News from FOPI Data

Kick-off Meeting - LEANNIS in HadronPhysics3 May 21 - 22, 2012, Prague





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Including Slides by Some Y. Herrmann Hang ann (HD) and Stefan Meyer Institute for Subatomic Physics Austrian Academy of Sciences

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Der Wissenschaftsfonds.





Contents

- FOPI at GSI
- Recent Experiments on Strangeness Production
 - Heavy Ion Collisions at maximum SIS energies
 - Proton + Proton Collisions (\rightarrow talk by R. Münzer)
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- Summary and Outlook





FOPI at GSI







FOPI at GSI







Systems studied by FOPI 2003-2011

- Heavy Ion Reactions K⁰, K[±], Λ, Φ, K^{*}, Σ^{*} Ni+Ni (1.93 and 1.91 AGeV), AI+AI (1.91 AGeV), Ni+Pb (1.91 AGeV), Ru+Ru (1.69 AGeV)
- Pion Induced Reactions
 K⁰, K[±], Λ, Φ
 π⁻ + C, AI, Cu, Sn, Pb (1.15 GeV/c, 1.7 GeV/c)
- Proton+Proton 3.1 GeV search for ppK⁻ bound state





Flow of Charged Kaons



FOPI Data in

vomparision

(w/ acceptance

transport

models

filter)

with

Ni+Ni, 1.91 AGeV (S325, S325e) σ =1.5b, b_{geo}=7 fm Potentials at $\rho = \rho_0$: HSD: U(K⁺)=20 MeV, U(K⁻)=50 MeV IQMD: U(K⁺)=40 MeV, U(K⁻)=90 MeV T.I. Kang, V. Zinyuk (Heidelberg)



Small sideflow of K⁺ Vanishing K⁻ sideflow K⁺ elliptic flow <0 (out of plane) K⁻ sideflow consistent with zero





Λp Correlations in HIC



К-рр?

 $\begin{array}{l} m=2.134 \ GeV \ \pm \ 4 \ MeV \\ \Gamma = \ 26 \ \pm \ 14 \ MeV \end{array}$

(statistical err.)

- Peak (cusp) at
 NΣ threshold
- seen in p+p collisions/ scattering

• FSI ?

present also in Λd?

COSY-TOF preliminary 2.95 GeV/c proton momentum (2.16 GeV)



Λp Correlations in HIC



K⁻pp?

 $m = 2.134 \text{ GeV} \pm 4 \text{ MeV}$ $\Gamma = 26 \pm 14 \text{ MeV}$

(statistical err.)

- Peak position consistent with p+p scattering data: M=2.135 ± 0.004 GeV (R. Siebert et al., NPA567(1984) – SPES4/SATURNE II) Suggested interpretation: D_t (q4 x q2 structure) A.T.M. Aerts and C.B. Dover, Phys. Lett. B146, 95 (1984)
- Object also seen in K⁻ + d $\rightarrow \Lambda p\pi^{-}$ (O. Braun et al., NPB 124,45 (1977))

Interpretation: ΣN – bound state H(2129)





Ad – Correlations Ni+Ni at 1.91 AGeV (S325e data)

N. Herrmann



FOPI 2003 and 2008 data are consistent, Inconsistent with cusp ($\Sigma - d$ – threshold) and FINUDA.





K. Wisniewsk

PID – Performance



System time resolution (on limited part of the available data so far): $\sigma_{sys} \sim 80 \text{ ps}$ K⁺ - identification up to 1.3 GeV/c Further background reduction under development.





Search for Light Hypernuclei in HIC (Yapeng Zhang, Heidelberg)

 3 H invariant mass



³He phase space distribution

Ni+Ni @ 1.91A GeV, ~ 56M events





Search for Light Hypernuclei in HIC (Yapeng Zhang, Heidelberg)

- Topological cuts
- Background reconstructed by mixed-event method: centrality classes
- Alignment of the reaction planes
- Removal of intersecting tracks
- With requiring the best description of non-signal region by mixed background

3 H invariant mass







[∧]³H lifetime (Yapeng Zhang, Heidelberg)



$$N = N_0 e^{-t/\tau}, t = r_s / (\beta \gamma)_T = r_s / (p_t / m)$$





Evidence for ${}_{\Lambda}{}^{4}H \rightarrow \pi^{-}{}^{4}He$ (Yapeng Zhang, Heidelberg)







Pion Induced Reactions





Strangeness Production in π^-A

Previous Experiment at 1.15 GeV/c

- inclusive K⁰ production cross section
- Kaon in-medium potential of 20 MeV suggested
- Λ and K⁺ production currently analyzed









Charged Kaons in 1.7 GeV/c π -A

$$\pi^-$$
 + Pb \rightarrow p + X (CDC)



Event topology

CDC acceptance covers the target rapidity/ low momenta region

 \rightarrow interesting region for in-medium effects





Charged Kaons in 1.7 GeV/c π -A





Carbon target

 particles are well separated over the full momentum range





Charged Kaons in 1.7 GeV/c π -A



Graphical cut for K± selection additional cuts for hit multiplicity, d0 and z0 (tracks from primary vertex) Charged kapons can be identified in the CDC only by means of dE/dx \rightarrow low momentum kaons \rightarrow no matching efficiency







GiBUU Transport Model http://gibuu.physik.uni-giessen.de/GiBUU/



Event topologies from GiBUU calculation $p_t/m vs$. lab rapidity







K⁺/K⁻ Ratio – Data and GiBUU



Preliminary FOPI data (CDC only, latest calibration)

GiBUU momentum filtered

Statistical errors only

Straight line fit

- similar trend
- slopes differ by 25%

GiBUU w/o in-medium potential





Φ in GiBUU Transport Model



 $\Phi(1020)$ can be reconstructed from K⁺K⁻ for all three targets (example: Pb)

But: transparency ratio much too small ...

P. Mühlich, NPA765(2006)188



 γA case: T_A (Cu) ca. 40%





Next Steps

- Re-iterate on K⁺/K⁻/Φ yield from data and GiBUU model
- Momentum dependence
- Possibility to include Kaon potential in GiBUU calculation (in collaboration with GiBUU group/A. Larionov, Gießen)
- Look to other strangeness channels, like K⁰,
 Λ, Σ[±] (several analyses under way)
- Include all available detector information: GEM-TPC, Helitron





Summary and Outlook

- Strangeness production is studied with different probes: HIC, π^- beam, p+p
 - Charged kaon flow
 - $-\Lambda p$, Λd correlations (bound states?)
 - $-K^{+}K^{-}/\Phi/K^{0}$... production on nuclei
 - Comparison to transport models
- The facility FOPI@GSI will probably close by the end of 2012 \rightarrow on the road to FAIR



