Kaon-Antikaon production in p+A Reactions at ANKE

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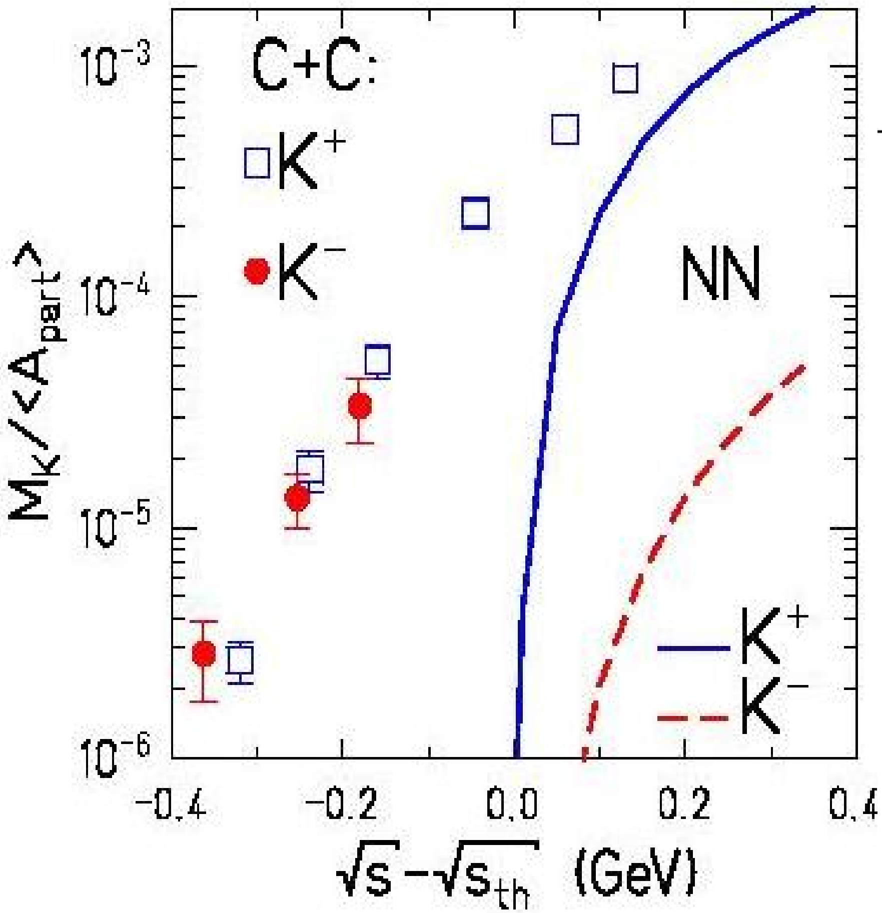
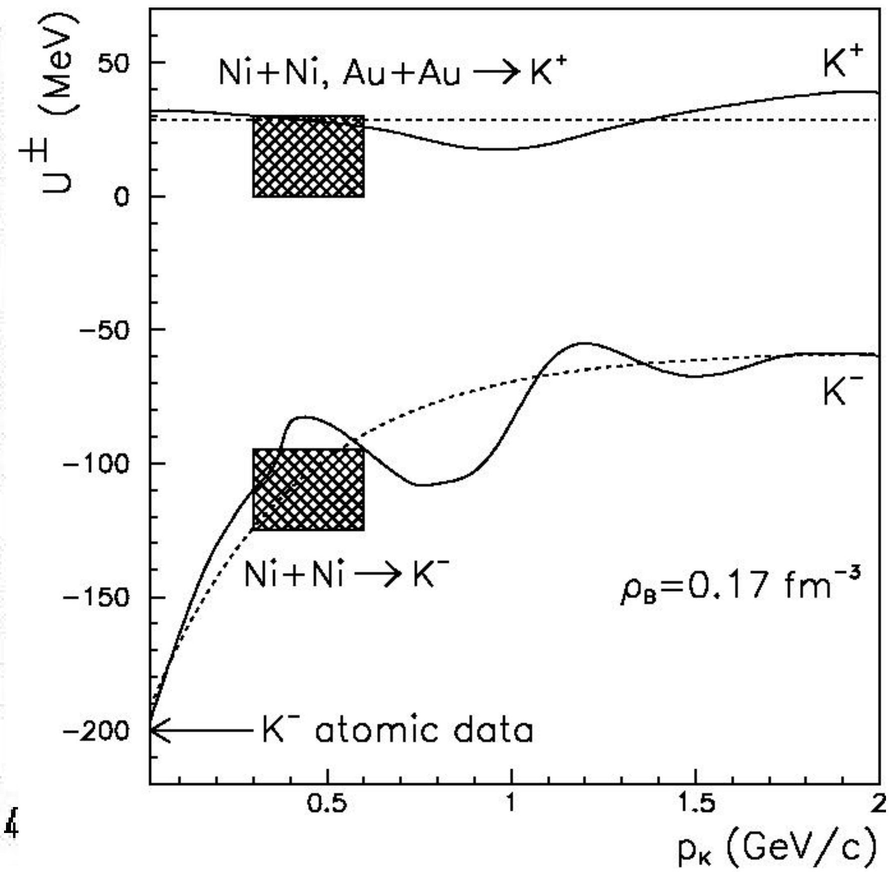
Overview

- **(Anti-) kaon potential in nuclear matter**
  - ⇨experimental data and their theoretical analysis
- **Φ meson in-medium properties**
  - ⇨predictions and recent calculations
  - ⇨experimental data
- **Rate estimation for K^+K^-/Φ production at ANKE**
  - ⇨feasible at ANKE
- **Production mechanism**
  - ⇨direct and higher order processes
- **Summary**

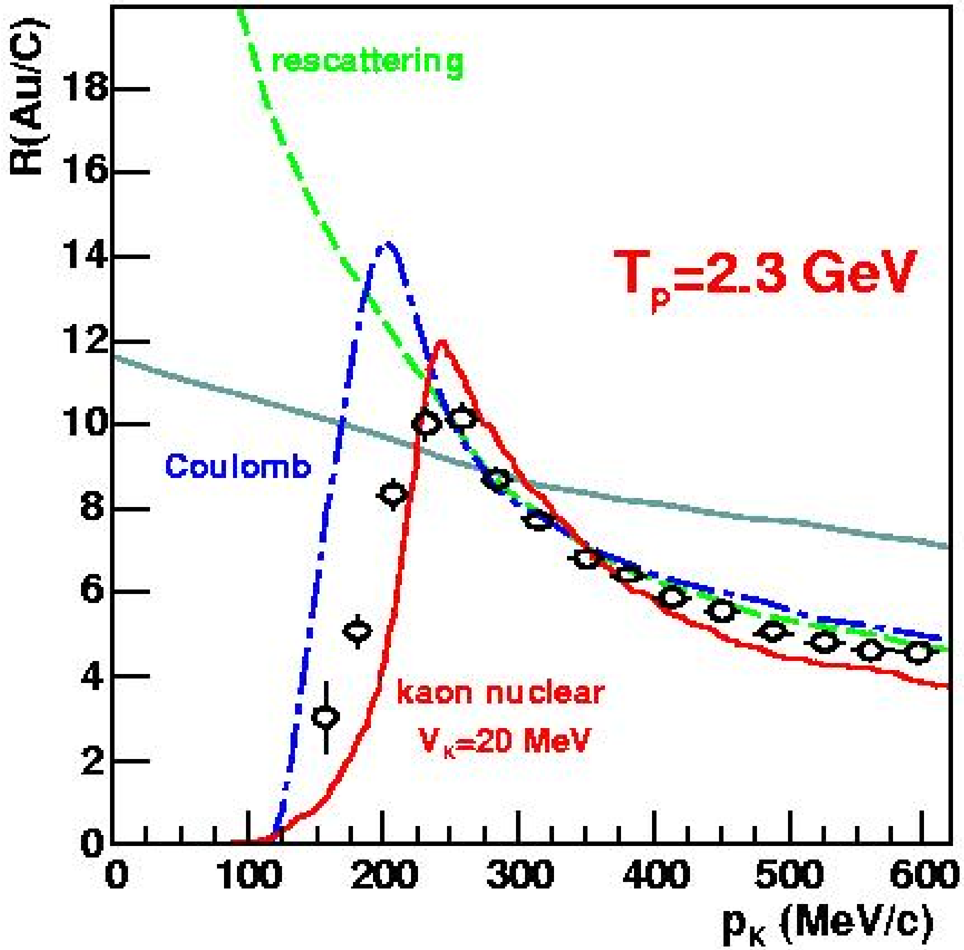
K^+ and K^- potential in nuclear matter





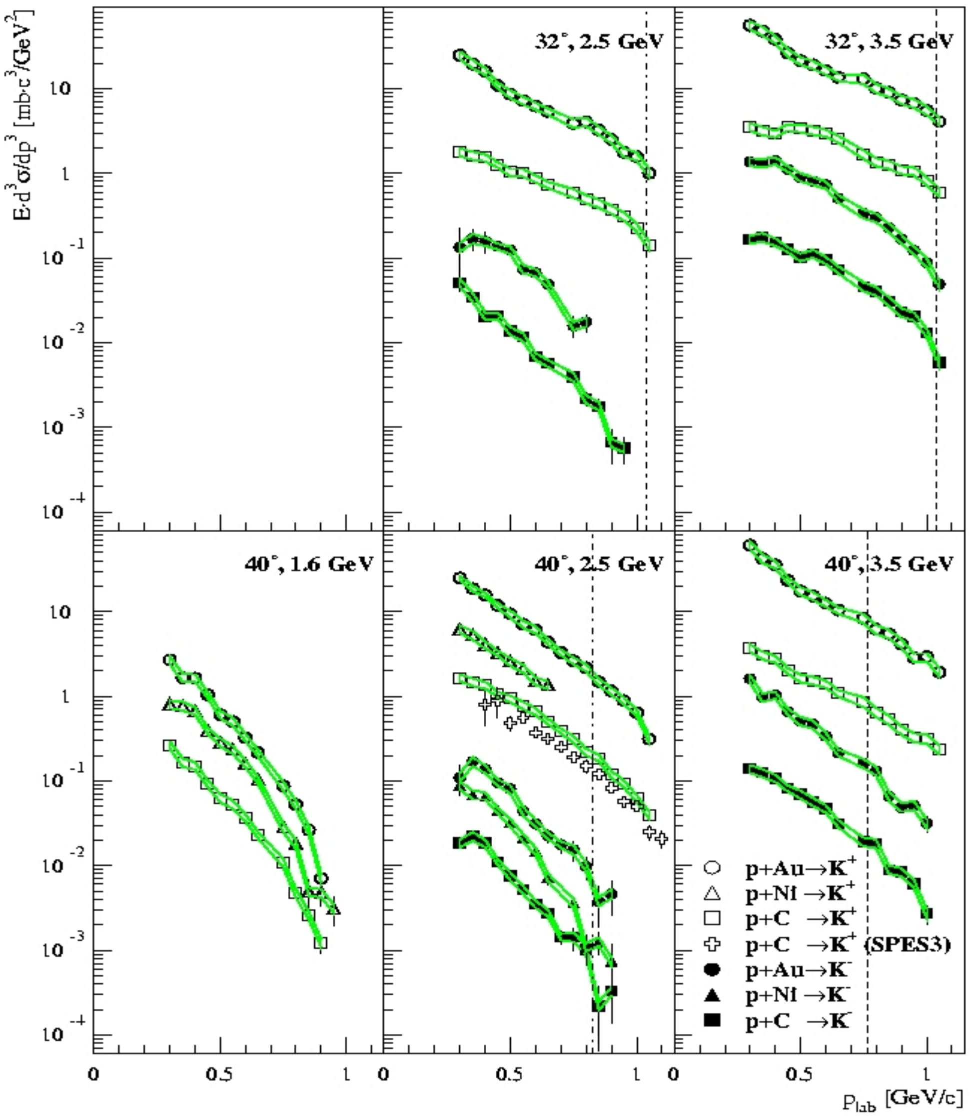
A. Sibirtsev, W. Cassing, Nucl. Phy. A641, p476 (1998)

Strong K^- potential should be visible at ANKE



M. Nekipelov et. al,
Phys. Lett. B540, 207 (2002)

Experimental data from KaoS collaboration

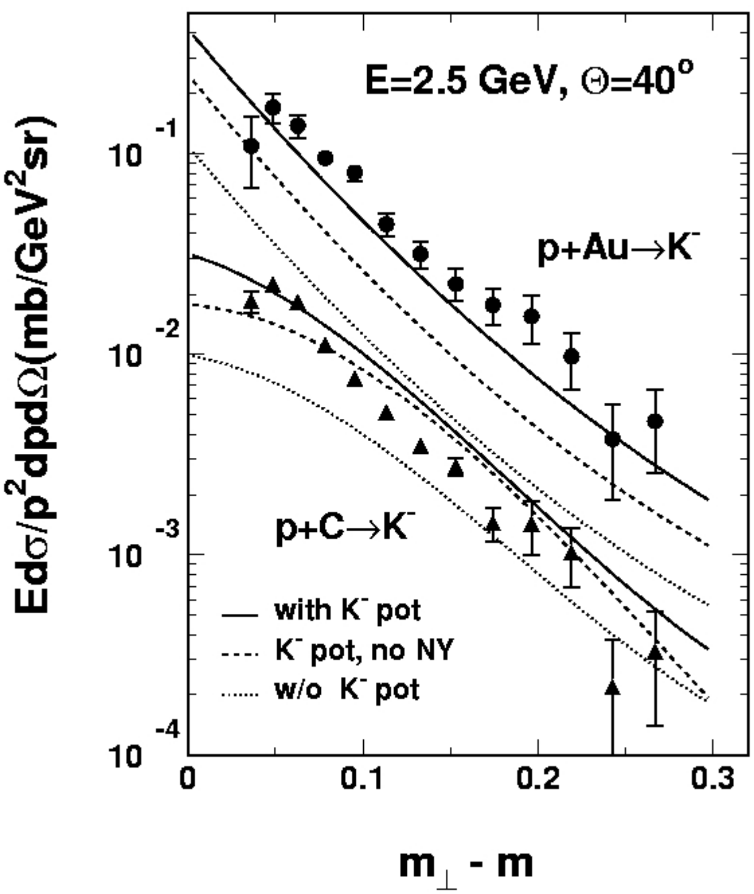


- ANKE
  - ⇨polar angle < 12°
  - ⇨p_{K^-} from 150 to 1 GeV/c
  - ⇨Good complementation!

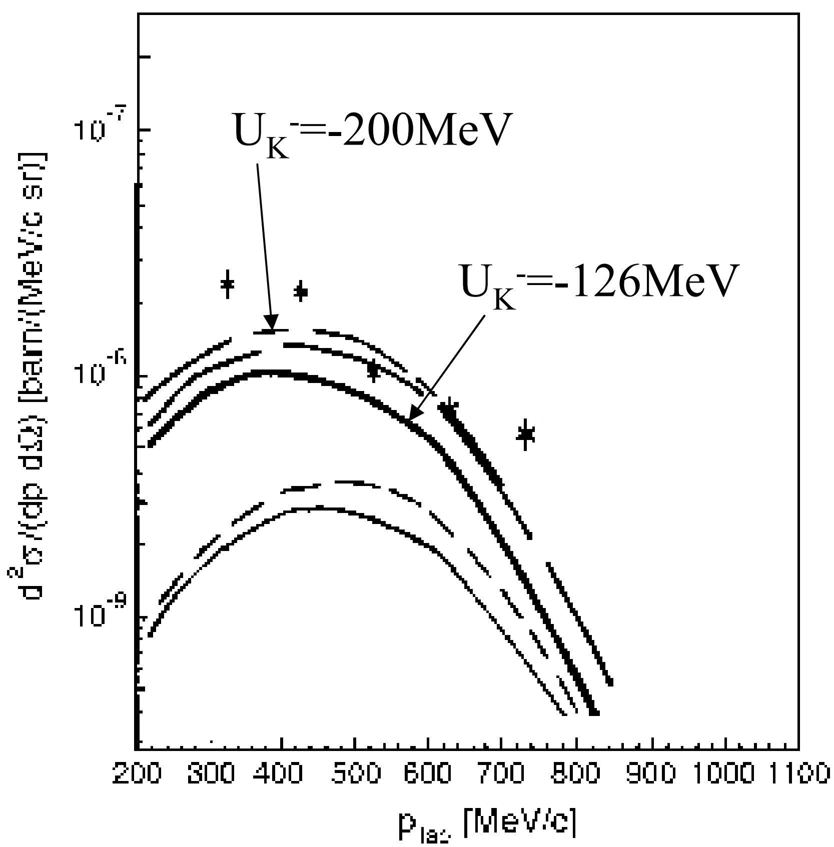
W. Scheinast, PhD., Dresden 2004
(exp. Data:KaoS,
full publication in preparation).

K^- potential ?

W. Scheinast, PhD., Dresden 2004
(exp. Data:KaoS)



E.Ya. Paryev, Eur. Phys. J. A 17, 145 (2003)
(exp. Data:KaoS, T_p=2.5GeV, Au, α=40º)



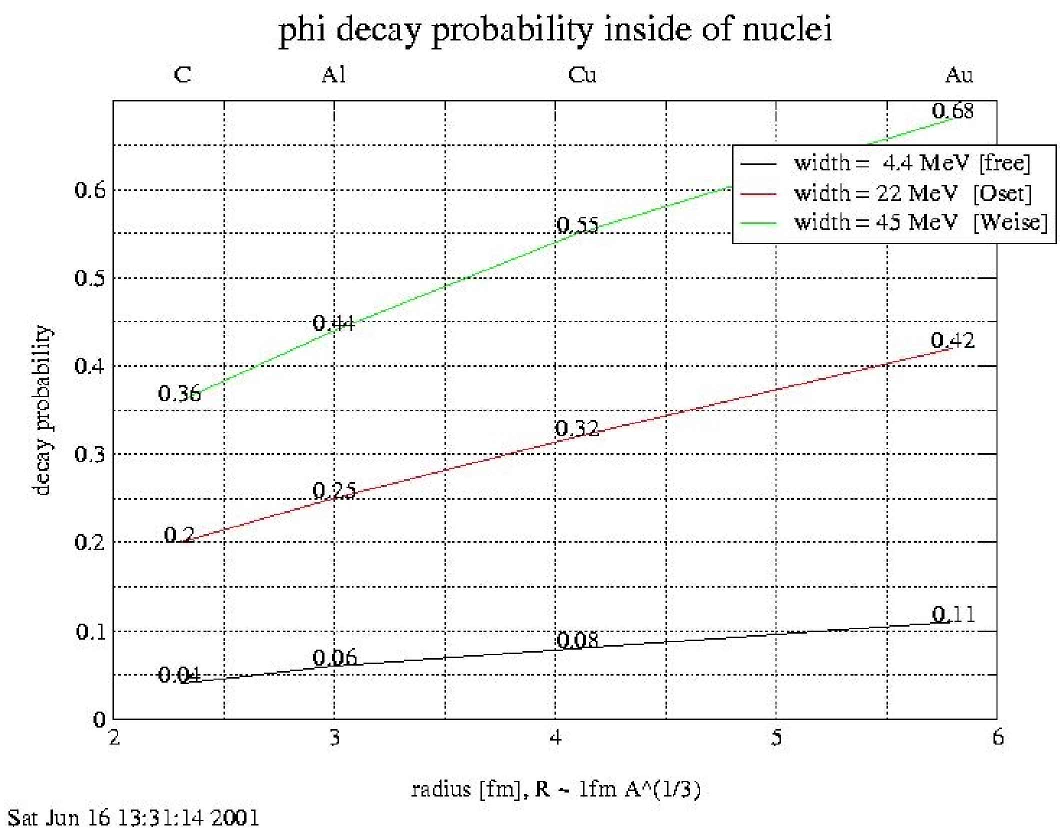
Theoretical predictions for the Φ properties in nuclear matter

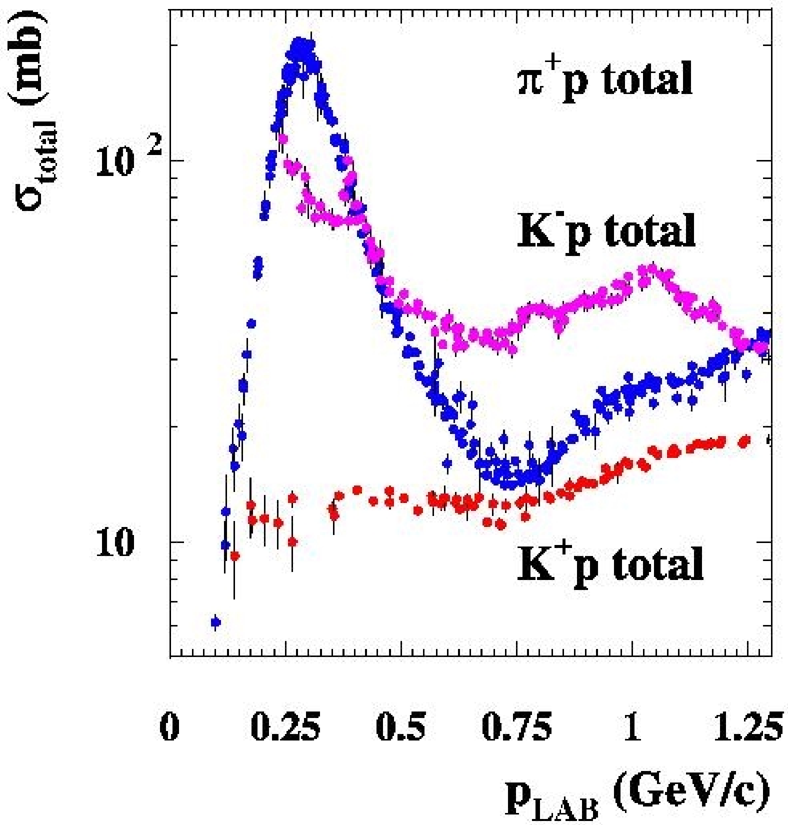
ϕ at rest in ρ_0	Δm_ϕ [MeV]	Γ_ϕ [MeV]
T.Hatsuda and S.H.Lee Phys. Rev. C46 (1992) R24	20 - 40	
F.Klingl, T.Waas, W.Weise Phys. Let. B43 (1998) 245	20 - 40	45
E.Oset and A.Ramos Nucl. Phy. A679 (2001)		22

- Binkley at al., Phys. Rev. Let. 37 (1976) 571
  $\sigma(A) = \sigma(1)\ A^\alpha$, $\alpha = 0.66 \pm 0.03$

- P.Mülich et. al., Phys. Rev. C46, (2003) 024605
  „not visible“

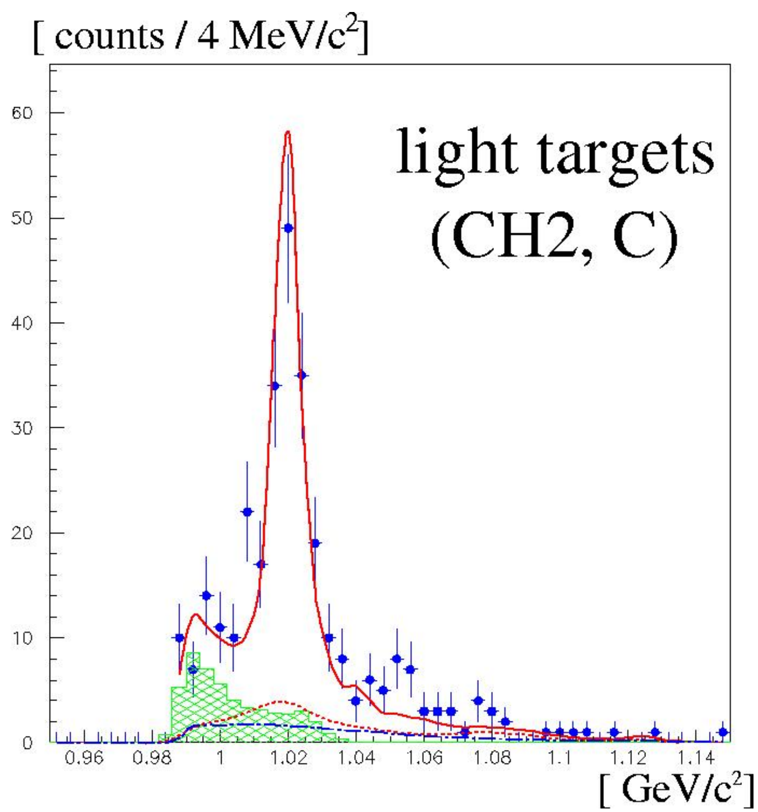
Φ decay probability

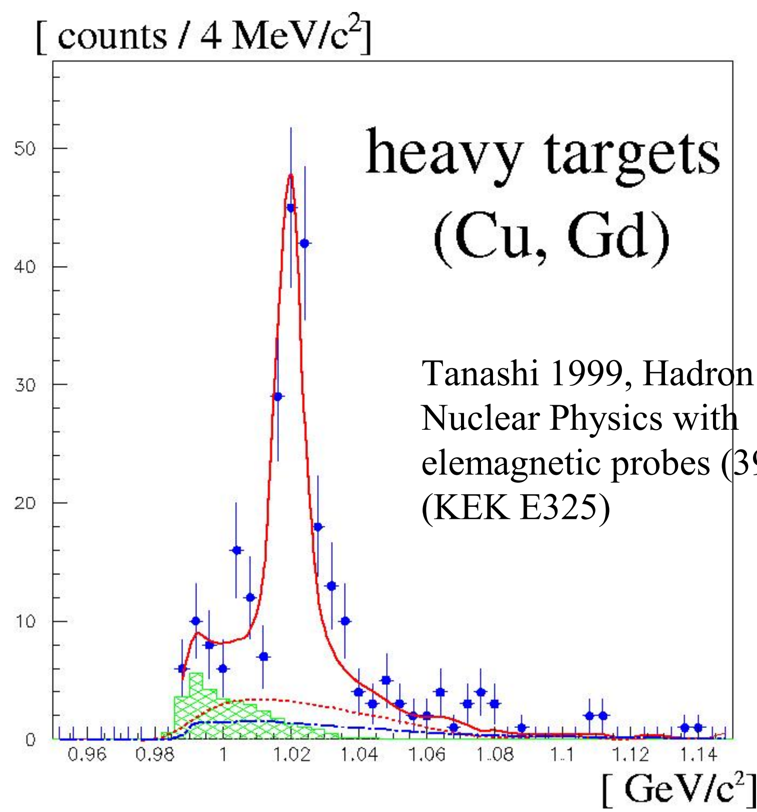




$<p_\Phi> = 1200$ GeV/c

Φ production in pA (KEK, Tp=12GeV)





Tanashi 1999, Hadron and Nuclear Physics with elemagnetic probes (39-48) (KEK E325)

$\sigma(A) = \sigma(1)\ A^{\alpha}$, $\alpha = 1.01 \pm 0.09$ ($\Phi \to K^+K^-$)

$\alpha = 1.27 \pm 0.21$ ($\Phi \to e^+e^-$)

data not yet published!

Φ production in AuAu (AGS/BNL)

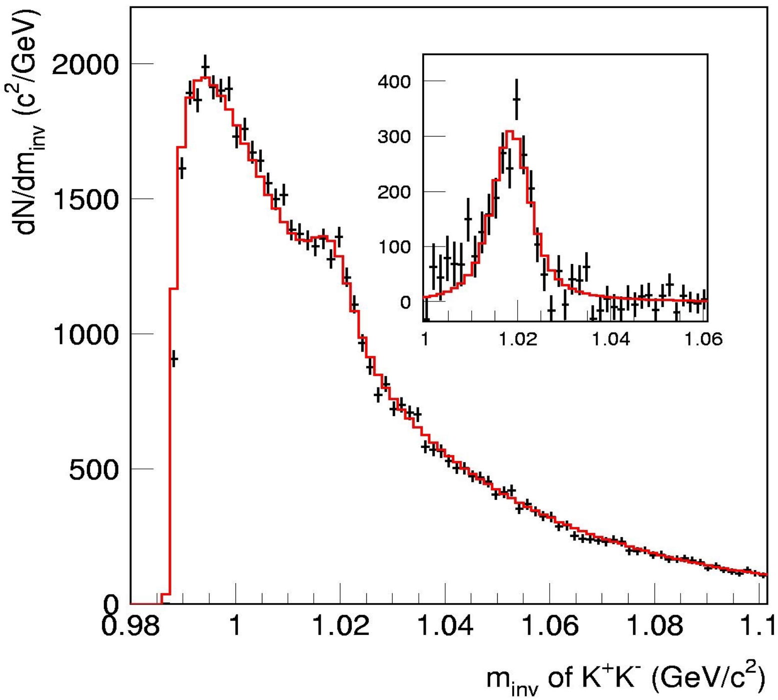


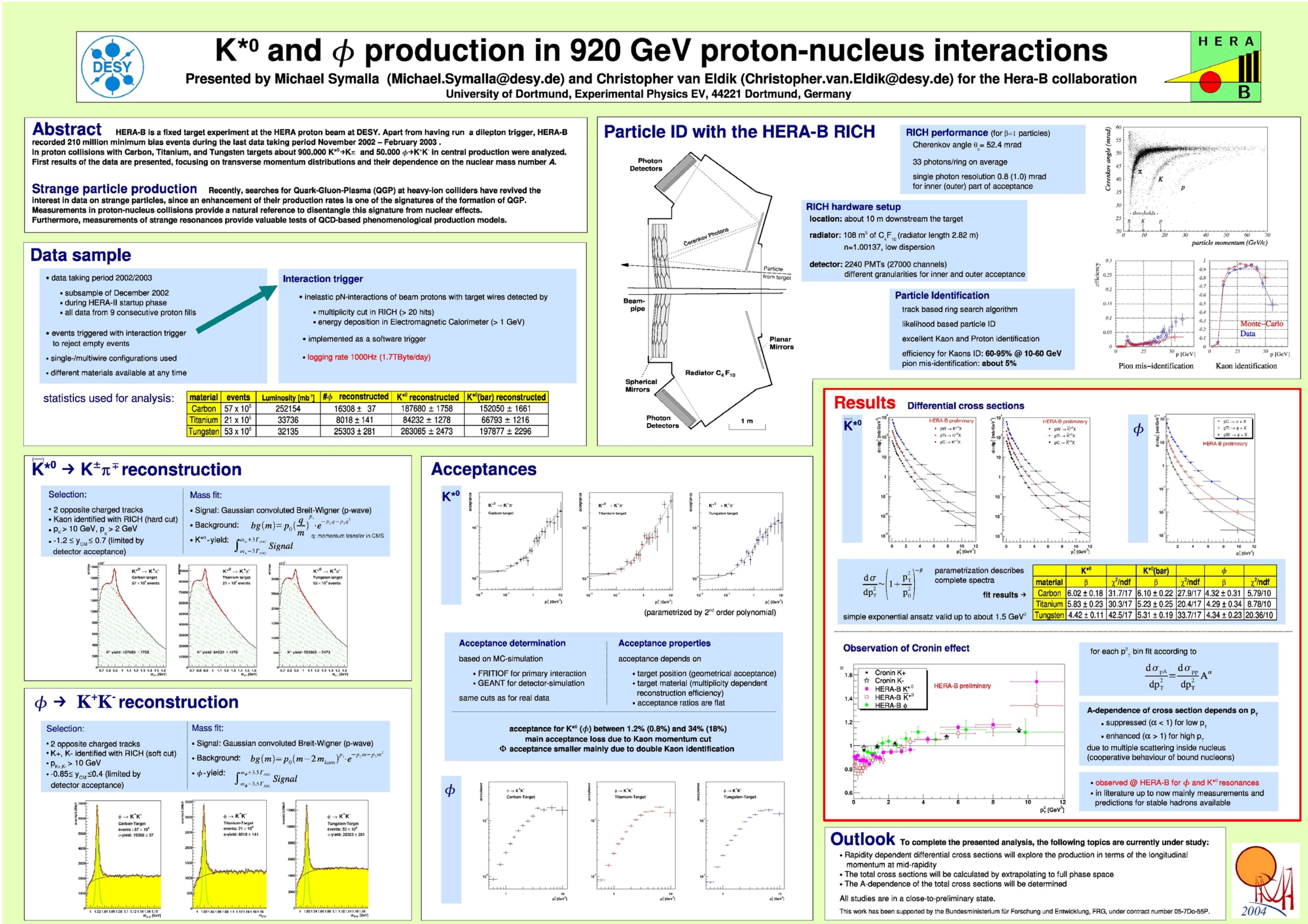
FIG. 2: The invariant mass (m_{inv}) distribution of K^+K^- pairs for minimum-bias events. The ϕ signal after background subtraction is shown in the inset. The ϕ distribution is fitted with a relativistic Breit-Wigner distribution convoluted with a Gaussian plus the background distribution from a mixed-event technique, as described in the text.

- Experiment E917
  Tp=11.7 AGeV

- m_Φ=1018.99±0.36MeV
  Γ_Φ =6.14±2.59MeV
  σ_Φ =2.43±1.11MeV

B. Back et. al, Phys. Rev. C69, 054901 (2004)

Φ production in p+A, Tp=920GeV (Hera-B)



Φ production in p+A, Tp=920GeV (Hera-B)

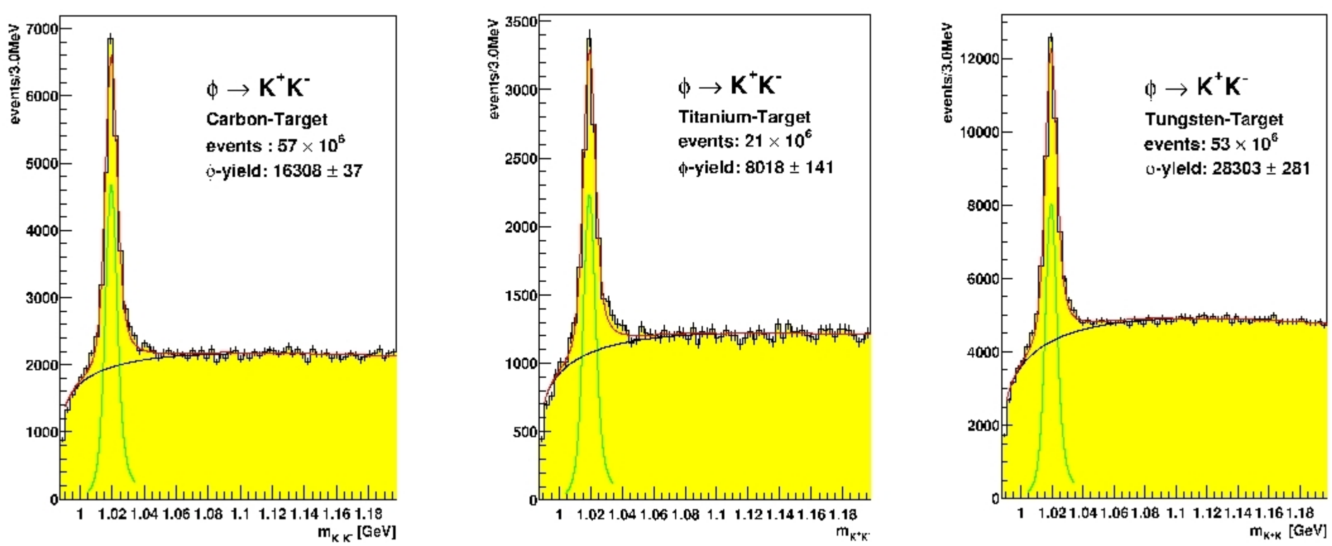
$\phi \rightarrow K^+K^-$ reconstruction

Selection:

- 2 opposite charged tracks
- K+, K- identified with RICH (soft cut)
- $p_{K+,K-}$ > 10 GeV
- $-0.85 \leq y_{CM} \leq 0.4$ (limited by detector acceptance)

Mass fit:

- Signal: Gaussian convoluted Breit-Wigner (p-wave)
- Background: $bg(m) = p_0 (m - 2m_{kaon})^{p_1} \cdot e^{-p_2 m - p_3 m^2}$
- ϕ-yield: $\int_{m_\Phi - 3.5\Gamma_{PDG}}^{m_\Phi + 3.5\Gamma_{PDG}} Signal$



Recent Φ calculations in nuclear matter (BUU)

H.W. Barz et. al, Phys. Rev. C69, 024605 (2004)

$$U_\Phi = -0.025 m_\Phi \frac{n}{n_0}$$

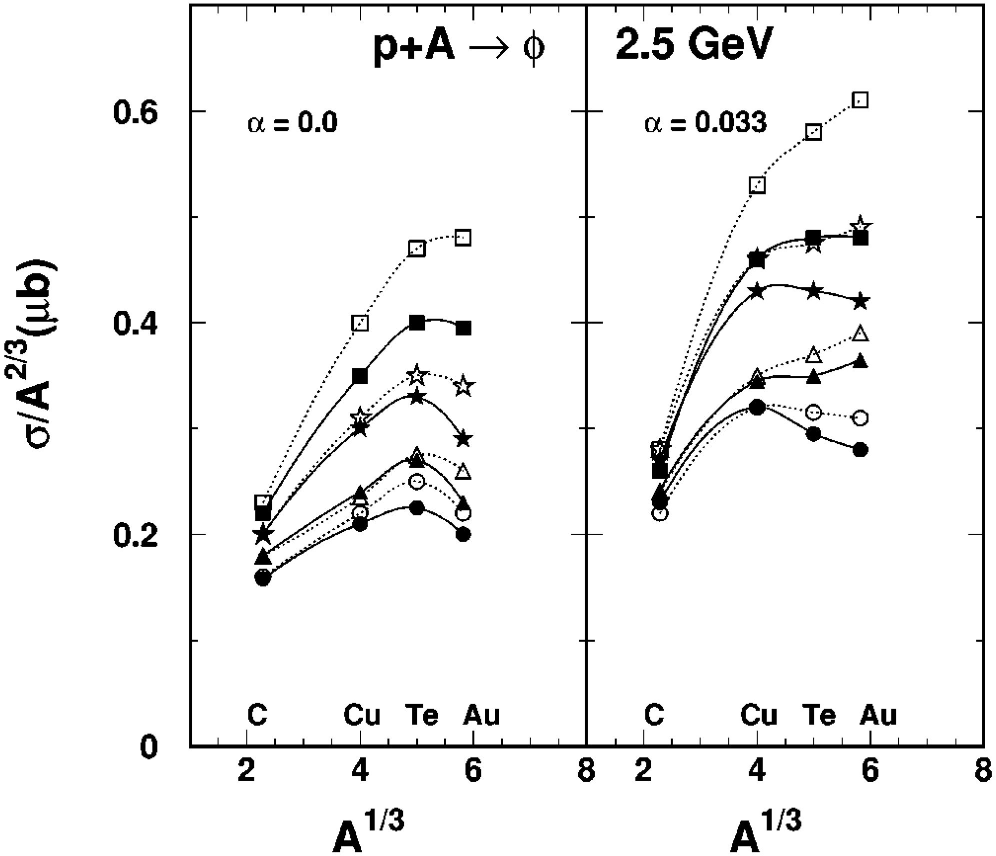
$$U_{K^+} = +0.04\, m_K \frac{n}{n_0}$$

$$U_{K^-} = -0.29\, m_K \frac{n}{n_0}$$

$$U_{K^-} = -[0.11 + 0.266 \exp(\frac{-p}{p_1})]\, m_{K^+} \frac{n}{n_0},\ p_1 = 0.4 GeV$$

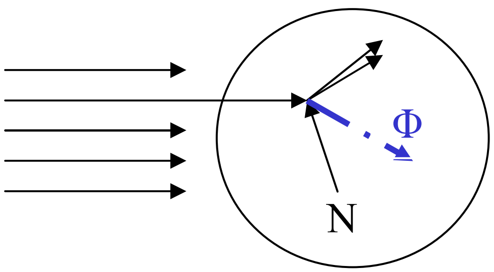
$$\Gamma = \Gamma_0 \frac{(m_\Phi + U_\Phi)^2}{m_\Phi^2} \frac{p_{med}^3}{p_0^3},\ \Gamma_0 = 4.4 MeV$$

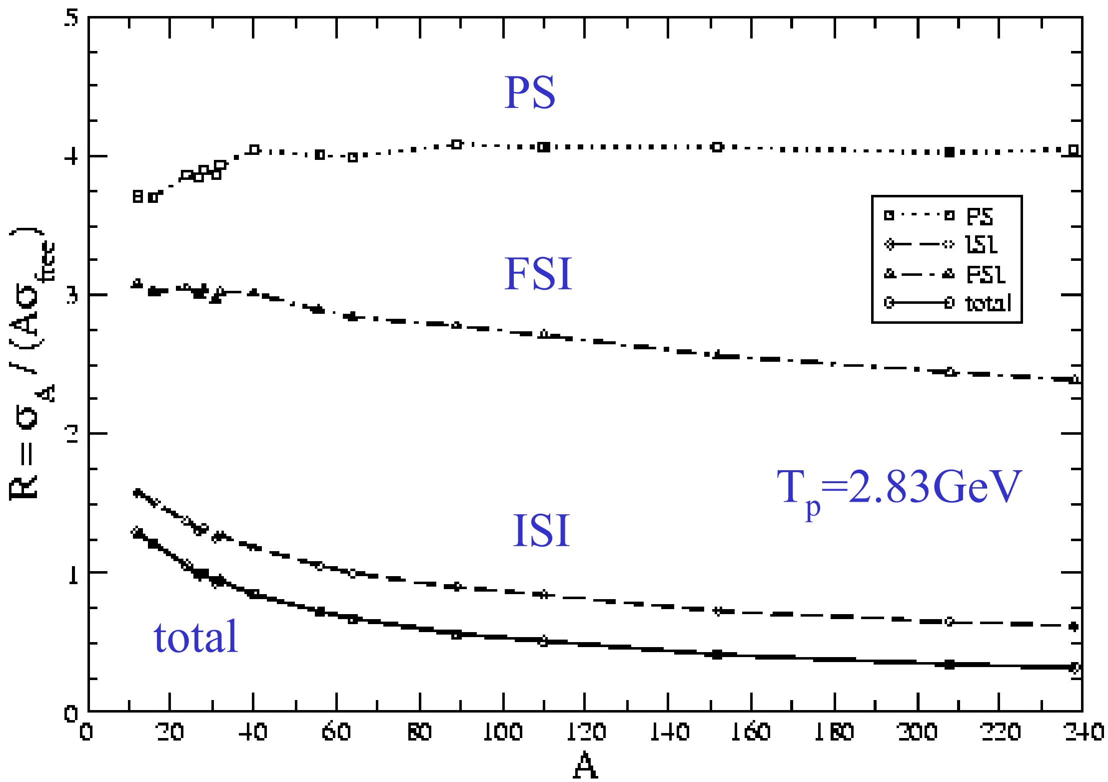
$$m_\phi^{med} = m_\phi^{vac}(1 - \alpha \frac{n}{n_0})$$



Recent Φ calculations in nuclear matter (Glauber)

V.K. Magas, L. Roca and E. Oset,
arXiv:nucl-th/0403067 (2004)





$\Gamma_\Phi(\rho \approx \rho_0) \sim 5 \cdot \Gamma_{\phi free} \approx 22$ MeV, meaningful A-dependence!

Recent Φ calculations in nuclear matter (Glauber)

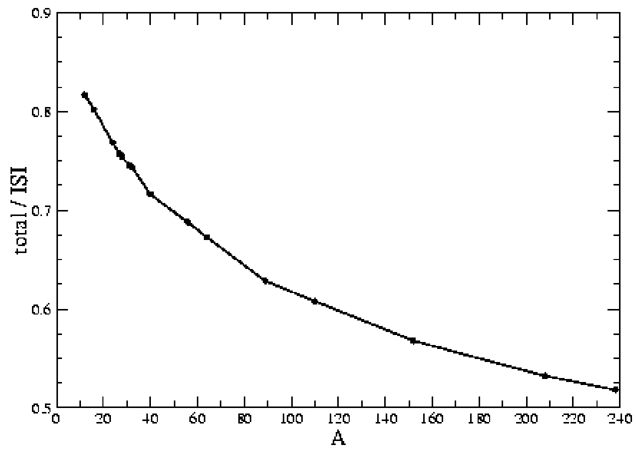


Figure 4: Ratio of the total cross section to ISI. Calculations are done for $T_p = 2.83$ GeV.

(ISI+FSI)/ISI

including two-step mechanism

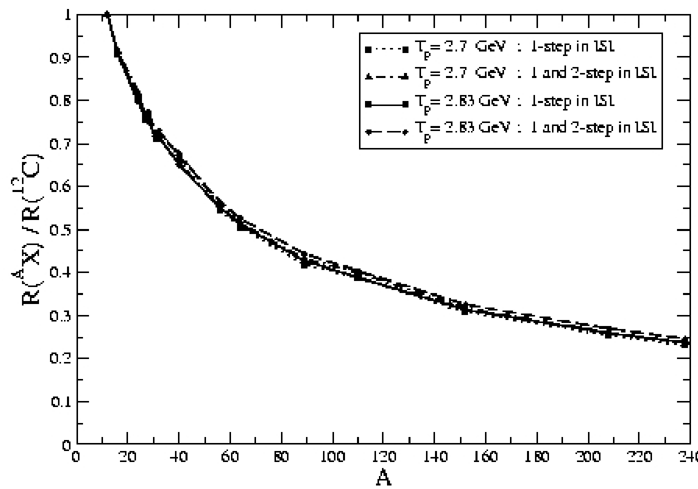
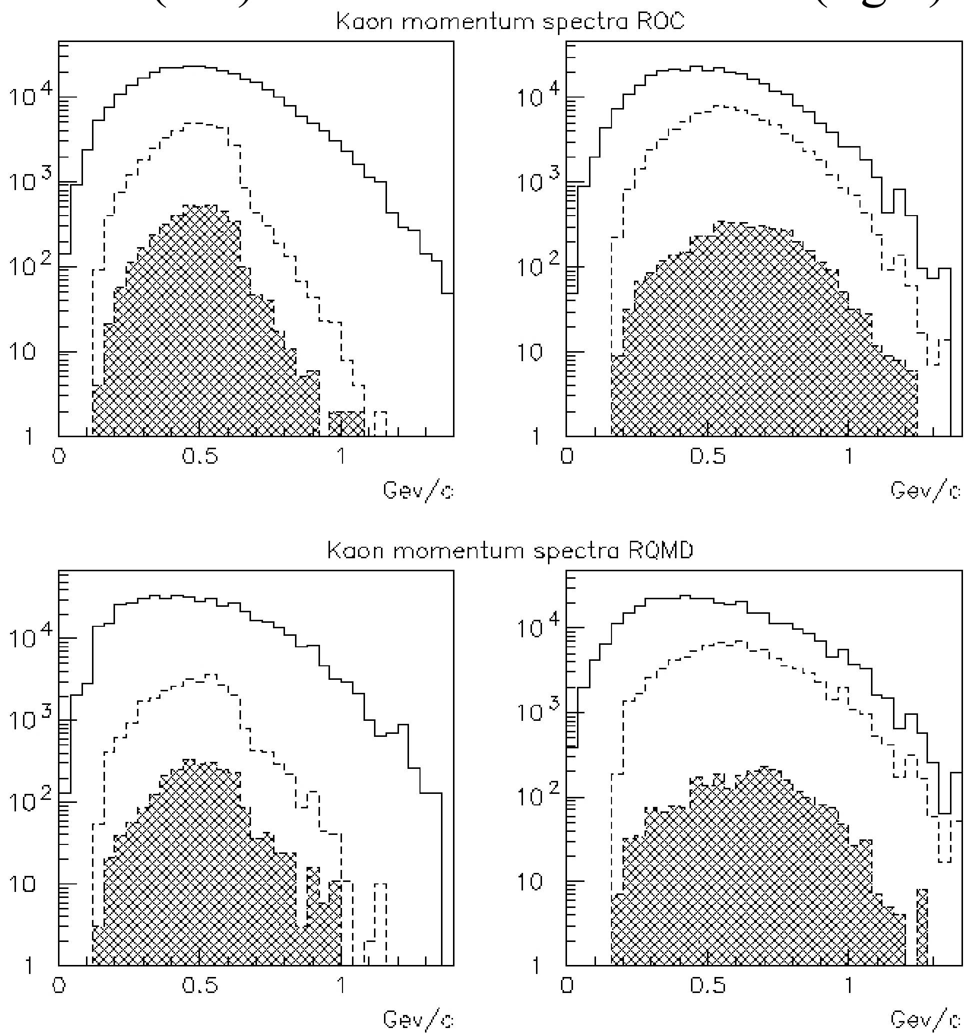


Figure 6: Ratio of the nuclear cross section normalized to ^{12}C for different proton kinetic energy and for the inclusion or not of the two-step mechanism in the evaluation of the ISI. The two-step process has been evaluated with $\Delta E = 400$ MeV.

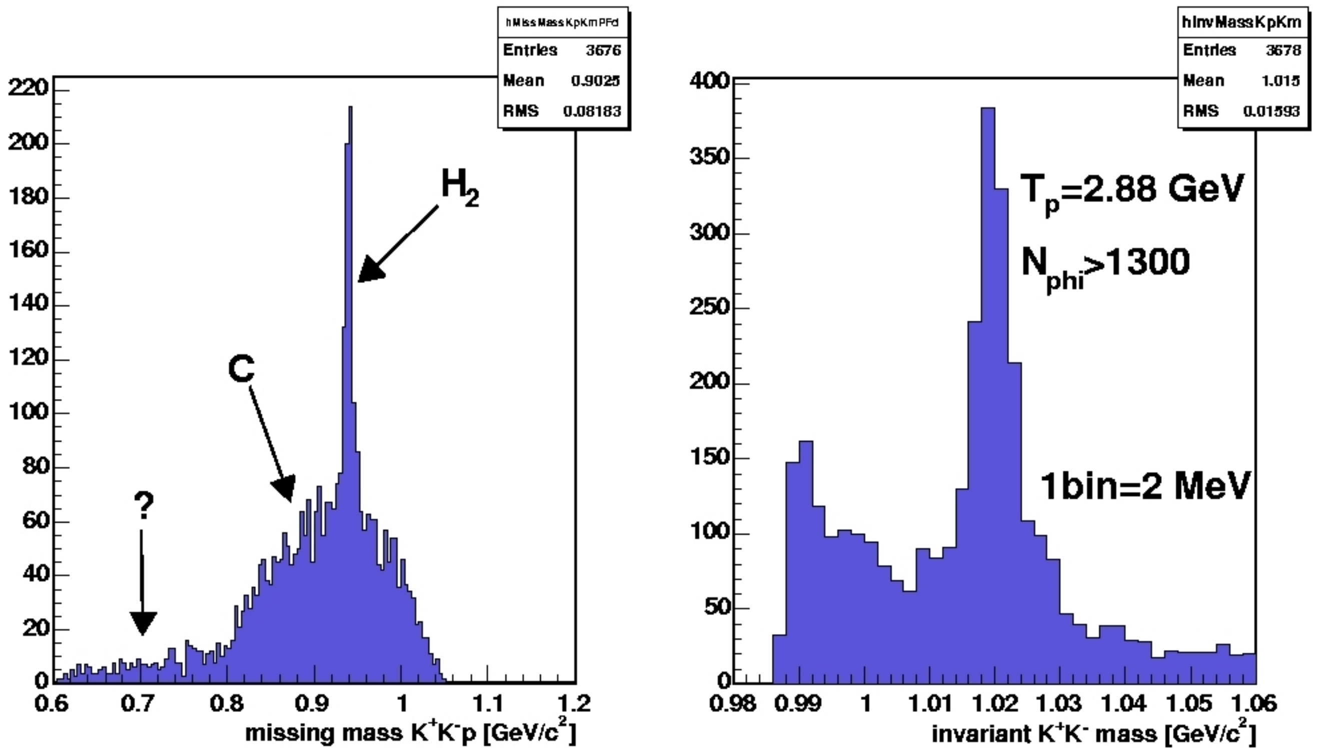
Rate estimations and kaon momenta at ANKE

K^+ (left) K^- (right)



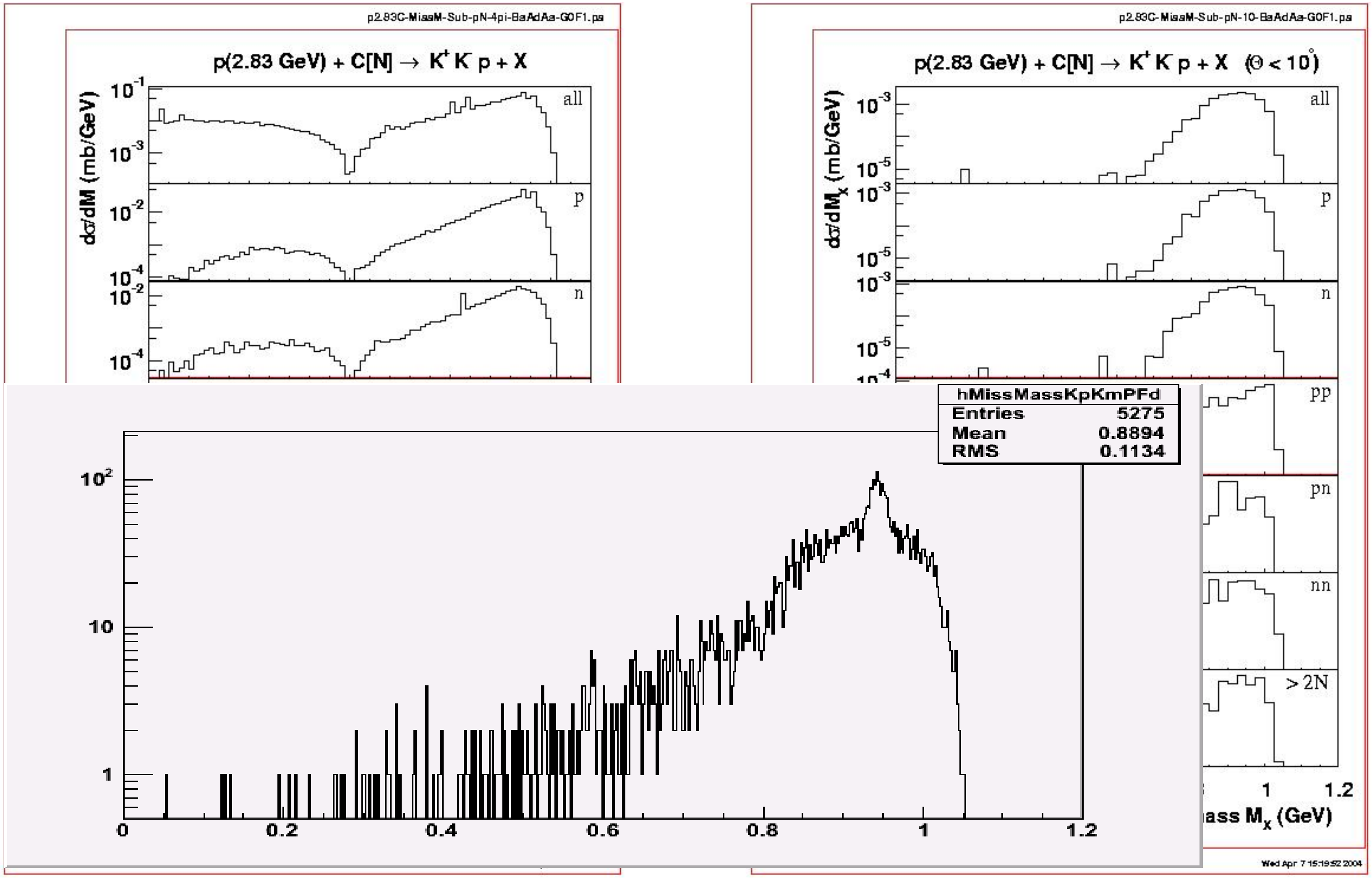
- ROC (G4, M.Hartmann, 2000)
  ROC,RQMD,BUU (G3, V.Dimitrov, 2003)
- Luminosity=$1 \cdot 10^{32}cm^{-2}s^{-1}$
  $pC \rightarrow K^+K^-X$, T_p=2.5GeV
- 200 K^+K^- pairs/hour on tape
  (with delayed VETO trigger)
- pC: 10.000 in 2 days
  pCu: 10.000 in 6 days (exp.)
  pAu: 10.000 in 8 days (exp.)

First Φ production in p+A (CH_2) at ANKE

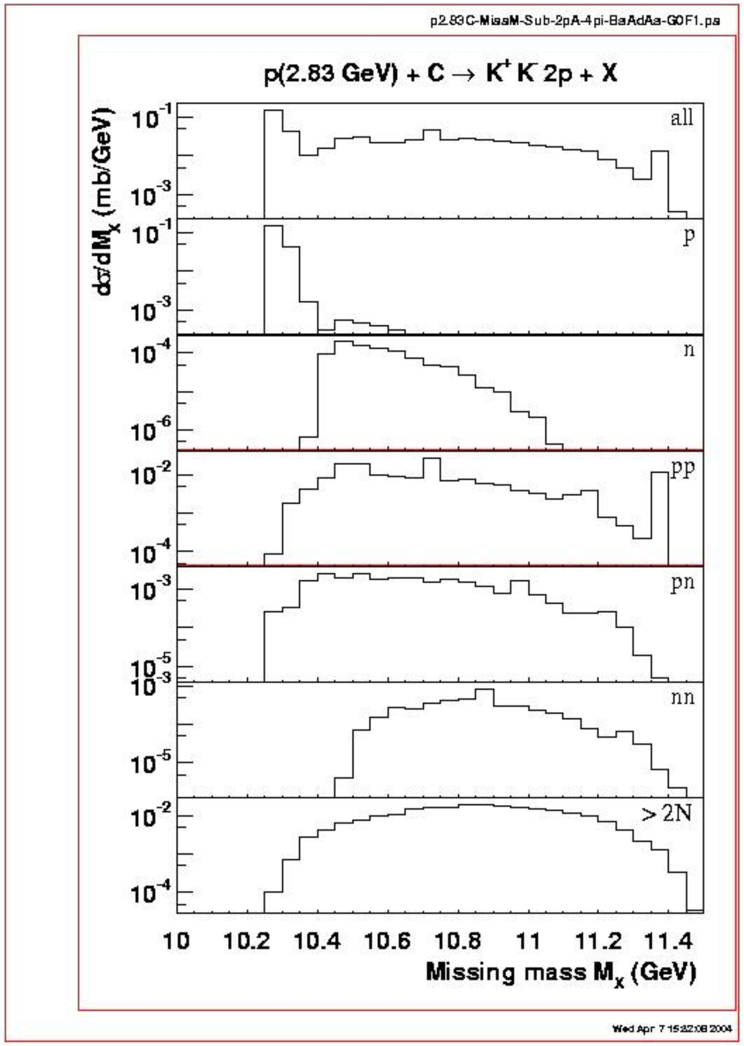


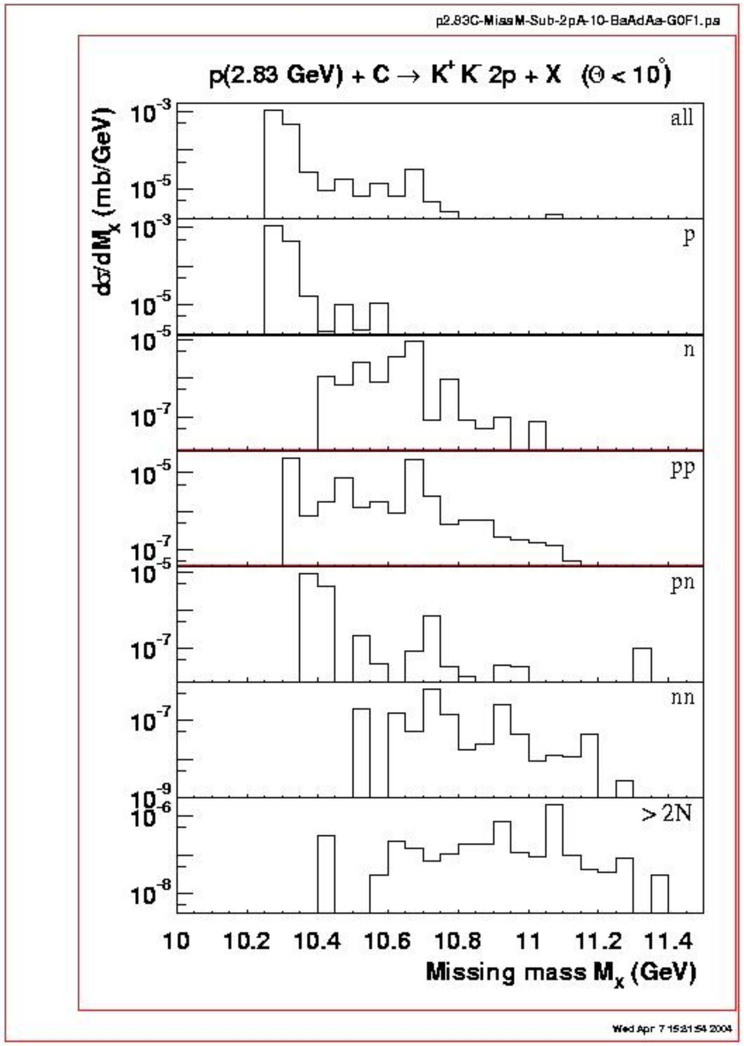
- 60% of the collected data
- No contradiction to the simulated rate estimation before (but hardly comparable!)

Production mechanism/ROC calculations



Production mechanism/ROC calculations





Summary / K^+K^- correlation at ANKE

- **Rate estimation and first experimental data shows that kaon-antikaon correlation can be studied at ANKE:**

  ⇨possible, with good statistic and reasonable resolution and with
  ⇨low background in the invariant K^+K^- mass distribution

  ⇨Cross-section (30%) and the A-dependence (ratios, 10%) which
  ⇨provide potentially information of the Φ in-medium properties,
  ⇨the Antikaon potential and
  ⇨maybe also about the production mechanism(??).

- **NEW proposal**

  ⇨First 2-3 weeks at highest energy (T_p=2.83 GeV) for the Φ in-medium investigation.
  ⇨Second 2-? weeks beam-time ('s) at lower energy around the free NN threshold or below (has to be discussed!).