Conversion rejection and S/B studies for dielectrons in BiBi@9.45

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Outline

- New DCA parameterization
- Rejection of conversion track candidates
- S/B studies for dielectrons

DCA selections

- DCA_x,y,z selections → reject tracks not from the primary vertex (conversion, weak decays, secondary interactions etc.)
- DCA selections are p_T, rapidity and centrality dependent → parameterization of the mean and width of DCA distributions (sigmalization) vs. p_T, rapidity and centrality → apply n-σ cuts for selection of primary tracks
- Sigmalization of DCA is done using the inclusive sample of reconstructed charged particle tracks (mostly pions, composition changes with momentum and centrality)
- Problems:
  - ✓ DCA parameterization approach (background and signal functions, vs. what variables etc.)
  - ✓ DCA parameterizations depend on the track selection cuts (n-hits, vertex, rapidity etc.)

DCA parameterizations, previously

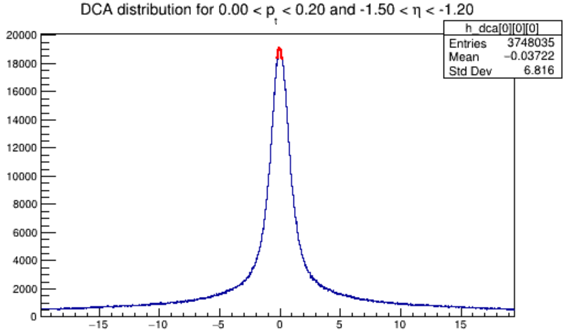
- Up to now, the DCA_x,y,z parameterizations provided by the method described in MpdRoot/macro/physical_analysis/Flow were used:

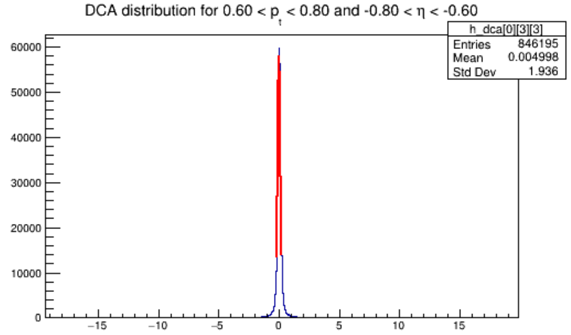
2.1 DCA calibration file
3 main steps:
--Get dca distributions and store them into calibration file;
--Fit dca distributions via gaus function to make primary particles selection in terms of n-sigma;
--Fit pt dependence of the dca distributions via polynomial function to reduce pt efficiency loss due to the dca distributions are split into discrete pt bins.
2.1.1 To get light calibration file containing only histograms with dca distributions get_dca.cxx is used in the mpdroot/macro/physical_analysis/get_dca/ directory:
2.1.2 Next, get_fit.cxx is used for 1-st iteration fitting procedure. It fits dca distributions with gaus functions:
2.1.3 Finaly, to be able to distinguish primary particles without pt efficiency loss due to pt-dependence of the dca distributions, 2-nd iteration of the fitting procedure is used:

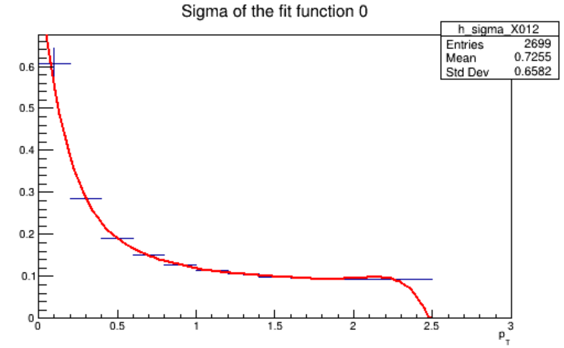
- The method works, but can be improved:
  - ✓ extend parameterization vs p_T to parameterization vs. p_T, η and centrality
  - ✓ improve the DCA parameterization approach

fits to DCA distributions (no background, fixed range)

fits to mean & width (mean is zero, polynomial parameterization works only in the fit range)

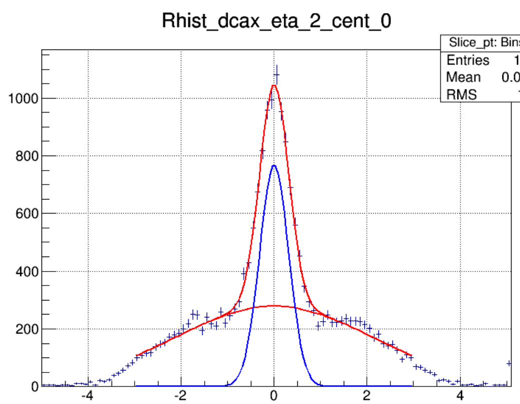


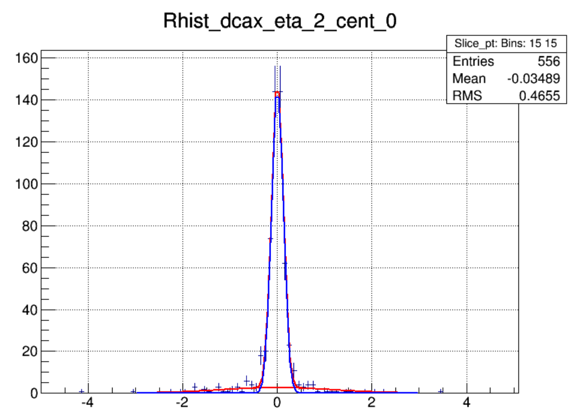




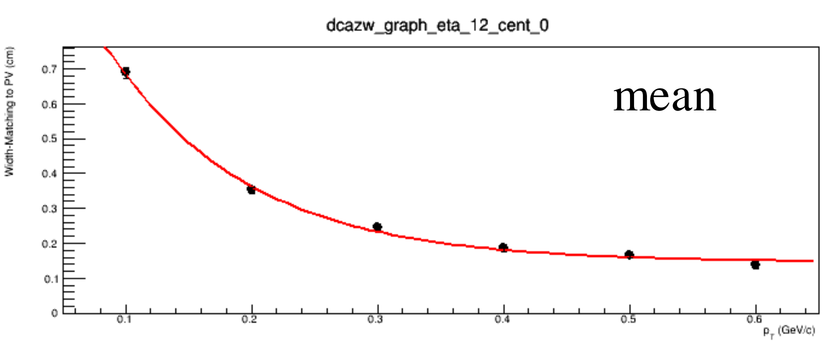
DCA parameterizations, new

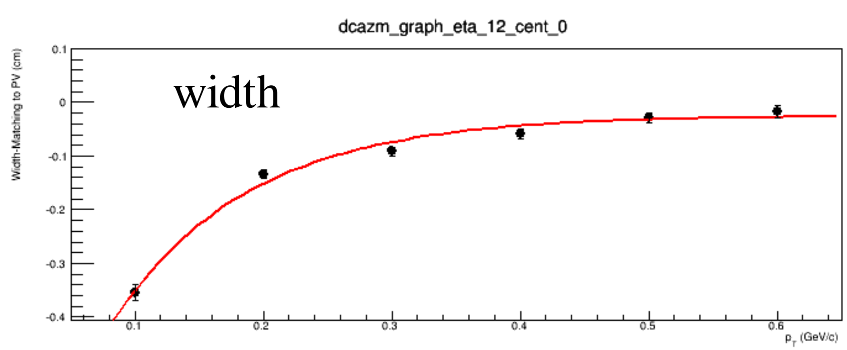
- Pretty much the same approach but with some modifications
- DCA_x,y and DCA_z distributions are accumulated more differentially (7,500 bins):
  - ✓ 30 bins in η, $-1.5 < \eta < 1.5$
  - ✓ 10 centrality bins, 0 – 100%
  - ✓ 25 p_T bins, 0.05 – 2.55 GeV/c
- Number of bins and ranges are driven by available statistics
- DCA_xy and DCA_z distributions are fit to (Gauss1 for signal + Gauss2 for background)





- Mean & width vs. p_T parameterized with functions that saturate at high p_T (extrapolation)





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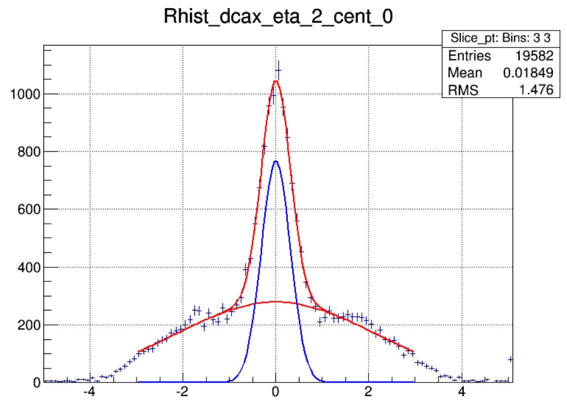

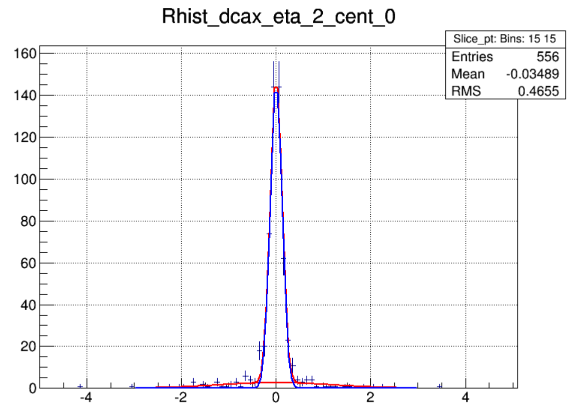

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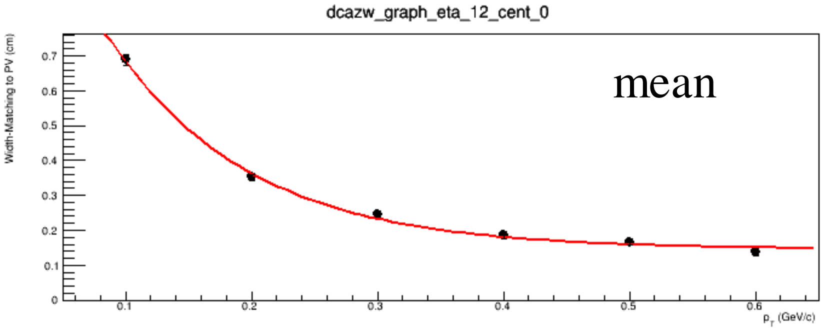
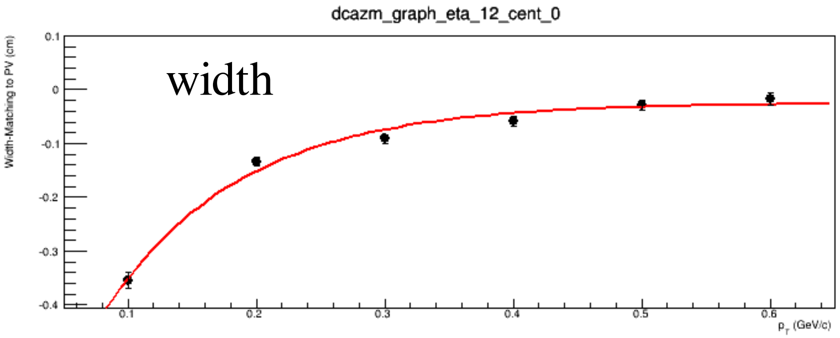
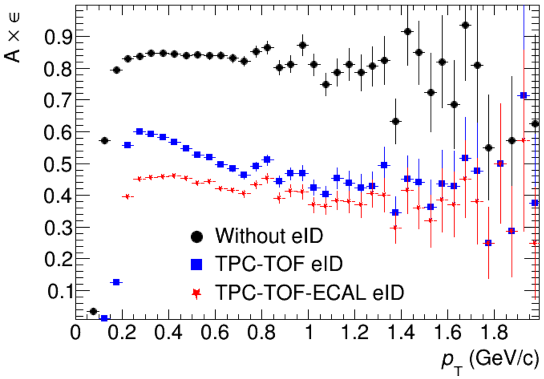


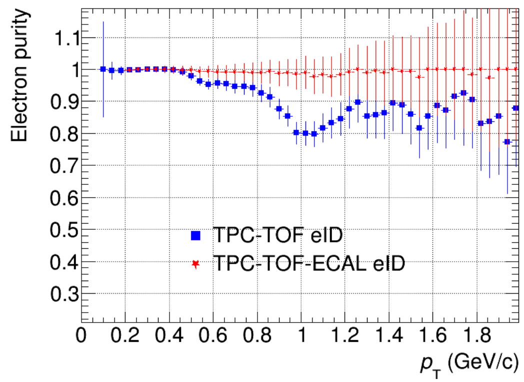


Single electrons and dielectrons

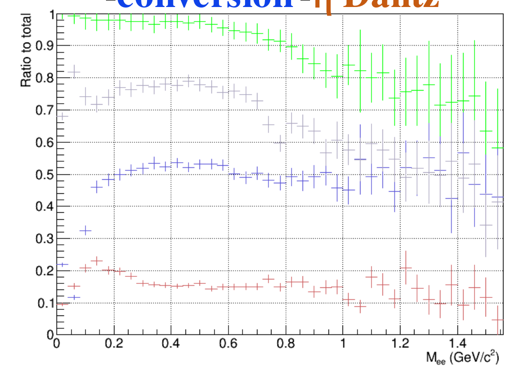
- 10 M minbias BiBi@9.45 (UrMQD v.3.4) events, **noID**, **TPC&TOF** or **TPC&TOF&ECAL**

✓ previous DCA_x,y,z parameterization





-true ee -π^0 Dalitz
-conversion -η Dalitz



S/B in 0.2-1.5: 0.022

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(s/sqrt(b)) w : 2.80; Phi : 1.07; LMR : 0.57

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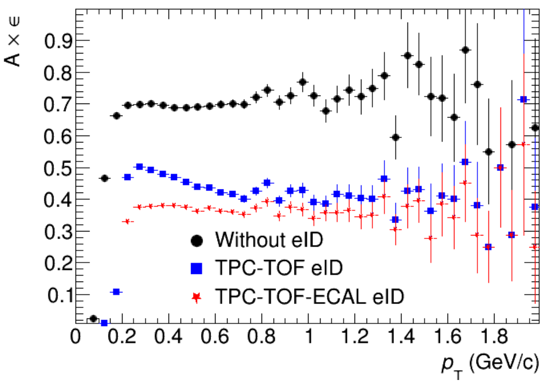
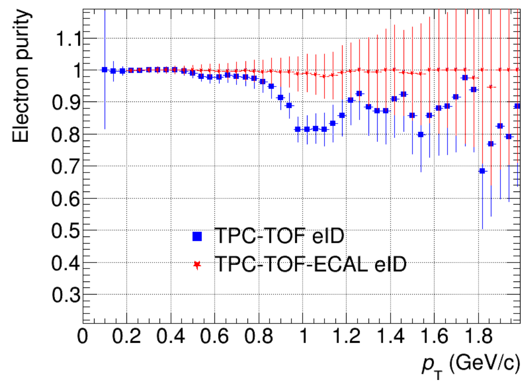
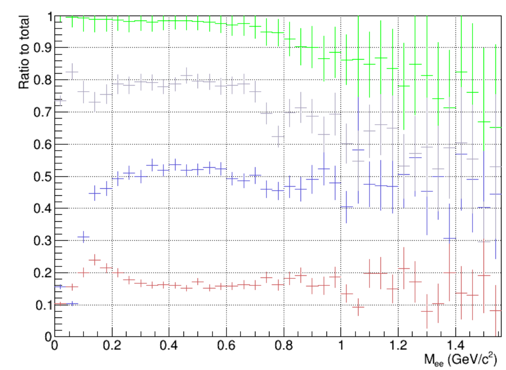
✓ new DCA_xy,z parameterization







S/B in 0.2-1.5: 0.025

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(s/sqrt(b)) w : 2.65; Phi: 1.07; LMR: 0.52

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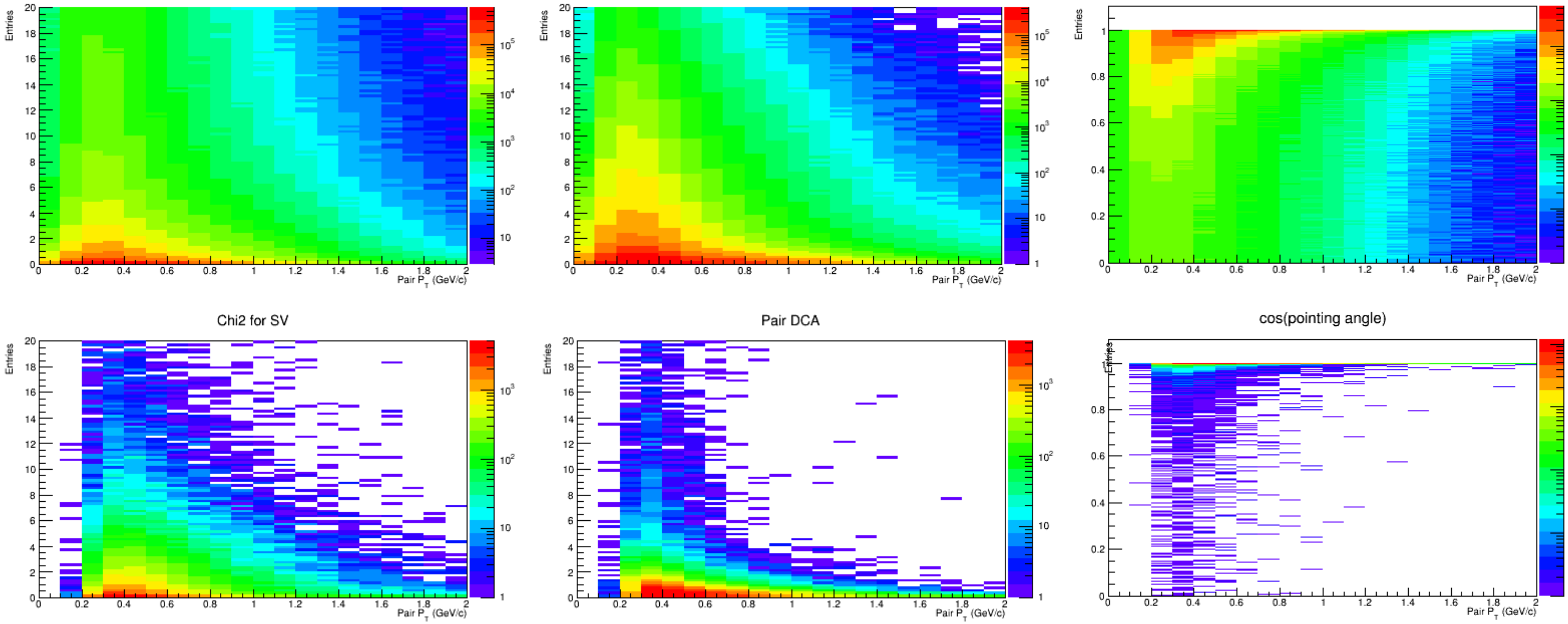
Conversions

- 10 M minbias BiBi@9.45 (UrMQD v.3.4) events
- Idea is to pair electron candidate tracks and then reject tracks that are consistent with $\gamma \rightarrow ee$
- Form pairs:
  - ✓ track #1 – passes tight dielectron analysis selection cuts (n-hits > 39, DCA < 2σ; |eta| < 1.0; p_T > 50 MeV/c; TPC-TOF 2σ eID + TPC π-ID 2σ veto)
  - ✓ track #2 – passes loose e-ID cuts (n-hits > 20; |eta| < 2.5; p_T > 50 MeV/c; TPC 2σ e-ID (no TOF) ‖ TPC-TPF 2σ e-ID
- Compare distributions for all pairs and for those from conversion:
  - ✓ Chi2 for secondary vertex, distance between the tracks
  - ✓ pointing angle
  - ✓ Mass_ee
  - ✓ distance to primary vertex
  - ✓ …. many more, but all variables are correlated

Chi2, DCA and PA distributions

- 10 M minbias BiBi@9.45 (UrMQD v.3.4) events

Chi2 for secondary vertex **DCA between the tracks** **Pointing angle**

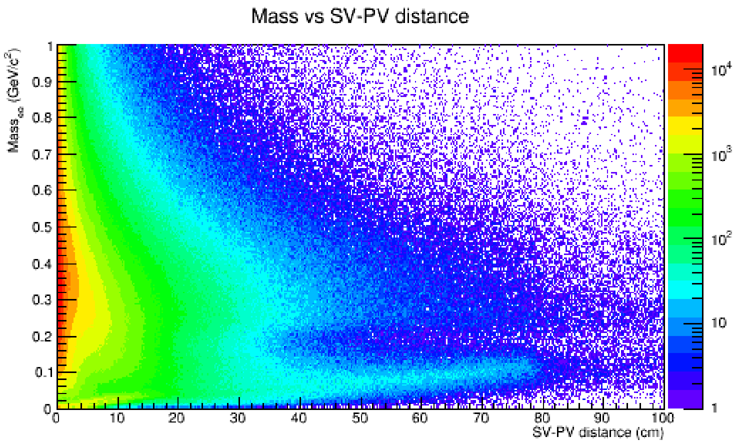


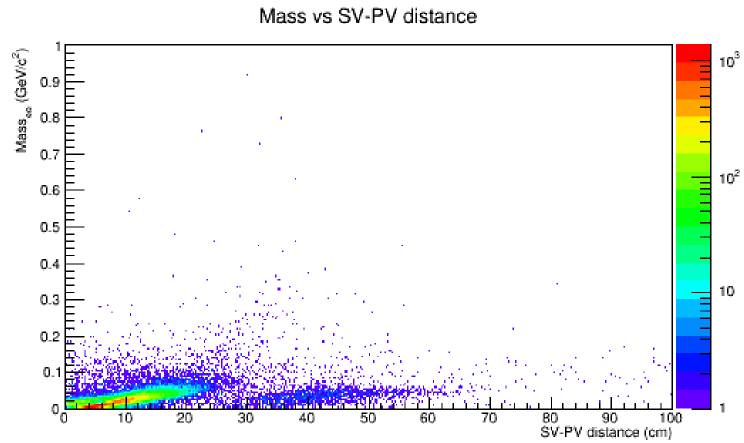
- p_T-dependent selections for Chi2, DCA and pointing angle are set to accept 95% of conversion pairs

Mass vs. distance distributions

- 10 M minbias BiBi@9.45 (UrMQD v.3.4) events

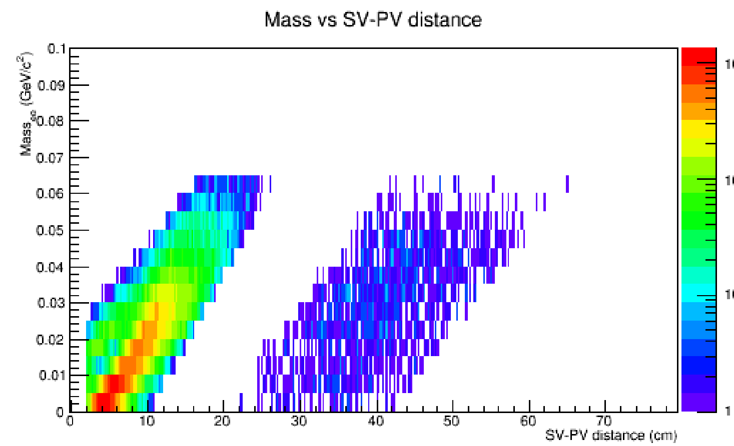
Mass vs. SV-PV distance





- Tight DCA cut for track#1 rejects conversions at large angles

- Selections for conversion pairs:
  - ✓ SV-PV distance > 2 cm
  - ✓ Mass_ee < 65 MeV/c^2
  - ✓ select two bands for the beam pipe and TPC vessels

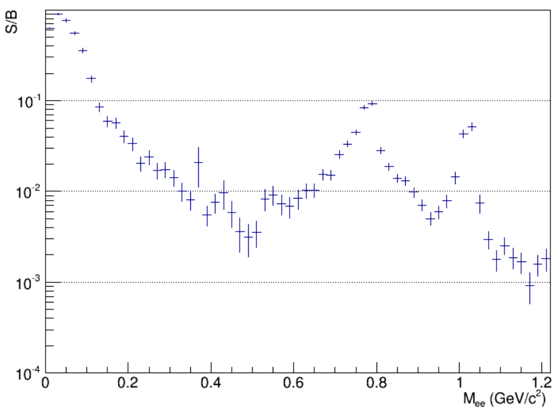


- Once find a loosely e-IDed track which is consistent with a conversion partner for the tightly e-IDed track → both tracks are tagged as a conversion pair candidates and then rejected from the analysis

Conversion rejection, results

- 10 M minbias BiBi@9.45 (UrMQD v.3.4) events

No conversion rejection



S/B in 0.2-1.5: 0.014

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Omega (s/sqrt(b)): 2.23
Phi (s/sqrt(b)): 0.86
LMR (s/sqrt(b)): 0.42

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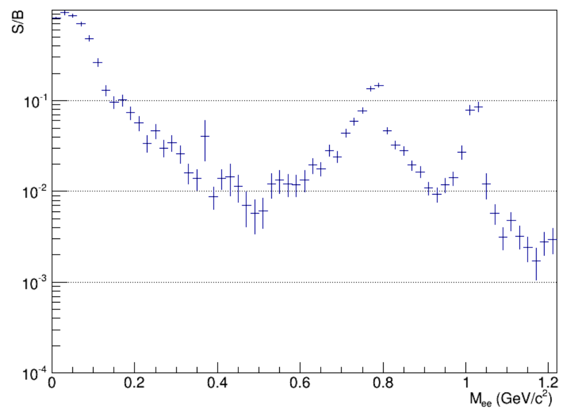
Previous variant of conversion rejection



S/B in 0.2-1.5: 0.025

===========================

Omega (s/sqrt(b)): 2.65
Phi (s/sqrt(b)): 1.07
LMR (s/sqrt(b)): 0.52

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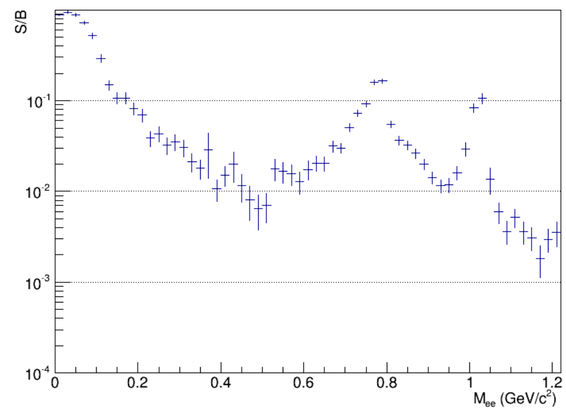
New variant of conversion rejection



S/B in 0.2-1.5: 0.028

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Omega (s/sqrt(b)): 2.93
Phi (s/sqrt(b)): 1.17
LMR (s/sqrt(b)): 0.56

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- Rejection of conversion candidates improves S/B by a factor of 2
- Signal significance also improves
- Mild improvements with respect to previous variant of conversion rejection for S/B
- New variant of conversion rejection is a new default variant

Optimization of analysis cuts

- Criteria:
  - ✓ larger statistical significance of signals → smaller statistical uncertainties
  - ✓ higher S/B ratio → smaller systematic uncertainties from background normalization

- Signals:
  - ✓ LM region 0.2-0.6 GeV/c^2
  - ✓ LVM: Omega, Phi

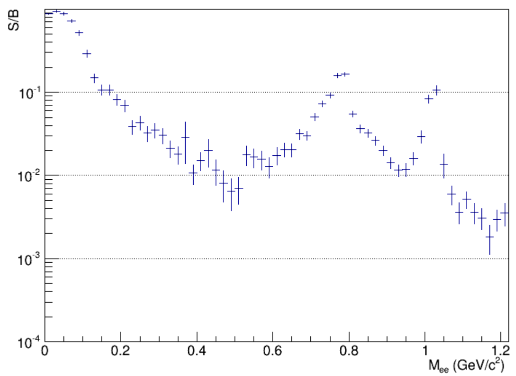
- Varied cuts:
  - ✓ electron DCA to PV within 1.5-3 σ
  - ✓ Dalitz cut within 0.1-0.2 GeV/c^2
  - ✓ $\sqrt{p_T^{e+} p_T^{e-}}$ cut within 0.25-0.4

Optimization of analysis cuts

- Criteria:
  - ✓ larger statistical significance of signals → smaller statistical uncertainties
  - ✓ higher S/B ratio → smaller systematic uncertainties from background normalization

- Best results:
  - ✓ DCA: 2.5 σ; $\sqrt{p_T^{e+} p_T^{e-}} > 0.325$; Dalitz cut > 0.135 GeV/c^2

No optimization



S/B in 0.2-1.5: 0.028

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Omega (s/sqrt(b)): 2.93
Phi (s/sqrt(b)): 1.17
LMR (s/sqrt(b)): 0.56

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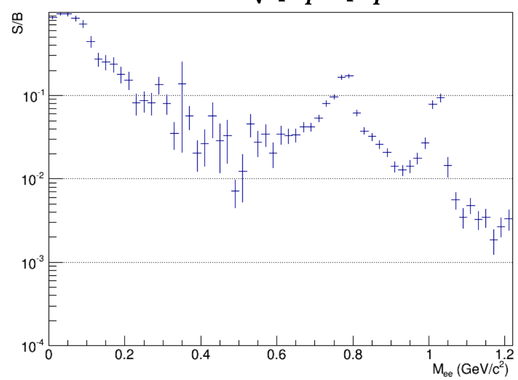
DCA: 2.5 σ; $\sqrt{p_T^{e+} p_T^{e-}} > 0.325$



S/B in 0.2-1.5: 0.053

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Omega (s/sqrt(b)): 3.22
Phi (s/sqrt(b)): 1.20
Rho (s/sqrt(b)): 0.58

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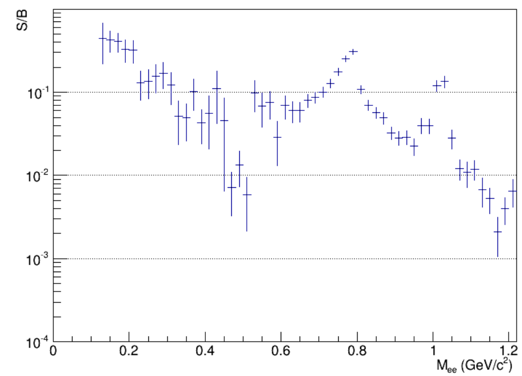
+ Dalitz cut



S/B in 0.2-1.5: 0.090

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Omega (s/sqrt(b)): 3.24
Phi (s/sqrt(b)): 1.14
Rho (s/sqrt(b)): 0.59

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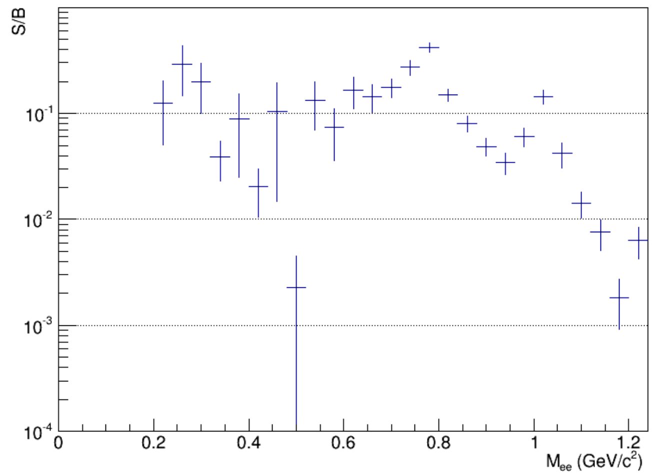
In pursuit of maximum S/B

- Best results:
  - ✓ DCA: 2.5 σ; $\sqrt{p_T^{e+} p_T^{e-}}$ > 0.4; Dalitz cut > 0.2 GeV/c²



S/B in 0.2-1.5: 0.12

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Omega (s/sqrt(b)): 2.51

Phi (s/sqrt(b)): 0.91

Rho (s/sqrt(b)): 0.40

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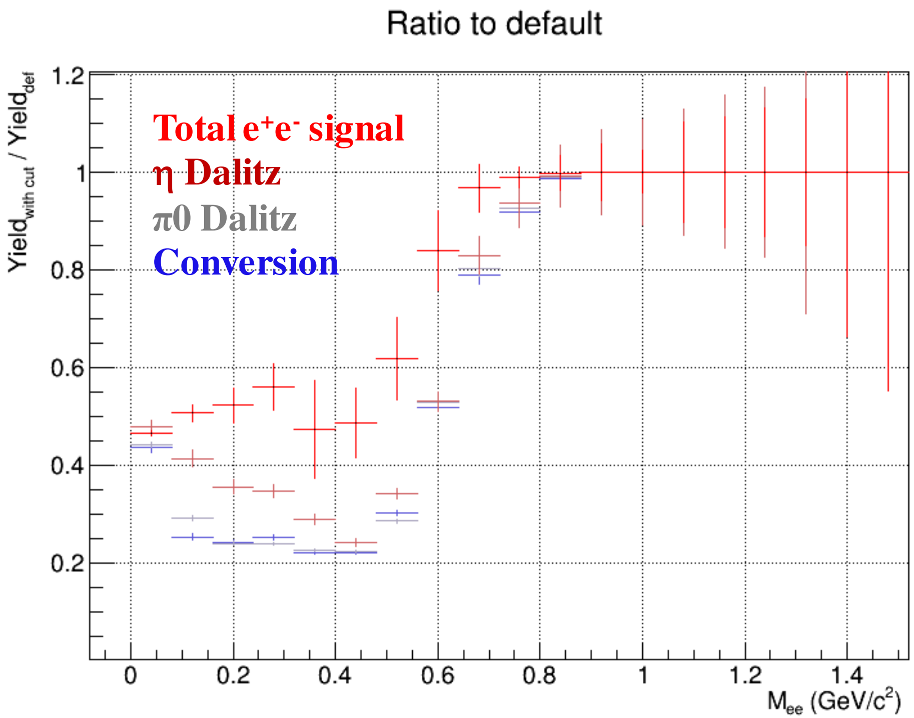
- S/B can be improved in expense of smaller statistical significance

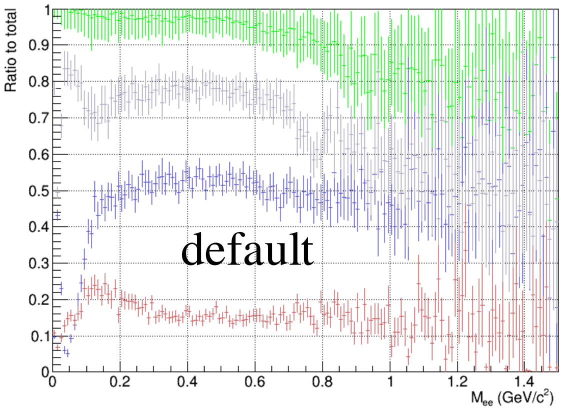
Summary

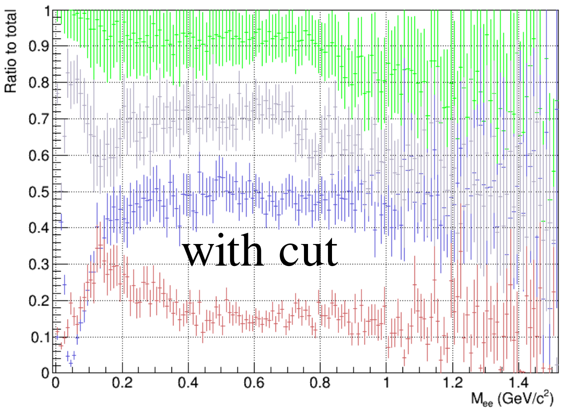
- New algorithm for conversion candidate rejection
- New optimized cuts, which preserve signal significance and improve S/B
- Further improvements of S/B are possible in the expense of smaller statistical significance
- Need a closer look at Dalitz pair rejection
- Need new production with updated dE/dx calculations

S/B, different cuts: asymmetry

- $\sqrt{p_T^{e-} p_T^{e+}} > \mathbf{0.3}$: a low-$p_T$ electron must pair only with a high-p_T electron







- The cut rejects ~ 50% of the total signal, 60% of e-η, 75% of e-π^0 and e-conversion pairs
- Redistribution of pairs for from different sources at low masses