Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Nuclear Physics A 00 (2016) 1–4
Nuclear Physics A
www.elsevier.com/locate/procedia

Jet suppression and the flavor dependence of partonic energy loss with ATLAS

Tomas Kosek on behalf of ATLAS collaboration

V Holesovickach 2, Praha 8, Charles University in Prague

Abstract

In relativistic heavy ion collisions, a hot medium with a high density of unscreened color charges is produced. One manifestation of the energy loss of jets propagating through the medium is a lower yield of jets and hadrons emerging from this medium than expected in the absence of medium effects. Therefore modifications of the jet yield are directly sensitive to the energy loss mechanism. Furthermore, jets with different flavor content are expected to be affected by the medium in different ways. In this publication, the latest ATLAS results on single hadron suppression along with the complementary measurements of single jet suppression are presented. Rapidity dependence, which is sensitive to the relative energy loss between quark and gluon jets, is discussed. Finally, a new measurement of jet fragmentation functions is presented.

Keywords:
ATLAS, Heavy-Ion, jet quenching, RAA, fragmentation functions

1. Introduction

In the past few years, since the beginning of LHC run 1, the ATLAS collaboration [1] has published several measurements showing strong modification of jet and hadron yields in Heavy-Ion (HI) collisions. Measurements of production of asymmetric dijets, single jets, measurement of jet fragmentation or production of neighboring jets provided fruitful information on the mechanism of jet energy loss and modification of the jet substructure [2, 3, 4, 5]. The next step is to study parton flavor dependence of the energy loss in HI collisions. Because the ratio of quark-initiated jets to gluon-initiated jets is changing with rapidity a possible first step is to study the (pseudo)rapidity dependence of jet or hadron properties.

2. Charged Particle R_{AA}

Charged particle spectrum is a fundamental observable for any hadronic reaction. Suppression of charged particle production in HI collisions relative to pp spectra was already measured in experiments at RHIC collider, however LHC data made it possible to extend measurements to a high-p_{T} regime. Observable quantity that expresses magnitude of suppression or enhancement is the nuclear modification factor

R_{AA}, which is defined as

$$R_{AA} = \frac{\frac{1}{N_{evt}} \frac{d^2 N_{Pb+Pb}}{dp_T dy}\Big|_{centr}}{\langle T_{AA} \rangle \frac{d^2\sigma_{pp}}{dp_T dy}} \tag{1}$$

where $\langle T_{AA} \rangle$ is the nuclear overlap function.

ATLAS measured p_T dependence of R_{AA} for charged particles in Pb+Pb and pp collisions at $\sqrt{s_{NN}}$ = 2.76 TeV in eight pseudorapidity (η) bins [6]. For Pb+Pb spectra data collected in 2010 and 2011 were used with integrated luminosity $L_{int}^{PbPb} = 0.15$ nb^{-1}. Pb+Pb data were collected with minimum-bias (MB) trigger in 2010 and MB and jet trigger in 2011. pp data were collected in 2011 and 2013 using MB and jet triggers, $L_{int}^{pp} = 4.2$ pb^{-1}.

Spectra were corrected for trigger and track reconstruction efficiencies and in pp also for vertex reconstruction efficiency. Badly reconstructed tracks and secondary tracks contributions were taken into account and corrected for. Track reconstruction efficiency correction was p_T, η and centrality dependent. Spectra were unfolded using the Bayesian unfolding.

The measured p_T dependence of R_{AA} is shown in Fig. 1. R_{AA} plots show that production of the charged particles at intermediate p_T is strongly suppressed in central collisions and that the size of the suppression decreases with increasing p_T up to 60 GeV where it saturates. The size of the suppression decreases from central to peripheral collisions though it is still significant in the peripheral collisions. No η dependence is observed.

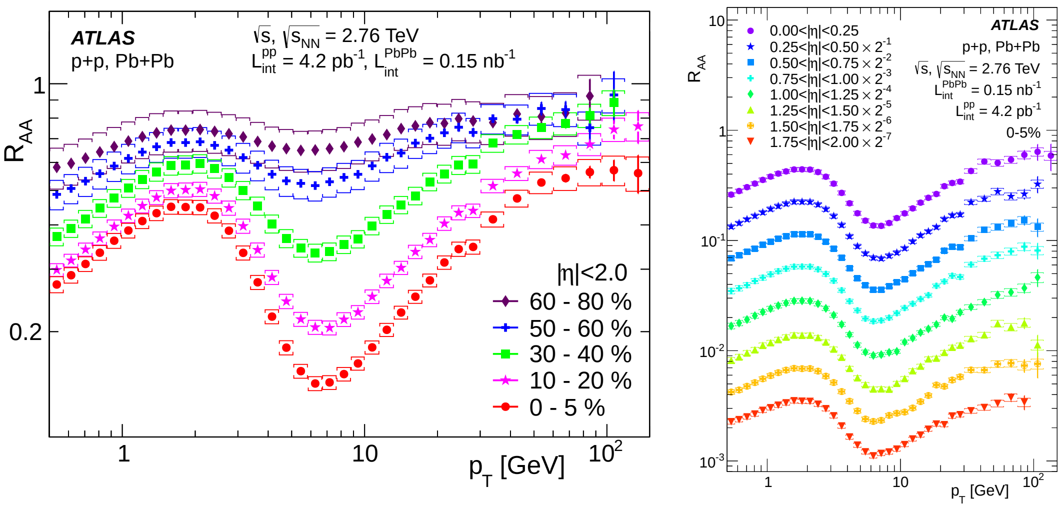

Fig. 1. Left: The dependence of the nuclear modification factor R_{AA} on p_T measured in five centrality bins. Right: The R_{AA} dependence on p_T measured in eight $|\eta|$ ranges for centrality interval 0-5% [6].

3. Jet R_{AA}

Complementary measurement to hadron R_{AA} is the measurement of jet R_{AA} [7]. For jet R_{AA} measurement, Pb+Pb data collected in 2011 ($L_{int} = 0.14$ nb^{-1}) and pp data collected in 2013 ($L_{int} = 4.0$ pb^{-1}) were used. MB and jet triggered samples were combined to get jet spectra in the interval of $32 < p_T^{jet} < 500$ GeV. Jets were reconstructed using the anti-k_t algorithm [8] with parameter $R = 0.4$.

Background contribution to the jet energy from the underlying event (UE) was estimated and subtracted on the event-by-event basis by the iterative procedure. This procedure was used in both pp and Pb+Pb collisions. Jet energies were calibrated by the procedure based on the MC. To account for the resolution effects an unfolding based on the Singular Value Decomposition method was used.

Various dependencies of jet R_{AA} are shown in Fig. 2. Left panel shows suppression of jet production in central collisions by a factor of approximately two which is weakly dependent on the jet p_T. Size of suppression gradually decreases from central to peripheral collisions but is significant even in 60-80% centrality bin. This is depicted also in lower right panel where $\langle N_{part} \rangle$ dependence of R_{AA} in one p_T and one rapidity (y) bin is shown. Upper right panel shows rapidity dependence of R_{AA} for three different centralities in $80 < p_T < 100$ GeV bin. No rapidity dependence is observed in the measured y range.

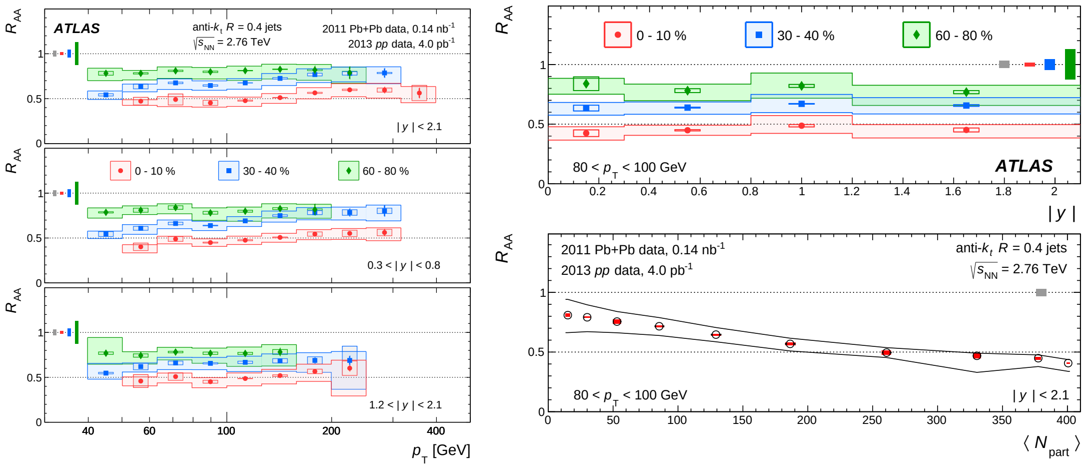

Fig. 2. Left: Jet R_{AA} as a function of p_T in three centrality bins with each panel showing a different range in $|y|$. Right: The R_{AA} for jets with $80 < p_T < 100$ GeV as a function of y for different centrality bins (top) and as a function of $\langle N_{part} \rangle$ for $|y| < 2.1$ range (bottom) [7].

4. Fragmentation Functions

Modifications of the jet internal structure can be directly accessed by measuring jet fragmentation functions [9]. ATLAS measured two sets of fragmentation functions, $D(p_T)$ and $D(z)$ which are defined as

$$D(p_T) = \frac{1}{N_{jet}} \frac{dN_{ch}}{dp_T^{ch}} \qquad D(z) = \frac{1}{N_{jet}} \frac{dN_{ch}}{dz} \tag{2}$$

where longitudinal momentum fraction $z = (p_T \cos \Delta R)/p_T^{jet}$ and ΔR is the distance between jet and track in $\eta - \phi$ space.

Jet triggered Pb+Pb and pp data taken in 2011 and 2013 were used in this analysis. Jets used in this analysis were clustered with anti-k_t algorithm, from UE background subtracted and fully calibrated. Calibrated jets with $100 < p_T < 398$ GeV were used in the analysis. Tracks with $p_T > 1$ GeV that match the jet within $\Delta R < 0.4$ were used. Tracks were corrected for reconstruction efficiency. Because of the large contribution from UE η dependent subtraction procedure based on event-by-event basis was applied to tracks with p_T less than 6 GeV. To correct for detector effects 2D Bayesian unfolding was used.

Ratios of jet fragmentation functions in Pb+Pb to pp jet fragmentation functions are shown in Fig. 3. Jet fragmentation functions in HI collisions exhibit enhancement in low and high p_T region and depletion at intermediate p_T compared to pp. Magnitude of the modification decreases for peripheral collisions. No significant difference between different η intervals at low p_T is observed but a hint of smaller enhancement in forward region compared to barrel region is observed at high p_T. Similar effect is observed for different jet p_T selections where enhancement at high p_T is smaller for high p_T jets.

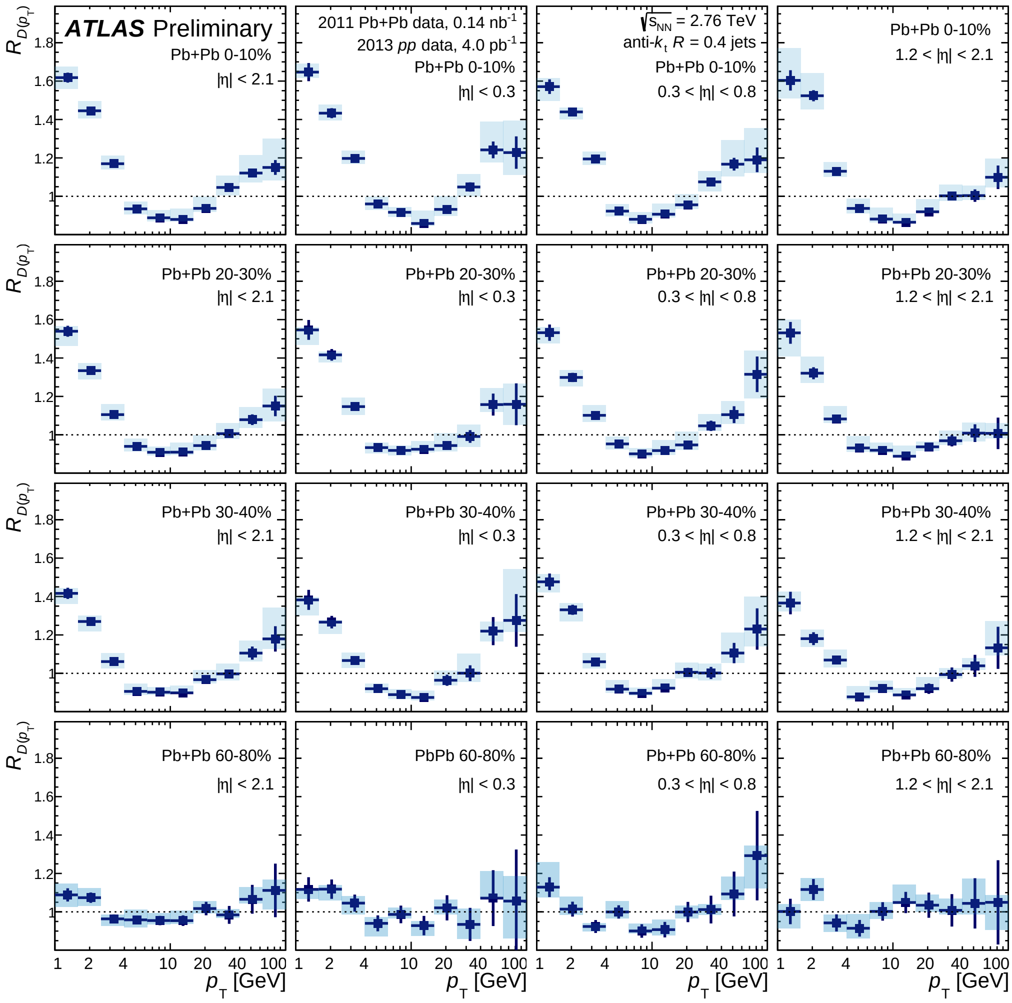

Fig. 3. The ratios of $D(p_T)$ distributions measured in HI collisions to $D(p_T)$ measured in *pp* collisions. Ratios are evaluated in four centrality bins (rows) and four selections on jet pseudorapidity (columns) [9].

5. Summary

Three measurements that provide complex view on the jet quenching phenomenon are presented. Measurements of single hadron and single jet R_{AA} show strong suppression of hadrons and jets in HI collisions which is y independent. Measurement of jet fragmentation functions shows modification of jet fragmentation in HI collisions which is η independent except high p_T region where a hint of η dependence is observed.

References

[1] ATLAS Collaboration, JINST 3 (2008) S08003.
[2] ATLAS Collaboration, Phys. Rev. Lett. 105 (2010) 252303. arXiv:1011.6182.
[3] ATLAS Collaboration, Phys. Lett. B719 (2013) 220–241. arXiv:1208.1967.
[4] ATLAS Collaboration, Phys. Lett. B739 (2014) 320–342. arXiv:1406.2979.
[5] ATLAS Collaboration, Phys. Lett. B751 (2015) 376–395. arXiv:1506.08656.
[6] ATLAS Collaboration, JHEP 09 (2015) 050. arXiv:1504.04337.
[7] ATLAS Collaboration, Phys. Rev. Lett. 114 (7) (2015) 072302. arXiv:1411.2357.
[8] M. Cacciari, G. P. Salam, G. Soyez, JHEP 04 (2008) 063. arXiv:0802.1189.
[9] ATLAS Collaboration, ATLAS-CONF-2015-055.