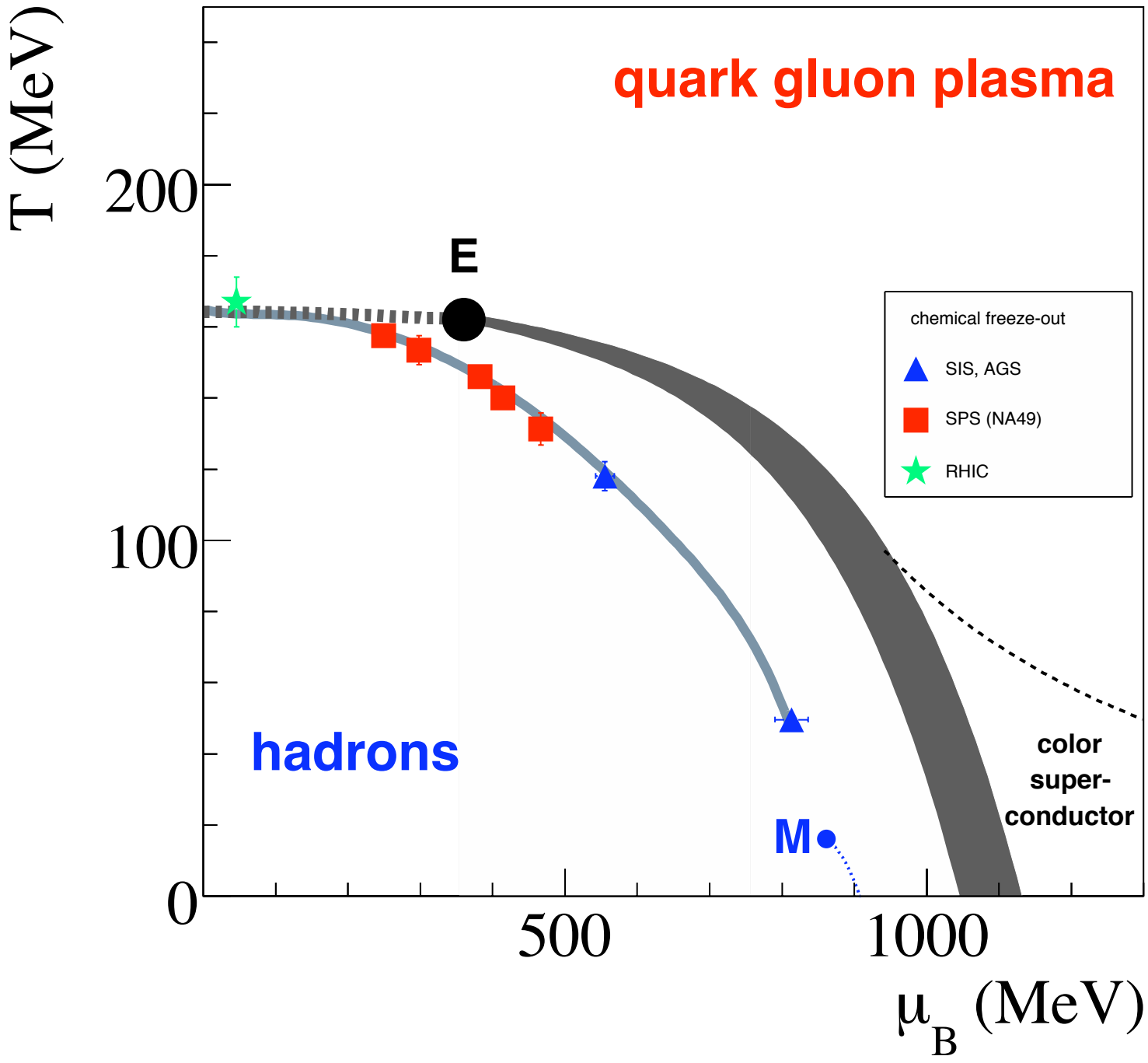
Symposium on dense baryonic matter

March 8–9, 2009, GSI

Physics in the vicinity of the hadronization phase transition

Reinhard Stock, Goethe University Frankfurt

GOETHE UNIVERSITÄT FRANKFURT AM MAIN


quark gluon plasma
T (MeV)
200
100
0
E
chemical freeze-out
SIS, AGS
SPS (NA49)
RHIC
hadrons
M
color
super-
conductor
500
1000
μB (MeV)

Consequences for the phase diagram: the radius of convergence

C. Schmidt, QM08

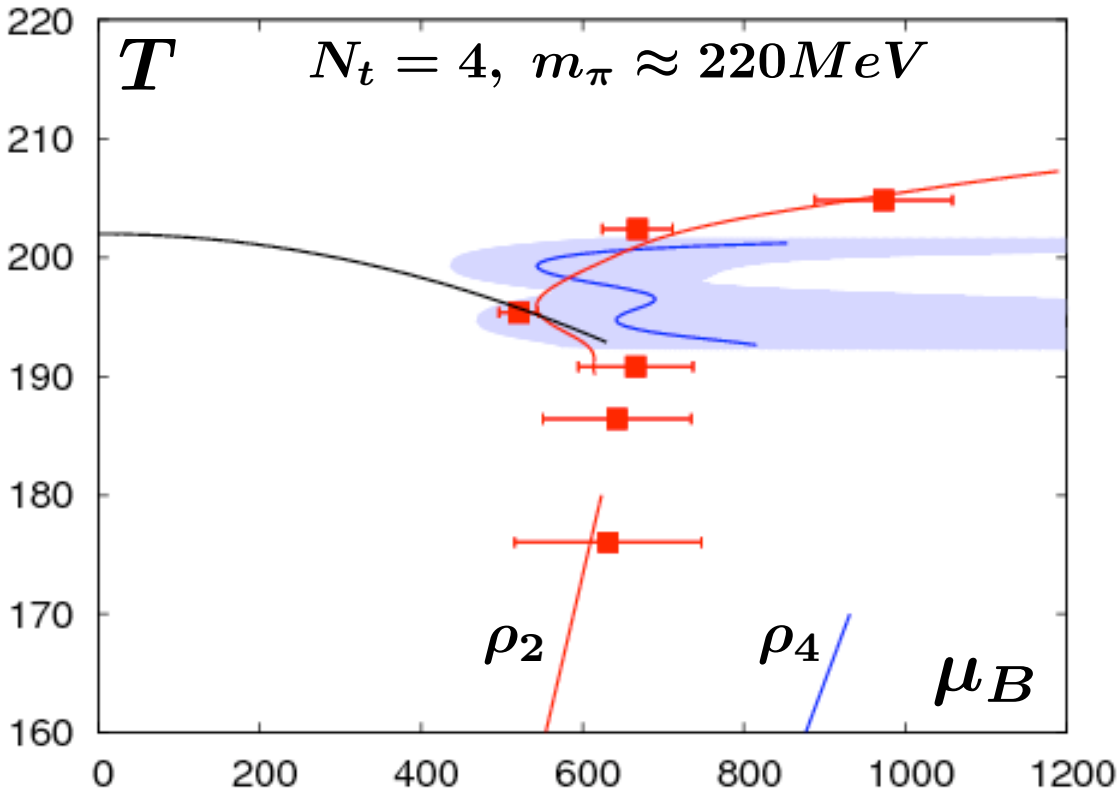
- the radius of convergence can be estimated by the Taylor coefficients of the pressure:

$$\rho = \lim_{n \to \infty} \rho_n$$

with

$$\rho_n = \sqrt{\frac{c_n^B}{c_{n+2}^B}}$$

- for $T > T_c, \quad \rho_n \to \infty$
- for $T < T_c$, ρ_n is bound by the transition line



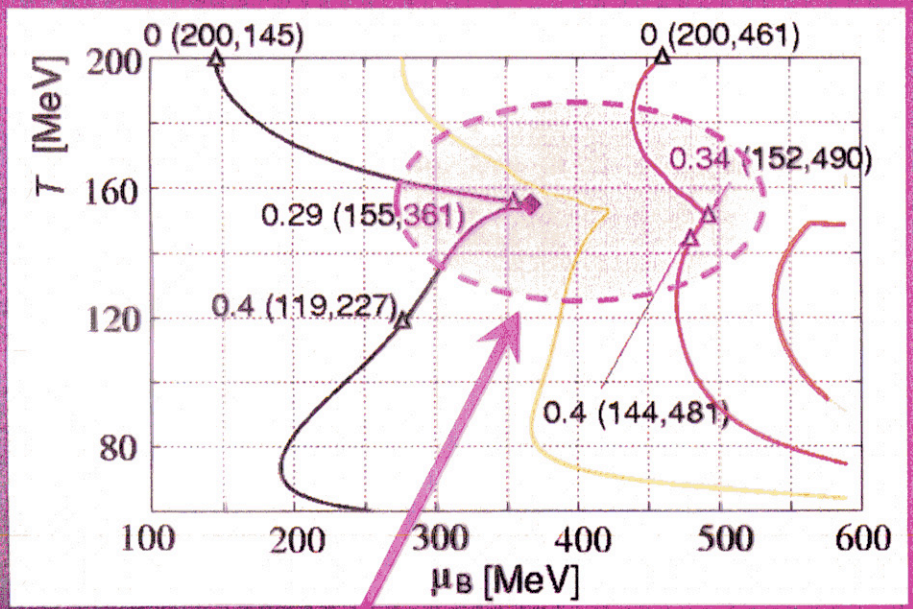
- non monotonic behavior of the convergence radius

$\longrightarrow$ **first hint for a critical region ?**

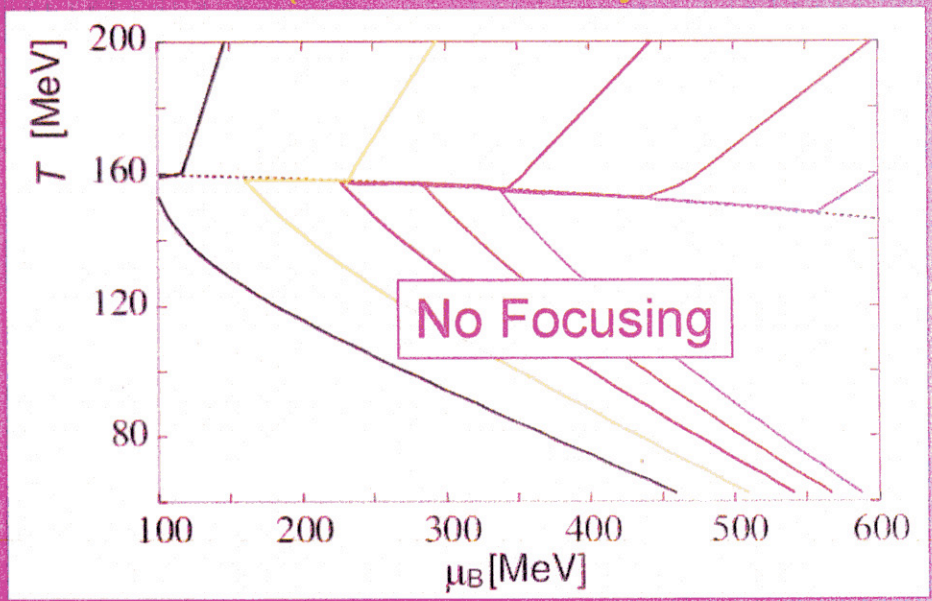
- higher order approximations are needed to locate the critical point

With Large Critical Region

with CEP



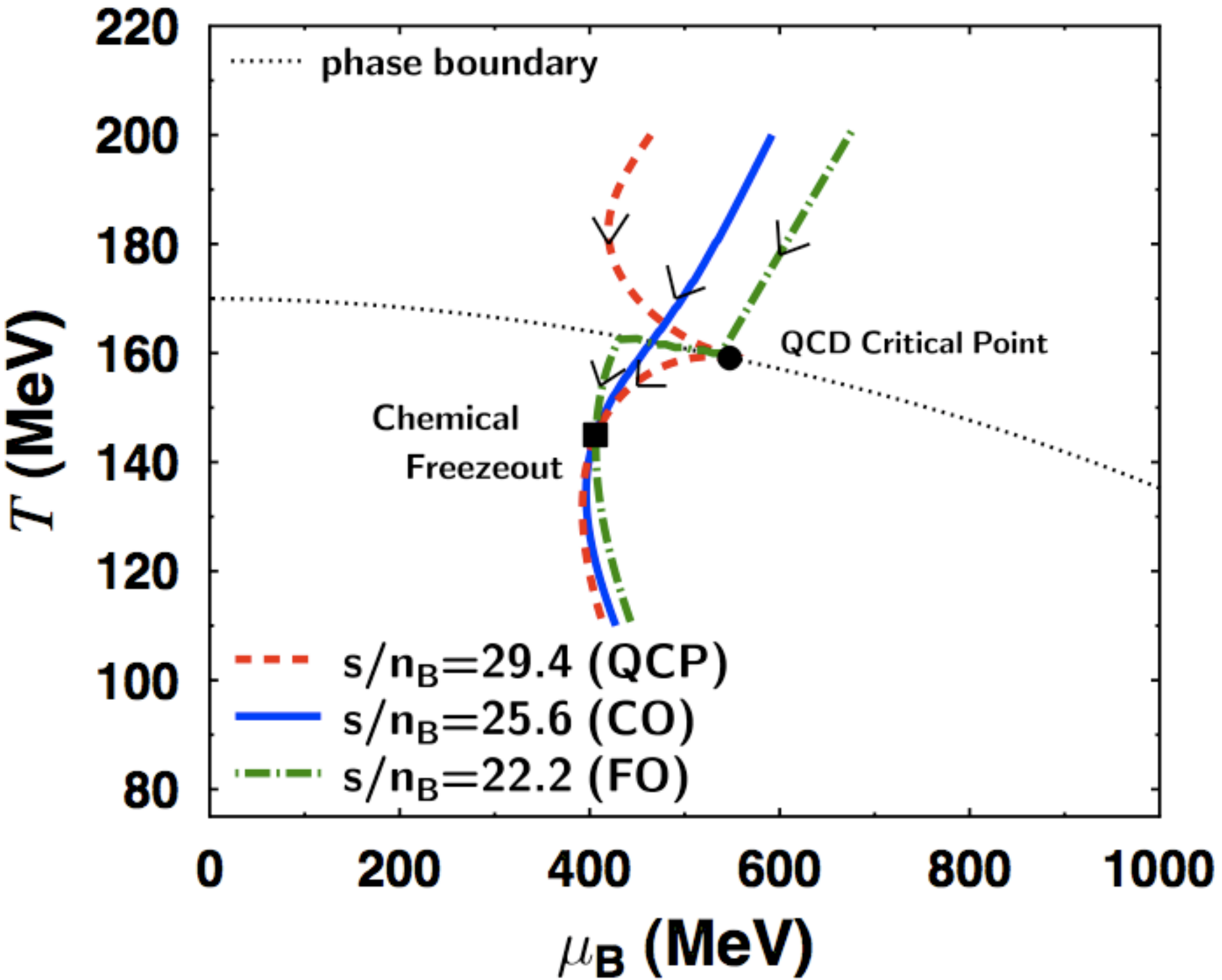
without CEP (EOS in usual hydro calculation)

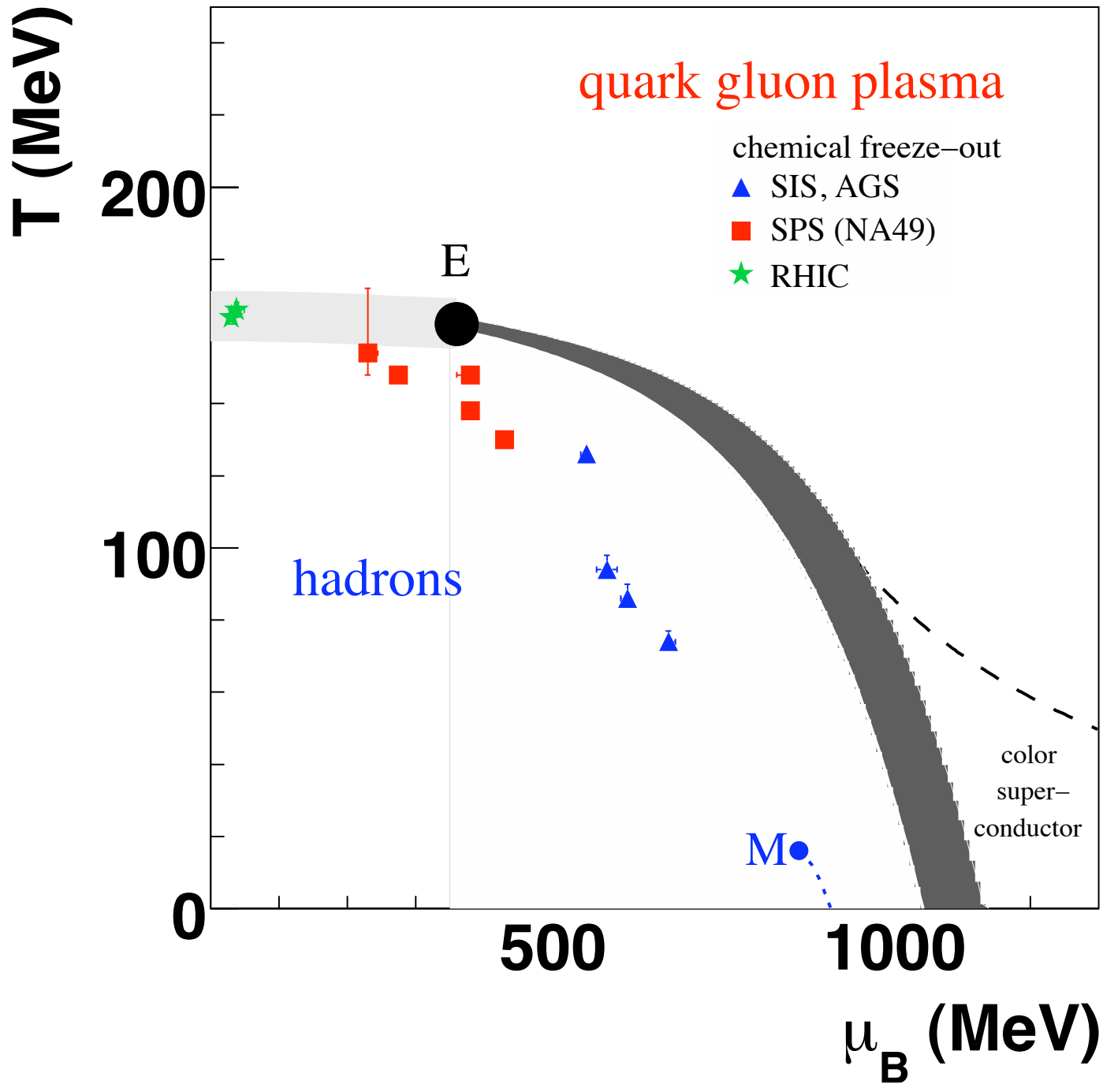


Focusing of Isentropic Trajectories

Excluded Volume Approximation
+ Bag Model EOS

used in most hydro calculations


phase boundary
QCD Critical Point
Chemical
Freezeout
s/n_B=29.4 (QCP)
s/n_B=25.6 (CO)
s/n_B=22.2 (FO)
T (MeV)
μ_B (MeV)
220
200
180
160
140
120
100
80
0
200
400
600
800
1000


T (MeV)
200
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μ_B (MeV)
quark gluon plasma
chemical freeze–out
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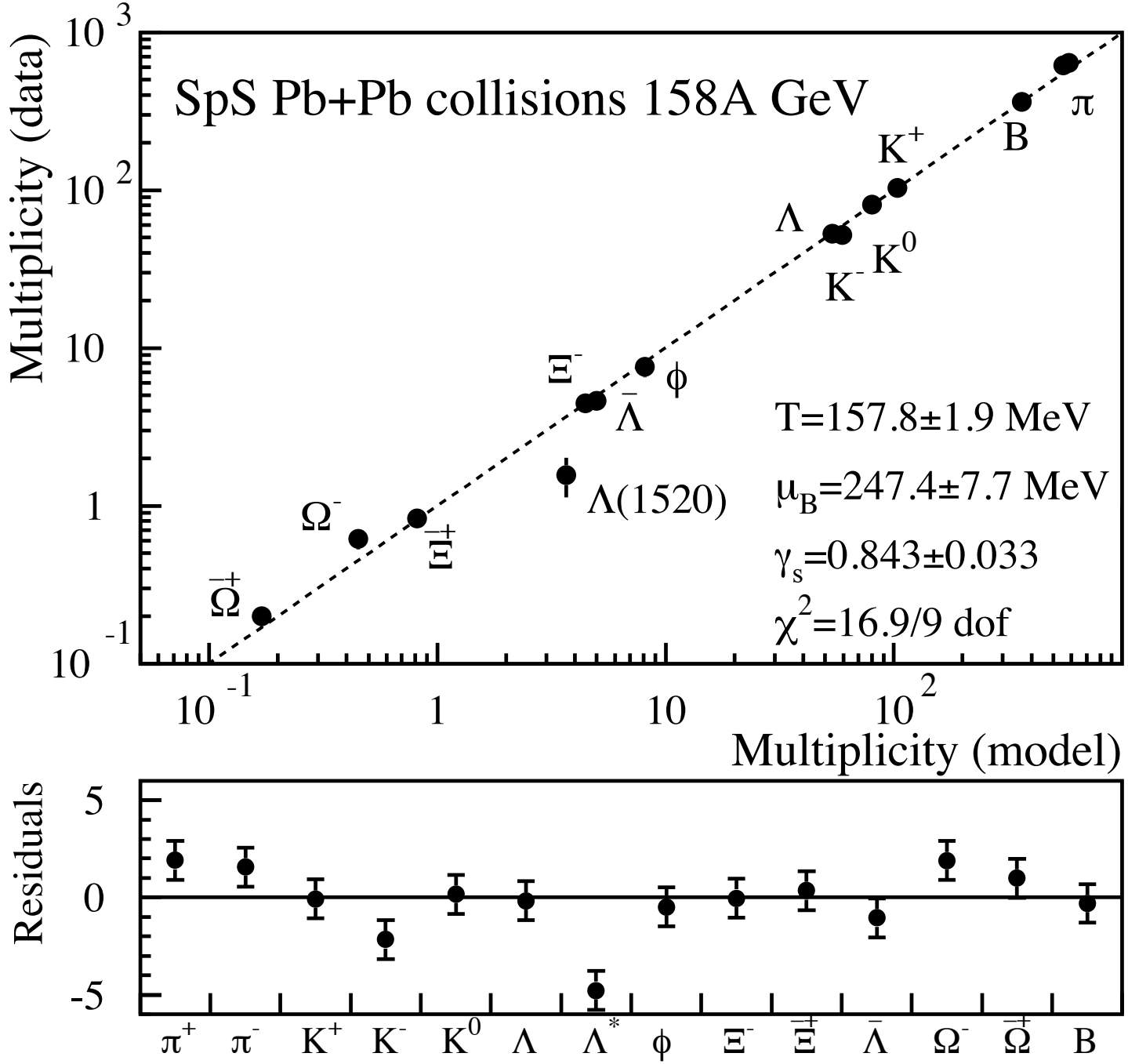
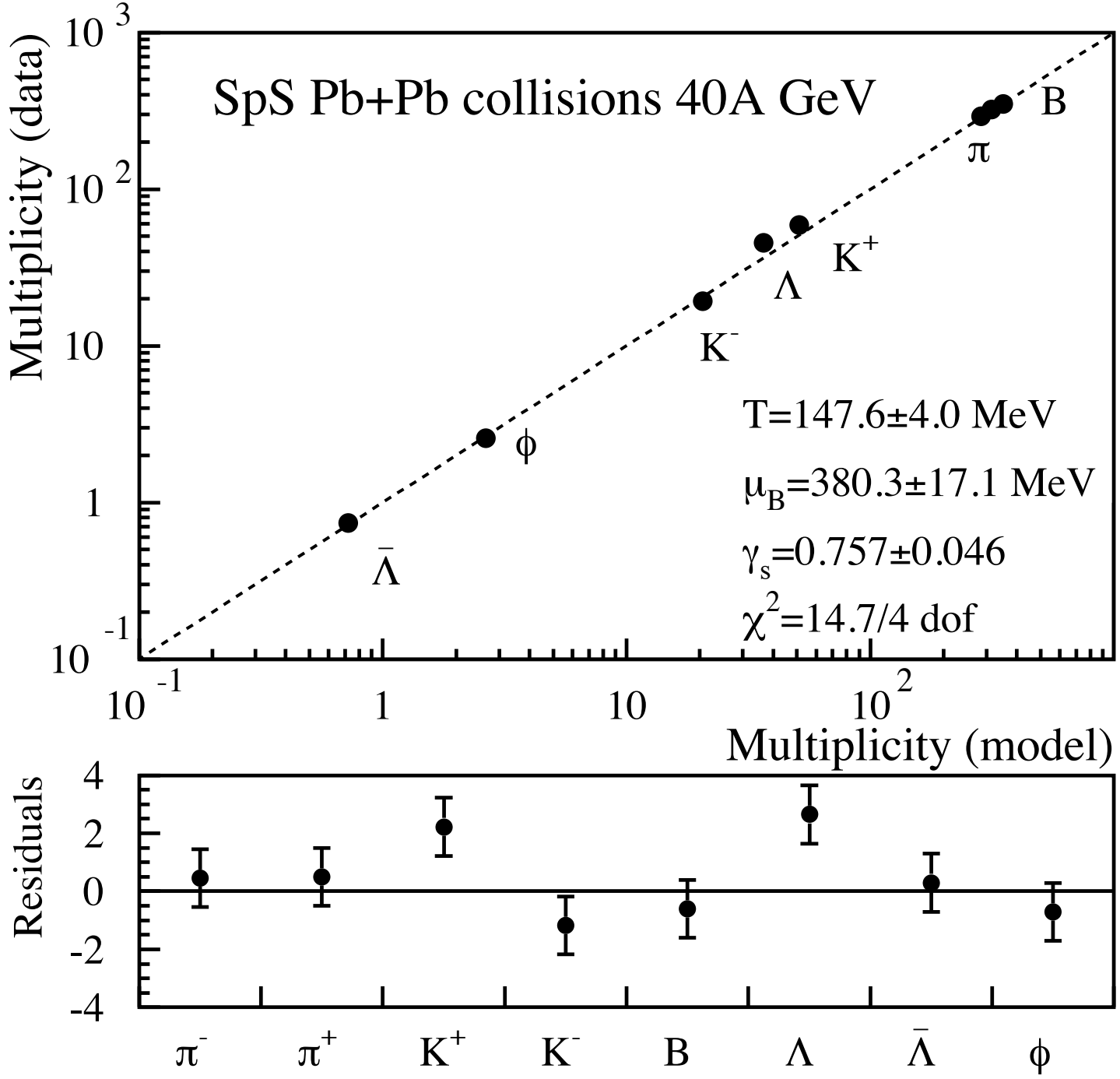
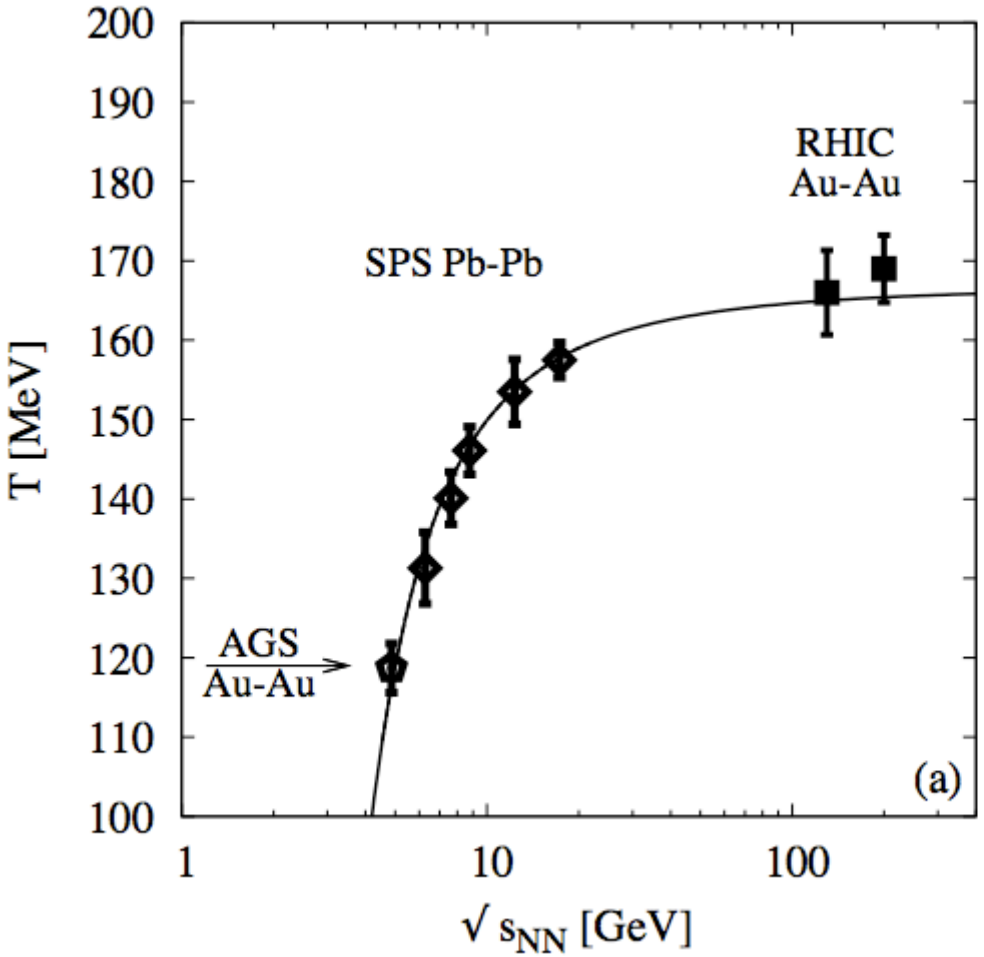
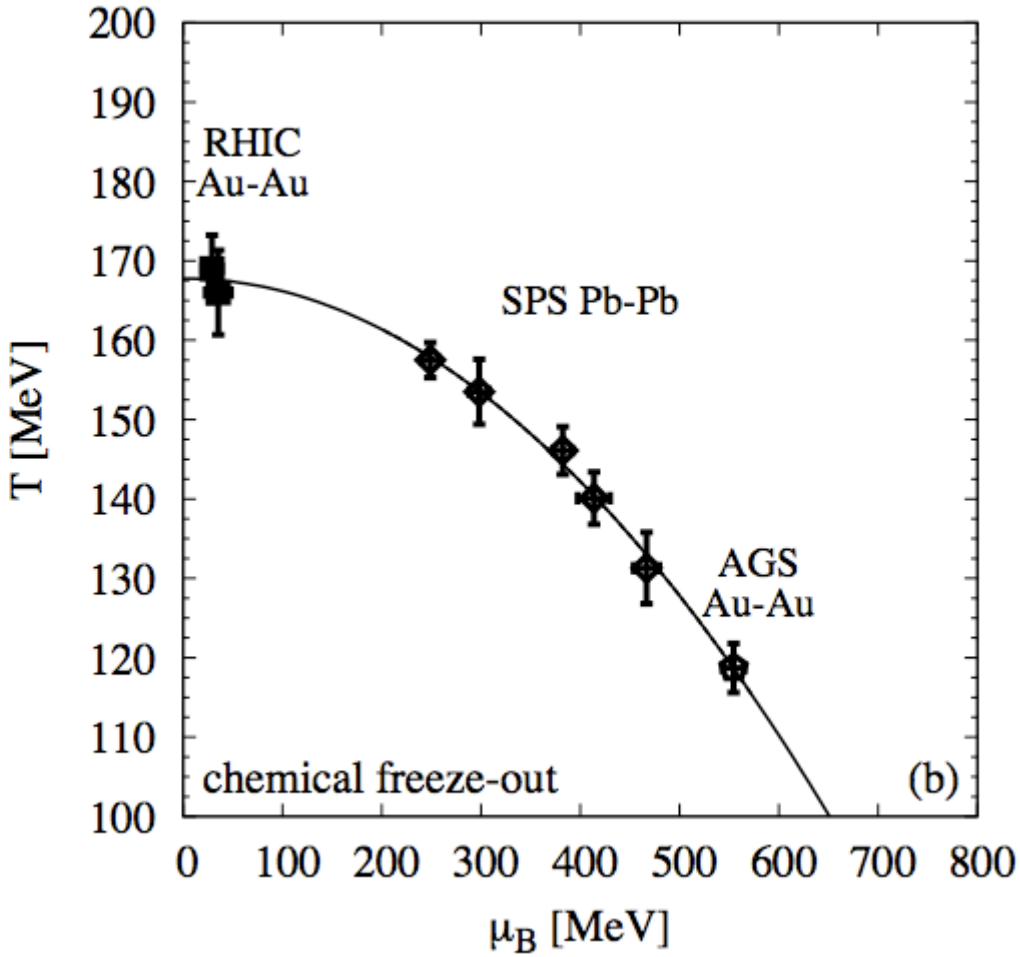
F. Becattini et al. PRC 69, 2004, 024905

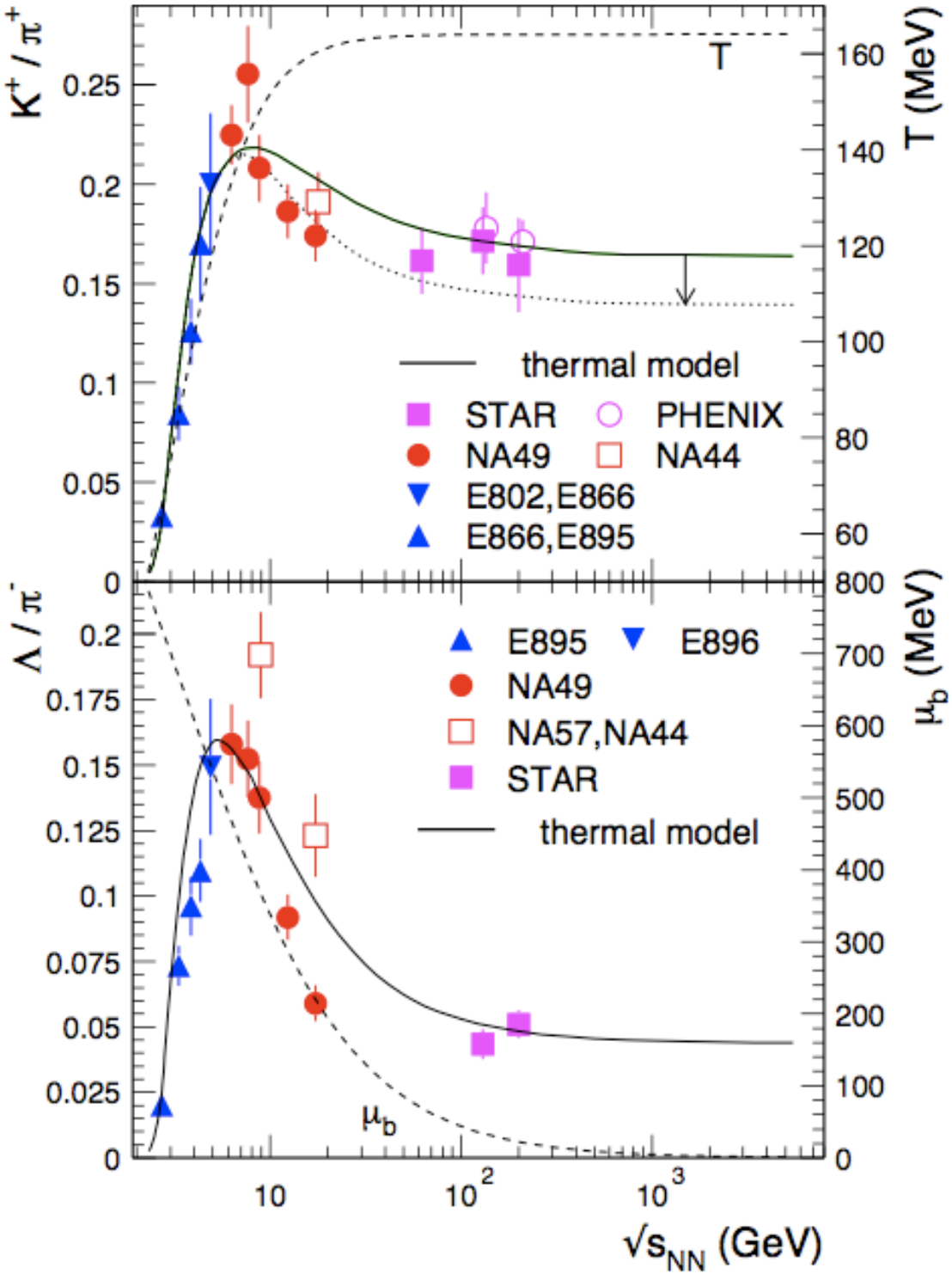



SpS Pb+Pb collisions 40A GeV
Multiplicity (data)
Multiplicity (model)
Residuals
T=147.6±4.0 MeV
μB=380.3±17.1 MeV
γs=0.757±0.046
χ2=14.7/4 dof
π
B
K+
Λ
K-
φ
Λ̄
π-
π+
K+
K-
B
Λ
Λ̄
φ

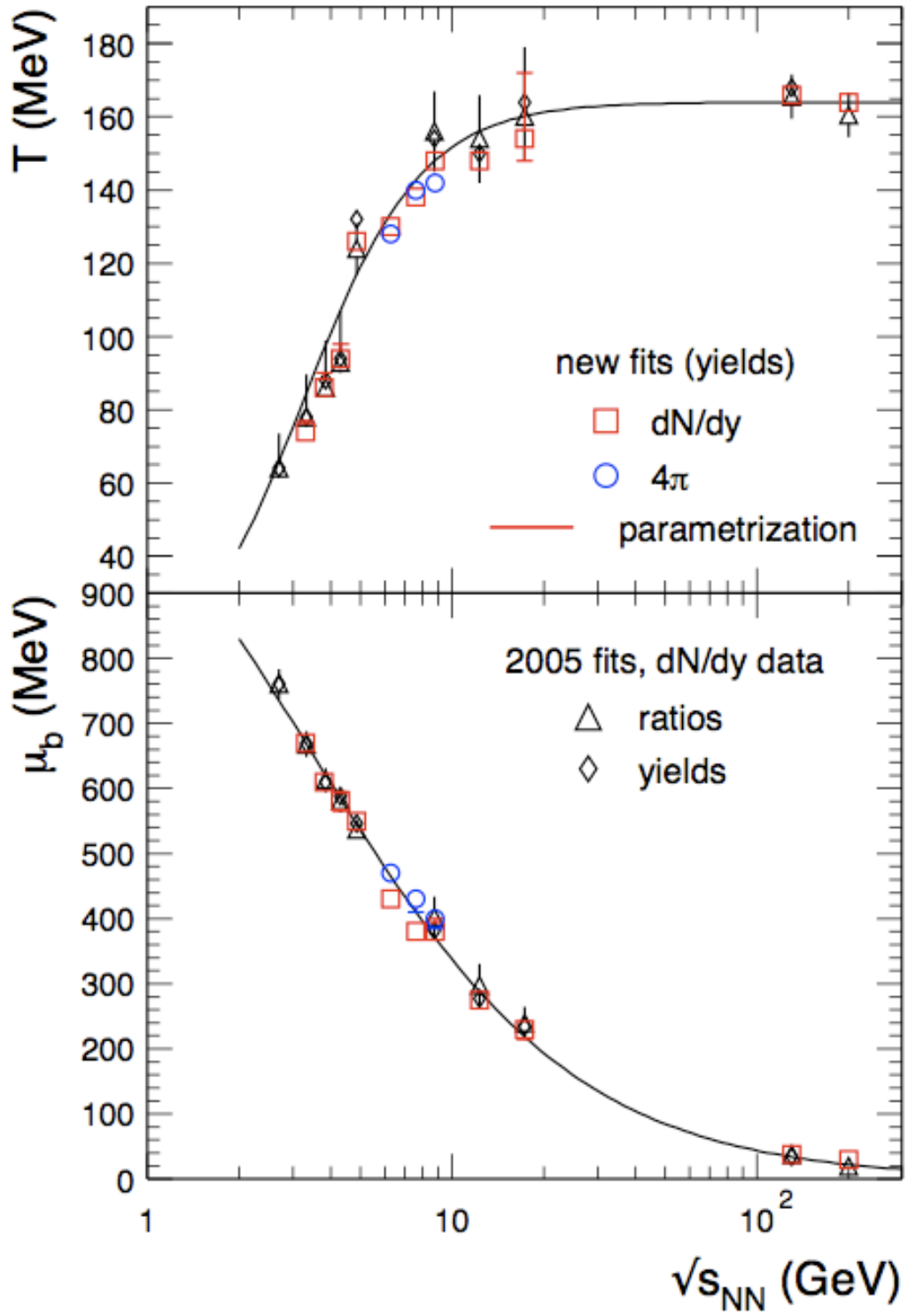
F. Becattini, J. Manninen



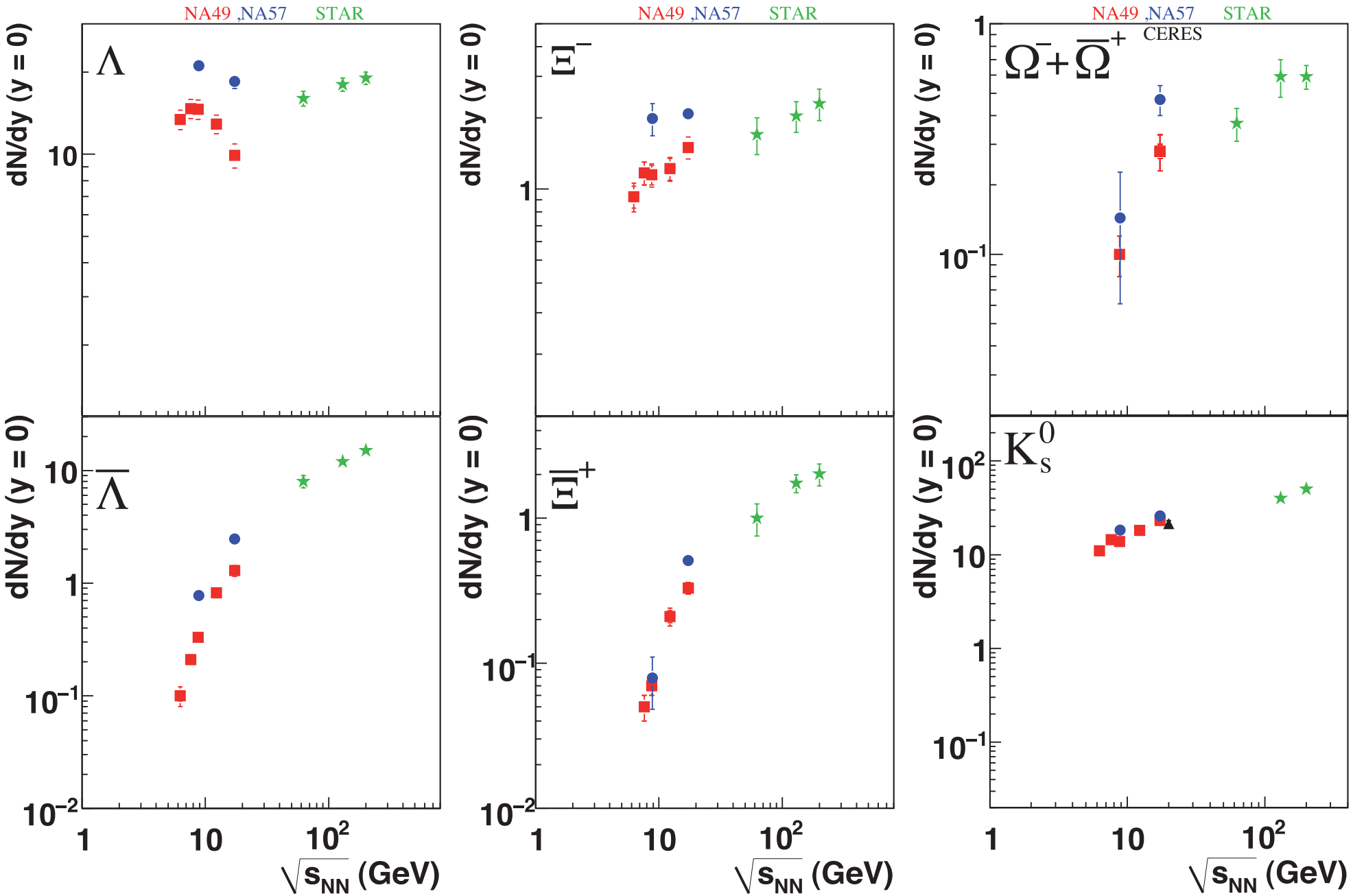




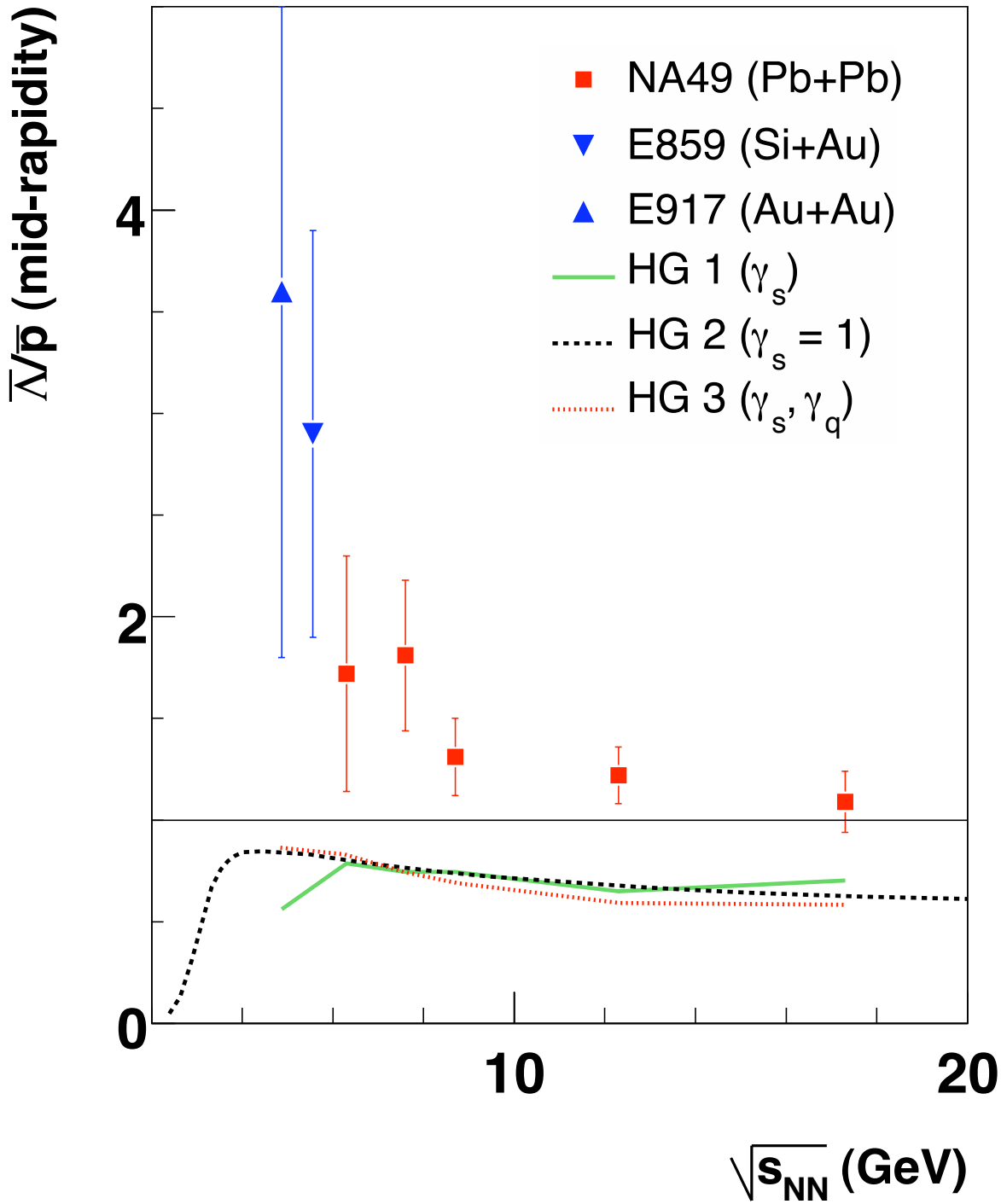
A. Andronic, P. Braun-Munzinger, J. Stachel 0812.1186 [nucl-th]


T (MeV)
180
160
140
120
100
80
60
40
new fits (yields)
dN/dy
4π
parametrization
μ_b (MeV)
900
800
700
600
500
400
300
200
100
0
2005 fits, dN/dy data
ratios
yields
1
10
10^2
$\sqrt{s_{NN}}$ (GeV)

M. Mitrovski, SQM06

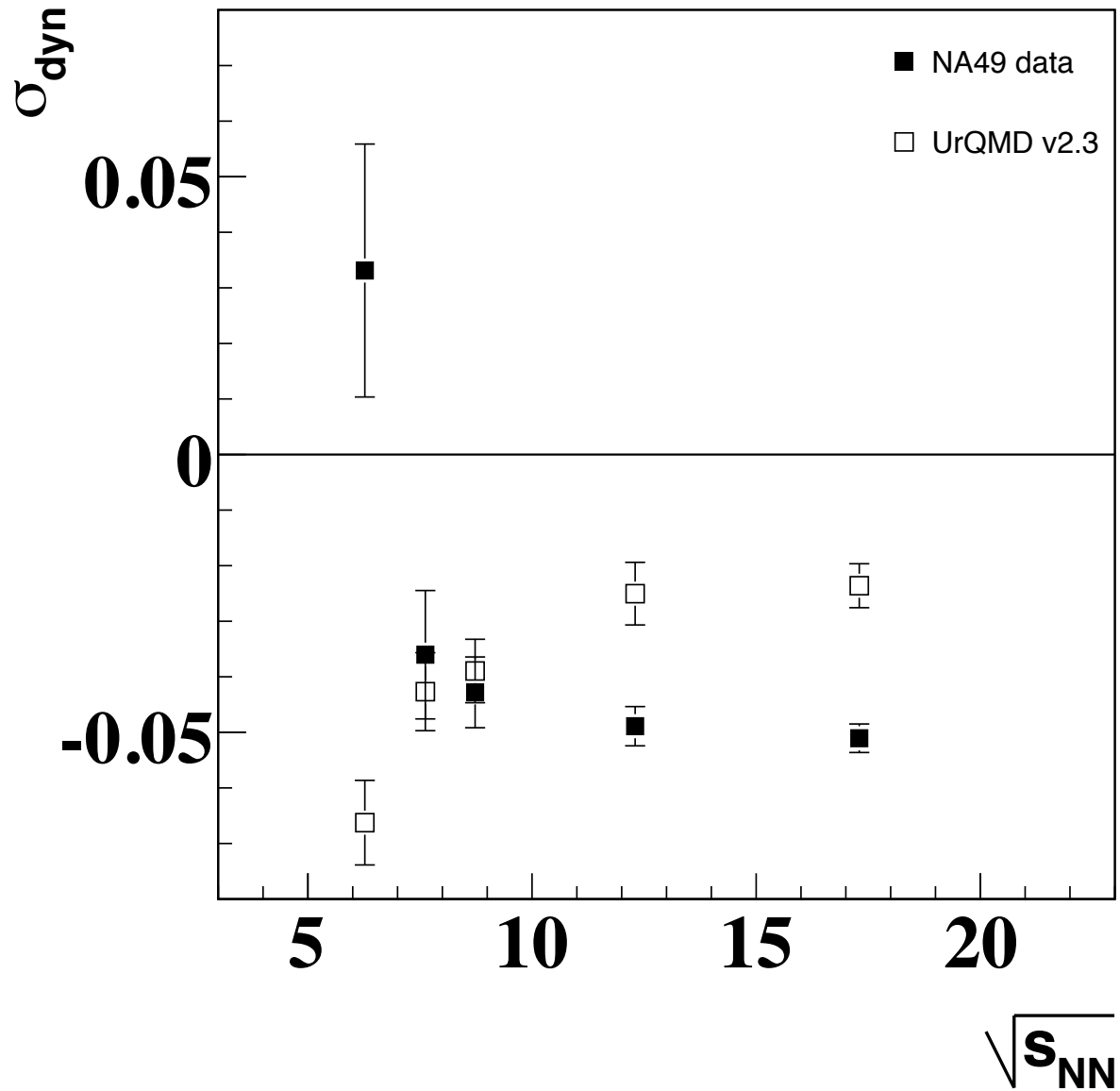


C. Alt et al. (NA49) PRC 73, 2006, 044910



T. Schuster et al. (NA49 preliminary)

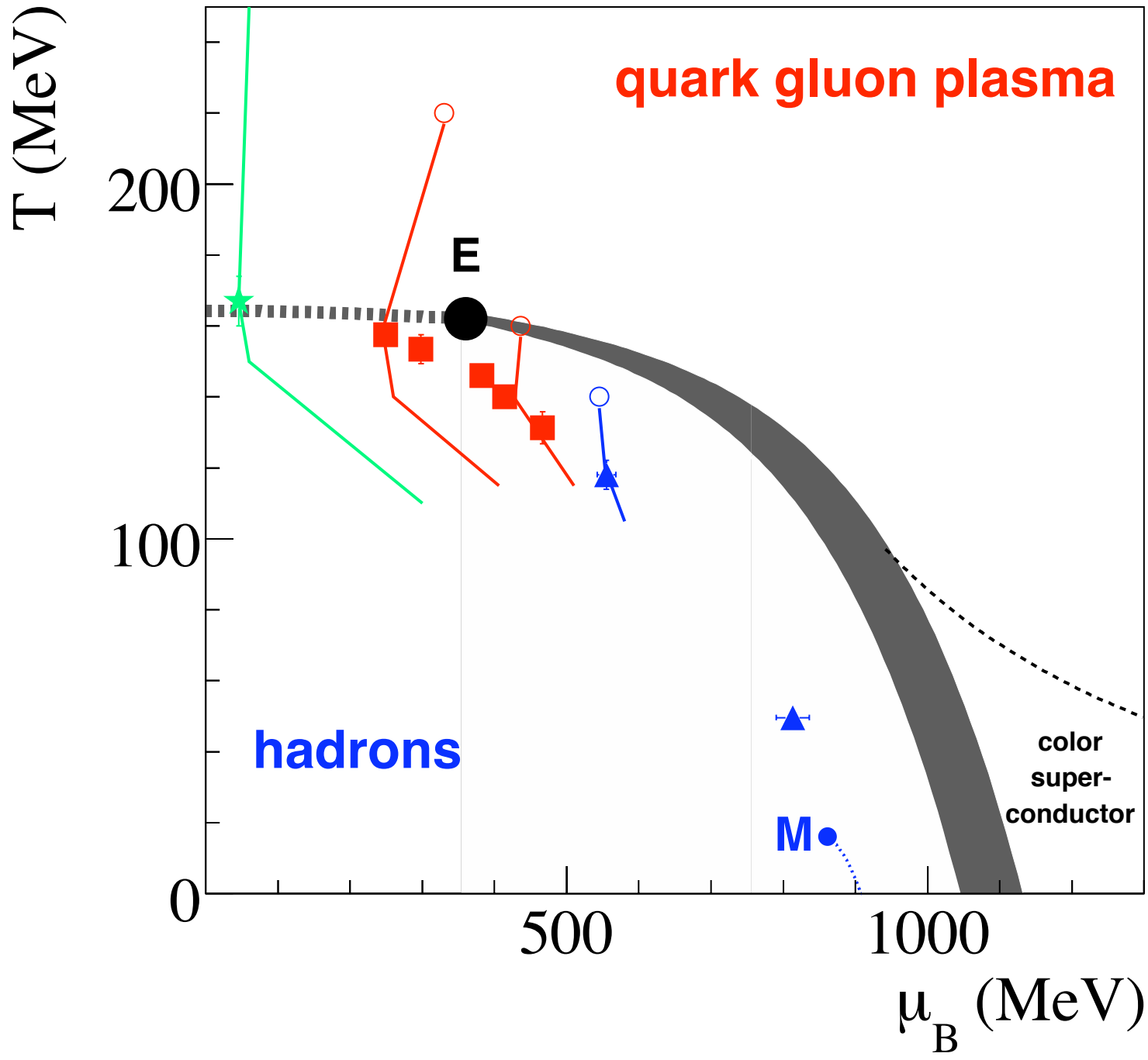
K/p dynamical fluctuations at SPS



σ_{dyn}(K/p) related to

$$C_{BS} = 1 + \frac{\chi_{us}+\chi_{ds}}{\chi_{ss}}$$

V. Koch et al.
PRL 95, 2005, 182301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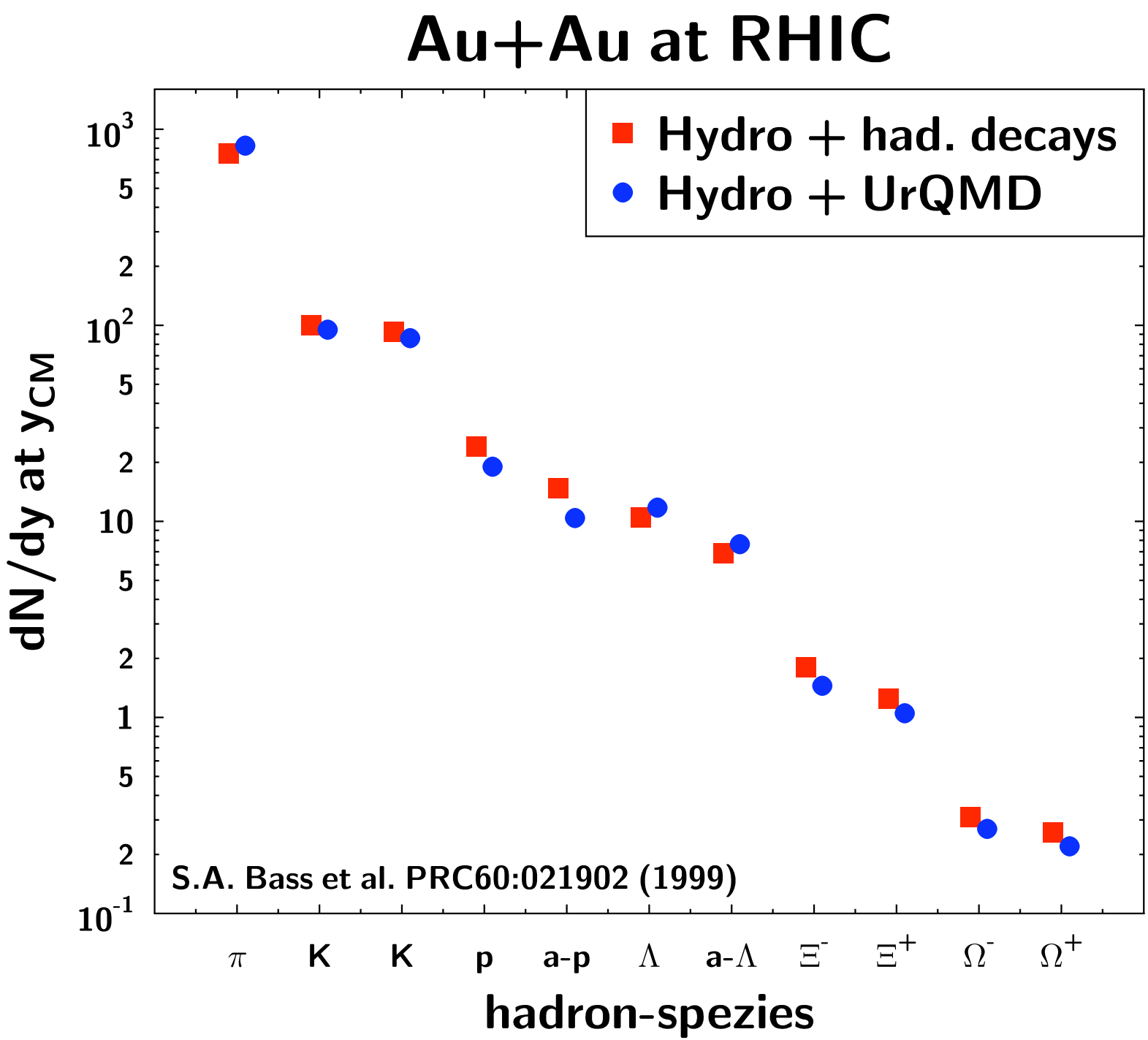
Au+Au at RHIC
Hydro + had. decays
Hydro + UrQMD
dN/dy at y_{CM}
10^3
5
2
10^2
5
2
10
5
2
1
5
2
10^{-1}
S.A. Bass et al. PRC60:021902 (1999)
π
K
K
p
a-p
Λ
a-Λ
Ξ^-
Ξ^+
Ω^-
Ω^+
hadron-spezies

Sequential chemical freeze-out

- Hadronic evolution at $\sqrt{s} < 10$ GeV:
- higher ρ/ρ_0, slower expansion
- new scenario!
- Determine $T_C \leq T_{F\text{-}O}(\Omega) \leq ... \leq T_{F\text{-}O}(\pi,N)$?

In addition: chiral restauration and critical point

DATA!