Update on dielectron studies in BiBi@9.2

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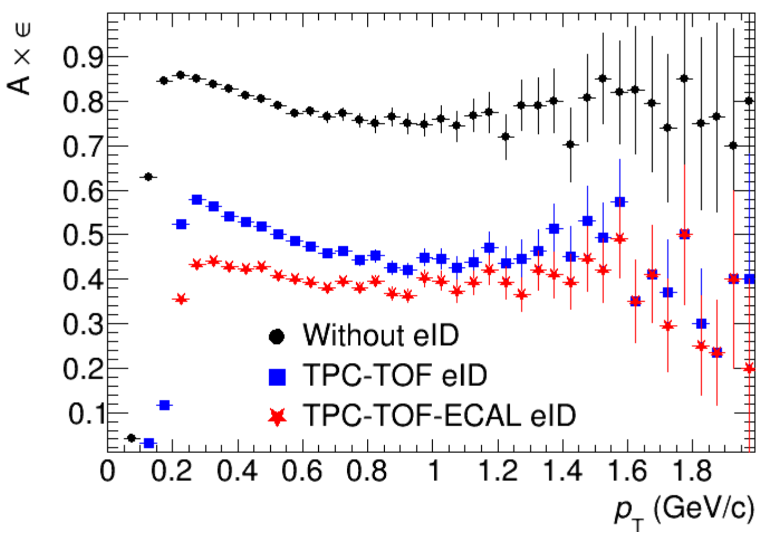
Outline

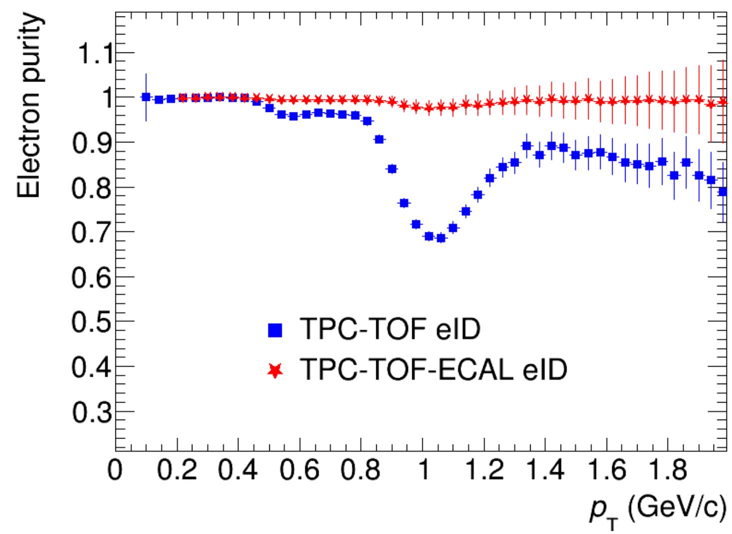
- Background rejection (centralized production - Request 11; minbias BiBi@9.2)
- New production (centralized production - Request 13; minbias BiBi@9.2) and problems

Background rejection: single tracks

- Single track background rejection cuts:
  - ✓ DCA_x,y,z parameterized as a function of p_T, centrality and η
    → 2-3σ selections for primary electrons, rejection of secondaries and conversion electrons at $R > R_{beam\ pipie}$
    → observe narrower DCA distributions for electrons at p_T < 250 MeV/c
  - ✓ dE/dx parameterized vs p_T for e/π
    → 1-3 σ selections for electrons
    → 2 σ veto selections for pions
  - ✓ dφ, dz matching to TOF and β parameterized vs. p_T
    → 2-3 σ matching cuts for suppression of miss-association of TPC tracks to TOF signals
    → 2 σ cut on β for electron selection and rejection of hadrons

- Achieved performance (driven by the detector performance, very limited potential for improvements):
  - ✓ Track selections: hits > 39, $|\eta| < 1$, $|DCA\_x,y,z| < 3\sigma$
  - ✓ e-ID selections: 2σ matching to TOF, 1-2σ TPC-eID, 2σ TOF-eID

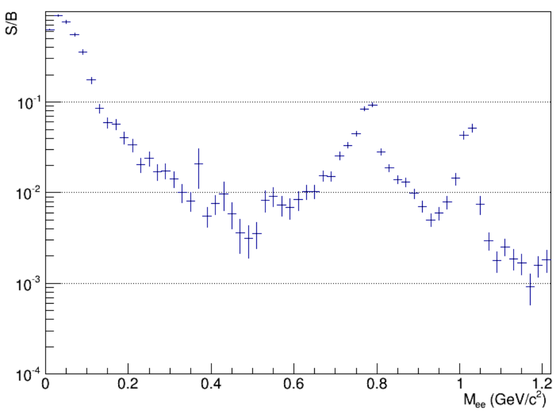




Background rejection: pairs

- Background rejection based on pair cuts.
- Conversion rejection:
  - ✓ tightly identified e-tracks are paired with loosely identified e-tracks in the event to be tested against conversion hypothesis based on: Chi2 for the secondary vertex (SV), distance between the tracks in SV, PV-SV distance, invariant mass → variables are correlated, 2D cuts are used
  - ✓ if a pair is consistent with a conversion pair hypothesis then both tracks are tagged and rejected
- Highly selective cuts → high multiplicity in central BiBi@9.2 collisions does not result in significant false rejection of electrons due to high combinatorics

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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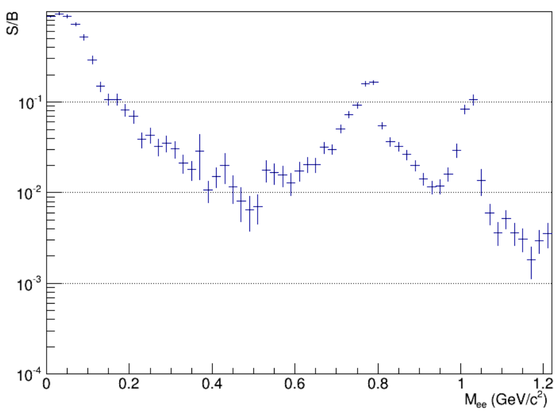
Conversion rejection



S/B in 0.2-1.5: 0.028

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

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

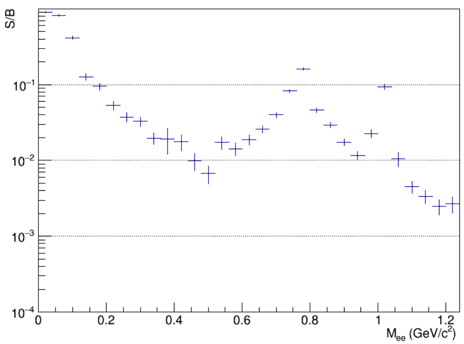
============================

- Rejection of conversion improves S/B by a factor of two
- Signal significance also improves

Background rejection: pairs

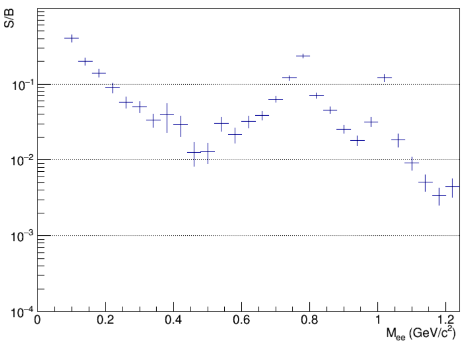
- Background rejection based on pair cuts.
- Dalitz rejection:
  - ✓ e-tracks are paired, if a pair invariant mass $M_{inv} < M_{cut}$ then both e-tracks are rejected as Dalitz candidates

No cut



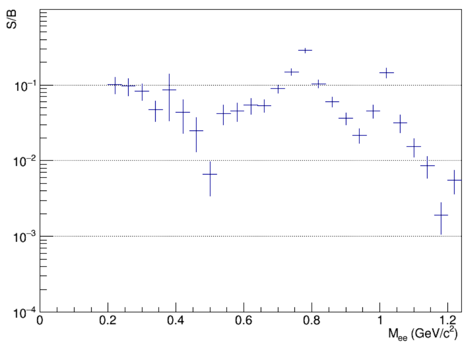
S/B in 0.2-1.5: 0.028
=====================
Omega (s/sqrt(b)): 2.93
Phi (s/sqrt(b)): 1.17
LMR (s/sqrt(b)): 0.56
=====================

M_{cut} = 100 MeV/c^2



S/B in 0.2-1.5: 0.046
=====================
Omega (s/sqrt(b)): 3.13
Phi (s/sqrt(b)): 1.2
LMR (s/sqrt(b)): 0.6
=====================

M_{cut} = 200 MeV/c^2

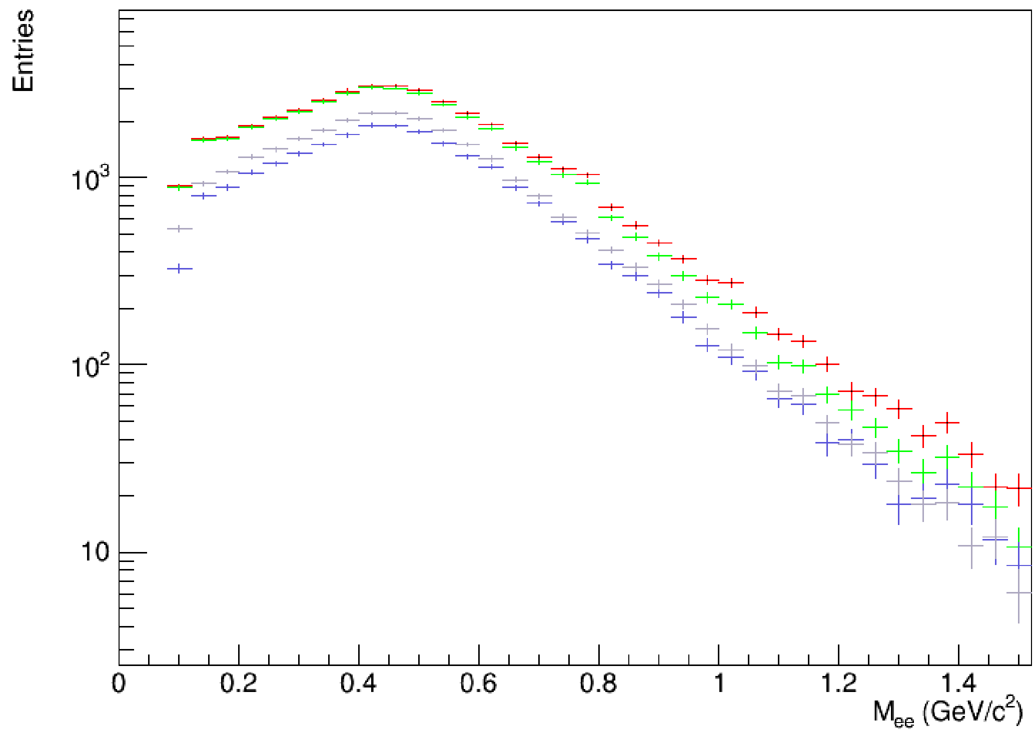


S/B in 0.2-1.5: 0.069
=====================
Omega (s/sqrt(b)): 2.62
Phi (s/sqrt(b)): 0.93
LMR (s/sqrt(b)): 0.49
=====================

- A cut of M_{inv} > 100 MeV/c^2 improves the S/B and signal significance; further improvements in S/B with a tighter cut is at the expense of smaller statistical significance
- The cut is not selective, its efficiency strongly depends on the event multiplicity

Invariant mass distributions

- Invariant mass distribution with single track and pair rejection cuts:
  - ✓ **reconstructed e^+e^- pairs**, **true e^+e^- pairs**, **e^+e^- pairs with at least one track from conversion**, e^+e^- pairs **with at least one track from π^0 Dalitz**

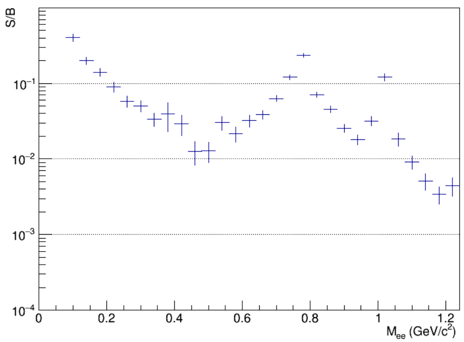


- Background from conversion and Dalitz decays prevails even after background rejection based on pair cuts
- In many cases only one track from true conversion or Dalitz decay is really registered in the event → pair cuts are not efficient since there is only one partner is really measured and second one is missing

Pair cut efficiency

- Efficiency of the pair cuts can be improved by increasing the chance to register the second partner:
  - ✓ limit acceptance for the primary (tightly identified) e-track → η for tracks, event z-vertex
  - ✓ loosen e-ID cuts for a partner → nhits, η, DCA

M_{cut} = 100 MeV/c^2



S/B in 0.2-1.5: 0.046
====================
Omega (s/sqrt(b)): 3.13
Phi (s/sqrt(b)): 1.2
LMR (s/sqrt(b)): 0.6
====================

Primary:

|η| < 1 → |η| < 0.5

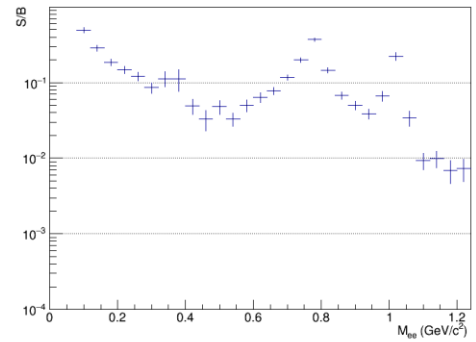
Partner:

nhits > 20 → nhits > 10

|DCA| < 2σ → |DCA| < 3.5σ

|η| < 3

M_{cut} = 100 MeV/c^2



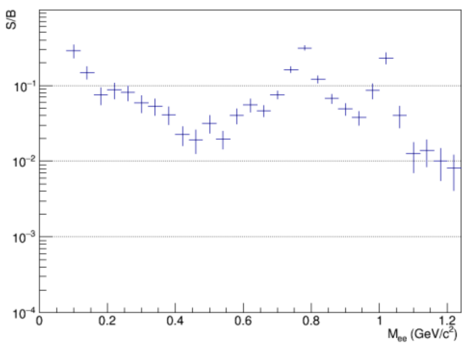
S/B in 0.2-1.5: 0.092
====================
Omega (s/sqrt(b)): 3.84
Phi (s/sqrt(b)): 1.66
LMR (s/sqrt(b)): 0.94
=====================

- A factor of two improvement in S/B
- Improved signal statistical significance even with lower efficiency for the signals

Pair cut efficiency

- p_T differential study:

M_{cut} = 100 MeV/c^2
p_T = 0-0.5 GeV/c



S/B in 0.2-1.5: 0.06
=====================
Omega (s/sqrt(b)): 2.47
Phi (s/sqrt(b)): 1.13
LMR (s/sqrt(b)): 0.55
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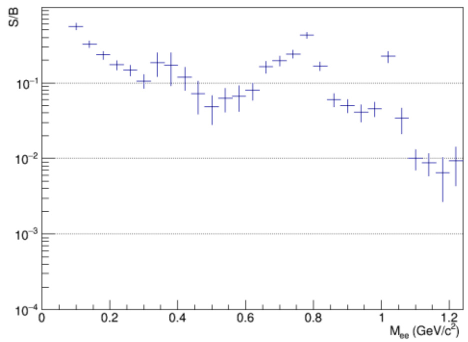
M_{cut} = 100 MeV/c^2
p_T = 0.5-1 GeV/c



S/B in 0.2-1.5: 0.14
=====================
Omega (s/sqrt(b)): 2.70
Phi (s/sqrt(b)): 1.10
LMR (s/sqrt(b)): 0.74
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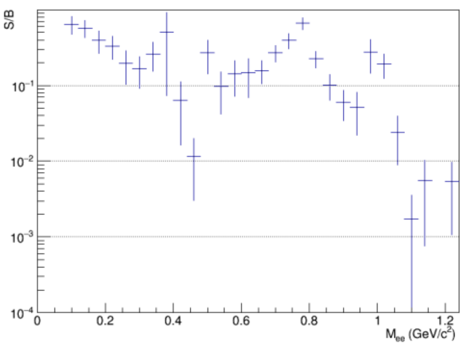
M_{cut} = 100 MeV/c^2
p_T = 1-2 GeV/c



S/B in 0.2-1.5: 0.22
=====================
Omega (s/sqrt(b)): 1.44
Phi (s/sqrt(b)): 0.52
LMR (s/sqrt(b)): 0.38
=====================

- New cuts do not limit the acceptance of the study, improvements are seen at all p_T's
- S/B improves with increasing transverse momentum

New Monte Carlo production

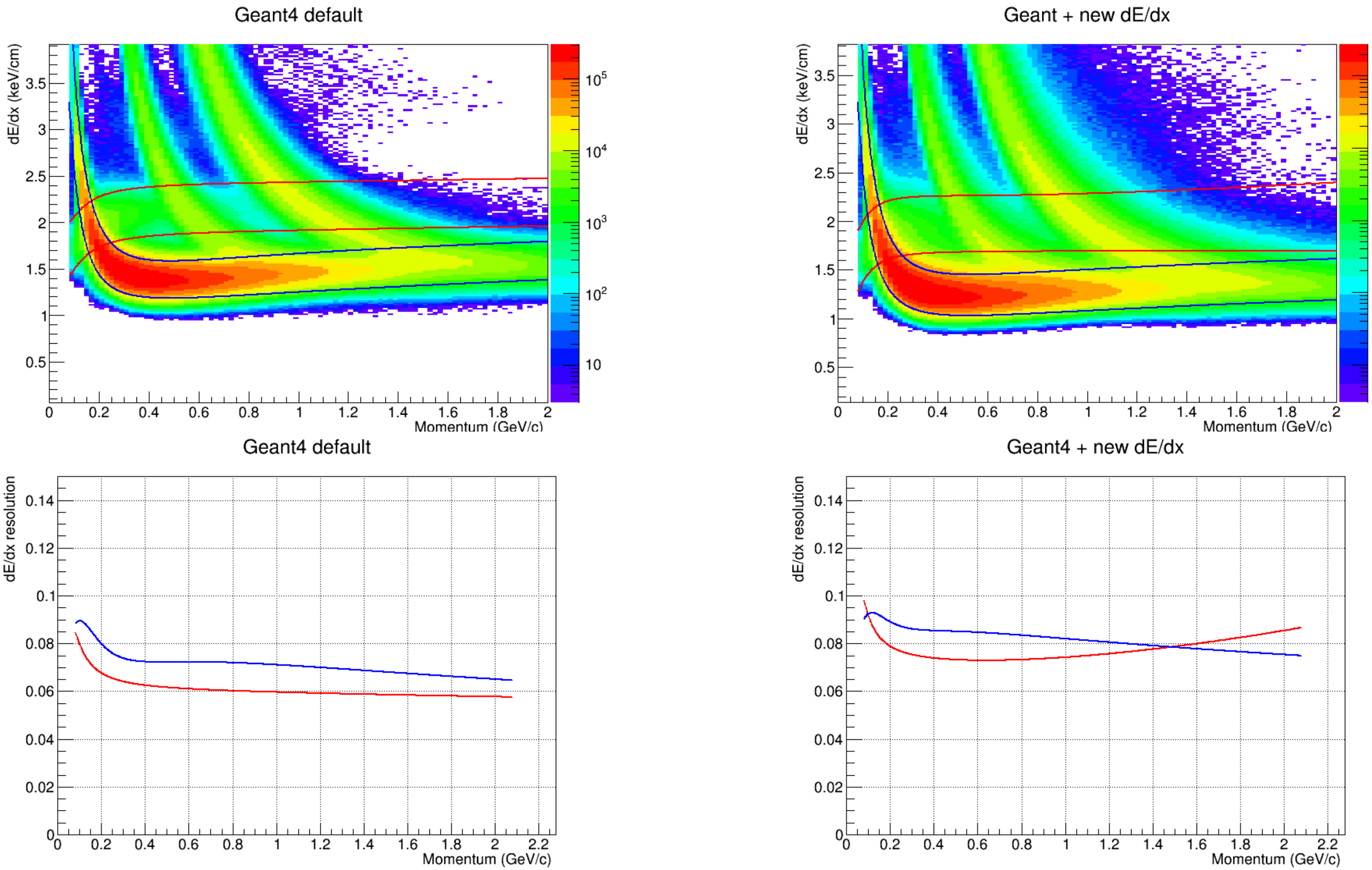
- Request13: *PWG4 - dielectrons, 15M minbias BiBi@9.2*
- Tracking and TOF performance is identical to "Request 11" production → confirmed by comparing DCA and TOF matching distributions, TOF e-ID performance, track reconstruction and e-ID efficiencies in the TPC, TOF and ECAL
- Aims at more realistic simulation of dE/dx in the TPC → the only difference compared with "Request 11"
- Output data:
  - ✓ DSTs:

    /eos/nica/mpd/sim/data/exp/dst-BiBi-09.2GeV-mp05-21-500ev/BiBi/09.2GeV-mb/UrQMD/BiBi-09.2GeV-mp05-21-500ev
  - ✓ MiniDSTs:

    /eos/nica/mpd/sim/data/MiniDst/dst-BiBi-09.2GeV-mp05-21-500ev/BiBi/09.2GeV-mb/UrQMD/BiBi-09.2GeV-mp05-21-500ev/eos/nica/mpd/sim/data/exp/dst-BiBi-09.2GeV-mp02-21-500ev/BiBi/09.2GeV-mb/UrQMD/BiBi-09.2GeV-mp02-21-500ev/
  - ✓ 30,000 DST files

dE/dx parameterization

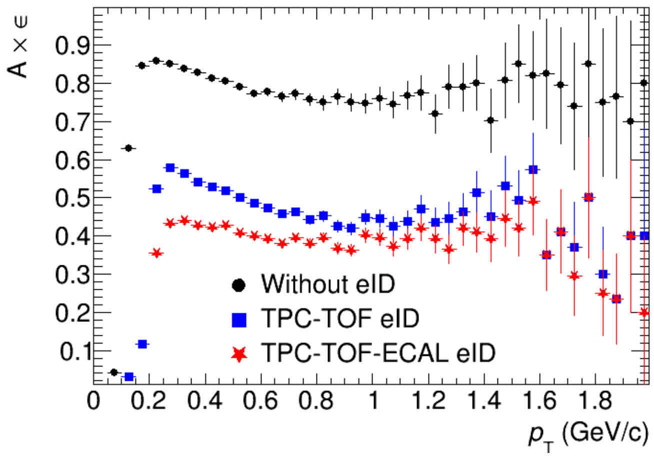
- Selected tracks:
  - ✓ hits > 39
  - ✓ $|\eta| < 1$
  - ✓ $|DCA\_x,y,z| < 2.5\ \sigma$
- Parameterized dE/dx vs. momentum for electrons and pions
- Red and blue bands show 2σ selections for $e^{\pm}$ and $\pi^{\pm}$

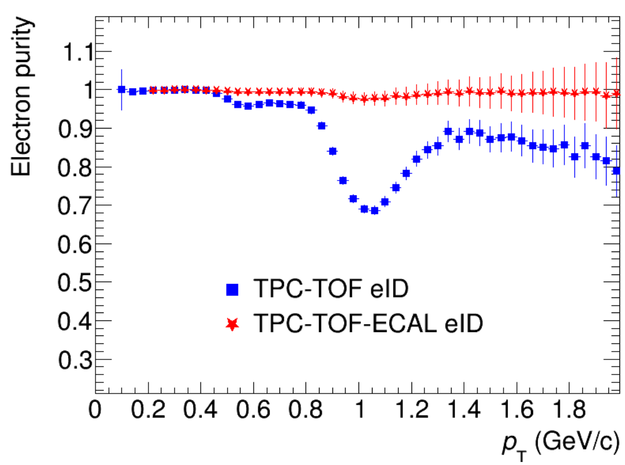


Efficiency and purity

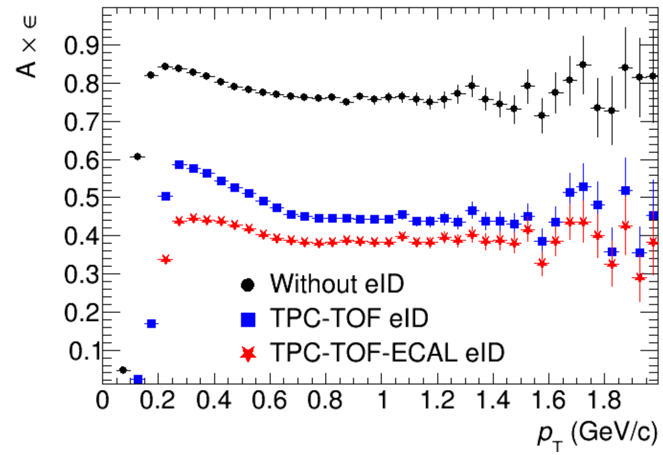
- Selected tracks:
  - ✓ hits > 39
  - ✓ |η| < 1
  - ✓ |DCA_x,y,z| < 2.5 σ
- eID selections:
  - ✓ 2σ matching to TOF
  - ✓ 1-2σ TPC-eID
  - ✓ 2σ TOF-eID

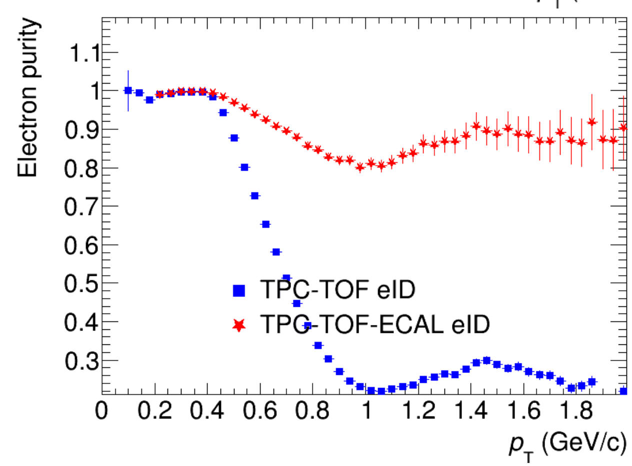
Geant4 default





Geant4 + new dE/dx

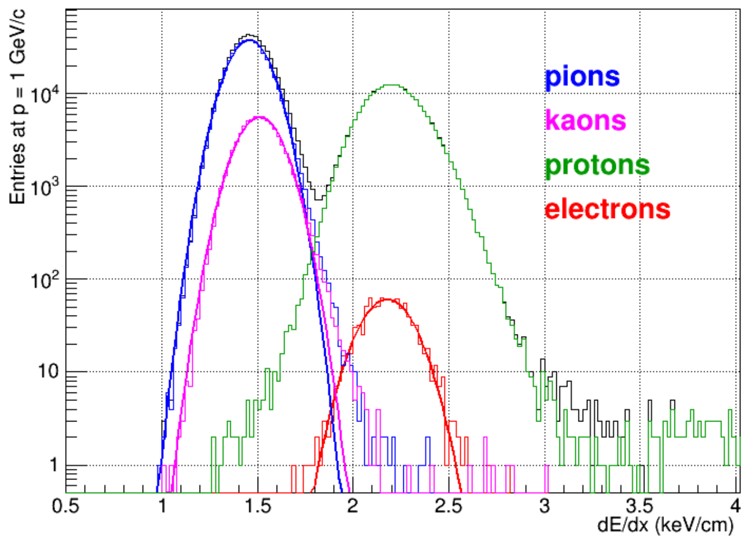




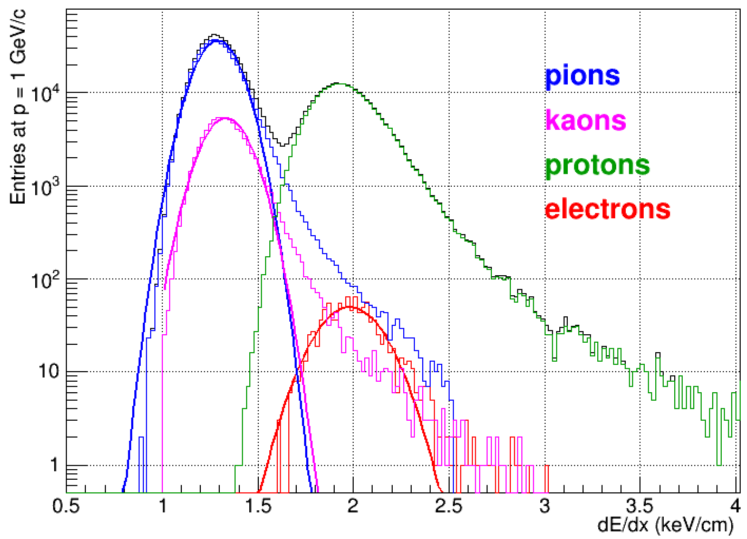
Closer look at dE/dx distributions

- Selected tracks:
  - ✓ hits > 39
  - ✓ $|\eta| < 1$
  - ✓ |DCA_x,y,z| < 2.5 σ
  - ✓ p_T = 1 GeV/c

Geant4 default



Geant4 + new dE/dx

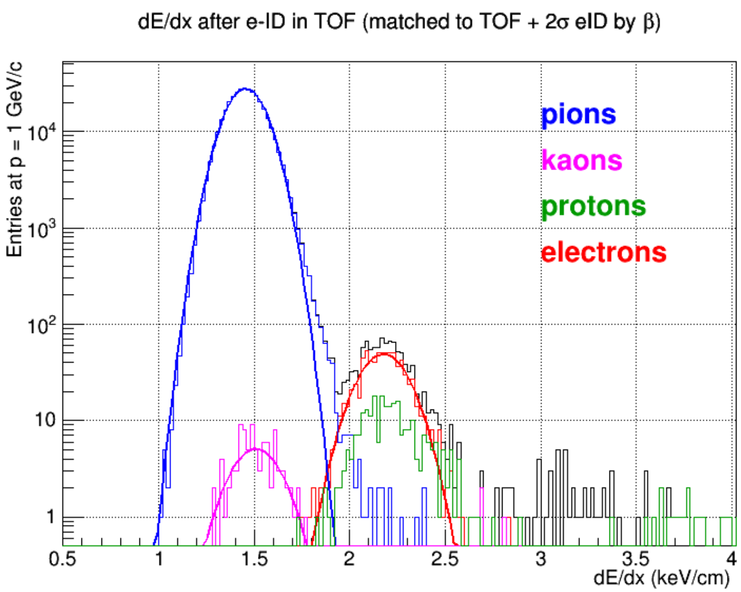


- Non-Gaussian distributions with new dE/dx results in much worse separation of electrons from pions and kaons
- Non-Gaussian tails contribute only very little to the width of dE/dx parameterizations → the parameterizations remain to be similar

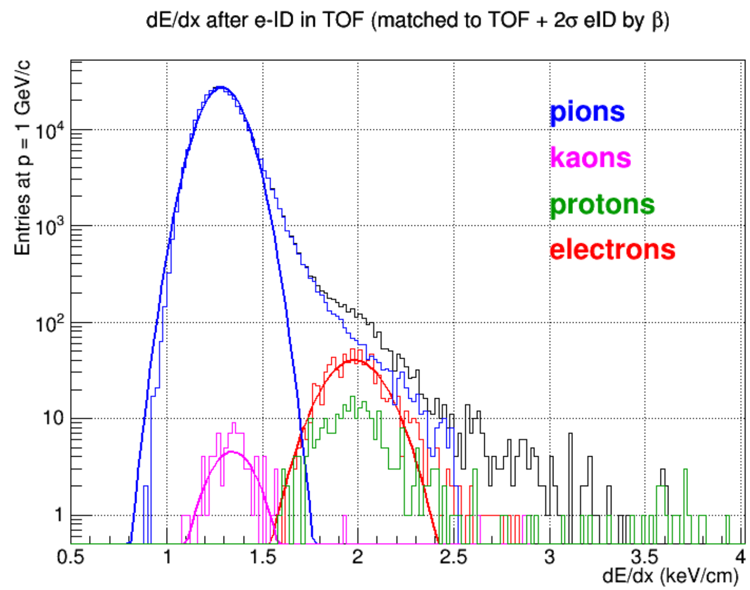
Closer look at dE/dx distributions + TOF e-ID

- Selected tracks:
  - ✓ hits > 39
  - ✓ |η| < 1
  - ✓ |DCA_x,y,z| < 2.5 σ
  - ✓ p_T = 1 GeV/c
- eID selections:
  - ✓ 2σ matching to TOF
  - ✓ 2σ TOF-eID

Geant4 default



Geant4 + new dE/dx



- Non-Gaussian distributions with new dE/dx results in much worse separation of electrons from pions
- Kaon and proton contributions are comparable after TOF e-PID

Conclusions

- Origin of the worse e-purity in "Request 13" production is non-Gaussian tails in dE/dx distributions measured for hadrons and electrons
- e-purity achieved with e-ID cuts 'ala STAR' is not consistent with results reported by STAR
- Which of the dE/dx calculations is more correct, "Request 11" vs. "Request 13" ???

BACKUP