STEP 4.1

Preliminary Measurements using TOF

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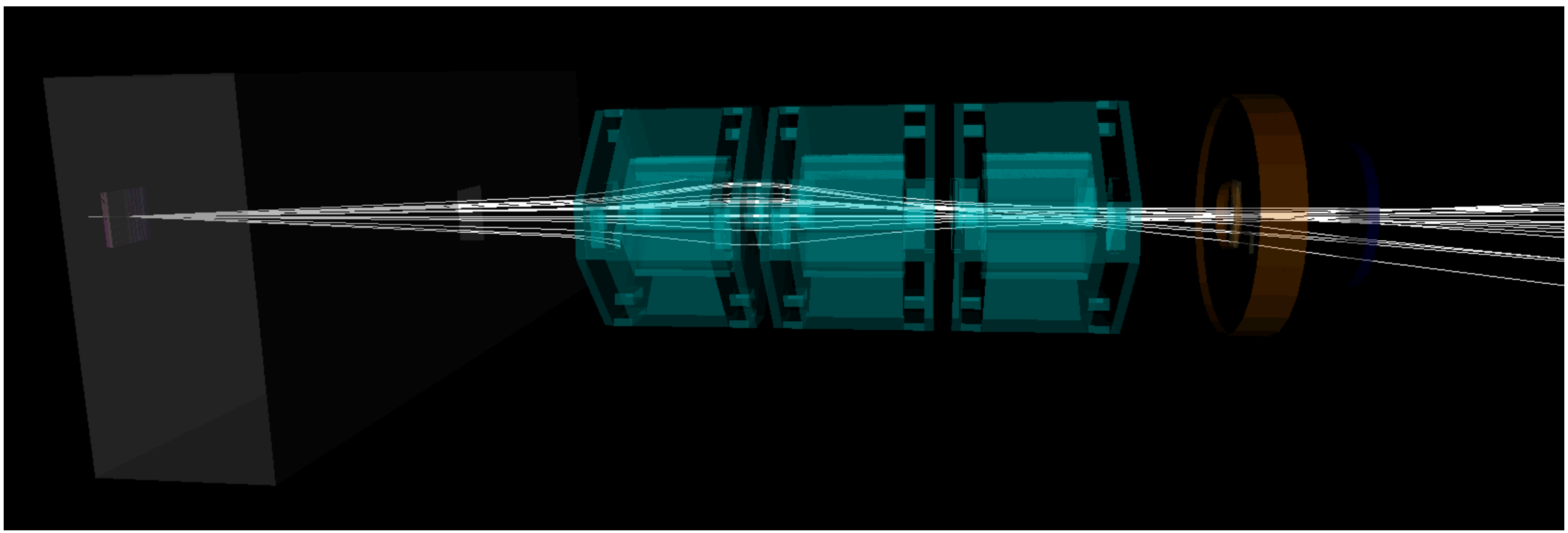
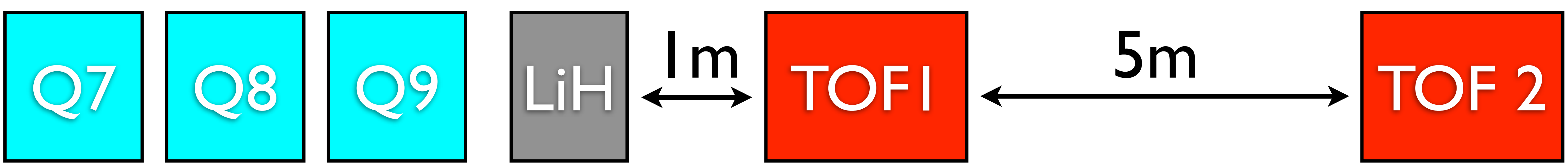
Motivation

- Make the first dE/dx measurements for the LiH (and possibly other materials) absorber in MICE Step 4 using only TOF1 and TOF2
- Take data before the arrival of spectrometer solenoids
- Have a PhD thesis done by Spring 2014

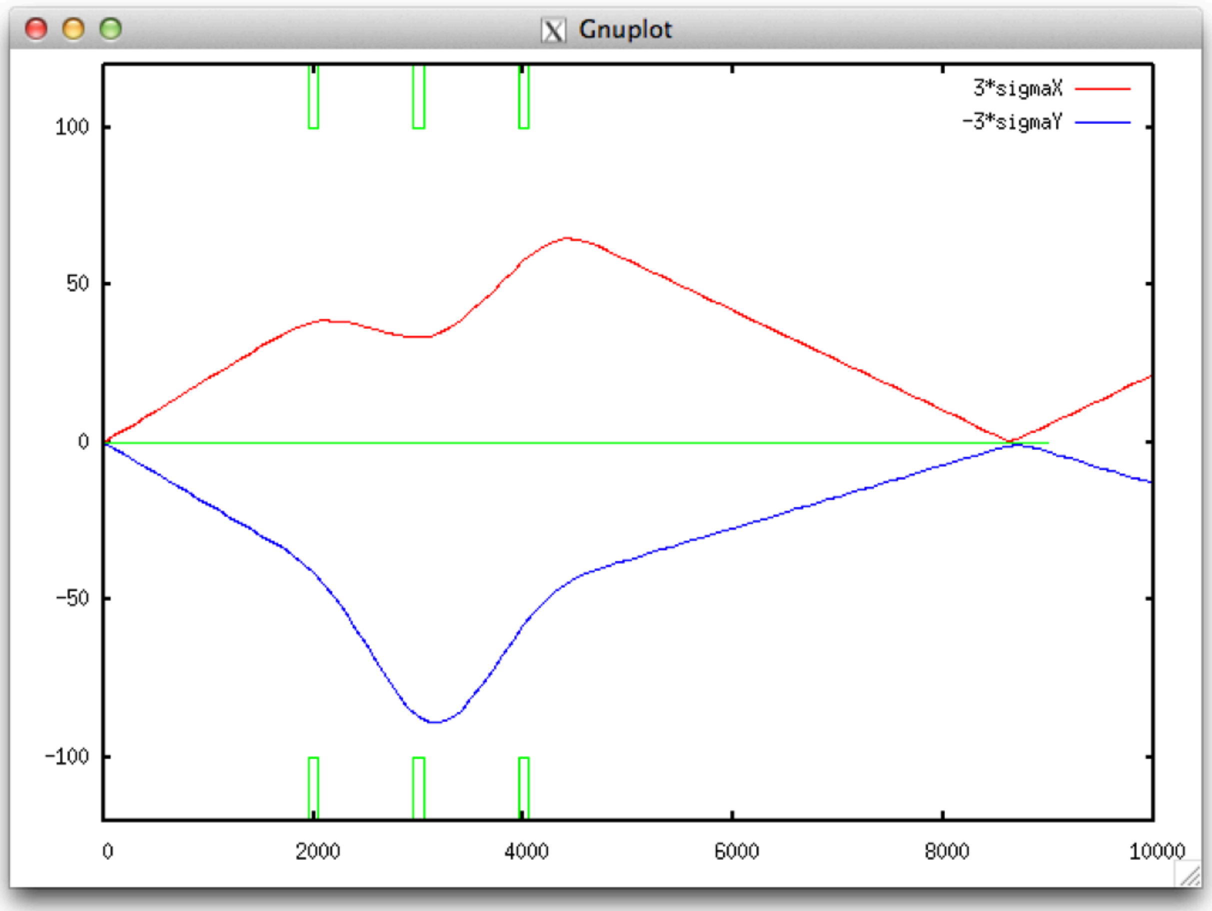
MAUS simulation with new optics

Beam specs:
Starting emittance (4d): 4 mm
momentum: 200 MeV/c
z position: just upstream of TOF0





Tuning Q7-Q9

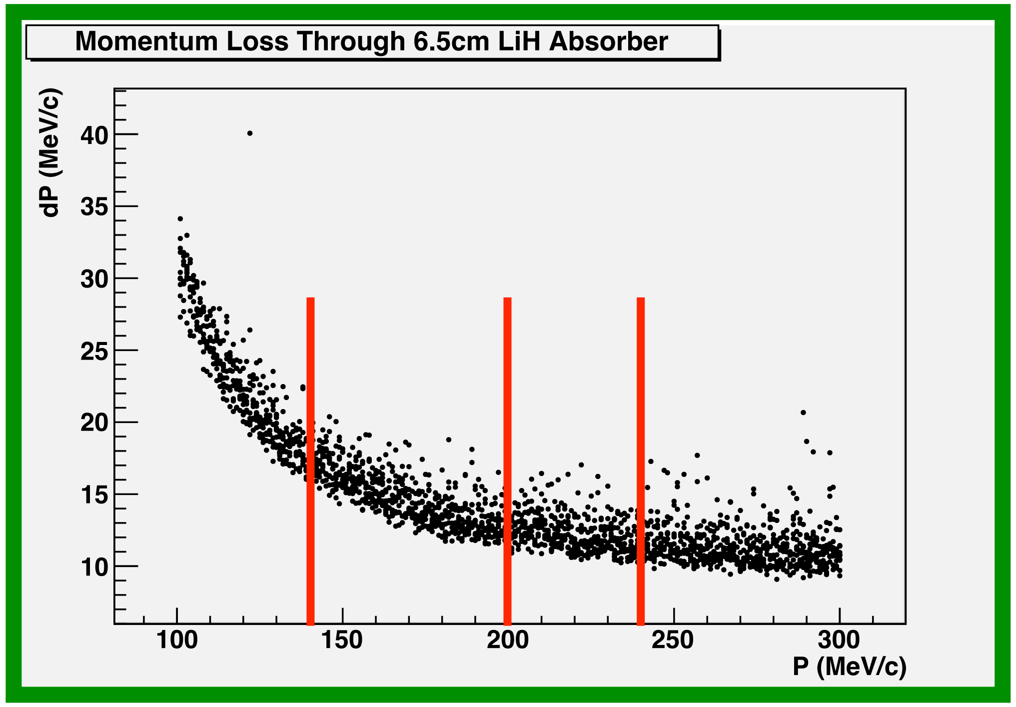


- The Quadrupoles can be tuned with an iterative genetic algorithm in G4Beamline for a given
    - momentum and;
    - initial emittance
- Geometry specifications for each quad imported from MAUS

- Initial simulations have been designed with a waist at TOF2 (to increase number of events)
- Paraxial transport is ideal

dE/dx for LiH

Simulated momentum loss through LiH flat absorber:



Density: 0.69 g/cm^3
Thickness: 6.5 cm

p_in (MeV/c)	p_out (MeV/c)	dt (ns) 4m from absorber
140	129	500
200	192	140
240	232	80

Calculated drift time differences:

$$\Delta t = \frac{s}{c}\left[\frac{1}{\beta} - \frac{1}{\beta'}\right] = \frac{s}{c}\left[\frac{\sqrt{p'^2 + m^2}}{p'} - \frac{\sqrt{p^2 + m^2}}{p}\right]$$

s = drift length

p = momentum in

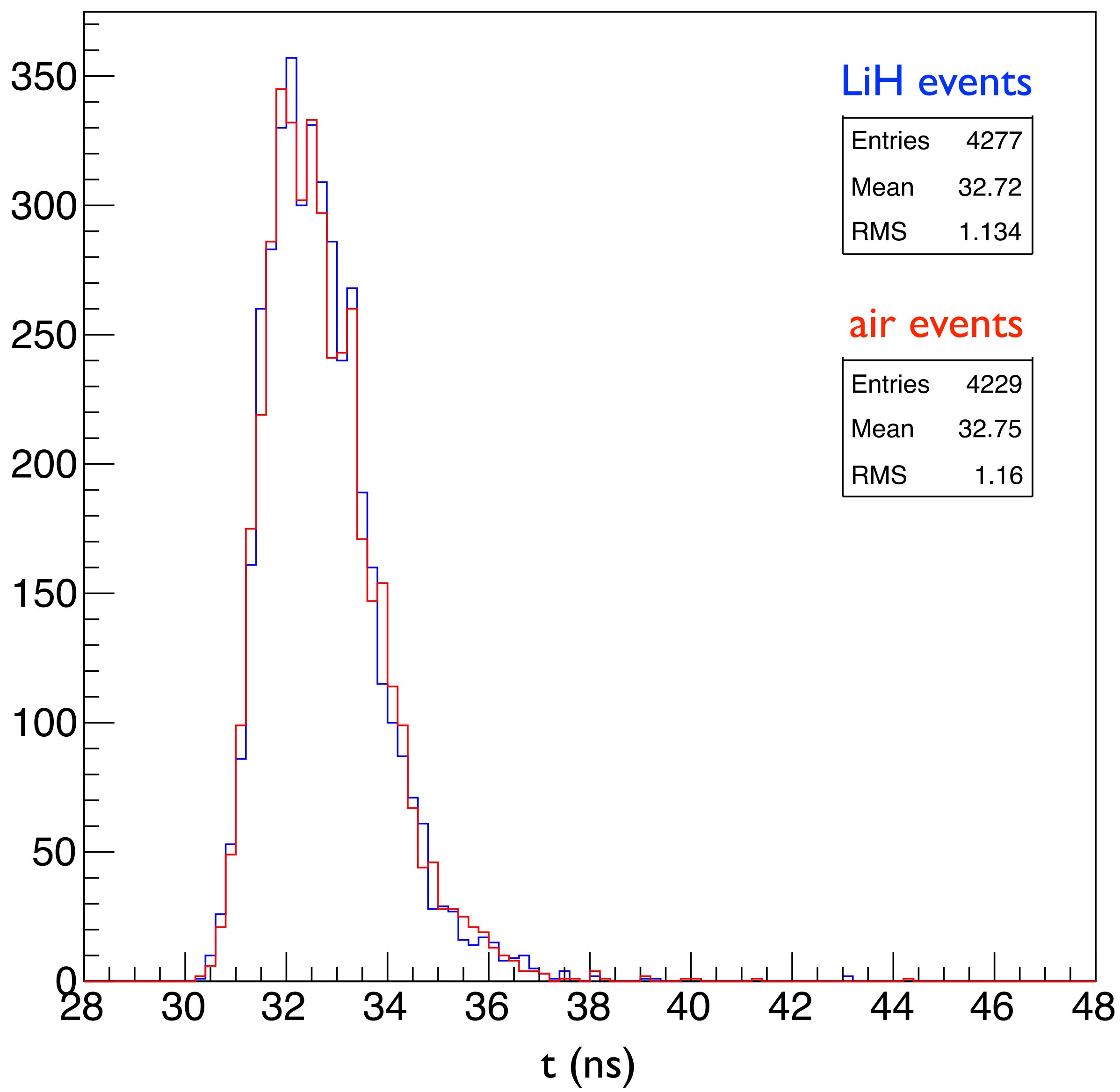
p' = momentum out

... within reach of TOF resolutions

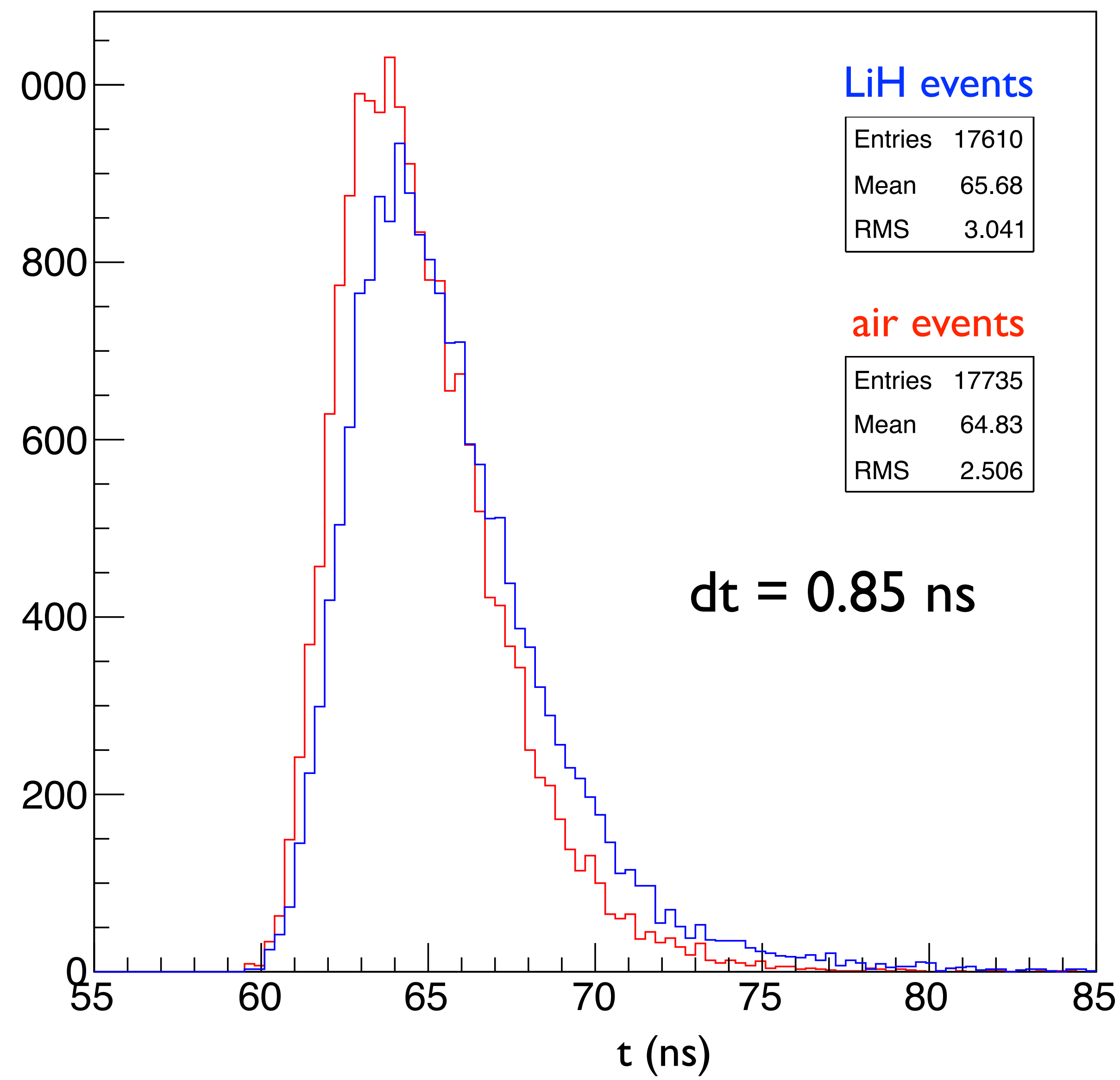
Station	Time Res (ps)
TOF1	53
TOF2	50
TOF1+TOF2 (delta t)	71(quadrature sum)

Time of Flight Differences

Time Upstream of Absorber



Time 5m Downstream of Absorber



LiH events = events in simulations with absorber in place

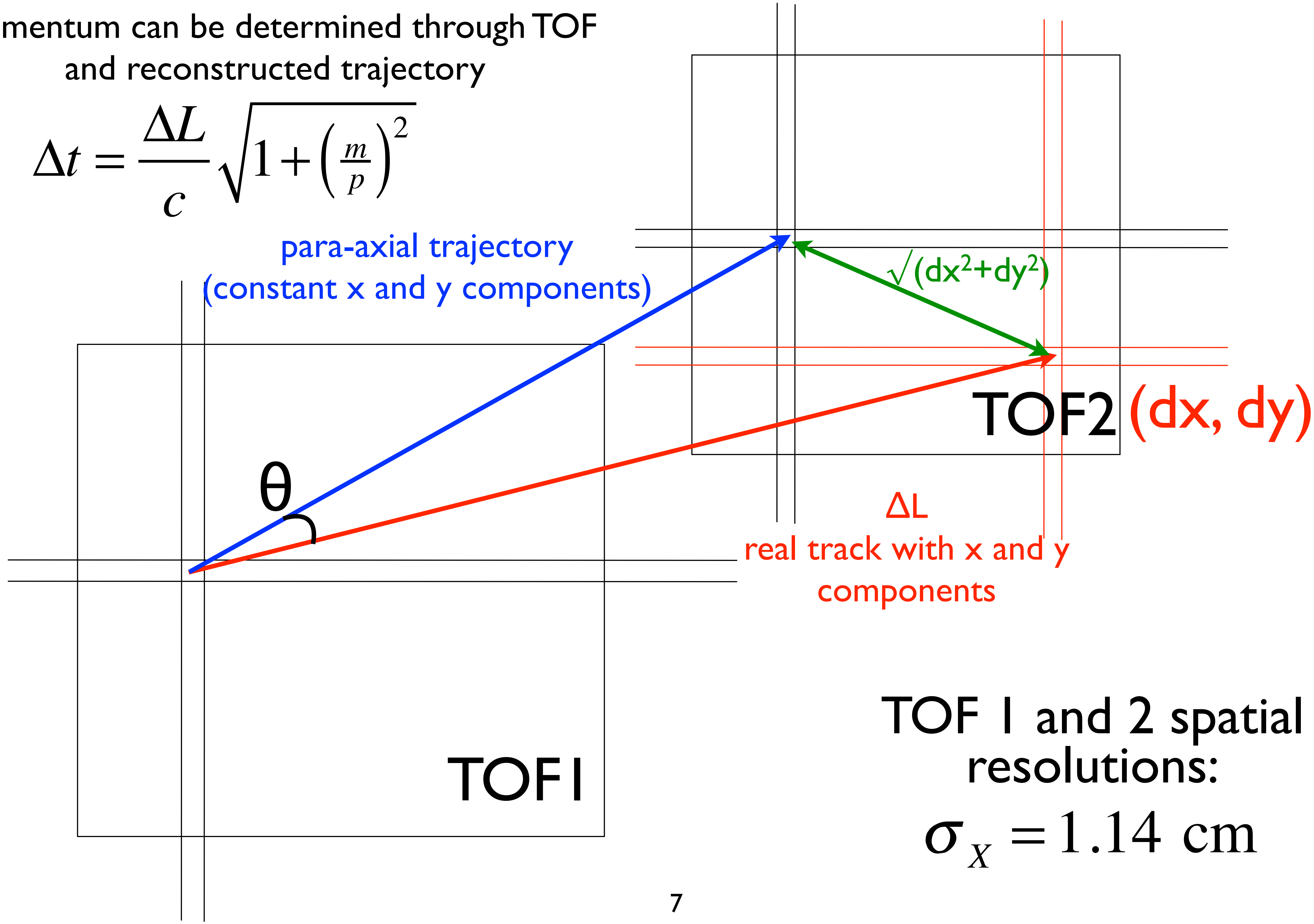
air events = events in simulations with absorber removed

Downstream times for air events correspond to ~160 MeV/c

Reconstructing Momentum with TOF 1 and TOF 2

Momentum can be determined through TOF and reconstructed trajectory

$$\Delta t = \frac{\Delta L}{c}\sqrt{1+\left(\frac{m}{p}\right)^2}$$



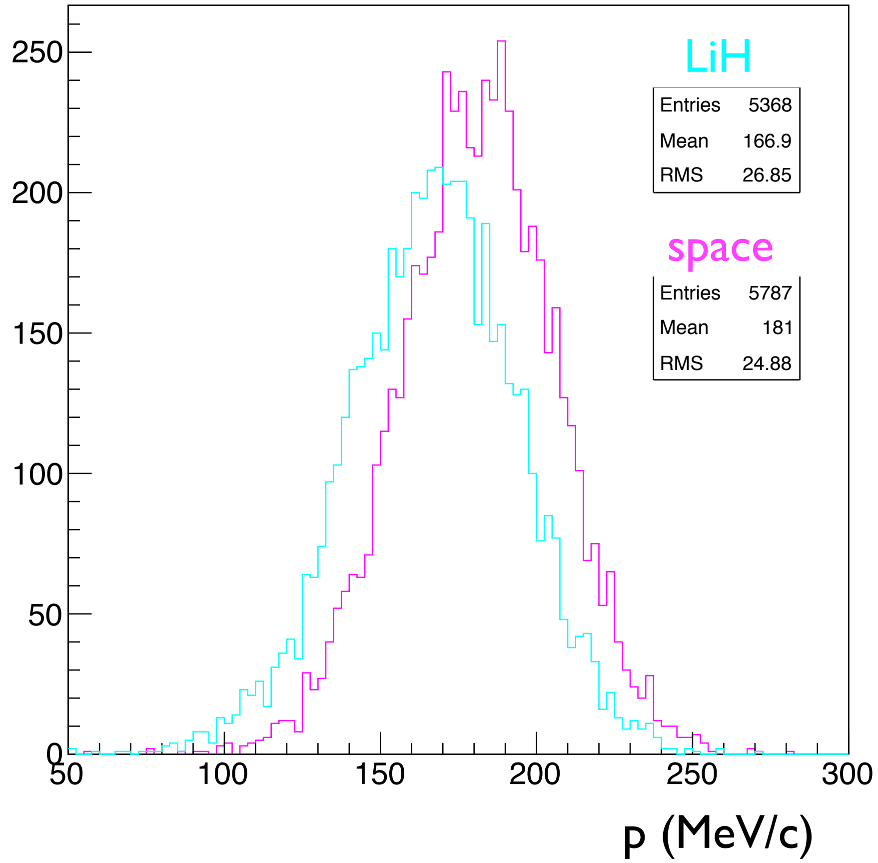
TOF 1 and 2 spatial resolutions:

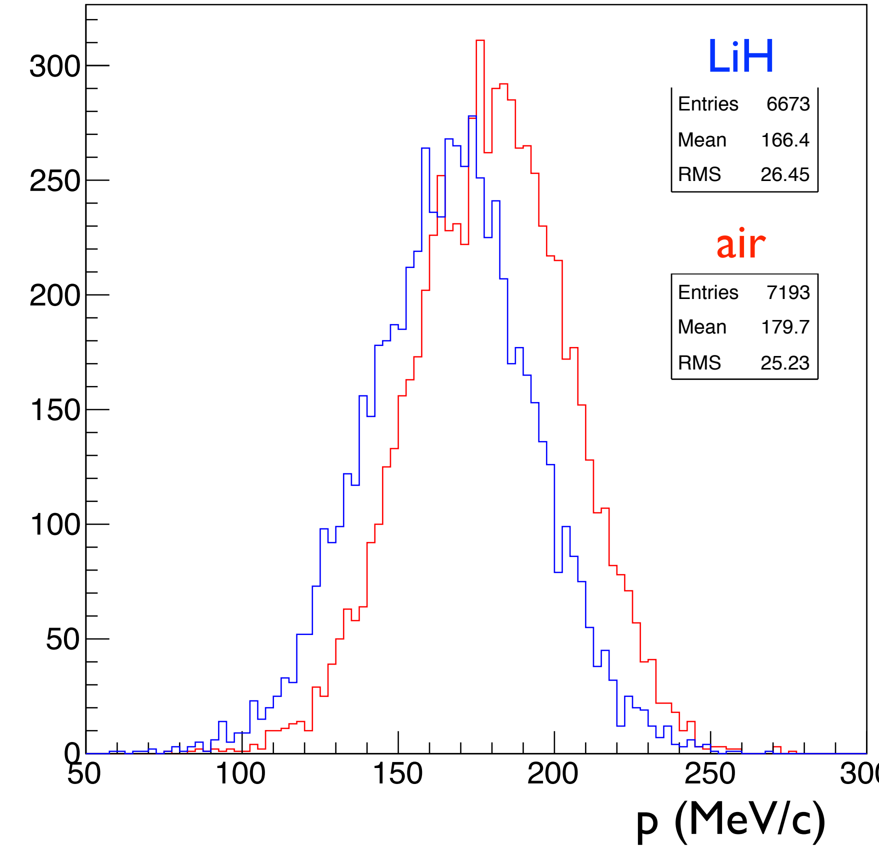
$$\sigma_X = 1.14 \text{ cm}$$

Momentum (Space)

Momentum (AIR)

MC Truth:





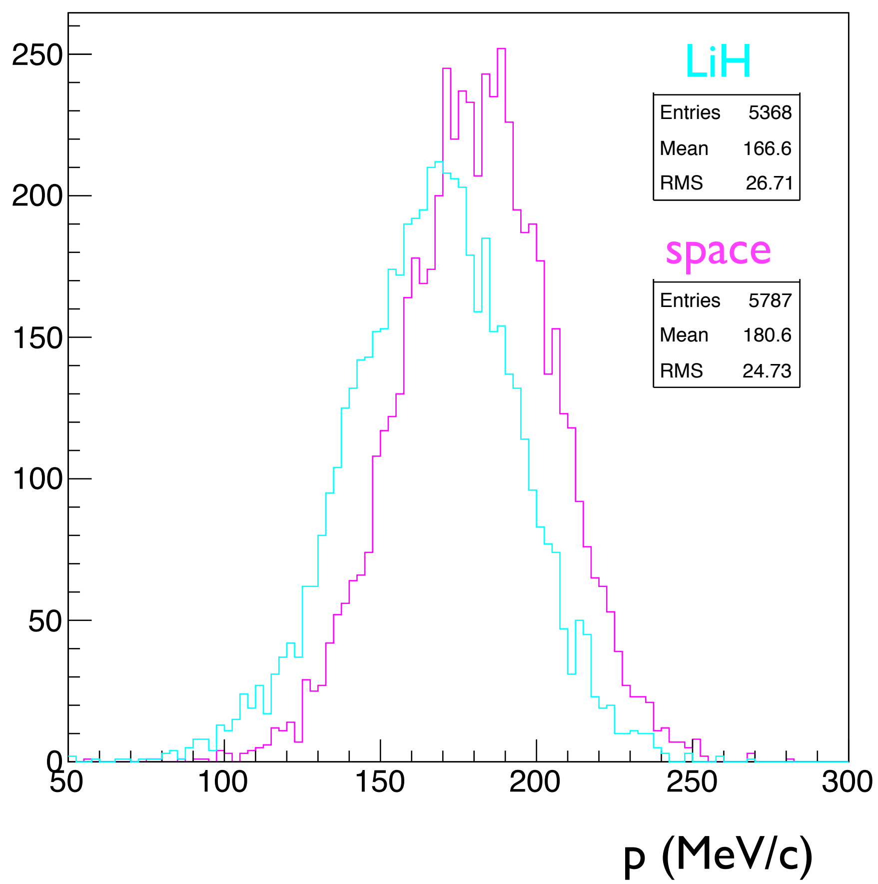
MC Reco

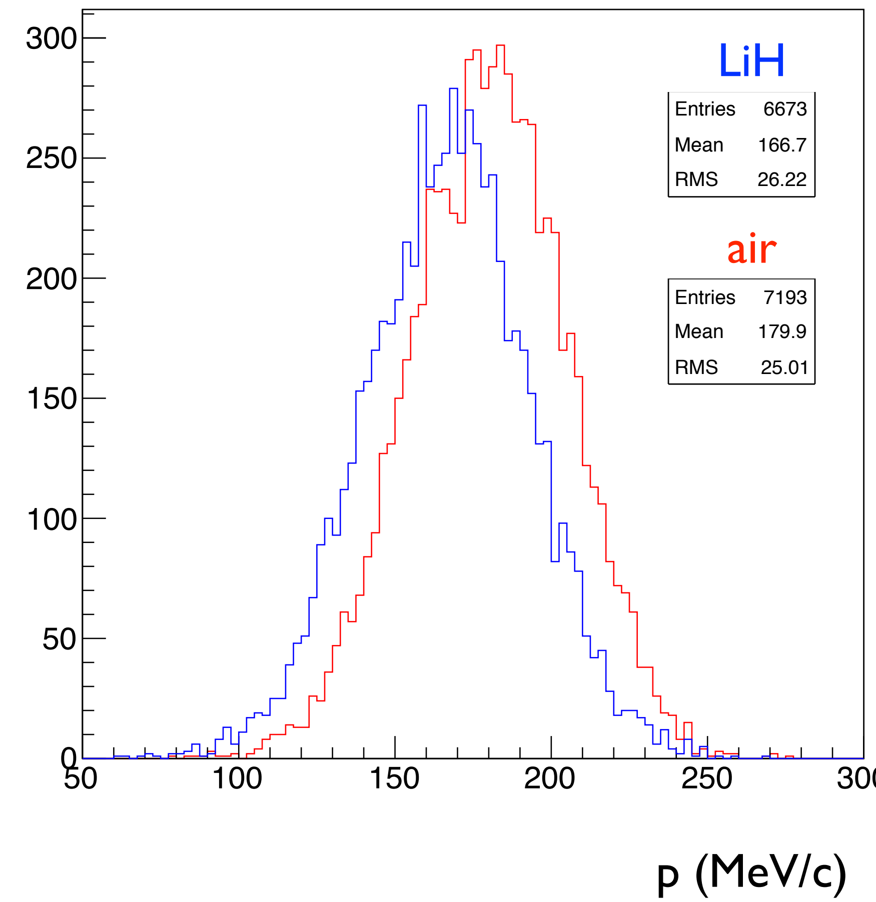
assuming straight tracks and includes spatial gaussian smears:

positions and times include gaussian smearing

$\sigma t = 50$ ps

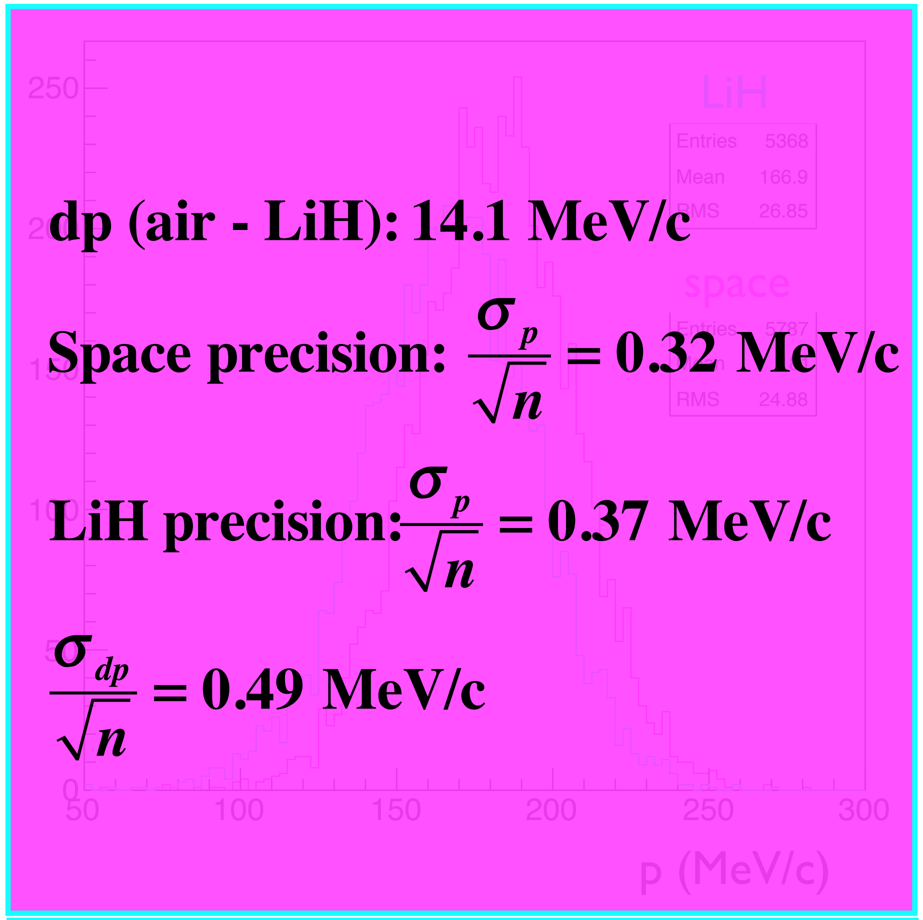
$\sigma x = 1.17$ cm





Momentum (Space) | Momentum (AIR)

MC Truth:

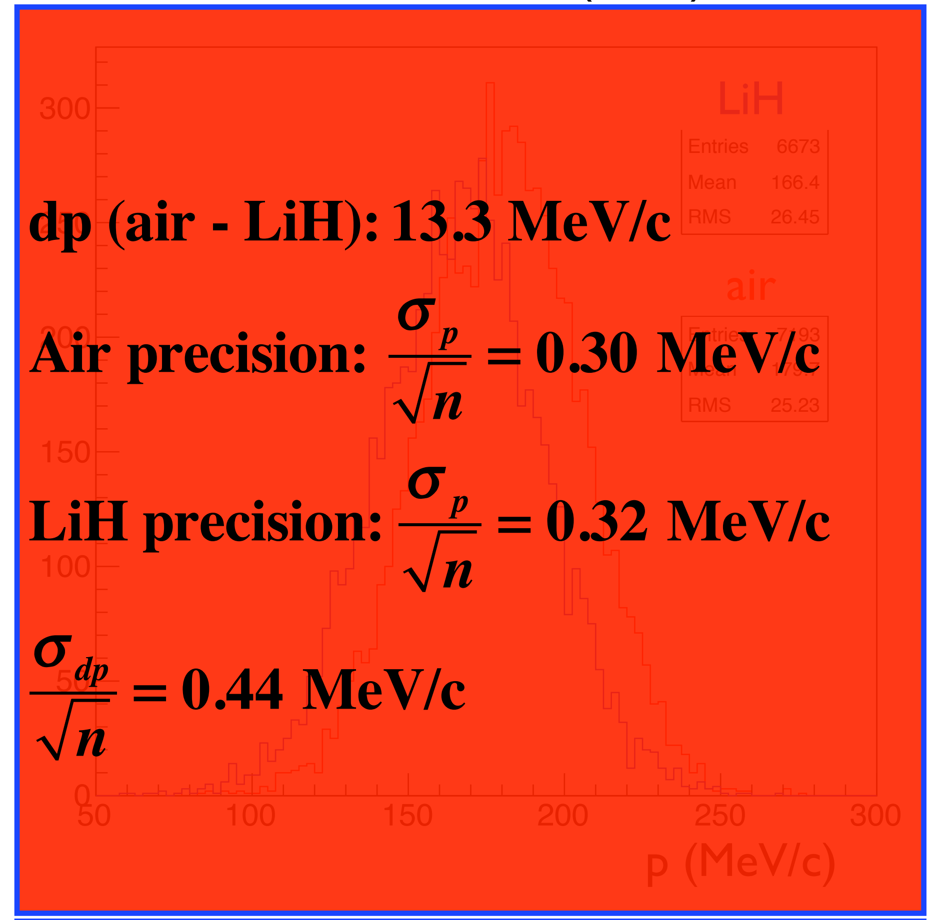


dp (air - LiH): 14.1 MeV/c

Space precision: $\frac{\sigma_p}{\sqrt{n}} = 0.32$ MeV/c

LiH precision: $\frac{\sigma_p}{\sqrt{n}} = 0.37$ MeV/c

$\frac{\sigma_{dp}}{\sqrt{n}} = 0.49$ MeV/c



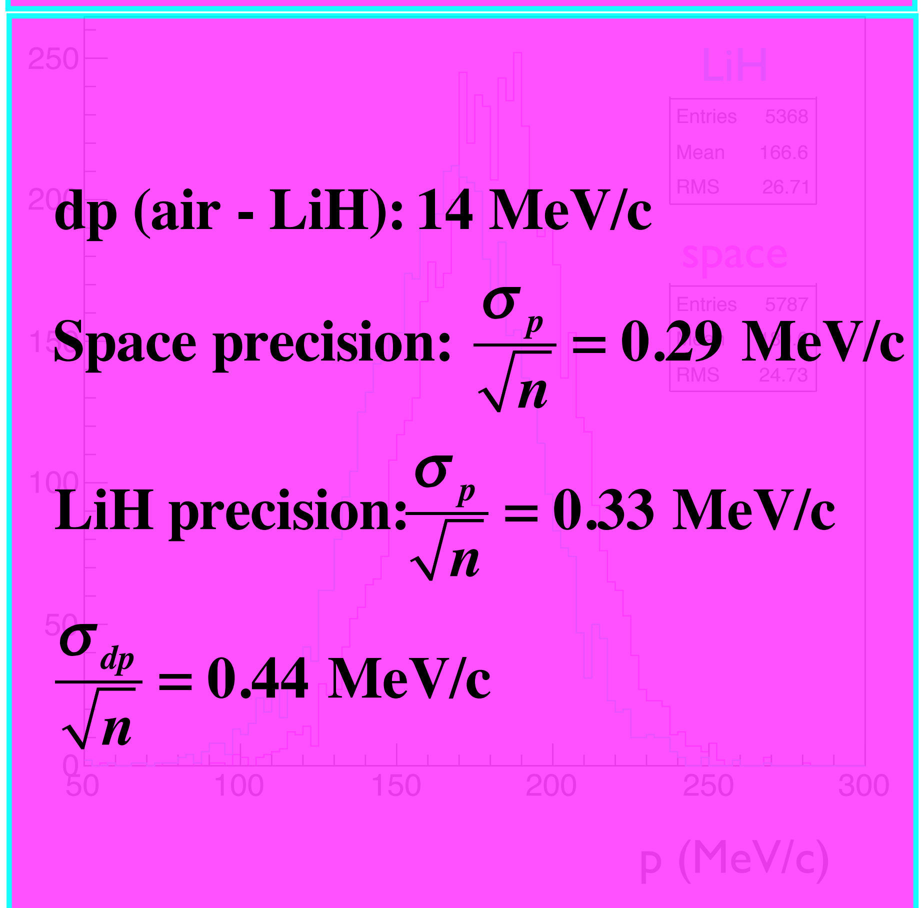
dp (air - LiH): 13.3 MeV/c

Air precision: $\frac{\sigma_p}{\sqrt{n}} = 0.30$ MeV/c

LiH precision: $\frac{\sigma_p}{\sqrt{n}} = 0.32$ MeV/c

$\frac{\sigma_{dp}}{\sqrt{n}} = 0.44$ MeV/c

MC Reco assuming straight tracks and includes spatial gaussian smears:

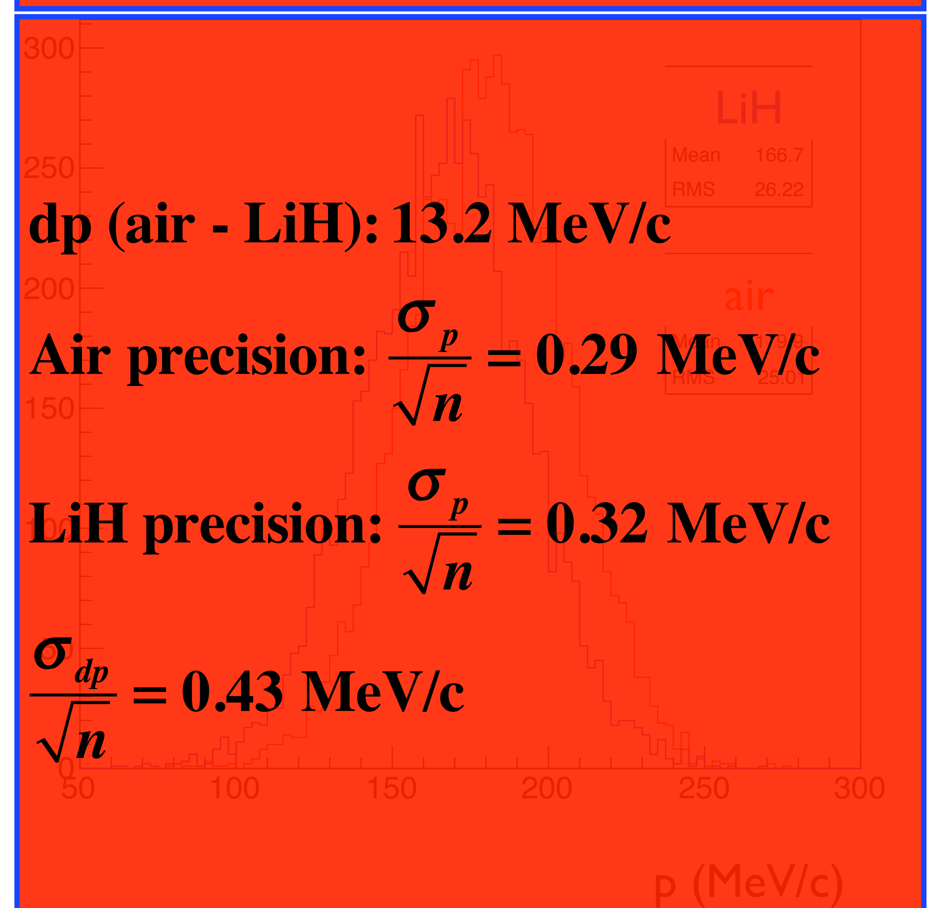


dp (air - LiH): 14 MeV/c

Space precision: $\frac{\sigma_p}{\sqrt{n}} = 0.29$ MeV/c

LiH precision: $\frac{\sigma_p}{\sqrt{n}} = 0.33$ MeV/c

$\frac{\sigma_{dp}}{\sqrt{n}} = 0.44$ MeV/c



dp (air - LiH): 13.2 MeV/c

Air precision: $\frac{\sigma_p}{\sqrt{n}} = 0.29$ MeV/c

LiH precision: $\frac{\sigma_p}{\sqrt{n}} = 0.32$ MeV/c

$\frac{\sigma_{dp}}{\sqrt{n}} = 0.43$ MeV/c

Given current RMS, can achieve ~0.1% precision with 1M events

Multiple Scattering

Average scattering angle $\left\langle \theta_{plane} \right\rangle = 0,$

RMS scattering angle $\sqrt{\left\langle \theta_{plane}^2 \right\rangle} = \theta_0$

$$\theta_{rms}^{plane} = \frac{13.6 MeV}{200 MeV} \left(\sqrt{\frac{z}{X}} \left(1 + 0.038 \ln \left(\frac{z}{X} \right) \right) \right)$$

$$= 17 \text{mrad}$$

LiH

z = 65mm

X = 79.62 gcm^{-2}

We can measure the overall change in scattering angles for an absorber run and compare it with a non-absorber run...WORK IN PROGRESS

Conclusion

- Will be able to measure dE/dx for LiH with a precision of ~0.1% with 1million events without the need of spectrometer solenoids
- Can extend the study to various materials
- Multiple scattering studies are in the works.