Calorimeter Status

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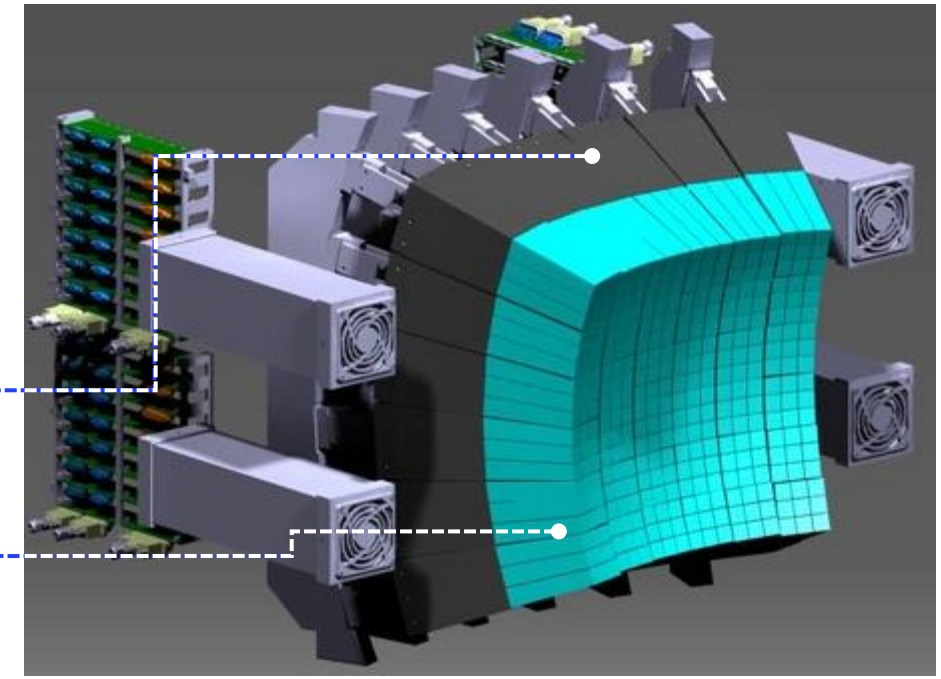
on behalf of the Turin Group

Detector Status

- ✓ 36 modules assembled and T-calibrated
- ✓ Pieces for new mechanical structure delivered last week
- ✓ Dismounting to start soon, to be completed by end of July
- ✓ Check of dead channels (likely detectors to be re-glued)
- ✓ Mount with new structure in September



Test each 6-modules layer after assembly

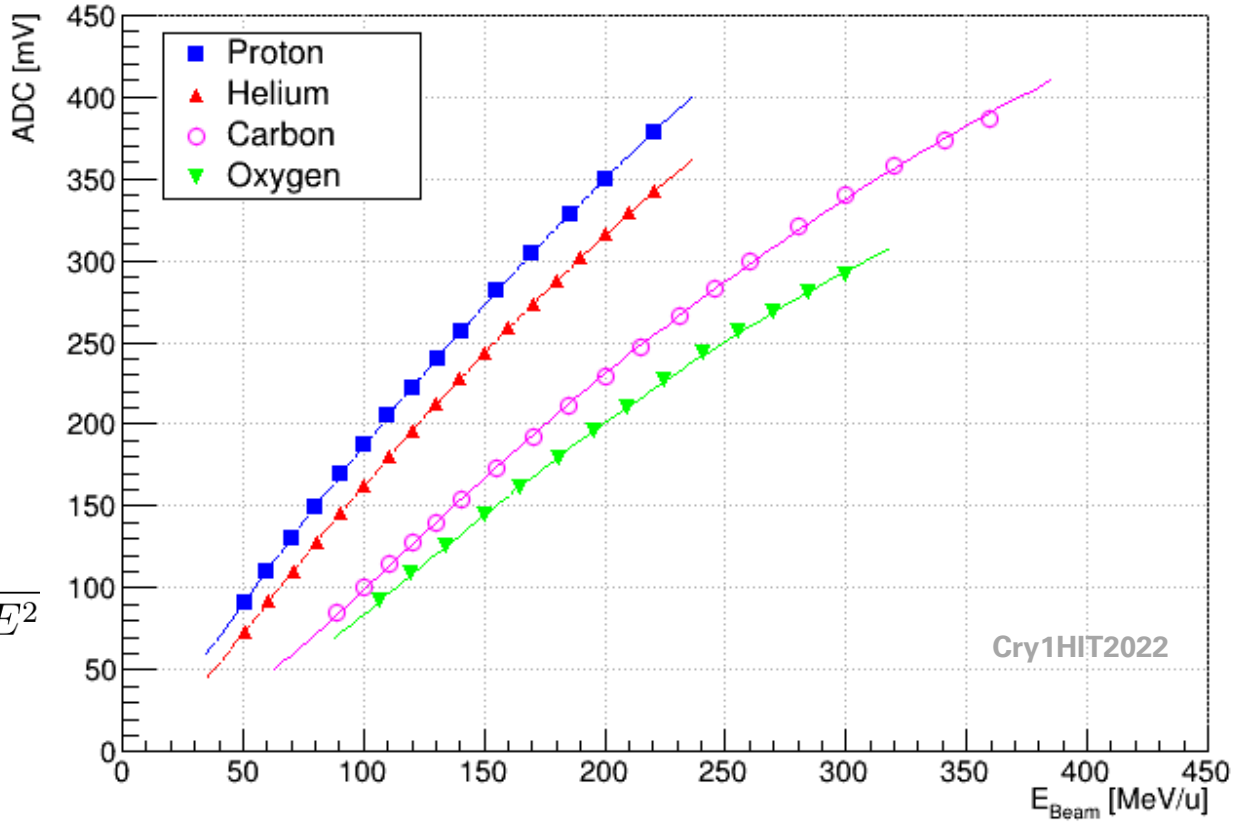
The Calibration Problem

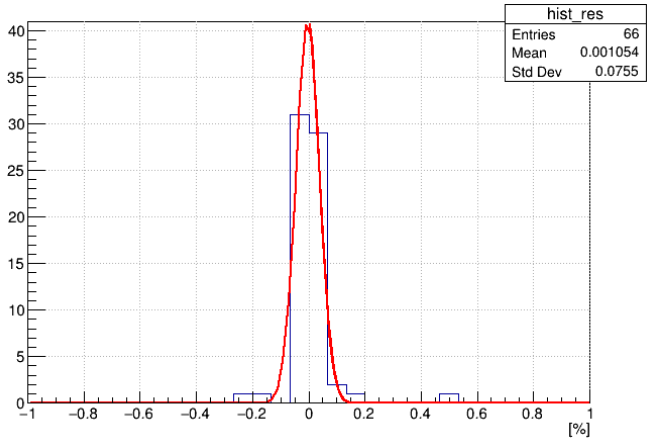
- ✓ The calorimeter linearity is affected by the Birks effect

$$\frac{dS}{dx} = \frac{A \cdot dE/dx}{1 + k \cdot B \cdot dE/dx}$$

- ✓ There is clear (unknown) dependence on Z
- ✓ The chosen fit function is derived from Birks formula, we call it modified Birks function (MBF)

$$ADC(E) = \frac{P_0 E^2}{1 + P_1 E + P_2 E^2}$$





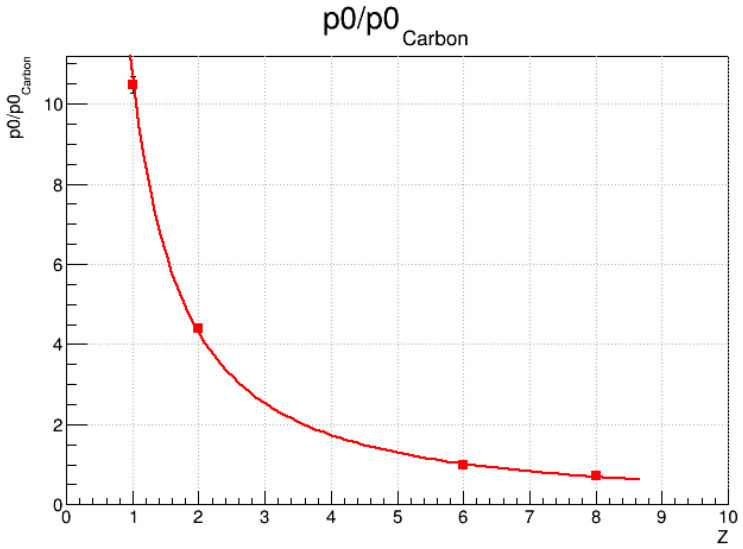
- ✓ Good fitting of experimental data

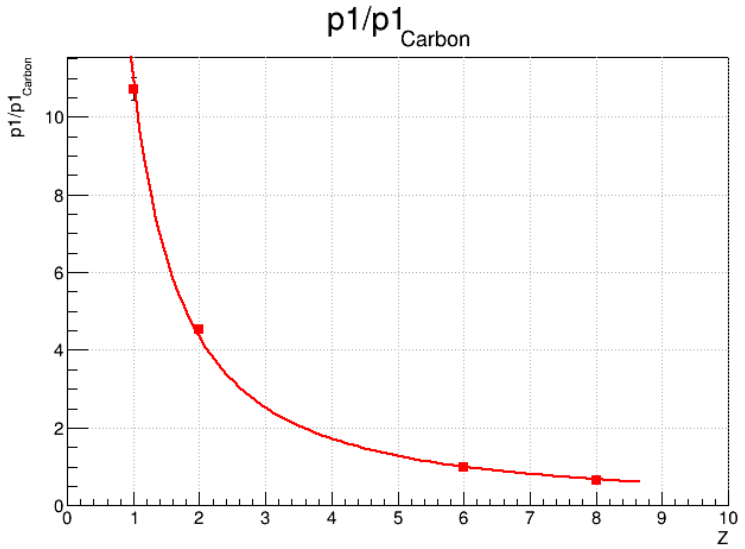
$$\frac{|E_{fit} - E_{ADC}|}{E_{fit}} < 1\%$$

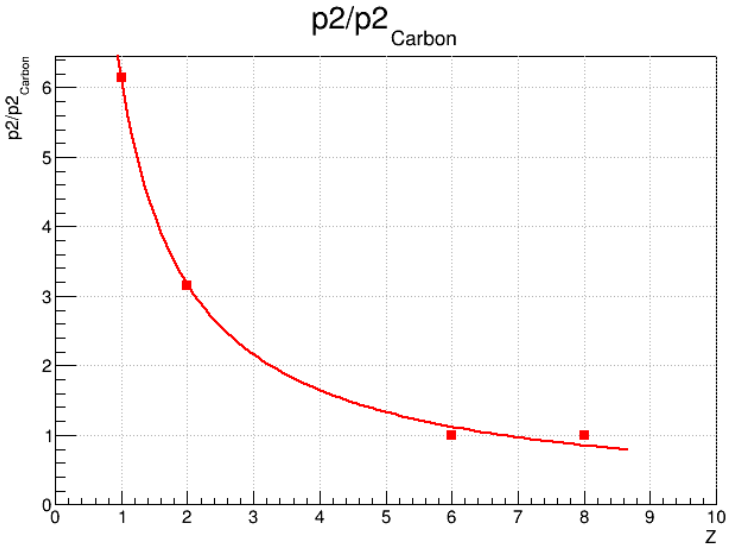
Charge Number Dependance

How to address the Z dependence problem?

$$ADC(E) = \frac{P_0 E^2}{1 + P_1 E + P_2 E^2}$$







Ratio of energy calibration curve parameters to Carbon curve parameters follow a power law (bad point for Oxygen in P2 curve)

$$\frac{P_x}{P_{x_{carbon}}} = a_0 Z^{a_1}$$

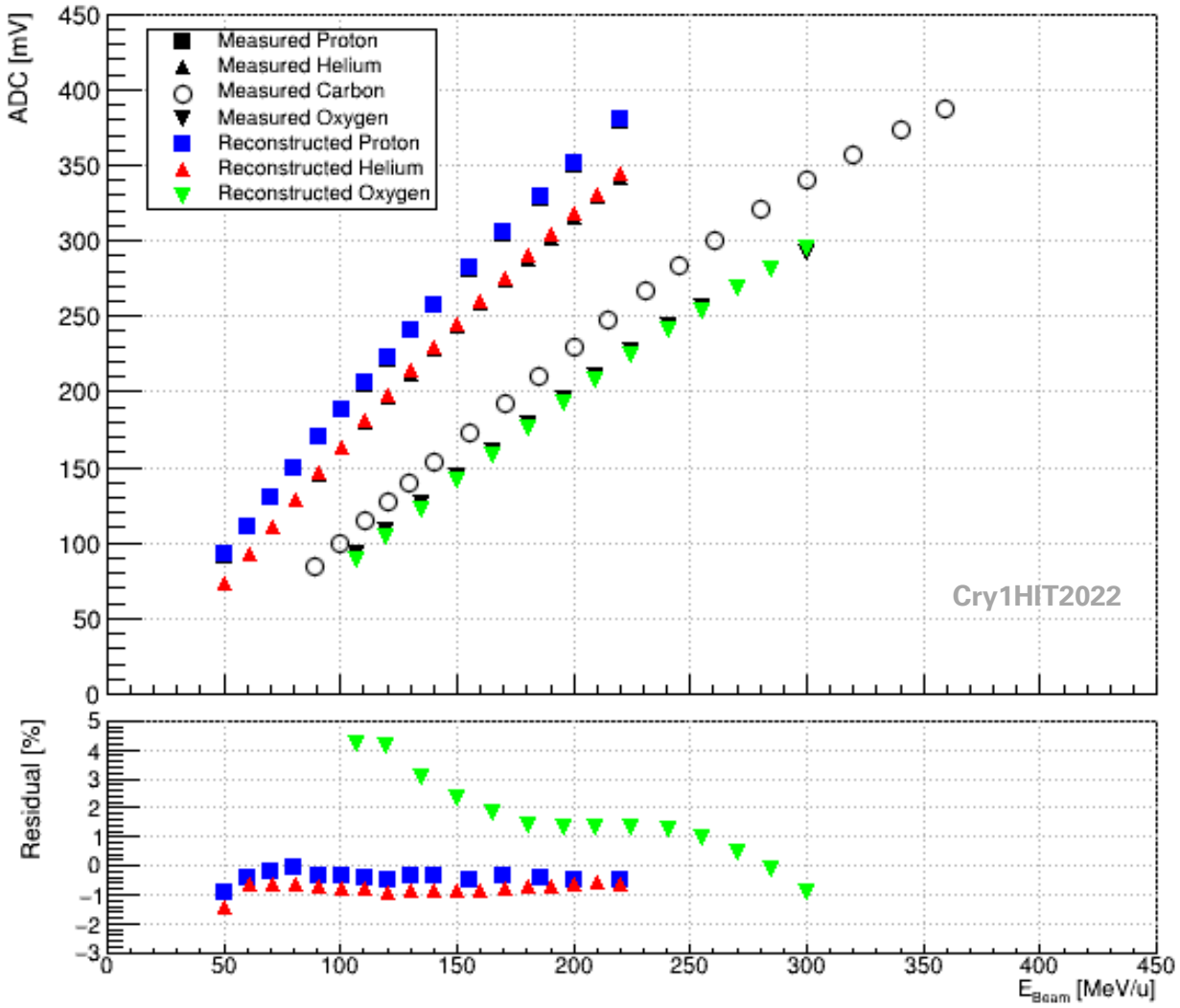
By measuring Z we can convert the ADC response to Energy for all the possible fragments

Energy Calibration

With the power law function from previous slide, it is possible to calculate proton, helium and oxygen point starting from carbon MBF parameter

Superimposition and residual to verify the performance of this method

It is possible to measure the kinetic energy by knowing the charge of the ion (TW)

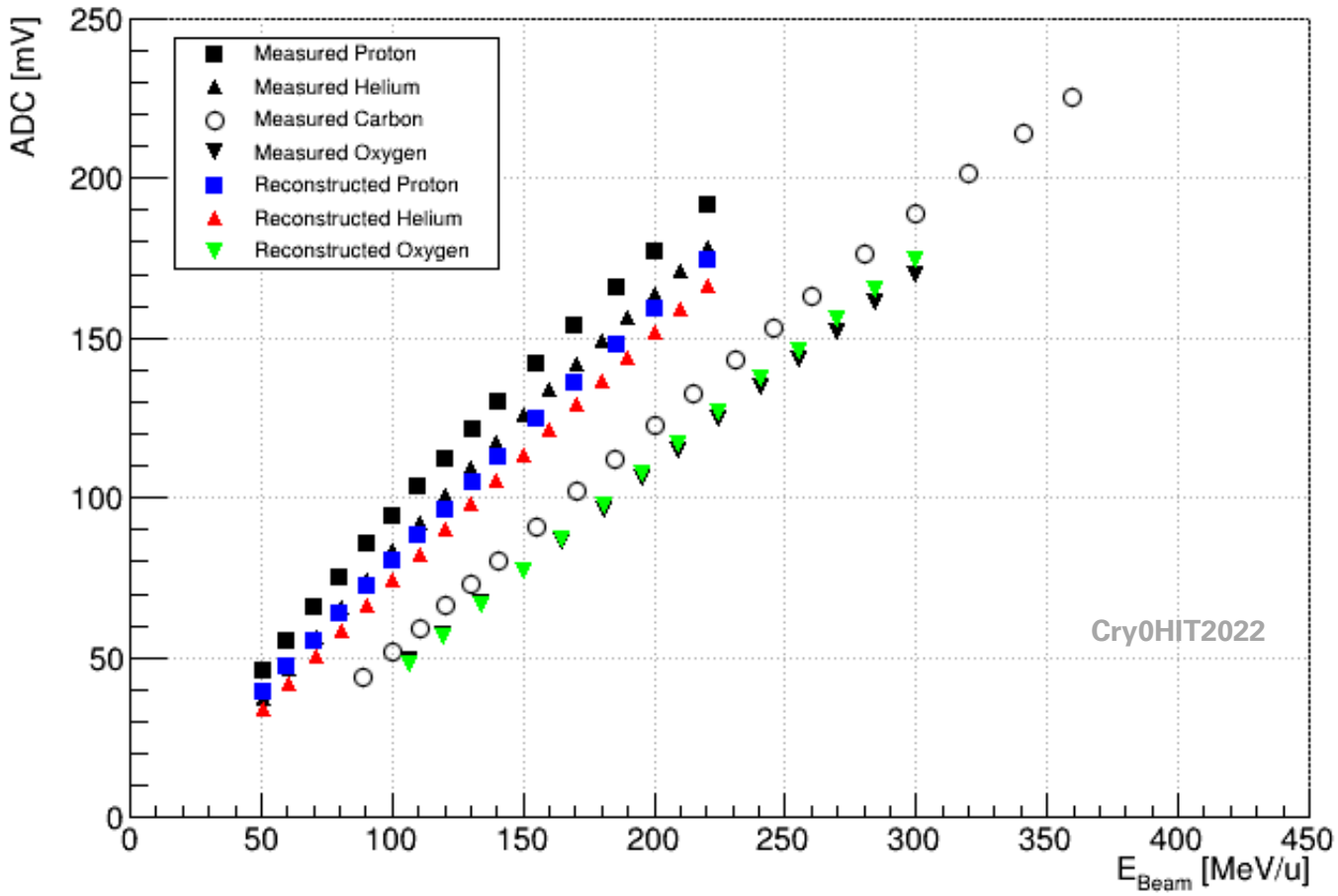


Energy Calibration – Applicability

Are the power law parameters the same for every crystal?

Reconstruct proton, helium and oxygen point of Cry0HIT2022 with power law parameter calculated from Cry1HIT2022

Each crystal has its own power law parameter

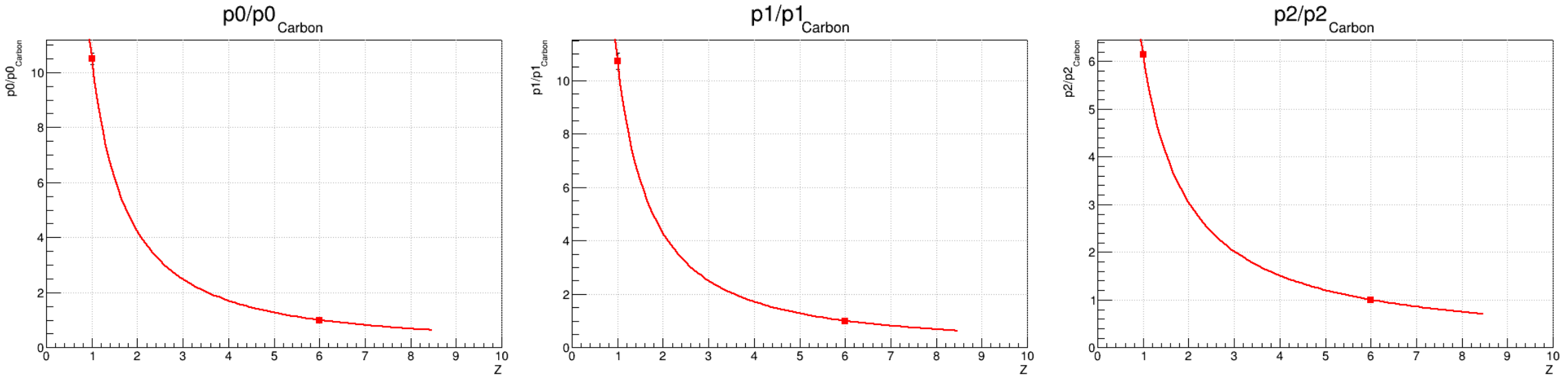


Energy Calibration – CNAO feasibility

- ✓ Taking data at HIT is a challenging task: not enough beam time available to us to measure the response of all the crystals
- ✓ Performing calibration procedure at CNAO is the solution but CNAO provides only Proton and Carbon ions

Does it work with just two ions?

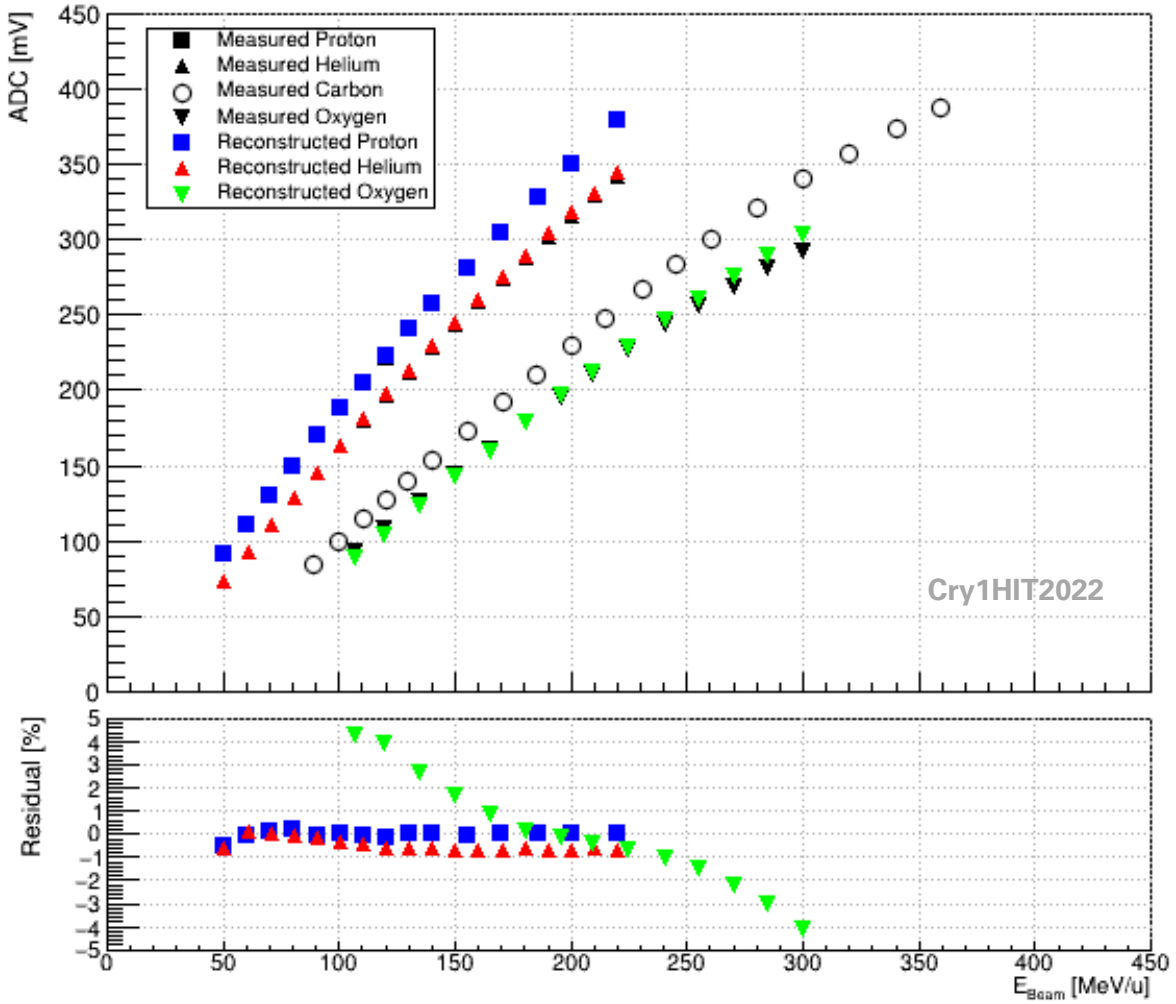
$$\frac{P_x}{P_{x_{carbon}}} = a_0 Z^{a_1}$$



Energy Calibration – CNAO feasibility

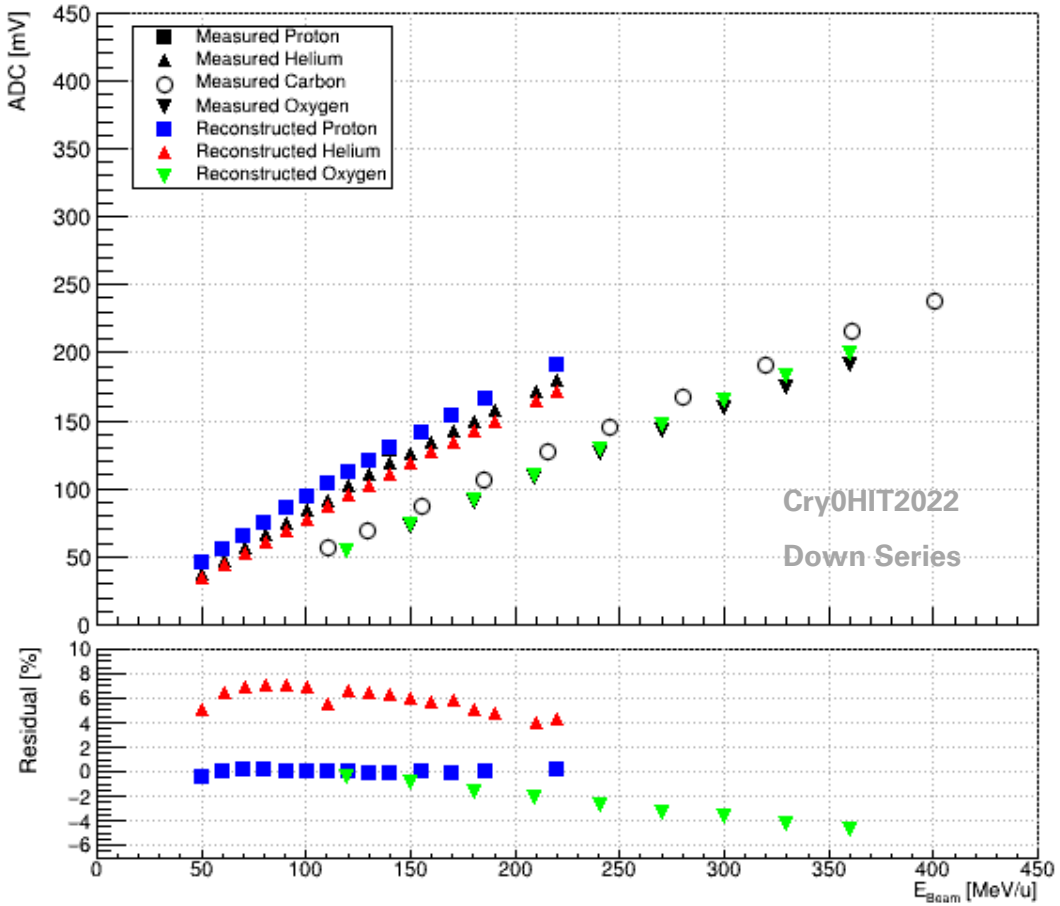
Same validation procedure used with 4-ions-power law

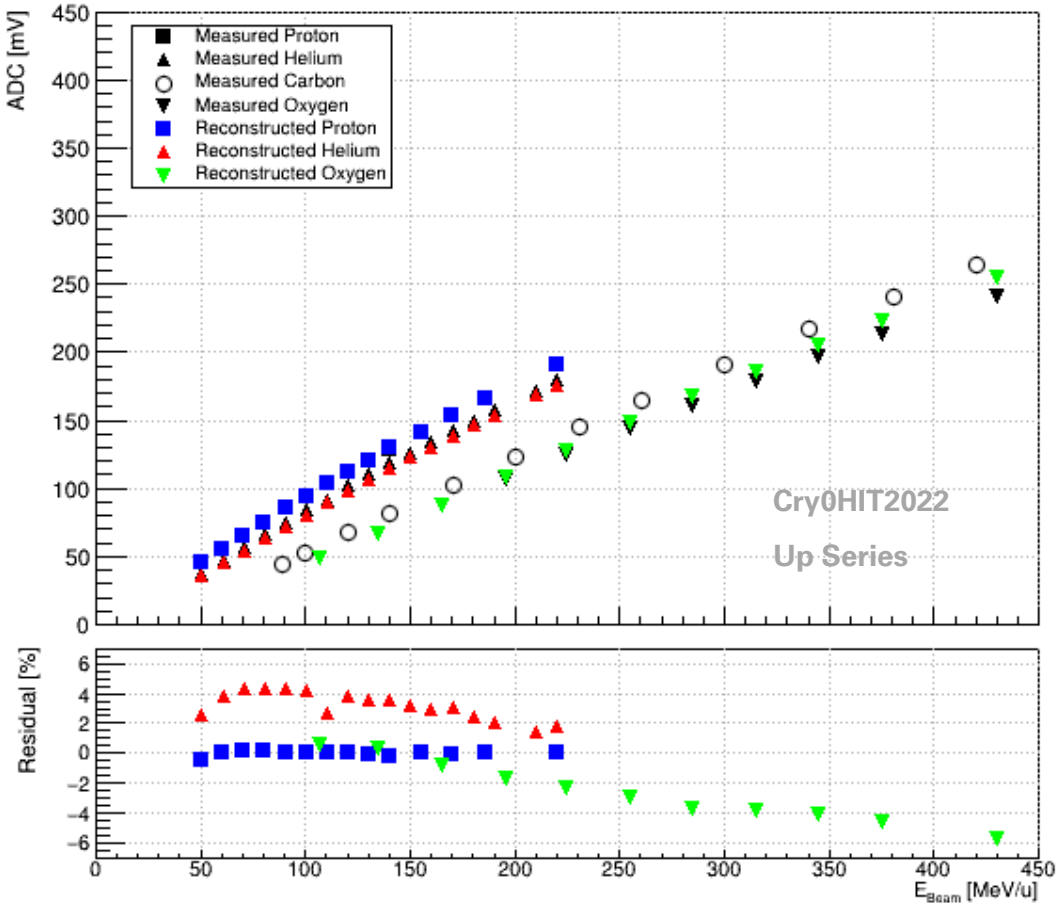
Seems possible to calibrate all crystals at CNAO with the provided ions*



* Higher residuals in Oxygen are weird, probably something happen back at HIT. Look at P2/P2carbon distribution

Energy Calibration – CNAO feasibility





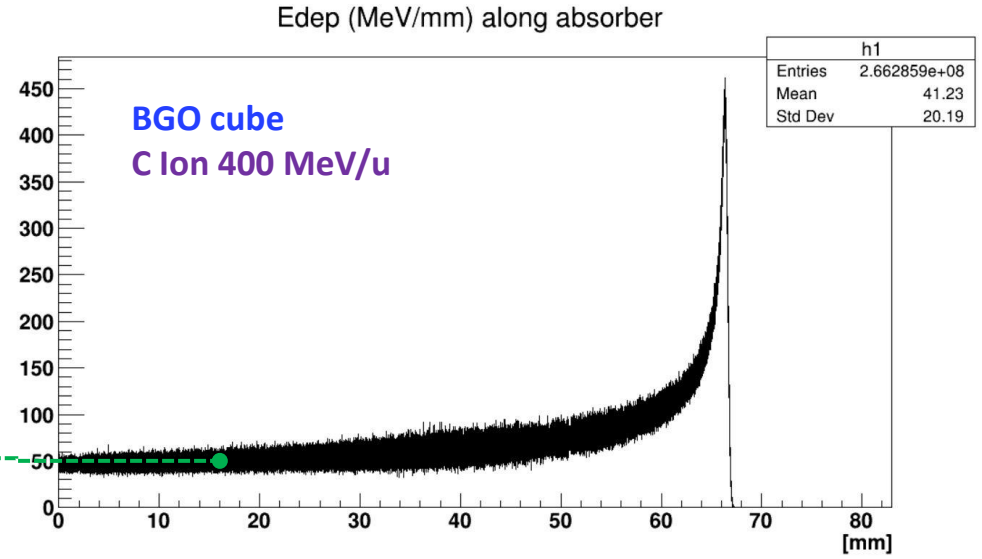
- ✓ The strategy does not work very well on the second crystal
- ✓ Residual worsening due to variation in measurement condition: system stability is crucial

Birks Integration

- ✓ We know that MBF is a very good calibration function
- ✓ If MBF is the integral of the Birks formula we could skip calibration (A and kB present in literature)

$$\frac{dS}{dx} = \frac{A \cdot dE/dx}{1 + k \cdot B \cdot dE/dx}$$

Energy loss (Bragg Curve) simulated with Geant4



Quenching comparison of BGO and BSO for heavy ions
https://doi.org/10.1016/j.nimb.2015.07.127

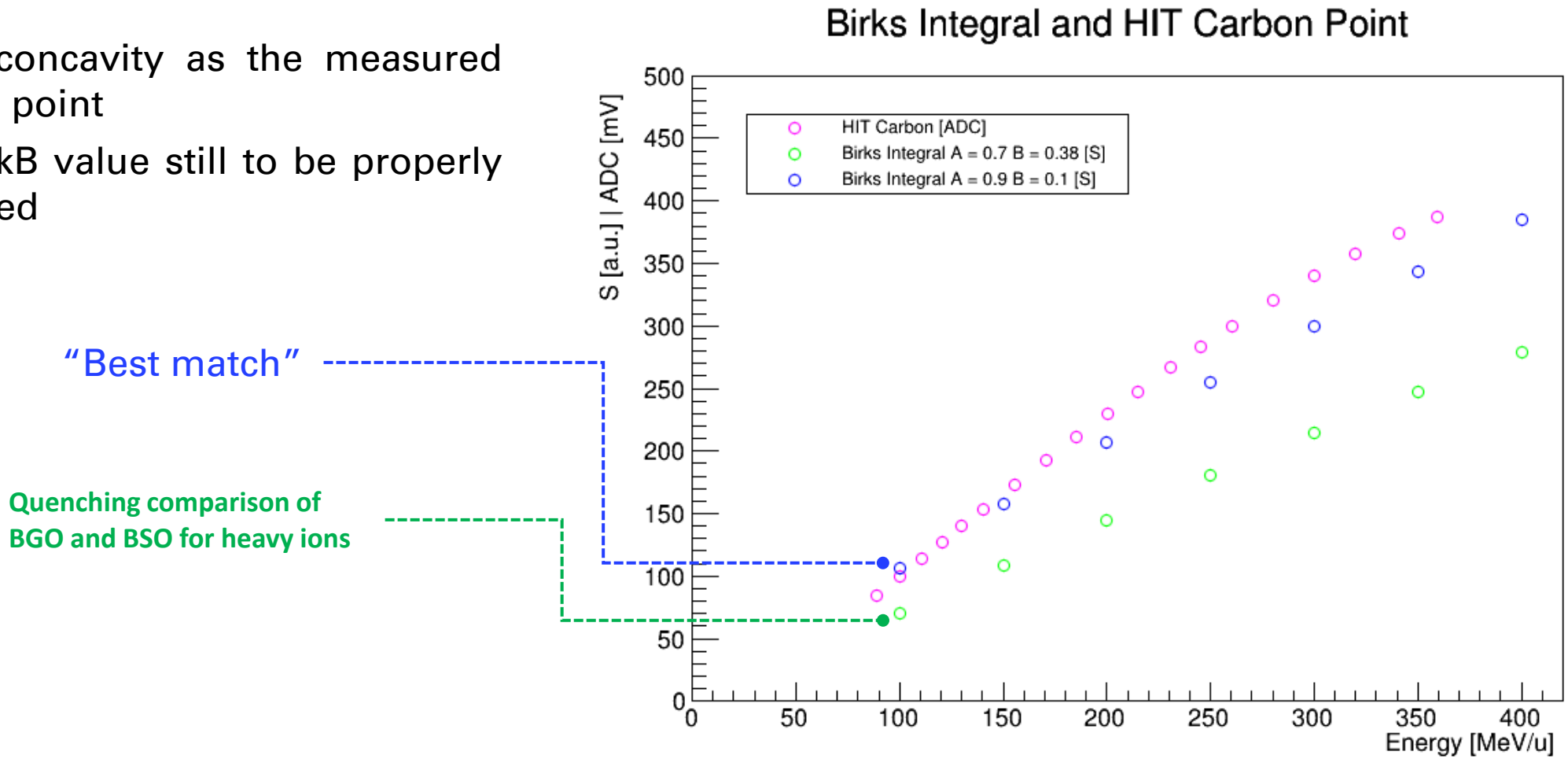
$$f(x) = A \cdot [R \cdot e^{-\alpha(L-x)} + (1-R)e^{-\alpha(L+x)}]$$

Range correction as studied by L. Scavarda

Numerical Integration

Birks Integration – Results

- ✓ Same concavity as the measured Carbon point
- ✓ A and kB value still to be properly identified



Summary and near future

- ✓ Final calorimeter construction to be completed by October 2024
- ✓ An intercalibration strategy has been found and tested with CNAO constrains
- ✓ A study on the integration of Birks formula has been approached

In view of CNAO2024

- ✓ Optimization of analysis software and decoding algorithm
- ✓ QA SHOE calibration
- ✓ Development of campaign-checking Macro*

* As suggested by M. Toppi