Universal scaling dependence of QCD energy loss from data driven studies

Peter Christiansen[1], Konrad Tywoniuk[2], Vytautas Vislavicius[1]

[1]Lund University, Sweden
[2] University of Barcelona

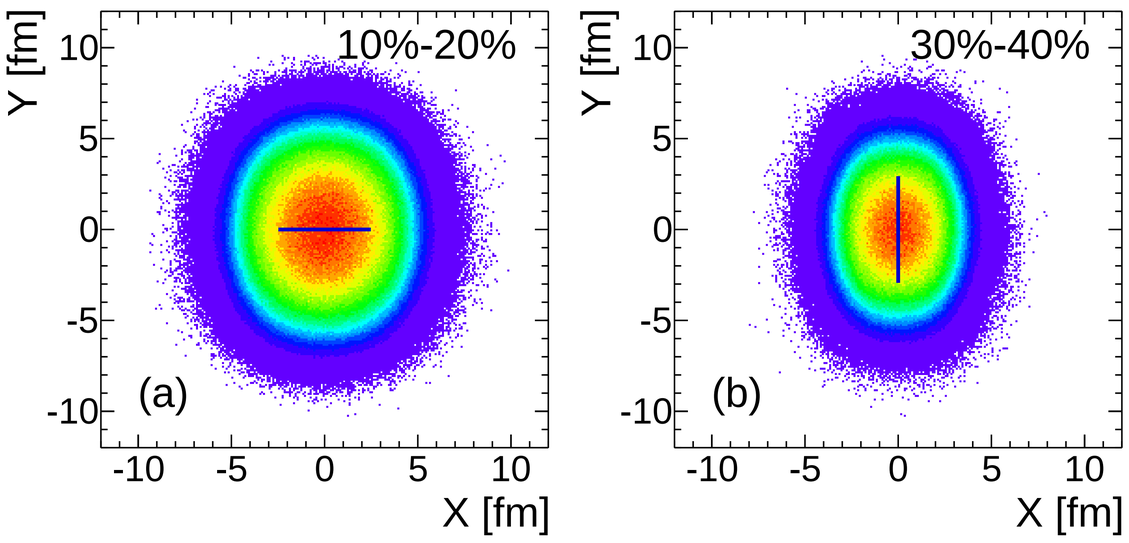
P. Christiansen, K. Tywoniuk and V. Vislavicius, Phys. Rev. C **89** (2014) 034912 [arXiv:1311.1173 [hep-ph]]

Motivation

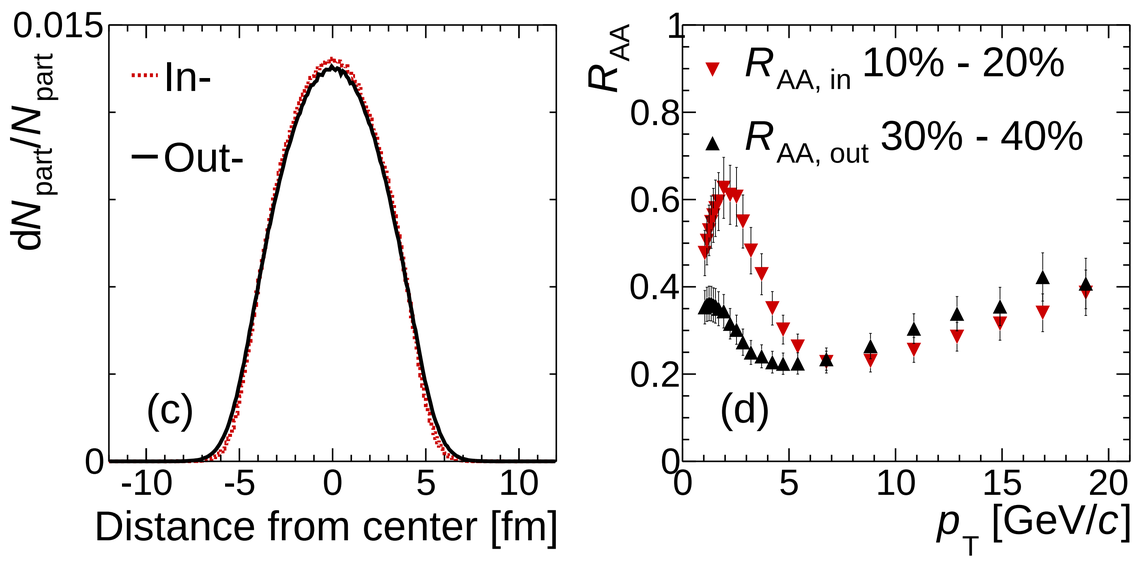
Currently, a number of models describing partonic energy loss in nuclear matter exist. The pQCD calculations for these models are extremely sensitive to initial parameters which cannot be determined with certainty, but rather have to be tuned to agree with the observables, either the *nuclear modification factor* R_{AA} or *elliptic flow coefficient* v_2 . Nevertheless, while regulating the initial parameters provides results consistent among different models, attempts to describe *both* of the measured obesvarbles simultaneously fail.

Idea

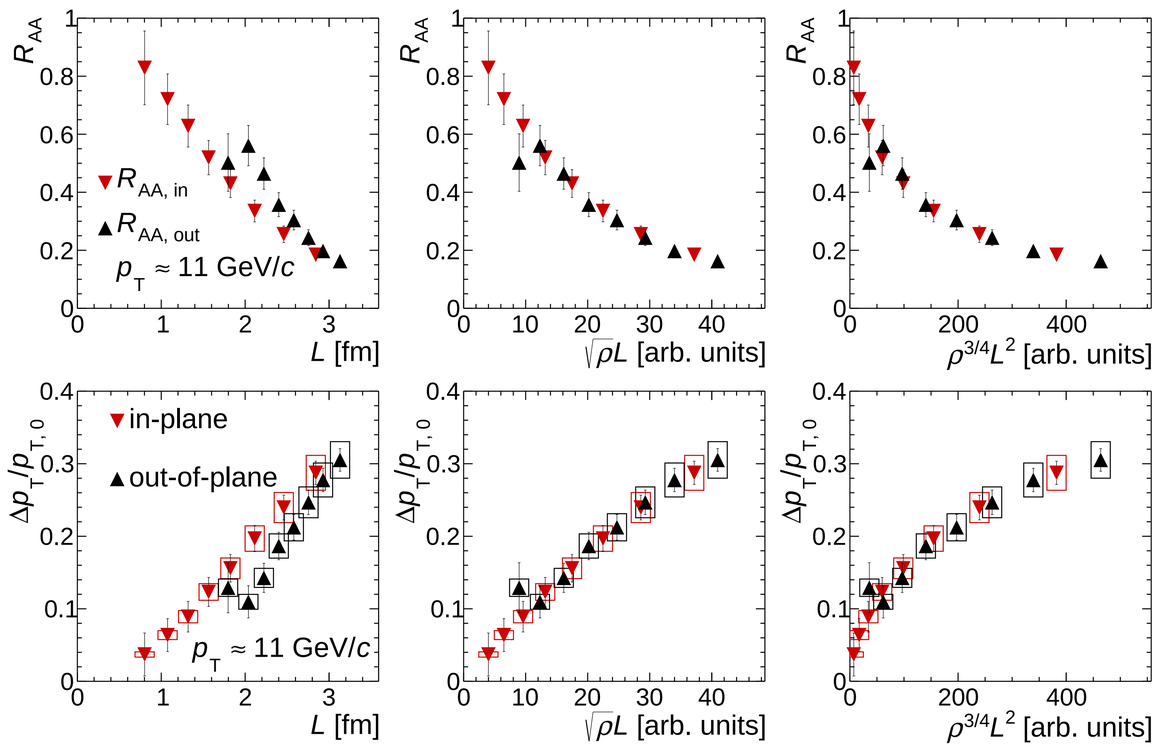
- Work in terms of $R_{\mathrm{AA,\,in/out}} = R_{\mathrm{AA}}\,(1 \pm 2v_2)$
  try to find a scaling variable x such that $R_{\mathrm{AA,\,in}} = R_{\mathrm{AA,\,out}}$ when $x_{in} = x_{out}$
- Expect linear scaling of the radiated energy, $\Delta E \propto \rho^{\kappa} L^{\lambda}$
  - with L characterizing the length a parton travels $\rightarrow$ RMS of participant distribution in our case
  - with ρ characterizing the density of the medium, $\rho \propto \frac{\mathrm{d}N_{\mathrm{ch}}}{\mathrm{d}\eta}$
  - ▷ Use Glauber MC to select centrality bins with similar L's



- Choose $p_{\mathrm{T}} > 8\mathrm{GeV}/c$, so flow effects are small if present $\Rightarrow$ quenching gives rise to v_2
- Similar participant distributions should result in similar R_{AA} 's

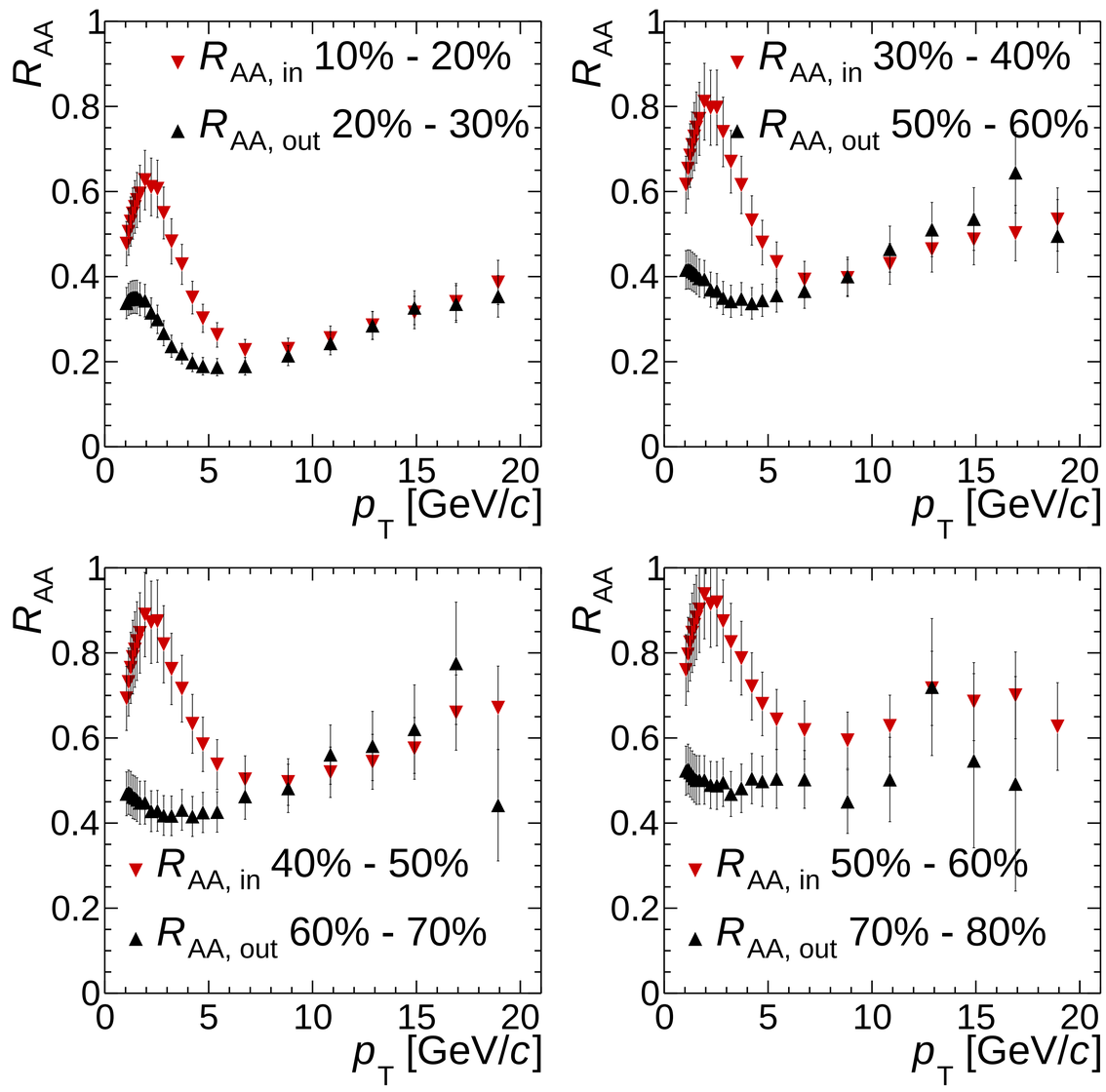


- $R_{\mathrm{AA,\,out}}$ is larger than $R_{\mathrm{AA,\,in}}$ $\Rightarrow$ need to regulate ρ^{κ} dependence
- Tuning the power of ρ^{κ} we find that ΔE scales linearly with $\sqrt{\rho}L$
  $\Rightarrow$ $R_{\mathrm{AA,\,in}}$ and $R_{\mathrm{AA,\,out}}$ can be paramterized by one scaling variable, i.e. $R_{\mathrm{AA,\,in/out}} = R_{\mathrm{AA}}(\sqrt{\rho}L)$

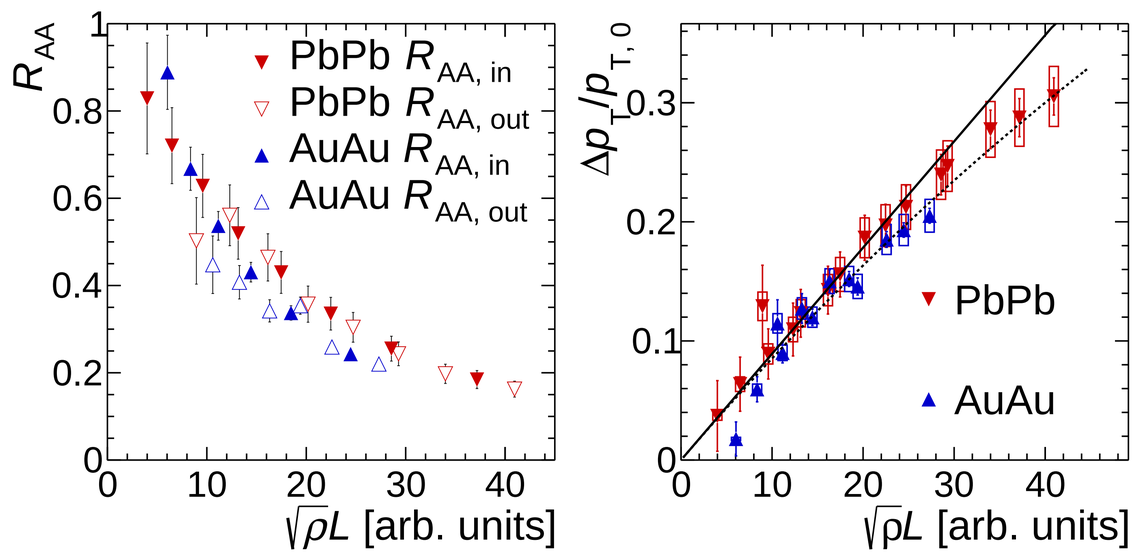


Results

- Experimental check: use Glauber MC to select centrality bins where $(\sqrt{\rho}L)_{in} \sim (\sqrt{\rho}L)_{out}$; expect $R_{\mathrm{AA,\,in}}$ and $R_{\mathrm{AA,\,out}}$ to be similar
  - ▷ A solid check, not biased by the analysis, as ATLAS and ALICE results [1, 2] are used



- Compare PbPb @ 2.76 TeV and AuAu @ 200 GeV data
  - ▷ Use Glauber MC to estimate characteristic lengths for AuAu
  - ▷ Center-of-mass energy is different by an order of magnitude
  - ▷ Charged particle multiplicity is different by a factor of ~ 2
  - ▷ Different parametrization powers of *pp* charged particle spectra



- Relative energy losses are consistent for different systems in different energy ranges
- AuAu R_{AA} is smaller than PbPb R_{AA}
  - ▷ Fixed by normalizing *pp* charged particle spectra parametrization powers

Summary and Conclusions

In a data driven study we have found a scaling variable $\sqrt{\frac{\mathrm{d}N_{\mathrm{ch}}}{\mathrm{d}\eta}}L$ that consistently describes R_{AA} and v_2 at $p_{\mathrm{T}} \gtrsim 8\mathrm{GeV}/c$. The density dependence observed in LHC data is consistent with RHIC data, though the energies are dramatically different; this suggests that the matter created at both RHIC and LHC has fundamentally similar properties. Although the scaling relations were obtained for a static medium and their translation to expanding diluting medium is not straightforward, the study suggests that in a realistic medium description some of the effects are likely to cancel. The results presented could hopefully provide guidance to further theoretical developments of jet quenching.

[1] G. Aad *et al.* [ATLAS Collaboration], Phys. Lett. B **707** (2012) 330
[2] B. Abelev *et al.* [ALICE Collaboration], Phys. Lett. B **720** (2013) 52