Field-off Multiple Coulomb Scattering in MICE
Preliminary results for Liquid Hydrogen Absorber

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Software used:

- MAUS v3.1.2
- Root 5.34/36
- MCS Analysis Framework MCS analysis framework by Dr. John Nugent & Dr Rayen Bayes

Field-off Multiple Coulomb Scattering in MICE

Preliminary results for Liquid Hydrogen Absorber

Overview

- Particle Selection
- Effects of Particle selection on initial beam
- Effect of Vessel on beam
- Beam position shift in Y axis/ Asymmetry check
- Scattering distributions!

Field-off Multiple Coulomb Scattering in MICE

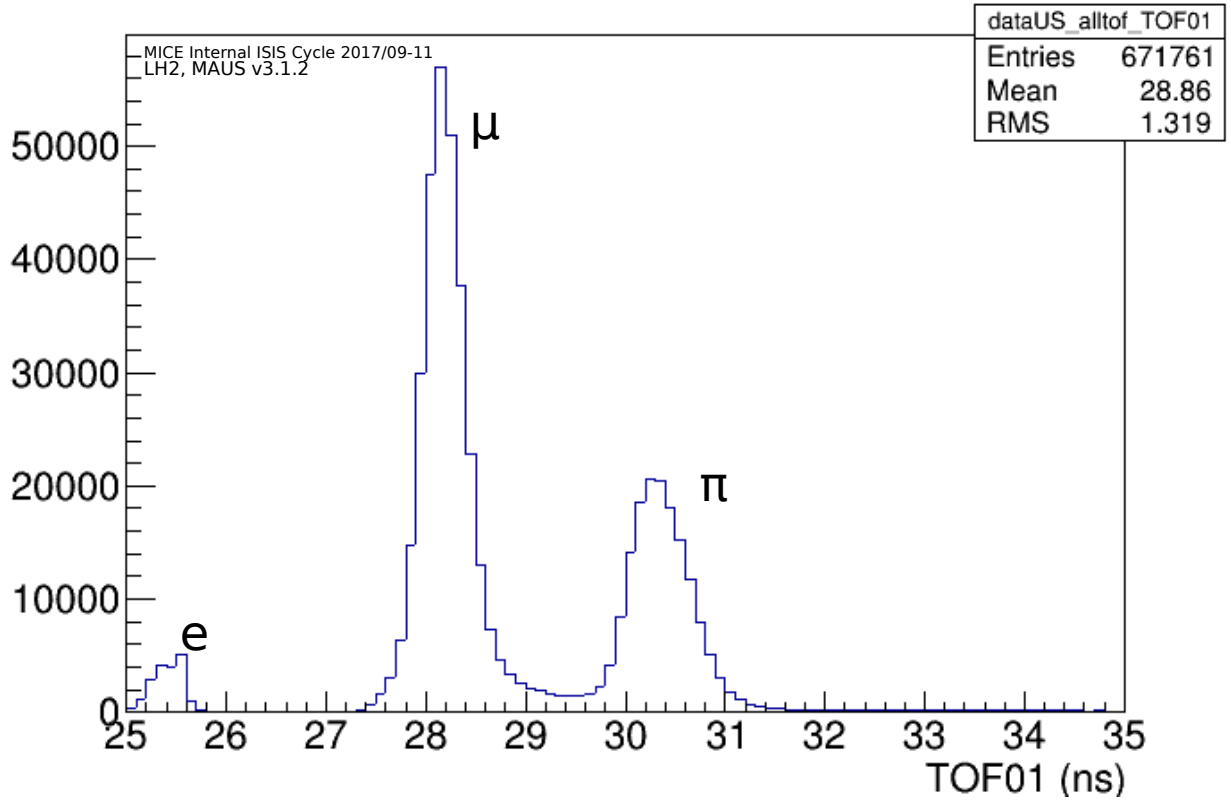
Preliminary results for Liquid Hydrogen Absorber

Data Used

User cycles 2017 – 09 -10 - 11

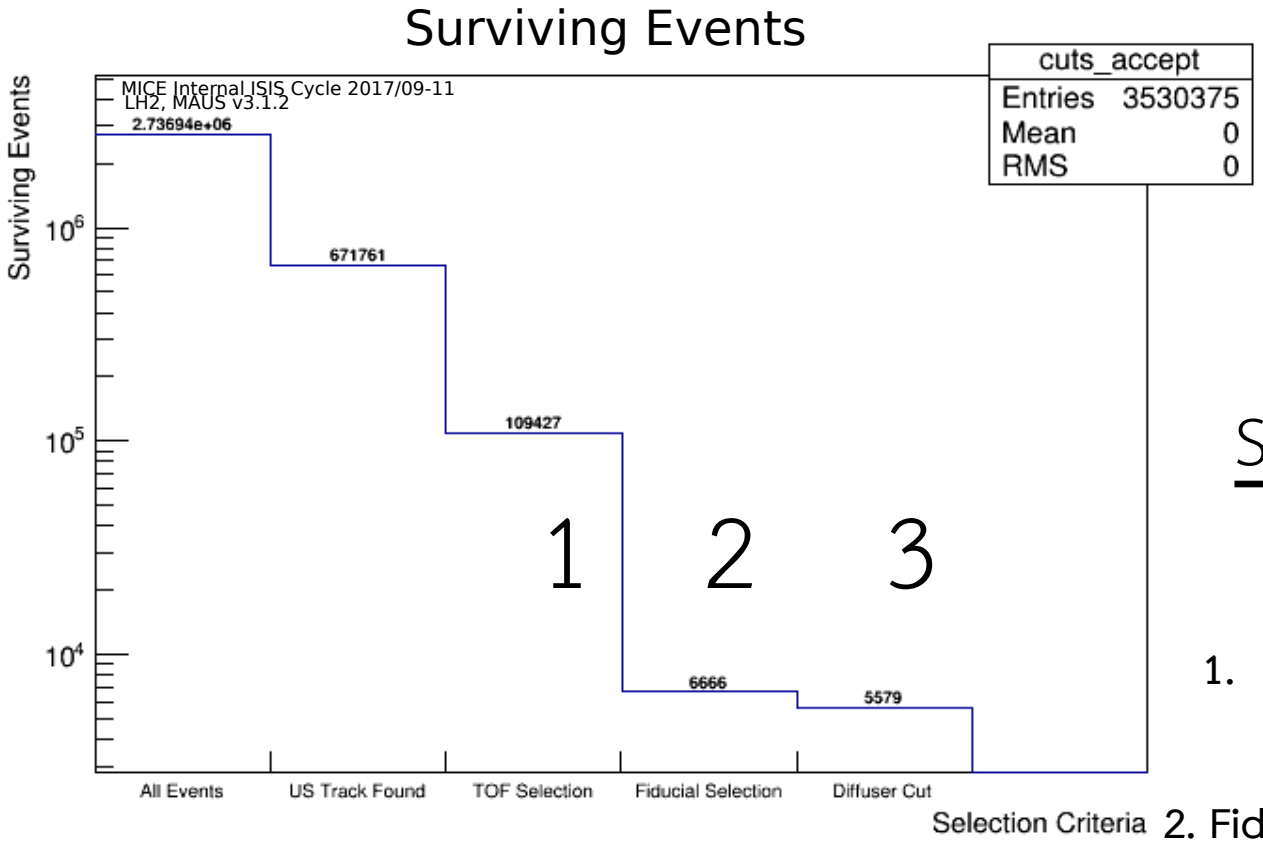
Empty LH2 Vessel	LH2 in Vessel
10093	09773
10156	09776
10157	09779
10158	09855
10164	09856
10168	09857
	09858
	09860

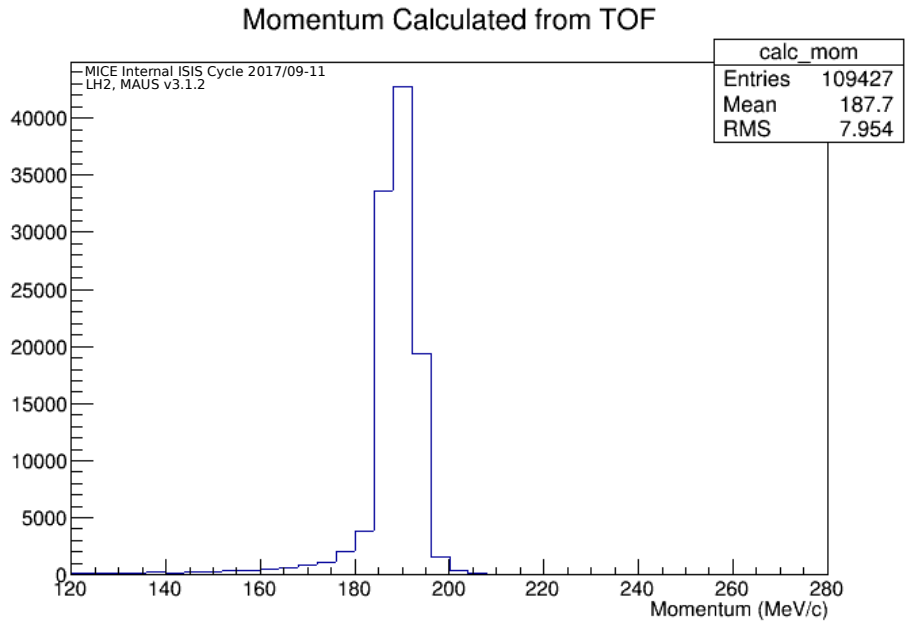
Time of flight distribution (TOF1-0) For calibration beam



- First scattering distributions for the LH2 MICE absorber
- 200 MeV/c momentum (for now)
- Adaptation to the calibration-beam is required
- Selection criteria need refining for LH2.

Particle Selection





Selection Criteria Used for this analysis

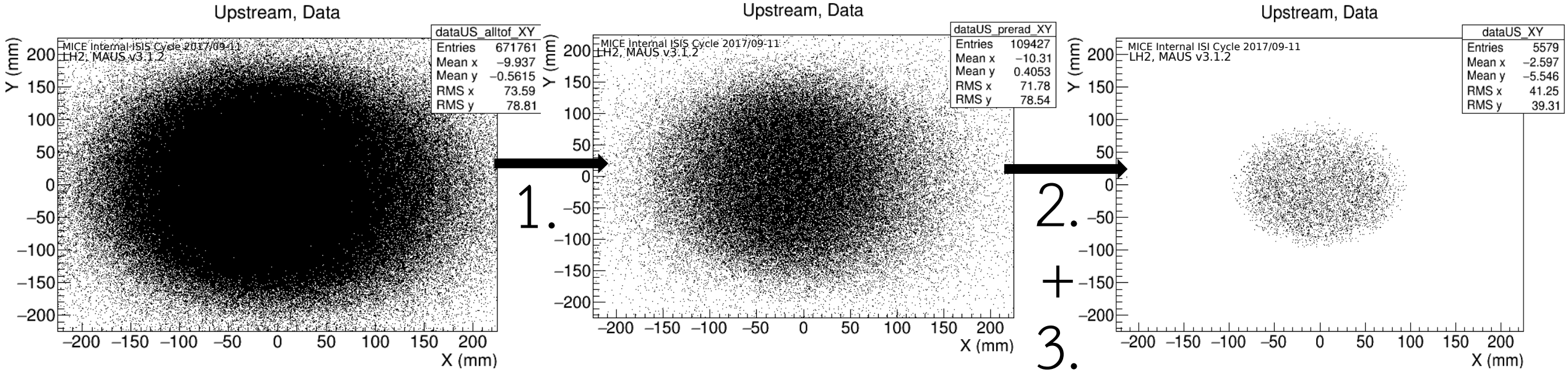
(TOF1 spacepoint and US Track present)

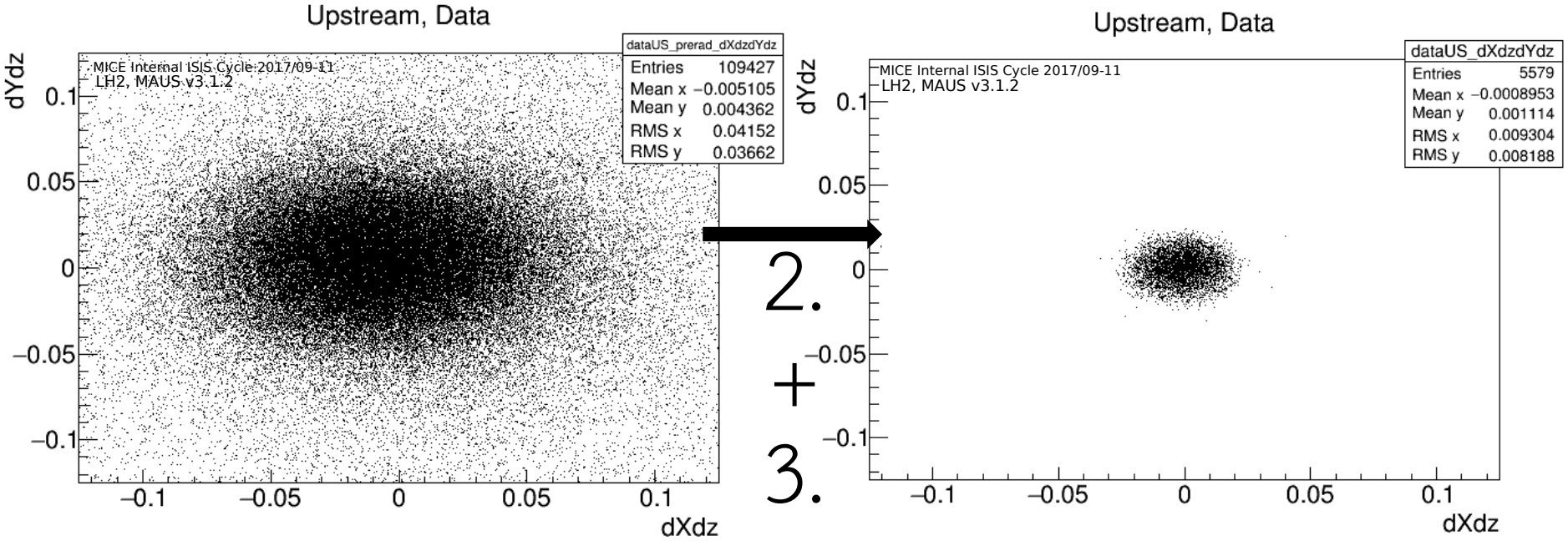
1. 200ps **TOF01** Window corresponding to 28.05 ns – 28.25 ns for ~200Mev/c momentum muons

2. **Fiducial Selection -** Rejection of tracks projected from US Tracker to DS and found outside of 140mm (+12mrad of scattering) radius

3. Tracks projected from US tracker to the center of the **Diffuser,** and found outside 100mm radius are rejected.

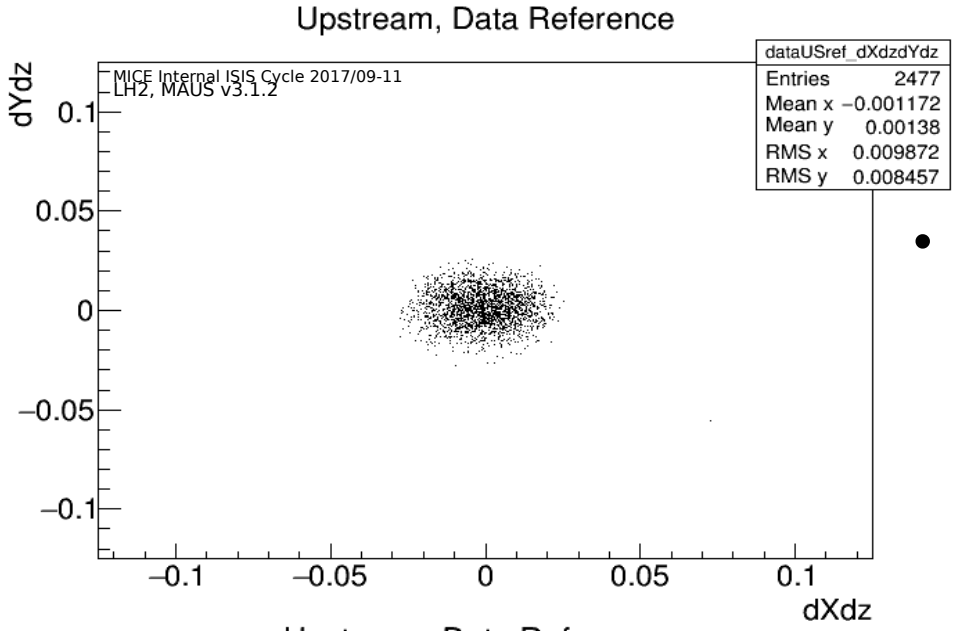
Particle Selection

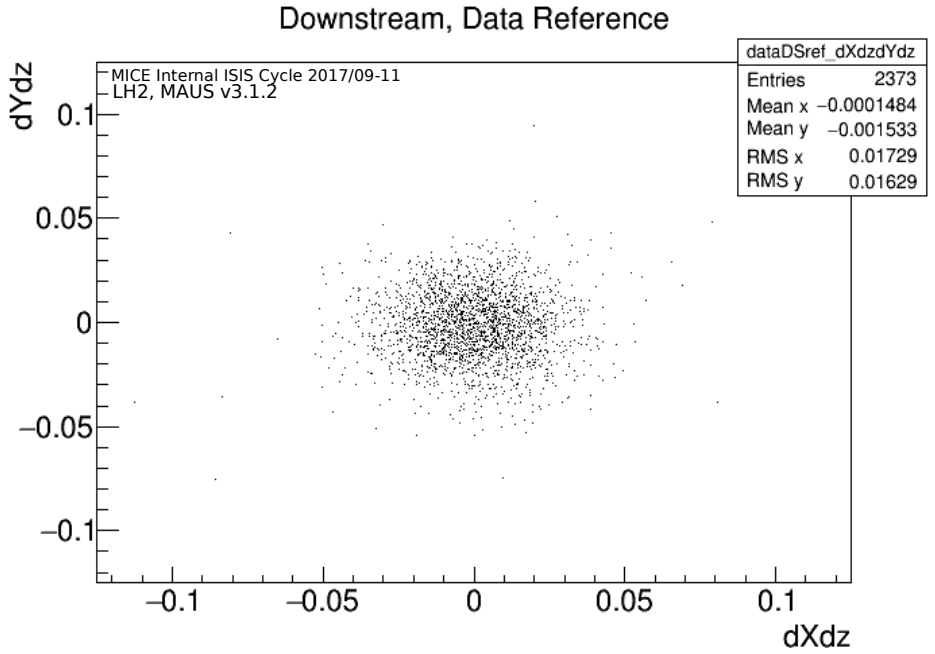




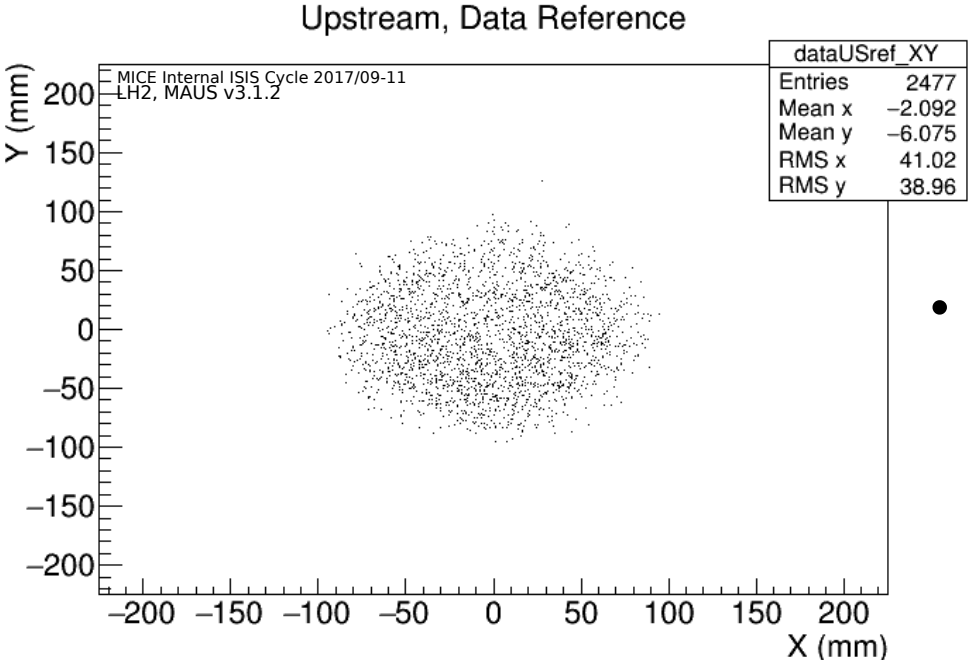
Effect of LH2 empty vessel on beam

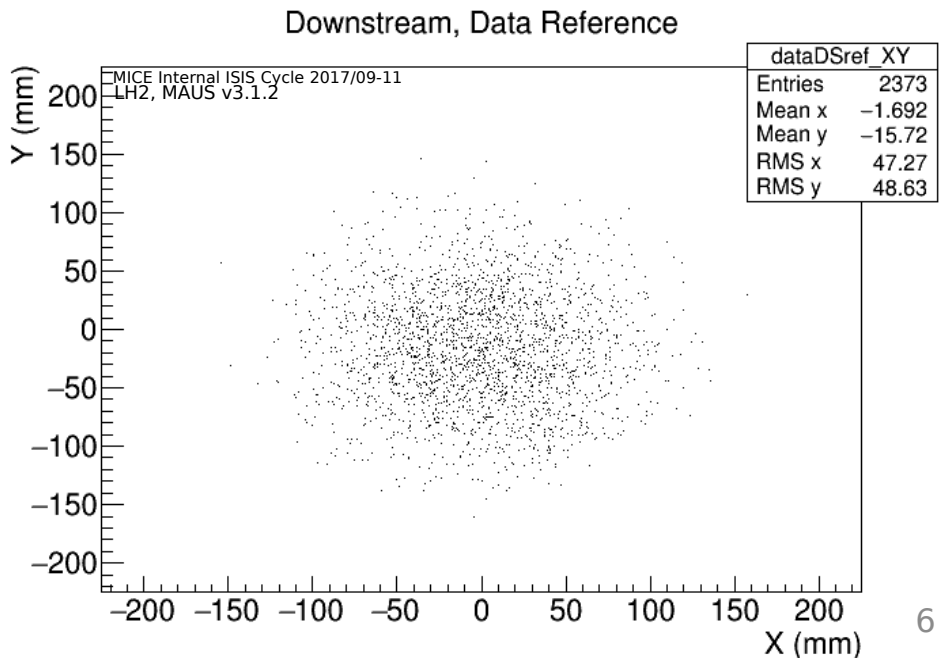
US **DS**





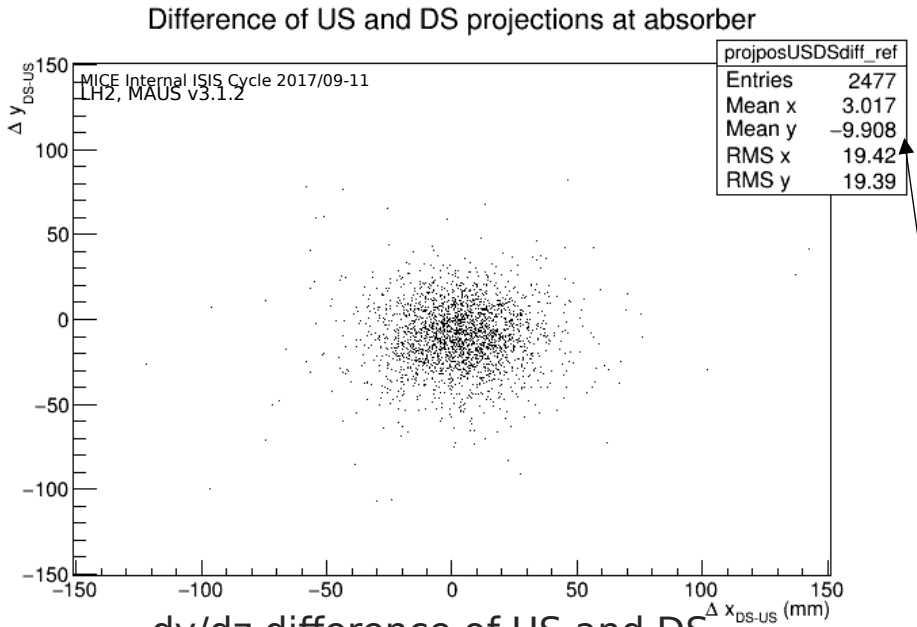
- Consistent directions for both X & Y after exiting the AFC

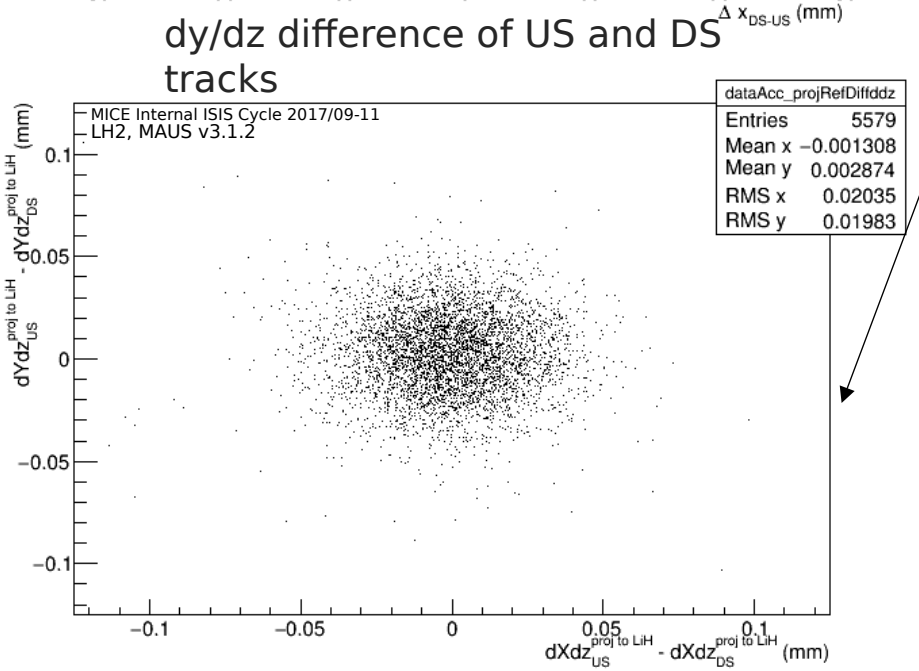




- 10mm distance between US/DS in Y

Difference between US and DS position and angles





Trajectories from US and DS trackers are projected to the absorber.

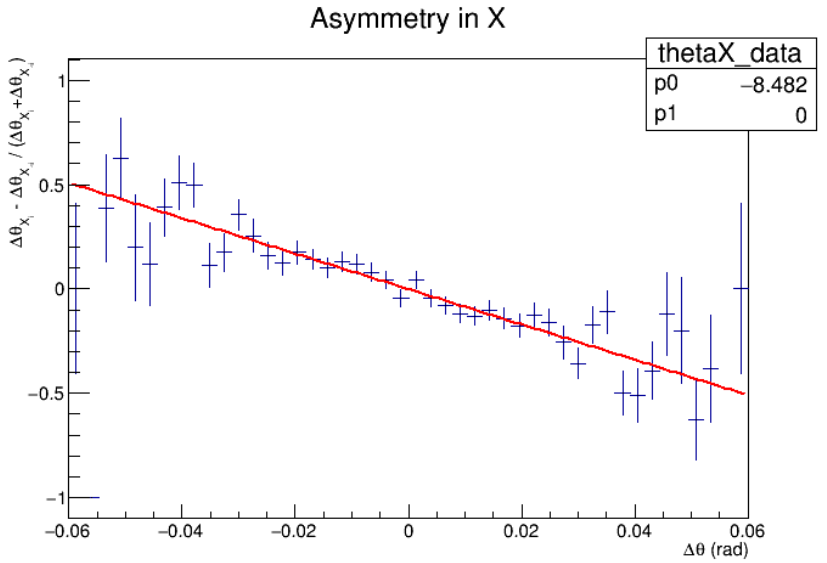
- Mean Y confirms the 10mm distance
- No discrepancy is observed in track direction.

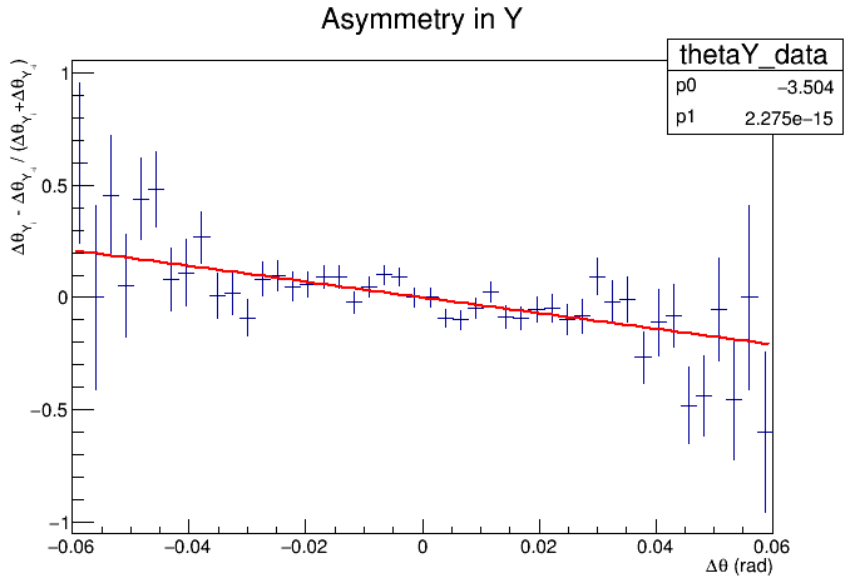
Ratio of the difference (in number of events) between opposing (w.r.t to the centre of the distribution) bins, with the sum of events in both.

or...

$$\Delta\theta_{X_i} - \Delta\theta_{X_{-i}} / (\Delta\theta_{X_i}+\Delta\theta_{X_{-i}})$$

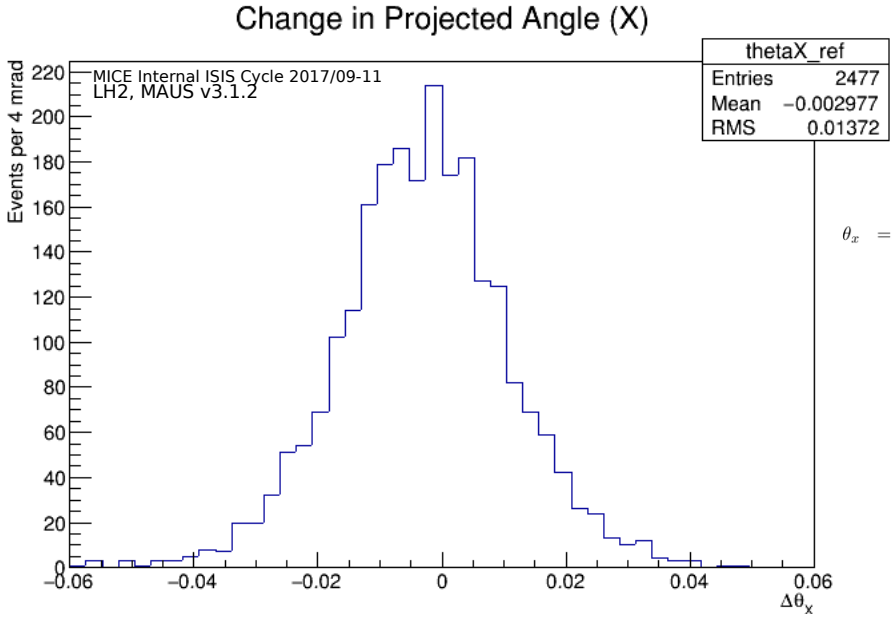
$$\Delta\theta_{Y_i} - \Delta\theta_{Y_{-i}} / (\Delta\theta_{Y_i}+\Delta\theta_{Y_{-i}})$$





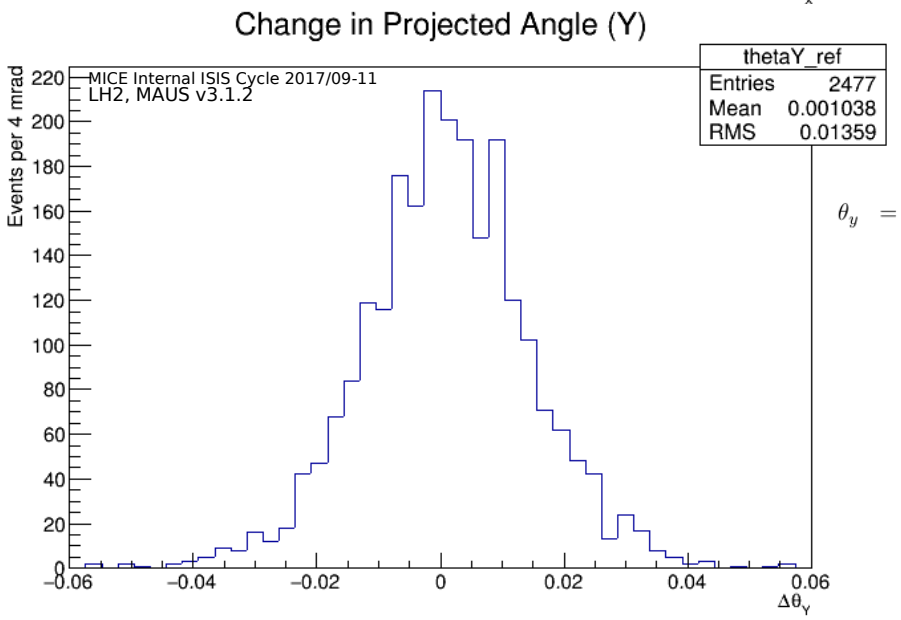
Effect of LH2 on Beam

Empty LH2 Vessel



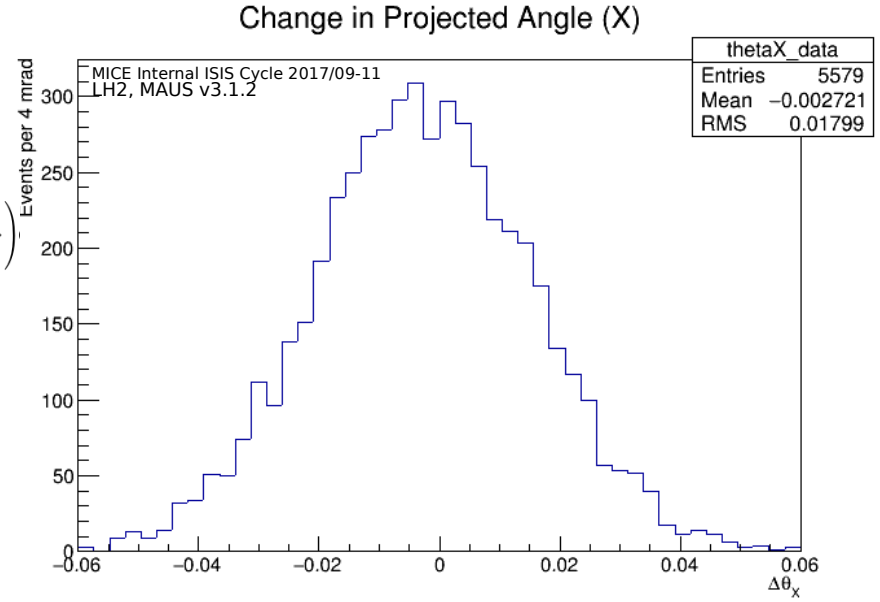
Projected scattering angle:

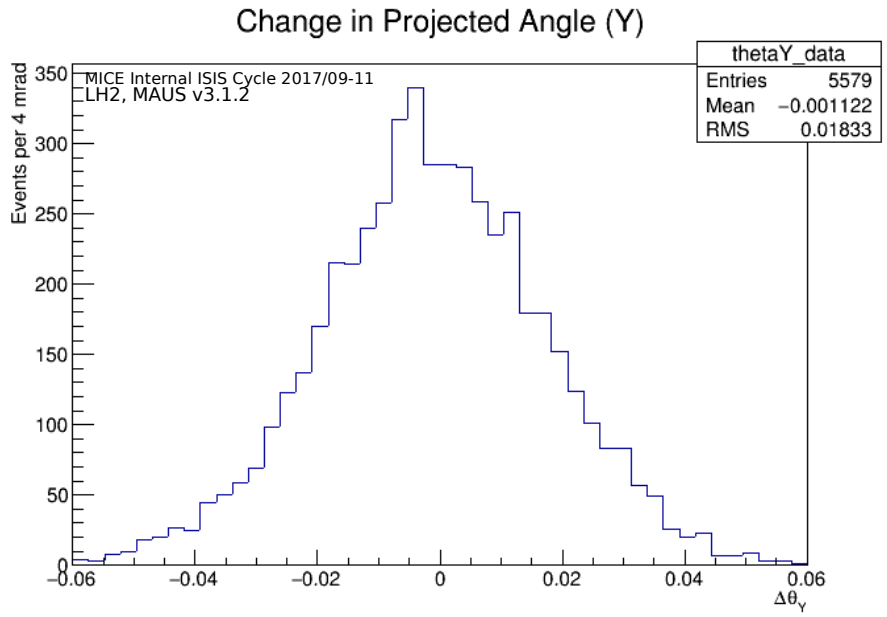
$$\theta_x = \text{atan}\left(\sqrt{\frac{1+\frac{dx}{dz}_{US}^2+\frac{dy}{dz}_{US}^2}{(1+\frac{dx}{dz}_{US}^2+\frac{dy}{dz}_{US}^2)(1+\frac{dx}{dz}_{US}^2)}}\left\{\frac{\frac{dy}{dz}_{DS}(1+\frac{dx}{dz}_{US}^2)-(\frac{dx}{dz}_{DS}\frac{dx}{dz}_{US}-1)\frac{dy}{dz}_{US}}{1+\frac{dx}{dz}_{US}\frac{dx}{dz}_{DS}+\frac{dy}{dz}_{US}\frac{dy}{dz}_{DS}}\right\}\right)$$



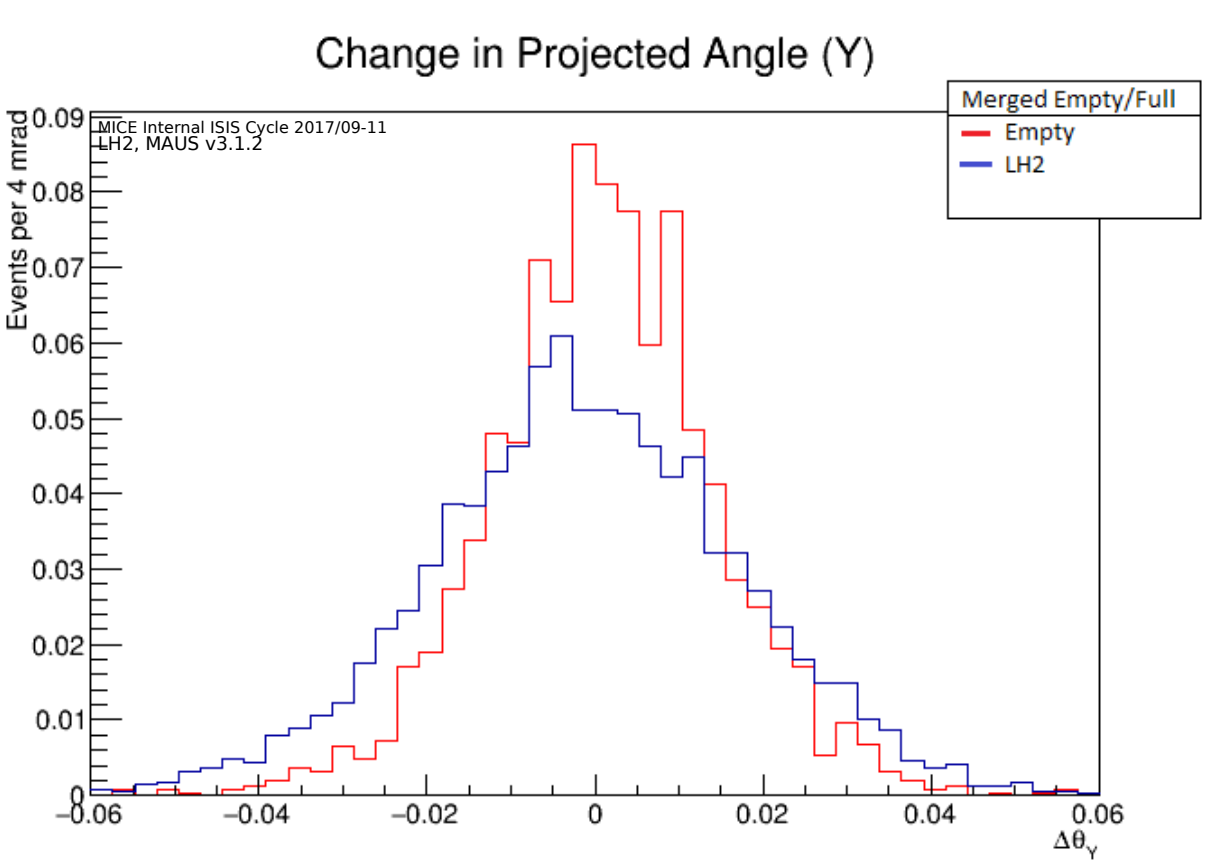
$$\theta_y = \text{atan}\left(\frac{\sqrt{1+\frac{dx}{dz}_{US}^2+\frac{dy}{dz}_{US}^2}}{\sqrt{1+\frac{dx}{dz}_{US}^2}}\left\{\frac{\frac{dx}{dz}_{DS}-\frac{dx}{dz}_{US}}{1+\frac{dx}{dz}_{US}\frac{dx}{dz}_{DS}+\frac{dy}{dz}_{US}\frac{dy}{dz}_{DS}}\right\}\right)$$

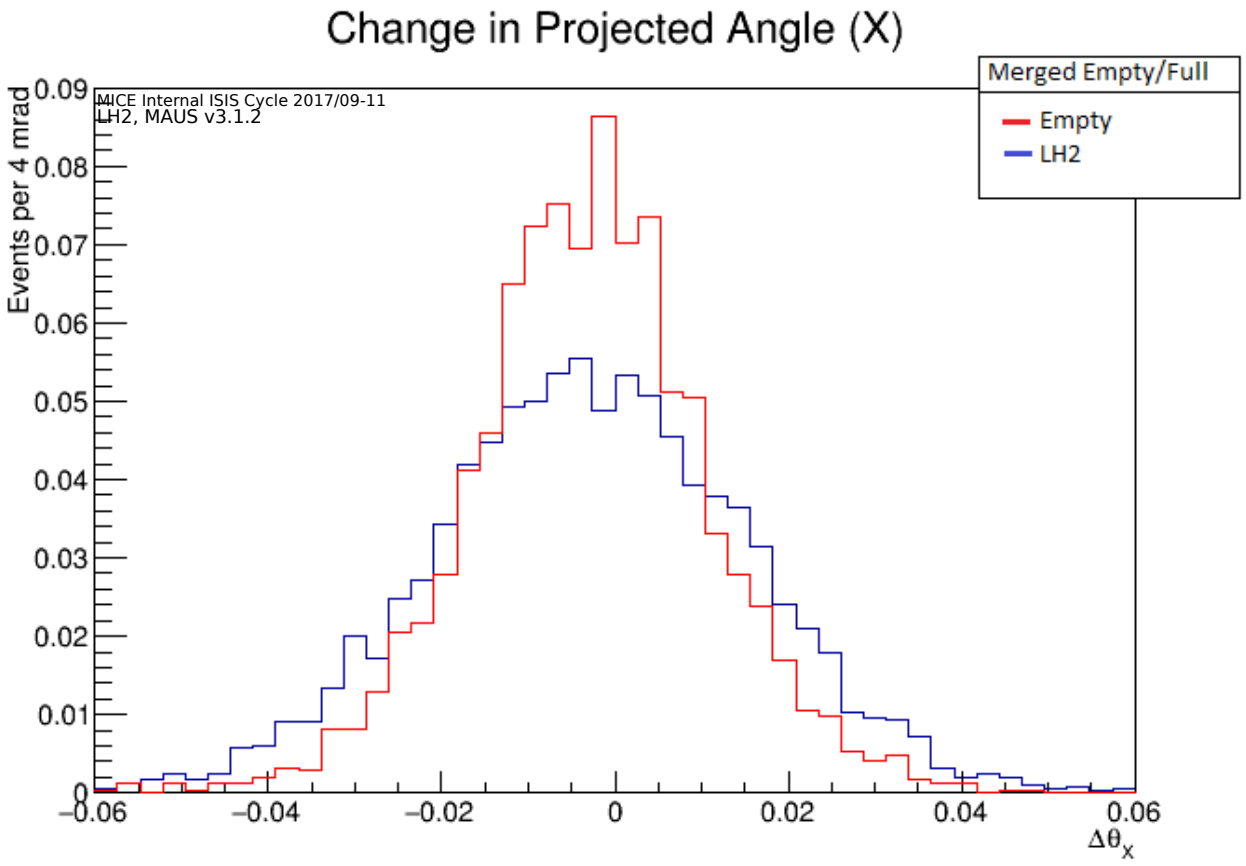
LH2 in Vessel





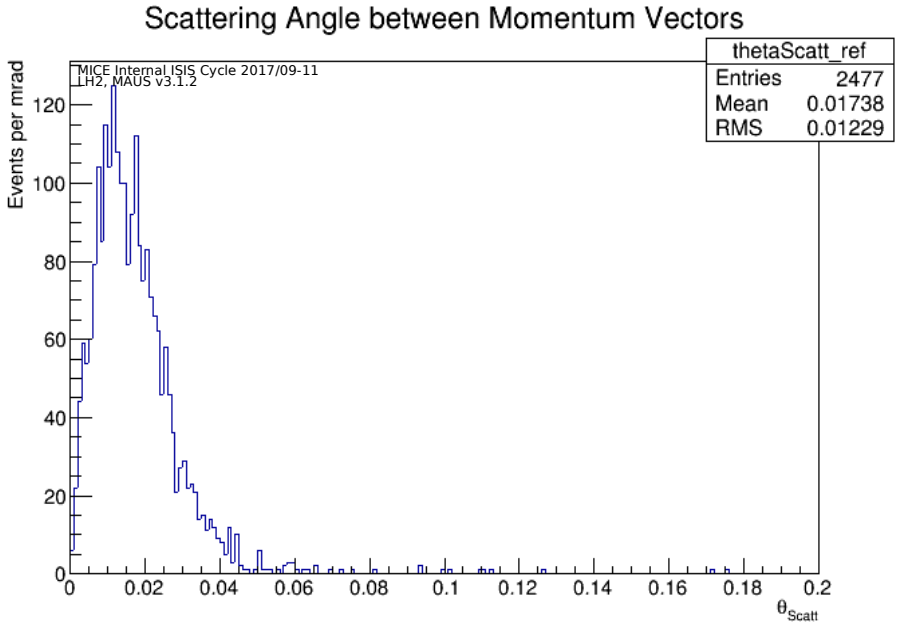
Effect of LH2 on Beam





Effect of LH2 on Beam

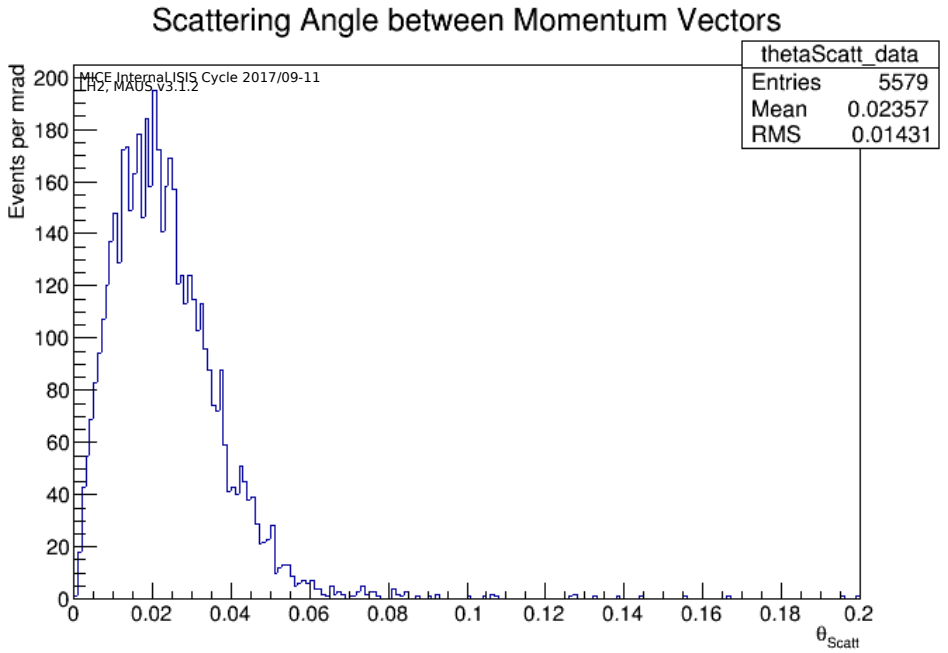
Empty LH2 Vessel

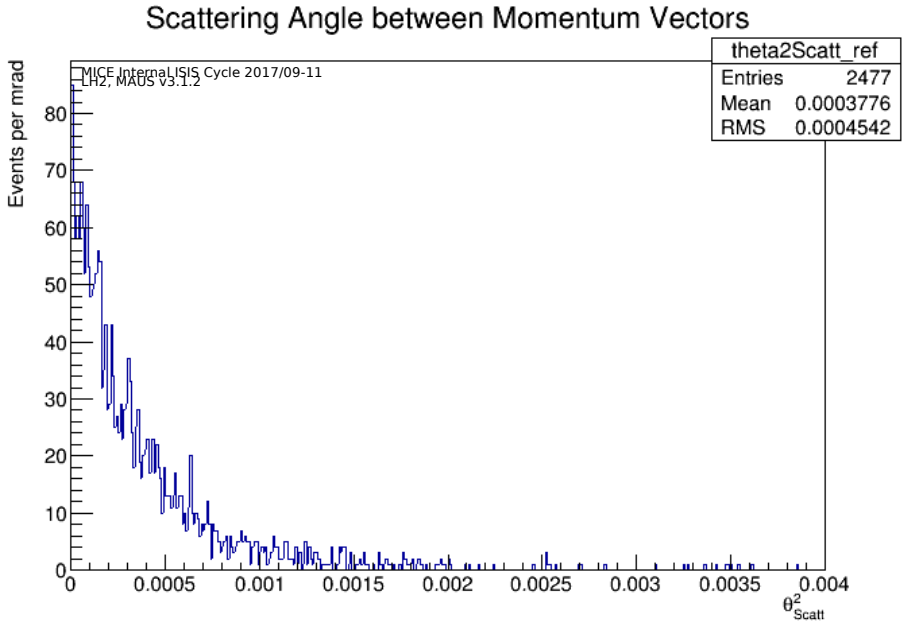


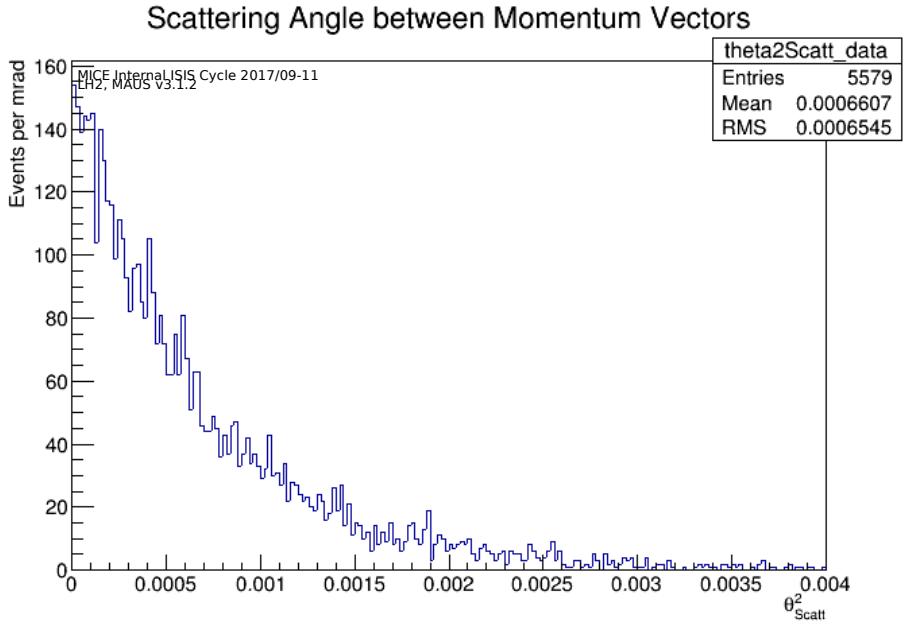
$$\theta_{Scatt} = \text{acos}\left(\frac{\mathbf{p}_{US}\cdot\mathbf{p}_{DS}}{|\mathbf{p}_{US}||\mathbf{p}_{DS}|}\right)$$

$$\approx \sqrt{\theta_x{}^2 + \theta_y{}^2}$$

LH2 in Vessel







Towards completing the analysis

- Enhance PID procedure by utilizing:
  - Cherenkov Detector
  - EMR/
  - KL Calorimeter
- Investigate selection criteria suitable for the LH2 runs
- Systematic error calculations:
  - Material fluctuations in absorber
  - Alignment
  - Angle definition
  - TOF system*
- Perform convolution/deconvolution with the models
  - Geant4 (Wentzel-IV)
  - Carlisle –Cobb (XY)
  - Moliere
- Quantify model/data consistency with Chi^2
- Repeat for all momentum spectra and perform momentum dependent analysis
- Comparison with Monte Carlo