Strangeness and QGP

CERN, HIF March 13, 2006

We explore the role of strangeness in the properties and observables of the QGP phase. Chemical over saturation of strangeness degree of freedom may influence the nature of, and location of the phase boundary between deconfined and confined phases. Kinetic calculations of strangeness production tuned to describe RHIC results indicates that this may occur at LHC. We will further discuss the soft hadron and heavy flavor particle observables of strangeness in QGP.

OBJECTIVES:

1. **Introduction: nonequilibrium + phases of matter**
2. **Statistical hadronization – lessons from RHIC**
3. **Strangeness equilibration in QGP with expansion**
4. **Centrality dependence of s/S at RHIC-200 and LHC**
5. **Soft strange hadrons at RHIC and LHC**

With Inga Kuznetsova, Jean Letessier, and Giorgio Torrieri

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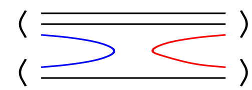
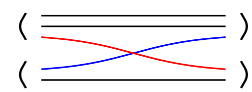
1. Chemical Non-equilibrium

FOUR QUARKS: $s, \bar{s}, q, \bar{q} \rightarrow$ FOUR CHEMICAL PARAMETERS

γ_i controls overall abundance of quark $(i = q, s)$ pairs	**Absolute** chemical equilibrium	HG production 
$\lambda_i = e^{\mu_i/T}$ controls difference between strange and light quarks $(i = q, s)$	**Relative** chemical equilibrium	HG exchange 

See Physics Reports 1986 Koch, Müller, JR

Boltzmann gas: $\gamma \equiv \frac{\rho(T,\mu)}{\rho^{\rm eq}(T,\mu)}$

DISTINGUISH: hadron 'h' phase space and QGP phase parameters: micro-canonical variables such as baryon number, strangeness, charm, bottom, etc flavors are continuous, and entropy is almost continuous across phase boundary:

$$\gamma_s^{\rm QGP}\rho_{\rm eq}^{\rm QGP}V^{\rm QGP} = \gamma_s^{\rm h}\rho_{\rm eq}^{\rm h}V^{\rm h}$$

Equilibrium distributions are different in two phases and hence are densities:

$$\rho_{\rm eq}^{\rm QGP} = \int f_{\rm eq}^{\rm QGP}(p)dp \neq \rho_{\rm eq}^{\rm h} = \int f_{\rm eq}^{\rm h}(p)dp$$

QGP fireball subject to rapid expansion and fast hadronization

For the past 15 years experiments demonstrate symmetry of $m_\perp$ spectra of strange baryons and antibaryons in baryon rich environment.

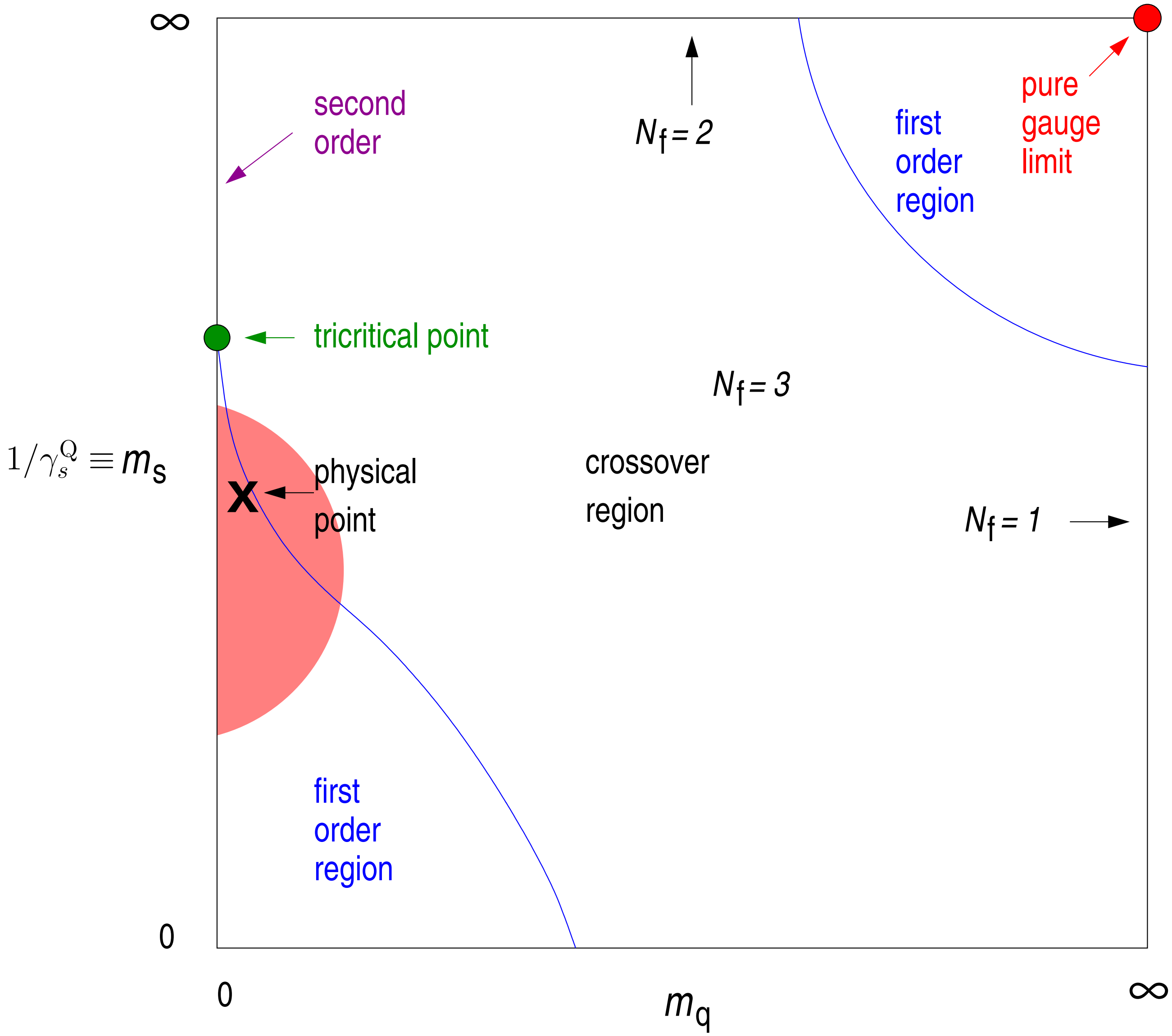
Interpretation: Common matter-antimatter particle formation mechanism, little antibaryon re-annihilation in sequel evolution.

Appears to be free-streaming particle emission by a quark source into vacuum. Such fast hadronization confirmed by other observables: e.g. reconstructed yield of hadron resonances. Note: within HBT particle correlation analysis: nearly same size pion source at all energies. **WHERE IS ONSET OF fast hadronization as function of $\sqrt{s_{\rm NN}}$? At the NA49 K^+/π^+ horn?**

We expect chemical nonequilibrium in final state $\gamma_i \neq 1$;
"Just an argument or is there some physics"?

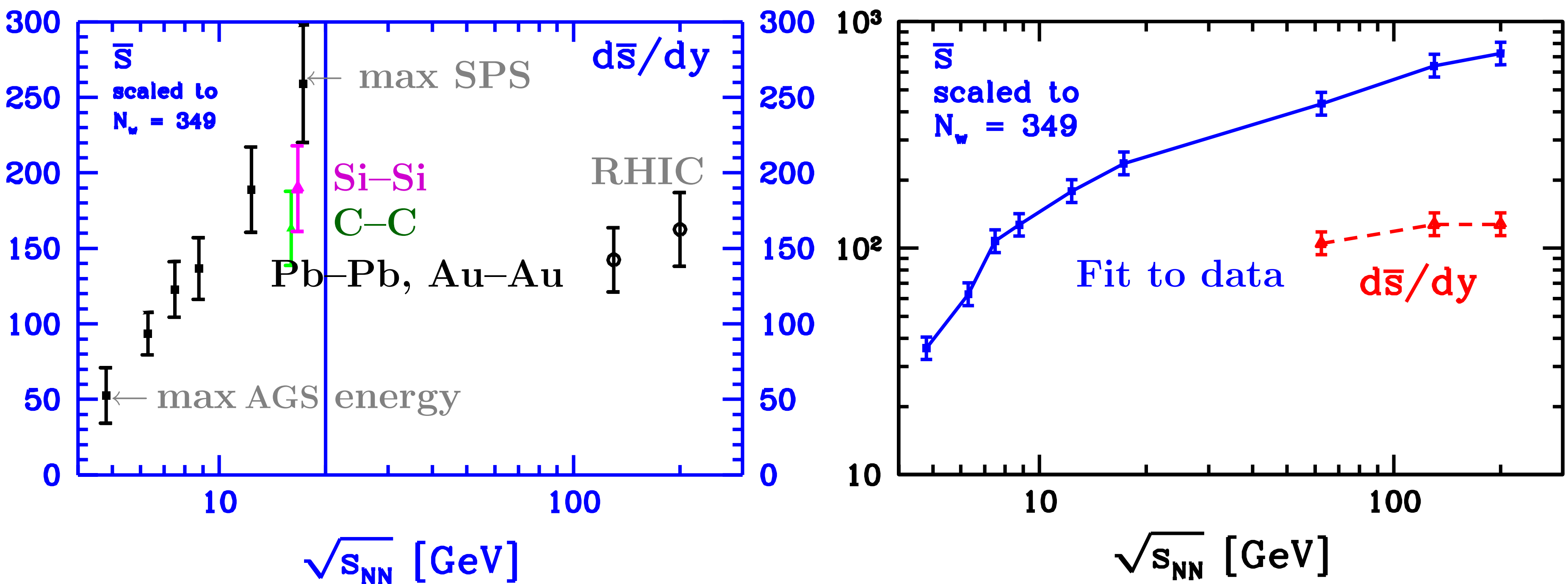
- **Shift in hadron yields between**
  a) baryons $\propto \gamma_q^3$ and mesons $\propto \gamma_q^2$: $\frac{\rm baryons}{\rm mesons} \propto \gamma_q$; $\frac{\rm strange\ \ hadrons}{\rm non-strange\ \ hadrons} \propto \gamma_s/\gamma_q$;
  b) shift in relative yields of CHARMED HADRONS (tomorrow).
- **Strangeness over-saturation $\gamma_s^{\rm H} > 1$ is a diagnostic signature of deconfinement.**
- **Chemical non-equilibrium quark 'occupancy' γ_s can favor /disfavor onset of phase transition. What $\mu_{\rm B}$ can do, γ_i can do better as both quark and anti-quark number increase/decrease together.**

Phase boundary considering Fermi degrees of freedom



adapted from: "The three flavor flavor chiral phase transition with an improved quark and gluon action in lattice QCD", **A. Peikert, F. Karsch , E. Laermann, B. Sturm,**(LATTICE 98), in Nucl.Phys.Proc.Suppl.73:468-470,1999.**Chemical equilibrium of strangeness. What if $\gamma_s^{\rm QGP} < 1$?**

Experimental STRANGENESS EXCITATION FUNCTION



Temperature of phase transition depends on quark degrees of freedom

- **For 0 flavor theory $T > 200$ MeV**
- **For 2 flavors: $T \to 170$ MeV and 1st order turns into 2nd order**
- **For 2+1 flavors: $T = 162 \pm 3$ and appearance of minimum $\mu_{\rm B}$ we need extra quarks to reach a 1st order transition**
- **For 3, 4 flavors further drop in T.**

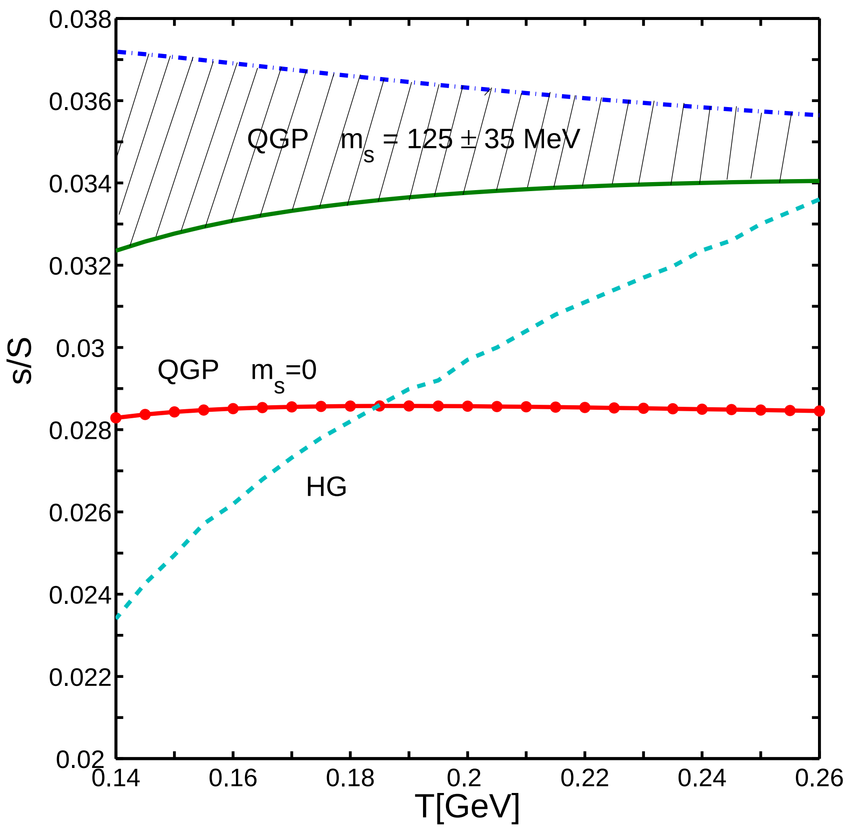
ACTUALLY: Not 2+1 but $2+\gamma_s^{\rm QGP}$, as function of energy $\gamma_s^{\rm QGP} \in (0.3, 1.5)$, $\gamma_s^{\rm QGP} > 1$ is a more effective help in creating a phase boundary than $\mu_{\rm B}$. For $\gamma_s^{\rm QGP} < 1$ (low energy collisions) need BIG $\mu_B(\gamma_s^{\rm QGP})$ to reach tri-critical point.

Smooth across the phase boundary are the yields
strangeness, charm, entropy = multiplicity
and hence ratios, we are interested in the observables:

$$\frac{s \text{ or } c}{S} = \frac{\text{number of valance strange, charm quark pairs}}{\text{multiplicity} = \text{entropy content in final state}}$$

And across any phase boundary when V does not adjust (and even in that case)

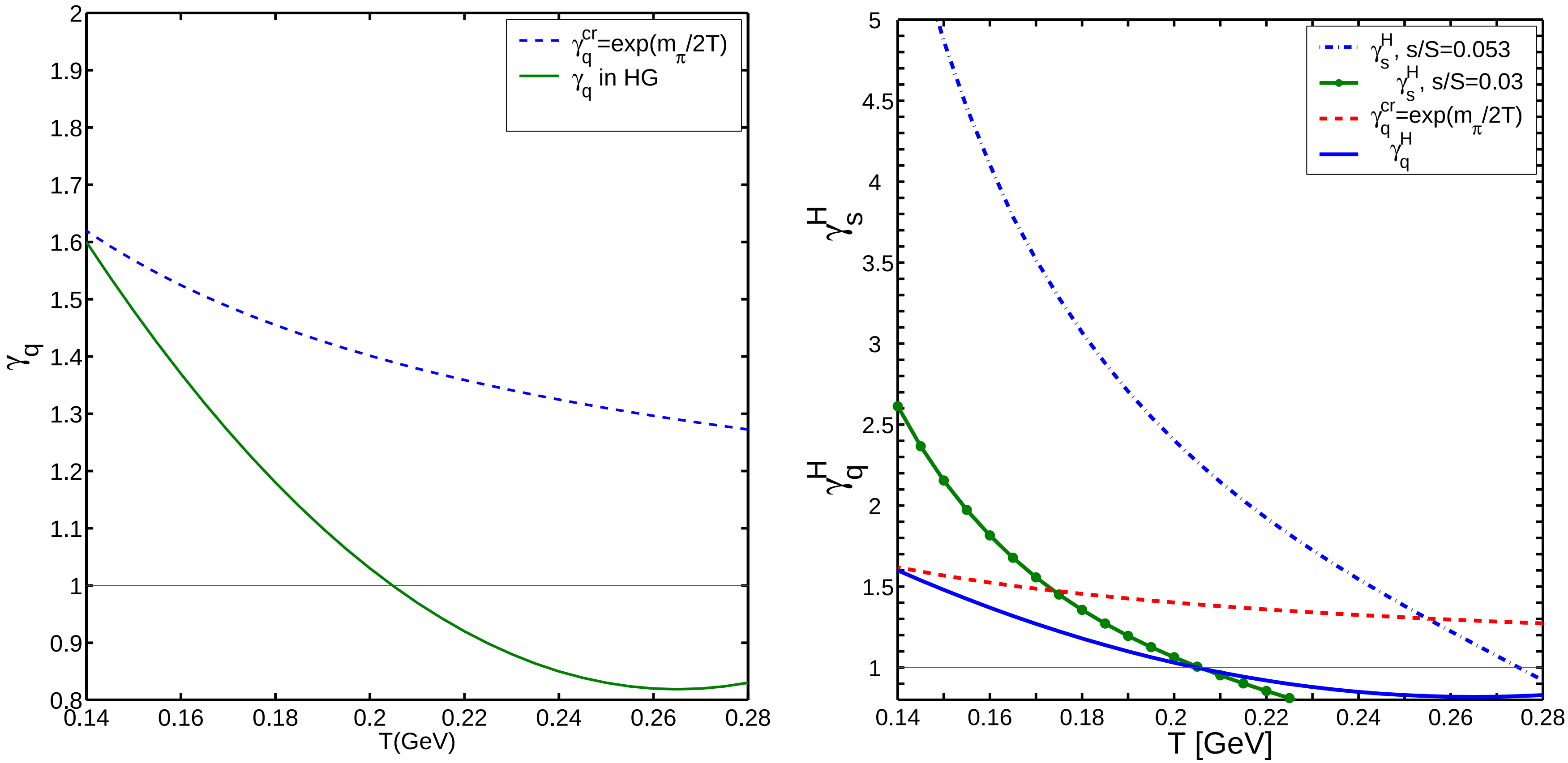
$$\gamma_s^{\rm QGP} \neq \gamma_s^{\rm h} \qquad \gamma_q^{\rm QGP} \neq \gamma_q^{\rm h}$$



Strangeness to entropy ratio s/S as function of temperature T, for the QGP (green, solid line for $m_s = 160$ MeV, blue dash-dot line for $m_s = 90$ MeV) with $k = 1$; and for HG (light blue,dashed line) phases for $\gamma_q = \gamma_s = \lambda_q = \lambda_s = 1$ in both phases. The line with points (red) corresponds to s/S obtained for $m_s = 0$.

Value of $s/S \simeq 1/30$ is ratio of strange to all degrees of freedom s/S greater in QGP compared to HG at same T = enhancement of strangeness at hadronization. The lowering of s yield for $m_s \to 0$ due to growth of perturbative QCD interaction.

QGP in chem equilibrium to hadron breakup at fixed V, S, and s



Strangeness / Entropy in QGP

Relative s/S yield measures the number of active degrees of freedom and degree of relaxation when strangeness production freezes-out. Perturbative expression in chemical equilibrium:

$$\frac{s}{S}=\frac{\frac{g_s}{2\pi^2}T^3(m_s/T)^2K_2(m_s/T)}{(g2\pi^2/45)T^3+(g_s n_{\rm f}/6)\mu_q^2 T}\simeq\frac{1}{35}=0.0286$$

much of $\mathcal{O}(\alpha_s)$ interaction effect cancels out. When considered $s/S\to 1/31=0.0323$

Allow for chemical non-equilibrium of strangeness $\gamma_s^{\rm QGP}$, and possible quark-gluon pre-equilibrium – gradual increase to the limit expected:

$$\frac{s}{S}=\frac{0.03\gamma_s^{\rm QGP}}{0.4\gamma_{\rm G}+0.1\gamma_s^{\rm QGP}+0.5\gamma_q^{\rm QGP}+0.05\gamma_q^{\rm QGP}(\ln\lambda_q)^2}\to 0.03.$$

We expect the yield of gluons and light quarks to approach chemical equilibrium fast and first: $\gamma_{\rm G}\to 1$ and $\gamma_q^{\rm QGP}\to 1$, thus $s/S\simeq 0.03\gamma_s^{\rm QGP}$.

CHECK: FIT YIELDS OF PARTICLES, EVALUATE STRANGENESS AND ENTROPY CONTENT AND COMPARE WITH EXPECTED RATIO, THEORETICAL STUDY HOW BIG s/S can be at LHC, help for phase transition at low μ_B

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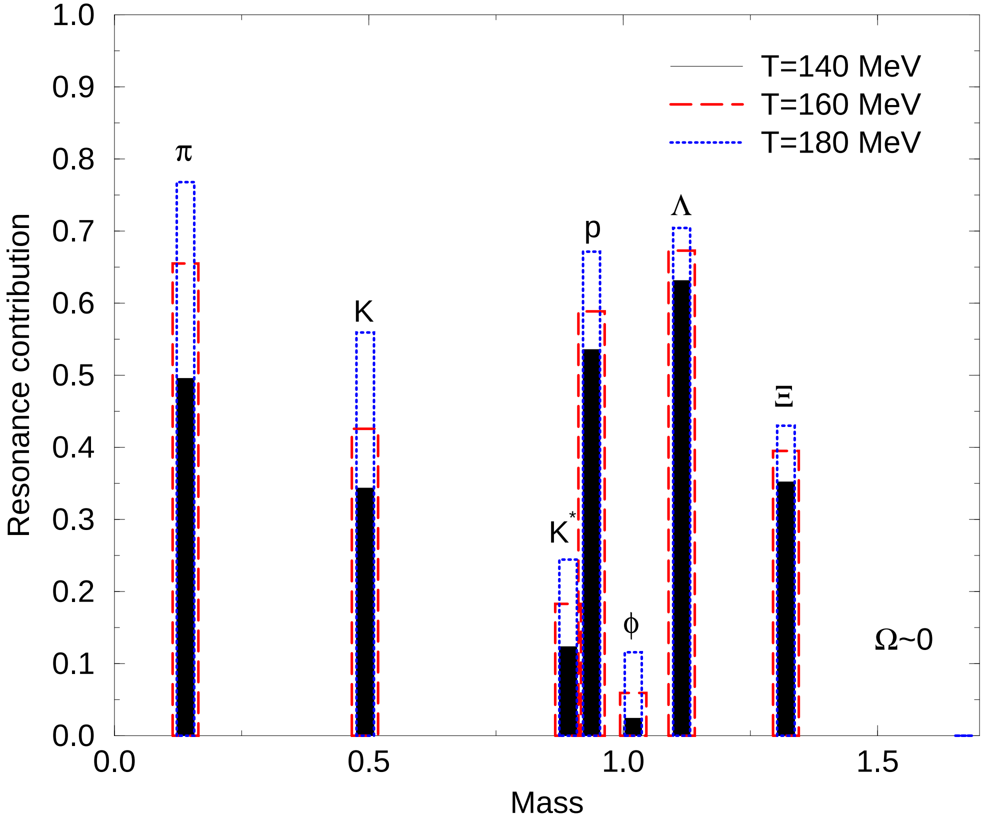
2. Statistical Hadronization:
OR how to use hadron yields to measure $\gamma_{q,s}^{\rm H}$

Hypothesis (Fermi, Hagedorn): particle production can be described by evaluating the accessible phase space.

Small Print Disclaimer: **Fermi: worked with hadron phase space, not a "hadron gas phase": for 'strong' interactions when all matrix elements are saturated ($|M|^2 \to 1$), rate of particle production according to the Fermi golden rule is the n-particle phase space. Micro canonical picture used by Fermi. With time begun to use (grand) canonical phase space, since number of particles and energy content sufficiently high (Hagedorn). WE HADRONIZE A QGP FIREBALL, nobody ever saw a hadron fireball except perhaps at lowest 20-SPS and AGS energies.**

Verification of statistical hadronization:

Particle yields with same valance quark content are in relative chemical equilibrium, e.g. the relative yield of $\Delta(1230)/N$ as of K^*/K, $\Sigma^*(1385)/\Lambda$, etc, is controlled by chemical freeze-out i.e. Hagedorn Temperature $T_{\rm H}$:



$$\frac{N^*}{N} = \frac{g^*(m^*T_{\rm H})^{3/2}e^{-m^*/T_{\rm H}}}{g(mT_{\rm H})^{3/2}e^{-m/T_{\rm H}}}$$

Resonances decay rapidly into 'stable' hadrons and dominate the yield of most stable hadronic particles.

Resonance yields test statistical hadronization principles. WE NEED MORE RESONANCE DATA

Resonances reconstructed by invariant mass; important to consider potential for loss of observability.

HADRONIZATION GLOBAL FIT:→

Statistical HAadronization with REsonsnces=SHARE

Full analysis of experimental hadron yield results requires a significant numerical effort in order to allow for resonances, particle widths, full decay trees, isospin multiplet sub-states.

Tucson-(Kraków)-McGill-Paris collaboration produced a public package SHARE Statistical Hadronization with Resonances which is available e.g. at

http://www.physics.arizona.edu/˜torrieri/SHARE/share.html

Lead author: Giorgio Torrieri

With (W. Broniowski, W. Florkowski), Sangyong Yeon, J. Letessier, S. Steinke, JR; nucl–th/0404083 Comp. Phys. Com. 167, 229 (2005) and nucl-th/0603026

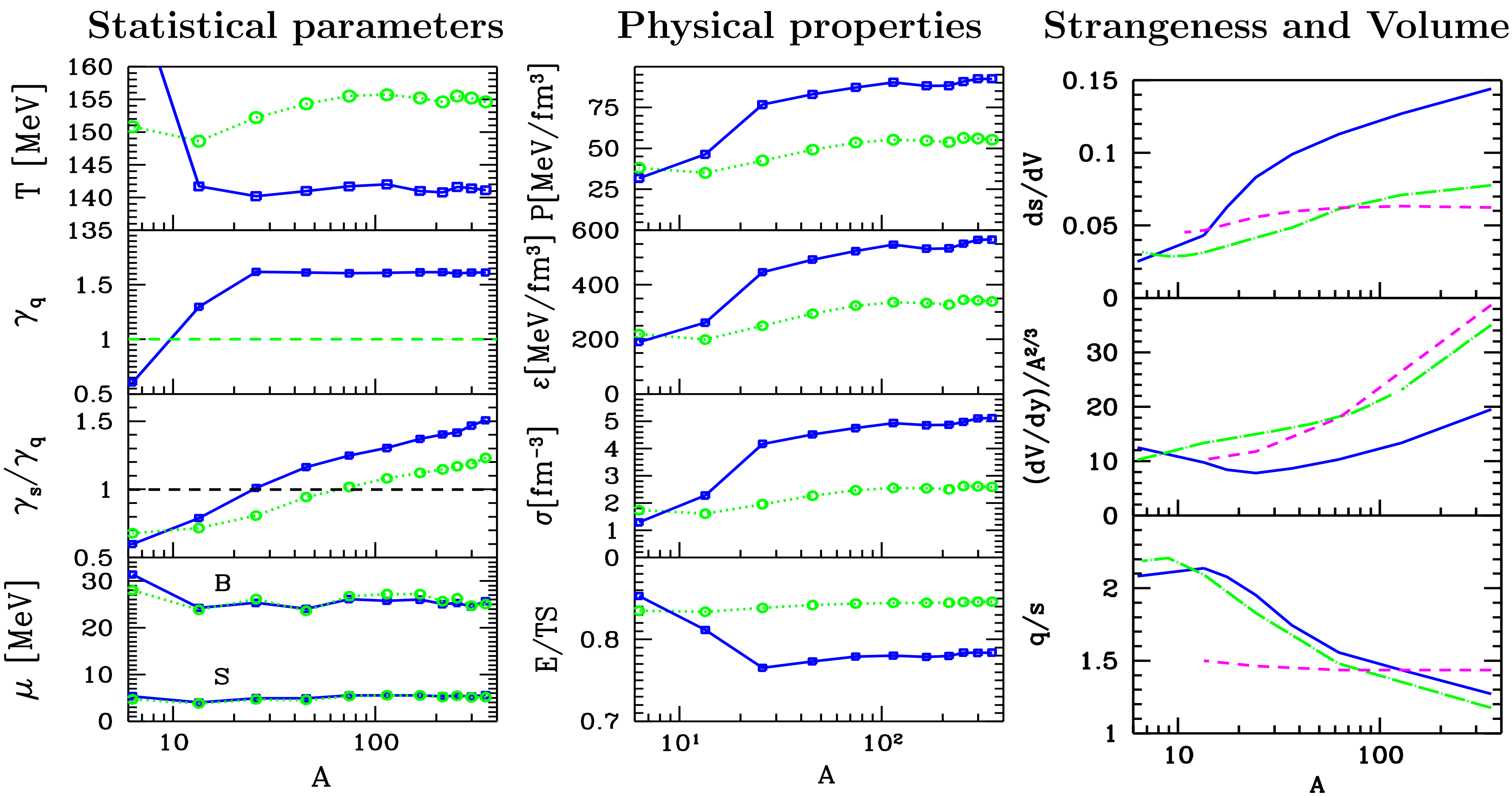
Online SHARE: Steve Steinke No fitting online (server too small)

http://www.physics.arizona.edu/˜steinke/shareonline.html

Aside of particle yields, also PHYSICAL PROPERTIES of the source are available, both in SHARE and ONLINE.

SHARE2 with many improvements and fluctuations on-line since March 8, 2006, see nucl-th/0603026

LESSON – RHIC200 results, dependence on centrality

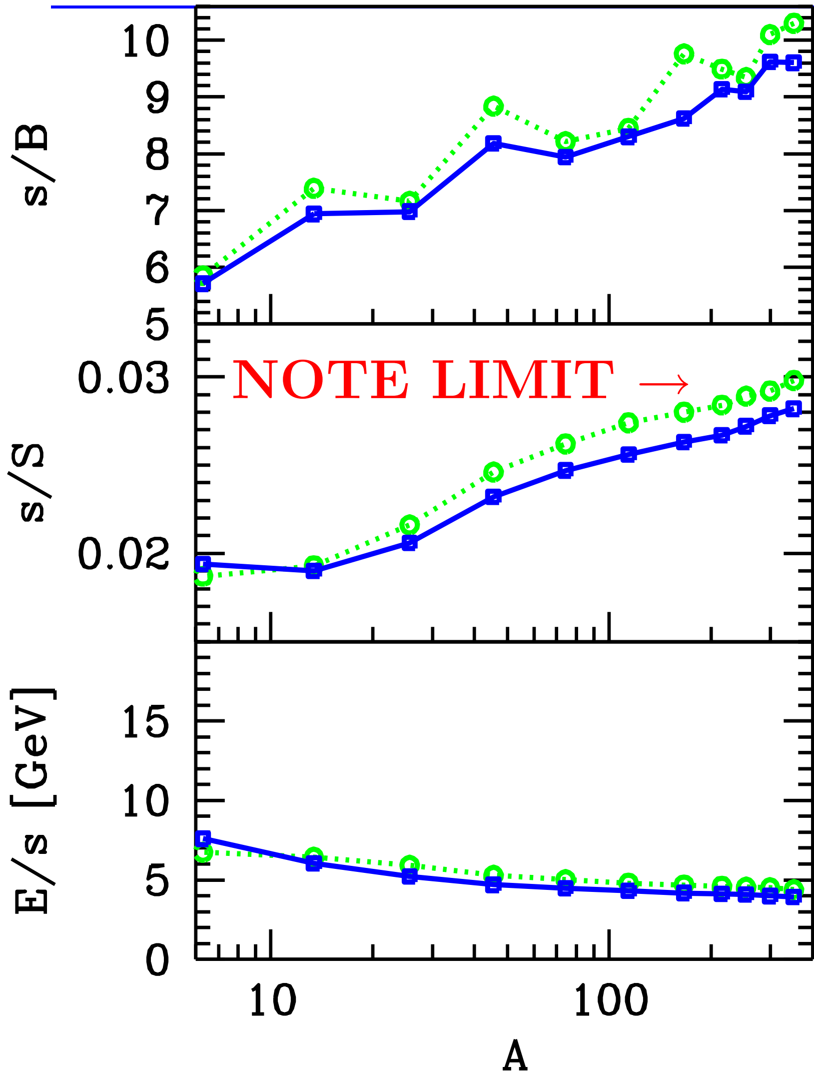


LINES: blue: nonequilibrium $\gamma_s^{\rm H}, \gamma_q^{\rm H} \neq 1$ and green semi-equilibrium $\gamma_s^{\rm H} \neq 1, \gamma_q^{\rm H} = 1$, $\gamma_s = \gamma_q = 1$

Highlights: $\gamma_q^{\rm H}$ changes with $A \propto V$ from under-saturated to over-saturated value,
$\gamma_s^{\rm H}$ increases steadily to 2.4, implying near saturation in QGP fireball at RHIC.
P, σ, ϵ increase by factor 2–3, at $A > 20$ (onset of new physics?),
E/TS decreases with A - test of EoS. Geometric transverse size scaling.
s-yield grows faster than q-yield (nonequilibrium) and s hadronization density increases with A.

Statistical + fit errors are seen in fluctuations, systematic error impacts absolute normalization by $\pm 10\%$.

s/b and s/S rise with increasing centrality $A \propto V$; E/s falls



Showing results for both $\gamma_q, \gamma_s \neq 1$, for $\gamma_s \neq 1, \gamma_q = 1$. Note little difference in the result, even though the value of T will differ significantly.

1) $s/S \to 0.027$, as function of V;
2) most central value near QGP chemical equilibrium;
3) no saturation for largest volumes available;

Behavior is consistent with QGP prediction of steady increase of strangeness yield with increase of the volume, which implies longer lifespan and hence greater strangeness yield, both specific yield and larger $\gamma_s^{\rm QGP}$.

Agreement between nonequilibrium (blue) and semi-equilibrium (green, $\gamma_q = 1$) in description of bulk properties implies that MOST particle distributions extrapolate well from the experimental data - differences in e.g. $\Omega, \overline{\Omega}$ yields sensitive to the model issues do not impact bulk properties decisively.

3. Strangeness equilibration in QGP with expansion

QCD allows to COMPUTE s/S and $\gamma_s^{\rm Q}$
fine-tune at RHIC - extrapolate $\to$ LHC:

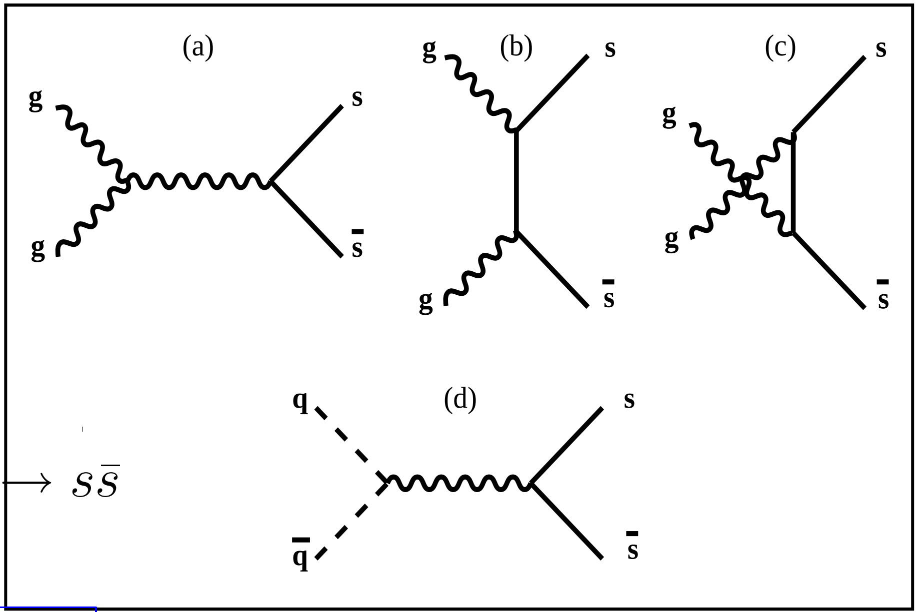
- **production of strangeness in gluon fusion $\boxed{GG \to s\bar{s}}$**
  strangeness linked to gluons from QGP;

dominant processes:

$$GG \to s\bar{s}$$

abundant strangeness
=evidence for gluons

10–15% of total rate: $q\bar{q} \to s\bar{s}$



- **coincidence of scales:** $\boxed{m_s \simeq T_c}$ $\to \boxed{\tau_s \simeq \tau_{\rm QGP}} \to$

  strangeness a clock for QGP phase

- **We use running $\alpha_s(T), m_s(T)$.**

Thermal average rate of strangeness production

Kinetic (momentum) equilibration is faster than chemical, use thermal particle distributions $f(\vec{p}_1, T)$ to obtain average rate:

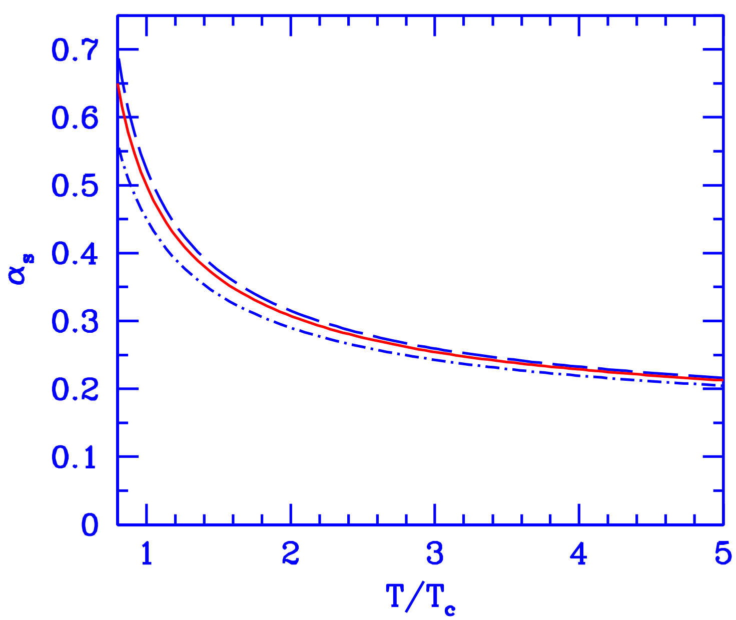
$$\langle \sigma v_{\rm rel} \rangle_T \equiv \frac{\int d^3p_1 \int d^3p_2 \sigma_{12} v_{12} f(\vec{p}_1, T) f(\vec{p}_2, T)}{\int d^3p_1 \int d^3p_2 f(\vec{p}_1, T) f(\vec{p}_2, T)}\,.$$

The generic angle averaged cross sections for (heavy) flavor s, $\bar{s}$ production processes $g + g \to s + \bar{s}$ and $q + \bar{q} \to s + \bar{s}$, are:

$$\bar{\sigma}_{gg\to s\bar{s}}(s) = \frac{2\pi\alpha_{\rm s}^2}{3s}\left[\left(1 + \frac{4m_{\rm s}^2}{s} + \frac{m_{\rm s}^4}{s^2}\right)\tanh^{-1}W(s) - \left(\frac{7}{8} + \frac{31m_{\rm s}^2}{8s}\right)W(s)\right]\,,$$

$$\bar{\sigma}_{q\bar{q}\to s\bar{s}}(s) = \frac{8\pi\alpha_{\rm s}^2}{27s}\left(1 + \frac{2m_{\rm s}^2}{s}\right)W(s)\,. \qquad W(s) = \sqrt{1 - 4m_{\rm s}^2/s}$$

RESUMMATION



The relatively small experimental value $\alpha_{\rm s}(M_Z) \simeq 0.118$, established in recent years helps to achieve QCD resummation with running $\alpha_{\rm s}$ and $m_{\rm s}$ taken at the energy scale $\mu \equiv \sqrt{s}$.
Effective T-dependence:

$$\alpha_s(\mu = 2\pi T) \equiv \alpha_s(T) \simeq \frac{\alpha_s(T_c)}{1 + (0.760 \pm 0.002)\ln(T/T_c)}$$

with $\alpha_s(T_c) = 0.50 \pm 0.04$ and $T_c = 0.16$ GeV.
α_s^2 varies by factor 10

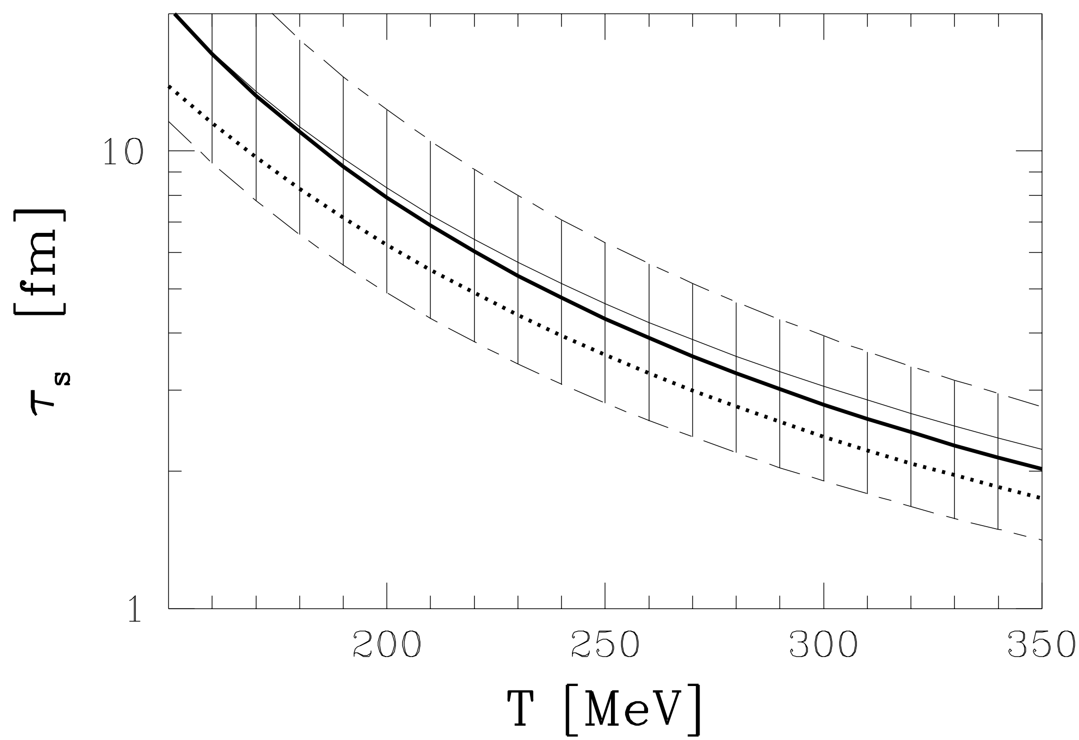
Strangeness relaxation to chemical equilibrium

Strangeness density time evolution in local rest frame:

$$\frac{1}{V}\frac{ds}{d\tau} = \frac{1}{V}\frac{d\bar{s}}{d\tau} = \frac{1}{2}\rho_g^2(t)\,\langle\sigma v\rangle_T^{gg\to s\bar{s}} + \rho_q(t)\rho_{\bar{q}}(t)\langle\sigma v\rangle_T^{q\bar{q}\to s\bar{s}} - \rho_s(t)\,\rho_{\bar{s}}(t)\,\langle\sigma v\rangle_T^{s\bar{s}\to gg,q\bar{q}}$$

Evolution for s and $\bar{s}$ identical, which allows to set $\rho_s(t) = \rho_{\bar{s}}(t)$.
Note invariant production rate A and the characteristic time constant τ_s:

$$A^{12\to 34} \equiv \frac{1}{1+\delta_{1,2}}\gamma_1\gamma_2\rho_1^\infty\rho_2^\infty\langle\sigma_s v_{12}\rangle_T^{12\to 34}. \qquad 2\tau_s \equiv \frac{\rho_s(\infty)}{A^{gg\to s\bar{s}}+A^{q\bar{q}\to s\bar{s}}+\ldots}$$



STRANGENESS IN ENTROPY CONSERVING EXPANSION

QGP expansion is adiabatic i.e. $(g_G = 2_s 8_c = 16, g_q = 2_s 3_c n_\mathrm{f})$

$$S = \frac{4\pi^2}{90} g(T) V T^3 = \textbf{Const.} \quad g = g_G \left(1 - \frac{15\alpha_s(T)}{4\pi} + \ldots\right) + \frac{7}{4} g_q \left(1 - \frac{50\alpha_s(T)}{21\pi} + \ldots\right) .$$

The volume, temperature change such that $\delta(gT^3V) = 0$**. Strangeness phase space occupancy,** $g_s = 2_s 3_c \left(1 - \frac{k\alpha_s(T)}{\pi} + \ldots\right), k = 2$ **for** $m_s/T \to 0$**:**

$$\gamma_s(\tau) \equiv \frac{n_s(\tau)}{n_s^\infty(T(\tau))}, \quad n_s(\tau) = \gamma_s(\tau) T(\tau)^3 \frac{g_s(T)}{2\pi^2} z^2 K_2(z), \quad z = \frac{m_s}{T(t)}, \quad K_i : \text{Bessel f.}$$

evolves due to production and dilution, keeping entropy fixed:

$$\frac{d}{d\tau}\frac{s}{S} = \frac{A_G}{S/V}\left[\gamma_\mathrm{G}^2 - {\gamma_s}^2\right] + \frac{A_q}{S/V}\left[\gamma_\mathrm{q}^2 - {\gamma_s}^2\right]$$

Which for γ_s **assumes the form that makes dilution explicit:**

$$\frac{d\gamma_s}{d\tau} + \gamma_s \frac{d \ln[g_s z^2 K_2(z)/g]}{d\tau} = \frac{A_G}{n_s^\infty}\left[\gamma_\mathrm{G}^2 - {\gamma_s}^2\right] + \frac{A_q}{n_s^\infty}\left[\gamma_\mathrm{q}^2 - {\gamma_s}^2\right]$$

For $m_s \to 0$ **dilution effect decreases, disappears, and** $\gamma_s \le \gamma_{G,q}$**, importance grows with mass of the quark,** $z = m_s(T)/T$**, which grows near phase transition boundary.**

Model of temporal evolution of Temperature

To integrate the equation for s/S we need to understand $T(\tau)$.

We have at our disposal the final conditions: $S(\tau_f)$, $T(\tau_f)$ and since particle yields $dN_i/dy = n_i dV/dy$ also the volume per rapidity, $\Delta V/\Delta y|_{\tau_\mathrm{f}}$. Theory (lattice) further provides Equations of State $\sigma(T) = S/V$. Hydrodynamic expansion with Bjørken scaling implies STRICTLY $dS/dy = \sigma(T) dV/dy = \mathrm{Const.}$ as function of time.

$dV/dy(\tau)$ expansion completes the model. This allows to fix $T(\tau)$.

$$\frac{dV}{dy} = A_\perp(\tau)\left.\frac{dz}{dy}\right|_{\tau=\mathrm{Const.}}. \qquad \mathrm{Bjørken:}\ z=\tau\sinh\, y\ \rightarrow \left.\frac{dz}{dy}\right|_{\tau=\mathrm{Const.},y=0} = \tau$$

We consider two transverse expansion pictures: bulk and donut ($dscaleswithR_\perp$):

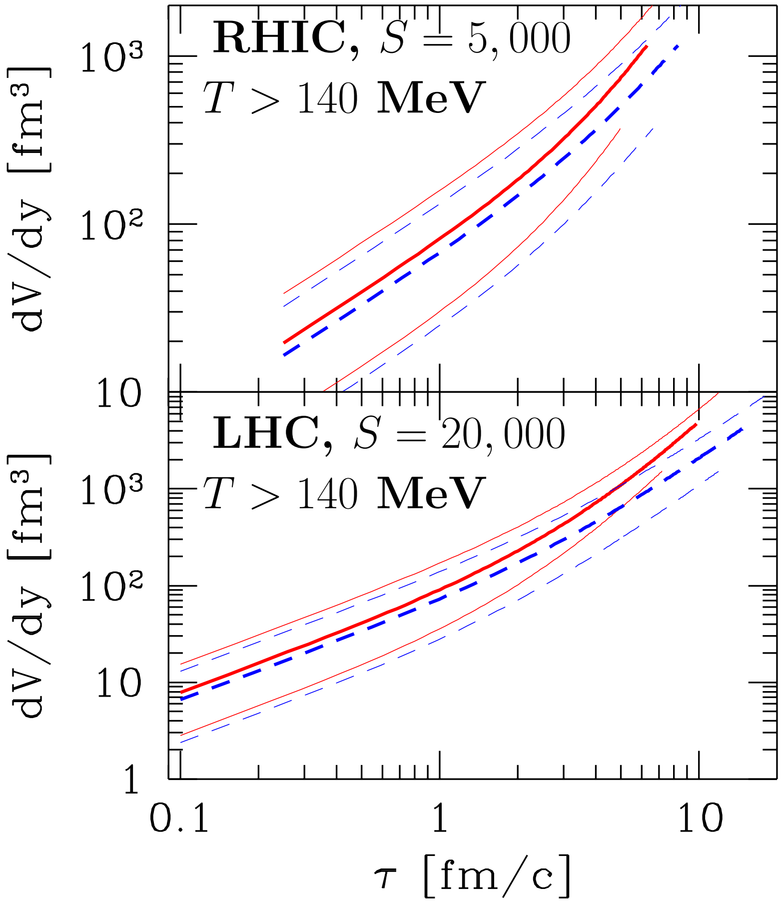
$$A_\perp = \pi R_\perp^2(\tau) \quad \text{or} \quad A_\perp = \pi\left[R_\perp^2(\tau) - (R_\perp^2(\tau)-d)^2\right]$$

We do assume gradual onset of expansion - hydro motivated:

$$v(\tau) = v_{\max}\frac{2}{\pi}\arctan[4(\tau-\tau_0)/\tau_v]$$

Values of $v_{\max}$ we consider are in the range of 0.5–0.8c, the relaxation time $\tau_c \simeq 0.5$ fm, and the onset of transverse expansion τ_0 was tried in range 0.1–1 fm.

We took $R_\perp(\tau_0) = 5\,$fm for 5% most central collisions. For centrality dependence, We further scale the initial entropy as function of centrality to assure $\frac{dS}{dy} \simeq 8(A^{1.1}-1)$ which we found in the centrality data analysis.



Three centralities: middle $R_\perp = 5$ fm and the upper/lower lines corresponding to $R_\perp = 7$, and, $R_\perp = 3$ fm/c. dashed lines for donut geometry $d = 2.1,\ 3.5$ and 4.9 fm.

Main difference LHC to RHIC, lifespan much longer, despite increase of average final expansion velocity from 0.6 to 0.8 c.

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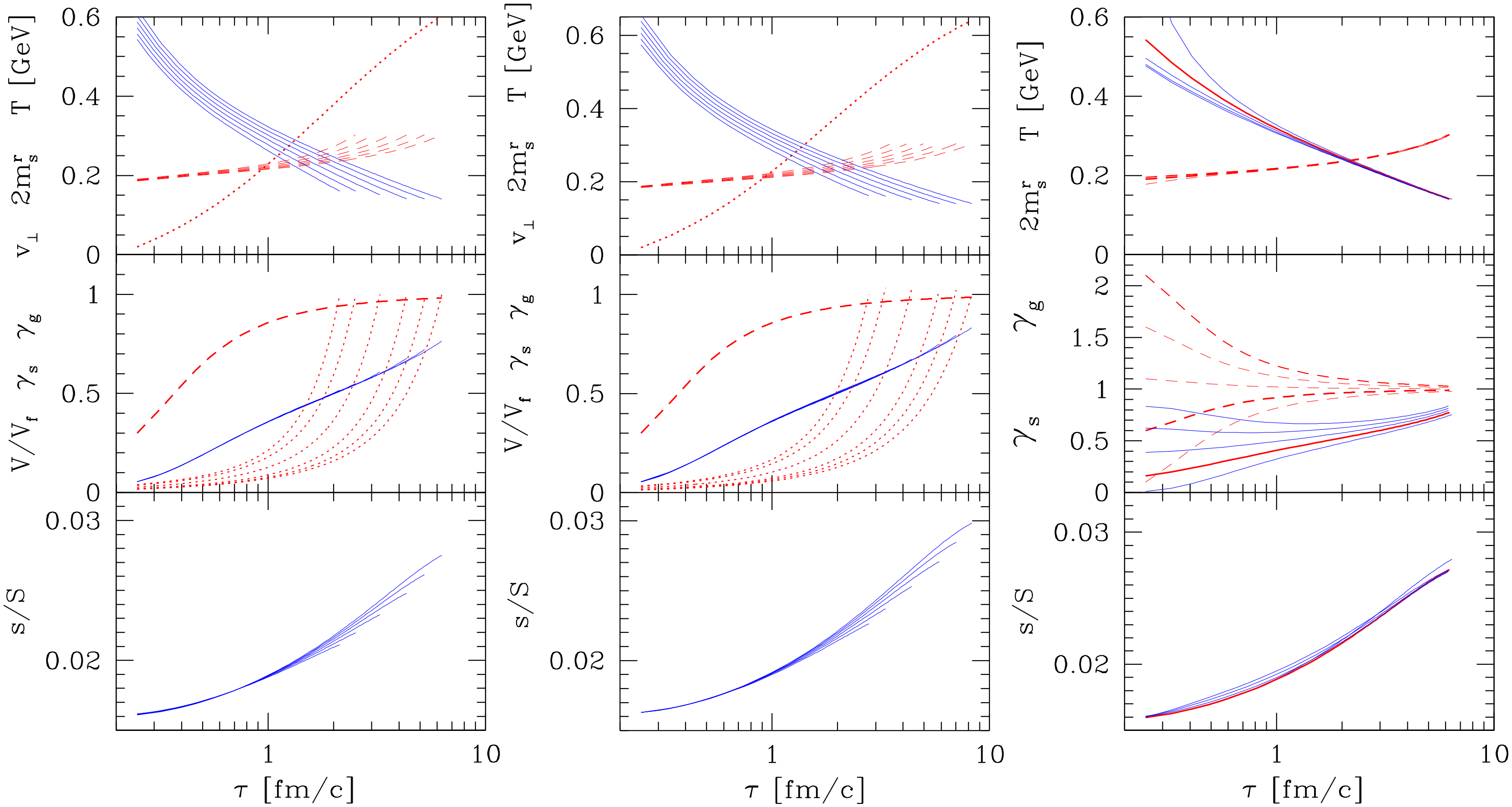
4. Centrality dependence of s/S at RHIC-200 and LHC

s/S and γ_s at RHIC: centrality dependence

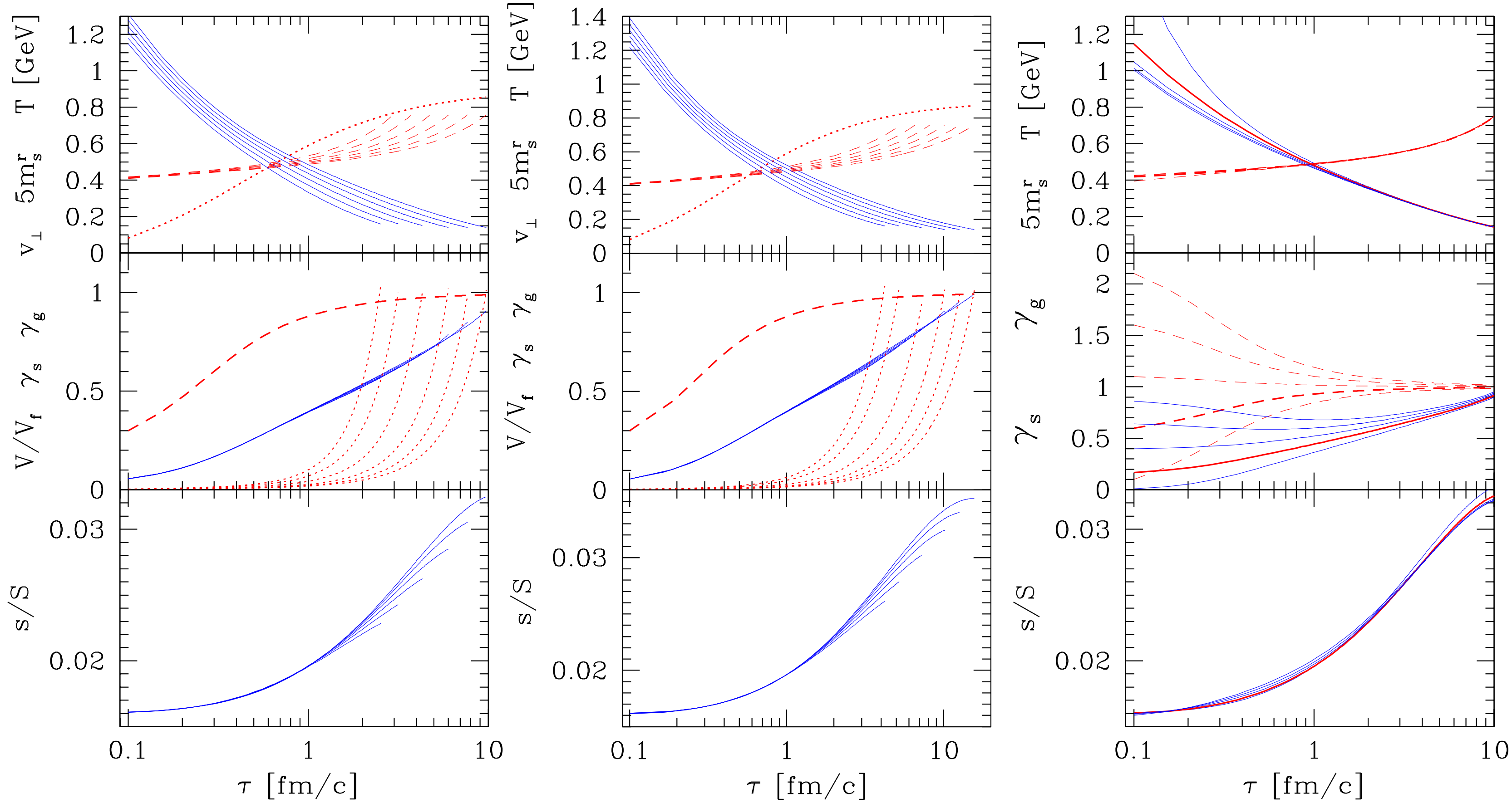


The two left panels: **Comparison of the two transverse expansion models, bulk expansion (left), and wedge expansion. Different lines correspond to different centralities.** **On right: study of the influence of the initial density of partons.**

Top: T, middle γ_s and bottom s/S

Assumptions:
dotted top panel: profile of $v_\perp(\tau)$, the transverse expansion velocity; middle panel: dashed $\gamma_g(\tau)$,(which determines slower equilibrating γ_q dotted: normalized $dV/dy(\tau)$ normalized by the freeze-out value.

What this means for LHC



Comments (same LHC and RHIC:

Top Panel: Initial temperatures accommodate $dS/dy|_{\rm f}$ beyond participant scaling.

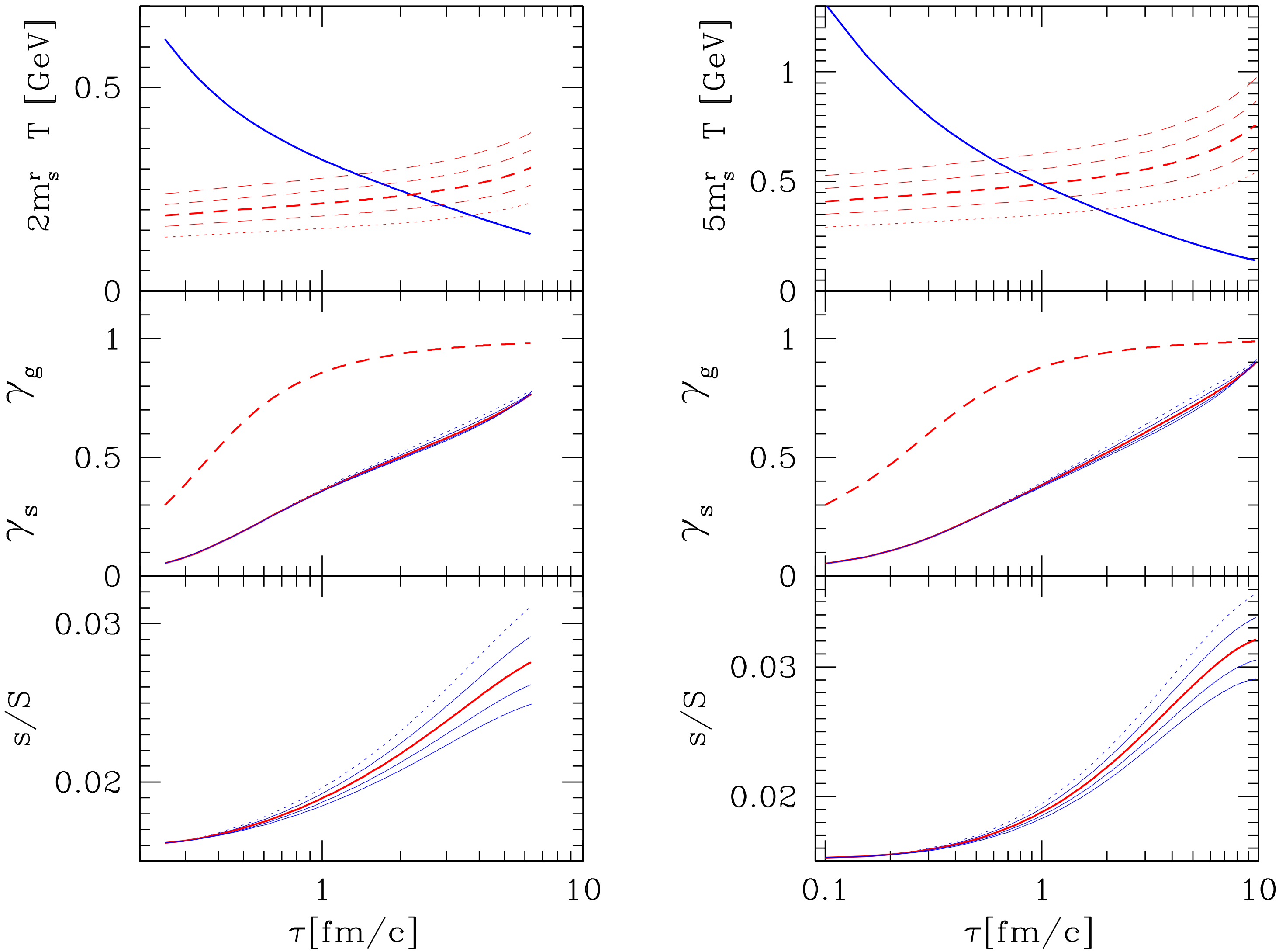
Middle Panel: Solid line(s): resulting γ_s for different centralities overlay;

Bottom panel: resulting s/S for different centralities, with R_0 stepped down for each line by factor 1.4.

Notable LHC differences to RHIC: (we assumed $dS/dy|_{\rm LHC} = 4dS/dy|_{\rm RHIC}$)

- **There is a significantly longer expansion time to the freeze-out condition (factor 2).**
- **There is a 20% growth in s/S**
- **There is a significant increase in initial temperature to accommodate increased entropy density.**

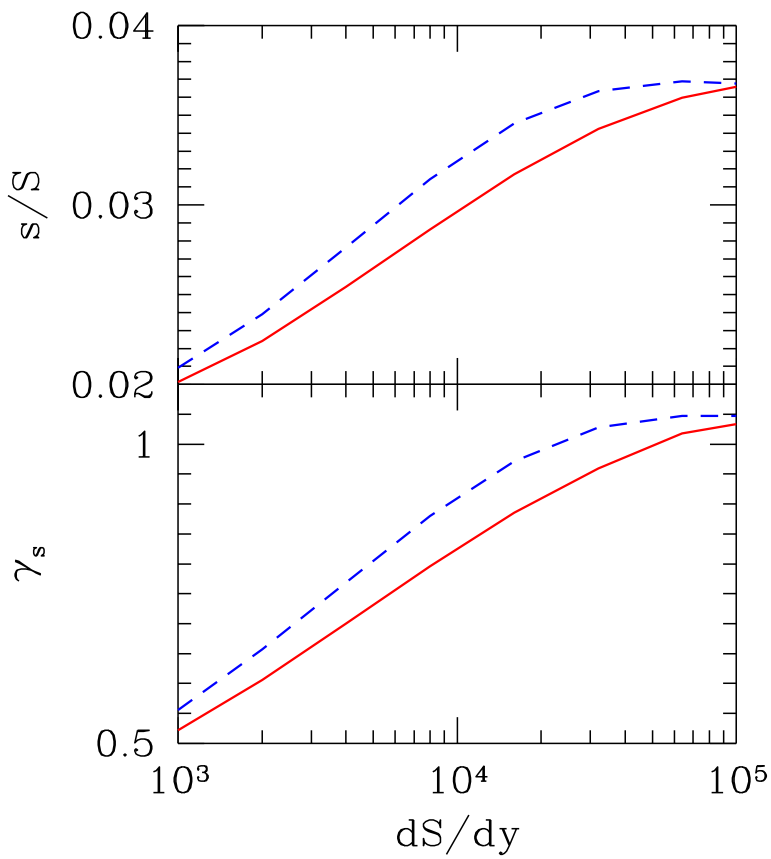
Strange quark mass matters



Left RHIC, right LHC, bulk volume expansion. m_s varies by factor 2.

γ_s overlays: Accidentally two effects cancel: for smaller mass more strangeness production, but by definition γ_s smaller. s/S of course bigger for smaller mass.

A first look at energy dependence



Solid, bulk expansion, dashed donut expansion.

Since the main parameter controlling the reaction energy dependence is the value of entropy (hadron multiplicity) produced, and we already have two points dS/dy**=5,000 and 20,000 (LHC) we complete for central collisions the results.**

QGP equilibrates gradually, some over-equilibration for large entropy content.

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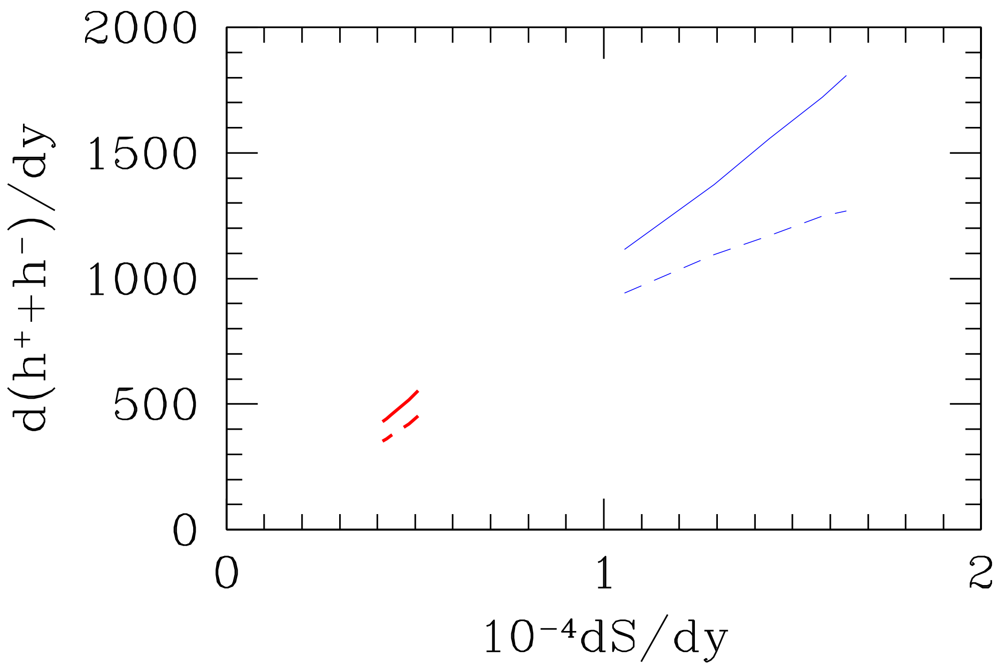
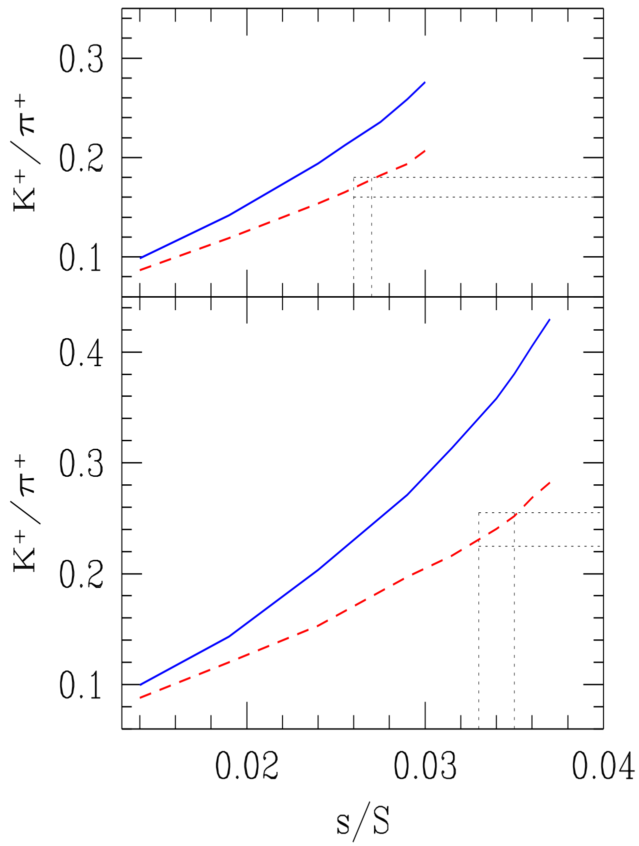
5. Soft (strange) hadrons at RHIC and LHC

For orientation: relationship of multiplicity to dS/dy



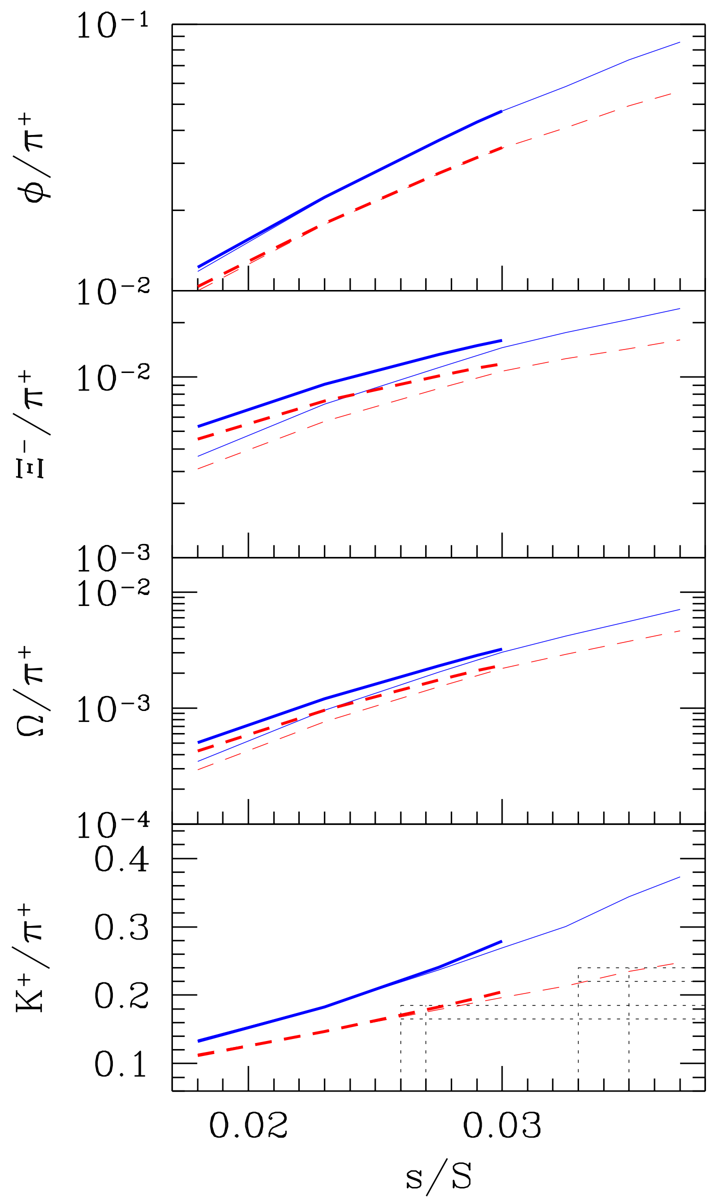
The yield of charged hadrons $d(h^- + h^+)/dy$ for different values of dS/dy. Solid lines: after all weak decays, dashed lines: before weak decays. Left domain for RHIC and right domain for LHC - defined at $E/b = 40, 412$ GeV respectively,obtained not as fit to data but assuming $E/TS = 0.78$, baryon conservation etc. See: hep-ph/0506140 and Eur. Phys. J. C (2005) -02414-7 by JR and JL "Soft hadron ratios at LHC"

How much enhancement in from RHIC to LHC K/π ?



K^+/π^+ ratio as function of attained specific strangeness at freeze-out, s/S. Solid lines bare yields, dashed lines after all weak decays have diluted the pion yields. Top for RHIC and bottom for LHC physics environment. An increase by about 40% is predicted from $K^+/\pi^+ = 0.17$ at RHIC to $K^+/\pi^+ = 0.24$ at LHC. If LHC is subject to donut-expansion, increase more significant.

Multi strange hadrons are more sensitive to s/S



Top three panels: Φ/π^+, Ξ^-/π^+, Ω^-/π^+ **(log scale) relative yields of multistrange hadrons, as function of** s/S Φ/π^+, Ξ^-/π^+, Ω^-/π^+ **(log scale).**

Solid lines primary relative yields, dashed lines after all weak decays. Thick line with $s/S < 0.3$ **are for RHIC and thin lines are for LHC physics environment.**

Bottom panel: restating for comparison K^+/π^+**.**

6. Conclusions

- **Strangeness equilibration impacts phase properties.**
- **Deconfinement in baryon rich phase influenced by presence of the third flavor, QCD matter system exceptionally fine tuned.**
- **Full analysis of strangeness and hadron energy excitation functions and centrality dependence is now available**
- **Evidence for CHEMICAL equilibration of the QGP at RHIC, not in final state hadrons: which abundances are controlled by prevailing valance quark yields;**
- **QCD based evaluation of the two QGP global observables γ_s and s/S produces strangeness enhancement – additional strangeness beyond initial state. Enhancement by a factor 1.6-2.2 for s/S seen.**
- **QCD kinetic model tuned to describe strangeness at RHIC, predicts further increase of specific enhancement at LHC with strong additional enhancement of multistrange hadrons and some noticeable increase in K^+/π^+.**