Development and evaluation of a jet-finding algorithm for the RHIC-sPHENIX experiment

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We study the method of the jet measurement by the super Pioneering High Energy Nuclear Interaction eXperiment (sPHENIX). A jet is a group of particles emitted in the same direction when a high-momentum parton created in the early stages of a collision breaks apart. Because the parent high-momentum partons interact with the quark-gluon plasma (QGP) created in the collision and lose their energy, jet measurement is considered as a key tool for understanding the properties of the QGPs. To analyze jets, we must separate them from the background particles produced by collisions. In this study, we develop a method to effectively separate the jets from the background particles.

The jet is reconstructed using an algorithm that considers the axis in the flight direction of the high-momentum particle and sums the energy and momentum of the particles within a range of the cone angle R from the axis. Anti-k_{T} is a well-established jet-reconstruction algorithms,[1)] and it is used in this study. A simple flowchart of the iterative process of a jet reconstruction and background cut in this study is shown in Fig. 1, in which the first and second process paths are indicated by black and red arrows, respectively.[2)] The jet is reconstructed using Anti-k_{T} with $R = 0.2$. In the first cut process, the seed jet is defined as a jet in which the highest p_{T} (p_{Tmax}) of particles constituting the jet is at least three times larger than the average p_{T} ($\langle p_{\mathrm{T}}\rangle$) of other constituent particles. Subsequently, all particles with ΔR smaller than 0.4 are removed, where ΔR is represented $\Delta R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$, and $\Delta\eta$ and $\Delta\phi$ are the differences between the seed jet axis and emitted direction of the constituent particles in the pseudorapidity and azimuth, respectively. The remaining particles are considered as background, and $\langle p_{\mathrm{T}}\rangle$ of the background is calculated for every η (width = 0.6) as it depends on η. Thereafter, $\langle p_{\mathrm{T}}\rangle$ is subtracted from each particle p_{T} at each η as the background. This process is repeated, and in the second process, the transverse energy (E_{T}) of the seed jet is required to be greater than 20 GeV, instead of the p_{T} cut. After the iterative background subtraction processes, jets are again reconstructed using Anti-k_{T} with $R = 0.4$, and the reconstructed jets with $p_{\mathrm{T}} > 20$ GeV/c are considered as jets obtained from the data.

In this study, we use the simulated data of 30 GeV dijet embedded in minimum-bias Au + Au simulated events at $\sqrt{s_{NN}} = 200$ GeV generated by HIJING.

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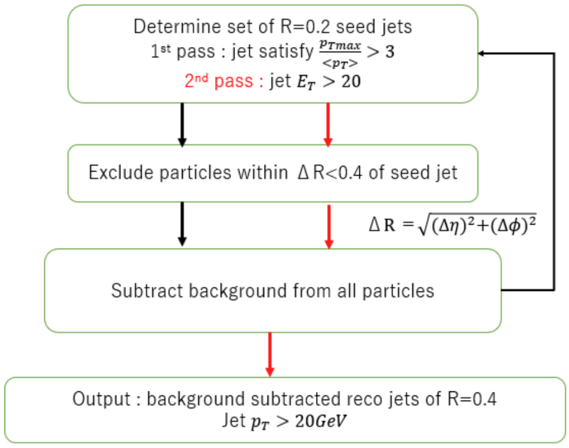

Fig. 1. Flowchart of jet separation from the background.

To apply Anti-k_{T}, an external tool called FastJet[3)] is used. Figure 2 shows the difference distribution of ϕ between the true and reconstruction jet axes for 14000 simulated events. As shown in Fig. 2, the distribution has a peak at 0. A similar result for the η is obtained. These indicate that jet reconstruction for ϕ and η is effective with this method although further studies are necessary for more detailed evaluation.

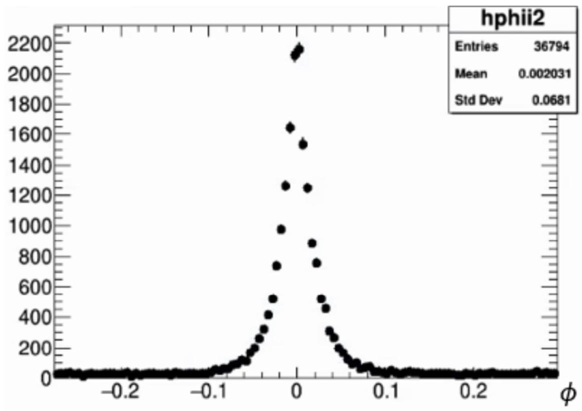

Fig. 2. Difference distribution of azimuthal angle ϕ [rad] between the true and reconstruction jet in the minimum-bias MC.

As the next step, we will calculate the purity and efficiency of the reconstructed jet assuming the peaks are formed by accurately reconstructed jets, and will review the background cut method to be improved to maximize the purity and efficiency.

References
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3) FastJet, `https://fastjet.fr/`.