Study of neutral $\pi$ meson in $\sqrt{s_{\text{NN}}} = 5.02$ TeV p-Pb collisions at ALICE
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Introduction
Quark-Gluon Plasma(QGP) which is believed to have existed in a very early universe, is a high temperature and dense matter. The high-energy heavy-ion collisions experiment is the only way to create QGP in the lab.

The ALICE experiment is optimized for heavy-ion collisions and intended to explore the property of QGP. The study of hadron production mechanism is essential for the properties of QGP matter. In p-Pb collisions at a high energy region, it enables estimation of the initial state of collisions in the QGP generation.

PHOton Spectrometer
PHOton Spectrometer(PHOS) is electro-magnetic calorimeter designed to measure the energy and hit coordinates of photons and electrons.

PHOS feature
- Position on distance of 4.6 m from the interaction point
- PbWO$_4$ crystal and APD readout @ 1 cell
- 3584 cells @ 1 module
- High energy resolution (1GeV @ 3%)
- Wide dynamic range (5MeV ~ 80GeV)
- High granularity allows to separate photons in high-multiplicity environment

These advantages provide precise measurement of energy for photons and electrons, and allow for identification of neutral $\pi$ mesons with higher transverse momentum.

Electron Energy-to-Momentum Ratio
Electron detection in PHOS is needed to verify the global energy scale of the PHOS calibration, to tune MC simulations, to study material budget in front of PHOS. Electron energy $E$ is measured by PHOS and electron momentum $p$ is measured by the central tracking system(ITS+TPC). $E/p$ is expected to be 1 because electrons deposit their total energy in PHOS. Electrons are identified by $dE/dx$ in TPC and matched PHOS cluster and TPC track.

Electron's $E/p$ has a clear peak around $E/p = 1$ and charged hadron contamination exists in lower $E/p$ region. This contamination is caused by mis-identification of TPC.

PHOS Module
3 PHOS modules were installed for now. $\Delta \phi = 20$ degree/module $|\eta| < 0.12$

$\pi^0$ Analysis via Two Photons
Invariant mass is reconstructed via two photons detected in PHOS in each event.

To select a photon cluster, track matching and shower shape cut are applied. The track matching was applied to reject clusters produced by charged particles. The shower shape cut was applied to select clusters with electromagnetic showers, and thus suppress hadronic cluster.

$$m_{\gamma\gamma} = \sqrt{2E_1 \cdot E_2 \cdot (1 - \cos \theta)}$$

$E_1, E_2$ : photon energy
$\theta$ : opening angle

$\pi^0$ spectrum is obtained via counting the number of reconstructed $\pi^0$'s in different $p_T$ bins.

Summary & Outlook
- Energy-to-momentum ratio for electron was measured by PHOS and central tracking system(ITS+TPC), and clear electron peak was obtained around $E/p = 1$.
- Non-linearity effect in lower $p_T$ region due to bremsstrahlung and energy loss
- This result is effective for MC simulations tuning
- PHOS detector allows to resolve photons in high-multiplicity environment

In comparing to pp collisions at same $p_T$ region, invariant mass distribution shows stronger signal peak and larger combinatorial background.

Invariant mass distribution in p-Pb collisions shows more clear signal peak and smaller combinatorial background than Pb-Pb collisions at same $p_T$ range.

The $\pi^0$ mass peak is sharper and the combinatorial background drops away with increased $p_T$.

The $\pi^0$ invariant mass was reconstructed via two-photons analysis with PHOS in p-Pb collisions.
- Mass peak is clearly seen and combinatorial background has different shape in $p_T$ and in collision system.
- The p-Pb data sample allows to measure the $\pi^0$ spectrum at $p_T$ up to 20 GeV/c with the minimum bias trigger and at $p_T$ up to 40 GeV/c with high-energy photon trigger(PHOS trigger).