Neutral pion production in pp collisions at LHC energies

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ALICE, one of the experiments at the Large Hadron Collider (LHC) at CERN, is aimed at studying heavy-ion collisions and the properties of a deconfined state of matter, the quark-gluon plasma (QGP)[1]. High-$p_{\rm T}$ particle production is a powerful tool for characterizing the QGP because the interaction between fast partons depends on the QGP transport properties. The hadron yields in heavy-ion collisions can be quantified by the nuclear modification factor ($R_{\rm AA}$), which is the ratio of the particle yield in heavy-ion collisions normalized by the number of inelastic nucleon–nucleon collisions to the yield in *pp* collisions. Previous experiments have shown that $R_{\rm AA}$ at high $p_{\rm T}$ is significantly smaller than 1, which can be explained by the energy loss of fast partons traversing in QGP.

The ALICE experiment includes a high-resolution and high-granularity electromagnetic calorimeter called PHOS[1]. One of the main physics goals achievable by PHOS is the study of energy loss through the measurement of high-$p_{\rm T}$ neutral mesons (π^0 and η). Three PHOS modules are installed in the ALICE experiment, which covers azimuthal angles in the range $260° < \phi < 320°$ and pseudorapidity $|\eta| < 0.125$. PHOS provides a photon trigger (PHOS trigger) owing to its requirement of the measured energy to be above a threshold. The threshold was set to be 2 and 4 GeV in *pp* collisions at $\sqrt{s} = 8$ TeV. By using the PHOS trigger, high-$p_{\rm T}$ neutral mesons can be efficiently measured in the ALICE experiment. This paper describes the analysis status of neutral-pion production measured with the PHOS trigger and minimum-bias (MB) trigger data in *pp* collisions. Further, neutral-pion production in *pp* collisions at $\sqrt{s} = 8$ TeV are compared with the results for other LHC energies (0.9, 2.76, and 7 TeV)[2)3)]. In this analysis, MB-trigger ($0.3nb^{-1}$) and PHOS-trigger ($70nb^{-1}$) data are used in *pp* collisions at $\sqrt{s} = 8$TeV.

The invariant cross section is predicted by the pQCD theory considering the particle production mechanism as follows[4].

$$E\frac{d\sigma}{d^3p}(pp \rightarrow \pi^0 X) = \frac{F(x_{\rm T})}{p_{\rm T}^n} \quad (1)$$

The exponent n in the LO QCD should be 4; however, in reality, it is approximately 6 owing to scaling violation. Eq.(1) can be converted by using $x_{\rm T} = 2\sqrt{s}/p_{\rm T}$ as below.

$$\sqrt{s}^n E\frac{d\sigma}{d^3p}(pp \rightarrow \pi^0 X) = \left(\frac{2}{x_{\rm T}}\right)^n F(x_{\rm T}) = G(x_{\rm T}) \quad (2)$$

The $G(x_{\rm T})$ is expected not to depend on the collision energy, but only on $x_{\rm T}$[4]. Therefore, the following equation is expected between different collision energies. This is called $x_{\rm T}$ scaling

$$\sqrt{s_1}^n E\frac{d\sigma_1}{d^3p}(x_{\rm T}) = \sqrt{s_2}^n E\frac{d\sigma_2}{d^3p}(x_{\rm T}) \quad (3)$$

The exponent n depends on the energy, and at RHIC energies, a good scaling behavior is observed for $n = 6.24$. The results of LHC energies are shown in Fig. 1. The exponent n is extrapolated using the global fit of these 3 energies and n is 5.08. As is evident, the high $p_{\rm T}$ region of each energy shows very good agreement with each other; however, all low $p_{\rm T}$ regions violated the scaling because of the soft QCD.

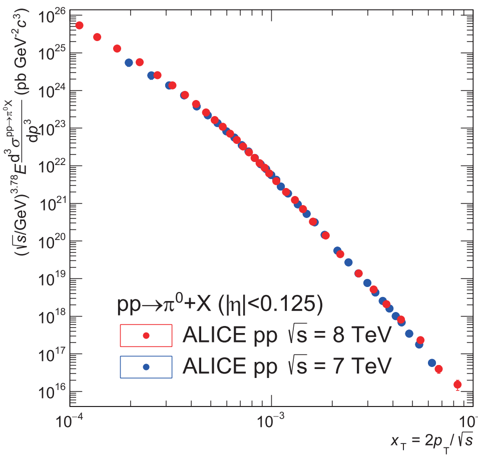

Fig. 1. The $x_{\rm T}$ scaling result of LHC and RHIC.

$x_{\rm T}$ scaling at high $p_{\rm T}$ is observed at LHC energies. The exponent n is smaller than RHIC. At high $x_{\rm T}$ regions, good scaling is observed. The results imply that the particle production mechanism at LHC energies is the same as the previous experiment.

References

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