Update on photon conversion and dielectron studies in BiBi@9.2

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Dielectrons - productions

New Monte Carlo production

- Request13: *PWG4 - dielectrons, 15M minbias BiBi@9.2*
- Geant-4 based simulation
- Same as Request 11 but with a different simulation of dE/dx in the TPC
  - ✓ new dE/dx
  - ✓ new TPC digitizer (MpdTpcDigitizerAZlt vs. MpdTpcDigitizerAZ)

- Output data:
  - ✓ DSTs:

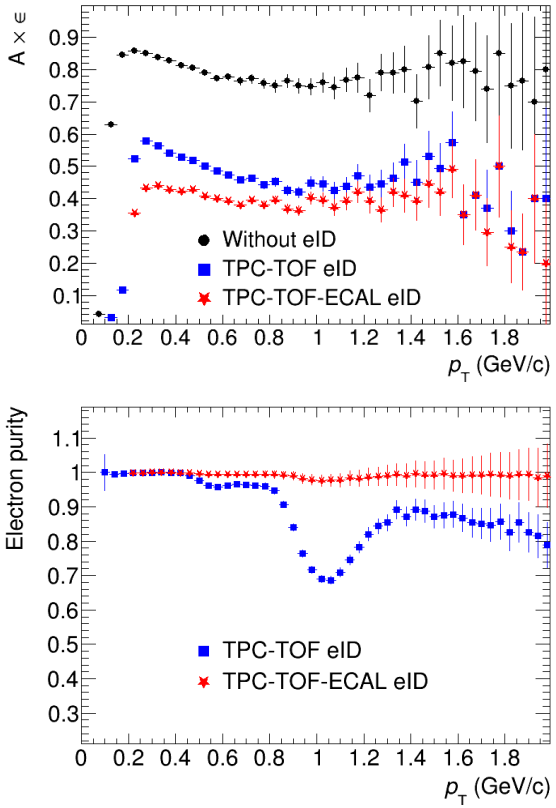
    /eos/nica/mpd/sim/data/exp/dst-BiBi-09.2GeV-mp05-21-500ev/BiBi/09.2GeV-mb/UrQMD/BiBi-09.2GeV-mp05-21-500ev
  - ✓ MiniDSTs:

    /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

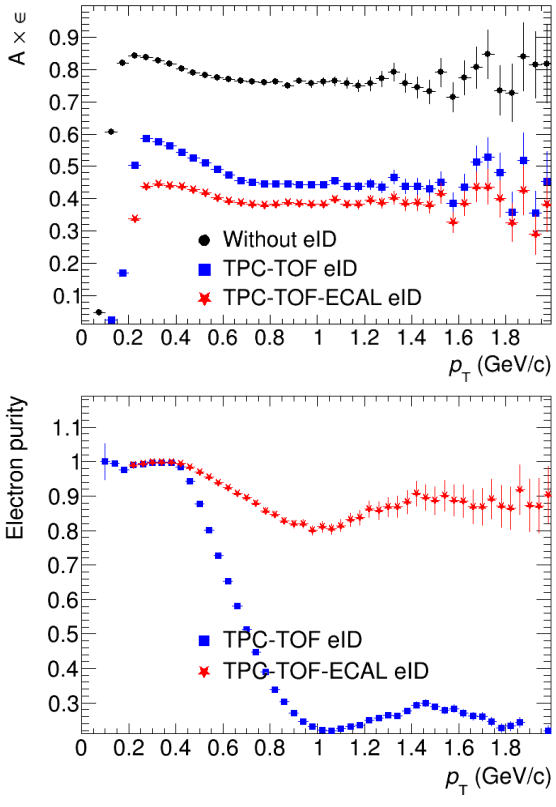
Efficiency and purity

- Selected tracks:
  - ✓ hits > 39
  - ✓ $|\eta| < 1$
  - ✓ $|DCA\_x,y,z| < 2.5\ \sigma$
- eID selections:
  - ✓ 2σ matching to TOF
  - ✓ $1\text{-}2\sigma$ TPC-eID
  - ✓ 2σ TOF-eID

Request 11



Request 13

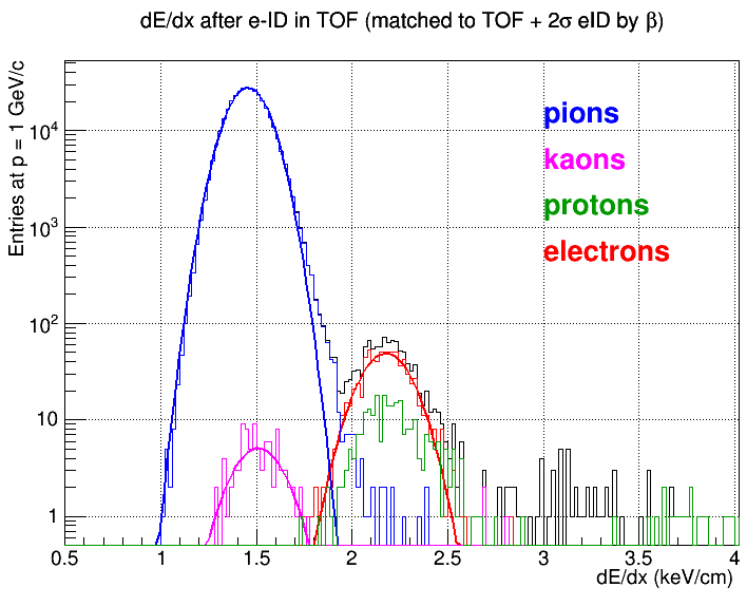


- Similar reconstruction efficiencies with different electron selection and ID cuts
- Observe problems with electron purity for Request13

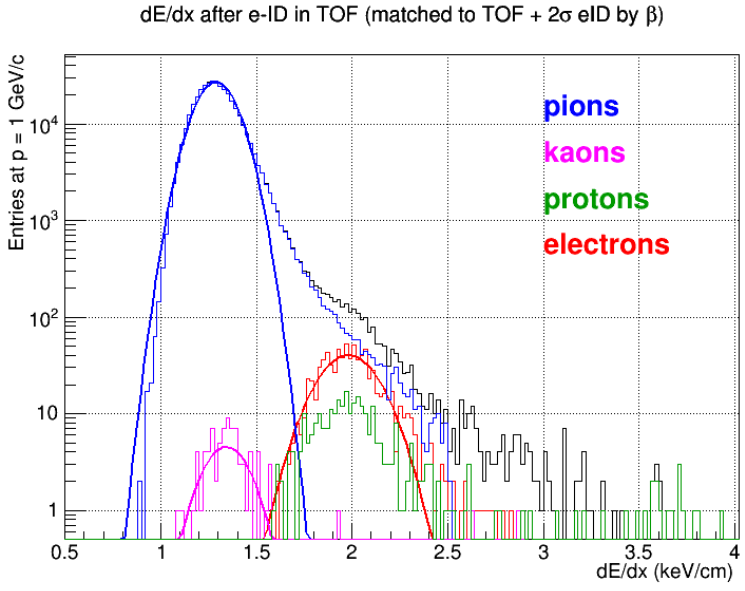
Closer look at dE/dx distributions + TOF e-ID

- Selected tracks:
  - ✓ hits > 39
  - ✓ $|\eta| < 1$
  - ✓ $|DCA_{x,y,z}| < 2.5\ \sigma$
  - ✓ $p_T = 1$ GeV/c
- eID selections:
  - ✓ 2σ matching to TOF
  - ✓ 2σ TOF-eID

Request 11



Request 13



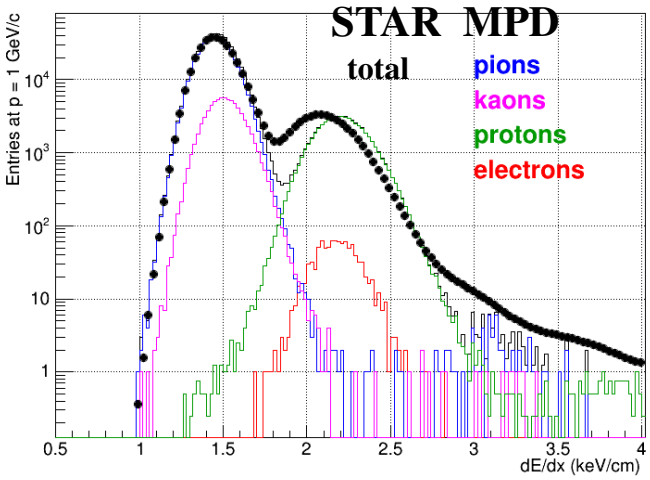
- The problem of electron purity is traced to long non-Gaussian tails of dE/dx distributions for hadrons in Request 13, electrons can not be distinguished from the pion tail
- Kaon and proton contributions are comparable after TOF e-PID

Comparison to dE/dx from STAR - I

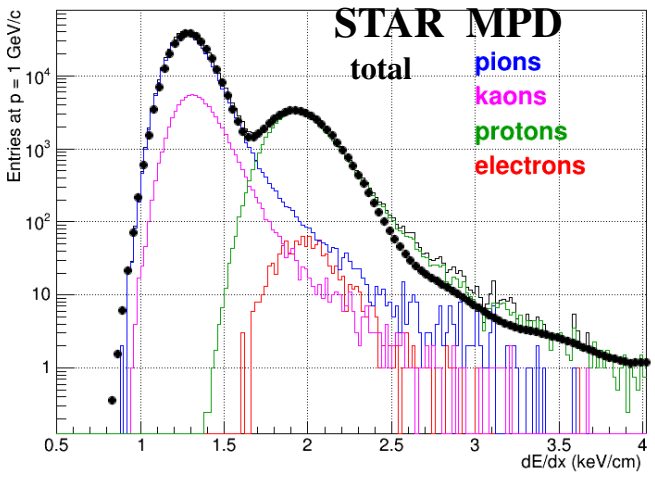
- STAR dE/dx distribution was provided by Chi Yang (for internal checks only) :
  - ✓ minbias AuAu@54 GeV
  - ✓ basic event and track quality cuts ($|\eta| < 1.0$, $|DCA| < 1$ cm), $p_T \sim 1$ GeV/c

- For comparison:
  - ✓ dE/dx of STAR is scaled to reproduce the pion peak (arbitrary calibration)
  - ✓ MPD proton peak is scaled to reproduce the second peak (different K/π and p/ π ratios)

Request 11

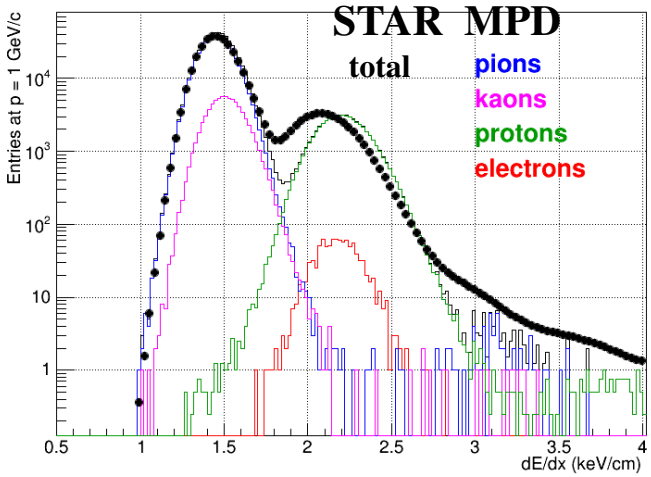


Request 13

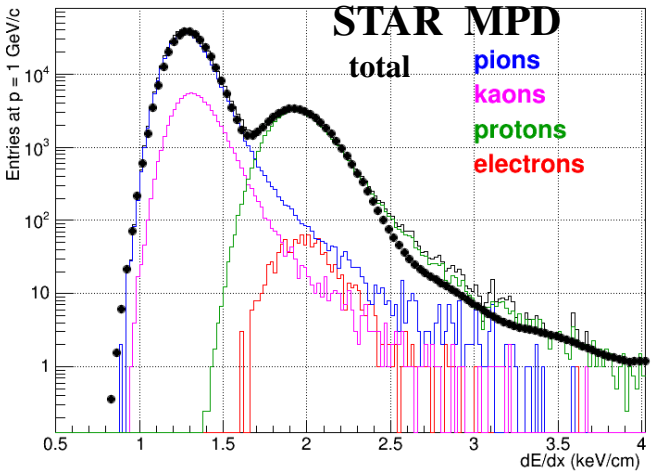


Comparison to dE/dx from STAR - II

Request 11



Request 13



- Mean values of dE/dx are better reproduced in Request 13.
- Tails of dE/dx distributions get overestimated in Request 13 → the MPD total distribution is above that of STAR at dE/dx > 2 keV/cm even though STAR additionally includes signals from deuterons:

→ new dE/dx (used in Request 13) are better tuned to STAR data (relative peak position)

→ new TPC digitizer (used in Request 13) results in excessive tails of dE/dx distributions

Conclusions

- The latest TPC digitizer does not quite reproduce the expected shape of dE/dx distributions for hadrons
- There is no production with new dE/dx and old TPC digitizer
- So far, we stick to Request 11 production for dielectrons
- The whole Request 11 production was retrieved from the tape:

  /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 files

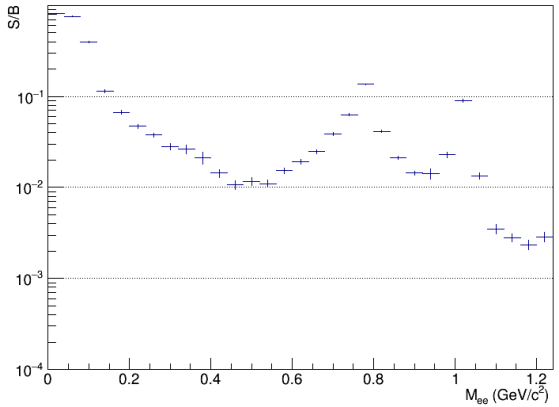
  15M minbias BiBi@9.2 events

Dielectrons - background (erratum)

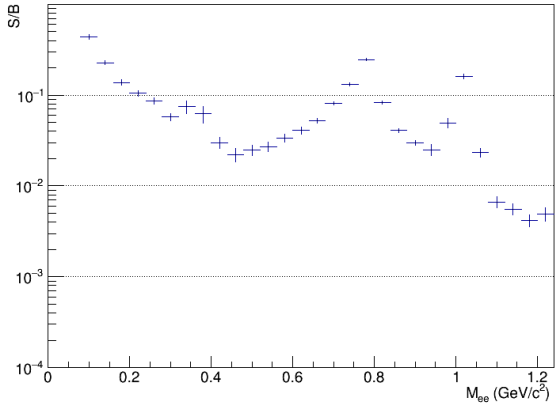
Pair cuts, loosening cuts for a partner

- Conversion rejection cuts are applied as described in the previous presentation
- Dalitz rejection, Mconv = 0.1 GeV/c^2:
  - ✓ e-tracks are paired, if a pair invariant mass $M_{inv} < M_{cut}$ then both e-tracks are rejected as Dalitz candidates
- Varied the pair selection cuts:
  - ✓ tight selection cuts for a primary electron in the pair (same cuts as for e+e- continuum)
  - ✓ loosen selection cuts for a partner in search for conversion/Dalitz candidates

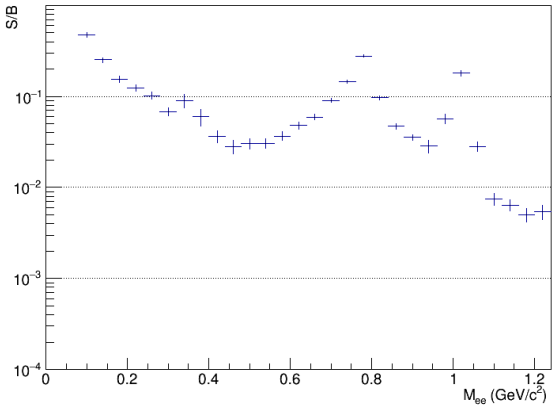
tight cuts for a partner → **nhits > 10** → **nhits > 10 && dca < 3.5σ**



S/B in 0.2-1.5: 0.026
==========
Omega (s/sqrt(b)): 4.9
Phi (s/sqrt(b)): 2.3
LMR (s/sqrt(b)): 1.2
==========



S/B in 0.2-1.5: 0.059
==========
Omega (s/sqrt(b)): 5.3
Phi (s/sqrt(b)): 2.4
LMR (s/sqrt(b)): 1.3
==========



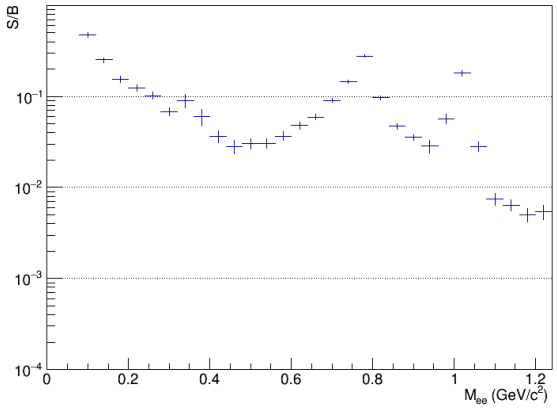
S/B in 0.2-1.5: 0.068
==========
Omega (s/sqrt(b)): 5.4
Phi (s/sqrt(b)): 2.4
LMR (s/sqrt(b)): 1.3
==========

- By loosening the cuts for a partner (to some limit) we increase efficiency of background rejection

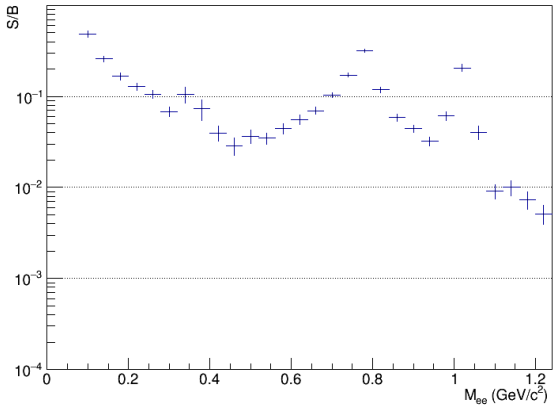
Pair cuts, limiting acceptance for a primary e

- Idea was to limit acceptance for a primary electron → easier to find a **reconstructed** conversion or Dalitz partner for rejection
- Last time presented wrong plots and made wrong conclusions (the calculations were correct)

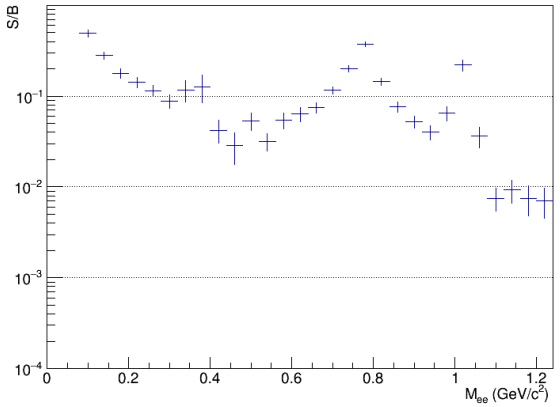
$|\eta| < 1$ → **$|\eta| < 0.75$** → **$|\eta| < 0.5$**



S/B in 0.2-1.5: 0.068
==========
Omega (s/sqrt(b)): 5.4
Phi (s/sqrt(b)): 2.4
LMR (s/sqrt(b)): 1.3
==========



S/B in 0.2-1.5: 0.077
==========
Omega (s/sqrt(b)): 4.6
Phi (s/sqrt(b)): 2.0
Rho (s/sqrt(b)): 1.2
==========



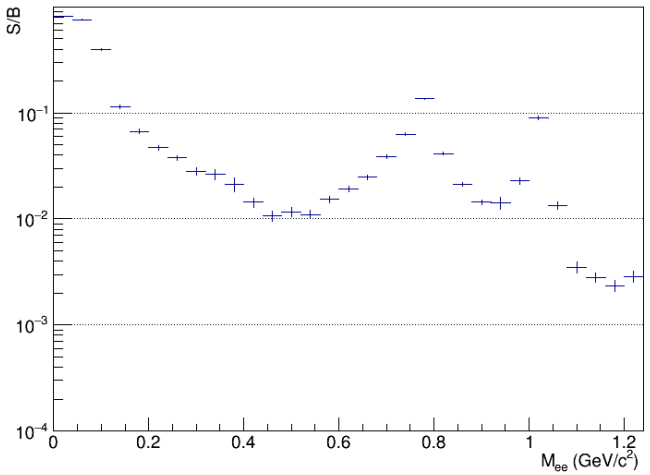
S/B in 0.2-1.5: 0.092
==========
Omega (s/sqrt(b)): 3.3
Phi (s/sqrt(b)): 1.4
Rho (s/sqrt(b)): 0.9
==========

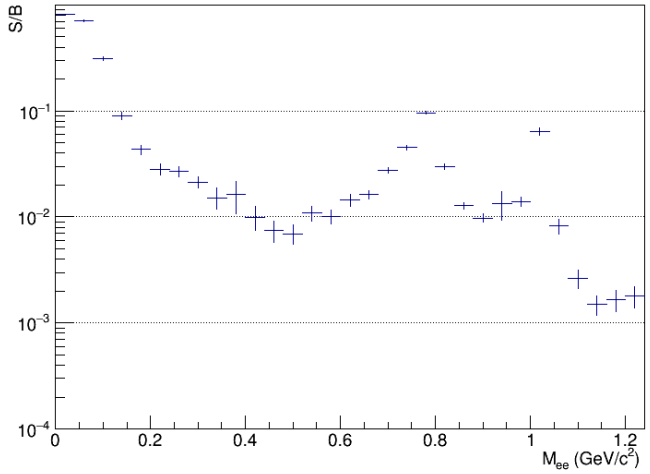
- By limiting acceptance for a primary electron, we indeed improve the S/B ratio but loose statistical significance of the signals
- Is it just effect of lower multiplicity ???

Pair cuts, multiplicity ?

- Compared default variant with the one when every second track is rejected (random selection)

Default (reference) → **Drop every second track**





S/B in 0.2-1.5: 0.026
==========
Omega (s/sqrt(b)): 4.9
Phi (s/sqrt(b)): 2.3
LMR (s/sqrt(b)): 1.2
==========

S/B in 0.2-1.5: 0.018
==========
Omega (s/sqrt(b)): 2.1
Phi (s/sqrt(b)): 1.0
Rho (s/sqrt(b)): 0.49
==========

- Lower multiplicity does not improve S/B and signal significance

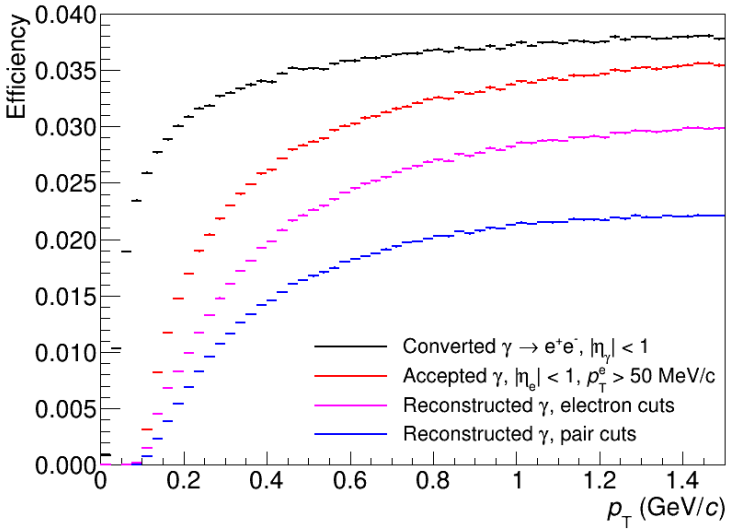
Conclusions

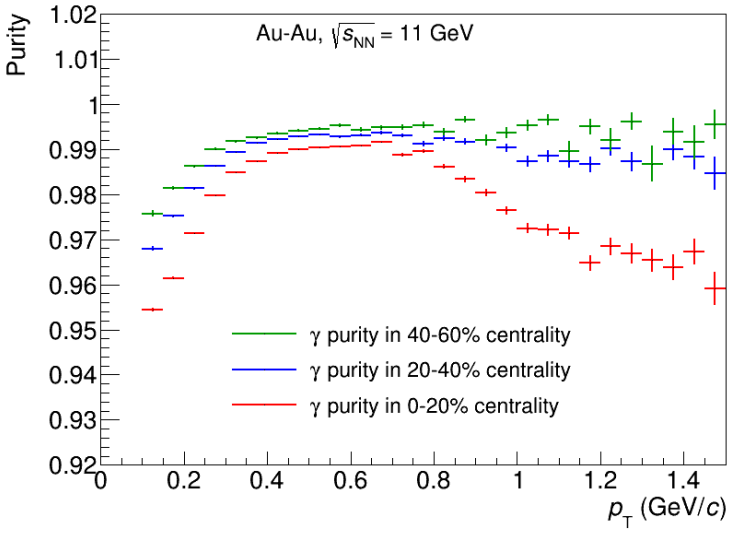
- Loosening the partner selection in electron pair cuts helps to improve S/B and signal significance
- Limiting acceptance for a primary electron helps to improve S/B BUT in the expense of smaller signal significance
- Optimization of cuts is ongoing. S/B of ~ 0.1 with a reasonable penalty for signal significance can be reached

Conversion

Photon efficiency and purity

- Studied with MpdRoot for Stage-1 detector
- MpdParticle to build secondary vertices, cuts optimized to maximize signal significance
- Typical cuts on electrons:
  - ✓ $|\eta|<1$, $p_T > 50$ MeV/c, ≥ 20 hits in TPC, $\pm 4\sigma$ electron PID selections in the TPC/TOF
- Typical cuts on pairs:
  - ✓ small DCA ($\chi 2 < 10$)
  - ✓ vertex R > 10 cm
  - ✓ direction to vertex: $\theta < \exp(-2.777-2.798*p_T) + 0.0175$
  - ✓ Mee$< 0.022 + 0.017*p_T$ [GeV]
  - ✓ ee-pair plane orientation wrt B: ΨPair < 0.1 rad

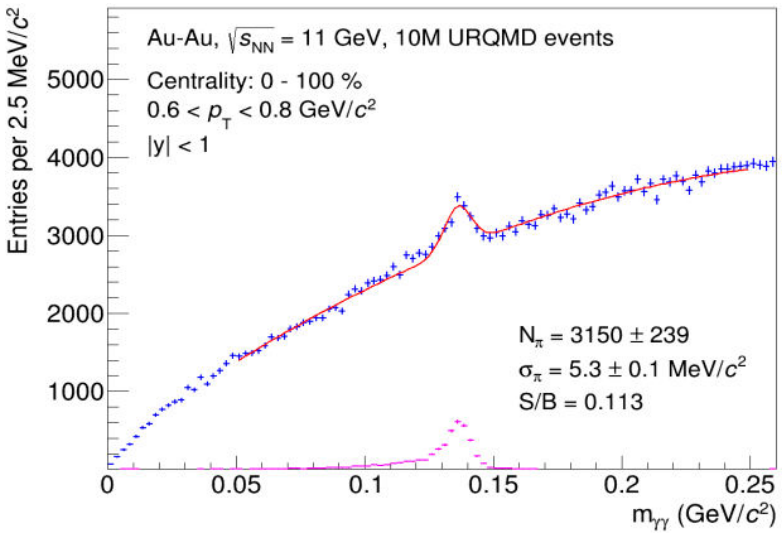


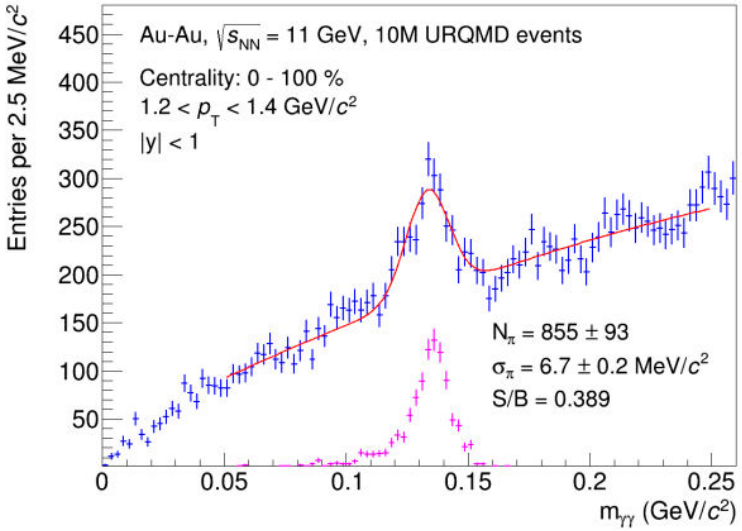


- Photon reconstruction efficiency of $\leq 2\%$ with purity > 95%

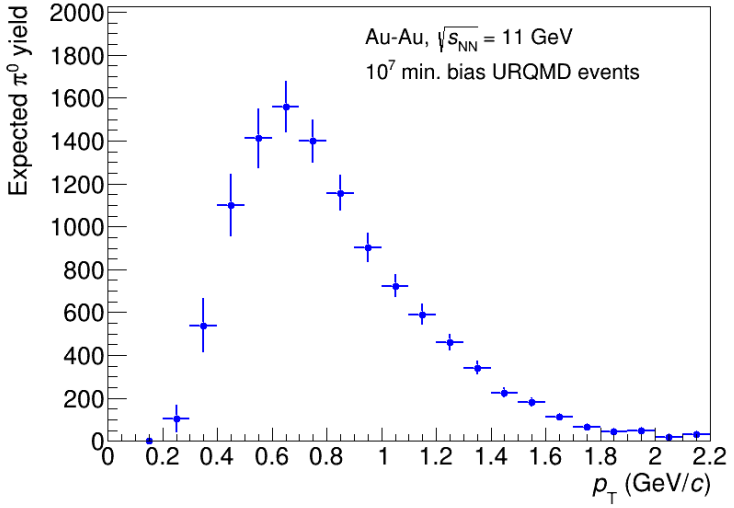
Neutral pions

- 10M minimum bias AuAu@11 URQMD events

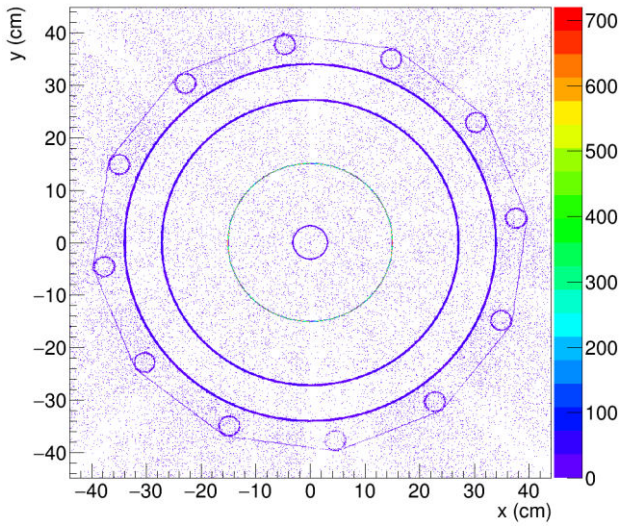


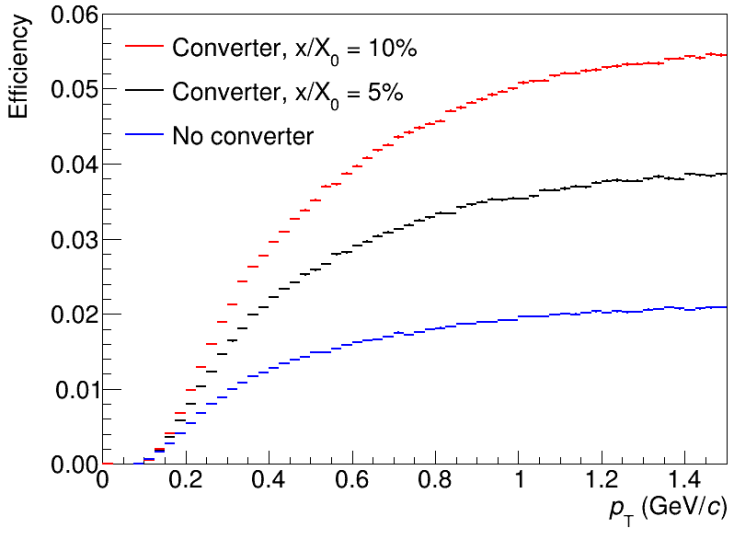


- Due to high photon reconstruction purity the mixed-event background subtraction is not needed
- Pion signal is clearly visible in a wide p_T range → day-1 measurements
- First measurements of η would require a factor of ~ 10 larger data sample



Dedicated photon converter - I

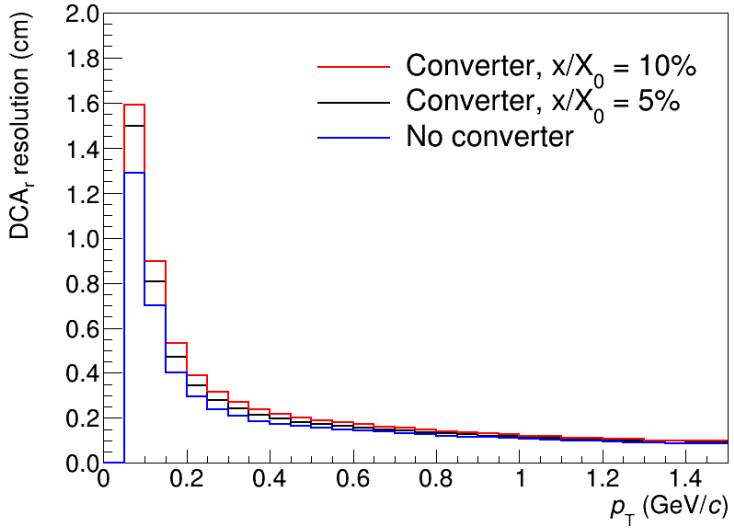


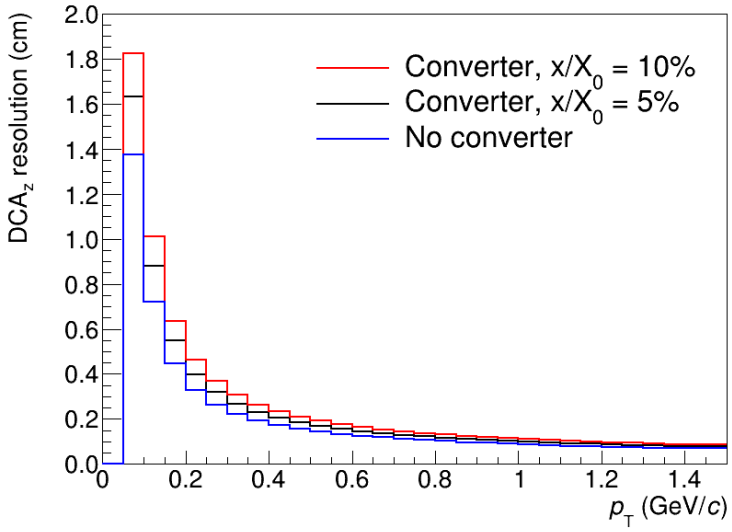


- A dedicated conversion layer under investigation:
  - ✓ cylindrical copper pipe with radius of 15 cm
  - ✓ radiation length: 5% and 10% (0.7 and 1.4 mm)
- Advantages:
  - ✓ photon reconstruction efficiency can be increased by a factor ~3, neutral mesons ~ 10
  - ✓ minimization of systematic uncertainties due to well known material budget
- Disadvantages:
  - ✓ ruins single electron and dielectron measurements
  - ✓ deteriorates hadron measurements ???

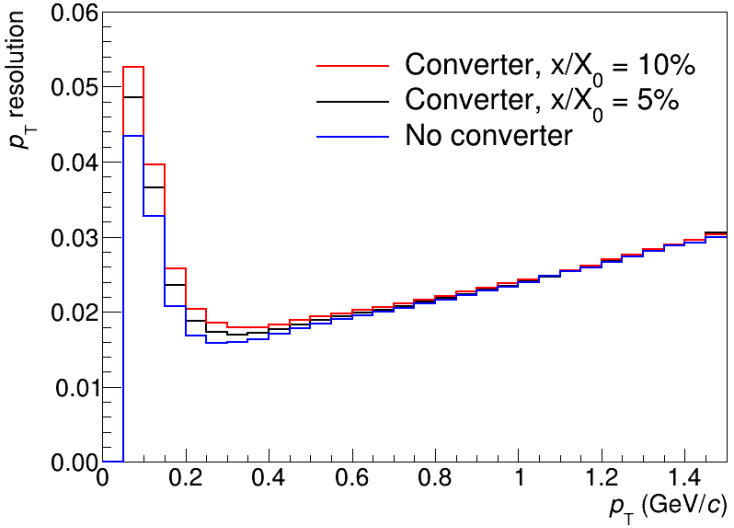
Dedicated photon converter - II

- DCAr and DCAz distributions:



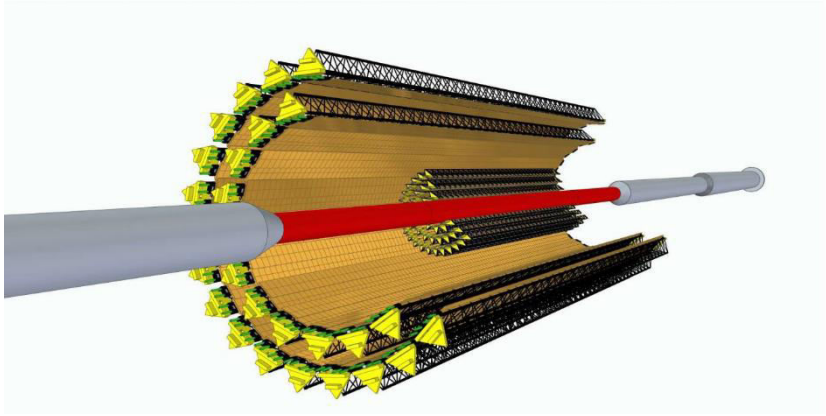


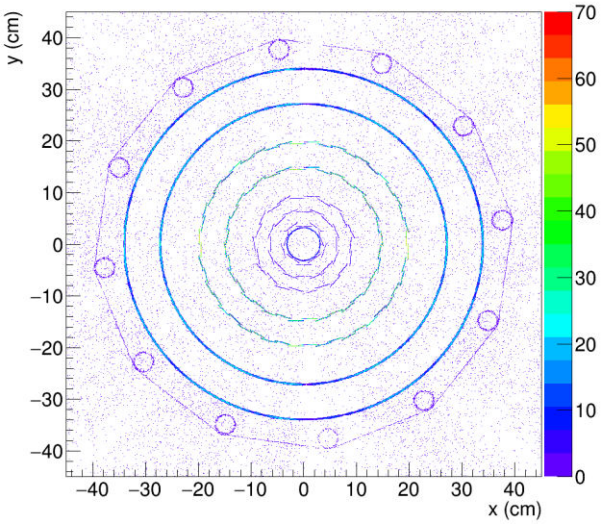
- Momentum resolution:



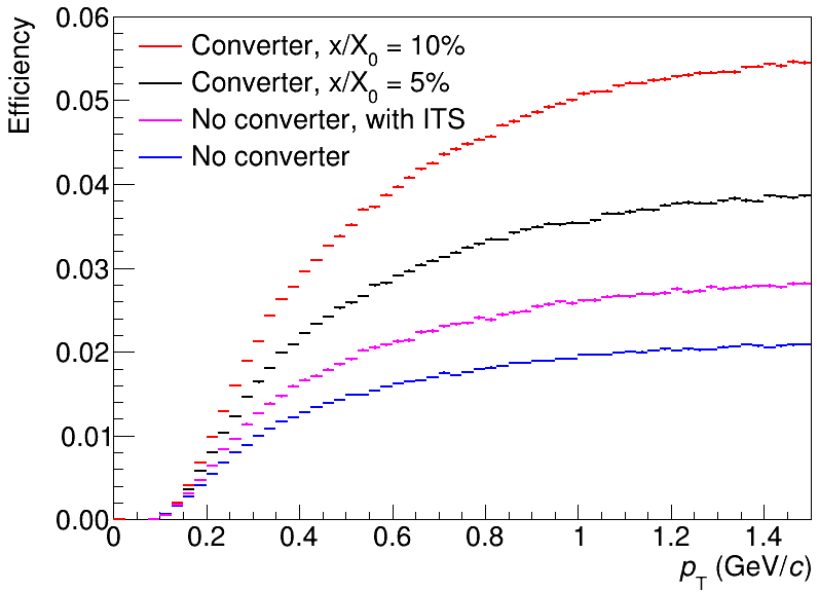
- Marginal decrease in the reconstruction quality of charged particles
- The decrease is noticeable only at low $p_T < 0.5$ GeV/c

Photon conversion in Stage-2





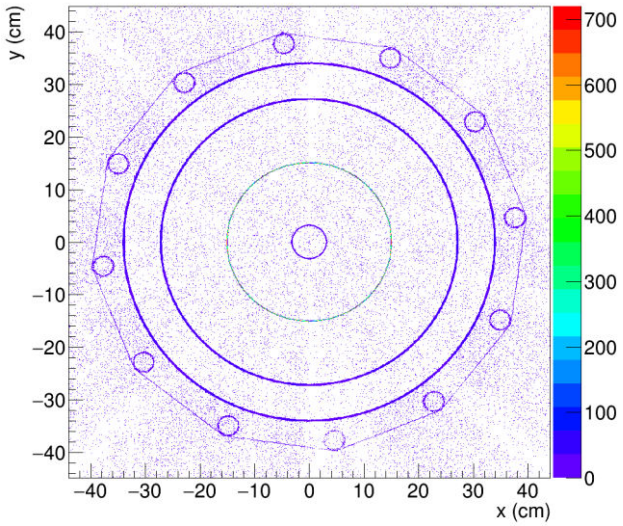
- ITS in Stage-2:
  - ✓ five layers of Monolitic Active Pixel Sensors
  - ✓ ~ 0.4% X_0 in current design
  - ✓ Photon reconstruction efficiency slightly improves compared to Stage-1 setup



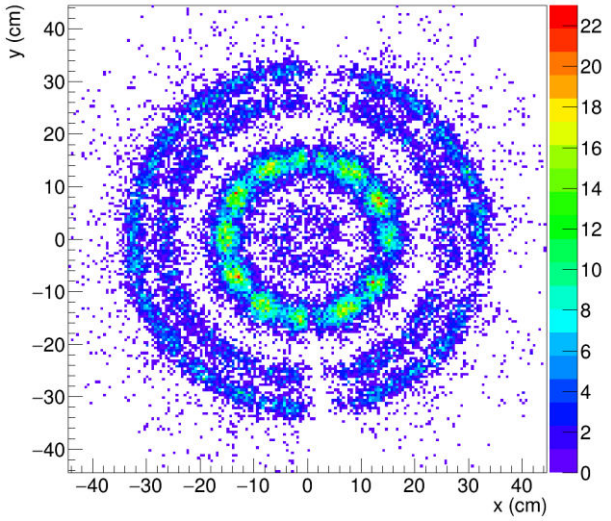
- Photon reconstruction efficiency slightly improves compared to Stage-1 setup

Probing material budget

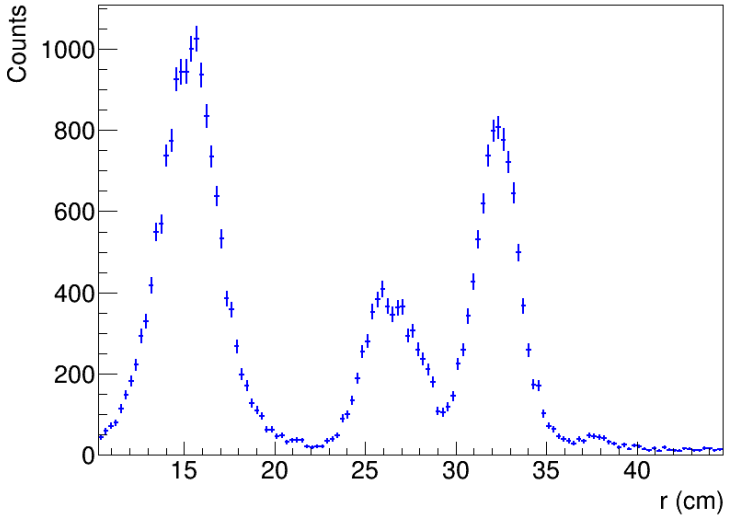
Real detector geometry



Reconstructed conversion centers



- Reconstructed ee-pairs can be used for detector alignment and estimation of the material budget
- Radiation length of the converter is known with high precision and can be used as a reference
- Spatial resolution needs to be improved



Conclusions

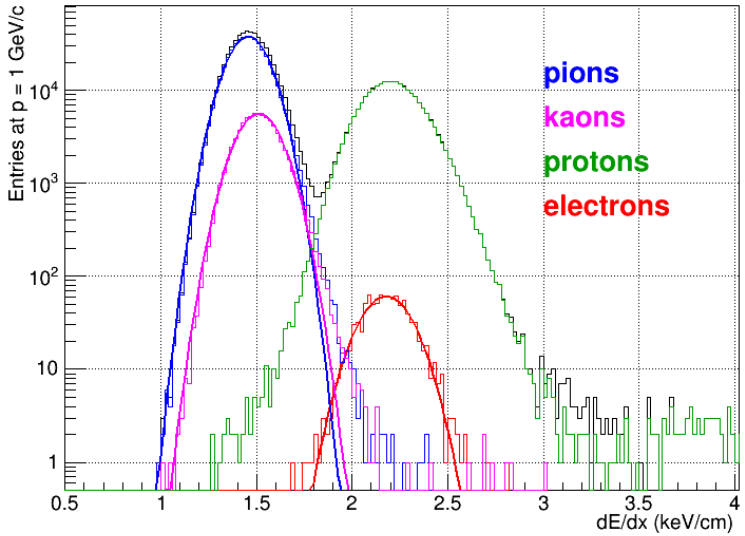
- Photon conversion method is a powerful tool to measure photons and neutral mesons
- Feasibility studies on the dedicated converter and Stage 2 setup show promising results
- Further developments: conversion for precise detector alignment and for estimation of the detector material budget

BACKUP

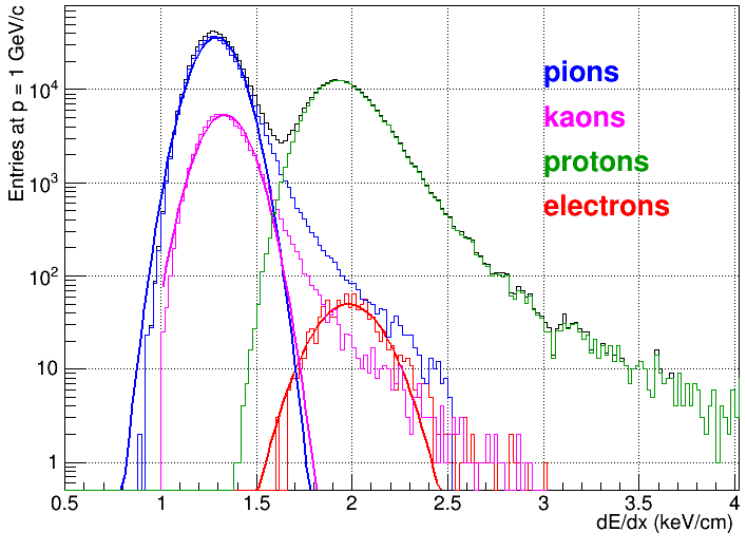
Closer look at dE/dx distributions

- Selected tracks:
  - ✓ hits > 39
  - ✓ $|\eta| < 1$
  - ✓ $|DCA\_x,y,z| < 2.5\ \sigma$
  - ✓ $p_T = 1$ 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