High Statistics Elliptic Flow Measurements of Ξ and Ω at RHIC

M. Oldenburg, K. Schweda
Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720

Quantum Chromo-Dynamics (QCD) is the theory of strong interactions. Lattice calculations of QCD predict that at a critical temperature of $T_c \simeq 170$ MeV, corresponding to an energy density of $\varepsilon_c \simeq 1\,\mathrm{GeV/fm^3}$, a phase transition of ordinary nuclear matter to a deconfined state of quarks and gluons occurs. In ultra-relativistic nuclear collisions, energy densities are expected to reach and even exceed the critical energy density ε_c. In general, the development of collectivity at the partonic level (among quarks and gluons) and the degree of thermalization are closely related to the equation of state (EOS) of partonic matter. Due to their large mass and small hadronic cross sections, multi-strange baryons are less affected by the late hadronic stage [1]. Therefore, they serve as an ideal tool for studying early, possibly partonic, dynamics.

Ellitic flow (characterized by the second order Fourier coefficient v_2 of the azimuthal momentum distribution) itself probes the early stages of the collision dynamics [2]. It is generated from the initial spacial anisotropy of the collision zone in non-central heavy-ion collisions. Rescattering among the constituents of the hot and dense system converts this spacial anisotropy into an anisotropy in momentum space, which can be observed in the final state.

We utilized the high statistics data from Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV from RHIC's fourth year of data taking recorded by the STAR experiment. About 11 million events were used for this study, which increased the statistics by more than a factor of 5 compared to two years earlier.

By combining Λ candidates with $\pi^{\pm}$ ($K^{\pm}$) we obtained the 'signal plus background' (S+B) for Ξ^- and $\overline{\Xi}^+$ (Ω^- and $\overline{\Omega}^+$). The 'background' (B) was estimated by rotating the Λs by 180°, which breaks the correlation between them and the mesons. For both distributions – 'signal plus background' and 'backround' alone – the $\langle\cos(2(\phi-\Psi_R))\rangle$ was determined for each bin in invariant mass m_{inv}. Since v_2 is additive, one can write the total v_2 as a sum of these two contributions, weighted by the relative yields:

$$v_2^{\mathrm{Tot}}(m_{\mathrm{inv}}) = v_2^{\mathrm{S}} \cdot \frac{\mathrm{S}}{\mathrm{S+B}}(m_{\mathrm{inv}}) + v_2^{\mathrm{B}}(m_{\mathrm{inv}}) \cdot \frac{\mathrm{B}}{\mathrm{S+B}}(m_{\mathrm{inv}}).$$

v_2^{B} was assumed to be a quadratic function of m_{inv}. The results obtained with this new technique are in good agreement with the ones from the method used previously [3], but the number of free fit parameters could be reduced significantly and we made use of the full range in m_{inv} of the signal and background distributions of v_2.

Figure 1 (top panel) shows the minimum bias (centrality 0–80 %) results for Ξ and Ω $v_2(p_t)$, together with fits to the v_2 of Λ and K^0_S from [4]. The Ξ and Ω show significant flow, which confirms the previous measurements. Both particle species flow similar to the other baryons, which is espacially visible at $p_t > 2$ GeV/c. From this it seems that even the Ω v_2 obeys number-of-constituent-quark scaling. At lower transverse momentum mass-scaling for the Ξ compared to the other hadrons is observed. The lower panel of Fig. 1 shows the elliptic flow parameter $v_2(p_t)$ of the Ξ for three different centrality bins. The improved statistics will allow for much more detailed studies and model comparisons than before.

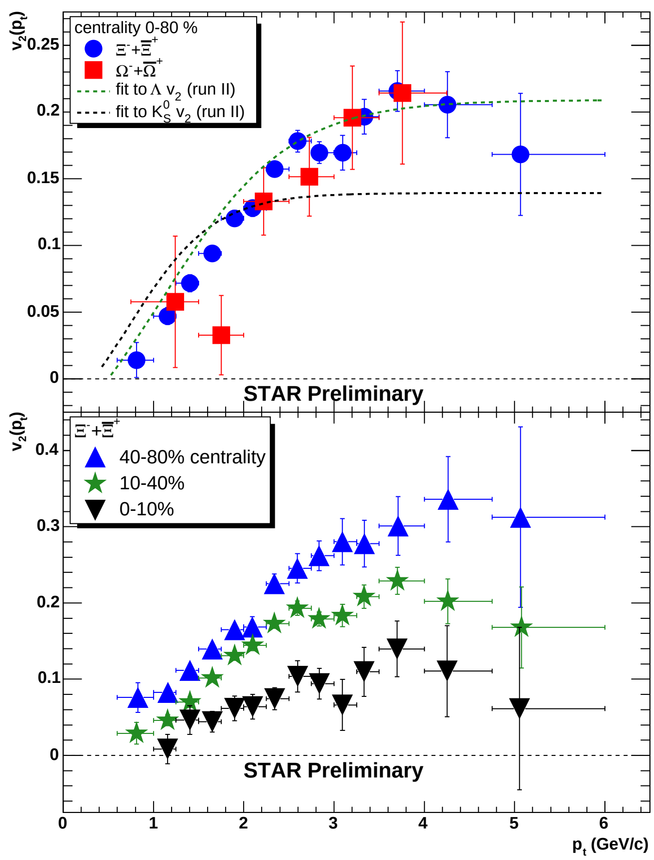

FIG. 1: Measurement of the elliptic event anisotropy parameter v_2 for multi-strange baryons. The top panel shows the minimum bias $v_2(p_t)$ for Ξ and Ω. The bottom graph shows Ξ $v_2(p_t)$ for three different centrality classes.

In summary our elliptic flow measurements demonstrate that partonic collectivity – collective flow of partons – has been developed in 200 GeV Au+Au collisions at the Relativistic Hadron Collider (RHIC). The next, maybe final step for a QGP discovery, is to address the degree of thermalization of light quarks.

[1] J. Adams et al. (STAR), Phys. Rev. Lett. **92**, 182301 (2004).
[2] J.-Y. Ollitrault, Phys. Rev. **D46**, 229 (1992).
[3] J. Adams et al. (STAR) (2005), nucl-ex/0504022.
[4] J. Adams et al. (STAR), Phys. Rev. Lett. **92**, 052302 (2004).