2.3 GeV Mollers

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Spring 2017 Collaboration Meeting

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Moller Generator

- Moller generator (egs5)
  - /u/group/hps/production/mc/egs5/moller_v3.exe
- Saves Moller events from the subroutine
  - hps-mc/egs5/egs/egs5_moller.f
- Generator cuts:
  - E > 10 MeV
  - Theta_y > 5mrad

Preliminaries

- HPS-jar: 3.11-SNAPSHOT (updated 03/31/2017)

- File locations:

Pure (.slcio: “dst” -> “recon” in the path):

/cache/mss/hallb/hps/production/postTriSummitFixes/dst/moller/2pt3/3.11-20170331/molv3_5mrad_10to1_HPS-PhysicsRun2016-Nominal-v5-0-fieldmap_3.11-20170331_run7984_singles0_*

Data (run 7984 Moller skim, pass0):

/cache/hallb/hps/physrun2016/pass0/skim/dst/moller/hps_007984.*_moller_R3.9.root

2.3 GeV Luminosity (normalization)

Different from WBT (500k bunches)

- MC Pure Mollers
- Lumin $= (\text{num\_files}) * (74 \text{ scatterers/atom}) * (\mathbf{2 * 10^6}\text{bunches}) * (2500\ \text{e}^-/\text{bunch}) * (4.062 * 10^{-4} \text{ atoms/cm/barn}) * (6.306 * 10^{-2} \text{ cm})$

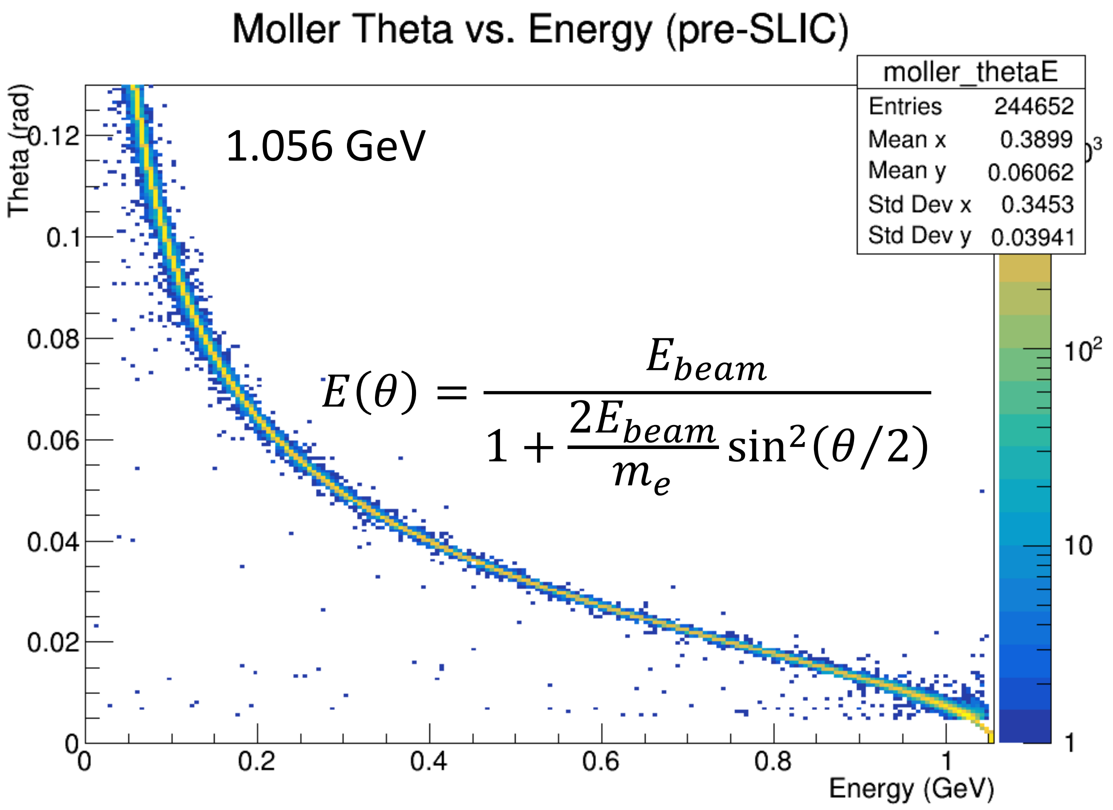
‘13’ for singles0

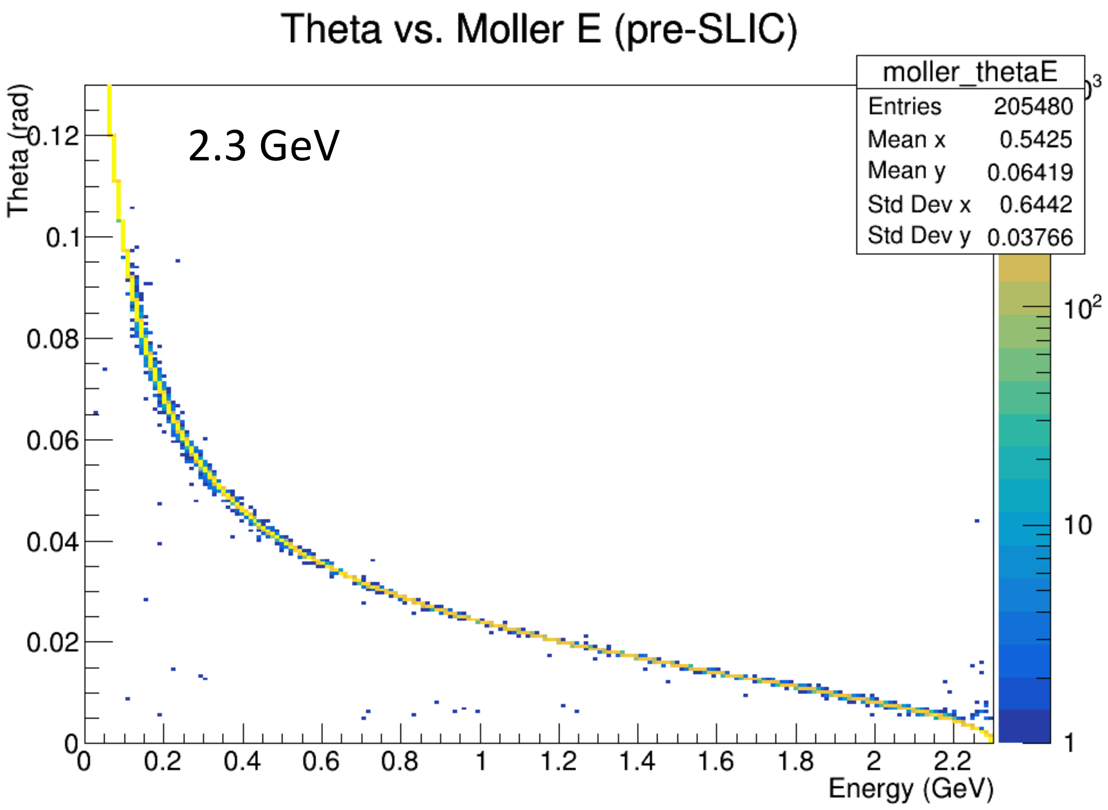
- Data
- Lumin $= 74 * (1 + 2^{Prescale}) * (FCup/q_e) * (4.062 * 10^{-4} \text{ atoms/cm/barn}) * (6.306 * 10^{-2} \text{ cm})$

$$FCup = 759002.3917\ nC$$

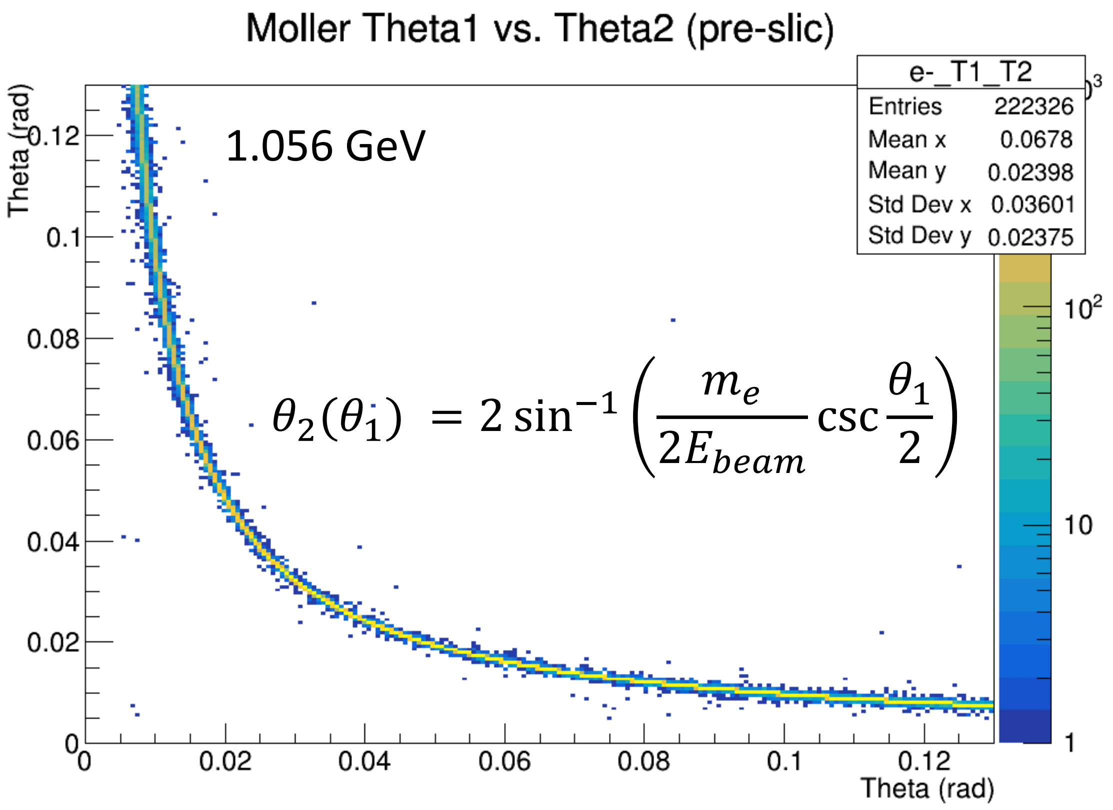
Run 7984 (gated)

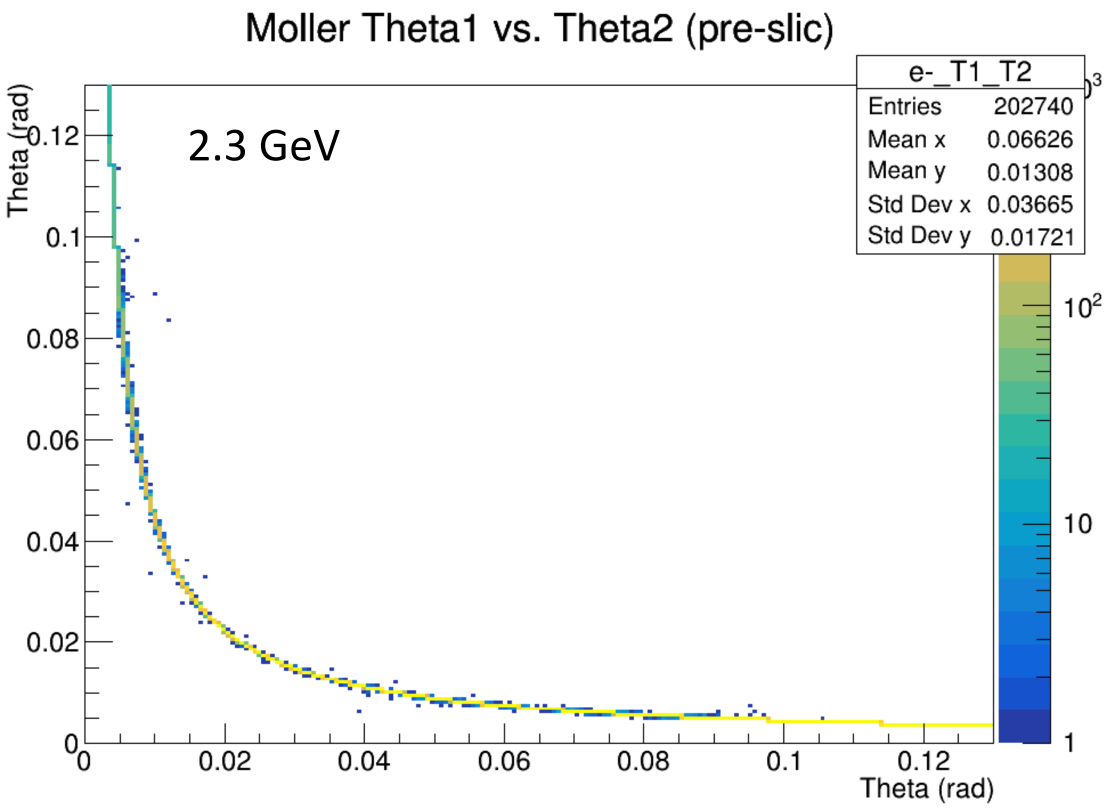
Moller Kinematics 1.056/2.3 GeV



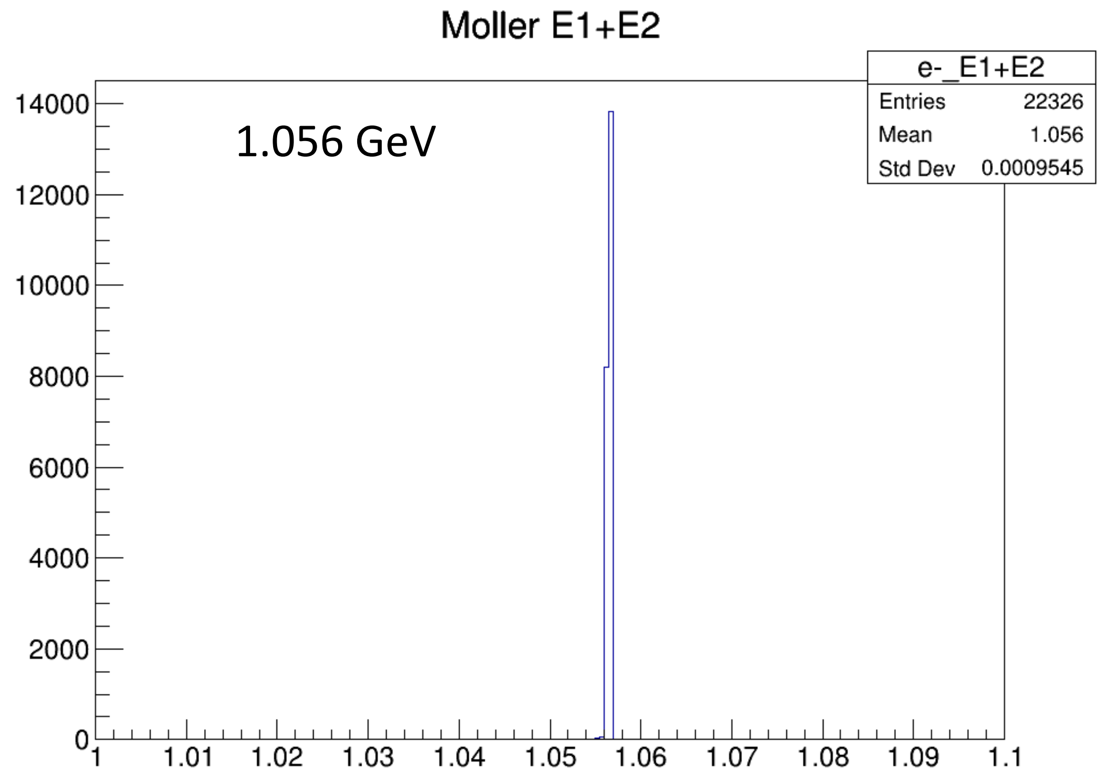


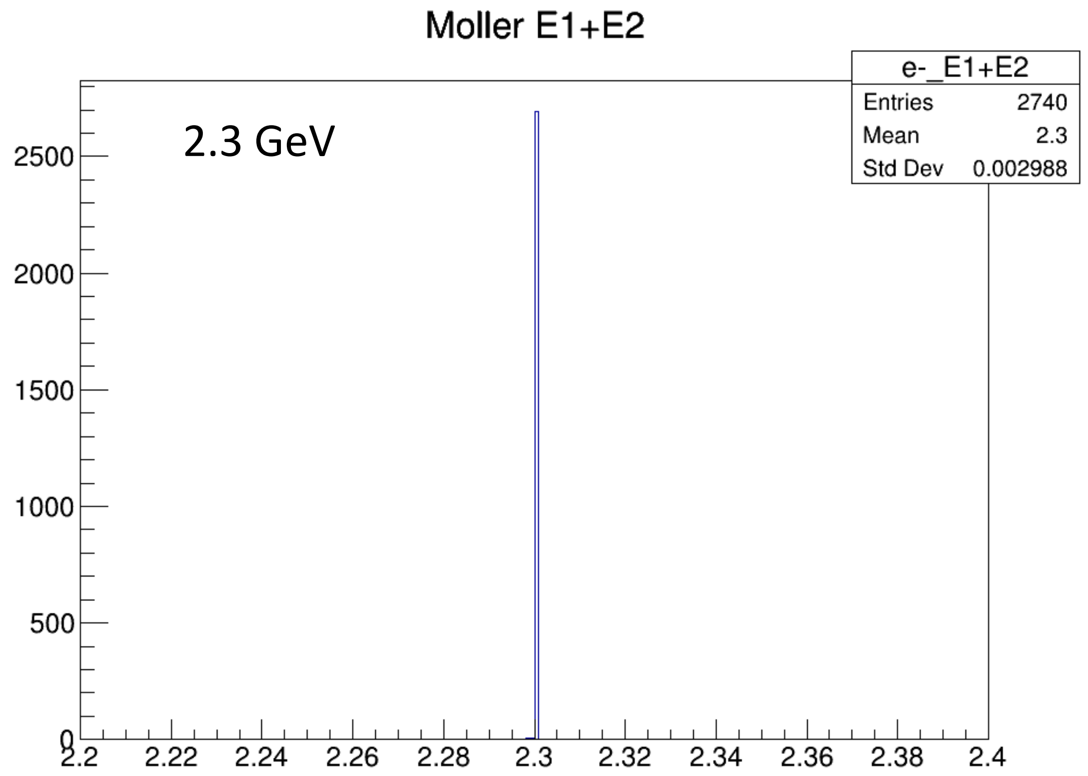
Moller Kinematics 1.056/2.3 GeV



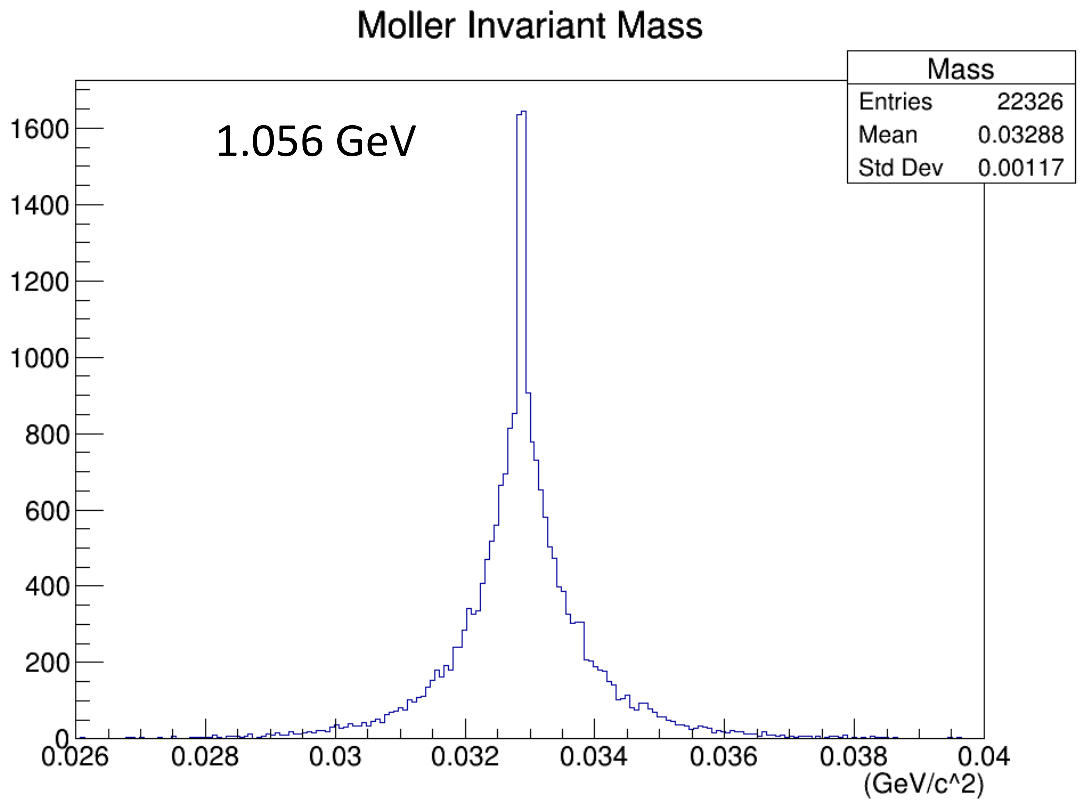


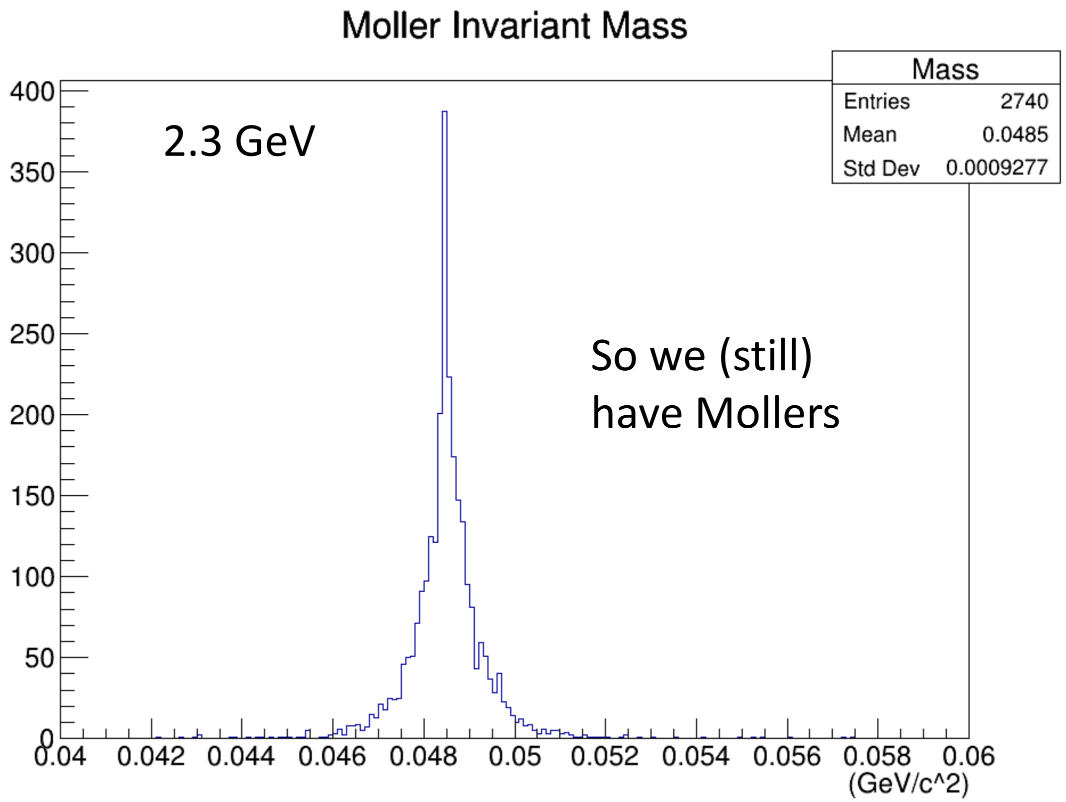
Moller Kinematics 1.056/2.3 GeV





Moller Kinematics 1.056/2.3 GeV





So we (still) have Mollers

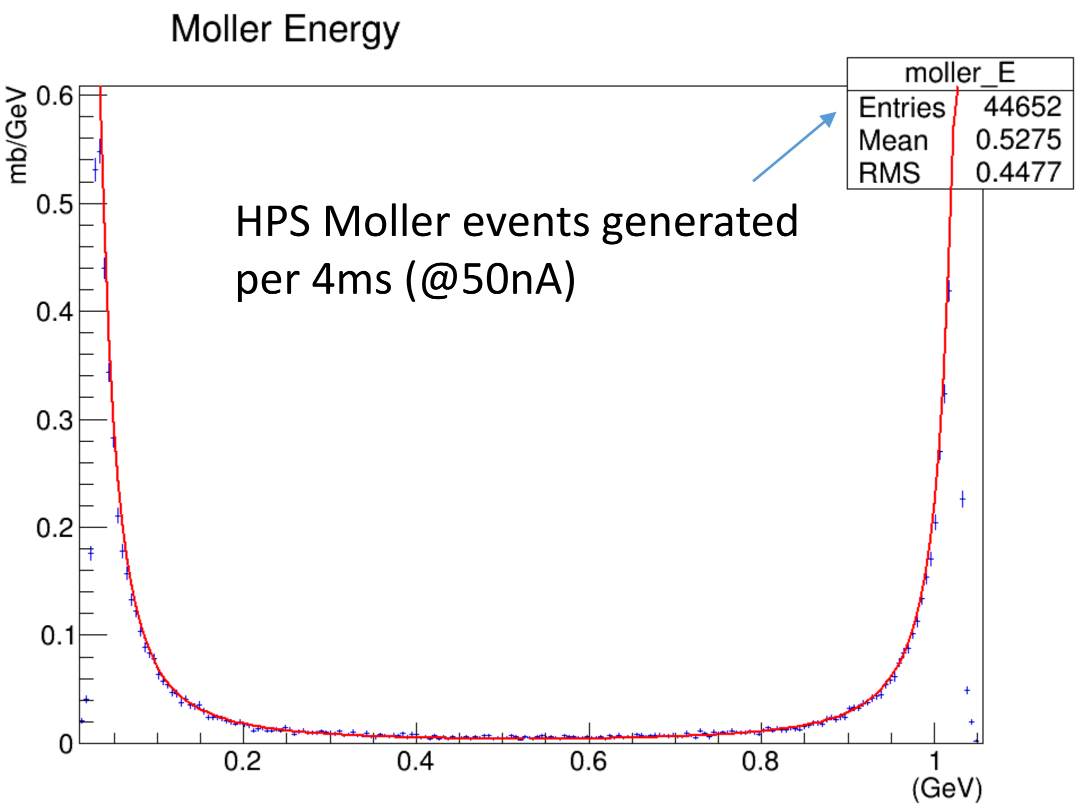
Moller Cross Section Model (Messel & Crawford)

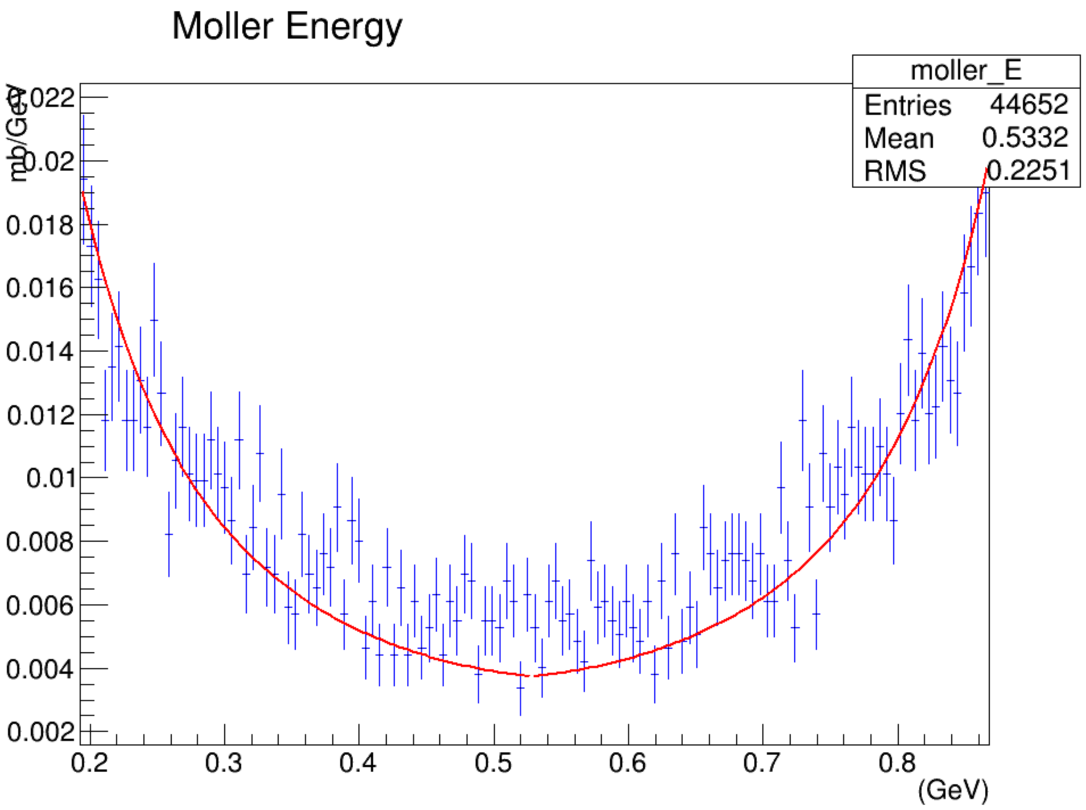
- $\{E, E_0\}$ = energy of {scattered, incident} electron
- $\{T, T_0\} = \text{kinetic energy}\,\{E - m,\ E_0 - m\}$
- $\gamma = E_0/m$
- $\beta = v/c$
- $r_0 = 1.2 * 10^{-13}cm$

$$\frac{1}{\chi_0}\frac{d\sigma(E)}{dE} = \frac{2\pi r_0^2 m}{\beta^2 T_0^2}\left[C_1 + \frac{1}{\varepsilon(E)}\left(\frac{1}{\varepsilon(E)} - C_2\right) + \frac{1}{\varepsilon'(E)}\left(\frac{1}{\varepsilon'(E)} - C_2\right)\right]$$

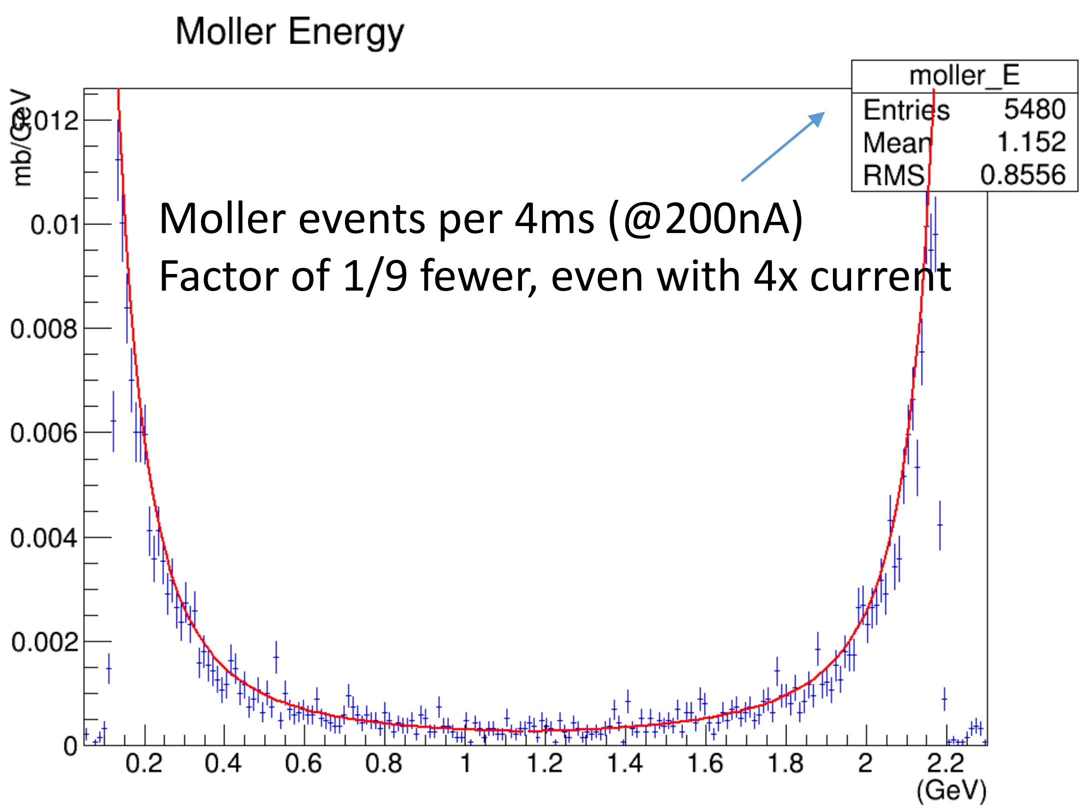
- $\varepsilon(E) = T/T_0$
- $\varepsilon'(E) = 1 - \varepsilon$
- $C_1 = [(\gamma - 1)/\gamma]^2$
- $C_2 = (2\gamma - 1)/\gamma^2$

Generated Moller Cross Section (1.056 GeV)

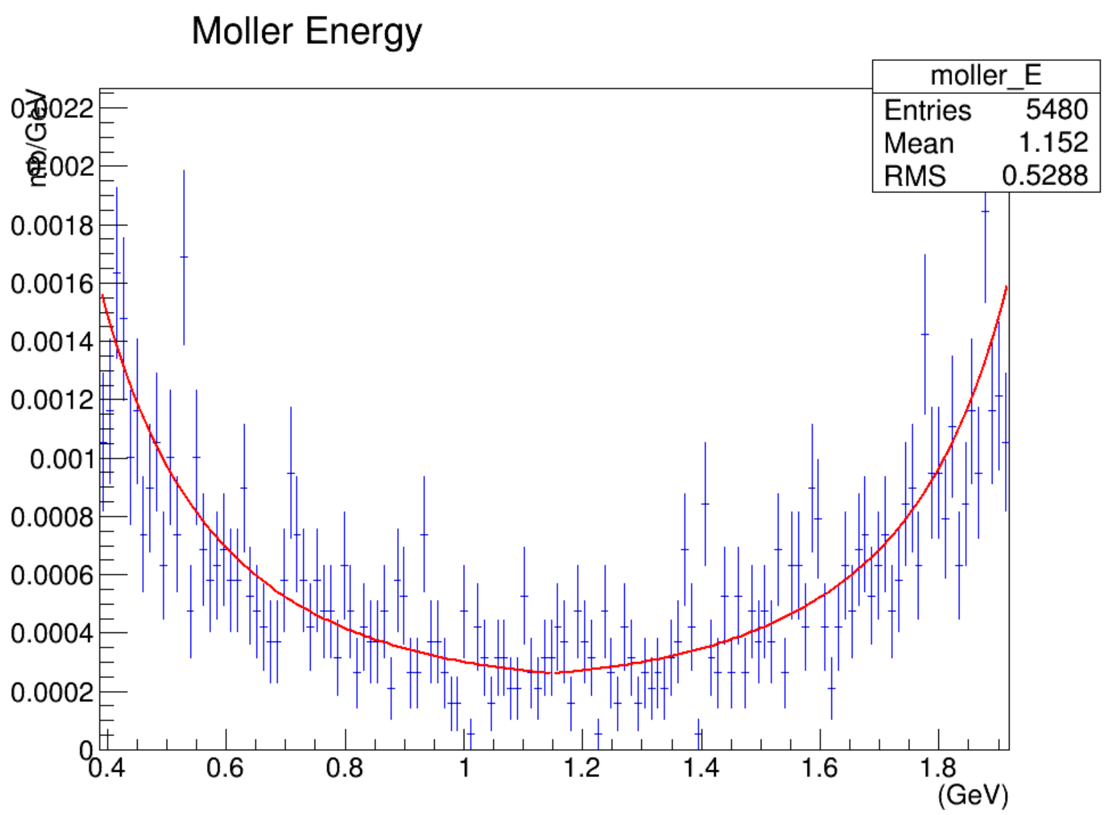




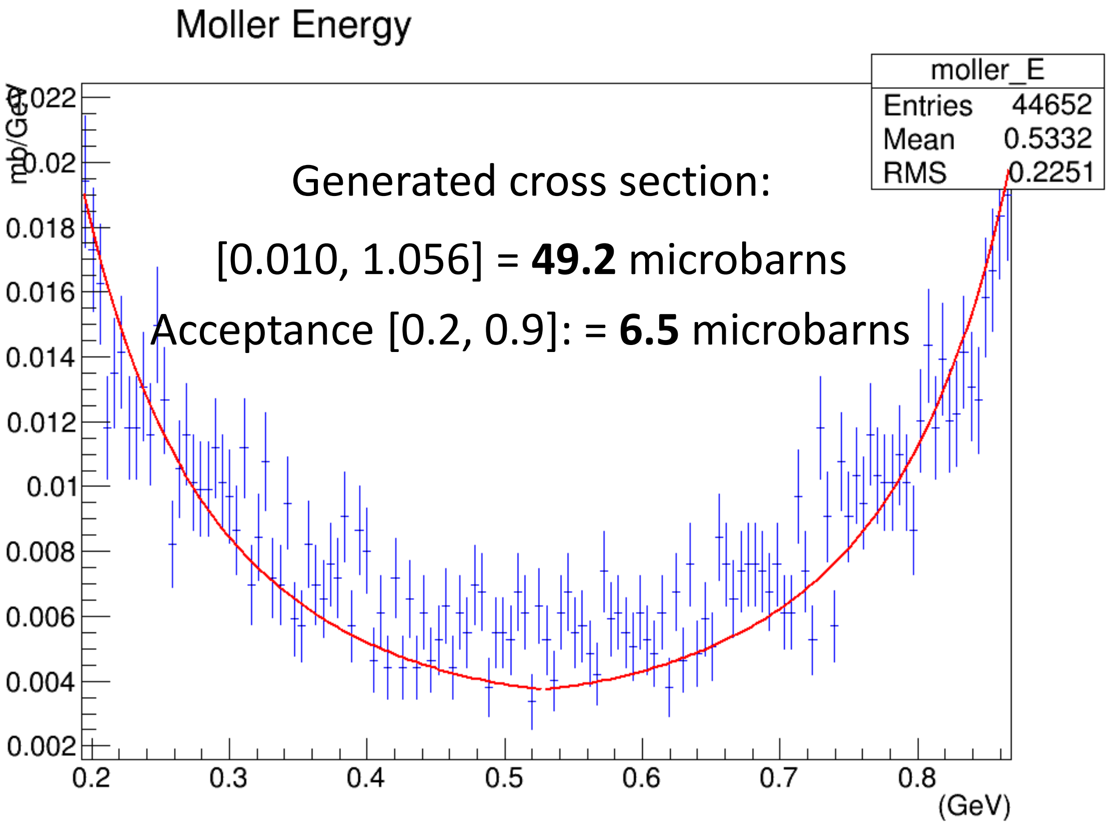
Generated Moller Cross Section (2.3 GeV)



Moller events per 4ms (@200nA)
Factor of 1/9 fewer, even with 4x current



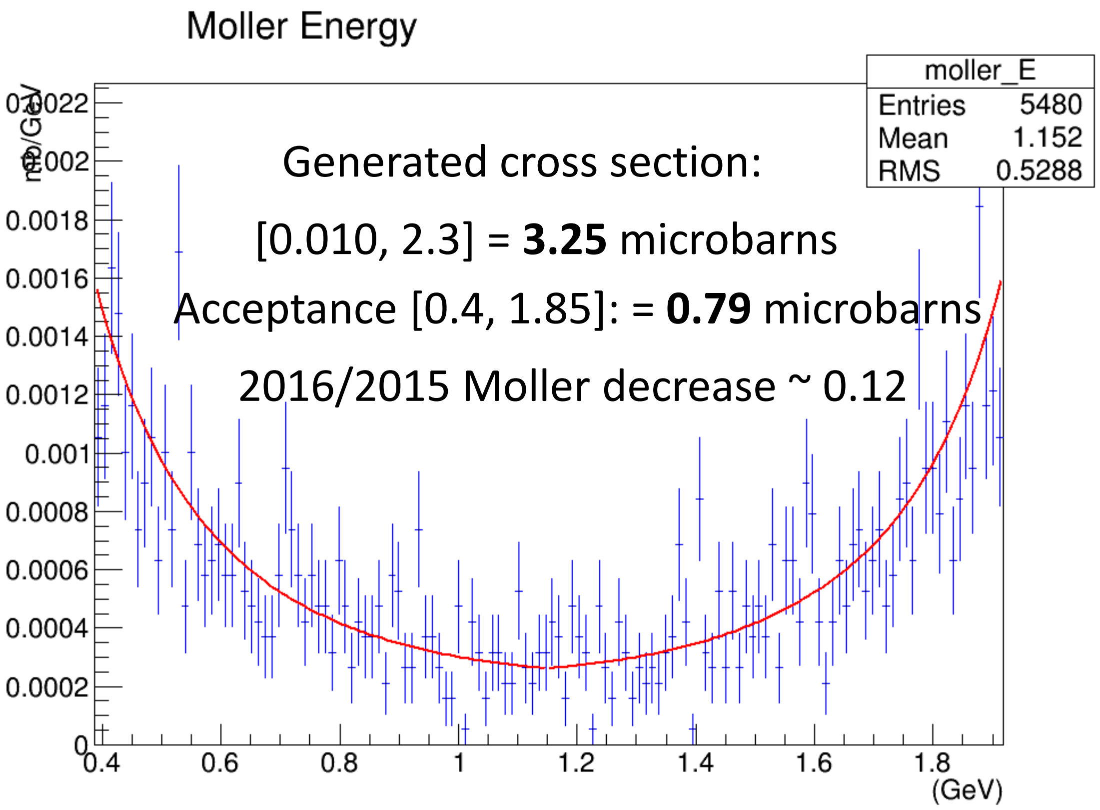
Generated Moller Cross Section (1.05 vs. 2.3 GeV)



Generated cross section:

[0.010, 1.056] = **49.2** microbarns

Acceptance [0.2, 0.9]: = **6.5** microbarns



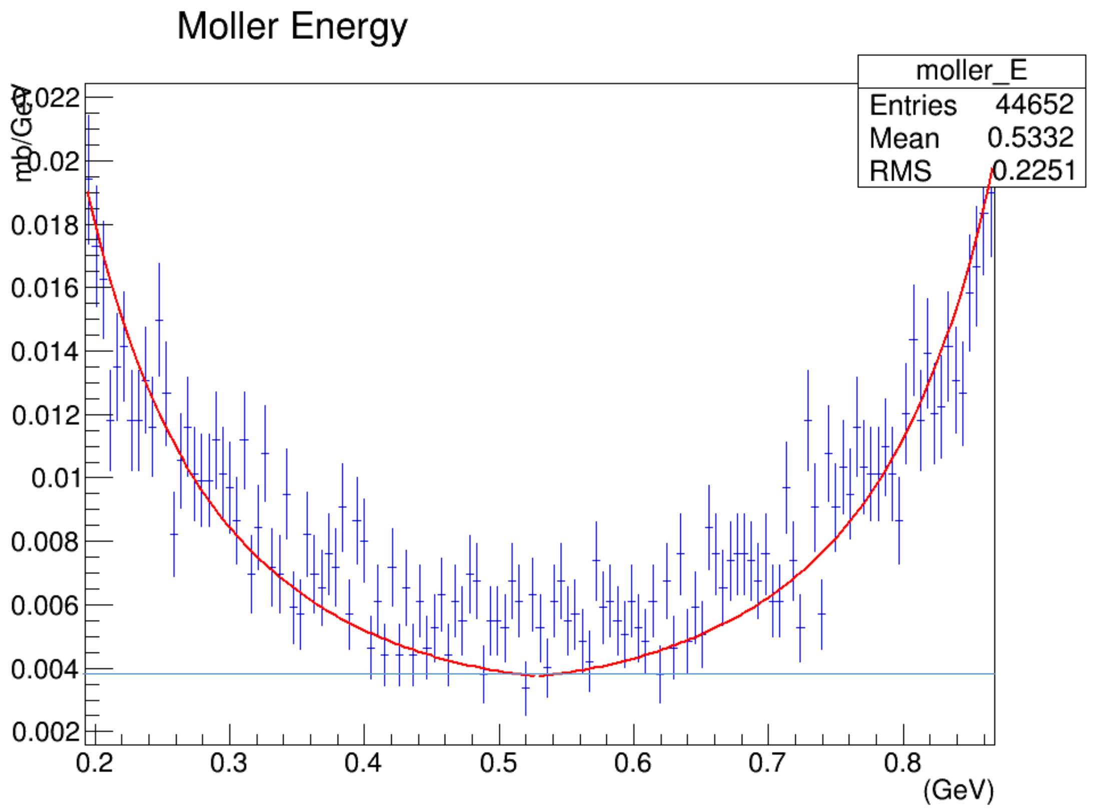
Generated cross section:

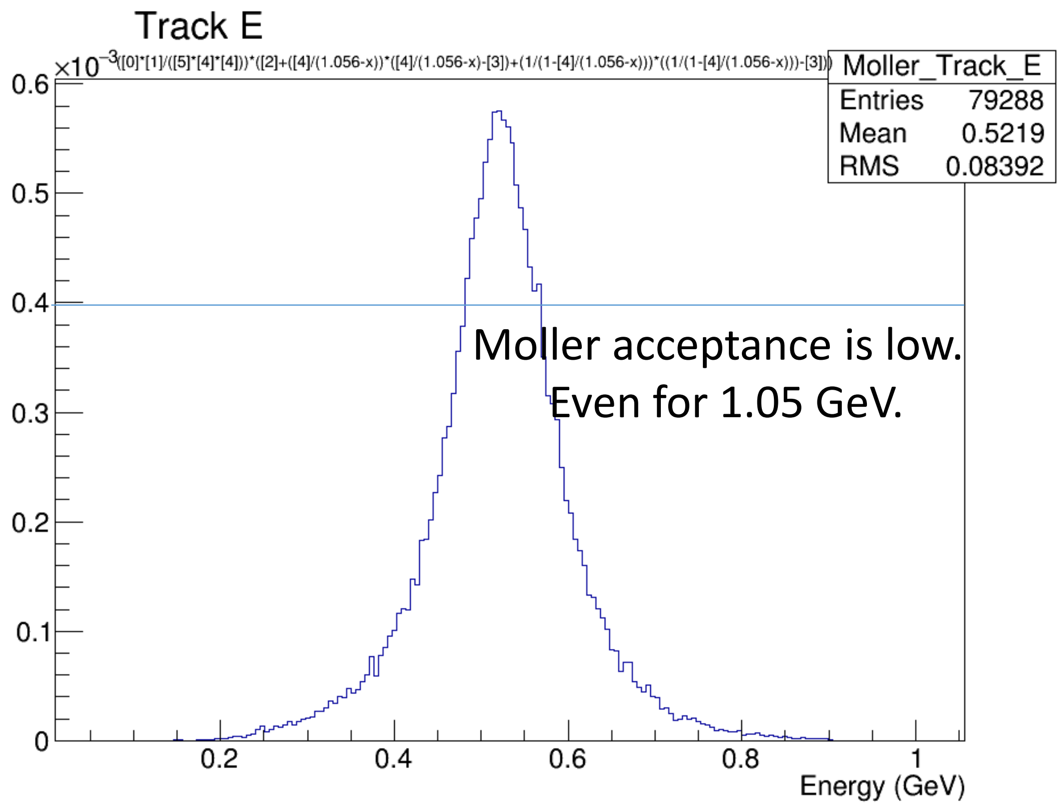
[0.010, 2.3] = **3.25** microbarns

Acceptance [0.4, 1.85]: = **0.79** microbarns

2016/2015 Moller decrease ~ 0.12

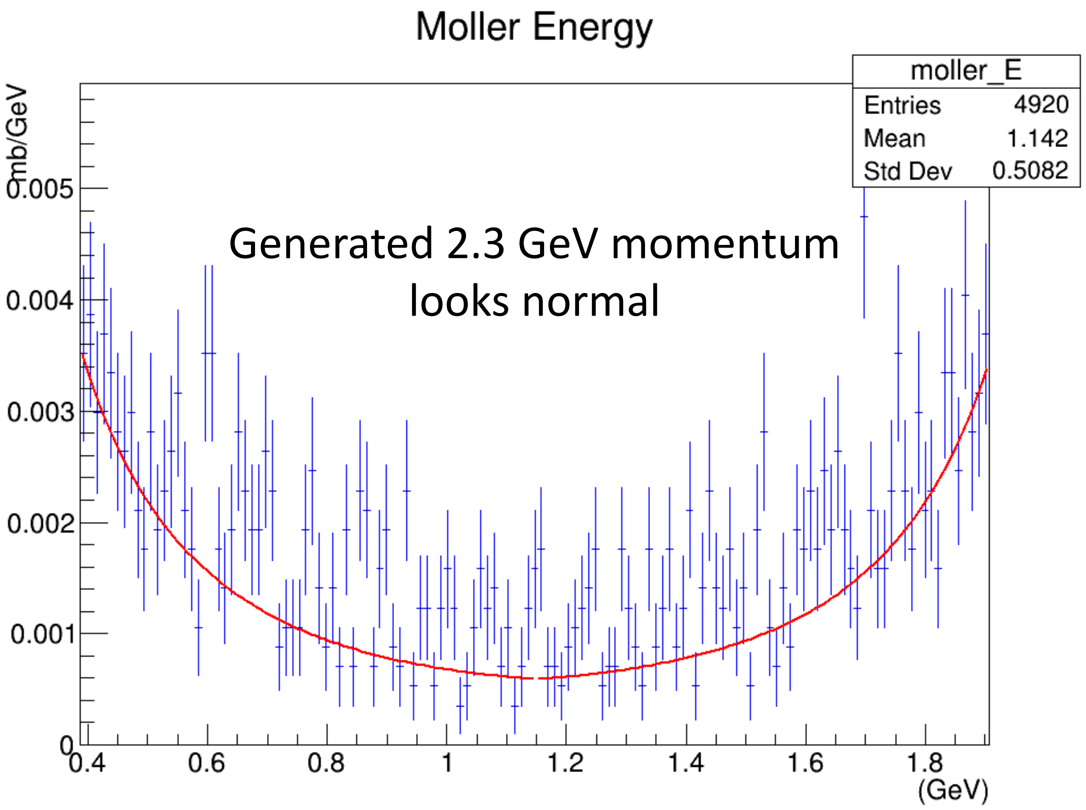
Generated vs. Recon (1.056 GeV)



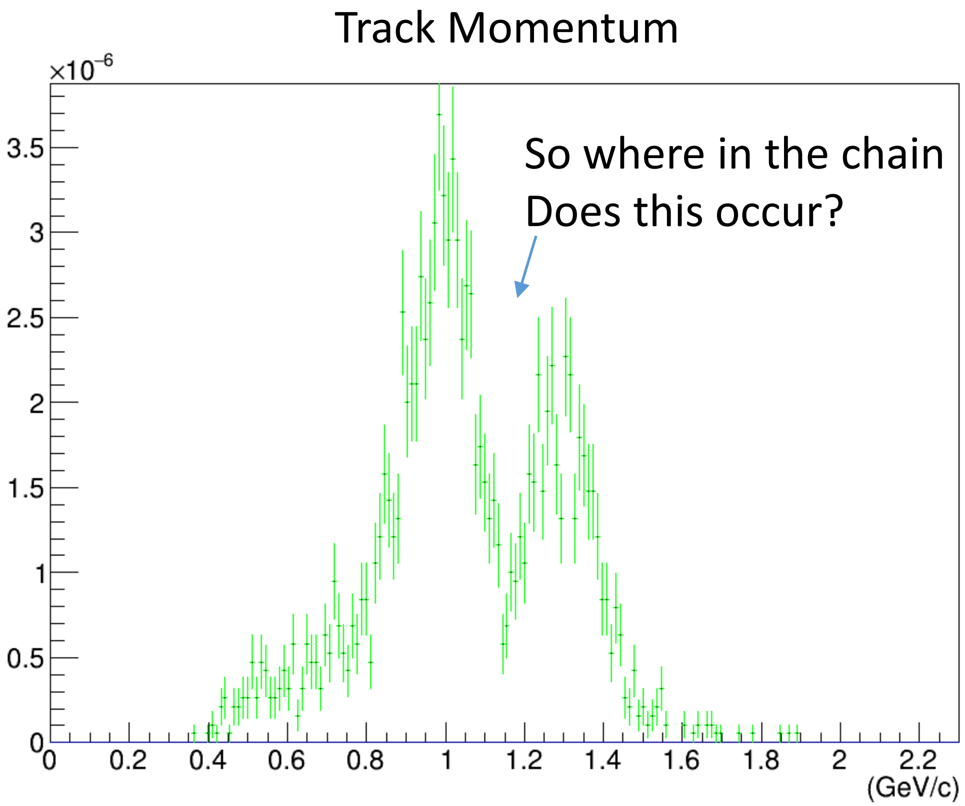


Moller acceptance is low.
Even for 1.05 GeV.

Generated vs. Recon (2.3 GeV)

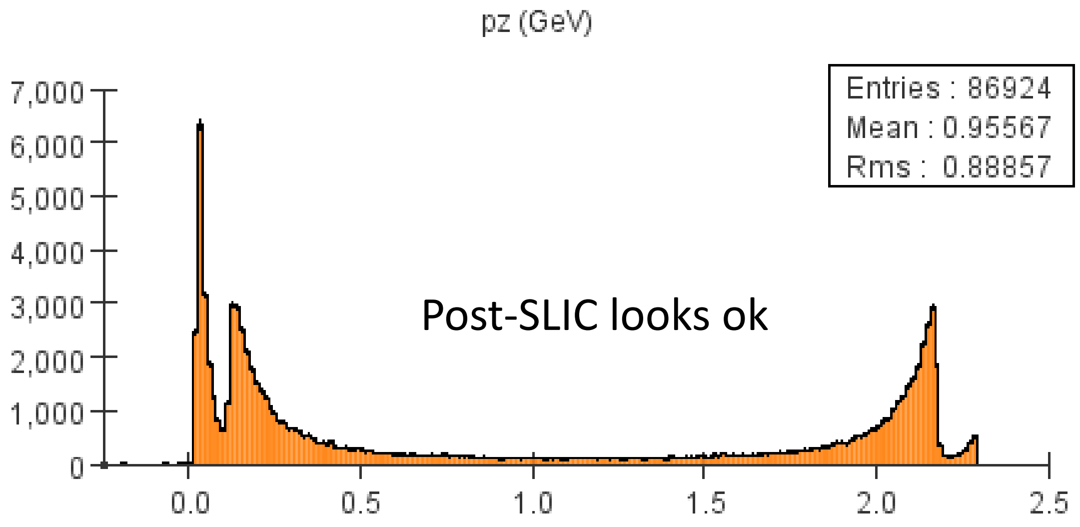


Generated 2.3 GeV momentum looks normal

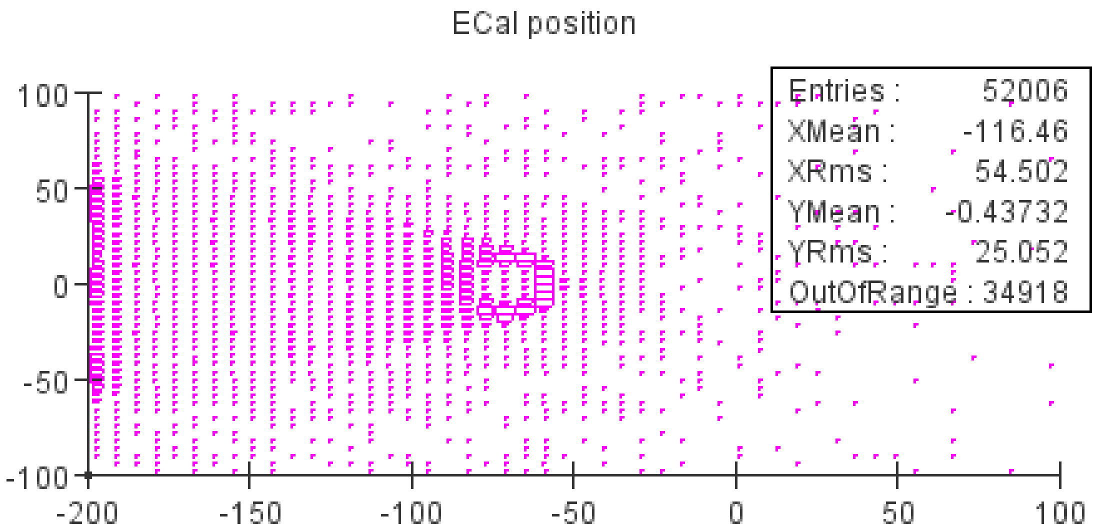


So where in the chain Does this occur?

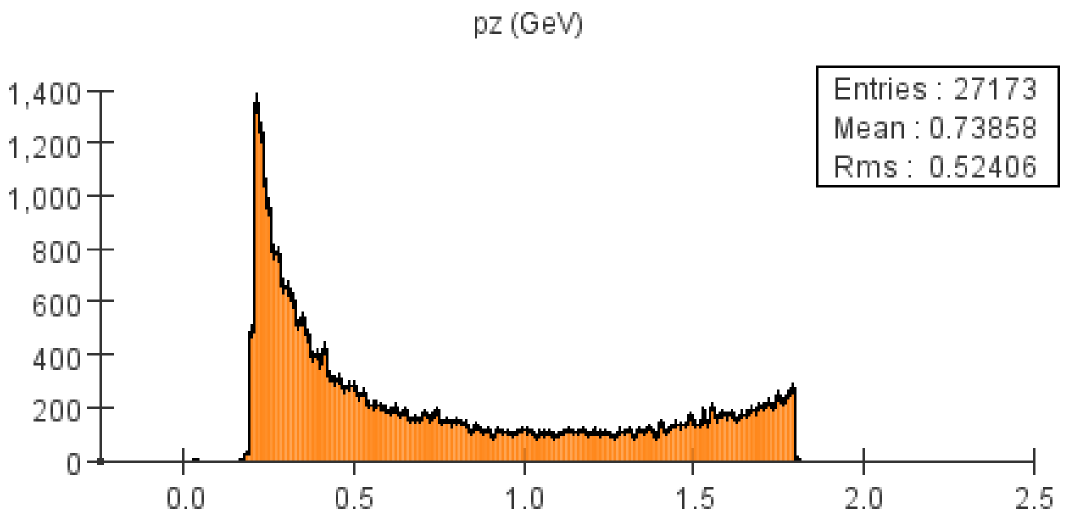
SLIC (uncut MC Particles)

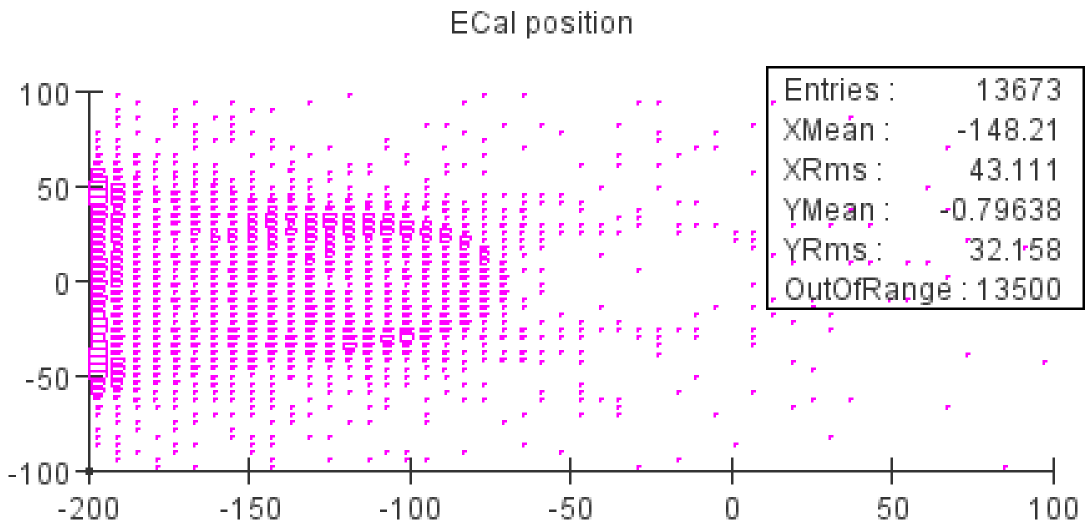


Post-SLIC looks ok

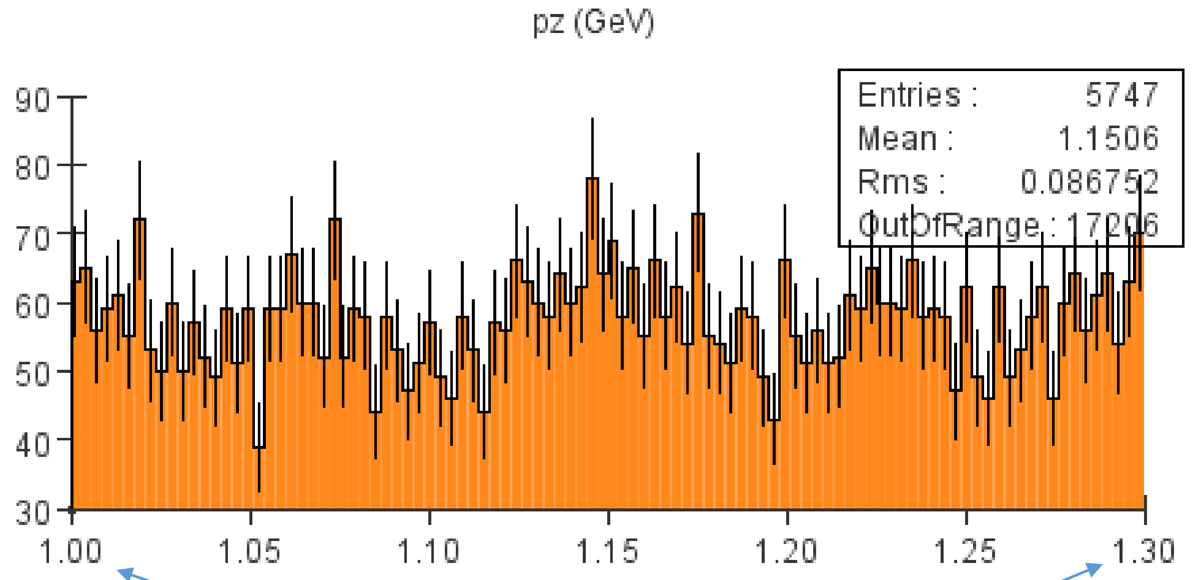


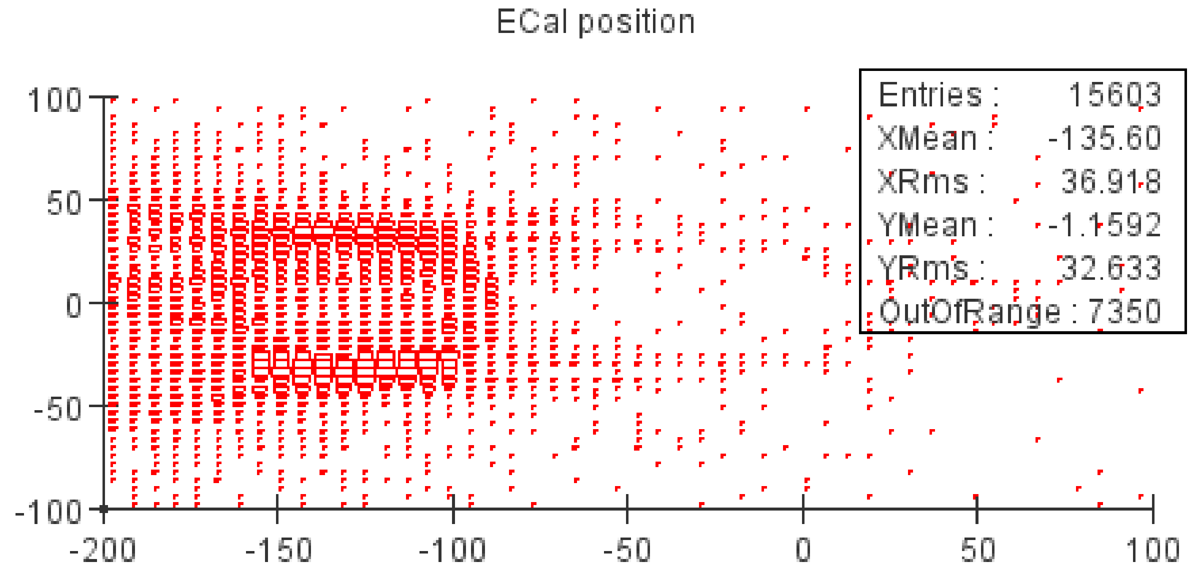
SLIC (MCP momentum: 0.2 - 1.8 GeV)

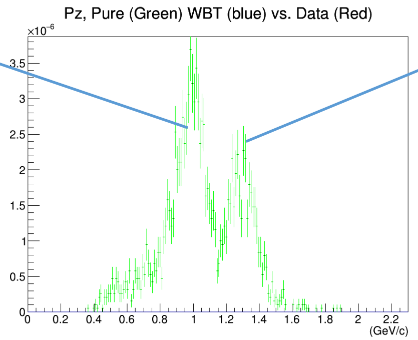




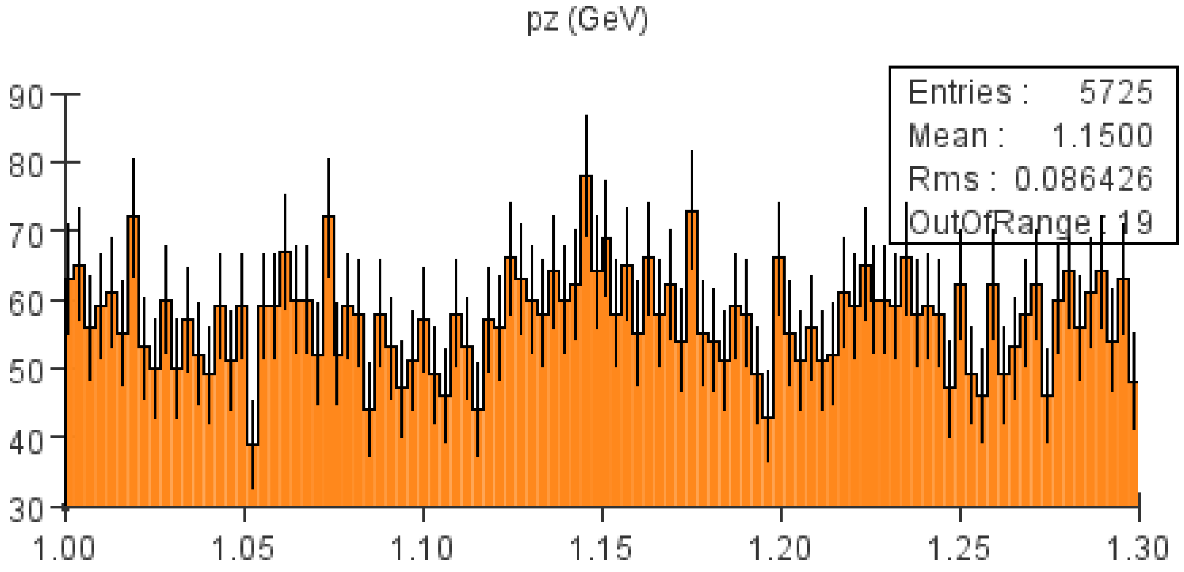
SLIC (MCP momentum: 0.6 - 1.6 GeV)

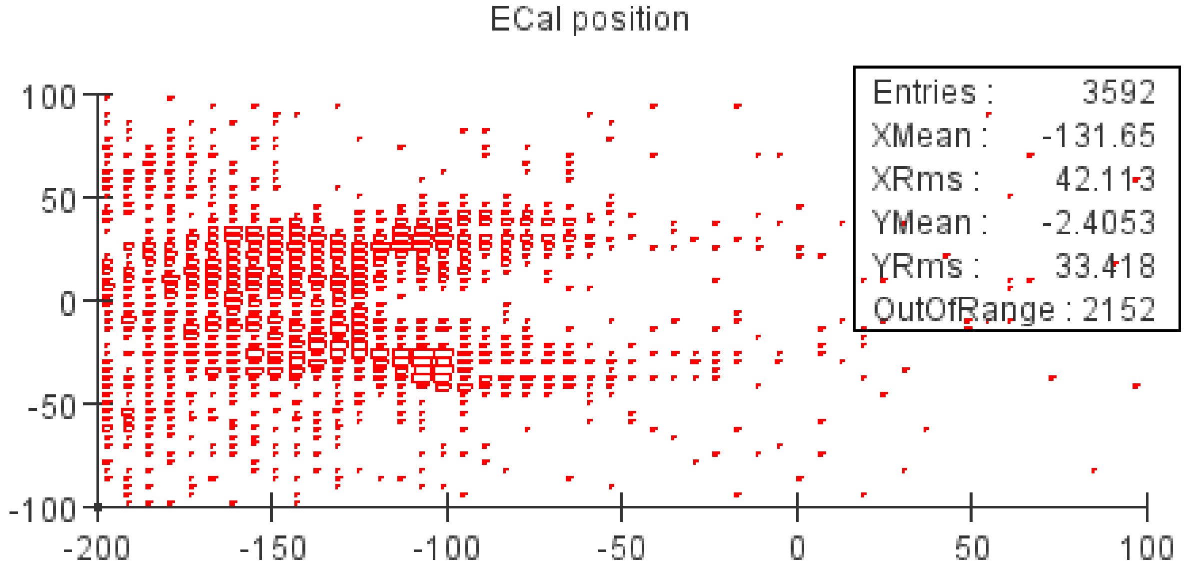




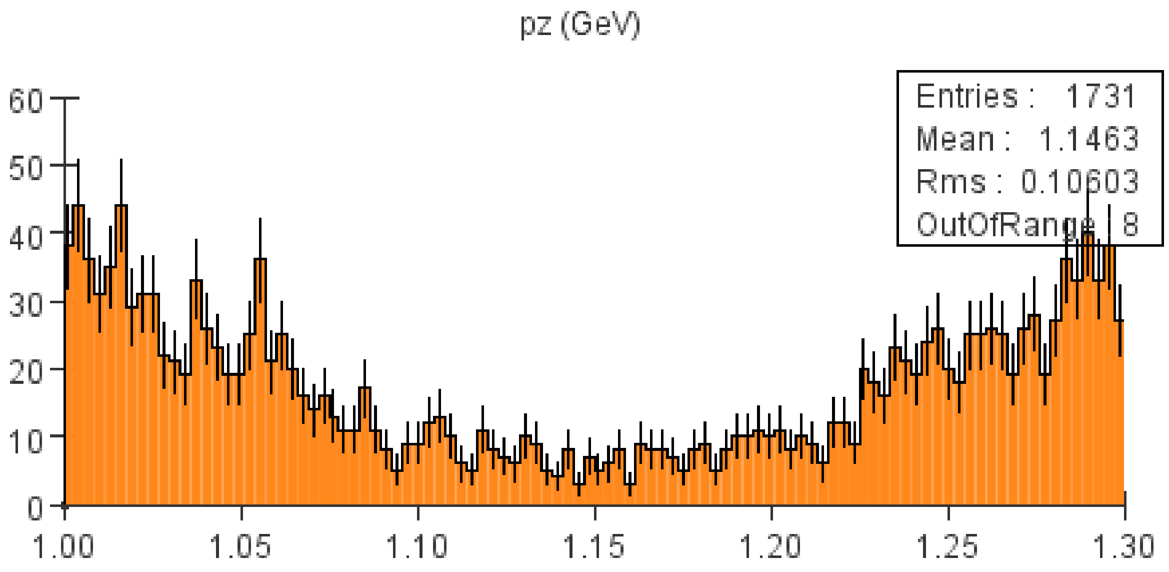


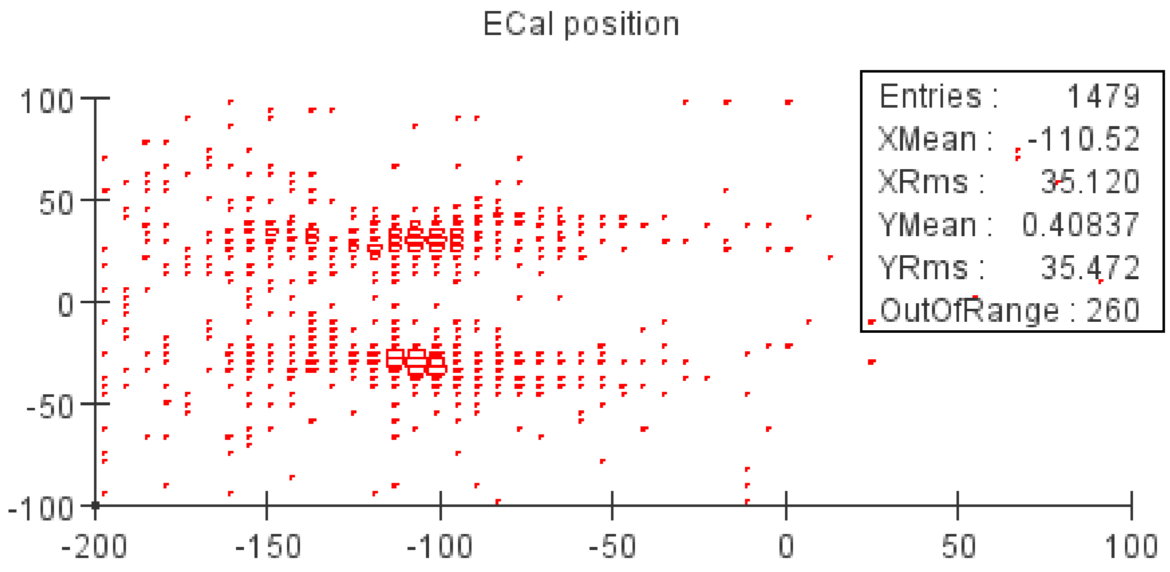
SLIC (MCP momentum: 1 - 1.3 GeV)





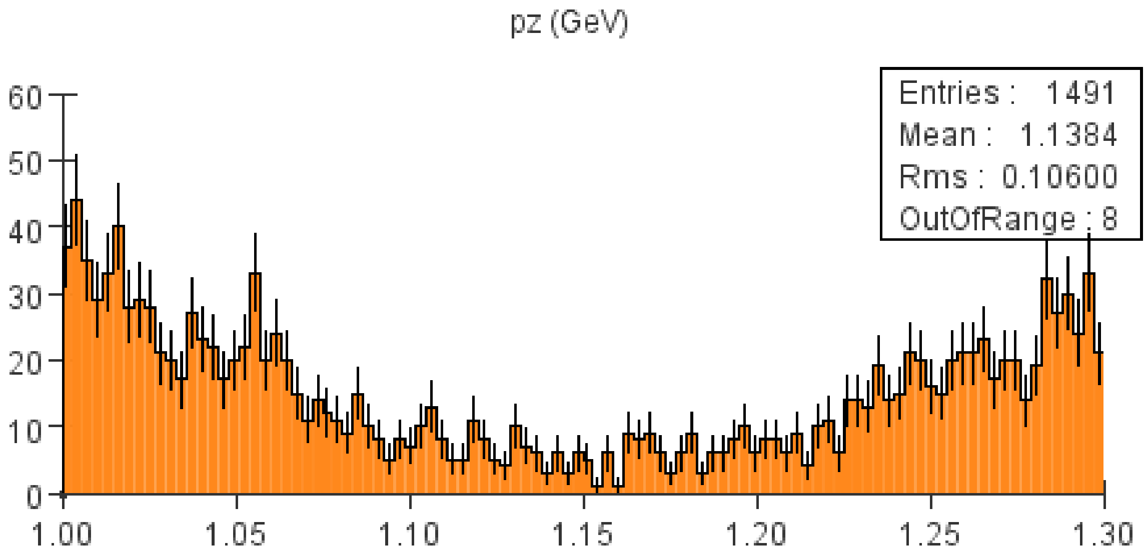
Readout (MCP momentum: 1 - 1.3 GeV)

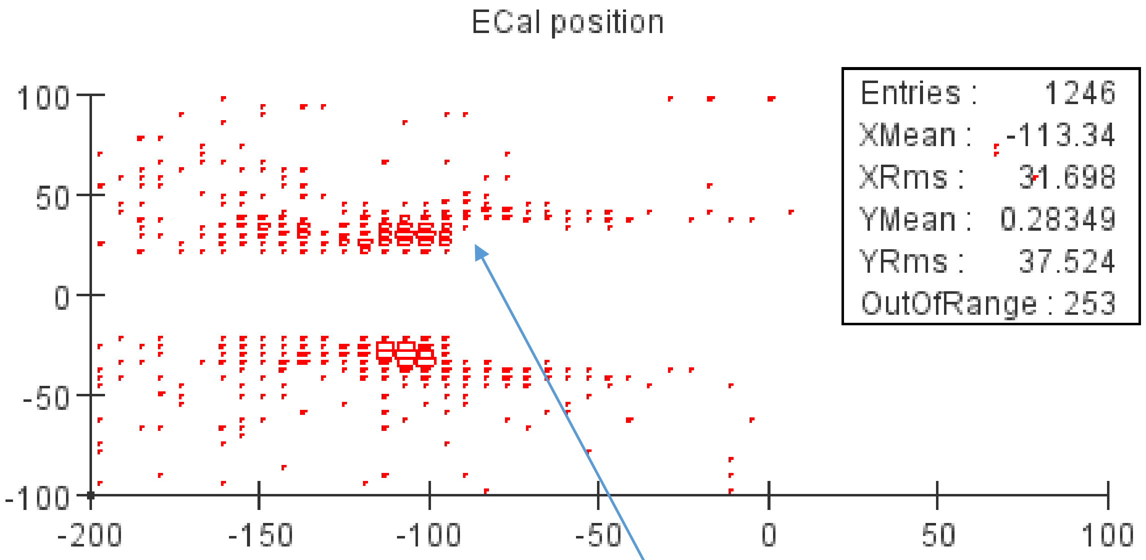




These events get rejected at the readout level, before tracks are assigned.
What are these clusters like?

Readout (MCP momentum: 1 - 1.3 GeV)

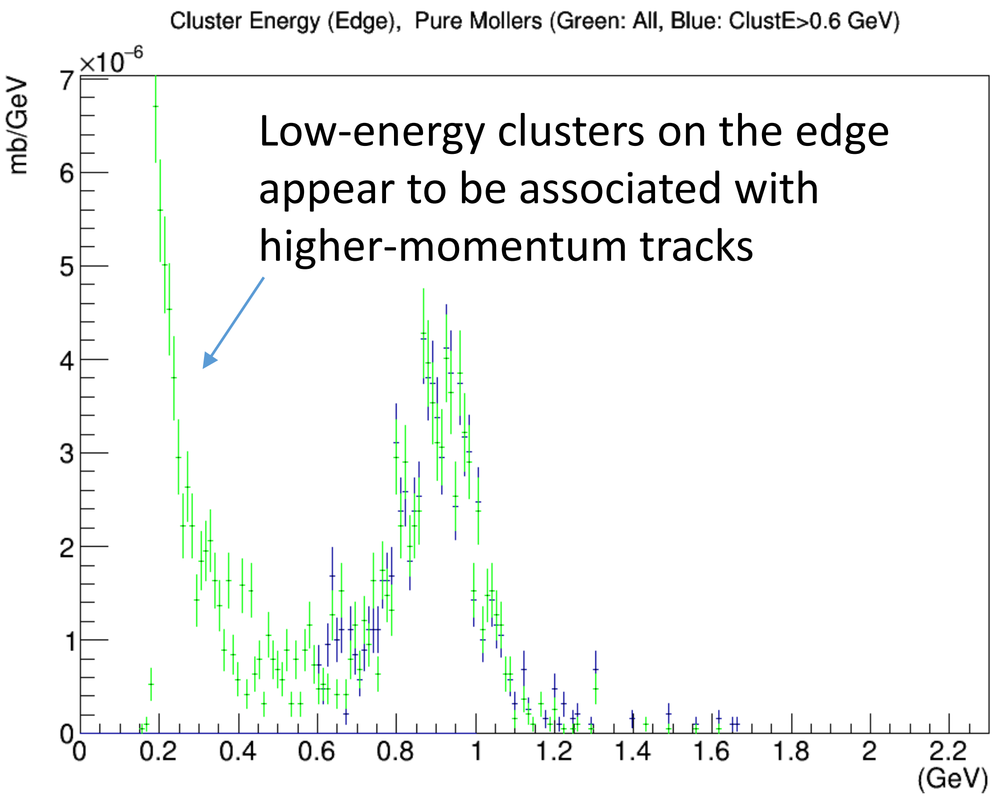


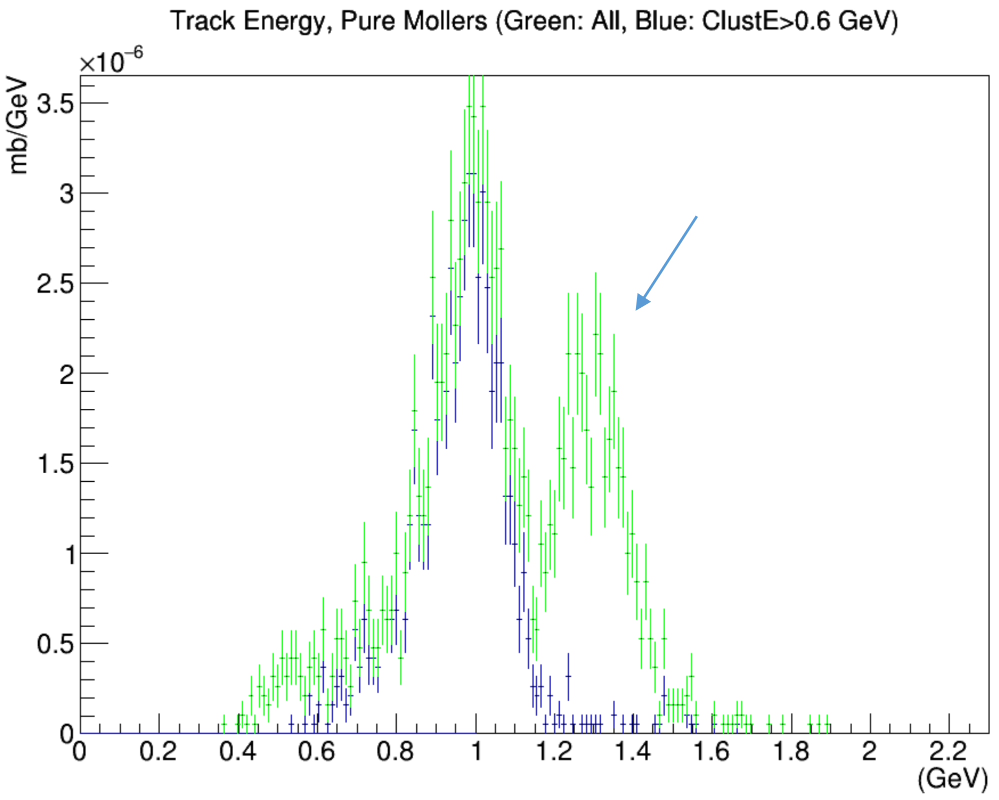


very near the edge

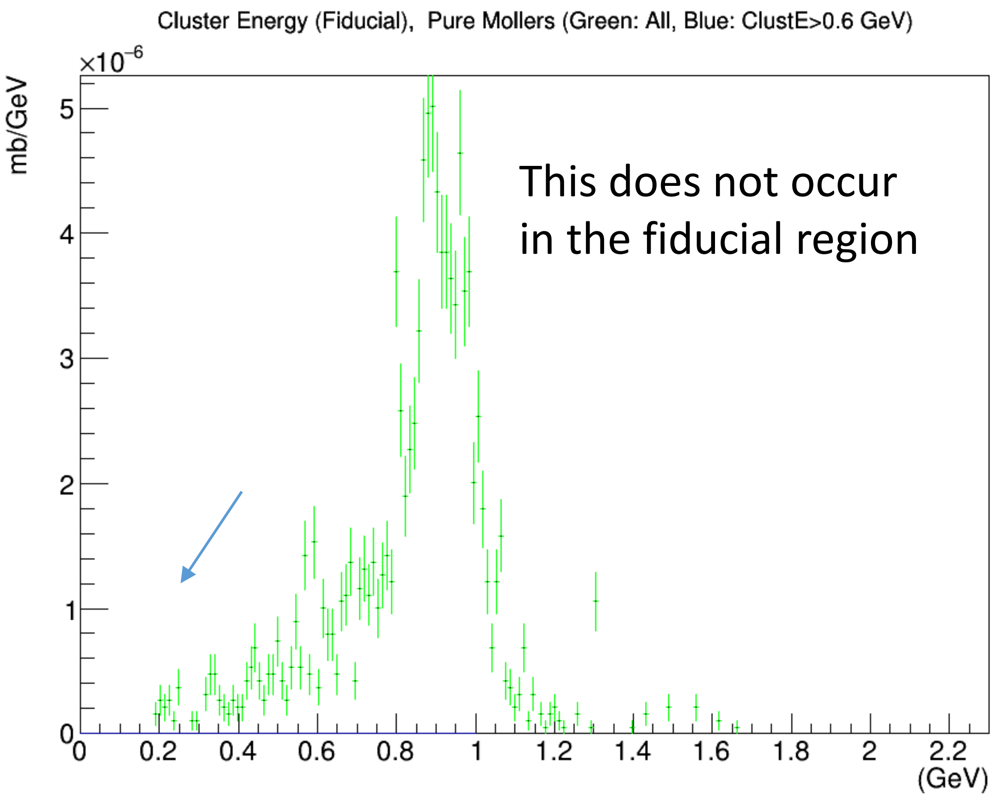
These events get rejected at the readout level, before tracks are assigned.
What are these clusters like?

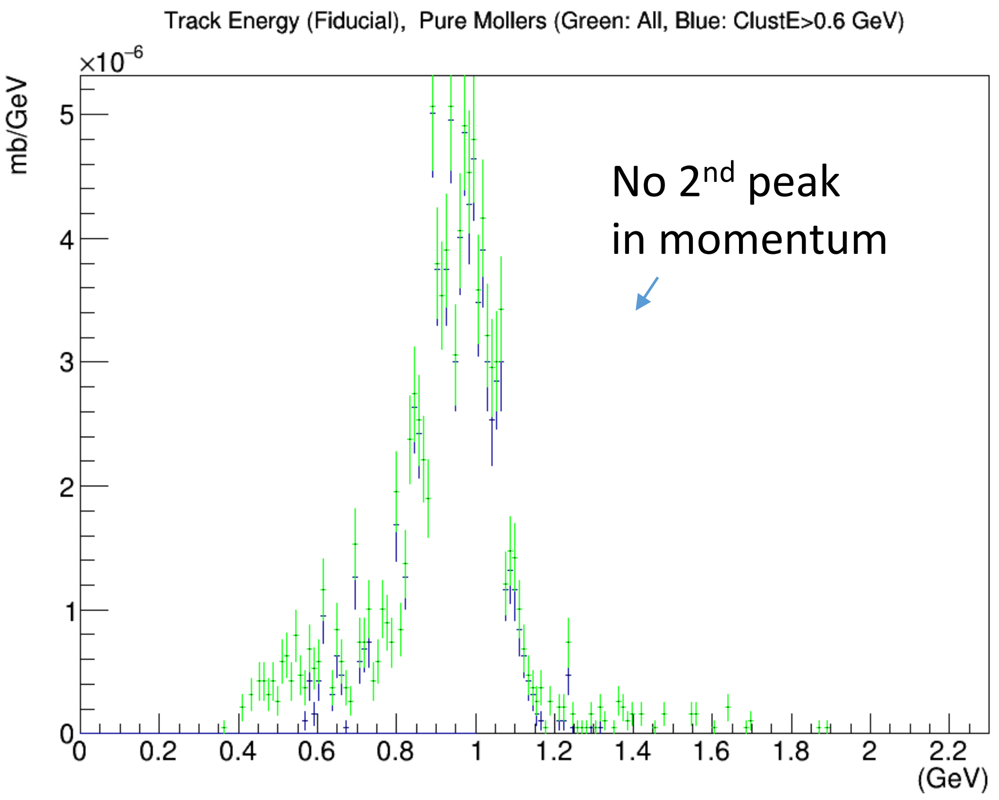
Cluster vs. Track (edge)



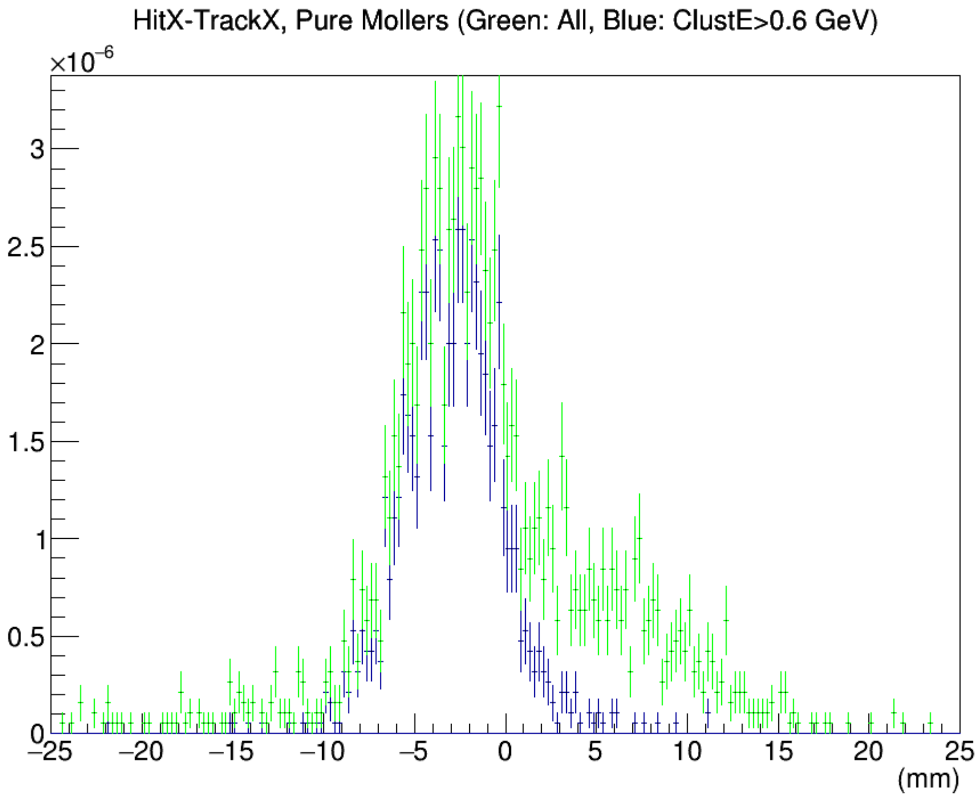


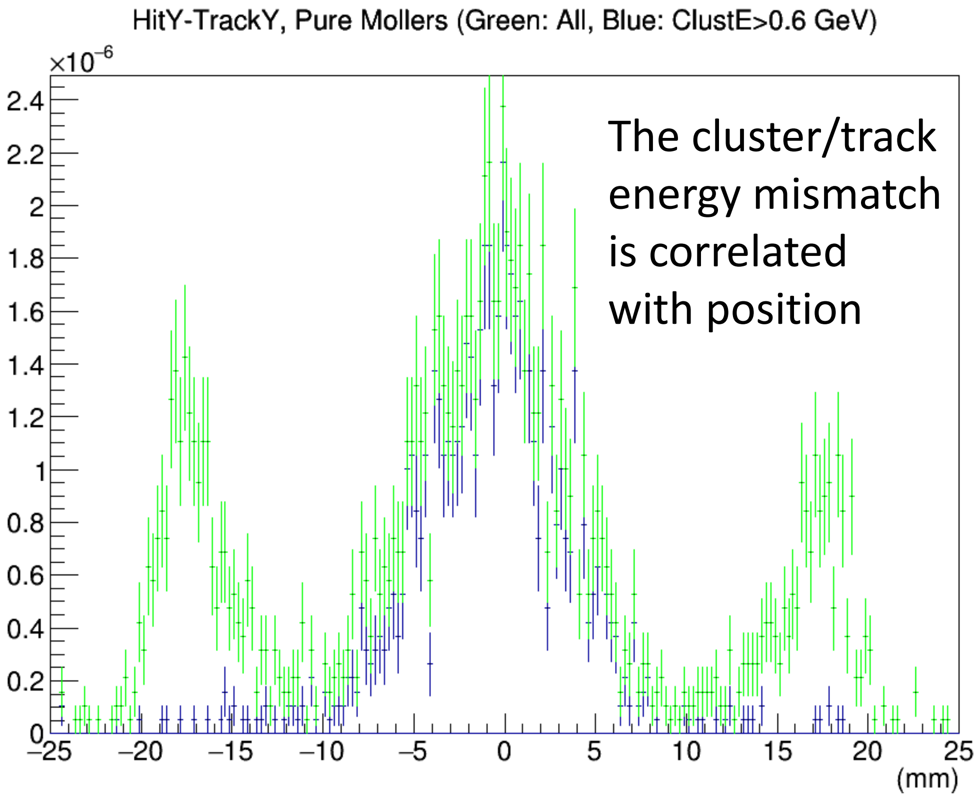
Cluster vs. Track (fiducial)



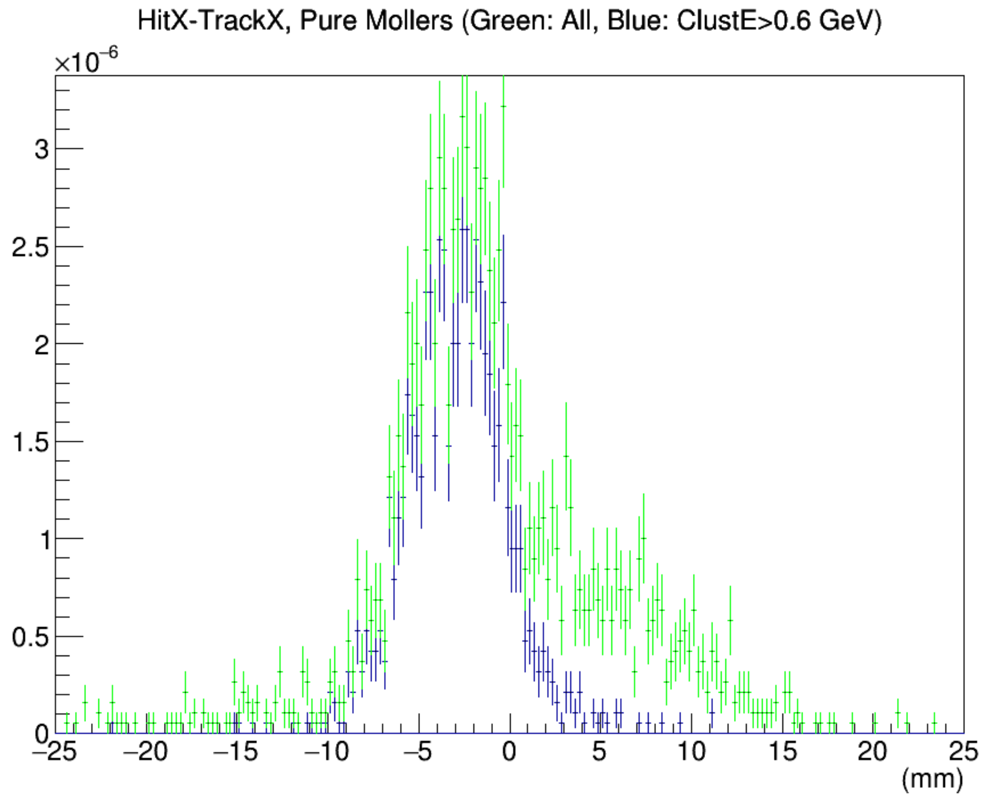


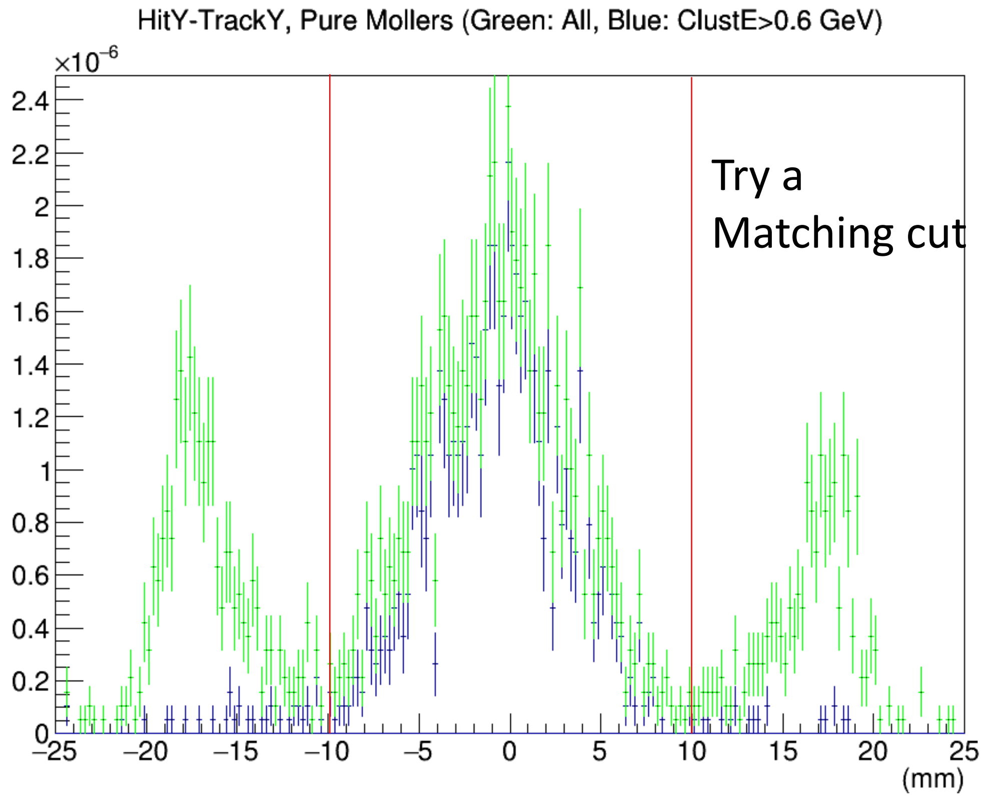
Cluster-Track matching



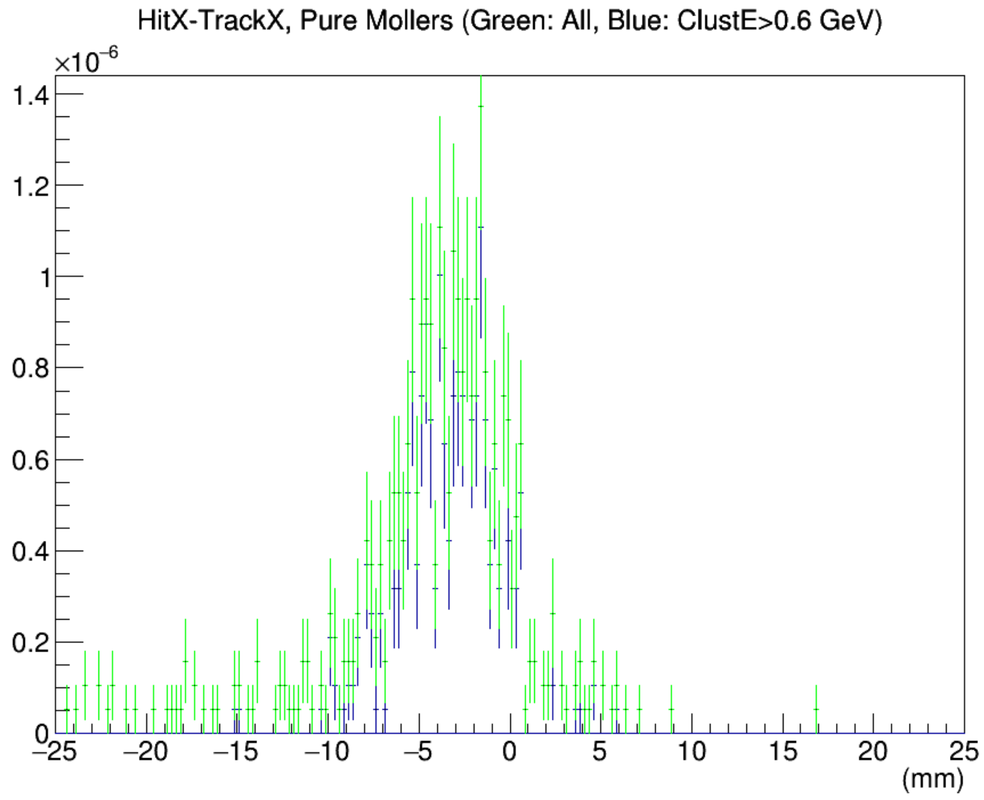


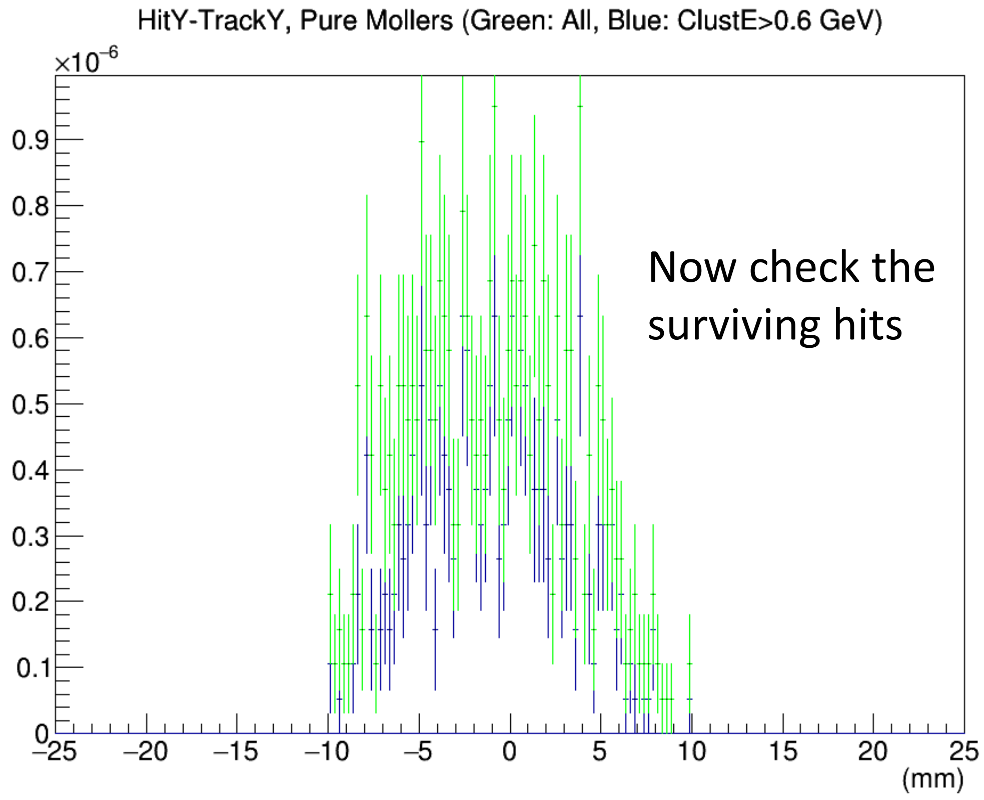
Cluster-Track matching





Cluster-Track matching

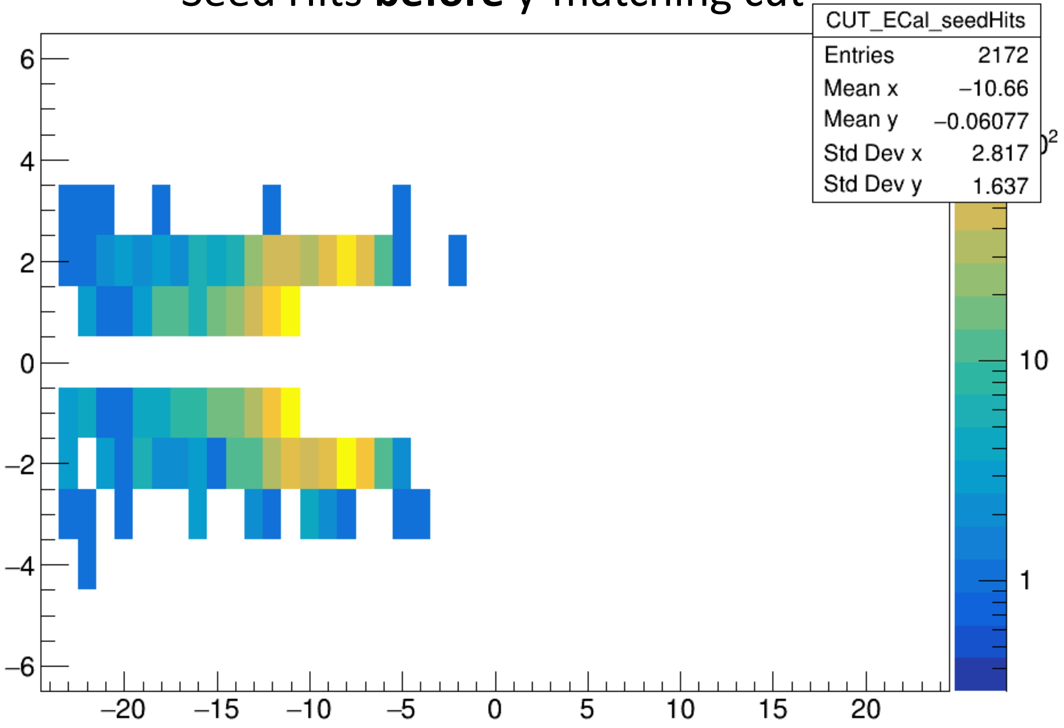




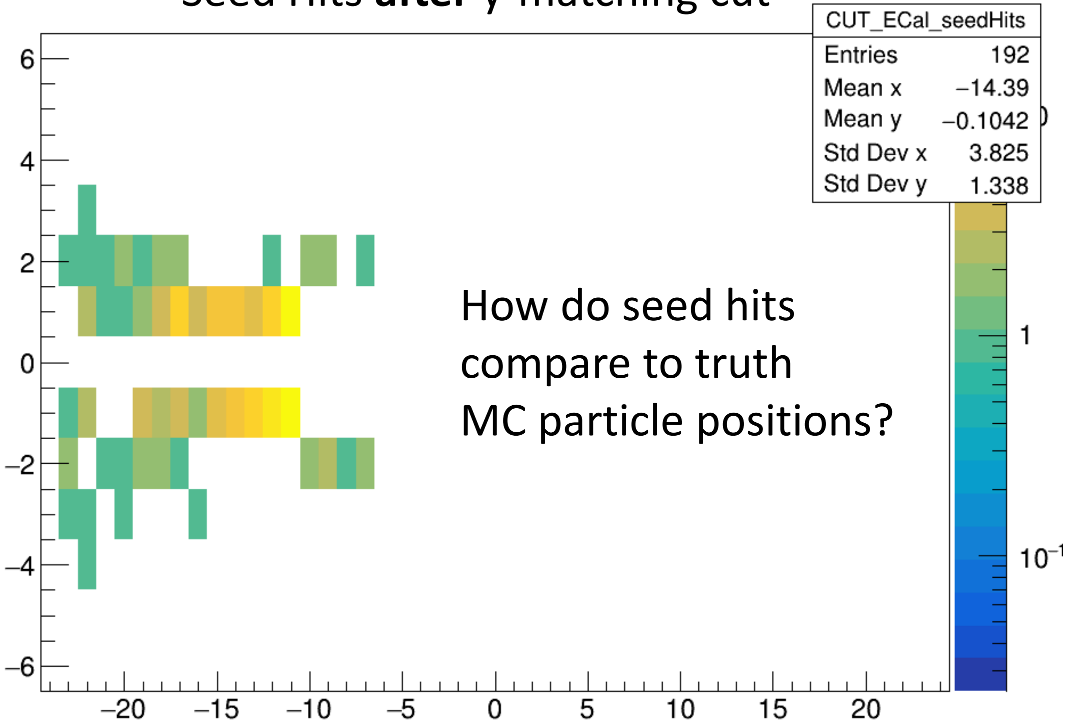
Now check the surviving hits

Cluster-Track matching

Seed Hits **before** y-matching cut



Seed Hits **after** y-matching cut

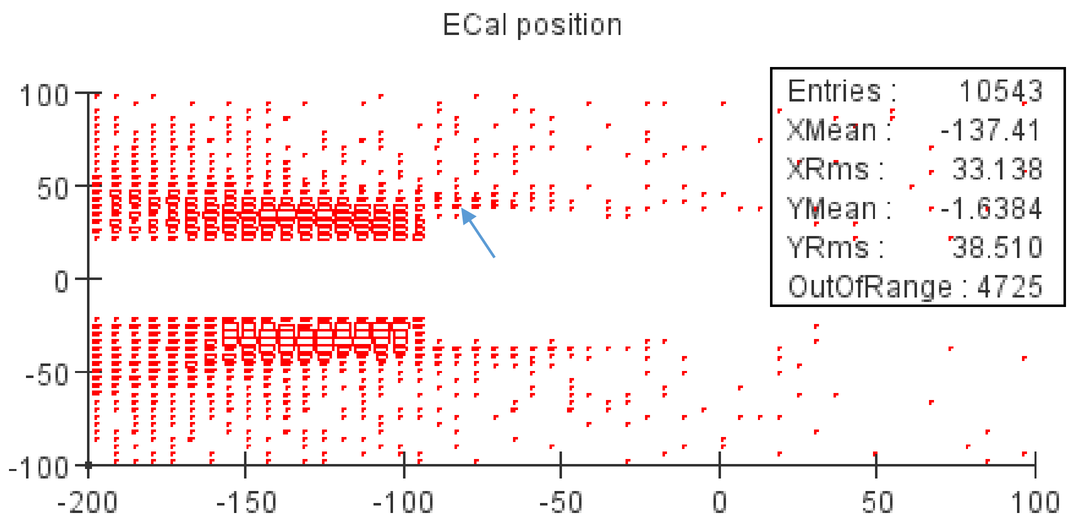


How do seed hits compare to truth MC particle positions?

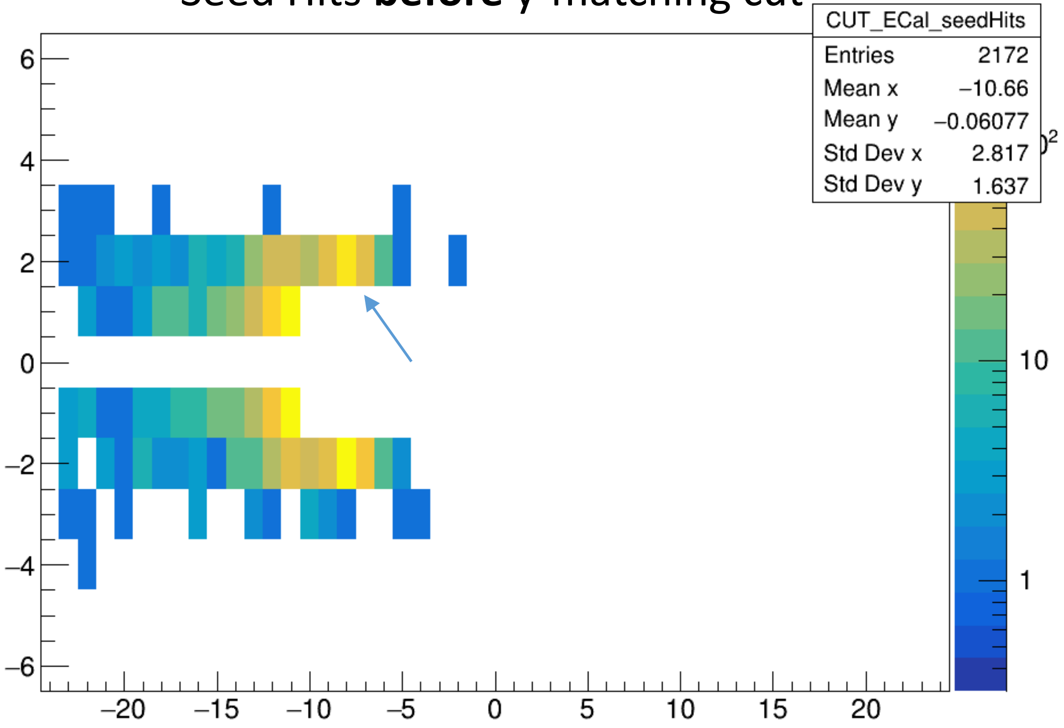
Cluster-Track matching

Range of the double-peak in MC

SLIC MC particles **P[0.6, 1.6 GeV]**

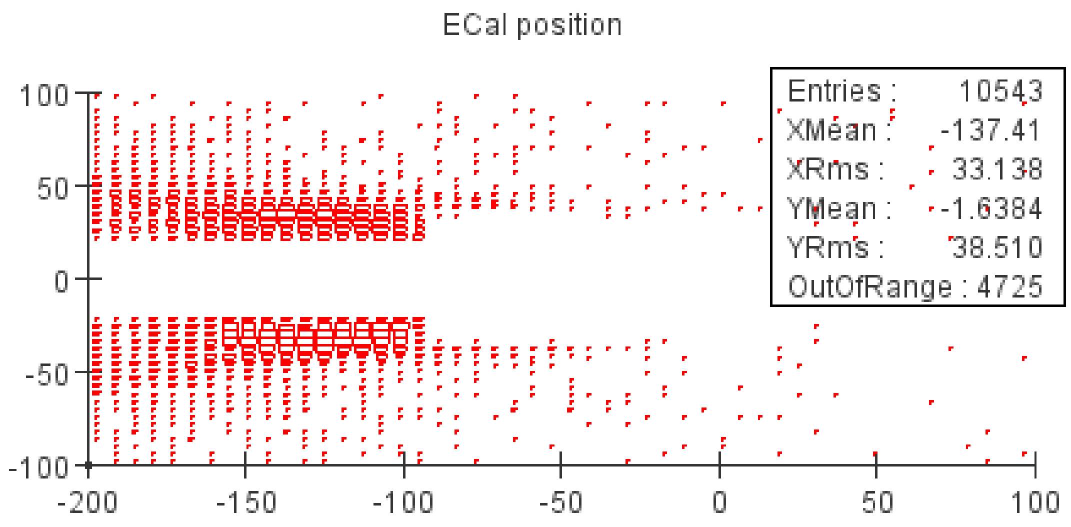


Seed Hits **before** y-matching cut

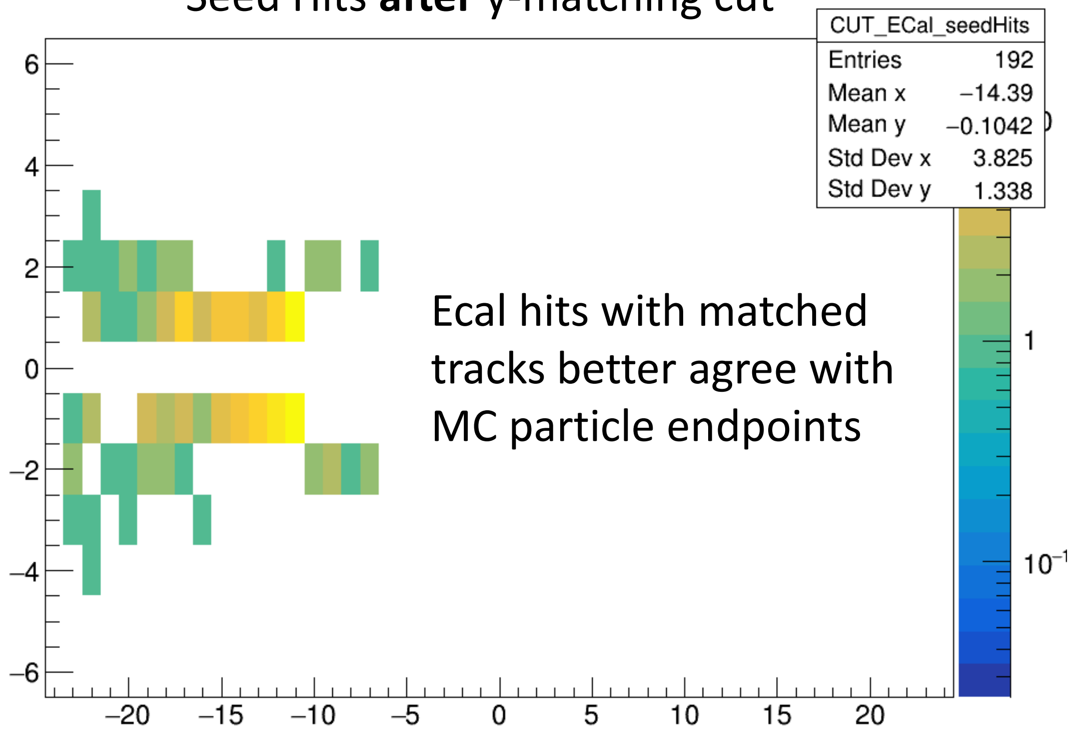


Cluster-Track matching

SLIC MC particles **P[0.6, 1.6 GeV]**



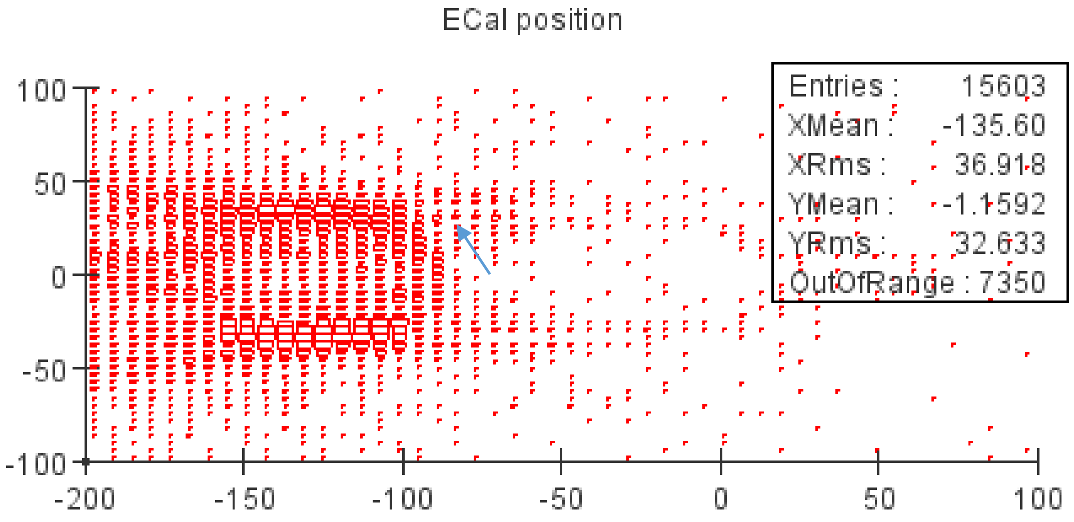
Seed Hits **after** y-matching cut



Ecal hits with matched tracks better agree with MC particle endpoints

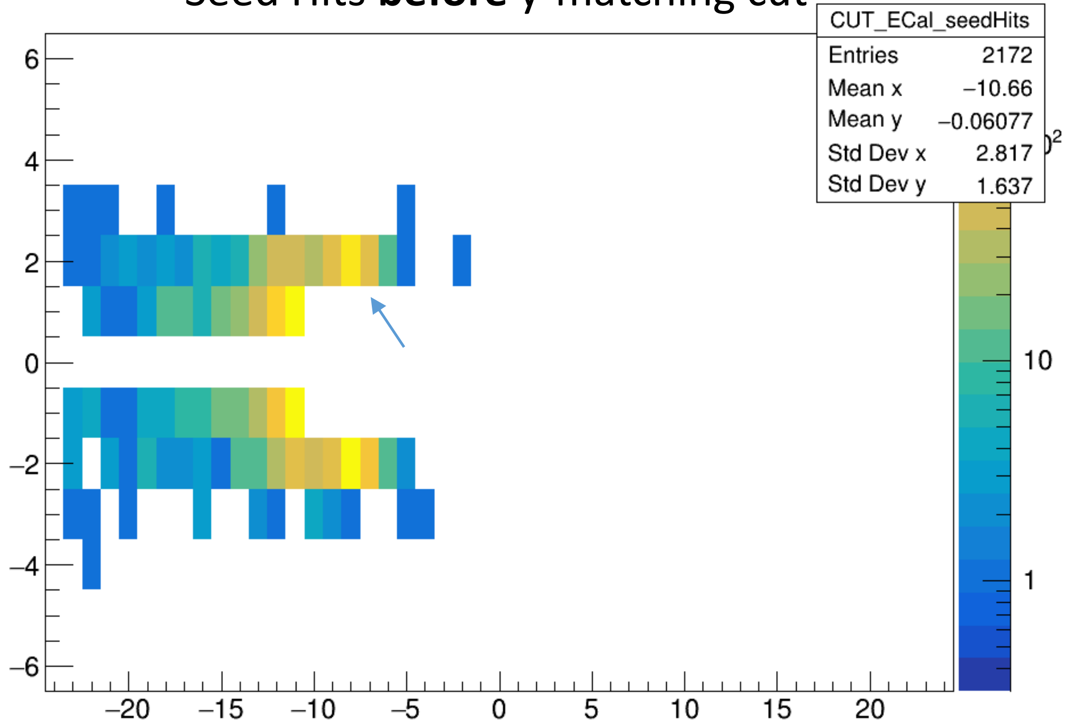
Cluster-Track matching

SLIC MC particles **P[0.6, 1.6 GeV]**



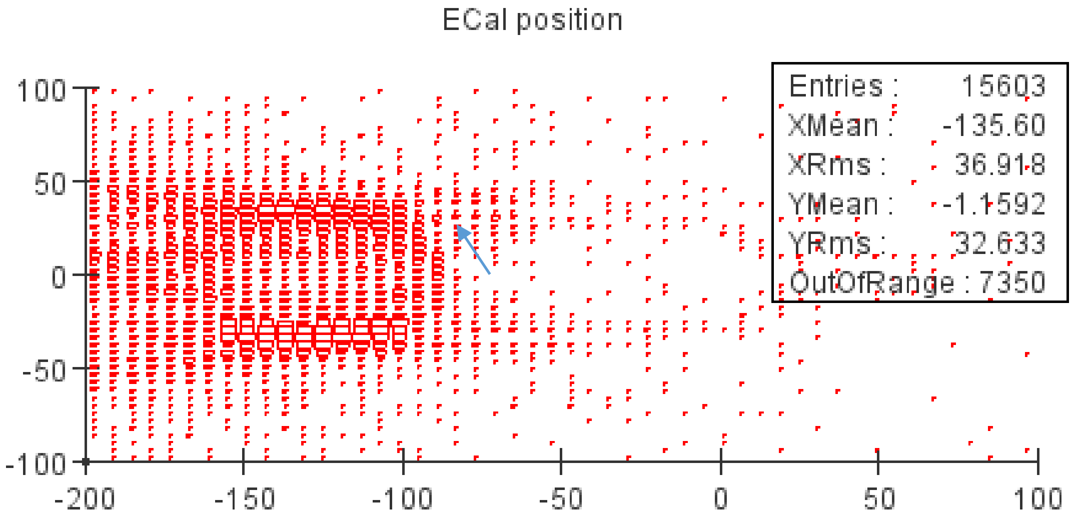
Adding back the unaccepted particles

Seed Hits **before** y-matching cut

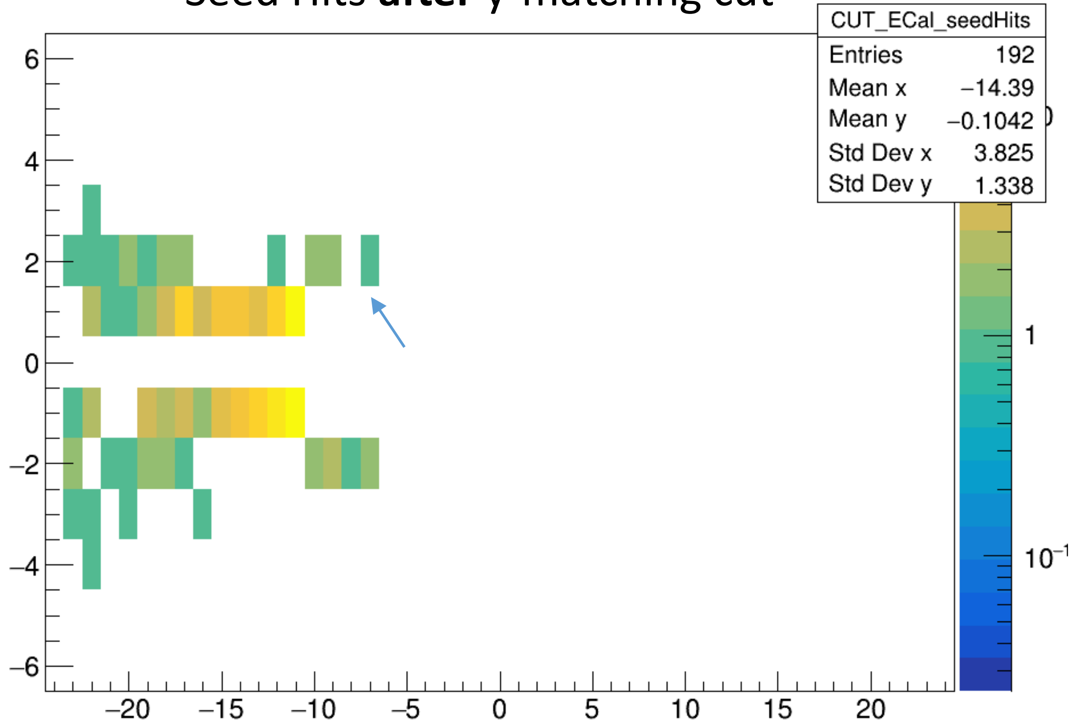


Cluster-Track matching

SLIC MC particles **P[0.6, 1.6 GeV]**

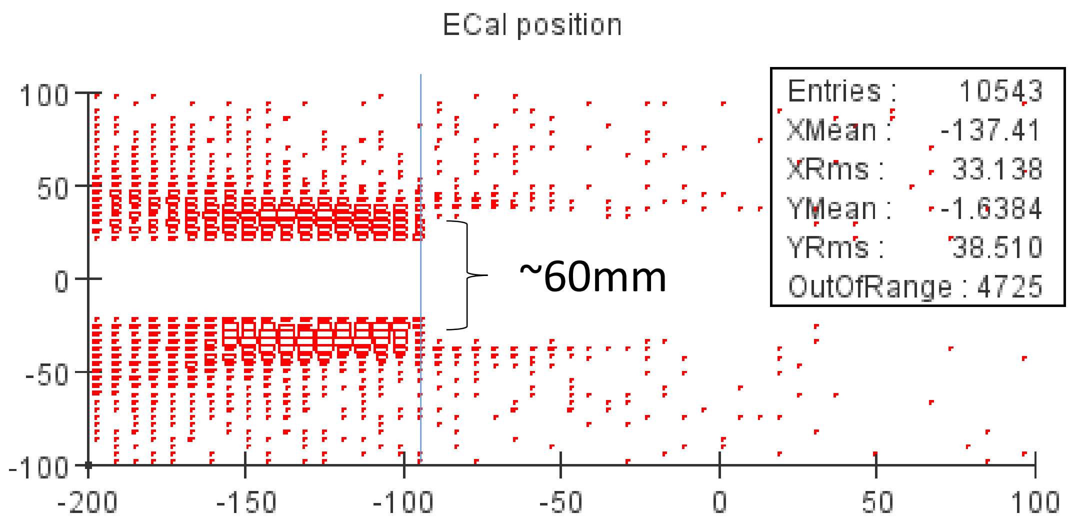


Seed Hits **after** y-matching cut

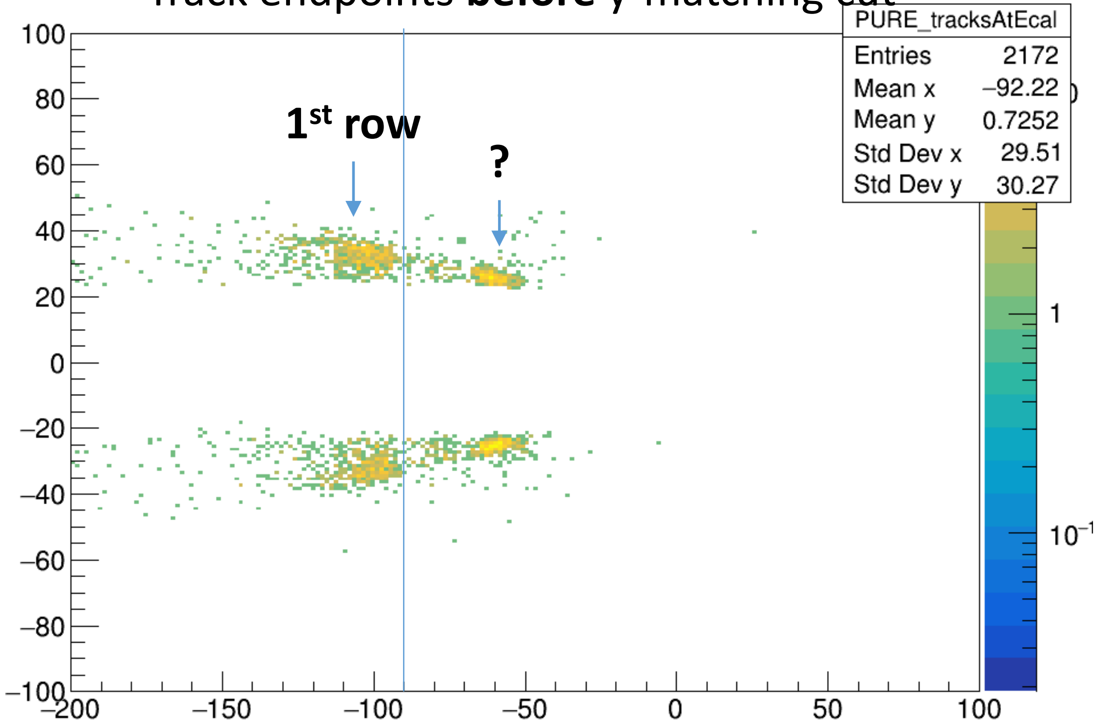


Cluster-Track matching

SLIC MC particles **P[0.6, 1.6 GeV]**

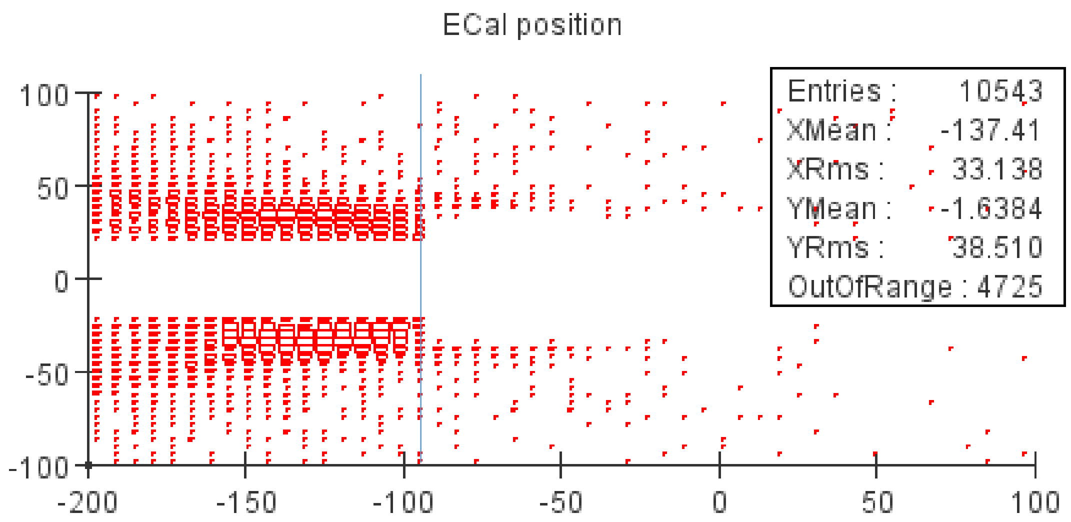


Track endpoints **before** y-matching cut

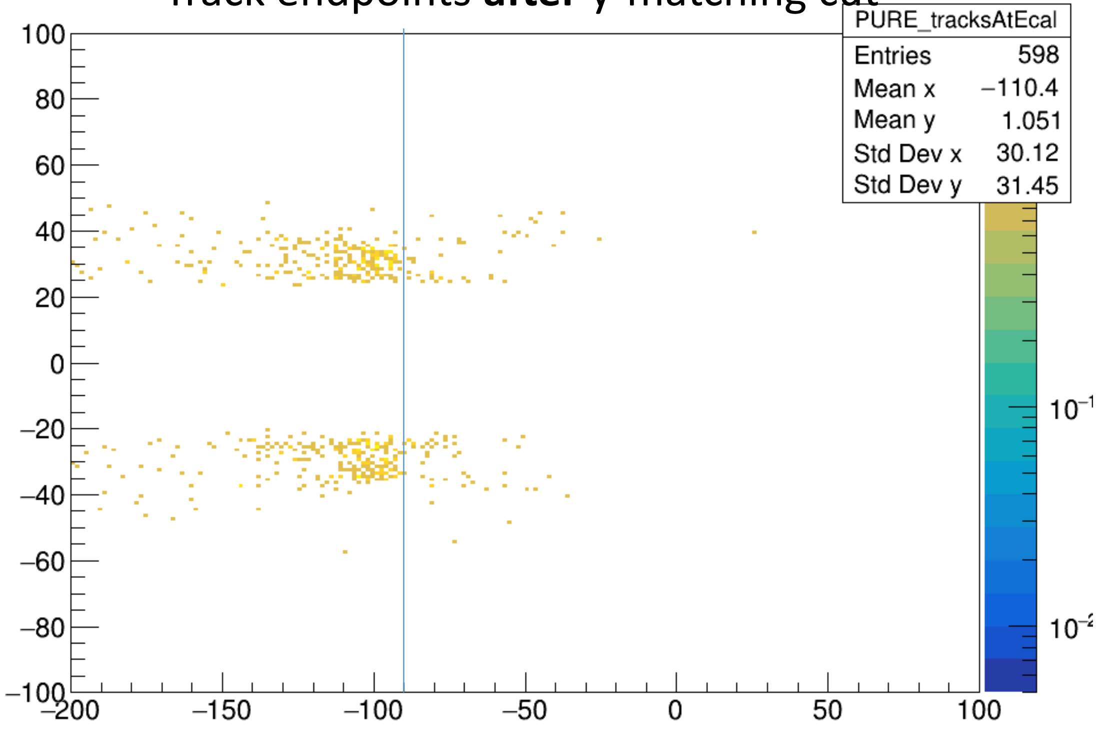


Cluster-Track matching

SLIC MC particles **P[0.6, 1.6 GeV]**

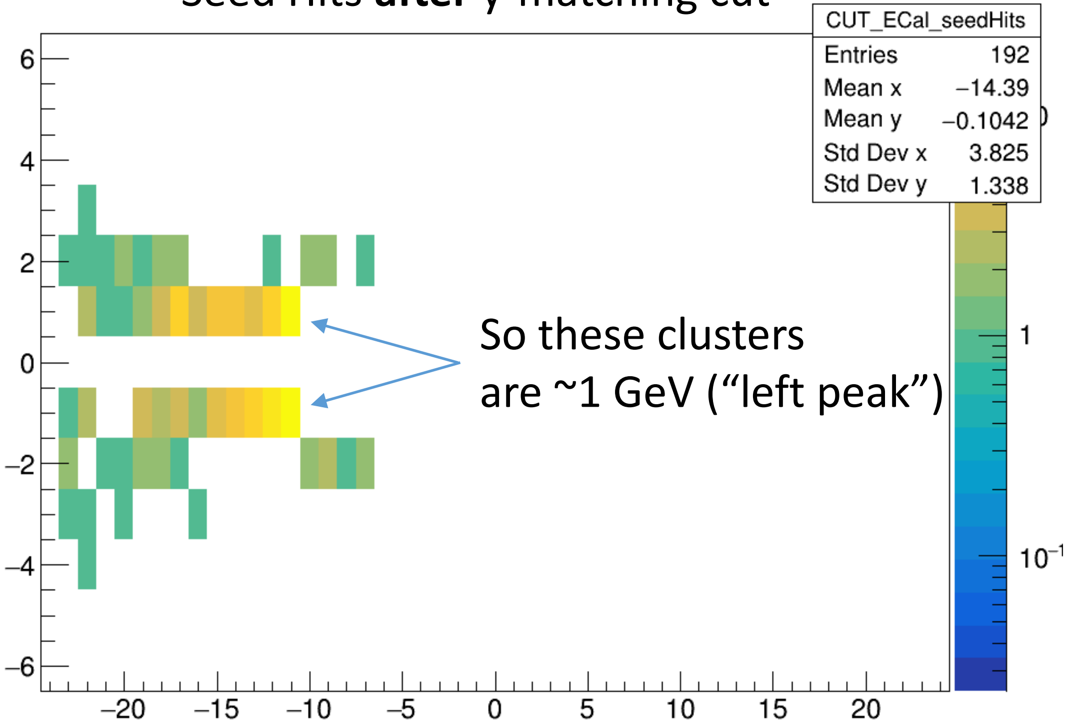


Track endpoints **after** y-matching cut



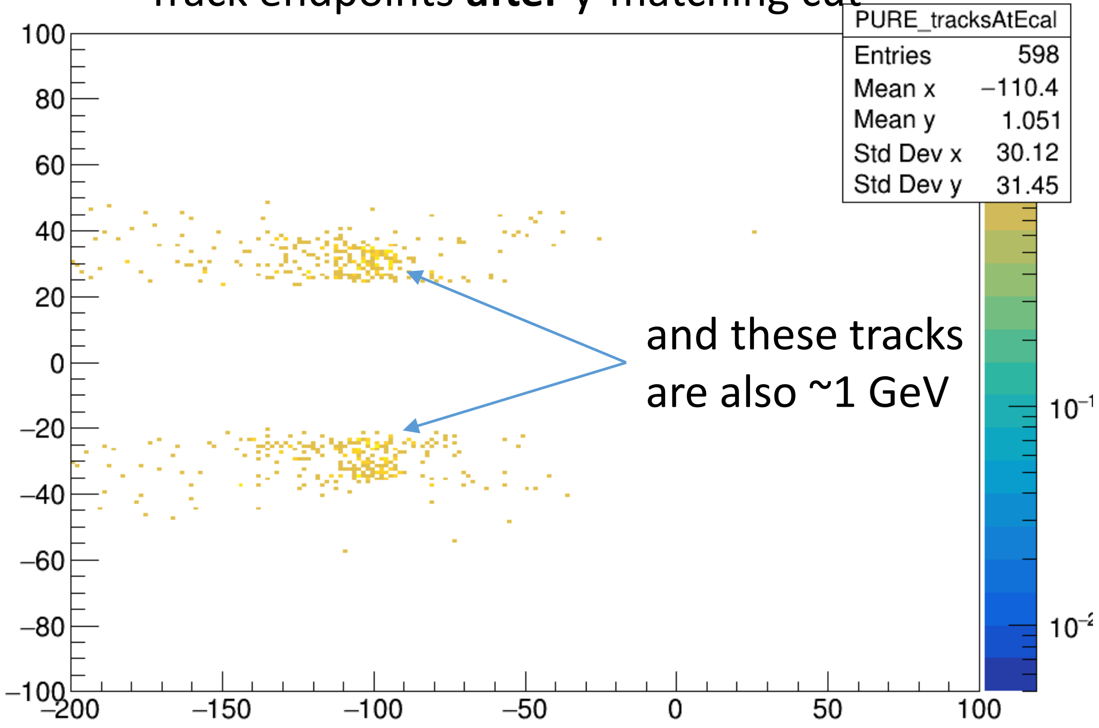
Cluster-Track matching

Seed Hits **after** y-matching cut



So these clusters
are ~1 GeV ("left peak")

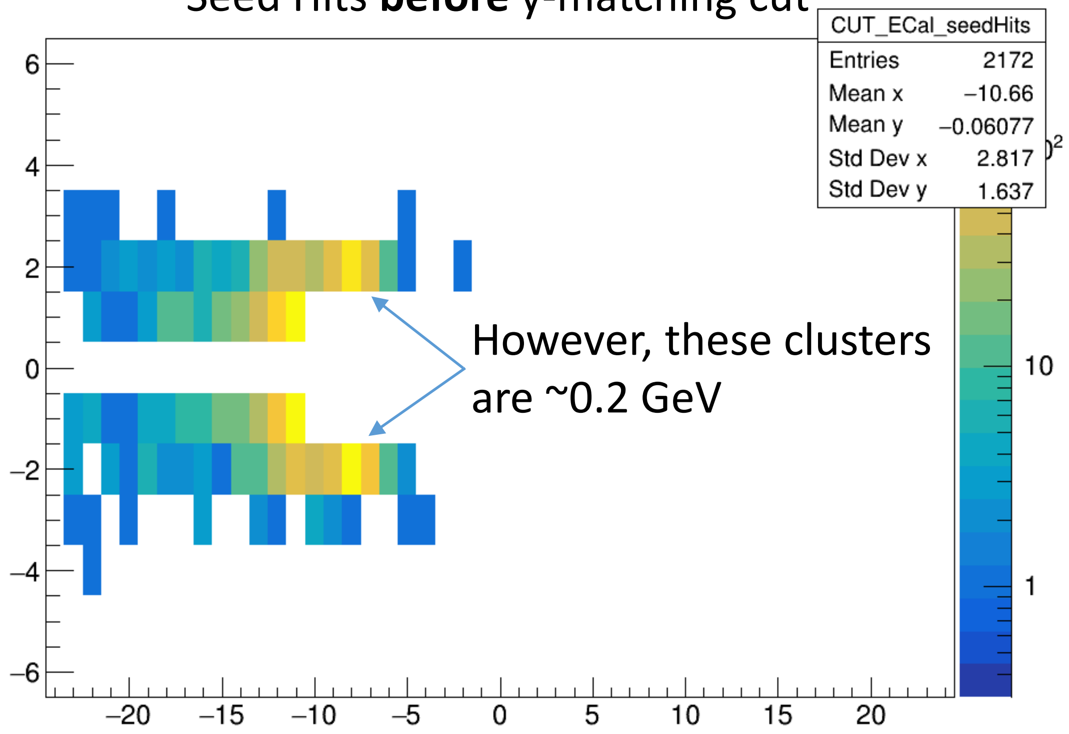
Track endpoints **after** y-matching cut



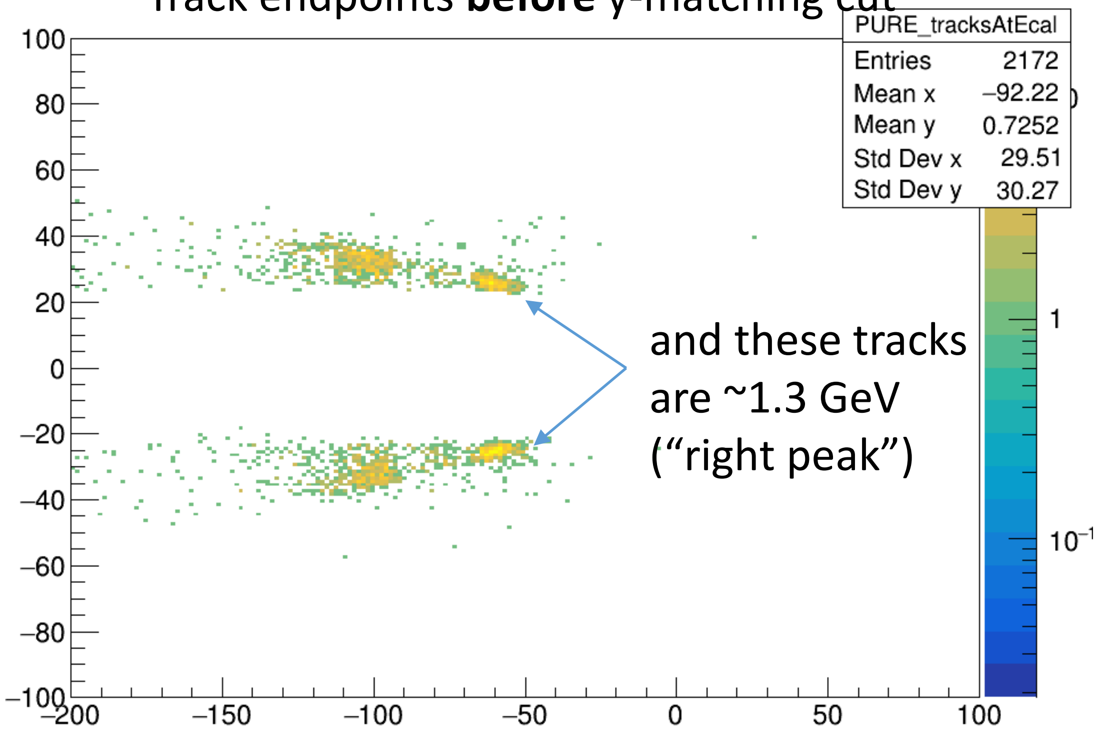
and these tracks
are also ~1 GeV

Cluster-Track matching

Seed Hits **before** y-matching cut

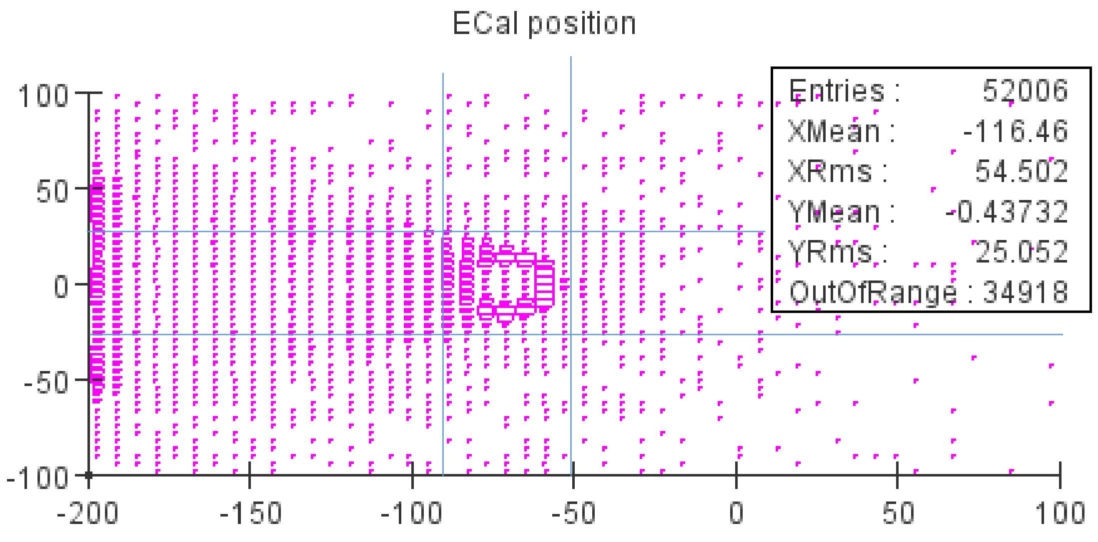


Track endpoints **before** y-matching cut

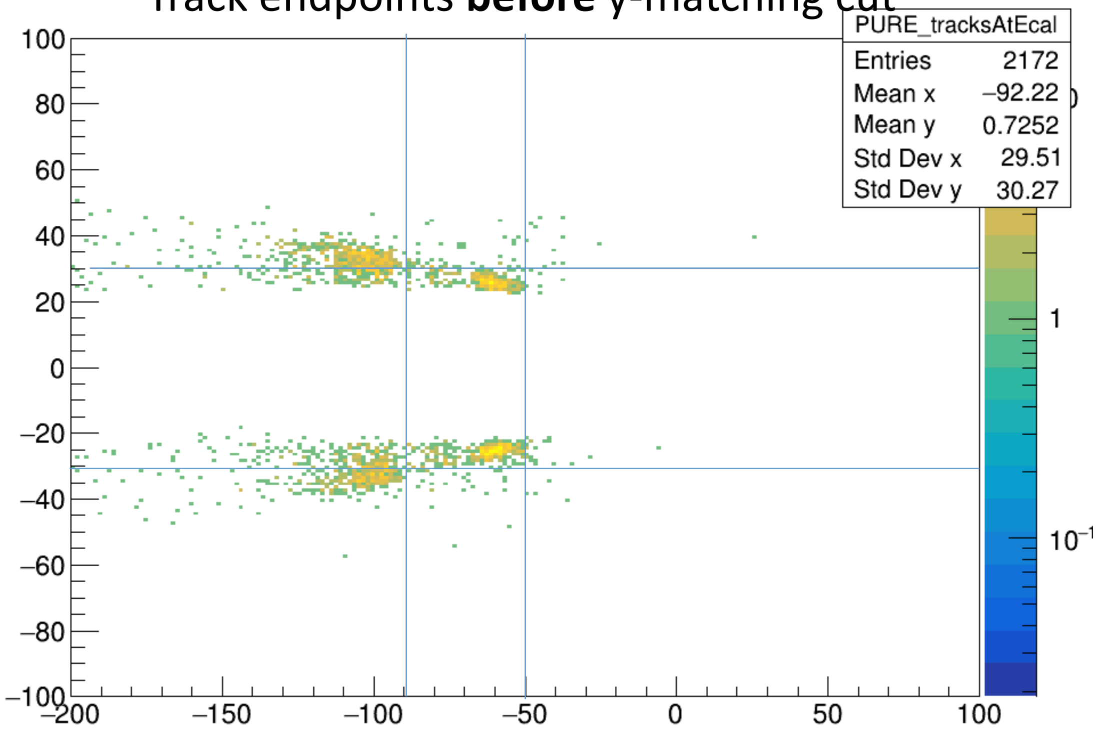


Cluster-Track matching

Uncut SLIC MC Particles at ECal position

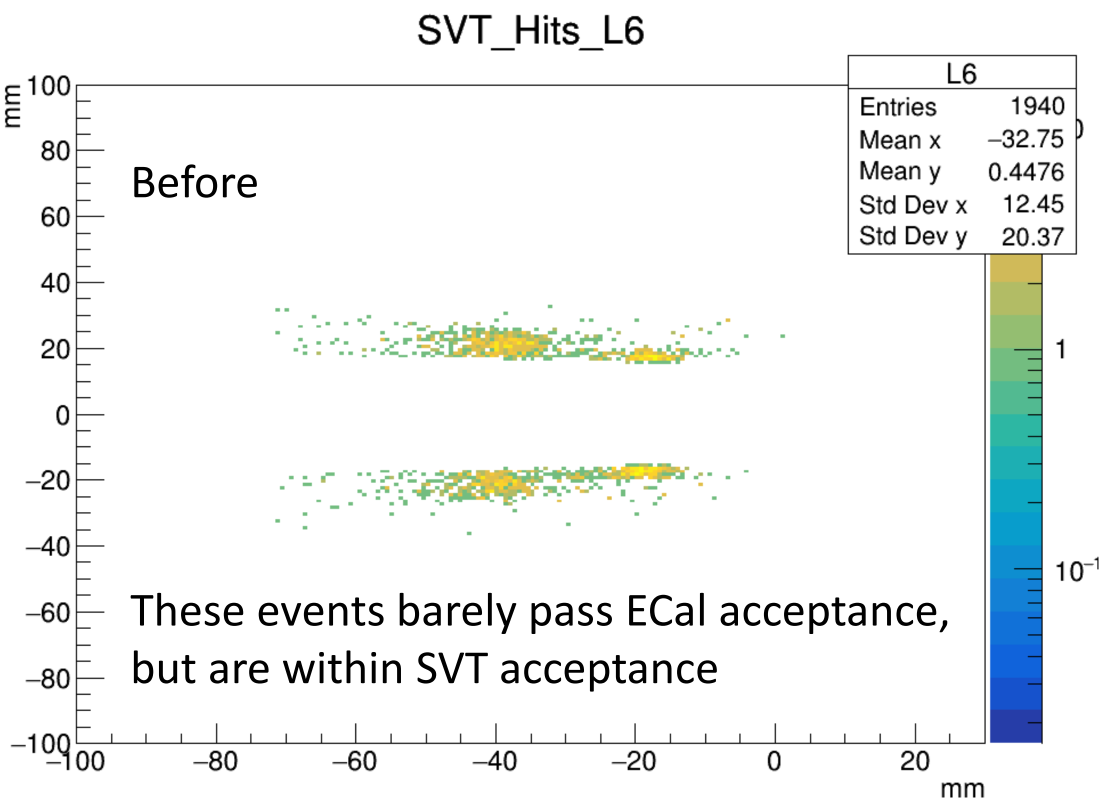


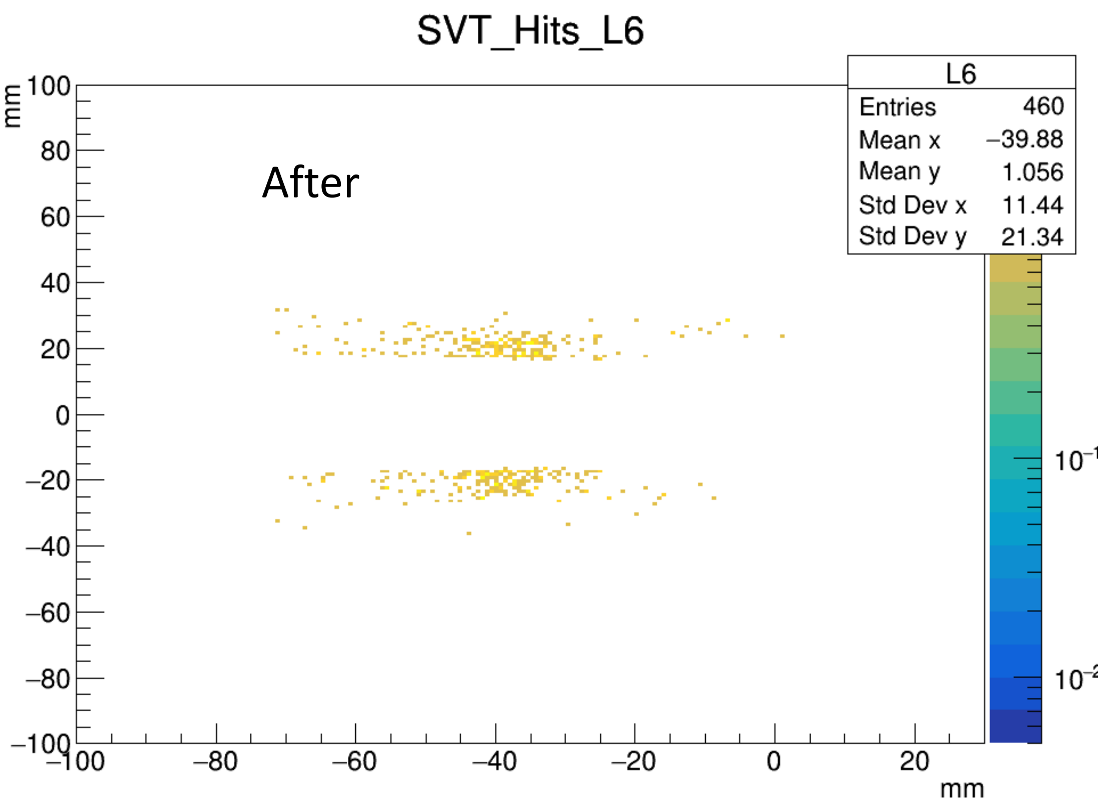
Track endpoints **before** y-matching cut



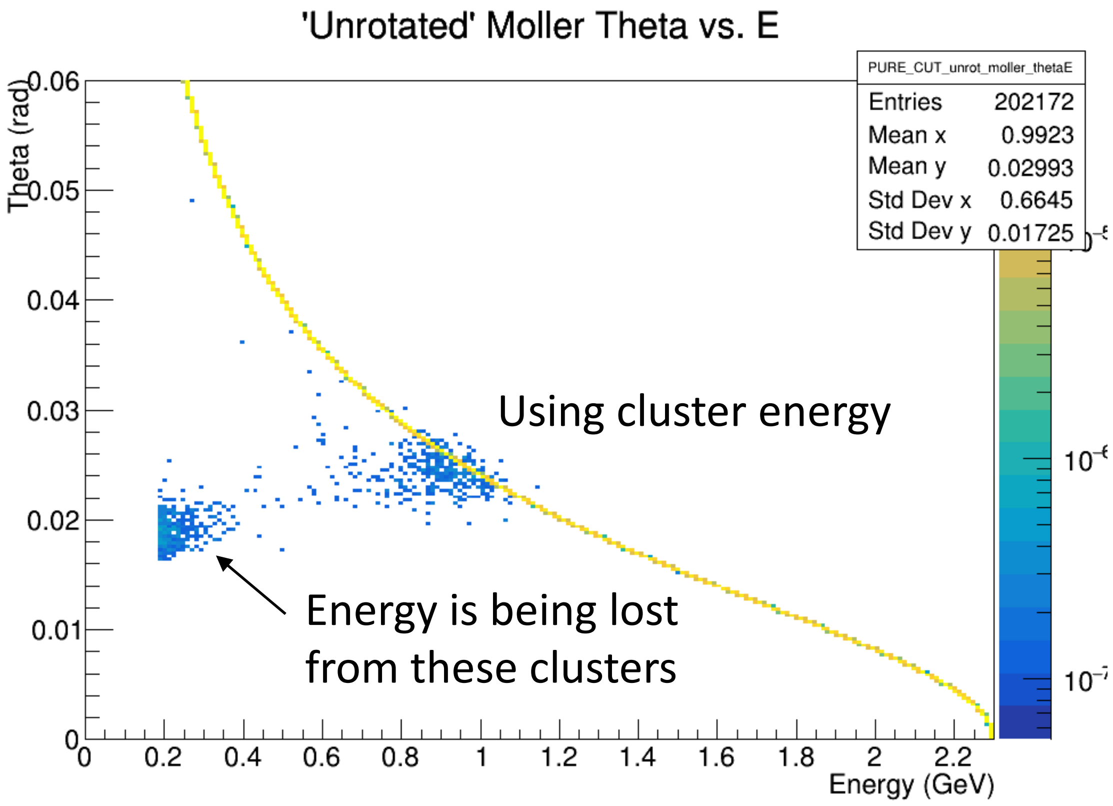
It looks like electrons passing through the ECal hole are creating low-E hits/clusters, while being assigned tracks

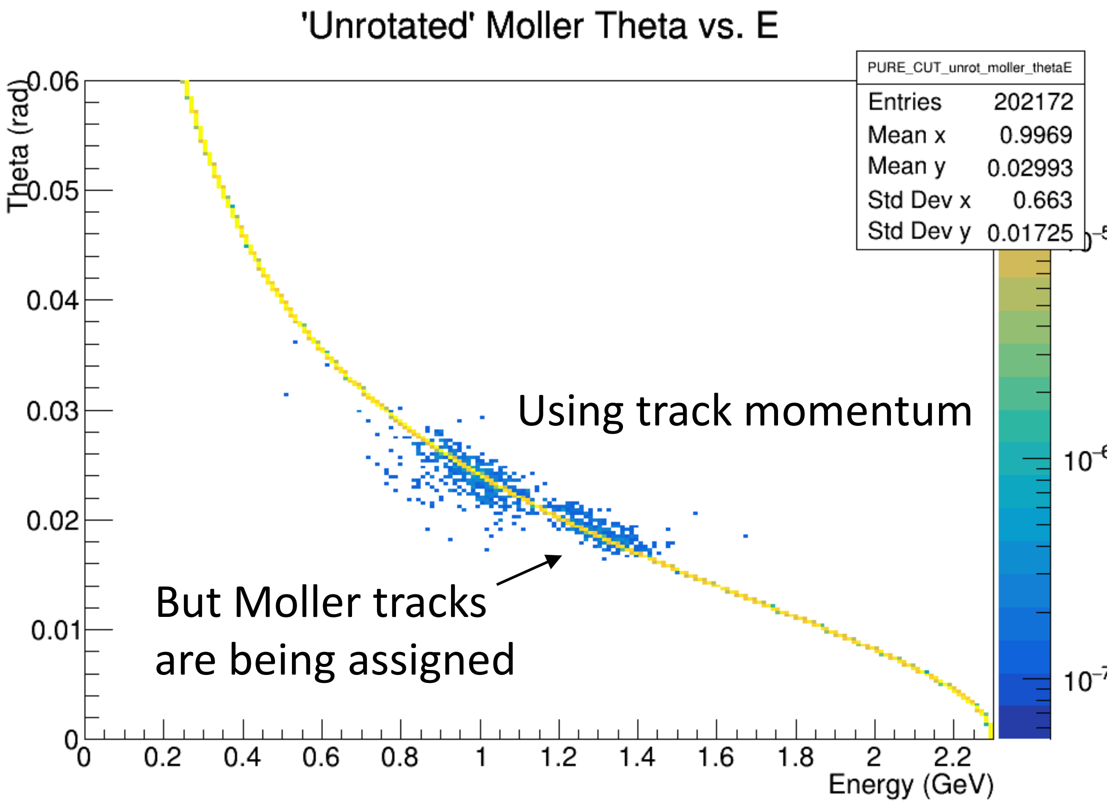
Cluster-Track matching



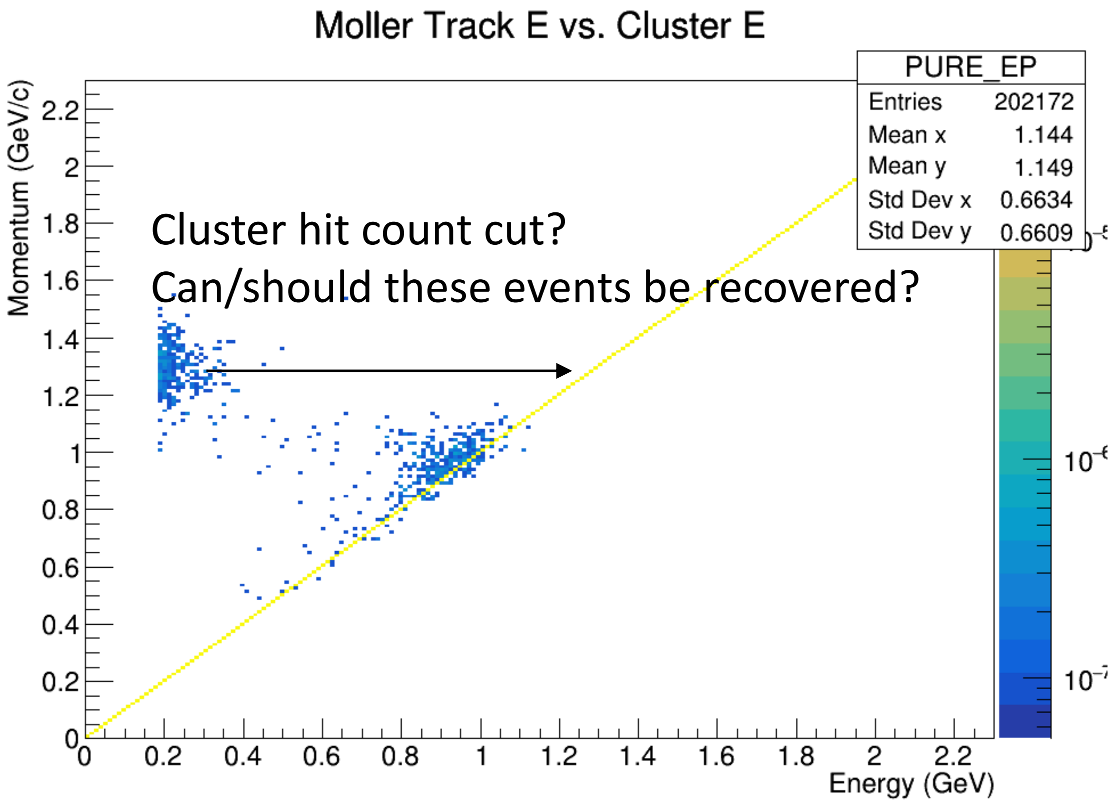


Checking Kinematics

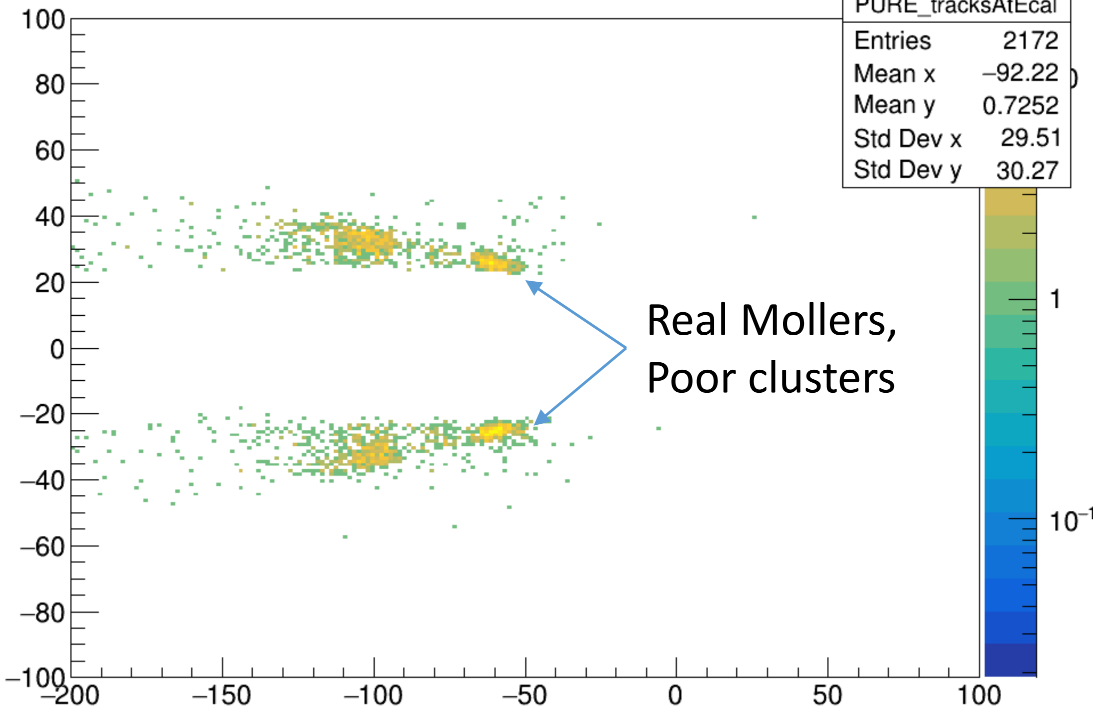




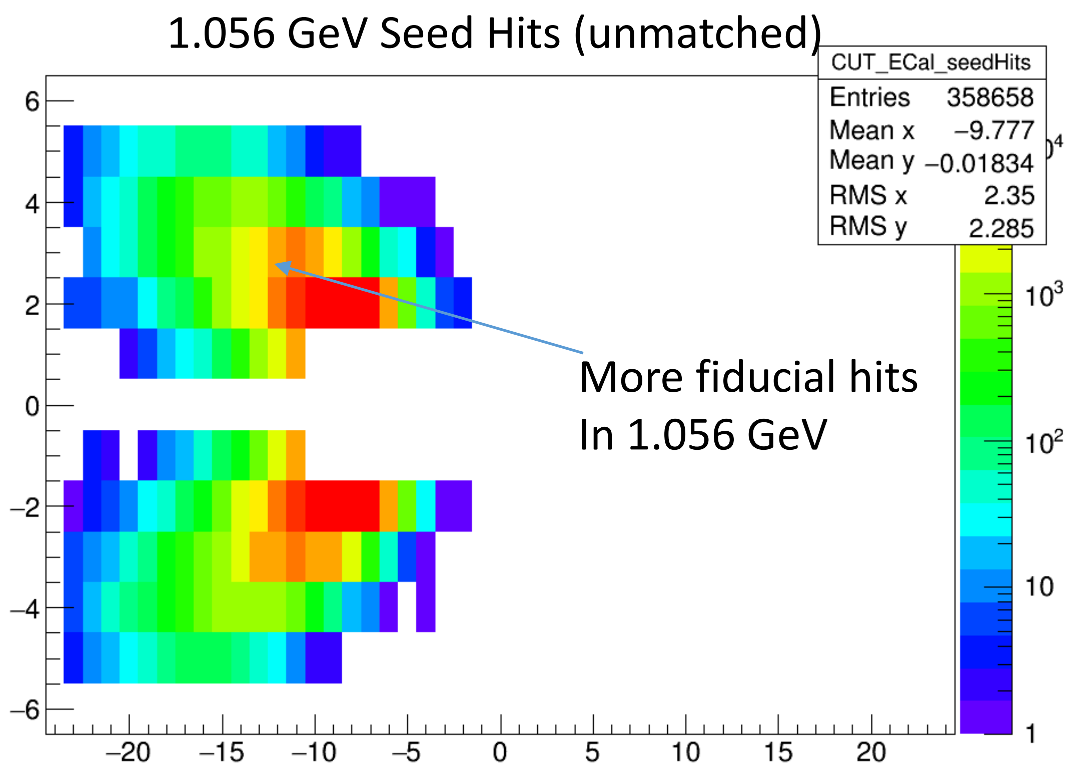
Cluster-Track matching

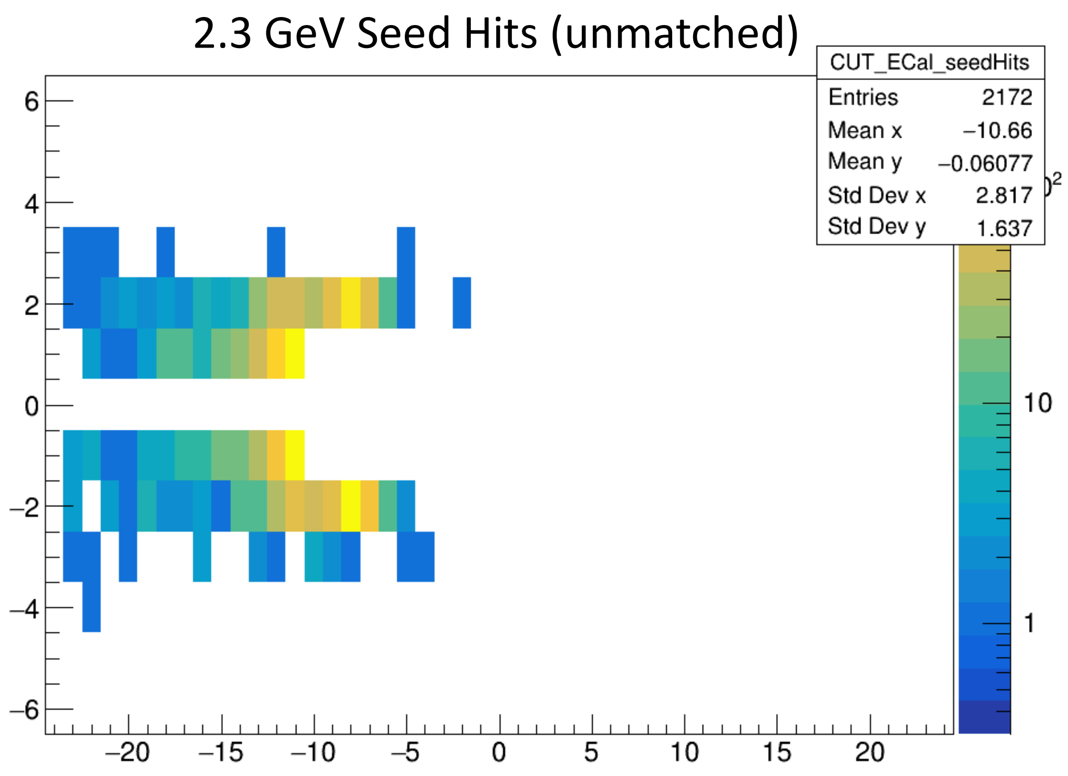


Track endpoints **before** y-matching cut

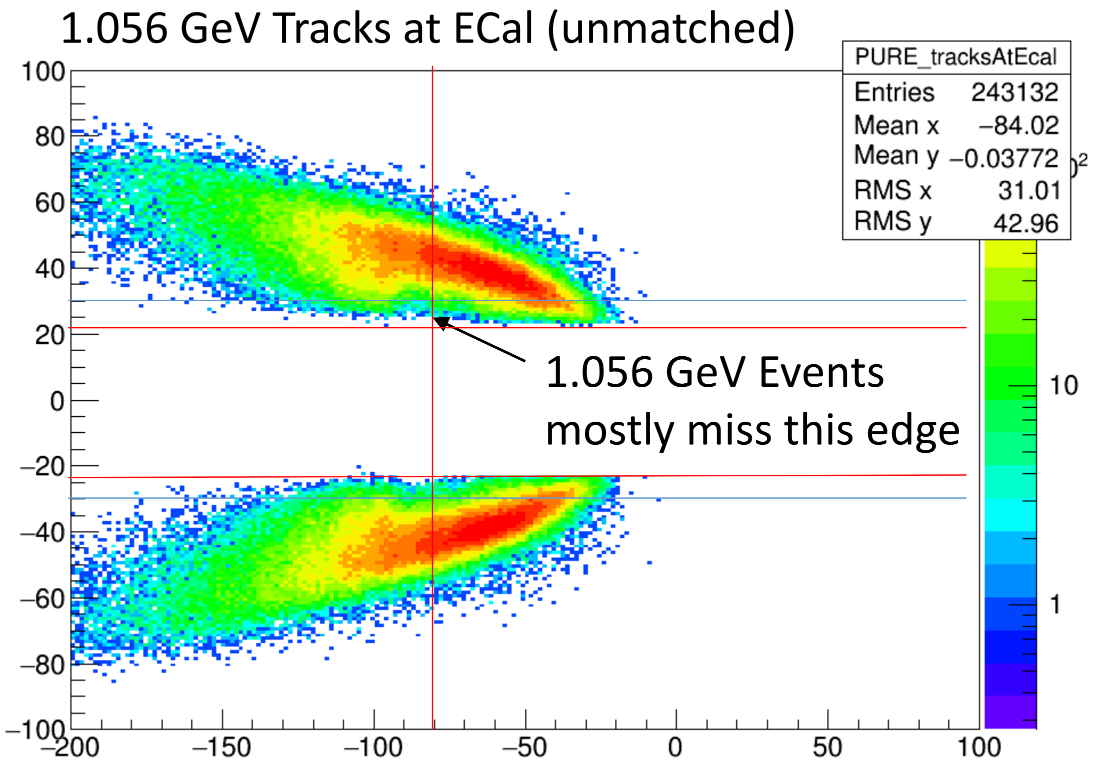


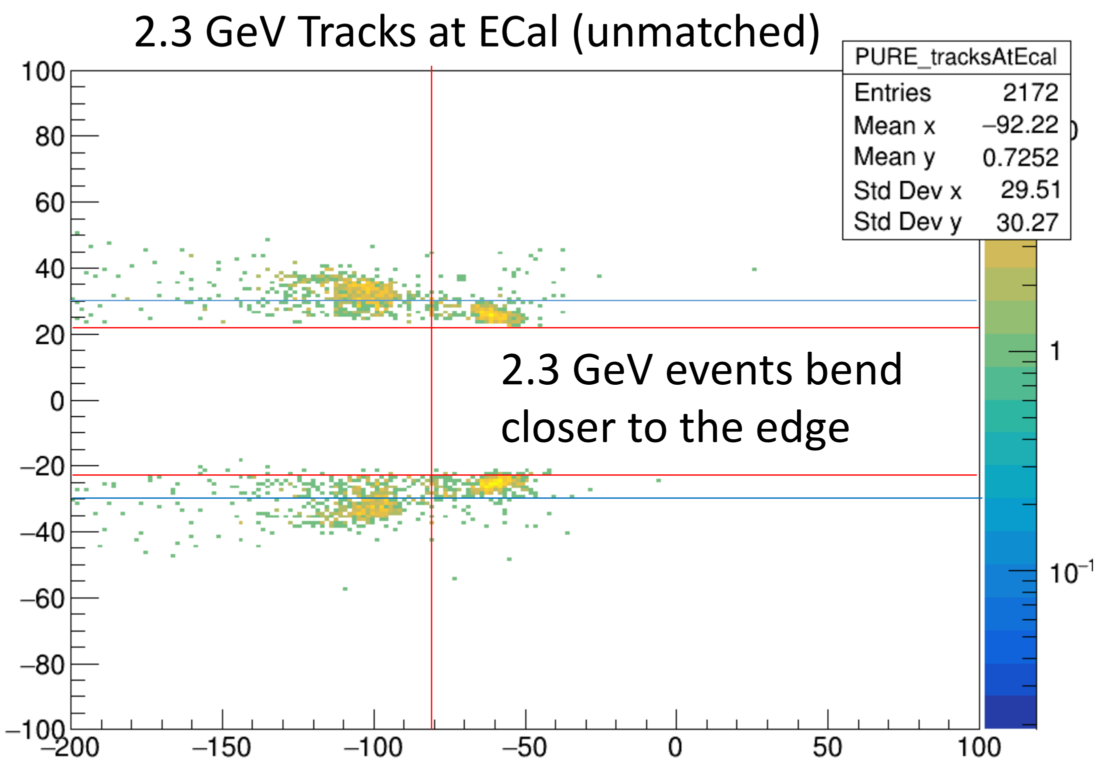
1.056/2.3 GeV Comparison



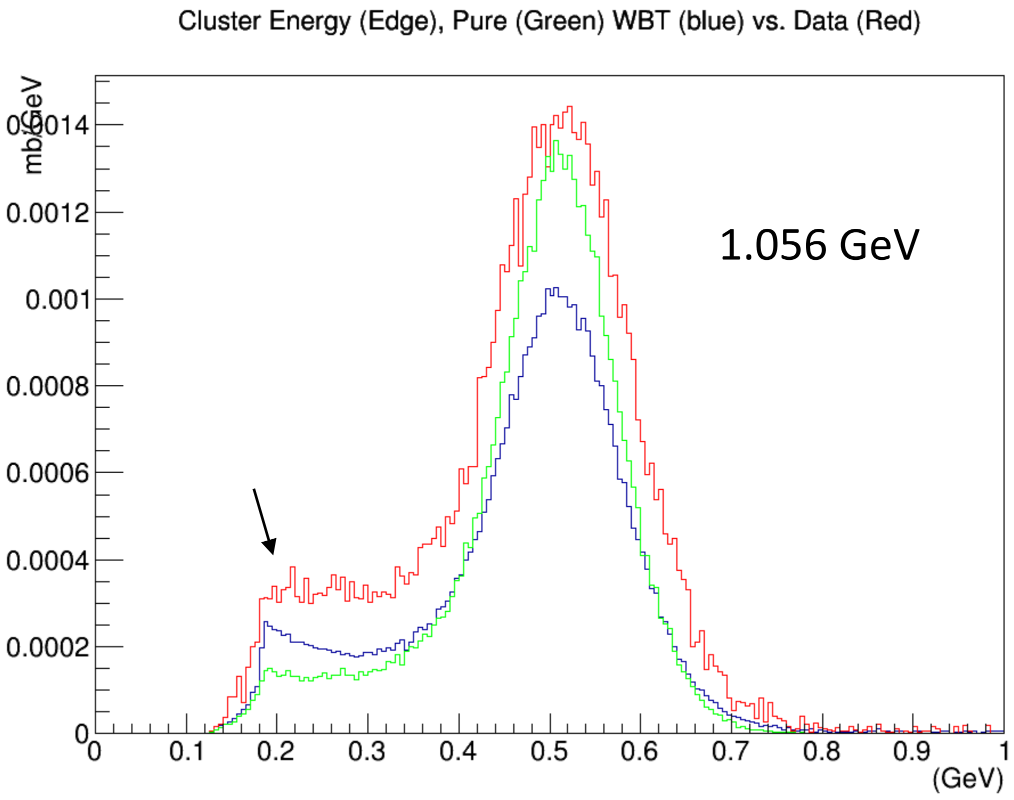


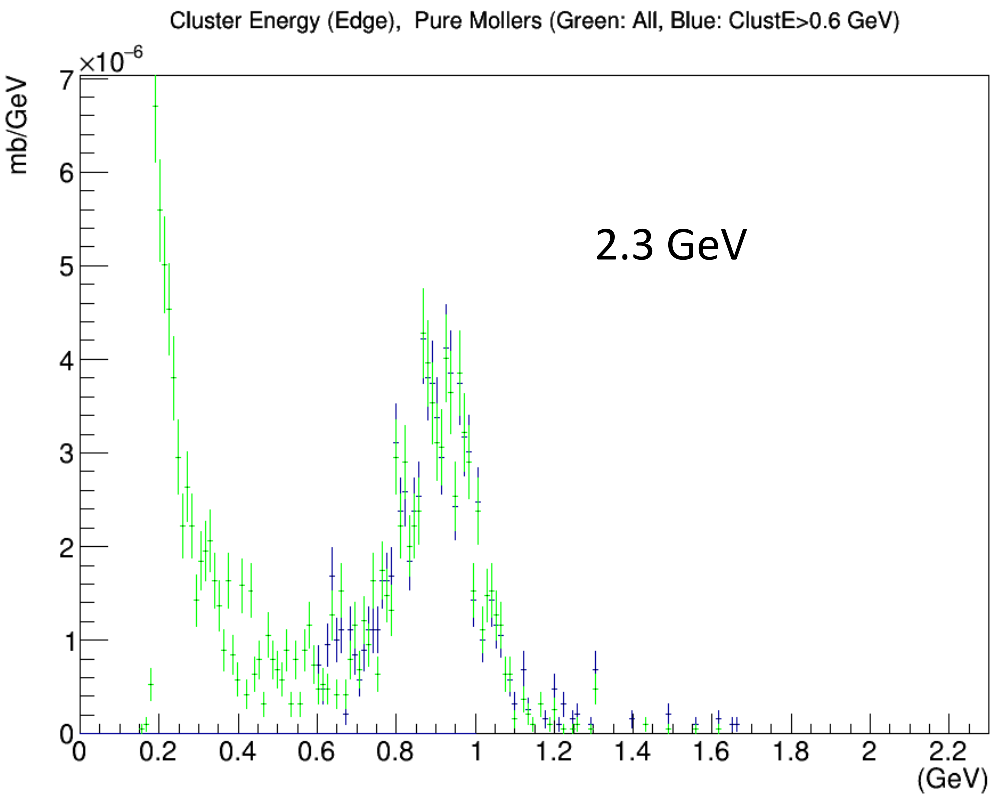
1.056/2.3 GeV Comparison



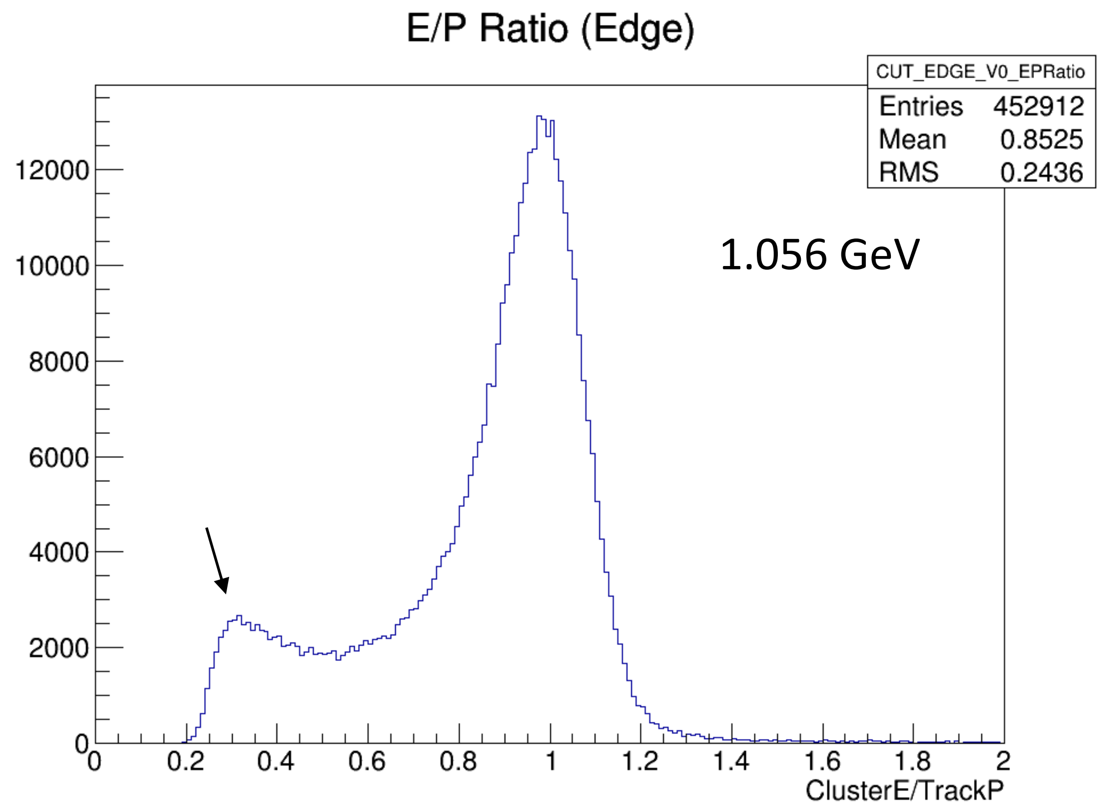


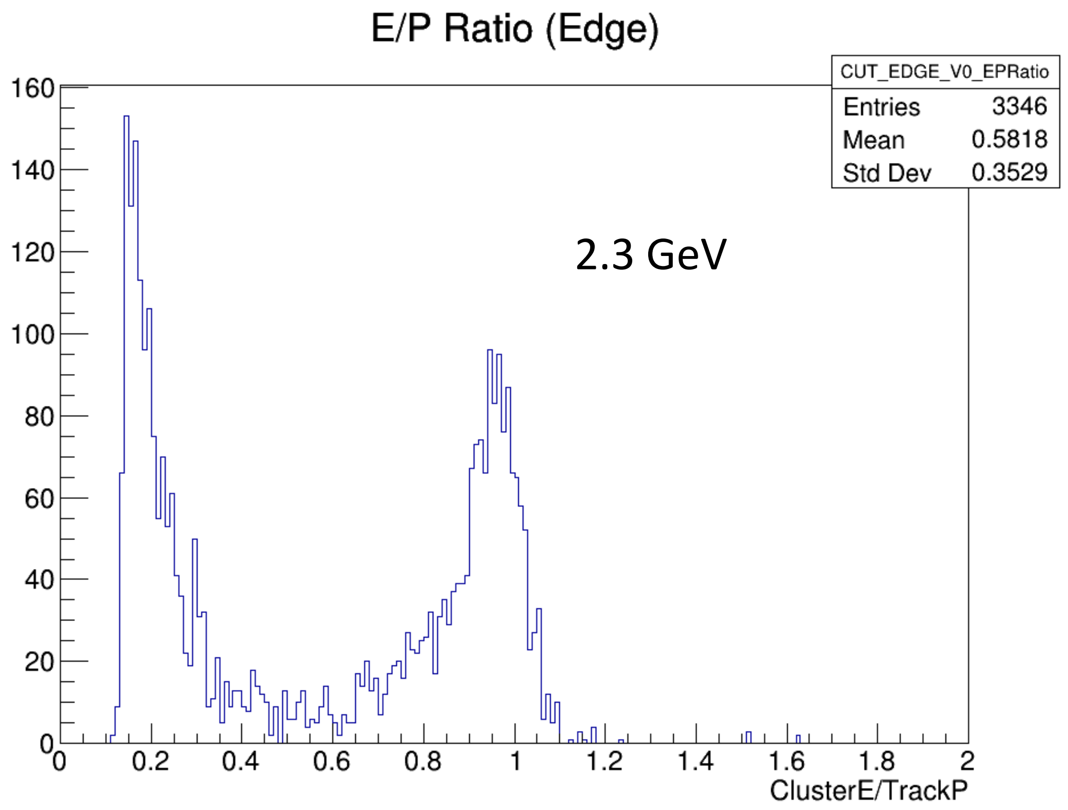
1.056/2.3 GeV Comparison





1.056/2.3 GeV Comparison



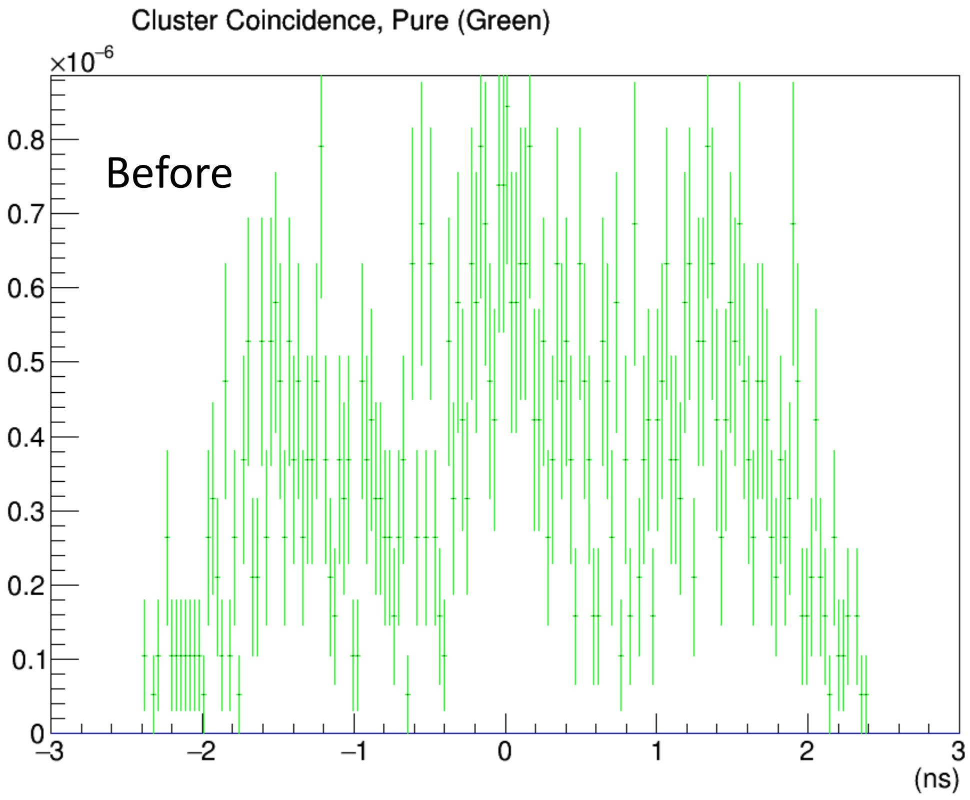


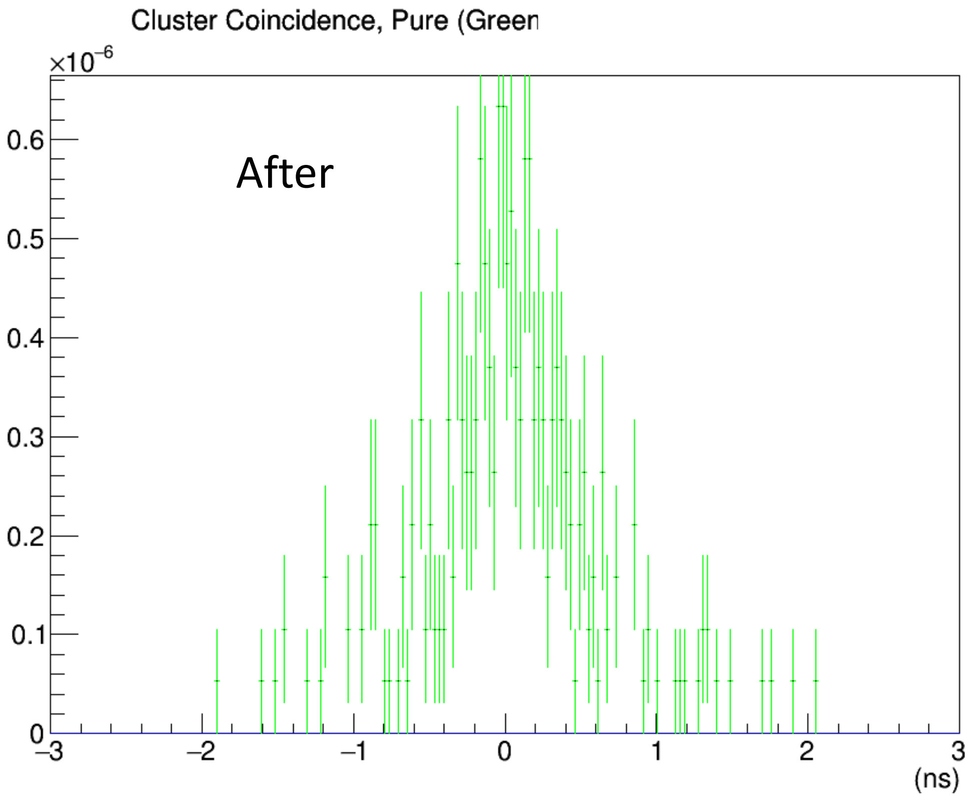
Cluster-Track matching

- So the 2.3 GeV “Moller gap” in momentum is likely caused by mid-energy electrons (~1.2 GeV) missing the ECal, but still depositing enough energy in nearby edge crystals to get a track

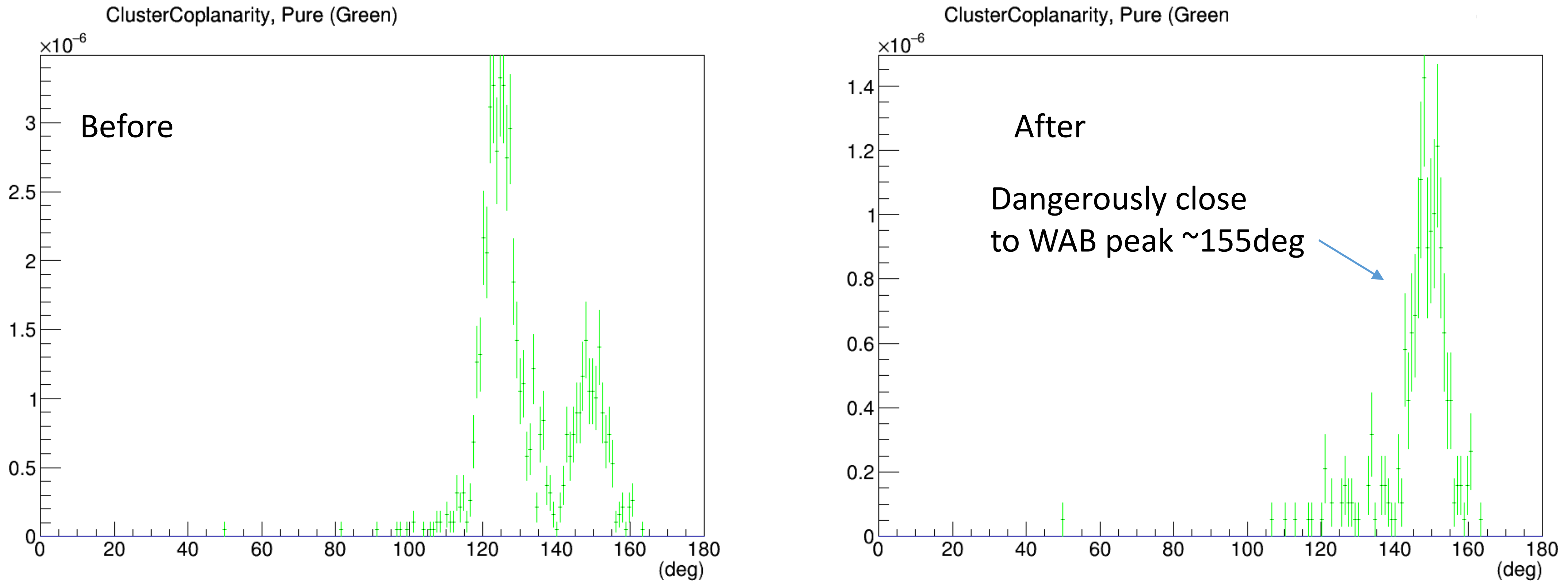
- Forcing a track-cluster match in y (<10mm) as a temporary solution, what other effects does this have?

Other Effects from a 10mm y-matching cut

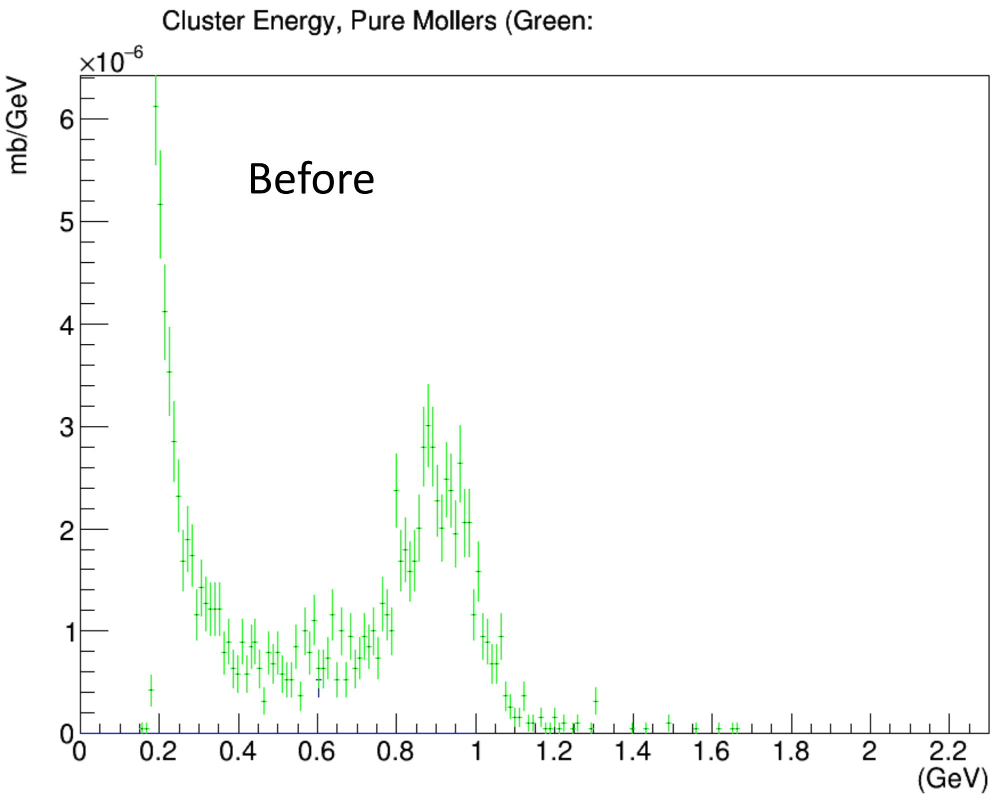


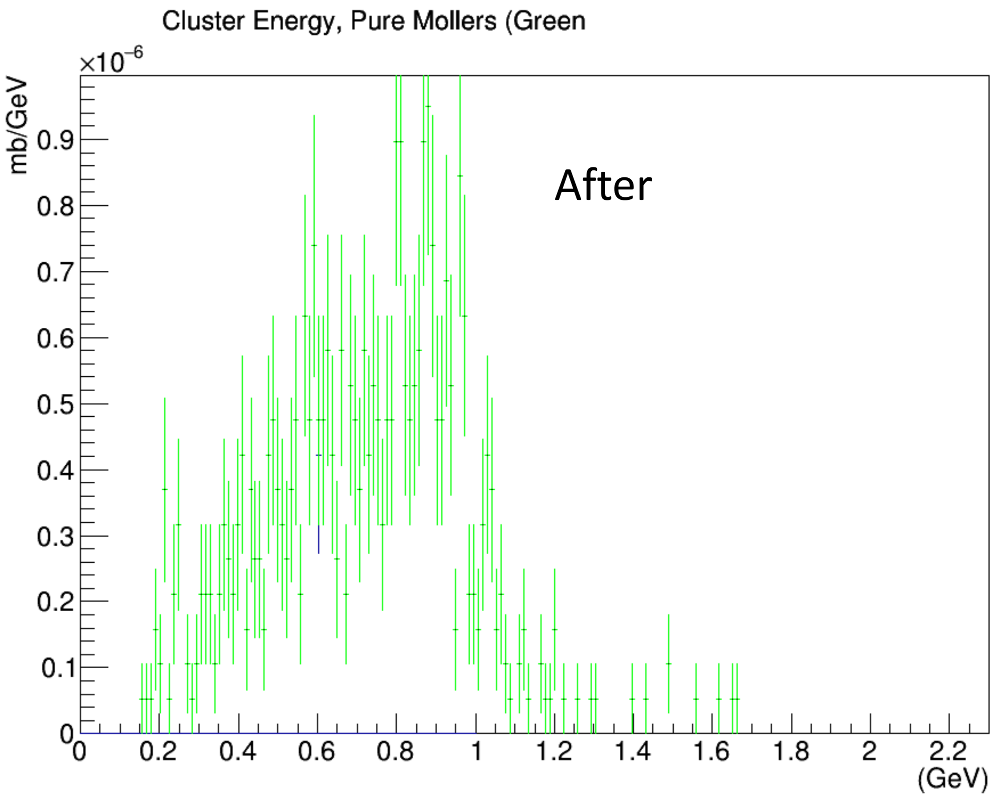


Other Effects from a 10mm y-matching cut

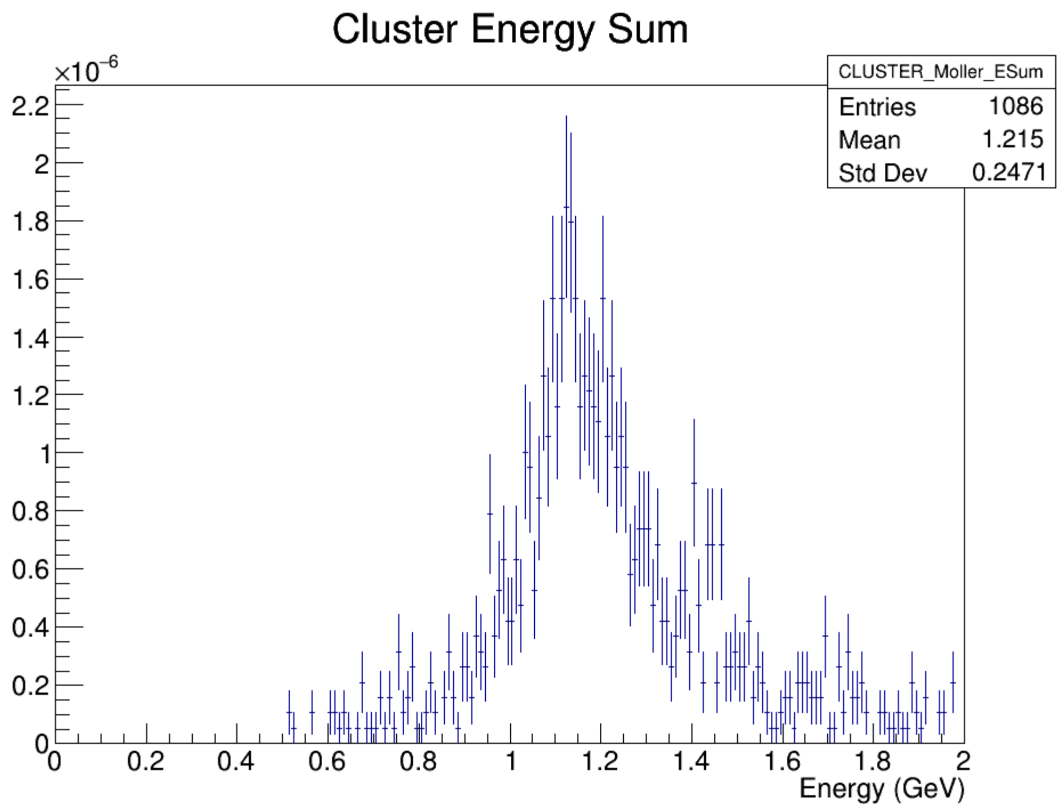


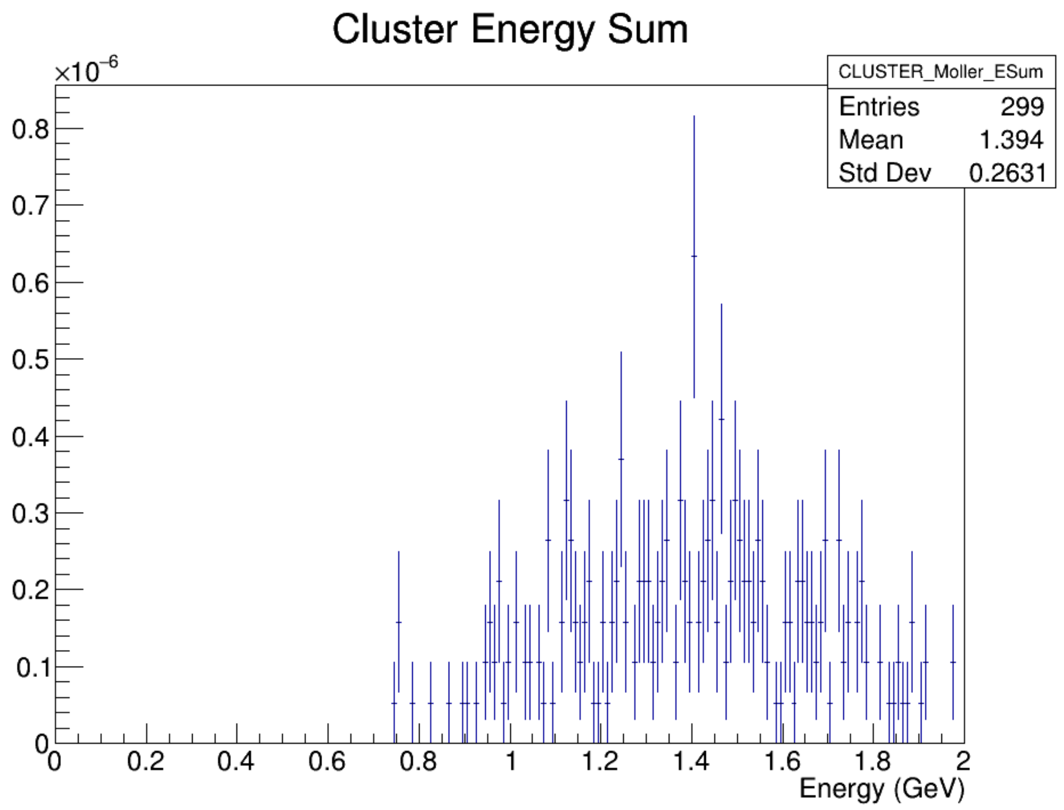
Other Effects from a 10mm y-matching cut



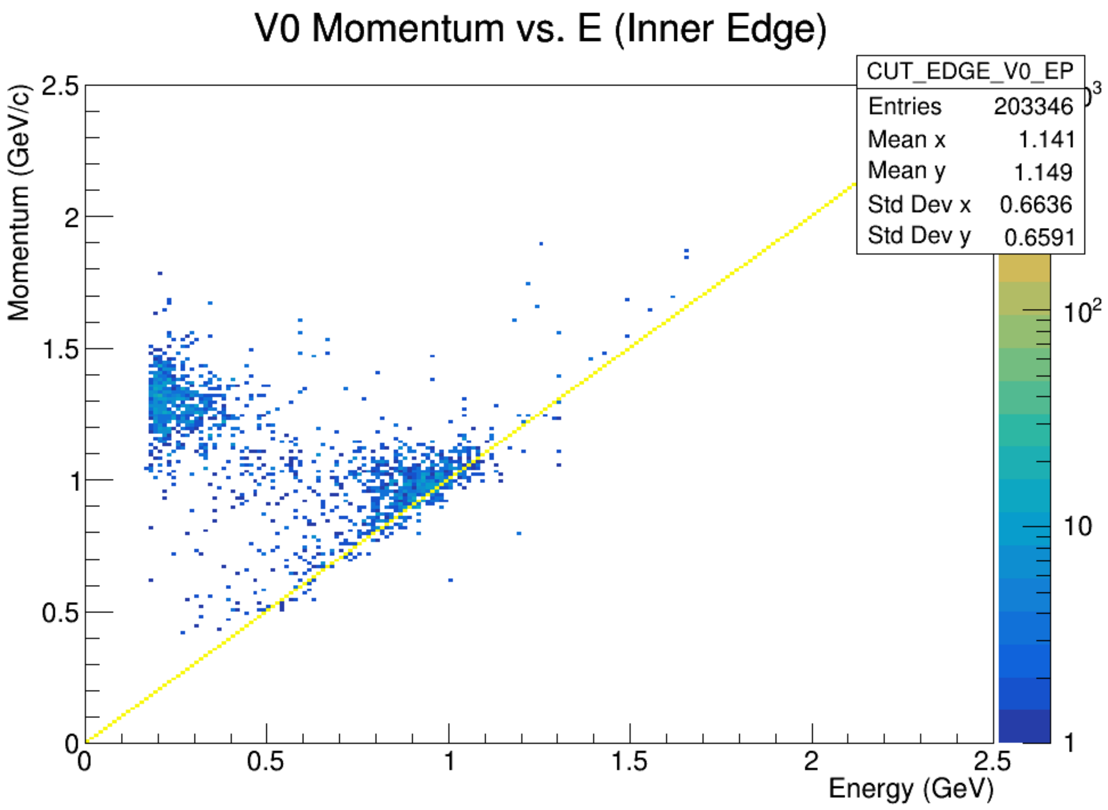


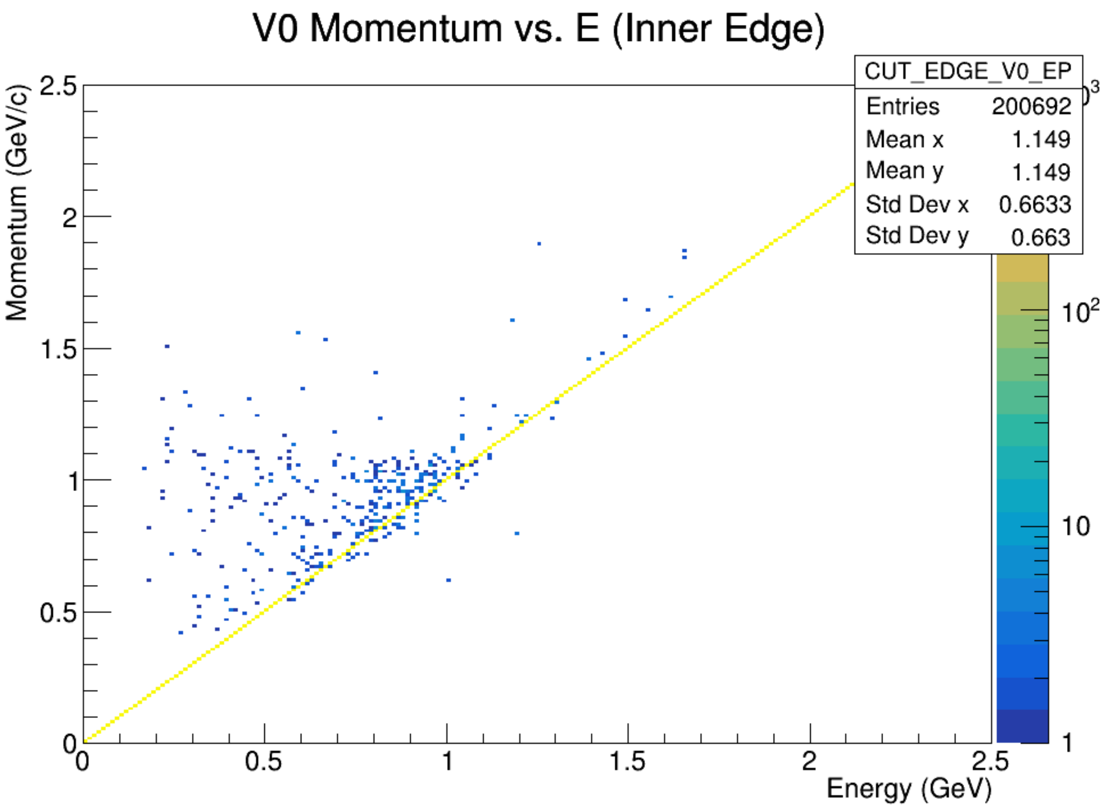
Other Effects from a 10mm y-matching cut



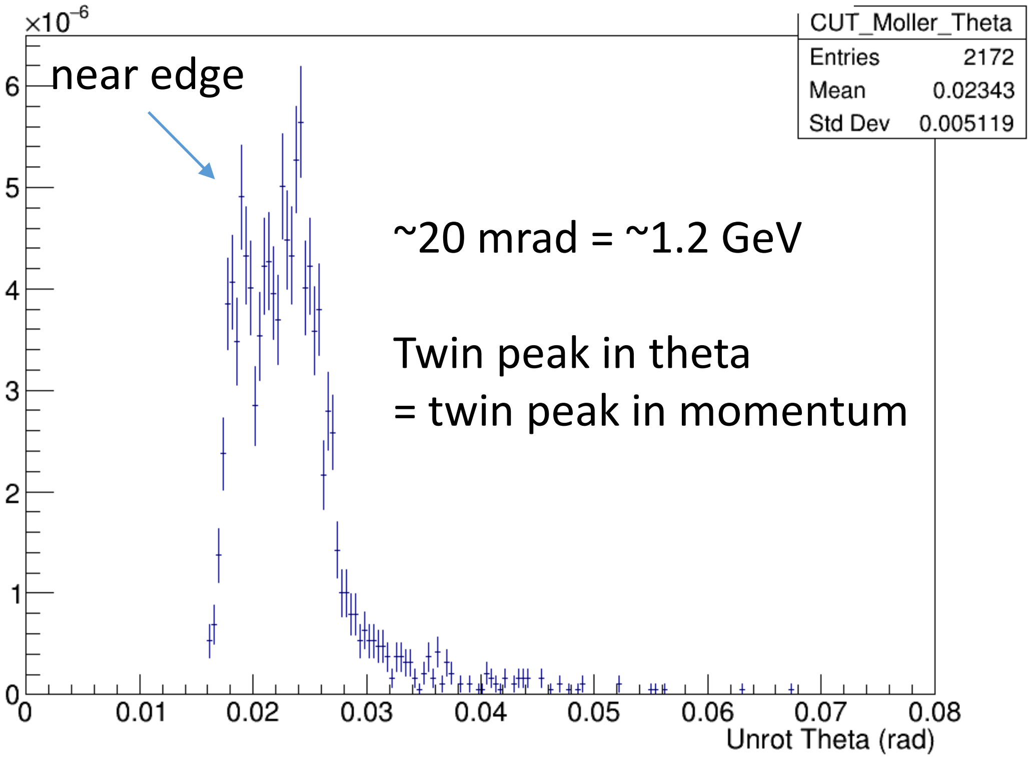


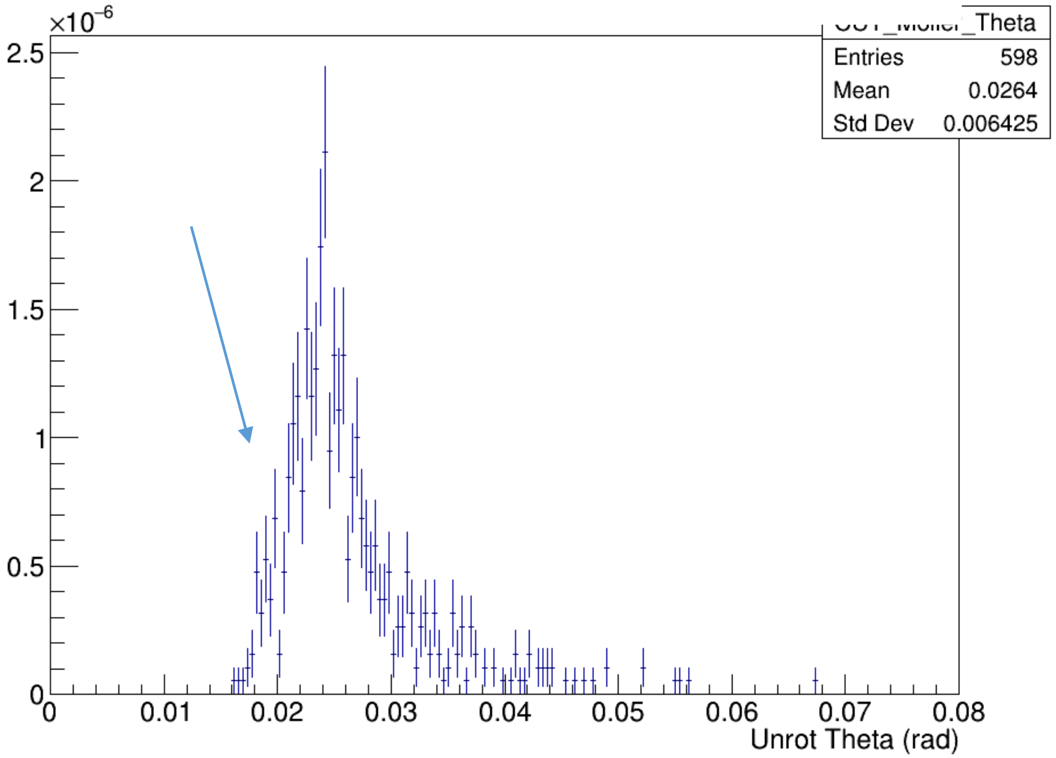
Other Effects from a 10mm y-matching cut



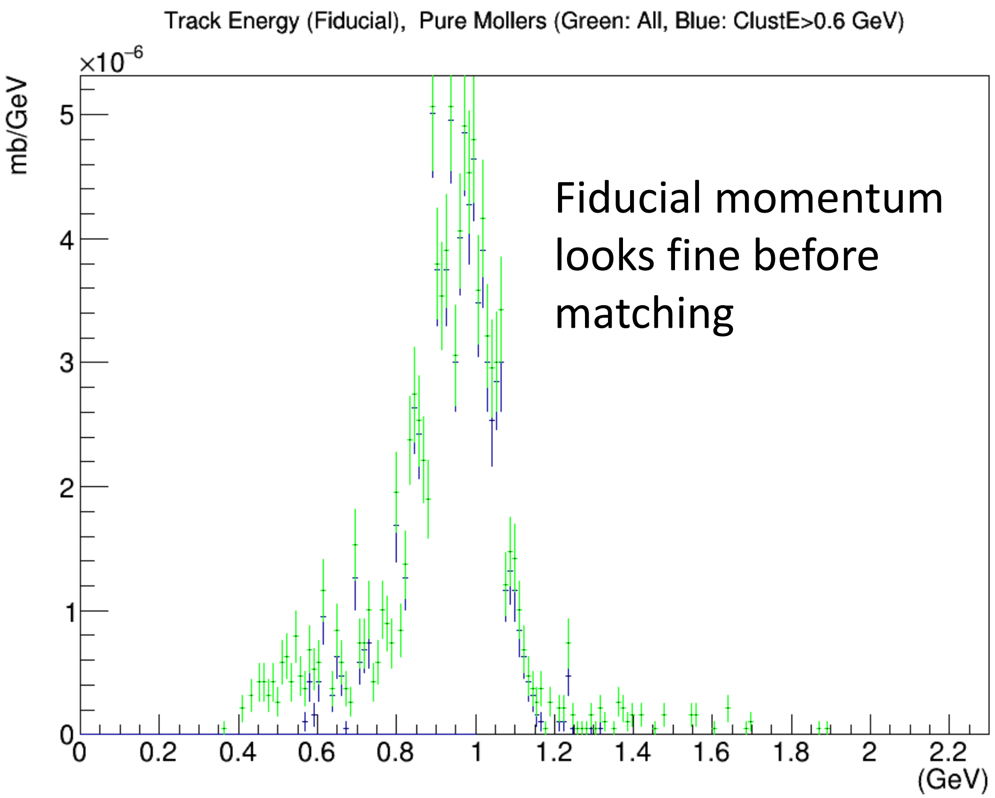


Other Effects from a 10mm y-matching cut

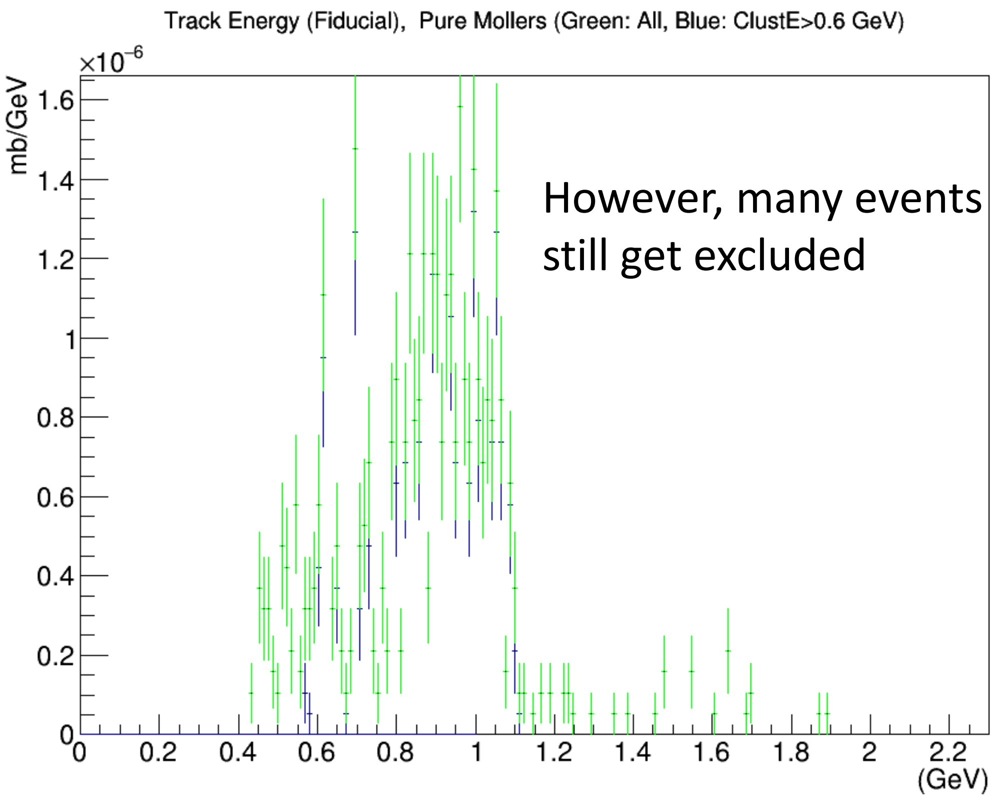




Other Effects from a 10mm y-matching cut



Fiducial momentum looks fine before matching

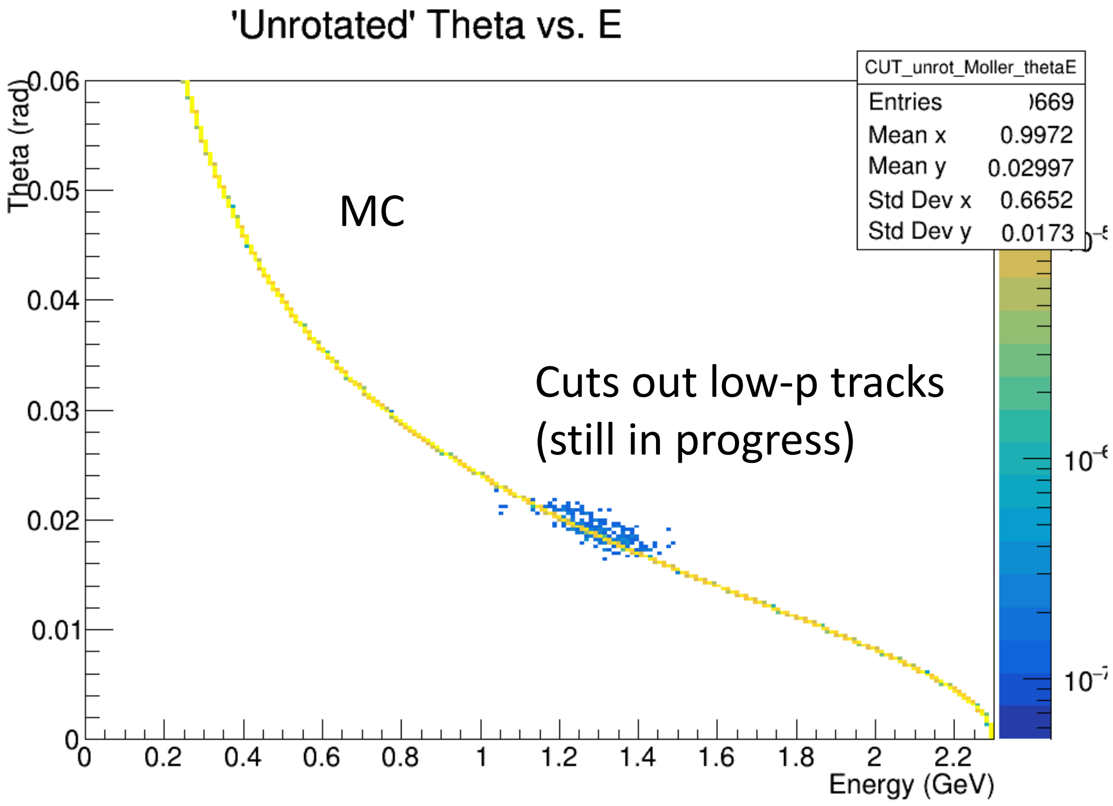


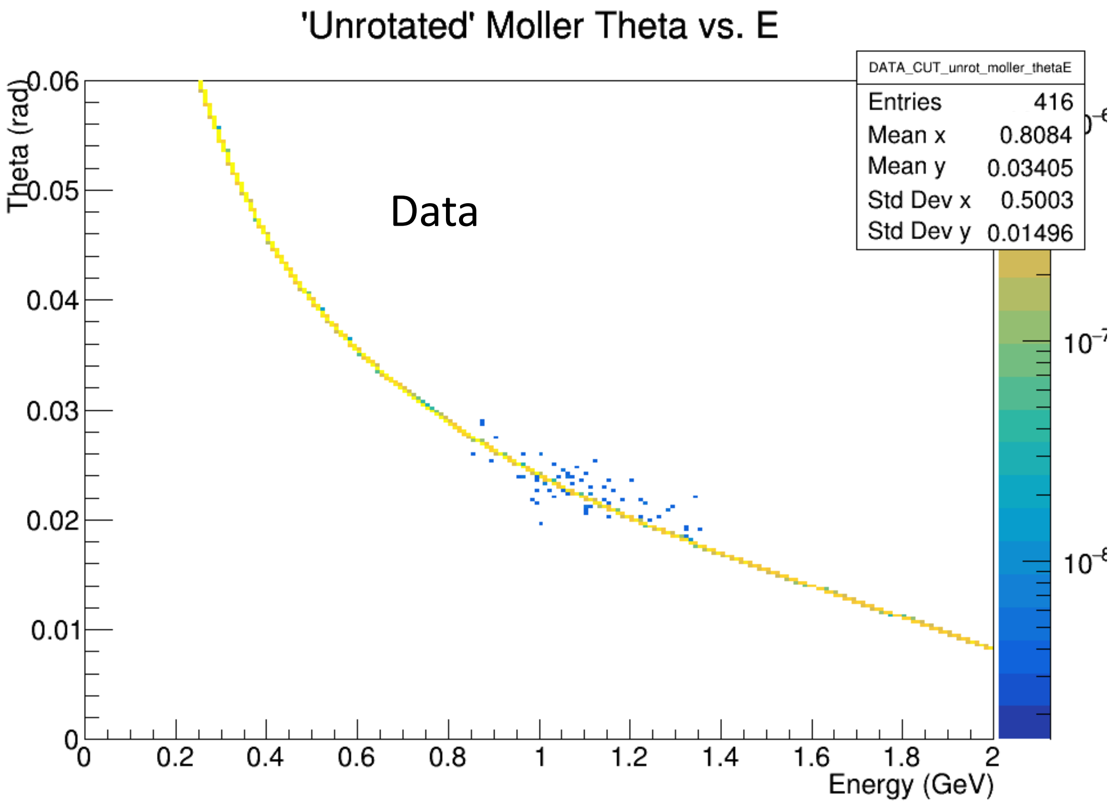
However, many events still get excluded

2.3 GeV Moller Selection (preliminary)

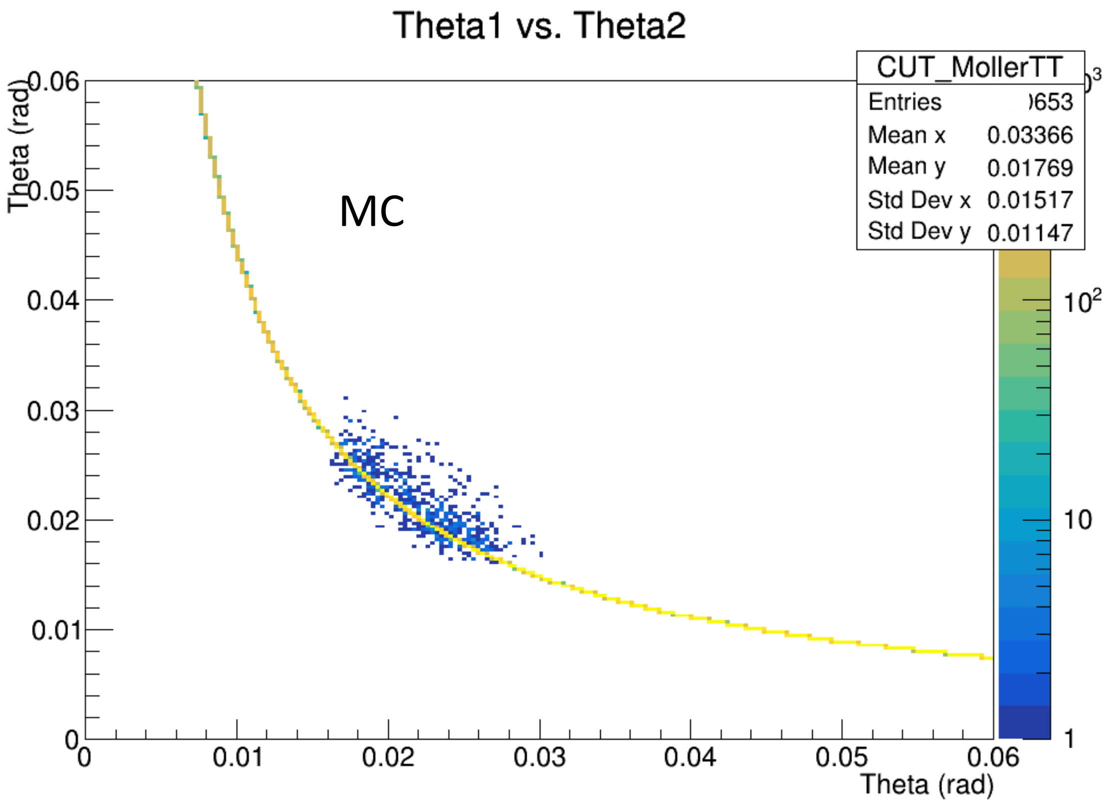
- Beamspot constrained Moller Candidates (improved the E/P ratio for 1.056 GeV)
- GBL Tracks
- Singles0 trigger (Pairs0 had low statistics in data)
- Cluster Coincidence < 1.7 ns (used for 1.056 GeV)
- Theta1 + Theta2 < 50 mrad (from pure MC)
- 2 GeV < Momentum1 + Momentum2 < 2.5 GeV

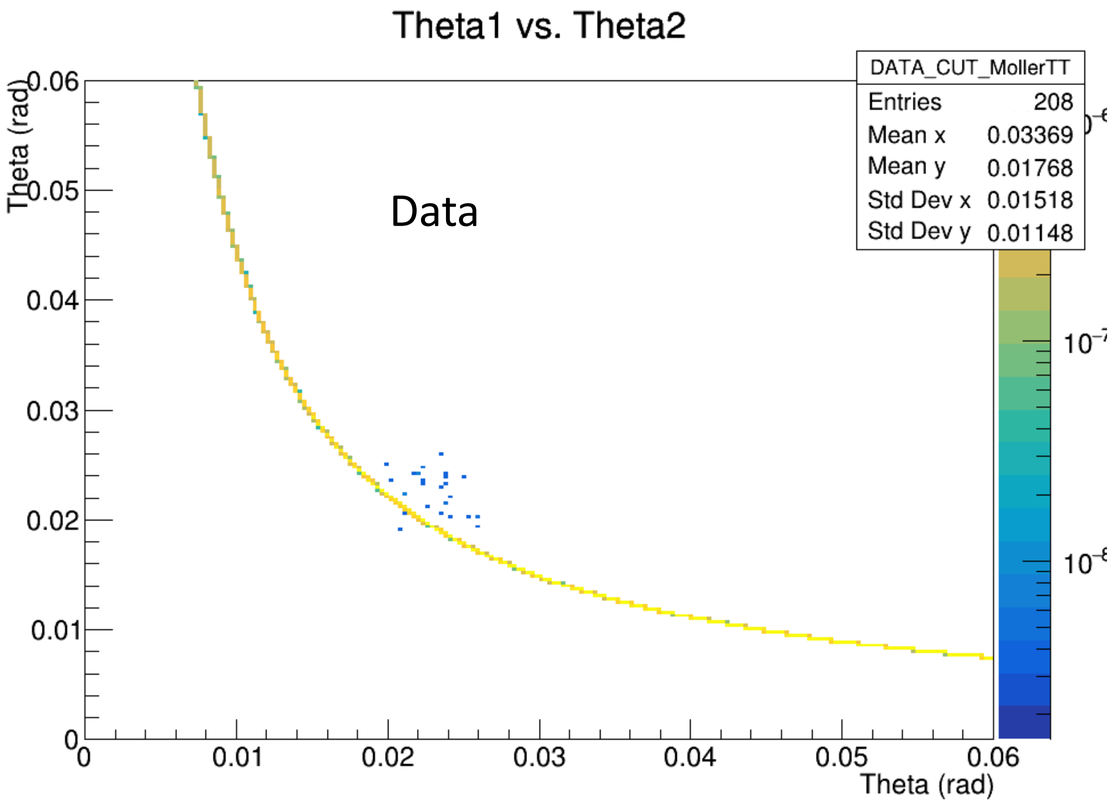
Prelim. Selection (no matching cut)



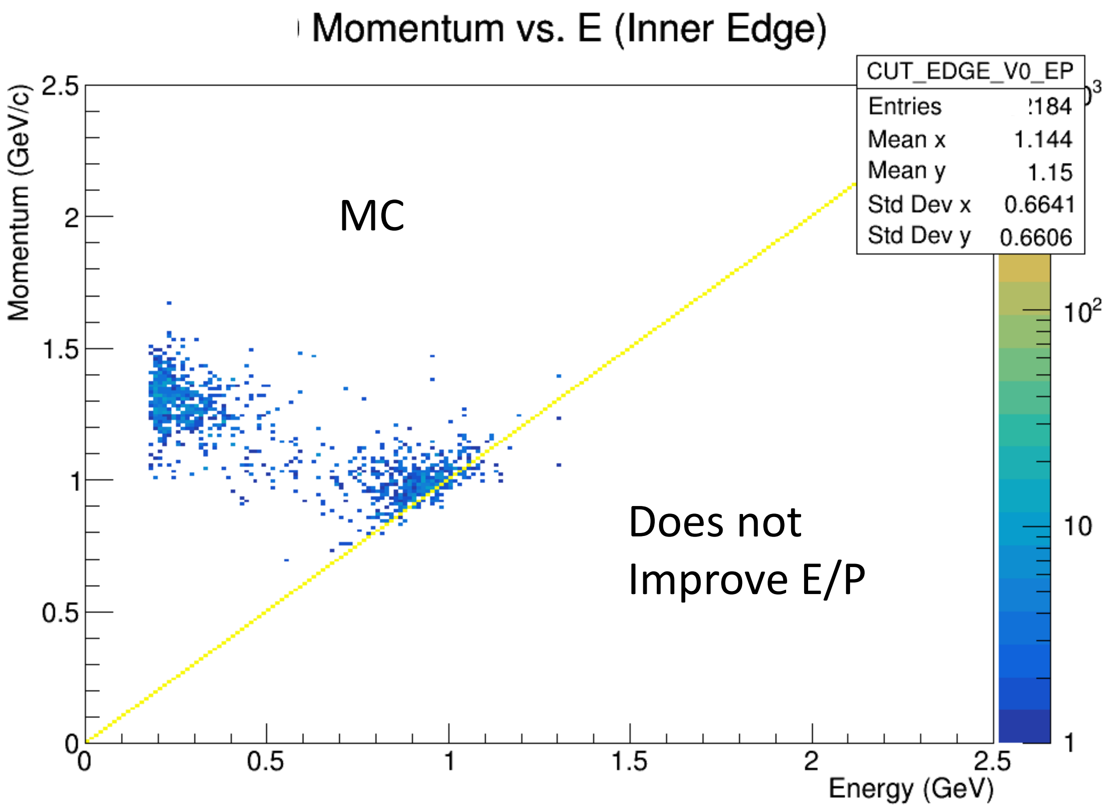


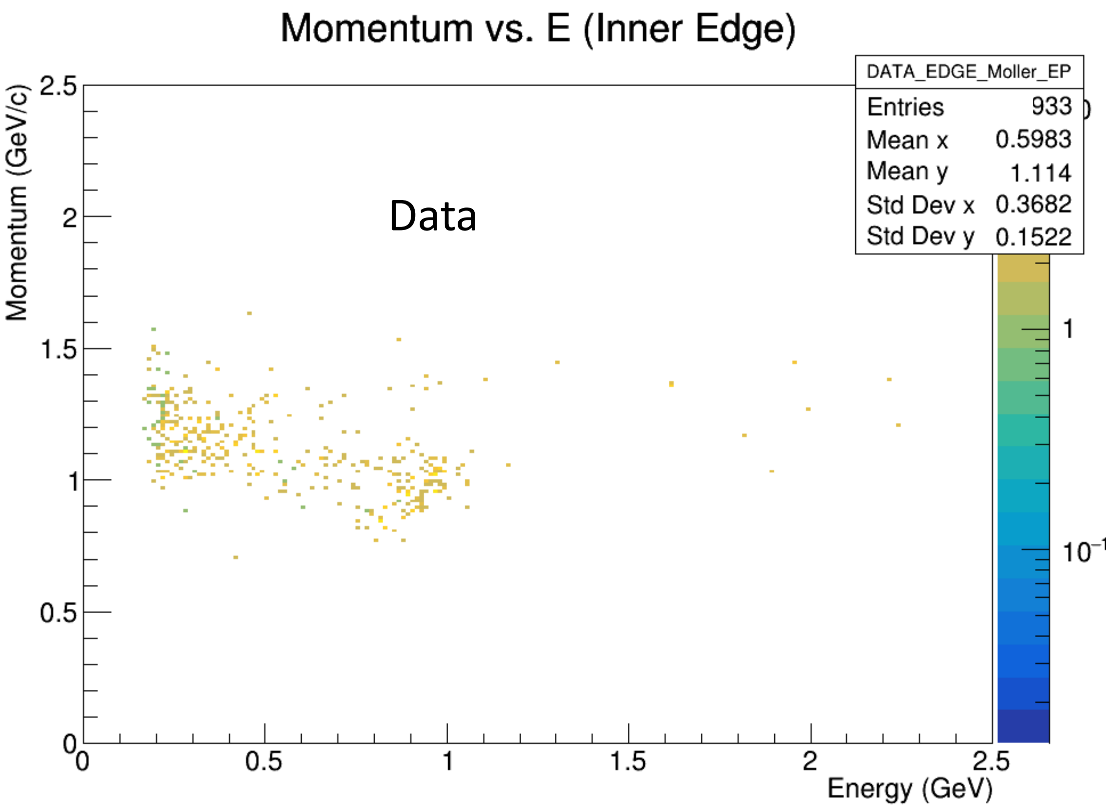
Prelim. Selection (no matching cut)



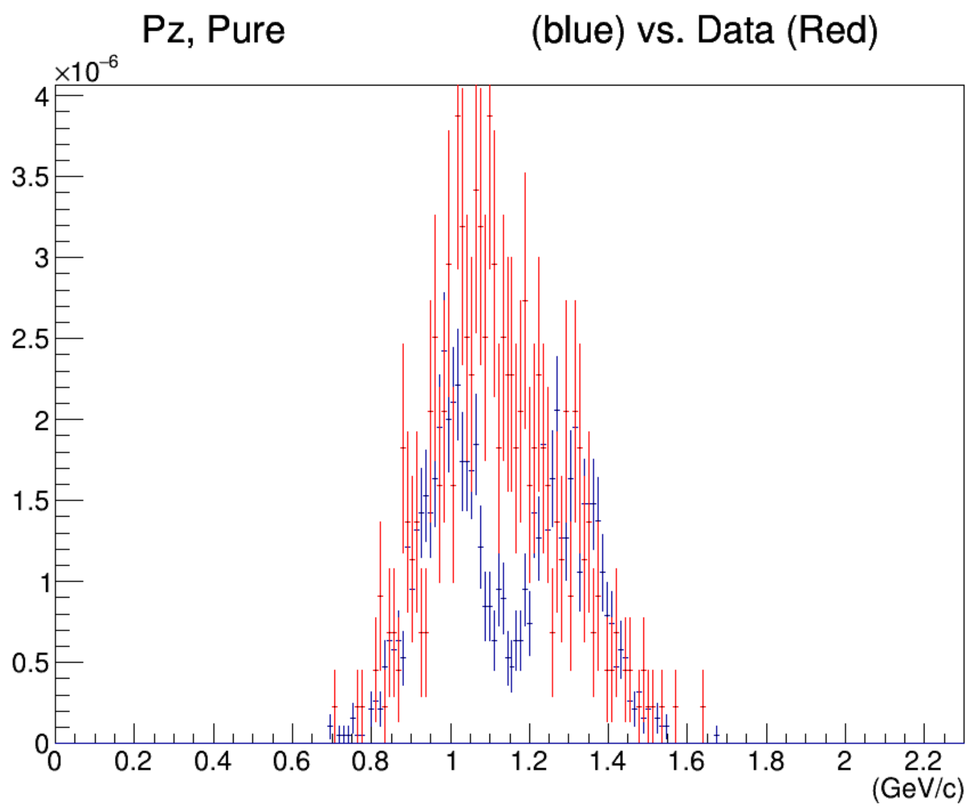


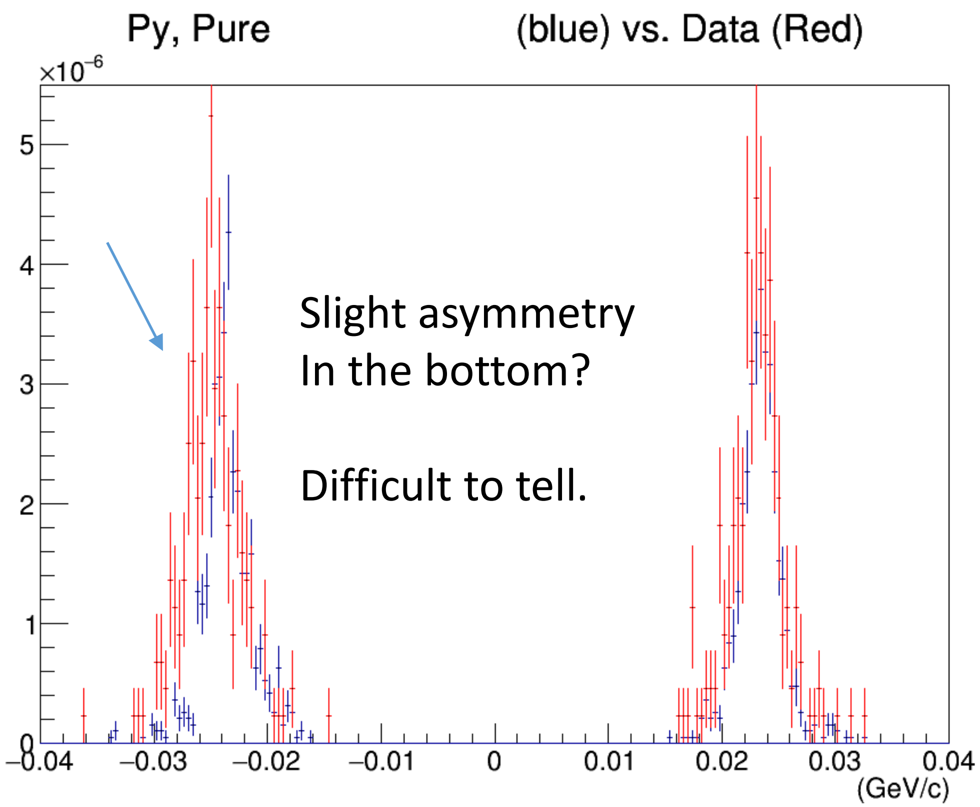
Prelim. Selection (no matching cut)



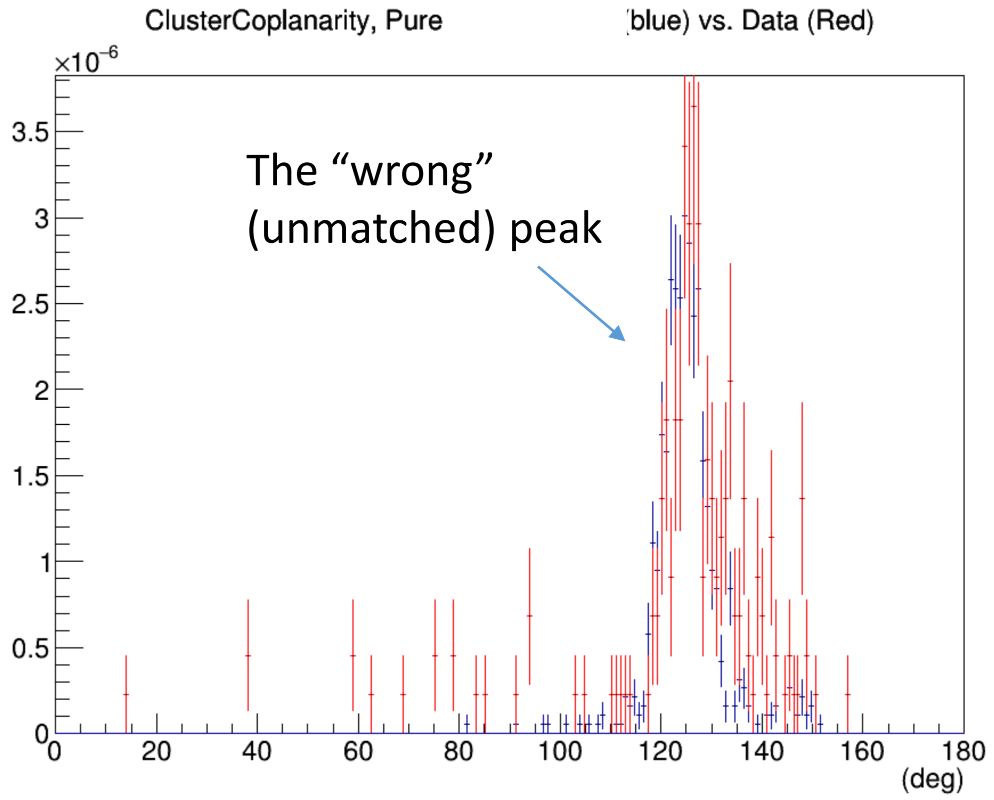


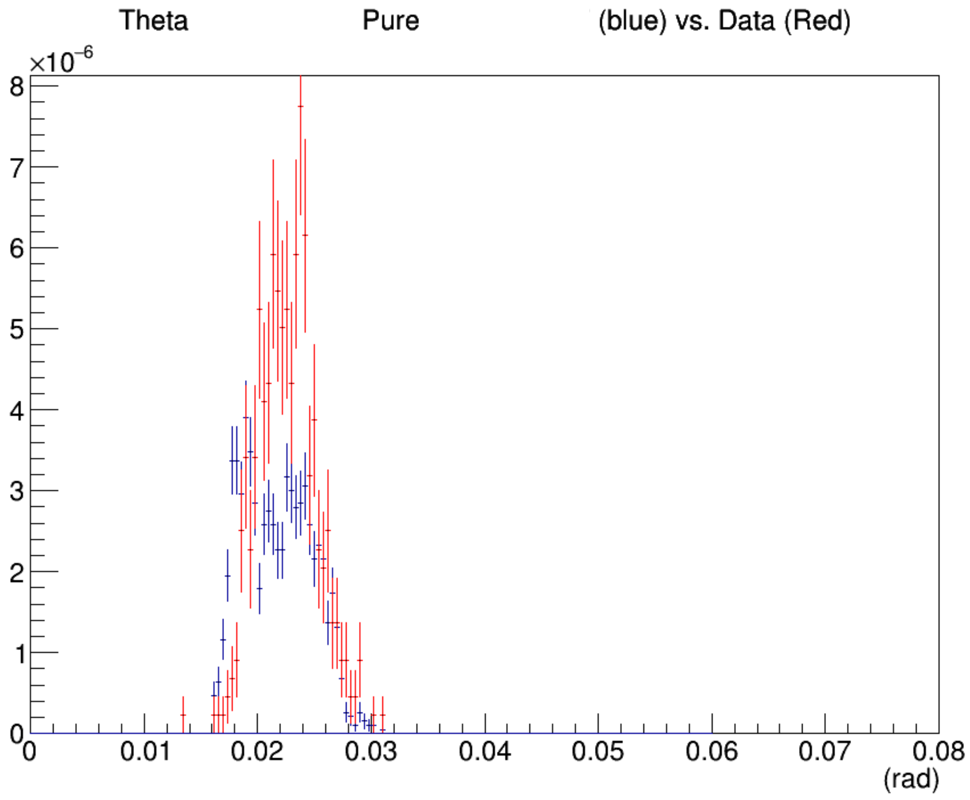
Prelim. Selection (no matching cut)



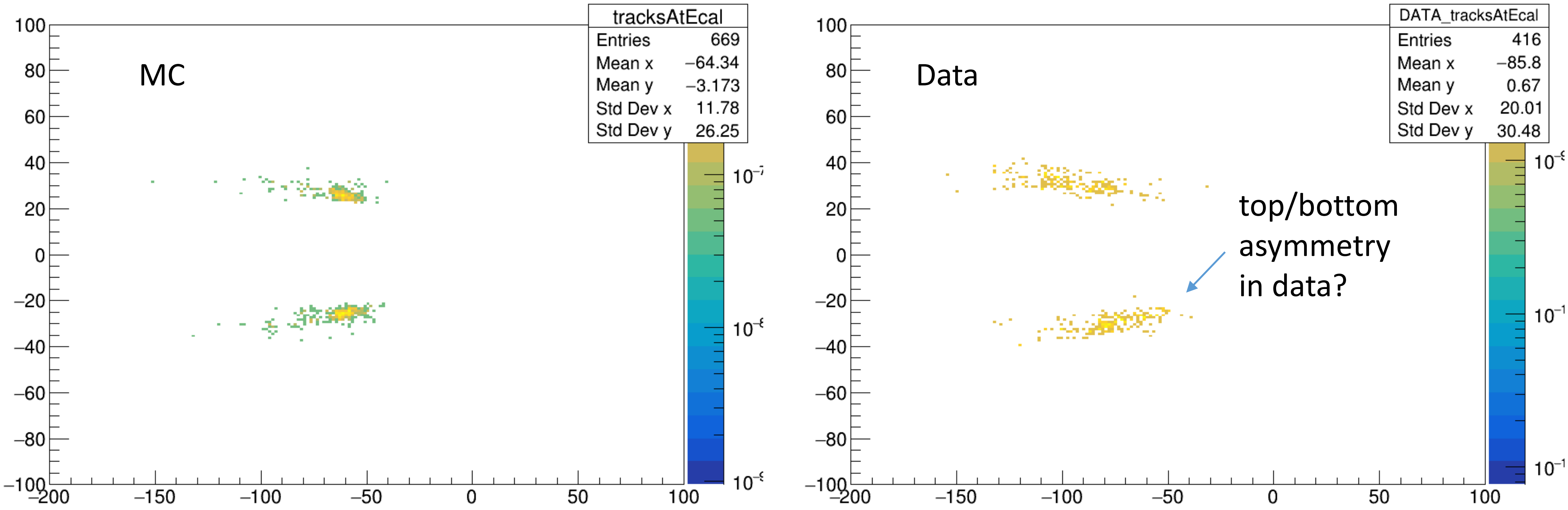


Prelim. Selection (no matching cut)

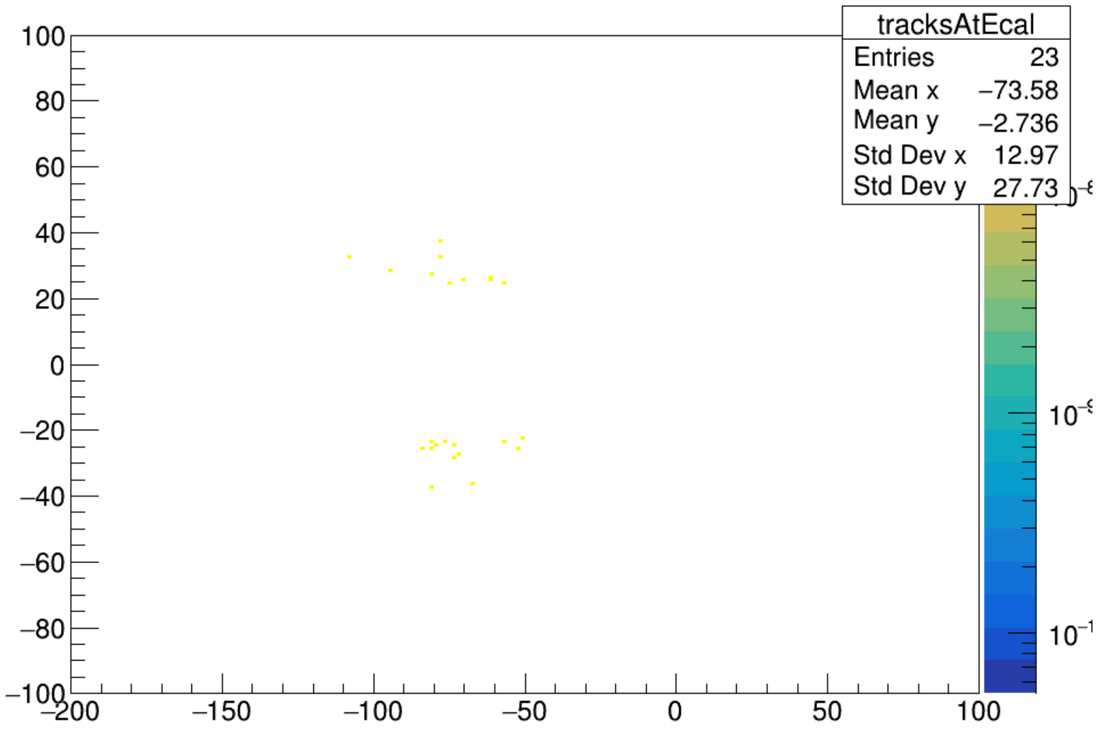


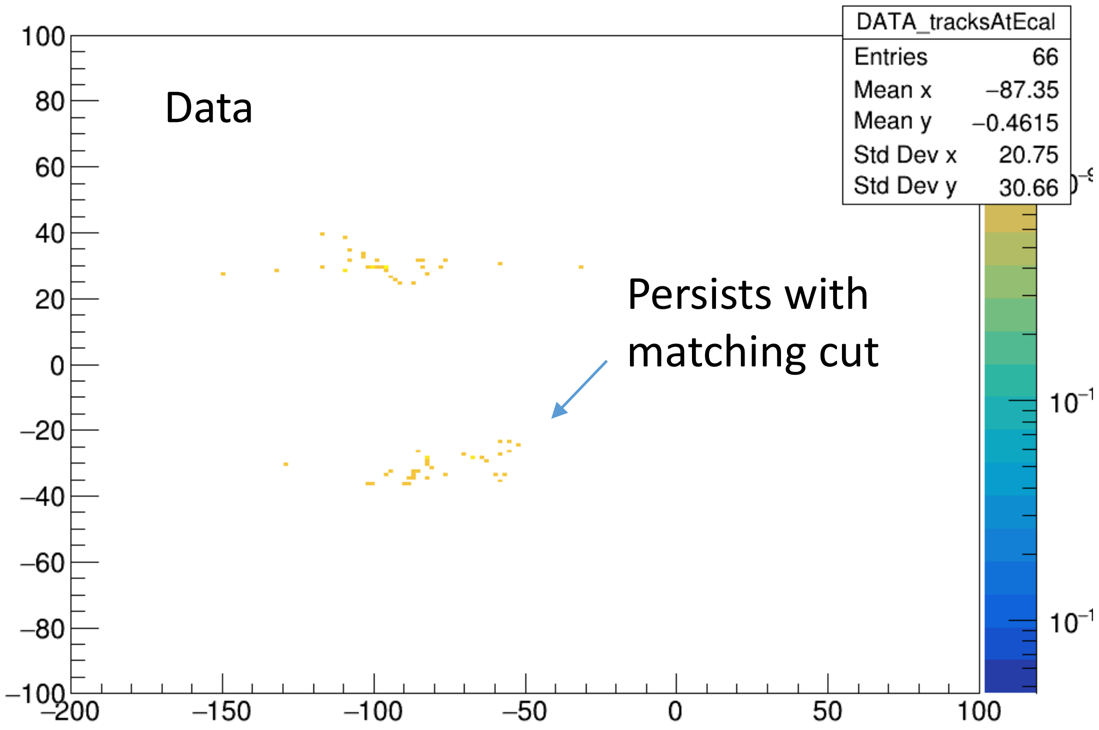


Prelim. Selection (no matching cut)

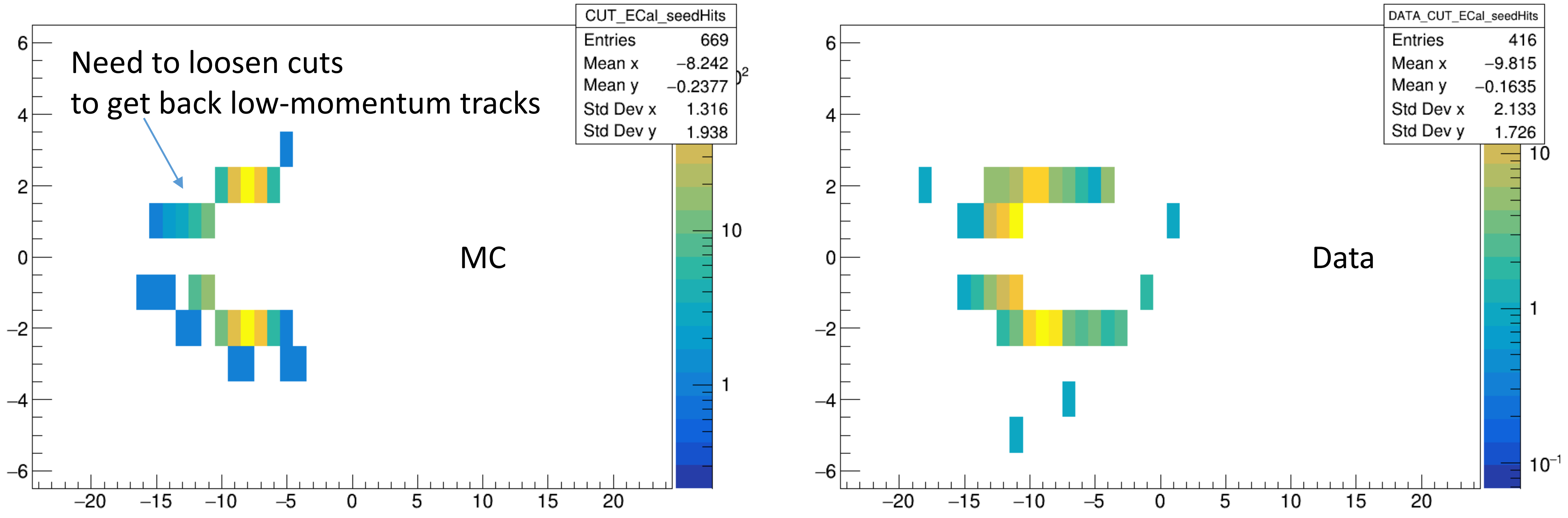


Prelim. Selection (w/10mm y-matching cut)

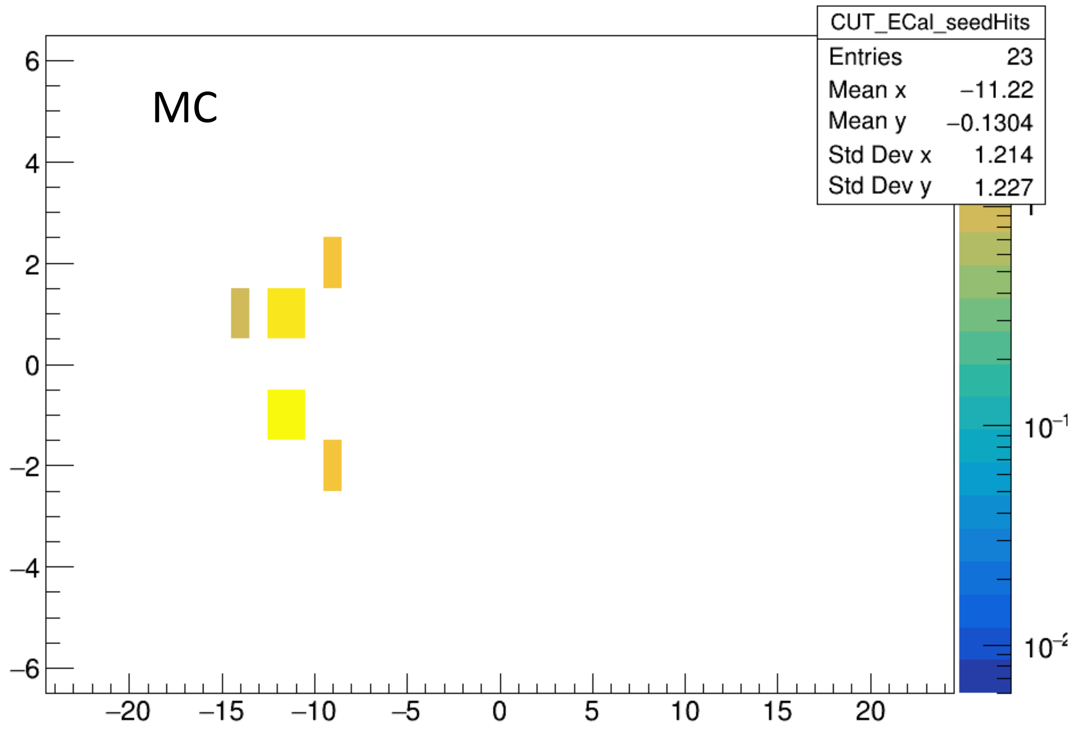


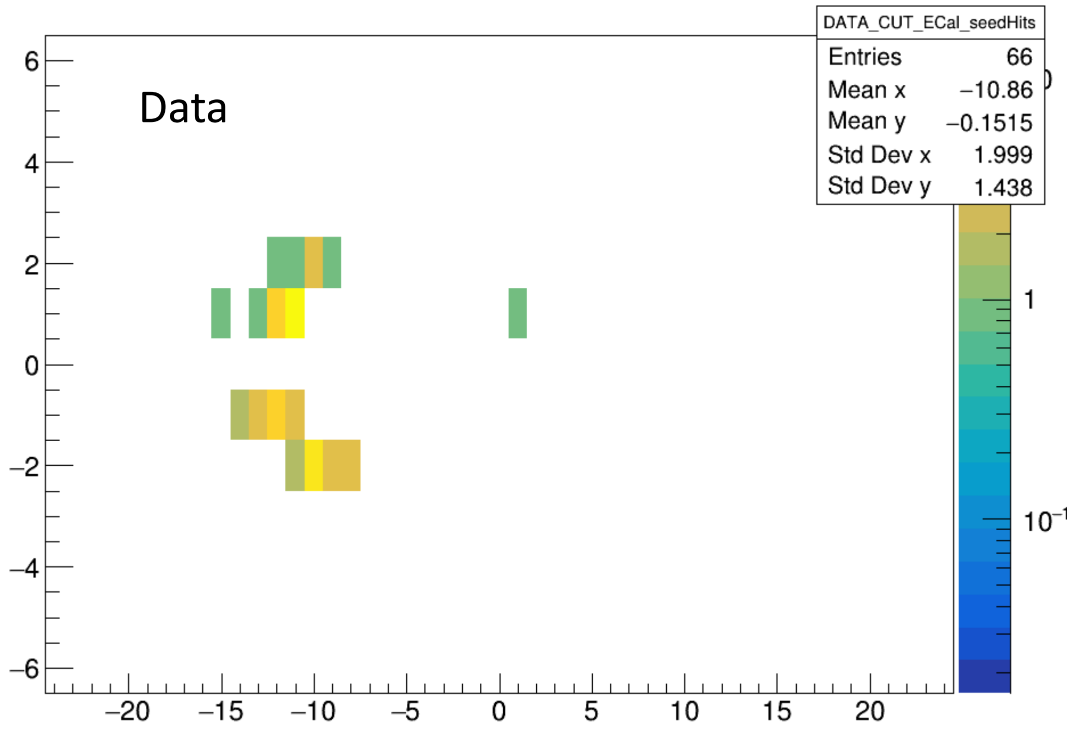


Prelim. Selection (no matching cut)

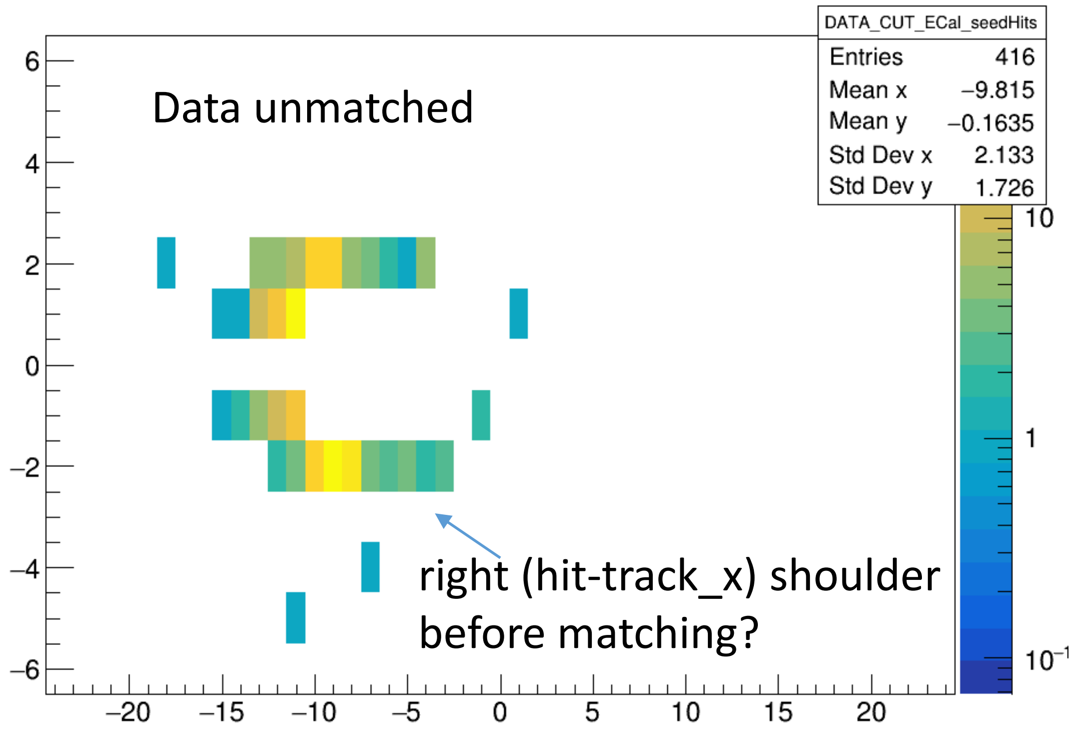


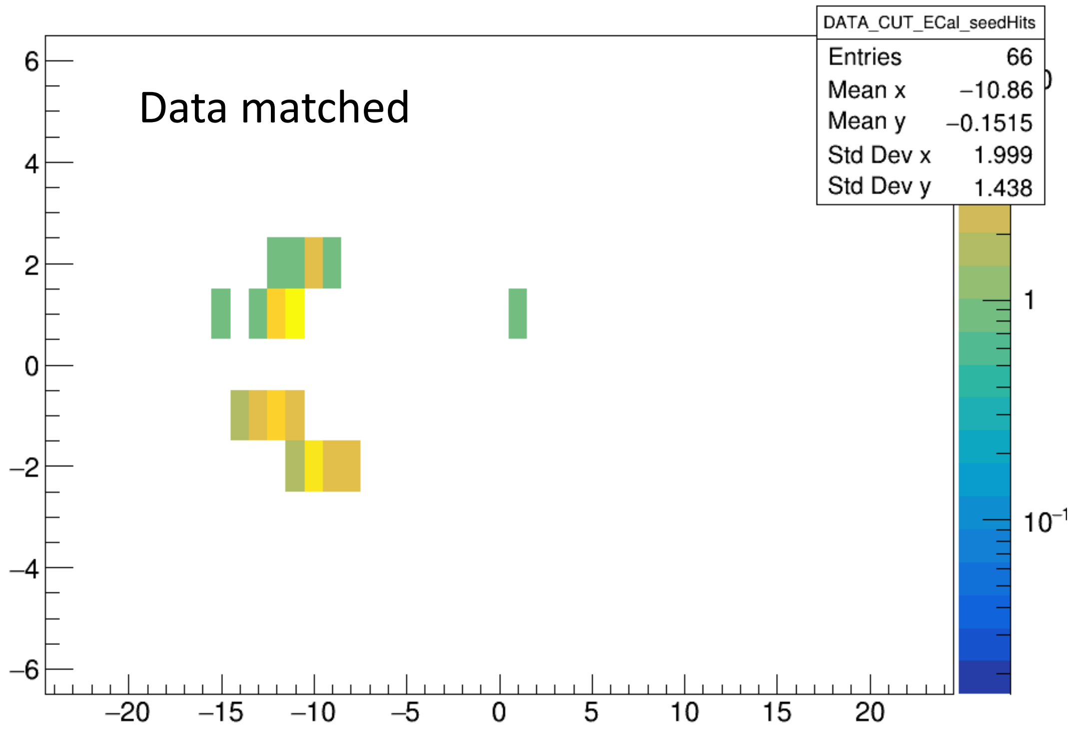
Prelim. Selection (w/10mm y-matching cut)



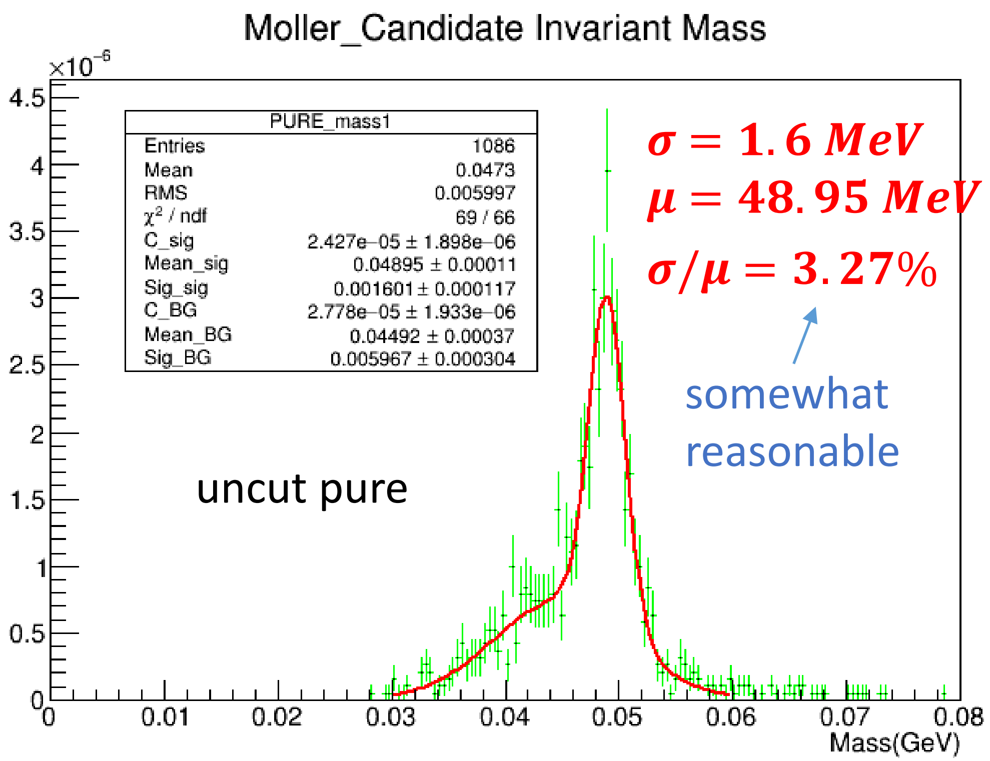


Prelim. Selection (unmatched vs. matched)





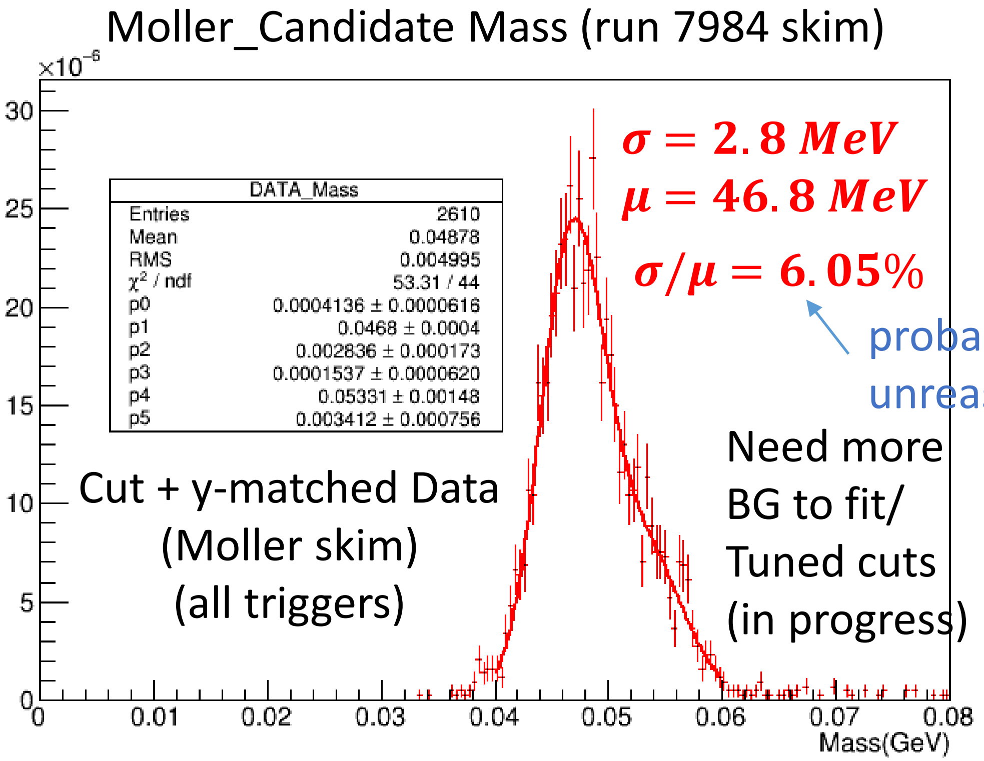
Mass fits (very preliminary)



$\sigma = 1.6\ MeV$
$\mu = 48.95\ MeV$
$\sigma/\mu = 3.27\%$

somewhat reasonable

uncut pure



$\sigma = 2.8\ MeV$
$\mu = 46.8\ MeV$
$\sigma/\mu = 6.05\%$

probably unreasonable

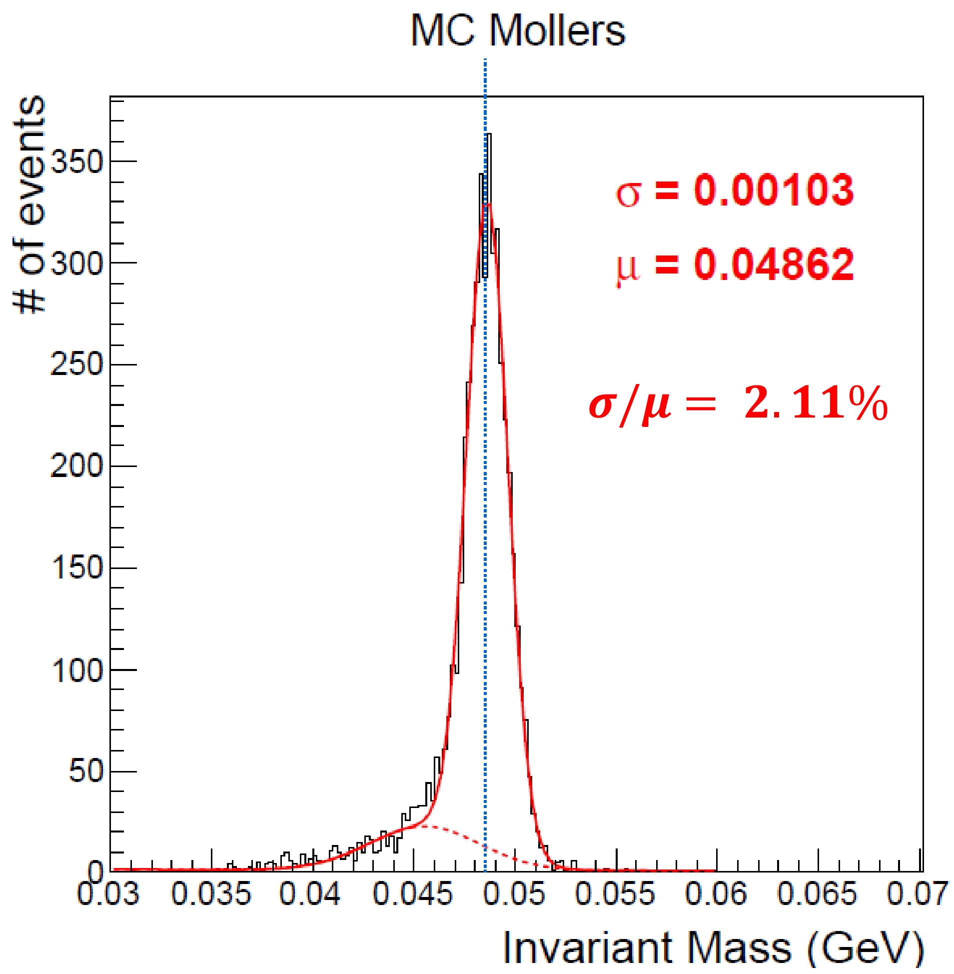
Cut + y-matched Data
(Moller skim)
(all triggers)

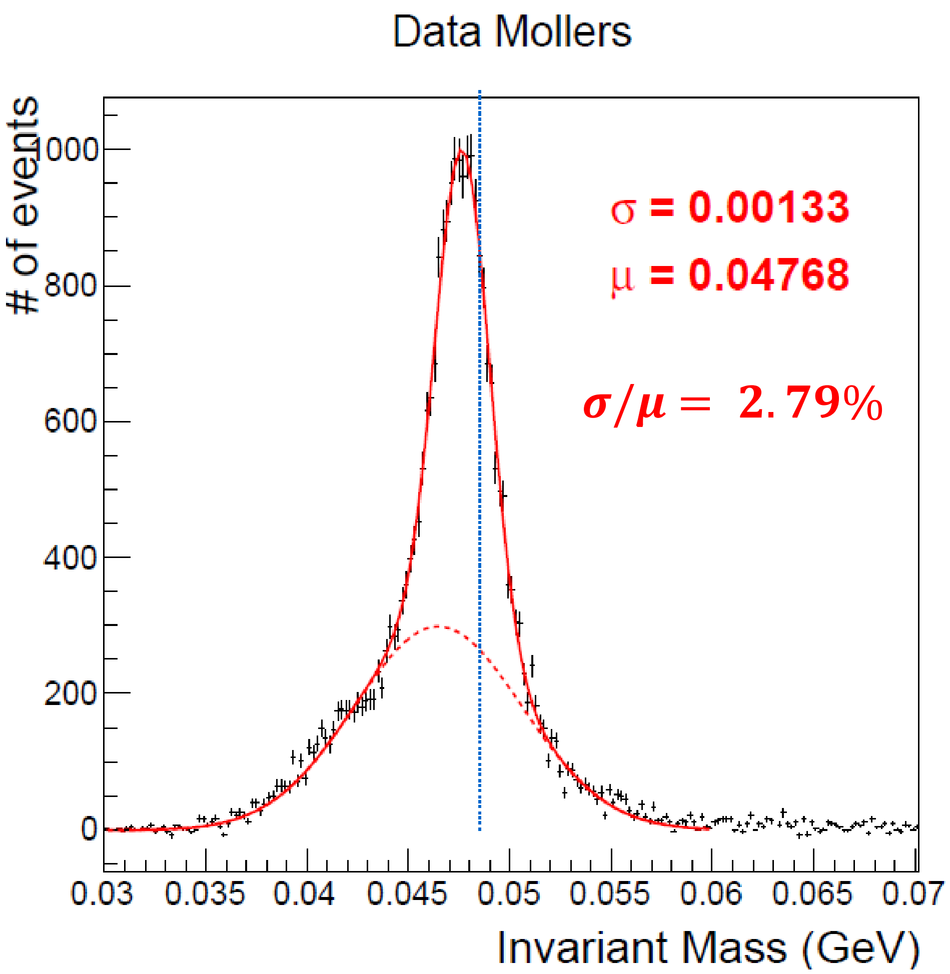
Need more BG to fit/
Tuned cuts
(in progress)

Sebouh's Moller Selection and Mass Fits

- single0 trigger
- both track fit $\chi^2/\mathrm{d.o.f.} < 5$
- both tracks — doca — < 1.5 mm Cuts into WAB tail
- both tracks $p < 1.75$ GeV
- track time difference < 2 ns $(\approx 2\sigma_{t\_track})$
- p_{total} between 1.75 GeV and 2.6 GeV
- only one cluster; $x_{\mathrm{cluster}} < -80$ mm
- no positrons

Sebouh’s Moller Selection and Mass Fits





Summary

- Currently, cluster and track positions/energies are not correctly matched for edge hits, particularly around the corners of the e-hole
  - This effect is more dramatic for 2.3 GeV, with increased bend along edge
- Poor clusters with artificially low energy, are assigned high-momentum tracks
  - Can this be corrected? It should be affecting non-Moller events as well
- MC/Data normalizations look good so far
- Current “best” 2.3 GeV Moller mass resolutions for MC/Data: 2.11%/2.79%
  - Need to properly check/normalize these events
  - If correct, much better than for 1.056 GeV (MC/Data = 1.319MeV/1.557MeV = 6%/7.5%)
  - 1.056 GeV: 1.5% difference in MC/Data resolution, 2.3 GeV: < 1% difference?