Bjorken, Heavy Ions, some reminiscences

Bjorken Symposium Nov. 9, 2024

Postdoc at SLAC 1978-1980

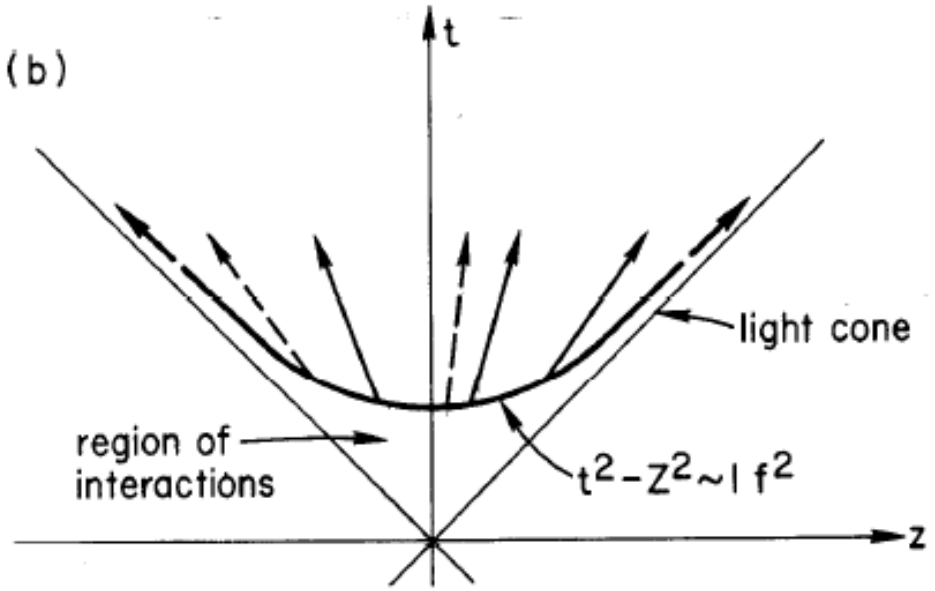
Had done some work computing properties of high density quark matter, and Bj was a little interested.
We wrote a “crazy” paper together suggesting that some Cosmic ray events (Centauros) might be generated by metastable globs of strange quark matter And of course, the data was wrong. Bj got me a little interested in cosmic ray physics.
He told me it was good to try to understand cosmic ray results,
”They are almost always wrong, but they can simulate the imagination.”

In 1980, I was to go to a meeting in Europe, my first time there. I needed to do something new for the meeting, and one of the projects I decided to work on was to see if there was sufficient time and energy density to make approximately equilibrated matter in high energy collisions (Quark Gluon Plasma).
I needed to understand a space-time picture of high energy nuclear collisions and this is where Bj had unique knowledge

Bjorken Lectures at International Summer Institute in Theoretical Physics, DESY, September 1975 SALC-PUB-1756

Bj had worked out the space-time picture of particle production. Elements were in works of Gribov and Feynman, but Bj independently made a simpler physical picture and conceptual framework

(1+1 dimensional picture easily generalized to 1+3 assuming)

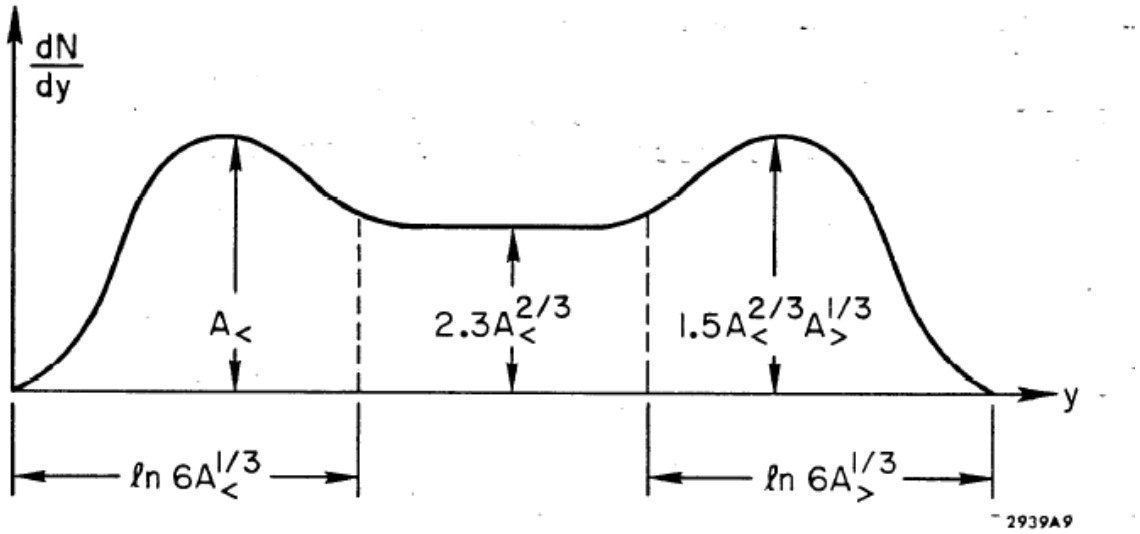


Particle produced at fixed proper time $\tau = \sqrt{t^2 - z^2}$

At late times, assuming the collision region is compact: $u^\mu = x^\mu / \tau$

$$y = \frac{1}{2} ln \frac{E + p^z}{E - p^z} = \frac{1}{2} ln \frac{1 + v}{1 - v} = \frac{1}{2} ln \frac{t + z}{t - z}$$

Together with Anishetty and Koehler, we used Bj's simple physical picture to estimate energy densities and time scales in fragmentation region. Central region was harder because of uncertainty in multiplicity.



Bj's guess in 1976

In 1982, Bj turned this into a question:

PRD, 27, 183 (1983)

$$\epsilon = \frac{1}{\tau_0 \pi R^2} \frac{dE_T}{dy}$$

R is nuclear size

τ_0 is natural time, taken to be about 1 Fm/c

$\frac{dE_T}{dy}$ is the produced transverse energy to be taken from experiment

The picture that emerges from his space-time arguments is a fragmentation region that is hot and baryon rich and a few units of rapidity wide, and a central region which is approximately a plateau whose height is to be determined by experiment

At a time $\tau = \tau_0$
there are initial conditions for hydrodynamic equations:

$$u^\mu = x^\mu/\tau \qquad \epsilon(\tau)$$

$$T^{\mu\nu} = (\epsilon + P)u^\mu u^\nu + g^{\mu\nu}P$$

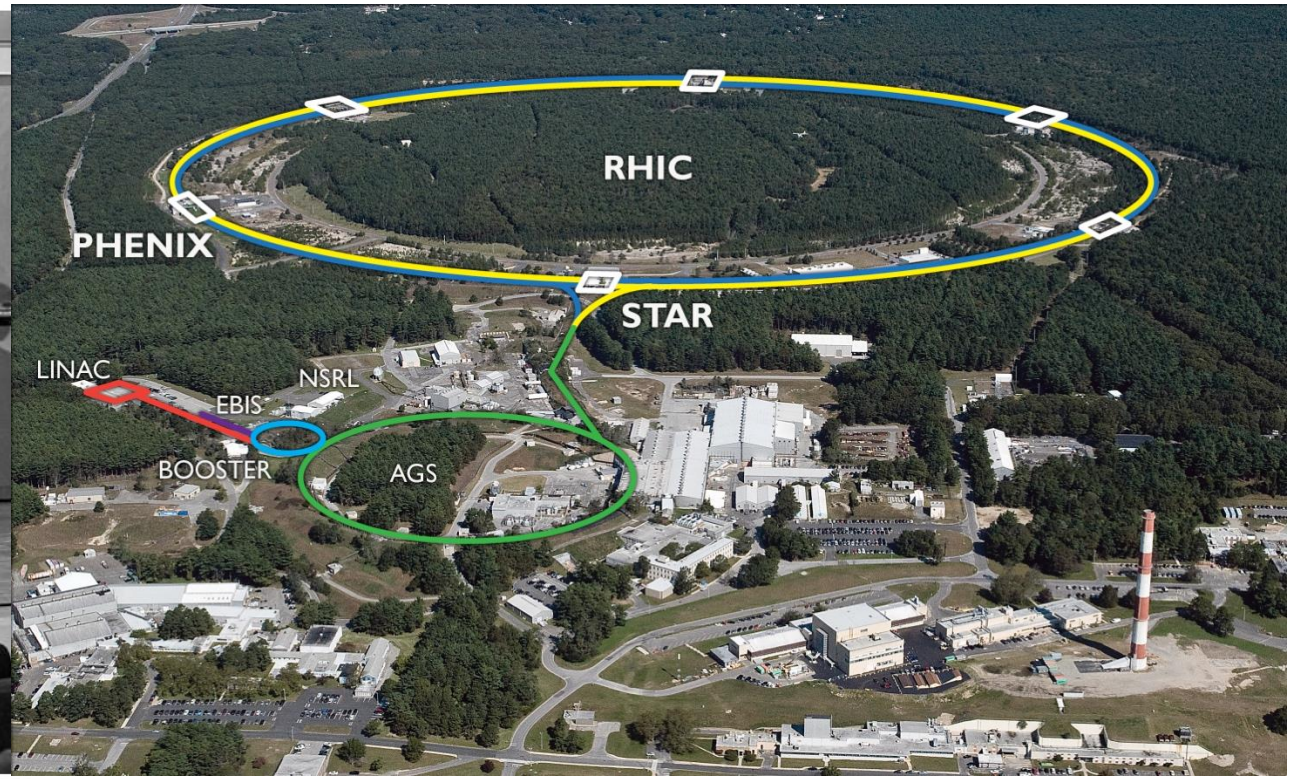
$$\partial_\mu T^{\mu\nu} = 0$$

These equation are boost invariant. Bj worked this out for 1+1 d (large nucleus)

Bjorken also somewhat later applied his space time picture to jet quenching in heavy ion collisions.
Fermilab-Pub-82/59-THY (unpublished)

Tools based on hydrodynamic analysis, and the space-time picture of jet quenching are the mainstay of heavy ion experiments, and are the basis of much analysis which has led to the experimental characterization of the Quark Gluon Plasma in such collision

On the experimental front, experimentalists, were discussing possible heavy ion programs at CERN and at BNL which led to the experimental programs at the LHC and at RHIC



At Quark Matter 83 in BNL: Bj, Miklos Gyulassy, Allen Bromley, Reinhard Stock, Arthur Schwarzschild, and Kozi Nakai

Impressions of Bjorken:

As a postdoc at SLAC: I saw that Bj would say very little and what was said very simple, but I would not understand it until I had thought very hard. Bj thought in pictures, and used mathematics to express and check these pictures. My training was the other way around, and it took a long time for me let intuitive pictures guide my thinking. It changed me in a basic and fundamental way, not just in physics.

I knew Bj later at FNAL when I was on the faculty. Still, understanding Bj's thinking was difficult, and he had a mystical quality in the way in which he thought about things. Years later, he dropped by a few times at my "dacha" in Oregon when I was there in winter for skiing, and we skied together. He enjoyed talking with my wife, and was relaxed, but still very private, when he visited.

Twice Bj came to BNL while I was on the staff. Each time he was unannounced. He was driving around the country and decided to drop in. Both times he visited, we had to retrieve him from the guardhouse where he was not let in until someone called the lab director. (We had many jokes about a hypothetical jail where the lab sent unannounced visitors. In the jokes, Bj was a well known prisoner. There was a time long long ago when access to national labs was much less formal.) On one visit, he came in and we sat in my office and talked, and TD Lee walked by. TD saw Bj, and I never saw such a happy smile from TD. TD sat down, and they joked about physics gossiped about friends. I was the fly on the wall. It was a time when Bj was very relaxed. Bj's smile was as big as TDs.

Last time I saw Bj, Jennifer Rittenhouse West took me up to Skyline drive to meet BJ for lunch at the restaurant where he would spend his days doing physics. She had been working with him for some time. Bj was excited about unification and all manner of angles and masses. He had a limp from a bad knee that contrasted strongly with his childlike enthusiasm for physics.