Extracting bottom quark contributions to non-photonic electron yields and the bottom quark energy loss in the dense matter in STAR

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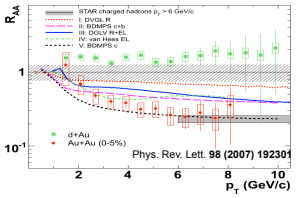
Abstract

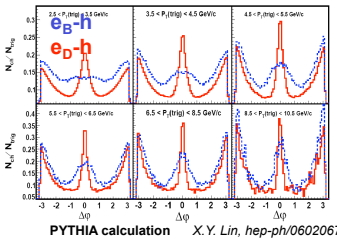
At STAR-RHIC, B decay contribution has been studied by measuring azimuthal angular correlations between non-photonic electrons and charged hadrons. Our measurement indicates that B decay contribution is about 50% of the non-photonic electron yields for p_T greater than 5 GeV/c. Combined with the previously reported large suppression of non-photonic electrons allows us to constrain the nuclear modification factor for semi-leptonic electron decay from B (R_{AA}^{eB}) and D mesons (R_{AA}^{eD}) . We also present correlations between R_{AA}^{eB} and R_{AA}^{eD}.

Motivation

- Energy loss for heavy flavor in the dense matter was thought to be small. But electron yield from charm and bottom ("non-photonic" electron) is strongly suppressed as with light hadrons.



- Currently we don't know the contribution from bottom to non-photonic electron. If bottom contribution is significant, energy loss for bottom is larger than expected.

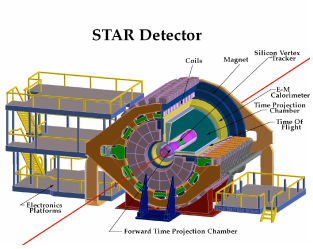


PYTHIA calculation X.Y. Lin, hep-ph/0602067

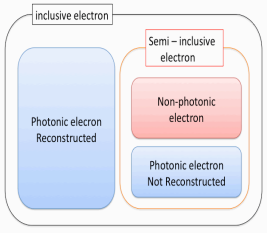
- e-h correlation is one method for B/D separation
  - ✓ correlation between hadron and electron from B meson makes wider near side peak than that of D meson

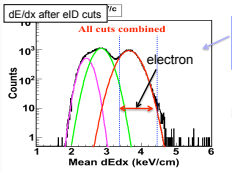
Analysis

- STAR experiment
  - Large acceptance
    Full azimuthal coverage
    => good for azimuthal correlation study
  - TPC
    measure momentum & dE/dx
  - EMC + SMD
    measure energy & shower shape
    => electron identification

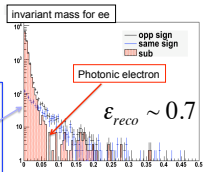


- Dataset ; RHIC year 5 and 6
  pp 200 GeV





Electron purity
98% for p_T < 6 GeV/c
80% for 9 GeV/c @ pp



Photonic electrons are experimentally reconstructed by calculating invariant mass at DCA for two electrons

$$N_{e^\gamma}^{reco} = N^{opp} - N^{same}$$

$$N_{e^\gamma} = N_{e^\gamma}^{reco} / \varepsilon_{reco}$$

- electron sample after removing opposite sign electron (inv. mass<0.1) forms "semi" inclusive electron.
- Non-photonic electron can be calculated as;

$$\Rightarrow N_e^{non-\gamma} = N_e^{semi} - (1/\varepsilon_{reco} - 1) N_e^{reco-\gamma} + N_e^{same}$$

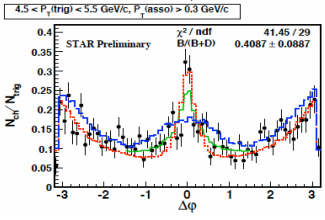
$$\Delta\phi_{e^{HF}-h} = \Delta\phi_{e^{semi}-h} - (1/\varepsilon_{reco} - 1)\Delta\phi_{e^\gamma - h} + \Delta\phi_{e^{same}-h}$$

- Experimental result is fit by simulation results

$$\Delta\phi_{e-h}^{exp} = r_B \Delta\phi_{e^B-h} + (1-R_B)\Delta\phi_{e^D-h}$$

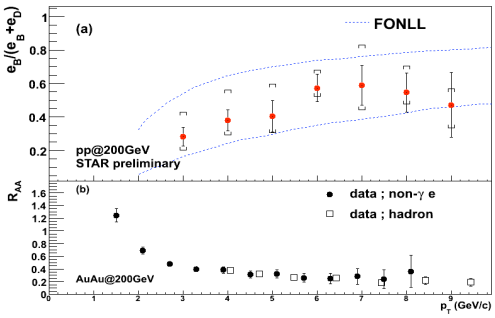
$$r_B = e_B/(e_D + e_B)$$

Azimuthal correlation between $e^{non-\gamma}$ and hadron



- We measured the correlations with several momentum ranges and obtained r_B values

B contribution & R_{AA} for heavy flavor decays



- B decay contribution to the non-photonic electrons measured by e-h correlations.
- B decay contribution is ~50% at and above 5 GeV/c. R_{AA} for non-photonic electron consistent with charged hadrons

- R_{AA} for charm decay (R_{AA}^{eD}) and botom (R_{AA}^{eB}) are connected by B decay contribution @ pp

Fraction of c, b decay in pp

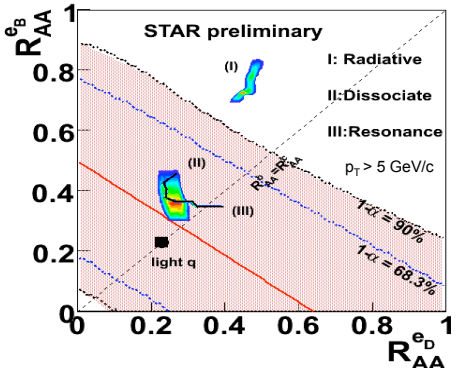
$$R_{AA}^{nony} = \frac{e_B^{AA} + e_D^{AA}}{N_{bin}(e_B^{pp} + e_D^{pp})}$$

$$= \frac{e_B^{AA}}{N_{bin} e_B^{pp}} \cdot \frac{e_B^{pp}}{(e_B^{pp} + e_D^{pp})} + \frac{e_D^{AA}}{N_{bin} e_D^{pp}} \cdot \frac{e_D^{pp}}{(e_B^{pp} + e_D^{pp})}$$

$$= R_{AA}^{eB} r_B + R_{AA}^{eD}(1 - r_B)$$

$$r_B = e_B^{pp}/(e_B^{pp} + e_D^{pp})$$

- With the measurements of r_B @ pp and R_{AA}, we can derive a relationship between R_{AA}^{eD} and R_{AA}^{eB}.



I; Radiative energy loss via a few hard scatterings with initial gluon denisty is 1000 *[Phys. Lett. B 632, 81 (2006)]*

II; collisional dissociation of D and B *[Phys. Lett. B 649, 139 (2007)]*

III; assuming large elastic scattering cross section associated with resonance states of D and B *[Phys.Rev.Lett.100(2008)192301]*

- R_{AA}^{eB} < 1 with 90% CL ; B meson suppressed
- Experimental result prefer the models which predict large bottom energy loss (Dissociate & Resonance).

=> indicates a large suppression of not only D meson but also B meson.

Summary

- B decay contribution increases with p_T and is comparable to the contribution from D meson decay at and above p_T 5 GeV/c.
- R_{AA} <1 for electron decay from B with 90 % C.L. This result indicates that B meson production is suppressed at high p_T.