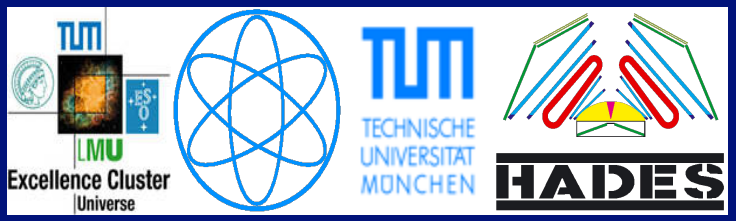


Kaon Production in Pion-Induced Reactions at 1.7 GeV/c

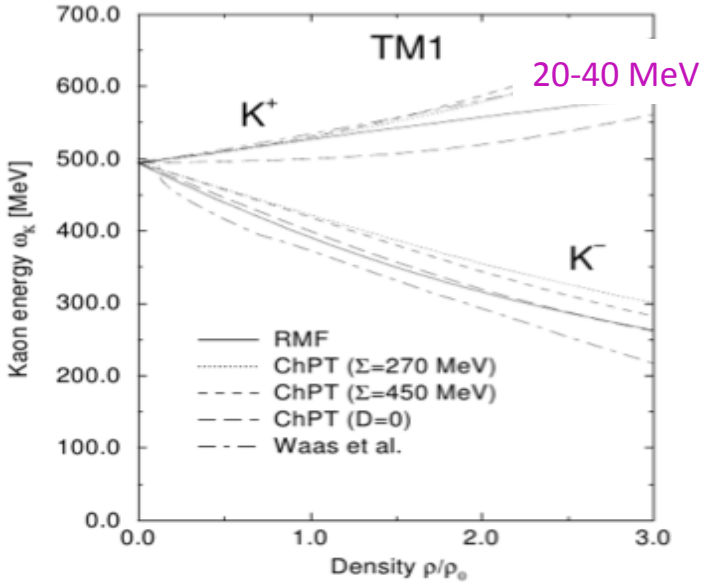
Joana Wirth, Laura Fabbietti, Steffen Maurus and Alessandro Scordo for the HADES Collaboration

55. International Winter Meeting on Nuclear Physics
27.01.2017

(Anti)Kaon in Medium

Kaon-Nucleon Potential

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 Potential*

→ *Coulomb-Scattering*

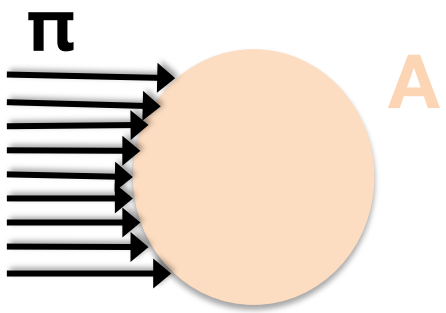
Antikaon can be absorbed in nuclear environment:

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

No conventional mechanism for kaon absorption:

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

Pion-Induced Kaon Production

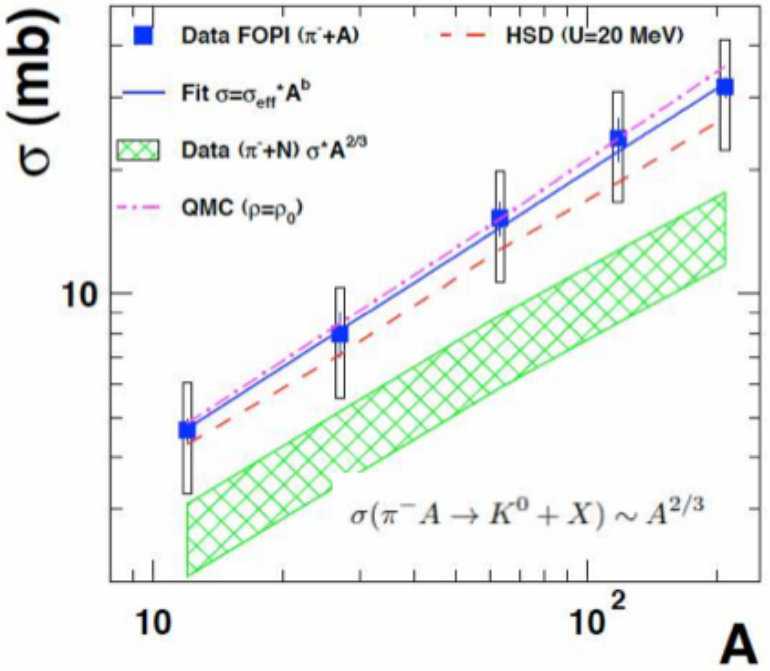


$\lambda = 1.5\,fm \;\; (p_\pi = 1.7 \;\; GeV/c)$

$d_{C/Pb} = 5.5/14.2\,fm$

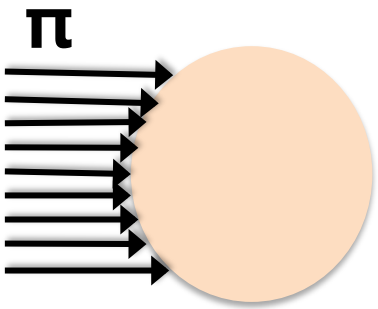
→ **π** is likely to undergo reactions with nucleus on the surface of the target nucleus

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)

Pion-Induced Kaon Production



A = C/W

$$\lambda = 1.5\,fm \;\; (p_\pi = 1.7 \;\; GeV/c)$$

$$d_{C/Pb} = 5.5/14.2\,fm$$

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

(Anti)Kaon:

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

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

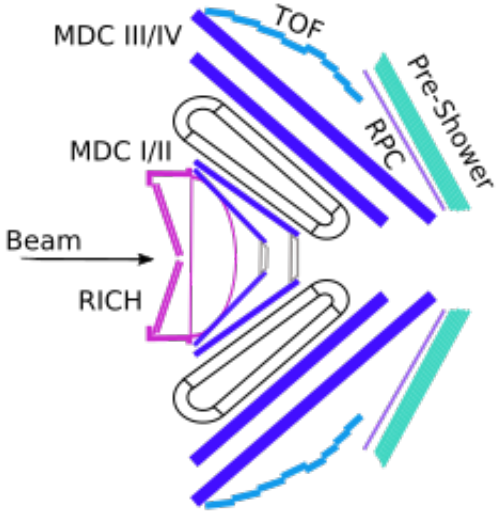
→ **Phi:** $\Phi \rightarrow K^- K^+, \;\; BR \sim 49\%$

→ **K^- from ϕ feed-down:**

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

(Anti)Kaon and Phi with HADES

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



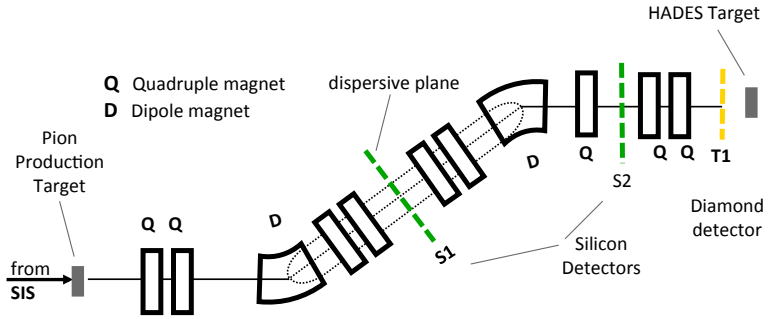
Secondary Pion Beam @ 1.7 GeV/c

→ **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, 243-244 (2016)



→ $3 \cdot 10^5$ K^+, $6.5 \cdot 10^3$ K^- and 300 Φ in π^- + W

→ $2.5 \cdot 10^5$ K^+, $1 \cdot 10^4$ K^- and 500 Φ in π^- + C

(Anti)Kaons

Kaon Selection

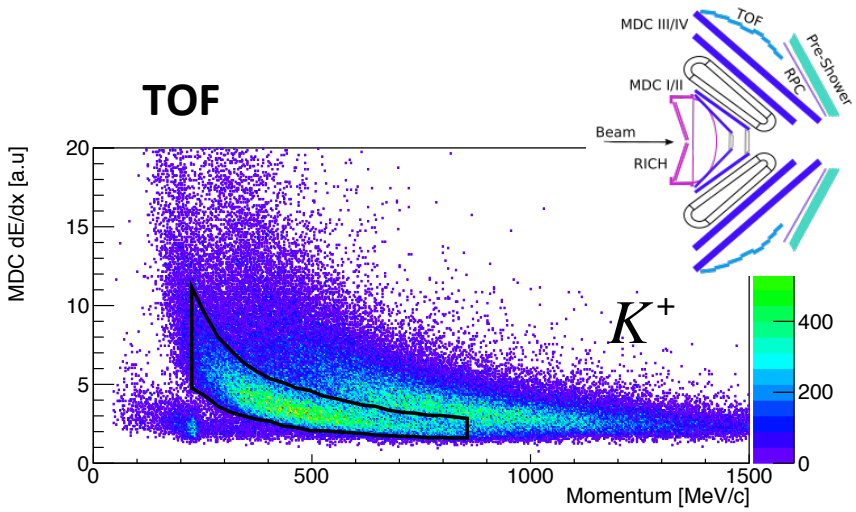
Applied cuts:

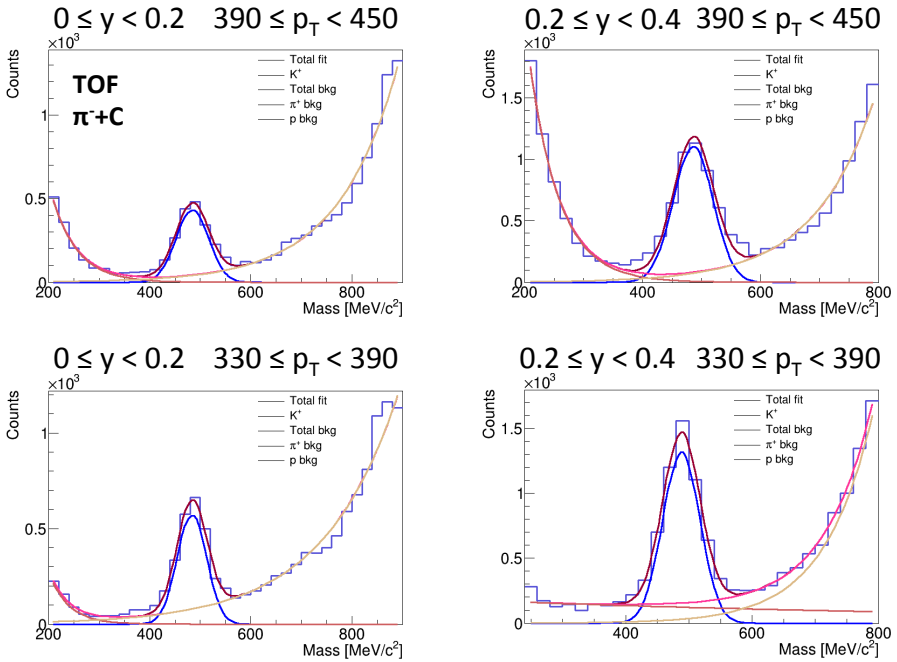
- Primary vertex:
  - - 85 < z vertex < - 5 mm
  - - 10 < x,y vertex < 10 mm
- Energy loss: $0 < dE/dx_{MDC} < 50$
- Velocity: $0 < \beta < 1$
- Particle identification via dE/dx and p

Energy loss and magnetic field correction

Kaon yield:

- Signal: SIM(PID) → σ from gauss → ''gauss (fixed σ) + polN''
- Background: ''exp'' left tail (π^+) + ''exp'' right tail (p)
- Signal + Background:
  - ''gauss(σ) + exp_p + exp_π (+ polN)''





π⁻+C/W

Kaon Selection

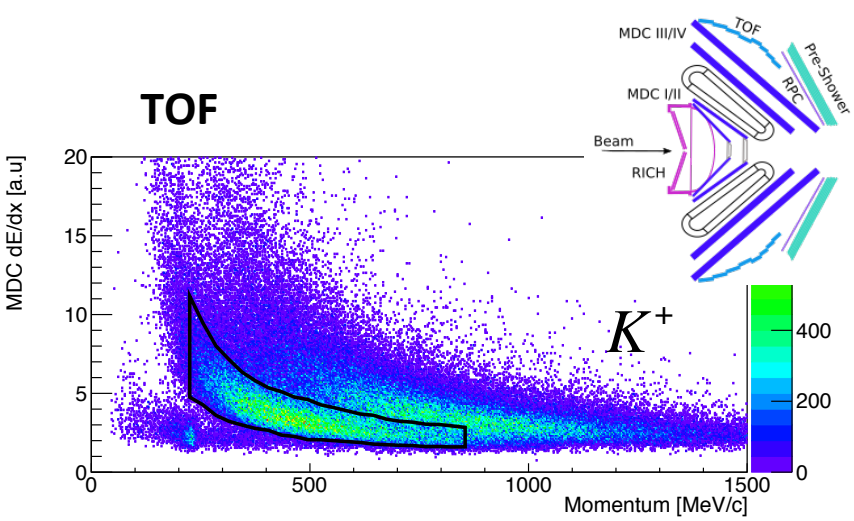
Applied cuts:

- Primary vertex:
  - - 85 < z vertex < - 5 mm
  - - 10 < x,y vertex < 10 mm
- Energy loss: $0 < dE/dx_{MDC} < 50$
- Velocity: $0 < \beta < 1$
- Particle identification via dE/dx and p

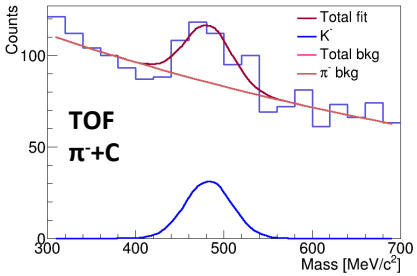
Energy loss and magnetic field correction

Antikaon yield:

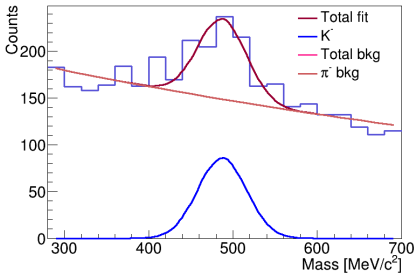
- Signal: SIM(PID) → σ from gauss → ''gauss (fixed σ) + polN''
- Background: ''exp'' left tail (π^-)
- Signal + Background:
  - ''gauss(σ) + exp_π (+ polN)''



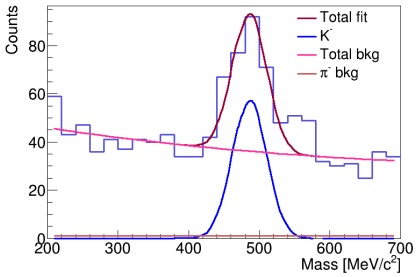
$0.2 \le y < 0.4$ $270 \le p_T < 330$



$0.4 \le y < 0.6$ $270 \le p_T < 330$



$0.2 \le y < 0.4$ $210 \le p_T < 270$



Corrected Yields: K^+/K^-

Acceptance and efficiency correction based on simulation (GiBUU):

$$F_{corr}(p_T, y) = \frac{O_{sim}(p_T, y)}{I_{sim}(p_T, y)}$$

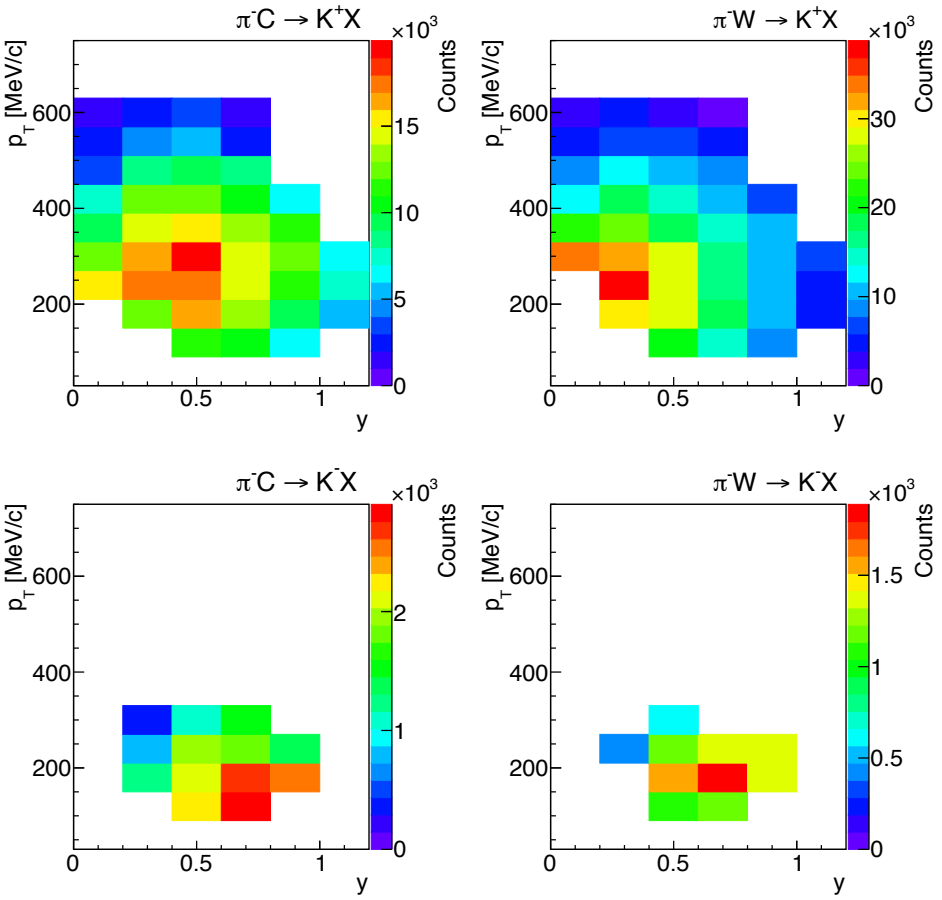
$F_{corr}(p_T, y) :=$ *correction factor*

$I_{sim}(p_T, y) :=$ *input from simulation*

$O_{sim}(p_T, y) :=$ *output of sim. (acc., tracking, analysis)*

p_T-y		TOT
C	K^+	415456
	K^-	22542
W	K^+	585961
	K^-	11963

p-θ		TOT
C	K^+	404294
	K^-	19215
W	K^+	581318
	K^-	10862

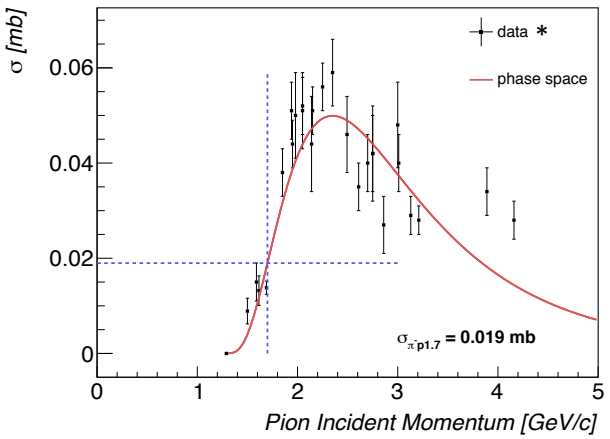


Ratio: $K^-/K^+(W)/K^-/K^+(C)$

π^-+C/W

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
$\Sigma^-(1385)K^+$	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

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

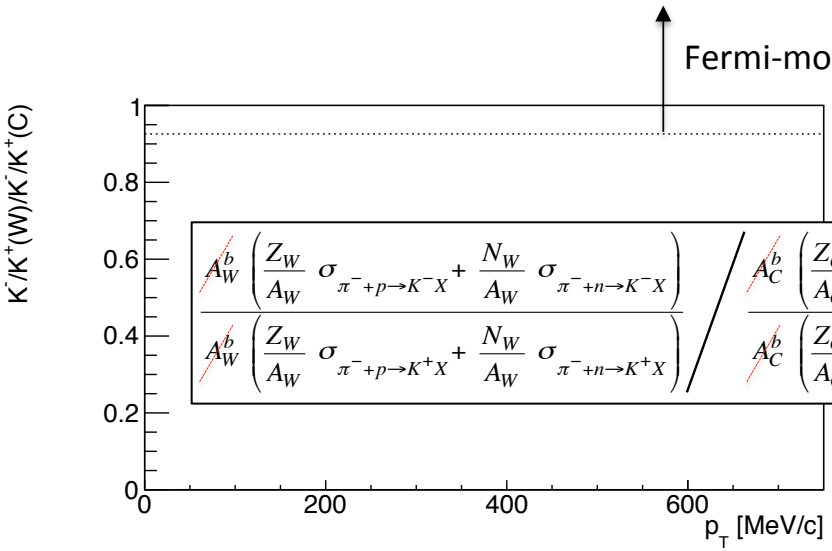


$$\sigma = A\left(1-\frac{s_0}{s}\right)^B\left(\frac{s_0}{s}\right)^C$$

$\sigma_{\pi^-+p\rightarrow K^-X}$ [mb]	0.021
$\sigma_{\pi^-+n\rightarrow K^-X}$ [mb]	0
$\sigma_{\pi^-+p\rightarrow K^+X}$ [mb]	0.3548
$\sigma_{\pi^-+n\rightarrow K^+X}$ [mb]	0.0697

	Tungsten	Carbon
Z	74	6
A	184	12
N	110	6

Fermi-motion



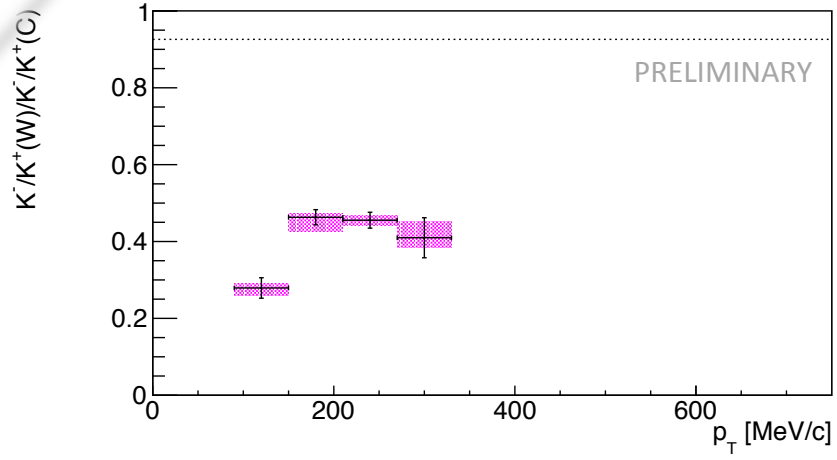
$$\frac{A_W^b\left(\frac{Z_W}{A_W}\sigma_{\pi^-+p\rightarrow K^-X}+\frac{N_W}{A_W}\sigma_{\pi^-+n\rightarrow K^-X}\right)}{A_W^b\left(\frac{Z_W}{A_W}\sigma_{\pi^-+p\rightarrow K^+X}+\frac{N_W}{A_W}\sigma_{\pi^-+n\rightarrow K^+X}\right)} \Big/ \frac{A_C^b\left(\frac{Z_C}{A_C}\sigma_{\pi^-+p\rightarrow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

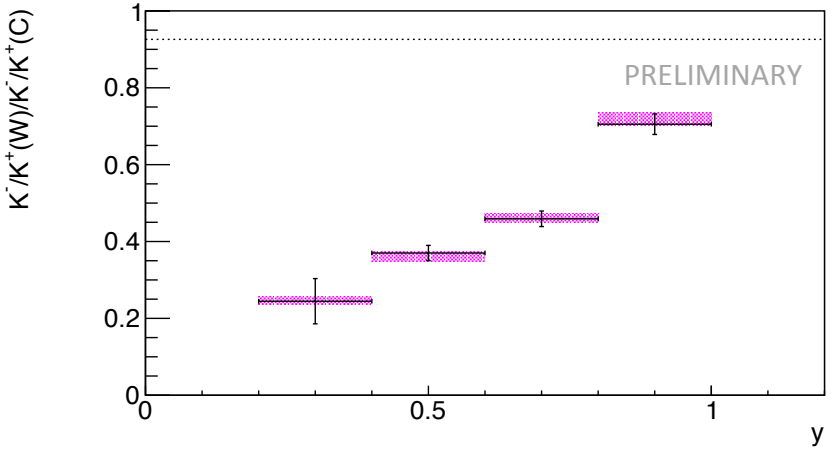
* Landolt-Börnstein

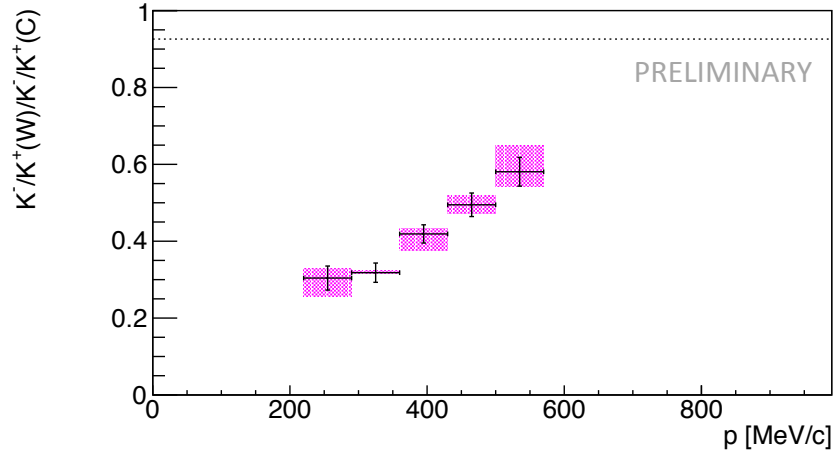
π⁻+C/W

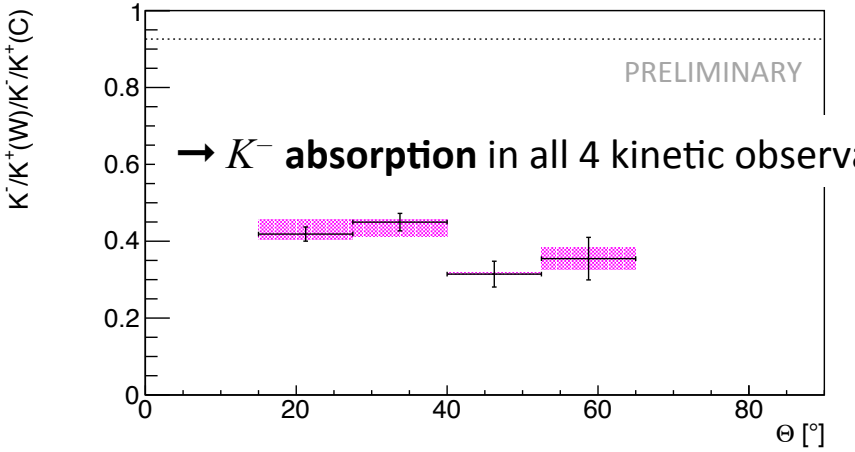
Ratio: $K^-/K^+(W)/K^-/K^+(C)$

Inside HADES acceptance





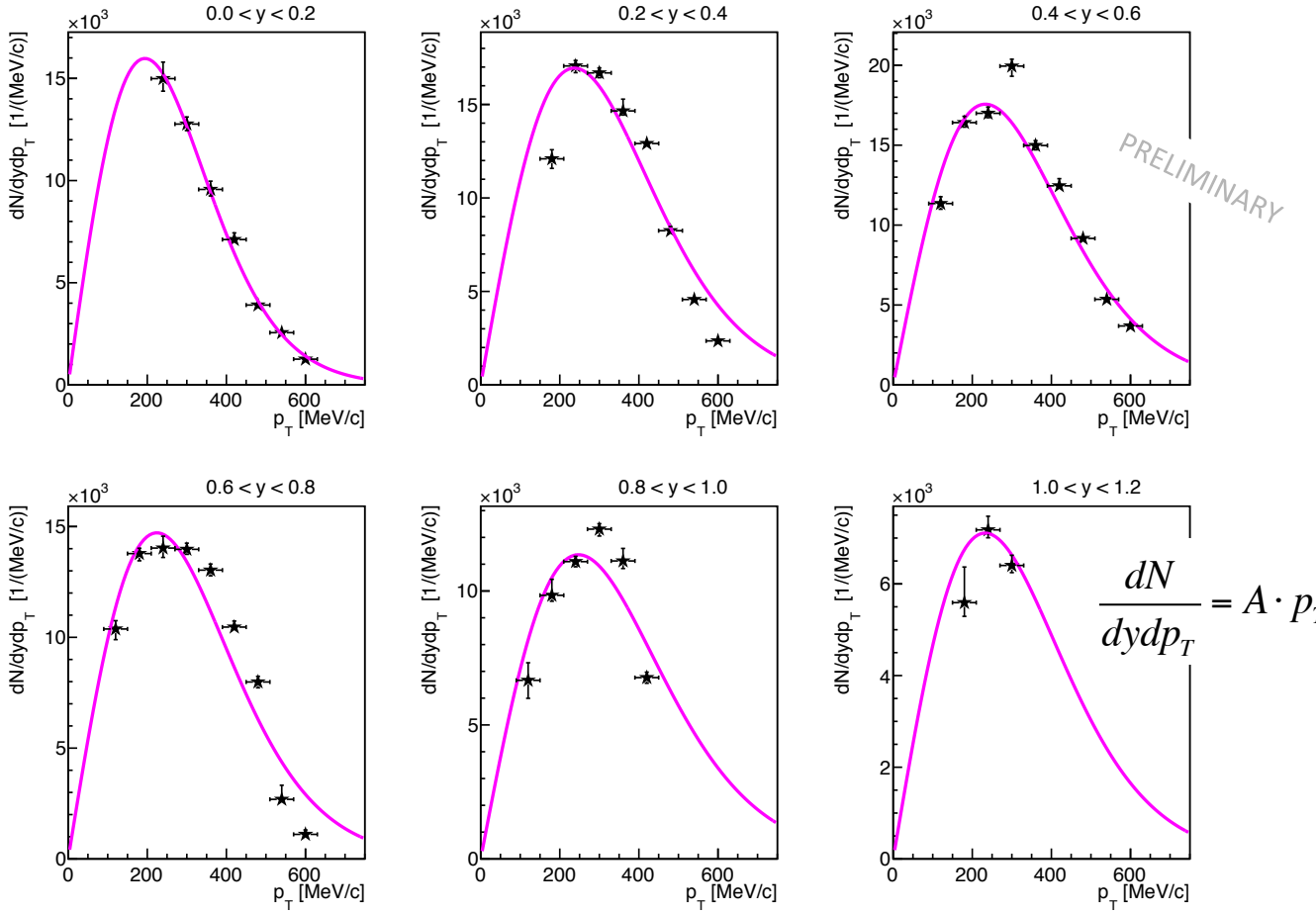




→ K^- **absorption** in all 4 kinetic observables

p_T-y Distribution: K^+

Yield extrapolation in p_T



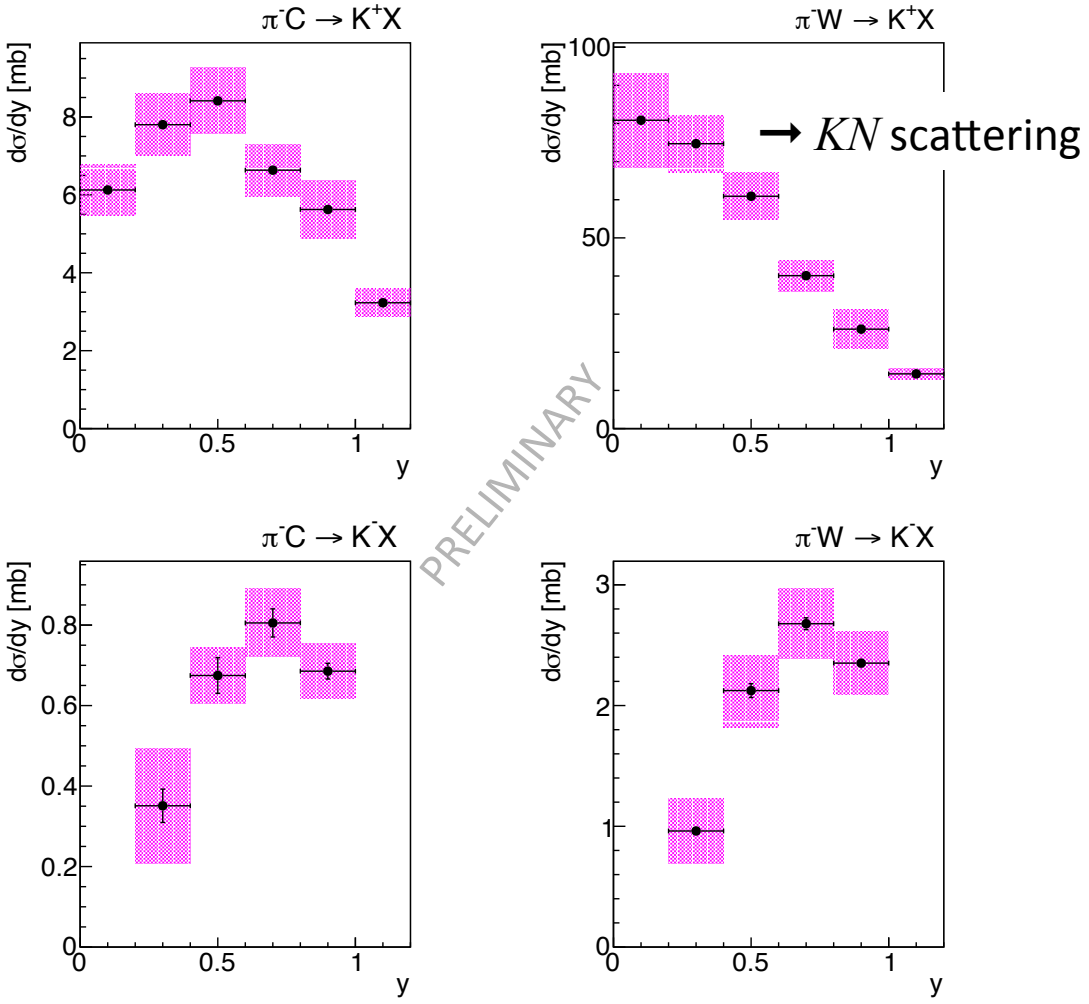
$$\frac{dN}{dydp_T} = A \cdot p_T \sqrt{p_T^2 + m_0^2} \cdot e^{-\frac{\sqrt{p_T^2+m_0^2}}{T_B}}$$

Cross-Section: K^+/K^-

π^-+C/W

Inside HADES acceptance
0 < y < 1.2

	Particle	σ [mb]
C	K^+	37.8
	K^-	2.5
W	K^+	296.9
	K^-	8.1



Phi

π⁻+C/W

Φ Reconstruction

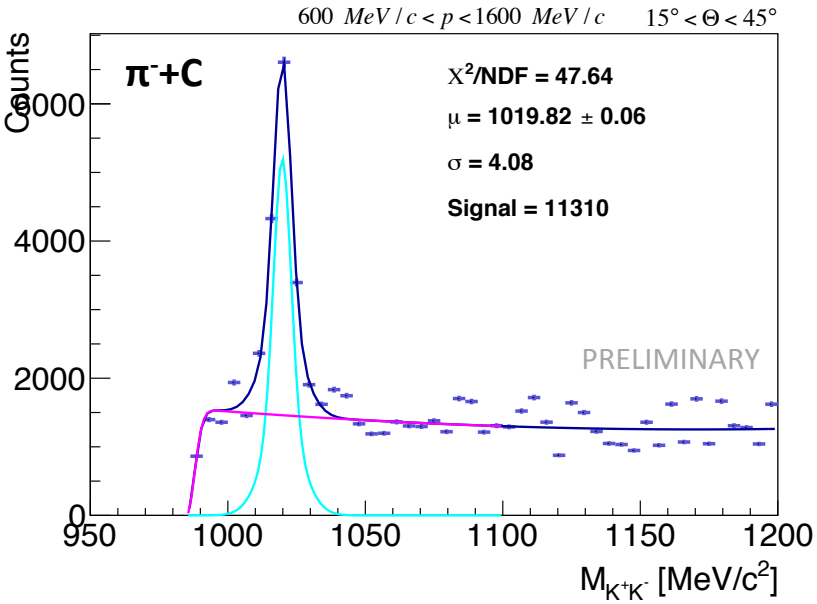
Applied cuts:

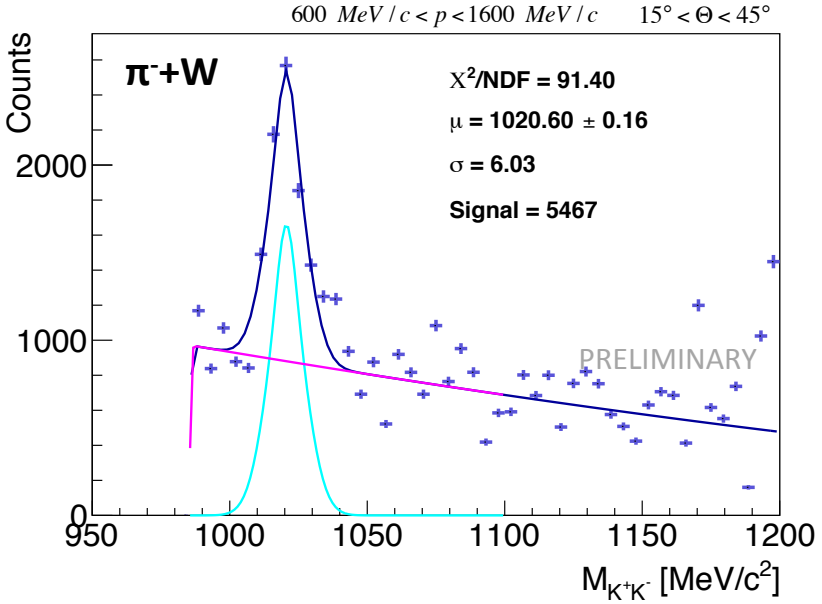
- Primary vertex:
  - - 65 < z vertex < - 5 mm
  - - 10 < x,y vertex < 10 mm
- Kaon mass: 400 < M_K < 600 MeV/c^2
- Particle identification via β and p
  - ($\beta \lessgtr (p/\sqrt{(p^2+m_K^2)} \pm 0.5$)

Energy loss and magnetic field correction

Phi yield:

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





π⁻+C/W

Antikaons from Phi Feed-Down

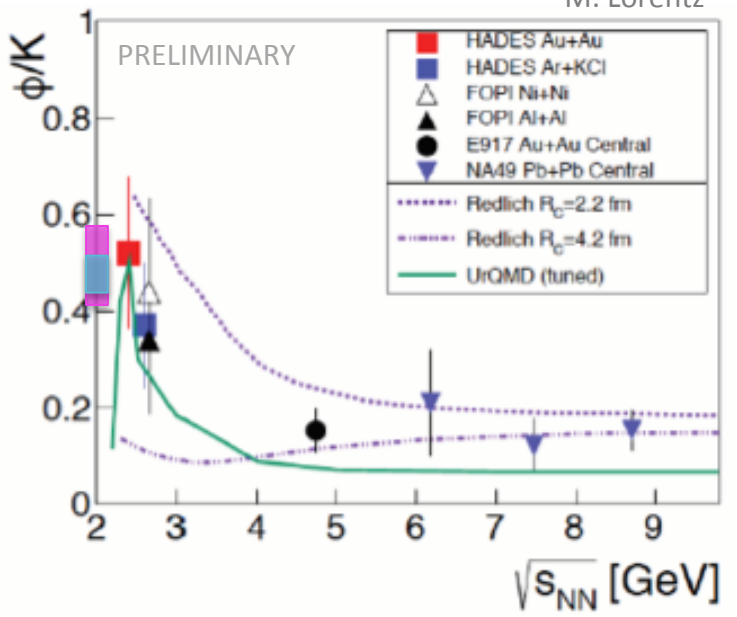
p_T-y		TOT
C	K^-	22542
W	K^-	11963

p_T-y		TOT
C	ϕ	9146
W	ϕ	5297

p-θ		TOT
C	K^-	19215
W	K^-	10862

p-θ		TOT
C	ϕ	11310
W	ϕ	5467

M. Lorentz



$$\sqrt{s_{\pi^- N}} = 1.99\ GeV$$

π⁻+C

$$\Phi / K^- (p_T, y) = 0.41 \pm 0.01\ (stat)$$

$$\Phi / K^- (p, \Theta) = 0.59 \pm 0.01\ (stat)$$

π⁻+W

$$\Phi / K^- (p_T, y) = 0.44 \pm 0.02\ (stat)$$

$$\Phi / K^- (p, \Theta) = 0.50 \pm 0.02\ (stat)$$

Summary

Summary:

Kaons

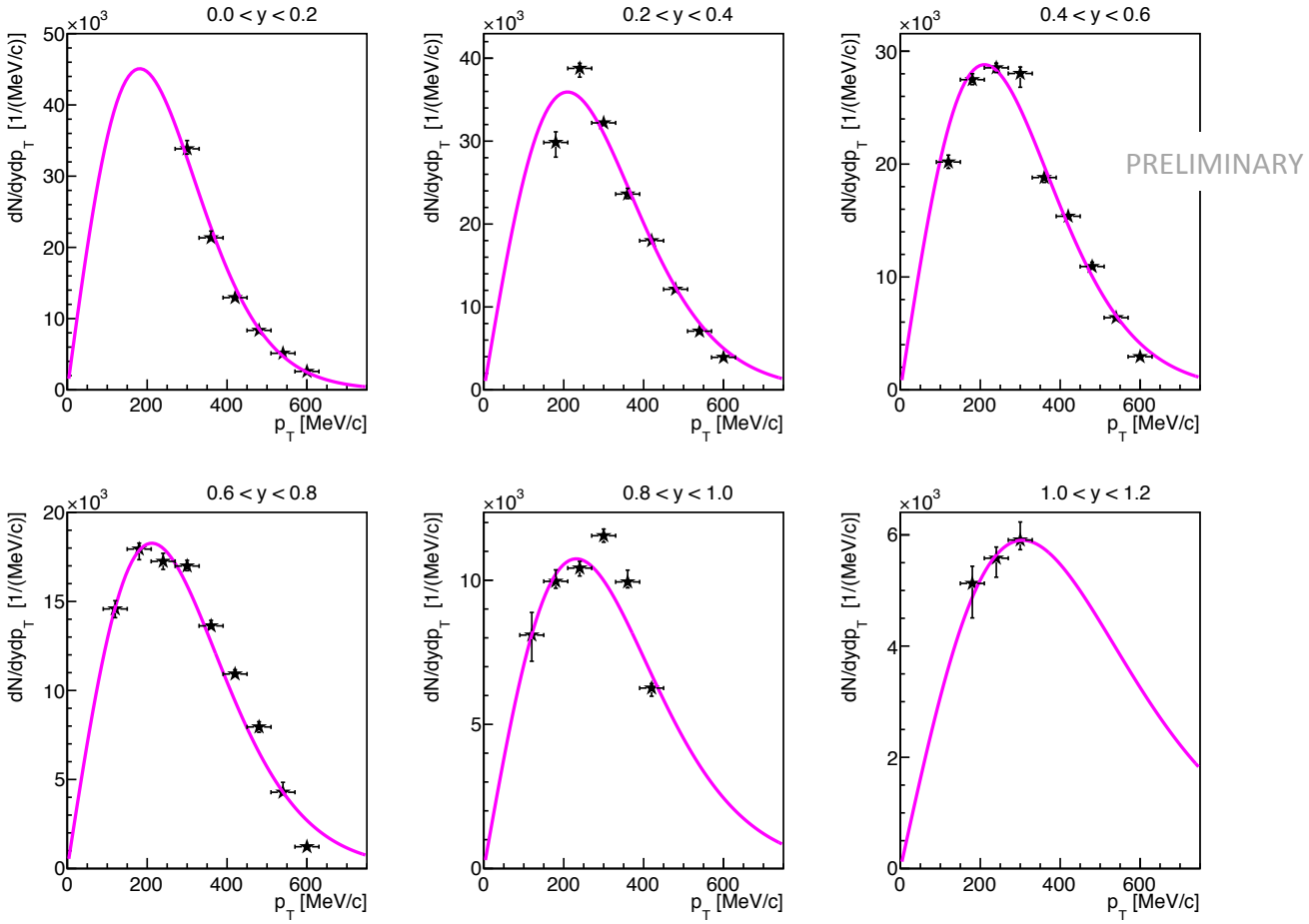
- p-Θ and p_T-y analysis almost compatible in terms of reconstructed kaons
- K^- **absorption** in four kinetic observables
- Rapidity distribution of K^+ different for C and W
- Rapidity distribution of K^- very similar for C and W
- **σ(K^+/K^-,C/W)** inside HADES acceptance

Phi

- p-Θ and p_T-y analysis almost compatible in terms of reconstructed phis
- K^- from Φ **feed-down**: $\Phi / K^-(C) = 0.50 \pm 0.01\ (stat)$, $\Phi / K^-(W) = 0.47 \pm 0.01\ (stat)$

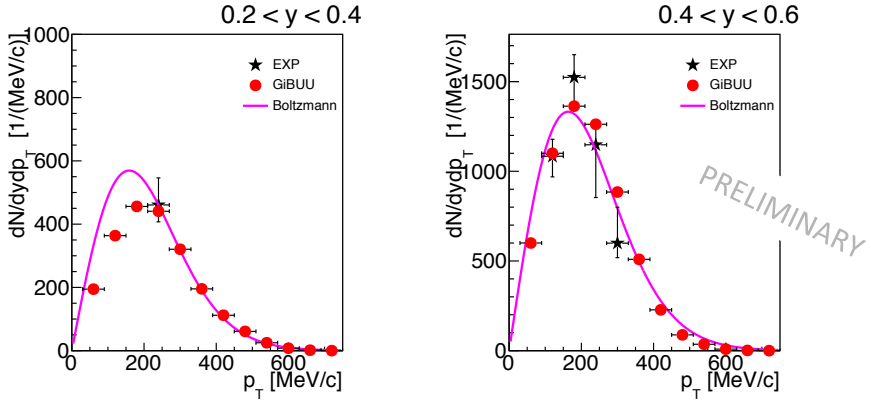
Thank you for your attention!

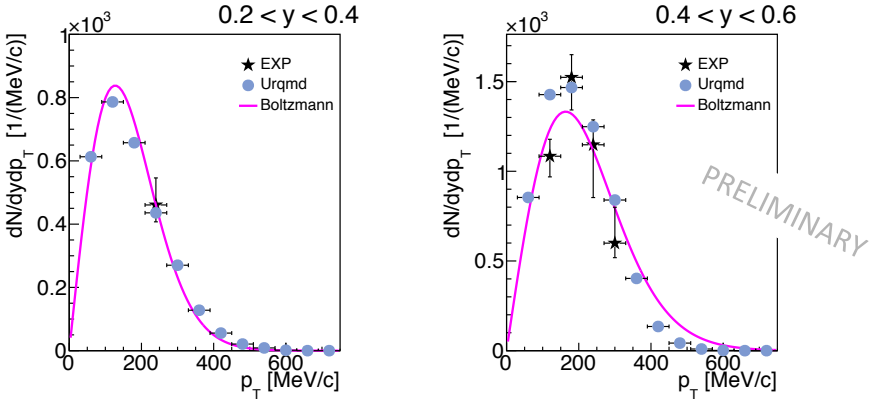
p_T-y Distribution: K^+



p_T-y Distribution: K^-

GiBUU **Urqmd**

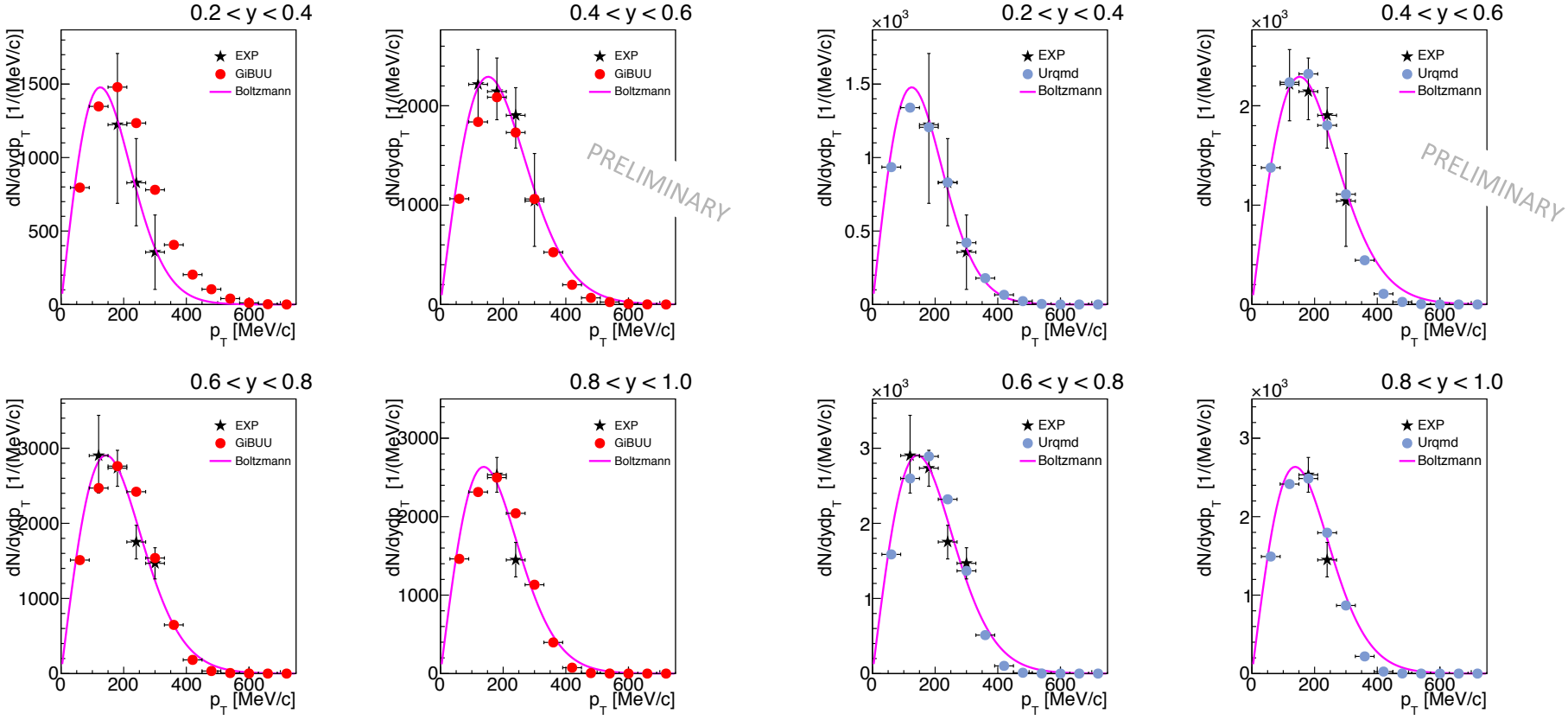




GiBUU/Urqmd scaled in each rapidity bin seperatly to discribe the p_T-distribution

p_T-y Distribution: K^-

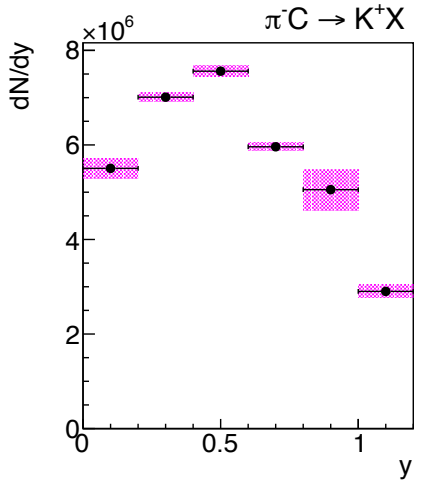
GiBUU **Urqmd**

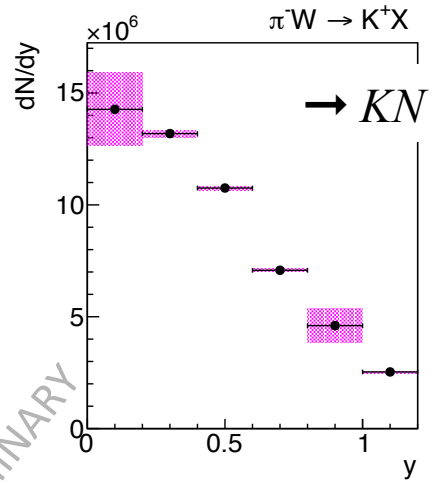


GiBUU/Urqmd scaled in each rapidity bin seperatly to discribe the p_T-distribution

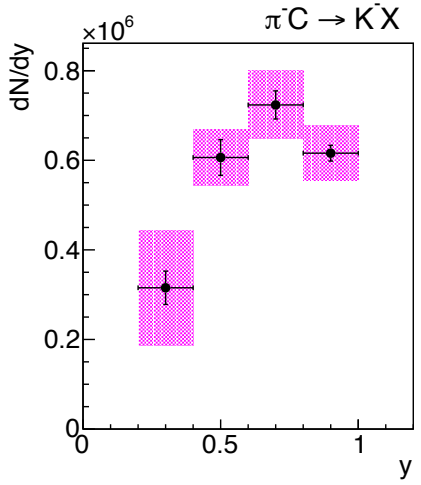
π⁻+C/W

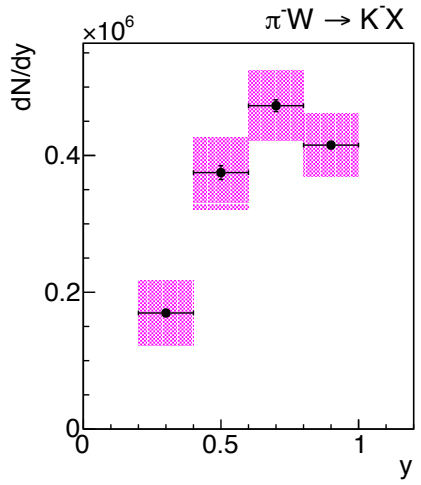
Rapidity Distribution: K^+/K^-





→ KN scattering apparent

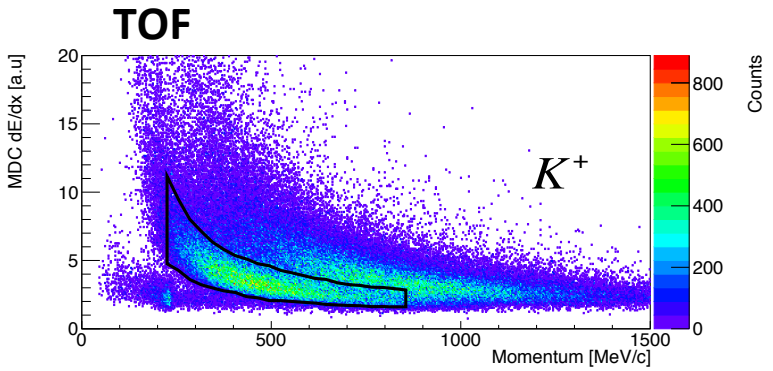




PRELIMINARY

Statistic and Systematic Error

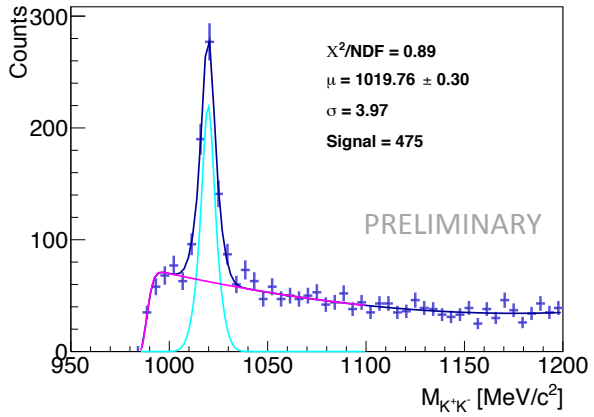
Statistic Error	Piosson/Gauss
Systematic Error	**Particle Idenification** via dE/dx and p → Asymmetric cut: $4\sigma_K/3\sigma_K$ → $4.5\sigma_K/3.5\sigma_K$ → $3.5\sigma_K/2.5\sigma_K$
	Kaon spectrum fit: → Gauss(σ) + $expo_p$ + $expo_\pi$ (+ polN) → $\sigma \pm \sigma_{error}$
	Extrapolation in p_T: → $\sigma_{Boltzmann}$
	Normalization: 10%

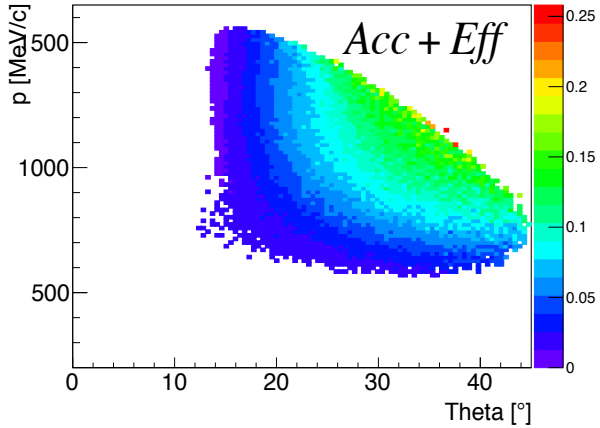


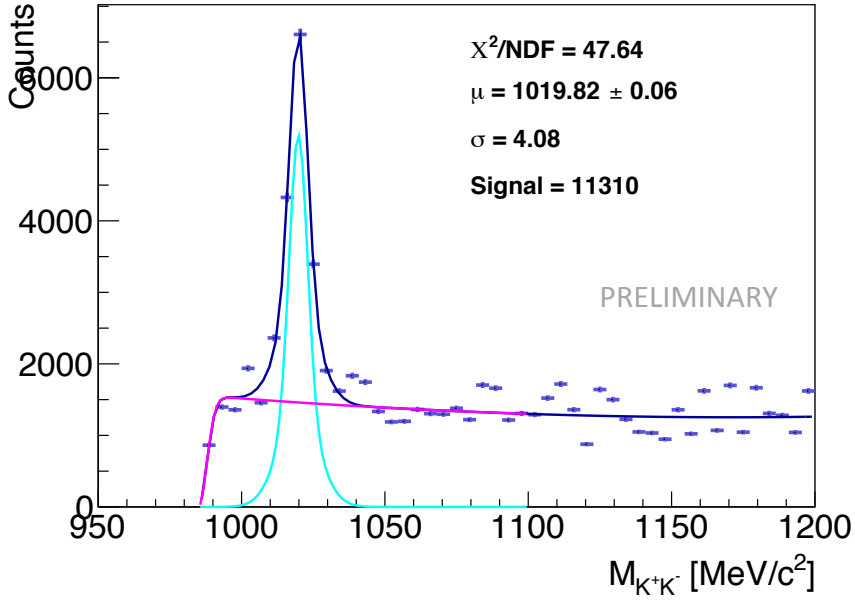
Phi

Corrected Yield: Φ

Event-by-event acceptance and efficiency correction based on simulation (Pluto):

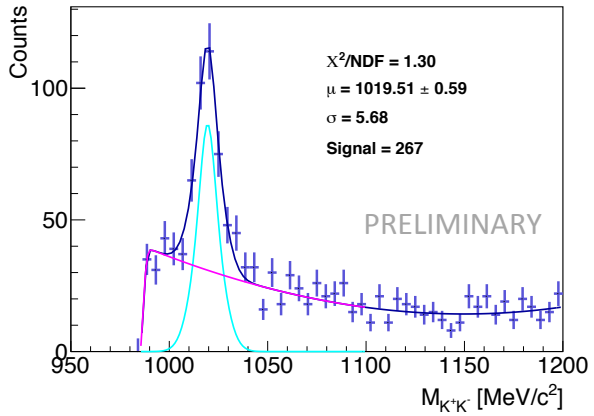


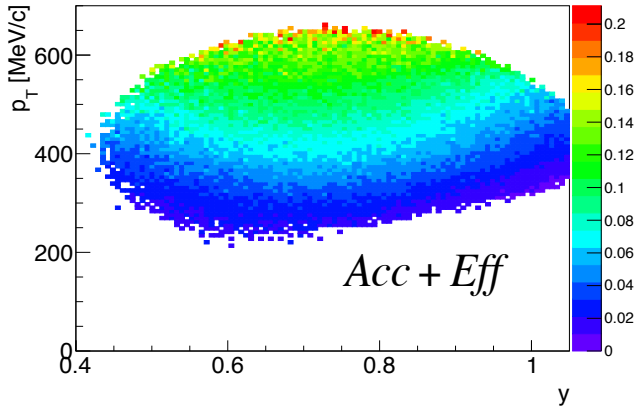


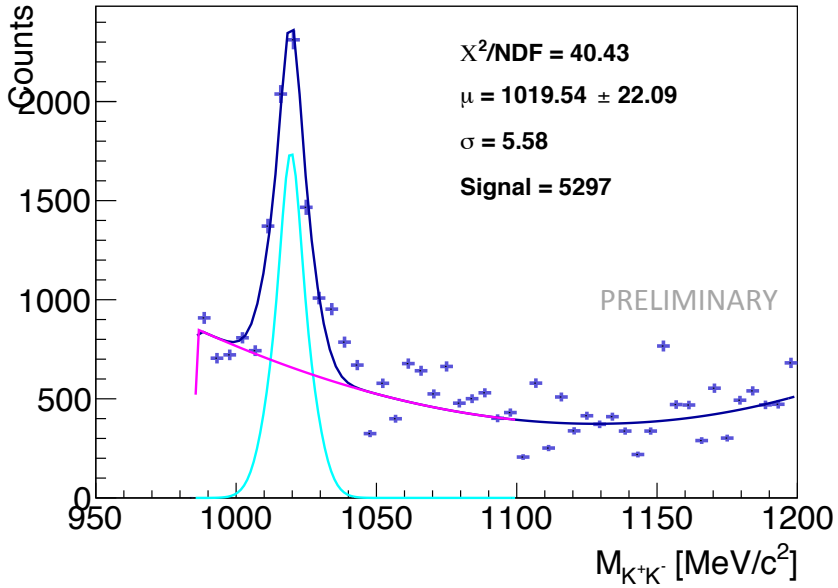


Corrected Yield: Φ

Event-by-event acceptance and efficiency correction based on simulation (Pluto):

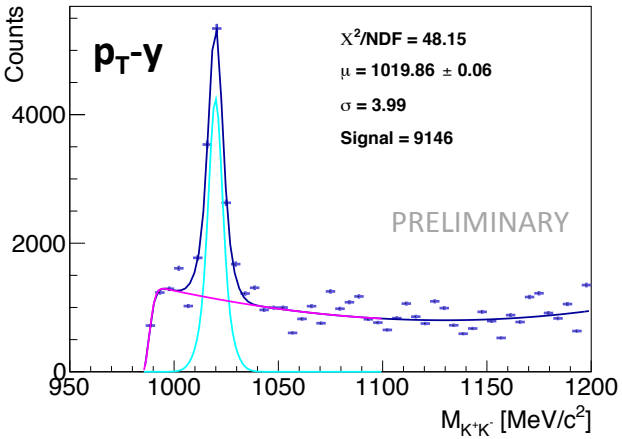


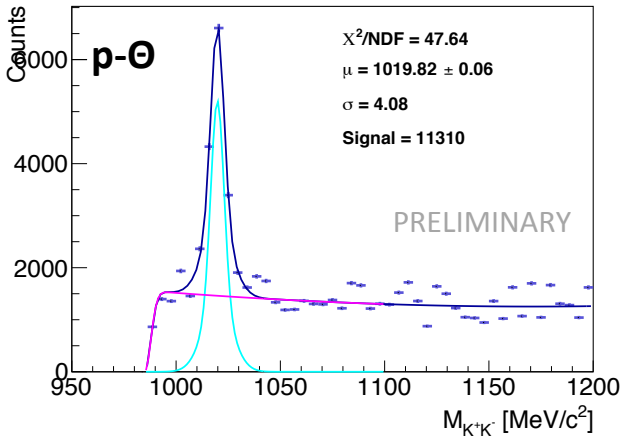




Corrected Yield: Φ

π⁻+C





π⁻+W