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Effect of meson cloud on the jet nuclear modification factor in pA collisions

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Factorization of hard and soft process suggests that in the cross section of hard reactions the soft physics can be accumulated in parton distribution functions (PDFs) of colliding particles. However, the factorization theorems do not forbid the existence of correlations between hard and soft final particles. The correlations of this type have been observed in recent measurements by ATLAS [1] of the centrality dependence of the jet nuclear modification factor R_{pA} for $p + Pb$ collisions at $\sqrt{s} = 5.02$ TeV. The R_{pA} for jet production is defined as

$$R_{pA} = \frac{dN^{\rm jet}_{pA}/dp_T dy}{N_{\rm coll} dN^{\rm jet}_{pA}/dp_T dy}, \qquad (1)$$

where $N^{\rm jet}_{pA}$ and $N^{\rm jet}_{pp}$ are the jet yields in pA and pp collisions, and $N_{\rm coll}$ is the number of the binary collisions. In [1] it has been observed that the jet nuclear modification factor R_{pPb} in the broad (minimum bias) $0 - 90\,\%$ centrality region is close to unity. However, it is not the case for narrow centrality bins. For high p_T the R_{pPb} has been found to be suppressed in central events ($R_{pPb} < 1$) and to be enhanced in peripheral events ($R_{pPb} > 1$). The effect is more pronounced for the proton-going rapidities ($y > 0$). In [2] it was proposed that the ATLAS data [1] can be explained by the initial state correlations of the hard and soft partons in the wave function of the projectile proton. The mechanism of [2] assumes that in the presence of an energetic parton (which is necessary for a hard process to occur) the number of soft partons in the projectile is suppressed. It leads naturally to correlation of the jet R_{pA} with the multiplicity/centrality. However, of course, the analysis [2] is of a qualitative nature. Because, due to the nonperturbative physics of the underlying events (UEs), it is impossible to obtain robust predictions for the multiplicity/centrality dependence of R_{pA} within the parton level schemes.

We study the effect of the meson-baryon Fock components in the proton on the jet nuclear modification factor. It is known that the total weight of the meson-baryon Fock states in the fast physical nucleon may be as large as $\sim 40\,\%$ [3]. The meson cloud of the proton plays an important role in the flavor dependence of nucleon PDFs in deep inelastic scattering, and is probably responsible for the violation of the Gottfried sum rule [3]. The emergence of the centrality dependence of R_{pA} in the scenario with the meson cloud is conceptually very similar to the partonic mechanism of [2]. In the scenario with the meson-cloud the hard process selects in the projectile proton wave function fluctuations with a reduced fraction of the meson-baryon states (as compared to the soft interactions). It results in suppression of the UEs multiplicity in jet production at high p_T, that should lead to centrality dependence of R_{pA} due to difference in the centrality categorization for minimum bias (soft) events and jet events. We simulate the UE activity in jet events within the Monte-Carlo Glauber wounded nucleon model with the meson cloud developed in [4, 5]. Comparison of our results for R_{pPb} with the ATLAS data [1] is shown in Fig. 1. One can

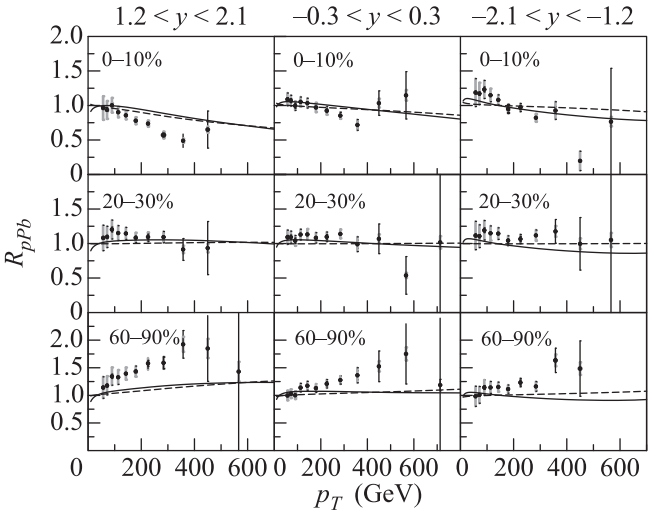

Fig. 1. R_{pPb} versus p_T for $p + Pb$ collisions at $\sqrt{s} = 5.02$ TeV for different rapidity windows for 0–10 % (upper), 20–30 % (middle), 60−90 % (lower) centrality classes. The solid curves show our results with the EKS98 correction, and the dashed ones without it. Data points are from ATLAS [1]

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see thar our R_{pPb} shows the same tendency as that observed by ATLAS. The meson cloud suppresses the central jet events and enhances the peripheral jet events. But quantitatively the effect is somewhat smaller than in the data.

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