Sensitivity of Heavy Quark Observables to Event Geometries in Pb + Pb Collisions

Weiyao Ke[1], J. Scott Moreland[1], Shanshan Cao[2] & Steffen A. Bass[1]

[1]Duke University, [2]Lawrence Berkeley National Lab

wk42@phy.duke.edu

Introduction

- Heavy quark observables $R_{\rm AA}$ and v_2 are sensitive to HQ interaction with the QGP medium and its evolution.
- Event geometries (initial eccentricities and initial charm/soft correlation) also affect HQ observables.
- This project: study the sensitivity of heavy quark observables to underlying event geometries.

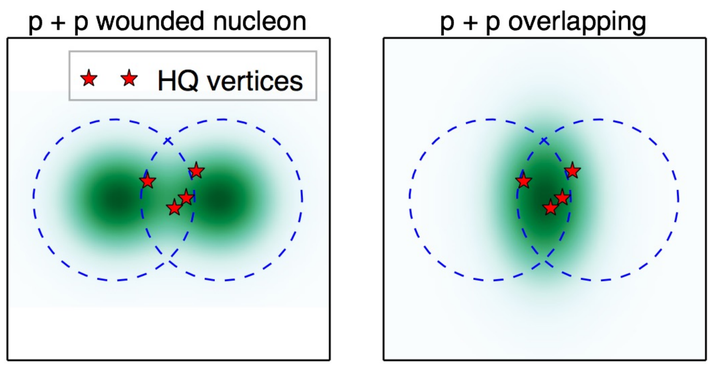
Event Geometry: Wounded Nucleon v.s. Overlapping

- Glauber model: nuclear thickness function $T_{\rm A}(\vec{x}_T)$ and $T_{\rm B}(\vec{x}_T)$
- T_RENTo: effective model of initial entropy deposition in pp, pA and AA collisions [1], parameterizes mappings from $T_{\rm A}$, $T_{\rm B}$ to $\frac{{\rm d}S}{{\rm d}\eta_s {\rm d}^2x_{\rm T}}$,

$$\left.\frac{{\rm d}S}{{\rm d}\eta_s {\rm d}^2x_{\rm T}}\right|_{\eta_s=0} = CT_{\rm R}(T_{\rm A},T_{\rm B};p), \tag{1}$$

$$T_{\rm R}=\left(\frac{{T_{\rm A}}^p+{T_{\rm B}}^p}{2}\right)^{\frac{1}{p}}=\begin{cases}\frac{1}{2}(T_{\rm A}+T_{\rm B}), & p=1\\ \sqrt{T_{\rm B}T_{\rm B}}, & p=0\end{cases}. \tag{2}$$

- $p=1$: wounded nucleon geometry (adding binary collision component to reproduce multiplicity distribution).
- $p=0$: overlapping geometry, favoured by model to data comparison, which mimics the behaviour of IP-sat model (see posters by J. Bernhard and J. S. Moreland).



Medium evolution

- Hydrodynamic evolution: OSU 2+1D second-order viscous hydrodynamics, $\eta/s=0.06$ (wounded nucleon), 0.08 (overlapping).
- Cooper-Frye freezeout $T=165$ MeV $\rightarrow$ UrQMD afterburner.

HQ Initial Condition

- $\vec{x}_\perp$: sampled according to $T_{\rm AA}=\int_{S_\perp}{\rm d}\vec{x}_\perp^2 T_{\rm A}(\vec{x}_\perp)T_{\rm B}(\vec{x}_\perp)$. Overlapping geometry: local initial charm/soft spatial correlation $N_{\rm charm}\propto N_{\rm ch}^2$.
- $\vec{p}$: leading order QCD calculation from CTEQ PDF with shadowing effect included [2].

Langevin Transport Approach

- Langevin transport model [2],

$$\frac{{\rm d}\vec{p}}{{\rm d}t}=-\eta_D(p)\vec{p}+\vec{\xi}-\frac{{\rm d}\vec{p}_g}{{\rm d}t} \tag{3}$$

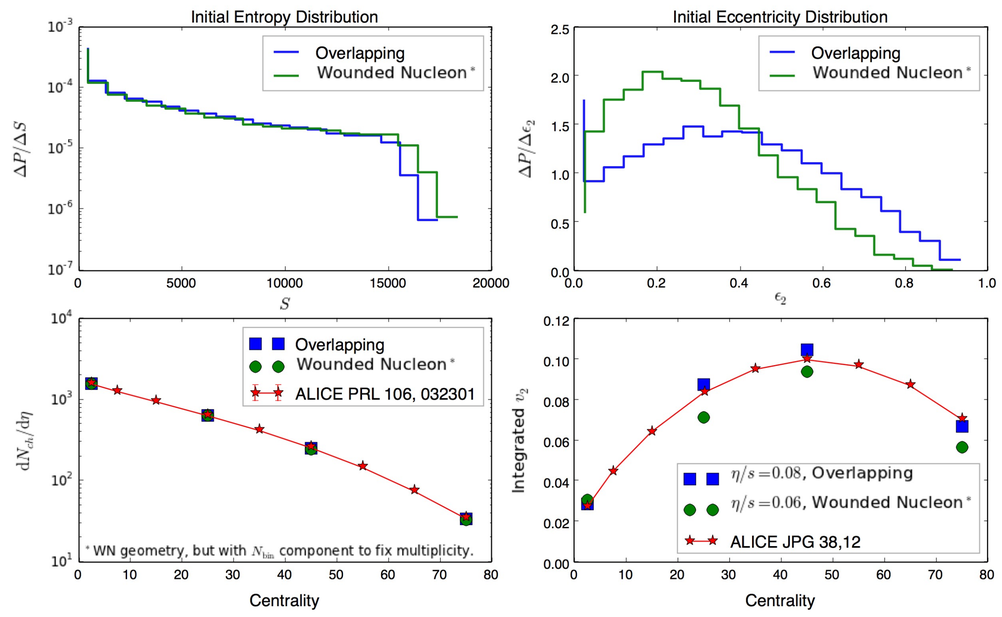
- Spectrum of medium induced gluon radiation,

$$\frac{{\rm d}N_g}{{\rm d}x{\rm d}k_\perp^2{\rm d}t}=\frac{2\alpha_s P(x)\hat{q}}{\pi k_\perp^4}\sin^2\left(\frac{t-t_i}{2\tau_f}\right)\left(\frac{k_\perp^2}{k_\perp^2+x^2M^2}\right)^4 \tag{4}$$

- Charm quark hadronization: fragmentation and recombination.

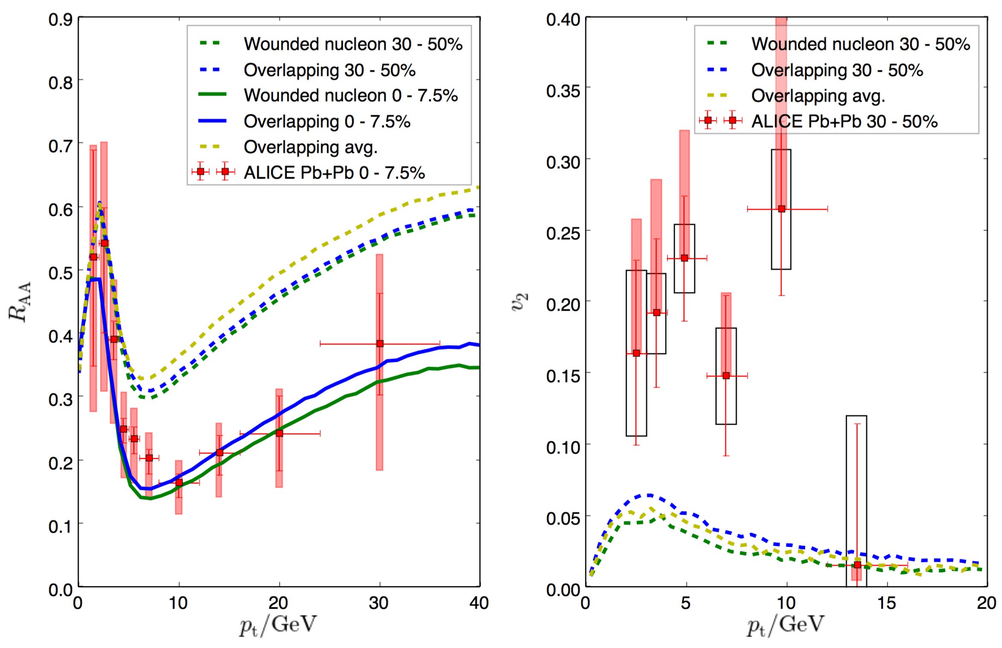
Comparison of Underlying Events

- Both IC models yield similar initial entropy (centrality cuts).
- Both IC models describe the ${\rm d}N_{\rm ch}/{\rm d}\eta$ over centralities.
- Overlapping geometry has significant larger ϵ_2 and leads to relatively larger charged particle integrated $v_2\{2\}$ ($0.2<p_{\rm T}<5.0$ GeV).



Key Results

- Overlapping and wounded nucleon geometry result in similar $R_{\rm AA}$. v_2 is more sensitive to initial eccentricity of QGP medium.
- Overlapping geometry produces 30-50% more flow than wounded nucleon geometry at intermediate and high $p_{\rm T}$.
- Inclusion of initial charm/soft spatial correlation in overlapping geometry increases high $p_{\rm T}$ D-meson suppression and slightly increases v_2.
- Changing initial geometries and inclusion of initial charm/soft spatial correlation are inadequate to fix the underestimated v_2 from Langevin model.



Forthcoming Research

- Initial geometry analysis with linearized Boltzmann calculation.
- Rapidity dependent initial condition for soft matter and charm quark.

[1] J. S. Moreland, J. Bernhard, and S. A. Bass. *Phys. Rev. C*, 92(011901), 2015.

[2] S. Cao, G. Qin, and S. A. Bass. *Phys. Rev. C*, 88(044907), 2013.

[3] B. Abelev et al. (ALICE Collaboration). *Phys. Rev. Lett.*, 111(102301), 2013.

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