Charm and beauty isolation in heavy flavor electron measurements in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV at RHIC

Fan Si
University of Science and Technology of China
State Key Laboratory of Particle Detection and Electronics

Abstract

We develop a data-driven method to isolate charm and beauty contributions from the inclusive heavy flavor electrons (HFE) based on the most recent open charm hadron measurements in minimum bias Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV at RHIC. The individual electron nuclear modification factor ($R_{AA}$) and elliptic flow ($v_2$) from charm and beauty decays are reported. Model comparisons and discussions are also given.

Motivation

Heavy quarks (charm and beauty):
- Produced early and experience entire evolution of QGP ($t_{c,b} < t_{QGP}$).
- Production cross sections can be evaluated by pQCD ($m_{c,b} \gg \Lambda_{QCD}$).
- Predicted mass dependent energy loss: $\Delta E_R > \Delta E_{b,d} > \Delta E_{c} > \Delta E_{\pi}$. Heavy quark evolution

Data-driven method

Charmed hadron measurements
- Parameterized with functions/models
- Semileptonic decay simulations
- Normalized with measured cross sections and B.R.
- Charm decay electron spectra
- Extract beauty contribution $f_{b\rightarrow e}$

$R_{AA}$ and $v_2$

Charmed hadron inputs

- $D^0$, $D_s$, and $J/\psi$: parameterized and extrapolated by Levy and power-law functions.
- $D^0$: scaling $D^0$ spectrum by $D^0/D^0$ ratio.
- $\Lambda_c$: average of 4 model calculations.

Data and parameterization are from [1].

<table>
<thead>
<tr>
<th>Charmed hadron</th>
<th>Mass (MeV/$c^2$)</th>
<th>Branching ratio ($\rightarrow eX$) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D^0$</td>
<td>1864.2±0.05</td>
<td>6.49±0.11</td>
</tr>
<tr>
<td>$D_s$</td>
<td>1869.6±0.05</td>
<td>16.07±0.30</td>
</tr>
<tr>
<td>$\Lambda_c$</td>
<td>2199.34±0.07</td>
<td>6.5±0.14</td>
</tr>
<tr>
<td>$J/\psi$</td>
<td>3096.90±0.006</td>
<td>5.99±1.3</td>
</tr>
</tbody>
</table>

Output decay electron spectra

$b \rightarrow e = HFE - c \rightarrow e$, where HFE from [2].

$v_2$ isolation

- $D^0$, $v_2$ measurement [6]
- Parameterized & NCO scaling: $D$-meson and $\Lambda_c$, $v_2$

$v_2^{b\rightarrow e} = \frac{\langle 1 - f_{b\rightarrow e}^{\text{HFE}} \rangle}{\langle 1 - f_{b\rightarrow e}^{\text{pp}} \rangle} v_2^{\text{HFE}}$ (3)

Non-zero $v_2^{b\rightarrow e}$ is observed at $p_T > 3$ GeV/$c$ at the first time.

References

[1] F. Si et al., arxiv: 1906.08974