Neutral mesons measurement in jets in pp collisions in ALICE

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Motivation

The main objective of this analysis is to calculate the ratio η/π^0. Quark compositions of these 2 neutral mesons are below:

$$\pi^0 = \frac{u\bar{u} - d\bar{d}}{\sqrt{2}} \qquad \eta = \frac{u\bar{u} + d\bar{d} - 2s\bar{s}}{\sqrt{6}}$$

When a hard parton (quark or gluon) goes out from the interaction, it fragments into many particles with high momentum moving in the same direction, which is called "jet". Fragmentation Functions (FFs) are not yet fully understood by theory, but they are obtained using measured data. This "in-jets" measurement could give a constraint on FFs.

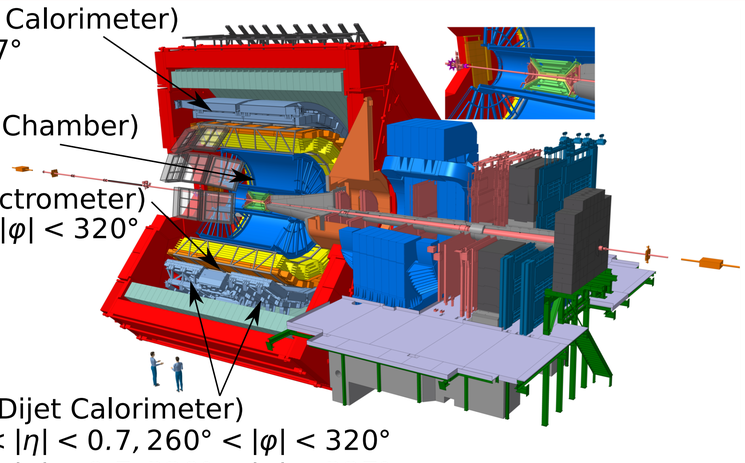
Strangeness enhancement in nuclear collisions has been predicted [1]. Therefore, modification of FFs could be observed by comparing η/π^0 found inside jets in Pb–Pb, p–Pb and pp collisions.

The ALICE detector

EMCal (Electromagnetic Calorimeter)
$|\eta| < 0.7, 80° < |\varphi| < 187°$

TPC (Time Projection Chamber)
$|\eta| < 0.9$

PHOS (Photon Spectrometer)
$|\eta| < 0.12, 250° < |\varphi| < 320°$



DCal (Dijet Calorimeter)
$0.22 < |\eta| < 0.7, 260° < |\varphi| < 320°$
$|\eta| < 0.7, 320° < |\varphi| < 327°$

Jet reconstruction

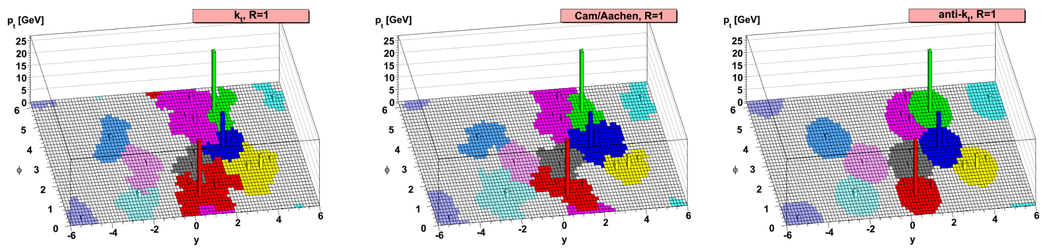


Figure 1: Jets reconstructed in one event by different algorithms [2]

The FastJet package provides provides 3 jet finding algorithms k_t, Cambridge/Aachen, anti-k_t. The anti-k_t algorithm was used in the analysis.

Configuration	Value
algorithm	anti-k_t
recombination scheme	p_T
jet radius	0.4
min. track p_T	0.15 GeV/c
jet type	Charged jets
min. jet p_T	10 GeV/c
jet axis range	$\lvert\eta_{axis}\rvert < 0.5$

Meson reconstruction methods

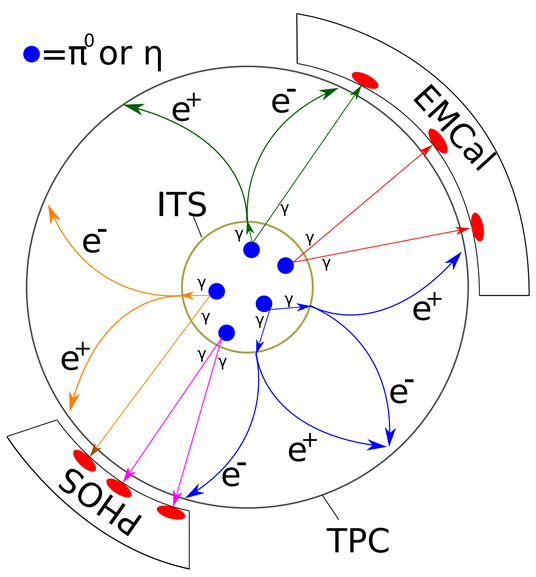


Figure 2: Schematics of reconstruction methods

There are 5 mass reconstruction methods using π^0 or $\eta \to 2\gamma$ decay channel.

- PCM–PCM
- PCM–EMCal
- PCM–PHOS
- EMCal–EMCal
- PHOS–PHOS

γ which converted to $e^{\pm}$ pair can be reconstructed by PCM (Photon Conversion Method). Combination of these five methods allows us to measure mesons with greatest precision.

Signal extraction

Invariant mass $M_{\gamma\gamma}$ is calculated for photon candidates.

$$M_{\gamma\gamma} = \sqrt{2E_{\gamma_1}E_{\gamma_2}(1 - \cos\theta_{12})}$$

where E_{γ_1}, E_{γ_2} are the energies of reconstructed photon, and θ_{12} is the opening angle between two photons. Invariant mass is calculated for all possible photon candidates in the same event.

Event mixing method is used to estimate combinatorial background in the invariant mass distribution. In event mixing method, pairs of photons are selected from different events to get uncorrelated mass distribution to subtract the background from signal. However, event mixing does not reproduce background completely as it contains also residual correlated background from resonance decays, in-jet correlations etc. [3]. The correlated background further increases in-jet analysis.

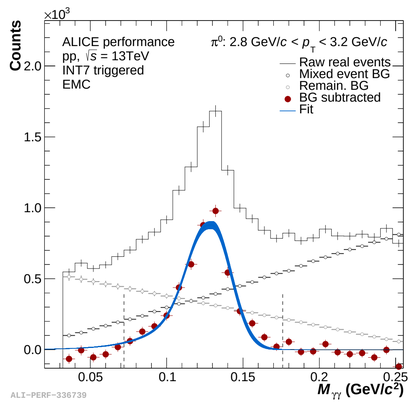


Figure 3: Invariant mass distribution in the region of π^0 peak

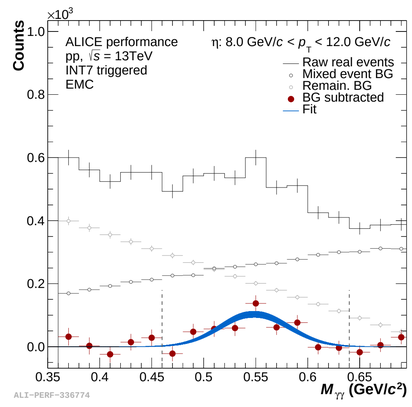


Figure 4: Invariant mass distribution in the region of η peak

The EMCal-EMCal reconstruction method is applied for for pp collisions at $\sqrt{s} = 13$ TeV. Mesons are defined to be "in-jet" if the distance between the meson and jet axis is smaller than the jet radius. π^0 can be reconstructed up to $p_T < 20$ GeV/c with EMCal. Two clusters originating from π^0 are merged for $p_T > 20$ GeV/c

Measured π^0 and η mesons inside jets

Mesons were measured in pp collisions at $\sqrt{s} = 5.02$ TeV combining EMCal–EMCal, PCM–EMCal, PCM–PCM and PHOS–PHOS methods. PCM–PHOS was not used because of low statistics. η mesons can't be reconstructed by PHOS-PHOS method due to large opening angle of photons coming from η mesons. The η/π^0 ratio measured inside jets is smaller than that of Minimum bias (MB) result up to $p_T < 7$ GeV/c. In higher p_T region, in-jets and MB results are in agreement within the uncertainty. PYTHIA8 simulation also predicts smaller η/π^0 ratio for in-jets measurement and gets closer to MB result for high p_T region.

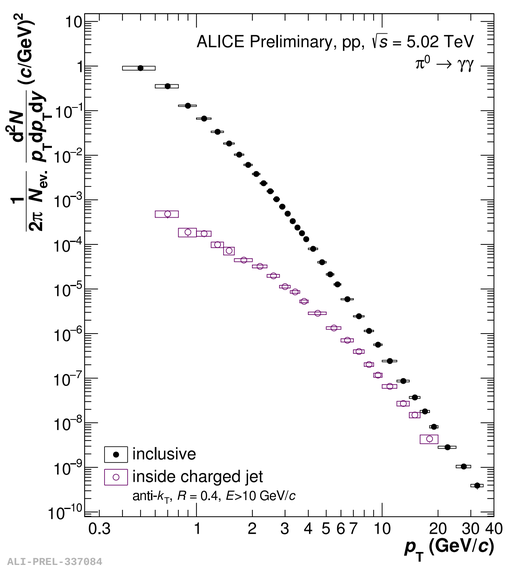


Figure 5: Invariant yield of π^0 in pp collisions at $\sqrt{s} = 5.02$ TeV

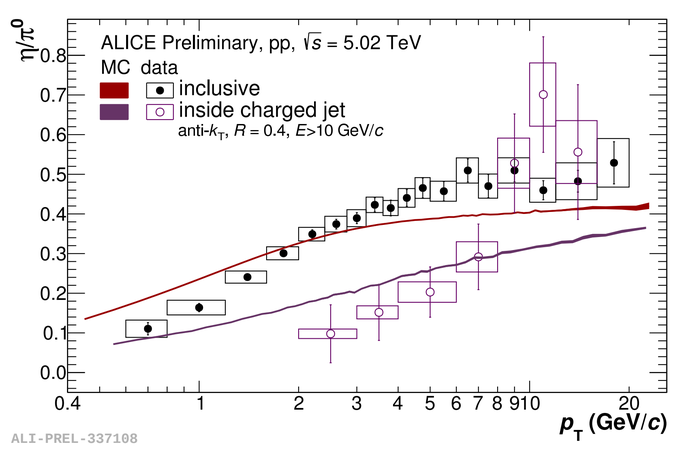


Figure 6: Measured η/π^0 in MB and "in-jets"

References

[1] P. Koch, B. Muller, and J. Rafelski, "Strangeness in Relativistic Heavy Ion Collisions", Phys. Rept. 142 (1986) 167–262

[2] Matteo Cacciari et al., "The anti-k_t jet clustering algorithm", JHEP04(2008)063

[3] S. Acharya et al., "Neutral pion and η meson production in p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV", arXiv:1801.07051

Summary & outlook

- π^0 and η meson spectra were measured in-jets in MB pp collisions at $\sqrt{s} = 5$ TeV.
- Background enhancement in low mass region was observed in η measurement.
- Analysis in pp collisions at $\sqrt{s} = 13$ TeV is ongoing:
  - Background enhancement in low mass region was observed in η measurement.
  - π^0 and η will be measured also by other reconstruction methods to calculate η/π^0.
  - FFs of π^0 and η will be measured using jet energy.

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