

Transverse momentum balance of dijets in Xe+Xe collisions at the LHC (postprint)

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Abstract

We present a theoretical study of the medium modifications on the p_T balance (x_J) of dijets in Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV. The initial production of dijets is carried out by the POWHEG+PYTHIA8 prescription, which matches the next-to-leading order (NLO) QCD matrix elements with the parton shower (PS) effect. The in-medium evolution in nucleus-nucleus collisions is described by the SHELL model with a transport approach. The theoretical results of the dijet x_J in Xe+Xe collisions exhibit more imbalanced distributions than that in p+p, consistent with the recently reported ATLAS data. By utilizing the Interleaved Flavor Neutralisation, an infrared-and-collinear-safe jet flavor algorithm, to identify the flavor of the reconstructed jets, we classify dijets processes into three categories: gluon-gluon (gg), quark-gluon (qg) and quark-quark (qq), and investigate the respective medium modification patterns and fraction changes of the gg, qg, and qq components of the dijet sample in Xe+Xe collisions. It is shown that the qg component plays a key role in the increased imbalance of the dijet x_J , and especially the q_{1q}^2 (quark-jet-leading) dijets experience more significant asymmetric energy loss than the g_{1q}^2 (gluon-jet-leading) dijets as traversing the QGP. By comparing the $\Delta\langle x_J \rangle$ of inclusive, ccbar and bbbar dijets in Xe+Xe collisions, we observe $\Delta\langle x_J \rangle_{incl.} > \Delta\langle x_J \rangle_{ccbar} > \Delta\langle x_J \rangle_{bbbar}$. Moreover, $\rho_{Xe,Pb}$, the ratios of nuclear modification factors of dijets in Xe+Xe to that in Pb+Pb, are calculated, which indicates that the yield suppression of dijets in Pb+Pb is more pronounced than that in Xe+Xe due to the larger radius of the lead nucleus.

Full Text

Preamble

Transverse momentum balance of dijets in Xe+Xe collisions at the LHC

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We present a theoretical study of medium modifications to the transverse momentum balance (x_J) of dijets in Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV. The initial production of dijets was carried out using the POWHEG+PYTHIA8 prescription, which matches next-to-leading-order (NLO) QCD matrix elements with parton shower (PS) effects. The in-medium evolution of nucleus-nucleus collisions was described using the SHELL model with a transport approach. Our theoretical results for dijet x_J in Xe+Xe collisions exhibit more imbalanced distributions than those in p+p collisions, consistent with recently reported ATLAS data. By utilizing Interleaved Flavor Neutralisation—an infrared- and collinear-safe jet flavor algorithm—to identify the flavor of reconstructed jets, we classify dijet processes into three categories: gluon-gluon (gg), quark-gluon (qg), and quark-quark (qq), and investigate the respective medium modification patterns and fraction changes of these components in Xe+Xe collisions. We show that the increased fraction of the qq component at small x_J contributes to dijet imbalance; in particular, $q_{1g}2$ (quark-jet-leading) dijets experience more significant asymmetric energy loss than $g_{1q}2$ (gluon-jet-leading) dijets traversing the QGP. By comparing $\Delta\langle x_J \rangle = \langle x_J \rangle_{pp} - \langle x_J \rangle_{AA}$ for inclusive, $c\bar{c}$, and $b\bar{b}$ dijets in Xe+Xe collisions, we observe $\Delta\langle x_J \rangle_{\text{incl.}} > \Delta\langle x_J \rangle_{c\bar{c}} > \Delta\langle x_J \rangle_{b\bar{b}}$. Moreover, we calculate $\rho_{\text{Xe,Pb}}$, the ratios of nuclear modification factors for dijets in Xe+Xe relative to Pb+Pb, which indicates that yield suppression is more pronounced in Pb+Pb than in Xe+Xe due to the larger radius of the lead nucleus.

Introduction

Ultra-relativistic heavy-ion collisions at the Large Hadron Collider (LHC) and Relativistic Heavy Ion Collider (RHIC) provide a unique arena for creating and studying quark-gluon plasma (QGP), a novel state of nuclear matter in which the quark and gluon degrees of freedom within protons and neutrons are deconfined [1–5]. The strong interactions between hard-scattered partons and the medium, known as the “jet quenching” phenomenon, open new avenues for understanding the properties of this strongly-coupled matter [6–9] and for testing quantum chromodynamics (QCD) under extreme hot and dense conditions [10–16]. Over the past two decades, a variety of observables have been extensively investigated to probe these strong partonic interactions, including the

suppression factor R_{AA} for high- p_T hadrons and jets [17–22], the momentum asymmetry of dijets [23–34], correlations of vector boson-associated jets [35–40], global event geometry [41, 42], and jet substructure [43–52].

Dijets hold a unique position in jet physics because they represent the dominant QCD processes in hadronic collisions and are less susceptible to underlying background effects than inclusive jets. The back-to-back configuration of the two leading jets in the transverse plane significantly suppresses contributions from the underlying event to jet reconstruction in both p+p and A+A collisions. In vacuum, parton shower effects and higher-order QCD processes can break the symmetry of the final-state dijets, leading to deviations from perfect back-to-back azimuthal alignment and unequal transverse momenta between the leading and subleading jets. In A+A collisions, because the two jets typically experience asymmetric energy loss while traversing the QGP medium, the transverse momentum balance $x_J \equiv p_{T,2}/p_{T,1}$ [53]—defined as the ratio of subleading to leading jet p_T —can be further modified by in-medium interactions, showing different sensitivity to the path-length dependence of jet quenching [25] and jet-by-jet fluctuations in jet-medium interactions [54]. More imbalanced $A_J \equiv (p_{T,1} - p_{T,2})/(p_{T,1} + p_{T,2})$ and x_J distributions of dijets have been observed in Pb+Pb collisions relative to p+p at $\sqrt{s_{NN}} = 2.76$ TeV and $\sqrt{s_{NN}} = 5.02$ TeV by ATLAS [23, 53, 55] and CMS [28, 56, 57], and in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV by STAR [58]. These observations have been extensively investigated through theoretical calculations [26, 27, 31–34].

Recently, the ATLAS Collaboration measured dijet x_J in Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV for the first time [59]; however, timely theoretical studies remain lacking. Because the xenon nucleus is smaller than lead, studying jet production in different collision systems deepens our understanding of the system-size dependence of jet quenching [53, 55, 60–64]. Furthermore, since dijet events consist of gg , qg , and qq components, and jet energy loss is closely related to the flavor of the hard parton ($\Delta E_g/\Delta E_q \sim C_A/C_F = 9/4$, where $C_A = 3$ and $C_F = 4/3$) [2, 18], it is essential to determine their respective modification patterns and assess their roles in the overall medium modification of dijet x_J . Additionally, massive heavy quarks are believed to lose less energy than light quarks due to the “dead-cone” effect [65–68], leading to a mass hierarchy of partonic energy loss $\Delta E_q > \Delta E_c > \Delta E_b$ [49, 69–71]. It is particularly interesting to explore the mass dependence of medium modifications on dijet x_J by comparing light- and heavy-flavor (such as $c\bar{c}$ and $b\bar{b}$) dijets in high-energy nuclear collisions.

This paper presents the first theoretical study of medium modifications to the dijet p_T balance x_J in Xe+Xe collisions. The initial dijet production was calculated using the POWHEG+PYTHIA8 prescription, matching NLO QCD matrix elements with parton shower effects. The in-medium evolution of dijets in nucleus-nucleus collisions is described by the SHELL model, which incorporates both elastic and inelastic partonic interactions in the QGP. We first present theoretical results for dijet x_J in Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV com-

pared with recent ATLAS measurements. Specifically, we discuss the flavor and mass dependence of medium modifications on dijet x_J . We study the respective medium-modification patterns and fraction changes of the gg , qg , and qq components, as well as the $q_{1g}2$ and $g_{1q}2$ subcomponents, in dijet samples for both p+p and Xe+Xe collisions. We also investigate mass effects on x_J modifications by comparing Δx_J for inclusive, $c\bar{c}$, and $b\bar{b}$ dijets in Xe+Xe collisions. Finally, we present calculated nuclear modification factors for dijets in Xe+Xe at $\sqrt{s_{NN}} = 5.44$ TeV and Pb+Pb at $\sqrt{s_{NN}} = 5.02$ TeV, compared with recent ATLAS data.

Theoretical Framework

In this study, we generated next-to-leading-order (NLO) matrix elements for QCD jet processes [72] using POWHEG-BOX-V2 [73–75] and simulated the parton shower (PS) with PYTHIA 8.309 [76] to produce p+p events. The CT18NLO parton distribution functions (PDF) [77] were used for the calculations. Jets were reconstructed using the anti- k_T clustering algorithm with radius parameter $R = 0.4$, as implemented in the FastJet package [78]. The two highest- p_T jets in each event were selected as dijet candidates. The leading jet transverse momentum $p_{T,1}$ and subleading jet transverse momentum $p_{T,2}$ were required to be greater than 100 GeV/ c and 32 GeV/ c , respectively. The two jets were required to be nearly back-to-back in azimuth with $\Delta\phi \equiv |\phi_1 - \phi_2| \geq 7\pi/8$ and to lie within the rapidity region $|y| < 2.1$. When all these conditions were satisfied, the dijet candidate was accepted.

[Figure 1: see original paper] shows the normalized x_J distributions of dijets in p+p collisions at $\sqrt{s} = 5.02$ TeV for six $p_{T,1}$ intervals: [100, 112], [112, 126], [126, 141], [141, 158], [158, 171], and [171, 200] GeV/ c , compared with ATLAS data [55]. The POWHEG+PYTHIA8 calculations provide a decent description of the x_J distributions at small x_J for all six $p_{T,1}$ intervals, though they slightly overestimate the distributions near $x_J \sim 1$ compared to the ATLAS data. At each p_T interval, the x_J distribution peaks near $x_J \simeq 1$, where the leading and subleading jets are nearly balanced. However, higher-order perturbative QCD corrections and splitting processes during vacuum parton showers produce a considerable fraction of dijets with imbalanced transverse momentum in the smaller x_J region.

The in-medium evolution of both light- and heavy-flavor dijets was simulated using the SHELL model [34, 79], which incorporates elastic and inelastic partonic energy loss in the hot/dense QGP medium. The initial spatial distribution of hard scatterings was sampled using a Monte Carlo Glauber model [80]. Since massive parton propagation in the QCD medium can be viewed as “Brownian motion,” heavy quark transport is well described by modified Langevin equations:

$$\Delta\vec{x}(t) = \frac{\vec{p}(t)}{E} \Delta t,$$

$$\Delta\vec{p}(t) = -\eta_D\vec{p}\Delta t + \vec{\xi}(t)\Delta t - \vec{p}_g(t).$$

These equations describe position and momentum updates for heavy quarks traversing the QGP medium. η_D is the drag coefficient controlling the energy dissipation strength of heavy quarks in the medium. The stochastic term $\vec{\xi}(t)$ denotes random kicks from scattering with thermal particles, which follows a Gaussian distribution. The diffusion coefficient κ relates to η_D through the fluctuation-dissipation theorem $\kappa = 2\eta_D T$. The first two terms on the right-hand side of the momentum equation represent collisional energy loss of heavy quarks, while the last term $-\vec{p}_g$ is the momentum correction from medium-induced gluon radiation.

In our framework, the higher-twist formalism [66, 81–83] simulates medium-induced gluon radiation of jet partons, with the gluon radiation spectrum for an energetic parton in QGP given by:

$$\frac{dN_g}{dxdk_{\perp}^2} = \frac{2\alpha_s P(x)\hat{q}}{\pi(k_{\perp}^2 + x^2M^2)^2} \sin^2\left(\frac{t-t_i}{2\tau_f}\right),$$

where x and k_{\perp} denote the energy fraction and transverse momentum of the radiated gluon, respectively. $P(x)$ is the QCD splitting function for processes $g \rightarrow g + g$ and $q(Q) \rightarrow q(Q) + g$ [84], $\tau_f = 2Ex(1-x)/(k_{\perp}^2 + x^2M^2)$ is the formation time of the daughter gluon, and \hat{q} denotes the general jet transport parameter in QGP [85]. The last term in the equation represents the suppression factor from the “dead-cone” effect of heavy quarks [65, 86], which reduces gluon radiation probability within a small cone ($\theta \sim M_Q/E$). Collisional energy loss dominates for low-energy heavy quarks due to the dead-cone effect, while radiative energy loss becomes significant at $p_T^Q > 5m_Q$ [87].

For massless partons, collisional energy loss is estimated via pQCD calculations within the Hard-Thermal-Loop approximation [88, 89], while their radiative contribution uses the same higher-twist formalism as for massive partons. The hydrodynamic space-time evolution of the QGP medium is described using CLVisc programs [90, 91], which provide the temperature and velocity of the expanding hot/dense nuclear matter. The SHELL model has been successfully applied to heavy-flavor jet studies in high-energy nuclear collisions, providing satisfactory descriptions of experimental measurements such as p_T imbalance [34], radial profiles [79, 92–94], fragmentation functions [95], and Z^0 +HF hadron/jet correlations [96, 97].

[Figure 2: see original paper] shows (a) calculated normalized dijet x_J distributions in Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV compared with ATLAS data for four centrality bins (0%–10%, 10%–20%, 20%–40%, and 40%–80%) and two $p_{T,1}$ intervals (green: [158, 199] GeV/c); and (b) comparison of normalized dijet x_J distributions between Xe+Xe and p+p collisions at $\sqrt{s_{NN}} = 5.44$ TeV

for two $p_{T,1}$ intervals (left: [100, 126] GeV/ c , right: [158, 199] GeV/ c), with Xe+Xe/p+p ratios shown in the bottom panels.

Numerical Results and Discussions

In Figure 2: see original paper, we first present dijet x_J distributions in Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV calculated by the SHELL model, compared with ATLAS data for four centrality bins and two $p_{T,1}$ intervals ([100, 126] GeV/ c and [158, 199] GeV/ c). The centrality bins and corresponding impact parameter values are listed in , calculated using a Monte Carlo Glauber model [80]. For simplicity, we use the average impact parameter $\langle b \rangle$ in our calculations. The SHELL model provides satisfactory descriptions of the recently reported ATLAS data for nearly all centrality bins and $p_{T,1}$ intervals, except for data at $158 < p_{T,1} < 199$ GeV/ c in central 0%–10% collisions, where the x_J distribution shifts toward larger values compared to the ATLAS data. Furthermore, our theoretical results show more balanced x_J distributions for higher- p_T dijets ($158 < p_{T,1} < 199$ GeV/ c) than for lower- p_T ones, consistent with the trend observed in ATLAS measurements.

To quantify the centrality and jet p_T dependence of medium modifications to dijet x_J distributions, we compare the x_J distributions in Xe+Xe collisions with their p+p baseline for two p_T intervals, as shown in the bottom panels of Figure 2: see original paper. The x_J distributions shift toward smaller values in Xe+Xe collisions compared to the p+p baseline, particularly for the most central collisions. This phenomenon—where dijet transverse momentum becomes more imbalanced in A+A collisions due to asymmetric energy loss suffered by the leading and subleading jets as they traverse the QGP [25, 54]—has been observed in previous Pb+Pb measurements at 2.76 TeV [53] and 5.02 TeV [55]. In central collisions, such asymmetric energy loss can be more significant due to the larger medium size and higher temperature compared to peripheral collisions. Additionally, we observe slightly weaker x_J modifications for higher- p_T dijets than for lower- p_T ones, consistent with theoretical expectations.

The flavor dependence of medium modifications to dijet p_T balance is also an important topic in heavy-ion collisions. Due to different color factors, gluon-initiated jets are expected to lose more energy than quark-initiated jets when traversing hot and dense nuclear matter, and the dead-cone effect leads to smaller energy loss for heavy quarks than for light quarks [2, 18, 65–68]. An important step toward understanding this is determining jet flavor in nucleus-nucleus collisions using an infrared- and collinear-safe algorithm. In recent years, four IRC-safe jet-algorithm-based approaches have been developed to identify the flavor of underlying hard partons for reconstructed jets: “flavor- k_T ” [98], “flavor anti- k_T ” [99], “flavor-dressing” [100], and “Interleaved Flavor Neutralisation (IFN)” [101]. In this study, we employ the IFN algorithm to identify jet flavors at the parton level for gluon jets, light-quark jets, and heavy-flavor jets in both p+p and nucleus-nucleus collisions. Because flavor information is accessible at each stage of the clustering sequence, the IFN algorithm provides

consistent flavor identification for both full jets and their substructures. While identifying gluon and quark jets experimentally remains challenging, such identification can be achieved through Monte Carlo simulations using complete flavor information of jet particles. Note that the IFN algorithm is applicable to all jets at the parton level but is currently only accessible for heavy-flavor jets at the hadron level. As a first theoretical exploration, we identify jet flavor at the parton level in this work, enabling efficient flavor identification for both inclusive and heavy-flavor dijets.

Using the IFN algorithm, inclusive dijet events can be classified into three categories: gluon-gluon (gg), quark-gluon (qg), and quark-quark (qq). In particular, by distinguishing the flavor of the leading jet, qg dijets can be further divided into $q_{1g}2$ and $g_{1q}2$, denoting quark-jet-leading and gluon-jet-leading quark-gluon dijets, respectively.

In the left column of [Figure 3: see original paper], we show normalized x_J distributions for gg , qg , qq , and inclusive dijets in both p+p and 0%–10% Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV, with Xe+Xe/p+p ratios plotted in the bottom panel. We find that gg dijets have a more imbalanced initial distribution than qq dijets. Quarks and gluons experience different parton shower processes in vacuum due to their different color factors and splitting functions [76, 102]. In the bottom panel, qg dijets exhibit slightly stronger suppression near $x_J \sim 1$ and enhancement near $x_J \sim 0$ compared to the other components. The different color charges carried by the leading and subleading jets in qg dijets lead to enhanced asymmetric energy loss in Xe+Xe collisions relative to qq and gg jets. However, qg dijets contain two subsets, $q_{1g}2$ and $g_{1q}2$, which may exhibit different modification patterns. In the right column of [Figure 3: see original paper], we observe stronger enhancement at small x_J and stronger suppression at $x_J \sim 1$ for $q_{1g}2$ dijets compared to $g_{1q}2$. Relative to $g_{1q}2$ dijets, the leading jet in $q_{1g}2$ dijets loses less energy while the subleading jet loses more energy. In other words, the flavor configuration of $q_{1g}2$ dijets results in more significant asymmetric energy loss than $g_{1q}2$ when traversing the QGP medium.

[Figure 4: see original paper] shows the calculated fractions of subset dijets within inclusive dijets as a function of x_J in p+p and 0%–10% Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV, which helps understand the role of jet flavor in jet-medium interactions. The left column displays fractions of gg , qg , and qq in inclusive dijets for p+p (top) and Xe+Xe (middle), along with their differences (bottom). We find that qg has the largest initial fraction ($\sim 50\%$) in p+p collisions, and this fraction increases at small x_J but decreases near $x_J \sim 1$ in Xe+Xe collisions. Second, the gg fraction is overall reduced while the qq fraction is enhanced because gg dijets generally lose more energy, making them less likely to survive the jet selection criteria relative to qq . Since qg constitutes the dominant fraction in the dijet sample, the enhanced qg fraction at small x_J in Xe+Xe contributes to the increased p_T imbalance of inclusive dijets. Furthermore, it is essential to address fractional changes in the $q_{1g}2$ and $g_{1q}2$ subsets in A+A collisions. In the right column of [Figure 4: see original paper], we observe opposite behavior

for the fractions of $q_{1q}2$ and $g_{1q}2$ in Xe+Xe collisions relative to their initial values. The $q_{1q}2$ fraction is significantly enhanced at small x_J after traversing the QGP, whereas the $g_{1q}2$ fraction decreases in this region.

To quantify the overall shift in the x_J distribution in Xe+Xe collisions relative to p+p, we calculated the average values $\langle x_J \rangle$ of dijet x_J distributions and their differences $\Delta\langle x_J \rangle$ between p+p and A+A collisions, defined as:

$$\langle x_J \rangle \equiv \int x_J \frac{dN_{\text{pair}}}{dx_J} dx_J,$$

$$\Delta\langle x_J \rangle = \langle x_J \rangle_{pp} - \langle x_J \rangle_{AA}.$$

In the left column of [Figure 5: see original paper], we show $\langle x_J \rangle$ for inclusive, $c\bar{c}$, and $b\bar{b}$ dijets in p+p and Xe+Xe collisions as a function of centrality, along with their differences $\Delta\langle x_J \rangle$. We find that $\Delta\langle x_J \rangle$ decreases monotonically from central to peripheral collisions, as seen in Figure 2: see original paper. The $\Delta\langle x_J \rangle$ values for these three dijet types obey the hierarchy $\Delta\langle x_J \rangle_{\text{incl.}} > \Delta\langle x_J \rangle_{c\bar{c}} > \Delta\langle x_J \rangle_{b\bar{b}}$ in Xe+Xe collisions for the same centrality bin. This indicates that massive dijets suffer less asymmetric energy loss in A+A collisions than massless light-flavor dijets. Future measurements focusing on these comparisons will help test the mass dependence of jet energy loss. In the right column of [Figure 5: see original paper], we also plot $\Delta\langle x_J \rangle$ for $q_{1q}2$ and $g_{1q}2$ dijets in Xe+Xe; the former shows significantly larger values than the latter for each centrality bin.

To quantitatively characterize the relative dijet yield suppression between Xe+Xe and Pb+Pb collisions, we define the nuclear modification factor for leading jets as:

$$R_{AA}(p_{T,1}) = \frac{d\sigma_{\text{pair}}^{AA}/dp_{T,1}}{\langle T_{AA} \rangle d\sigma_{\text{pair}}^{pp}/dp_{T,1}},$$

$$\rho_{\text{Xe,Pb}}(p_{T,1}) = \frac{R_{\text{XeXe}}(p_{T,1})}{R_{\text{PbPb}}(p_{T,1})}.$$

A similar definition applies for subleading jets ($\rho_{\text{Xe,Pb}}(p_{T,2})$). [Figure 6: see original paper] shows the calculated $\rho_{\text{Xe,Pb}}(p_{T,1})$ (left) and $\rho_{\text{Xe,Pb}}(p_{T,2})$ (right) for dijets in three centrality bins: 0%–10%, 10%–20%, and 20%–40%. Note that we applied a cut $x_J > 0.32$ in the calculation to be consistent with ATLAS measurements. We observe that $\rho_{\text{Xe,Pb}}$ values are generally greater than one for both leading and subleading jets across all centrality bins. This indicates weaker dijet yield suppression in Xe+Xe collisions than in Pb+Pb for the same centrality, a phenomenon that persists even in peripheral collisions. These findings are consistent with previous phenomenological studies [62–64]. Because the xenon

nucleus is smaller than lead, the system size and mean temperature of the QGP medium formed in Xe+Xe collisions are expected to be smaller than those in Pb+Pb collisions within the same centrality interval [103]. Consequently, dijets traverse a longer path-length medium and experience more effective energy loss in Pb+Pb collisions.

Conclusion

In this paper, we present the first investigation of medium modifications to dijet p_T balance (x_J) in Xe+Xe collisions at $\sqrt{s_{NN}} = 5.44$ TeV. The initial x_J distributions of dijets were calculated using the POWHEG+PYTHIA8 prescription, matching NLO QCD matrix elements with parton shower effects. The in-medium evolution of dijets in nucleus-nucleus collisions is described by the SHELL model, which incorporates both elastic and inelastic partonic interactions in the quark-gluon plasma. Our theoretical results for dijet x_J in Xe+Xe collisions exhibit more imbalanced distributions than in p+p collisions, consistent with recently reported ATLAS data. The dijet x_J becomes increasingly imbalanced from peripheral to central Xe+Xe collisions, consistent with previous Pb+Pb measurements at the LHC. Furthermore, using an infrared-and-collinear-safe flavor jet algorithm, we explored the flavor dependence of medium modifications to dijet p_T balance in nucleus-nucleus collisions. We studied the respective medium-modification patterns and fraction changes of the gg , qg , and qq components in the dijet sample for both p+p and Xe+Xe collisions. We demonstrated that the qg component plays a key role in the increased imbalance of dijet x_J . In particular, we found that q_{1g}^2 dijets experience more significant asymmetric energy loss than g_{1q}^2 dijets when traversing the QGP. By comparing $\Delta\langle x_J \rangle$ for inclusive, $c\bar{c}$, and $b\bar{b}$ dijets in Xe+Xe collisions, we observe $\Delta\langle x_J \rangle_{\text{incl.}} > \Delta\langle x_J \rangle_{c\bar{c}} > \Delta\langle x_J \rangle_{b\bar{b}}$, consistent with the mass hierarchy of partonic energy loss. In addition, the nuclear modification factors $\rho_{\text{Xe,Pb}}$ of dijets in Xe+Xe at $\sqrt{s_{NN}} = 5.44$ TeV and Pb+Pb at $\sqrt{s_{NN}} = 5.02$ TeV are consistent with ATLAS data, indicating that yield suppression is more pronounced in Pb+Pb than in Xe+Xe due to the larger radius of the lead nucleus.

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