Measurement of charged jet v_2 using ALICE PbPb collision data at $\sqrt{s_{NN}} = 5.02$ TeV

T. Kumaoka[*1,*2,*3] for the ALICE Collabolation

A quark-gluon plasma (QGP) is a state of matter in which quarks and gluons are deconfined. Quantum chromodynamics (QCD) predicts its existence at very high temperatures or high densities. Because we cannot observe teh QGP in nature, so it can be created by generating heavy-ion collisions using a large collider, such as the large hadron collider (LHC) and relativistic heavy ion collider (RHIC). Understanding QGP properties can help to elucidate the evolution of the universe and prove the QCD. However, even basic QGP properties are not clarified well such as temperature, components, and viscosity.

In this study, we focused on the parton energy loss mechanism in the QGP. When a high-energy parton passes through QGP, it loses its energy in the QGP, and the energy loss is observed as the jet suppression. Clarifying the energy loss mechanism can help to understand the viscosity of the QGP and interaction in the QGP. Moreover, measurements of the parton energy loss have indicated that the QGP properties can be expressed by using an anti de Sitter-conformal field theory (AdS-CFT) model relating the super-string theory. To investigate this, we measured v_2 of charged jets in Pb-Pb collisions by the LHC-ALICE, aiming to evaluate the degree of energy loss per unit length. The v_2 of jets is calculated using the in-plane and out-of-plane jet yields of the QGP with an elliptical shape. The v_2 of jets is expressed as,

$$v_2^{\mathrm{ch\,jet}}(p_{\mathrm{T}}^{\mathrm{jet}}) = \frac{\pi}{4}\frac{1}{\mathcal{R}}\frac{N_{\mathrm{in}}(p_{\mathrm{T}}^{\mathrm{jet}}) - N_{\mathrm{out}}(p_{\mathrm{T}}^{\mathrm{jet}})}{N_{\mathrm{in}}(p_{\mathrm{T}}^{\mathrm{jet}}) + N_{\mathrm{out}}(p_{\mathrm{T}}^{\mathrm{jet}})}, \tag{1}$$

where $p_{\mathrm{T}}^{\mathrm{jet}}$ is the transverse momentum of the jet, $\mathcal{R}$ is the resolution of the event plane determination, and N_{in} and N_{out} are the jet yields the in-plane and out-of-plane, respectively.

For this measurement, we utilized Pb-Pb collision data at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV taken by the LHC-ALICE in 2018. Particularly, we used the data with centrality 30–50%. A noncentral collision creates an elliptical reaction region, leading to different radial lengths between in-plane and out-of-plane orientations. Such collisions are expected to make of a jet positive v_2, because out-of-plane partons traveling through longer paths in the QGP.

Charged tracks of jets are reconstructed using the inner tracking system (ITS) and time-projection chamber (TPC) detector of the LHC-ALICE. Charged jets are consisted of charged tracks using the anti-k_{T} algorithm of the Fastjet package. This algorithm clusters tracks in a certain jet cone radius R. In this study, we used $R = 0.2$ because the background fluctuations in this cone size are sufficiently small.[1)] The transverse momentum of a jet reconstructed using anti-k_{T} ($p_{\mathrm{T}}^{\mathrm{anti}\text{-}k_{\mathrm{T}}}$) includes a large amount of background track p_{T} owing to the inability to distinguish between tracks belonging to the jet and backgrounds. Consequently, the raw jet p_{T} without the background ($p_{\mathrm{T}}^{\mathrm{raw\,jet}}$) was obtained by subtracting the background p_{T} ($\sim$10%),[2)] which was evaluated in regions uncorrelated with the jet. The $p_{\mathrm{T}}^{\mathrm{raw\,jet}}$ distribution was unfolded using the response matrix to remove the distortions caused by the background and detector effects. The unfolded jet p_{T} was independently obtained for in-plane and out-of-plane cases. Finally, the charged jet $v_2^{\mathrm{ch\,jet}}(p_{\mathrm{T}}^{\mathrm{jet}})$ was evaluated using Eq. (1) and the jet yields of each region. Figure 1 shows the jet v_2 results. The green and blue points represent this measurement results and results obtained using $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV ALICE data.[2)] Moreover, the red points show teh ATLAS jet v_2 results[3)] at the same collision energy. The line bars are statistical errors and the band bars indicate systematic uncertainty. The measurement results show that $v_2^{\mathrm{ch\,jet}}$ is positive, which indicates pass length dependency of the parton energy loss. Moreover, it was consistent with other measurements within uncertainty.

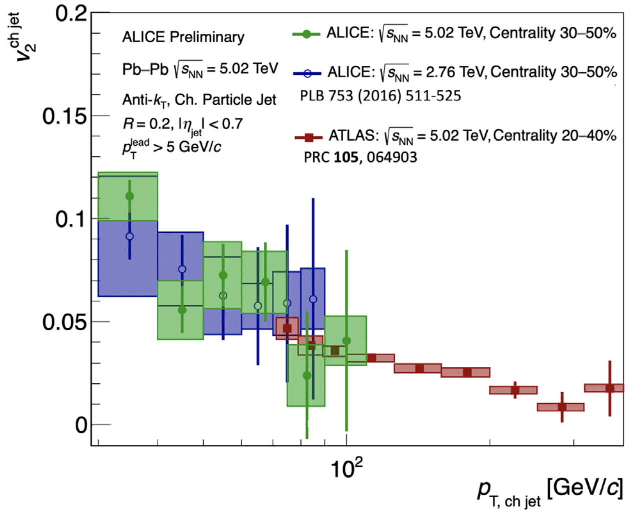

Fig. 1. Jet v_2 distribution for jet p_{T}.

References

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*1 Department of Physics, University of Tsukuba
*2 Department of Physics, University Grenoble Alpes
*3 RIKEN Nishina Center

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