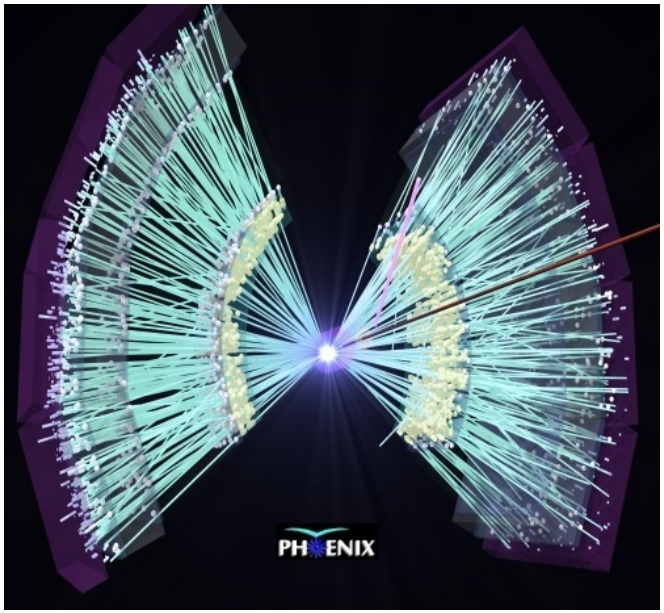


Heavy Flavor in PHENIX

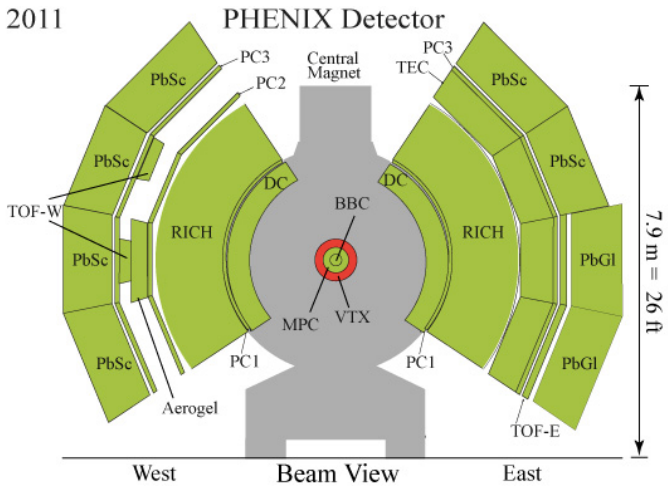
Marzia Rosati
Iowa State University

PHENIX Experiment

Hadrons, electron, photons

$|\eta|<0.35$ $\Delta\Phi = 2 \times \pi/2$

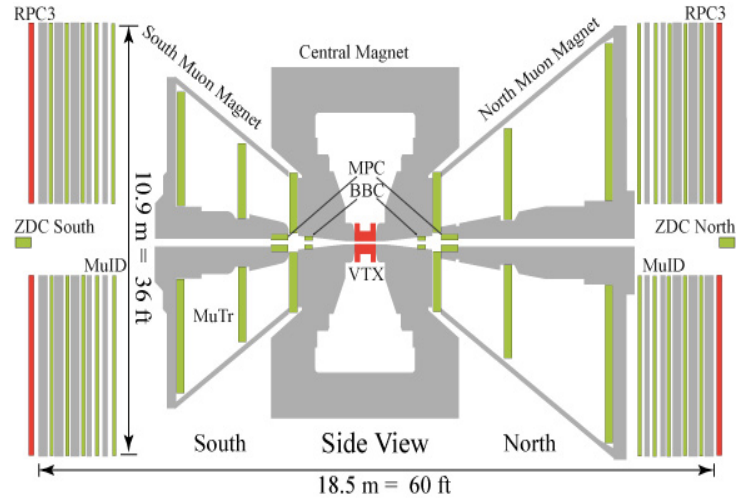
CENTRAL ARMS



Muons

$-2.2<\eta<-1.2$ $1.2<\eta<2.2$ $\Delta\Phi=2\pi$

MUON ARMS



- PHENIX has made extensive measurements at RHIC of **quarkonia** by studying dilepton decays and **open heavy flavor** through semileptonic decays.
  - New silicon vertex trackers: VTX (2011) and FVTX (2012)

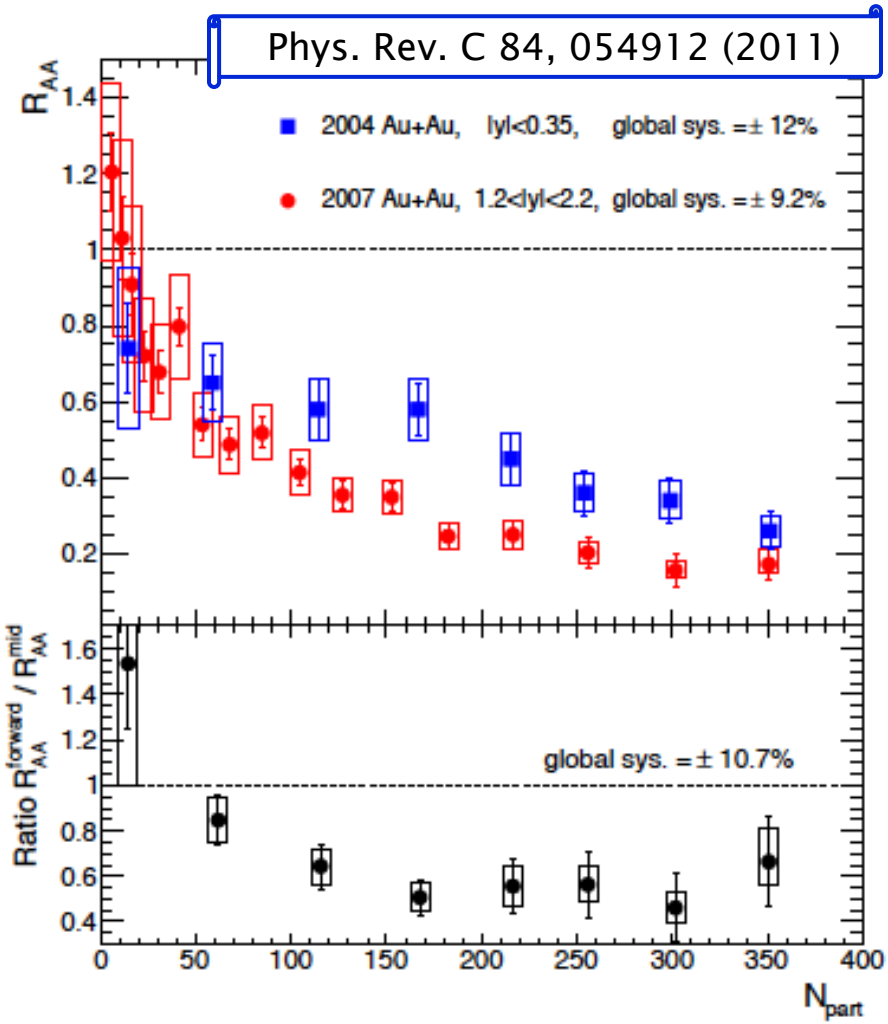
Outline

- Quarkonia
  - J/Ψ Production in Au+Au collisions at lower energy
  - J/Ψ Production in Cu+Au collisions

- Open Heavy Flavor
  - Bottom/Charm Ratio in p+p collisions
  - Bottom/Charm Ratio in Au+Au collisions
  - Bottom and Charm nuclear modification factor

Not covered in this talk are quarkonium and heavy flavor measurements in **d+Au** discussed in M. Wysocki's talk (plenary IC on Monday)

J/ψ R_{AuAu} at 200 GeV/c

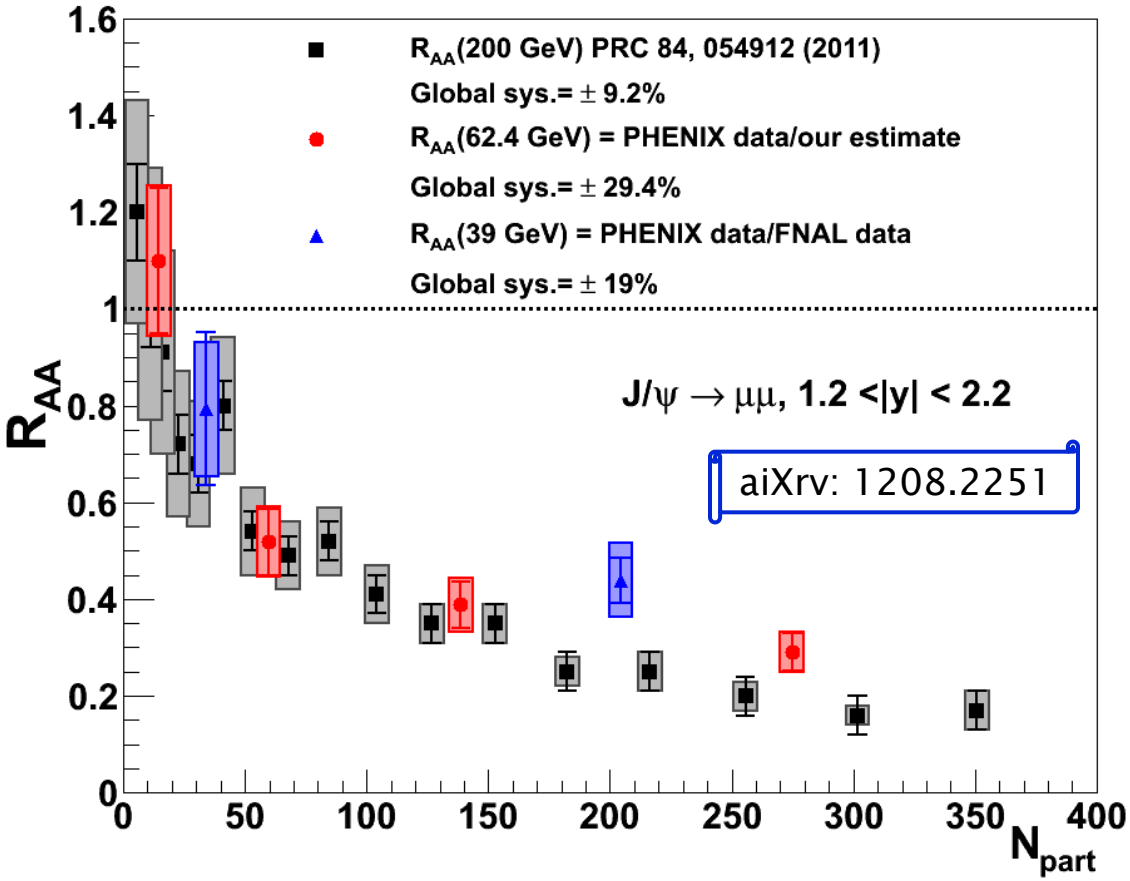


Understanding quarkonium production in media requires disentangling the interplay between

- cold nuclear matter effects
- quark gluon plasma screening
- possible production through regeneration

J/ψ R_{AuAu} at forward rapidity

- New J/ψ R_{AuAu} at $\sqrt{s} =$ 62 GeV and 39 GeV

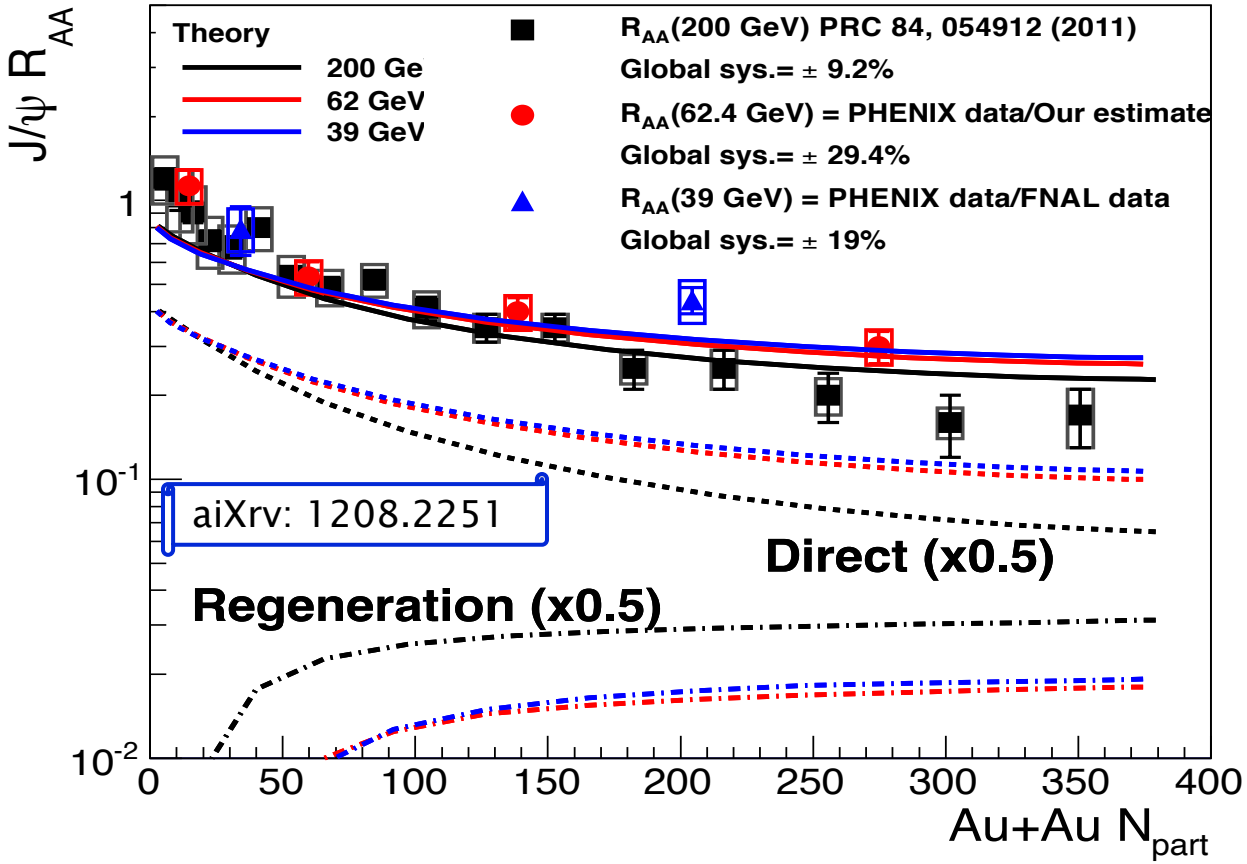


62 GeV suppression follows the trend of the 200 GeV

These data provide a strong constraint to theoretical models

J/ψ R_{AuAu} at forward rapidity

X. Zhao, R. Rapp
Phys Rev C82 064905 (2010)

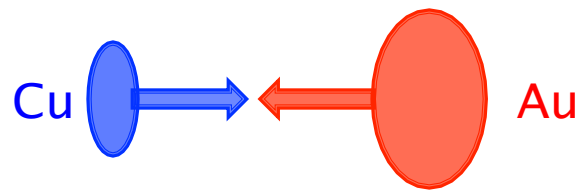


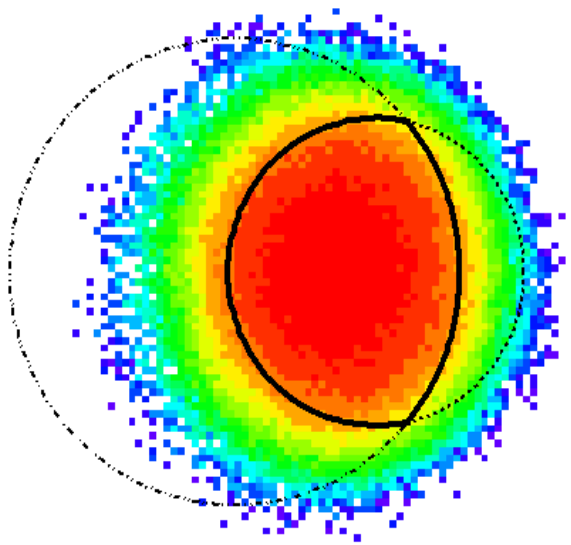
Theory agrees with data, suggesting similarity of R_{AA} from 39 to 200 GeV originates from cancellation of suppression and regeneration

D. McGlinchey's talk Parallel 1D on Tuesday

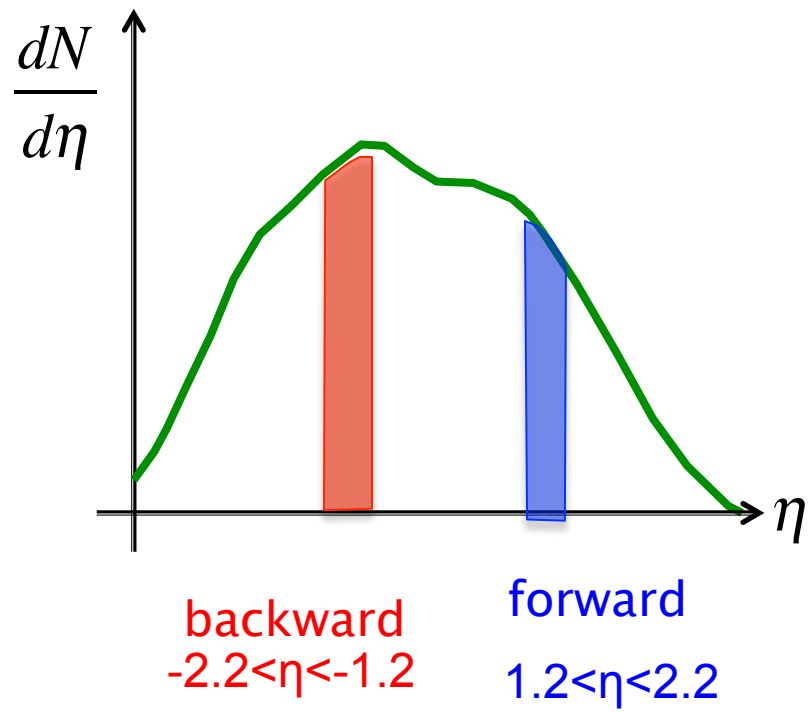
NEW: $J/\Psi \rightarrow \mu^+\mu^-$ in Cu+Au Collisions

New asymmetric Collisions in Run 2012: geometry control

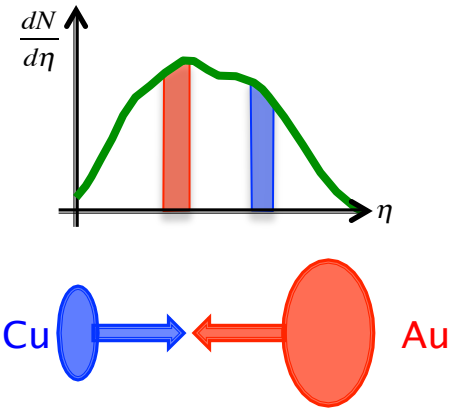


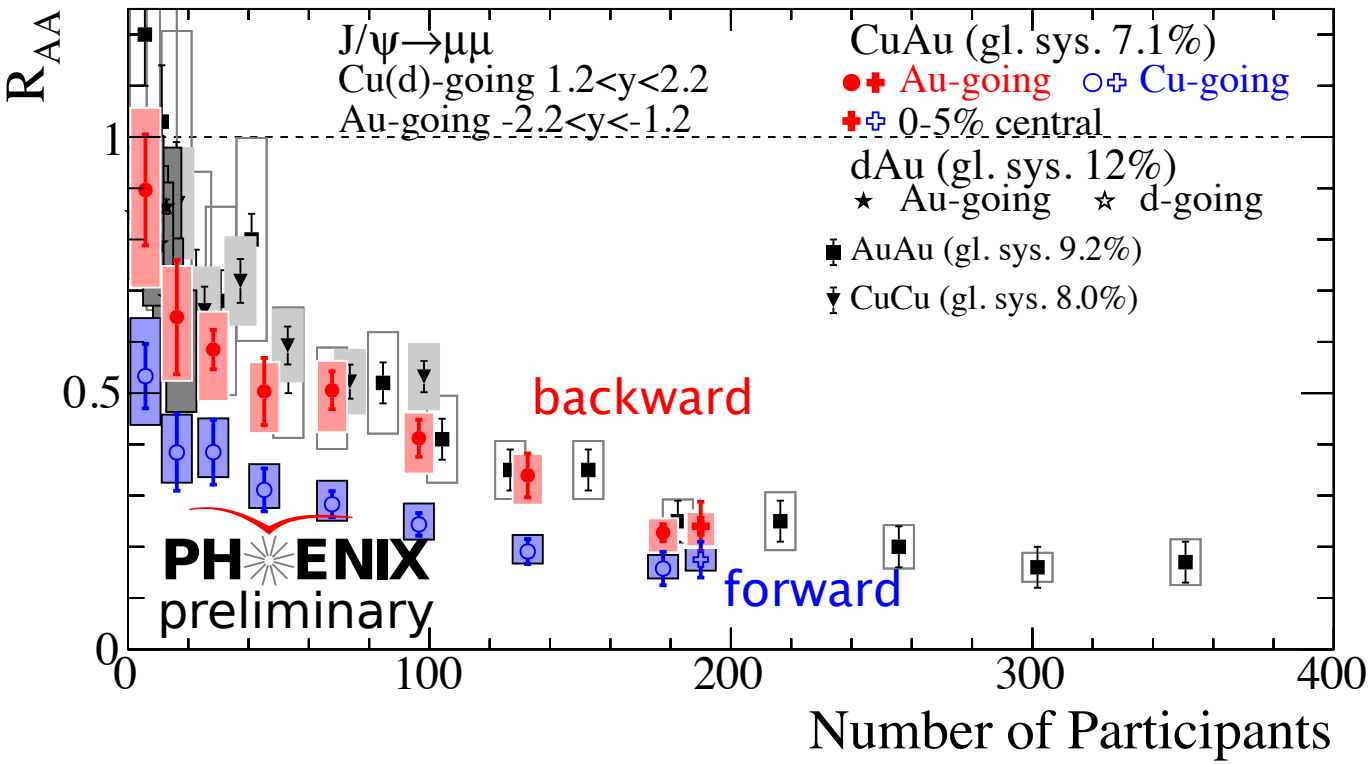


Cu+Au – b=4fm
Nuclear overlap
Density function



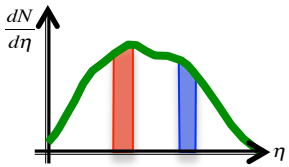
$J/\psi \rightarrow \mu^+\mu^-$ production in Cu+Au

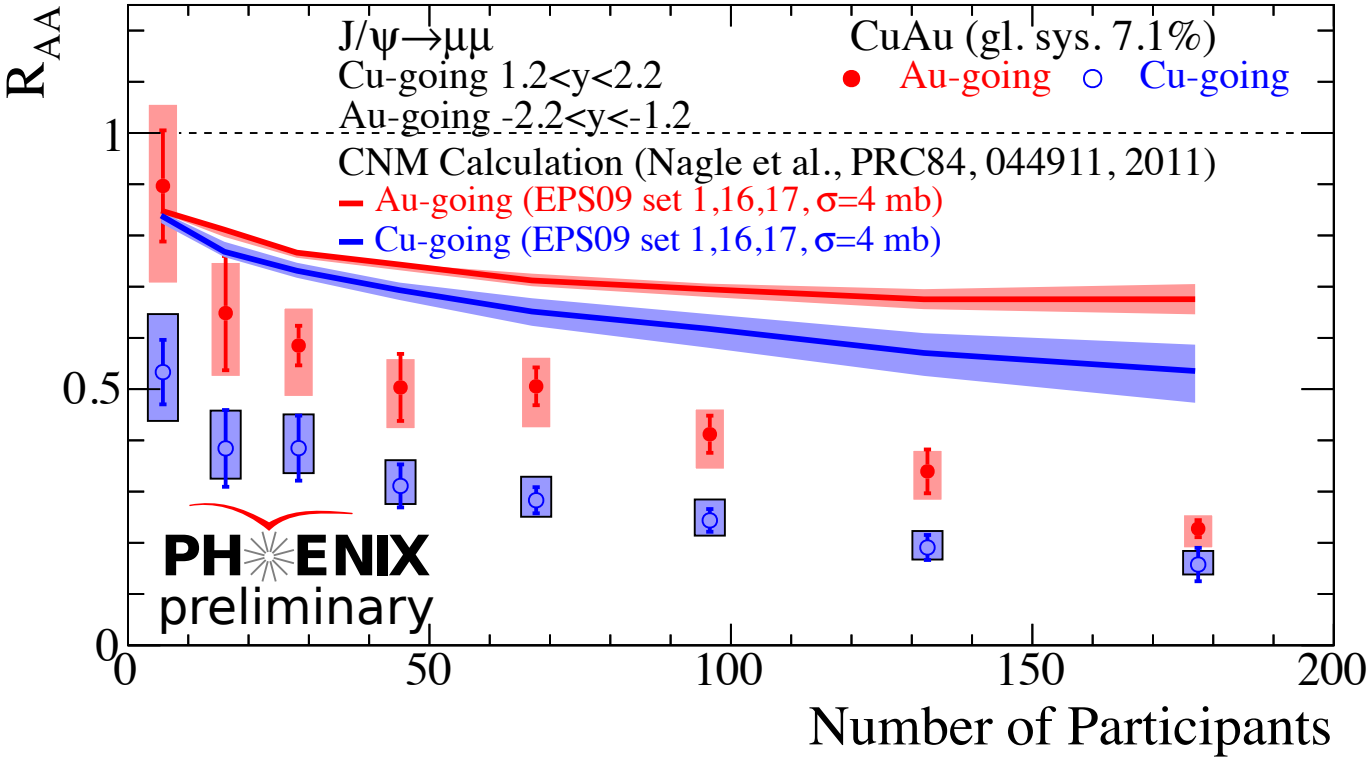


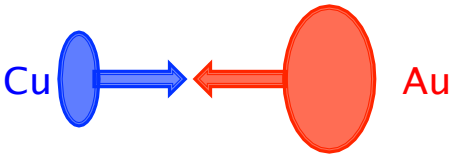


- Au-going follows trend
- Cu-going shows stronger suppression

J/ψ→μ⁺μ⁻ production in Cu+Au



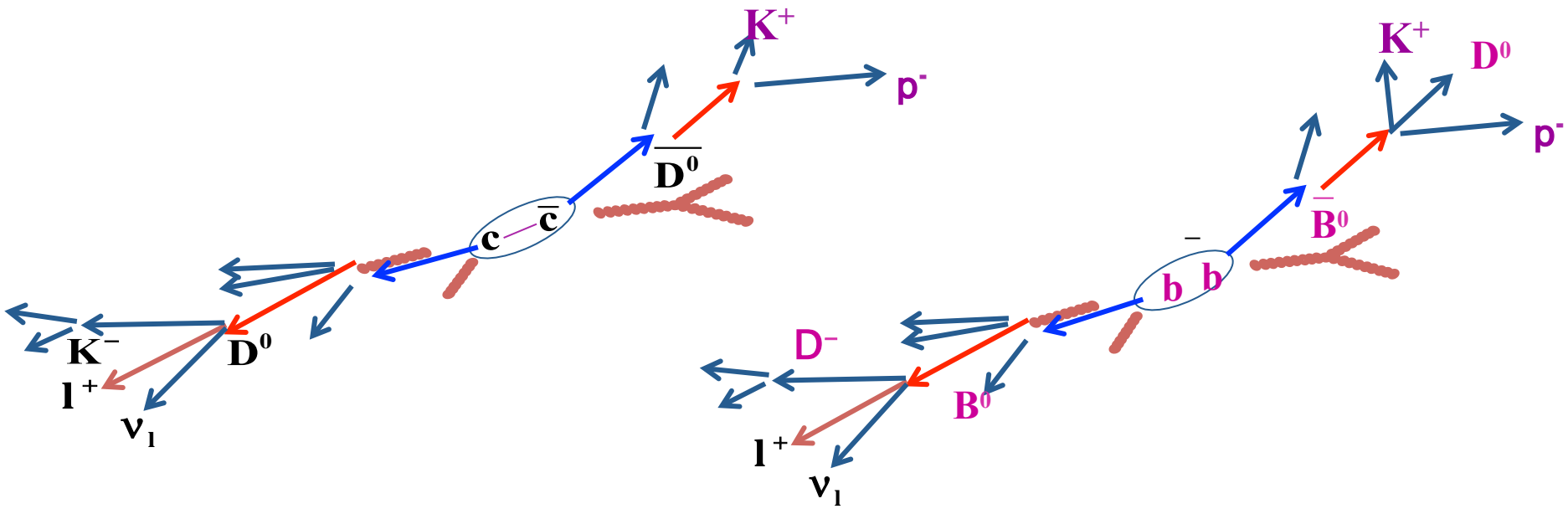




- Cold nuclear matter effects have the same trend but the data show additional suppression

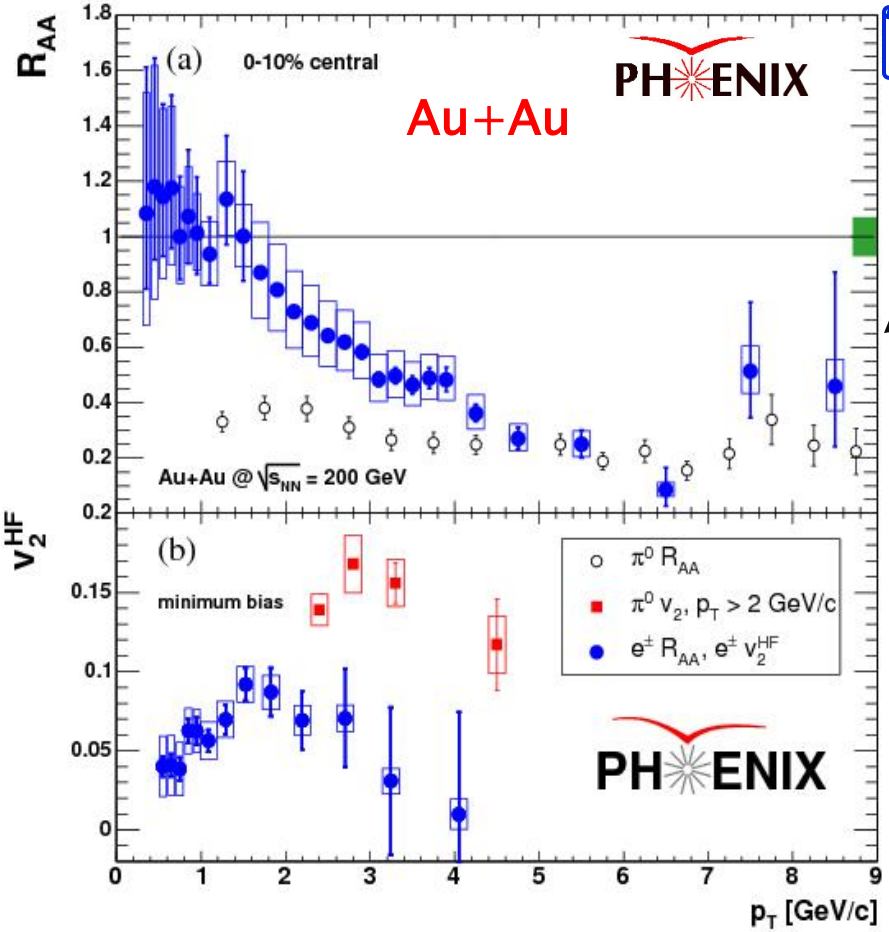
R. Hollis' talk Parallel 7D on Friday

Open Heavy flavor Measurements



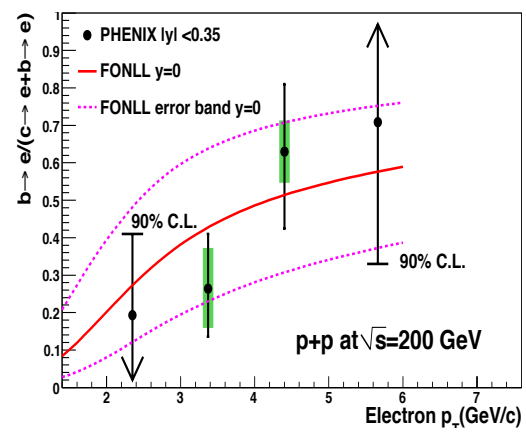
- Indirect measurement using semileptonic heavy-flavor decays
- Measure contribution of heavy flavor to lepton spectra

PHENIX Open Heavy Flavor



Phys.Rev. C84 (2011) 044905

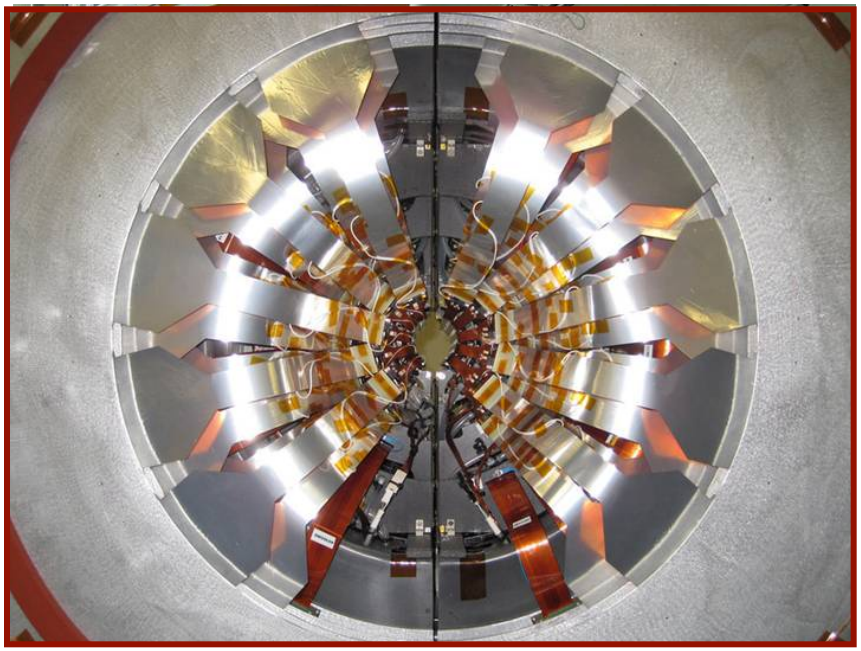
- Extensive measurement of heavy flavor R_{AA} and v_2.
- Indirect measurement of bottom/charm ratio in p+p collisions using e-h correlations



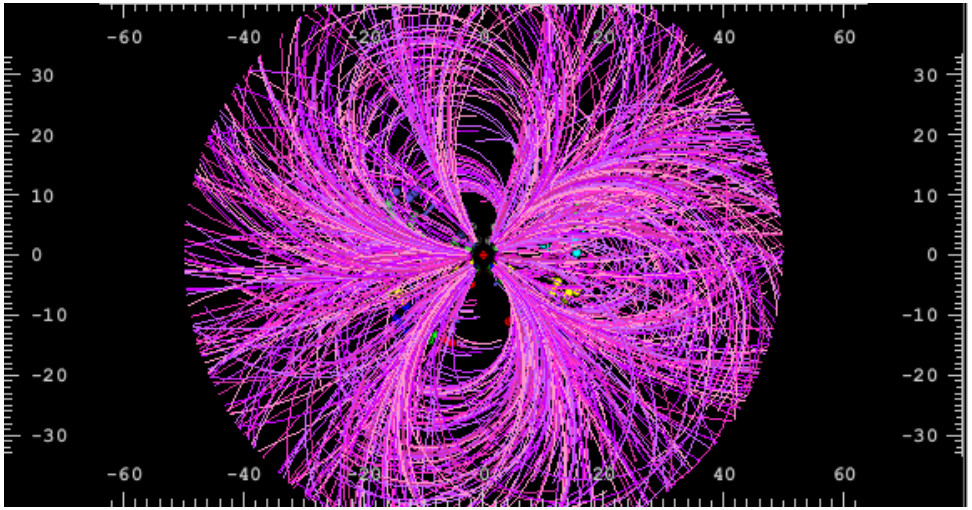
Phys. Rev. Lett. 103, 082002 (2009)

2011 PHENIX VTX upgrade

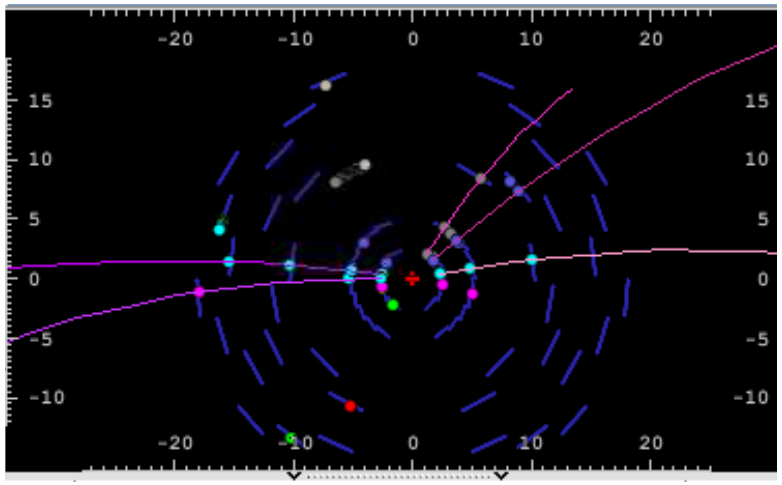
Front view of VTX



RUN2011: Au+Au at 200 GeV



Run 2012: p+p at 200 GeV



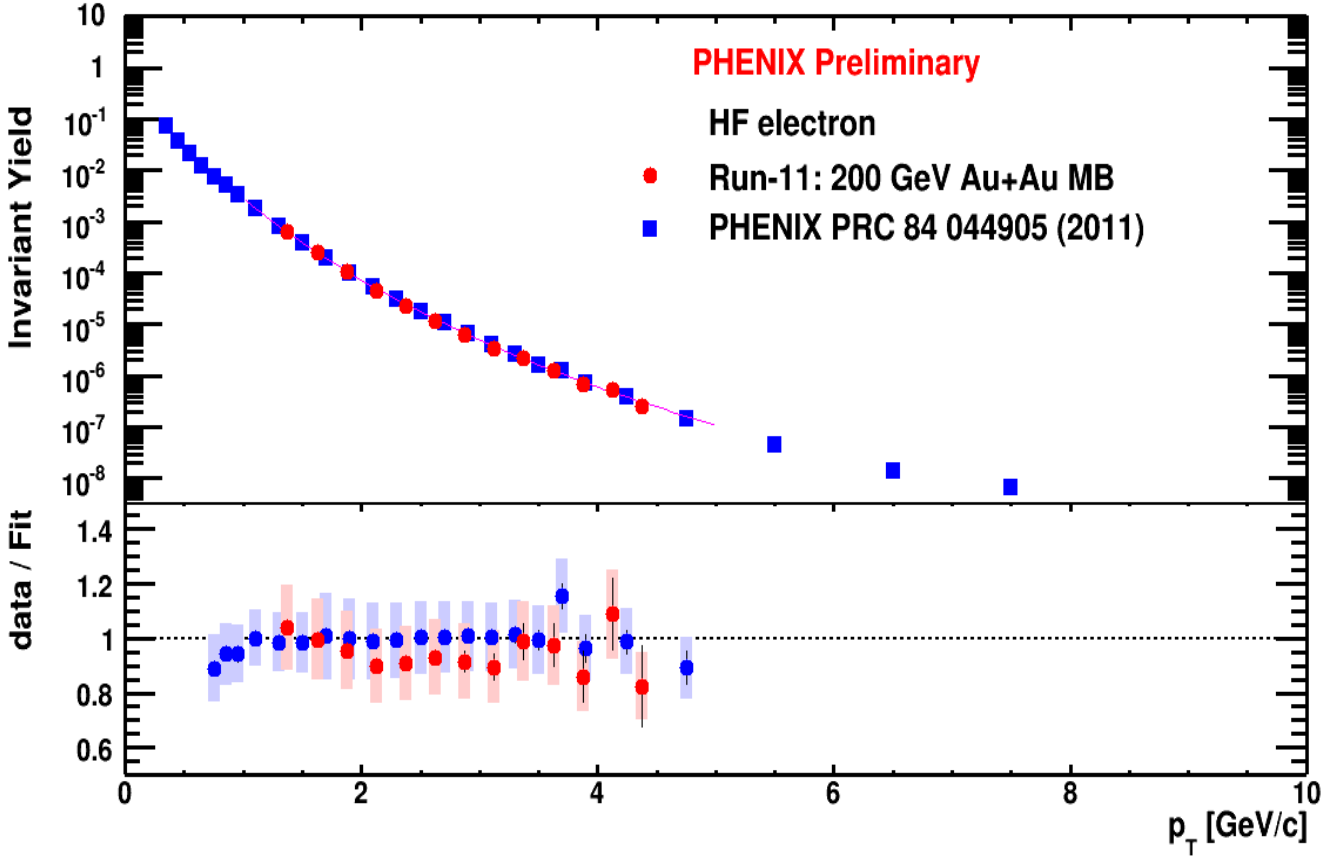
Heavy Flavor electron spectra

- Inclusive electron spectra include:
  - Charm semi-leptonic decays
  - Bottom semi-leptonic decays
  - π^0 Dalitz decays and photon conversions (photonic)

- VTX provides two new capabilities:
  1) Tag and reject conversion providing an independent measurement of photonic background
  2) Measure distance of closest approach to separate charm and bottom components of heavy flavor spectra

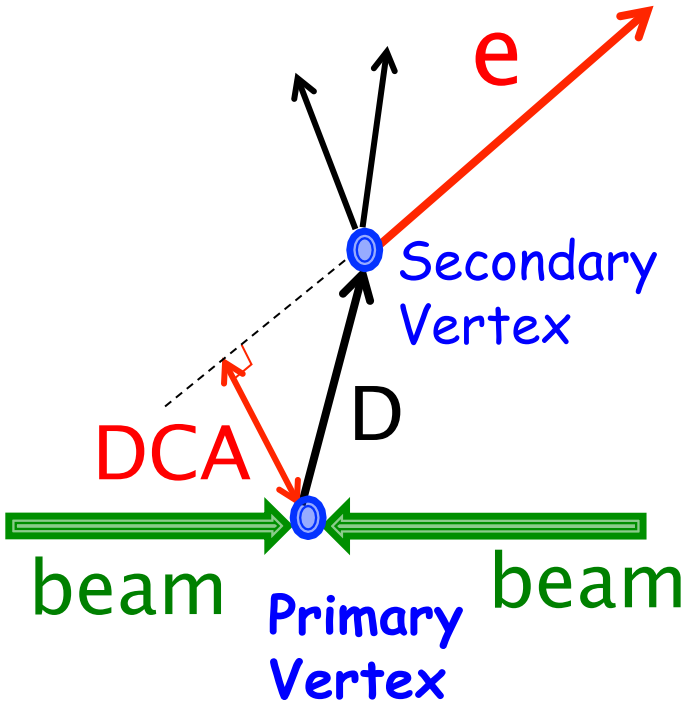
HF invariant yield in Au+Au

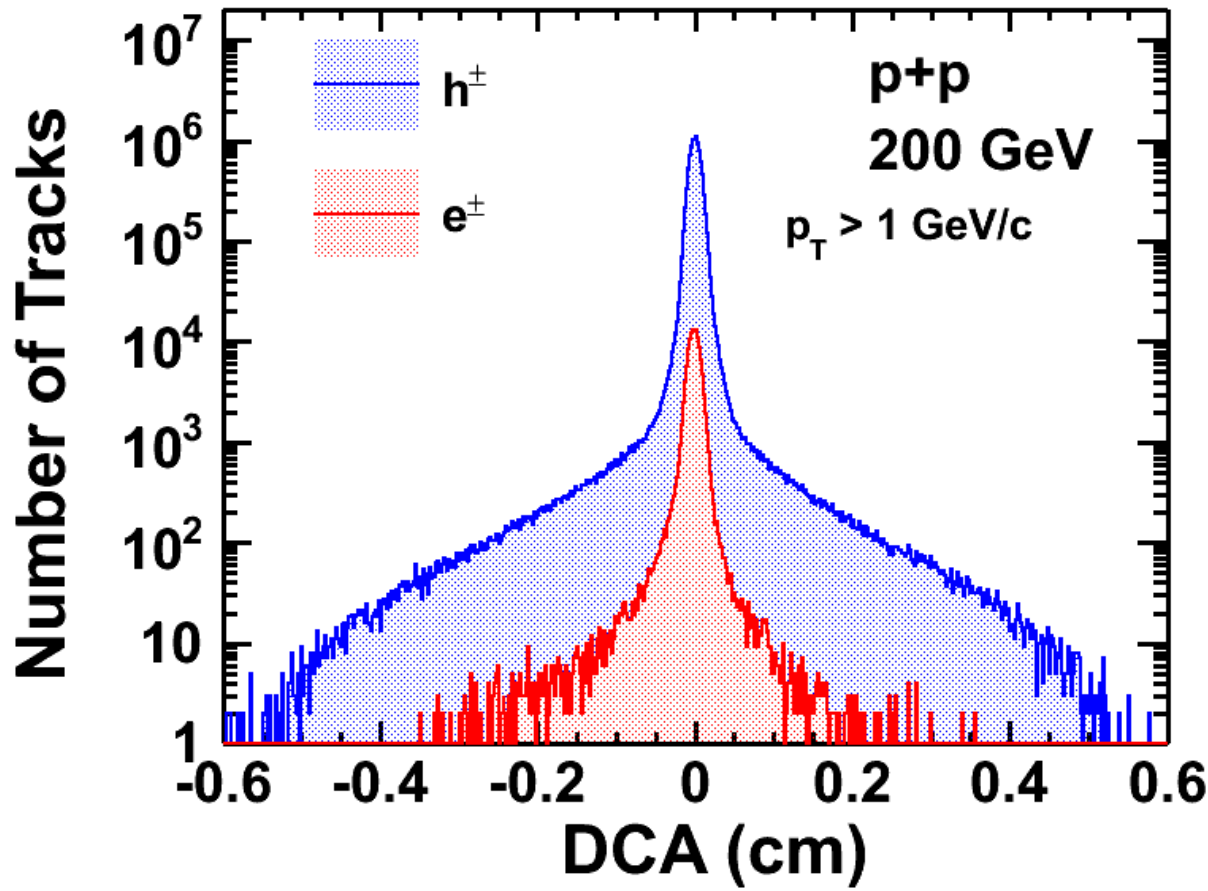
- Using the photonic electron estimated by the VTX, we measure the heavy flavor (HF) electron spectra



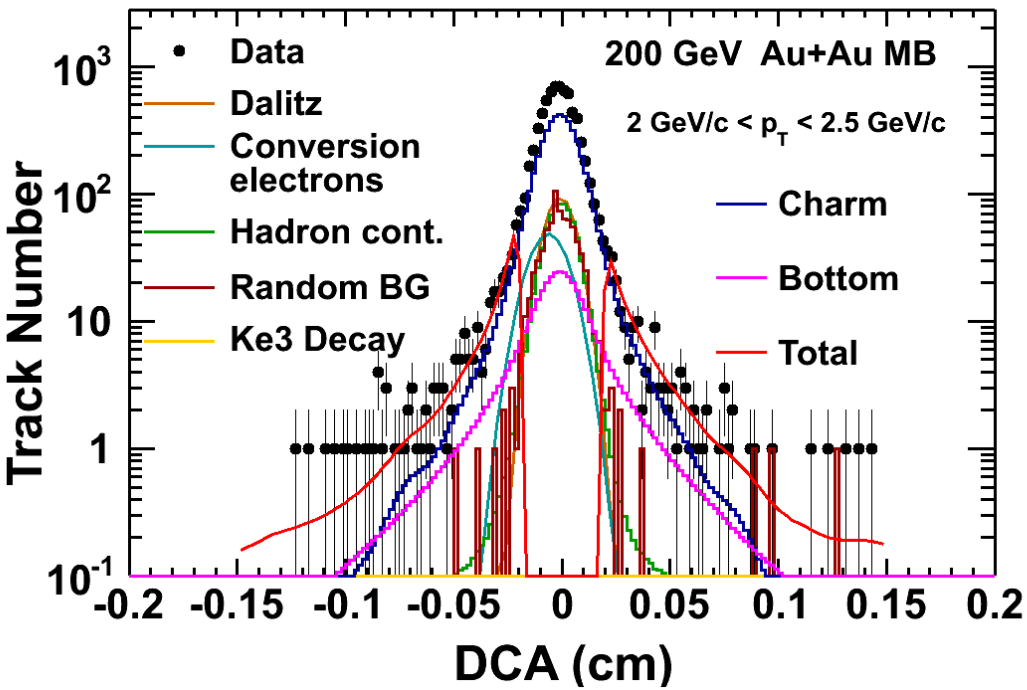
Run 2011 HF spectra consistent with previously published HF by PHENIX

Distance of closest approach (DCA)





Electron Distance of Closest Approach



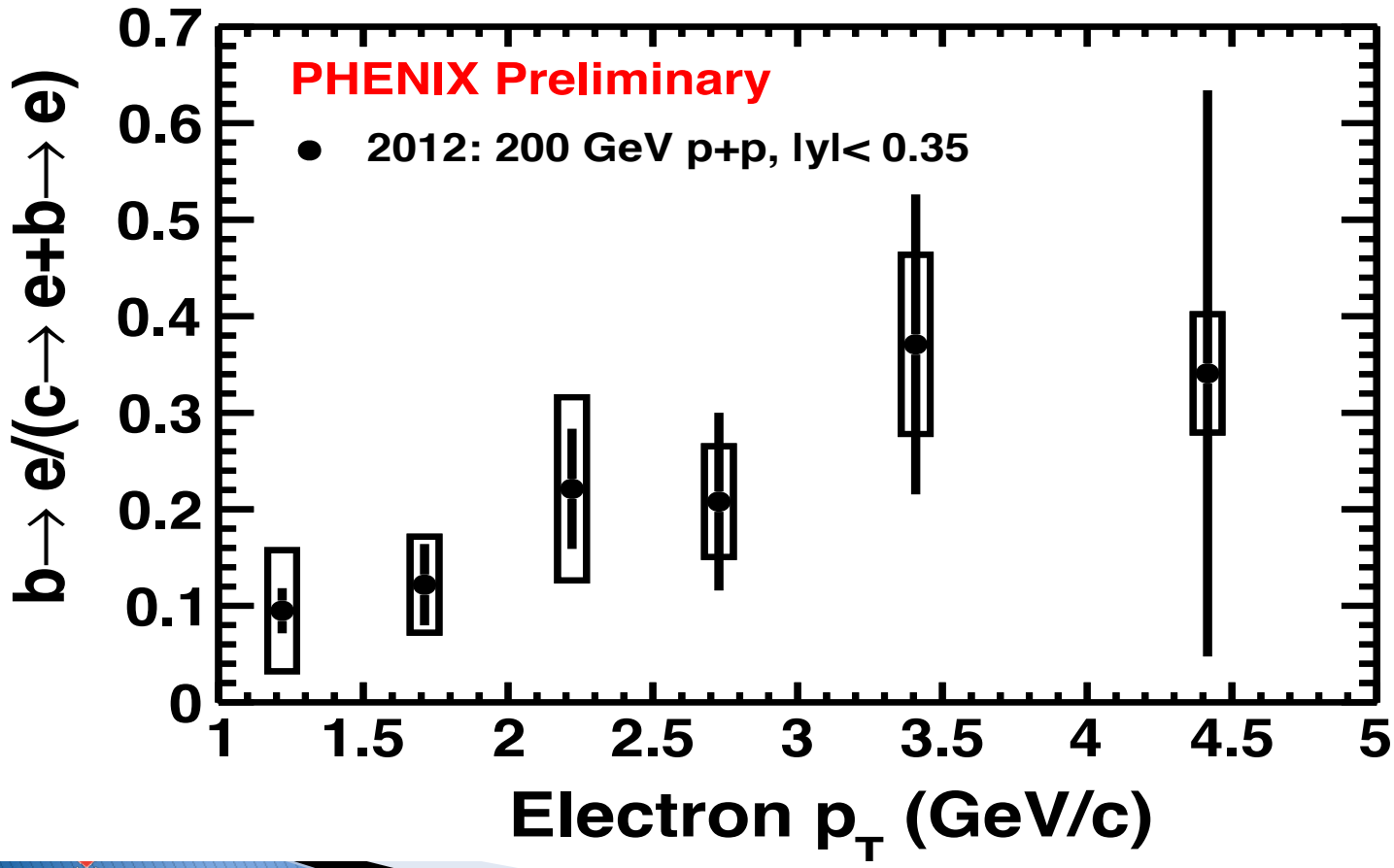
- DCA decomposition uses expected DCA shapes from simulation for all known electron sources to extract bottom/charm ratio

$$\frac{b \to e}{c \to e + b \to e} = 0.08 \pm 0.02$$

R. Nouicer's talk
Parallel #6A on Friday

First direct measurement of bottom production at RHIC: p+p

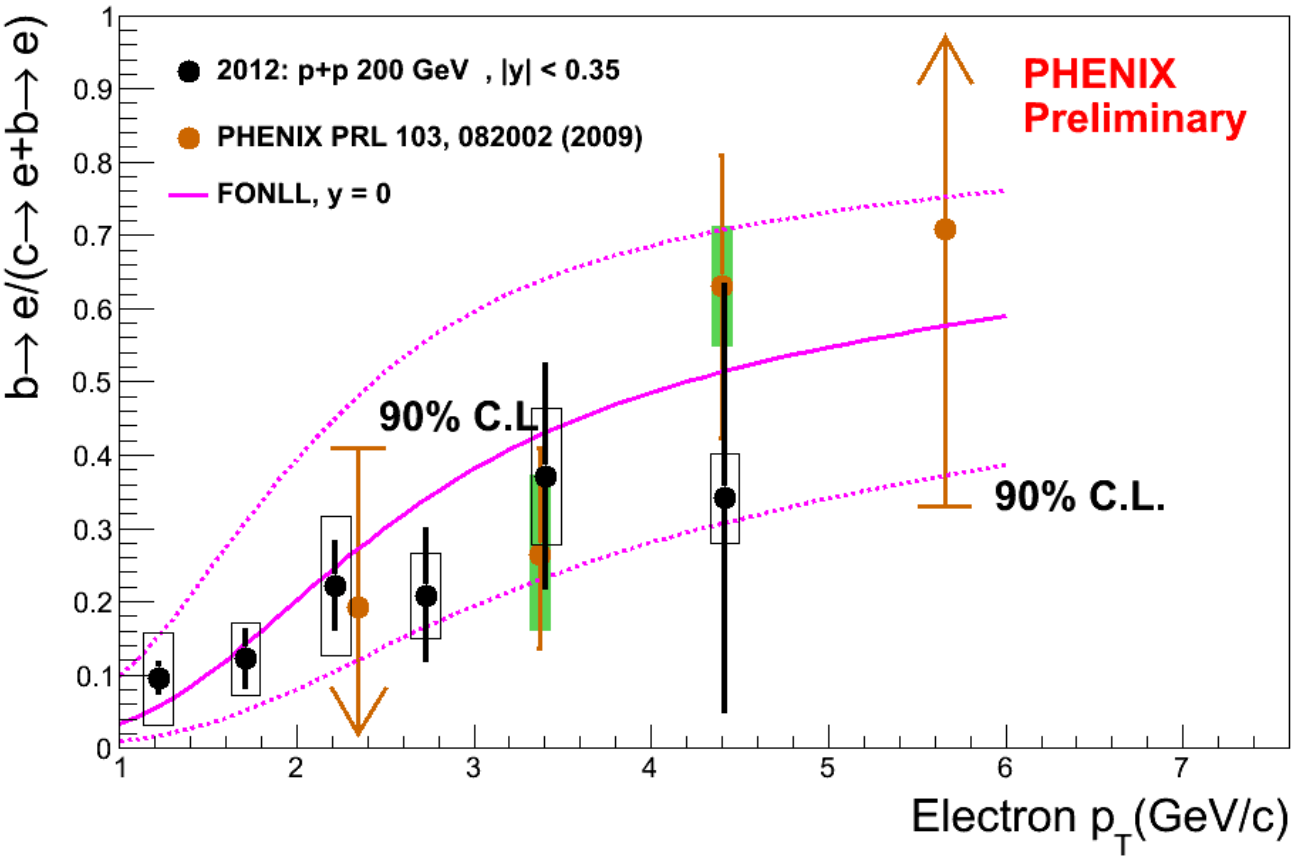
- From the fit of the DCA distributions $\frac{b \to e}{c \to e + b \to e}$



First direct measurement of bottom production in p+p at RHIC

- From the fit of the DCA distributions

$$\frac{b \rightarrow e}{c \rightarrow e + b \rightarrow e}$$

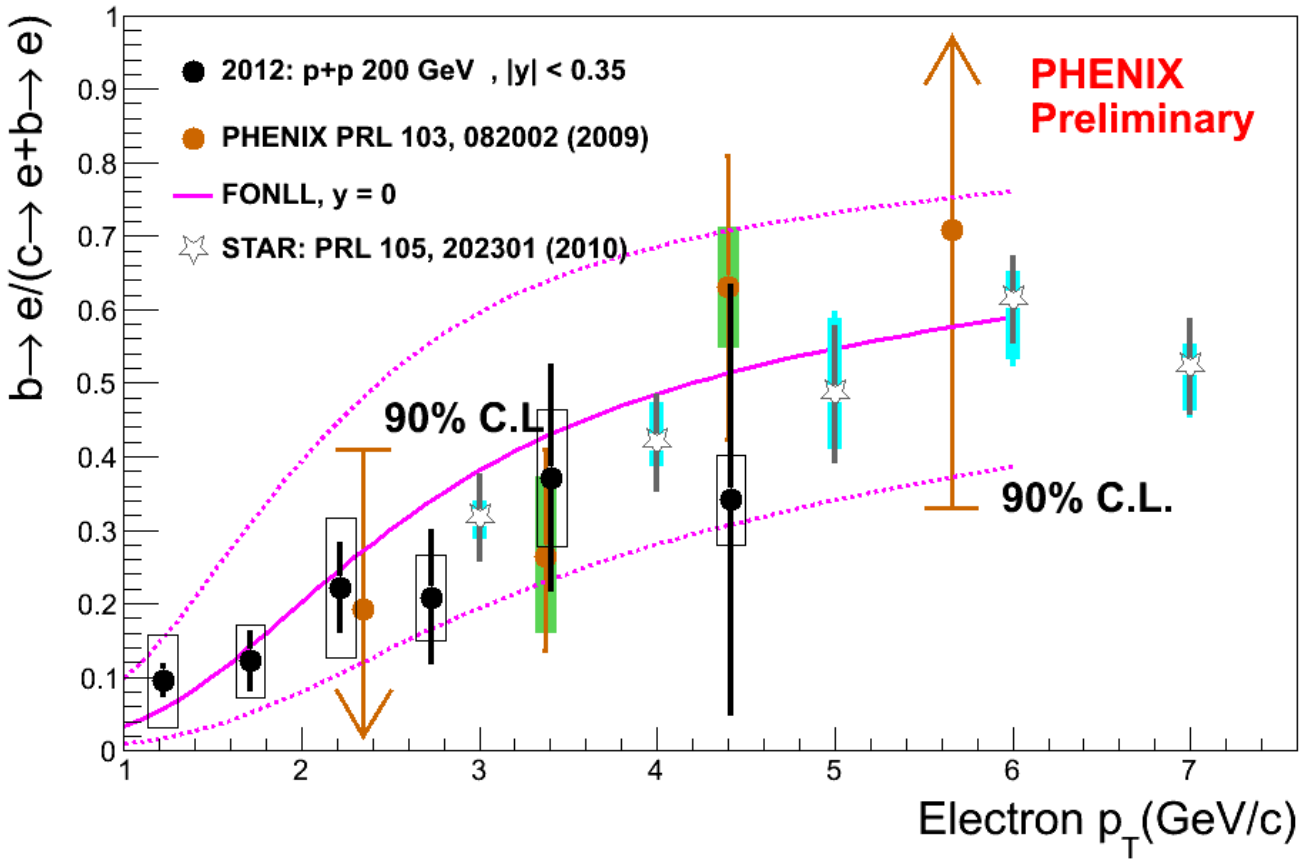


FONLL agrees with our data

First direct measurement of bottom production in p+p at RHIC

- From the fit of the DCA distributions

$$\frac{b \to e}{c \to e + b \to e}$$



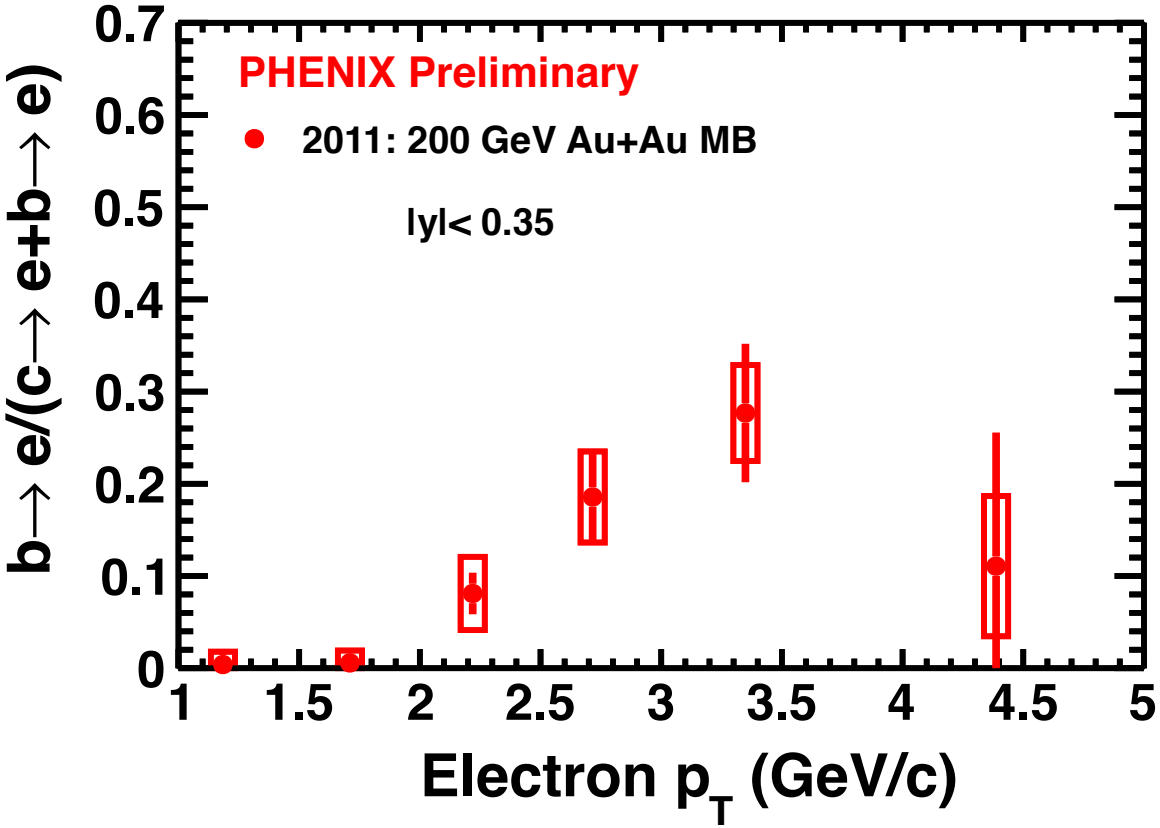
FONLL agrees with our data

STAR indirect measurement consistent with our data

First direct measurement of bottom production at RHIC: Au+Au

- From the fit of the DCA distributions

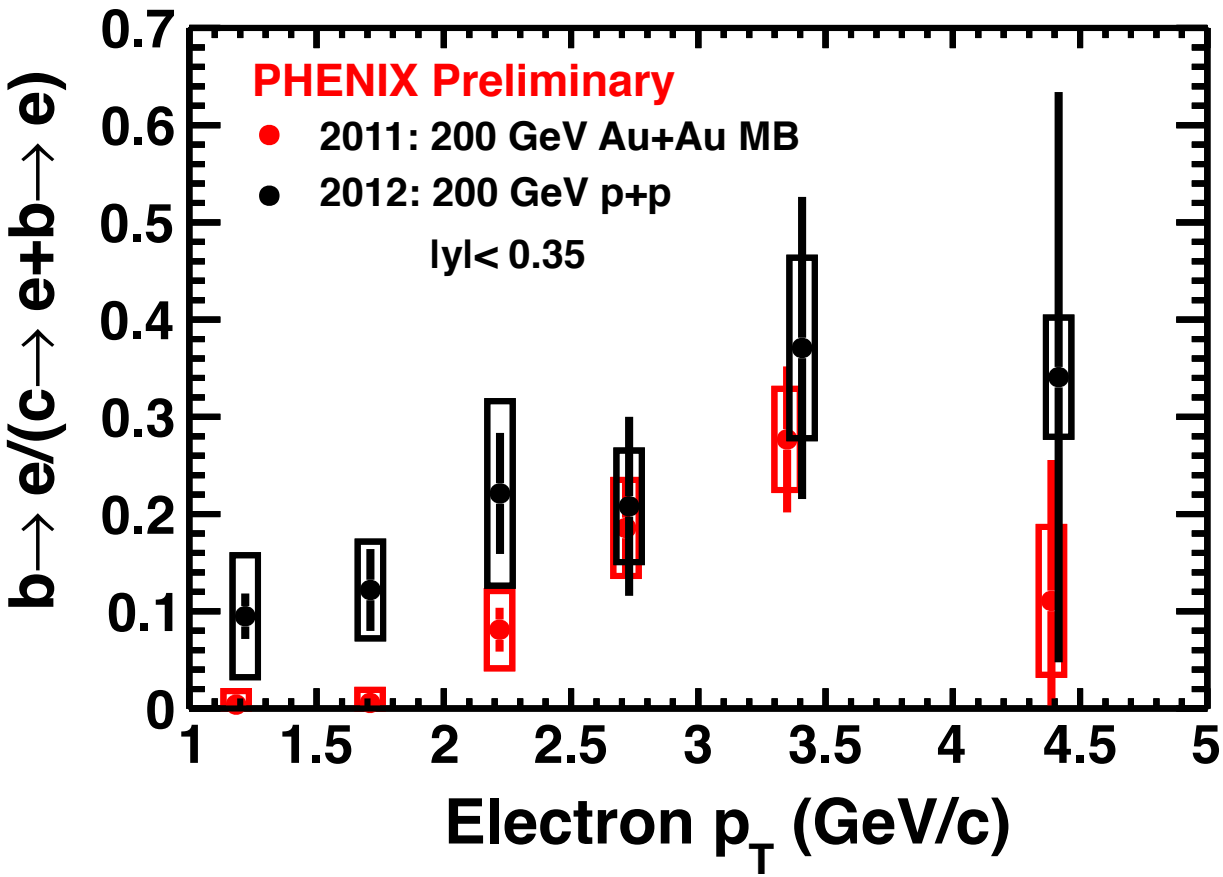
$$\frac{b \to e}{c \to e + b \to e}$$



First direct measurement of bottom production at RHIC: Au+Au

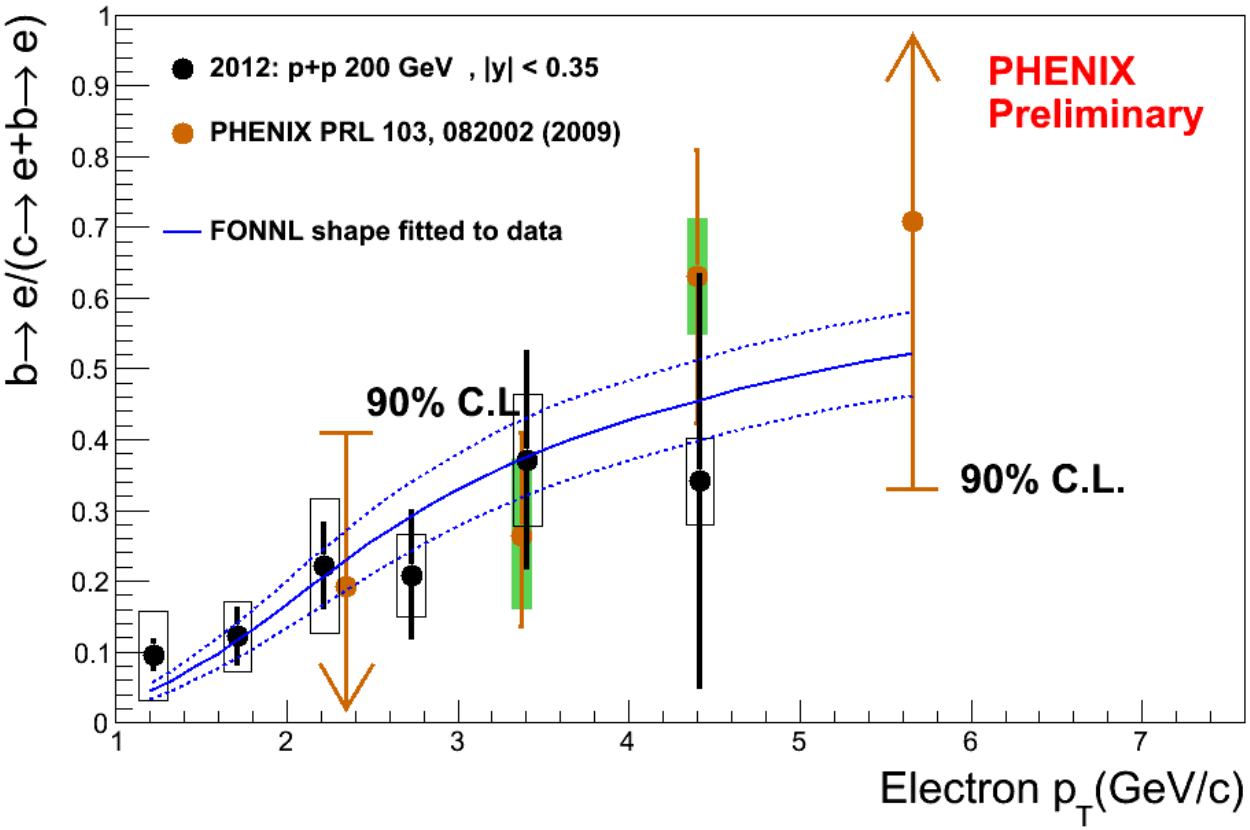
- From the fit of the DCA distributions

$$\frac{b \rightarrow e}{c \rightarrow e + b \rightarrow e}$$



Bottom in Au+Au appears more suppressed

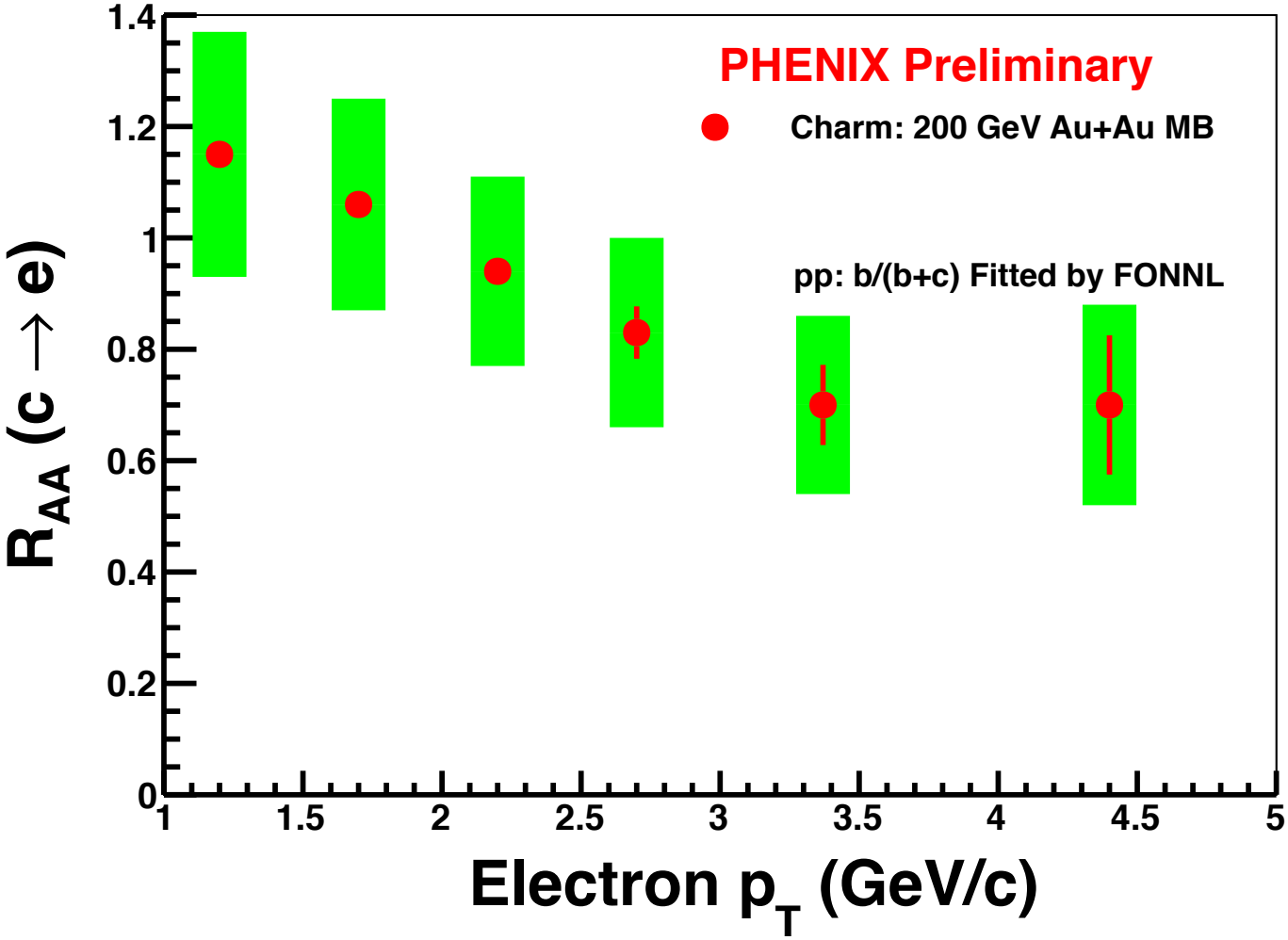
Bottom fraction in p+p and FONLL



- p+p data trend is in good agreement with FONLL
- We use the FONLL shape to **fit** the data and determine a p+p reference

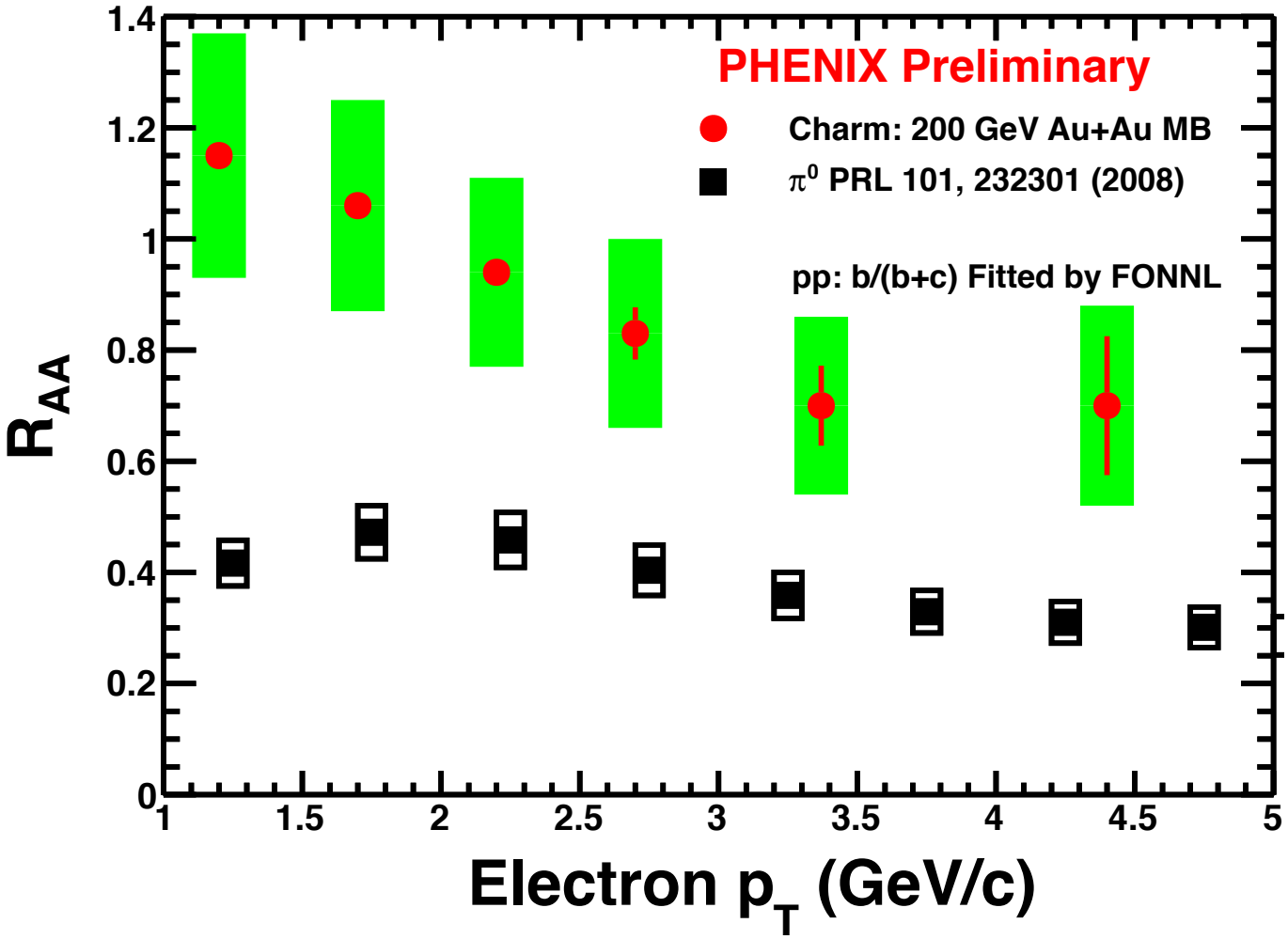
Charm R_{AA}

$$R_{AA}(c \to e) = R_{AA}^{HF} \frac{F_{AA}^{c \to e}}{F_{pp}^{c \to e}}$$



Charm R_{AA}

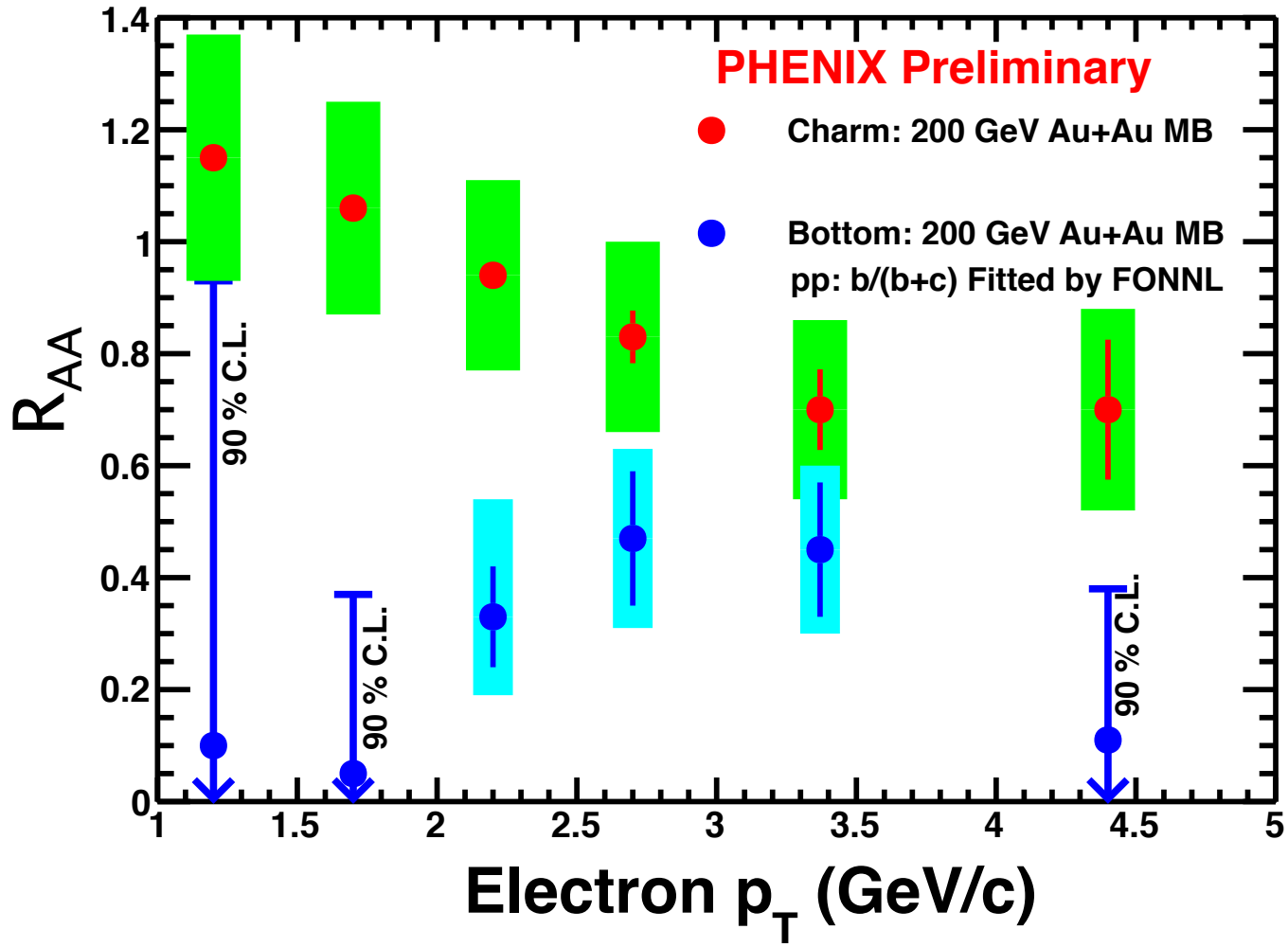
$$R_{AA}(c \to e) = R_{AA}^{HF} \frac{F_{AA}^{c \to e}}{F_{pp}^{c \to e}}$$



Charm less suppressed than π^0

Bottom and Charm R_{AA}

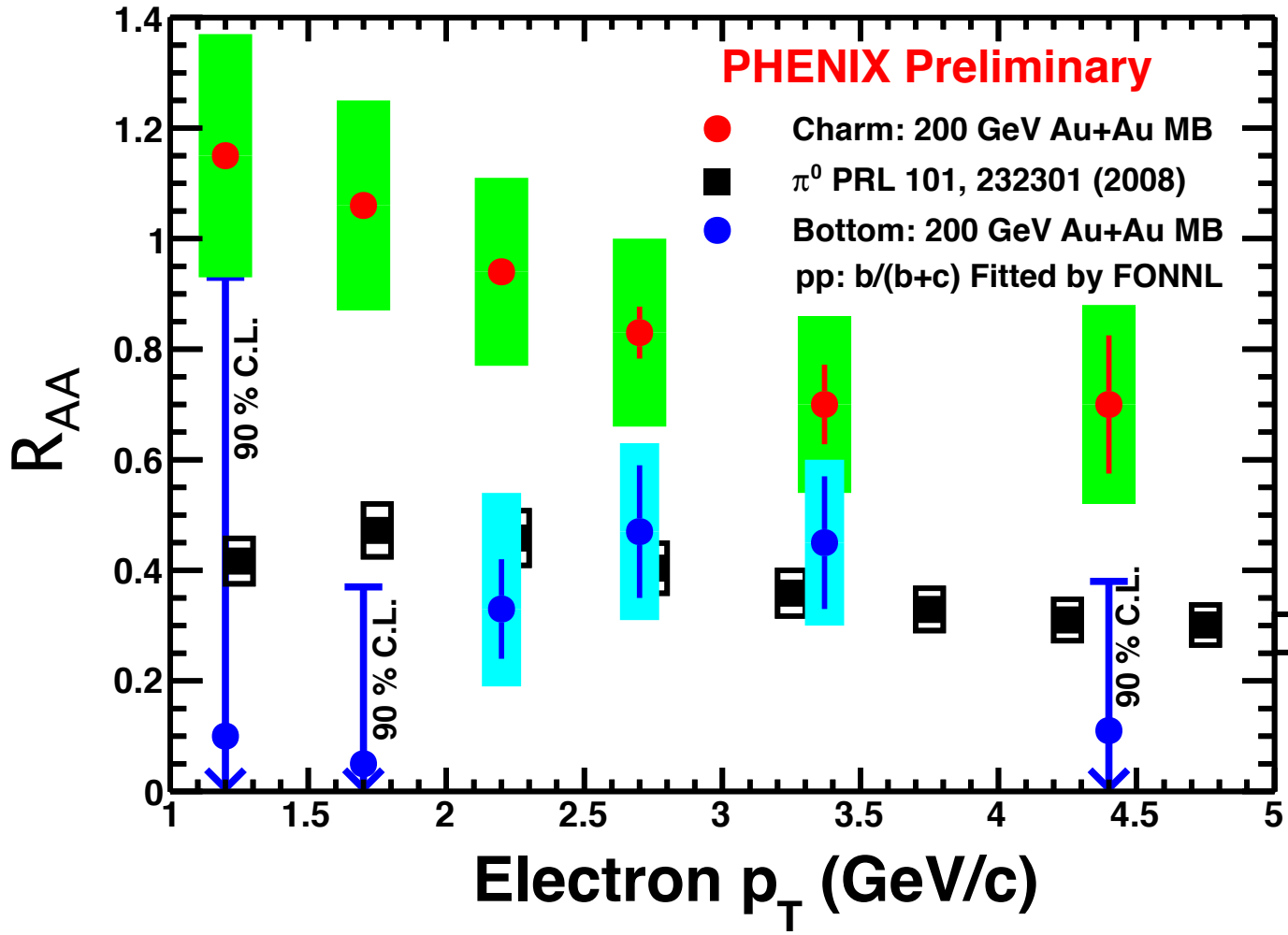
$$R_{AA}(b \to e) = R_{AA}^{HF} \frac{F_{AA}^{b\to e}}{F_{pp}^{b\to e}}$$



No simple mass hierarchy in heavy flavor

Bottom and Charm R_{AA}

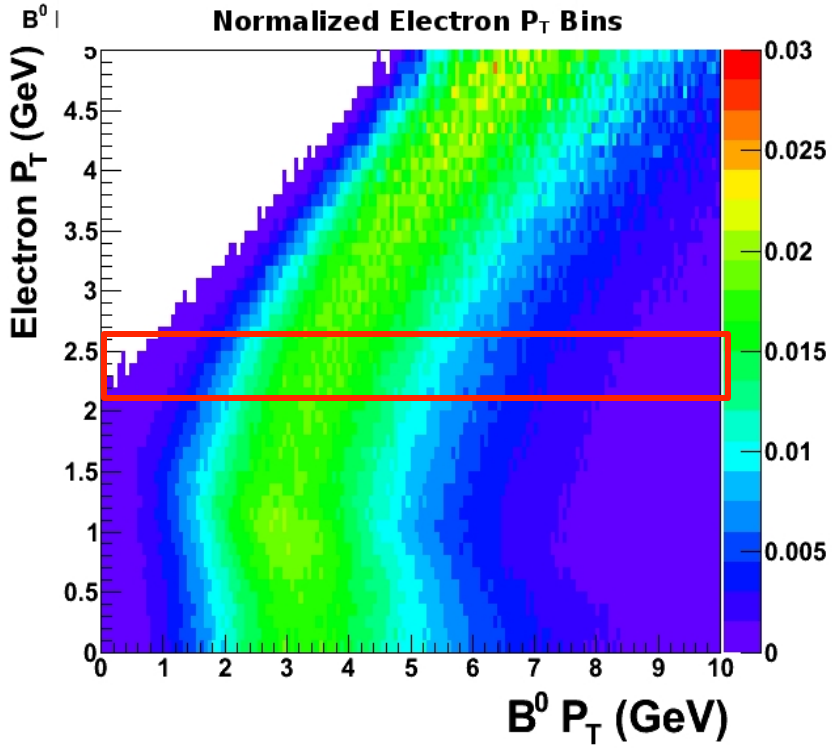
$$R_{AA}(b \to e) = R_{AA}^{HF} \frac{F_{AA}^{b\to e}}{F_{pp}^{b\to e}}$$



- No simple mass hierarchy in heavy flavor

R. Nouicer's talk Parallel 6A on Friday

We measure electrons

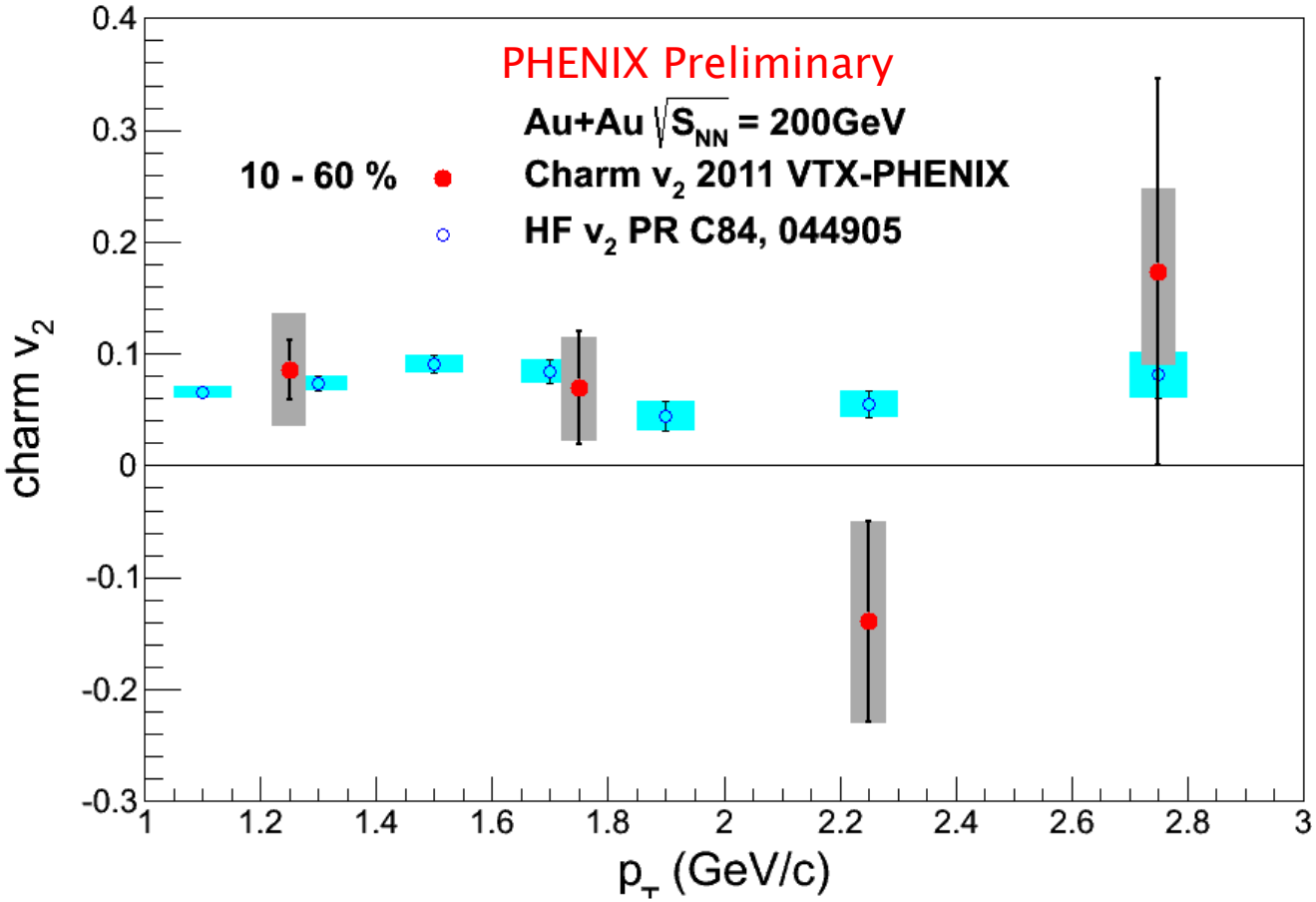


PYTHIA simulation of B^0 decays

Electrons with $2GeV/c<p_T<2.5GeV/c$ are coming from B mesons with $p_T=2-4GeV/c$ that have $\beta\gamma=0.4-0.8$

Charm v_2

Using DCA decomposition



M. Kurosawa talk Parallel #3A talk on Wednesday

More on Quarkonia and Heavy Flavor

- Plenary IC on Monday: M Wysocki – PHENIX Results on Cold Nuclear Matter
- Parallel 1D on Tuesday: D. McGlinchey – Recent Heavy Quarkonia Results from PHENIX
- Parallel 3A on Wednesday: M. Kurosawa – Higher harmonics flow measurement of charged hadrons and electrons in wide kinematic range with PHENIX VTX tracker
- Parallel 6A on Friday: R. Nouicer – Probing Hot and Dense Matter with c and b measurements with PHENIX VTX tracker
- Parallel 7D on Friday: R. Hollis – Forward/backward raction plane dependent J/ψ production and hadron v_n in Cu +Au Collisions in PHENIX
- Poster #134: R. Akimoto – Measurement of charm and bottom yields in Au+Au collisions at PHENIX
- Poster # 152: N. Apadula – Single electrons from heavy flavor decays in 200GeV Cu+Cu collisions at PHENIX
- Poster # 118: C. Chen – Production of heavy flavor quark in p+p collisions
- Poster # 130: L. Ding – PHENIX v2 measurement of single electron from heavy flavor decays in Au+Au at 62GeV
- Poster #131: M. Durham – A detailed study of open heavy flavor production, enhancement, and suppression at RHIC
- Poster# 127: T. Hachiya – Event anisotropy from charm and bottom quark decays in 200 GeV Au+Au collisions at RHIC_PHENIX
- Poster #125: A Iordanove – Forward J/ψ production in Au+Au and CU+Au collisions at PHENIX
- Poster #133: A. Lebedev – χ_C measurement in PHENIX: the present, the future
- Poster #128: K. Lee –Cold Nuclear Matter effects on ϒ(1S+@S+#S) production
- ster # 151: S. Lim – Heavy Quark Production at forward rapidity in d+Au Collisions at 200GeV
- Poster #121: L. Patel – Study of bbar production using correlated like sign di-muon at PHENIX
- Poster #122: A. Sen – PHENIX J/ψ measurement in Au+Au collisions at 39 and 62 GeV
- Poster #123: S. Whitaker – Measurement of ϒ R_{AA} at PHENIX

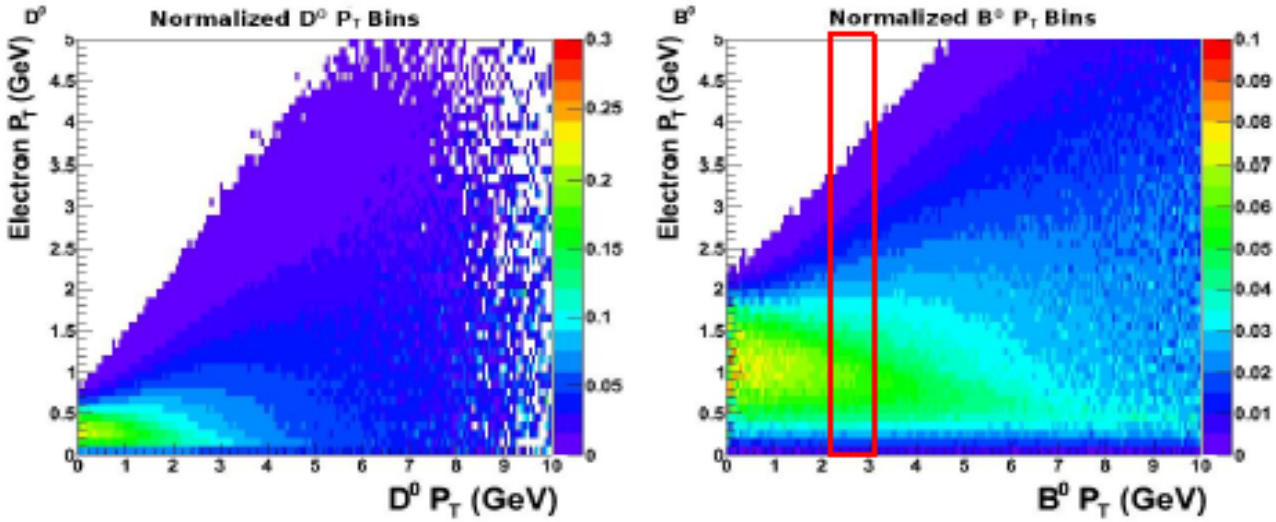
5 talks
13 posters

Summary

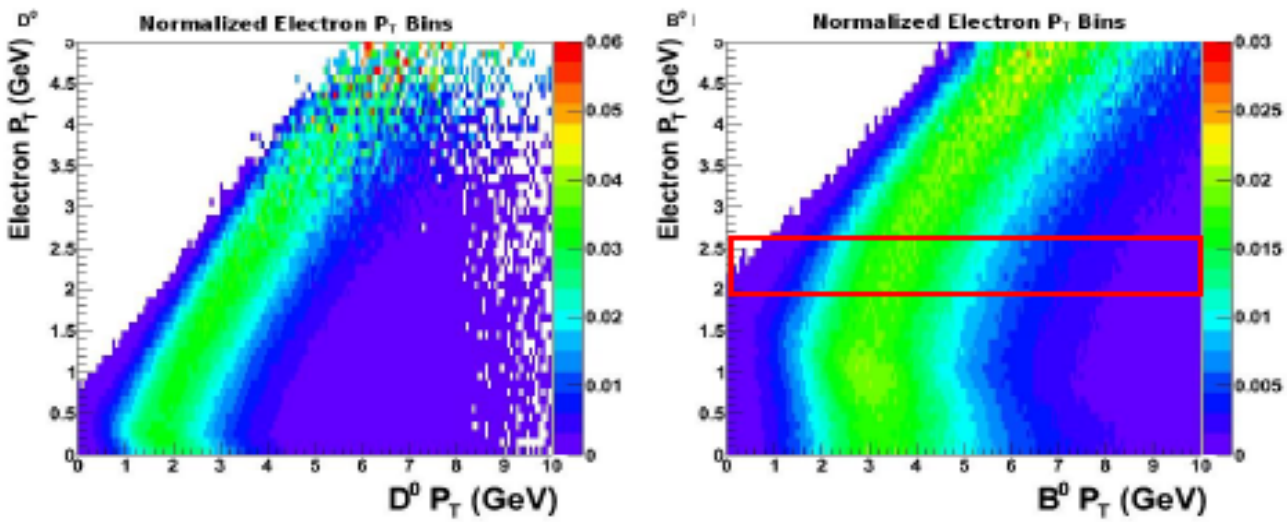
- New quarkonium results explore suppression by varying collision energy and geometry that provides stringent constraints on theoretical models.

- First direct measurement of charm and bottom separately shows that suppression pattern is complex and doesn't follow simple mass hierarchy

Backup



Example: Distribution of electron p_T for B mesons with p_T = 2-3 GeV/c



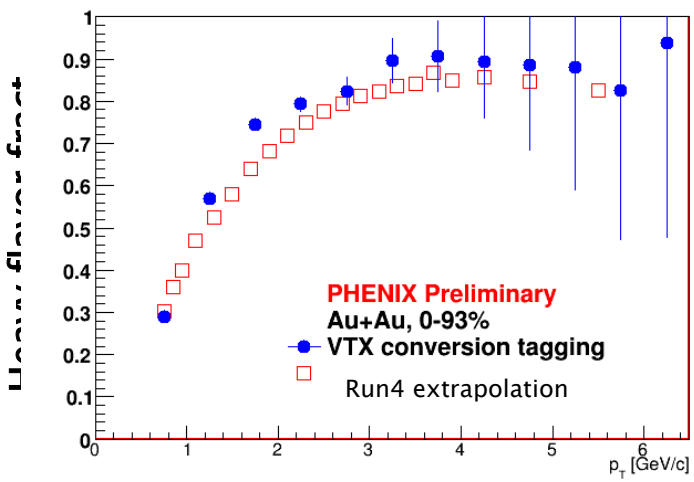
Example: Distribution parent B meson pT for electrons with p_T = 2-2.5 GeV/c

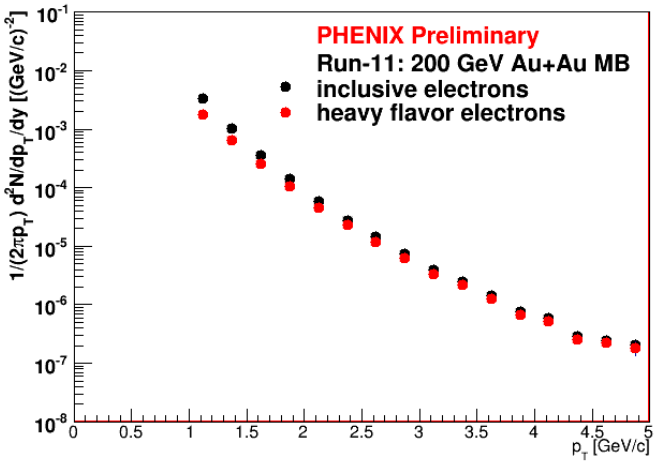
Wide range of D/B meson pT's contribute to electron DCA in a given electron pT bin.
We do not know the D/B meson pT distribution a priori

3

Heavy Flavor electron spectra

- Inclusive electron spectra have two major components:
  - Photonic
  - Heavy flavor
- Photonic component was estimated with two different methods:
  - Cocktail method
  - Conversion tagging in the VTX





DCA Distributions

- Raw DCA distributions for charged hadrons and electrons in <u>Au+Au at 200 GeV</u>