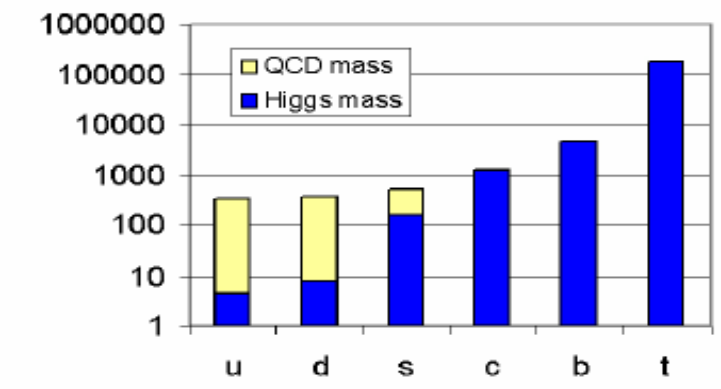
Measurement of Open Heavy Flavor Production in STAR Experiment at RHIC

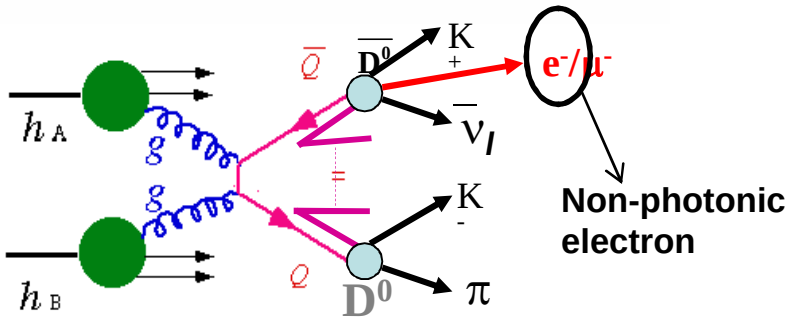
W. Xie for STAR Collaboration

(Purdue University, West Lafayette)

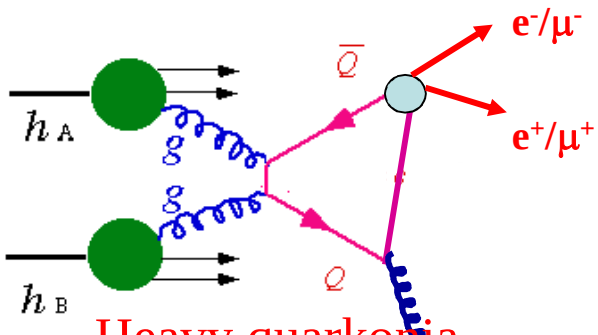
Motivation for Studying Heavy Quarks

- Heavy quark mass are external parameter to QCD.
- Sensitive to initial gluon density and gluon distribution.
- Interact with the medium differently from light quarks.
- Suppression or enhancement pattern of heavy quarkonium production reveal critical features of the medium.
- Cold Nuclear effect (CNM):
  - Different scaling properties in central and forward rapidity region CGC.
  - Gluon shadowing, etc



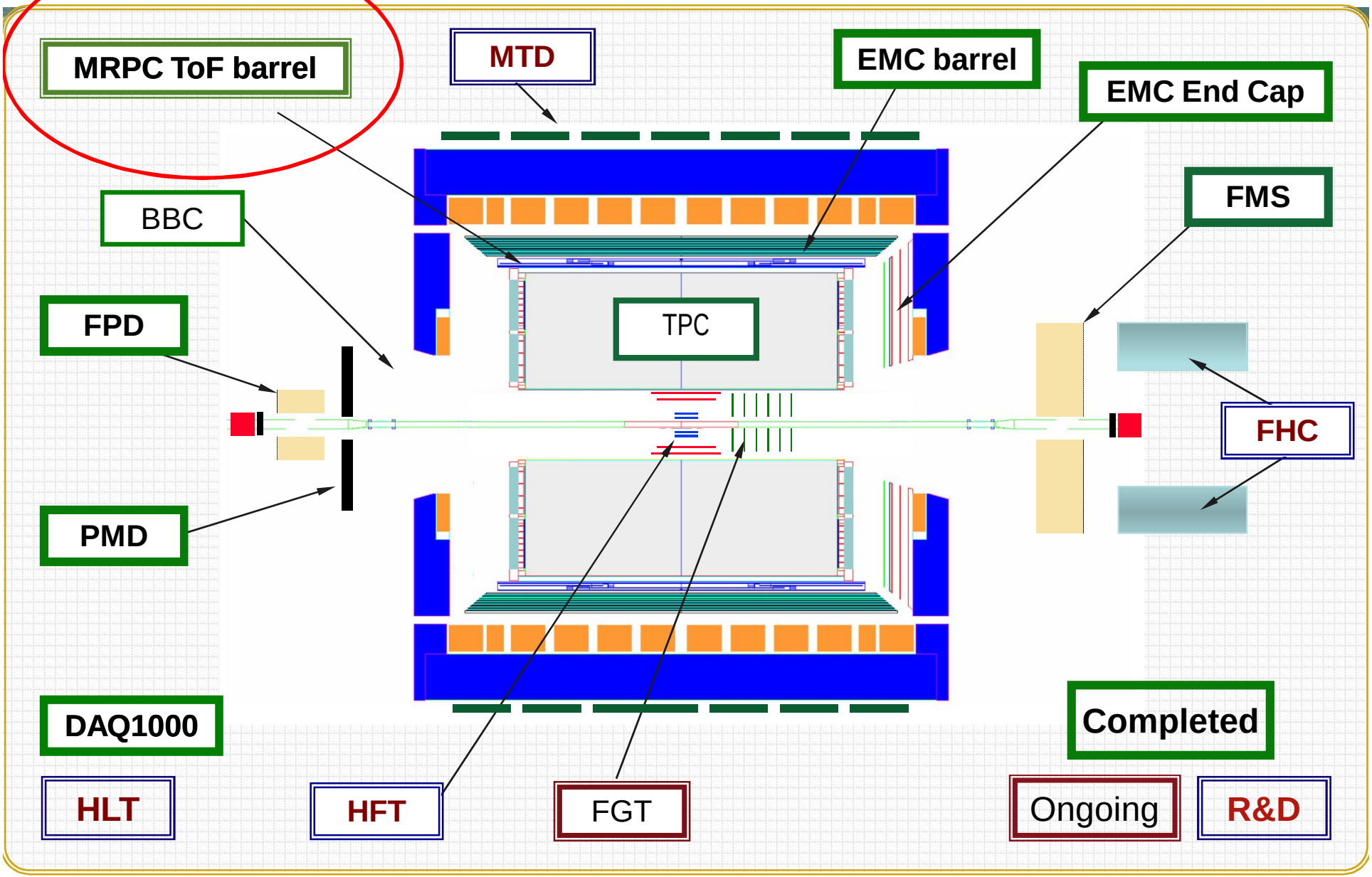


Open heavy flavor

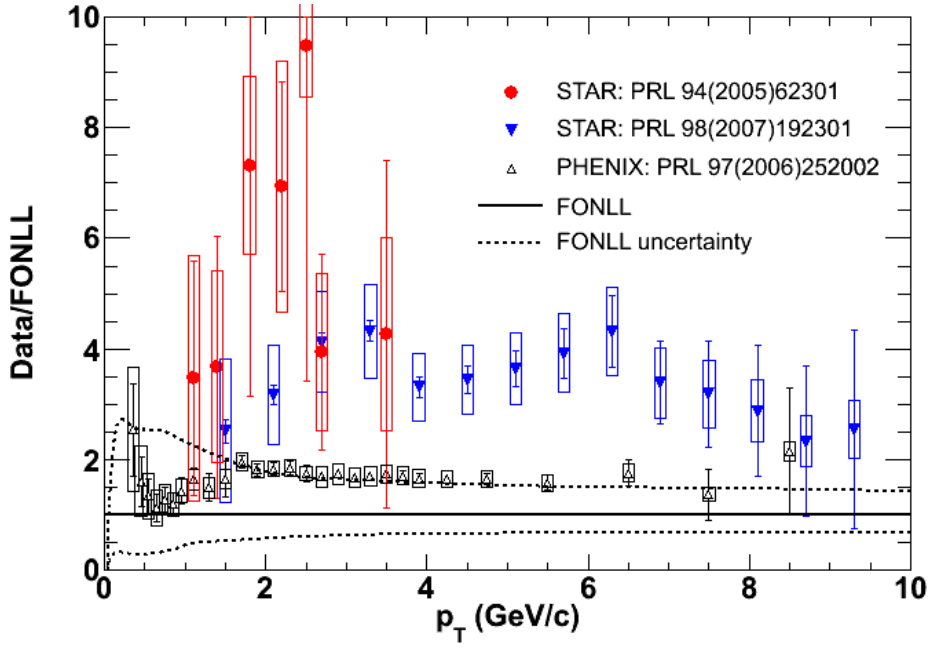


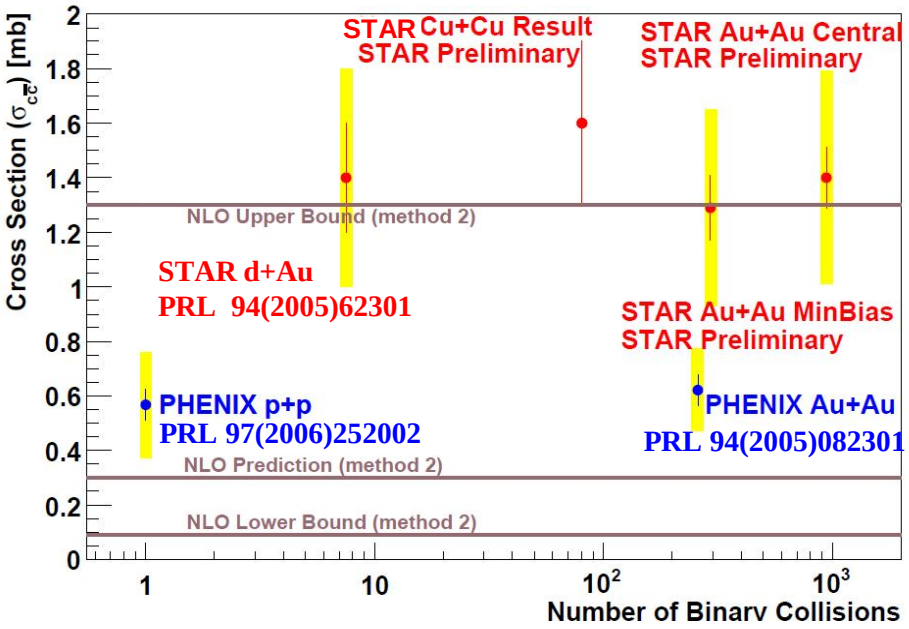
Heavy quarkonia

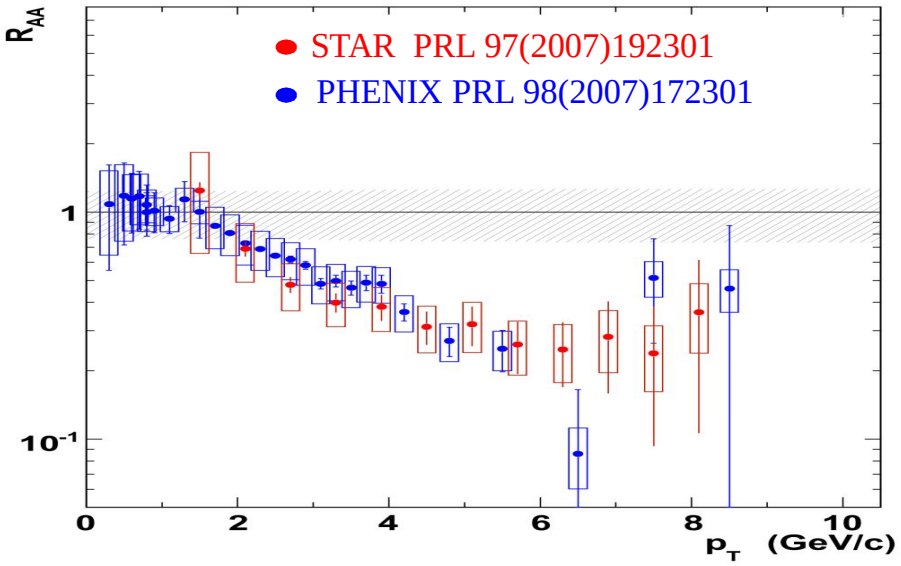
The STAR Detector



The Long Standing Issue on RHIC NPE Measurement







Results differ by a factor of two in

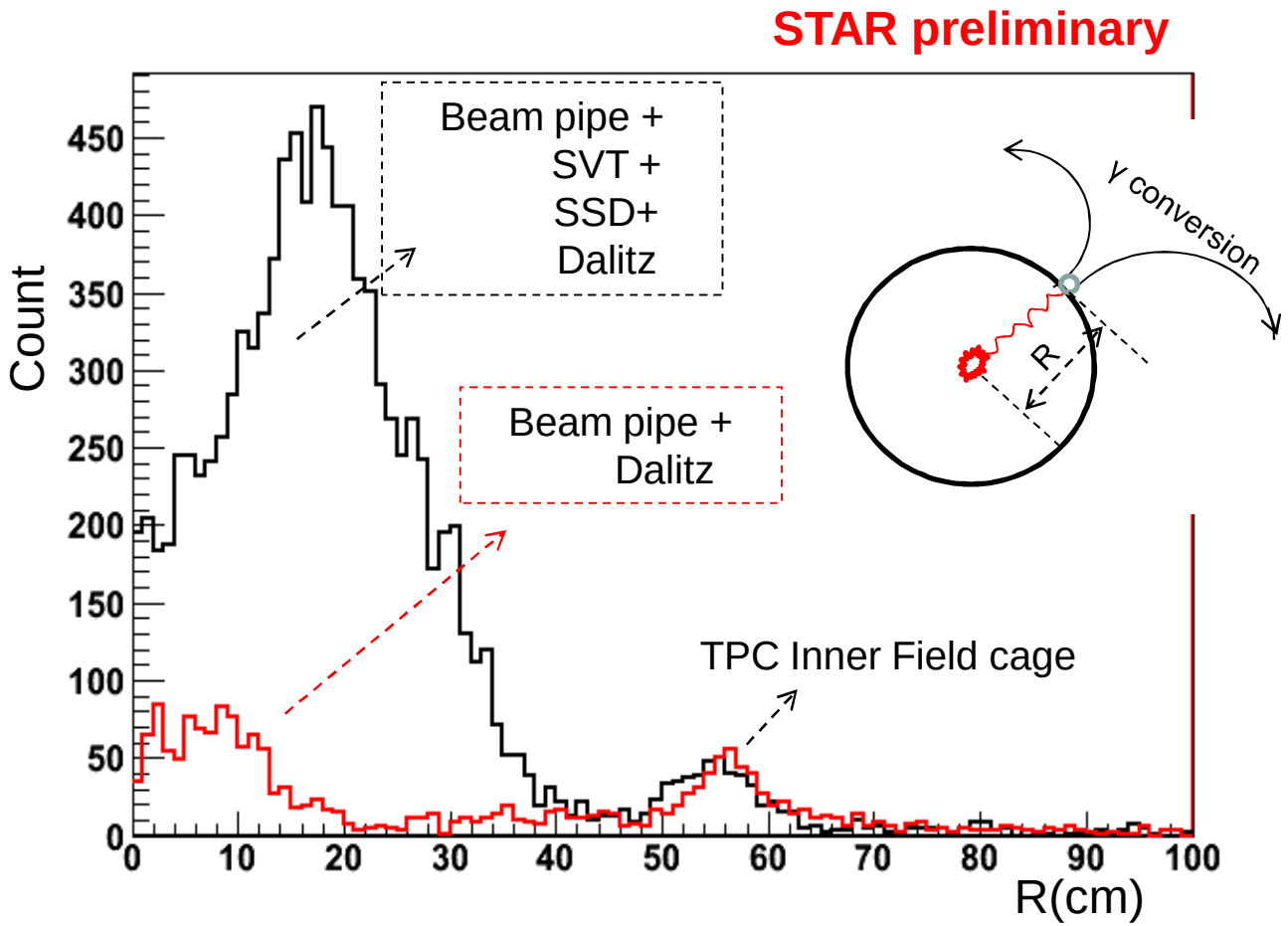
- ✓pT spectra
- ✓Total cross section
- ✓p+p collisions
- ✓Au+Au collisions

Investigation is underway

STAR Solution

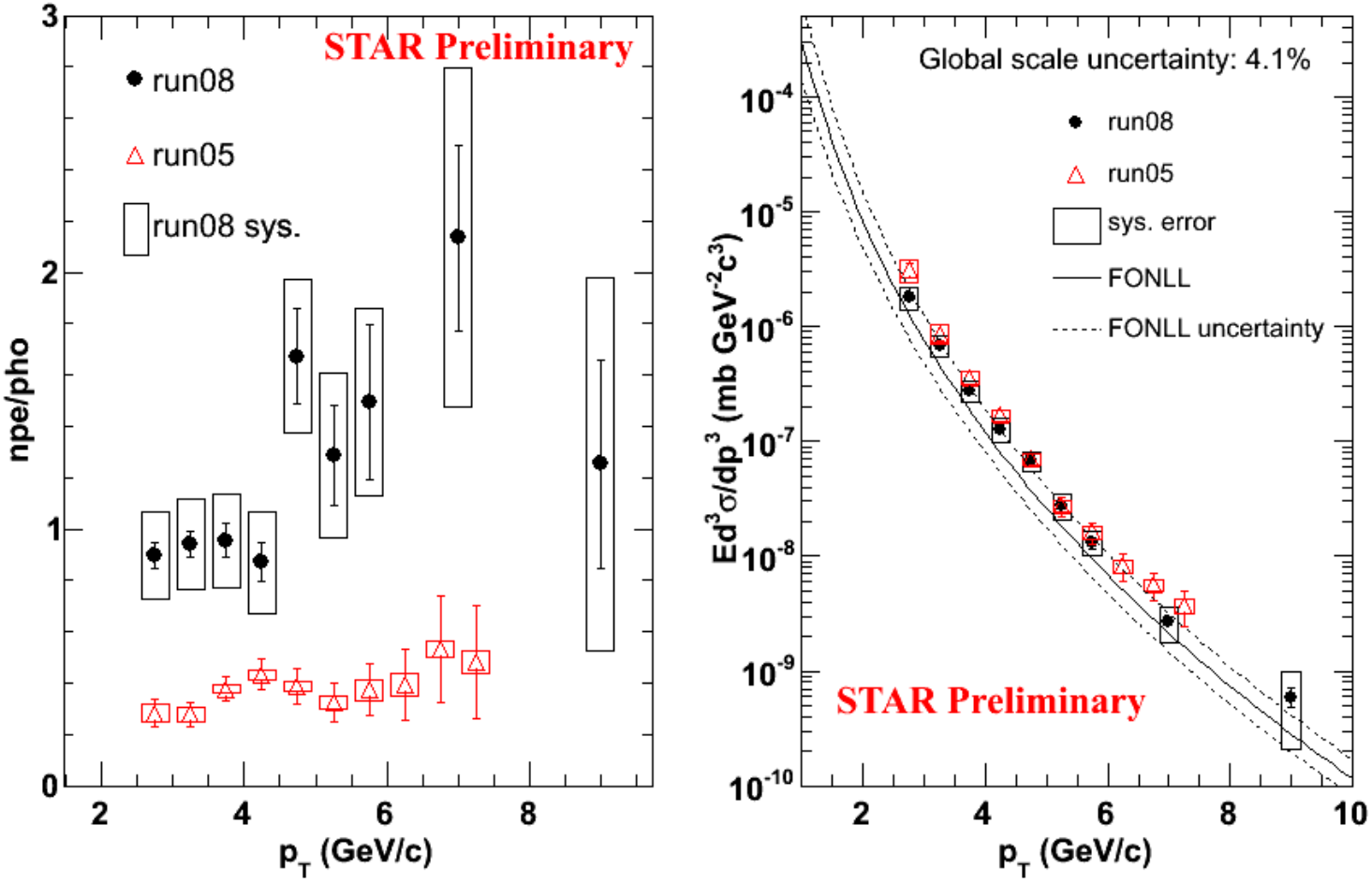
✓Significantly Increase the S/B of this analysis (2008-present)

✓Cross check NPE measurements with early runs.



Yield of conversion electrons at different radial location

STAR high pT NPE Measurements in 200GeV p+p collisions

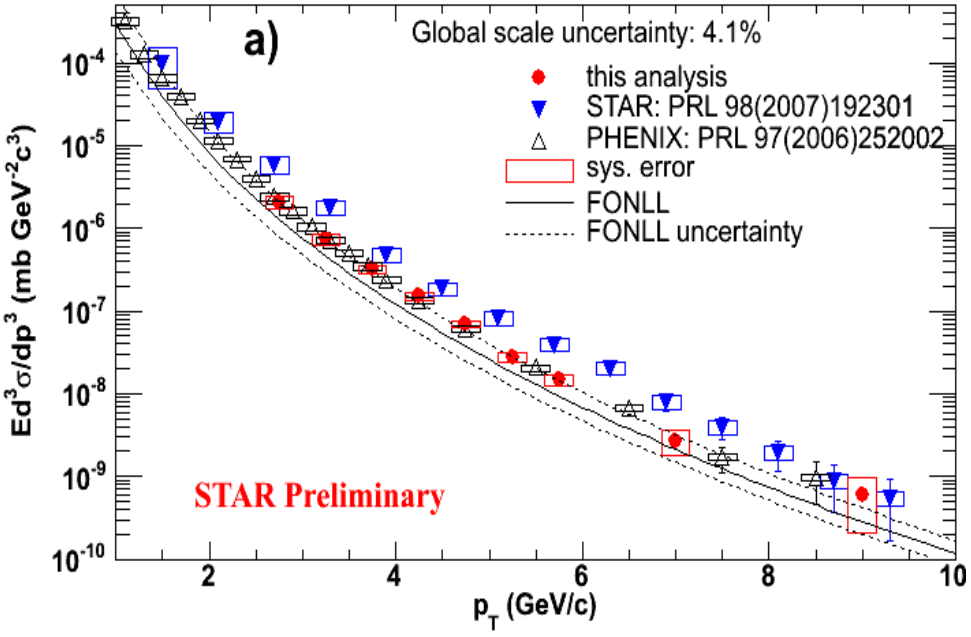


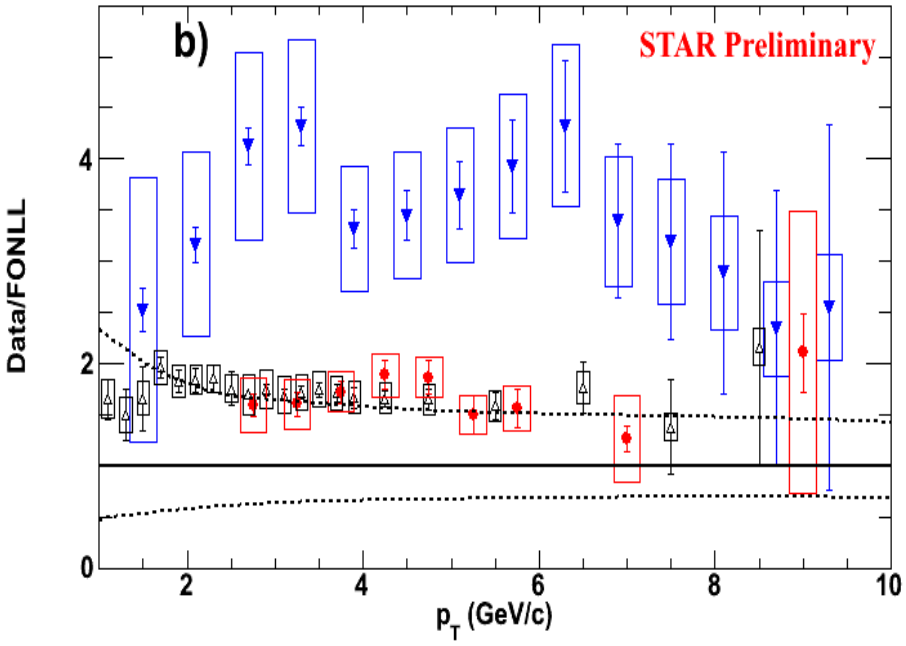
Measurement done using TPC+EMC using run08 and run05 data.

✓pT>2.5GeV/c NPE measurement with dramatically different background agree with each very well

• Combined using "Best Linear Unbiased Estimate". χ^2/ndf = 4.81/7 = 0.69

Comparison with the Published NPE Results



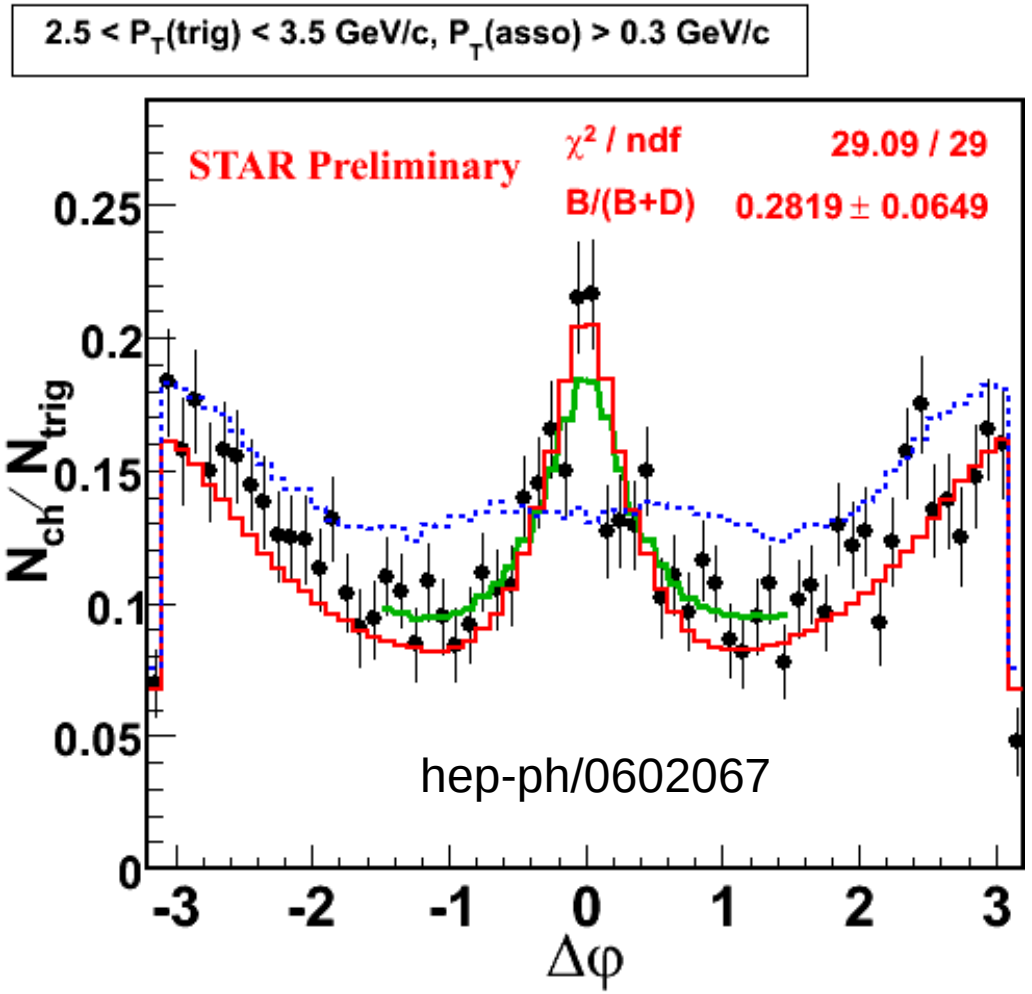


STAR and PHENIX NPE result in 200GeV p+p collisions

✓Are consistent within errors at pt > 2.5 GeV/c

STAR High pT NPE results are consistent with FONLL in 200GeV p+p collisions

Disentangle Charm and Bottom Production



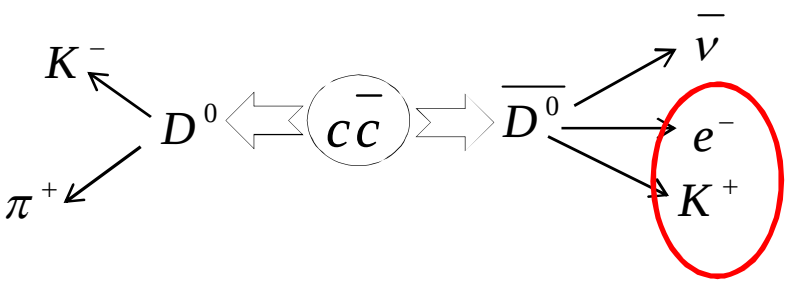
$$\Delta\phi_{e-h} = r_B \Delta\phi^B_{e-h} + (1 - r_B)\Delta\phi^D_{e-h}$$

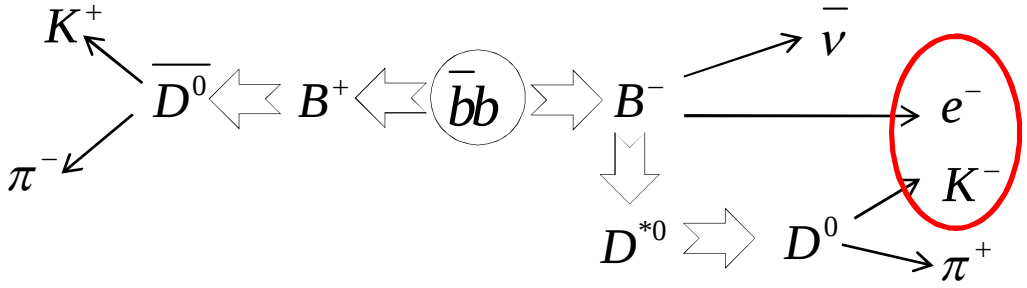
$$r_B = e_B / (e_D + e_B)$$

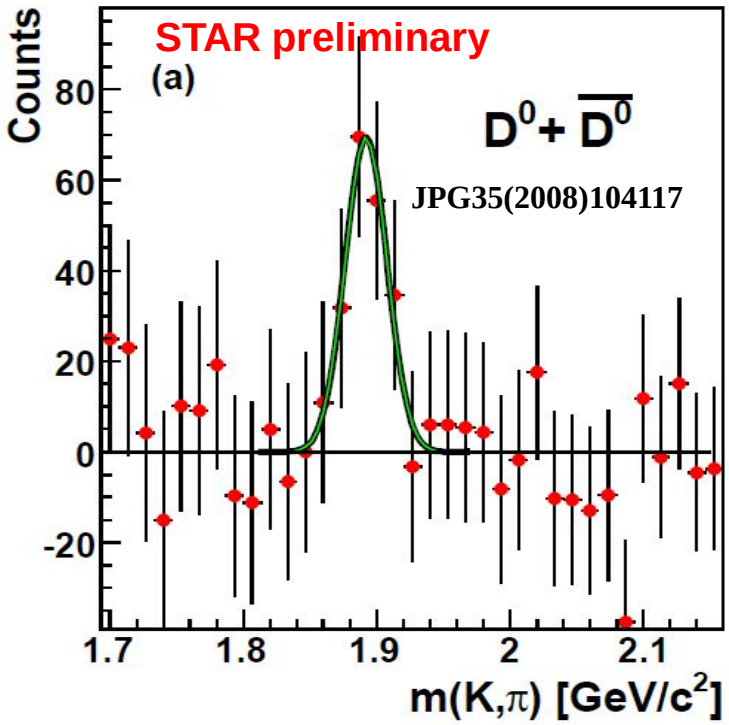
- Wider Δφ distribution for B meson because of the larger mass.

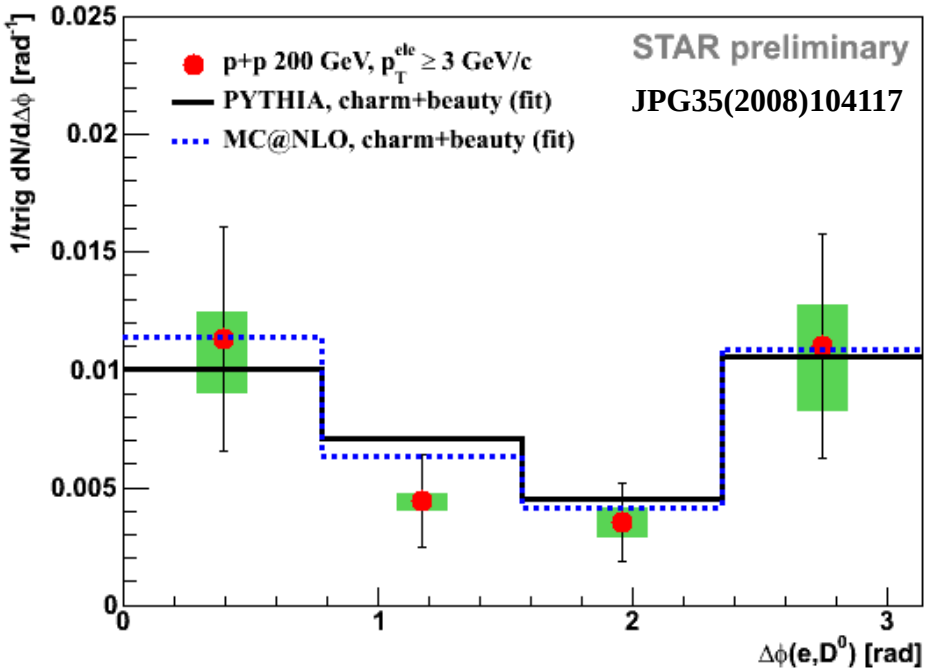
- Combined fit on data to obtain the B meson contribution to non-photonic electron.

Disentangle Charm and Bottom Production



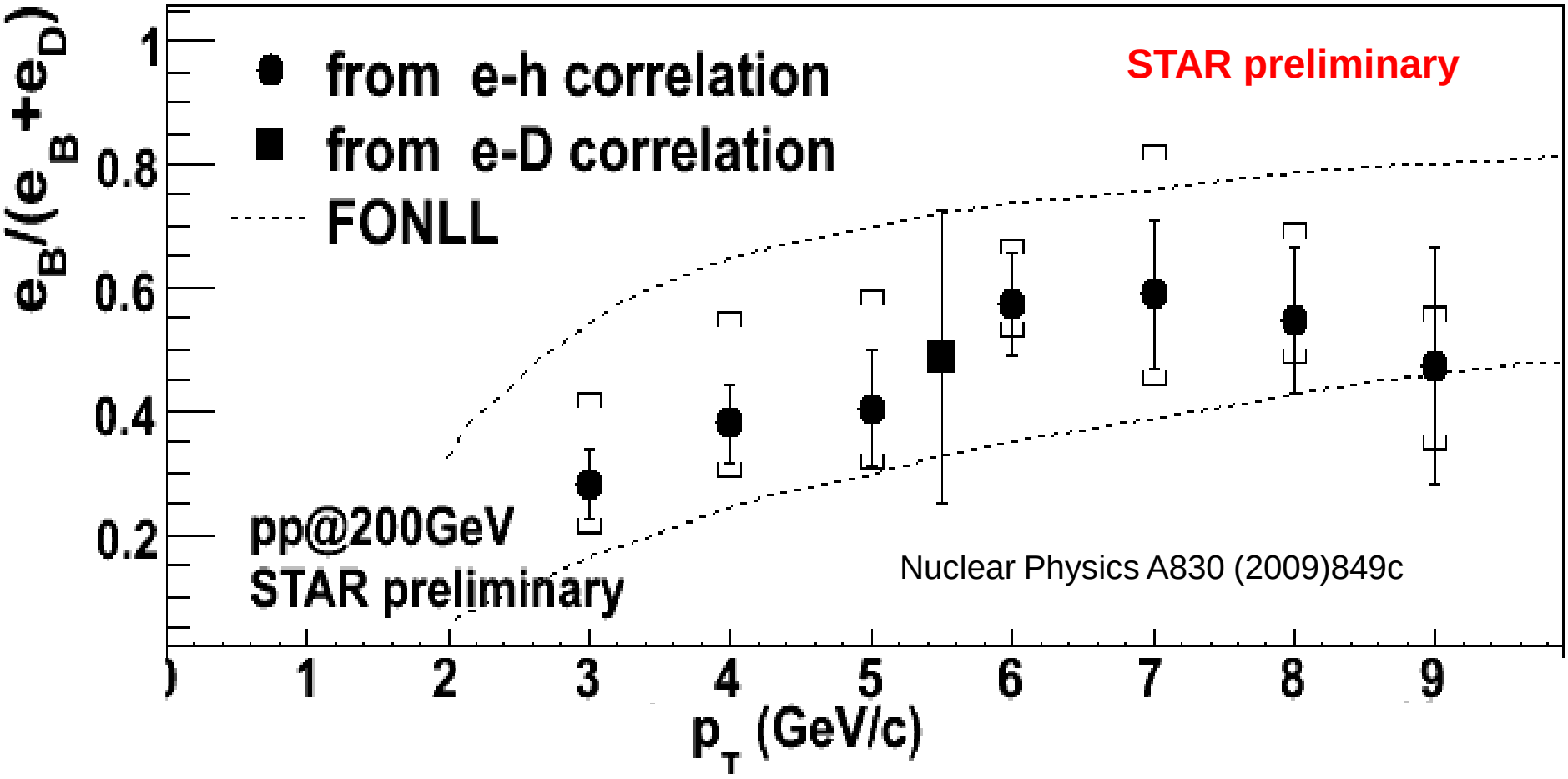






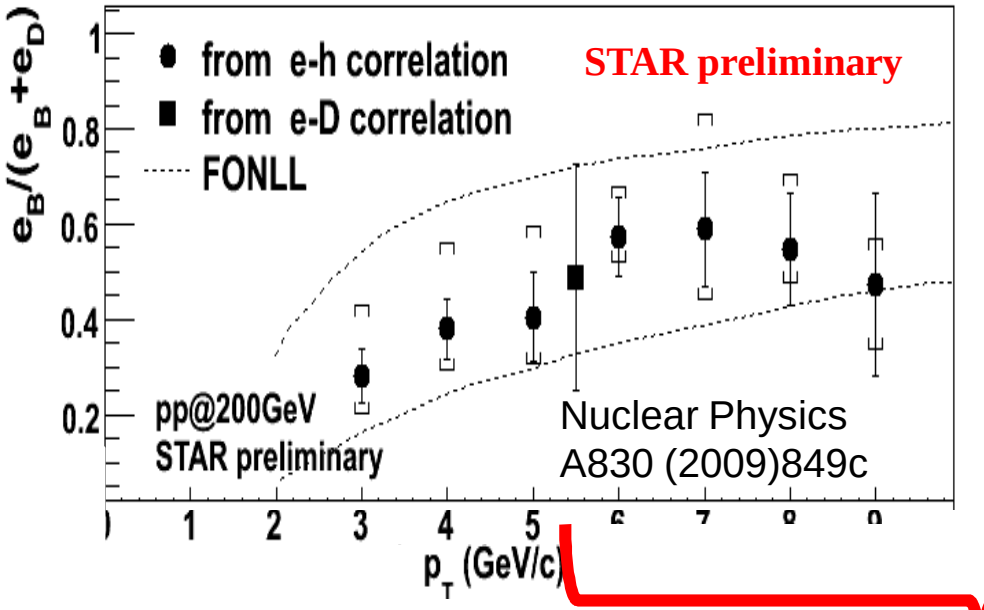
- Near side: mostly from B mesons
- Away side: charm (~75%), Bottom (~25%)

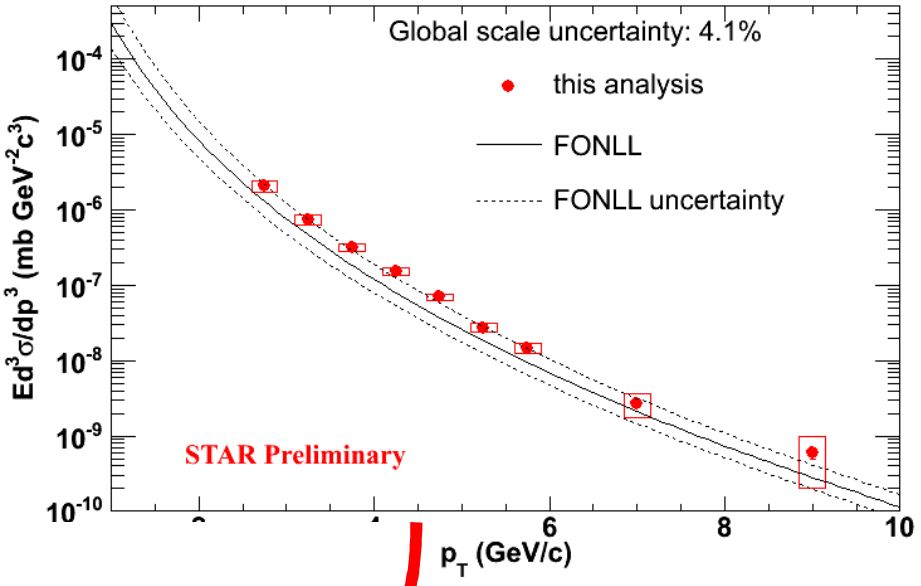
B Quark contribution is Significant in p+p colliosions



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

Constrain B quark Cross Section

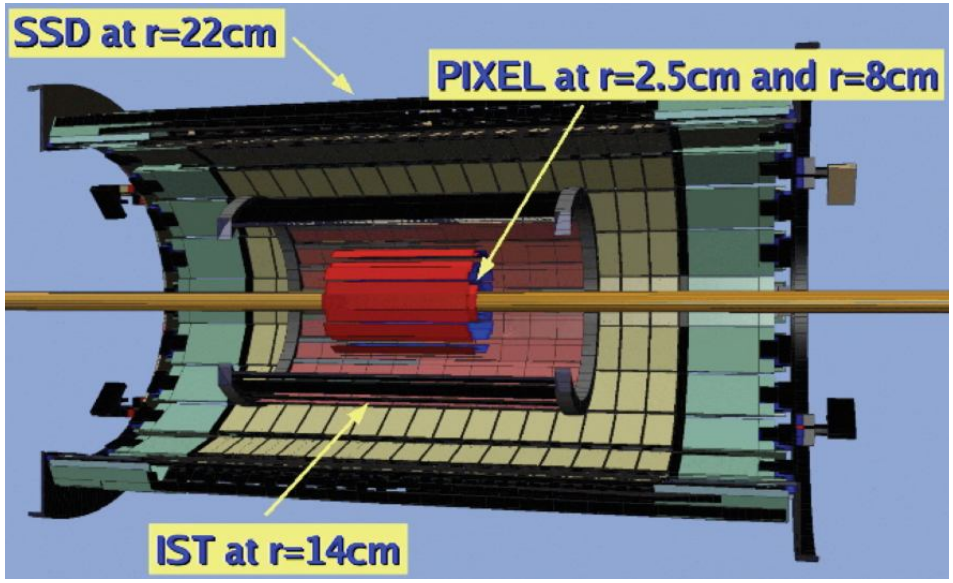


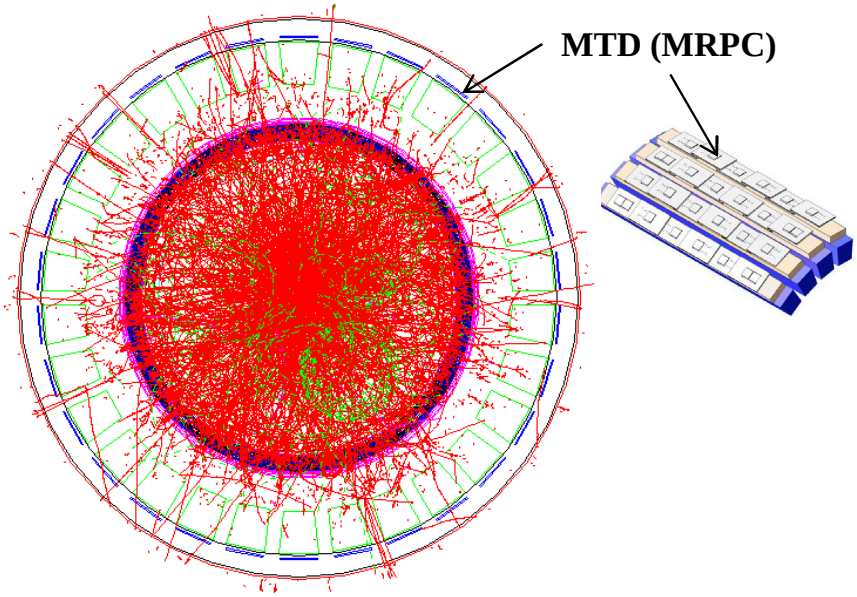


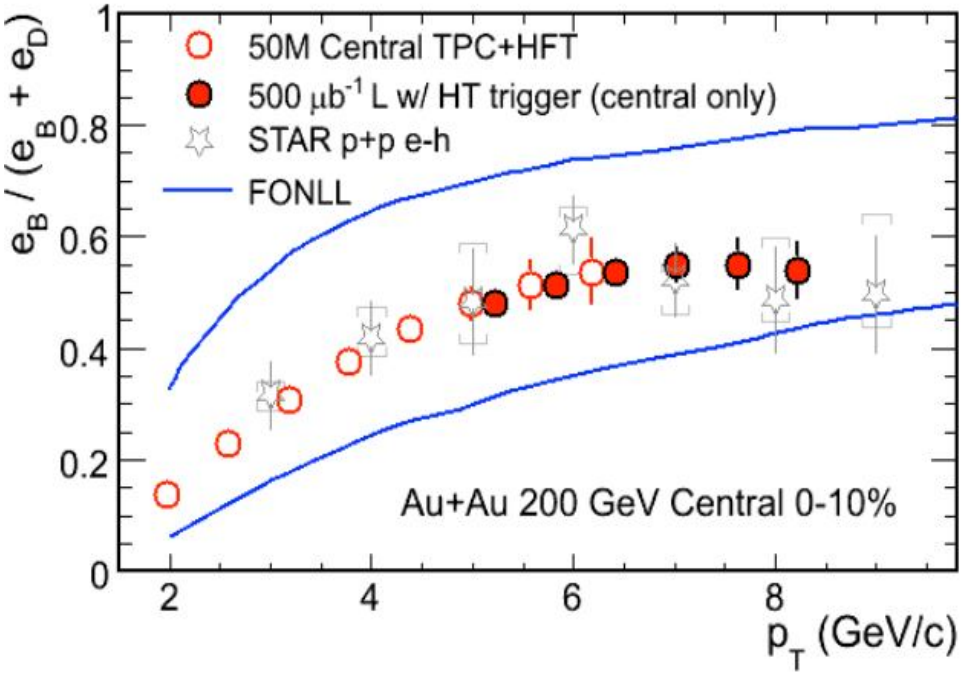
- **Obtain B quark high pT spectrum**

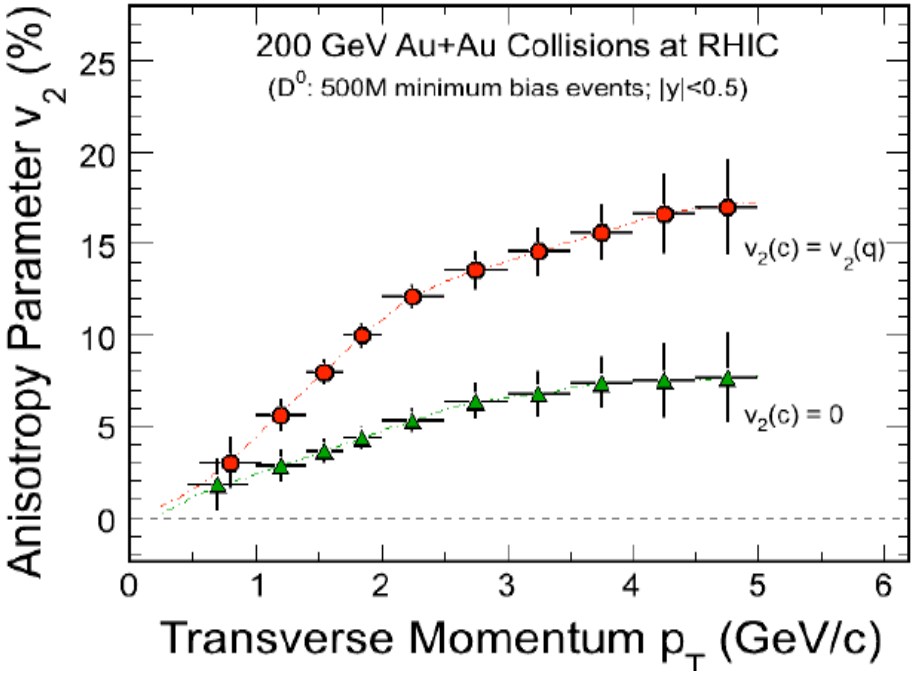
- **Constrain B quark Production Cross Section at RHIC using Model predictions.**

Future of Heavy Flavor Measurement at STAR









Summary and Perspective

✓STAR NPE results and PHENIX published result are consistent within errors at pt > 2.5 GeV/c in 200GeV p+p Collisions.

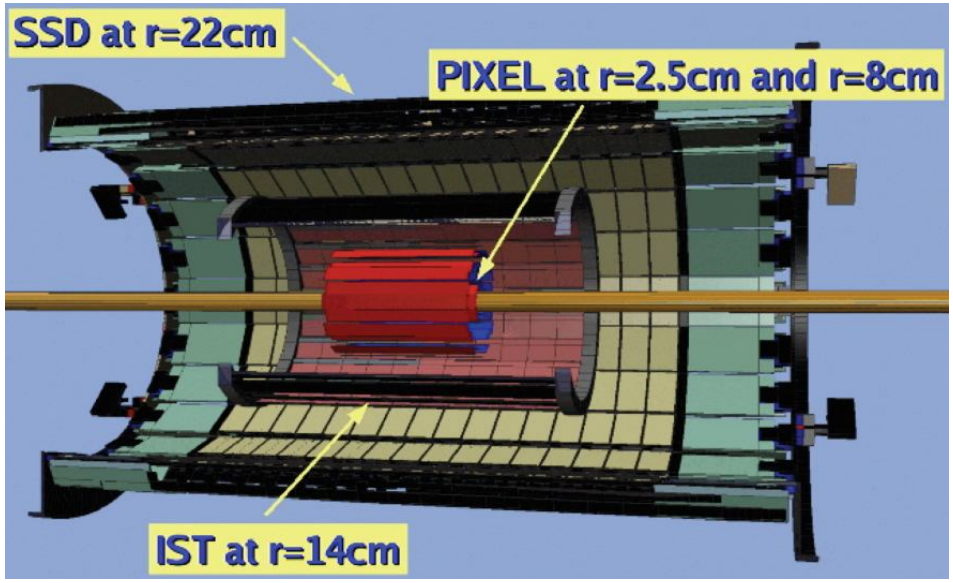
✓ STAR hight pT NPE Results are consistent with FONLL.

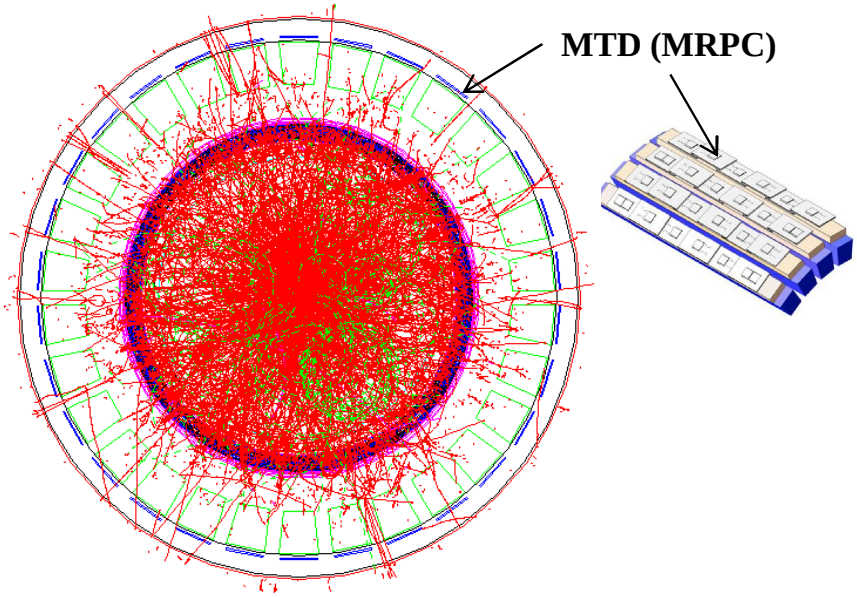
✓ New measurements of D mesons and low pT NPE using TOF should provide good constraints on total charm cross section

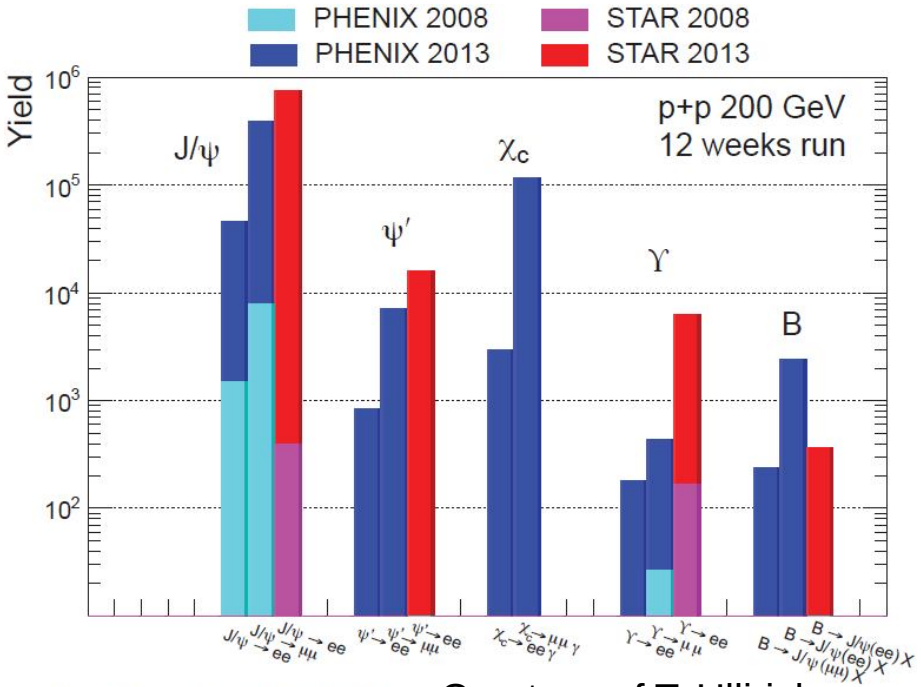
✓Expecting exciting results in the coming years with upgraded detectors and luminosity.

backup

Future of Heavy Flavor Measurement at STAR

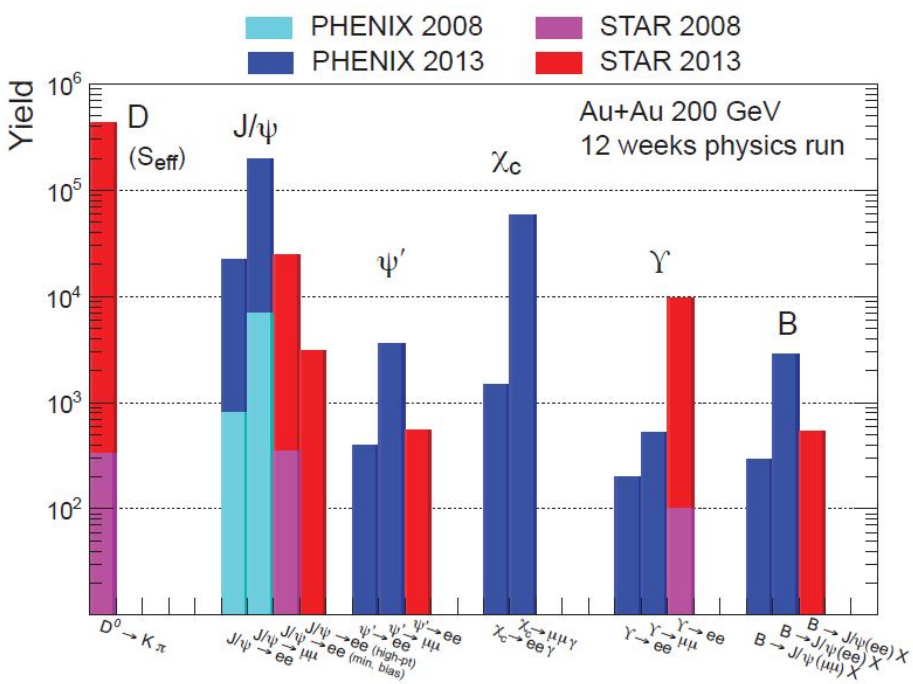






Source: Phys. Rept. 462: 125-175, 2008

Courtesy of T. Ullirich



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RHIC II

Beams: **p to U**
All combinations $\sqrt{s}$ = **22-200 GeV**

Central Au+Au: T ~ 2 T_c

Detectors:
PHENIX STAR eRHIC detector?

12 weeks / year physics (split runs)
Average luminosity 7 * 10^{27} cm^{-2} s^{-1}
Au+Au lum/year 18,000 μb^{-1}

$Lint_{RHIC}/Lint_{LHC}$ = **36**

N_{cc} ~ 10 N_{bb} ~ 0.05 (central)

LHC

Beams: **p to Pb**
p+p $\sqrt{s}$ = **14 TeV**
p+Pb $\sqrt{s}$ = **8.8 TeV**
Pb+Pb $\sqrt{s}$ = **5.5 TeV**

Central Pb+Pb: T ~ 3.5 T_c

Detectors:
ALICE ATLAS CMS

4 weeks / year physics
Average luminosity 5 * 10^{26} cm^{-2} s^{-1}
Pb+Pb luminosity/year 500 μb^{-1}

$\sigma(J/\psi)_{LHC}$ = $\sigma(J/\psi)_{RHIC}$ * **13**
$\sigma(\Upsilon)_{LHC}$ = $\sigma(\Upsilon)_{RHIC}$ * **55**

N_{cc} ~ 115 N_{bb} ~ 5 (central)

Analysis Method in STAR for High pT NPE

Dominant background: $\pi^0 \rightarrow \gamma + e^+ + e^-$

$\gamma \rightarrow e^+ + e^-$

$$N(npe) = N(inclusive) - \frac{N(photonic)}{\varepsilon}$$

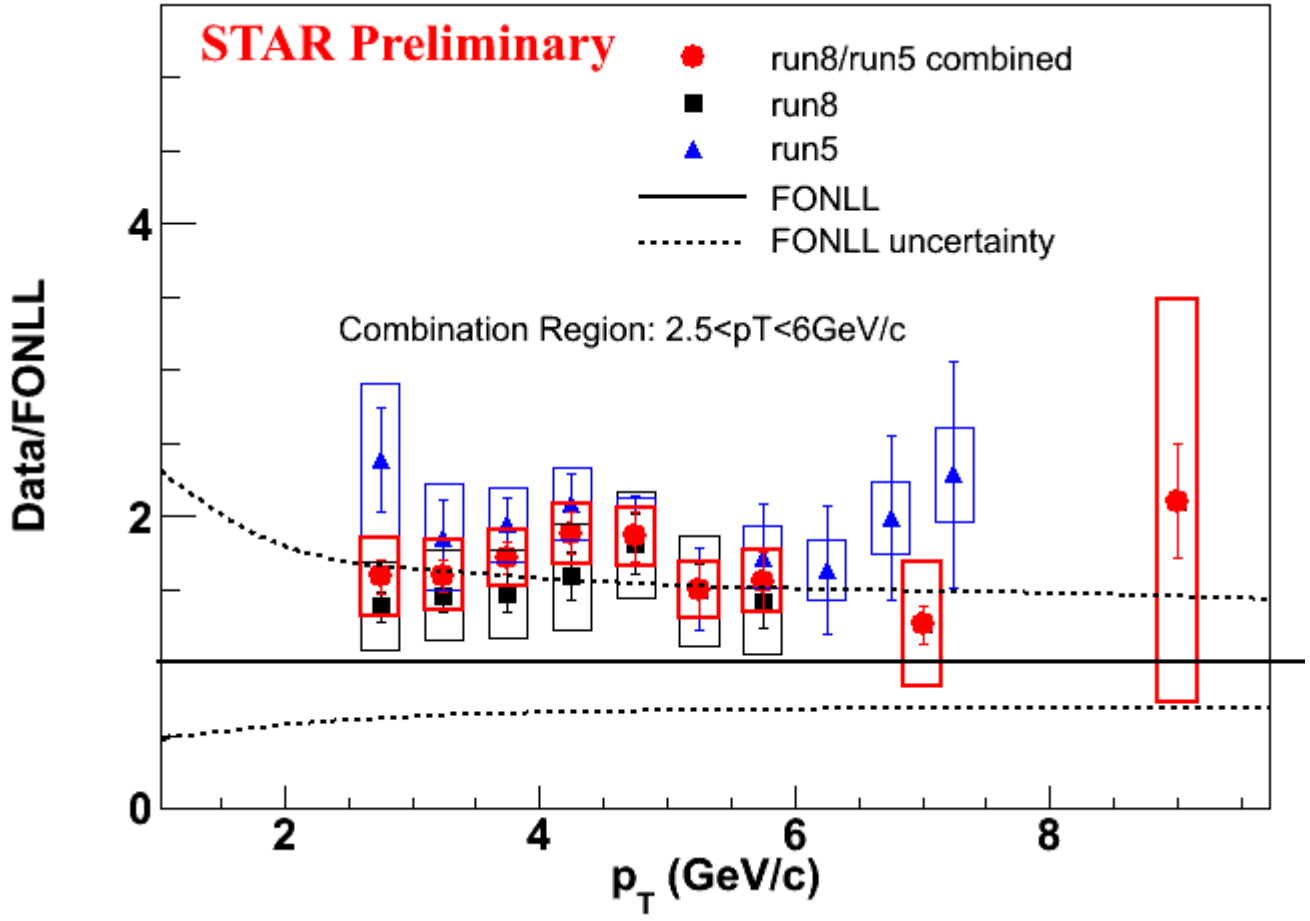
Photonic Reconstruction Efficiency

✓ estimated from embedding.

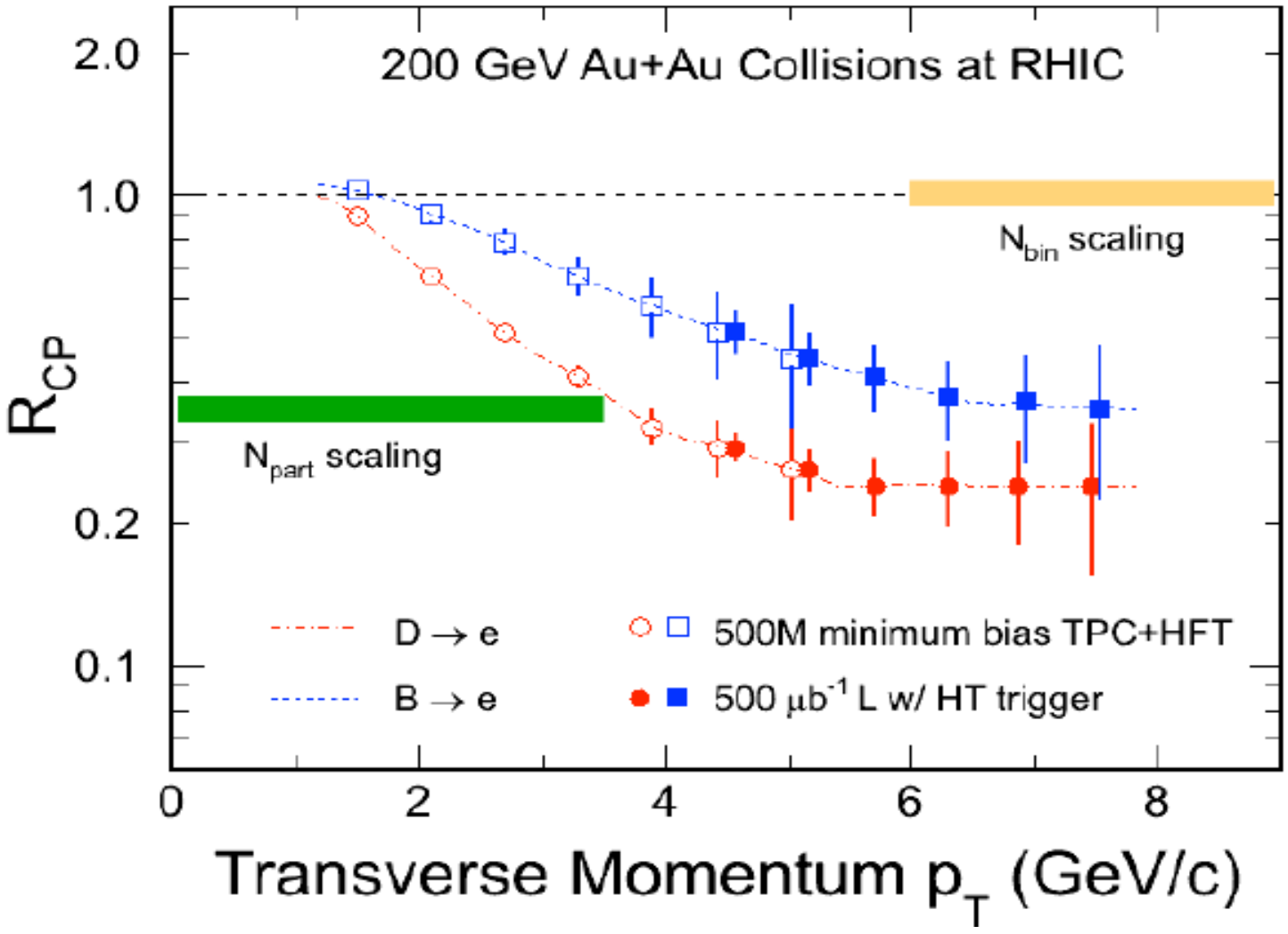
✓Small variation in ε can leads to large difference in NPE

Combining run5 and run8 results

Using “Best Linear Unbiased Estimate” *NIM A500(2003)391*,



- χ^2/ndf = 4.8/7 = 0.69
- Run05 and run08 are consistent with each other.


200 GeV Au+Au Collisions at RHIC
R_{CP}
2.0
1.0
0.2
0.1
N_{bin} scaling
N_{part} scaling
D → e
B → e
500M minimum bias TPC+HFT
500 μb^{-1} L w/ HT trigger
0
2
4
6
8
Transverse Momentum p_T (GeV/c)