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Inclusive jet measurements in Pb+Pb collisions at 5 TeV with the ATLAS detector

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Abstract

In relativistic heavy ion collisions, a hot medium with a high density of unscreened color charges is produced. Jets are produced at the early stages of this collision and are known to be affected by parton energy loss during their propagation through the hot medium. One manifestation of this energy loss is a lower yield of jets propagating the medium than expected in the absence of medium effects. ATLAS has provided a quantification of this jet suppression by the jet R_{AA} measurement in run 1 of the LHC. A factor of two suppression was seen in central heavy ion collisions with respect to pp collisions. The R_{AA} exhibited only a weak, if any, rapidity dependence, and a slow rise with increasing jet momentum. These proceedings summarizes results on the inclusive jet production, new results on dijet measurements and the measurement of the jet fragmentation in Pb+Pb collisions at center of mass energy of 2.76 TeV.

Keywords:
heavy ion collisions, jet quenching, fragmentation functions

Relativistic heavy-ion collisions provide a unique opportunity to study the most intriguing aspects of the strong interaction in the laboratory. In high energy ion-ion collisions studied at RHIC and the LHC, the energy densities are sufficiently high to produce a new form of matter referred to as the quark-gluon plasma

In the past few years, since the beginning of run 1 of the LHC, the ATLAS Collaboration [1] has published several measurements showing a strong modification of the jet and hadron yields in lead-lead (Pb+Pb) collisions. Measurements of production of asymmetric dijets, single jets, measurement of jet fragmentation and production of neighbouring jets should provide new information on the mechanism of jet energy loss and modification of the jet substructure [2][3][4].

1. Nuclear modification factor of jets

The observable quantity that expresses the magnitude of suppression or enhancement of jets in the environment of nuclear collisions is the nuclear modification factor, R_{AA}. The R_{AA} is defined for given centrality bin as

$$R_{\mathrm{AA}} = \frac{\frac{1}{N_{\mathrm{evt}}}\frac{\mathrm{d}^2 N_{\mathrm{jet}}}{\mathrm{d}p_{\mathrm{T}}\mathrm{d}y}\Big|_{\mathrm{centrality}}}{\langle T_{\mathrm{AA}}\rangle \frac{\mathrm{d}^2\sigma^{pp}_{\mathrm{jet}}}{\mathrm{d}p_{\mathrm{T}}\mathrm{d}y}} \quad (1)$$

where T_{AA} is the nuclear overlap function, N_{evt} is the number of events in Pb+Pb collisions and σ^{pp} is the cross section of pp collisions.

The R_{AA} measurement was published in Ref.[5]. For this jet measurement, Pb+Pb data collected in 2011 (luminosity $L_{\mathrm{int}}^{\mathrm{PbPb}}$=0.14 nb^{-1}) and pp data collected in 2013 ($L_{\mathrm{int}}^{\mathrm{pp}}$=4.0 pb^{-1}) at $\sqrt{s_{\mathrm{NN}}}$ = 2.76 TeV were used. Jets were reconstructed using the anti-k_t algorithm [6] with parameter R = 0.4. Jet triggered samples were combined with Minimum bias (MB) data to get the jet spectra in the interval of $32 < p_{\mathrm{T}}^{\mathrm{jet}} < 500$ GeV. In Pb+Pb collisions, background contribution to the jet energy from the underlying event (UE) was estimated and subtracted on an event-by-event basis by an iterative procedure. The Singular Value Decomposition unfolding was used

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to account for smearing of the jet momentum due to detector effects.

Jet R_{AA} is shown in Fig.1 as a function of jet p_T for different centrality bins. The suppression of jet production in all centrality bins in Pb+Pb collisions is weakly dependent on the jet p_T. In the central Pb+Pb collisions, jet yield is suppressed approximately by a factor of two and it gradually decreases from central to peripheral collisions. The suppression remains significant even in the 60-80% centrality bin. This is quantified also in Fig.2 where the lower panel shows the number of participants N_{part} dependence of R_{AA} in one p_T and one rapidity (y) bin. The upper panel shows rapidity dependence of R_{AA} for three different centralities in $80 < p_T < 100$ GeV bin. No significant rapidity dependence is observed in the measured y range.

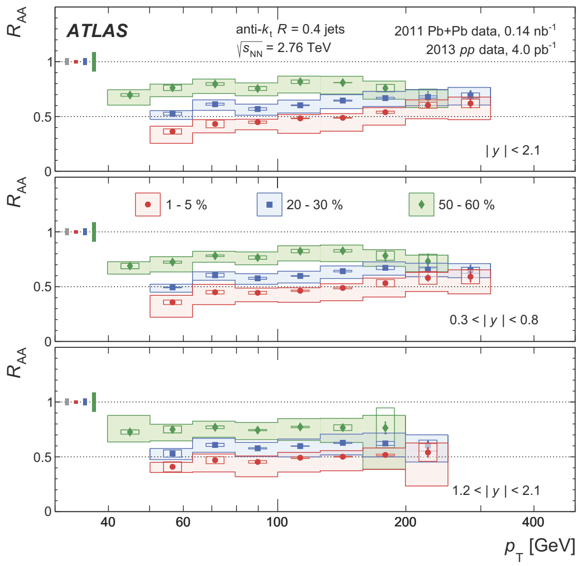

Figure 1: The R_{AA} for jets as a function of jet p_T in different centrality bins with each panel showing a different range in y. The fractional luminosity and T_{AA} uncertainties are indicated separately as shaded boxes centered at one. The boxes, bands, and error bars indicate uncorrelated systematic, correlated systematic, and statistical uncertainties, respectively [5].

2. Measurement of production of asymmetric dijets

A new measurement of dijet p_T correlations in p-p and Pb+Pb collisions at $\sqrt{s_{NN}}$ =2.76 TeV [7] was performed using the ATLAS detector. Introducing the variable $x_J = p_{T_1}/p_{T_2}$, the momentum balance of the dijet was measured. Here p_{T_1} and p_{T_2} are the transverse momenta of the jets with the highest and second highest p_T in the event, respectively. Measurements of $\frac{1}{N}\frac{dN}{dX_J}$

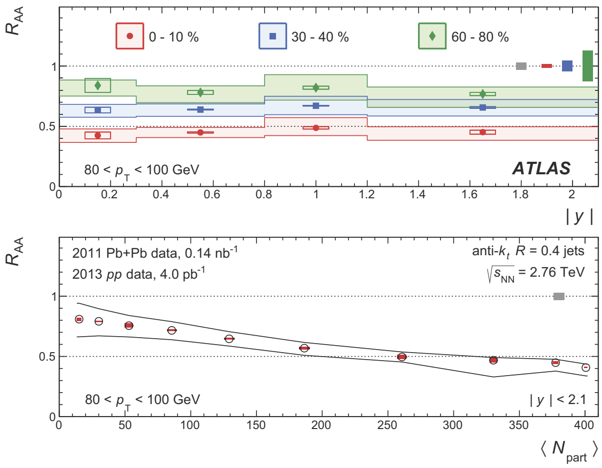

Figure 2: The R_{AA} for jets with $80 < p_T < 100$ GeV as a function of $|y|$ for different centrality bins (top) and as a function of N_{part} for the $|y| < 2.1$ range (bottom). The boxes, bands, and error bars indicate uncorrelated systematic, correlated systematic, and statistical uncertainties, respectively [5].

were performed as a function of p_{T_1} and collision centrality.

The $\frac{1}{N}\frac{dN}{dX_J}$ distributions obtained in Pb+Pb and pp collisions are shown in Fig.3 for the most central events. For $100 < p_T < 126$ GeV, the distributions develop a broad peak at $x_J \sim 0.5$, corresponding to the subleading jet with half the p_T of the leading jet. The modifications are decreasing with increasing p_{T_1}. This evolution is much more abrupt than the p_T dependence of the single jet R_{AA}, which is approximately logarithmic. In contrast, the distributions in pp collisions have the most probable value near $x_J \sim 1$ corresponding to the dijet pairs having nearly the same p_T.

To account for detector-specific experimental effects, namely the resolution on the measured jet p_T, which lead to distortions of the distributions, a two-dimensional Bayesian unfolding procedure was used. That was not done in the previous experimental results [8][9][10]. The new measurement of dijet asymmetry is free from experimental biases and can be directly compared to theoretical calculations.

3. Fragmentation functions

Modifications of the jet internal structure can be directly accessed by measuring jet fragmentation functions. ATLAS recently measured [11] two sets of fragmentation functions, $D(p_T)$ and $D(z)$ which are defined