PHENIX Measurements of Heavy Flavor Production and Flow in Au+Au Collisions

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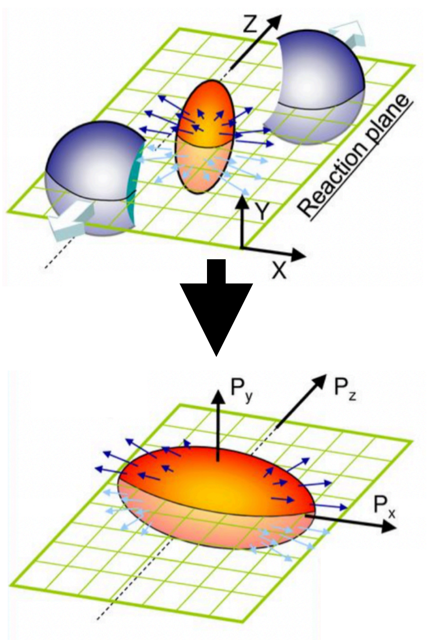
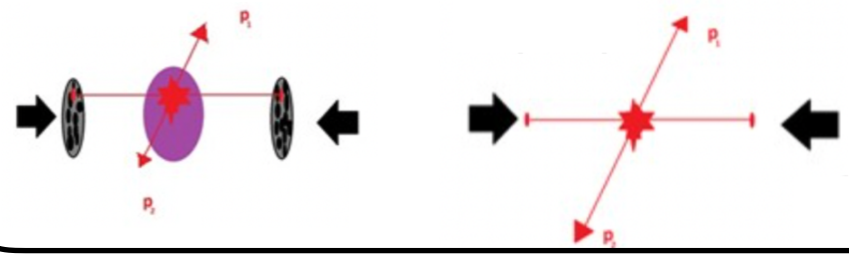
Motivation

- The quark gluon plasma (QGP) is a hot and dense state of matter created in high energy nuclear collisions where quarks and gluons become deconfined
- Heavy quark (charm and bottom) production is a powerful tool for probing the QGP
  - Large mass (M_c~1.3 GeV/c^2, M_b~4.2 GeV/c^2) means they are produced in initial hard scatterings
- PHENIX measurements for nuclear modification (R_{AA}) and elliptic flow (v_2) of heavy quarks probe unique QGP properties, which are reflected in modifications to yield and azimuthal distributions.
- Mass ordering is expected for both energy loss and flow, which we aim to test

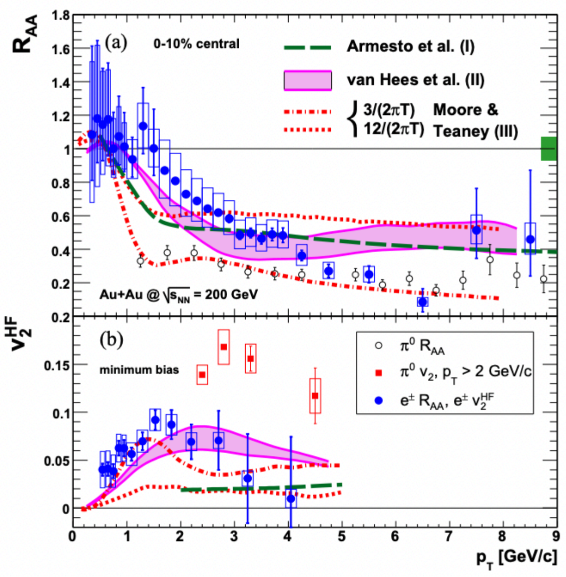
v_2 and R_{AA}

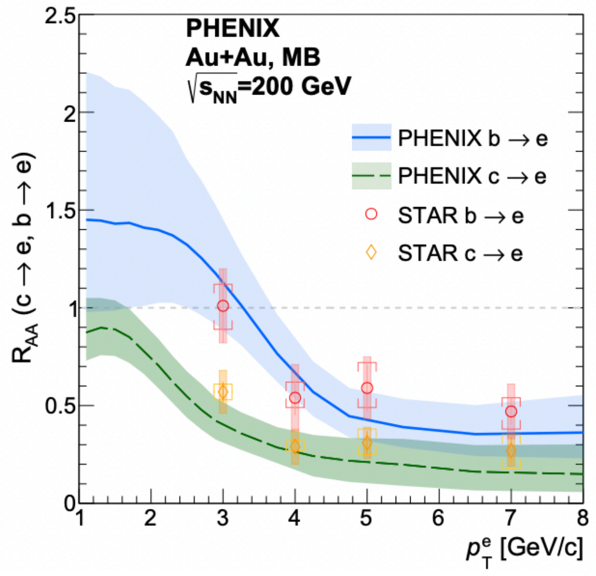
- In heavy ion collisions the initial overlap region is ellipsoidal
  - Initial state spatial anisotropy creates pressure gradients that drive final state momentum anisotropy
  - Final state momentum anisotropy is described using Fourier series with coefficients v_n
- Hard-scattered partons lose energy propagating through QGP leading to suppression of hadron production relative to p+p collisions. For heavy-flavor quarks both elastic (collisional) and inelastic (gluon radiation) energy loss play a role
- J/Ψ yields are suppressed due to color screening in QGP and path length dependence may create azimuthal anisotropy

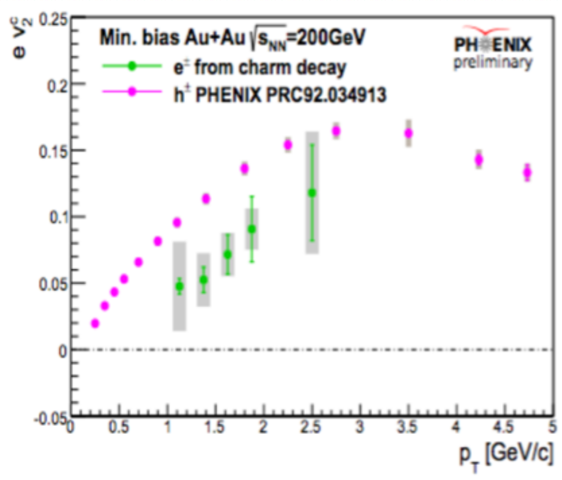


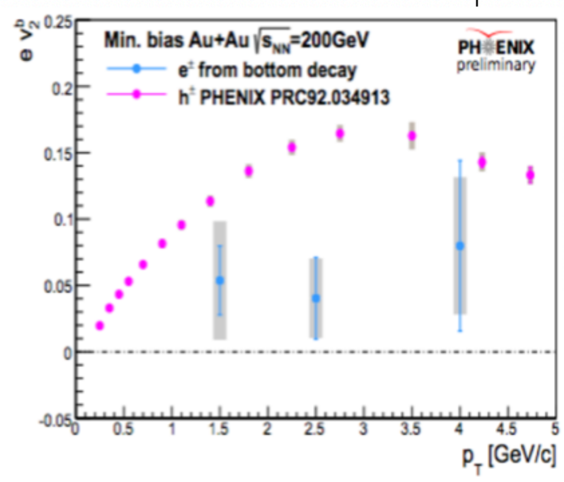


Open heavy flavor measurements



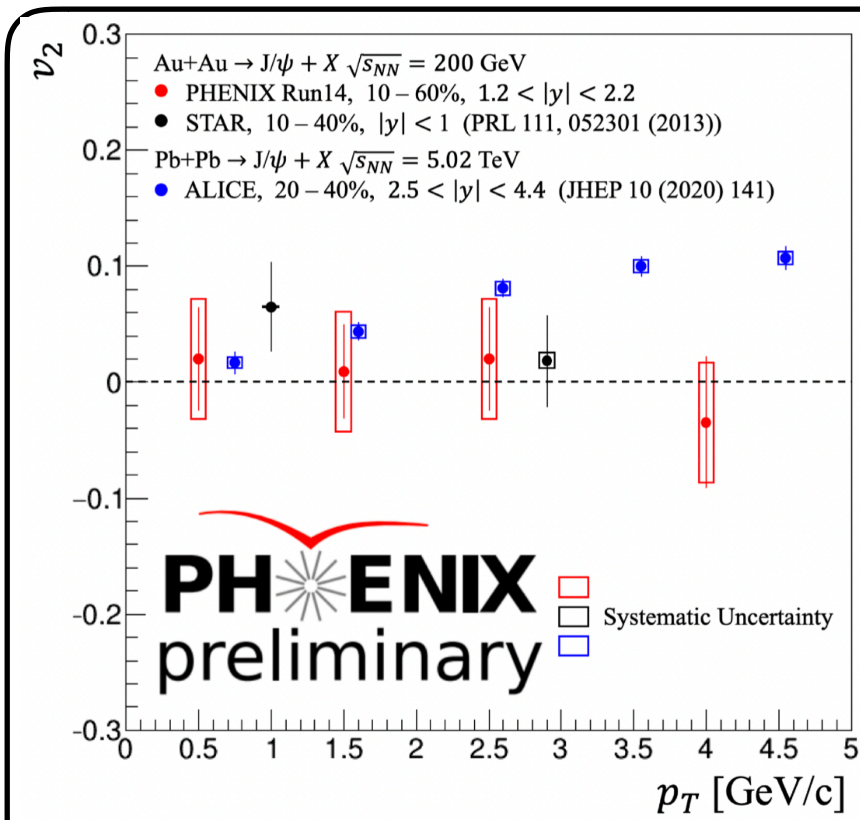


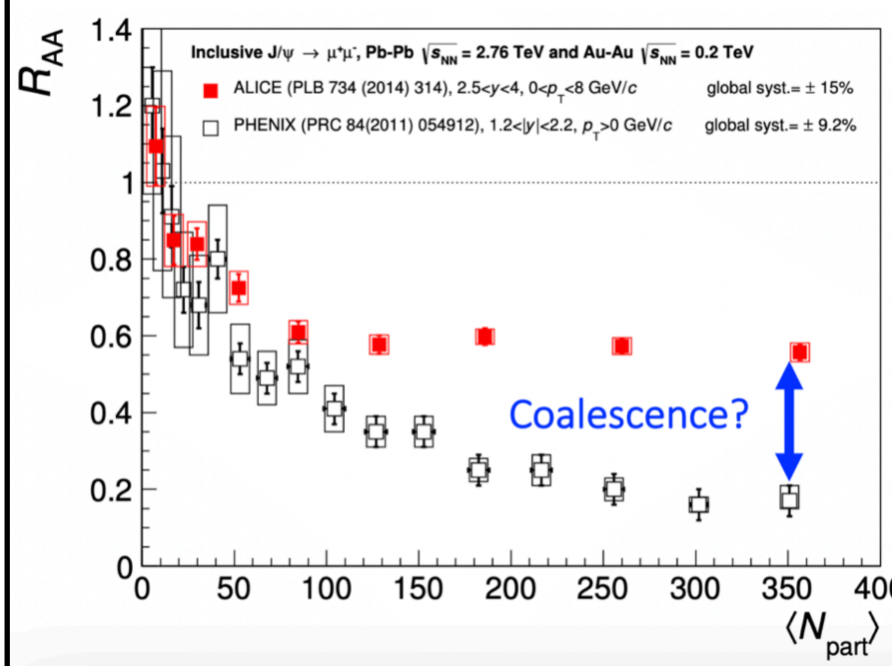




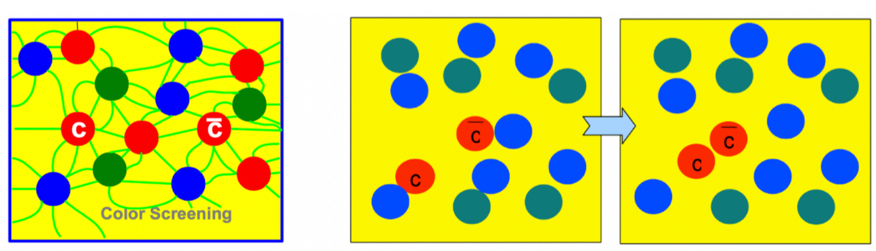
- Electrons from inclusive open heavy flavor v_2 and R_{AA} (top left) show significant differences compared to neutral pions
  - Validates mass ordering theory of particle interaction with QGP
- RHIC measurements of separated *c* and *b* R_{AA} also show mass ordering behavior
- Electrons from charm have positive v_2 and similar p_T dependence as charged hadrons, whereas v_2 of electrons from bottom is less conclusive
  - More measurements necessary to determine if bottom "flows"

J/Ψ measurements





- RHIC measurements of J/Ψ v_2 are consistent with zero, whereas higher energy ALICE measurements are not
- ALICE measurements also show significantly less suppression than PHENIX measurements for J/Ψ R_{AA}
- Higher energy collisions create more $c\bar{c}$ pairs which can then flow with the medium more readily, as independently they have a lower mass than the J/Ψ



Summary

- Heavy quarks are useful probes of the unique properties of the QGP
- Yield modifications and anisotropic azimuthal distributions of particles are medium-induced effects that can be used to study the QGP
- RHIC and LHC measurements of J/Ψ v_2 and R_{AA} are not consistent, but this can be explained by increased quark coalescence at higher energies
- Inclusive and separated open heavy flavor measurements confirm mass ordering of particle interactions with QGP
- More study needed to confirm if bottom quarks flow at RHIC energies

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