TOR VERGATA
UNIVERSITY OF ROME

XIV FOOT Collaboration Meeting

TW calibration for HIT2022

Triestino Minniti et al., Physics Department, University of Rome "Tor Vergata" & INFN Sez. Roma2, Italy.

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Experimental setup

Heidelberg, from July 17 to July 25 (2022)

^{4}He(100-140-200-220 MeV/u) on ^{12}C

11 Mevts (min bias)
4 Mevents (frag. trig)

The FOOT HIT 2022 setup

- Start Counter
- Beam Monitor
- Micro Strip Detector
- ToF-Wall
- 7 modules (63 crystals) of the calorimeter

Available Fragmentation Channels

Using ^{4}He projectiles, the only final state channels (excluding target fragmentation) are:

~as many 3He as t are expected

$$
^4\text{He} \rightarrow \begin{cases} n + {}^3\text{He} \\ p + {}^3\text{H} \\ {}^2\text{H} + {}^2\text{H} \\ n + p + {}^2\text{H} \\ n + n + p + p \\ \left[{}^4He + X,\ {}^4He + X^* \right] \end{cases}
$$

$$X^* \rightarrow X + \gamma$$

It would be fundamental to aim to both Z & A identification using the BGO modules, even in a limited solid angle

$E_{sep}(^4\text{He} \rightarrow n+^3\text{He}) = E_{bind}(^4\text{He}) - E_{bind}(^3\text{He}) = 28.3 - 7.7 = 20.6$ MeV

$E_{sep}(^4\text{He} \rightarrow {}^2\text{H} + {}^2\text{H}) = E_{bind}(^4\text{He}) - E_{bind}(^2\text{H}) = 28.3 – 2.23 = 26.07$ MeV

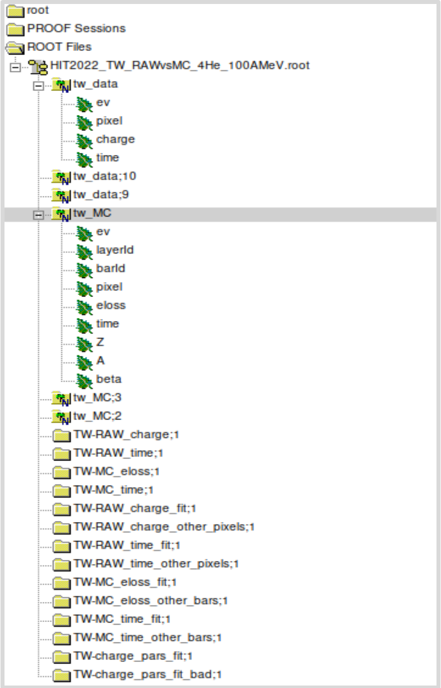
TW calibrations

- We analyzed data acquired in the **HIT 2022 campaign** that refer to ^{4}He beam on a 5 mm graphite target at energies of (100-140-200-220) MeV/u

- Global gain of the TW set to ~2.5 (instead of ~ 1 as in the previous FOOT data taking)

- First step: data acquired written by the DAQ system in binary format (.dat) are unpacked and a ROOT Tree is generated

^{4}He BEAM ENERGY	RAW DATA EVENTS	MC EVENTS
100 MeV/u	4.4 M	5 M
140 MeV/u	4.1 M	5 M
200 MeV/u	8.3 M	5 M
220 MeV/u	2.4 M	5 M



TW Energy Calibration

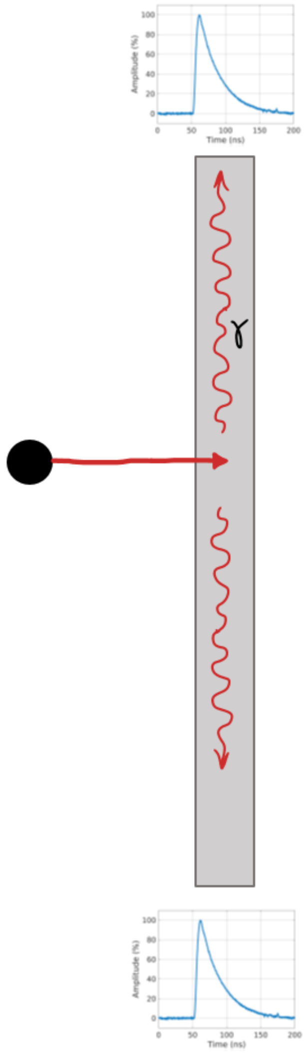
- We need to extract the energy loss of the fragments passing through this detector

- The total charge values were obtained directly from the TW signals. The two channels of each bar involved in the event were processed separately and the charge collected in each of them (Q_A and Q_B) was evalueted as the integral of the signals

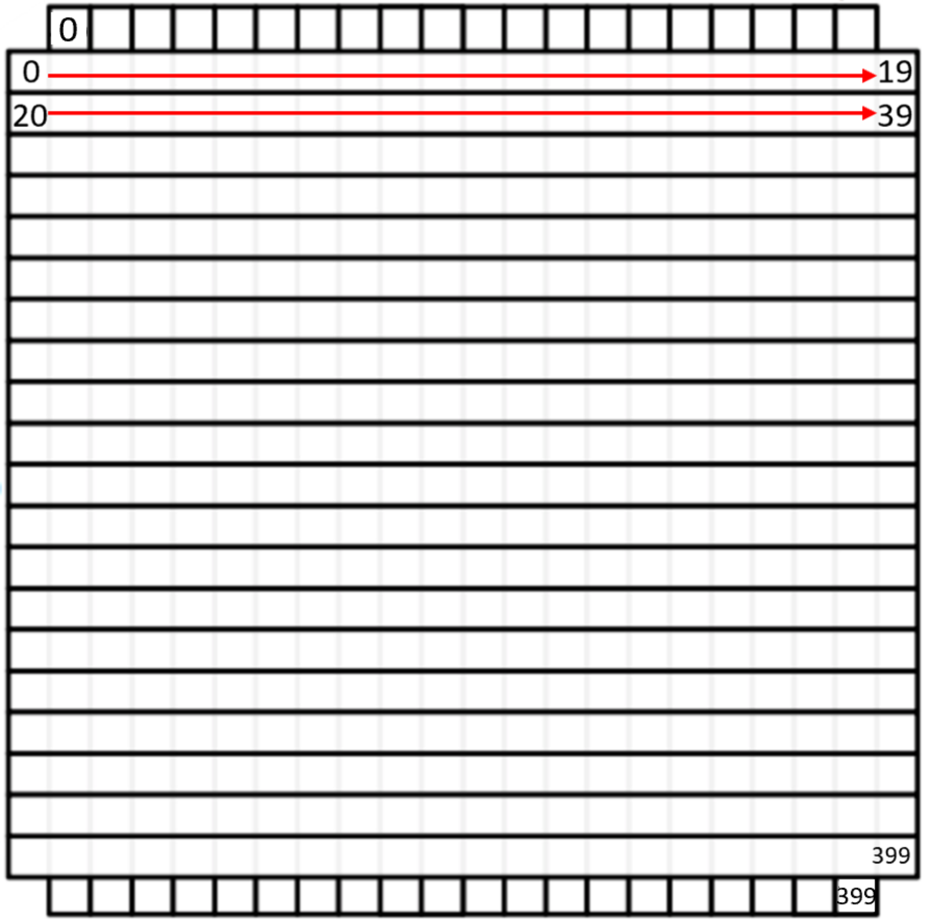
- The raw energy loss of the particles that pass through the bar was defined as:

$$Q = \sqrt{Q_A \cdot Q_B}$$

- Once this quantity is retrieved, analyzing each event, it is possible to obtain the mean values of the deposited energy of the fragments, and plot them according to the expected MC energy releases

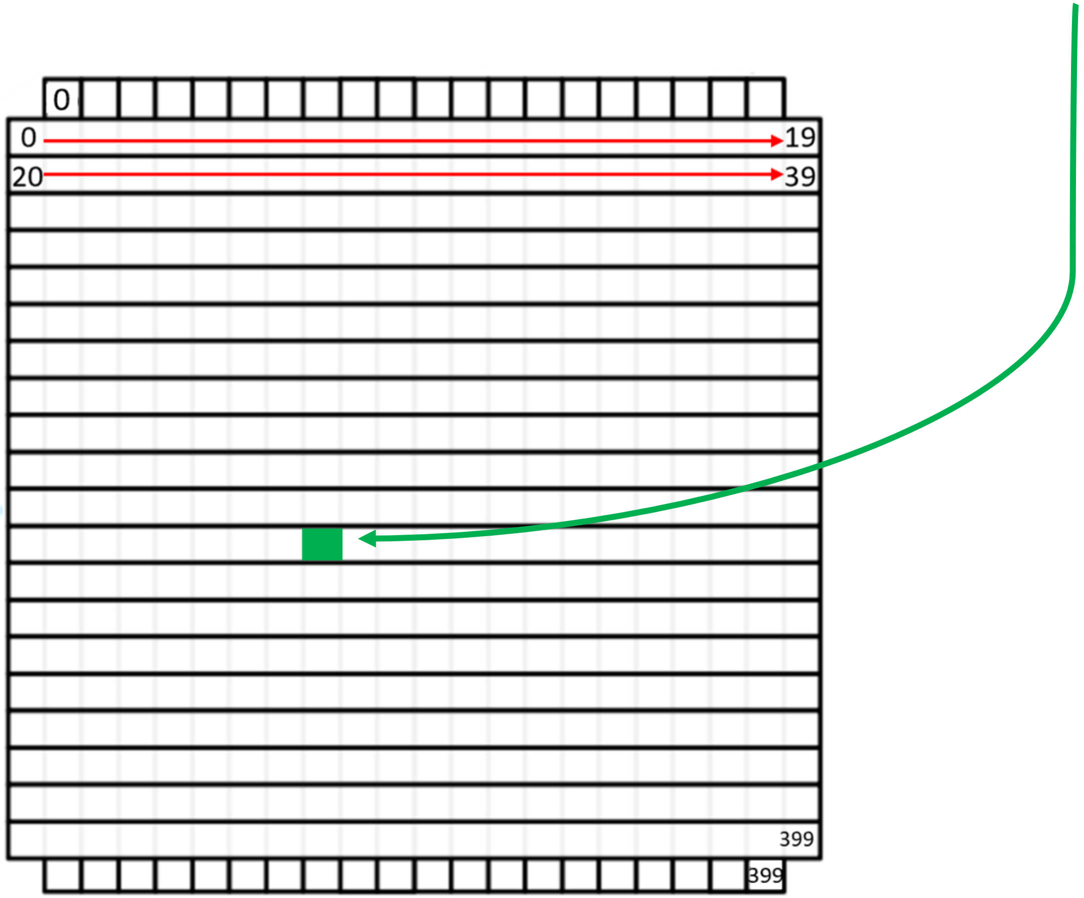


TW Calibration Map



- Each of the two layers was ideally divided into 400 equal regions with an area of $2{\times}2\ \mathrm{cm}^2$ that we called ***pixels***
- A pixel is identified as the area of intersection between a horizontal bar on the front layer and a vertical bar on the rear layer
- The pixel numbering for both layers goes from 0 to 399
- At the end we will obtain 800 well-calibrated positions

- All the steps of the TW energy and TOF calibration procedure for the pixel n. 228 are presented as an example

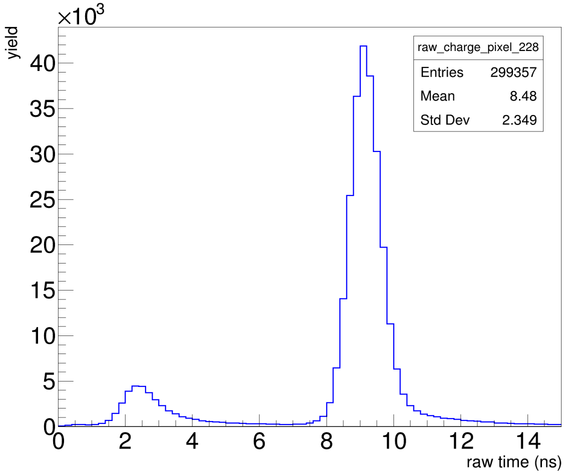


- We repeated recursively the same procedure for all the 800 pixels in order to obtain a complete calibration map containing all the calibration parameters

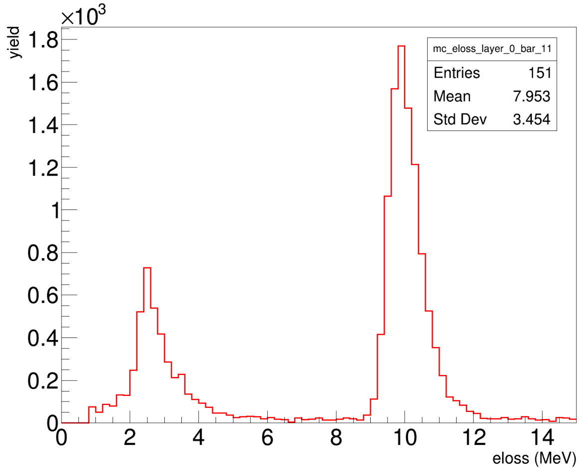
Energy loss distributions for pixel n. 228

MC DATA

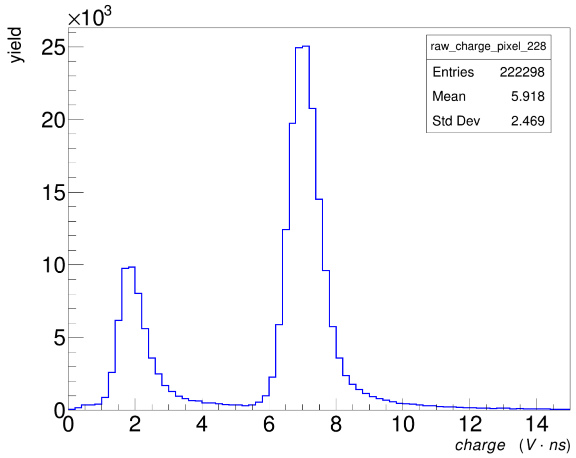
RAW DATA



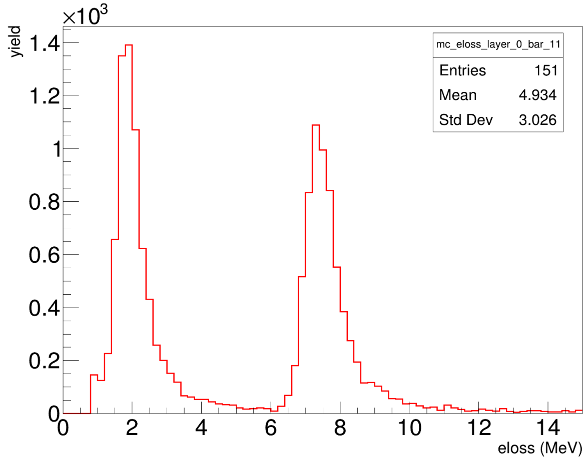
100 MeV/u



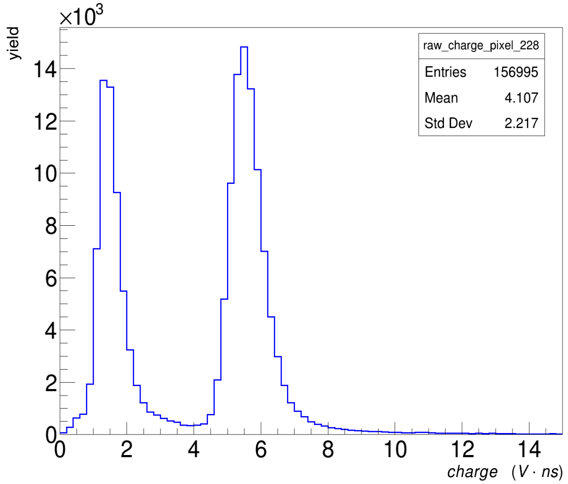
100 MeV/u



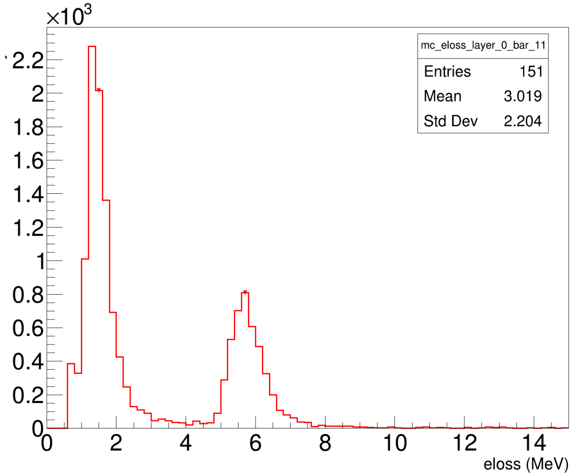
140 MeV/u



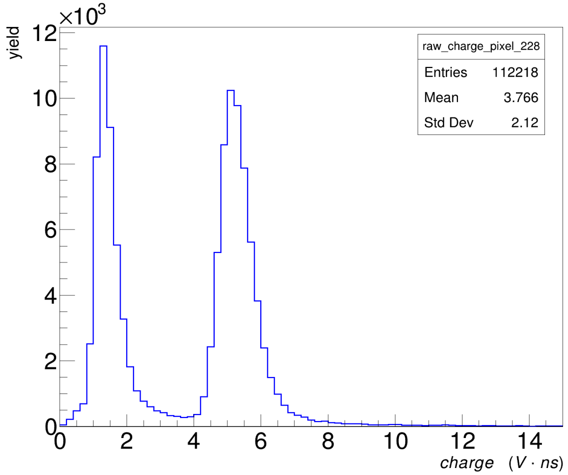
140 MeV/u



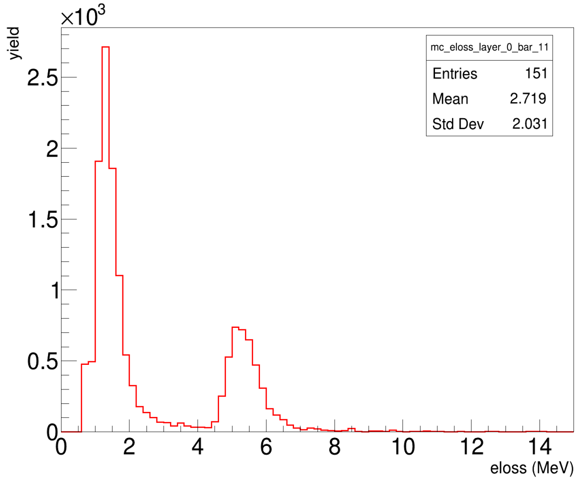
200 MeV/u



200 MeV/u



220 MeV/u



220 MeV/u

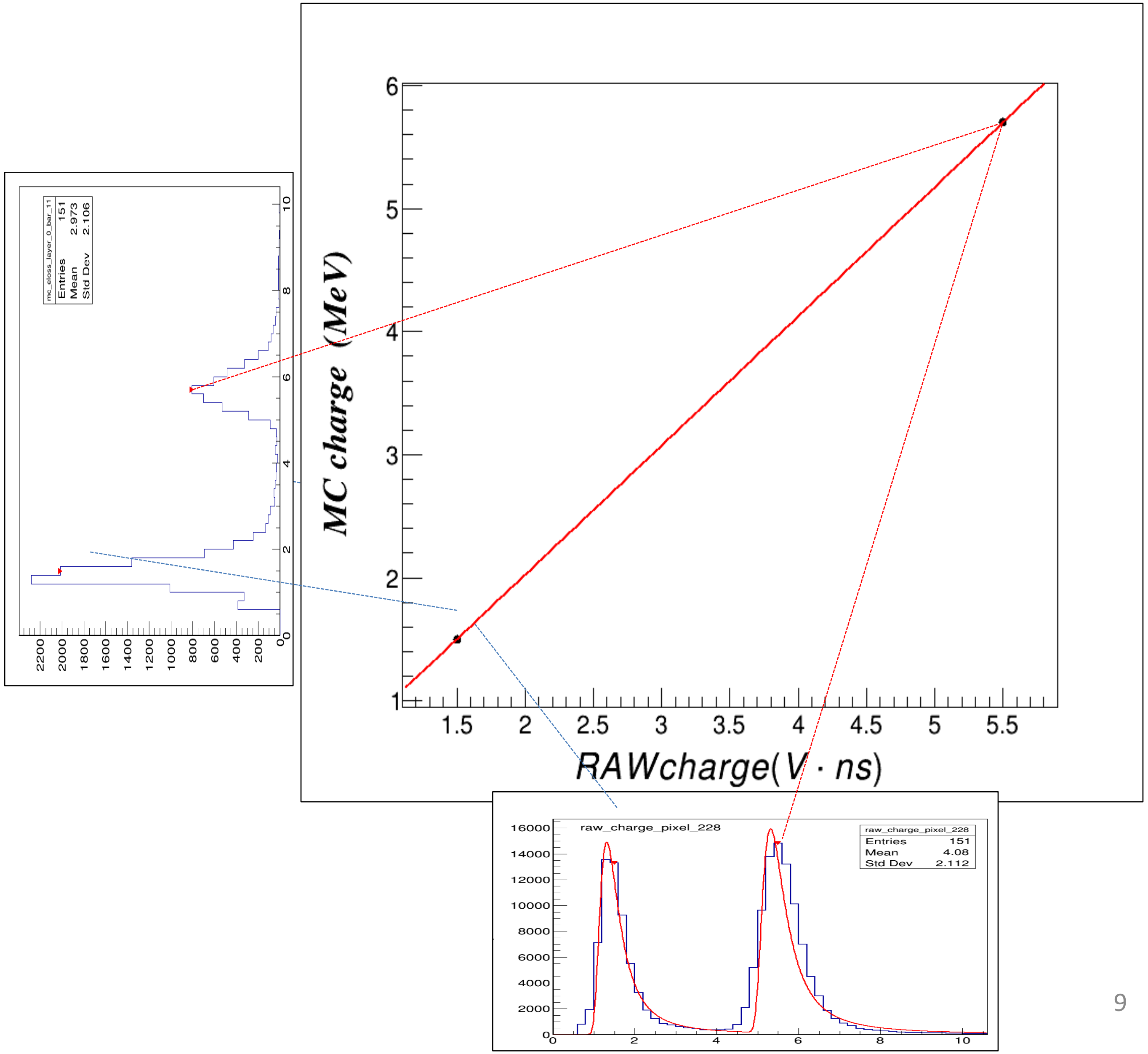
- The two fit with a Landau curve and the mean value of both raw charpeaks of the raw energy loss distribution are automatically ge peaks are extracted

- The mean values of both MC energy loss peaks are extracted with the support of the ROOT TSpectrum class

- Linear fit: $\mu(\Delta E_{MC}) = p_0 \cdot \mu(Q) + p_1$

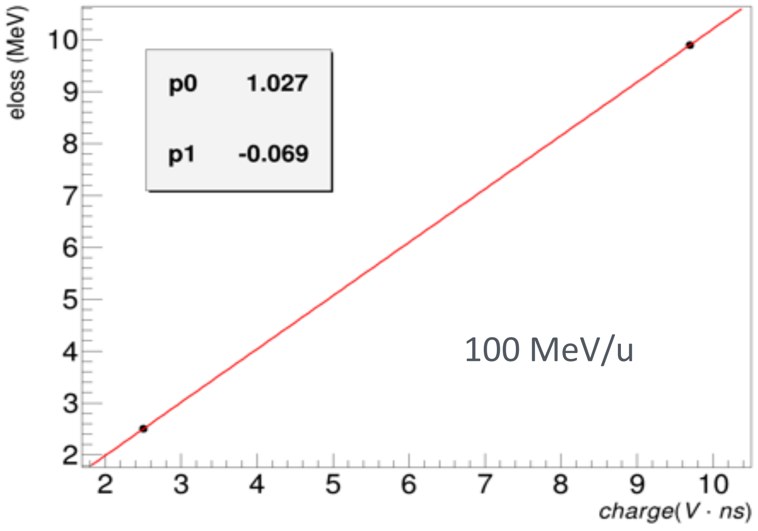
  - $p_0\ (MeV/V \cdot ns)$ represents the charge conversion factor between the MC and the experimental data

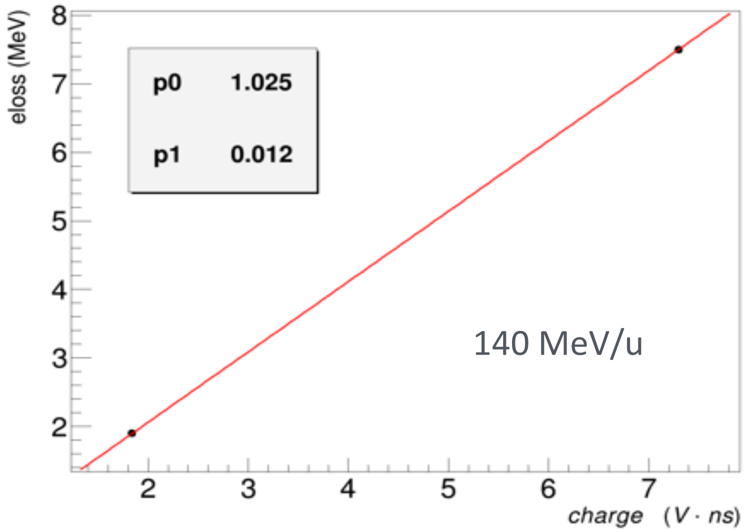
  - p_1 has the dimensions of MeV

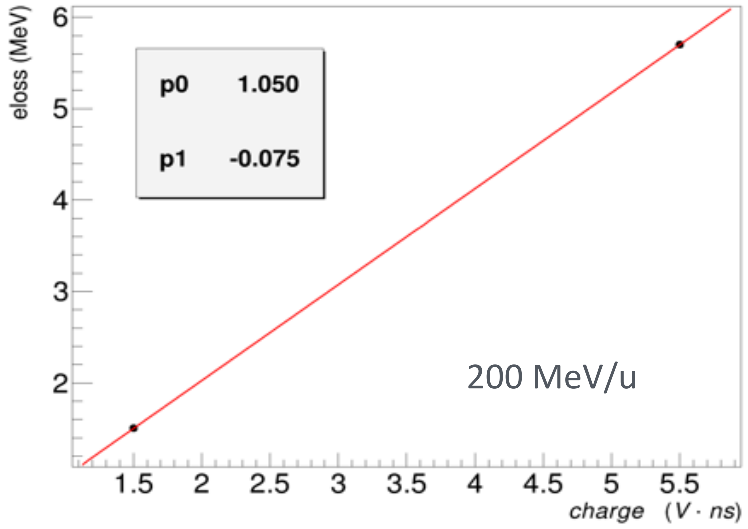


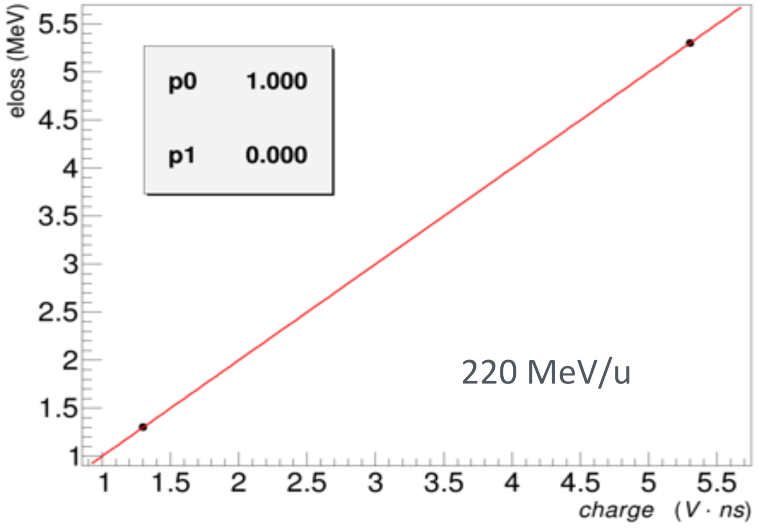
Energy Calibration Lines

- The same procedure is repeated for each energy value
- In the final energy calibration file that will be pushed in SHOE for each pixel will be given the correspondent parameters p_0 e p_1









Time-Of-Flight (TOF) Calibration

- ➢ The start time t_{st} of each event was extracted from the SC waveforms

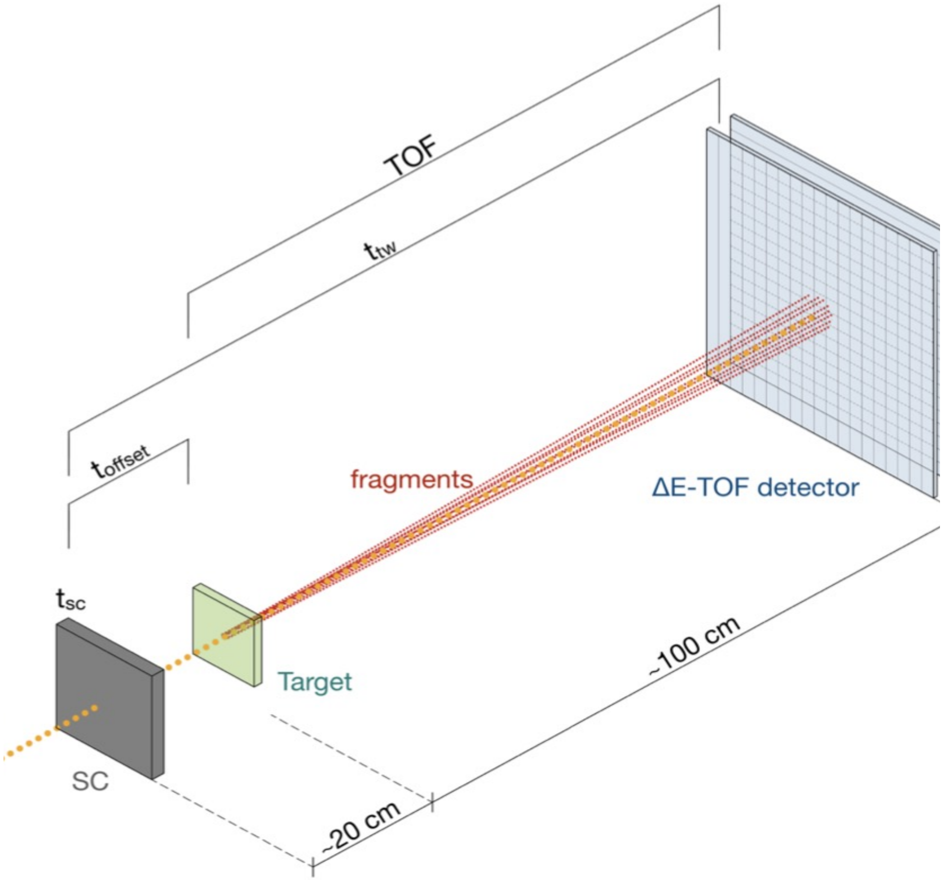
- ➢ The arrival time t_{tw} of the passing fragments was extracted from the TW signals.

$$TOF_{raw} = t_{tw} - t_{st} = \frac{t_A + t_B}{2} - t_{st}$$

- where t_A and t_B are the timestamps taken at right and left side of the detector's bar

- ➢ For the TOF calibration we referred to the same calibration map of the energy

- ➢ We calibrated the TOF for all the 800 pixels



TOF distributions for pixel n. 228

MC DATA

RAW DATA

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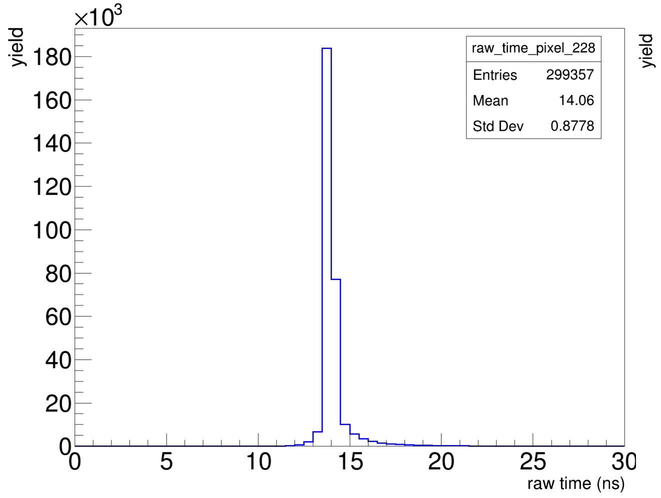
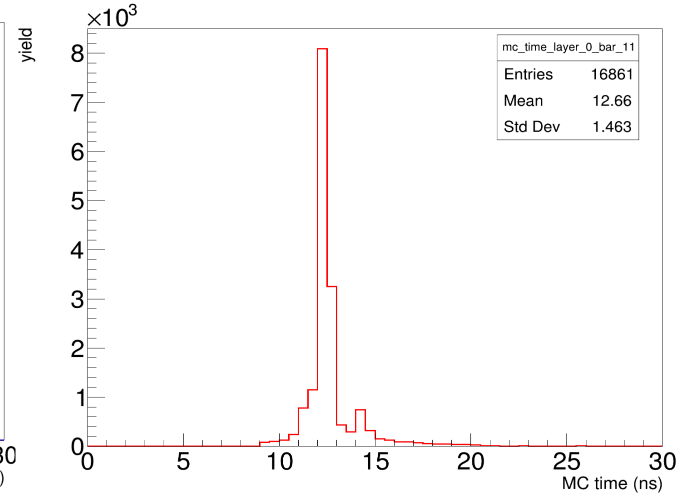
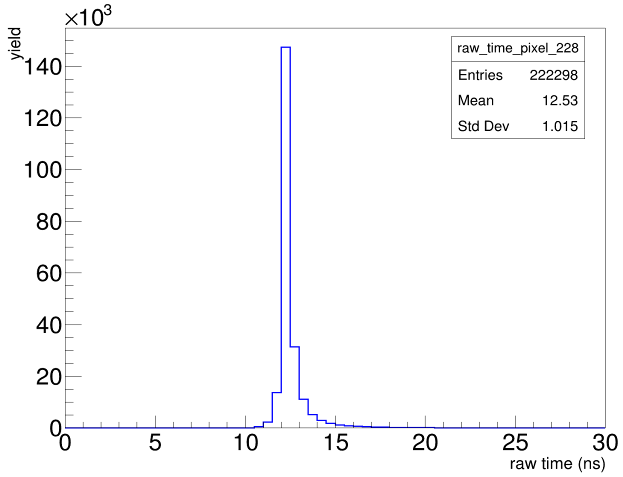


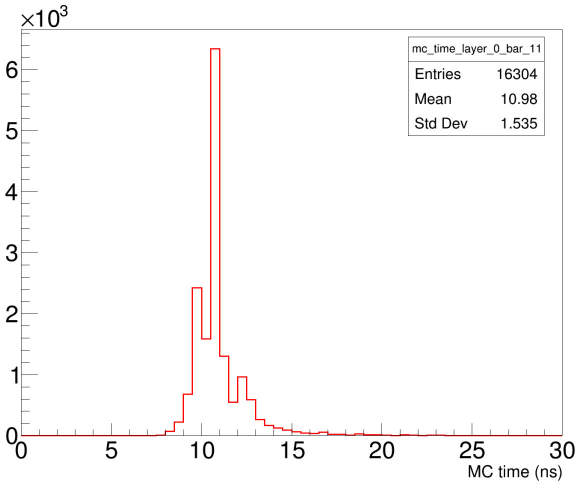
100 MeV/u



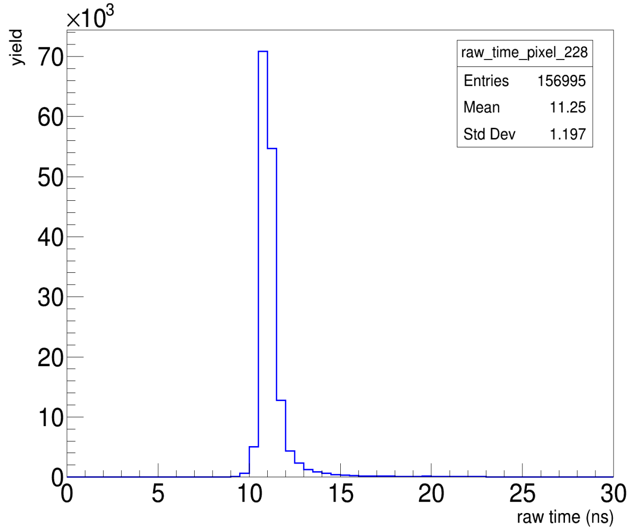
100 MeV/u



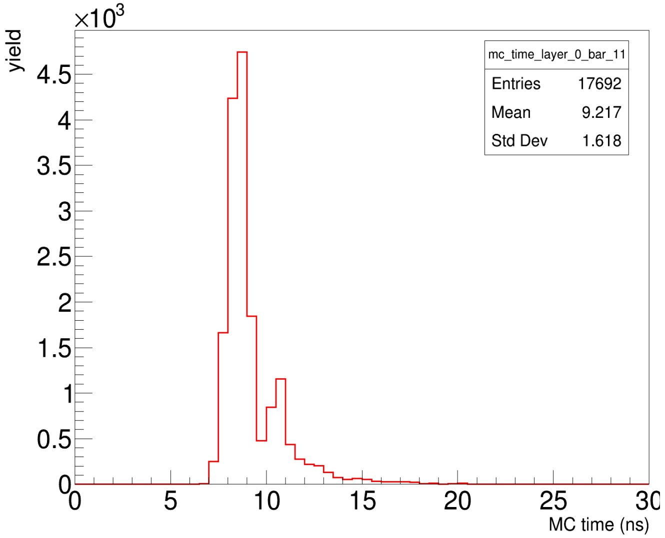
140 MeV/u



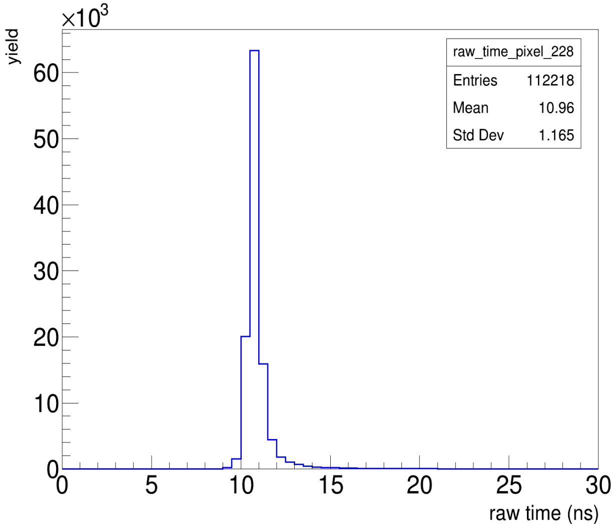
140 MeV/u



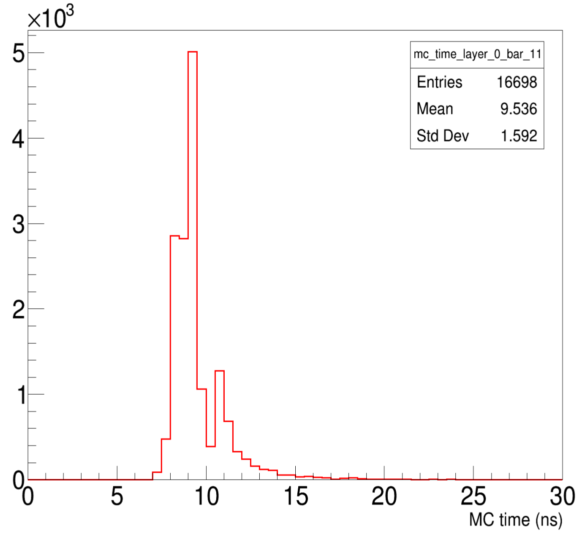
200 MeV/u



200 MeV/u



220 MeV/u



220 MeV/u

- TOF calibration consists in relating the mean value of the TOF_{raw} distribution the mean value of the TOF_{MC} one:

$$\boldsymbol{\mu(TOF_{MC}) = \mu(TOF_{raw}) - \Delta t}$$

- We derived $\mu(TOF_{MC})$ and $\mu(TOF_{raw})$ once again with the ROOT TSpectrum class
- The variable Δt considers all the possible experimental time offsets due for instance to electronics and signal propagation delay through cables

- In the time calibration file that will be pushed in SHOE for each pixel will be given the correspondent parameter Δt. For pixel n. 228 we obtained $\Delta t = 1.5\ ns$ for each value of beam energy

Conclusions

✓ A TW calibration (energy and ToF) for the HIT2022 data taking which has involved Z = 1 and Z = 2 fragments was done. All the files are ready to be uploaded on SHOE.

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1. Isotopic fragments identification combining the measures of TW and calorimeter is under way

2. Hopefully final goal is to study differential cross sections for the FOOT HIT2022 campaign