

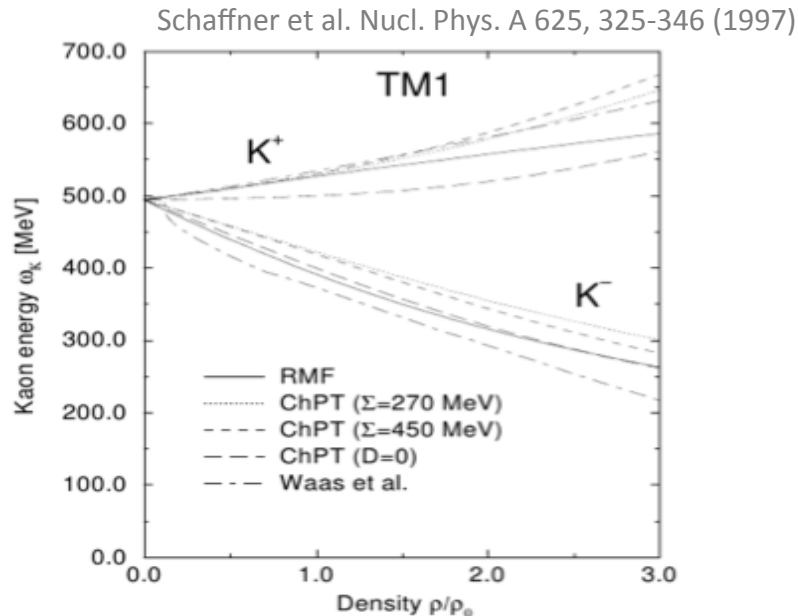
Kaon and Phi Production in Pion-Nucleus Reactions at 1.7 GeV/c*

Joana Wirth, Laura Fabbietti and
Alessandro Scordo for the HADES Collaboration

*supported by SFB 1258

(Anti)Kaon in Medium

Kaon-Nucleon Interaction



K_s^0 properties: Ar + KCl, p + p, p + Nb
 Agakishiev et al. Phys. Rev. C82, 044907 (2010)
 Agakishiev et al. Phys. Rev. C90, 054906 (2014)

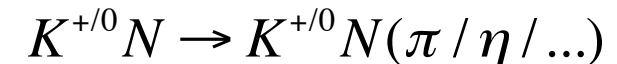
Scattering effects of (anti)kaons inside nuclear matter:

- *Kaon-Nucleon Interaction*
- *Coulomb-Scattering*

Antikaon can be absorbed in nuclear environment:

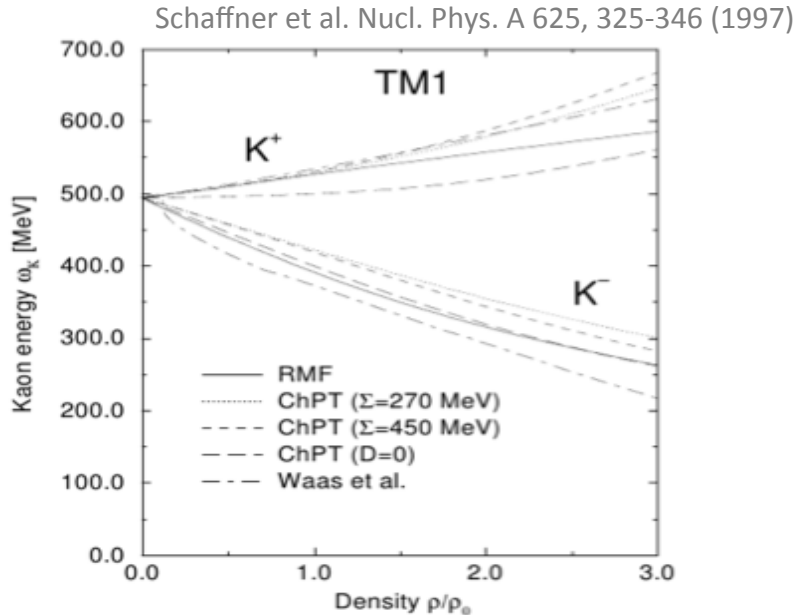


No conventional mechanism for kaon absorption:



(Anti)Kaon in Medium

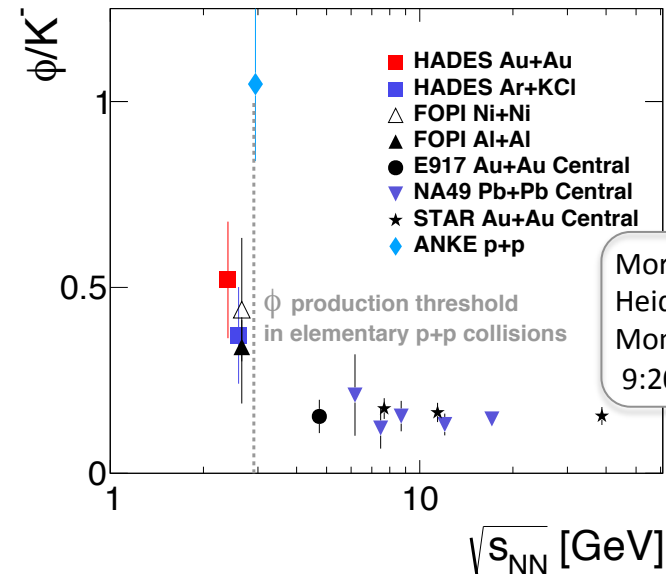
Kaon-Nucleon Interaction



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Antikaon from Phi feed-down:

$$\phi \rightarrow K^- K^+, \quad BR \sim 49\%$$

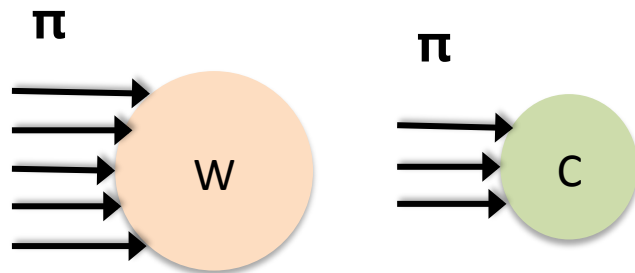


More:
 Heidi Schuldes
 Mon 10 Jul 2017
 9:20

→ ϕ important source for K^- production below NN threshold

ϕ/K^- ratios: p + p, A + A
 Blume et al. Prog. Part. Nucl. Phys. 66, 834-879 (2011)
 Adamczewski-Musch et al. arXiv:1703:08418v [nucl-ex]

Pion-Induced Kaon Production

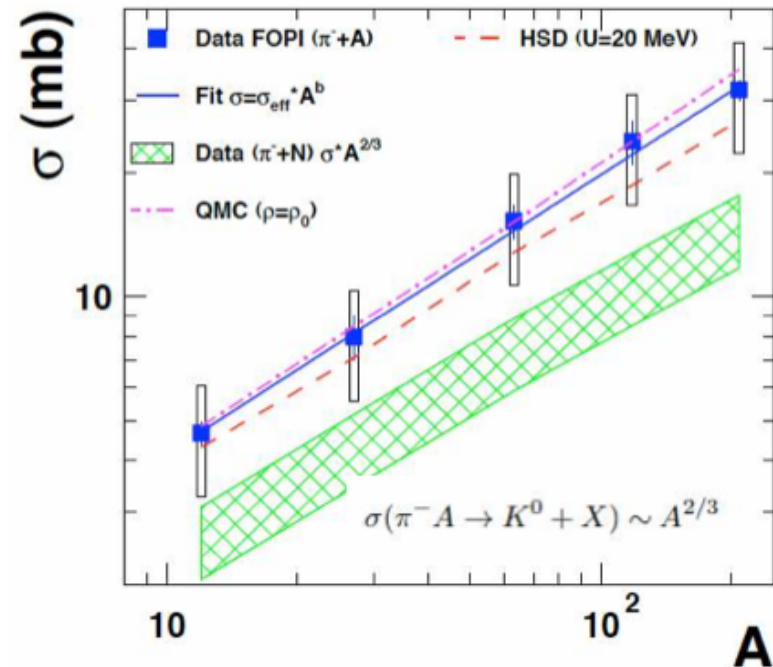


$$\lambda = 1.5 \text{ fm} \quad (p_\pi = 1.7 \text{ GeV}/c)$$

$$d_{C,W} \approx 5.5, 14.2 \text{ fm}$$

→ π is likely to undergo reactions with nucleus on the surface of the target nucleus

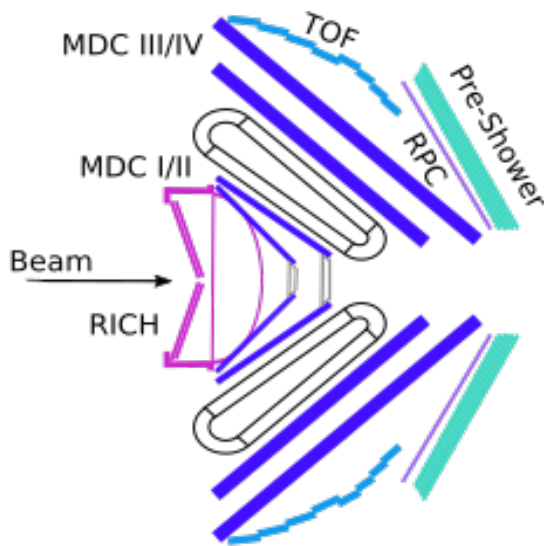
Benabderrahmane et al. Phys. Rev. Lett. Bd. 102, 182501 (2009)



→ K^0 production scales with the surface of the nucleus in pion-induced reactions (@ 1.15 GeV/c)

(Anti)Kaon and Phi with HADES

High Acceptance Di-Electron Spectrometer @ GSI

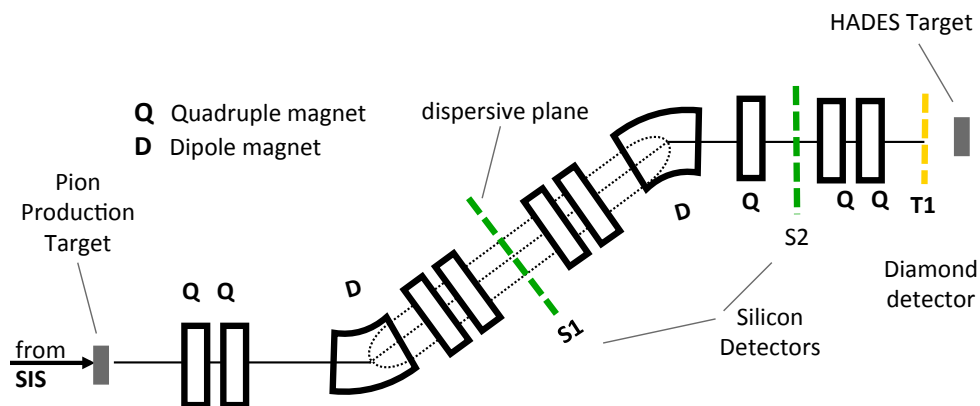


- Full azimuthal coverage
- 15°- 85° in polar angle
- $\delta p/p \approx 2-6\%$

Secondary Pion Beam @ 1.7 GeV/c

- **CEntRAL BEAm TRacker for PiOnS @ TU Munich**
- High π^- rates (up to 10^7 part./s)
- Self-triggering and $\sigma(p_\pi) < 0.5\%$

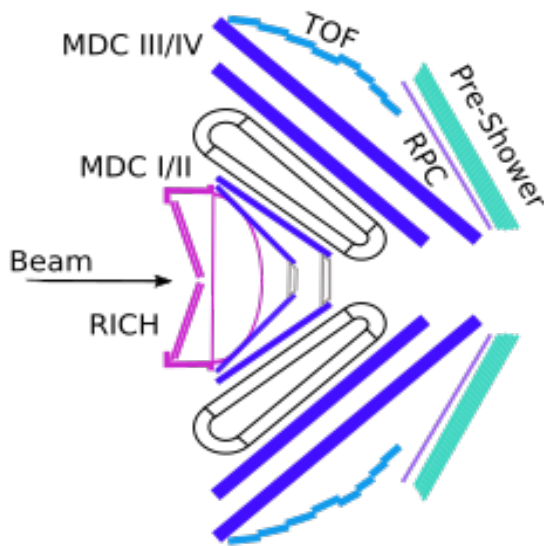
Wirth et al. Nucl. Inst. and Meth., Phys. Res. A, p. 243-244 (2016)



Adamczewski-Musch et al.: "A Facility For Pion Induced Nuclear Reaction Studies with HADES" submitted to EPJA

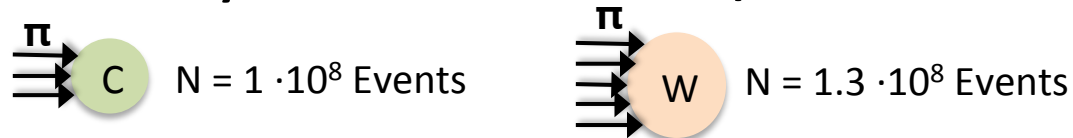
(Anti)Kaon and Phi with HADES

High Acceptance Di-Electron Spectrometer @ GSI



- Full azimuthal coverage
- 15°- 85° in polar angle
- $\delta p/p \approx 2-6\%$

Secondary Pion Beam @ 1.7 GeV/c



(Anti)Kaon:

- Momentum distribution
- Rapidity distribution
- K^- absorption:

$$\frac{K^-}{K^+}(W) / \frac{K^-}{K^+}(C)(y, p_T / \Theta, p)$$

Phi: $\phi \rightarrow K^- K^+$, $BR \approx 49\%$

- K^- from ϕ feed-down:

$$\frac{\phi}{K^-}(C/W)$$

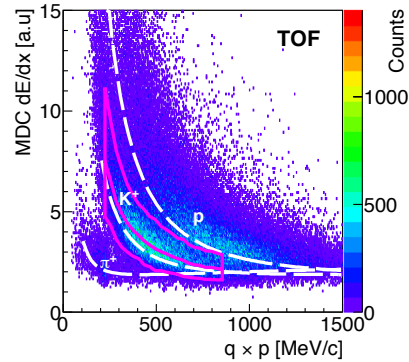
(Anti)Kaons

Kaon Selection

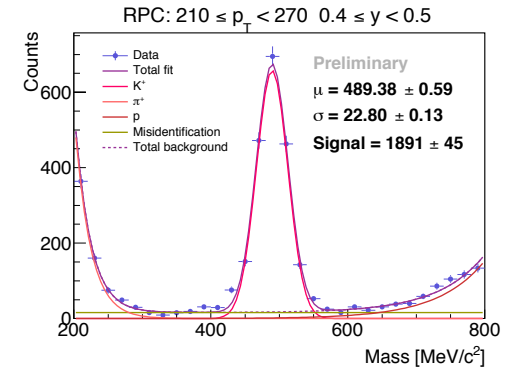
Event Selection:

- Primary vertex:
 - $-80 < z \text{ vertex} < 5 \text{ mm}$
 - $r(x,y \text{ vertex}) \leq 20 \text{ mm}$
 - Velocity: $0 < \beta < 1$
- Energy loss and magnetic field correction

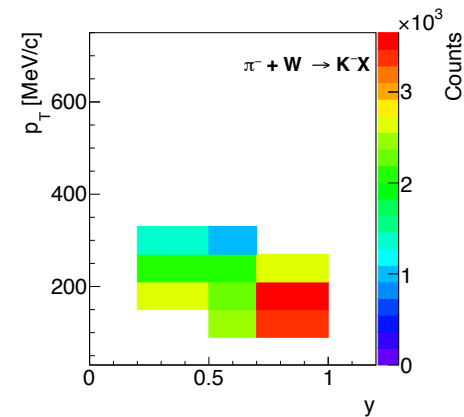
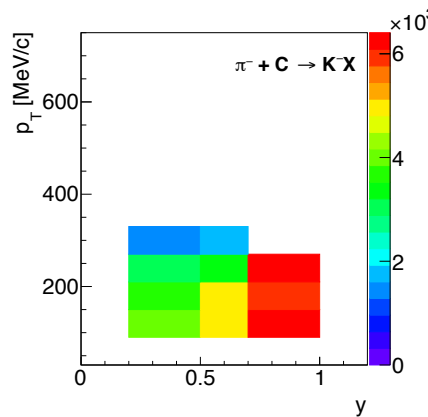
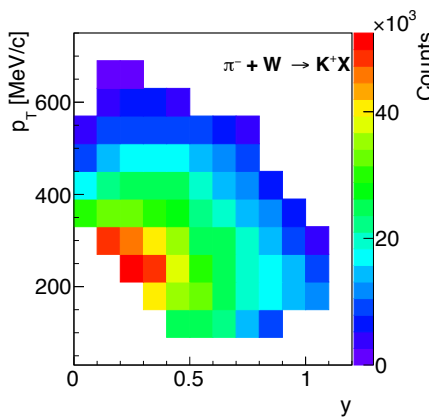
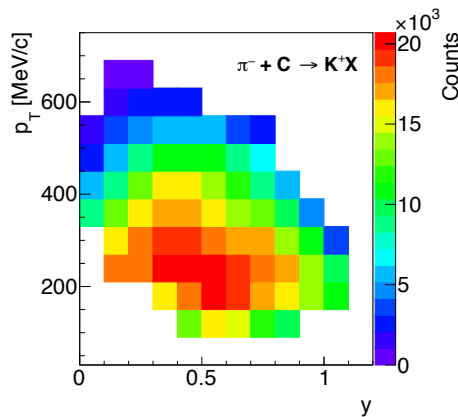
Kaon Identification:



Kaon Yield Extraction:

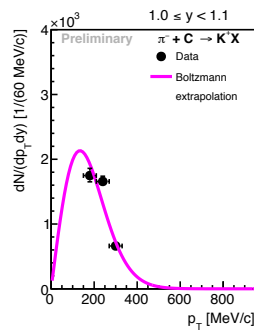
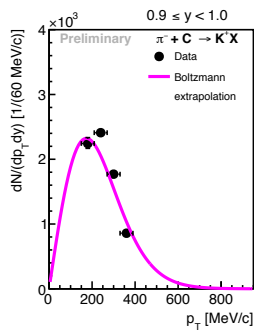
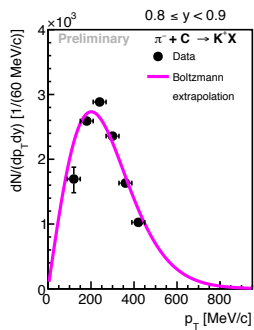
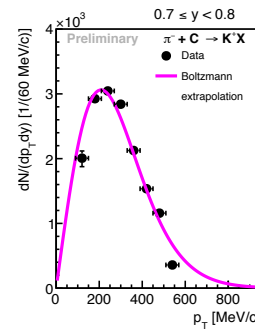
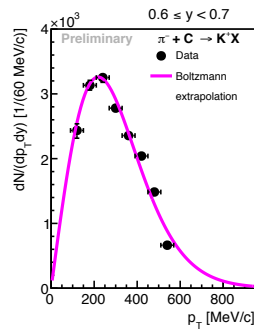
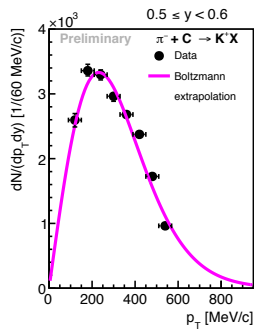
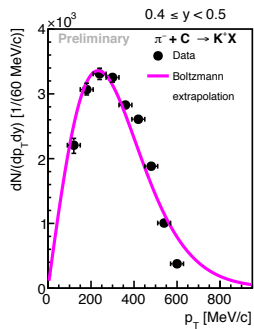
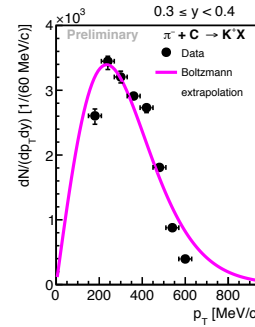
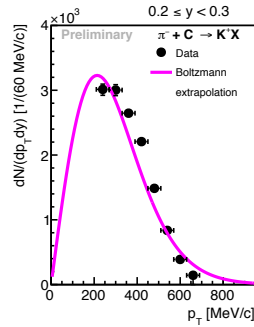
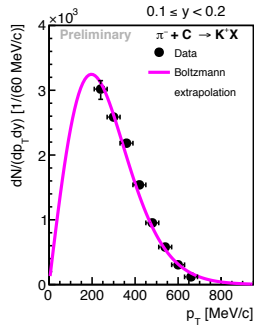
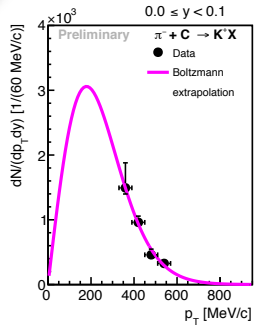


Corrected Kaon Yield*:



* Acceptance \otimes efficiency corrected (GiBUU)

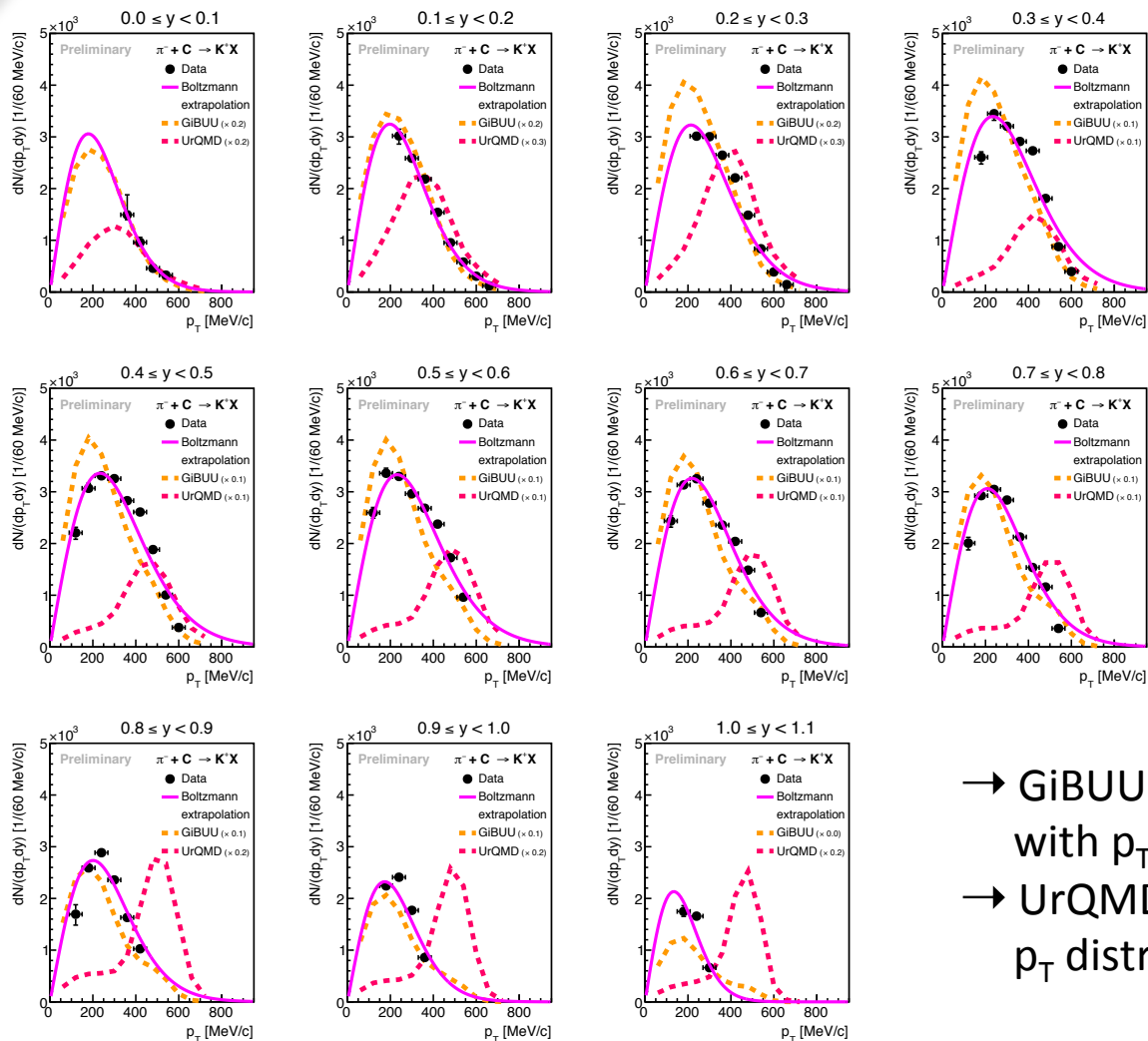
p_T - y Distribution: K^+



Yield extrapolation in p_T

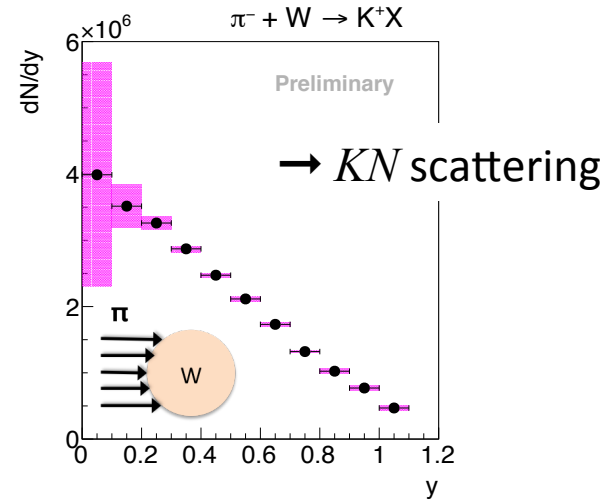
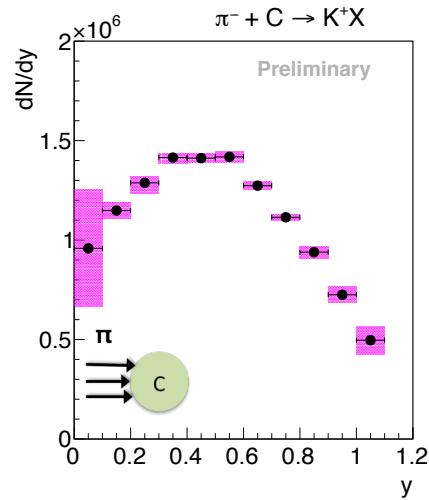
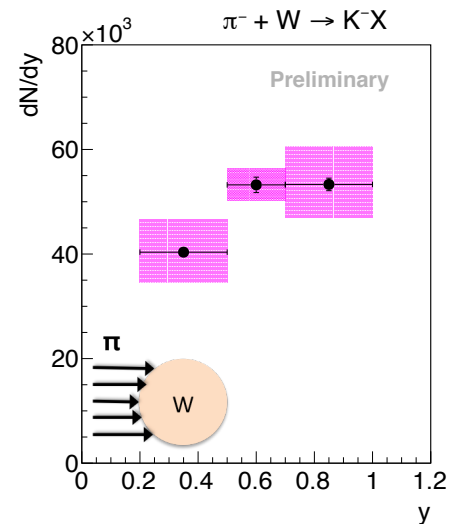
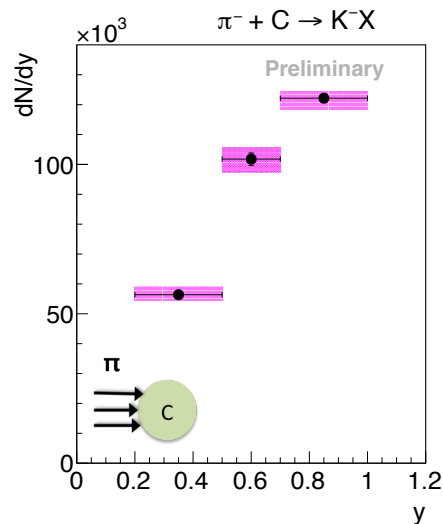
$$\frac{dN}{dy dp_T} = A \cdot p_T \sqrt{p_T^2 + m_0^2} \cdot e^{-\frac{\sqrt{p_T^2 + m_0^2}}{T_B}}$$

p_T - y Distribution: K^+



- GiBUU is almost in agreement with p_T distributions
- UrQMD does not describe p_T distributions in all y bins

Rapidity Distribution: K^+/K^-

 K^+  K^- 

Ratio: $K^-/K^+(W)/K^-/K^+(C)$

	Tungsten	Carbon
Z	74	6
A	184	12
N	110	6



$$\frac{K^-}{K^+}(W) / \frac{K^-}{K^+}(C) = \frac{\cancel{A_W^b} \left(\frac{Z_W}{A_W} \sigma_{\pi p \rightarrow K^- X} + \frac{N_W}{A_W} \sigma_{\pi n \rightarrow K^- X} \right)}{\cancel{A_W^b} \left(\frac{Z_W}{A_W} \sigma_{\pi p \rightarrow K^+ X} + \frac{N_W}{A_W} \sigma_{\pi n \rightarrow K^+ X} \right)} / \frac{\cancel{A_C^b} \left(\frac{Z_C}{A_C} \sigma_{\pi p \rightarrow K^- X} + \frac{N_C}{A_C} \sigma_{\pi n \rightarrow K^- X} \right)}{\cancel{A_C^b} \left(\frac{Z_C}{A_C} \sigma_{\pi p \rightarrow K^+ X} + \frac{N_C}{A_C} \sigma_{\pi n \rightarrow K^+ X} \right)} = ?$$

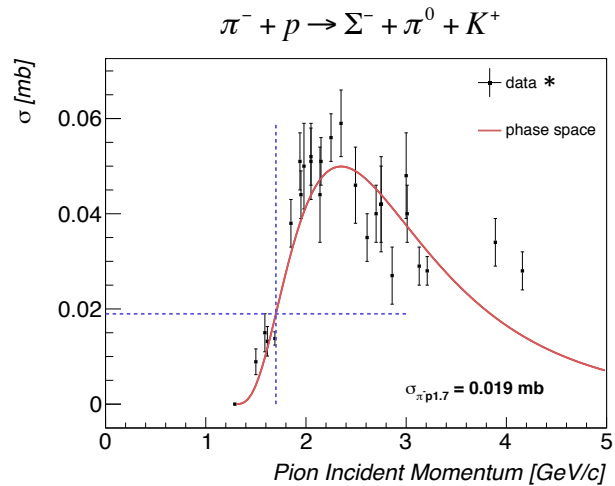
Ratio: $K^-/K^+(W)/K^-/K^+(C)$

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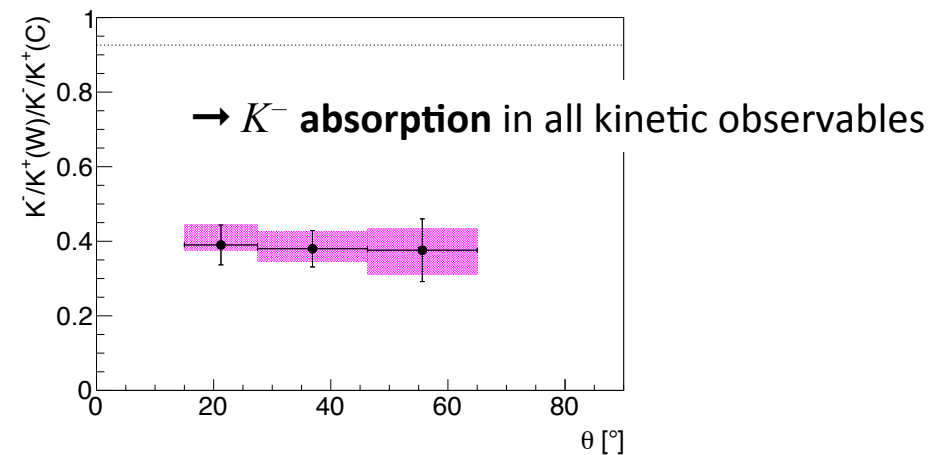
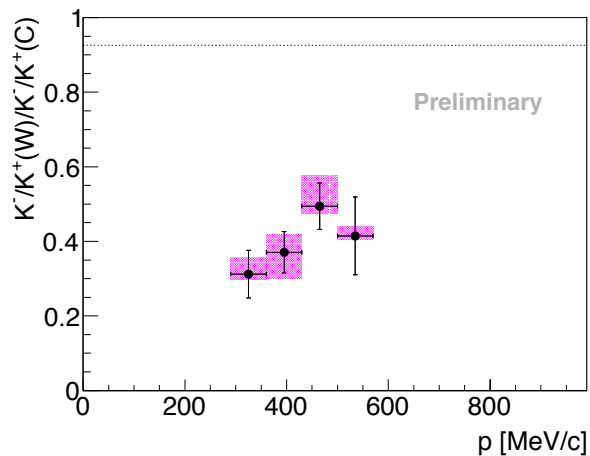
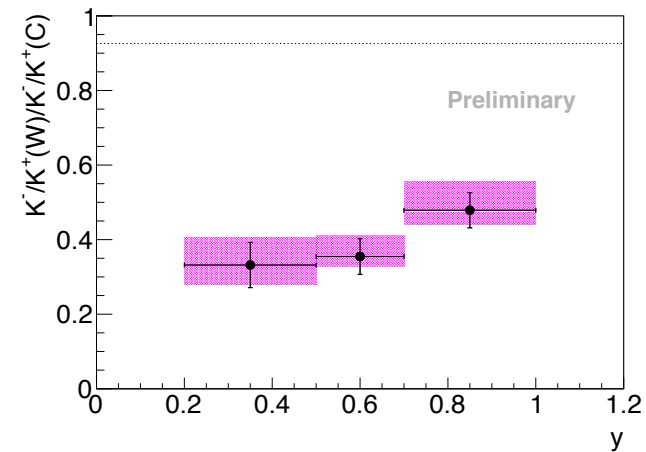
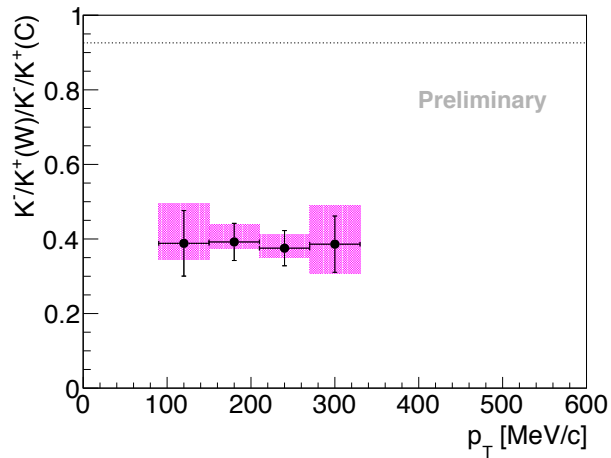
$\pi^- + p$	Threshold p_{lab} [GeV/c]	$\pi^- + p$	Threshold p_{lab} [GeV/c]
$\Lambda \pi^+ 2\pi^- K^+$	1.711	$\Sigma^-(1385) K^+$	1.399
$\Lambda \pi^0 \pi^- K^+$	1.407	$p \pi^0 K^0 K^-$	1.785
$\Lambda \pi^- K^+$	1.144	$p \pi^- K^+ K^-$	1.790
$\Sigma^+ \pi^0 2\pi^- K^+$	1.861	$p K^0 K^-$	1.497
$\Sigma^+ 2\pi^- K^+$	1.568	$n \pi^+ K^0 K^-$	1.801
$\Sigma^0 \pi^+ 2\pi^- K^+$	1.879	$n \pi^- K^+ K^0$	1.801
$\Sigma^0 \pi^- K^+$	1.290	$n K^+ K^-$	1.495
$\Sigma^- \pi^+ \pi^0 \pi^- K^+$	1.879	$n \Phi$ (BR: 0.49)	1.559
$\Sigma^- \pi^+ \pi^- K^+$	1.585		
$\Sigma^- \pi^0 K^+$	1.290	$\pi^- + n$	
$\Sigma^- K^+$	1.035	$\Sigma^- \pi^- K^+$	1.296
$\Sigma^0(1385) \pi^- K^+$	1.680	$p \pi^- K^0 K^-$	1.792
$\Sigma^-(1385) \pi^0 K^+$	1.680		



* Landolt-Börnstein

Ratio: $K^-/K^+(W)/K^-/K^+(C)$

Inside HADES acceptance (without p_T/y extrapolation)



Phi

Phi Reconstruction

Event and Kaon Selection:

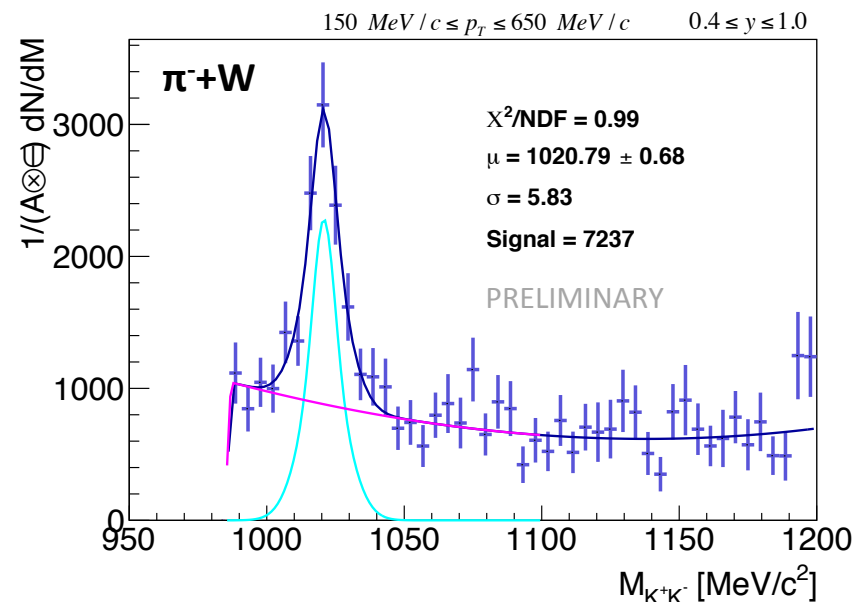
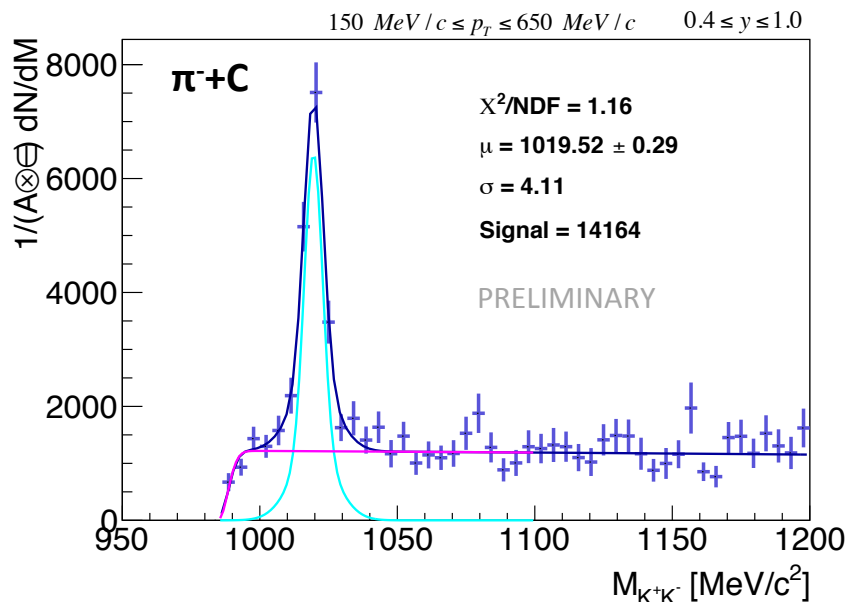
- Primary vertex:
 - - 80 < z vertex < 5 mm
 - r(x,y vertex) \leq 20 mm
- Kaon mass: $400 < M_K < 600 \text{ MeV}/c^2$
- Particle identification via β and p
 - $(\beta \leq (p/\sqrt{p^2+m_K^2}) \pm 0.5)$

Energy loss and magnetic field correction

Phi Yield Extraction*:

- Signal: “gauss + gauss”
 - σ_1 : finite resolution effects
 - σ_2 : multiple scattering
- Background: “polN · (1 – gauss(x, threshold, σ))”

*Event-by-event acceptance \otimes efficiency corrected (Pluto)



Antikaons from Phi Feed-Down

$\pi^- + C$

$$\phi / K^- (p_T, y) = 0.31 \pm 0.044 \text{ (stat)}$$

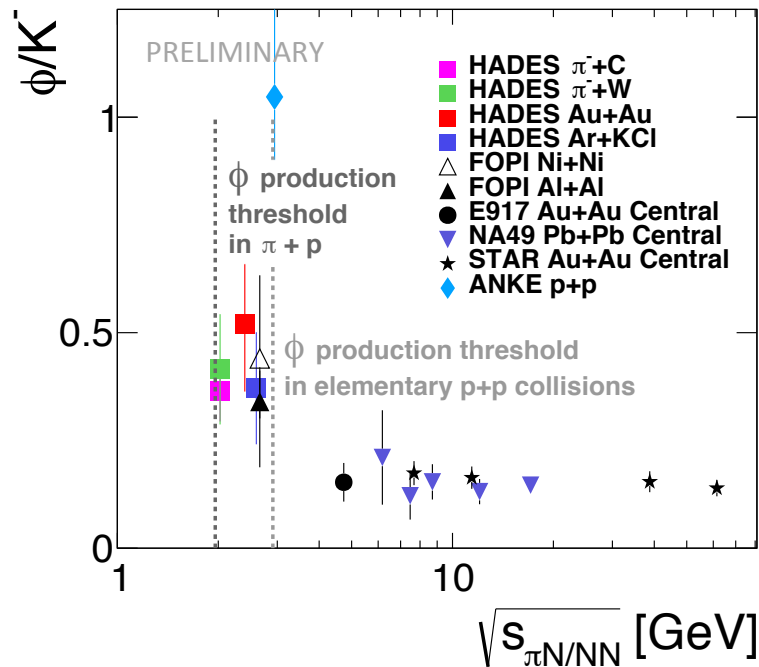
$$\phi / K^- (p, \Theta) = 0.42 \pm 0.045 \text{ (stat)}$$

$\pi^- + W$

$$\phi / K^- (p_T, y) = 0.30 \pm 0.056 \text{ (stat)}$$

$$\phi / K^- (p, \Theta) = 0.53 \pm 0.057 \text{ (stat)}$$

$$\sqrt{s_{\pi N}} \approx 2 \text{ GeV}$$



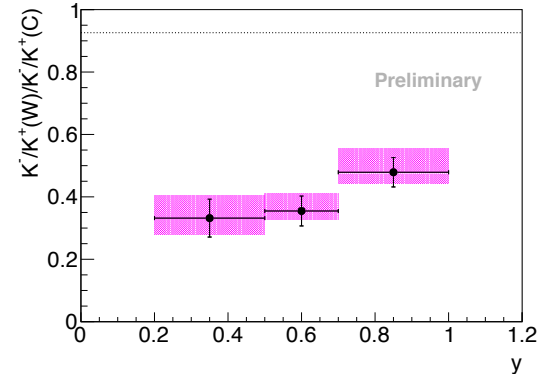
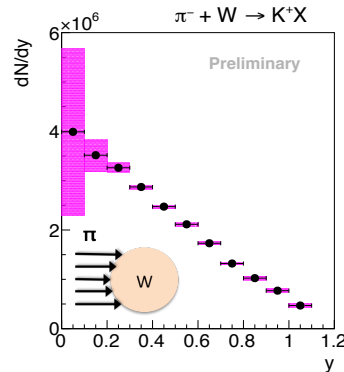
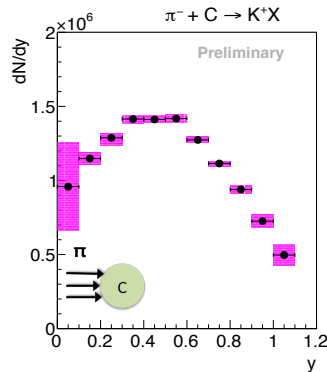
→ ϕ / K^- ratio is the same in $\pi^- + C$ and $\pi^- + W$

→ K^- is absorbed in Tungsten

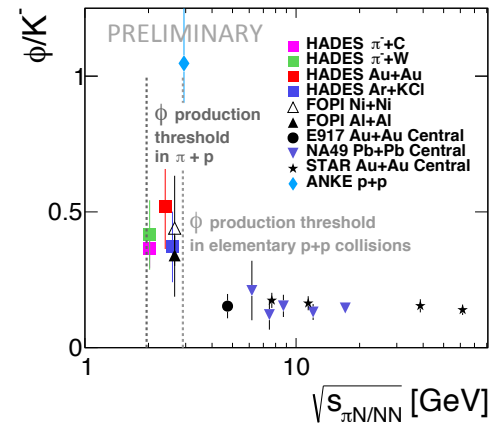
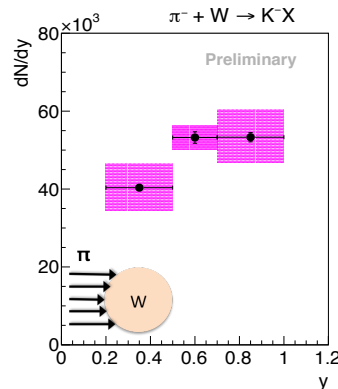
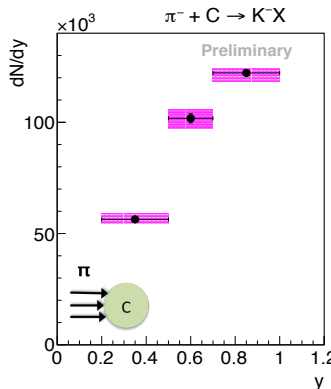
→ What happens to ϕ ?

Summary

K^+



K^-



→ K^- absorption in $\pi^- + W$ with respect to $\pi^- + C$

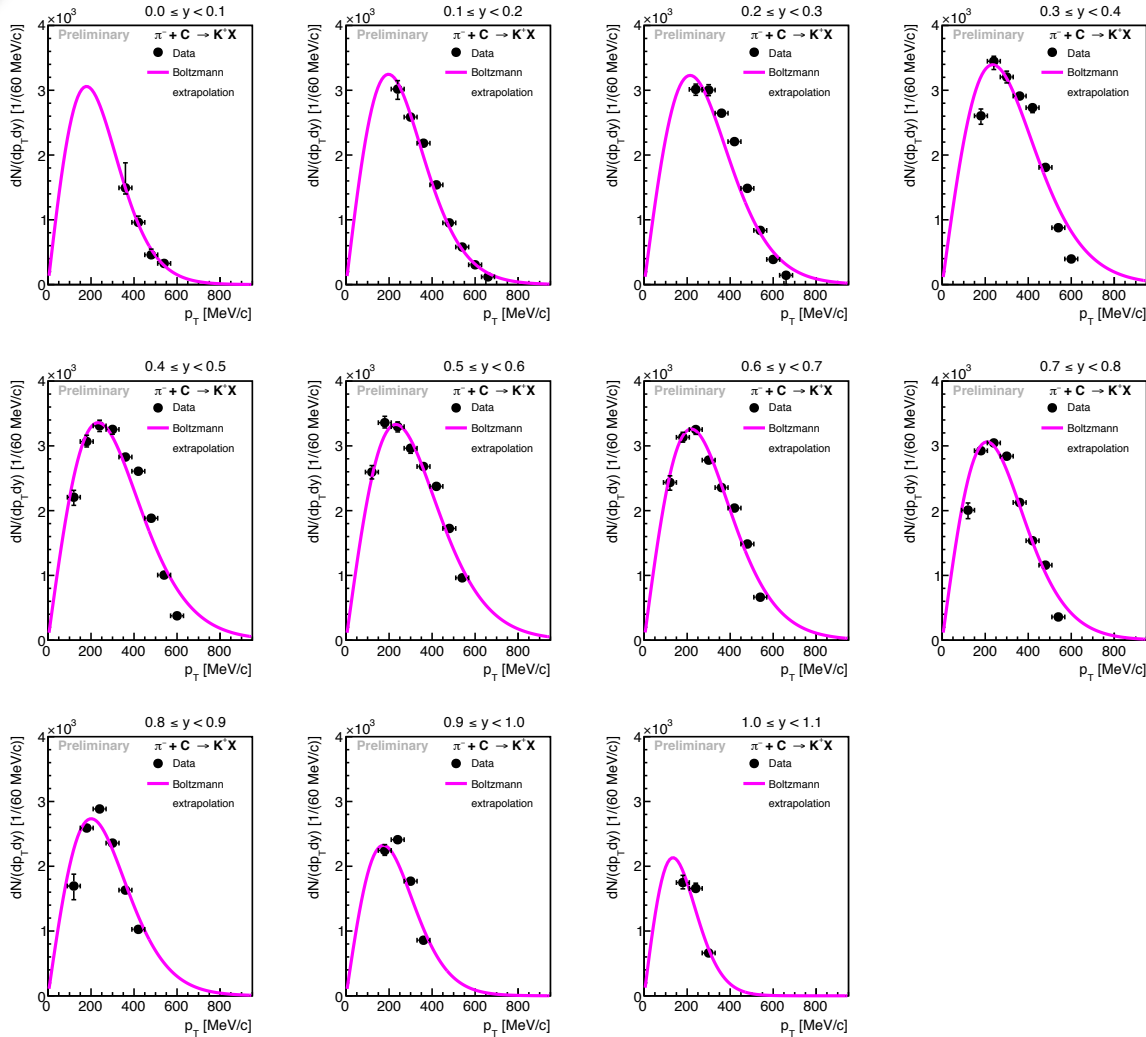
→ ϕ/K^- ratio constant for $\pi^- + W$ and $\pi^- + C$

→ ϕ disappearance as K^-

→ Resonance disappearance

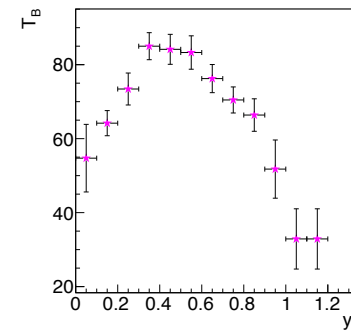
→ ϕN cross-section not small

p_T - y Distribution: K^+

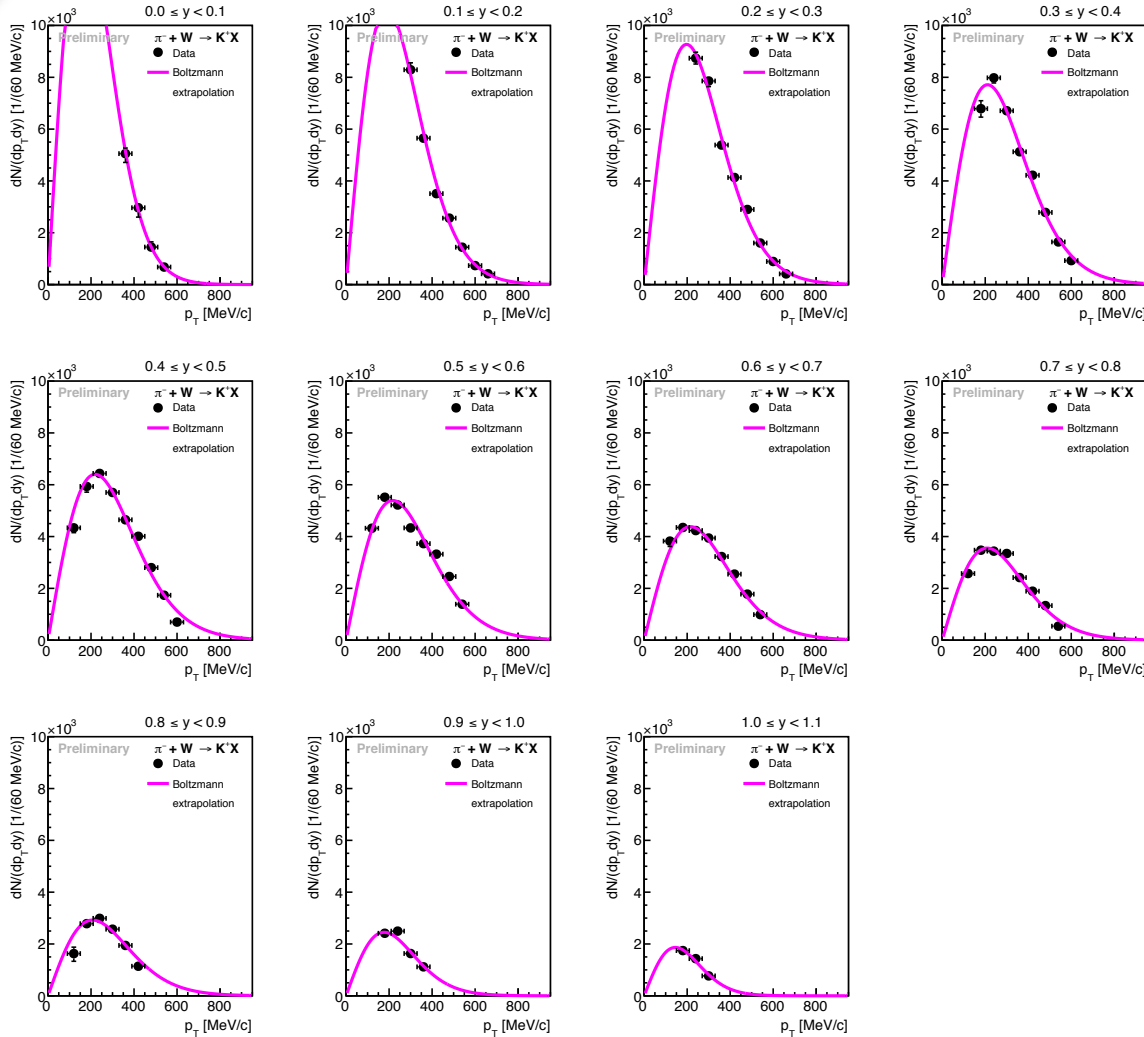


Yield extrapolation in p_T

$$\frac{dN}{dy dp_T} = A \cdot p_T \sqrt{p_T^2 + m_0^2} \cdot e^{-\frac{\sqrt{p_T^2 + m_0^2}}{T_B}}$$

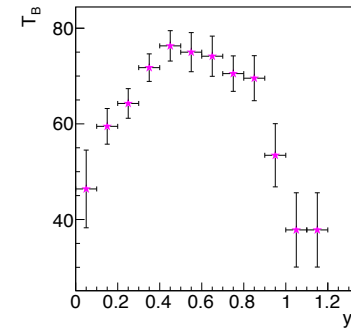


p_T - y Distribution: K^+

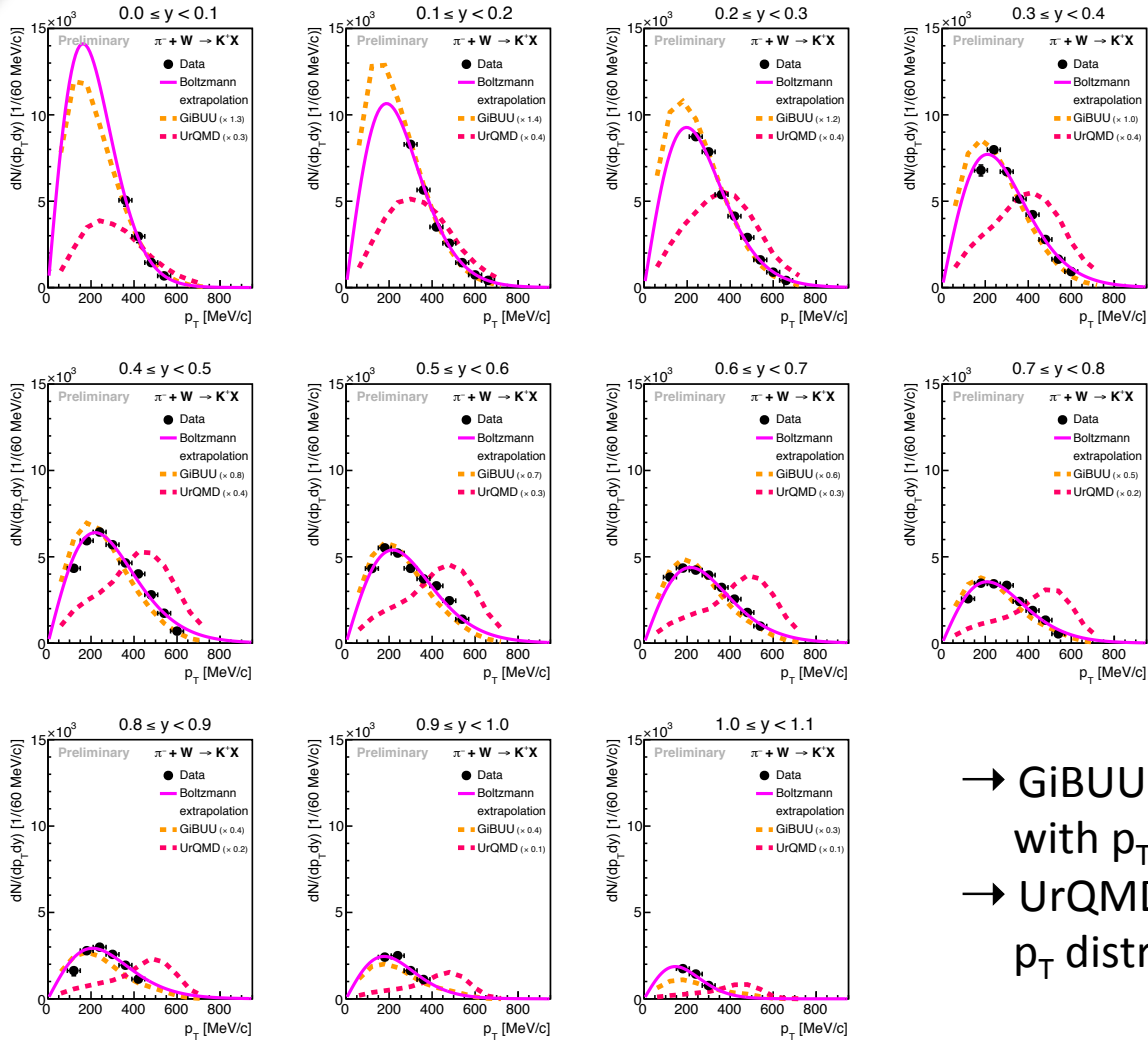


Yield extrapolation in p_T

$$\frac{dN}{dy dp_T} = A \cdot p_T \sqrt{p_T^2 + m_0^2} \cdot e^{-\frac{\sqrt{p_T^2 + m_0^2}}{T_B}}$$



p_T - y Distribution: K^+



- GiBUU is almost in agreement with p_T distributions
- UrQMD does not describe p_T distributions in all y bins

p_T - γ Distribution: K^-

