XXIII International Workshop on DIS and Related Subjects

Measurements of Open Heavy Flavor Production in Semi-Leptonic Channels at STAR

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1. University of Illinois at Chicago
2. Central China Normal University

Outline

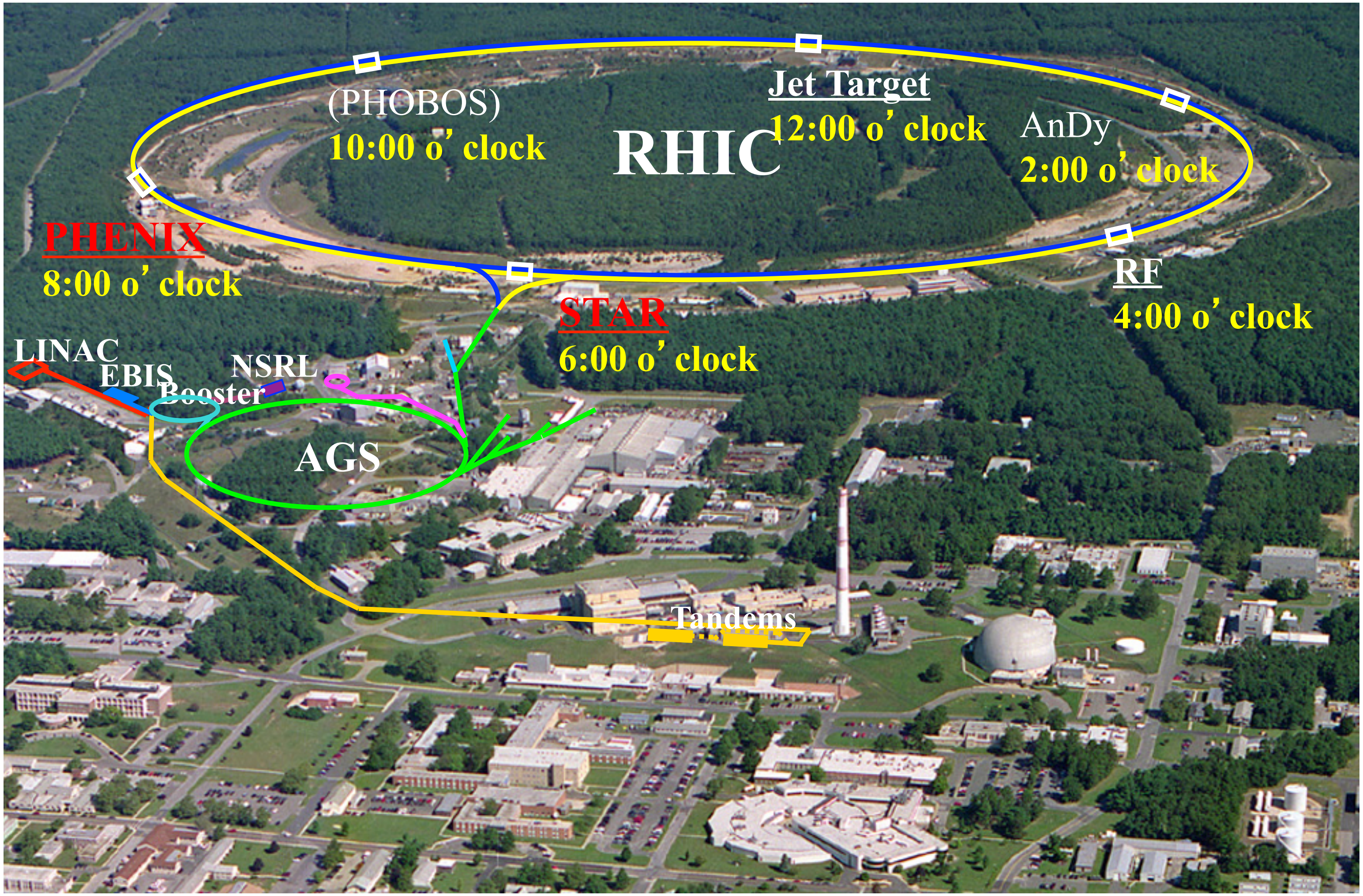
- Introduction
- Non-photonic Electron Measurements
- Prospects of Open HF studies
- Summary

UIC The University of Illinois at Chicago

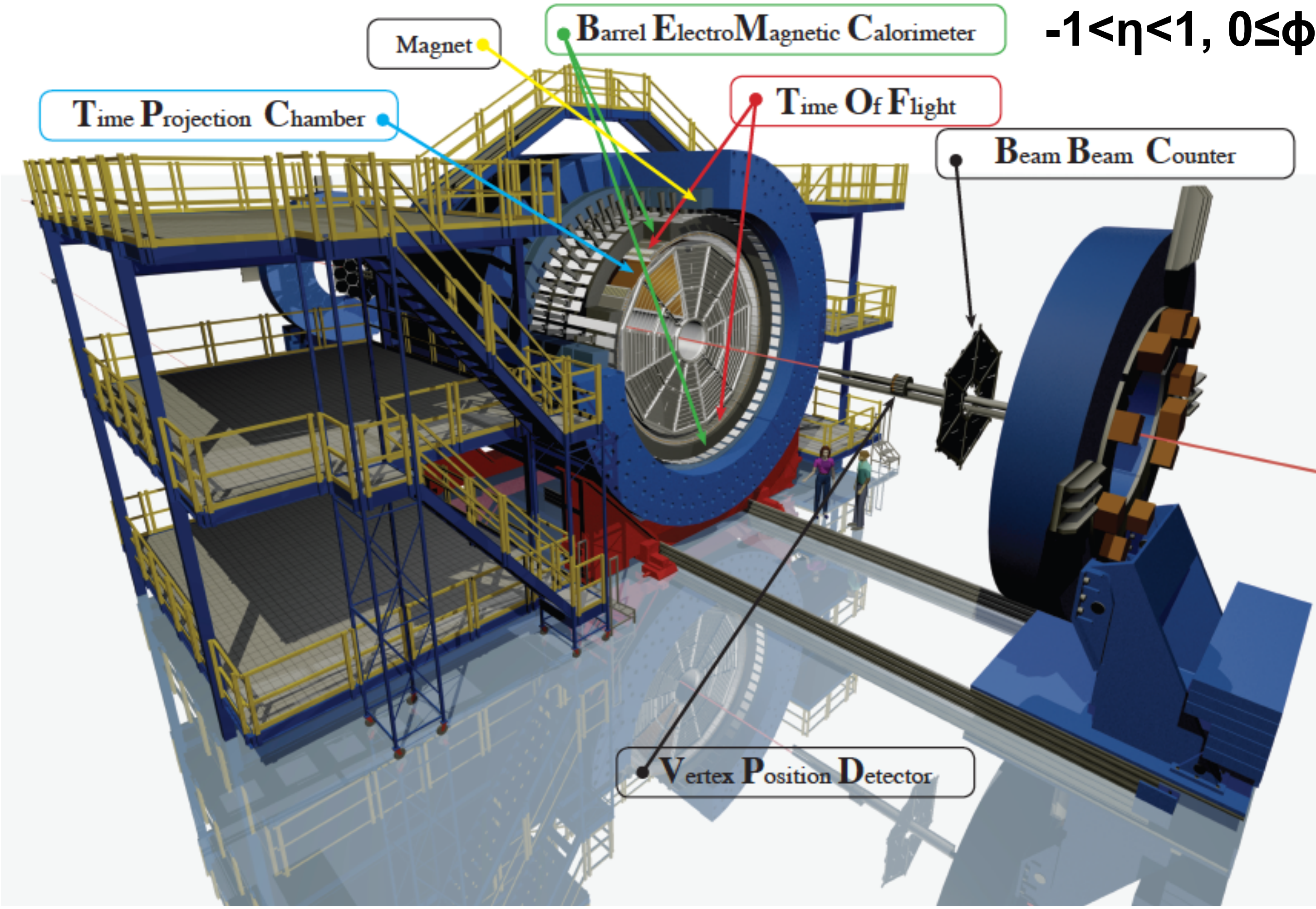
Office of Science U.S. DEPARTMENT OF ENERGY

UIC 華中師範大學 HuaZhong Normal University

Relativistic Heavy Ion Collider



STAR Detector (2012)



-1<η<1, 0≤ϕ<2π

TPC:
Tracking,
PID (dE/dx)

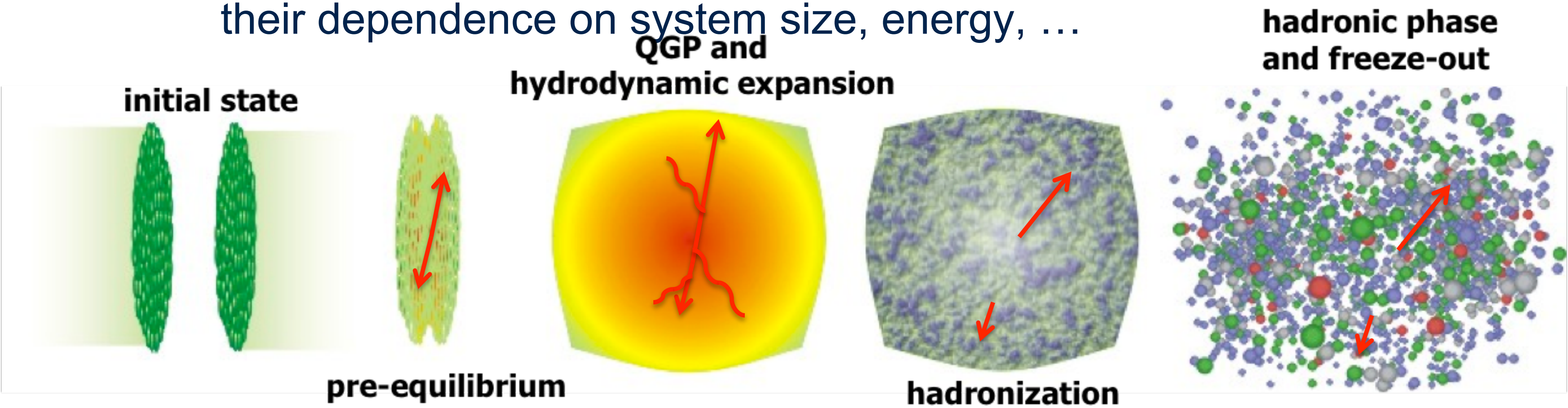
TOF:
PID (1/β)

BEMC:
High p_T trigger,
eID (p/E)

VPD:
MinBias trigger

Why Heavy Flavor?

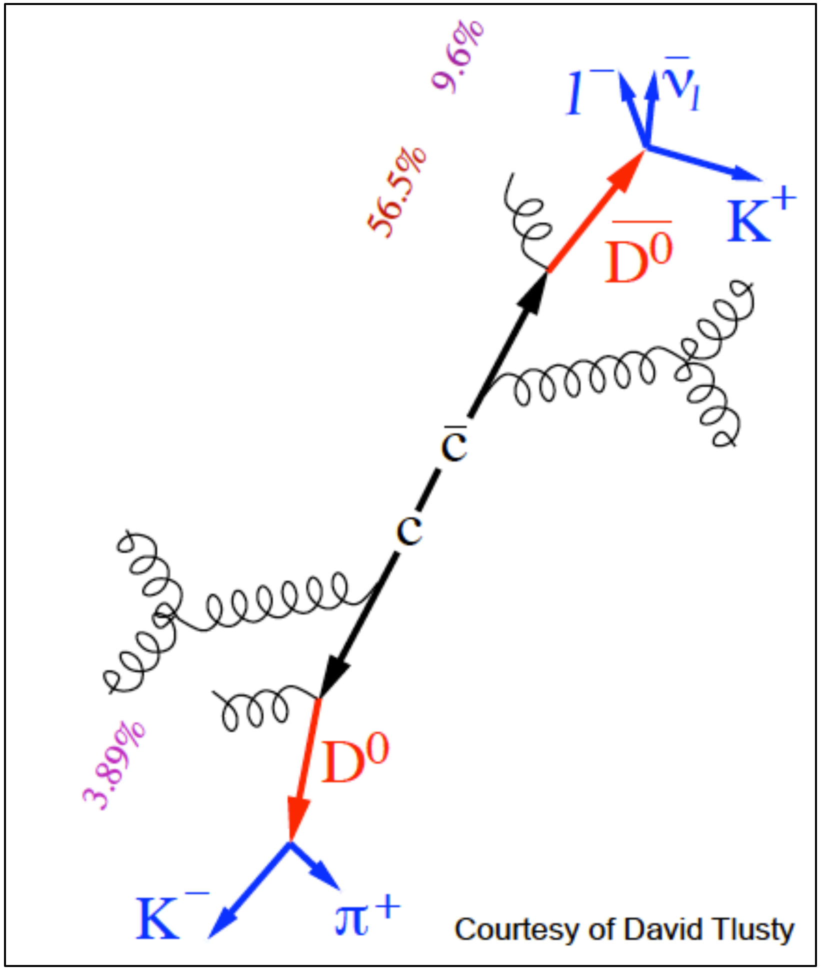
- HF quarks (b, c) are produced primarily in initial hard scatterings, and are exposed to the evolution of the hot nuclear matter created in heavy ion collisions.
- **Au+Au, Cu+Cu, U+U, …**
  - How does a parton lose its energy in the QGP? $\Delta E_g > \Delta E_q > \Delta E_c > \Delta E_b$?
  - Using the HF as a probe to study properties of the QGP and their dependence on system size, energy, …



Why Heavy Flavor?

- HF quarks are produced primarily in initial hard scattering, and are exposed to the evolution of the hot nuclear matter created at RHIC.
- **Au+Au, Cu+Cu, U+U, …**
  - How does a parton lose its energy in the QGP? $\Delta E_g > \Delta E_q > \Delta E_c > \Delta E_b$?
  - Using the HF as a probe to study properties of the QGP and their dependence on system size, energy, …
- **p+p**
  - Test of pQCD and Reference for studies of the QGP
- **p+Au, d+Au**
  - Cold Nuclear Matter effects (shadowing, CGC, Cronin effect, …)

Heavy Flavor Production and Decay



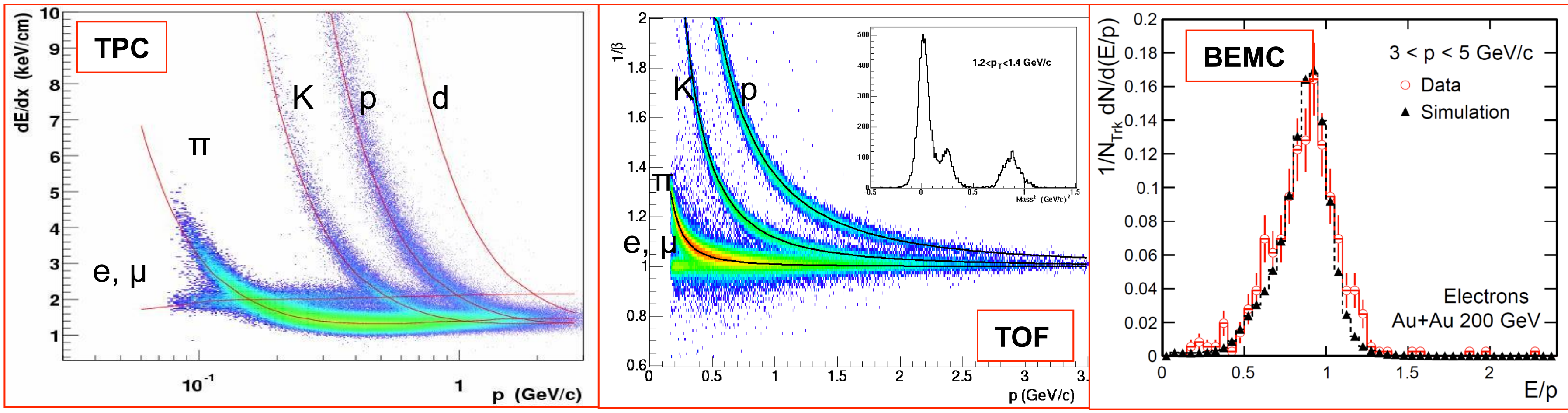
Semi-leptonic channel:

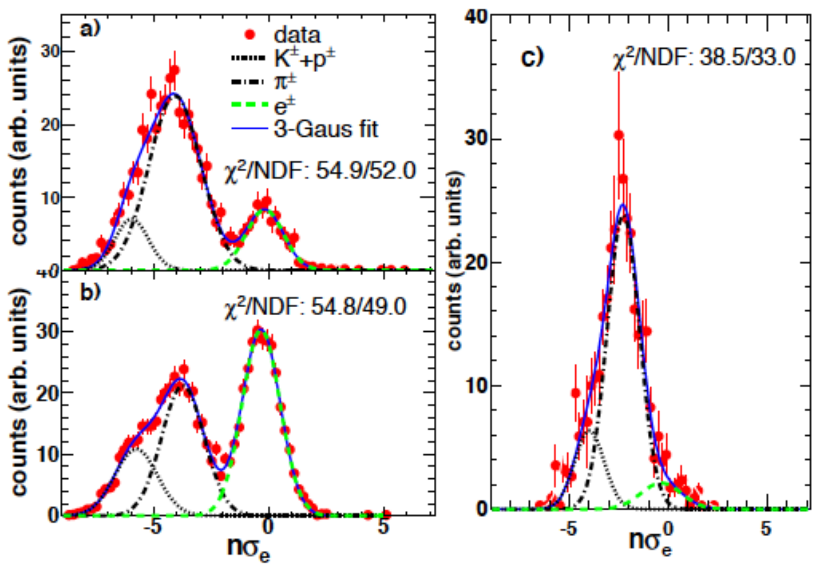
- Single $e^{\pm}$ with background subtraction estimated from MC+data
- Larger branching ratio; online trigger on high p_T charged leptons
- No direct access to the kinematics of the original charm hadrons; Contribution from charm and bottom

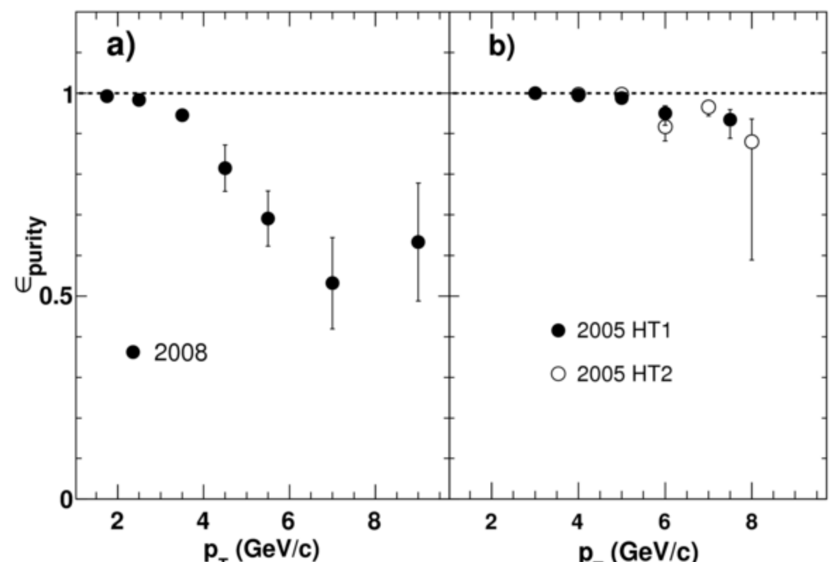
Hadronic channel:

- Fully reconstructed open charm hadrons with background estimated from data
- Smaller branching ratio; no direct trigger online; large background contribution w/o good secondary vertex measurement

Non-Photonic Electron Measurement



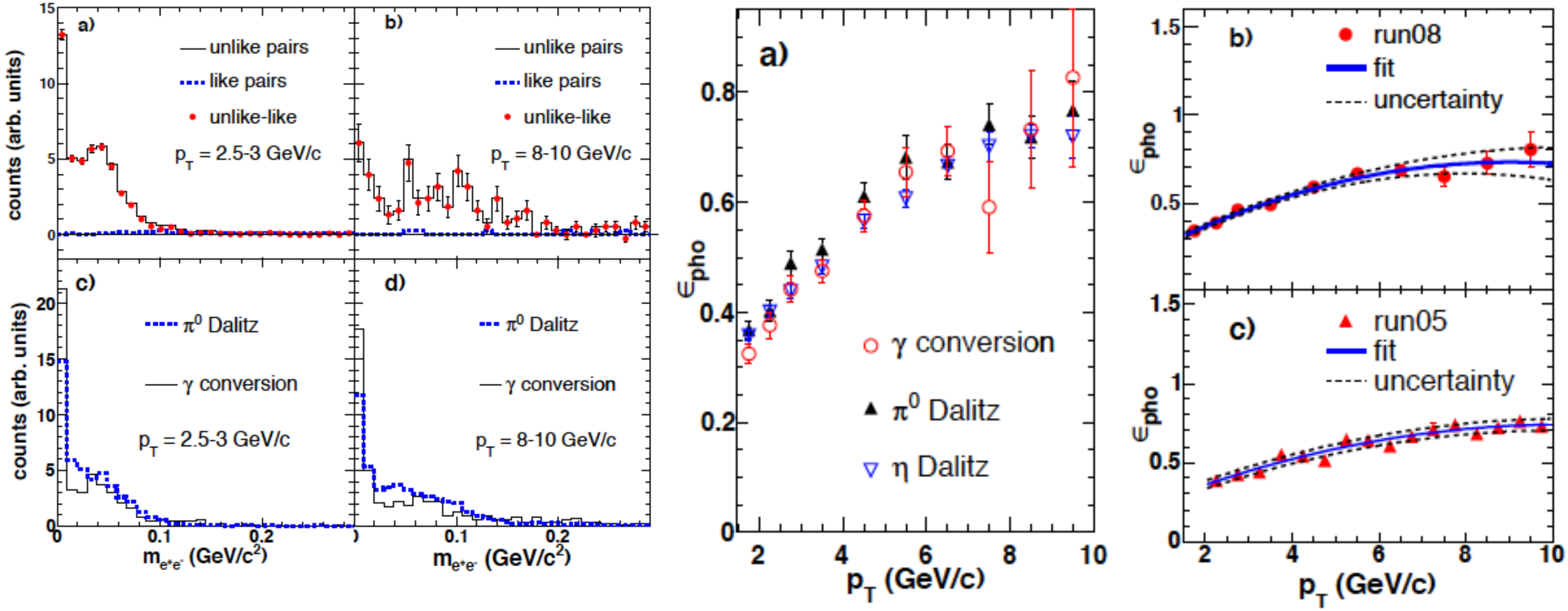




STAR: PRD 83, 052006 (2011)

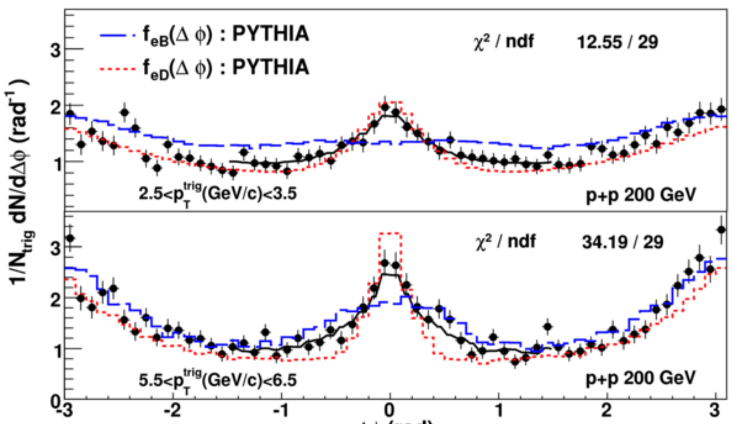
Non-Photonic Electron Measurement

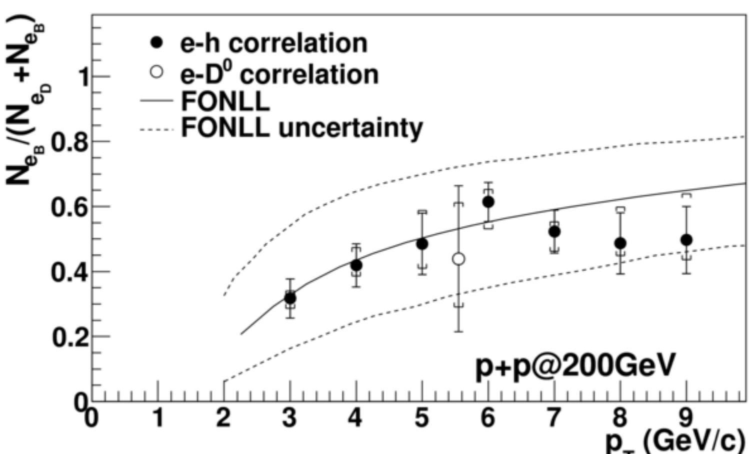
$$N(npe) = N(inc) \cdot \epsilon_{purity} - N(pho)/\epsilon_{pho}$$



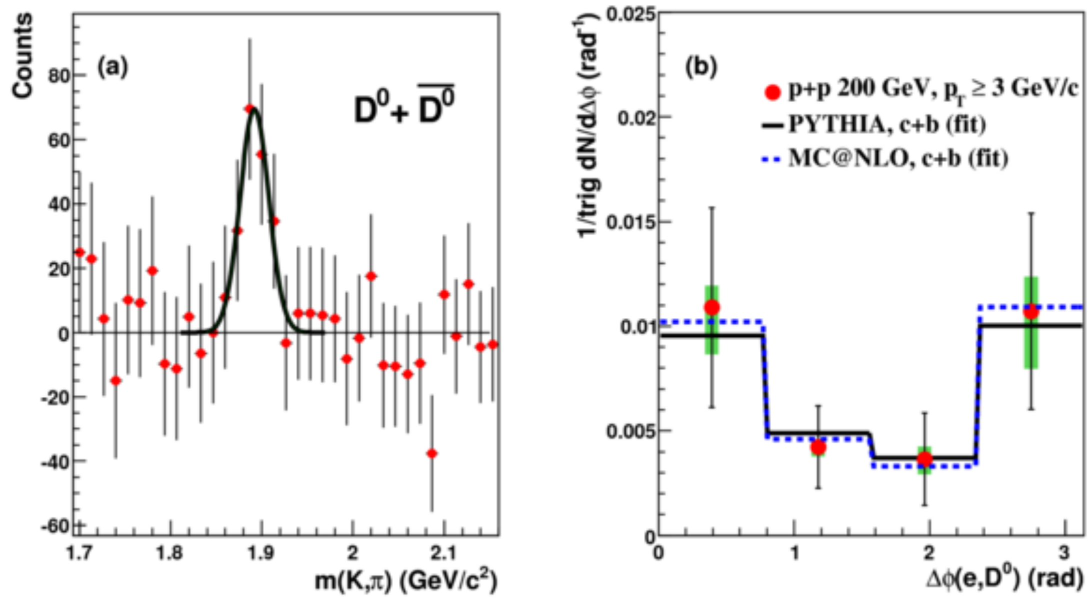
STAR: PRD 83, 052006 (2011)

Non-Photonic Electron Production – p+p (200 GeV) –





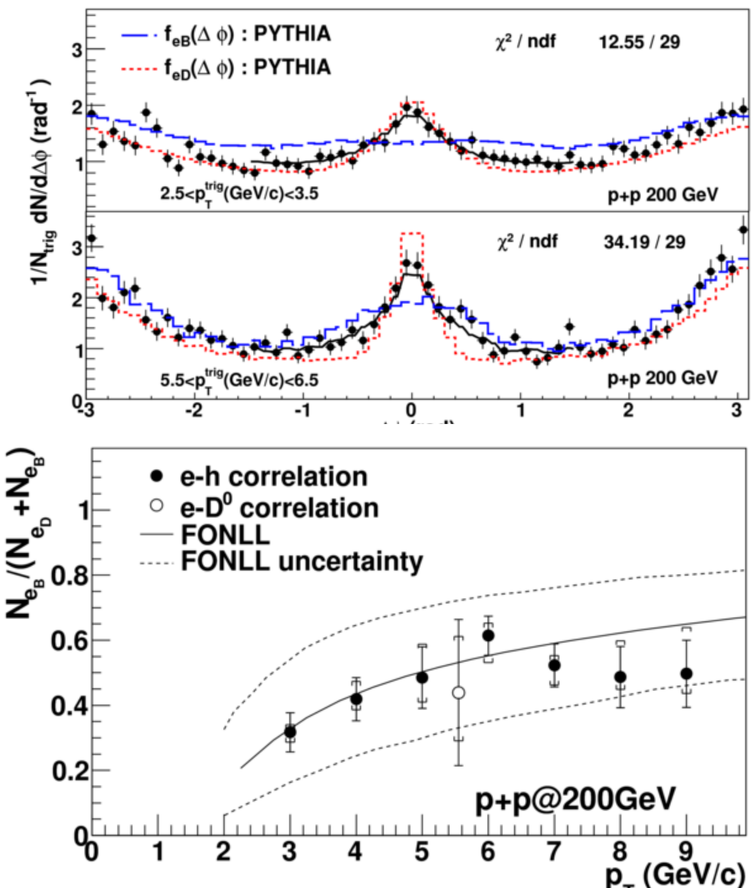
STAR: PRL 105, 202301 (2010)



FONLL (Fixed Order Next-to-Leading Log): M. Cacciari, P. Nason and R. Vogt, PRL 95, 122001 (2005)

D->e and B->e extracted from e-h/D⁰ correlation, consistent with pQCD calculations

Non-Photonic Electron Production – p+p (200 GeV) –



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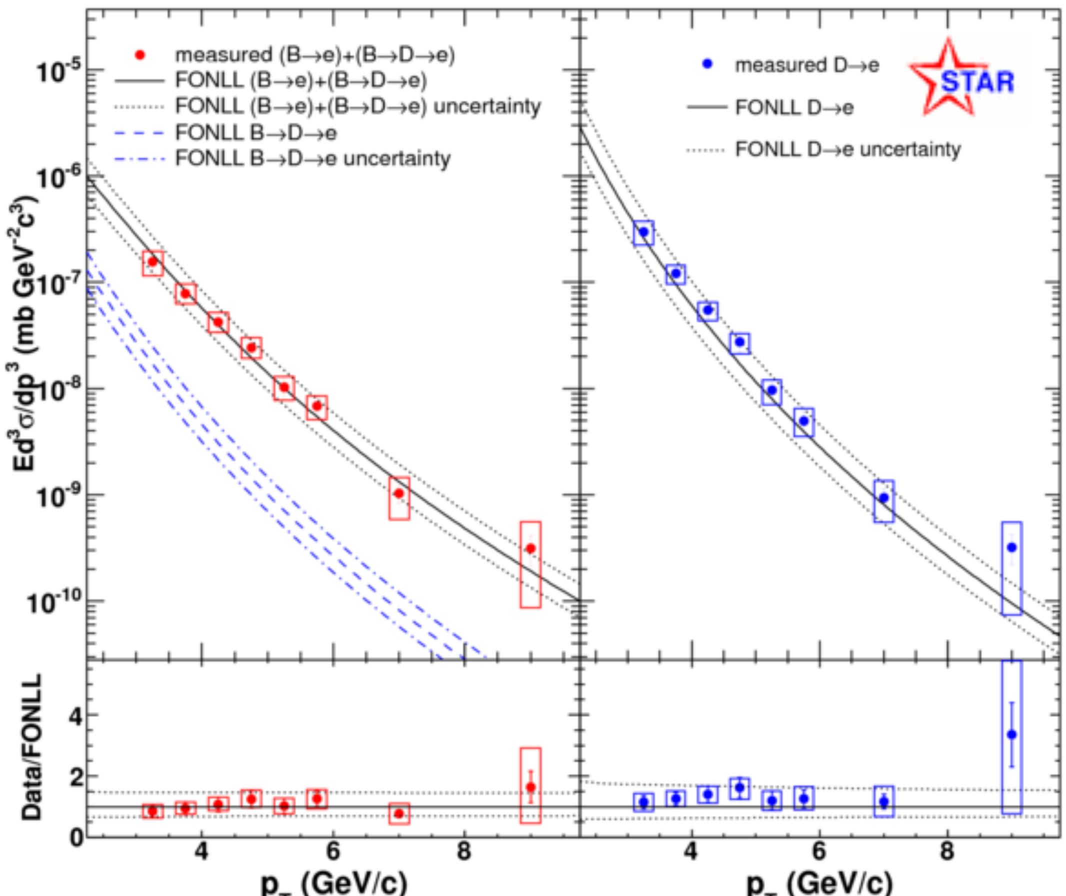
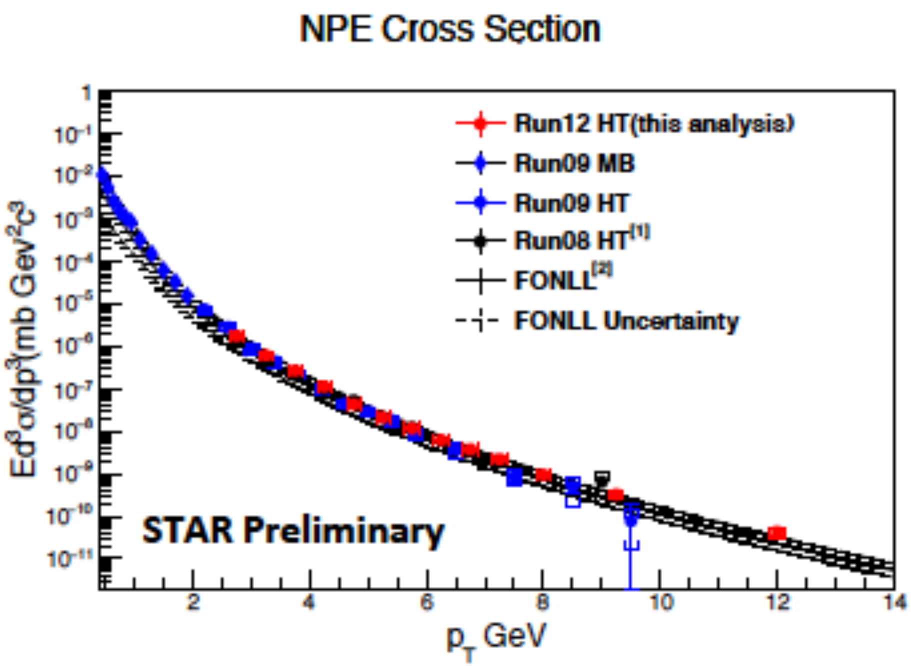
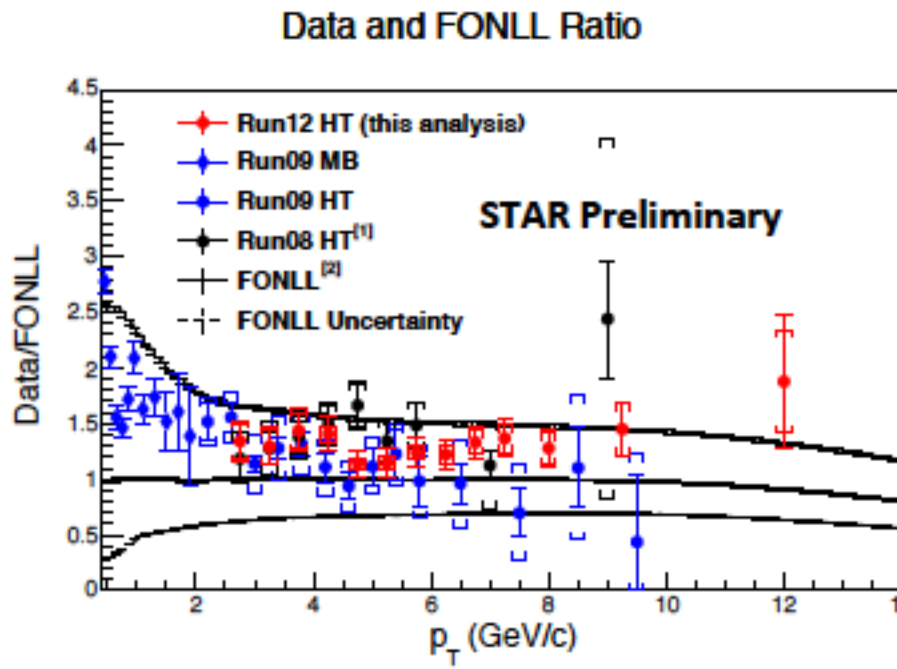


STAR: PRD 83, 052006 (2011)

D->e and B->e extracted from e-h/D^0 correlation, consistent with pQCD calculations

Non-Photonic Electron Production – p+p (200 GeV) –

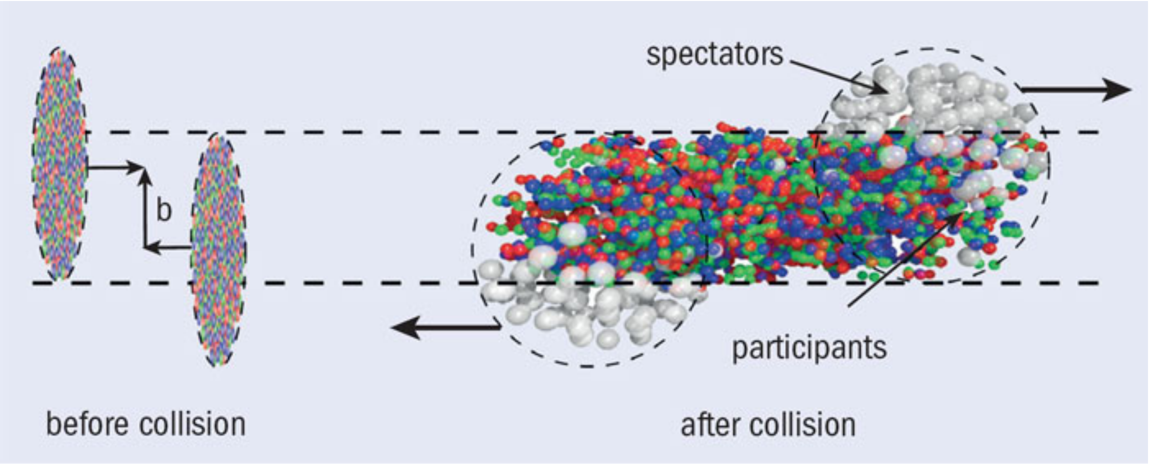




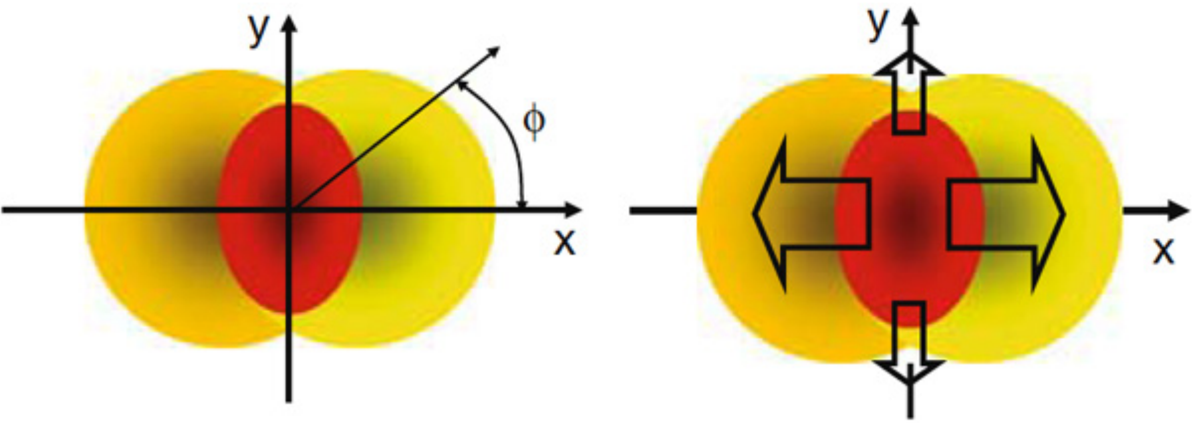
Run08: PRD 83, 052006 (2011)
FONLL: M. Cacciari, P. Nason, R. Vogt, PRL 95, 122001 (2005)

New STAR results have improved uncertainties and wider p_T coverage

Non-Photonic Electron Production – Au+Au –

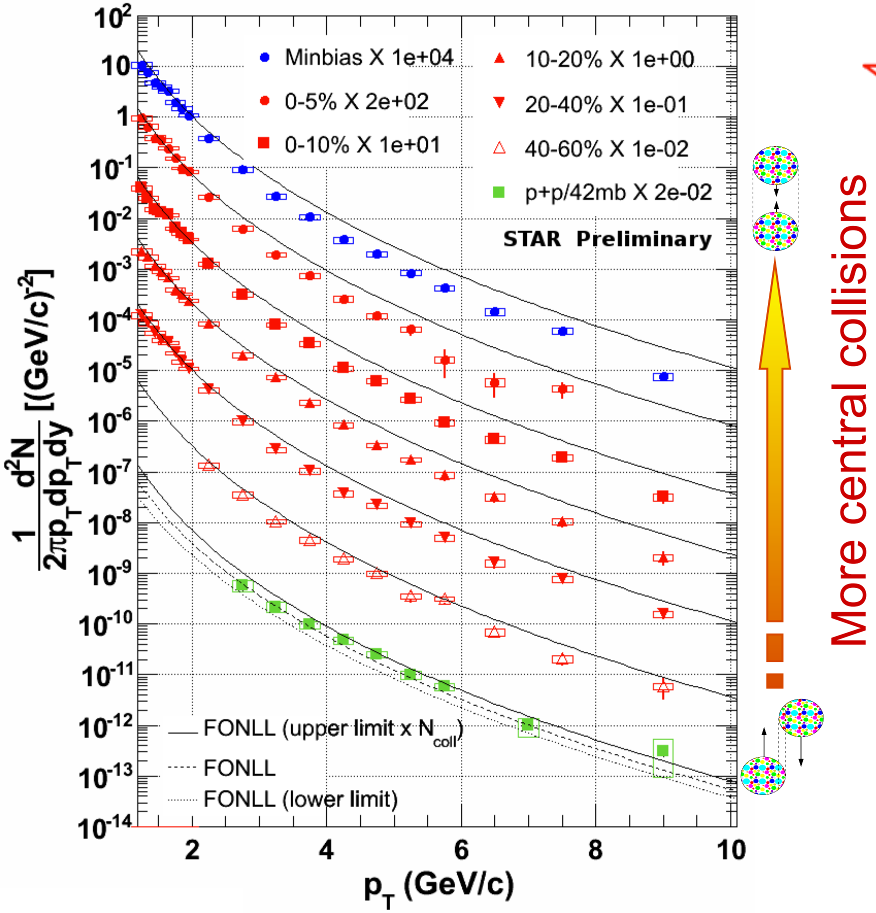


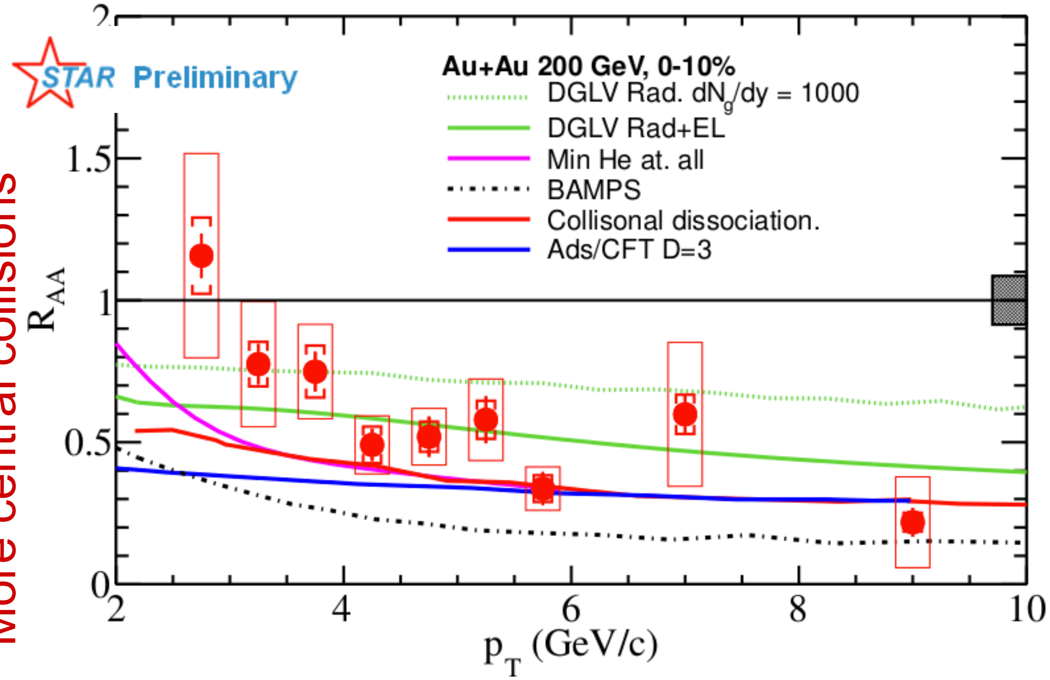
$$R_{AA} = \frac{dN_{AA}/dy}{N_{binary} \cdot dN_{pp}/dy}$$



$$\frac{dN}{d\phi} = N_0\left[1 + \sum_n 2v_n \cos n\phi\right]$$

Non-Photonic Electron Production – Au+Au (200 GeV) –

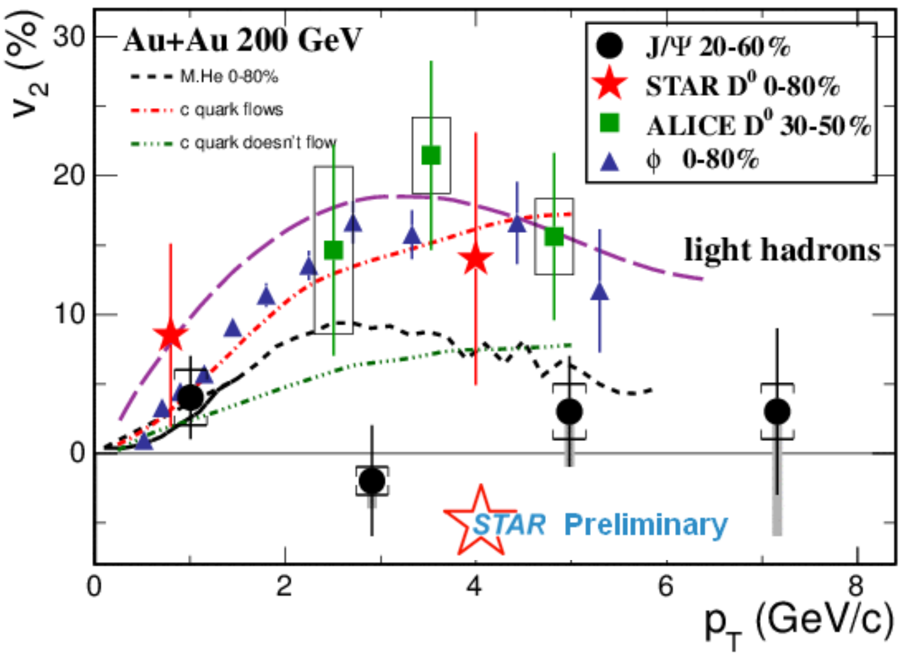


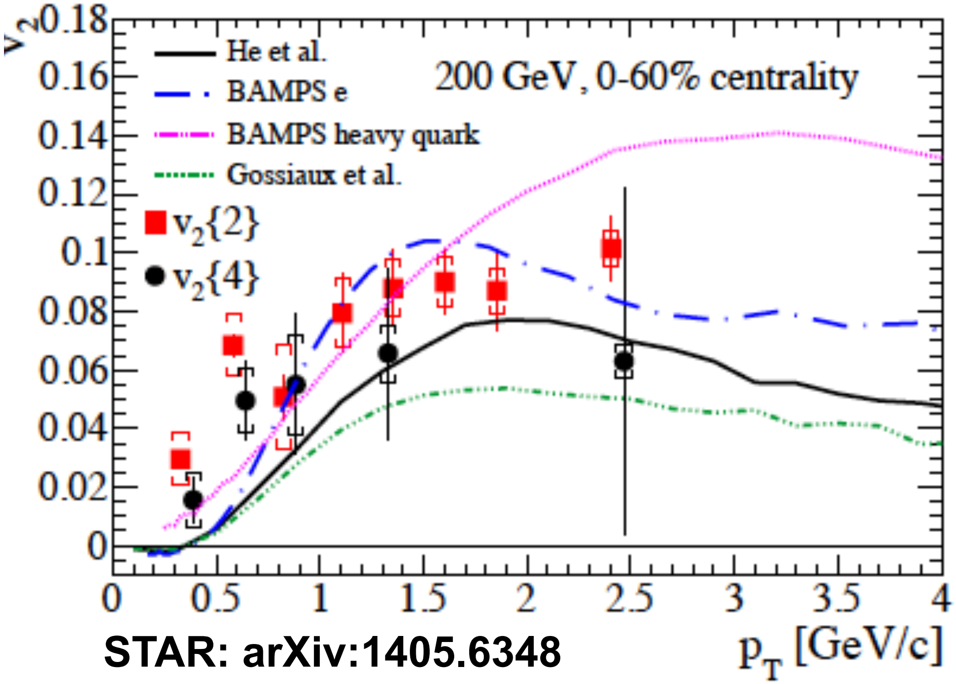


$$R_{AA} = \frac{dN_{AA}/dy}{N_{binary} \cdot dN_{pp}/dy}$$

Data tends to disfavor model with radiative energy loss only.
New p+p results can further constrain models.

Non-Photonic Electron Production – Au+Au (200 GeV) –



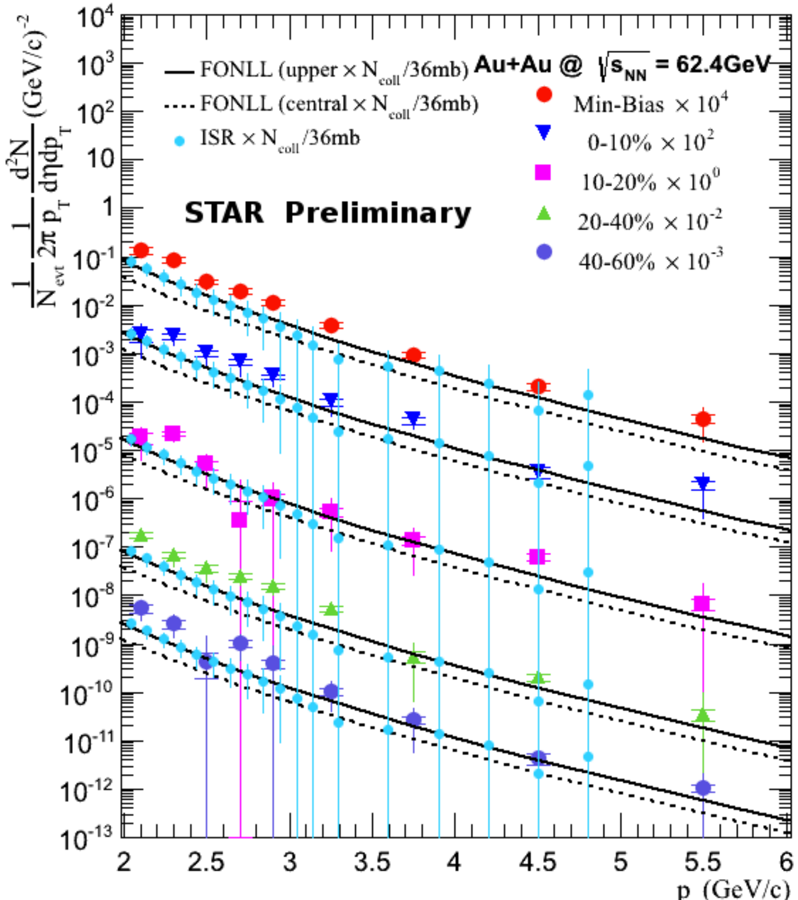


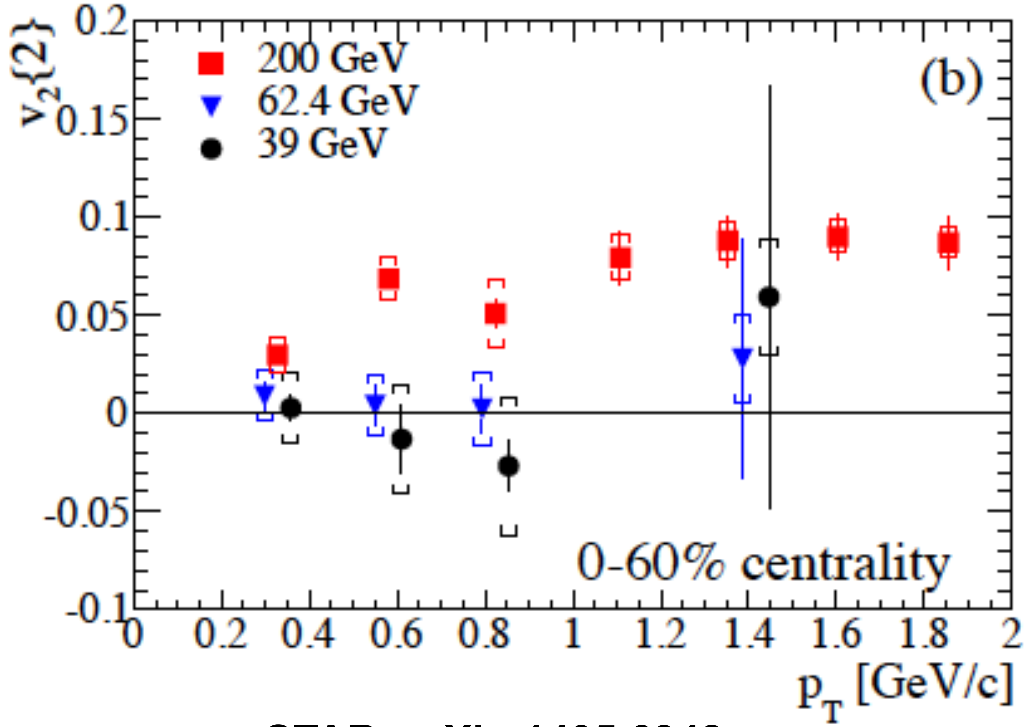
STAR: arXiv:1405.6348

$$\frac{dN}{d\phi} = N_0\left[1 + \sum_n 2v_n \cos n\phi\right]$$

Significant non-zero NPE v_2 at low p_T:
is it from coalescence with light quark and/or charm quark flow?

Non-Photonic Electron Production – Au+Au (62.4 and 39 GeV) –

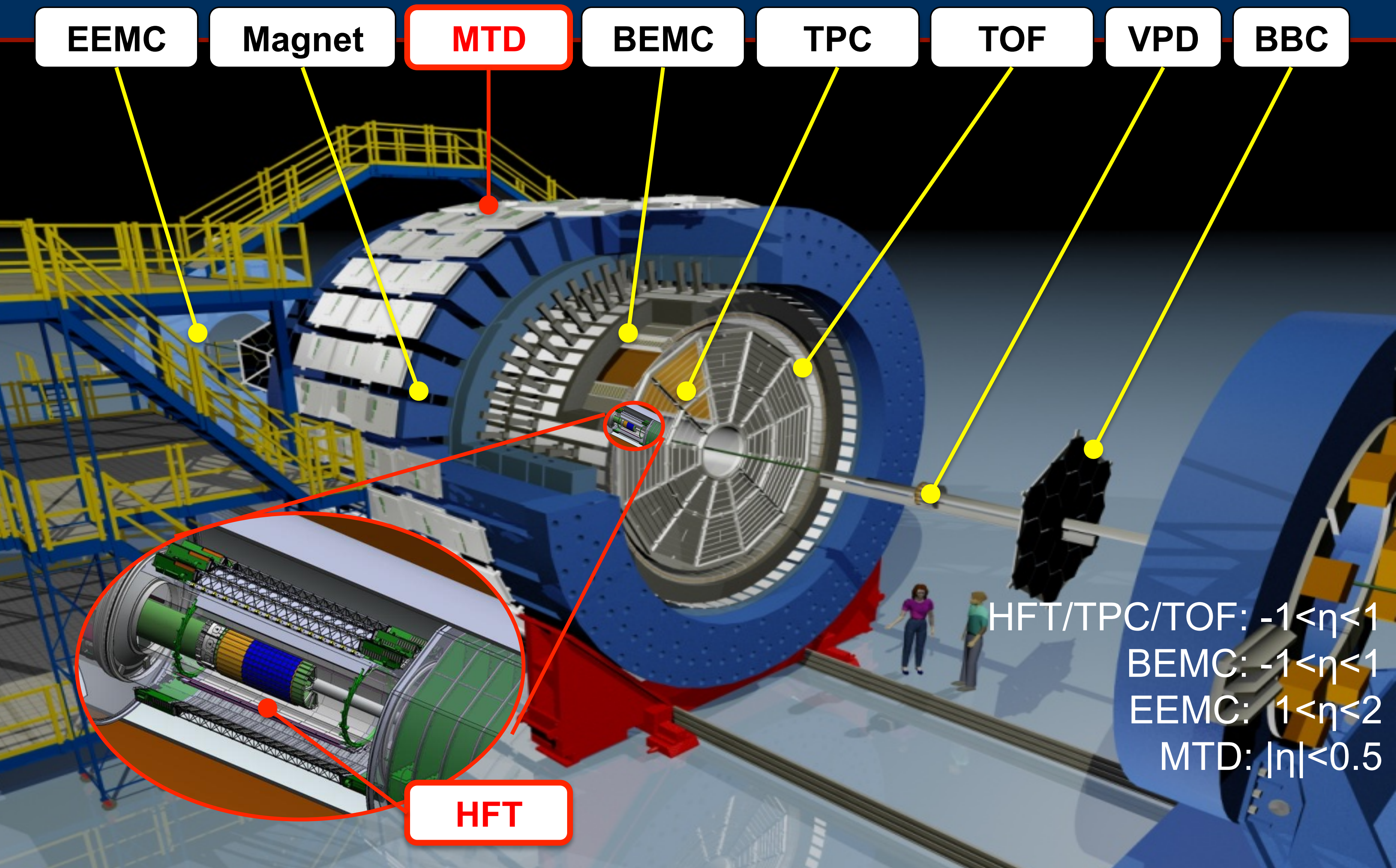




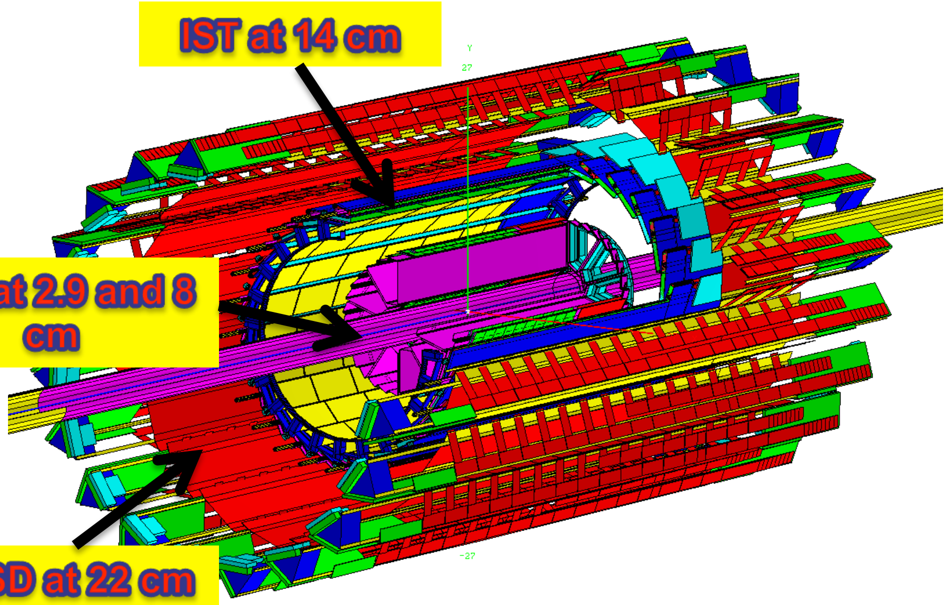
STAR: arXiv:1405.6348

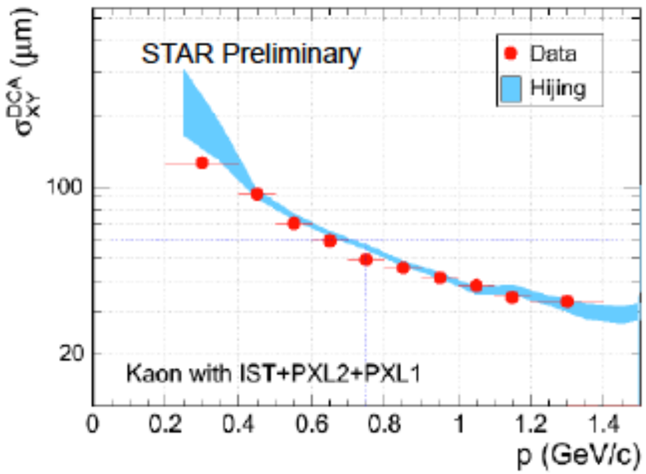
Strong suppression of NPE at 200 GeV, no suppression at 62.4 GeV; Significant v_2 at 200 GeV, v_2 compatible with zero at 62.4 and 39 GeV.

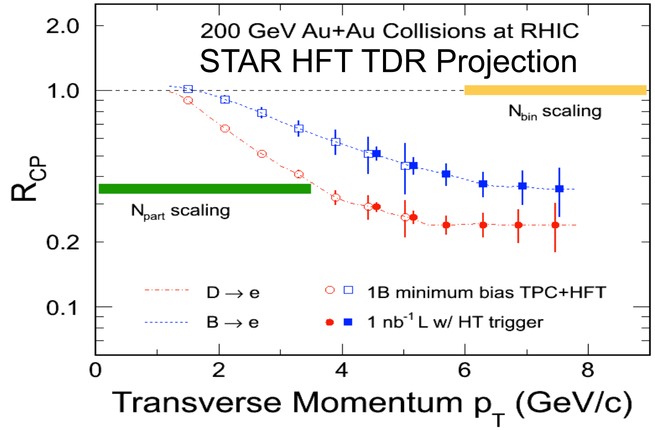
STAR Experiment (2014+)



Heavy Flavor Tracker for 2014+



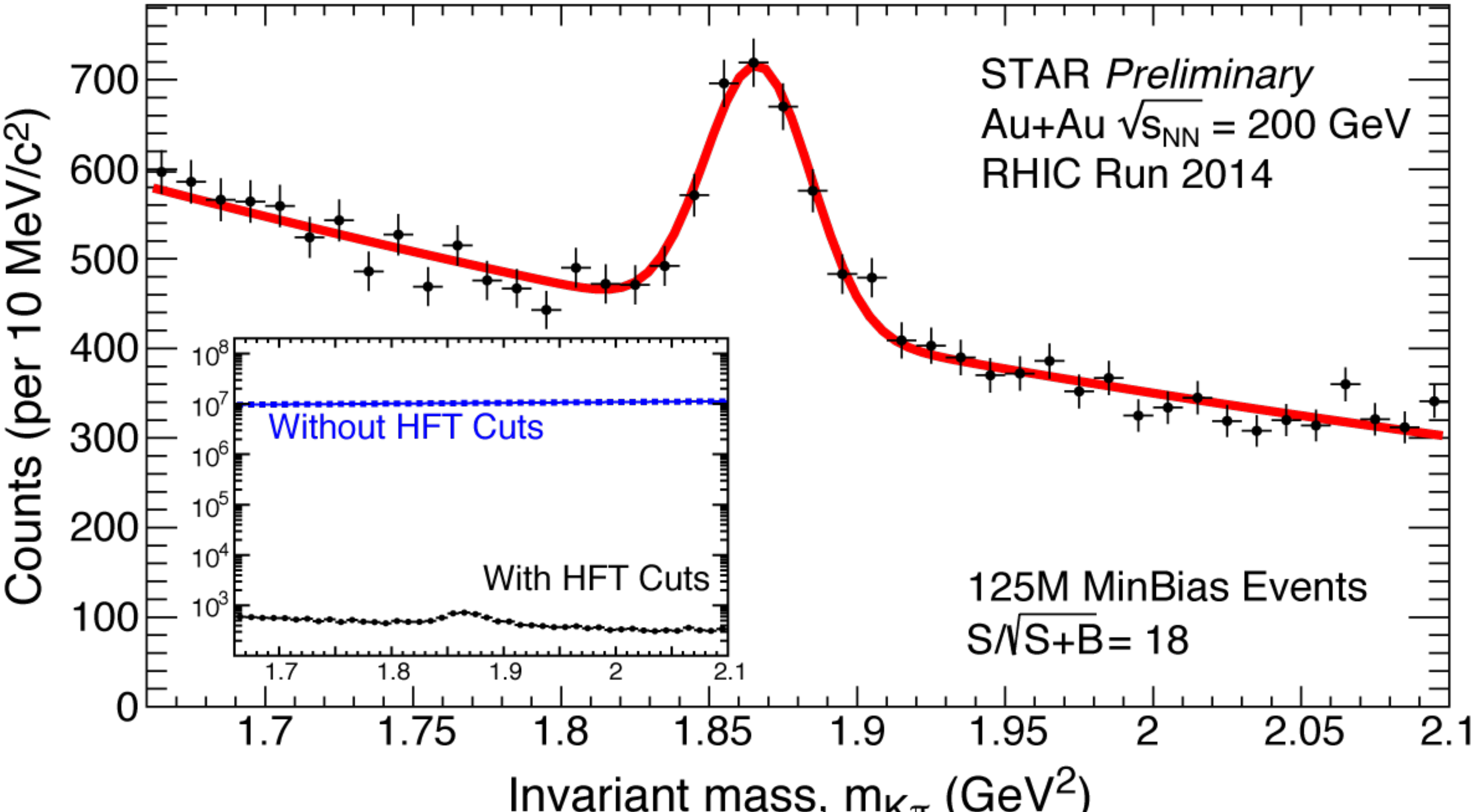




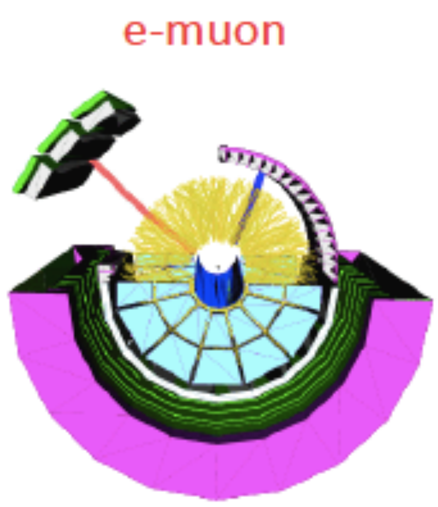
- 2 layers of thin silicon pixel (MAPS): 360M pixels, 20x20μm pitch, 0.4-0.6%X_0/layer,
- 2 layers of silicon strip detectors: fast readout, bridging TPC and PXL

Will achieve unprecedented precision to study QGP separately with B and D

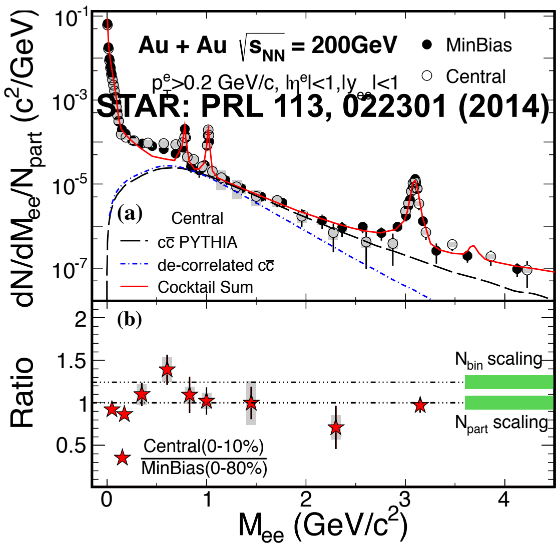
Heavy Flavor Tracker for 2014+

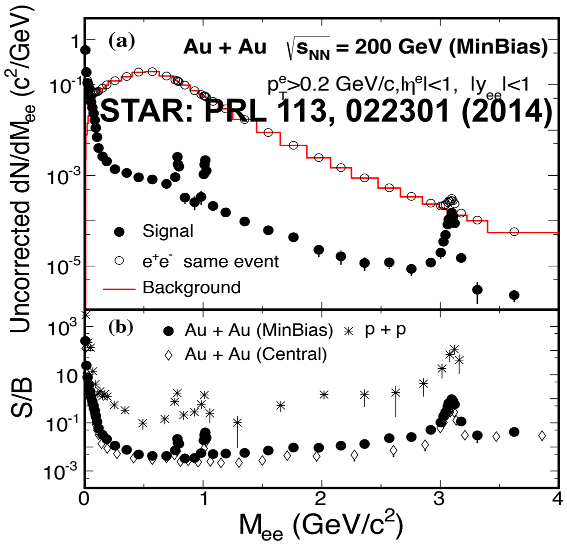


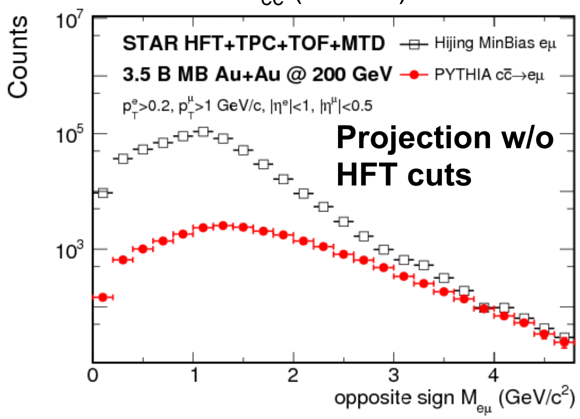
Muon Telescope Detector for 2014+

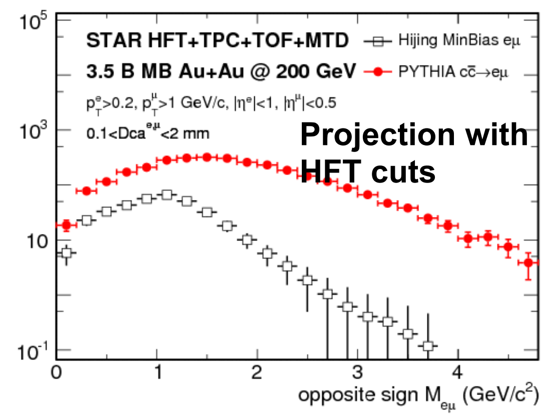


- Multigap Resistive Plate Chamber, avalanche mode
- Acceptance: 45% at $|\eta|<0.5$, covers the magnet iron bars









(together with HFT) single muons, e-mu correlations

Summary and Outlook

- Open charm and bottom production measured in 200 GeV p+p collisions consistent with FONLL calculations within uncertainties.
- Strong suppression observed for NPE in 200 GeV Au+Au collisions but not in 62 GeV Au+Au collisions. Significant azimuthal anisotropy observed for NPE in 200 GeV Au+Au collisions, but not in 62 or 39 GeV Au+Au collisions.
- New detectors take data starting in 2014 for HF physics: precise measurements down to low p_T to study how heavy flavor quarks interact with the hot nuclear medium, and the medium properties.