Measurements of open **bottom** and **charm** hadron production through **multiple decay channels** in **p+p** and **Au+Au** collisions with the **STAR** experiment

Quark Matter 2017, February 8, 2017, Chicago

Kunsu OH[1,2] for the STAR collaboration

1. Pusan National University, Korea
2. Lawrence Berkeley National Laboratory

Outline

- ★ Introduction
- ★ STAR experiment
- ★ Measure bottom production using *impact parameter method* enabled by **Heavy Flavor Tracker (HFT)** in 200 GeV Au+Au collisions
  - ★ **Non-prompt *J/ψ***
  - ★ **Non-prompt D^0**
  - ★ ***c/b* separation** in **non-photonic electron** (*NPE*)
- ★ Summary and outlook

Introduction

★**Heavy Flavor** production

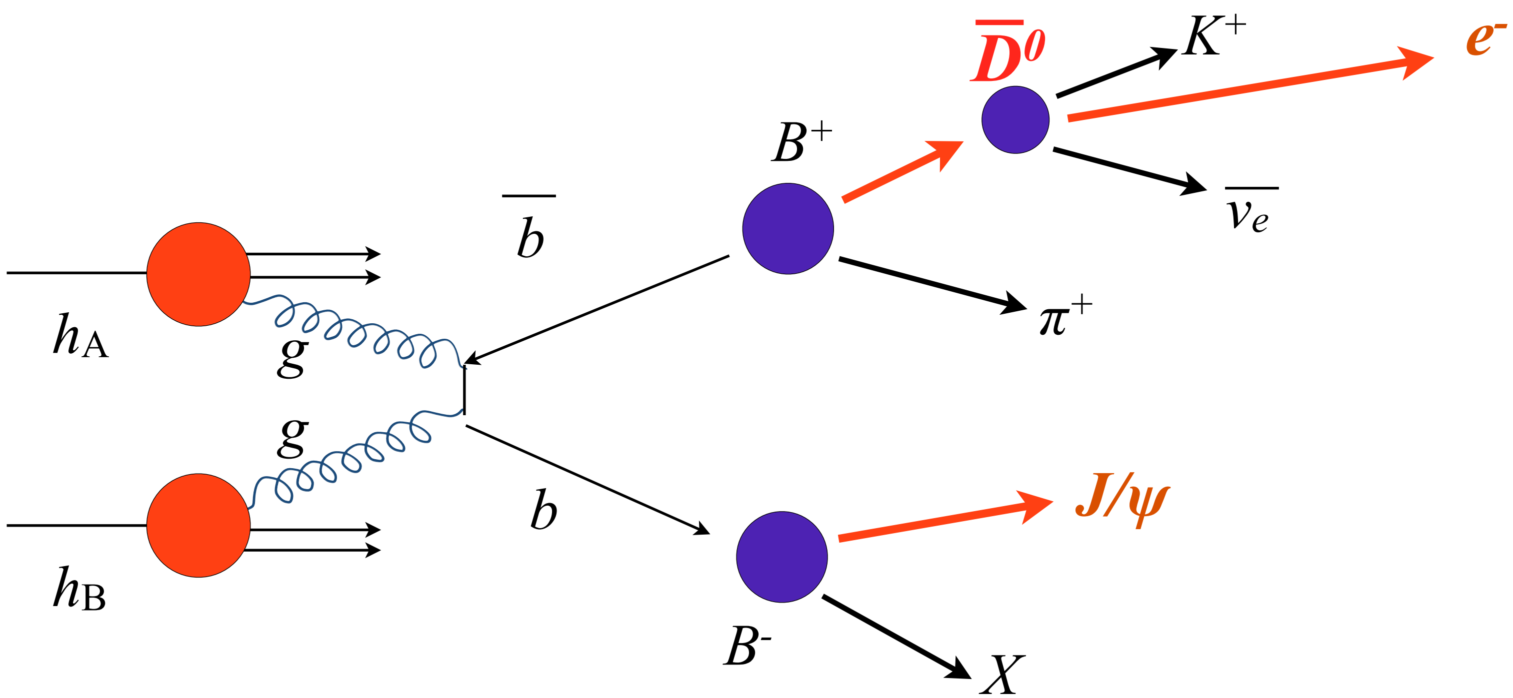
★HF quarks are primarily produced in initial hard scatterings, and interact with the **medium (Hot Nuclear Matter)** created in **heavy-ion collisions**.

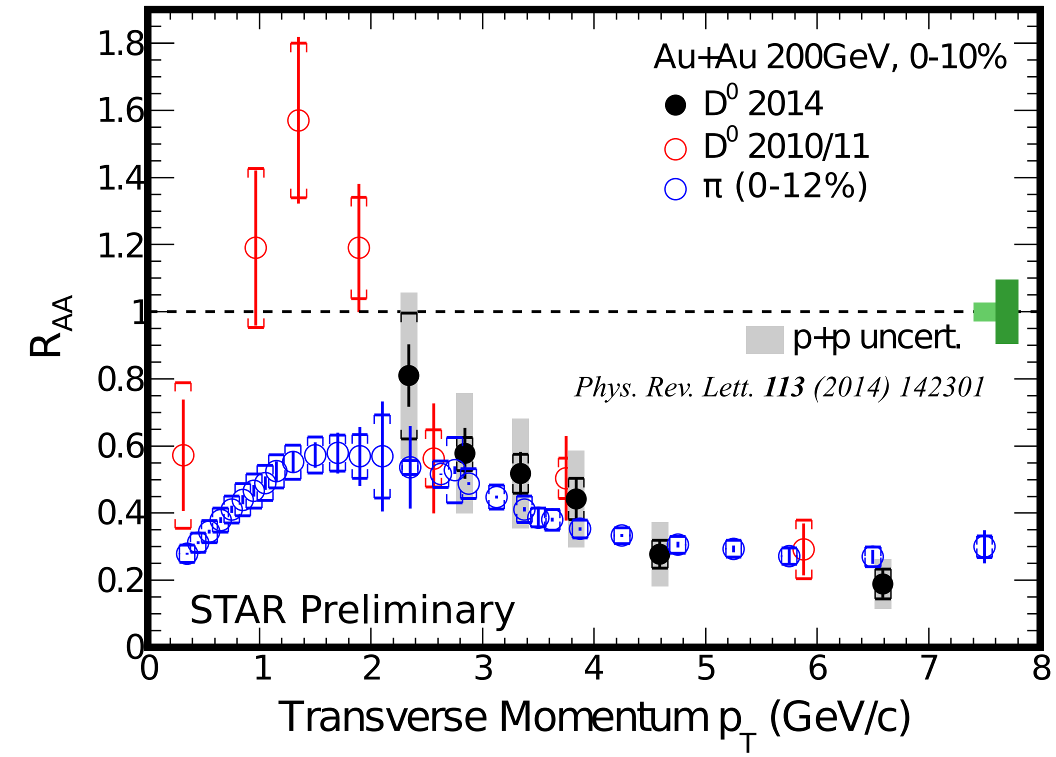
★Use HF quarks to probe the properties of the **quark gluon plasma** via studying the flavor dependence of the parton energy loss.

→ Theoretical prediction for ΔE in medium: $\Delta E_g > \Delta E_q >$ $\boldsymbol{\Delta E_c > \Delta E_b}$ **?**

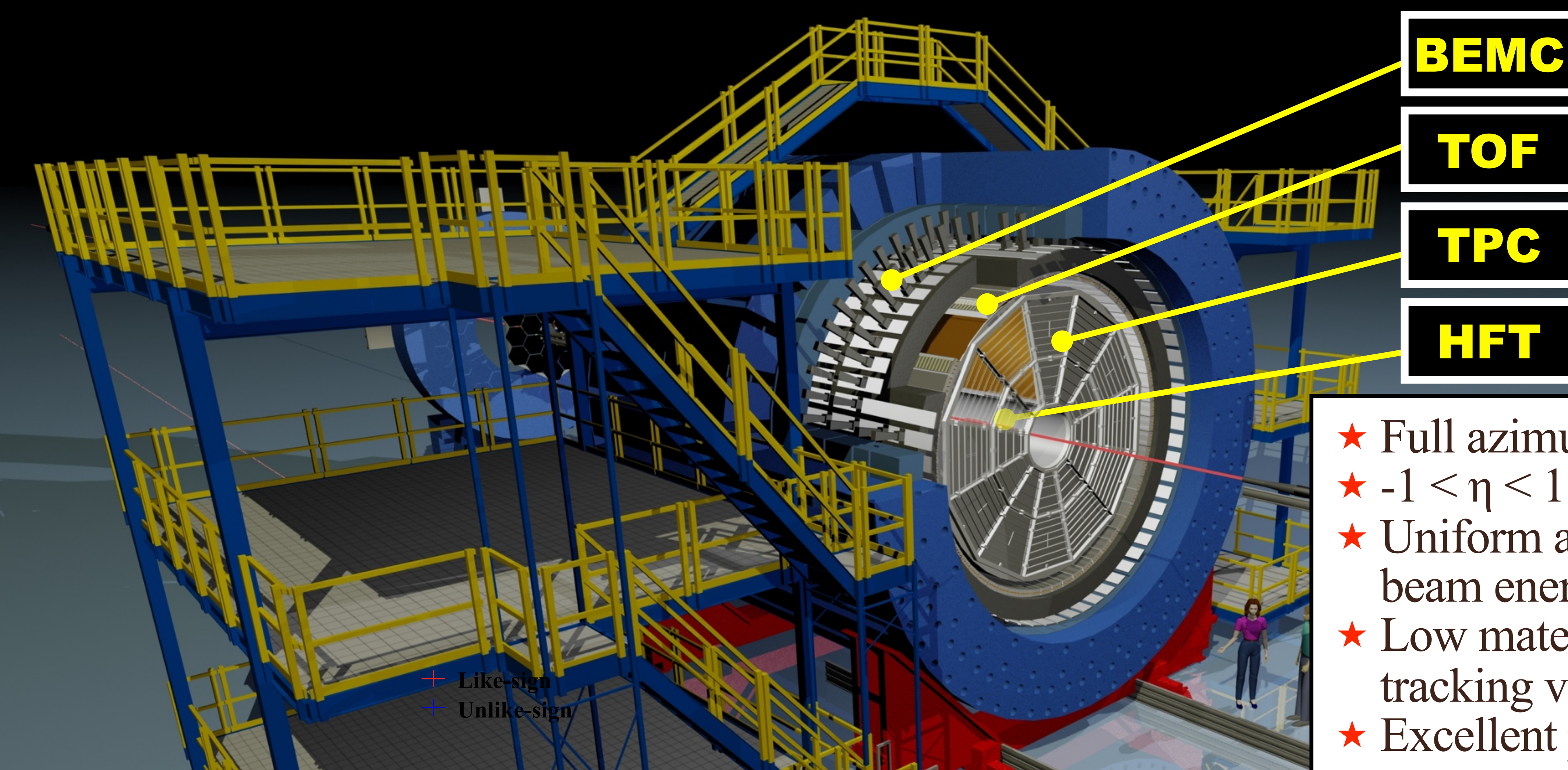
R. Baier et al., Ann. Rev. Nucl. Part. Sci. 50, 37 (2000); M. Gyulassy et al., nucl-th/0302077.

→ Precise measurements of ***c* and *b* quark energy loss separately** are crucial for understanding the parton interactions with the medium.

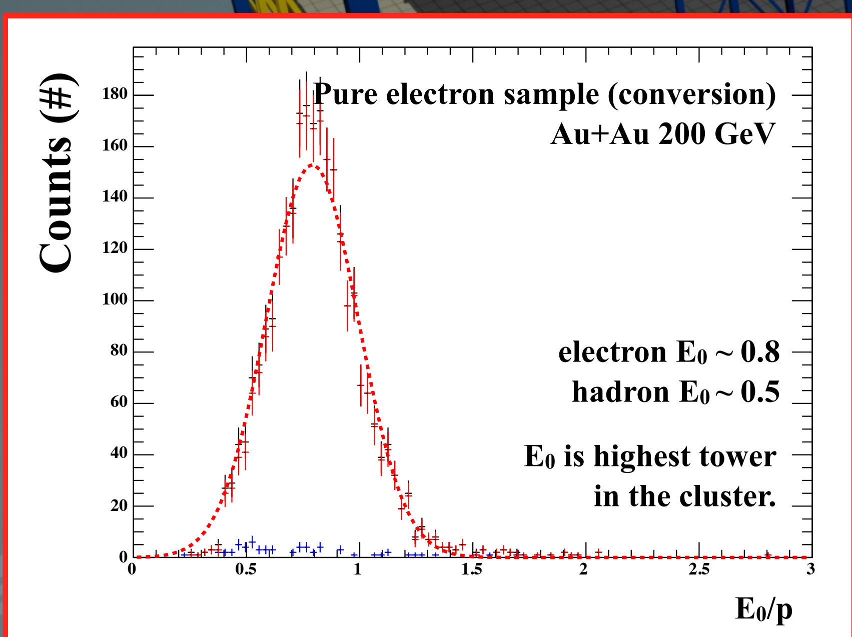


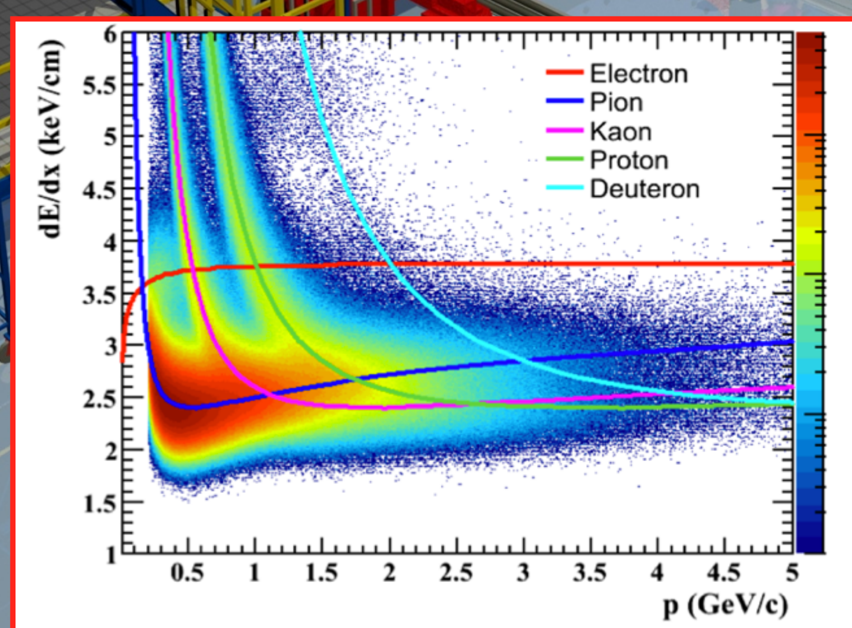


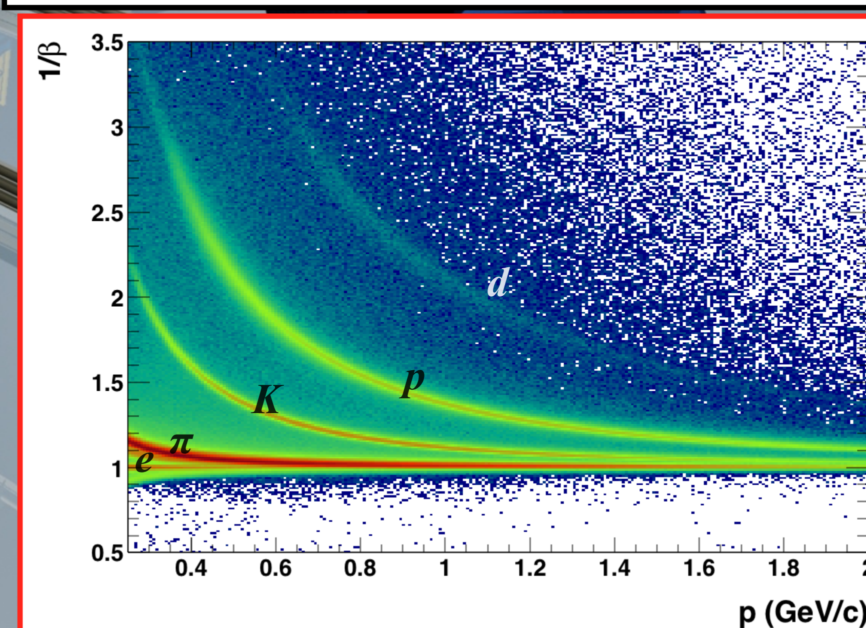
The Solenoidal Tracker At RHIC (STAR)



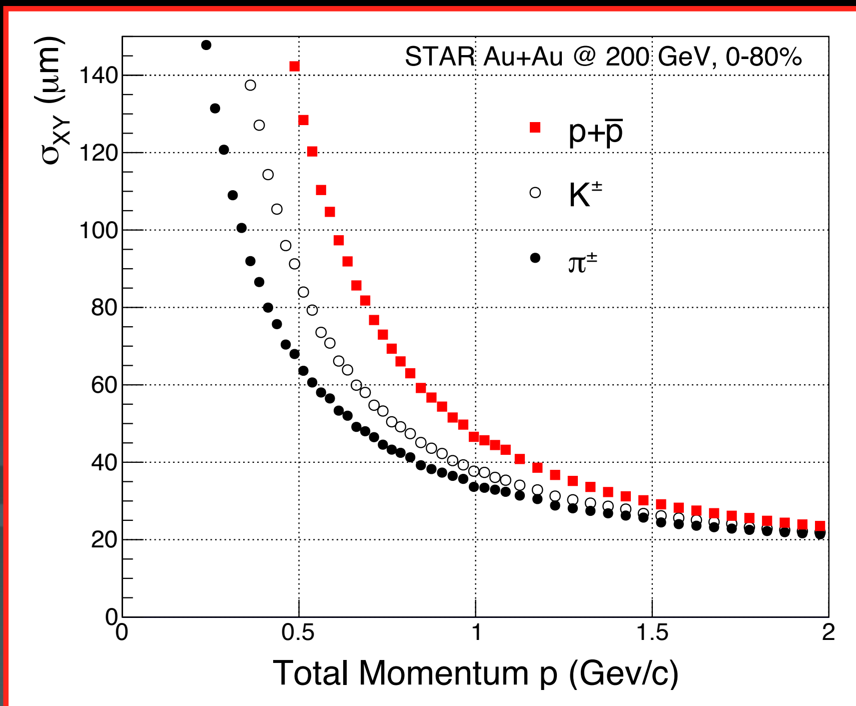
- ★ Full azimuthal coverage
- ★ $-1 < \eta < 1$ coverage
- ★ Uniform acceptance for all beam energies
- ★ Low material budget in the tracking volume
- ★ Excellent particle identification

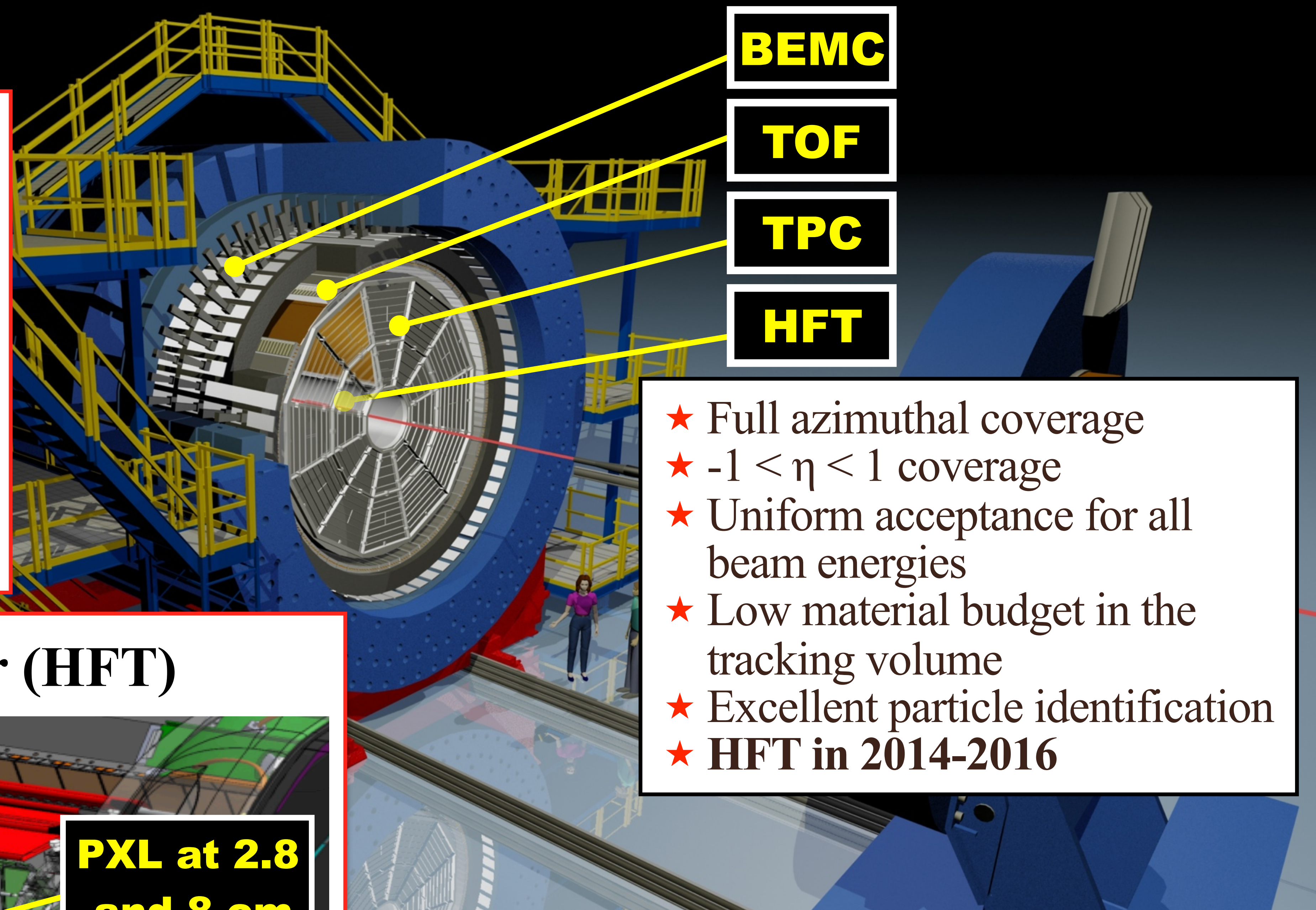






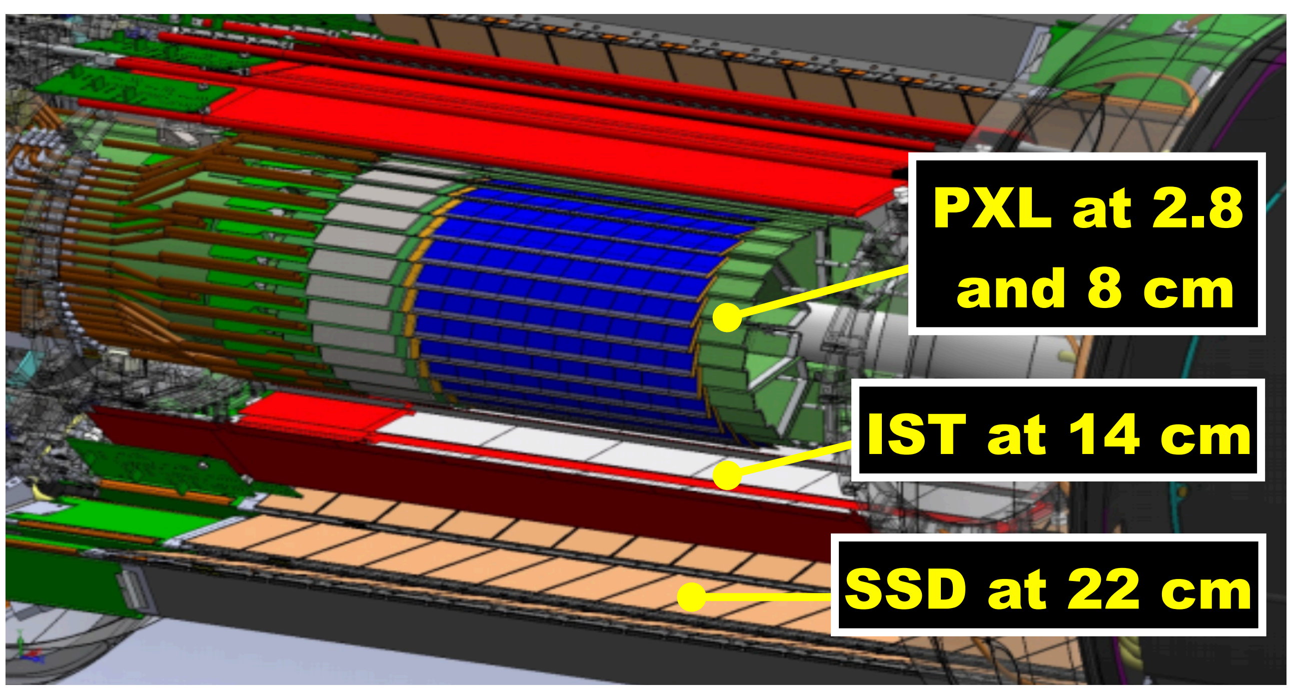
The Solenoidal Tracker At RHIC (STAR)





- ★ Full azimuthal coverage
- ★ $-1 < \eta < 1$ coverage
- ★ Uniform acceptance for all beam energies
- ★ Low material budget in the tracking volume
- ★ Excellent particle identification
- ★ **HFT in 2014-2016**

Heavy Flavor Tracker (HFT)

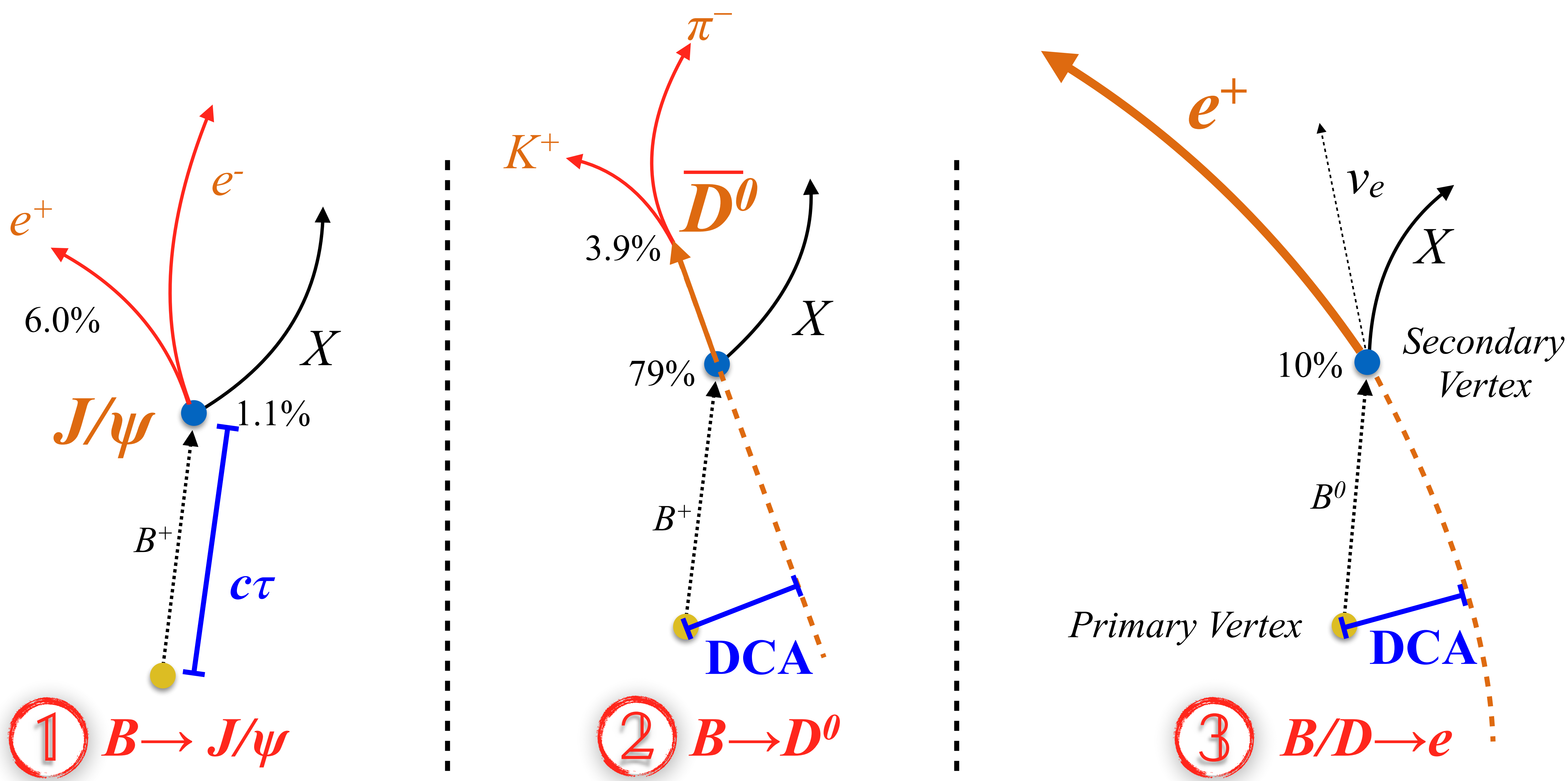


★ 2 layers of silicon pixel (MAPS) — PXL:
- Low material budget: ~0.5% X_0 (*in 2014*)
- Excellent DCA resolution: ~30 μm at p_T = 1.5 GeV/c

★ 2 layers of silicon pad/strip detectors — IST and SSD:
- Fast readout, bridging TPC and PXL

by Maria & Alex Schmah

Analysis Scheme



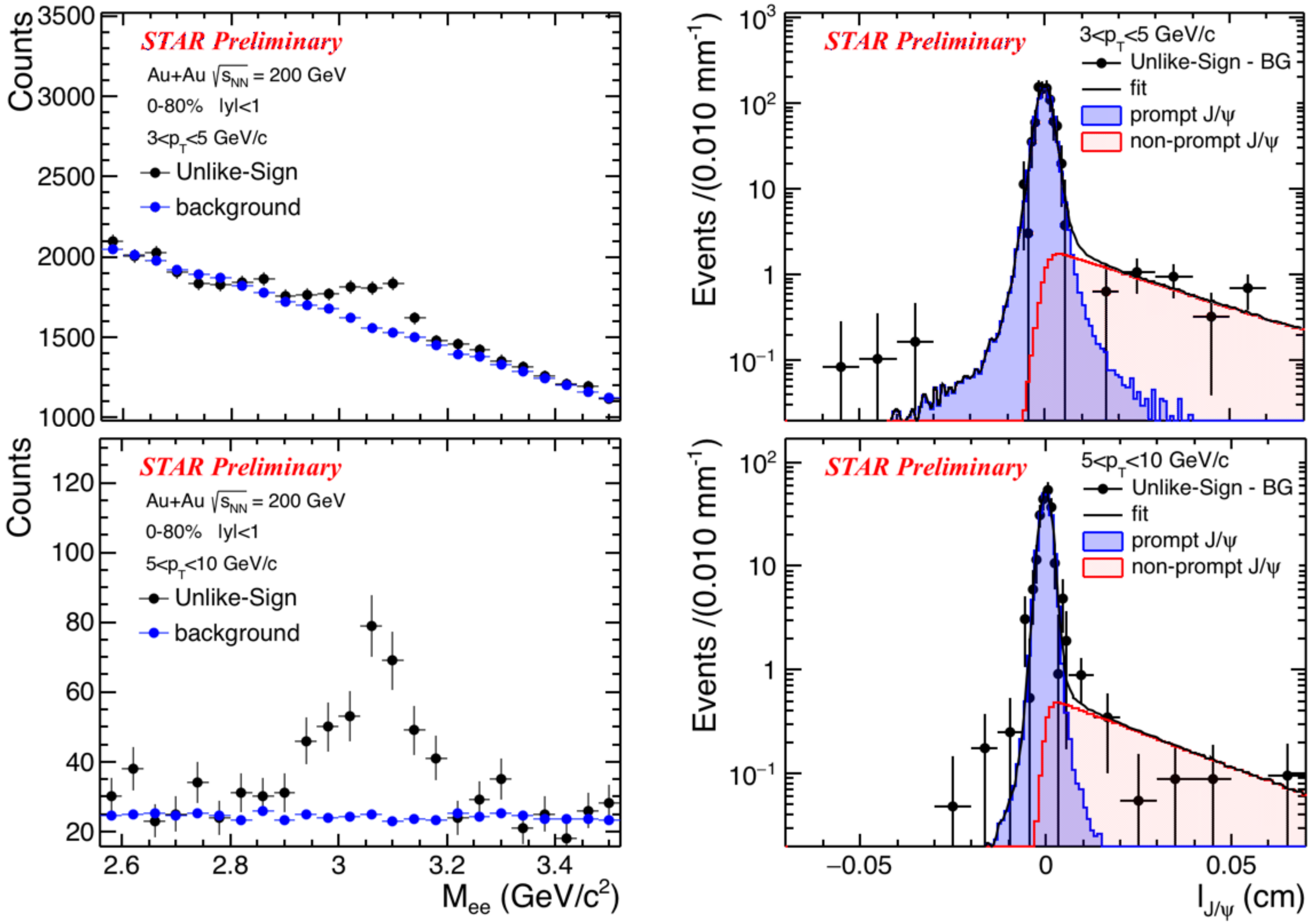
- We have measured 3 different decay channels of **B hadrons** enabled by the **HFT**.

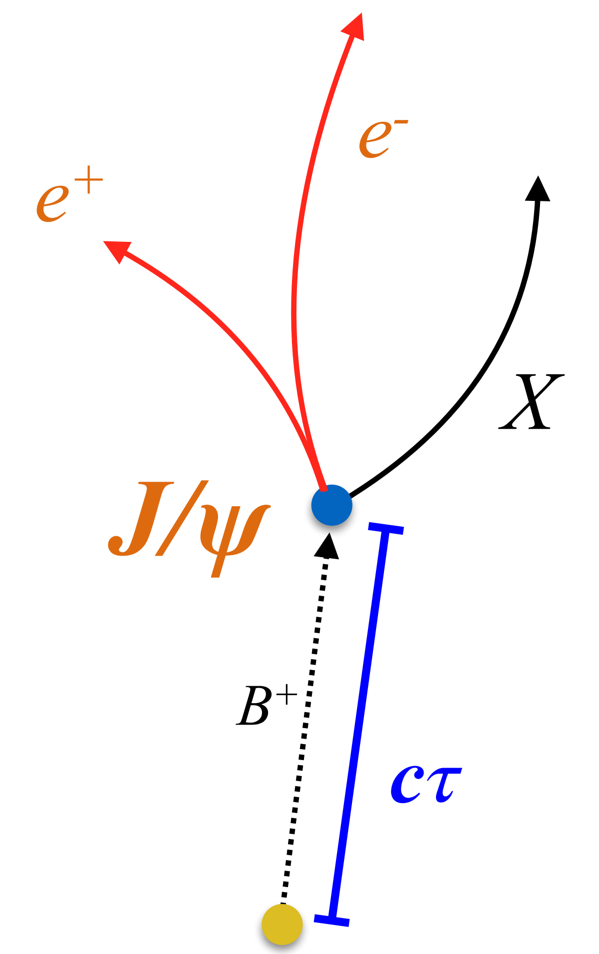
  1 → ~900M MB (2014) + ~1.2 nb^{-1} HT events (2014 + 2016)

  2 → ~900M MB (2014)

  3 → ~900M MB (2014) + ~0.2 nb^{-1} HT events (2014)

$B \to J/\psi$ in Au+Au 200 GeV



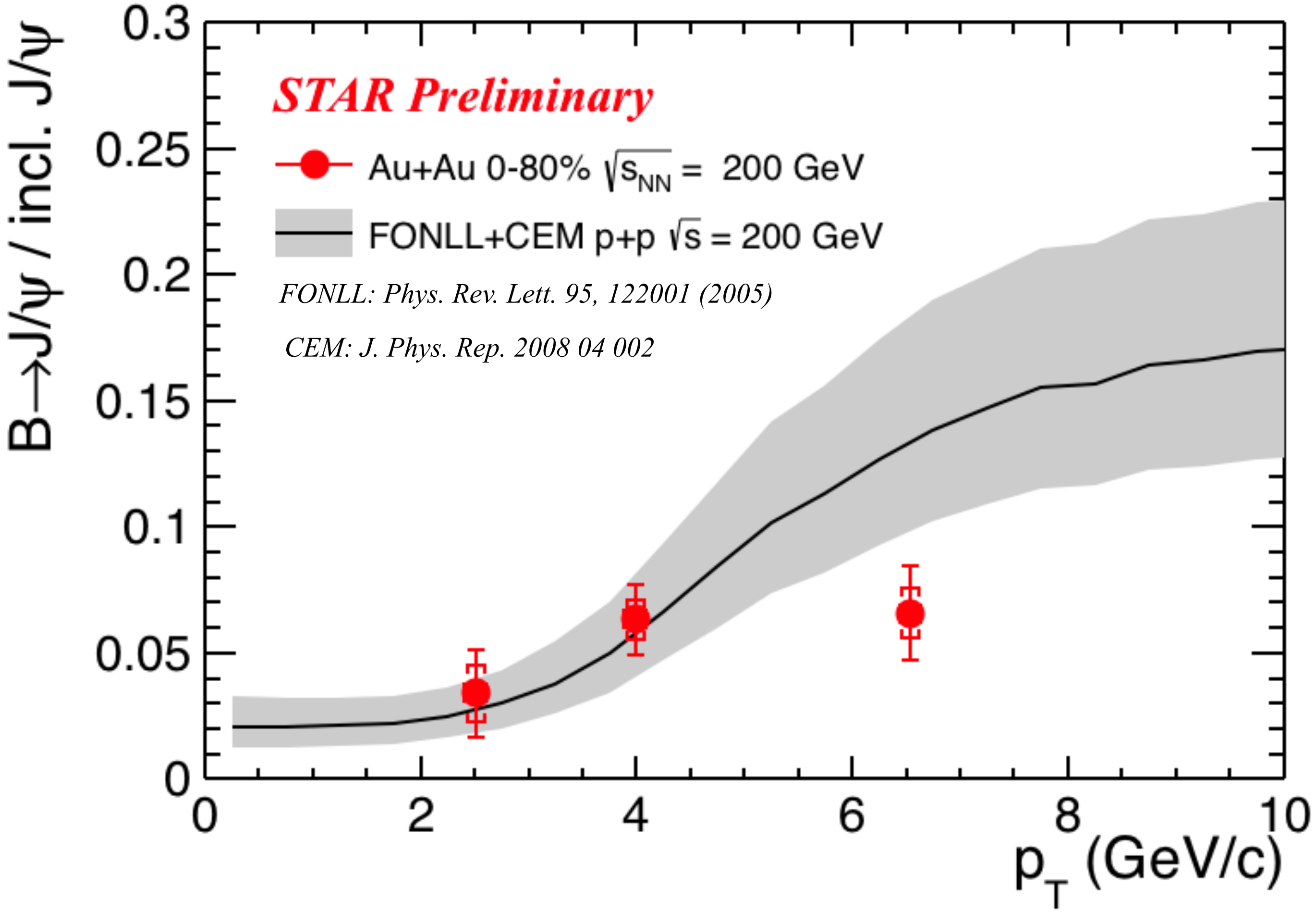


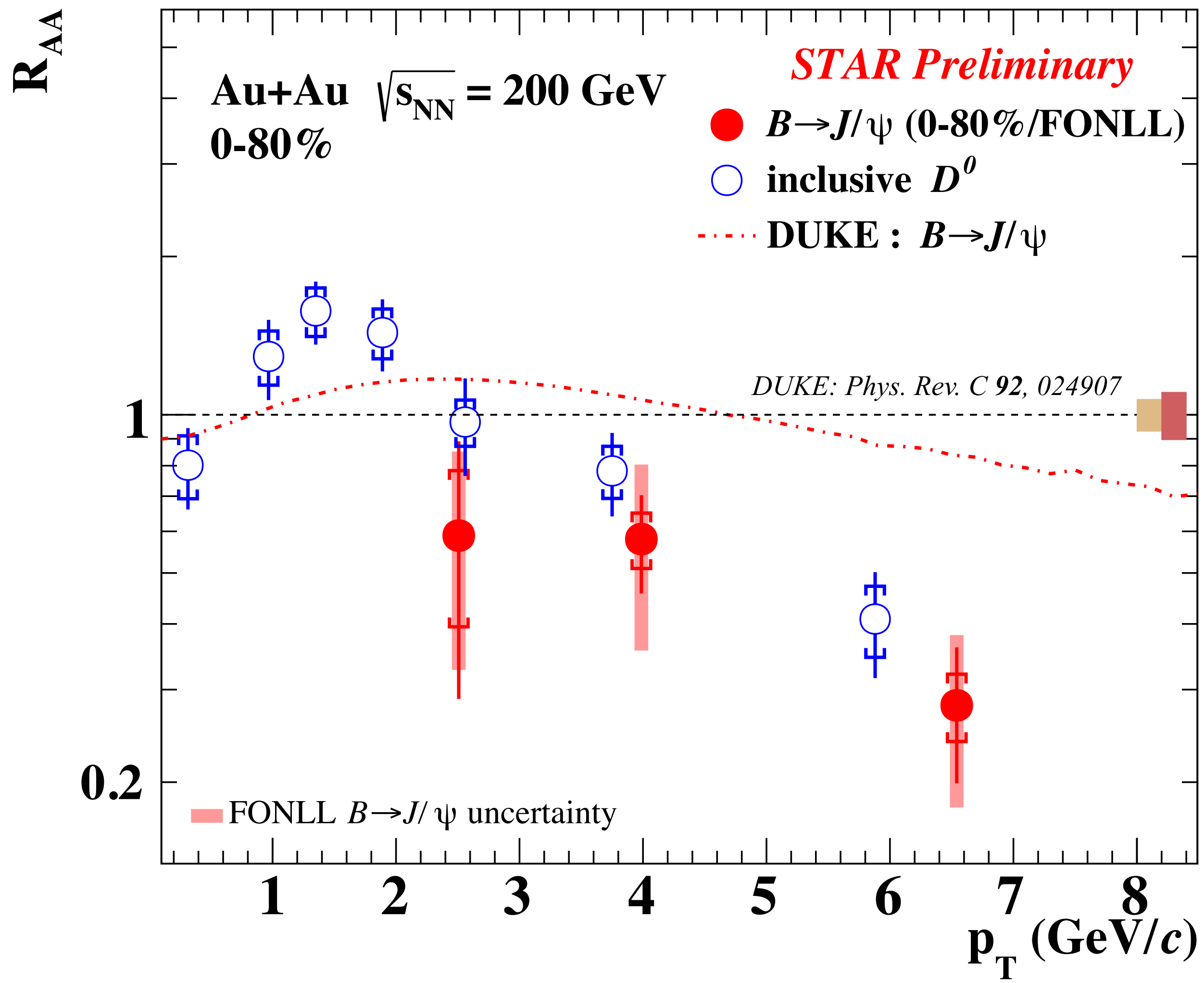
$$l_{J/\psi} = \frac{\vec{L} \cdot \hat{p}}{|p|/c} M_{J/\psi}$$

- Background is estimated using event mixing method.
- $l_{J/\psi}$ distribution is fitted to non-prompt and prompt J/ψ templates.

① $B \rightarrow J/\psi$ in Au+Au 200 GeV

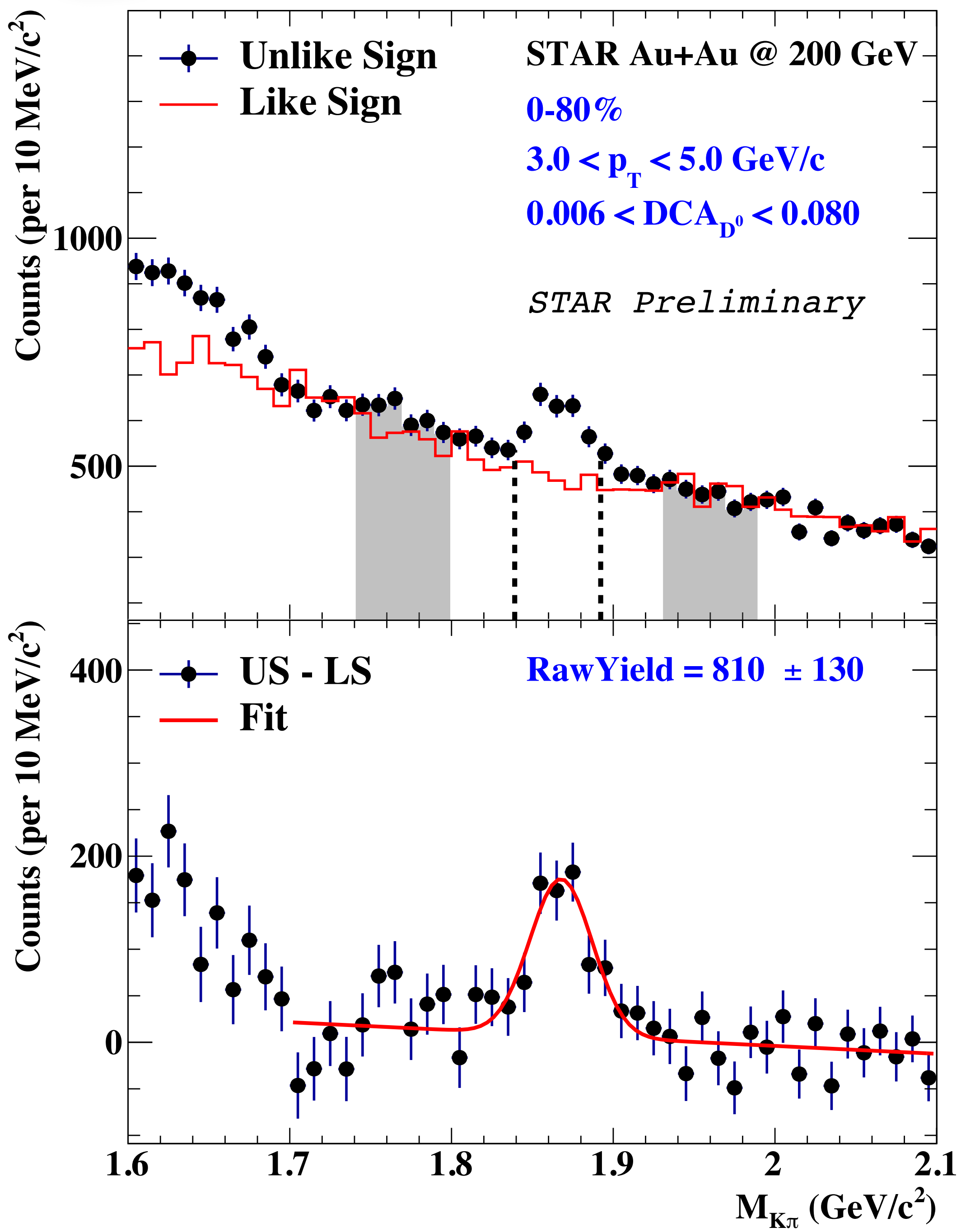
$$R_{AA}^{B\rightarrow J/\psi} = \frac{f_{Au+Au}^{B\rightarrow J/\psi}(data)}{f_{p+p}^{B\rightarrow J/\psi}(theory)} R_{AA}^{inc.\ J/\psi}(data)$$

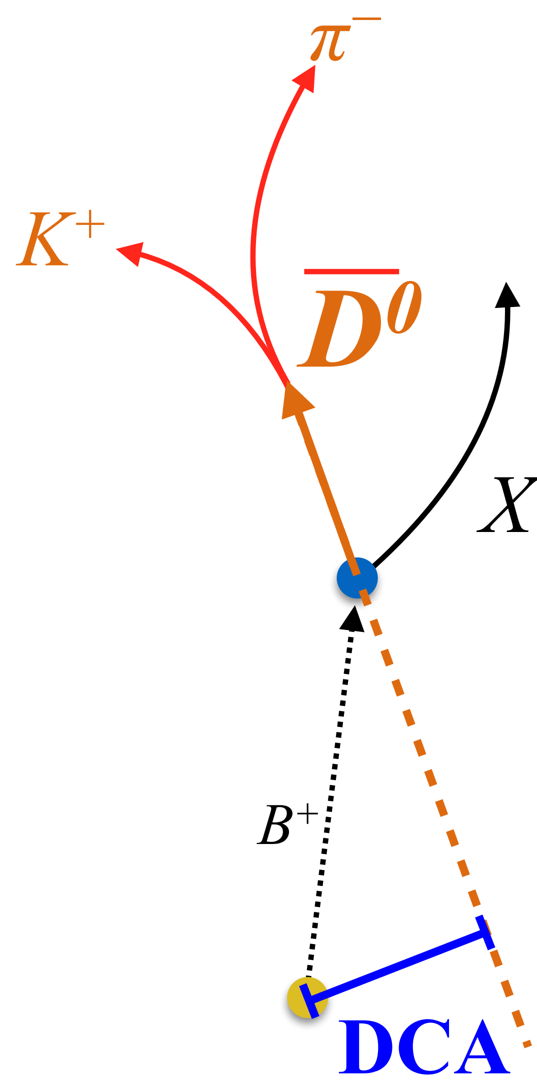


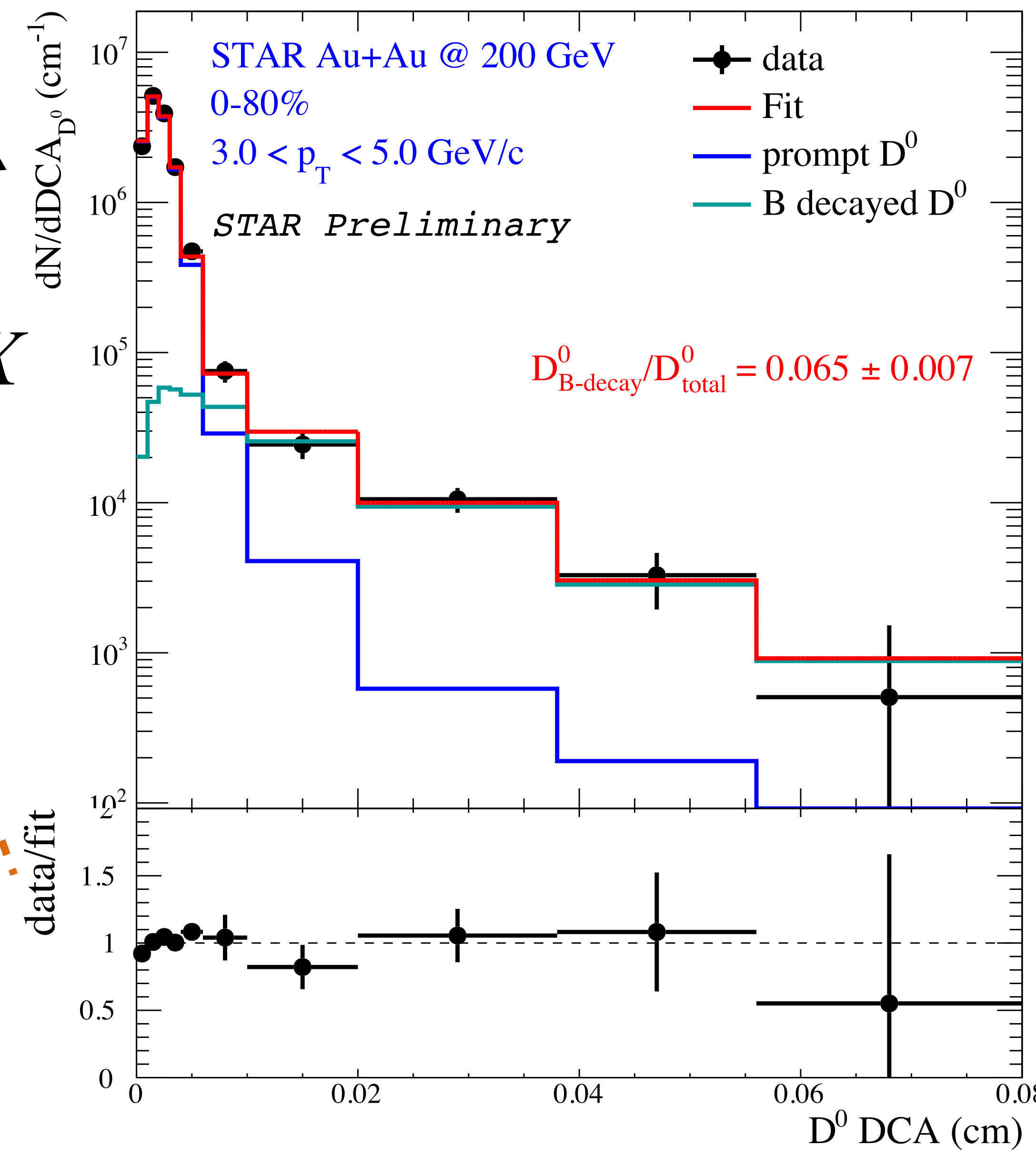


- Nuclear modification factor is calculated with non-prompt J/ψ fraction in p+p from FONLL+CEM and measured inclusive J/ψ R_{AA}.
  → Strong non-prompt J/ψ suppression at high p_T

② $B \rightarrow D^0$ in Au+Au 200 GeV



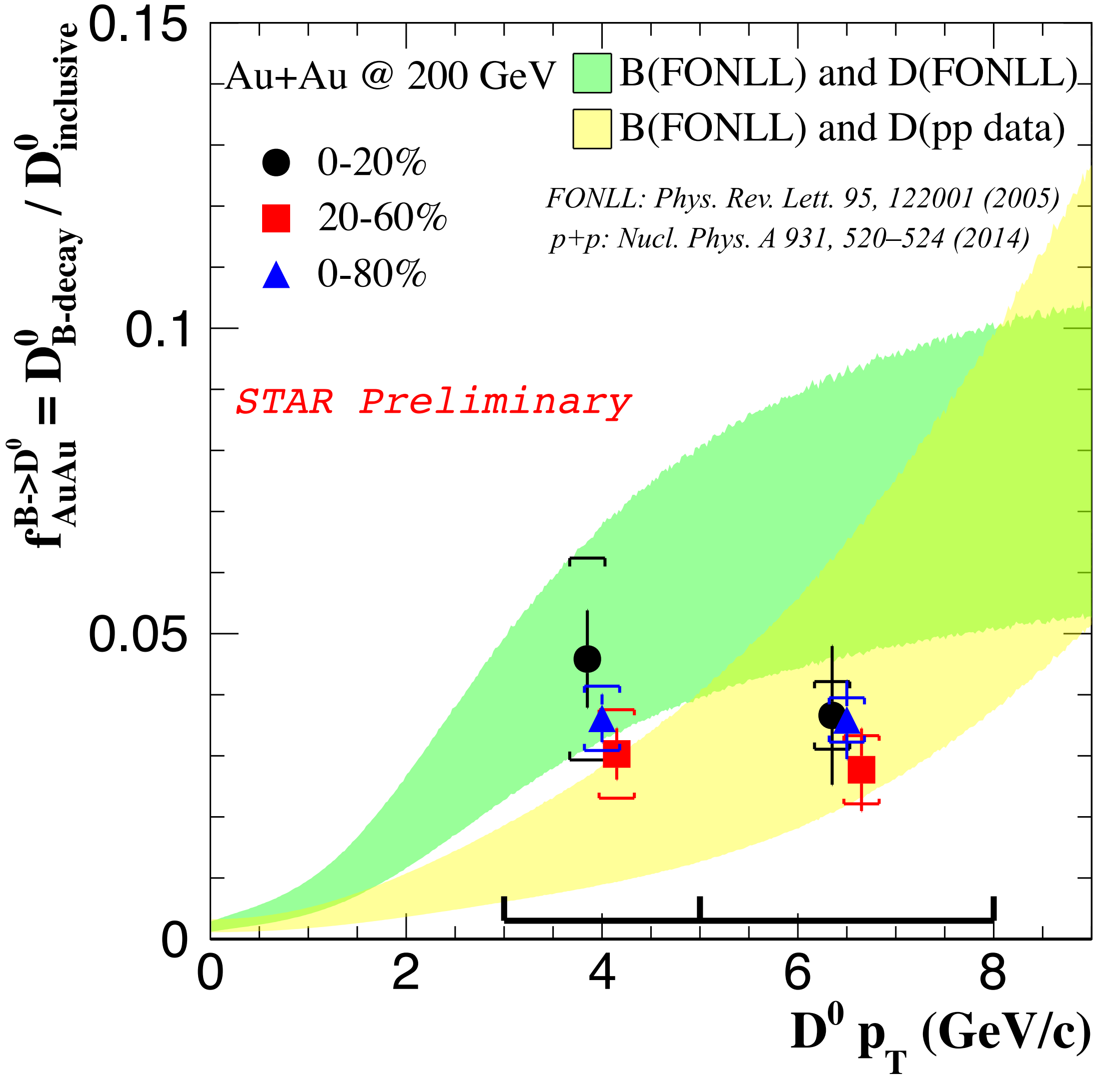


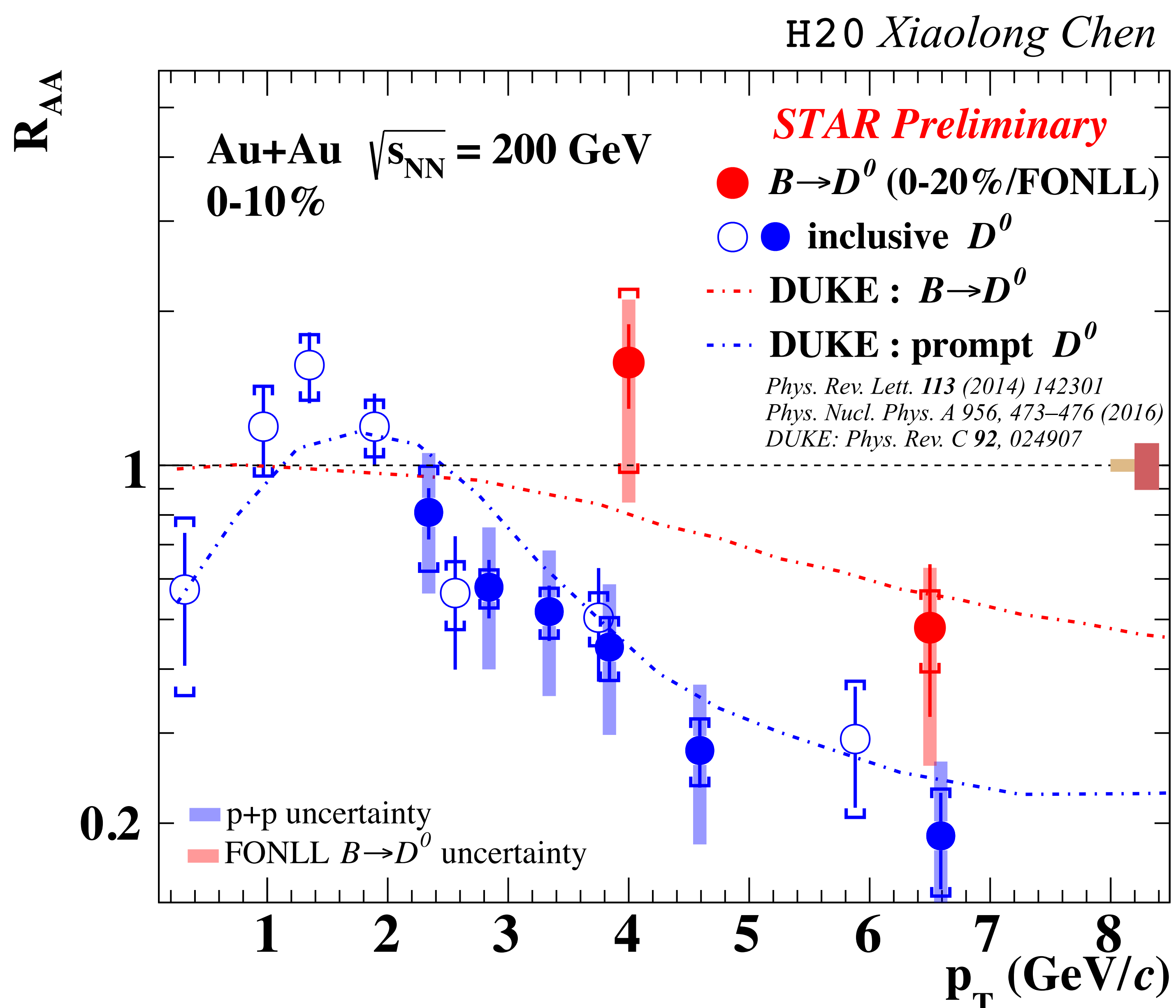


- Background is estimated from side bands.
- D^0 DCA distribution is fitted to non-prompt and prompt D^0 templates.

② $B \to D^0$ in Au+Au 200 GeV

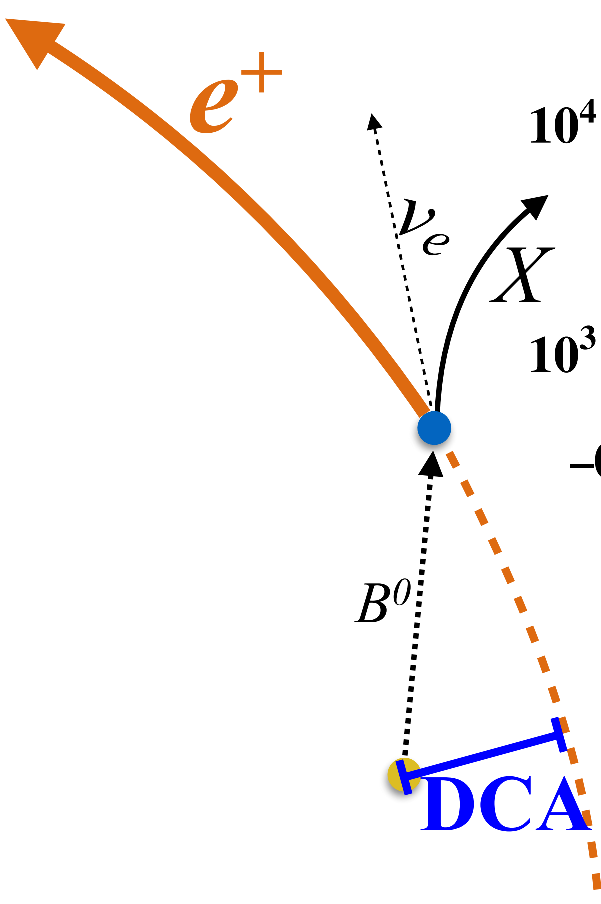
$$R_{AA}^{B\to D^0} = \frac{1}{<N_{coll}>} \frac{f_{Au+Au}^{B\to D^0} \times dN_{Au+Au}^{incl.\ D^0}/dp_T}{dN_{FONLL}^{B\to D^0}/dp_T}$$

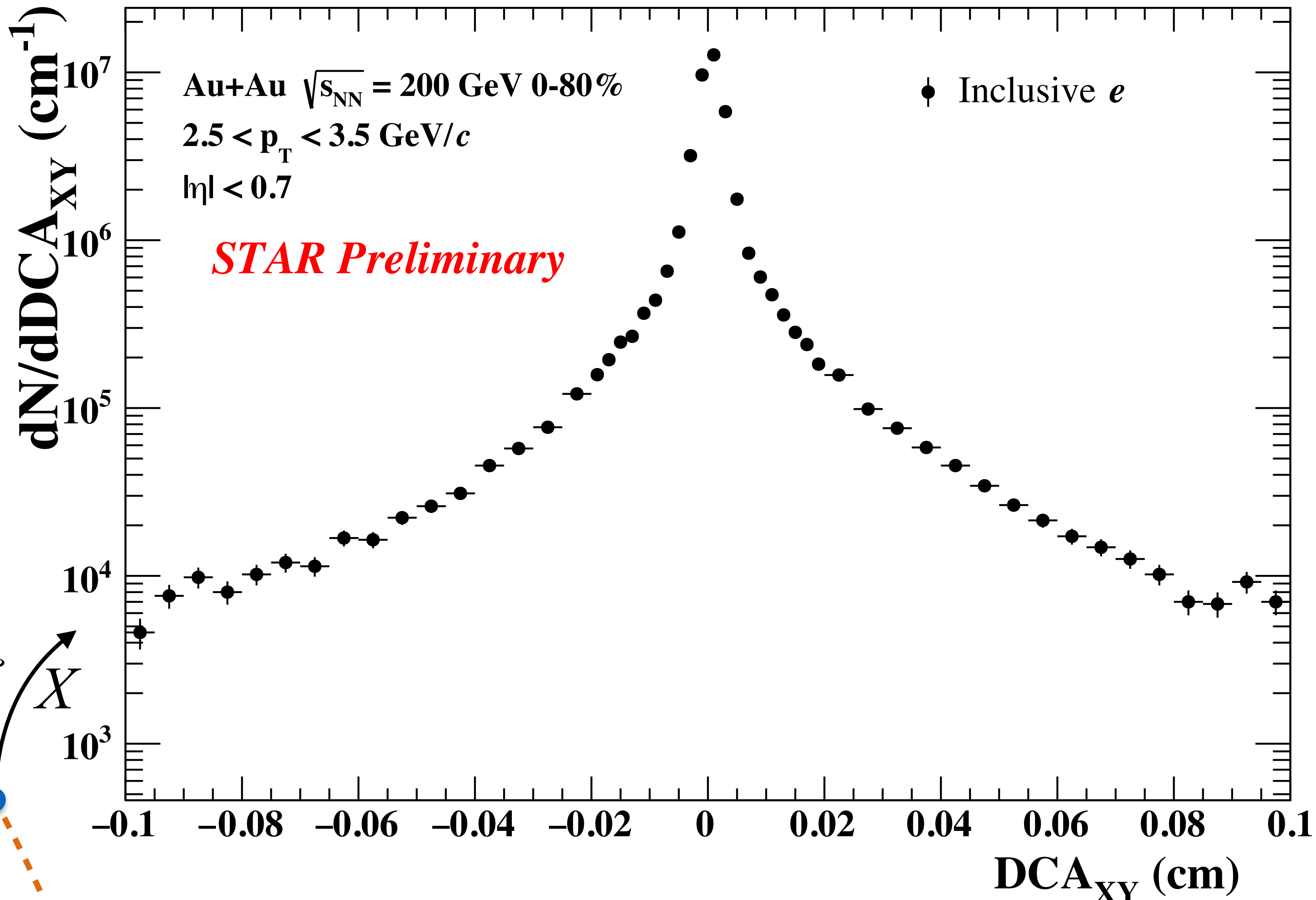




- Nuclear modification factor is calculated with non-prompt D^0 yield in p+p from FONLL prediction.
  → Strong non-prompt D^0 suppression at high p_T (p_T > 5 GeV/c)
  → Hint of less suppression for non-prompt than prompt D^0 at 3-8 GeV/c

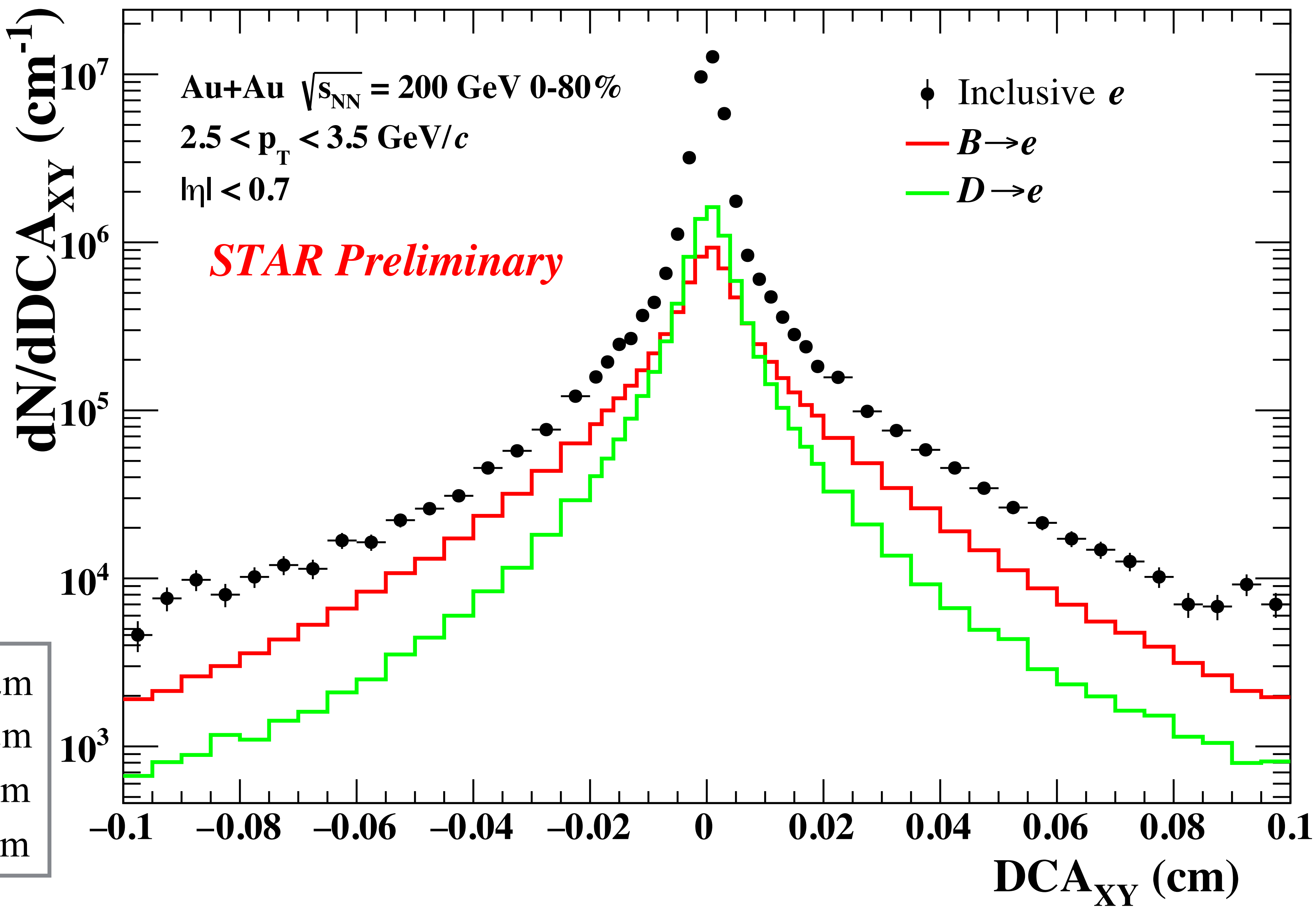
③ *B/D→e* in Au+Au 200 GeV





- Inclusive single electron DCA distribution fitted to **charm**- and **bottom**-decayed electron, **photonic** electron, and **hadron** contamination templates.

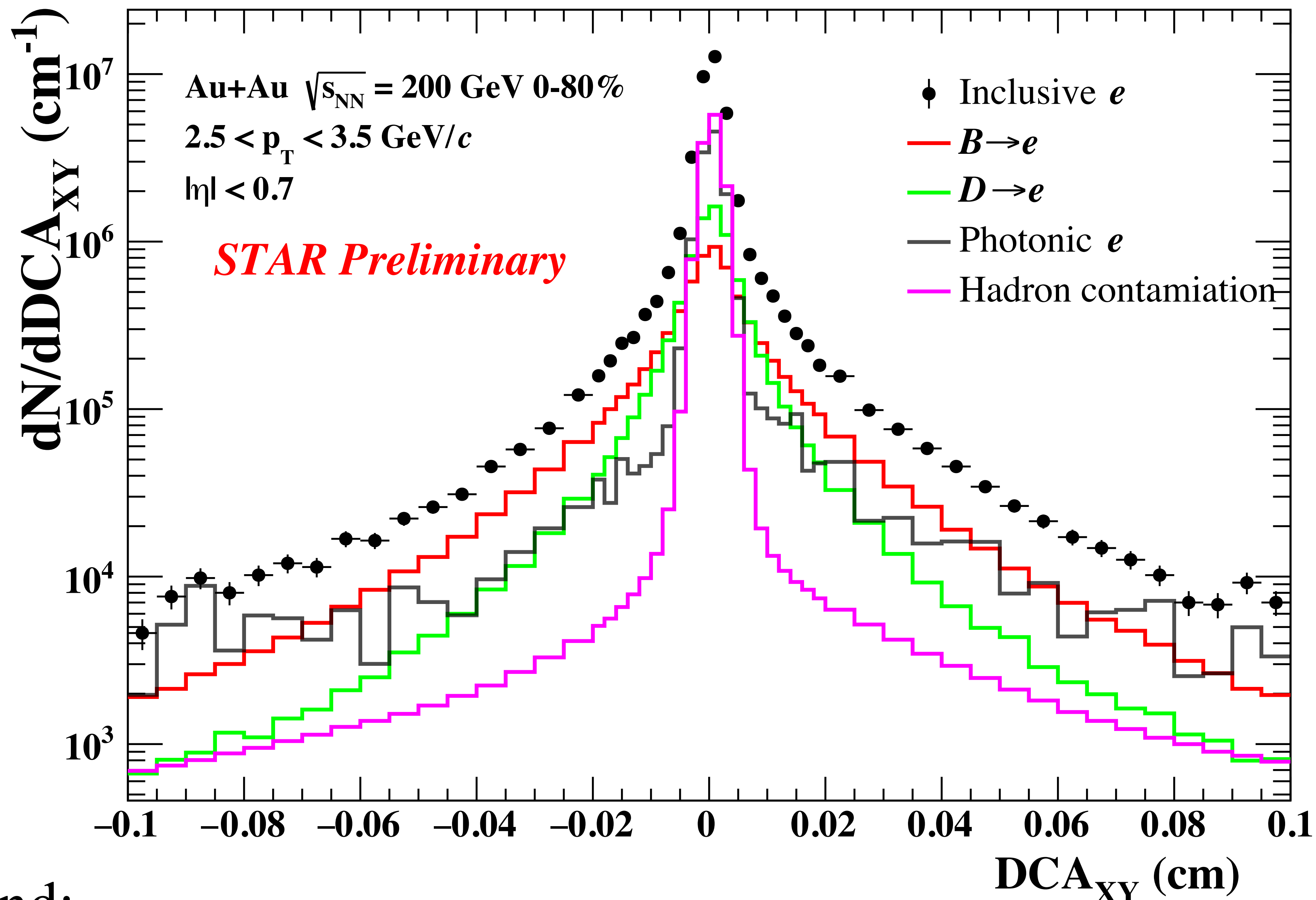
③ *B/D→e* in Au+Au 200 GeV



$c\tau(D^0)$	~ 123 μm
$c\tau(D^\pm)$	~ 312 μm
$c\tau(B^0)$	~ 459 μm
$c\tau(B^\pm)$	~ 491 μm

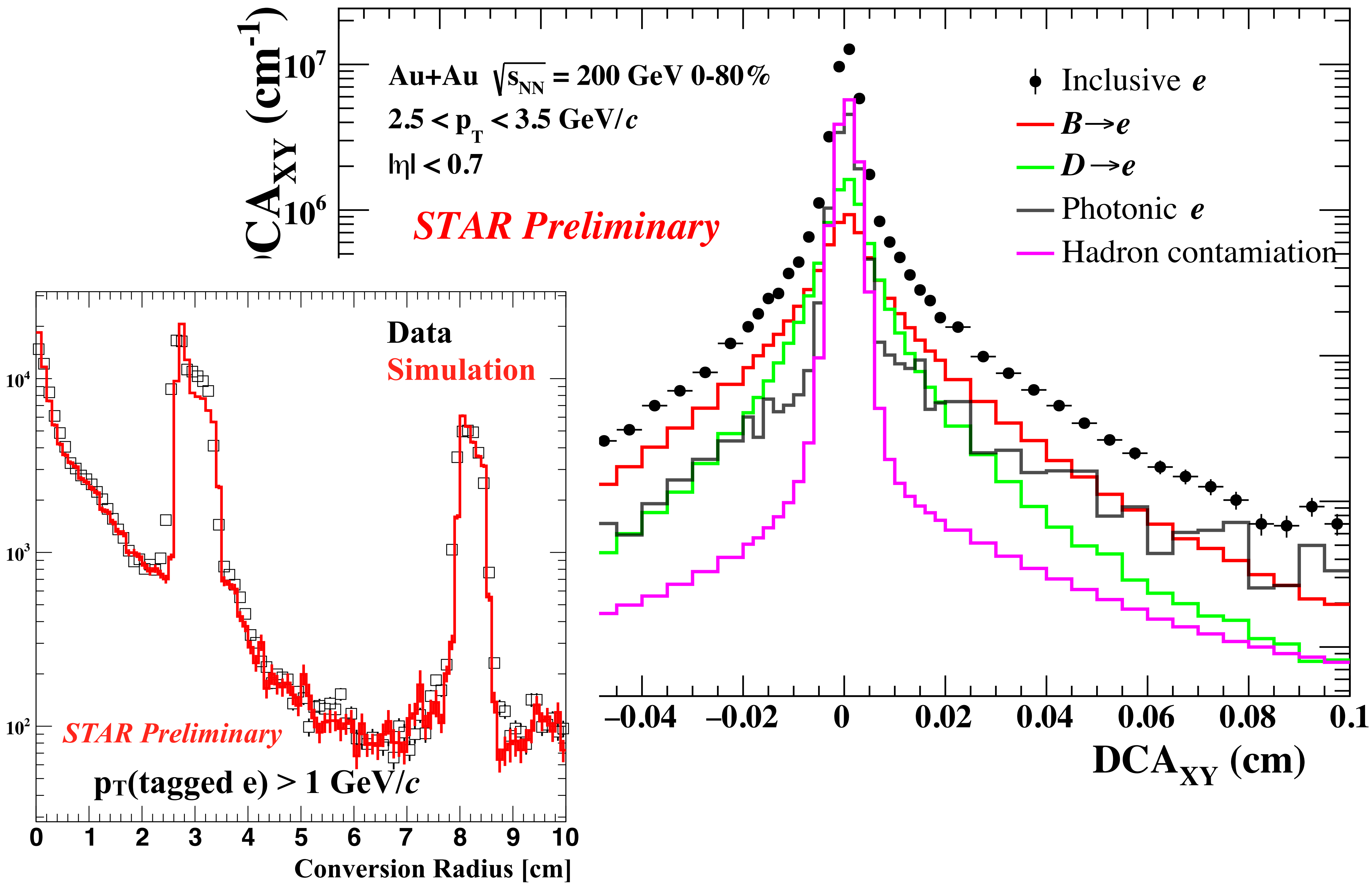
- *B* hadrons have longer life time than *D* hadrons → broader DCA$_{XY}$ distribution for **bottom**- than **charm**-decayed electrons

③ *B/D→e* in Au+Au 200 GeV



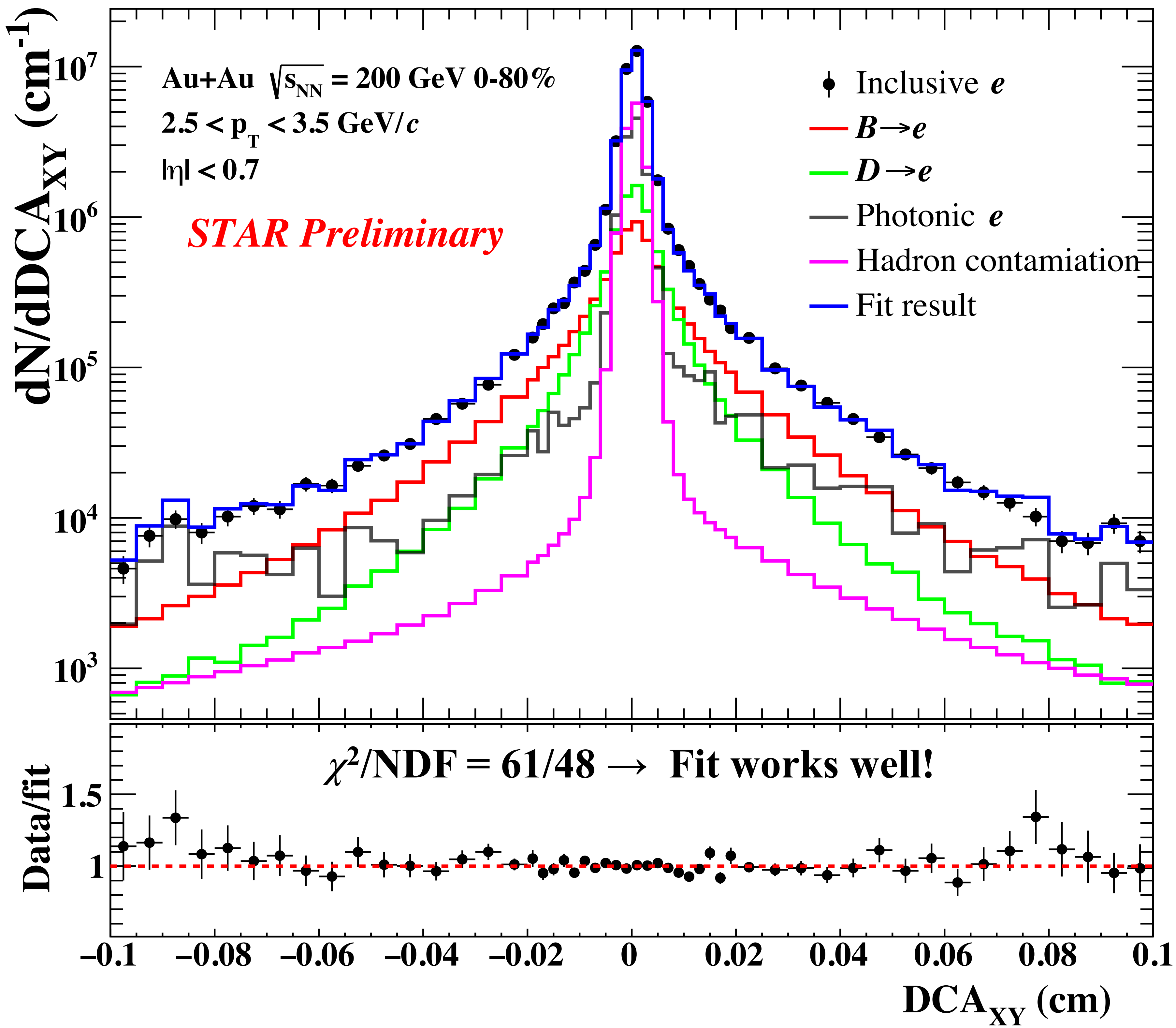
- Background:
  - mis-identified **hadron** (other primary electrons)
  - **photonic electron** — gamma conversion and light meson Dalitz decay

③ *B/D→e* in Au+Au 200 GeV



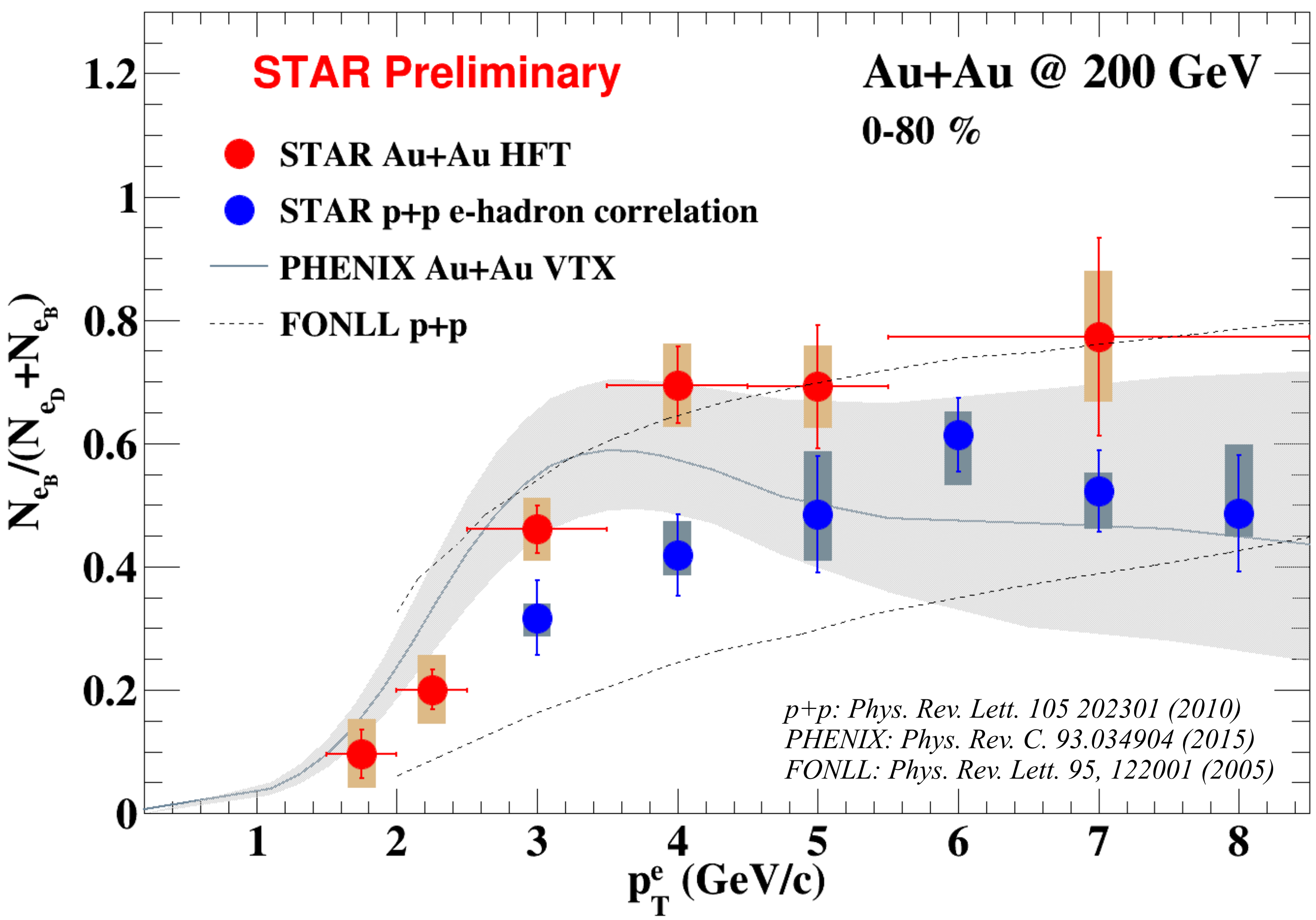
- Radius distribution of photonic electron pairs in data can be well described by detector simulation.

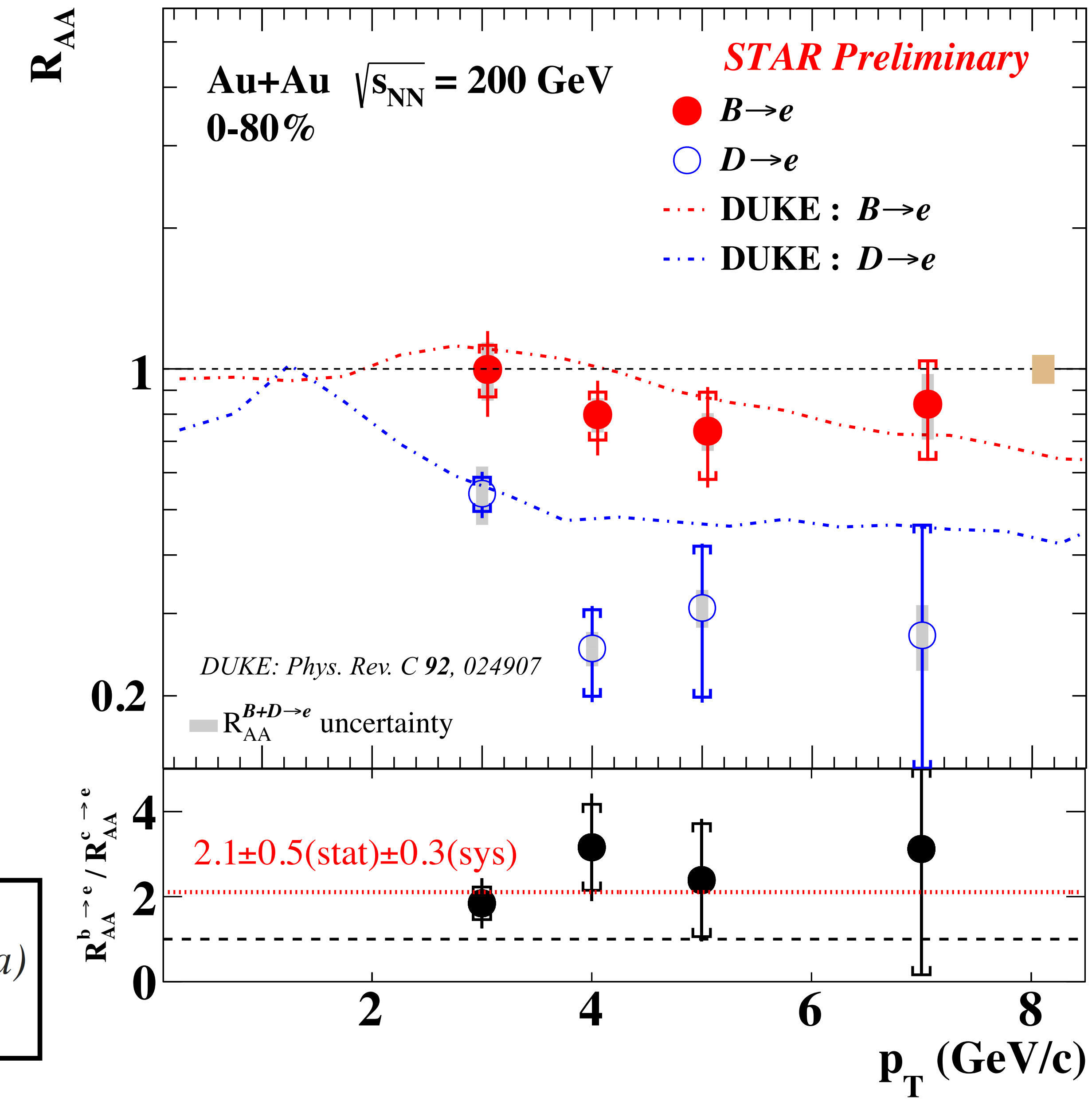
③ *B/D→e* in Au+Au 200 GeV



C07 *Xiaozhi Bai*, I01 *Shenghui Zhang*

③ *B/D→e* in Au+Au 200 GeV





$$R_{AA}^{B\to e}=\frac{f_{Au+Au}^{B\to e}(data)}{f_{p+p}^{B\to e}(data)}R_{AA}^{inc.\ e}(data),\quad R_{AA}^{D\to e}=\frac{1-f_{Au+Au}^{B\to e}(data)}{1-f_{p+p}^{B\to e}(data)}R_{AA}^{inc.\ e}(data)$$

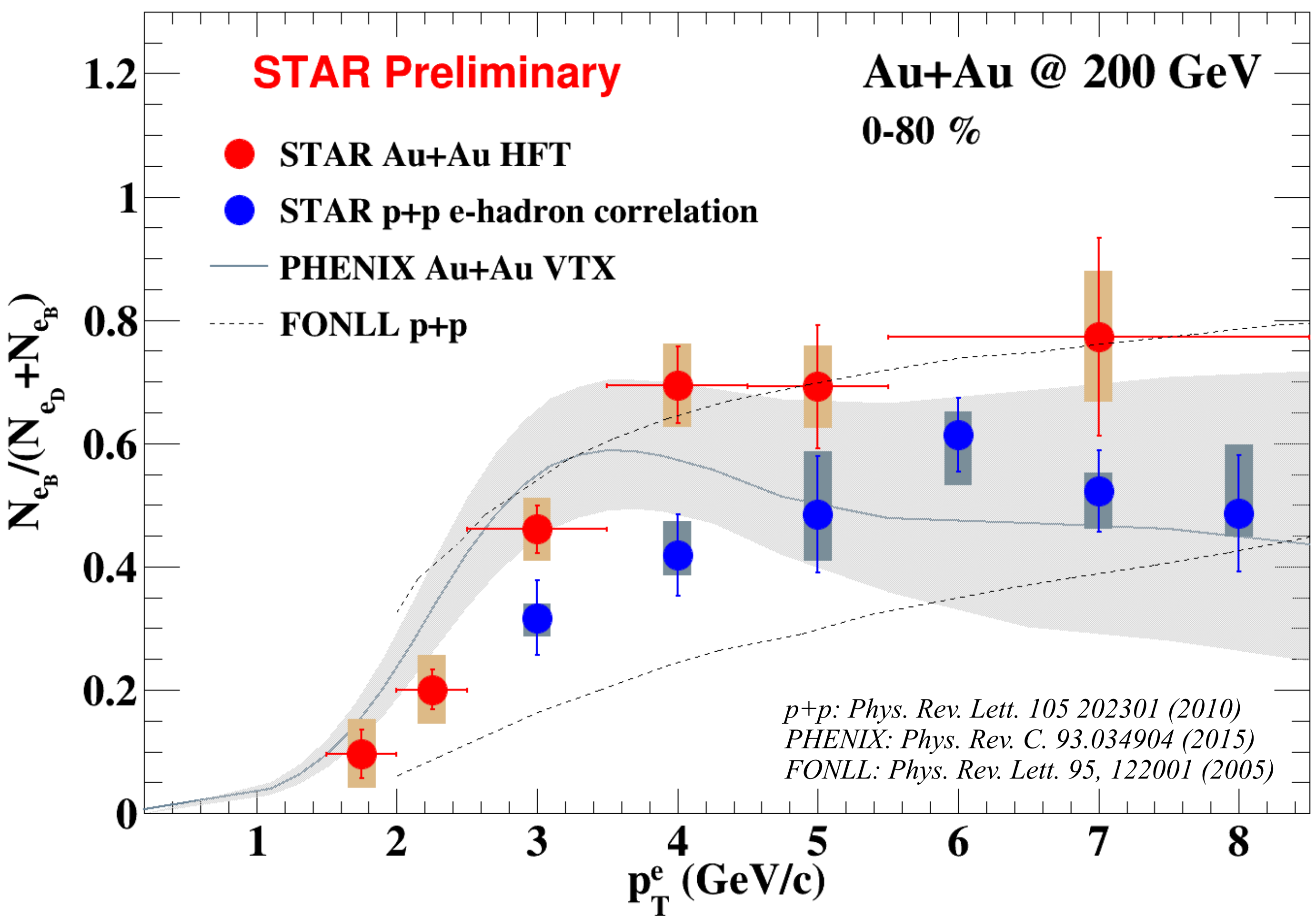
- Nuclear modification factor calculated with inclusive NPE R_{AA}, and bottom-decayed electron fractions measured in p+p and Au+Au.

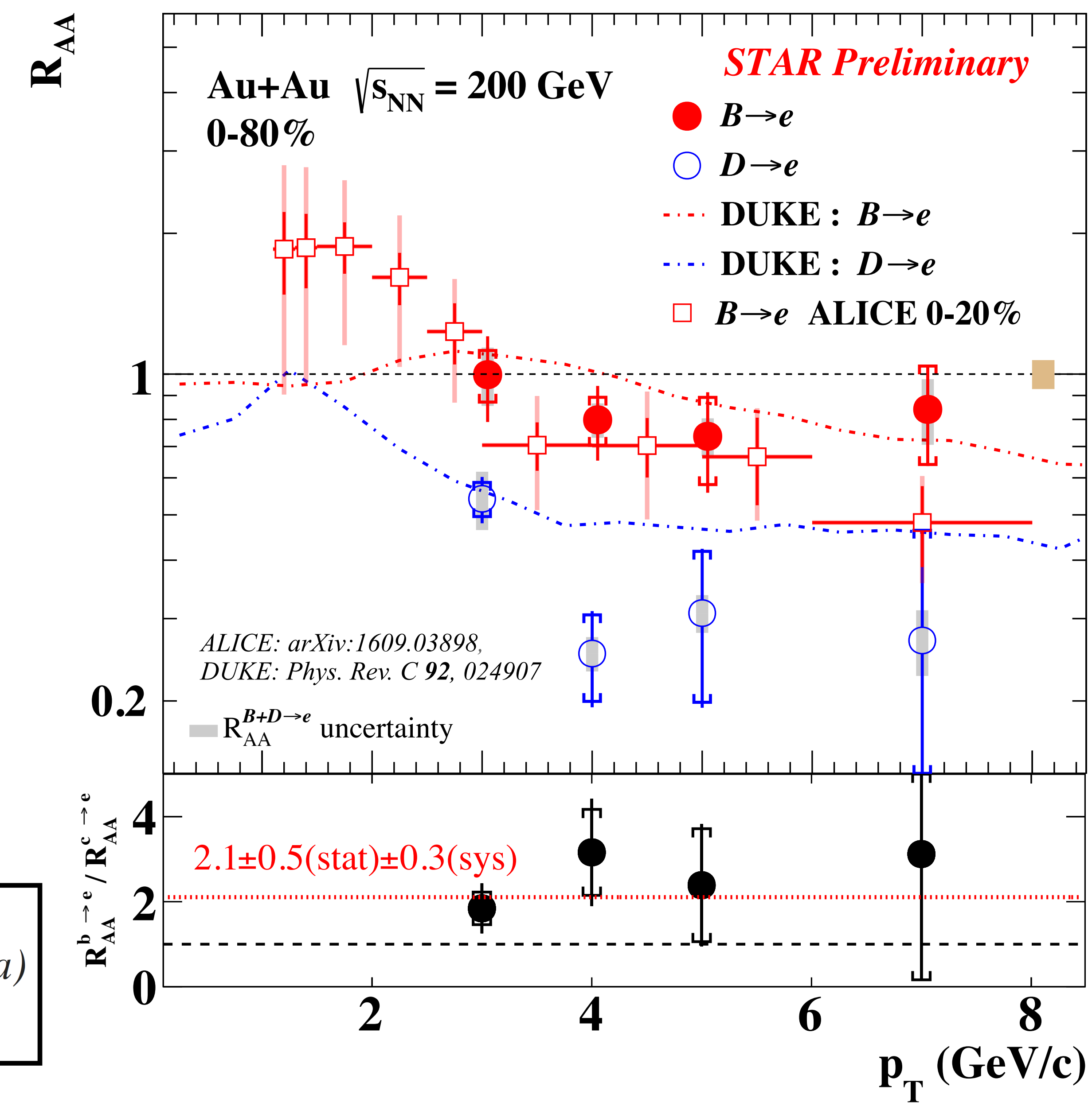
→ R_{AA} (e_D) < R_{AA} (e_B) (~2σ at 3-8 GeV/c)

→ Consistent with mass hierarchy for parton energy loss ($\Delta E_c > \Delta E_b$)

C07 *Xiaozhi Bai*, I01 *Shenghui Zhang*

③ *B/D→e* in Au+Au 200 GeV



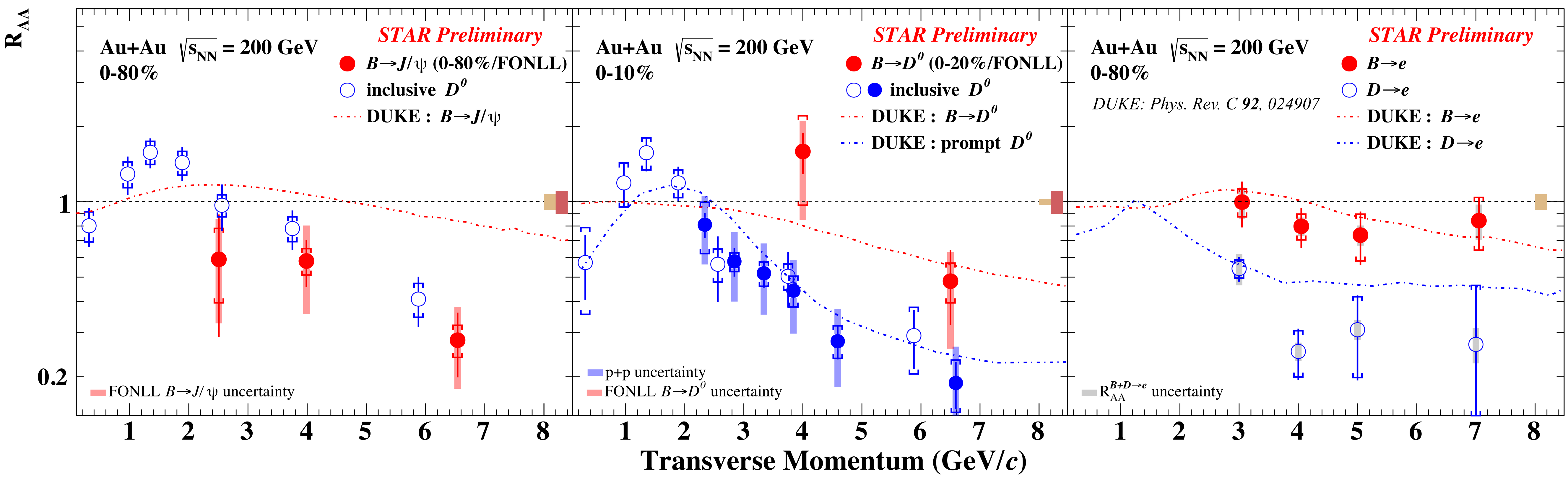


$$R_{AA}^{B\to e}=\frac{f_{Au+Au}^{B\to e}(data)}{f_{p+p}^{B\to e}(data)}R_{AA}^{inc.\ e}(data),\quad R_{AA}^{D\to e}=\frac{1-f_{Au+Au}^{B\to e}(data)}{1-f_{p+p}^{B\to e}(data)}R_{AA}^{inc.\ e}(data)$$

- *B→e* R_{AA} precision competitive to other experiments
- 5× more statistics from year 2016

B measurements in STAR

1 $B \to J/\psi$ 2 $B \to D^0$ 3 $B/D \to e$



- ★ We have measured ***B* production** via J/ψ, D^0 and electron decay channels **in 200 GeV Au+Au collisions** at **STAR**.
  - ➢ Strong suppression for $B \to J/\psi$ and D^0 at high p_T.
  - ➢ Indication of less suppression for $B \to e$ than $D \to e$ (~2 σ): consistent with $\Delta E_c > \Delta E_b$

- ★ Outlook:
  - ★ 2B MB events for $B \to D^0$ and 1 nb^{-1} (5× times) HT events for $B/D \to e$ from 2016
  - ★ Proposed HFT$^+$ upgrade for precision bottom measurements in 2022+. (N09 *Yaping Wang*)

Backup

Comparison with PHENIX