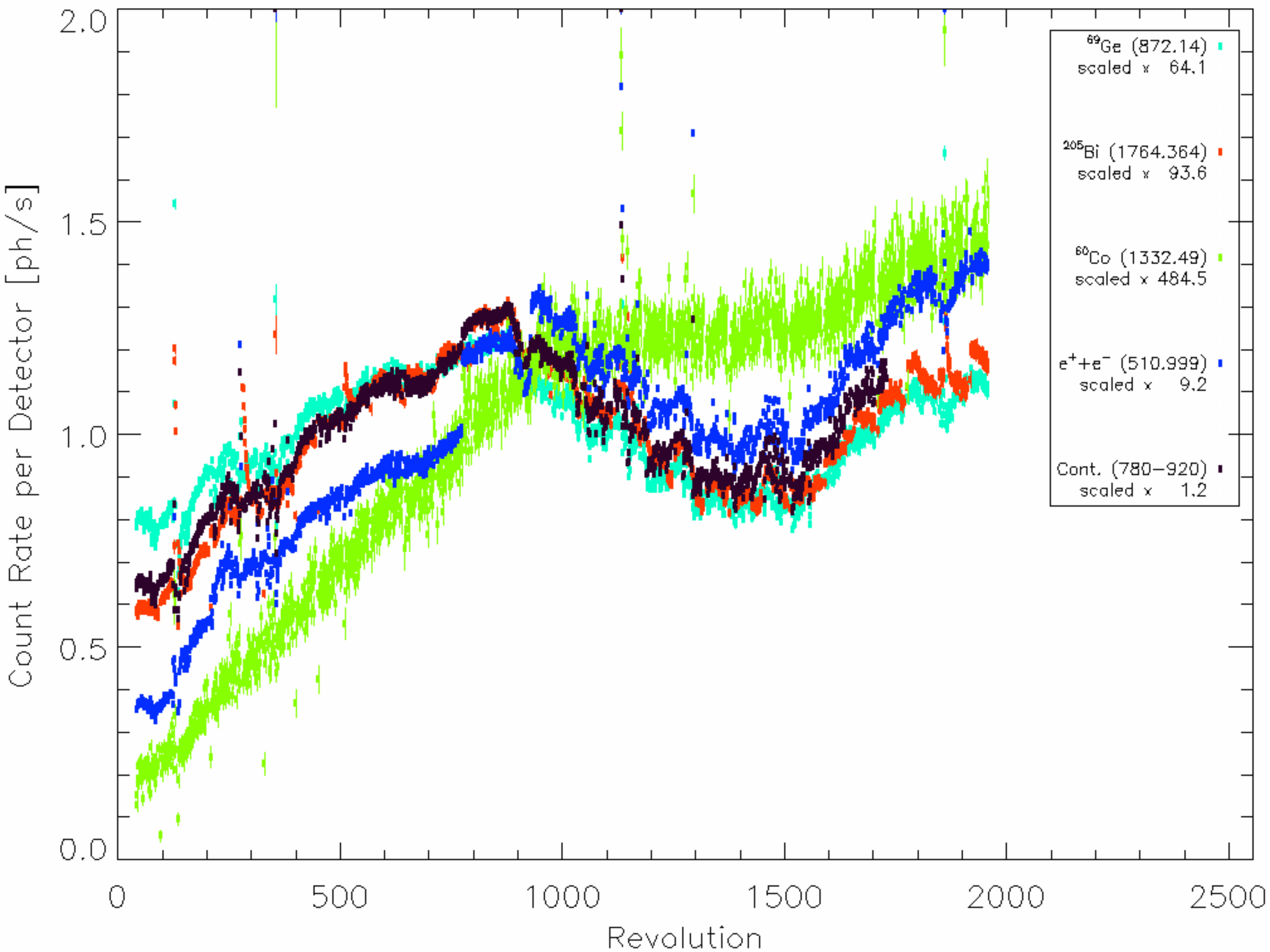
SPI Background Monitoring

- Status Feb 2018 (revolution 1911)



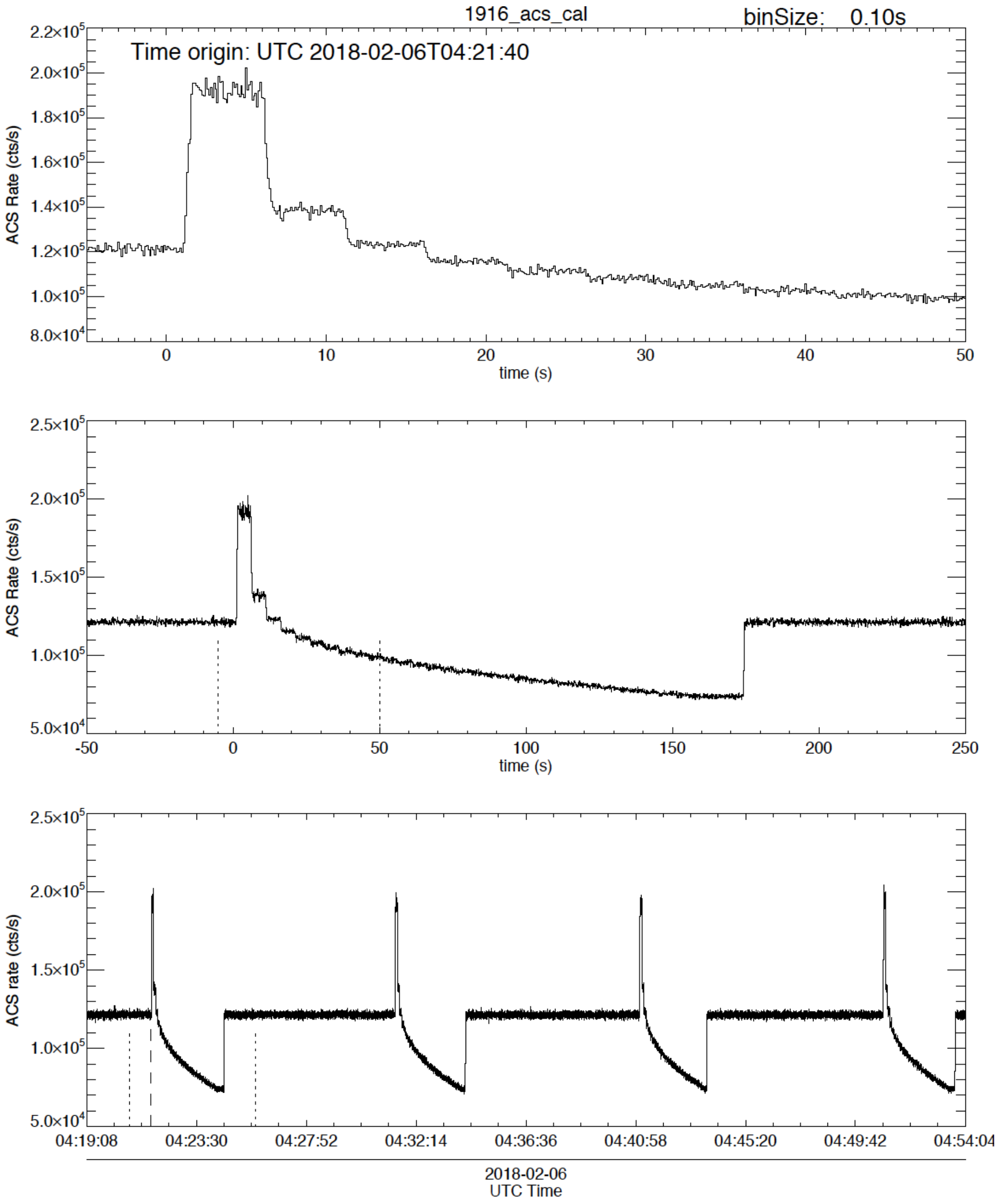
SPI Background Monitoring

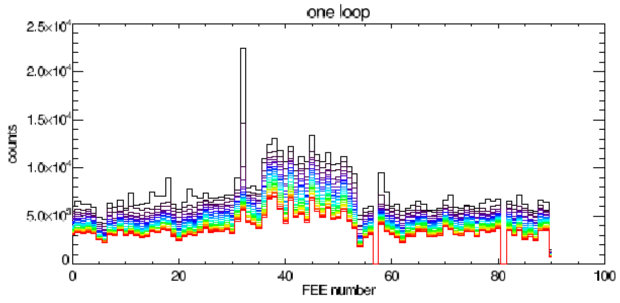
- current status (revolution 1978)



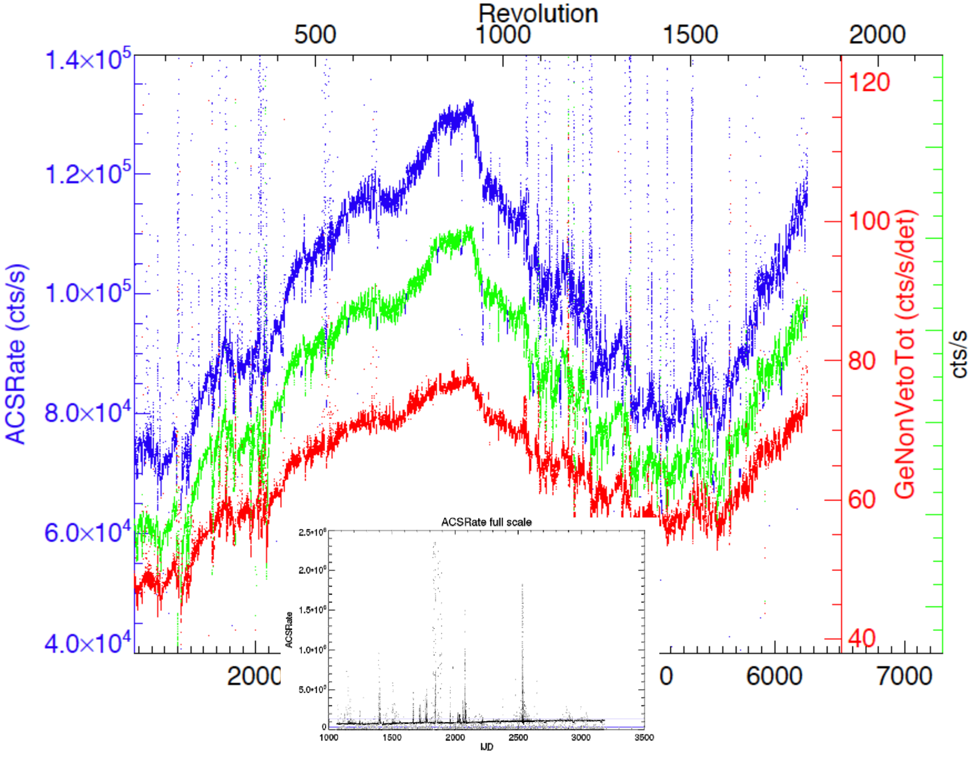
ACS Calibration

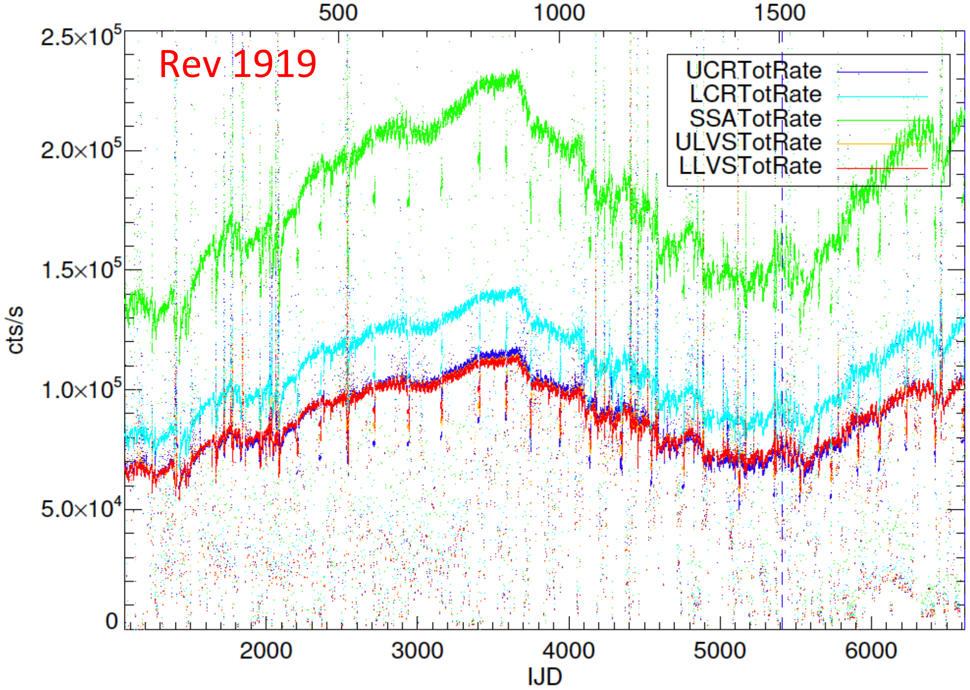
- Regular calibrations of ACS system: threshold steps
  - ☞ Rate reduction with increasing threshold (32 steps, ~50 loops)
  - ☞ Compare performance for remaining 89 of 91 FEE rate outputs among successive calibrations





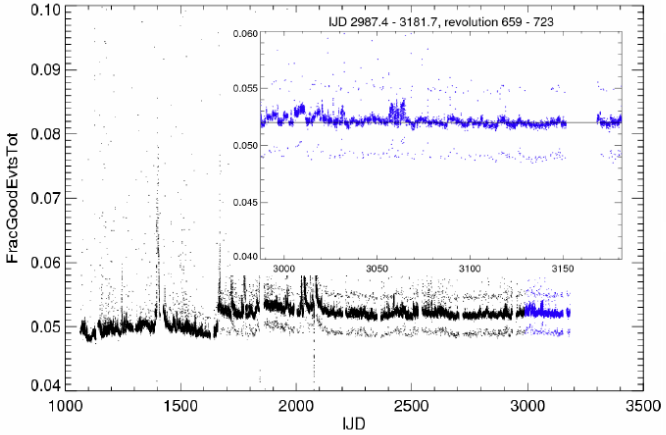
ACS In-flight performance

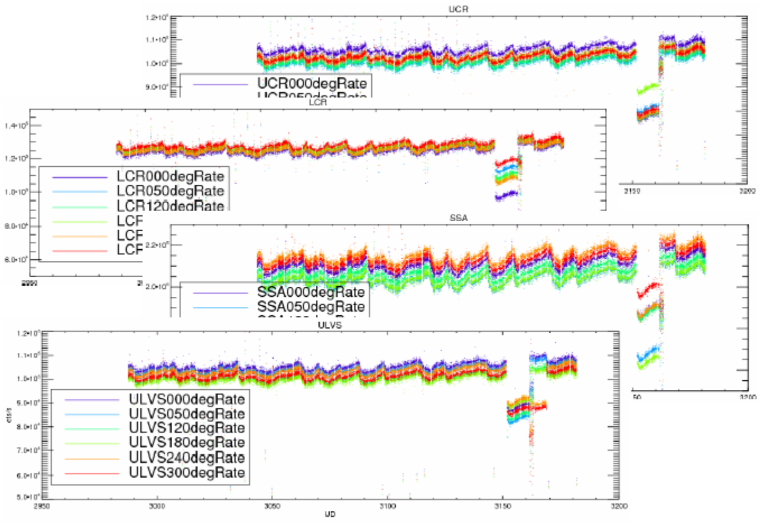




☆ 'differential' monitoring

- ☞ any component different from the others?





In-orbit analysis of ACS calibrations (V2)

from meeting 4 Sep 2018 (FS, XZ, TS, AvK, RD)

- Datasets: ~1000 loops through 32 threshold values, for 89 FEE units

  ☞ ~10^7 data points $D_{aijk} = D_{annealing;cycle;threshold;FEE}$

- Model: count rate results from incident particles (& photons) as seen by BGO integrated above a threshold energy

- Assumptions:
  - Incident particle spectrum can be expressed as an analytical formula, e.g. power-law
  - Incident particle spectrum remains constant during one ACS calibration
  - Incident particle spectrum does not change shape between ACS calibrations (i.e., only intensity)
  - threshold electronics implements equal-amplitude steps above their minimum value
  - threshold function (i.e. 0 → 1 transition to a module's efficiency) is characterised by a range τ
  - BGO response has an energy threshold that is not sharp and different for each module
  - BGO light yields have been calibrated pre-launch with radioactive sources
  - BGO response has weak variations: with temperature, different prelaunch/in-flight, with time

$$I(E) = a_0 \cdot E^{-a_1}$$

$$E_{j,k} = E_k + j \cdot dE_k$$

$$\varepsilon\ (E) = \frac{1}{1 + e^{-\tau(E - E_j)}}$$

$$R_k(E) = \frac{\eta_{k0}}{1 + e^{-\sigma_k (E - E_{k0})}}$$

$$\frac{R_k(E)}{R_l(E)} = \lambda_{kl} \frac{R_{k0}(E)}{R_{l0}(E)}$$

- Analysis task:

  ☆ Fit data D_{ijk} by a model $m(\overbrace{a_0, a_1}^{\text{incident particles}}, E_{jk}, \overbrace{\sigma_k, \eta_{k0}, \lambda_{kl}}^{\text{ACS response}}, \overbrace{\tau_k}^{\text{ACS electronics}})$ that minimises residuals

  for $D_{jk} = \int_{E_j}^{\infty} \lambda_k R_k \cdot \varepsilon \cdot I \cdot dE$

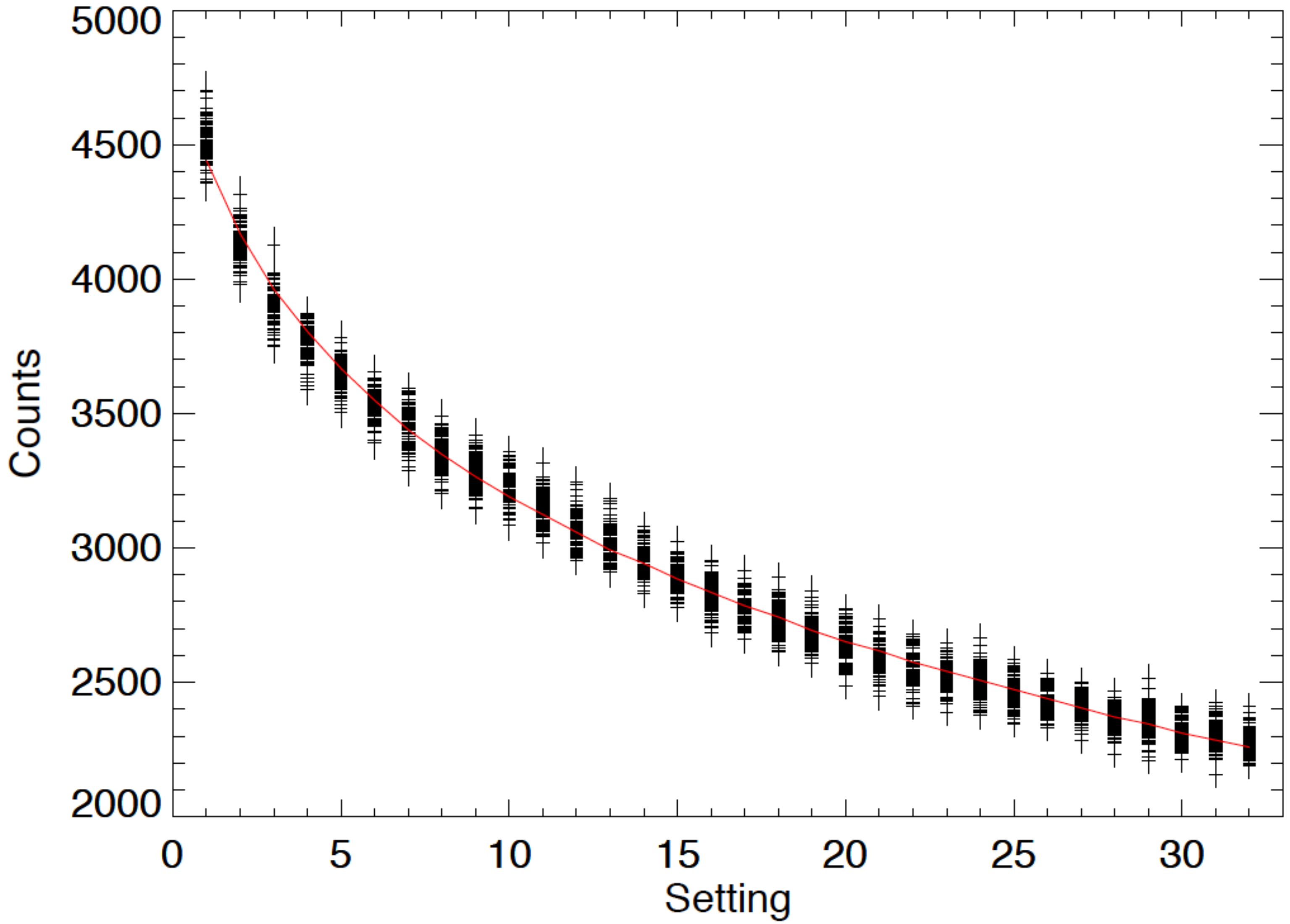
  → check if parameters vary among annealings

  (this could imply variations w temperature, time, or failures)

ACS Performance Assessment: Status Nov 2018

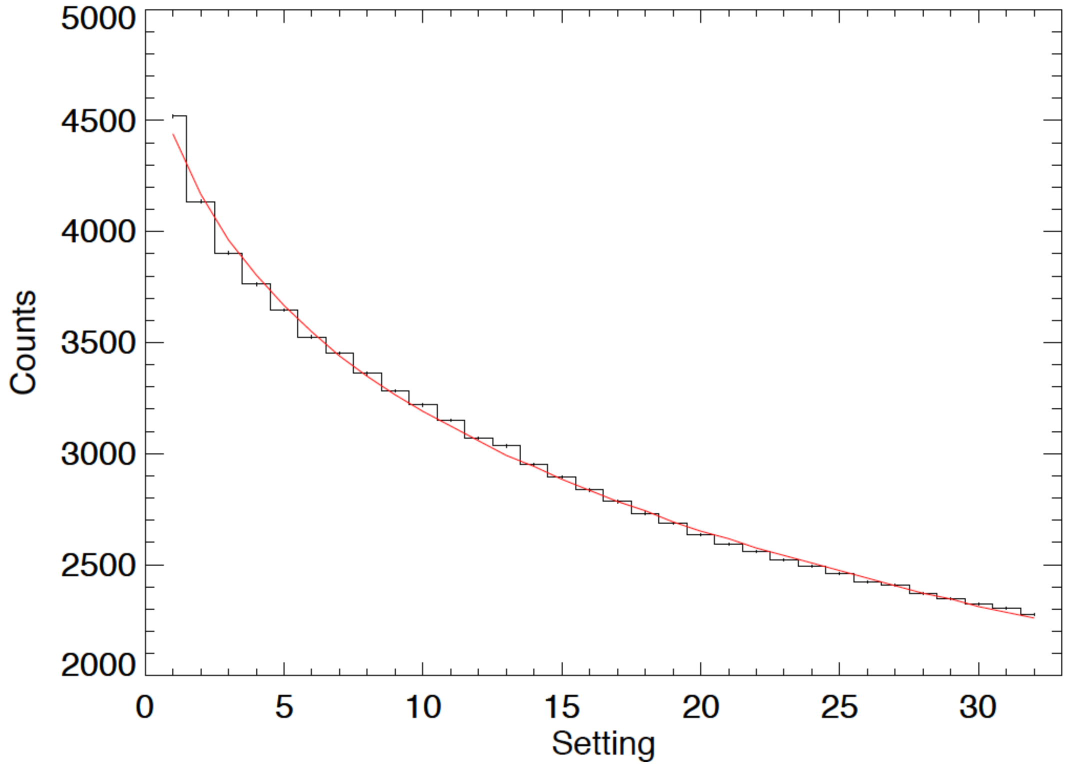
- Prelaunch calibration data re-acquired
    - ☞ Individual PMTs (disconnect one of 2 and calibrate with 137Cs source; von Kienlin)
    - ☞ Spreadsheet of calibration logs digitised
    - ☞ Many inconsistencies: Often no peak recognised in spectra; sometimes "negative" gains; Many useful peak-channel/energy data as well.
    - ☞ B.Sc. Student project, Felix Schmuckermaier, Aug – Dec 2018
- ACS calibration data per annealing fitted for each FEE
    - ☆ Algorithm shows inadequacy of single powerlaw function for CR spectrum
    - ☆ Degeneracies between threshold parameters and energy steps
    - ☆ Needed to adopt an initial energy scale

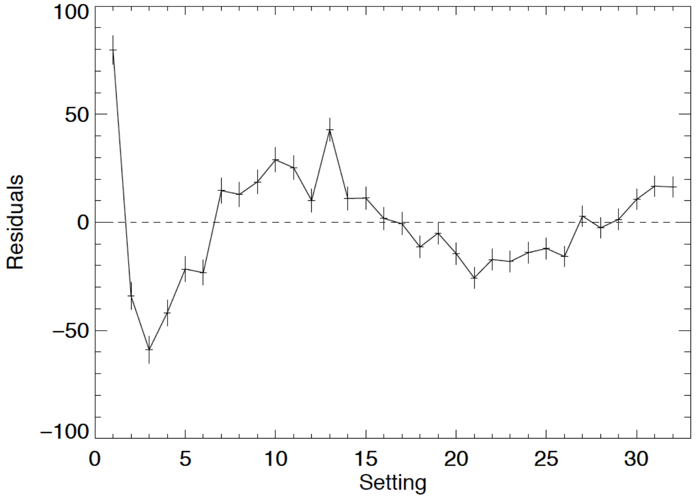
Threshold loops: fitting each loop, at one annealing



Threshold loops: the mean, at one annealing

- ☆ The behaviour does not trace one smooth trend
  - ☞ Our assumptions are not strictly valid:
    - The ‘excitation function’ (CRs) may not be a smooth power law
    - The steps in energy per threshold setting may not be linear
    - The threshold width may not be described by a smoothed step (E, width)

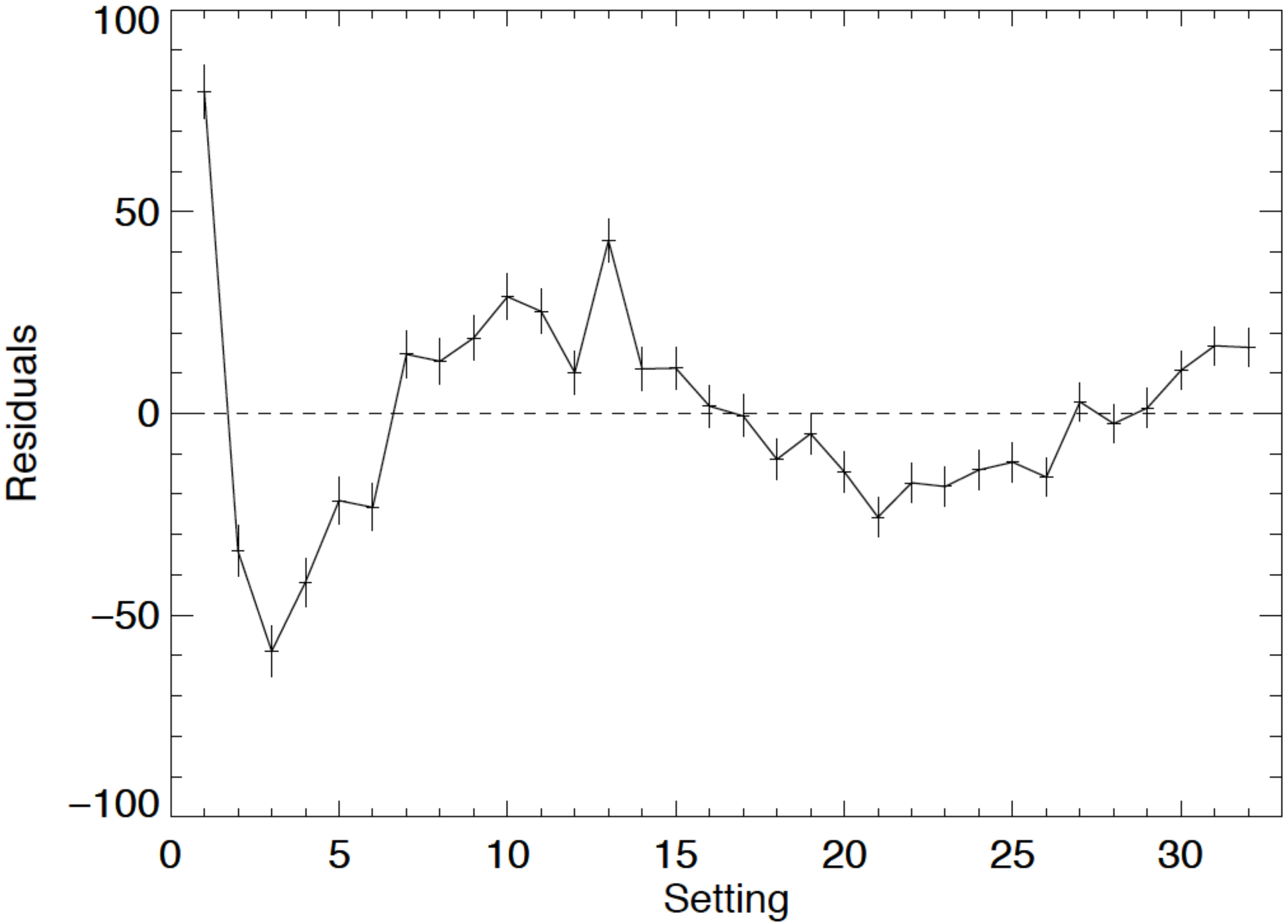




- ☆ Inspect the residuals from the expected behaviour
  - ☞ Do all FEE/elements show behaviour similarities?
  - ☞ Can we learn about ACS element groups?

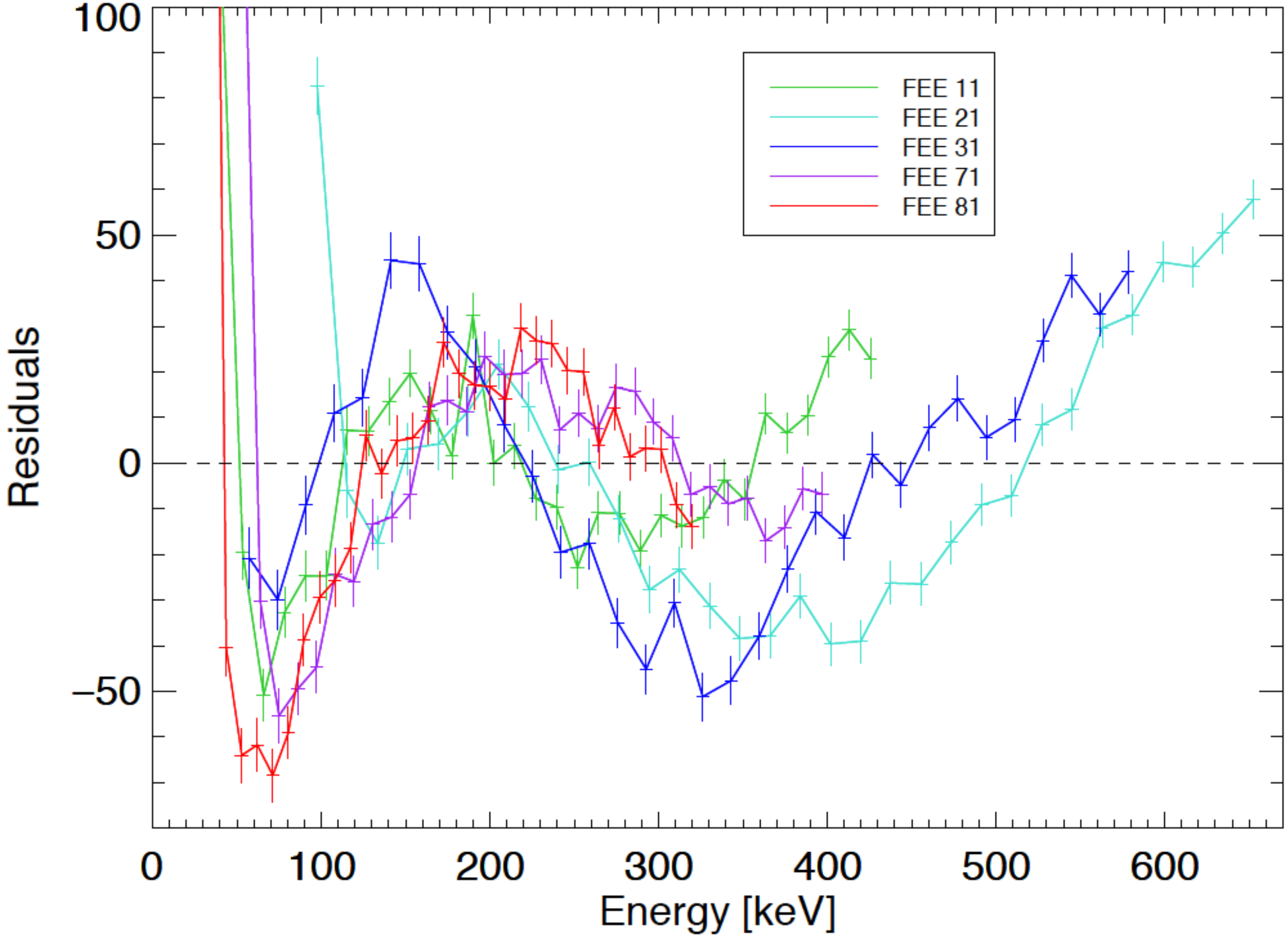
Threshold loops: the mean, at one annealing

Inspect the residuals from the expected behaviour



Threshold loops: the mean, at one annealing

- ☞ Can we learn about ACS element groups?
- ☞ → a "stretch" factor for relative normalisation?



ACS Calibration: Next

- Finalisation of B.Sc. Thesis Felix (Nov'18)
  - ☆ Documentation of ground calibration results
  - ☆ Documentation of calibration method
    - ☞ Algorithm, excitation spectrum, threshold functions, ACS AE response
  - ☆ Status of fits per FEE, including residuals
- Finalisation of calibration (Dec/Jan)
  - ☆ Assessment of approximations
  - ☆ Review of absolute energy calibration
  - ☆ Grouping of ACS subunits
  - ☆ Repetition of calibration data fits with constraints
- Comparison/Validation on ACS burst data and simulations

Late-Mission Activities @ MPE

- Review routine procedures (→ automatic; documented)
  - ☆ Data import
  - ☆ Routine processing
  - ☆ Quality checking
  - ☆ Spectral fitting → response database
  - ☆ Performance validation (incl annealings)
  - ☆ Software maintenance
- Develop multi-instrument analysis software
  - ☆ Model parameter fitting
  - ☆ Instrumental response and background treatment encapsulated
  - ☆ Start with GBM, SPI, LAT, …
  - ☆ Python based
- Prepare handover of MPE-INTEGRAL activities
  - ☆ RD retirement 2019; 2 PhD students till 2020/21; DLR support XZ till 2021