Chemical freeze-out of hadrons within the advanced Hadron Resonance Gas Model

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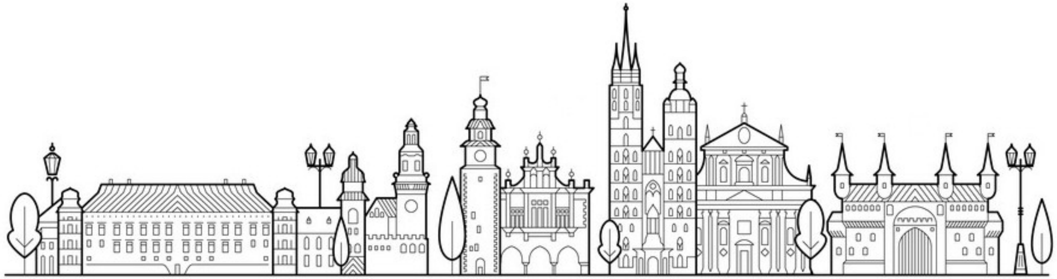

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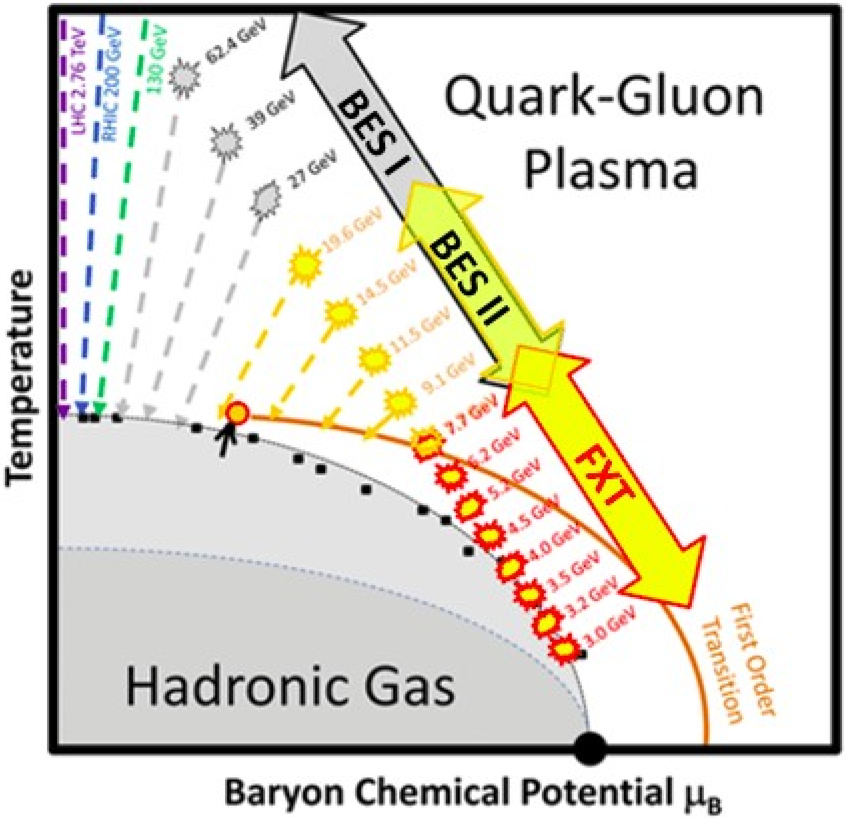
Motivation

Exploring of the QCD phase diagram:

- detect signals of colour deconfinement;
- detect signals of chiral symmetry restoration;
- locate critical endpoint of QCD phase diagram.

In order to solve these tasks we need a good tool to analyze the data!



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Induced Surface Tension EOS

pressure

induced surface tension coefficient

$$\begin{cases} p = T \sum\limits_{k=1}^{N} \phi_k \exp\left[\frac{\mu_k - pV_k - \Sigma S_k}{T}\right], \\ \Sigma = T \sum\limits_{k=1}^{N} R_k \phi_k \exp\left[\frac{\mu_k - pV_k - \alpha \Sigma S_k}{T}\right]. \end{cases}$$

R_k , V_k , S_k are hard-core radius, eigenvolume and eigensurface of hadron of sort k,

φ_k - thermal density of the k-th particle sort with BW mass distribution function for resonances

Advantages

- 2 equations, does not depend on the number of different hard core radii
- Allow one to go beyond the Van der Waals approximation, since it reproduces 2-nd, 3-rd and 4-th virial coefficients of the gas of hard spheres for $\alpha = 1.245$.

V. V. Sagun et al., EPJ Web of Conferences 137 (2017) 09007
K. A. Bugaev et al., Nucl. Phys. A 970 (2018) 133-155

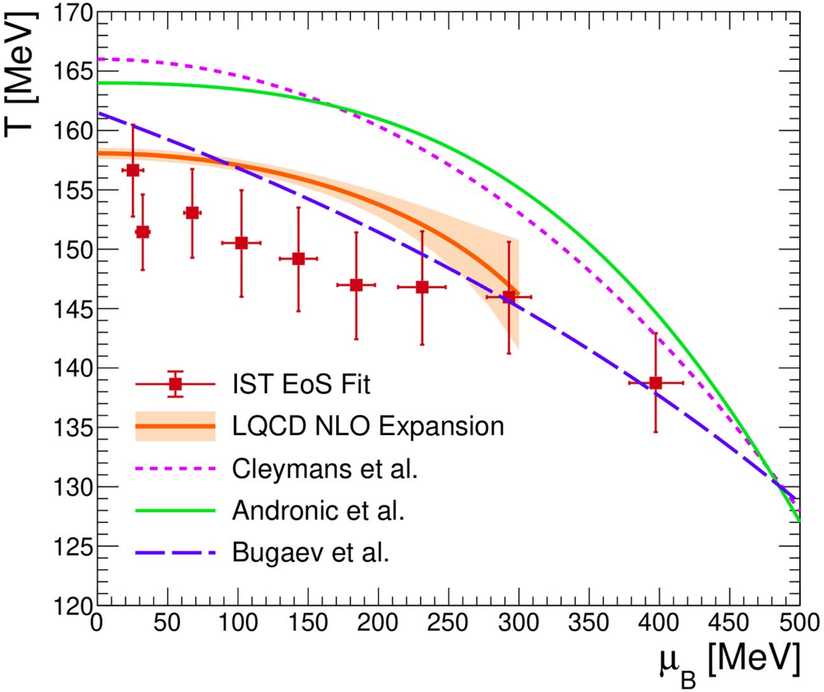
Inclusion of weak decays for STAR data in the IST EOS

STAR data at energies: √s = 7.7 - 200 GeV.

Local fit parameters: **T, μ_B, μ_{I3}, μ_S, γ_S**

Global fit parameters: **R_π, R_K, R_{mesons}, $R_{baryons}$, R_Λ**

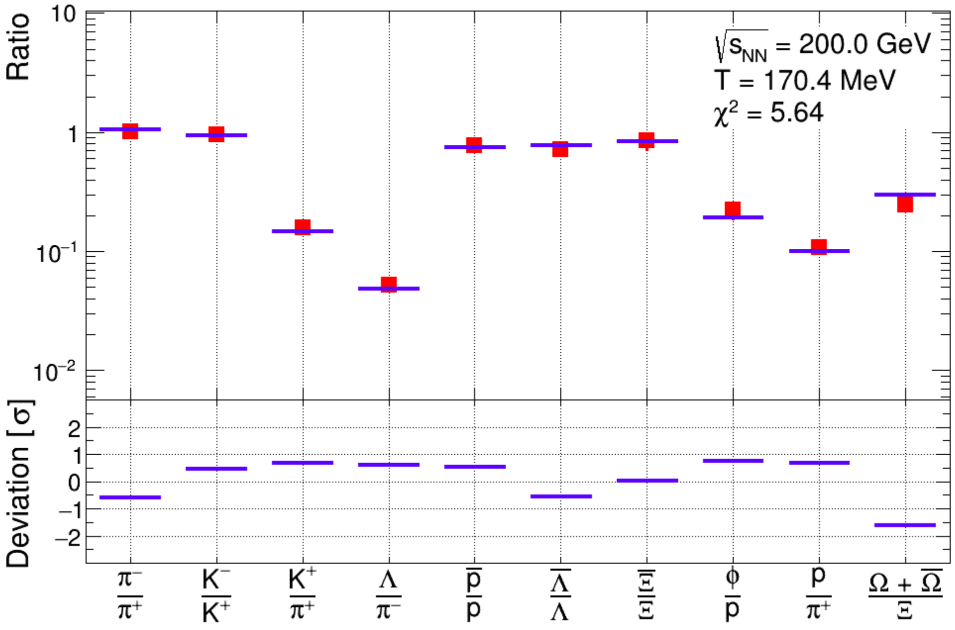
- Fit by STAR Collaboration for √s>27 GeV has T~160-170 MeV
- Inclusion of weak decays **decreases** temperature of chemical freeze-out by **10 MeV!**



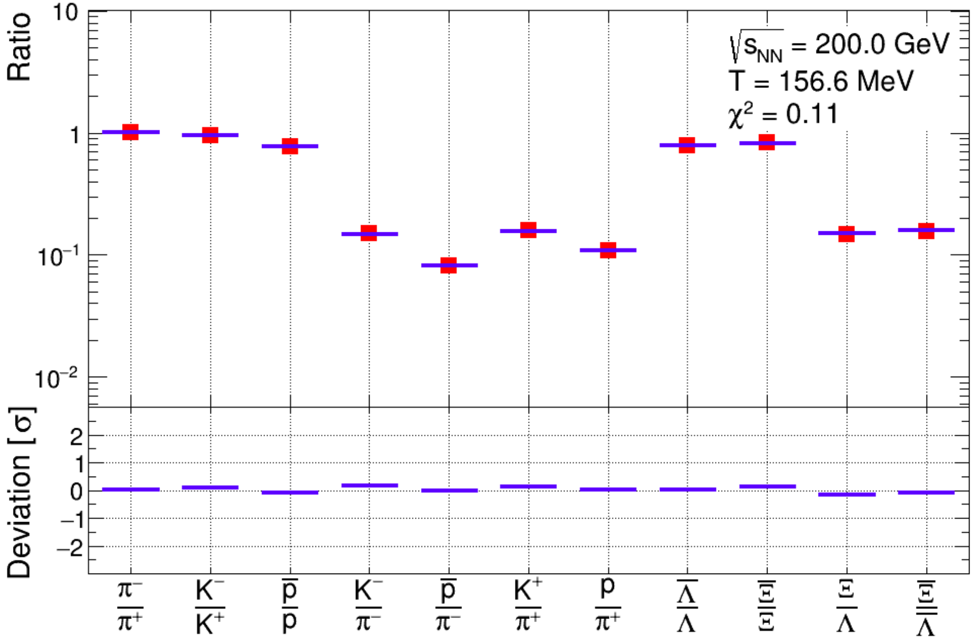
A. Andronic et al., Nucl. Phys. A 834 (2010) 237c
K. A. Bugaev et al., Ukr. J. Phys. 61 (2016) no. 8, 659
J. Cleymans et al., Phys. Rev. C 73 (2006) 034905
S. Borsanyi et al., Phys. Rev. Lett. 125 (2020) 052001

IST EOS fit of the hadron ratios from STAR data at 200 GeV

Without inclusion of weak decays



With inclusion of weak decays



- Inclusion of weak decays **greatly** improves the description of particle ratios in the experimental data (**50 times better** in this case).

Conclusion

- IST EOS is a good tool to decribe particle yields and to get chemical freeze-out parameters

- Inclusion of weak decays:
    - Brings the chemical freeze out T to the right track. It gets lower than LQCD predictions for pseudocritical T
    - Provides an excellent decription of the STAR data
    - Now the chemical freeze-out T of STAR and ALICE data are consistent with each other