Reconstruction of neutral mesons and discussion of the electron purity

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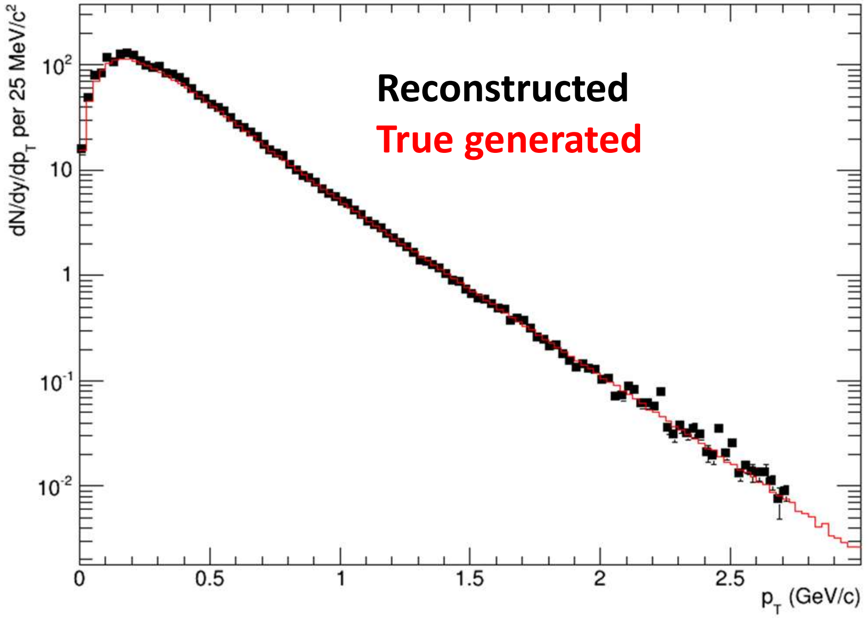
Outline

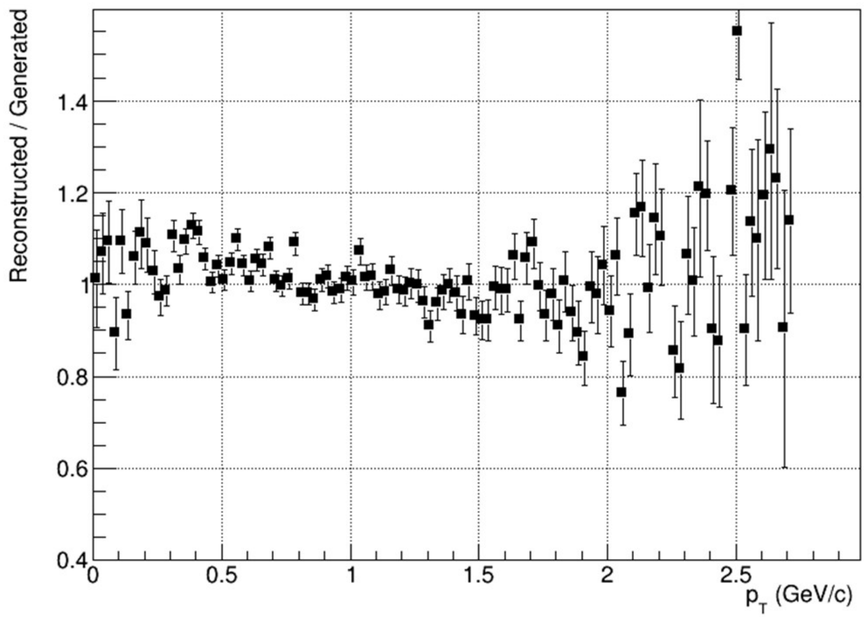
- Neutral mesons: π^0 and η reconstruction vs. centrality, MC closure tests
- Electron purity and dielectrons, future plans

Neutral mesons

Previously …

- 4M events, UrQMD. Minbias AuAu@11, realistic vertex distribution, first centralized prod-n

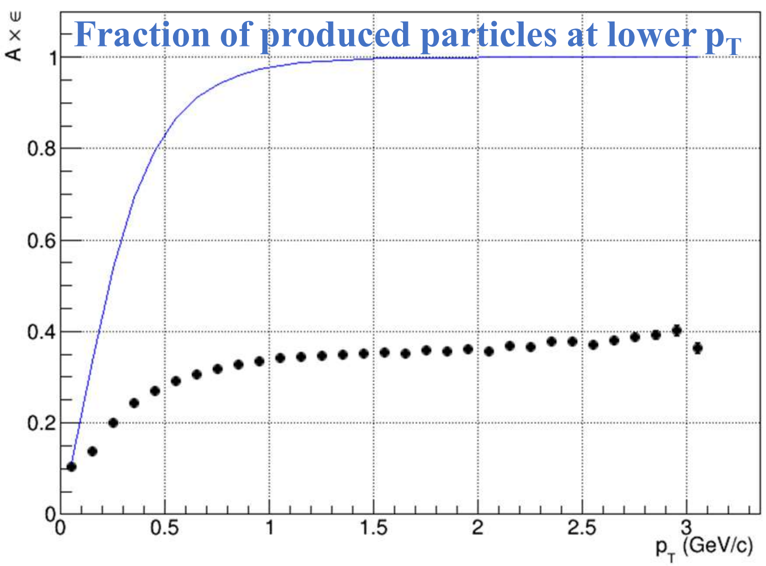


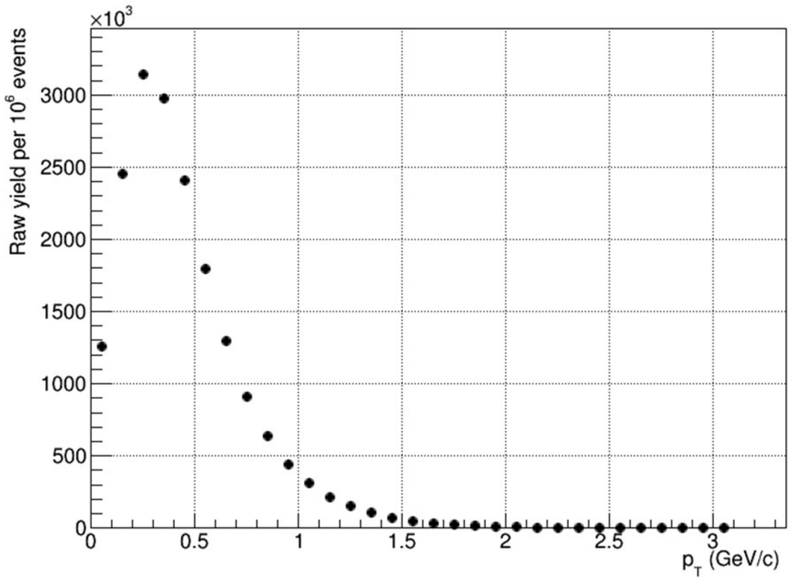


- Last time:
  - ✓ presented MC closure test results for π^0 in minbias AuAu@11, 4M events
  - ✓ fully corrected reconstructed spectrum matches the generated one within uncertainties
  - ✓ observed systematic effects at low momentum related to peak shape uncertainties
  - ✓ observed peaks for η with ~ 15M minbias AuAu@11
- Today:
  - ✓ higher statistics, minbias AuAu@11, ~ 15M events
  - ✓ centrality dependence + η in minbias collisions
  - ✓ tighter cuts to minimize systematic effects

π^0 reconstruction, optimal cuts

- Cuts optimized for better π^0 and η significance :
  - ✓ Events: UrQMD, |z-vertex| < 50 cm
  - ✓ Photons: $E_{core2\%}$ > 0 GeV, $T_{reduced}$ < 2 ns, charged track veto, Chi2/NDF < 4.0
  - ✓ Pairs: , |en1-en2|/(en1+en2) < 0.75, |y| < 0.5

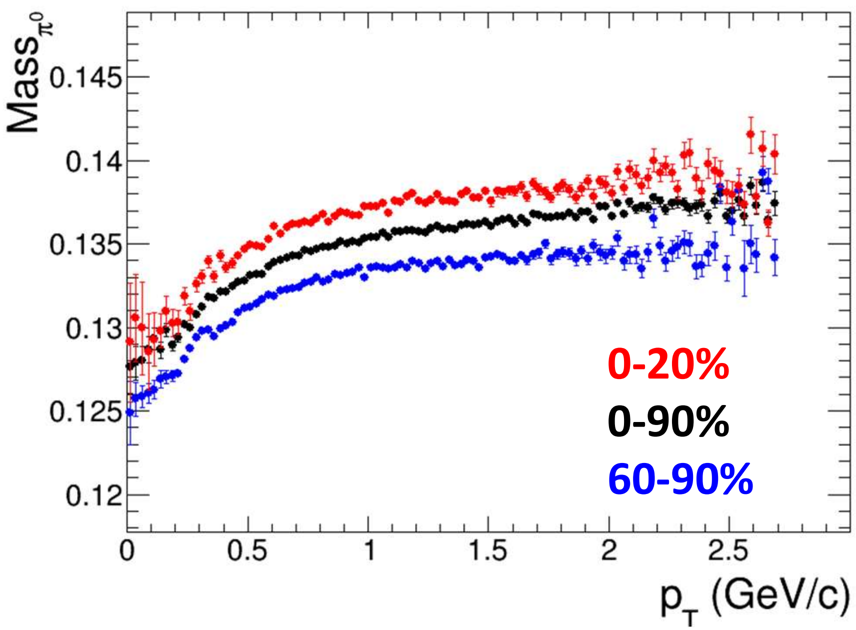


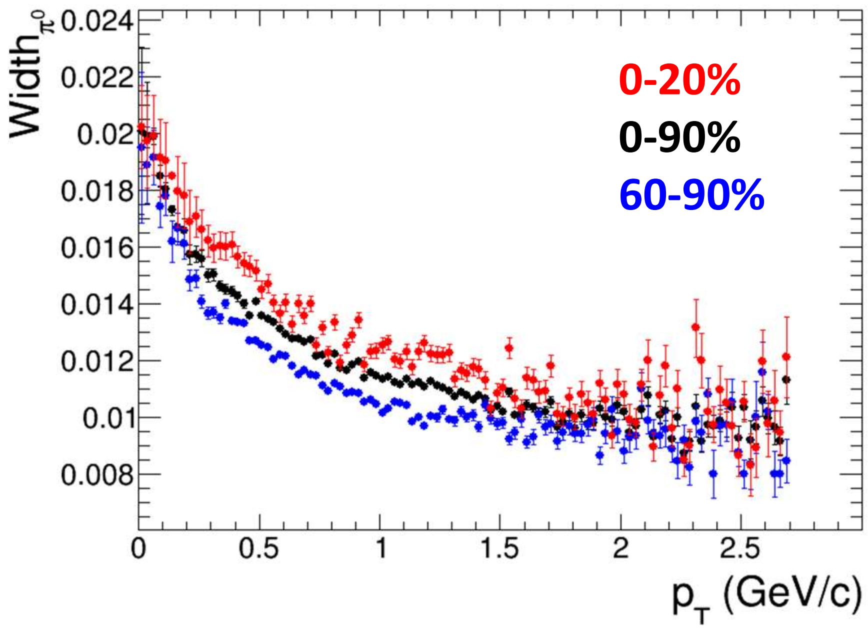


- Efficiency for π^0 is > 10%, increasing with p_T
- Signal is measurable starting from ~ 50 MeV/c, ~ the whole production spectrum is sampled
- Maximum raw yield of π^0 is expected at ~ 300 MeV/c
- The cuts provide Gaussian-like shapes of the reconstructed peaks on top of the correlated background, deviations are still present

π^0 mass and width vs. centrality

- Same cuts and selections for all centralities





- Reconstructed mass increases with multiplicity and p_T:
  - ✓ shower merging at high multiplicity
  - ✓ energy leakage and non-linearity

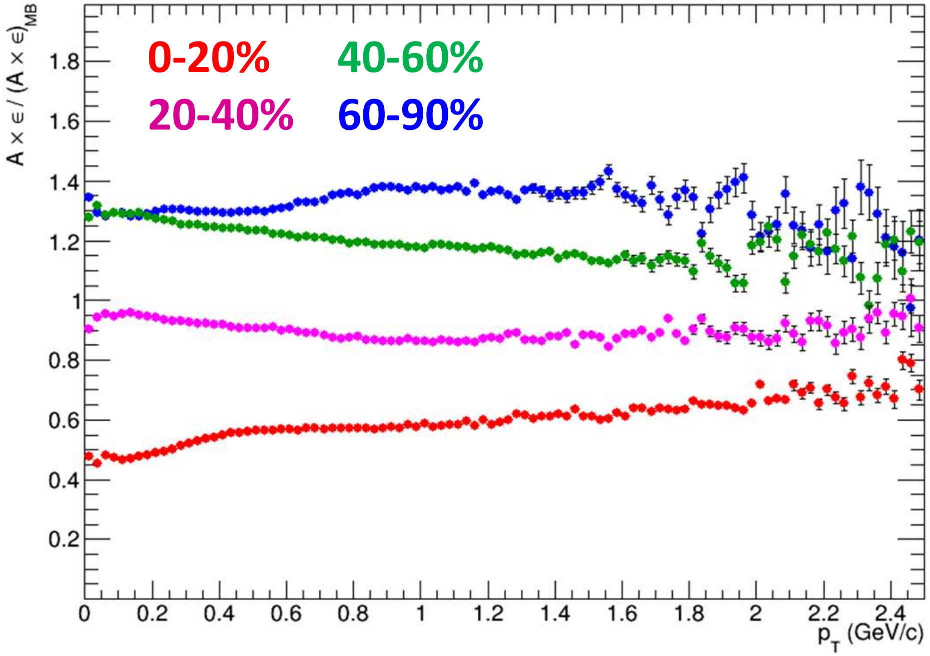
- Reconstructed width increases with multiplicity and decreases with p_T:

✓ energy resolution is multiplicity dependent

✓ energy resolution improves with increasing energy

π^0 reconstruction efficiency vs. centrality

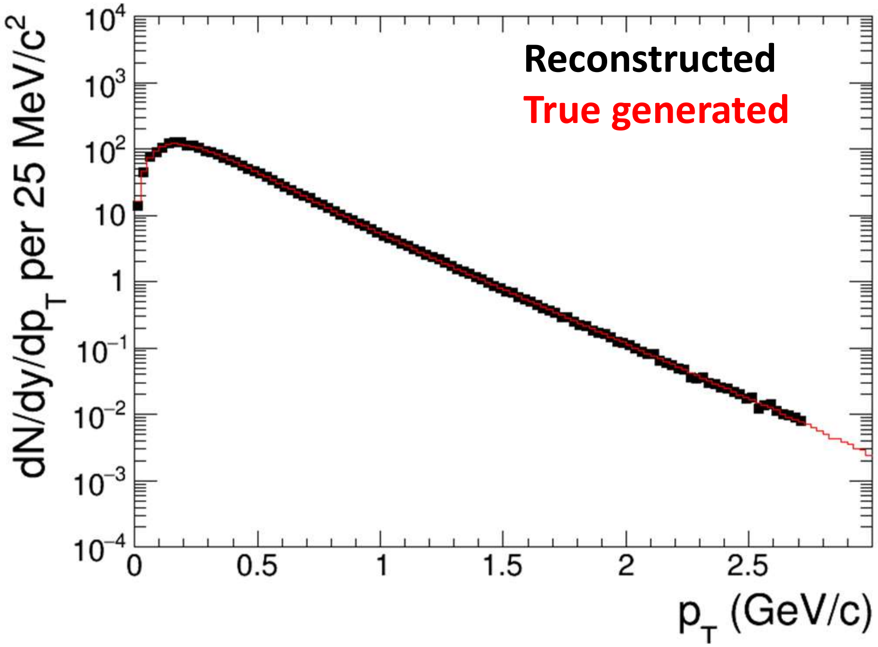
- Same cuts and selections for all centralities

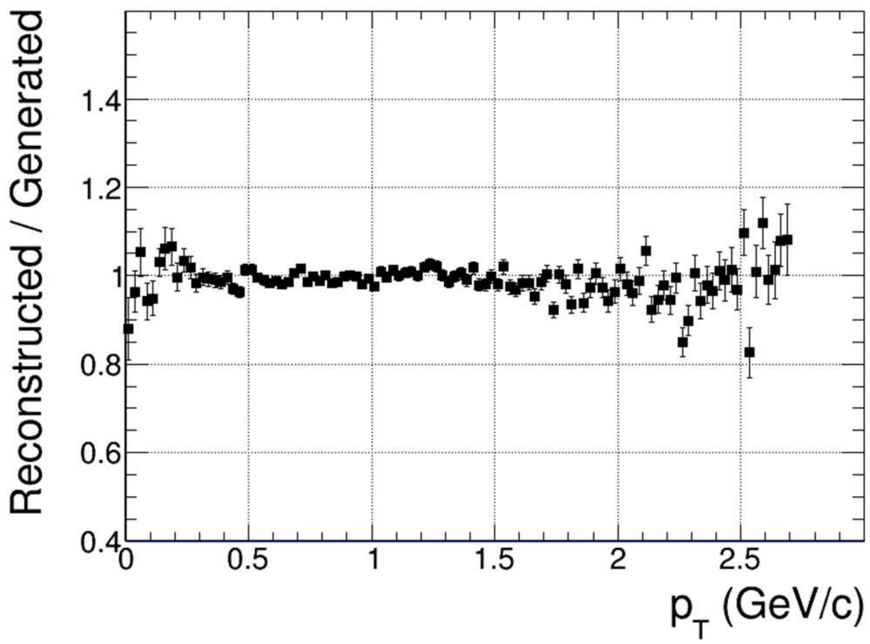


- Reconstruction efficiency shows strong multiplicity dependence:
  - ✓ multiplicity dependence of false track matching (false veto)
  - ✓ larger fraction of merged clusters with non-EM shower shapes at high multiplicity

π^0 in minbias AuAu@11: MC closure test

- 15M minbias AuAu@11 events

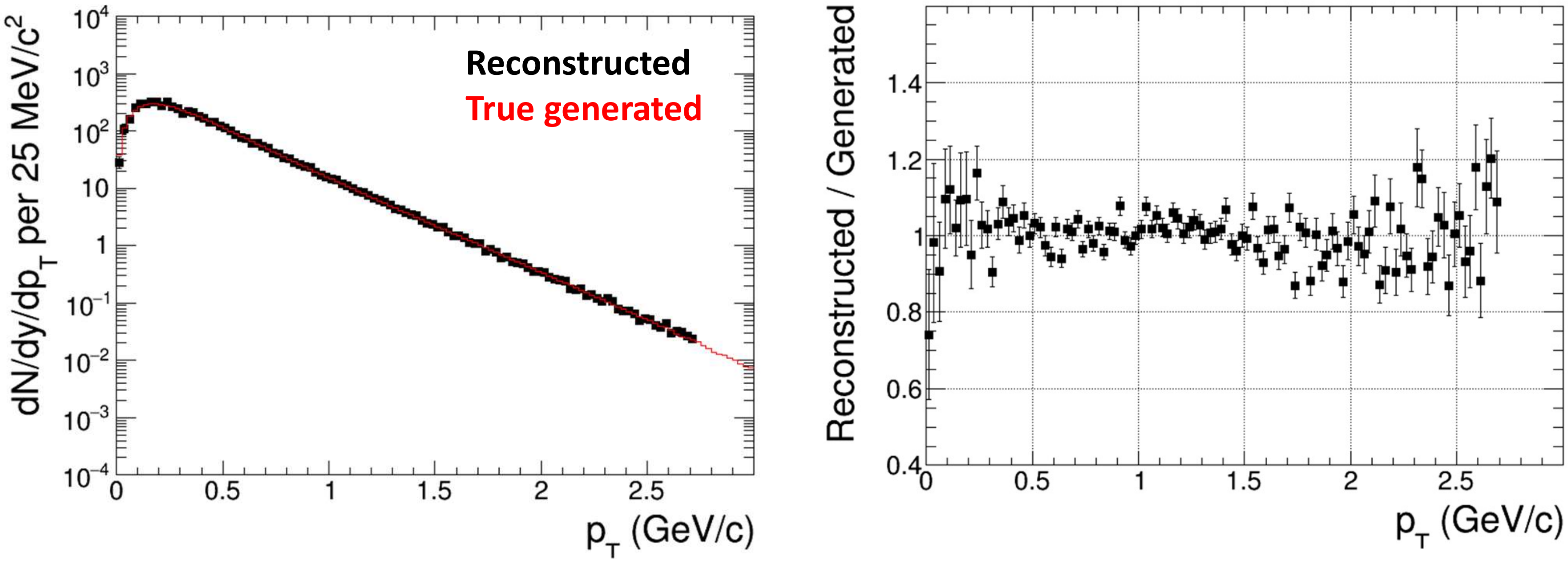




- Statistical fluctuations are much reduced with higher statistics (15M events vs. 4M events)
- Reconstructed spectrum matches the generated one within uncertainties
- Reliable raw yield extraction starts at p_T > 50 MeV/c
- Signal is present at lower p_T < 50 MeV/c but the signal shape is not trivial
- Small systematic effects at low momentum remain

π^0 in 0-20% AuAu@11: MC closure test

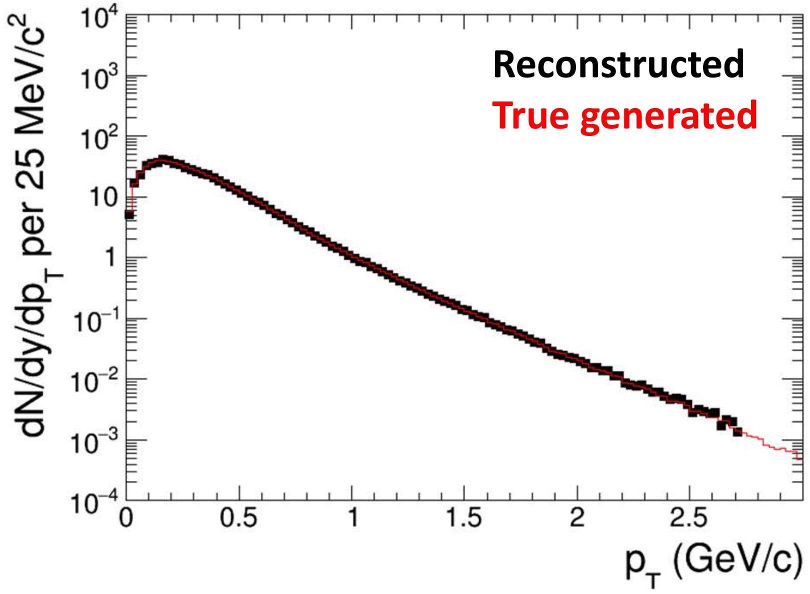
- 15M minbias AuAu@11 events

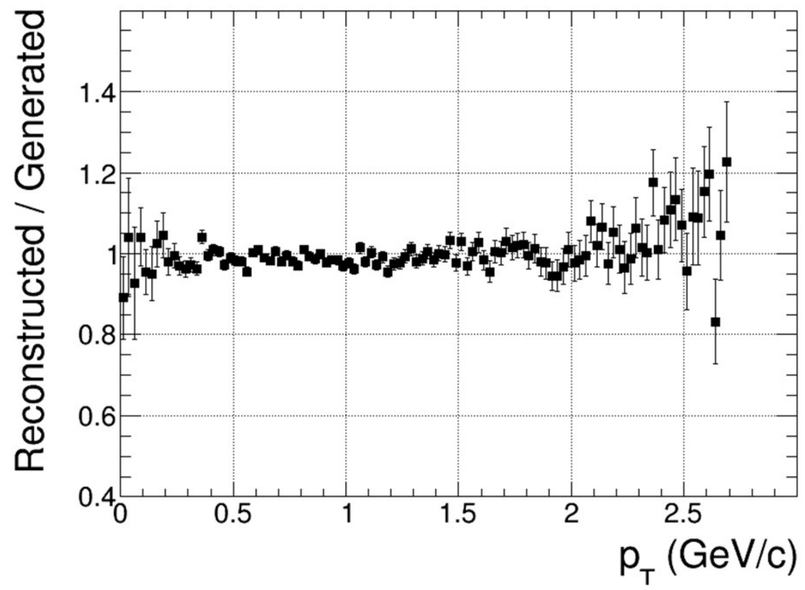


- Reconstructed spectrum matches the generated one within uncertainties
- Reliable raw yield extraction starts at $p_T > 50$ MeV/c
- Signal is barely seen at lower $p_T < 50$ MeV/c
- Systematic effects at low momentum are smeared by statistical uncertainties

π^0 in 60-90% AuAu@11: MC closure test

- 15M minbias AuAu@11 events

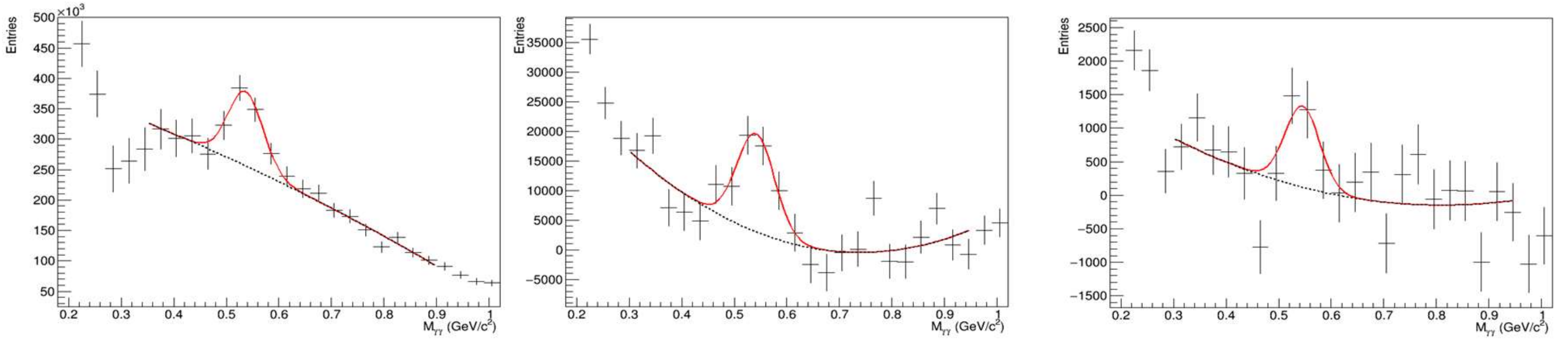


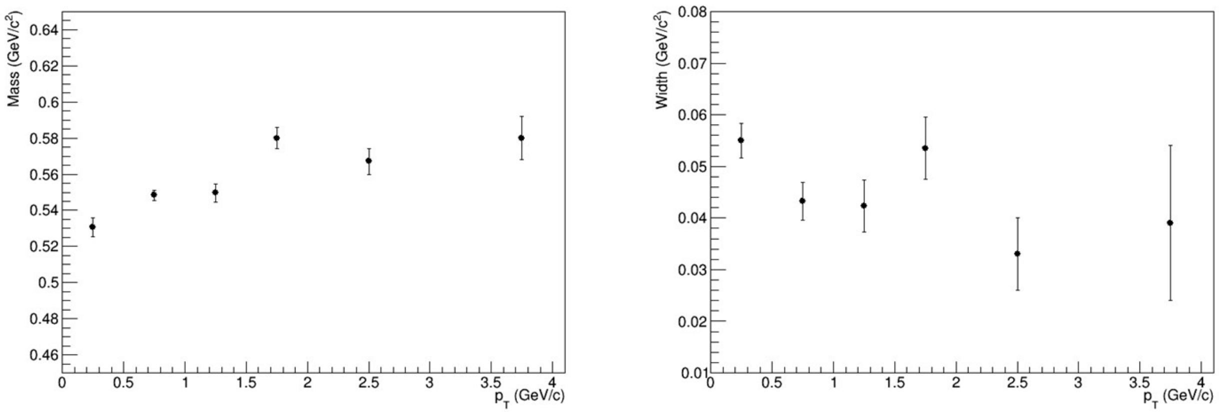


- Reconstructed spectrum matches the generated one within uncertainties
- Reliable raw yield extraction starts at $p_T > 50$ MeV/c
- Systematic effects are minimal

η reconstruction in minbias AuAu@11

- 15 M minbias AuAu@11 events



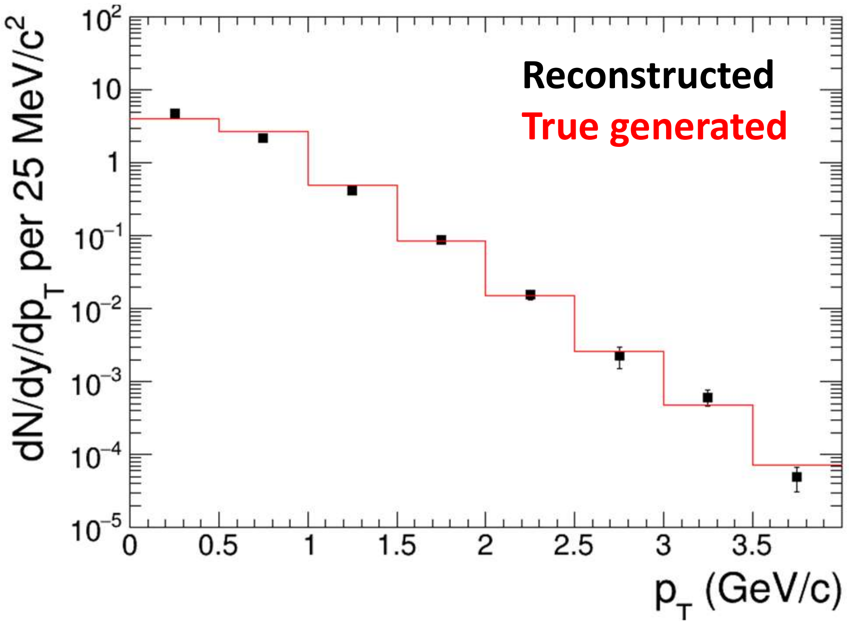


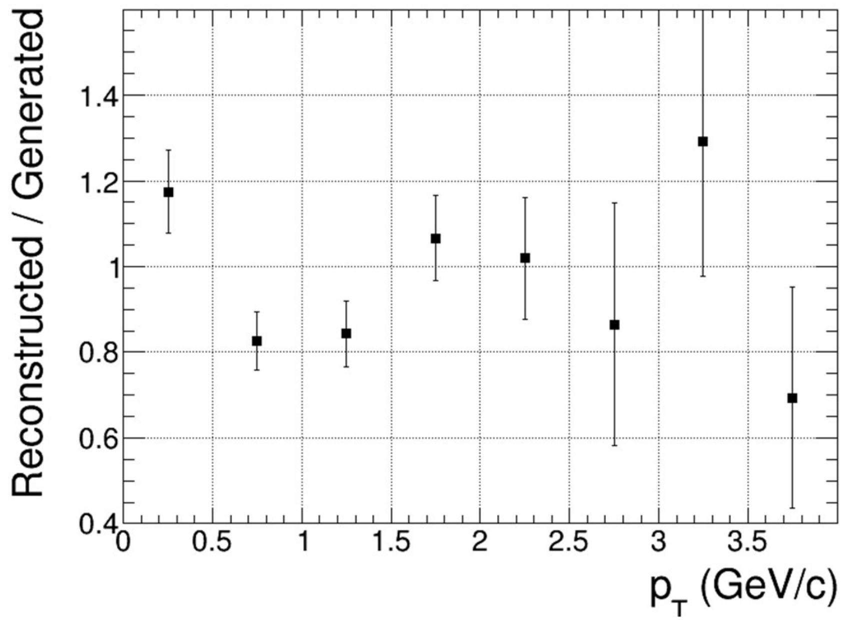
- Efficiency is higher compared to π^0 due to higher decay photon energies
- Produced at much lower rate compared to π^0 at low p_T < 2-3 GeV/c, $\eta/\pi \sim 0.5$ at $p_T >> 1$
- $\eta \to \gamma\gamma$ results in a much wider peak (~40 MeV/c vs. ~10 MeV/c for π^0)

  → need much larger statistics for observation of the signal
- Signal is observed with 15M sampled AuAu@11 events
- Multiplicity dependent study needs higher statistics (embedded simulations)

η in minbias AuAu@11: MC closure test

- 15M minbias AuAu@11 events





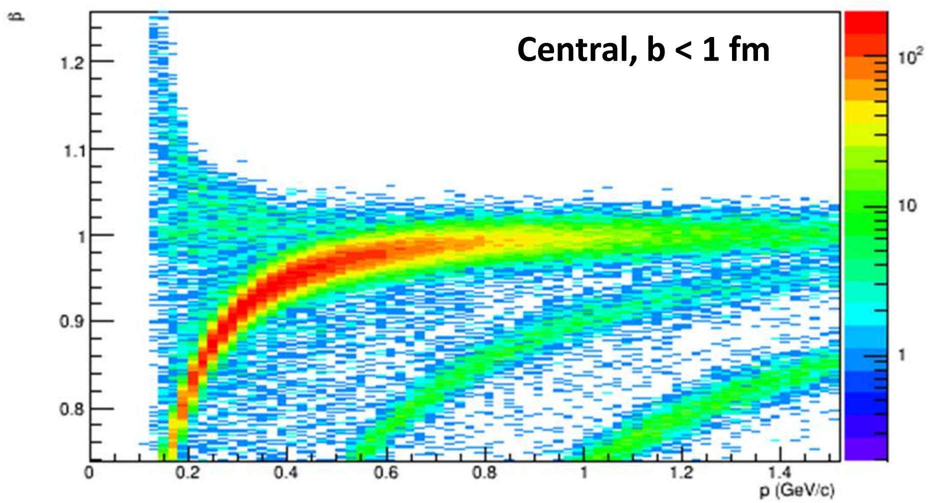
- Coarse p_T binning and large statistical uncertainties
- Reconstructed spectrum matches the generated one within uncertainties
- Possible systematic effects are smeared by statistical fluctuations

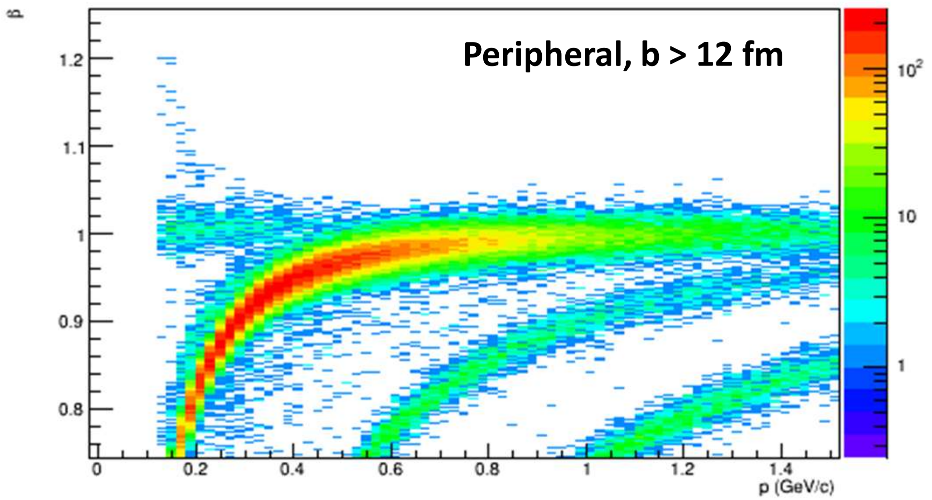
Status & conclusions

- Neutral pions can be reliably reconstructed at $p_T > 50$ MeV/c with $> 10^7$ sampled AuAu@11 events (given the full acceptance)
- Some issues with π^0 signal shape at low p_T remain → focus is on low p_T signal reconstruction, look at alternative γ-ID and cut selections
- Centrality dependent studies for η require embedded simulations
- Consistency of simulated ECAL parameters with the beam test results is the remaining task

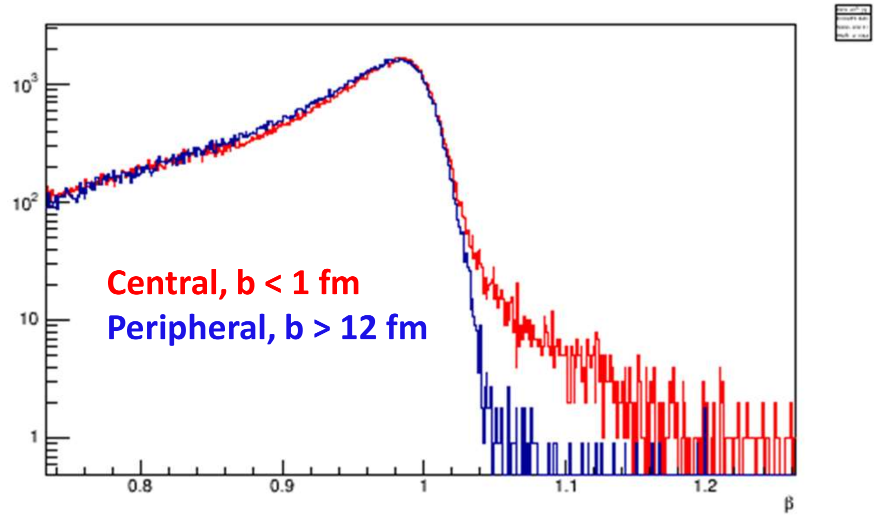
(Di)electrons

Particle identification, TOF: MPD





- Observed non-physical tail (β > 1) in the TOF: much more prominent in high multiplicity events (b < 1 fm); the tail is almost absent in peripheral collisions (b > 12 fm)
- Ascribed the effect to track mismatching in the TOF



Particle identification, TOF: STAR

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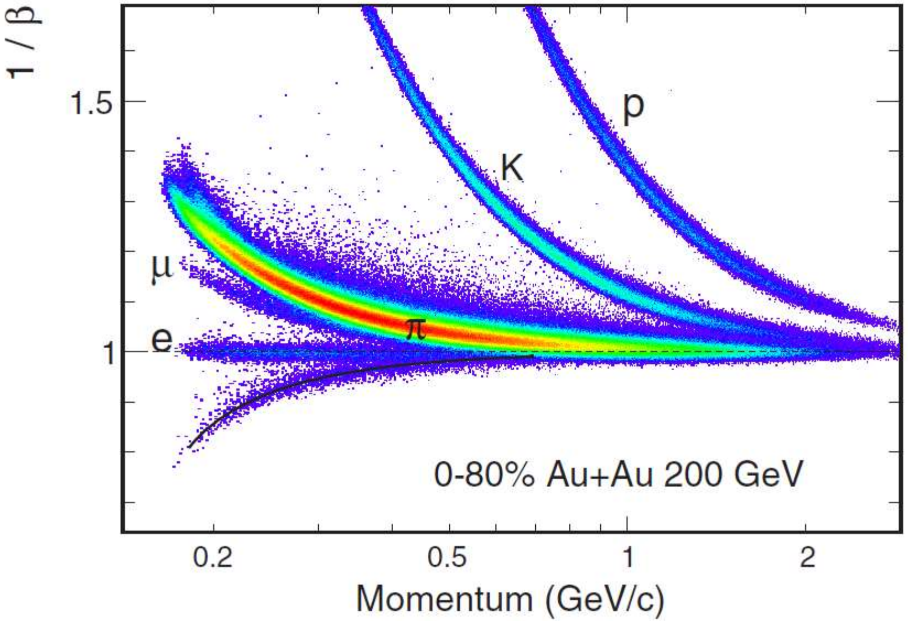
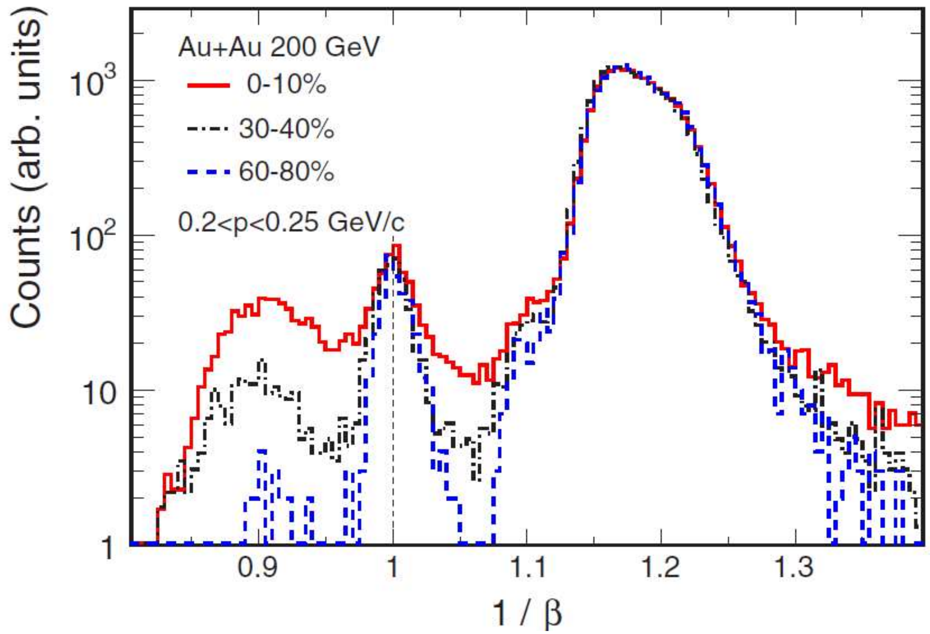
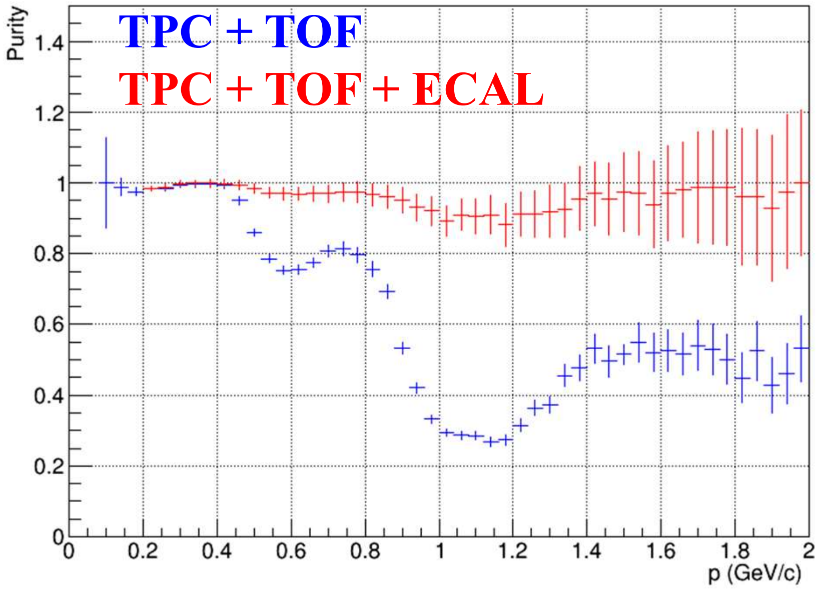




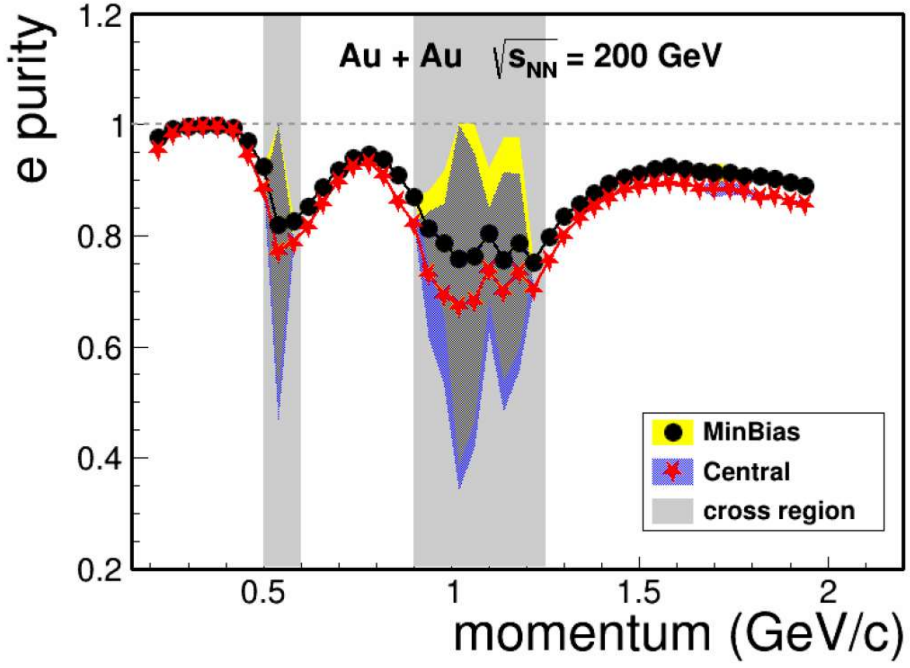
- Similar non-physical effect of $1/\beta < 1$ is observed in the TOF
- Same centrality dependence as in the MPD: the tail is prominent in central collisions; the tail goes away in peripheral collisions
- Similar conclusions on the source of the tail: with increasing multiplicity the fake association fraction increases substantially. These random associations were further confirmed using MC GEANT [28] simulations.
- Degree of contamination depends on the matching criteria, which are not transparent for the MPD and STAR

Electron purity: MPD vs. STAR

MPD (last presentation)

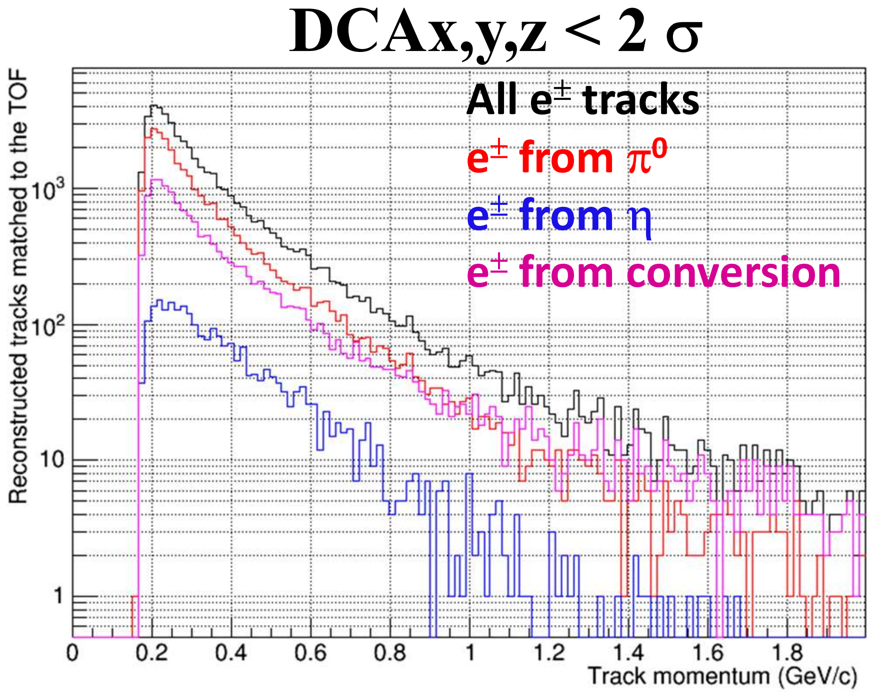


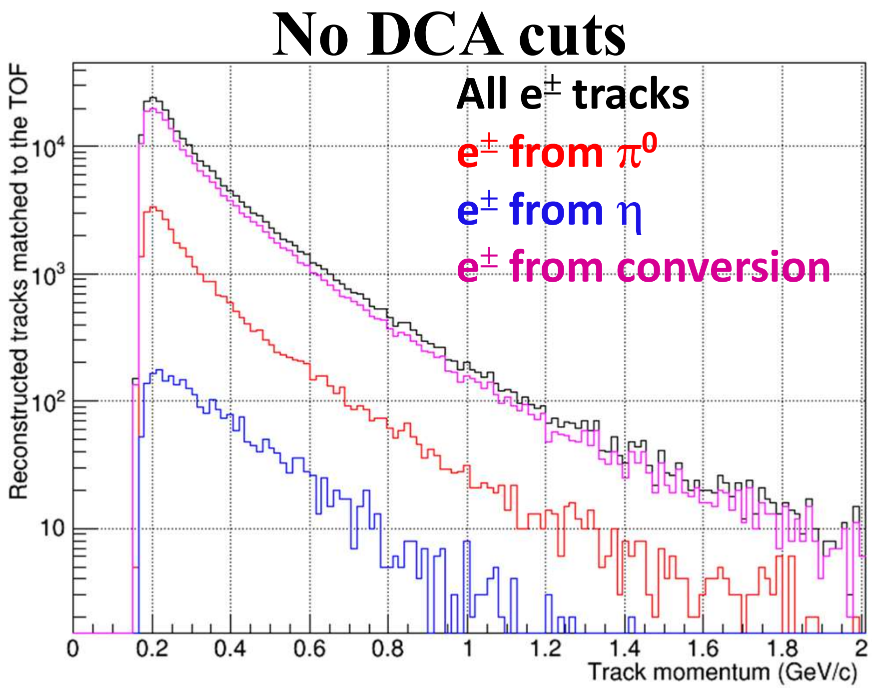
STAR



- STAR reports better electron purity at p > 600 MeV/c using TPC&TOF only
- Note rather large uncertainties at p ~ 500 MeV/c and p ~ 1000 MeV/c
- Can we directly compare the purities between the MPD and STAR → no, because the final purity depends on the initial (before eID) e/h ratio as a function of momentum
- What drives the e/h ratio in different momentum ranges?

Sources of electrons: MPD



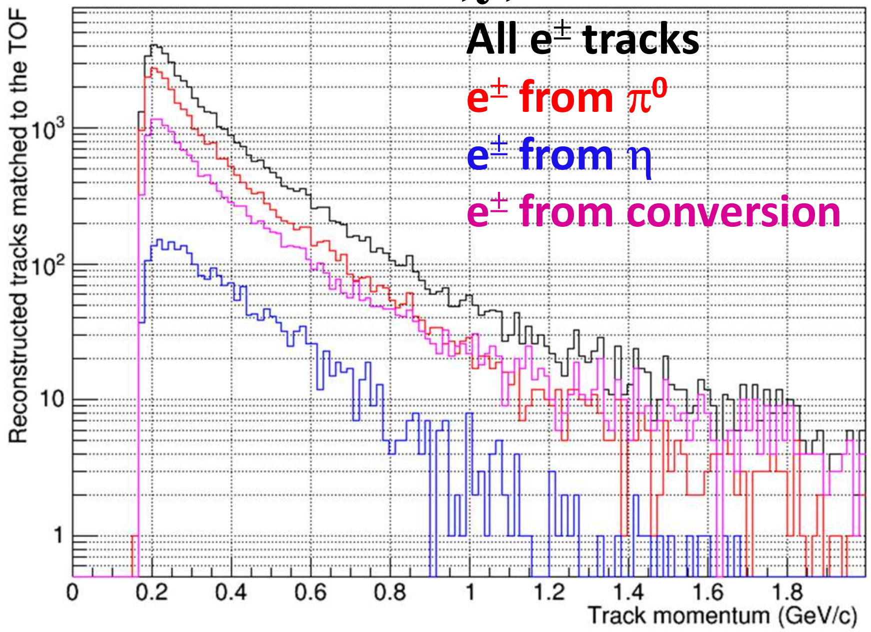


- Minbias AuAu@11 collisions (centralized production #3, AuAu@11 with Geant-3)
- Only TPC $e^{\pm}$ tracks matched to the TOF are selected, the only difference is in DCAx,y,z cuts
- With tight DCAx,y,z cuts the main source of electrons is π^0 (Dalitz decays)
- With no DCAx,y,z selections, the electron spectrum is totally dominated (by an order of magnitude) by conversion electrons while contributions from π^0 and η remain ~ the same

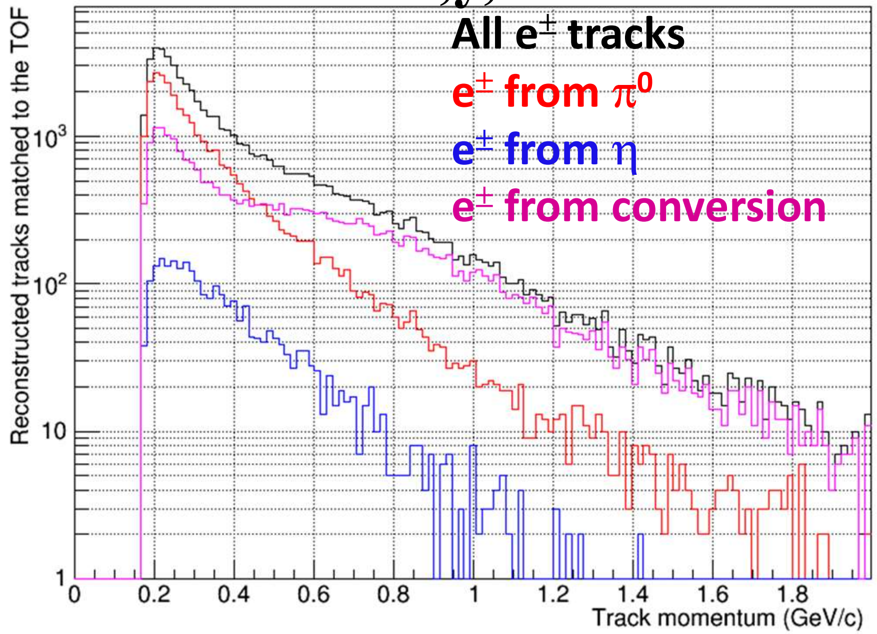
→ Comparison of the electron purities make sense only when contributions of conversion are comparable in the experiments (materials and cuts)

DCAx,y,z cuts: MPD vs. STAR

DCAx,y,z < 2 σ



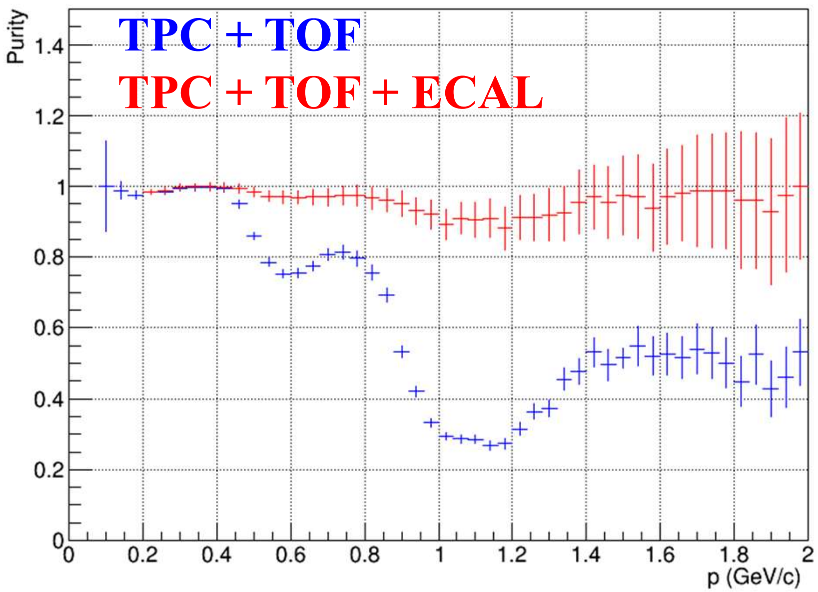
DCAx,y,z < 1 cm



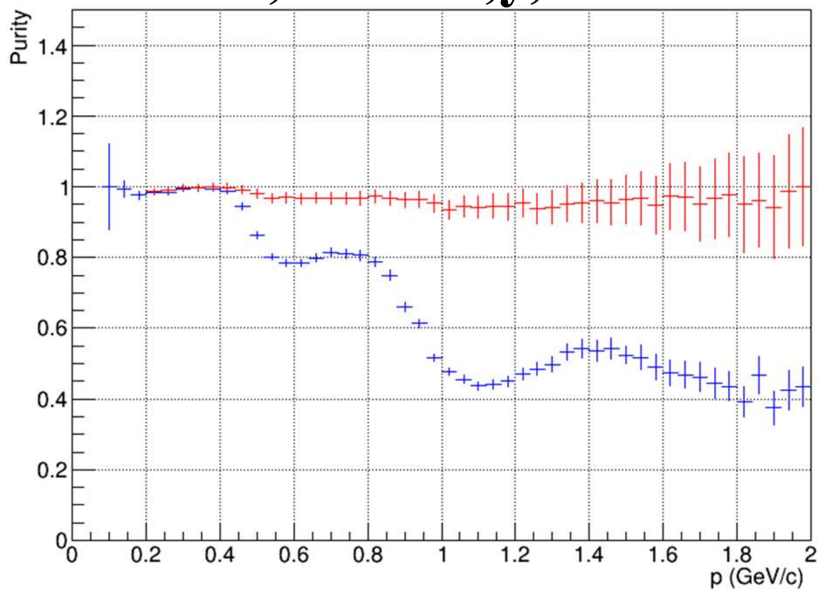
- MPD: p_T-dependent 2σ cut on DCAx,y,z; mean&width is parameterized for inclusive tracks
- STAR: the only mention is:
  - the distance of closest approach (DCA) to the primary vertex should be less than 1 cm in order to reduce contributions from secondary decays;
- The DCA < 1 cm cut for the MPD is consistent at low momentum and is too loose at high p_T
- Contribution of conversion in the MPD is much larger with DCA < 1 cm cut at p > 500 MeV/c → just the place where the purities start to diverge in the MPD and STAR

Electron purity vs. DCAx,y,z: MPD

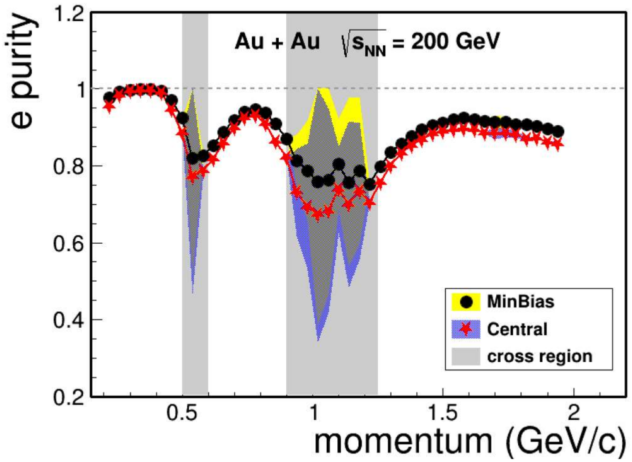
MPD, DCAX,y,z < 2σ



MPD, DCAX,y,z < 1 cm

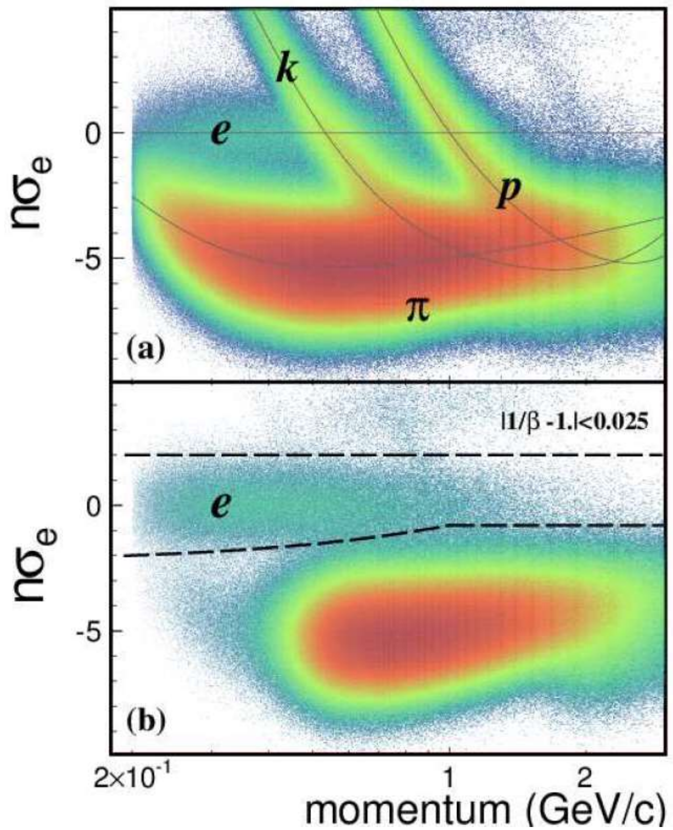


- Purity gets better with looser DCA cuts due to larger contamination by conversion electrons
- The purity with "STAR-like" DCA cut is still worse than that at STAR at p > 1.3 GeV/c

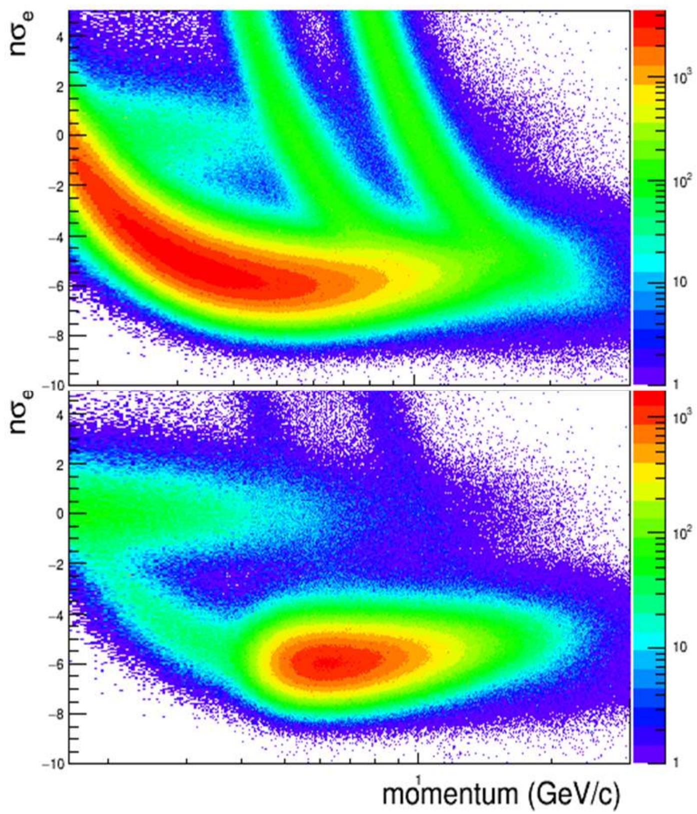


TPC-TOF eID options

STAR, AuAu@200

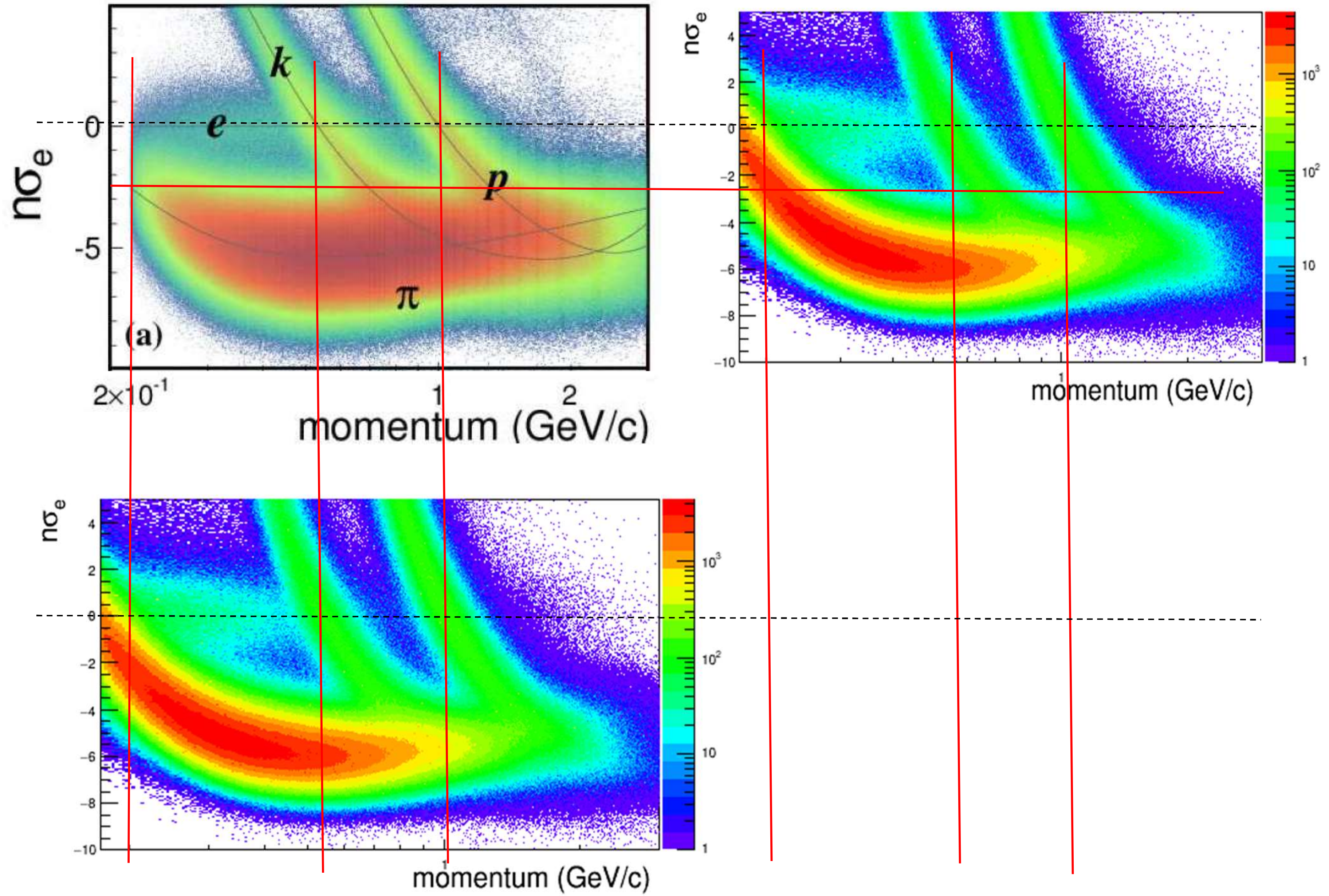


MPD, AuAu@11



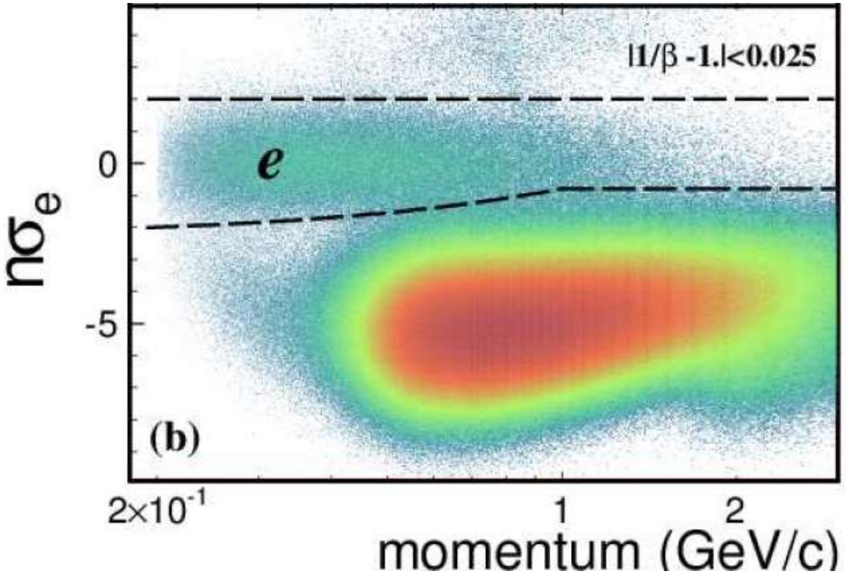
- Only tracks matched to TOF; tracks with TOF e-ID by $|1/\beta - 1| < 0.025$ on the bottom
- For the MPD, the $|1/\beta - 1| < 0.025$ cut is pretty much the same as 2σ TOF-eID cut
- Selection power of $|1/\beta - 1| < 0.025$ is stronger at STAR, higher track mismatching in MPD?
- Obvious difference for TPC π-ID between MPD and STAR (see also next slide)

TPC eID: MPD vs. STAR

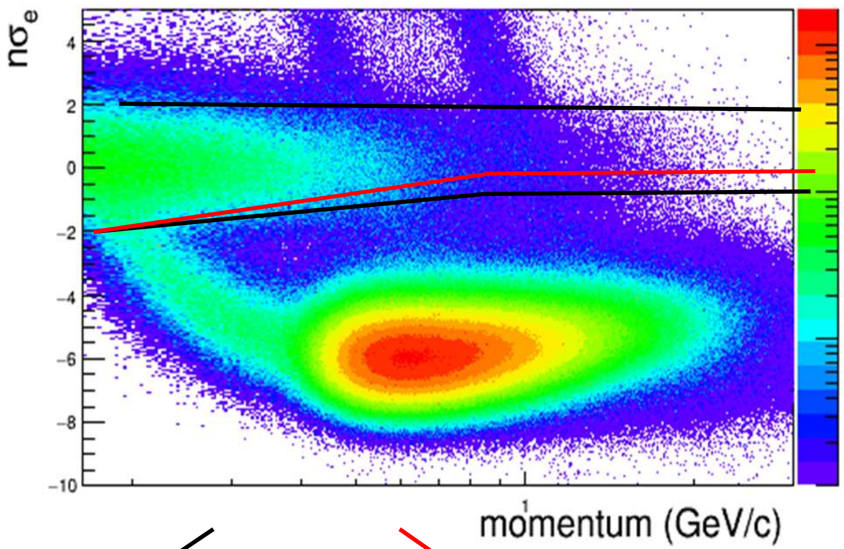


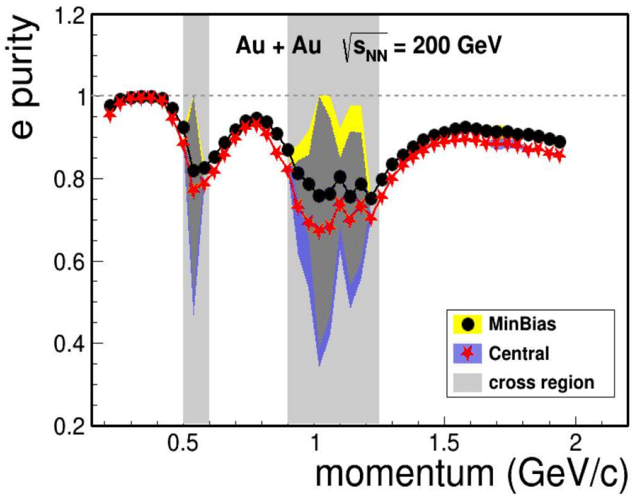
TPC eID options

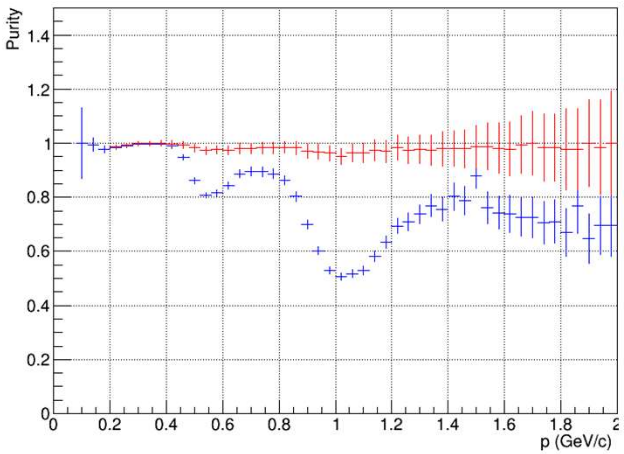
STAR, AuAu@200



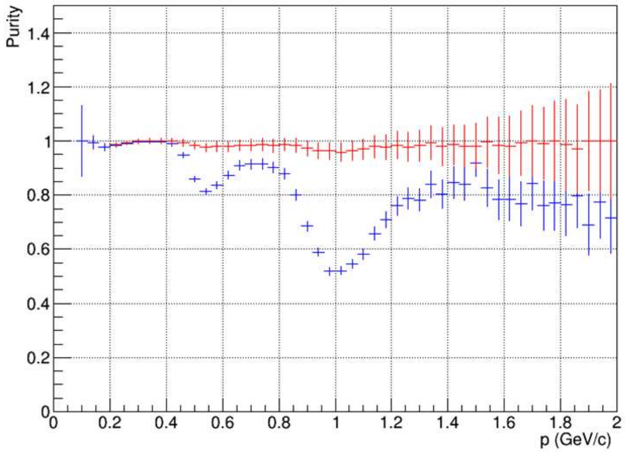
MPD, AuAu@11





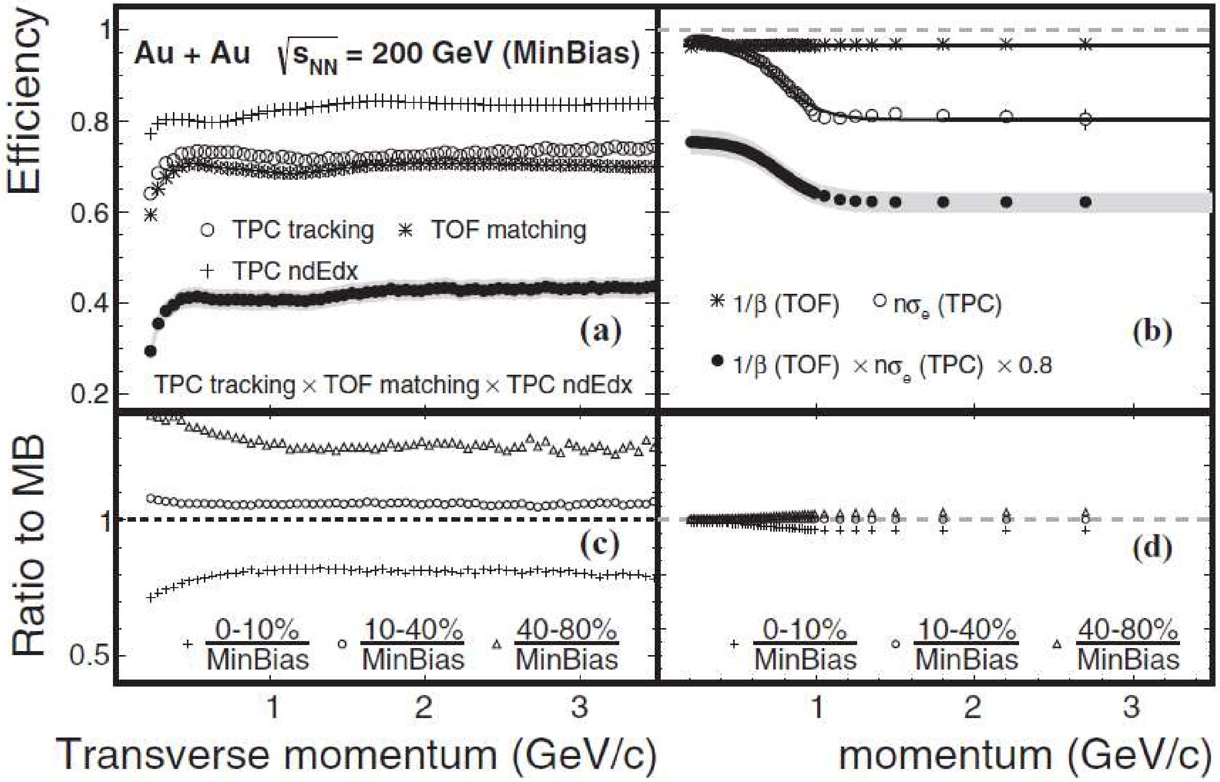


Lower efficiency by ~ 15%



Lower efficiency by ~ 30%

eID efficiency: STAR

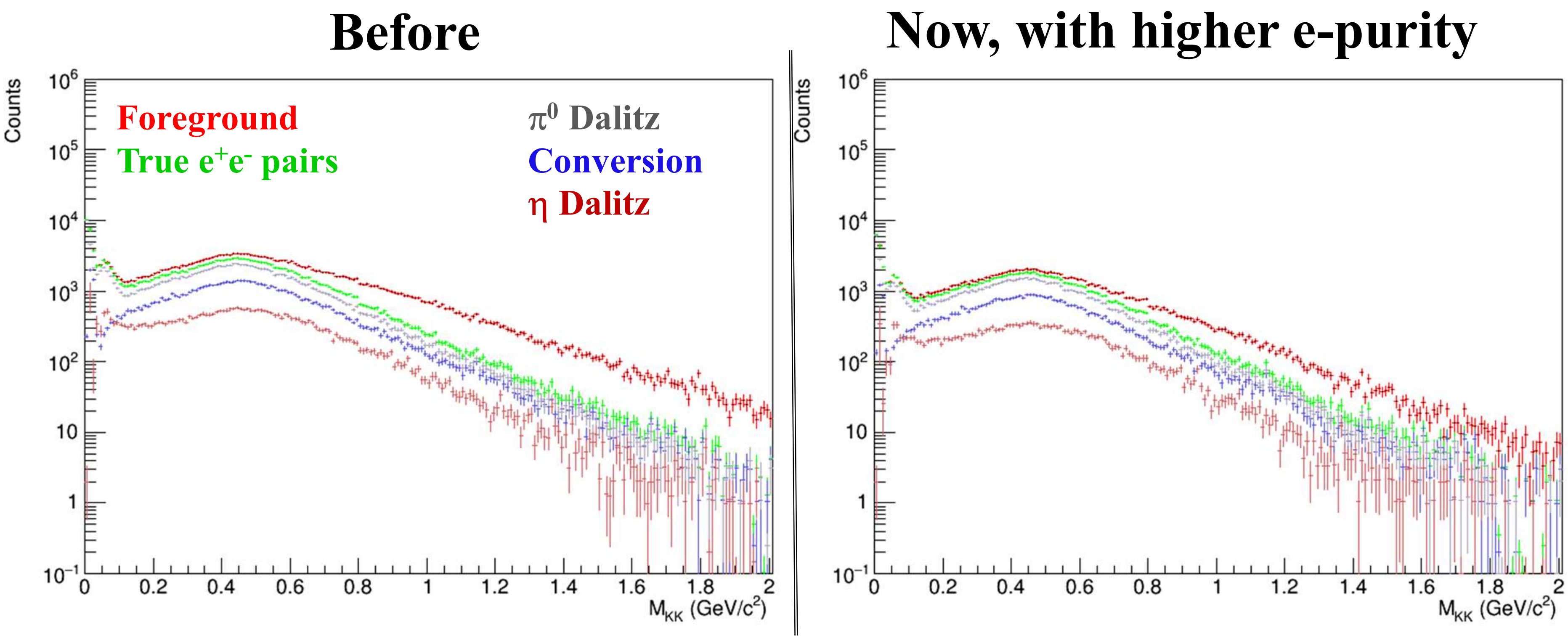


$$\varepsilon_{\mathrm{eID}} = \varepsilon_{\beta} \times \varepsilon_{\mathrm{dEdxPID}}$$

$$\varepsilon_{\mathrm{dEdxPID}} = \varepsilon_{\mathrm{ndEdx}} \times \varepsilon_{n\sigma_e}$$

- Single eID efficiency at p_T > 200 MeV/c (STAR): ~ 0.45 · (0.93-0.75) = 30-40%
- The MPD TPC-TOF-ECAL single eID efficiency with tight cuts is comparable

Dielectrons, MPD



- 15M minbias AuAu@11, MPD with TPC&TOF eID only
- Higher electron purity corresponds to smaller hadron contamination
- The ω/ϕ peak significance does not improve because of smaller efficiency
- Higher purity does not automatically mean better signal

Status & conclusions

- Single electron purity & efficiency should be considered together, for each observable
- TOF tail ($\beta > 1$) is from track mismatching, confirmed by similar observations in STAR
- e-purity in the MPD is worse than that in the STAR on the average:
  - ✓ dE/dx bands for charged electrons/pions are different
  - ✓ TOF matching parameters are most suspicious → need more details
- Need more input on the generated signals: PLUTO … ?
- Plans:
  - ✓ conversion rejection
  - ✓ scaling to PHSD predictions
  - ✓ setup new simulation with fixed resonance widths and η-Dalitz phase space