DREENA framework as a multipurpose tool for QGP tomography

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МИНИСТАРСТВО ПРОСВЕТЕ, НАУКЕ И ТЕХНОЛОШКОГ РАЗВОЈА

Abstract

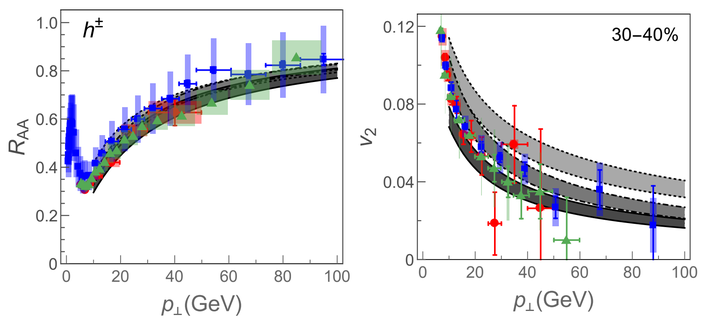
DREENA framework is fully optimized numerical procedure, based on our dynamical energy loss formalism, which has unique properties in the description of high-$p_\perp$ parton interactions with the medium. Importantly, DREENA provides a natural framework where temperature profile from any medium evolution can be straightforwardly implemented. We exploit this by implementing different state-of-the-art medium evolutions within DREENA framework. DREENA does not use fitting parameters, i.e. it's only input is the temperature profile that comes directly from various hydrodynamics and kinetic theory models. This opens possibility to use DREENA on both light and heavy flavor to test and differentiate between different available QGP evolution models, including both large and smaller systems. This makes DREENA a unique multipurpose QGP tomography tool, which enables us to gain a better understanding of the bulk QGP medium created at RHIC and LHC.

Introduction

- Dynamical energy loss formalism:
  - finite size finite temperature QCD medium
  - finite temperature field theory and generalized HTL approach M Djordjevic, PRC74 ('06), PRC 80 ('09)
  - same theoretical framework for both radiative and collisional energy loss
  - applicable to both light and heavy flavor
  - finite magnetic mass effects M. Djordjevic and M. Djordjevic, PLB 709:229 (2012).
  - running coupling M. Djordjevic and M. Djordjevic, PLB 734, 286 (2014).
  - relaxed soft-gluon approximation B. Blagojevic, M. Djordjevic and M. Djordjevic, PRC 99, 024901, (2019).
- all effects are important for accurate description of high $p_\perp$ data
  B. Blagojevic and M. Djorjdevic J.Phys. G42 (2015) 7, 075105
- the goal is to keep all elements of the state-of-the art energy loss formalism, while introducing more complex temperature evolutions

DREENA framework

- **D**ynamical **R**adiative and **E**lastic **EN**ergy loss **A**pproach: fully optimized numerical procedure for suppression calculations based on dynamical energy loss formalism.
- Version **C**: evolution taken in a simplest form (through constant temperature medium) [1]
  useful for exploring the influence of medium evolution on both light and heavy flavour and different observables
- version **B**: introduced medium evolution through 1+1D Bjorken expansion [2]
  differences in results should suggest the sensitivity of observables to different aspects of medium evolution
- Version **A**: full temperature evolution profile
  introduces full medium evolution but not at the expense of simplified energy loss
  capable to account for event-by-event fluctuations



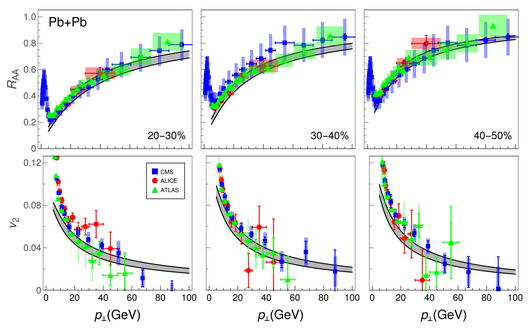
Contrary to the existing models, which for full hydro evolution models lead to v_2 puzzle, **with DREENA we obtain a very good joint agreement between R_{AA} and v_2 data**. This well known puzzle therefore appears to be a consequence of a simplified energy loss commonly used by other models – once a proper description of parton medium interactions is used, v_2 puzzle is abolished. While a widely accepted paradigm is that proper medium evolution description dominates in explaining high-$p_\perp$ data, **this result strongly suggests that proper description of parton-medium interactions is much more important.**

DREENA-A

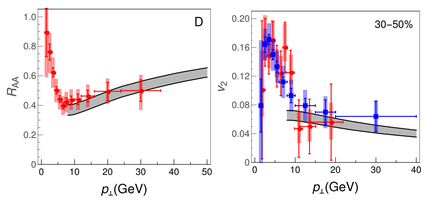
Glb-eBCFit, τ_0 = 1.0 fm

- used in **Molnar-Holopainen-Huovinen-Niemi 3d hydro**
  energy density based on a third-order polynomial of the binary collision density from optical Glauber

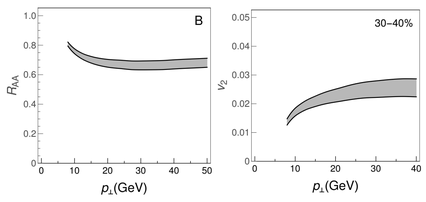
$Pb+Pb$, $\sqrt{s_{NN}} = 5.02\,TeV$, Charged hadrons



$Pb+Pb$, $\sqrt{s_{NN}} = 5.02\,TeV$, D meson



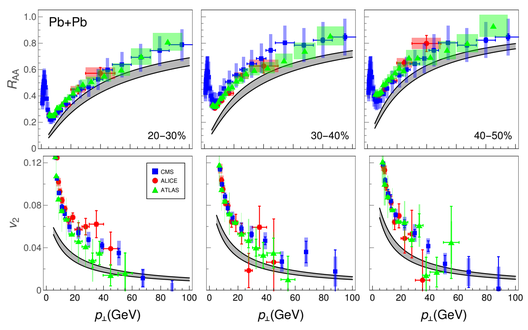
$Pb+Pb$, $\sqrt{s_{NN}} = 5.02\,TeV$, B meson



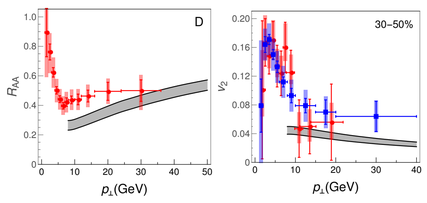
Glb-eBC, τ_0 = 0.5 fm

- used in **SONICv1.7**
  energy density based on the binary collision (BC) density from optical Glauber

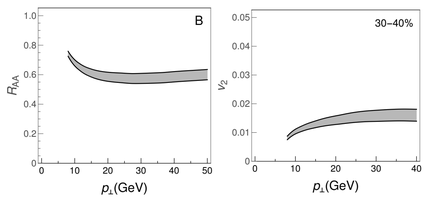
$Pb+Pb$, $\sqrt{s_{NN}} = 5.02\,TeV$, Charged hadrons



$Pb+Pb$, $\sqrt{s_{NN}} = 5.02\,TeV$, D meson



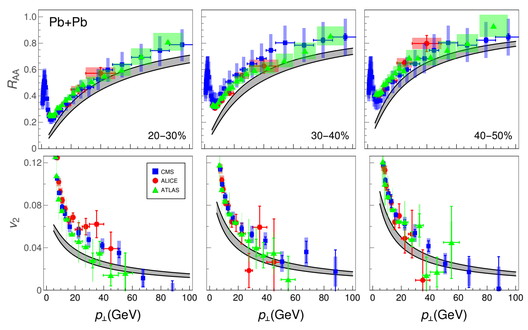
$Pb+Pb$, $\sqrt{s_{NN}} = 5.02\,TeV$, B meson



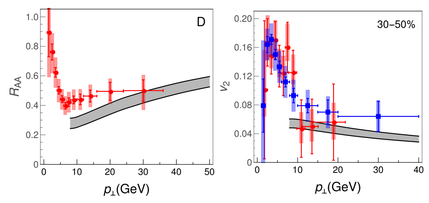
MCGlb-sMix, τ_0 = 0.6 fm

- used in **iEBE-VISHNU**
  entropy density based on a mixture of wounded nucleon and binary collision densities from Monte Carlo Glauber

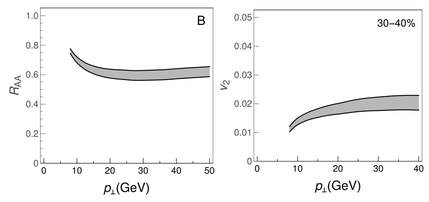
$Pb+Pb$, $\sqrt{s_{NN}} = 5.02\,TeV$, Charged hadrons



$Pb+Pb$, $\sqrt{s_{NN}} = 5.02\,TeV$, D meson



$Pb+Pb$, $\sqrt{s_{NN}} = 5.02\,TeV$, B meson



Both high-$p_\perp$ R_{AA} and v_2 predictions are notably sensitive to different temperature profiles $\rightarrow$
$\rightarrow$ DREENA framework provides unique opportunity for exploring bulk QGP properties through high-$p_\perp$ theory and data, i.e. for QGP tomography.

Conclusion

- **DREENA-C**:
  overall good agreement with data given the simplicity of approximation;
  all other implementation need to have const T limit.
- **DREENA-B**:
  explains high $p_\perp$ data;
  this form of time evolution is suitable for studying the influence of initial stages of QGP evolution on high $p_\perp$ observables
- **DREEA-A**:
  uses full temperature profile without simplification in energy loss; can use any temperature profile (hydro, transport coefficients,...)
  first framework that contains both state-of-the-art energy loss and state-of-the art medium evolution $\rightarrow$ uniquely suited for exploring the bulk QGP properties, i.e., for QGP tomography!

References

[1] D. Zigic, I. Salom, J. Auvinen, M. Djordjevic and M. Djordjevic, J. Phys. G **46**, no. 8, 085101 (2019)
[2] D. Zigic, I. Salom, J. Auvinen, M. Djordjevic and M. Djordjevic, Phys. Lett. B **791**, 236 (2019)

Acknowledgments

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