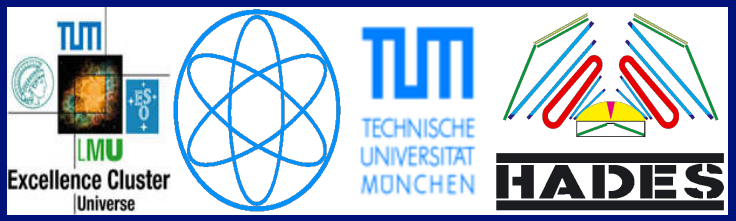


Kaon and Phi Production in Pion-Nucleus Reactions at 1.7 GeV/c*

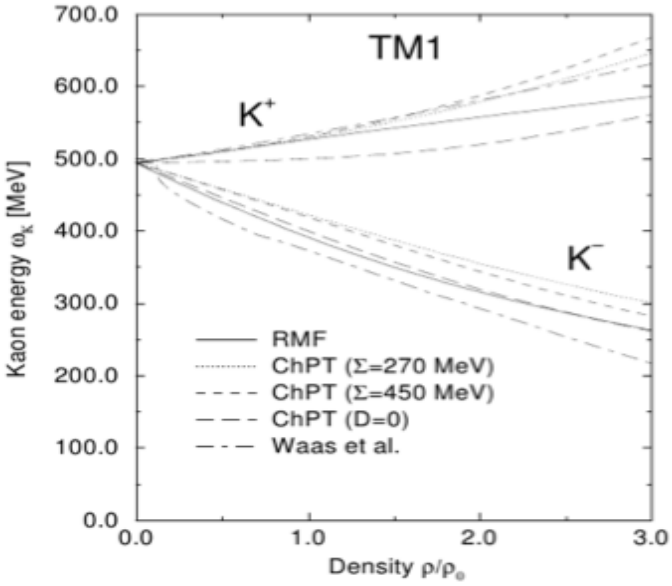
Joana Wirth, Laura Fabbietti and
Alessandro Scordo for the HADES Collaboration

*supported by SFB 1258

(Anti)Kaon in Medium

Kaon-Nucleon Interaction

Schaffner et al. Nucl. Phys. A 625, 325-346 (1997)



K^0_s 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:

$$K^- N \rightarrow Y\pi \qquad K^- NN \rightarrow YN$$

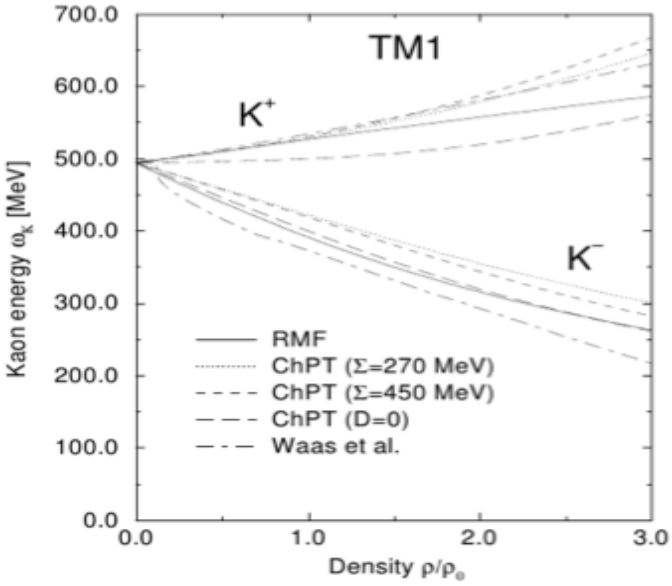
No conventional mechanism for kaon absorption:

$$K^{+/0} N \rightarrow K^{+/0} N(\pi / \eta / \ldots)$$

(Anti)Kaon in Medium

Kaon-Nucleon Interaction

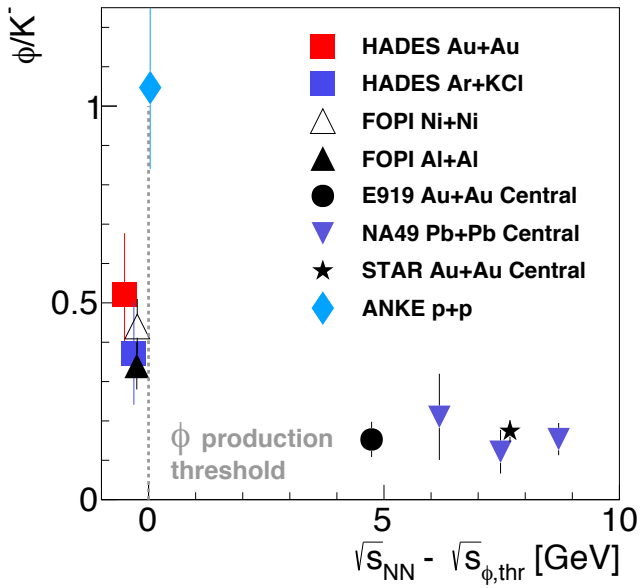
Schaffner et al. Nucl. Phys. A 625, 325-346 (1997)



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

Antikaon from Phi feed-down:

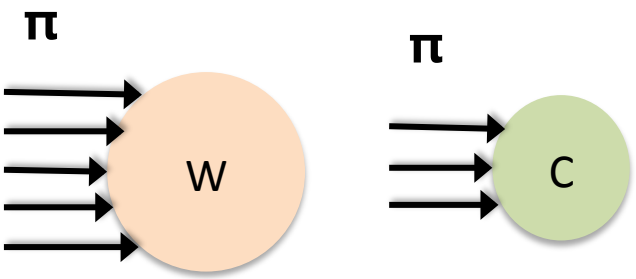
$$\phi \rightarrow K^- K^+, \quad BR \sim 49\%$$



→ 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

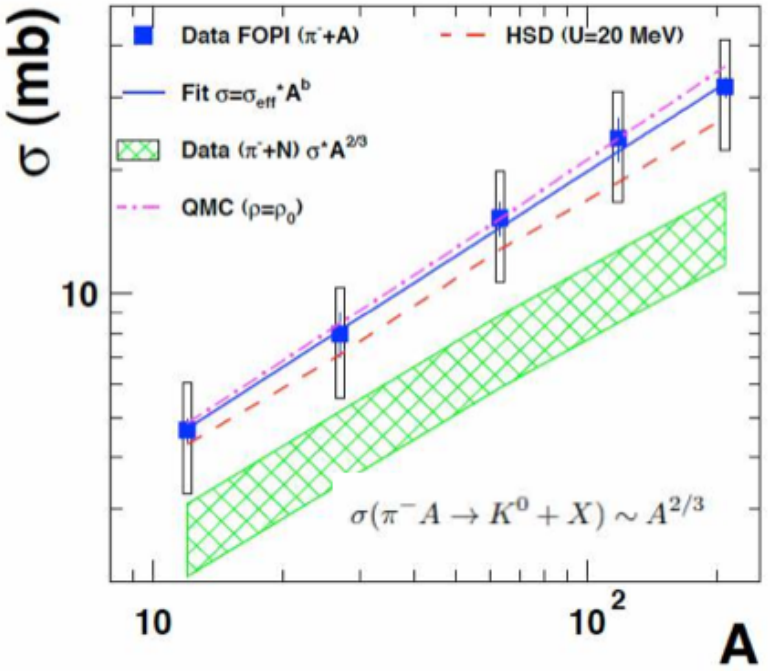


$\lambda = 1.5 \text{ fm} \quad (p_\pi = 1.7 \text{ GeV/c})$

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

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

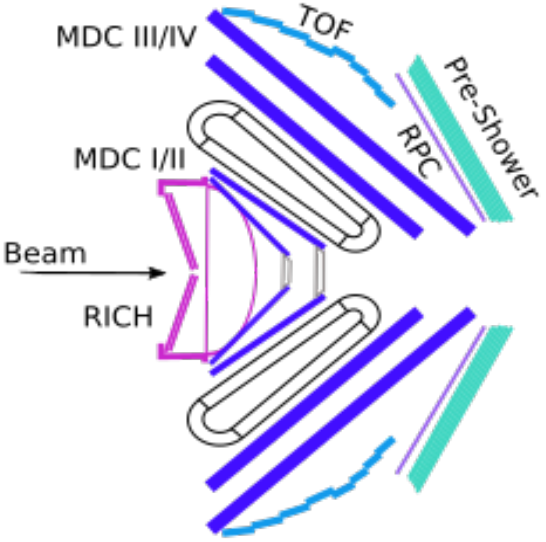
Benabderrahmane et al. Phys. Rev. Lett. Bd. 102, 182501 (2009)



→ 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 **A**cceptance **D**i-**E**lectron **S**pectrometer @ GSI

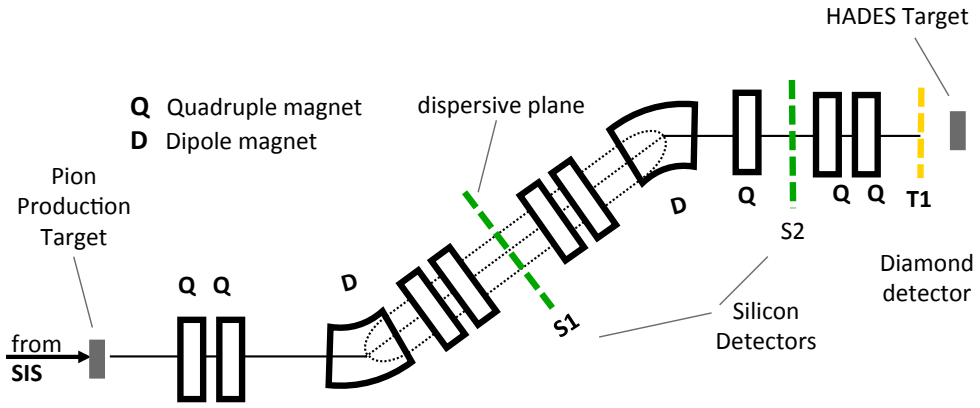


→ Full azimuthal coverage
→ 15°- 85° in polar angle
→ δp/p ≈ 2-6%

Secondary Pion Beam @ 1.7 GeV/c

→ **CE**nt**R**al **BE**am T**R**acker for Pi**O**n**S** @ TU Munich
→ High π^- rates (up to 10^7 part./s)
→ Self-triggering and $\sigma(p_\pi) < 0.5$ %

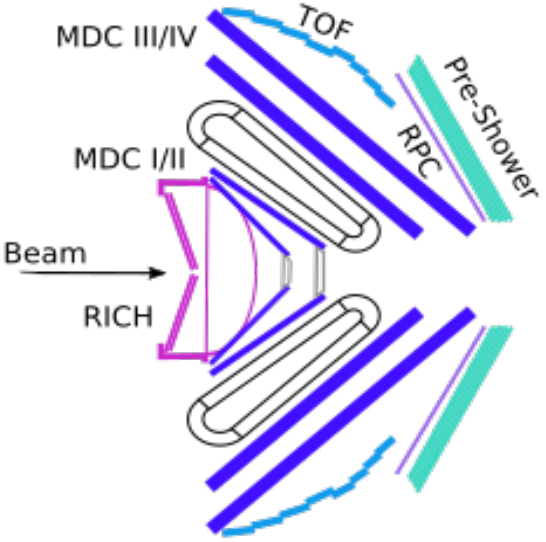
Wirth et al. Nucl. Inst. and Meth., Phy. Res. A, p. 243-244 (2016)



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

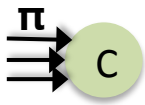
(Anti)Kaon and Phi with HADES

High **A**cceptance **D**i-**E**lectron **S**pectrometer @ GSI

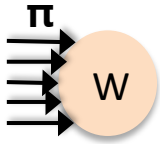


→ Full azimuthal coverage
→ 15°- 85° in polar angle
→ δp/p ≈ 2-6%

Secondary Pion Beam @ 1.7 GeV/c



N = 1 ·10^8 Events



N = 1.3 ·10^8 Events

(Anti)Kaon:

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

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

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

→ **K^- from ϕ feed-down:**

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

(Anti)Kaons

Kaon Selection

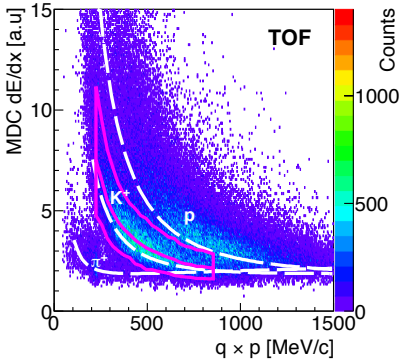
π⁻+C/W

Event Selection:

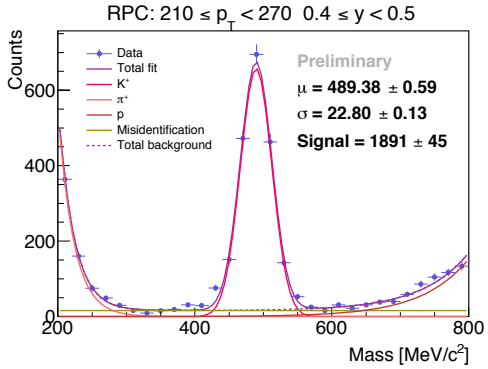
- Primary vertex:
  - - 80 < z vertex < 5 mm
  - r(x,y vertex) ≤ 20 mm
- Velocity: 0 < β < 1

Energy loss and magnetic field correction

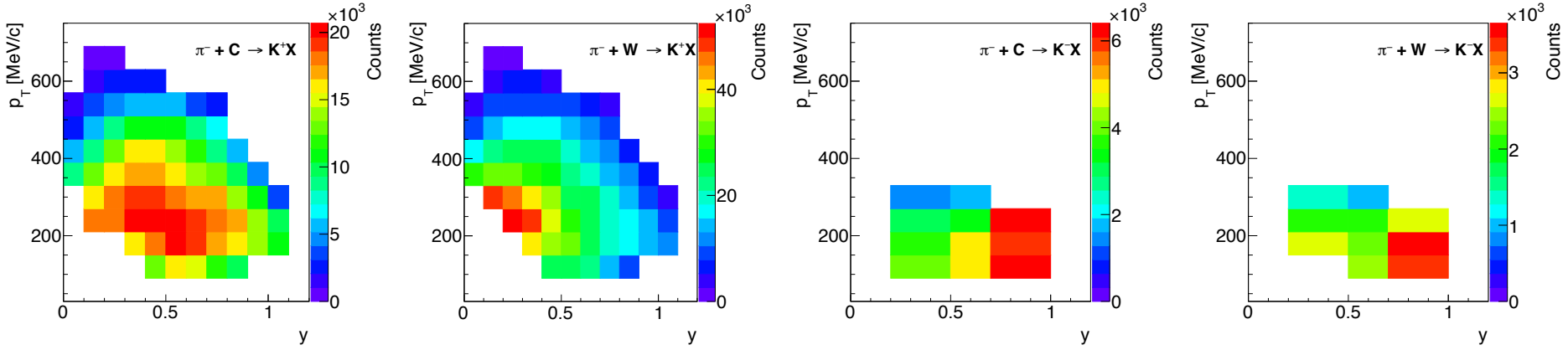
Kaon Identifaction:



Kaon Yield Extraction:

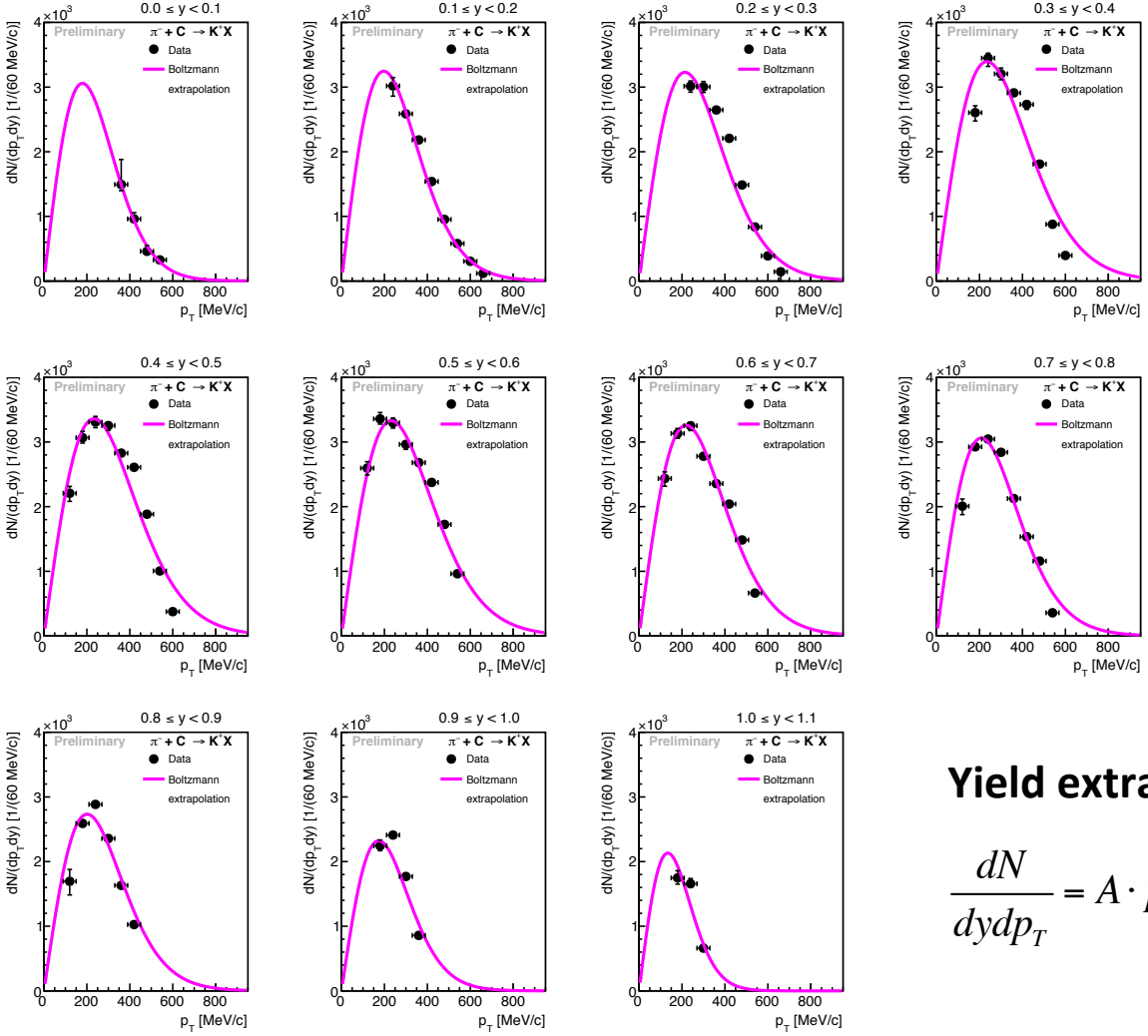


Corrected Kaon Yield*:



*Acceptance⊗efficiency corrected (GiBUU)

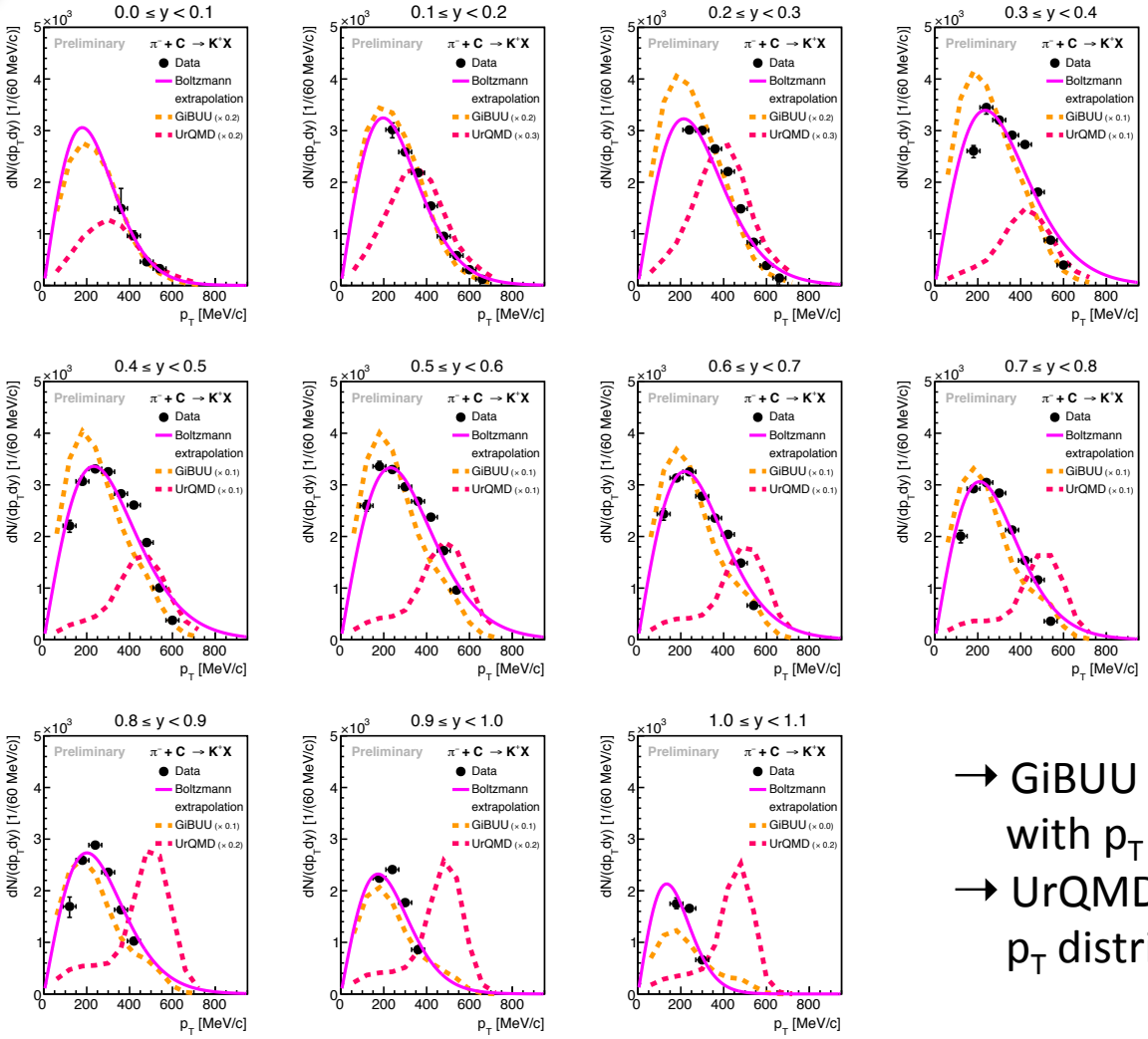
p_T-y Distribution: K^+



Yield extrapolation in p_T

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

p_T-y Distribution: K^+



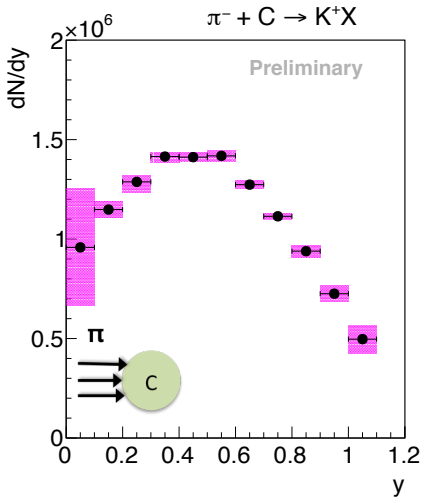
→ GiBUU is almost in agreement with p_T distributions

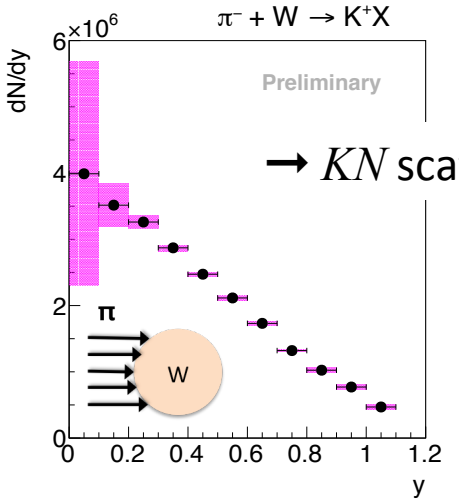
→ UrQMD does not describe p_T distributions in all y bins

π⁻+C/W

Rapidity Distribution: K^+/K^-

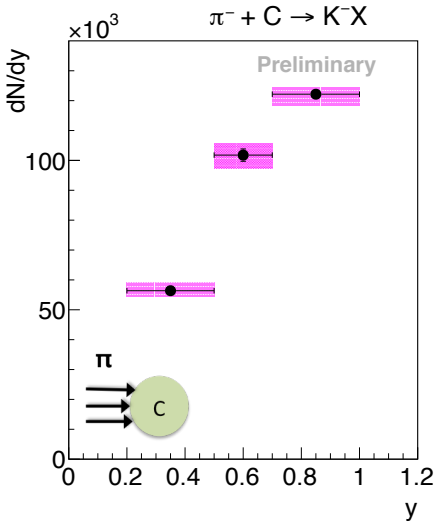
K^+

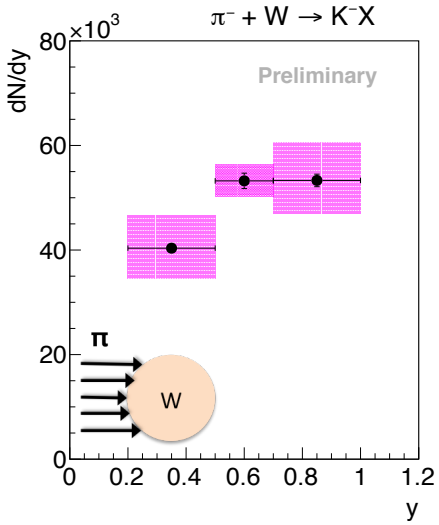




→ KN scattering

K^-





π⁻+C/W

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

	Tungsten	Carbon
Z	74	6
A	184	12
N	110	6

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

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

π^-+C/W

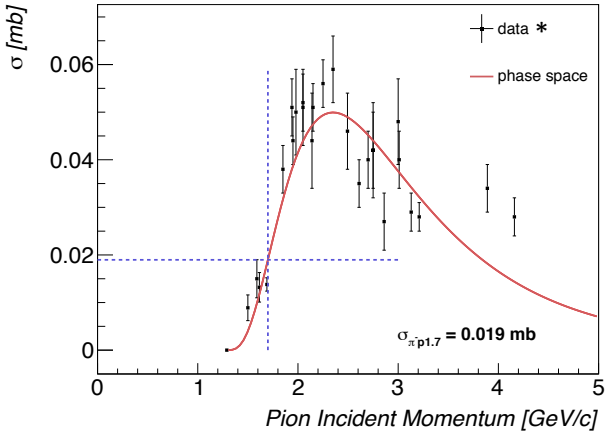
	Tungsten	Carbon
Z	74	6
A	184	12
N	110	6

$$\frac{K^-}{K^+}(W) \Big/ \frac{K^-}{K^+}(C) = \frac{A_W^b \left(\frac{Z_W}{A_W} \sigma_{\pi p \to K^- X} + \frac{N_W}{A_W} \sigma_{\pi n \to K^- X} \right)}{A_W^b \left(\frac{Z_W}{A_W} \sigma_{\pi p \to K^+ X} + \frac{N_W}{A_W} \sigma_{\pi n \to K^+ X} \right)} \Bigg/ \frac{A_C^b \left(\frac{Z_C}{A_C} \sigma_{\pi p \to K^- X} + \frac{N_C}{A_C} \sigma_{\pi n \to K^- X} \right)}{A_C^b \left(\frac{Z_C}{A_C} \sigma_{\pi p \to K^+ X} + \frac{N_C}{A_C} \sigma_{\pi n \to K^+ X} \right)} = 0.926$$

π^-+p	Threshold p_{lab} [GeV/c]
$\Lambda\pi^+2\pi^-K^+$	1.711
$\Lambda\pi^0\pi^-K^+$	1.407
$\Lambda\pi^-K^+$	1.144
$\Sigma^+\pi^02\pi^-K^+$	1.861
$\Sigma^+2\pi^-K^+$	1.568
$\Sigma^0\pi^+2\pi^-K^+$	1.879
$\Sigma^0\pi^-K^+$	1.290
$\Sigma^-\pi^+\pi^0\pi^-K^+$	1.879
$\Sigma^-\pi^+\pi^-K^+$	1.585
$\Sigma^-\pi^0K^+$	1.290
Σ^-K^+	1.035
$\Sigma^0(1385)\pi^-K^+$	1.680
$\Sigma^-(1385)\pi^0K^+$	1.680

π^-+p	Threshold p_{lab} [GeV/c]
$\Sigma^-(1385)K^+$	1.399
$p\pi^0K^0K^-$	1.785
$p\pi^-K^+K^-$	1.790
pK^0K^-	1.497
$n\pi^+K^0K^-$	1.801
$n\pi^-K^+K^0$	1.801
nK^+K^-	1.495
$n\Phi$ (BR: 0.49)	1.559
π^-+n	
$\Sigma^-\pi^-K^+$	1.296
$p\pi^-K^0K^-$	1.792

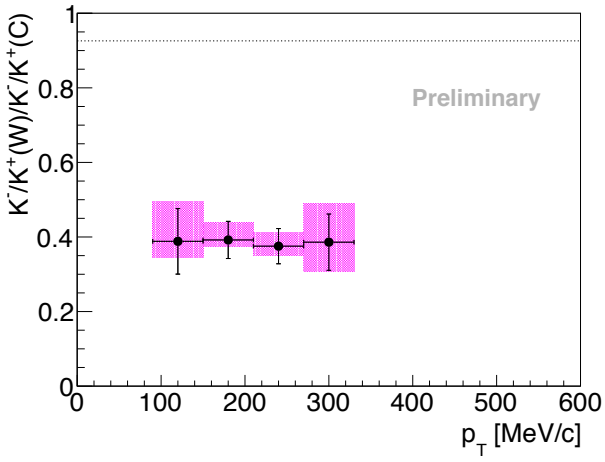
$$\pi^- + p \to \Sigma^- + \pi^0 + K^+$$

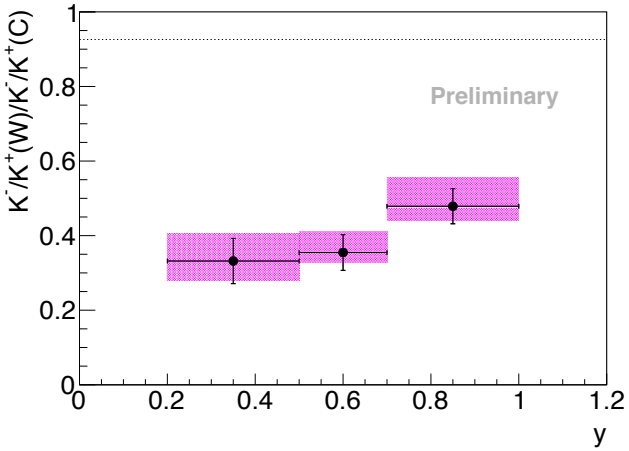


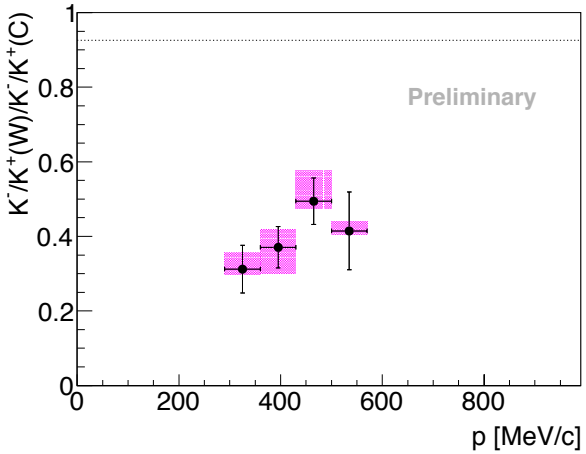
* Landolt-Börnstein

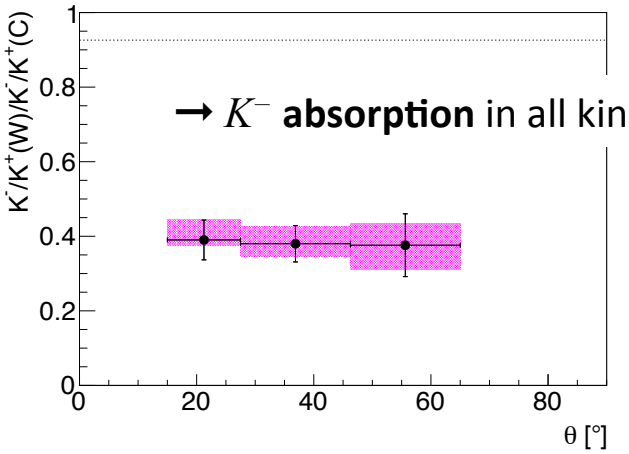
Ratio: $K^-/K^+(W)/K^-/K^+(C)$

Inside HADES acceptance (without p_T/y extrapolation)









→ K^- **absorption** in all kinetic observables

Phi

Phi Reconstruction

π⁻+C/W

Event and Kaon Selection:

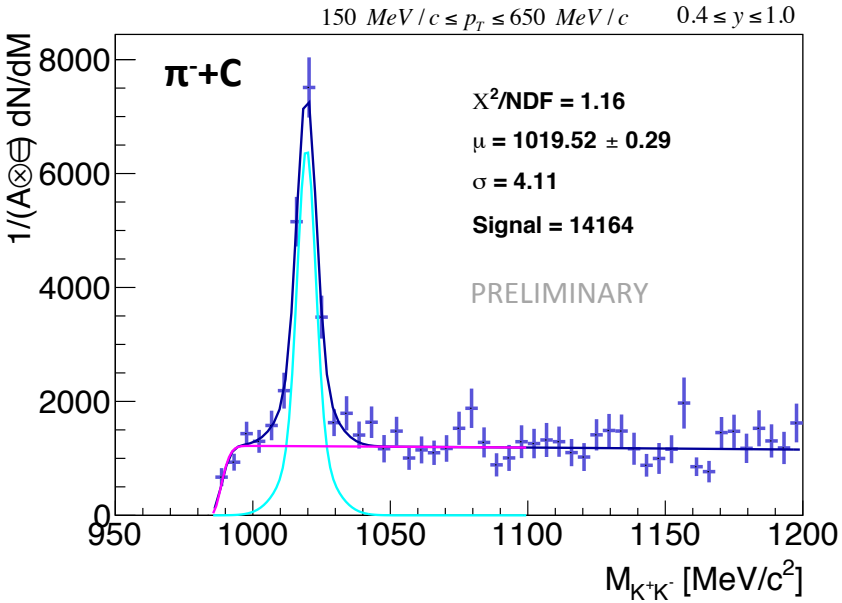
- Primary vertex:
  - - 80 < z vertex < 5 mm
  - r(x,y vertex) ≤ 20 mm
- Kaon mass: 400 < M_K < 600 MeV/c^2
- Particle identification via β and p
  - (β ≶ (p/√(p^2+m_K^2)) ± 0.5)

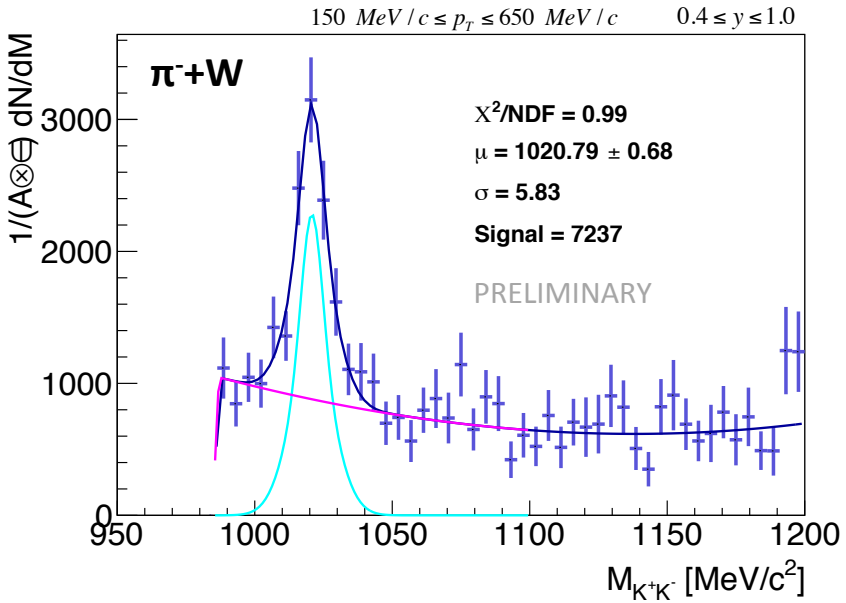
Energy loss and magnetic field correction

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⊗efficiency corrected (Pluto)





π⁻+C/W

Antikaons from Phi Feed-Down

Inside HADES acceptance (without p_T/y extrapolation)

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

π⁻+C

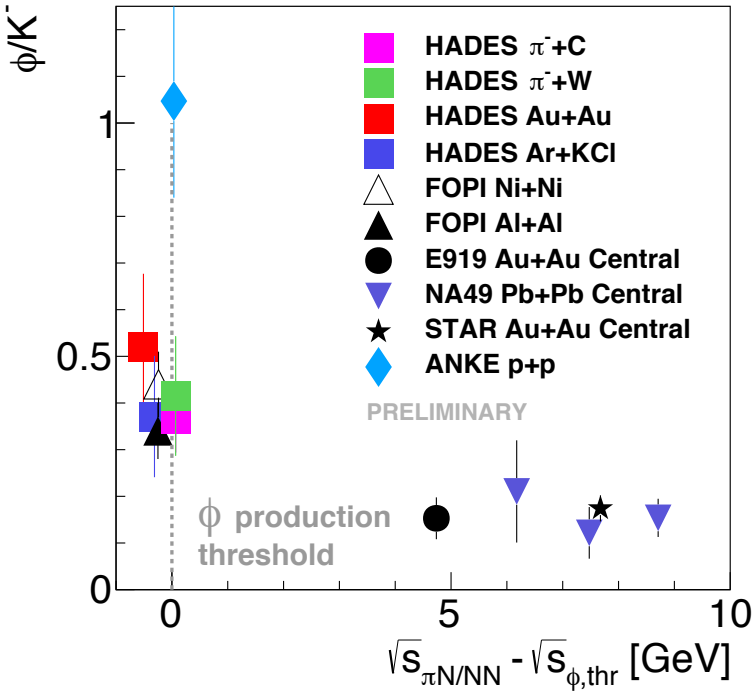
$$\phi / K^- (p_T, y) = 0.31 \pm 0.044\ (stat)$$

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

π⁻+W

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

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



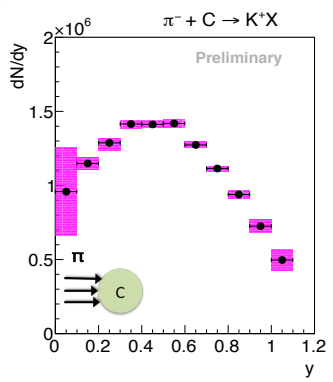
→ ϕ/K^- ratio is the same in π^- + C and π^- + W

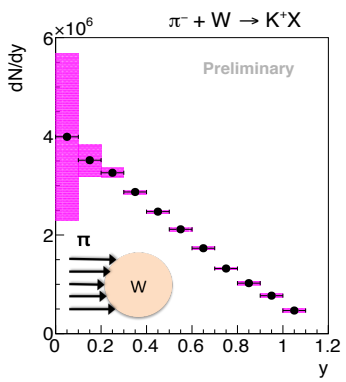
→ K^- is absorpted in Tungsten

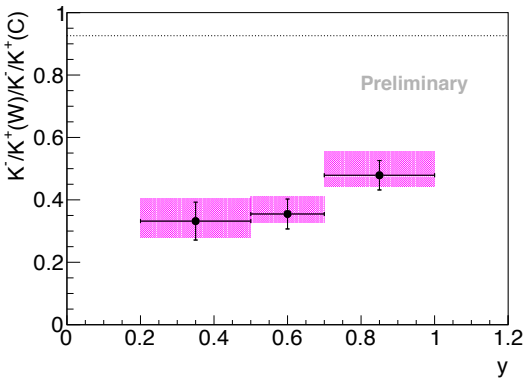
→ What happends to ϕ?

Summary

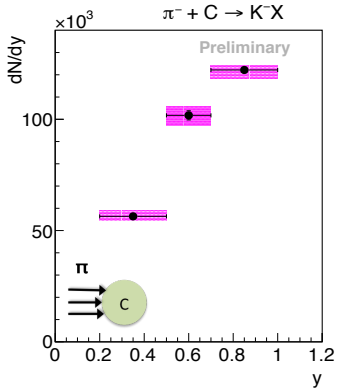
K^+

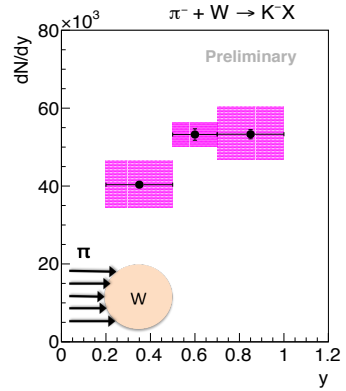


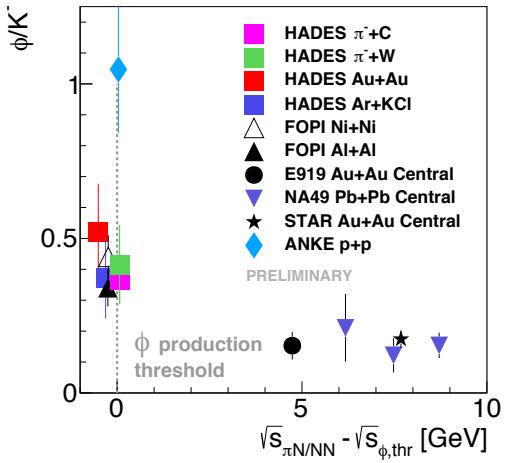




K^-







→ K^- absorption in π⁻ + W with respect to π⁻ + C

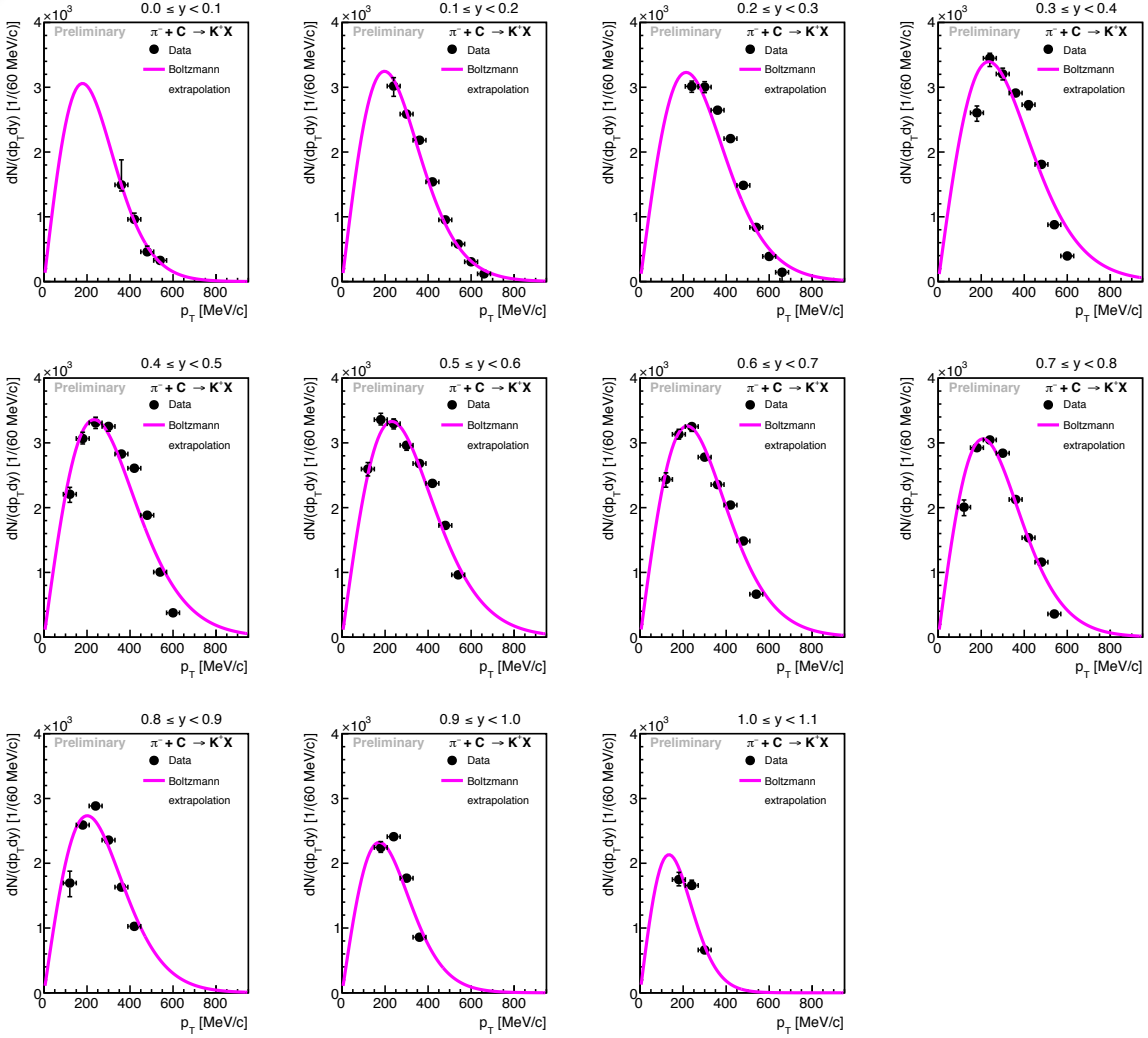
→ ϕ/K^- ratio constant for π⁻ + W and π⁻ + C

→ ϕ disappearance as K^-

→ Resonance disappearance

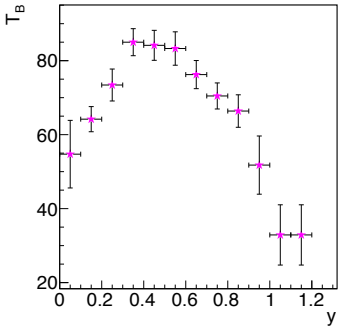
→ ϕN cross-section not small

p_T-y Distribution: K^+

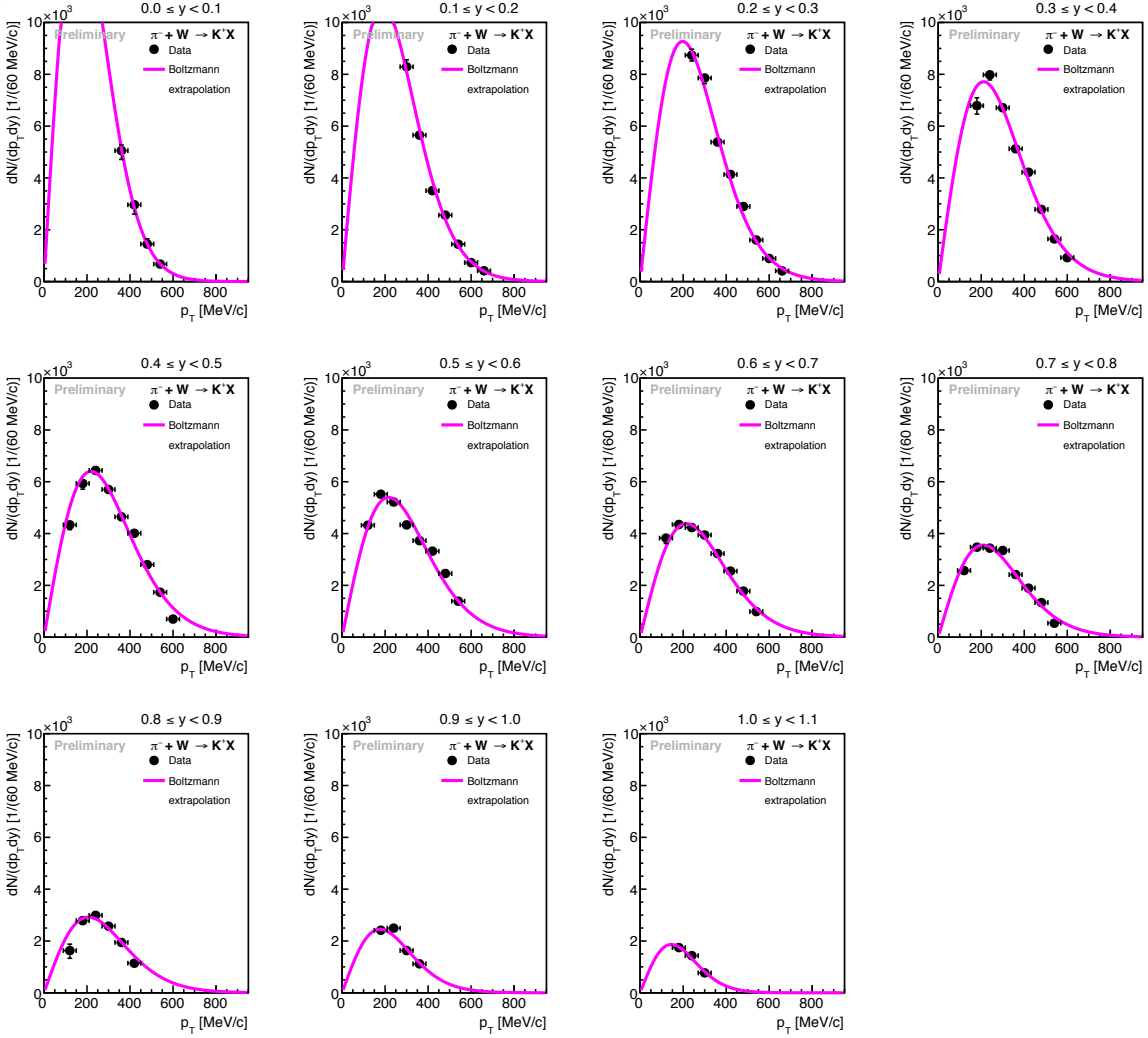


Yield extrapolation in p_T

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

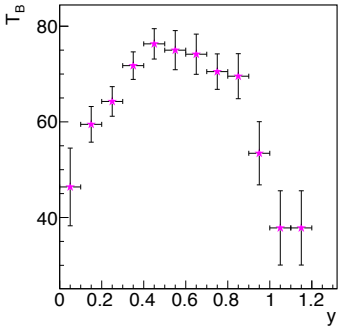


p_T-y Distribution: K^+



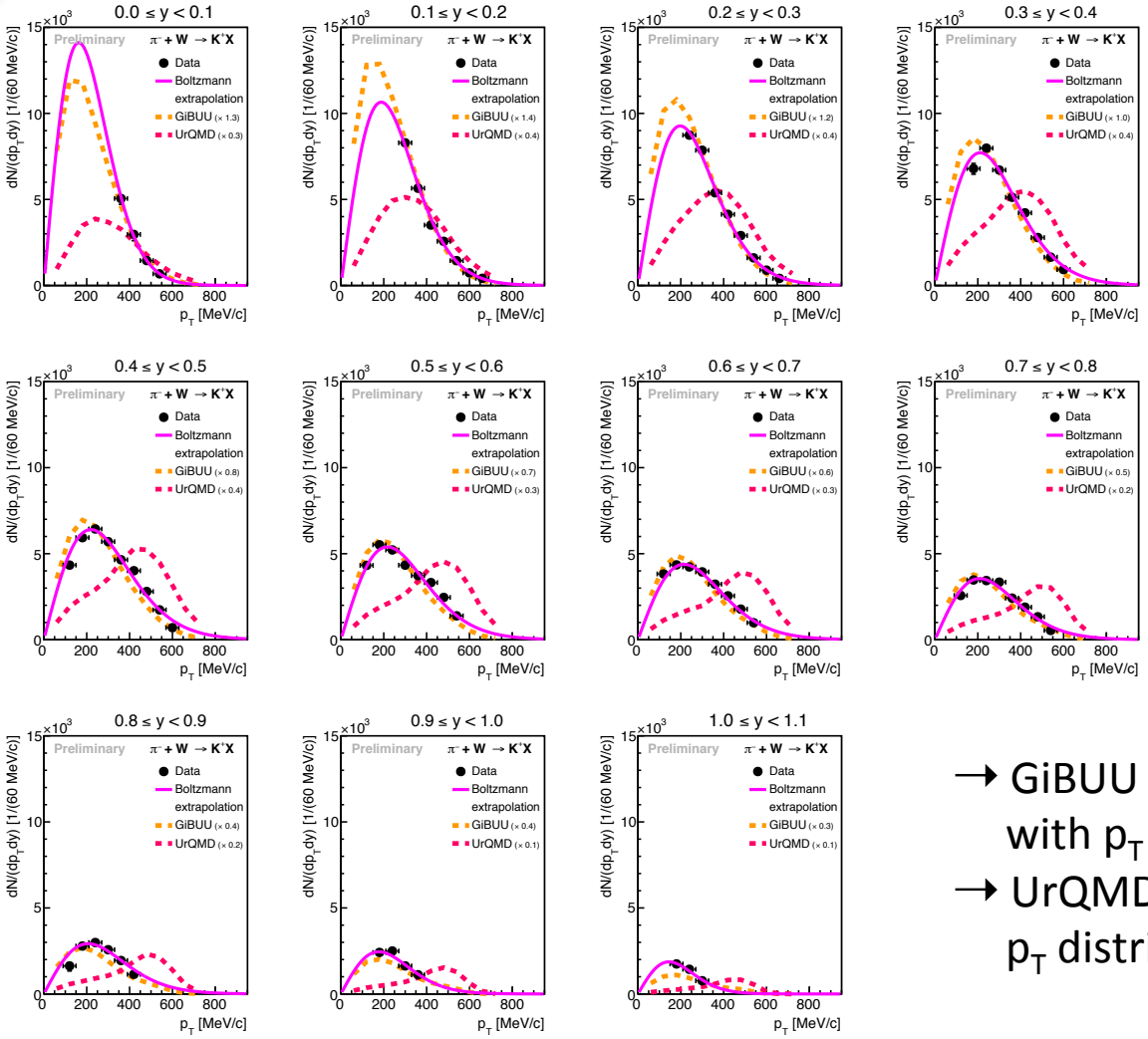
Yield extrapolation in p_T

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



π⁻+W

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

π⁻+C/W

p_T-y Distribution: K^-