Field-off LiH Energy Loss

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Aim to use TOF data to measure muon energy loss from Absorber without field.

First approximation at last CM.
Since last CM produced a full algorithm detailing the energy of the muon at each point in the cooling channel.

Lot of effort into accuracy of measurement. Where a measurement is taken has a large effect.

Quick overview of algorithm

MAUS Simulation.

7469 momentum verification

Applied to 3pi-200 datasets.

- Assume Energy Loss in TOF and Tracker is known. Otherwise no hope.

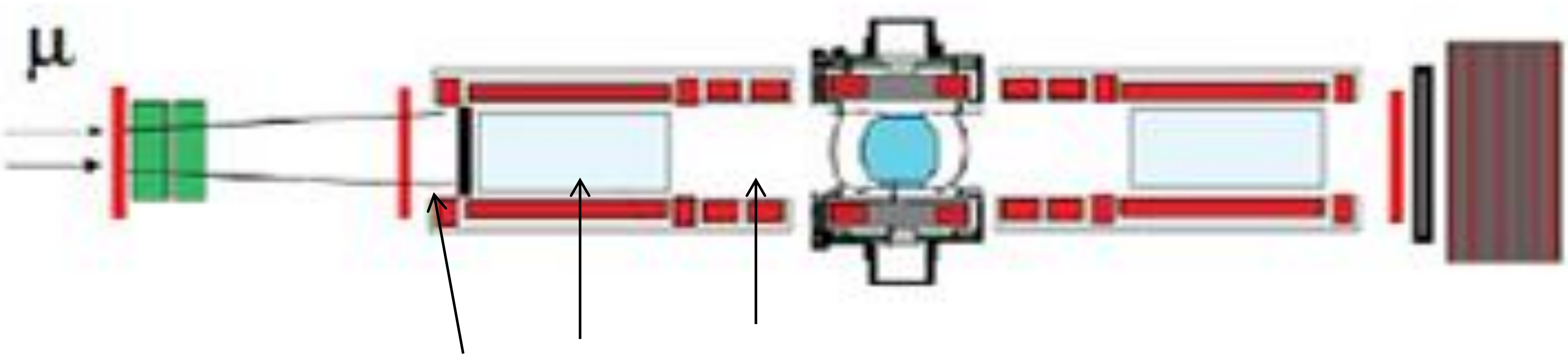
- Get momentum before TOF1 using Rayner reconstruction (from Victoria's code).

- Using the expression:

$$\frac{\Delta\beta}{\beta} = \frac{m^2}{p^2}\frac{\Delta E}{E}$$

- Obtain the velocity of a particle given an Energy Loss.

- Use this to get the muon velocity after TOF1, then after the tracker.

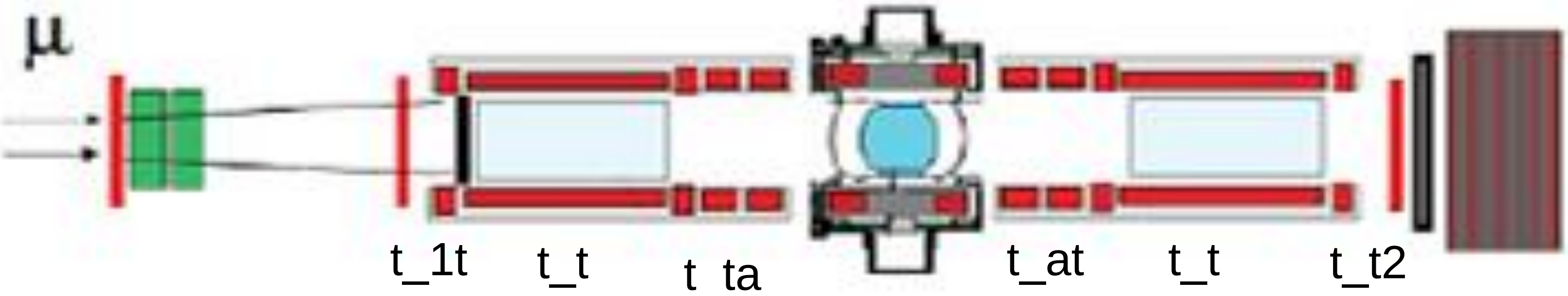


Velocities before absorber now known.

From velocities, now also know:

- time of flight of muon before tracker
- time of flight of muon inside tracker
- time of flight of muon between tracker and absorber.

- Note that it is important to make sure that the point where the measurement is taken is well known. Small differences in length make a large difference to the final result.



To get velocity after absorber use iterative:

- Define t_postabs = t12 – t1t – ttracker – tta - ,

where t1t, t_TKU and tta are time of flights between respective points.
t_abs is an approximation of the time of flight inside the particle

- Use t_postabs as a first guess for the velocity after absorber.

- Then use this guess and known Energy Loss in tracker and get velocities inside tracker, after tracker.

- Gives you t_at, t_TKD, and t_t2.
- We want t_postabs = t_at + t_TKD + t_t2 + t_abs,

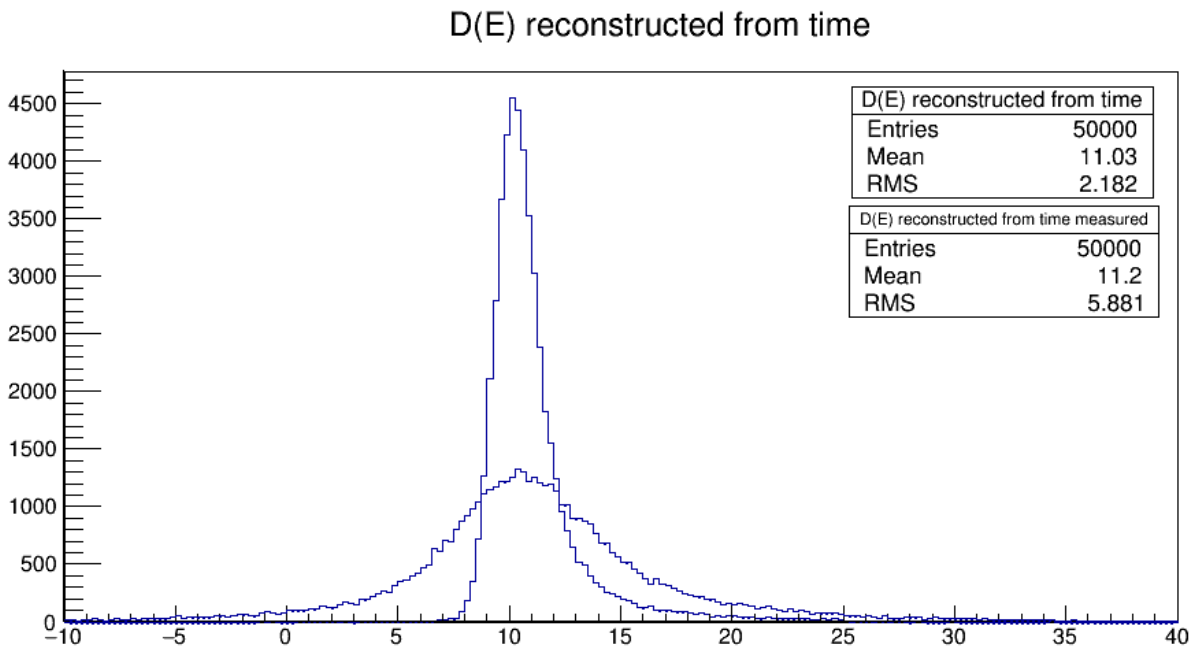
but this won't be the case immediately.

- Modify the guess of velocity after absorber accordingly and repeat.

- Iterates towards solution of velocity after absorber, and hence Energy Loss
- can be measured.

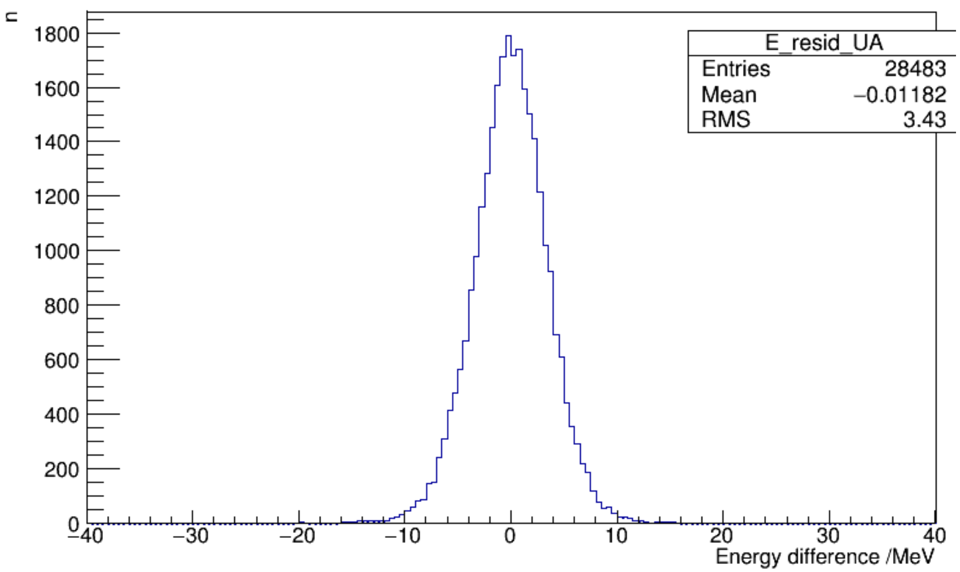
Simple Simulation to test feasibility:

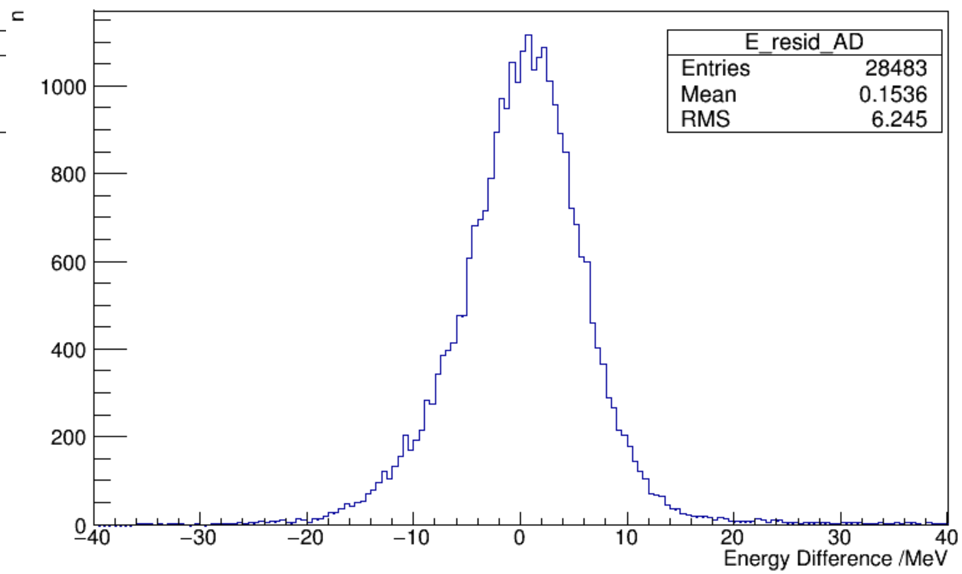
- Pencil beam 200MeV muons.
- Energy loss of 11.6MeV, landau shape.
- Simulated errors in time from TOF resolution.



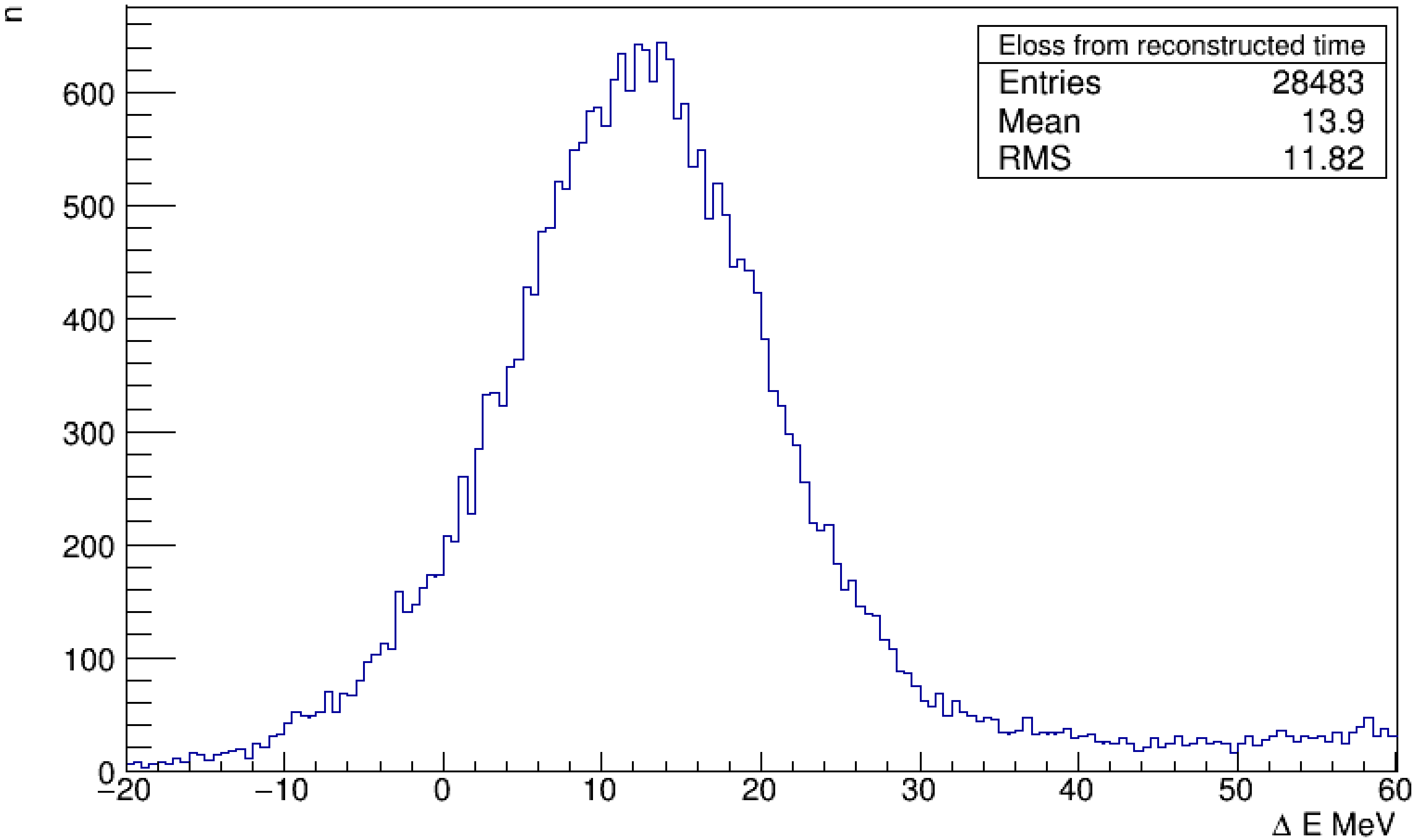
MAUS simulation

- Geometry 152 with “no field” cooling channel tag
- 200MeV muons, width 25MeV generated before TOF0
- 600000 events generated so far.
- MAUS v2.3.1
- Below plots show difference between MC truth data and reconstructed energy before and after absorber.
- Cuts taken to select particles that provide good data in all TOFs, and go straight through TKU in the center (to minimise scatter effects)





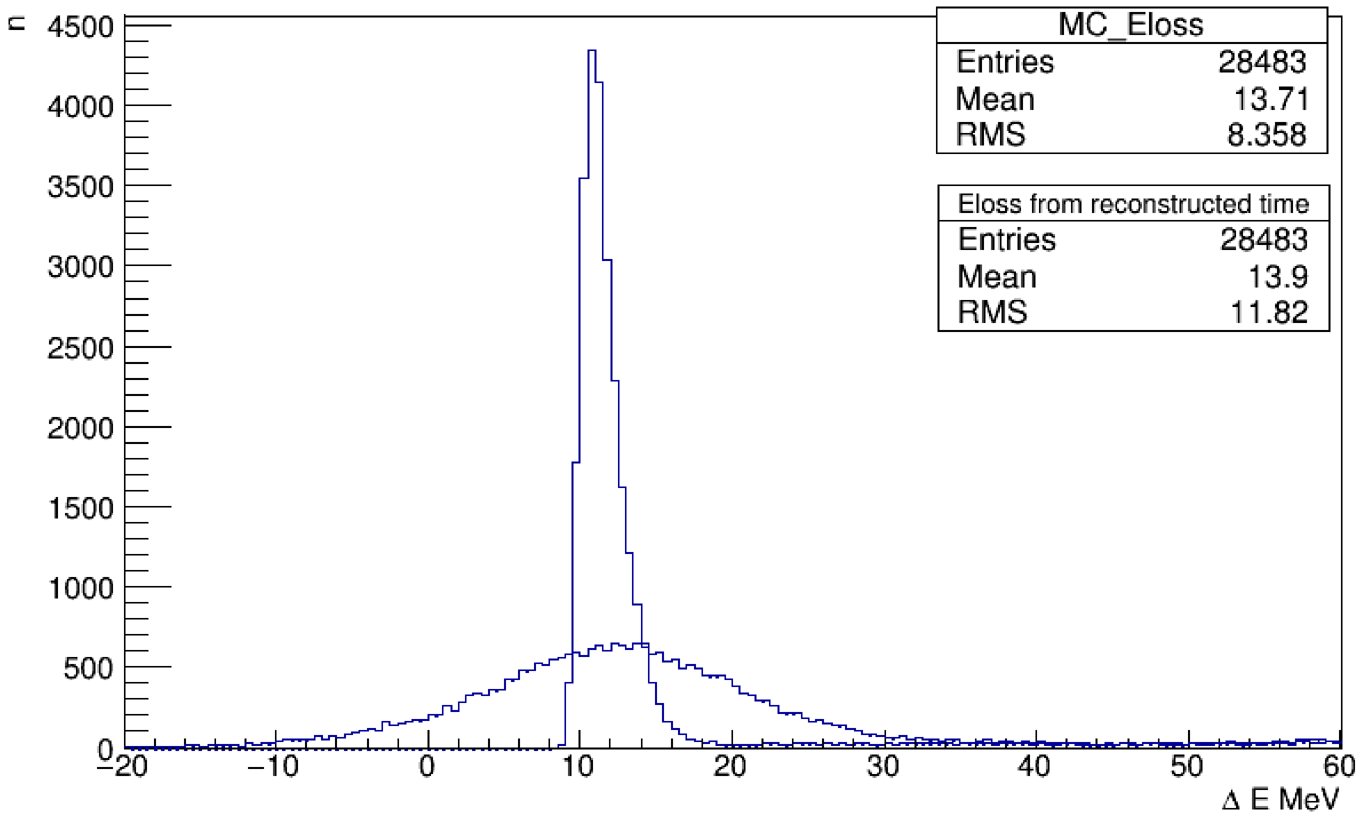
Energy Loss in MC



Energy loss reconstructed from TOF data, generated from MAUS.

Mean = 13.9, error = 0.07

Energy Loss in MC

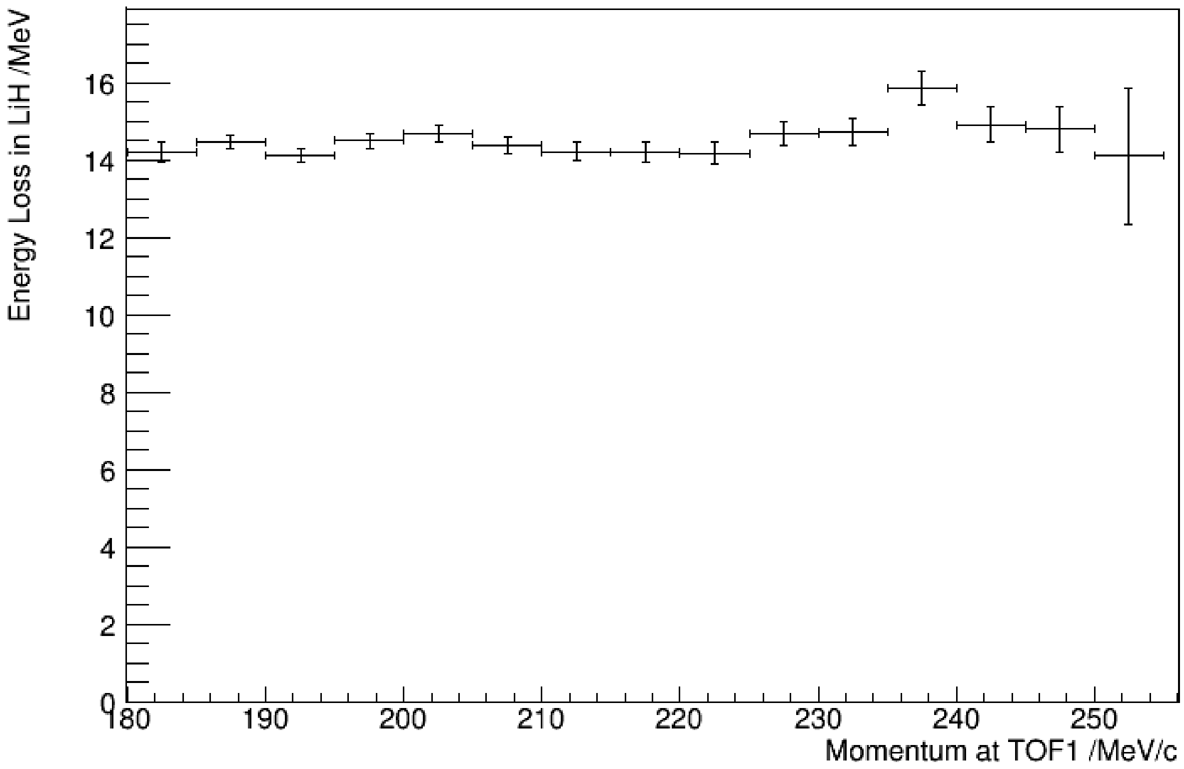


MC Energy loss from truth data vs Energy loss reconstructed from time.

Note good agreement in mean of both distributions.

Average Energy loss vs Momentum

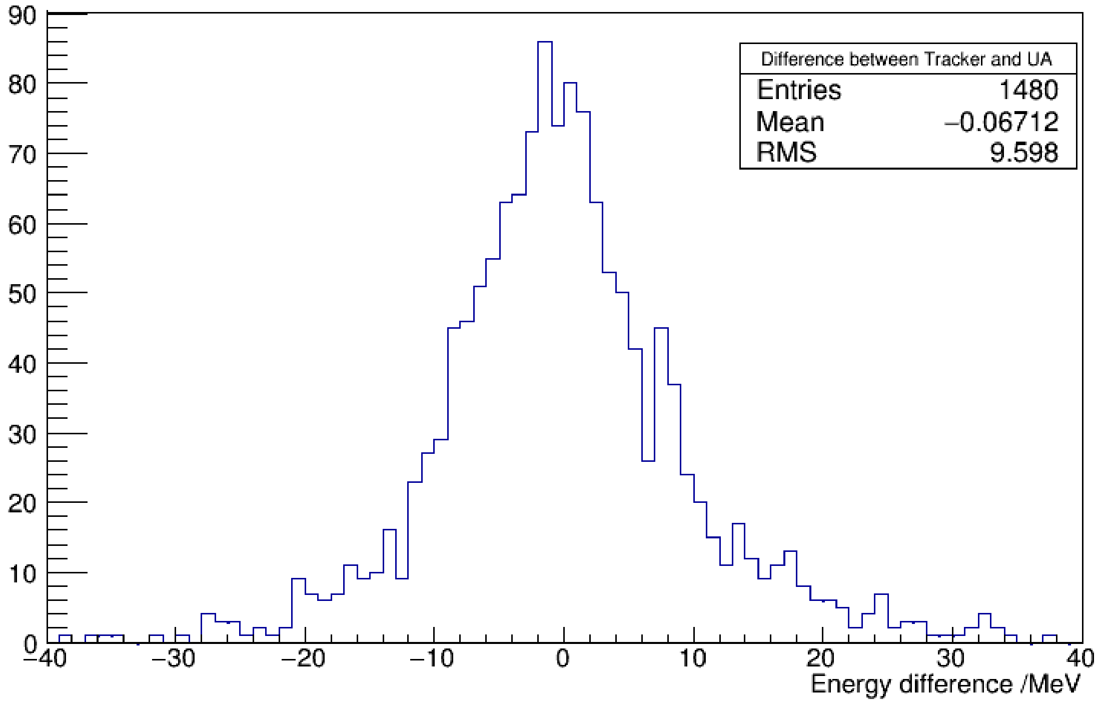
- 5MeV intervals from 180 – 260MeV/c taken at TOF1
- Reconstructed energy losses from time



Peak around 235MeV/c need to be investigated. As this data set is only from a 200MeV/c gaussian beam, 235MeV/c is on edge of curve.

7469 Data - Verification

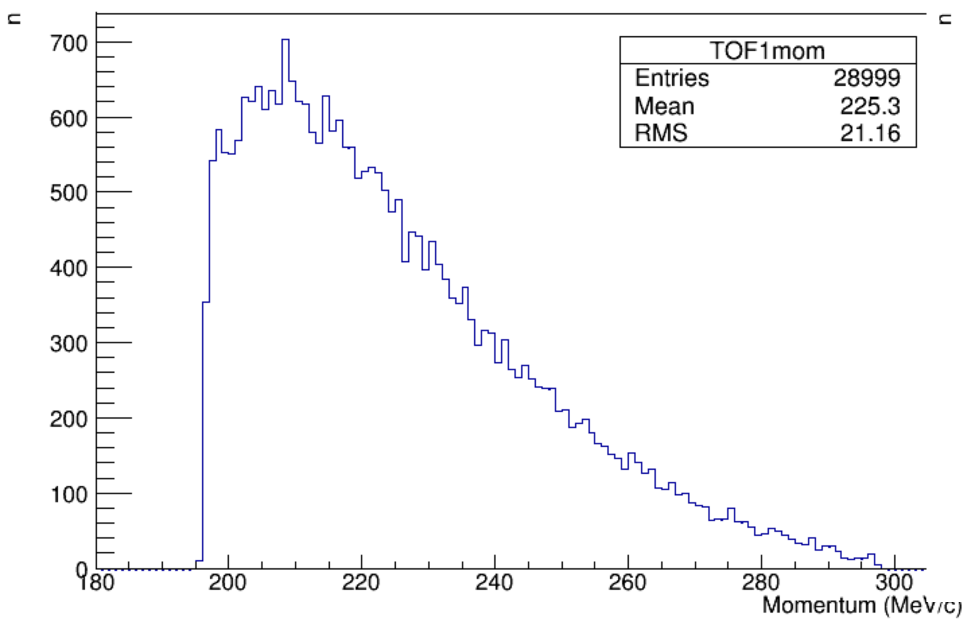
- Use this SSU dataset to verify momentum before absorber.
- Cuts on time TOF0->TOF1 <28.9ns
- Lower statistics as also requiring data in TOF2.



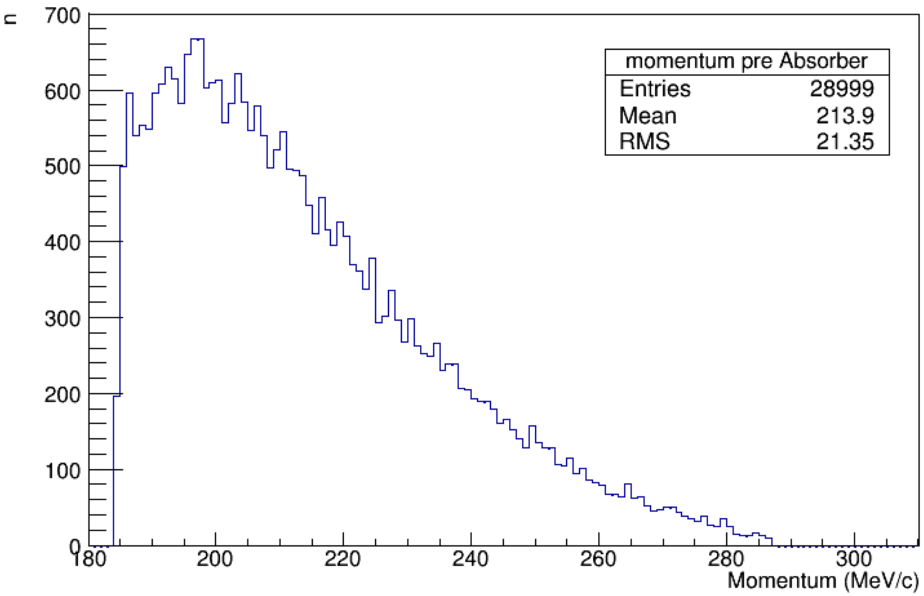
- Energy reconstructed from time agrees well with the TKU momentum reconstructed.

Real data

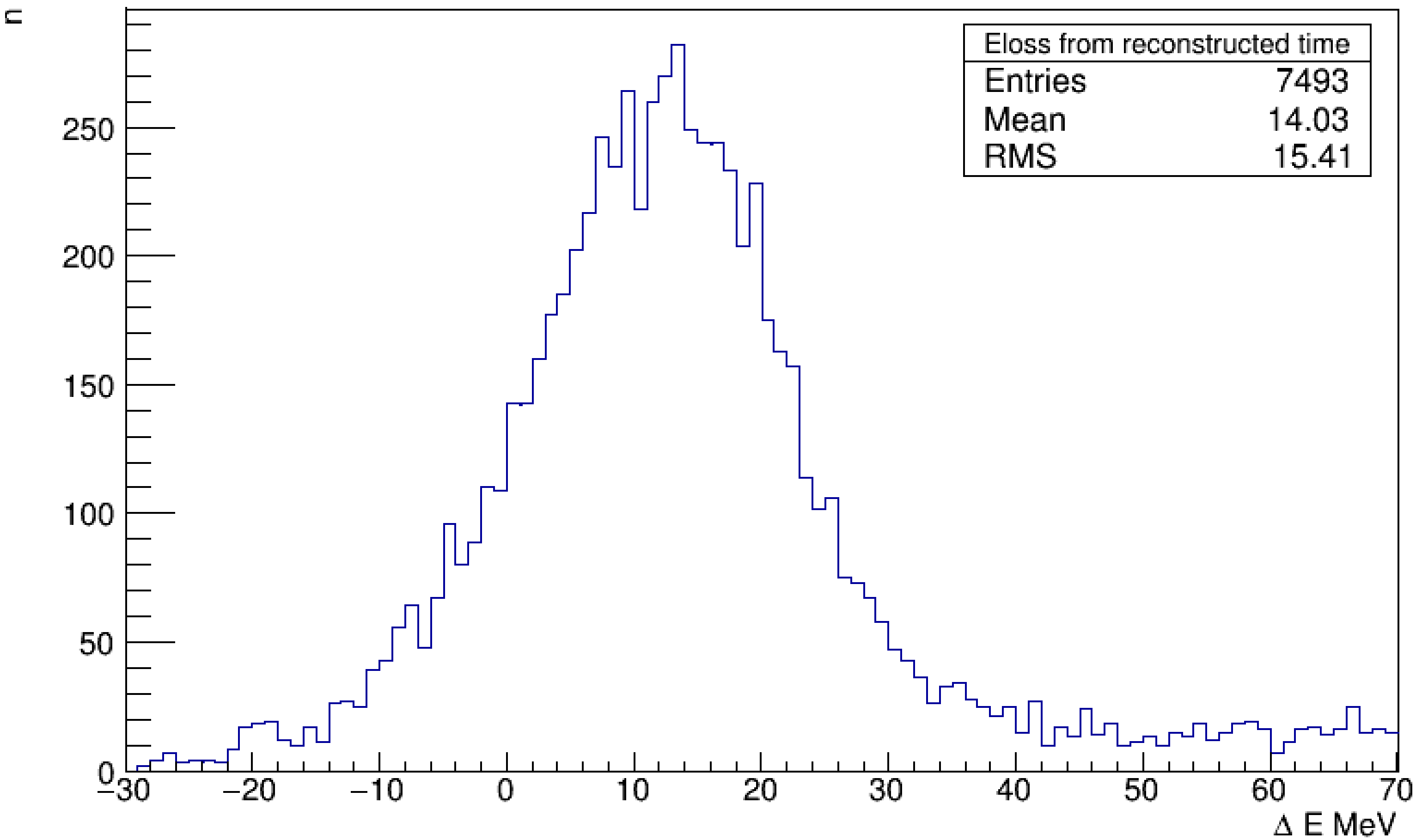
- LiH data using 3-200-M0 optics
- Runs 7834-7838 accumulated together for these plots.
- Cut for time between TOF0->TOF1 < 28.9ns
- Tracker spacepoints cut for straight tracks
(in Energy loss measurement)



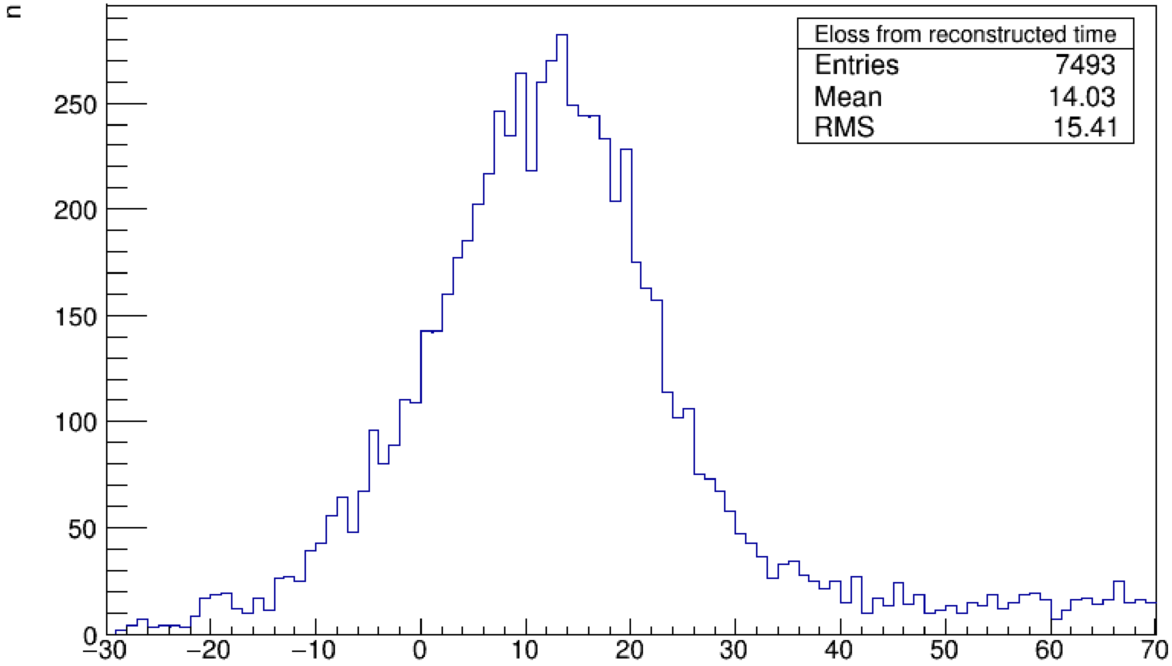
Energy from before TOF1

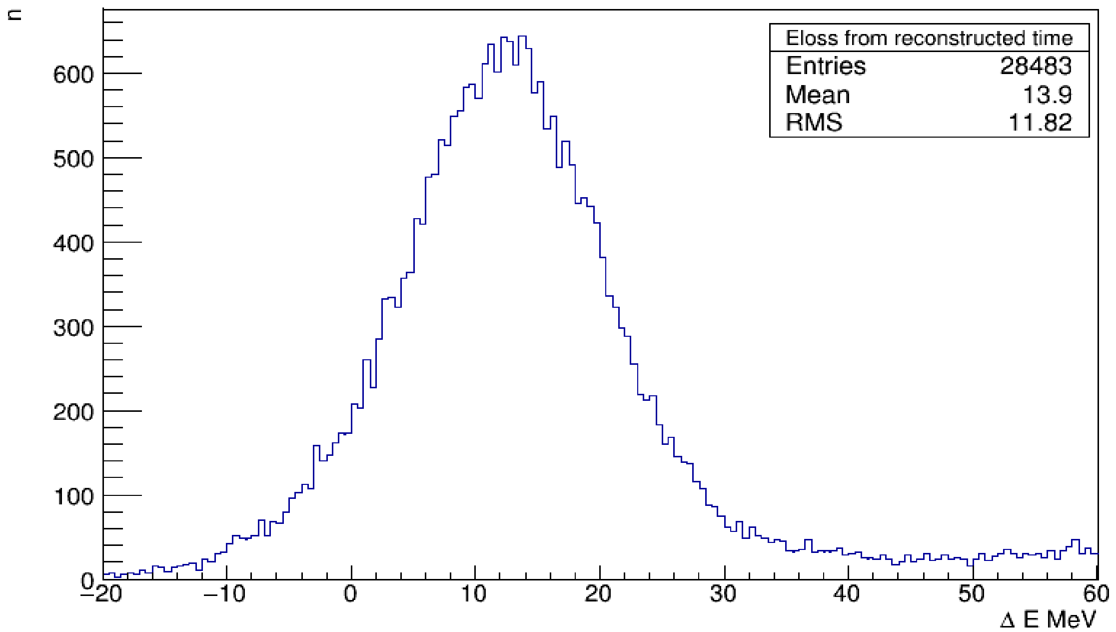


Reconstructed Energy before Absorber



Energy loss seems in agreement with MC predictions, error 0.17MeV.


n
Eloss from reconstructed time
Entries 7493
Mean 14.03
RMS 15.41
0
50
100
150
200
250
−30
−20
−10
0
10
20
30
40
50
60
70


n
Eloss from reconstructed time
Entries 28483
Mean 13.9
RMS 11.82
0
100
200
300
400
500
600
−20
−10
0
10
20
30
40
50
60
Δ E MeV

Conclusions and next steps

Good agreement between truth data and reconstructed energy loss data.

SSU data confirms that reconstructed momentum before absorber is reconstructed well

We will be able to verify that this process reconstructs energy correctly both sides of the absorber with a dataset where there is field in both trackers.

Investigate energy loss differences at high momenta
May be mitigated with the 240MeV/c datasets.
Will allow the range of momenta investigated to be increased

Plot against the Bethe curve for LiH