Azimuthal anisotropy $v_2$ in central U+U collisions at STAR

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Motivation

The prolate shape of uranium nuclei provides the possibility to study

- Local parity violation
- Path length dependence of jet quenching
- Particle production in heavy ion collisions

However

- Can we see a difference between Au+Au and U+U?
- Can we separate body-body and tip-tip collisions in U+U?
Can we separate body-body and tip-tip?

We often assume multiplicity depends partially on the number of participants and partially on the number of collisions.

Use Zero Degree Calorimeter (ZDC) to select on spectators.

Central U+U collisions are an ideal testing ground for particle production: Is large $v_2$ associated with lower $N_{ch}$?
 Observable

- Cumulant $v_2\{2\}$ with acceptance corrections
  
  \[ c_2\{2\} = \langle \cos 2(\phi_1 - \phi_2) \rangle - \langle \cos 2(\phi_1) \rangle \langle \cos 2(\phi_2) \rangle - \langle \sin 2(\phi_1) \rangle \langle \sin 2(\phi_2) \rangle \]
  
  \[ v_2\{2\} = \sqrt{c_2\{2\}} \]

- Study multiplicity dependence of $v_2\{2\}$

\[ \frac{dN}{d\phi} \propto (1 + 2 \sum_{n=1}^{+\infty} v_n \cos [n(\phi - \psi_n)]) \]

\[ v_n = \langle \cos n(\phi - \psi_n) \rangle \]
Data Set

- Large $\eta$ coverage
- $|\eta| < 1.0$
- Full azimuthal acceptance

<table>
<thead>
<tr>
<th>$\sqrt{s_{NN}}$ (GeV)</th>
<th>Year</th>
<th># of events *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Au+Au</td>
<td>200</td>
<td>2011</td>
</tr>
<tr>
<td>U+U</td>
<td>193</td>
<td>2012</td>
</tr>
</tbody>
</table>

* Events for 1% most central ZDC used in analysis
1% ZDC

- Use normalized multiplicity to cancel multiplicity independent efficiency
- Apply a linear fit to extract multiplicity dependence of $v_2$, the slope parameter
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• Apply a linear fit to extract multiplicity dependence of $v_2$, the slope parameter
We see a clear difference between U+U and Au+Au
Slope vs. ZDC

- Compare with eccentricity calculated from glauber simulations

- Simulation results are scaled down to match the experimental $v_2$
  - Scale factor is 0.2 for U+U, 0.25 for AuAu
Summary

• We observed a difference between U+U and Au+Au at central collisions

• We observed a correlation between $v_2$ and multiplicity in central U+U collisions
  – Possible ways to separate body-body and tip-tip
  – Weaker than glauber model predictions