Offline energy reconstruction and resolution

26th April 2022

Energy resolution results using LLAMA data

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Status

💡 Reminder:

🙂 Pro: Availability of storing full waveforms in LLAMA data allows for **offline optimization of energy and timing reconstruction** algorithms

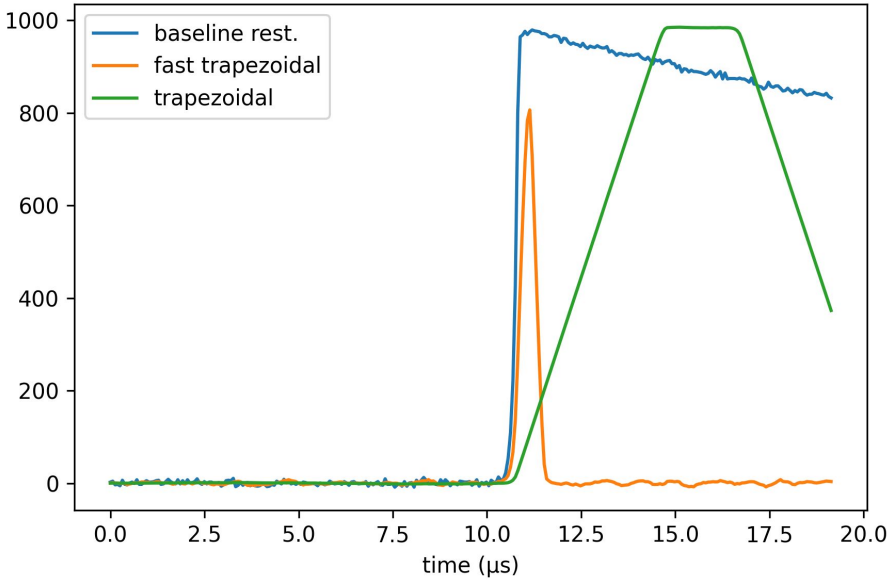
😐 Con: Large set of parameters to be studied ⏳

📋 To-do list:

- ☑ Determine shaping parameters for optimal resolution
- ☑ Define optimal quality cut values for non-pile up events
- ☐ Implement energy reconstruction for pile-up events

Digital signal processing (DSP) chain

- Baseline restoration (→ baseline parameters)
- Leading edge triggering (→ trigger position)
- Fast trapezoidal shaping (→ trigger number)
- Trapezoidal shaping with fixed pick-off (→ amplitude)
- (Pseudo-Gaussian shaping)

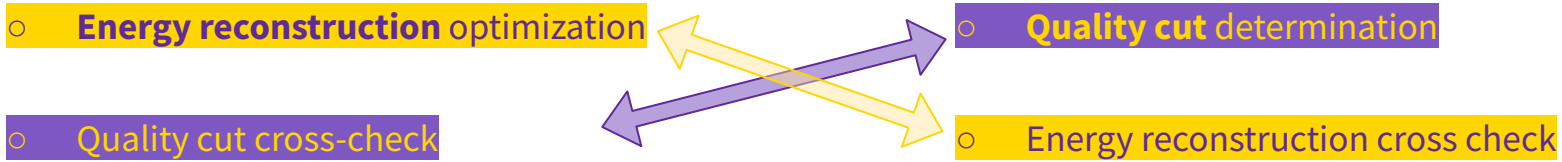


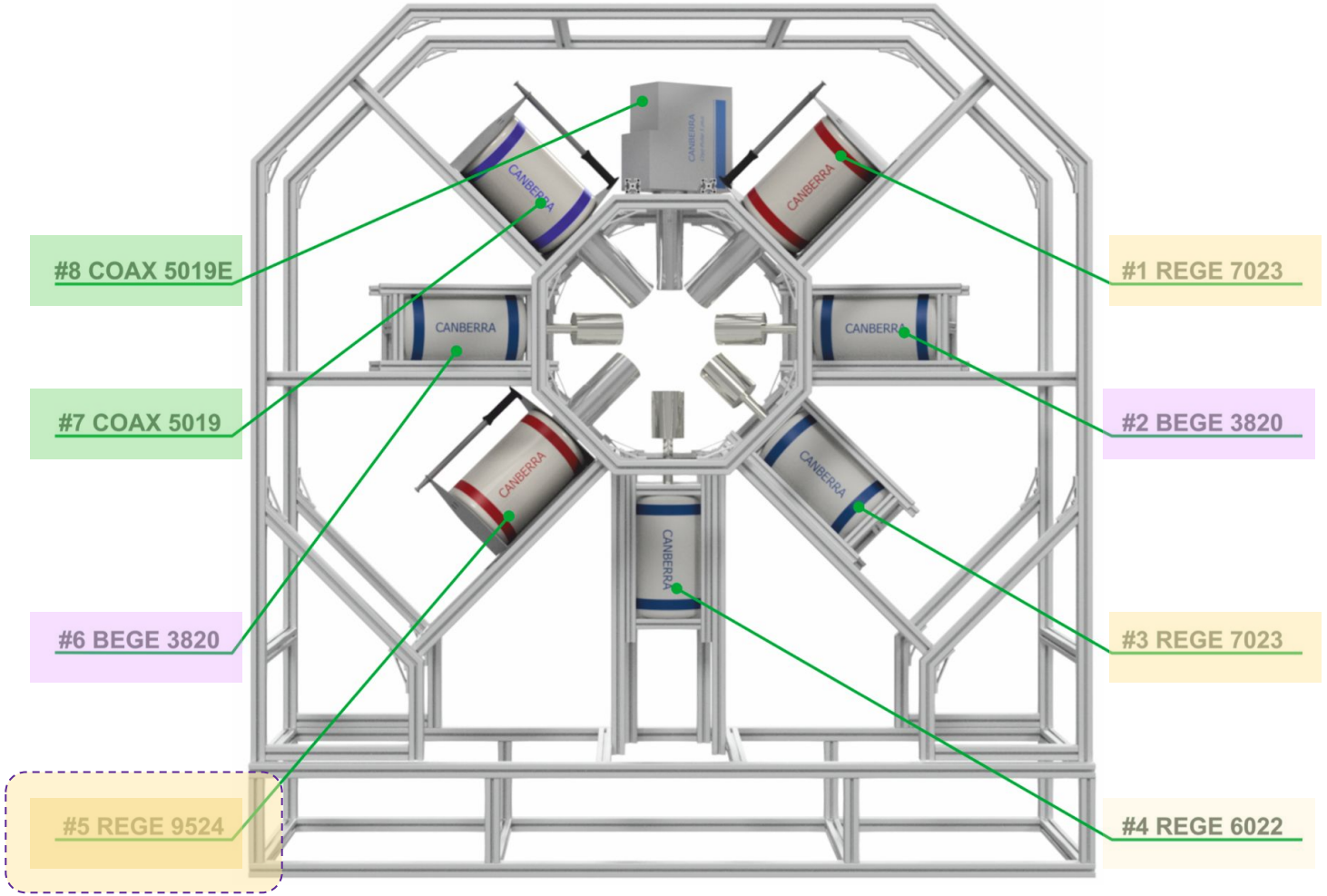
💡 Reminder: Using GERDA (GELATIO*) signal processing algorithms software

*M Agostini *et al* 2011 JINST 6 P08013]

Datasets

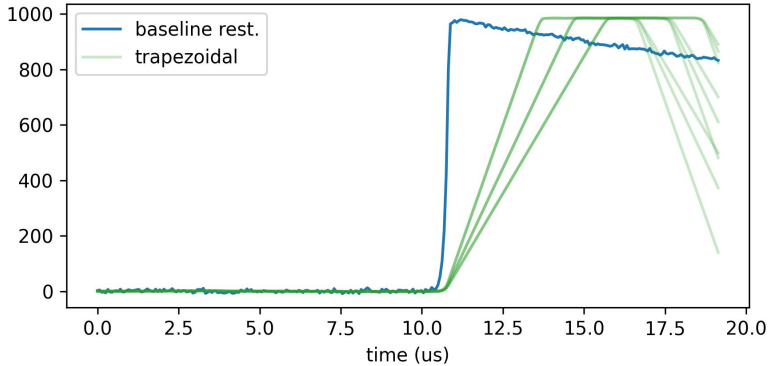
- ^{60}Co from calibration run on the 20th Oct.
- ^{136}Ba from run on the 22nd of Oct.

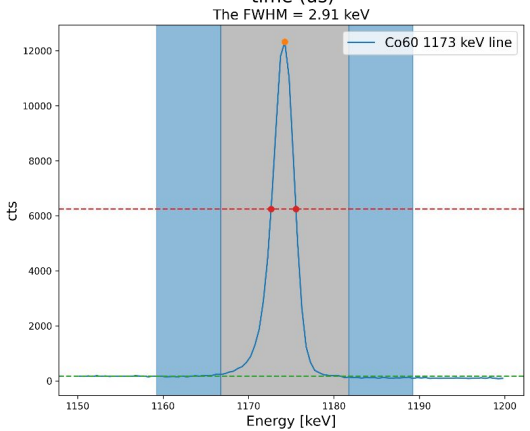



#8 COAX 5019E
#7 COAX 5019
#6 BEGE 3820
#5 REGE 9524
#1 REGE 7023
#2 BEGE 3820
#3 REGE 7023
#4 REGE 6022
CANBERRA

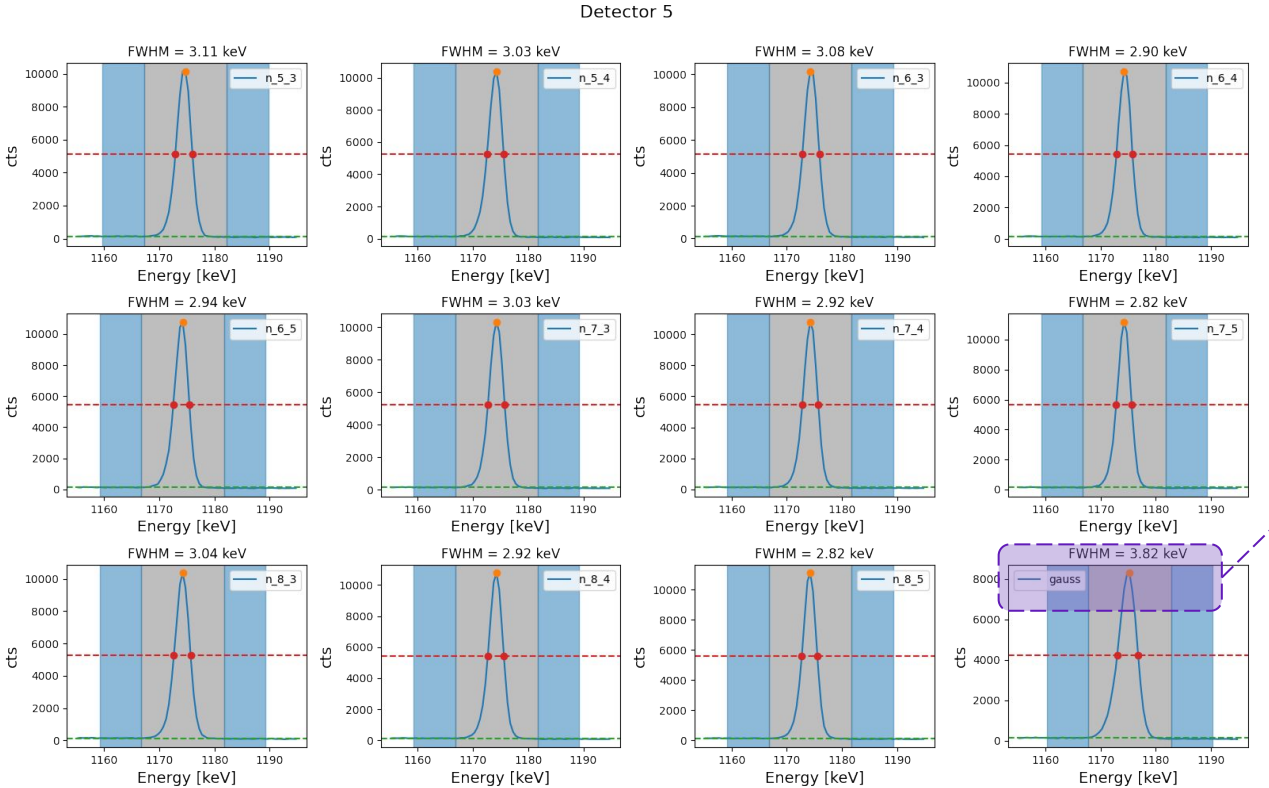
Energy reconstruction optimization

- Trapezoidal shaping with
  - [5, 6, 7, 8] µs moving window deconvolution (MWD) = RT + flat top (FT)
  - [3, 4, 5] µs moving window average (MWA) = rise time (RT)
- One-point calibration & preliminary quality cuts to remove pile-up and spurious events
- FWHM of 1173 keV ^{60}Co peak



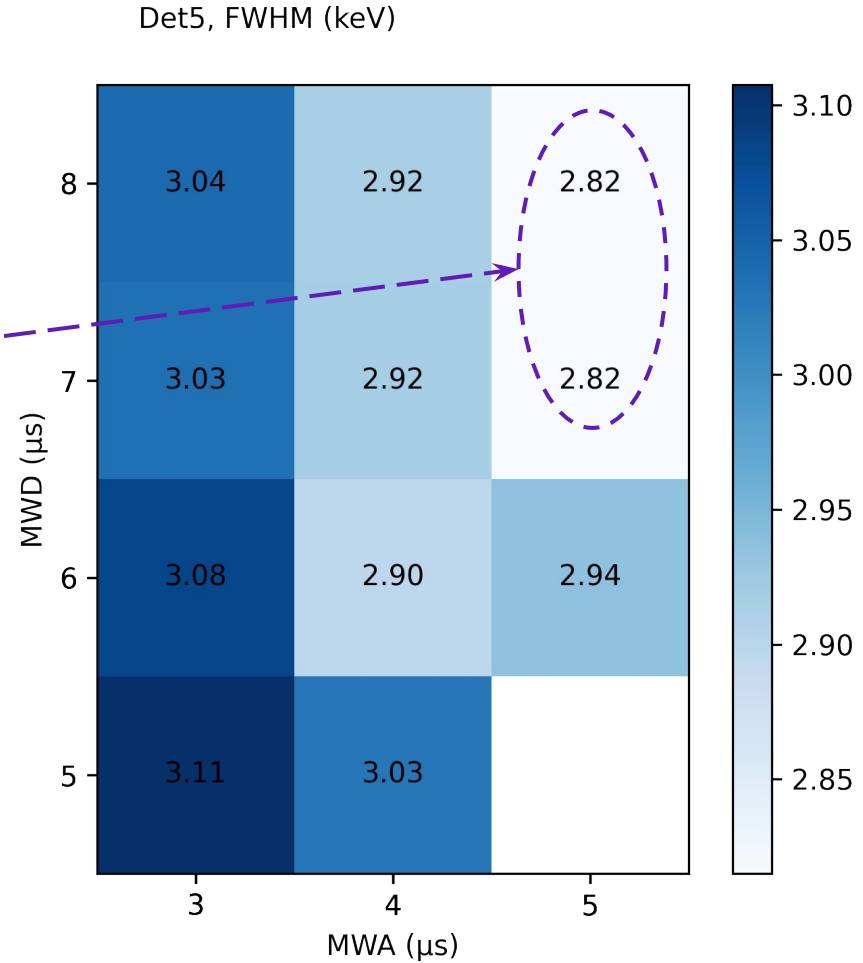


Energy reconstruction optimization



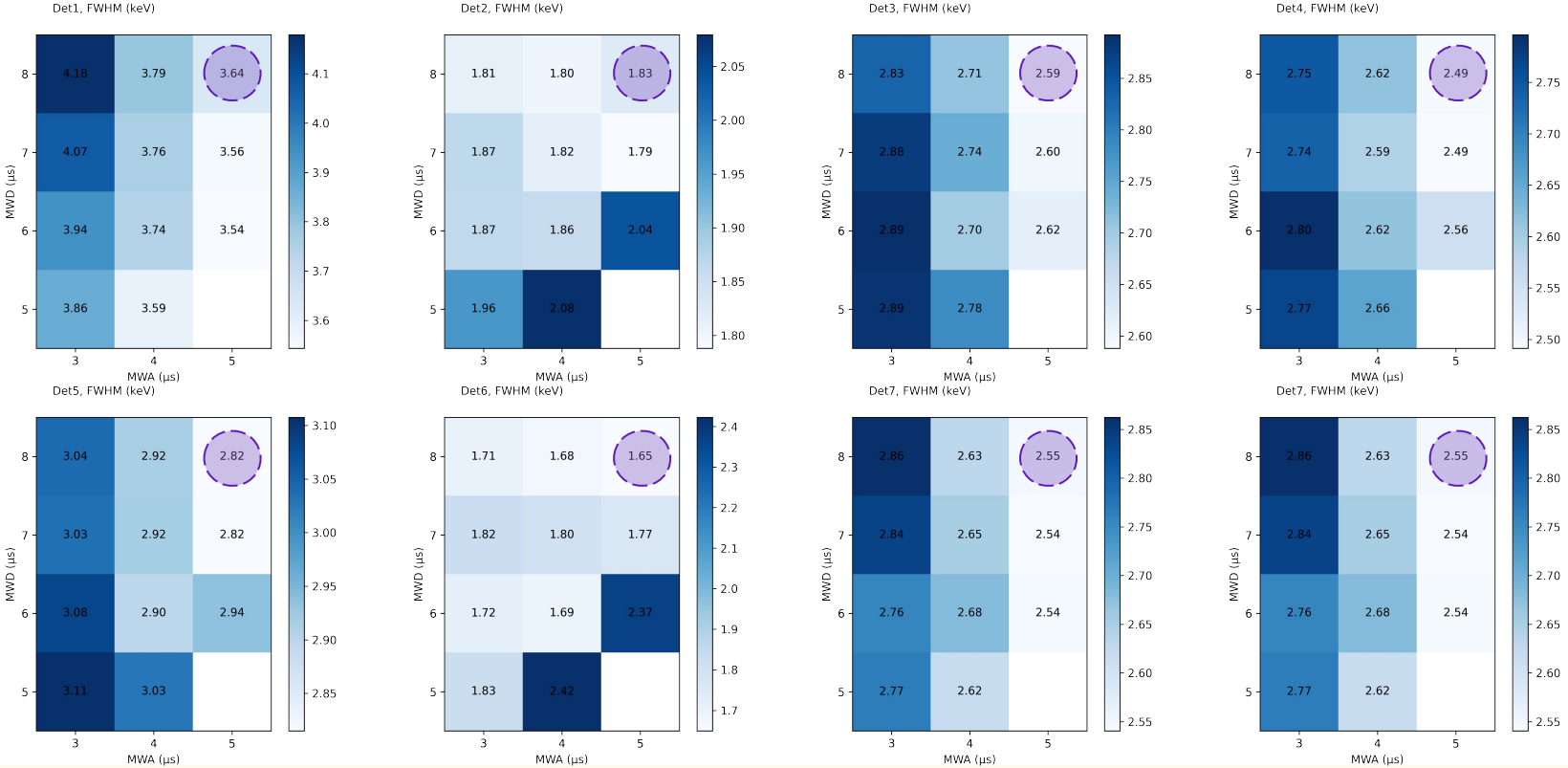
Energy reconstruction optimization

Best resolution obtained with long shaping-times

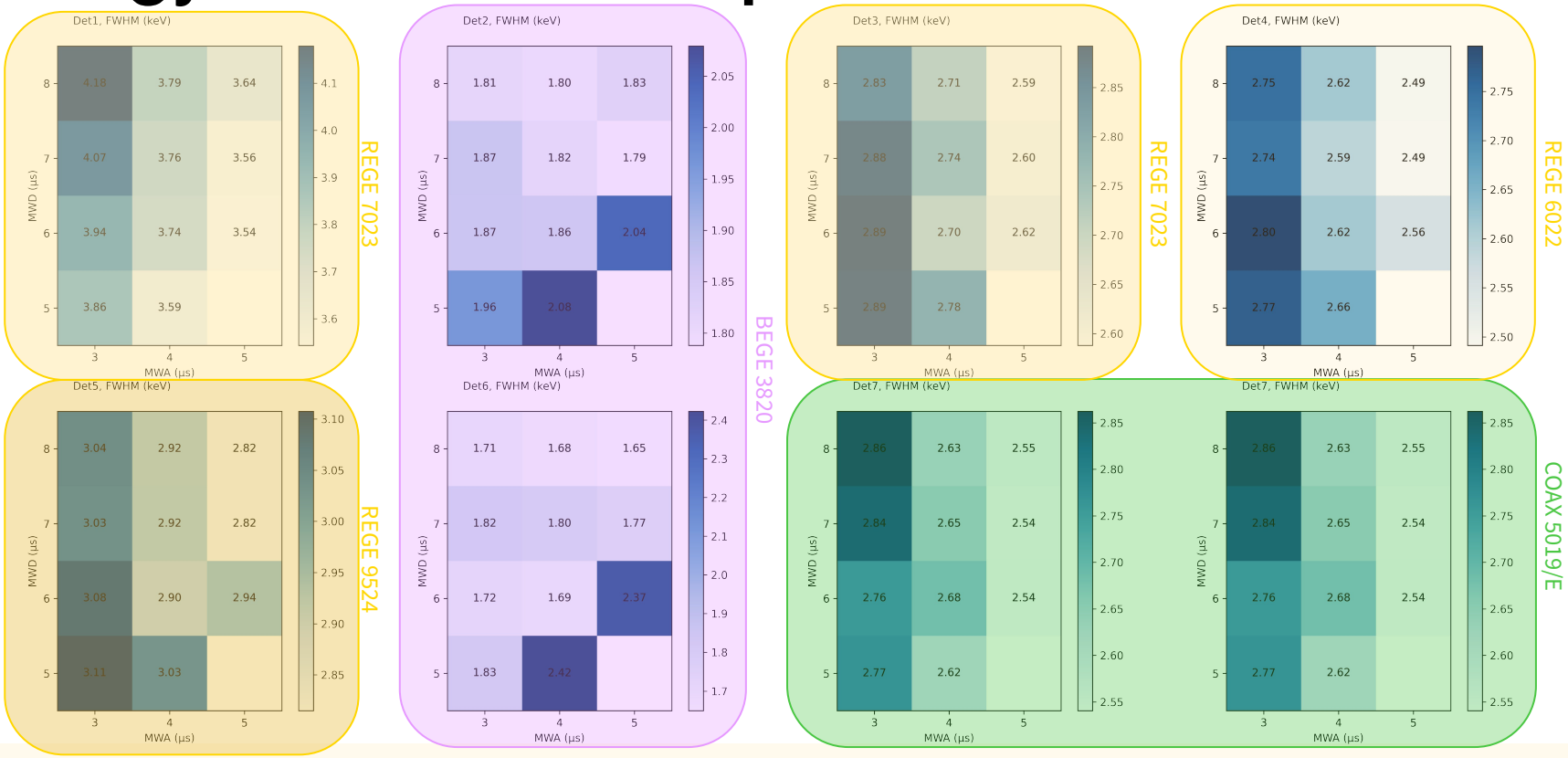


Energy reconstruction optimization

Global shaping parameters common to all the detectors
→ MWD/MWA = 8/5 µs



Energy reconstruction optimization



Energy reconstruction optimization

- Common shaping for all detectors with MWD(FT+RT)= 8µs, MWA(RT) = 5µs

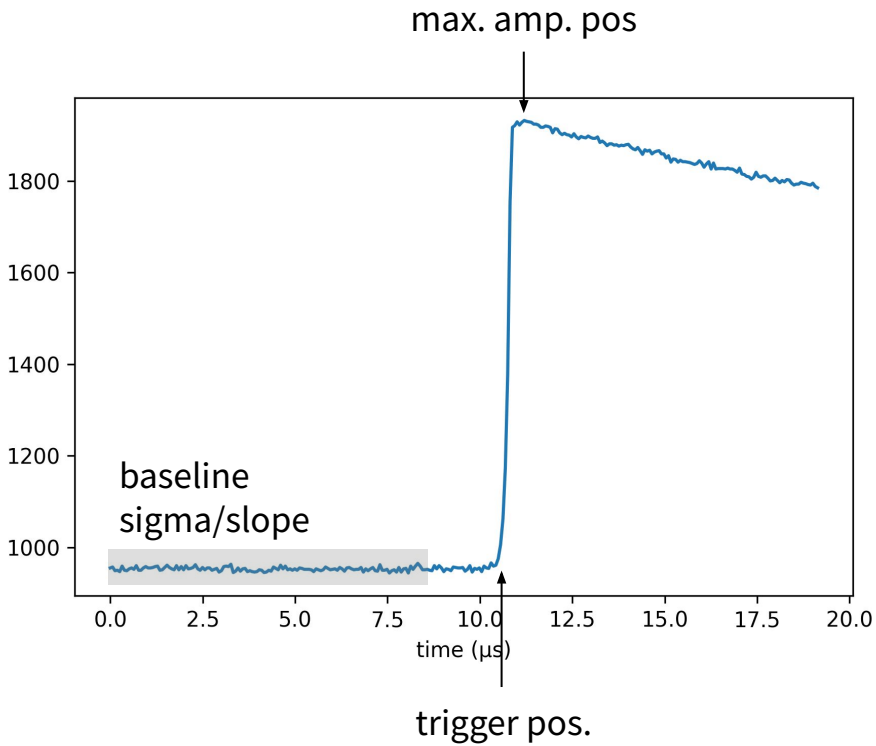
Detector	LLAMA FWHM, ^{60}Co [keV]	MIDAS FWHM, ^{60}Co [keV]
1) REGe 7023	3.64	4.48
2) BEGe 3820	1.83	1.81
3) REGe 7023	2.59	3.13
4) REGe 6022	2.49	3.16
5) REGe 9524	2.82	3.36
6) BEGe 3820	1.65	1.67
7) COAX 5019	2.55	3.05
8) COAX 5019E	2.55	2.53

Quality cuts

- **Remove spurious “non-physical” pulses and pile-up events**

Parameters:

- Baseline sigma (→ noise level)
- Baseline slope (→ pre-trace pile-up)
- Trigger number (→ in-trace pile-up)
- Trigger position, Maximum amplitude position (→ pulse properties)

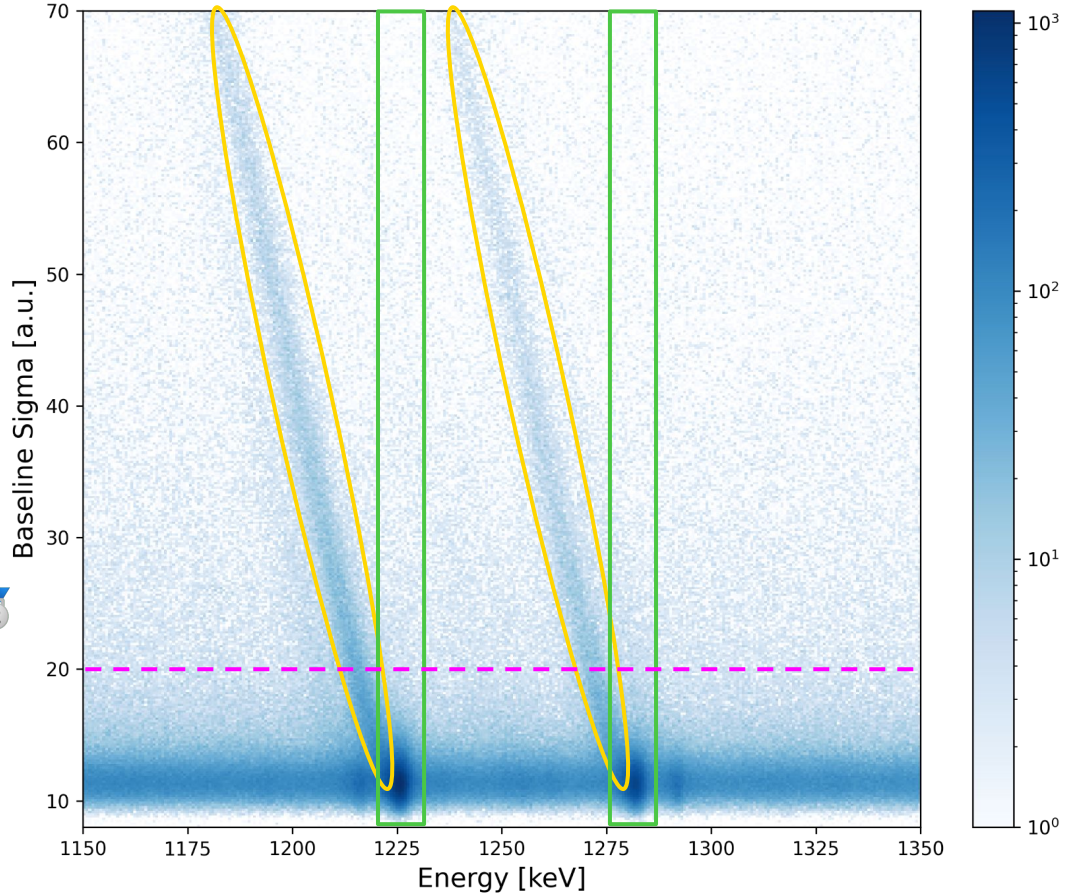


Quality cuts

- Pile-up events are reconstructed with degraded energy
- Only acceptance of peak events counts

Approach

- Set stringent (detector-specific) cuts 🥇, implement dedicated pile-up treatment 🥈



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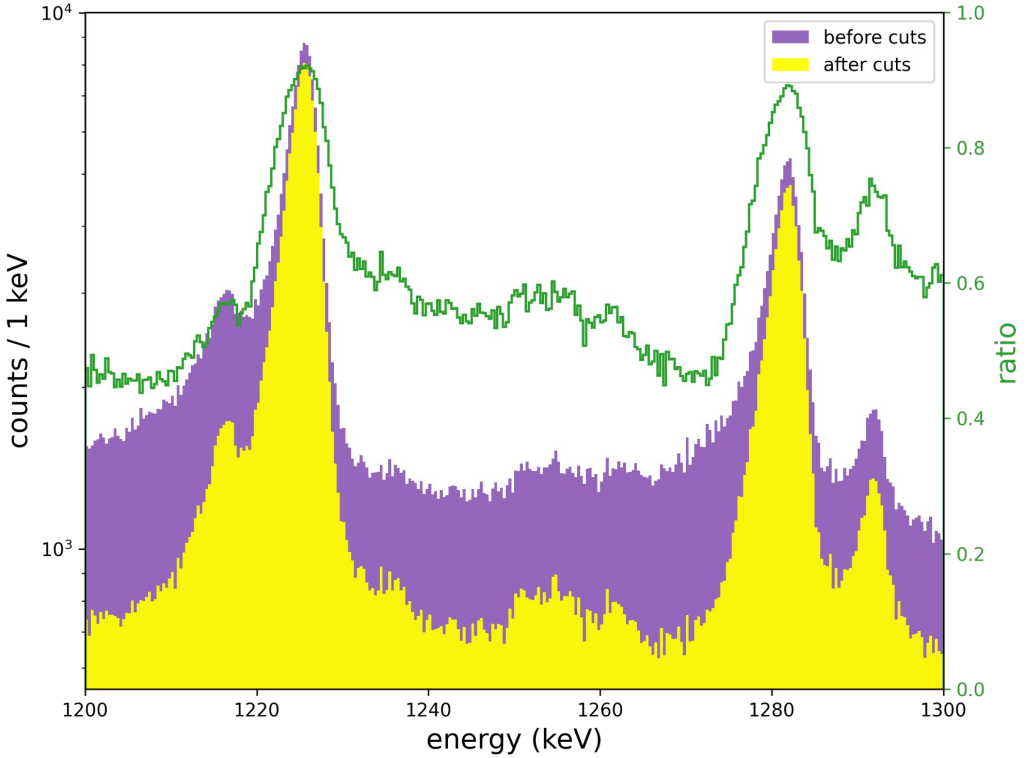
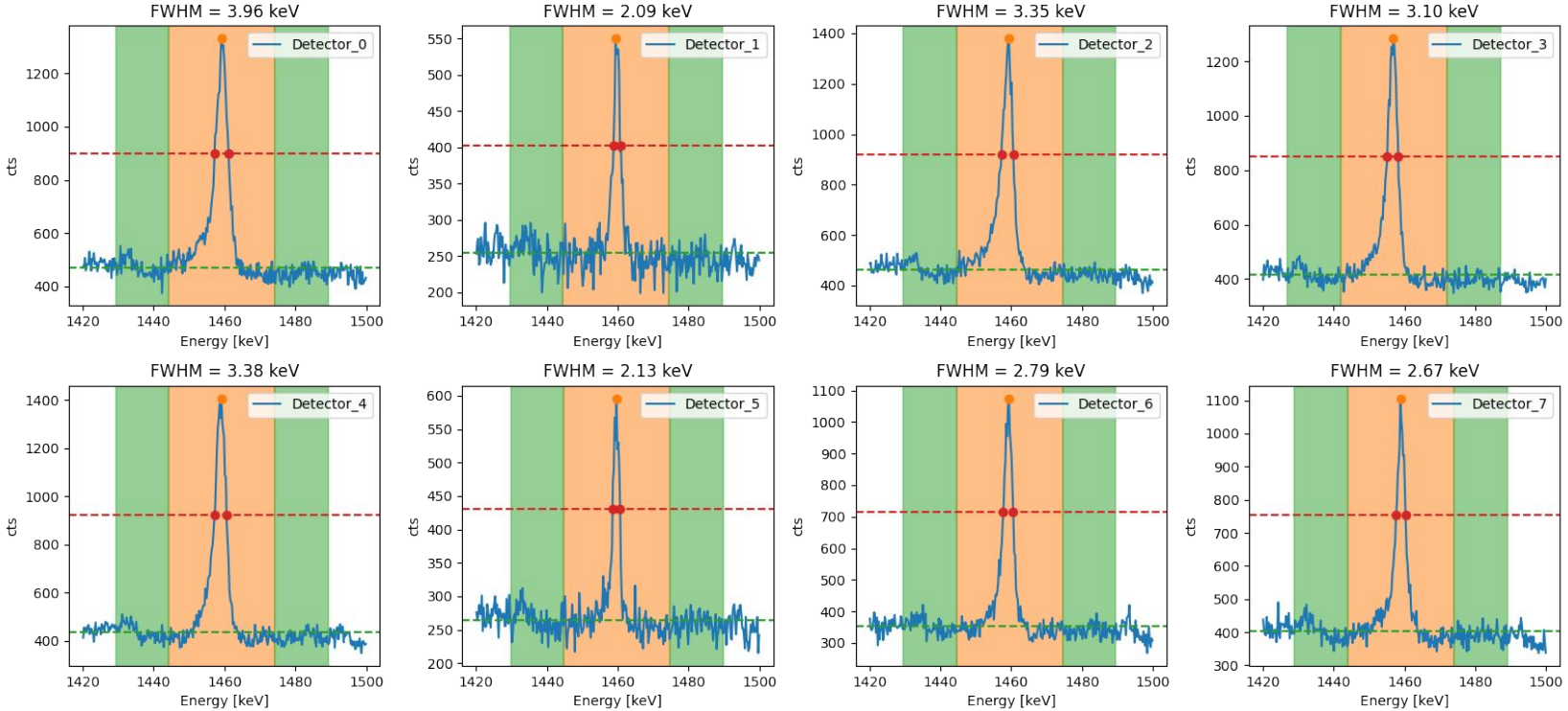
- Peak acceptance > 80% (evaluation with proper side-band subtraction to be implemented)



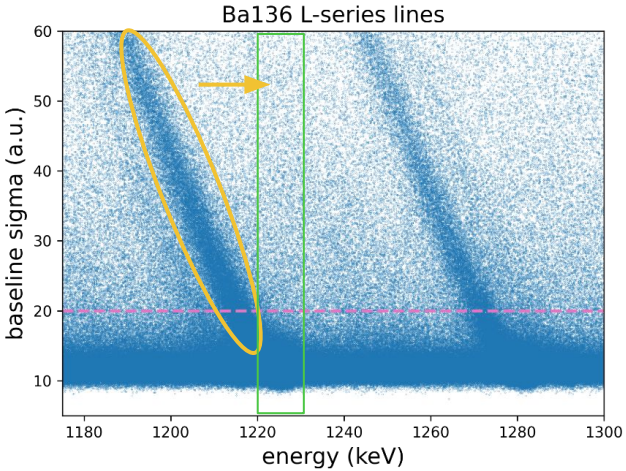
Energy resolution of ^{40}K peak

Rather consistent with calibration data, but low statistics… 📈



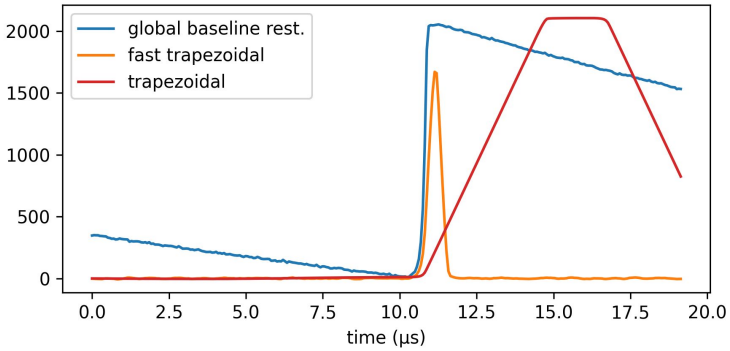
Reconstruction of pile-up events

Dedicated treatment of pile-up event may allow us to use them in the analysis (→ silver dataset) 🥈



Two approaches to be studied:

- Pile-up correction 🚧
- Unbiased shaping 🏗️

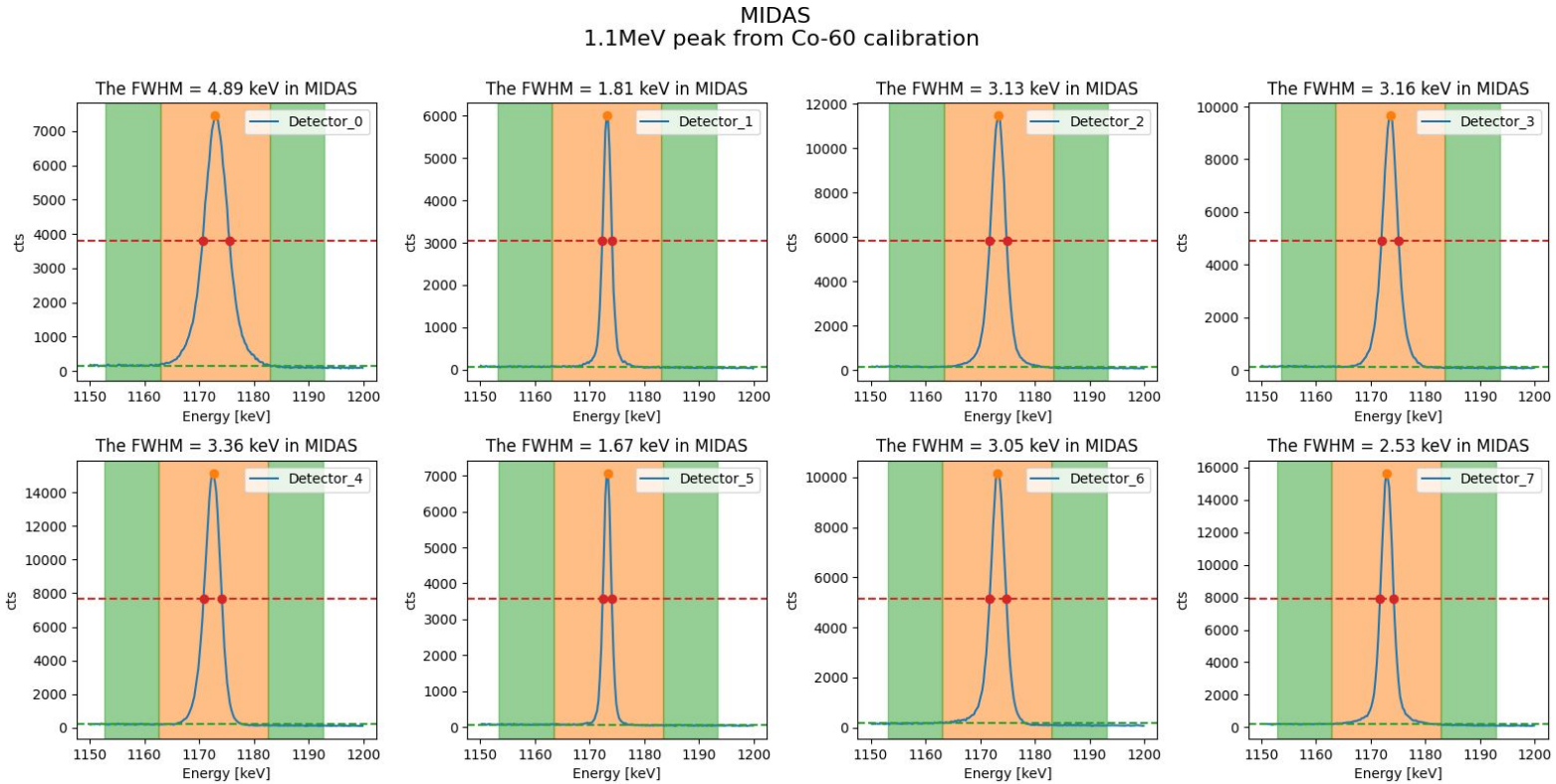


Conclusions

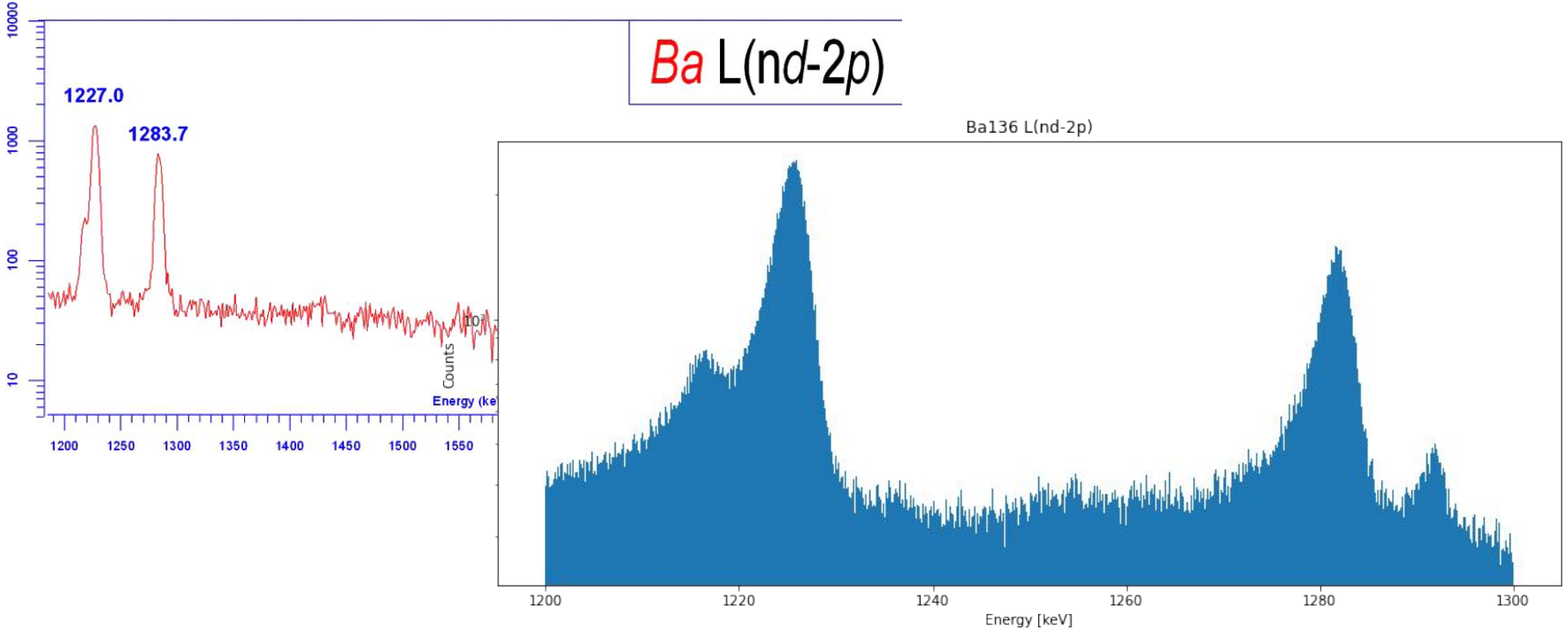
- 🏆 Optimization of trapezoidal shaping for best energy resolution
- 🏆 Energy resolution overcomes MIDAS performance (could use similar shaping in next campaign)
- 🏆 Quality cuts studied with ^{136}Ba data and cross-checked with ^{60}Co calibration data
- 👷 Pile-up treatment (silver data set) is work in progress

Backup

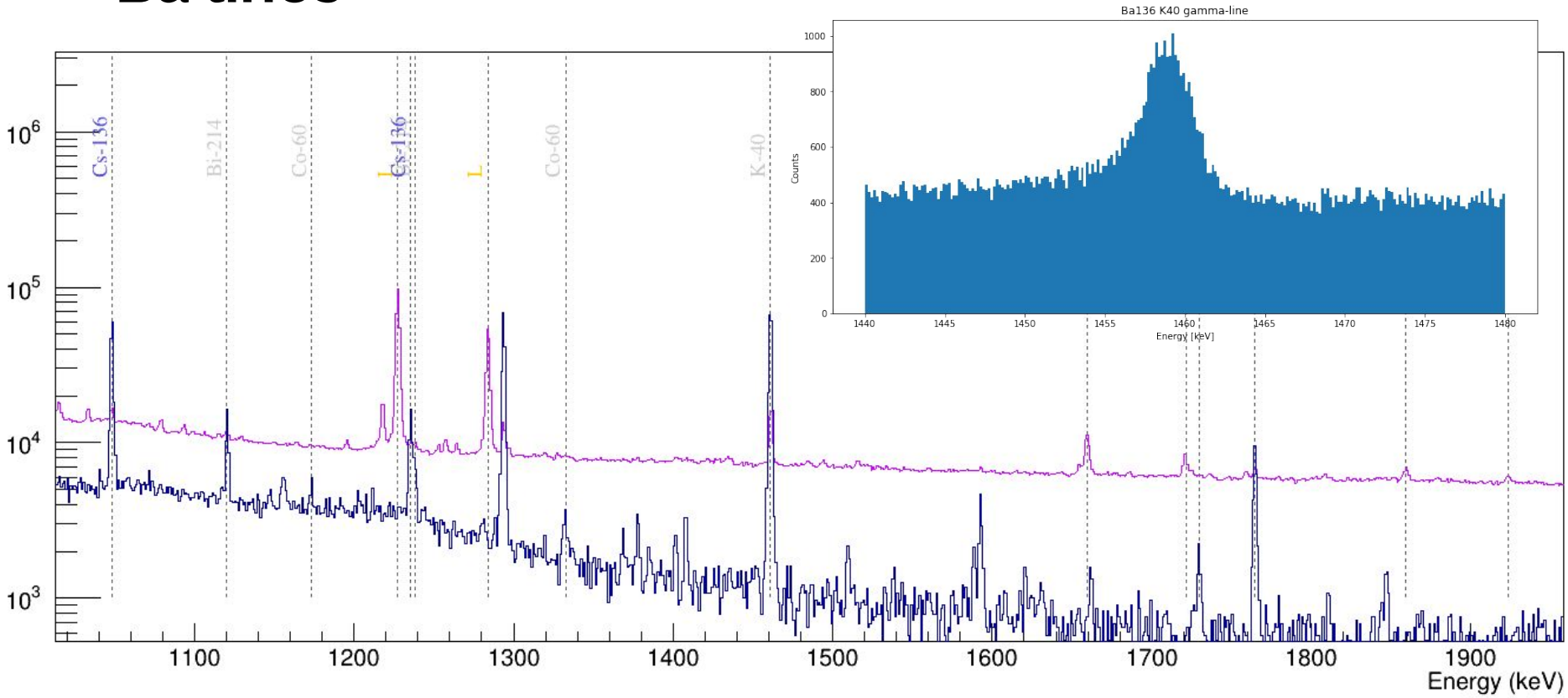
FWHM for MIDAS data



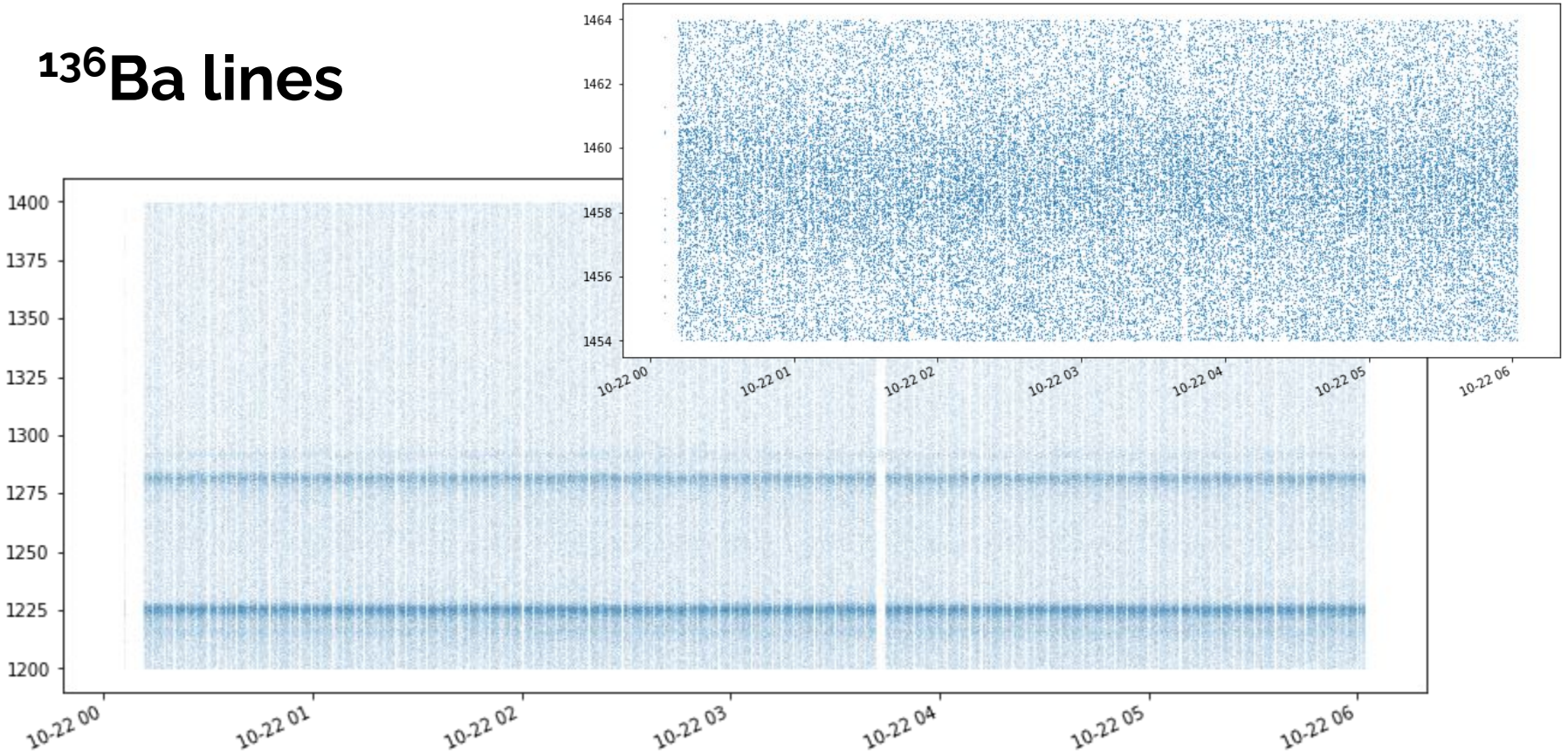
^{136}Ba lines


Ba L(nd-2p)
1227.0
1283.7
Counts
Energy (ke
10000
1000
100
10
1200
1250
1300
1350
1400
1450
1500
1550
Ba136 L(nd-2p)
1200
1220
1240
1260
1280
1300
Energy [keV]

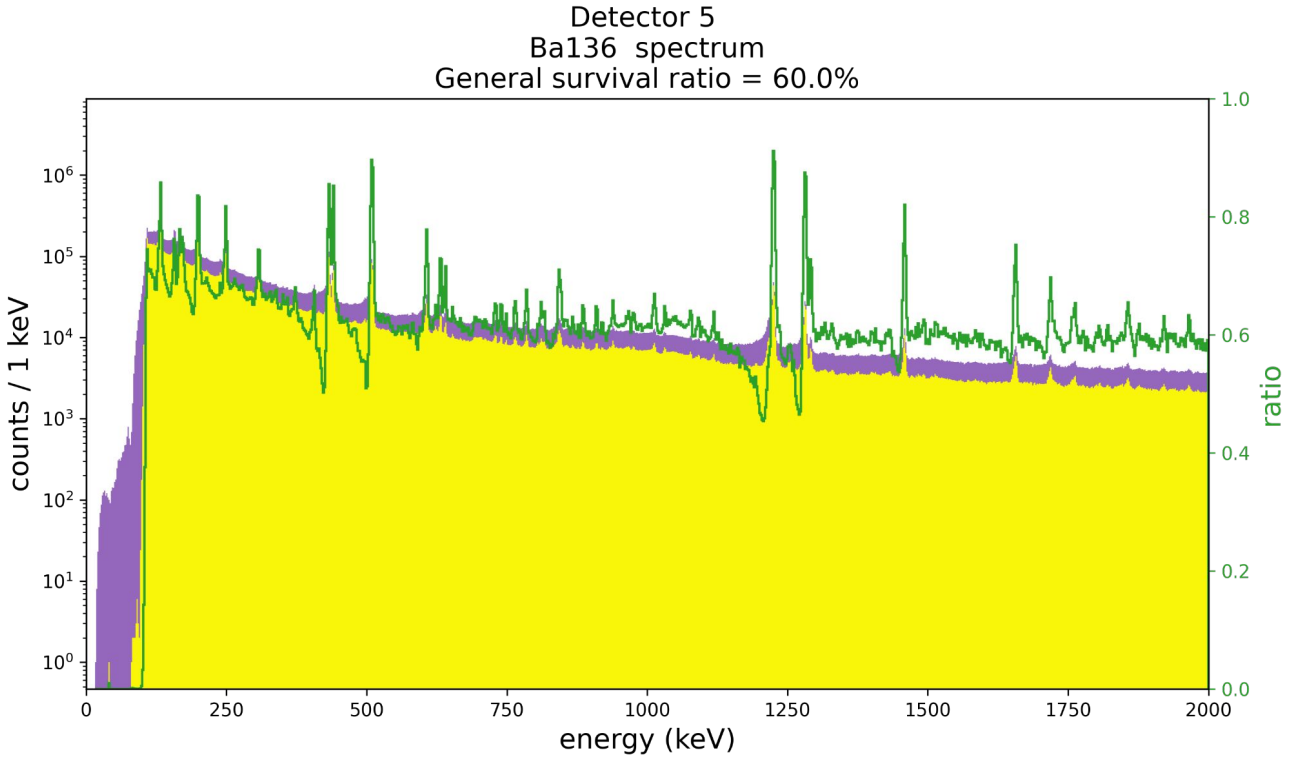
^{136}Ba lines


Cs-136
Bi-214
Co-60
L
Cs-136
L
Co-60
K-40
10^6
10^5
10^4
10^3
1100
1200
1300
1400
1500
1600
1700
1800
1900
Energy (keV)
Ba136 K40 gamma-line
Counts
Energy [keV]

^{136}Ba lines


1464
1462
1460
1458
1456
1454
1400
1375
1350
1325
1300
1275
1250
1225
1200
10-22 00
10-22 01
10-22 02
10-22 03
10-22 04
10-22 05
10-22 06

^{136}Ba spectrum



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