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

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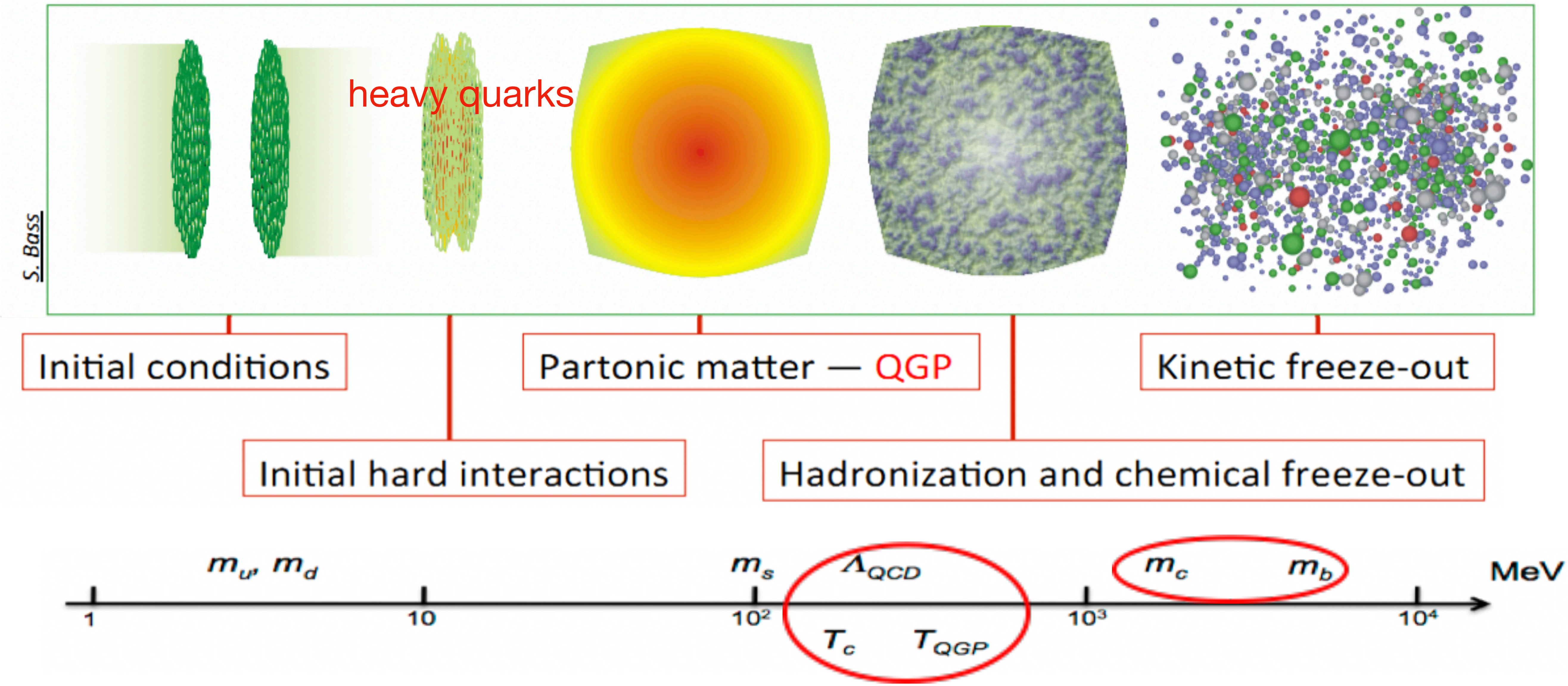
Outline

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

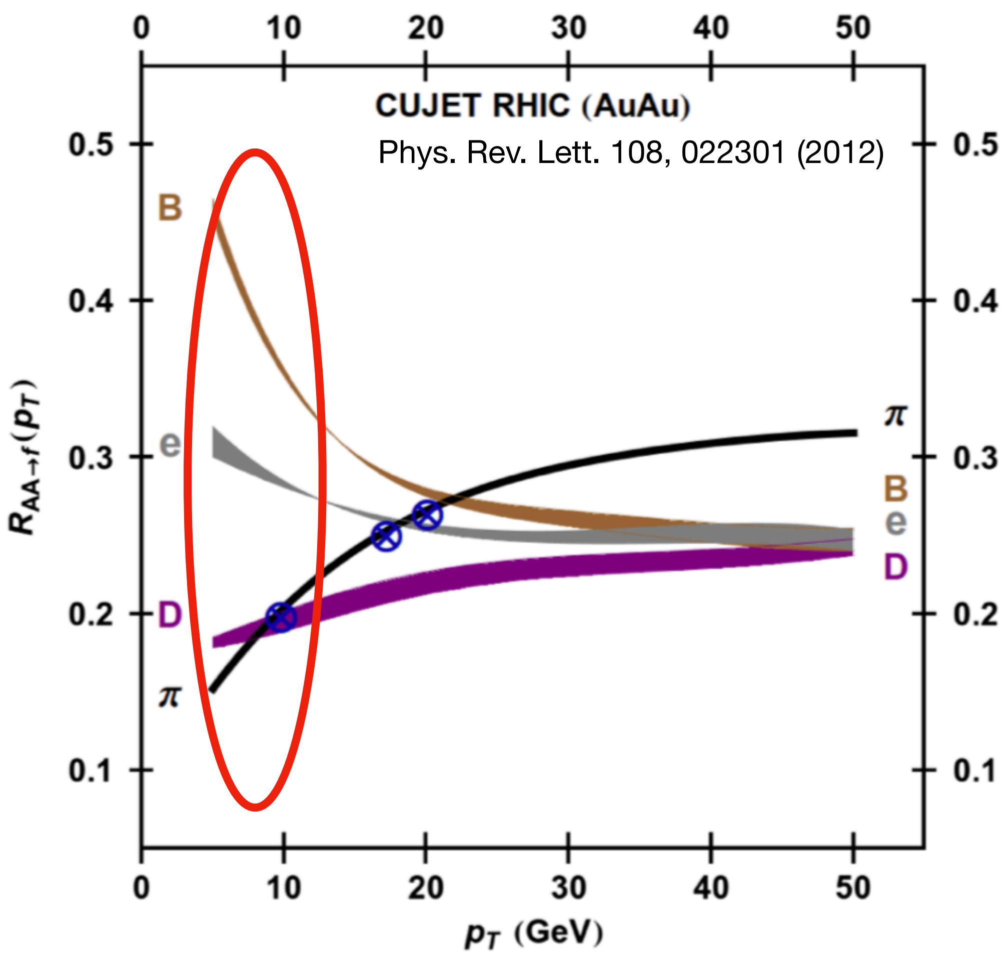
Why heavy flavor?

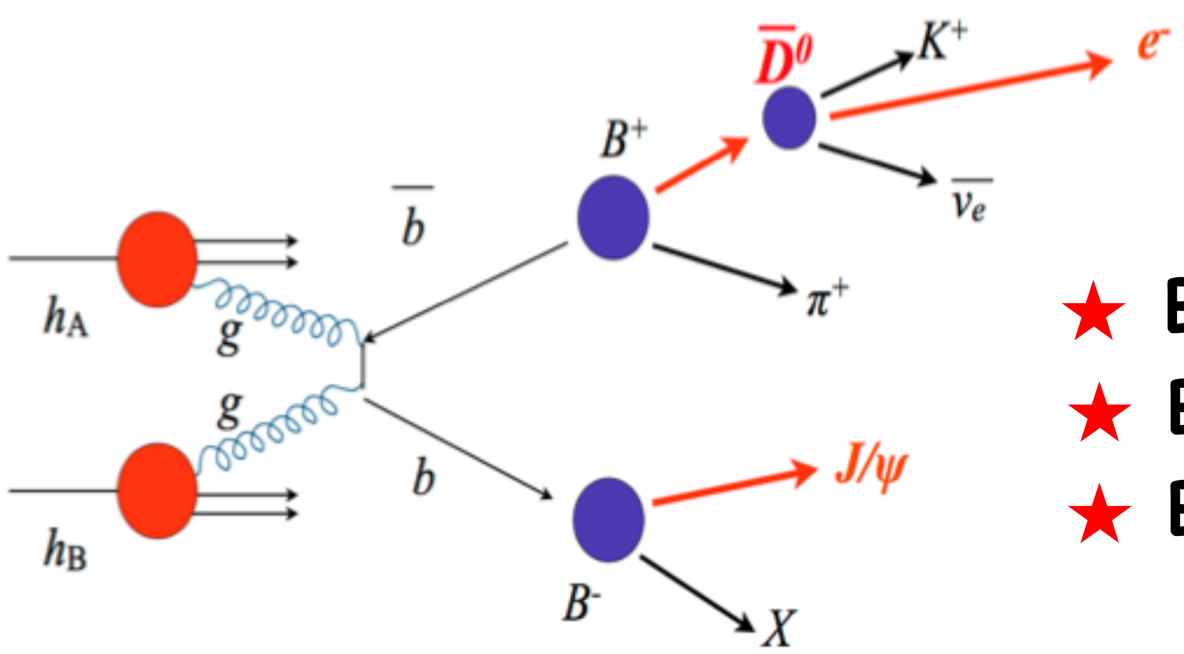


- $m_{c,b} >> T_{QGP}$: **dominantly produced in hard scattering at the early stage**
  - ★ experience all stages of QGP evolution: carry information of interactions with the medium.
  - ★ an excellent probe to study the properties of the QGP.

Observable

- **Energy loss of heavy quarks: a unique tool to study the interactions between heavy quarks and the QGP.**
  - ★ 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**.

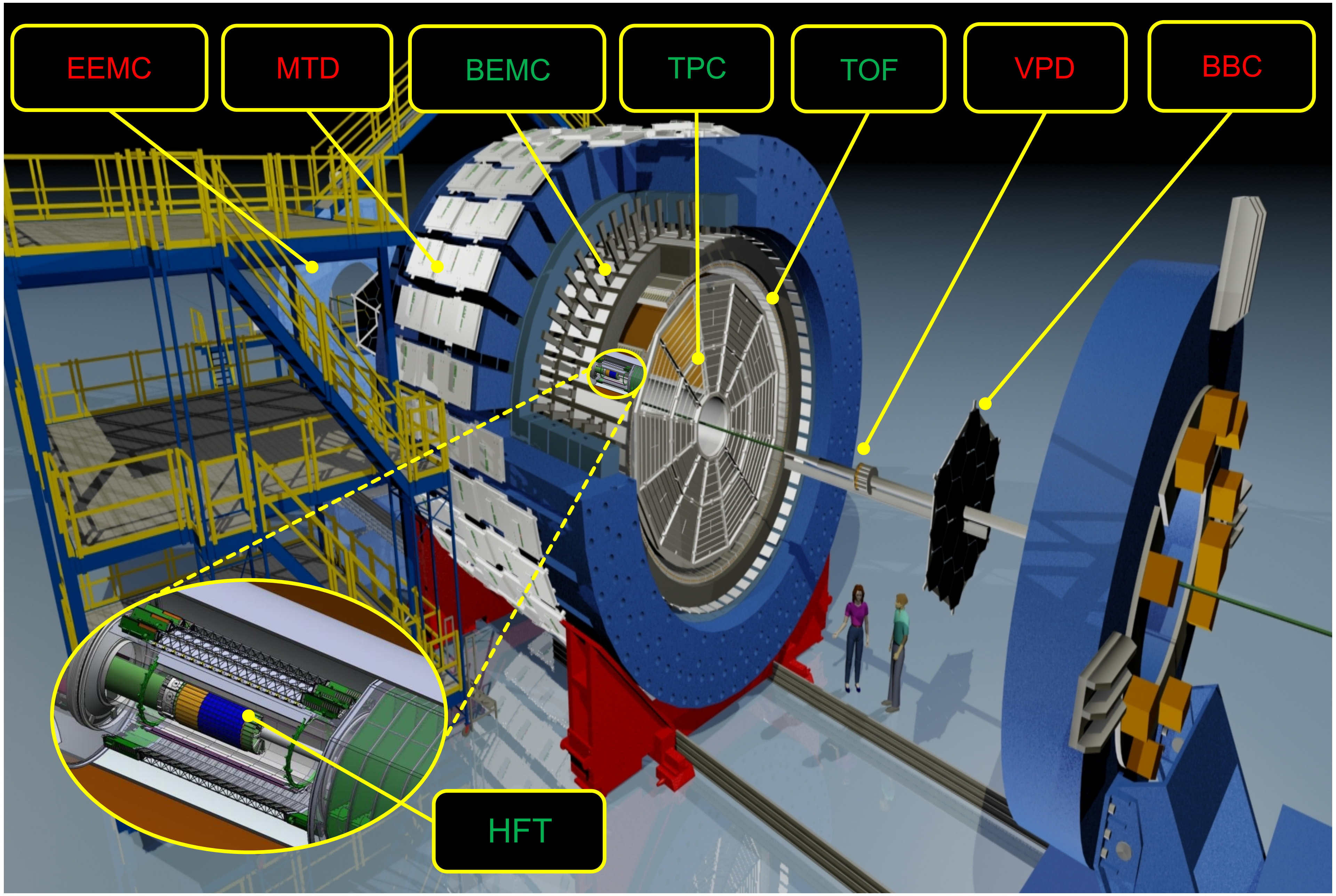




- ★ B → e
- ★ B → J/ψ
- ★ B → D^0

STAR detector

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



Time Projection Chamber (TPC)
- Momentum determination
- PID through dE/dx

Time of Flight (TOF)
- PID through $1/\beta$
- Timing resolution:~85 ps

Barrel Electromagnetic Calorimeter (BEMC)
- PID through p/E
- Triggering on high-p_T electrons

Heavy Flavor Track (HFT)
- Precise reconstruction of **displaced vertices**

STAR detector

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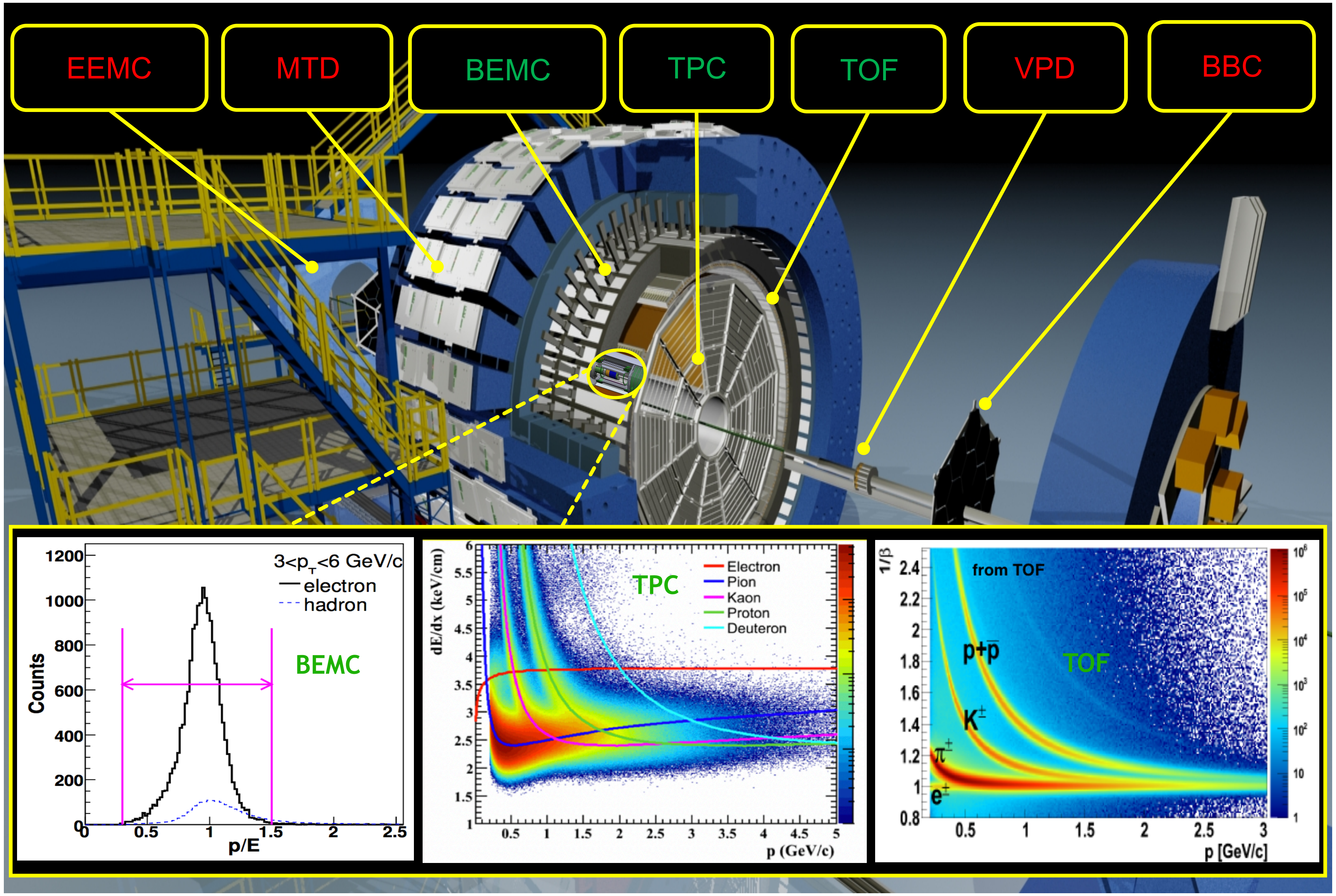

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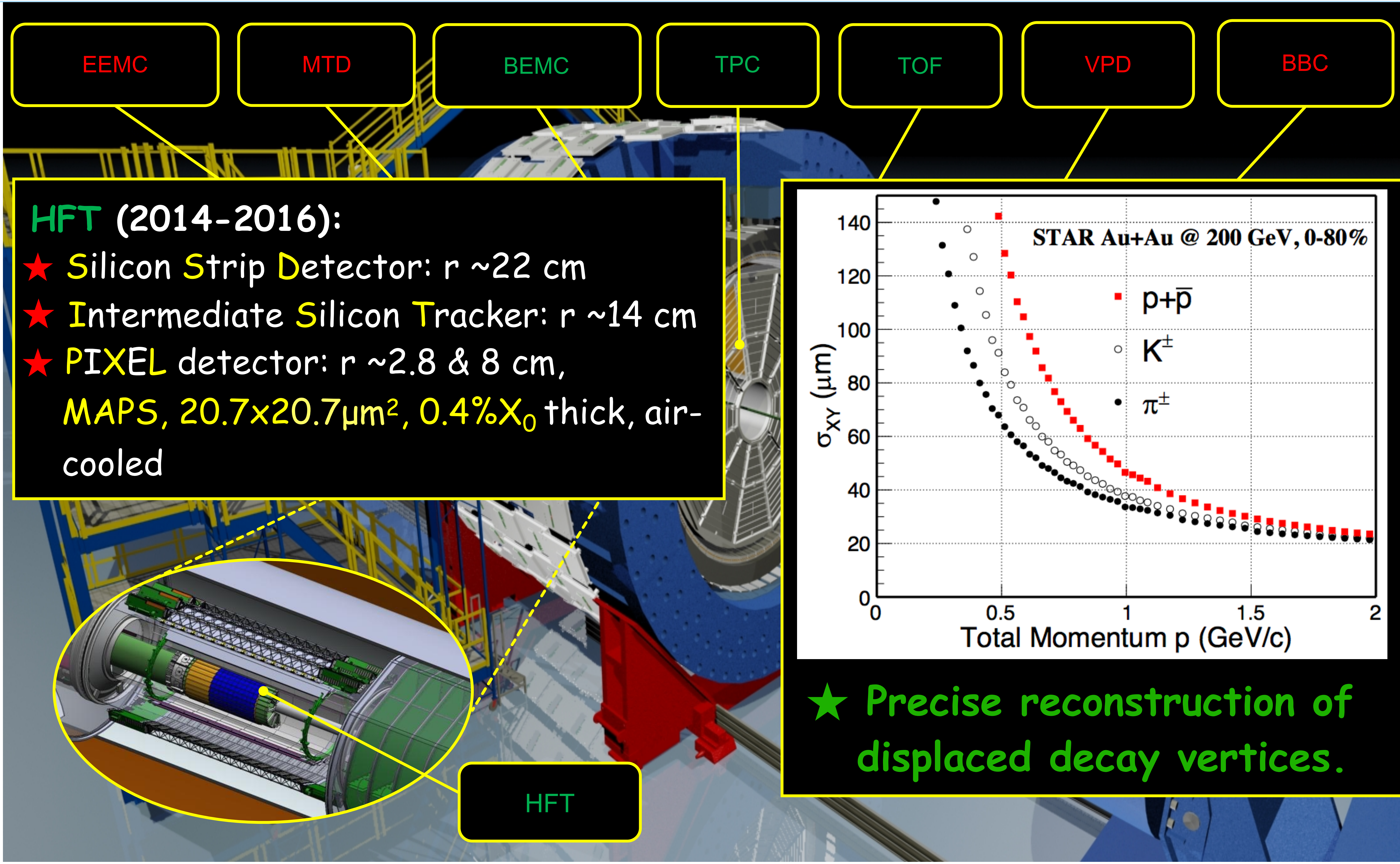


HFT (2014-2016):

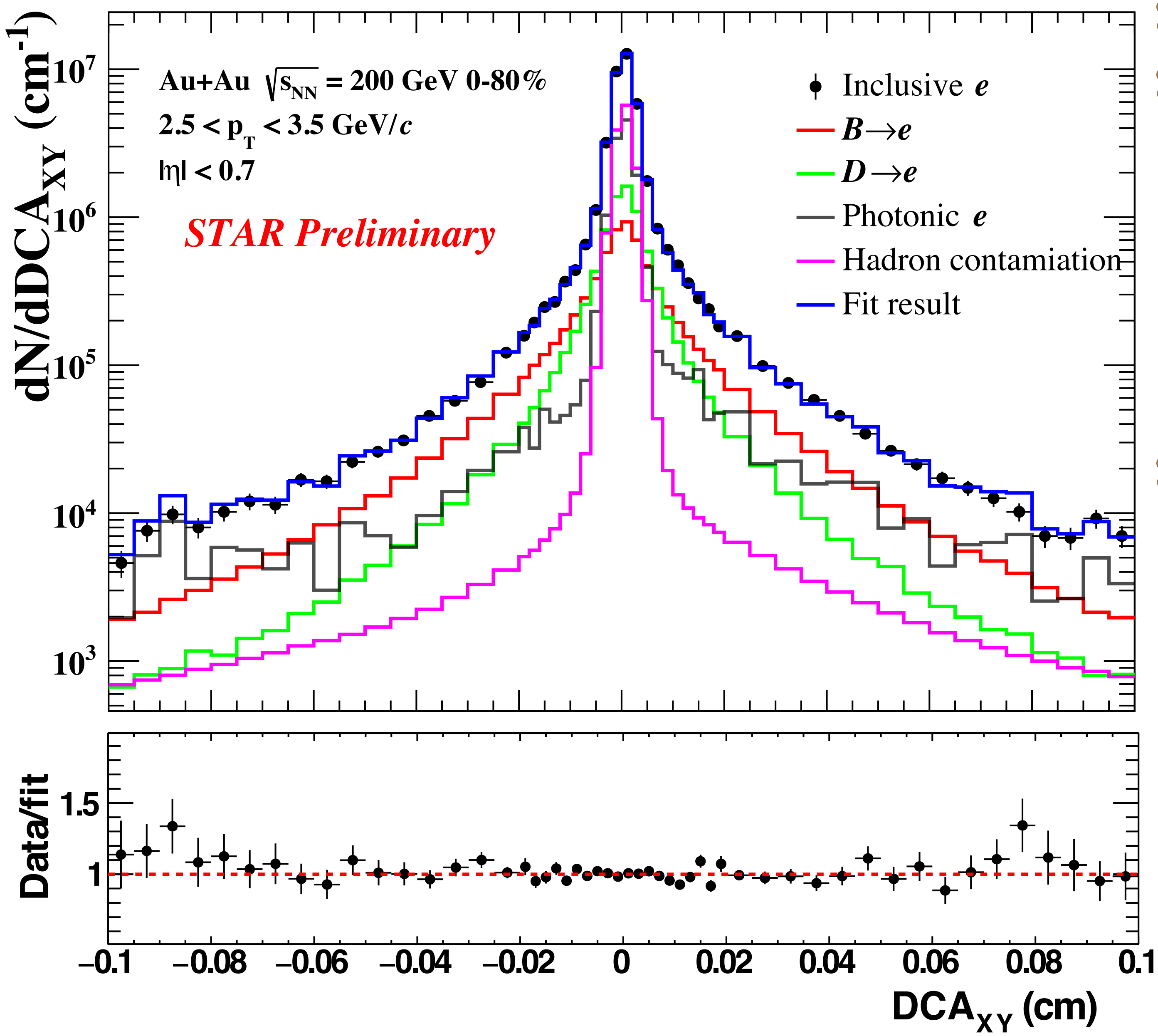
- ★ Silicon Strip Detector: r ~22 cm
- ★ Intermediate Silicon Tracker: r ~14 cm
- ★ PIXEL detector: r ~2.8 & 8 cm, MAPS, 20.7x20.7μm², 0.4%X_0 thick, air-cooled

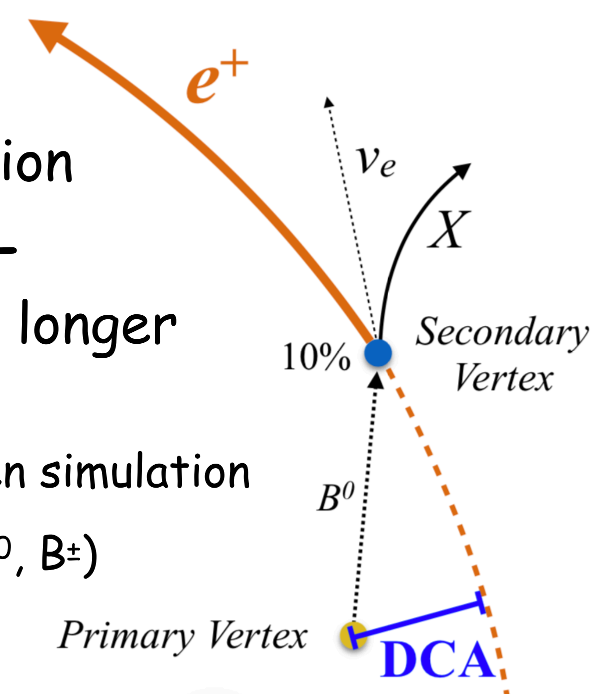
★ Precise reconstruction of displaced decay vertices.

Extract B/D → e

Template fitting of DCA_{xy} distribution for inclusive electrons from different sources

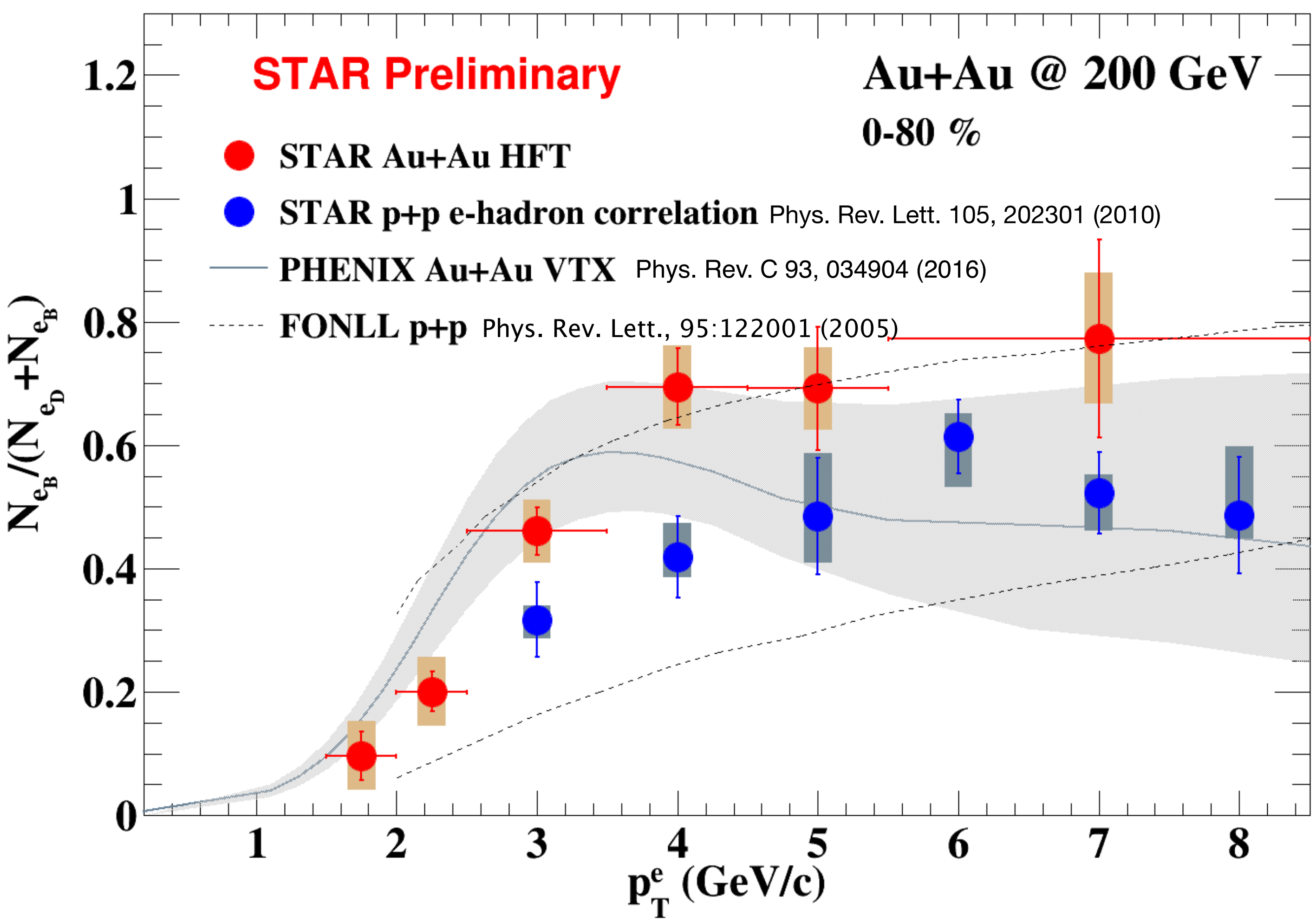
~900M MB + ~0.2 nb^{-1} BEMC triggered (HT) events in 2014

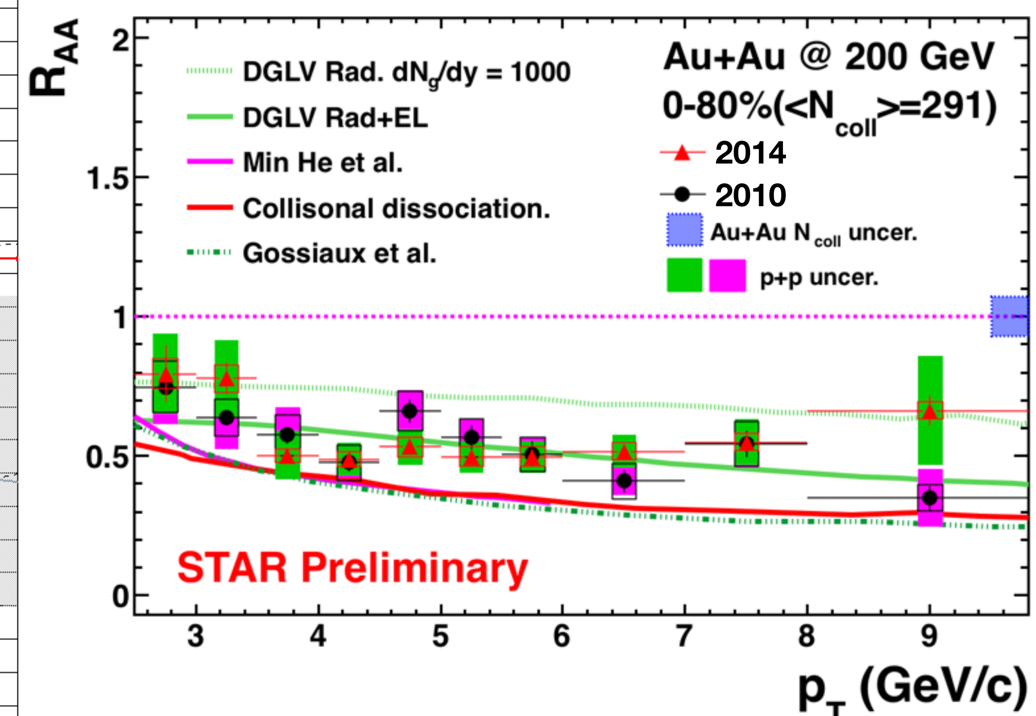




- **Inclusive electrons**
- Broader DCA_{XY} distribution for **bottom**- than **charm**-decayed electrons due to longer lifetime of B hadrons
  - Signal template: Data-driven simulation + EvtGen decayer (D^0, $D^{\pm}$, B^0, $B^{\pm}$)
- Background:
  1) **Hadron contamination** — hadrons misidentified 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/D → e fraction





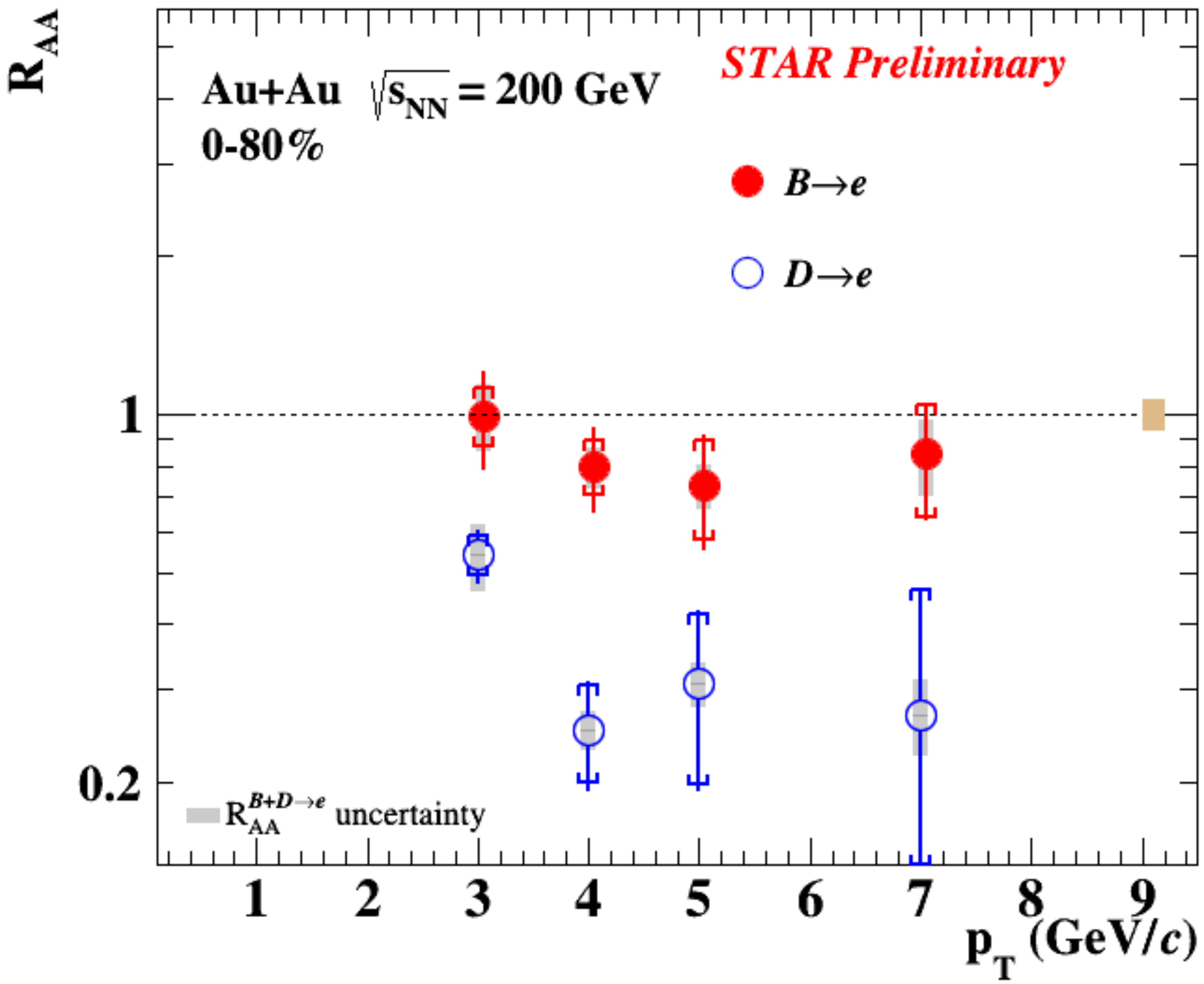
DHLV: Physics Letters B 632 (1) (2006) 81 86
Min He et al.: Phys. Rev. C 86 (2012) 014903
Phys. Rev. C 88 (2013) 044907.
Collisional dissociation: Phys. Rev. C 80 (2009) 054902
Gossiaux et al.: Journal of Physics G: Nuclear and Particle Physics 37 (9) (2010) 094019
Phys. Rev. C 78 (2008) 014904
ActaPhys.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

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

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

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

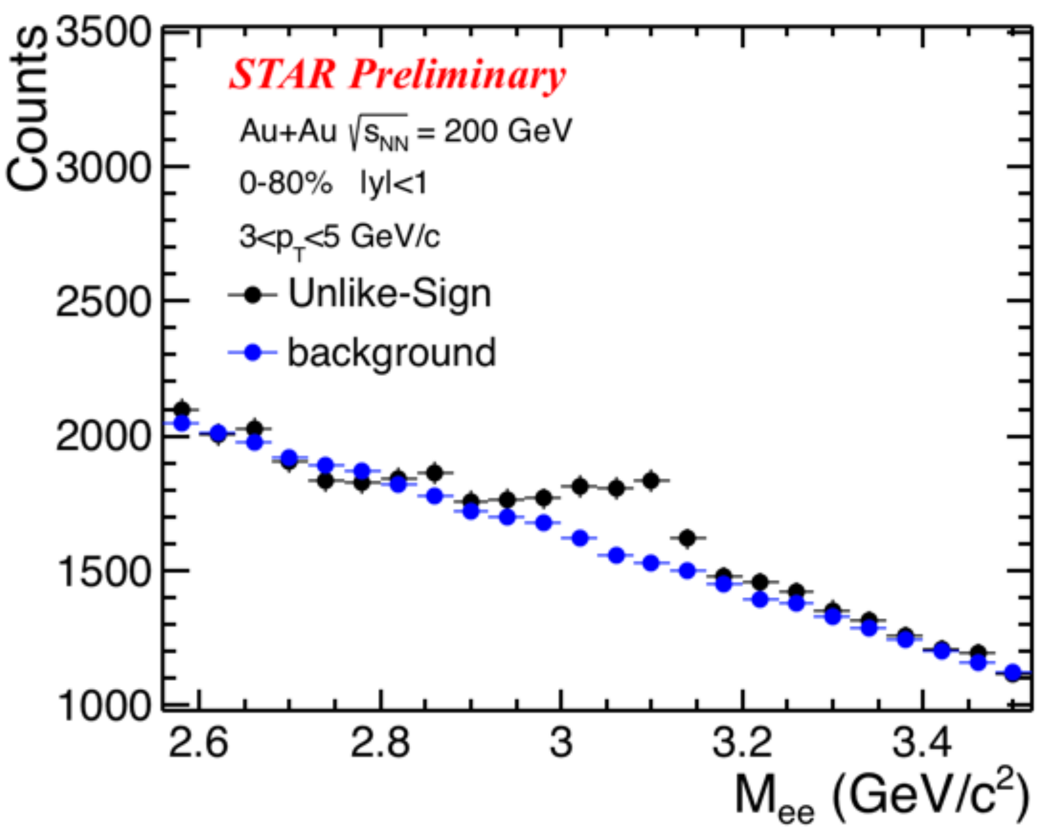
B/D → e R_{AA}

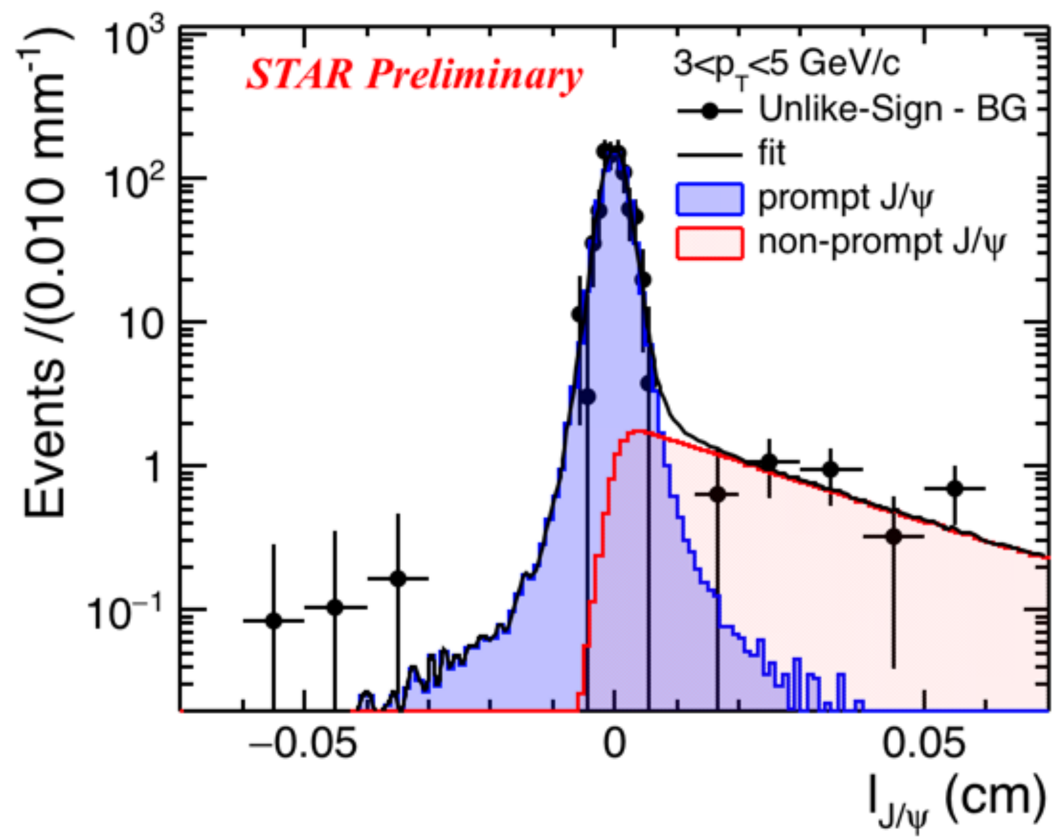


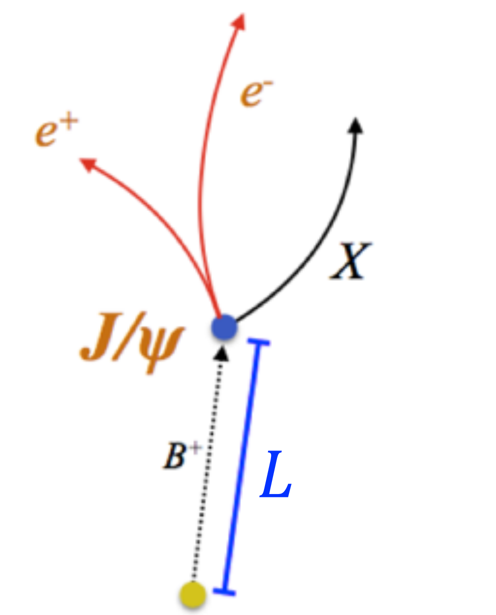
- First separate measurements of electrons from charm and bottom hadron decays in heavy-ion collisions at STAR.
- R_{AA} (e_D) < R_{AA} (e_B) (~2σ at 3 - 7 GeV/c).
- Consistent with mass hierarchy of parton energy loss (ΔE_c > ΔE_b) .

Template fitting of B→ J/ψ in 200 GeV Au+Au collisions

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





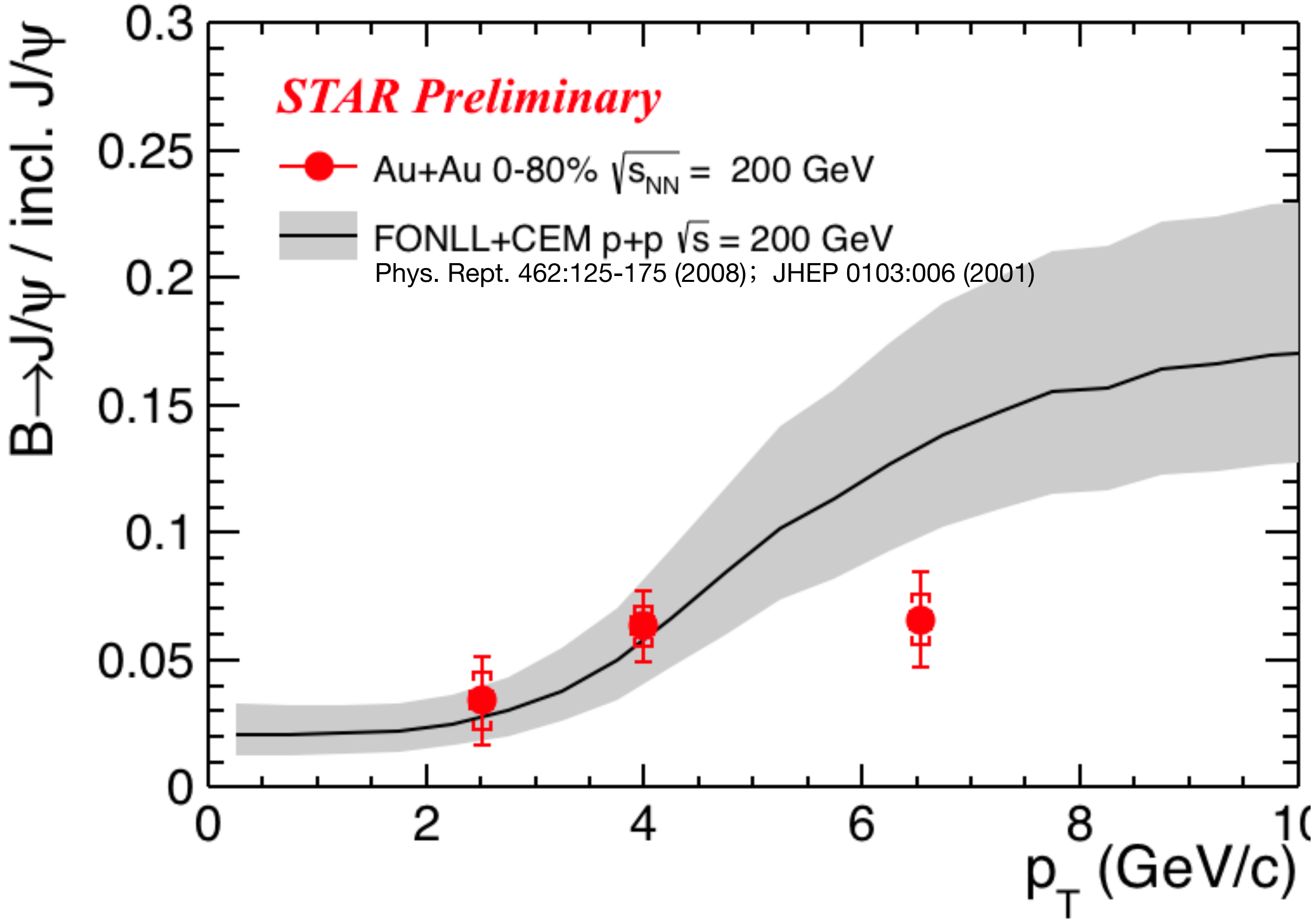


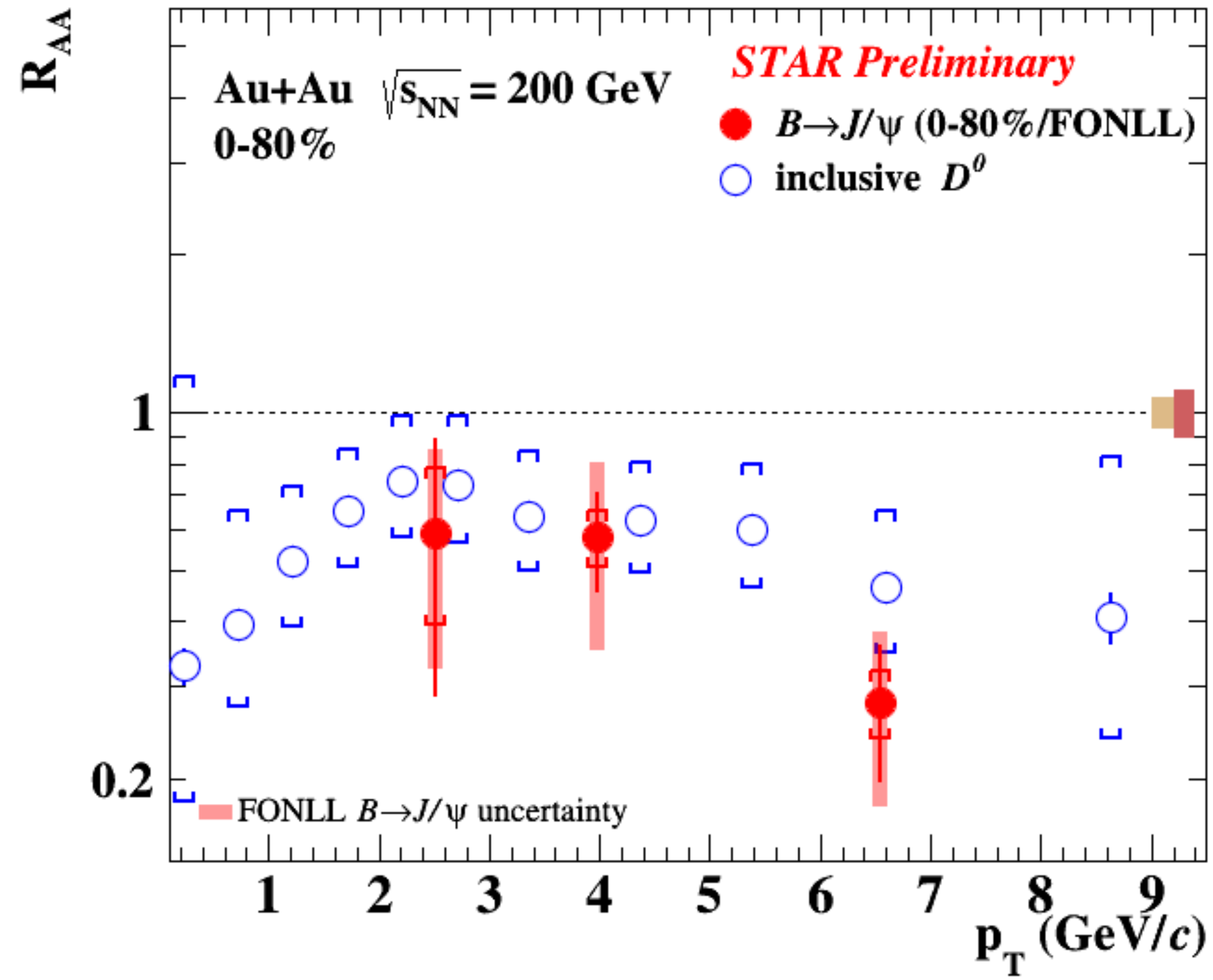
$$l_{J/\psi} = \frac{\vec{L}\cdot\hat{p}}{|\vec{p}|/c}\cdot M_{J/\psi}$$

- Obtain the pseudo-proper decay length ($l_{J/\psi}$) distribution of J/ψ.
- Template for prompt J/ψ : 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

B → J/ψ fraction and R_{AA}

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



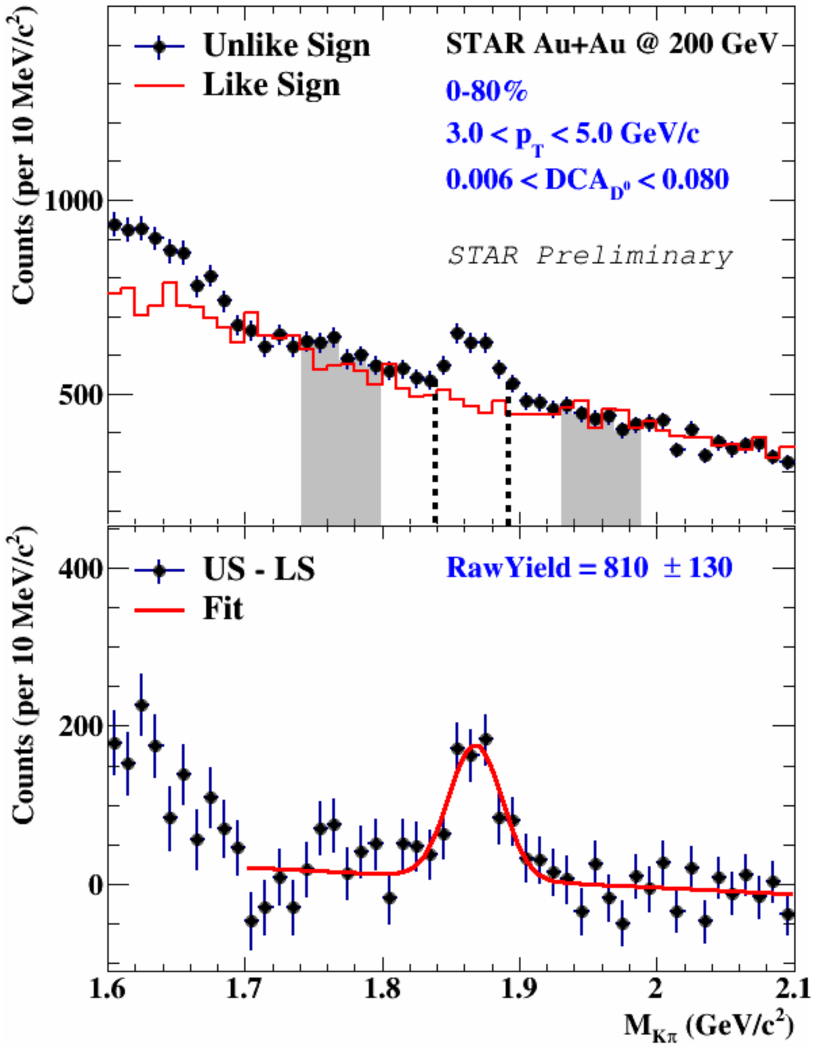


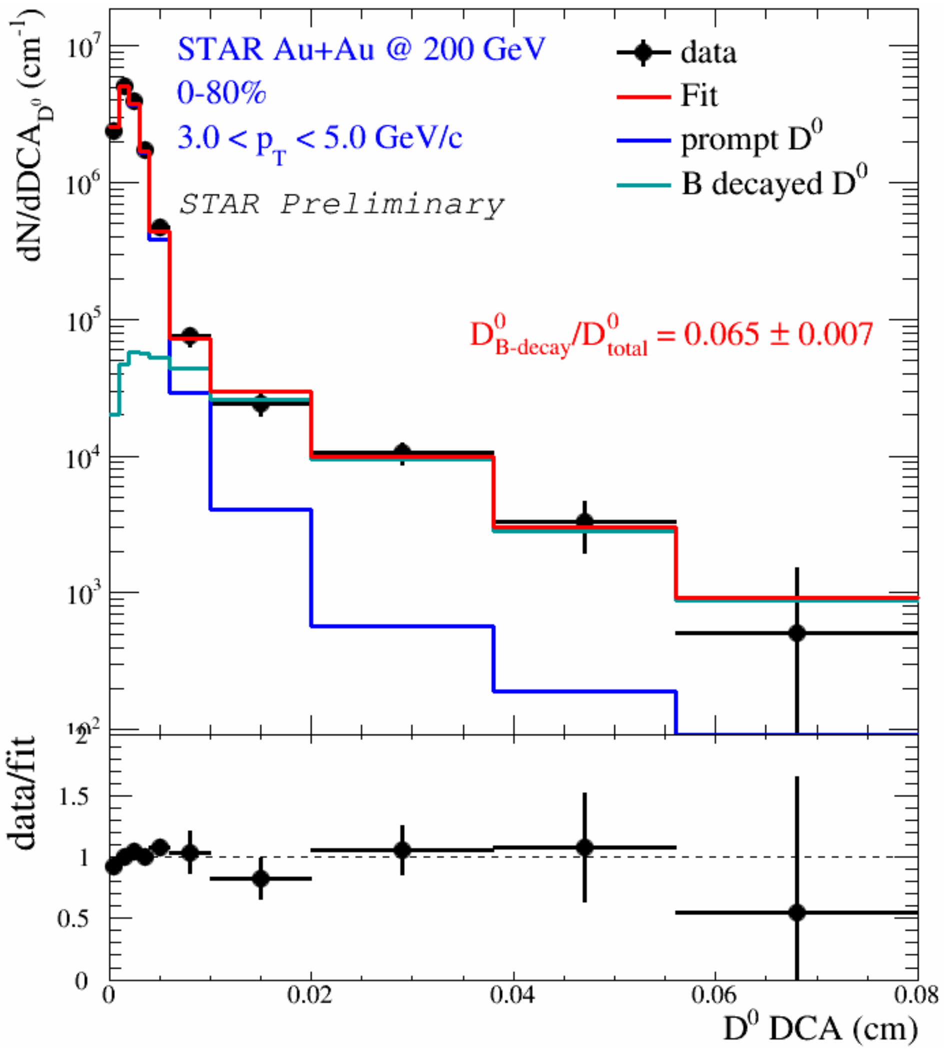
- **Strong suppression** is observed for non-prompt J/ψ at high p_T and is similar to that of D^0 mesons.

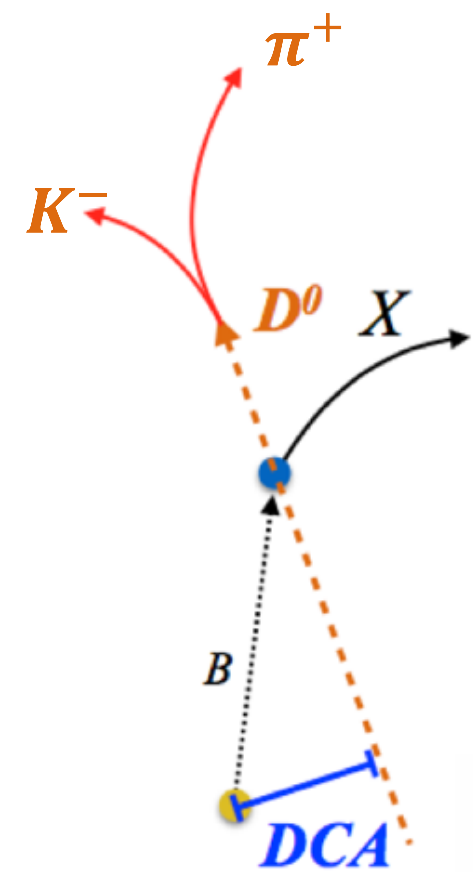
Extract B → D⁰

Template fitting of B → D⁰ in 200 GeV Au+Au collisions

~900M MB events in 2014

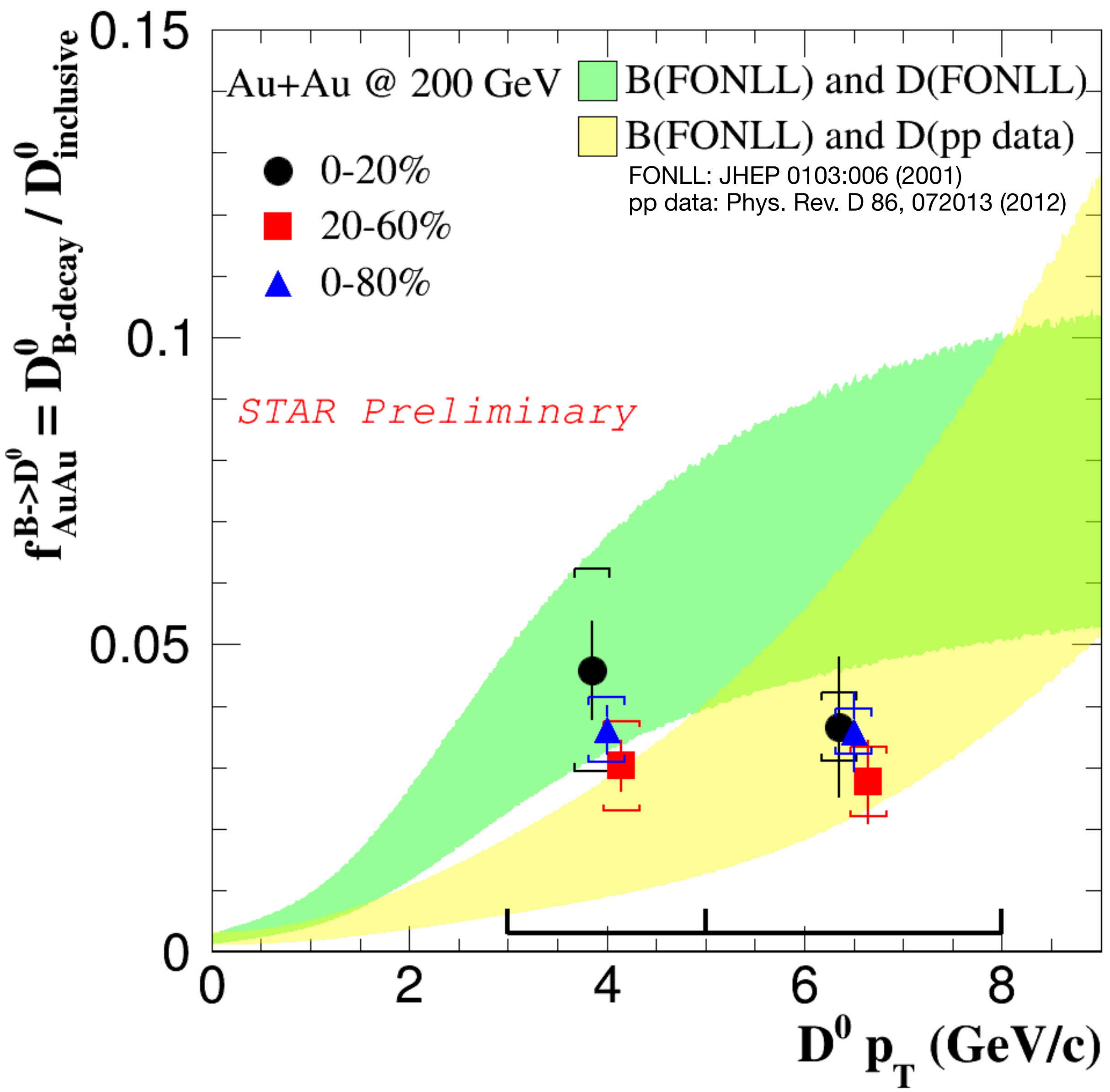




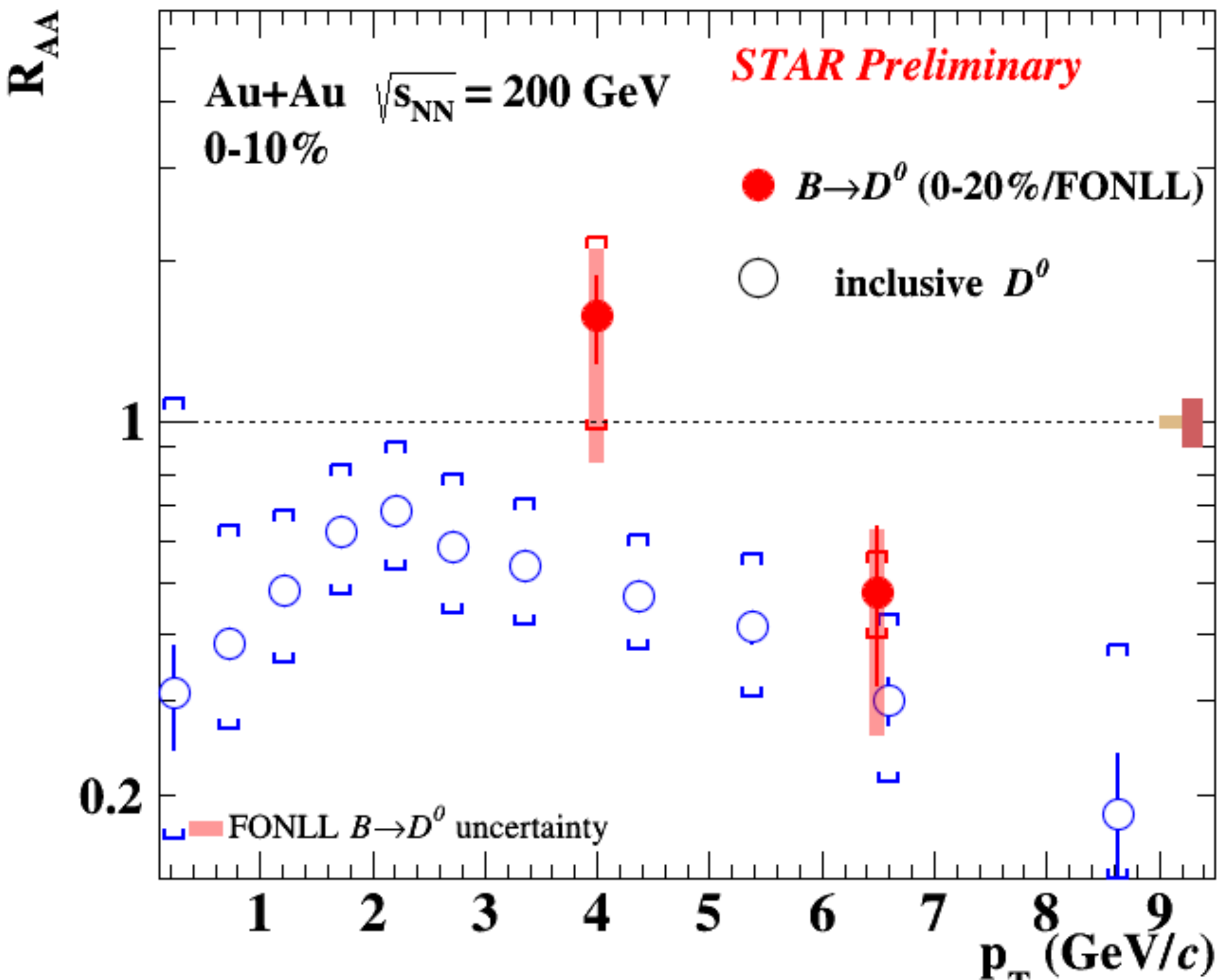


- Obtain the distribution of the D⁰'s distance of closest approach (DCA) to the primary vertex from data.
- Template for prompt D⁰: FONLL + data-driven simulation of detector effects.
- Template for non-prompt D⁰ : B-hadrons (B^0, $B^\pm$) from FONLL decayed to D⁰ via PYTHIA + data-driven simulation of detector effects.

$B \rightarrow D^0$ fraction and R_{AA}

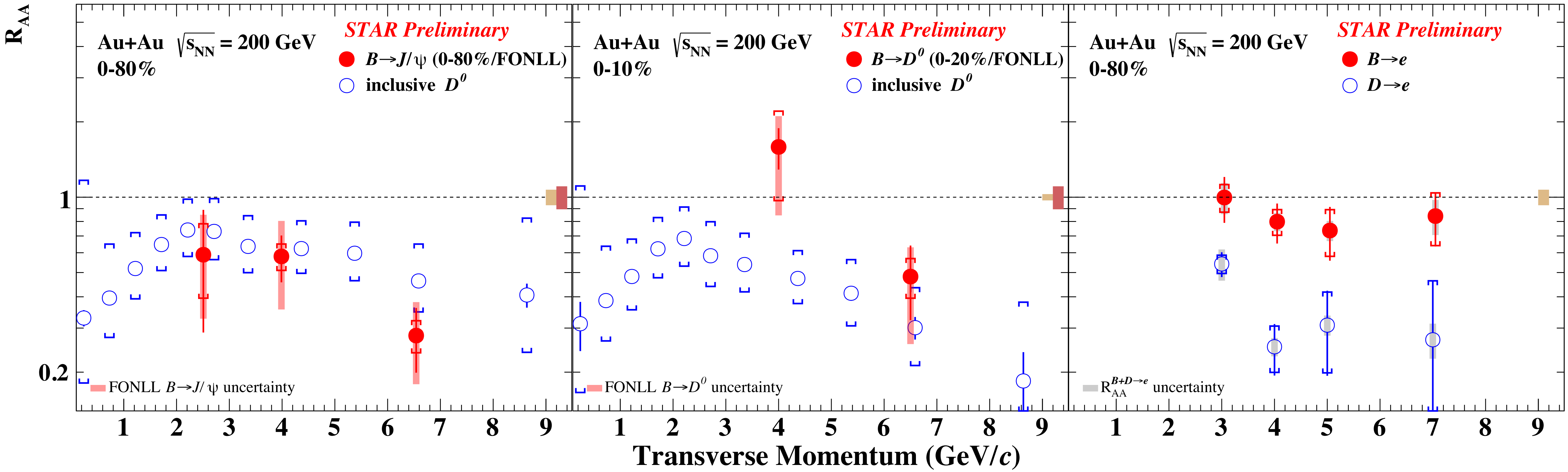


$$R_{AA}^{B\rightarrow D^0} = \frac{1}{< N_{coll} >} \frac{f_{Au+Au}^{B\rightarrow D^0} \times dN_{Au+Au}^{inc.\,D^0}/dp_T}{dN_{FONLL}^{B\rightarrow D^0}/dp_T}$$



- **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 200 GeV Au+Au collisions**
  - ★ Strong suppression for $B \to J/\psi$ and $B \to D^0$ at high p_T.
  - ★ Indication of less suppression for $B \to e$ than $D \to e$ (~2σ): consistent with $\Delta E_c > \Delta E_b$.
- **Outlook**

A factor of ~ 1.5 more MB and ~ 5 more HT Au+Au events recorded in 2016 for D^0 and electron decay channels .

BACK UP

HFT Design

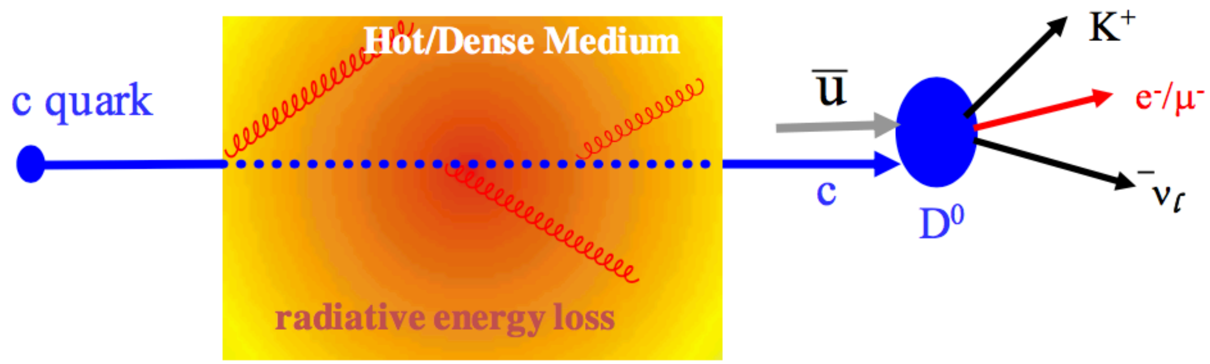
- HFT consists of 3 sub-detector systems inside the STAR Inner Field Cage

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)

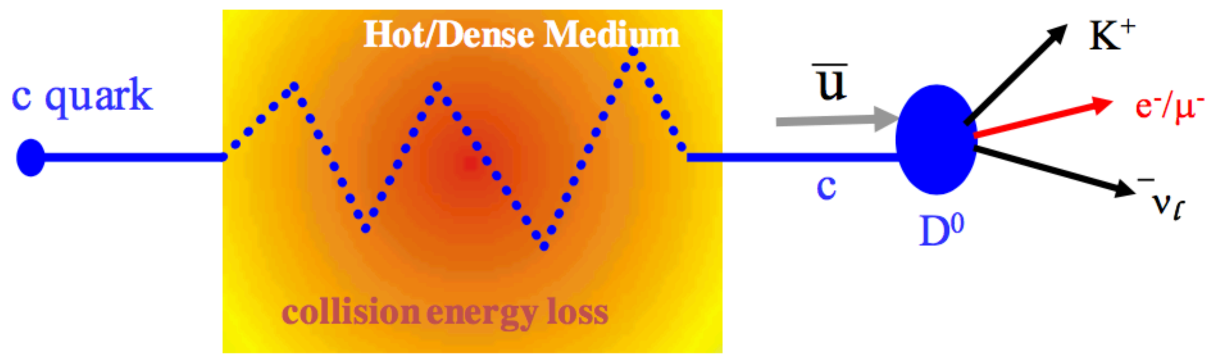
➢ **IST** one layer of silicon strips along beam direction, guiding tracks from the SSD through PIXEL detector - **proven pad technology**

➢ **PIXEL** double layers, 20.7x20.7 μm pixel pitch, 2 cm x 20 cm each ladder, 10 ladders, delivering ultimate pointing resolution. **- new active pixel technology**



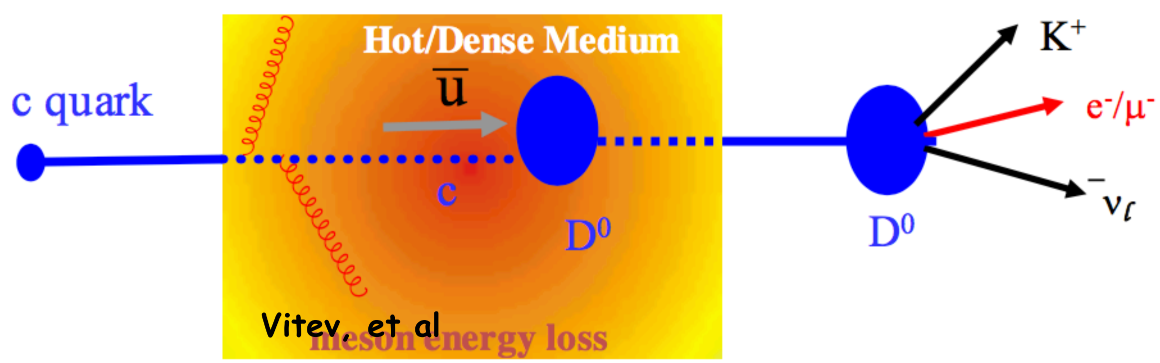
(Baier *et al*, Kharzeev *et al*, Djordjevic *et al*, Wiedemann *et al* .)

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

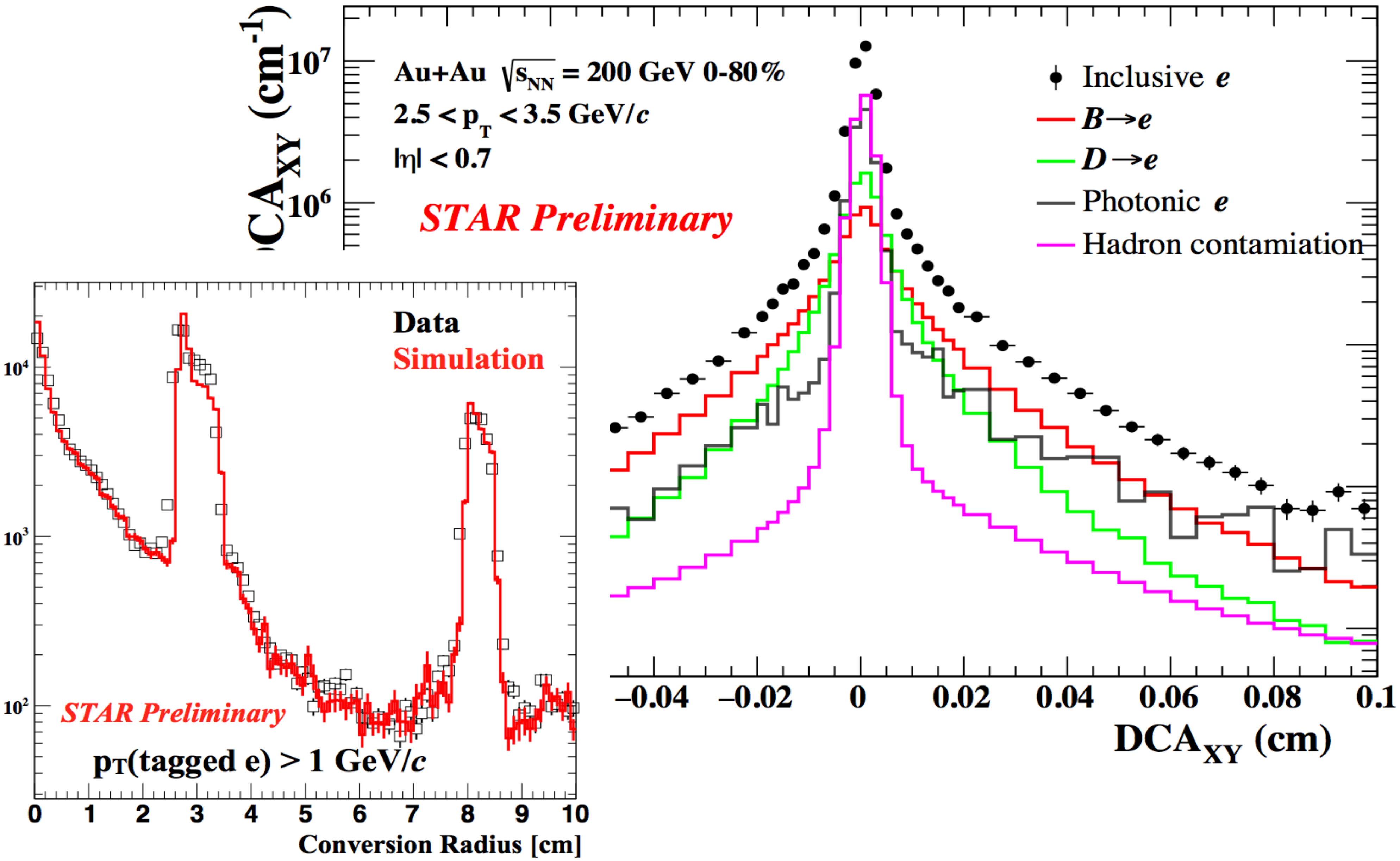


(Teaney *et al*, Rapp *et al*, Molnar *et al*, Gossiaux *et al*.)

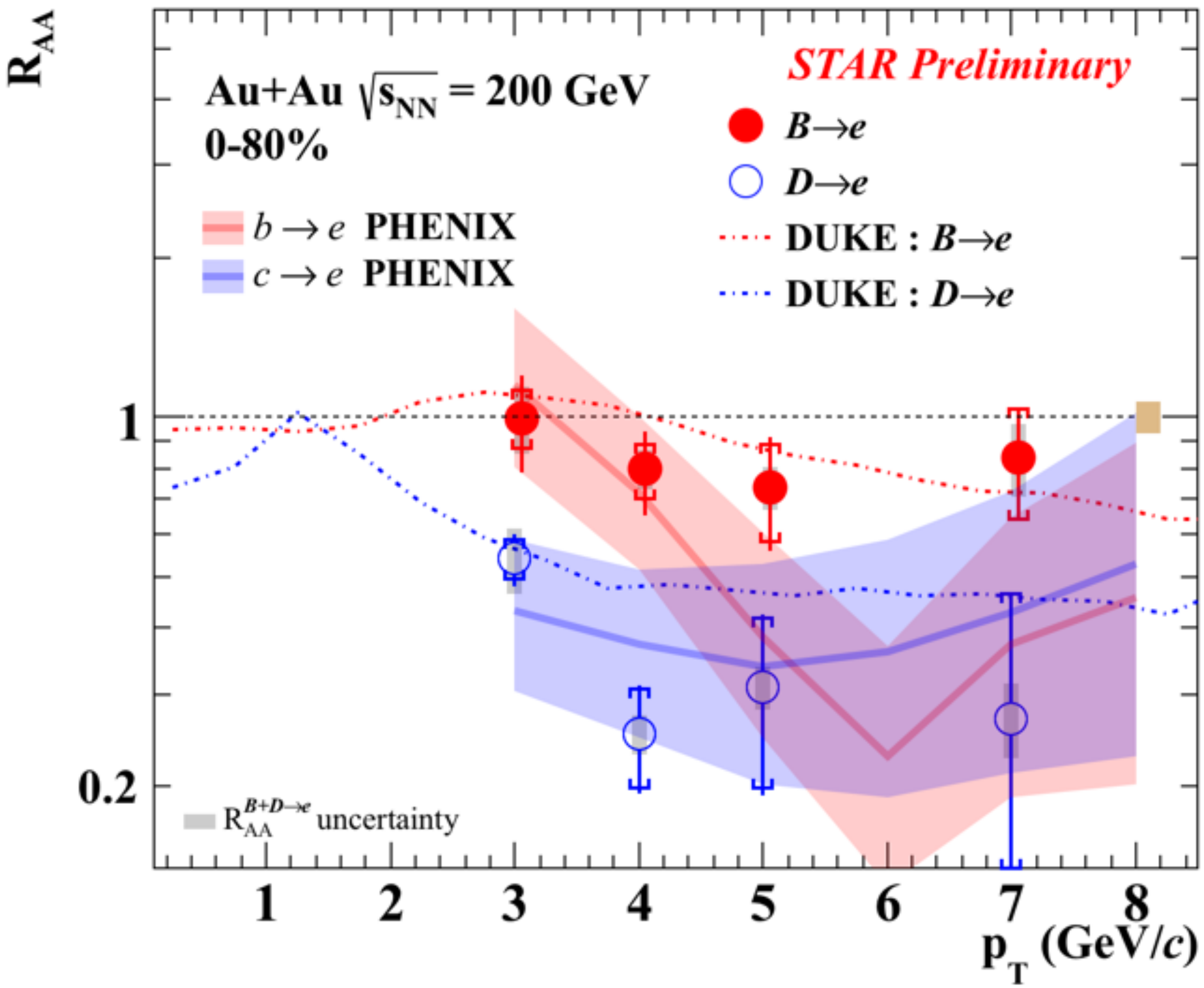
Collisional energy loss. Heavy quarks lose energy through elastic collisions with other partons.



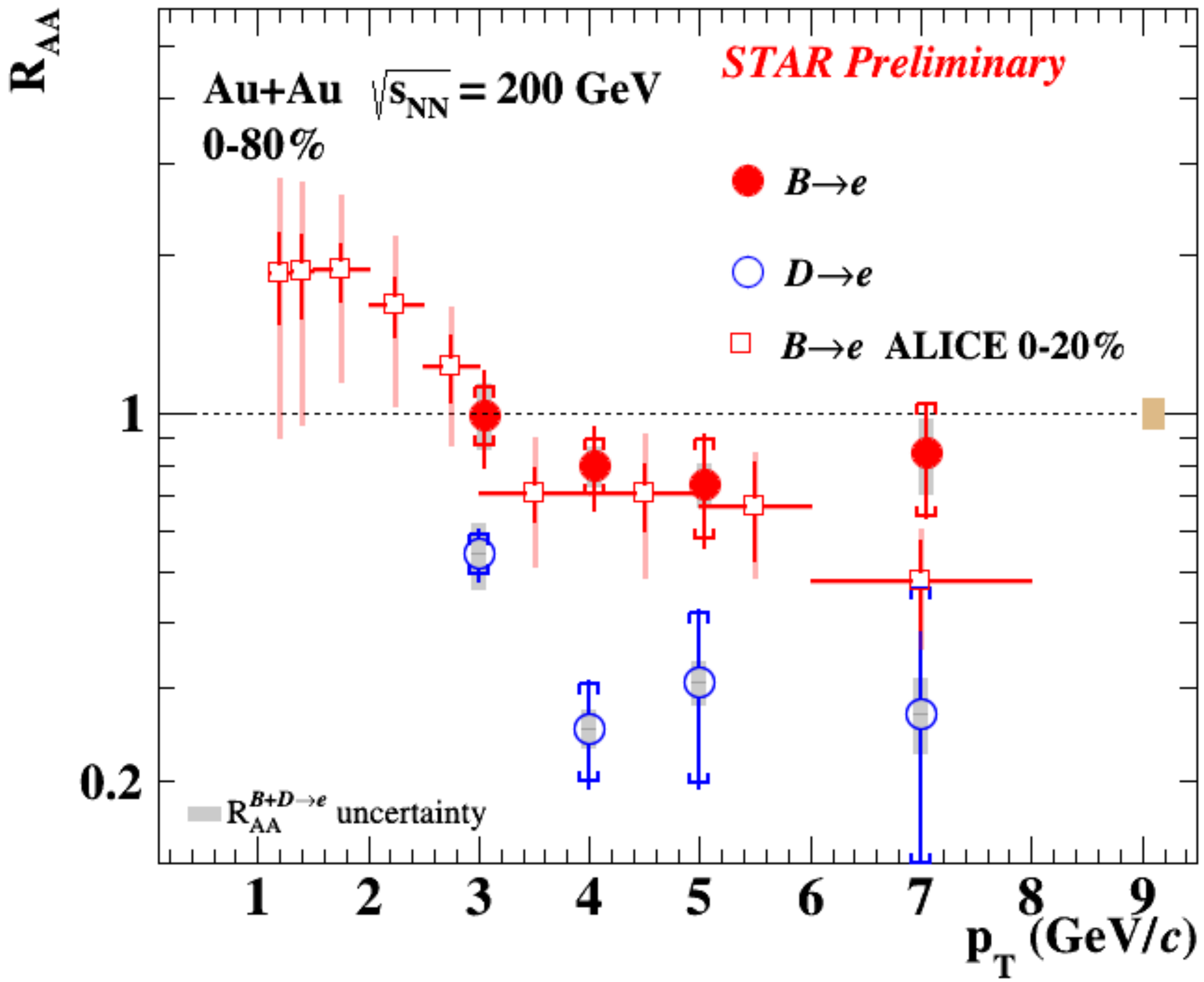
Collisional Dissociation. Medium induced dissociation of heavy mesons.



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



Consistent with PHENIX result within uncertainty.



Consistent with ALICE result within uncertainty.