OBSERVATION OF DECONFINEMENT PHASE TRANSITION IN NUCLEUS-NUCLEUS COLLISIONS

- BASIC IDEA
- SIGNALS OF DECONFINEMENT
- CONCLUSIONS AND FUTURE

M. GAŹDZICKI
IKF FRANKFURT
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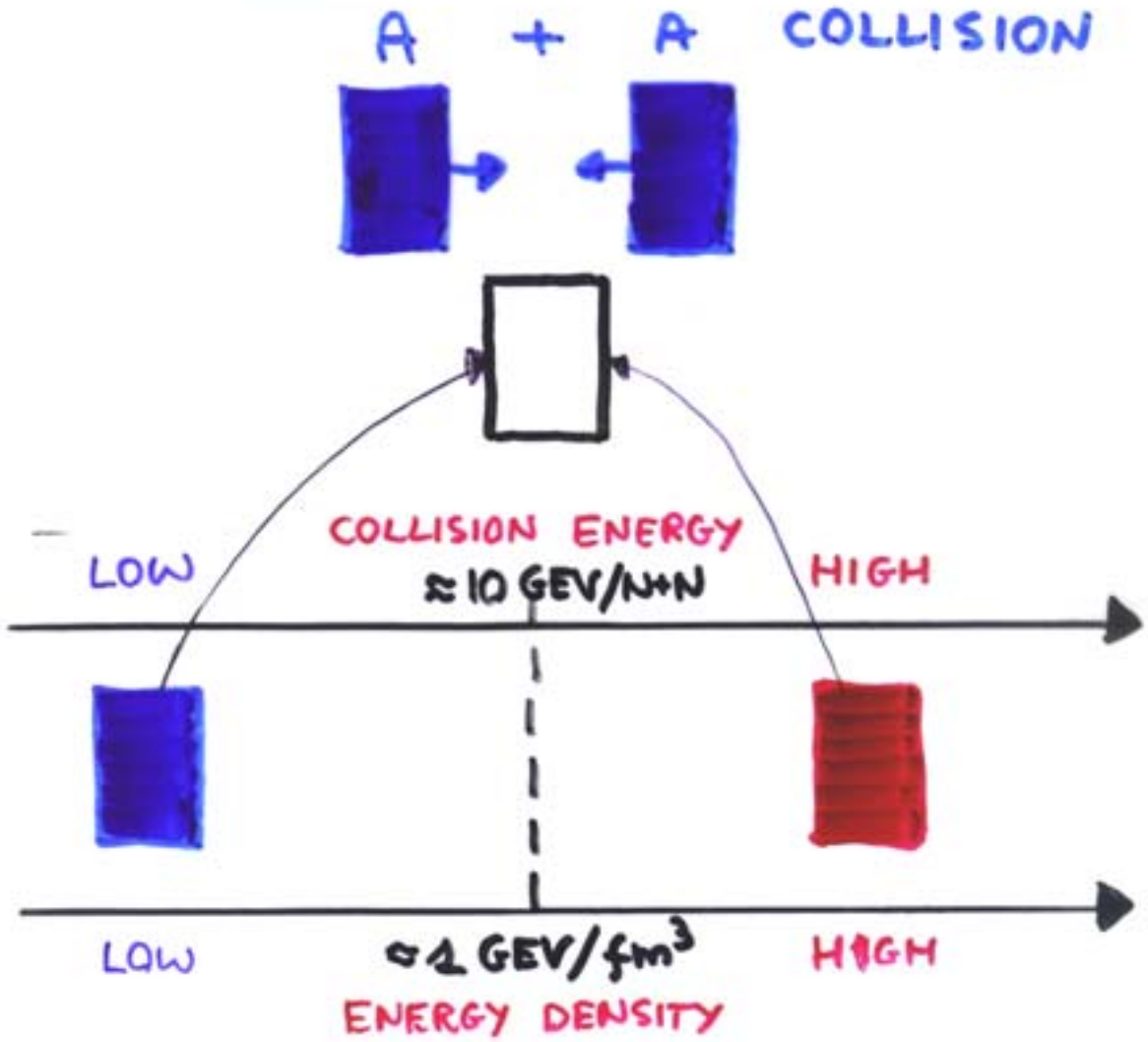
BASIC IDEA



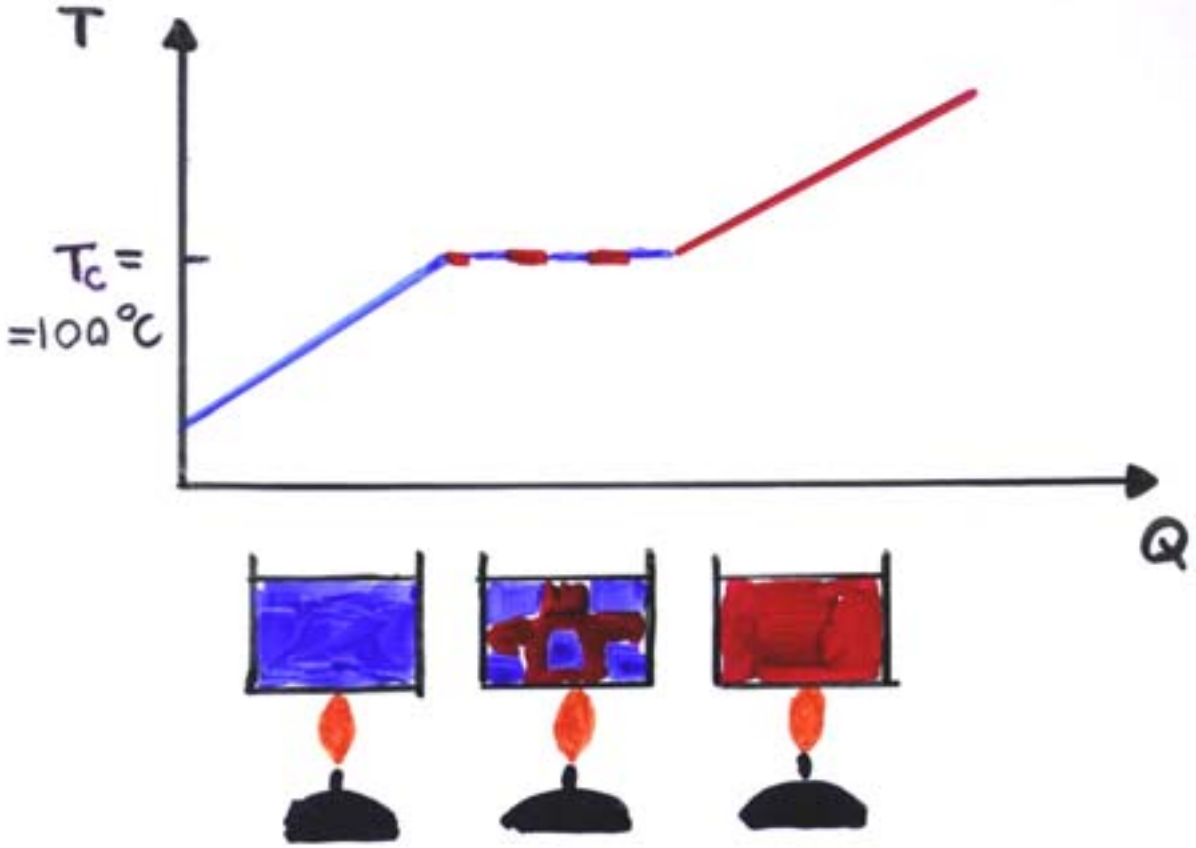
DEGREES OF FREEDOM

HADRONS

QUARKS AND GLUONS

IN THE CASE OF TRANSITION ONE EXPECTS ANOMALIES IN THE ENERGY DEPENDENCE OF THE RELEVANT OBSERVABLES

A SIMPLE ANALOGY:



SIGNALS OF DECONFINEMENT

BASIC DATA:

NA49 AT CERN SPS

ENERGY SCAN PROGRAM AT CERN SPS

+ AGS

+ RHIC

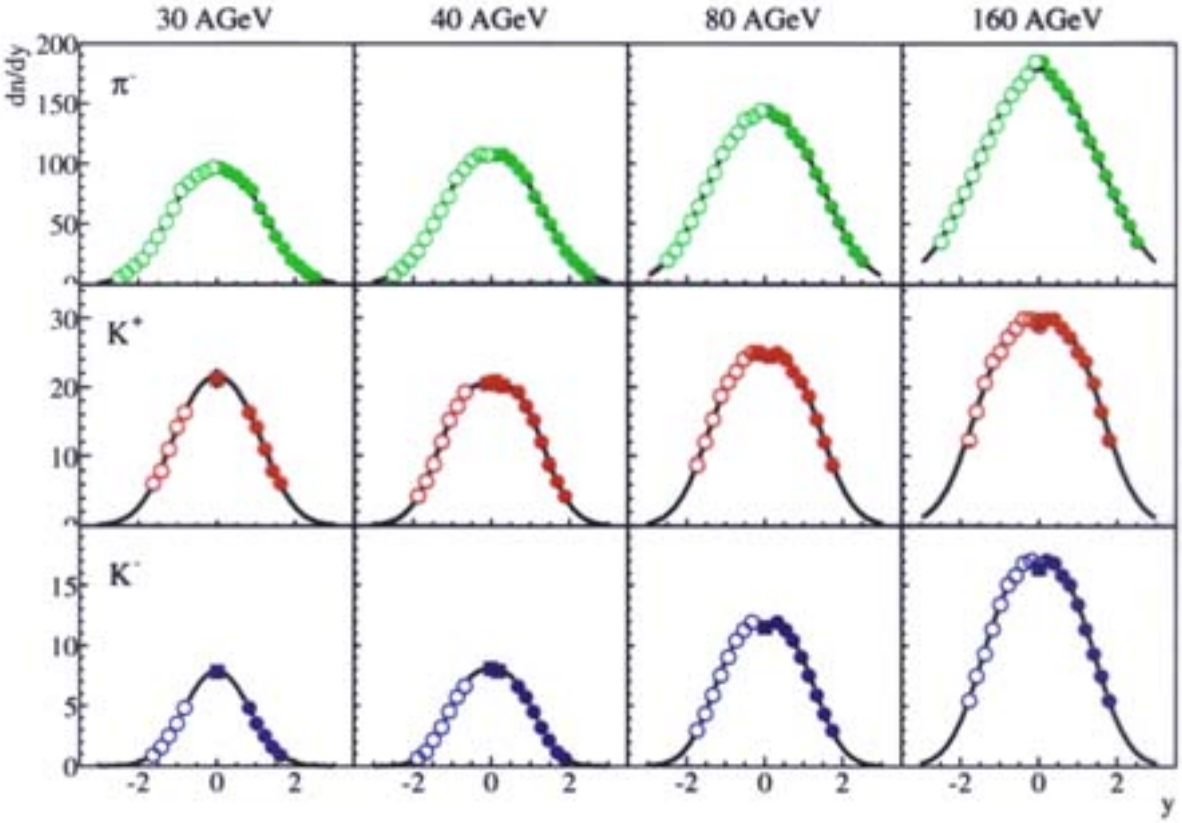
BASIC IDEAS:

STATISTCAL MODEL OF THE EARLY STAGE (SMES)

M. G., M. I. GORENSTEIN

ACTA PHYS. POLON. B30 (99) 2705

CENTRAL PB + PB AT:



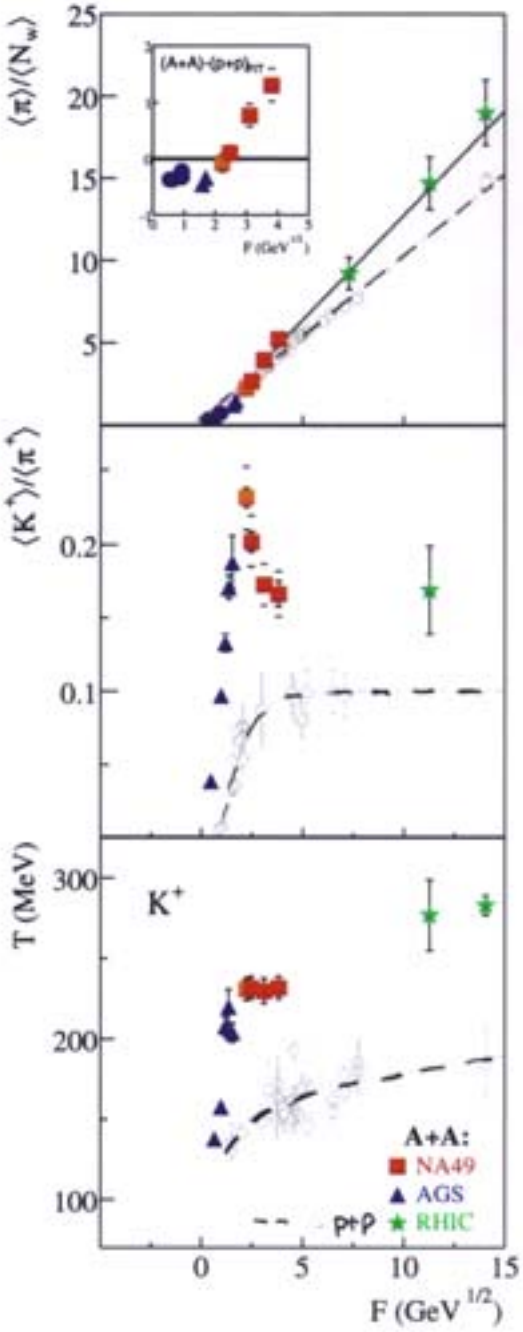
FULL - MEASURED

OPEN - REFLECTED

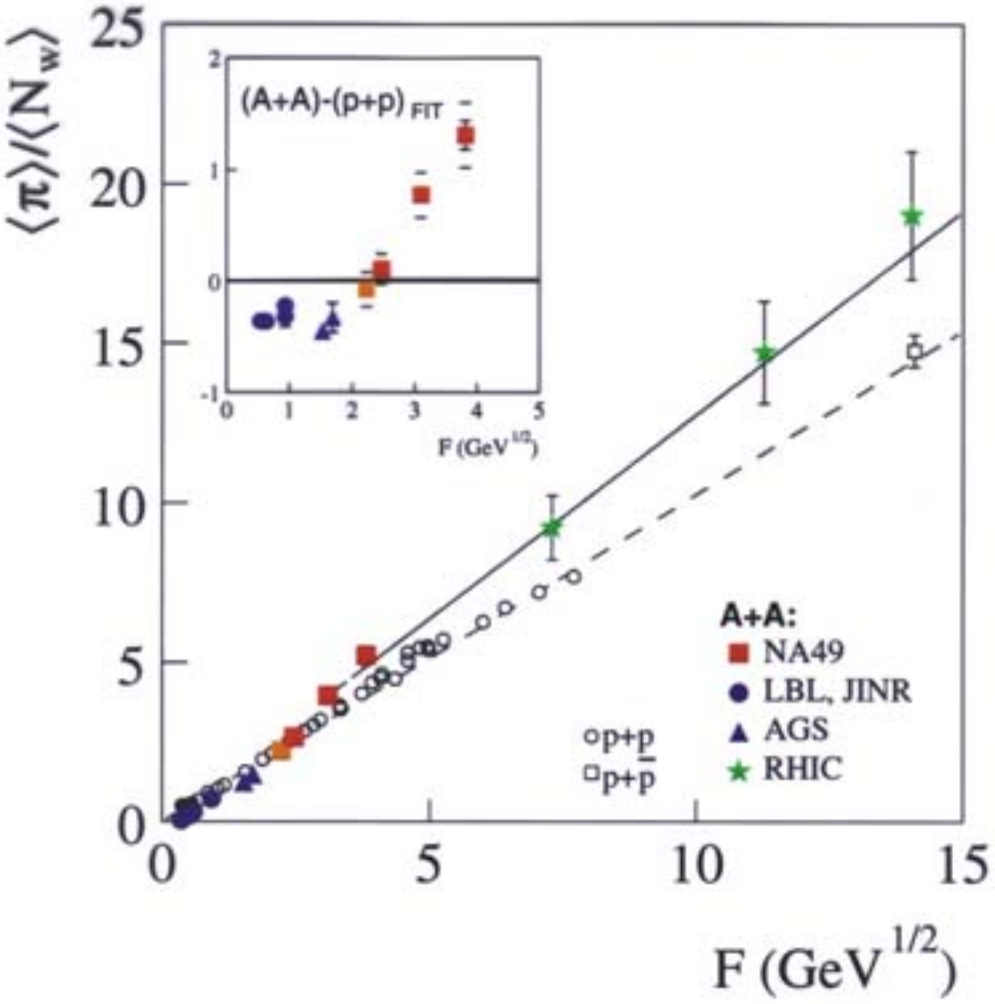
THE PION KINK

SIGNALS OF DECONFINEMENT

- THE PION KINK:
- THE STRANGE HORN:
- THE STEP IN SLOPES:



$F \approx \sqrt{s_{NN}}$



$\approx \sqrt{\sqrt{s_{NN}}}$

$\langle \pi \rangle \equiv \frac{3}{2}\left(\langle \pi^+ \rangle + \langle \pi^- \rangle\right)$

$\langle N_w \rangle \equiv$ MEAN NUMBER OF WOUNDED NUCLEONS

THE PION KINK

DECONFINEMENT

⇓

AN INCREASE OF ENTROPY PRODUCTION

DUE TO HIGH NUMBER OF EFFECTIVE DEGREES OF FREEDOM IN QGP, g

$\langle \pi \rangle \sim$ ENTROPY

AN INCREASE OF PION YIELD AT THE ONSET OF DECONFINEMENT

WITHIN SMES:

$$\boxed{\langle \pi \rangle \sim g^{1/4} \cdot F} + \varepsilon$$

$$F \approx \sqrt{\sqrt{s_{NN}}}$$

M.G. Z. PHYS. C66(95)659

$\varepsilon < 0$ PION ABSORPTION DURING EXPANSION

A + A COLLISION AT $\sqrt{s}$

THE EARLY STAGE OF THE COLLISION

$E \sim \sqrt{s}$

$V \sim V_0/\gamma \sim (\sqrt{s})^{-1}$

$$\varepsilon \equiv \frac{E}{V} \sim (\sqrt{s})^2 ; \quad \varepsilon \sim g T^4$$

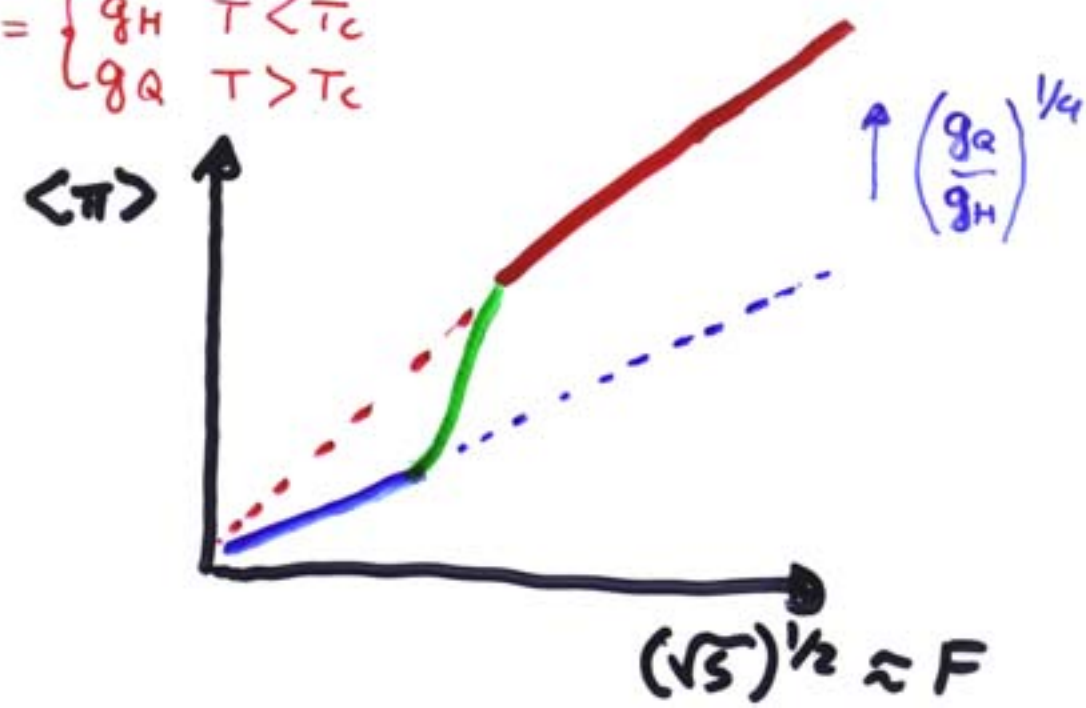
$$\Downarrow$$

$$T \sim g^{-1/4} \cdot (\sqrt{s})^{1/2}$$

$$\langle \pi \rangle \sim S \sim g \cdot V \cdot T^3 \sim g \cdot (\sqrt{s})^{-1} \cdot g^{-3/4} \cdot (\sqrt{s})^{3/2}$$

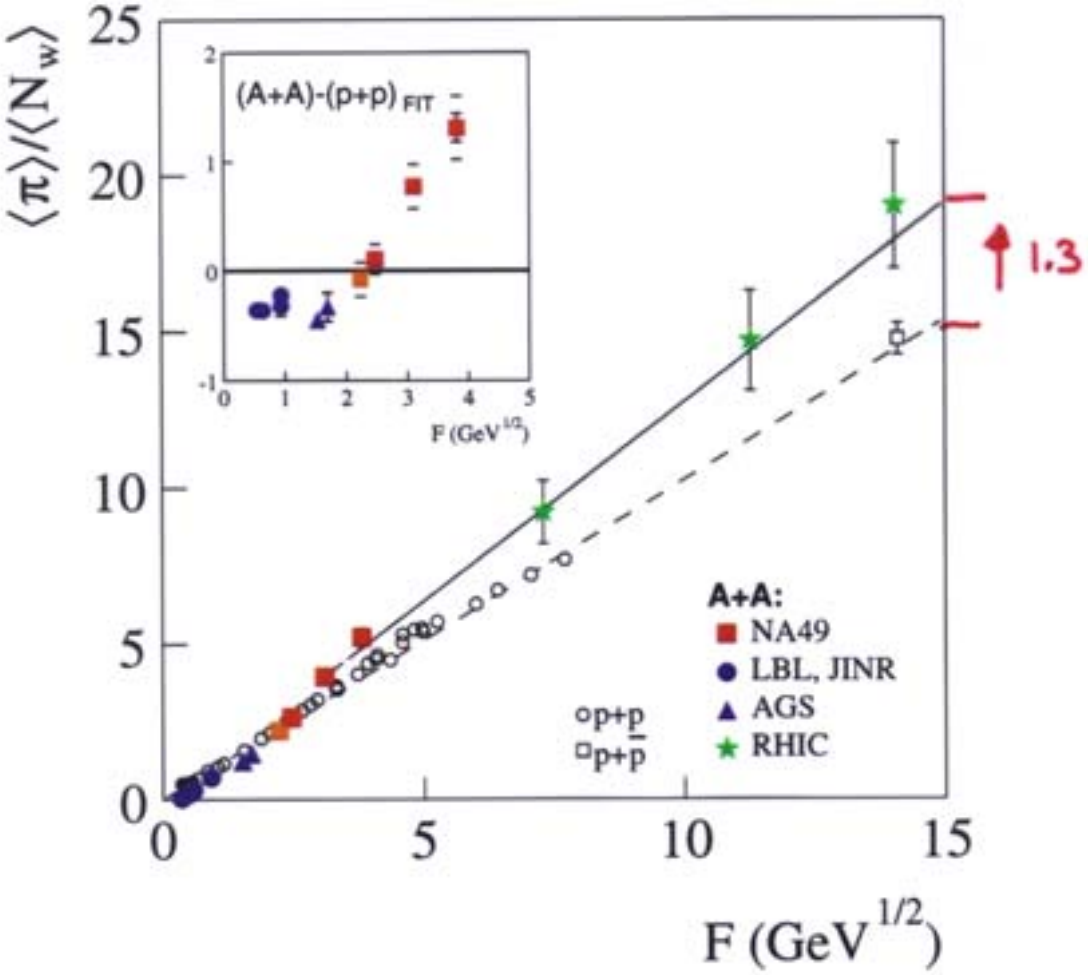
$$\langle \pi \rangle \sim g^{1/4} \cdot (\sqrt{s})^{1/2}$$

$$g = \begin{cases} g_H & T < T_c \\ g_Q & T > T_c \end{cases}$$



WITHIN SMES

ONSET OF DECONFINEMENT AT ≈ 30 AGEV



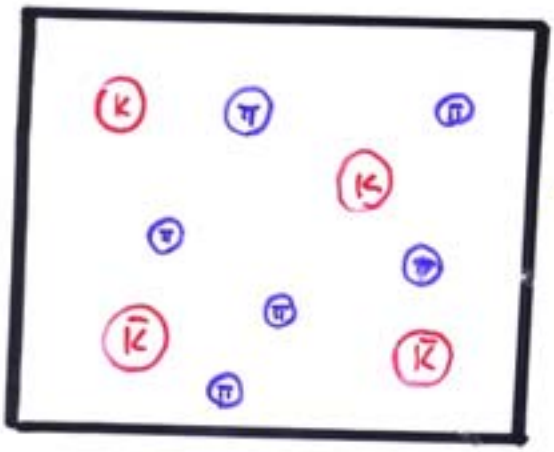
$$\frac{\varepsilon_{QGP}}{\varepsilon_{CONF}} \approx (1.3)^4 \approx 3$$

THE STRANGE HORN

STRANGE/NON STRANGE RATIO

HADRON GAS: $(K+\bar{K})/(\pi)$

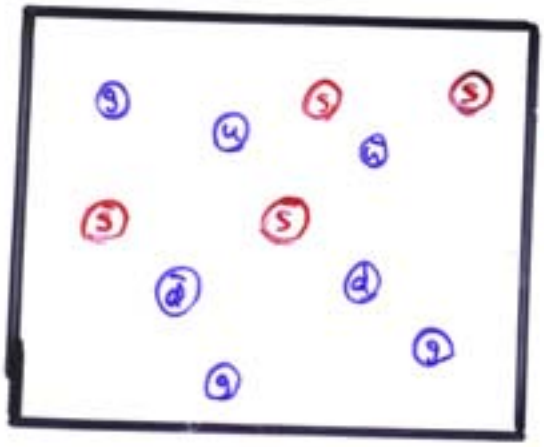
FOR $T \approx T_c$



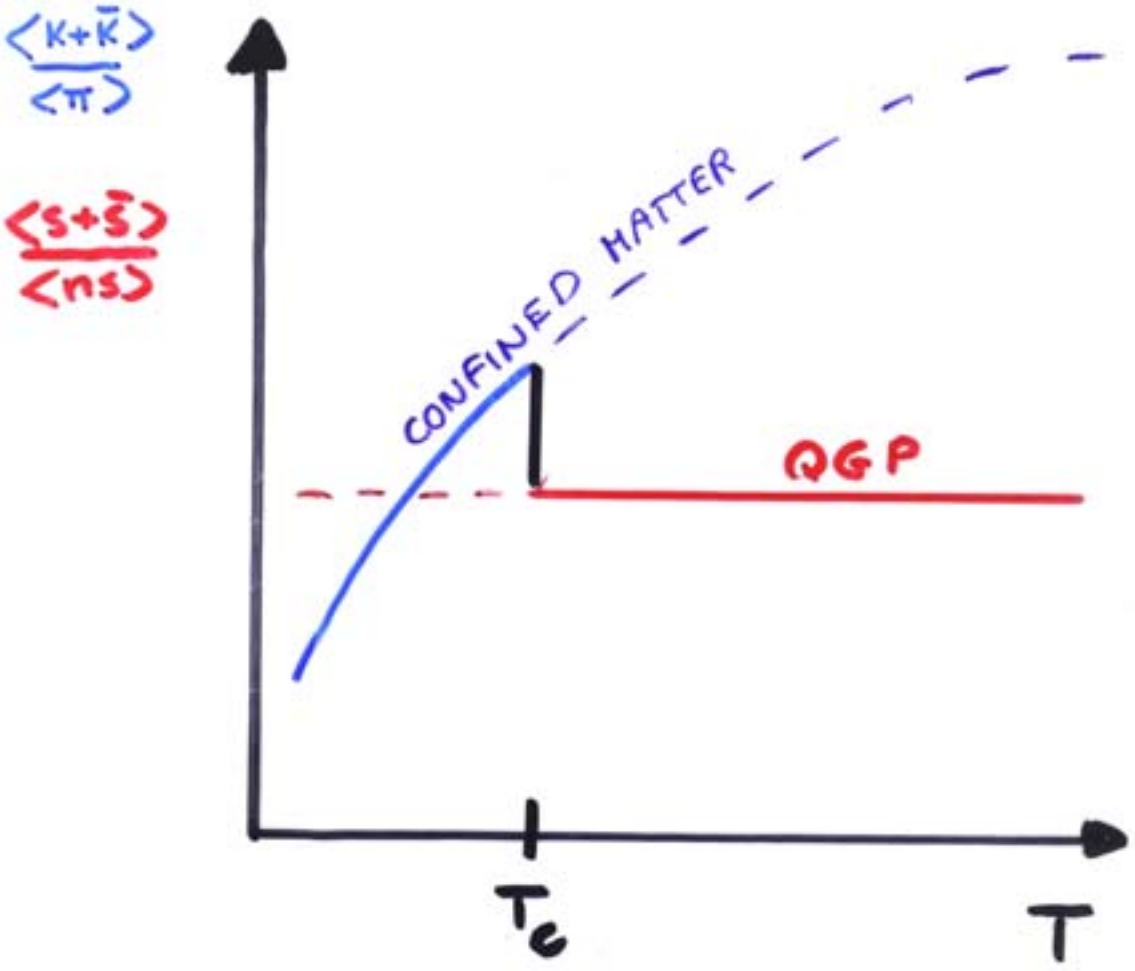
$$\frac{\langle K+\bar{K}\rangle}{\langle \pi \rangle} \sim \frac{g_K\, T^{3/2} e^{-m_K/T}}{g_\pi \cdot T^3}$$

QGP: $(s+\bar{s})/(g+u+\bar{u}+d+\bar{d})$

$T > T_c \quad (m_s < T)$

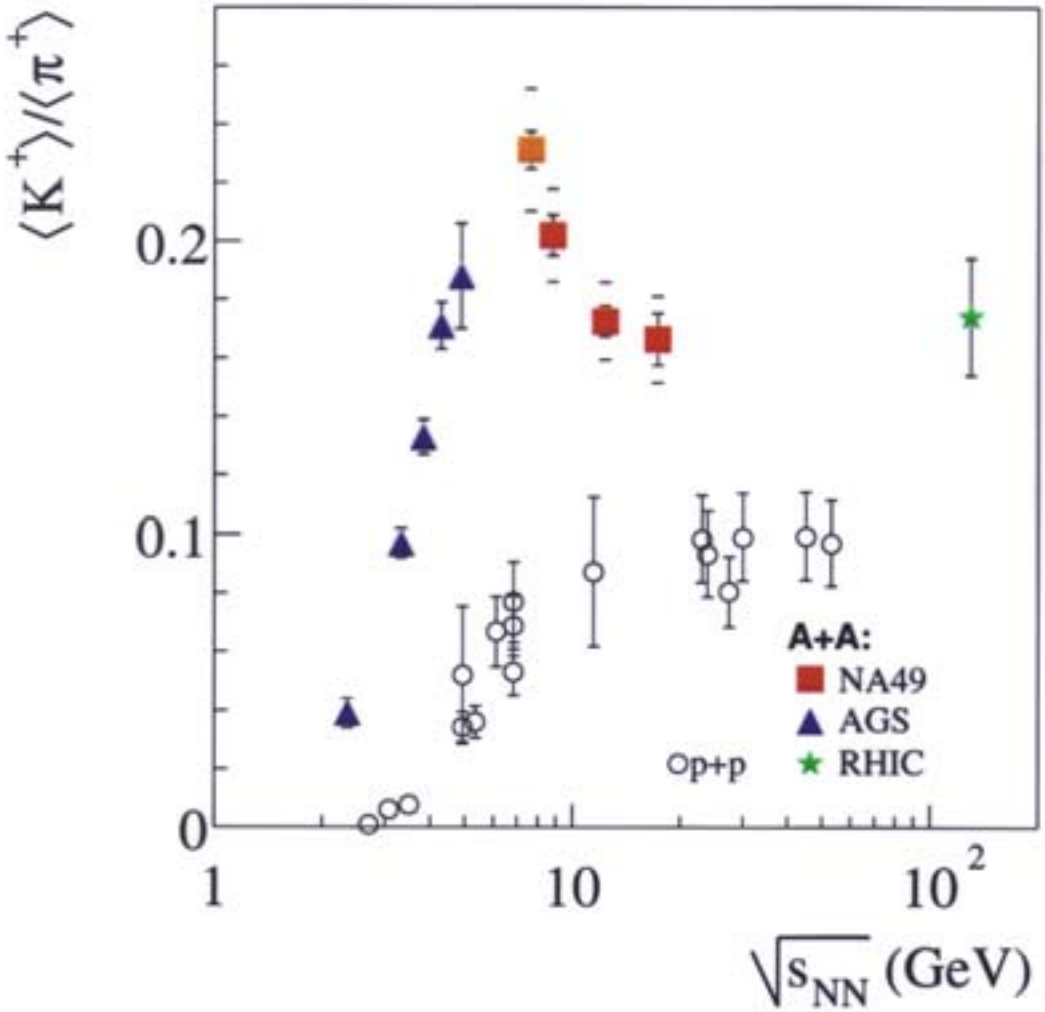


$$\frac{\langle s+\bar{s}\rangle}{\langle n_s \rangle} \sim \frac{g_s\, T^3}{g_{ns}\, T^3}$$

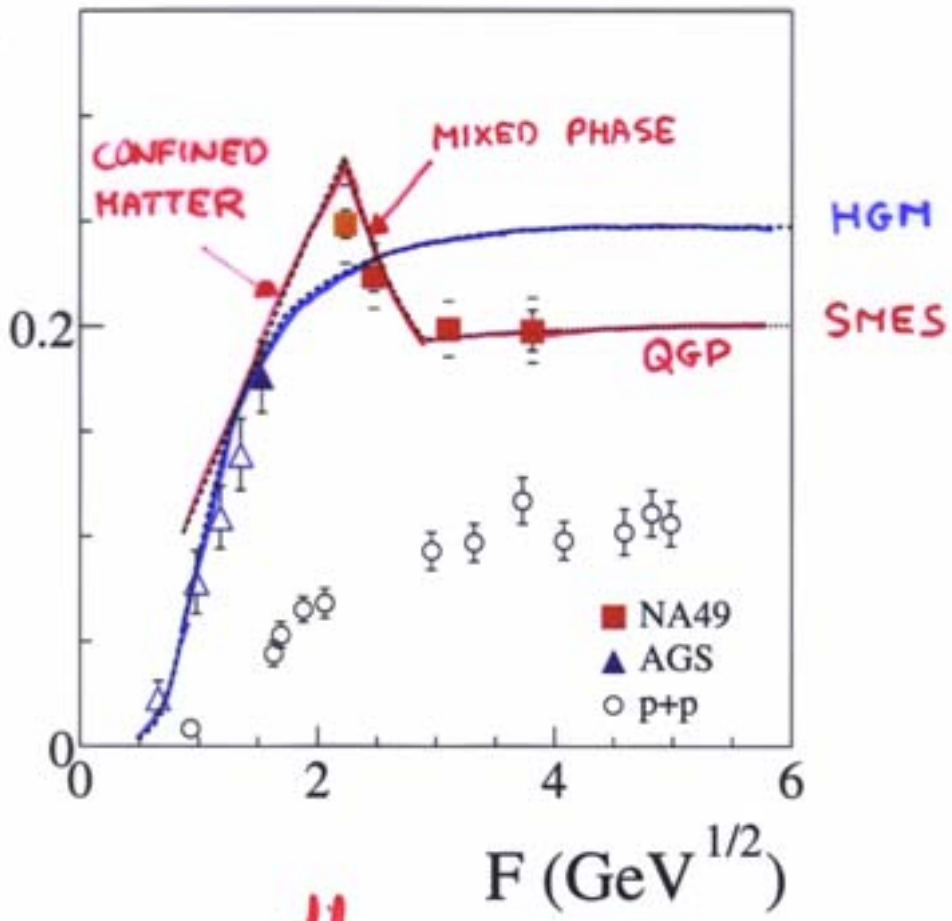


M.G., D. RÖHRICH, Z. PHYS. C71 (1996) 55

M.G., M.I. GORENSTEIN, APP B30 (1999) 2705


$\langle K^+\rangle/\langle\pi^+\rangle$
0.2
0.1
0
1
10
10^2
$\sqrt{s_{NN}}$ (GeV)
A+A:
NA49
AGS
RHIC
p+p

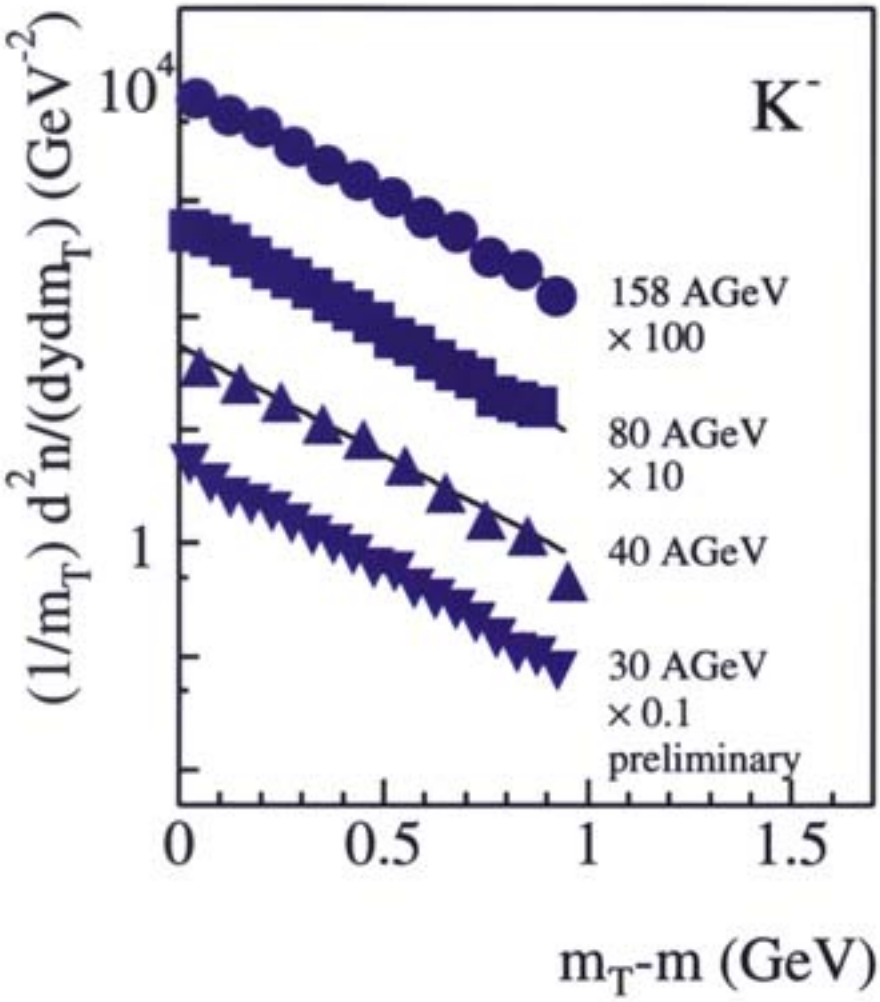
$$E_s^{III} = \frac{\langle \Lambda \rangle + \langle K + \bar{K} \rangle}{\langle \pi \rangle}$$

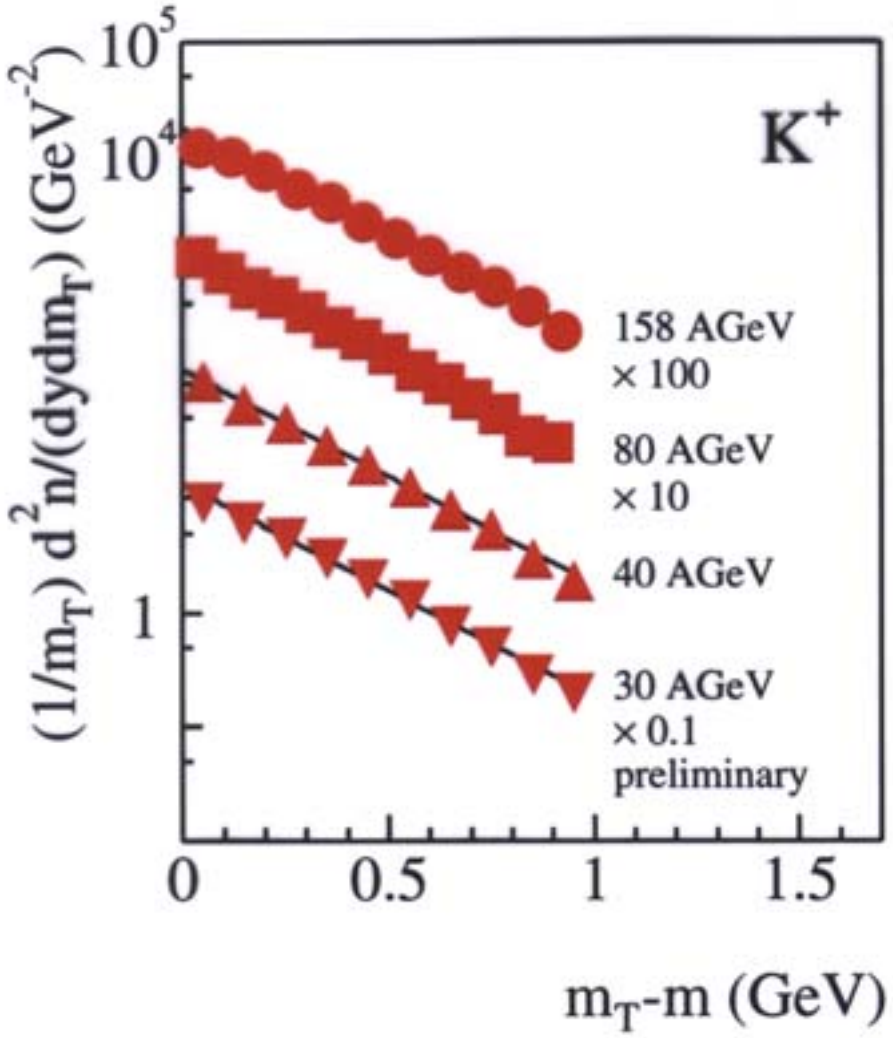


WITHIN SMES ONSET OF DECONFINEMENT AT ≈ 30 A·GEV

PROBLEMS OF MODELS WHICH DO NOT ASSUME PHASE TRANSITION E.G.: HADRON GAS MODEL BY CLEYMANS, REDLICH

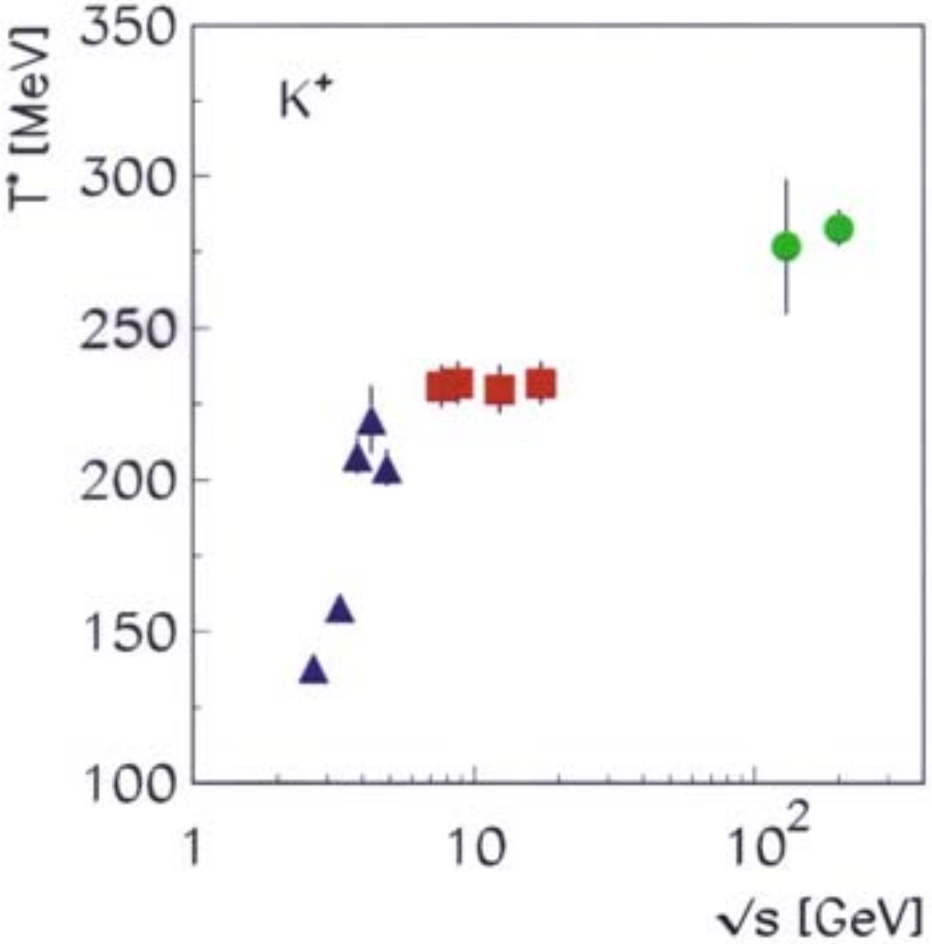
THE STEP IN SLOPES

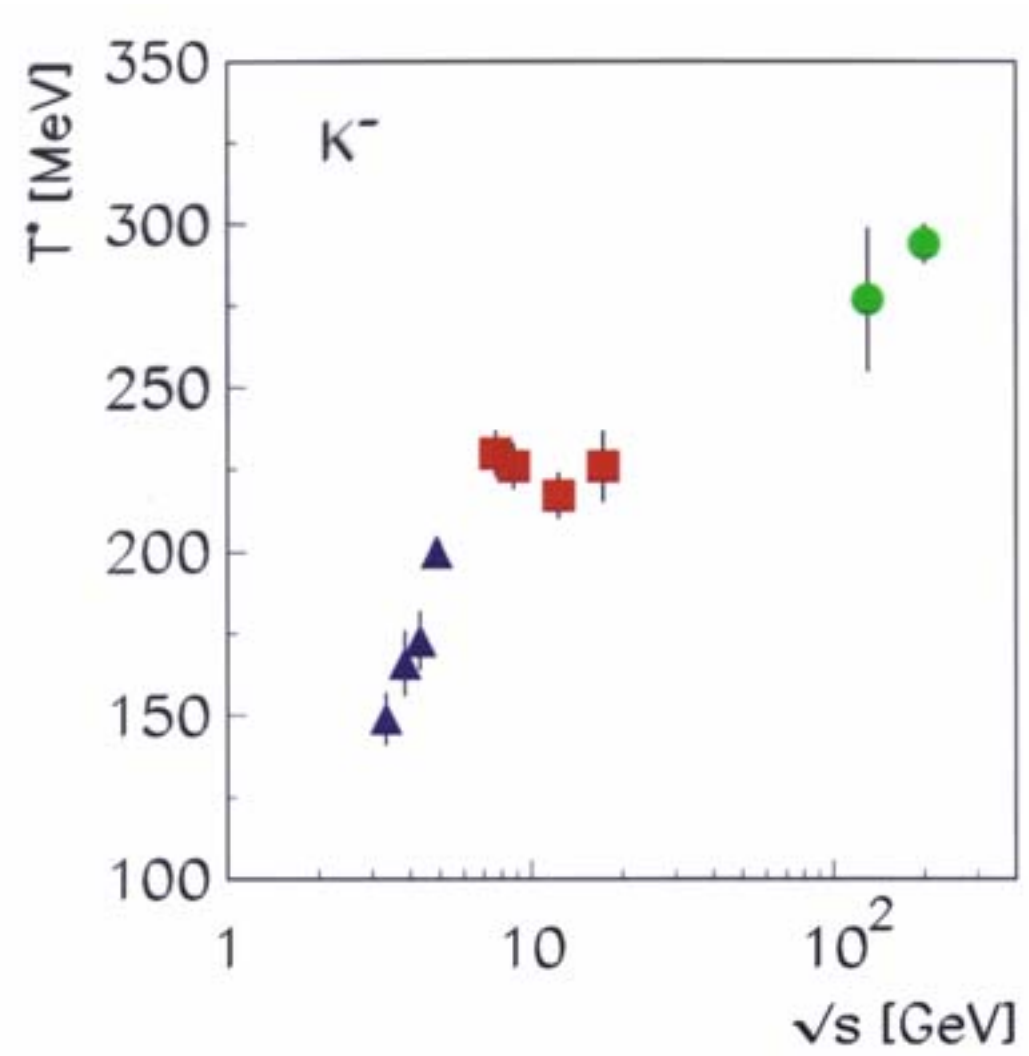



10^5
10^4
1
$(1/m_T)\, d^2n/(dydm_T)$ (GeV^{-2})
K^+
158 AGeV
× 100
80 AGeV
× 10
40 AGeV
30 AGeV
× 0.1
preliminary
0
0.5
1
1.5
m_T-m (GeV)

$$\frac{1}{m_T}\frac{dn}{dm_T} \sim e^{-m_T/T^*}$$

$$\left(m_T \equiv \sqrt{p_T^2 + m^2} \right)$$




T* [MeV]
350
300
250
200
150
100
K⁻
1
10
10²
√s [GeV]

THE STEP IN SLOPES

ONSET OF DECONFINEMENT

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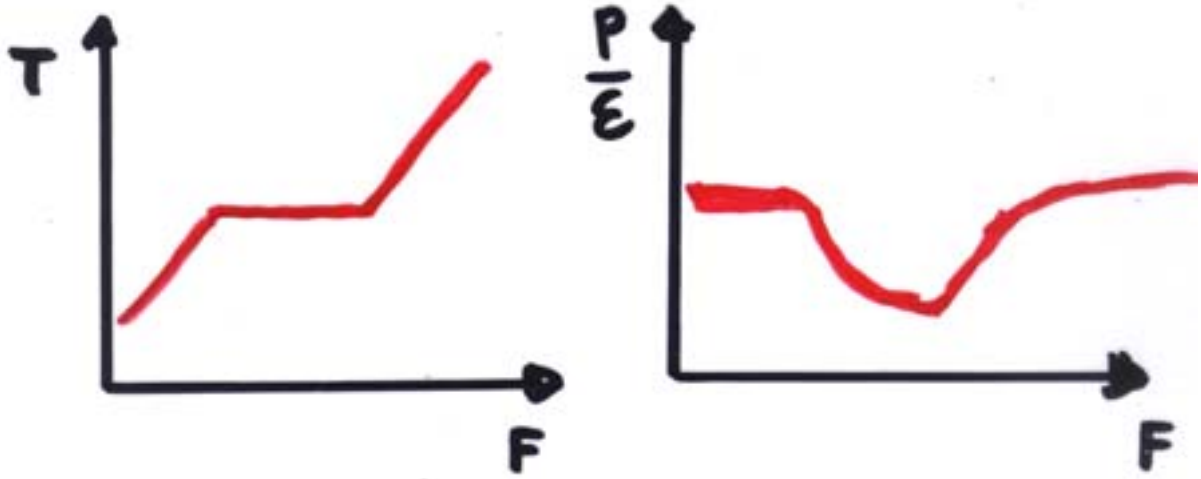
MODIFICATION OF EOS



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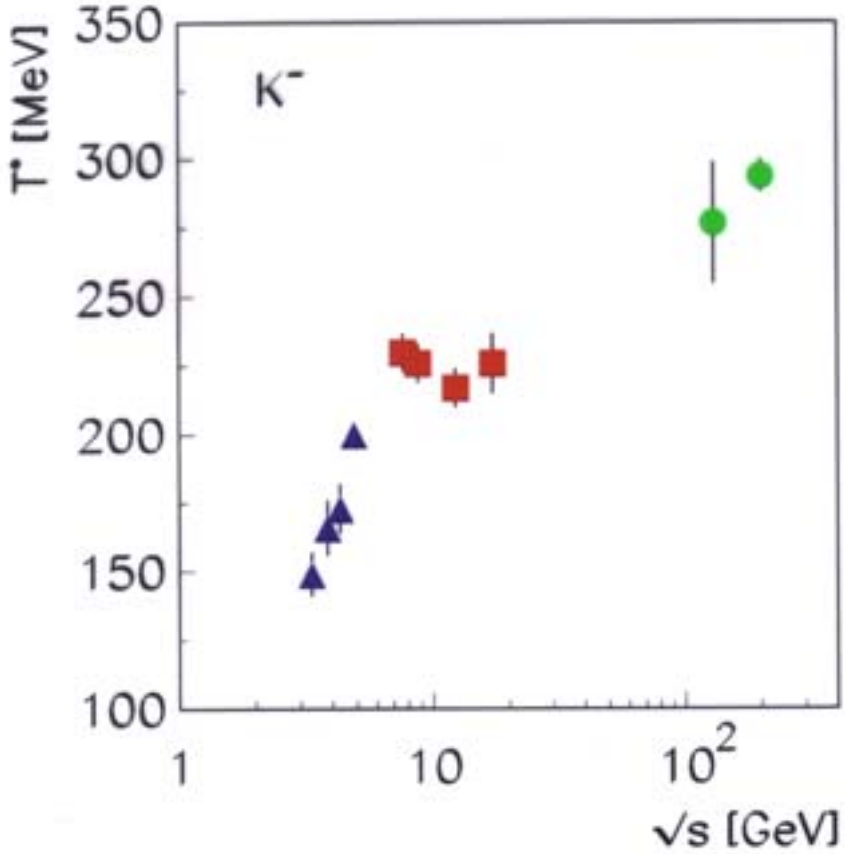
ANOMALY IN TRANSVERSE EXPANSION

L. Van Hove, PHYS. LETT.
B118, 138 (82)

$$\frac{1}{m_T}\frac{dn}{dm_T}\Big|_{y\approx 0} \sim e^{-m_T/T^*}$$



WITHIN SMES (QUALITATIVELY)

ONSET OF DECONFINEMENT AT ≈ 30 A GEV

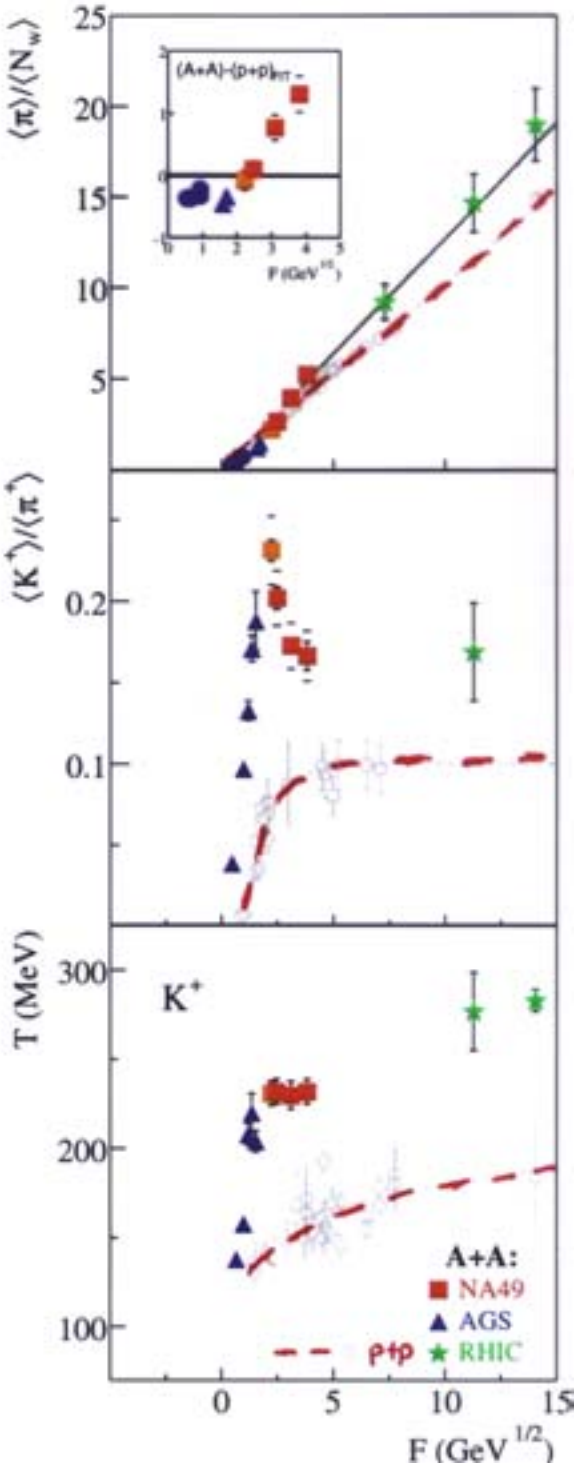
GORENSTEIN, M.G., BUGAEV,
hep-ph/0303041, to appear in PHYS. LETT.

SIGNALS OF DECONFINENENT

THE PION KINK:

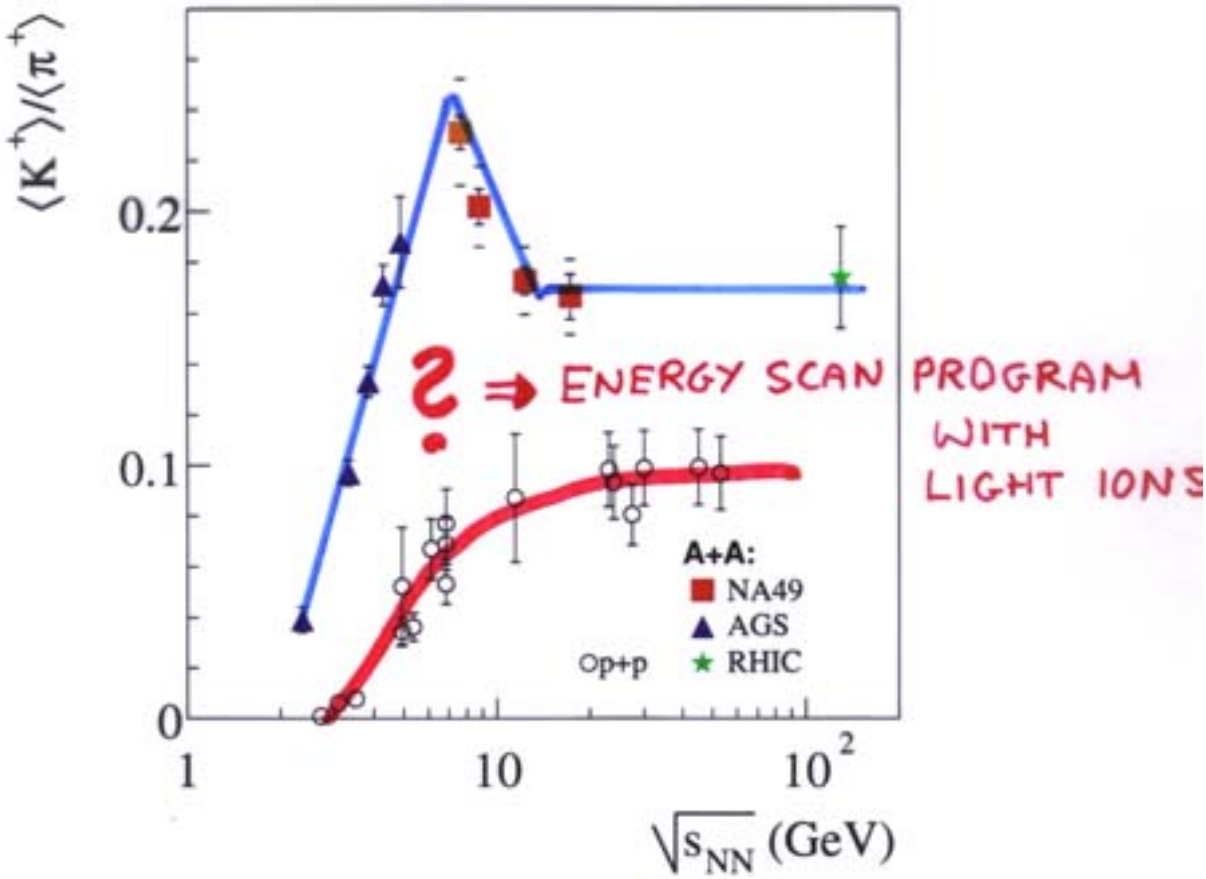
THE STRANGE HORN:

THE STEP IN SLOPES:



POSSIBLE NEW MEASURMENTS:
p+p, p+A, C+C, Si+Si .. at 10-200 A GEV

WE ARE LOOKING FOR NEW COLLABORATORS



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STUDY ONSET OF DECONFINEMENT AS A FUNCTION OF SYSTEM SIZE