



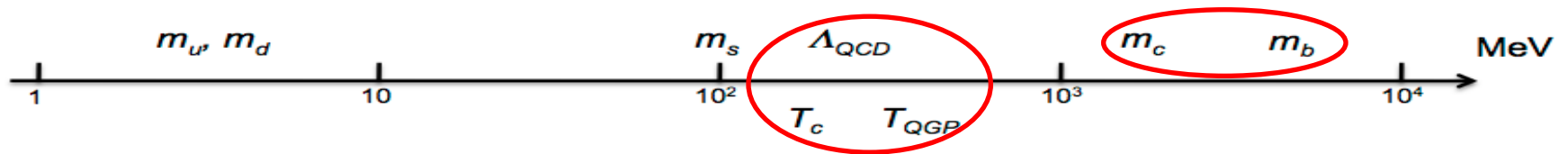
***Open bottom production in Au+Au collisions
at $\sqrt{s_{NN}} = 200$ GeV with the STAR experiment***

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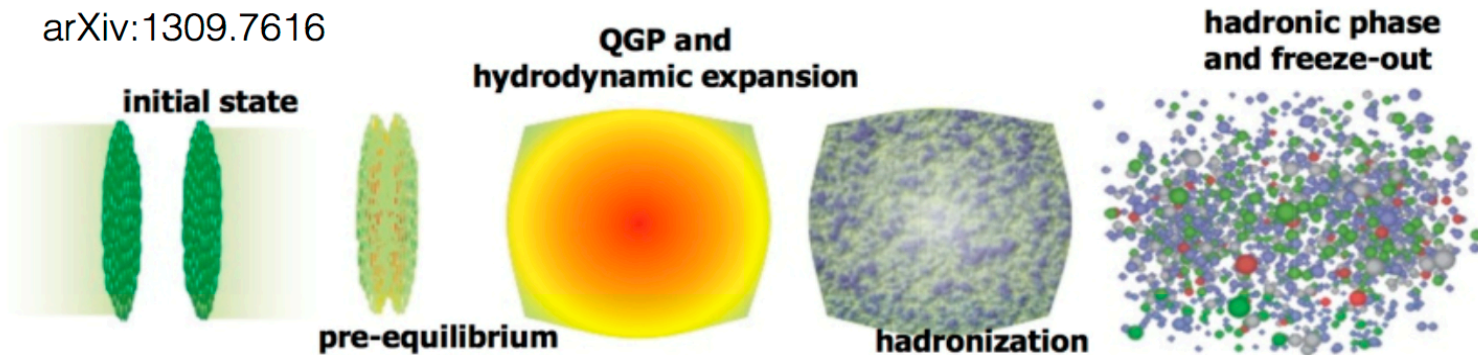
- Why heavy flavor?
- The STAR experiment
- Bottom production in 200 GeV Au+Au collisions
 - ★ $B/D \rightarrow e$
 - ★ $B \rightarrow J/\psi$
 - ★ $B \rightarrow D^0$
- Summary and Outlook

Why Heavy Flavor?



- $m_{c,b} \gg T_{\text{QGP}}$; dominantly produced in hard scatterings at the early stage of heavy-ion collisions.
 - ★ Experience all stages of QGP evolution
→ carry information of interactions with the medium.
 - ★ An excellent probe to study the properties of the QGP.

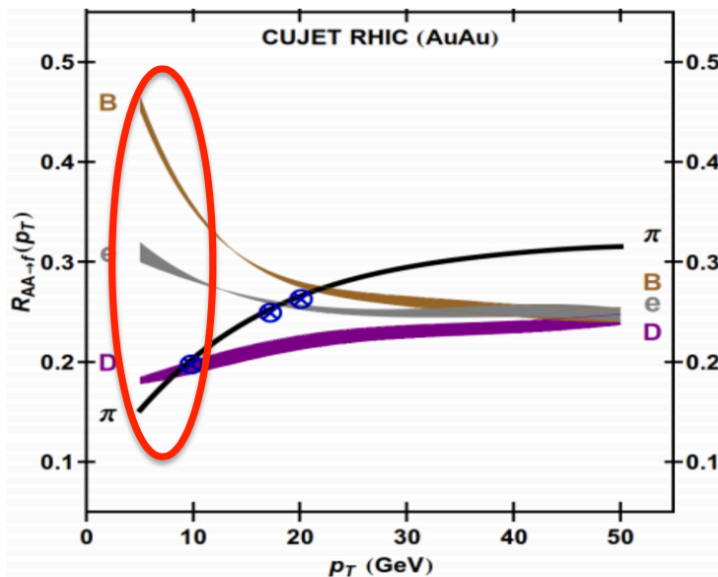
arXiv:1309.7616



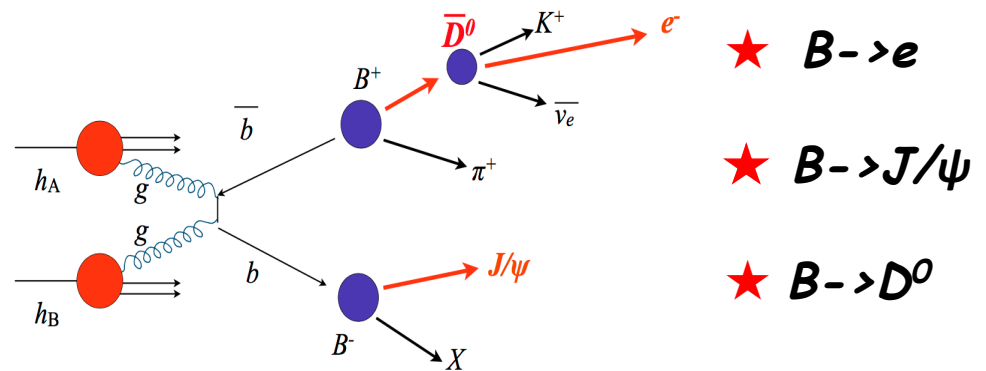
Why Heavy Flavor?

Observables:

- Study flavour dependence of parton energy loss.
 - Theoretical prediction for ΔE in medium: $\Delta E_g > \Delta E_{u,d,s} > \Delta E_c > \Delta E_b$.
 - Precise measurements of c and b quark energy losses separately are crucial to test the **mass hierarchy** of the parton energy loss.

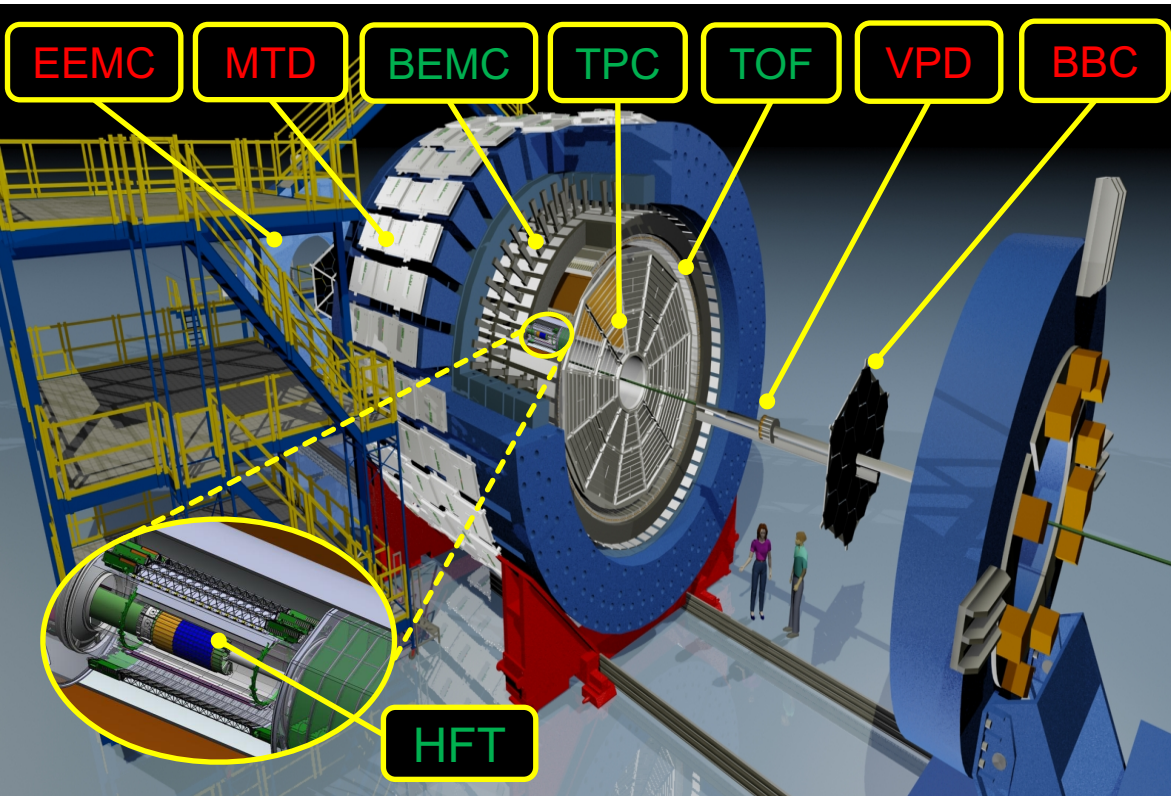


PRL 108 (2012) 022301



The STAR detector

★ $|\eta| < 1$ and full azimuthal coverage



Time Projection Chamber (TPC)

- Momentum determination
- PID through dE/dx

Time of Flight (TOF)

- PID through time-of-flight
- Timing resolution: ~ 85 ps

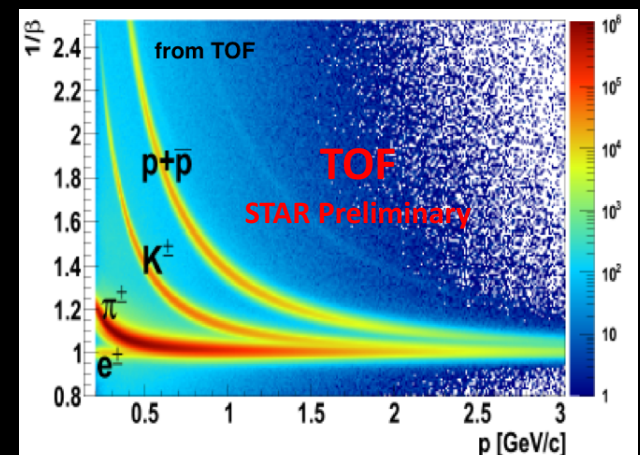
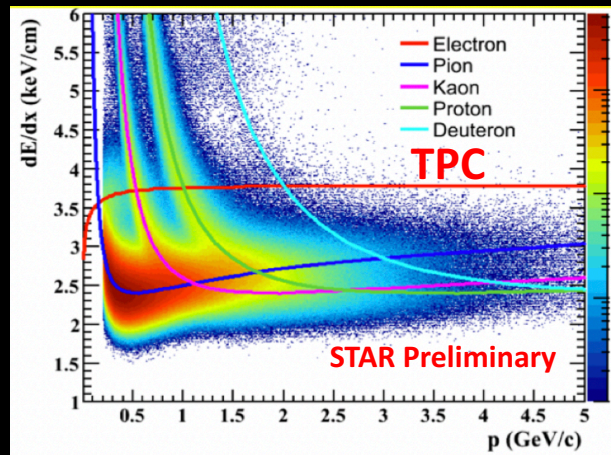
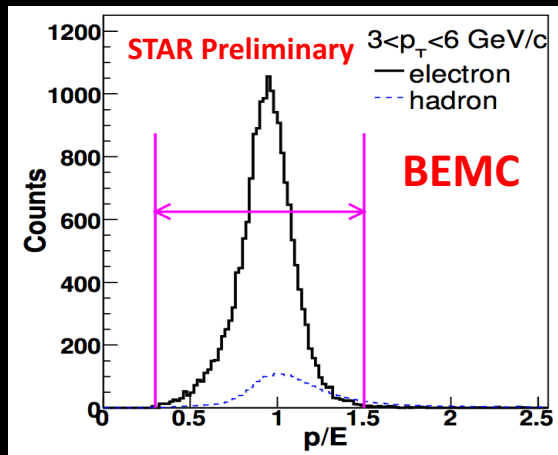
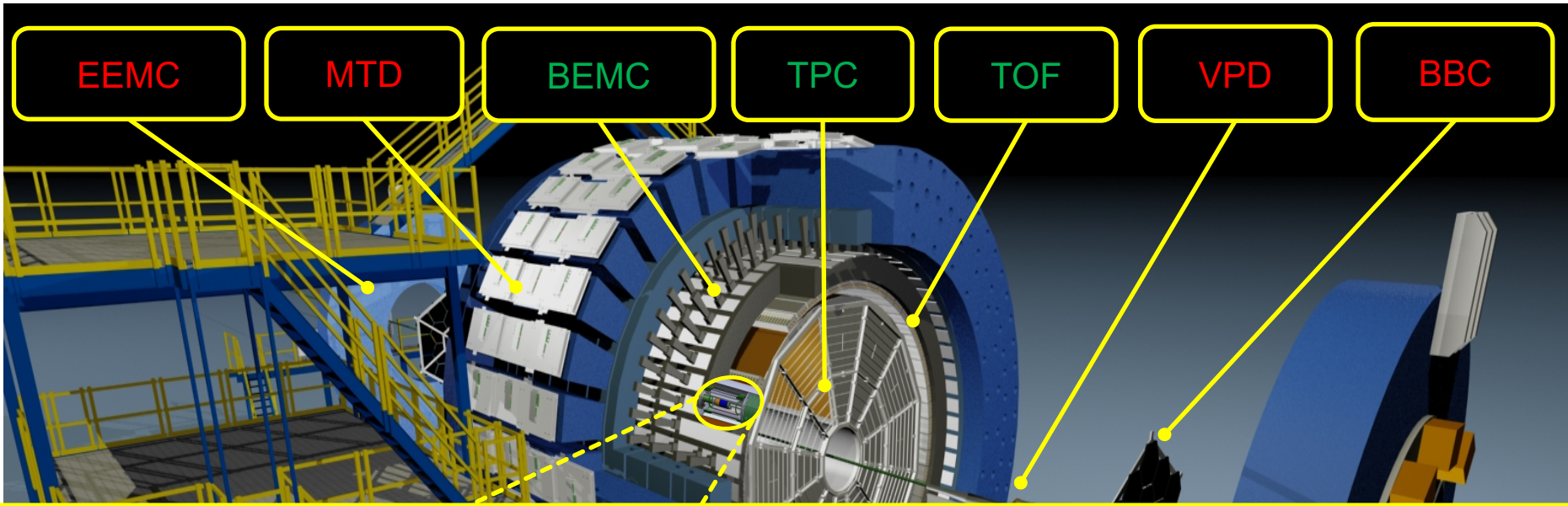
Barrel Electromagnetic Calorimeter (BEMC)

- PID through p/E
- Trigger on high- p_T electrons

Heavy Flavor Track (HFT)

- Precise measurements of **displaced vertices**

The STAR detector



The STAR detector

EEMC

MTD

BEMC

TPC

TOF

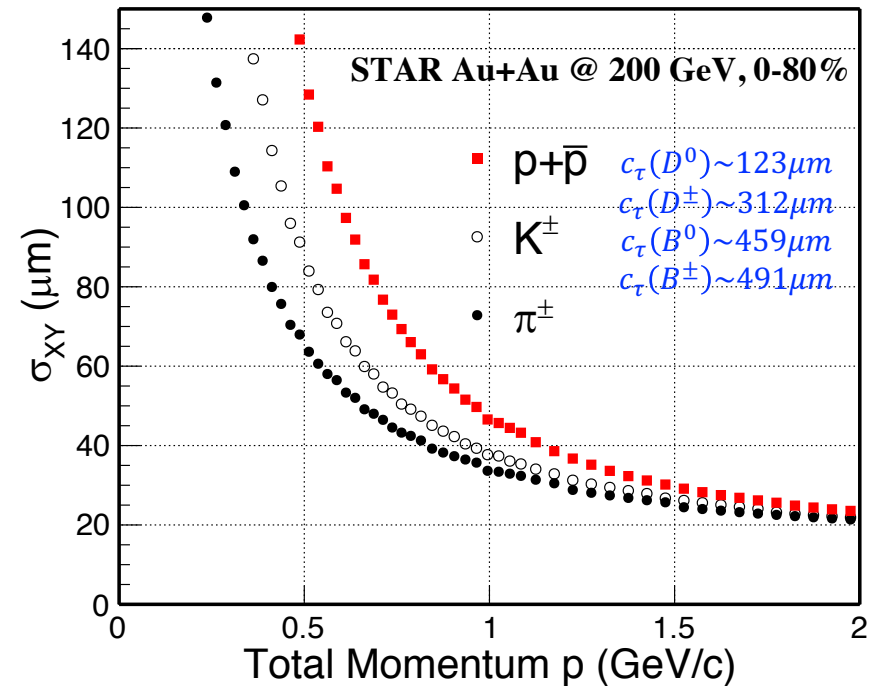
VPD

BBC

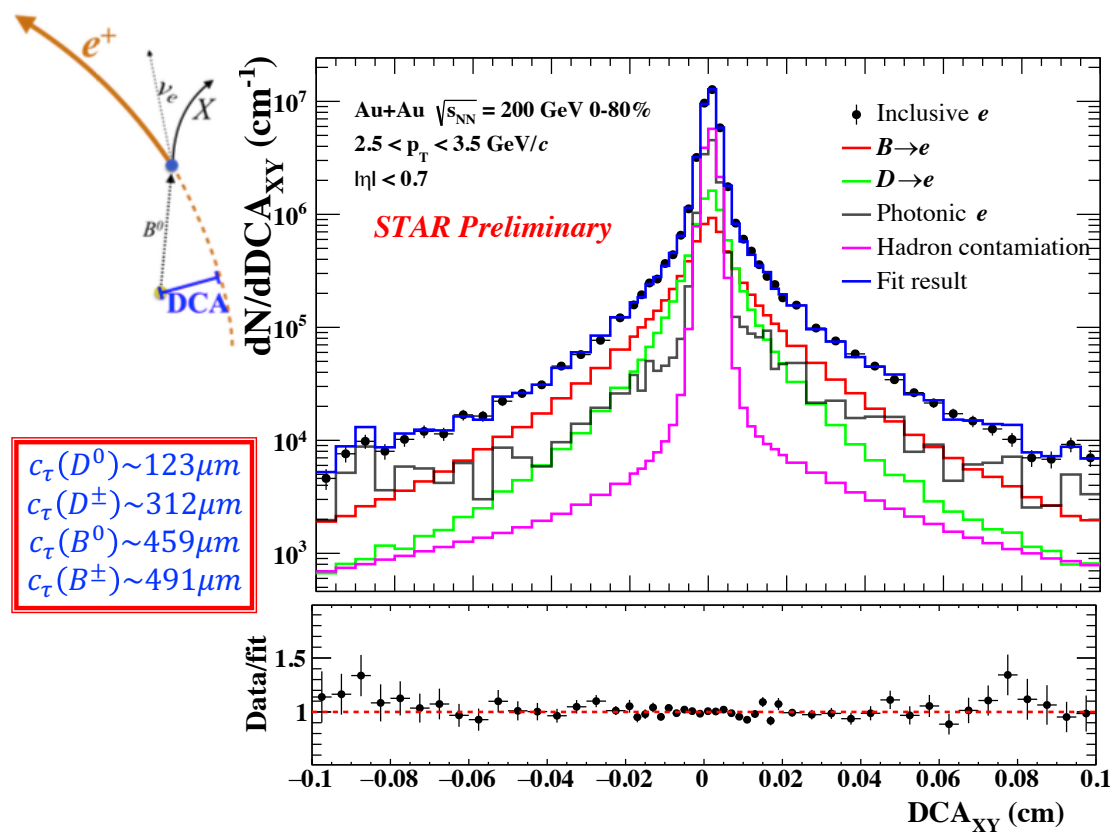
HFT (2014-2016):

- ★ Silicon Strip Detector: $r \sim 22$ cm
- ★ Intermediate Silicon Tracker: $r \sim 14$ cm
- ★ PIXEL detector: $r \sim 2.8$ & 8 cm, MAPS, 20×20 mm², $0.4\%X_0$ thick, air-cooled

HFT



Analysis Procedure - Template fitting of $B/D \rightarrow e$ in 200 GeV Au+Au collisions $\sim 900\text{M MB} + \sim 0.2 \text{ nb}^{-1} \text{ HT events}$



❖ Inclusive electrons

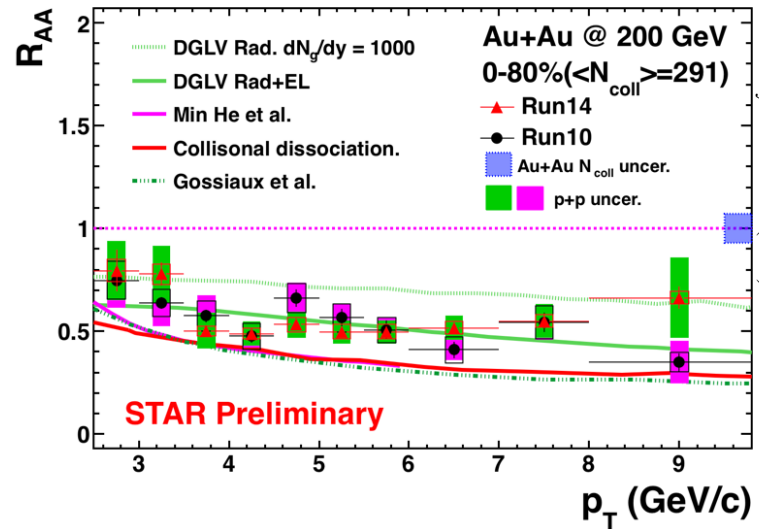
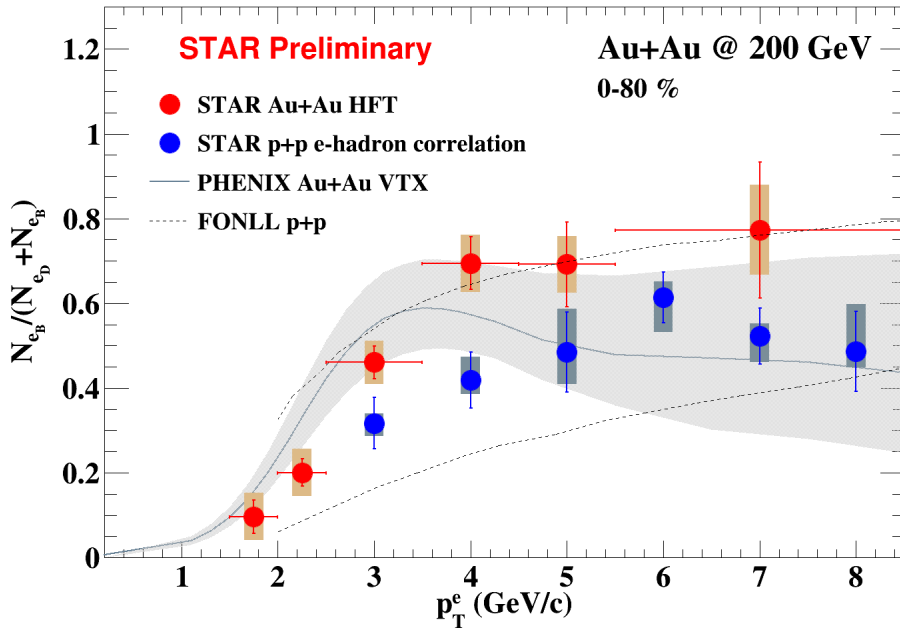
❖ Broader DCA_{XY} distribution for **bottom**- than **charm**-decayed electrons due to longer lifetime of B hadrons

→ Signal template: Data-driven simulation + EvtGen decayer ($D^0, D^{\pm}, B^0, B^{\pm}$)

❖ Background:

- 1) **Hadron contamination** — hadrons misidentified as electron candidates
 → Template: inclusive hadron distribution from data and contribution constrained using inclusive electron purity
- 2) **Photonic electron** — gamma conversion and light meson Dalitz decays
 → Template: from data with correction factors extracted from Hijing simulations

$B \rightarrow e$ fraction in 200 GeV Au+Au collisions



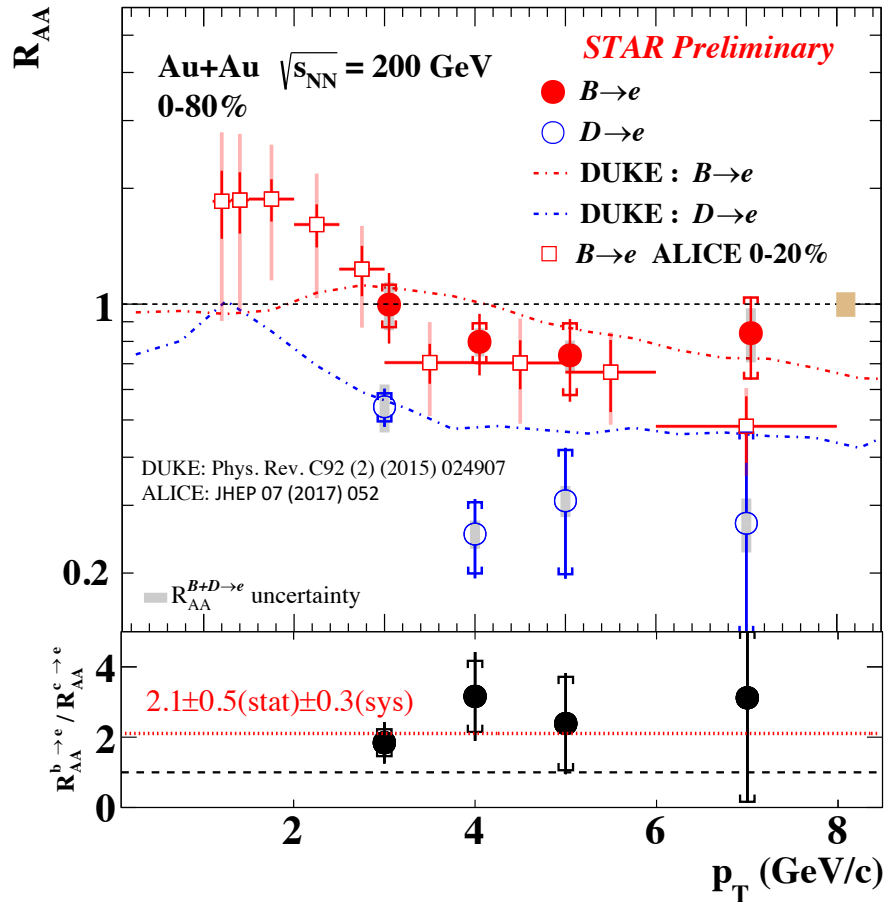
❖ Enhancement of the fraction of electrons from B -hadron decays is observed in Au+Au collisions compared to that in p+p collisions.

$$R_{AA}^{B \rightarrow e} = \frac{f_{Au+Au}^{B \rightarrow e}(data)}{f_{p+p}^{B \rightarrow e}(data)} R_{AA}^{HF_e}(data),$$

$$R_{AA}^{D \rightarrow e} = \frac{1 - f_{Au+Au}^{B \rightarrow e}(data)}{1 - f_{p+p}^{B \rightarrow e}(data)} R_{AA}^{HF_e}(data)$$

DHLV: Physics Letters B 632 (1) (2006) 81-86
 Min He et al.: Phys. Rev. C 86 (2012) 014903
 Phys. Rev. C 88 (2013) 044907
 Collisional dissociation: Phys. Rev. C 80 (2009) 054902
 Gossiaux et al.: Journal of Physics G: Nuclear and Particle Physics 37 (9) (2010) 094019
 Phys. Rev. C 78 (2008) 014904
 ActaPhys. Polon. B 43 (2012) 655-662

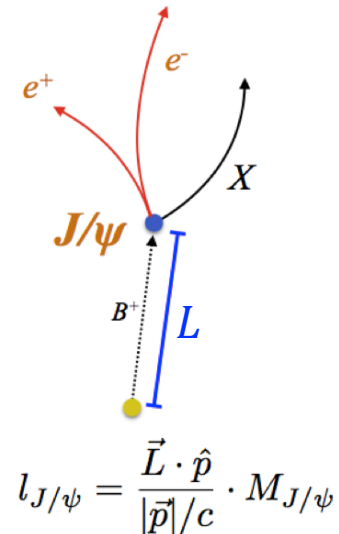
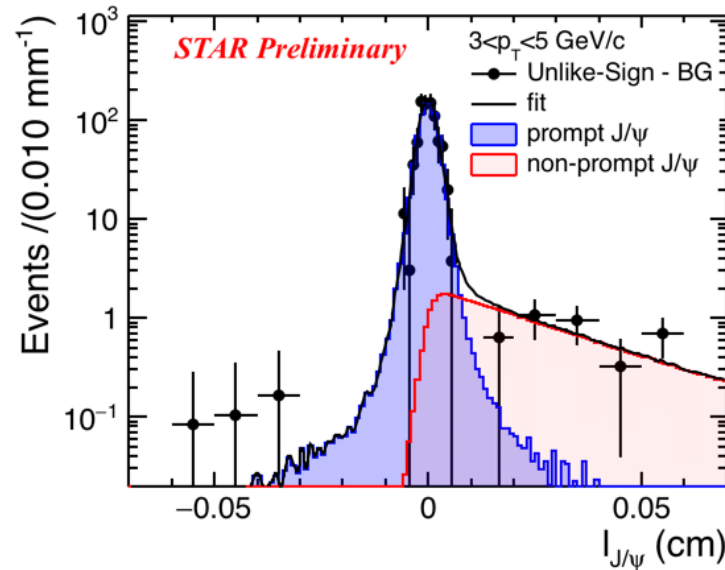
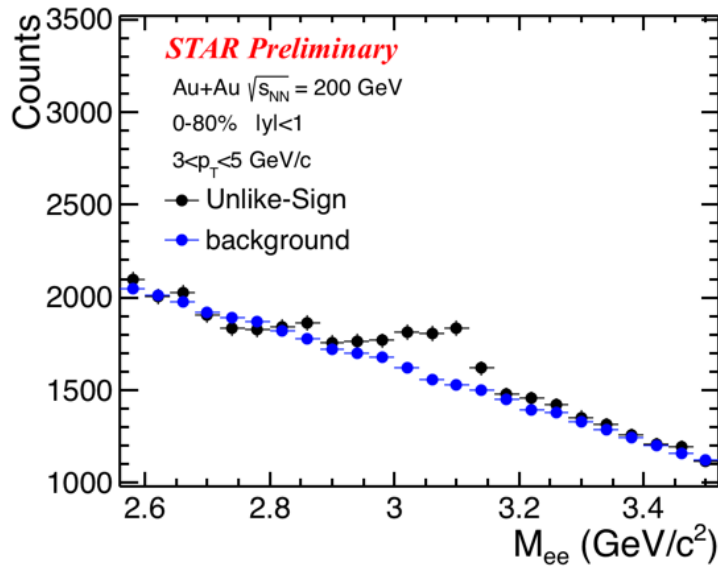
R_{AA} of $B/D \rightarrow e$ in 200 GeV Au+Au collisions



- ❖ First STAR measurements of electrons from charm and bottom hadron decays separately.
- ❖ $R_{AA}(e_D) < R_{AA}(e_B)$ ($\sim 2\sigma$ at 3 - 7 GeV/c).
- ❖ Consistent with mass hierarchy of parton energy loss ($\Delta E_c > \Delta E_b$).

$B \rightarrow J/\psi$

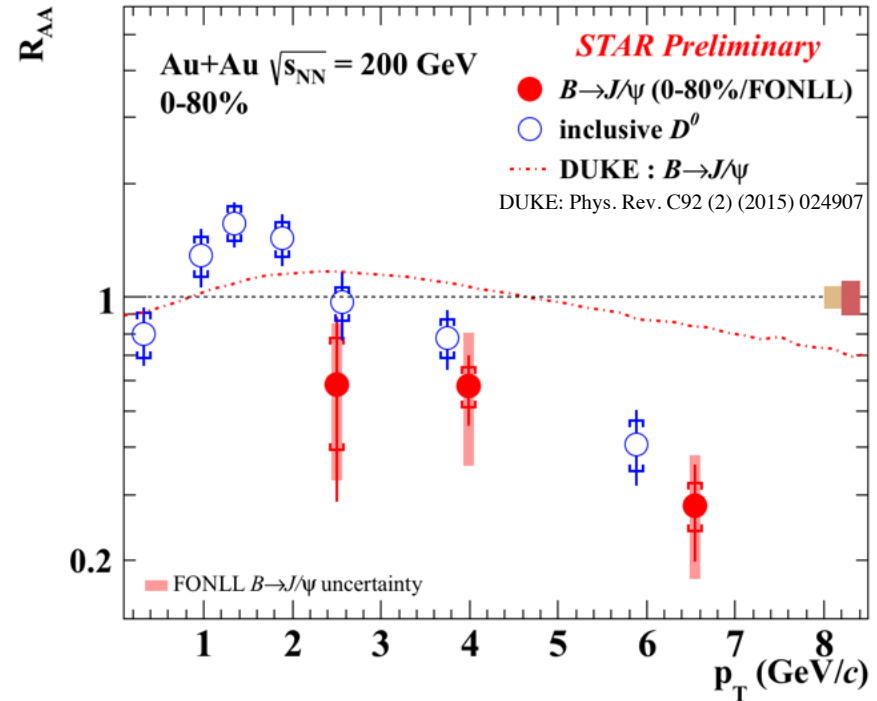
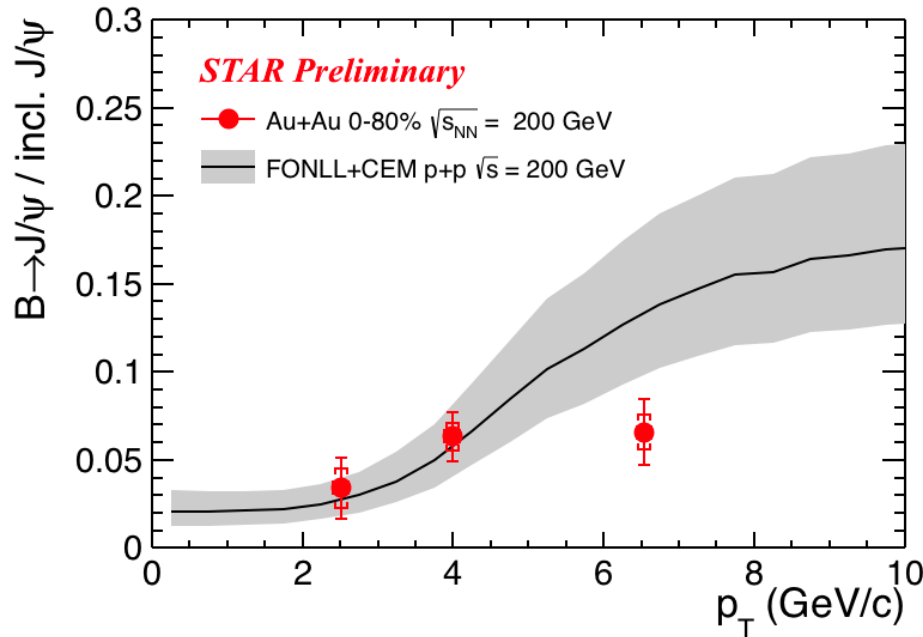
Analysis Procedure - Template fitting of $B \rightarrow J/\psi$ in 200 GeV Au+Au collisions $\sim 900\text{M MB} + \sim 1.2 \text{ nb}^{-1}$ HT events



- ❖ Obtain the pseudo-proper decay length ($l_{J/\psi}$) distribution of J/ψ .
- ❖ Template for prompt J/ψ : prompt J/ψ from FONLL + data-driven simulation of detector effects
- ❖ Template for non-prompt J/ψ : B-hadrons (B^0, B^\pm) from FONLL decayed to J/ψ via PYTHIA + data-driven simulation of detector effects

R_{AA} of $B \rightarrow J/\psi$ in 200 GeV Au+Au collisions

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

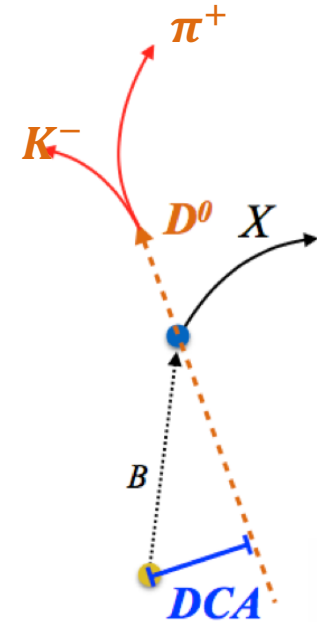
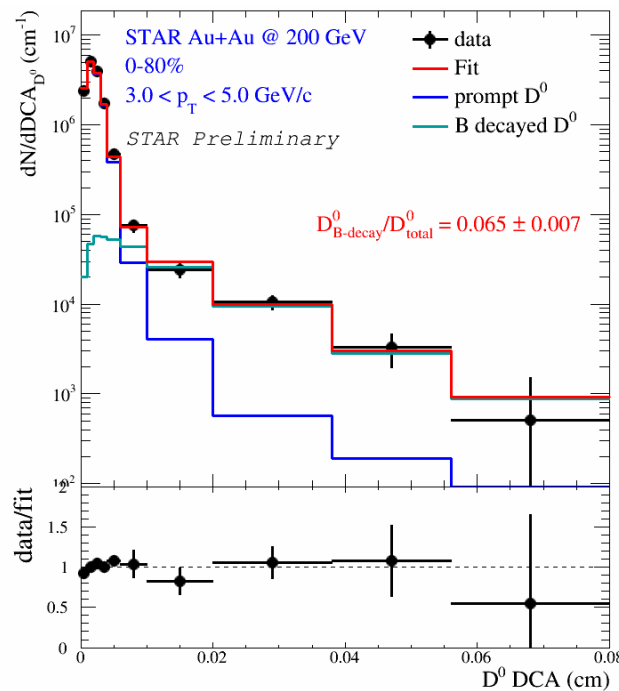
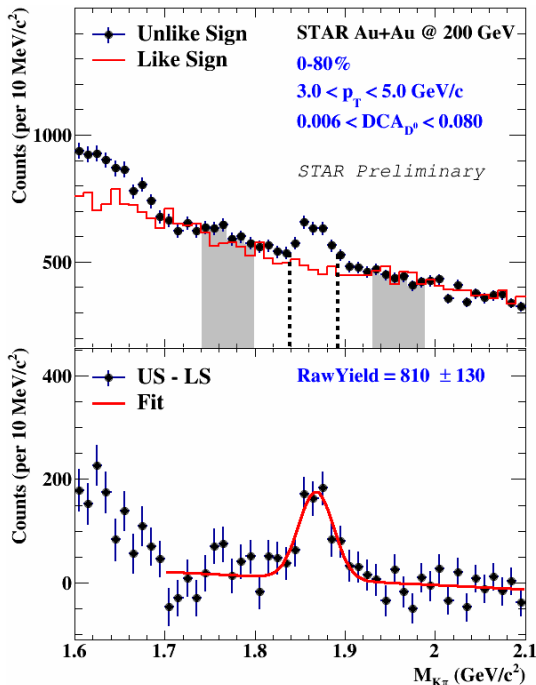


- ❖ **Strong suppression** is observed for non-prompt J/ψ at high p_T and is similar to that of D^0 mesons.

$B \rightarrow D^0$

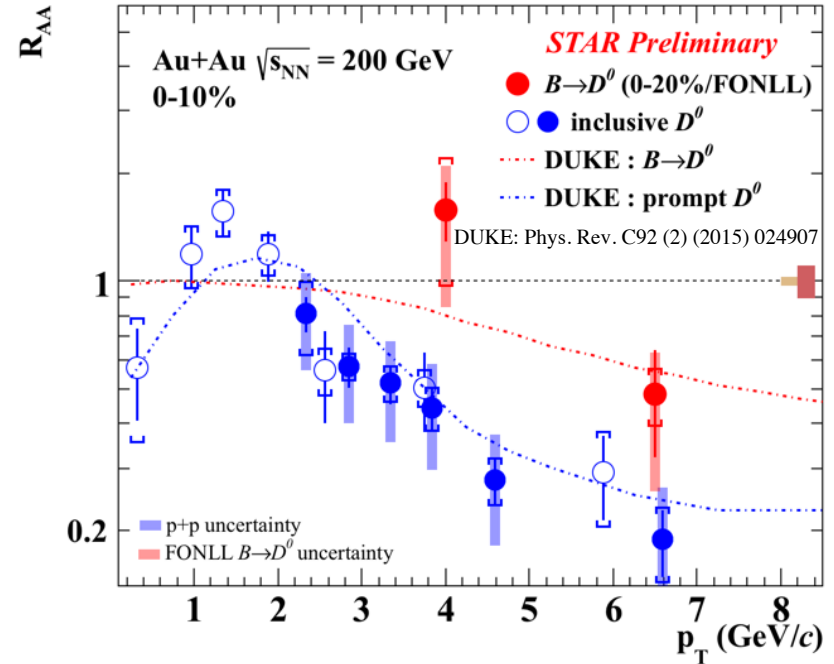
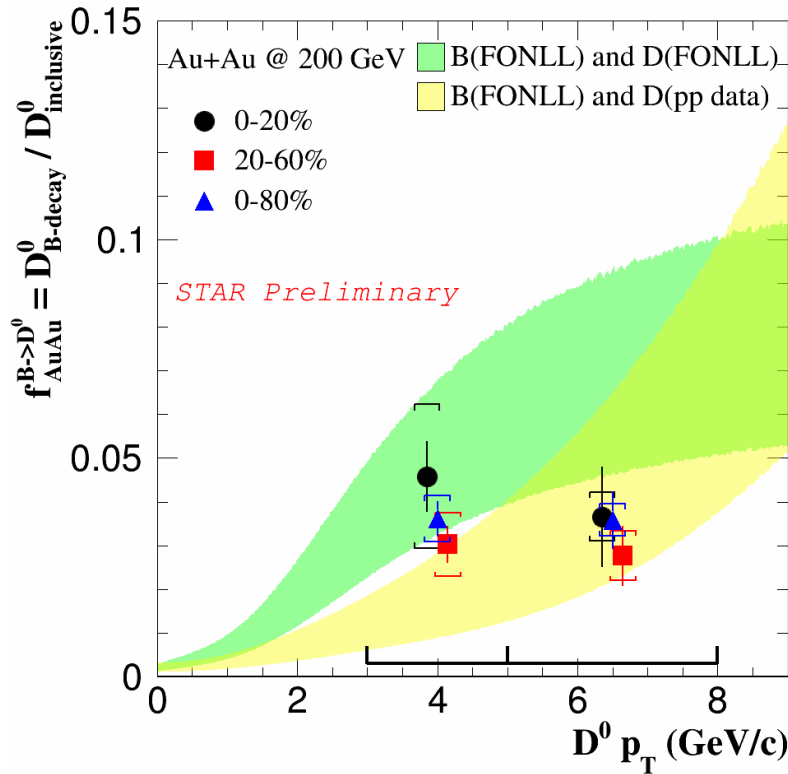
Analysis Procedure - Template fitting of $B \rightarrow D^0$ in 200 GeV Au+Au collisions

~900M MB



- ❖ Obtain the distance of closest approach to the primary vertex (DCA) distribution of D^0 from data.
- ❖ Template for prompt D^0 : prompt D^0 from FONLL + data-driven simulation of detector effects
- ❖ Template for non-prompt D^0 : B-hadrons (B^0, B^\pm) from FONLL decayed to D^0 via PYTHIA + data-driven simulation of detector effects

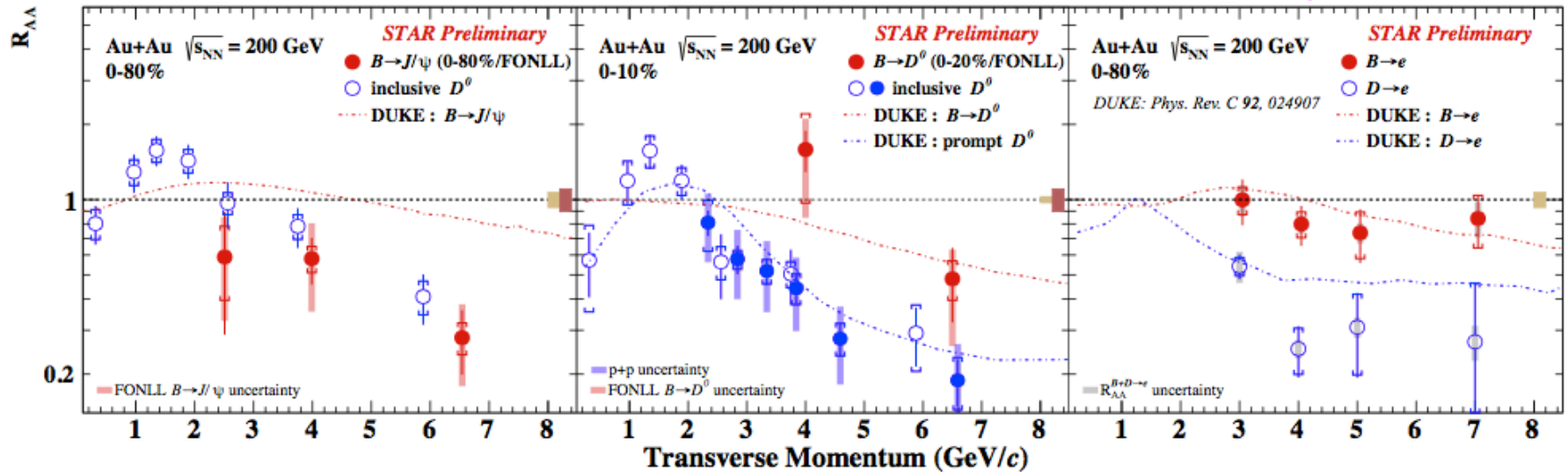
R_{AA} of $B \rightarrow D^0$ in 200 GeV Au+Au collisions



$$R_{AA}^{B \rightarrow D^0} = \frac{1}{\langle N_{coll} \rangle} \frac{f_{Au+Au}^{B \rightarrow D^0} \times dN_{Au+Au}^{inc. D^0} / dp_T}{dN_{FONLL}^{B \rightarrow D^0} / dp_T}$$

- ❖ **Strong suppression** of non-prompt D^0 is observed at high p_T .
- ❖ A hint of **less suppression** for non-prompt D^0 compared to prompt ones at $4 < p_T < 6.5$ GeV/c.

Summary



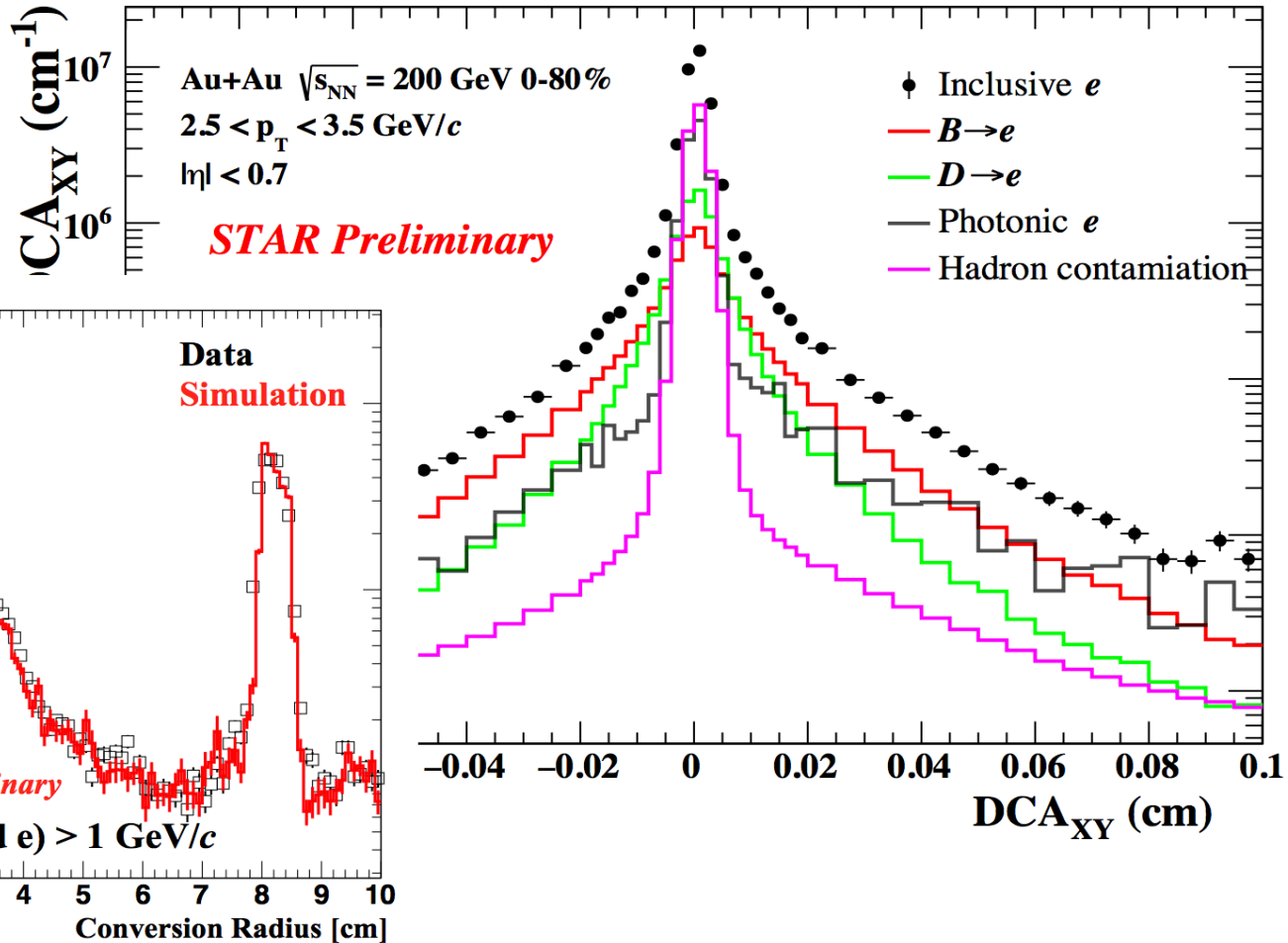
◆ Measured B production via J/ψ , D^0 and electron decay channels in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV

- 1) Strong suppression for $B \rightarrow J/\psi$ and $B \rightarrow D^0$ at high p_T .
- 2) Indication of less suppression for $B \rightarrow e$ than $D \rightarrow e$ ($\sim 2\sigma$): consistent with $\Delta E_c > \Delta E_b$.

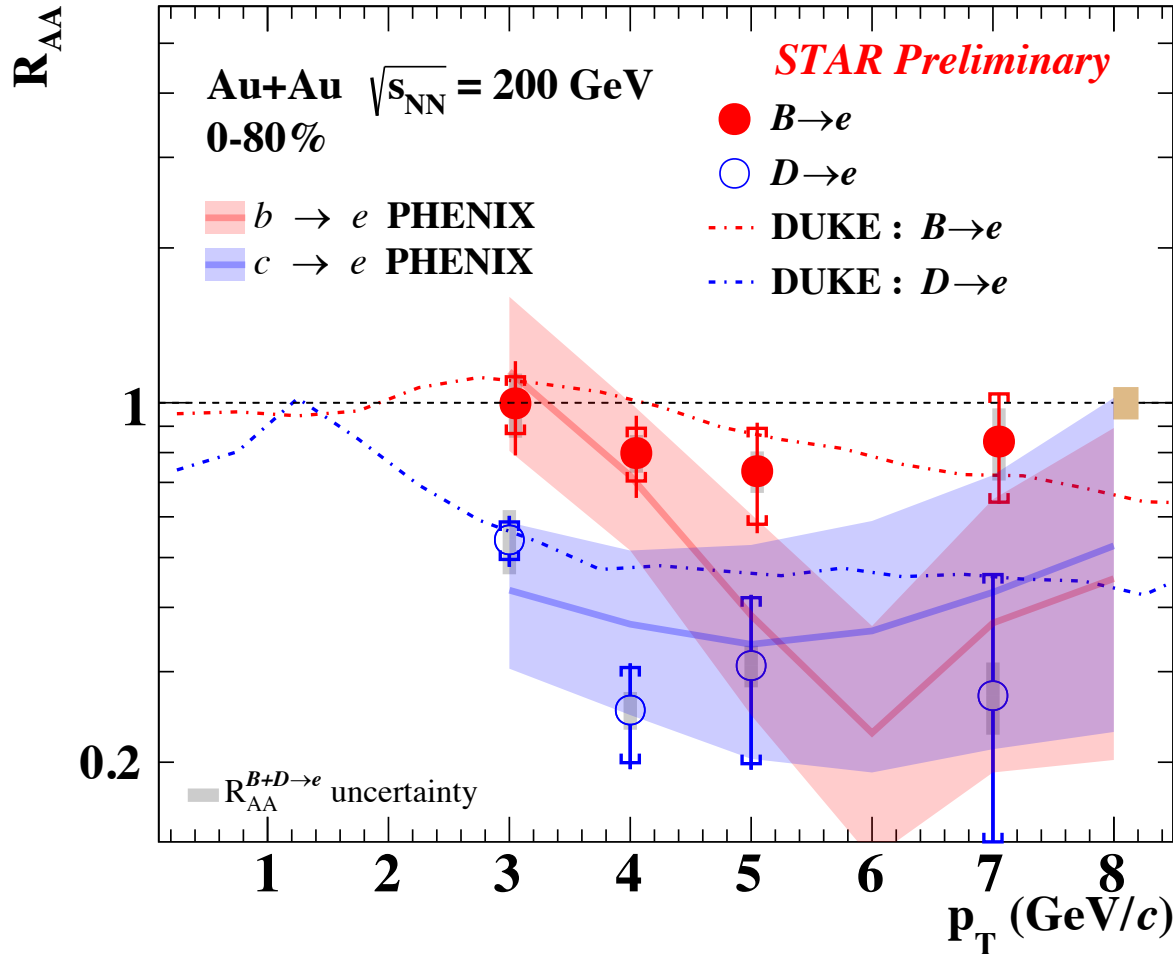
◆ Outlook

A factor of ~ 2 more MB and ~ 5 more HT Au+Au events recorded in 2016.

Back up



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



Consistent with PHENIX result within uncertainty.

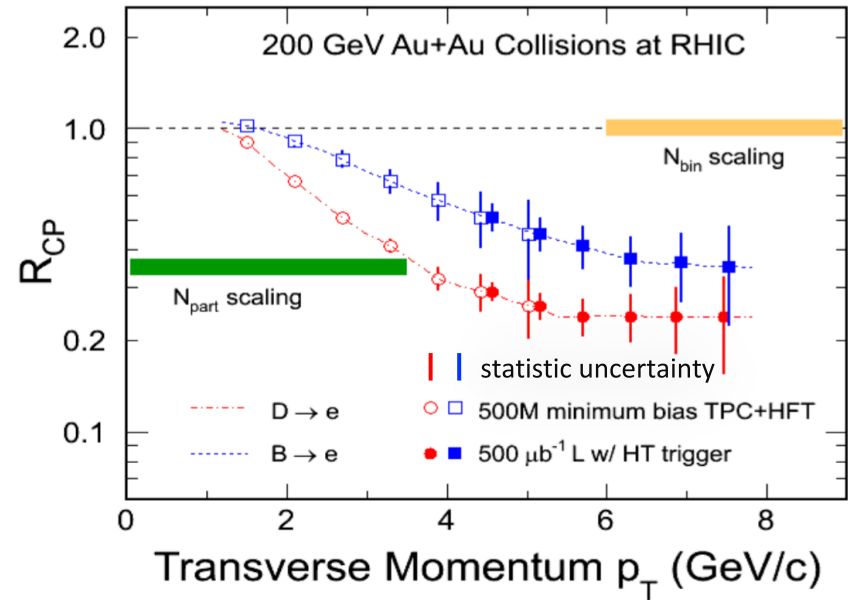
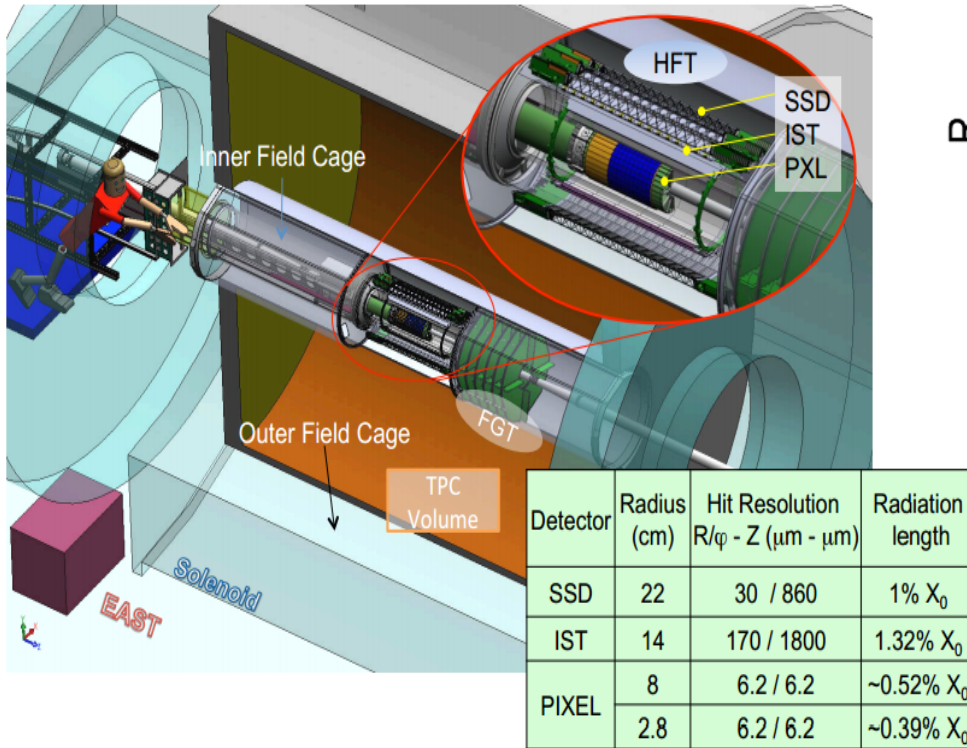
HFT Design

- HFT consists of 3 sub-detector systems inside the STAR Inner Field Cage

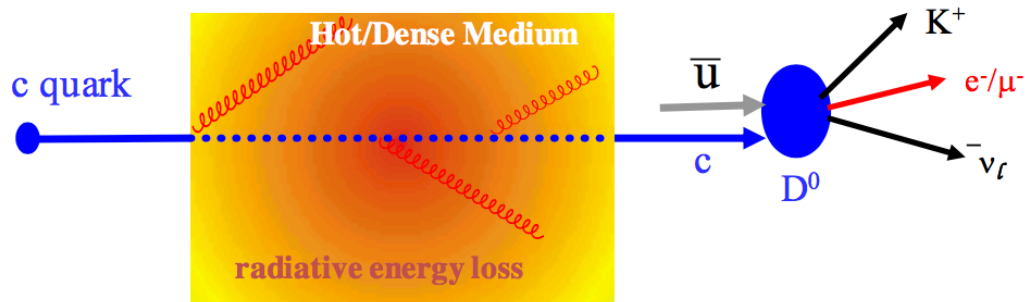
Detector	Radius (cm)	Hit Resolution R/ φ - Z (μm - μm)	Thickness
SSD	22	30 / 860	1% X_0
IST	14	170 / 1800	1.32 % X_0
PIXEL	8	6.2 / 6.2	~ 0.52 % X_0
	2.8	6.2 / 6.2	~ 0.39 % X_0

- **SSD** existing single layer detector, double side strips (electronic upgrade)
- **IST** one layer of silicon strips along beam direction, guiding tracks from the SSD through PIXEL detector - **proven pad technology**
- **PIXEL** double layers, 20.7x20.7 mm pixel pitch, 2 cm x 20 cm each ladder, 10 ladders, delivering ultimate pointing resolution. - **new active pixel technology**

HFT

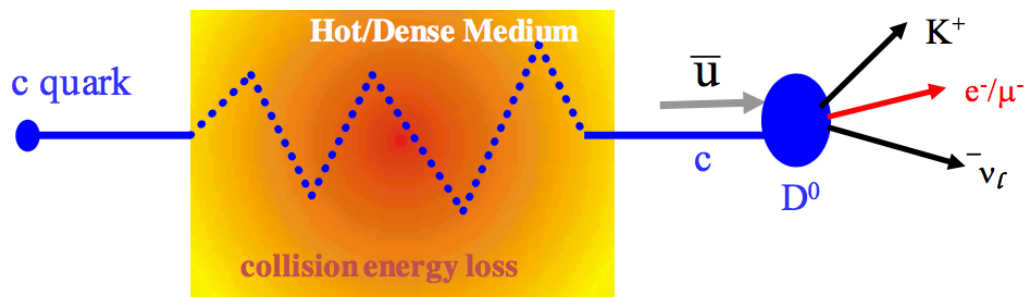


- ✓ HFT will allow a direct measurement of B→e spectrum in Au+Au collisions via reconstructing displaced decay vertices.
- ✓ Help better understand the interactions between heavy quarks and the medium.



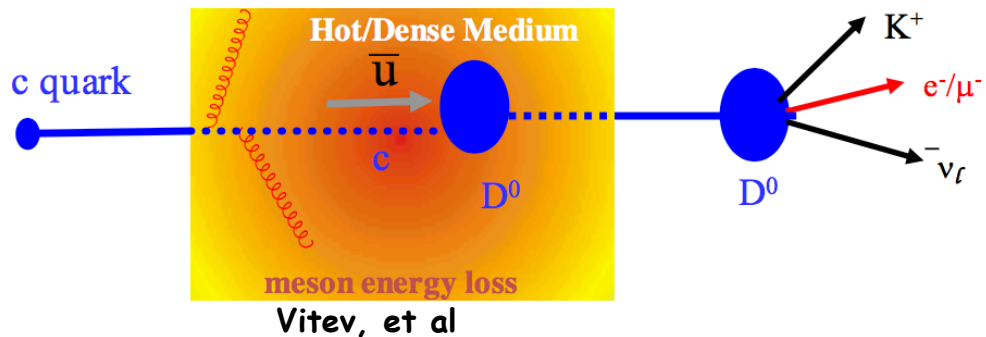
Gluon radiation and the dead cone effect. Suppressed at $\theta < M_Q/E_Q$

(Baier *et al*, Kharzeev *et al*, Djordjevic *et al*, Wiedemann *et al* .)



Collisional energy loss. Heavy quarks lose energy through elastic collisions with other partons.

(Teaney *et al*, Rapp *et al*, Molnar *et al*, Gossiaux *et al*.)



Collisional Dissociation. Medium induced dissociation of heavy mesons.