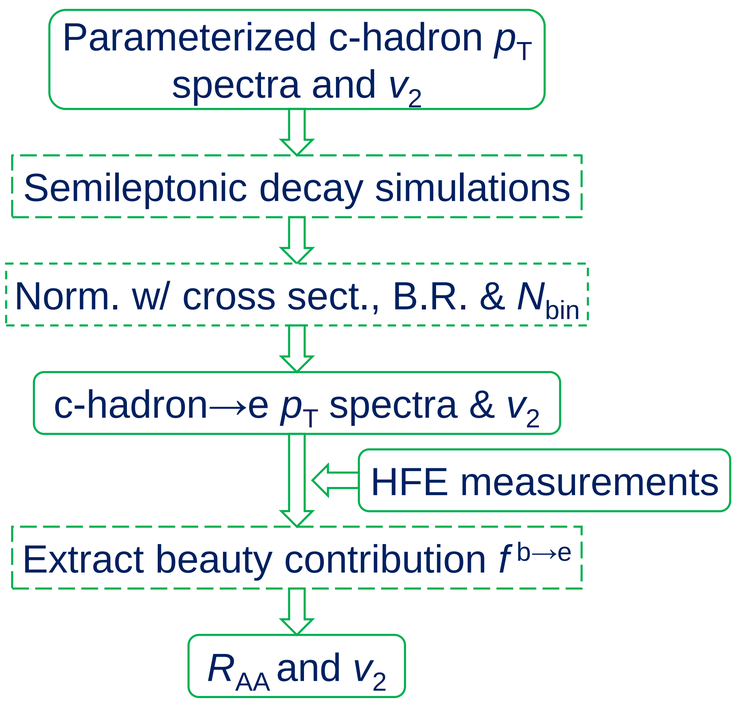
Data-driven isolation for charm and beauty decay electrons at RHIC and LHC

Fan Si
University of Science and Technology of China

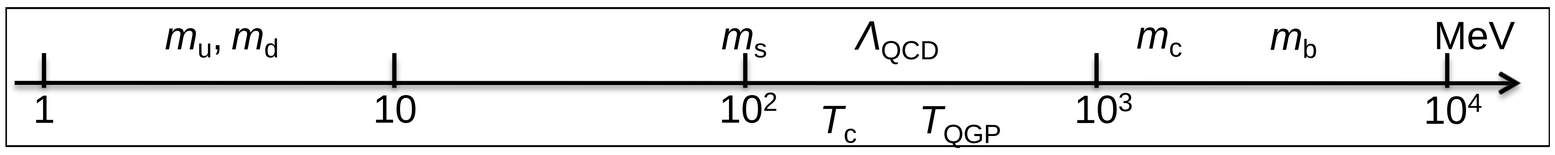
Abstract

We develop a data-driven method to isolate charm and beauty contributions from inclusive heavy flavor electrons (HFE) based on recent charmed hadron measurements at RHIC and LHC. The individual electron transverse momentum (p_T) spectra, nuclear modification factors (R_{AA}) and elliptic flows (v_2) from charm and beauty decays are reported. Comparisons of charm and beauty behaviors at RHIC and LHC energies are given.

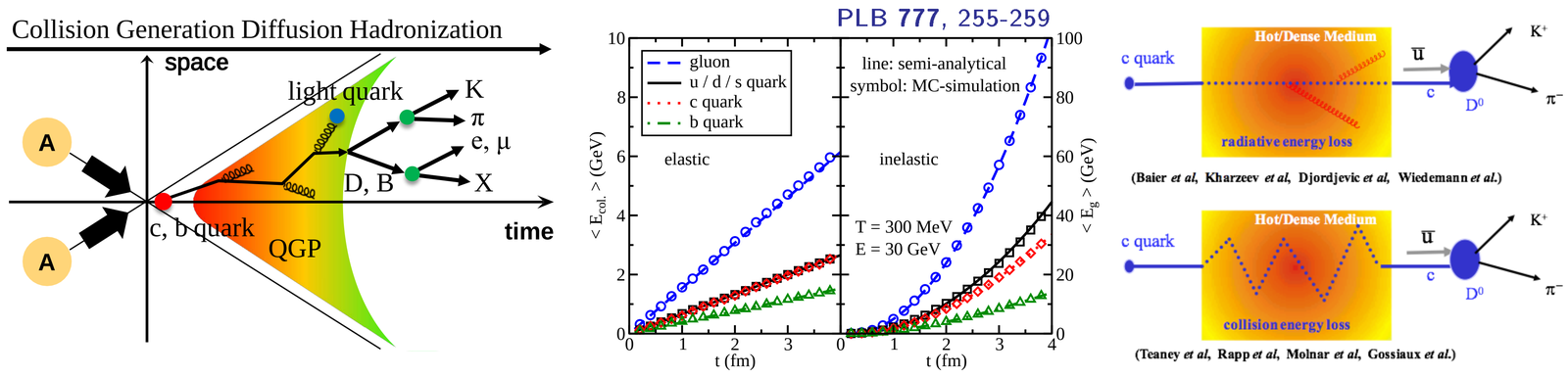
Data-driven method



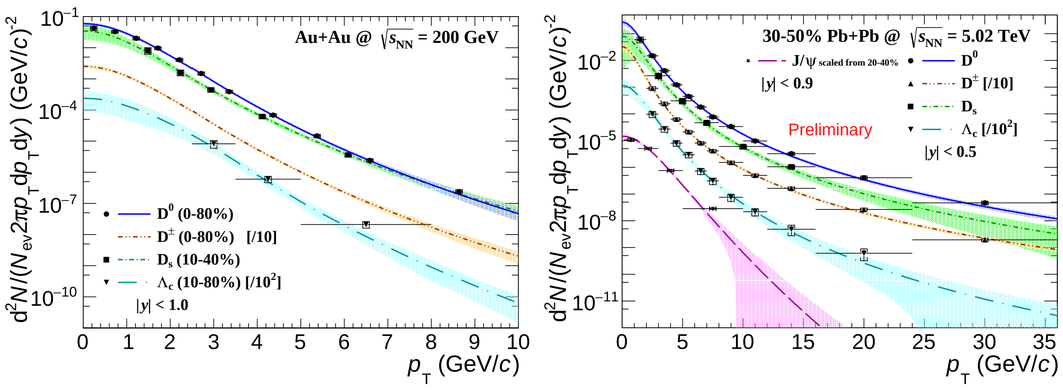
Heavy quarks: charm & beauty



- Produced early and experience full time evolution of QGP.
- Calculable by pQCD and numbers are conserved.
- Sensitive to properties of QGP: diffusion, η/s, transport, etc.
- Predicted mass-dependent energy loss: $\Delta E_g > \Delta E_{u,d,s} > \Delta E_c > \Delta E_b$.



Charmed hadron inputs



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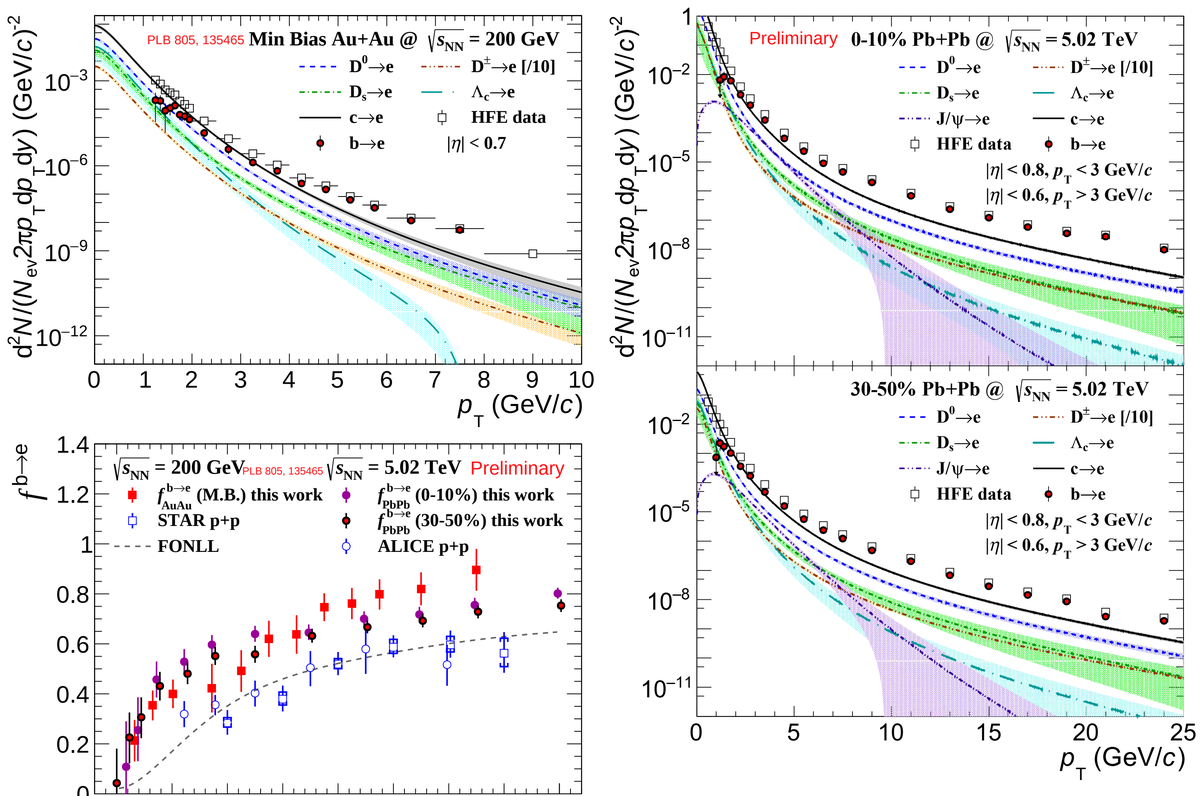
Charmed hadron	Mass (MeV/c^2)	B.R. ($\to$eX) (%)
$D^0(\bar{D}^0)$	1864.83	6.49
$D^\pm$	1869.65	16.07
$D_s^\pm$	1968.34	6.5
$\Lambda_c^\pm$	2286.46	3.95
J/ψ	3096.90	5.971

Output decay electron spectra

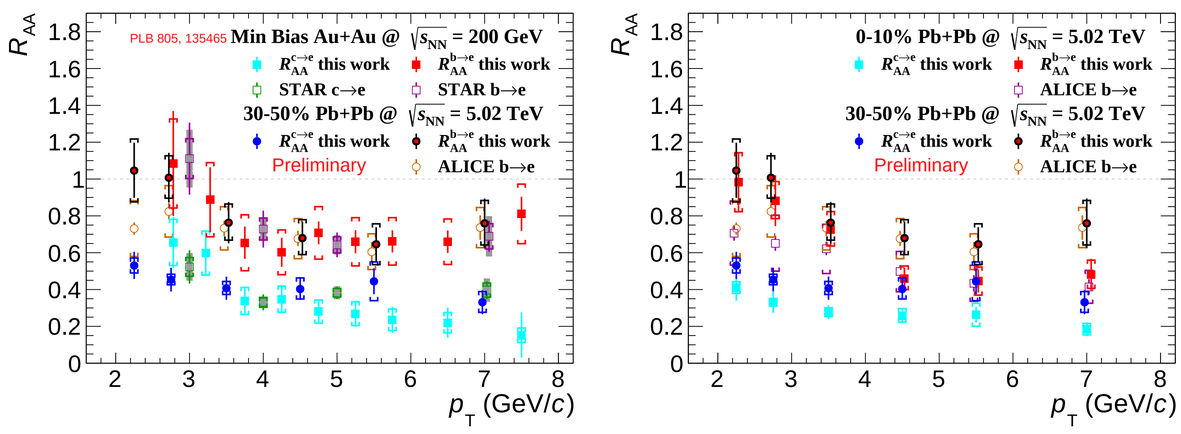


$$b \to e = HFE - c \to e$$

$$f^{b\to e} = b \to e/HFE$$

$$c \to e = D^0 \to e + D^\pm \to e + D_s \to e + \Lambda_c \to e \ (+J/\psi \to e \text{ @ LHC})$$

R_{AA} isolation

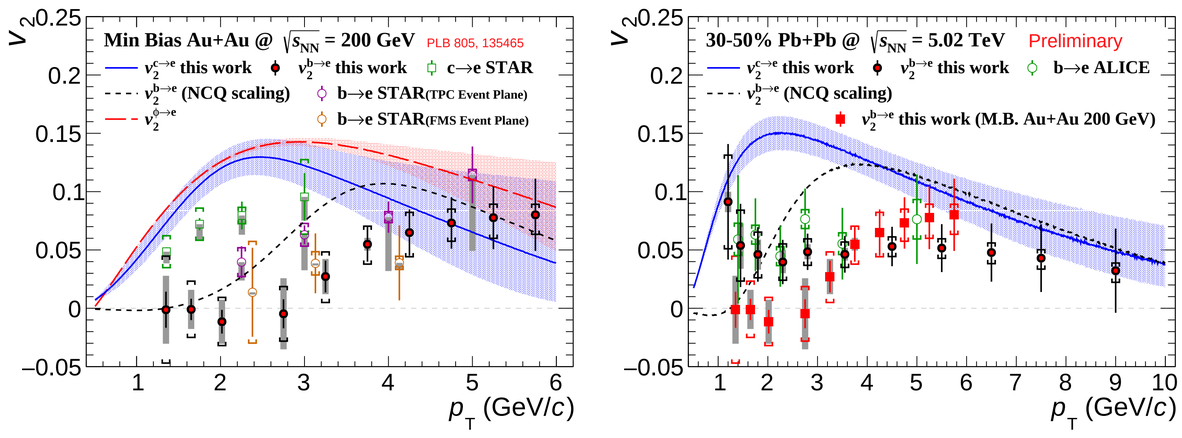


- Consistent with STAR [6] & ALICE [7].
- Centrality dependence of suppression.
- Similar beauty energy loss at RHIC and LHC energies.
- Stronger suppression of charm than beauty.

$$R_{AA}^{c\to e} = \frac{1 - f_{AA}^{b\to e}}{1 - f_{pp}^{b\to e}} R_{AA}^{HFE}$$

$$R_{AA}^{b\to e} = \frac{f_{AA}^{b\to e}}{f_{pp}^{b\to e}} R_{AA}^{HFE}$$

v_2 isolation



- Agree with STAR [6] & ALICE [10].
- Non-zero $v_2^{b\to e}$ observed at RHIC ($p_T > 3$ GeV/c) and LHC.

$$v_2^{b\to e} = \frac{v_2^{HFE} - \left(1 - f_{AA}^{b\to e}\right) v_2^{c\to e}}{f_{AA}^{b\to e}}$$

- Clear deviation of $v_2^{b\to e}$ from the curve assuming B-meson v_2 follows NCQ scaling at intermediate p_T.
- Beauty is unlikely thermalized at RHIC and incompletely thermalized at LHC.
- Larger deviation of $v_2^{b\to e}$ from NCQ scaling at LHC than at RHIC.

References

[1] This work at RHIC: F. Si *et al.*, PLB **805**, 135465 (2020).
[2] ALICE D-meson spectra: S. Acharya *et al.* (ALICE), JHEP **10**, 174 (2018).
[3] ALICE Λ_c/D^0 ratio: C. Terrevoli (ALICE), JPCS **1602**, 012031 (2020).
[4] ALICE J/ψ spectra: S. Acharya *et al.* (ALICE), PLB **805**, 135434 (2020).
[5] ALICE HFE spectra: S. Acharya *et al.* (ALICE), PLB **804**, 135377 (2020).
[6] STAR $f_{pp/AuAu}^{b\to e}$, $R_{AA}^{c/b\to e}$, $v_2^{c/b\to e}$: M. Kelsey (STAR), NPA **1005**, 121806 (2021).
[7] ALICE $f_{pp/AuAu}^{b\to e}$, $R_{AA}^{c/b\to e}$: D. Thomas's Talk @ Quark Matter 2019.
[8] ALICE D-meson v_2: S. Acharya *et al.* (ALICE), PRL **120**, 102301 (2018).
[9] ALICE v_2^{HFE}: D. Moreira De Godoy (ALICE), NPA **967**, 636-639 (2017).
[10] ALICE $v_2^{b\to e}$: S. Acharya *et al.* (ALICE), PRL **126**, 162001 (2021).