Recent Open Heavy Flavor Results from STAR

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Outline:

I. Introduction.

II. Recent results:

1. Charm cross-section in p+p at 200 and 500 GeV.
2. D^0 measurement and Nuclear Modification Factor in Au+Au at 200 GeV and U+U at 193 GeV.
3. Non-photonic electrons spectra and azimuthal anisotropy.

III. Heavy Flavor Tracker physics program.

Heavy quarks as probes of sQGP

Heavy quarks are *almost exclusively* created through initial hard scattering at RHIC. Thus, they experience all the stages of medium evolution → their kinematics carry information about their interaction with the medium.

Measurement can be eventually used to extract medium properties (gluon density, $\hat{q}$, drag and diffusion coefficients, etc …) through different models.

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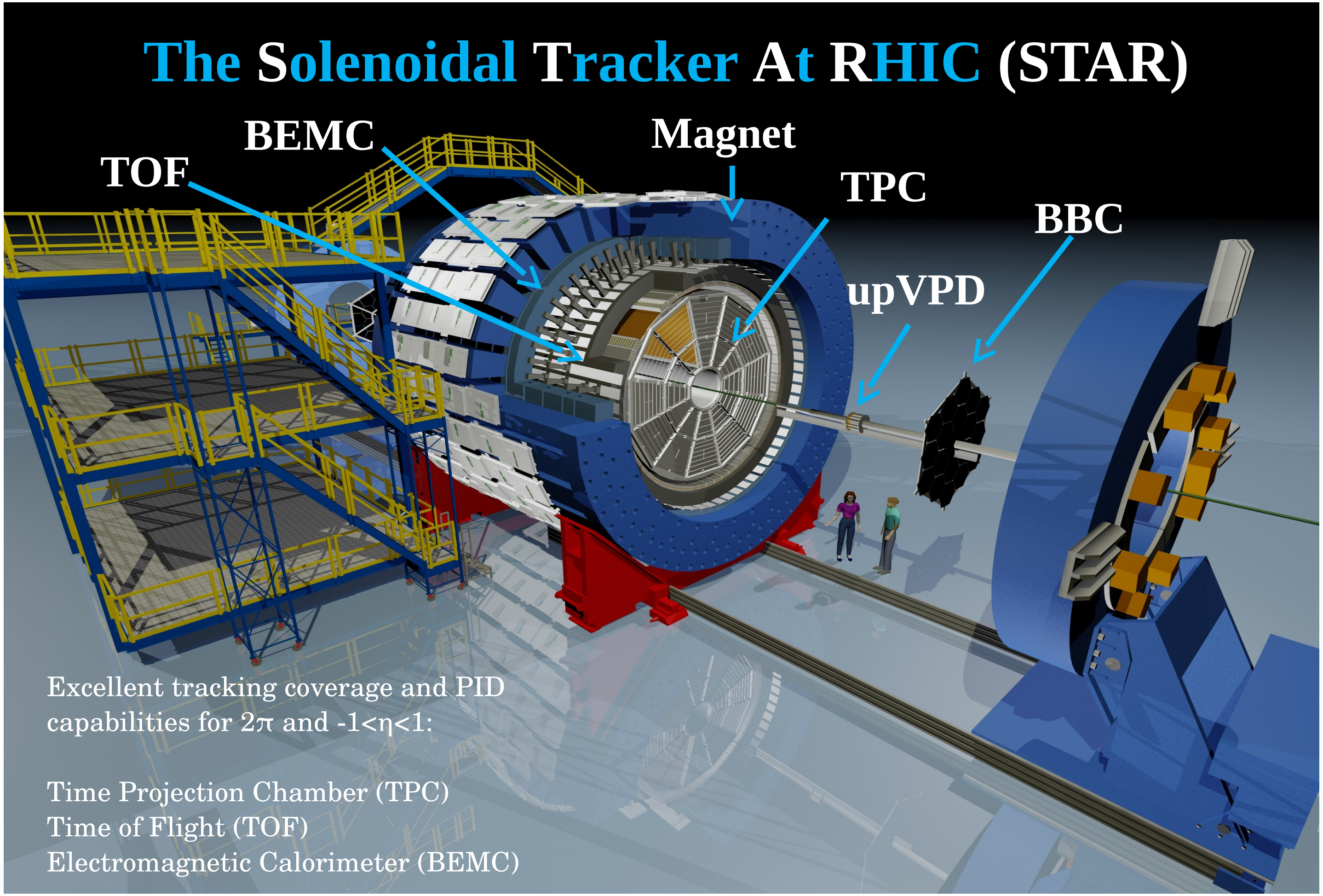
Observables:

- Nuclear modification factor
  - Study flavor dependence of partons energy loss.

- Azimuthal Anisotropy
  - Low $\mathbf{p_T}$ v_2 (< 2 GeV/c)
    - Charm flow ⟶ testing the thermalization of the bulk matter.
    - Important to understand the contribution to J/ψ v_2 in a recombination scenario.
  - High $\mathbf{p_T}$ v_2 (>6 GeV/c).
    - path length dependence of energy loss.

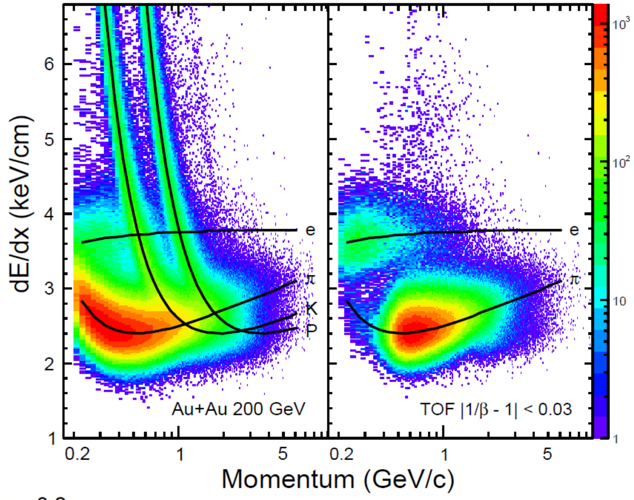
Experimental Setup



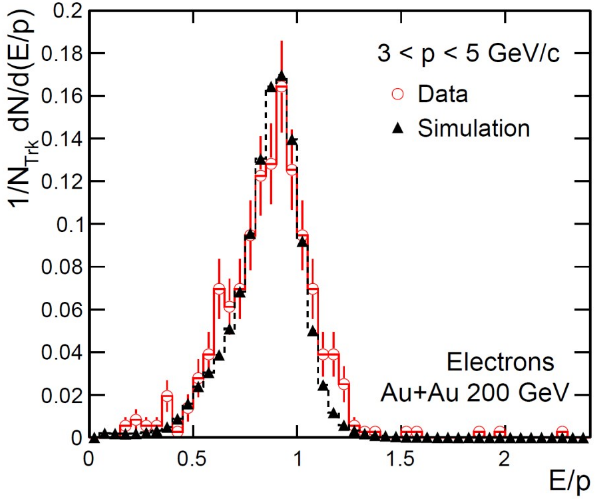
Particle identification

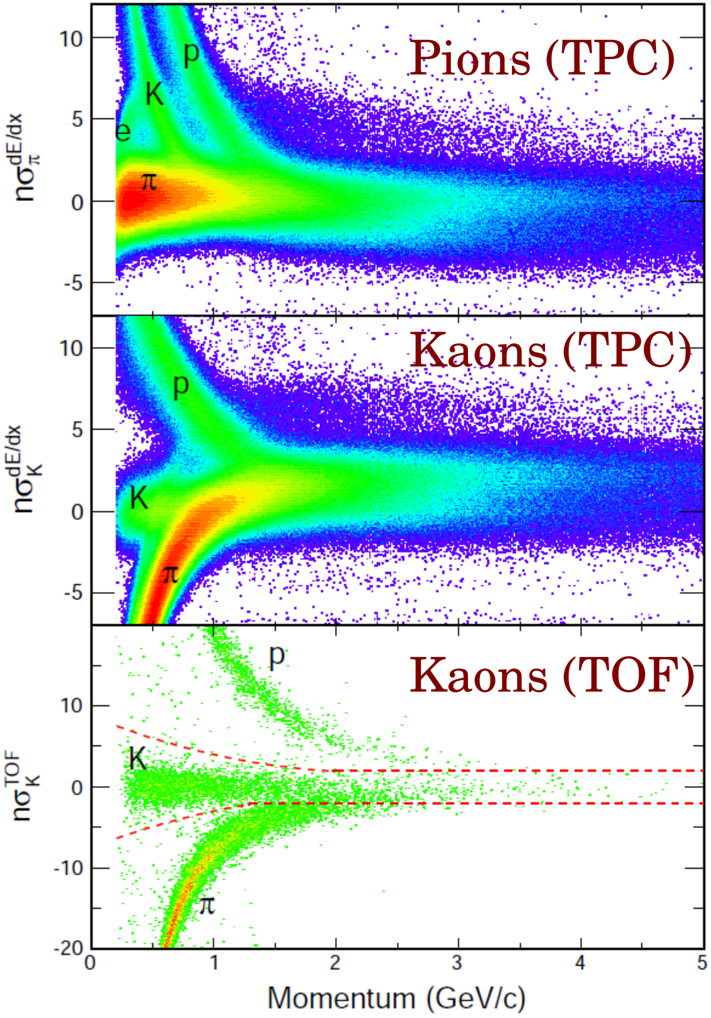
Electrons

Low p_T (< 1 GeV/c) using TOF+TPC

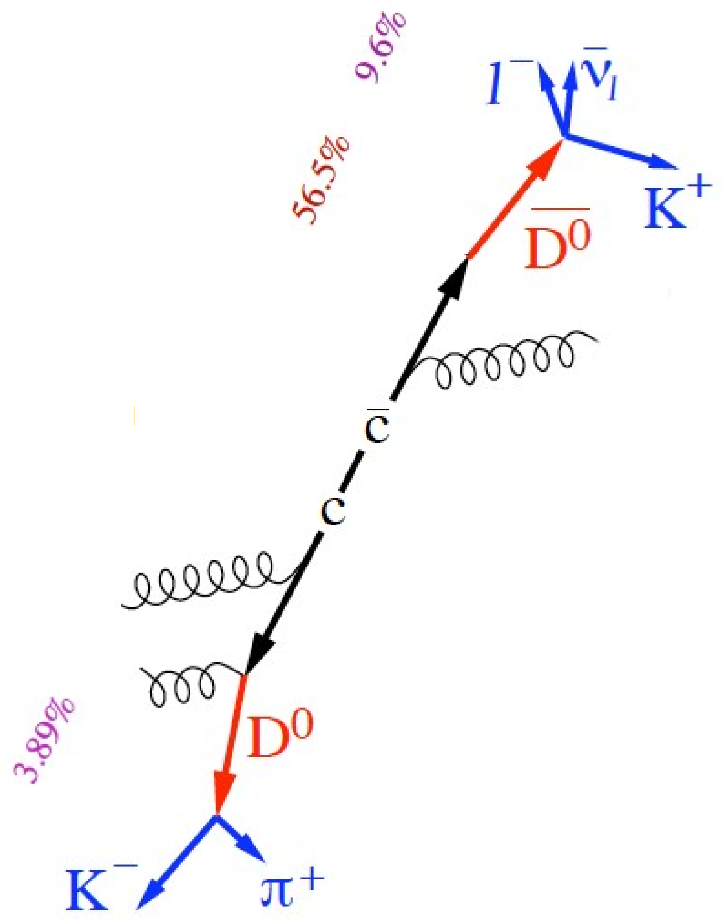


High p_T using TPC+EMC





Reconstructing open heavy flavor



Semi-leptonic channels

Proxy for direct reconstruction.

High p_T reach.

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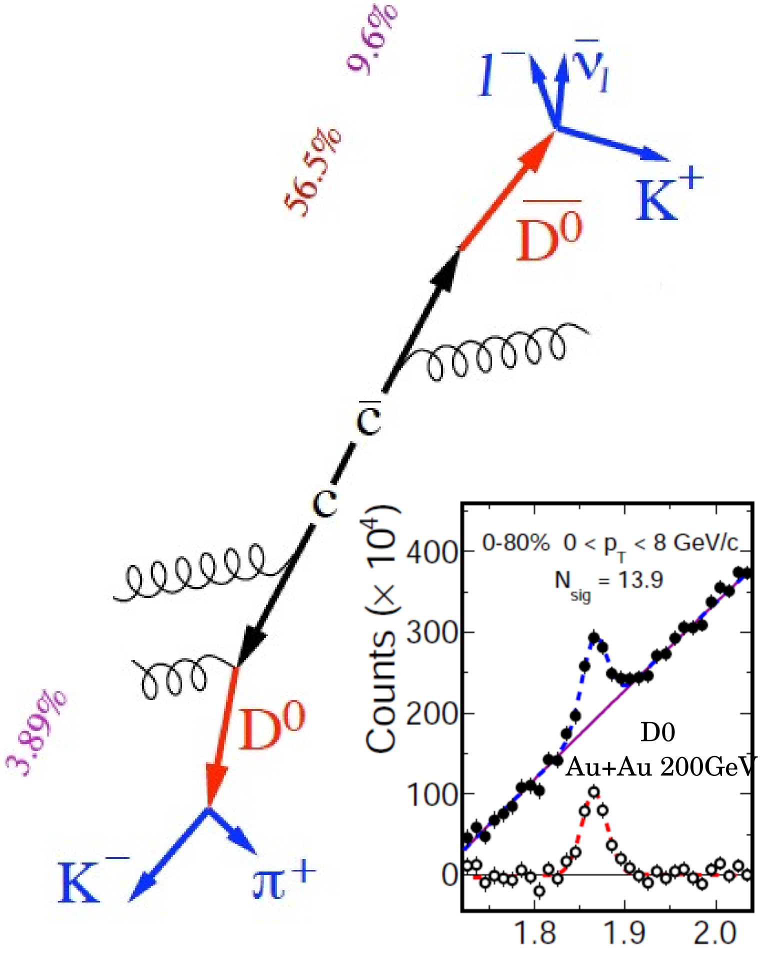
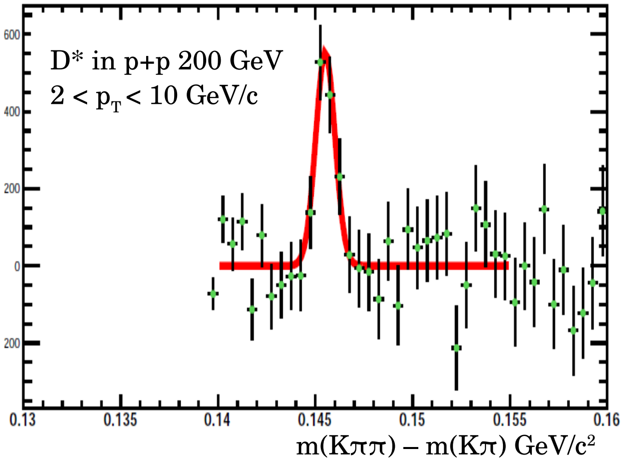
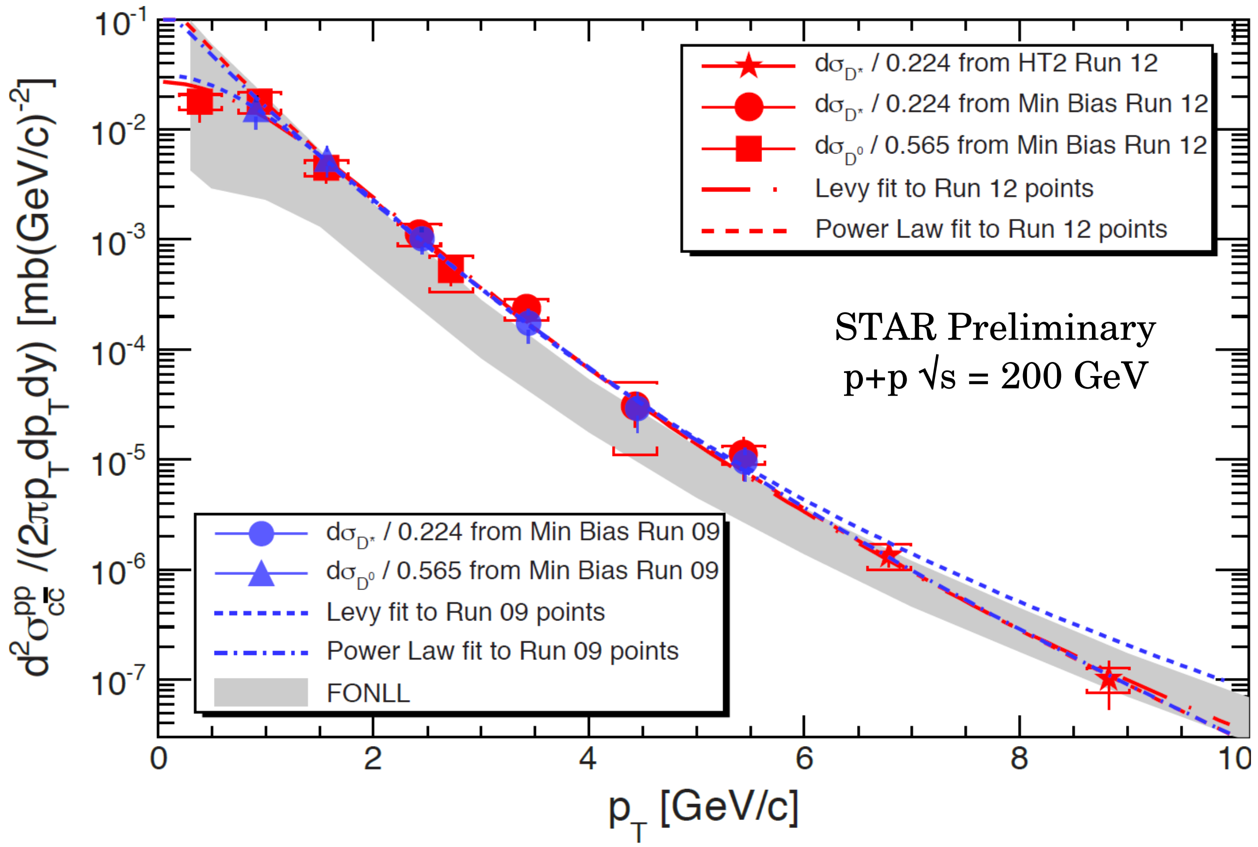




Topological reconstruction

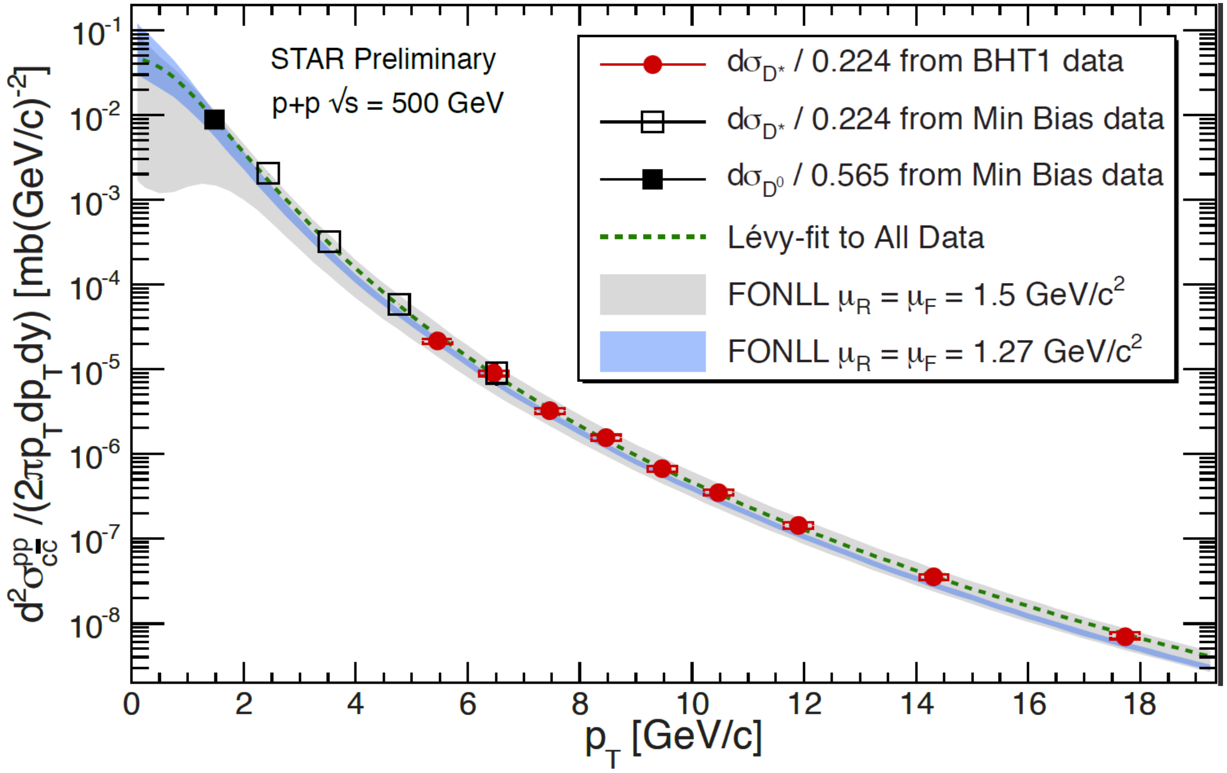
Results

Charm cross-section in p+p at √s = 200 GeV



New measurement of D^0 low p_T (0-0.7) constrains the total charm cross-section.

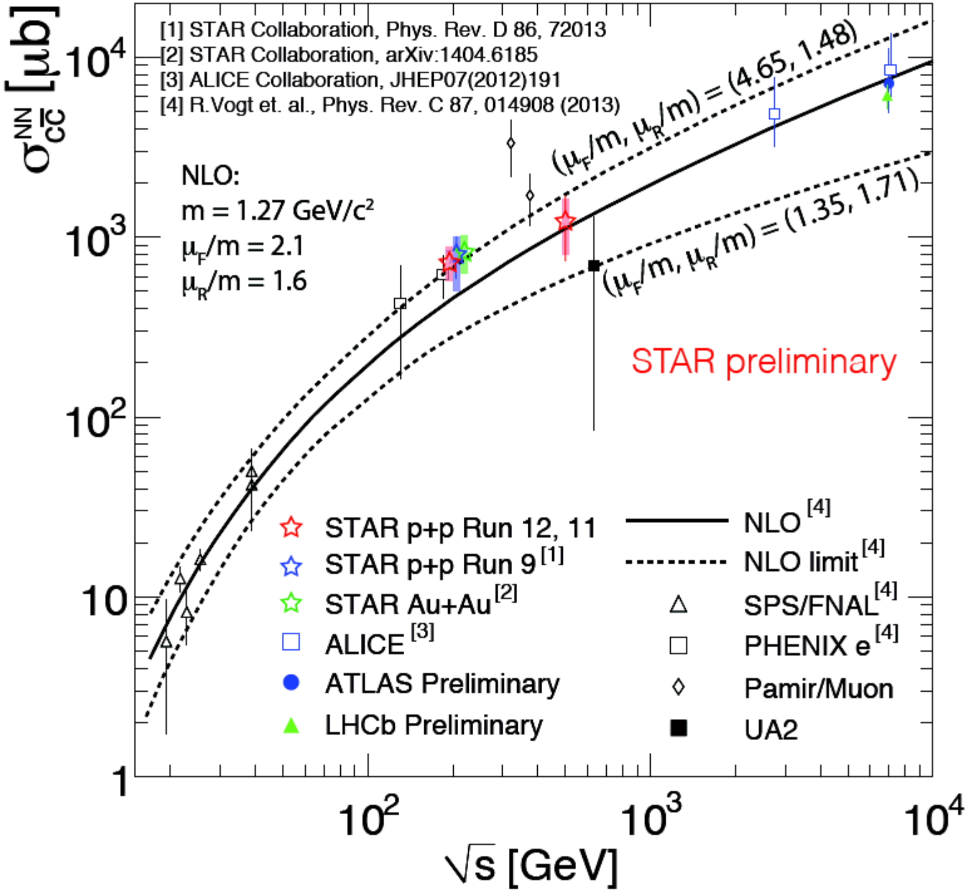
Charm cross-section in p+p at √s = 500 GeV



Measurement extends to high $p_{T.}$

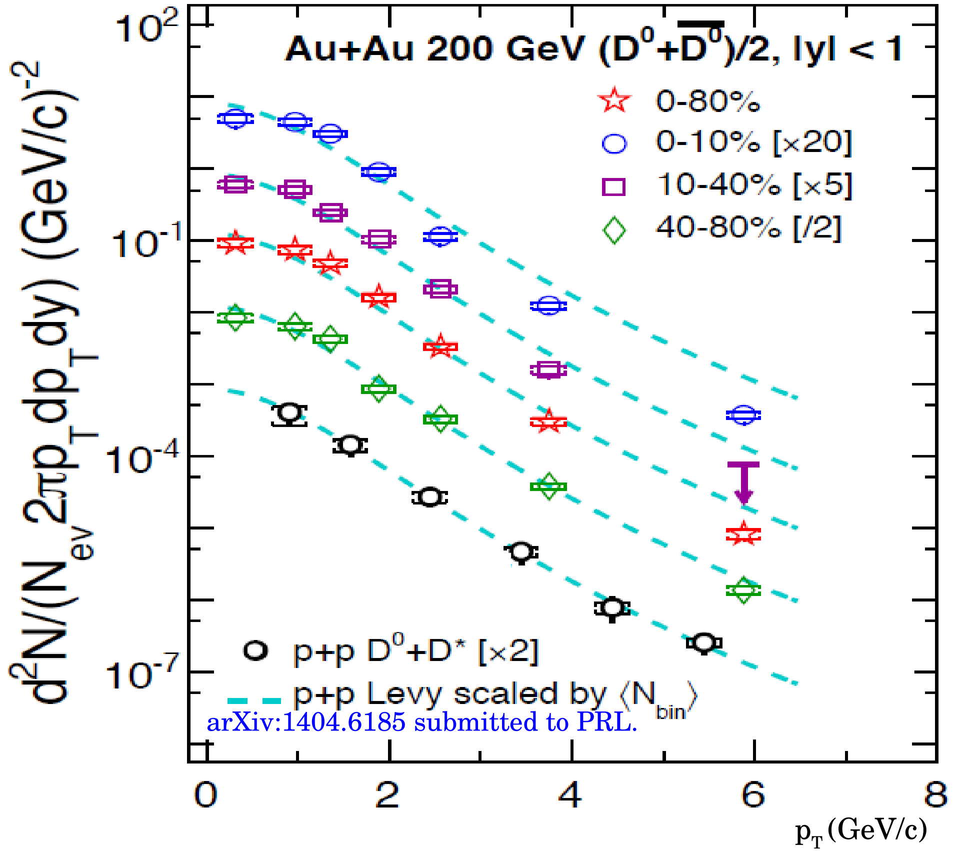
Very good agreement with FONLL calculation.

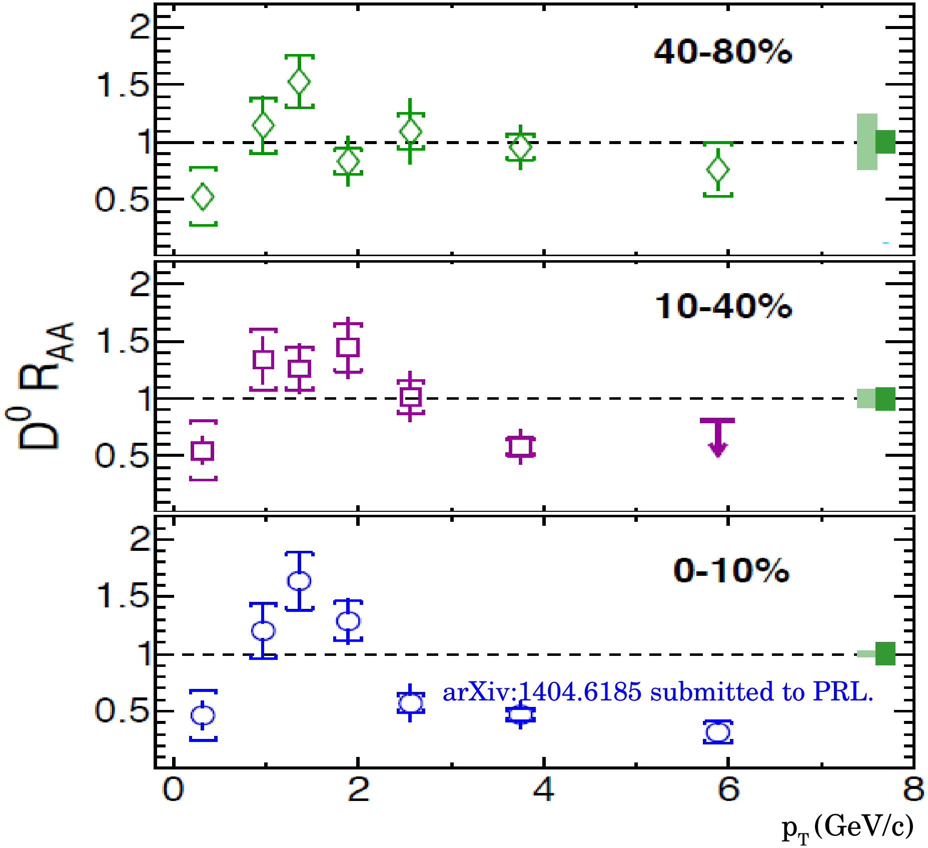
Total charm cross-section in p+p



Measurements are in agreement with pQCD calculations and world data trend.

D^0 in Au+Au at $\sqrt{s_{NN}} = 200$ GeV

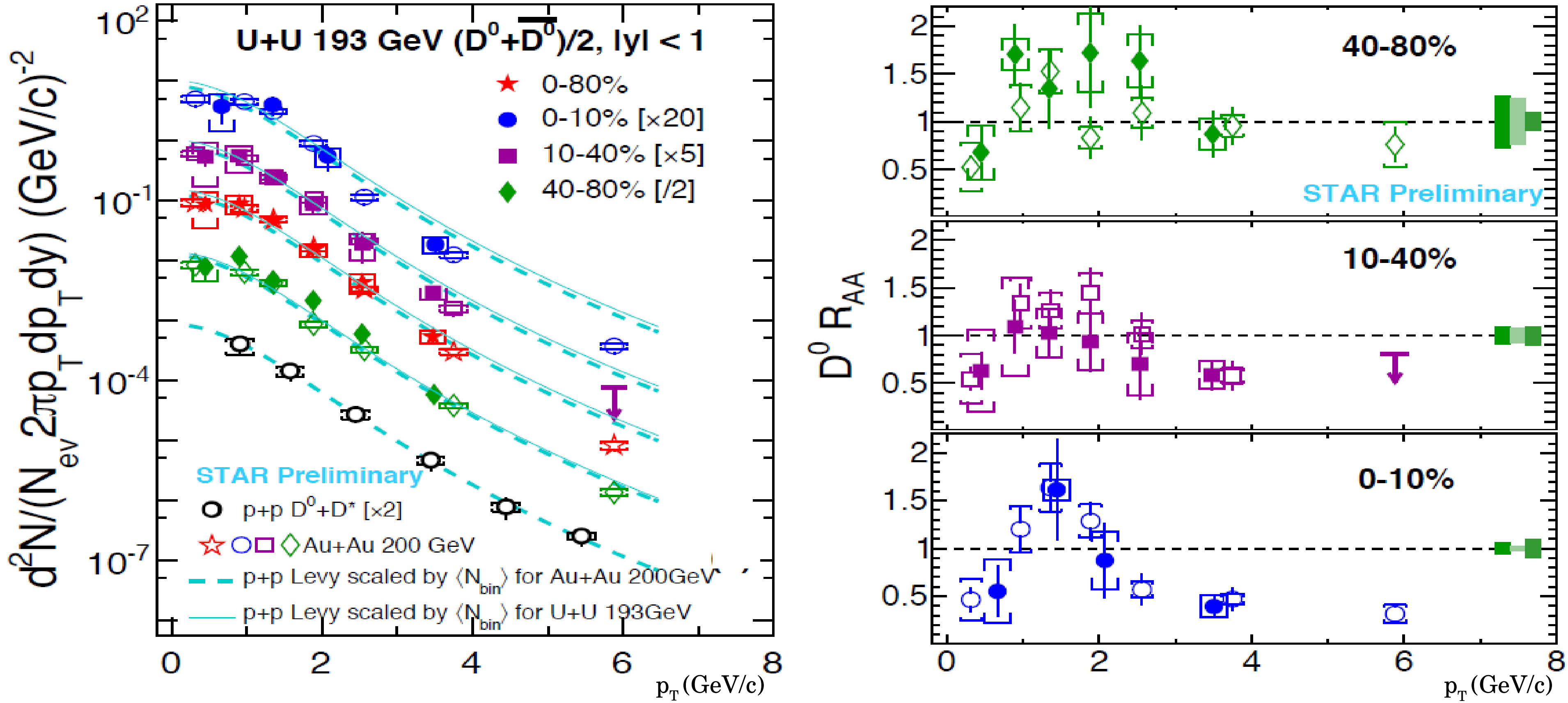




Enhancement at p_T ~ 1.5 GeV in all centralities.

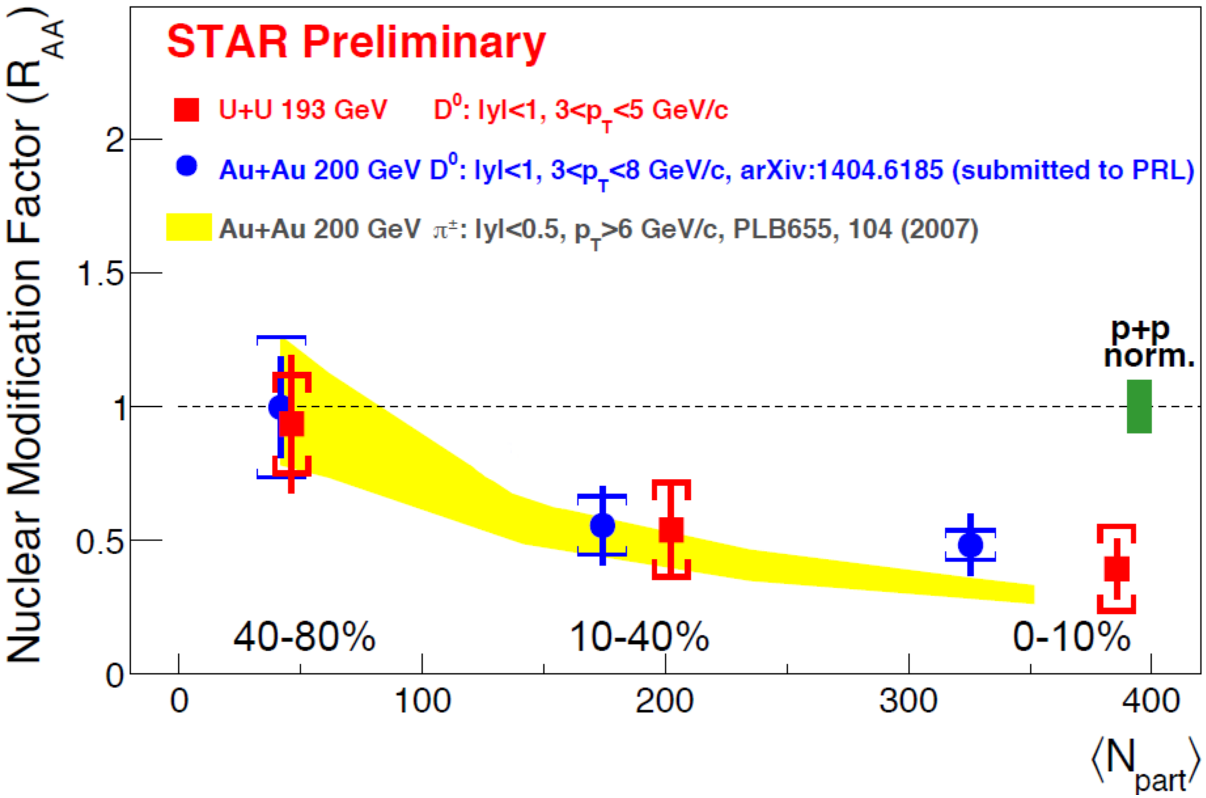
Suppression at high-p_T in most central bin.

D^0 in U+U at $\sqrt{s_{NN}}$ = 200 GeV



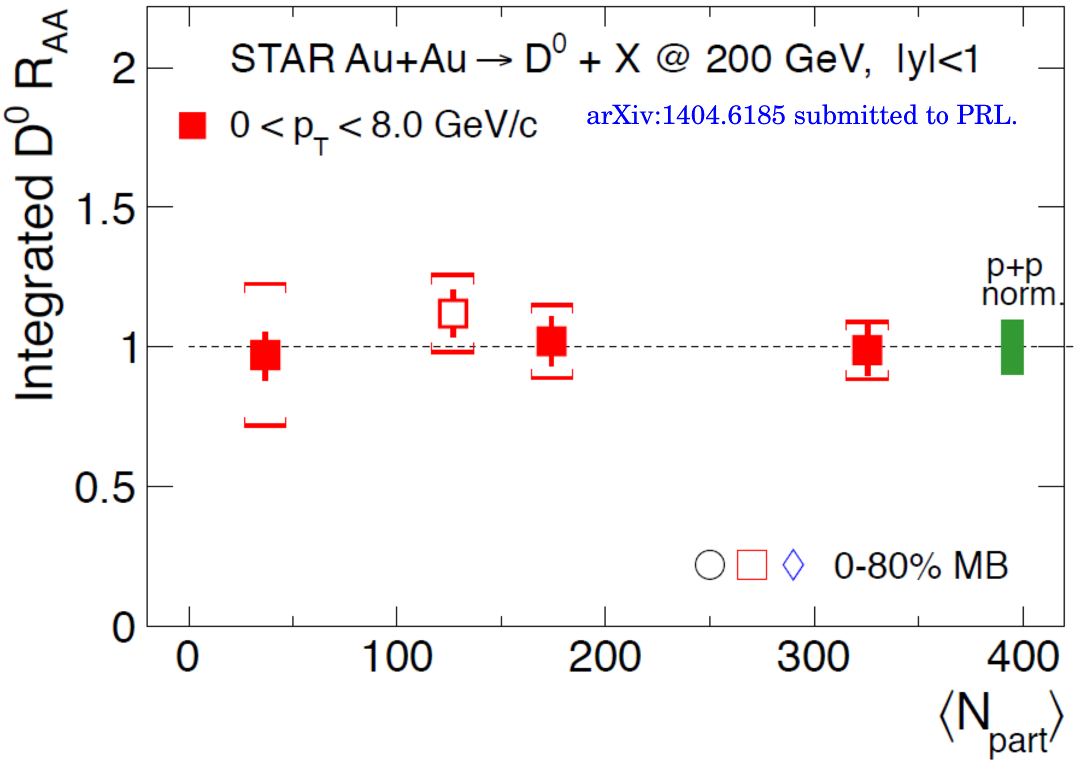
Suppression and enhancement features in U+U are similar to Au+Au.

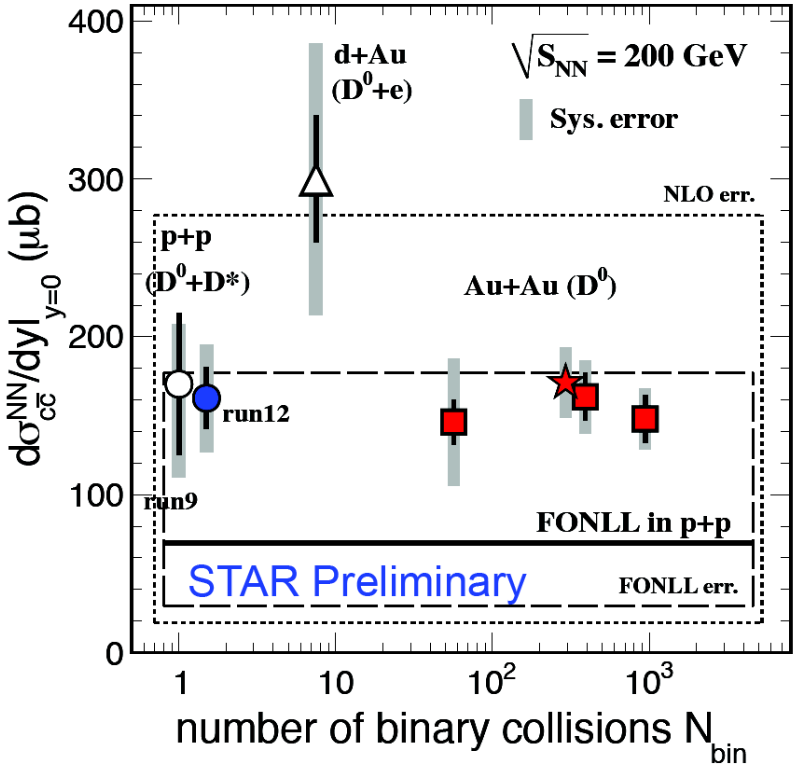
System size dependence of high-p_T suppression



Suppression of D^0 production closely follows that of pions across different system sizes.

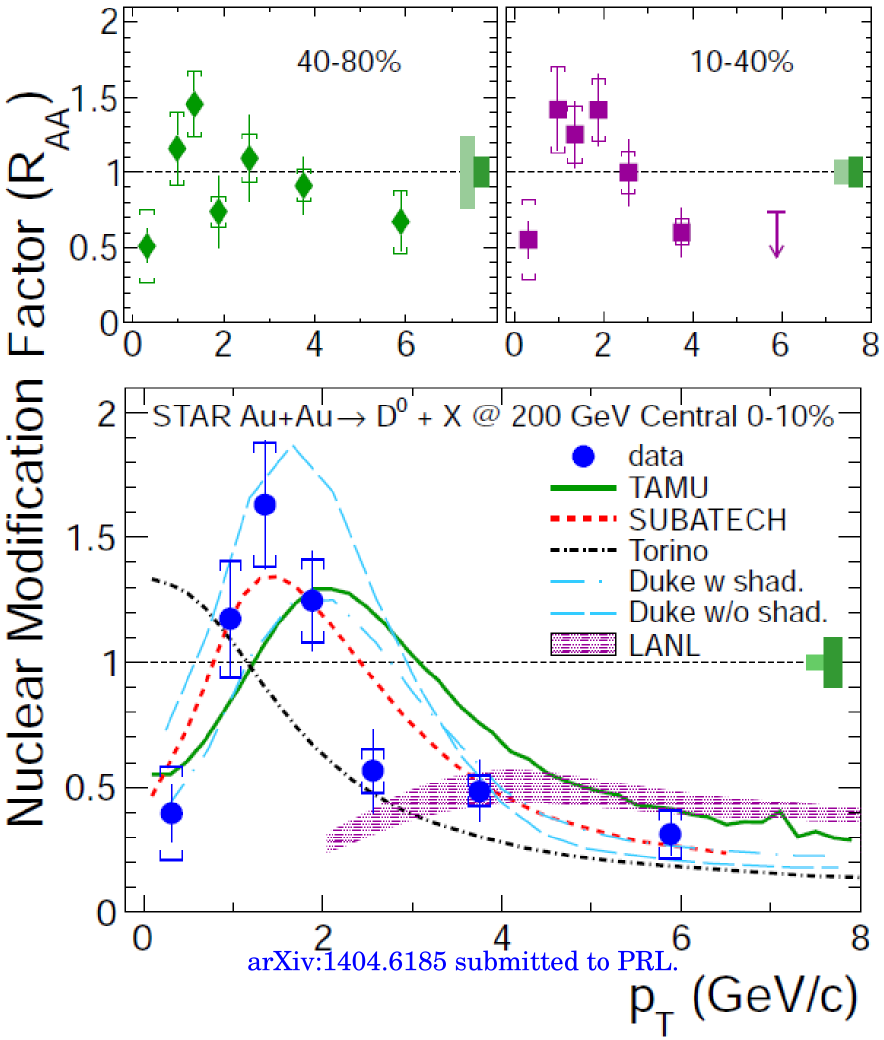
Total charm cross-section in Au+Au





Number of binary collision scaling of charm cross-section is observed in different system sizes at RHIC top energy.

Comparison to models:



arXiv:1404.6185 submitted to PRL.

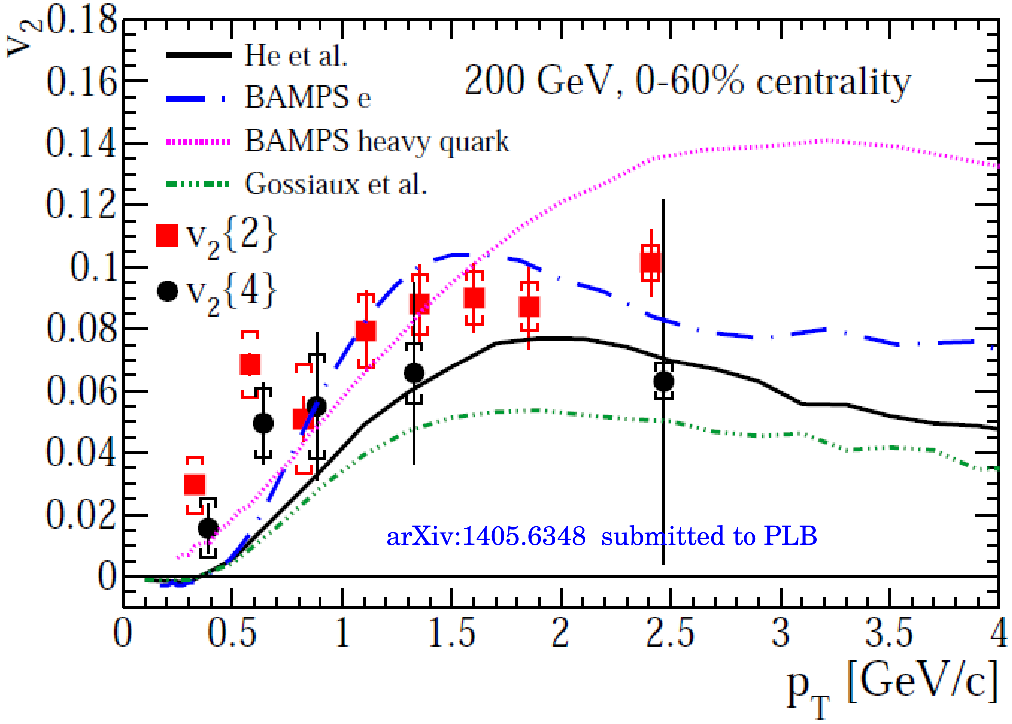
- Models with collisional energy loss + coalescence reproduce the R_{AA} features at low and high p_T.

- Torino model with hadronization only through fragmentation doesn't reproduce the bump.

- LANL energy loss which include mesons dissociation also reproduce the level of observed suppression.

- Does CNM contribute to the observed enhancement ?

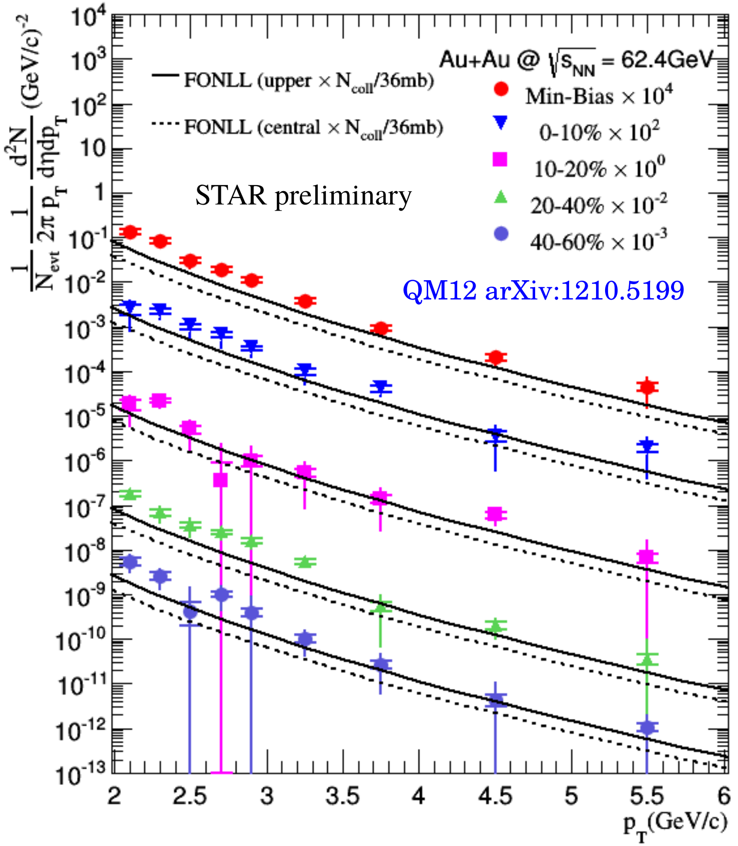
Non-photonic electrons v_2



Models which assume strong charm-medium coupling are consistent with the data within the current uncertainties.

Charm flows at RHIC top energy?

Searching for the onset energy of strong charm-medium coupling :



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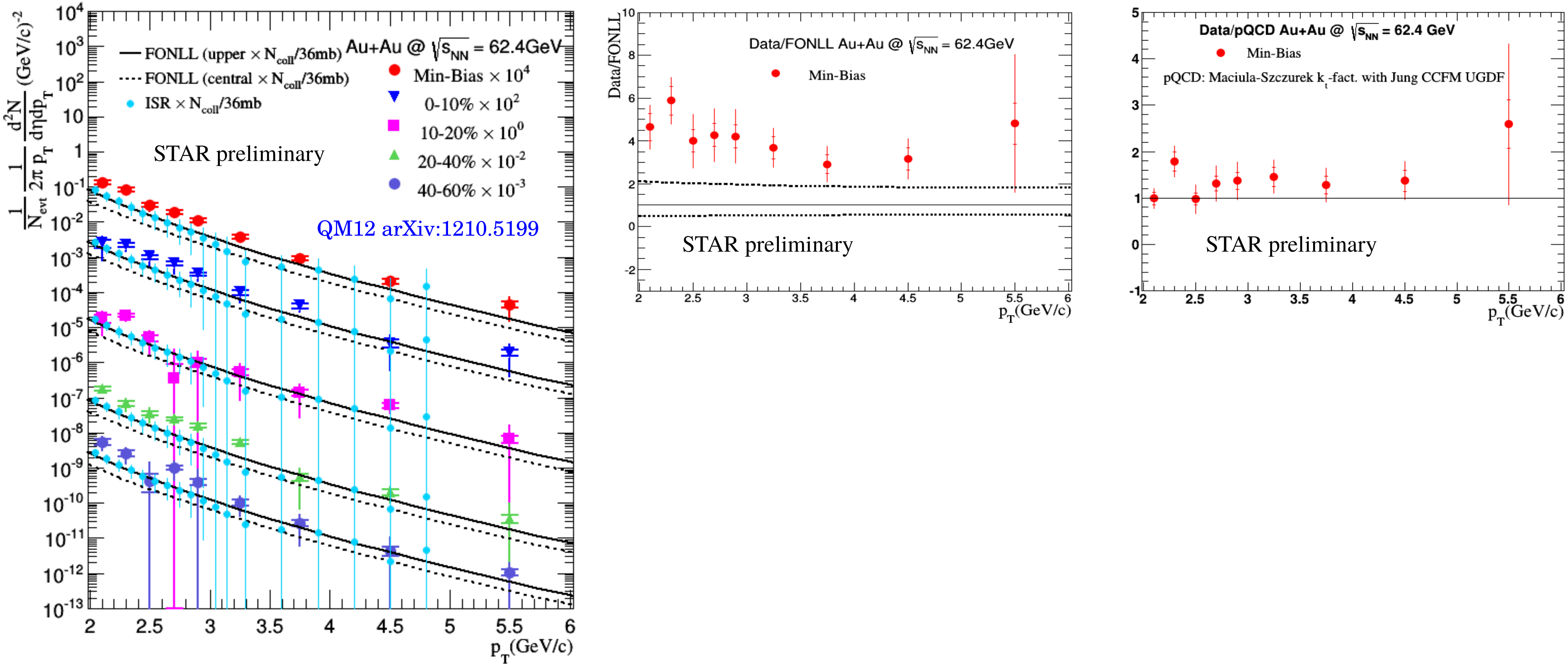

- Enhancement at intermediate p_T and no sign of suppression compared to pQCD calculations and ISR measurements.

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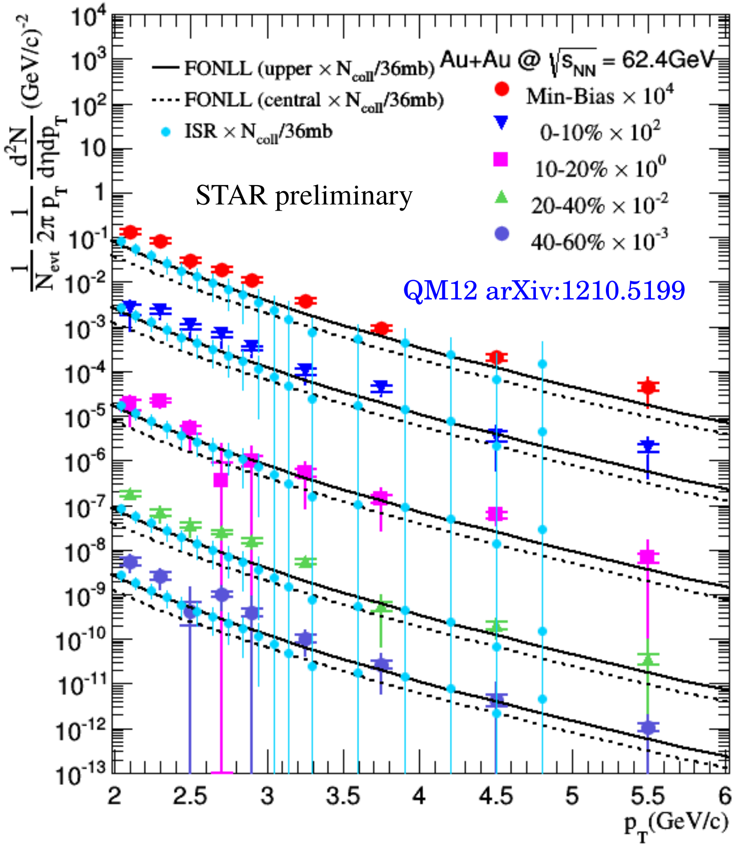
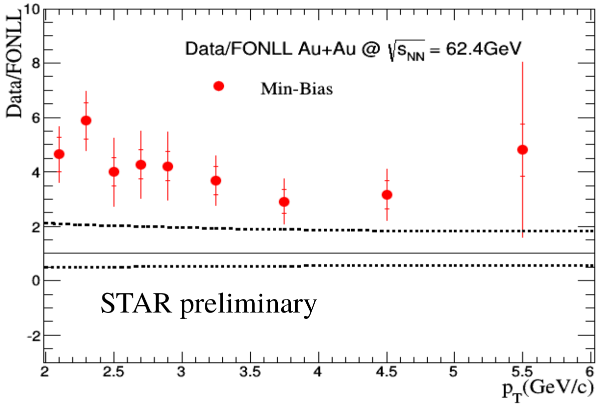
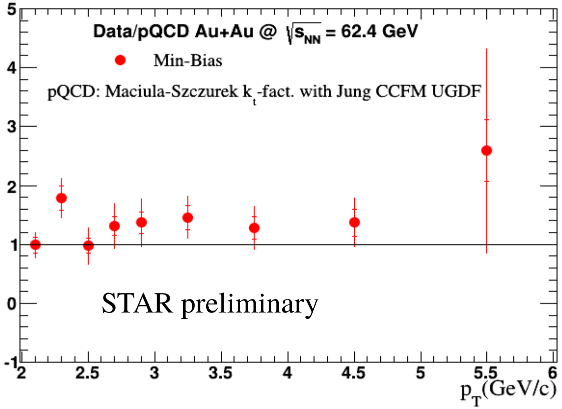
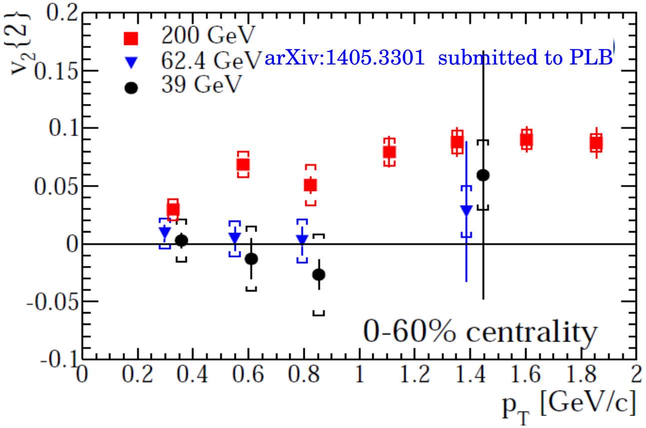








- Enhancement at intermediate p_T and no sign of suppression compared to pQCD calculations and ISR measurements.
- v_2 {2} is consistent with zero at 62.4, 39 GeV, and statistically different from 200 GeV for p_T < 1 GeV/c.

Summary:

- New charm production measurement in p+p at 200 and 500 GeV are improved and consistent with pQCD calculations.

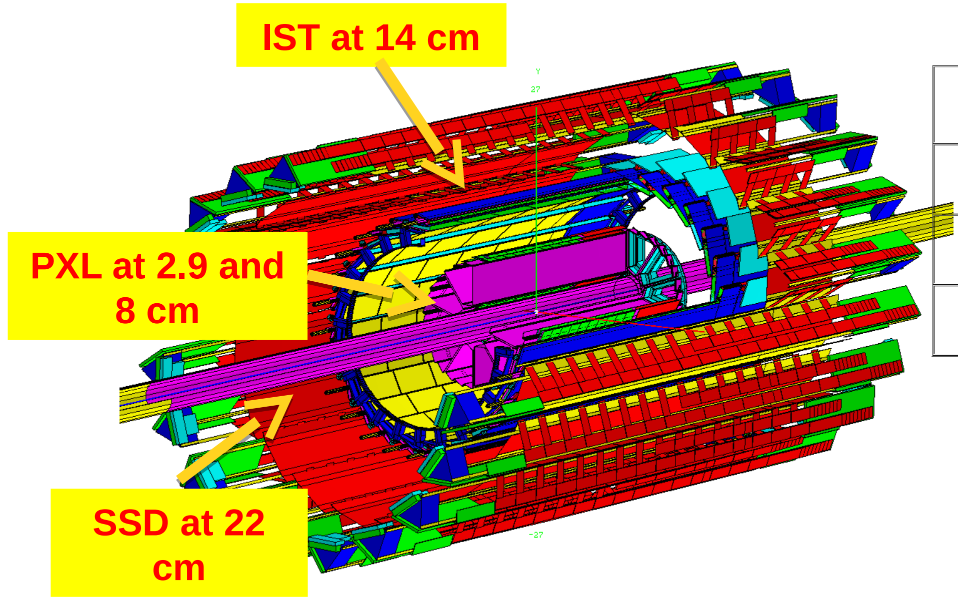
- D^0 suppressed ($\mathbf{p_T}$>3 GeV/c), enhanced ($\mathbf{p_T}$<2. GeV/c) in Au+Au and U+U central collisions compared to charm production in p+p collisions.

- Finite v_2 of non-photonic electrons at top RHIC energy, consistent with zero at lower energies.

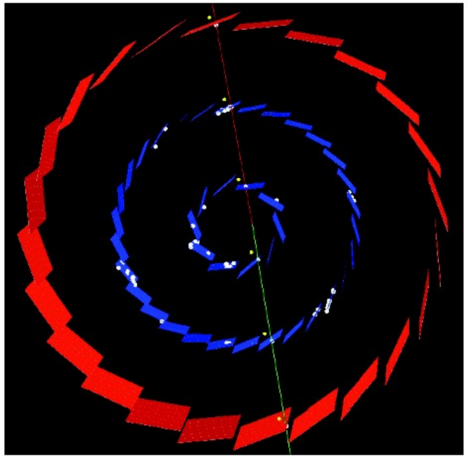
- Enhancement of non-photonic electrons production at 62.4 GeV compared to ISR and pQCD calculations.

STAR
Heavy Flavor Tracker
(HFT)

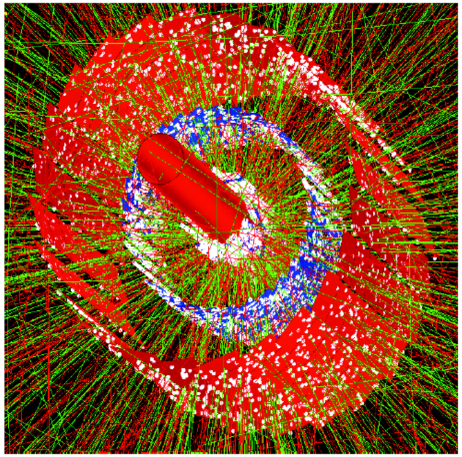
Heavy Flavor Tracker (HFT):



	Radius (cm)	$\sigma_{r\text{-}\varphi}$(μm)	σ_z(μm)	X/X_0
SSD	22	20	740	1%
IST	14	170	1800	<1.5%
PXL	8 and 2.9	7.6	7.6	0.4%/layer

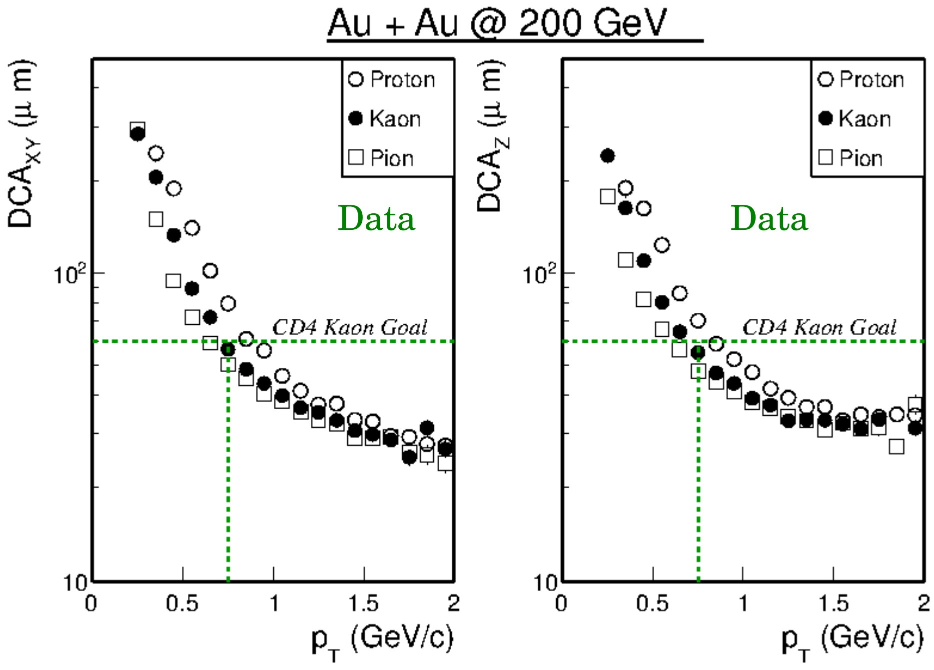


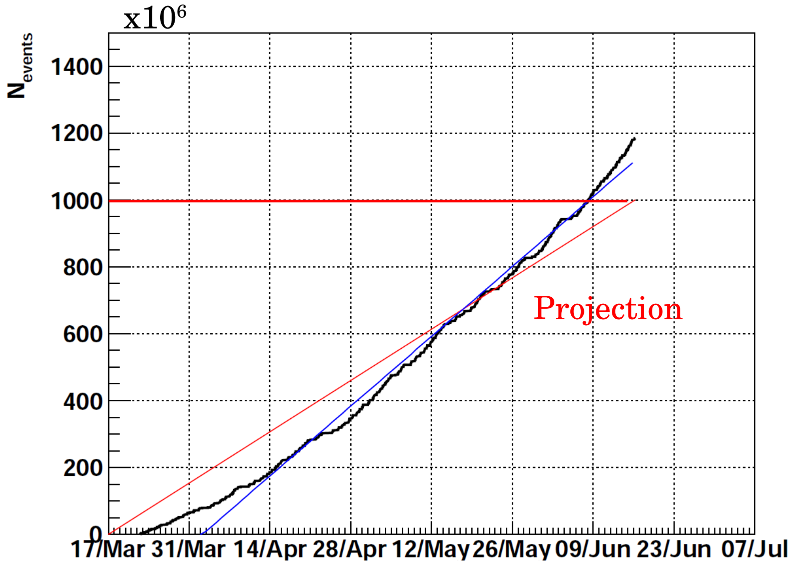
Cosmic ray event



Au+Au 200 GeV

HFT performance and data taking in Run14:



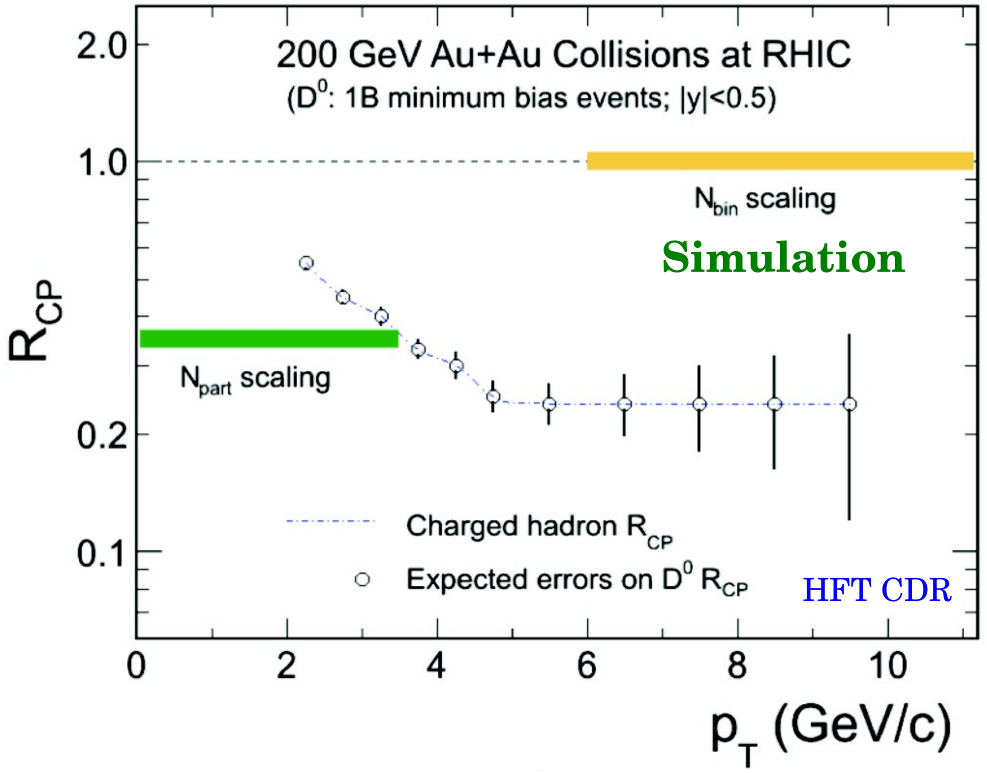


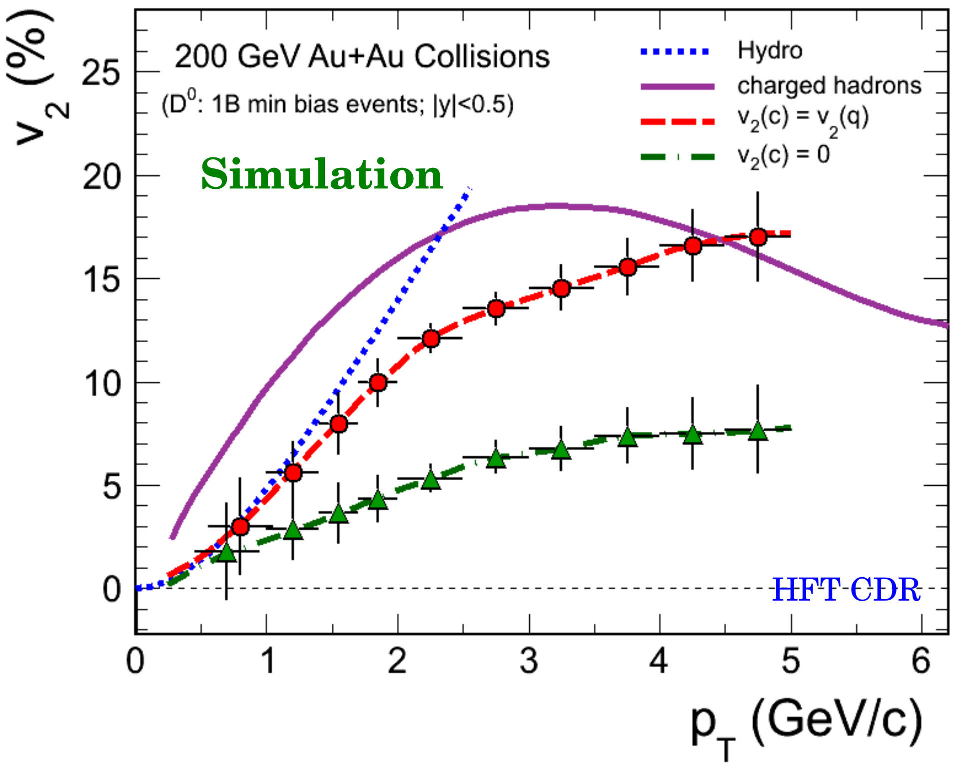
DCA resolution for tracks with 1 IST hit + 2 PXL hits is ~ 30 μm at high p_T. Below project goal of 60 μm for kaons at 750 MeV.

Au+Au @ 200 GeV data taking successfully ended on June 16th with STAR reaching its goals.

Physics in the **HFT** era

Charm medium interaction and energy loss:

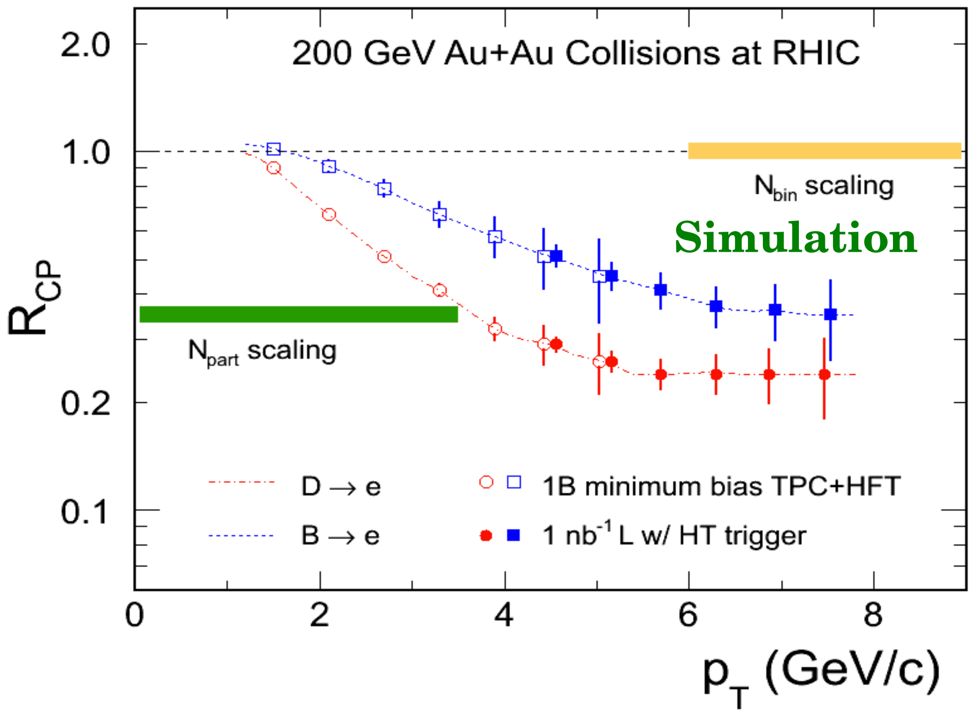


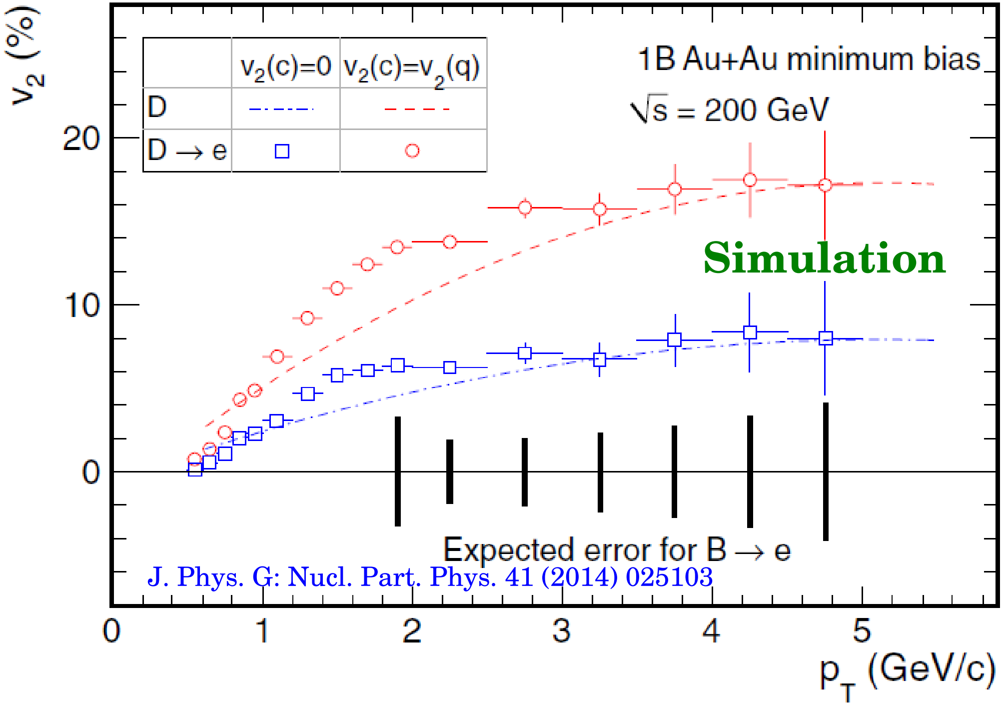


Estimated for 1B good minimum-bias events.

Physics in the **HFT** era

Separate charm and bottom measurements:





Estimated for 1B good minimum-bias events and 1 nb^{-1} HT trigger.
Using impact parameter distribution we can separate charm and bottom contributions to electrons from heavy flavor decays (Y. Zhang et. al. JPG 41, 25103).

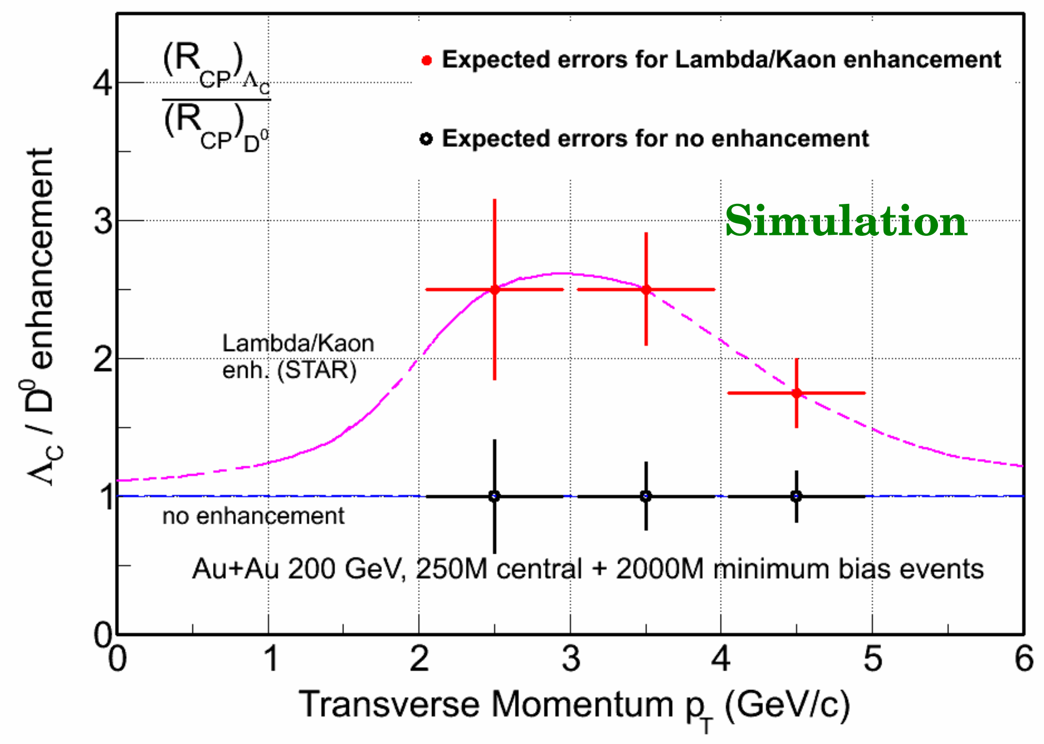
Physics in the **HFT** era

Charmed hadrons chemistry in heavy-ion collisions:

Does a coalescence or a modified fragmentation scenario change the charmed hadron chemistry D^0/D, D^{+-}/D, D_s/D compared to production in vacuum?

How does strangeness enhancement and coalescence change D_s/D compared to in vacuum fragmentation?

How about a charmed baryon enhancement (Λ_c/D^0) ?



Based on 2B minimum-bias + 250 central events (Requested for Run 16).

Outlook:

STAR **Heavy Flavor Tracker** has taken data during Run 2014 and simulations show promising physics results.

Run 2014 Au+Au $\sqrt{s_{NN}}$ = 200	Run 2015 p+Au $\sqrt{s_{NN}}$ = 200 GeV p+p $\sqrt{s}$ = 200 GeV	Run 2016 Au+Au $\sqrt{s_{NN}}$ = 200
D^0 v_2 and R_{cp} Separate charm/bottom NMF	Address CNM effects HFT p+p baseline	Charm hadron chemistry (D_s/D^0, D^{+-}/D^0, Λ_c/D^0)