PID v_2 and v_4 from Au+Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV at RHIC

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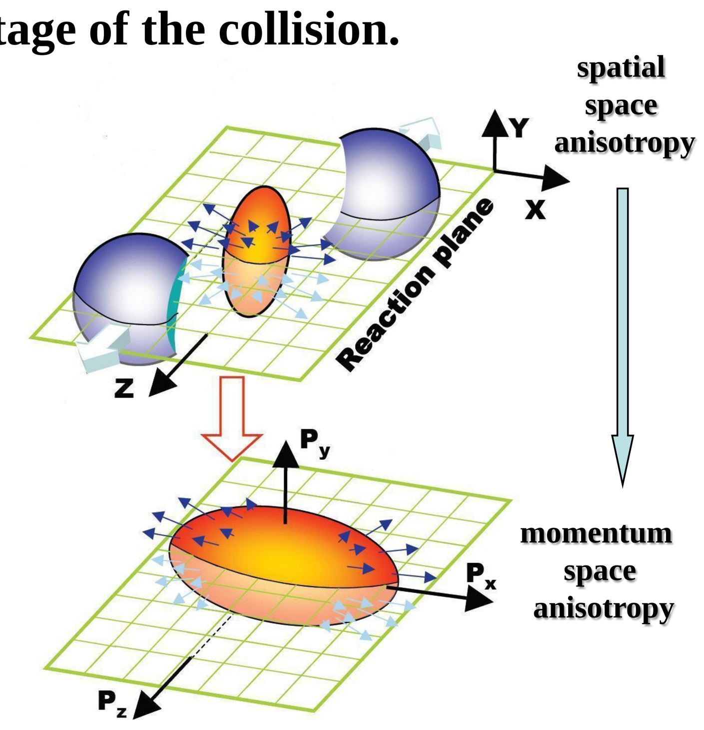
Motivation

In relativistic heavy ion collisions, the hot and dense medium called Quark-Gluon Plasma (QGP) is considered to be created at the early stage of the collision.

- De-confinement
- Collectivity
- Local thermalization

Important questions



In non-central collisions, the anisotropy in spatial space will convert to the anisotropy in momentum space. Because the spatial asymmetries rapidly decrease with time, anisotropic flow must be sensitive to the particle interactions very early in the system evolution, and is a unique hadronic observable providing direct information about the stage where the QGP may be the main player.

Measurement:

Elliptic flow v_2, which is the second harmonic coefficient of the fourier expansion of the final momentum-space azimuthal anisotropy can provide information about the dynamics at the early stage. Baryon and meson elliptic flow follow the number of quark (N_q) scaling indicates that partonic flow builds up at RHIC [1].

If system reaches local thermal equilibrium, according to ideal hydro dynamic calculation, v_4/v_2^2 is approaching 0.5 at about 2 GeV/c.

[1] J. Adams et al. [STAR Collaboration], Phys. Rev. C 77 (2008) 54901

[2] R. S. Bhalerao et.al PLB 627,49; Borghini and Ollitrault, PLB642,227

Experiment

STAR:

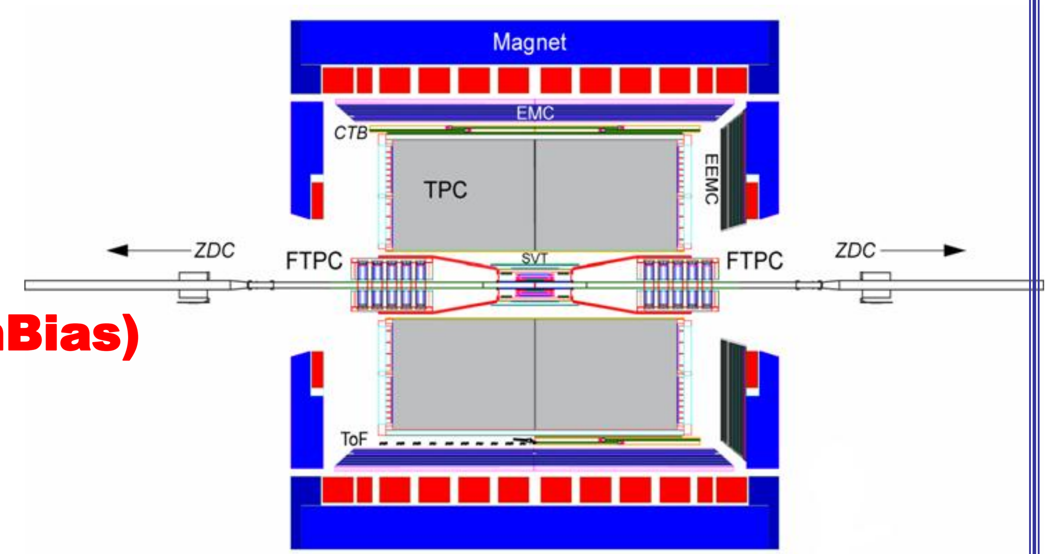
The Solenoidal Tracker at RHIC (STAR) is a detector which specializes in tracking the thousands of particles produced by each ion collision at RHIC. Weighing 1,200 tons and as large as a house (note ladder in image at left), STAR is a massive detector. It is used to search for signatures of the form of matter that RHIC was designed to create: the quark-gluon plasma. It is also used to investigate the behavior of matter at high energy densities by making measurements over a large area.

TPC:

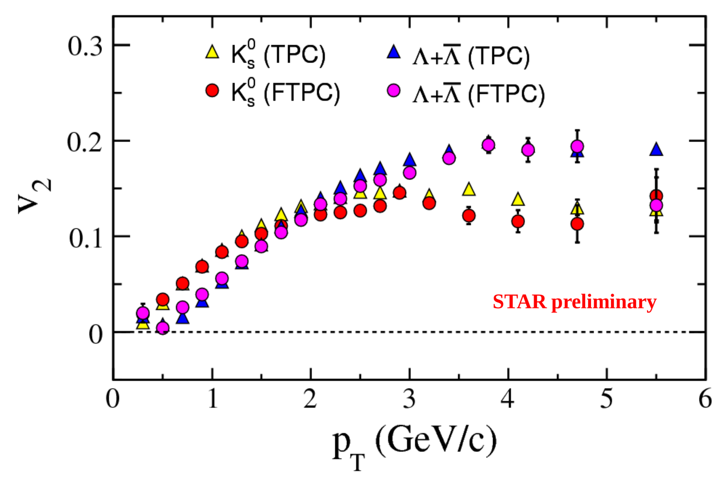
STAR's "heart" is the Time Projection Chamber, made of many electronic systems, which tracks and identifies particles emerging from heavy ion collisions. As each collision occurs, STAR measures many parameters simultaneously to look for signs of the quark-gluon plasma. By using powerful computers to reconstruct the sub-atomic interactions which produce the particles emerging from each collision, the detector can, in a sense, run time backwards. This process can be compared to examining the final products which come out of a factory and trying to determine what kinds of machines produced them.

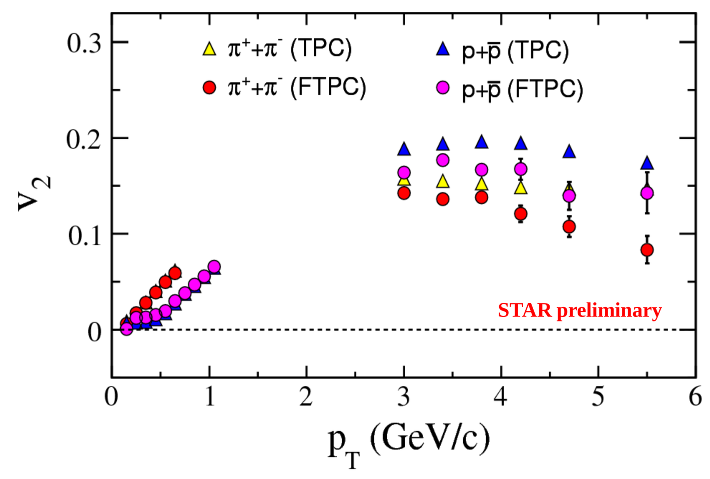
Data Sample

- System: Au+Au collision
- Energy : $\sqrt{s_{NN}}$ = 200 GeV
- Event sample : ~60 M events (minBias)
- Year: 2007
- Rapidity range:
  TPC : $-1.0 < \eta < 1$
  FTPC : $2.5 < |\eta| < 4.0$



Anisotropy Parameters v_2

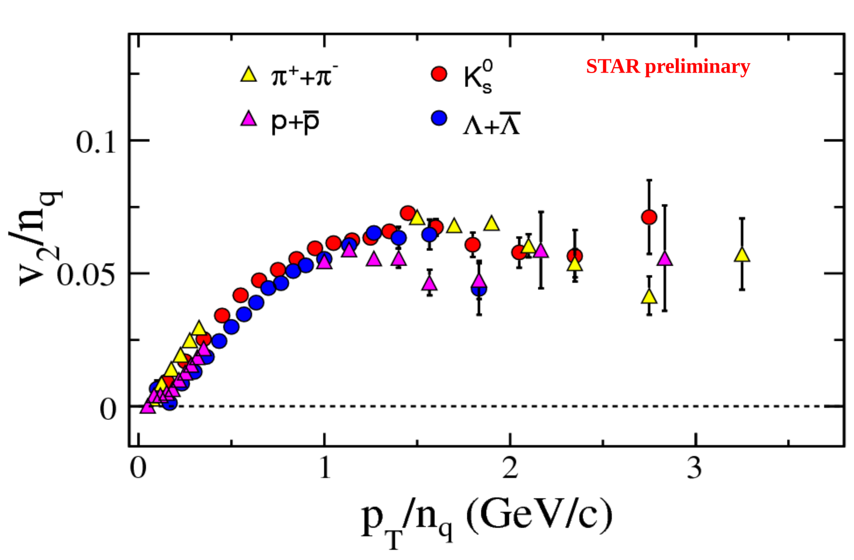


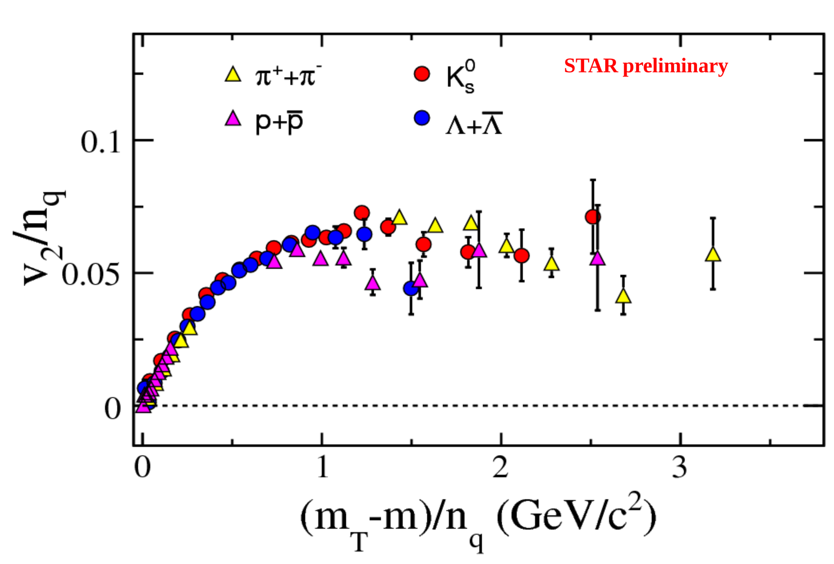


- Tracks from TPC and FTPC are used to reconstruct the event plane separately.
- Detector bias is removed by applying phi weights to the tracks. Additional shift correction is added for FTPC for acceptance effect .
- The purity for proton is about 70%, and the contamination on proton v_2 will be about 10% base on run4 study.

> Non-flow effect reduced significantly by using the FTPC event plane as the data shown.

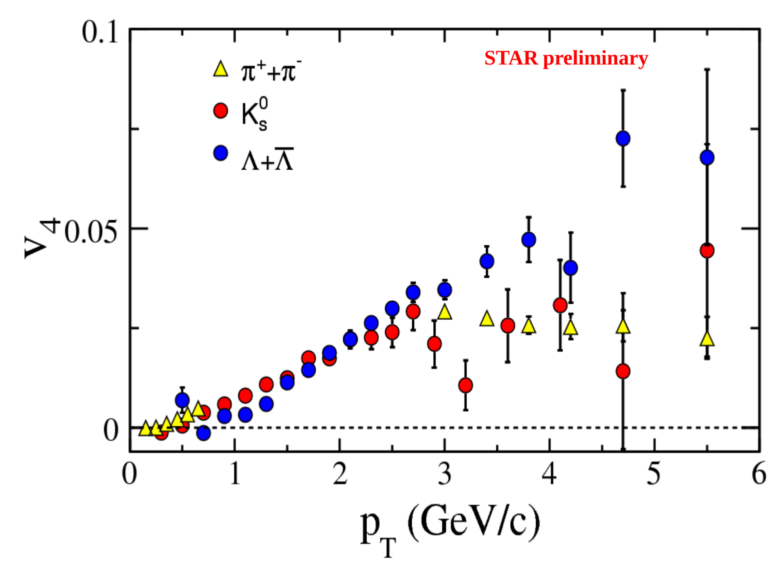
Number of Quark Scaling:



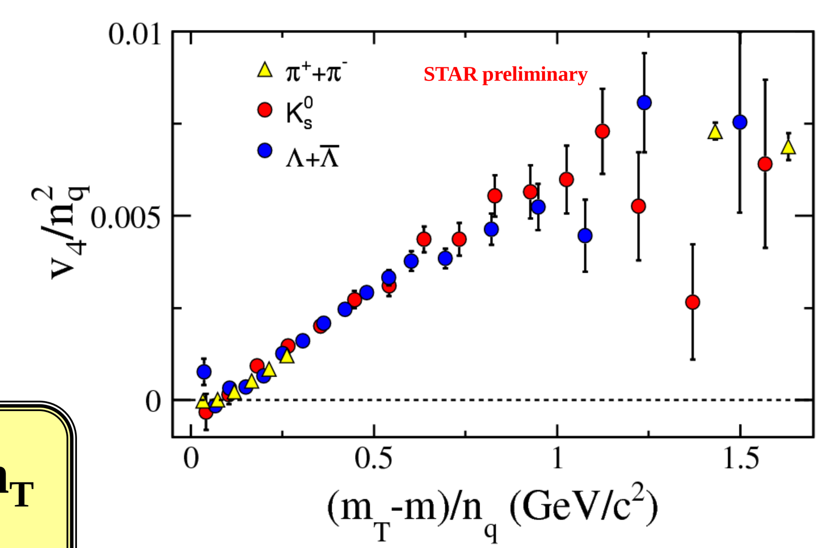


> *Using FTPC event plane to remove non-flow effect.*
> *The number of quark scaling for π, proton, K_S^0 and Λ holds up to $(m_T - m)/n_q \sim 1$ GeV/c².*
> *Protons seem to deviate from the scaling at about 1 GeV/c².*

Anisotropy Parameters v_4

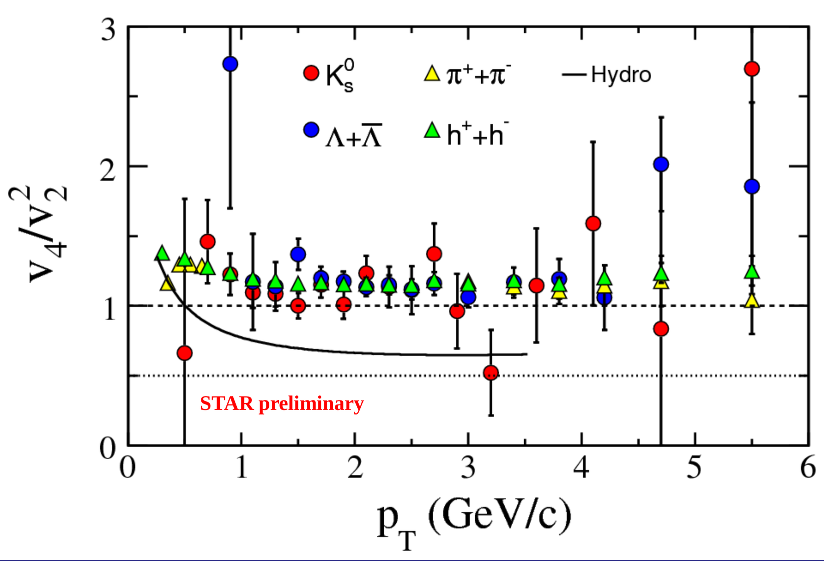


- 2^{nd} harmonic and TPC tracks are used to reconstruct event plane.
- $v_4(p_T)$ has been measured for π, K_S^0 and Λ.



Number of Quark Scaling:

> The N_q scaling for v_4 is observed at $(m_T - m)/n_q < 1$ GeV/c², similar to that of v_2.



> *v_4/v_2^2 is about 1 at $p_T \sim 2$ GeV/c, larger than the value 0.5 expected from ideal fluid calculations.*

Summary

- Proton and anti-proton seems to deviate from the number of quark scaling at $(m_T - m)/n_q \sim 1$ GeV/c² .
- The number of quark scaling has been observed for v_4 at $(m_T - m)/n_q < 1$ GeV/c².
- Mesons and baryons (π, K_S^0 and Λ) have similar $v_4/(v_2)^2$ ratios. It is close to unity at $p_T > 1$ GeV/c, higher than ideal hydrodynamic model predictions.

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