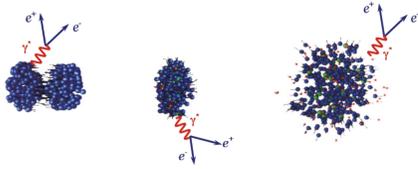


# Reconstruction of $\pi^0$ mesons via conversion method in Au+Au at 1.23 GeV/u with HADES

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## Motivation



Au+Au collision at 1 GeV/u simulated with UrQMD. Three stages of the heavy-ion collision are shown. Lepton pairs are emitted at all stages of a heavy-ion collision.

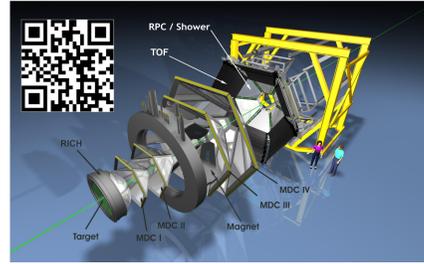
Dominant sources are:

- First-chance NN collisions: Baryonic sources ( $N^* + \Delta$  Dalitz decays), NN Bremsstrahlung
- Hot and dense stage: In-medium spectral functions?
- Freeze-out: Long-lived mesons  $\pi^0, \eta, \omega$

Goal: Understand all stages of a heavy-ion collision

Understanding the freeze-out stage with reconstruction of the  $\pi^0$

## HADES Gold Beam



The HADES detector:

- Installed at the SIS 18 (GSI Helmholtzzentrum für Schwerionenforschung, Germany)
- 6 identical sectors surrounding the beam axis
- Full azimuthal angle, polar angle  $18^\circ - 85^\circ$
- Diamond START detector
- Ring Imaging Cherenkov detector (RICH)
- 4x6 Multiwire Drift Chambers (MDC)
- Superconducting toroidal magnet
- Time-of-flight walls (TOF and RPC)

Gold Beam Time:

- Au beam  $E_{kin} = 1.23$  GeV/u
- Au target, segmented geometry to suppress leptons from  $\gamma$  conversion
- Impact parameter  $b_{max} < 9$  fm
- High Multiplicity Trigger selection: Mult (TOF)  $> 20$
- $2.1 \cdot 10^9$  events used

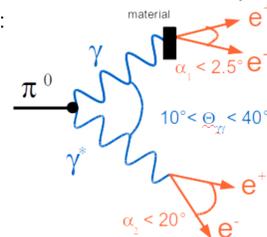
## Analysis Method

Dominant leptonic decay channels of  $\pi^0$ :

- $\pi^0 \rightarrow \gamma\gamma \xrightarrow{conv} e^+e^-e^+e^-$  (BR $_{\pi^0 \rightarrow \gamma\gamma}$ : 98.82% [1])
- $\pi^0 \rightarrow \gamma e^+e^- \xrightarrow{conv} e^+e^-e^+e^-$  (BR $_{\pi^0 \rightarrow \gamma e^+e^-}$ : 1.17% [1])

Reconstruction Steps:

- Lepton identification:
  - $p < 500$  MeV/c
  - $p$  dependent  $\beta$  cut
- Reconstruction of  $\pi^0$  via topological cuts:

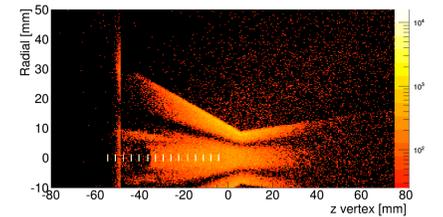


Background estimation:

- Dominant background channel: 2  $\gamma$  from different  $\pi^0$ 
  - Uncorrelated background
- Using event mixing technique with reconstructed photons, consider their kinematics

Conversion probability:

- Conversion probability estimated using Geant3 simulations of  $\gamma$  coming from the decays of  $\pi^0$
  - Only photons converting in the inner parts of the spectrometer<sup>a</sup> can be reconstructed.
- The conversion probability is  $conv_\gamma = 1.6\%$



Efficiency and acceptance estimation:

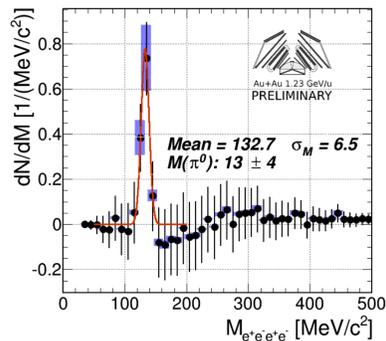
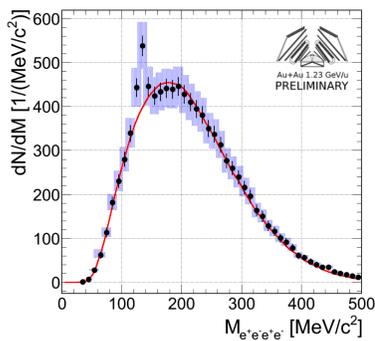
- Simulation of  $10^{11}$   $\pi^0$  with Pluto Event Generator (T1: 39 MeV, T2: 79 MeV) [2]
- Propagation through detector geometry  $\rightarrow \epsilon_{Acc} \cdot conv_\gamma$
- Tracking and event selection like in measured data  $\rightarrow \epsilon_{reco}^{4e}$
- Identification of leptons,  $\gamma$  and  $\pi^0 \rightarrow \epsilon_{PID}$

$$\epsilon_{tot} = \epsilon_{Acc} \cdot conv_\gamma^2 \cdot \epsilon_{reco}^{4e} \cdot \epsilon_{PID} = 2.2\% \cdot 1.6\%^2 \cdot 3.5\% \cdot 45\% = 8.94 \cdot 10^{-8}$$

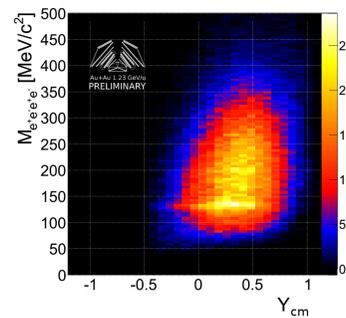
<sup>a</sup> target, target-holder, beam-pipe and RICH radiator gas

## $\pi^0$ Signal

- Spectrum after subtraction is corrected with  $\epsilon_{tot}$  and normalized to the number of analyzed events
- Integration of the spectra in the  $2\sigma$  range gives  $M(\pi^0): 13 \pm 4$   $\pi^0$  per event
- Comparable with the result of charged  $\pi$  from FOPI  $M(\pi^\pm): 10.4$  [3]



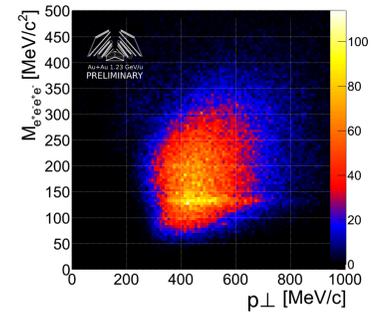
## Phase space coverage of $\pi^0$



Rapidity coverage:

- Forward rapidity well covered up to a value  $y_{cm} = 1$ .
- Mid rapidity coverage ( $Y_{mid} = 0.74$ ) is feasible as well
- Backward rapidity analysis is barely possible.

Coverage:  $0 < Y_{cm} < 1$

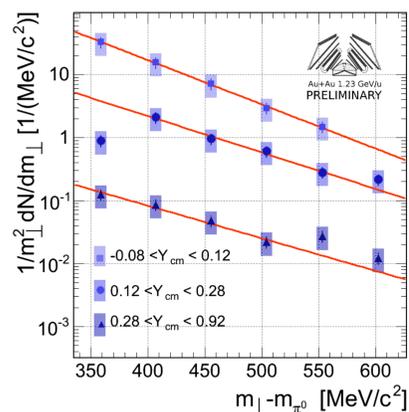


Transverse Momentum coverage:

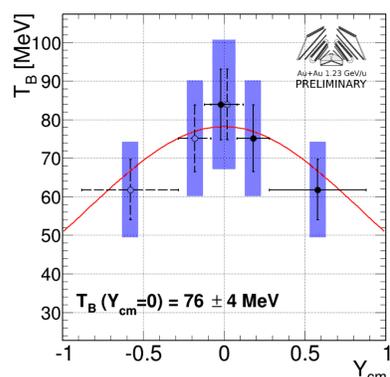
- $\pi^0$  with a low momenta are not covered due to the acceptance of the decay products ( $e^+, e^-$ ) in HADES

Coverage:  $300 \text{ MeV}/c < p_\perp < 650 \text{ MeV}/c$

## Yields of $\pi^0$ as a function of $m_\perp - m_{\pi^0}$



- Results are mirrored with respect to mid-rapidity.
- Resulting slopes can be fitted with a 1./coshy distribution
- Inverse slope parameter at mid-rapidity  $T_B$  ( $Y_{cm} = 0$ ):  $76 \pm 4$  MeV

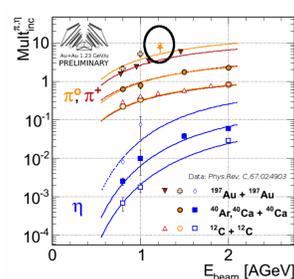


- The efficiency corrected differential yields, together with Boltzmann fits
- Single slope fit can describe the data

## Summary & Outlook

Summary

- Reconstruction of  $\pi^0$  via 2 $\gamma$  conversion
- Number of  $\pi^0$  per event  $M(\pi^0) 13 \pm 4$
- Phase space coverage of signal
  - $0.0 < Y_{cm} < 1.0$
  - $300 \text{ MeV}/c < p_\perp < 650 \text{ MeV}/c$
- Reconstructed inverse slope  $T_B$  ( $Y_{cm} = 0$ ):  $76 \pm 4$  MeV

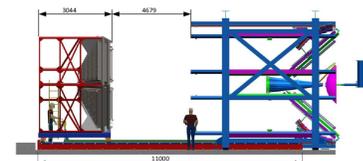


Outlook

- $A_{part}$  dependent analysis of  $\pi^0$
- No data for  $M(\eta)$  in Au+Au above 1 GeV/c
- Measure  $M(\eta)$  with same method
- Compare the resulting cross sections with the results from dilepton analysis

Future

- EM Calorimeter will be added for SIS100, FAIR



## References

- [1] *Pdg. Phys. Rev.*, D86, 2012.
- [2] *PoS*, ACAT2007:076, 2007.
- [3] *Nucl. Phys.*, A781:459–508, 2007.

## Contact



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