Update on dielectron studies in BiBi@9.46

V. Riabov

Outline

- Status of new production
- PHSD vs. UrQMD for dielectron input, signal significance
- TOF ePID with tighter matching cut

New production

New Monte-Carlo request

- New Monte Carlo request has been submitted a while ago
- Aims at dielectron studies but good for most of other analyses
- Recently, the request was reformatted to account for the latest advancements in ‘mpdroot’, https://mpdforum.jinr.ru/t/request5-pwg4-dielectrons-in-bibi-9-46/235
- Features:
  - ✓ collision system – BiBi@9.46, most probable first beams
  - ✓ fixed problem with zero width of resonances in Geant4, unstable particles are now decayed by Pythia8, including Dalitz decays of ω (was missing in Pythia6 before)
  - ✓ π^0 and η are decayed by Pythia8 to solve the problem of Dalitz decays of η in Geant, these particles are now treated as unstable particles
  - ✓ LVM decays to e^+e^- are enhanced by x20 for smaller fluctuations
  - ✓ production is still usable for most of general purpose analyses
- Remaining issues:
  - ✓ None, so far …
- Production status:
  - ✓ centralized production is in progress …
  - ✓ 2.5M are already available at NICA cluster, /eos/nica/mpd/sim/data/exp/dst-BiBi-9.5GeV-mp07-20-pwg4-250ev/BiBi/09.5GeV-mb/UrQMD/BiBi-9.5GeV-mp07-20-pwg4-250ev-1

PHSD vs. UrQMD vs. …

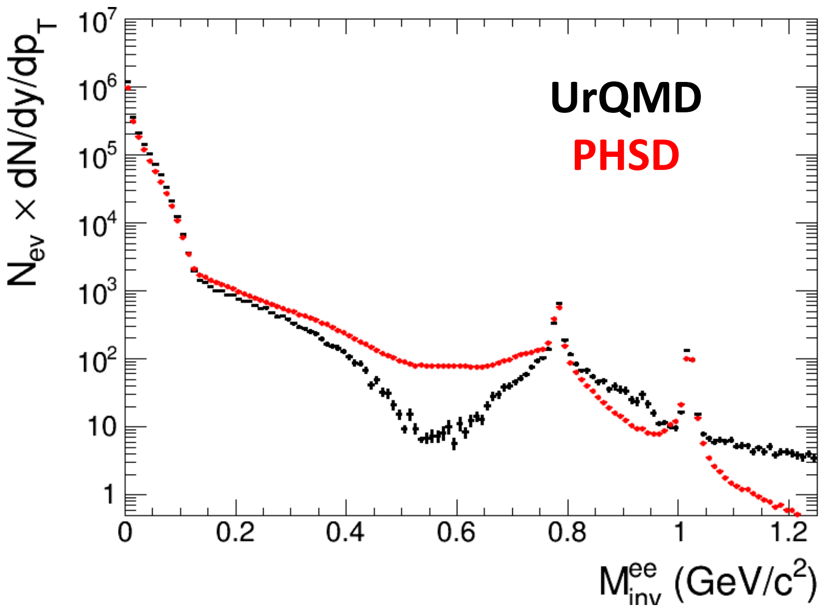
(BiBi@9.46)

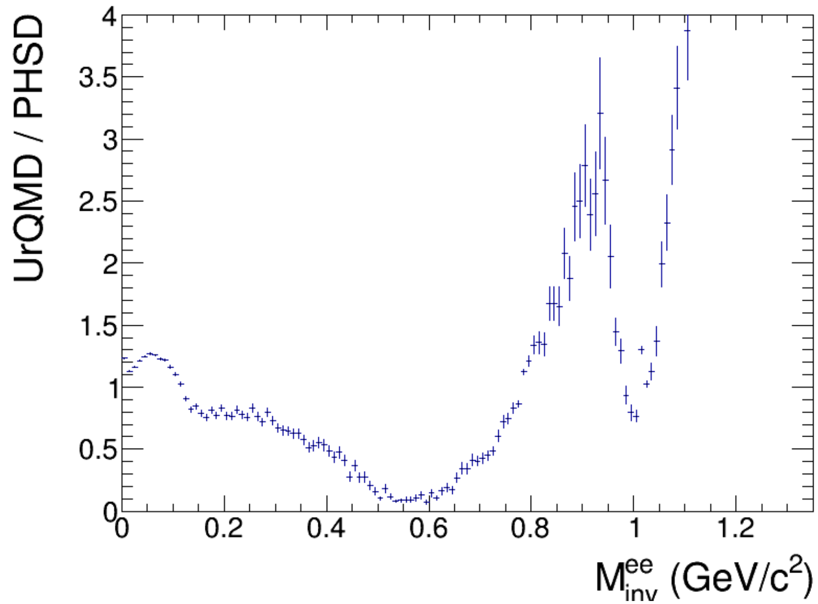
Simulated signals for dielectron studies

- Just a few event generators can simulate di-electron signals:
  - ✓ UrQMD with reweighting and extra steps/efforts (see previous presentations)
  - ✓ PHSD as a guideline for the simulated signals, M_{ee} continuum which can not be injected directly
  - ✓ PLUTO, input from Sudhir
  - ✓ private input ???

Generated dielectron continuum: UrQMD vs. PHSD

- M_{ee} distributions, BiBi@9.46, ~ 2.5 M events (new production)

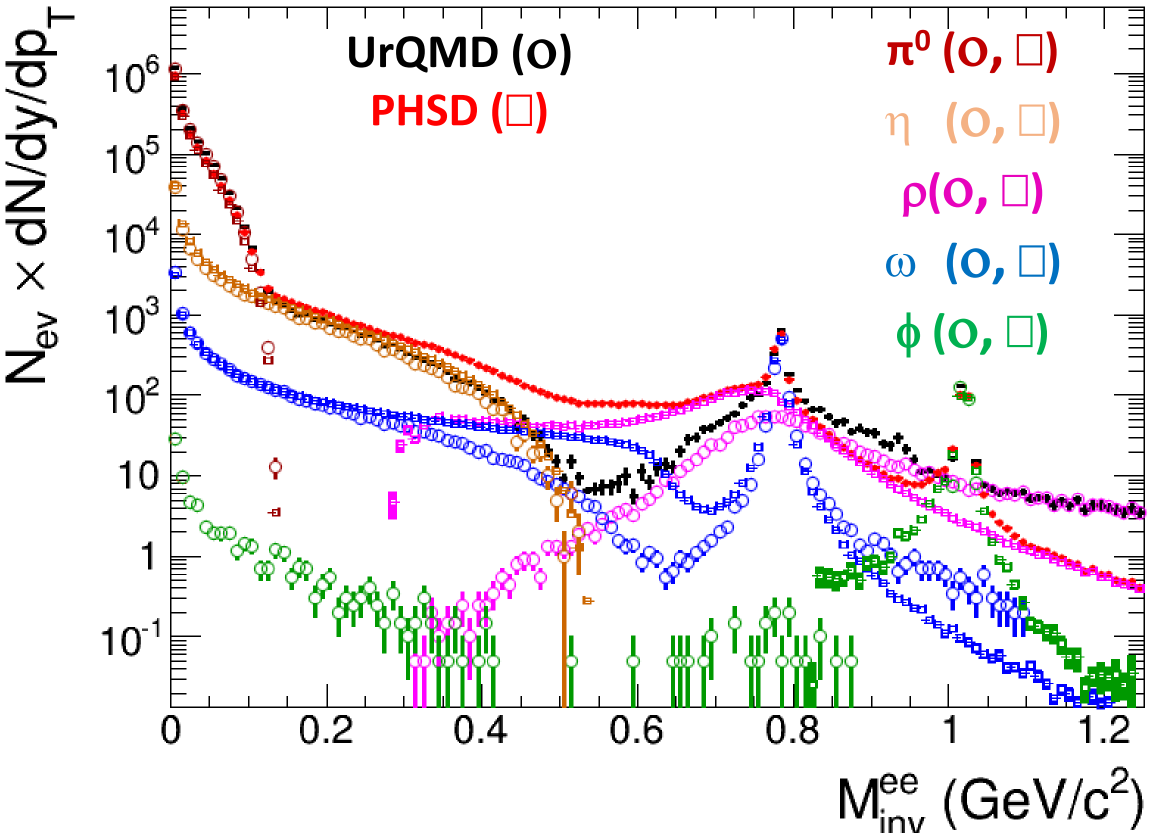




- Reasonable overall agreement for most of the M_{ee} range
- Obvious disagreement in the ρ(770) mass region, the disagreement is larger than that with Pythia6

Cocktail contributions: UrQMD vs. PHSD

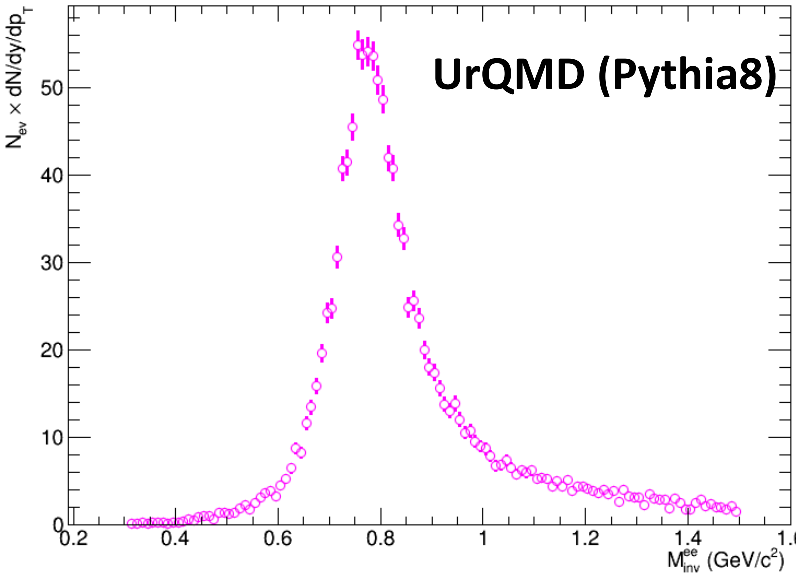
- M_{ee} distributions, BiBi@9.46, ~ 2.5 M events (new production)

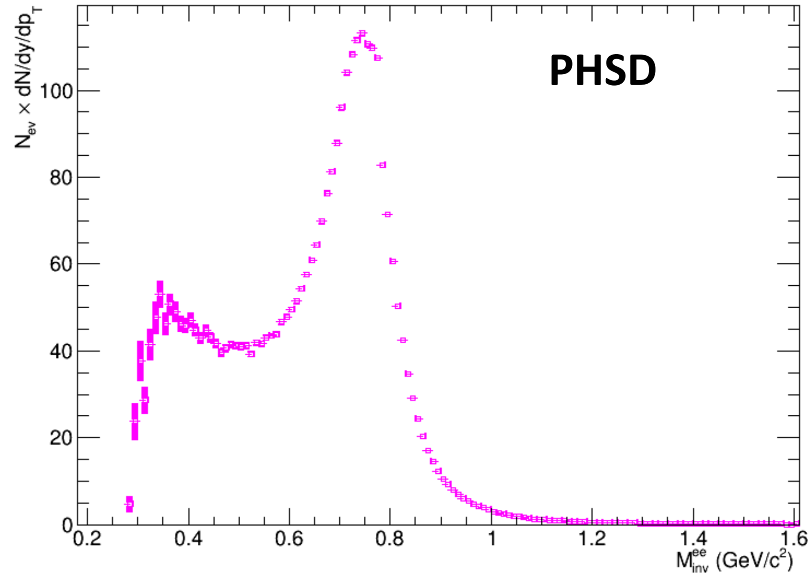


- Shapes are similar for π^0 and η Dalitz decays, ϕ decays
- Different shapes for ω Dalitz decays in Pythia8 and PHSD
- Very different shapes for $\rho \rightarrow ee$ decays

ρ(770) →ee contributions: UrQMD vs. PHSD

- M_{ee} distributions for ρ(770), BiBi@9.46, ~ 2.5 M events (new production)





- Pyhtia8 decays ρ(770) by rBW with Γ-parameter depending on mass (J = 1):

$$\mathrm{rBW}(M_{\pi\pi}) = \frac{A M_{\pi\pi} M_0 \Gamma(M_{\pi\pi})}{(M_0^2 - M_{\pi\pi}^2)^2 + M_0^2 \Gamma^2(M_{\pi\pi})} \qquad \Gamma(M_{\pi\pi}) = \left(\frac{M_{\pi\pi}^2 - 4m_\pi^2}{M_0^2 - 4m_\pi^2}\right)^{(2J+1)/2} \times \Gamma_0 \times M_0/M_{\pi\pi}$$

- Pyhtia6 decays ρ(770) by rBW with fixed Γ-parameter, $\Gamma \equiv \Gamma_0$
- PHSD smears ρ(770) to account for R.Rapp-like spectral shape modification. Similar shape modifications were observed in ρ→ππ production in dense systems and in ρ(770) photoproduction

Simulations with PHSD input

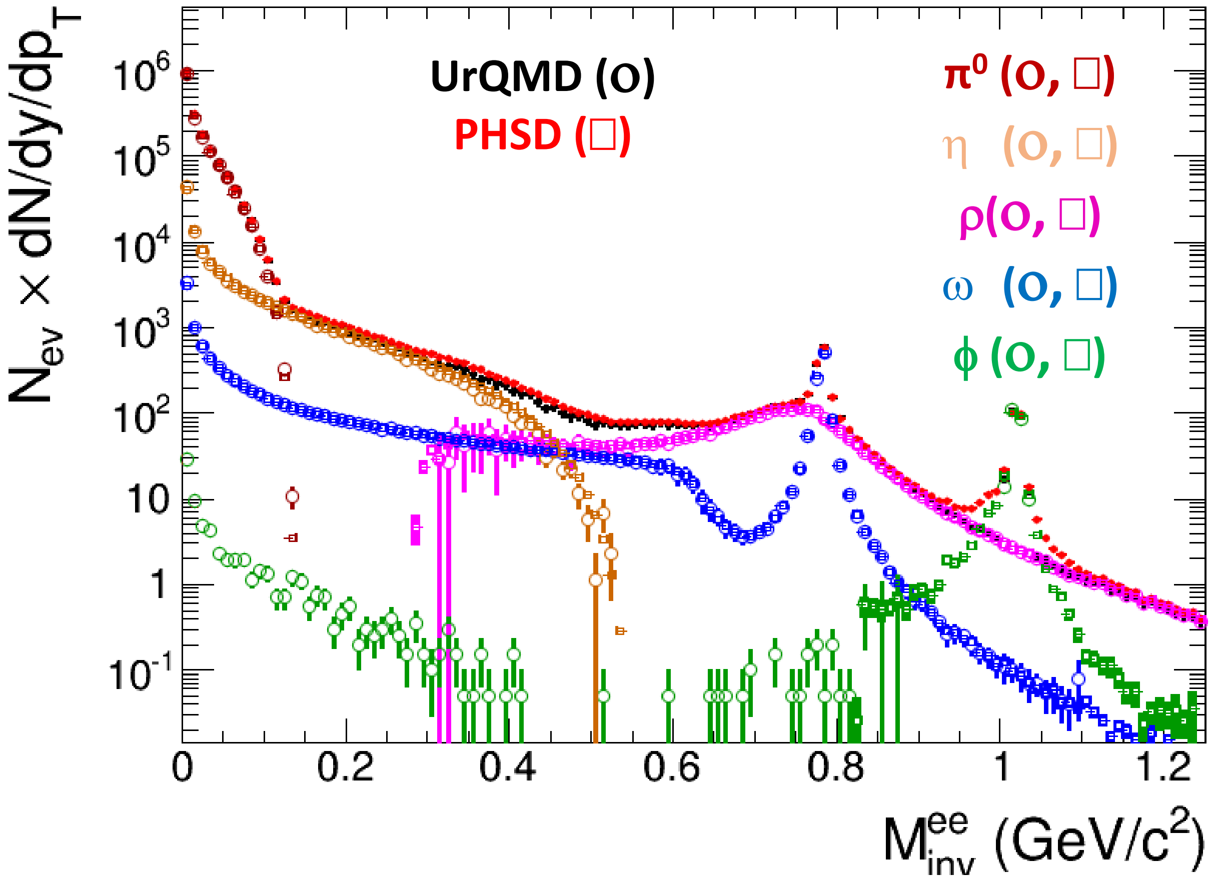
- BiBi@9.46, ~ 2.5 M events (new production)
- The UrQMD production can be rescaled to PHSD input:
  - ✓ origin of each generated and reconstructed track is known in simulations
  - ✓ each e^+e^- pair in generated/reconstructed M_{ee} spectrum is reweighted by parentID_$e^{\pm}$ and parentMass_$e^{\pm}$ - dependent weight:

    weight = Weight(parentID_e^+, parentMass_e^+) x Weight(parentID_e^-, parentMass_e^-),

    where: parentID = π^0, η, ρ, ω, ϕ etc.
    parentMass is a generated mass of π^0, η, ρ, ω, ϕ etc.
  - ✓ by construction, the procedure reweights as signals (e^+e^- pairs from π^0, η, ρ, ω, ϕ etc.) as background e^+e^- pairs, for example from e^+(from π^0 Dalitz)e^-(from ω) etc., each generated and reconstructed $e^{\pm}$ track has its own weight based on its origin and parent particle mass

Rescaled generated M_{ee} distributions

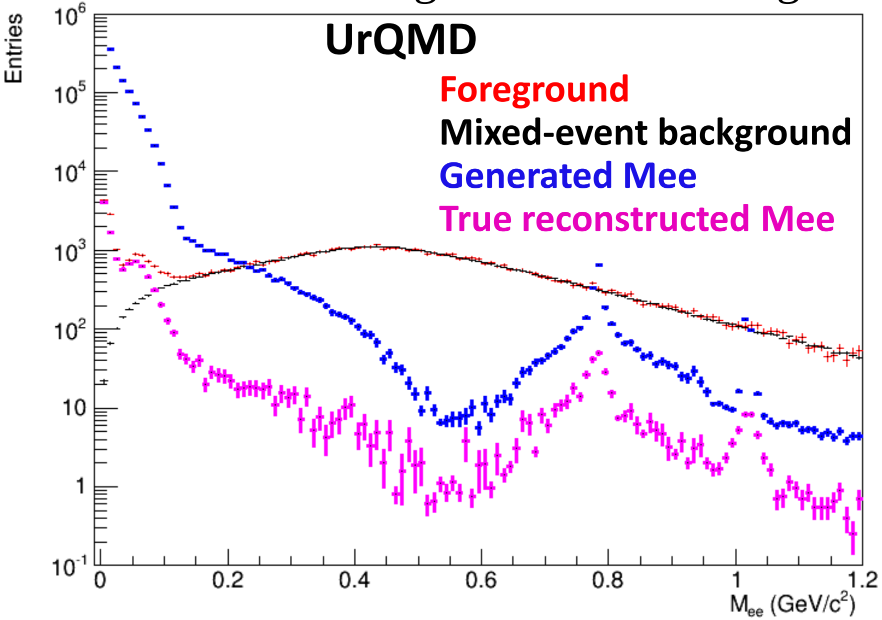
- M_{ee} distributions, BiBi@9.46, ~ 2.5 M events (new production)

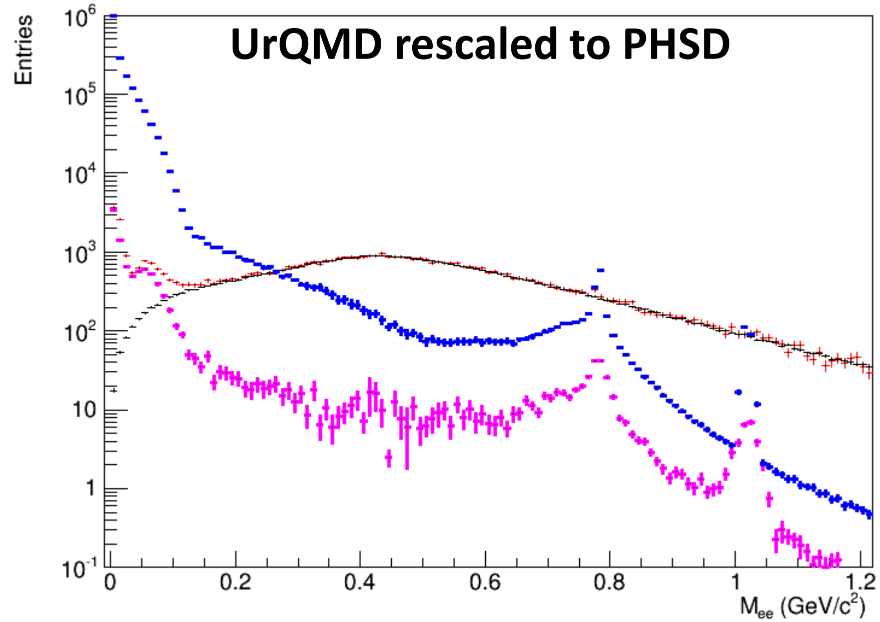


- Shapes and integrals of generated signals (rescaled UrQMD) are now consistent with PHSD input

Rescaled reconstructed M_{ee} distributions

- M_{ee} distributions, BiBi@9.46, ~ 2.5 M events (new production)
- Reconstructed signals after rescaling





- Reweighting to PHSD input changes the signal significance:
  - ✓ ω peak significance: 2.36 → 2.62
  - ✓ ϕ peak significance: 0.95 → 0.95
  - ✓ S/B in mass region [0.2-1.5] GeV/c^2: 0.014 → 0.021
    due to ~20% smaller yield of π^0 and ~ 50% larger yield of ρ(770) in PHSD

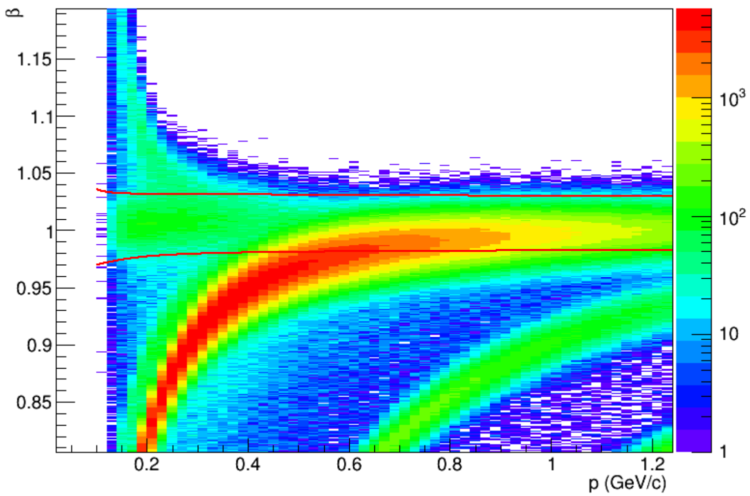
Status & conclusions

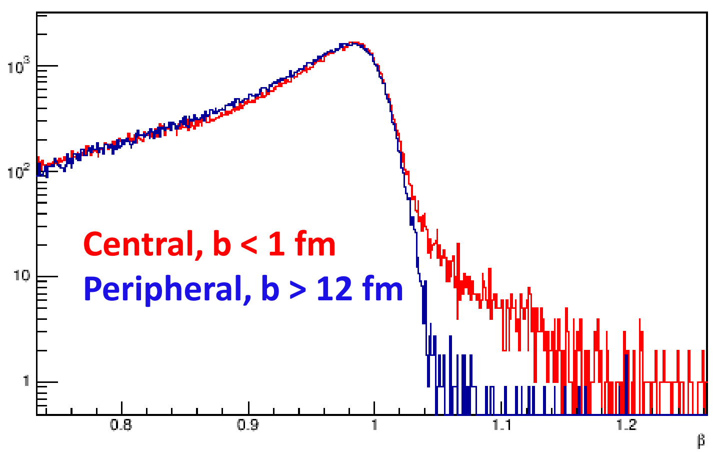
- Large BiBi@9.46production is in progress, 2.5 M events (~ 25%) are already available
- Procedure for reweighting of simulated dielectron input (UrQMD by default) is developed and tested
- Some small issues with reweighting should be polished out, need full statics of the centralized BiBi@9.46 production
- PHSD input provides better S/B compared to UrQMD predictions
- PLUTO is to be tested once input is provided …

TOF eID

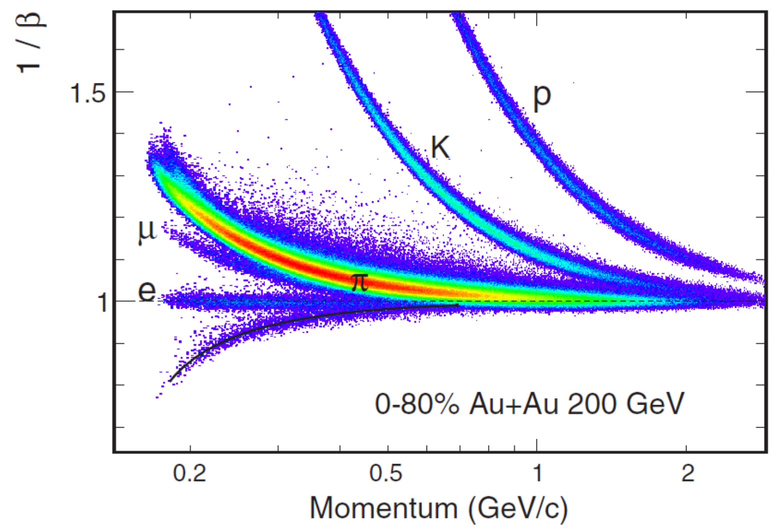
Problem of TOF-TPC track mismatching

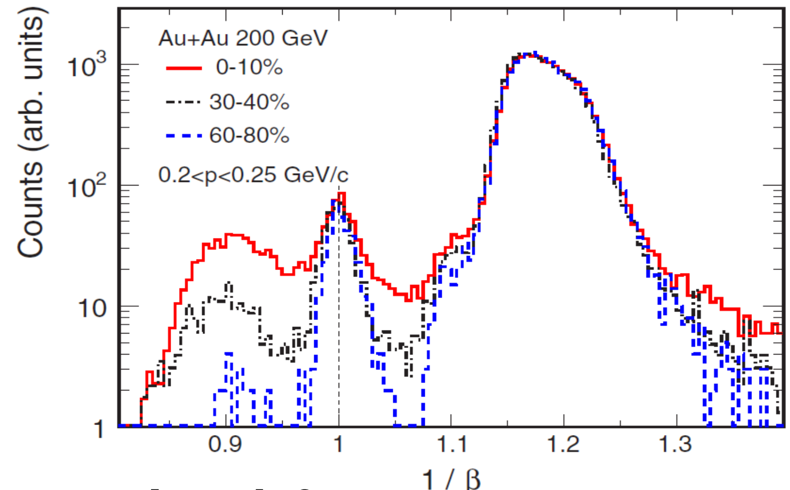
MPD





STAR





- Both STAR and MPD observe non-physical TOF signals with $\beta > 1$,
- Unphysical signals are most prominent in central collisions, diminished in peripheral
- Effect is explained by track mismatching in the TOF

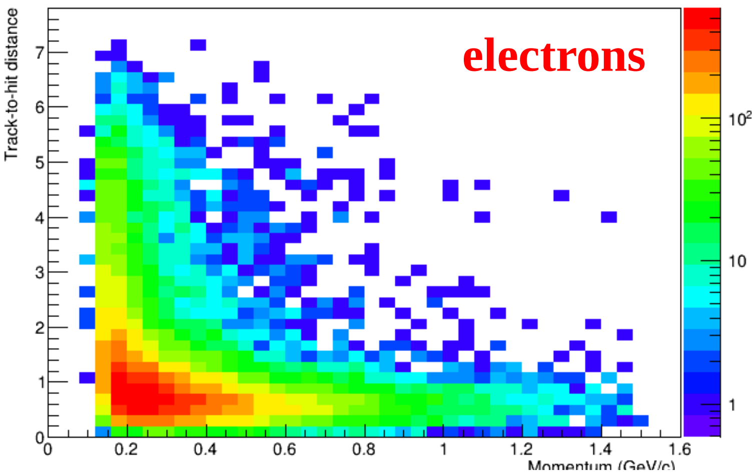
Problem of TOF-TPC track mismatching

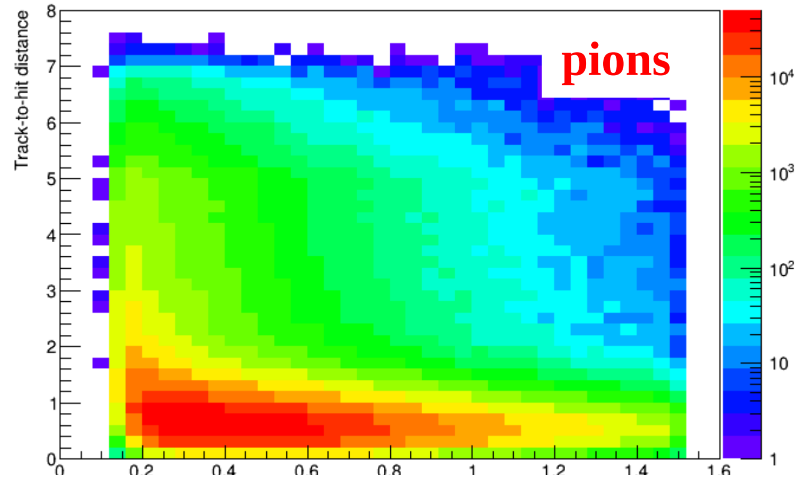
- High probability of track mismatching in the TOF prevents reliable identification of electrons at intermediate momenta → previously observed electron purity is not as high as in STAR (see previous presentations)
- Little control over the matching parameters in ‘mpdroot’
- The only available parameters are:
  - ✓ track quality (number of hits, rapidity cut, matching to primary vertex etc.)
  - ✓ MpdTofMatchingData::GetWeight(), where: weight = 1./(estPointOnPlate - hitPosition).Mag();

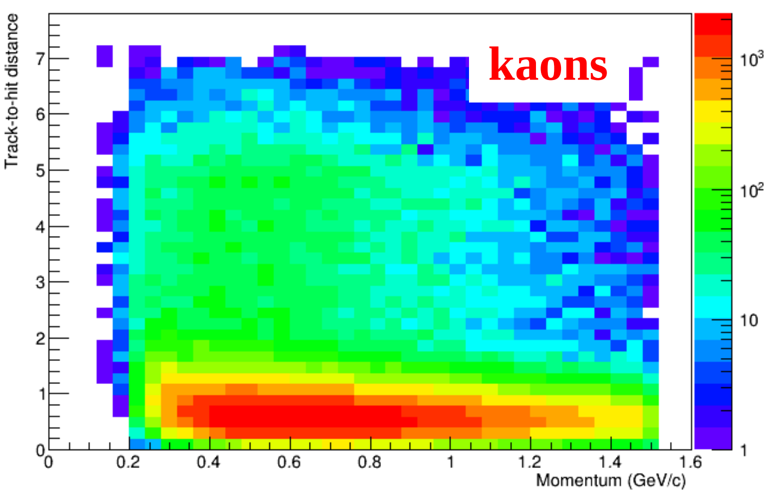
- Track quality cuts (within some reasonable limits: nHits > 20-40, DCA< 1-3σ, |y| < 0.5-1) do not noticeably improve the situation with track mismatching in the TOF
- Matching parameter is quite useful

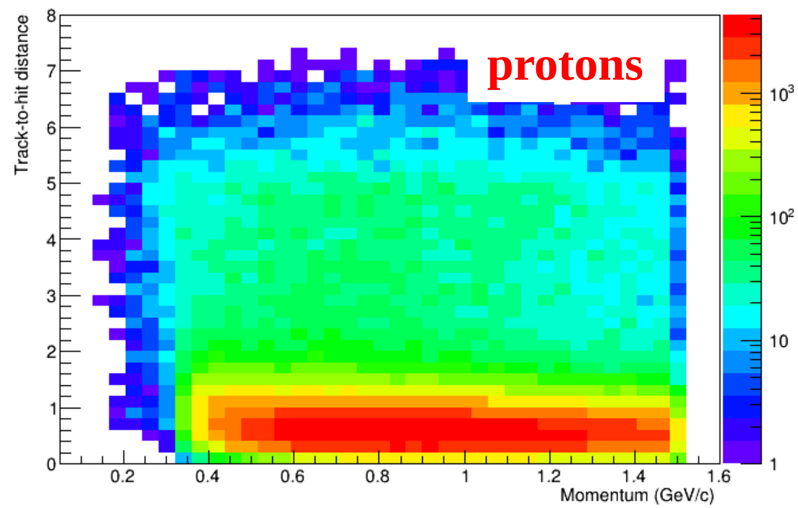
Matching distributions vs. p_T

- Track-to-hit distance in the TOF (or 1/weight) vs. p_T, minbias BiBi@9.46





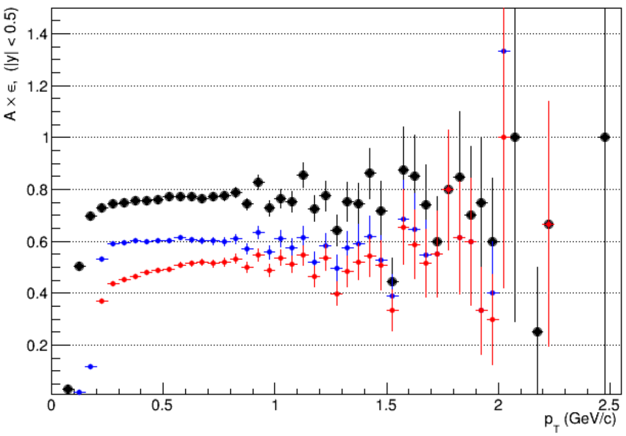


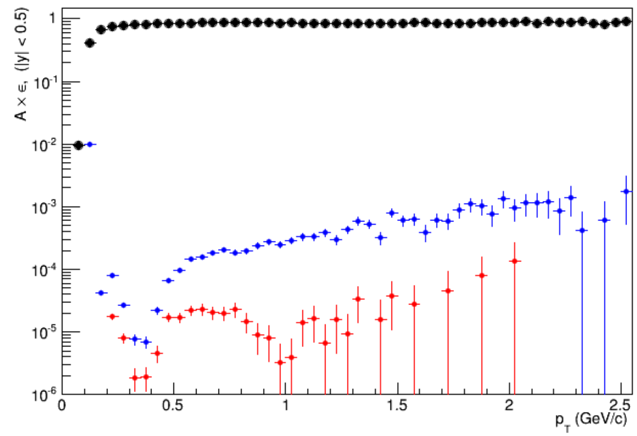


- Matching distributions are quite wide (too wide ???)

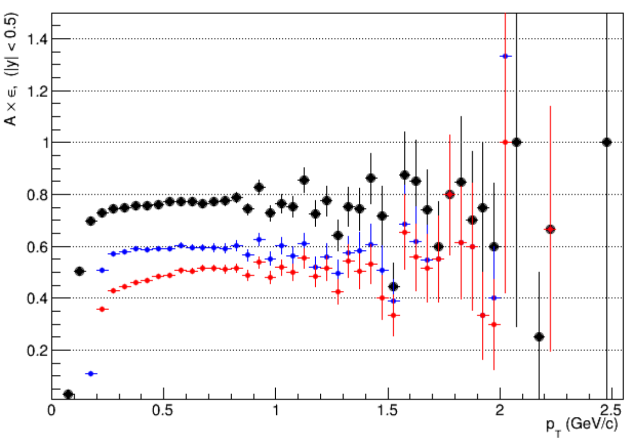
Electron track reconstruction efficiency vs. p_T

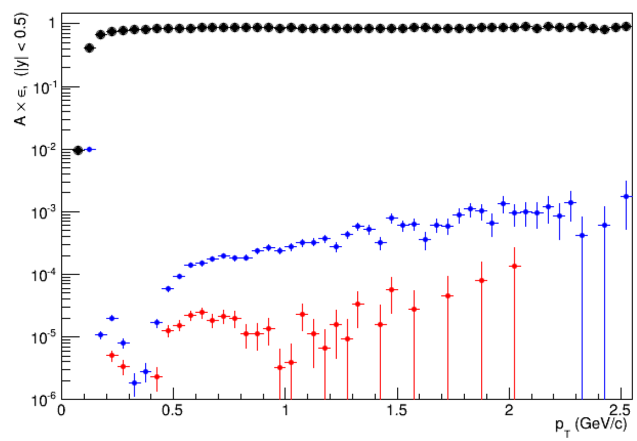
- eID with **noPID**, **TPC&TOF** and **TPC&TOF&EMC**
  - ✓ Default matching





  - ✓ |dist| < 2 cm

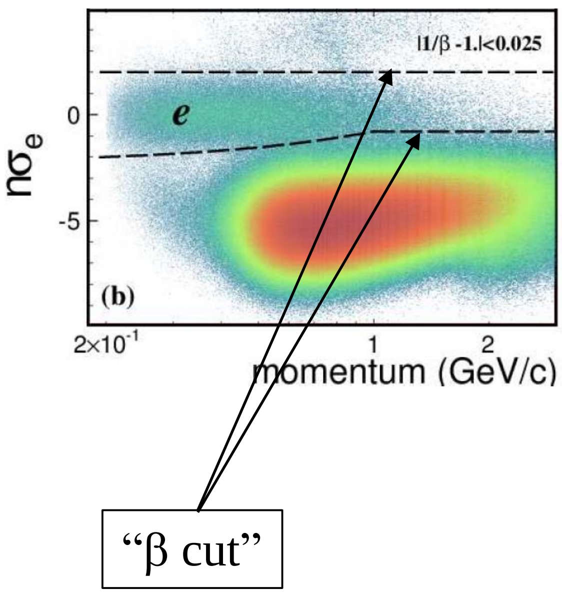




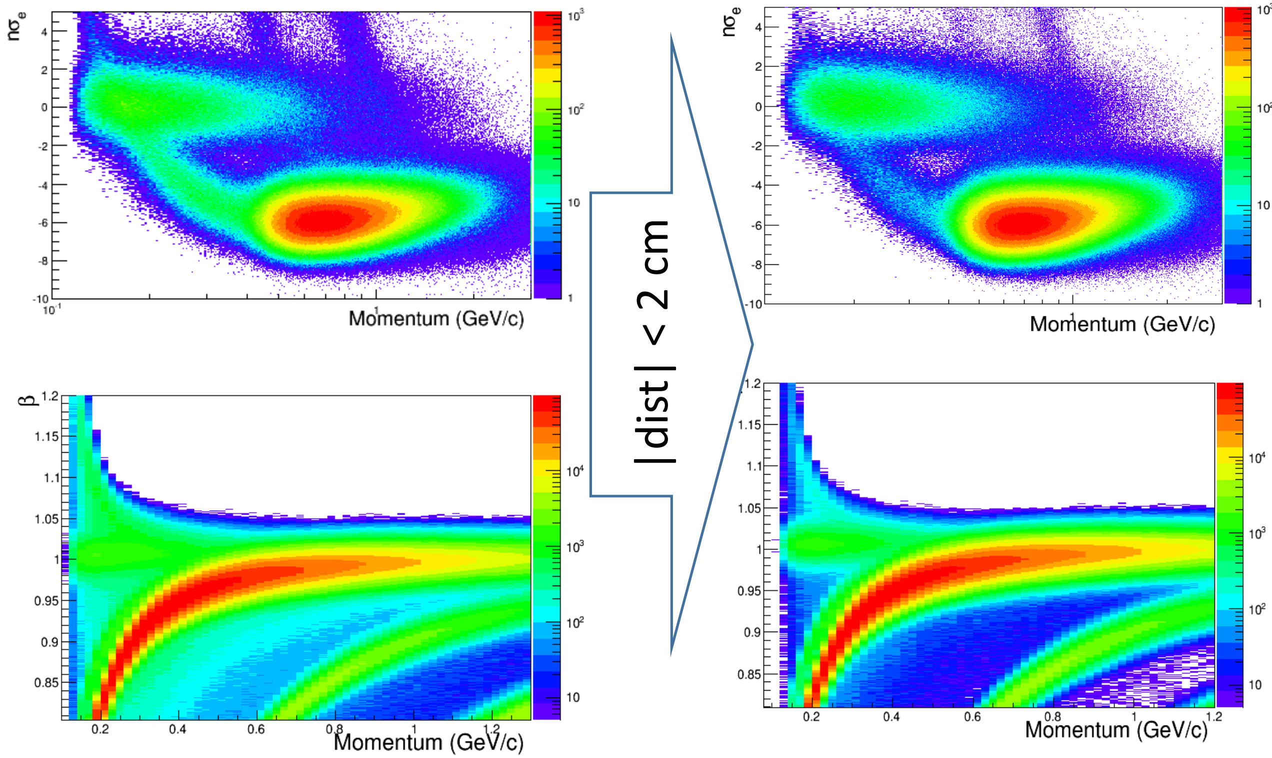
- Tighter matching cut (<2cm) only slightly reduces the electron efficiency at p_T < 200 MeV/c
- Yet it reduces pion efficiency by a factor of ~ 2-3 with eID cuts at p_T < 400 MeV/c

dE/dx selections with 2σ eID TOF cut

STAR, AuAu@200



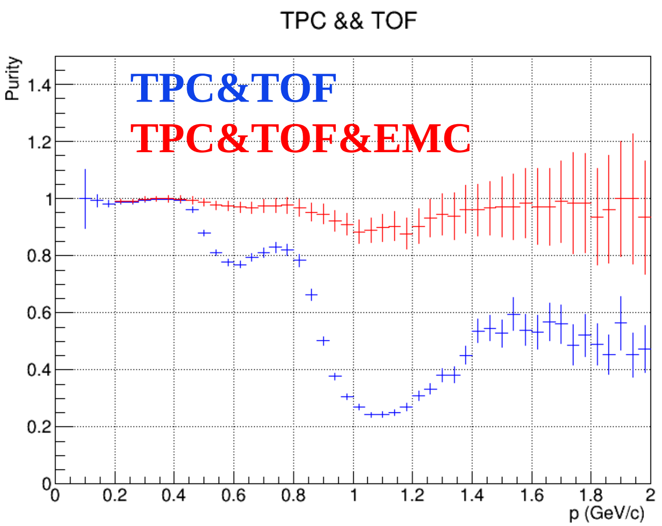
MPD, BiBi@9.46

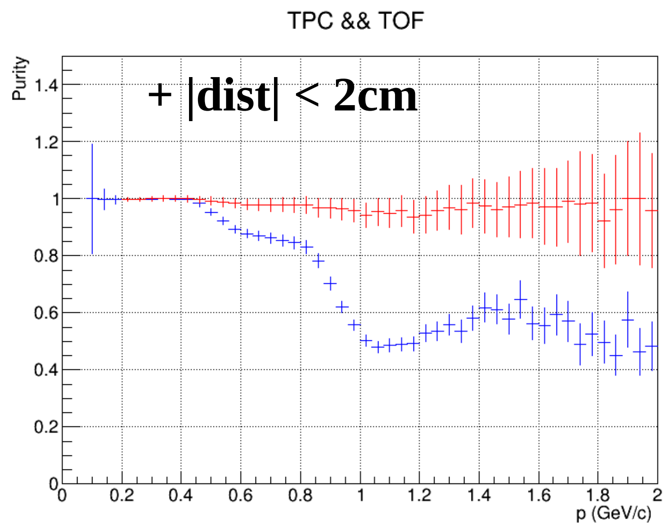


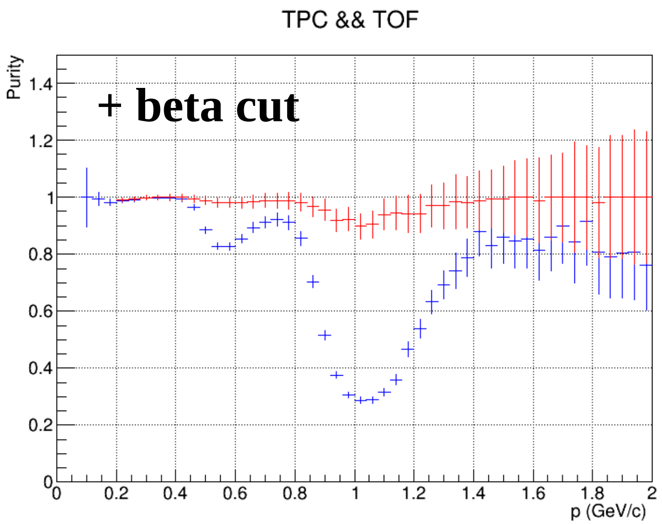
- Tighter matching (|dist| < 2cm) cut:
  - ✓ suppresses the grass and the β > 1 tail
  - ✓ significantly improves e/π and probably π/K separation

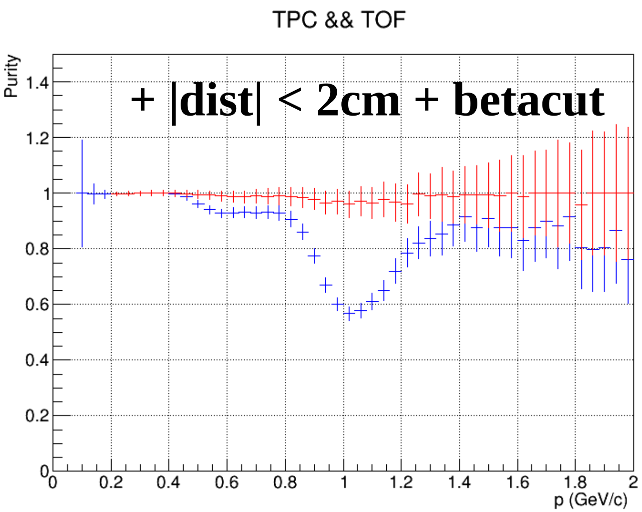
Electron purity

- BiBi@9.46, ~ 2.5 M events (new production)



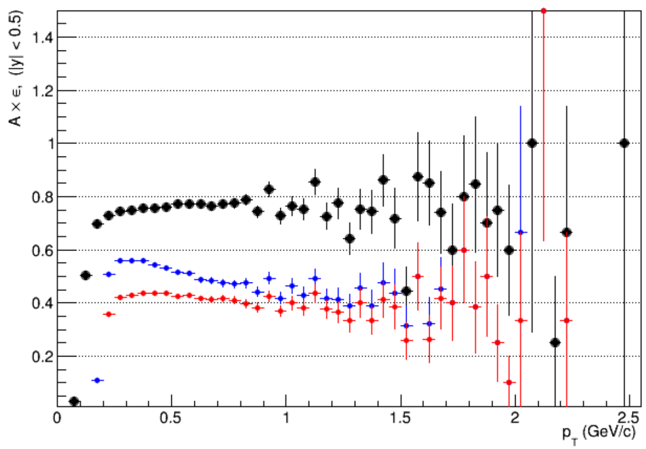


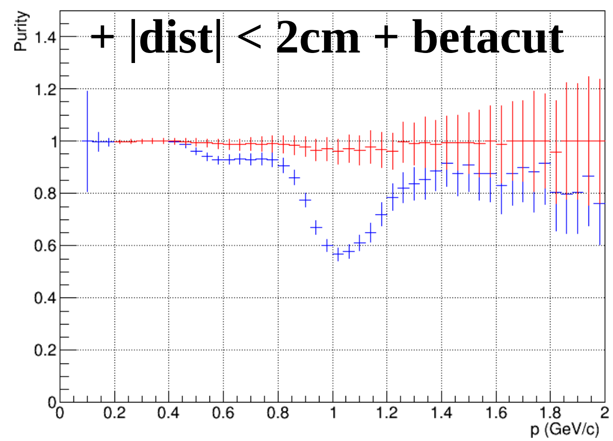




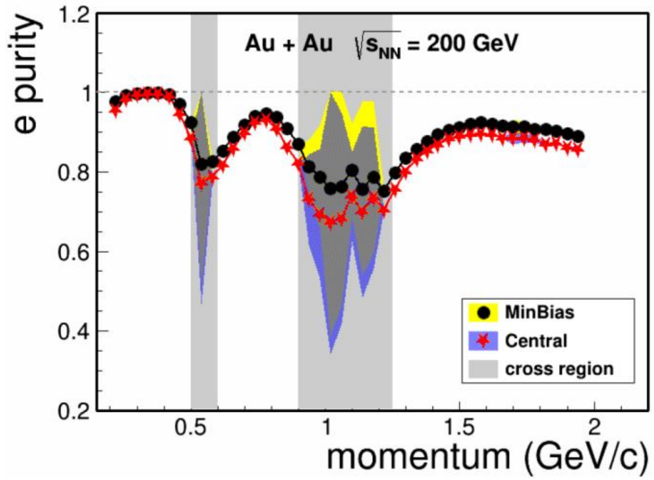
Summary for tighter matching cut

- BiBi@9.46, ~ 2.5 M events (new production)
- **noID**, **TPC&TOF** or **TPC&TOF&ECAL** eID selection + beta cut + |dist| < 2cm





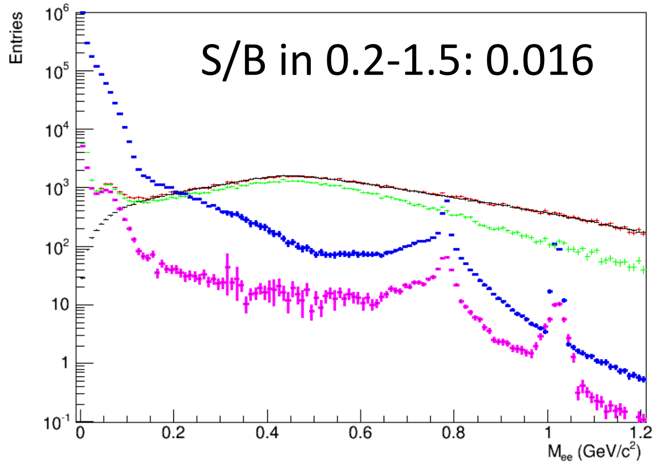
STAR: single electron efficiency at p_T > 200 MeV/c is 30-40%

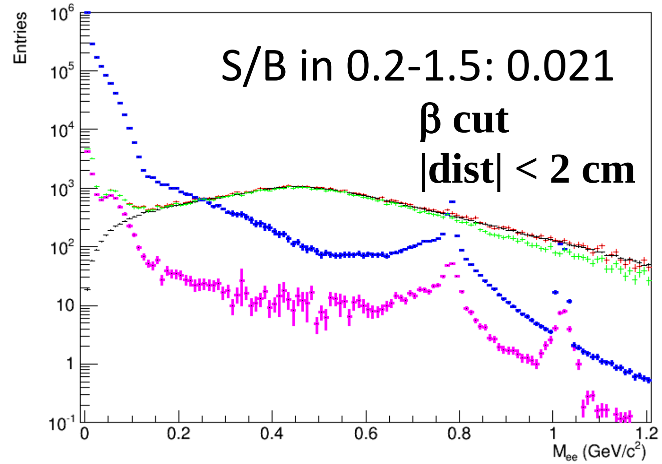


- Achieved purity & efficiency with **TPC&TOF** eID are comparable/better to STAR
- Tight matching cut makes eID by **TPC&TOF** quite sufficient for eID

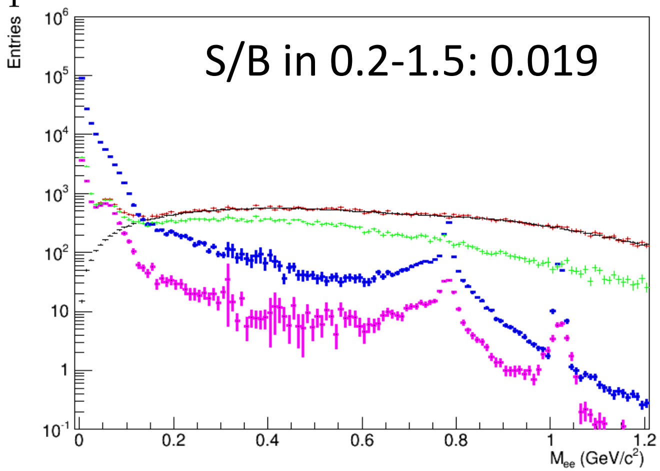
First look at M_{ee}

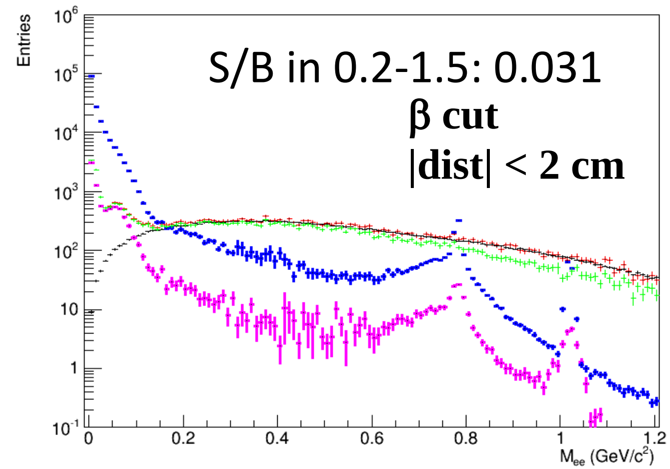
- BiBi@9.46, ~ 2.5 M events (new production)
  - ✓ p_T - integrated





  - ✓ p_T > 0.5 GeV/c





- Smaller hadron contamination, better S/B ratios, the higher the p_T the larger the gain
- Tighter matching cut is important for dielectron studies