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Nuclear modification factor I_{AA} in AA collisions at RHIC and LHC energies in scenarios with and without quark-gluon plasma formation in pp collisions

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We calculate the away-side hadron-triggered modification factor I_{AA} in AA collisions at RHIC and LHC energies for scenarios with and without quark-gluon plasma formation in pp collision. We find that for both scenarios theoretical results for I_{AA} agree well with the available data for 2.76 TeV Pb + Pb and 0.2 TeV Au + Au collisions. We make predictions for I_{AA} in 7 TeV O + O collisions that are planned at the LHC. Our results show that measuring I_{OO} in the whole centrality interval and at small centrality ($\lesssim 5\,\%$) may give information on the presence of jet quenching in pp collisions.

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The experimental observation of the collective flow effects and the strong suppression of high-p_T hadrons in heavy ion collisions at RHIC and LHC provides a strong evidence of quark-gluon plasma (QGP) formation in AA collisions (for reviews see, e.g., [1, 2]). The observation at LHC energies of the ridge effect in pp collisions [3, 4] supports the idea [5] that QGP formation is possible in hadron collisions as well. The steep growth of the strangeness production in pp collisions at charge multiplicity density $dN_{ch}/d\eta \sim 5$ [6] also may be interpreted as strong evidence in favor of the QGP formation in pp events with sufficiently high multiplicity. The scenario with the onset of the QGP formation regime in pp collisions at charge multiplicity density $dN_{ch}/d\eta \sim 5$ is also supported by the analysis of $\langle p_T \rangle$ as a function of multiplicity [7], employing van Hove's arguments [8]. If a liquid like droplet of the QGP is formed in pp collisions, then, similarly to AA collisions, there must be some jet modification (jet quenching) due to radiative [9–13] and collisional [14] parton energy loss in the QGP. In recent years the QGP formation and jet quenching in small systems has received considerable experimental and theoretical attention (see, e.g., a recent review [15]).

The suppression of high-p_T spectra in AA collisions is quantified by the nuclear modification factor R_{AA}. It is defined as ratio of the particle yield in AA collisions to the one in pp collisions times the number of hard binary collisions. An alternative method to probe the medium jet modification is measuring the away-side factor I_{AA} describing the two-particle correlations with the hadron/photon triggers [16, 17]. Experimentally, the factor I_{AA} is defined as the ratio

$$I_{AA} = \frac{Y_{AA}(\{p_T\},\{y\})}{Y_{pp}(\{p_T\},\{y\})}, \tag{1}$$

where $Y_{AA}(Y_{pp})$ is the per-trigger particle (h^t) yield of the associated (h^a) hadron production in $AA(pp)$ collisions, and $\{p_T\} = (p_T^a, p_T^t)$, $\{y\} = (y^a, y^t)$ are the sets of the transverse momenta and rapidities of the trigger particle and the associated hadron. A unique advantage of the factor I_{AA}, as compared to the R_{AA}, is that it is defined in terms of the self-normalized quantities $Y_{AA,pp}$. For this reason, for I_{AA} there is no problem with the determination of the number of hard process. Also, it is important that by measuring the away-side I_{AA} at different p^a one can probe the medium modification of the jet fragmentation functions in the broad range of z_T. The factor I_{AA} has a weaker sensitivity to the nuclear PDFs than R_{AA}. This makes it a good observable to probe jet quenching in light ion collisions, where the jet modification is weak. The comparison with the heavy ion data on I_{AA} is interesting, since comparison with data on I_{AA} allows one to test the jet quenching scheme in a different region of the variable z_T (for the available heavy ion data on I_{AA} [18–20] it is $z_T \sim 0.1 - 0.5$) as compared to the case of R_{AA}, which is sensitive to the fragmentation functions at z_T close to unity.

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in pp collision. We perform calculations within the jet quenching model of [21] without free parameters using α_s obtained by fitting the LHC heavy ion data on R_{AA} for the scenarios with and without QGP formation in pp collisions. We find that for both scenarios theoretical results for I_{AA} agree well with the available data for 2.76 TeV Pb + Pb and 0.2 TeV Au + Au collisions. We make predictions for I_{AA} in 7 TeV O + O collisions that are planned at the LHC in 2025. The results for I_{AA} at LHC energies are shown in Fig. 1 (there we also plot

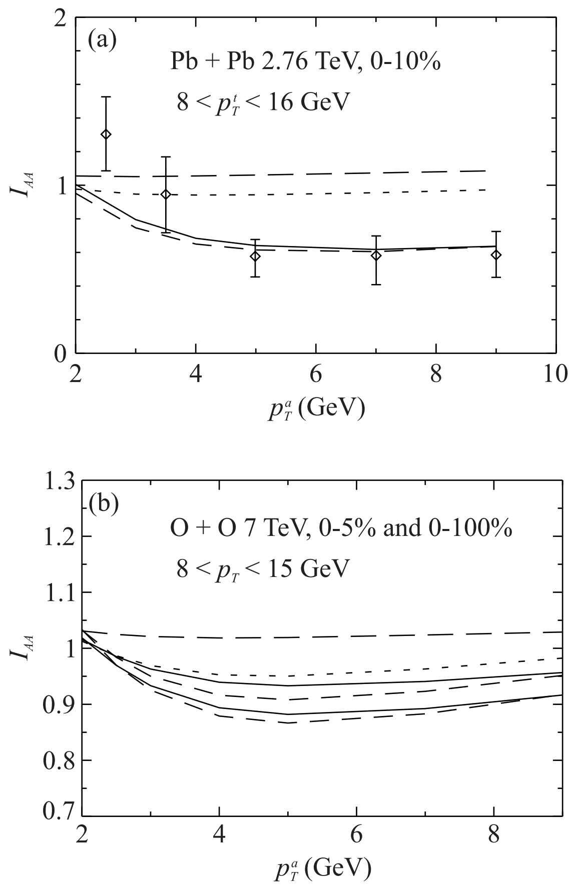

Fig. 1. The away-side I_{AA} versus p_T^a in AA collisions at LHC energies in the scenarios with (solid) and without (dashed) QGP formation in pp collisions in (a) 2.76 TeV Pb + Pb collisions for 0–10 % centrality and $8 < p_T^t < 16$ GeV, (b) in 7 TeV O + O collisions for (top to bottom) 0–100 % and 0–5 % centrality at $8 < p_T^{tr} < 15$ GeV. Long-dashed curves show I_{AA}^{pdf}, and dotted curves show I_{pp}. Data points are from ALICE [20]

results for the medium modification factor I_{pp} in pp collisions, and the factor I_{AA}^{pdf}, which quantifies the effect of the difference between proton and nuclear PDFs). Our results show that measuring I_{OO} in the whole centrality interval and at small centrality ($\lesssim 5$ %) may give information on the presence of jet quenching in pp collisions.

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