Update on Dielectron analysis with MPD

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MPD Cross-PWG meeting

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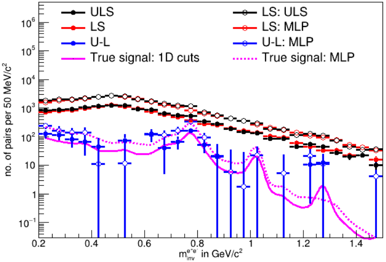
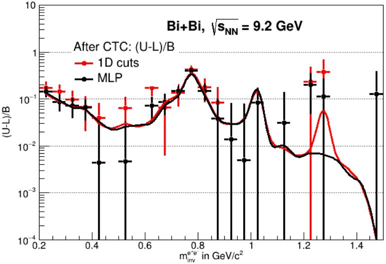
- Track Matching using Machine learning?
- A look at the Low B sample.
- Conclusions and Outlook

Brief recap

$0.2 < m_{inv}^{e^+e^-} < 1.5 \text{ GeV}/c^2$



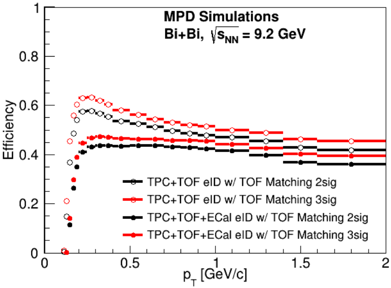


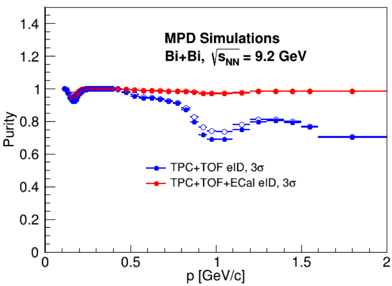
Aft. CTC	1D cuts	MLP
U	12340±111	26978±164
B	11559±108	25573±160
U-B	781±155 (759)	1405±229 (1649)
(U-B)/B(%)	6.76±0.09 (6.57)	5.49±0.05 (6.45)
BFE	26 (24)	38 (51)

Machine learning helps in improving the PID, leading to better significance.

Track-to-TOF and -Ecal matching cuts: Req. 34

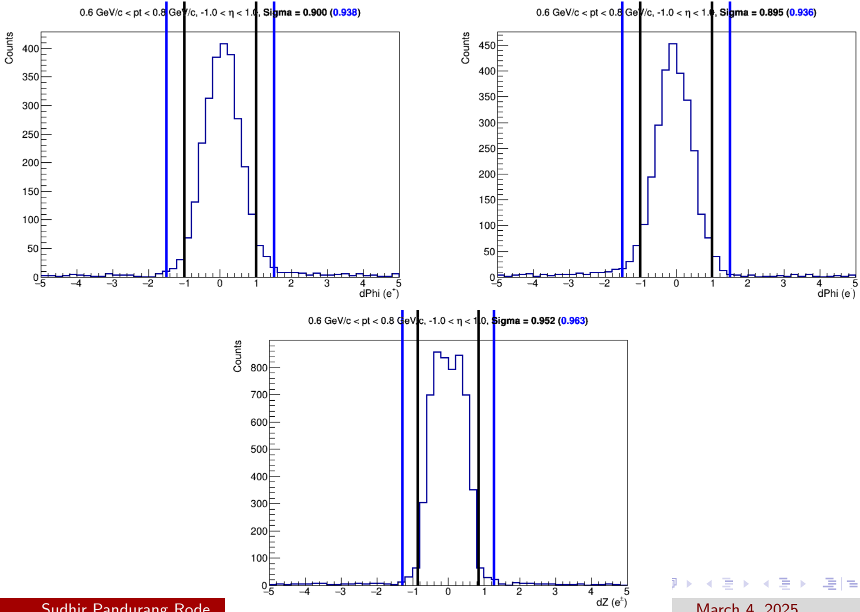
- So far, track-to-Tof matching cut of 2σ and track-to-Ecal matching cut of 3σ is being used in the analysis.
- Relaxing the track-to-Tof matching cut to 3σ does not seem to change the purity with benefit of more efficiency.





- Interesting to see if machine learning can help in improving the matching efficiency even more.

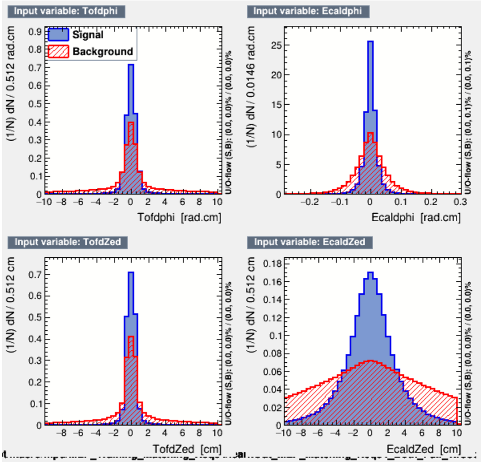
TOF matching: dphi and dz of electrons



Track matching and Machine learning

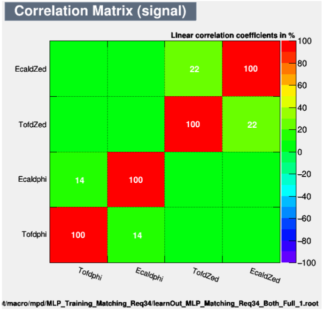
- At the moment, the track matching to TOF and ECal is achieved through selection cuts on dphi and dz distributions between the track and hit in the TOF or ECal.
- dphi and dz in TOF: < 2 or 3σ.
- dphi and dz in ECal: $< 3\sigma$
- Machine learning approach is used to reduce the inefficiency coming from these four 1-D selection cuts.

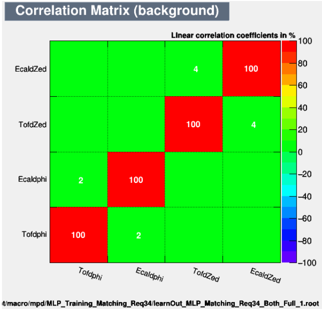
ML training for track matching

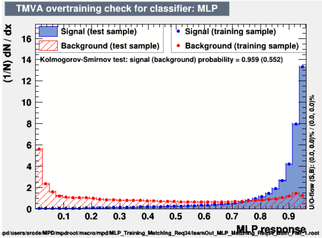


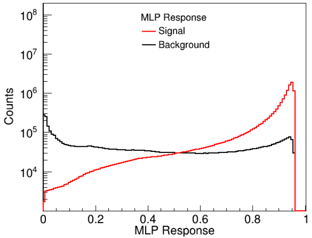
- Signal: charged tracks with true hit in the TOF and ECal when looked at the closest hit.
- Background: Otherwise.
- Four variables: two dphi and two dz coordinates.
- Training number of signal and background with actual fraction in the sample.
- Classifier: MLP.

Training

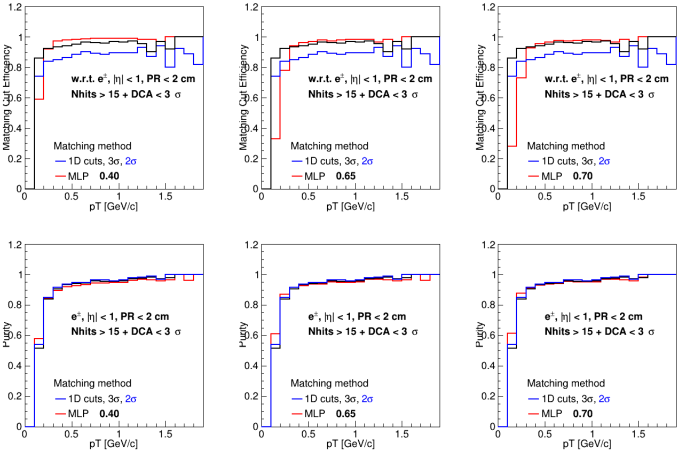

Correlation Matrix (signal)
Linear correlation coefficients in %
EcaldZed
TofdZed
Ecaldphi
Tofdphi
22
100
100
22
14
100
100
14
Tofdphi
Ecaldphi
TofdZed
EcaldZed
100
80
60
40
20
0
−20
−40
−60
−80
−100
t/macro/mpd/MLP_Training_Matching_Req34/learnOut_MLP_Matching_Req34_Both_Full_1.root


Correlation Matrix (background)
Linear correlation coefficients in %
EcaldZed
TofdZed
Ecaldphi
Tofdphi
4
100
100
4
2
100
100
2
Tofdphi
Ecaldphi
TofdZed
EcaldZed
100
80
60
40
20
0
−20
−40
−60
−80
−100
t/macro/mpd/MLP_Training_Matching_Req34/learnOut_MLP_Matching_Req34_Both_Full_1.root


TMVA overtraining check for classifier: MLP
Signal (test sample)
Signal (training sample)
Background (test sample)
Background (training sample)
Kolmogorov-Smirnov test: signal (background) probability = 0.959 (0.552)
(1/N) dN / dx
MLP response
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%


MLP Response
Signal
Background
Counts
MLP Response

Efficiency and Purity



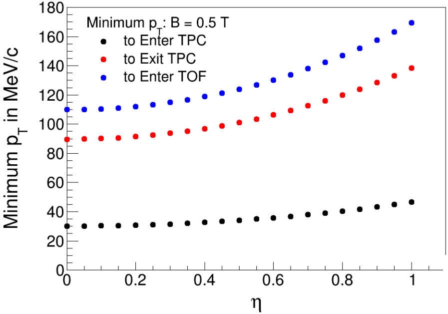
- Machine learning can bring some benfit with relaxed MLP response cut for $p_{\mathrm{T}} > 0.3$ GeV/c $\rightarrow$ improvement isn't drastic.

Prospects of using Low B sample (B = 0.2T) for dielectrons

Low B sample in dielectron analysis

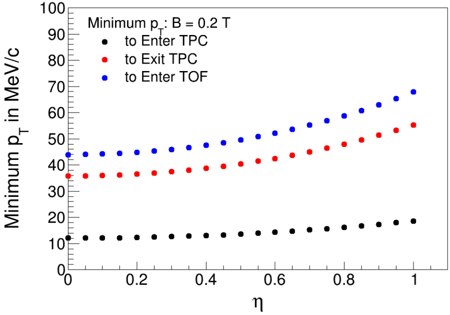
- It was suggested to use the low B sample in the dielectron analysis.
- As it would help in better reconstruction of low p_{T} tracks.
- Request 28: 10M events.
- For the time being, the same parameterizations as normal B are used for the preliminary studies.

Low B: Minimum p_T to enter or exit the TPC

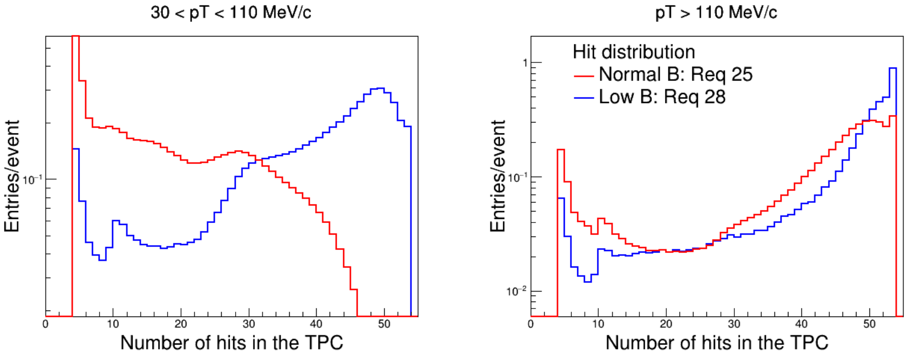


Cut-offs to enter or exit the TPC decreased with low B sample ($|\eta| \approx 0$).

- 30 MeV/c $\rightarrow \approx$ 10 MeV/c.
- 90 MeV/c $\rightarrow \approx$ 35 MeV/c.
- 110 MeV/c $\rightarrow \approx$ 45 MeV/c.

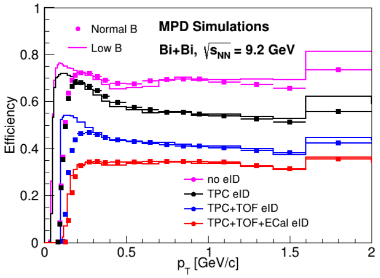


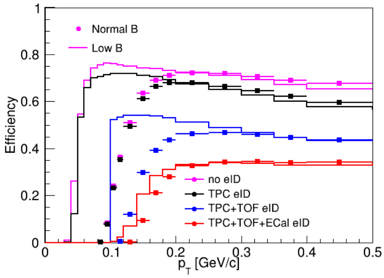
Low and Normal B: Hit distributions



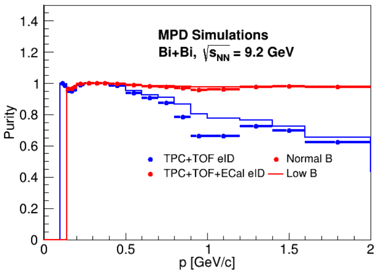
- As expected, less bending of the tracks provides better hit reconstruction at low and intermediate p_{T}.

Low (Req28) and Normal (Req25) B: DCA $< 3\sigma$

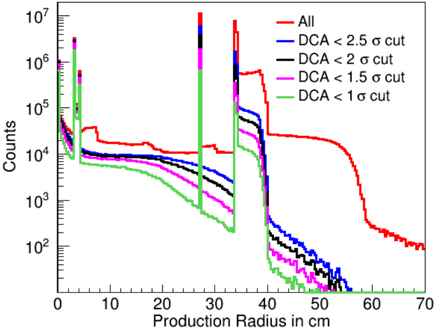




Low p_T electron tracking is improved along with similar purity, however, there is an issue.

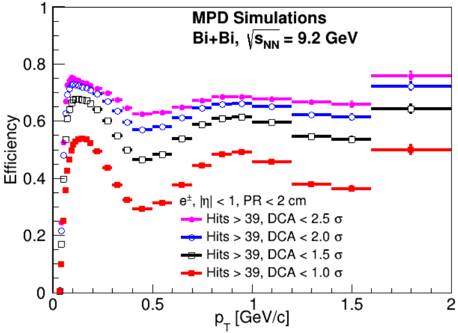


Low B

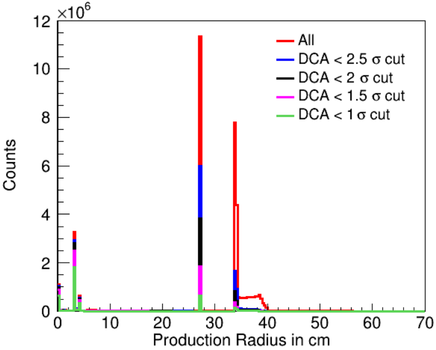


Conversions at large production radii are not rejected despite applying tight DCA selections.

This would lead to significant increase in combinatorial background.



Low B



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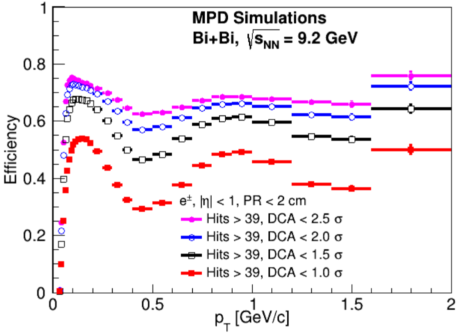
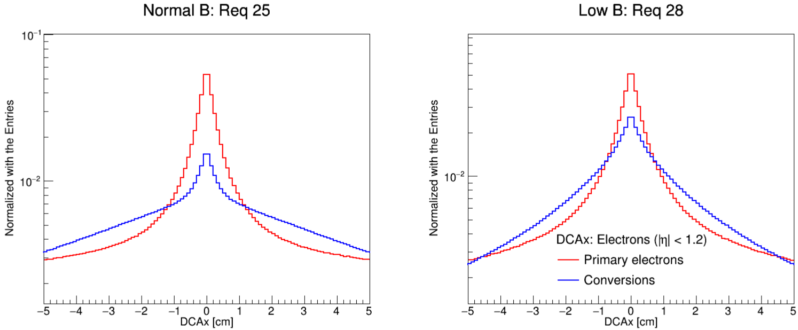


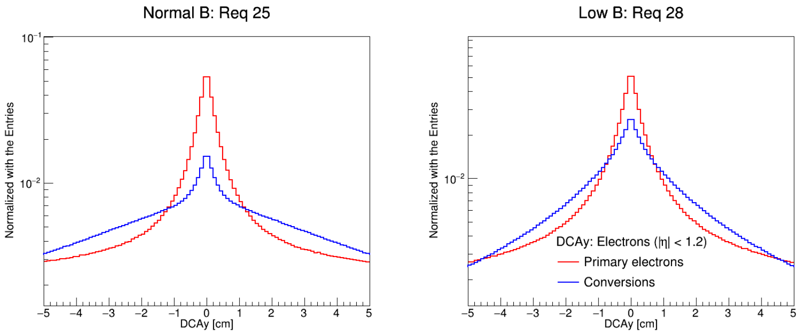
Low and Normal B: DCAx distributions (Electrons within $|\eta| < 1.2$)



I. Secondaries (here, conversions electrons) have wider DCA in Low B compared Normal B.

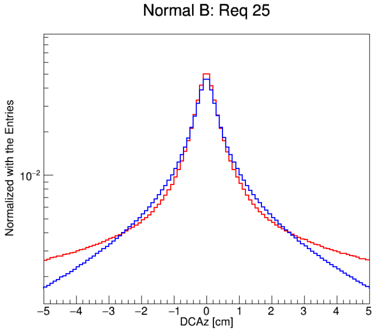
II. Shape of primary electrons (all electrons except conversions) have similar shapes.

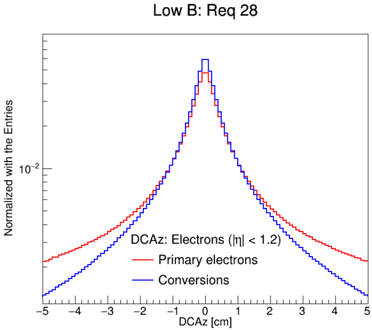
Low and Normal B: DCAy distributions (Electrons within $|\eta| < 1.2$)



I. Same conclusion for DCAy.

Low and Normal B: DCAz distributions (Electrons within $|\eta| < 1.2$)

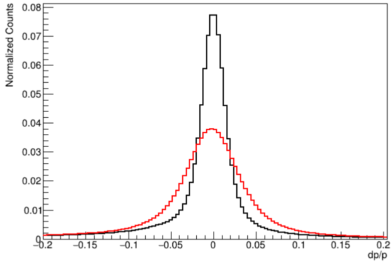




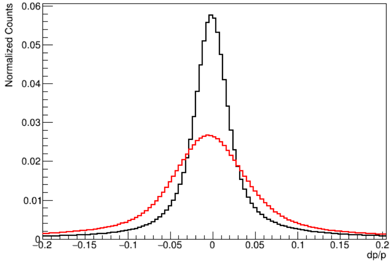
I. However, z-component of DCA has similar shapes in both Low B and Normal B.

Low (Req28) and Normal (Req25) B: Momentum resolution

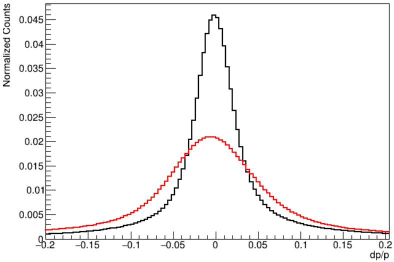
0.3 GeV/c < p < 0.4 GeV/c, Req28, Req25



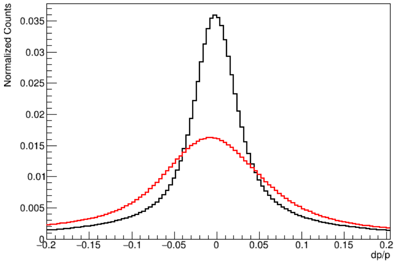
0.9 GeV/c < p < 1.0 GeV/c, Req28, Req25



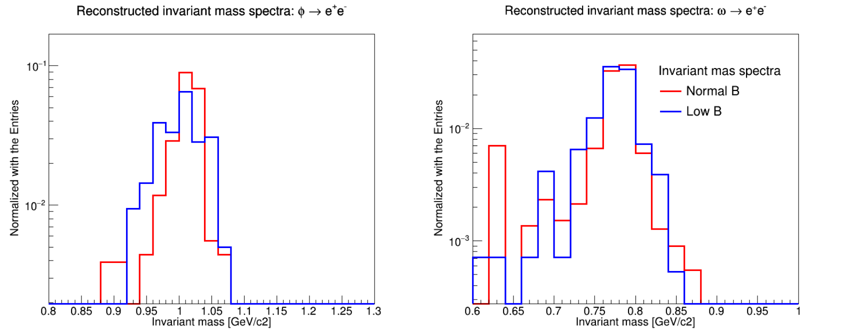
1.3 GeV/c < p < 1.4 GeV/c, Req28, Req25



1.7 GeV/c < p < 1.8 GeV/c, Req28, Req25



Low (Req28) and Normal (Req25) B: Mass resolution



I. Along with momentum, mass resolution also gets worse with low magnetic field.

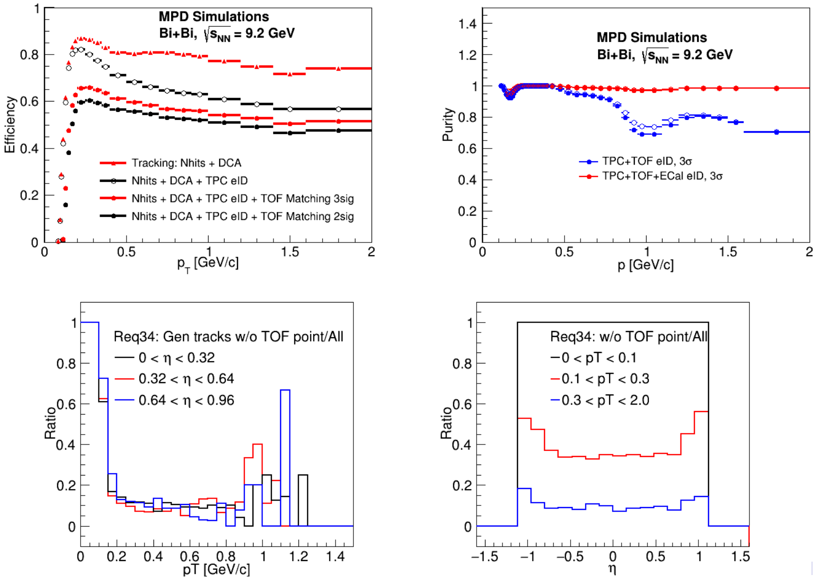
Conclusions and Outlook

- Machine learning was used to examine the track matching in TOF and ECal.
- It seems to improve the matching with loose MLP response cut compared to traditional 1D cuts on dphi and dz but it is not drastic.
- Low magnetic field provides better track reconstruction of low pT tracks.
- It also helps in improving the electron efficiency in the low transverse momentum region $\rightarrow$ at the cost of poor conversion rejection and worse momentum and mass resolution.
- Need a closer look at the DCA parameterizations and optimize others as well.
- As to what's next, we plan to employ machine learning tools to explore low p_{T} tracking.
- ML training for PID with TOF matching 3σ cut and obtain corresponding dielectron invariant mass spectra.

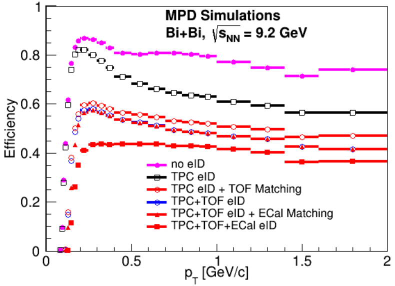
THANK YOU

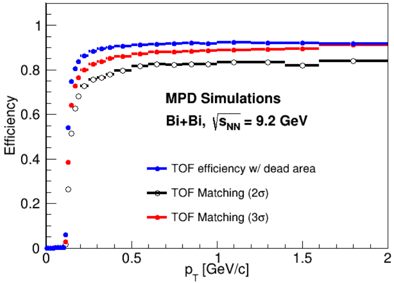
BACK-UP

TOF Matching cut

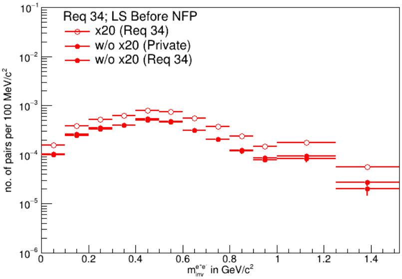


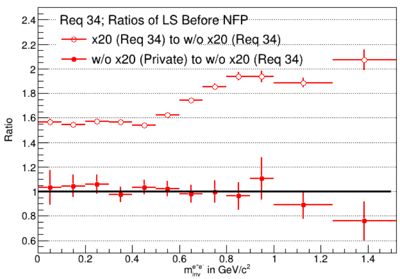
Step-wise efficiency: Req 34



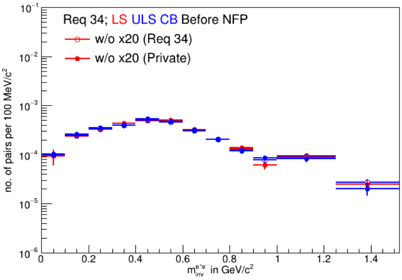


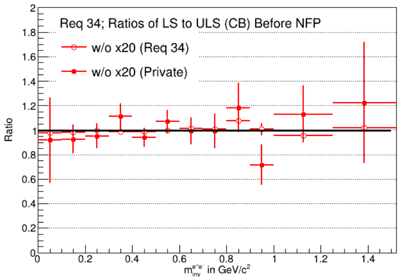
Comparision between LS: Private (547K events)





Comparision between LS and (ULS-TrueSignal)





Revised Analysis Strategy

⇒ Three electron pools:

→ Pool-1 - fully reconstructed tracks[1] in fiducial area ($|\eta| < 0.7$) - $p_{\rm T} \gtrapprox 110$ MeV/c

→ Pool-2 - fully reconstructed tracks in veto area $0.7 < |\eta| < 1.0$ - $p_{\rm T} \gtrapprox 110$ MeV/c.

→ Pool-3 with tracks reconstructed in TPC.

- $p_{\rm T} <= 110$ MeV/c → not reaching the TOF.
- $p_{\rm T} > 110$ MeV/c → reaching the TOF.

- Step 1 - No further pairing (NFP): Tagging between Pool 1 and Pool 2.
- Step 2 - Close TPC cut (CTC): Tagging between Pool 1 and 3, and pairs within certain $M_{\rm inv}$ and opening angle are removed.
- Step 3: Rest of the tracks with $p_{\rm T} > 200$ MeV from Pool-1 are paired among themselves to build ULS and LS pair spectra.

[1] TOF and ECal matched tracks identified in the TPC, TOF and ECal

Track selection - 1D cuts analysis

→ Pool-1 - fully reconstructed tracks[2] in fiducial area ($|\eta| < 0.7$)

- NHits > 39, DCA $< 3\sigma$, TPC dEdX (p dep. ($p < 0.8$) and -1 to 2σ ($p > 0.8$)), TOF Matching ($d\phi$ and dz $< 2\sigma$), TOF (-2 to 2σ), ECal PID (p dep. $<$ E/p < 1.5 and $\mathrm{m}^2 < 2\sigma$), ECal Matching ($< 3\sigma$).

→ Pool-2 - fully reconstructed tracks in veto area ($0.7 < |\eta| < 1.0$) (Same cuts.).

→ Pool-3 with tracks reconstructed in TPC.

- $p_\mathrm{T} <= 110$ MeV/c → not matched in TOF and ECal - ($|\eta| < 2.5$, NHits > 10, DCA $< 5\sigma$, TPC dEdX (-4 to 4σ)).
- $p_\mathrm{T} > 110$ MeV/c → not matched in TOF but matched in ECal - ($|\eta| < 2.5$, NHits > 10, DCA $< 5\sigma$, TPC dEdX (-3 to 3σ), ECal (p dep. $<$ E/p $<$ 1.5 and $\mathrm{m}^2 < 2\sigma$, ECal Matching ($< 3\sigma$)).
- $p_\mathrm{T} > 110$ MeV/c → not matched in ECal but may or may not in TOF - ($|\eta| < 2.5$, NHits > 10, DCA $< 5\sigma$, TPC dEdX (-1 to 2σ), TOF PID (if matched).

- No further pairing (NFP): $M_\mathrm{inv} < 120$ MeV/c^2.
- Close TPC cut (CTC): $M_\mathrm{inv} < 80$ MeV/c^2 and opening angle < 10 or 5^o.

[2] TOF and ECal matched tracks identified in the TPC, TOF and ECal