Heavy Ion Physics
Discussion Group E

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Long-range angular correlations on the near and away side in p–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV by the ALICE collaboration

arXiv:1212.2001v2
Motivation

- Why study p-Pb collisions?
  - QCD at high parton density
  - Probe parton distribution functions
    - Inspect Pb-ion with proton
  - Important control measurement for observables in Pb-Pb

- Why study two-particle angular correlations?
  - Interesting tool to study high-multiplicity events
    - Significant structures observed in pp collisions
  - Different underlying physics possibly relevant in p-Pb
Two Particle Correlation

- **Associate** a particle to a **trigger** particle in specific $p_T$ intervals
  - $p_{T,assoc} < p_{T,trig}$

\[
\frac{1}{N_{trig}} \frac{d^2 N_{assoc}}{d\Delta \varphi d\Delta \eta}
\]

- 4 hour test run in September 2012
  - 1.7 million $p$-Pb events
Event Classes

- Define four event classes based on forward multiplicity measurement

- **Pb**
  - 0 – 20 %: Highest multiplicity
  - 20 – 40 %
  - 40 – 60 %
  - 60 – 100 %: Lowest multiplicity
The Ridge

Near-side jet
($\Delta \phi \sim 0$, $\Delta \eta \sim 0$)

Away-side (recoil) jet
($\Delta \phi \sim \pi$, spread in $\Delta \eta$)

Near-side ridge
($\Delta \phi \sim 0$, spread in $\Delta \eta$)

$2 < p_{T,\text{trig}} < 4 \text{ GeV/c}$
$1 < p_{T,\text{assoc}} < 2 \text{ GeV/c}$

$p$-Pb $\sqrt{s_{NN}} = 5.02 \text{ TeV}$
0-20%
Excess of yield on near-side previously measured by CMS*

- Excess of yield on near-side and away-side

*arXiv:1210.5482 [nucl-ex].

p-Pb $s_{NN} = 5.02$ TeV
- 0-20% $2 < p_{T,\text{trig}} < 4$ GeV/c
- 20-40% $1 < p_{T,\text{assoc}} < 2$ GeV/c
- 40-60% stat. uncertainties only
- 60-100%

pp 2.76 TeV

pp 7 TeV

1/N_{\text{trig}} dN_{\text{assoc}}/d\Delta \phi$ per $\Delta \eta - \text{const}$ (rad$^{-1}$)
Subtracting the Background
→ Separate jet and ridge component!

Double ridge structure

0 – 20 %

60 – 100 %
The Double Ridge Projection in $\Delta \phi$

- Significant contributions from $\cos(2\Delta \phi)$ and $\cos(3\Delta \phi)$ terms

Data

- $a_0 + a_2 \cos(2\Delta \phi) + a_3 \cos(3\Delta \phi)$
- $a_0 + a_2 \cos(2\Delta \phi)$
- Baseline for yield extraction
- HIJING shifted

$p$-Pb | $s_{NN} = 5.02$ TeV
(0-20%) - (60-100%)

2 < $p_{T,\text{trig}}$ < 4 GeV/c
1 < $p_{T,\text{assoc}}$ < 2 GeV/c
Strength of $v_2$ and $v_3$ Coefficient

- Strong dependence on $p_T$
- Light dependence on centrality

- Light dependence on $p_T$ within uncertainties

Same underlying physical origin for ridges?!
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Summary

- Significant double ridge structure has been observed in high-multiplicity p-Pb collisions → Results confirmed by ATLAS, arXiv:1212.5198 [hep-ex].

  Structure described qualitatively by hydrodynamic models!

  Drops of strongly coupled medium?

- ... also described qualitatively by other models...

  → Strongly implied by ATLAS & CMS

- No clear answer from theory

- p-Pb maybe not good as control measurement, but a lot more...
Thank you for your attention!

... and many thanks to Krishna!!!
Backup Slides
A Large Ion Collider Experiment

- Inner Tracking System (ITS)
  - Track reconstruction and particle identification
- Time Projection Chamber (TPC)
  - Main detector for tracking and particle identification
- VZERO
  - Scintillator tiles used for centrality estimation
- Zero Degree Calorimeter
  - Neutron calorimeters
Event classes
And track selection

| Event class | V0M range (a.u.) | $\langle dN_{ch}/d\eta \rangle|_{|\eta|<0.5}$ | $\langle N_{trk} \rangle|_{|\eta|<1.2}$ |
|-------------|-----------------|---------------------------------|---------------------------------|
| 60–100%     | < 138           | $6.6 \pm 0.2$                   | $6.4 \pm 0.2$                   |
| 40–60%      | 138–216         | $16.2 \pm 0.4$                  | $16.9 \pm 0.6$                  |
| 20–40%      | 216–318         | $23.7 \pm 0.5$                  | $26.1 \pm 0.9$                  |
| 0–20%       | > 318           | $34.9 \pm 0.5$                  | $42.5 \pm 1.5$                  |

- Standard track selection criteria for tracks with $0.5 < p_T < 4$ GeV/c
- Tracks within fiducial region of $|\eta|<1.2$
Symmetric Ridge Consistency Check

- Subtract symmetric double ridge component estimated in $1.2 < |\Delta \eta| < 1.8$
Recent results from ATLAS* (& CMS)

- Analysis from long p-Pb run in early 2013

→ Excellent agreement between data and hydrodynamic model

*arXiv:1303.2084v2