Measurement of Neutral Pions via their $e^+e^-\gamma$ Decay in p-Pb Collisions at $\sqrt{s_{NN}} = 5.02$ TeV with ALICE at the LHC

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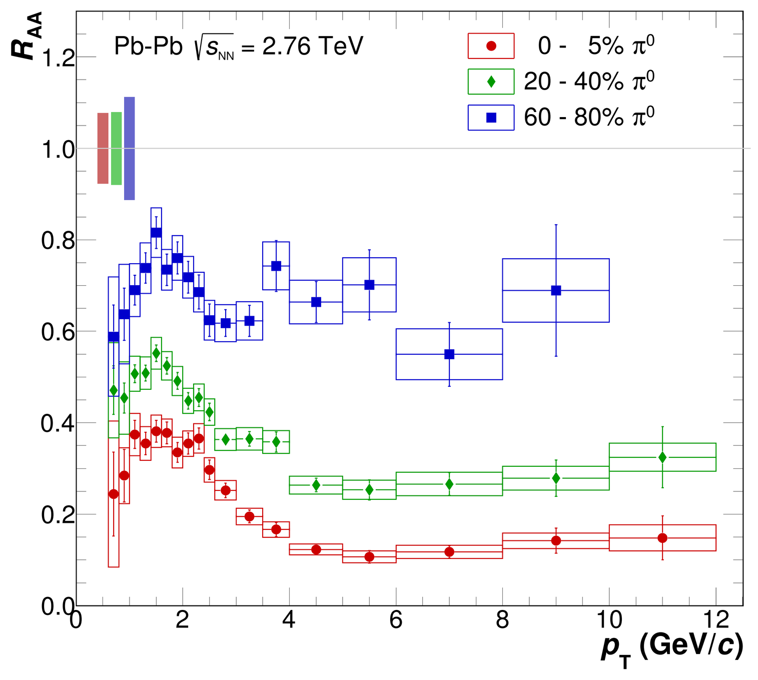
Physics Motivation

The study of neutral meson production in p-Pb collisions is of importance to confirm that the strong suppression observed in central Pb-Pb collisions is a final-state effect of the produced dense medium. Furthermore the neutral pion production is essential for the extraction of the direct photon spectra, as it is the main source of background for direct photons.

$$R_{pPb}(p_T) = \frac{d^2N_{ch}^{pPb}/d\eta dp_T}{< T_{pPb} > d^2\sigma_{ch}^{pp}/d\eta dp_T} \quad (1)$$

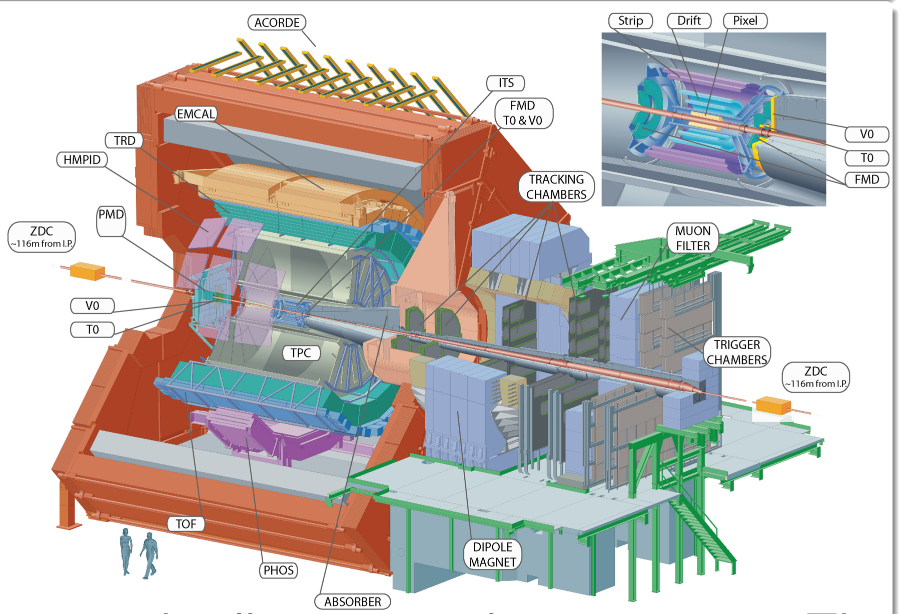


π^0 R_{AA} in Pb-Pb collisions at 2.76 TeV. Plot taken from [1].

ALICE Experiment

ALICE [2] is one of the four main LHC experiments designed to study strongly interacting matter and the Quark-Gluon-Plasma in nucleus-nucleus collisions.
The detectors used in this analysis are:

- VZERO,
- ITS (Inner Tracking System),
- TPC (Time Projection Chamber)



The VZERO is used for the minimum bias trigger and collision centrality estimation. The ITS and the TPC are used to measure photon conversions and for primary track reconstruction. The electron identification is carried out using the specific energy loss in the TPC.

Analysis Strategy

ALICE measures neutral pions using either calorimetry or photon conversions in the material of inner detectors. In this analysis the π^0 meson is identified via its Dalitz decay channel $\pi^0 \to \gamma^*\gamma \to e^+e^-\gamma$ (branching ratio = 1.174%). The steps followed in this analysis are:

- **Signal extraction of the $e^+e^-\gamma$**
  The invariant mass is calculated using:

$$M^2 = (E_\gamma + E_{\gamma^*})^2 - \|\mathbf{p}_\gamma + \mathbf{p}_{\gamma^*}\|^2 = \underbrace{m_\gamma{}^2}_{0} + m_{\gamma^*}{}^2 + 2(E_\gamma \cdot E_{\gamma^*} - \mathbf{p}_\gamma \cdot \mathbf{p}_{\gamma^*}) \quad (2)$$

- **Background subtraction**
  The combinatorial background under the π^0 peak is calculated using the mixed event technique. The e^+e^- pairs of the current event are mixed with the photons of the event pool ("up to 80 events") belonging to the same z vertex class and to the same charged particle multiplicity class.
- **Corrections**
  The raw yield is corrected for efficiency, acceptance, branching ratio BR(Dalitz) and contamination from the $\pi^0 \to \gamma\gamma$ channel:

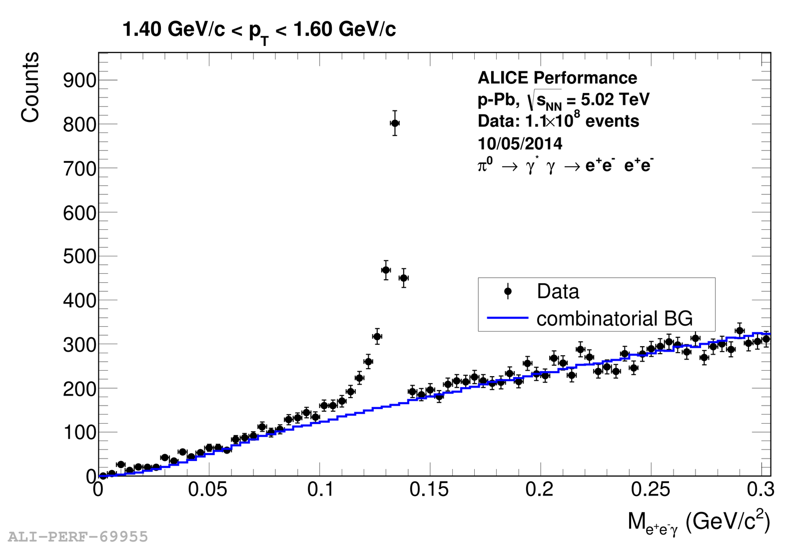
$$E\frac{d^3N}{dp^3} = \frac{d^3N}{p_T dp_T dy d\phi} = \frac{1}{2\pi}\frac{1}{p_T}\frac{d^2N^{\pi^0}}{dy dp_T} = \frac{1}{2\pi}\frac{1}{N_{events}}\frac{1}{p_T}\frac{1}{\epsilon}\frac{1}{Acc}\frac{1}{BR}\frac{N^{\pi^0}_{raw,correc}}{\Delta y \Delta p_T} \quad (3)$$

The contamination from the $\gamma\gamma$ channel is defined as:

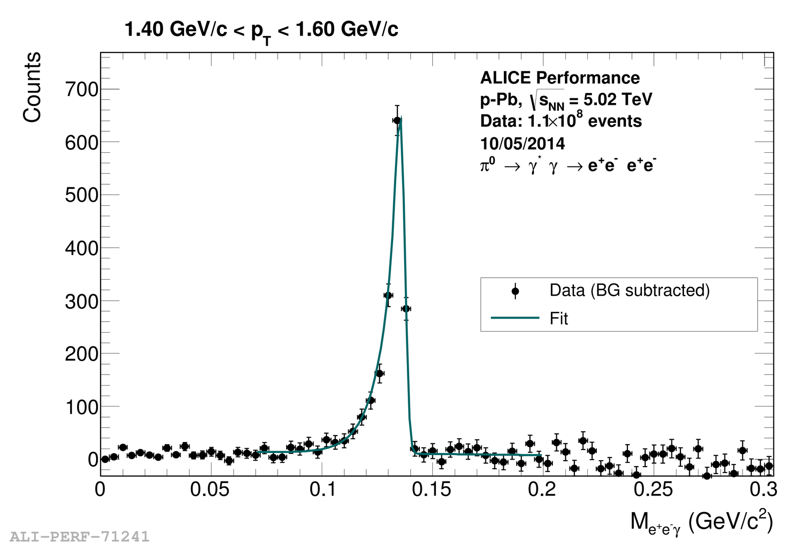
$$Cont(p_T) = \frac{N_{raw}^{\pi^0\to\gamma\gamma}}{N_{raw}^{\pi^0\to\gamma\gamma} + N_{raw}^{\pi^0\to e^+e^-\gamma}} \quad (4)$$

The data contamination fraction is assumed to be the same as the Monte Carlo one. In order to correct the results for the contamination, the following equation is used:

$$N^{\pi^0}_{raw,correc}(p_T) = N^{\pi^0}_{raw}(p_T) \times (1 - Cont(p_T)) \quad (5)$$



Invariant Mass of $e^+e^-\gamma$ with combinatorial background

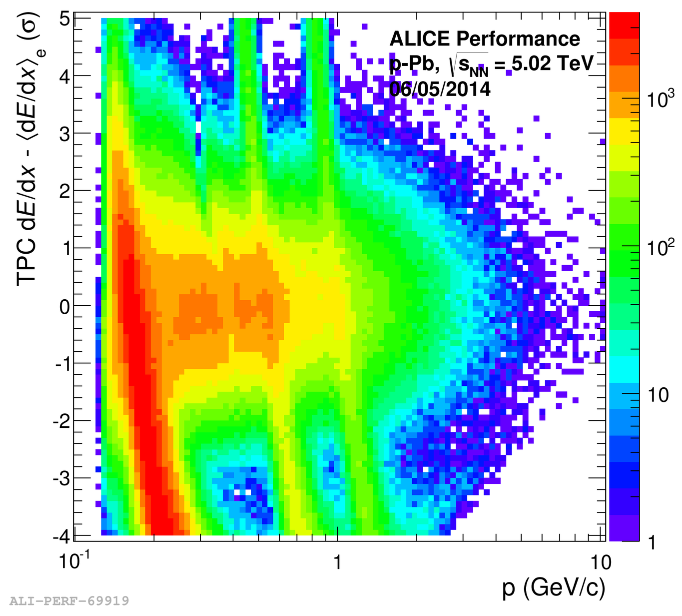


Invariant Mass of $e^+e^-\gamma$ after background subtraction

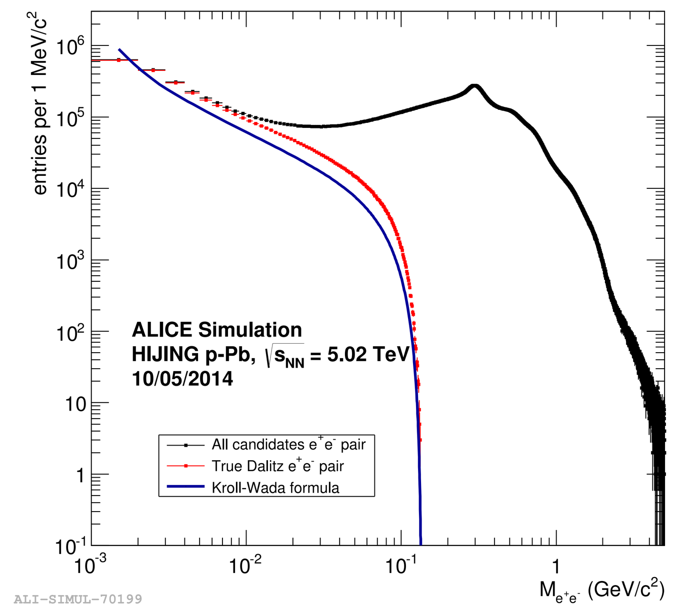
Electron Selection

- Several cuts are applied to the reconstructed tracks in order to select the primary charged particles. For example, a cut on the distance of closest approach to the reconstructed vertex and a minimum number of clusters in the ITS and TPC detectors are required.
- The electron selection among all charged particles is based on the specific energy loss signal (dE/dx) in the TPC.
- The remaining contamination from charged pions at low momentum can be reduced by cutting on the invariant mass of the primary e^+e^- pair as the decay topology of the π^0 meson on the Dalitz channel follows the Kroll-Wada formula.

$$\frac{dn_{ee}}{dm_{ee}} = \frac{2\alpha}{3\pi}\frac{1}{m_{ee}}\sqrt{1-\frac{4m_e^2}{m_{ee}^2}}\left(1+\frac{2m_e^2}{m_{ee}^2}\right)\left(1-\frac{m_{ee}^2}{M_h^2}\right)^3 |F(m_{ee}^2)|^2 \quad (6)$$



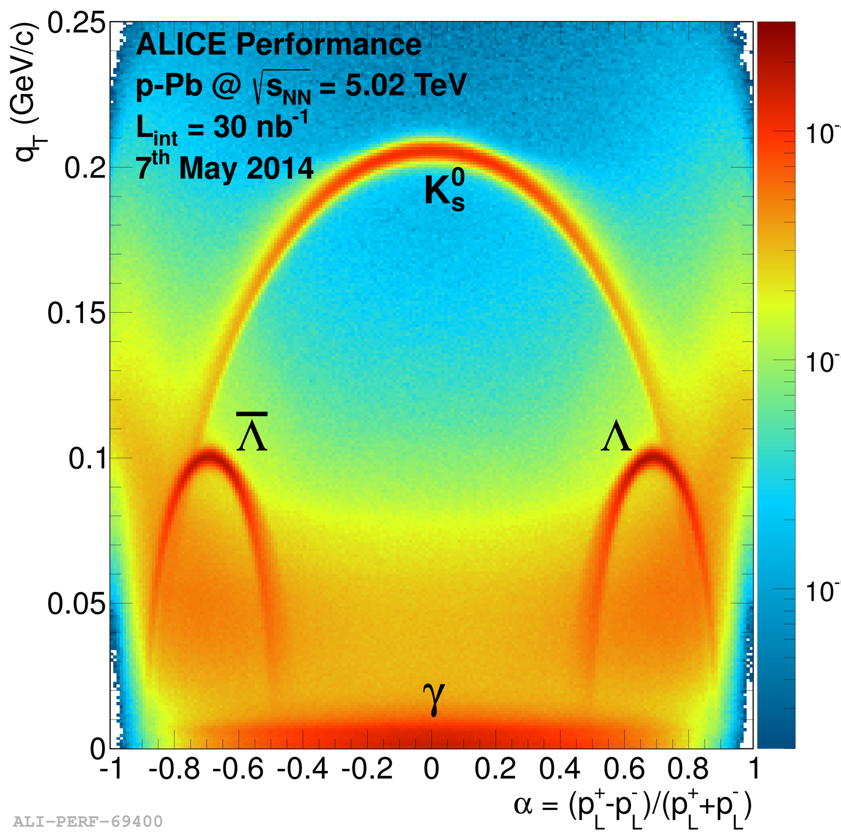
Number of σ to the theorical (dE/dx) line of electrons



Invariant Mass of the primary e^+e^-

Photon Selection

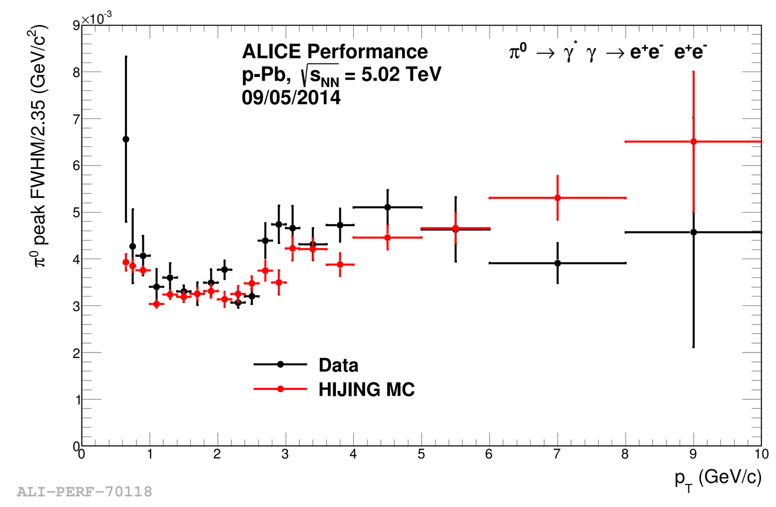
- Photons are reconstructed via their conversion products in the ITS and TPC detectors. Candidate track pairs for photon conversions are reconstructed using a secondary vertex finder (V0) algorithm.
- In order to select photons among all secondary vertices (mainly γ, K^0_S, Λ and $\bar{\Lambda}$), electron selection and pion rejection cuts are applied using TPC (dE/dx).
- To extract a clean photon sample several quality cuts are applied such as no kinks and minimum p_T of the tracks, q_T (Armenteros-Podolanski plot), χ^2 of the V^0 candidates with constraints on the invariant mass and the pointing direction of the reconstructed candidate.



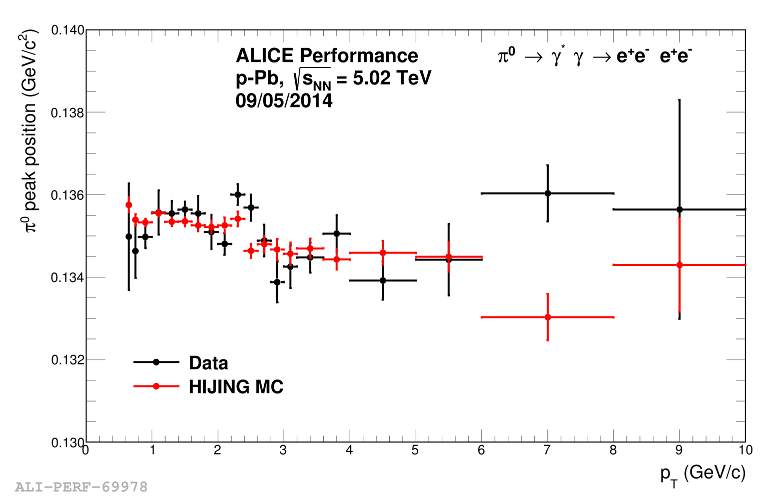
Armenteros-Podolanski plot

Current Status of the Analysis

- A data set of about 110 million minimun bias events collected during January 2013 is used in this analysis.
- The efficiency, acceptance and contamination from the $\gamma\gamma$ channel are computed with a HIJING Monte Carlo simulation of about 40 million minimun bias events.
- The comparison between data and MC for the π^0 reconstructed mass and FWHM agree within statistical errors.



π^0 width (FWHM)



π^0 peak position

Summary and Outlook

- The π^0 is measured by its Dalitz decay channel in the p_T range of $0.6 < p_T < 10$ GeV/c.
- This method will be compared to the different methods for π^0 detection available in ALICE and contribute to the combined result.
- The R_{pPb} will be calculated and compared to model calculations.
- The pp reference needed for the R_{pPb} will be computed using the measured π^0 invariant cross-section at 7 TeV [3] and at 2.76 TeV [1].

References

[1] "Neutral pion production at midrapidity in pp and Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV", CERN-PH-EP-2014-091.

[2] "The ALICE experiment at the CERN LHC", K. Aamodt et al. (the ALICE Collaboration), 2008 JINST 3 S08002.

[3] "Neutral pion and η meson production in proton-proton collisions at $\sqrt{s} = 0.9$ TeV and 7 TeV", ALICE Collaboration, Physics Letters B 717 (2012), pp. 162-172.

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