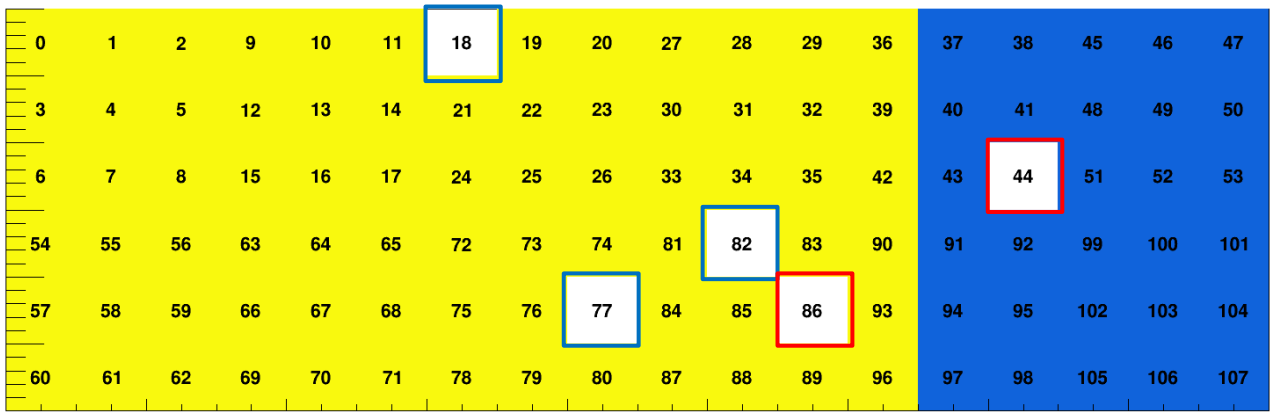
Calorimeter Update: Crystals intercalibration

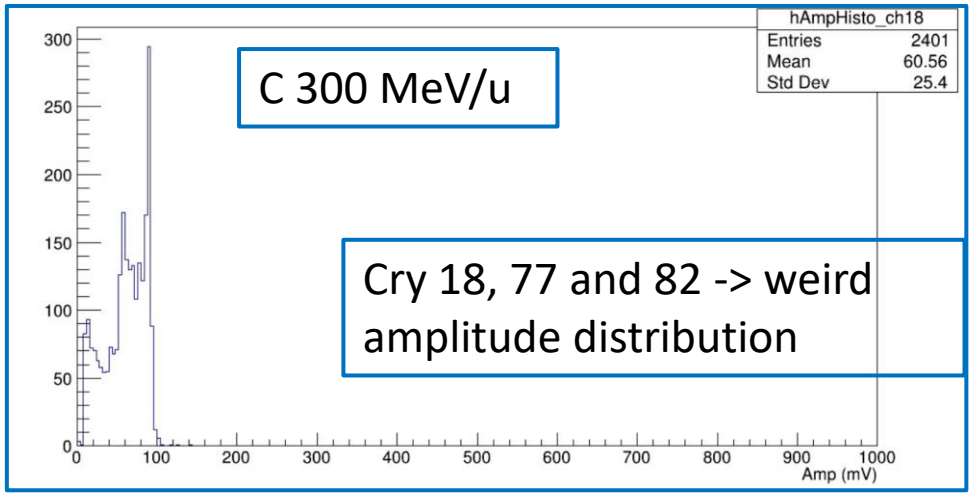
CNAO2022 Screensaver Runs: Quick Reminder

How many cristals have been «swept»?



78 crystals swept

Crystals that beam could not reach



Cry 44 and 86 -> Broken

Which energies have been used?

- Carbon 115 MeV/u
- Carbon 200 MeV/u
- Carbon 300 MeV/u
- Proton 227 MeV/u

Which detectors were present on beam line?

- TOF-Wall
- Calorimeter

CNAO2022 Screensaver Runs: Intercalibration Strategies

How can we equalise crystal response?

By analysing carbon Runs we conceive two strategies revolving around the modified Birks function

$$ADC(E) = \frac{p_0 x^2}{1 + p_1 x + p_2 x^2}$$

P0 Shift Method

Equalisation done with a single multiplying factor

- Easier to implement in SHOE
- Less precise
- Not-swept crystals friendly

Crystal Calibration Method

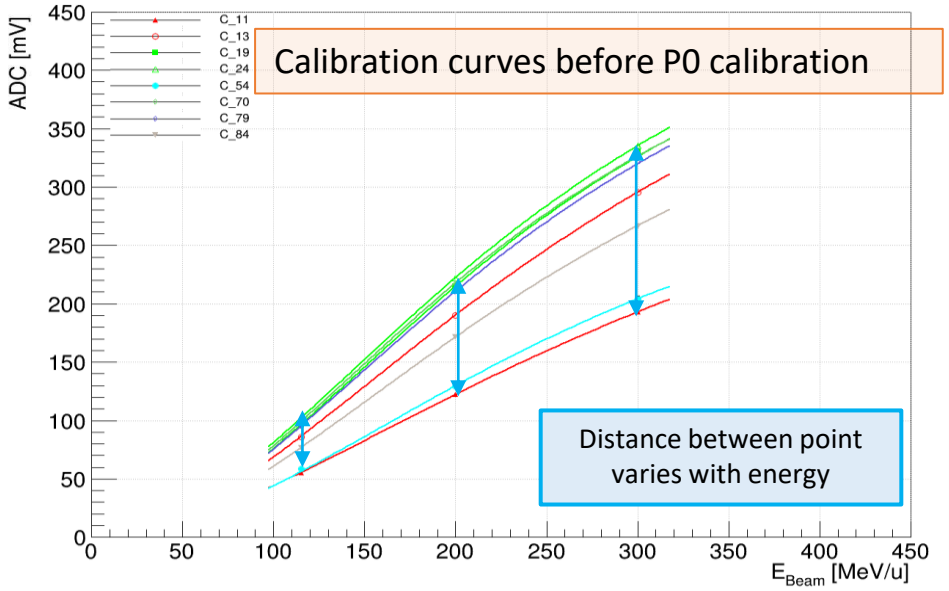
Equalisation done by calculate energy response curve for each crystal

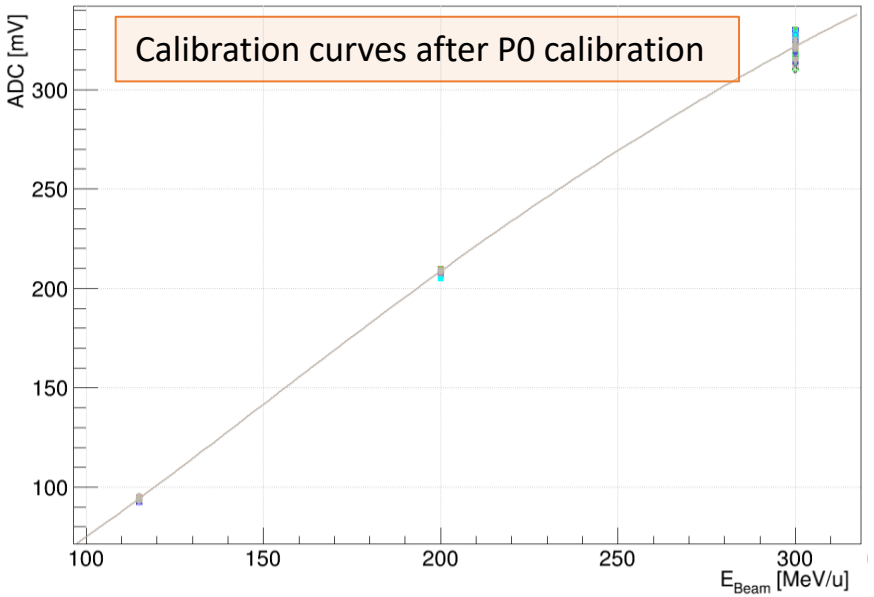
- Harder to implement in SHOE
- More precise
- Impossible retrieve info from not-swept crystals

Intercalibration Strategies: P0 Methods

How can we equalise with a single number?

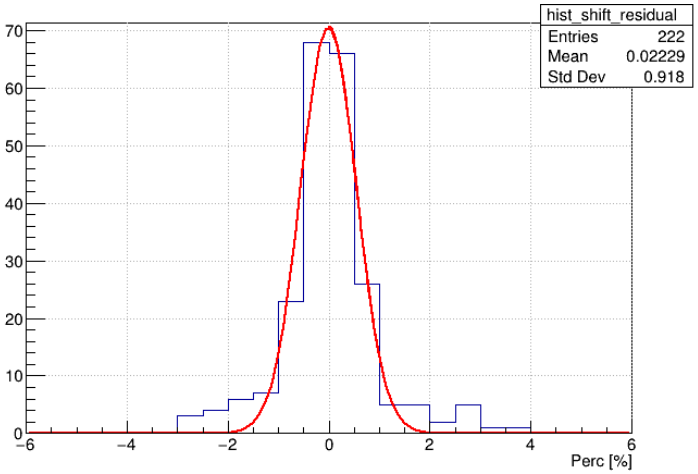
Fit reference crystal with free parameter → Fit all other crystals with P1 and P2 fixed → $P0_{23}/P0_{cry}$ is the intercalibration factor






```
FCN=27.1527 FROM MIGRAD    STATUS=CONVERGED      93 CALLS          94 TOTAL
                     EDM=4.16105e-09    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1  Constant     7.06857e+01   7.06111e+00   1.31198e-02   1.14155e-05
  2  Mean         2.19694e-03   3.96364e-02   1.02058e-04  -6.93488e-04
  3  Sigma        5.49849e-01   3.82597e-02   3.18030e-05   6.88296e-03
```

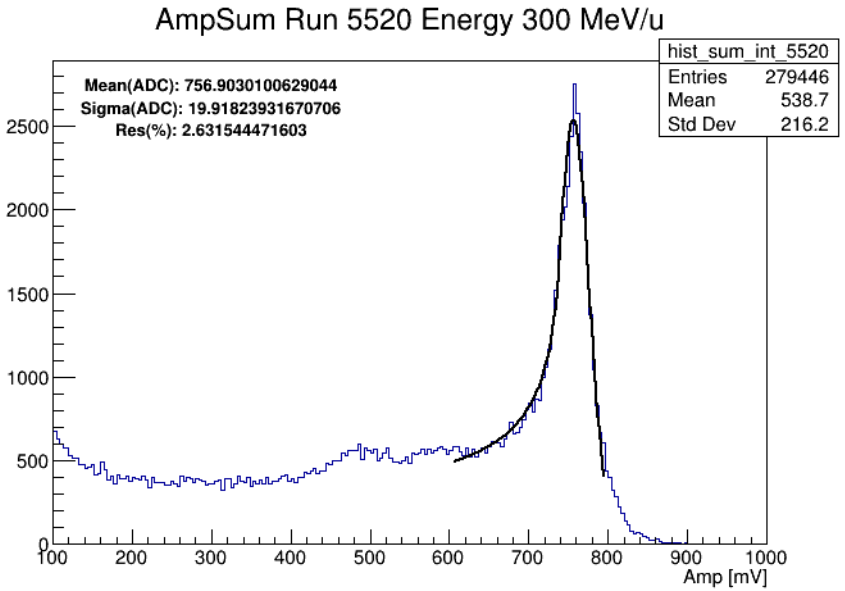
Residual distribution after P0 calibration

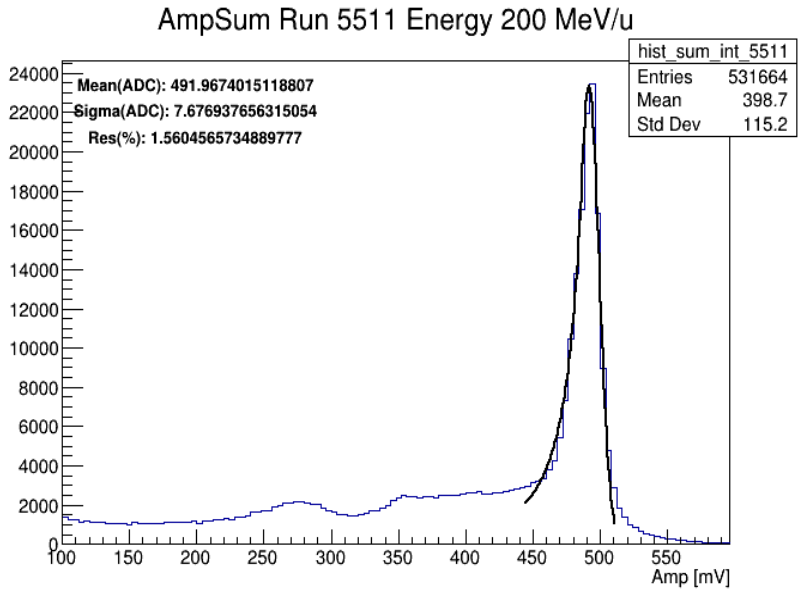


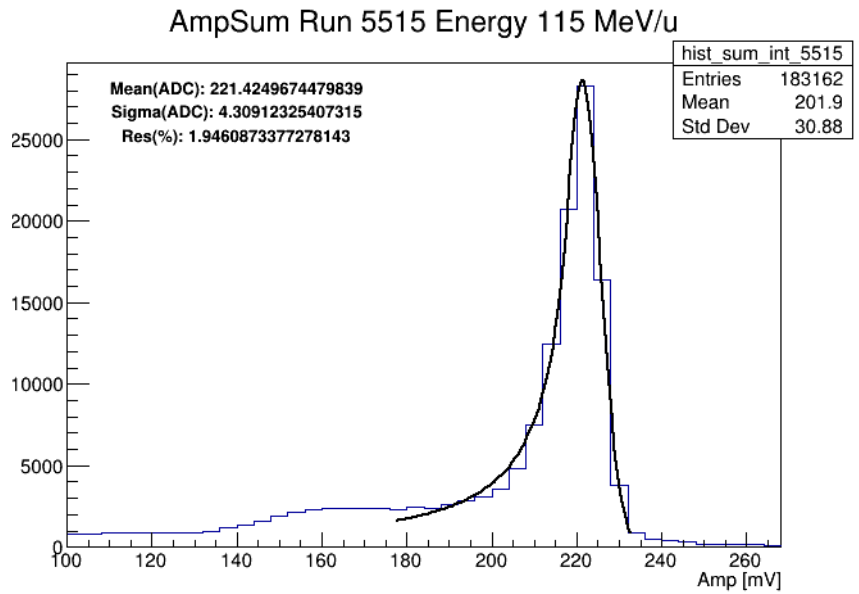
Intercalibration Strategies: P0 Methods – Integral Resolution

How can we check how the P0 Methods works?

Sum amplitude distribution of all 74 crystal after equalization to esteem the total calorimeter resolution



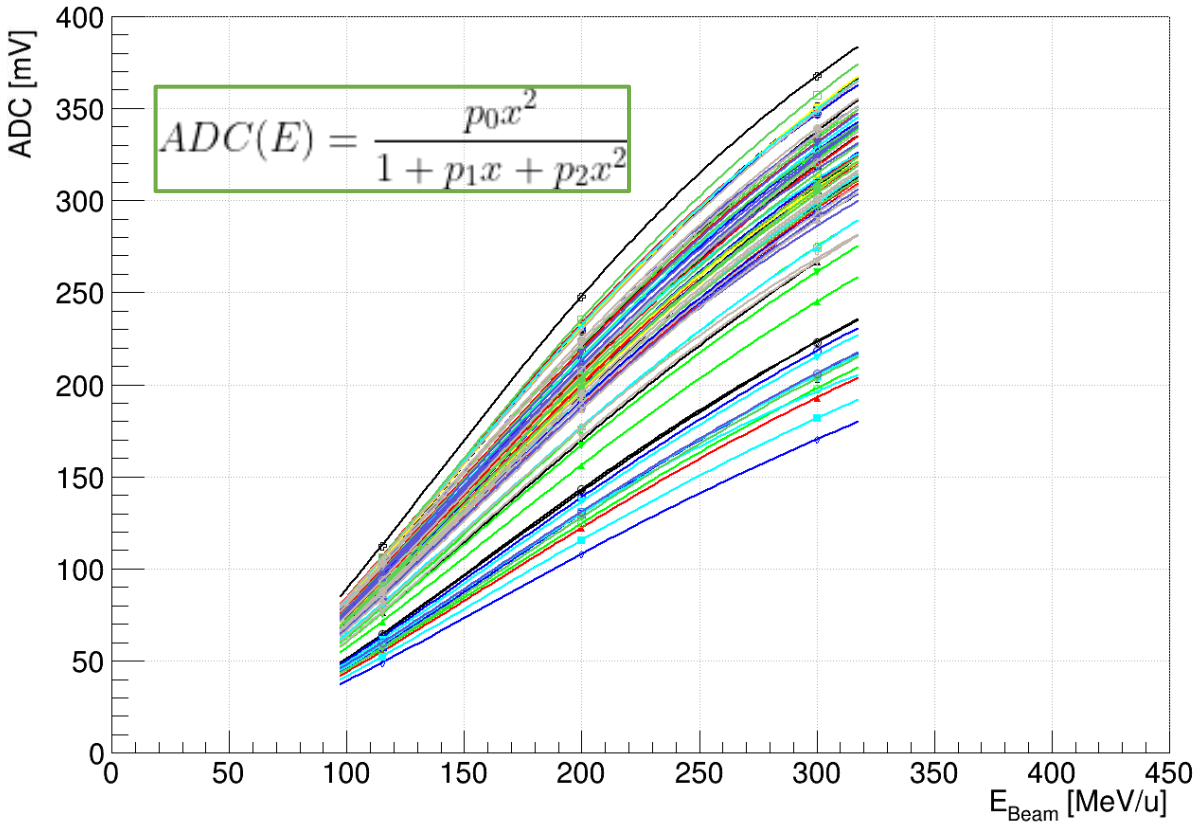




Already implemented in SHOE

Intercalibration Strategies: Crystal Calibration Methods

How can we improve equalisation?



Three Carbon energy screensaver points

↓

For each crystal we obtain p0, p1 and p2

↓

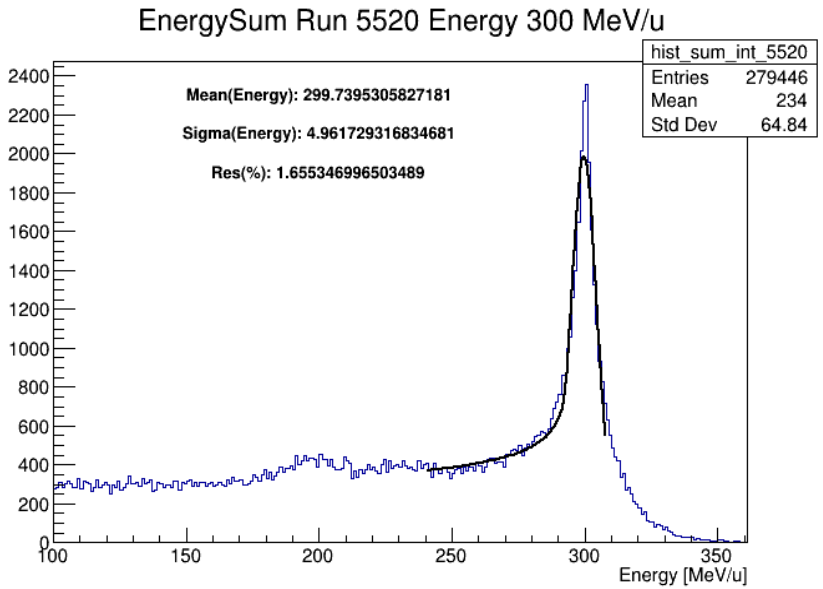
Energy esteemed as inverse modified Birks

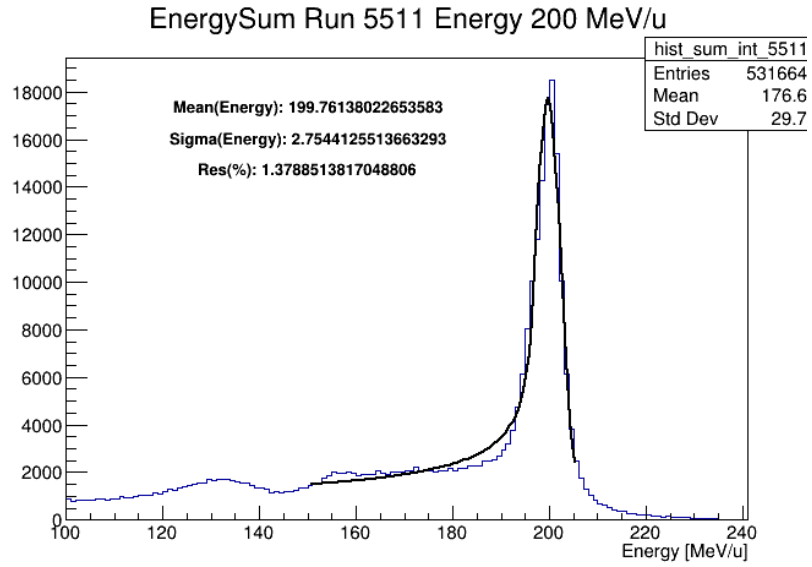
$$E(ADC) = \frac{-p_1 ADC - \sqrt{(p_1 ADC)^2 - 4ADC(p_2 ADC - p_0)}}{2(p_2 ADC - p_0)}$$

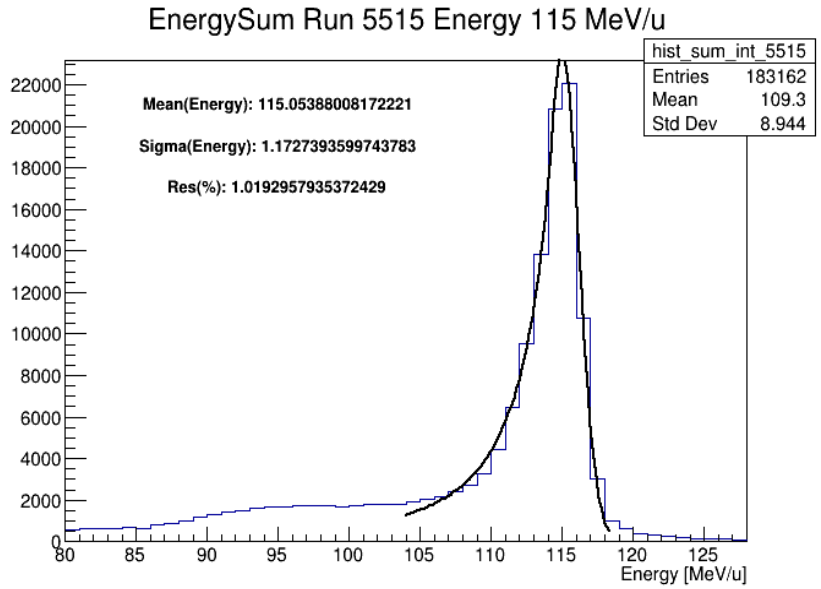
Intercalibration Strategies: Crystal Calibration Methods – Integral Resolution

Does integral resolution improve with this method?

Sum Energy distribution of all 74 crystal after ADC to Energy conversion to esteem the total calorimeter resolution







Best strategy for next data taking

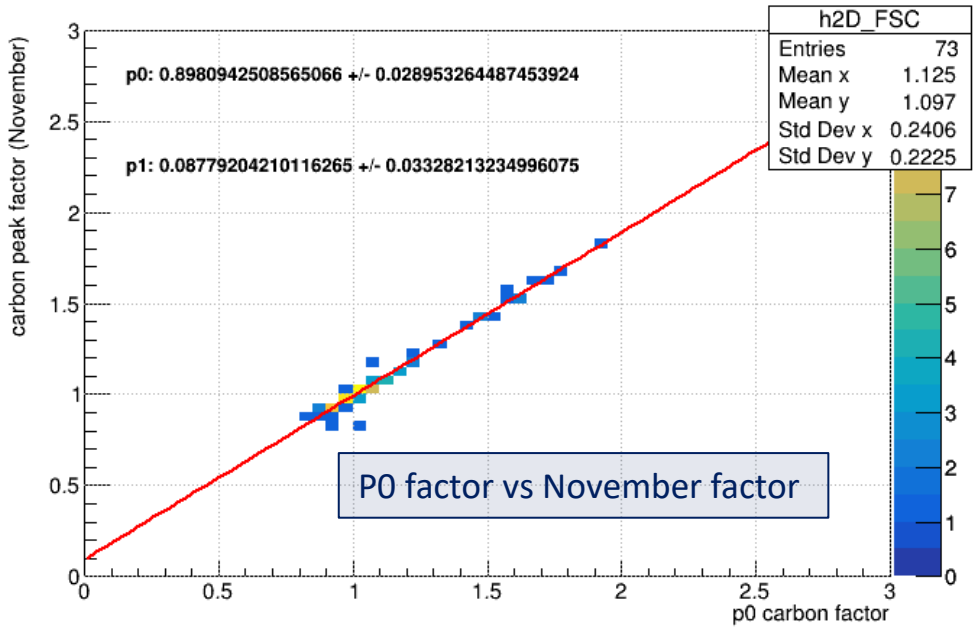
Equalising not-swept crystals – Comparison with November data taking

Can we obtain equalisation factor of crystal which did not participate in screensaver runs?

In November data taking we collected Carbon runs at 300 MeV/u with beam centered in each crystals.

From November run we obtain Equalization Factor for each crystal but limited to one single energy

If we can find a relation between November and P0 shift intercalibration series we can derive the missing factors



$$y = p_0 x + p_1$$

Now we have all 108 equalization factors with the P0 Methods

Temperature calibration and correction: Another quick summary

During the data takings the temperature of each crystals is acquired with Arduino and registered in the global DAQ as mV value

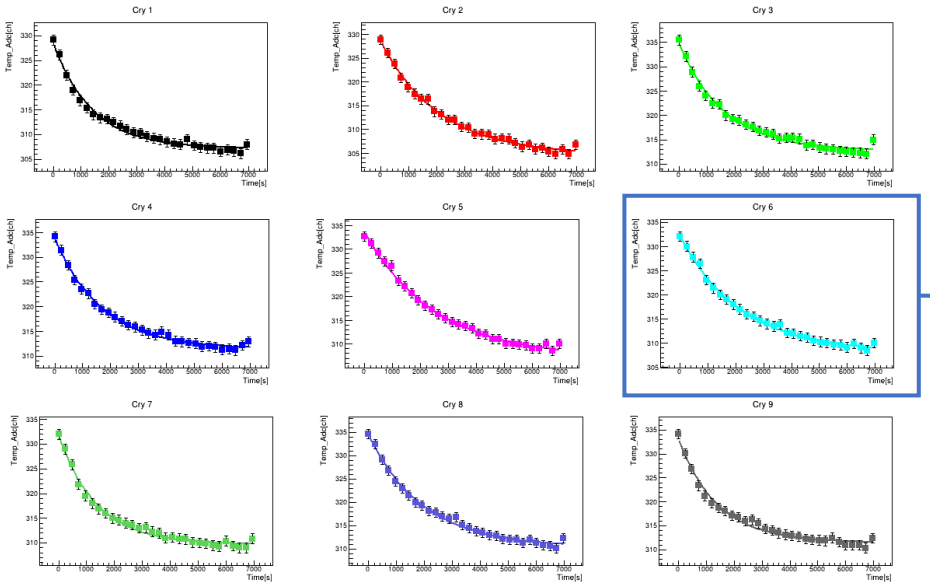
→ Needs for a calibration function to obtain Temperature Steinhart – Hart formula (Rt proportional to ADC)

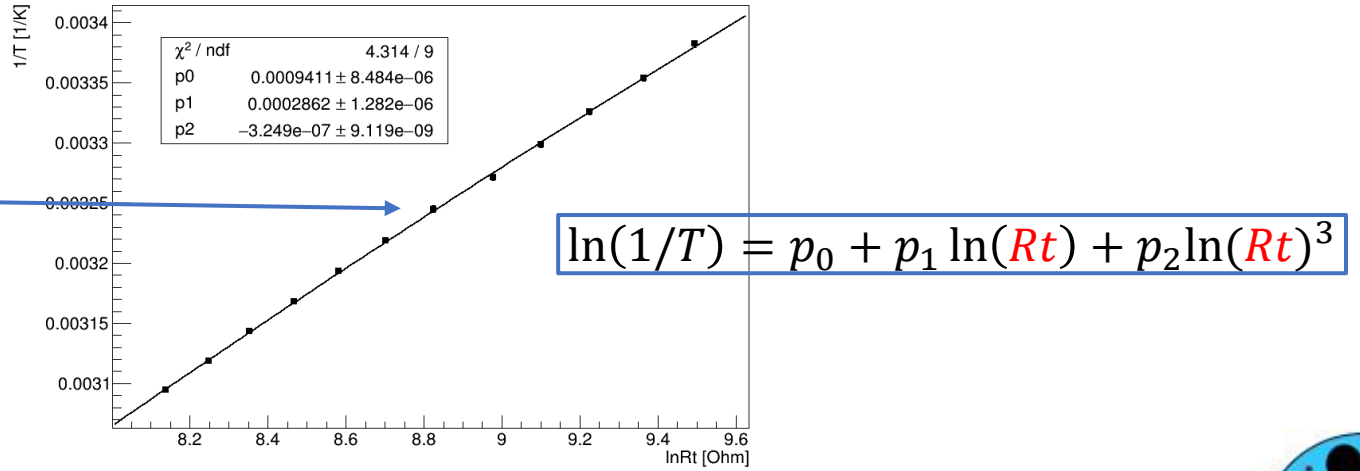
For the temperature calibration a climate chamber has been used

→ Range 22.5 – 50°C in 2.5°C steps

Each measurement lasts 2 hours

→ Enough point to identify the exponential trend

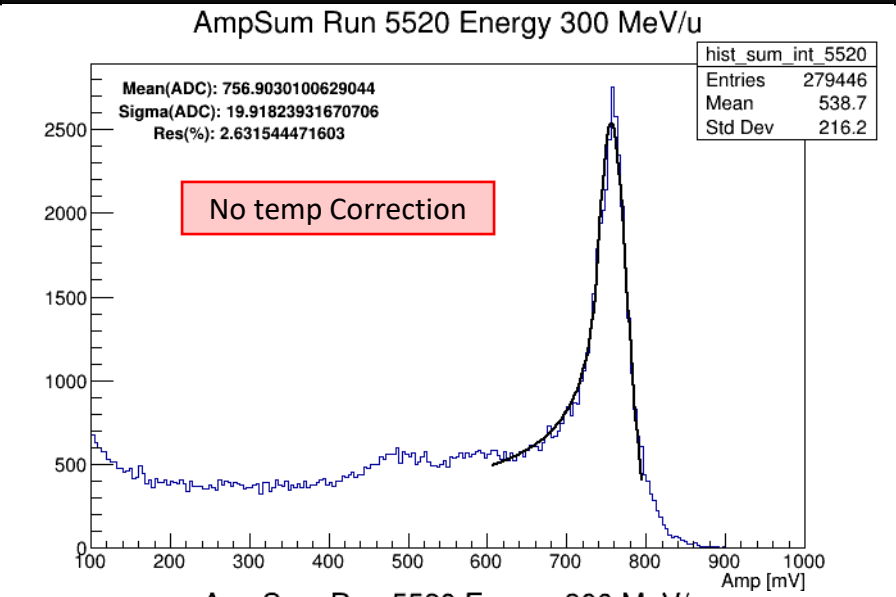


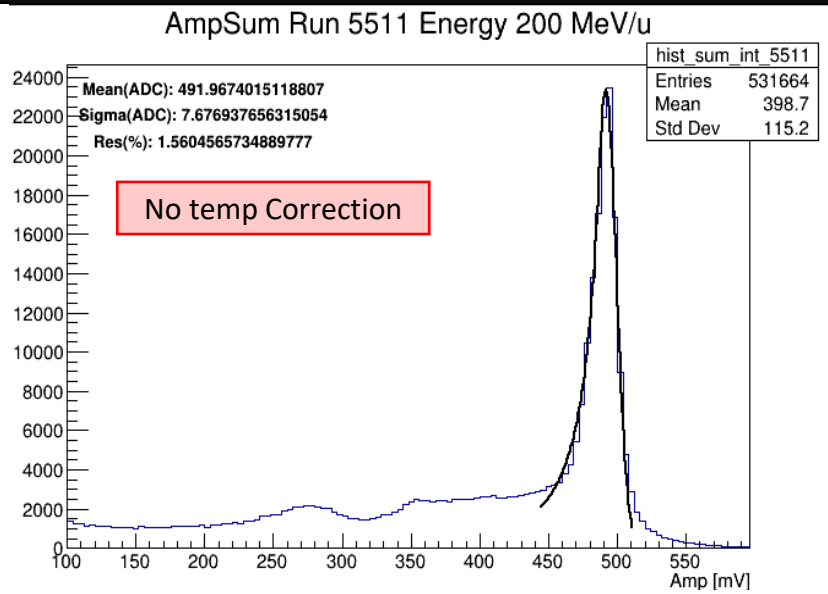


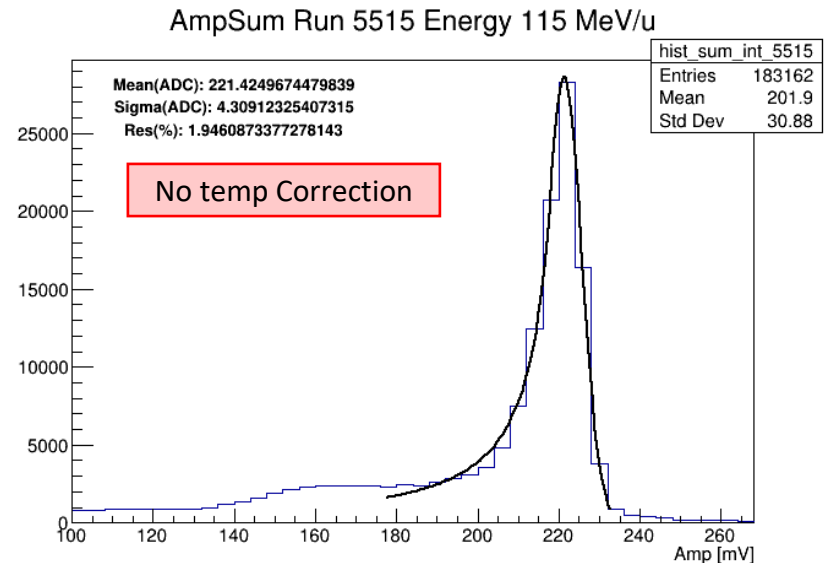
$$\ln(1/T) = p_0 + p_1 \ln(Rt) + p_2 \ln(Rt)^3$$

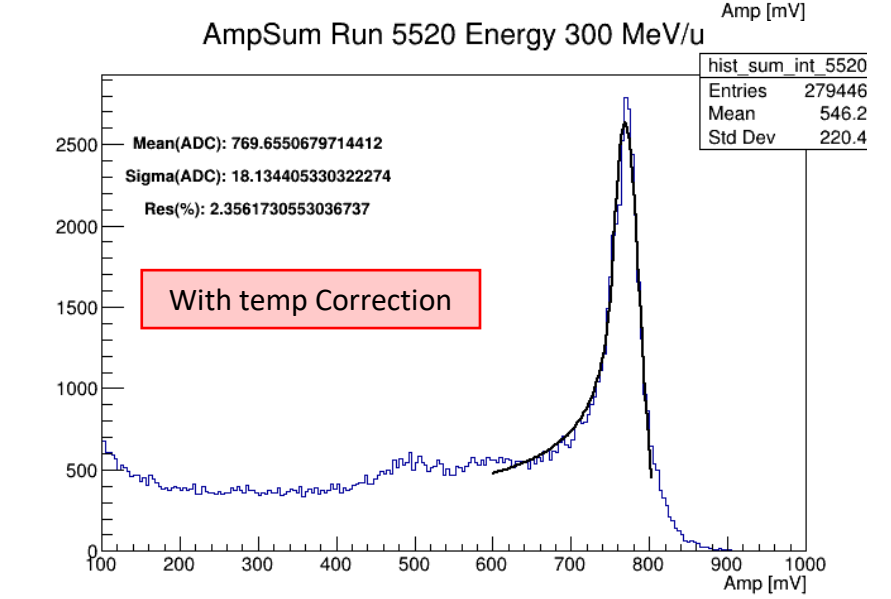
All 12 CNAO2022 and HIT2022 Modules has been calibrated

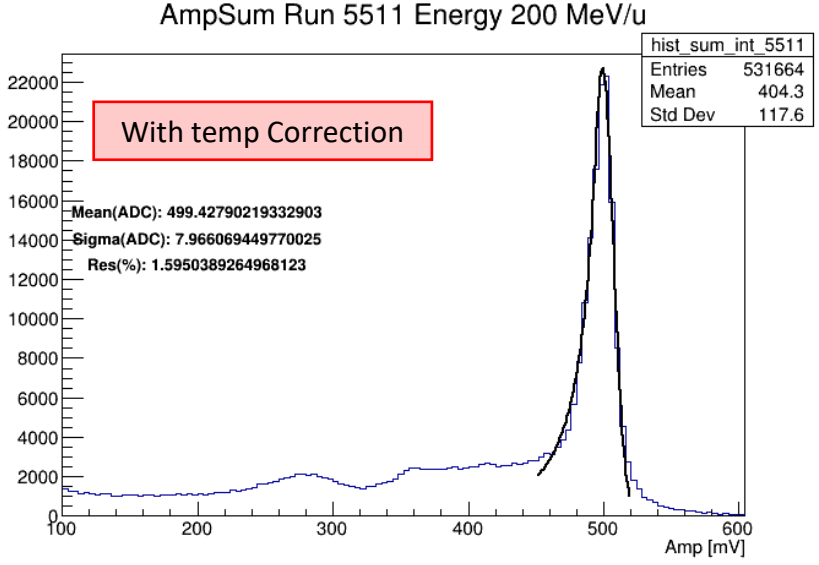
Temperature Correction: P0 Method – Integral Resolution

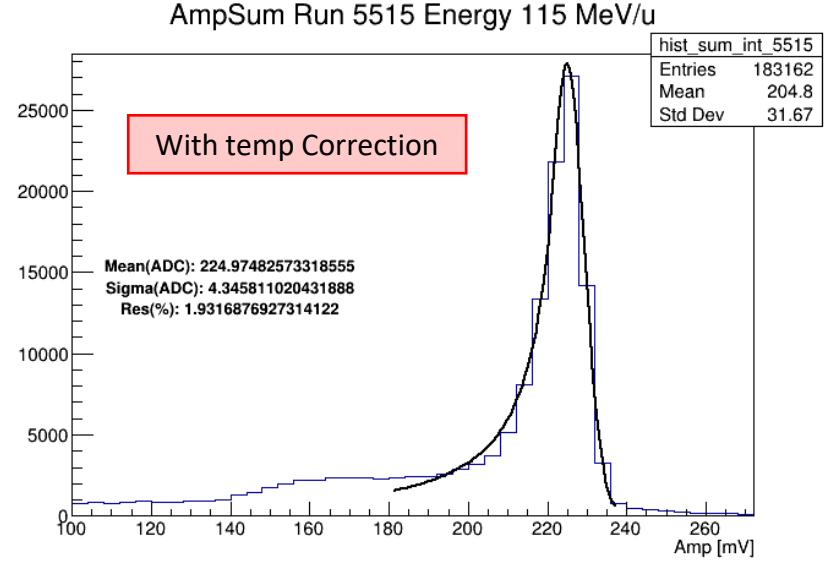












Summary

In order to allow the analysis group to work we have implemented these results in SHOE

What have we already done?

- Energy Calibration for each possible Z ions (HIT)
- Intercalibration factors (p0 method)
- Temperature calibration

Next steps?

- Check the work done by measure HIT2022 masses
- Finish modules temperature calibration
- Full Calorimeter calibration runs

Methods comparison