STAR Faster Heavy Flavor Tracker (HFT+) in 2021+

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UIC The University of Illinois at Chicago

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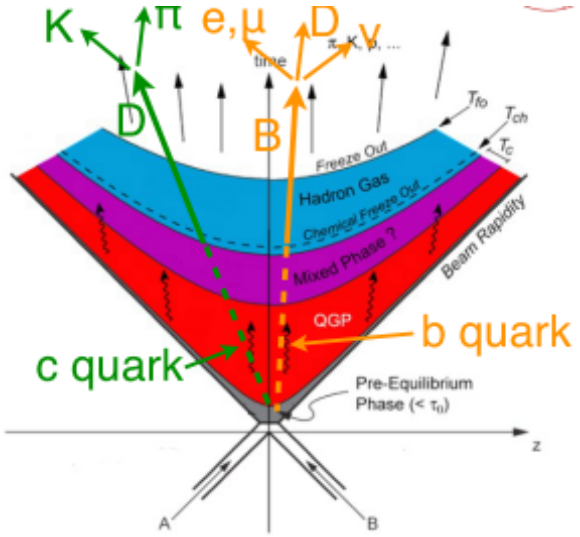
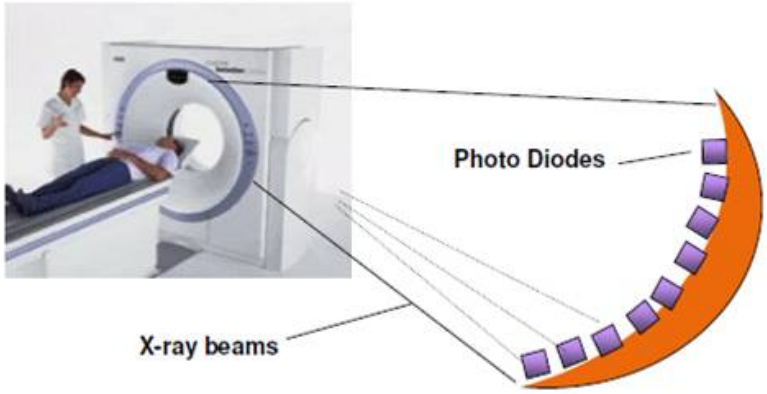
Heavy Flavor Quarks

Heavy quark tomography

- produced mostly from initial hard parton scatterings at RHIC energies; exposed to the whole evolution of the QGP
- yield or mass not (significantly) altered within the QGP





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Heavy quark tomography

- produced mostly from initial hard parton scatterings at RHIC energies; exposed to the whole evolution of the QGP
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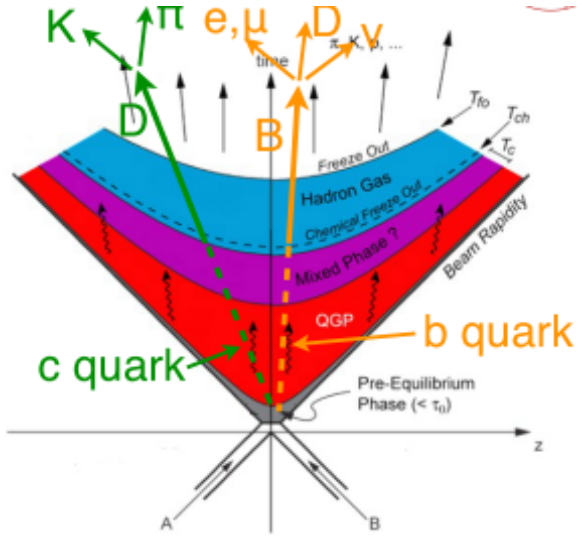
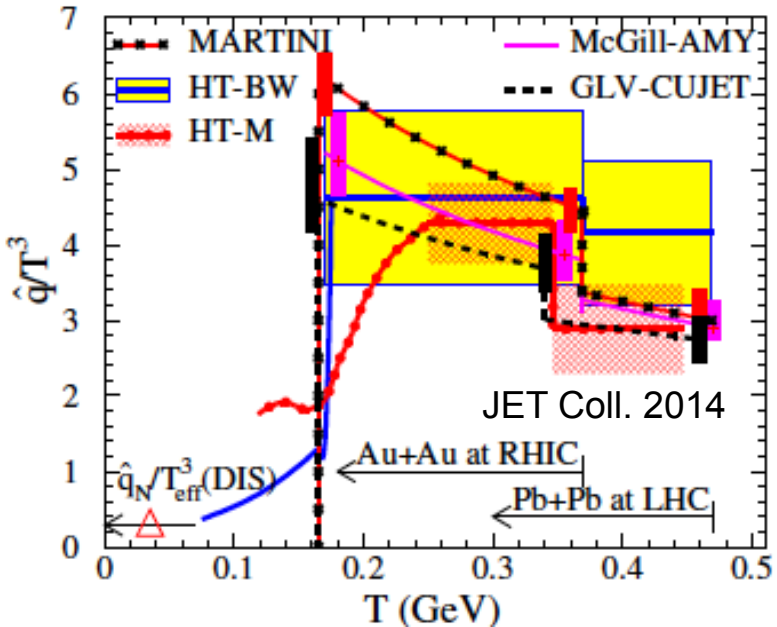
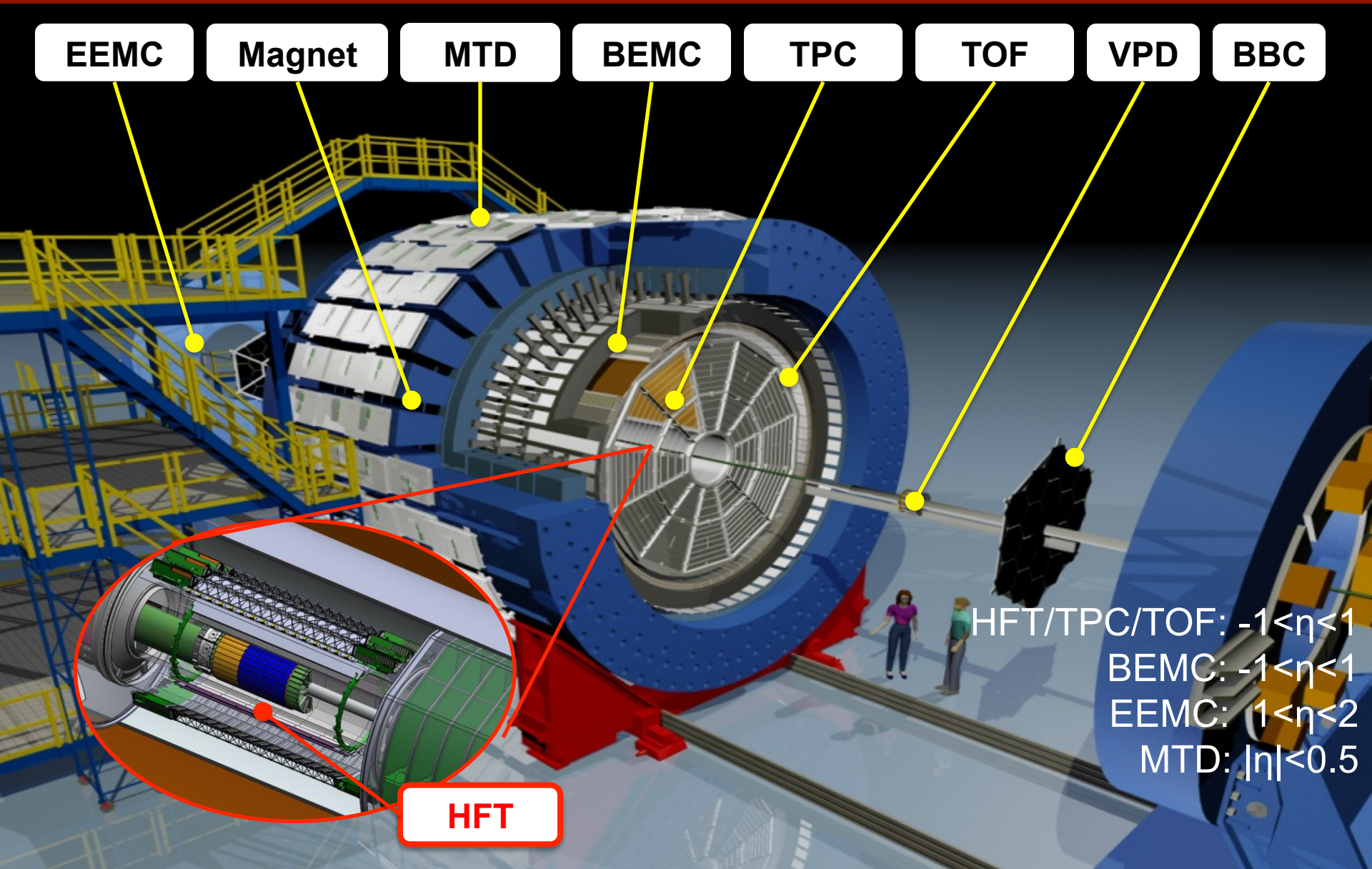
Sensitive to parton-medium interactions and medium properties

- Comparing light, charm and bottom to disentangle radiative vs collisional energy losses
- Extraction of temperature-dependent parton transport coefficients needs precise charm and bottom experimental data at both low and high p_T from RHIC

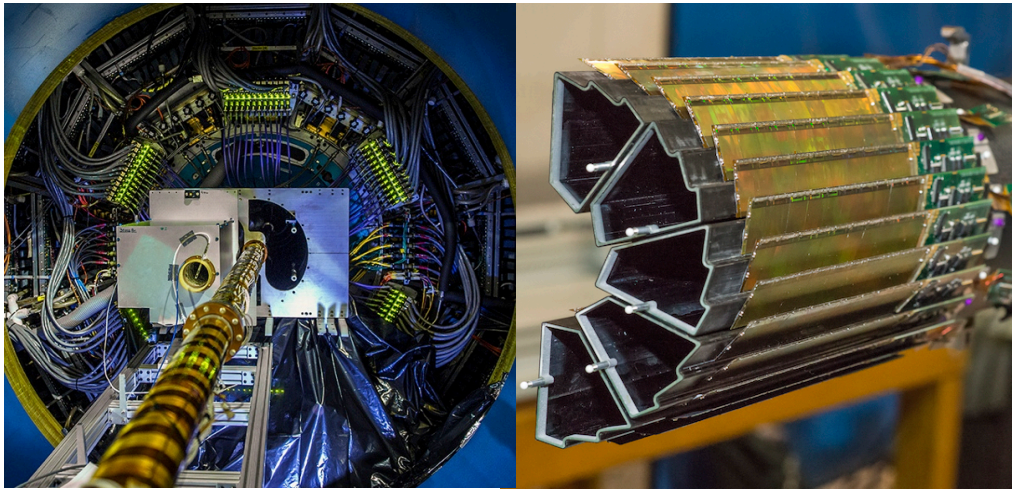


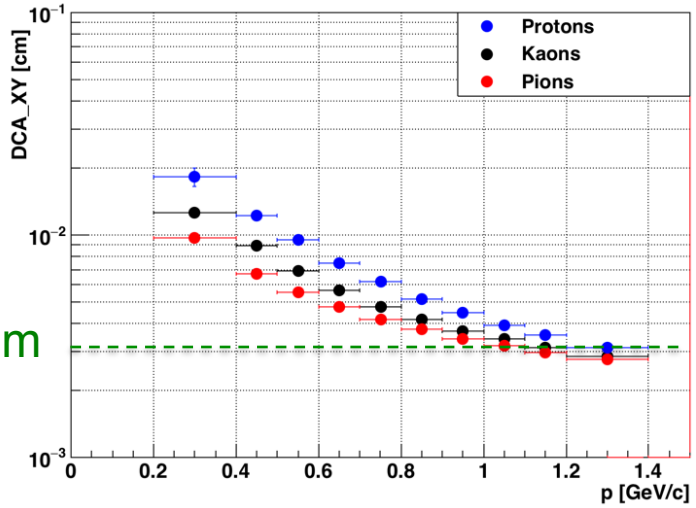


STAR Experiment at RHIC



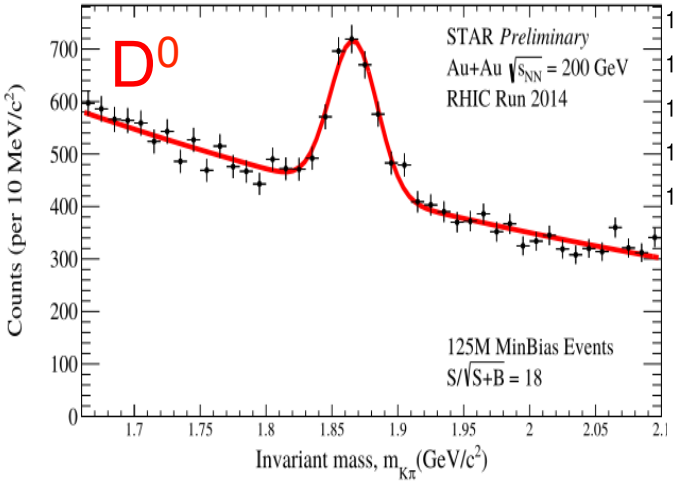
STAR Heavy Flavor I (2014-2016)

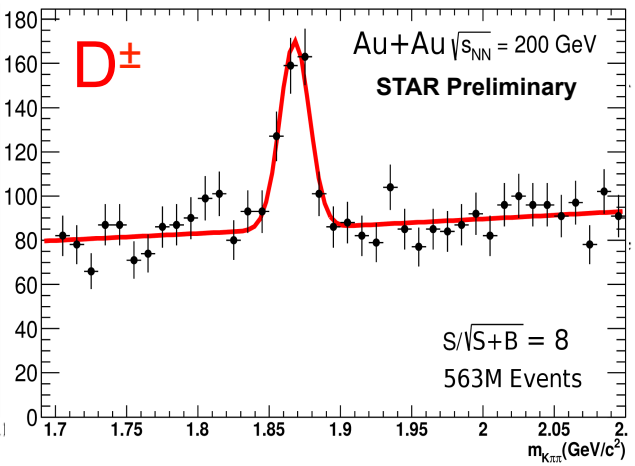


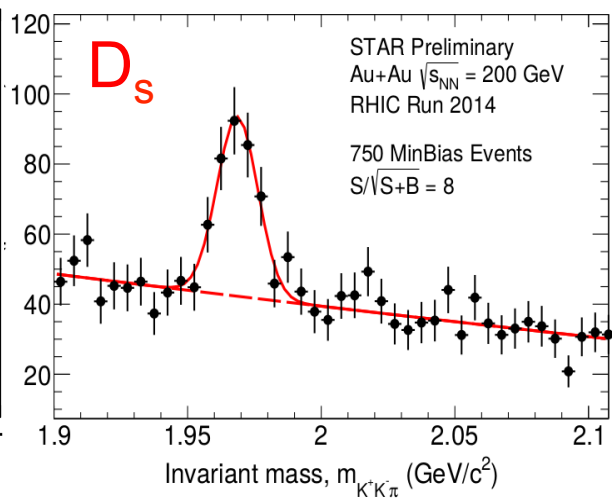


PXL: 2-layer MAPS, 360M pixels, 20x20μm, inner layer 0.4%X_0
IST: 1-layer single-sided double-metal Silicon pad detector
SSD: 1-layer double-sided single-metal Silicon strip detector

Run14 Au+Au @ 200 GeV
1.2B MB events with HFT







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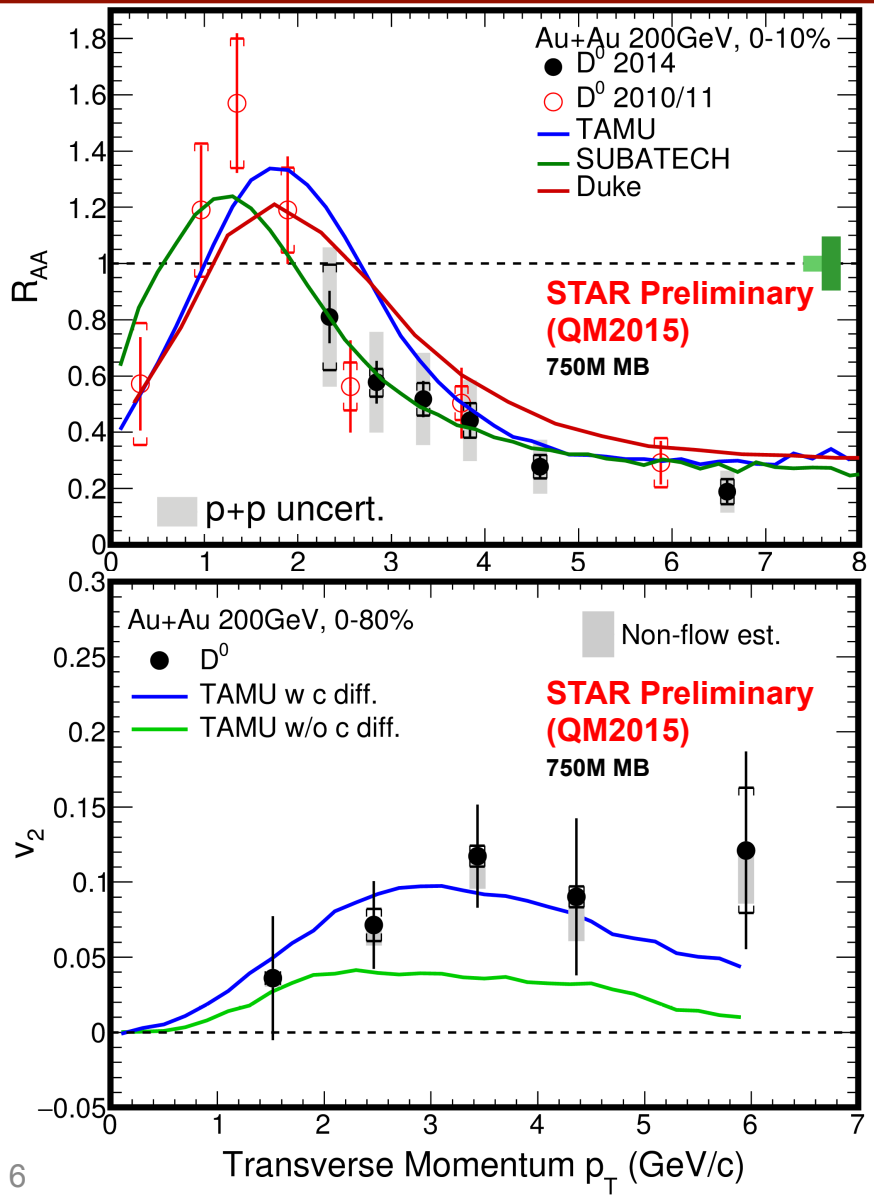

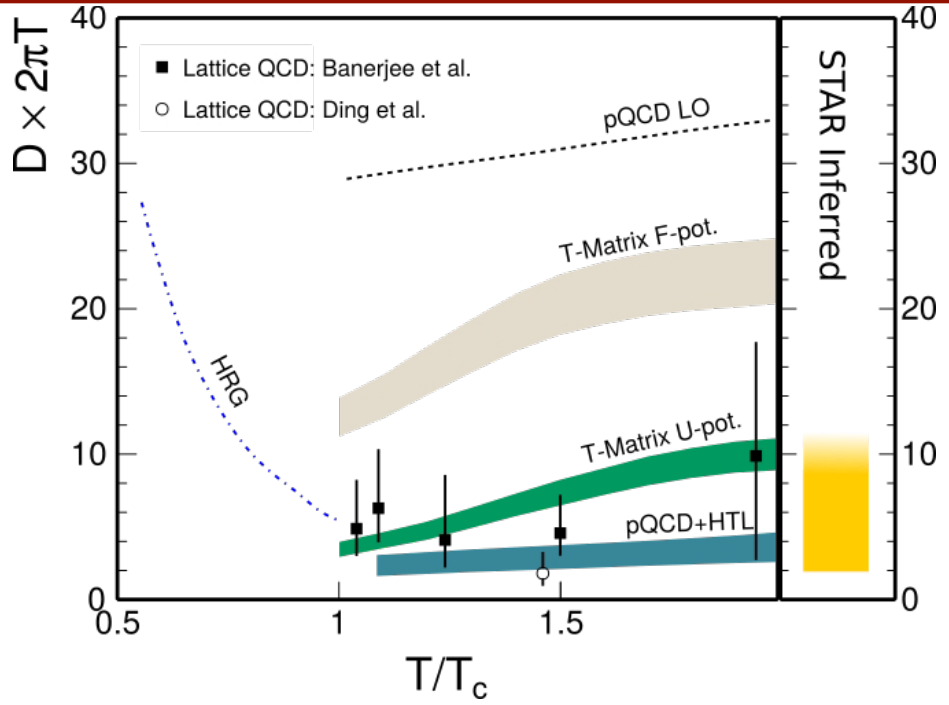

	D × 2πT	Diff. Calculation
TAMU	2-11	T-Matrix
SUBATECH	2-4	pQCD+HTL
Duke	7	Free parameter

Models with charm diffusion coefficient of 2 -~10 describe STAR D^0 R_{AA} and v_2 data. Lattice calculations are consistent with values inferred from data

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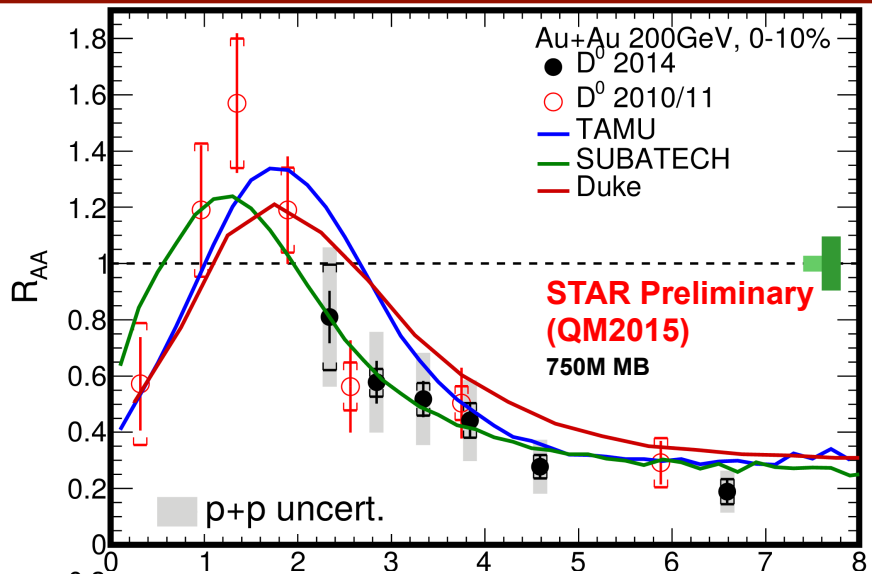

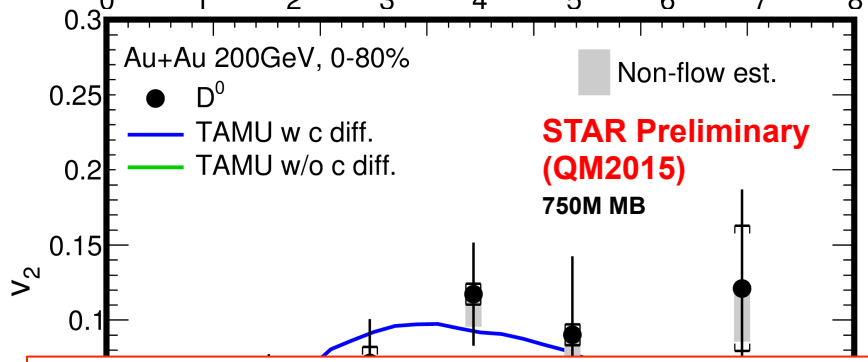

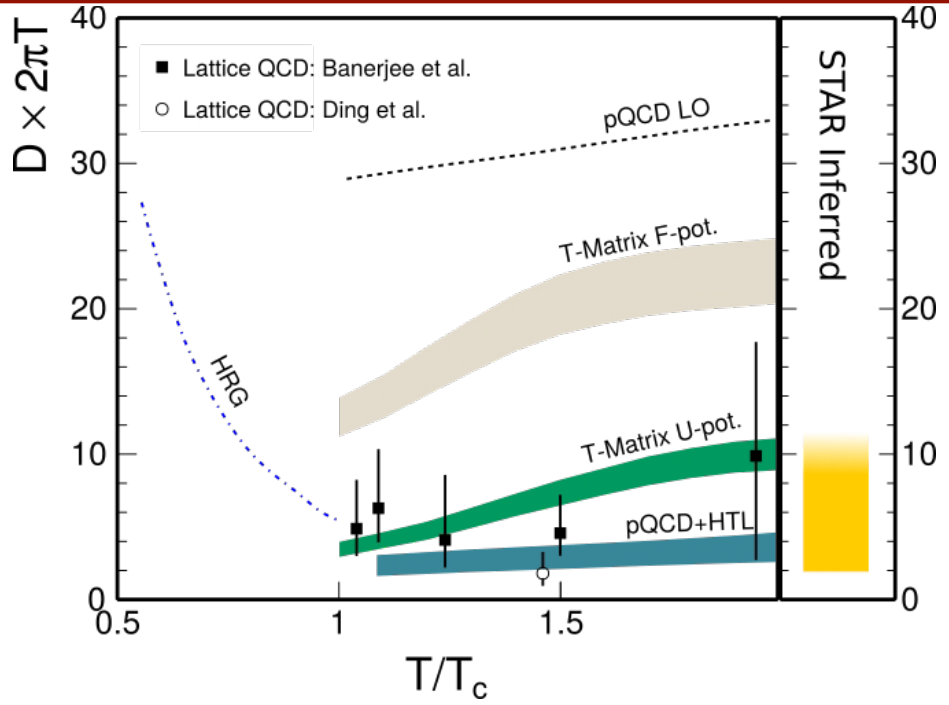

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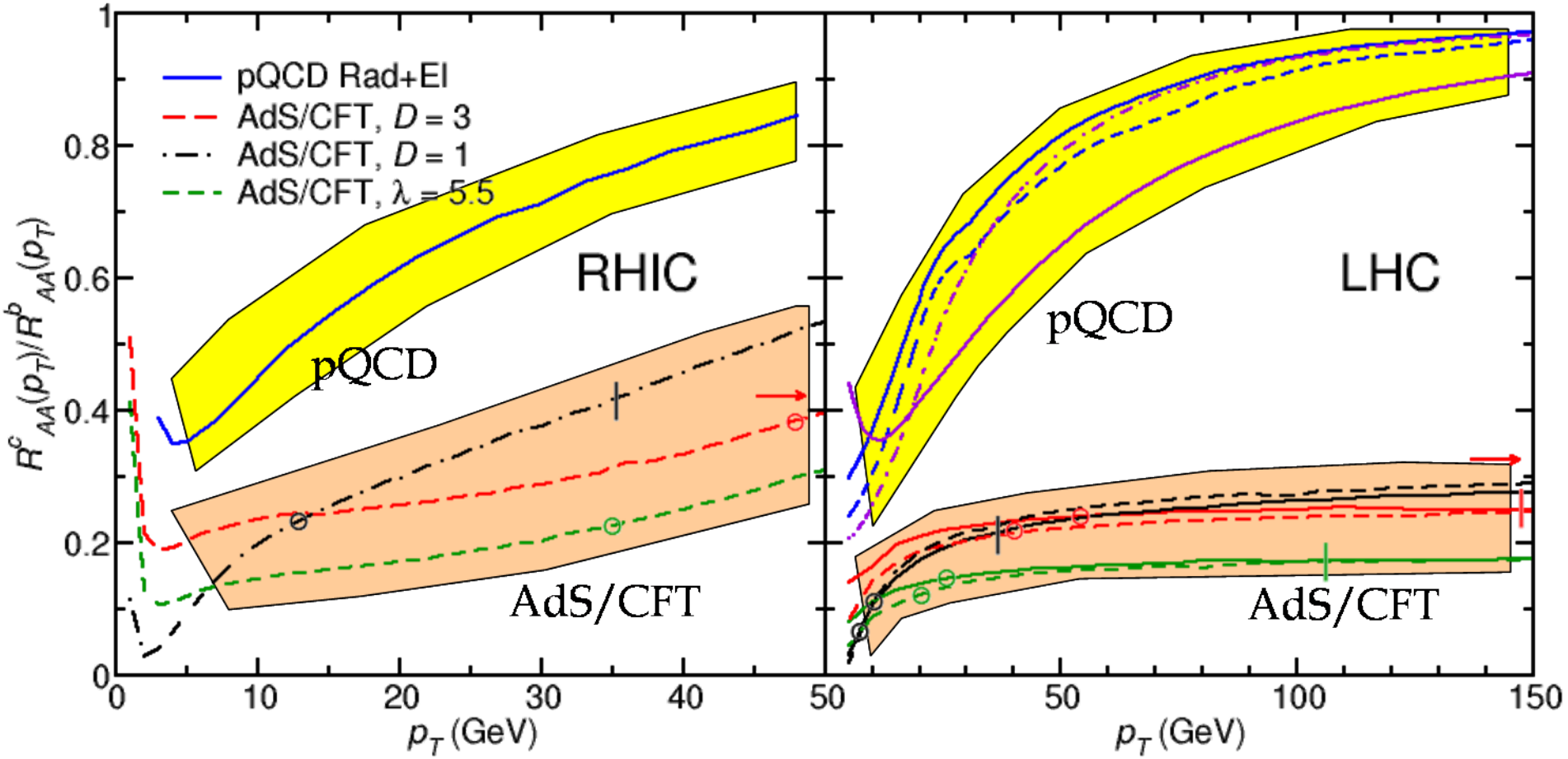
Precise charm results over wide p_T from STAR in Run14-16

Run14: Au+Au, QM15 results based on ~70% statistics

Run15: p+p baseline, p+Au for CNM effects

Run16(+14): x4 Au+Au statistics than QM15, inner PXL 0.5->0.4%X_0 with Al cables

STAR Heavy Flavor II (2021-2022)



W. Horowitz and M. Gyulassy, arXiv:0710.0703

Without Bottom from RHIC, we can't claim that we fully understand the energy loss mechanisms, or mass- and temperature-dependent parton transport coefficients of the QGP. Does b quark diffuse in the QGP at RHIC energies and if so how much?

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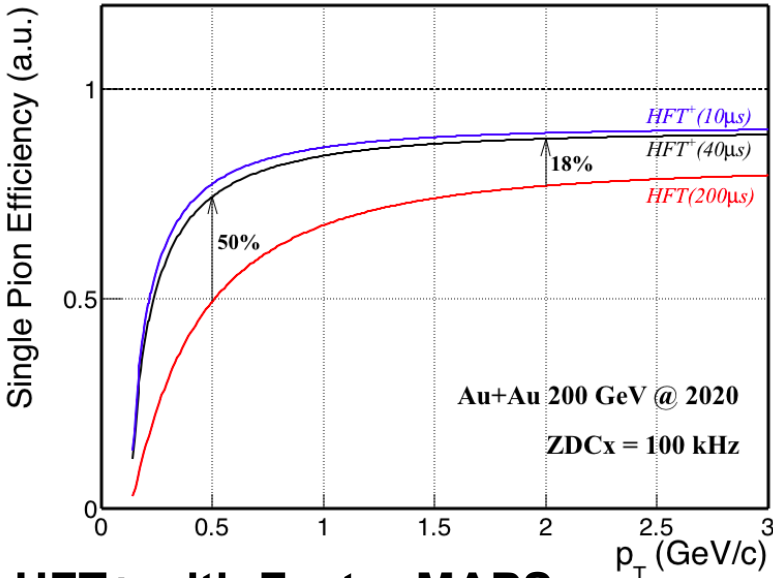
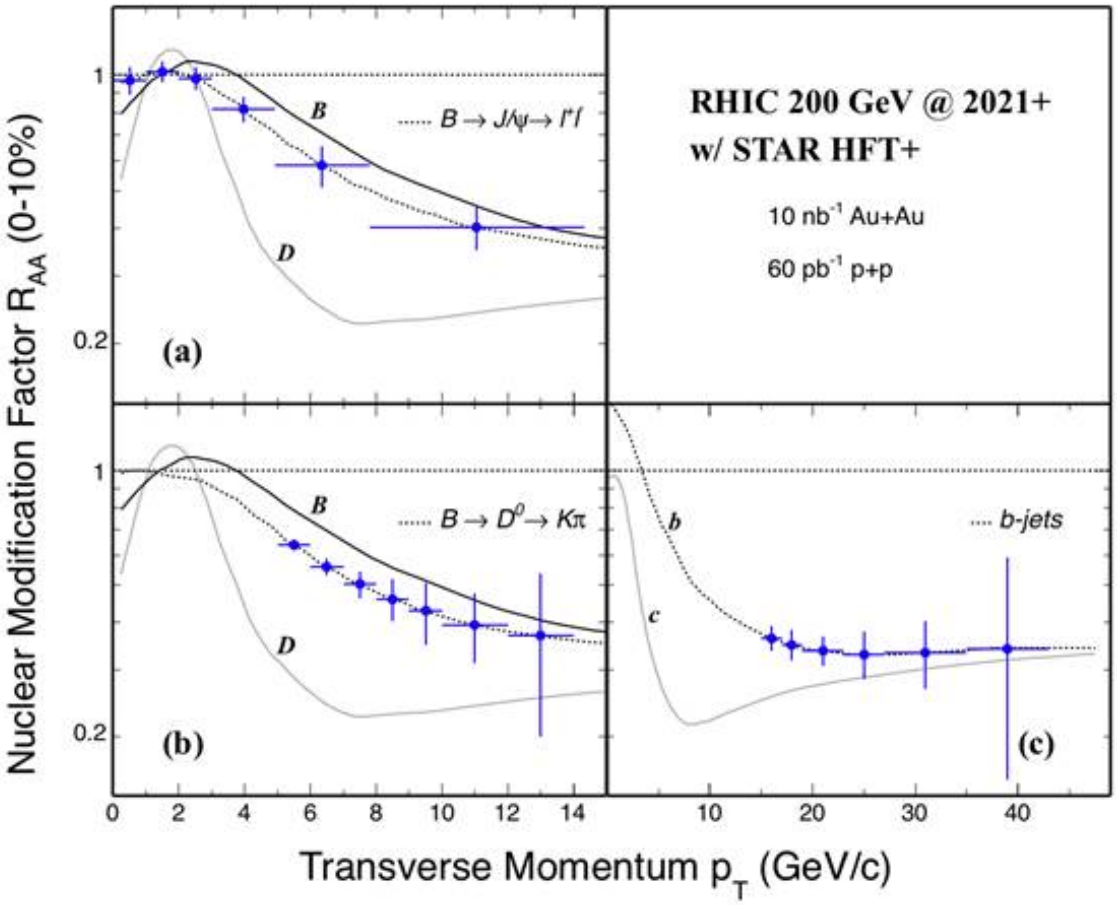


HFT+ with Faster MAPS sensors

- integration time from ~185 μs to below 40 μs – less pile-up hits and thus better tracking efficiency
- use chips developed for ALICE ITS upgrade and existing HFT infrastructure – cost effective
- experienced team worked on HFT



Projected R_{AA}(0-10%) stat. uncertainty for RHIC pp and AuAu running in 2021-22

Precise bottom measurements with the HFT+ to complete the heavy flavor physics at RHIC. Complementary to ALICE HF and sPHENIX Jet and Upsilon programs.

2015 NSAC Long Range Plan

RECOMMENDATION I

- **The progress achieved under the guidance of the 2007 Long Range Plan has reinforced U.S. world leadership in nuclear science. The highest priority in this 2015 Plan is to capitalize on the investments made.**
  - …
  - *The upgraded RHIC facility provides unique capabilities that must be utilized to explore the properties and phases of quark and gluon matter in the high temperatures of the early universe and to explore the spin structure of the proton.*

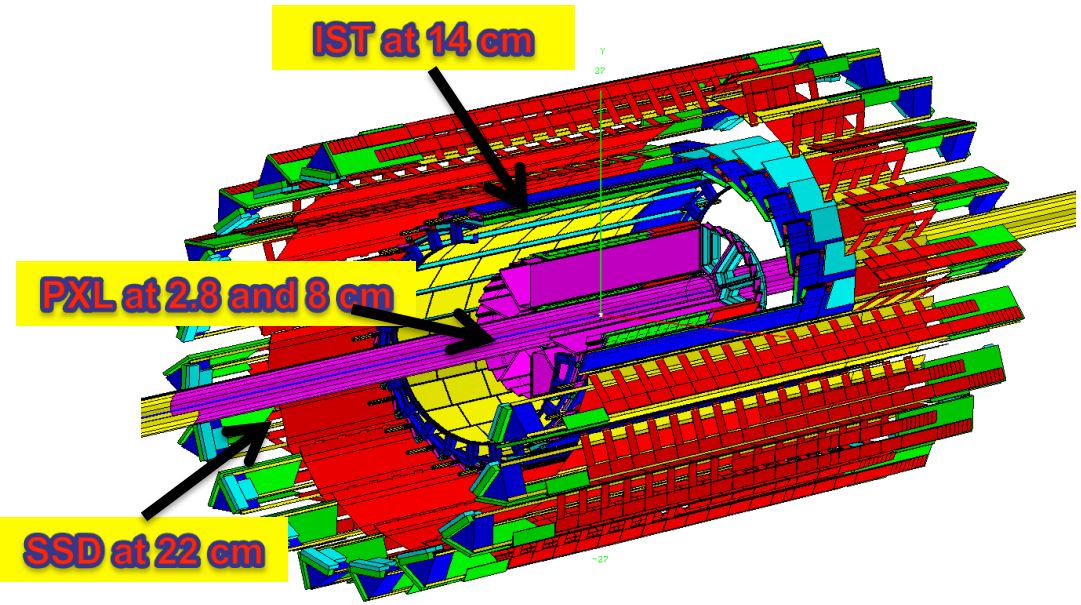
RECOMMENDATION IV

- **We recommend increasing investment in small-scale and mid-scale projects and initiatives that enable forefront research at universities and laboratories.**

The proposed HFT+ upgrade and its explored unique physics is fully in-line with NSAC Long Range Plan recommendations

Backup Slides

STAR Heavy Flavor Tracker

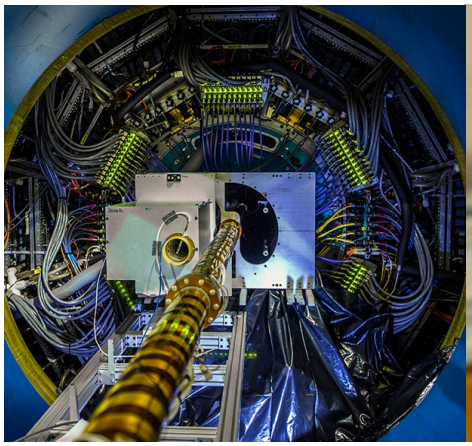


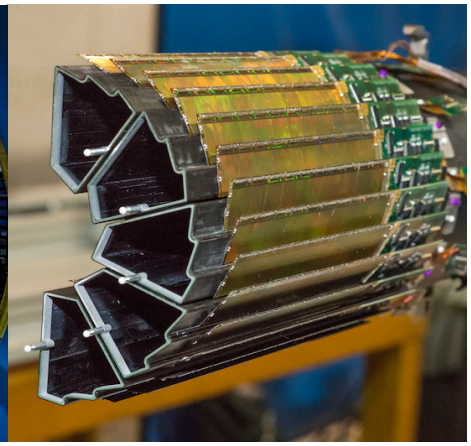
HFT consists of

- 2 layers of thin silicon MAPS: 360M pixels, each 20x20μm
- 2 layers of silicon pad/strip: fast readout, bridging TPC/PXL

Taking data since 2014:

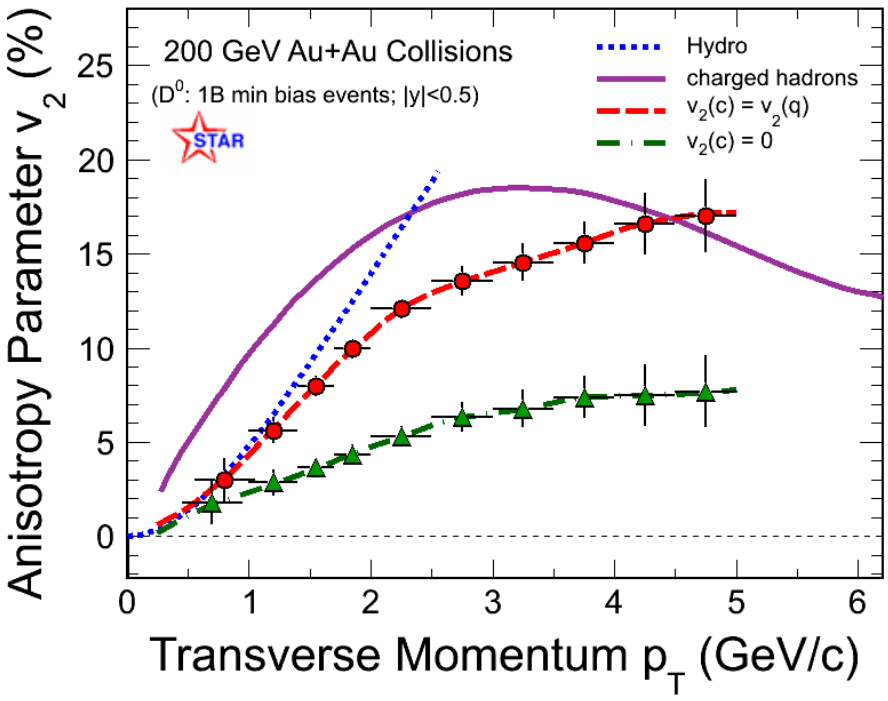
- Au+Au 200 GeV in Run14
- p+p, p+Au 200 GeV in Run15
- Au+Au 200 GeV in Run16

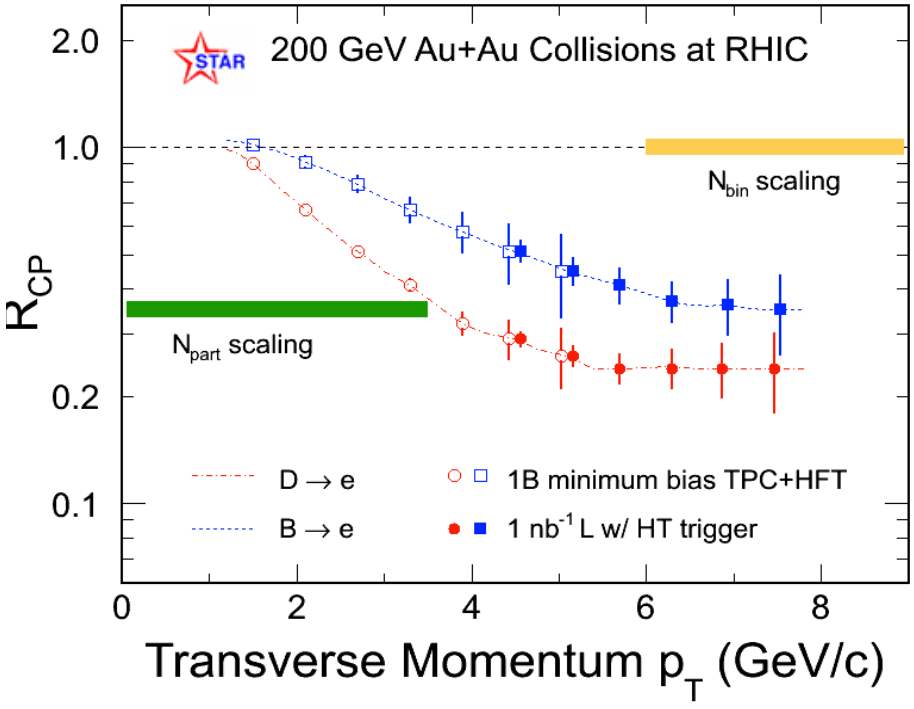




Detector	Radius (cm)	Hit Resolution R/φ - Z (μm)	Radiation length
SSD	22	20 / 740	1% X_0
IST	14	170 / 1800	<1.5 %X_0
PXL	8	6 / 6	~0.5 %X_0
	2.8	6 / 6	~0.4% X_0

STAR Heavy Flavor Tracker





High precision R_{AA}, R_{pA}, v_2, correlations results for D mesons and HF leptons;
Unique at low p_T -> medium thermalization, total charm production

HFT+ Upgrade plan (2021+)

HFT+ upgrade motivation:

- Measure **bottom quark hadrons** at the RHIC energy
- Take data in **higher luminosity** with high efficiency

HFT+ detector requirements:

- **Faster** frame readout of 40 μs or less
- **Similar or better** pointing resolution
  S/N ratio
  total power consumption
  radiation length
- **Compatible** with the existing insertion mechanism, support structure, air cooling system

HFT+ read-out electronics requirements:

- **Compatible** with STAR DAQ system and trigger

ALICE ITS Upgrade
MAPS sensor

STAR HFT
mechanics and services

STAR + ALICE
new development