STAR measurements of open charm production in dAu collisions at $\sqrt{s_{NN}}$=200 GeV

An Tai

UCLA

For the STAR Collaboration

(1) Motivations

(2) Data analysis

(3) Results and Conclusions

Motivations:

- Study heavy quark dynamic in medium, such as heavy quark energy loss in dense matter, and probe medium properties through heavy quarks
- Gluon structure function of nuclei
- Comparing ratios of different open charm species with the statistical model prediction--- is the charm quark hadronization modified by the thermal medium ?

dAu provides an important reference to study heavy flavor production in Au+Au

Decay channels used in this analysis

$$D^0 \rightarrow K^-\pi^+ (3.8\%)$$

$$D^0 \rightarrow K^-\pi^+\rho^0(\pi^+\pi^-) \ (6.2\%)$$

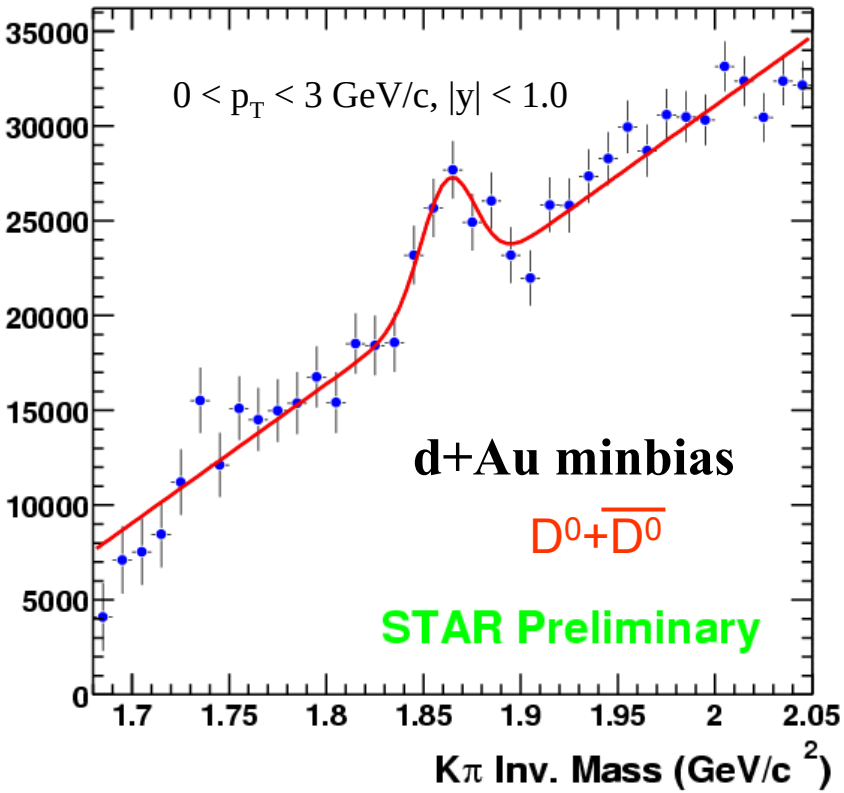
$$D^\pm \rightarrow K\pi\pi \qquad (9.1\%)$$

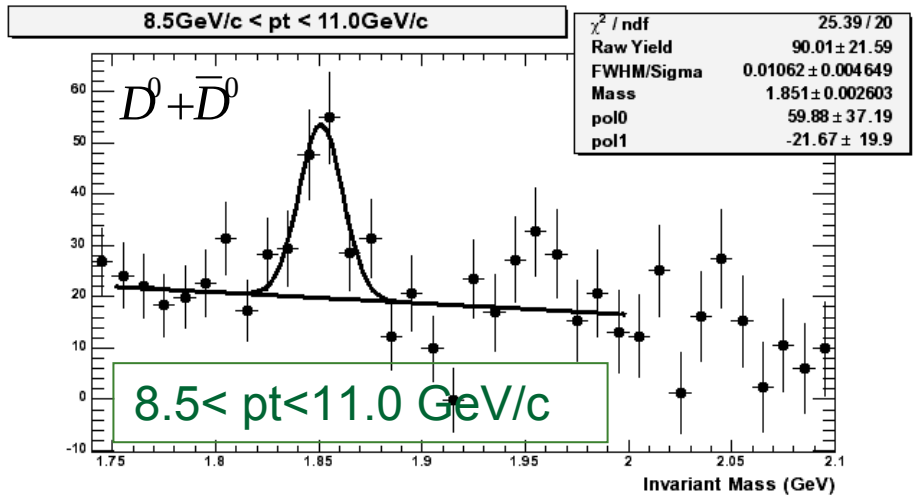
$$D^{*\pm} \rightarrow D^0\pi_s(68\%), D^0 \rightarrow K\pi(3.8\%)$$

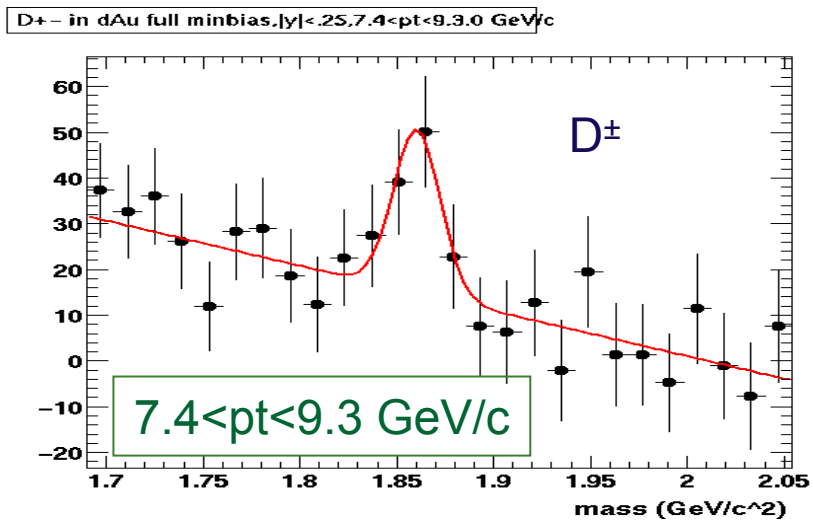
About 15 M dAu minbias events are used in the analysis

we also measure D from its semi-leptonic decay to electrons in both dAu and pp collisions at $\sqrt{s_{NN}}$=200 GeV

Mass plots from dAu data using event-mixing technique



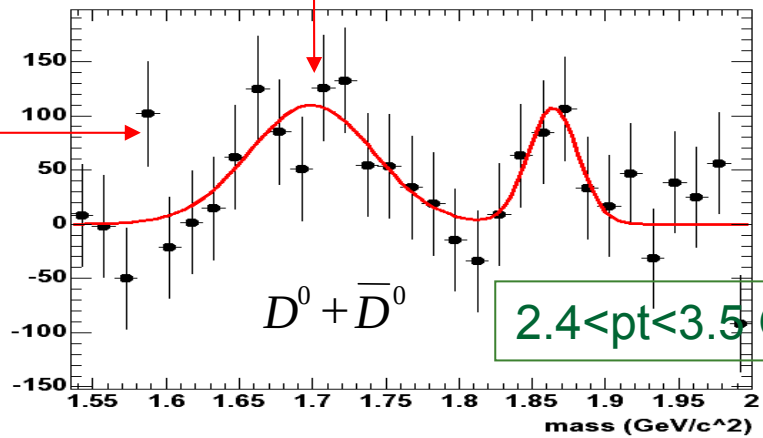




D*± Signal

D0→K-π+π0 (13.1%)

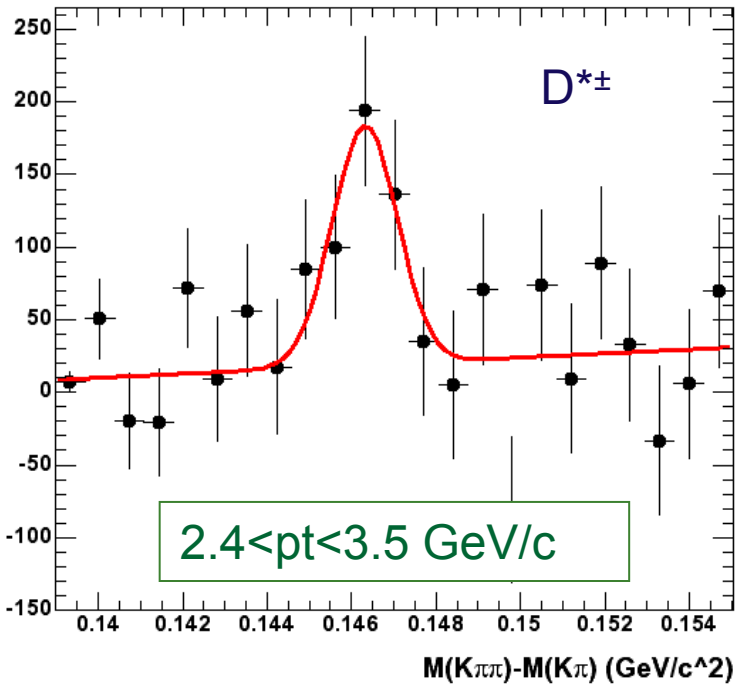
D0 from D* in dAu full minbias,|y|<.25,2.4<pt<3.5 GeV/c



D^0 from D^* decay (tagged D^0)

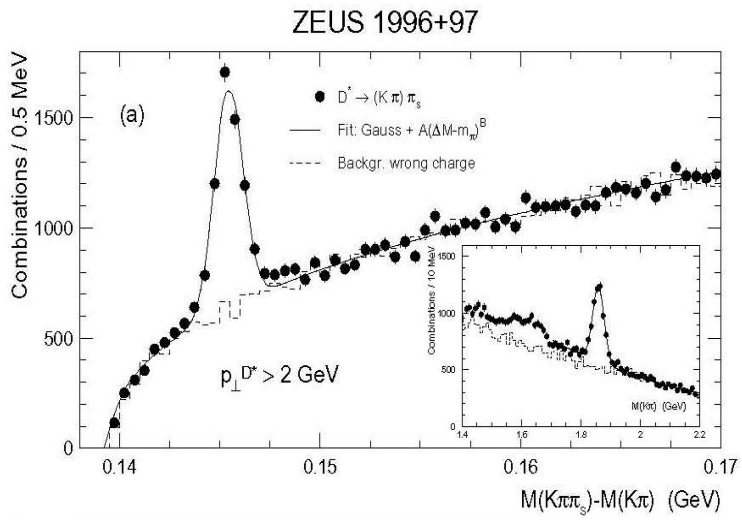
2.4<pt<3.5 GeV/c

D*, dAu minbias,|y|<0.25,2.4<pt<3.5 GeV/c



2.4<pt<3.5 GeV/c

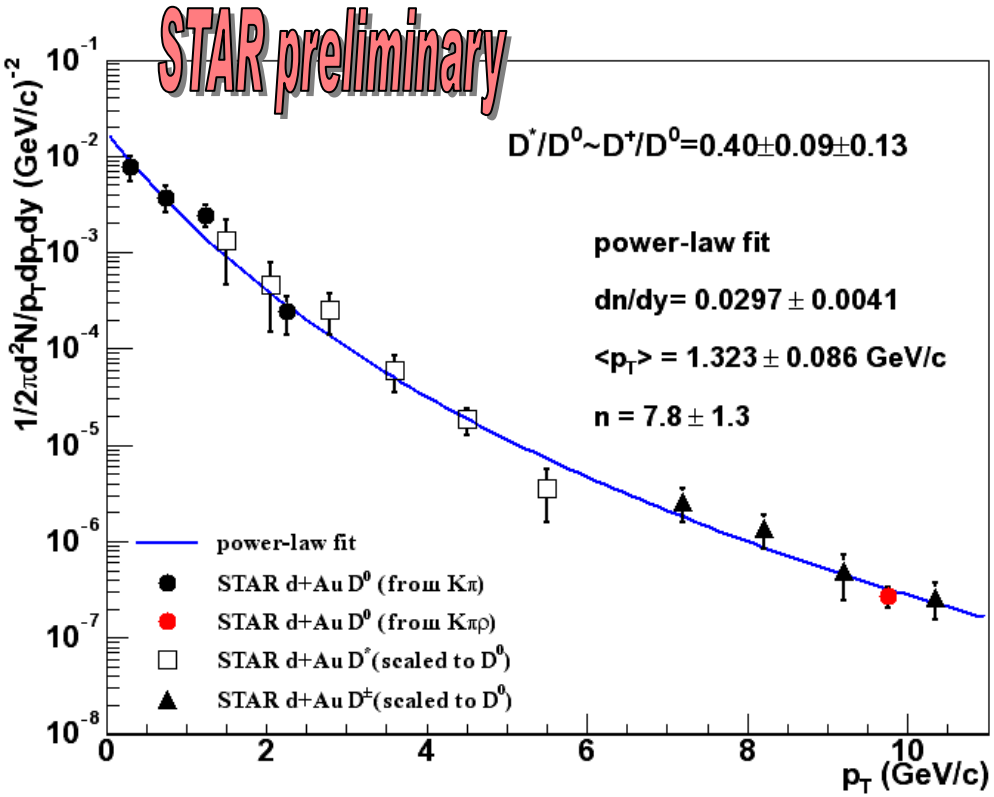
ZEUS 1996+97



Results

Assuming $\sigma(D^*) = \sigma(D^{\pm})$ and scale $\sigma(D^*)$ and $\sigma(D^{\pm})$ to match D0 by $D^*/D0=0.40$

dAu minbias at $\sqrt{s}$=200 GeV



$$\sigma_{c\bar{c}} = 1.2 \times \left(\frac{\sigma(D^0) + \sigma(D^+) + c.c.}{2} \right)$$

$$\sigma_D^{NN} = \frac{(dn/dy) \times \sigma_{inel}}{N_{bin}} \times 4$$

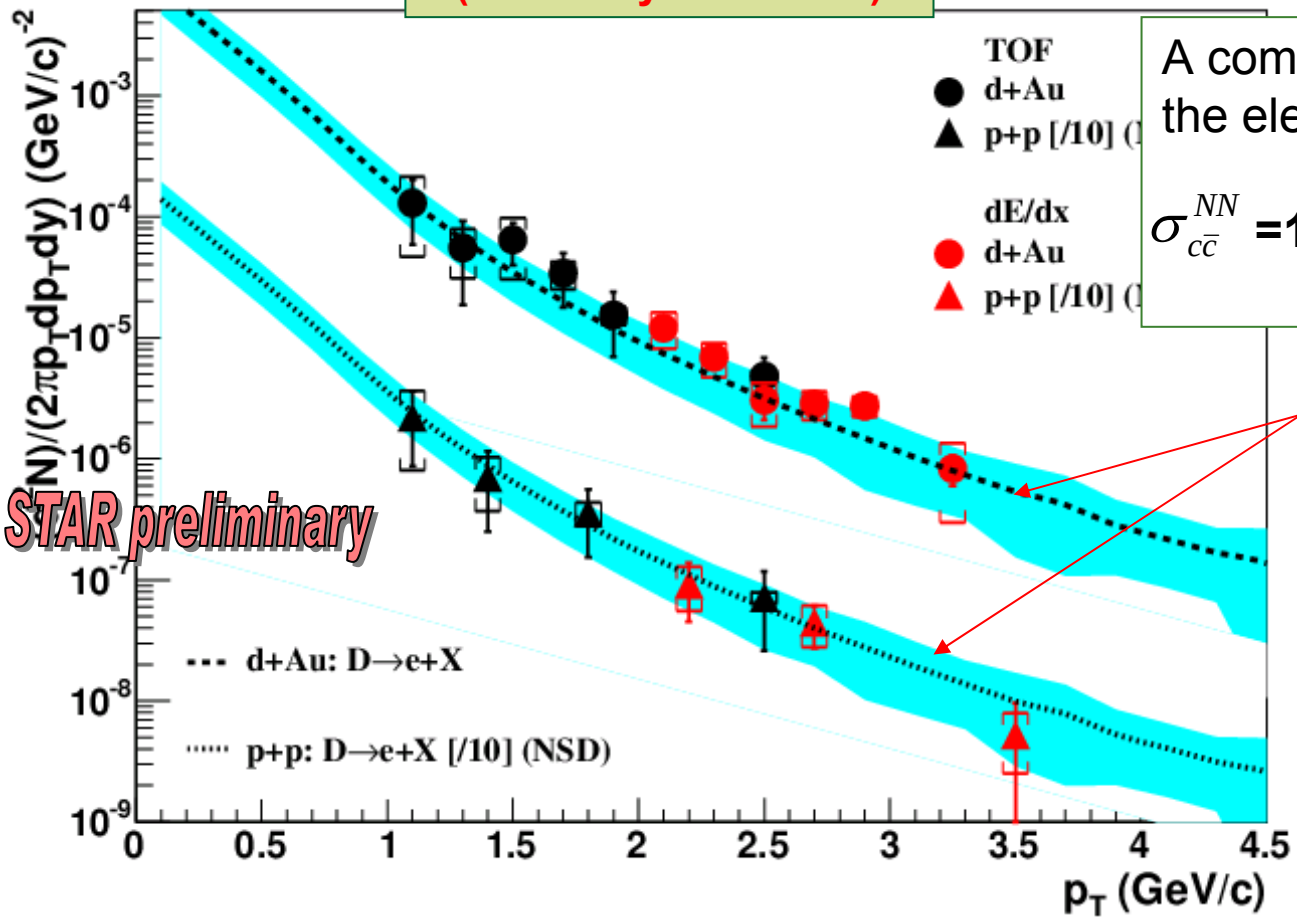
= dn/dy*42*4/7.5

$$\sigma_{c\bar{c}}^{NN} = 1.12 \pm 0.20 \pm 0.37 \text{ mb}$$

total multiplicity=4*dn/dy(|y|<0.5)

The measurements of open charms are consistent with background-subtracted electron data in STAR !

Lijuan Ruan's talk (Thursday afternoon)



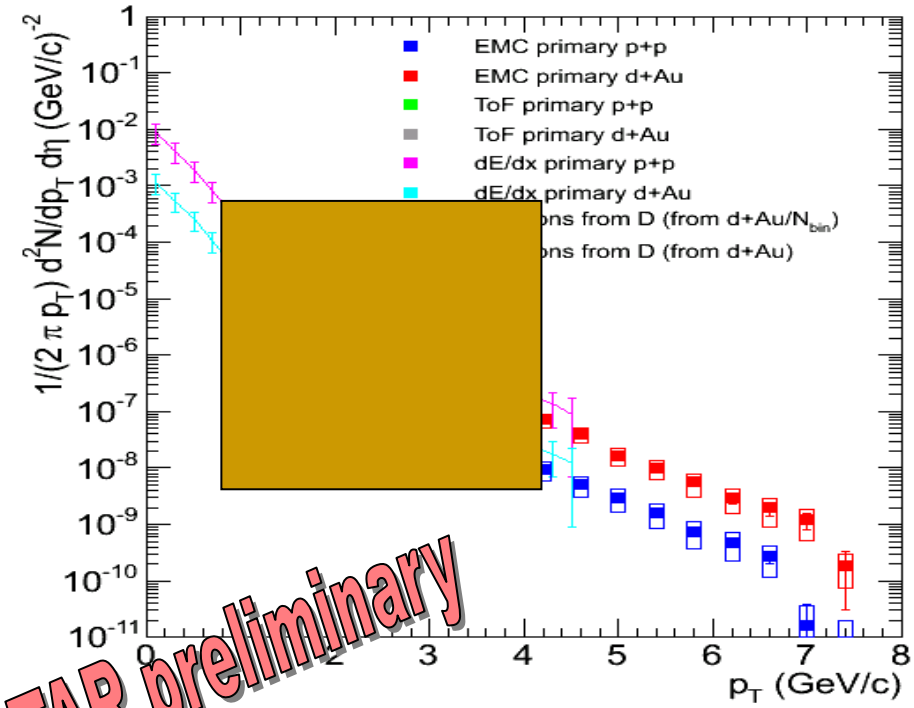
A combined fit using D^0 and the electron data leads

$\sigma_{c\bar{c}}^{NN}$ **=1.36± 0.20 ± 0.39 mb**

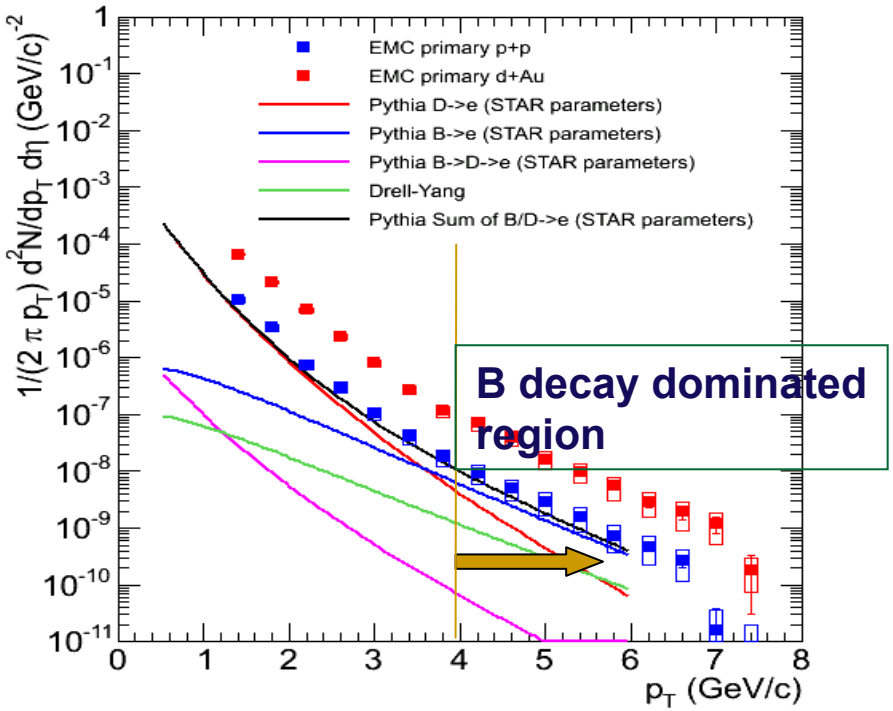
The band is obtained from D decay based on the power-law fit to the measured open charm spectrum.

STAR background-subtracted electrons by EMC first time seeing beauty at RHIC !

Alex Suaide's talk (Thursday afternoon)

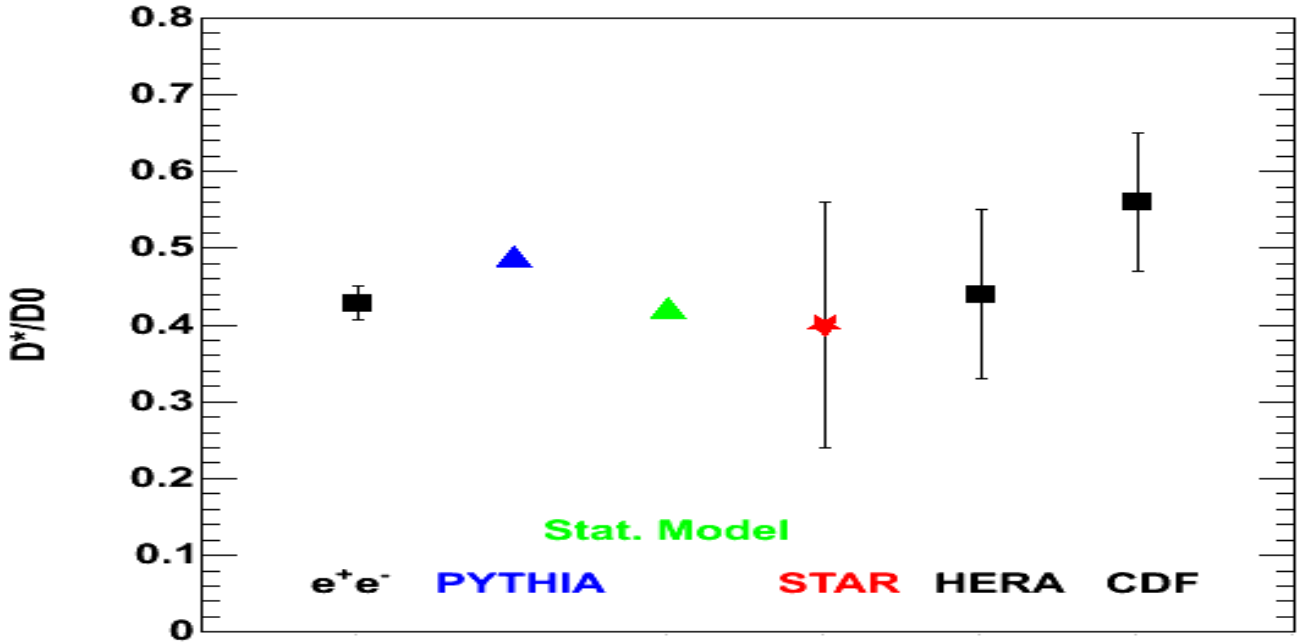


STAR preliminary



B decay dominated region

D^*/D^0 ratios --- consistent with other experiments



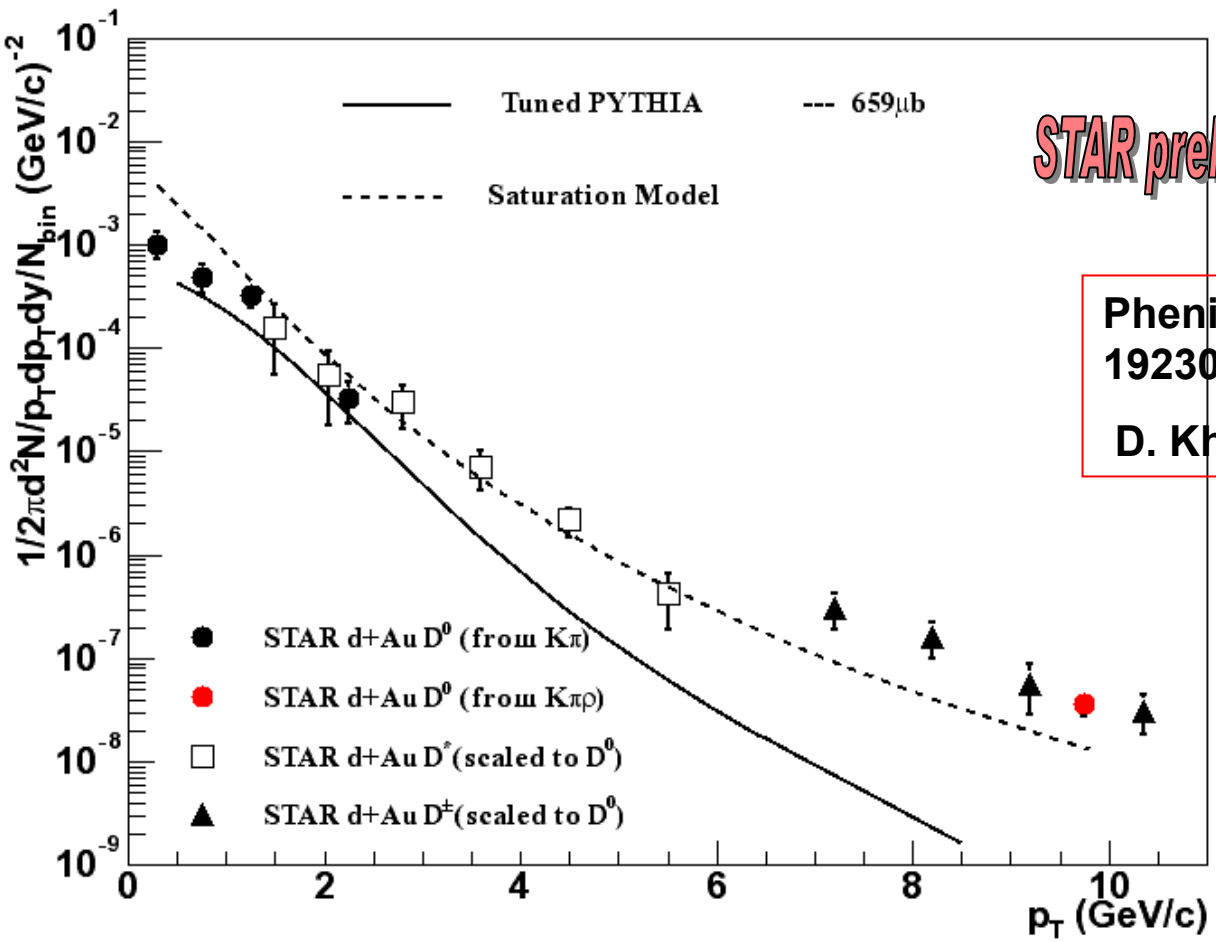
CDF: hep-ex/0307080

HERA: www-h1.de/h1/www/publications/conf_list.html

e+e-: hep-ph/0312054

Statistical model: A. Andronic etc. nucl-th/0209035 and private communication.

Open charm spectrum is hard !

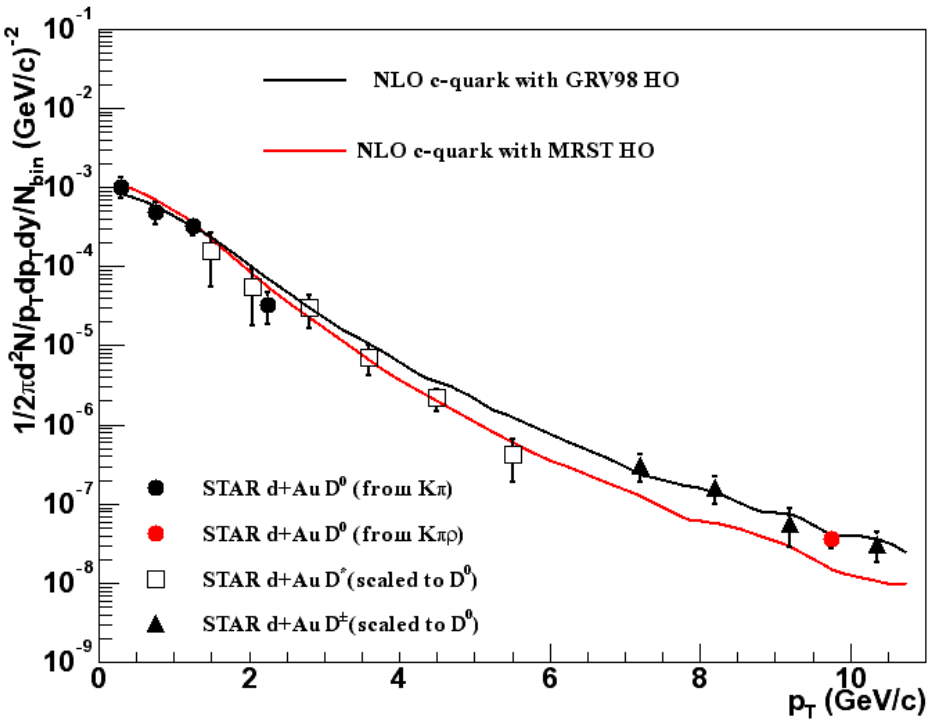


Phenix: Phys. Rev. Lett. 88, 192303(2002)

D. Kharzeev,hep-ph/0310358

Charm quark hadronization at RHIC

bare c-quark spectrum,
normalized to measured dn/dy



- D spectrum would be drop by a factor of 3 at pt~10GeV/c when Peterson fragmentation function is set in.
- Harder fragmentation function, like, δ(z-1), is needed
- c-quark may hadronize through recombination mechanism.

NLO pQCD predictions are provided by R. Vogt, Int. J. Mod. Phys. E12 (2003) 211

Conclusion I

- **D0,D* and D± are first measured in dAu run at $\sqrt{s}$=200 GeV using STAR TPC with a p_T coverage of 0<pt<11 GeV/c**
- **$\sigma_{c\bar{c}}^{NN}$ =1.12 ± 0.20 ± 0.37 mb from directly-measured open charm and $\sigma_{c\bar{c}}^{NN}$ =1.36± 0.20 ± 0.39 mb from D^0 and the single electron measurement**
- **D^*/D^0= 0.40±0.09(stat)±0.13(sys), consistent with other experimental results.**

Conclusion II

- **STAR measured D spectrum and single electron are consistent.**
- **The measured D pt spectrum coincides with the bare-quark distribution from the NLO calculation.**
- **A hard D meson p_T spectrum may be obtained from k_T factorization scheme (Kharzeev et al), or charm quark recombination or very hard charm fragmentation function (δ(z-1) function).**

k_T broadening and c-quark fragmentation at fixed target experiment

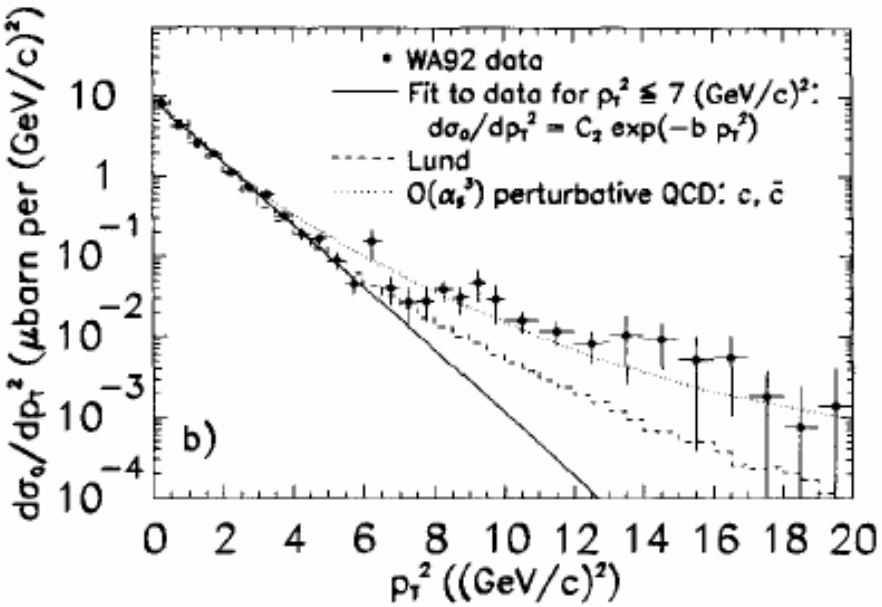
momentum loss due to fragmentation can be counter-balanced by initial k_T

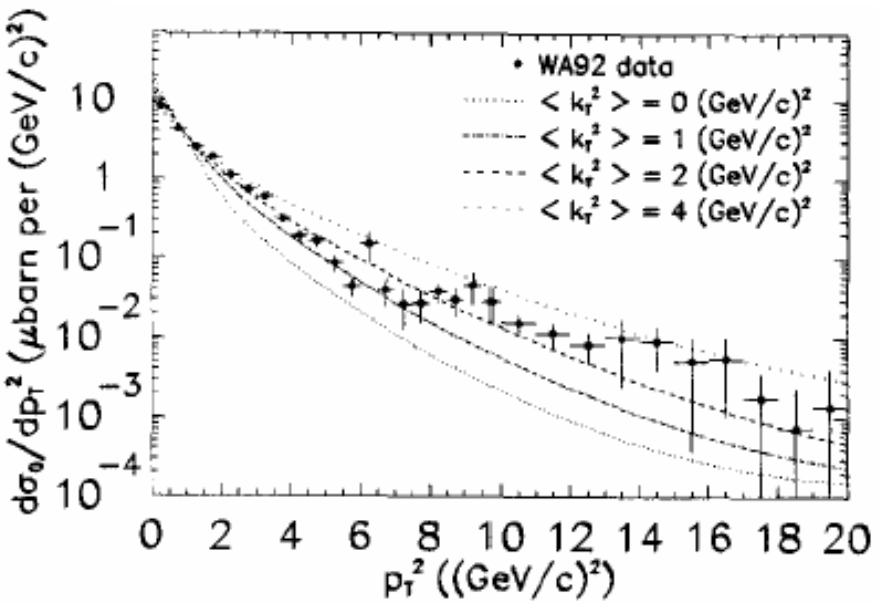
Bare c-quark spectrum

π+A scattering at 350 GeV/c

After k_T and fragmentation

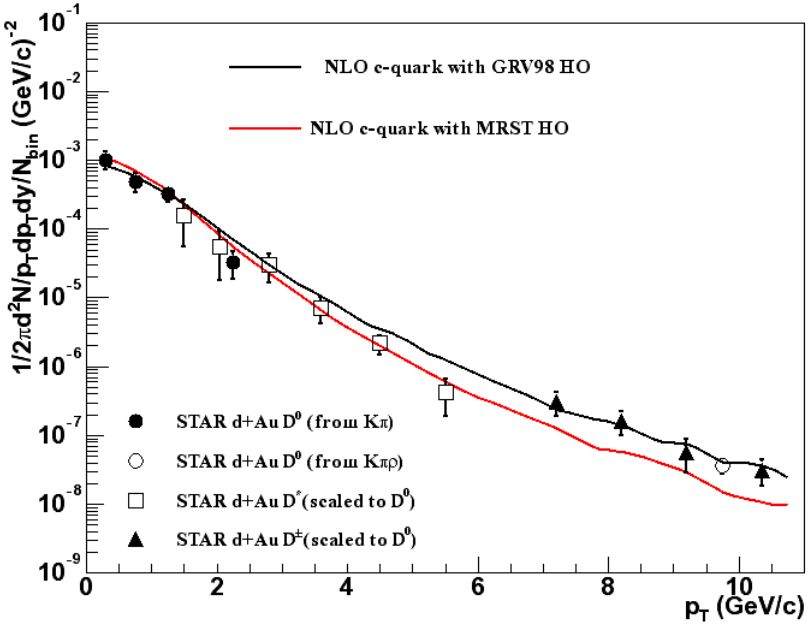
ε=0.06



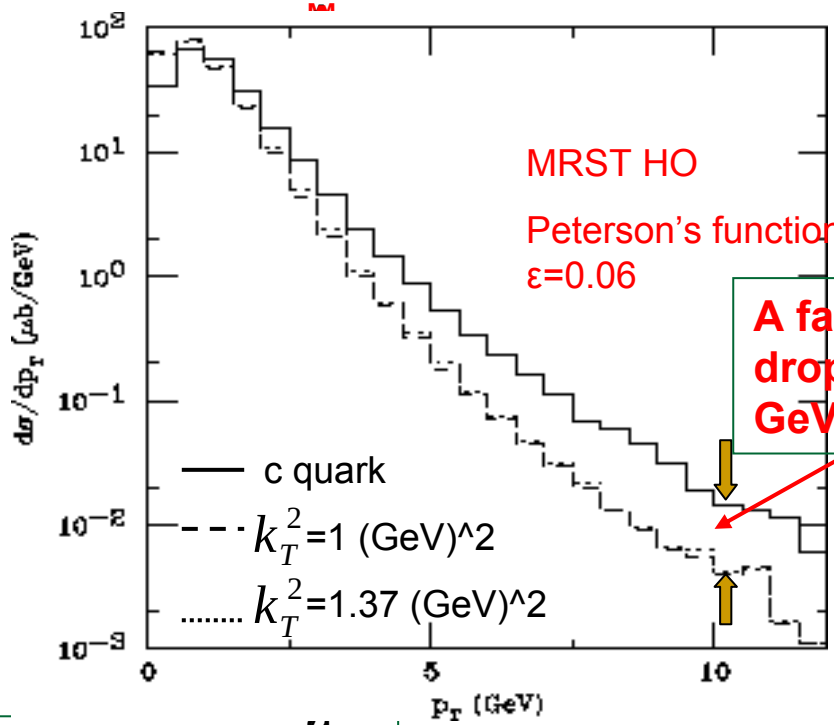


Charm quark hadronization at RHIC ---- harder fragmentation function or c-quark recombination ??

bare c-quark spectrum, normalized to measured dn/dy



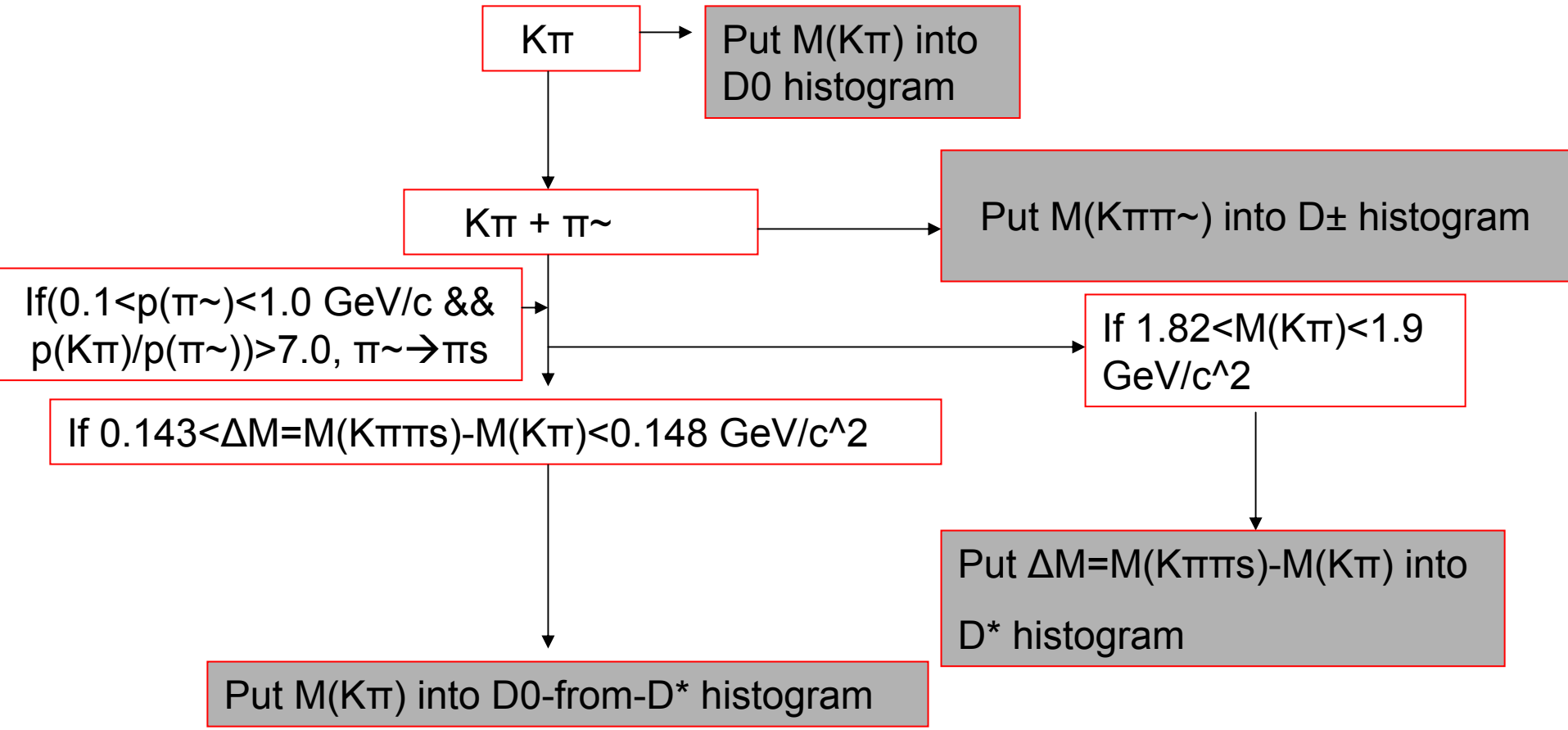
After k_T and fragmentation



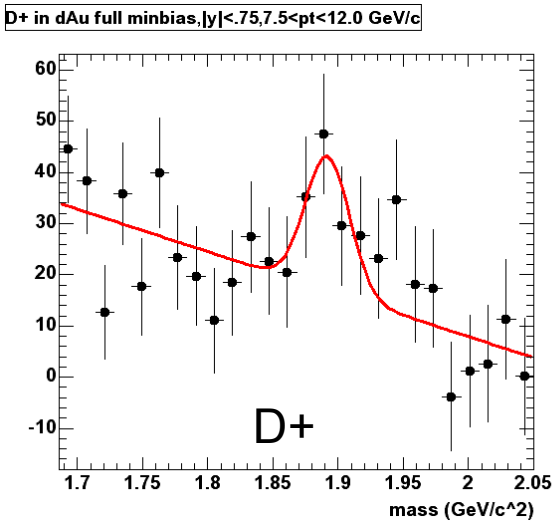
A factor of ~3 drop at pt~10 GeV/c

NLO pQCD predictions are provided by R. Vogt

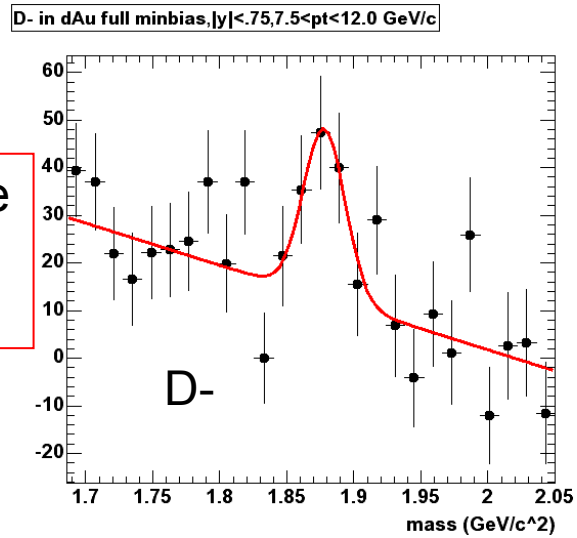
Analysis procedure

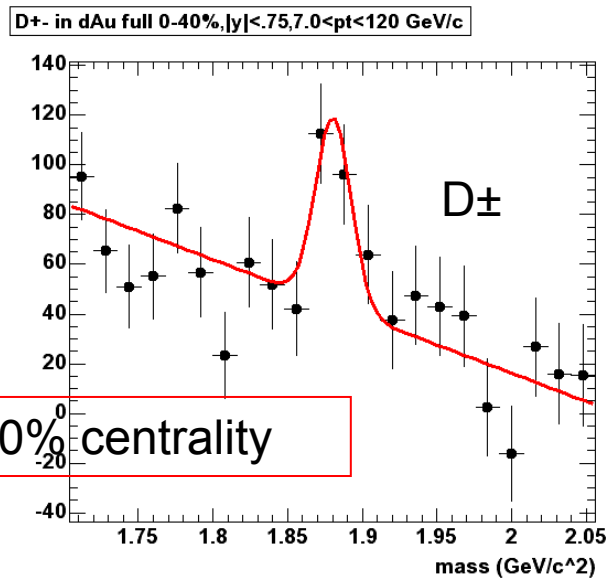


D± signal is real



Raw countings are close for D+ and D-

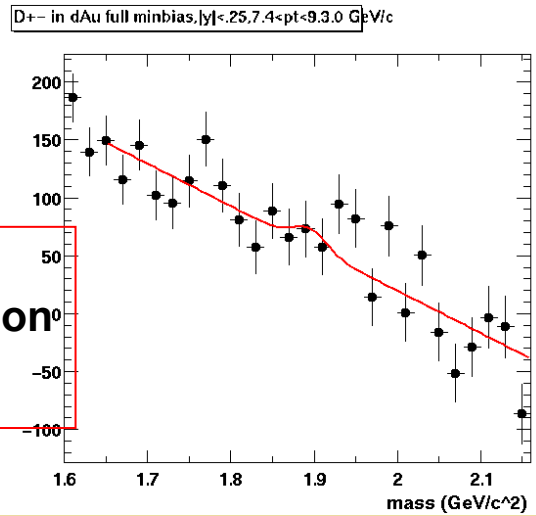




0-40% centrality

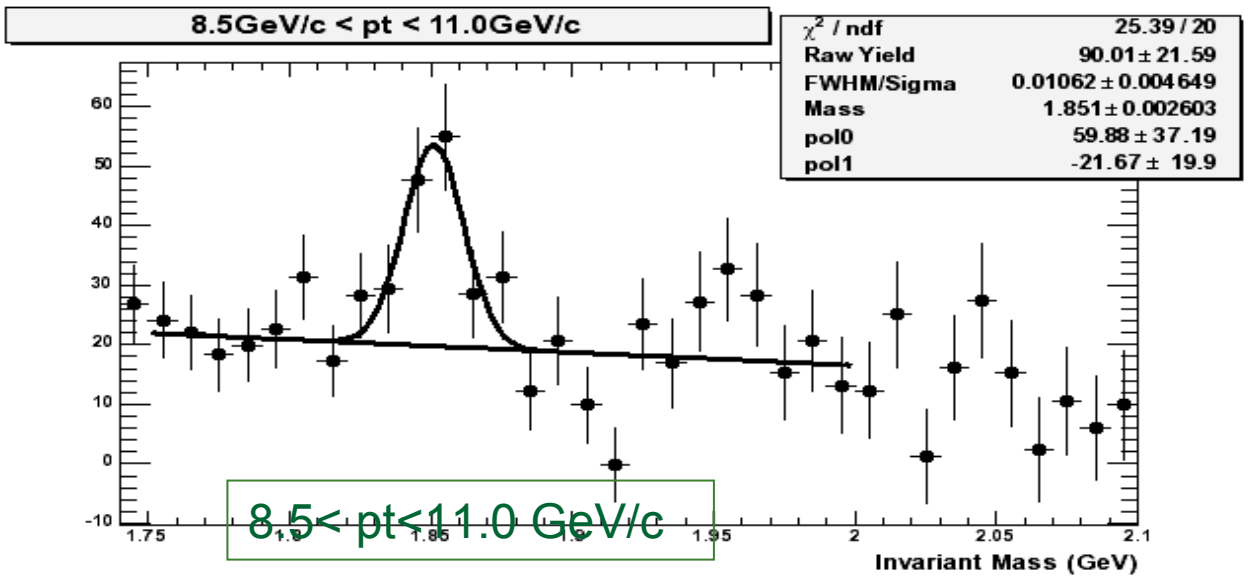
K-π+π- ---wrong charge combination

No signal !



D^0 signal from $D^0 \to K^-\pi^+\rho^0(\pi^+\pi^-)$ BR=6.2%

0.53GeV < m(ρ) < 0.95GeV



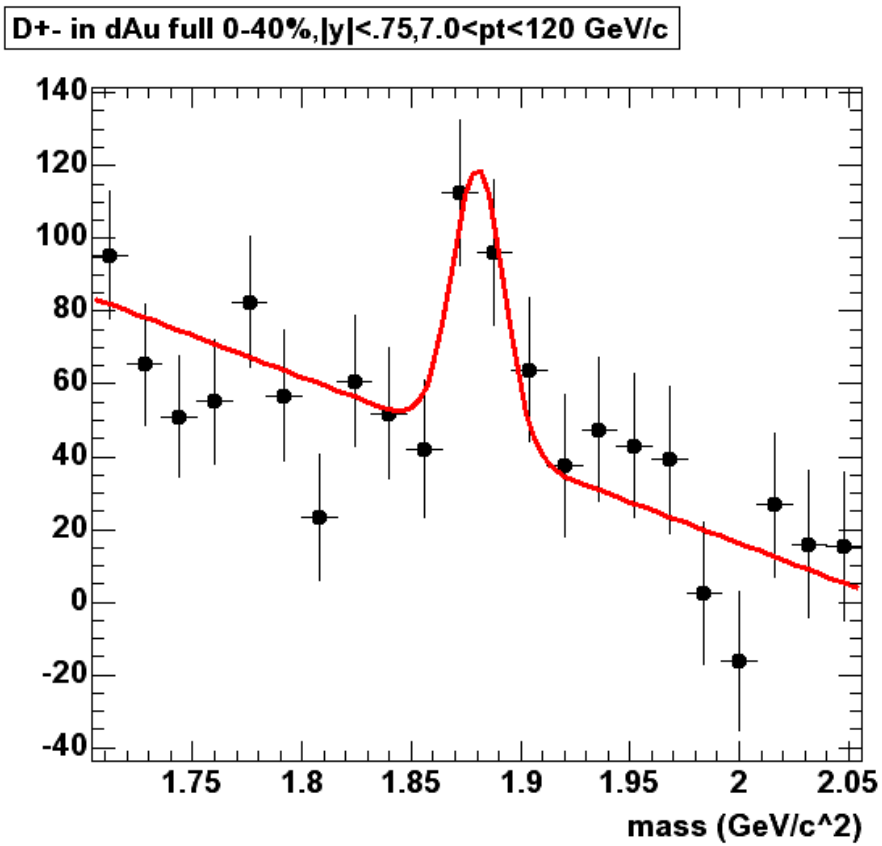
$D^{\pm}$ signal is real

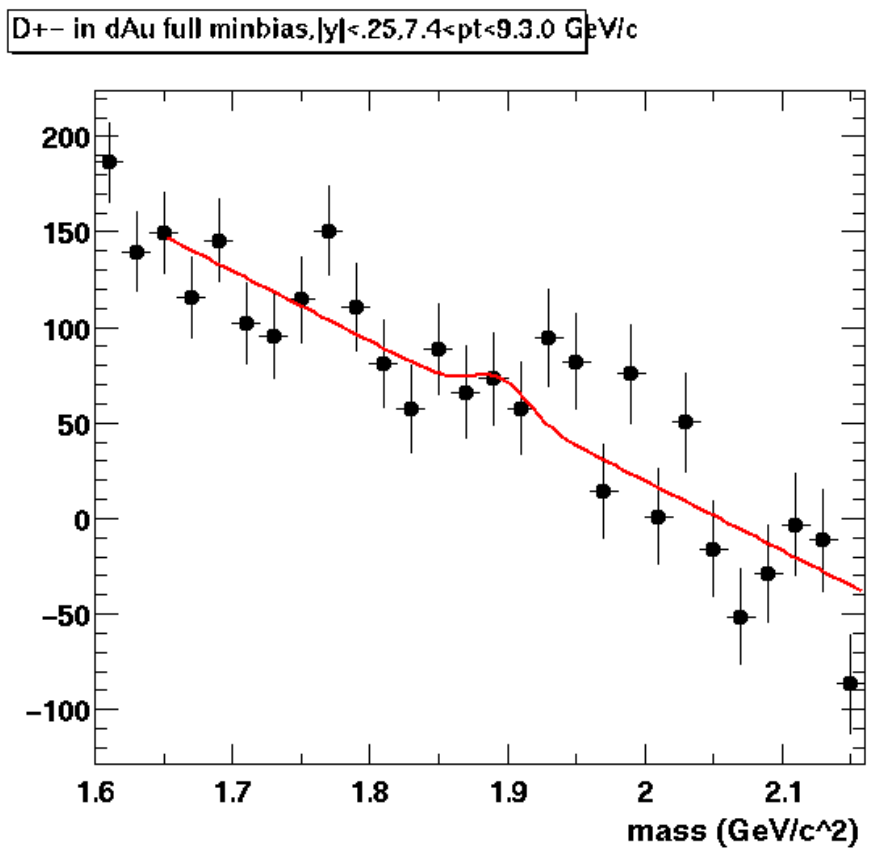
0-40% centrality

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

wrong charge combination

No signal !





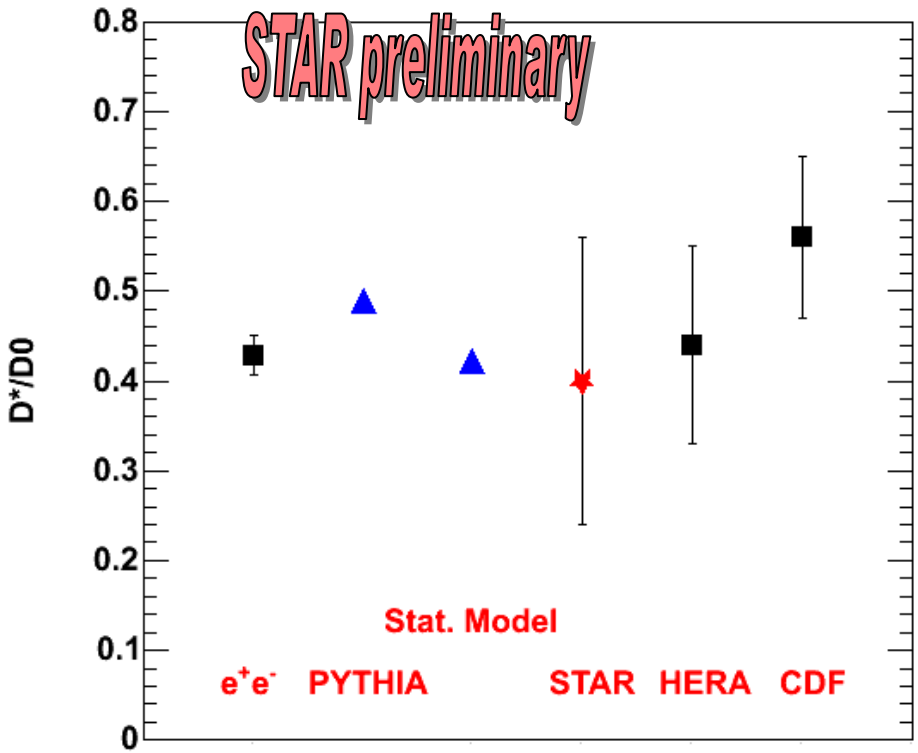
D^*/D^0 ratios

CDF: hep-ex/0307080

HERA: www-h1.de/h1/www/publications/conf_list.html

e+e-: hep-ph/0312054

Statistical model: A. Andronic etc. nucl-th/0209035 and private communication.



(1) Assume $D^* = D^0(\text{dir})$

$D^0 = D^0(\text{dir}) + 0.68 D^{*\pm} + D^{*0}$

$D^*/D^0 = 0.37$

(2) Assume $D^* = 3D^0(\text{dir})$

$D^0 = D^*/3 + 0.68 D^{*\pm} + D^{*0}$

$D^*/D^0 = 0.50$

Mass and width: Measured vs Monte Carlo
------Agree well
width is dominated by detector resolutions

D^0

mass=1.867±0.006 GeV
mass(MC)=1.865 GeV
Sigma=13.7±6.8 MeV
Sigma(MC)=14.5 MeV

$D^{\pm}$

mass=1.864±0.0052 GeV
mass(MC)=1.868±0.002 GeV
Sigma=13.83±3.7 MeV
Sigma(MC)=14.9±1.6 MeV

$D^* - D^0$

mass=0.1467±0.00016 GeV
mass(MC)=0.1451 GeV
Sigma=0.43±0.14 MeV
Sigma(MC)=0.67 MeV

Pythia parameters

Phenix-tuned pythia parameters:

<kt>=1.5 GeV/c, mc=1.25 GeV/c^2

K-factor=3.5, CTEQ5L, PARP(67)=1

σ(ccbar)=653μb

STAR tuned pythia parameters <kt>=2.0 GeV/c, mc=1.7 GeV/c^2,

K-factor=2.2, CTEQ5M1, PARP(67)=4

σ(ccbar)=1078 μb