Open Heavy Flavor Production in STAR Experiment at RHIC

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Outline:

- ❑Physics Motivation
- ❑Indirect heavy flavor measurement
  - Non-photonic electron (NPE) spectra
  - Non-photonic electron-hadron correlations
- ❑Direct measurements: open charm mesons reconstruction
- ❑STAR future open heavy flavor program and summary

Motivation for Studying Heavy Quarks

- Quark-Gluon Plasma (QGP) can be studied in heavy-ion collisions.

  - Results from p+p and d+Au collisions are critical references.

- Heavy quarks are ideal probes to study QGP.

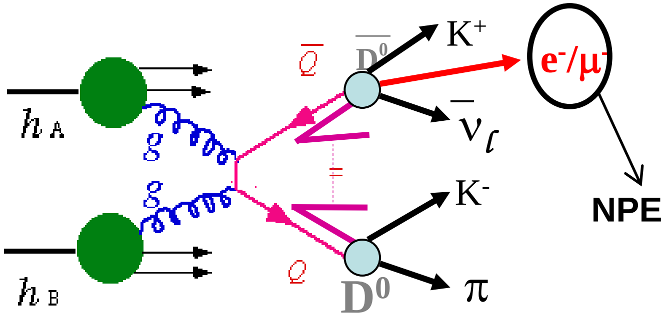
  - Produced early in collisions.

  - Interact with the medium differently from light quarks and hard to thermalize.

- Sensitive to initial gluon density and gluon distribution.

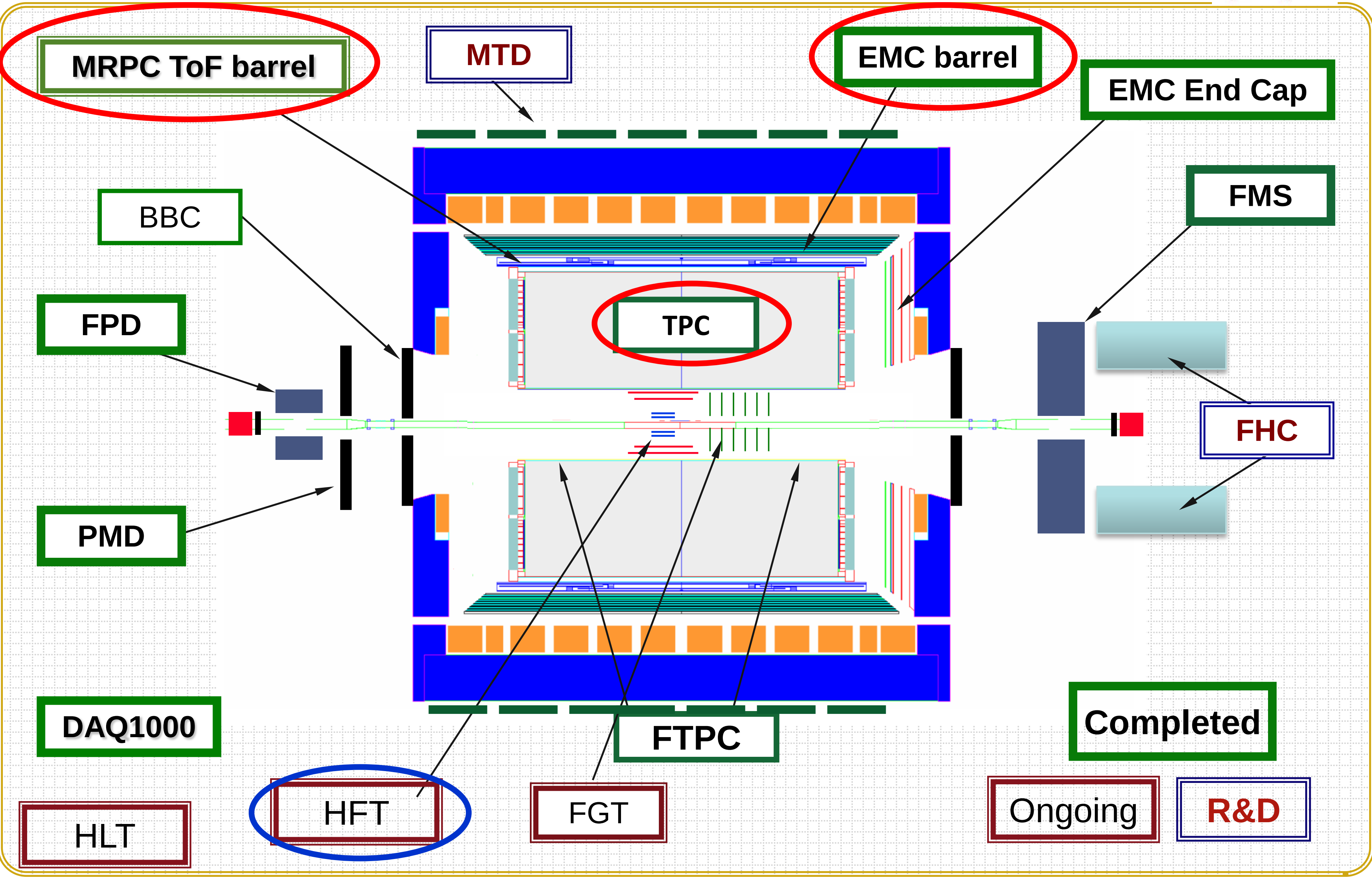
To study heavy quark production:

- Measuring non-photonic electrons from heavy quark semi-leptonic decay
- Direct reconstruction of open heavy flavor mesons via their hadronic decays



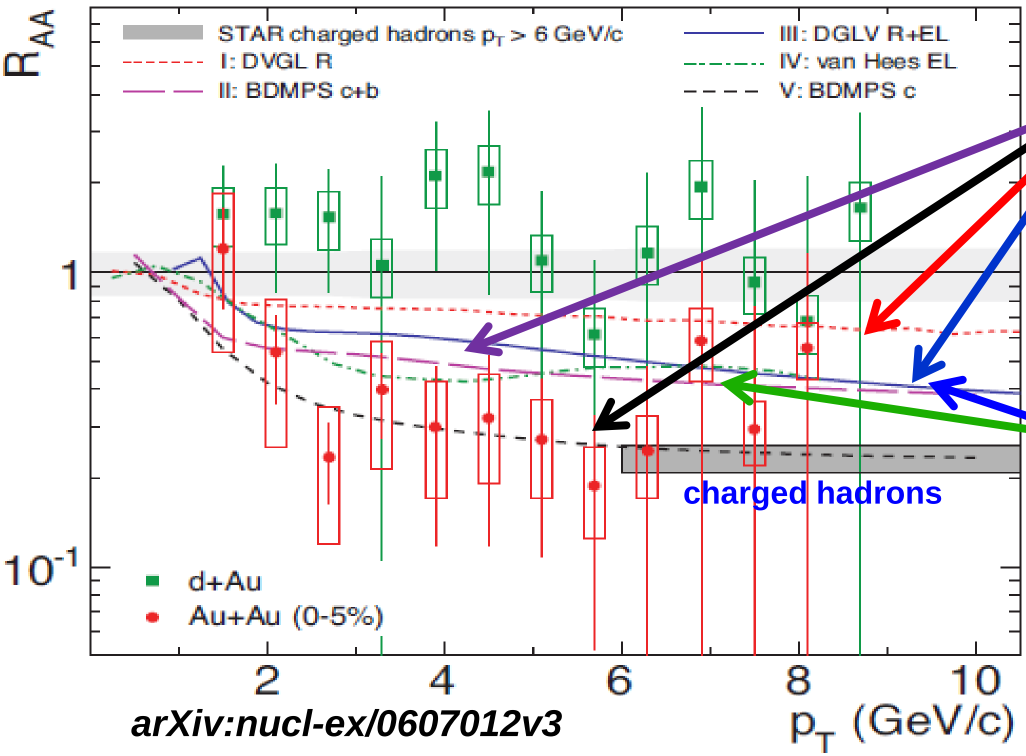
Open heavy flavor

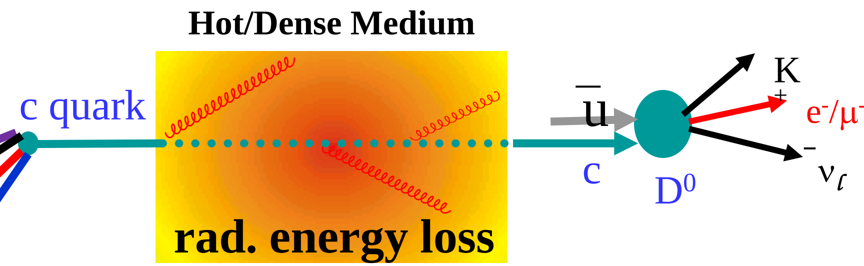
The STAR Detector



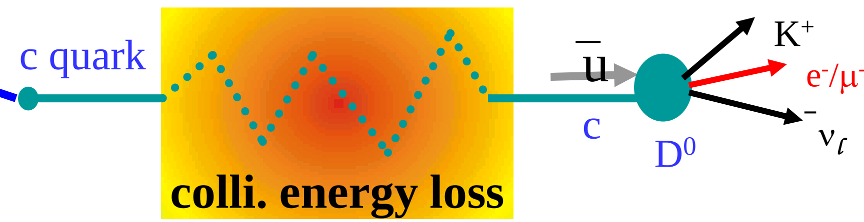
Indirect Heavy Flavor Measurement through Non-photonic Electrons

The Nuclear Modification Factor R_{AA} for Au+Au and d+Au

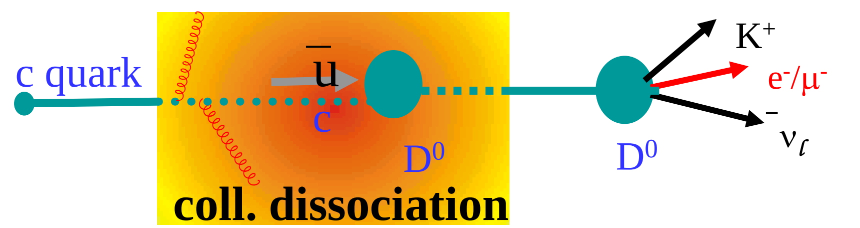




(D. Kharzeev, M.Djordjevic *et al.*)



(D. Teaney, R. Rapp, D. Molnar et al.)

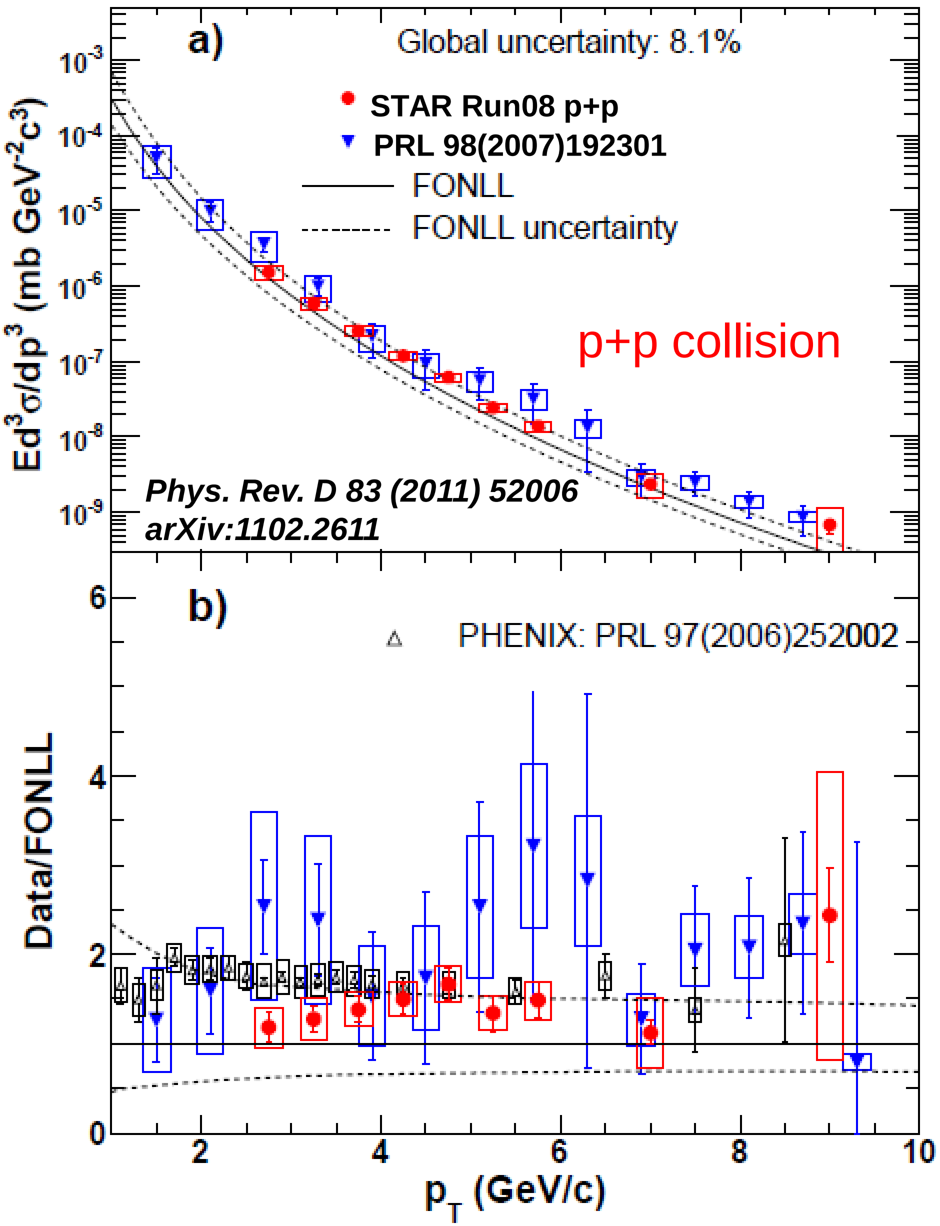


I. Vitev, et al

High-p_T non-photonic electron suppressed to the level of charged hadrons

$$R_{AA} = \frac{yield(A+A)}{yield(p+p)\cdot N(collisions)}$$

Non-photonic Electron Invariant Cross Section in 200GeV p+p Collisions



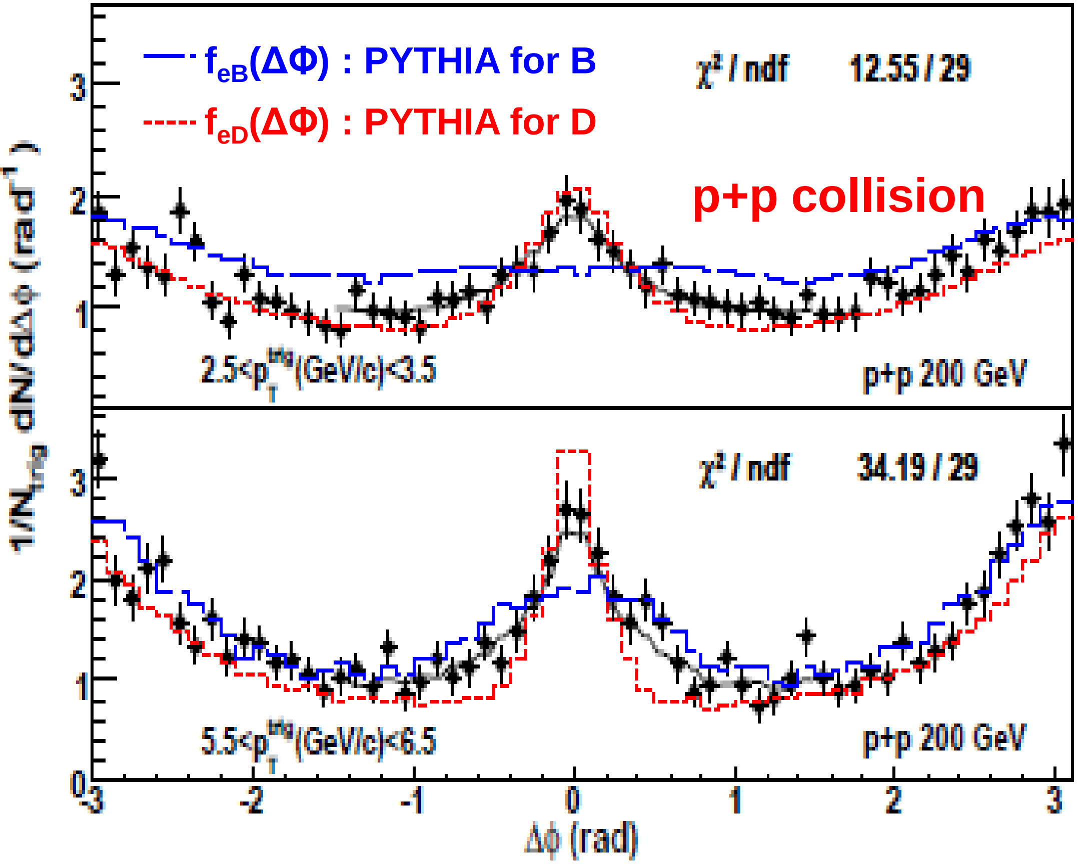
STAR and PHENIX NPE result in 200GeV p+p collisions

✓Are consistent within errors at $p_T > 2.5$ GeV/c

STAR High p_T NPE results are consistent with FONLL , i.e. Fixed Order plus Next to Leading Log (*M. Cacciari*, *R. Vogt*) pQCD calculation in 200GeV p+p collisions

Study Heavy Quark Production through Electron-hadron Correlation Measurements

Disentangle Charm and Bottom Production



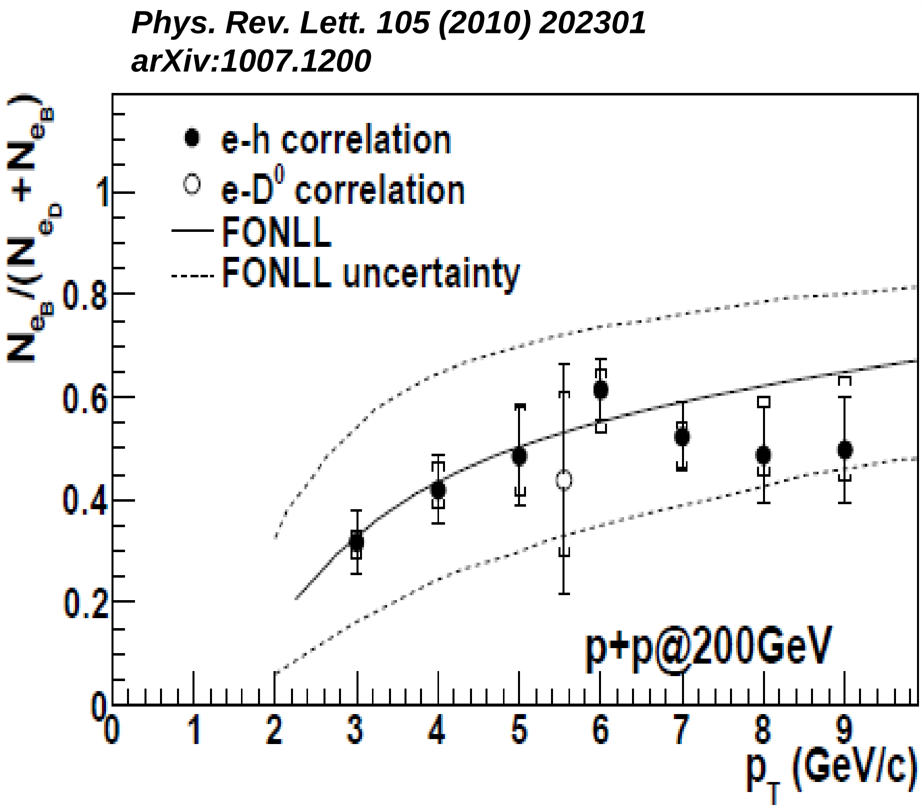
$$\Delta\phi_{e-h} = r_B \Delta\phi_{e-h}^{B} + (1 - r_B)\Delta\phi_{e-h}^{D}$$

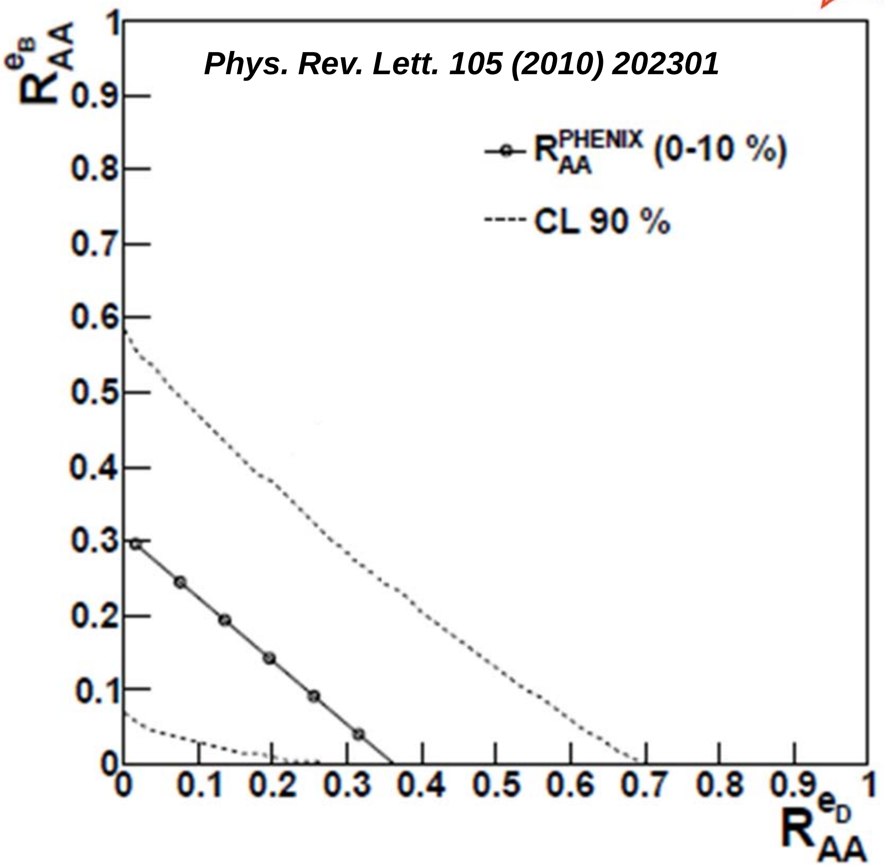
$$r_B = e_B / (e_D + e_B)$$

- Wider e-h correlation for B meson because of the larger mass. The trigger electron has (top) 2.5 < p_T < 3.5 GeV/c and (bottom) 5.5 < p_T < 6.5 GeV/c

- Combined fit on data to obtain the B meson contribution to non-photonic electron.

B Meson is Suppressed in 200GeV Au+Au Collisions

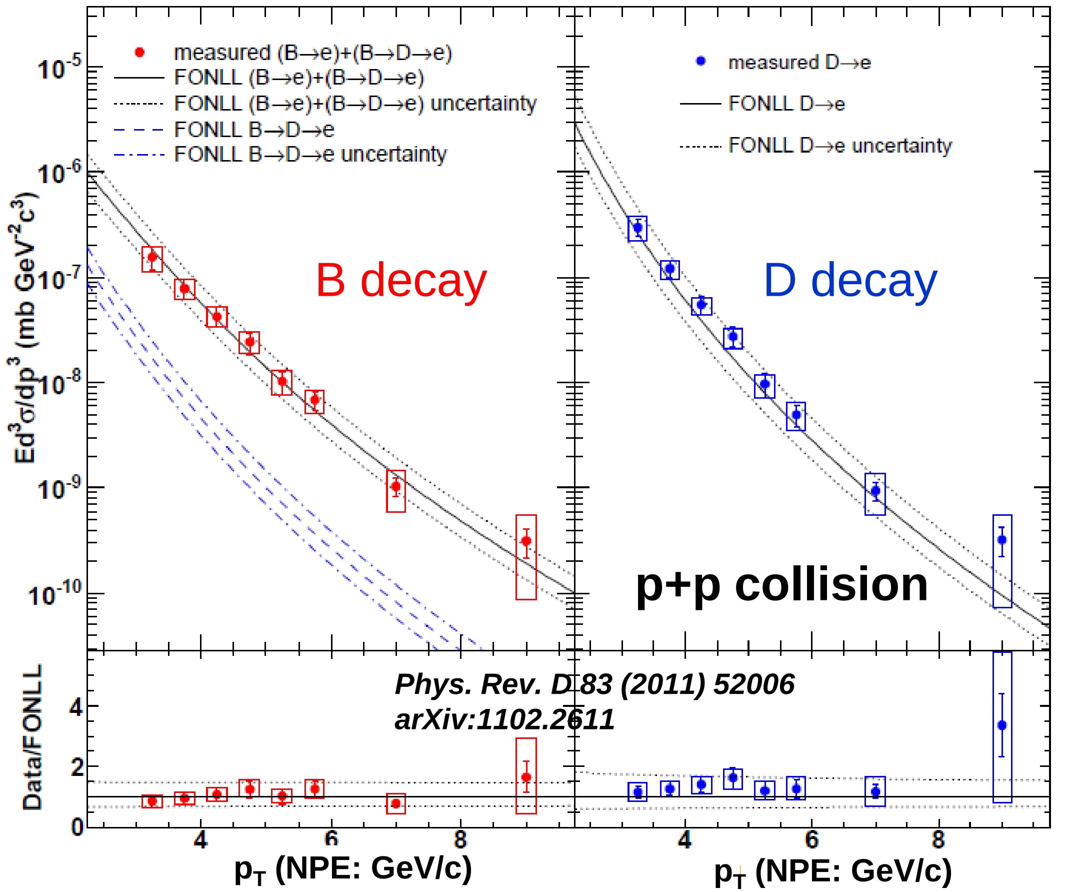




- ~30-60% of non-photonic electron come from B meson in 200GeV p+p collisions.

- Assume the same fraction in Au+Au collisions, results indicate B meson is suppressed

B-decay and D-decay Electrons Spectra



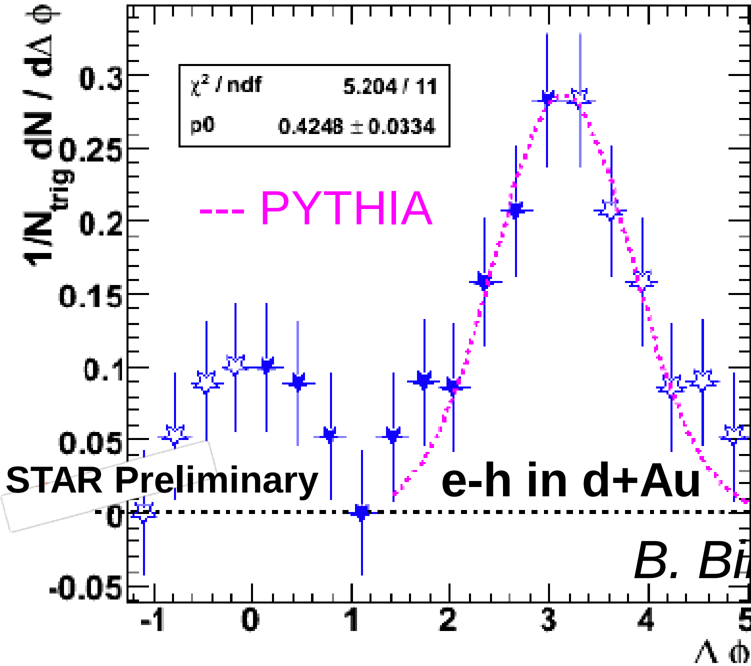
At 3 GeV/c < p_T (NPE) < 10 GeV/c:

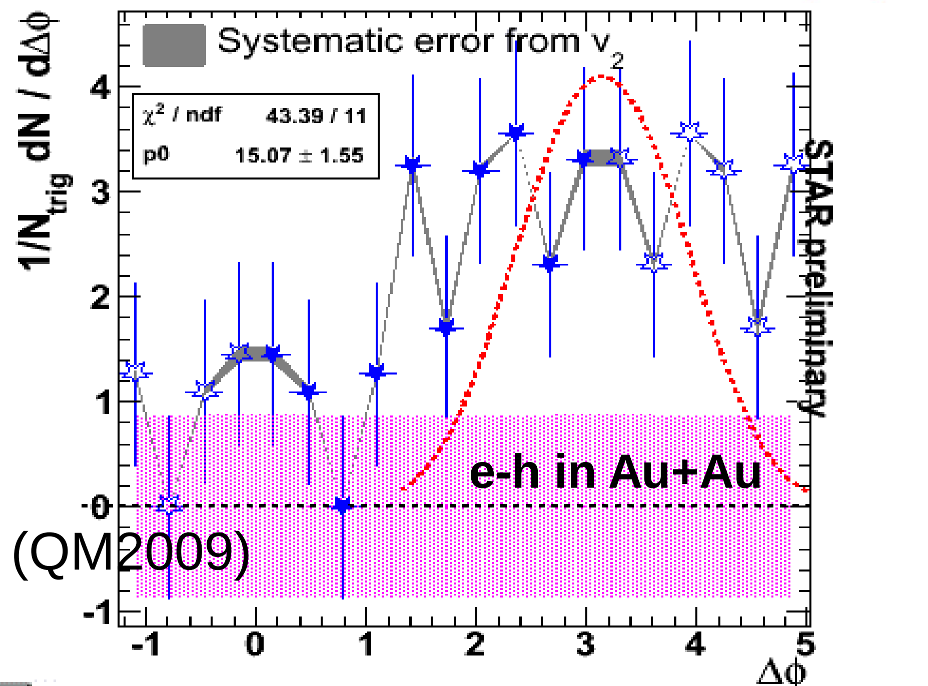
$$\frac{d\sigma_{(B\to e)+(B\to D\to e)}}{dy_e}\Big|_{y_e=0} = 4.0 \pm 0.5(\mathrm{stat.}) \pm 1.1(\mathrm{syst.})\mathrm{nb}$$

$$\frac{d\sigma_{D\to e}}{dy_e}\Big|_{y_e=0} = 6.2 \pm 0.7(\mathrm{stat.}) \pm 1.5(\mathrm{syst.})\mathrm{nb}$$

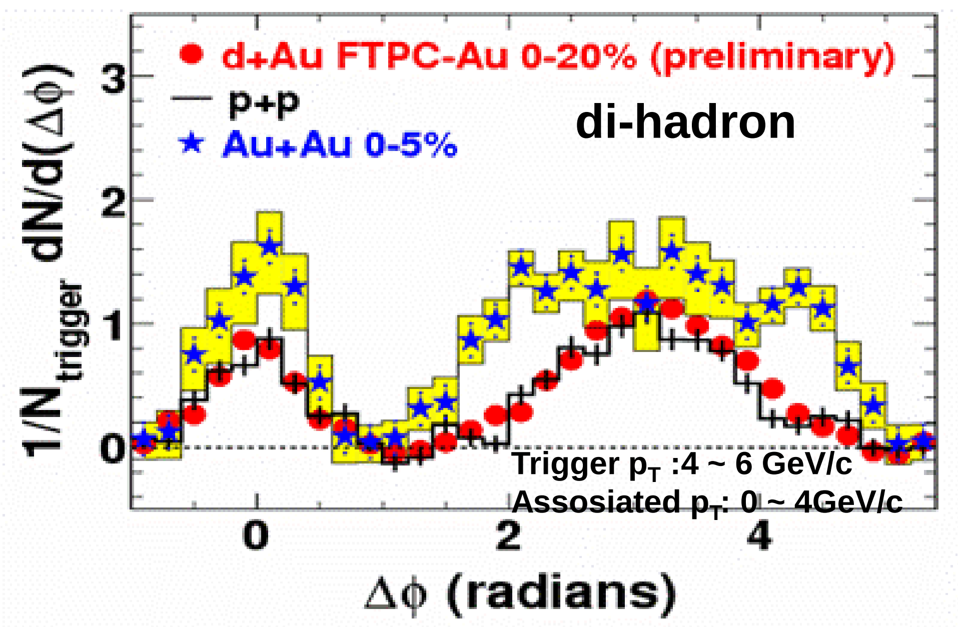
- **Consistent with FONLL with its uncertainties.**

Broadened Away-side in the NPE and Hadron Correlations





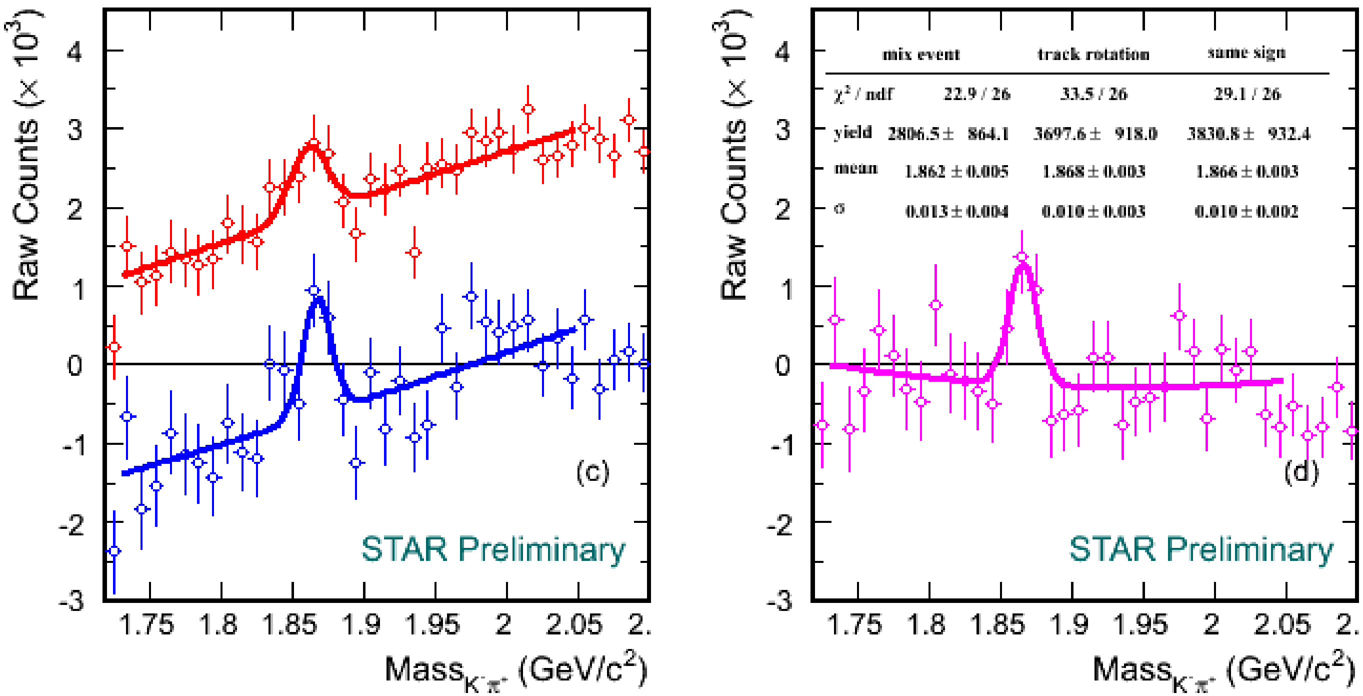
B. Biritz (QM2009)



Result indicates the broadening of the awayside peak in both di-hadron and e-h correlation in Au+Au central collisions

Direct Heavy Flavor Measurements:
Open Charm Mesons Reconstruction

D^0 reconstruction in p+p 200GeV



$$D^0 \rightarrow K^-\pi^+ \ (BR \ = 3.83\%)$$

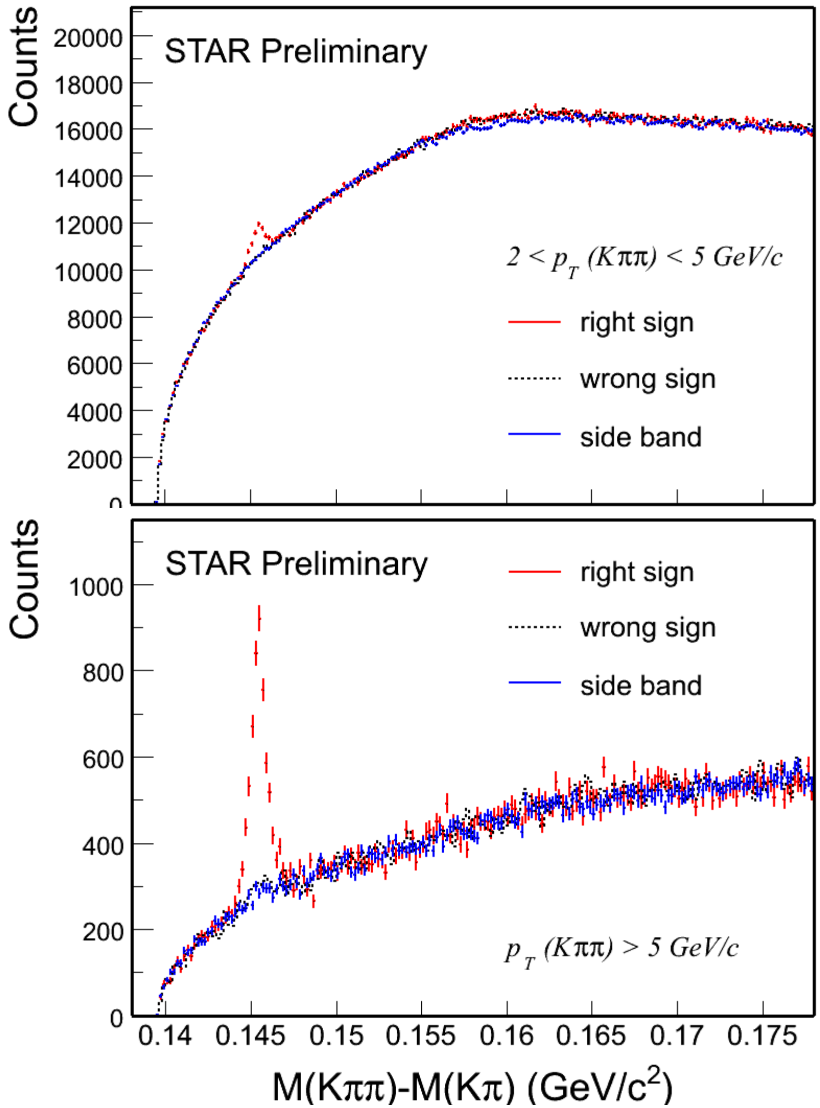
Zoom in mass window (1.72 – 2.1 GeV/c²)

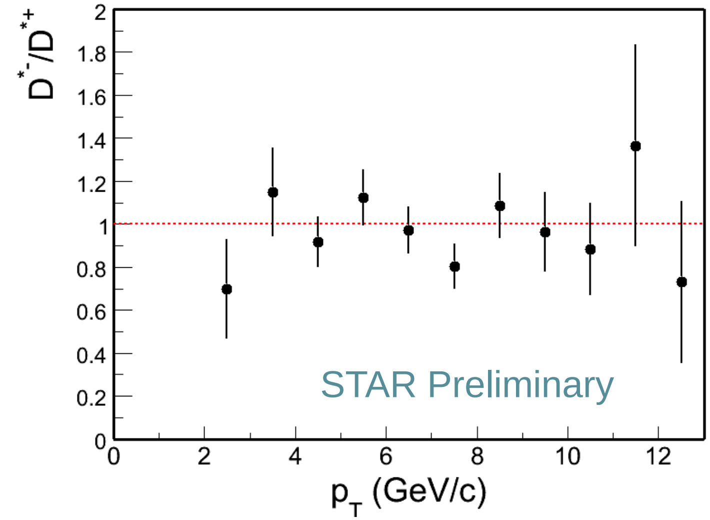
~ 4σ signal observed.

p_T coverage ~ 0.5 - 2.0 GeV/c

	mix event	track rotation	same sign
χ^2 / ndf	22.9 / 26	33.5 / 26	29.1 / 26
yield	2806.5 ± 864.1	3697.6 ± 918.0	3830.8 ± 932.4
mean	1.862 ± 0.005	1.868 ± 0.003	1.866 ± 0.003
σ	0.013 ± 0.004	0.010 ± 0.003	0.010 ± 0.002

D* reconstruction in p+p 200GeV





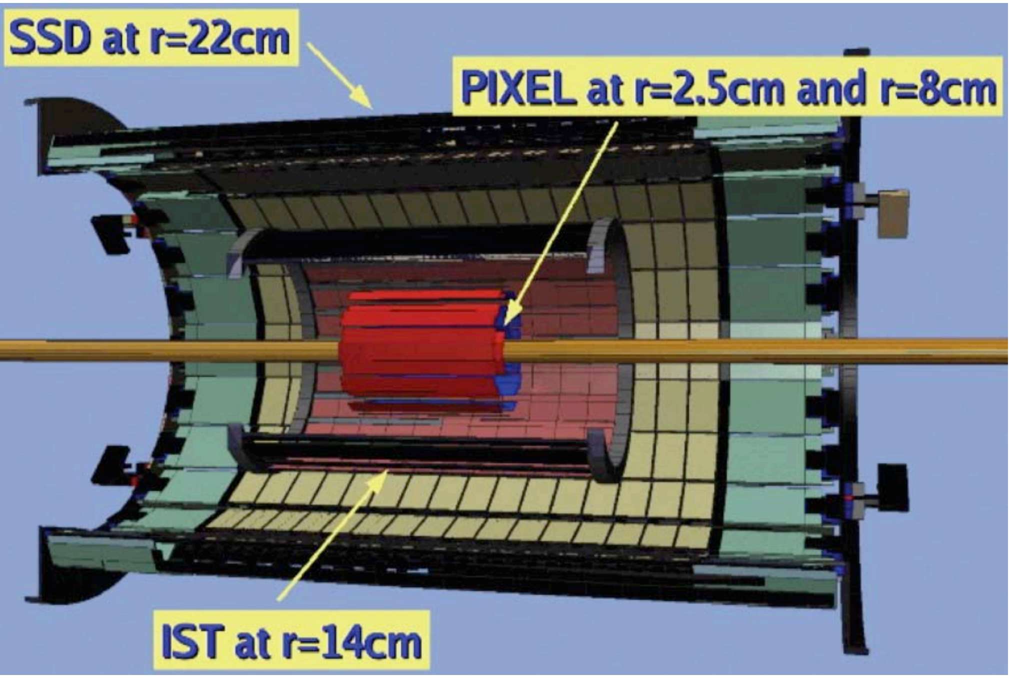
No significant charge asymmetry is observed

$$D^{*+} \rightarrow D^0\pi^+ \ (BR = 68\%)$$
$$\hookrightarrow K^-\pi^+$$

More than 4σ signal at low p_T and very significant at high p_T - mostly from EMC-based high neutral energy triggers.

Both wrong sign and side-band methods reproduce background well.

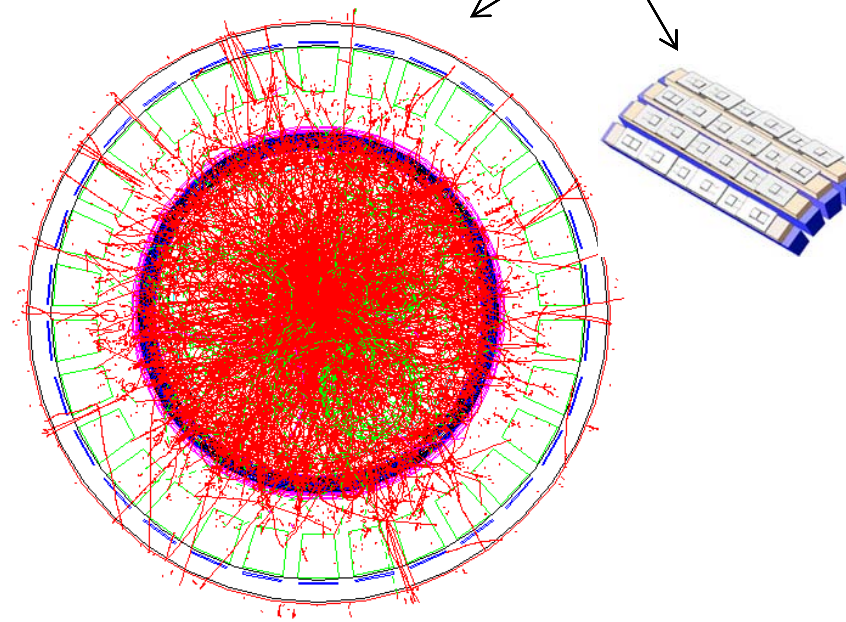
Future of Heavy Flavor Measurement at STAR



Heavy Flavor Track (HFT)

Precise determination of secondry-decay vertex of heavy flavor mesons

Muon telescope detector (MTD)



Heavy flavor measurement through decay muon channels

Summary and Perspective

❑ Indirect heavy flavor measurement using non-photonic electron (NPE).

- High p_T NPE production in central Au+Au collisions is suppressed.

- STAR measurement of High p_T NPE production in p+p collisions are consistent with published RHIC results.

❑ Study heavy quark production through electron – hadron correlation.

- Measurements of the $N_{eB}/(N_{eD}+N_{eB})$ and R_{AA} indicate B meson suppressed in central Au+Au collisions.

- Measured D→e and B→e spectra in p+p collisions are consistent with FONLL.

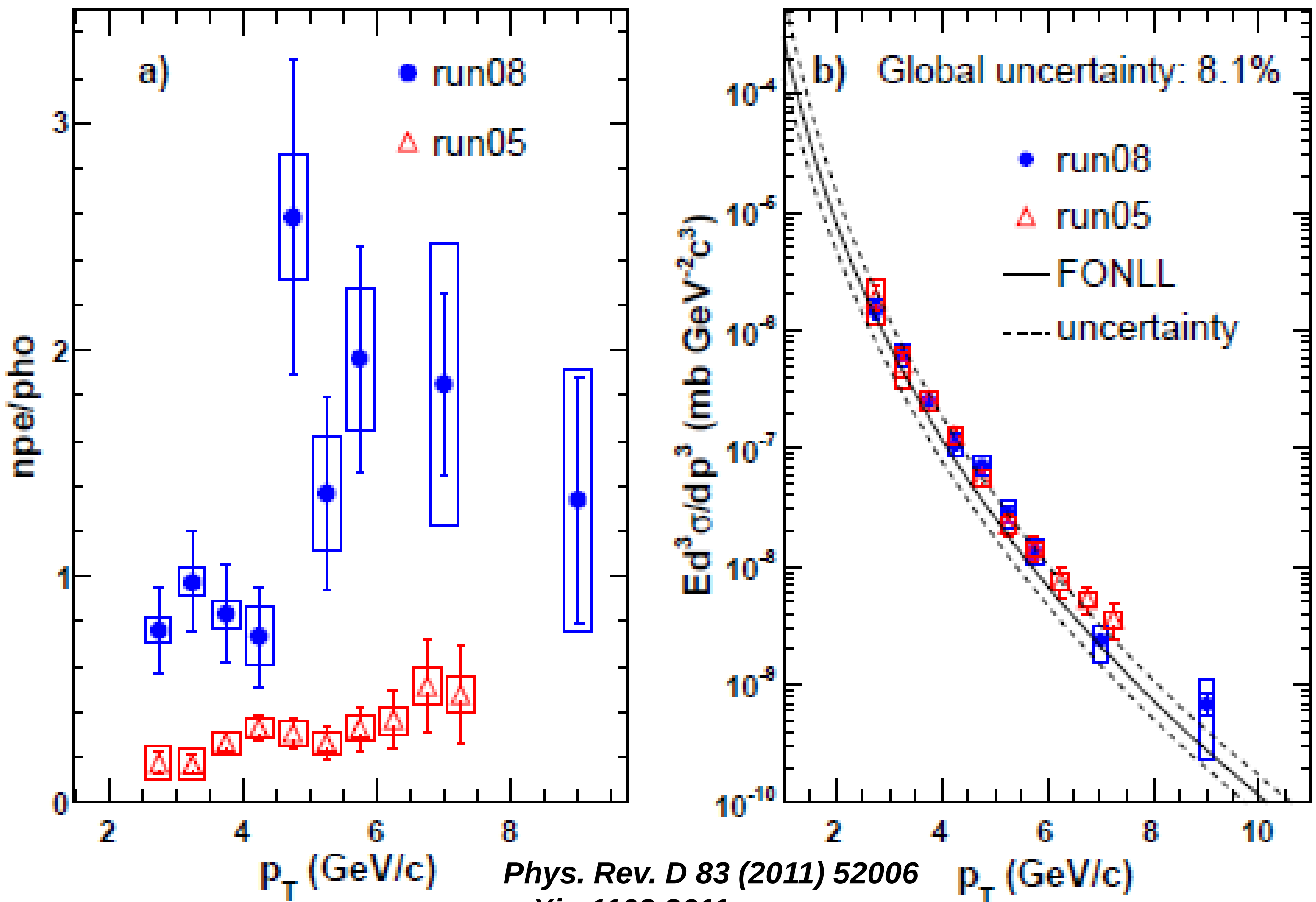
- Measured azimuthal correlation triggered by NPE indicates broadening on the awayside.

❑ Significant signal of directly reconstructed D^0 and D* meson are observed.

❑ precision measurements of heavy quark production with the upgraded detectors and luminosity.

Backup Slide

STAR High p_T NPE Measurements in 200GeV p+p Collisions



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arXiv:1102.2611

Measurement done using TPC+EMC using run08 and run05 data.

✓p_T>2.5GeV/c NPE measurements with dramatically different backgrounds agree with each other very well

R^{eD}_{AA} and R^{eB}_{AA} Correlation

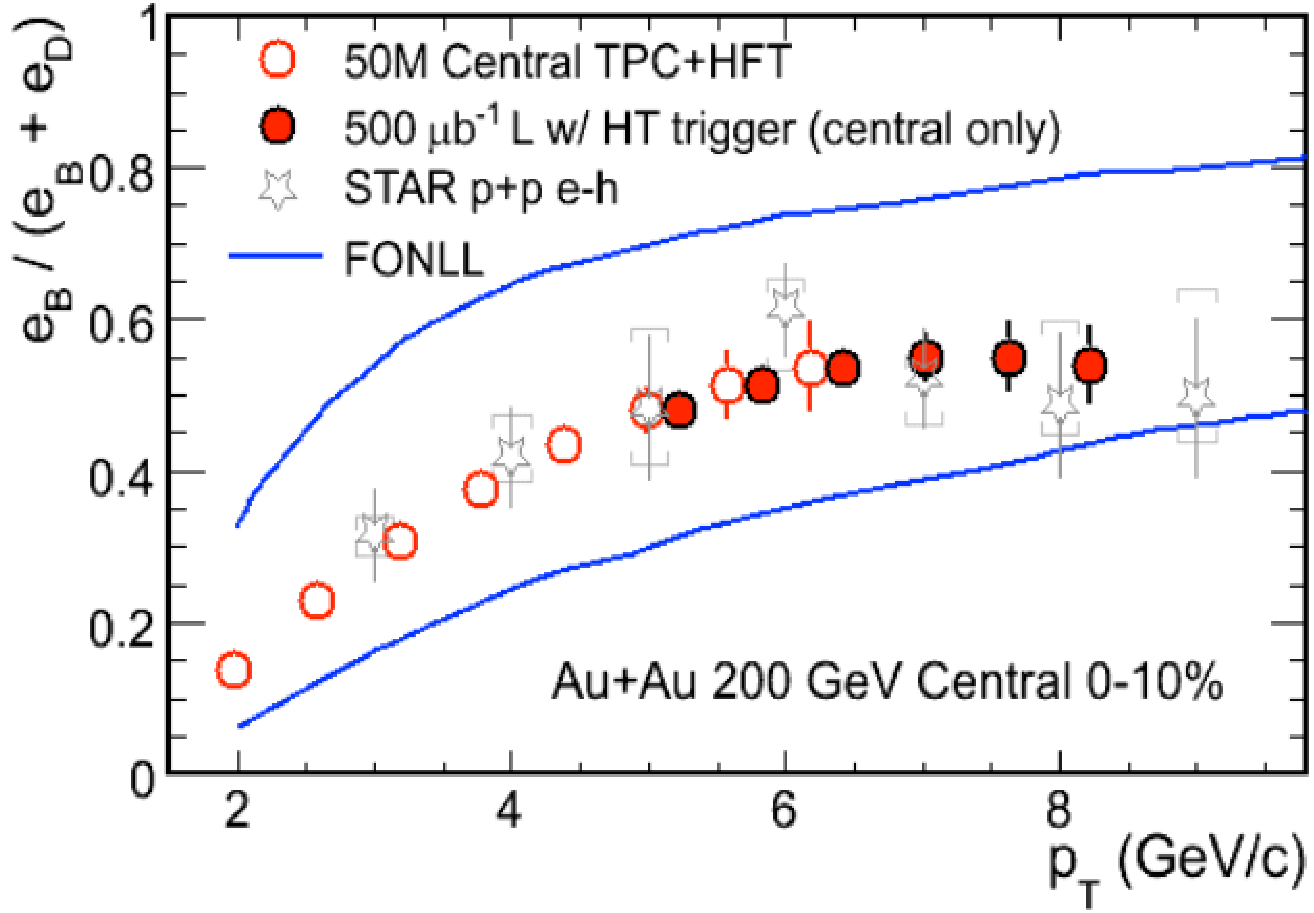
The R_{AA} for heavy flavor non-photonic electrons (R^{HF}_{AA}) is given by:

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

$$R_{AA} = 0.167^{+0.0562}_{-0.0485}\ (\mathrm{stat})^{+0.0512}_{-0.0815}\ (\mathrm{syst}) \pm 0.0117\ (\mathrm{norm})$$

$$r_B = 0.54 \pm 0.0349\ (\mathrm{sta.}) \pm 0.0666\ (\mathrm{sys.})$$

Then we calculate a likelihooddistribution for R^{eB}_{AA} as a function of R^{eD}_{AA}



50M Central TPC+HFT
500 μb⁻¹ L w/ HT trigger (central only)
STAR p+p e-h
FONLL
Au+Au 200 GeV Central 0-10%
$e_B / (e_B + e_D)$
p_T (GeV/c)
0
0.2
0.4
0.6
0.8
1
2
4
6
8