J/ψ Elliptic Flow in PHENIX Run14 Au+Au at 200 GeV

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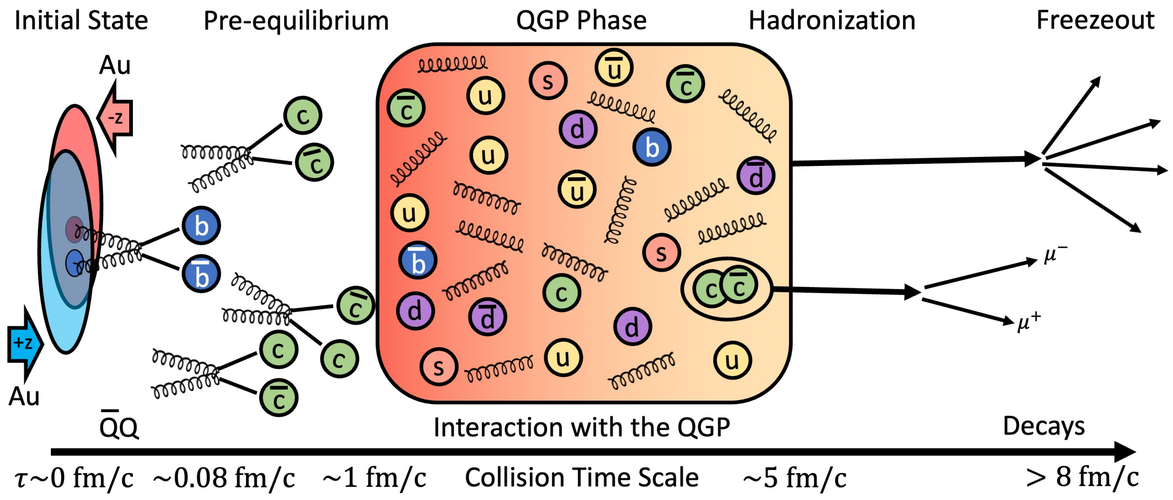
Motivation

PROBING THE QUARK GLUON PLASMA USING THE J/ψ

- Interactions of heavy quarks are still under investigation
- Heavy quarks play a special role due to their large mass
- Open heavy-flavor particles flow. **Does the J/ψ flow?**



ANISOTROPIC FLOW MECHANISMS

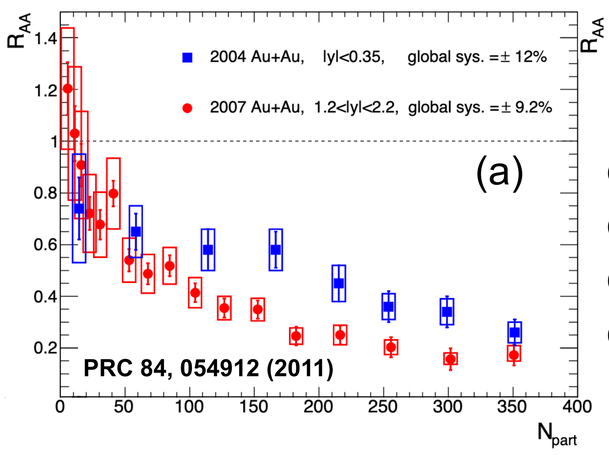
- Patterns of anisotropic flow can be characterized by the Fourier expansion:

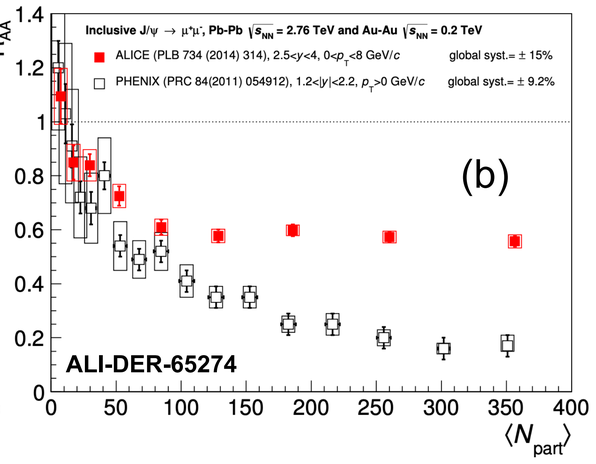
$$E\frac{d^3N}{d^3\mathbf{p}} = \frac{1}{2\pi}\frac{d^2N}{p_T dp_T dy}\left(1 + 2\sum_{n=1}^{\infty} v_n \cos[n(\phi - \Psi_{RP})]\right)$$

- J/ψ may be dissolved by the QGP, creating anisotropies due to the different path lengths in the medium.
- J/ψ may dissociate, and charm quarks could equilibrate which could lead to J/ψ regeneration.
- J/ψ may thermalize inside the medium and follows the pressure gradients as lighter particles do.

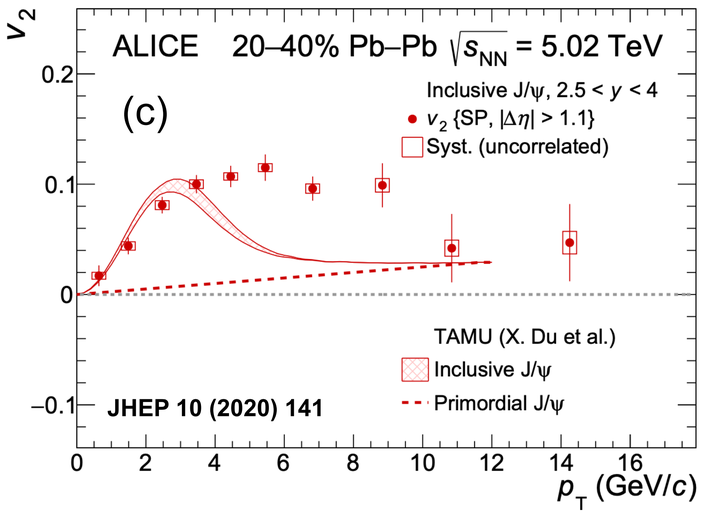
J/ψ SUPPRESSION PUZZLE

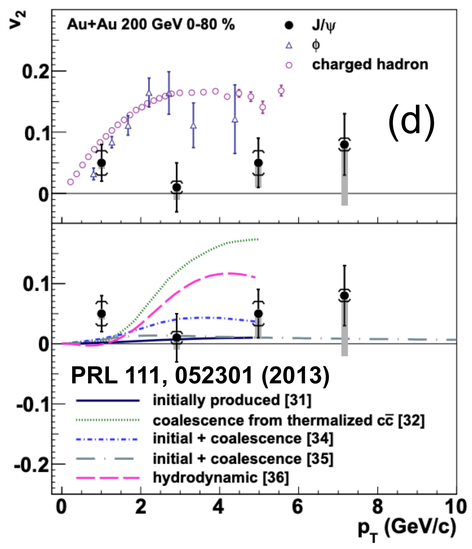
- Larger suppression of J/ψ R_{AA} at PHENIX is observed in forward rapidity compared to mid-rapidity, contrary to expectations. (a)
- Similar behavior is observed comparing J/ψ R_{AA} between RHIC and LHC. (b)
- ~20 $c\bar{c}$ pairs produced per event in central collisions at RHIC (most produced at mid-rapidity).
- ~10 times as many $c\bar{c}$ pairs are produced at LHC.
- **Solution: contribution from coalescence via a recombination mechanism between charm and anticharm quarks**





J/ψ v_2 AT LHC (c) AND RHIC (d) ENERGIES

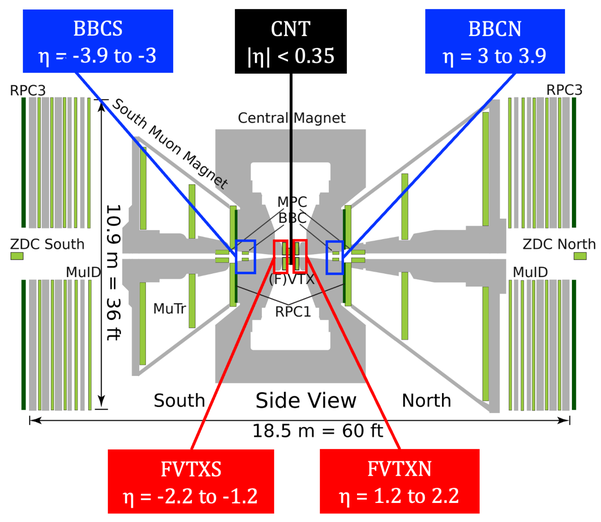


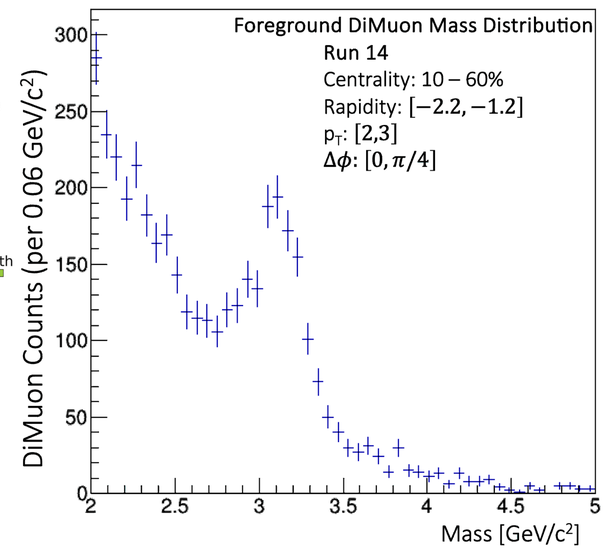


Data Analysis

PHENIX RUN14 Au+Au AND J/ψ RECONSTRUCTION

- The PHENIX experiment has a unique coverage at forward rapidity with muon identification.
- A large dataset of Au+Au collisions (19B events) collected in 2014 will allow for a statistically improved measurement of J/ψ elliptic flow.
- The dimuon decay channel ($J/\psi \rightarrow \mu^+ + \mu^-$) is used to reconstruct candidate J/ψ.





- Mixed-event method is used for combinatorial background subtraction:

$$S = N_{SE}^{+-} - R \cdot N_{ME}^{+-}$$

- Where S is the signal, N_{SE}^{+-} are foreground dimuons, N_{SE}^{+-} are muons from event mixing, and R is a normalization factor
- 2 Crystal Ball functions are fitted to the data, centered at the J/ψ mass (green) the $\psi(2S)$ mass (blue), and an exponential for the residual background (red).

J/ψ v_2 MEASUREMENT (IN/OUT EVENT PLANE METHOD)

- The reconstructed J/ψ are split into 2 bins of $\Delta\phi = \phi - \Psi_2$
- In-plane and out-of-plane with the event plane (EP):

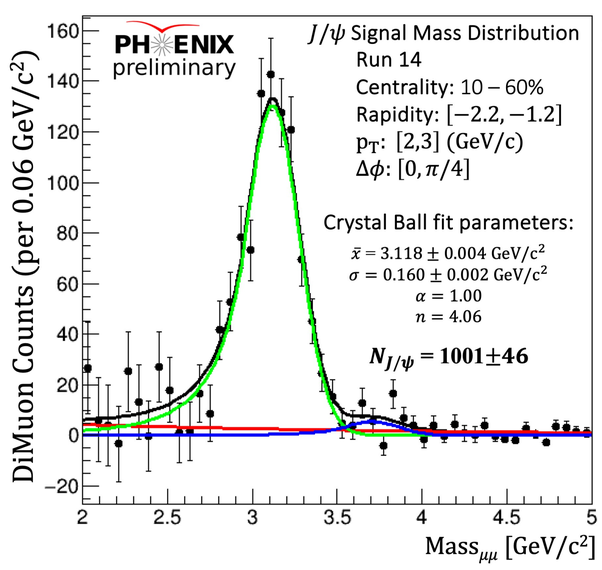
$$N_{in} = \Delta\phi \in [0, \pi/4] \qquad N_{out} = \Delta\phi \in [\pi/4, \pi/2]$$

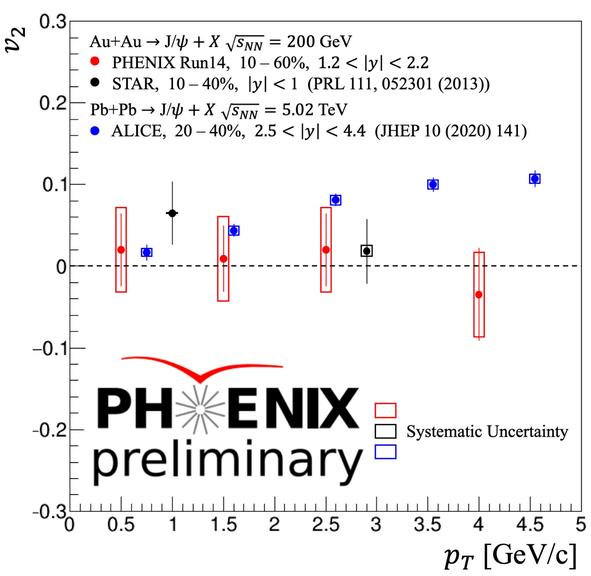
- We can then extract v_2^{obs} for our J/ψ using:

$$v_2^{obs} = \frac{\pi}{4}\frac{N_{in} - N_{out}}{N_{in} + N_{out}}$$

- Correcting with the EP resolution yields the final v_2:

$$v_2 = \frac{v_2^{obs}}{\sigma_{EPR}}$$





Conclusion

- **PHENIX has measured a J/ψ v_2 at forward rapidity consistent with 0.**
- The ALICE result which is clearly nonzero is different from our measurement.
- An observation of nonzero v_2 agrees with J/ψ formed via charm quark coalescence in the QGP.
- Systems where fewer $c\bar{c}$ pairs are formed should have a smaller azimuthal anisotropy.
- Forward and mid-rapidity results at RHIC agree, but the uncertainties are large.
- Final measurement will include Run16 (15B events) nearly **doubling statistics** and improving statistical uncertainties.

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