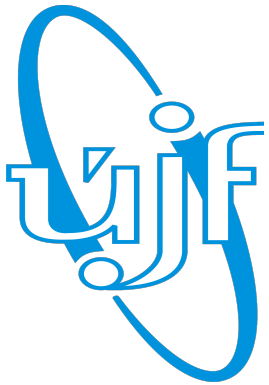
14. Zimányi

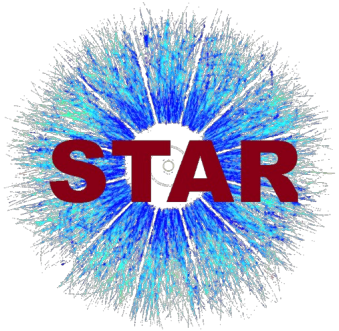
Winter School on Heavy Ion Physics

December 1-5, 2014

Budapest, Hungary

D meson measurements at STAR





Pavol Federič

for the STAR collaboration
NPI ASCR

esf evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Motivation

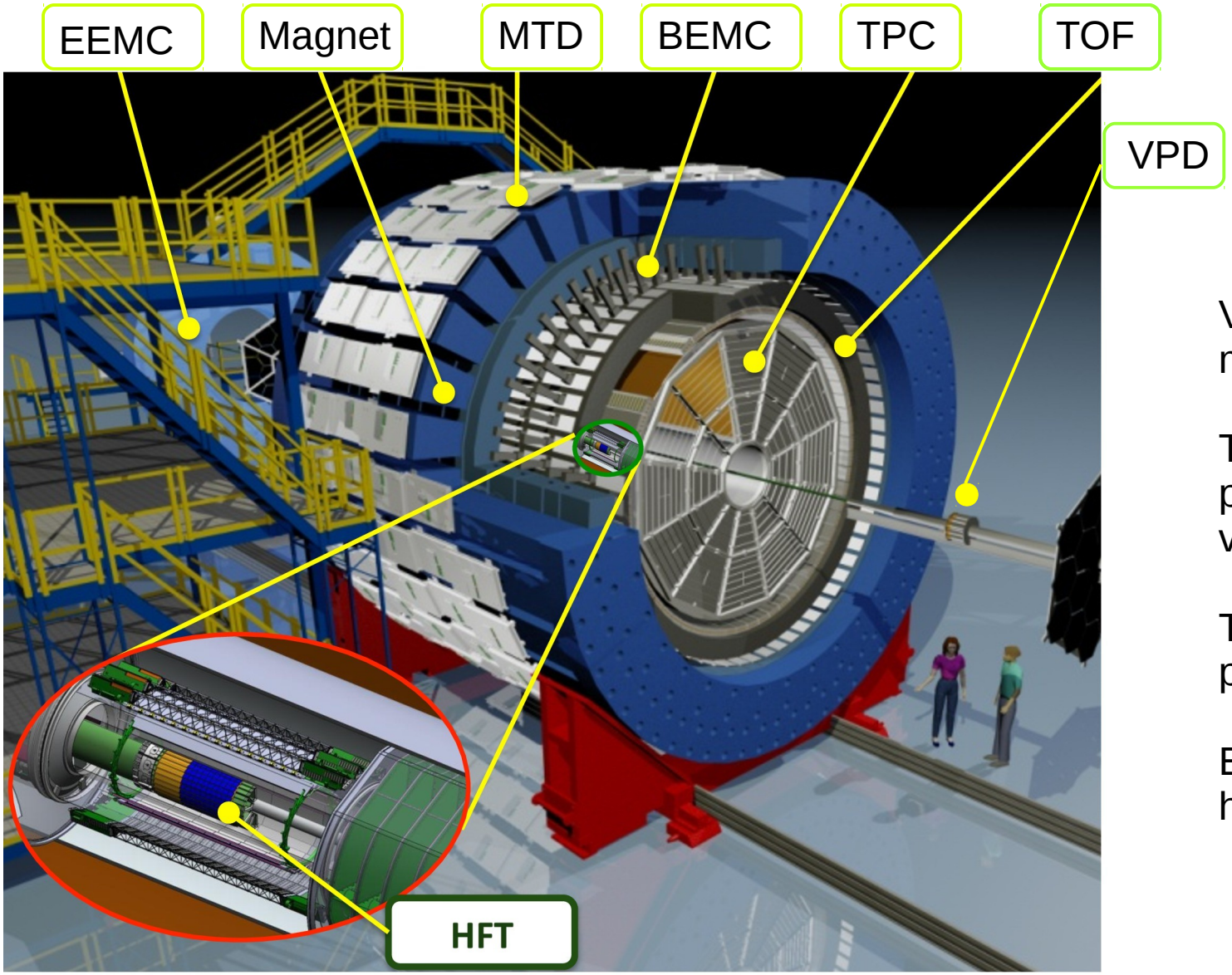
Topics

- properties of the Quark-Gluon Plasma (QGP) at RHIC
- interactions of heavy quarks with QCD matter

Heavy quarks (c, b)

- produced in initial hard processes (due to large masses)
- probe the strongly interacting QGP
- modified spectrum: mechanism of energy loss
- collective flow: sensitive to dynamics, thermalization

The STAR detector



VPD:
minimum bias trigger

TPC:
particle identification
via dE/dx, tracking

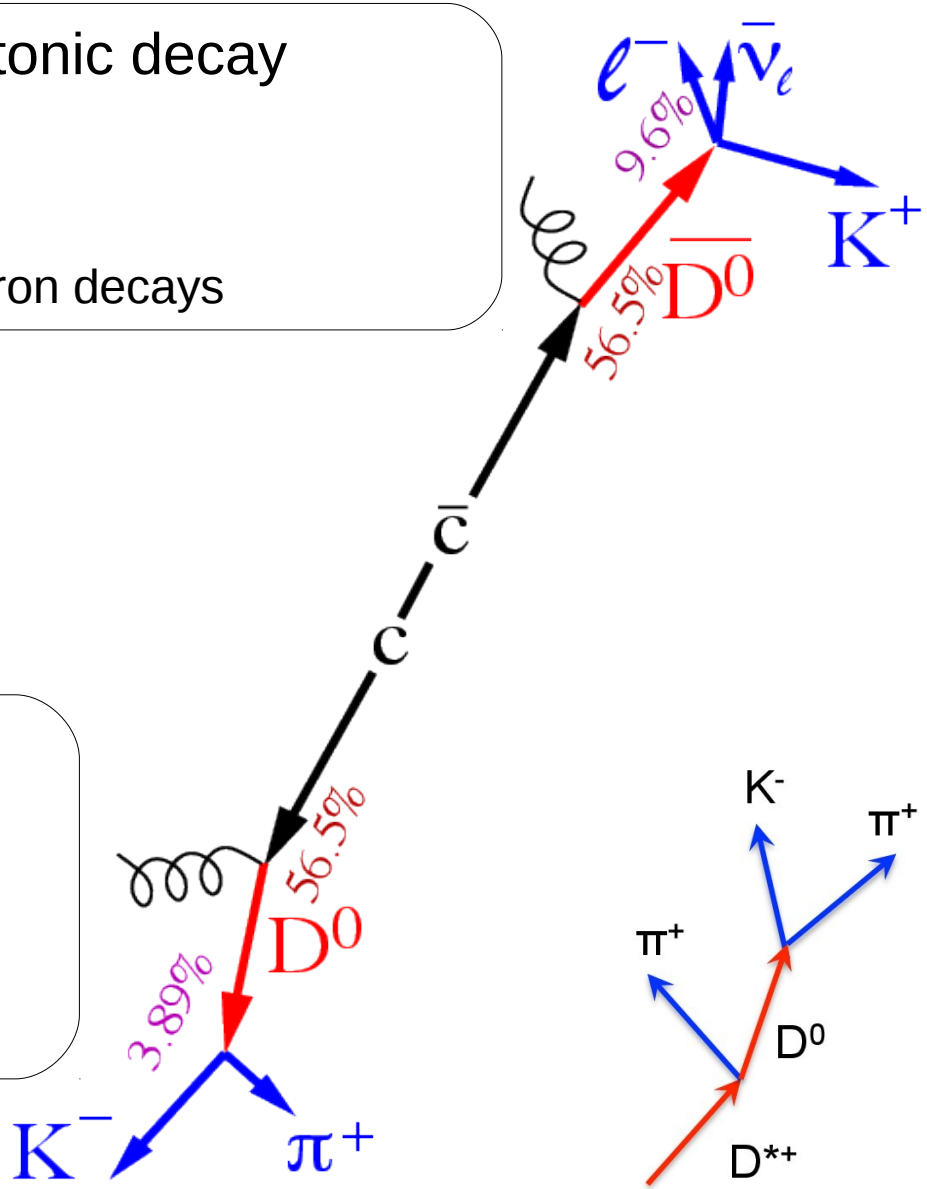
TOF:
particle identification

BEMC:
high p_T trigger

Measurement of charm quarks

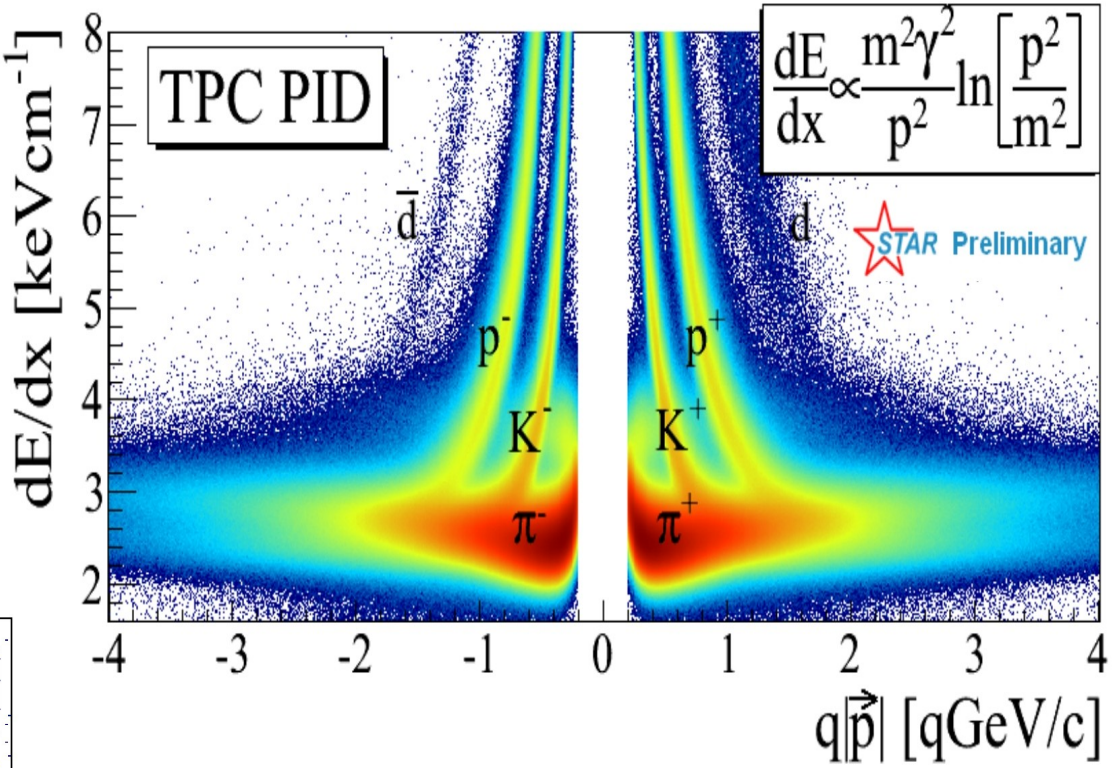
- Indirect measurements through semileptonic decay
  - + easy to trigger (hight p_T electrons)
  - + higher branching ratio
  - - no direct access to parent hadron kinematics
  - - contribution from both charm and bottom hadron decays

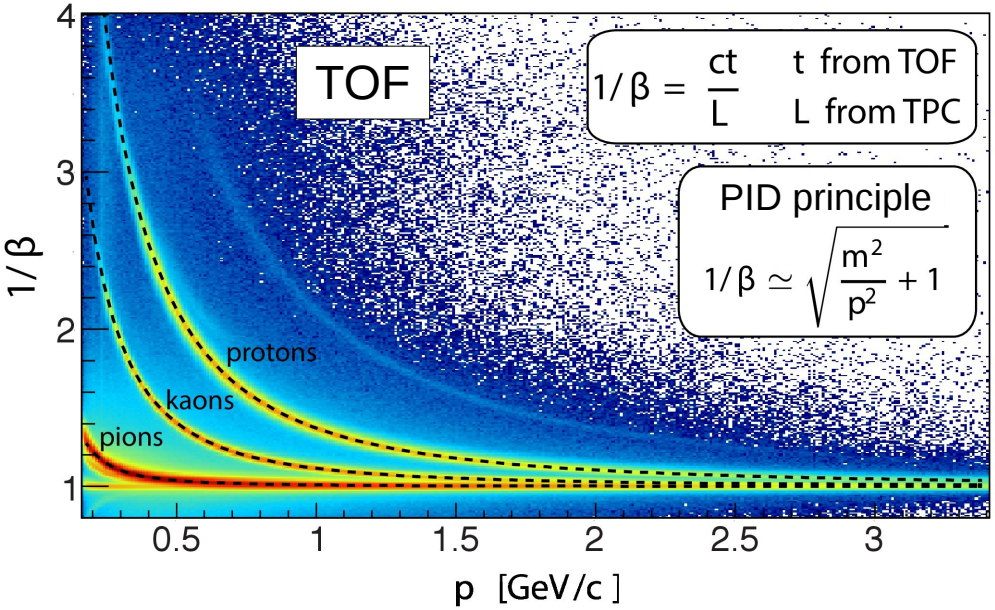
- **Direct open charm reconstruction**
  - + direct access to parent hadron kinematics
  - - smaller branching ratio
  - - large combinatorial background (without vertex detector)



Particle identification

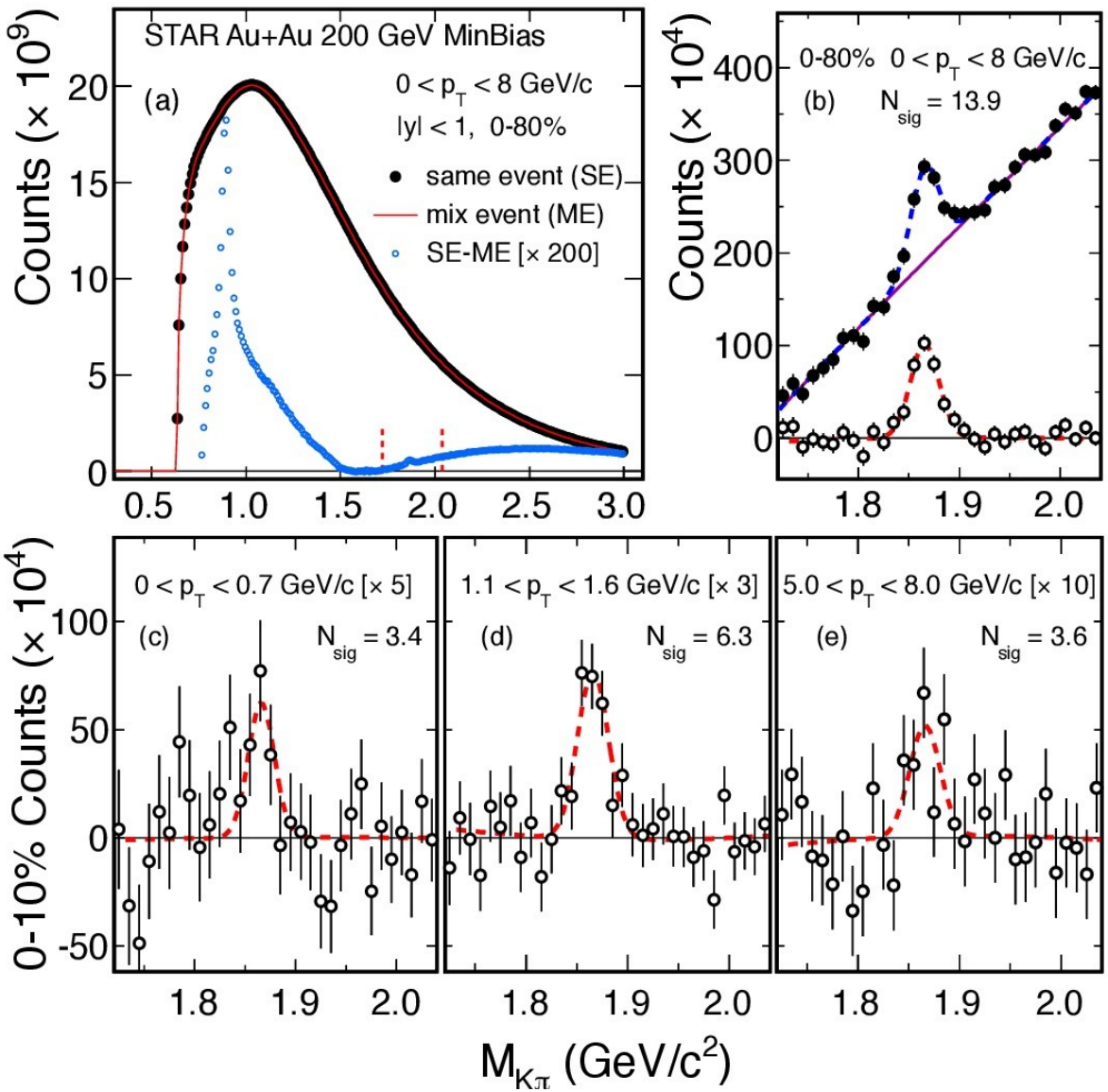
- TPC better than TOF for kaon/pion seperation with momentum above ~2.5 GeV/c
- TOF provides clean sample of kaons with momentum up to ~1.6 GeV/c

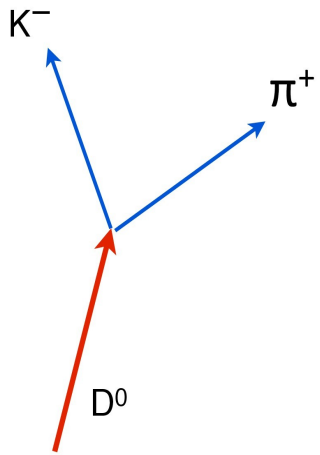




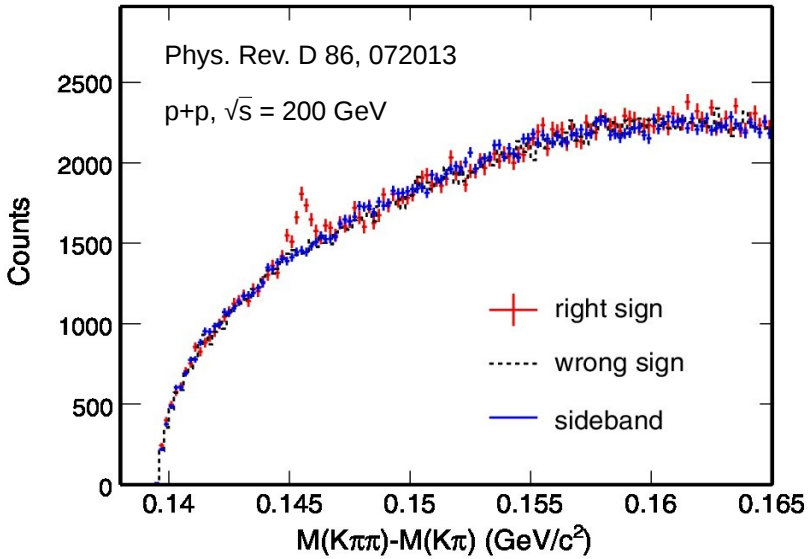
D^0 reconstruction in Au+Au

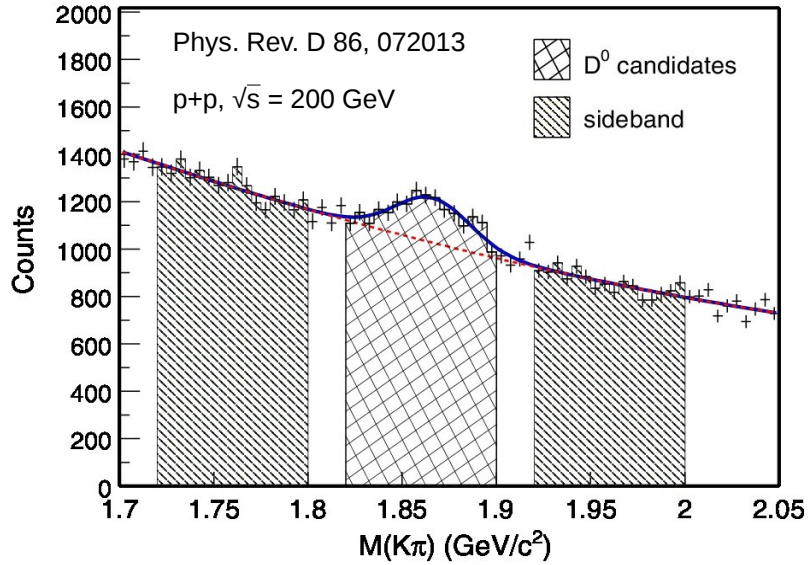
Phys. Rev. Lett. 113, 142301 (2014)





D* reconstruction in p+p



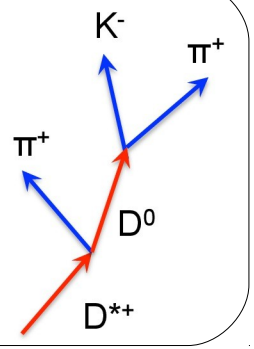


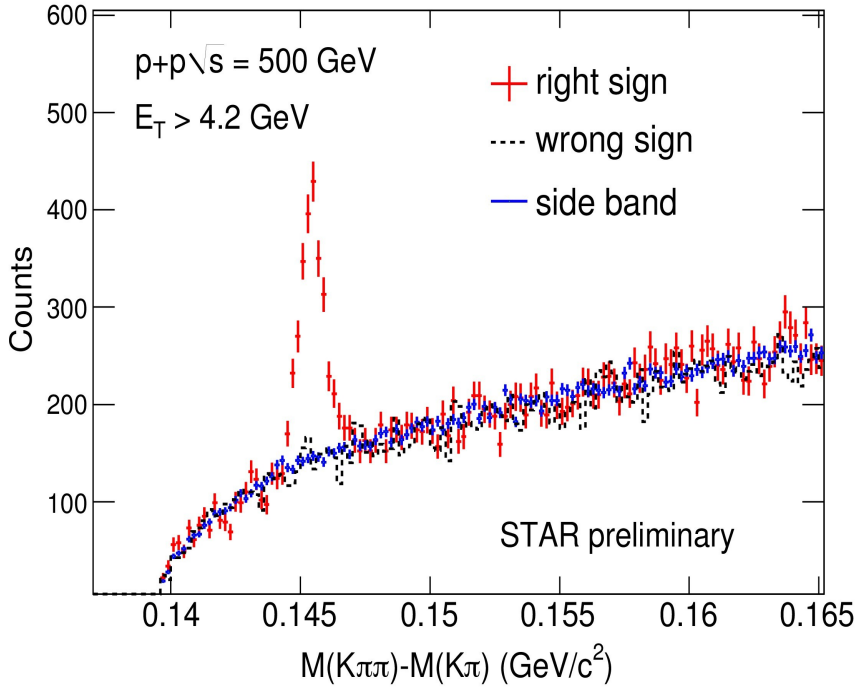
wrong sign

$K^-\pi^+\pi^-$

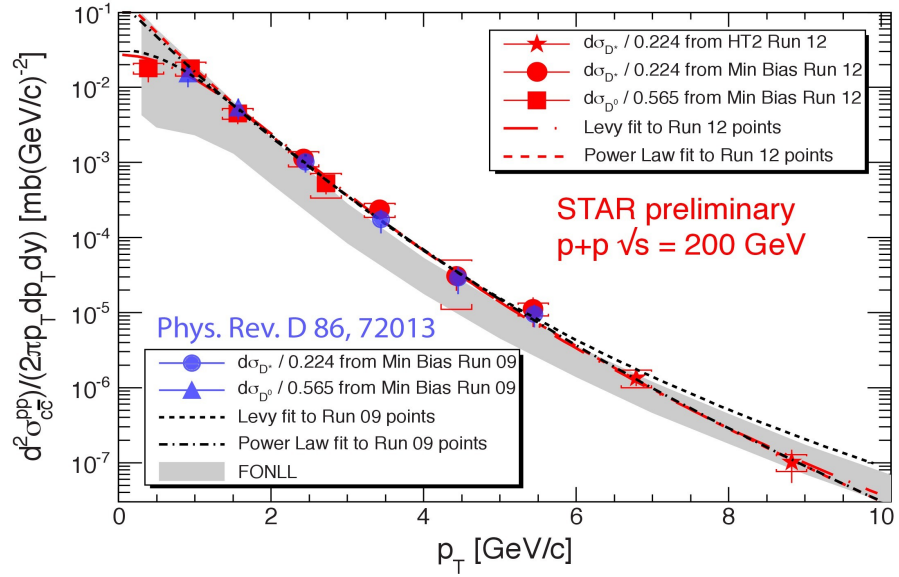
right sign

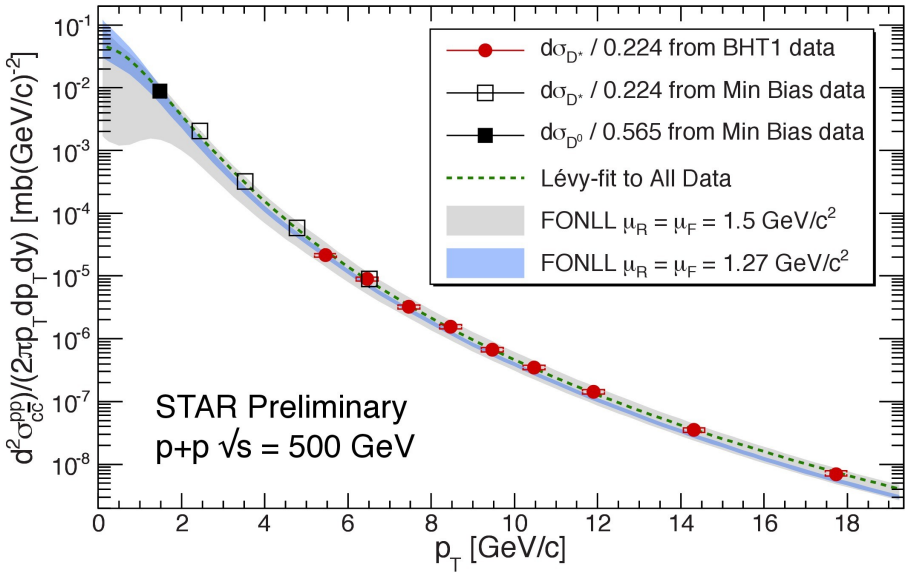
$K^-\pi^+\pi^+$

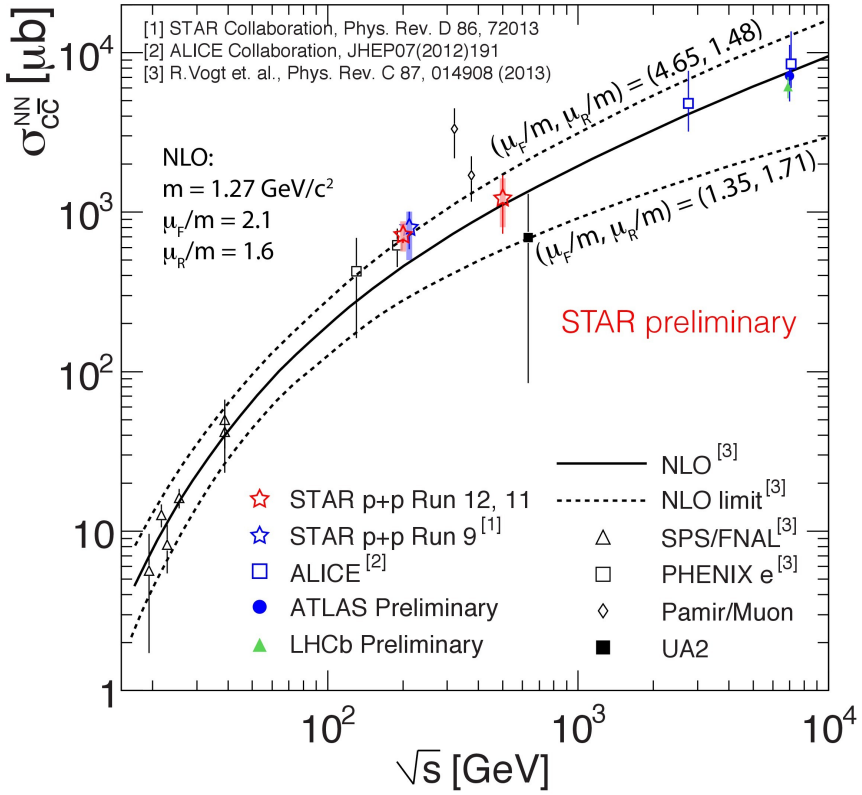




Production cross section in p+p



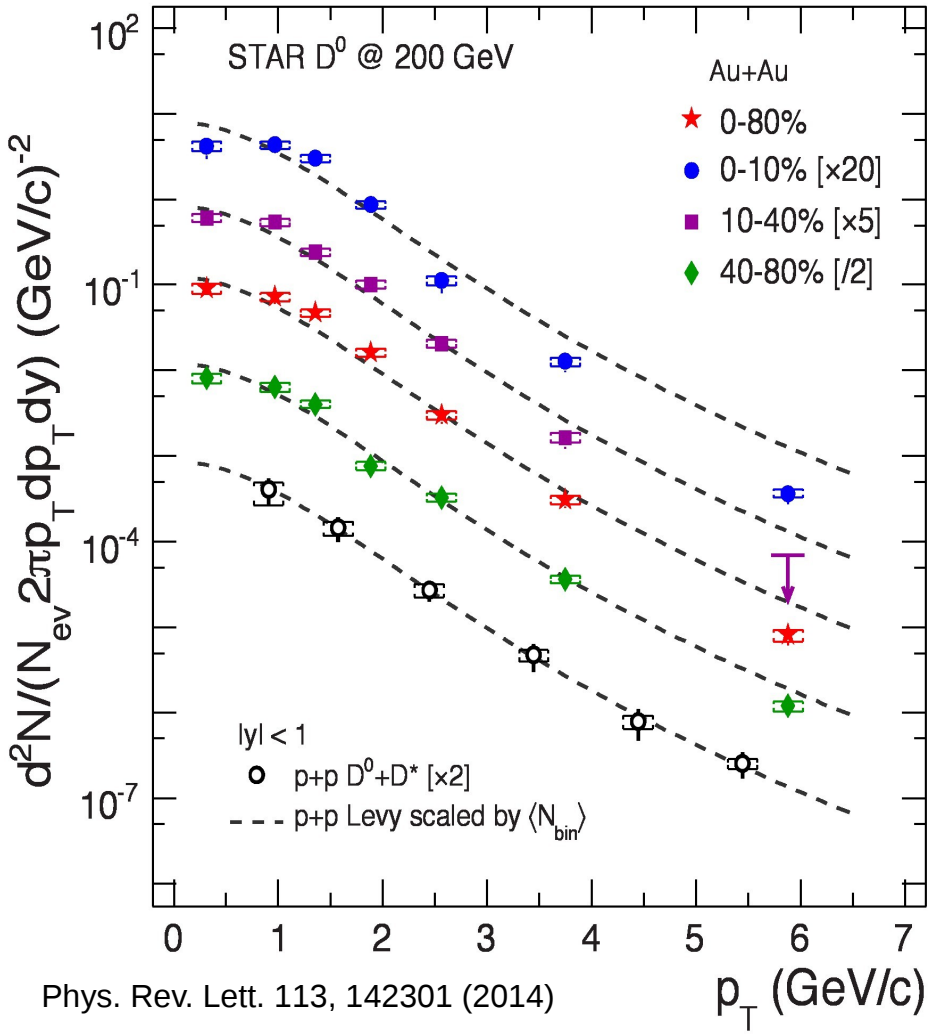




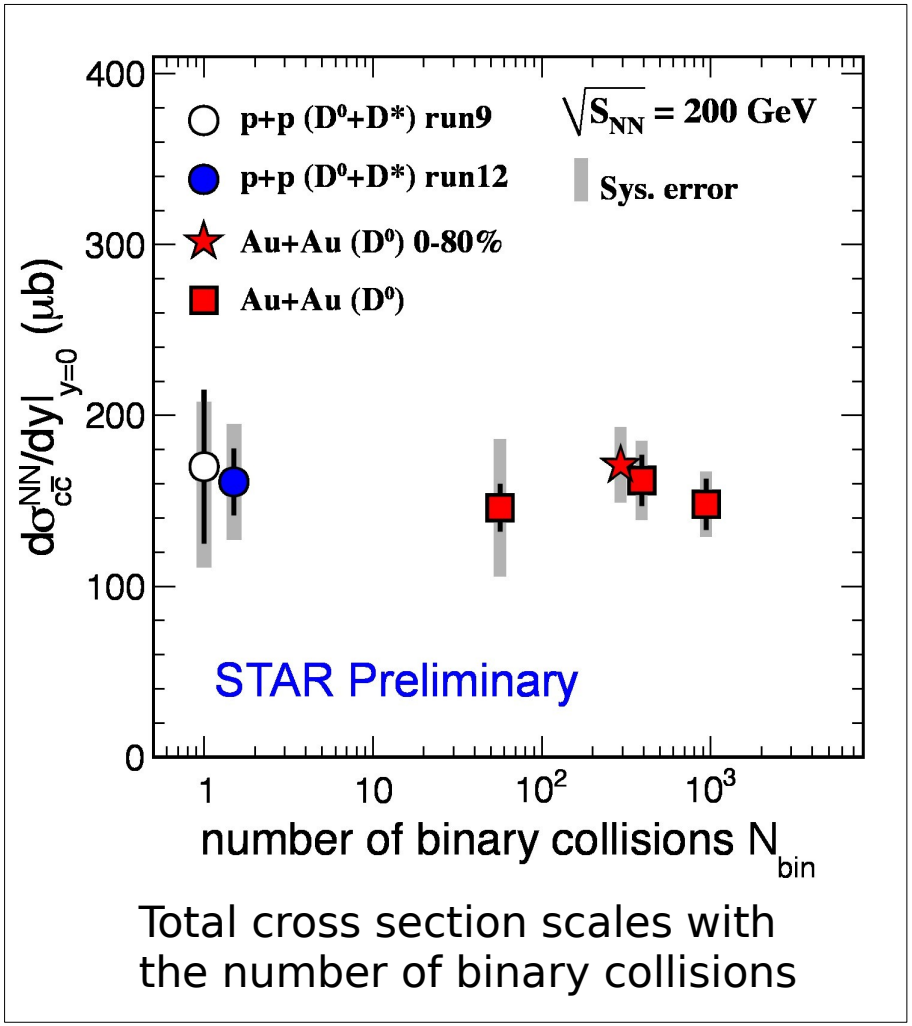
- p+p 200 GeV
  - essential as a baseline for Au+Au
  - consistent with FONLL upper limit
  - new low p_T point between 0 and 0.7 GeV/c
    - Levy fit describes data well
- new p+p 500 GeV measurement
  - consistent with FONLL

FONLL: Fixed Order plus Next-to-Leading Logarithms calculation, $\mu_F = \mu_R = m_c$, $|y| < 1$, arXiv: 1210.4610

D^0 production in 200 GeV Au+Au



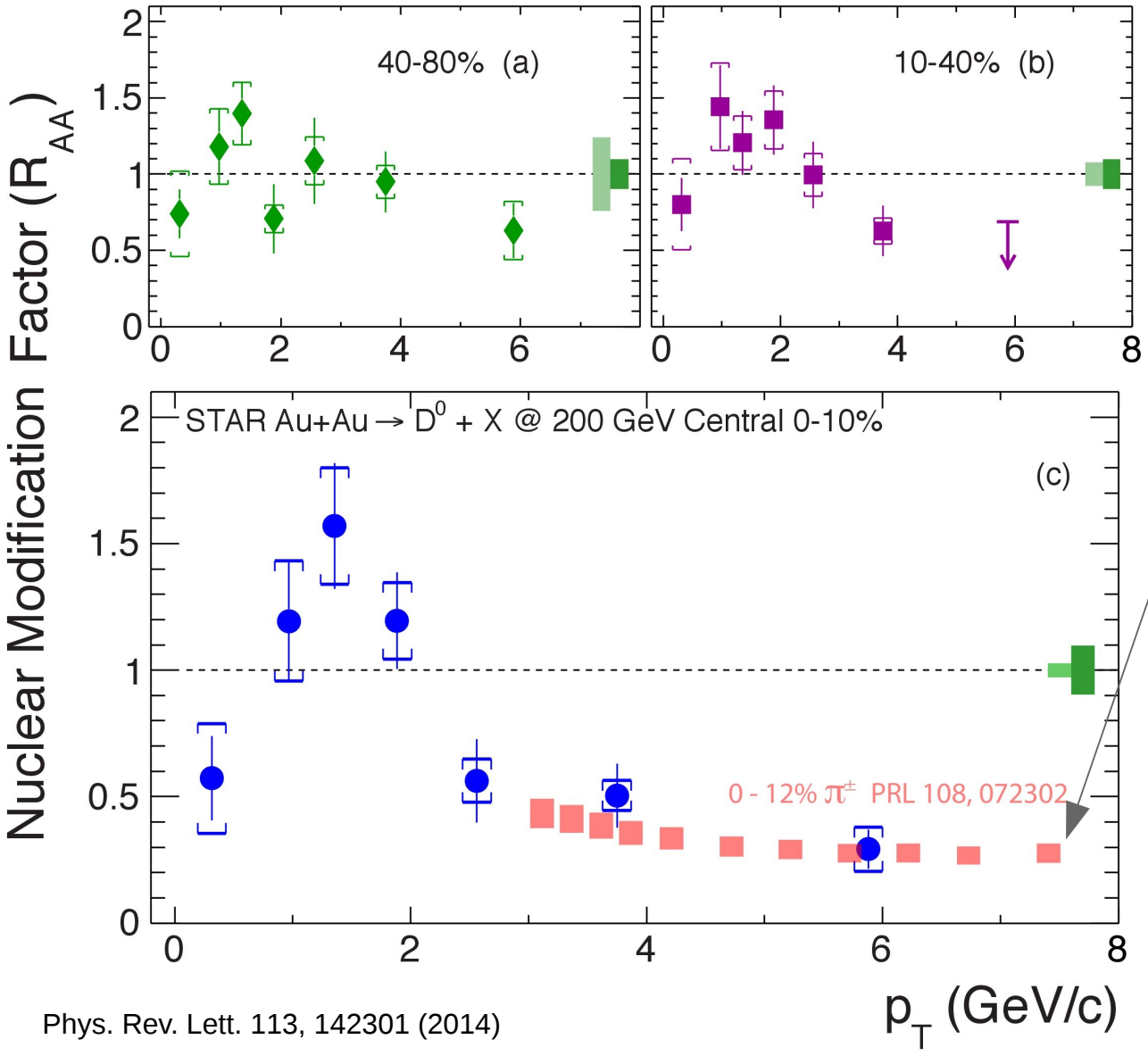
Phys. Rev. Lett. 113, 142301 (2014)



Total cross section scales with the number of binary collisions

Charm is mostly produced in initial hard processes

D^0 suppression in 200 GeV Au+Au



Phys. Rev. Lett. 113, 142301 (2014)

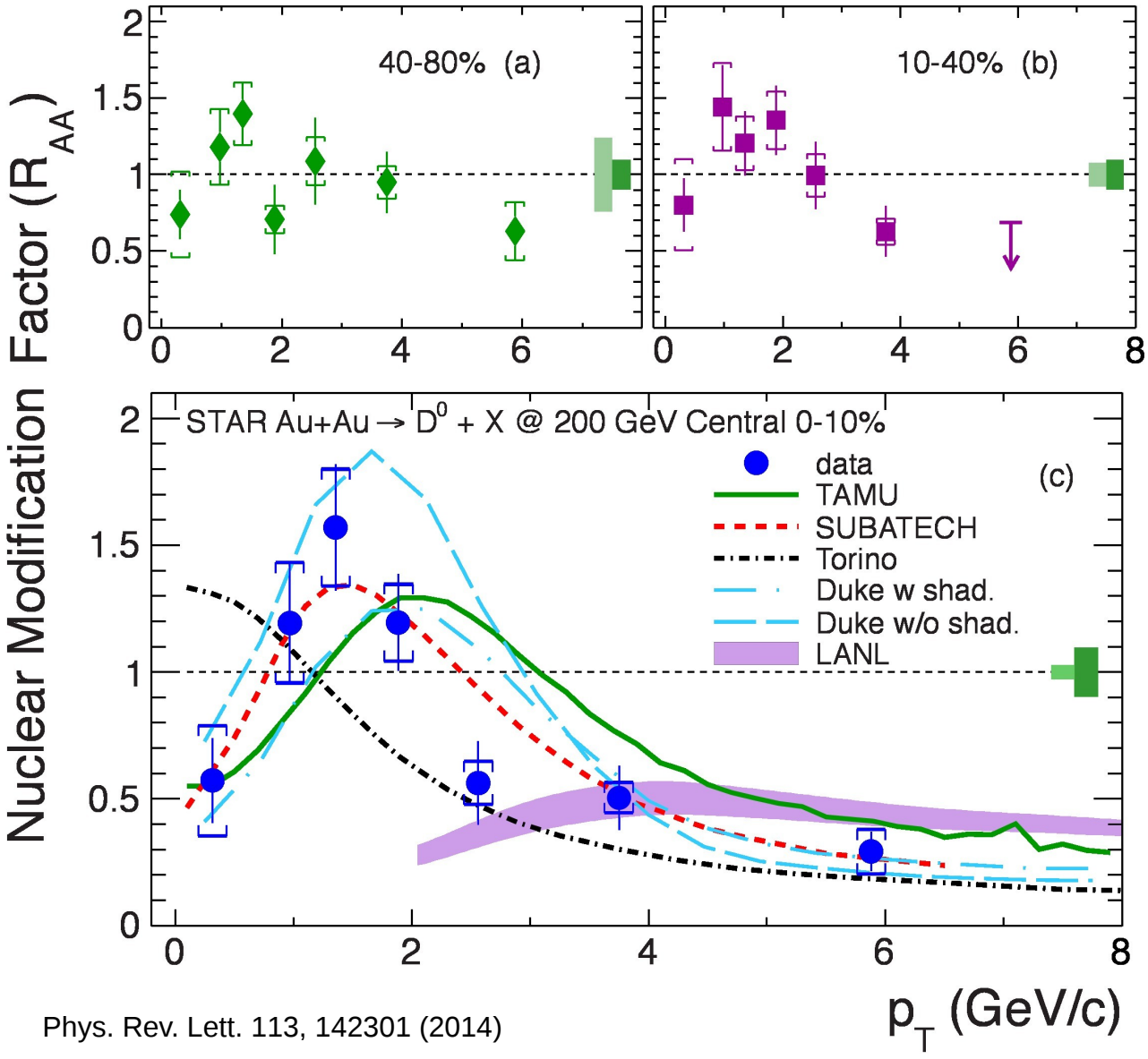
- p+p baseline from Levy fit to Run 09 data
- strong suppression in central collisions at p_T > 2GeV/c

  similar suppression to pions
- enhancement at 1 < p_T < 2 GeV/c

$$R_{AA} = \frac{1}{\langle N_{coll} \rangle} \frac{dN/dy^{AuAu}}{dN/dy^{PP}}$$

R_{AA} = 1 indicates no modification of the production in the medium.

D^0 suppression in 200 GeV Au+Au



Phys. Rev. Lett. 113, 142301 (2014)

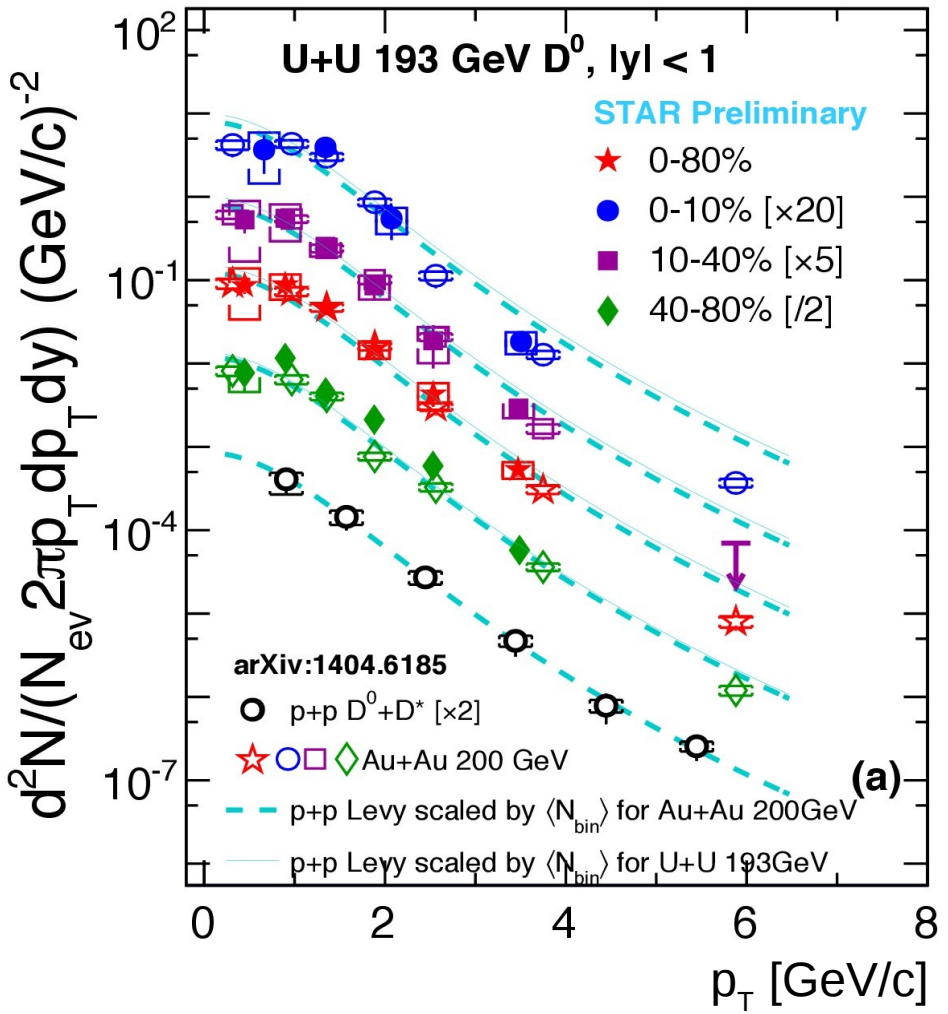
- p+p baseline from Levy fit to Run 09 data
- strong suppression in central collisions at $p_T > 2$GeV/c

  similar suppression to pions
- enhancement at $1 < p_T < 2$ GeV/c

Understanding from models:

- The enhancement is consistent with models that include charm–light quark coalescence
- The suppression is consistent with strong charm-medium interaction
- Cold Nuclear Matter effects might be important

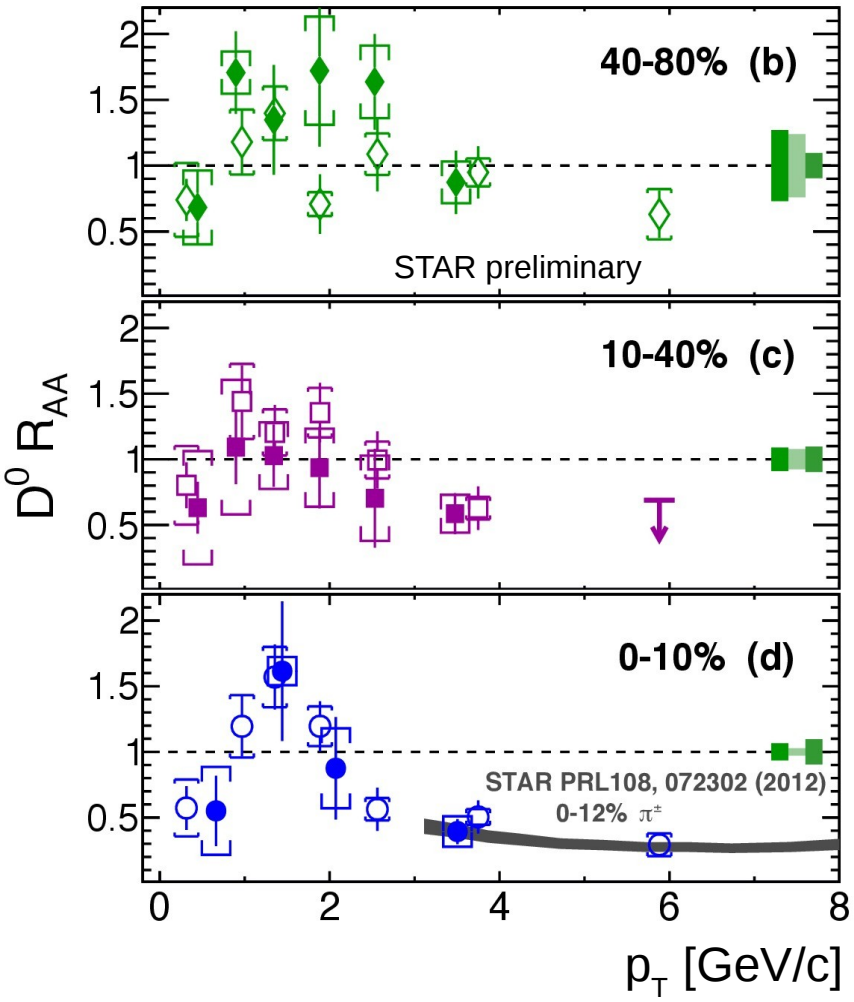
D^0 in 193 GeV U+U



Open symbols: Au+Au
Closed symbols: U+U

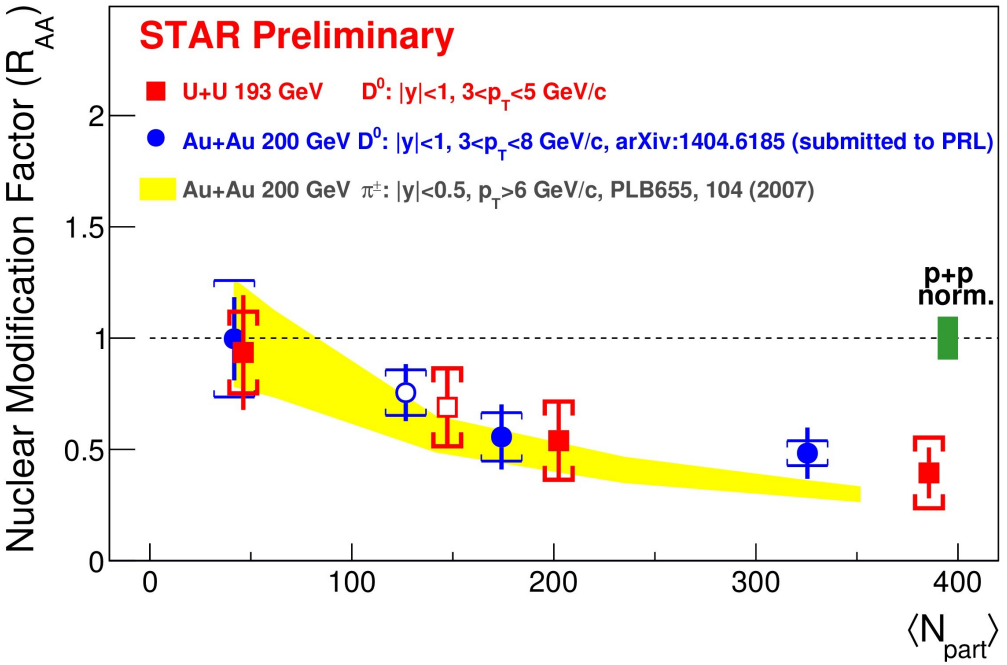
U+U collisions reach ~20% higher Bjorken energy density than Au+Au: Phys. Rev. C 84 054907

D^0 in 193 GeV U+U



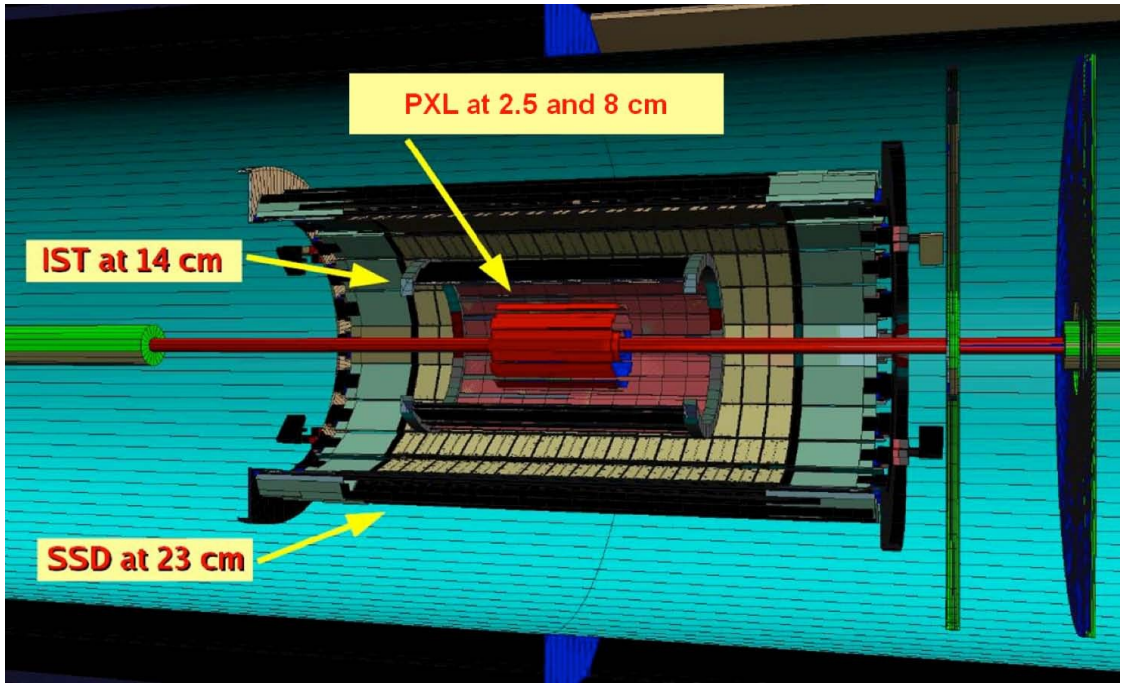
Open symbols: Au+Au
Closed symbols: U+U

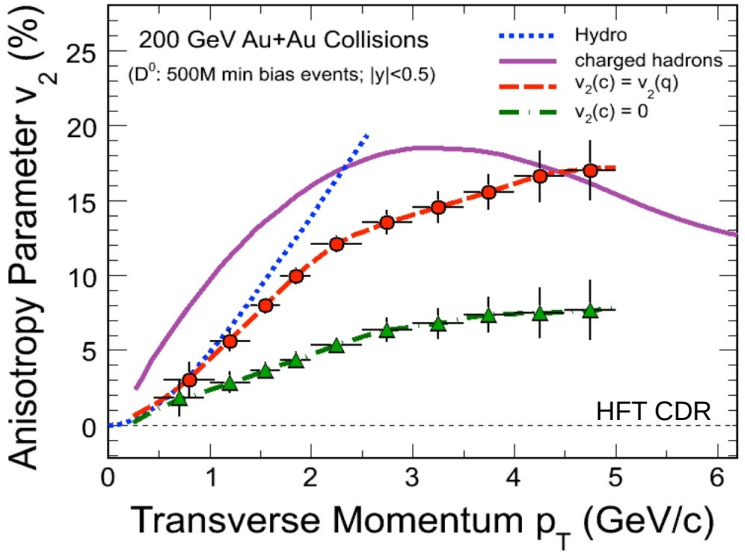
U+U collisions reach ~20% higher Bjorken energy density than Au+Au: Phys. Rev. C 84 054907

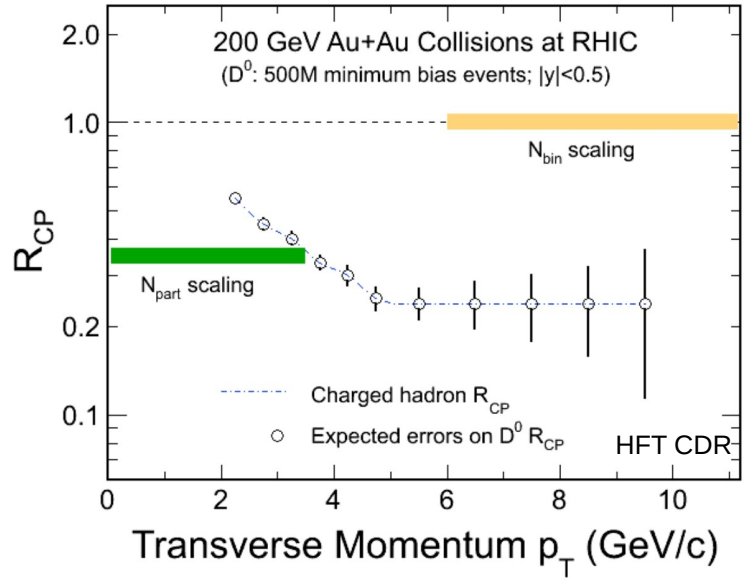


- Increasing suppression for p_T > 3 GeV/c with N_{part}
- Trend in Au+Au continued in U+U

Heavy Flavor Tracker (HFT)







- Precision measurement of heavy quark production
- Reconstruction of secondary vertices (separate charm and bottom)
- Run14 was taken with HFT fully operational

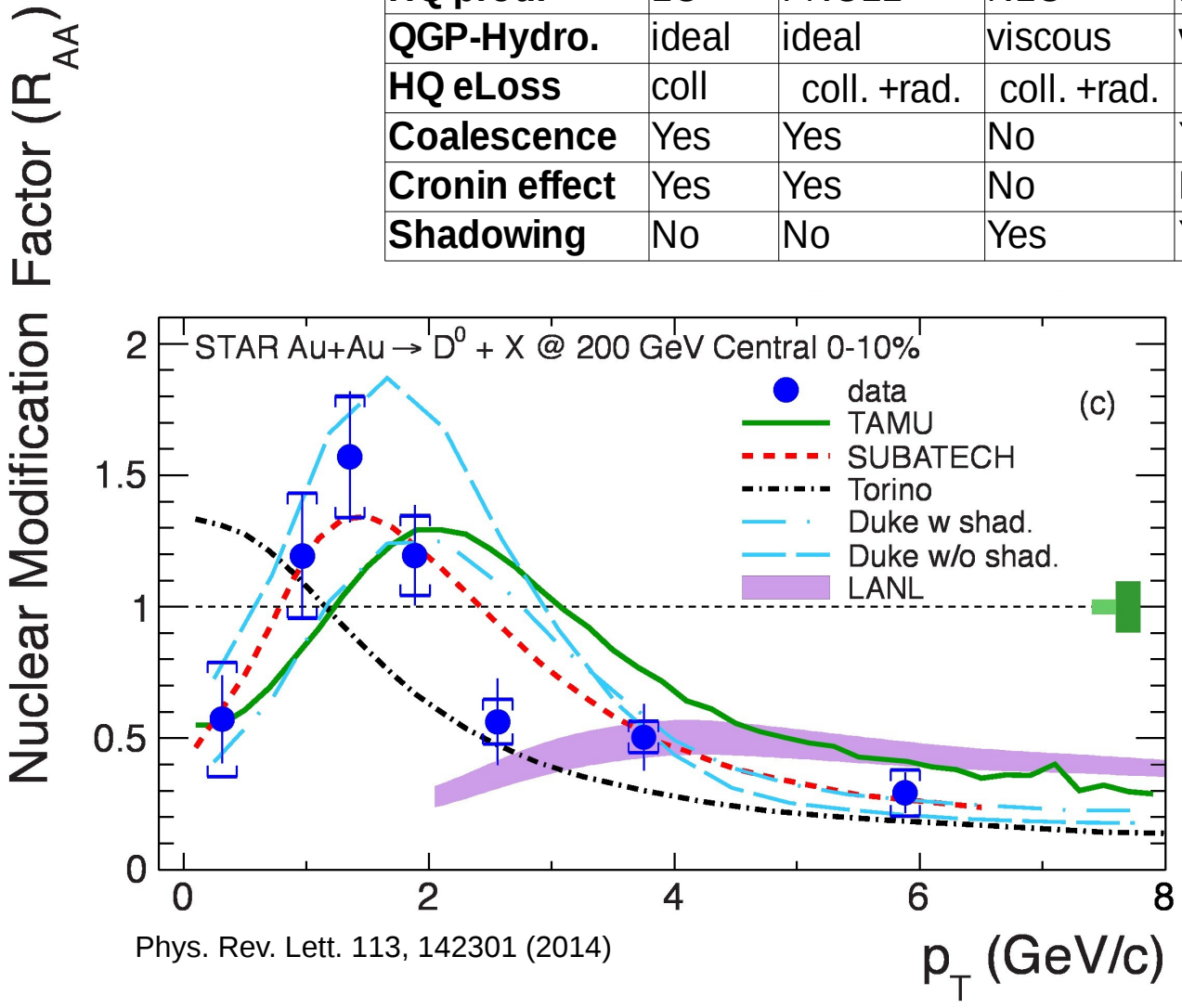
Summary

- Charm quark production cross-section in p+p collisions is consistent with pQCD predictions
- Total D^0 cross-section follows N_{bin} scaling confirming that charm is mostly produced in initial hard processes
- D^0 enhancement in central Au+Au collisions around 1.5 GeV/c suggests production via charm–light quark coalescence
- Strong suppression of D^0 production above 3 GeV/c in central Au+Au collisions indicates strong charm-medium interaction
- U+U measurements show similar suppression pattern to Au+Au

Backup

Models for R_{AA}

	TAMU	SUBTECH	Torino	Duke	LANL
HQ prod.	LO	FNOLL	NLO	LO	LO
QGP-Hydro.	ideal	ideal	viscous	viscous	ideal
HQ eLoss	coll	coll. +rad.	coll. +rad.	coll. +rad.	diss.+rad.
Coalescence	Yes	Yes	No	Yes	No
Cronin effect	Yes	Yes	No	No	Yes
Shadowing	No	No	Yes	Yes/No	Yes



Phys. Rev. Lett. 113, 142301 (2014)

Understanding from models:

- The enhancement is consistent with models that include charm–light quark coalescence
- The suppression is consistent with strong charm-medium interaction
- Cold Nuclear Matter effects might be important