Measurements of Pion, Kaon and Proton Spectra with Heavy Flavor Tracker in Au+Au 200GeV at STAR Experiment

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Outline

- Motivation
- Analysis
  - STAR detector
  - Heavy Flavor Tracker
- Results
  - p_T spectra
  - particle ratios
  - dN/dy distribution

Motivation

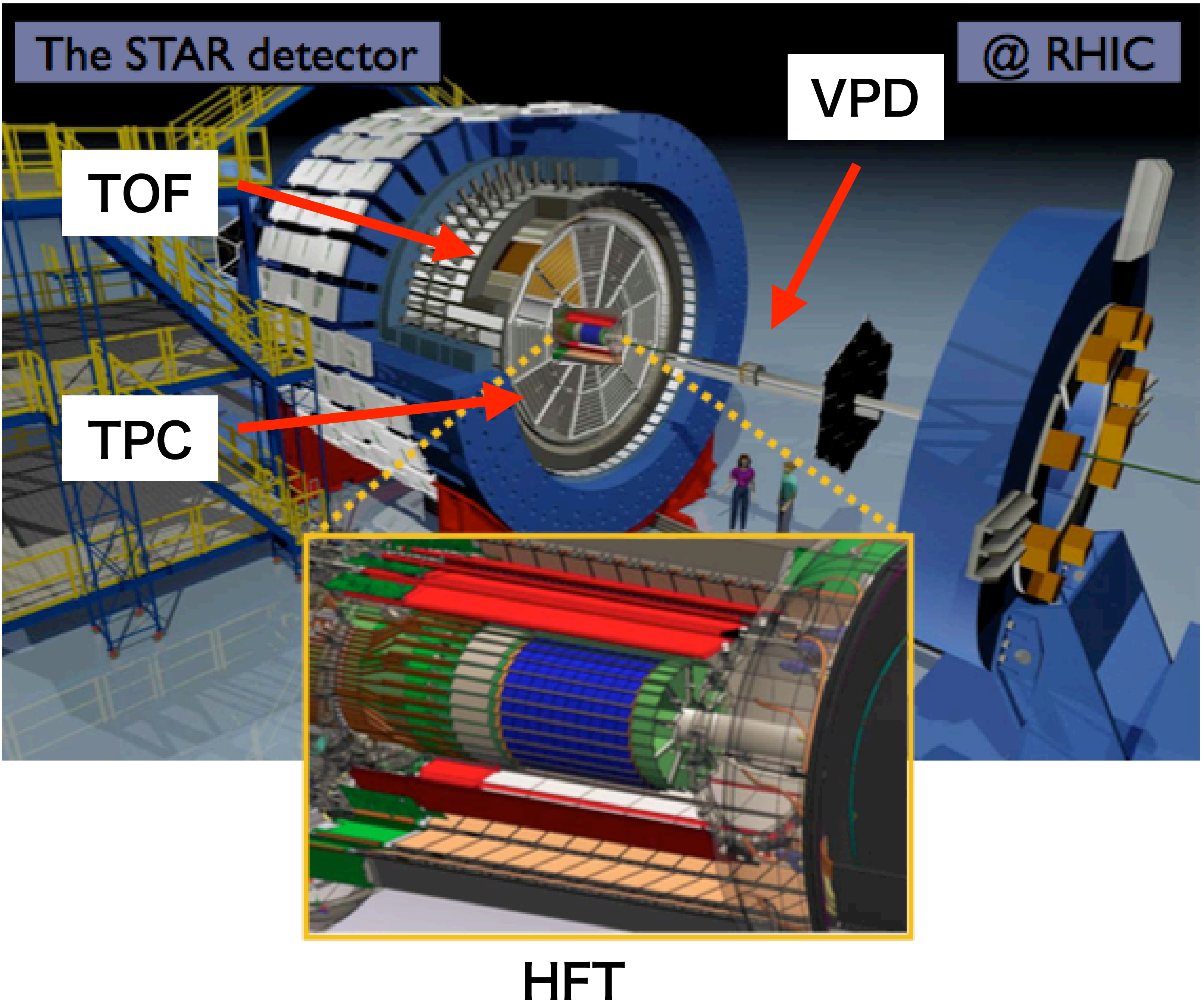
- Inclusive proton includes ~40% of protons from weak decay in Au+Au 200GeV.

PRL 92, 112301 (2004)
PRC 69, 034909 (2004)

- STAR - inclusive proton spectra
  not corrected for weak decay feed down contribution
  PHENIX - prompt proton spectra
  proton coming from Λ is estimated based on model simulations

- This result will be first direct measurement of prompt proton p_T spectra with new HFT detector at RHIC.

STAR detector



Vertex Position Detector

Minimum bias trigger

Time Projection Chamber

Centrality definition

Particle trajectory

Momentum measurement

PID (dE/dx)

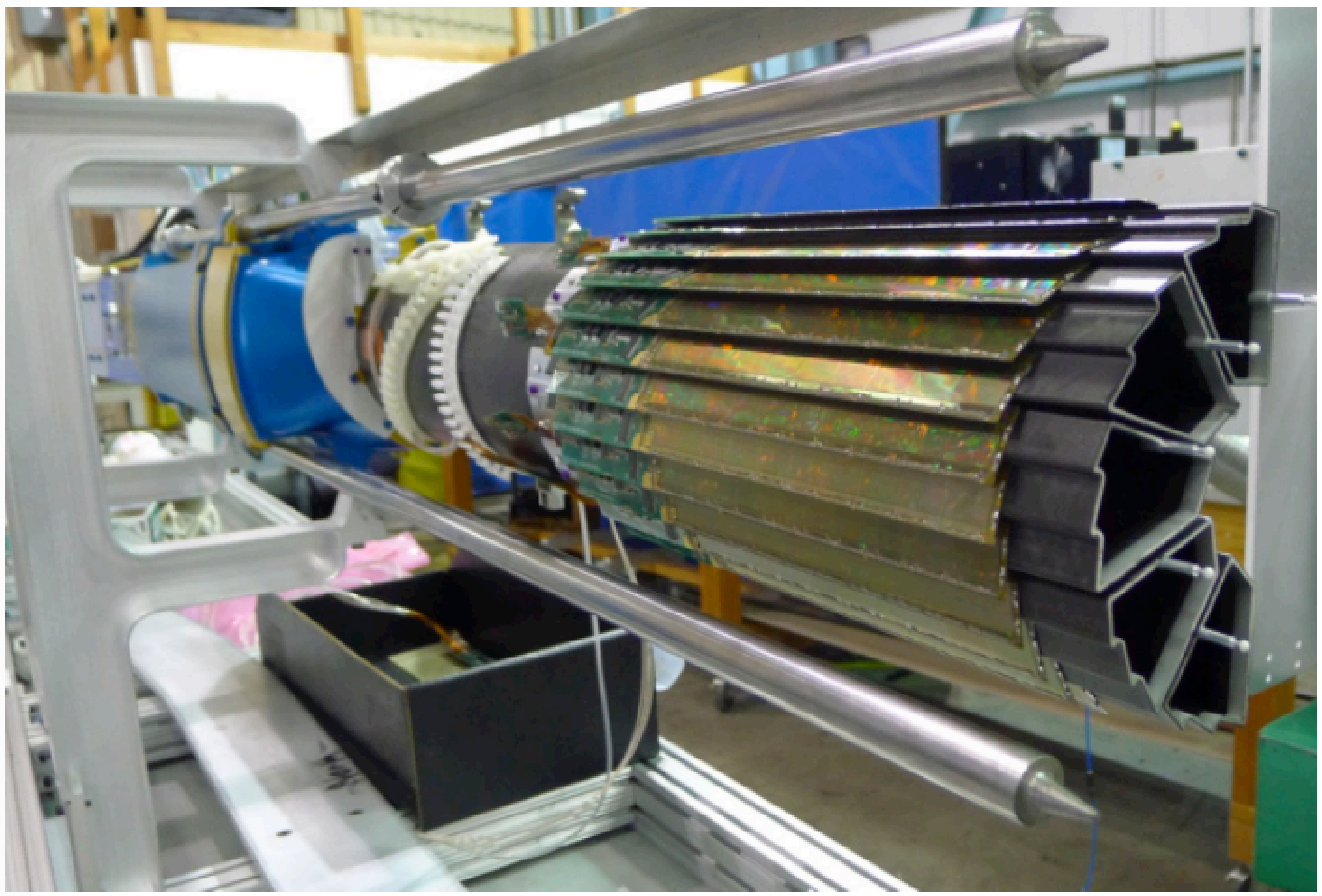
Time Of Flight

PID (flight time : 1/β)

Heavy Flavor Tracker

Heavy Flavor Tracker detector

PIXEL detector

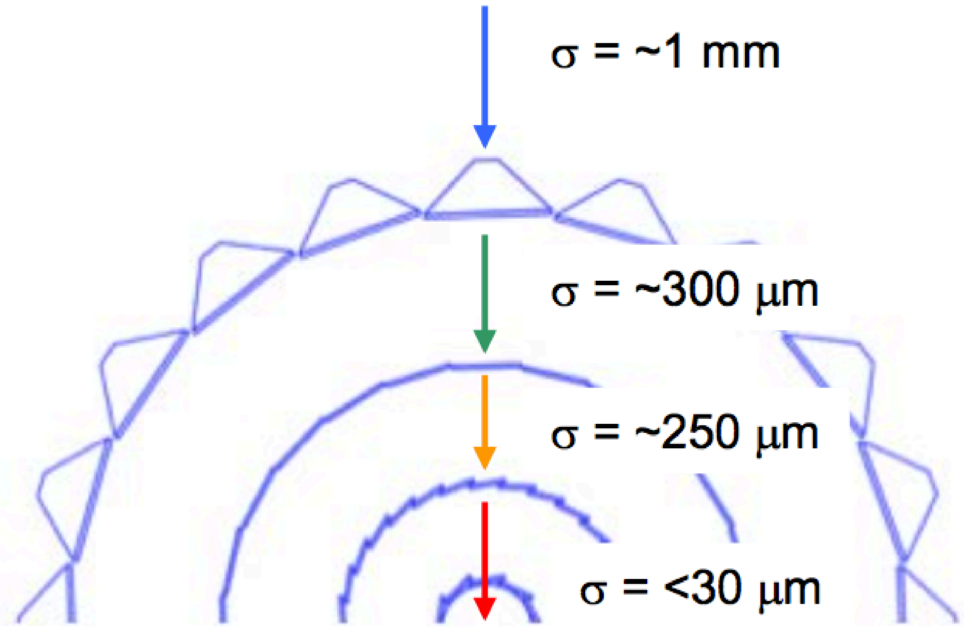


Acceptance

$-1 < \eta < 1$

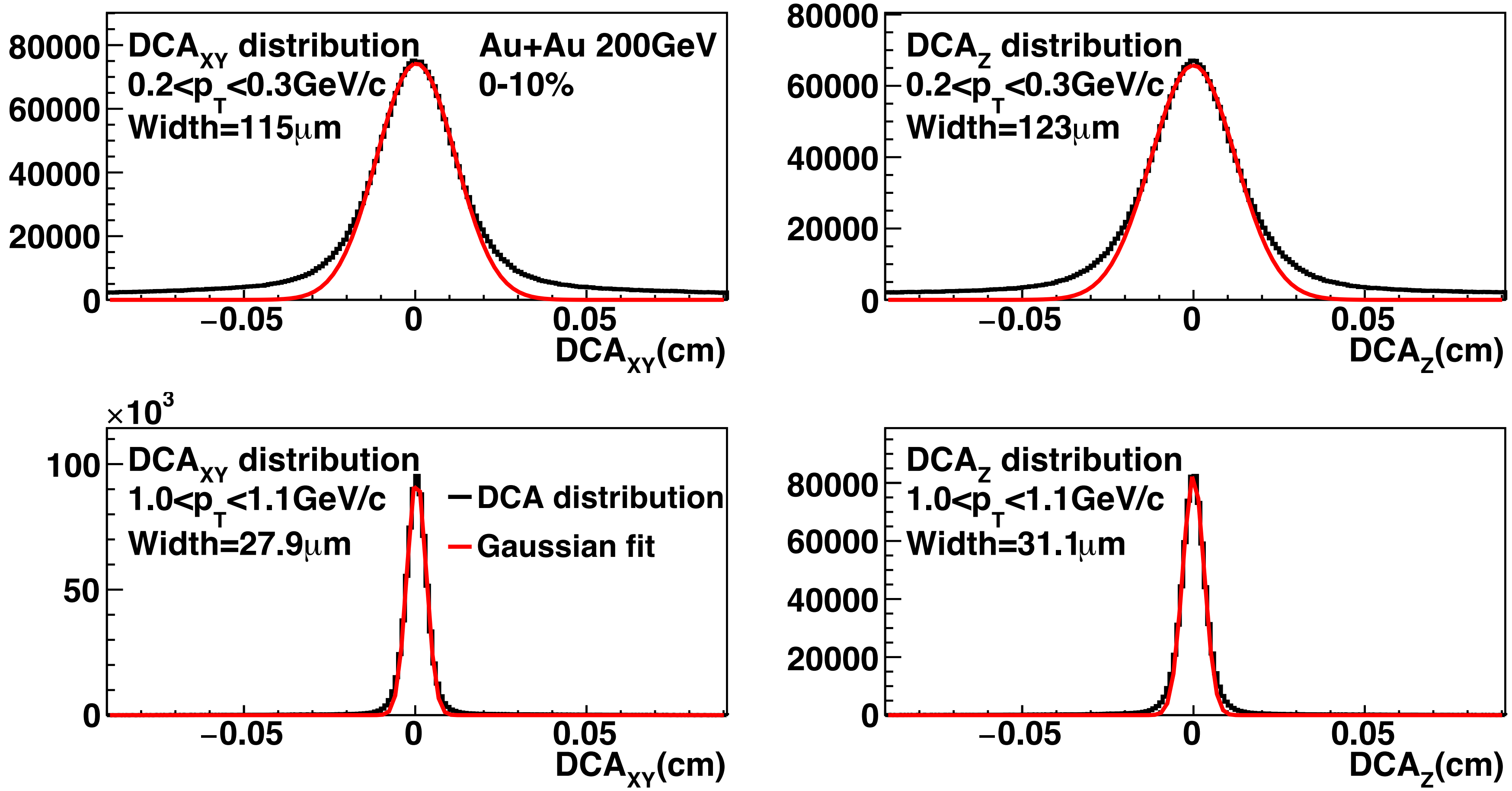
$0 < \phi < 2\pi$

Good resolution of DCA
(Distance of Closest Approach)
Particle track - collision point



Silicon **S**trip **D**etector : r~22cm
Intermediate **S**ilicon **T**racker : r~14cm
PIXEL : r~2.8, 8cm

HFT performance

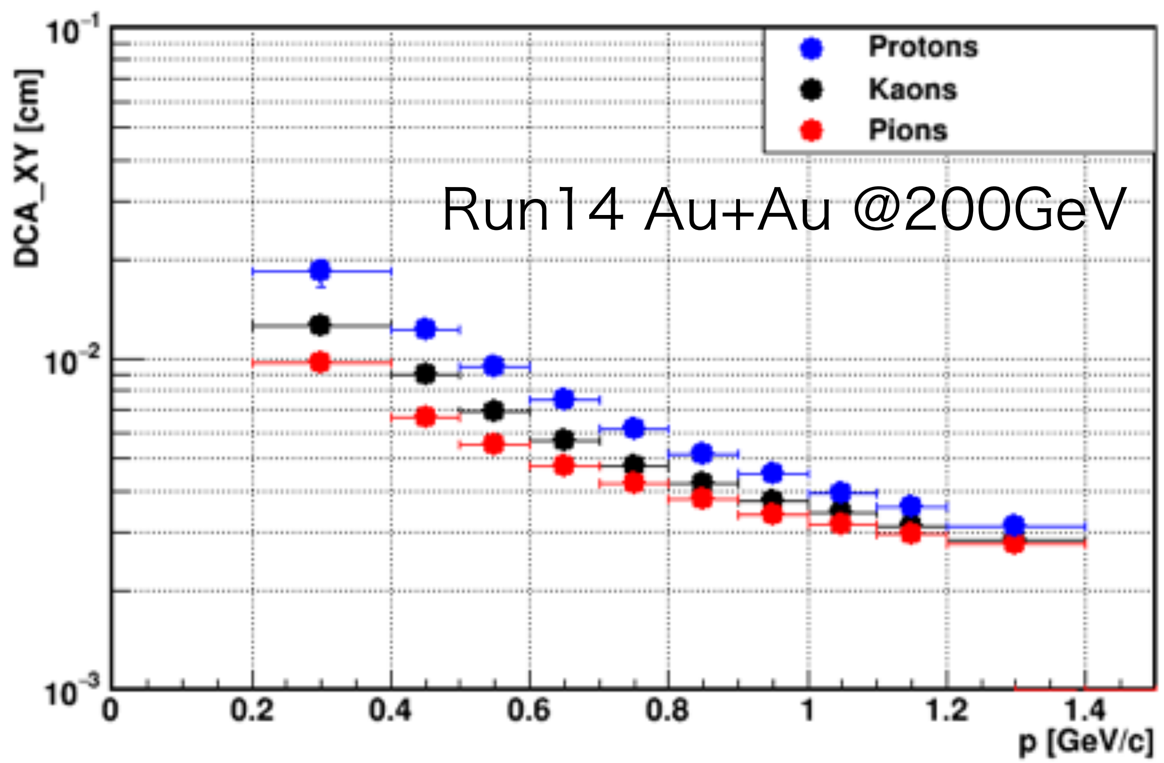


DCA distribution from data in AuAu 200GeV

0-10% centrality

inclusive charged particles

DCA Resolution



DCA in XY plane and Z direction

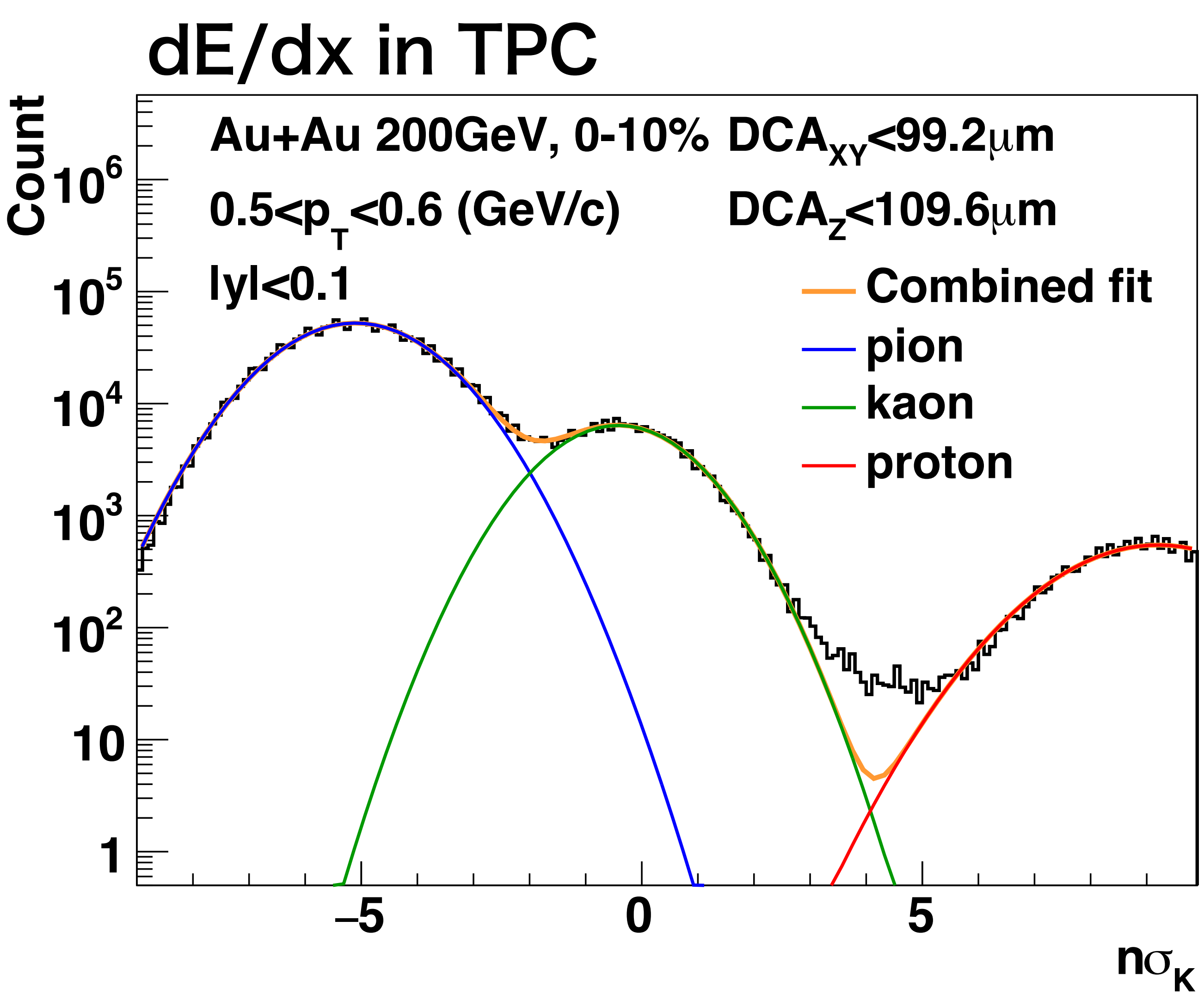
Width : <50μm at p_T=1GeV/c

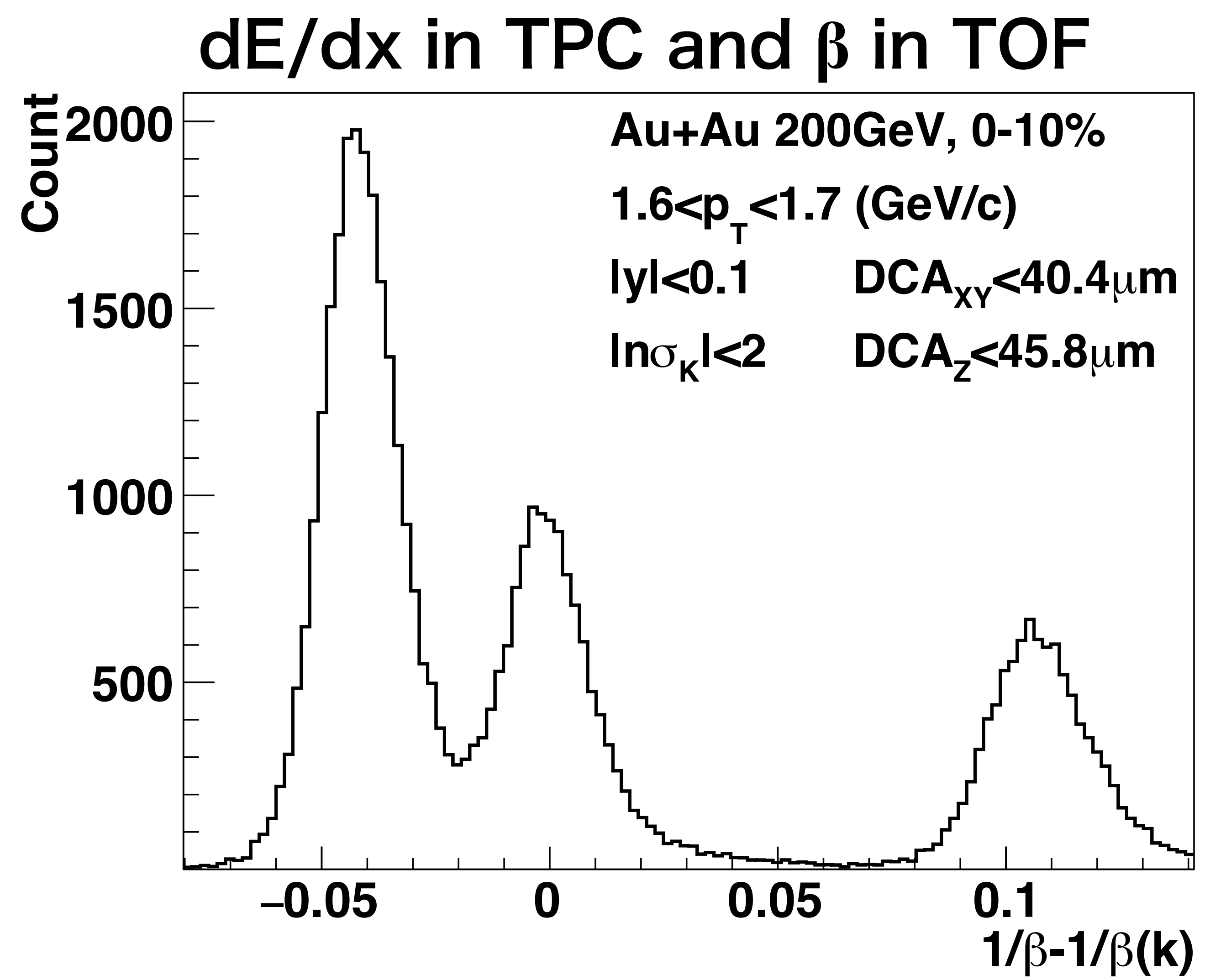
Particle Identification

Track selection

At least one hit for each HFT layer

DCA selection is determined with resolution.





Detector efficiency & acceptance

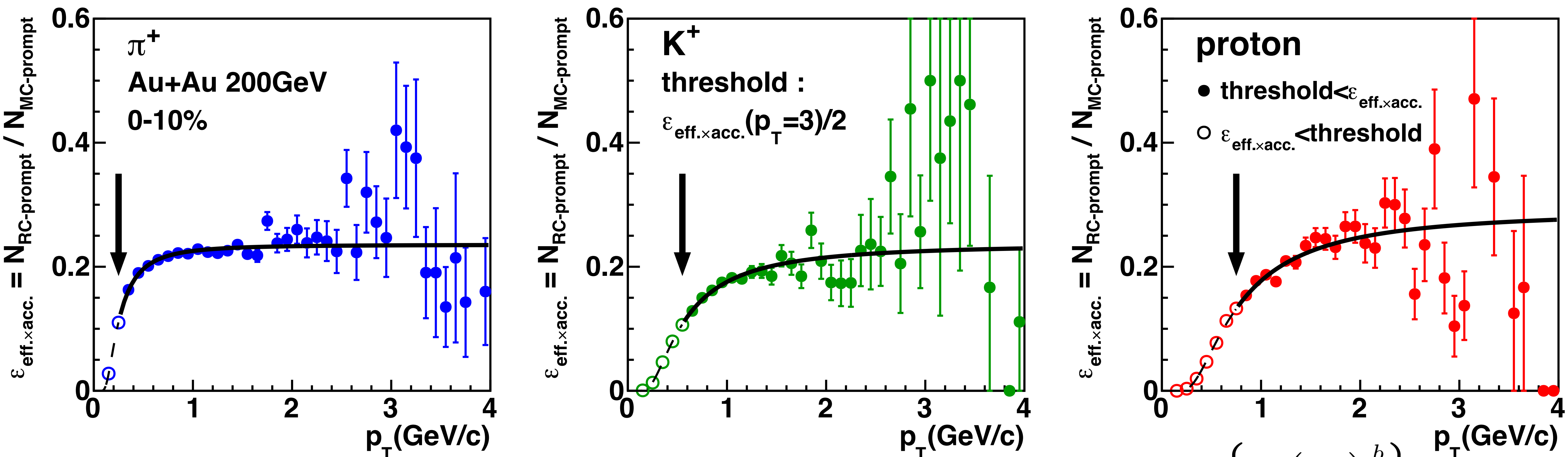
Extracted from HIJING and GEANT simulation

The combination of TPC and HFT efficiency and acceptance

$$\varepsilon_{\mathrm{eff.\times acc.}} = \frac{N_{\mathrm{RC-prompt\ particle}}}{N_{\mathrm{MC-prompt\ particle}}}$$

$N_{\text{MC-prompt particle}}$: The number of created prompt particles

$N_{\text{RC-prompt particle}}$: The number of reconstructed real prompt particles



$$F = A\exp\left\{-\left(\frac{a}{p_T}\right)^b\right\}$$

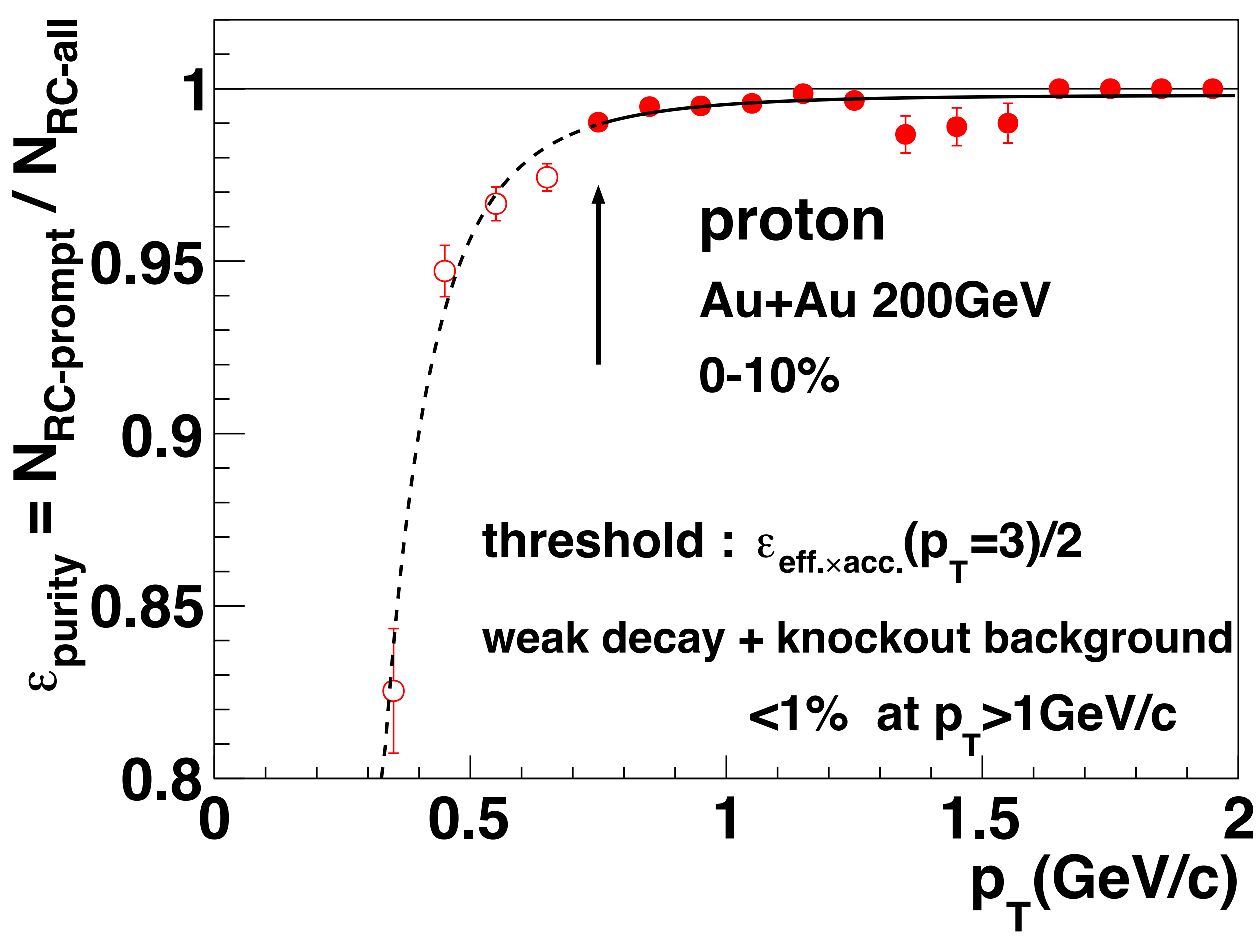
The purity of prompt particles

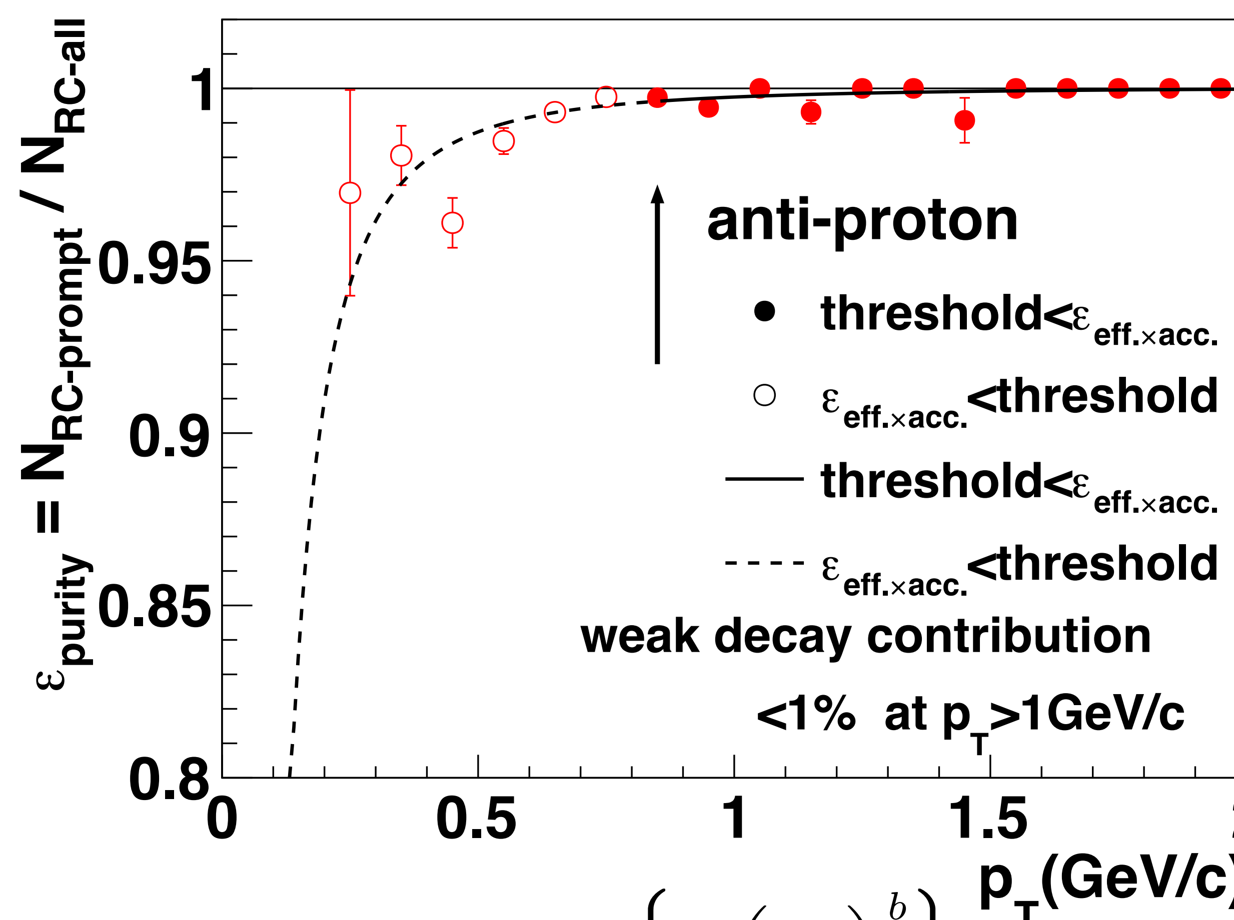
Extracted from HIJING and GEANT simulation.

$$\varepsilon_{\text{purity}} = \frac{N_{\text{RC-prompt particle}}}{N_{\text{RC-all particle}}}$$

$N_{\text{RC-all particle}}$: The number of reconstructed all of particles

$N_{\text{RC-prompt particle}}$: The number of reconstructed real prompt particles





$$F = A \exp\left\{ -\left(\frac{a}{p_T}\right)^b \right\}$$

p_T spectra correction

$$\frac{1}{2\pi p_T}\frac{d^2N}{dp_T dy} = \frac{1}{2\pi p_T}\frac{1}{N_{evt}}\frac{\varepsilon_{\mathrm{purity}}}{\varepsilon_{\mathrm{eff.\times acc.}}}\frac{N}{\Delta p_T \Delta y}$$

Systematic uncertainty

TPC efficiency : ~5%

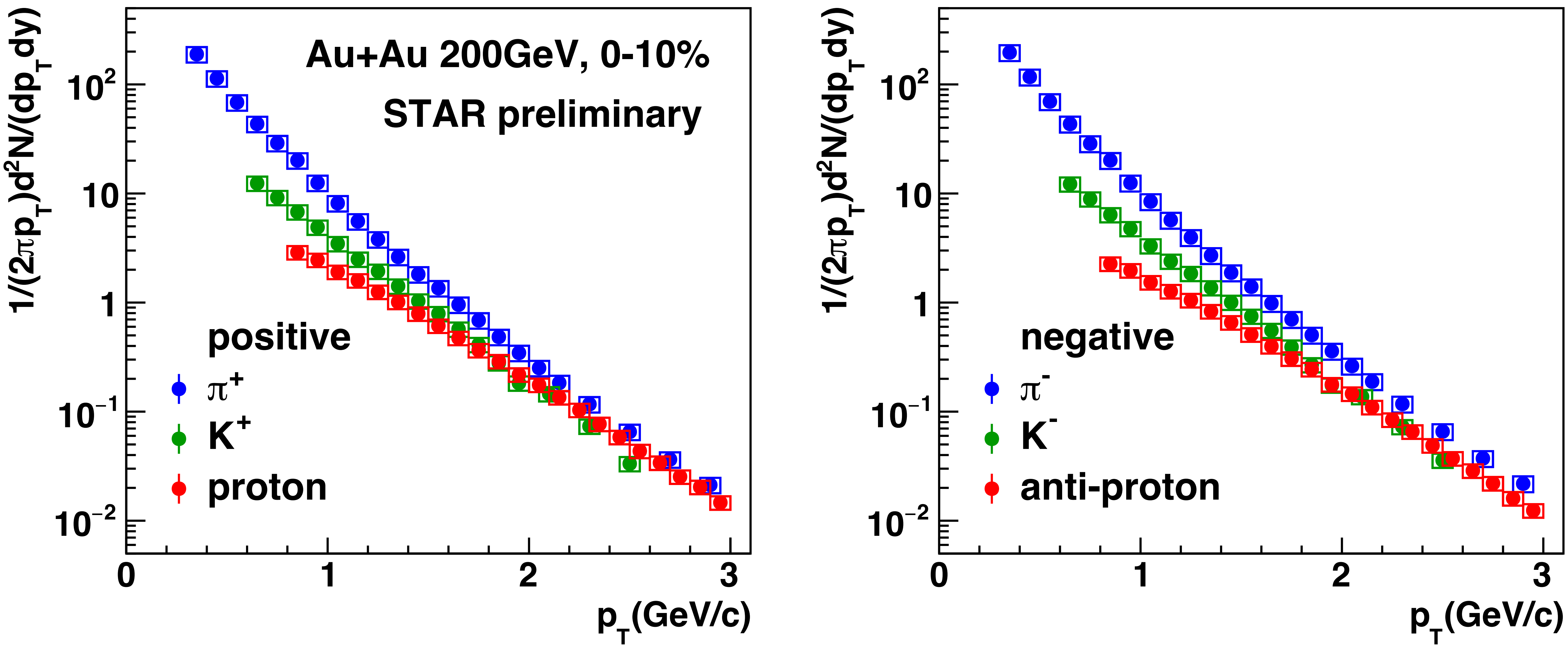
HFT matching efficiency : <13%

- The difference of HFT matching efficiency between data and simulation

DCA selection : <10%

- Particle species dependent

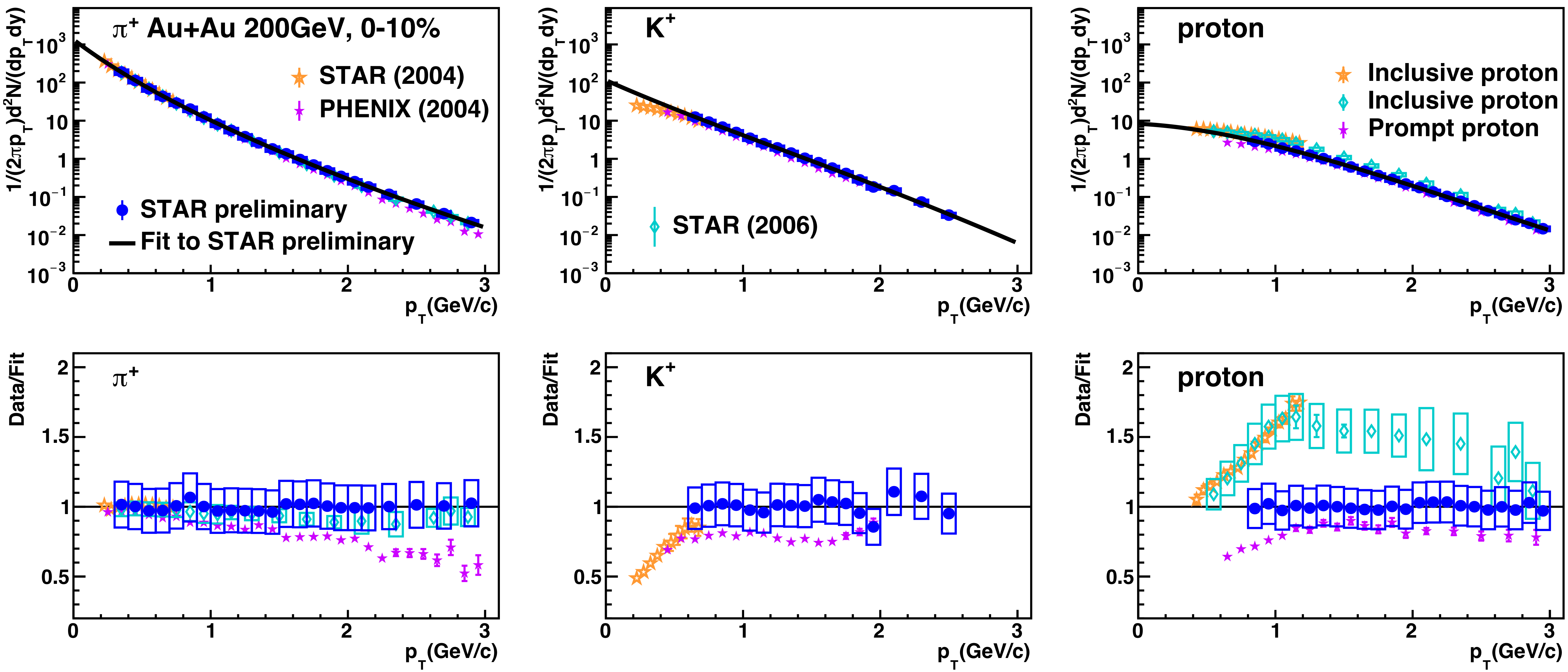
π, K, p p_T spectra



PID spectra with the HFT in Au-Au 200GeV

The shape depends on particle mass.

π, K, p p_T spectra



Modify Hagedorn equation

$$F = \frac{A}{\{\exp\left(-ap_T - bp_T^2\right) + p_T/p_0\}^n}$$

PRL 92, 112301 (2004)

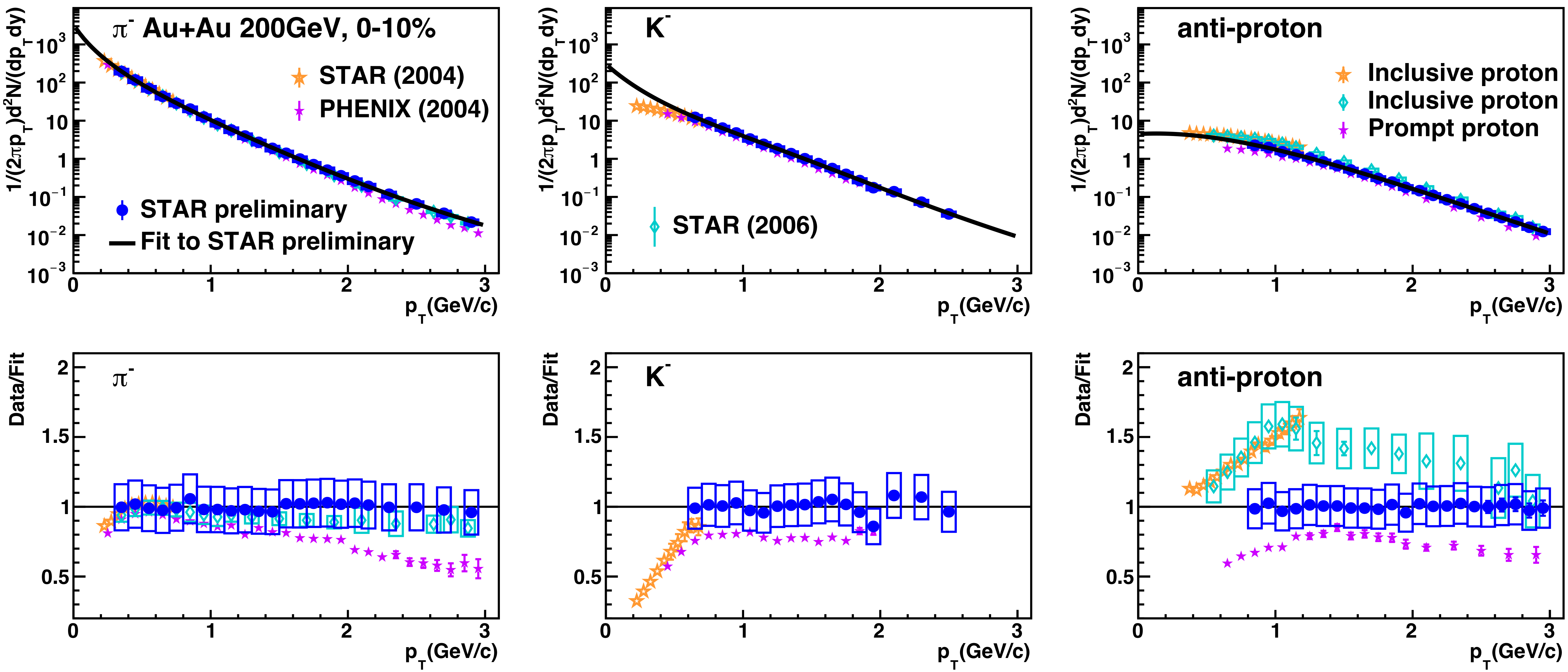
PRC 69, 034909 (2004)

PRL 97, 152301 (2006)

STAR results (orange, cyan) : inclusive proton

PHENIX results (magenta) : corrected for weak decay from Λ

π, K, p p_T spectra



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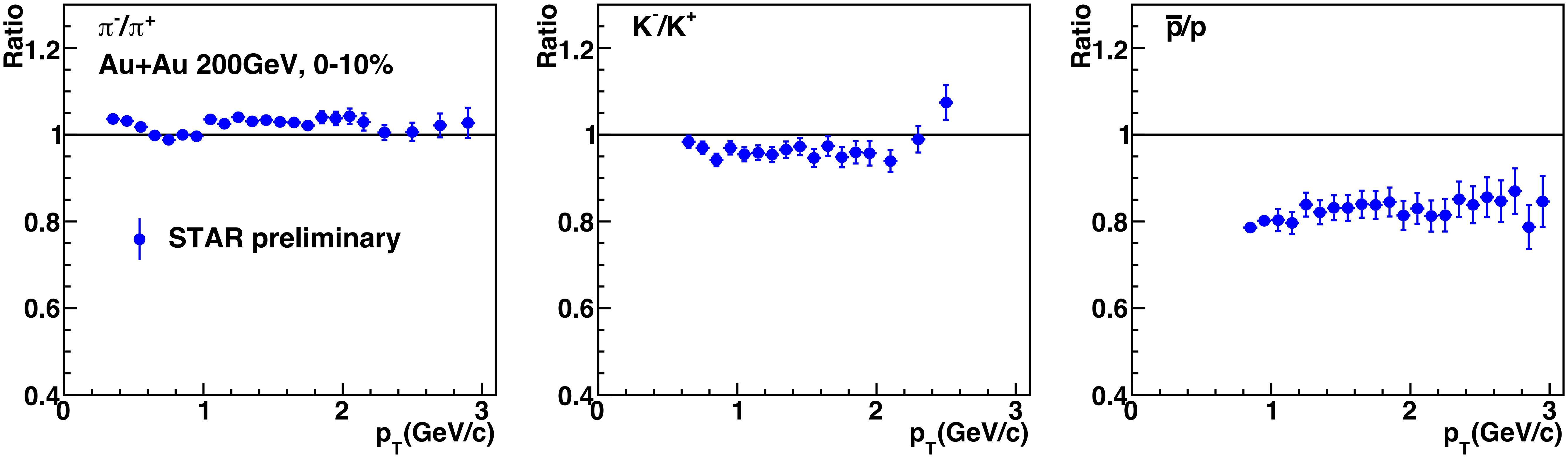
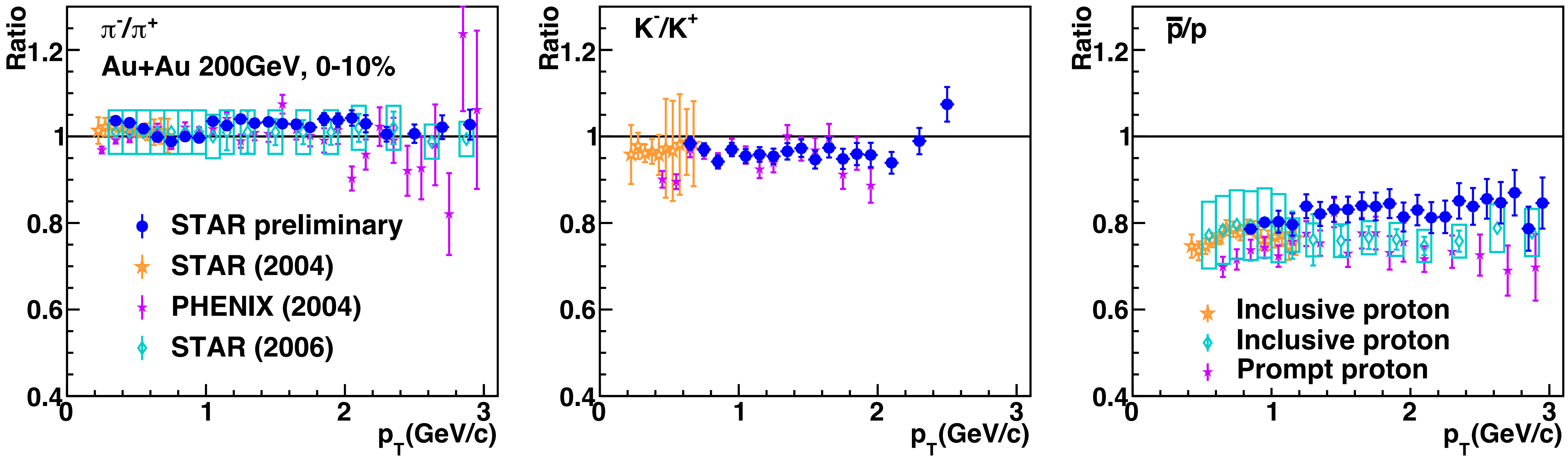
Anti-particle to particle ratio



The ratios are about 1, 0.95, 0.8 for π, K, p at RHIC energy.

Anti-particle to particle ratio



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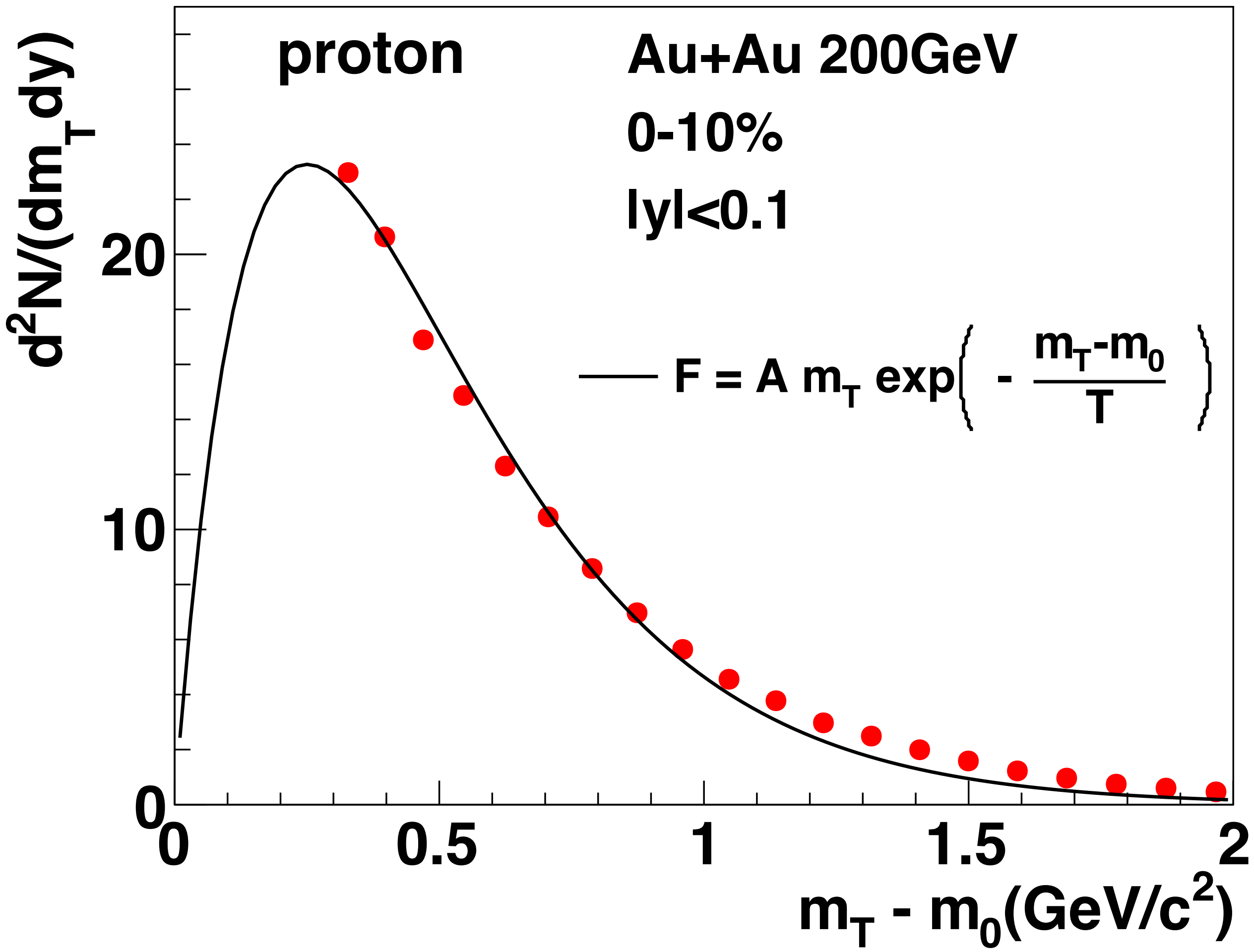
There is no significant difference between inclusive and prompt proton ratio.

Estimating dN/dy distribution



Out of range of measured spectra

Extrapolating with equations

The difference of equations are defined as systematic uncertainty.

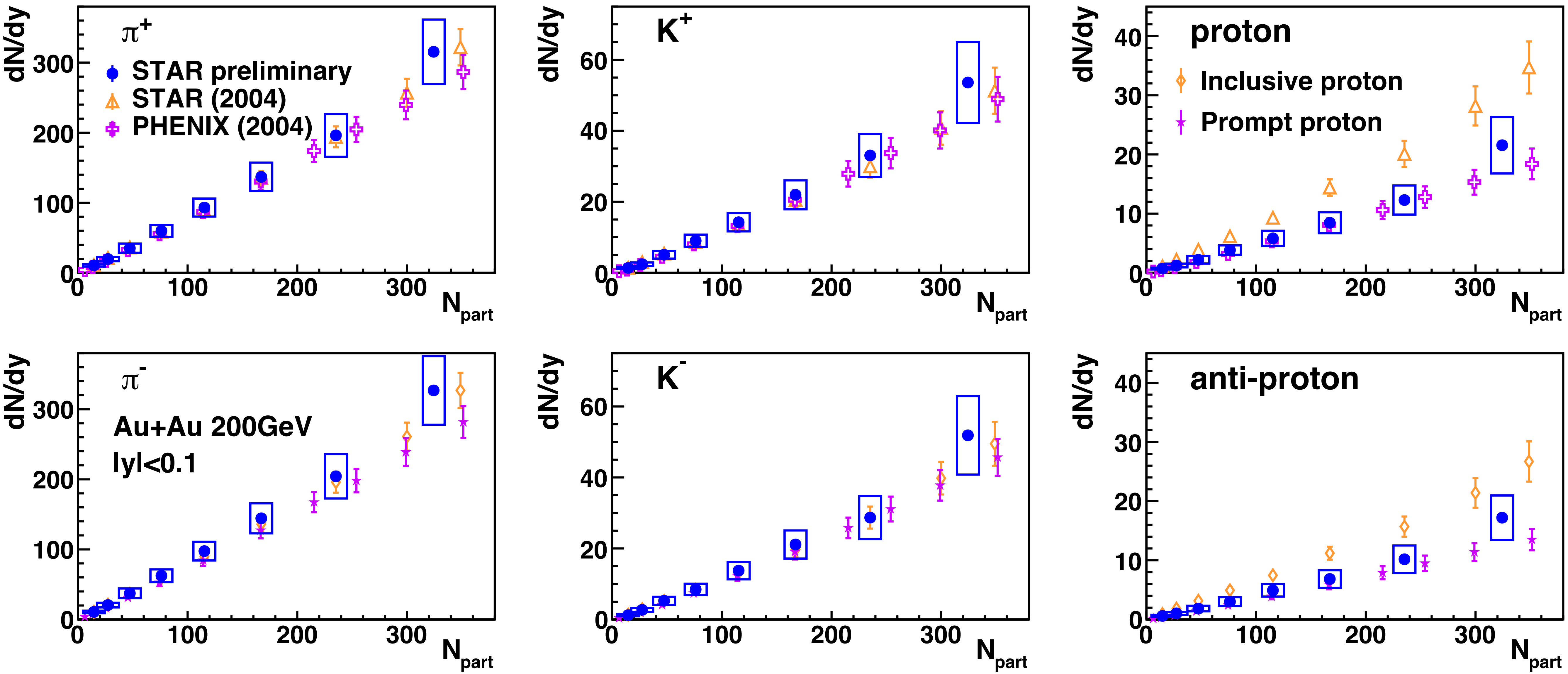
Fraction of dN/dy

	measured dN/dy	extrapolated dN/dy low p_T	extrapolated dN/dy high p_T
π^+	168.7 (53.5%)	146.7 (46.4%)	0.14 (0.1%)
K^+	26.8 (50%)	26.7 (49%)	0.1 (1%)
proton	11.1 (51%)	10.4(48%)	0.11 (1%)

For pion, Bose-Einstein equation, m_T exponential (for estimating systematics)

For kaon and proton, p_T exponential, m_T exponential

dN/dy distribution



STAR results (orange, cyan) : inclusive proton

PHENIX results (magenta) : corrected for weak decay from Λ

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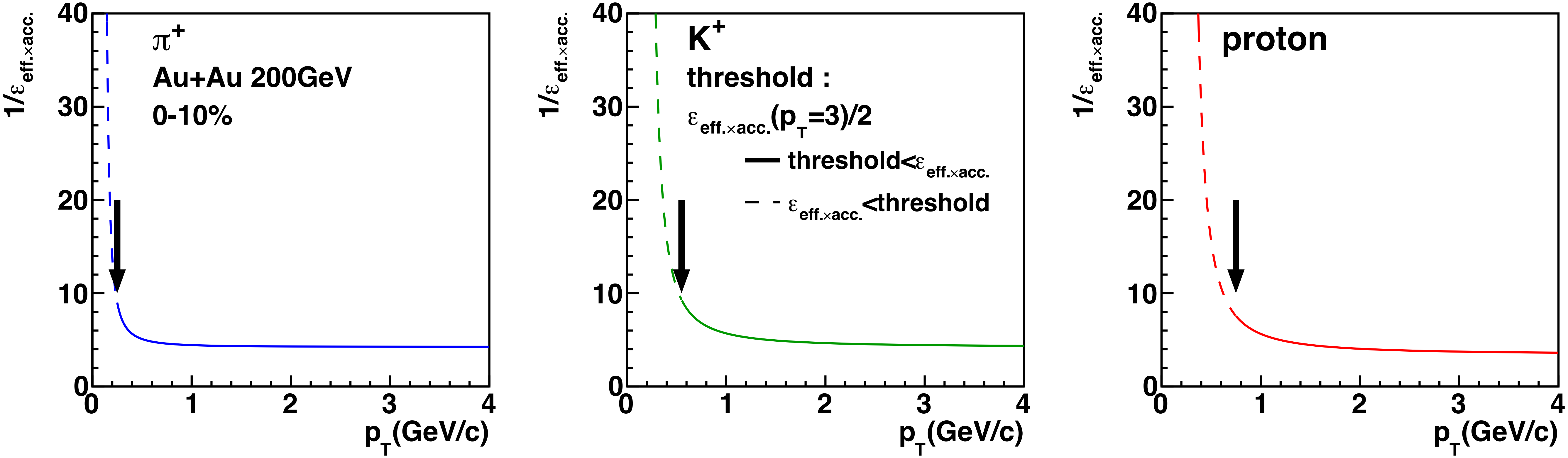
Summary

- The first result of prompt π, K, p p_T spectra with the HFT in Au+Au 200GeV collisions at STAR experiment

- The anti-particle to particle ratio

  There is no significant difference between inclusive and prompt proton results.

Efficiency correction



$$\varepsilon_{\mathrm{eff.}\times\mathrm{acc.}} = \frac{N_{\mathrm{RC-prompt\ \ particle}}}{N_{\mathrm{MC-prompt\ \ particle}}}$$

Correction of detector efficiency and acceptance

Correction factor get large in low p_T region