QUARK MATTER 2015

The XXVth International Conference on Ultrarelativistic Nucleus-Nucleus Collisions

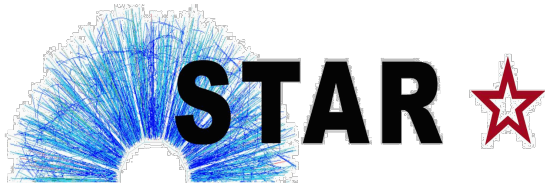
Nuclear Modification Factors of D^0 Meson in Au+Au Collisions at $\sqrt{s_{NN}} = 200$ GeV

Guannan Xie

University of Science and Technology of China

Lawrence Berkeley National Laboratory

(for the STAR Collaboration)



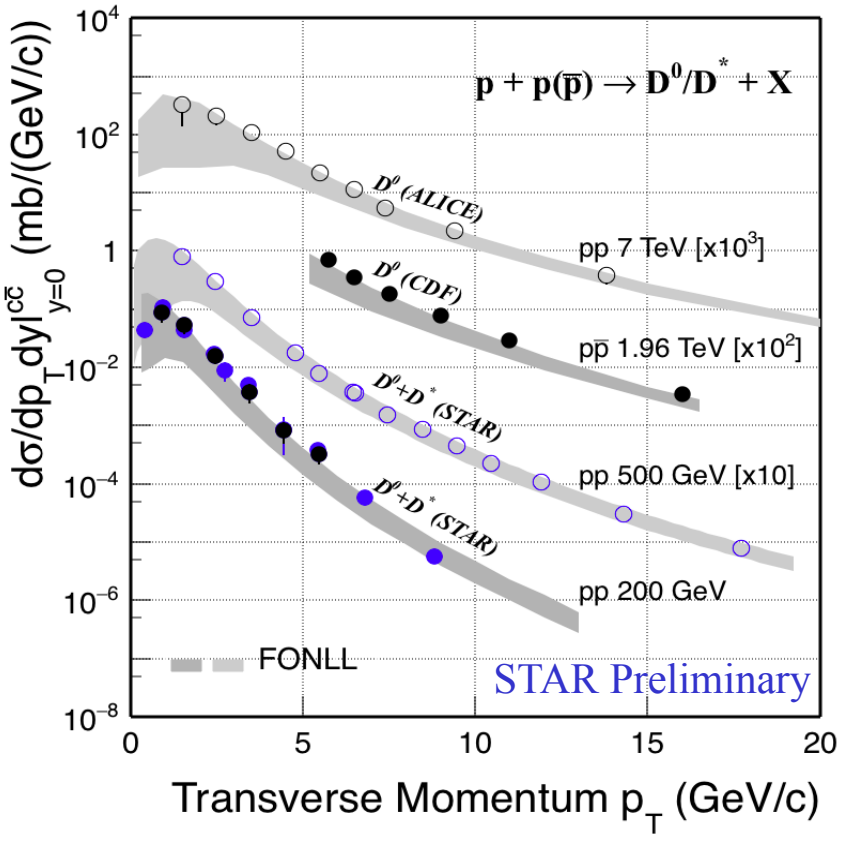
Outline

- Physics Motivation
- STAR with Heavy Flavor Tracker
- Analysis Details
  - D^0 Reconstruction & Efficiency correction
- Results & Discussion
- Summary & Outlook

Motivation

Charm quarks: $m_c >> T_C, \Lambda_{QCD}, m_{u,d,s}\ T_{QGP(RHIC/LHC)}$

- Produced early in collision at RHIC through hard scattering
- Experience the whole evolution of the system -> good probe for medium properties



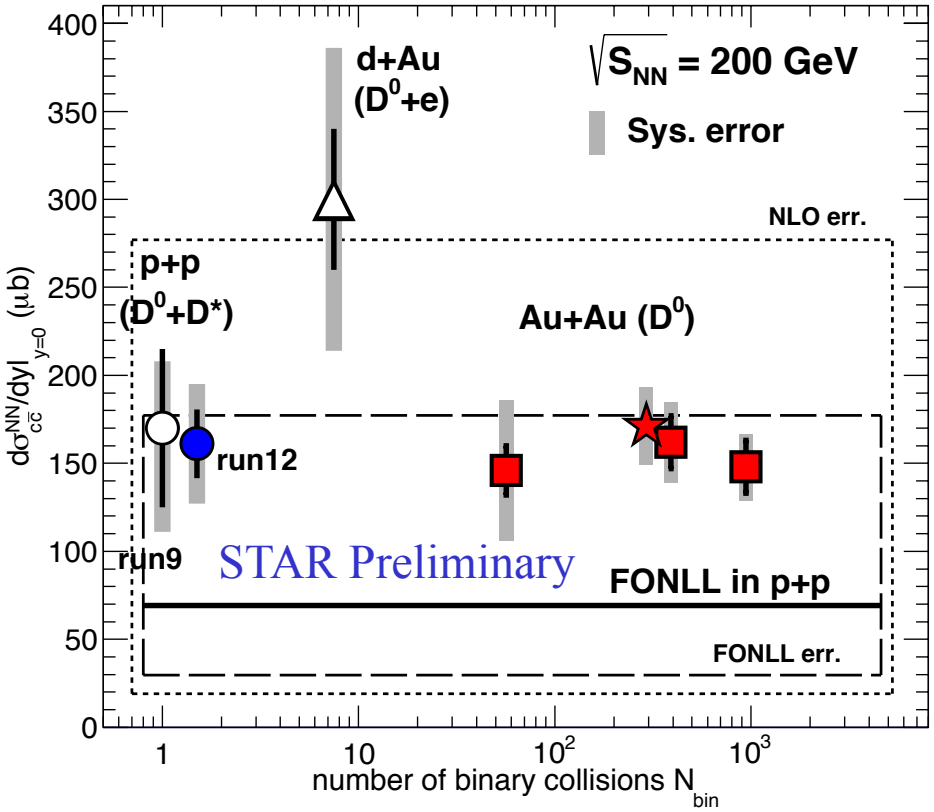
Perturbative QCD calculations (FONLL) are consistent with experimental data.

STAR: PRD 86 (2012) 072013, NPA 931 (2014) 520
CDF: PRL 91 (2003) 241804
ALICE: JHEP01 (2012) 128
FONLL: PRL 95 (2005) 122001

Motivation

Charm quarks: $m_c >> T_C, \Lambda_{QCD}, m_{u,d,s}\ T_{QGP(RHIC/LHC)}$

- Produced early in collision at RHIC through hard scattering
- Experience the whole evolution of the system -> good probe for medium properties



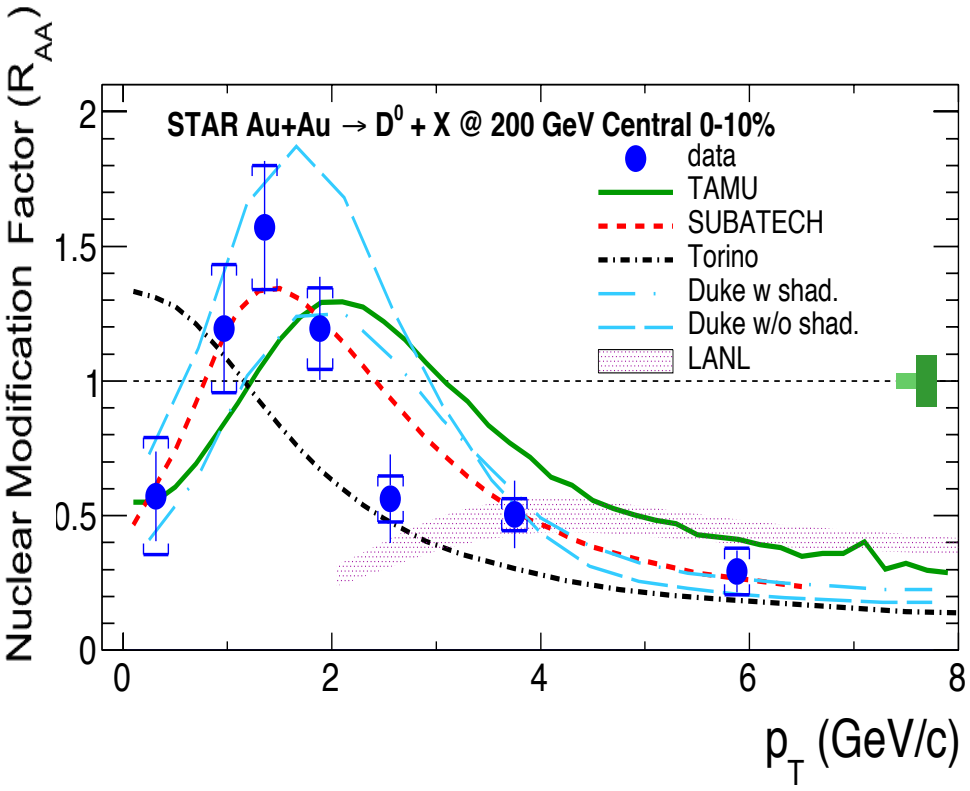
Perturbative QCD calculations (FONLL) are consistent with experimental data.

Charm cross section follows number of binary collisions scaling =>
At RHIC, charm quarks are produced via initial hard scatterings.

STAR: PRL 94 (2005) 62301,
PRD 86 (2012) 072013,
PRL 113 (2014) 142301
FONLL: PRL 95 (2005) 122001
NLO: Eur.Phys.J.ST 155 (2008) 213

Results Before HFT

STAR: PRL 113 (2014) 142301



- High p_T: large suppression due to energy loss, strong charm-medium interaction.
- Enhancement at p_T ~0.7-2 GeV/c, described by models with coalescence of charm and light quarks.

- Precision measurement is needed to further constrain models and to quantify medium properties.
- New run 2014 Au+Au results with HFT will be presented
  -- p+p and p+Au data with HFT are recorded on tape (run 2015)

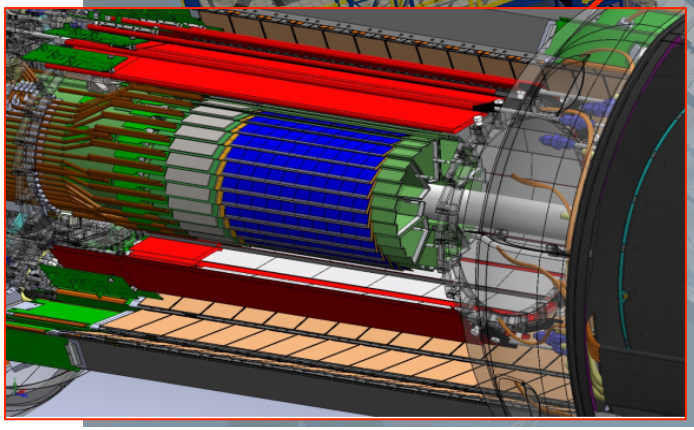
STAR Detector

Time Projection Chamber:
Tracking, PID (dE/dx)

Time Of Flight detector:
PID (1/β)

Vertex Position Detector:
minimum bias trigger

Heavy Flavor Tracker

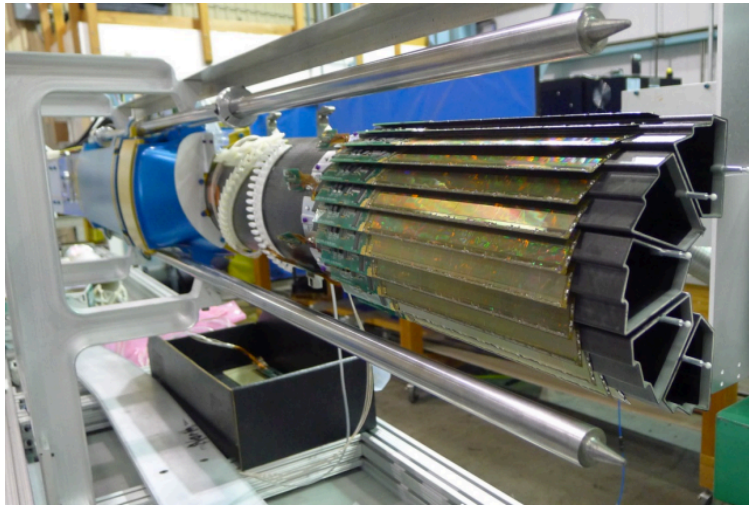


HFT:

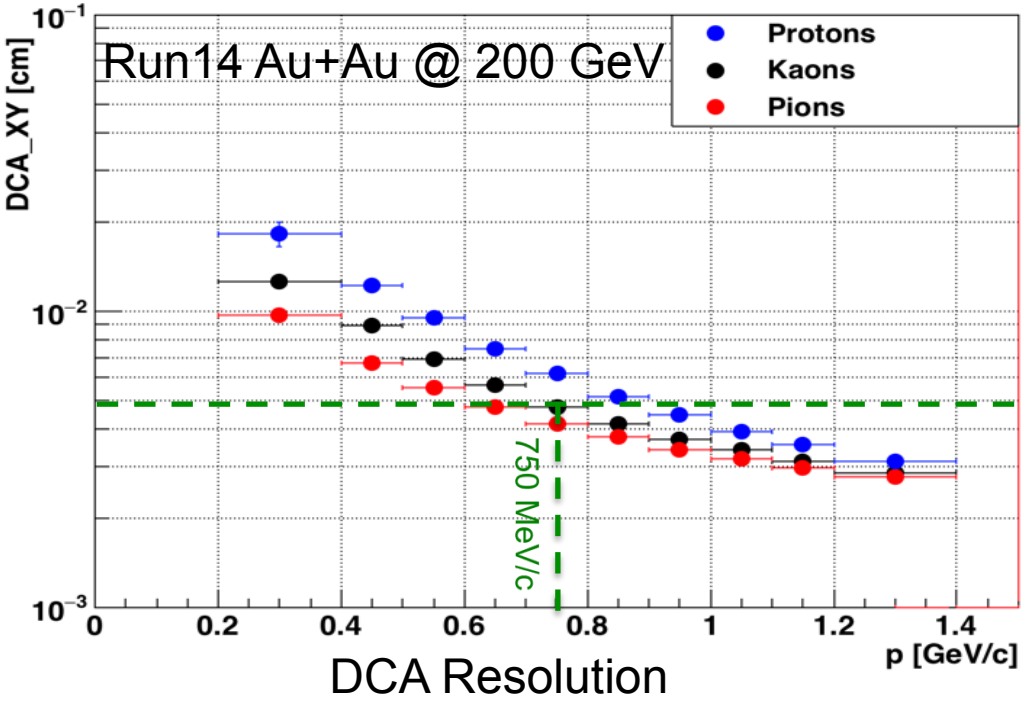
- Silicon Strip Detector: r ~22 cm
- Intermediate Silicon Tracker: r ~14 cm
- PIXEL detector: r ~2.8 & 8 cm,
  MAPS, 20x20 μm^2, 0.4%X_0 thick, air-cooled
  See talk by G. Contin (Tue. 15:00)

HFT Performance

Au+Au @ 200GeV Run2014, with Heavy Flavor Tracker
~780M minimum bias events analyzed (out of total 1.2B recorded in 2014)



PIXEL detector



DCA Resolution

DCA (Distance of Closest Approach) resolution

- ~ 30 μm at high p_T
- Kaon with p = 750 MeV/c, DCA resolution <50 μm

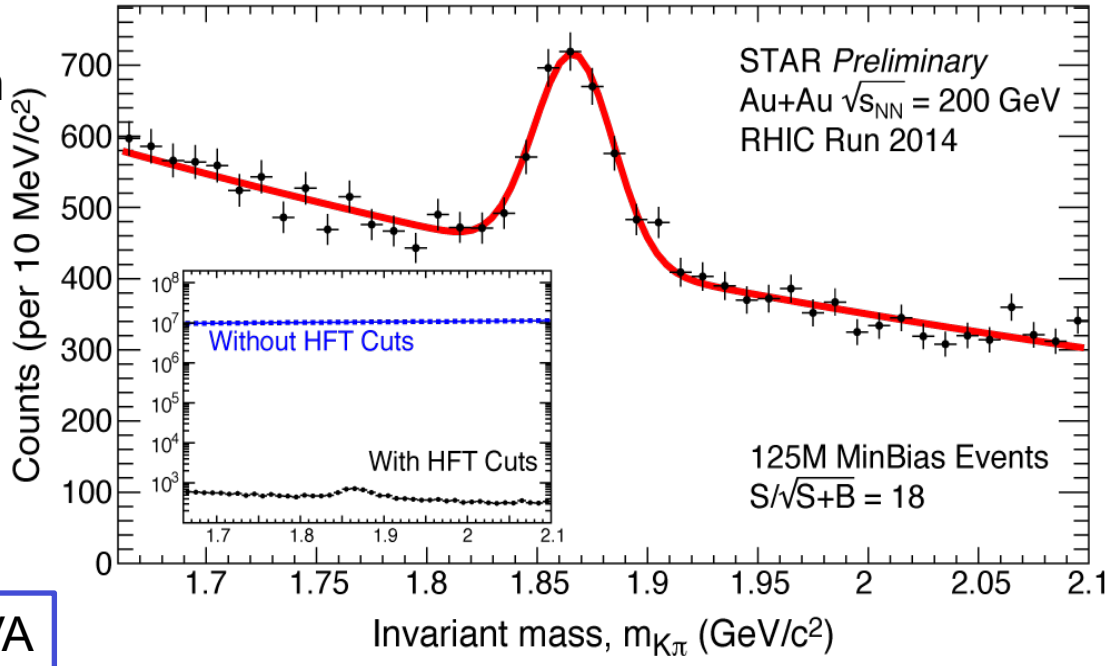
D^0 Meson Reconstruction

Direct topological reconstruction through hadronic channel:

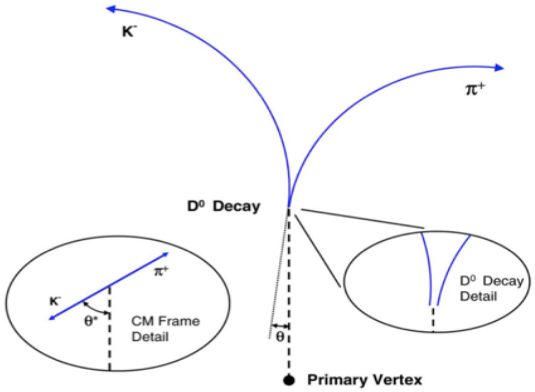
$$D^0(\overline{D^0}) \rightarrow K^{\mp}\pi^{\pm}(BR\ 3.89\%)$$

$$c\tau \approx 120\mu m$$

With HFT:
Greatly reduced combinatorial background

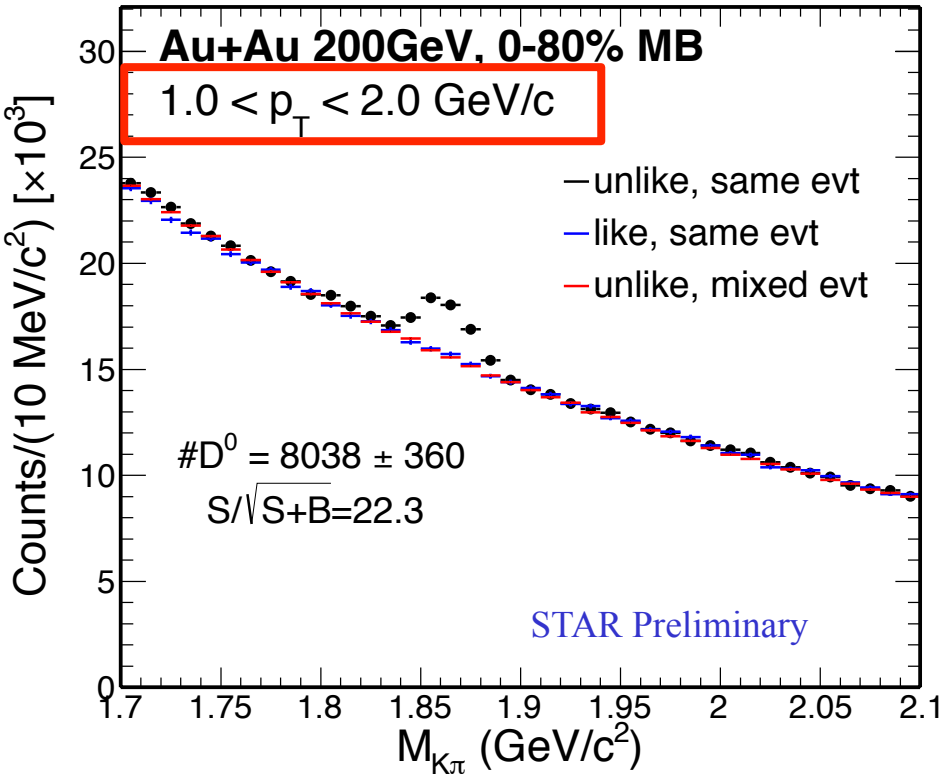


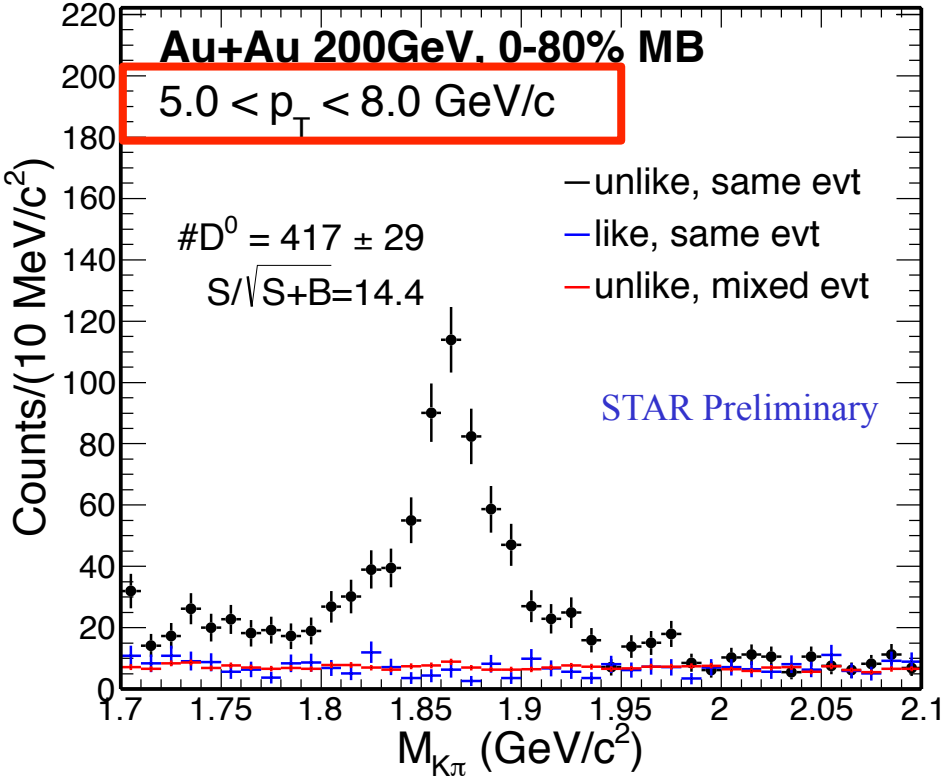
TopologicL cuts optimized by TMVA (Toolkit for Multi Variate Analysis)



D^0	w/o HFT	with HFT
Year	2010 + 2011	2014
# Events (MB) analyzed	1.1 B	780M
Significance per billion events	13	51

D^0 Meson Signal





- Clean D^0 signals reconstructed with significantly enhanced signal-to-background ratios with the HFT in a broad range of transverse momentum

Efficiency Correction

D^0 efficiency = TPC tracking eff ⊗ HFT tracking eff ⊗ topological cuts

Data-driven simulation (5-15% p_T-dependent systematics)

- HFT matching and resolution smearing using distributions extracted from data:
  - HFT eff. × geometrical acceptance: (HFT matched tracks) / TPC tracks.
  - Spatial resolution: DCA distributions of HFT matched tracks (XY-Z dependence).

Luminosity, centrality, azimuth and pseudo-rapidity dependence have been considered.

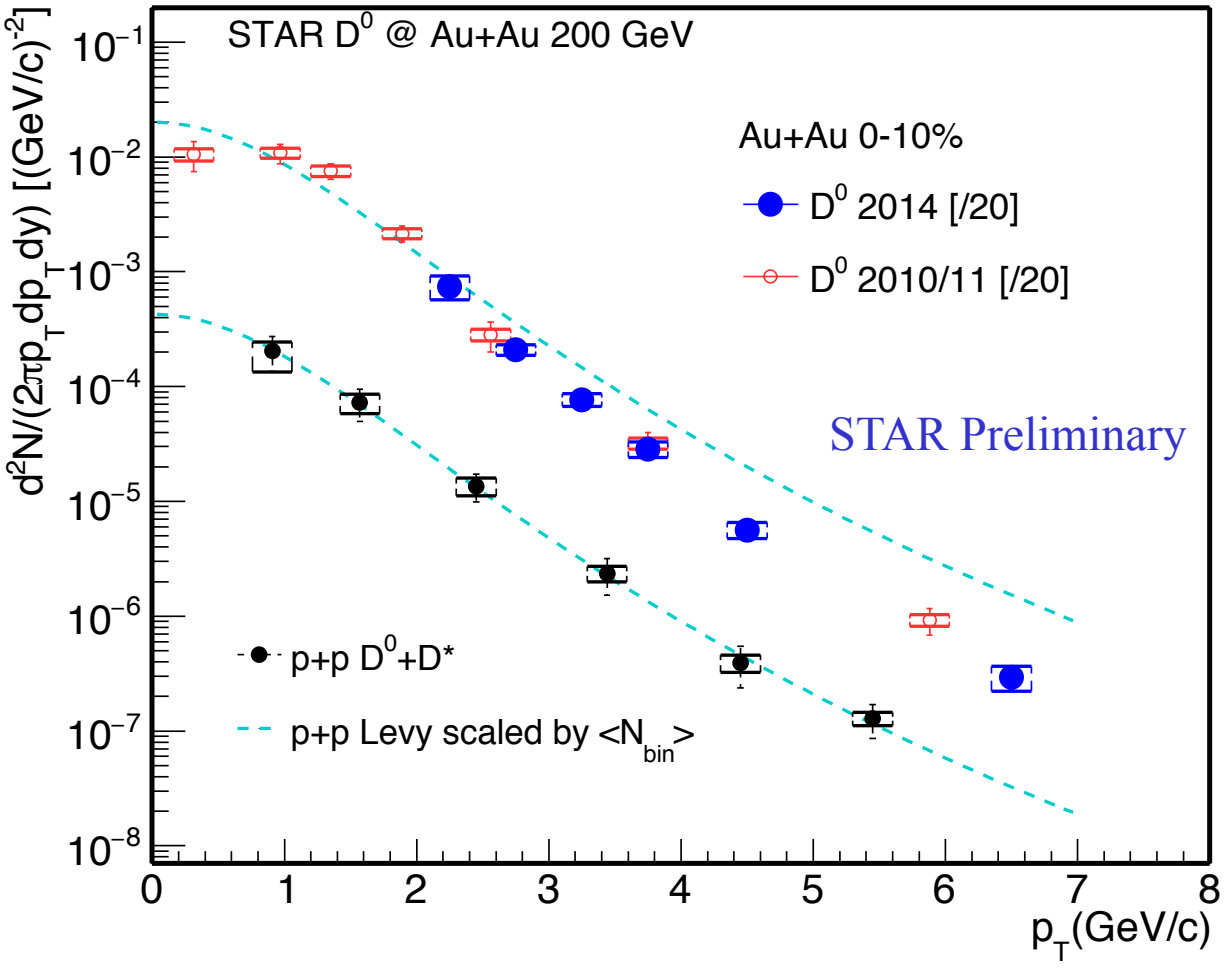
Embedding (~3% systematic uncertainty)

- Full STAR GEANT simulation

  + MC embedded in real raw data + data reconstruction chain

Invariant yields

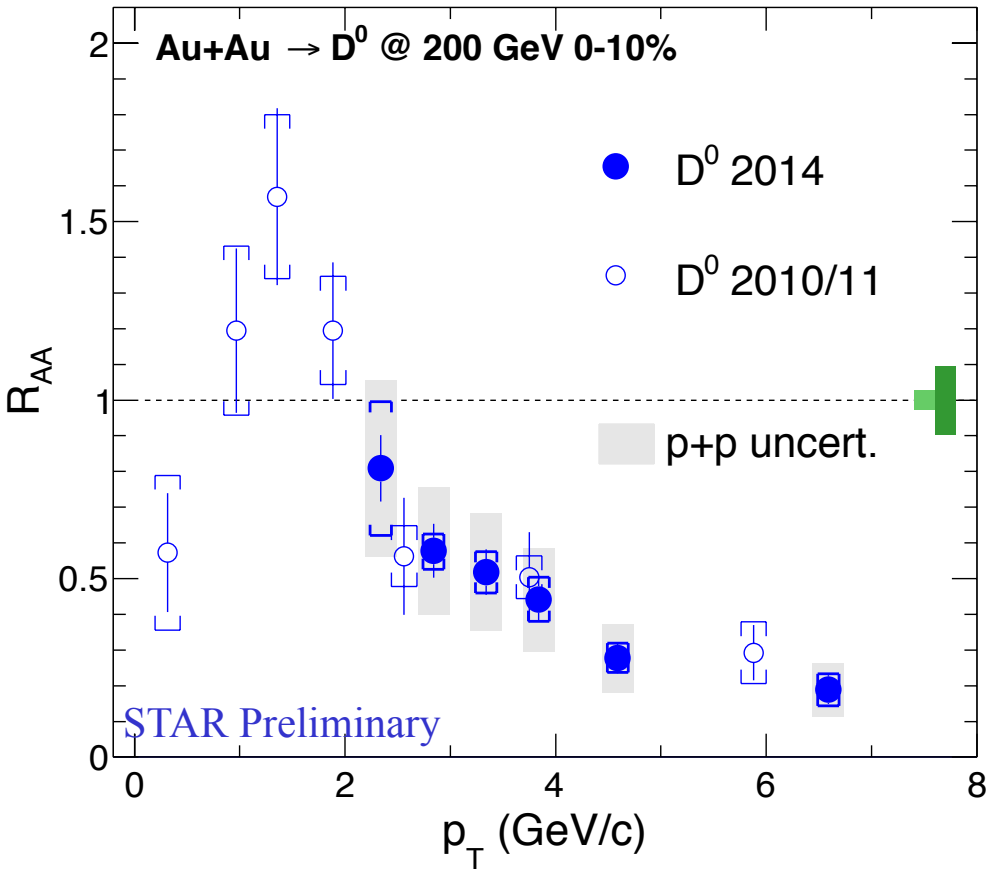
STAR: PRL 113 (2014) 142301



- [High p_T] Consistent with published result, with improved statistical precision
  - Finalizing systematic uncertainties for p_T< 2 GeV/c and in peripheral collisions

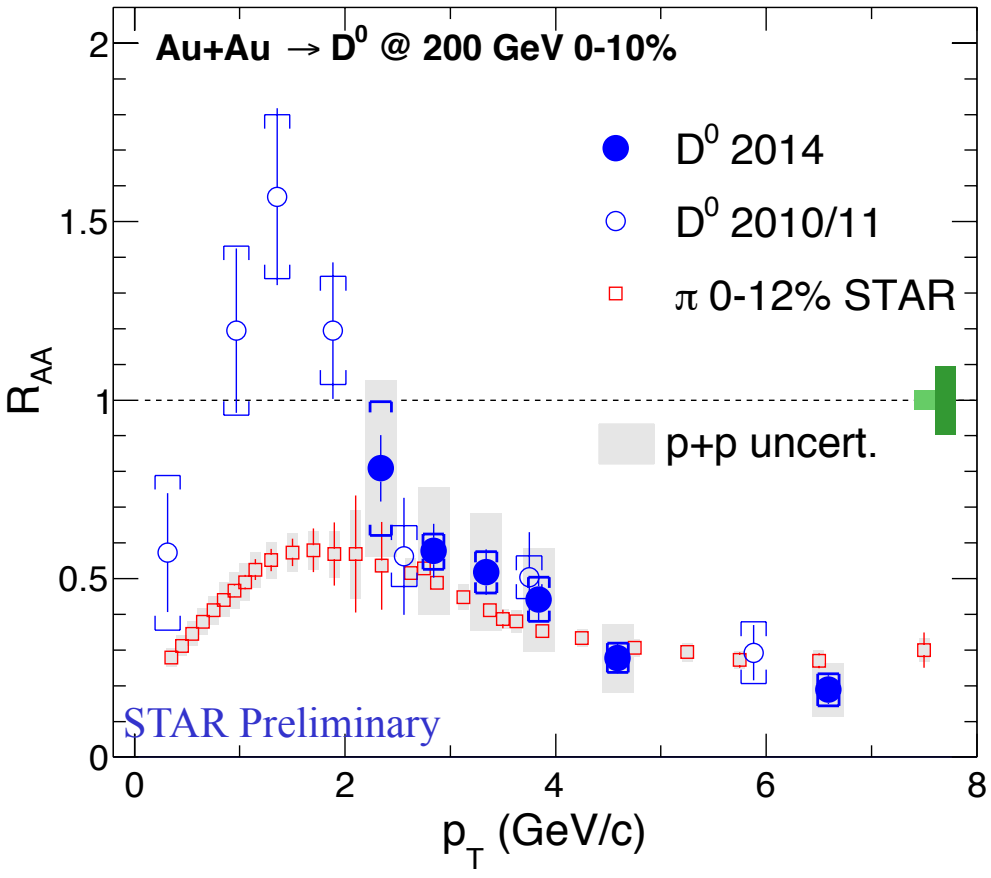
Nuclear Modification Factors

STAR: PRL 113 (2014) 142301



- High p_T: significant suppression in central Au+Au collisions. New results have improved precision.
- p+p precision to be improved using 2015 data with HFT

D^0 vs. π

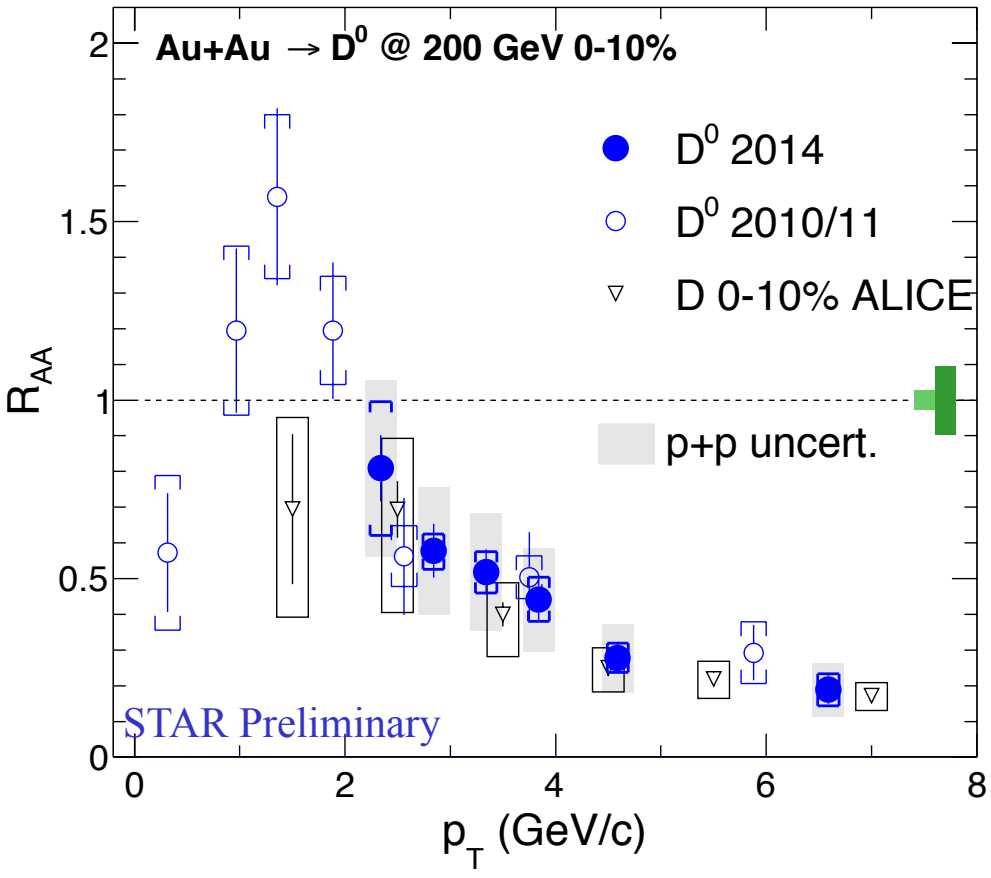


- $R_{AA}(D) \sim R_{AA}(\pi)$ at p_T>4 GeV/c

Similar energy loss for light partons and charm quarks at high p_T

STAR: PRL 113 (2014) 142301
PLB 655 (2007) 104

RHIC vs. LHC

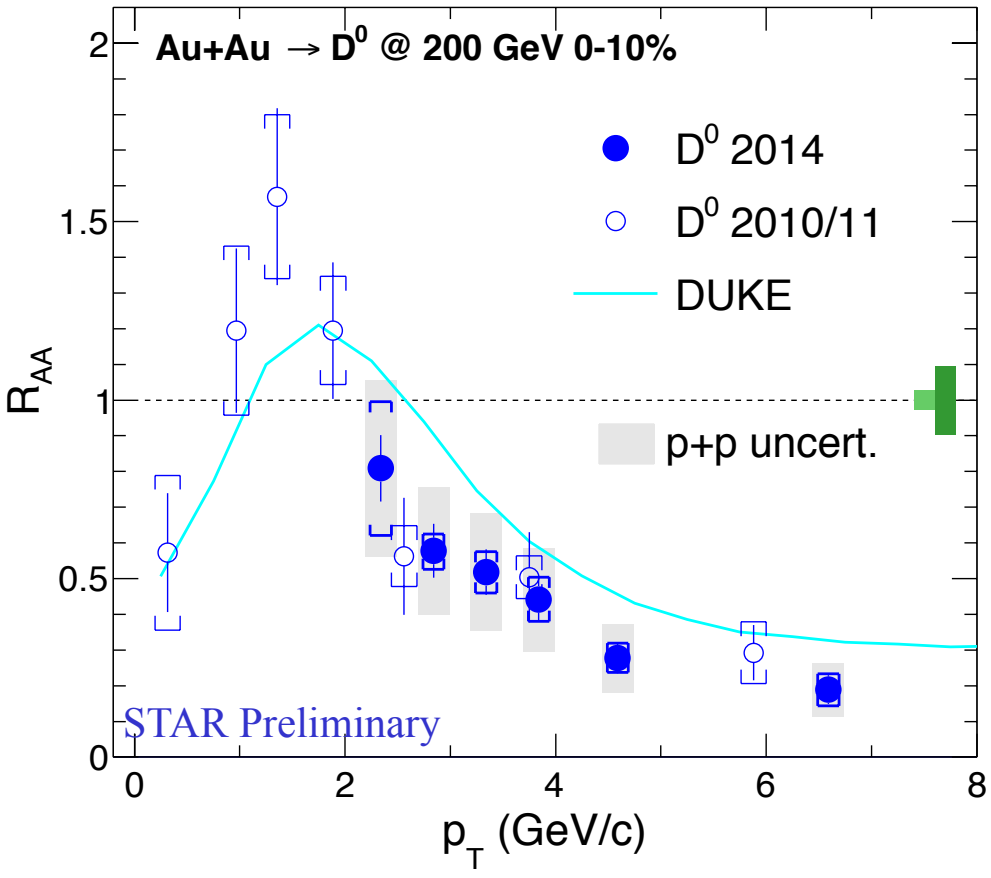


- R_{AA}@ RHIC ~ R_{AA}@LHC

strong charm-medium interaction at RHIC and LHC

STAR: PRL 113 (2014) 142301
ALICE: arXiv: 1509.06888

Comparison to Models

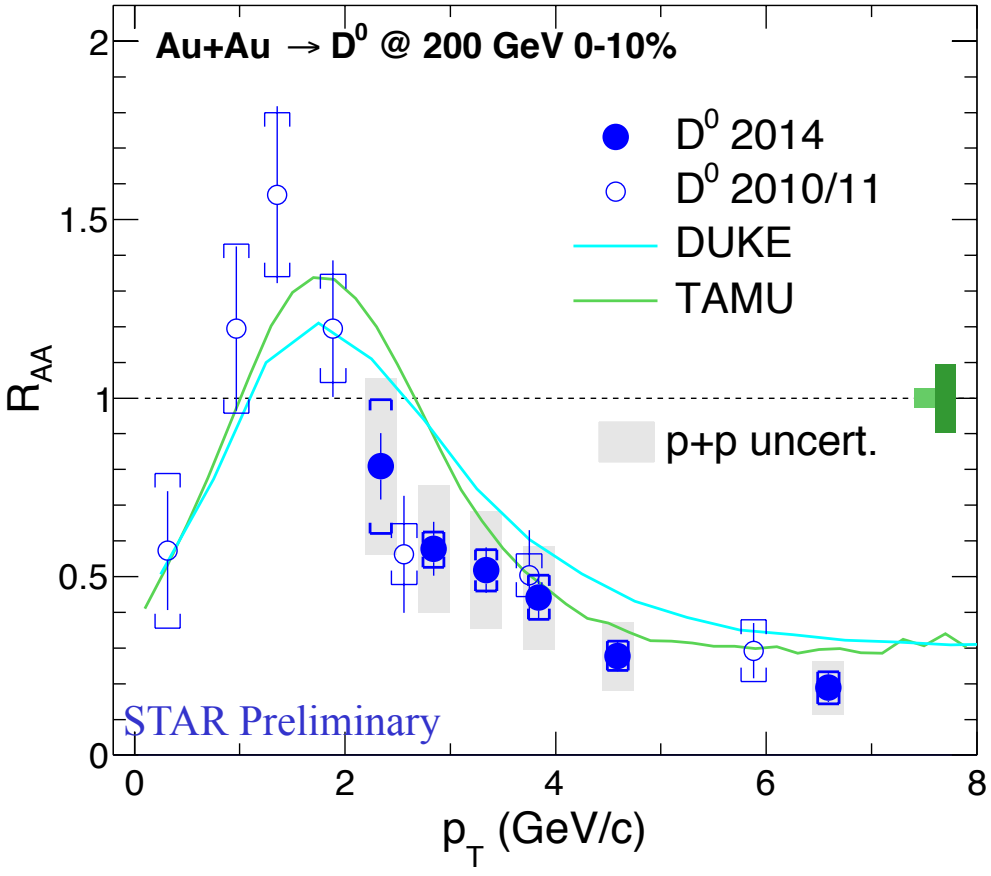


DUKE: Langevin simulation, input parameter $(2\pi T)D=7$ (tuned to the LHC data)

STAR: PRL 113 (2014) 142301
DUKE: PRC 92 (2015) 024907
A. Andronic arXiv:1506.03981(2015)

Theory curves: latest calculations from private communications

Comparison to Models



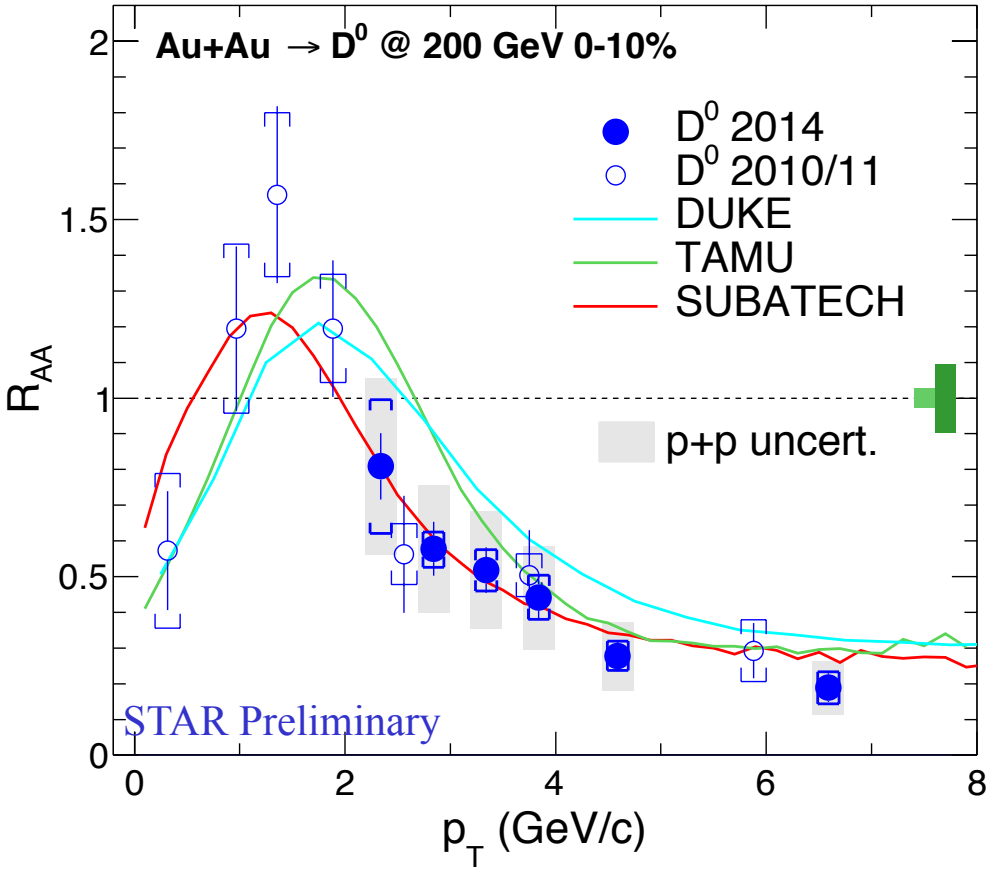
DUKE: Langevin simulation, input parameter $(2\pi T)D=7$ (tuned to the LHC data)

TAMU: non-perturb., $(2\pi T)D$ = 2-10

STAR: PRL 113 (2014) 142301
DUKE: PRC 92 (2015) 024907
A. Andronic arXiv:1506.03981(2015)

Theory curves: latest calculations from private communications

Comparison to Models



DUKE: Langevin simulation, input parameter $(2\pi T)D=7$ (tuned to the LHC data)

TAMU: non-perturb., $(2\pi T)D = 2\text{-}10$

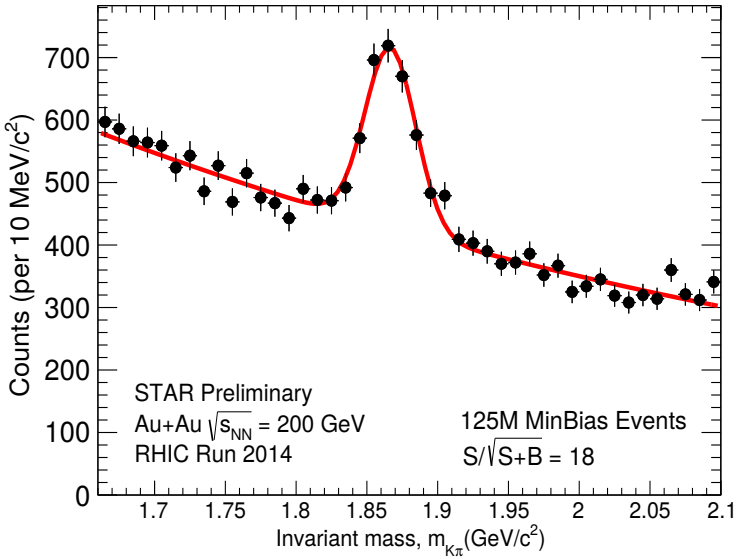
SUBATECH: perturb. +resummation, $(2\pi T)D = 2\text{-}4$

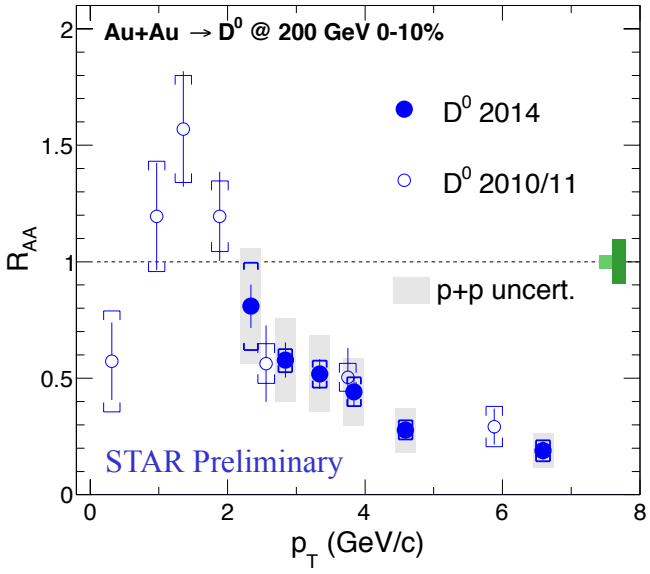
For v_2, see talk by M. Lomnitz (Tue. 9:00)

STAR: PRL 113 (2014) 142301
DUKE: PRC 92 (2015) 024907
A. Andronic arXiv:1506.03981(2015)

Theory curves: latest calculations from private communications

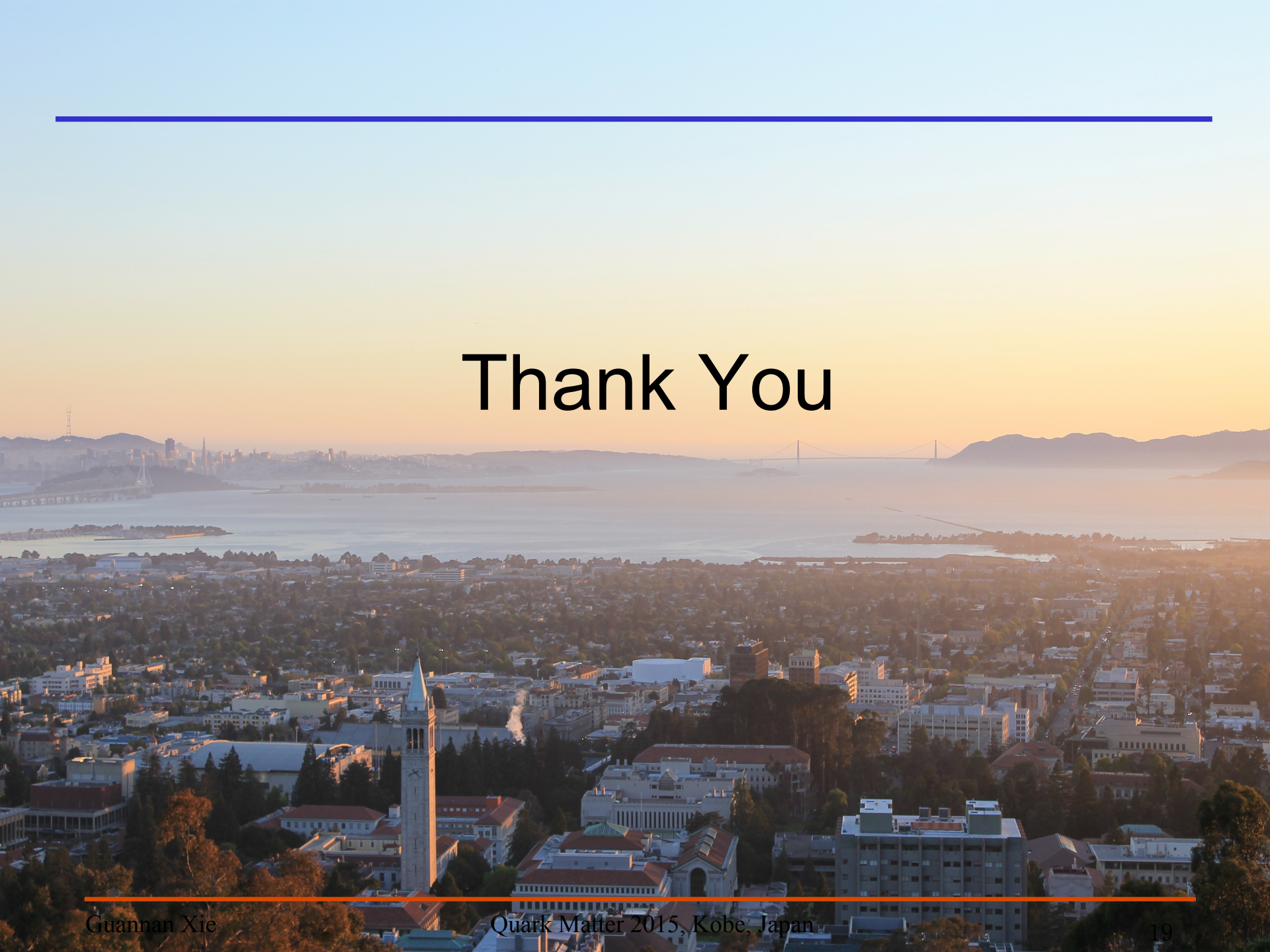
Summary & Outlook





- First measurement of D^0 R_{AA} using STAR HFT.
  - Significant suppression at high p_T in 0-10% Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV
  - Improved data precision with HFT will further constrain different models

- Near future outlook
  - D^0 spectra and R_{AA} with HFT in full p_T and peripheral Au+Au collisions
  - Year 2015 p+p and p+Au data to improve baseline and to address CNM effects


Thank You

BackUp

Topology distribution comparison