Study of hadron yields produced in Pb-Pb collision.

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Introduction

The study of hadron yields using simple statistical model has proved to be extremely successful. Such models can very well reproduce all the essential features of particle production in heavy-ion collisions including elementry collisions at LHC. They were first implemented in studying the data from AGS and also to the first data from CERN SPS. Such success of statistical thermal model has led to the creation of several software codes and here THERMUS(one of such code) is utilized. THERMUS is a thermal model analysis package which analyses the particle production in relativistic heavy-ion collisions and is based on the object-oriented ROOT framework [1].

Performing fits using THERMUS

THERMUS basically works on the implementation of six different parameters T, μ_B , μ_S , μ_Q , γ_S , R and on imposing any of the three statistical ensembles; a grand canonical, a fully canonical treatment and a mixed-canonical ensemble. As of heavy-ion collisions, the large number of baryons and charged particles generally allows baryon number and charge to be treated grand-canonically. So we perform fits on the basis of grand-canonical ensemble, considering full strangeness saturation $\gamma_S = 1$ and constraining the ratio B/2Q which leaves T and μ_B as free parameters.

Now making use of hadron yields from Pb-Pb collsion NA49 experiment with different S_{NN} from SPS (Super Protron Syncrotron) CERN (European Organization for Nuclear Research) we perform the fits.

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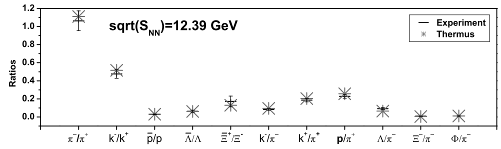

FIG. 1: The plot shows fits for Pb-Pb collision at centre of mass energy 12.39 GeV.

Considering the fits at different values of $\sqrt{S_{NN}}$ the resulting values of thermal parameters are listed in the table below where the calculated values from EV-HRG are also included from Ref.[2].

TABLE I: Values of freeze-out temperature for Pb-Pb collision at different energies

$\sqrt{S_{NN}}$(GeV)	T_{ch}(MeV)^a	T_{ch}(MeV)^b
6.406	126.503±2.8	125.6 ± 5.4
7.733	139.425±4.1	138.5 ± 1.9
8.863	142.251±3.4	138.9 ± 1.7
12.39	139.811±3.0	144.4 ± 2.4
17.32	142.404±3.0	146.7 ± 1.6

[a]THERMUS
[b]EV-HRG

TABLE II: Values of baryonic chemical potential for Pb-Pb collision at different energies.

$\sqrt{S_{NN}}$ (GeV)	μ_B (MeV)^a	μ_B (MeV)^b
6.406	423.231±11.03	505.1 ± 7.2
7.733	397.942±10.8	459.5 ± 5.5
8.863	361.236±9.42	424.9 ± 6.3
12.39	258.094±6.47	349.2 ± 5.5
17.32	207.334±5.08	292.03 ± 6.03

[a]THERMUS
[b]EV-HRG

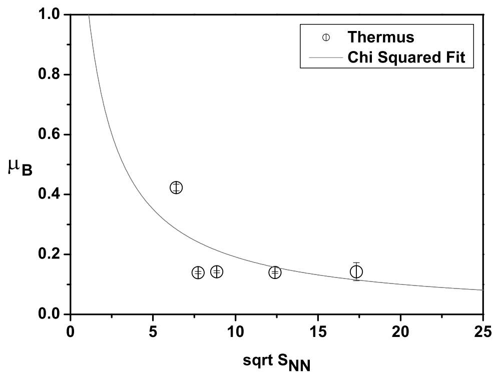

FIG. 2: The figure depicts the variation of baryonic chemical potential with the collision energy.

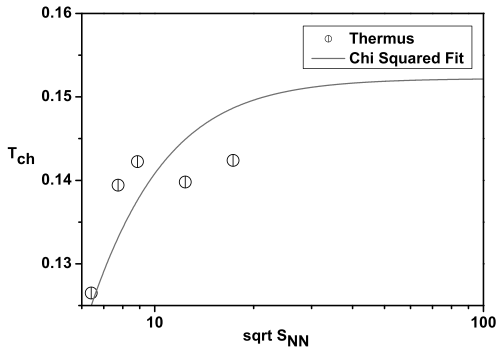

FIG. 3: The figure depicts the variation of freeze-out temperature with the collision energy.

The similarity between the results of two approaches can be seen from the tables.

Dependence of freeze-out parameters on collision energy

Now in order to reproduce the dependence of the chemical potential and the chemical freeze-out temperature on the collision energies we perform the following parametrization.

The dependence of the chemical potential freezeout parameters on the $\sqrt{S_{NN}}$ can be parametrized as

$$\mu_B = \frac{a}{1 + b\sqrt{S_{NN}}} \quad (1)$$

Similarly, the dependence of freezeout temperature on $\sqrt{S_{NN}}$ is parametrized as

$$T_{ch} = T_{lim}\left[\frac{1}{1 + exp\left[\frac{1.172 - ln\sqrt{S_{NN}}}{0.45}\right]}\right] \quad (2)$$

Conclusion

The values of obtained freeze-out parameters tend to show a relation with the collision energy. Higher is the value of collision energy lesser is the observed value of chemical potential. This drop in chemical potential can be very helpful in determing the critical point and also to determine the phase boundary between QGP and hadronic phase. The experiments conducted at RHIC and LHC have also shown constant results on such freezeout patterns and are in close approximation with the predicted values of Lattice QCD [3].

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