Dijet Asymmetry in Pb+Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV Using the ALICE Experiment

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A Large Ion Collider Experiment
Experiment at LHC
18 subdetectors in total
I focused on the EMCal (Electromagnetic Calorimeter) and the TPC (Time Projection Chamber)
“Our aim is to study the physics of strongly interacting matter at extreme energy densities, where the formation of a new phase of matter, the quark-gluon plasma [QGP], is expected.”*

* about ALICE

*aliceinfo.cern.ch
Covers almost the full TPC in $\eta$, but not $\phi$
Detects neutral particles

Tracks only charged particles
FastJet 2.4.1 – “Longitudinally invariant Kt, anti-Kt, and inclusive Cambridge/Aachen clustering using fast geometric algorithms, with area measures and optional external jet-finder plugins”*

PYTHIA 8.130 – “a program for the generation of high-energy physics events…contains theory and models for a number of physics aspects, including hard and soft interactions, parton distributions, initial- and final-state parton showers, multiple interactions, fragmentation and decay.”**

ktROOT (ROOT 5.32.03 + ktJet libraries) – “The ROOT system provides a set of OO [Object-Oriented] frameworks with all the functionality needed to handle and analyze large amounts of data in a very efficient way”***

Software Environment

Learning some basic Linux commands
Brushing up on my C++
Learning ktROOT
Debugging

Challenges
- Hard scatter of colored partons
- Jet - cone of hadrons produced by hadronization of these partons
- Jets tell us about properties (kinematics and topology) of original partons
- Final state is color neutral
- Jet production well described by QCD/MC generators like Pythia
QCD

- Confinement – quarks bound as hadrons
- Asymptotic Freedom – at high energies, quarks and gluons interact weakly to produce QGP

QGP

- Hot, dense soup which cools instantly

Jets

- Back-to-back scatter
- Fast, high energy shower of particles
- Strongly interacting, but not fully absorbed

Jet Quenching –

- jets transfer energy/momentum to the medium while traversing (gluon bremsstrahlung)

Without this background, QCD works well, and our Pythia simulation is a good model.

Jets offer an internal x-ray of the medium, similar to a Rutherford scattering.

Why Jets?
$A_J = \frac{p_{T,1} - p_{T,2}}{p_{T,1} + p_{T,2}}$

- Comparing Full-Full dijets to Full-Charged ones (useful since EMCal does not have full $\phi$ coverage)
- Making this comparison, after adding a background
- Reducing background effects on $A_J$
Compared the effects of different cuts

Cuts included: $\Delta \Phi$ (to obtain a true pair), $\eta$ (because of detector limitations), $p_T$ (to model true kinematics), $R_{cone}$ (balance of background exclusion, and jet inclusion)

Effect: larger $R_{cone}$, more balanced jets at higher $p_T$
Results I.

Full-Full $A_J$ v. Full-Charged $A_J$ v. Subleading Charged $p_T$

3D plots contain quickly accessible information, obtained by taking projections

- Constituent $p_T$ cut: 2 GeV
- Leading jet $p_T$ range: 80 – 100 GeV
Results II.

Full-Charged $A_j$ v. Full-Full $A_j$ for varying subleading charged jet $p_T$

10 – 20 GeV

20 – 40 GeV

40 – 60 GeV*

60 – 80 GeV

80 – 100 GeV**

10 – 100 GeV

- Constituent $p_T$ cut: 2 GeV
- Leading jet $p_T$ range: 80 – 100 GeV

*best $p_T$ range

**reflects leading jet kinematics
Because of more energetic constituents, background effects are reduced, so plots correspond well to Pythia-only ones.

Constituent $p_T$ cut: 2 GeV
Leading jet $p_T$ range: 80 – 100 GeV

Results II. with background

Full-Charged $A_j$ v. Full-Full $A_j$ for varying subleading charged jet $p_T$ with background
Results III.

A\_J for various p_{T} cuts

- Full-Full A\_J
- Full-Charged A\_J

- Constituent p_{T} cut: 2 GeV
- Leading jet p_{T} range: 80 – 100 GeV
Results IV.

- Constituent $p_T$ cut: 2 GeV
- Leading jet $p_T$ range: 80 – 100 GeV

$A_J$ without background, compared to $A_J$ with background
Further study will be required to fully map these two onto each other.

**Conclusion:** It is feasible to use the charged away side (TPC only) jet, applying a background suppression constituent $p_T$ cut to measure the dijet imbalance, $A_J$ in PbPb collisions in ALICE w.r.t. the full-full dijet case.

*2/3 of particles are charged, so 40 GeV subleading $p_T$ cut is comparable to 30 GeV subleading charged $p_T$ cut

**Results V.**

Full-Full $A_J$ with Full-Charged $A_J$ with background

- Constituent $p_T$ cut: 2 GeV
- Leading jet $p_T$ range: 80 – 100 GeV
References

- [https://sites.google.com/albl.gov/relativistic-nuclear-collisions/home](https://sites.google.com/albl.gov/relativistic-nuclear-collisions/home)