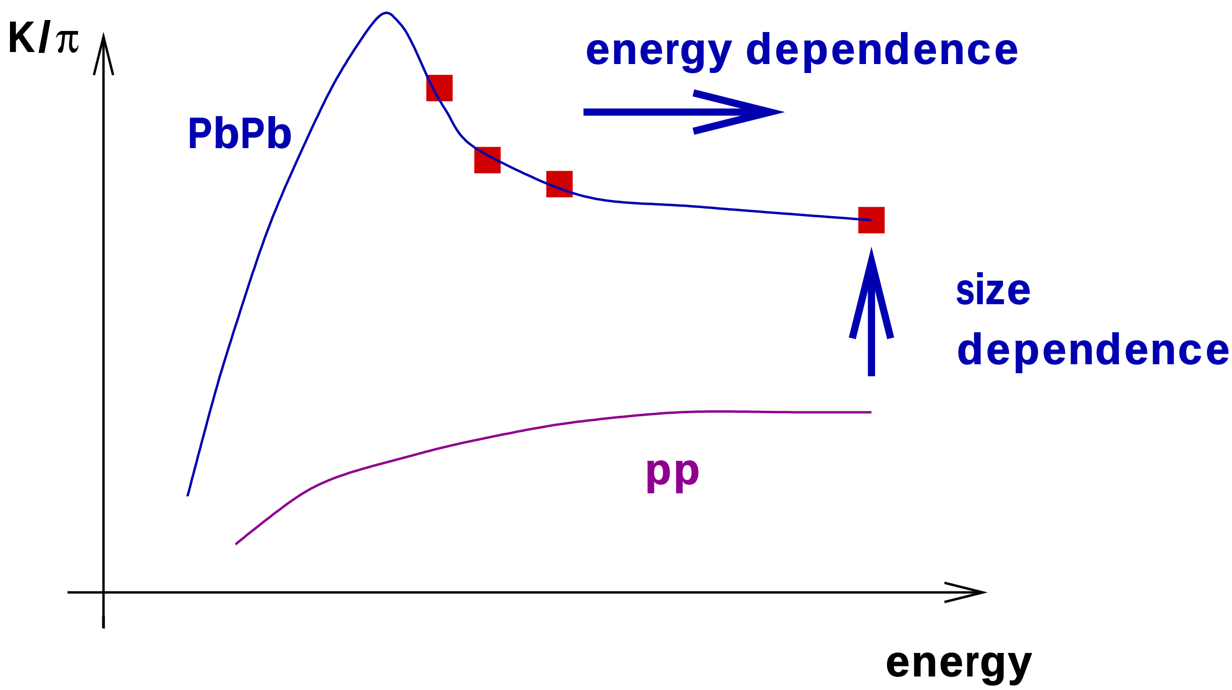
Publication on system size dependence of strangeness production at 160 A GeV

Two approaches to study the transition into deconfinement:



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Publication on

System size dependence of strangeness production .....

Draft for Letter circulated in editorial group
available from Claudia Höhne's group directory
thought as a basis for discussion

Experimental data to be presented:
π^{+-} K^{+-} ϕ Λ $\bar{\Lambda}$ in C+C and Si+Si
discussed together with p+p S+S Pb+Pb

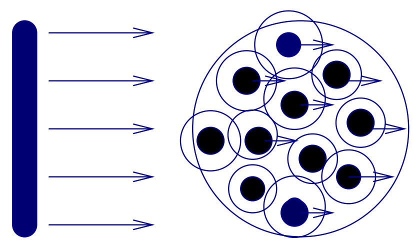
Main goal of the paper: to present an **interpretation**

Ideas:
- QGP
- canonical suppression
  Hagedorn - Rafelski - Redlich

What is canonical suppression ?

Application to our reactions
question: what is the nature of the thermally looking system ?
what phase of an AA collision is to be identified with it ?

- hadron gas picture: assumption: S determined in the hadronic phase
  counter-evidence: correction factor γ_S + ϕ $\bar{\Lambda}$
- partonic scenario:



target ref.frame

  - plausible/necessary to assume formation of coherent partonic subsystems by coalescence of resonances=strings=fireballs
  - statistical description of either the systems or their fragmentation (bridge to thermodynamics)
  - strangeness fraction determined here

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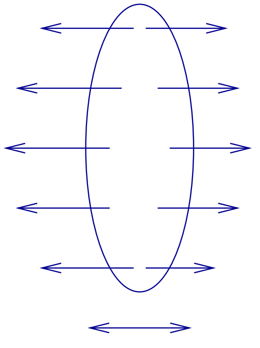
Semi-quantitative comparison

- theoretical saturation volume $V = (20 \pm 5)\ fm^3$
- expected size of coherent (sub-) volumes



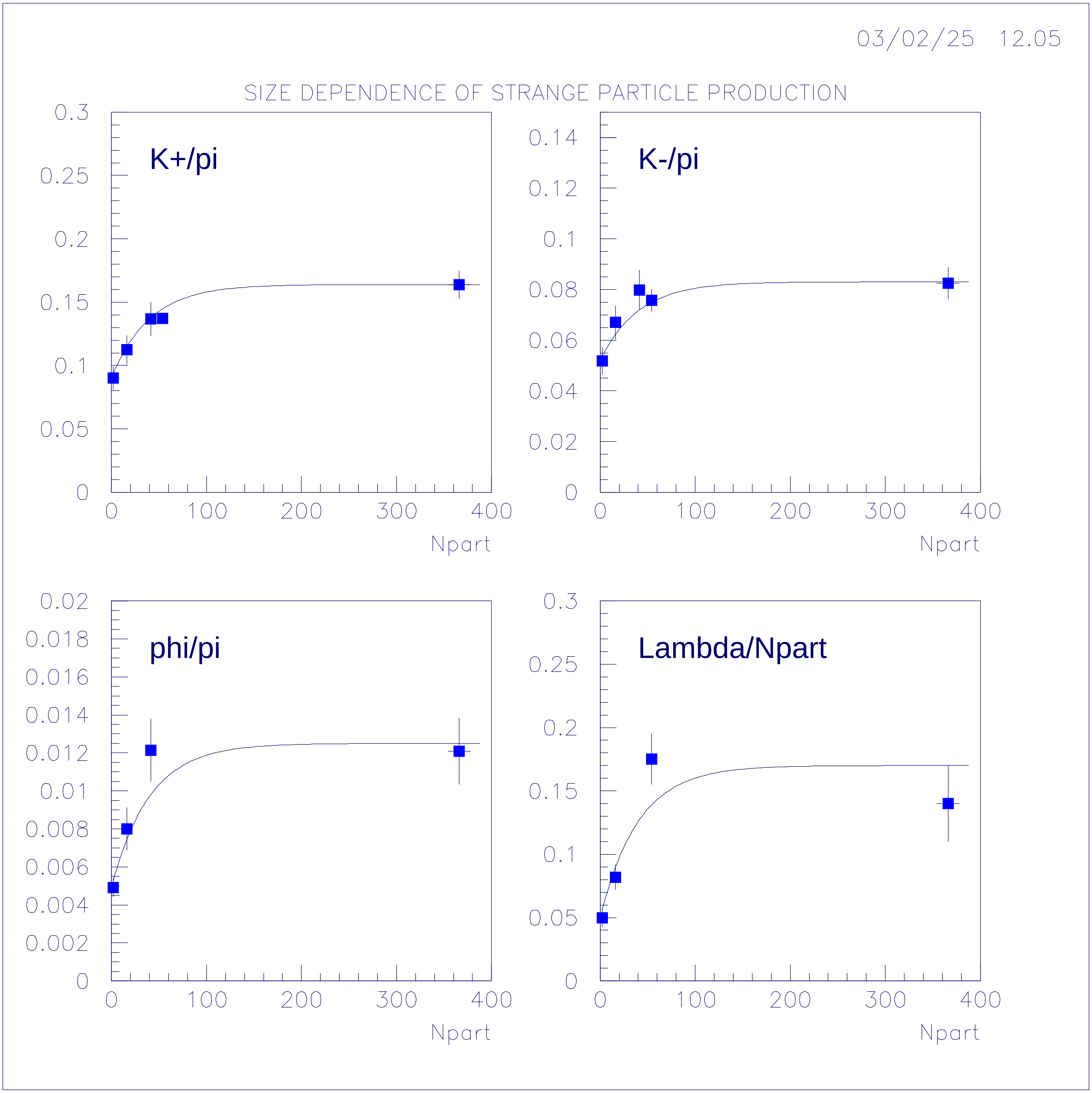
AA collision, A = 30, R = 3 fm
CMS of the collision, $\gamma = 9$

volume containing the primary NN collisions
$= \pi R^2 \cdot 1$ fm
after longitudinal expansion by +- 1 fm
$V = 80\ fm^3$ at hadronization
total volume ! not coherent because of rapidity spread

Estimate to be checked by UrQMD simulations (C. Höhne)

Outline of the discussion in the paper:

- assumption (no proof !): canonical suppression
- suggested model: formation of "coherent" partonic subsystems
- consistency between thermodynamic theory and
  estimated reaction volume
  no quantitative fit !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SIZE DEPENDENCE OF STRANGE PARTICLE PRODUCTION
K+/pi
K-/pi
phi/pi
Lambda/Npart
Npart
Npart
Npart
Npart

CANONICAL SUPPRESSION / ENHANCEMENT

Given: an equilibrated relativistic system of „non-interacting" particles, E, B, S, Q.. fixed

Goal: particle composition (+kinetic distr.)

Solution: statistical thermodynamics
canonical or grand-canonical ?
(treatment of conservation laws)
partition functions → observables

Aspect: strangeness production:
treated as an additional phase canonically,
the rest in grand-canonical approximation

Simplifying assumptions: Boltzmann statistics,
only a single strange species, e.g. $K\bar{K}$
(no resonances!)

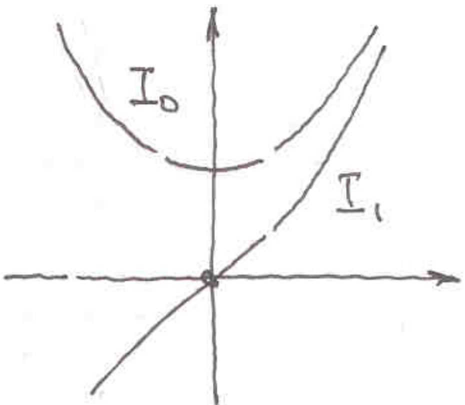
Result: analytical formula (Rafelski + Danos)

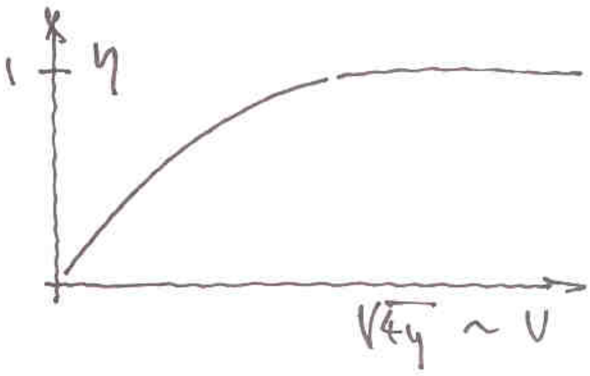
$$\langle n_{K\bar{K}} \rangle = \frac{I_1(\sqrt{4y})}{I_0(\sqrt{4y})} \cdot \frac{1}{2}\sqrt{4y}, \quad y = \left(\frac{VT^3}{2\pi^2}\right)^2 \left(\frac{m}{T}\right)^4 K_2^2\left(\frac{m}{T}\right)$$

$$\xrightarrow[\text{(large } V)]{y \gg 1} \sqrt{y} = \frac{VT^3}{2\pi^2}\left(\frac{m}{T}\right)^2 K_2\left(\frac{m}{T}\right) \xrightarrow{\frac{m}{T} \gg 1} V \cdot \left(\frac{mT}{2\pi}\right)^{3/2} e^{-m/T}$$

$$\xrightarrow{y \to 0} y = \text{square} \longrightarrow \ldots e^{-2m/T}$$

$$\frac{\langle n_{K\bar{K}} \rangle}{\langle \pi \rangle} \sim \left.\frac{I_1(\ldots V)}{I_0(\ldots V)}\right|_{m,T} = \text{canonical suppression f. } \eta$$





RAFELSKI + DANOS

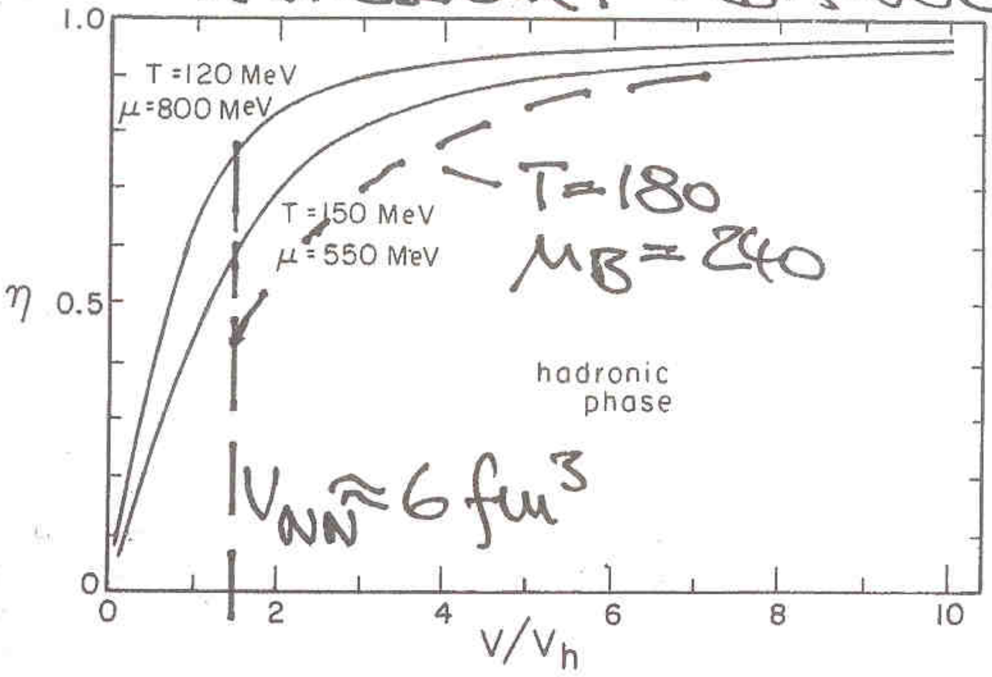


Fig. 1. The quenching factor η as a function of the reaction volume V in units of $V_h = \frac{4}{3}\pi(1\ \mathrm{fm})^3$, for two temperatures.

$= 4.2\ \mathrm{fm}^3$

RAFELSKI + DANOS

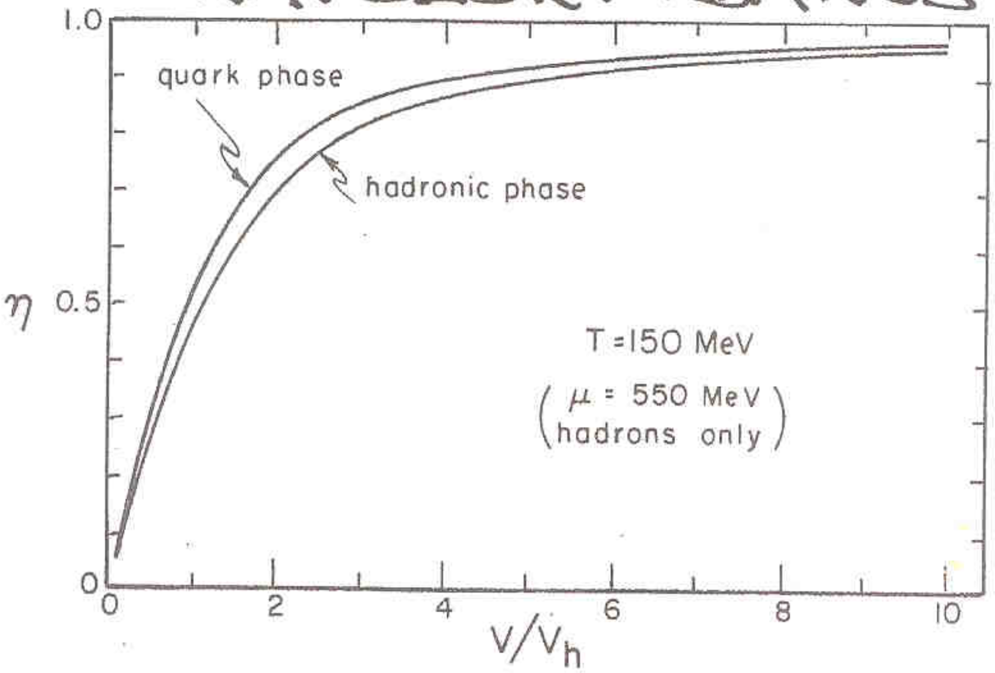


Fig. 2. Comparison of the quenching factors for hadronic and quark phases for $T = 150$ MeV.

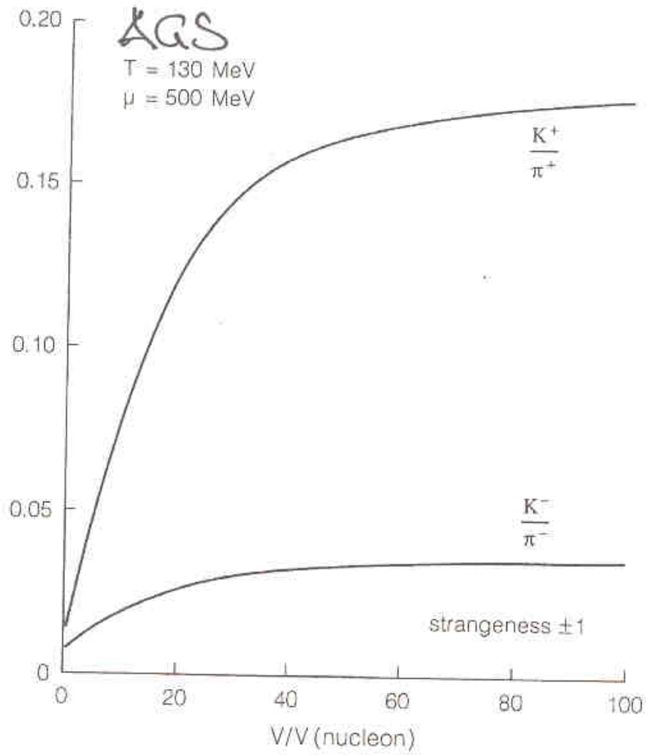


Fig. 1. K^+/π^+ and K^-/π^- ratios in a hadronic gas model as a function of the interaction volume normalized to the volume of the nucleon. The gas contains only particles having strangeness zero and ± 1. Strangeness conservation is exact

Cleymans Redlich Suhonen
Z. Phys. C 51 (1991) 137

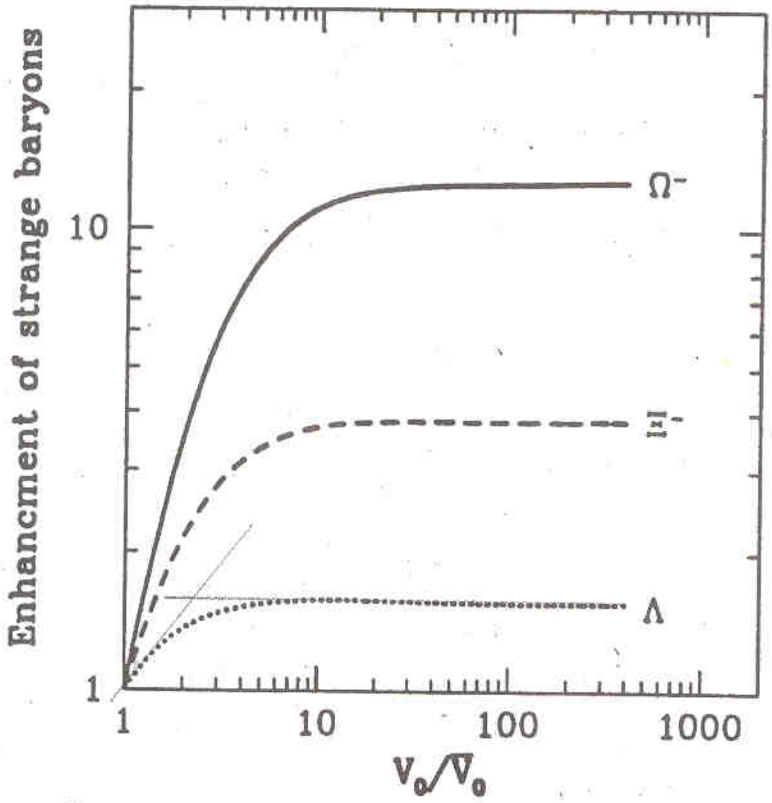
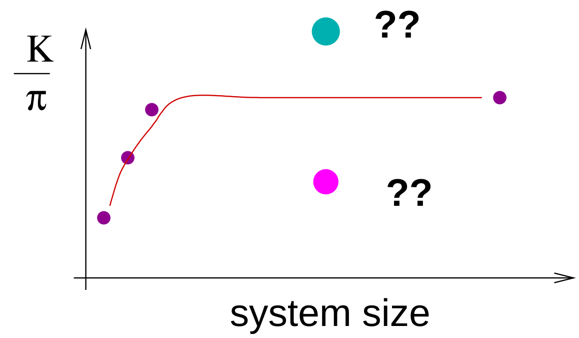


Fig. 1. Volume dependence of strange baryon densities normalized to their value calculated in $V_0 = \overline{V}_0 = 7.4\ \text{fm}^3$ for $T = 168$ MeV and $\mu = 266$ MeV. Hamieh, Tounsi, Redlich
Phys Lett B 486 (2000) 61

Comments (P. Seyboth, R. Stock, V. Friese)



- no proof of saturation behavior by the data
  however: given the present data + the theoretical ideas, saturation = most plausible scenario

- N_w instead of N_{part} on the abscissa

- inconsistencies of hadronic scenario:
  ϕ / π should not show canonical suppression
  Λ / π should show stronger effect than kaons

- canonical suppression should act differently in partonic and in hadronic scenarios
  m(K) = 500 m(π) = 140 m(s) = 460 m(u/d) = 310 MeV (constituent)

- not the partonic system itself (its u : d : s : g ratio), but the **process** of hadronization is to be described in a statistical way ! (contradiction to theoreticians)

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