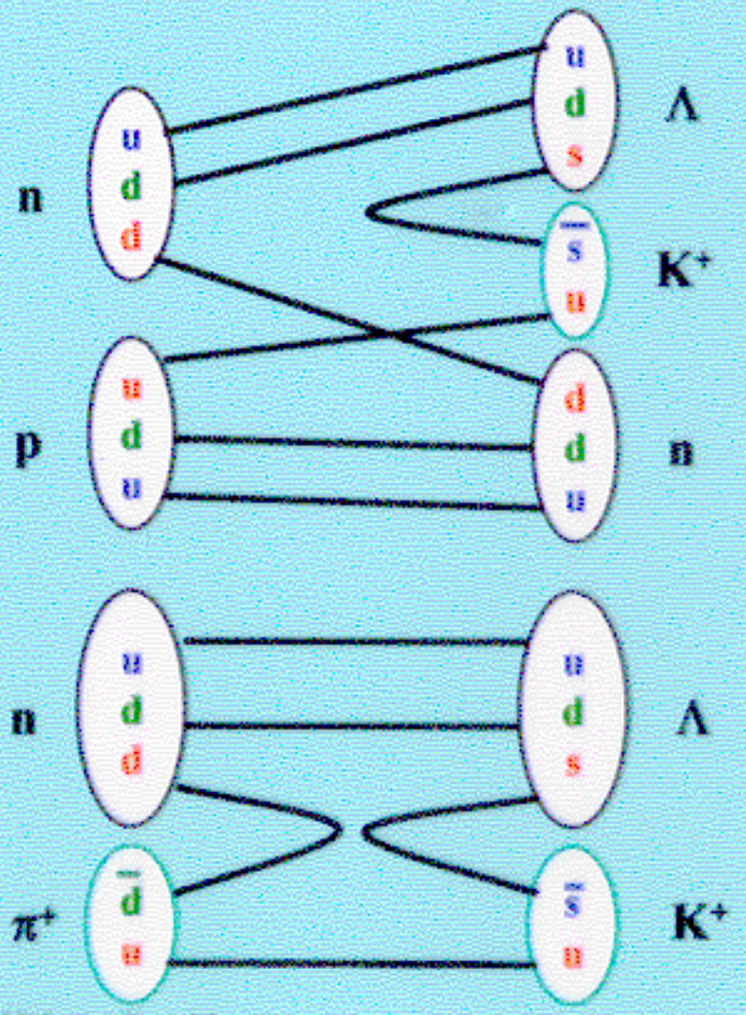
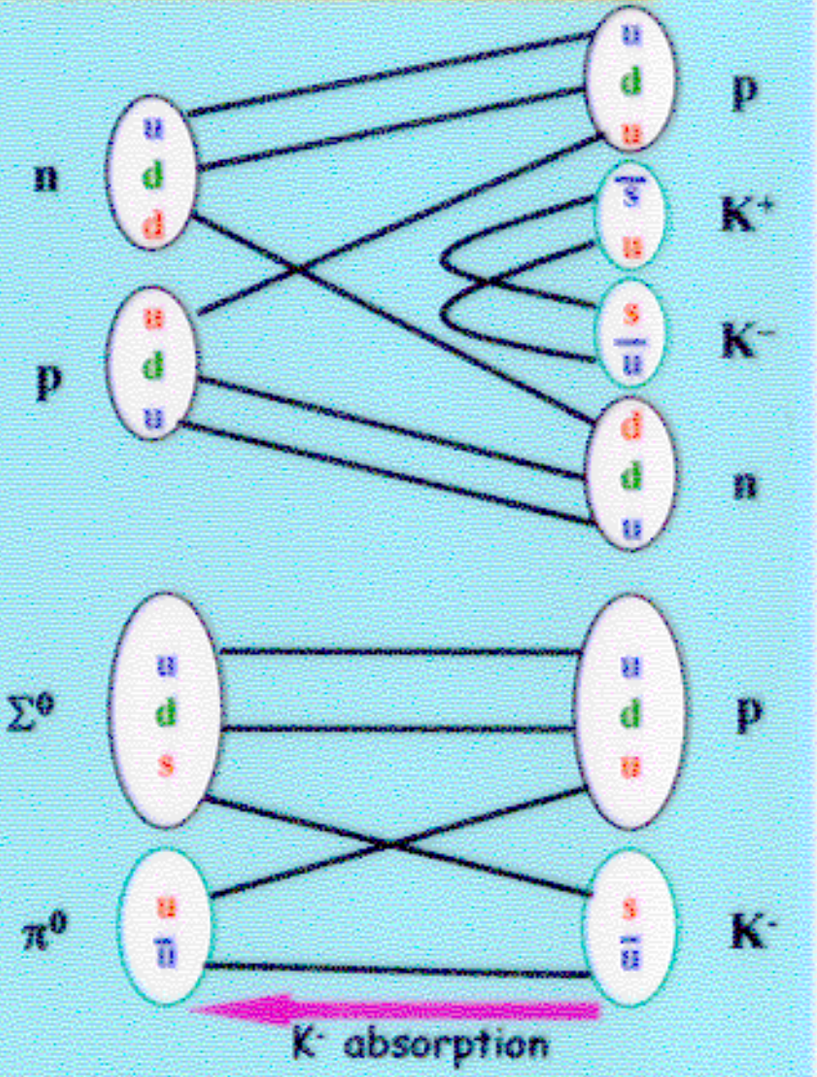
Strange Particle Production from SIS to LHC

Helmut Oeschler
Darmstadt University of Technology

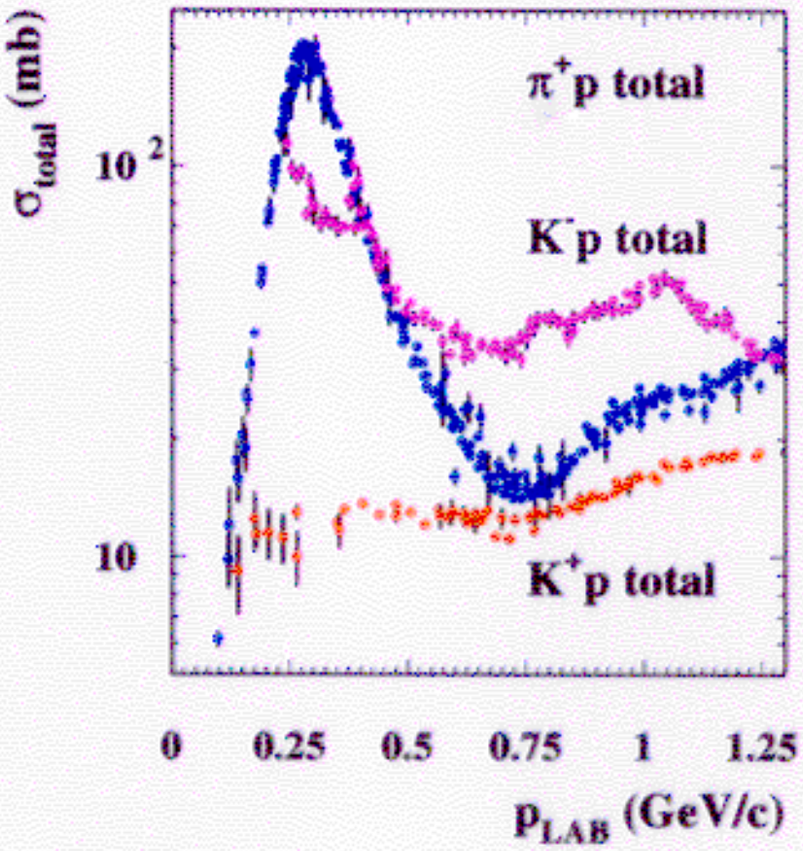
Creation of Strange Mesons





Helmut Oeschler

Mean free path of Kaons and Antikaons



mean free path at ρ_0:

$\lambda_{\pi+} \cong 0.3\ fm$

$\lambda_{K+} \cong 5\ fm$

$\lambda_{K-} \cong 0.8\ fm$

K$^-$ absorption by strangeness exchange reactions:

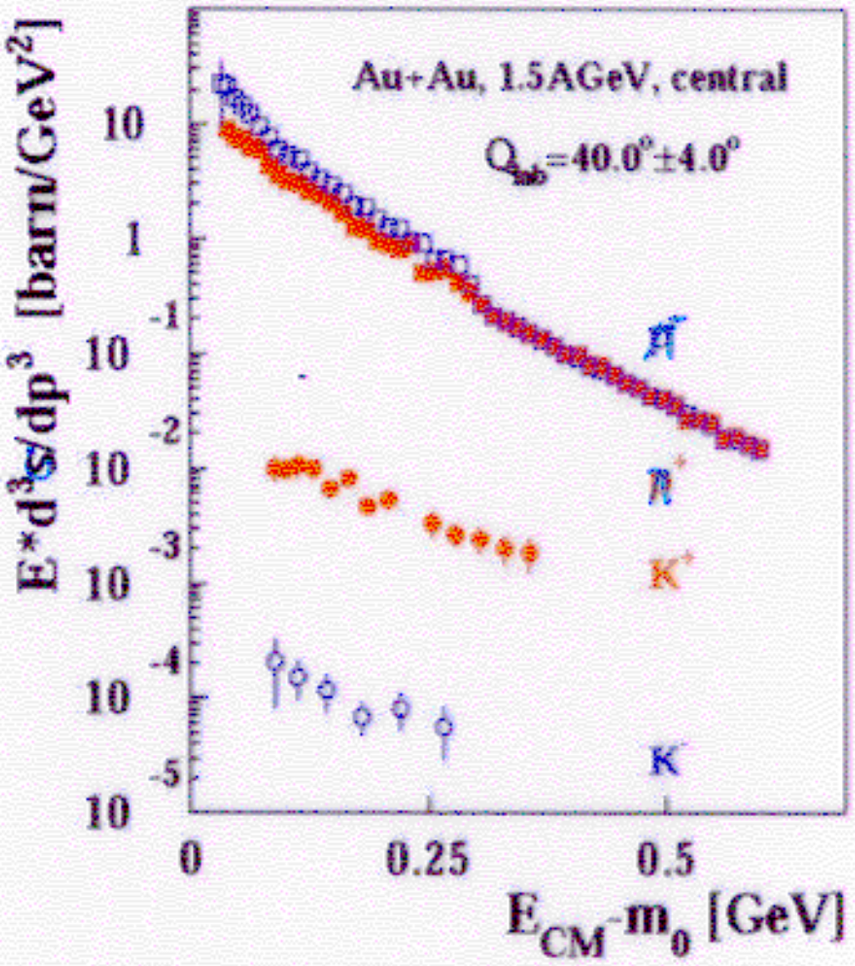
K$^-$ p → Y π^o

K$^+$:
nearly undisturbed messengers

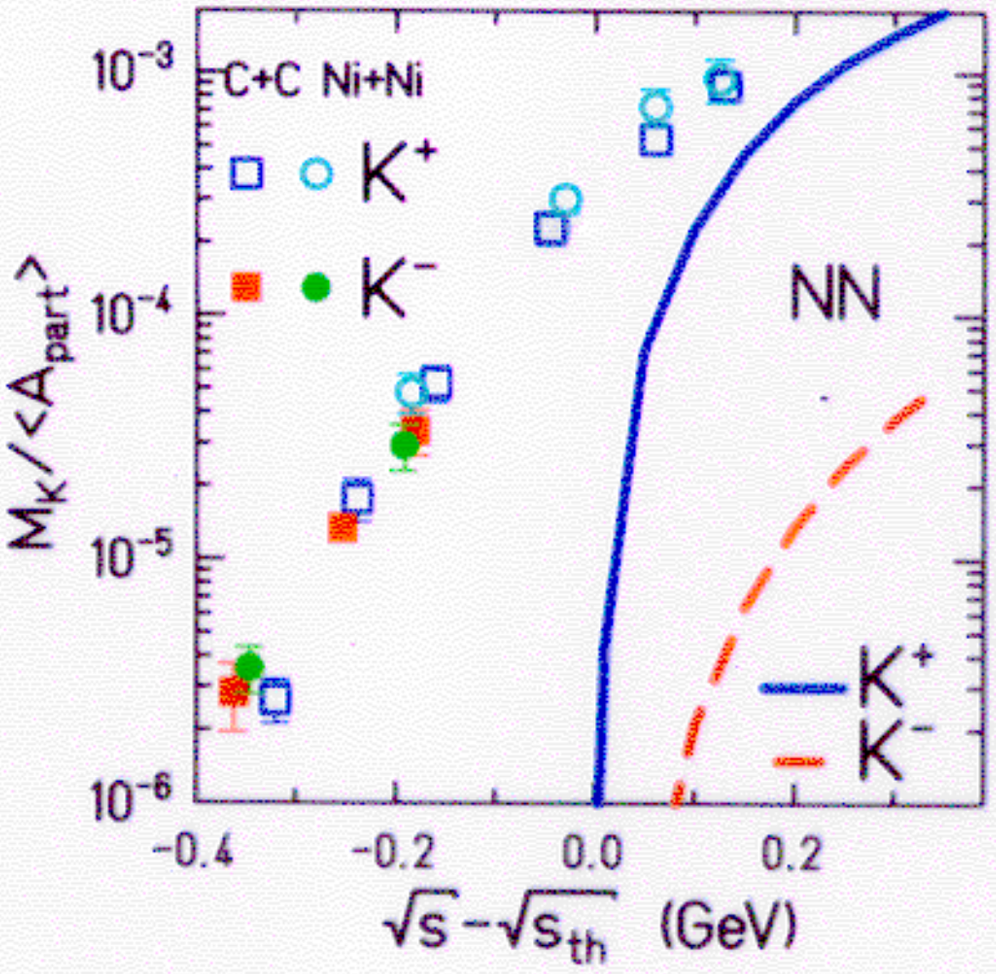
Au+Au collisions at 1.5 AGeV

A. Förster et al.,

KaoS



K^+ and K^- Production at SIS Energies



KaoS Collaboration

F. Laue, C. Sturm, et al.

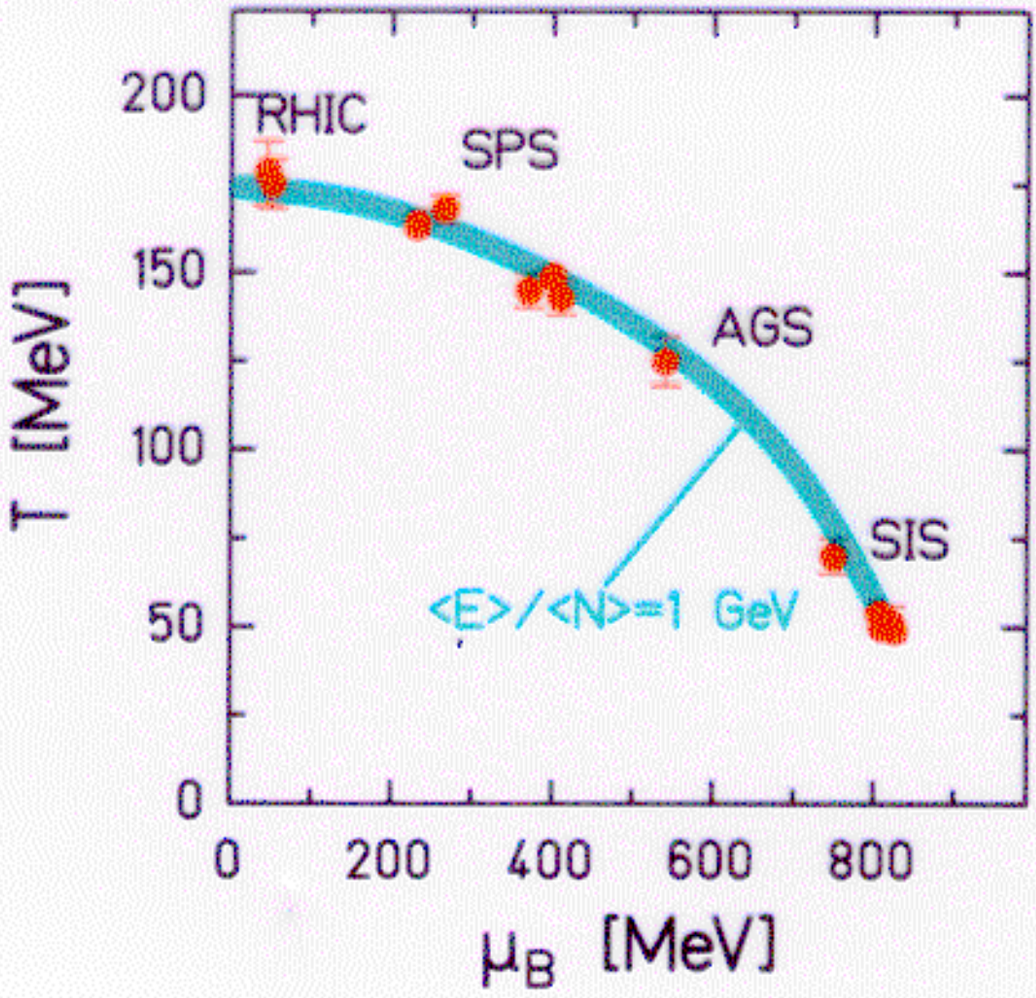
PRL 82 (1999) updated

NN: parametrization

A. Sibirtsev,

PLB 359 (1995)

Chemical Freeze Out from SIS to RHIC



J. Cleymans, K. Redlich, PRL 81(1998) 5284

Chemical Equilibrium at SIS Energies

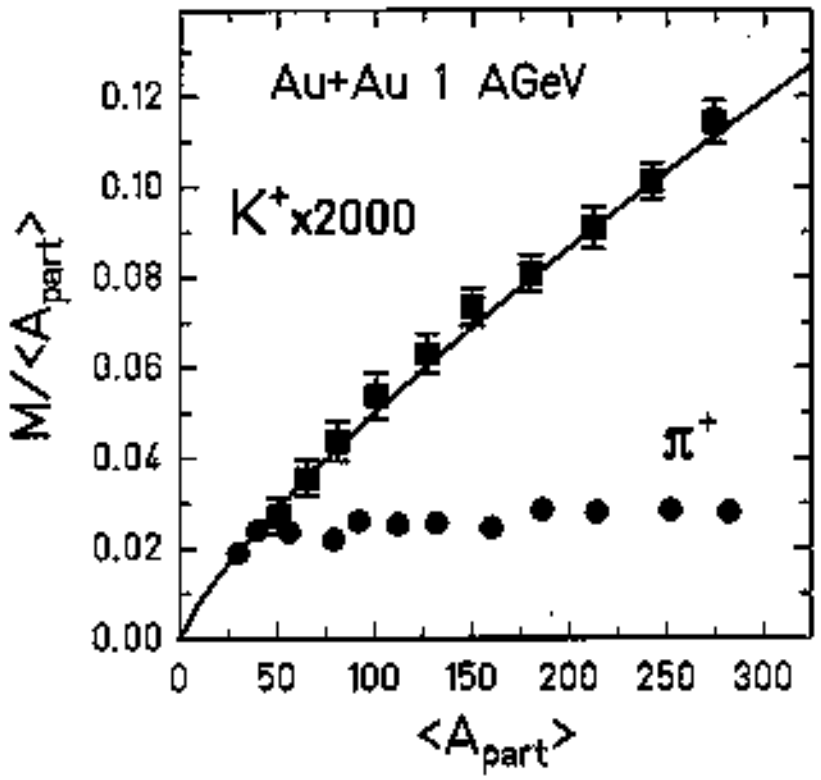
J. Cleymans, H. O., K. Redlich, PRC 59 (1999)
Pion production: $NN \to NN\pi$

$$n_\pi \sim \exp\left(-\frac{E_\pi}{T}\right)$$

Kaon production: $NN \to N\Lambda K^+$

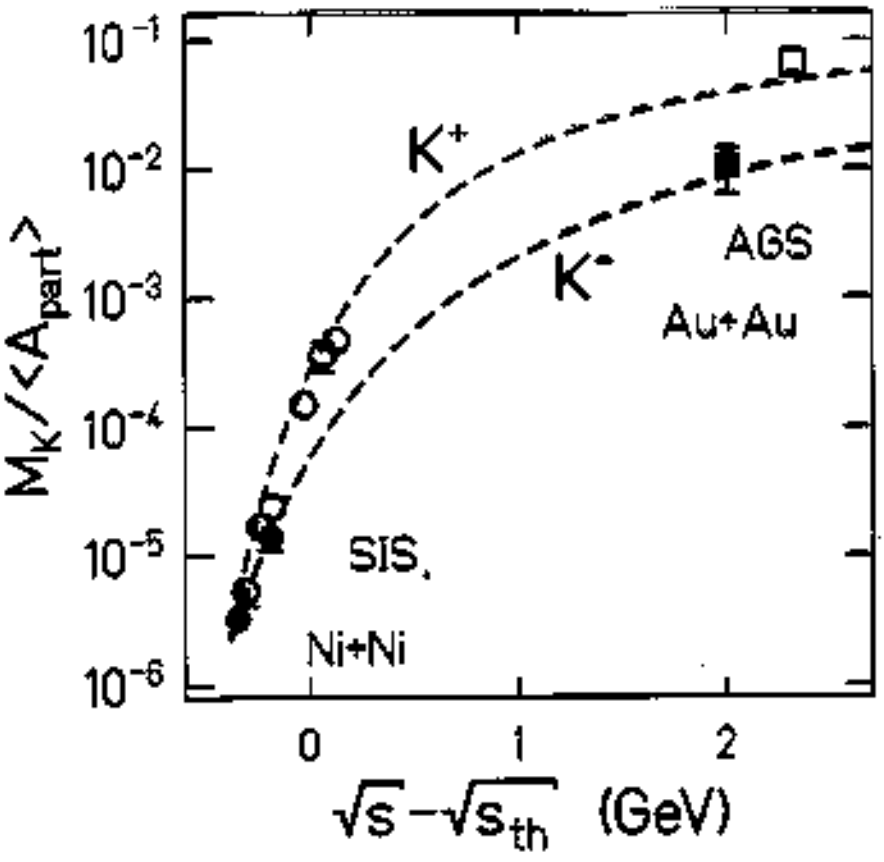
$$n_{K^+} \sim \exp\left(-\frac{E_{K^+}}{T}\right)\left[g_\Lambda V \int \frac{d^3p}{(2\pi)^3} \exp\left(-\frac{(E_\Lambda - \mu_B)}{T}\right)\right]$$

Strangeness $s\bar{s}$ suppression



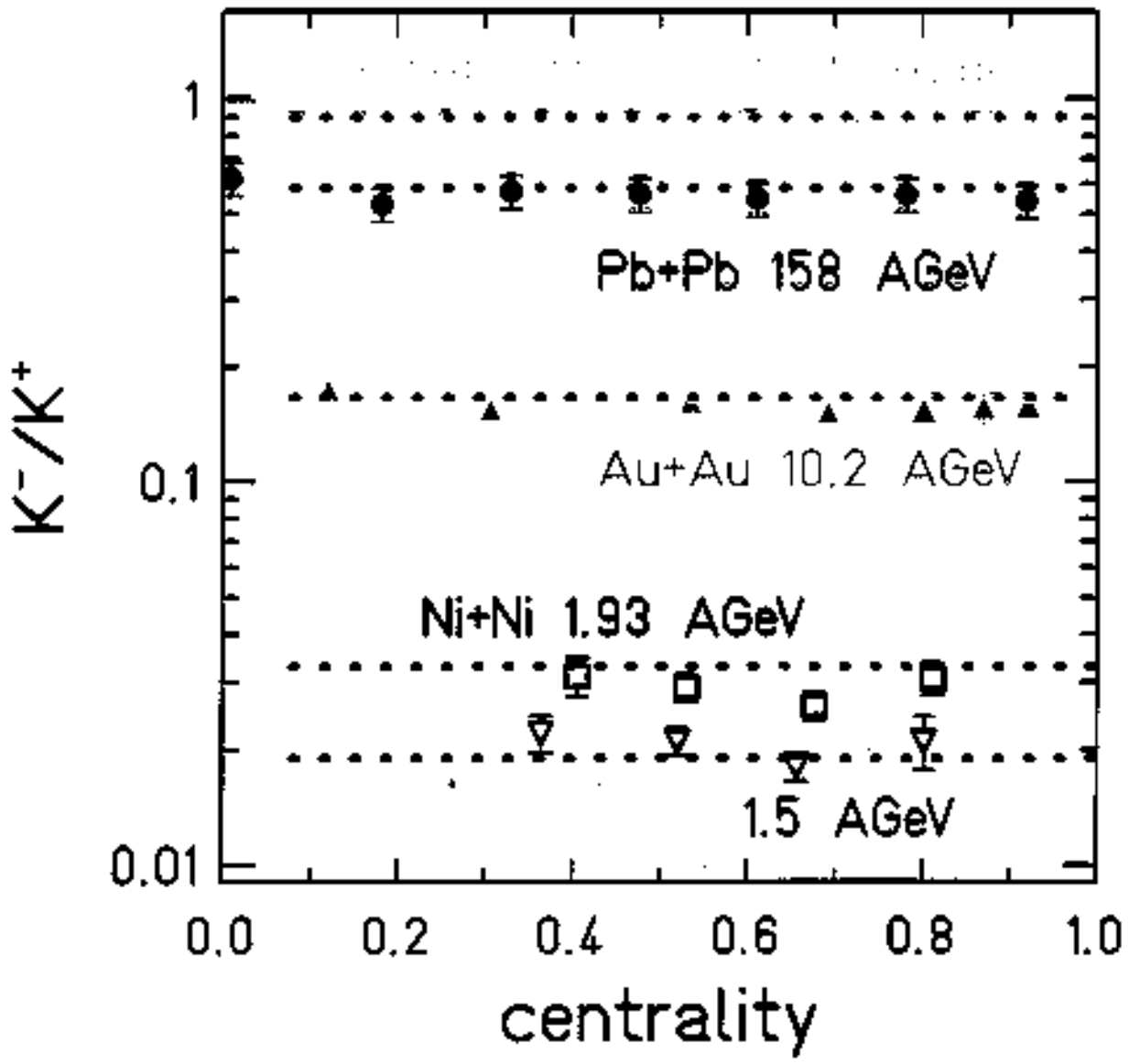
K^+ and K^- within the Statistical Model

J. Cleymans, H. O., K. Redlich,
Phys. Lett. B485(2000)



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

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

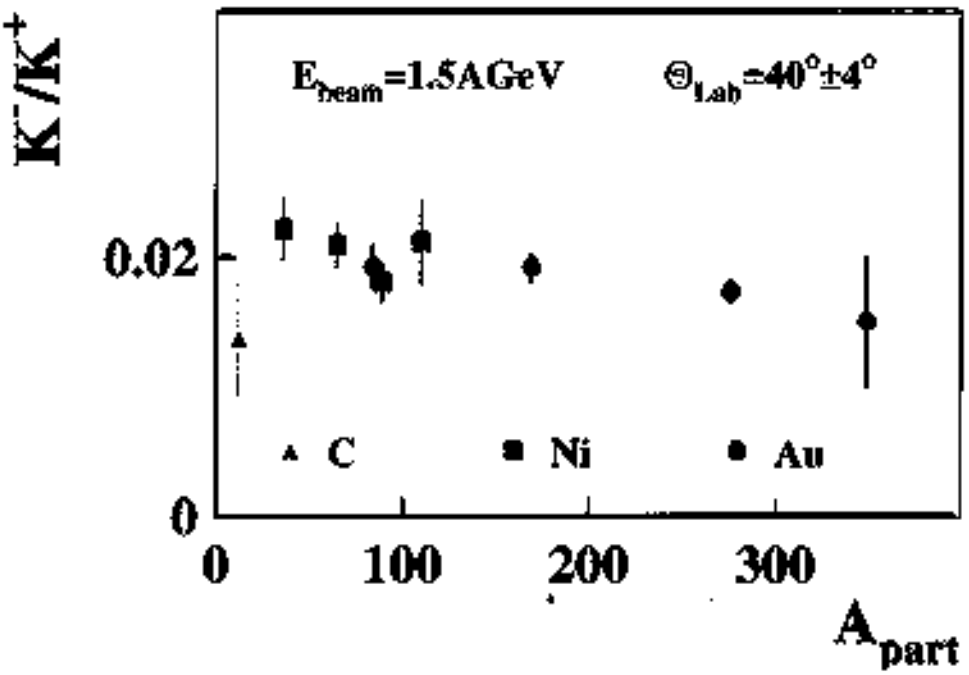


$$n_{K+} \sim \exp\left(-\frac{E_{K+}}{T}\right)\left[g_{\Lambda}V\int\frac{d^3p}{(2\pi)^3}\exp\left(-\frac{(E_{\Lambda}-\quad)}{T}\right)\right]$$

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

$E_{threshold}(K^+) \equiv 1.58$ GeV $\quad (\Rightarrow K^+\Lambda)$
$E_{threshold}(K^-) \equiv 2.6$ GeV $\quad (\Rightarrow K^-K^+)$

A. Förster, TU Darmstadt, KaoS Collaboration



Dominant channel for K^- production

$$\pi^{0,-} + \Lambda \rightleftharpoons K^- + p, n$$

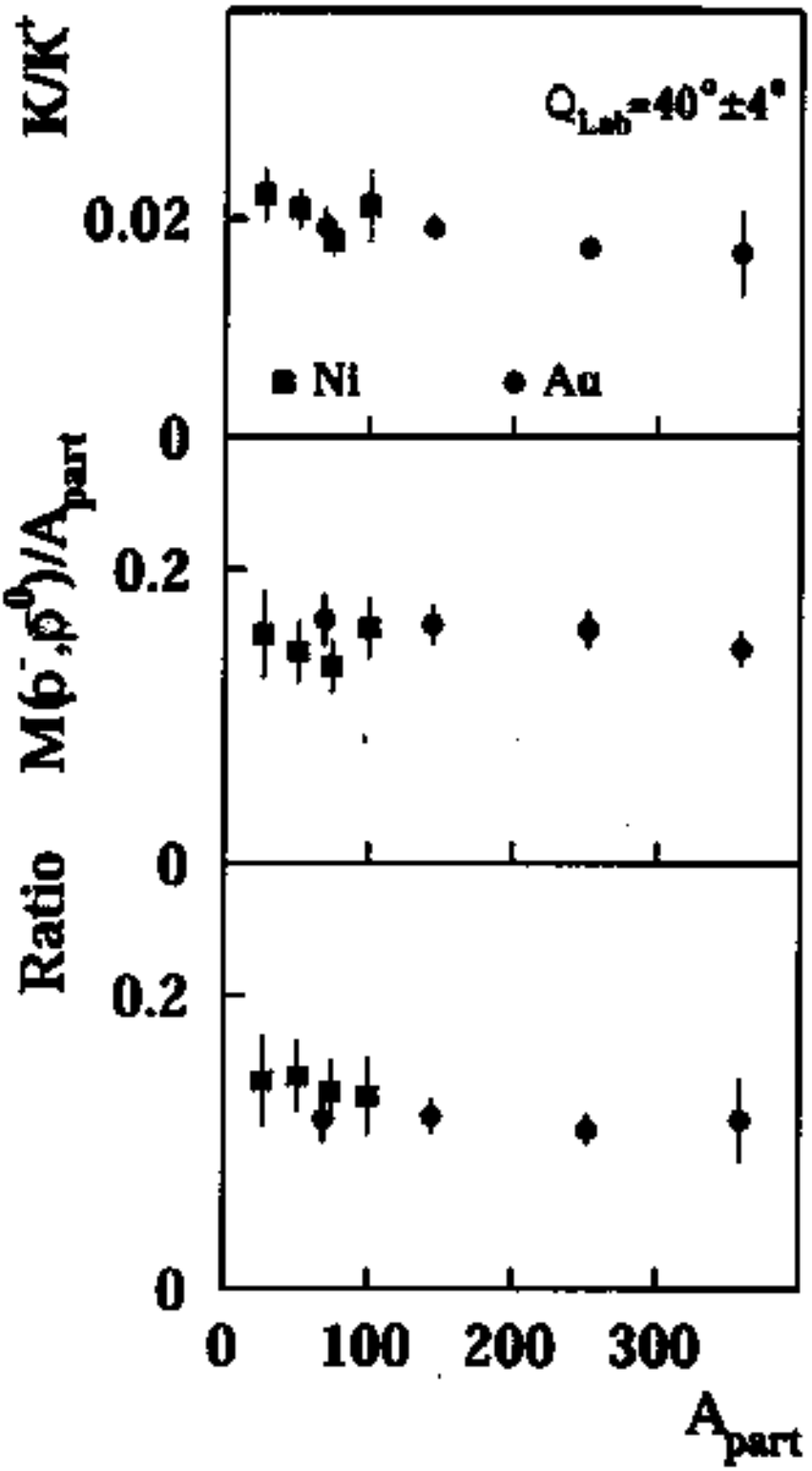
Law of Mass Action

$$\frac{[\pi] \cdot [\Lambda]}{[K^-] \cdot [N]} = \kappa$$

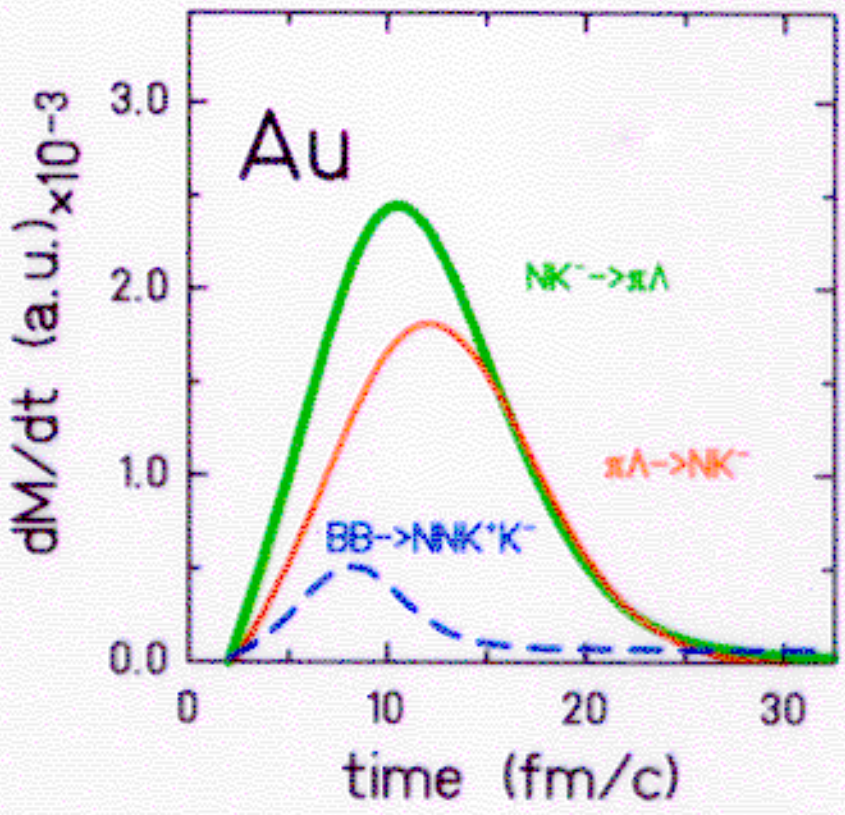
$[\Lambda] \sim [K^-]$

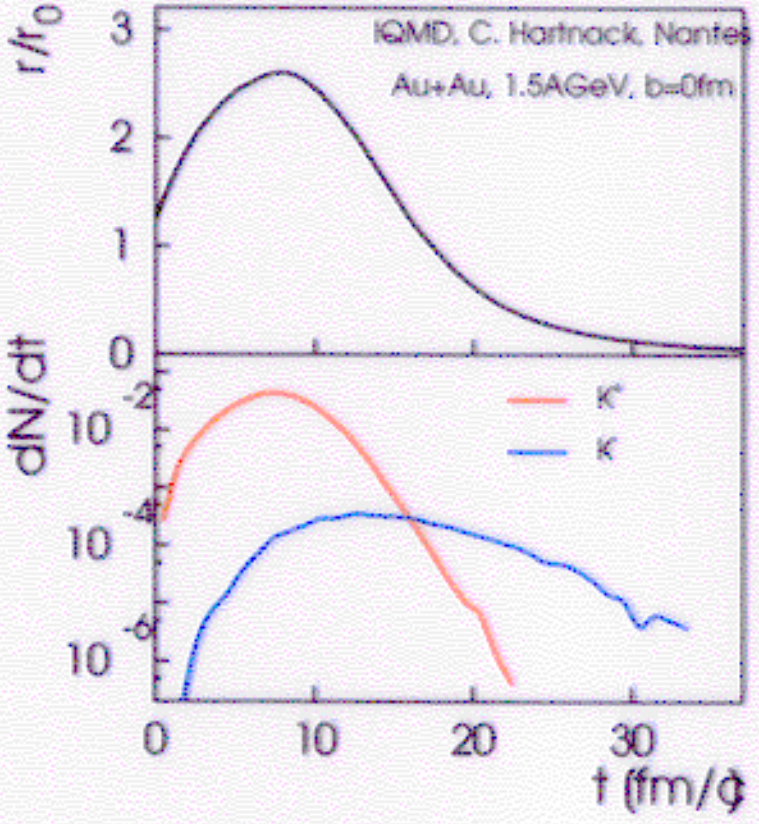
$$\frac{[K^-]}{[K^-]} \cdot \frac{[\pi]}{[N]} \sim \kappa$$

see also C. Hartnack, H. O., J. Aichelin, nucl-th/0109016


K/K+
θ_{Lab}=40°±4°
0.02
0
Ni
Au
Ratio M(p-,p0)/Apart
0.2
0
0.2
0
0
100
200
300
Apart

Time Evolution of K^+ and K^- Production





Helmut Oeschler

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

Elliptic Flow at Midrapidity

fit: $dN/d\phi \sim 1 + 2 \cdot v_1 \cdot \cos\phi + 2 \cdot v_2 \cdot \cos 2\phi$

data is corrected for the resolution of the reaction plane reconstruction

Ni+Ni, 1.93 AGeV

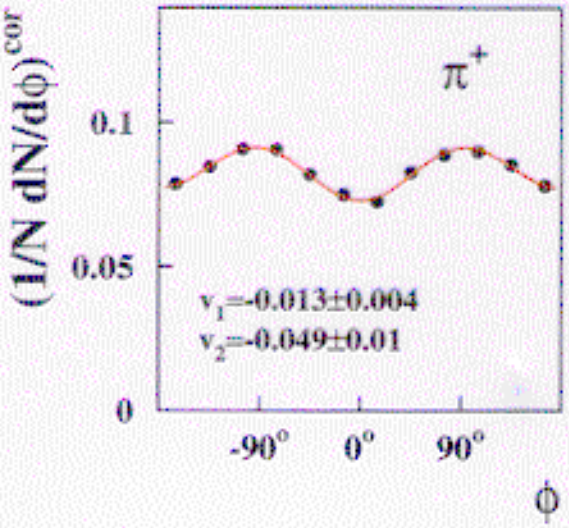
$0.4 < y/y_{beam} < 0.6$

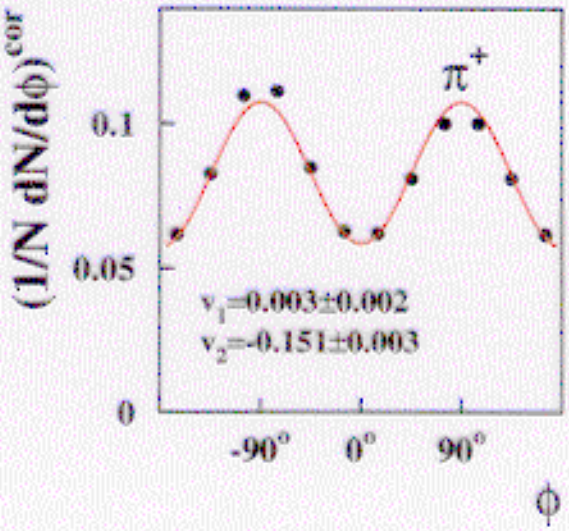
$b > 3.8$ fm

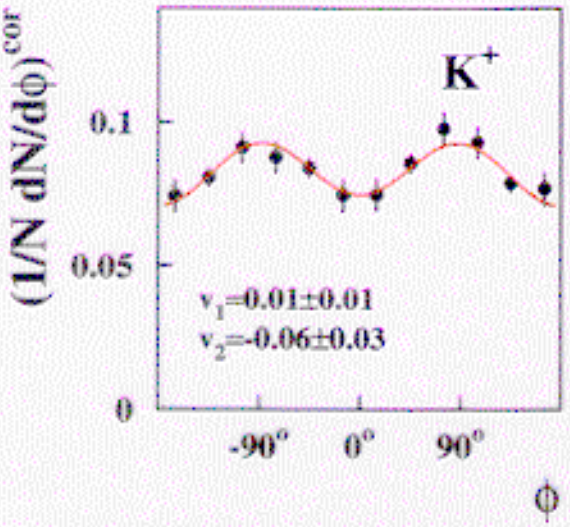
Au+Au, 1.5 AGeV

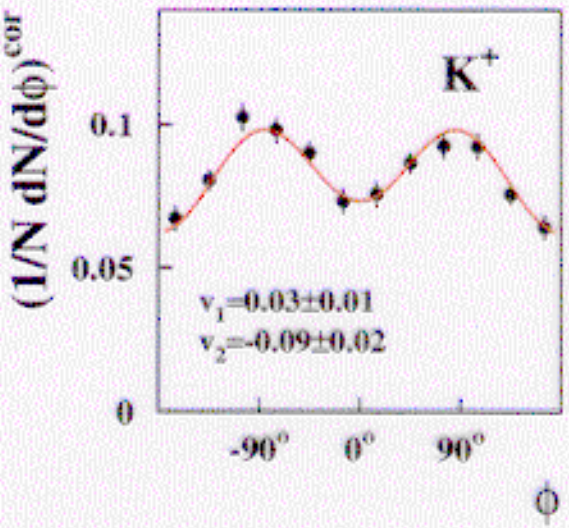
$0.3 < y/y_{beam} < 0.7$

$b > 5.9$ fm







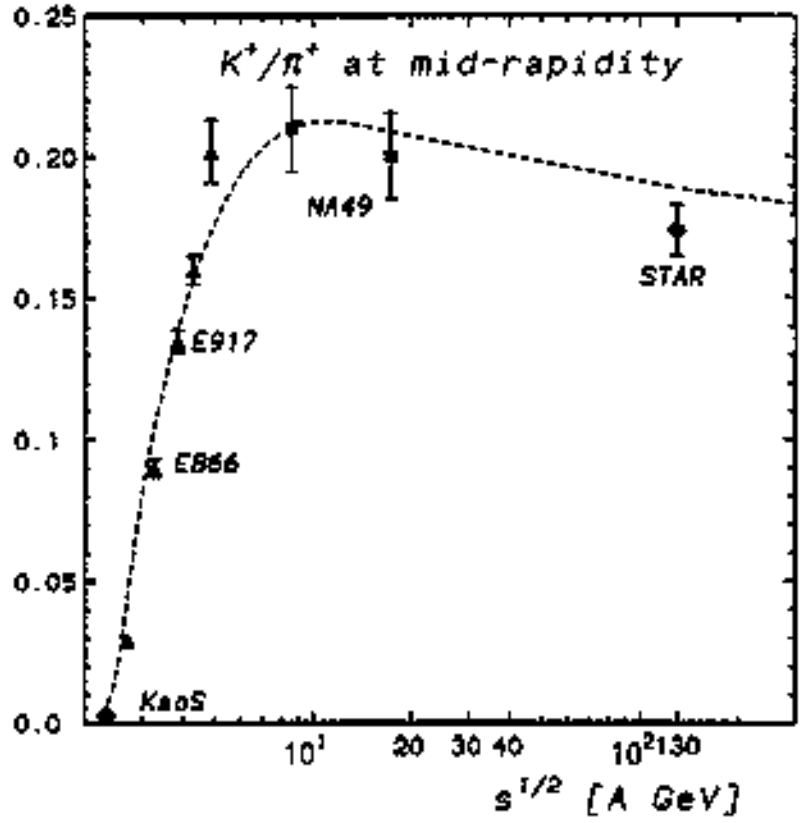


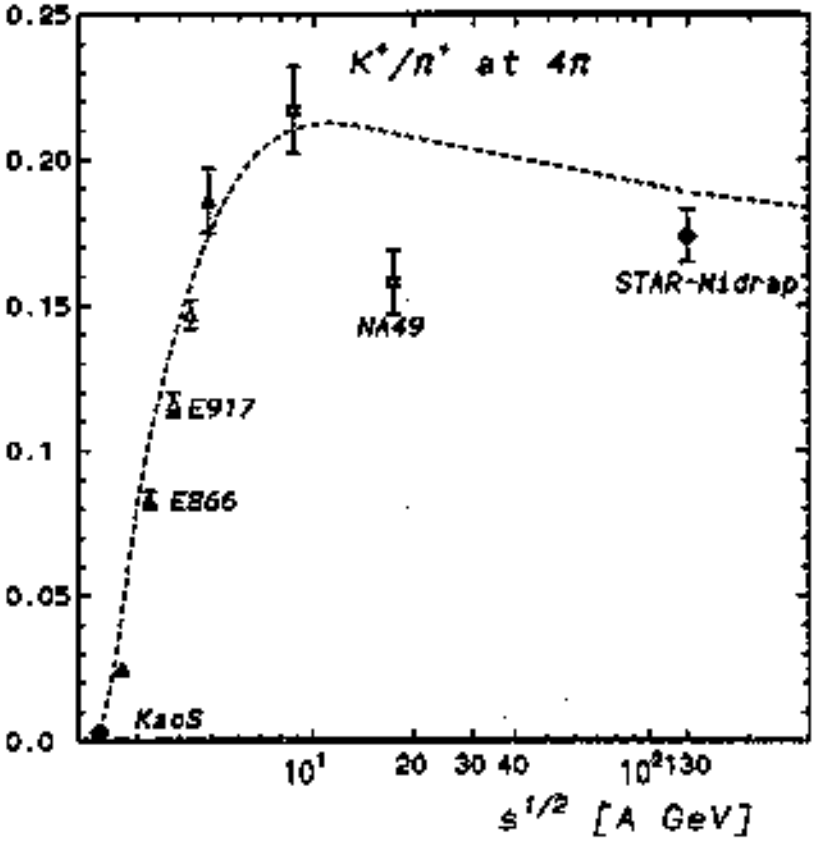
Problems worthy of attack

prove their worth by hitting back

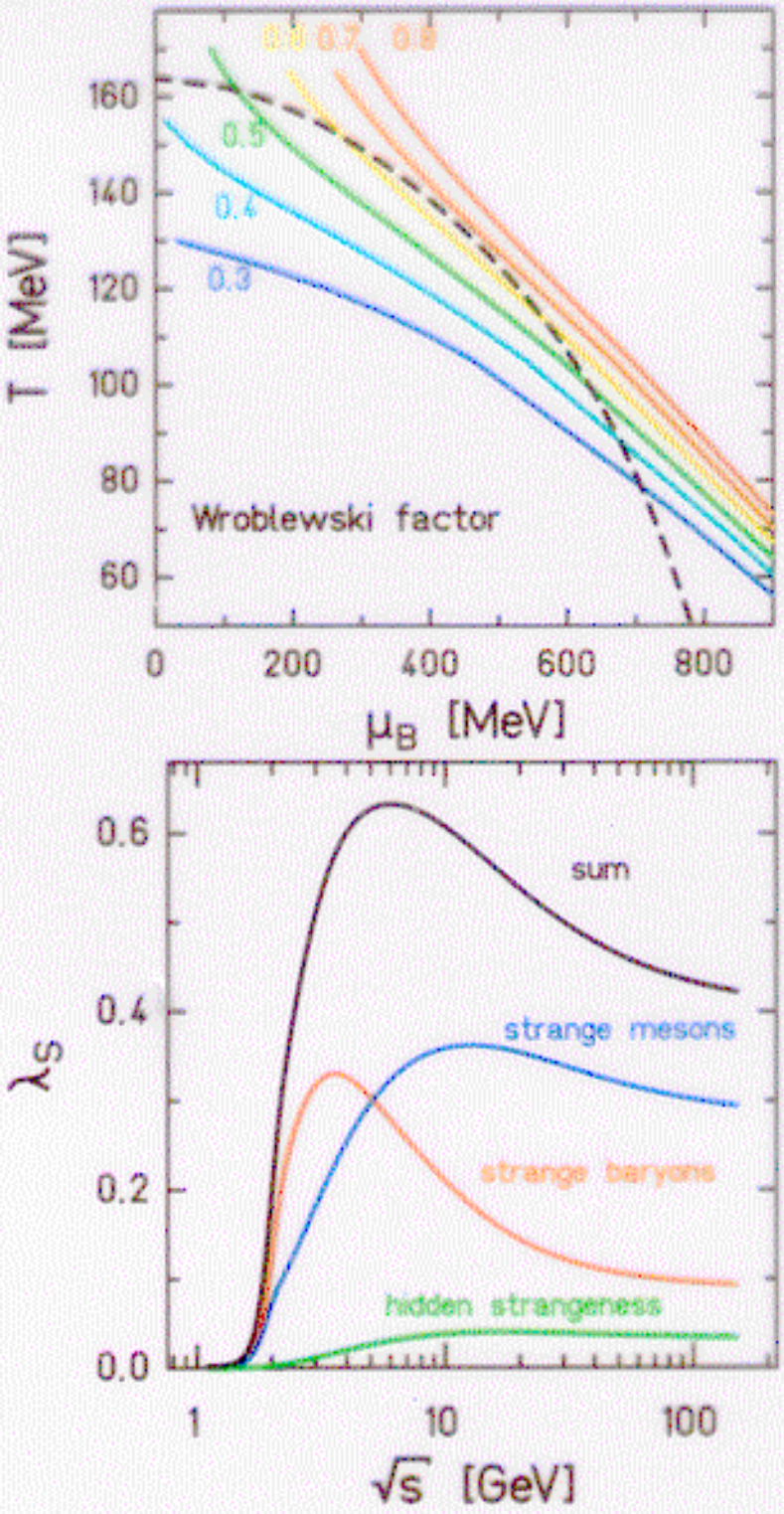
Piet Hein

K^+/π^+ ratio from SIS to RHIC

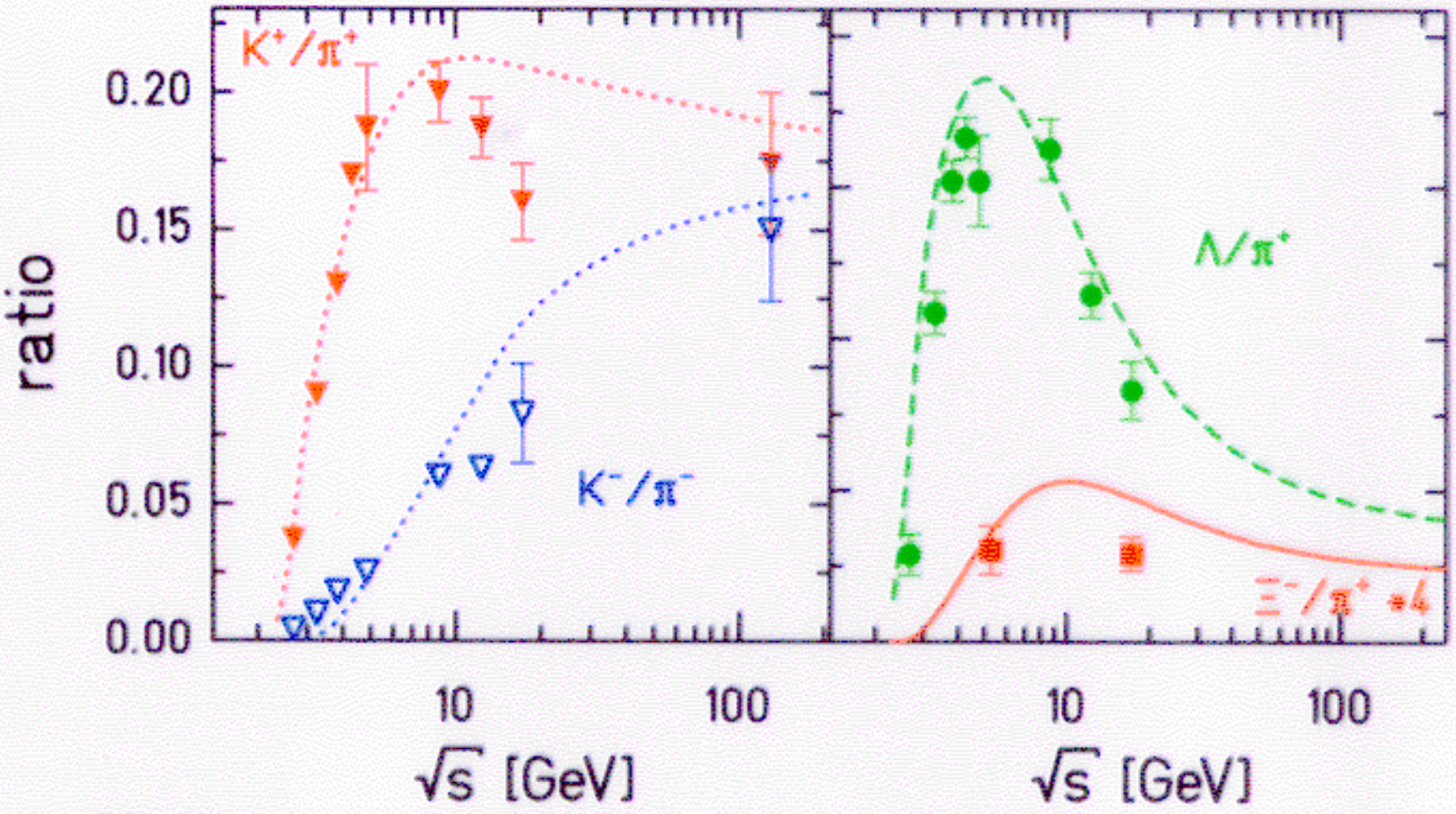




P. Braun-Munzinger, J. Cleymans, H. O., K. Redlich,
Nucl. Phys. A 697 (2002) 902



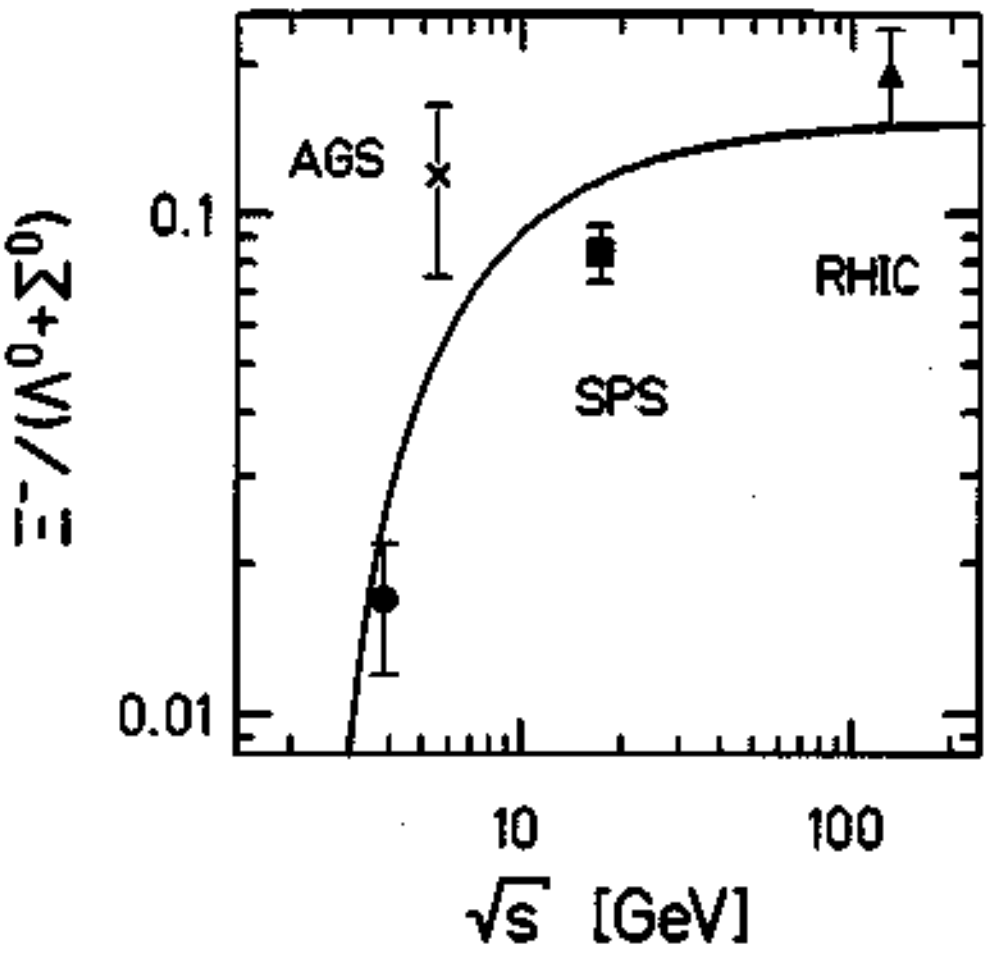
Difference Mesons - Baryons



Helmut Oeschler

Comparison with statistical model

P. Chung et al., EOS Collaboration



Summary I

- K^- emission at SIS energies:
  strangeness exchange dominant channel!
  Chem. equilibrium?

  Late emission of K^-! $T(K^-) < T(K^+)$
  isotropic distribution in polar angle
  in-medium masses? yields not sensitive?
  But v1, v2?

Summary II

- Maximum Strangeness around 30 AGeV: Effect of T and μ_B or onset of QGP?
- At LHC? T≈170 MeV and $\mu_B \approx 10$ MeV
  But hard collisions will dominate!