

# Strong Absorption of Hadrons with Hidden and Open Strangeness probed with Pion-Nucleus Collisions at 1.7 GeV/c \*

Joana Wirth for the HADES Collaboration

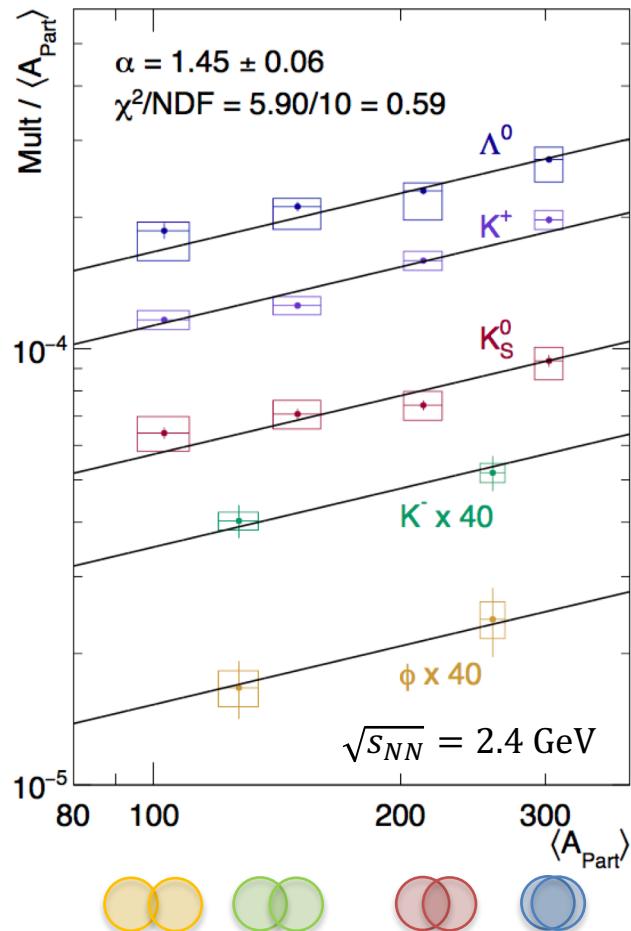
Dense and Strange Hadronic Matter (E62)  
Physik Department  
Technische Universität München  
[www.denseandstrange.ph.tum.de](http://www.denseandstrange.ph.tum.de)

\*supported by SFB 1258

# Universal Strangeness Production



Adamczewski-Musch et al., Phys. Lett. B793, 457 (2019)



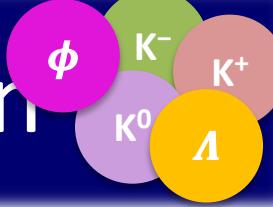
## Dense (and hot) nuclear matter

→ All strange hadrons produced below NN threshold:

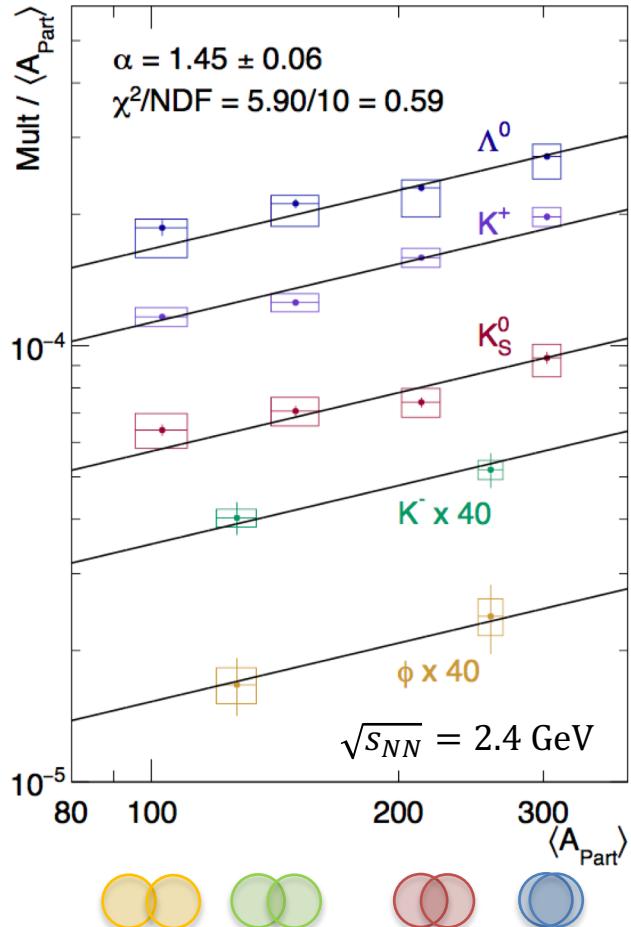
$$\rightarrow NN \rightarrow N\Lambda K (\approx -150 \text{ MeV})$$

$$\rightarrow NN \rightarrow N\bar{K}/NN\phi (\approx -450 \text{ MeV})$$

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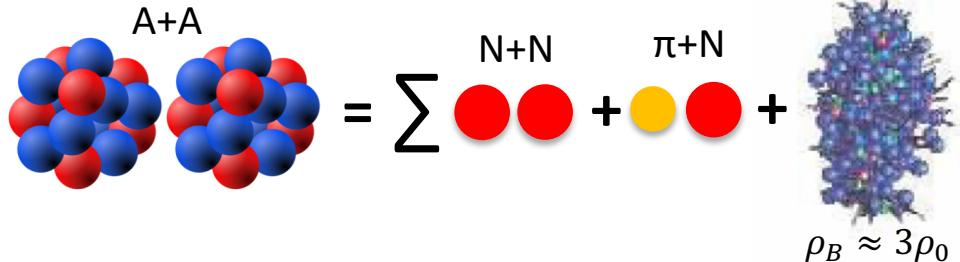
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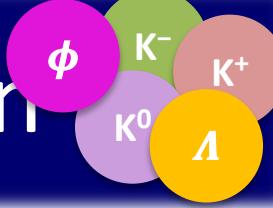
→ Universal scaling with  $A_{\text{part}}$

→ Sum of N+N and  $\pi+N$  reactions?

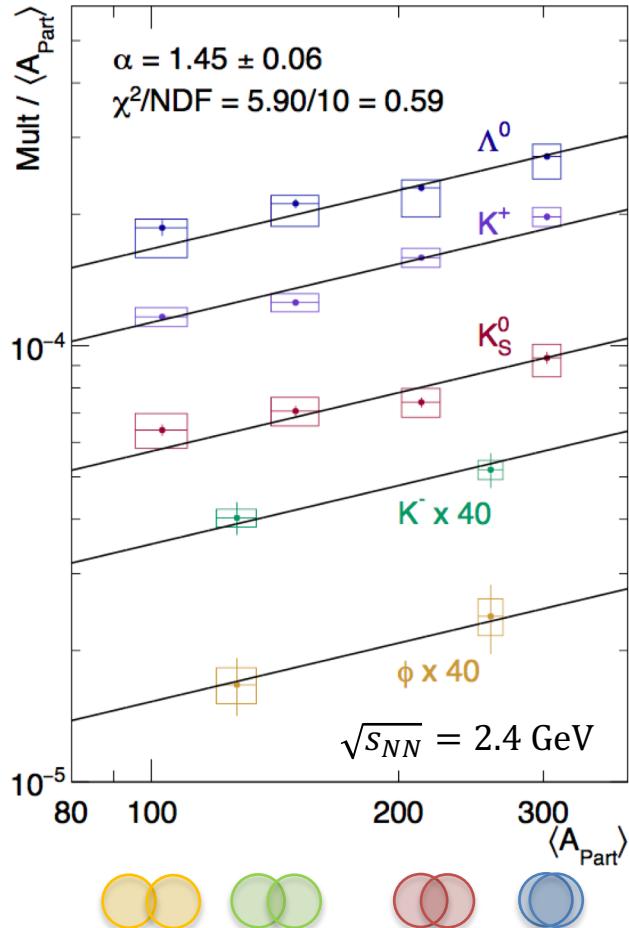
→ Collective effects? In-medium effects?



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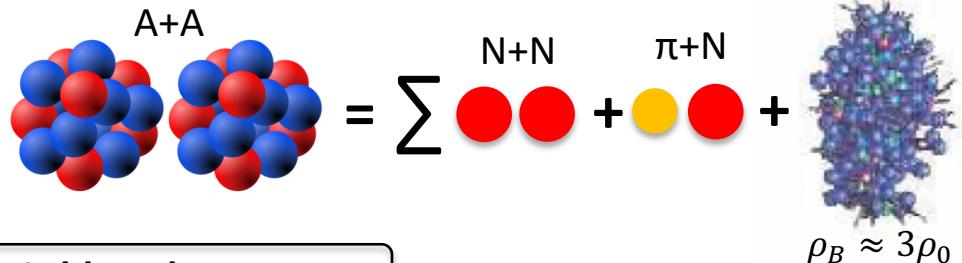
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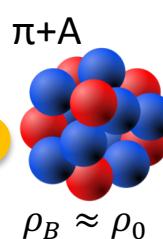
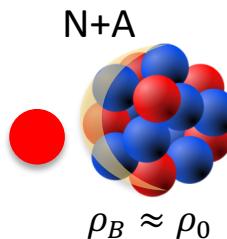
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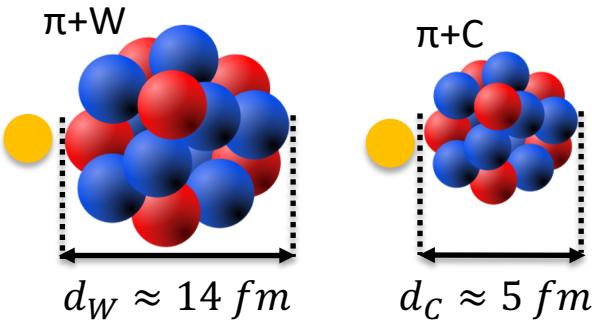


## Cold nuclear matter



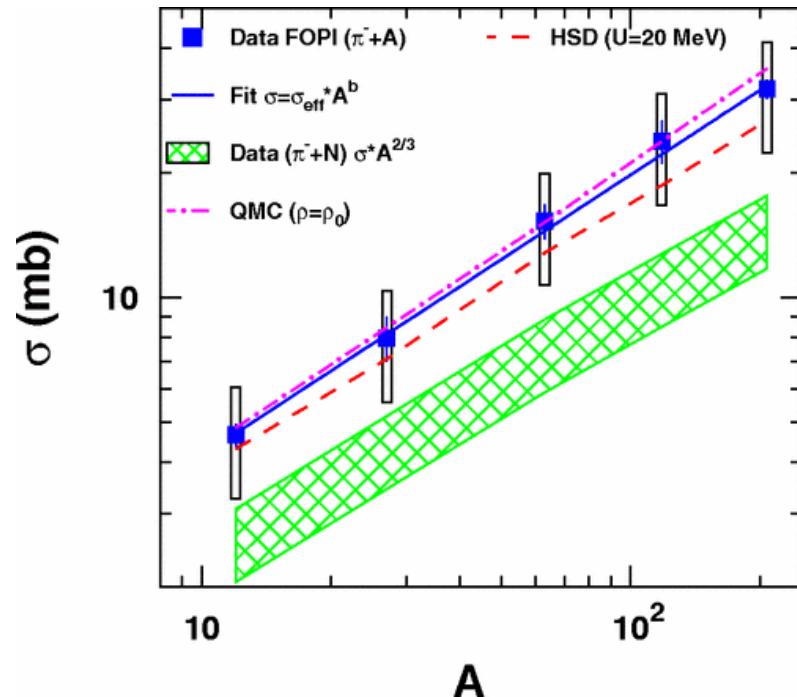
→ Dynamics less complex  
→ In-medium effects already present at  $\rho_0$

# Pion-Induced Strange Hadron Production



- Mean free path  $\lambda_\pi = 1.5 \text{ fm}$   
( $p_\pi = 1.7 \text{ GeV}/c$ ,  $\rho_B \approx \rho_0$ )
- $\pi$  is likely to undergo reactions with nucleus on the surface of the target nucleus

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



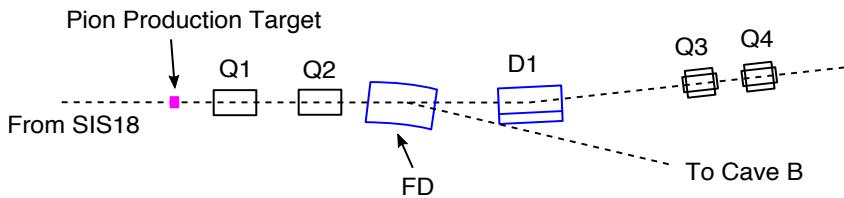
- $K^0$  production scales with the surface of the nucleus in pion-induced reactions (@ 1.15 GeV/c)

# Pion Facility with HADES

## SECONDARY PION BEAM @ 1.7 GeV/c

### CEntRal BEam TRacker for PiOnS (TUM)

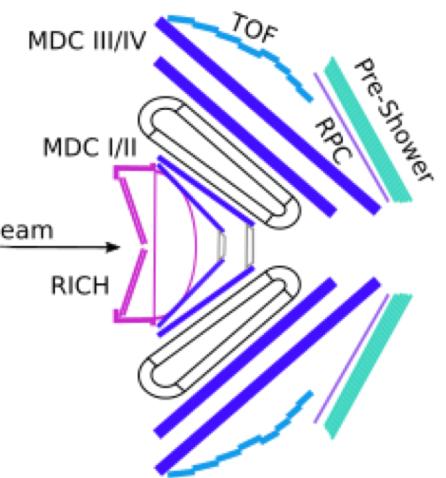
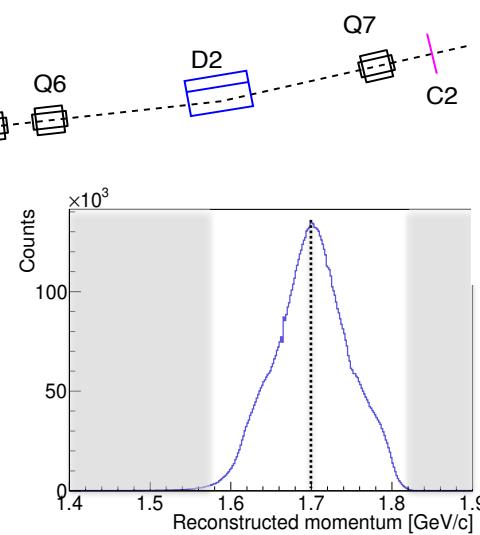
- Two tracking stations (C1, C2)
- High  $\pi^-$  rates ( $\leq 10^7$  part./s)
- Self-triggering and  $\sigma(p_\pi) < 0.5\%$



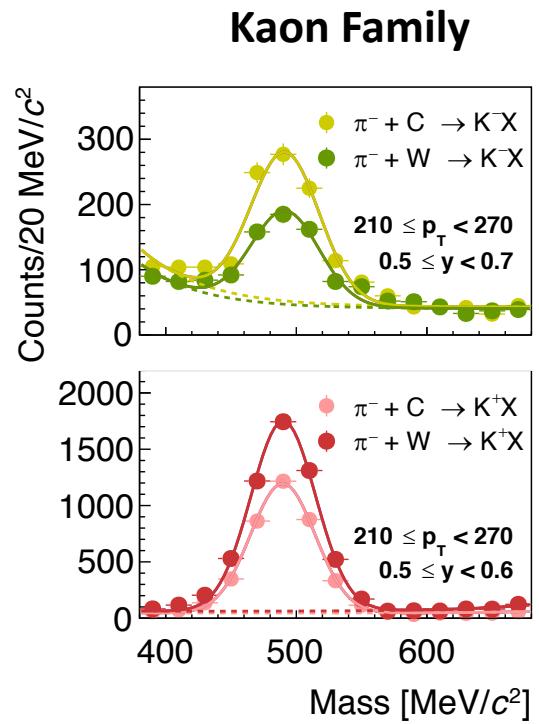
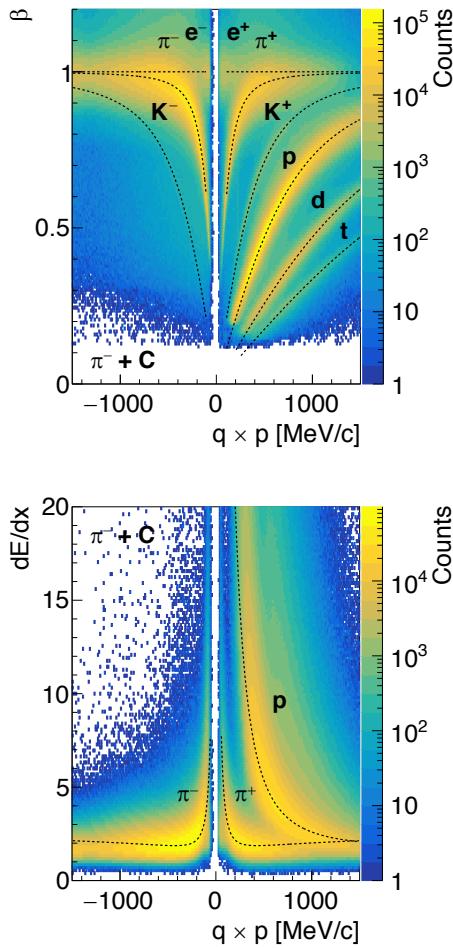
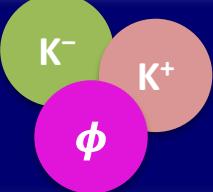
Wirth et al., Nucl. Inst. and Meth., Phys. Res. A, p. 243-244 (2016)  
Adamczewski-Musch et al., Eur. Phys. J. A 53, 188 (2017)

### High Acceptance DiElectron Spectrometer

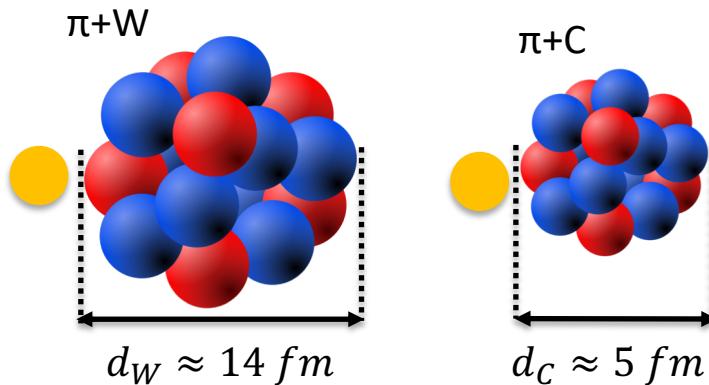
- Full azimuthal coverage
- $15^\circ$ - $85^\circ$  in polar angle
- $\sigma(p) \approx (2-6)\%$



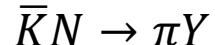
# Strange Hadron Selection



# Strange Hadrons in Nuclear Matter

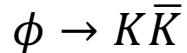


**Strangeness exchange:**

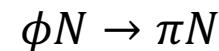


(mediated by resonances)

**Feed-down processes:**



**Absorption processes:**



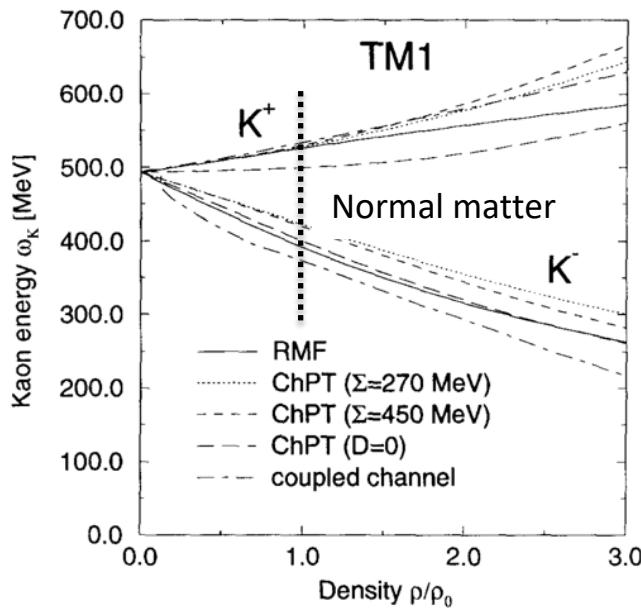
(OZI violation)

**Re-scattering with Nucleons:**



# Kaon-Nucleon Interaction

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

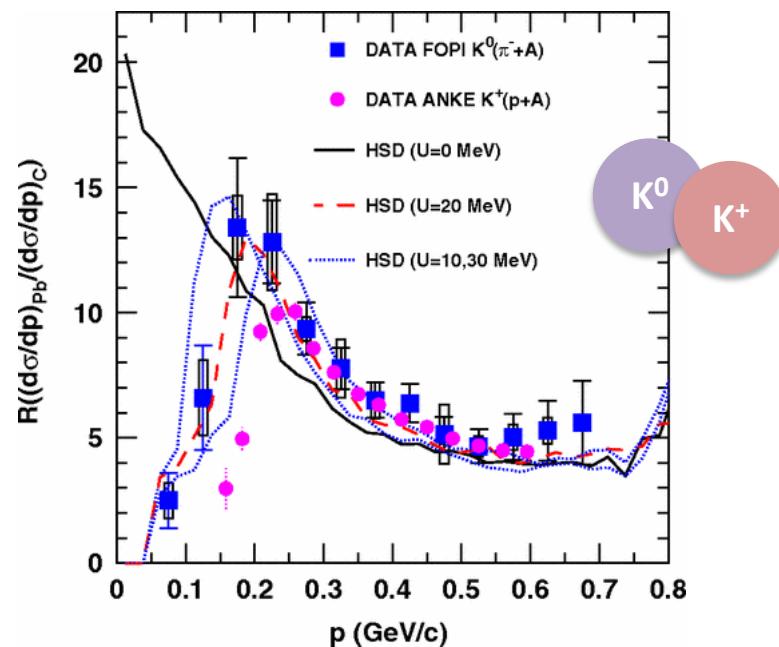


$$\omega_K^2 - \vec{q}_K^2 - m_K^2 - \Pi_K = 0 \rightarrow U_K = \Pi_K / 2\omega_K$$

- Repulsive  $KN$  interaction
- Attractive  $\bar{K}N$  interaction



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



→ Moderate **repulsive  $KN$  interaction**

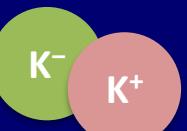
$$\rightarrow U_{KN} \approx 20 - 40 \text{ MeV}$$

$K^0_s$  properties: Ar + KCl, p + Nb (p + p)

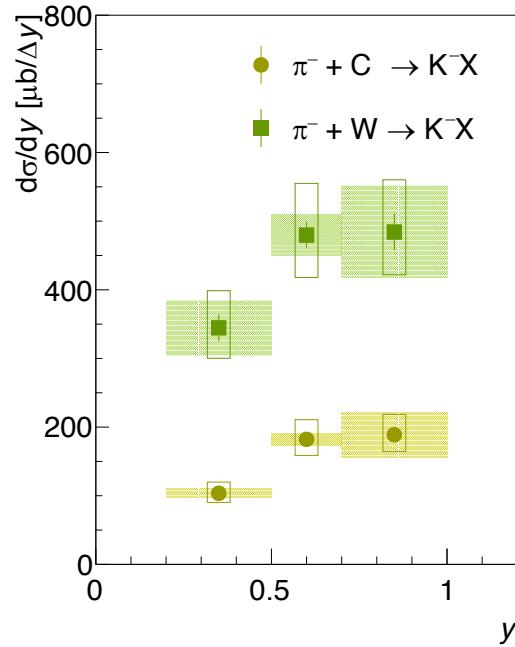
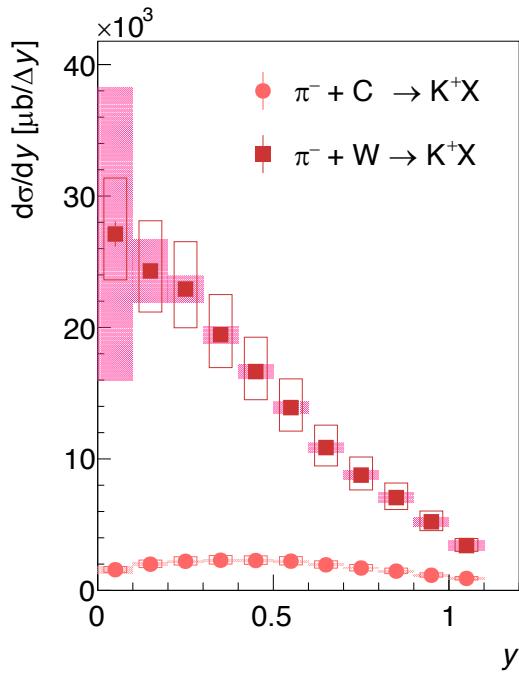
Agakishiev et al. Phys. Rev. C82, 044907 (2010)

Agakishiev et al. Phys. Rev. C90, 054906 (2014)

# Strangeness Production

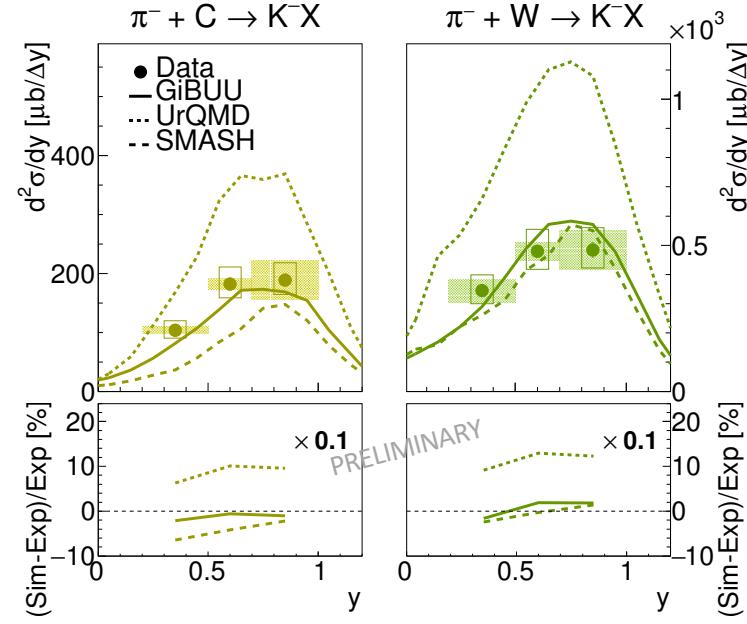
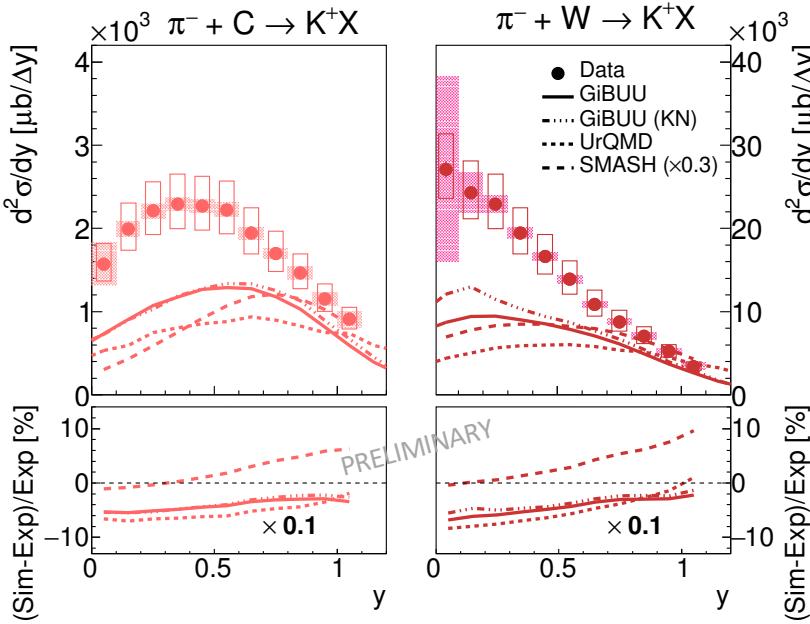
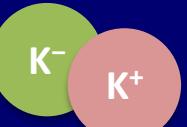


Adamczewski-Musch et al., Phys. Rev. Lett. 123, 022002 (2019)



- Symmetric distribution of all strange hadrons in  $\pi^- + C$
- Distribution shifted to backward rapidity of  $K^+$  in  $\pi^- + W$
- Shape of differential cross-section of  $K^-$  in  $\pi^- + W$  comparable to  $\pi^- + C$

# Strangeness Production



- State-of-the-art transport model calculation over-/underestimate yields
- **Strangeness locally conserved:** associated strange meson production
- **No conclusive description of all hadrons!**

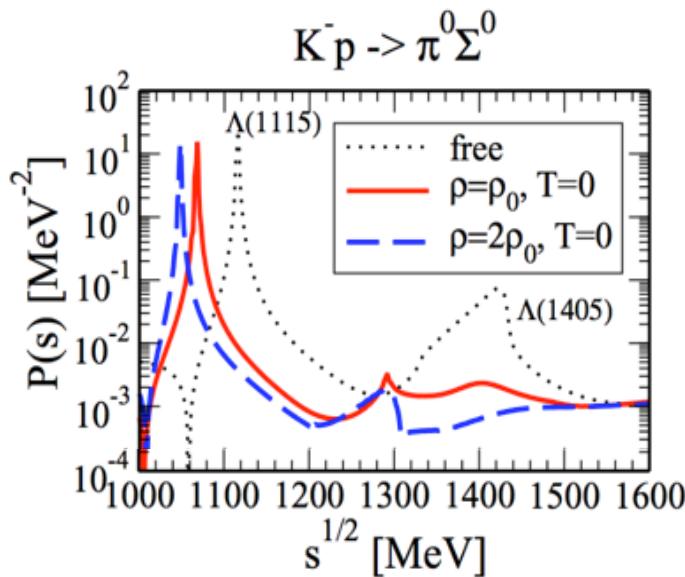
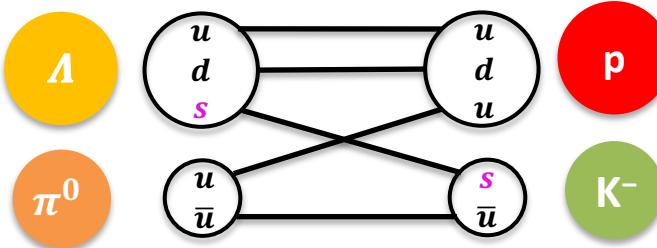
# Interplay of Antikaons and Hyperons

K-

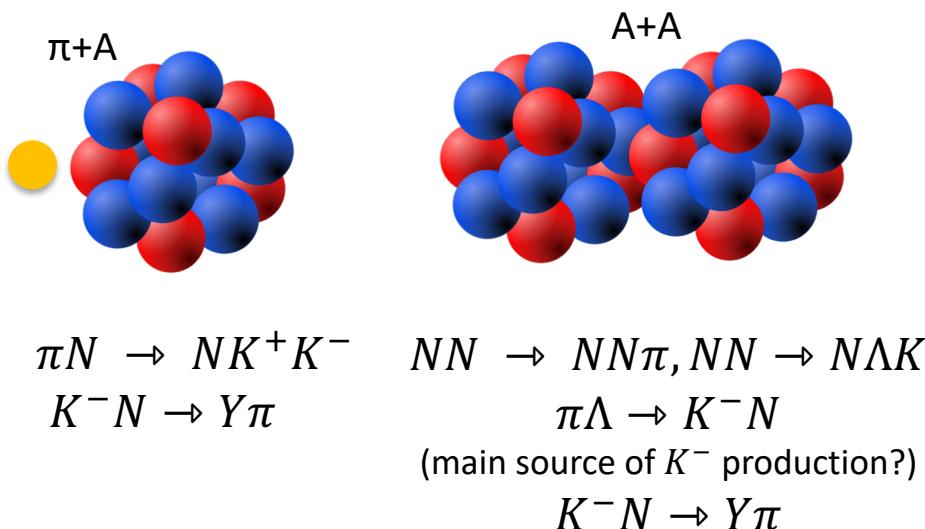
# Strangeness exchange in nuclear matter

$$K^- N \leftrightarrow Y\pi$$

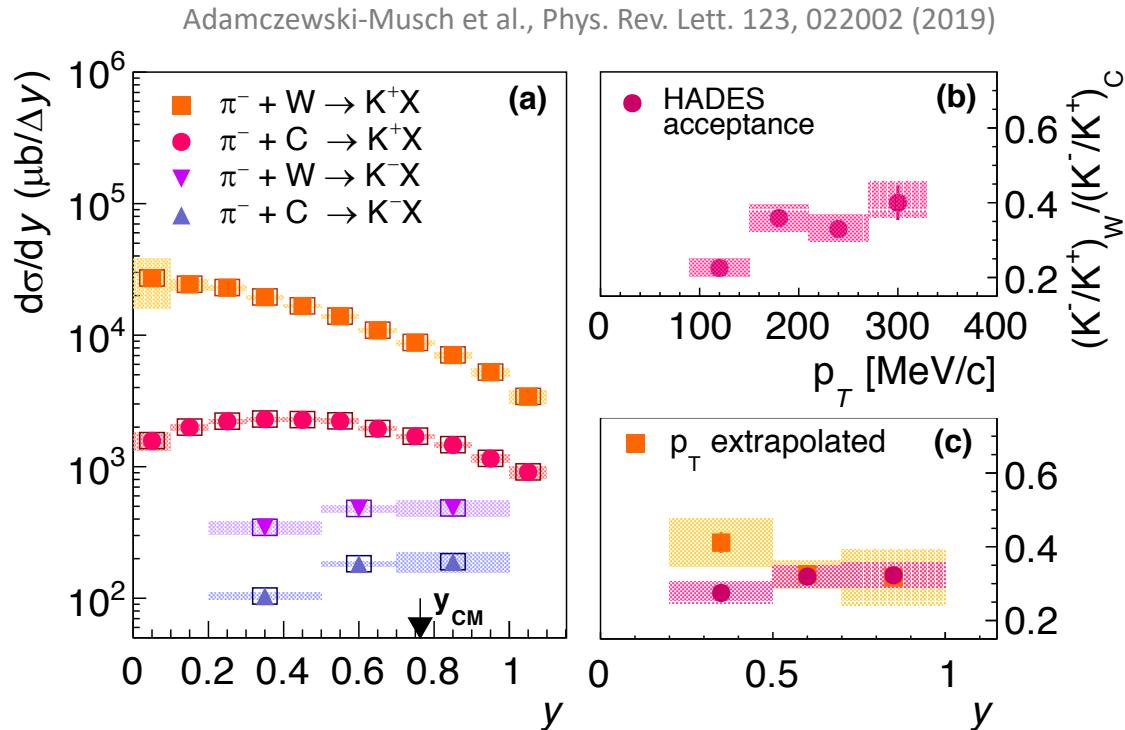
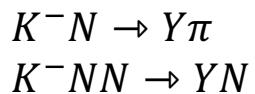
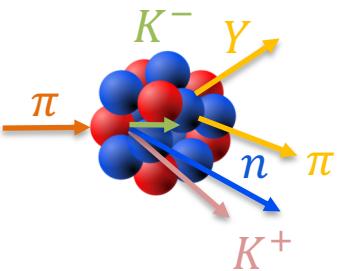
$$K^- NN \leftrightarrow YN$$



Cabrera et al., Phys.Rev. C 90, 055207 (2014)

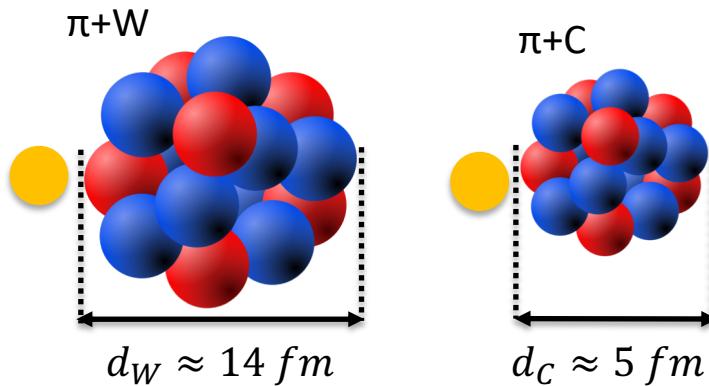


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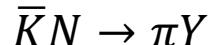


- Strong  $K^-$  absorption for  $\rho \leq \rho_0$
- First observation in heavy nuclei

# Strange Hadrons in Nuclear Matter

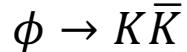


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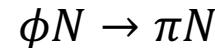


(mediated by resonances)

**Feed-down processes:**



**Absorption processes:**



(OZI violation)

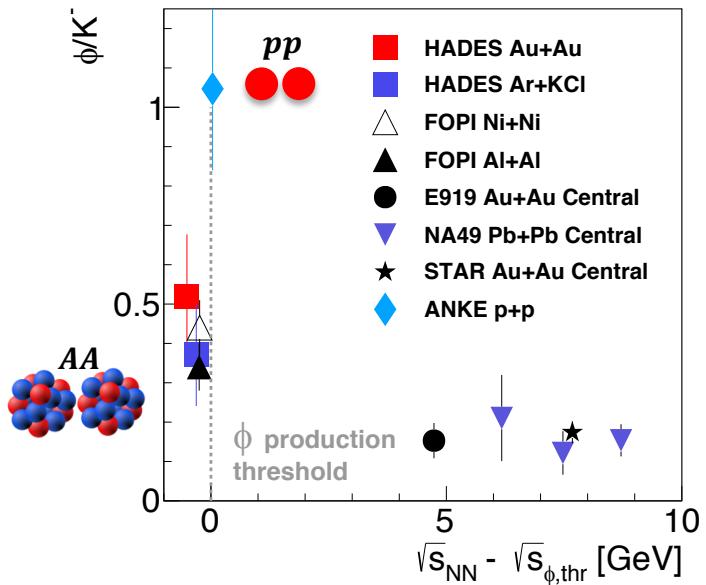
**Re-scattering with Nucleons:**



# Strange $\phi$ Meson

## Antikaon from Phi feed-down

$\phi \rightarrow K^+K^-$ ,  $BR \approx 50\%$

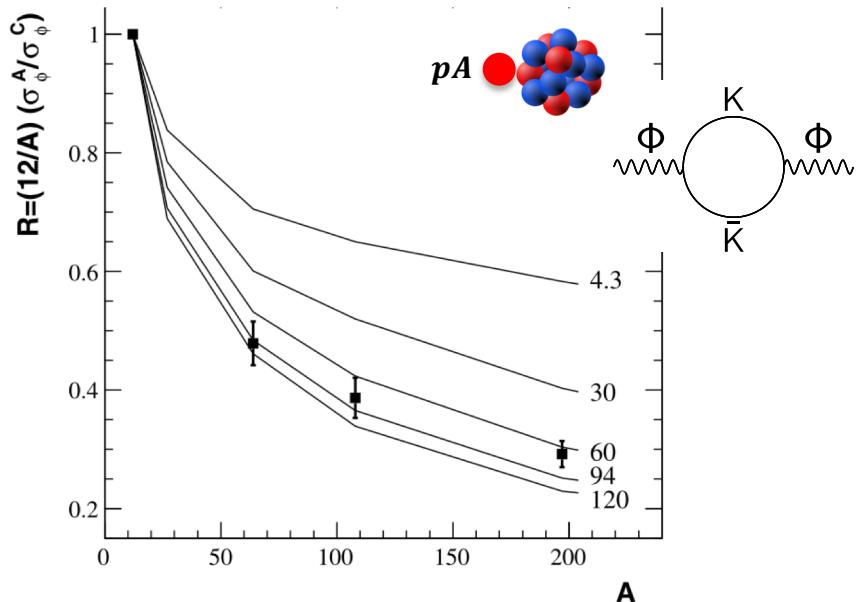


- $\phi$  important source for  $K^-$  production below NN threshold
- $\phi/K^-$  strongly increasing below threshold

Blume et al. Prog. Part. Nucl. Phys. 66, 834-879 (2011)  
 Adamczewski-Musch et al., Phys. Lett. B 778, 403 (2018)

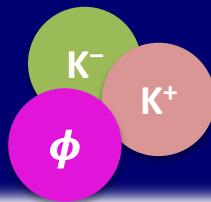
## Phi absorption in nuclear matter

Polyanskiy et al. Phys. Lett. B 695, 74 (2011)

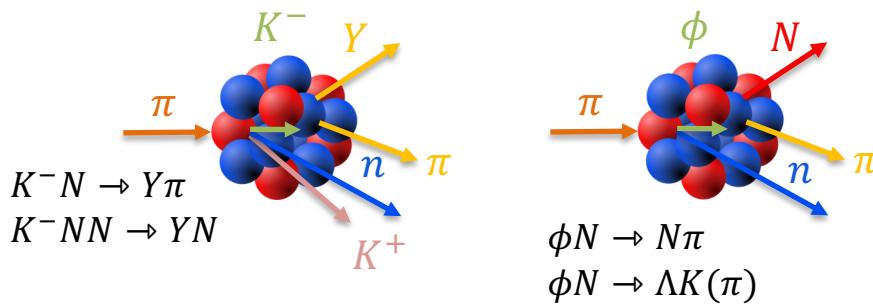
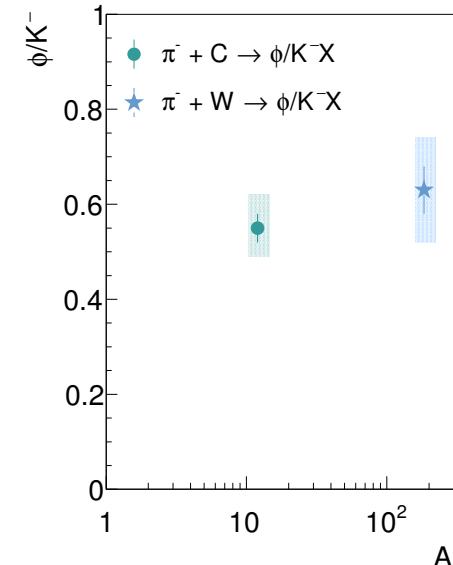
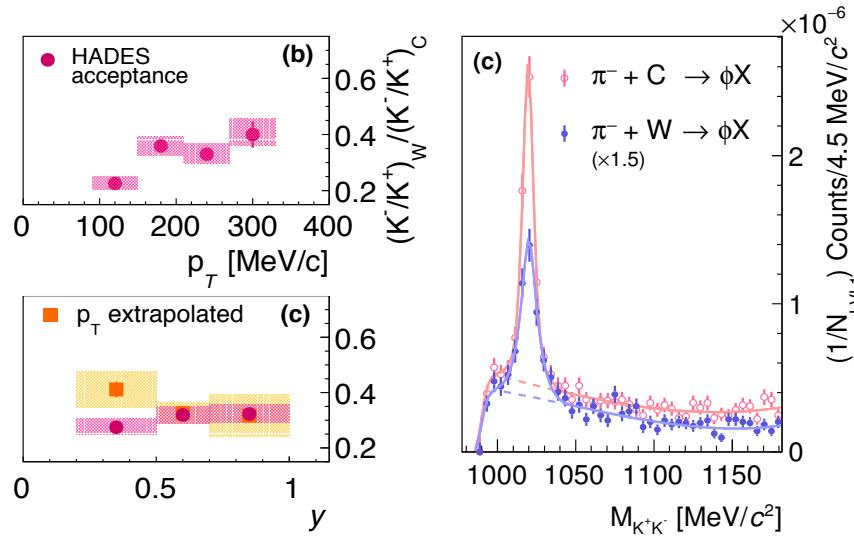


- Transparency ratio of  $\phi$  decreasing for increasing  $A$  ( $p + A$ )
- In-medium modification of  $\phi$ 
  - Increase of in-medium width

# Absorption Processes: $\phi$

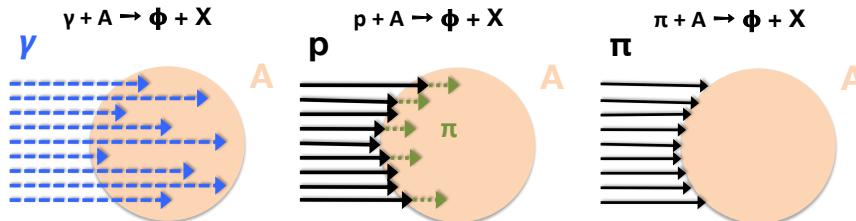


Adamczewski-Musch et al., Phys. Rev. Lett. 123, 022002 (2019)

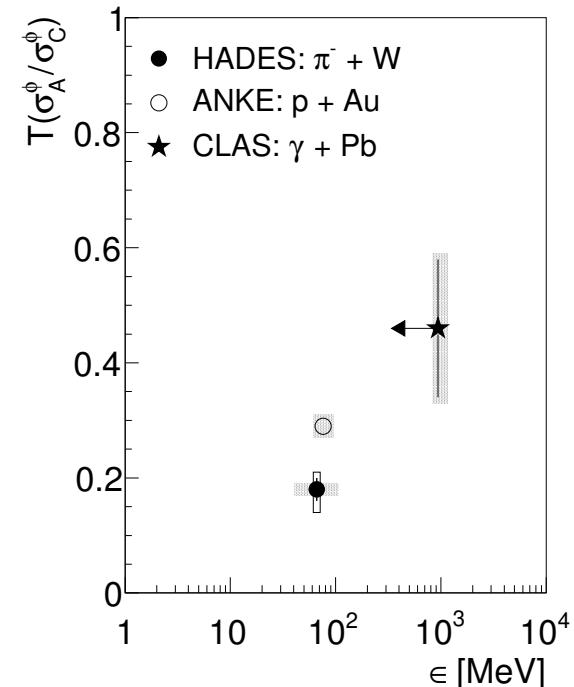
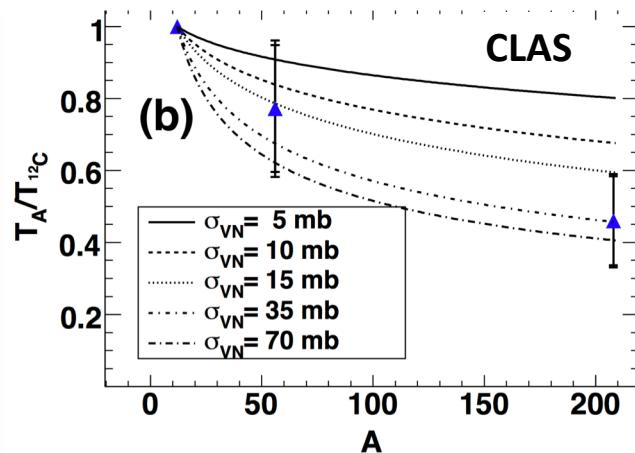


- $\phi/K^-$  ratio is the same in  $\pi^- + C$  and  $\pi^- + W$  reactions
- Significant  $K^-$  absorption in tungsten compared to carbon
- **First model-independent observation of  $\Phi$  absorption**

# Phi Transparency Ratio



Wood et al. Phys. Rev. Lett. 105, 112301 (2010)

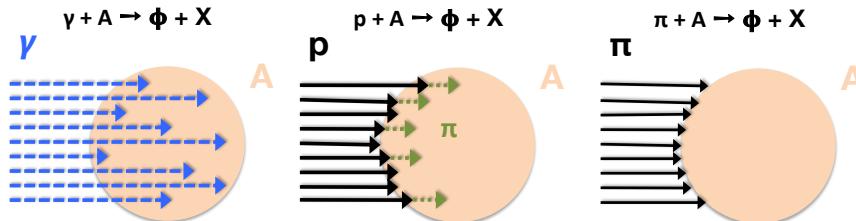


- Extracted transparency ratio lower in  $\pi^- + A$  reactions compared to proton- (ANKE) and photo-induced (CLAS) reactions
- Signature of  $\phi$  absorption

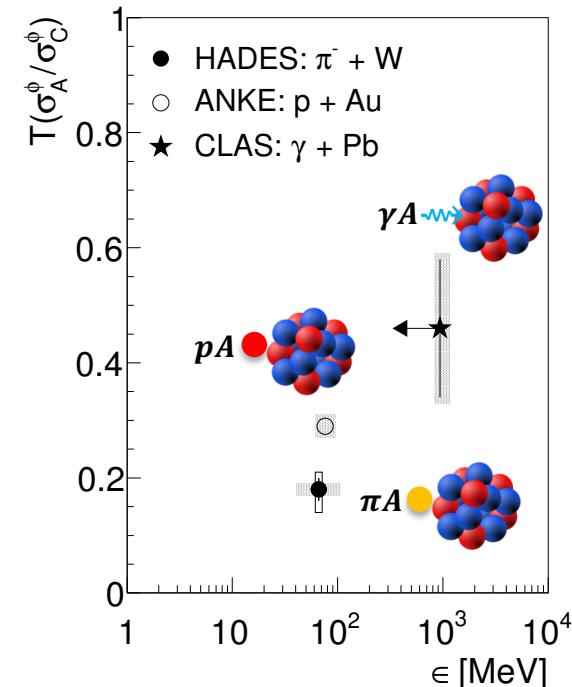
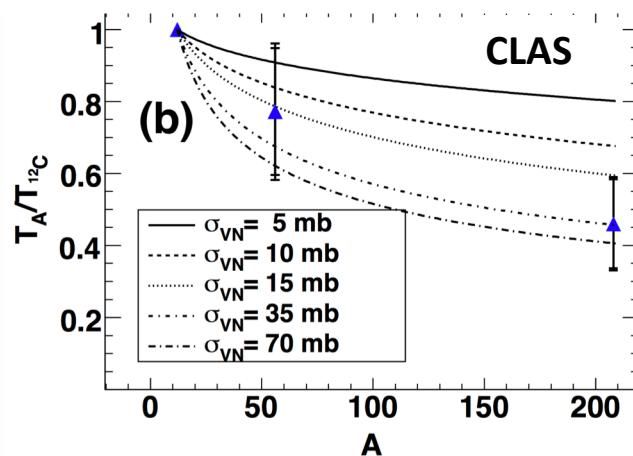
ANKE: Polyanskiy et al. Phys. Lett. B 695, 74 (2011)

HADES: Adamczewski-Musch et al., Phys. Rev. Lett. 123, 022002 (2019)

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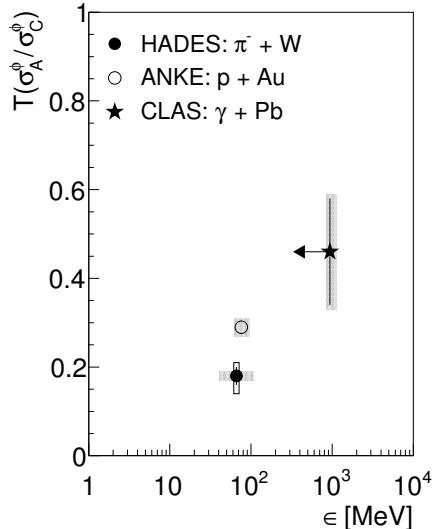
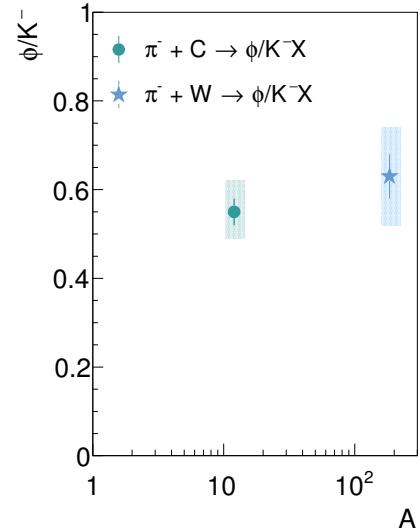
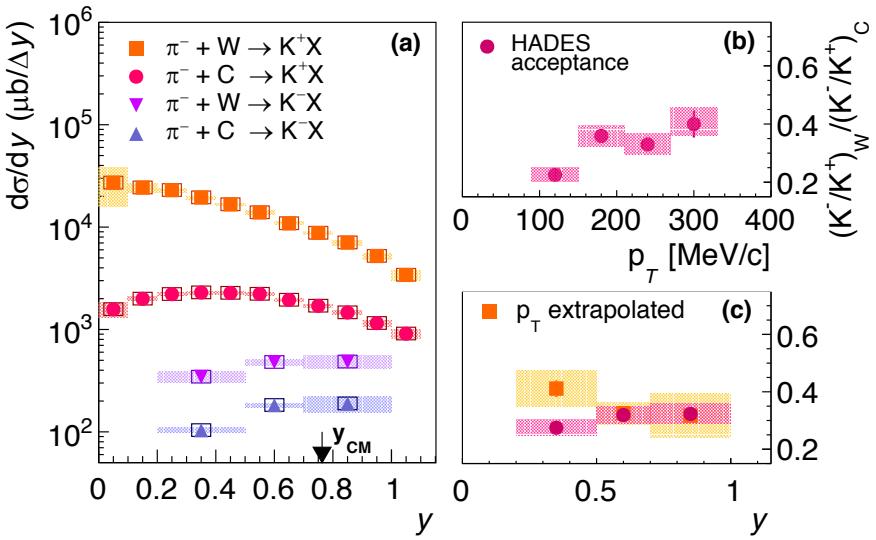
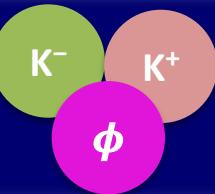


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ANKE: Polyanskiy et al. Phys. Lett. B 695, 74 (2011)

HADES: Adamczewski-Musch et al., Phys. Rev. Lett. 123, 022002 (2019)

# Strangeness Summary



- $K^+$  scattering in  $\pi^- + W$  with respect to  $\pi^- + C$
- $K^-$  absorption in  $\pi^- + W$  with respect to  $\pi^- + C$
- $\phi/K^-$  ratio constant for  $\pi^- + W$  and  $\pi^- + C$
- $\phi$  disappearance as well as  $K^-$

Adamczewski-Musch et al., Phys. Rev. Lett. 123, 022002 (2019)