Energy and centrality dependence of identified particle elliptic flow in relativistic heavy-ion collisions

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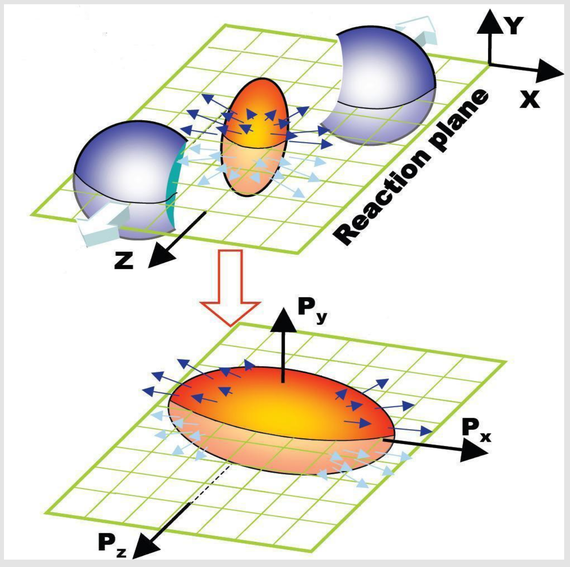
Abstract

The Beam Energy Scan (BES) program at the RHIC facility was initiated in the year 2010 to study the Quantum Chromodynamics (QCD) phase diagram. In the years 2010, 2012 and 2014 the STAR experiment recorded Au + Au collisions at $\sqrt{s_{NN}}$ = 7.7, 11.5, 14.5, 19.6, 27, 39, and 62.4 GeV within a pseudo-rapidity range of $|\eta|< 1$. Recently reported results from identified particle elliptic flow in minimum bias (0–80%) collisions revealed an energy dependent difference in elliptic flow between particles and antiparticles. This difference is increasing with decreasing collision energy and is almost identical for all baryons. In this poster we present the elliptic flow of identified particles for three centrality classes in Au + Au collisions at $\sqrt{s_{NN}}$ = 7.7 - 62.4 GeV. The centrality dependence and the data at $\sqrt{s_{NN}}$ = 14.5 GeV are new. Except at the lowest beam energies, we observe a similar relative v_2 baryon-meson splitting for all centralities. The larger v_2 for most particles relative to antiparticles, already observed for minimum bias collisions shows a centrality dependence, with the largest difference for the most central collisions.

Azimuthal anisotropy v_2

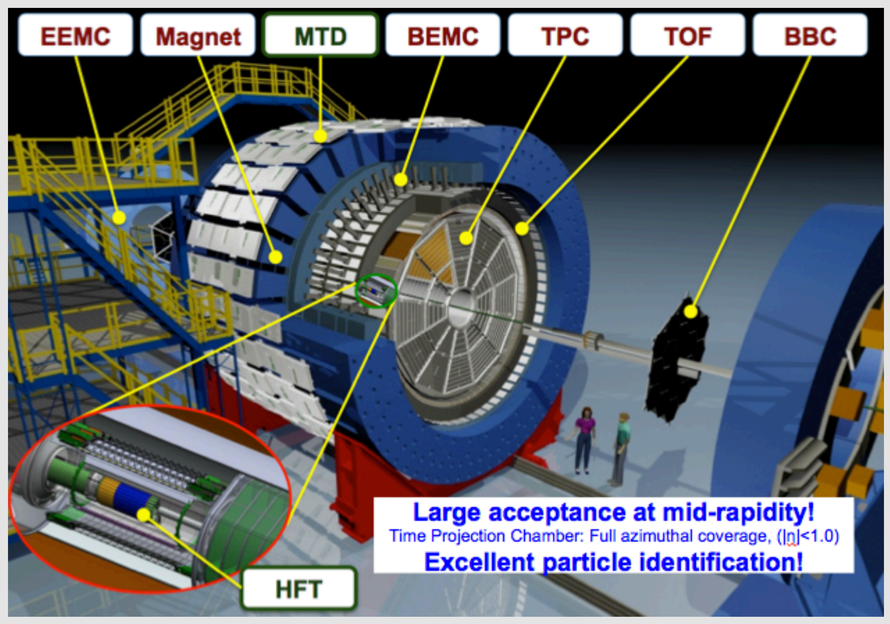


$$E\frac{d^3N}{d^3p} = \frac{1}{2\pi}\frac{d^2N}{p_t dp_t dy}\left(1+\sum_{n=1}^{\infty} 2v_n \cos\left(n(\phi-\Psi_r)\right)\right) \quad \Rightarrow \quad v_2 = \left\langle \cos(2[\phi-\Psi_r]) \right\rangle$$

Transverse Momentum Anisotropy

- Initial azimuthal anisotropy in coordinate space exists in non-central nucleus nucleus collisions.
- Density gradients and interactions between particles lead to conversion from spatial anisotropy to momentum-space anisotropy.
- The second harmonic parameter - elliptic flow parameter v_2 is especially sensitive to the early stage.

Experimental setup



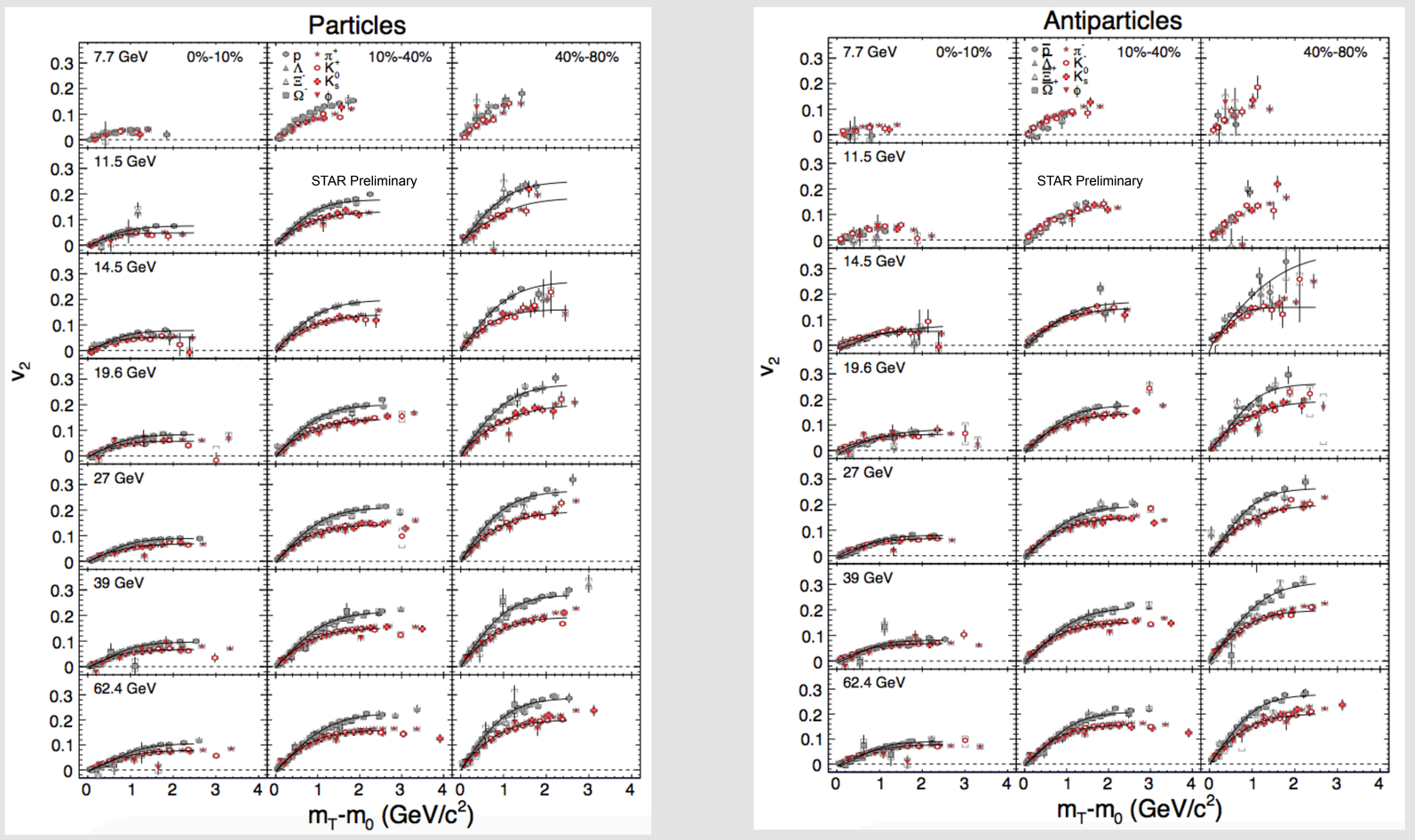
Particle Identification: TPC dE/dx, pion/kaon: p < 0.6 GeV/c; proton p < 1.0 GeV/c
TPC + TOF system
pion/kaon: p < 3.0 GeV/c; proton p < 3.4 GeV/c
Strange hadrons (K_S^0, Λ, ϕ, Ξ, Ω) reconstructed by the decay channels

v_2 methods

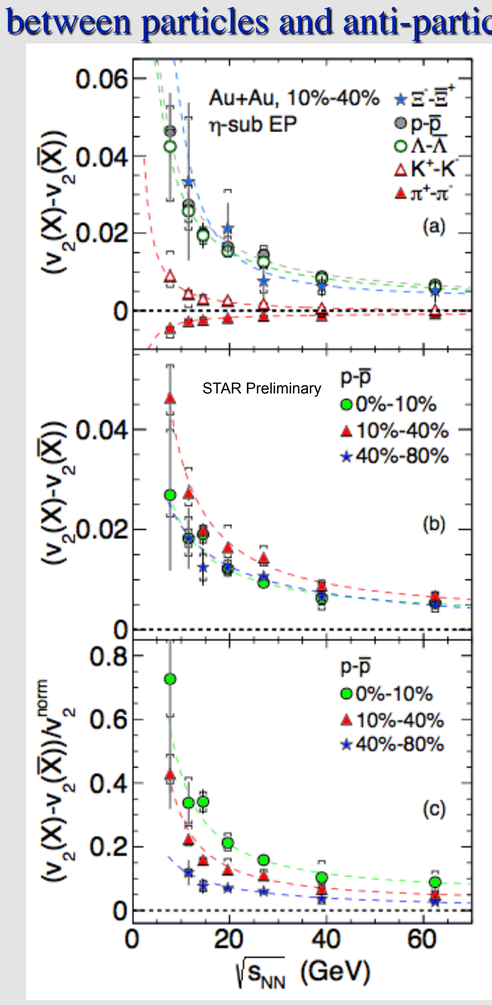
v_2{EtaSub}: each particle from negative (positive) pseudo-rapidity with the EP of positive (negative) pseudo-rapidity

Results

v_2 vs. m_T-m_0



v_2 between particles and anti-particles



Particles: A splitting between baryons and mesons is observed at all energies and centralities except for 7.7 GeV central collisions where there are not enough events to allow drawing a conclusion.
Anti-particles: The splitting between baryons and mesons is significant for all energies of 14.5 GeV and above. There is no observed splitting for all centralities at 11.5 GeV and below. For these energies we are limited by the number of events.

- The data at 14.5 GeV fit the energy dependency curve.
- The relative difference normalized by v_{norm} (the proton elliptic flow at p_T= 1.5 GeV/c) shows a centrality dependence with a bigger effect for the more central collisions.

Summary

- We present the measurement of identified hadron v_2 for Au + Au collisions for seven beam energies ($\sqrt{s_{NN}}$ = 7.7, 11.5, 14.5, 19.6, 27, 39, and 62.4 GeV), and three centralities (0%–10%, 10%–40%, and 40%–80%).
- The Baryon-Meson splitting for particle and antiparticle group at intermediate transverse momenta is observed center-of-mass energy at 14.5 GeV and above. For those energies below 14.5 GeV, we are limited by the number of events
- The v_2 of baryons is larger than that for antibaryons for all beam energies, and the relative increase for protons compared to antiprotons is larger for central collisions.

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The STAR Collaboration: http://drupal.star.bnl.gov/STAR/presentations

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