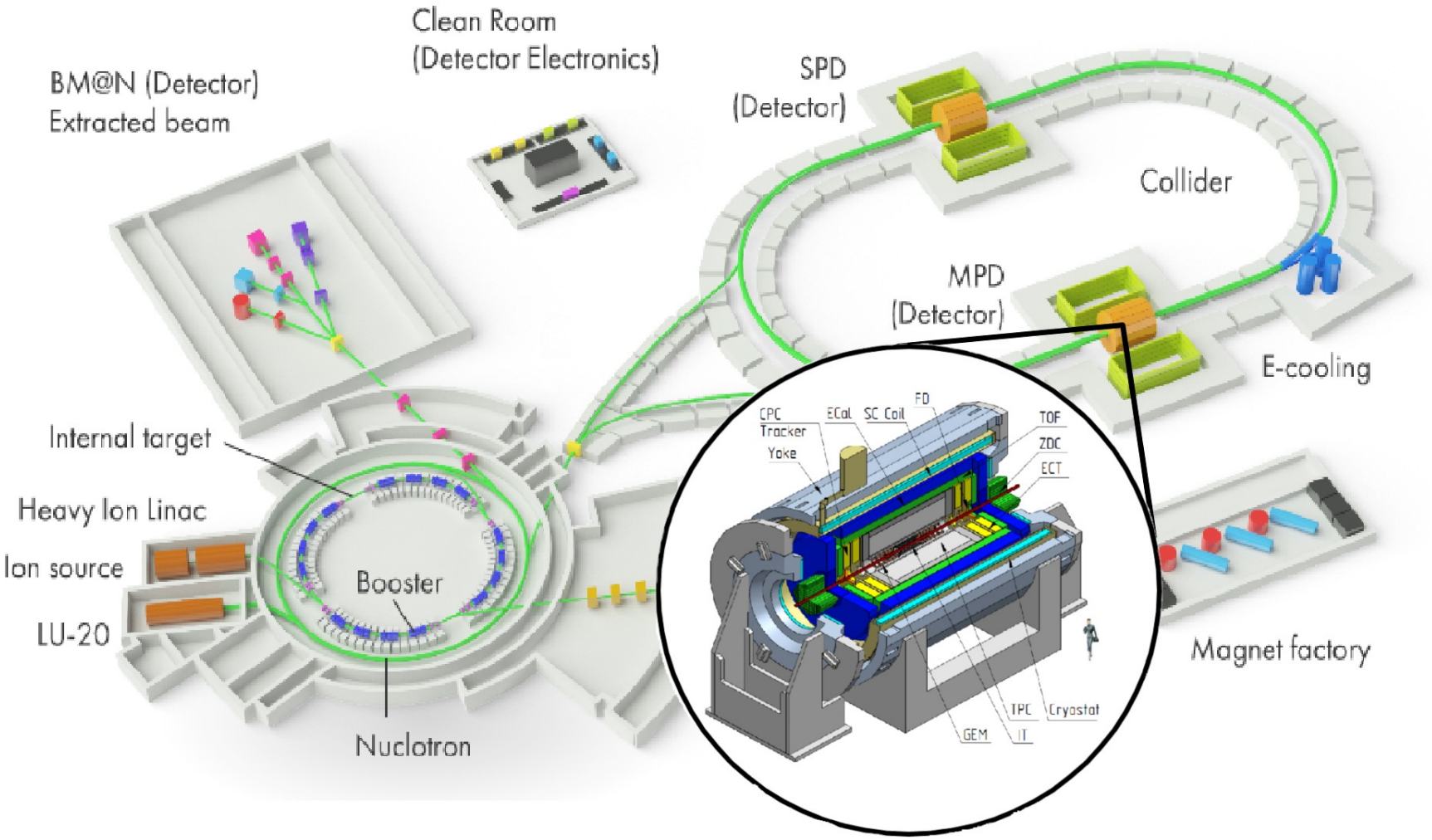
Searching for the baryon-to-meson transition region with the MPD at NICA

Rodrigo Guzmán Castro
MexNICA Collaboration

ICPPA - 2022

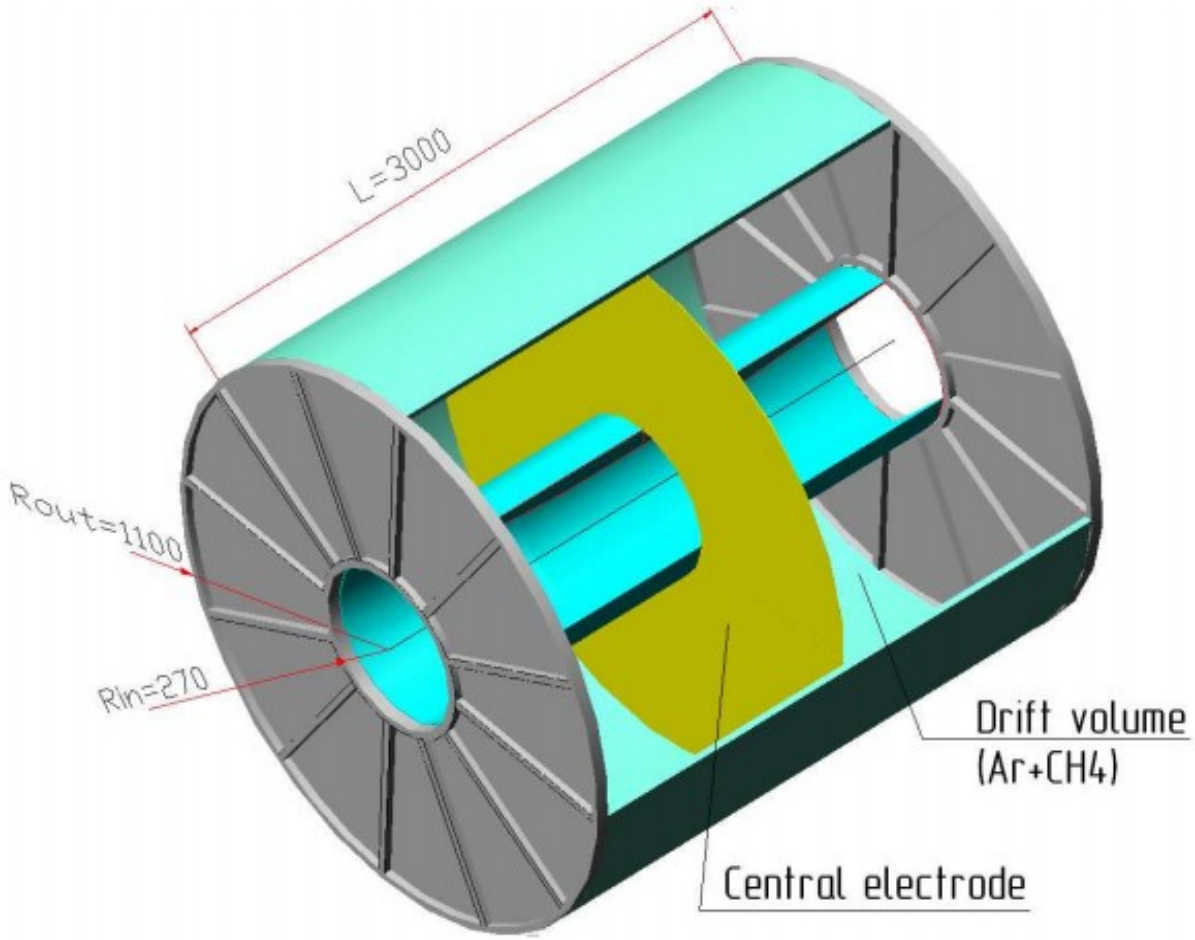
Instituto de Ciencias Nucleares,
Universidad Nacional Autónoma de México
December 2, 2022

NICA Complex



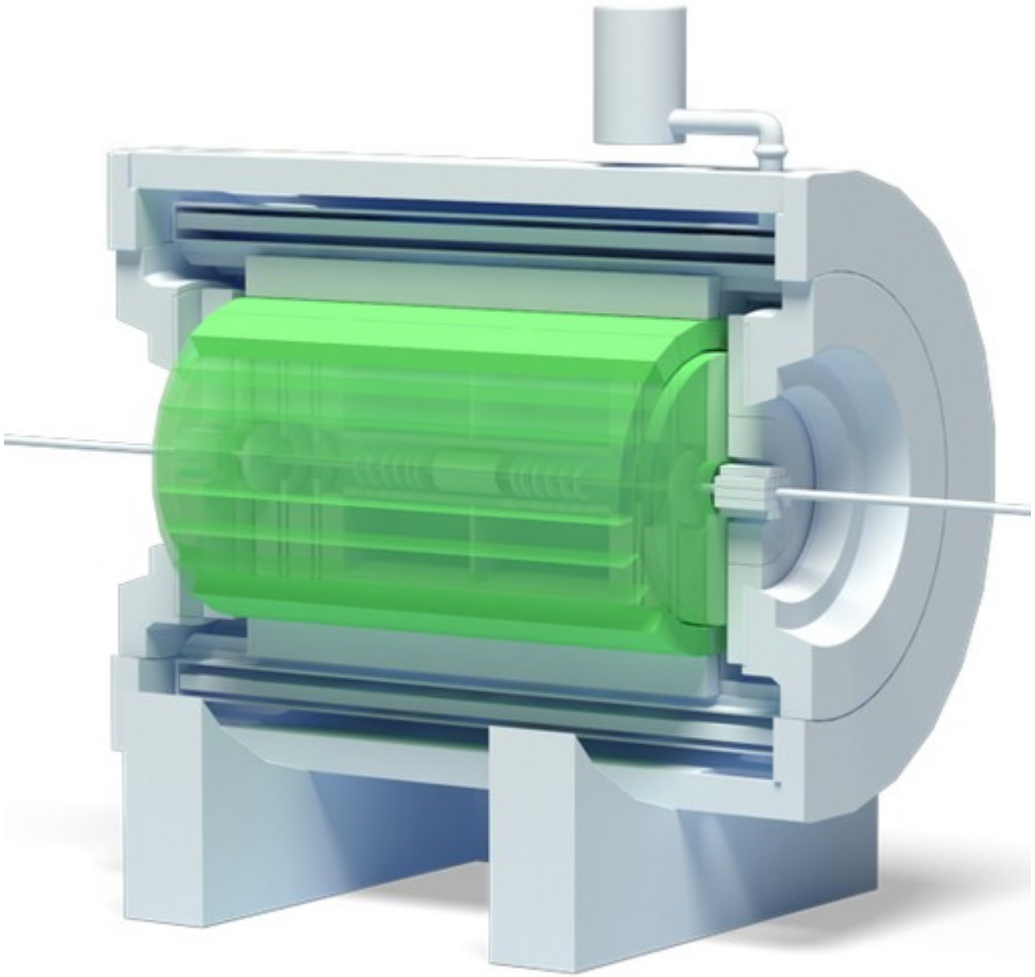
Study a variety of ion collisions, in the range $\sqrt{s_{NN}}$ = 4 to 11 GeV

Time Projection Chamber (TPC)



- 90% Ar + 10% CH_4
- $|\eta|<1.2$
- $P_T>100$ MeV/c
- Two-track resolution ~ 1 cm

Time Of Flight system (TOF)

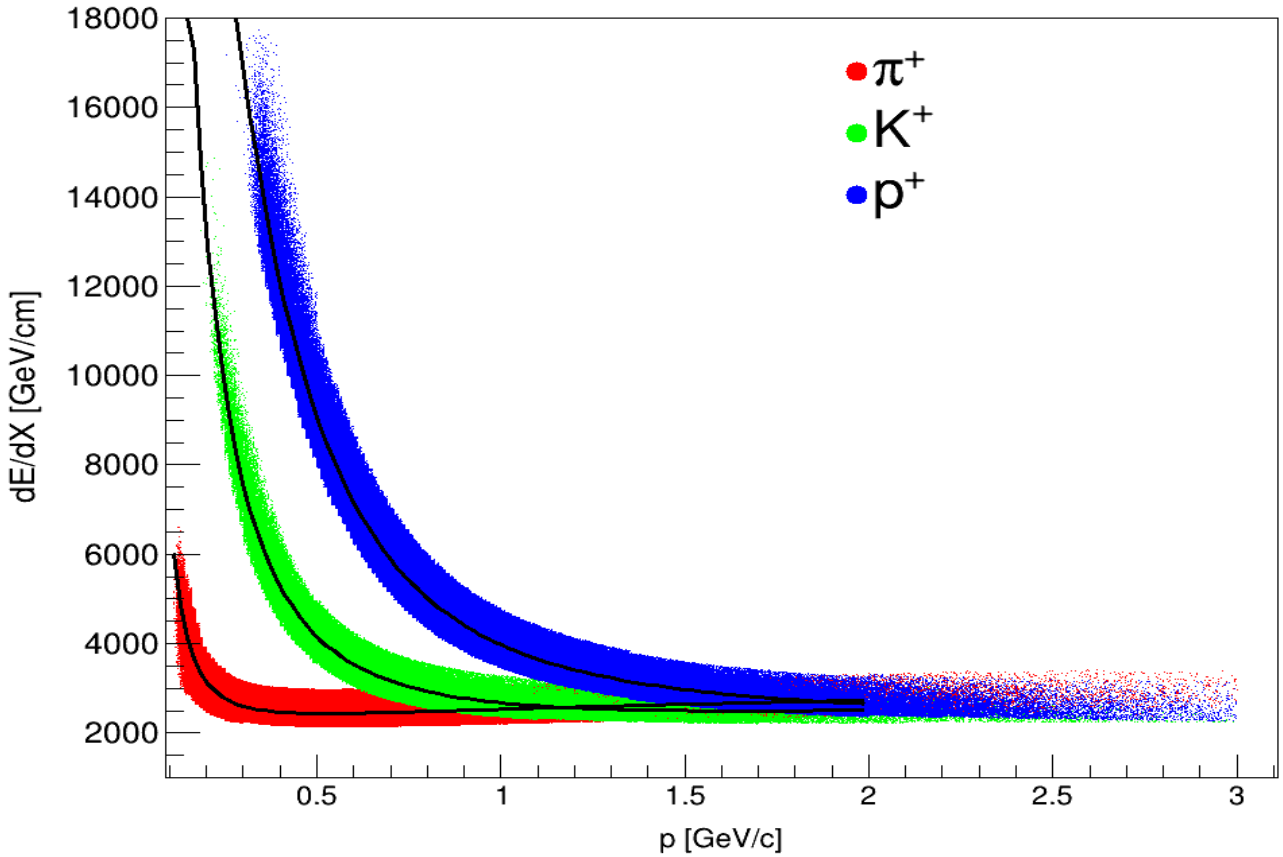


- 90% $C_2H_2F_4$ + 5% SF_6 + 5% i-C_4H_{10}
- $|\eta|<2$
- $0.1 < P_T < 2$ GeV/c
- Time resolution ~ 50 ps

Particle identification

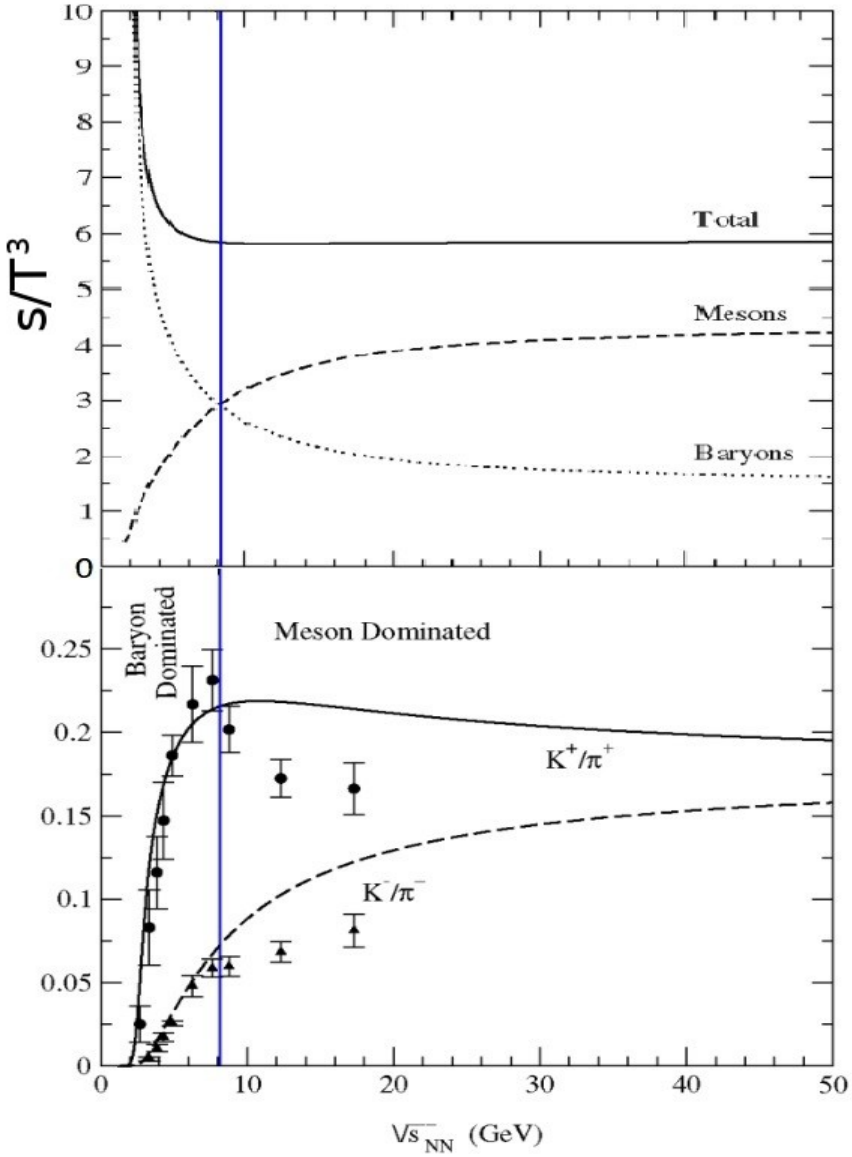
Allison and Cobb model[1]:

$$\left\langle \frac{dE}{dX} \right\rangle = \frac{p_1}{\beta^{p_4}} \left(p_2 + \beta^{p_4} - \ln\left(p_3 + \left(\frac{1}{\beta\gamma} \right)^{p_5} \right) \right) \quad , \quad \beta^2 = \frac{p^2}{m^2 + p^2}$$



[1]M. Allison and H. Cobb, An. Rev. Nucl. Part. Sci. **30** (1980) 253-296.

Motivation



In the framework of the statistical model, a rapid change is expected as the hadronic gas undergoes a transition from a baryon-dominated to a meson-dominance.[2]

The maximun in the K^+/π^+ ratio is predicted in this model which corresponds to this transition region.[2]

[2] J. Cleymans *et al.*, Phys. Lett. B **615** (2005) 50-54.

Data sample analyzed

Data sets generated with UrQMD 3.4v:

1) Au+Au collisions at 7.7 GeV
Reconstruction: Geant3 & 0.5 Tesla

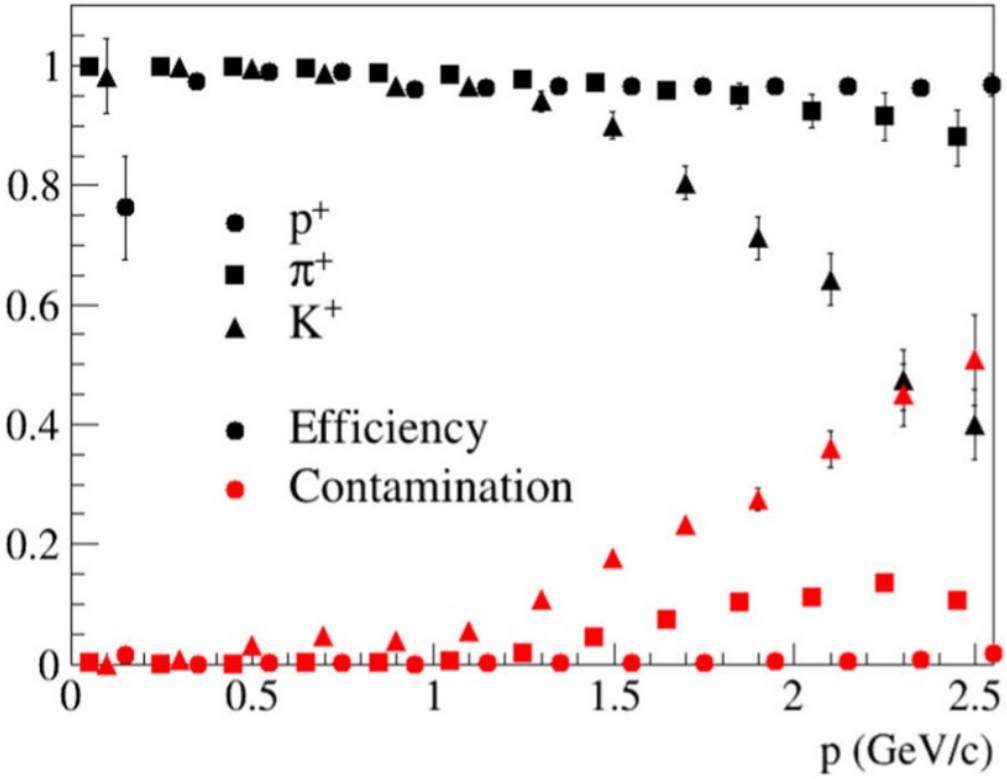
2) Au+Au collisions at 11.5 GeV
Reconstruction: Geant3 & 0.5 Tesla

3) Bi+Bi collisions at 9.2 GeV
Reconstruction: Geant4 & 0.5 Tesla

Reconstruction efficiency

Au+Au collisions

- MPD collaboration[3] (9 GeV)



$$Efficiency = \frac{True\ positives}{all\ selected\ tracks}$$

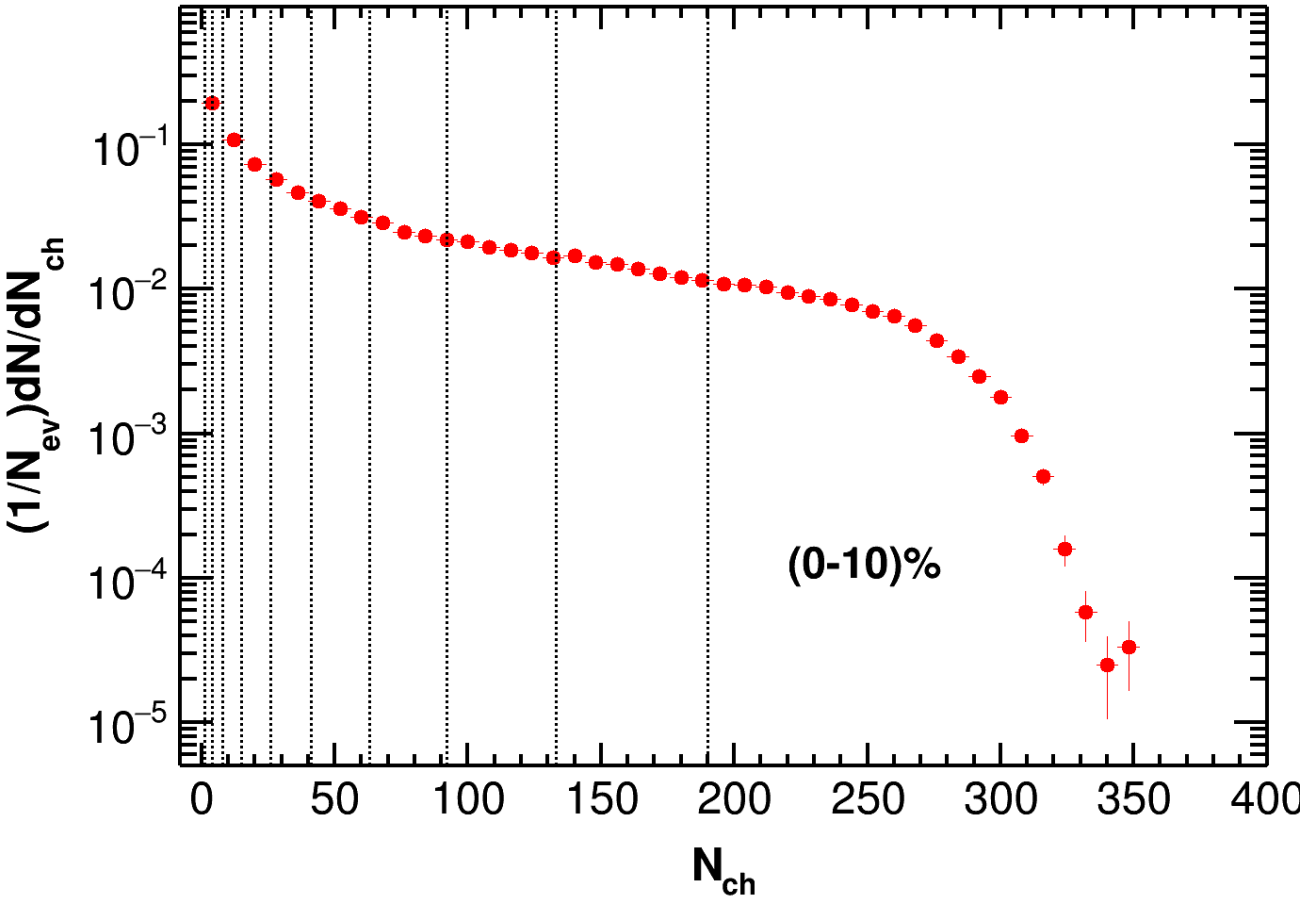
$$Contamination = \frac{False\ positives}{all\ selected\ tracks}$$

[3] V. Abgaryan *et al.* [MPD Collaboration], Eur. Phys. J. A **58**, 140 (2022).

Centrality for Au+Au at 11.5 GeV

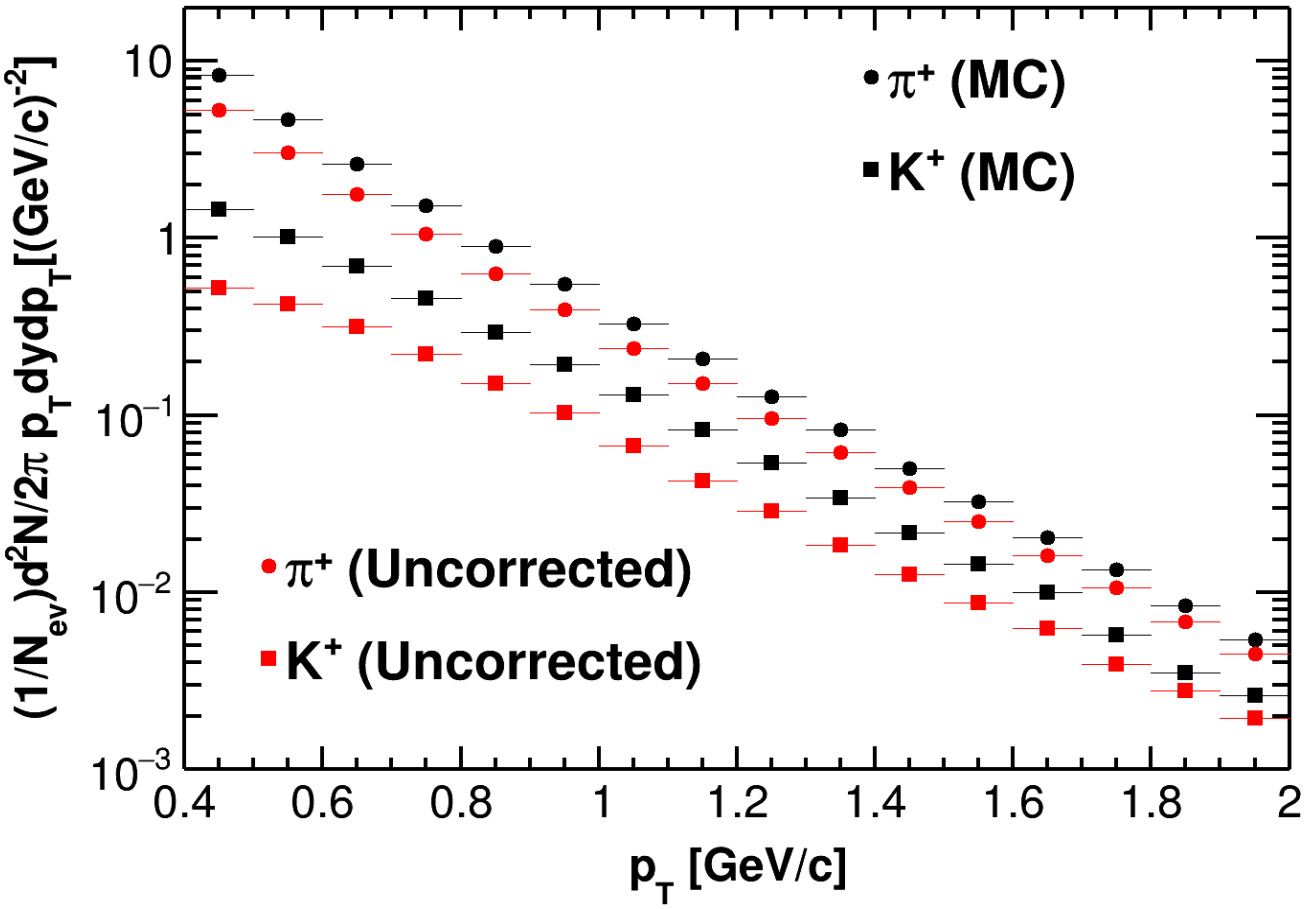
classes	Au+Au 11.5 GeV
(0-10)%	12295 (~10%)
(10-20)%	12080 (~10%)
(20-30)%	11833 (~10%)
(30-40)%	10991 (~9%)
(40-50)%	11924 (~10%)
(50-60)%	11246 (~10%)
(60-70)%	11882 (~10%)
(70-80)%	11696 (~10%)

- Reconstructed multiplicity



Transverse momentum distributions Monte Carlo (MC) vs. reconstruction

- Au+Au 7.7 GeV



Integrated yields ratio (rec./MC)

(0.4 – 2 GeV/c)

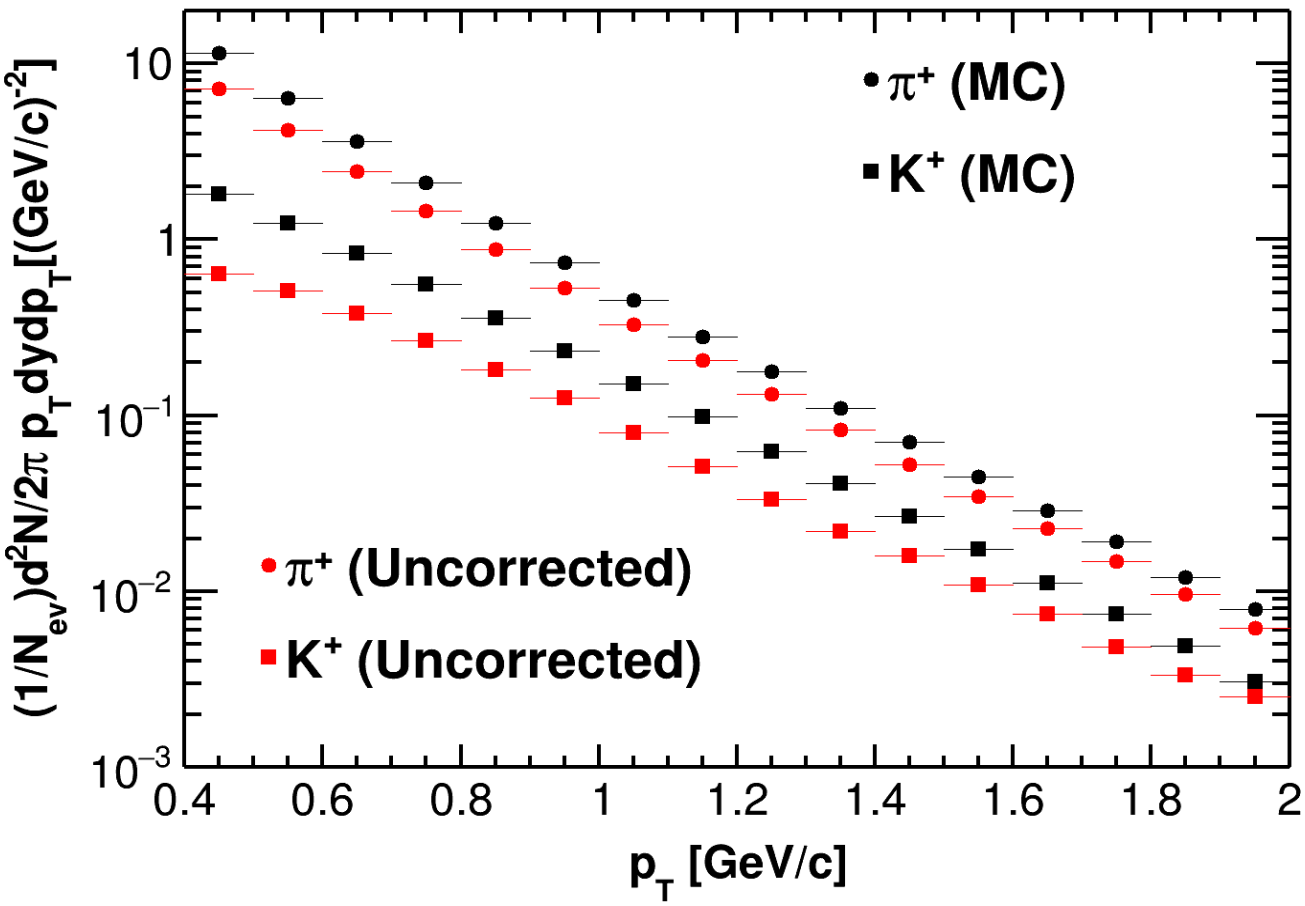
- $\pi^+ \sim 0.66$
- $K^+ \sim 0.58$

- $K^+/\pi^+ \sim 0.23$

(0.4 – 2 GeV/c)

Transverse momentum distributions Monte Carlo (MC) vs. reconstruction

- Au+Au 11.5 GeV



Integrated yields ratio (rec./MC)

(0.4 – 2 GeV/c)

- $\pi^+ \sim 0.66$
- $K^+ \sim 0.57$

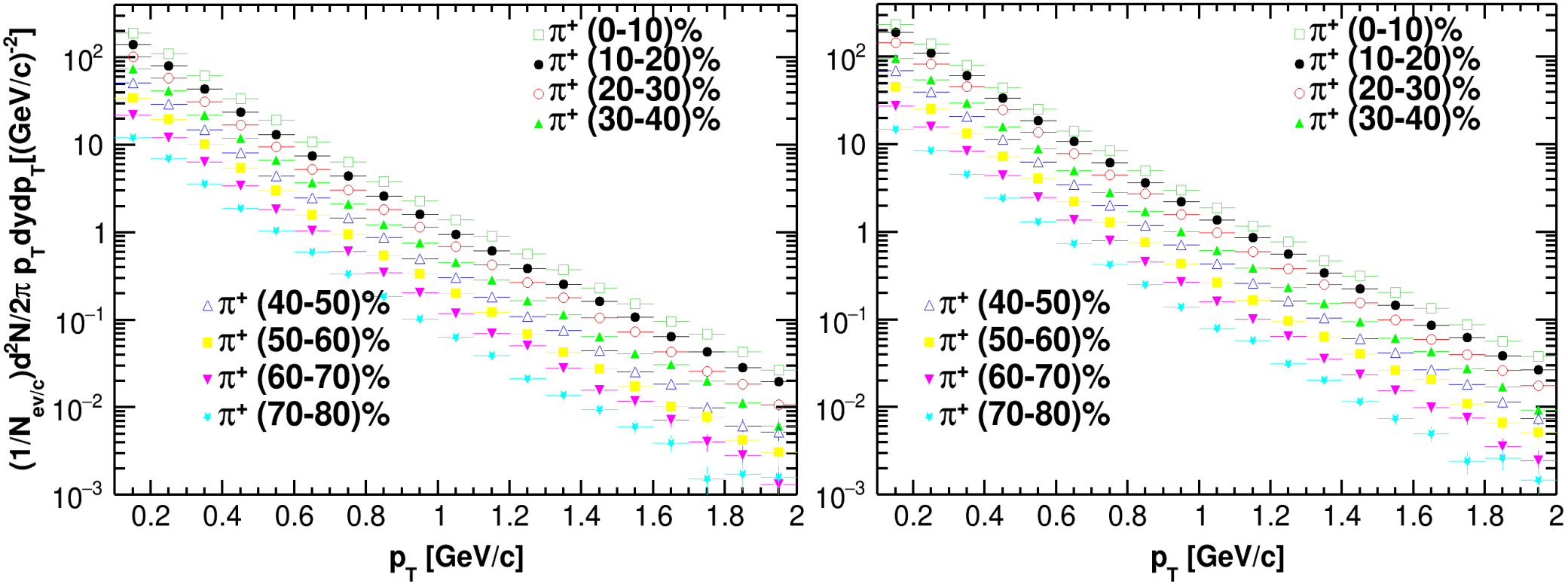
- $K^+/\pi^+ \sim 0.21$

(0.4 – 2 GeV/c)

Transverse momentum per centrality

Au+Au (MC)

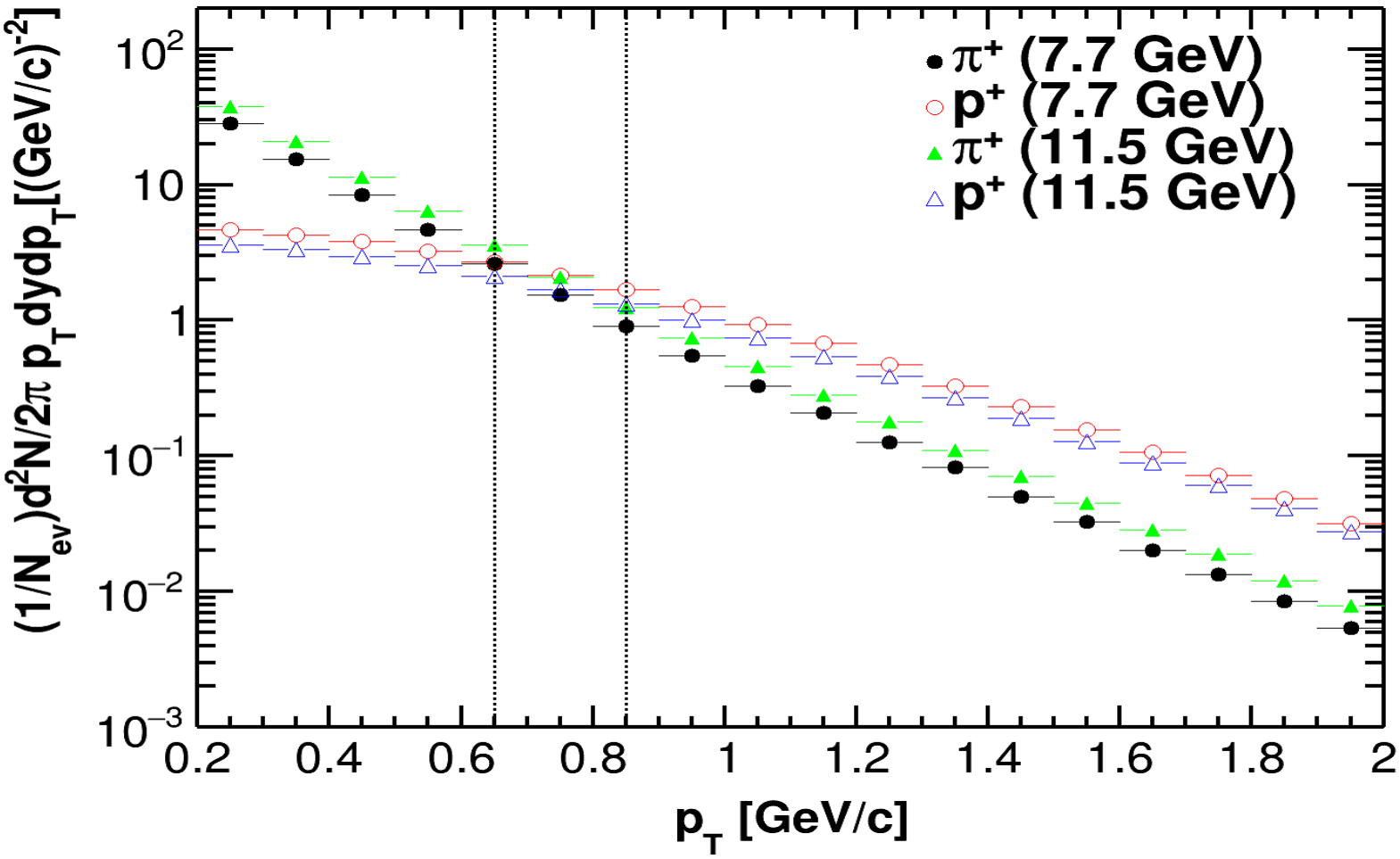
- 7.7 GeV
- 11.5 GeV



The distributions for the negative pions are similar

Crossing point between π^+ and p^+

Au+Au (|*y*|<0.5), MC

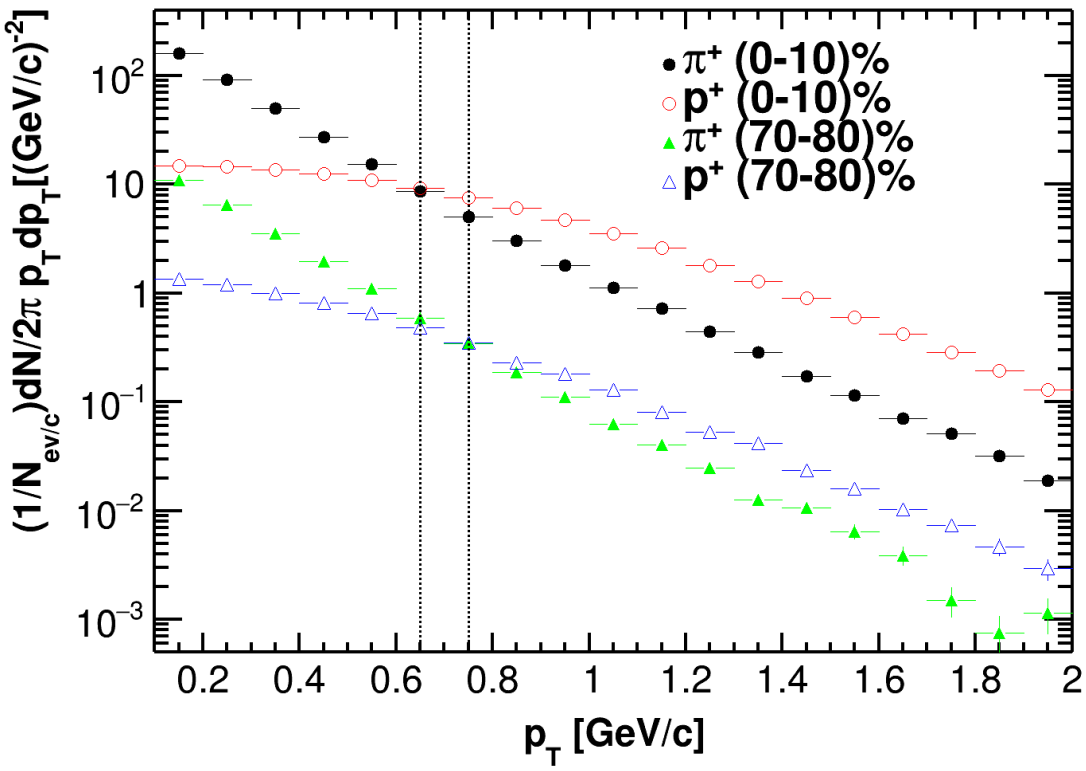


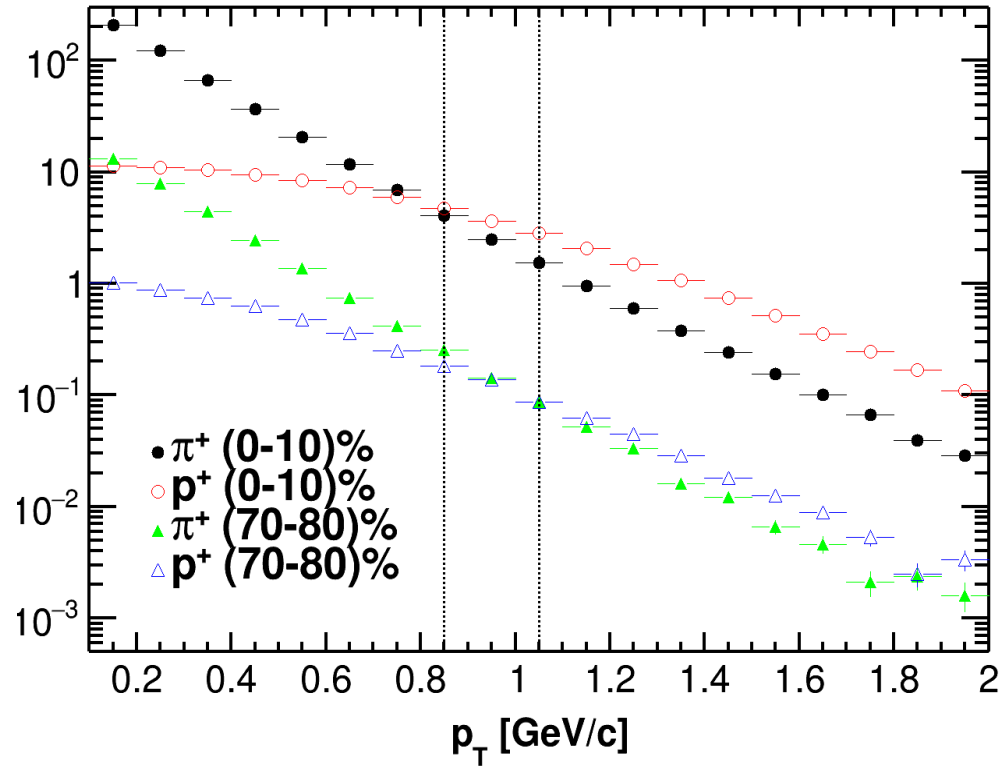
Distributions cross ~0.85 GeV/c for 11.5 GeV and ~0.65 GeV/c for 7.7 GeV

Crossing point at different centralities

Au+Au (|*y*|<0.5), MC

- 7.7 GeV
- 11.5 GeV

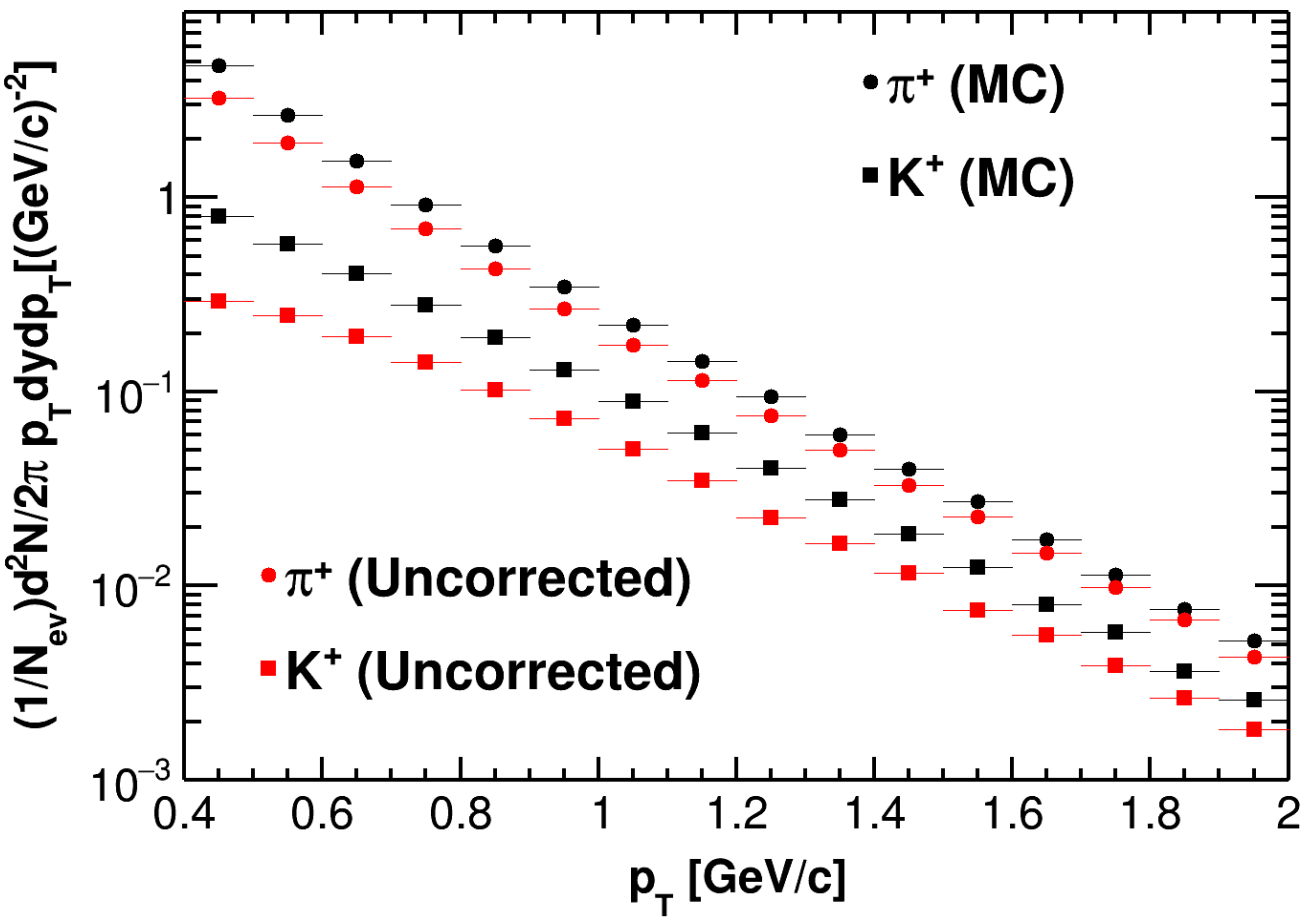




Crossing point at $p_T \sim 0.65$ and $p_T \sim 0.75$ GeV/c for the most central and peripherial (7.7 GeV), at $p_T \sim 0.85$ and $p_T \sim 1.05$ GeV/c for the most central and peripherial (11.5 GeV)

Transverse momentum distributions Monte Carlo (MC) vs. reconstruction

- Bi+Bi 9.2 GeV



Integrated yields ratio (rec./MC)

(0.4 – 2 GeV/c)

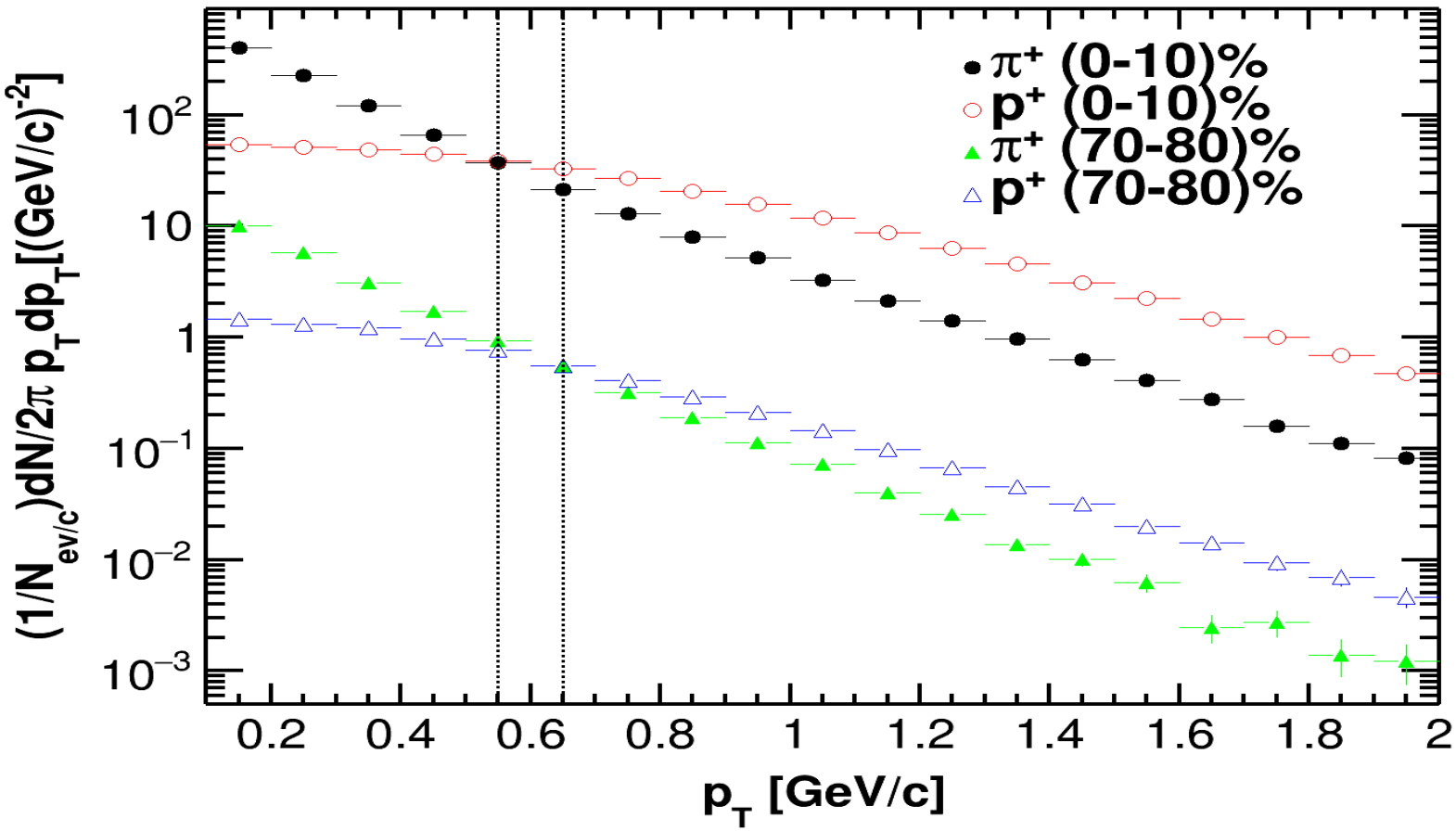
- $\pi^+ \sim 0.72$
- $K^+ \sim 0.64$

- $K^+/\pi^+ \sim 0.23$

(0.4 – 2 GeV/c)

Crossing point at different centralities

Bi+Bi 9.2 GeV (|*y*|<0.5), MC



Distributions cross at p_T ~ 0.55 GeV/c for the most central and p_T ~ 0.65 GeV/c for the most peripherial

Conclusions

For collisions Au+Au at 7.7 and 11.5 GeV & Bi+Bi at 9.2 GeV, generated by UrQMD and reconstructed in the MPD framework:

a) By measuring the particle integrated yields, we can study the baryon-to-meson dominated transition region.

b) We showed the evolution of the crossing point for pions and protons as a function of the energy and centrality classes for Au+Au and Bi+Bi.

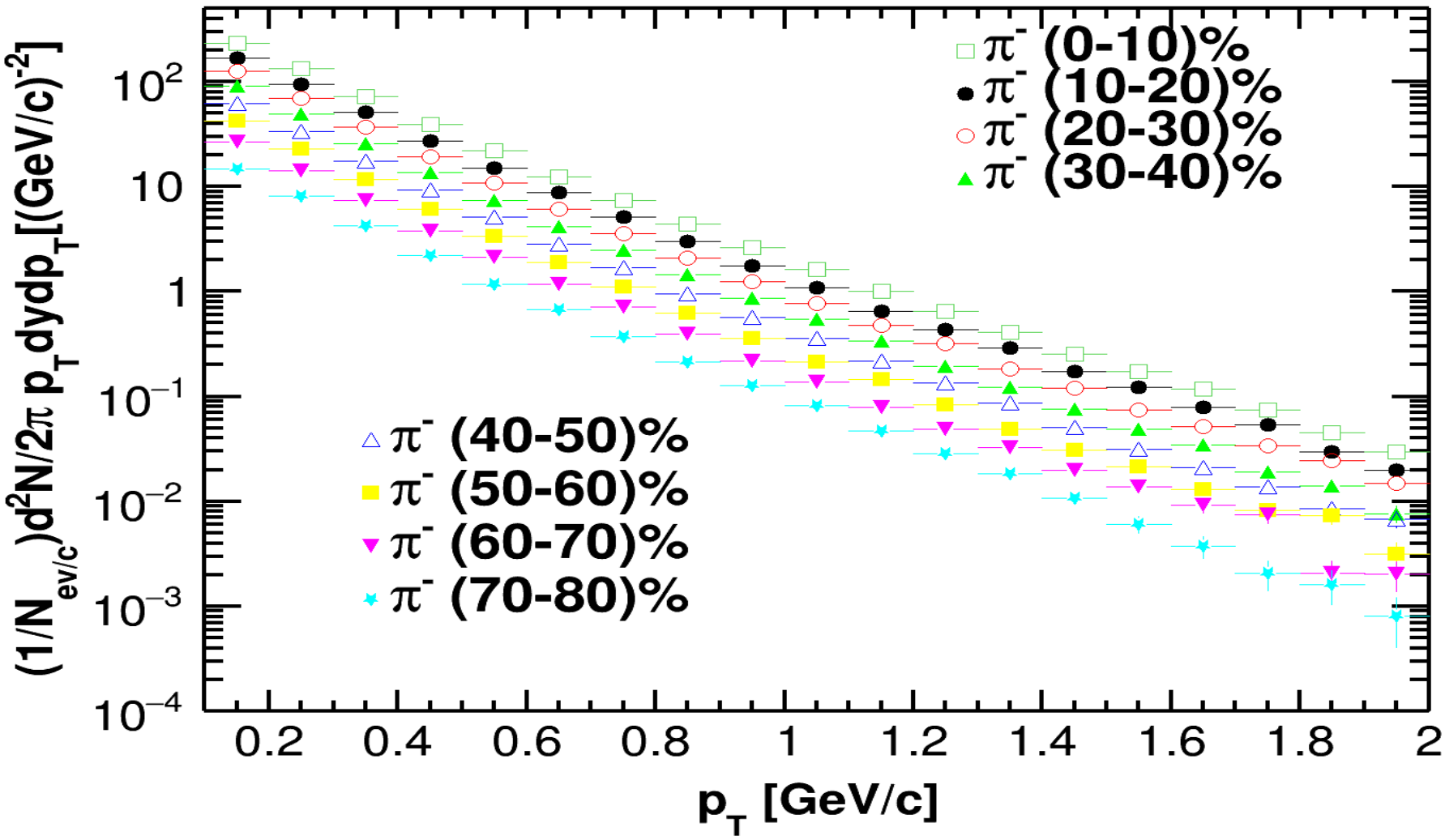
Studies of flow and production mechanisms, together with the freeze-out parameters, are needed to better characterize the transition region from meson-to-baryon dominance. Work in progress.

Thank you for your attention.
Special thanks to E. Cuautle, W. Bietenholz, A. Ayala, R. García, A. Mudrokh, V. Riabov and A. Aparin

Backup

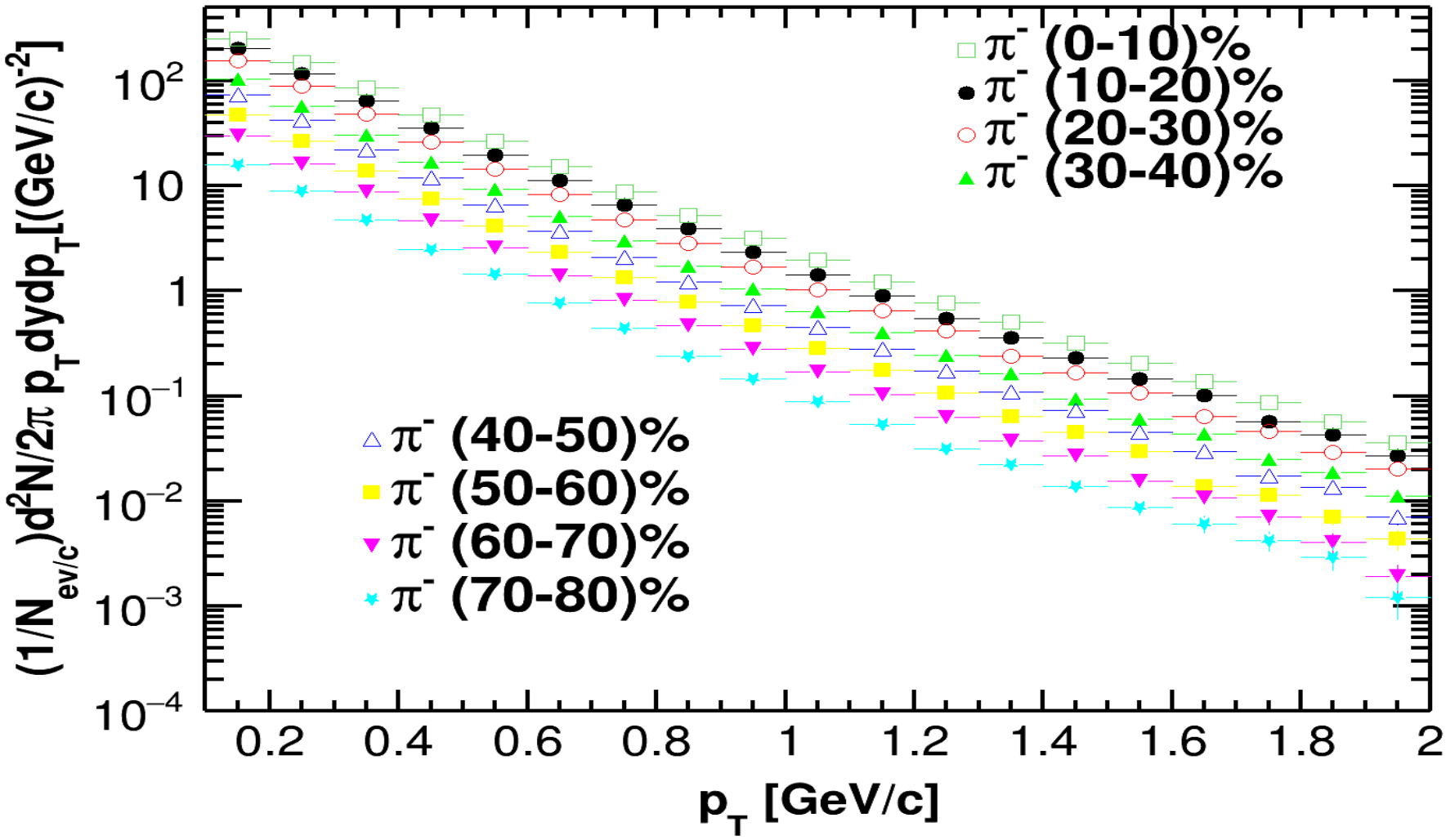
Transverse momentum for π^-

Au+Au 7.7 GeV



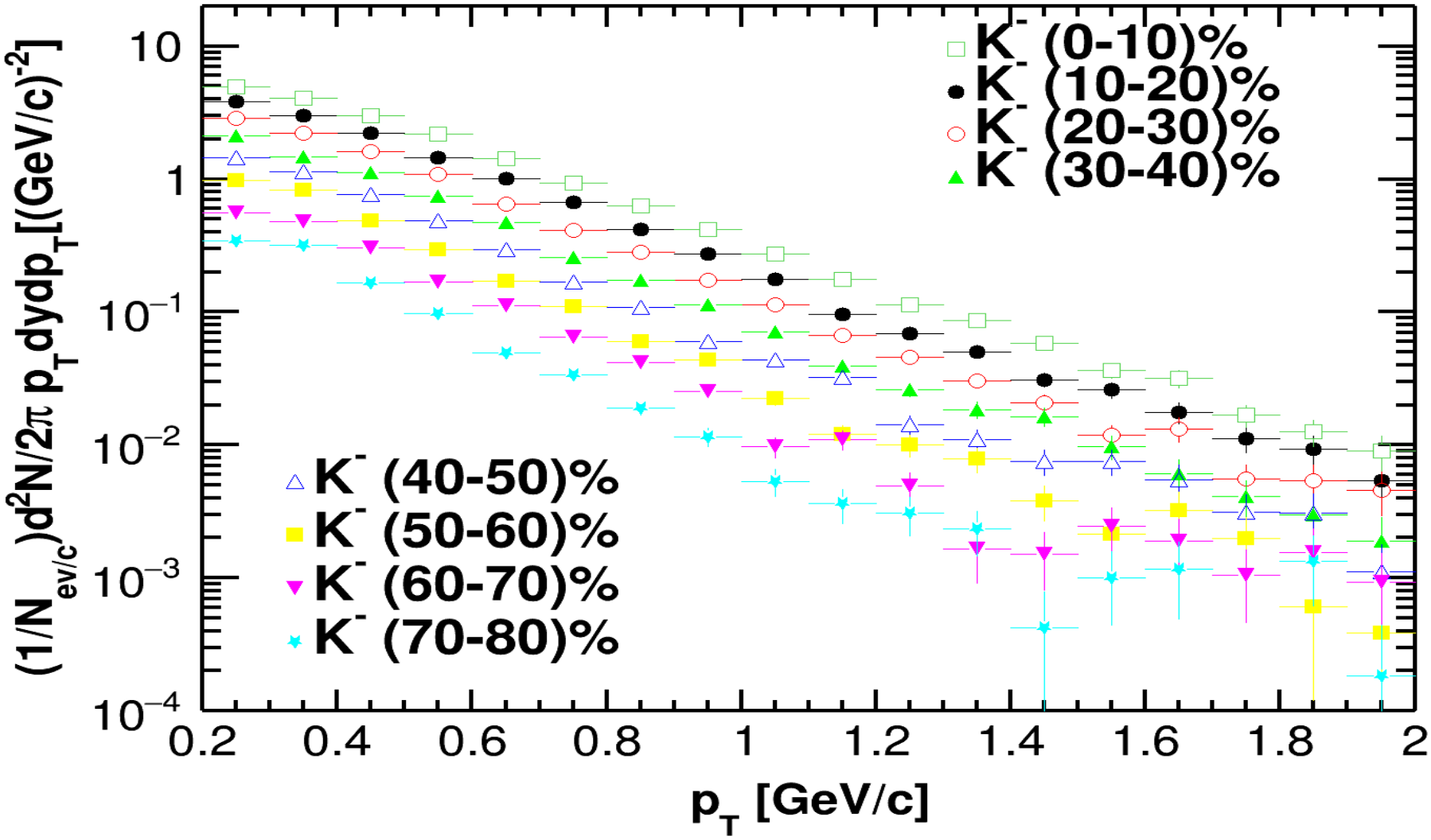
Transverse momentum for π^-

Au+Au 11.5 GeV



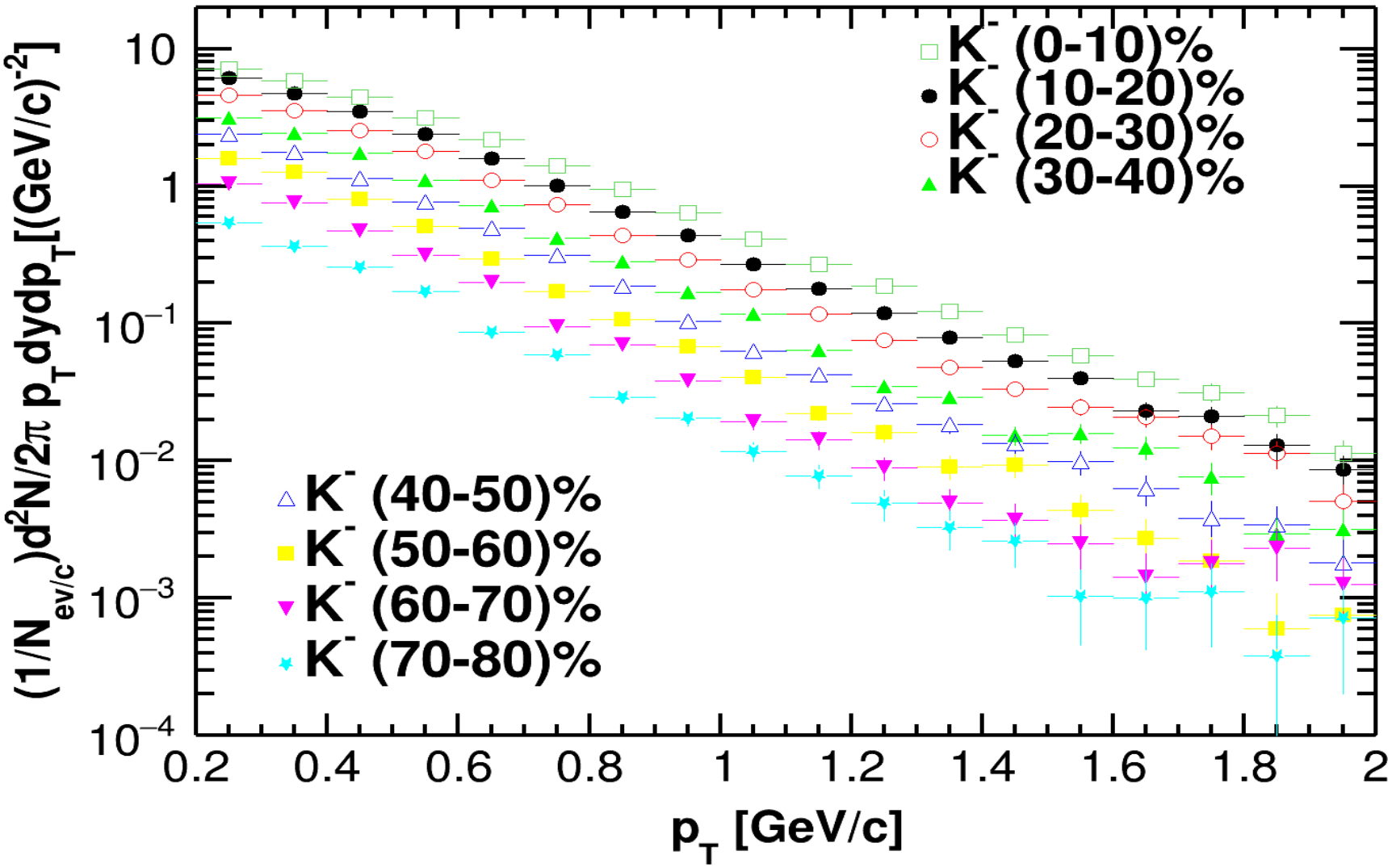
Transverse momentum for K^-

Au+Au 7.7 GeV



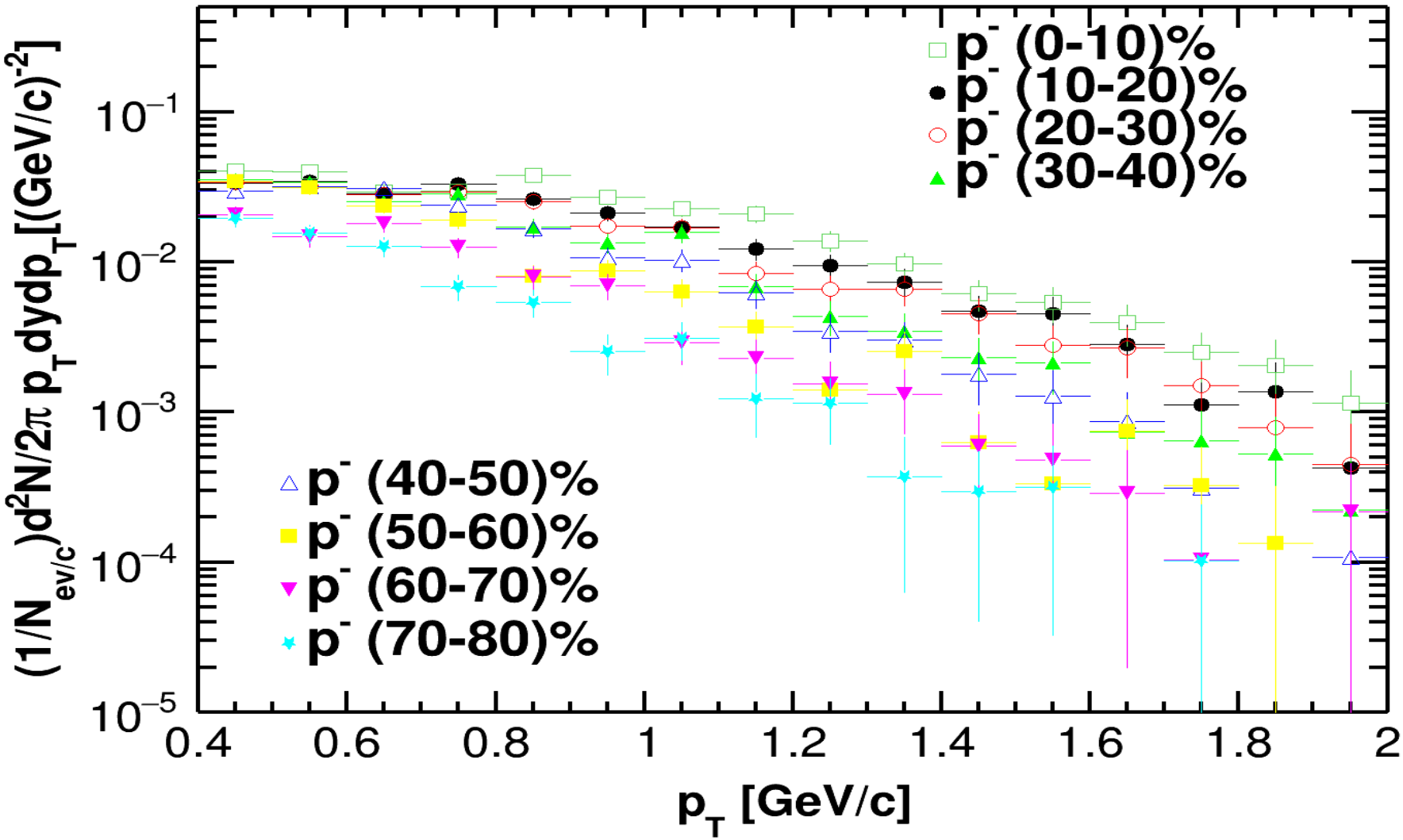
Transverse momentum for K^-

Au+Au 11.5 GeV



Transverse momentum for p^-

Au+Au 7.7 GeV



Transverse momentum for p^-

Au+Au 11.5 GeV