



Update on di-electron analysis

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MPD Cross-PWG meeting

- Improvement in S/B with current reconstruction algorithm: current status.
 - Close TPC Cut \rightarrow Improvement up to $\approx 75 - 80\%$ \rightarrow So far
 - Pairing electrons with photons identified using ECal to identify pairs from Dalitz and photon conversions \rightarrow Today
- Conclusions and next steps.

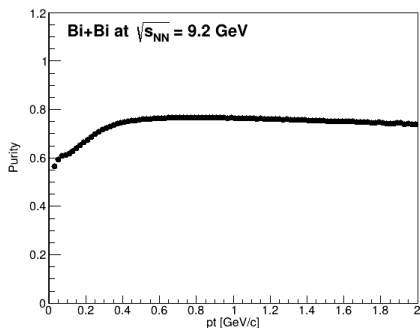
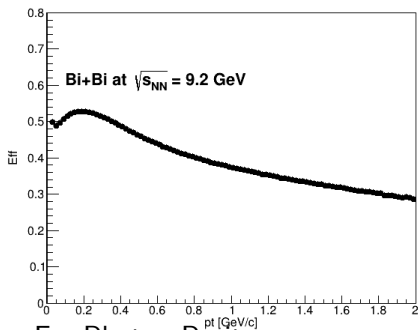
$e^- - \gamma$ pairing

- π^0 Dalitz decays have γ in decay product.
- Similarly, direct $\gamma\gamma$ decays have γ in decay product if one of the γ converts in the material.
- One can pair the electron with the photon detected in ECal and try to identify the electron as potential track from Dalitz or photon conversion by applying some selection cuts.
- For this, one has to look various kinematic variables, such as, invariant mass, opening angle (θ) and so on...

Track selection: TPC+TOF and Photon ID in ECal

- UrQMD: BiBi@9.2 GeV (Request 25).
- Event selection: $|V_z| < 100$ cm.
- Cuts on Principle tracks:
 - $|\eta| < 0.3$.
 - $DCA_{x,y,z} < 3\sigma$.
 - Nhits > 39
 - TPC nSigma: $p_T < 0.8$ GeV \rightarrow -2 (-1) to 2 sigma and $p_T > 0.8$ GeV \rightarrow -1 to 2 sigma + $|\text{TOF nSigma}| < 2\sigma$ matched within 2σ .
- For Photon Identification (following Pi0Analysis.C tutorial macro)
 - $\text{EMCCluster} \rightarrow \text{GetChi2}() < 4$
 - $\text{Tcl} < 2$ ns.
 - Charge Particle veto
 - $\text{EMCCluster} \rightarrow \text{GetE}() > 50$ MeV
 - Minimum number of towers in the cluster > 2

Photon Purity and Efficiency



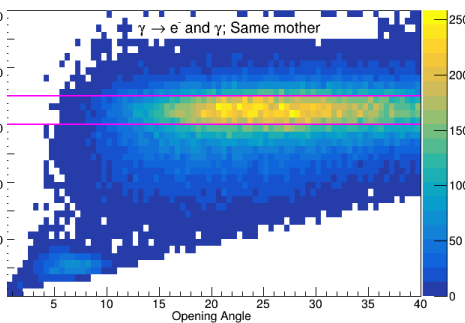
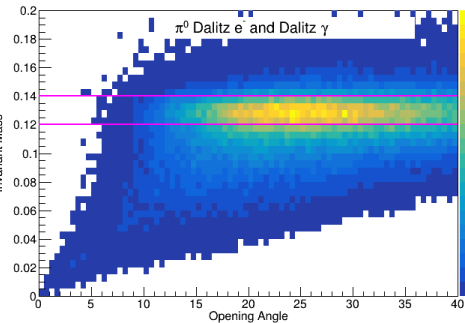
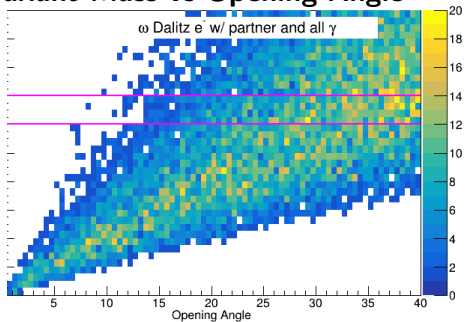
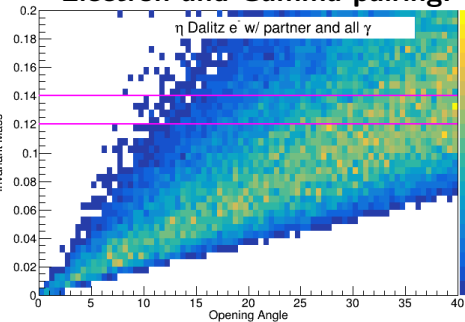
• For Photon Purity

- Denominator: $\text{EMCluster} \rightarrow \text{GetChi2}() < 4 + \text{Tcl} < 2 \text{ ns} + \text{Charge Particle veto} + \text{EMCluster} \rightarrow \text{GetE}() > 50 \text{ MeV} + \text{No of towers in cluster} > 2$.
- Numerator: True photons with same cuts.

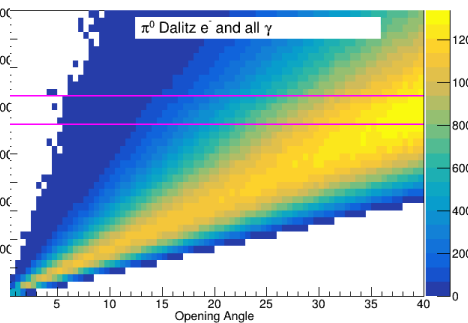
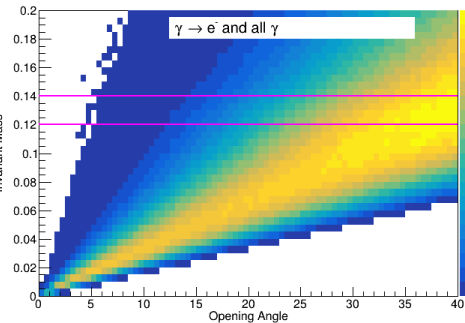
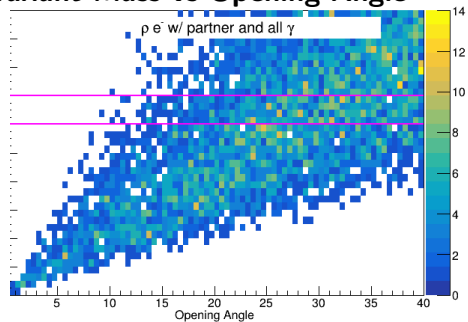
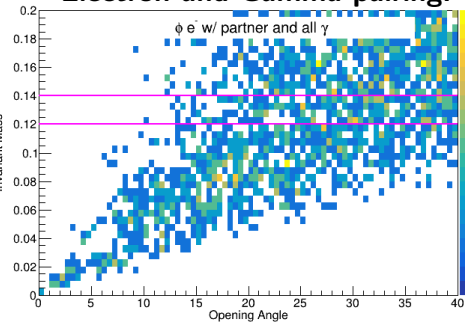
• For Photon Efficiency

- Denominator: $\text{EMCluster} \rightarrow \text{GetE}() > 50 \text{ MeV} + \text{No of towers in cluster} > 2$
- Numerator: $+ \text{EMCluster} \rightarrow \text{GetChi2}() < 4 + \text{Tcl} < 2 \text{ ns} + \text{Charge Particle veto}$.

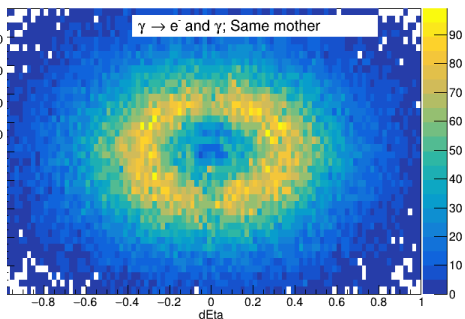
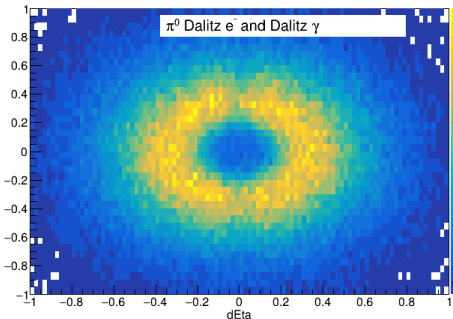
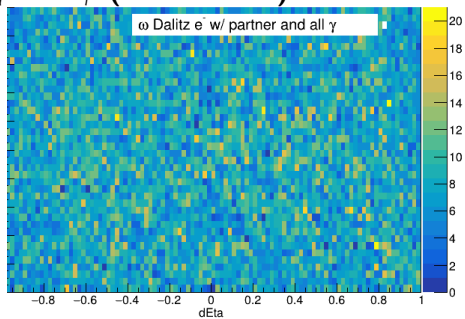
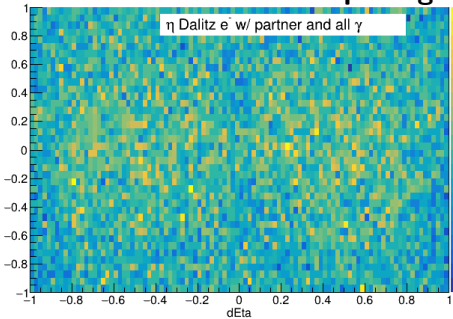
Electron and Gamma pairing: Invariant Mass vs Opening Angle



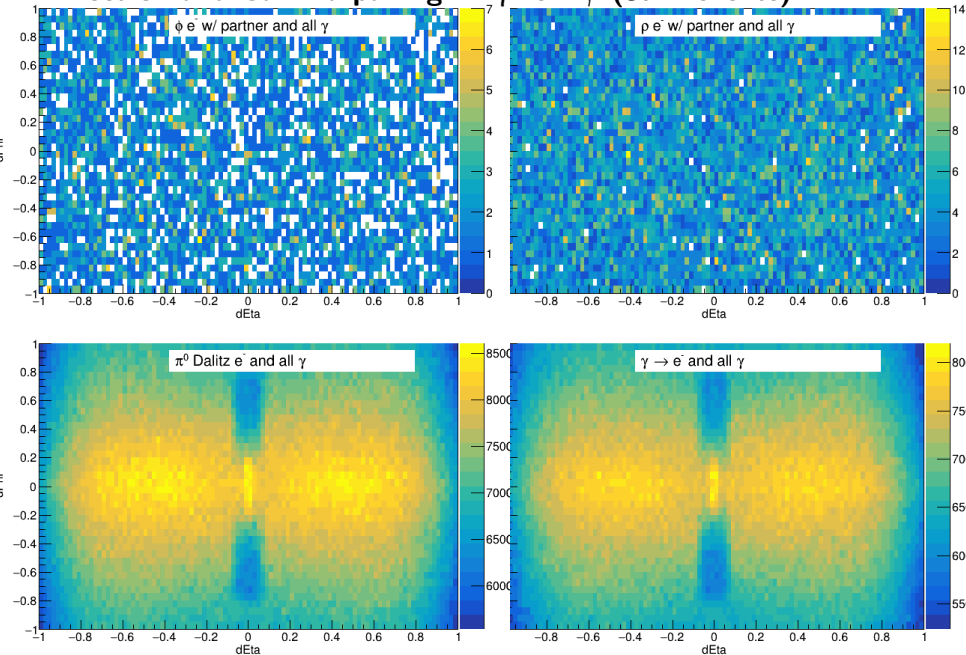
Electron and Gamma pairing: Invariant Mass vs Opening Angle



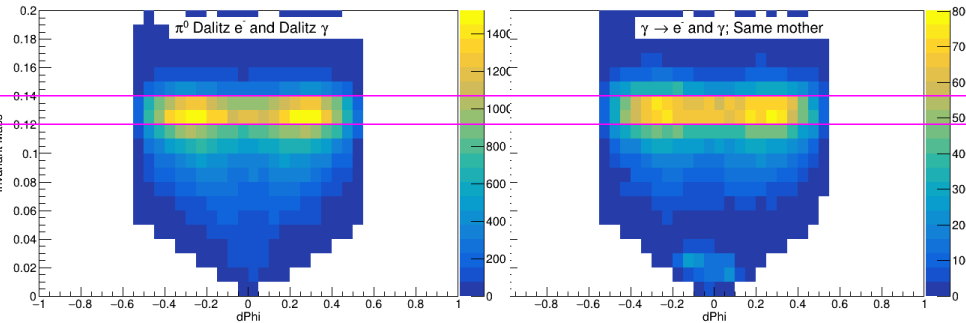
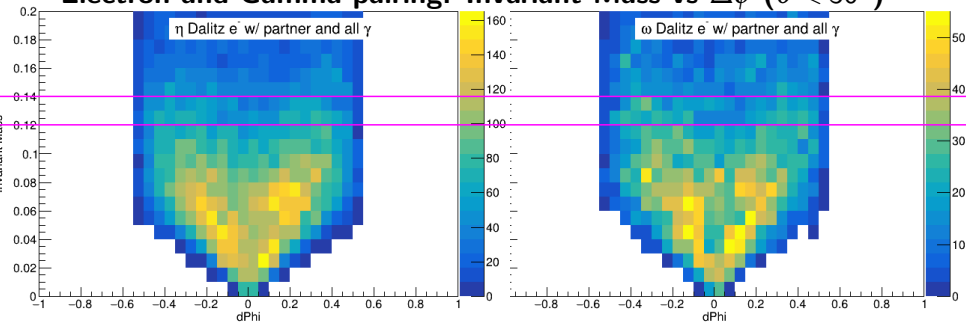
Electron and Gamma pairing: $\Delta\eta$ vs $\Delta\phi$ (37M events)



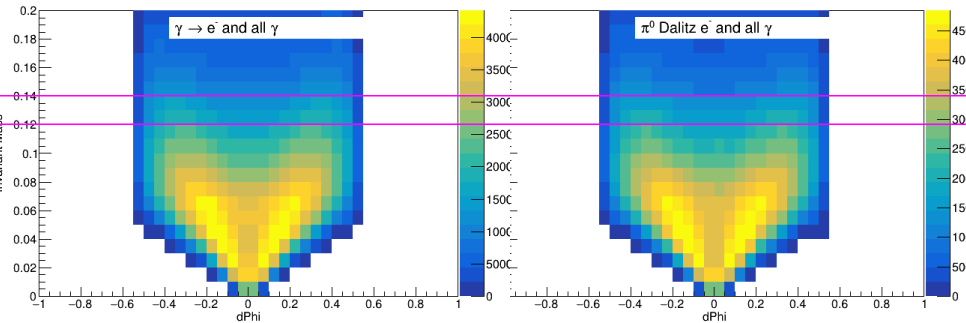
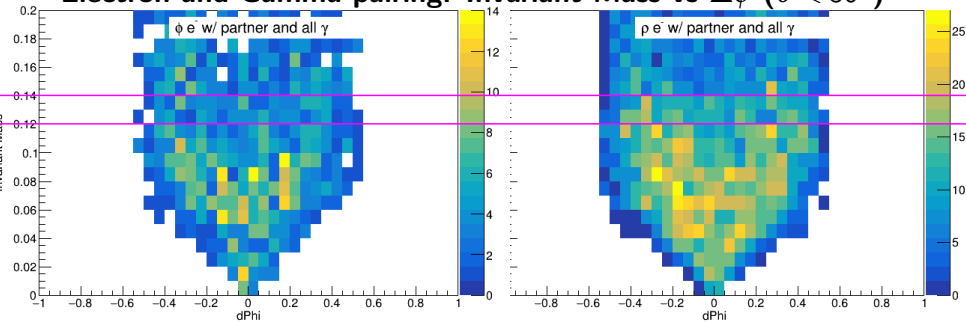
Electron and Gamma pairing: $\Delta\eta$ vs $\Delta\phi$ (37M events)



Electron and Gamma pairing: Invariant Mass vs $\Delta\phi$ ($\theta < 30^\circ$)

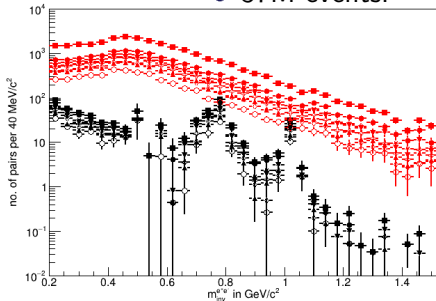


Electron and Gamma pairing: Invariant Mass vs $\Delta\phi$ ($\theta < 30^\circ$)

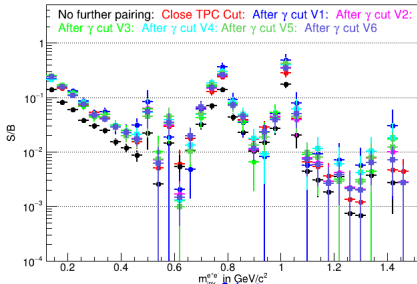


Di-electron continuum and S/B

● 37M events.



- Signal
- Before Close TPC cut
 - After Close TPC cut
 - After γ cut V1
 - After γ cut V2
- LS
- After γ cut V3
 - After γ cut V4
 - After γ cut V5
 - After γ cut V6



$\approx 80\%$ improvement

S/B

Signal	Sig	err	LS	LS err	S/B	err	Sig
666.262	25.812	26268	145.445	0.00133077	4.05969		
593.583	24.3636	13070.8	102.712	0.00261698	5.07792		

Significance not improved

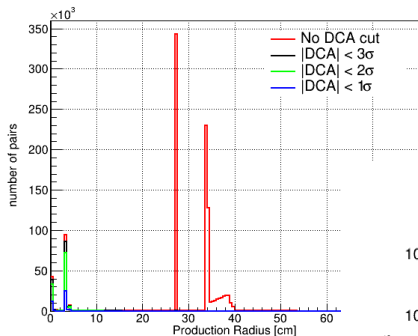
Lower Limit: 0.201
Upper Limit: 1.499

S/B After no further pairing:
S/B After close TPC cut:

Common Invariant Mass cut of 0.12 to 0.14 GeV/c²:

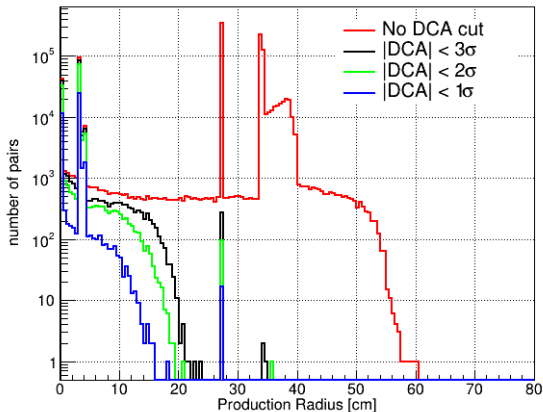
S/B Gamma Cut (Theta < 30 and dPhi < 0.3)	(V1):	0.0540322	236.875	15.3908	4383.97	59.4567	0.00542356	3.48465
S/B Gamma Cut (Theta < 30 and dPhi < 0.2)	(V2):	0.0483742	317.868	17.8289	6571.03	72.9846	0.00399892	3.82976
S/B Gamma Cut (Theta < 30 and dPhi < 0.1)	(V3):	0.0482272	449.445	21.2001	9319.32	86.7739	0.00344467	4.54733
S/B Gamma Cut (Theta < 25 and dPhi < 0.3)	(V4):	0.0489362	331.48	18.2066	6773.71	73.9639	0.00389316	3.9325
S/B Gamma Cut (Theta < 25 and dPhi < 0.2)	(V5):	0.0469763	407.575	20.1885	8676.2	83.7414	0.00327122	4.27637
S/B Gamma Cut (Theta < 25 and dPhi < 0.1)	(V6):	0.0475225	508.045	22.5399	10690.6	92.9132	0.00311242	4.80086

Conversion electrons



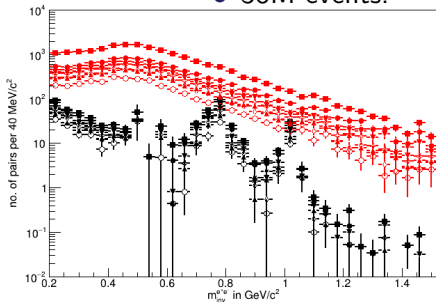
- May have a sizable effect on the S/B.
- This contribution should be removed manually ($R < 1$ cm) and investigate the cause of this.

- Significant contribution of electrons from γ conversion at $R = 0 \rightarrow$ seems artificial since there is no material there.

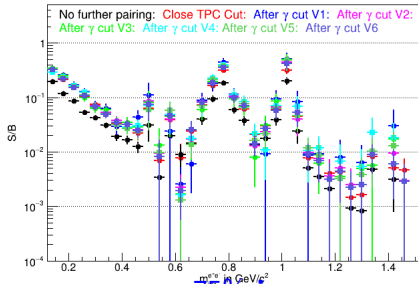


Di-electron continuum and S/B

● 38M events.



- Signal
- Before Close TPC cut
 - After Close TPC cut
 - After γ cut V1
 - After γ cut V2
- LS
- After γ cut V3
 - After γ cut V4
 - After γ cut V5
 - After γ cut V6



$\approx 75\%$ improvement

S/B
 0.0348708
 0.0610178

Significance not improved

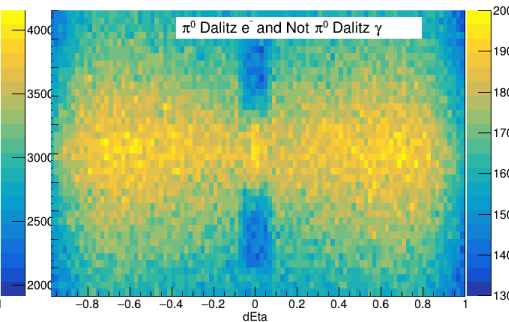
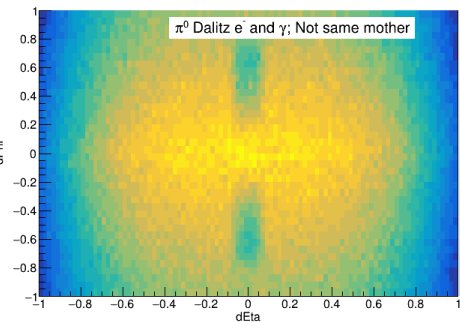
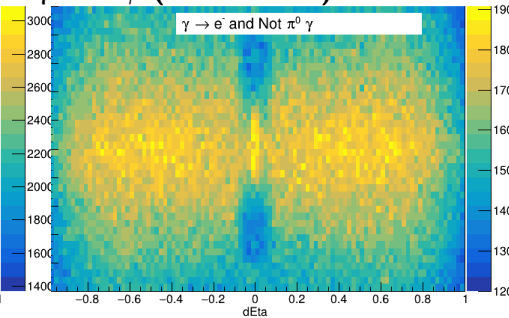
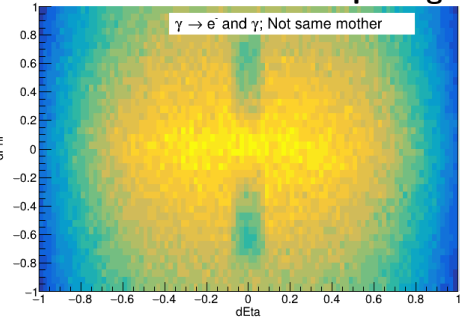
	S/B	Signal	Sig	err	LS	LS	err	S/B	err	Sig
S/B After no further pairing:	0.0348708	672.875	25.9398	19296.2	122.419	0.00181663				4.76163
S/B After close TPC cut:	0.0610178	599.679	24.4883	9827.93	87.5781	0.00349095				5.87254
Common Invariant Mass cut of 0.12 to 0.14 GeV/c ² :										
S/B Gamma Cut (Theta < 30 and dPhi < 0.3)	(V1): 0.0713081	236.83	15.3893	3321.23	50.9508	0.00721151				3.97037
S/B Gamma Cut (Theta < 30 and dPhi < 0.2)	(V2): 0.0654413	323.086	17.9746	4937.04	62.2083	0.00534534				4.45472
S/B Gamma Cut (Theta < 30 and dPhi < 0.1)	(V3): 0.0656149	458.584	21.4146	6989.02	73.8744	0.00461056				5.31387
S/B Gamma Cut (Theta < 25 and dPhi < 0.3)	(V4): 0.0661415	337.995	18.3846	5110.18	63.2072	0.00518778				4.57915
S/B Gamma Cut (Theta < 25 and dPhi < 0.2)	(V5): 0.0636406	416.686	20.4129	6547.49	71.58	0.00436107				4.99315
S/B Gamma Cut (Theta < 25 and dPhi < 0.1)	(V6): 0.0640884	515.211	22.6983	8039.08	79.2352	0.00414944				5.57049

Conclusions and Next Steps

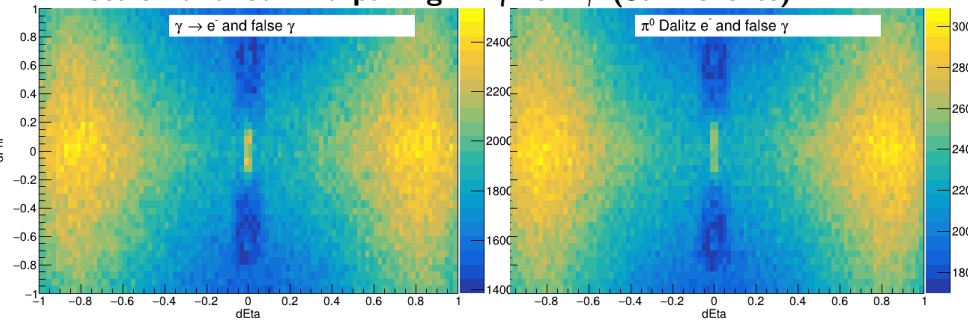
- The strategy to use reconstructed γ using ECal to identify the Dalitz or conversion contribution by pairing it with electrons does not yield strong improvement in S/B.
- Perhaps, this strategy is not effective at this stage, however, we will revisit this in future, once we develop current tools as well as understanding of the CB.
- NEXT STEPS:
 - Using TMVA package to improve the electron efficiency (with the help of Igor Rufanov).

BACK-UP

Electron and Gamma pairing: $\Delta\eta$ vs $\Delta\phi$ (37M events)



Electron and Gamma pairing: $\Delta\eta$ vs $\Delta\phi$ (37M events)

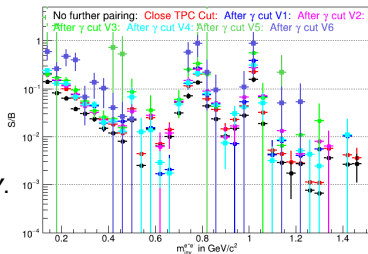
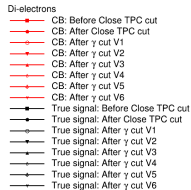
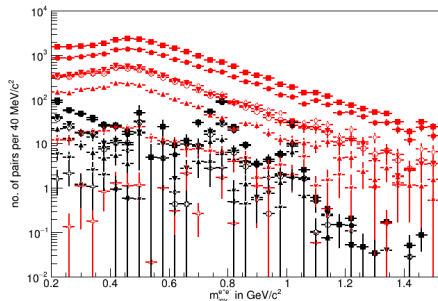


Track selection: TPC+TOF

- UrQMD: BiBi@9.2 GeV (Request 25).
- Event selection: $|V_z| < 100$ cm.
- Cuts on Principle tracks:
 - $|\eta| < 0.3$.
 - $DCA_{x,y,z} < 3\sigma$.
 - Nhits > 39
 - TPC nSigma: $p_T < 0.8$ GeV \rightarrow -2 (-1) to 2 sigma and $p_T > 0.8$ GeV \rightarrow -1 to 2 sigma + $|\text{TOF nSigma}| < 2\sigma$ matched within 2σ .
- Cuts on tracks to be used for tagging with TPC+TOF: I
 - $|\eta| < 2.5$.
 - $DCA_{x,y,z} < 3.5\sigma$.
 - Nhits > 10 + $|\text{TPC nSigma}| < 2\sigma$ + $|\text{TOF nSigma}| < 2\sigma$ matched within 2σ .
- Cuts on tracks to be used for tagging with TPC Only: II
 - $|\eta| < 2.5$.
 - $DCA_{x,y,z} < 3.5\sigma$.
 - Nhits > 10 + $|\text{TPC nSigma}| < 2\sigma$ + No Hit in TOF.

Photon ID in ECal

- For Photon Identification (following Pi0Analysis.C tutorial macro)
 - $\text{EMCCluster} \rightarrow \text{GetChi2}() < 4$
 - $\text{Tcl} < 2 \text{ ns}$.
 - Charge Particle veto
 - $\text{EMCCluster} \rightarrow \text{GetE}() > 50 \text{ MeV}$
 - Minimum number of towers in the cluster > 2
- For Photon Purity
 - Denominator: All reconstructed tracks/clusters with $\text{EMCCluster} \rightarrow \text{GetChi2}() < 4 + \text{Tcl} < 2 \text{ ns} + \text{Charge Particle veto} + \text{EMCCluster} \rightarrow \text{GetE}() > 50 \text{ MeV} + \text{Minimum number of towers in the cluster} > 2$.
 - Numerator: True photons with same cuts.
- For Photon Efficiency
 - Denominator: All reconstructed tracks/clusters with $\text{EMCCluster} \rightarrow \text{GetE}() > 50 \text{ MeV} + \text{Minimum number of towers in the cluster} > 2$
 - Numerator: $+ \text{EMCCluster} \rightarrow \text{GetChi2}() < 4 + \text{Tcl} < 2 \text{ ns} + \text{Charge Particle veto}$.



- 38M events.
- V1, V2, V3, V5, V6: No η cut on γ .
- V4: γ within $|\eta| > 0.3$.

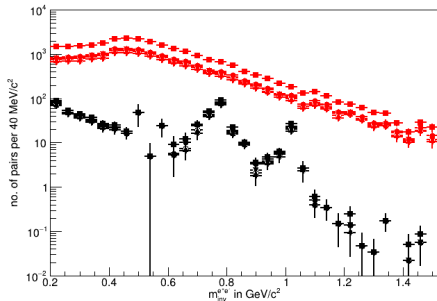
Lower Limit: 0.201
Upper Limit: 1.499

S/B After no further pairing:
S/B After close TPC cut:

S/B	Signal	Sig err	LS	LS err	S/B err	Sig
0.0252657	670.813	25.9001	26550.3	146.285	0.0013179	4.06582
0.0398679	624.138	24.9828	15655.2	112.427	0.00220299	4.89173

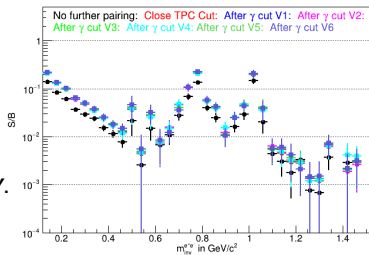
Common Invariant Mass cut of 0.12 to 0.14 GeV/c²:

S/B Gamma Cut (Theta < 30 and dPhi < 0.3)	(V1):	0.0452257	239.637	15.4802	5298.68	65.4408	0.00452944	3.22006
S/B Gamma Cut (Theta < 25)	(V2):	0.0418792	245.143	15.657	5853.58	68.8672	0.00357515	3.13906
S/B Gamma Cut (Theta < 30)	(V3):	0.056186	129.757	11.3911	2309.41	43.3355	0.00789132	2.62729
S/B Gamma Veto (> 0.3) (Theta < 30)	(V4):	0.0438328	251.523	15.8595	5738.24	68.3528	0.00428022	3.24992
S/B Gamma Cut	(V5):	0.076298	14.4002	3.79476	16.433	3.60934	0.27004	2.59334
S/B Gamma Cut (Theta < 40)	(V6):	0.127774	31.7582	5.63544	248.549	14.2357	0.0194157	1.89687



- 37M events.
- V1, V2, V3, V5, V6: No η cut on γ .
- V4: γ within $|\eta| > 0.3$.

- Di-electrons
- CB: Before Close TPC cut
 - CB: After Close TPC cut
 - CB: After γ cut V1
 - CB: After γ cut V2
 - CB: After γ cut V3
 - CB: After γ cut V4
 - CB: After γ cut V5
 - CB: After γ cut V6
 - True signal: Before Close TPC cut
 - True signal: After Close TPC cut
 - True signal: After γ cut V1
 - True signal: After γ cut V2
 - True signal: After γ cut V3
 - True signal: After γ cut V4
 - True signal: After γ cut V5
 - True signal: After γ cut V6



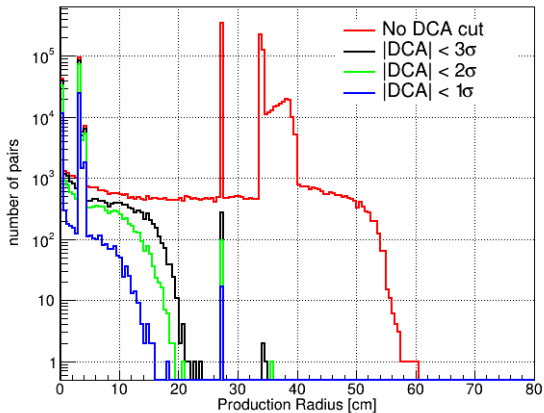
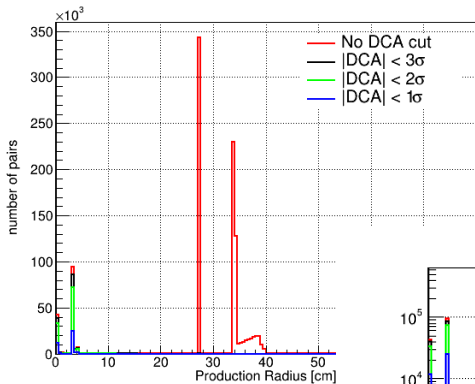
Lower Limit: 0.201
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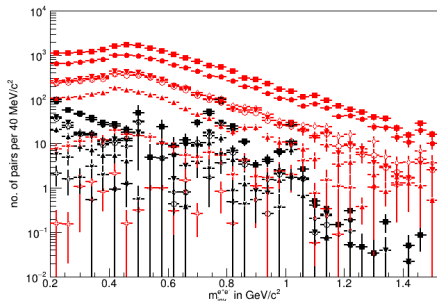
S/B After no further pairing:
S/B After close TPC cut:

Common Invariant Mass cut of 0.12 to 0.14 GeV/c²:

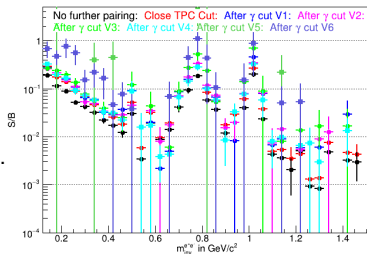
S/B Gamma Cut (Theta < 30, |dPhi| > 0.3, |dPhi| < 0.7 and |dEta| < 0.06) (V1): 0.04003 541.52 23.27 13526.88 104.52 0.00247 4.57
 S/B Gamma Cut (Theta < 25, |dPhi| > 0.3, |dPhi| < 0.7 and |dEta| < 0.06) (V2): 0.03968 567.06 23.81 14290.98 107.37 0.00237 4.65
 S/B Gamma Cut (15 < Theta < 30, |dPhi| > 0.3, |dPhi| < 0.7 and |dEta| < 0.06) (V3): 0.04003 541.52 23.27 13526.88 104.52 0.00247 4.57
 S/B Gamma Veto (> 0.3) (Theta < 30, |dPhi| > 0.3, |dPhi| < 0.7 and |dEta| < 0.06) (V4): 0.03930 594.88 24.39 15136.96 110.46 0.00225 4.74
 S/B Gamma Cut (|dPhi| > 0.3, |dPhi| < 0.7 and |dEta| < 0.06) (V5): 0.04126 504.78 22.47 12234.68 99.48 0.00270 4.47
 S/B Gamma Cut (Theta < 40, |dPhi| > 0.3, |dPhi| < 0.7 and |dEta| < 0.06) (V6): 0.04125 504.78 22.47 12238.43 99.49 0.00270 4.47

S/B	Signal	Sig err	LS	LS err	S/B err	Sig
0.02490	643.09	25.36	25826.21	144.25	0.00134	3.95
0.03907	595.24	24.40	15235.58	110.82	0.00224	4.73





- Di-electrons
- CB: Before Close TPC cut
 - CB: After Close TPC cut
 - CB: After γ cut V1
 - CB: After γ cut V2
 - CB: After γ cut V3
 - CB: After γ cut V4
 - CB: After γ cut V5
 - CB: After γ cut V6
 - True signal: Before Close TPC cut
 - True signal: After Close TPC cut
 - True signal: After γ cut V1
 - True signal: After γ cut V2
 - True signal: After γ cut V3
 - True signal: After γ cut V4
 - True signal: After γ cut V5
 - True signal: After γ cut V6



- 38M events.
- REMOVED γ conversions at $R < 1$ cm.
- V1, V2, V3, V5, V6: No η cut on γ .
- V4: γ within $|\eta| > 0.3$.

Lower Limit: 0.201
Upper Limit: 1.499

	S/B	Signal	Sig err	LS	LS err	S/B err	Sig
S/B After no further pairing:	0.0350953	689.393	26.2563	19643.5	123.554	0.00179257	4.83468
S/B After close TPC cut:	0.0542007	639.048	25.2794	11790.4	95.8731	0.00294223	5.73202

Common Invariant Mass cut of 0.12 to 0.14 GeV/c²:

	(V1):	(V2):	(V3):	(V4):	(V5):	(V6):
S/B Gamma Cut (Theta < 30 and dPhi < 0.3)	0.0623112	0.057356	0.0768091	0.0591723	0.882978	0.17696
S/B Gamma Cut (Theta < 25)	248.111	253.698	133.039	256.735	14.3014	33.0782
S/B Gamma Cut (Theta < 30)	15.7515	15.9279	11.5342	16.023	3.78172	5.75137
S/B Gamma Veto (> 0.3) (Theta < 30)	3981.8	4423.21	1732.07	4338.77	16.1968	186.925
S/B Gamma Cut	55.7761	58.7992	36.8506	58.4278	3.50938	12.1024
S/B Gamma Cut (Theta < 40)	0.00608375	0.00477722	0.0105744	0.00568945	0.269095	0.0267248
Sig	3.81487	3.70968	3.08054	3.7872	2.58965	2.23012