# $\phi$-meson Elliptic Flow in Au+Au Collisions at RHIC

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The goal of high-energy nuclear collisions at RHIC is to create a phase of matter called the Quark Gluon Plasma (QGP). An observable which is developed at an early stage in the system evolution and which may provide information on the QGP phase, is the elliptic flow $v_2$ of particles. In non-central Au+Au collisions, the anisotropy of particles in coordinate space is transformed into an anisotropy in momentum space as a result of interactions between the particles leading to pressure gradients. As the system expands over time, the $v_2$ signal self-quenches and therefore preserves information from the early stage.

Identified hadron $v_2$ for strange and non-strange particles at RHIC has been measured to be $> 10\%$ for $p_T > 2\text{GeV}/c$ indicating a large amount of elliptic flow for particles mainly consisting of the light $u$ and $d$ quarks [1]. However, in order to probe the partonic collectivity of the medium, it is important to measure the flow of heavier, multi-strange particles.

The $\phi$-meson ($s\bar{s}$) is expected to be a clean probe of the hot dense matter created in nucleus-nucleus collisions. Since it has a relatively long lifetime ($\sim$41 fm/$c$) compared to the lifetime of the fireball, it most likely decays outside the fireball. Additionally, since it has a presumably small interaction cross-section with non-strange hadrons [2], its $v_2$ signal created in the partonic stage should remain largely unaffected in the hadronic stage.

## METHOD AND RESULTS

Data were collected using the STAR detector at RHIC for Au+Au collisions at $\sqrt{s_{NN}}$= 200 GeV and $\sqrt{s_{NN}}$= 62.4 GeV. $\phi$-mesons were reconstructed on a statistical basis via the $\phi \rightarrow K^+ + K^-$ channel. Charged Kaons were identified in the STAR time projection chamber (TPC) from their $dE/dx$ energy loss in the TPC gas. The event mixing method was employed to estimate the background from uncorrelated $K^+K^-$ pairs.

A new method of extracting $v_2$ was used in this analysis based on [3]. For all signal $K^+K^-$ pairs, $v_2$ was plotted as a function of invariant mass $m_{inv}$. Following [3] it is possible to describe this distribution by:

$$v_{2T}(m_{inv}) = v_{2S} \cdot \frac{S}{S+B}(m_{inv}) + v_{2B}(m_{inv}) \cdot \frac{B}{S+B}(m_{inv}) \quad (1)$$

where $v_{2T}$ is the total $v_2$, and $v_{2S}$ ($v_{2B}$) is the the signal (background) $v_2$. $S/(S+B)$ denotes the ratio of the signal over the signal plus background distributions and $B/(S+B)$ is the ratio of the background over the signal plus background distributions. The ratios are functions of $m_{inv}$ and were extracted from fits to the $m_{inv}$ distribution in various transverse momentum $p_T$ bins. For each $p_T$ bin, the $v_2$ vs. $m_{inv}$ distributions were fitted using Eq. (1) and the extracted ratios where $v_{2S}$ was a fit parameter and $v_{2B}$ was parameterized using a quadratic (linear) function in $m_{inv}$ for the 62.4 GeV (200 GeV) data. The $\phi$-meson $v_2$ results are plotted compared to $v_2$ of $\Lambda$ and $K^0_S$ in Fig. 1. The top (bottom) panel shows the results for minimum bias Au+Au collisions at $\sqrt{s_{NN}}$= 62.4 GeV (200 GeV).

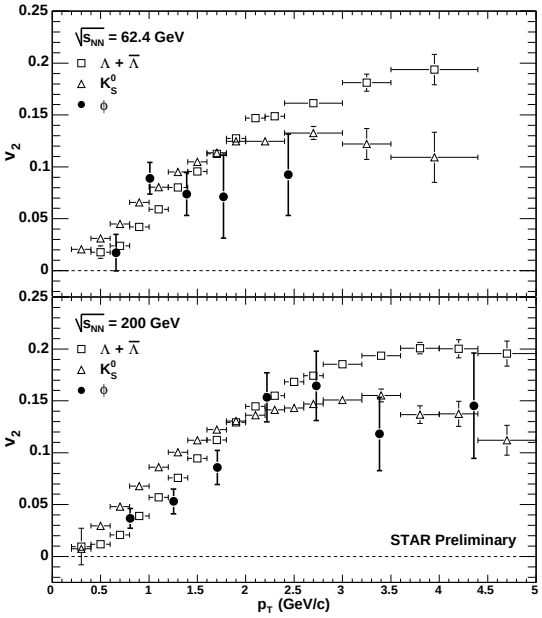


FIG. 1: $v_2$ vs. $p_T$ for $\sqrt{s_{NN}} = 62.4$ GeV (top) and $\sqrt{s_{NN}} = 200$ GeV (bottom) for the $\phi$-meson (solid circles) compared to $\Lambda$+$\overline{\Lambda}$ (squares) and $K^0_S$ (triangles). All errors shown are statistical only.

## DISCUSSION AND SUMMARY

For both collision energies, the $\phi$-meson has a non-zero elliptic flow and follows the same increasing $v_2$ trend as a function of $p_T$ as $\Lambda$ and $K^0_S$. Therefore it flows similarly to particles consisting mainly of lighter quarks. Future measurements will help to discriminate whether it flows like a meson or a baryon.

In summary, we have presented $v_2$ results for the $\phi$-meson in Au+Au collisions at two collision energies. In both cases, the $\phi$-meson has a large flow consistent with that of other identified particles. This may be a direct indication of partonic collectivity in the dense system produced in Au+Au collisions at RHIC.

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[2] A. Shor, Phys. Rev. Lett. **54**, 11 (1985).
[3] N. Borghini and J.-Y. Ollitrault, *nucl-th/0407041*.