Kaon Production in Heavy Ion Collisions – Which Observable is best suited to observe In-Medium Potentials

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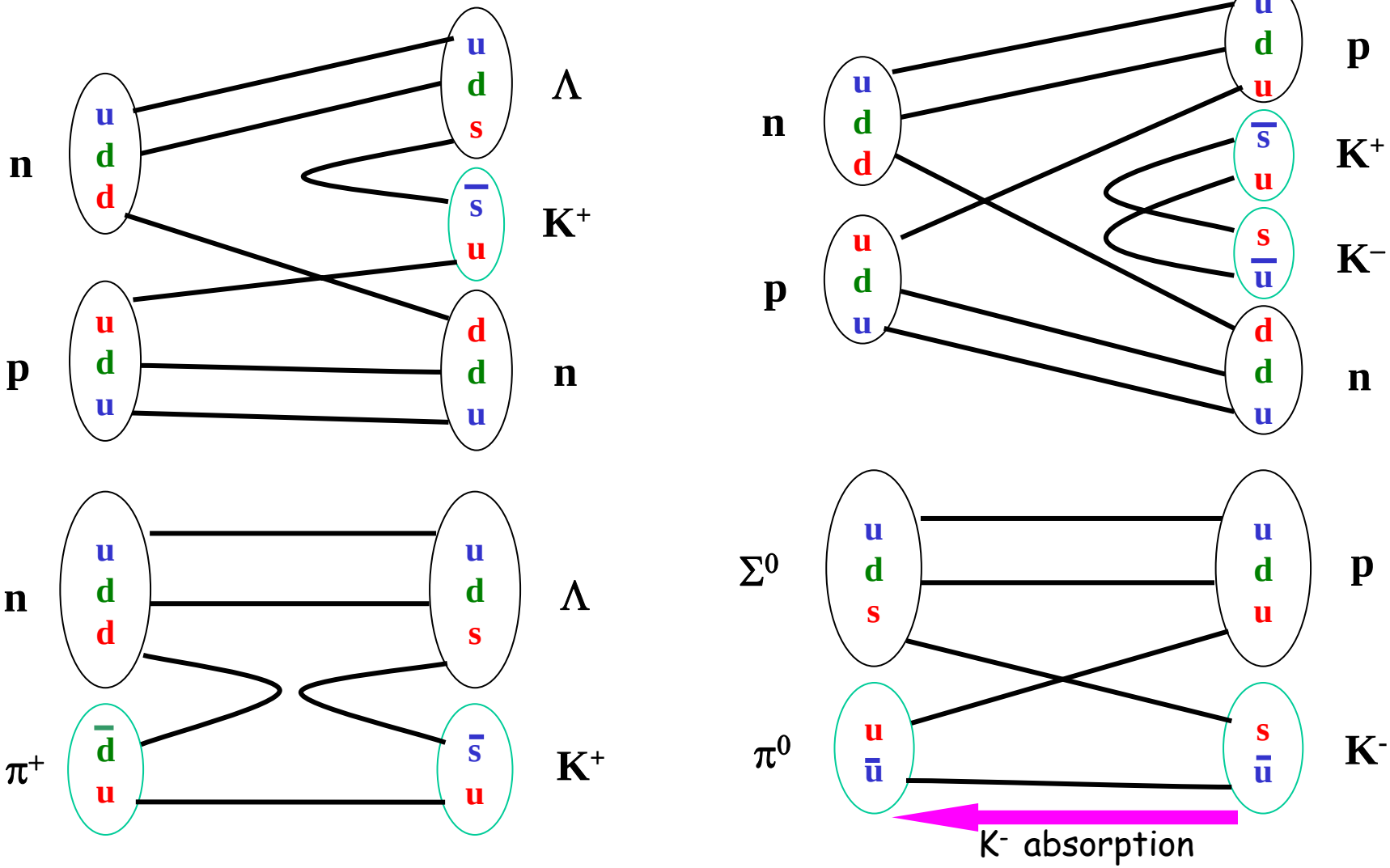
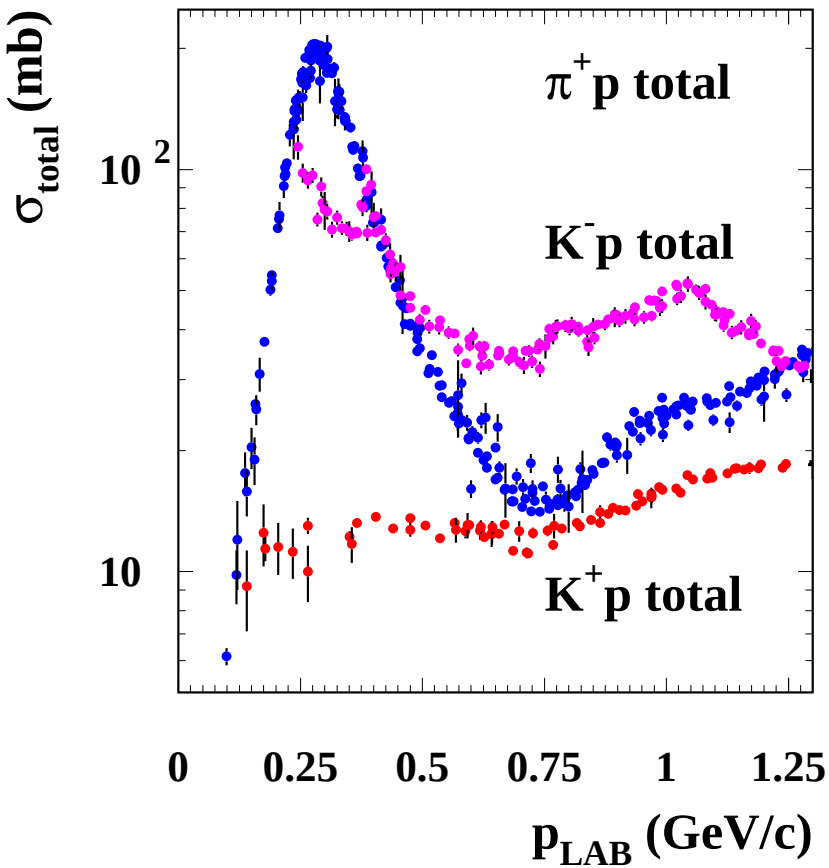
Giessen, November 2004

Creation of Strange Mesons



Mean free path of Kaons and Antikaons



mean free path at ρ_0:

$\lambda(\pi) = 0.3$ fm

$\lambda(K^+) = 5$ fm

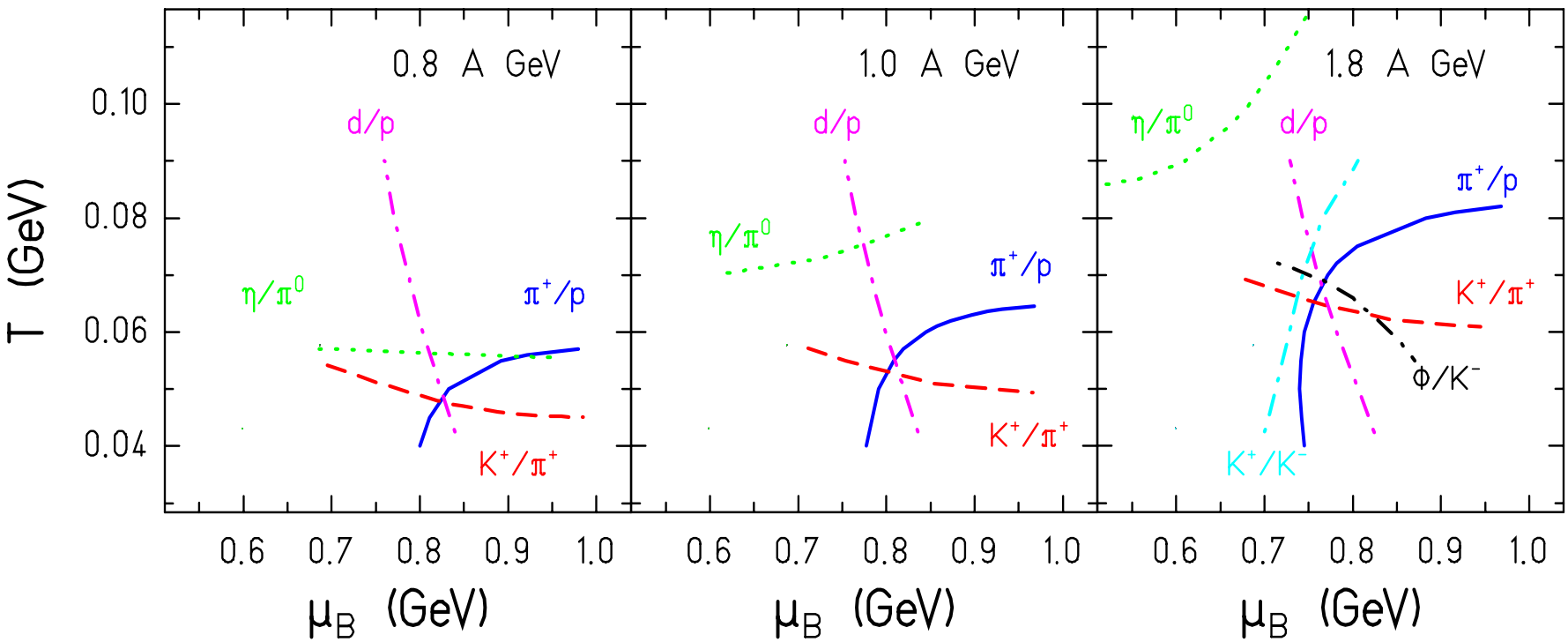
$\lambda(K^-) = 0.8$ fm

K^- absorption by strangeness exchange reactions:

$K^- p \rightarrow Y \pi^o$

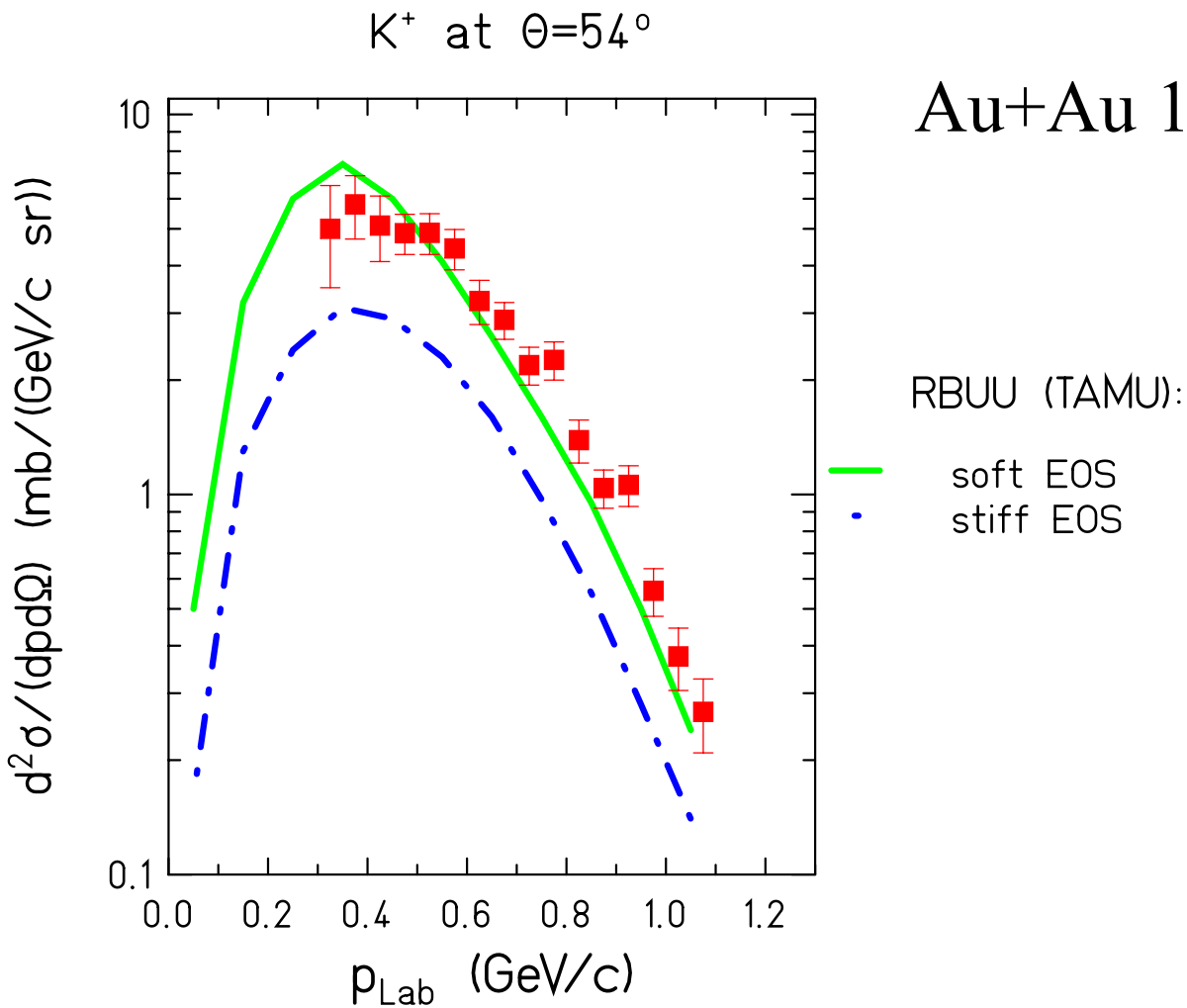
K^+:
nearly undisturbed messengers

Statistical Model for SIS

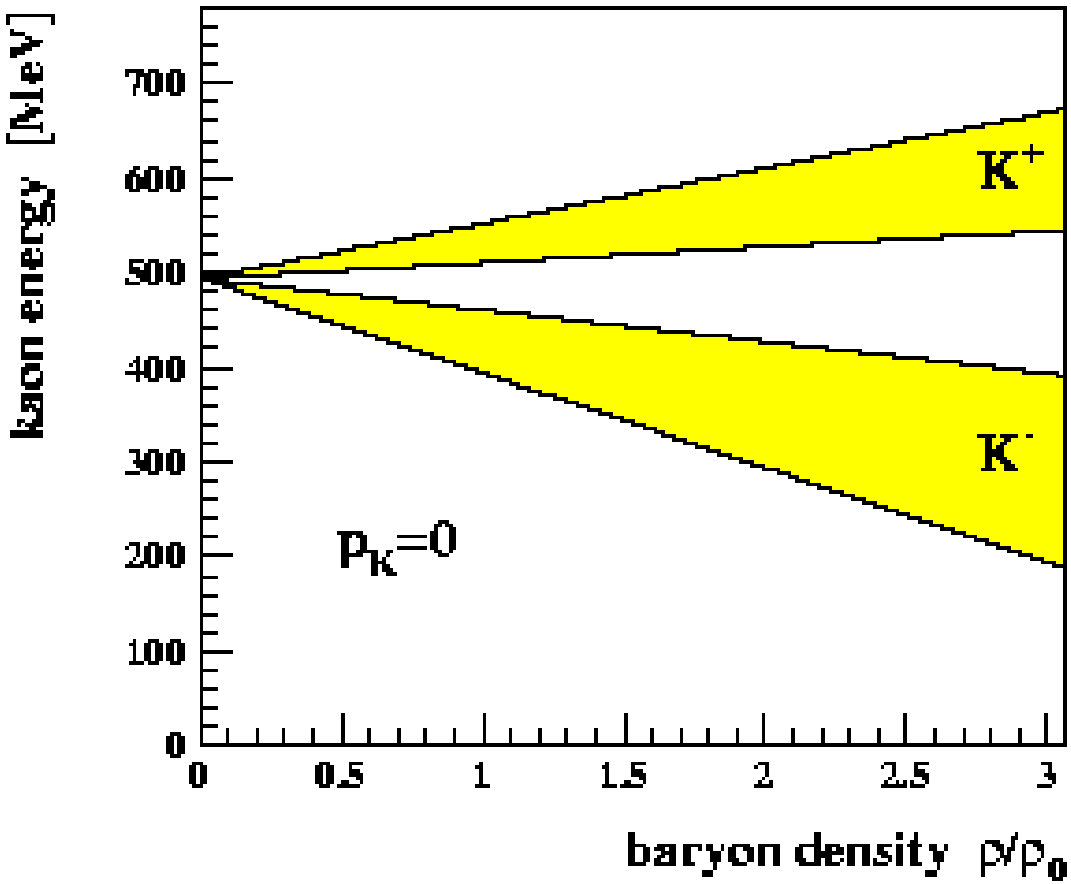


J. Cleymans, H. O., K. Redlich, PRC 59 (1999)

Early KaoS Results



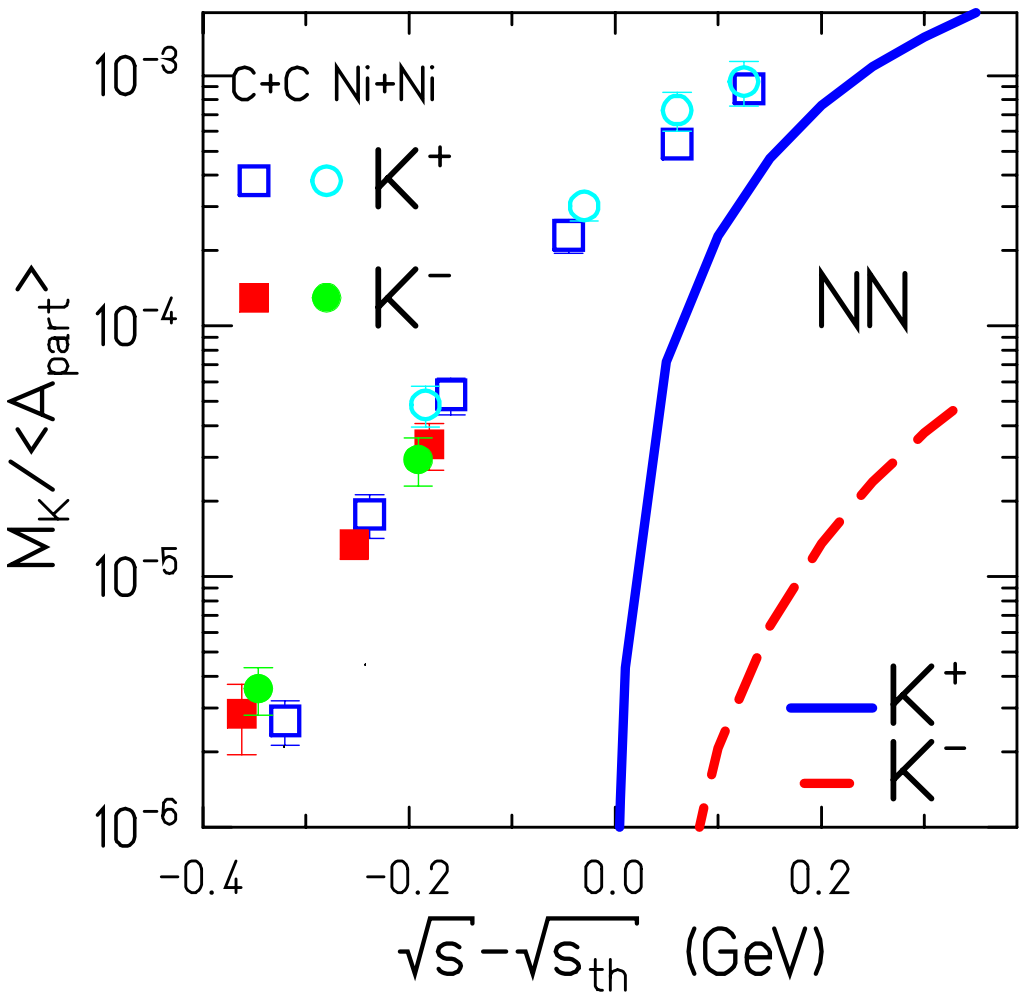
KN Potentials



repulsive K^+N

attractive K^-N

K^+ and K^- Production at SIS Energies



KaoS Collaboration

F. Laue, C. Sturm, et al.

PRL 82 (1999), updated

NN: parametrization

A. Sibirtsev,

PLB 359 (1995)

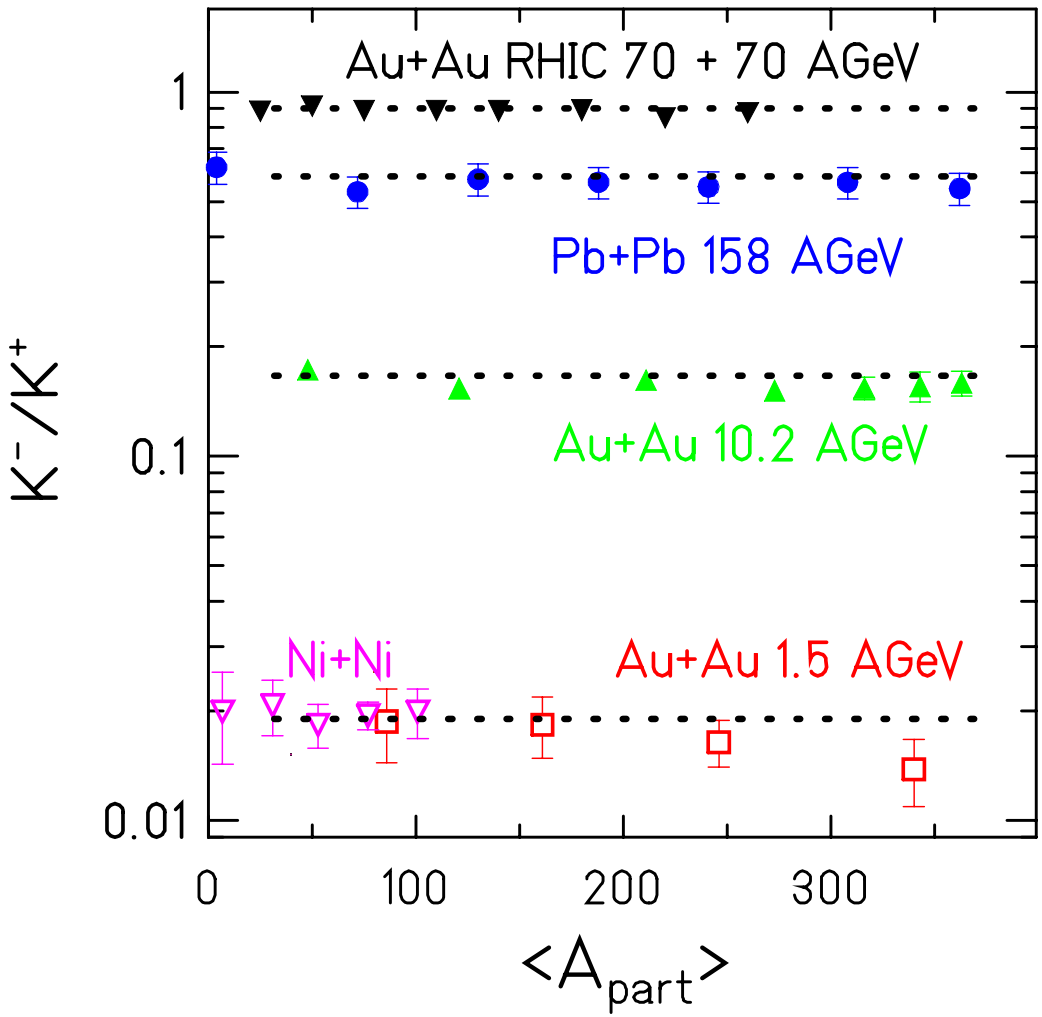
J. Cleymans,H. O.,
K. Redlich,

PLB 485 (2000)

$$n_{K+} \sim \exp\left(-\frac{E_{K+}}{T}\right)\left[g_{\Lambda}V\int\frac{d^3p}{(2\pi)^3}\exp\left(-\frac{(E_{\Lambda}-\mu_B)}{T}\right)\right]$$

$$n_{K-} \sim \exp\left(-\frac{E_{K-}}{T}\right)\left[g_{K+}V\int\frac{d^3p}{(2\pi)^3}\exp\left(-\frac{(E_{K+})}{T}\right)\right]$$

K^-/K^+ Ratio from SIS up to RHIC



K^- and K^+ are linked

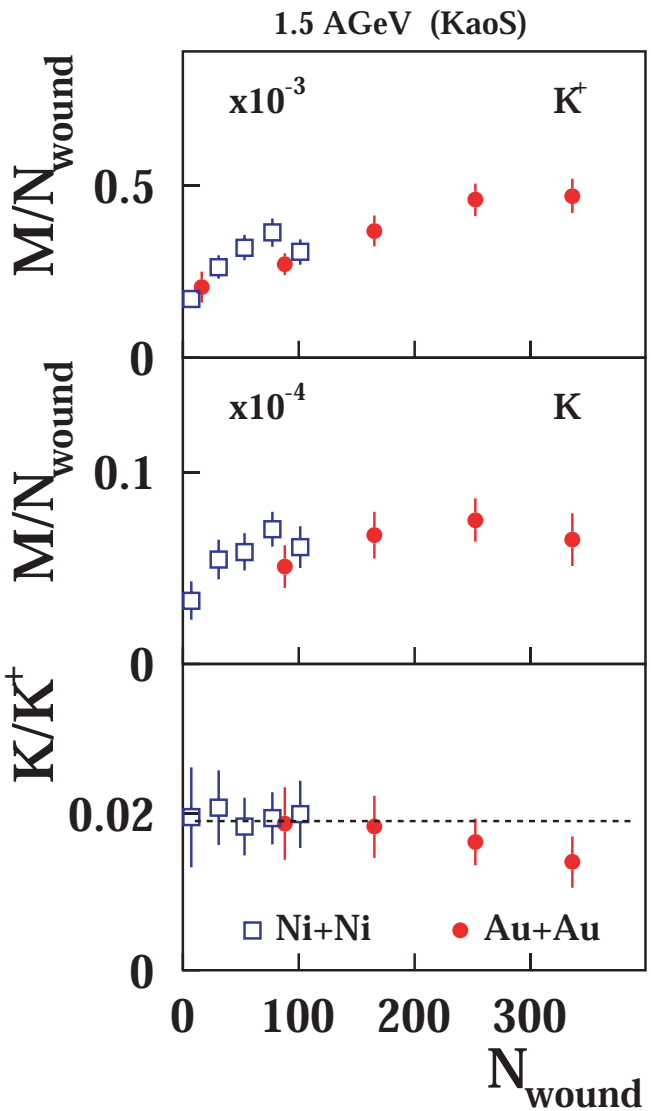
Au+Au 1.5 AGeV

Ni+Ni 1.5 AGeV

A. Förster, F. Uhlig et al.,

PRL 91 (2003) 152301

dashed line: stat. model



Strangeness Exchange

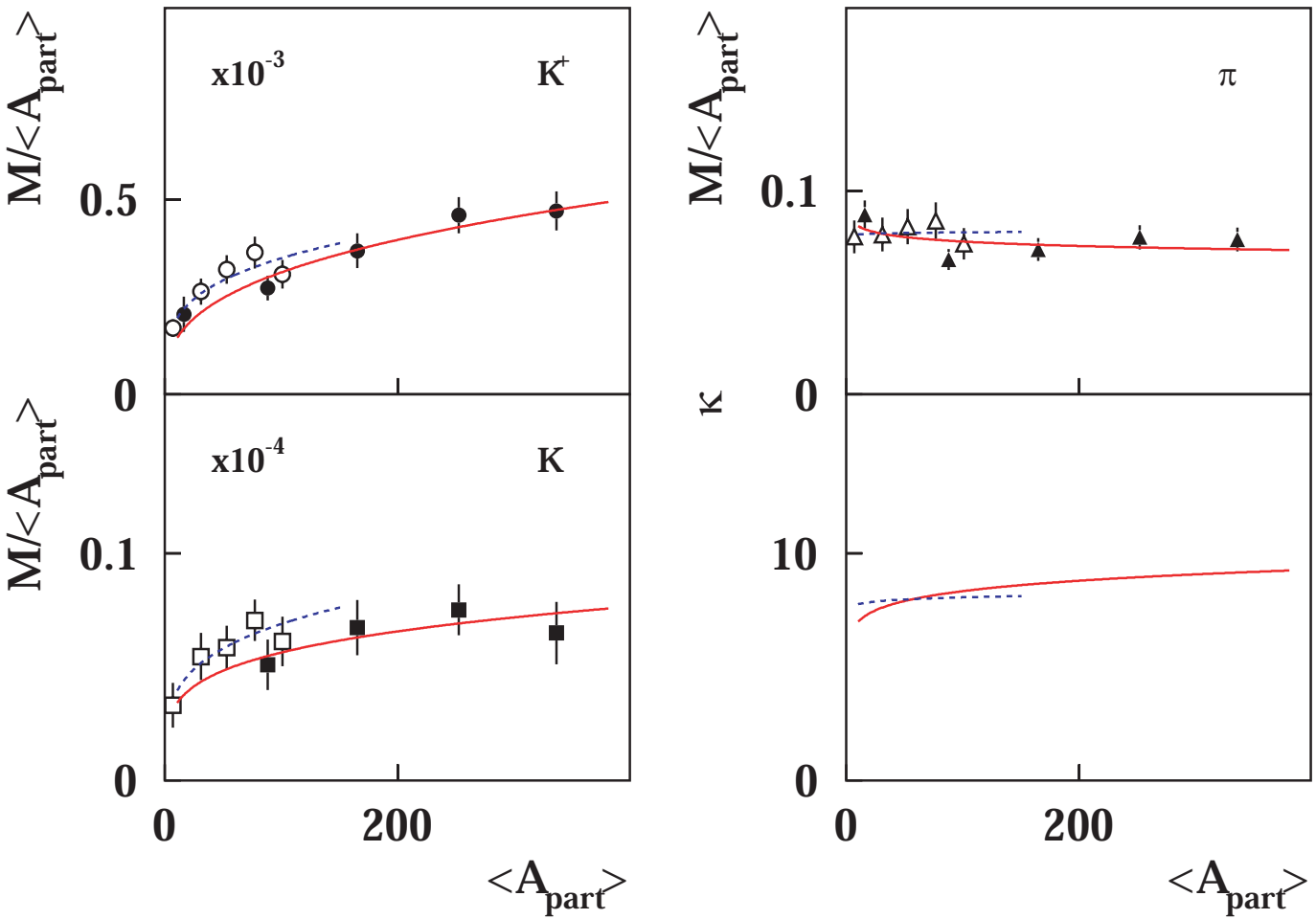
If equilibrium, then K^- yield just proportional to the density of K^+ and the density of pions!

K^+ proportional to Λ! (associate production!)

Hence: $K^-/K^+ \sim$ pion density!

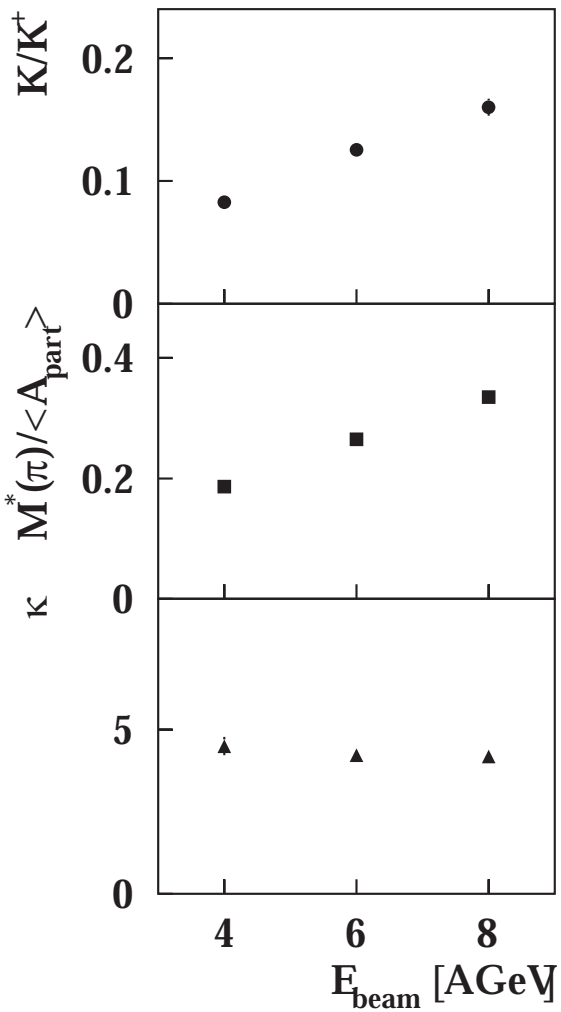
Test of the Law of Mass Action

J. Cleymans et al., PLB

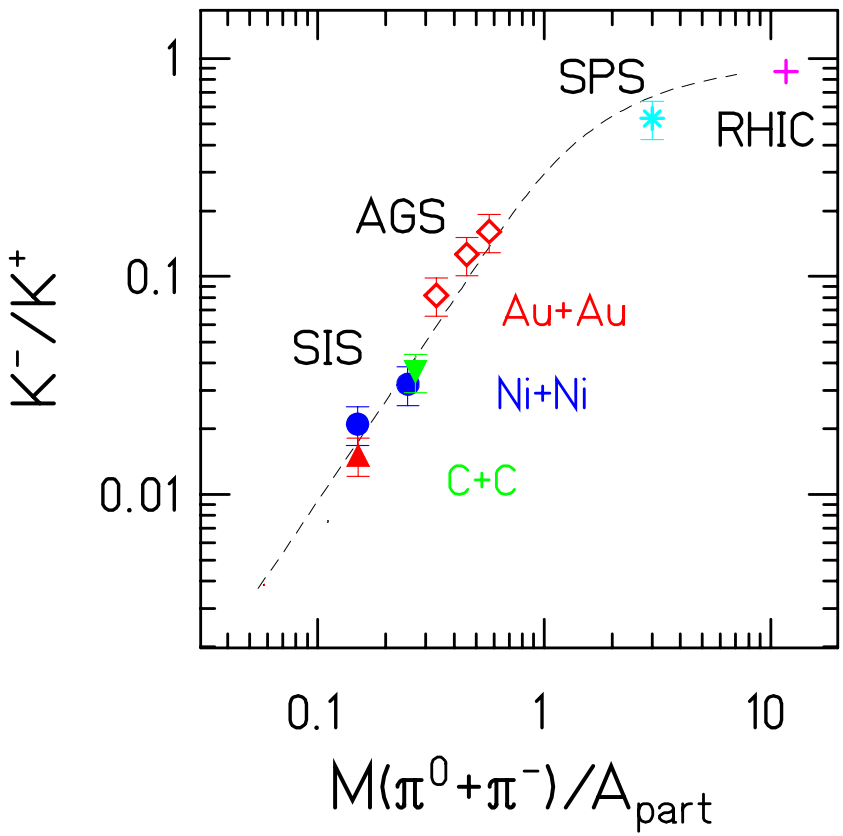


$\kappa = ([\pi]\,[Y])/([K^-]\,[N])$

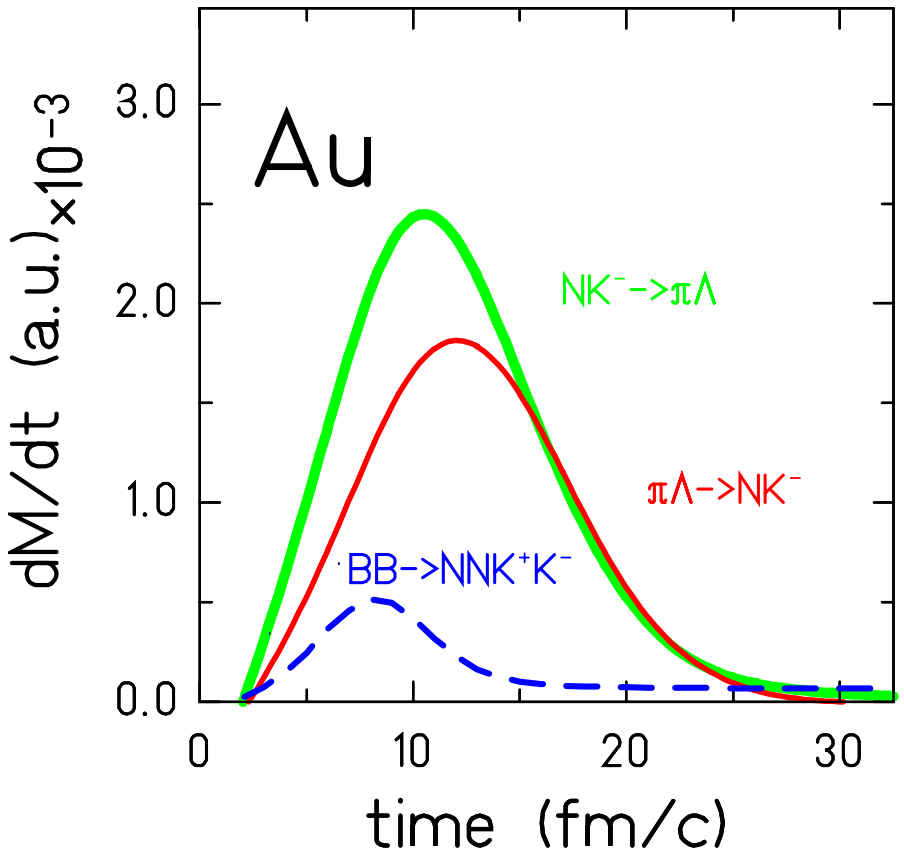
Strangeness Exchange at AGS?

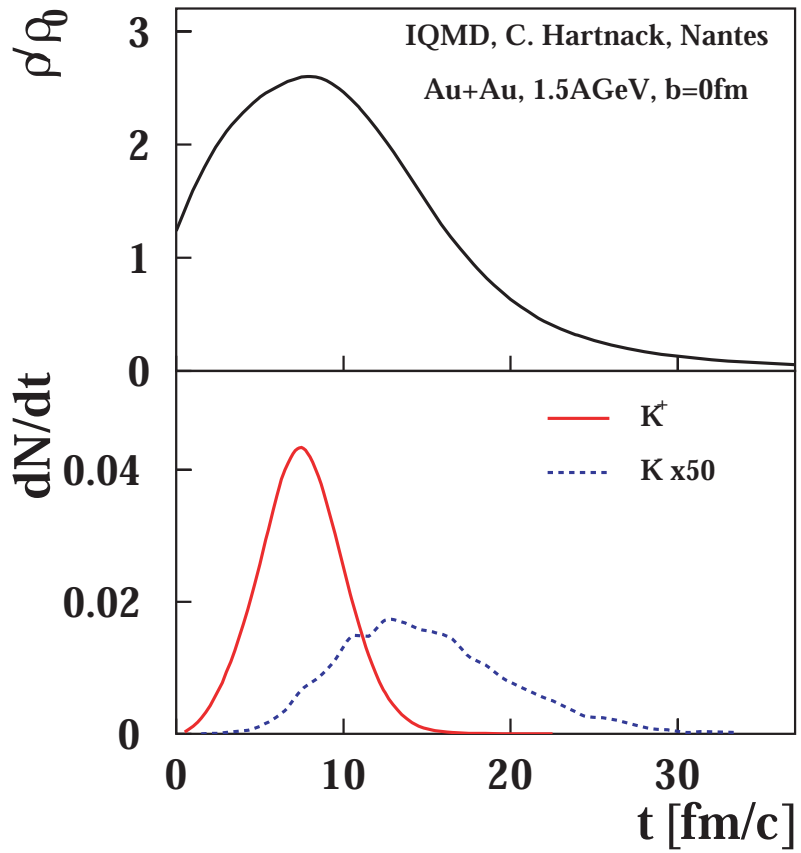


AGS:
L. Ahle et al., PLB 490
J. Klay et al., PRC68



Time Evolution of K^+ and K^- Production



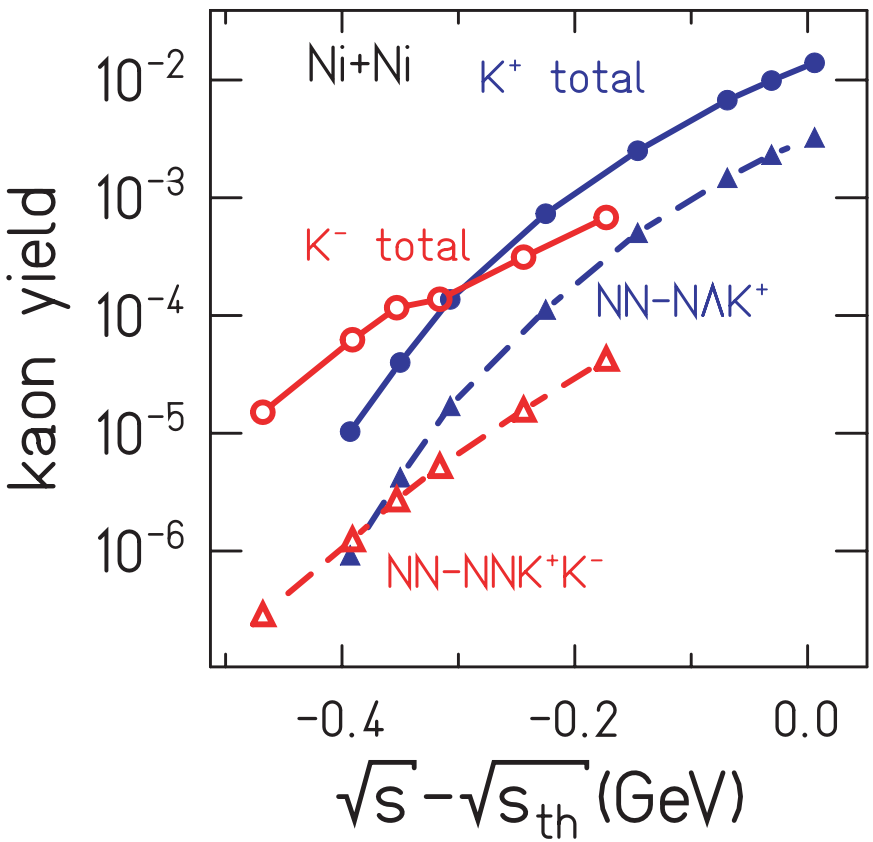


Strangeness exchange dominates!

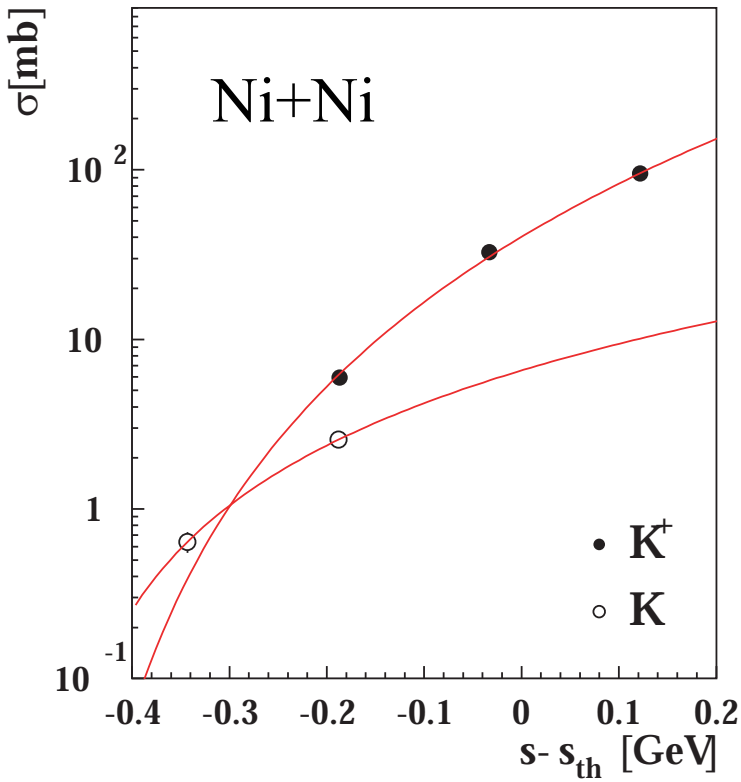
Only 20% of all K^- survive!

C.Hartnack, H.O., J. Aichelin, PRL 90(2003)

IQMD Nantes

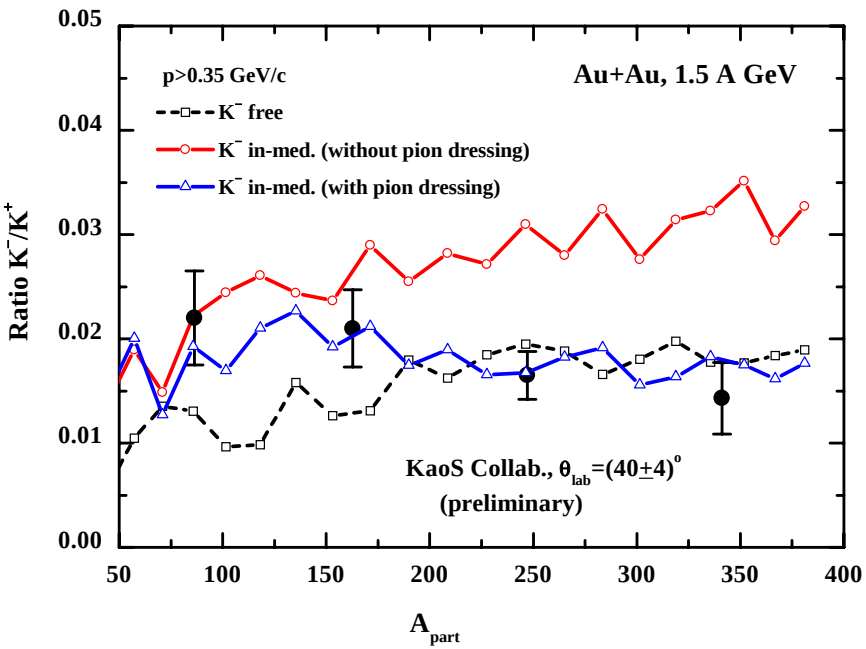


F. Uhlig, Ph.D., TU DA

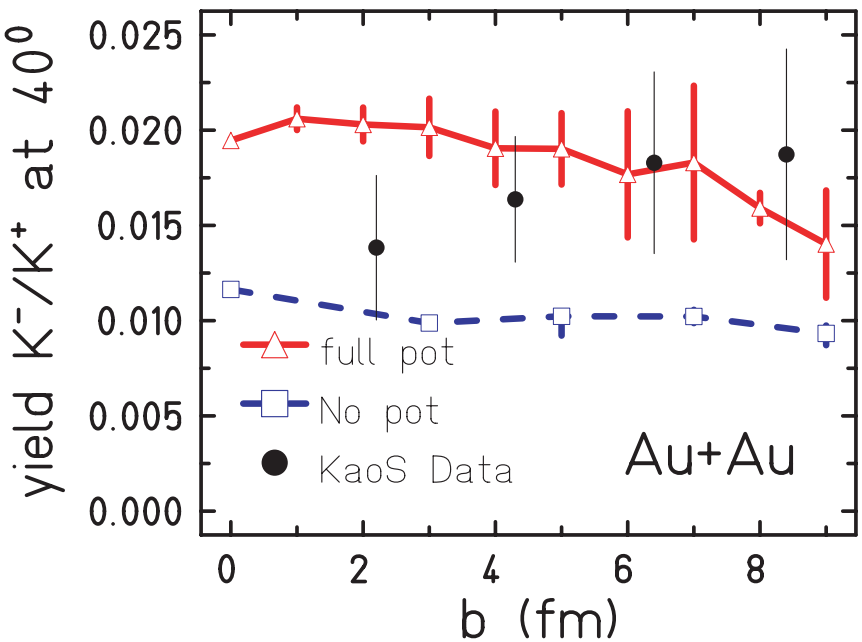


Centrality dependence of K^-/K^+ ratio

W. Cassing et al., NPA727



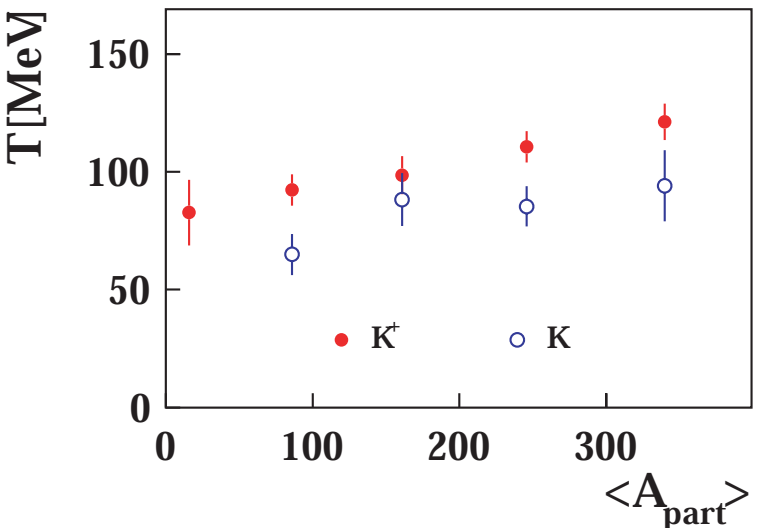
C. Hartnack et al., PRL 93



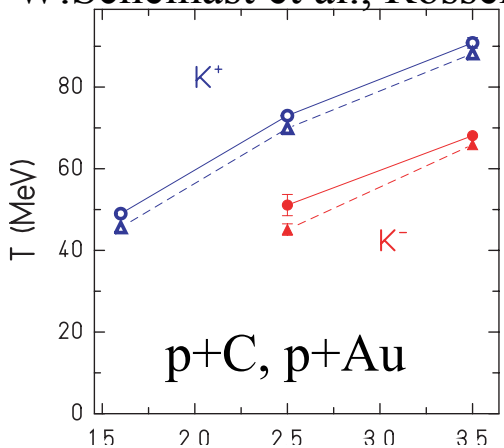
Inverse slope parameters

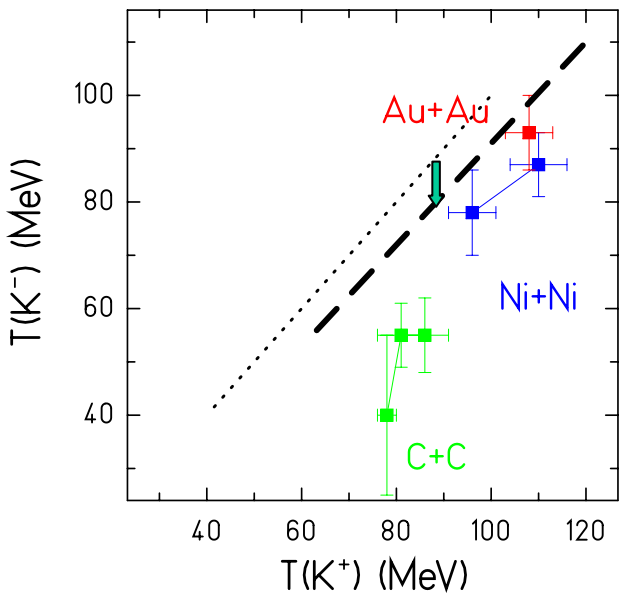
Au+Au 1.5 AGeV

A. Förster, et al., PRL 91



W.Scheinast et al., Rossendorf





thermal bath of π and Λ

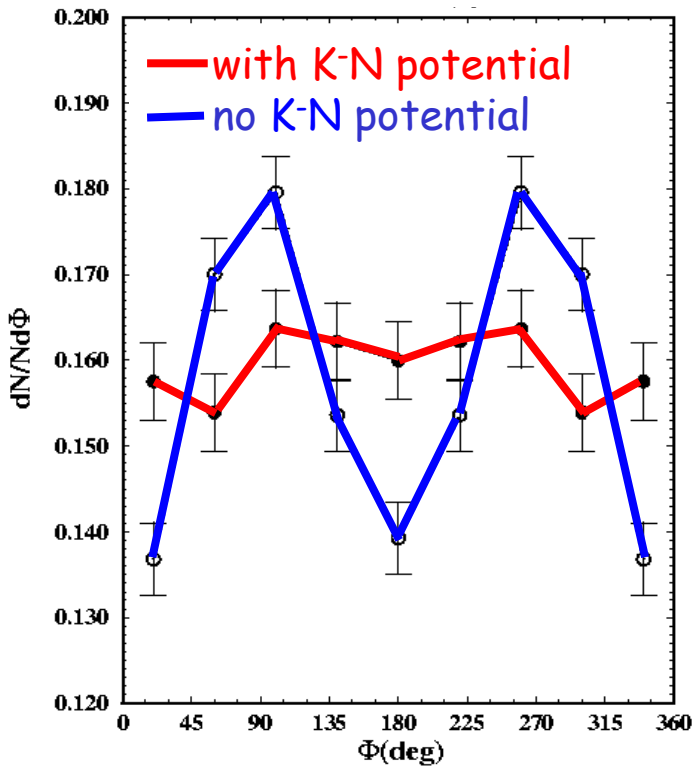
creating K^- which is emitted

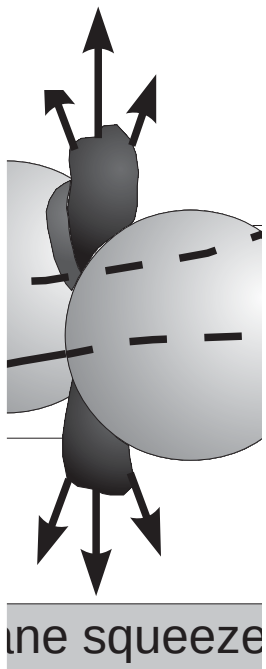
Out-of-plane Emission

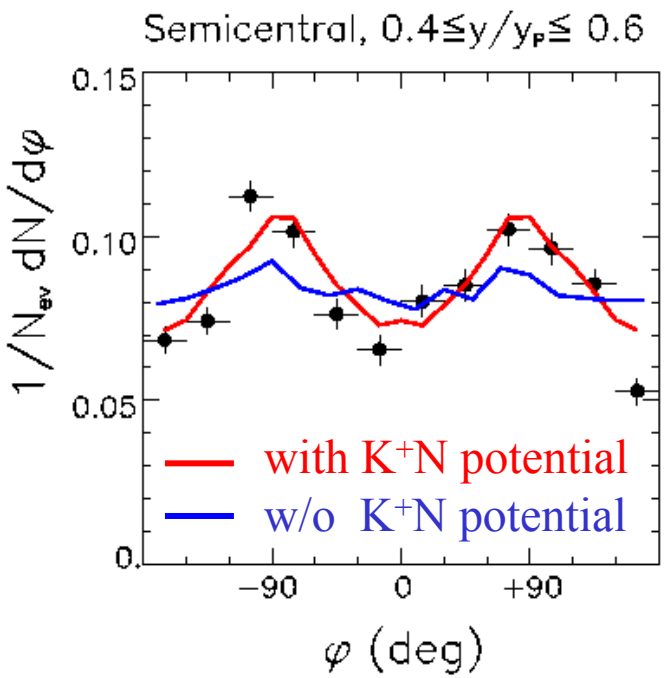
Au+Au, 1.8AGeV, b=8fm
Z.S.Wang et al. EPJ A5 (1999)

Data:Y.Shin PRL81

RBUU: G.Q.Liu PLB 381



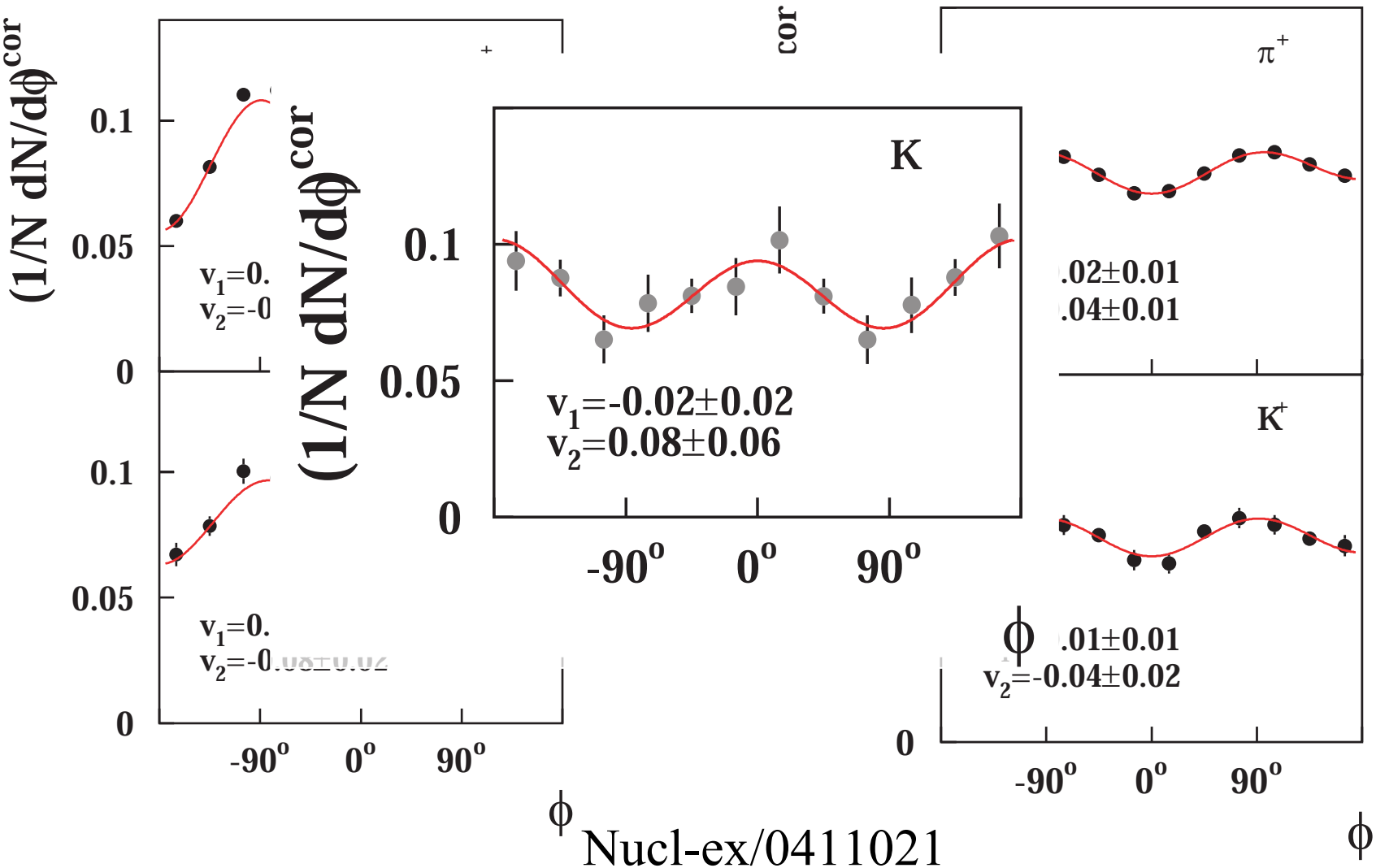




Azimuthal Distributions

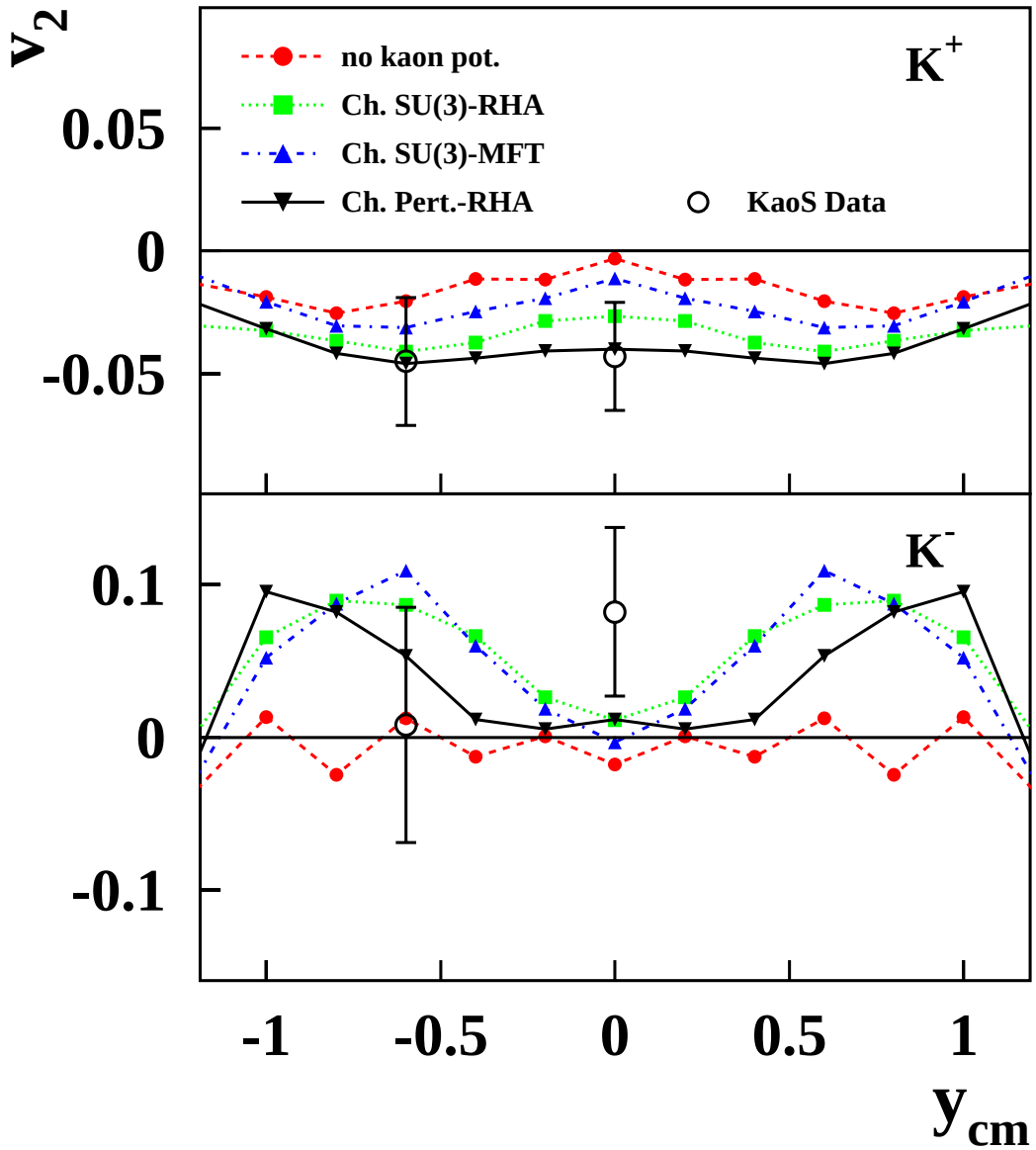
Au+Au 1.5 AGeV (A.Förster)

Ni+Ni 1.93 AGeV (F .Uhlig)

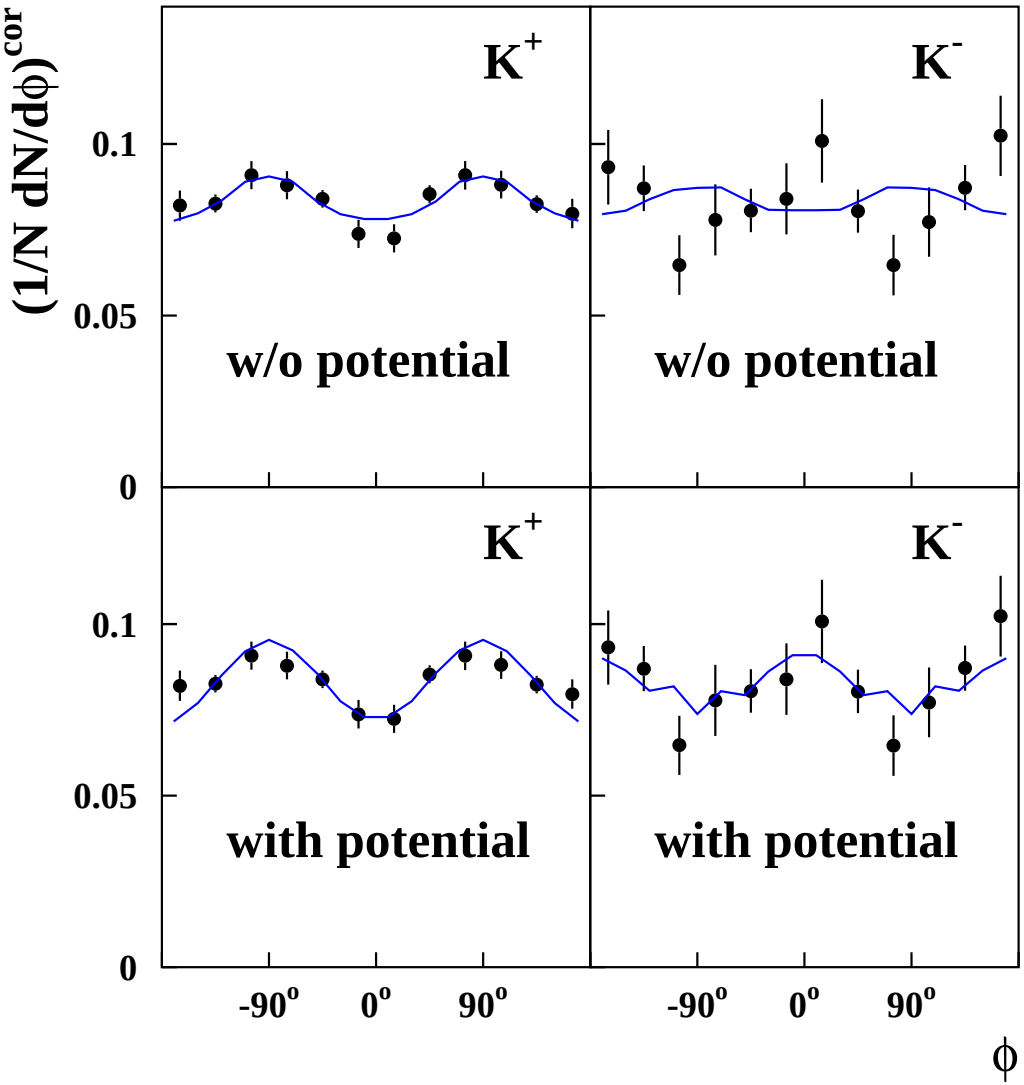


Nucl-ex/0411021

A. Mishra, E. L. Bratkowskaya et al., PRC 70 (2004)



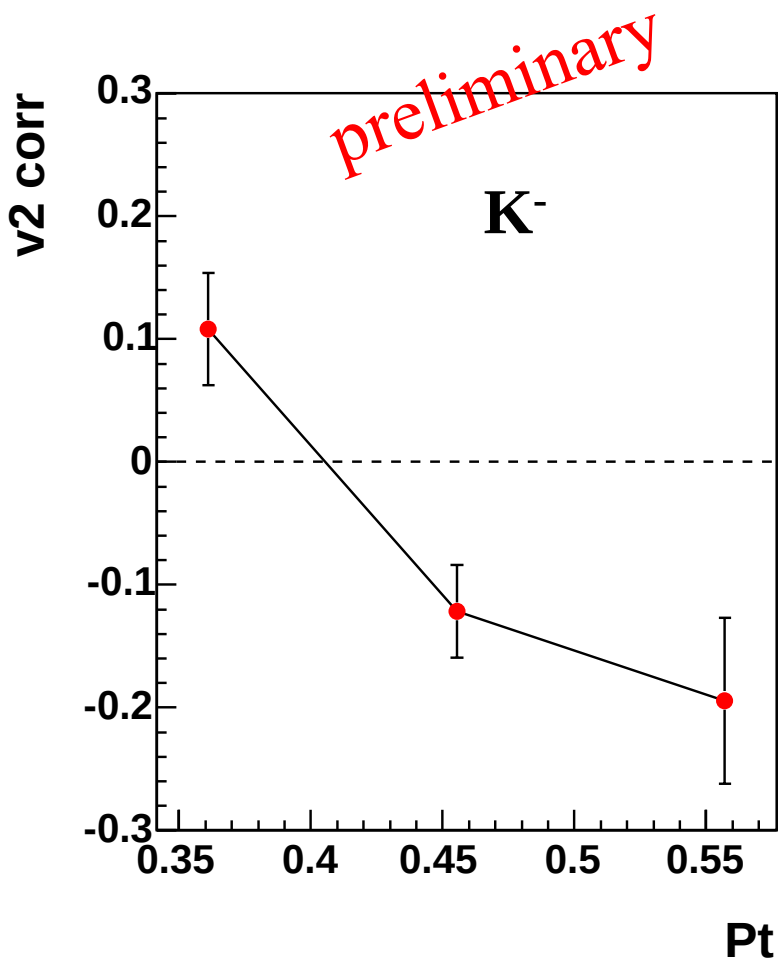
IQMD Calculations (C. Hartnack et al.)



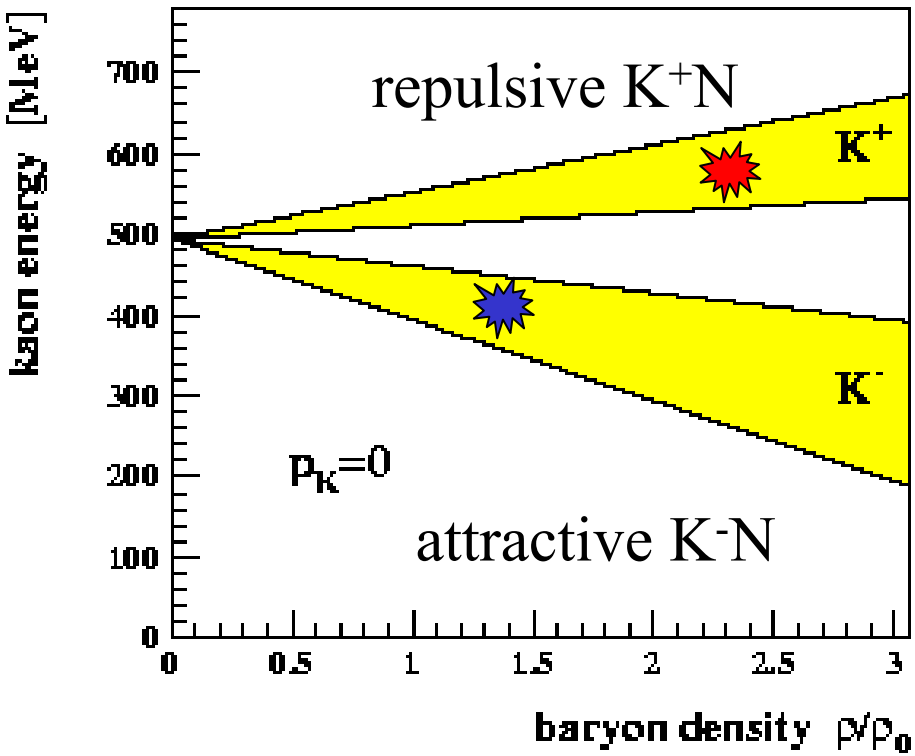
Latest from KaoS: K^- as a function of p_t

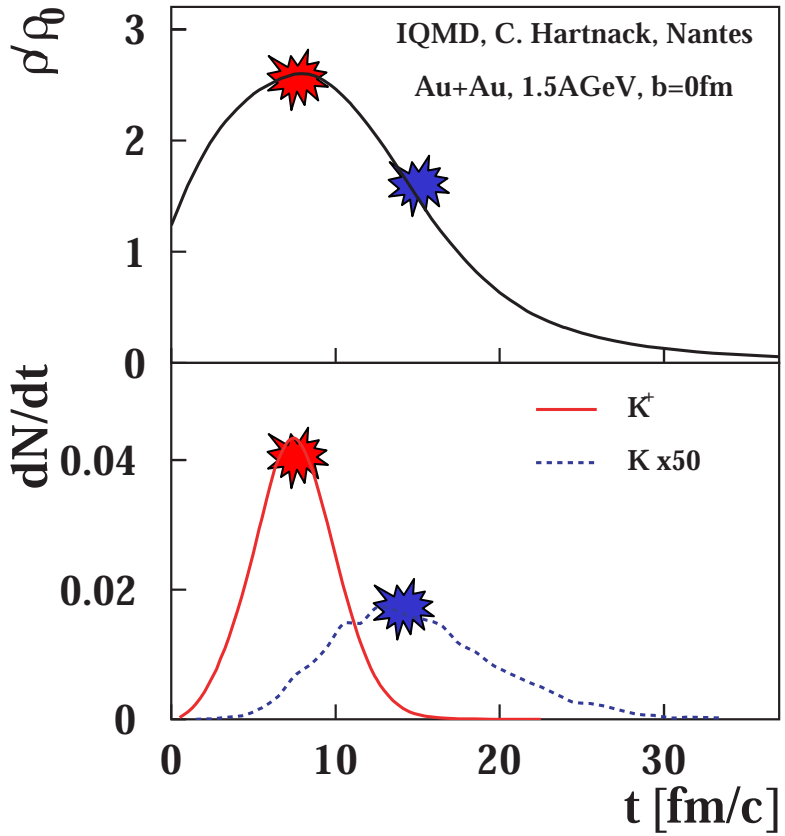
Au+Au 1.5 AGeV

M. Ploskon, GSI



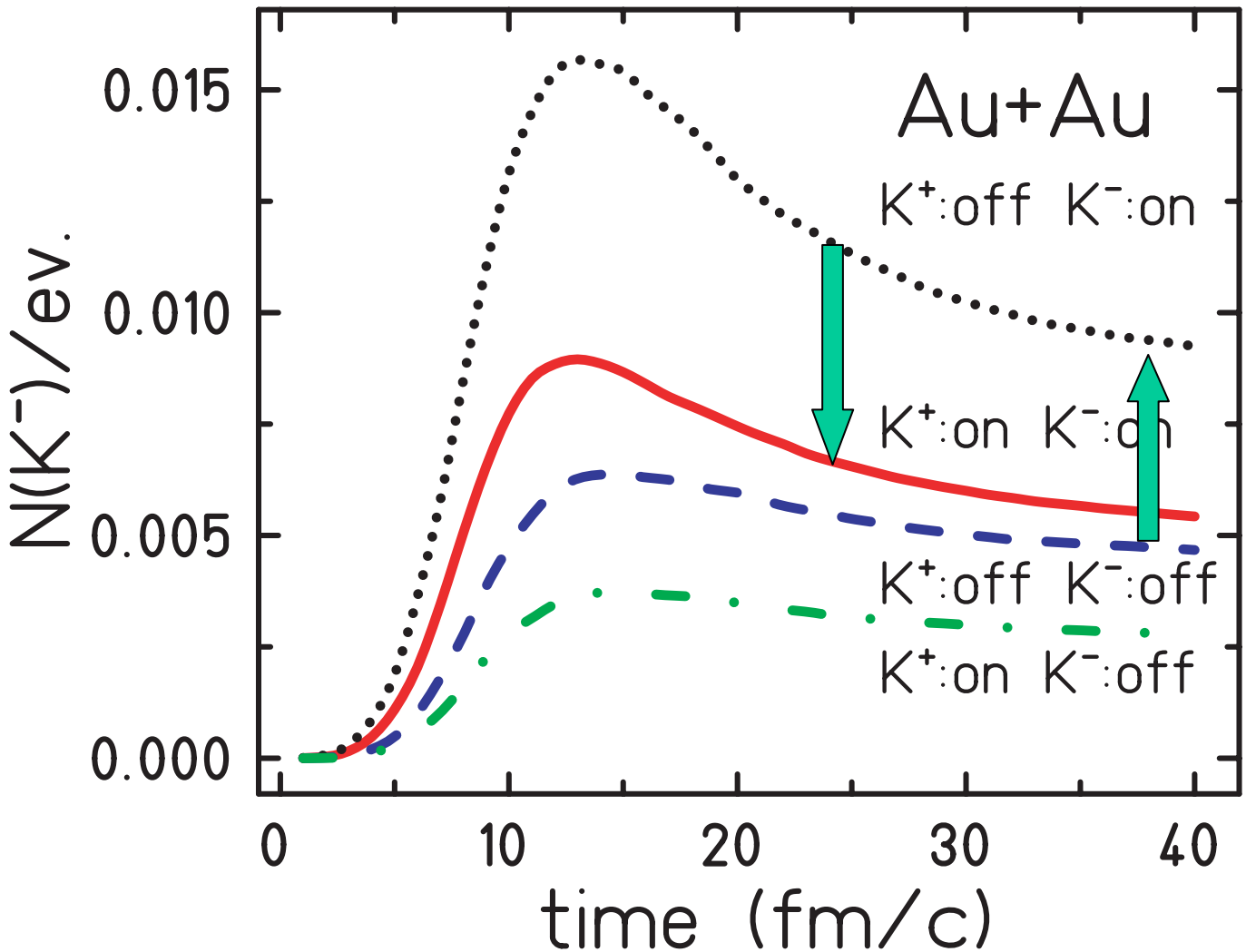
Two Effects!


repulsive K+N
K+
K-
pK=0
attractive K-N
kaon energy [MeV]
baryon density ρ/ρ0
0
100
200
300
400
500
600
700
0
0.5
1
1.5
2
2.5
3

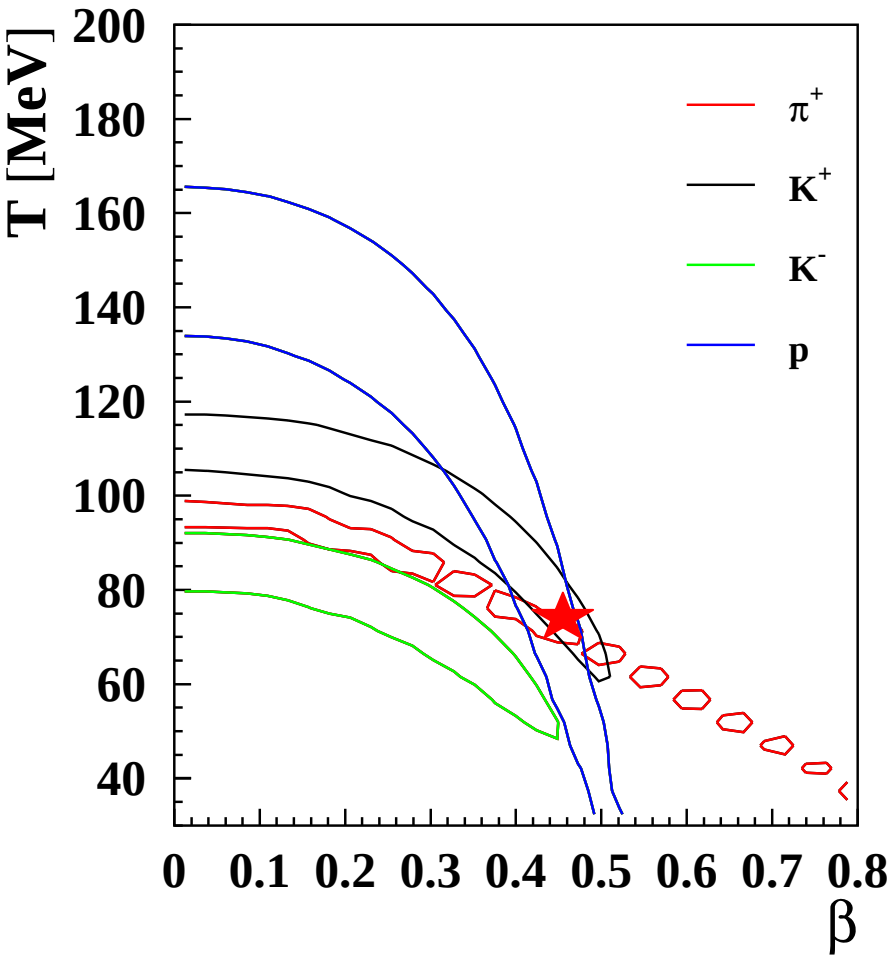

IQMD, C. Hartnack, Nantes
Au+Au, 1.5AGeV, b=0fm
ρ/ρ0
dN/dt
K+
K x50
0
1
2
3
0
0.02
0.04
0
10
20
30
t [fm/c]

IQMD

C. Hartnack et al., PRL 93 (2004)



Do the slopes make a consistent picture?



Ni+Ni 1.93 AGeV

F. Uhlig, TU DA Diss.

Protons, K^+ and pions cross

K^- differ!

T(stat. Model) = 74 MeV

PRC 59 (1999)

Dynamics of K^+ and K^-

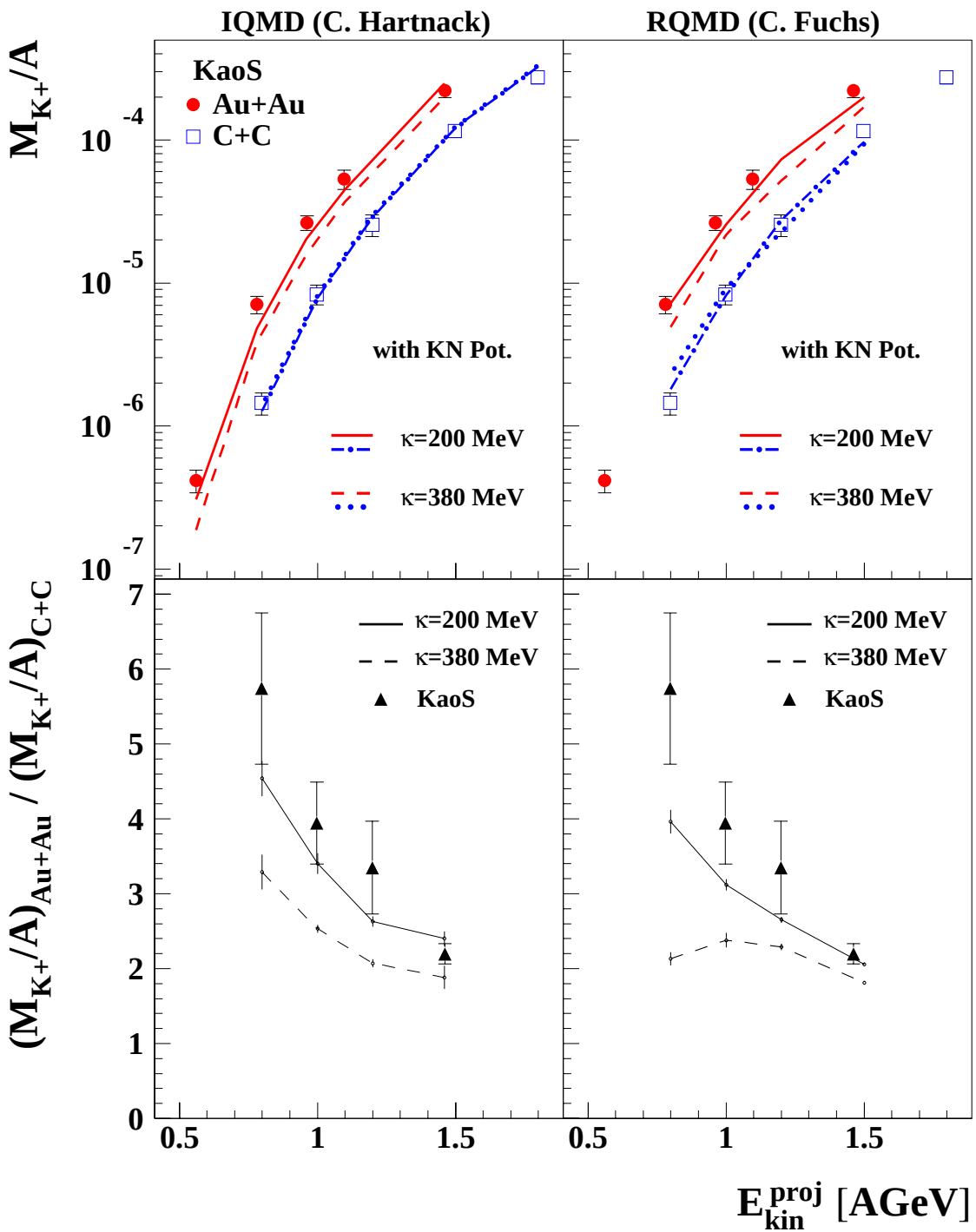
K^+ yield established early by the high-density phase,
not changed due to s-conservation (K^+ from the interior)

K^+ slopes (and angular distributions) dominated by rescattering

K^- yield established late by Λ and π concentration
(K^- from the surface)

Even if K^- from a thermal source of Λ and π, $T(K^-)$ is smaller than T(source). Only those K^- are observed which did NOT had an interaction

Stat. Model describes the ratios, but does not describe $T(K^-)$.



C. Sturm,

Ph.D.

TU DA

PRL 86 (2001)

Resume

K^+ yield	*	Input ?
K^- yield	-	Input, K^+, pi, …
K^-/K^+ ratio	-	Same only K^+ cancels
Difference in slopes	-	K^+ rescattering K^- decay
v_2 (K^+)	* (*)	Contribution of rescatt.?
v_2 (K^-)	* ?	Emission time and potential(?)
Ratio K^+(AuAu)/ K^+(CC)	* * *	EOS! Most uncertainties cancel

KaoS Collaboration

TU Darmstadt: A. Förster, H. Oeschler, S. Lang, C. Sturm, A. Schmah, F. Uhlig

GSI Darmstadt: P. Koczoń, M. Płoskoń, E. Schwab, P. Senger

Univ. Frankfurt: Y. Shin, T. Schuck, H. Ströbele

Univ. Marburg: I. Böttcher, B. Kohlmeyer, M. Menzel, F. Pühlhofer

Univ. Kraków: M. Debowski, W. Waluś

FZ Rossendorf: E. Grosse, L. Naumann, W. Scheinast, A. Wagner