Strangeness and In-Medium Effects in Heavy Ion Collisions from 1 to 2 AGeV

Signs for transition towards partially restored chiral symmetry ?

J.P. Alard, A. Andronic, R. Averbeck, Z. Basrak, N. Bastid, I. Belyaev, A. Bendarag, G. Berek, D. Best, R. Čaplar, N. Cindro, P. Crochet, A. Devismes, P. Dupieux, M. Dželalija, M. Eskef, Z. Fodor, L. Fraysse, A. Genoux-Lubain, A. Gobbi, Y. Grishkin, N. Herrmann, K.D. Hildenbrand, B. Hong, J. Kecskemeti, Y.J. Kim, M. Kirejczyk, M. Korolija, R. Kotte, M. Kowalczyk, T. Kress, R. Kutsche, A. Lebedev, K.S. Lee, Y. Leifels, V. Manko, H. Merlitz, S. Mohren, D. Moisa, W. Neubert, A. Nianine, D. Pelte, M. Petrovici, C. Plettner, F. Rami, W. Reisdorf, B. de Schauenburg, D. Schűll, Z. Seres, B. Sikora, K.S. Sim, V. Simion, K. Siwek-Wilczyńska, A. Somov, M. Stockmeier, G. Stoicea, M. Vasiliev, P. Wagner, G.S. Wang, K. Wiśniewski, D. Wohlfarth, J.T. Yang, I. Yushmanov, A. Zhilin

IPNE Bucharest, Romania
ITEP Moscow, Russia
CRIP/KFKI Budapest, Hungary
Kurchatov Institute, Moscow, Russia
LPC Clermont-Ferrand, France
Korea University Seoul, Korea
GSI Darmstadt, Germany
IReS Strasbourg, France
FZ Rossendorf/Dresden, Germany
Univ. of Warsaw, Poland
Univ. of Heidelberg, Germany
RBI Zagreb, Croatia

FOPI

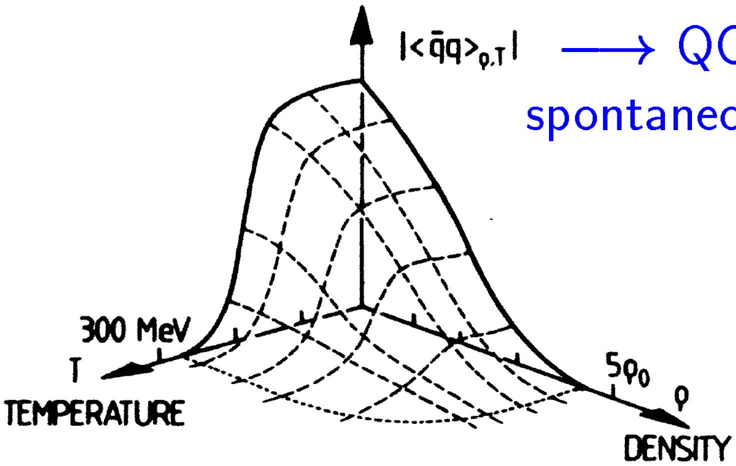
GSI Darmstadt

$\boxed{1}$ Kaons in dense nuclear matter

$\boxed{2}$ $\mathbf{K^-/K^+}$ ratio

$\boxed{3}$ $\mathbf{K^+}$ sideward flow

Kaons in Dense Nuclear Matter



$\longrightarrow$ QCD vacuum : $< \bar{q}q > \neq 0$

spontaneous chiral symmetry breaking

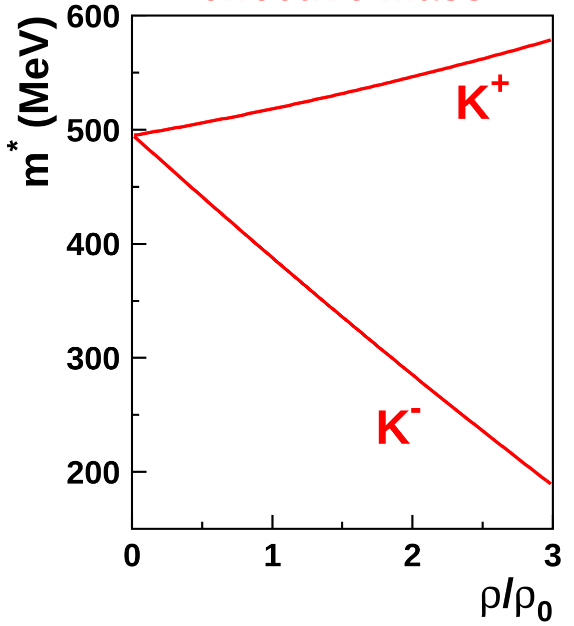
Tendency towards partial chiral symmetry restoration in hot & dense nuclear matter

$\Downarrow$

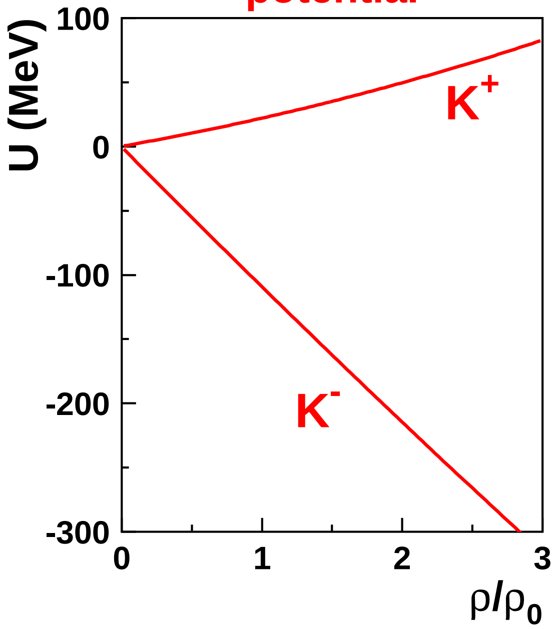
change of hadron properties

Kaon : Goldstone boson with strangeness

effective mass



potential



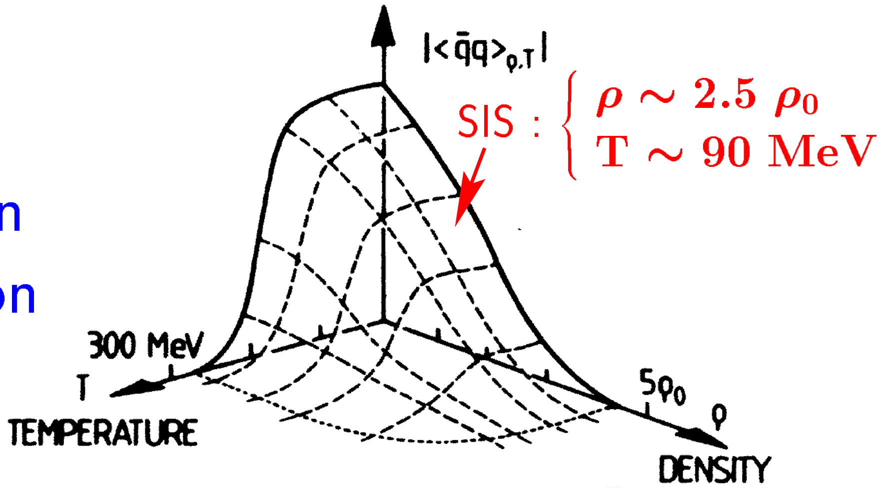
production $\longleftarrow$ characteristic $\longrightarrow$ propagation

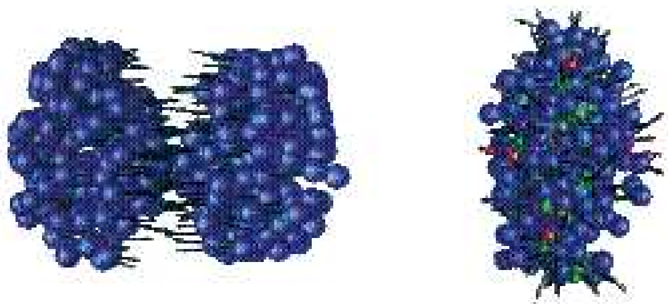
yield $\longleftarrow$ observable $\longrightarrow$ flow

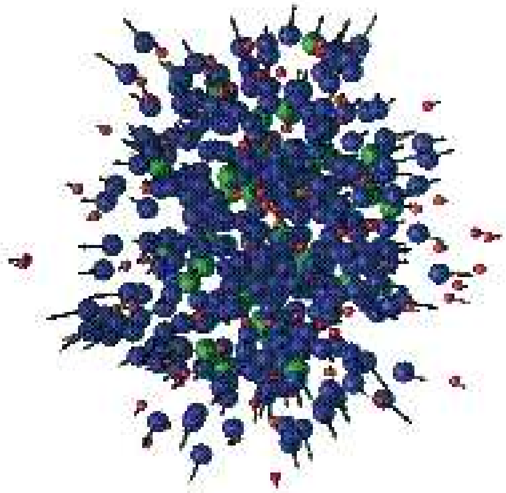
G.Q. Li and C.M. Ko, Nucl.Phys. A594(1995)460, C.H. Lee, Phys.Rep. 275(1996)255
W. Weise, Nucl.Phys. A610(1996)35c, W. Cassing et al., Nucl.Phys. A614(1997)415
C.M. Ko, V. Koch and G. Li, Ann.Rev.Nucl.Part.Sci. 47(1997)
J. Schaffner et al., Phys.Lett. B324(1994)268

Study of Hot and Dense Nuclear Matter at SIS Energies (1-2 AGeV)

- Heating
- Compression
- Nuclear Excitation
- Particle production close to threshold







- Complex dynamics
- Final state interactions
- $\sim \mathbf{1K^+(K^-)}$ each $\mathbf{1{\cdot}10^2(1{\cdot}10^4)}$ event

Observables : $\left\{ \begin{array}{l} \text{particle yields and ratios} \\ \text{particle spectra} \\ \text{flow} \end{array} \right.$

Detectors : ALADIN, FOPI, KAOS, LAND, TAPS... HADES

K^-/K^+ Ratio : Model Predictions

with in-medium effects

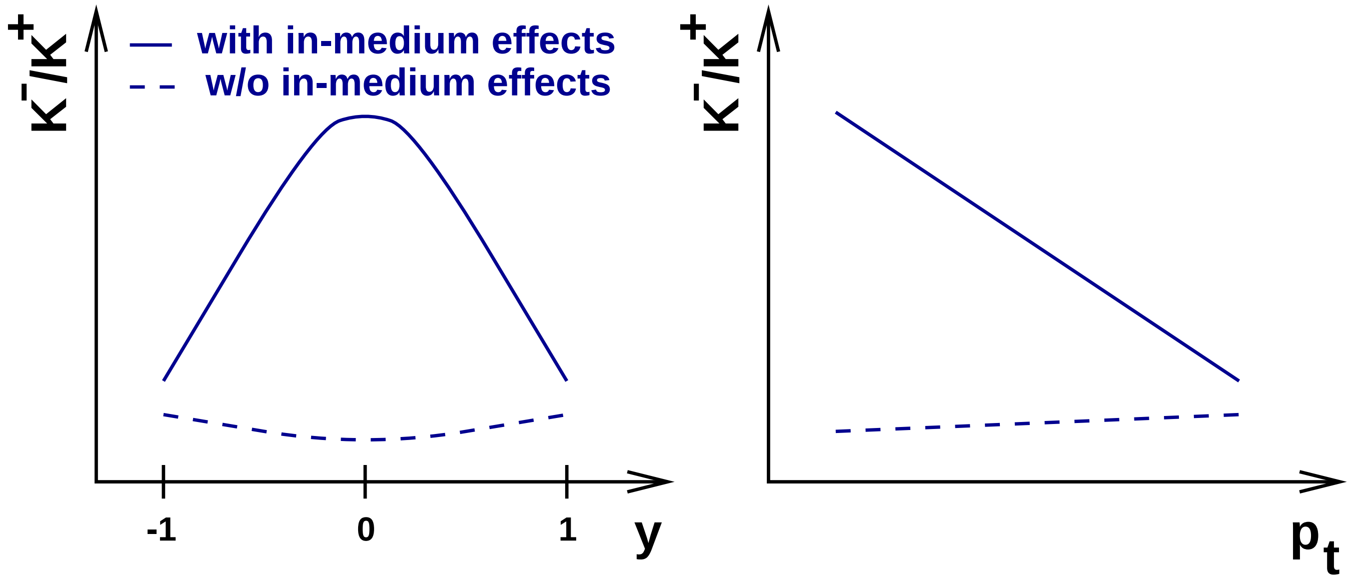
characteristic	mass	potential
K^-	decreased	attractive
K^+	increased	repulsive

observable	yield	momentum
K^-	increased	decreased
K^+	decreased	increased

In-medium effects act oppositely on K^- and K^+

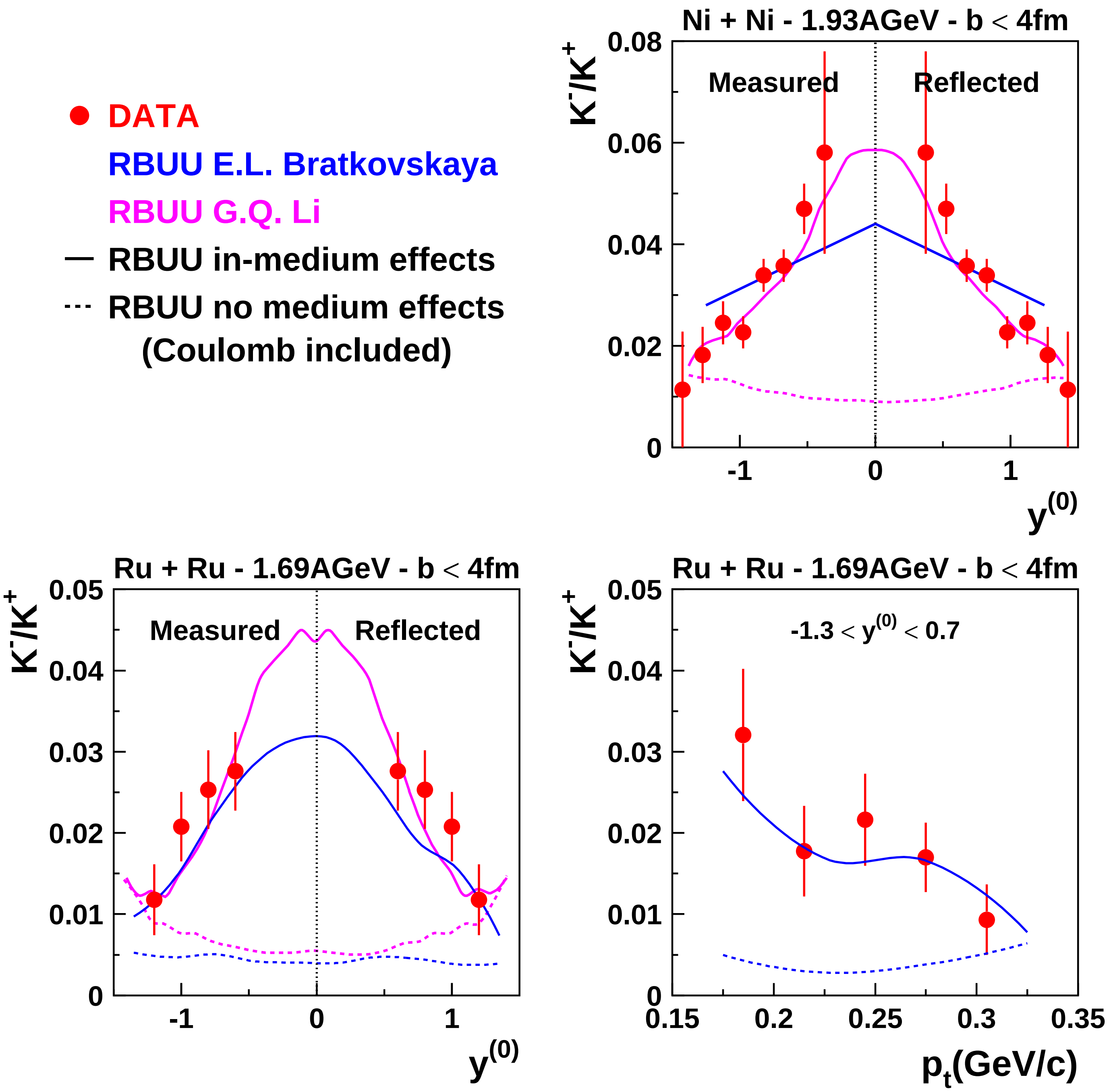
$\Rightarrow$ relevant observable : K^-/K^+ ratio

expected trends :



G.Q. Li and G.E. Brown, Phys.Rev. C58(1998), in press

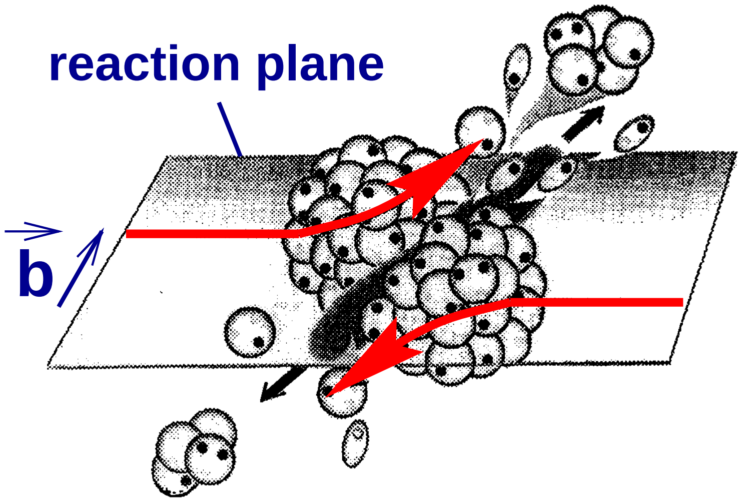
K^-/K^+ ratio *versus* $y^{(0)}$ and p_t

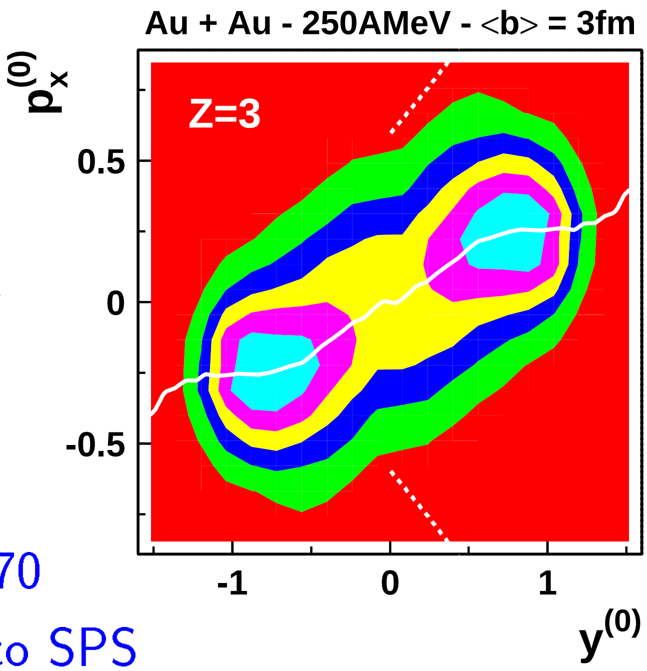


Data favour in-medium effects

K. Wiśniewski et al., GSI-report (1997), to be published

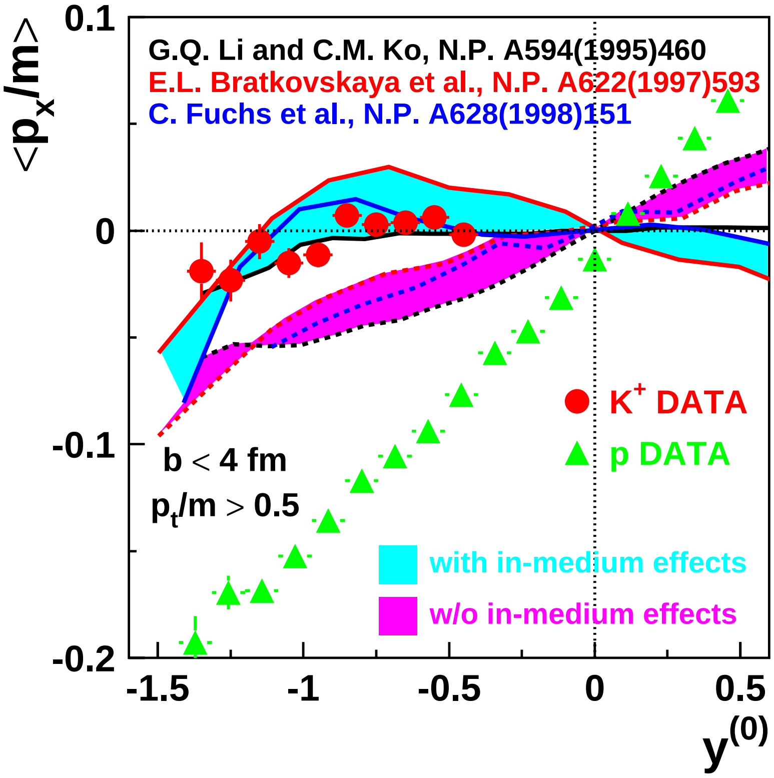
Sideward Flow





- Predicted by hydrodynamics '70
- Observed from GANIL/MSU to SPS

K^+ Sideward Flow in Ni+Ni @ 1.93 AGeV



3 $\neq$ models favour in-medium potential for K^+

BUT influence of :

production channels :
C. David et al., nucl-th/9805017

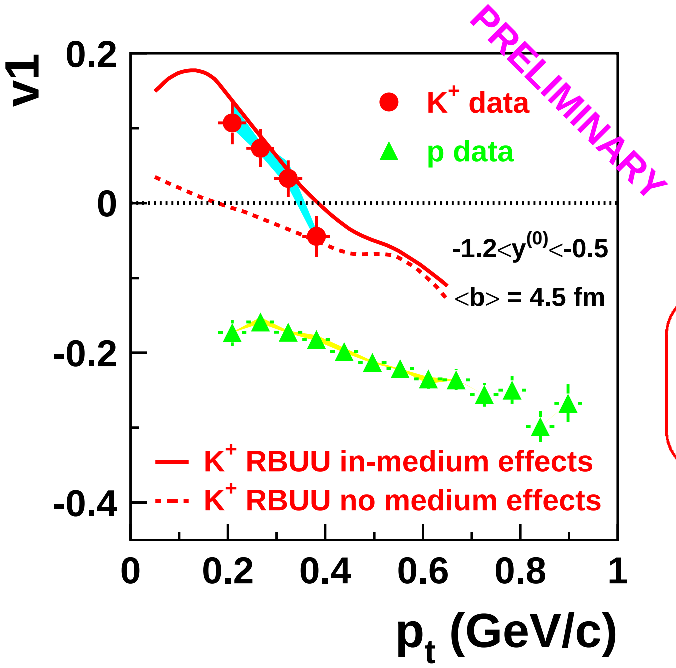
momentum dependent potential :
C. Fuchs et al., nucl-th/9801048

J. Ritman et al., Z.Phys. A352 (1995) 156, GSI report (1996)

K^+ flow *versus* p_t in Ru+Ru @ 1.69 AGeV

Fourier expansion of azimuthal distributions

First Fourier coefficient : $v_1 = \langle p_x \rangle / \langle p_t \rangle$



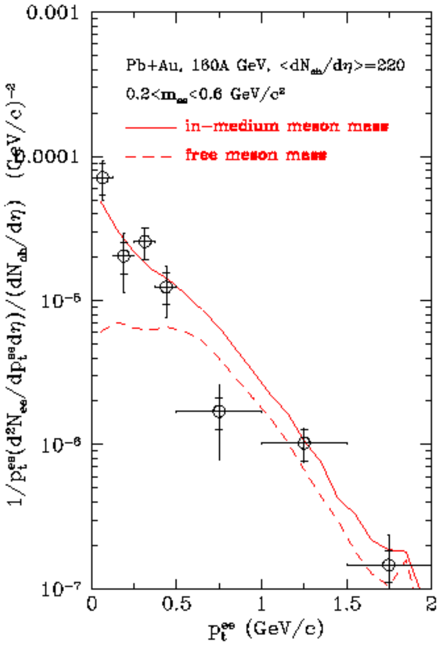
K^+ { anti-flow at low p_t; flow at high p_t }

- Data favour IME
- Sensitivity to IME at low p_t

RBUU by W. Cassing and E.L. Bratkovskaya

Dilepton Yield in Pb+Au @ 160 AGeV

CERES Data : G. Agakichiev et al., Phys.Lett. B422(1998)405



- Data favour IME
- Sensitivity to IME at low p_t

G.E. Brown et al., nucl-th/9806026, to appear in Acta Physica Polonica B

SUMMARY

Strangeness and In-Medium Effects
in Heavy Ion Collisions from 1 to 2 AGeV

Experimental data on
$\mathbf{K^-/K^+}$ ratio and $\mathbf{K^+}$ sideward flow
in Ni+Ni @ 1.93 AGeV and Ru+Ru @ 1.69 AGeV
need in-medium modification of kaon properties
to be satisfactory reproduced by transport models

Open questions and problems :

Theory : { alternative explanations for kaon data
description of baryon data

Experiment : { systematical errors
limited statistic

Future : $\mathbf{K^-}$ flow, $\mathbf{\Phi}$

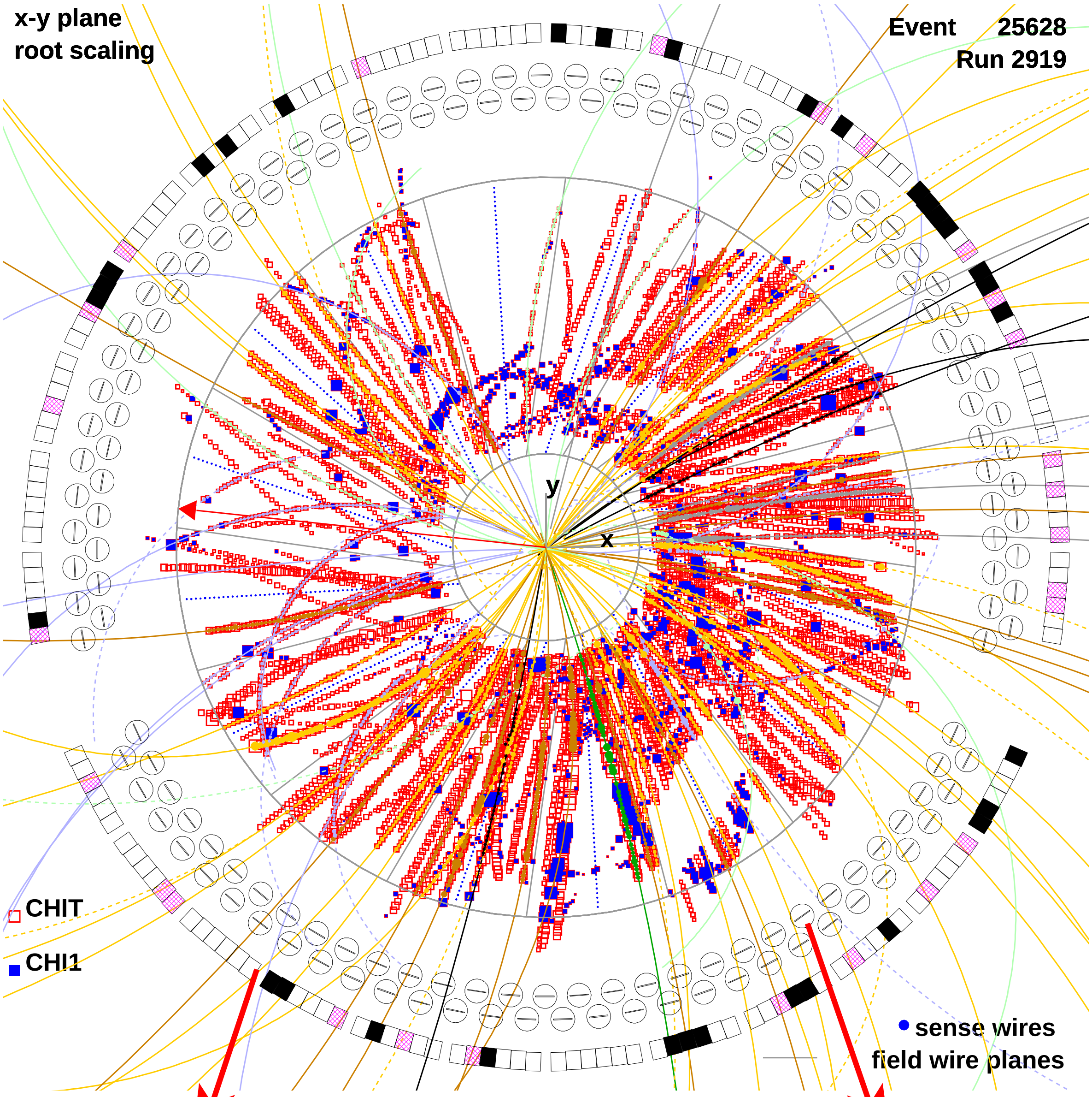
Larger sensitivity to in-medium effects

FOPI ToF upgrade : { more precise measurements
better statistic

FOPI @ GSI : ToF System Upgrade

Au + Au @ 1.5 AGeV

$N_{hit} \sim 4500$ $N_{track} \sim 100$ $P(K^-) = 1 \cdot 10^{-4}$



Existing plastic scint. barrel :

- granularity : **180**
- resolution $\sim$ **300 ps**

Pestov spark counters barrel :

- granularity : **830**
- resolution $<$ **100 ps**