Reconstruction of photons and neutral mesons in heavy-ion collisions with MPD at NICA

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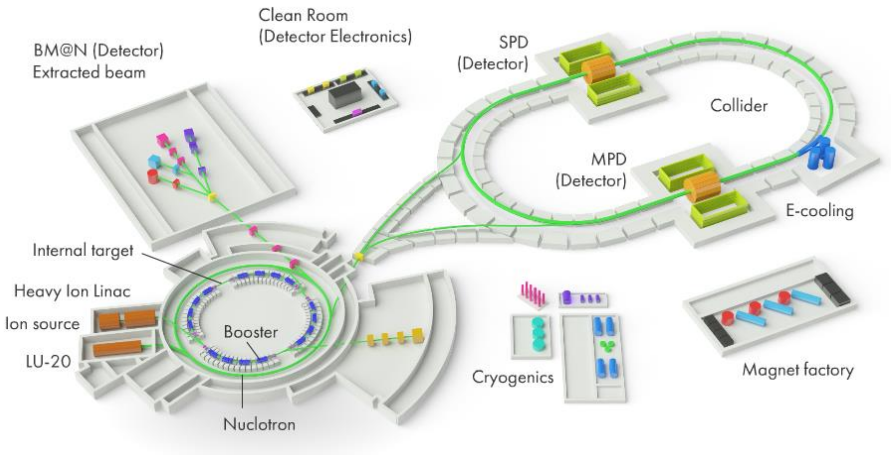
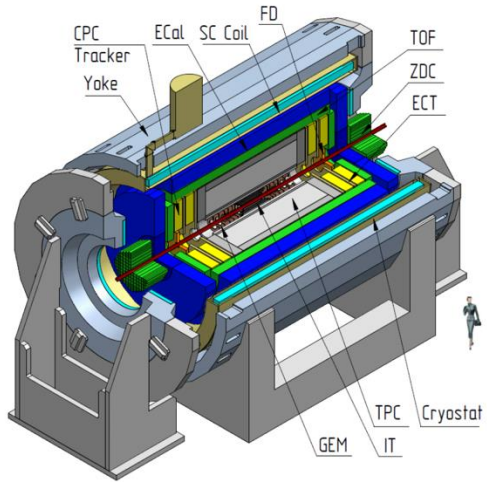
Outline

- NICA-MPD and motivation
- Photon reconstruction
  - Photon identification in ECal (Electromagnetic Calorimeter)
  - Photon reconstruction using the PCM (Photon Conversion Method)
- Neutral meson reconstruction
  - Neutral mesons reconstruction via invariant mass of two photons
  - Centrality dependence of p_T spectra
  - Comparison of reconstructed and generated neutral mesons
- Summary

NICA-MPD and motivation

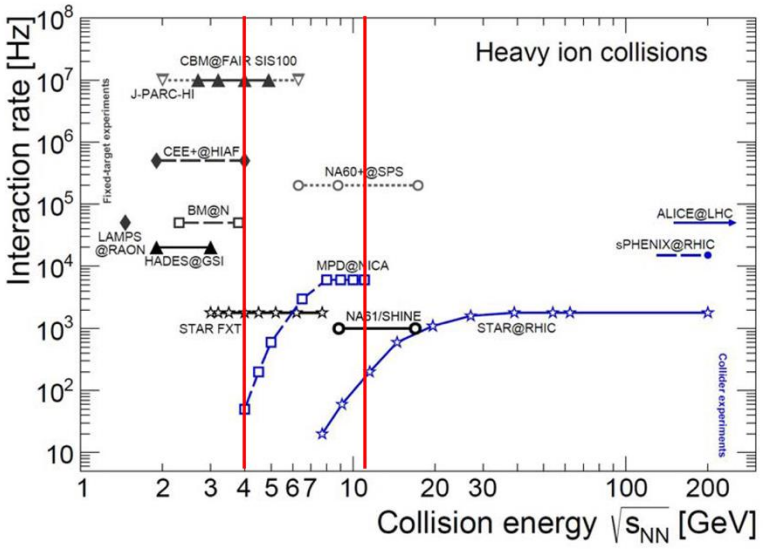


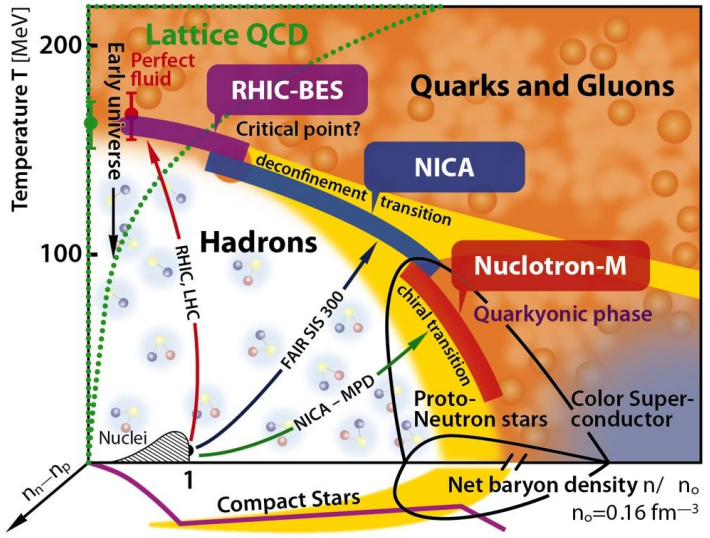
NICA complex



MPD detector

With heavy-ion collisions in the energy range $\sqrt{s_{NN}}$ = 4-11 GeV, the NICA-MPD will scan the baryon-reach region of the QCD phase diagram to look for the first order phase transition and critical end-point.





https://nica.jinr.ru/physics.php

Phase diagram

Use 50M UrQMD BiBi @ 9.2 GeV events to study detector performance for the measurement of photons and neutral mesons (π^0 and η).

Event cut: Primary vertex of event reconstructed and vertex_z cut < |100| cm.

Photon identification in ECal

1、number of towers in the shower/cluster >=2

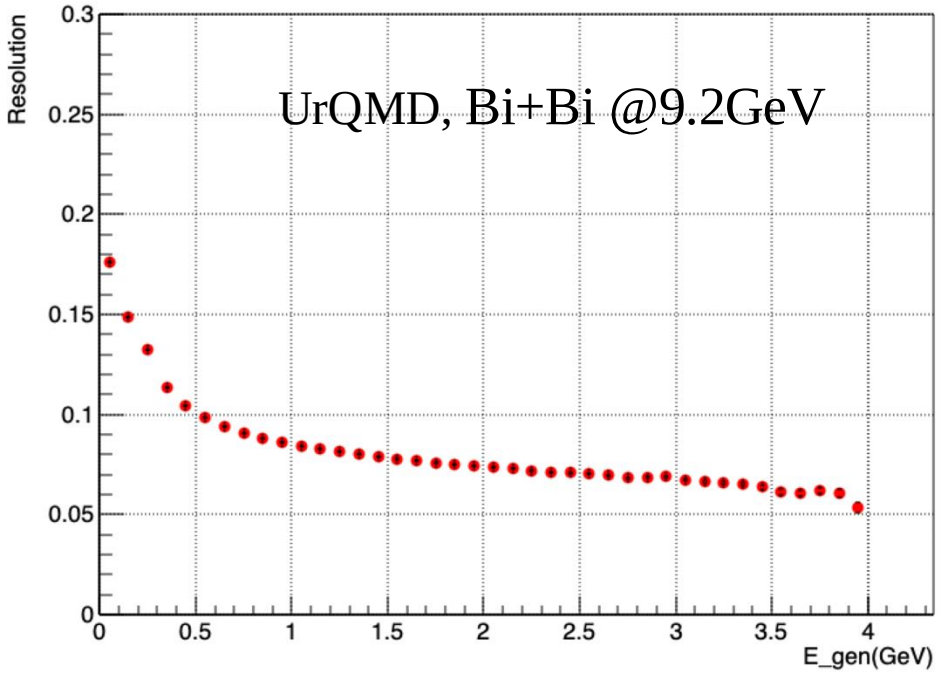
2、reconstructed energy>=75MeV

3、Chi2<=4(This variable says how close the cluster shape to the one expected for electromagnetic shower.)

4、tof<2ns(tof of the cluster, assumed ECAL time resolution dt = 0.5 ns)

5、optional charged particle veto cut (no matching to tracks reconstructed in the TPC and extrapolated to the ECAL within 10 cm) for systematic study

Photon's Energy Resolution



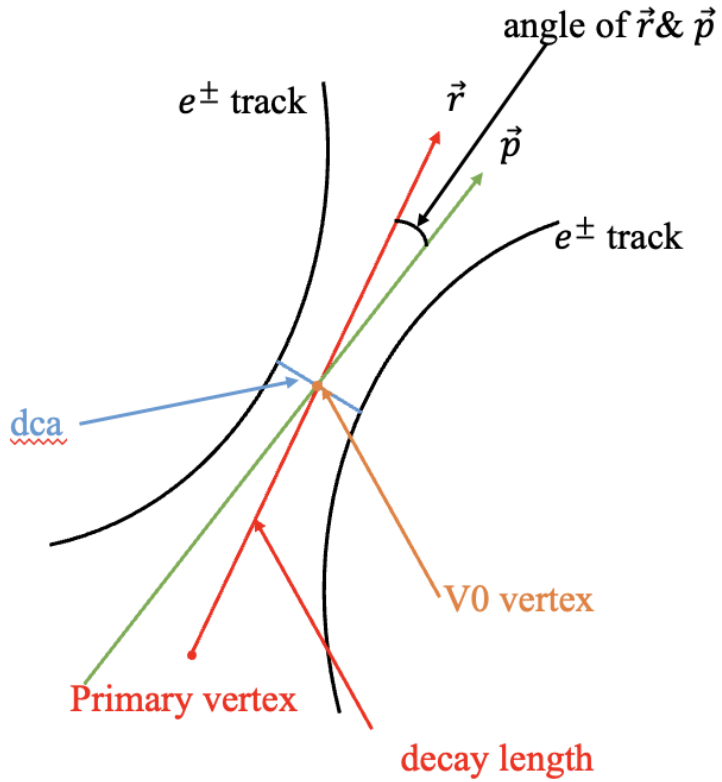
Photon reconstruction using PCM

The cuts of single $e^+(e^-)$ track for PCM:

1、nhit>10 in TPC

2、p_T > 50 MeV/c

3、TPC 2-sigma e-ID or TPC 2-sigma eID + 3-sigma TOF e-ID in case of track matching to the TOF



e^+e^- pair's variables for PCM:

1、dca: distance of closest approach for e^+e^- tracks

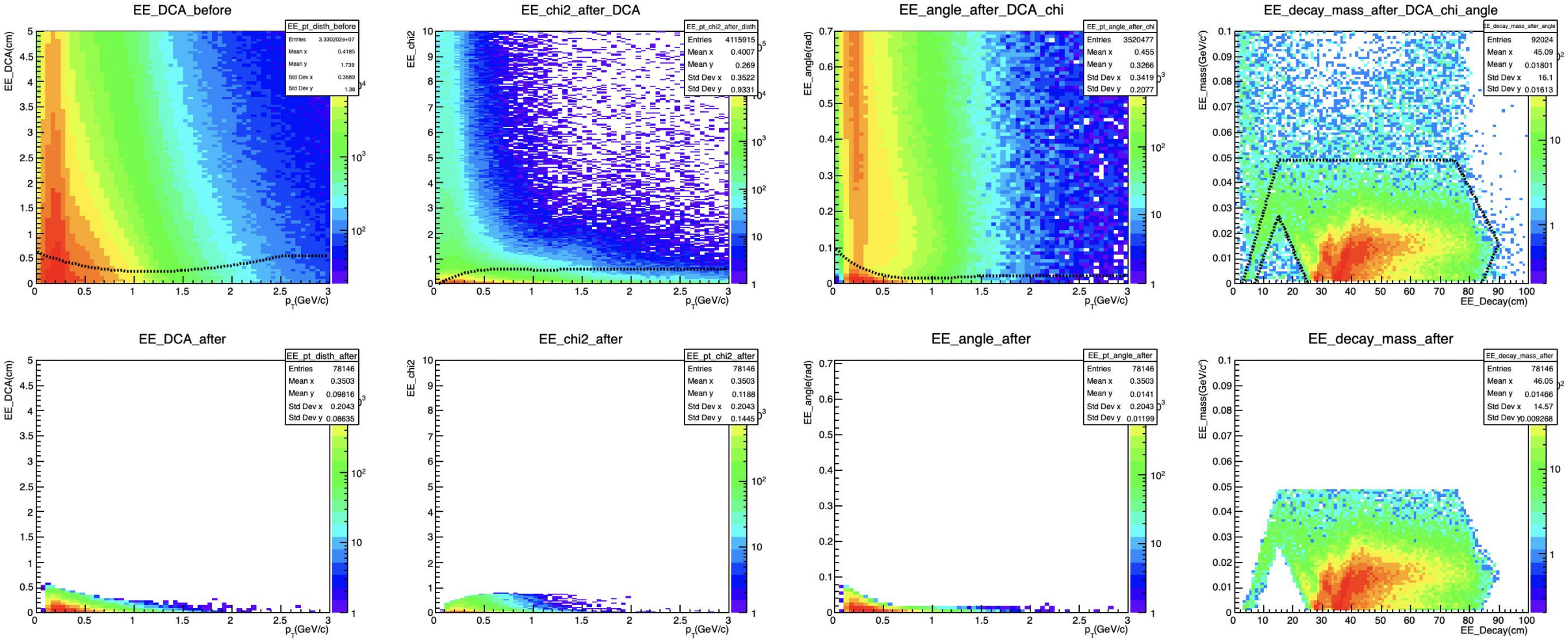
2、Chi2: quality of the secondary vertex reconstruction

3、angle: between $\vec{r}$ & $\vec{p}$

4、decay length: the distance from primary vertex to V0 vertex

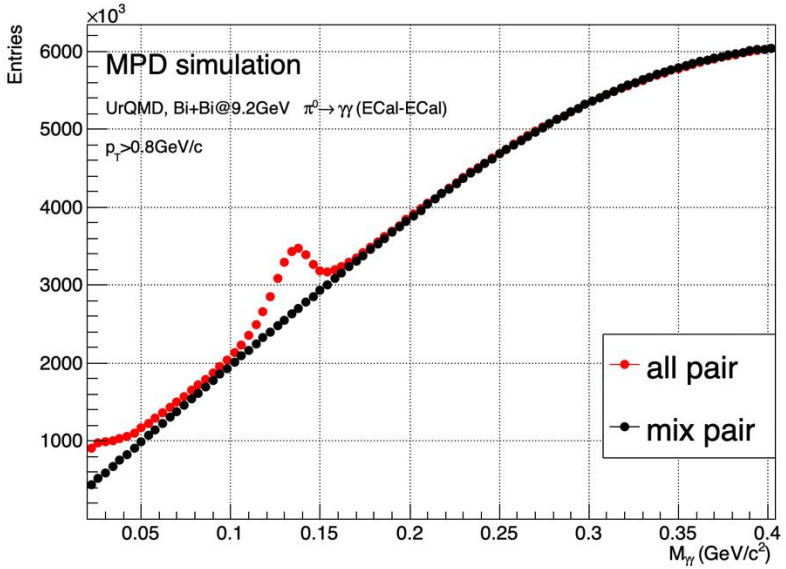
5、mass: the mass of mother particle of e^+e^- pair

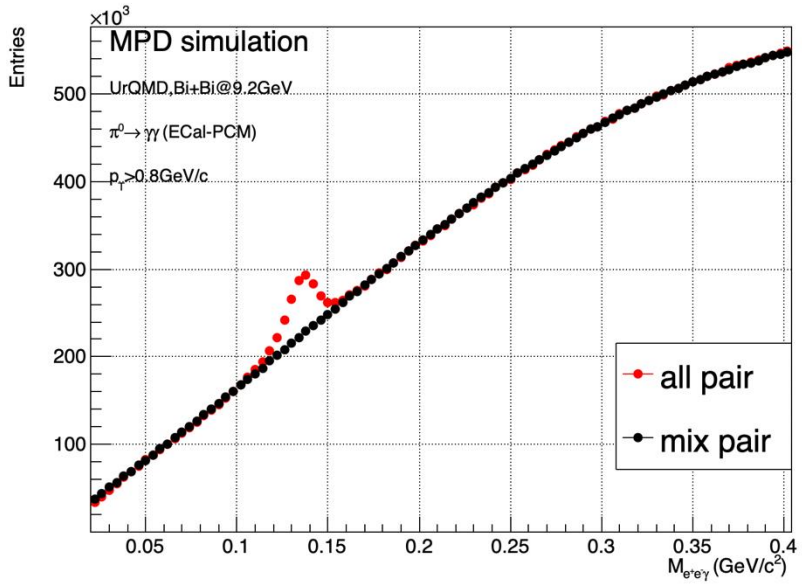
e^+e^- pairs selection for PCM

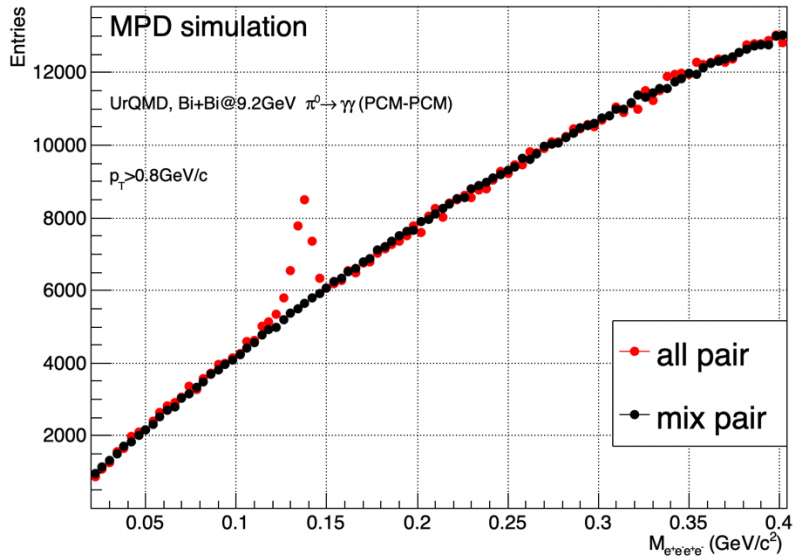


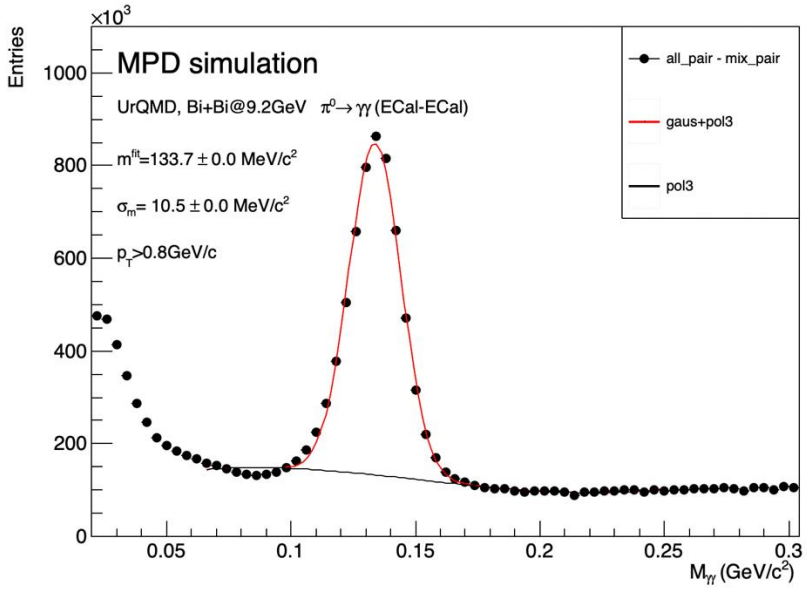
The upper are distributions of true conversion e^+e^- pairs.
The black dotted curves as 2*sigma selection, where sigma is either a Gaussian width (for distributions with Gaussian shape) or a range, which accounts for 65% of the total signal (2*sigma accounts for ~ 95% of the total signal).

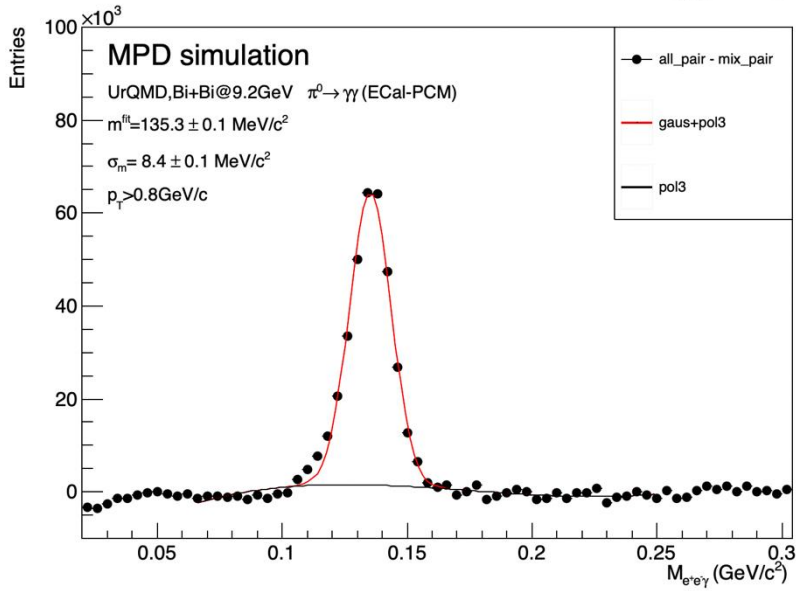
π^0 reconstruction via invariant mass of two photons

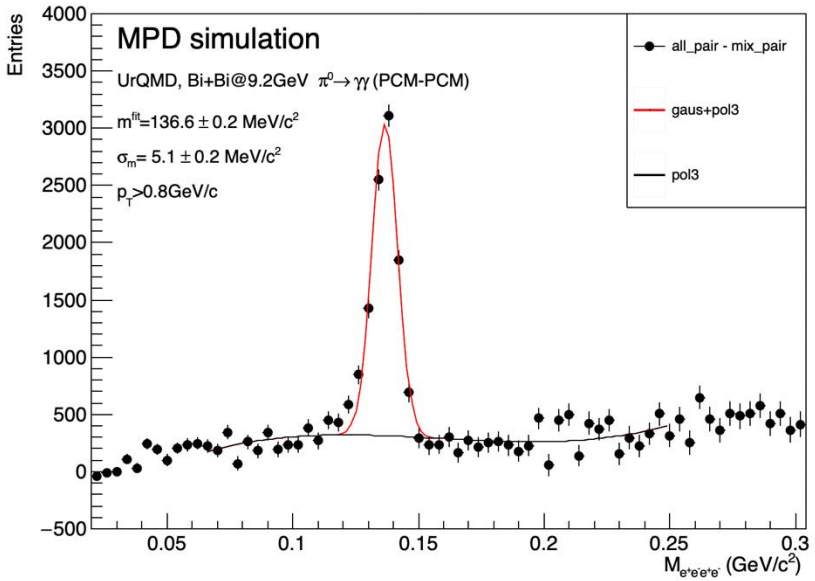






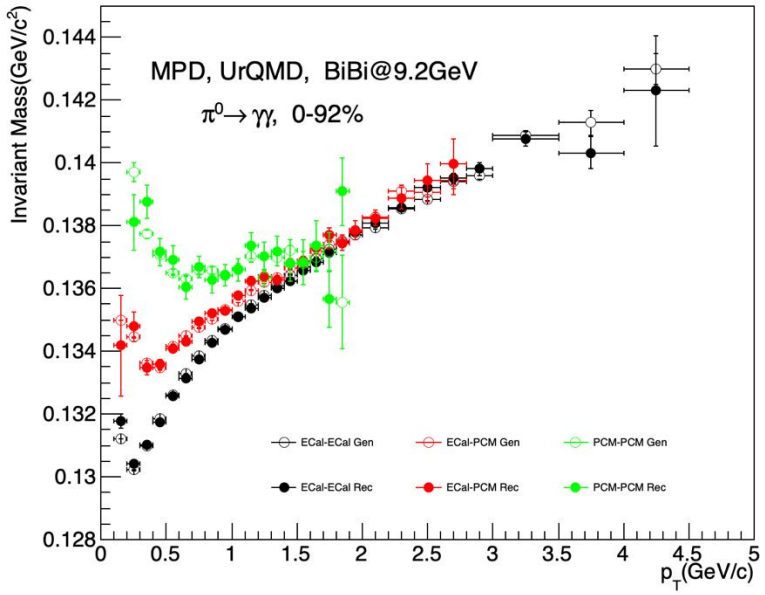


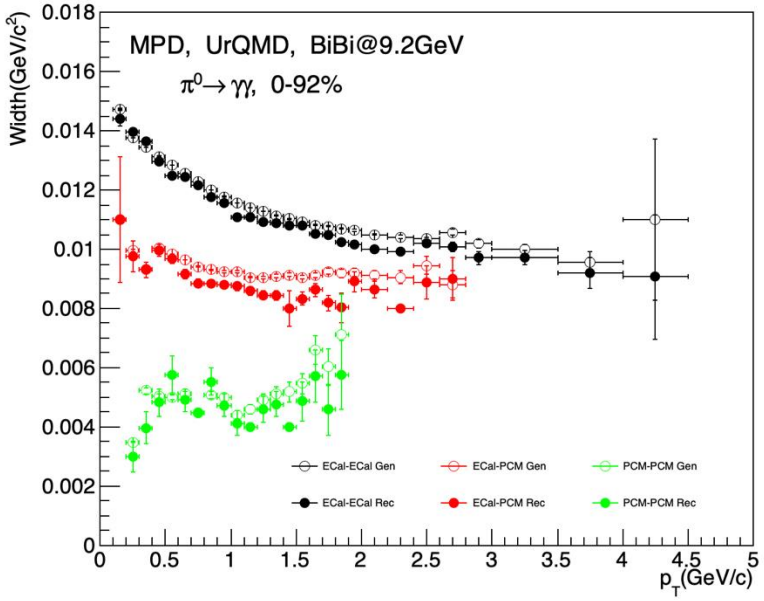


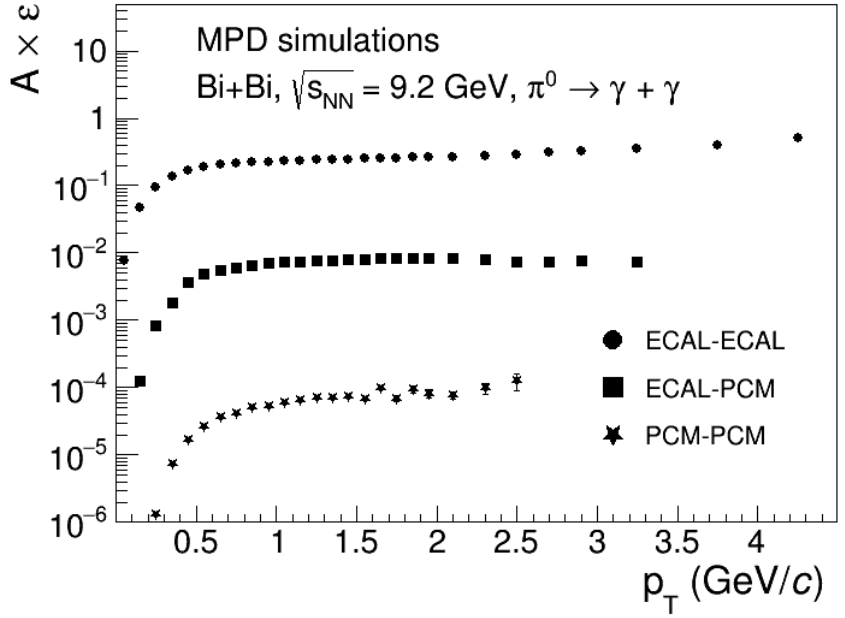


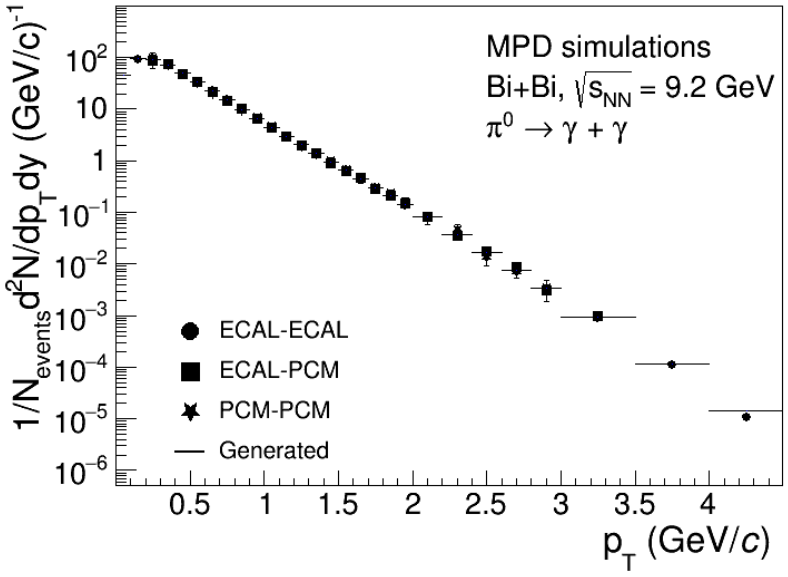
A clear excess is visible in distributions close to the nominal meson mass of 135 MeV/c^2 for the π^0.

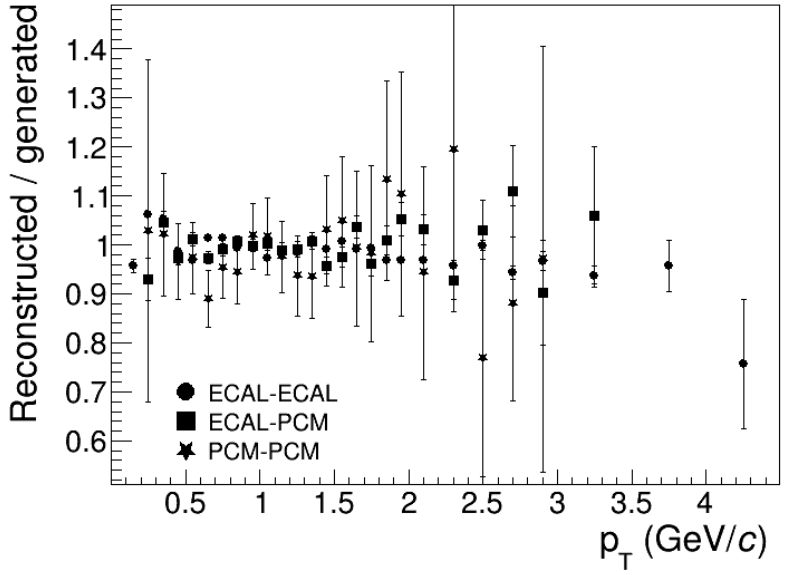
Comparison of reconstructed and generated π^0







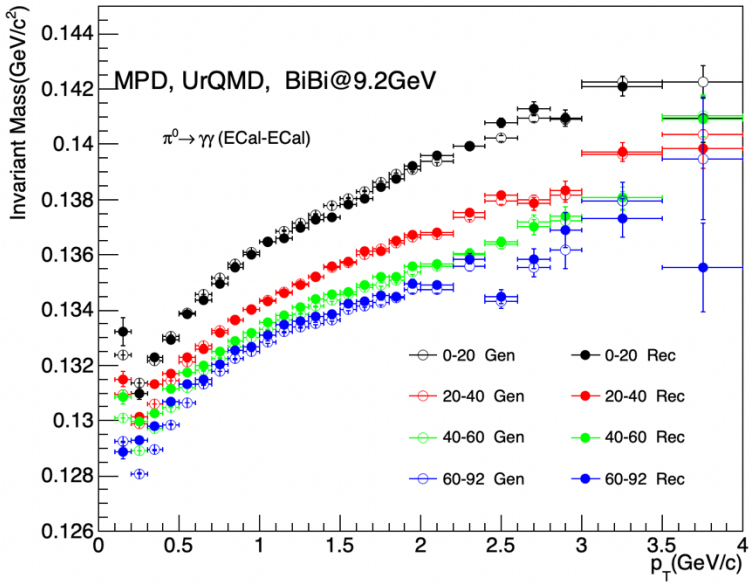


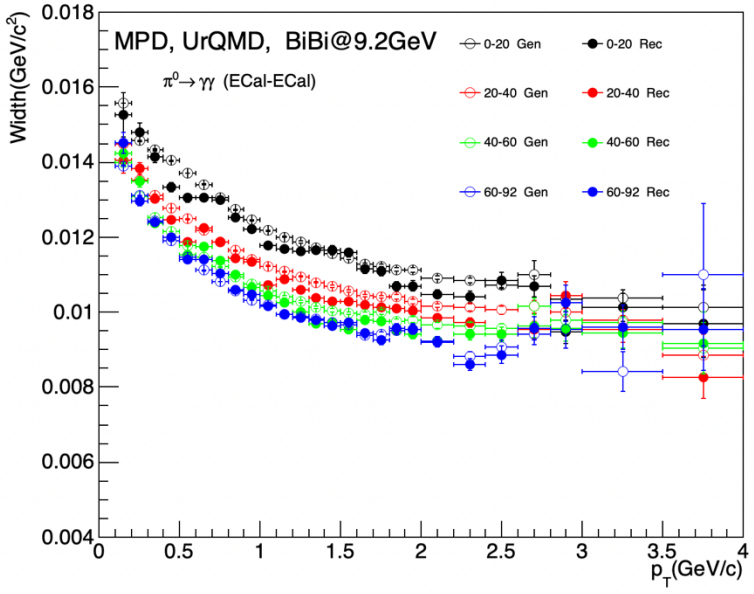


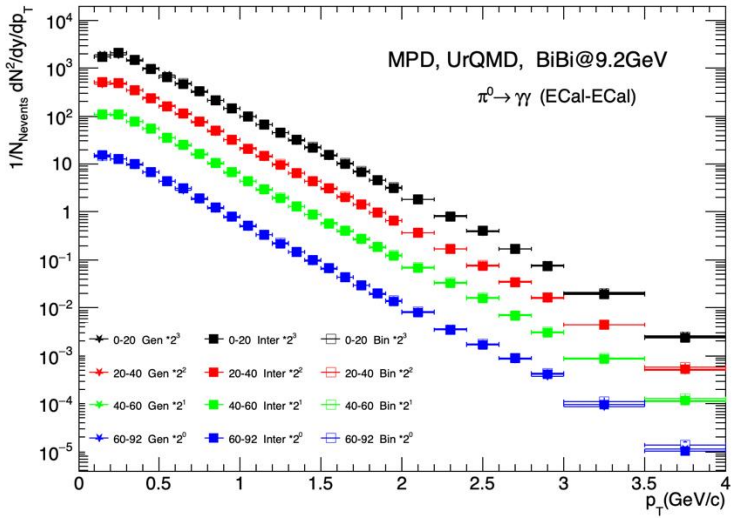
Measurements for π^0 are possible starting from p_T ~ 100 MeV/c in a wide rapidity range |y|<1.

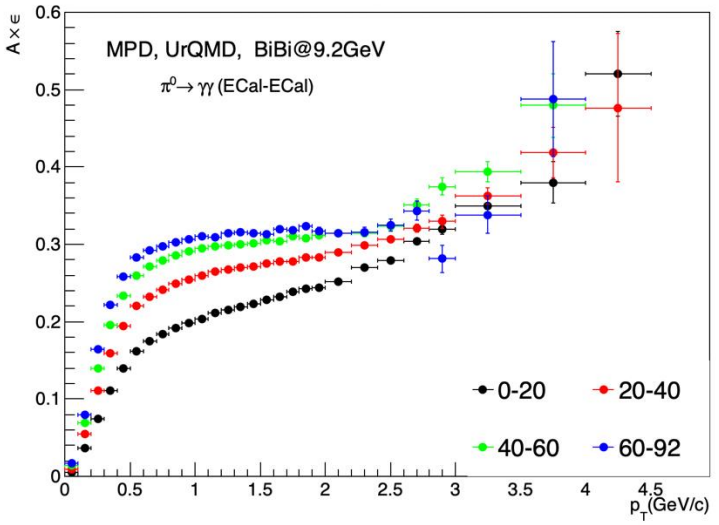
The corrected yields obtained by three methods for π^0 are consistent with truly generated.

Centrality dependence of π^0 in ECal-ECal





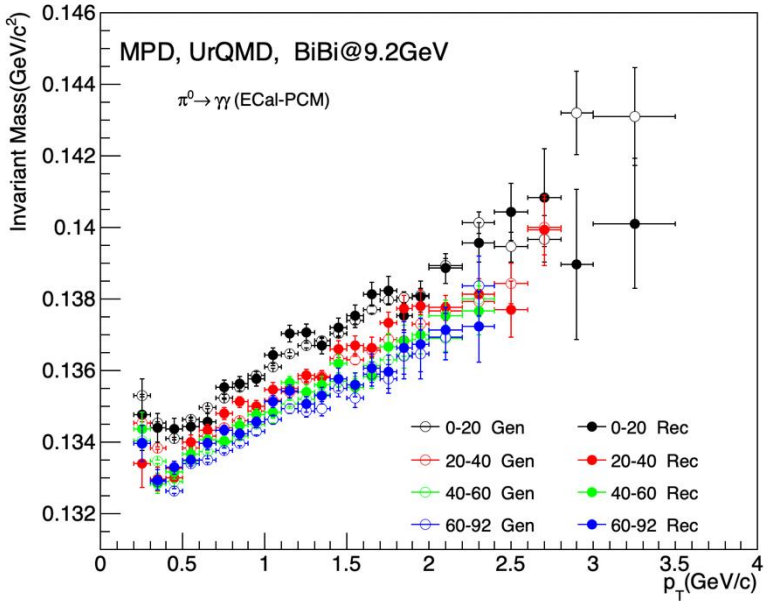


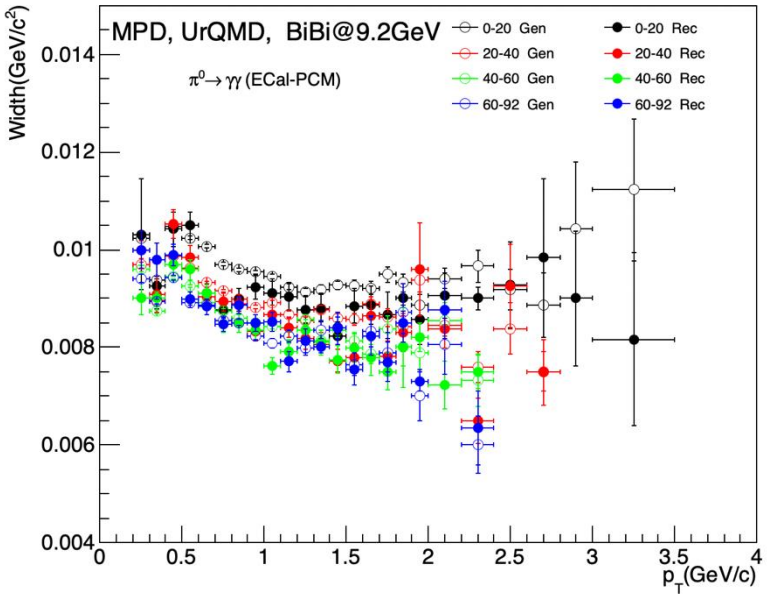


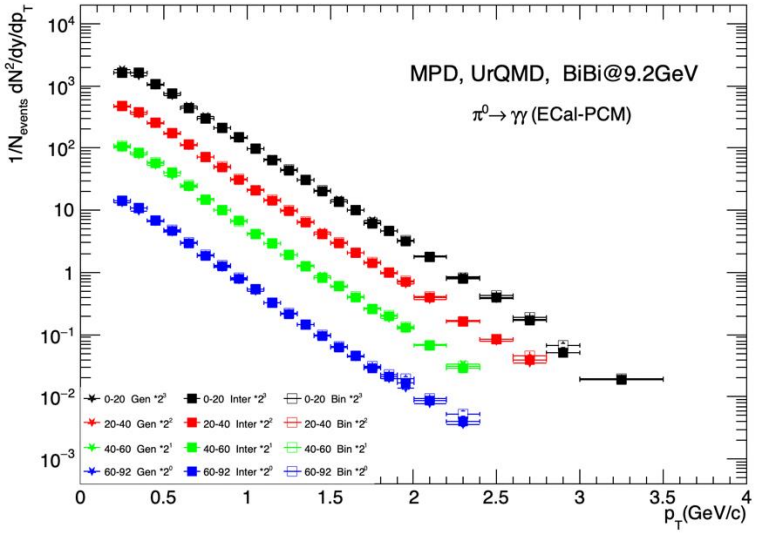
Centrality dependence of the peak mass/width and reconstruction efficiency is observed.

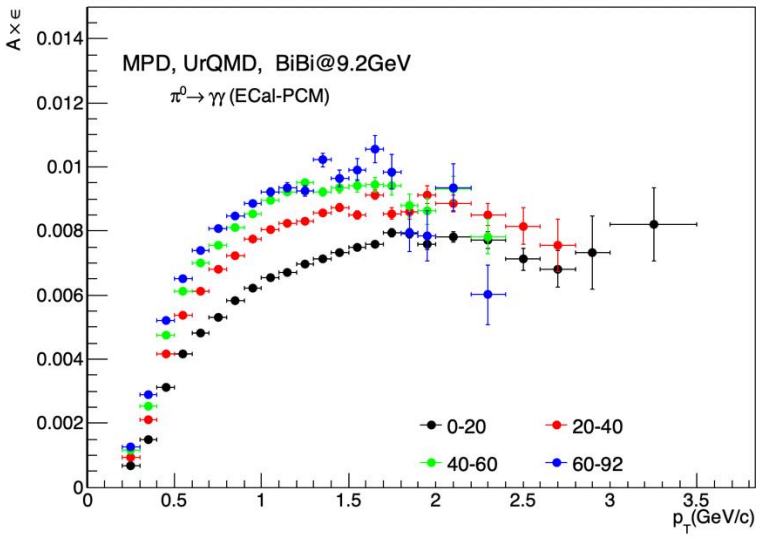
The corrected yields for π^0 are consistent with truly generated ones in each centrality interval.

Centrality dependence of π^0 in ECal-PCM





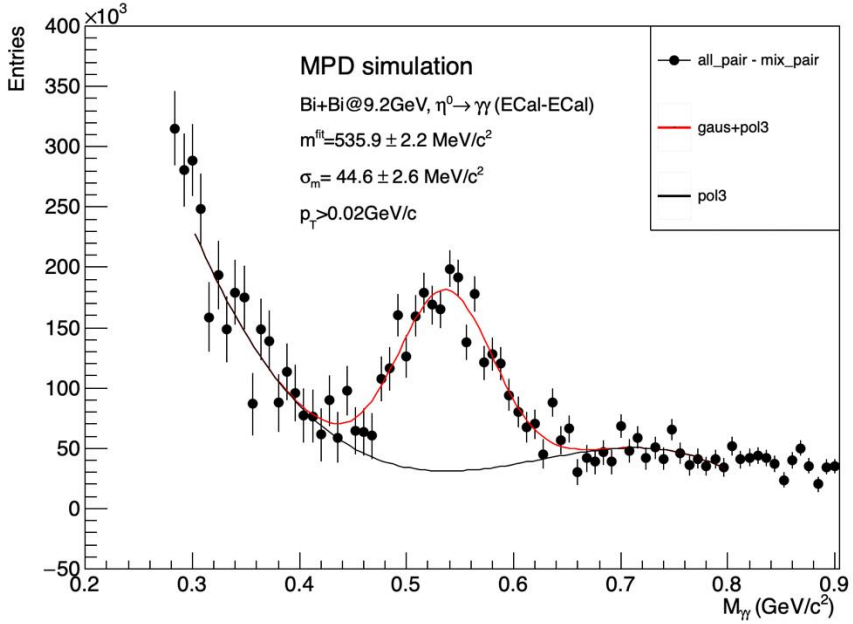


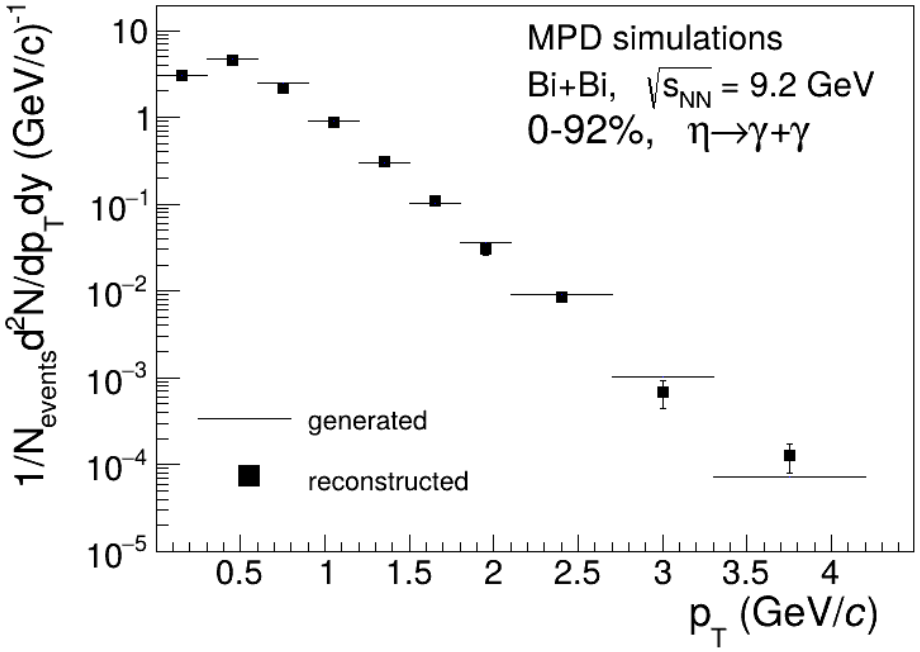


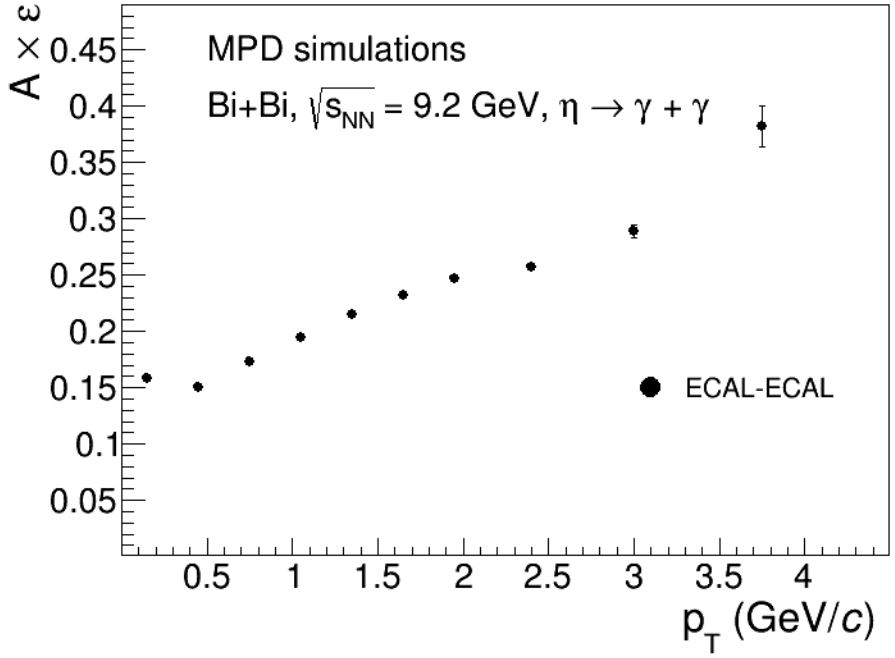
Centrality dependence of the peak mass/width and reconstruction efficiency is observed.

The corrected yields for π^0 are close to truly generated ones in each centrality interval.

η reconstruction via invariant mass of two photons







A clear excess is visible in distributions close to the nominal meson mass of 548 MeV/c^2 for the η.

The reconstructed results are consistent with the truly generated for η.

Summary

- Developed two methods for photon reconstruction: ECAL and PCM.
- With 50M Bi+Bi collisions at $\sqrt{s_{NN}}$=9.2 GeV:
  - reconstruct centrality dependent π^0 production with ECAL-ECAL and ECAL-PCM selections; PCM-PCM lacks statistics due to low efficiency
  - reconstruct η production in minbias collisions
- Reconstructed π^0 and η yields are consistent with truly generated signals.

Summary

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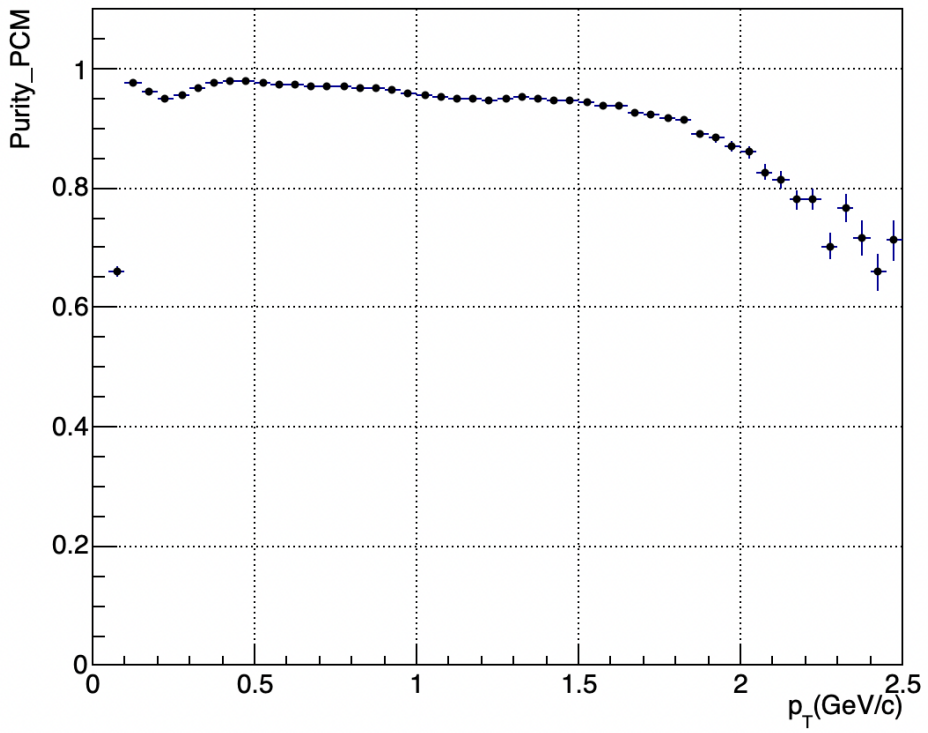
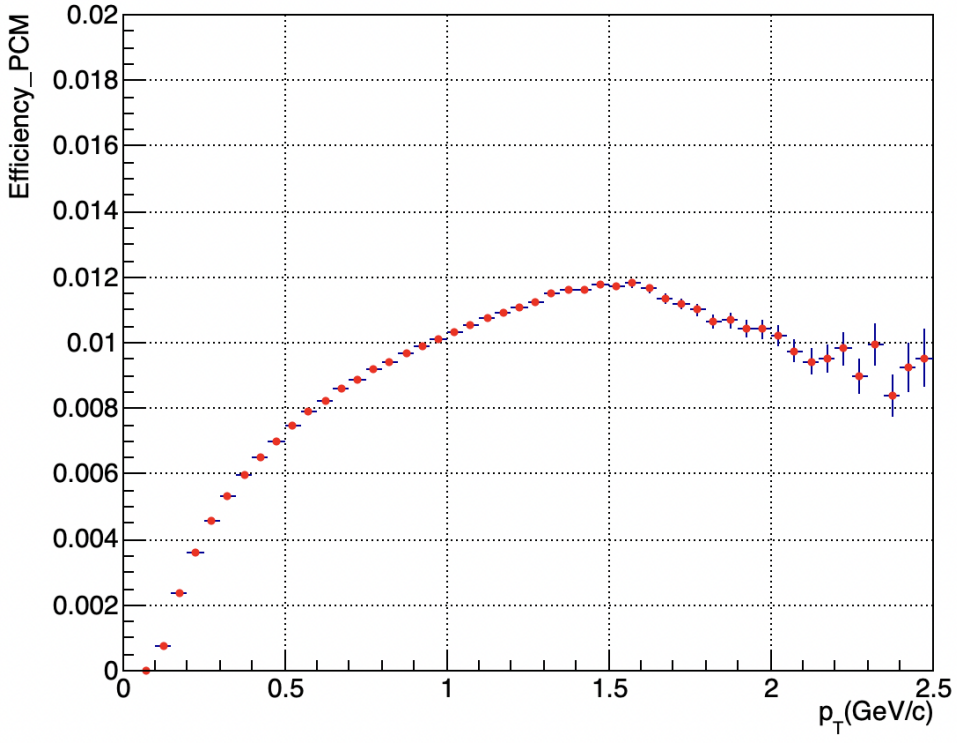
Thanks for your attention!

Backup

Photon purity and efficiency in PCM





$$\text{Purity} = \frac{\text{The number of } e^+e^- \text{pairs from photons after cut}}{\text{The number of } e^+e^- \text{pairs after cut}}$$

$$\text{Efficiency} = \frac{\text{The number of } e^+e^- \text{pairs from photons after cut}}{\text{The number of true photon(MC photon)}}$$

The photon purity obtained by PCM is higher than 80% at p_T < 2GeV/c.