Proton range calibration for the R³B-CALIFA calorimeter

Mrunmoy Jena

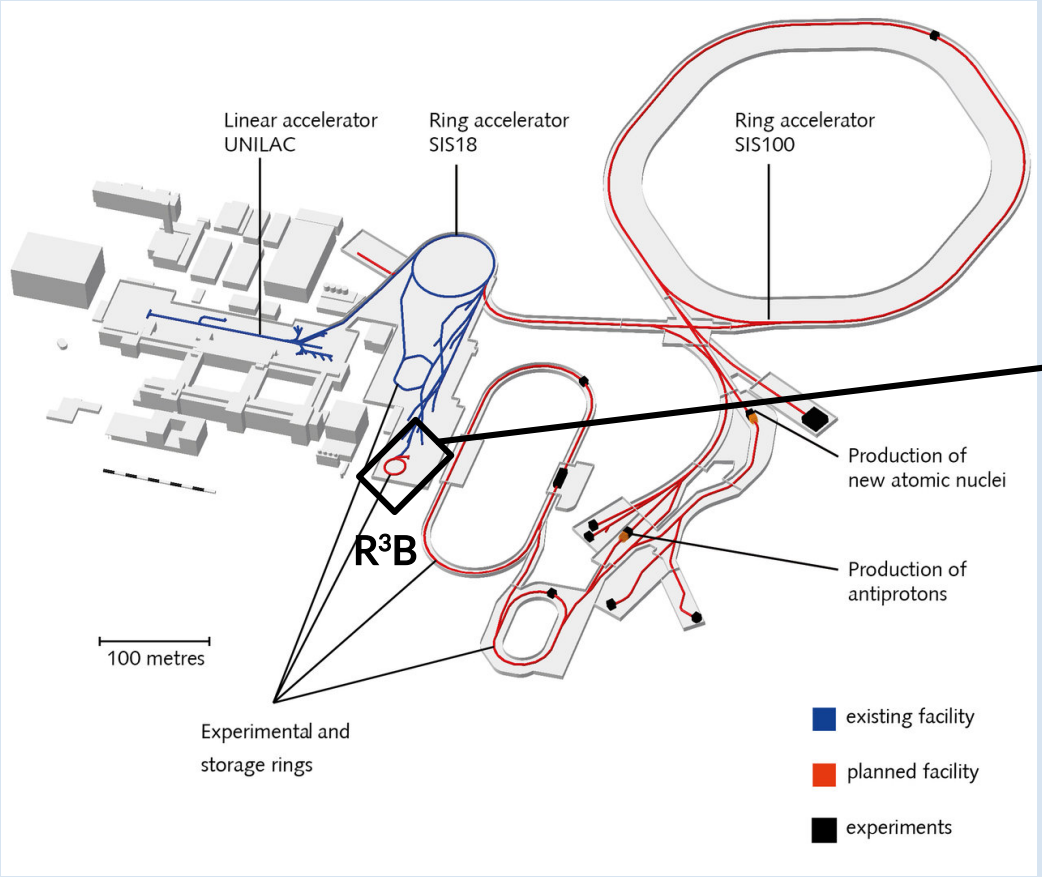
DPG Spring Meeting, Köln
HK 55.2
13.3.2025

Overview of R³B and CALIFA
Structure of calibration algorithm
Calibration in the gamma range
Extrapolation to proton range

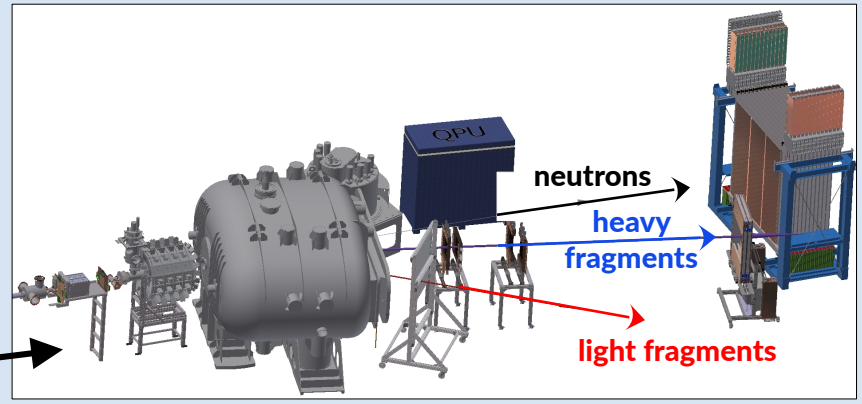
Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy, BMBF 05P24WO2, and the FAIR Phase-0 program

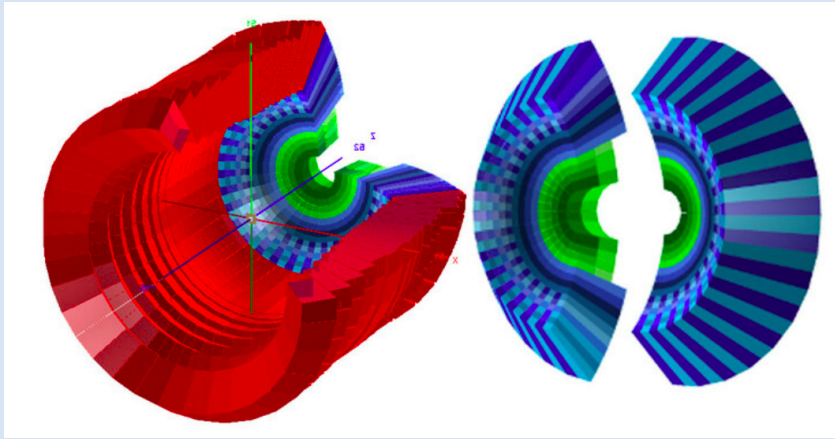
TUM Members:
Mrunmoy Jena, Tobias Jenegger, Roman Gernhäuser

Overview : R³B and CALIFA

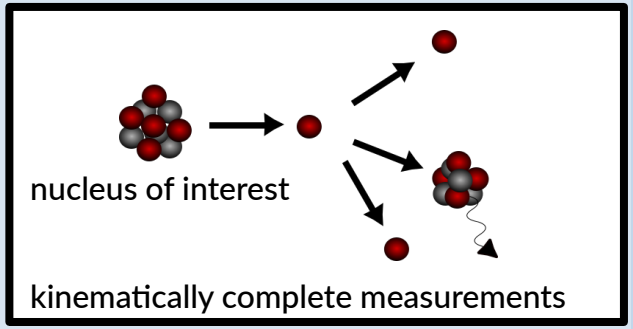


R³B: Reactions with Radioactive Beams





CALorimeter for the **I**n **F**light detection
of γ rays and light charged p**A**rticles



Barrel: $43^\circ < \theta < 140^\circ$

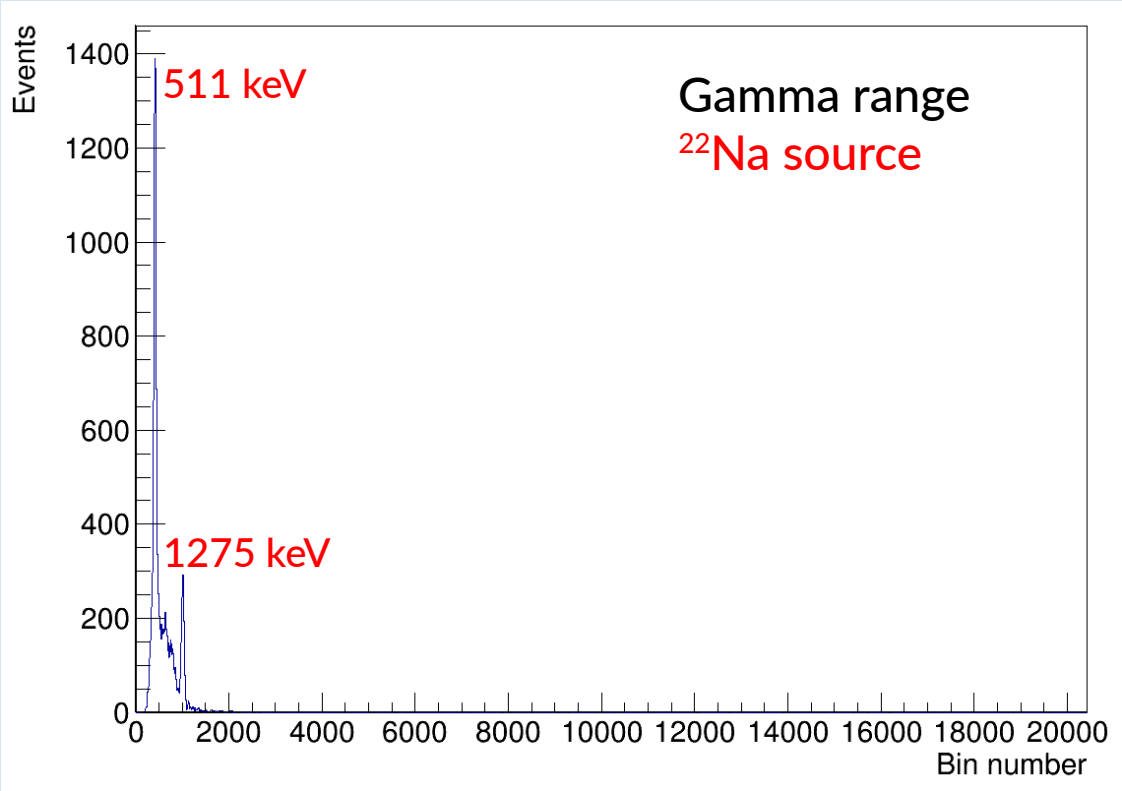
iPhos: $19^\circ < \theta < 43^\circ$

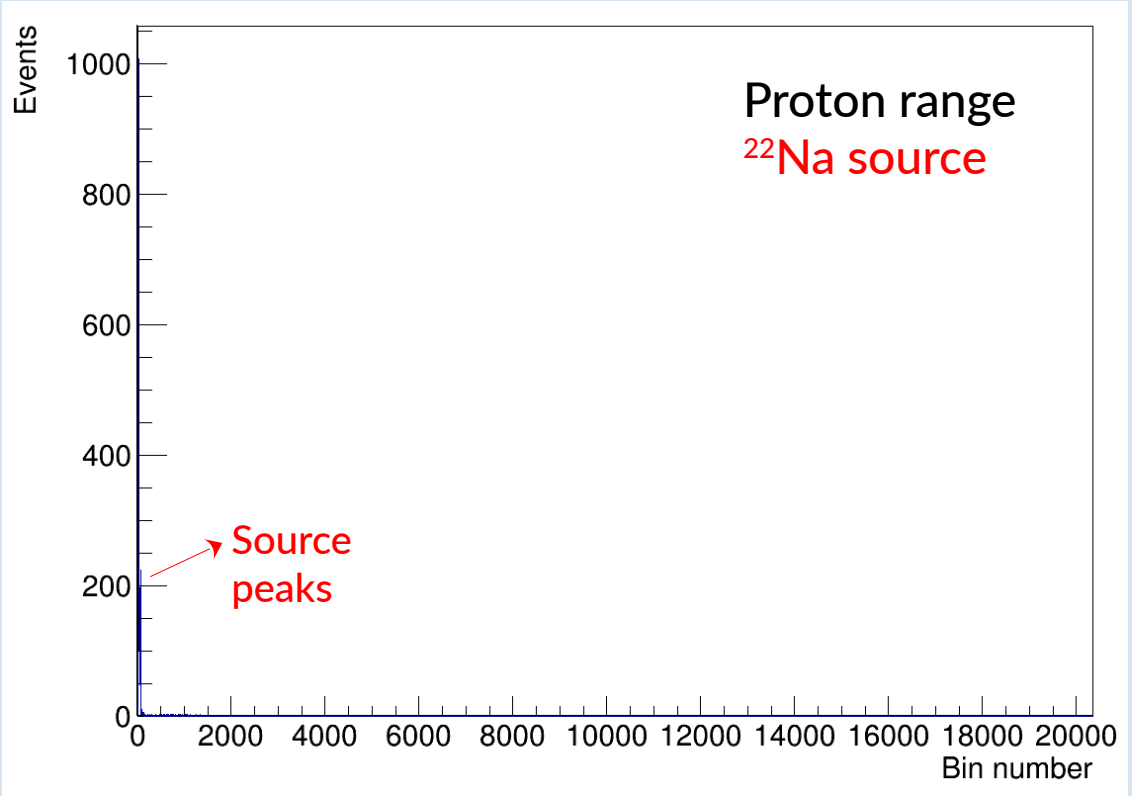
CEPA: $7^\circ < \theta < 19^\circ$

Group report:

HK 33.1, Tobias Jenegger (Wed.,17:30)

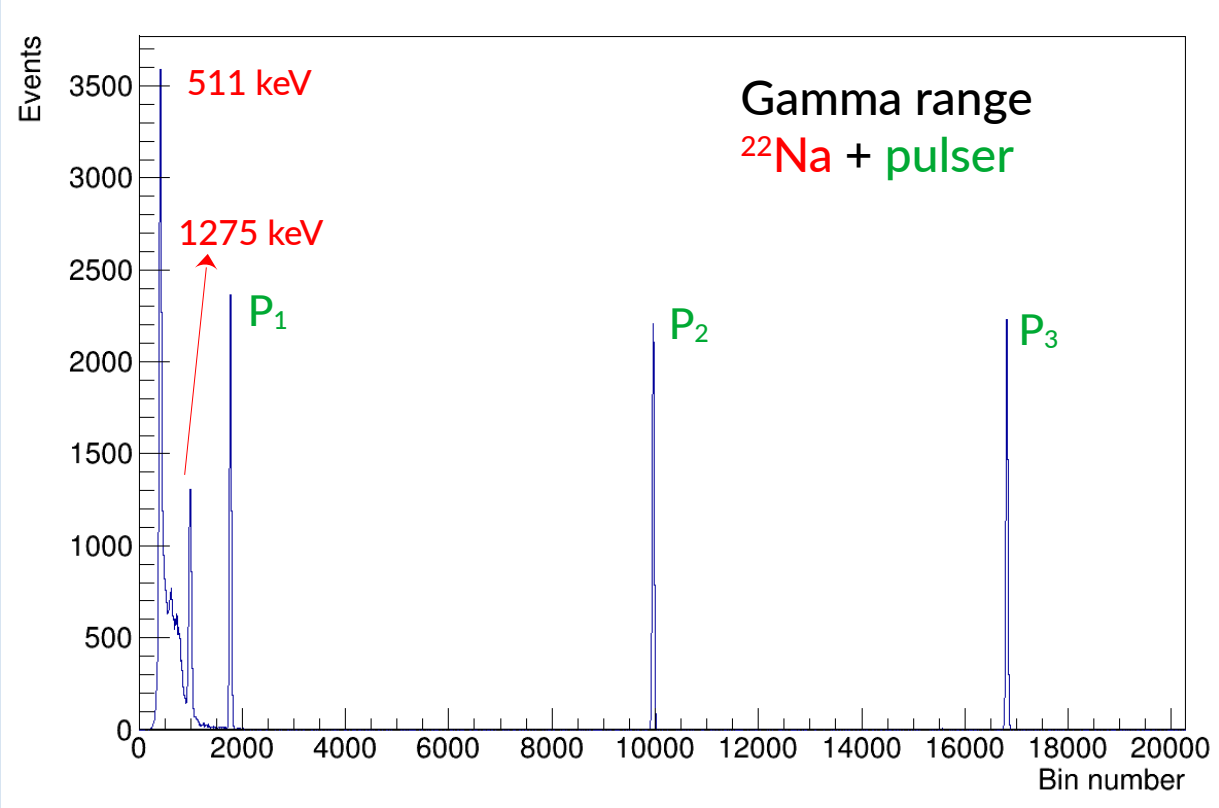
Introduction

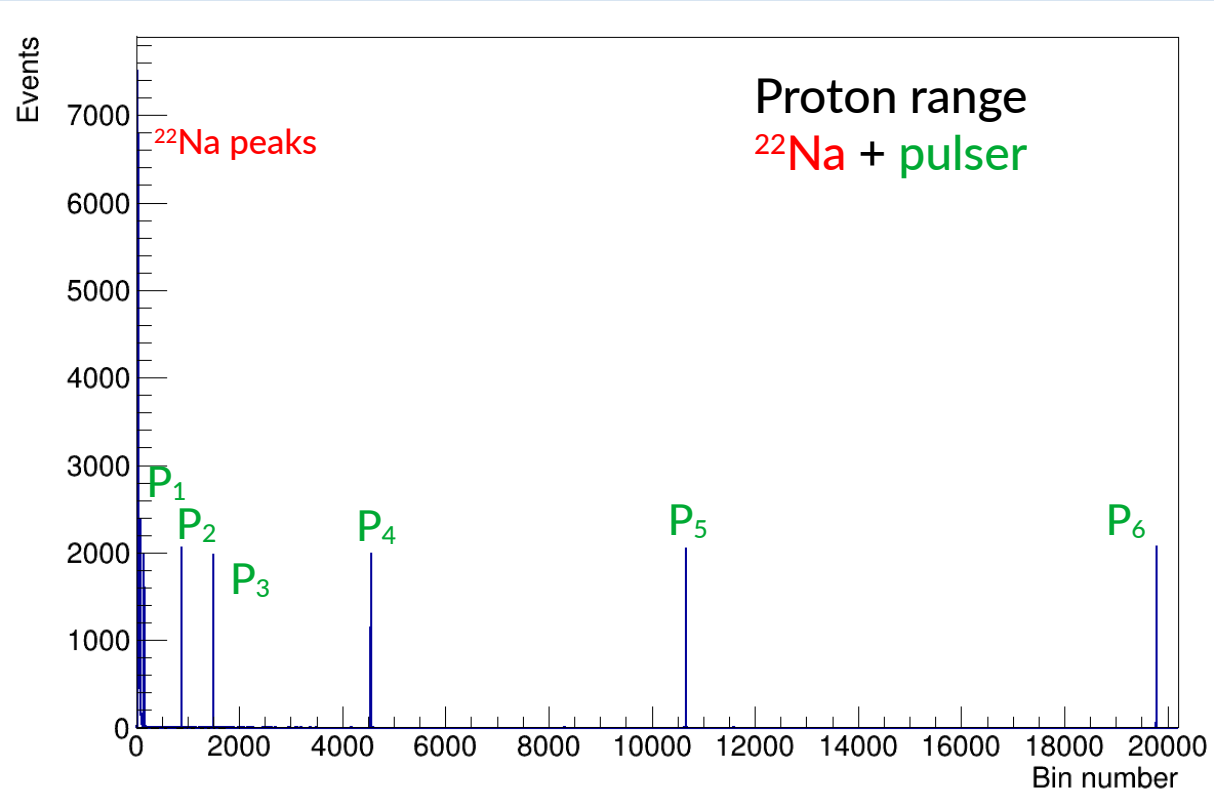




^{22}Na source hardly useful for performing calibration in the proton range !

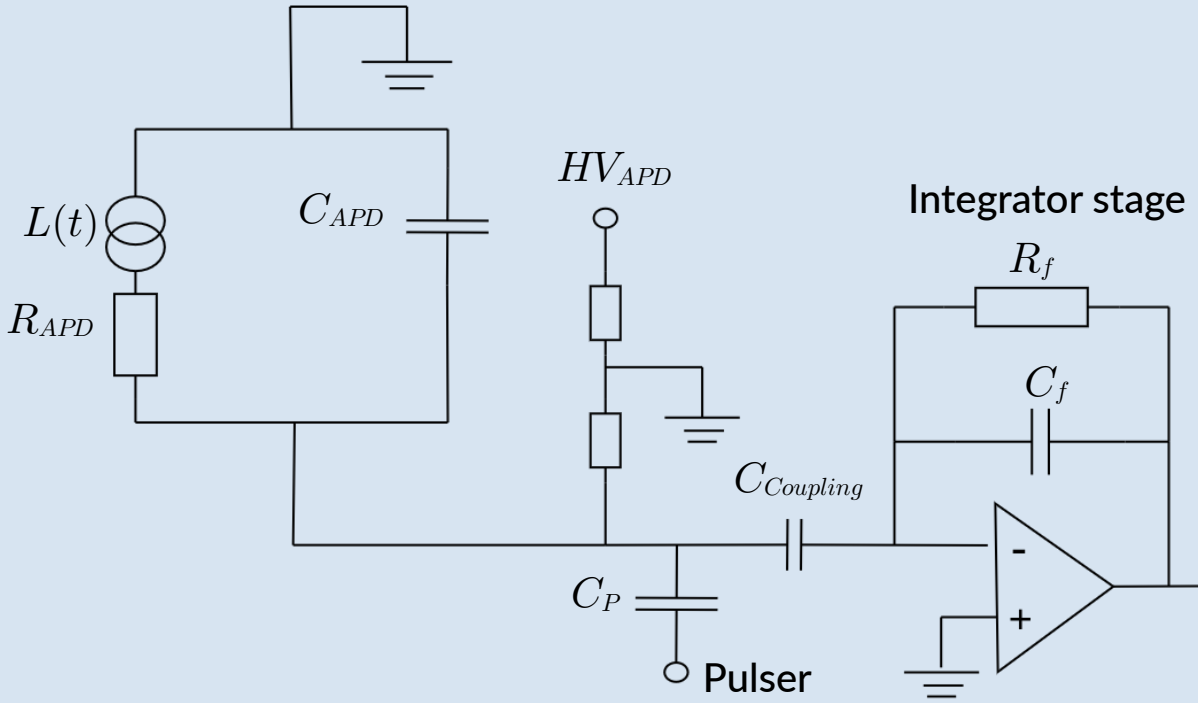
Introduction

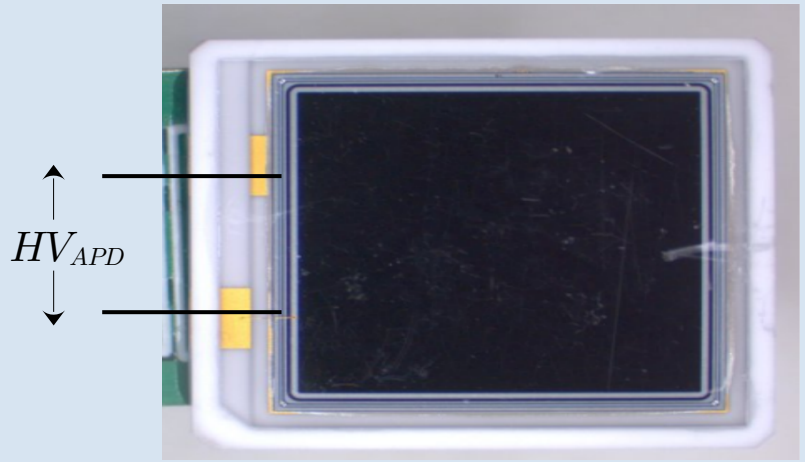


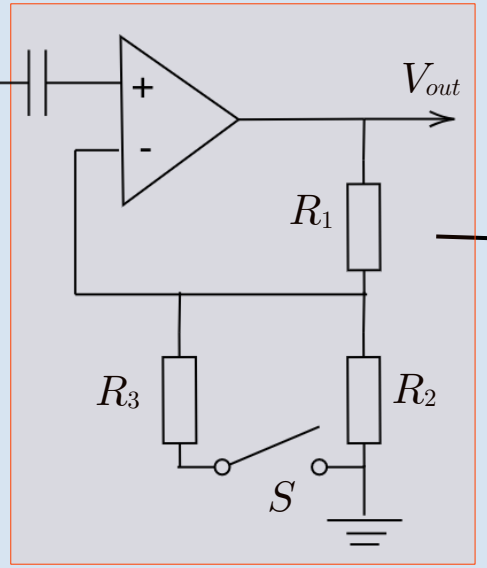


Using pulsers is essential for calibration in proton range

Introduction







$$L(t) \equiv f(N_\gamma \cdot c_{Transp.} \cdot c_{Absorp.} \cdot \epsilon_{APD} \cdot g_{APD})$$

Need to calibrate: $\frac{\int L(t)dt}{V_{out}}$

Calibration algorithm

Unpacking

data.lmd → Unpacker → unpacked_gamma.root, unpacked_proton.root

Calibration macro

Run bash script (bash_pulser_calibration.sh)

read all events and fill

spectra_gamma.root
spectra_proton.root
(5088 1D histograms)

for each histogram

find peaks

Gauss fit each peak

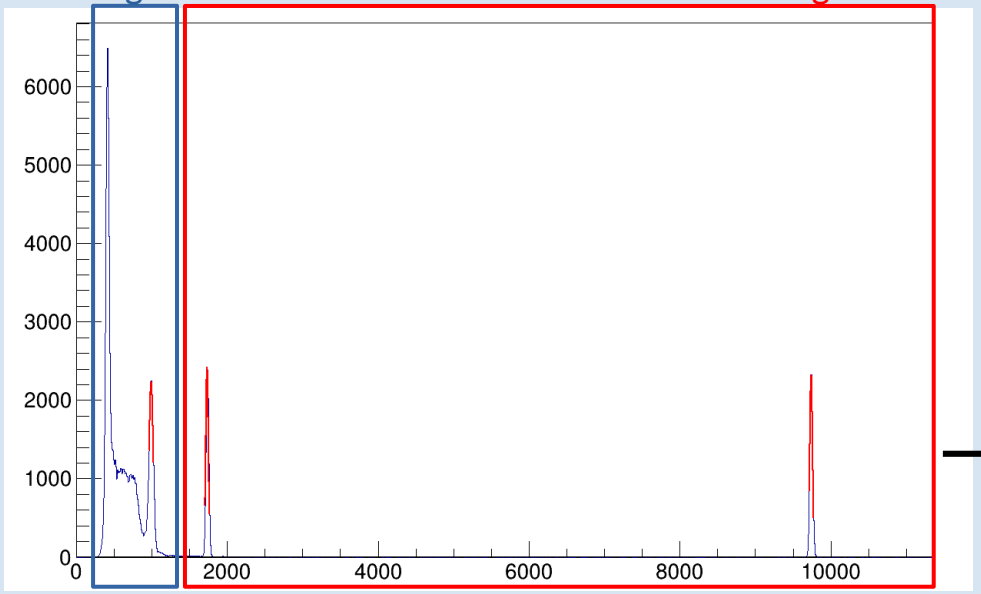
Mean, Sigma, Events

Peak parameters:
number and region for source and pulser peaks

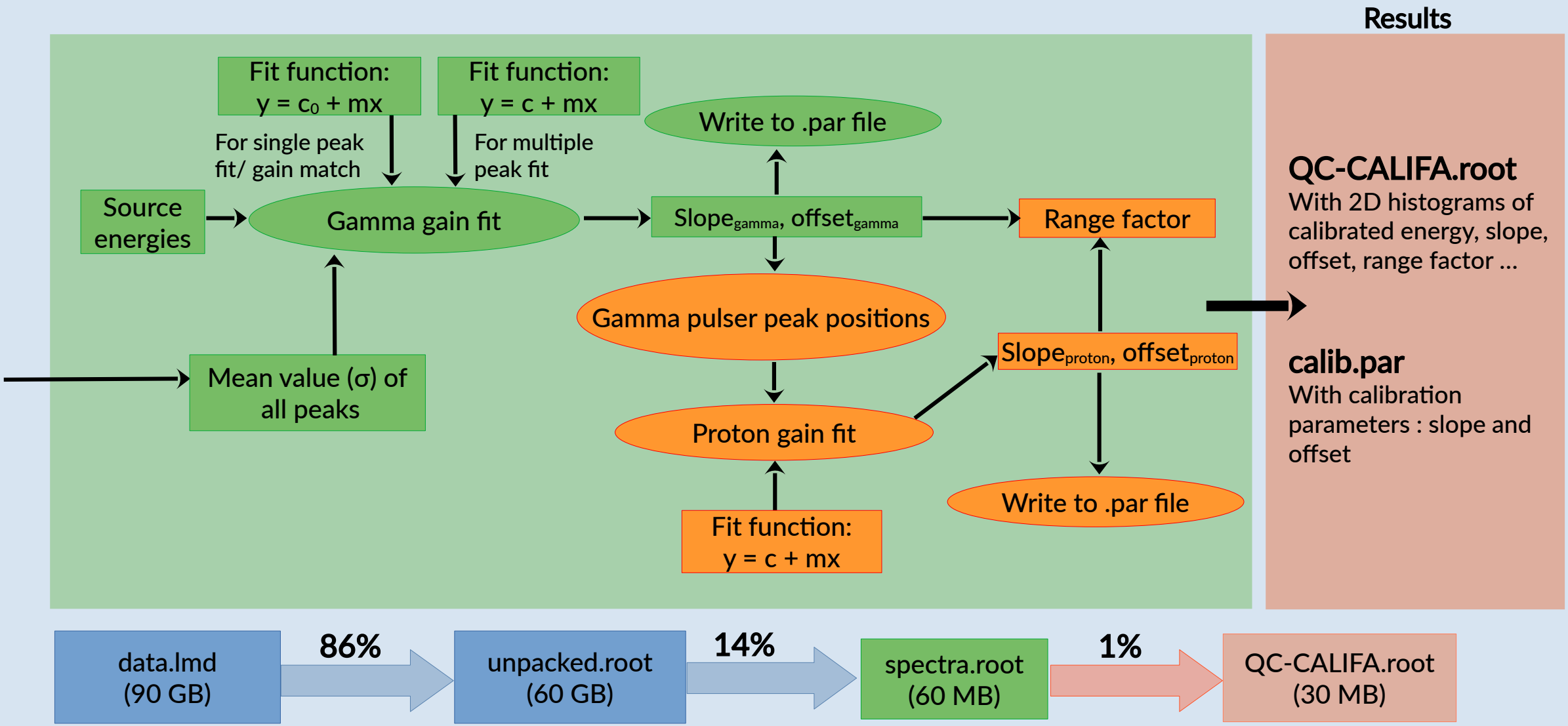
Fit parameters:
Expected width

Source region

Pulser region

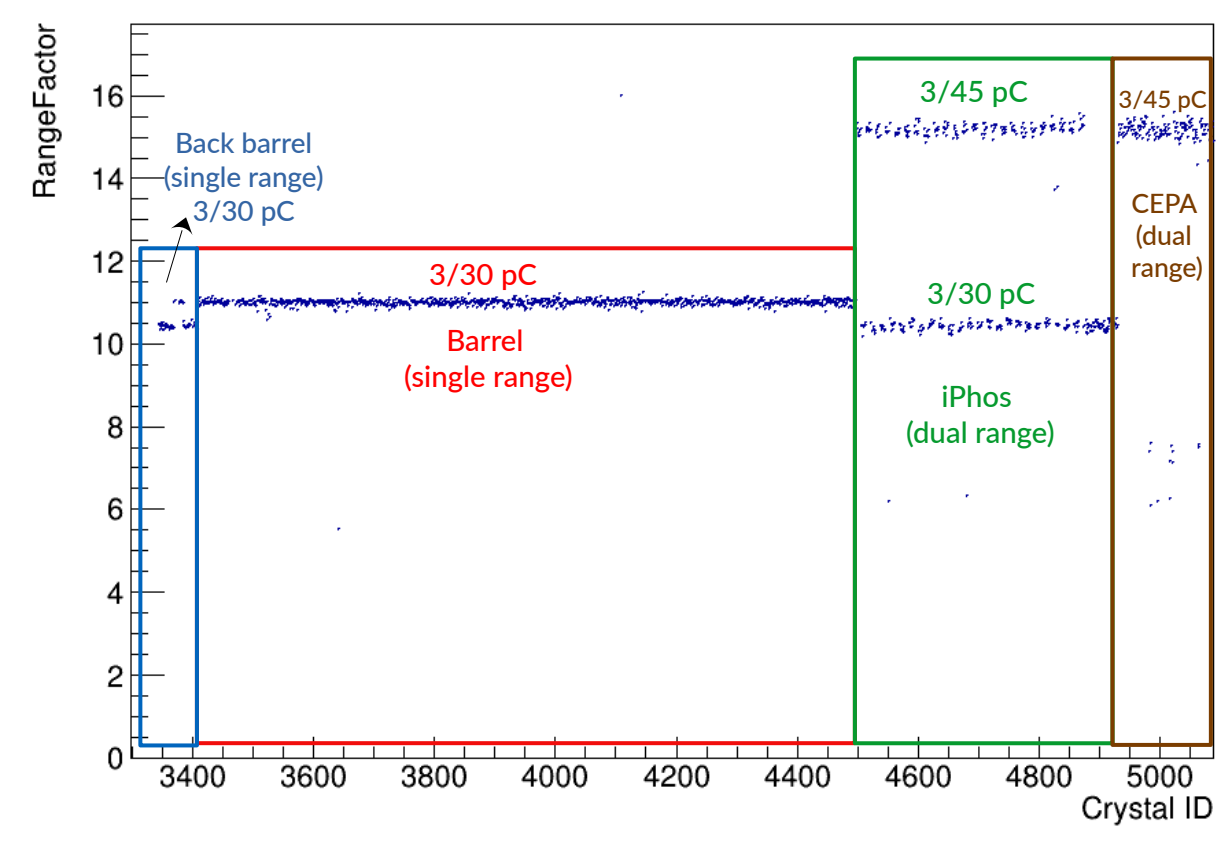


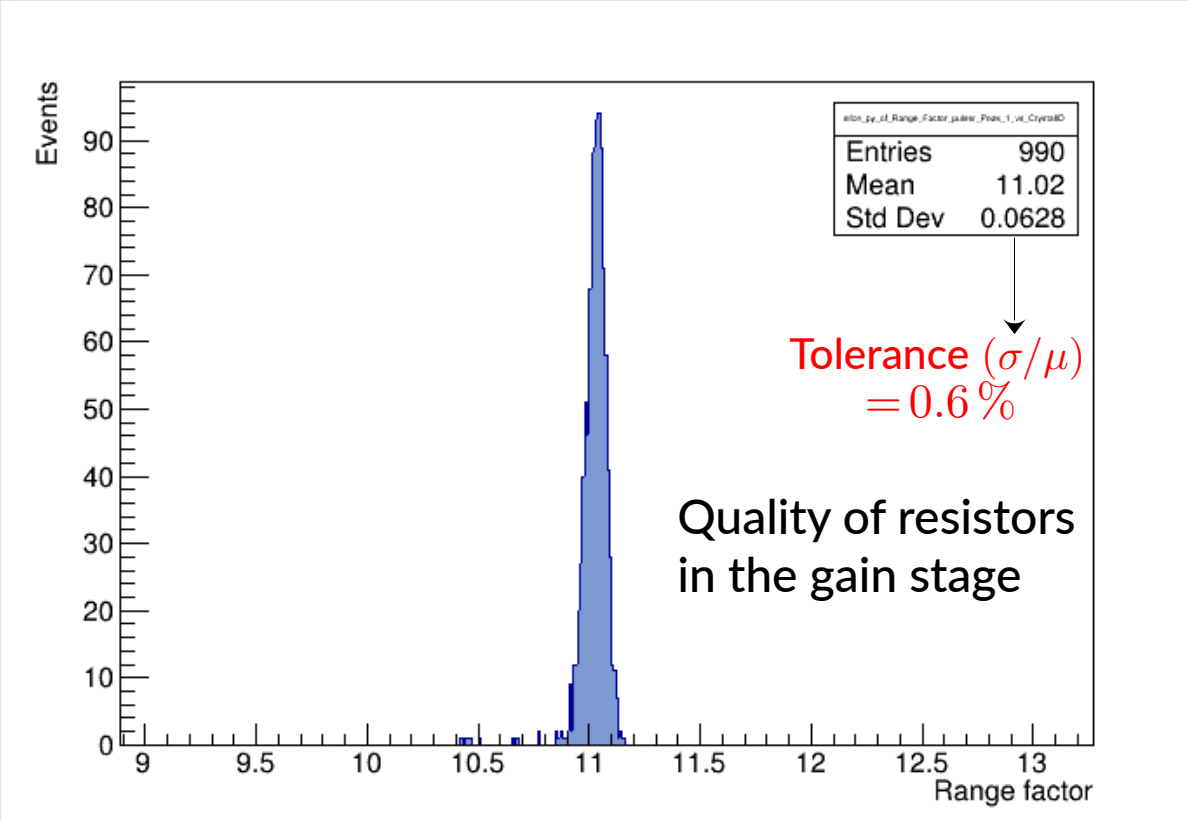
Calibration algorithm



* % in terms of time taken on an 12th Gen Intel Core i5-12500, 12 cores

Range factor

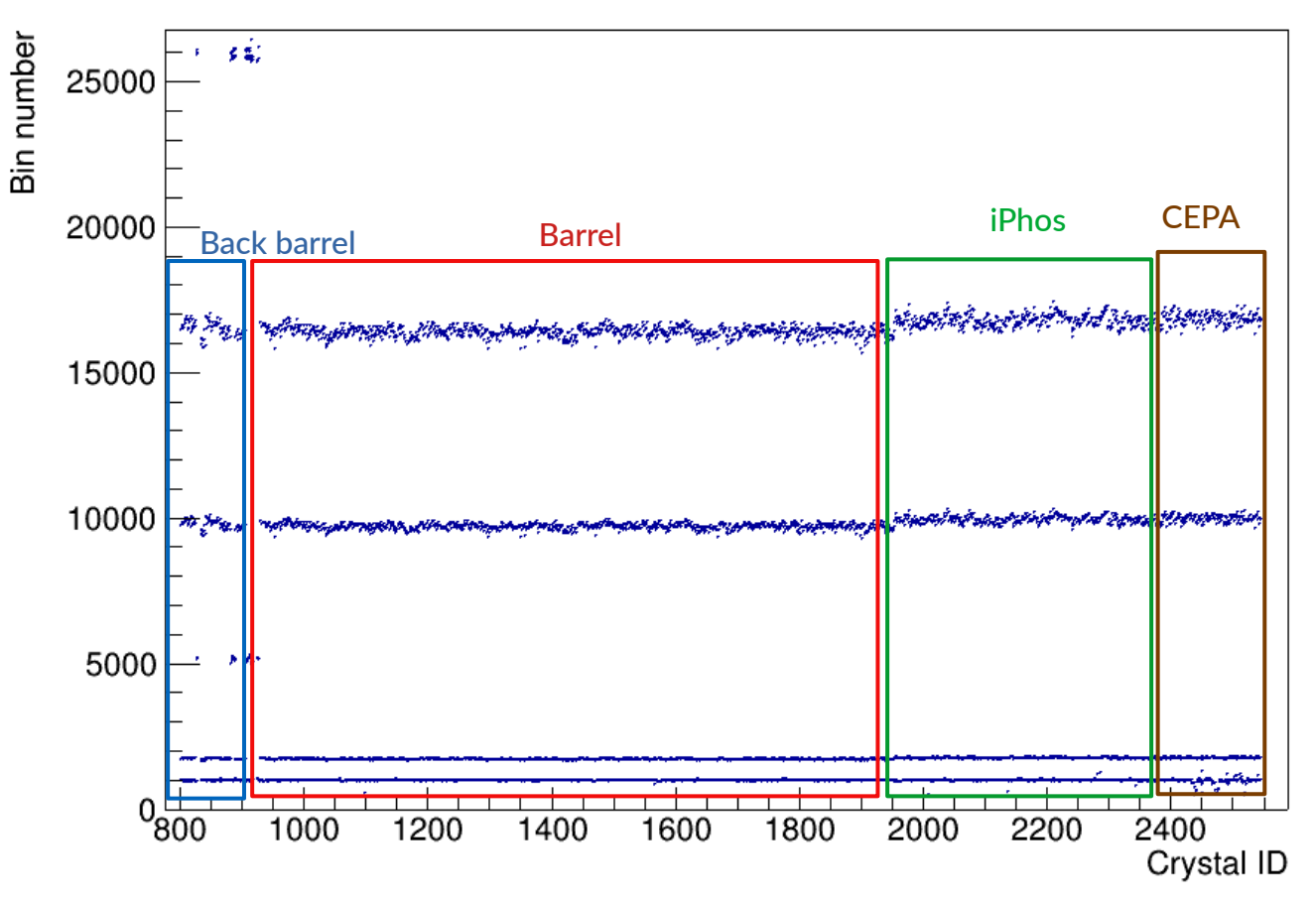


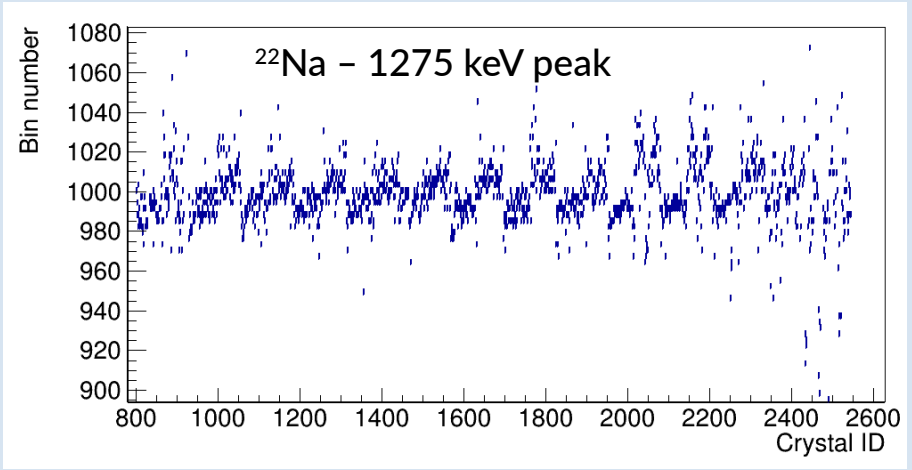


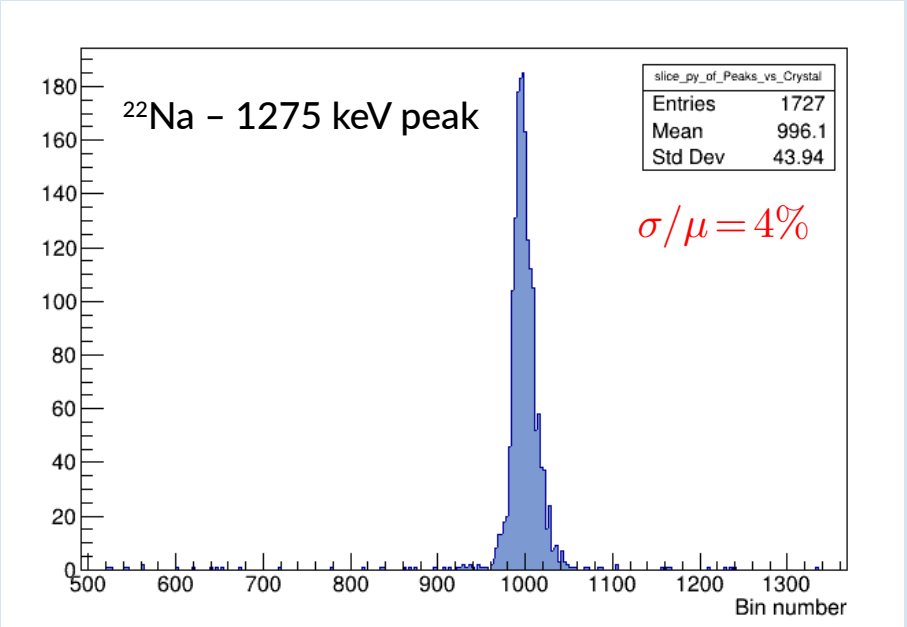
$$R = E_{\gamma\,(uncalib.)} / E_{p\,(uncalib.)} \approx 11$$

Serves as a translation factor between gamma range and proton range

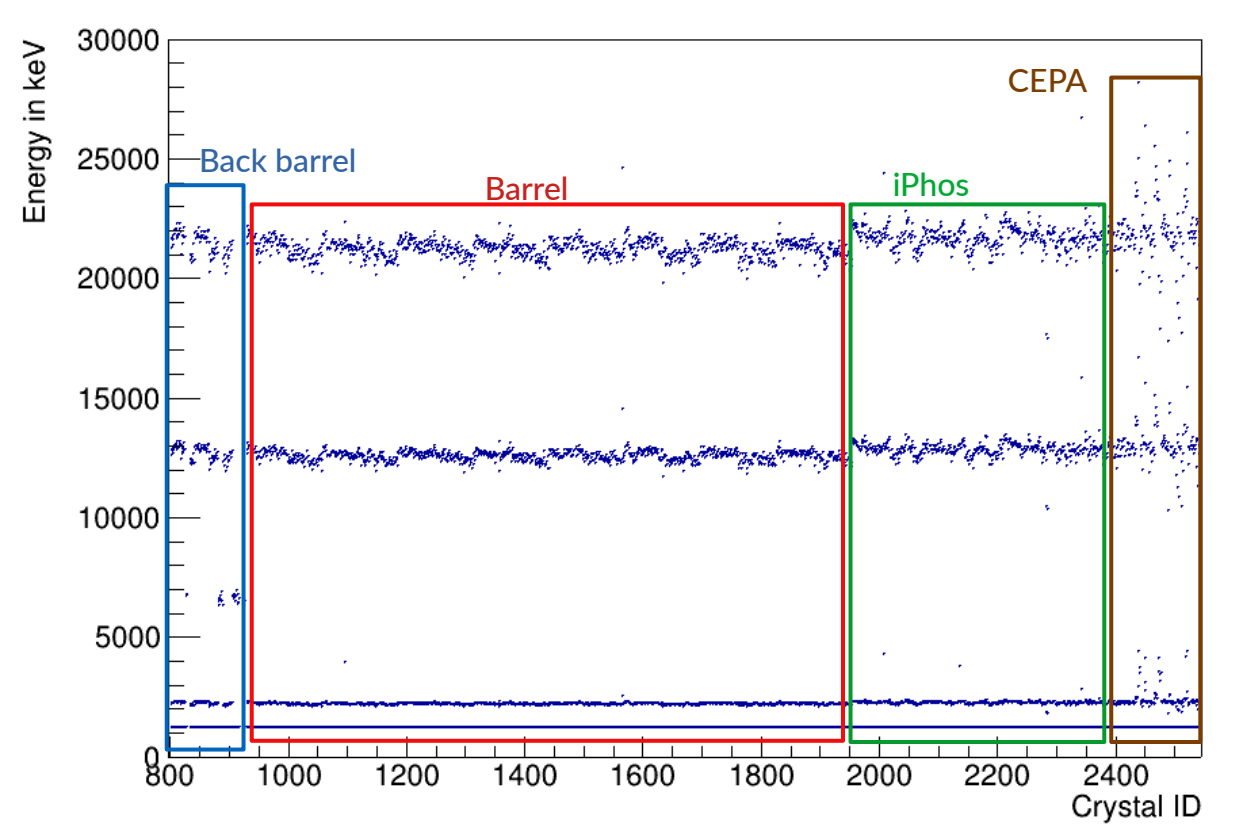
Gamma range: uncalibrated spectra

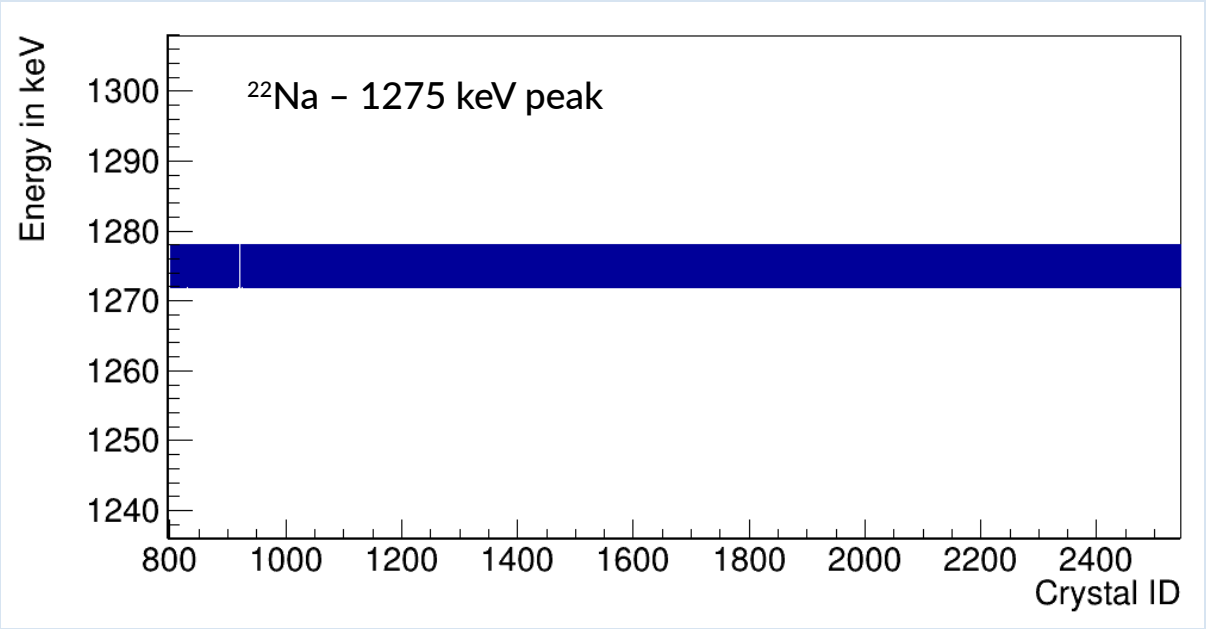






Gamma range: calibrated spectra



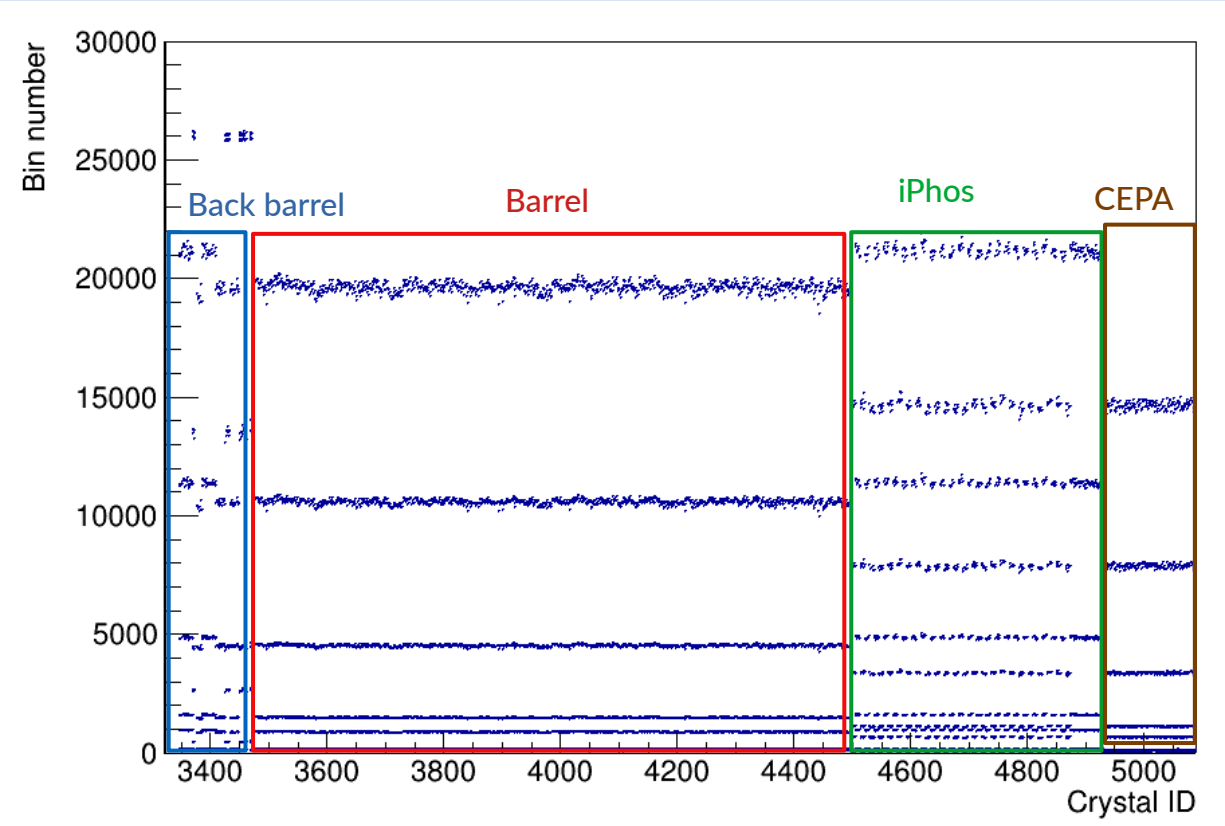


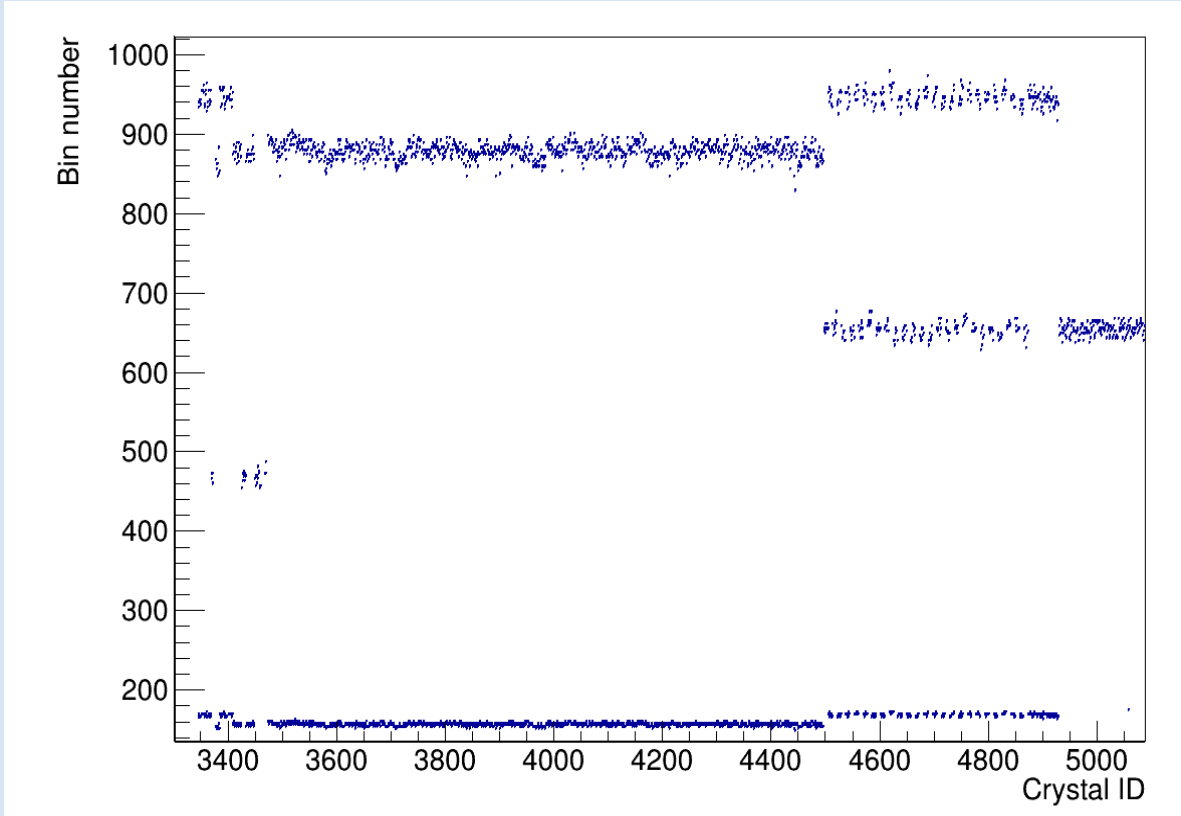
Applying a linear fit: $y = m_\gamma x + c_\gamma$

Software works !

Now we also have pulser peaks in keV

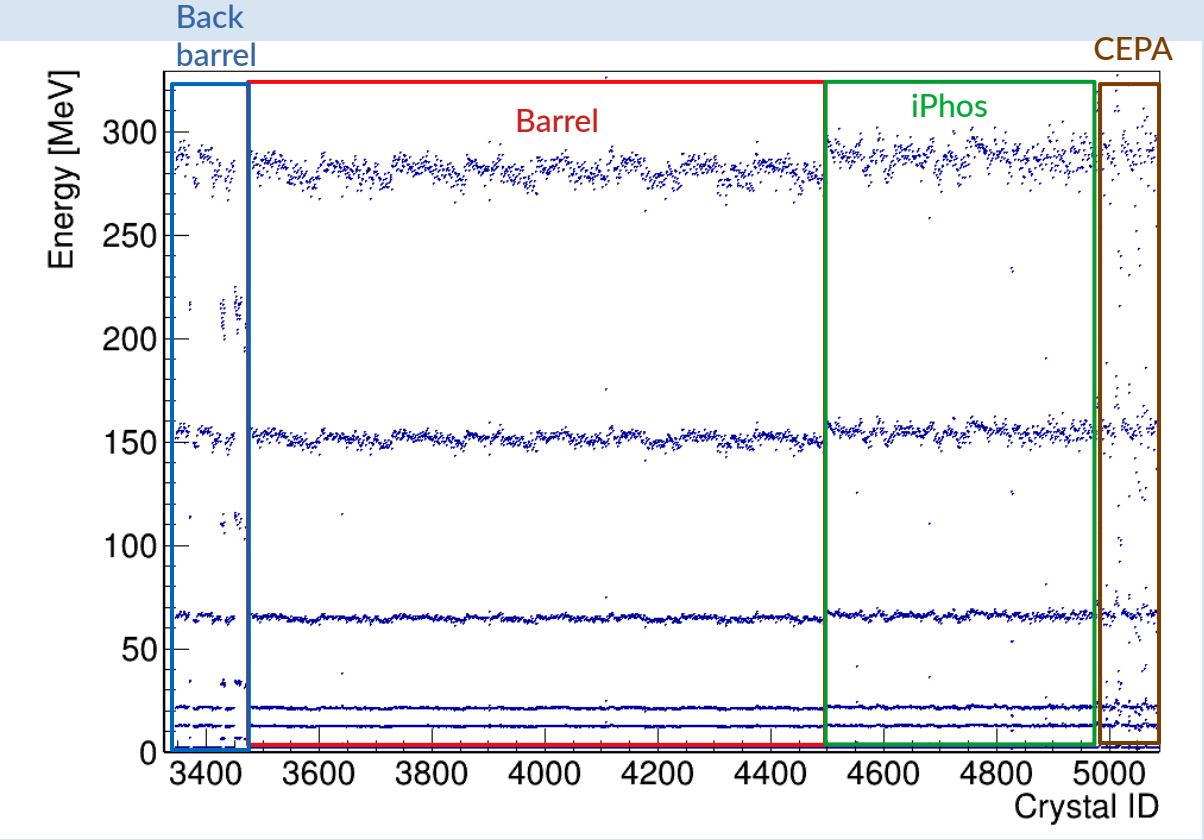
Proton range: uncalibrated spectra

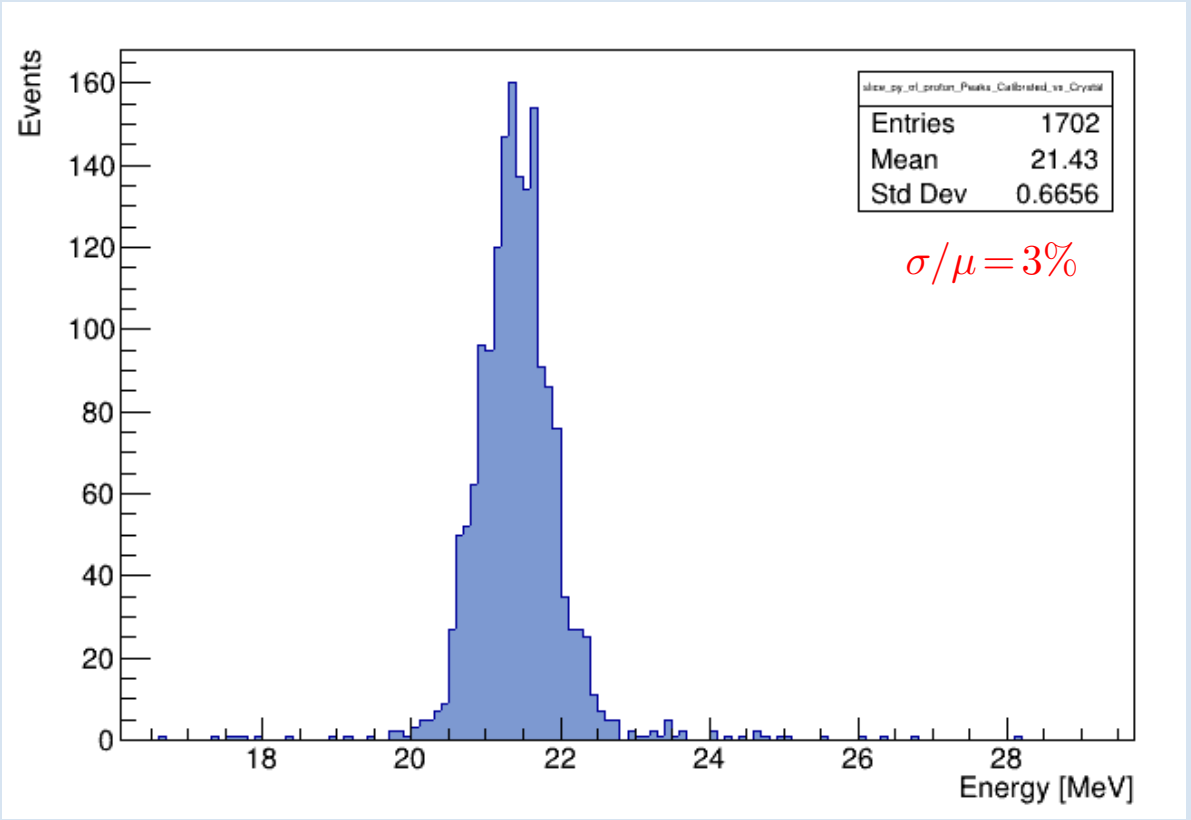




There are (channel to channel) variations in the electronics

Calibration in proton range

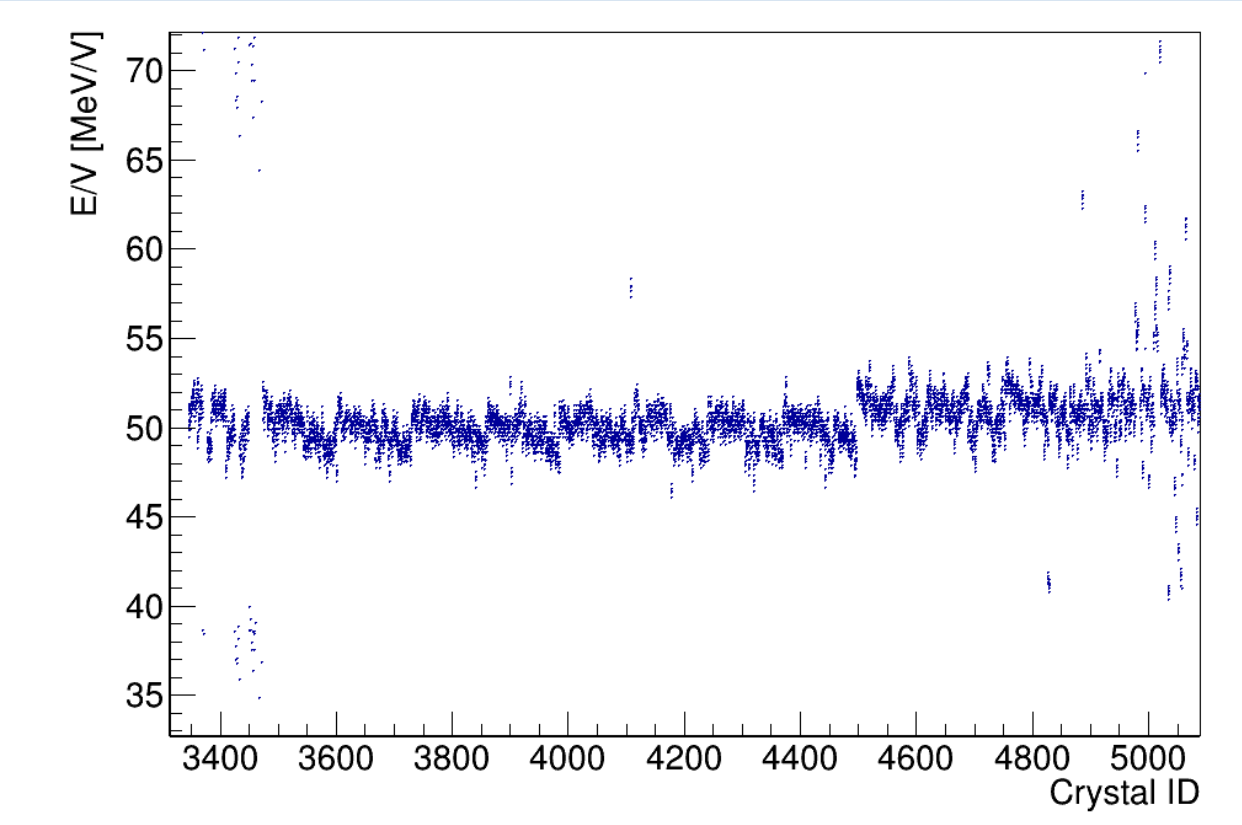


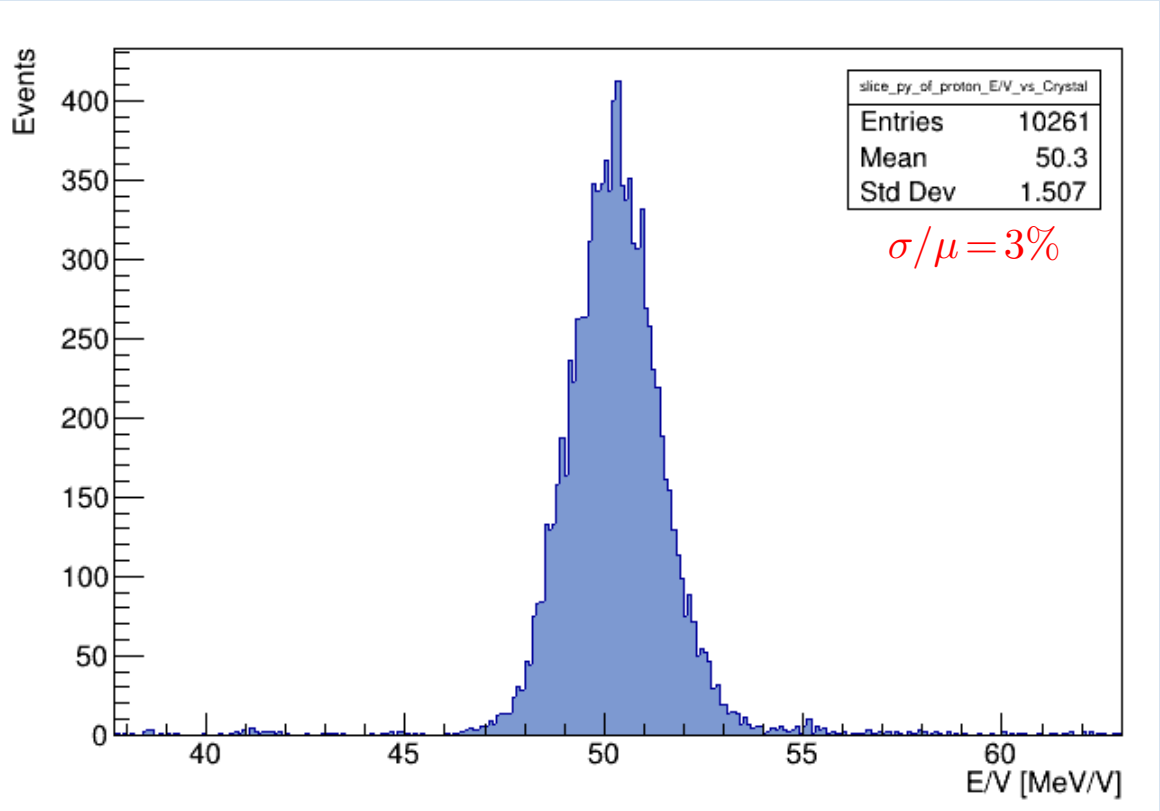


Energies for first 3 pulsers obtained from gamma calibration
Then doing a linear fit : $y = m_p x + c_p$ ⇒ All pulser energies in keV

Variation in pulsers include all uncertainities (depending on $L(t)$, R and C_{pulser})

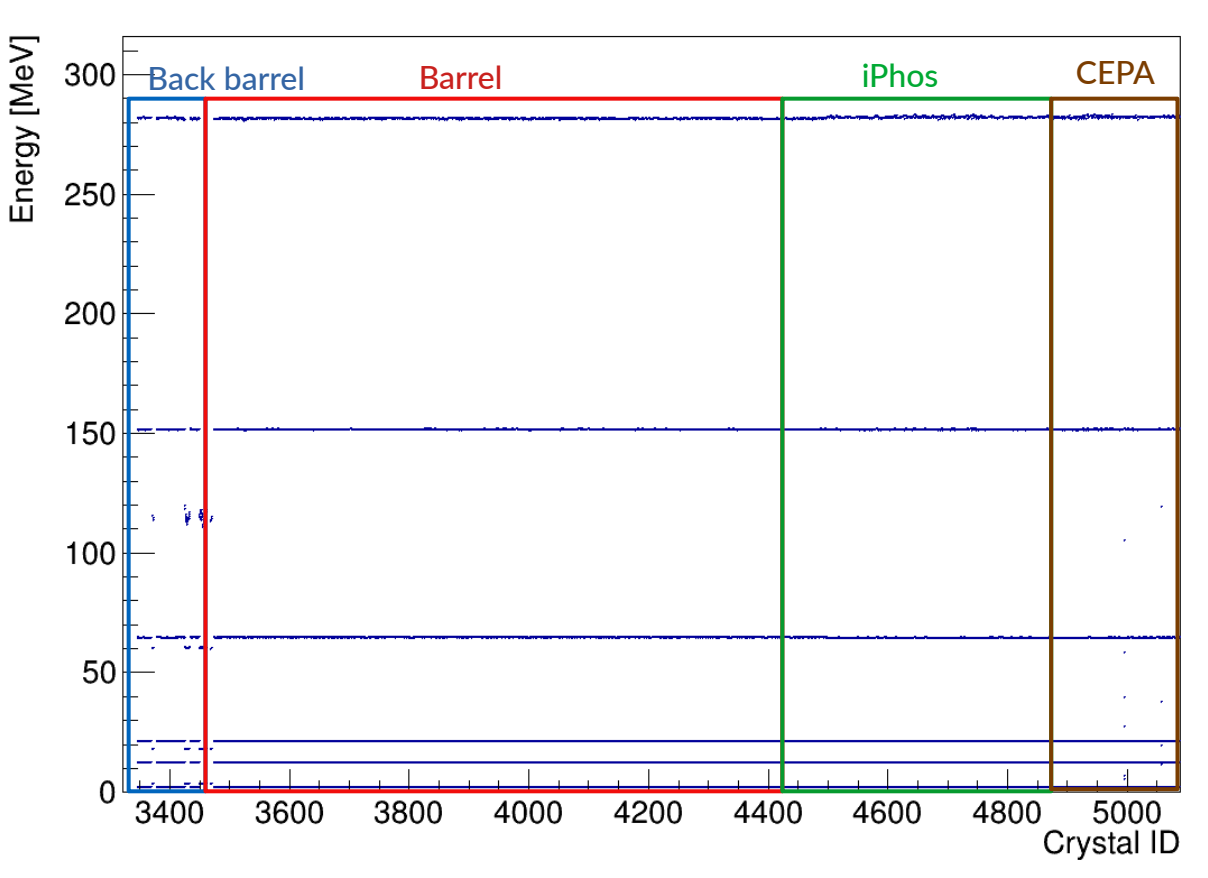
Pulser E/V ratio

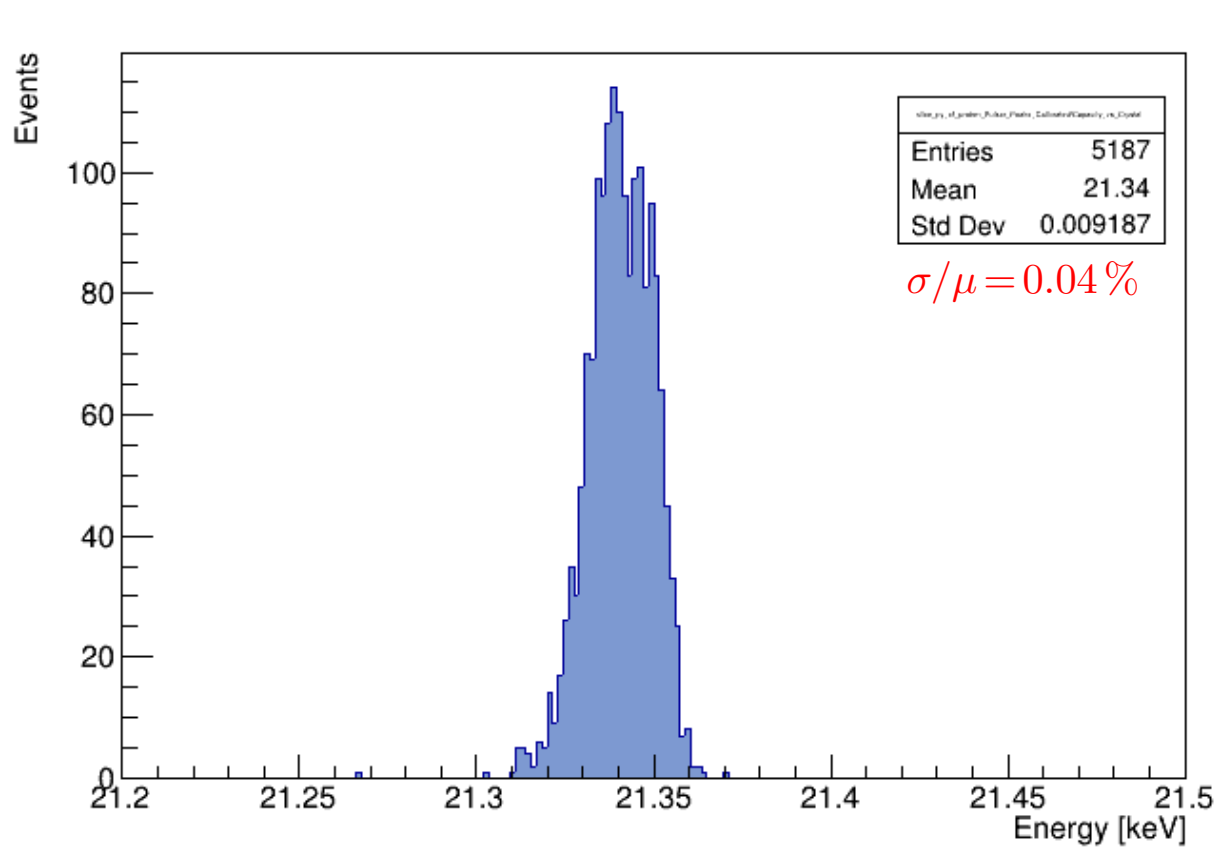




Variation in E/V for the pulsers again include all uncertainities ($L(t)$, R and C_{pulser})

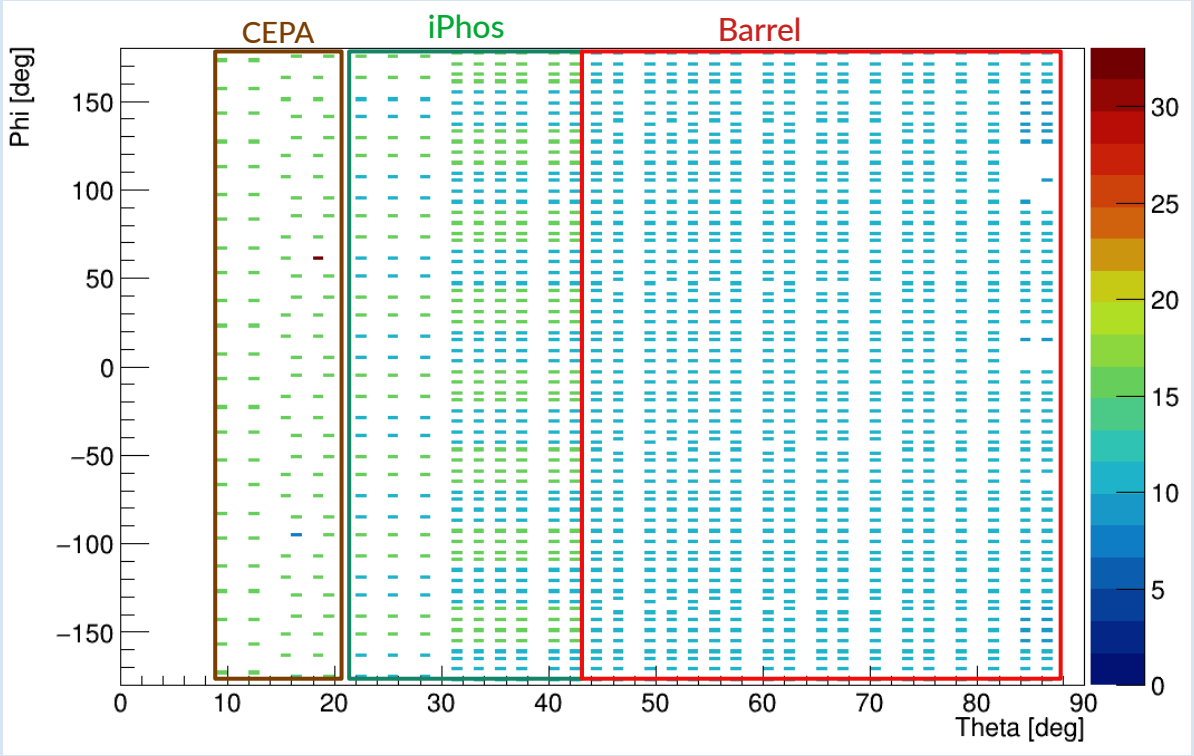
Proton range: calibrated spectra



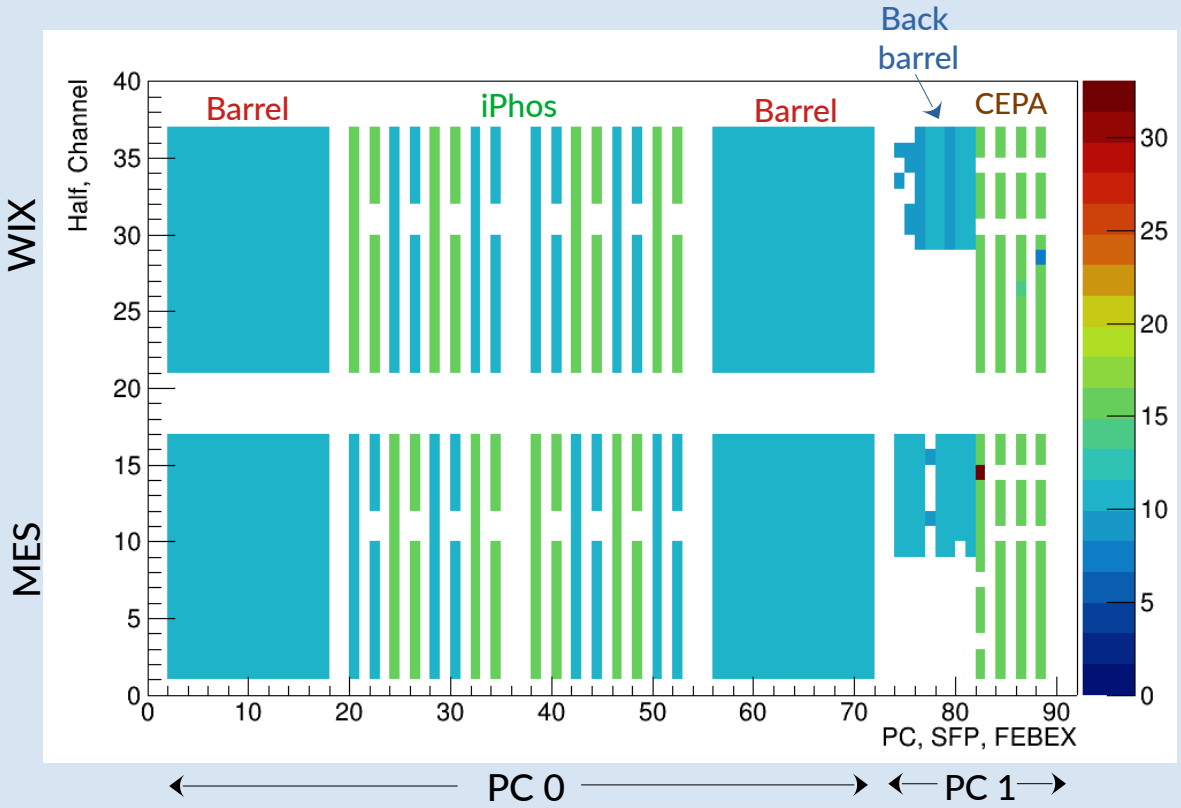


Software works !

QC Plots

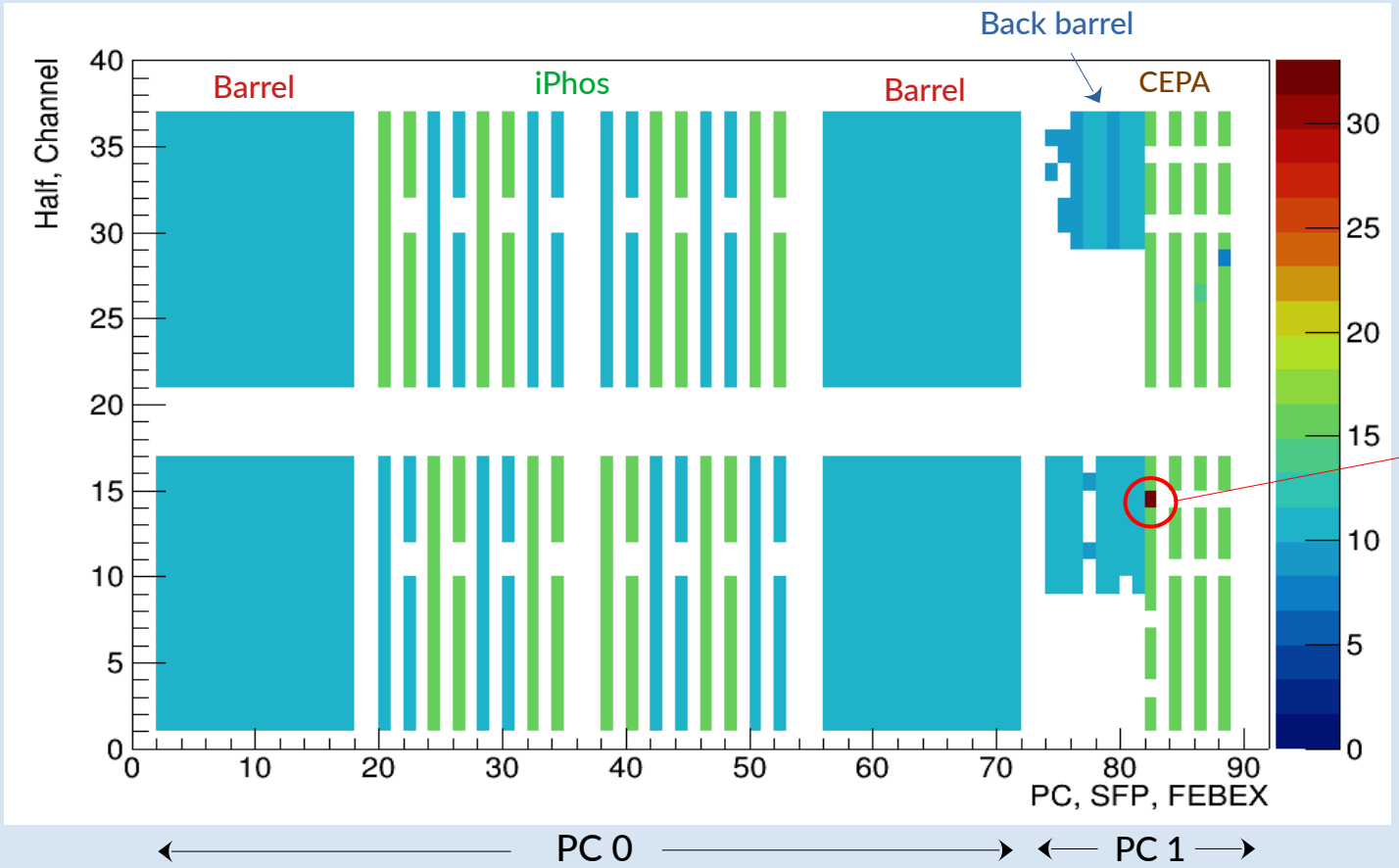


Quality Assessment Plot

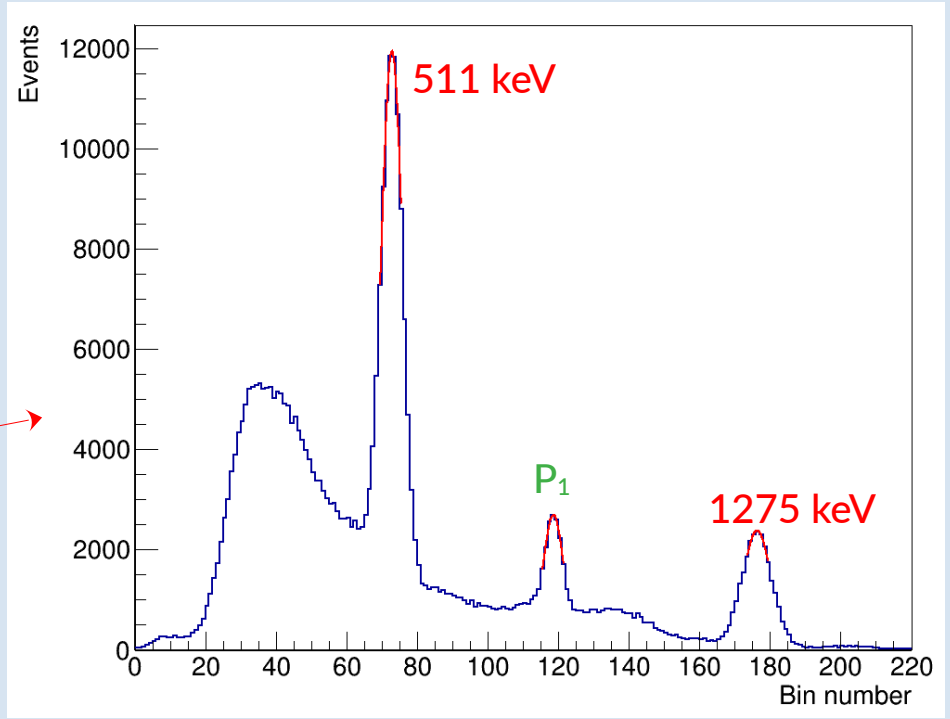


DAQ Plot (Hardware level)

QC Plots



DAQ Plot



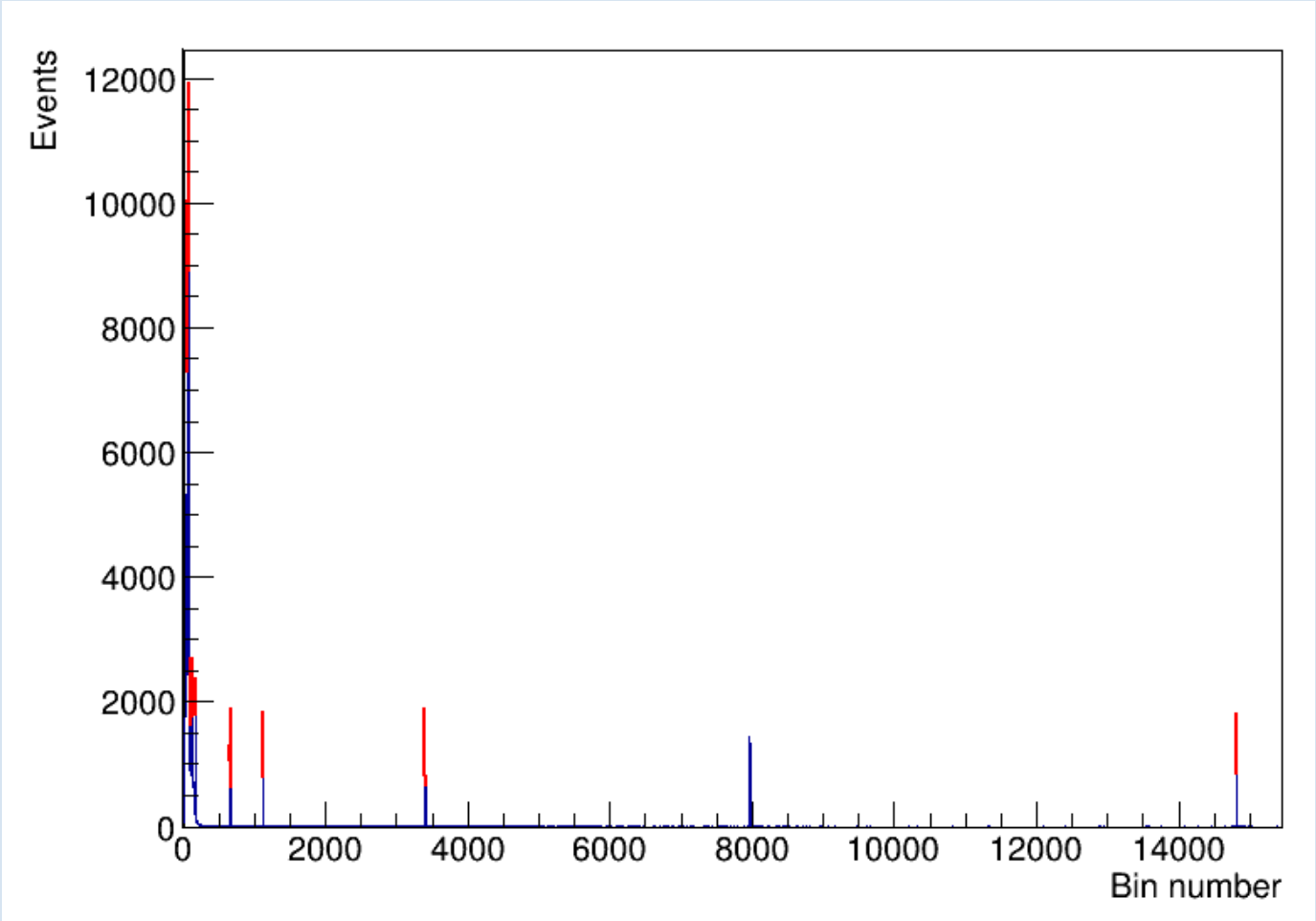
Spectrum for bad channel
(incorrect gain matching)

Thank You !

CALIFA @ Technical University of Munich
Mrunmoy Jena, Tobias Jenegger, Roman Gernhäuser

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Extras: Bad channel



Crystal ID: 5057, in CEPA

```
Crystal 5057
Source Peak 1, Bin number: 72.8852
Pulser Peak 1, Bin number: 118.622
Pulser Peak 2, Bin number: 176.335
Pulser Peak 3, Bin number: 664.026
Pulser Peak 4, Bin number: 1121.33
Pulser Peak 5, Bin number: 3402.16
Pulser Peak 6, Bin number: 14819.5
Range factor Pulser Peak 1: 15.2875
Range factor Pulser Peak 2: 57.8574
Range factor Pulser Peak 3: 25.9151
Range factor: 33.02
Pulser Offset: -2053.82
Pulser Slope: 36.794
```