Precision measurements of centrality dependence of elliptic flow for identified hadrons in Au + Au collisions at $\sqrt{s_{NN}} = 200$ GeV

Hiroshi Masui for the STAR collaboration
Lawrence Berkeley National Laboratory

**Abstract**

Elliptic flow $v_2$ is one of the key observables to study the bulk properties at freeze-out as well as hadron production mechanisms in the ultra relativistic heavy ion collisions. It has been observed that Number of Constituent Quark (NCQ) scaling of $v_2$ holds among measured identified hadrons at $s_{NN} = 62.4$ and 200 GeV in Au + Au collisions at RHIC. The scaling of $v_2$ strongly indicates that the collectivity develops at the stage where the partonic degrees of freedom are relevant. Studying the NCQ scaling of $v_2$ as a function of transverse momentum $p_T$ and centrality will shed light on the production mechanisms for hadrons in heavy ion collisions.

We present the measurements of $v_2$ as a function of $p_T$ for identified $\pi^\pm$, $K^\pm$, $K_S^0$, $p$, $\bar{p}$, $\Lambda$ and $\bar{\Lambda}$ in Au + Au collisions at $s_{NN} = 200$ GeV from high statistics year 2010 data. The NCQ scaling of $v_2$ in several different centrality classes is discussed.

**Data sets**

- Au+Au at $s_{NN} = 200$ GeV
- ~234 M events in 0-80% centrality

**Event selection**

- $|v_2| < 30$ cm
- $\sqrt{v_2^2 + v_3^2} < 2$ cm
- $|VPD\ v_2 - v_2| < 3$ cm

**Centrality determination**

- Centrality from uncorrected charged particle multiplicity distribution in $|\eta| < 0.5$ measured in the TPC
- Applied corrections as a function of time, $\times$-vertex, luminosity
- Trigger inefficiency at peripheral collisions is taken into account by Glauber Monte Carlo simulation with multiplicity fluctuation by negative binomial distribution

**Particle identification**

- $\pi$, $K$, $p$
- Momentum dependent mass square $m^2 + dE/dx$ cut in $p_T < 1$ GeV/c
- 2 dimensional signal extraction from $n_0$ and $m^2$ (top left figure) in $p_T > 1$ GeV/c
- Relative rise of $dE/dx$ in $p_T > 2.8$ GeV/c (pions)

**K$_S^0$, $\Lambda$**

- Topological reconstruction
- Rotational background method to evaluate combinatorial backgrounds

**Number of Constituent Quark Scaling**

- $v_2$, $K^\pm$, $K_S^0$, $p$, $\bar{p}$, $\Lambda$ and $\bar{\Lambda}$ in Au + Au collisions at $s_{NN} = 200$ GeV up to $p_T = 8$ GeV/c

**Event plane method**

- $TPC\ \eta$-sub event plane
  - reconstructed in negative ($-1 < \eta < -0.05$) and positive ($0.05 < \eta < 1$) pseudorapidity $\eta$ hemispheres
  - Additional 0.05 $\eta$ gap between particles and event plane to reduce short range $\Delta\eta$ correlation
  - reconstructed for $p_T < 2$ GeV/c

**Event plane resolution**

- calculated by three independent event planes
- Systematic uncertainties from the resolution by two subevents
- Correction is done event-by-event by using the average resolution in 5% increment of centrality.

**Results**

- Measure $v_2(p_T)$ up to $p_T = 8$ GeV/c
- Mass ordering below $p_T = 2$ GeV/c, i.e. heavier hadrons have smaller $v_2$
- Meson/baryon splitting in $m_{\pi_0}$ above ~0.5 GeV/c

**Uncertainties**

- Vertical error bars show statistical error only
- Global systematic uncertainty from event plane resolution (plotted only for $\pi$)
- Systematic uncertainties on $K_S^0$ and $\Lambda$ due to self-correlation subtraction

**Summary**

- Precision measurements of $v_2(p_T)$ for identified $\pi^\pm$, $K^\pm$, $K_S^0$, $p$, $\bar{p}$, $\Lambda$ and $\bar{\Lambda}$ in Au + Au collisions at $s_{NN} = 200$ GeV up to $p_T = 8$ GeV/c
- Overall in most centrality bins, the previously observed NCQ scaling of $v_2$ holds for all hadrons within 10%, in $p_T/n_0 > 1$ GeV/c, $(m_{\pi_0})/n_0 > 0.5$ GeV/c
- In the 10-40% centrality bin, one observes a sizable difference in $v_2$ between $\pi$ and $\Lambda$. The sources of the discrepancies is currently under study.