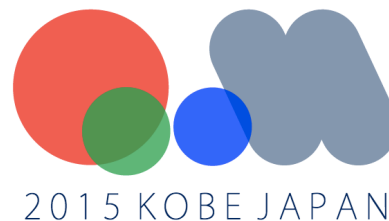


Measurements of  $D_s^\pm$  - meson  
production in Au+Au collisions at  
 $\sqrt{s_{NN}} = 200 \text{ GeV}$  in STAR

Md. Nasim

University of California, Los Angeles

*(for the STAR Collaboration)*





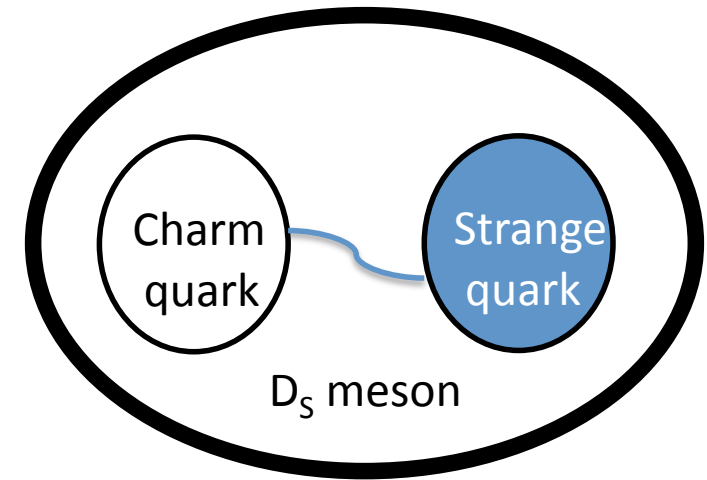
# Outline

- Motivation
- STAR detector and analysis details
- $p_T$  spectra, particle ratio and  $R_{AA}$
- Elliptic flow ( $v_2$ ) of  $D_S$
- Summary



# Why Study $D_s^\pm$ ?

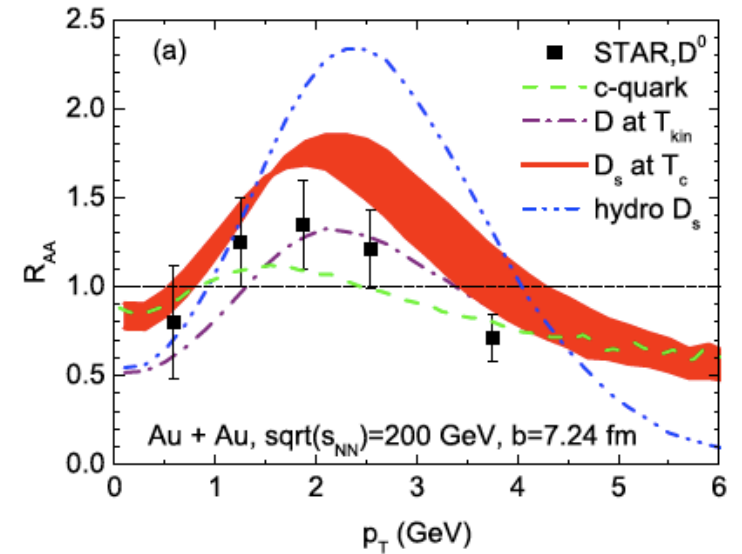
- $D_s$  meson : one charm and one strange quark
- Strangeness enhancement due to QGP is expected to affect the yield of  $D_s$





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- $R_{CP}$  or  $R_{AA}$  of  $D_s > D^0$  predicted



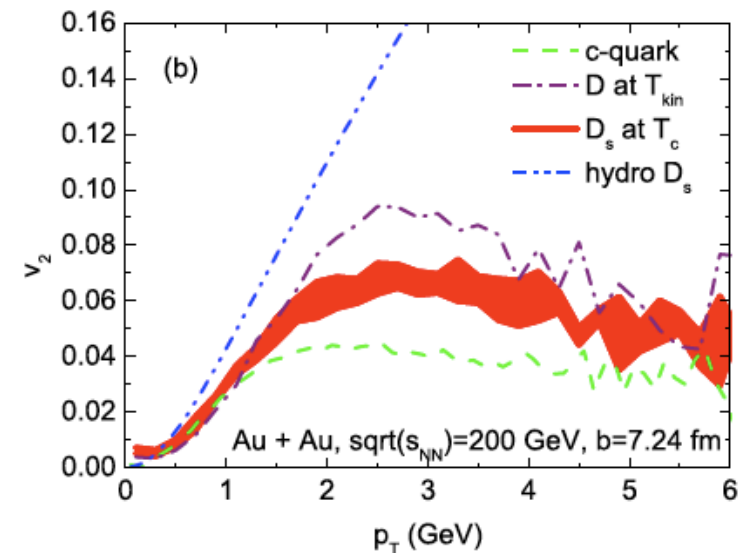
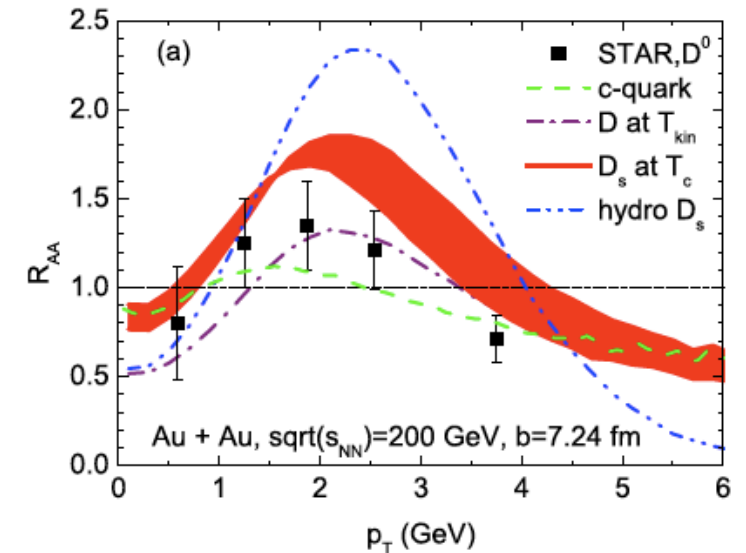
Ref: M. He et al., PRL 110, 112301 (2013)



# Why Study $D_s^\pm$ ?

- $D_s$  meson : one charm and one strange quark
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- $R_{CP}$  or  $R_{AA}$  of  $D_s > D^0$  predicted
- Elliptic flow of  $D_s < D^0$  is expected due to earlier freeze out of  $D_s$

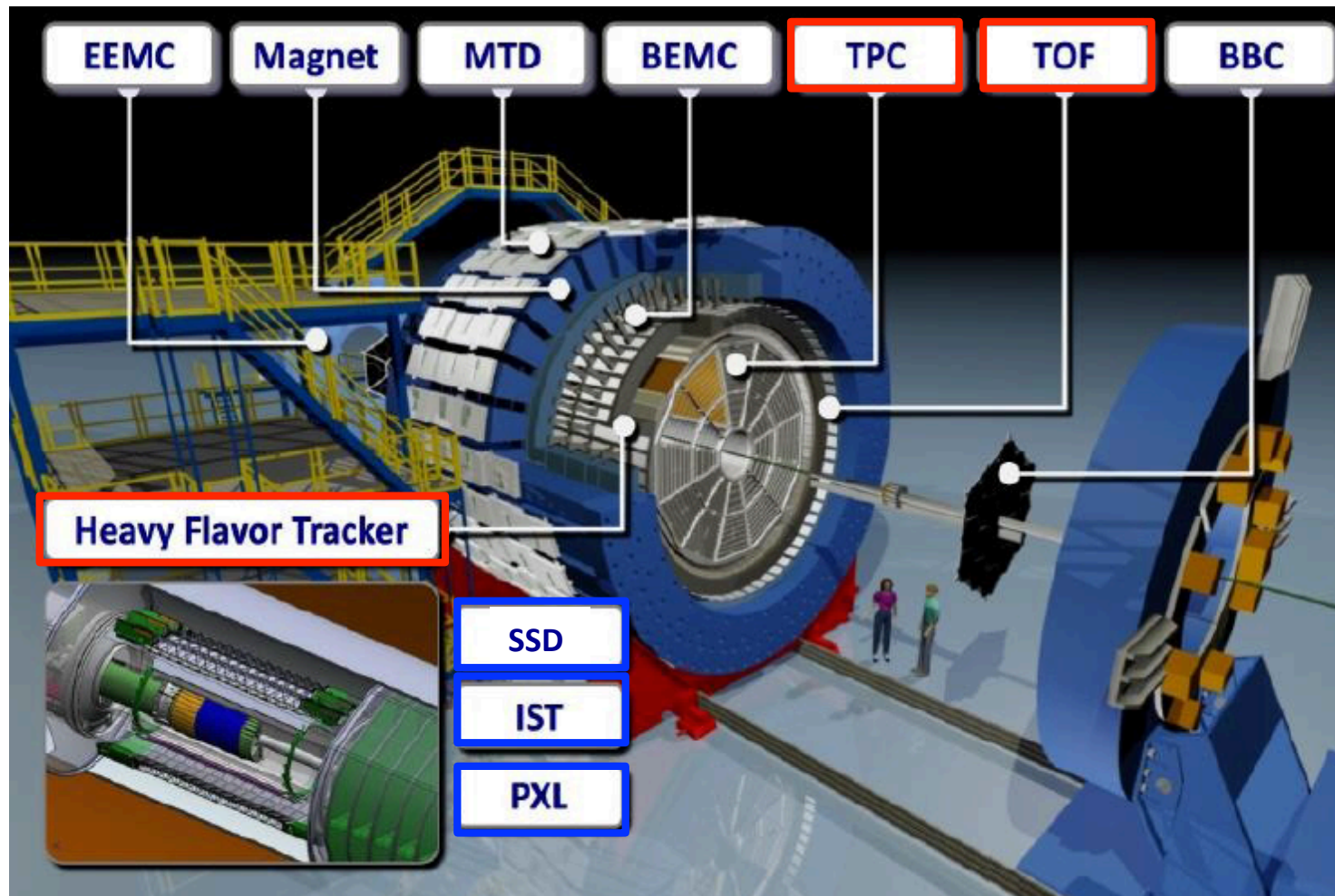
***Good Probe to study the hadronization and strangeness enhancement***



Ref: M. He *et al.*, PRL 110, 112301 (2013)



# STAR Detector in Year 2014

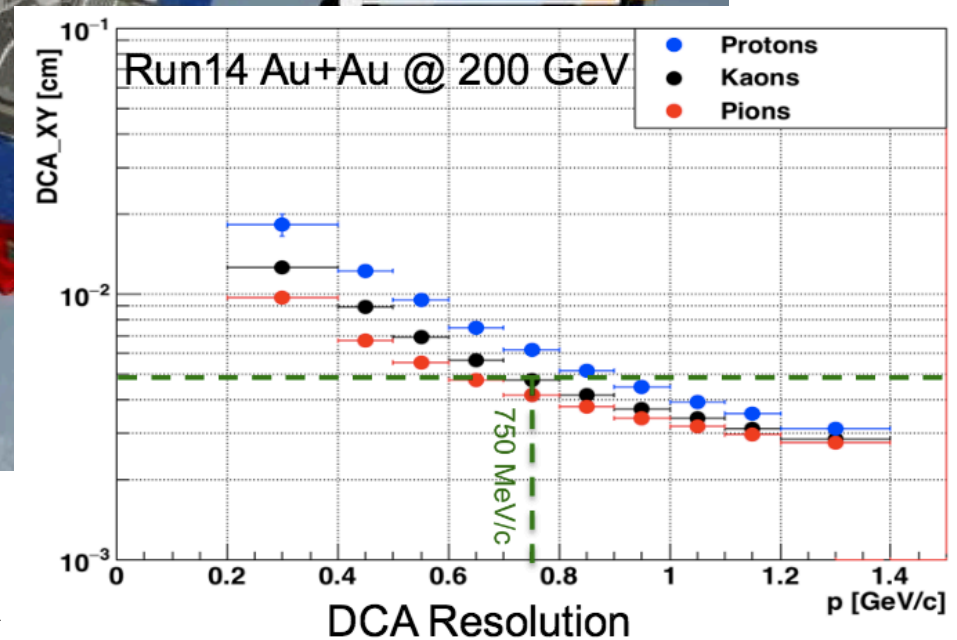
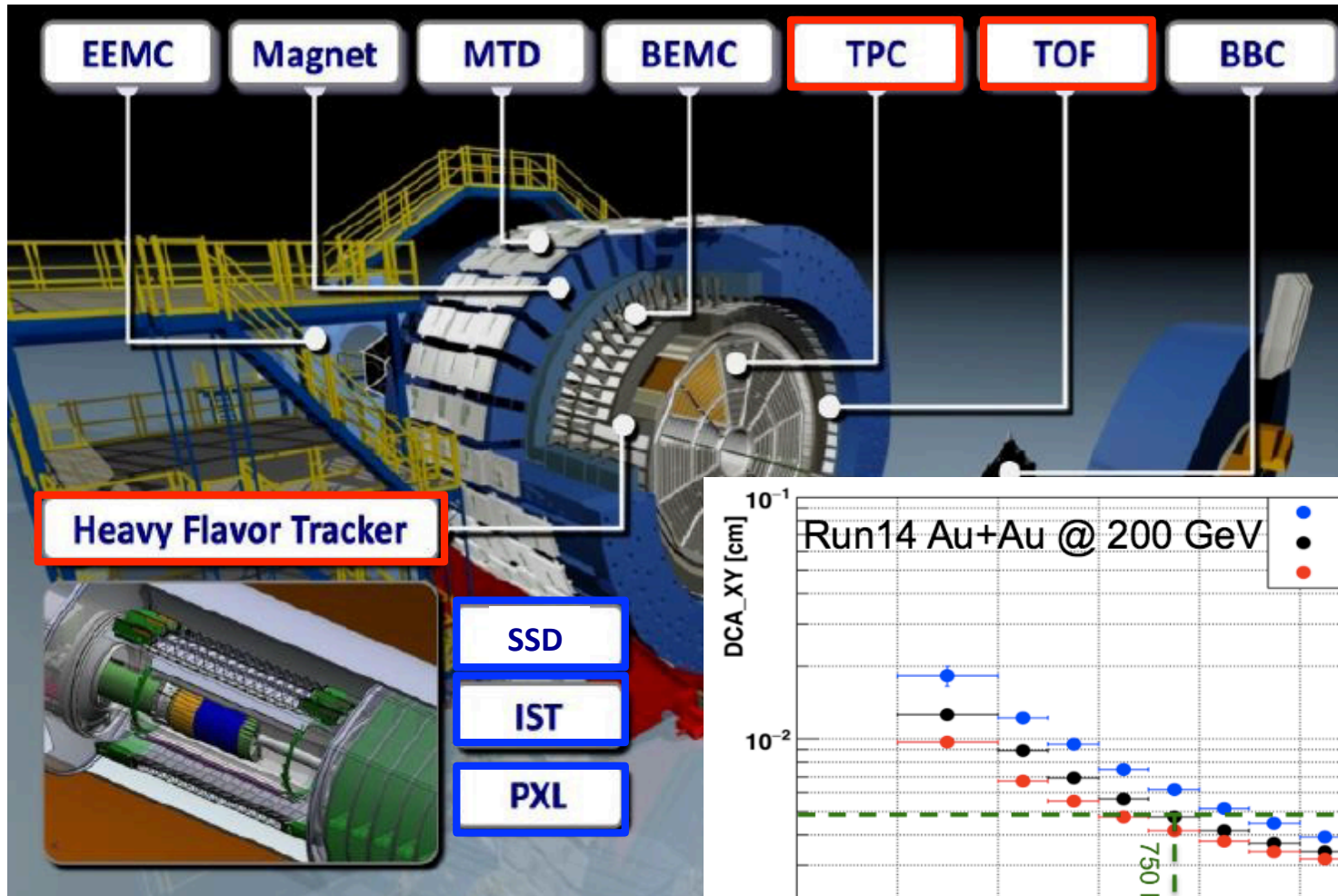


- Full  $2\pi$  coverage
- Pseudorapidity coverage  $\sim \pm 1$  unit





# STAR Detector in Year 2014



- Full  $2\pi$  coverage
- Pseudorapidity coverage  $\sim \pm 1$  unit



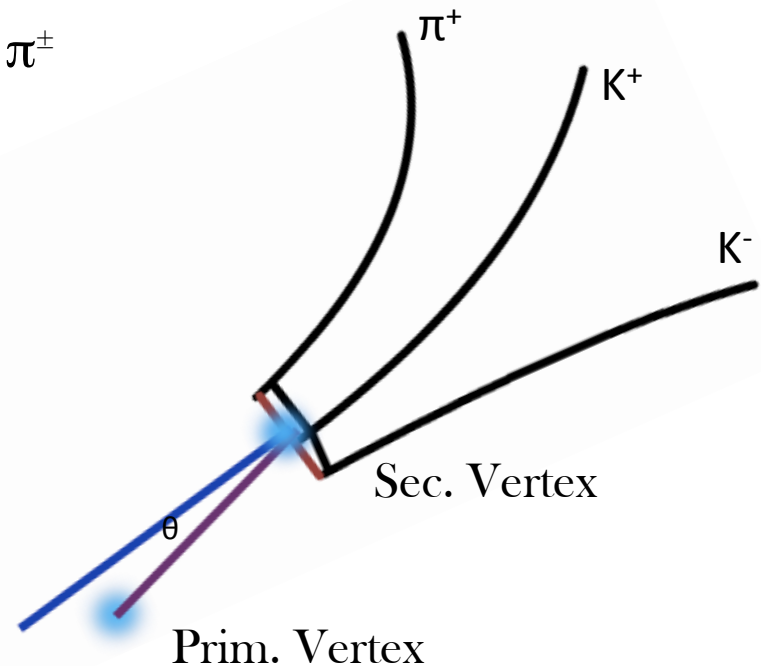
For Details about HFT : See talk by G. Contin (Tuesday, 3.00 PM, Futute Exp. Fac.<sup>7</sup> Upgr.



# Analysis Details

- Au+Au at  $\sqrt{s_{NN}} = 200$  GeV in 2014
- 750 M minimum bias events analyzed (70% of collected data)
- $|V_z| \leq 6$  cm
- Centrality using raw charged particle measured in TPC and Glauber Model
- Decay Channel :  $D_s^\pm \longrightarrow \phi (\longrightarrow K^+K^-) + \pi^\pm$
- Branching Ratio:  $2.32 \pm 0.14$  %
- Decay Length :  $150 \pm 2$   $\mu\text{m}$
- Mass :  $1968.47 \pm 0.33$  MeV/c<sup>2</sup>

Secondary Vertex :  
Using HFT



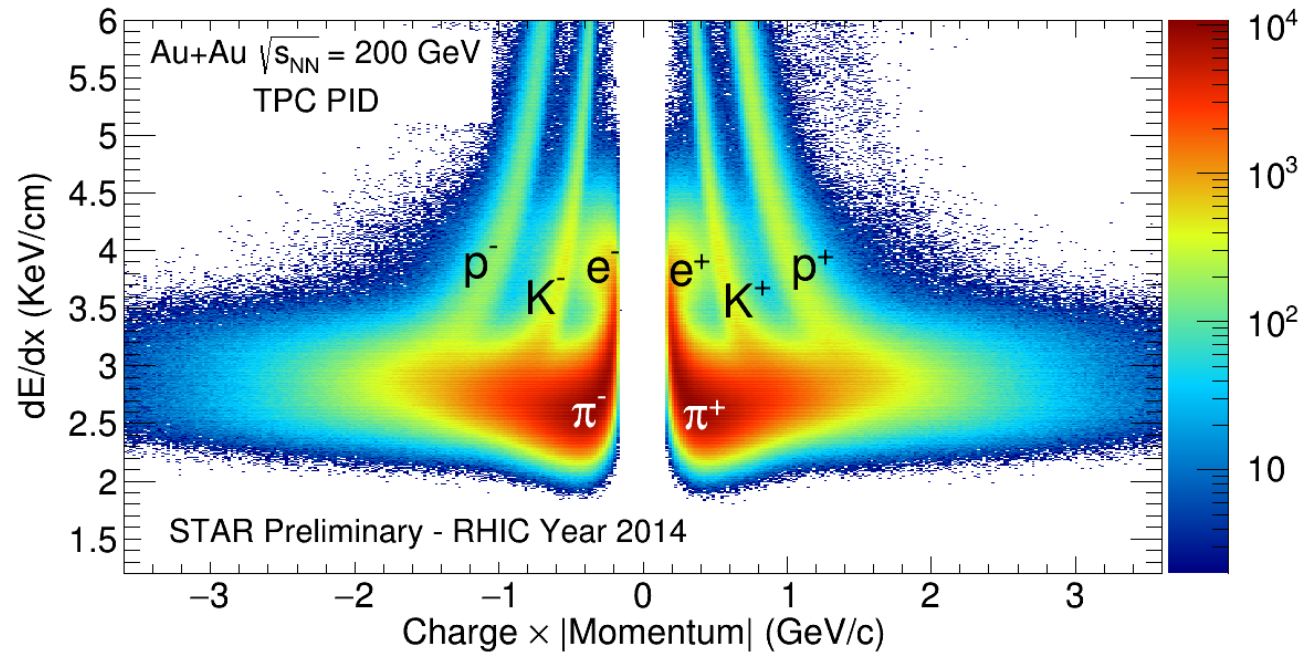
$D_s \longrightarrow K^* + K$  decay channel :  
See Poster by L. Zhou (ID :336)





# Particle Identification

## TPC



TPC PID: Using  $dE/dx$

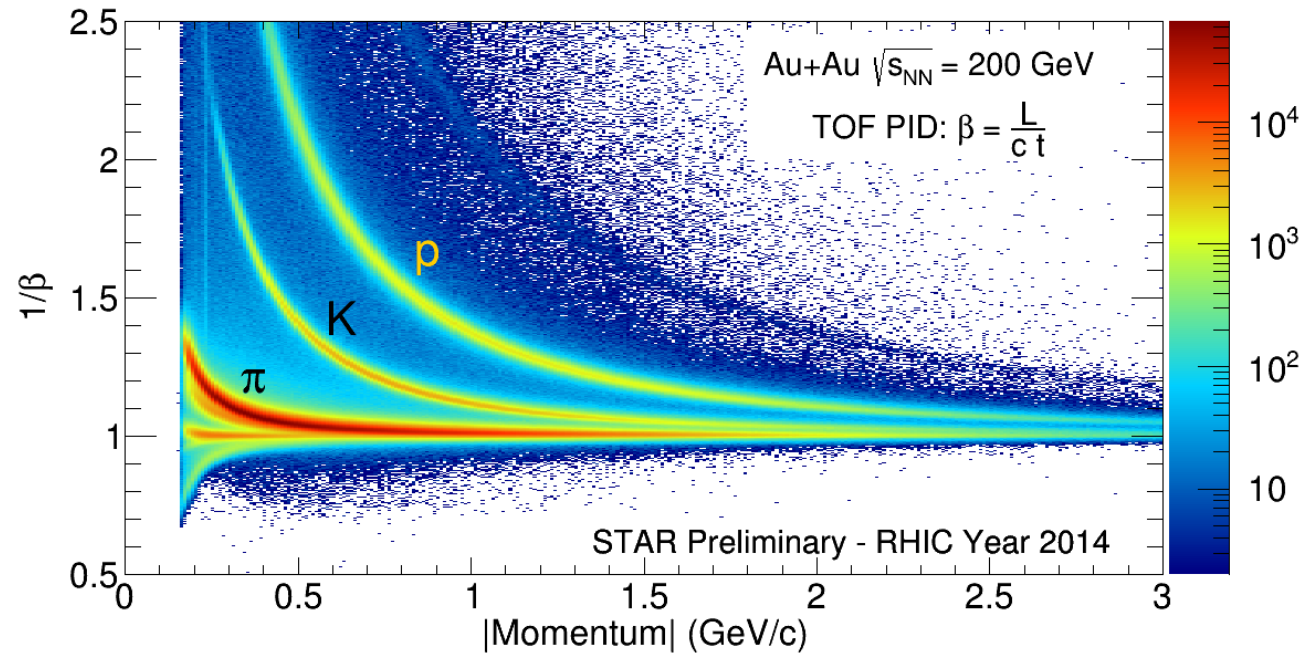
TOF PID: Using Time of Flight ( $\beta$ )<sup>\*</sup>

<sup>\*</sup> TOF PID has been applied only when  $\beta$  information is available.



# Particle Identification

TOF



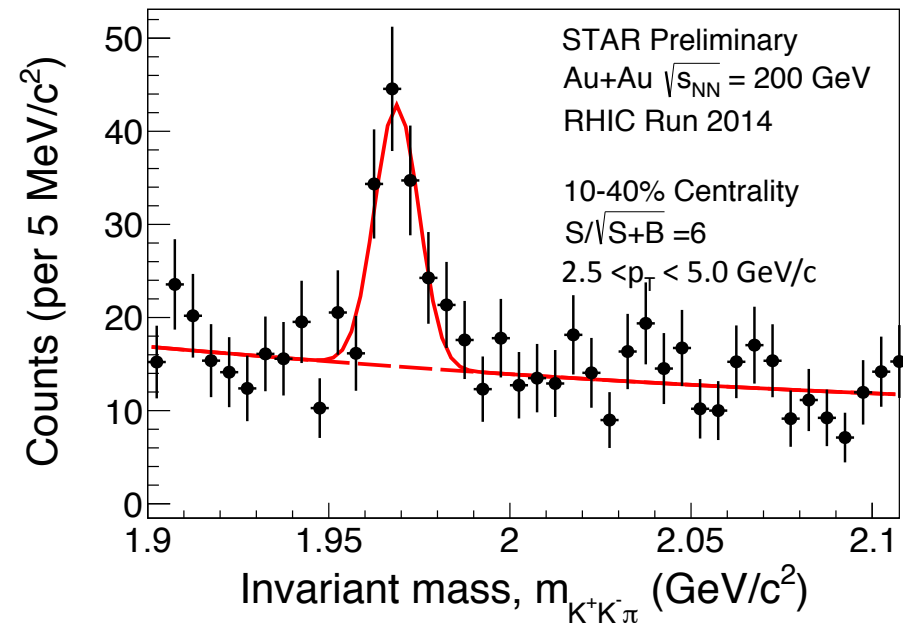
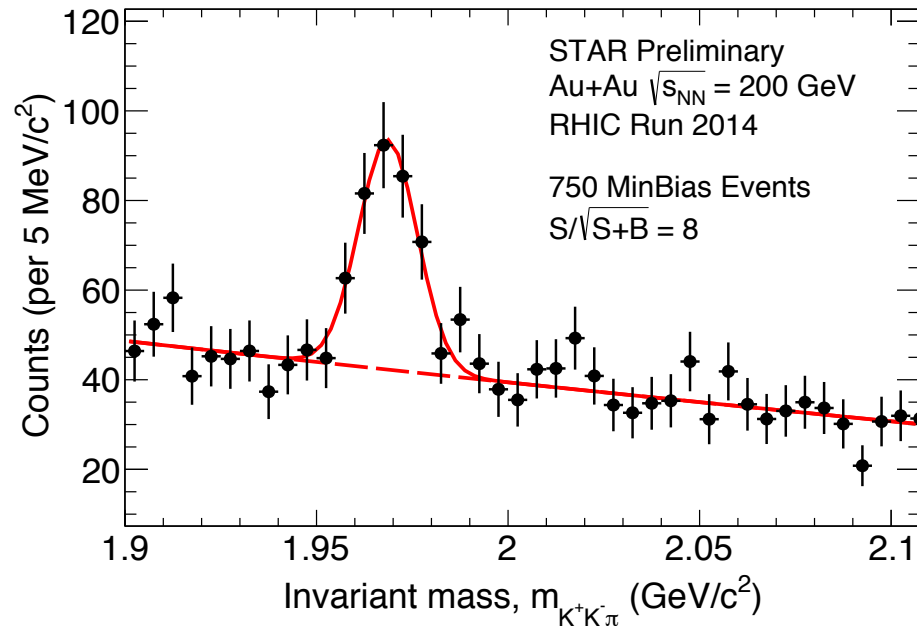
TPC PID: Using  $dE/dx$

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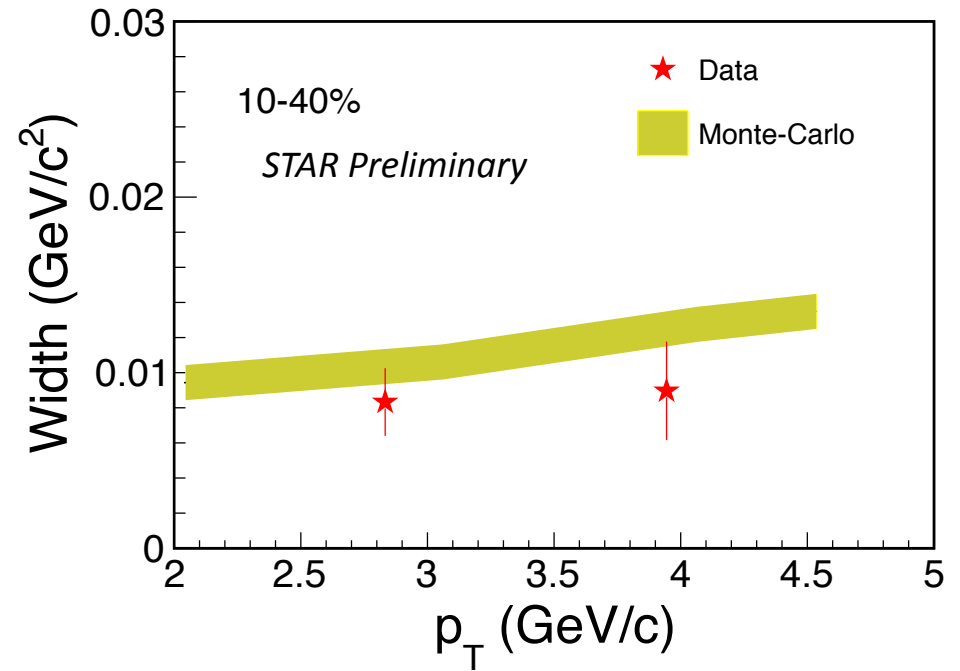
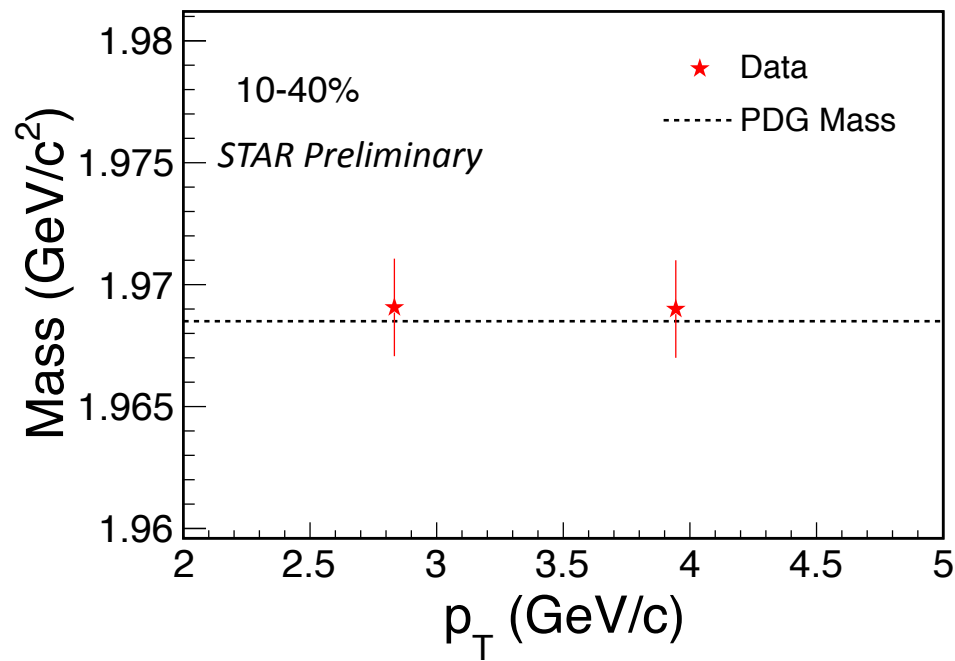
# $p_T$ integrated $D_S^\pm$ Signal



- First measurement of  $D_S$  meson at RHIC.
- We will present  $D_S$  spectra for 10-40% centrality and for  $2.5 < p_T < 5.0$  GeV/c.
- Lower  $p_T$  and more peripheral collisions studies are underway.



# Mass and width



→ Mass is consistent with PDG value  
Width is consistent with the results from detector simulations.

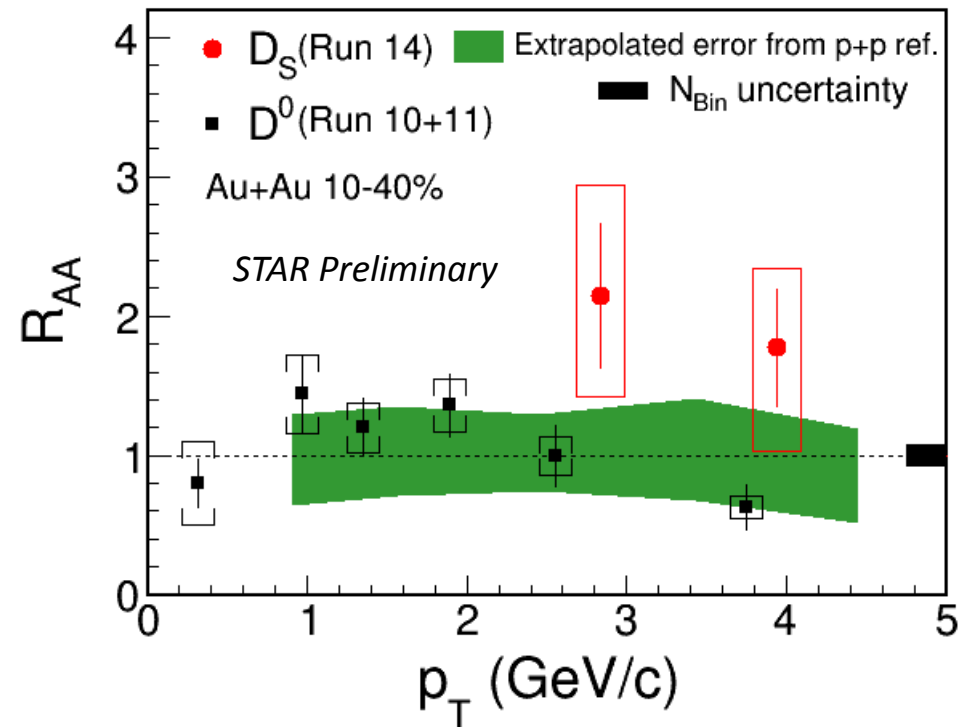
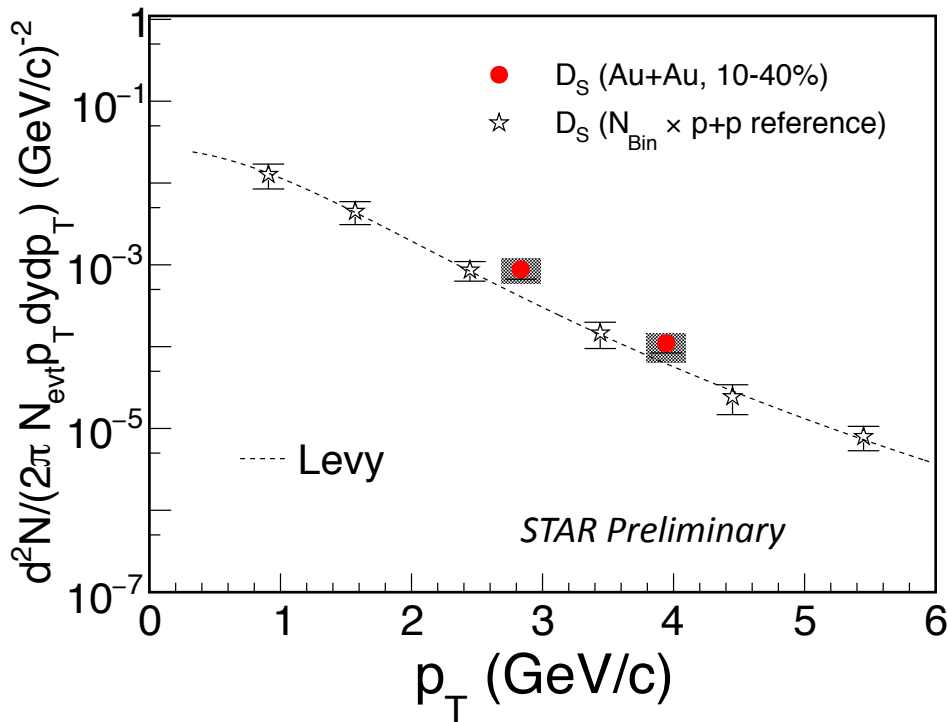


# $R_{AA}$ of $D_S$

STAR charm cross-section: Phys. Rev. D 86 (2012) 72013

$$R_{AA} = \frac{1}{N_{Bin}} \times \frac{dN^{AA}/dp_T}{dN^{pp}/dp_T}$$

$D_S$  spectra for p+p collision has been calculated from measured charm cross-section in STAR. Fragmentation factor from charm to  $D_S$  is  $0.09 \pm 0.01$  \*



→ The  $R_{AA}$  of  $D_S$  is higher than unity but statistically not significant.

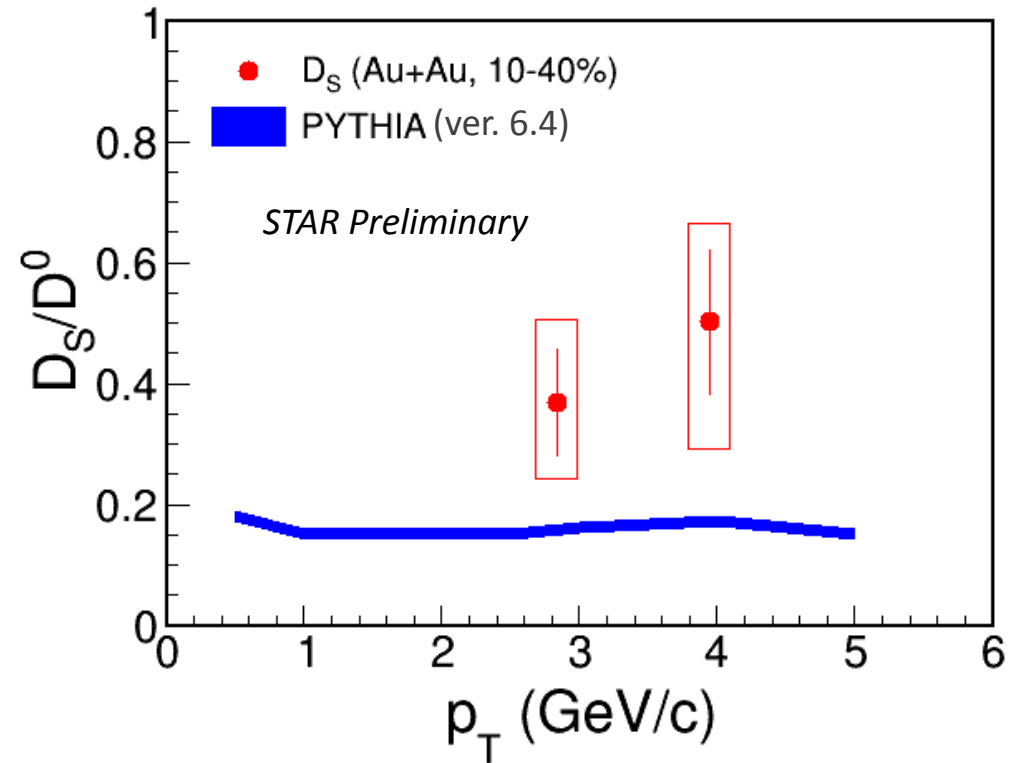
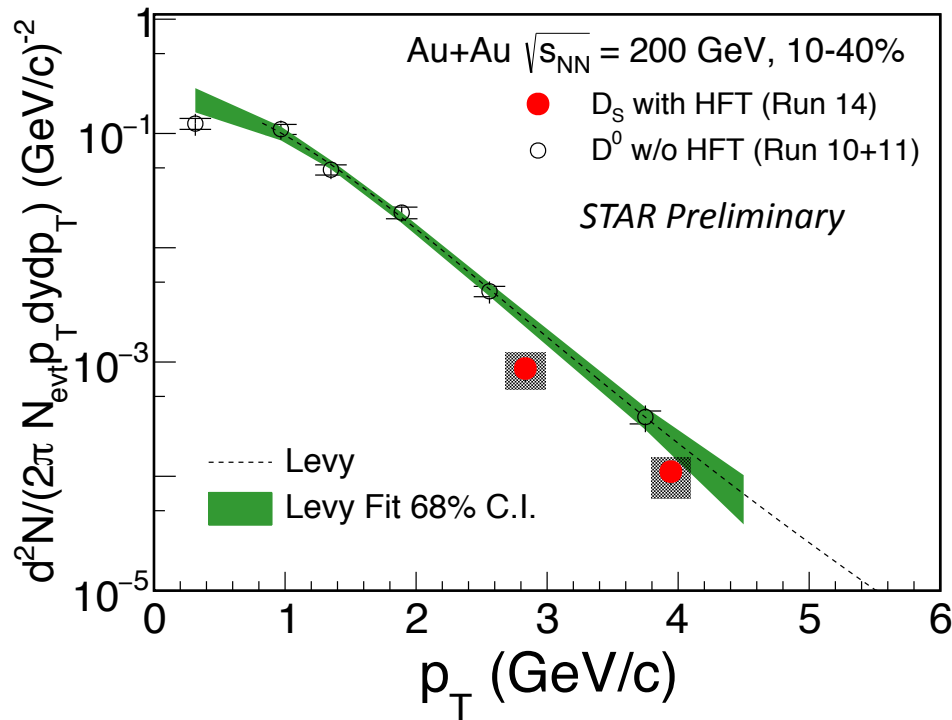
STAR  $D^0$   $R_{AA}$ : Phys. Rev. Lett. 113 (2014) 142301

\*Ref: H1 Collaboration, Eur.Phys.J.C38(2005)447 and ZEUS Collaboration, Eur.Phys.J.C44(2005)351





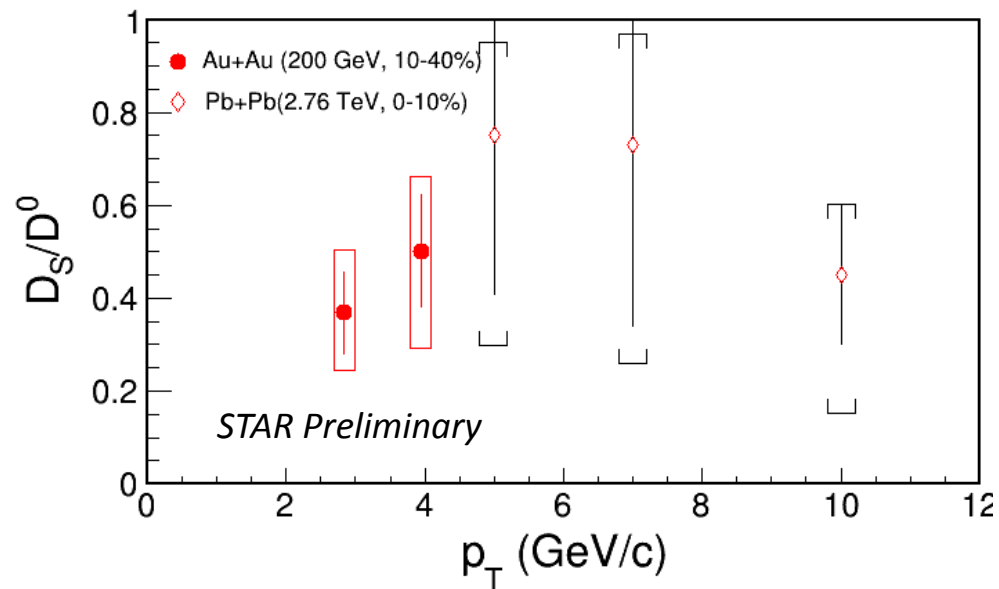
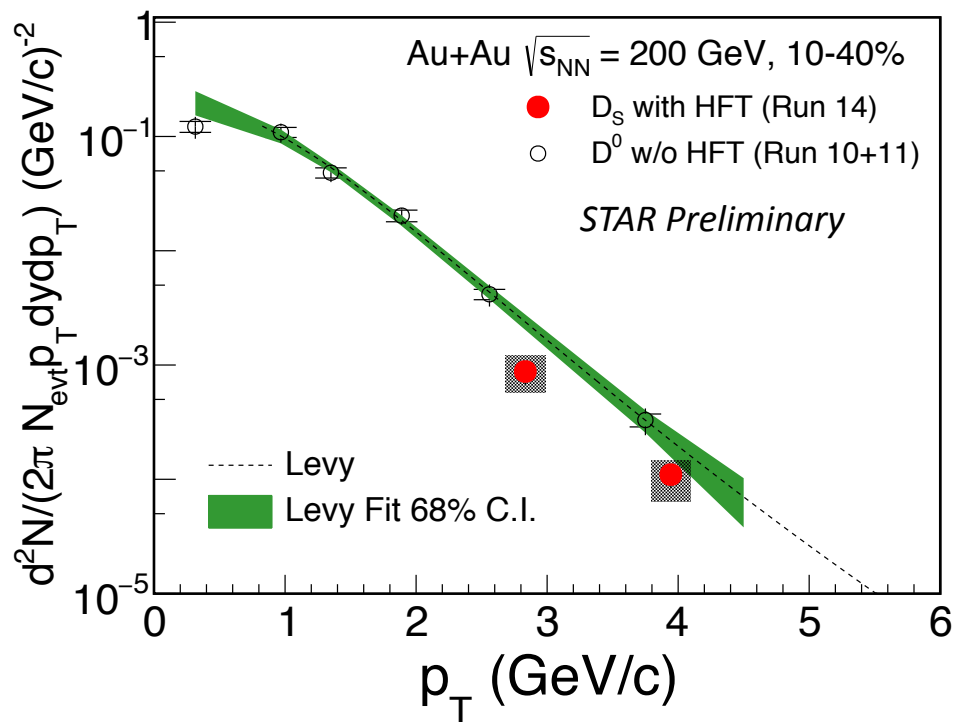
# Invariant Yield and $D_S/D^0$



→ The ratio  $D_S/D^0$  is less than unity and seems to be higher than prediction for p+p collision from PYTHIA



# Invariant Yield and $D_S/D^0$



STAR and ALICE data are consistent with large uncertainties





# Elliptic Flow Analysis

$$v_2 = \langle \cos(2(\phi - \psi_2)) \rangle \times R^{-1}$$

Method: Full Event Plane

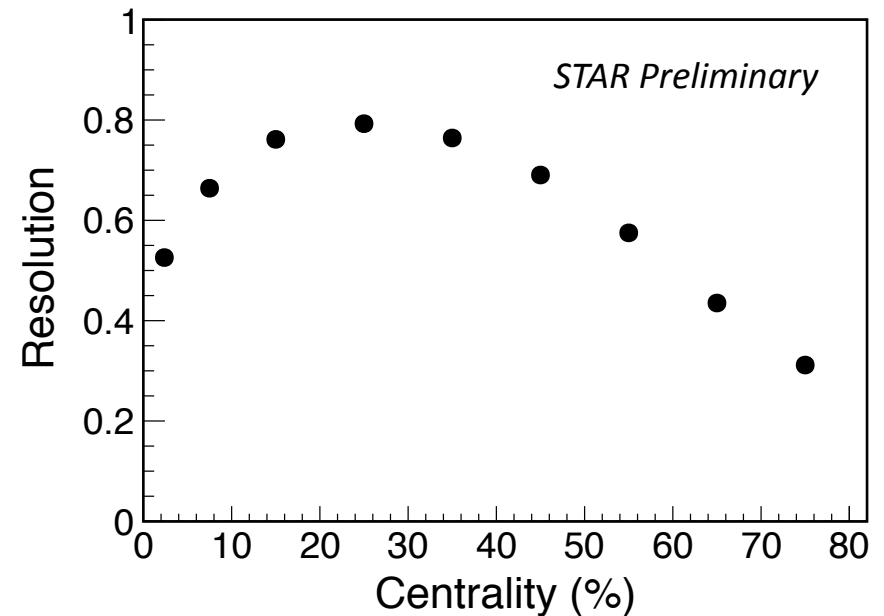
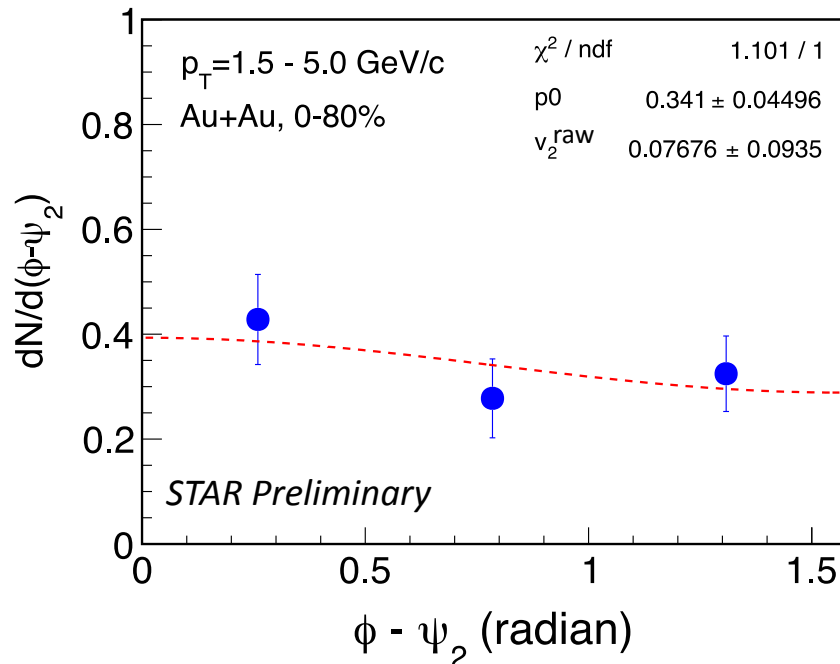
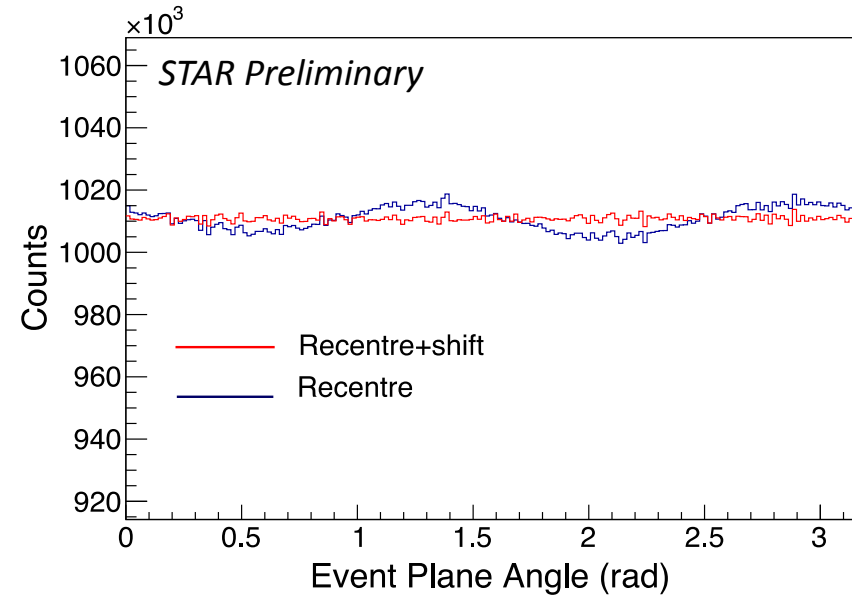
Event Plane: Using TPC tracks

Resolution: Using Eta sub-event

$D_S v_2$ :

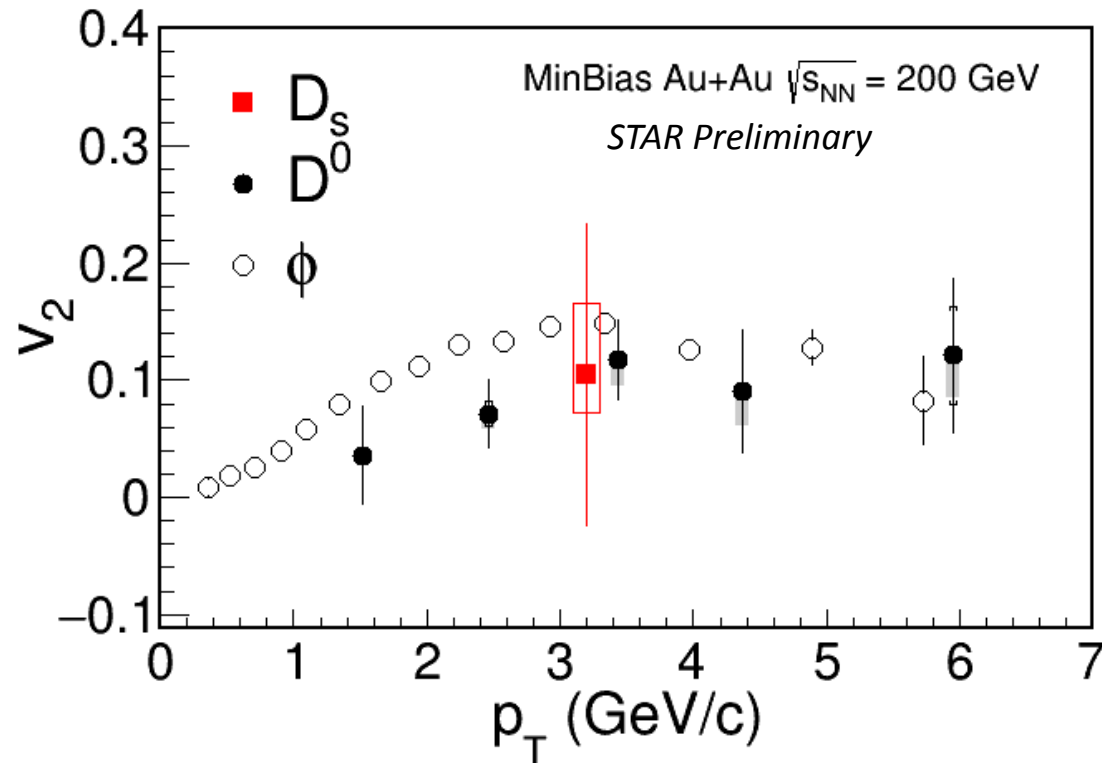
By fitting Yield vs  $(\phi - \psi_2)$

with function  $p_0(1 + 2 v_2^{\text{raw}} \cos(2(\phi - \psi_2)))$





# Elliptic Flow of $D_S$



For  $D^0$   $v_2$  :  
See talk by  
M. Lomnitz  
(Tuesday, 9 AM,  
Collective  
Dynamics)

$\phi$ -meson  $v_2$   
e-Print :1507.05247



First measurement of  $D_S$   $v_2$  in heavy-ion experiment.  
Need more statistics.



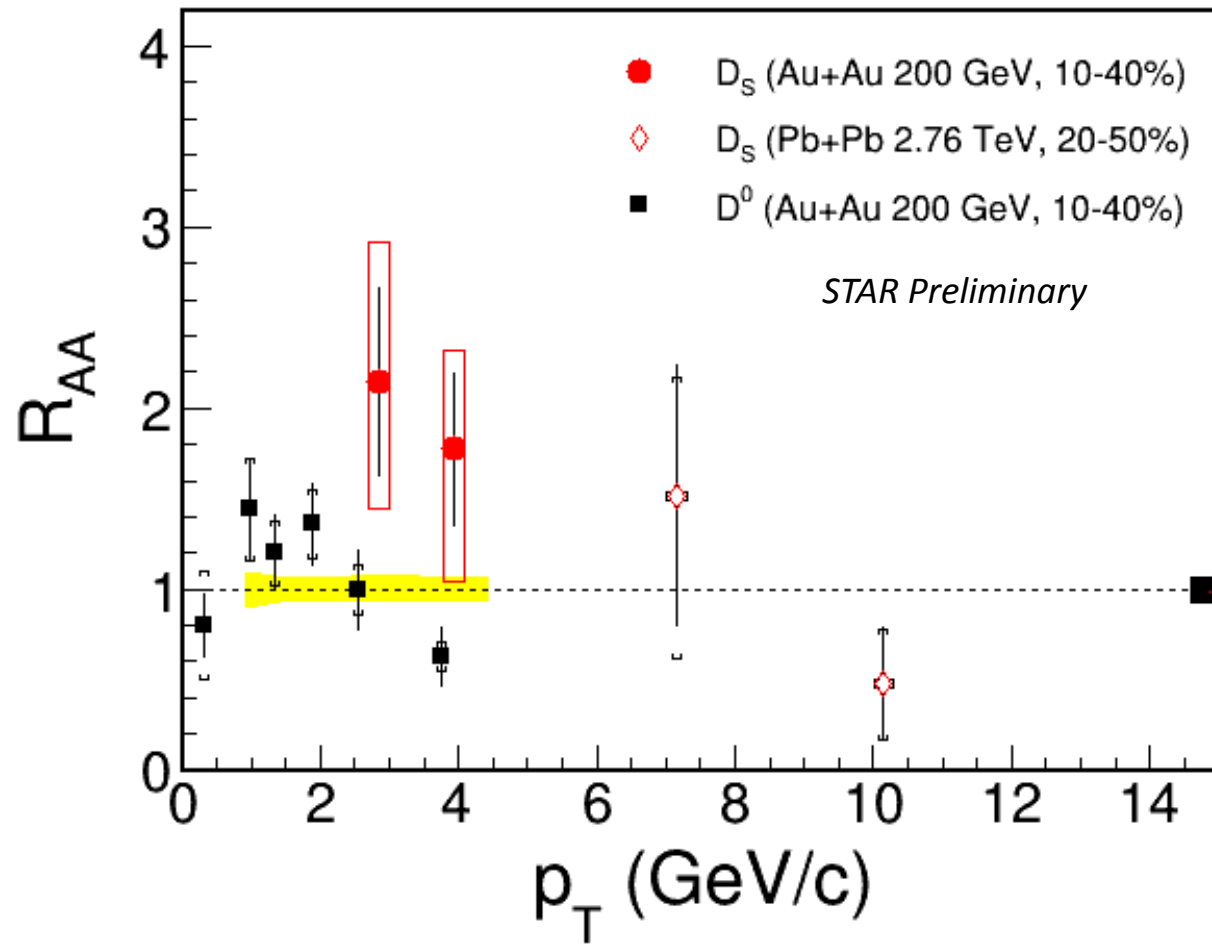
# Summary

- We have observed a clear signal of  $D_S$  at RHIC for the first time
- $D_S$  in Au+Au 200 GeV for 10-40% central collisions:
  - $D_S/D^0$  seems to be higher than p+p prediction (from PYTHIA 6.4) at  $p_T = 2.8$  and  $3.9$  GeV/c
  - $R_{AA} = 2.1 \pm 0.5 \pm_{0.7}^{0.7}$  and  $1.7 \pm 0.4 \pm_{0.7}^{0.5}$  at  $p_T = 2.8$  and  $3.9$  GeV/c, respectively
- First measurement of elliptic flow of  $D_S$  is presented
- Stay tuned for Run 16 Data with increased statistics and improved detector performance

*Thank You*

# Back-up

# $R_{AA}$



$D_S$  Pb+Pb (ALICE: arXiv:1509.07287)  
 $D^0$  Au+Au (STAR: PRL 113 (2014) 142301)

# $\phi$ -meson signal

