Looking For the Ridge in dAu at RHIC

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Field: Nuclear Physics
Using Really Big Machines to Shoot Really Small Things At Each Other

- Relativistic Heavy Ion Collider
- 3.8 km circumference
- 6 interaction Points
- 2 active experiments, PHENIX, STAR
STAR: How It Works

- Collisions between particle beams
- pPb, PbPb, dAu, AuAu, pp, ...
- particle production
- How to detect the charged particles? The TPC
STAR: The Time Projection Chamber

- the TPC is a 3D “camera” for charged particles
- TPC is inside a magnetic field
- calculate momentum from the curvature of a track
- pictured: Au-Au collision
2 Particle Correlations

- Event by event correlation
- $\Delta \phi = \phi(\text{trigger}) - \phi(\text{associated})$
  relative azimuthal angle
- $\Delta \eta = \eta(\text{trigger}) - \eta(\text{associated})$
- $\eta = -\ln \left[ \tan \left( \frac{\theta}{2} \right) \right]$
- $\theta =$ angle made with the beam axis, longitudinal
What is Expected in pp and pPb

- partons - undetectable
- partons undergo hadronization - produce narrow cone of hadrons, called a jet
- Jets can be used to probe what's happening in the collision
- In pp, studies QCD, in pPb, studies cold nuclear matter, in PbPb, studies hot nuclear matter (QGP)
But, a surprise in pPb at the LHC

- higher multiplicity - more central collision

- multiplicity dependent structure detected, a “near-side ridge”, in both pPb and PbPb

- In PbPb, this can be explained as a collective flow (v3) phenomenon
What could this mean in pPb/dAu collisions?

- Could it still be a collective flow effect?
- or, CGC- color glass condensate effects: gluon saturation, there can’t be an infinite number of gluons in a finite space
Why is RHIC interesting?

- different collision energies
- LHC = 5.2 TeV
- RHIC = 200 GeV
- CGC has a scale, x, parton energy divided by the collision energy
- for fixed jet energy, x is larger at smaller collision energies.
- CGC effects expected at small x

**d+Au minimum bias**

3<p_{t}^{\text{trig}}<4\text{GeV/c}
How? My Analysis So Far

• The two particle correlation plots

• Detectors have a geometric acceptance, $|\eta| \leq 1$ for both trigger and associated tracks

• how to deal with geometric acceptance and detector inefficiencies? Event mixing

• The following data is from my simulation
How-2 Events, Simple Example

Event 1

Event 2
First, select a trigger
Next, do the signal correlation
Now, Event Mixing with Unrelated Event
What Does This Give Us?

- Our Signal Correlation
- Our Event Mixing Correlation
When We Divide, bin by bin...

- We get a flat signal
- Advantages of Event Mixing
- Statistical error can be made arbitrarily small
- Corrects for detector inefficiencies
Remember the dEta Distribution?

- We started here
- This is the result-flat, as expected
Pythia Results

- Pythia - used to simulate Jet production in collisions
- I used Pythia + a random number generator to simulate a background
Non-flat Eta Distribution

- My background simulates the eta distribution of a dAu collision
- if the event mixing works, it should correct for this in the final dEta distribution
Event Mixing

Normalized Event Mixing, 1-3 GeV, Jet Energy 10-70 GeV

<table>
<thead>
<tr>
<th>hCorrEtadPhiMixCorrected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entries</td>
</tr>
<tr>
<td>Mean x</td>
</tr>
<tr>
<td>Mean y</td>
</tr>
<tr>
<td>RMS x</td>
</tr>
<tr>
<td>RMS y</td>
</tr>
</tbody>
</table>

Wednesday, August 7, 13
Corrected Correlation, 1-3 GeV, Jet Energy 10-70 GeV

Corrected Correlation, 1-3 GeV, Jet Energy 10-70 GeV

- Entries: 8.476219e+07
- Mean x: 1.932e-05
- Mean y: 0.0004879
- RMS x: 1.895
- RMS y: 1.124
Corrected Correlation
Eta Projection

Eta Projection, 1-3 GeV, Jet Energy 10-70 GeV

Entries: 8.476219e+07
Mean: 0.0004879
RMS: 1.124
Phi Projection

Phi Projection, 1-3 GeV, Jet Energy 10-70 GeV

\[ \frac{dN}{N^p d\Delta\phi} \]

Entries: 8.476219e+07
Mean: 1.932e-05
RMS: 1.895
Onto STAR!

- Collision energy - 200 GeV
- 3.59 million minimum bias events
- One more complication - collisions don’t necessarily happen in the middle of the detector
This distorts the Eta Distribution

- Eta for z~25 cm
- Eta for z~25 cm
Results! 2D Correlation

dAu 2P Correlation, 1-3 GeV

[Image of a 2D correlation plot]

Correlation Output

Entries: 4.378716e+07
Mean x: -0.0002502
Mean y: -0.0002916
RMS x: 1.84
RMS y: 1.142

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3D Correlation

dAu 2P Correlation, 1-3 GeV

Correlation Output
Entries 4.378718e+07
Mean x -0.0002582
Mean y -0.0002918
RMS x 1.84
RMS y 1.142
Delta Eta Projection

$\Delta \eta$ Projection, 1-3 GeV

Correlation Output

<table>
<thead>
<tr>
<th>Entries</th>
<th>$4.378718e+07$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>$-0.0002918$</td>
</tr>
<tr>
<td>RMS</td>
<td>$1.142$</td>
</tr>
</tbody>
</table>

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Delta Phi Projection

$\Delta \phi$ Projection, 1-3 GeV

Correlation Output px

Entries: $4.378718 \times 10^7$
Mean: $0.0002562$
RMS: $1.84$

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Delta Phi at Large
Delta Eta

$\Delta \phi$ Projection, $1.2 < |\Delta \eta| < 1.7$, 1-3 GeV

Long Range Eta

<table>
<thead>
<tr>
<th>Entries</th>
<th>2.261733e+07</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>-0.023e-05</td>
</tr>
<tr>
<td>RMS</td>
<td>1.856</td>
</tr>
</tbody>
</table>
Conclusions & Accomplishments

• Possible weak signal

• Could just be from the wide near side jet correlation

• Further analysis required

• Accomplished - Creation of a working, flexible analysis class that can handle multiple data types

• Integration of my code into an auxiliary ROOT library - 16-20x performance increase over loaded macro

• Preliminary analysis of RHIC data - to be continued