Update of U+U and Cu+Au results from PHENIX

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Outline

• Introduction and Motivation
• Energy density and elliptic flow in UU
• Anisotropic flow\((v_1,v_2)\) in CuAu
• Particle production in CuAu collisions
• Summary
Elliptic Flow in UU
The geometry and density effect

U + U 193 GeV

Body-body

Tip-tip

1. The geometry is significantly different for body-body and tip-tip collisions

2. Theory predicts that maximum medium density from tip-tip is around 60% higher than that of central AuAu

Flow in Cu + Au
Initial geometry and its fluctuation

1. An asymmetric initial geometry has been produced in Cu + Au

2. Odd order collective flow such as $v_1$, $v_3$ come not only from fluctuation as they do in Au+Au, but also from original geometry

At middle rapidity, the spectra ratio of AuAu(60-92%)/dAu(0-20%) has no species dependence. The J/Ψ production is asymmetric at forward/backward rapidity.

Measurement of the identified particle production in CuAu will help us to further study the initial state and final state effect, which play different roles in particle production in dAu and AuAu collisions.
1. 1.2B and 7.6B MB events are recorded in $|\text{bbcz}| < 30\text{cm}$ for UU and CuAu collisions respectively.

2. The key FVTX upgrade performs well in its first heavy ion run such as CuAu

3. FVTX:
   - Separate the muon from C/B decay
   - Enhance S/B for $J/\Psi$ and $\psi'$
   - Event plane
Energy density and Multiplicity in UU

The top 1% central UU $\varepsilon\tau$ is only 20% higher that of AuAu.

NBD(negative binominal distribution) fold only with Npart can reproduce the BBC charge distribution well.

60% higher $\varepsilon\tau$ from theory prediction for TT

A tail is expected due to extra Ncoll

Event-by-event flow is required for the TT and BB separation
The $v_2$ of charged hadron in UU collisions are higher than that of AuAu in different centrality.

Strong mass ordering for $\pi$ & p $v_2$ in central U + U collision at 193 GeV are observed even though the increase in $\varepsilon\tau$ is relatively small.

Radial flow or geometry?

C. Shen, U. Heinz et al
An asymmetric azimuthal distribution with respect to $\Psi_1$ plane from Au-going spectators

Both data and AMPT show sizeable $v_1$ but with opposite signs at $p_T > 1$ GeV/c

3 mb string melting cross section is not enough to reproduce the measured $v_2$
1. Two groups can reproduce the $v_1$ sign by E-by-E hydro calculations.
2. The asymmetric medium density in transversal plane plays an important role.
3. The $v_1$ of proton/anti-proton will provide more information since the baryon/anti-baryon densities are quite different.

Event by Event Hydro
Hashimoto, Murase and Hirano, JPS13

Event plane correlation in Cu+Au Collision

- (ψ_{South}^{1,BBC}, ψ_{South}^{1,SMD}) correlation is stronger than (ψ_{North}^{1,BBC}, ψ_{South}^{1,SMD}). It indicates that v_1 is larger in the Au-going direction.

- Ψ_3 is expected to be correlated with Ψ_1 and Ψ_2 due to the initial asymmetric geometry, while data shows a pretty weak raw correlation.

- The event-plane resolution correction and FVTX event plane will be helpful for further study.
1. Event plane resolutions are significantly improved by FVTX detector for $\Psi_2$ and $\Psi_3$

2. The measurements of $v_3$ and $v_4$ in CuAu will come out soon with FVTX EP and full statistics
Identified particle ($\pi/p$) production in CuAu

1. $p/\pi$ ratio in 0-10% central CuAu collision is significant higher than that of peripheral collisions
2. The $R_{AB}$ of $\pi$ in 0-10% central CuAu collision is similar to that of 20-30% AuAu Collisions (similar Ncoll and Npart)
3. The particles production in CuAu and AuAu is similar at mid-rapidity
In the Au-going direction, the J/ψ suppression is comparable with that of AuAu and CuCu collision

In the Cu-going direction, slightly more suppression is observed

No significant suppression in completely swallowed-Cu (top 5%) events, which is contradicted with core-corona model expectation

Currently, a full analysis with FVTX is going to further investigate the results in Cu-going direction
FVTX improvement for J/ψ

A. U.

Basic muon cut

Add DCA$_R$ < 2cm

Basic muon cut + DCA$_R$ < 2cm

Cu–Au run sample

1. The signal to background ratio is improved by FVTX cut for primary muon trackers

2. The $v_2$ of J/ψ and open charm will be measured at both forward and backward rapidity by FVTX, which will shed the light on the charm production
Summary

- In the central UU collision, strong mass ordering is observed for the $v_2$ of pions and protons.

- With the $\Psi_1$ measured by Au-going spectator, a positive $v_1$ is observed for the charged hadrons as $p_T > 1$ GeV/c. The sign of $v_1$ is different with AMPT calculation but consistent with other hydro calculations.

- The $\Psi_1$ plane correlation between BBC and SMD indicates a larger $v_1$ in the Au-going direction. And the raw $\Psi_3$ plane is weakly correlated with $\Psi_1$ and $\Psi_2$ plane.

- The pion and proton production at mid-rapidity in Cu Au is similar to that of AuAu collision. But an asymmetric J/$\Psi$ suppression is observed at forward/backward rapidity in CuAu. On the Cu-going side, the suppression is little bit stronger than that on the Au-going side.