Westfälische Wilhelms-Universität Münster

Neutral Pion and η Meson Production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE at the CERN LHC

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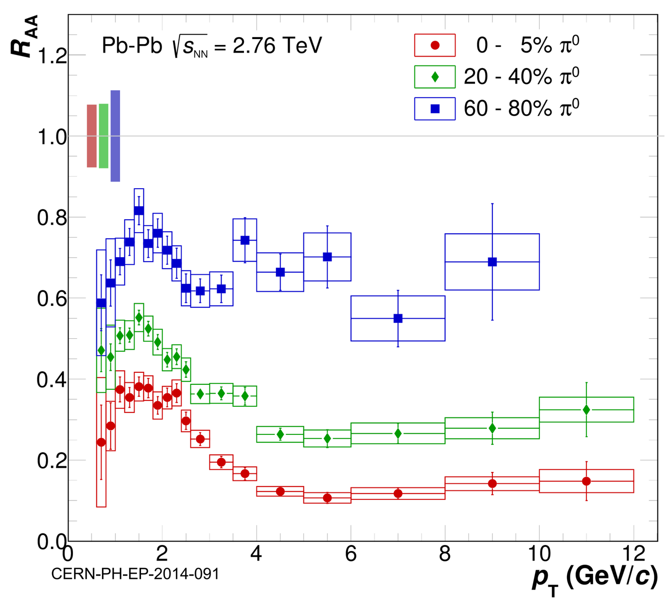
Motivation

The measurement of identified particle production in p-Pb collisions at LHC energies serves a dual purpose:

- It allows the study of fundamental properties of quantum chromodynamics (QCD) at low parton momentum fraction x (10^{-4} – 10^{-2}) and high gluon densities.
- It can help to disentangle initial and final state effects and their role in the observed suppression of hadron production at high p_T in Pb-Pb collisions.



Measurements in p-Pb provide an insight into phenomena such as parton shadowing or gluon saturation and can deliver new constraints to the parton distribution function (PDF) of the lead nucleus.
The simultaneous measurement of π^0 and η mesons in a broad p_T range is important to test the validity of m_T scaling in p–A collisions at LHC energies.
In addition, the neutral pion and η yields are crucial as input for the extraction of the direct photon spectrum, which is more sensitive to the gluon distribution in the lead nucleus. They are also a prerequisite for understanding the electron background for a charm and beauty measurement.

Photon/Meson Reconstruction with ALICE

Neutral mesons are reconstructed via their two photon and their Dalitz decay channel:

- $\pi^0 \rightarrow \gamma\gamma$ (B.R. 98.8%); $\pi^0 \rightarrow \gamma^*\gamma \rightarrow e^+e^-\gamma$ (B.R. 1.174%)
- $\eta \rightarrow \gamma\gamma$ (B.R. 39.3%)

Photons can be reconstructed in one of the calorimeters (PHOS and EMCal) or via converted electron pairs in ITS and TPC using the Photon Conversion Method (PCM). Primary electron pairs from the Dalitz channel are measured with ITS and TPC.

The meson signal is obtained from the invariant mass of the decay products:

- Four complementary π^0 analyses (Fig.1): PHOS, EMCal, PCM and PCM-γ*γ
- Two complementary η analyses (Fig.2): EMCal and PCM

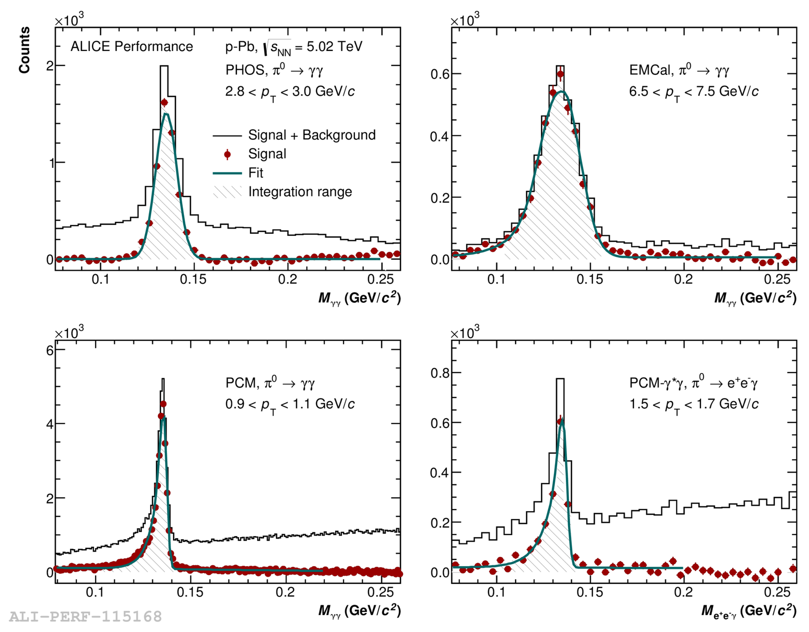


Fig. 1: π^0 invariant mass distributions.

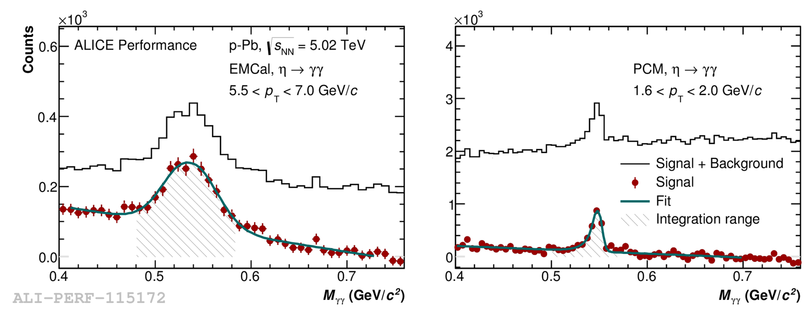
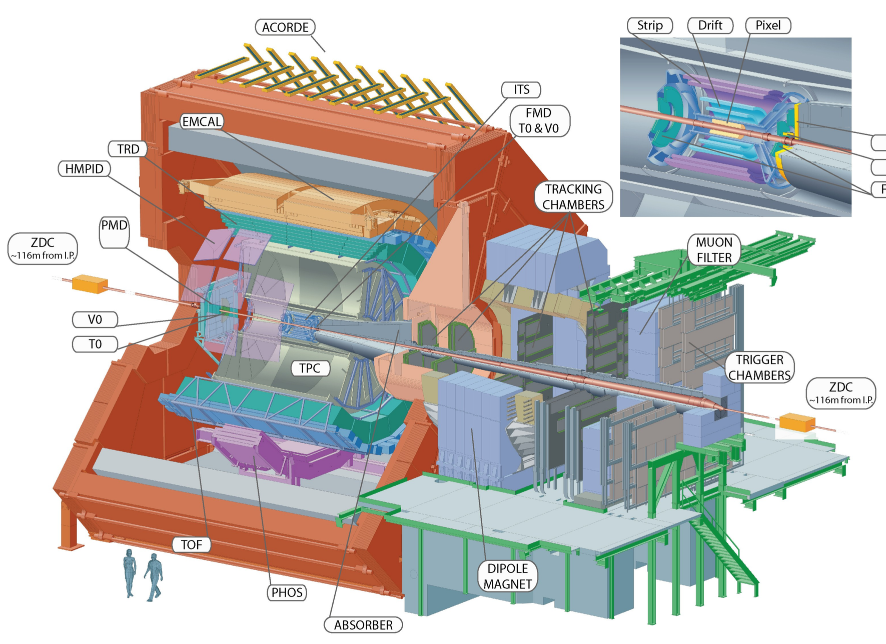


Fig. 2: η invariant mass distributions.

ALICE at the LHC

ALICE is a general purpose heavy ion experiment designed to study strongly interacting matter and the Quark-Gluon Plasma in nucleus-nucleus collisions at the LHC.
The analyzed dataset of about 100 million minimum bias p-Pb collisions was recorded in January 2013.



pp Reference

The nuclear modification factor $R_{\rm p\text{-}Pb}$ is defined as: $R_{\rm p-Pb}(p_T) = \dfrac{d^2N^{\rm p-Pb}_{\pi^0}/dydp_T}{\langle T_{\rm p-Pb}\rangle \cdot d^2\sigma^{\rm pp}_{\pi^0}/dydp_T}$

For the calculation, a pp reference at the same collision energy is needed.
As a measured π^0 pp spectrum is not available at present, the pp reference is calculated by interpolating between the measured (PCM and PHOS) spectra at $\sqrt{s}$ = 2.76 TeV [1] and $\sqrt{s}$ = 7 TeV [2] assuming a power-law behavior in p_T as a function of $\sqrt{s}$.
The reference is calculated for each method separately to cancel systematic uncertainties that are common for pp and p-Pb, like the material budget error for PCM or the uncertainty of the global energy scale for PHOS.

Combination

The meson yields, η/π^0 ratio, and the nuclear modification factor $R_{\rm p\text{-}Pb}$ are produced separately for every method.
For the combined ALICE results, correlations between the methods are taken into account using the Best Linear Unbiased Estimate (BLUE) method [3]. All results are normalized per NSD (non single diffractive) collision.

Results

- Fig. 3: The comparison of the measured yields with EPOS3 calculations [4] shows a good agreement for the pion over the whole p_T range, but not for the η. This result highlights that the η meson can be very challenging to model in string fragmentation due to the mixed quark content.
- Fig. 4: The η/π^0 ratio increases with p_T and reaches a plateau of 0.47 ± 0.02 for p_T > 4 GeV/c. The plateau value agrees with previous measurements at other collision systems and energies. While m_T scaling is fulfilled above 4 GeV/c, it is violated at low p_T. Earlier measured η/π^0 ratios at low p_T in p–Be and p–Au collisions at $p_{\rm beam}$ = 450 GeV/c by the joint TAPS/CERES collaboration [5] are consistent with the ALICE result and also support a deviation from m_T scaling.
- Fig. 5: The measured $R_{\rm p\text{-}Pb}$ is consistent with unity above 2 GeV/c. This is expected in the absence of nuclear effects in the p_T region where hard processes dominate particle production. All shown model calculations describe the data satisfactorily although the central values lie above the distributions from the calculations for intermediate p_T between 2 and 4 GeV/c.

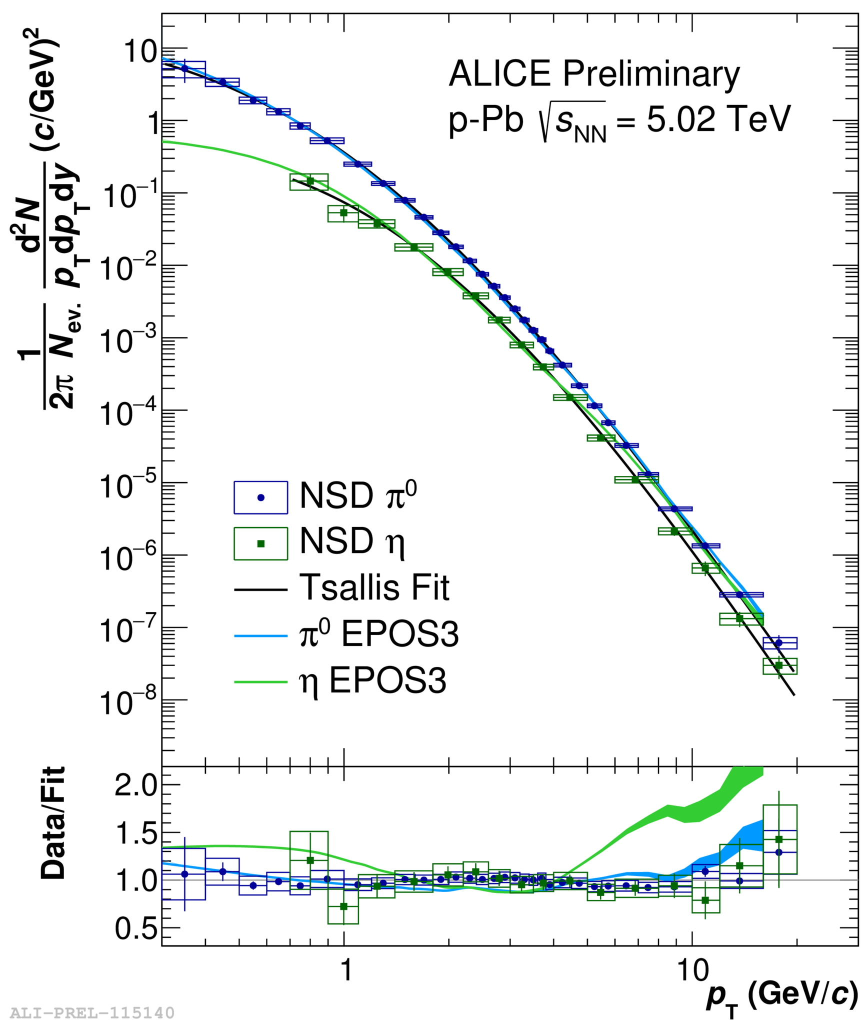


Fig. 3: Invariant π^0 and η yields, compared to EPOS3.

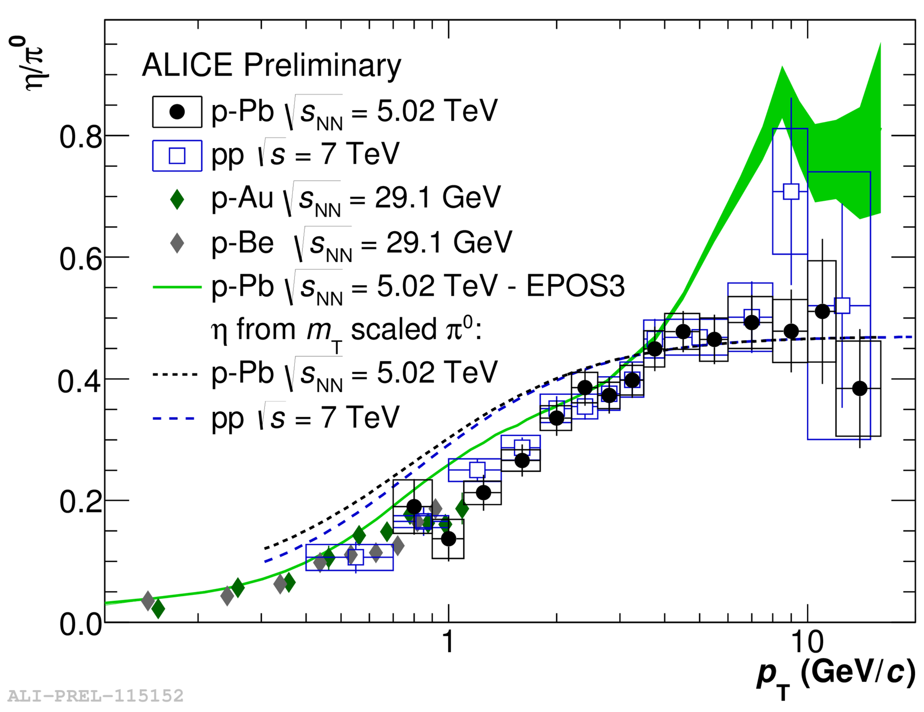


Fig. 4a: η/π^0 ratio, compared to other measurements and predictions from EPOS3 and m_T scaling.

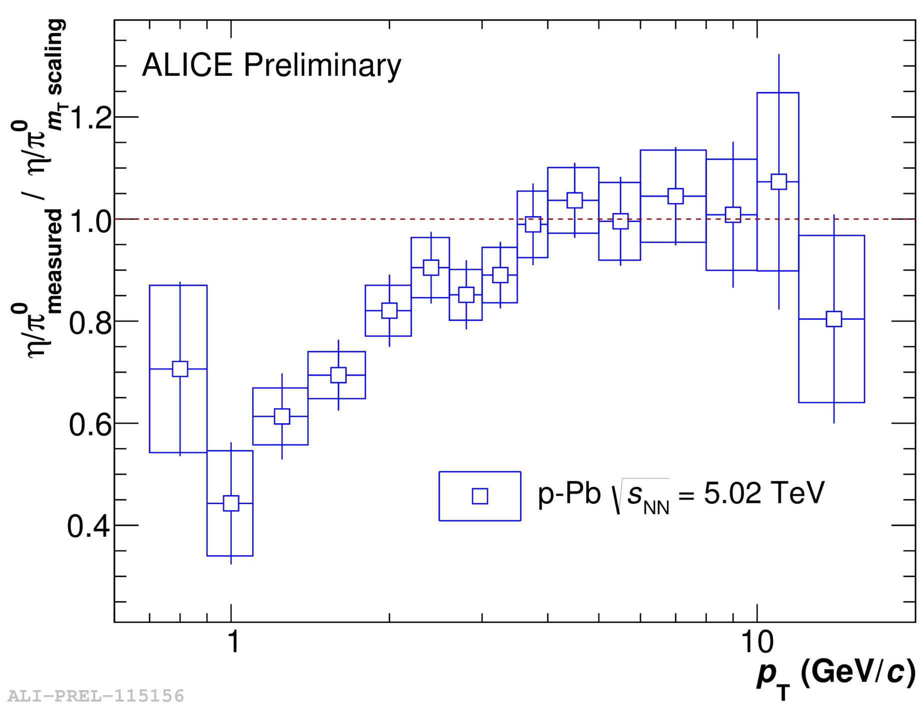


Fig. 4b: Double ratio: measured η/π^0 ratio divided by the m_T scaling prediction.

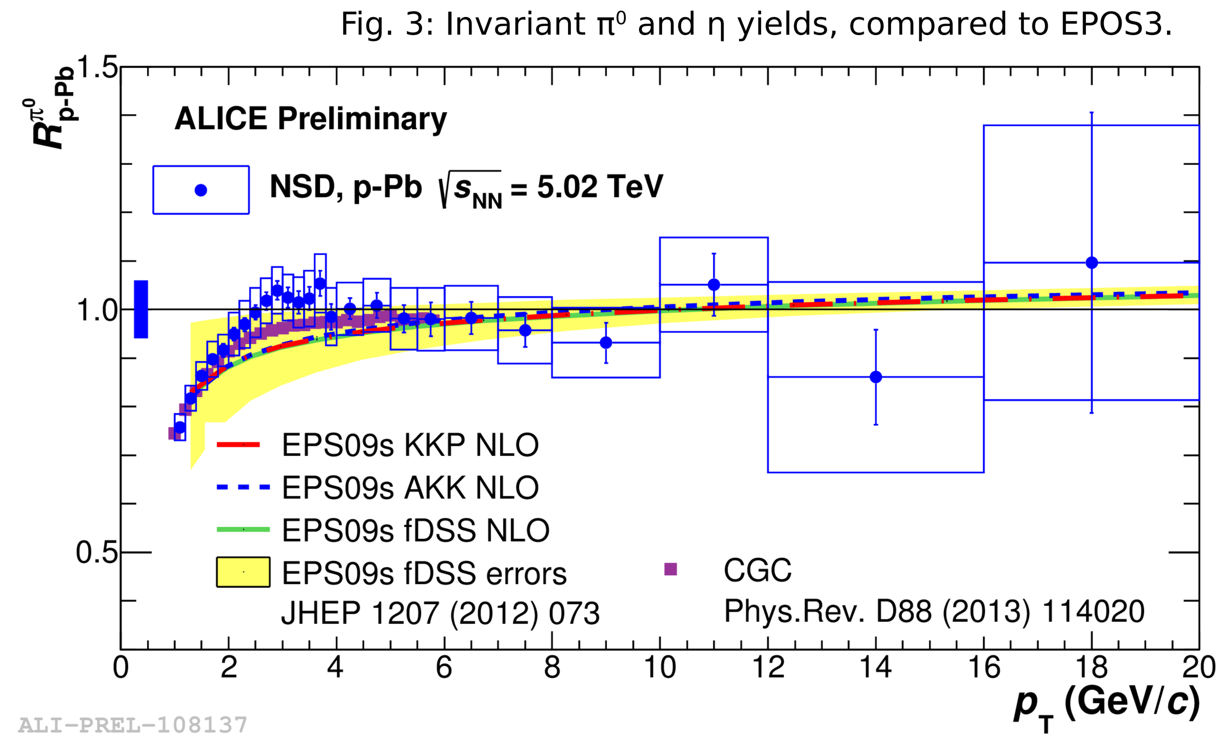


Fig. 5: Nuclear modification factor $R^{\pi^0}_{\rm p\text{-}Pb}$, compared to models.

References: [1] Eur.Phys.J. C74 (2014) 3108; [2] PLB717 (2012) 162; [3] Nucl.Instrum.Meth. A270 (1988) 110; [4] Phys. Rev. C 89, 064903 (2014) and priv. comm. with K. Werner; [5] Eur.Phys.J. C4 (1998) 249