

Longitudinal dependence of B and D mesons nuclear modification factor in relativistic heavy ion collisions

Caio A. G. Prado (开友)

with Wen-Jing Xing, Shanshan Cao, Guang-You Qin, Xin-Nian Wang

28th International Conference on Ultra-relativistic Nucleus-Nucleus Collisions



Outline

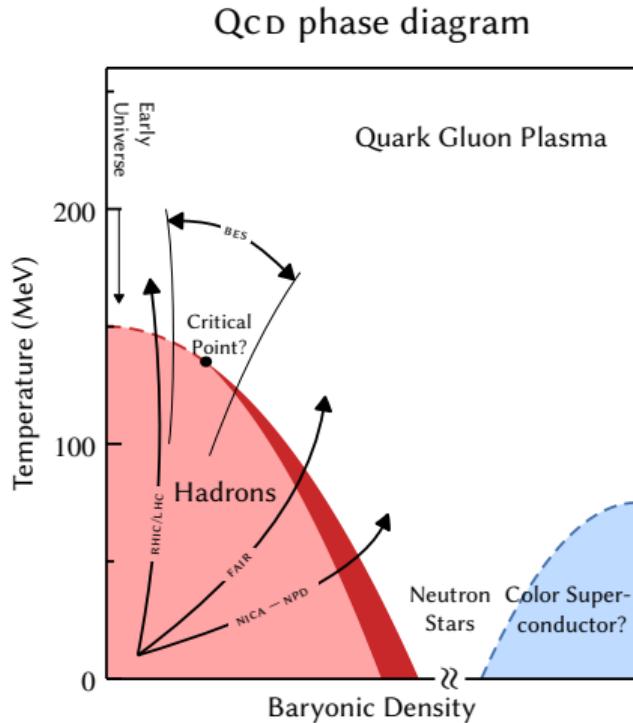
Introduction

Monte-Carlo simulation

Results

Summary

Heavy quarks in heavy ion collisions



- Heavy Ion Collisions

- Experimental assessment of nuclear matter
- Properties of the Quark Gluon Plasma

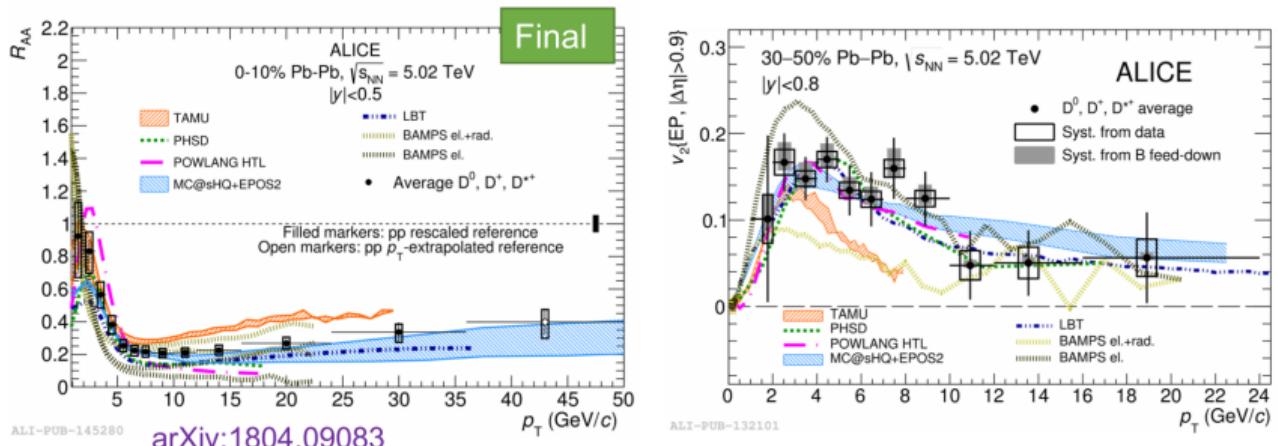
- The case for heavy flavor:

- Pre-equilibrium production (hard scattering)
- Long relaxation times
- $m_Q > \Lambda_{\text{QCD}} \Rightarrow \text{pQCD calculations}$
- Strongly affected by QGP
- Weakly affected by late time evolution
- Hard fragmentation

- Nuclear modification factor:

$$R_{AA}(p_T, y) = \frac{1}{\mathcal{N}} \frac{dN_{AA}/dp_T dy}{dN_{pp}/dp_T dy},$$

Current status



- Simultaneous description between R_{AA} and v_2 ?
- Multiple models with different physics seems to **only** qualitatively describe the data
- How can we further constraint the models to better understand what's really going on?
- One alternative: bet on new observables not very well explored yet (higher order harmonics, event shape engineering, soft-heavy correlations, longitudinal dependence, ...)

Exploring the longitudinal dependence



- So far longitudinal dependence of observables are still in development;
- The medium dynamics can be very different at large rapidity: temperature, size, ...
- Is it possible to discriminate similar models on an analysis of the large rapidity spectra?



General framework

- Coding of the simulation:
 - C++/Fortran, ROOT and PYTHIA
 - Modular programming (QCD factorization)
 - Freedom in executing different hydro backgrounds.
- Transport model
 - Relativistic Langevin equation: $\frac{dp}{dt} = -\eta_D(p)p + \xi + f_g$
 - Classic fluctuation-dissipation relation with $D(2\pi T) = 7$
 - f_g : recoil due to gluon emission.
- Hadronization
 - Hybrid fragmentation plus coalescence:
 - $T_c = 165$ MeV.
 - No re-scattering in the final hadronic phase.
- Heavy quarks probes:
 - Sampled at the beginning of the simulation
 - No medium response is implemented.

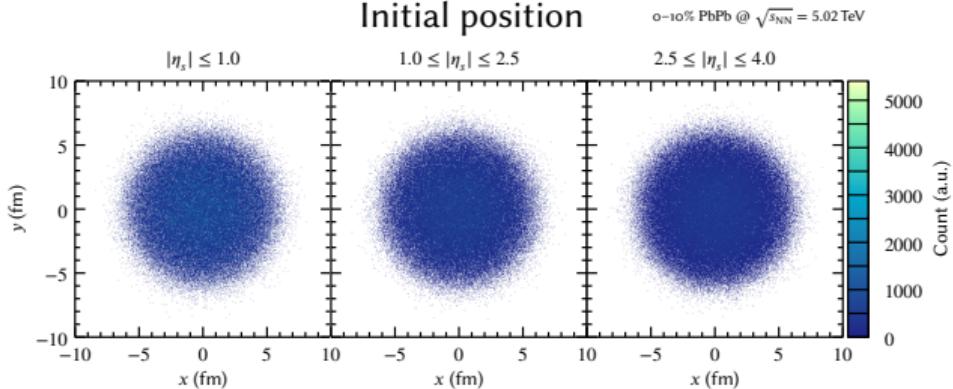


Initial Conditions and Hydrodynamics

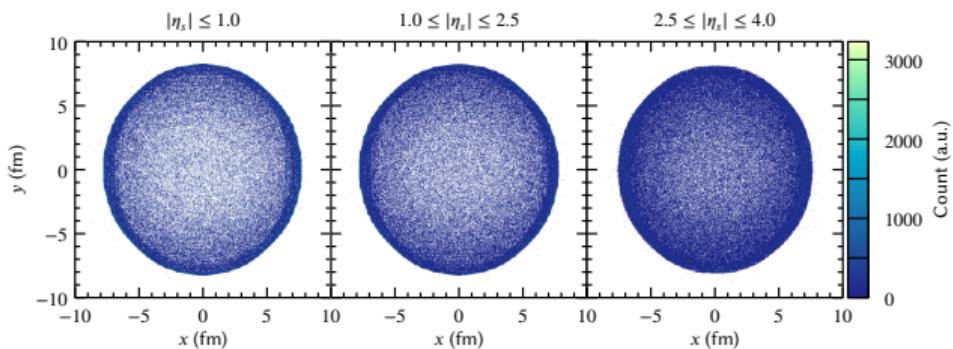
- Input of the program;
- 3D profiles for the hydro:
 - Energy density;
 - Temperature;
 - Transverse velocity;
 - Longitudinal velocity;
- T_RENTO initial conditions (IP-Glasma);
- Quarks position given by Glauber Model;
 - Initial momentum distribution given by pQCD (LO).
- Viscous average 3D+1 hydrodynamics: CLvisc
 - $\eta/s = 0.15$;
 - $T_{f0} = 165 \text{ MeV}$;
 - $\tau_0 = 0.6 \text{ fm/c}$;
 - s95p-PCE EoS.

Heavy quark density distribution

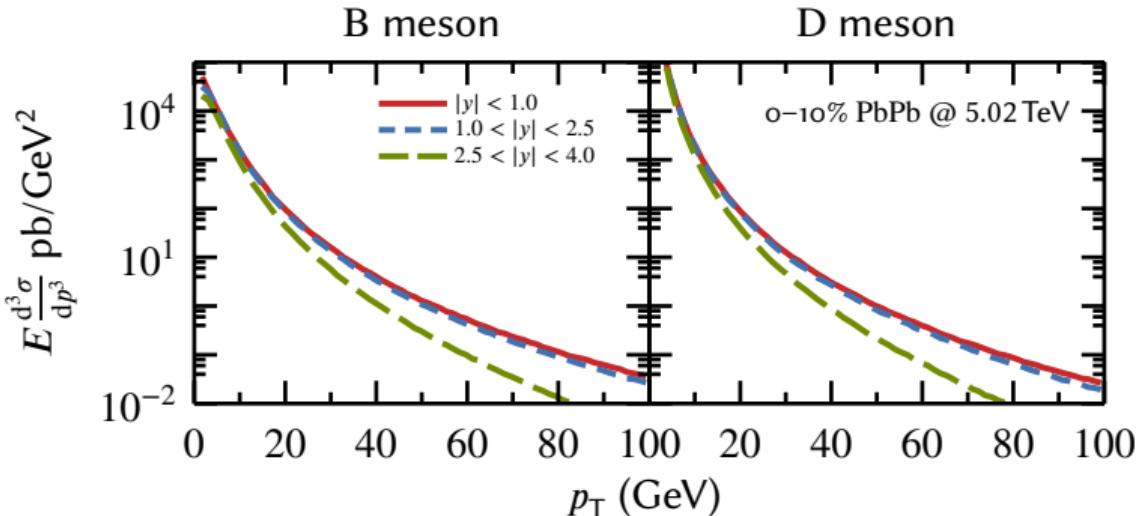
Initial position



Final position

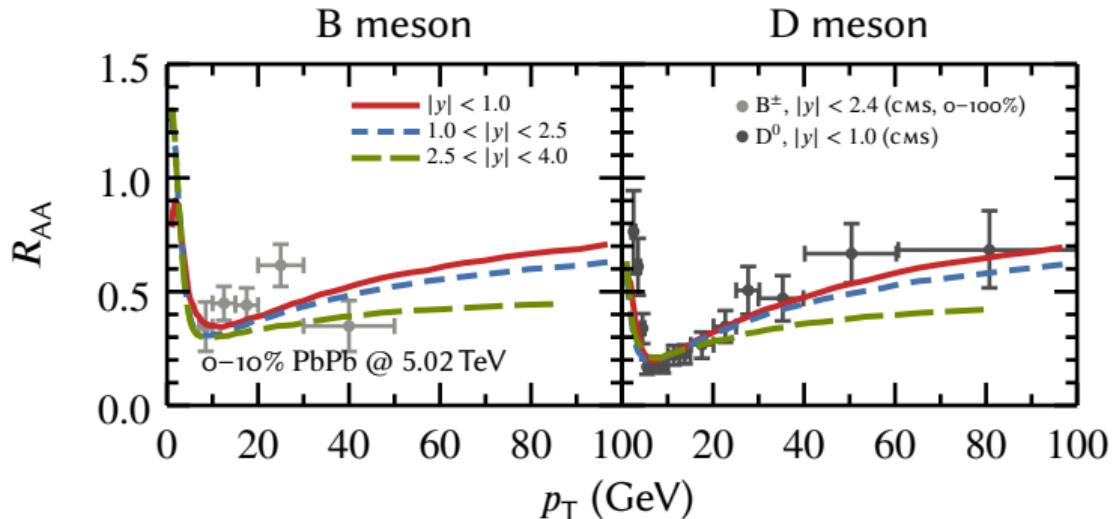


Transverse momentum distribution



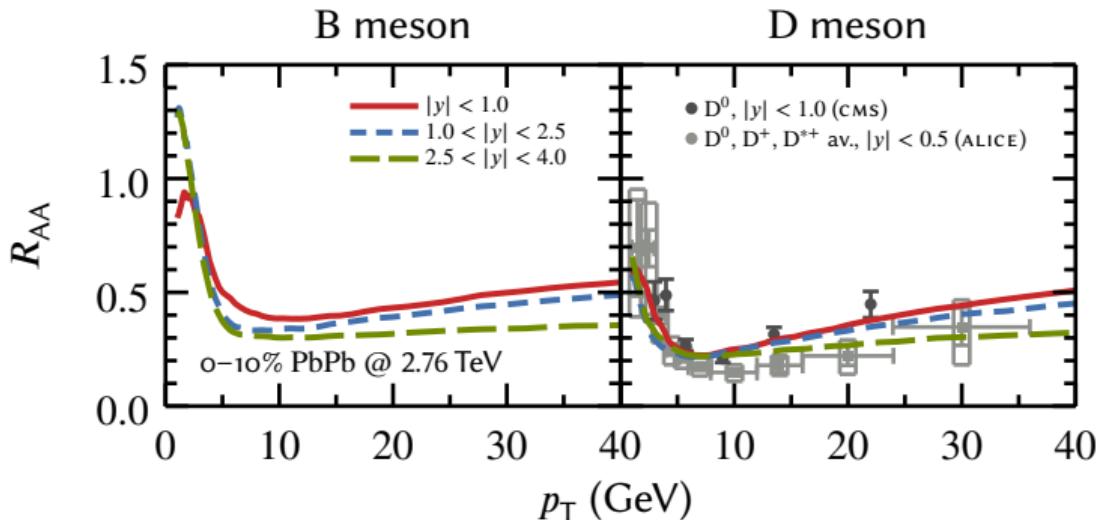
- Production spectra reaches lower p_T with large rapidity.

Nuclear modification factor



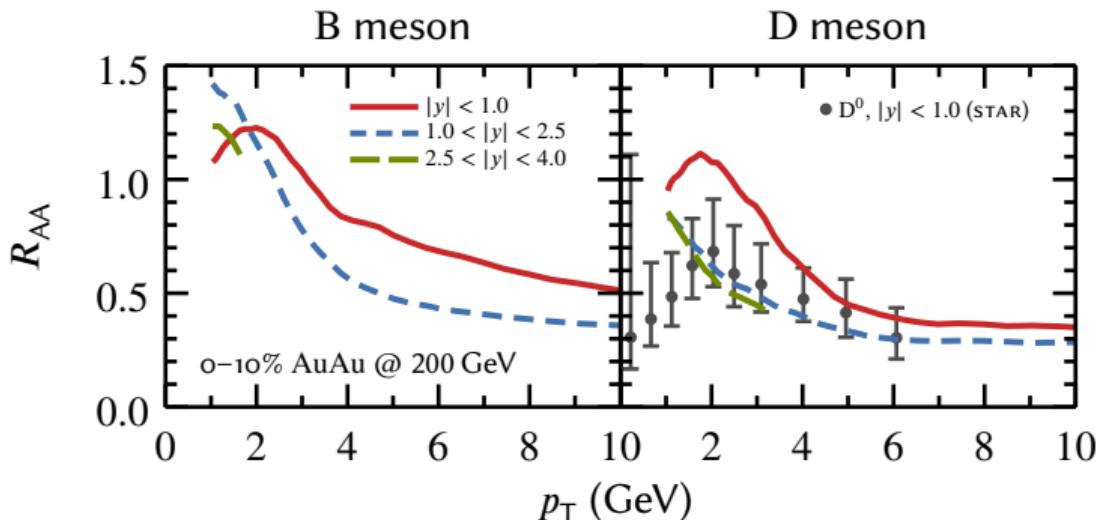
- Good agreement with CMS experimental data for D^0
- Behavior dominated by the steeper yield spectra
- Low p_T regime involves much complicated physics

Nuclear modification factor



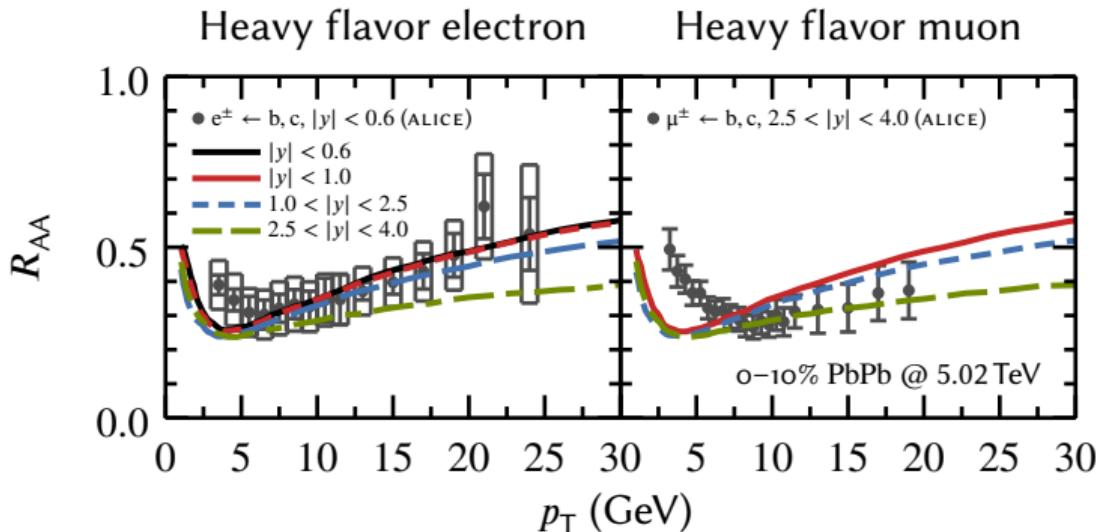
- Good agreement with CMS data for D mesons
- Data from ALICE disagrees with CMS
- Behavior similar to that of $\sqrt{s_{NN}} = 5.02 \text{ TeV}$ collision

Nuclear modification factor



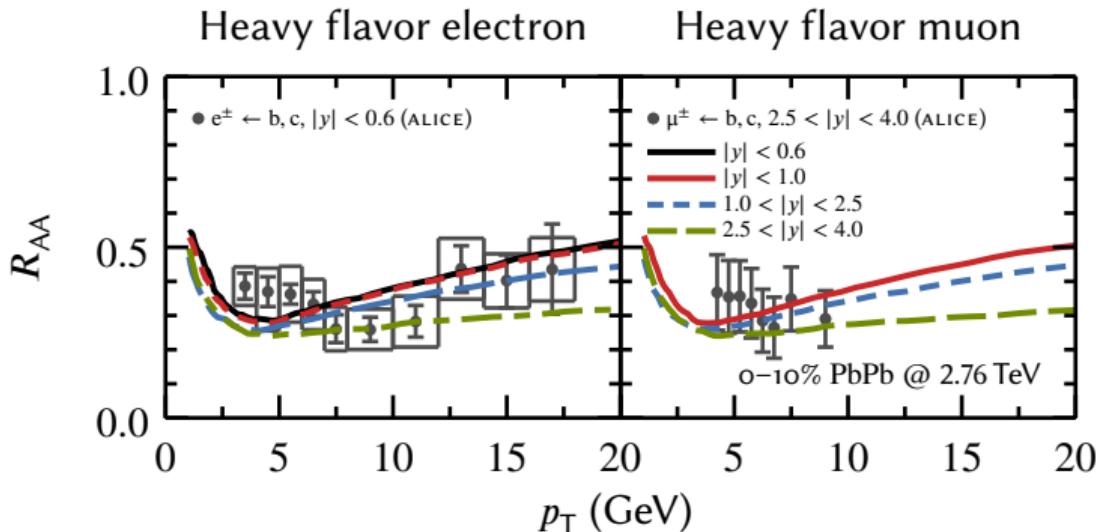
- Agreement with data only on the higher p_T regime
- Due to lower collision energy, large rapidity is limited on p_T

Nuclear modification factor



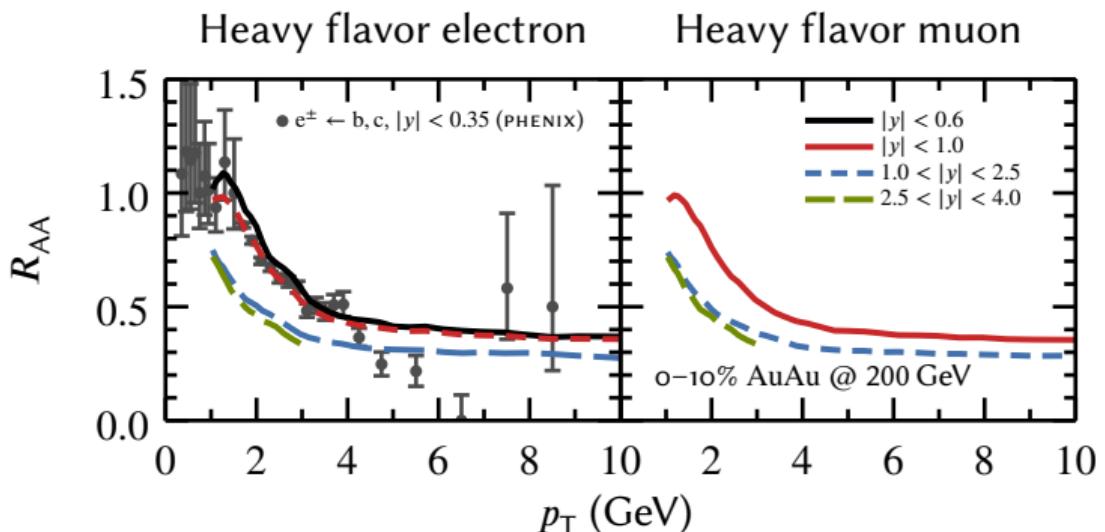
- Simulation results matches both electrons and muons data.
- Larger p_T range of experimental data allows for more clearer separation in rapidity
- In the low p_T regime, simulation underestimates the data

Nuclear modification factor



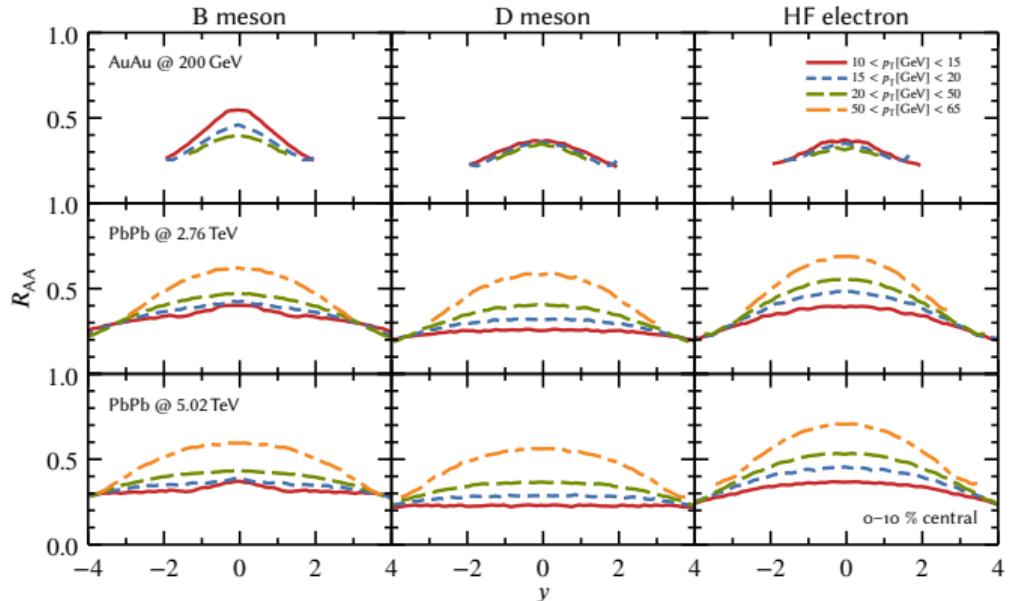
- For large p_T we observe good agreement with data for both electrons and muons
- Experimental error bars cover all the three curves for muon
- In the low p_T regime, simulation still underestimates the data

Nuclear modification factor



- Good agreement with data for electrons despite the previous D meson results
- Overall behavior from B and D is propagated to electrons

Nuclear modification factor – Summary



- With increasing rapidity, R_{AA} tends to decrease
- Interplay between medium and production spectra
- Production spectra prevails and generates more suppression



Summary

- Longitudinal dependence of R_{AA} of charm quarks and D mesons:
 - Interplay between heavy flavor production spectra and medium size compete at large rapidity
 - Production spectra dominates R_{AA} results at large rapidity
 - Nuclear modification factor becomes flat with p_T at large rapidity
 - Different behavior depending on p_T regime
 - Further exploring the large rapidity regime might be able to provide further constraints on phenomenological models
- Future prospects:
 - Include comparison for other transport models
 - Study elliptic azimuthal anisotropy for heavy mesons
 - Event-by-event computations.