Status of Resonance search analysis

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Event Selection

- Description of selection cuts
  - Cut efficiencies
  - Final (as of now) invariant mass distribution
- ECal time correction

Things to do, and the timeline

Cuts to select final event samples

DST v0 skim: V0 candidates from MOUSE cuts

- Have already applied not tight cuts on most of variables (details os MOUSE cuts in backup slides)

- e^- and e^+ Cluster time difference
- Track - cluster time difference
- Track - cluster matching
- Electron maximum momentum (Anti FEE cut)
- d0 cut (Anti WAB cut)
- L1 requirement for e^+ tracks
- P_{sum} Min cut
- P_{sum} Max cut
- Track χ^2/NDF

In general for the rest of cuts, a “Tight” cuts are applied to the rest of variables, and the distribution of a given variable is looked

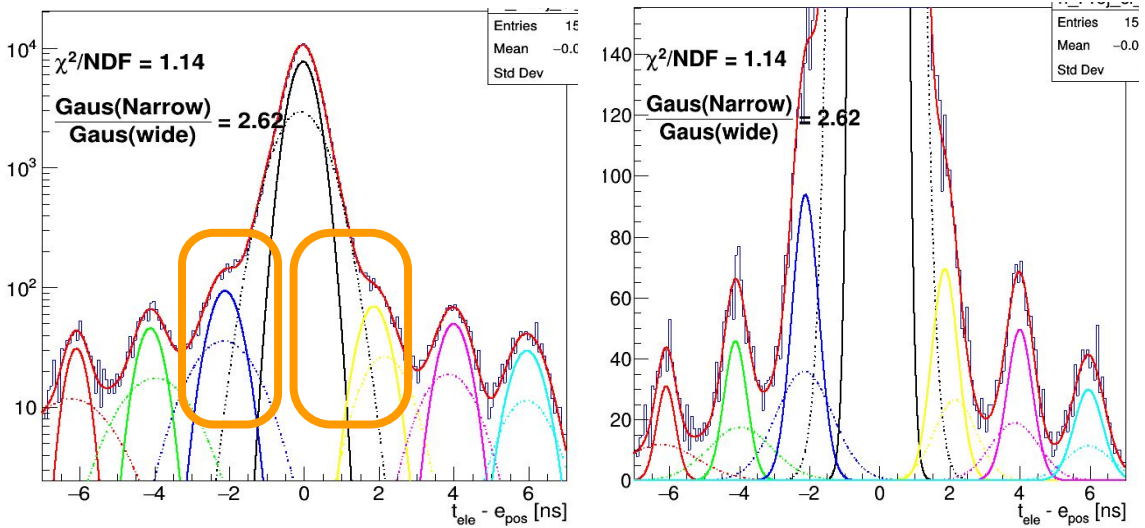
The cluster time difference cut

Question remained unanswered from the analysis of pass1

The 1st cut cluster time difference cut:

The idea was to check individually all clusters, to see of there is an outlier causing this asymmetry.

Shoulders at ± 2 ns are not symmetric.



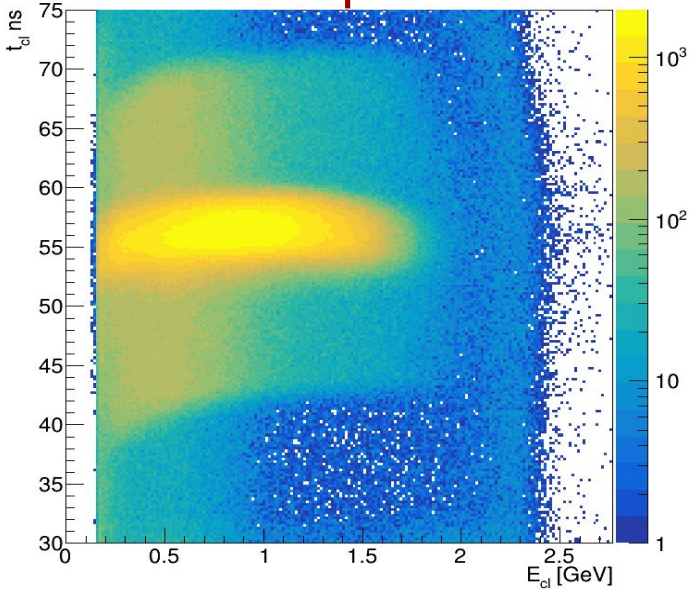
Cluster time vs Energy

In “pair1”, the trigger time is determined by the bottom cluster time, that is why we see a the effect of the coincidence window in top clusters, while we don’t see for clusters in the bottom half.

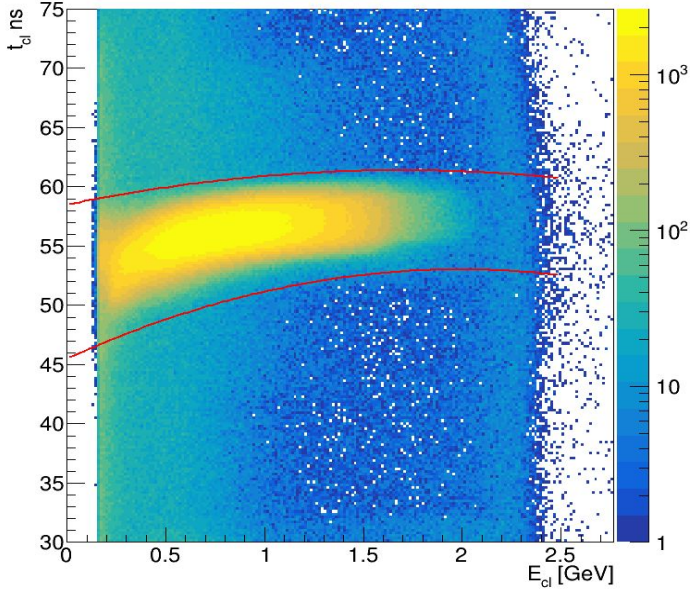
The 1st cut is to cut bottom cluster: pairs outside red curves are discarded.

No cut on Top cluster time at this point: out of time clusters will be cut w/ cluster Δt cut

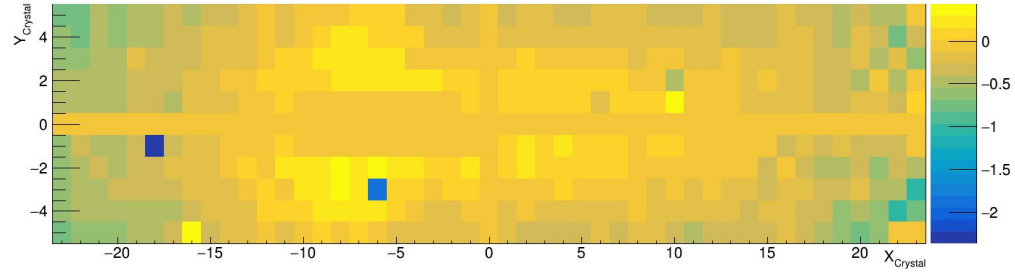
Top

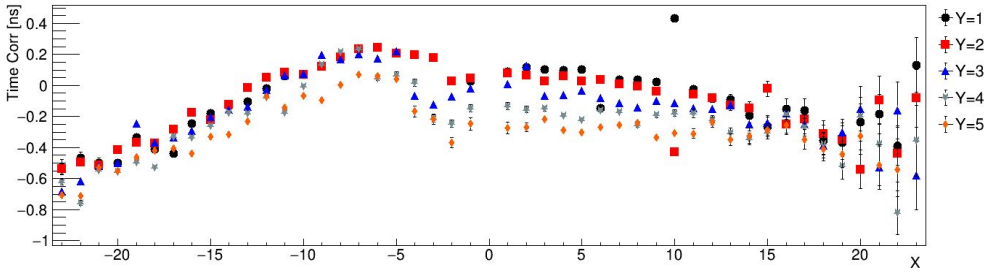


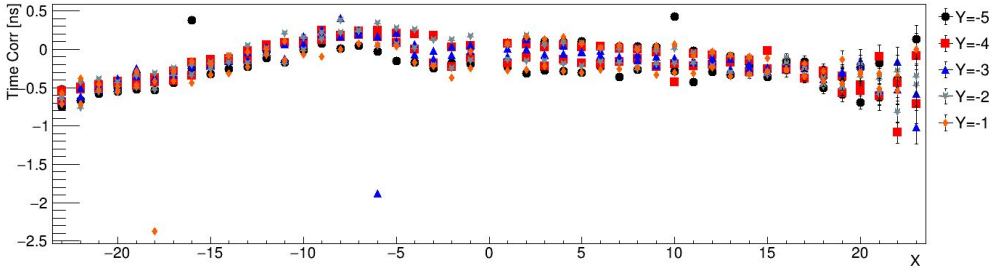
Bottom



High Esum region







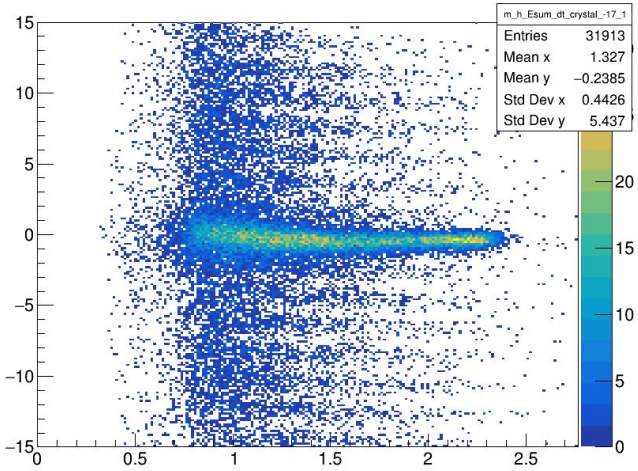
Top-bot pairs with $E_{Sum} > 0.75\ E_b$ selected.

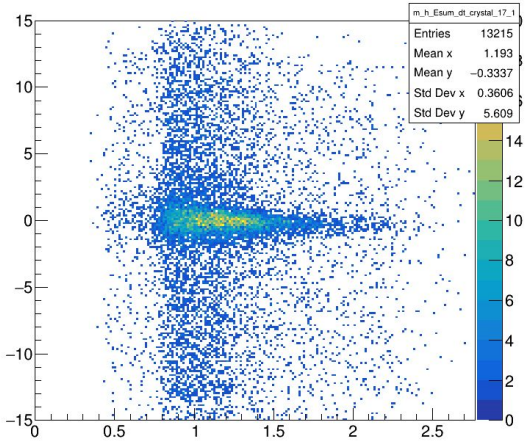
For each crystal the difference between it's and pairs time is plotted.

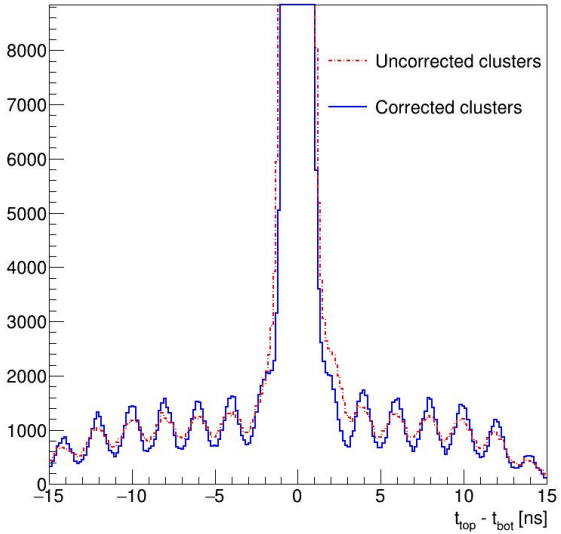
Ideally one would expect all mean values to be at 0.

- Two crystals in the bottom electron side have times shifted by about 2 ns.
- Several more crystals have shifts significant (but less than 2ns) in both: top and bottom halves.
- There is a general dependence of the time offset on the crystal "iX", (probably Energy dependence), Might be time walk corrections might be improved?

Some dependence on the Esum







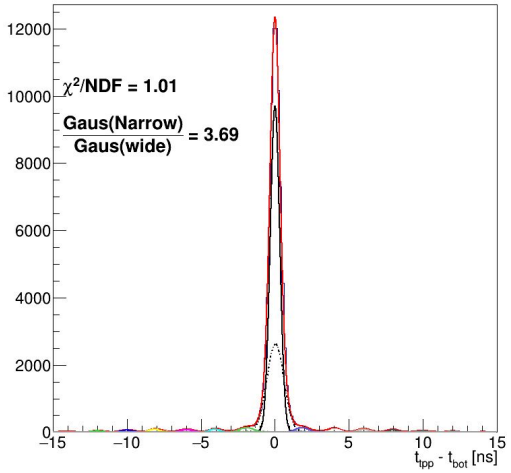
- Secondary peaks are now symmetric.
- Peaks and dips are now sharper, which means the the time resolution got a bit better

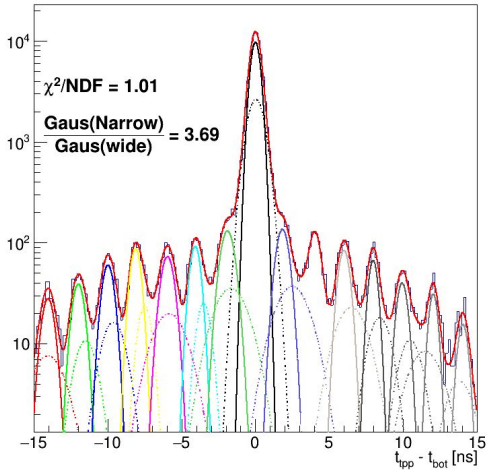
No further digging: For each crystal the time is corrected by these “<u>mean</u>” values

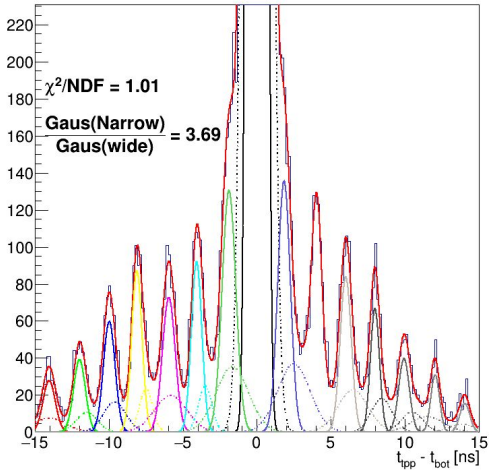
$$F = \sum_{i=0}^{N_{peak}} a_i \cdot \left(Gaus(x - \mu_i^1, \sigma_i^1) + b \cdot Gaus(x - \mu_i^2, \sigma_i^2) \right)$$

The distribution has 15 peaks:

Each peak added 2 Gaussians i the fit function. The ratio “b” between two Gaussians is the same for all peaks.







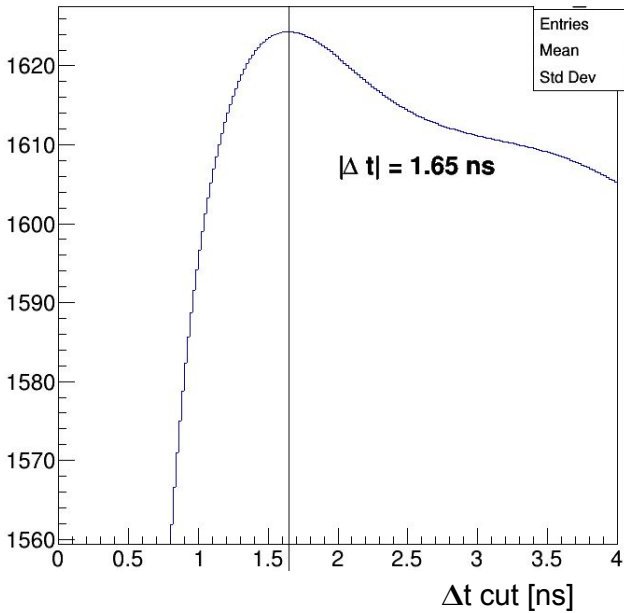
The function fits the distribution reasonably well

The Optimum time cut

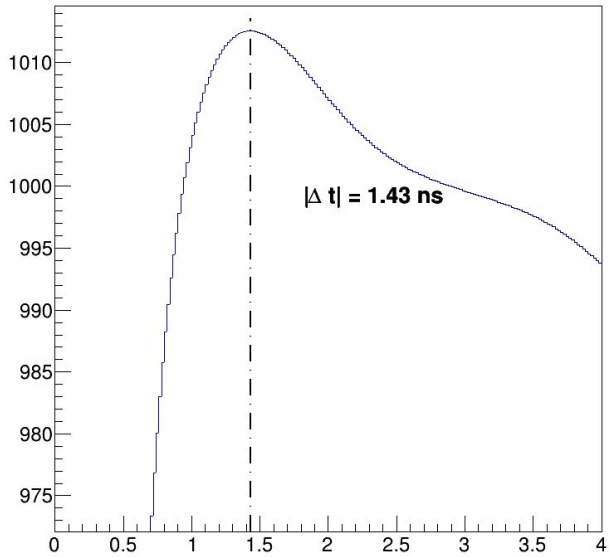
The Optimum Δt cut is chosen the value which maximized the S/Sqrt(S+Bgr) ratio

S: The peak at 0
S+Bgr: Sum of all functions

Old time cut



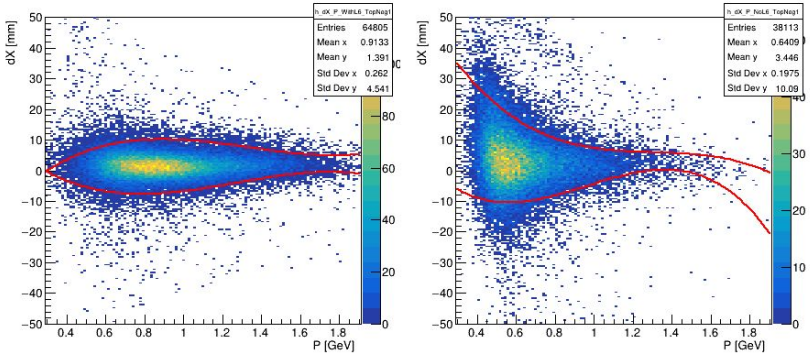
Time cut after the correction

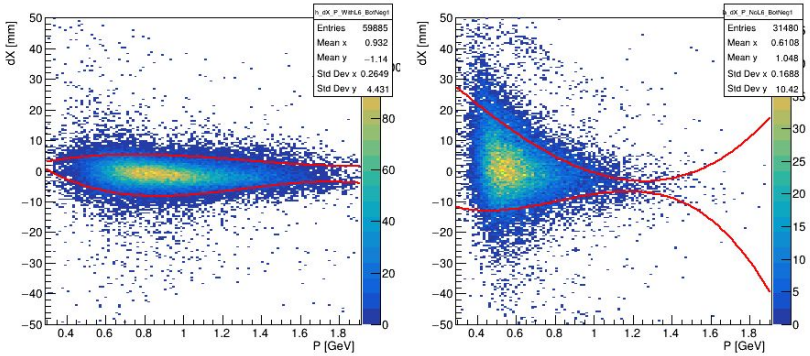


Some of Tight cuts

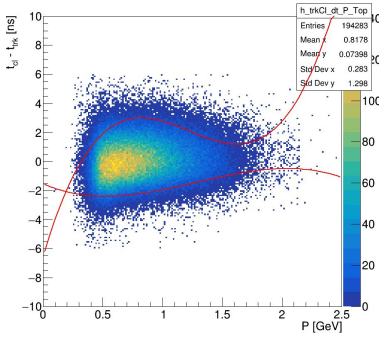
Track-Cluster dX

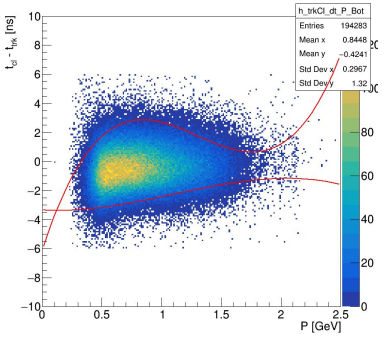
Negatives





Track-cluster time difference

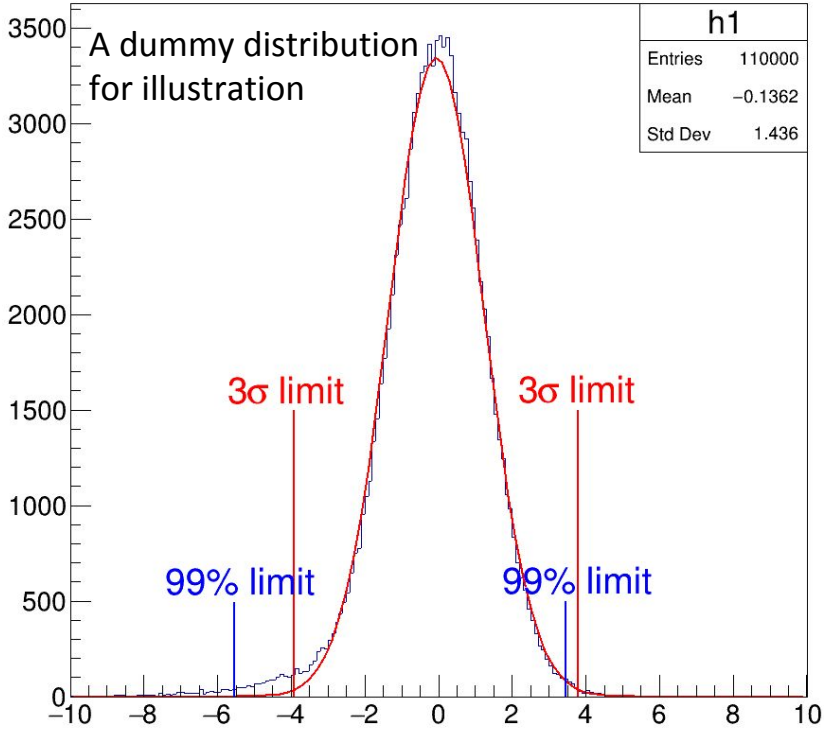




Tight cuts are placed visually. The point is just to make sure cut is tight, and selected events mostly contain signal rather than a bgr.

Choosing cut limits

Some distributions are not quite Gaussian: and just fitting and putting $\pm 3\sigma$ limits is not quite right



Instead: For each "X" bin of 2D (mostly X axis is Momentum) distribution is projected into "Y" axis, and cut limits are identified as limits which exclude 0.5% from each side of the distribution.

Some details

If total # of events is small (<45 in this case), then the everything is considered as out of acceptance.

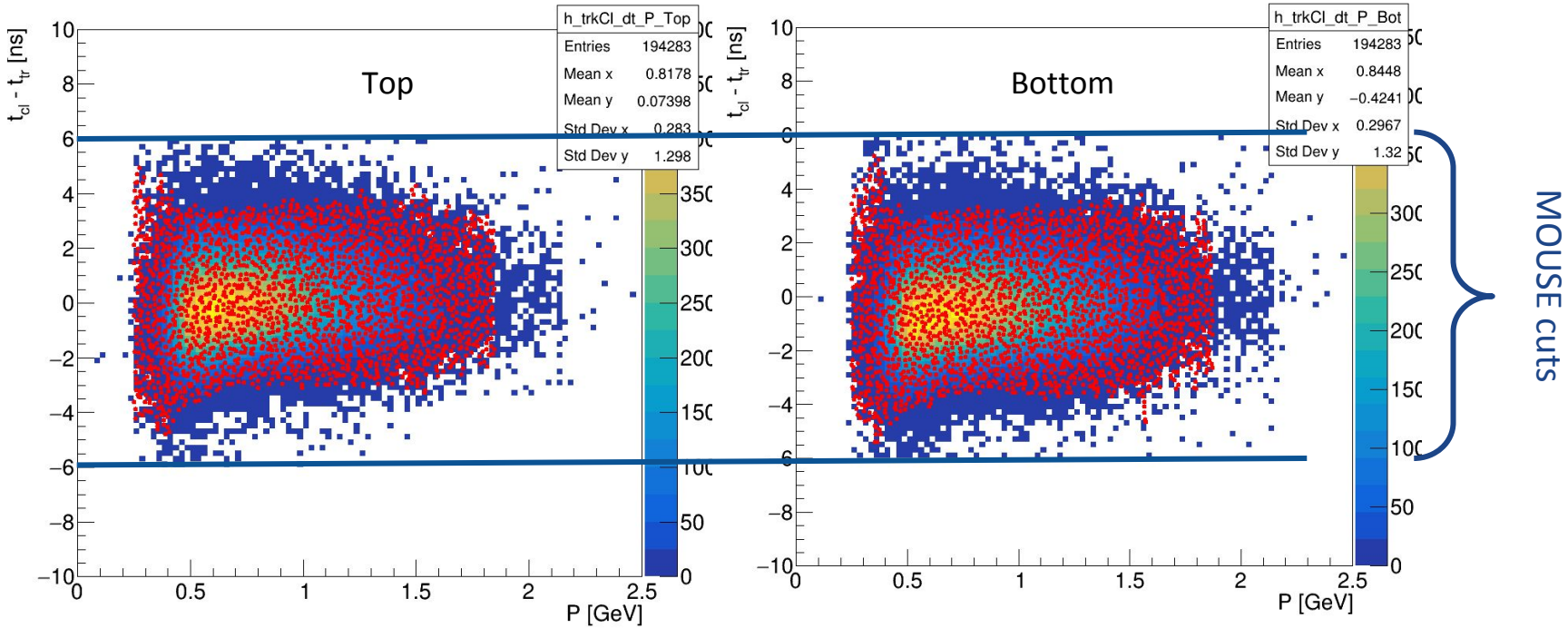
- If total # of events is < 100, then throw 5%
- If total # of events is < 200, then throw 4%
- If total # of events is < 500, then throw 2%

Note: # of events in above mentioned cases are too small. In the 2D histogram # of events are around 400K.

Track-Cluster time difference

Trk-Cl time difference was looked for different type of tracks (pos/neg - 5hit/6hit - top/bot), however only difference was observed in Top and Bottom only.

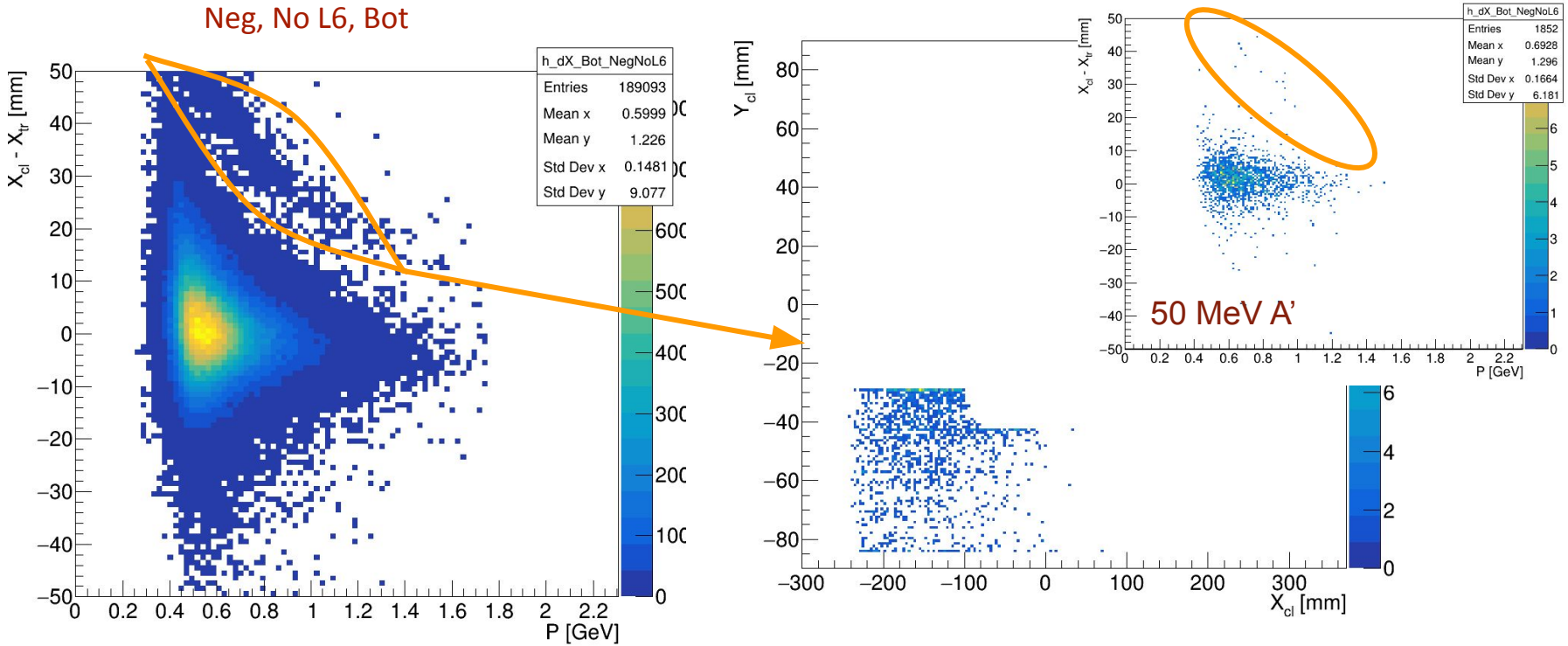
Above 1.85 GeV, # of events is too small, and therefore all these regions are cut, however “Signal” electrons are below 1.85 GeV.

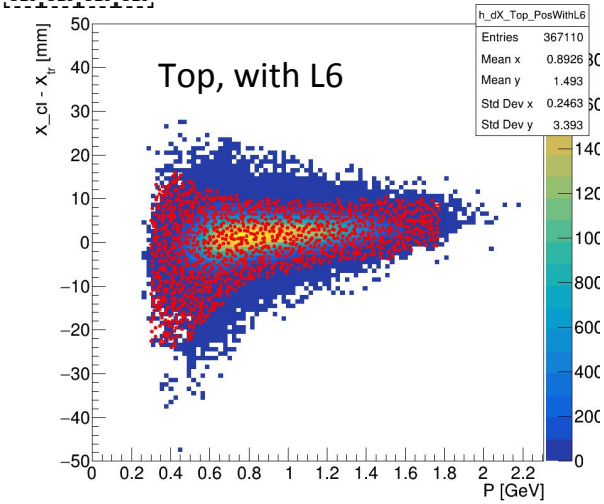


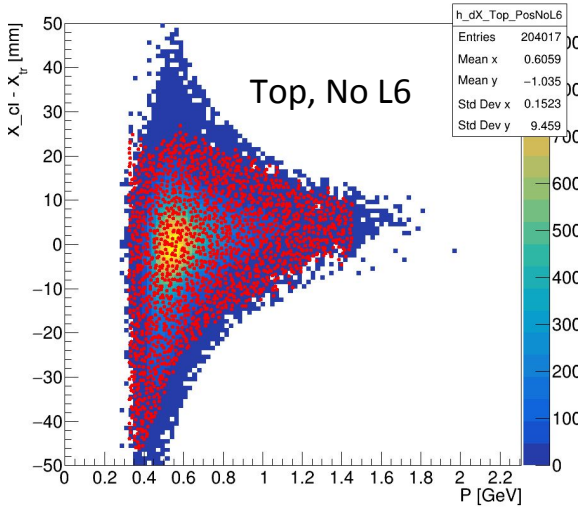
Track - Cluster Matching

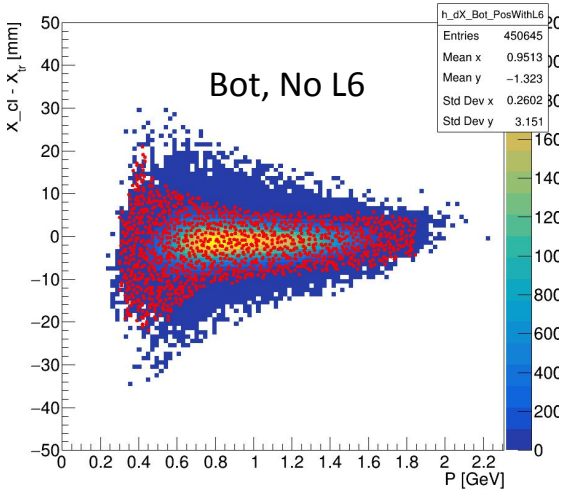
The "dX = X_{Cl} - X_{tr}" is studied as a function of momentum. It depends on detector half, the track charge, and whether it has L6 hit or not.

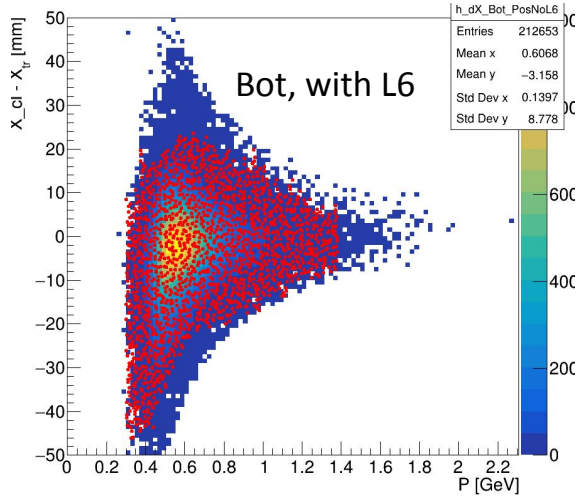
The reason is not clear. However these events are order of 1%. They were cut in the analysis







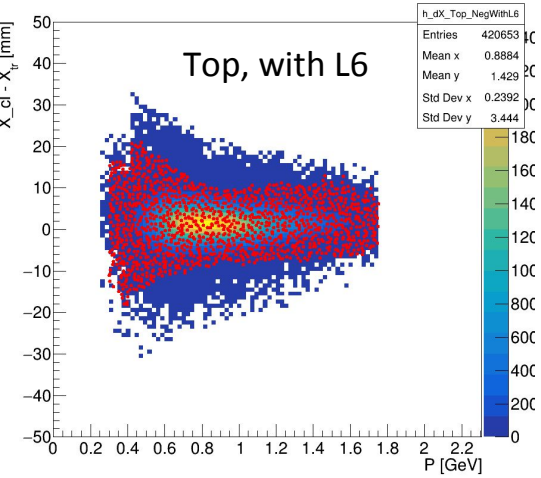


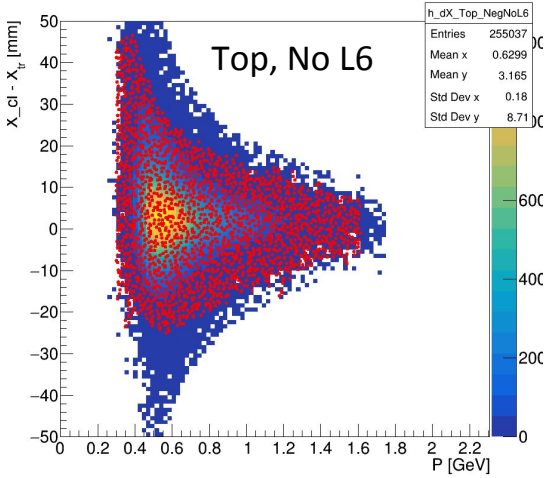


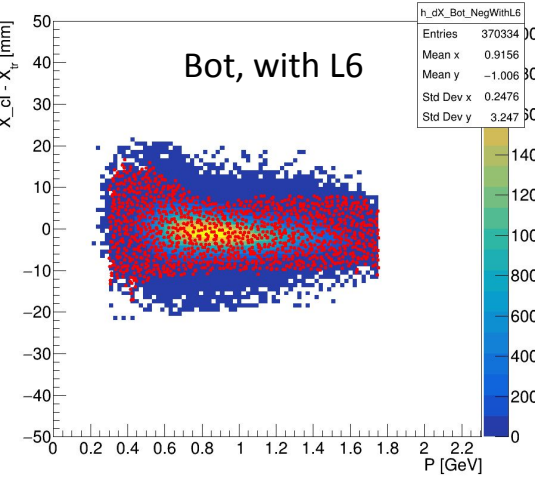
Positive tracks

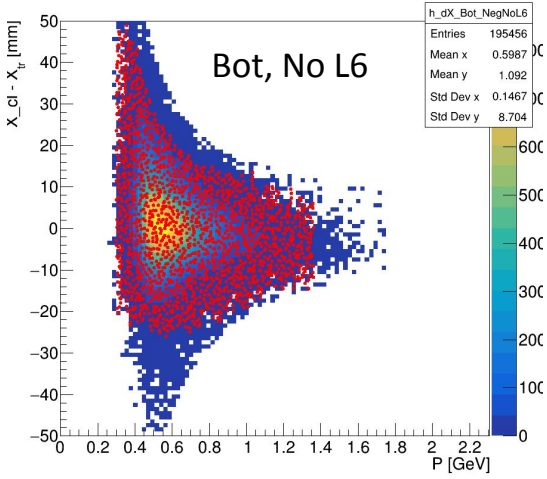
Red histogram represent the acceptance region

Negative tracks





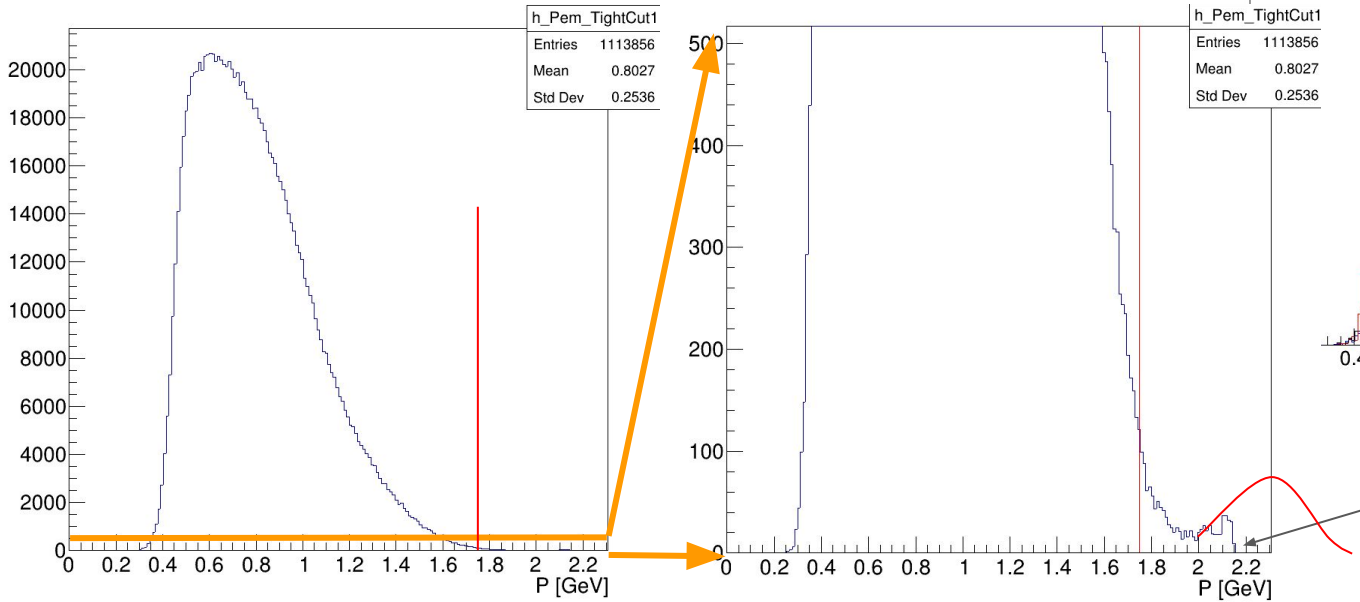


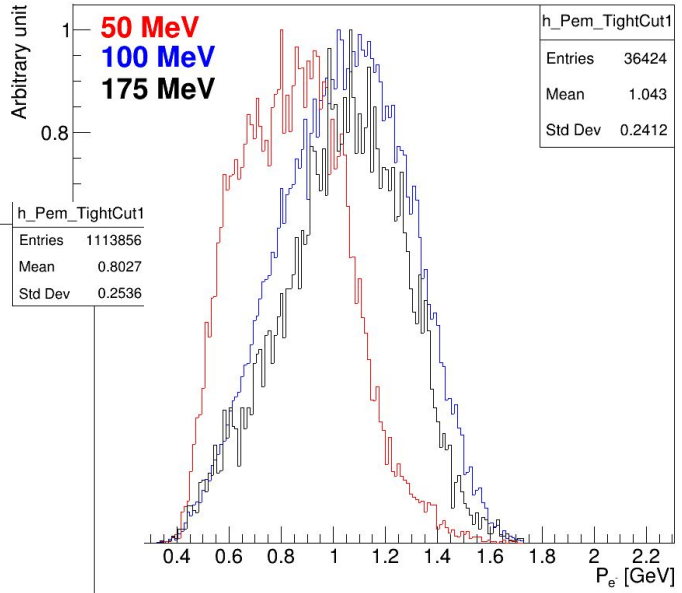


Electron maximum momentum (Anti FEE cut)

Based on MC, 1.75 GeV cut was applied to electron momentum.

When cuts are applied to the rest of variables, essentially no FEE enters into the final sample.



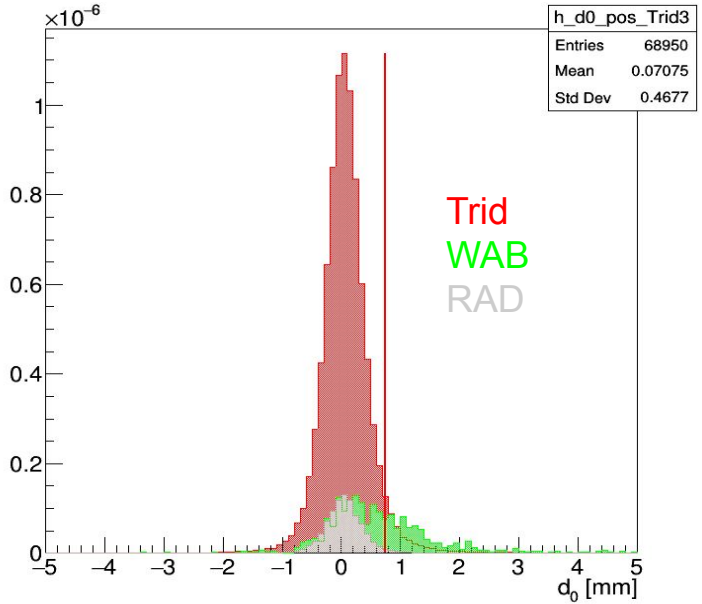


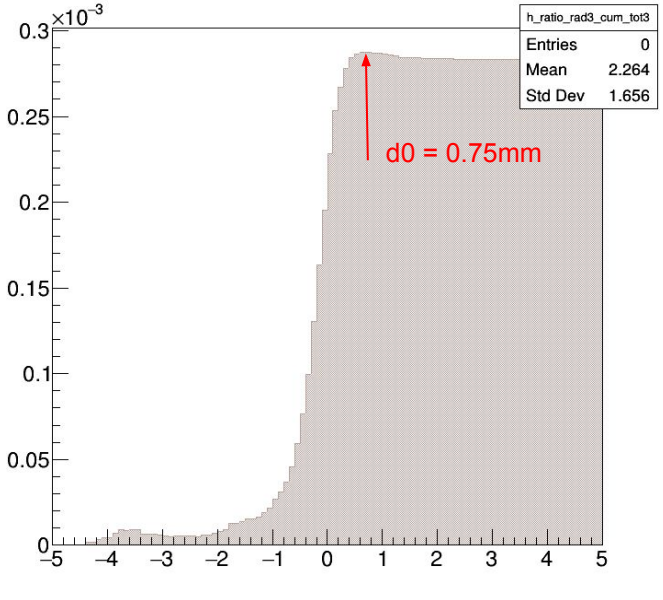
d0 cut (Suppressing Converted WABs)

We didn't have enough MC, for new alignment, about 200 cWAB events

Tongtong produced new MC with about 20K cWABs yesterday, but haven't looked at yet

Just reminding the cut based on pass1 MC data

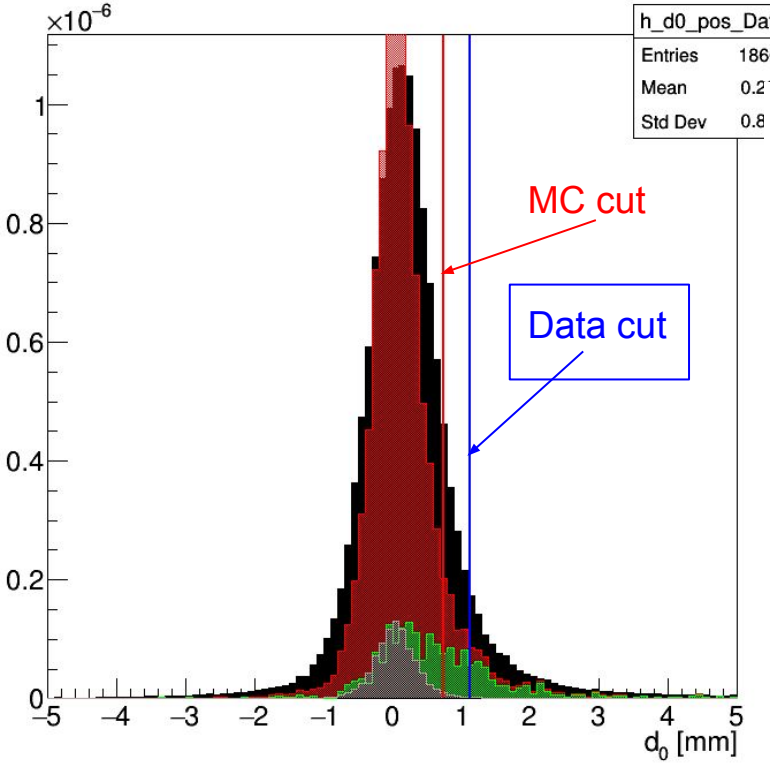




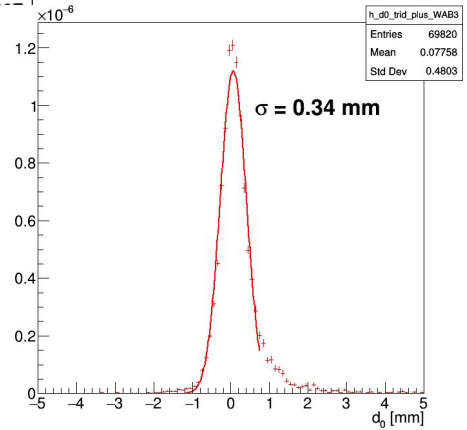
Using only MC, the d0 cut is optimized as N_rad/sqrt(N_trid + N_WAB)

d0 cut (Suppressing Converted WABs)

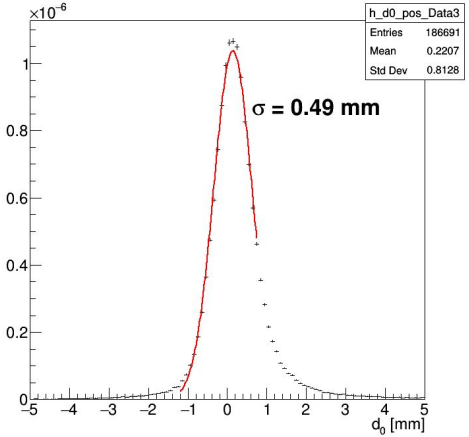
Data and MC resolutions are not the same, so same d0 cut should not be applied



Trident + WAB



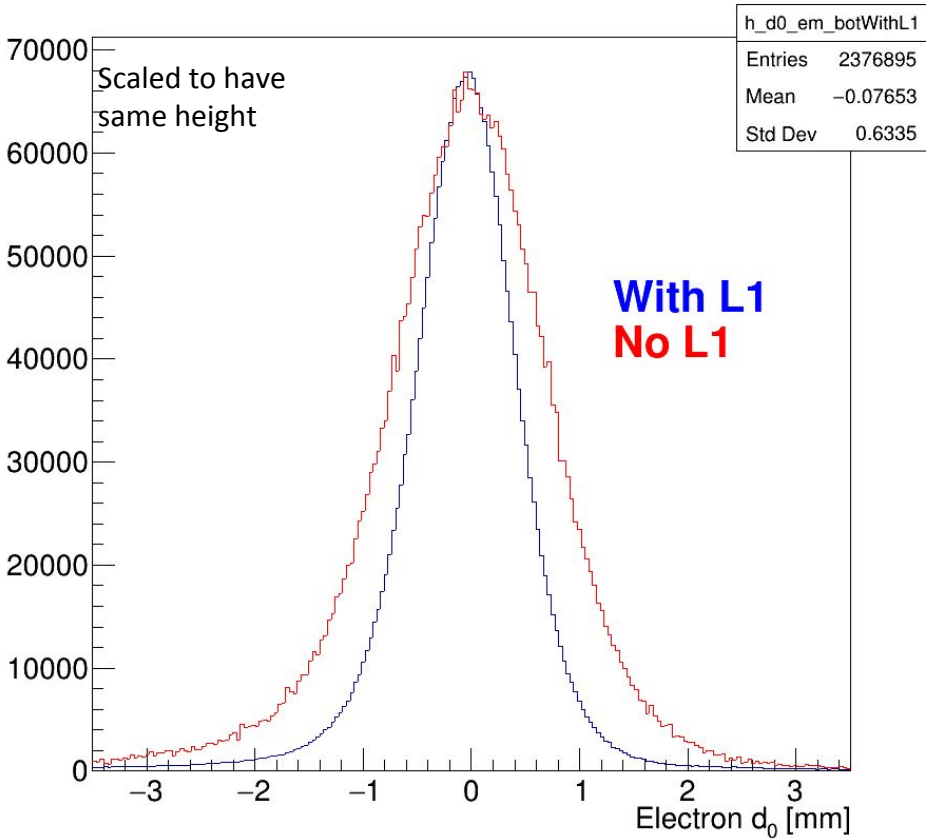
Data



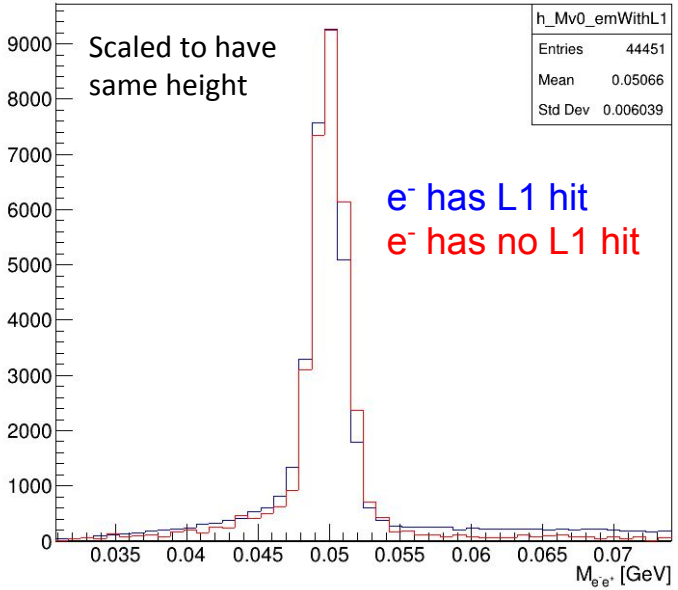
d0_cut(data) = **μ**(data) + (d0_cut - **μ**(MC))**σ**(Data)/**σ**(MC)

This number will be updated soon, when I use the New MC.

d0 cut (Suppressing Converted WABs)



Target Constrained mass, 50 MeV A'

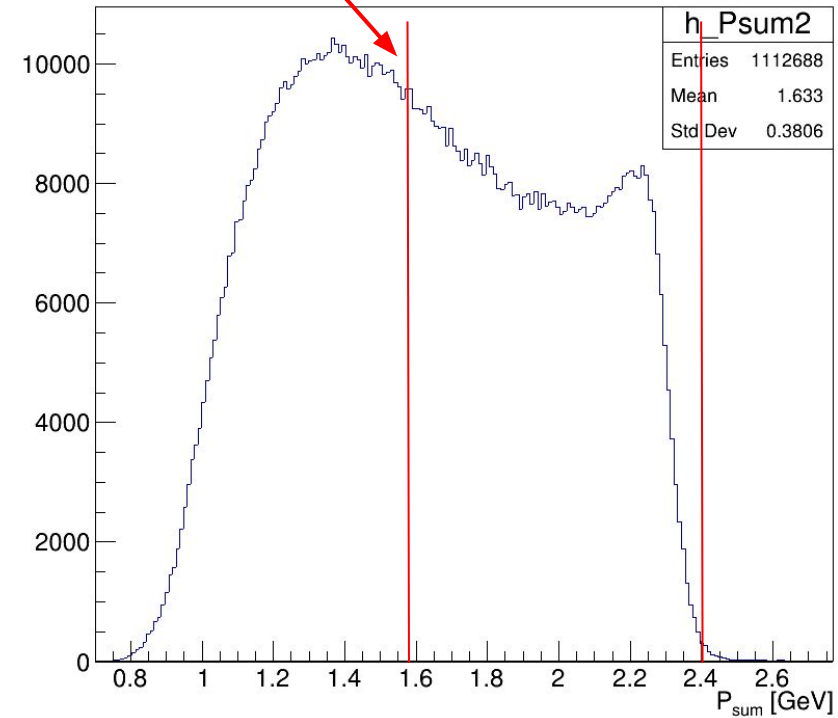


Unlike my expectation, absence of L1 doesn't worsen the mass resolution.

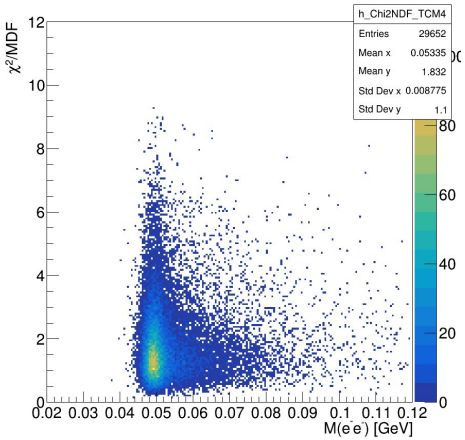
So no requirement of L1 for electrons!

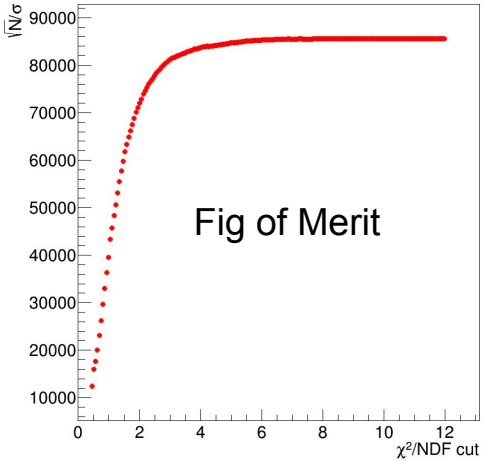
Psum cuts

Based on pass1 MC



Track χ2/NDF cuts

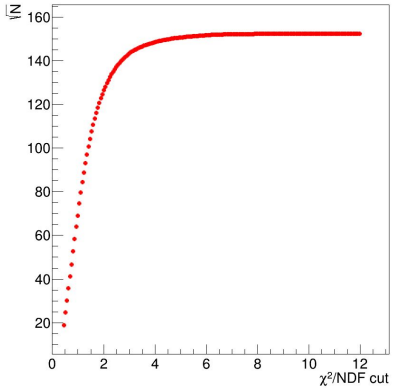


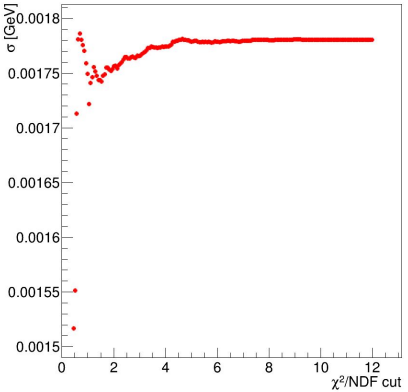


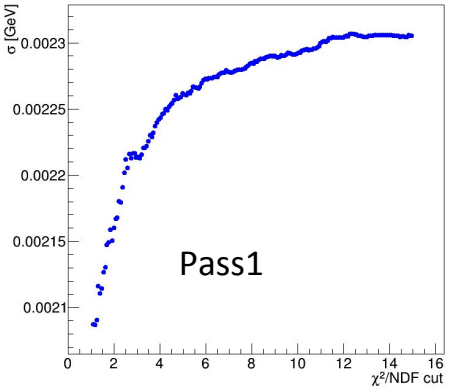
$$\chi^2 = \chi^2_1 + \chi^2_2$$

NDF = 2*(NHits1 + NHits2) - 10

Resolution improved wrt pass1
Almost no depenendence on χ^2/NDF.
Still No local maximum for Fig Of Merit.
So no cut is imposed to the track χ^2/NDF.

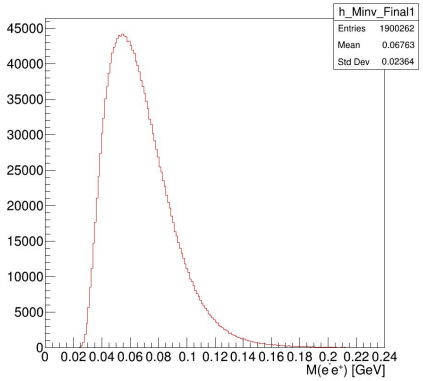


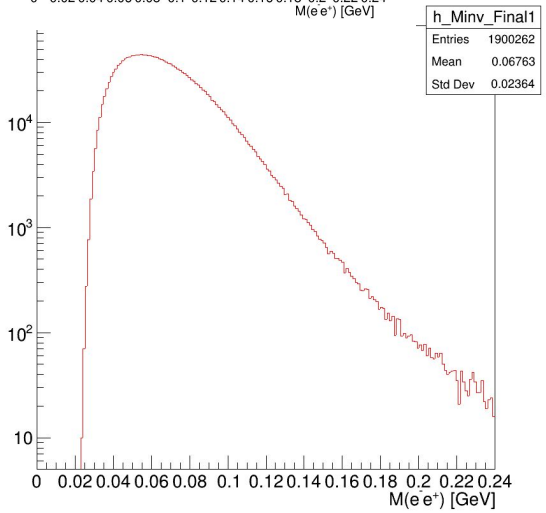




The invariant Mass distribution

One full run 8099





Cut Name	Cut fraction
Psum Min	0.57
d0 cut	0.898
e^- track-Cluster matching	0.967
e^+ track-Cluster matching	0.971
cluster time difference	0.974
e^- P_Max (Anti-FEE) cut	0.991
e^- track-Cluster time difference	0.991
e^+ track-Cluster time difference	0.993
PSum Max cut	0.997

In the backup slides the effect of Minv distribution for each cut is shown

Things to do

- Analysis note is started, the cluster time difference is written
- Revise Mass parametrization with the new MC
- Finalize d0 and PsumMin cut with New MC: seems is going well (Tongtong's talk)
- Check Normalization with New MC
- Systematic uncertainties
- BumpHunter (Kyle)

The Analysis codes and the note are in github https://github.com/rafopar/BumpHunt_2016/tree/master/pass4

Timeline

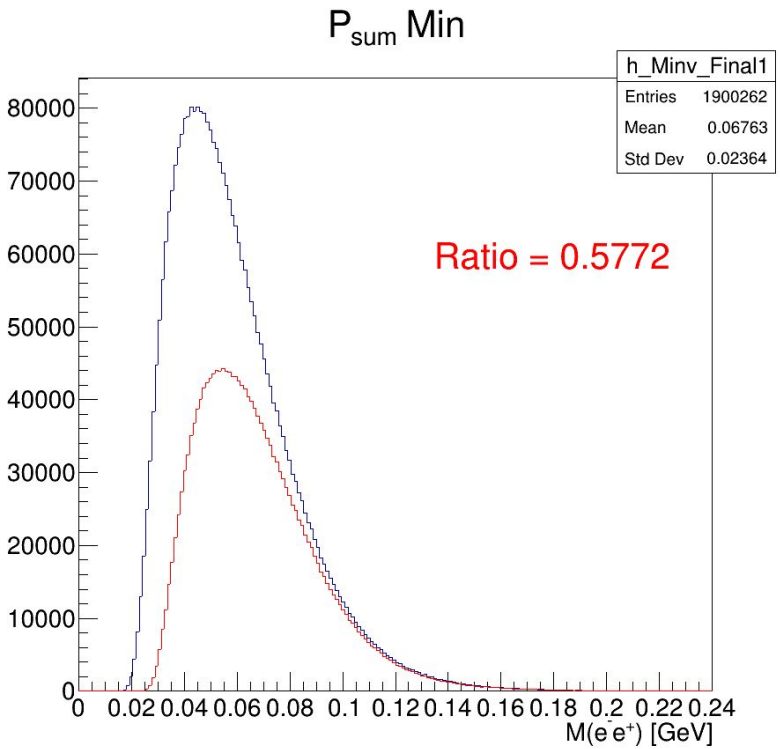
- Bring documentation up to date with the analysis 1 week. By Nov 29
- Determine the mass parametrization through MC and scale by Data_Moeller/MC_Moeller, By Dec 15
- Finalize d0 and PsumMin cut with New MC, by Dec 20
- Systematic uncertainties, by the end of January

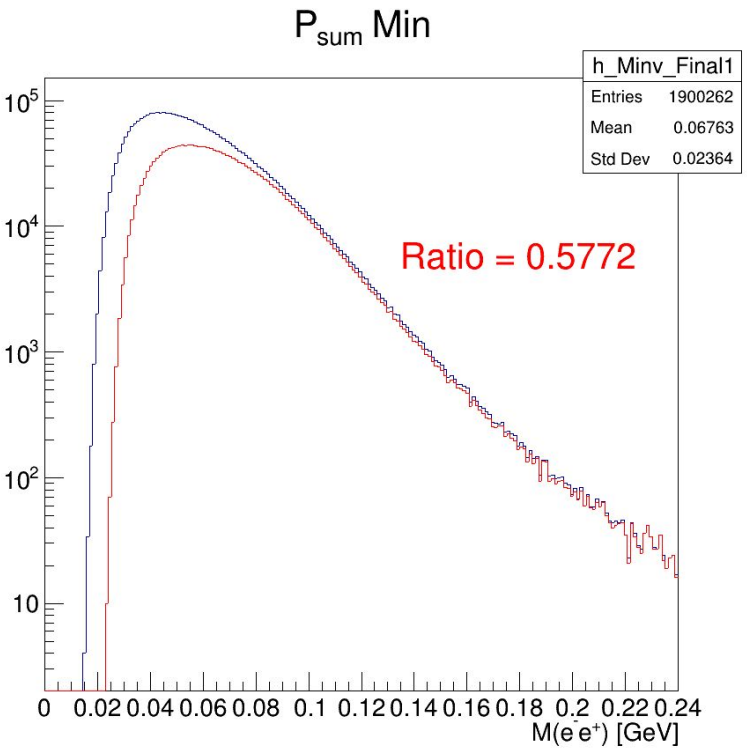
Backup slides

CUTS ON LCIO OBJECTS

LCIO Collection	Requirement	Driver where Implemented
MatchedTracks	<5 shared hits	AmbiguityResolver in MergeTrackCollections
GBLTracks	Prob(χ^2_{GBL}; dof) > 10^{-5}	GBLRefitterDriver
FinalStateParticles e- , e+ : e- : γ :	GoodnessOfPID$_{MATCH}$ < 10 $\lvert\Delta t_{TRACK\text{-}CLUSTER} - \text{offset}\rvert$ < 6ns p(e-) < 0.75 E_{beam} Loosened Unmatched clusters	[Hps]ReconParticleDriver
OtherElectrons (new!)	GBLTrack charge -1 Not in FinalStateParticles	[Hps]ReconParticleDriver
V0Candidates, V0Vertices	Made from FinalStateParticles Opposite halves (top-bottom) p(V0) < 1.2 E_{beam} Loosened Prob(χ^2_{VTX}) > 10^{-5} Loosened $\lvert\Delta t_{CLUSTER\text{-}CLUSTER}\rvert$ < 2ns Loosened	[Hps]ReconParticleDriver
VcCandidates, VcVertices (new!)	Same as V0, but same half (top-top or bot-bot) Unconstrained only	[Hps]ReconParticleDriver , optional
MollerCandidates, MollerVertices	Made from FinalStateParticles/OtherElectrons Single neg-charged GBLTrack in each volume 0.8 E_{beam} < $p(V_{MOLLER})$ < 1.2 E_{beam}	[Hps]ReconParticleDriver , optional

- BilloirVertex object now has layerCode member, persisted in Parameters map of LCIO Vertex object
  - For easy selections in Skims etc (2 = "L1L1" , 3 = "L1L2", 4 = "L2L2")


P_{sum} Min
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.5772
80000
70000
60000
50000
40000
30000
20000
10000
0
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]


P_{sum} Min
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.5772
10^5
10^4
10^3
10^2
10
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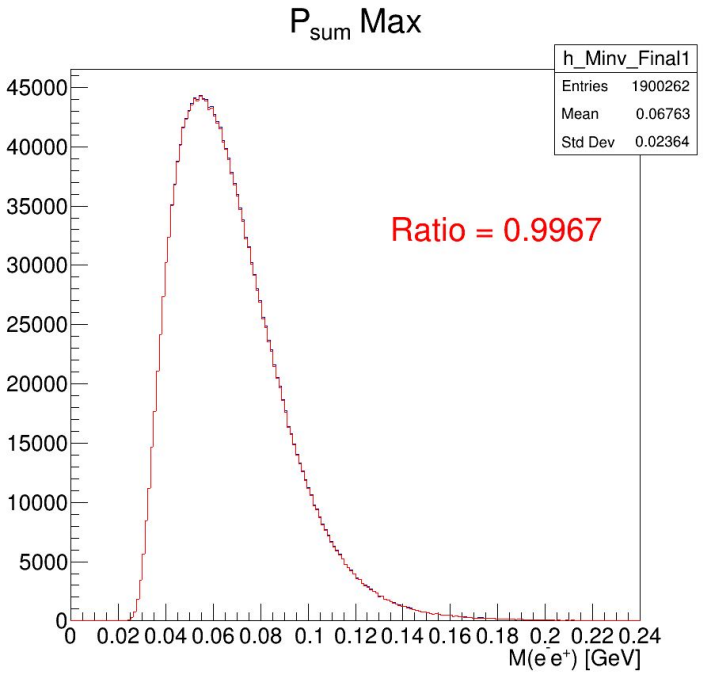
M(e⁻e⁺) [GeV]


P_{sum} Max
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9967
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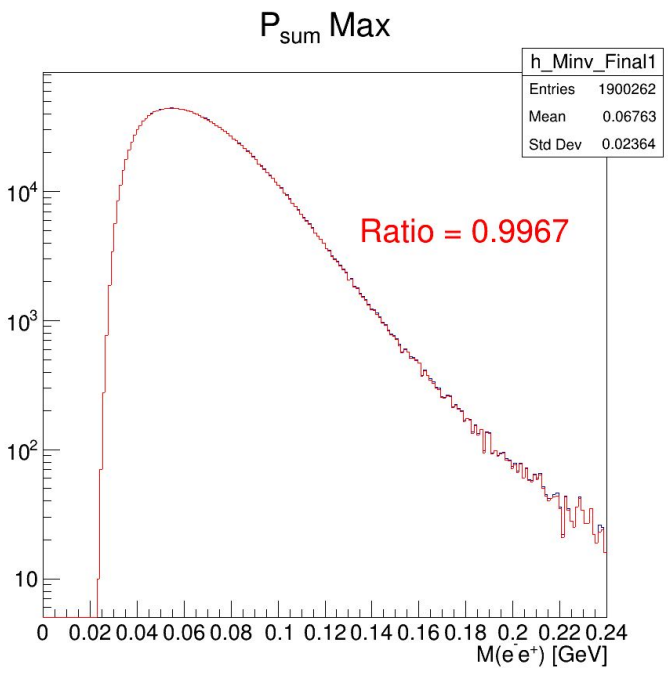
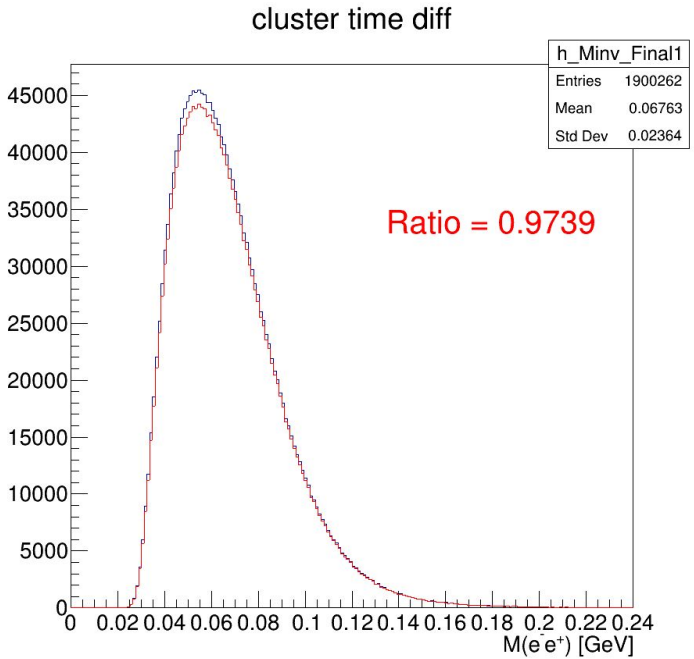
40000
35000
30000
25000
20000
15000
10000
5000
0
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]


P_{sum} Max
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9967
10^4
10^3
10^2
10
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]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h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9739
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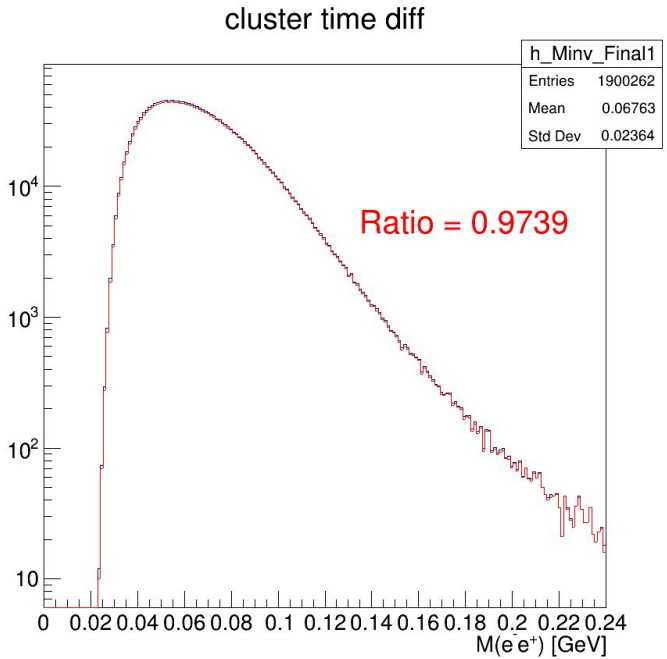
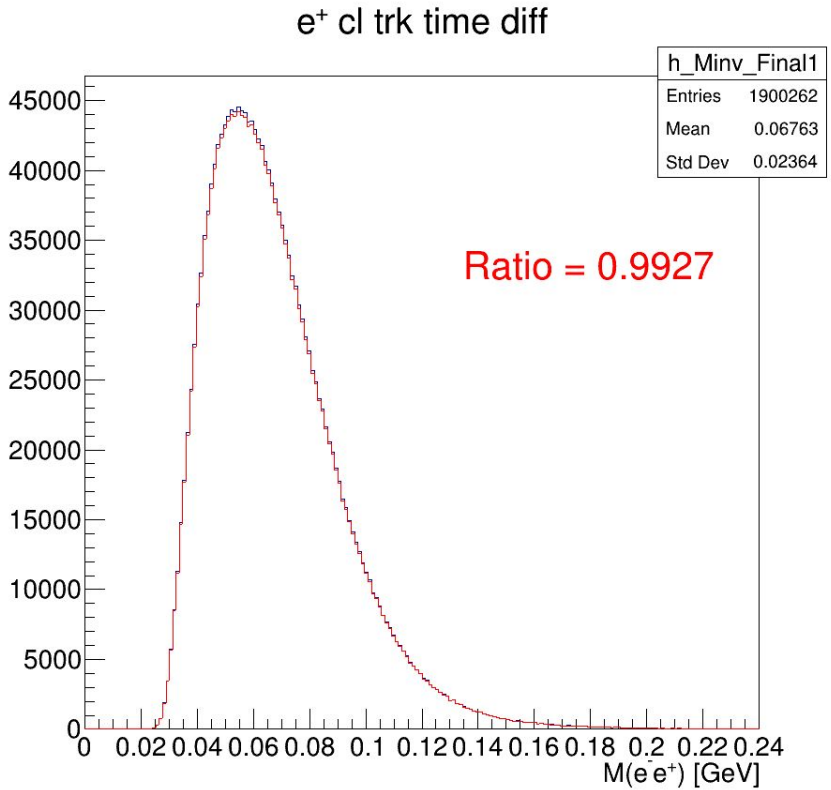
40000
35000
30000
25000
20000
15000
10000
5000
0
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]


cluster time diff
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9739
10⁴
10³
10²
10
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]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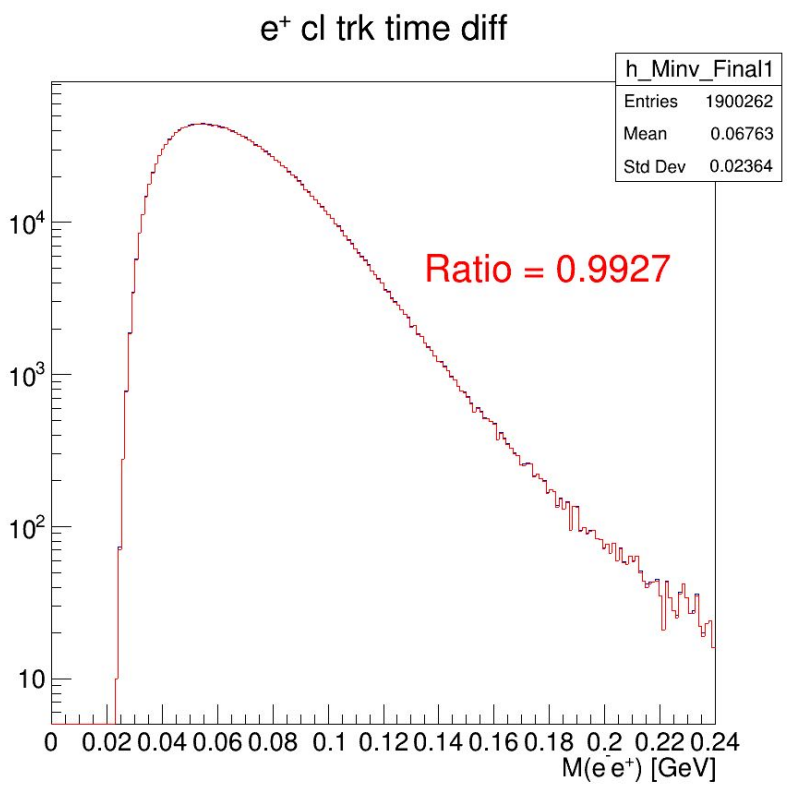
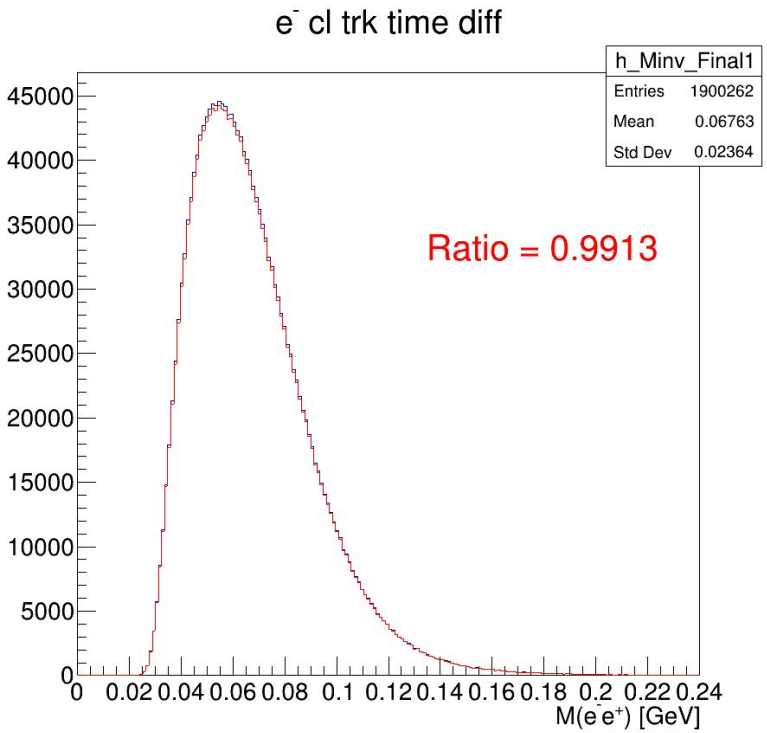
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9927
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]


e⁺ cl trk time diff
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9927
10⁴
10³
10²
10
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]


e⁻ cl trk time diff
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Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9913
45000
40000
35000
30000
25000
20000
15000
10000
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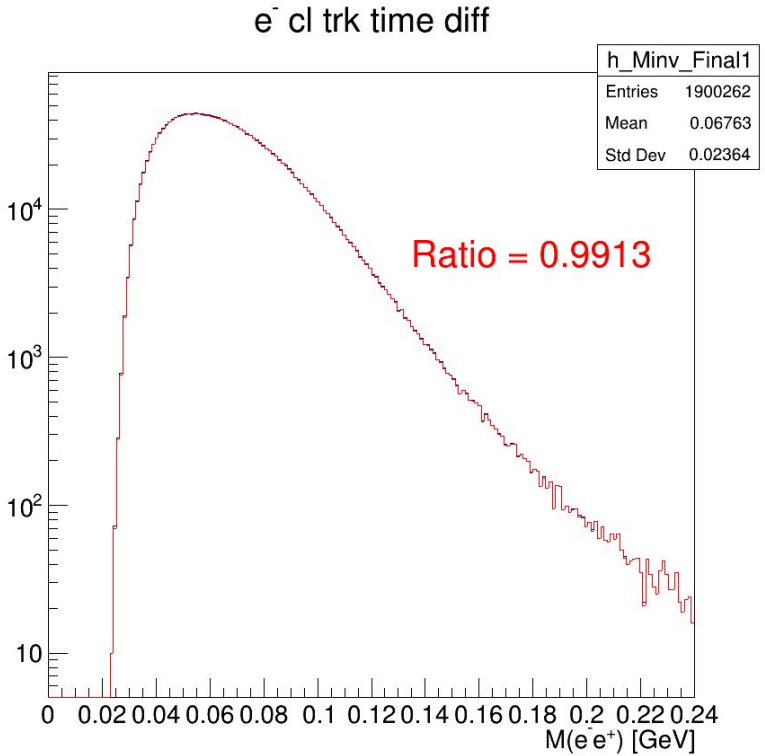
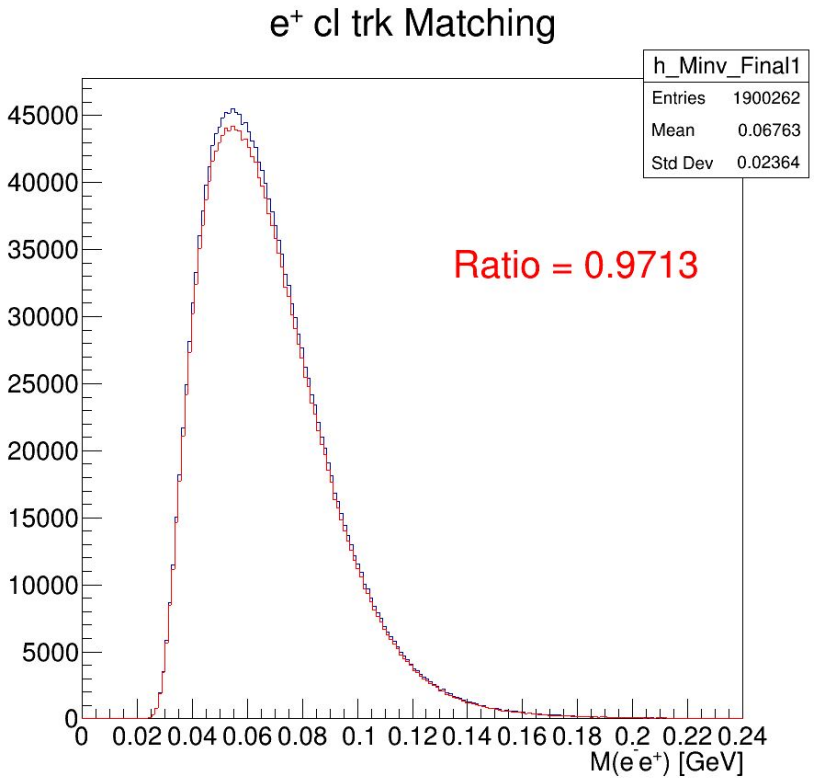
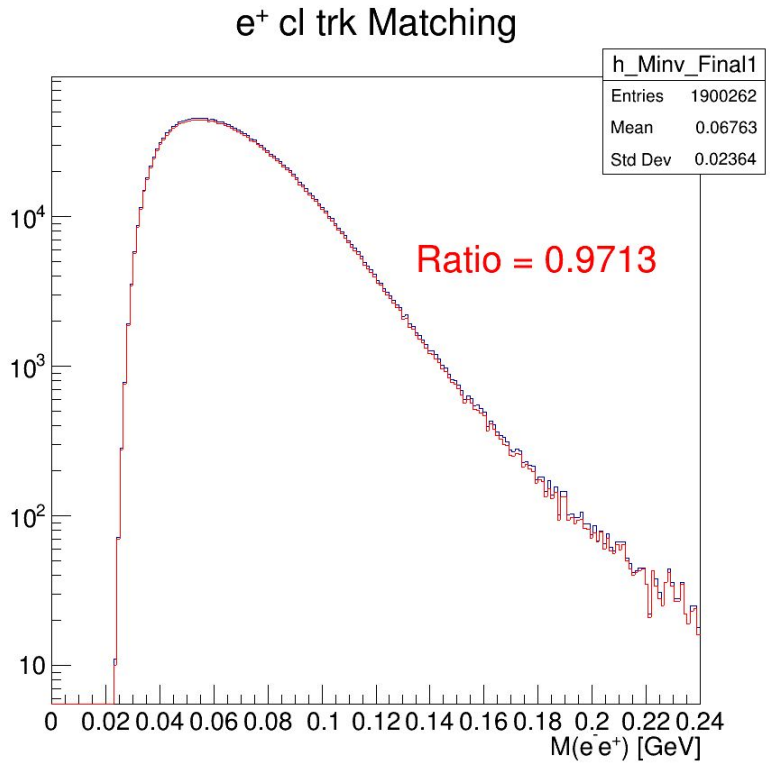
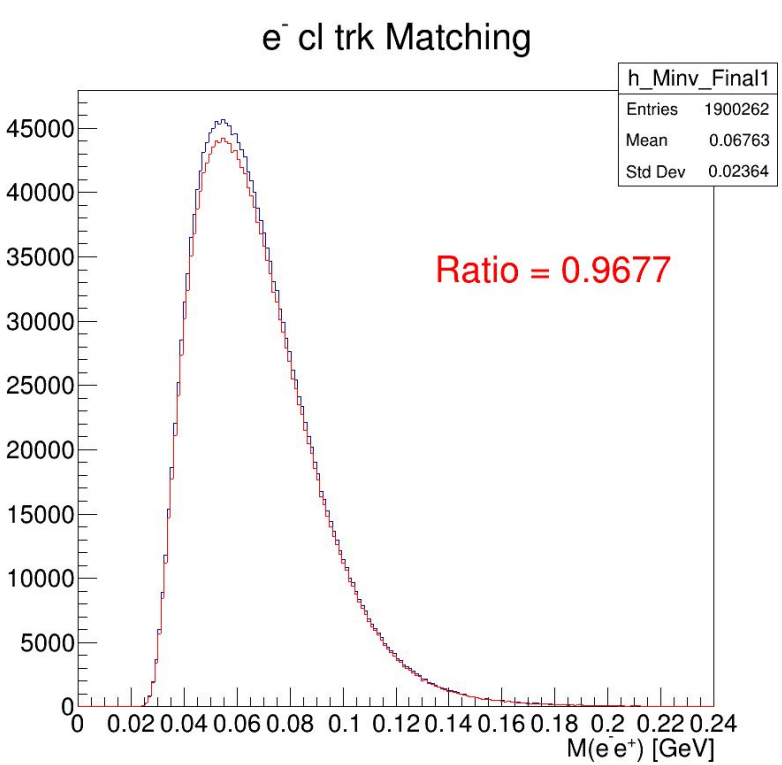
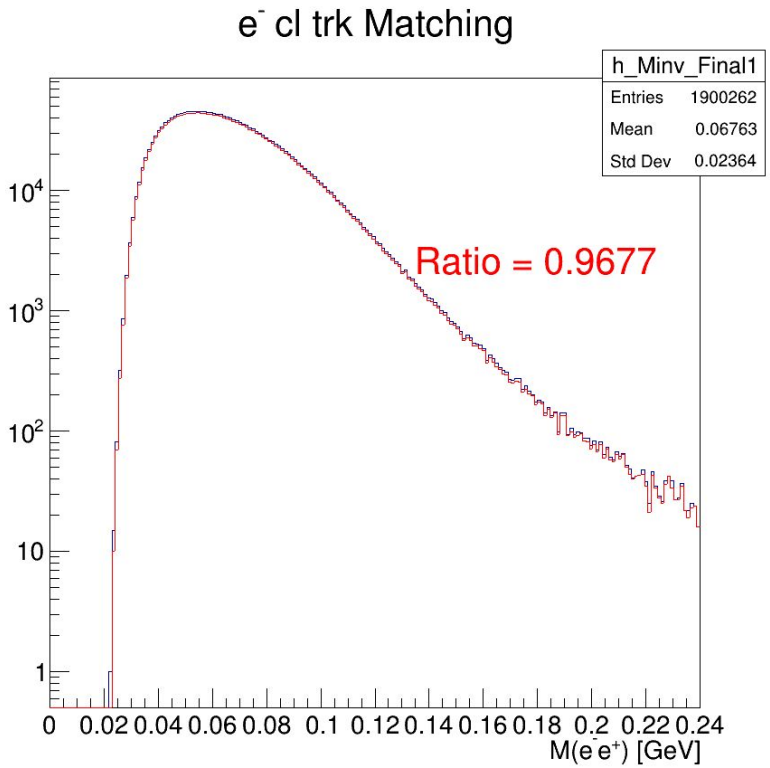
0
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]

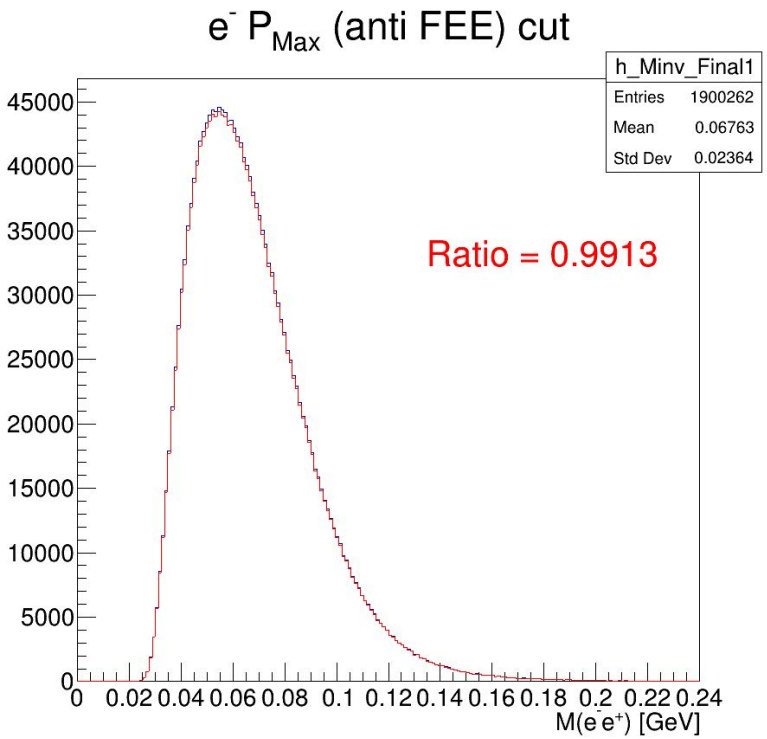

e⁻ cl trk time diff
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9913
10⁴
10³
10²
10
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]

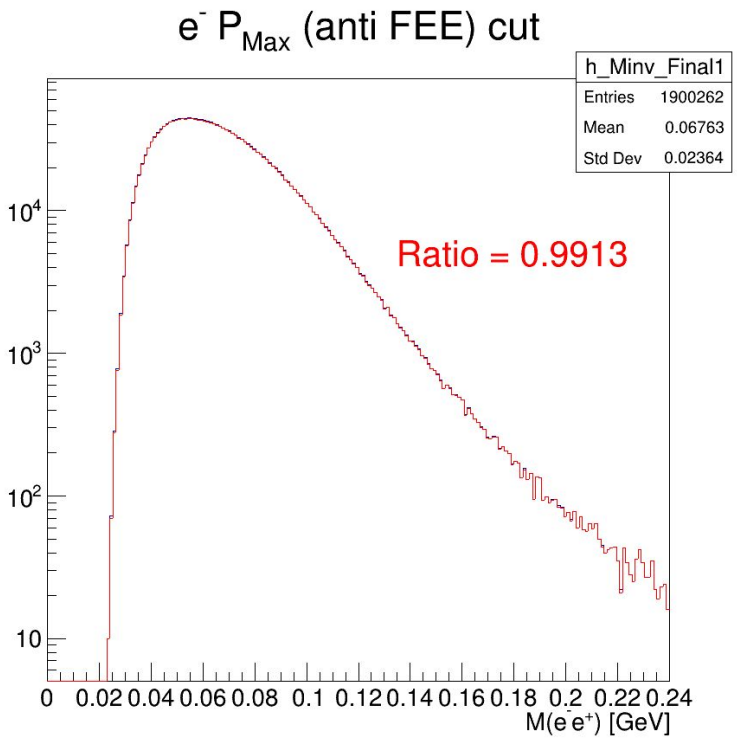

e⁺ cl trk Matching
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9713
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]

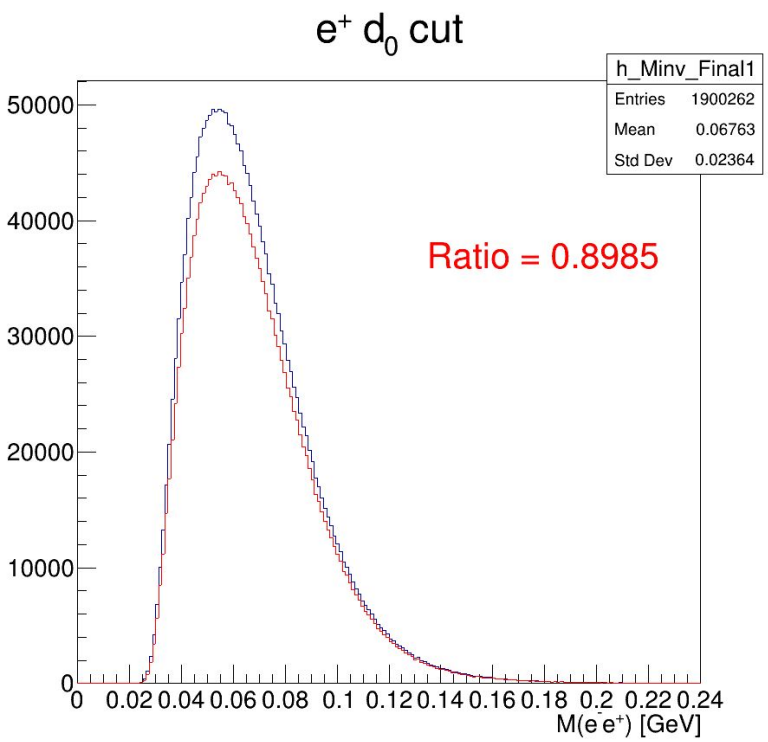

e⁺ cl trk Matching
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9713
10⁴
10³
10²
10
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]

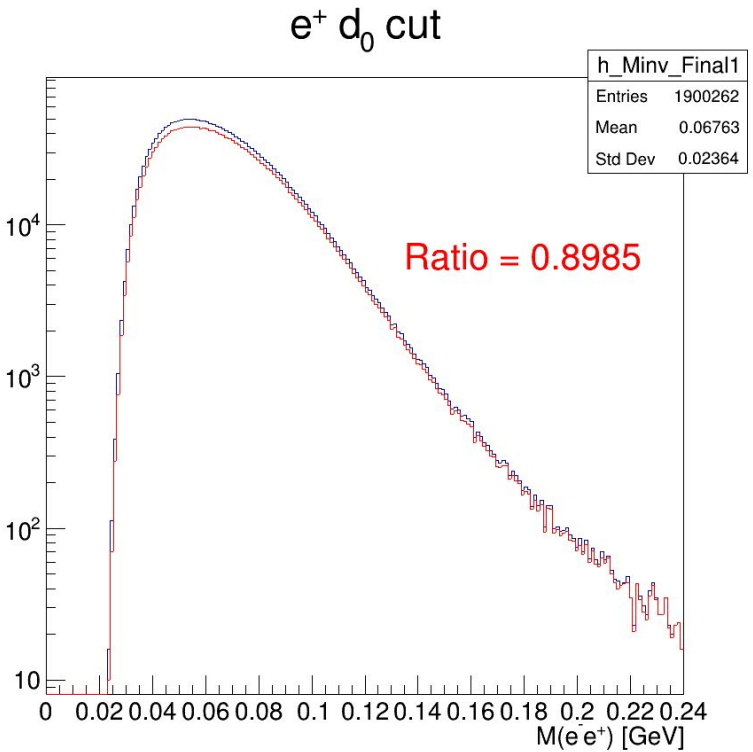

e⁻ cl trk Matching
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9677
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]


e⁻ cl trk Matching
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9677
10⁴
10³
10²
10
1
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]


e⁻ P_Max (anti FEE) cut
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9913
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]


e⁻ P_Max (anti FEE) cut
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.9913
10⁴
10³
10²
10
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e⁻e⁺) [GeV]


e+ d0 cut
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.8985
50000
40000
30000
20000
10000
0
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e-e+) [GeV]


e+ d0 cut
h_Minv_Final1
Entries 1900262
Mean 0.06763
Std Dev 0.02364
Ratio = 0.8985
10^4
10^3
10^2
10
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14 0.16 0.18 0.2 0.22 0.24
M(e-e+) [GeV]