Recent updates in di-electron measurements with MPD experiment

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XV MPD Collaboration meeting

Content

- Optimization of the acceptance and underestimated reconstructed signal
- A look at the Low B sample.
- Alternative approach for dielectron analysis [Yonghong].
- Conclusions

Analysis Strategy

$\Rightarrow$ Three electron pools:

$\rightarrow$ Pool-1 - fully reconstructed tracks$^{(*)}$ in fiducial area ($|\eta| < \mathbf{0.7}$) - $p_{\mathrm{T}} \gtrapprox 110$ MeV/c

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

$\rightarrow$ Pool-3 with tracks reconstructed in TPC.

- $p_{\mathrm{T}} <= 110$ MeV/c $\rightarrow$ not reaching the TOF.
- $p_{\mathrm{T}} > 110$ MeV/c $\rightarrow$ 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_{inv} and opening angle are removed.
- Step 3: Rest of the tracks with $p_{\mathrm{T}} > 200$ MeV from Pool-1 are paired among themselves to build ULS and LS pair spectra.

$^{(*)}$TOF and ECal matched tracks identified in the TPC, TOF and ECal

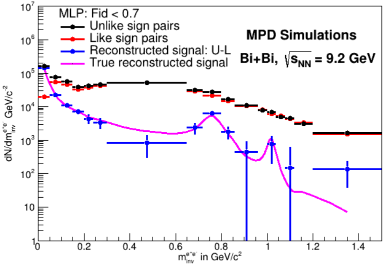
MLP: Req. 34 (12.1M except Fid. < 0.6: 11.6M) Invariant mass: **0.2-1.5 GeV/c2**

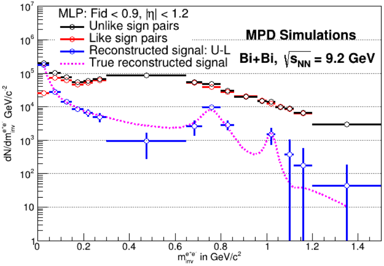
	Fid. < 0.6	Fid. < 0.7	Fid. < 0.75	Fid. < 0.8	Fid. < 0.85	Fid. <0.9 $\lvert\eta\rvert < 1.2$
U	21491±147	30976±176	35688±189	40566±201	45954±214	51297±226
B	20504±143	29455±172	34026±184	38863±197	44052±210	49267±222
U-B	987±205	1521±246	1663±264	1703±282	1902±300	2030±317
(U-B)/B	**4.81±0.05**	**5.16±0.04**	**4.89±0.04**	**4.38±0.03**	**4.32±0.03**	**4.12±0.03**
(†)BFE	23	38	40	37	40	41
S	1359	1860	2071	2314	2534	2724
S/B	**6.63**	**6.31**	**6.09**	**5.95**	**5.75**	**5.53**
BFE	44	57	61	67	71	73

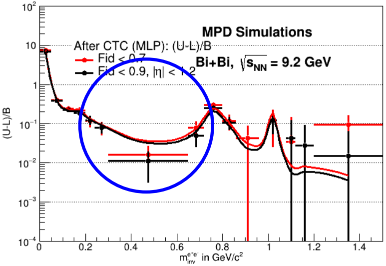
- B - Combinatorial background approximated by like sign pairs.
- Fiducial acceptance was varied from $|\eta| < 0.6$ to 0.9.
- The signal increases with acceptance but the background increases faster and consequently S/B decreases.
- Measured signal is underestimated compared to true reconstructed signal.

(†)Background free equivalent signal - signal with same relative statistical error as in background free situation; BFE $= \frac{S^2}{S+2B} \approx \frac{S^2}{2B}$ (S <<< B)

ULS, LS and Signal: MLP







MLP: Req. 34 (12.1M except Fid. < 0.6: 11.6M) Invariant mass: **0.65-1.5 GeV/c2**

	Fid. < 0.6	Fid. < 0.7	Fid. < 0.75	Fid. < 0.8	Fid. < 0.85	Fid. < 0.9 $\lvert\eta\rvert < 1.2$
U	5485±74	8259±91	9724±99	11212±106	12941±114	14874±122
B	4920±70	7406±86	8739±93	10232±101	11917±109	13736±117
U-B	566±102	852±125	985±136	980±146	1025±158	1138±169
(U-B)/B	**11.50±0.23**	**11.51±0.18**	**11.27±0.17**	**9.57±0.13**	**8.60±0.11**	**8.28±0.10**
(‡)BFE	31	46	53	45	42	45
S	562	774	876	971	1074	1167
S/B	**11.42**	**10.45**	**10.03**	**9.49**	**9.01**	**8.49**
BFE	30	38	42	44	46	48

- B - Combinatorial background approximated by like sign pairs.
- Same numbers as previous table but for 0.65 GeV $< m_{inv}^{e^+e^-} <$ 1.5 GeV.
- The measured signal and true reconstructed signal are close to each other in this region.

(‡)Background free equivalent signal - signal with same relative statistical error as in background free situation; BFE $= \frac{S^2}{S+2B} \approx \frac{S^2}{2B}$ (S <<< B)

MLP: Req. 34 (12.1M except Fid. $<$ 0.6: 11.6M) Invariant mass: **0.2-0.65 GeV/c2**

	Fid. $<$ 0.6	Fid. $<$ 0.7	Fid. $<$ 0.75	Fid. $<$ 0.8	Fid. $<$ 0.85	Fid. $<$0.9 $\lvert\eta\rvert < 1.2$
U	16005$\pm$127	22717$\pm$151	25965$\pm$161	29354$\pm$171	33012$\pm$182	36423$\pm$191
B	15584$\pm$125	22048$\pm$148	25287$\pm$159	28630$\pm$169	32135$\pm$179	35531$\pm$188
U-B	421$\pm$178	669$\pm$212	678$\pm$226	724$\pm$241	877$\pm$255	892$\pm$268
(U-B)/B	**2.70$\pm$0.03**	**3.03$\pm$0.03**	**2.68$\pm$0.02**	**2.53$\pm$0.02**	**2.73$\pm$0.02**	**2.51$\pm$0.02**
BFE	6	10	9	9	12	11
S	796	1086	1195	1343	1460	1557
S/B	**5.11**	**4.93**	**4.73**	**4.69**	**4.54**	**4.38**
BFE	20	26	28	31	32	33

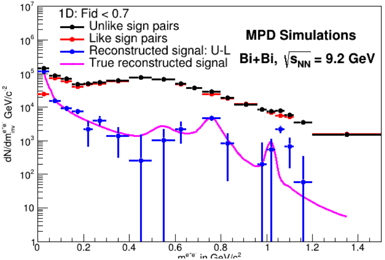
- B - Combinatorial background approximated by like sign pairs.
- Same numbers for 0.2 GeV $< m_{inv}^{e^+e^-} <$ 0.65 GeV.
- Similar underestimation of measured signal.
- Deficit seems to remain intact even in case of two independent samples: e.g. (Fid $<$ 0.7) and (Fid $<$ 0.9 - Fid $<$ 0.7).
- Statistics or systematic?

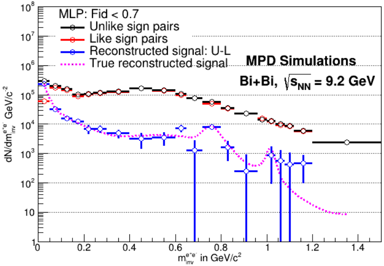
Production Request 25 (31M): Fid. < 0.7

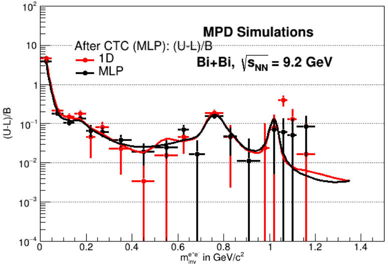
	1D	MLP	1D	MLP	1D	MLP
	0.2 to 1.5 GeV/c2		**0.2 to 0.65 GeV/c2**		**0.65 to 1.5 GeV/c2**	
U	37561±194	79304±282	29483±172	64071±253	9736±99	18742±137
B	36329±191	76174±276	28767±170	61803±249	9210±96	17794±133
U-B	1232±272	3130±394	716±241	2268±355	526±138	948±191
(U-B)/B (%)	**3.39±0.02**	**4.11±0.02**	**2.49±0.02**	**3.67±0.02**	**5.71±0.08**	**5.33±0.06**
BFE	21	63	9	41	15	25
S	1647	3291	1025	2130	656	1244
S/B (%)	**4.53**	**4.32**	**3.56**	**3.45**	**7.12**	**6.99**
BFE	37	70	18	36	23	42

- B is combinatorial background approximated by like sign pairs.
- Similar numbers from previous results with request 25 production.
- Slight underestimation in case of 1D cuts, but within uncertainties, there is none in case of MLP.
- Hinting towards statistics issue in Request 34: though strong claim to be made after the check with more statstics.

ULS, LS and Signal: Req 25: 1D and MLP





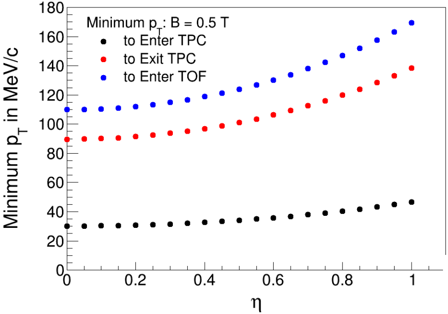


- The underestimate of the yield in low mass region seems to be statistics.
- Would be interesting to have a new production with higher statistics.
- Similar to ρ, ω and ϕ decays, enhance η-Dalitz decays by some factor: Not as as large as 20 factor (e.g. 4 or 5).

Analysis w/ Low magnetic field (B = 0.2T) sample

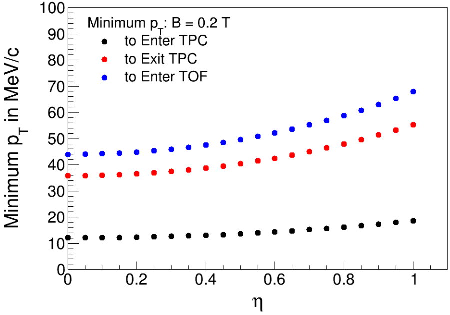
- Combinatorial background can be suppressed by increasing tagging efficiency of π^0-Dalitz and conversion pairs.
- It was suggested to use the low B sample in the dielectron analysis.
- As it would help in better reconstruction of low p_{T} tracks.
- Request 28: 10M events.
- New parameterizations were obtained for these studies.

Low B: Minimum p_T to enter or exit the TPC

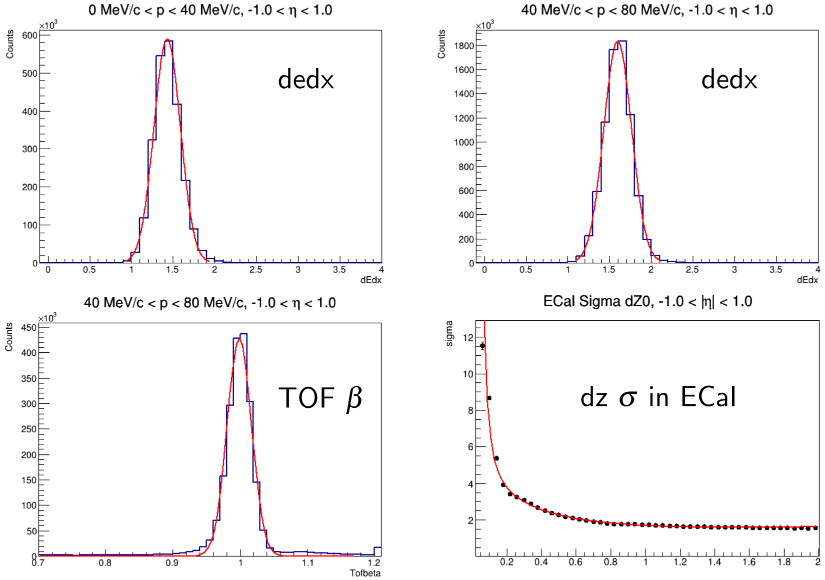


Cut-offs to enter or exit the TPC decreased with low B sample ($|\eta| \approx 0$).

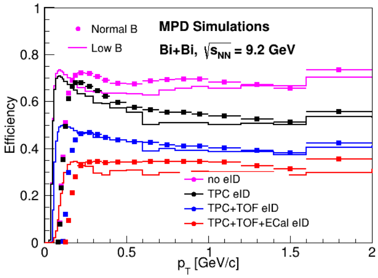
- 30 MeV/c $\rightarrow \approx$ 10 MeV/c.
- 90 MeV/c $\rightarrow \approx$ 35 MeV/c.
- 110 MeV/c $\rightarrow \approx$ 45 MeV/c.

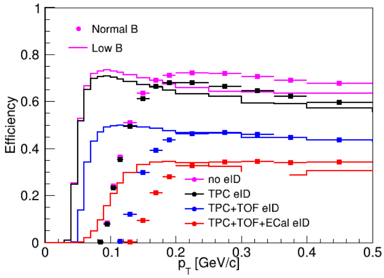


Parameterizations: extended acceptance in p_T

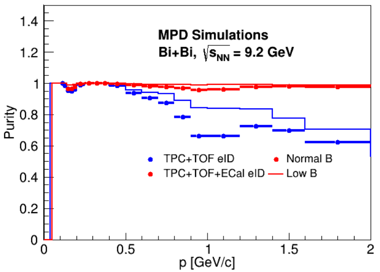


Efficiency and Purity: Low (Req. 28) and Normal (Req. 25) B

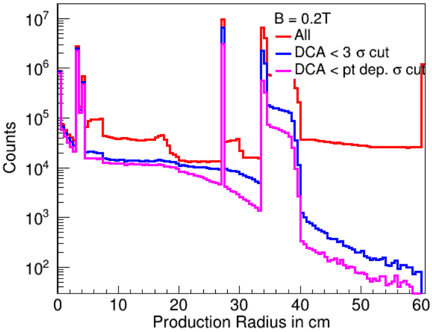




Low p_T electron tracking is improved along with similar purity, however, there is an issue.

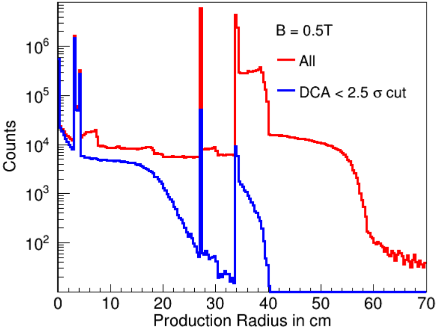


Conversion rejection: Low (Req. 28) and Normal (Req. 25) B

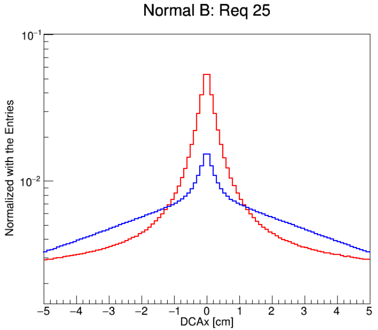


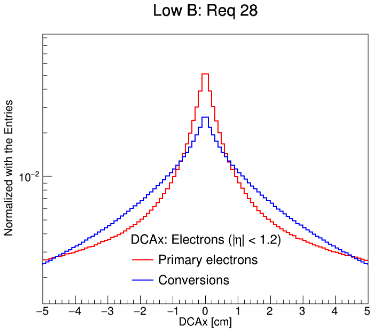
Conversions at large production radii are not rejected despite applying tight DCA selections.

This would lead to significant increase in combinatorial background.



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.

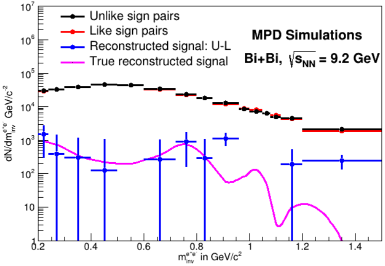
1D cuts (Fid. < 0.7)

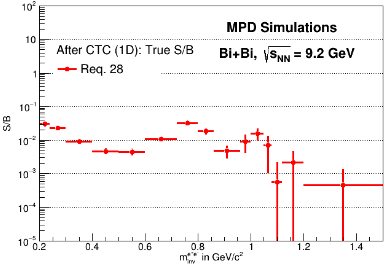
Req. 25: B = 0.5T (7.7M), Req. 28: B = 0.2T (8M)
Invariant mass: 0.2 to 1.5 GeV/c2

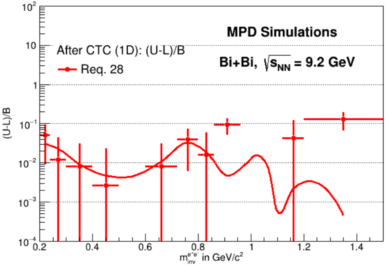
	Bef. No Further Pairing	Aft. No Further Pairing	Aft. Close TPC Cut
Invariant Mass in MeV	-	120	80
Opening Angle in degrees	-	-	10 (5)
U	28178±168	21690±147	9129±96
U	82708±288	56495±238	26610±163
B	28054±167	21558±147	8935±95
B	82329±287	56345±237	26304±162
U-B	125±237	131±208	194±134
U-B	379±406	149±336	306±230
(U-B)/B (%)	**0.44±0.00**	**0.61±0.01**	**2.17±0.03**
(U-B)/B (%)	**0.46±0.00**	**0.27±0.00**	**1.16±0.01**
BFE	0	0	2
BFE	1	0	2
S	404	395	347
S	359	329	300
S/B (%)	**1.44**	**1.83**	**3.89**
S/B (%)	**0.44**	**0.58**	**1.14**
BFE	3	4	7
BFE	1	1	2

- B - Combinatorial background approximated by like sign pairs.

ULS, LS and Signal: 1D cuts





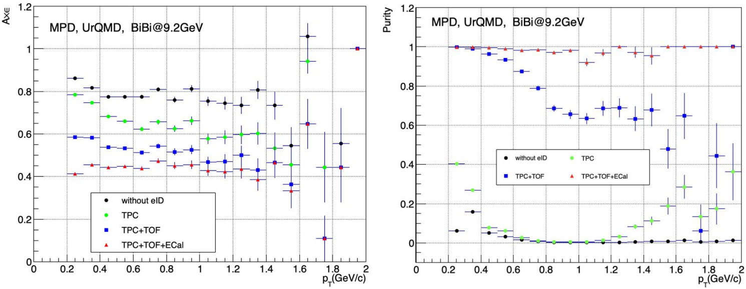


Alternative approach for dielectron analysis by Yonghong

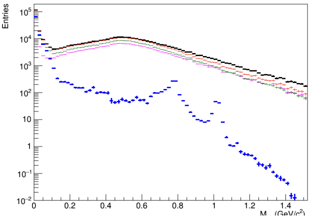
- The dielectron measurements are complex in nature.
- An alternative approach is being developed by Yonghong.
- Similar basic philosophy as Close TPC Cut analysis: to remove the combinatorial background from pi0-Dalitz and conversions by increasing tagging efficiency.
- This method is based on linear selection cuts (No ML).
- Pairs from conversions (PCM) and pi0-Dalitz are rejected by tagging partner with loose cuts.
- Results are compared with Close TPC cut analysis method.

Track reconstruction and eID

- event cut: zvertex < 80cm $\rightarrow$ 11M in total
- Track cut: $|\eta| < 1$; nhits > 39; dca $|n\sigma| < 2.5$; $p_{\mathrm{T}} > 0.2$ GeV/c;
- PID cut:
  - TPC e-ID: $|n\sigma_{\pi}| > 2$: if p<0.7 GeV/c, (1.67×p - 2.167) $<$ nσ_e $<$ 2: if p $>$ 0.7GeV/c, -1 $<$ nσ_e $<$ 2
  - matched to TOF (3σ in dphi, 2σ in dzed); TOF e-ID: $|\sigma_{\beta}| < 2$
  - matched to ECal (2σ in dphi and dzed); ECal PID

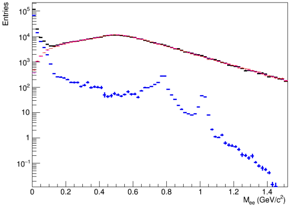


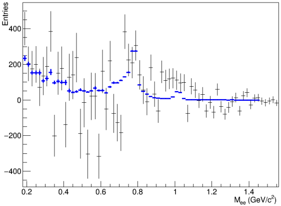
Combinatorial background: Invariant mass spectra



FG
True e+e-
Conversion
Dalitz
True signal

- Most of combinatorial background are from pairs:
  - where at least one electron is from pi0 Dalitz decay.
  - where at least one electron is from photon conversion.



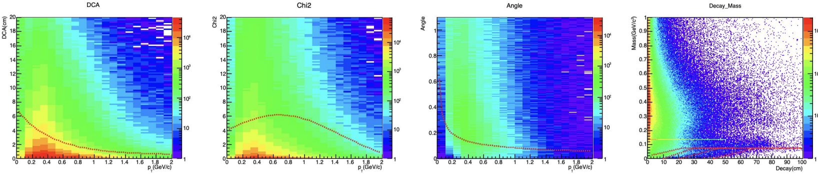


S is true recon-structed signal

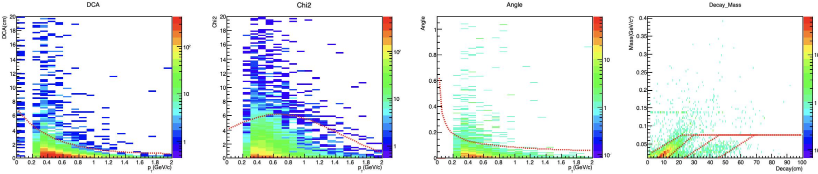
```
 S/B (0.2-1.5 GeV/c2) 0.0118605
==============================
LM    (s/sqrt(b)) (0.20-0.6 GeV/c2): 4.36974; S = 1912.91 BG = 191636
Omega (s/sqrt(b)) (0.6-0.85 GeV/c2): 5.43012; S = 1542.1 BG = 80650.6
Phi   (s/sqrt(b)) (0.85-1.2 GeV/c2): 1.29382; S = 237.513 BG = 33700.1
ALL   (s/sqrt(b)) (0.20-1.5 GeV/c2): 6.58875; S = 3660.2 BG = 308605
==============================
```

Tagging electrons from conversion using PCM

- Pair tightly identified electrons with loosely reconstructed and identified oppositely charged electrons with following cuts:
- $p_{\mathrm{T}} > 50$ MeV/c; nhits > 10; $|\eta| < 2.5$; TPC 2σ eID or (TPC 2σ and TOF 2σ) eID if matched to TOF.



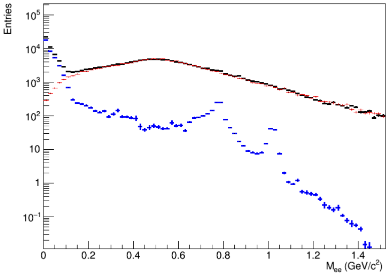
all e+e- pair candidates after eID cuts (PCM cut)

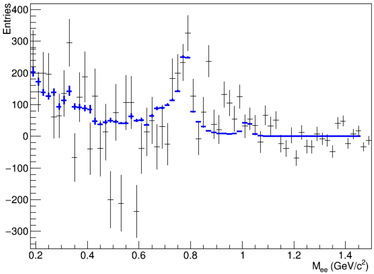


true e+e- pairs from γ just after e track cut

$\approx$ 80% of pairs from the PCM are selected for tagging with the applied cuts.

Tagging electrons from conversion using PCM: Invariant mass spectra

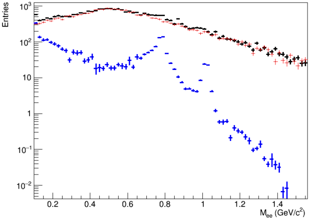


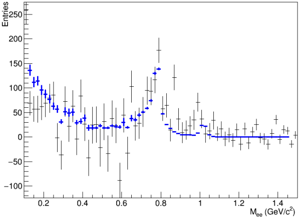


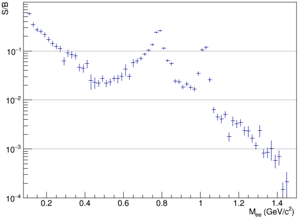

```
 S/B (0.2-1.5 GeV/c2) 0.0244392
===============================
LM    (s/sqrt(b)) (0.20-0.6 GeV/c2): 5.94993; S = 1705.94 BG = 82206.2
Omega (s/sqrt(b)) (0.6-0.85 GeV/c2): 7.4507; S = 1403.71 BG = 35494.7
Phi   (s/sqrt(b)) (0.85-1.2 GeV/c2): 1.72344; S = 216.878 BG = 15835.8
ALL   (s/sqrt(b)) (0.20-1.5 GeV/c2): 8.9767; S = 3297.21 BG = 134915
===============================
```

Tagging electrons from Dalitz

- Pair tightly identified electrons with loosely reconstructed and identified oppositely charged electrons with following cuts:
- $p_{\mathrm{T}} > 50$ MeV/c; nhits > 10; $|\eta| < 2.5$; TPC 2σ eID or (TPC 2σ and TOF 2σ) eID if matched to TOF; DCA $< 5\sigma$; Mee < 0.1 GeV/c2.

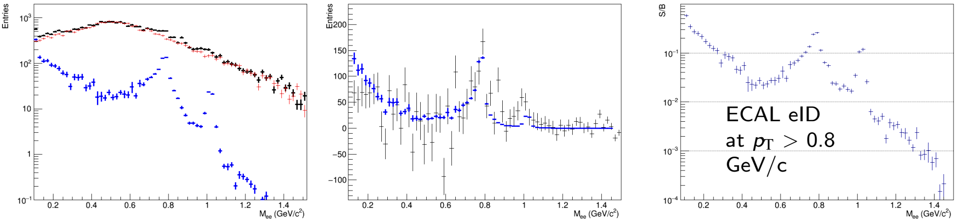







```
 S/B (0.2-1.5 GeV/c2) 0.0622429
===============================
LM    (s/sqrt(b)) (0.20-0.6 GeV/c2): 6.40842; S = 745.148 BG = 13520.2
Omega (s/sqrt(b)) (0.6-0.85 GeV/c2): 8.40359; S = 708.388 BG = 7105.8
Phi   (s/sqrt(b)) (0.85-1.2 GeV/c2): 1.89845; S = 116.563 BG = 3769.84
ALL   (s/sqrt(b)) (0.20-1.5 GeV/c2): 9.83515; S = 1554.08 BG = 24968
===============================
```

Best results so far and comparison with CTC analysis




```
S/B (0.2-1.5 GeV/c2) 0.0655446
================================
LM    (s/sqrt(b)) (0.20-0.6 GeV/c2): 6.44846; S = 739.767 BG = 13160.7
Omega (s/sqrt(b)) (0.6-0.85 GeV/c2): 8.49436; S = 697.668 BG = 6745.86
Phi   (s/sqrt(b)) (0.85-1.2 GeV/c2): 2.0094; S = 113.183 BG = 3172.68
ALL   (s/sqrt(b)) (0.20-1.5 GeV/c2): 10.0299; S = 1534.82 BG = 23416.4
================================
```

1D cuts	S/B (%)	$S/\sqrt{B}$	BFE	(U-B)/B (%)
LM	5.05	4.89	12	2.51
ω	11.87	6.47	20	13.82
ϕ	4.22	1.46	1	-2.44
All	6.39	7.5	27	4.40

ML	S/B (%)	$S/\sqrt{B}$	BFE	(U-B)/B (%)
LM	5.12	7.27	26	2.92
ω	11.20	8.99	38	13.18
ϕ	4.34	2.14	2	1.71
All	6.31	10.84	57	5.16

Results are close to those from CTC analysis with ML approach.
Similar cuts should be applied for apple-to-apple comparison: further optimization is foreseen.

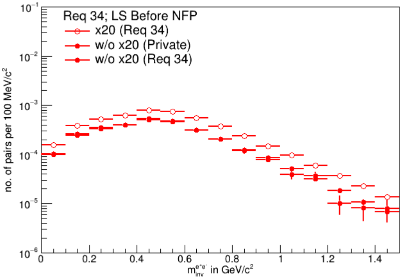
Conclusions

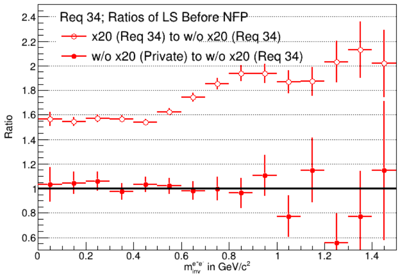
- Optimization of fiducial and veto region is studied: more checks are needed.
- Reconstructed signal between 0.2 to 0.65 GeV/c is underestimated: seems to be due to statistics.
- Enhancement of $\eta-$Dalitz decays might help reconstructing the signal in the region.
- Low magnetic field provides better efficiency at low $p_{\mathrm{T}} \rightarrow$ poor conversion rejection.
- S/B ratio is worse than Normal B scenario (Request 25) due to large CB from conversions: however, optimization of the pair reconstruction cuts and Machine learning could bring some improvement.
- Alternative analysis approach is being developed by Yonghong: CB rejection is performed using PCM and Dalitz tagging.
- first results are comparable with CTC analysis: apple-to-apple comparison needs to be performed $\rightarrow$ similar cuts, weighing procedure etc.

THANK YOU

BACK-UP

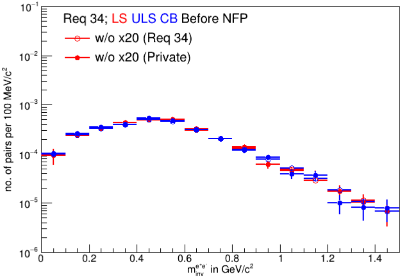
Comparision between LS: Private (547K events)

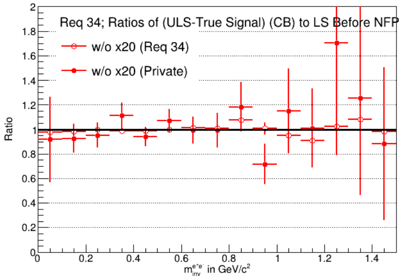




- No flat enhancement in LS after 20 factor.
- LS after reweighting back 20 factor have simialr shape as without enhancement case.

Comparision between LS and (ULS-TrueSignal)





- In the analysis, combinatorial background is approximated by Like sign.
- It seems no distortion within actual combinatorial (ULS-True signal) is visible either.
- Thus, enhancing η-Dalitz may work as well: Similar excercise can be carried out for this.

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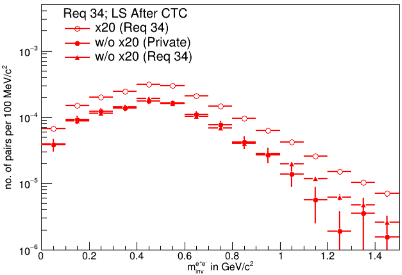

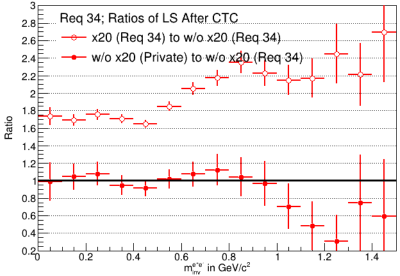

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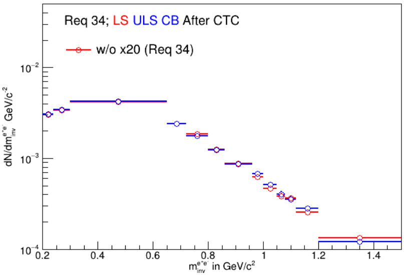
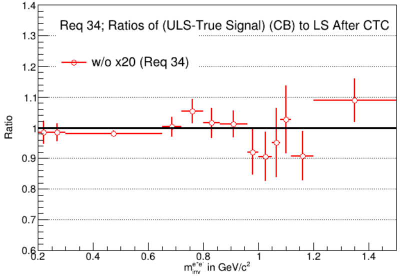
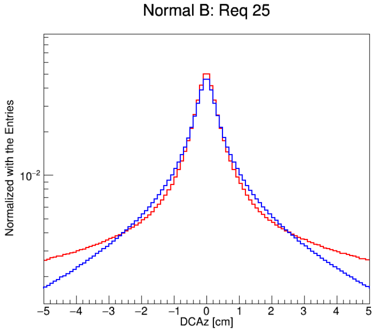
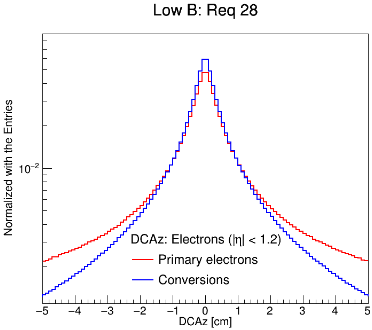




- In the analysis, combinatorial background is approximated by Like sign.
- It seems no distortion within actual combinatorial (ULS-True signal) is visible either.
- Thus, enhancing η-Dalitz may work as well: Similar excercise can be carried out for this.

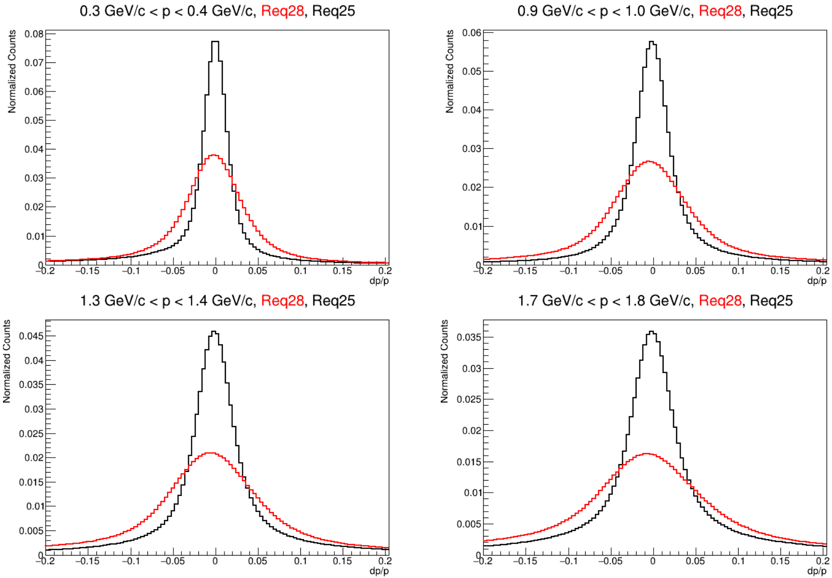
Low and Normal B: DCAz distributions (Electrons within $|\eta| < 1.2$)



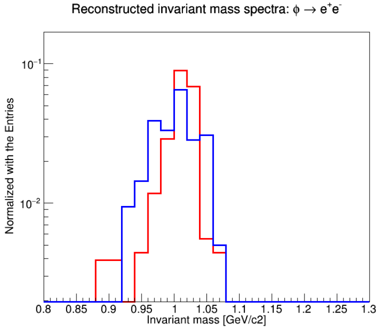


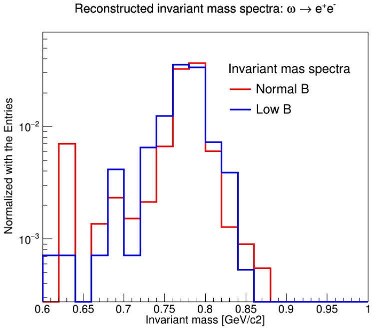
I. However, z-component of DCA has similar shapes in both Low B and Normal B.

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



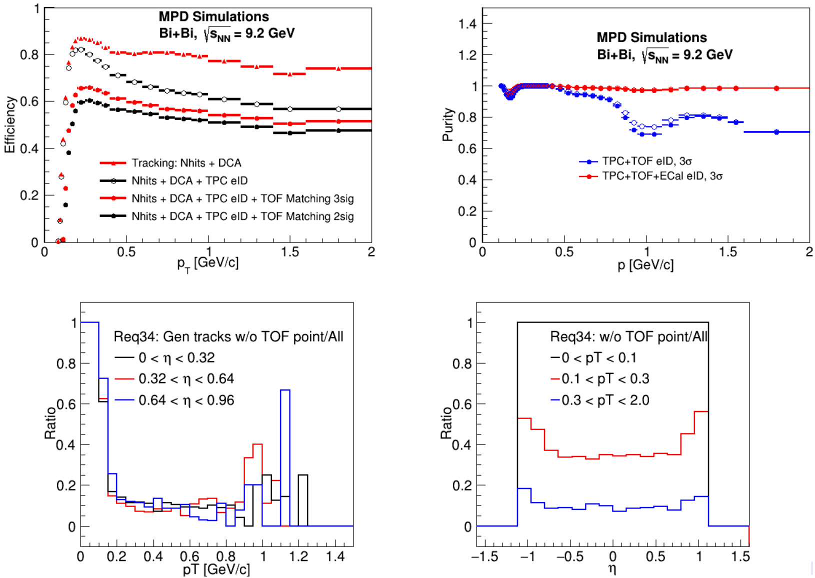
Low (Req28) and Normal (Req25) B: Mass resolution





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

TOF Matching cut



Track selection - 1D cuts analysis

→ Pool-1 - fully reconstructed tracks[(§)] 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 $dz < \mathbf{3}\sigma$), TOF (-2 to 2σ), ECal PID (p dep. $< E/p < 1.5$ and $m^2 < 2\sigma$), ECal Matching ($< 3\sigma$).

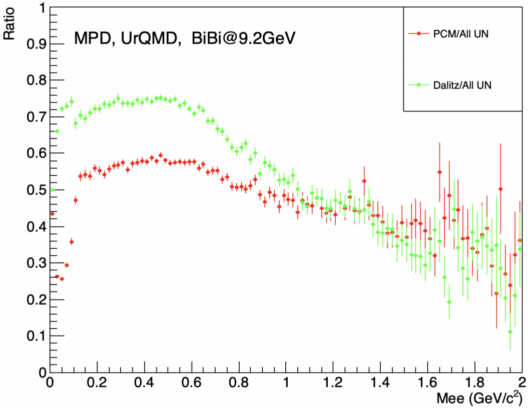
→ Pool-2 - fully reconstructed tracks in veto area ($0.7 < |\eta| < 1.0$) (Same cuts.).

→ Pool-3 with tracks reconstructed in TPC.

- $p_T <= 110$ MeV/c → not matched in TOF and ECal - ($|\eta| <2.5$, NHits > 10, DCA $< 5\sigma$, TPC dEdX (-4 to 4σ)).
- $p_T > 110$ 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 $m^2 < 2\sigma$, ECal Matching ($< 3\sigma$)).
- $p_T > 110$ 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.

(§)TOF and ECal matched tracks identified in the TPC, TOF and ECal


MPD, UrQMD, BiBi@9.2GeV
PCM/All UN
Dalitz/All UN
Ratio
Mee (GeV/c2)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.2
0.4
0.6
0.8
1.2
1.4
1.6
1.8
2