FramentatiOn
Of Target

Z identification (ZID) with TW detector

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What we have done

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- The idea is to parametrize Bethe-Bloch (BB) curves as a function of ToF (β depends on the tracking (L) while the Z info has to be provided before tracking) and assign to each TW hit (ToF,Eloss) the Z corresponding to the closest BB curve

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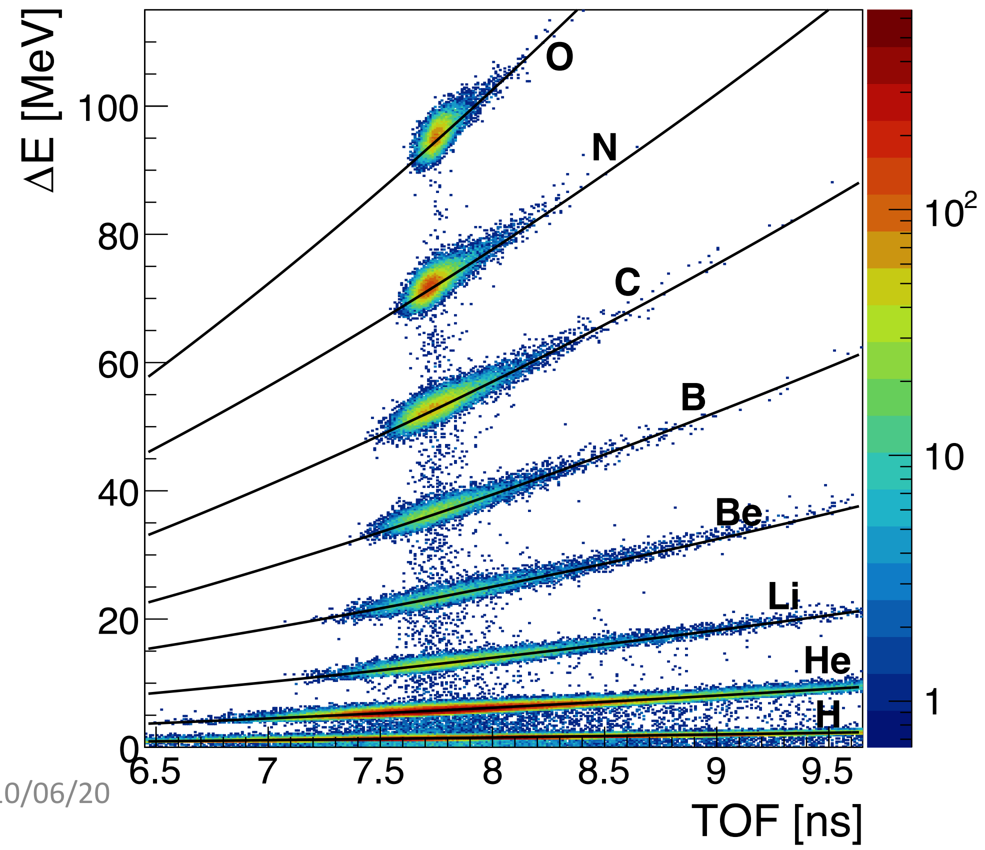
- This has been tuned for various MC productions (^{12}C and ^{16}O with full and GSI geometries) and applied on GSI DATA (^{16}O 400 MeV/n) after having introduced in SHOE the calibration preformed by the TW - Pisa group

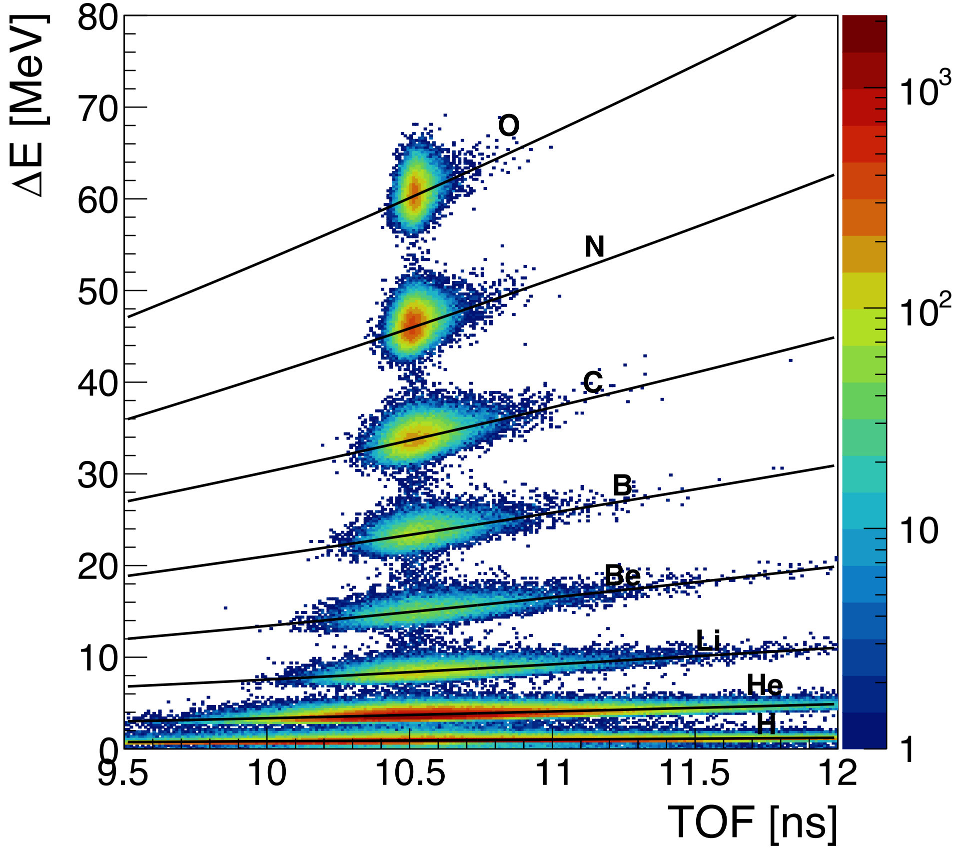
Bethe-Bloch parametrization

Bethe-Bloch parametrization from **Monte Carlo truth**, asking for primary fragmentation and Z_MC.

^{16}O – 200 MeV/n MC true – full geo

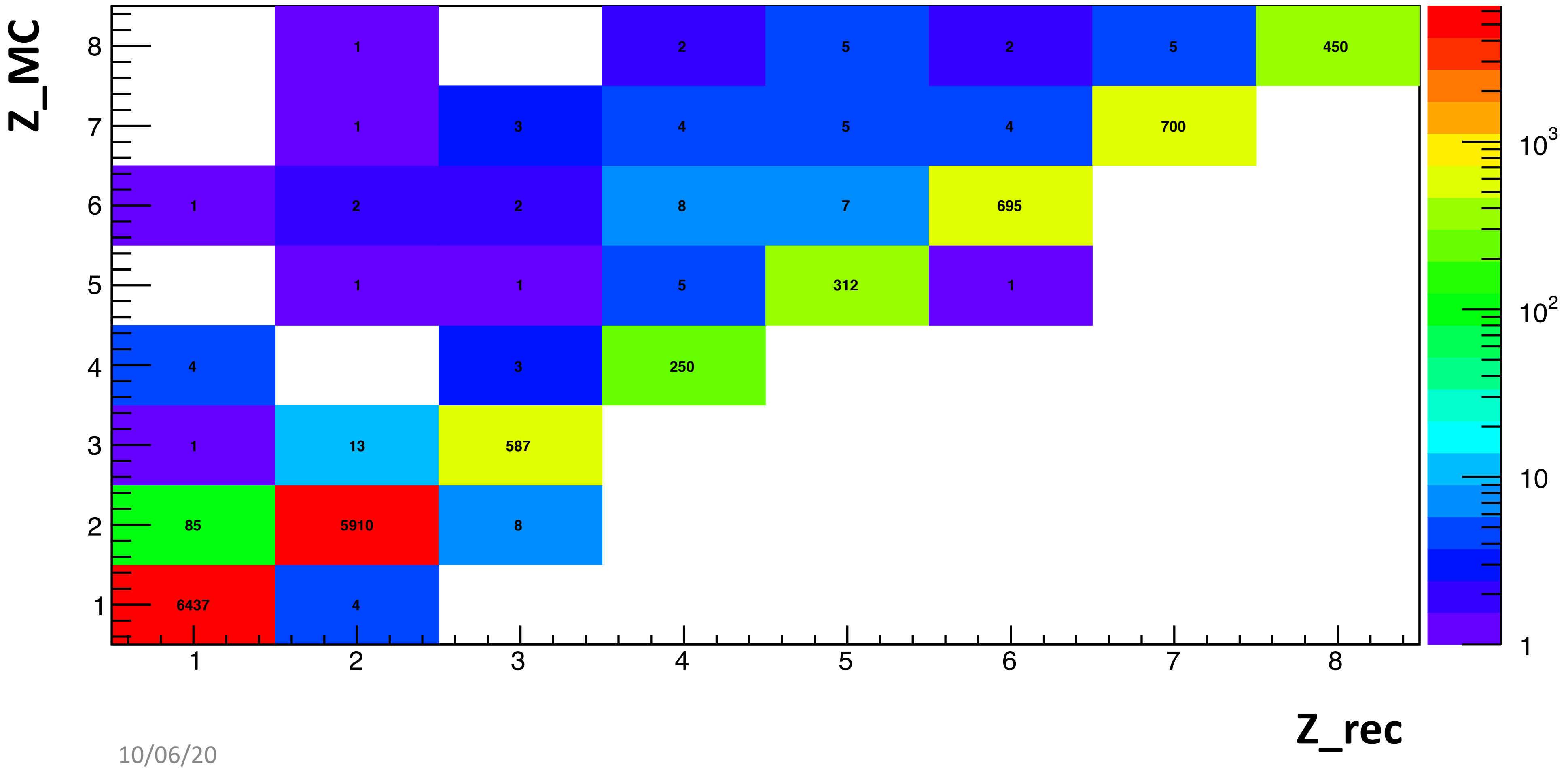


^{16}O – 400 MeV/n MC true - GSI



Algorithm performances: MC true

^{16}O – 200 MeV/u MC rec – full geo



Good ZID algorithm performances (wrong Z charge assigment < **1.2%**)

→ MC true with request of only primary fragments in order to tune the algorithm

ZID for reconstructed MC

The BB curves are superimposed on the **reconstructed MC**. Pile-up and Eloss and ToF resolution from calibration data (thanks to Pisa group) have been implemented in SHOE

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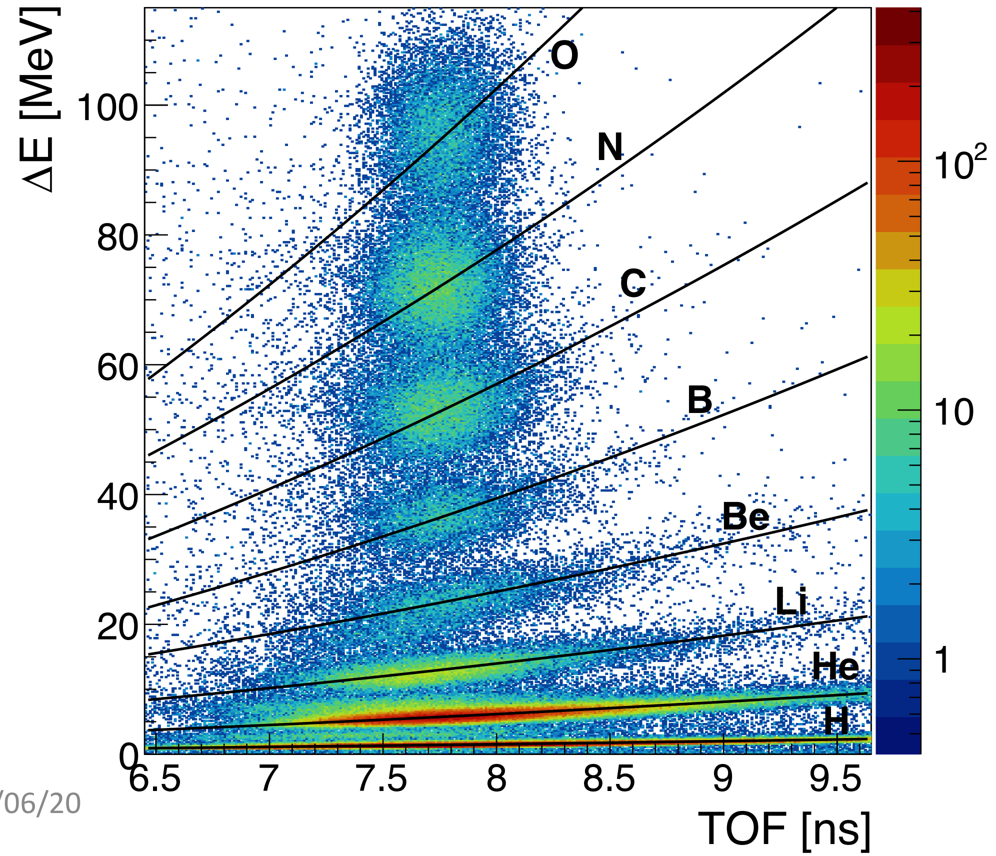

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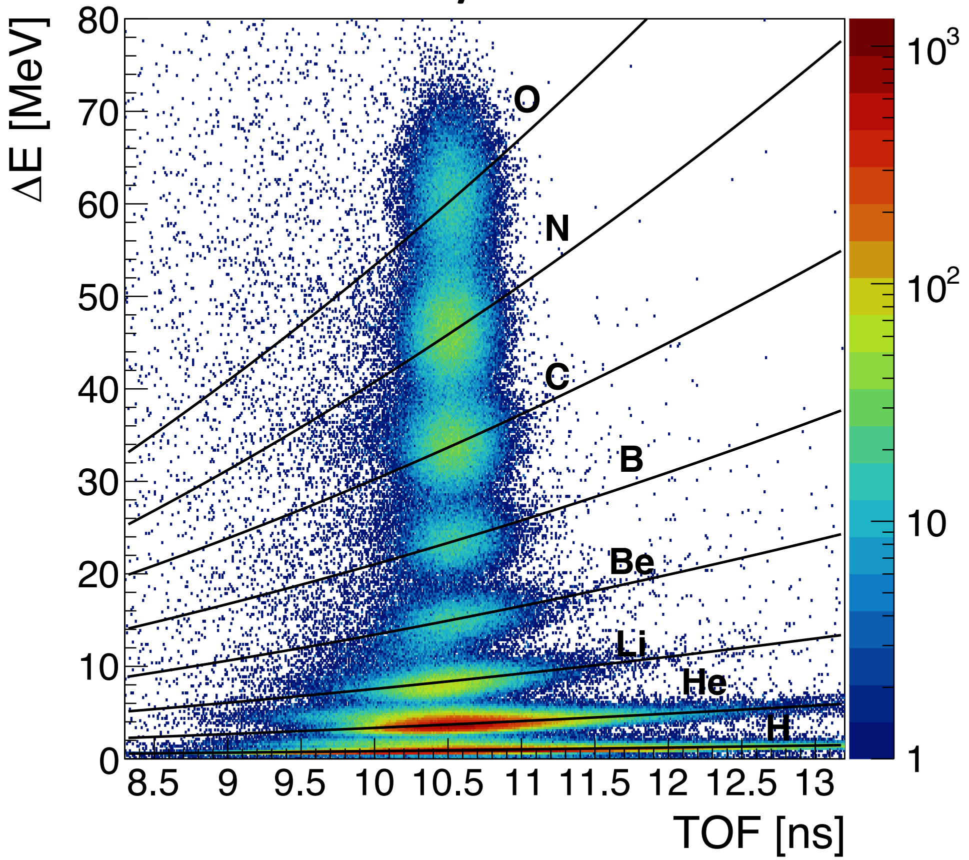

Algorithm performances: MC rec

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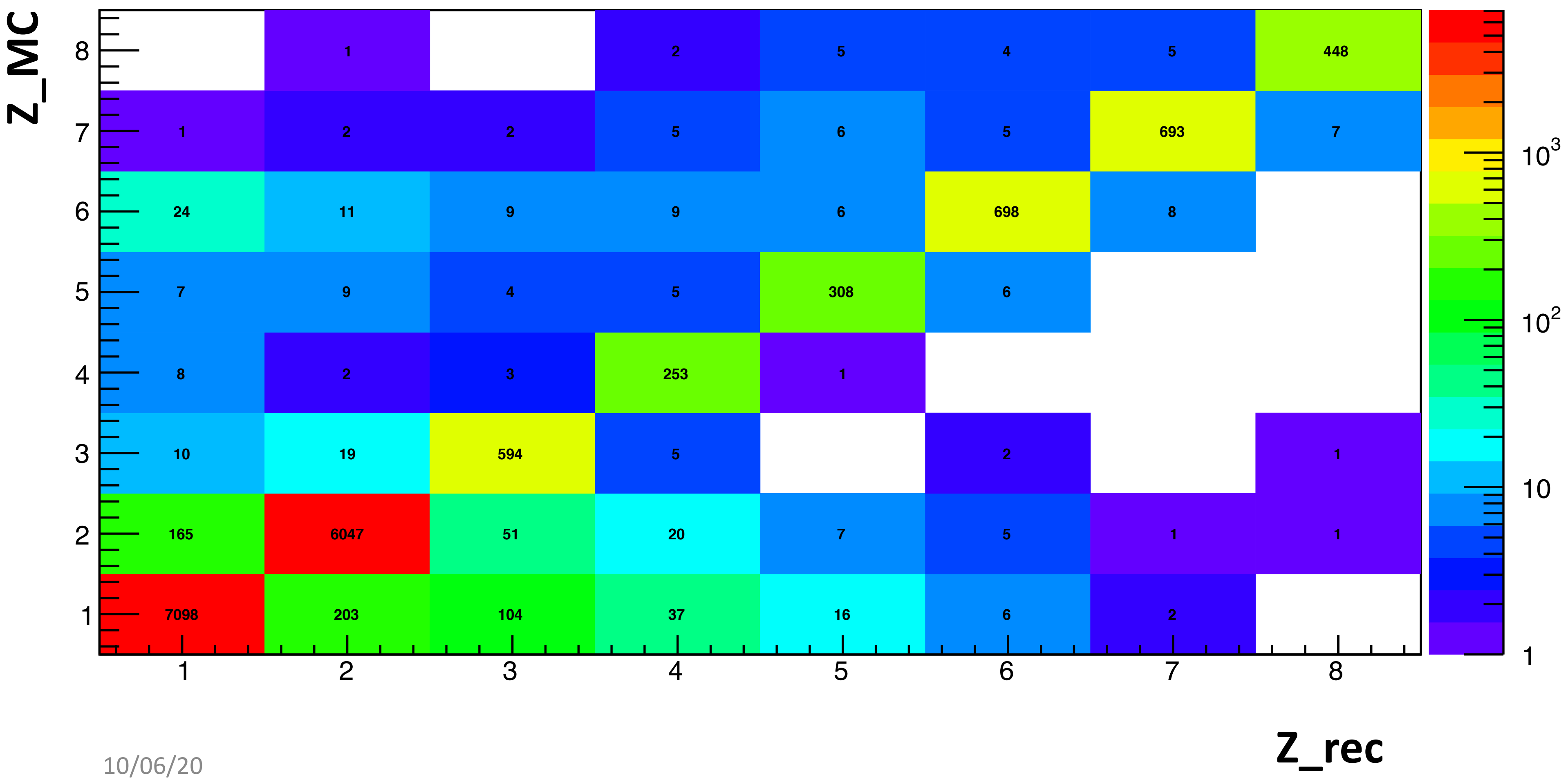

Good Zid performances. (wrong Z charge assigment < **4.8%**)

[Here reconstr. MC with no Pile-Up: impossible to assign a true MC Z charge in the case of Pile-Up]

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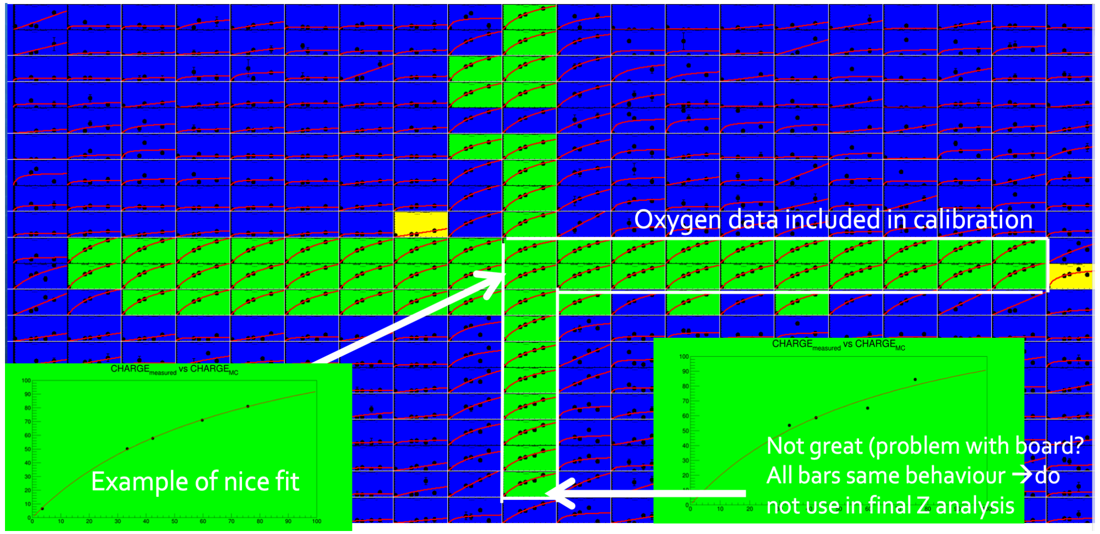

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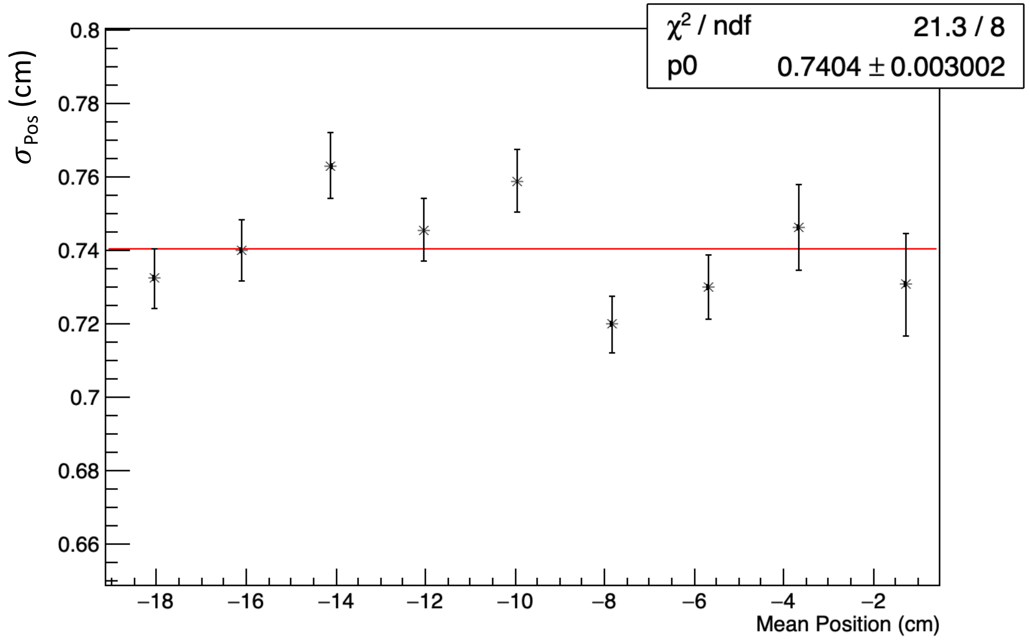
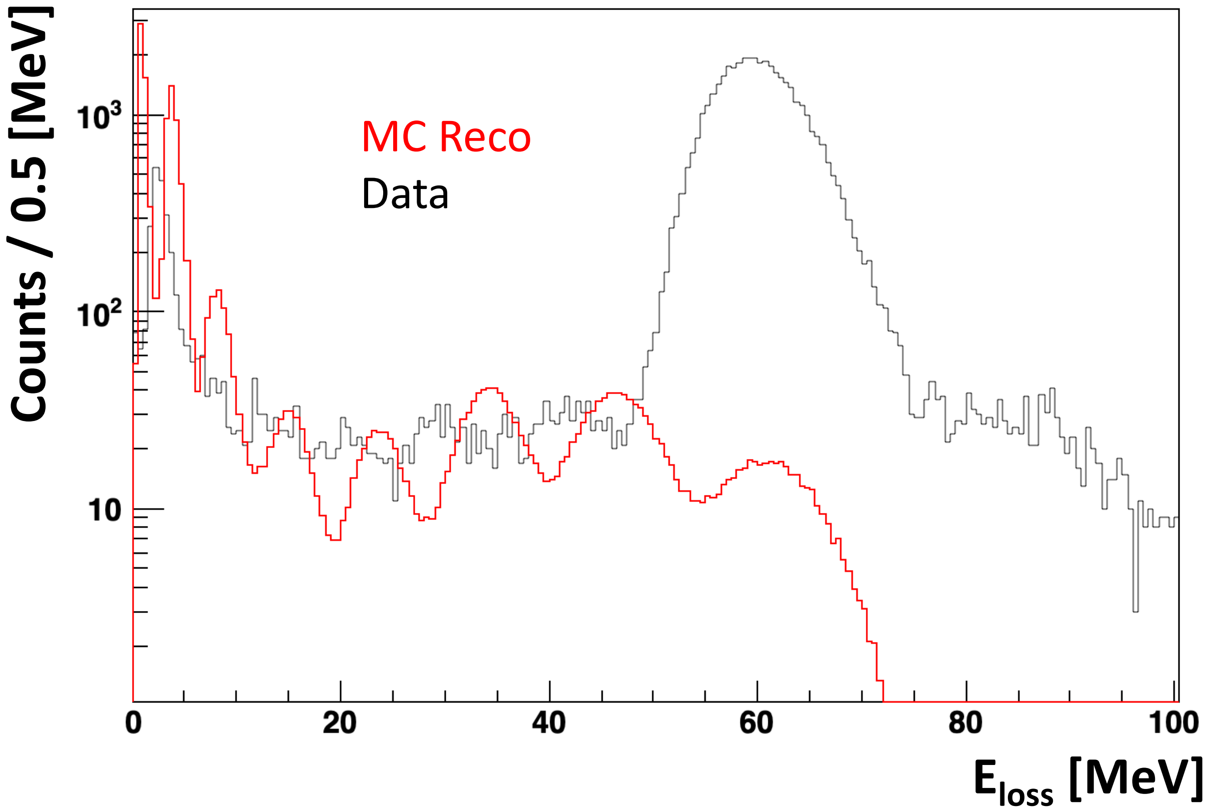
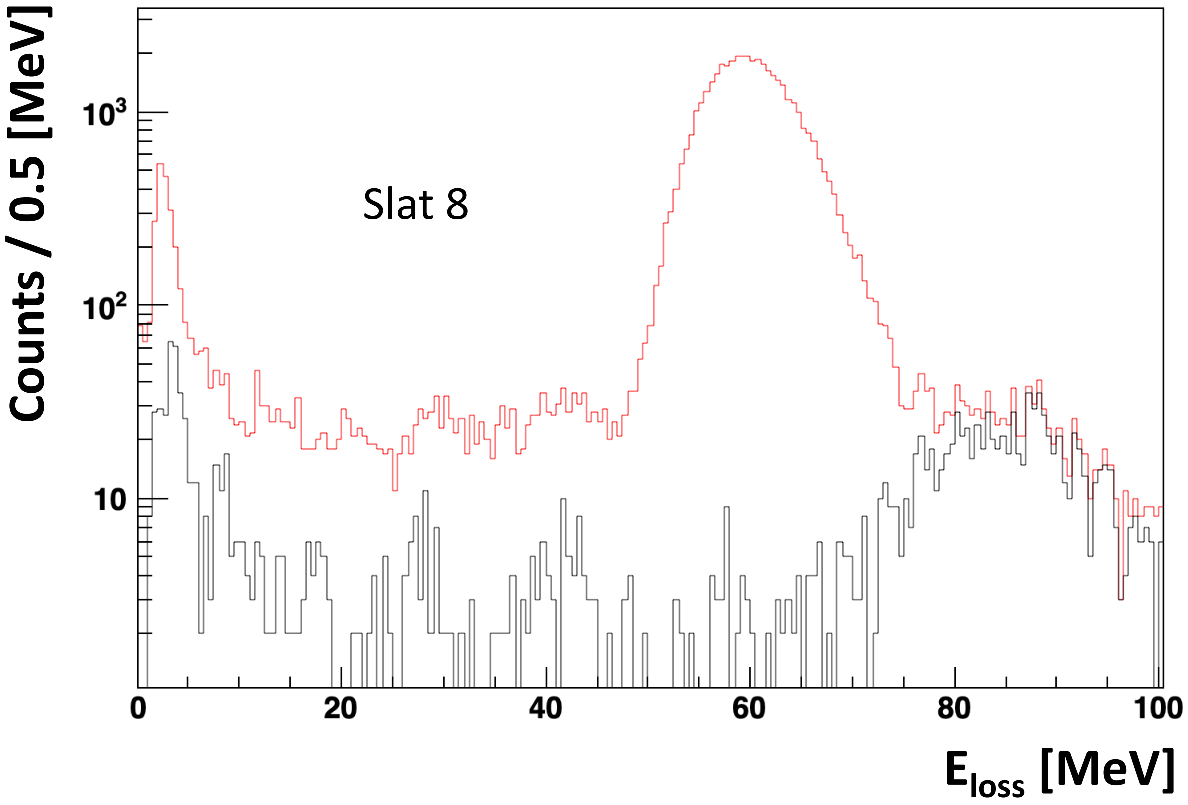


Moving ZID from MC to GSI DATA

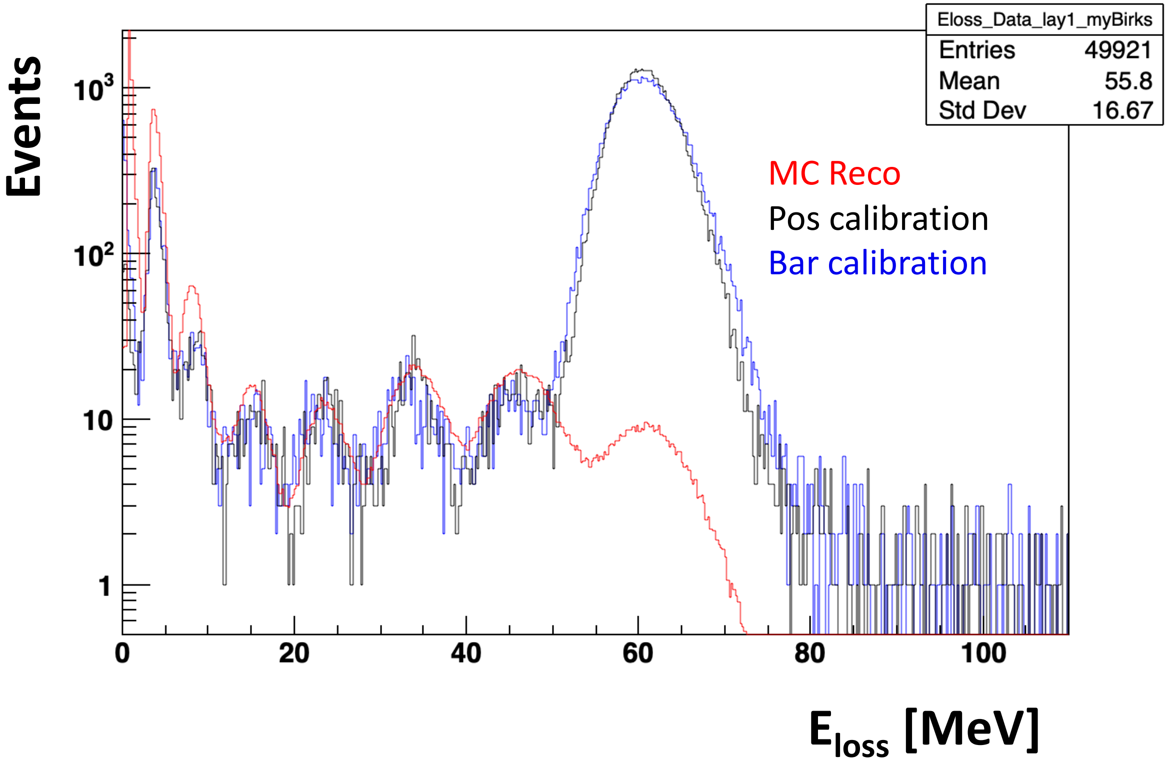
4. After calibration a further small tuning of the peaks to the MC energy has been necessary

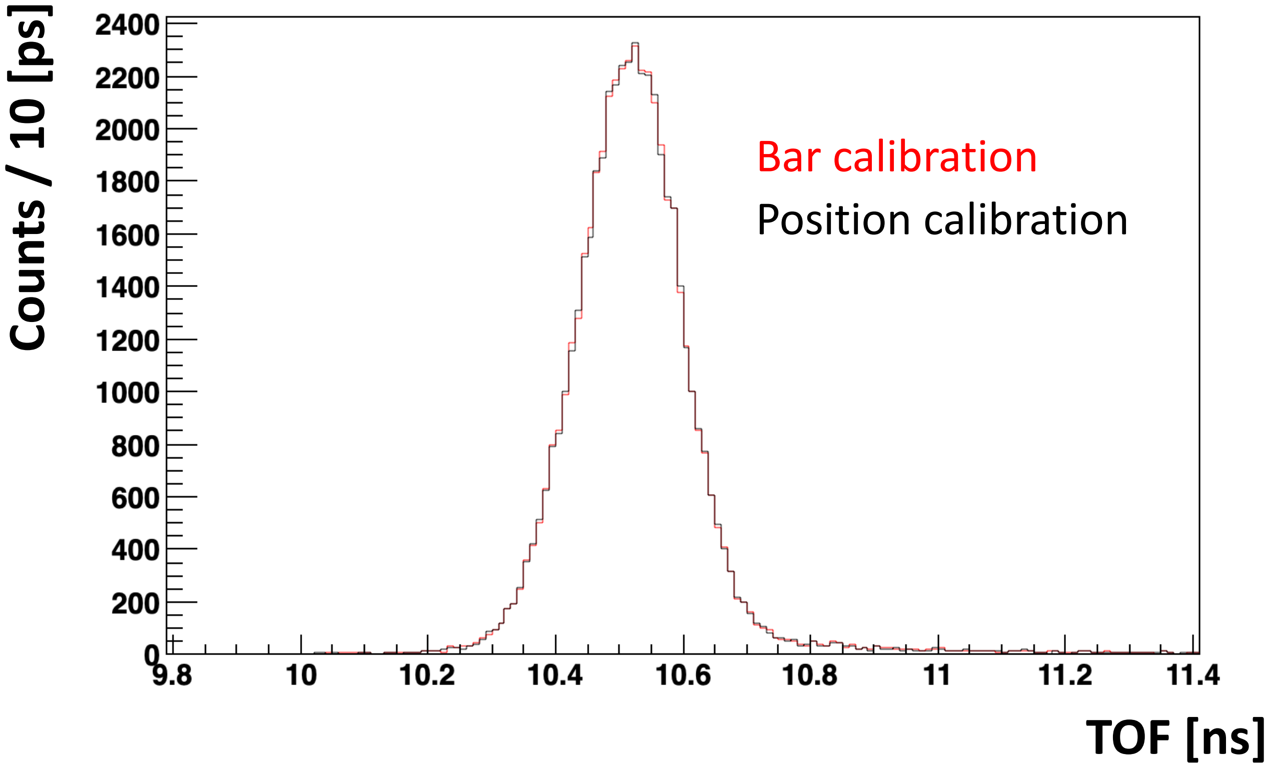




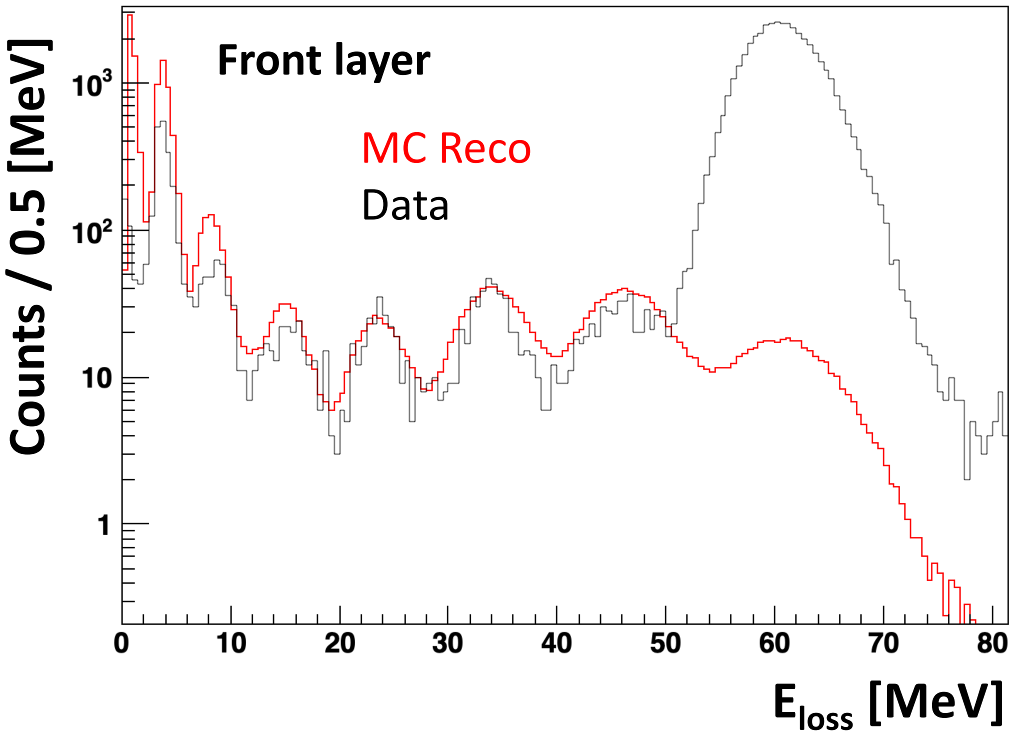
Moving ZID from MC to GSI DATA

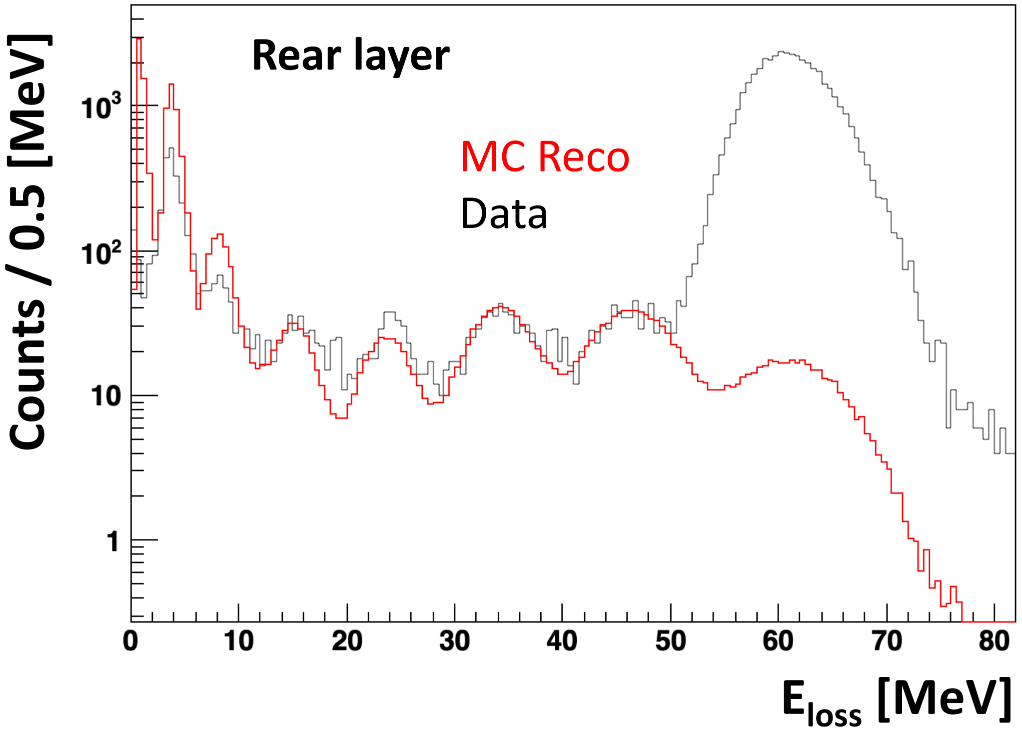
5. Crosschecked different Eloss and TOF calibration strategies succesfully (GSI fragmentation data standalone)





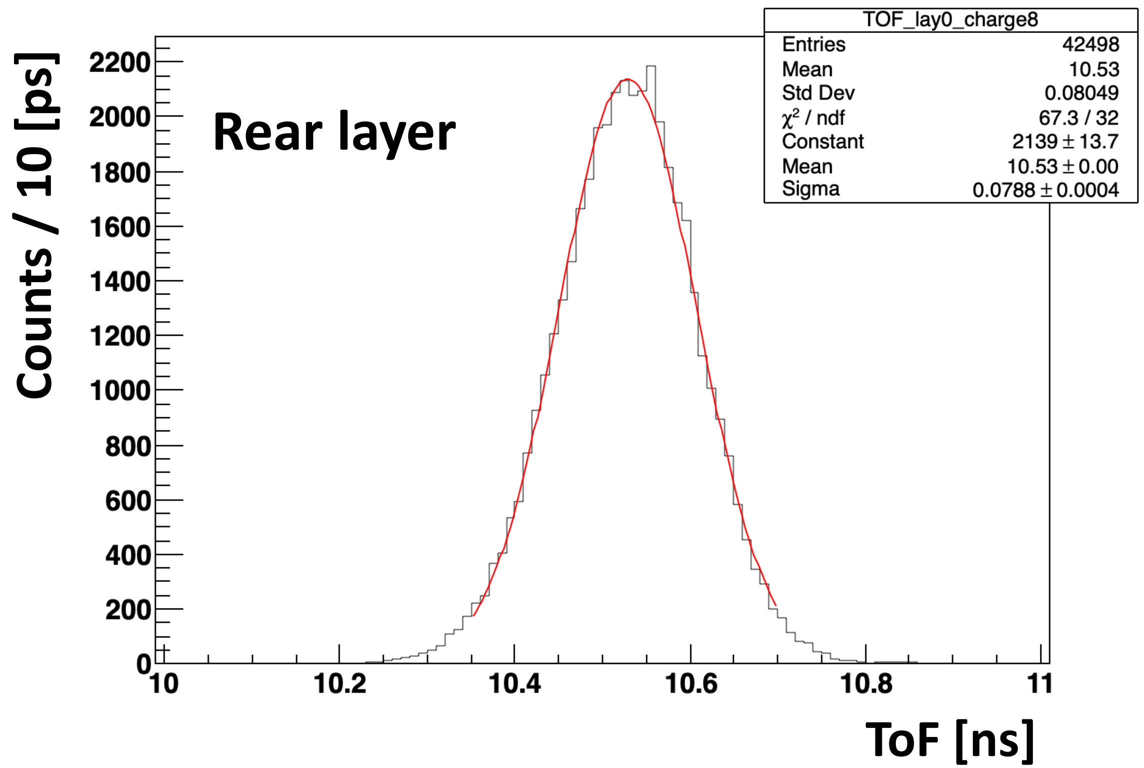
Energy loss distributions

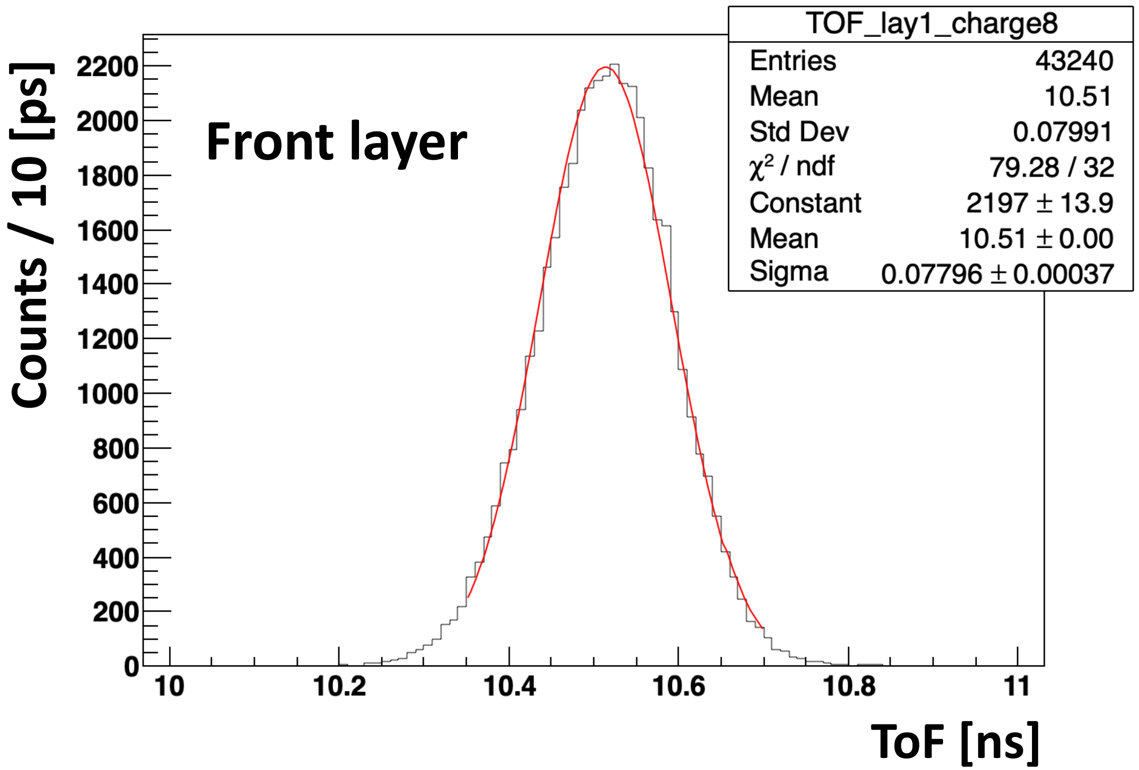




- Nice comparison Data - MC reconstructed
- Normalization to C peaks: FLUKA is able to reproduce very nicely the yield ratios for Z=4-7 (Concerning Oxygen: MC implements a fragmentation trigger)
- Recovered mis-calibrated bars in layer rear

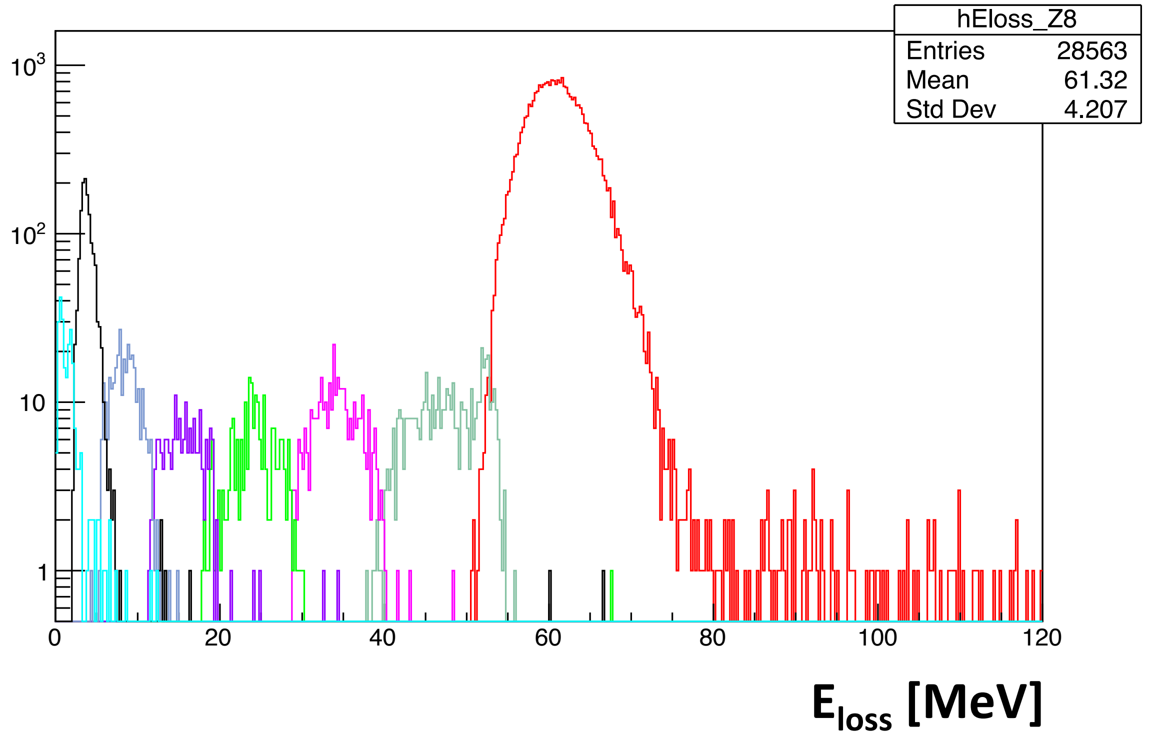
TOF in fragmentation runs

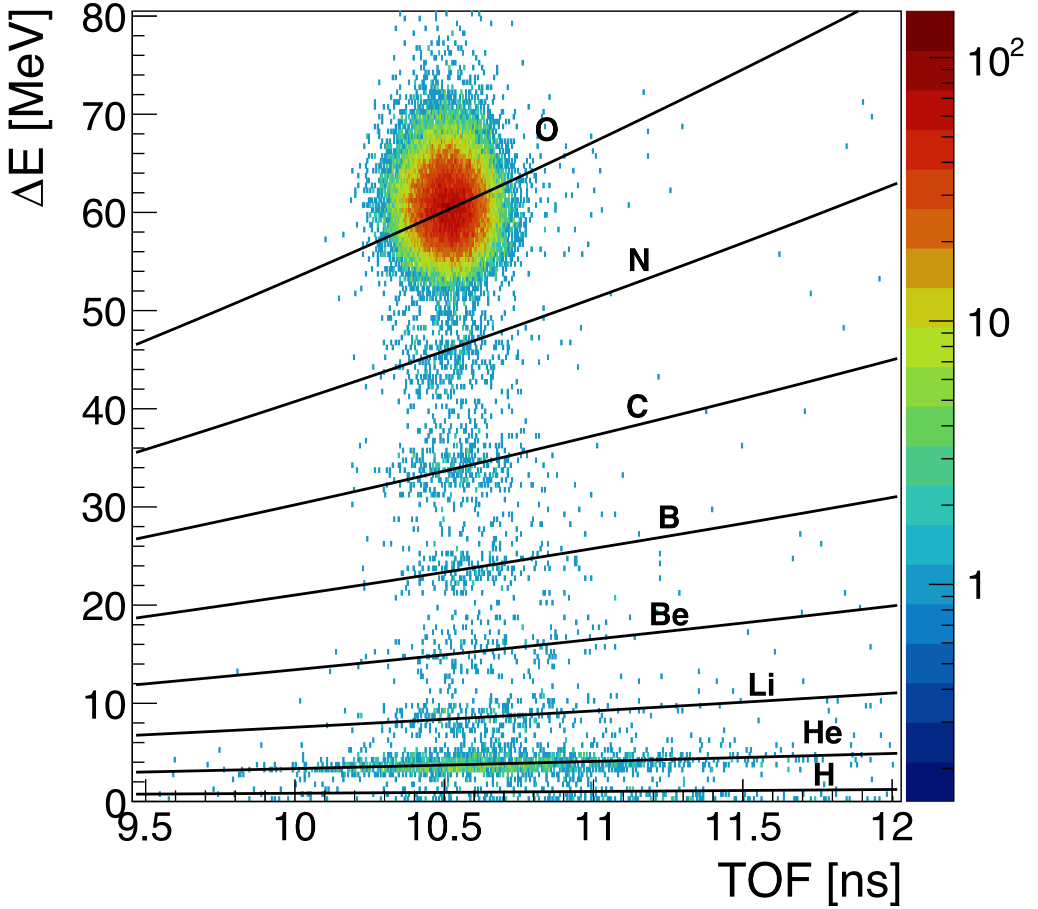




- Cross checked a TOF calibration «position per position» with a calibration per bar shifting: $TOF_{raw} = (t_A+t_B)/2 - t_{SC}$ from GSI data to the value expected from MC simulation.
- **$\sigma_{TOF} \approx$ 78 ps** [see also Giacomo's talk tomorrow]

ZID for GSI data





Applying the ZID algorithm implemented in SHOE is possible to distinguish the different Eloss distribution due to each fragment in GSI data.

Conclusions

- **Charge Z identification algorithm available now in SHOE for MC and GSI data**
- Implementation in SHOE of TW energy loss and TOF calibration for GSI data

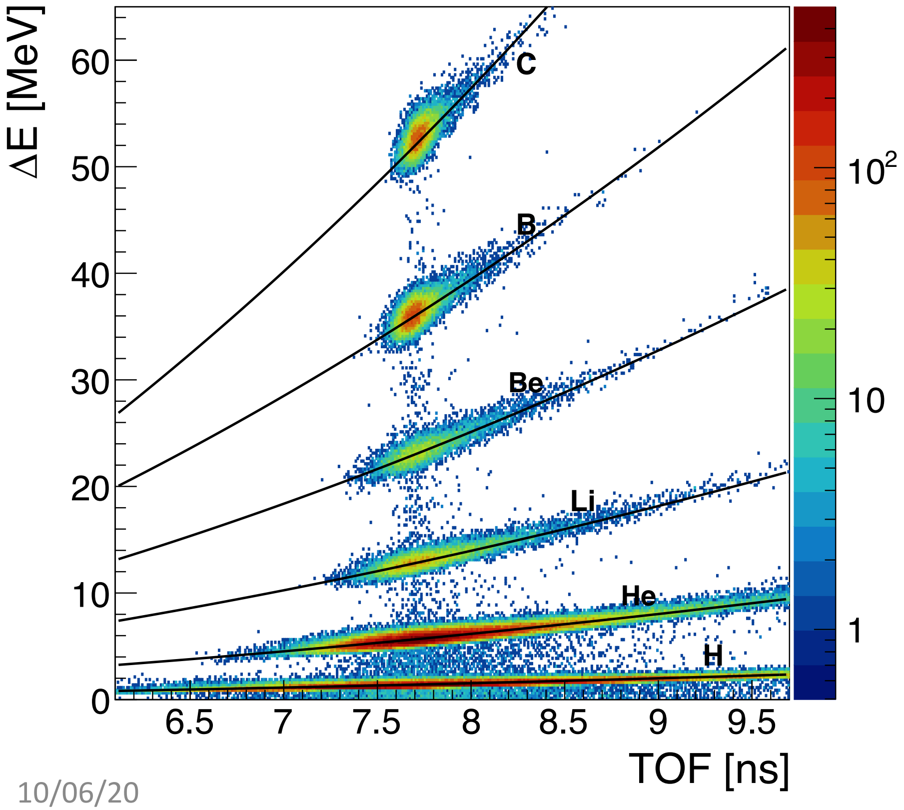
- **Next steps:**
  - Prior: move TOF and Eloss calibration from dedicated branch in SHOE to newgeom and master branch
  - Implement in SHOE an improved TW clustering needed for global reconstraction
  - Estimate TOF and Eloss resolution for different fragments selecting the Ekin of the fragment
  - Measurement of elemental cross section for Z>1 (integrated and maybe in some Ekin and angle bin for He and Oxygen) as natural continuation of fragment Z identification to be finalized with a publication of GSI data

Spare slides

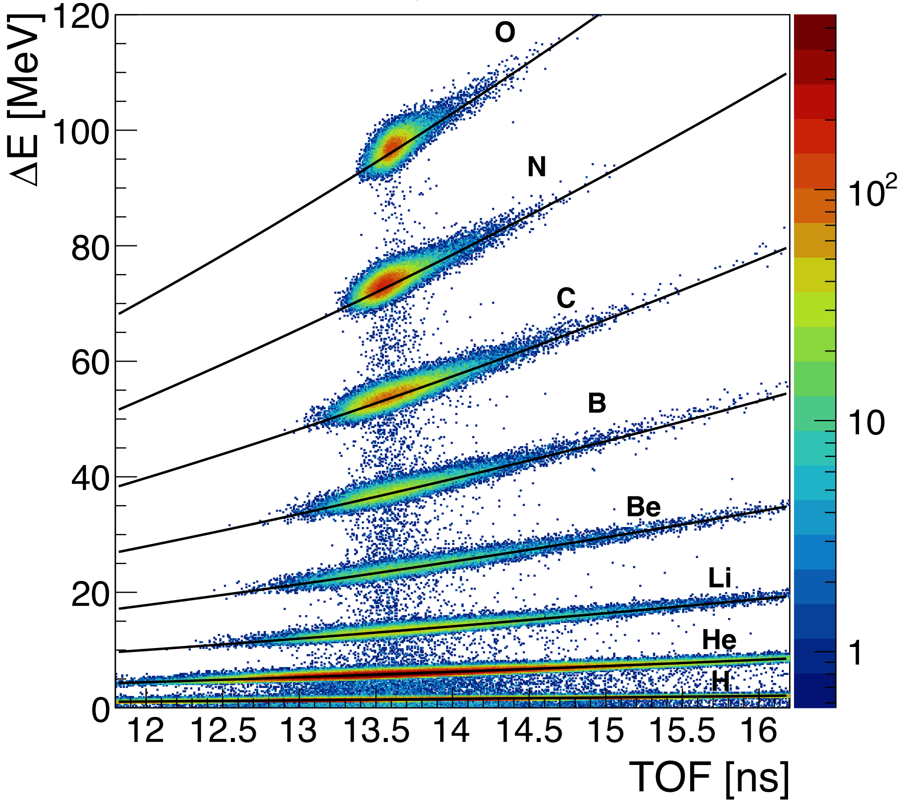
Bethe-Bloch parametrization

- Bethe-Bloch parametrization from **Monte Carlo truth**, asking for primary fragmentation and Z_MC

12C – 200 MeV/n MC true – full geo



16O – 200 MeV/n MC true – GSI



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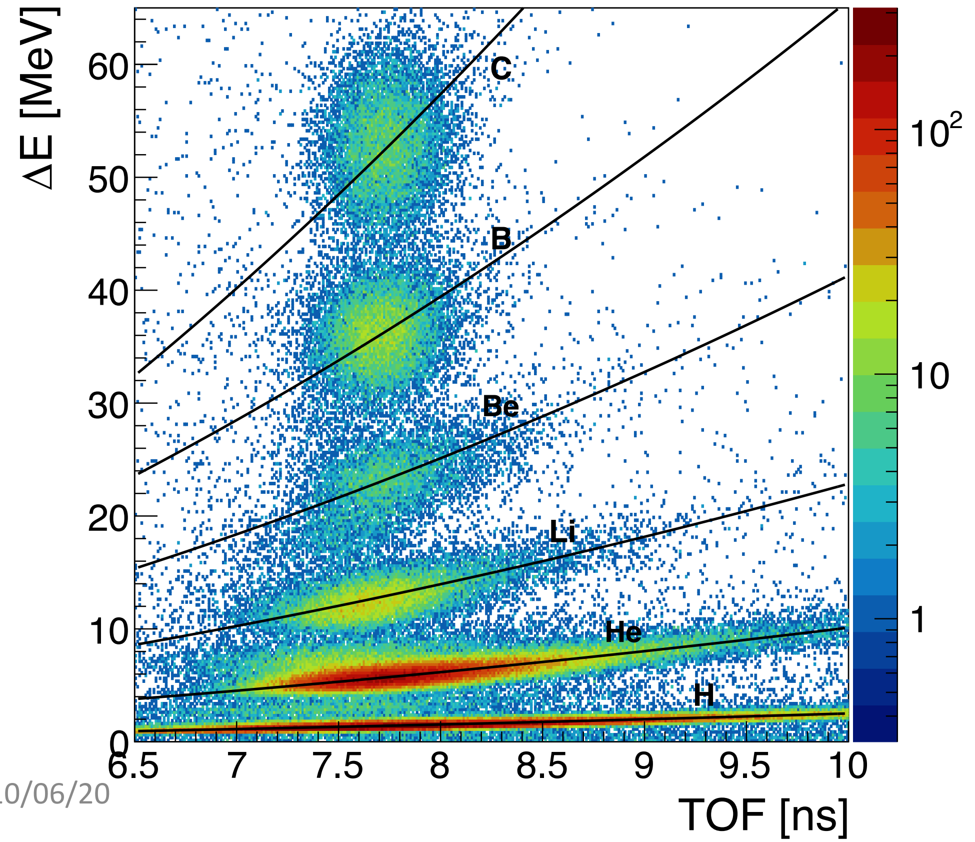

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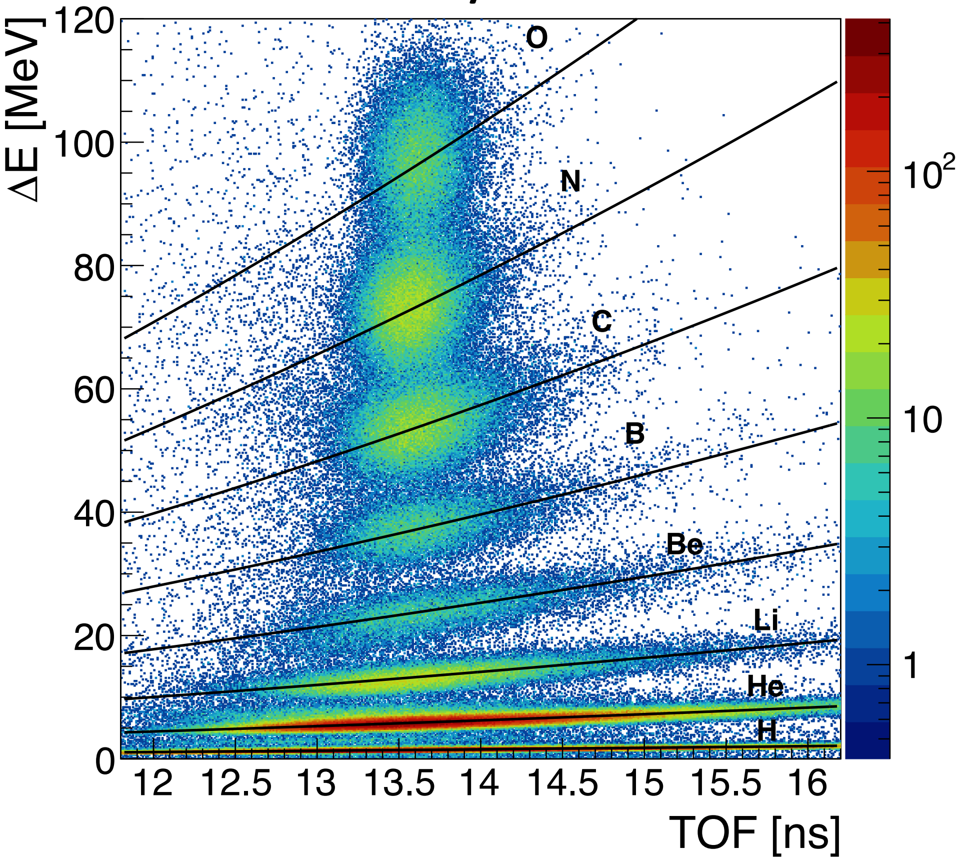
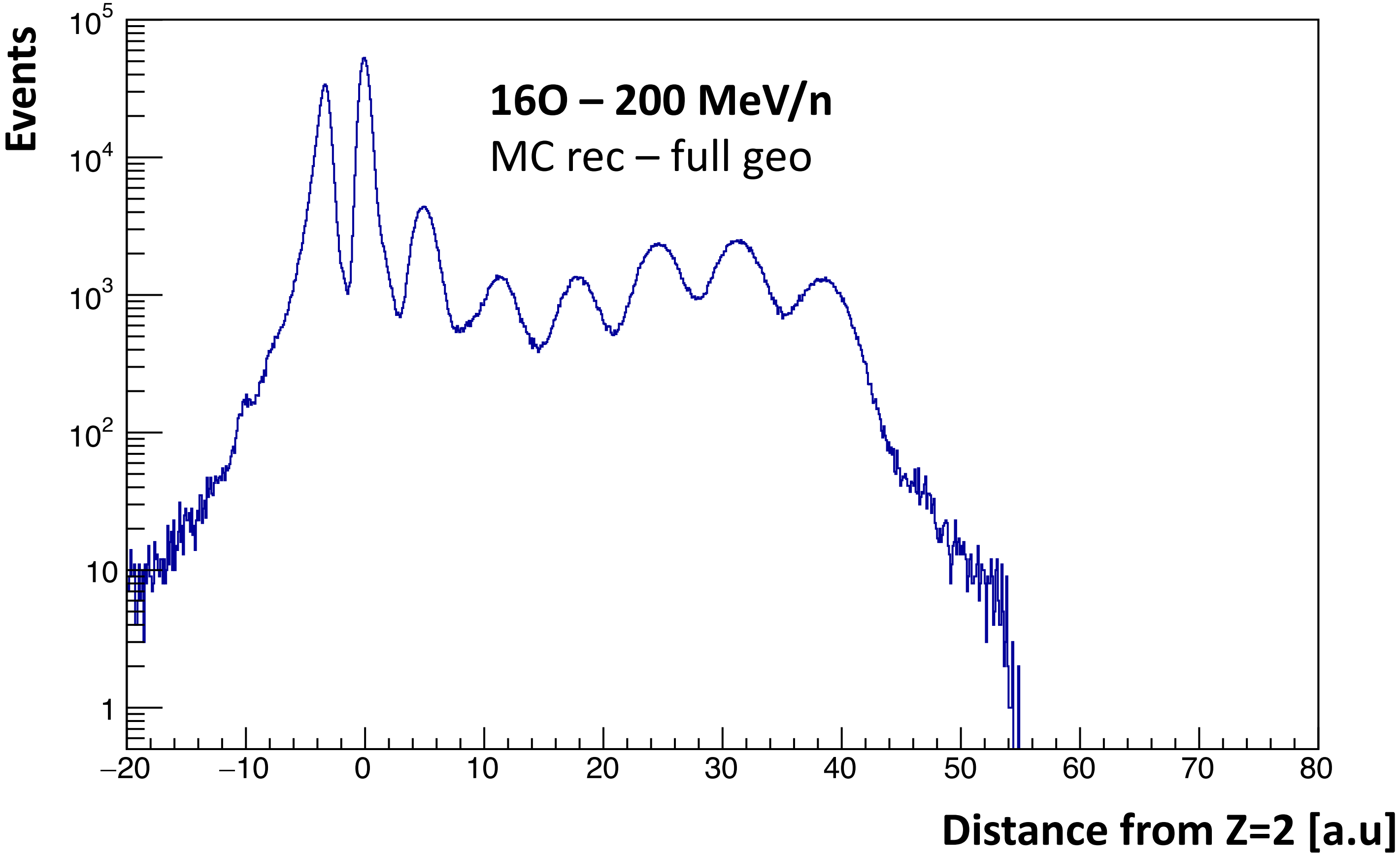


Minimum distance method



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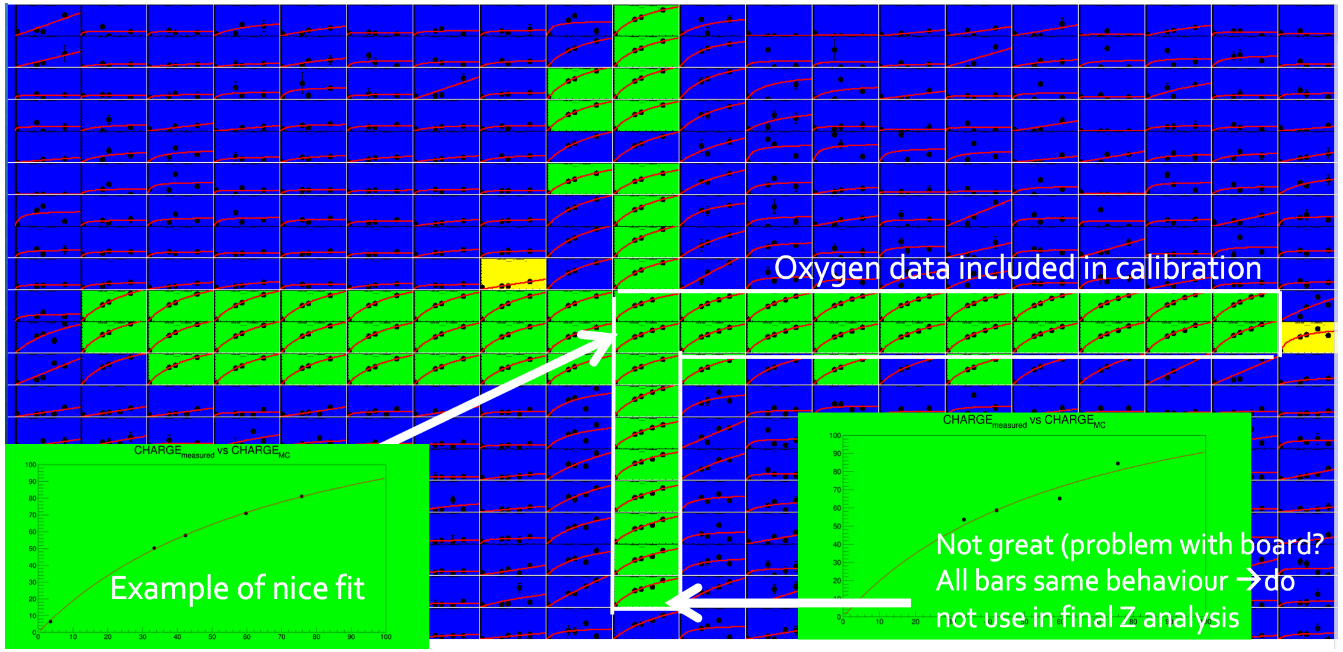
- Extended the calibration to the not-calibrated position filling empty positions with the average of the calibrated positions of the same bar/layer
- Ghosts have been managed on an event-by-event basis exploiting the reconstructed position along the bar from time differences at the bar edges (with resolution<8 mm, less than bars cross)
- After calibration a further small tuning of the peaks to the MC energy has been necessary
- TOF calibration performed per bar and per position have been crosschecked and imported in SHOE
- Crosschecked different Eloss and TOF calibration strategies succesfully (available in SHOE)

Talking about data: Energy Calibration

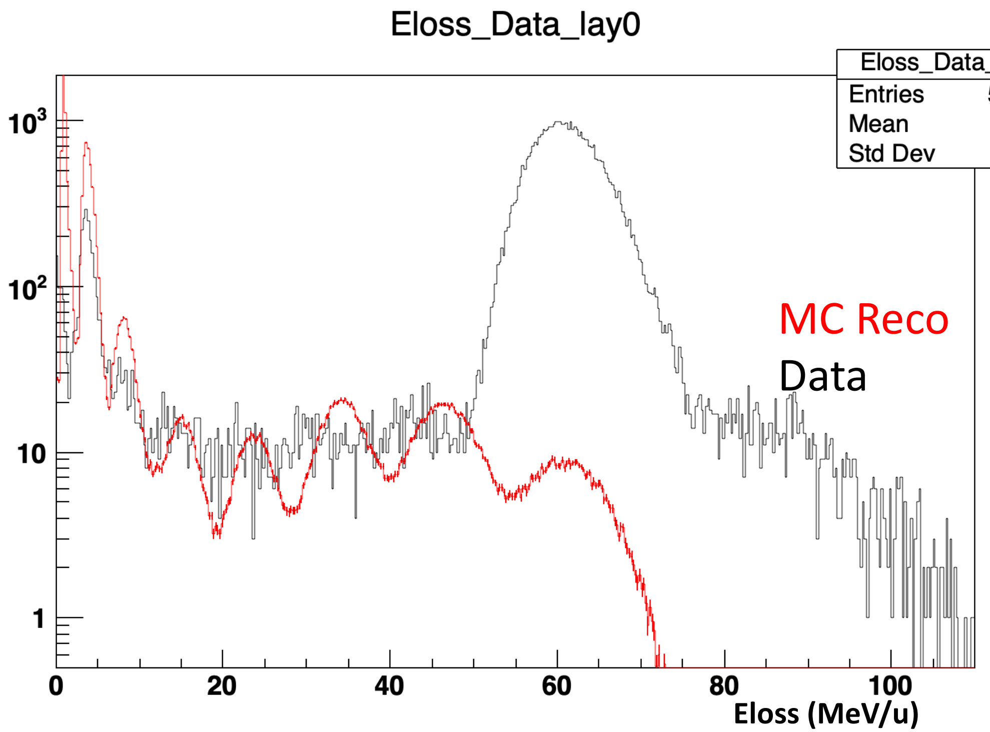
Thanks to the Pisa group we have a very precise «Position per Position» front and rear energy calibration for the TW.

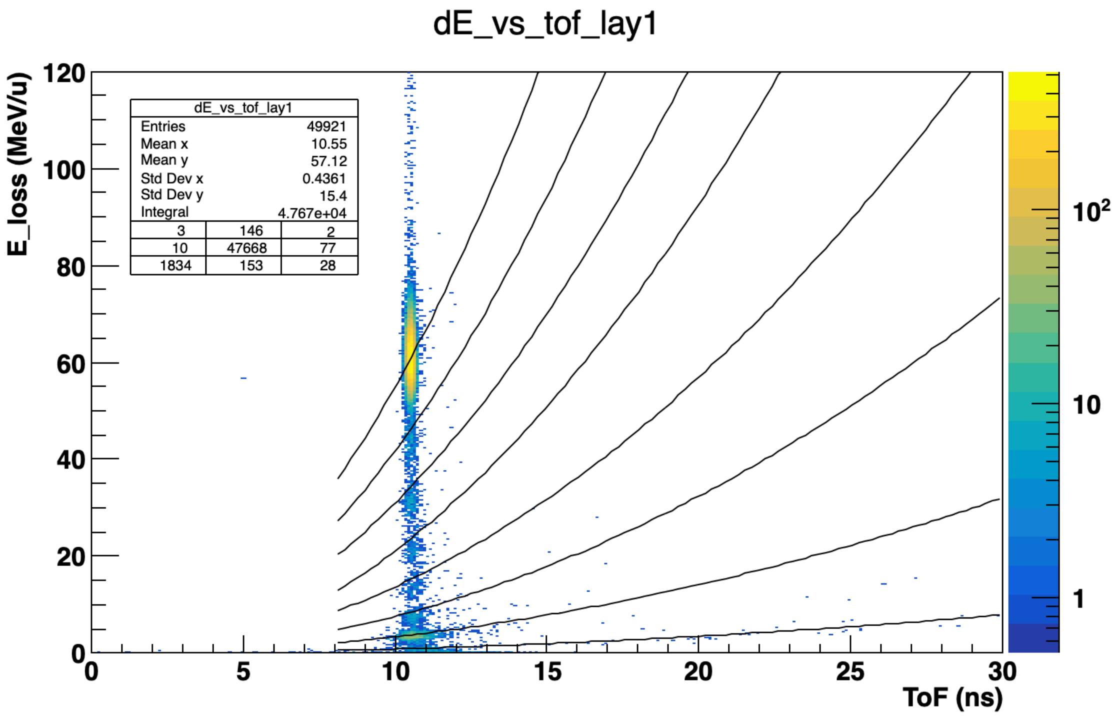


In order to implement Pisa calibration in SHOE and to apply it to GSI fragmentation data, we have extended the calibration to the not-calibrated position:

- Empty position are filled with the average of the calibrated positions of the same bar, whenever we have it.
- If one bar is totally empty its parameters are taken from the average of all the good positions in the same layer.

Data comparison with MC: run 2239-2240-2241



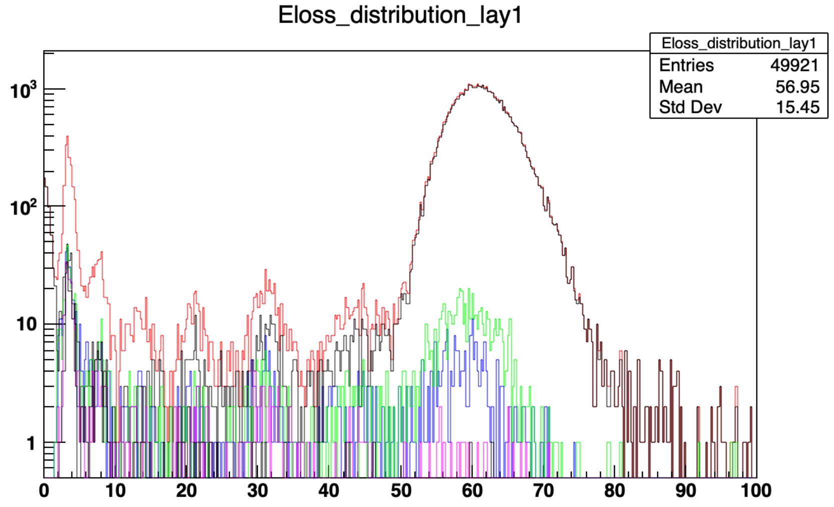


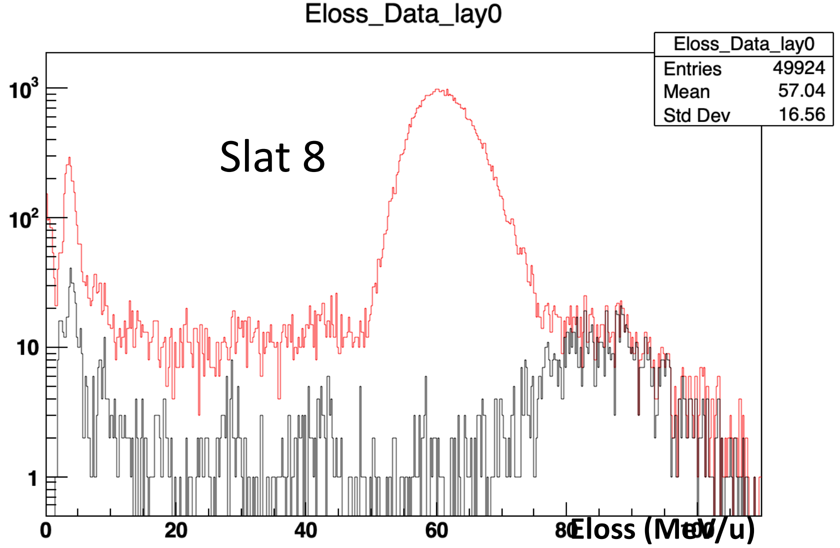
- Comparing MC Reconstructed with Calibrated Data is still evident a small shift for some peaks (Z=5, Z=6, Z=7)) → this worsen charge identification (ZID) performances
- We've now implemented in SHOE in TW digitizer for MC reconstructed the resolution from calibration data (for both Eloss and TOF) Roberto Zarrella provided us (thanks!)

Energy loss per bar

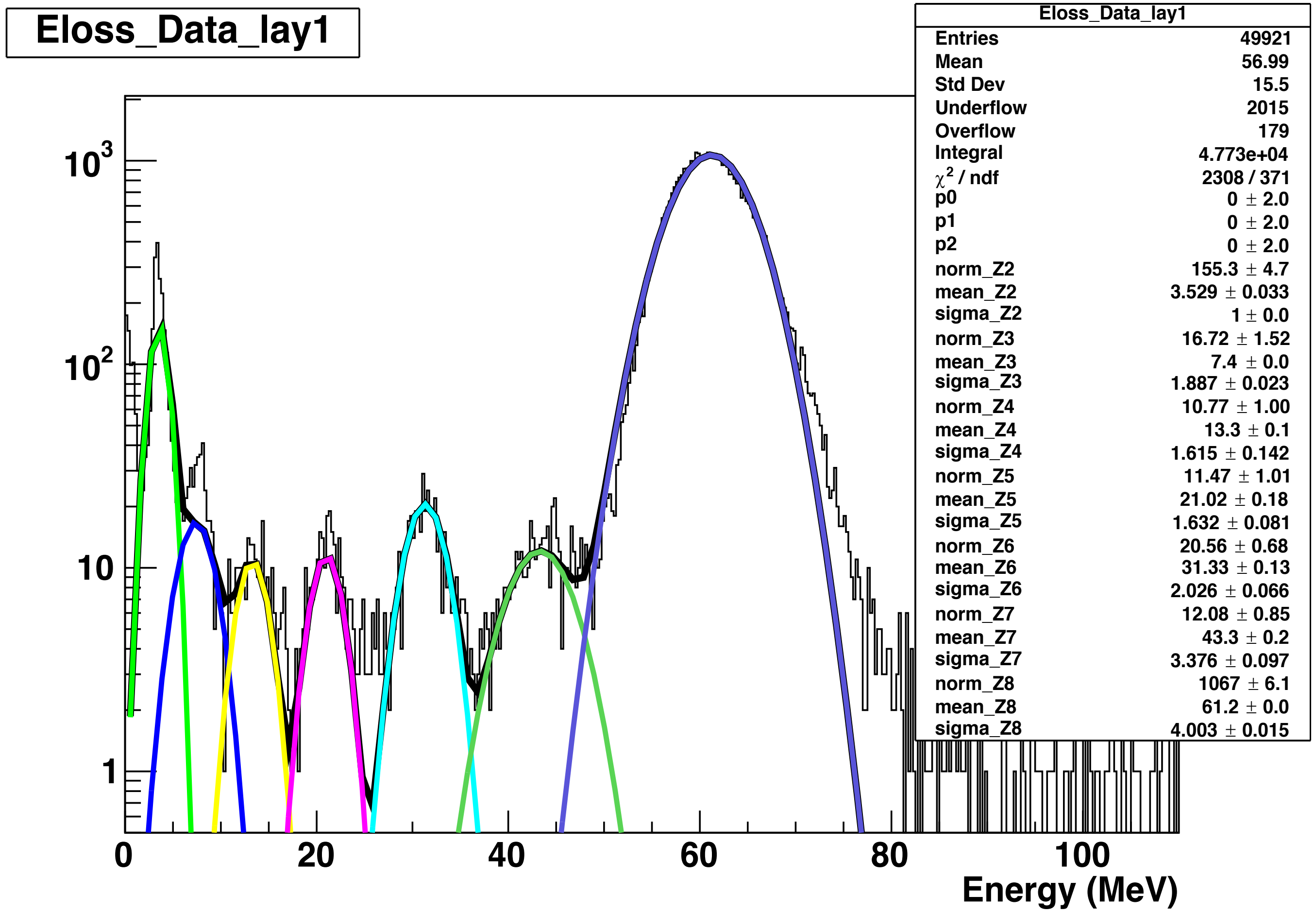
Observed energy loss distribution per bar (not easy for very low statistics for not central bars) :

- For layer 1 (Front layer, orizzontal bars) very good equalization thanks to the calibration procedure for all peaks and all 20 bars
- For layer 0 (Rear layer, vertical bars) again good equaization with the exception of the bars 8 and 10 that were impossible to calibrate in calibration runs
  - ➢ Even if poor in statistics we have tried to recover these data also and equalize the peaks to MC





Energy Loss tuning

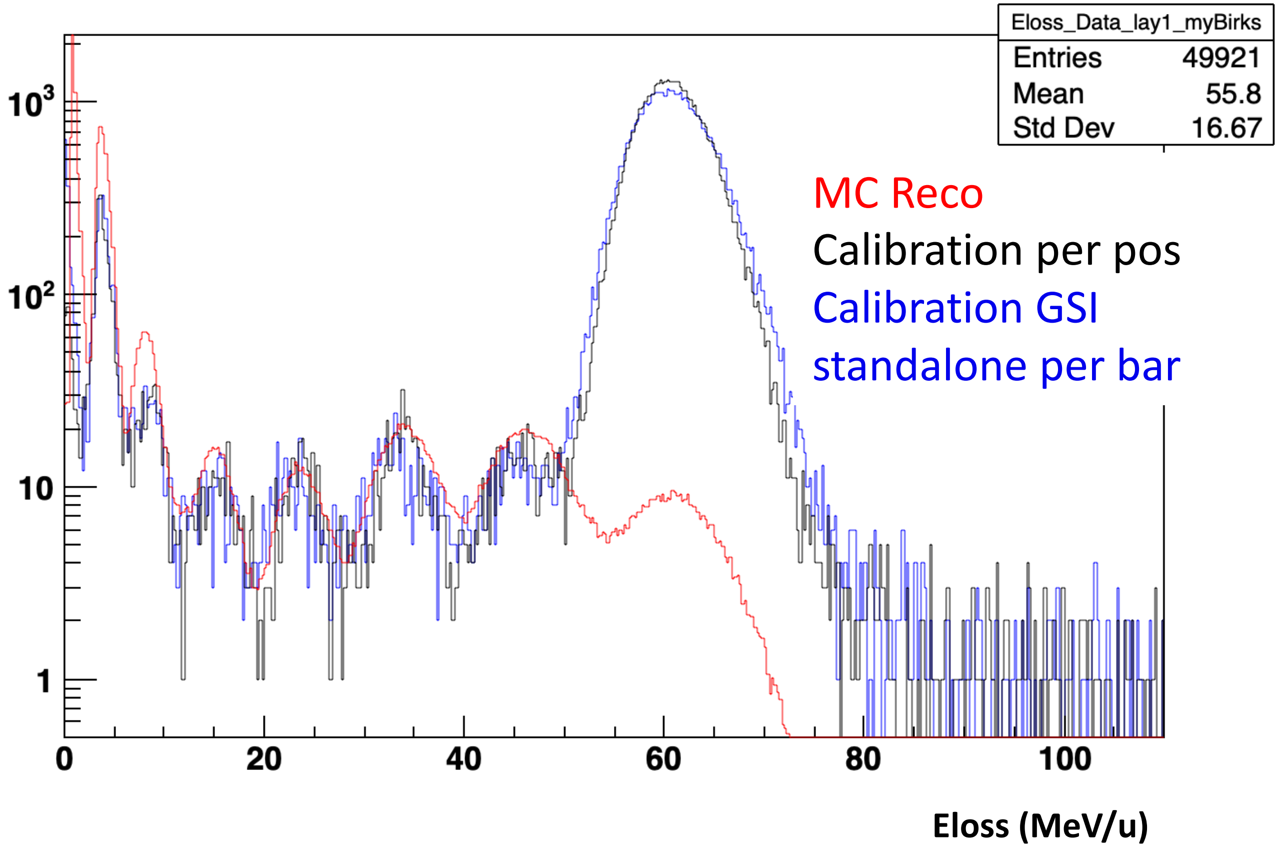


Fitting all the peaks with a convolution of gaussians we re-tune the calibrated energy mean values to the MC energy peaks(with effects only on Z=4,5,6)

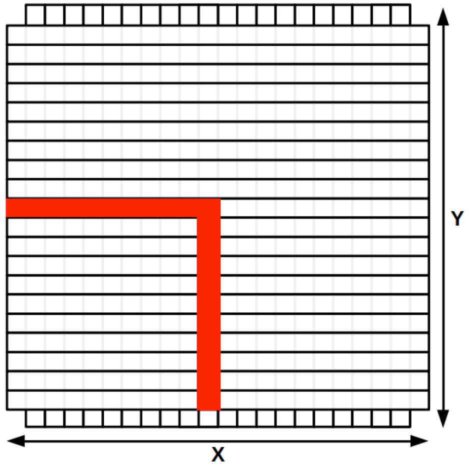
GSI standalone bar calibration

Alternative calibration for cross-check, performed with the only standalone fragmentation data @ GSI (run 2239,2240,2241)

Not bad…As expected the resolution is always worse than the calibration performed by position, but not that much



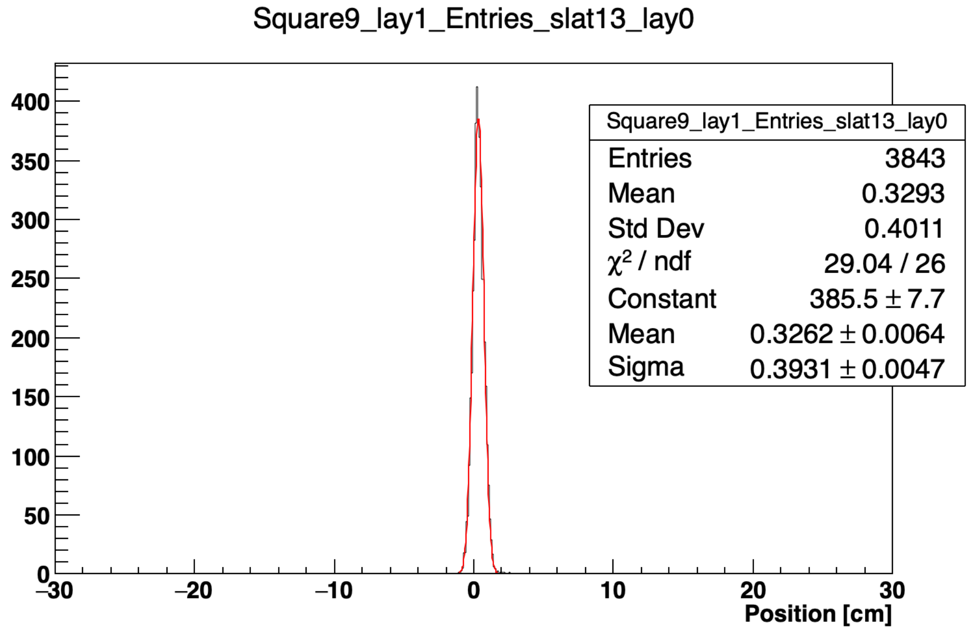
Check on time delay given by cables



In GSI calibration run 2242 (no target) only few bars have been irradiated by 16O beam at 400 MeV/n.

Few events in slats<9 are given by fragmentation.

With this data it's possible to check for time difference given by cables during data acquisition.

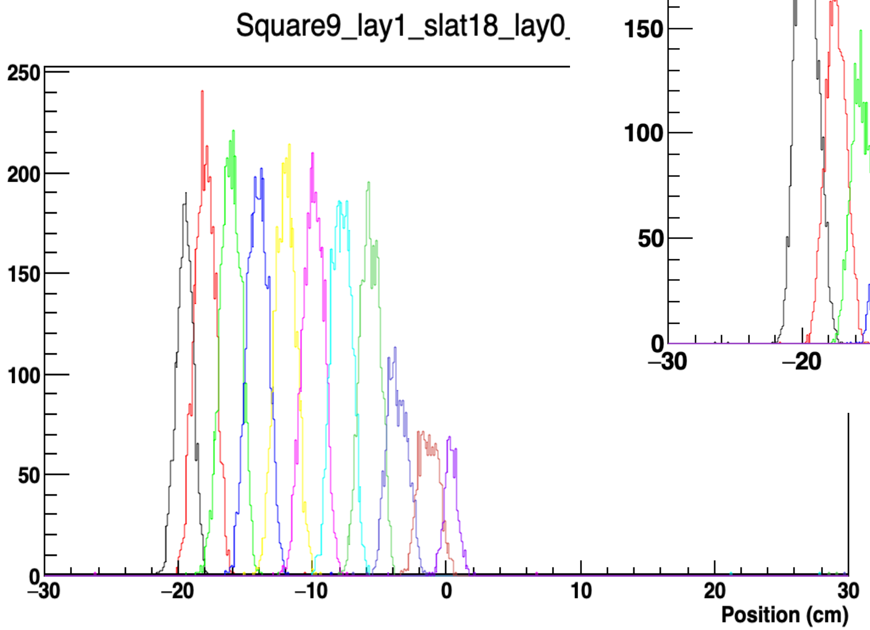


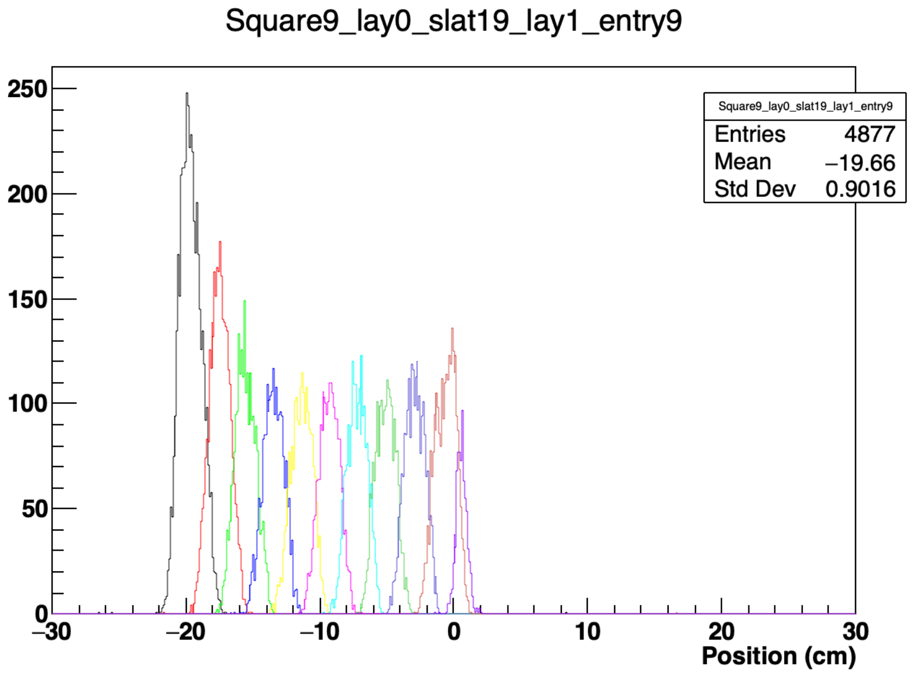
It is possible to notice that the mean value given by this gaussian fit is comparable with 0 in $1\boldsymbol{\sigma}$.

No Δtime cable effect. No differences in time have been considered.

Check on propagation velocity in TW

- From GSI run 2242 we have cross checked the value of propagation velocity in TW v_p with the one provided by Pisa group in calibration runs (65 ps/cm).
- To have a reliable value v_p is fundamental to clusterize TW front/rear information in multiple fragments events
- By selecting each intersection between bars separately we can correlate difference in time tA-tB for each bar to the cross position along the bar





Check on propagation velocity in TW

$$(TimeB - TimeA)/2 = p0 + p1 * X$$

$$\frac{1}{V_p} = 66\ ps/cm$$

Now implemented in SHOE (before it was wrong: 140 ps/cm).
From datasheet (refraction index=1.58→ 1/v ~53 ps/cm).
For future data acquisition it could be important mesure it for each bar (also with a source)