Spherocity in Relativistic High-Energy pp Collisions

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History of Particle Physics

[1]

1808

John Dalton proposed the idea that atoms were the building blocks of matter

J.J. Thomson discovered the electron

1897

[2]

[3]

1911

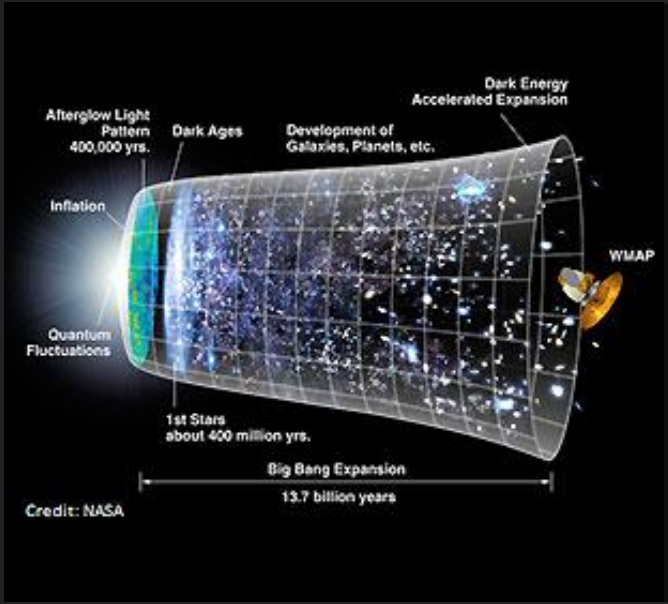
Ernest Rutherford discovered the nucleus

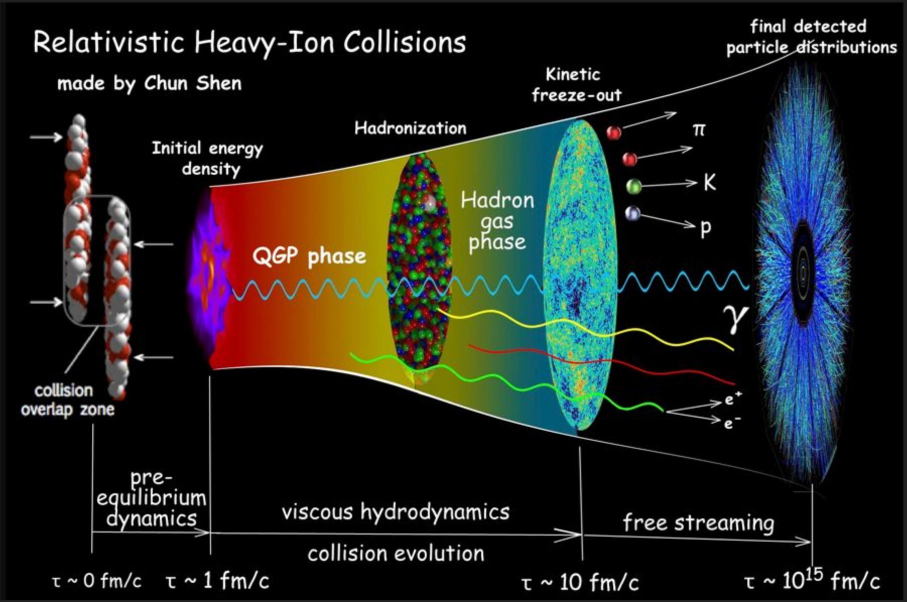
Murray Gell-Mann and George Zweig proposed the idea of quarks

1964

[4]

Particle Physics Today





[5] [6]

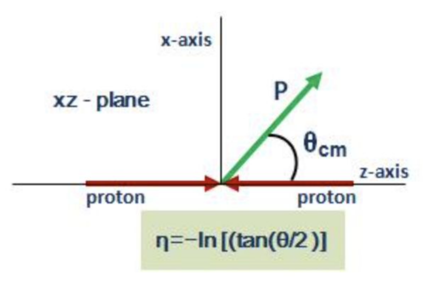
Big Bang vs. Mini Big Bang

Scientists recreate the conditions of the Big Bang,
where we believe the QGP to exist

The Kinematic Variables of Relativistic High-Energy Collisions

Pseudorapidity

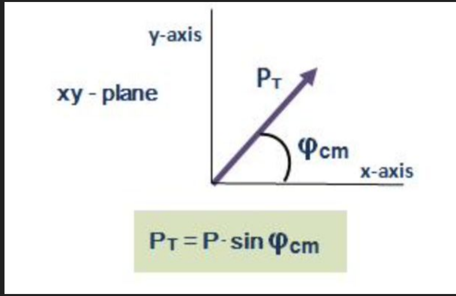
The radial angle the particle makes after the collision in the x-z plane



[7]

Azimuthal Angle

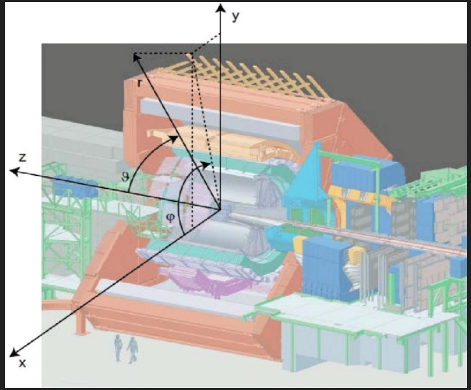
The scattering angle the particle makes after the collision in the x-y plane



[7]

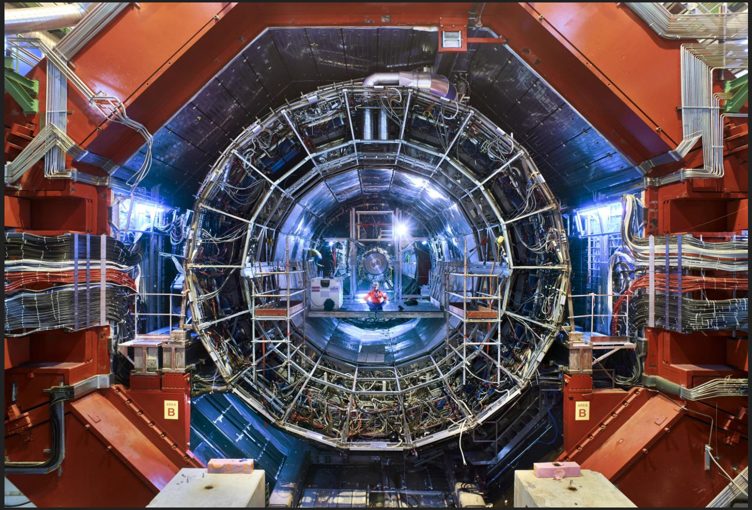
Transverse Momentum

The momentum of the particle in the x-y plane



[8]

Pythia - High Energy Collision Simulator



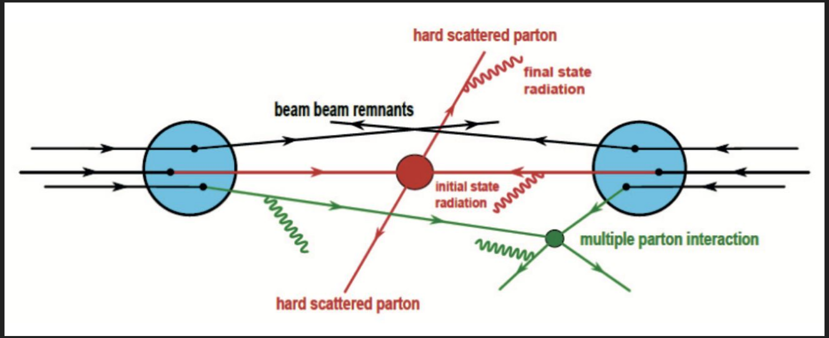
V0M Detectors in ALICE are useful for ultimately determining spherocity

[9]

V0A	$2.8 < \eta < 5.1$
V0C	$-3.7 < \eta < -1.7$

[8, p. 70]

[10, p. 49]



- Based on the Lund String Model
- 5 million events generated
- V0 limits on pseudorapidity giving full azimuthal angle coverage

Introduction to Spherocity

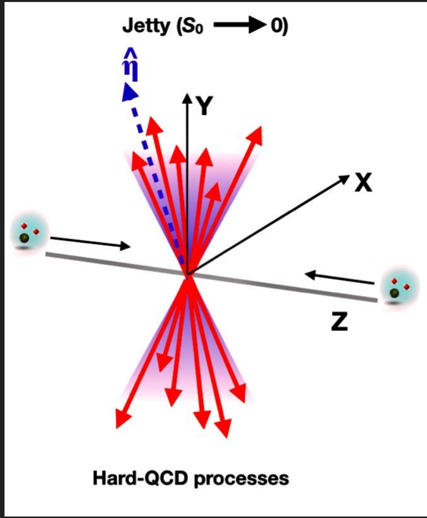
The magnitude of spherocity is related to how isotropic the distribution of azimuthal angles are when the particles hit the detectors.

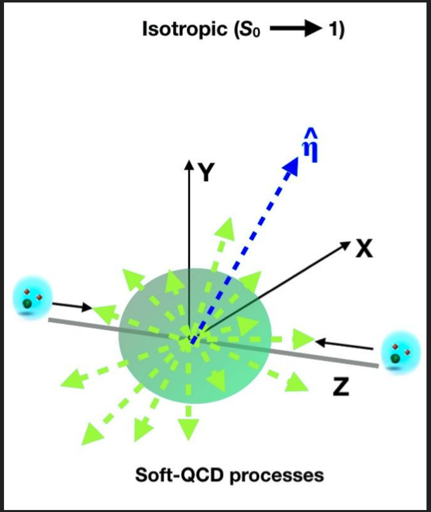
[10, p. 117]

$$S_0 = \frac{\pi^2}{4}\left(\frac{\sum_i \overrightarrow{p_{Ti}} \times \hat{\mathbf{n}}}{\sum_i p_{Ti}}\right)$$

[10, p.117]

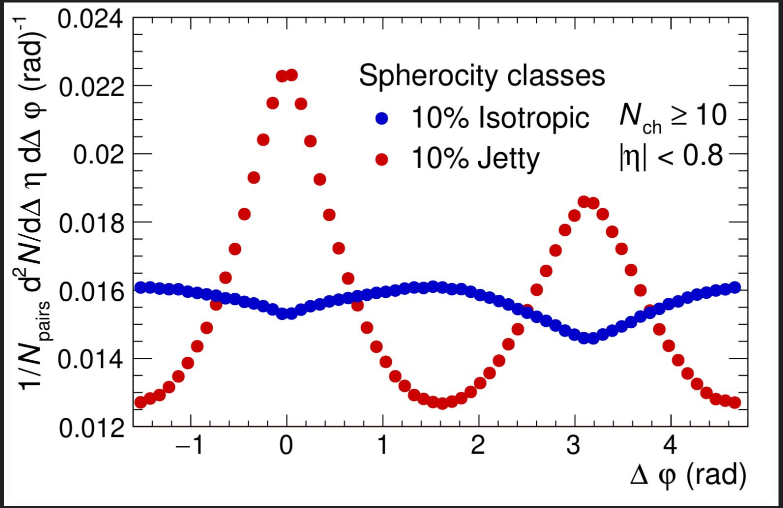
$$S_0 = \begin{cases} 0, & \text{“jetty-like” limit .} \\ 1, & \text{“isotropic” limit .} \end{cases}$$





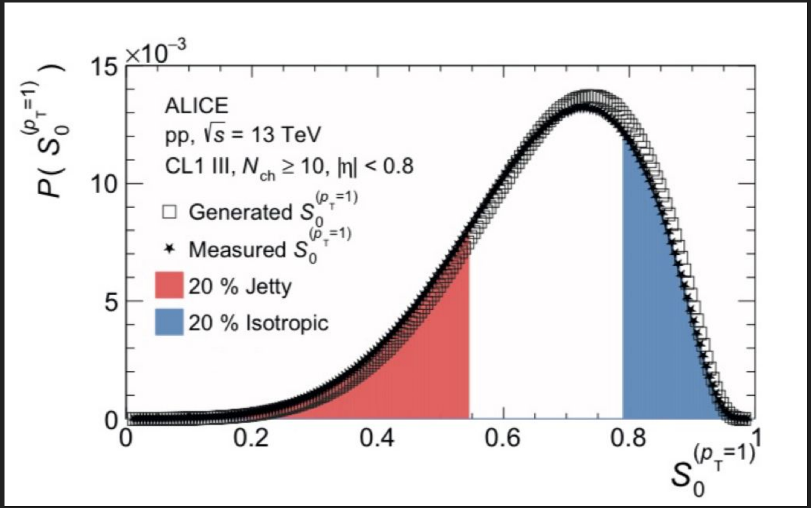
[11]

Isotropic Events vs. Jetty-Like Events



The number of particles with a certain difference in the azimuthal angle

$$d\Delta\phi = \phi_1 - \phi_2$$



There's two classifications of spherocity: Jetty and Isotropic

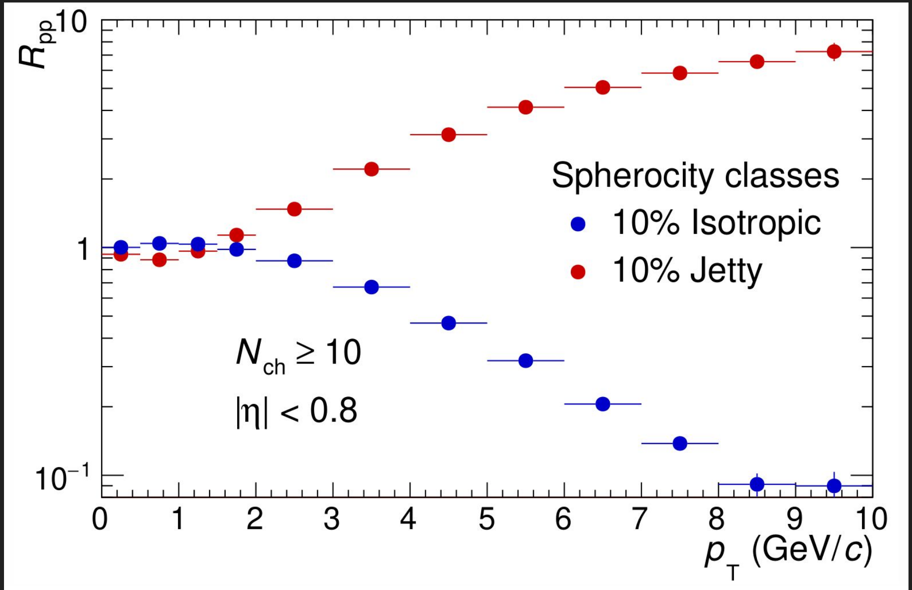
[10, p.119]

The Transverse Momentum of Jetty-Like and Isotropic Events

- This graph tells us that the isotropic events are characterized by soft processes (sQCD)

- Jetty events are characterized by hard processes (hQCD)

$$R_{pp} = \frac{d^2N_{ch}^{Jet/Iso}/\langle dN^{Jet/Iso}/d\eta\rangle d\eta dP_T}{d^2N_{ch}^{MB}/\langle dN^{MB}/d\eta\rangle d\eta dP_T}$$

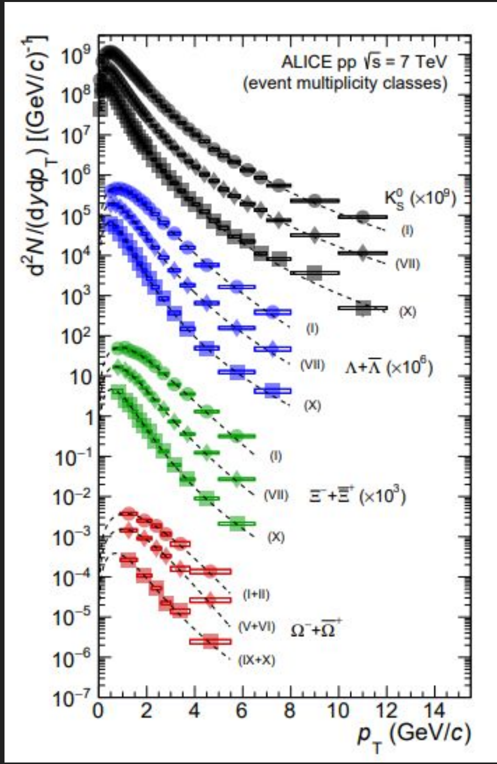


Relevance & Future Research

Strangeness enhancement is the observation of strange hadron production with high transverse momentum spectrum during the formation of the QGP

The observables were inspired to further the hypothesis that strangeness enhancement is produced during at a point in the QGP

Future work at Vanderbilt to develop new phenomenological models to increase the potential to find unique particles such as the charmonium state particle called X3872 by the CMS collaboration



Conclusion

Spherocity is a way we can classify events based on their topology. And these events can fall between jet-like events which is a spray of hadrons or isotropic events which states that the particles are distributed in a way that the angles between them are symmetrical.

There are more particles with higher transverse momentum in jet-like events than there are in isotropic events. This is due to the hard processes that happen during the collision of quarks and gluons. In contrast, we consider isotropic events to have more soft processes.

"I would rather have questions that can't be answered than answers that can't be questioned."

Richard P. Feynman

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