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Investigating jet modification in heavy-ion collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ and 2.76 TeV with ALICE

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The LHC heavy-ion physics program aims at investigating the fundamental properties of nuclear matter under extreme conditions of energy density and temperature, where a transition to a Quark–Gluon Plasma (QGP) is expected. Jets, defined as sprays of hadrons resulting from the fragmentation of high-energy partons, are among the most powerful probes of QGP transport properties. Jets indeed suffer substantial energy loss while traversing the medium, which can be quantified by the modification of several experimental observables, such as yields, fragmentation pattern and structure of jets. Here we report on the ALICE measurement of jet nuclear modification factors and cross section ratios for different jet resolution parameters $R = 0.2$ and 0.3 using data sets from $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV pp, p–Pb, and Pb–Pb collisions at the LHC. These measurements are compared to the same measurements performed at the energy of 2.76 TeV. Additionally, recent results of jet measurements are presented for a more comprehensive understanding of jet modification at LHC.

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1. Introduction

The Quark–Gluon Plasma (QGP), a hot and dense deconfined state of matter, is expected to be created in head-on collisions of heavy nuclei at high energies. One of the most remarkable signatures of QGP formation turned out to be "jet quenching" [1]: the attenuation of jet yields in central Pb–Pb collisions compared to pp. Such attenuation attributed to partonic energy loss in the medium provides valuable insights into the thermodynamical and transport properties of the medium.

Two observables are presented in this article to assess jet quenching. One is the nuclear modification factor (R_{AA}) defined as the ratio of jet yields in heavy-ion collisions compared to a reference spectrum from pp collisions scaled by the number of binary nucleon-nucleon collisions

$$R_{\mathrm{AA}} = \frac{1}{\langle N_{\mathrm{coll}} \rangle} \frac{d\sigma^{\mathrm{AA}}_{\mathrm{jets}}/dp_{\mathrm{T}}}{d\sigma^{\mathrm{pp}}_{\mathrm{jets}}/dp_{\mathrm{T}}}, \tag{1.1}$$

where $\langle N_{\mathrm{coll}} \rangle$ is the average number of nucleon-nucleon collisions per heavy-ion collision, given by the Glauber model which incorporates a detailed description of the nuclear collision geometry. The other is the cross section ratio between different jet resolution parameters, which is sensitive to the jet radial profile. Thus, it helps in understanding jet broadening due to parton fragmentation in the medium. These measurements can discriminate among competing models of energy loss and fragmentation mechanisms, and/or reduce the systematic uncertainties from each theoretical formalism [2].

2. Jet measurements in ALICE

The ALICE experiment is dedicated to the study of the QGP, and is consequently optimized for heavy-ion collisions [5]. Jet measurements utilize the Inner Tracking System (ITS) and the Time Projection Chamber (TPC) for the tracking of charged constituents, and the electromagnetic

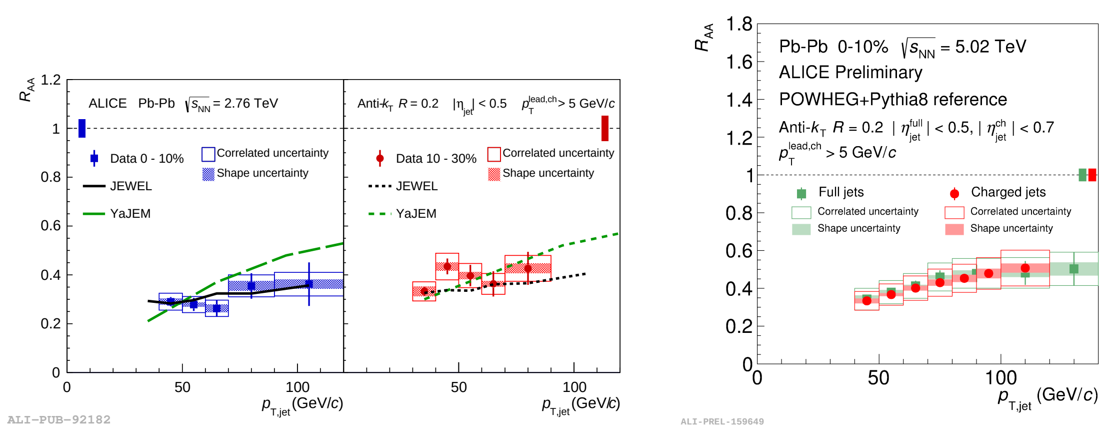

Figure 1: Nuclear modification factor (R_{AA}) of inclusive jets with $R = 0.2$ in the most central Pb–Pb collisions (0–10%) for $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV (left) [3] and $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV (right).

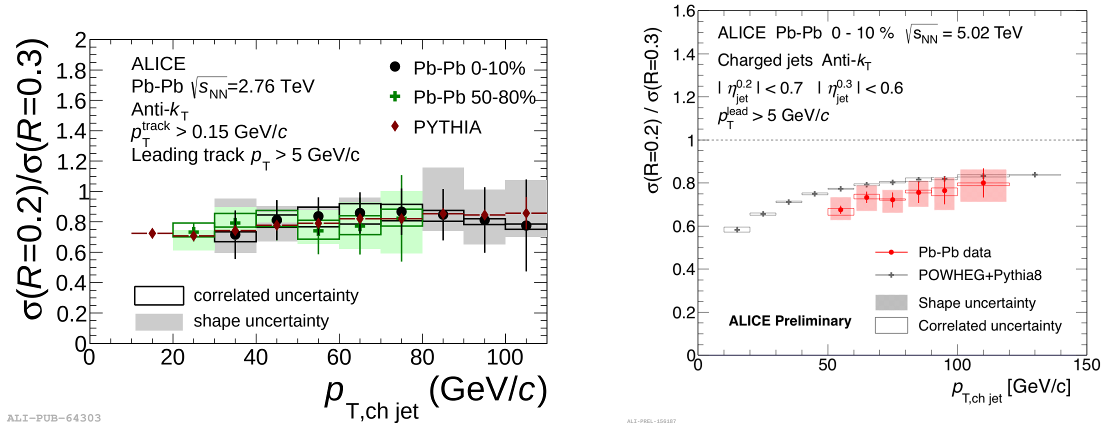

Figure 2: Ratio of the jet cross section between different resolution parameters $R = 0.2$ and $R = 0.3$ in the most central Pb–Pb collisions for $\sqrt{s_{NN}} = 2.76$ TeV (left) [4] and $\sqrt{s_{NN}} = 5.02$ TeV (right).

calorimeters for the neutral components. Jets are reconstructed by feeding the anti-k_T sequential clustering algorithm implemented in FastJet [6] with a jet resolution parameter R. Since the anti-k_T algorithm merges harder particles first it is less sensitive to a back-reaction from the soft underlying event, hence is well suited for the Pb–Pb environment. Furthermore, the effects from detector smearing and fluctuating underlying event in heavy-ion collisions are restored using unfolding techniques [7].

3. Measurement in pp and p–Pb collisions

The measurement of jet production in pp collisions serves as a test of QCD as well as a reference of the nuclear modification factors in Pb–Pb collisions. The ALICE jet measurement in pp gives good agreement with pQCD calculations both for inclusive production cross sections and its ratios. As for p–Pb collisions, the results obtained so far appeared comparable to that in pp collisions. They indicate less parton energy loss with a medium induced out-of-cone energy transport for jets with $R = 0.4$ and $15 < p_{T,jet}^{ch} < 50$ GeV/c less than 0.4 GeV/c in 5.02 TeV p–Pb collisions [8].

4. Measurement in Pb–Pb collisions

Figure 1 shows the jet R_{AA} in the most central Pb–Pb collisions for centre-of-mass energies of $\sqrt{s_{NN}} = 2.76$ TeV and 5.02 TeV [3]. A strong suppression is observed which weakens in peripheral collisions. In addition, the magnitudes are comparable between two collision energies. It might be understood as a stronger jet suppression in higher energy collision compensated by a flatter spectrum shape.

The measurement of the cross section ratio between $R = 0.2$ and 0.3 is given in Fig. 2 compared with the pp prediction from pQCD calculations at the same energy [4]. The level of jet broadening in Pb–Pb collisions, which is consistent to that in pp collisions, implies a hard jet core at least up to $R = 0.3$.

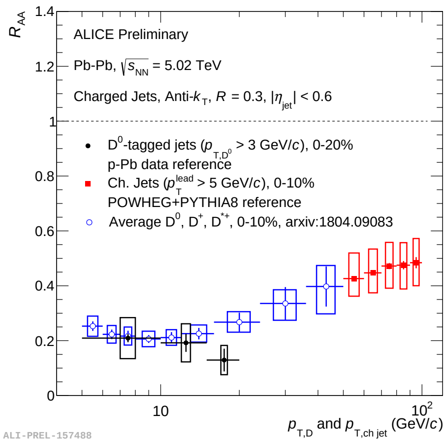

Figure 3: Nuclear modification factor (R_{AA}) of D^0-tagged jets in the most central Pb–Pb collisions (0–10%). Jets are reconstructed with a resolution parameter of $R = 0.3$. The R_{AA} of D mesons and inclusive charged jets ($R = 0.2$) are shown on the same plot.

5. Summary

Jet production in pp collisions can be well described by pQCD calculations. For p–Pb collisions no jet quenching effect is observed, implying no QGP creation or a too small volume of the medium to induce quantifiable parton energy loss. In Pb–Pb collisions, the existence of hard core jets are observed in spite of their strong suppression in the most central collisions.

Recently, in addition to inclusive jet studies, the jet quenching measurement of identified partons has been performed in ALICE. The charm tagged jet R_{AA}, presented in Fig. 3, shows a strong suppression comparable to that of single charm mesons. Quark flavor/mass dependent jet measurements are inevitable for a comprehensive understanding of parton energy loss mechanism. Such detailed investigations will be possible in LHC Run 3 and 4 due to the higher experimental precision.

References

[1] M. Gyulassy and M. Plumer, Phys. Lett. B243 (1990) 432-438

[2] A. Majumder and M. Van Leeuwen, Prog. Part. Nucl. Phys. 66 (2011) 41-92

[3] J. Adam et al. [ALICE Collaboration], Phys. Lett. B746 (2015) 1-14

[4] B. Abelev et al. [ALICE Collaboration], JHEP 1403 (2014) 013

[5] K. Aamodt et al. [ALICE Collaboration], JINST 3 (2008) S08002

[6] M. Cacciari et al., Eur. Phys. J. C72 (2012) 1896

[7] A. Hocker and V. Kartvelishvili, Nucl. Instrum. Meth. A372 (1996) 469-481

[8] S. Acharya et al. [ALICE Collaboration], Phys. Lett. B783 (2018) 95-113