Mechanisms of jet quenching in PbPb collisions at the LHC

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PYQUEN (PYthia QUENched)

event generator to simulate rescattering, radiative and collisional energy loss of hard partons in expanding quark-gluon plasma in heavy ion collisions (implemented as modification of standard PYTHIA6.4 events)

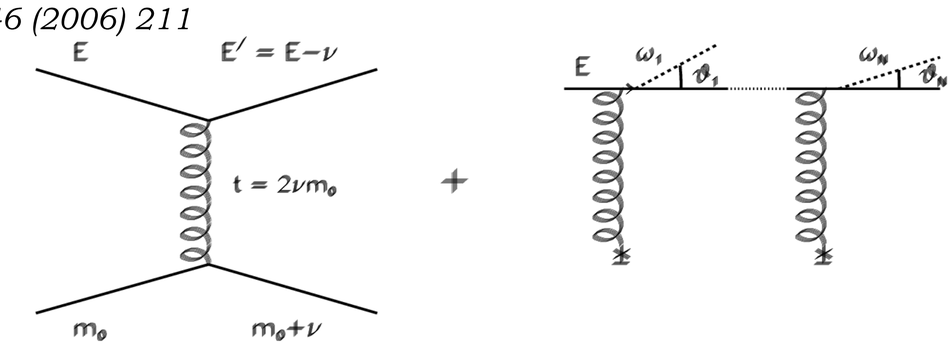
http://cern.ch/lokhtin/pyquen

I.P.Lokhtin, A.M.Snigirev, Eur. Phys. J C 46 (2006) 211

Collisional loss ⇒ high momentum transfer approximation

Radiative loss ⇒ BDMPS model, coherent radiation

- Small-angular radiation $\frac{dN^g}{d\theta} \propto \sin\theta \exp\left(\frac{-(\theta-\theta_0)^2}{2\theta_0^2}\right), \quad \theta_0 \sim 5^o$
- Wide-angular radiation $\frac{dN^g}{d\theta} \propto \frac{1}{\theta}$



The LHC data on various jet characteristics (nuclear modification factors, internal structure) in PbPb collisions at $\sqrt{s_{NN}}$=2.76 TeV are analyzed and interpreted within PYQUEN jet quenching model

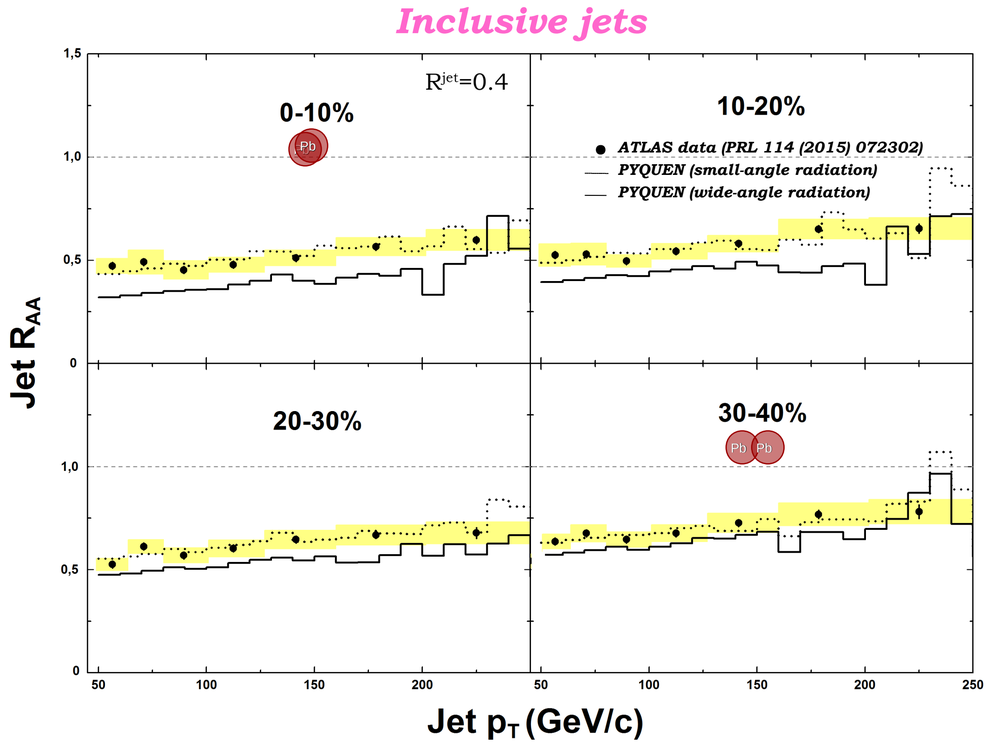
I.P. Lokhtin, A.A. Alkin, A.M. Snigirev, arXiv:1410.0147, Eur. Phys. J. C, in press

Jet nuclear modification factors

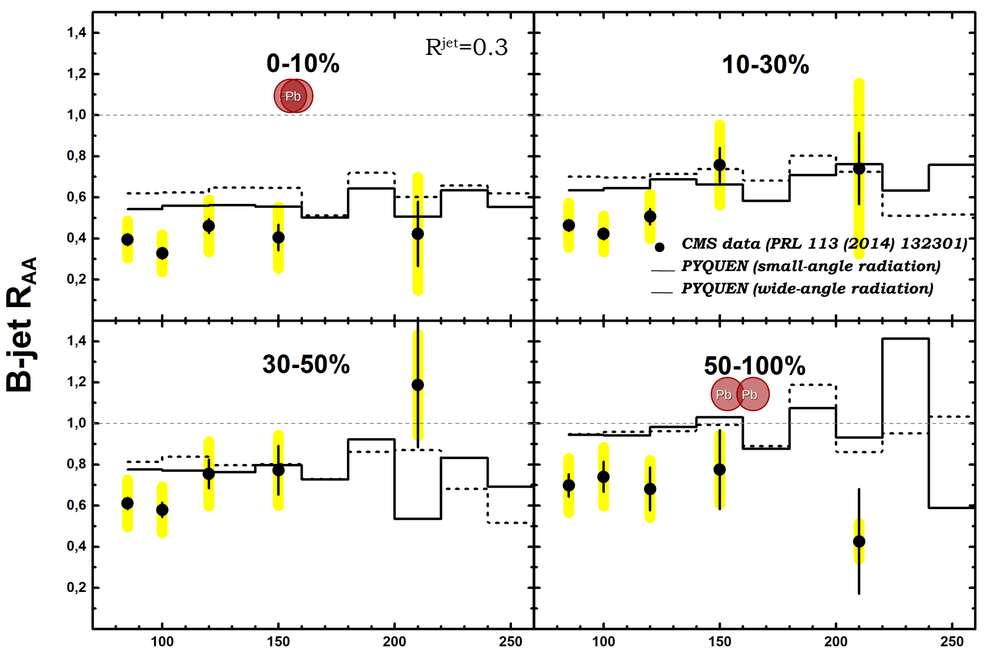
$$R_{AA} = \frac{\sigma_{pp}^{inel}}{\langle N_{coll} \rangle} \frac{d^2N_{AA}/dp_T d\eta}{d^2\sigma_{pp}/dp_T d\eta} \sim \frac{\text{“QCD Medium”}}{\text{“QCD Vacuum“}}$$

R_{AA}>1: enhancement
R_{AA}=1: no medium effect
R_{AA}<1: suppression

Inclusive jets



B-jets

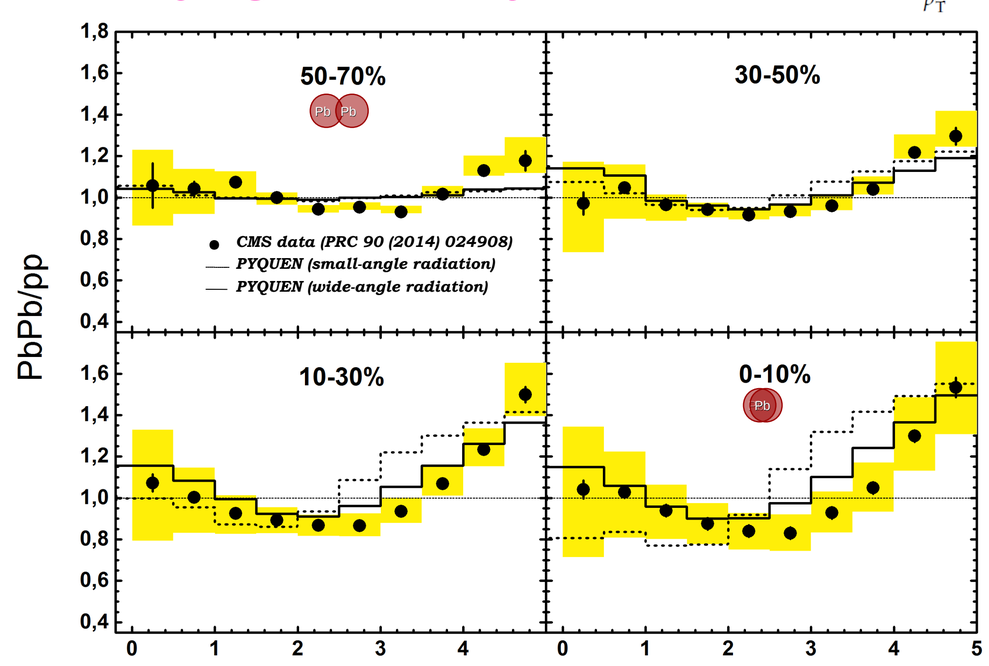


Simulation results for R_{AA} are close to the data within statistical and systematic experimental uncertainties. Since no qualitative difference between wide-angle and small-angle radiation scenarios seen for the energy dependence of R_{AA} (only numerical difference ≤20% independently of E_T), making unambiguous conclusions in favor of either scenario based on jet R_{AA} measurements is difficult.

Jet internal structure

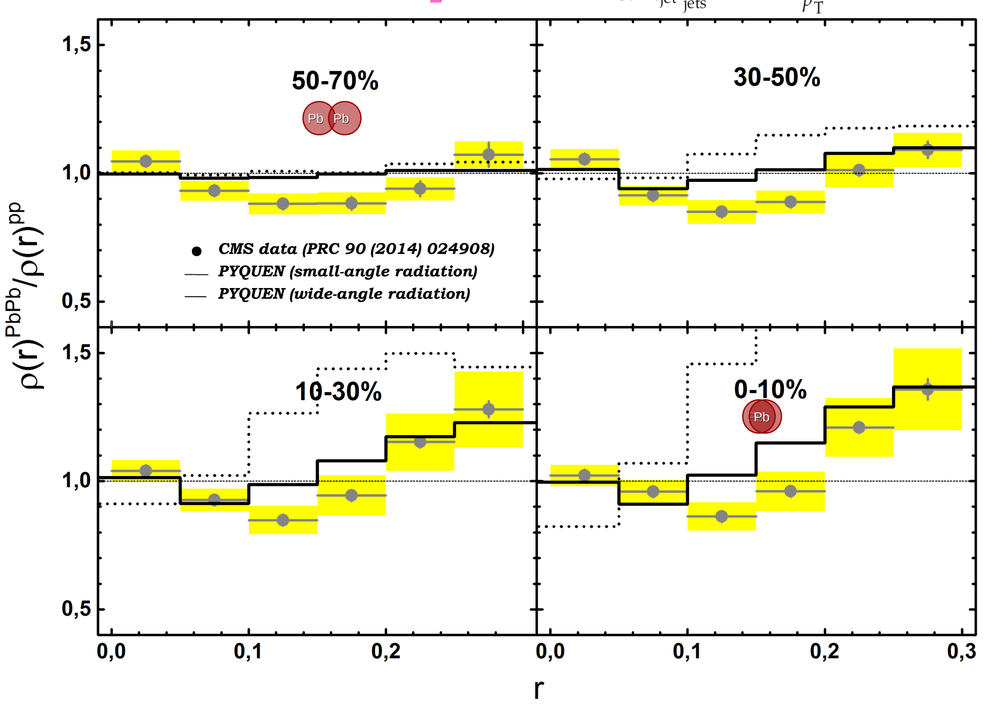
Jet fragmentation function

$$\xi = -\ln z = -\ln \frac{p_T^{track}}{p_T^{jet}}$$

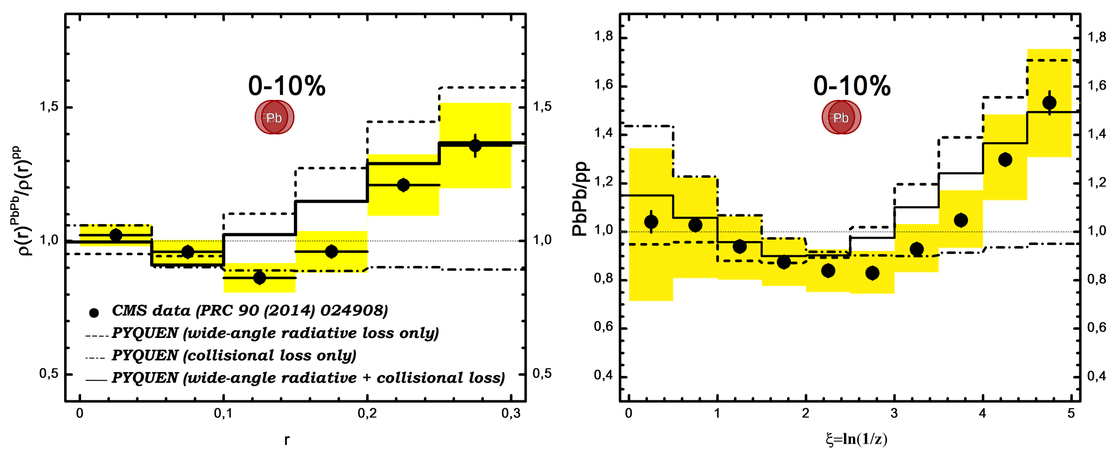


Jet shapes

$$\rho(r) \sim \frac{1}{\delta r} \frac{1}{N_{\text{jet}}} \sum_{\text{jets}} \frac{p_T(r-\delta r/2, r+\delta r/2)}{p_T^{\text{jet}}}$$



The specific modification of longitudinal and radial jet profiles is reproduced by PYQUEN with wide-angle radiative + collisional loss. The scenario with small-angle loss is inconsistent with the data.



The contribution from wide-angle radiative loss to the medium-modified intra-jet structure dominates. With all this the scenario with wide-angle radiative loss alone cannot match the data well, so taking into collisional loss is also necessary.

Conclusions

Suppression factors for inclusive jets and b-jets, as well as a specific modification of longitudinal and radial jet profiles in most central PbPb collisions, are reproduced by PYQUEN simulations taking into account wide-angle radiative and collisional partonic energy loss. Precise measurements of jet internal structure can put strong constraints on the theoretical models of jet quenching.