Motivation

Recent measurements at both RHIC and the LHC continue to indicate that particles produced in small collision systems exhibit collective behavior similar to those observed in large collision systems. The PHENIX experiment has measured substantial modification of leptons from heavy flavor decays in d+Au collisions at \( \sqrt{s_{NN}} = 200 \text{ GeV} \) [1], as shown in Fig. 1. These measurements indicate that the \( \mu \) is strongly coupled to the initial collision geometry and are in good agreement with hydrodynamic calculations which include a QGP phase.

PHENIX has also measured strong rapidity and \( p_T \) dependent modification of leptons from heavy flavor decays in d+Au collisions at \( \sqrt{s_{NN}} = 200 \text{ GeV} \) [2, 3]. In order to further investigate the origin of these modifications, as well as the potential for QGP formation even in small collision systems, we present measurements of the \( \mu_2(p_T) \) of muons from open heavy flavor decays at forward (d-going) and backward (Au-going) rapidities in d+Au collisions.

Heavy flavor muon extraction

![Figure 2: The invariant yield of inclusive muons and various components at backward (Left) and forward (Right) pseudorapidities in 0-20% central d+Au collisions at \( \sqrt{s_{NN}} = 200 \text{ GeV} \) [3].](image)

Inclusive muons are measured in the two PHENIX muon arms covering \(-2.2 < \eta < -1.2 \) and \( 1.2 < \eta < 2.2 \) respectively. They are identified by tracks which penetrate to the last gap of the muon identifier (MuID), through 19 cm of copper and 60 cm of iron absorbers. The inclusive track sample is dominated by four main sources: 1) muons from decays of light-flavor mesons, 2) hadrons which reach the final MuID gap, referred to as “punch-through hadrons”, 3) muons from heavy flavor resonance (J/\( \psi \) and \( \Upsilon \)) decays, and 4) muons from open heavy flavor decays. We group the contributions from 1) and 2) and show the various contributions to the inclusive track sample in Fig. 2. The fraction of muons from heavy flavor decays is \( > 20% \) for \( 1 < p_T \) (GeV/c) < 3.

Heavy flavor muon \( \mu_2 \)

![Figure 4: The \( \mu_2 \) of charged hadrons and muons from open heavy flavor decays as a function of \( p_T \) at backward (Left) and forward (Right) pseudorapidities in 0-20% central d+Au collisions at \( \sqrt{s_{NN}} = 200 \text{ GeV} \).](image)

The \( \mu_2 \) of heavy flavor muons is calculated using the inclusive muon track sample (\( \mu^{\text{incl}} \)), the fraction of heavy flavor muons (\( \mu^{\text{HF}} \)) shown in Fig. 2, and the \( \mu_2 \) of charged hadrons (\( \mu_2^{\text{HF}} \)) as

\[
\mu_2^{\text{HF}} = \frac{1}{\mu^{\text{HF}}} (\mu_2^{\text{incl}} - \mu_2^{\text{HF}}). \tag{1}
\]

The resulting \( \mu_2^{\text{HF}} \) is shown in Fig. 4 compared to the \( \mu_2^{\text{incl}} \).

We observe a heavy flavor muon \( \mu_2 \) which is non-zero and consistent with the \( \mu_2 \) of charged hadrons. While the charged hadrons show a larger \( \mu_2 \) at backward rapidity compared to forward rapidity, it is unclear if the heavy flavor \( \mu_2 \) shows the same trend given the large statistical uncertainties. While the uncertainties on the measurement are large, we calculate a confidence level for \( \mu_2^{\text{HF}} \) > 0 integrated from 1.0 < \( p_T \) (GeV/c) < 3.0 of

\[
-0.3 \leq \eta < 1.4: 49.98\%, \tag{2}
\]

\[
-1.4 \leq \eta < 2.0: 99.93\%. \tag{3}
\]

References

1. Adare A. et al. (PHENIX Collaboration), Heavy Flavor Muon Production in Forward and Backward Rapidity in d+Au and p+Pb Collisions at \( \sqrt{s_{NN}} = 200 \text{ GeV} \). (PRL 109, 232301)
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