Stopping in $\sqrt{s_{NN}} = 62.4$ GeV Au+Au collisions

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Stopping in heavy ion collisions has been measured at several energies from AGS to RHIC (spanning $\sqrt{s_{NN}} = 5$ GeV to $\sqrt{s_{NN}} = 200$ GeV).The systematics of stopping hint the onset of a collision regime that might include LHC energies. Stopping in $\sqrt{s_{NN}} = 62.4$ GeV Au+Au collisions contribute to the understanding of different collision systems.

I. ANALYSIS

The data presented here were taken with the BRAHMS experiment at RHIC [1, 2]. The BRAHMS experiment consists of two spectrometers that can measure and identify charged protons and anti-protons in the range $-0.1 < y < 3.1$. Figure 1 shows invariant spectra of protons and anti-protons.

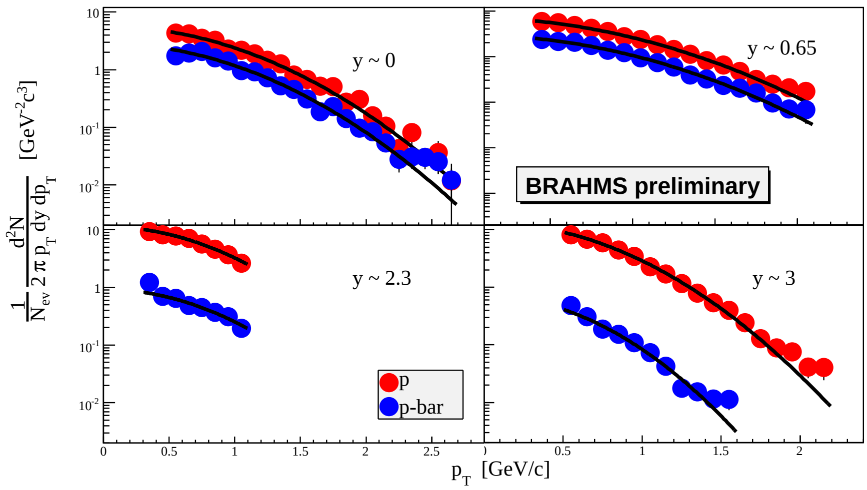

FIG. 1: Spectra of identified protons and antiprotons for $y \sim 0$, $y \sim 0.7$, $y \sim 2.3$ and $y \sim 3$ respectively. Included in the figure are the fit functions used to determine the yield. Vertical bars show statistical errors only.

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II. RAPIDITY LOSSES

The usual way to quantify stopping is by means of the rapidity loss [3]:

$$\delta y = y_{beam} - \frac{2}{N_{part}} \int_0^{y_{beam}} y \frac{dN_{B-\bar{B}(y)}}{dy} dy \tag{1}$$

Here y_{beam} is the beam rapidity, N_{part} is the number of participants and $\frac{dN_{B-\bar{B}(y)}}{dy}$ is the measured net-baryon distribution. As the BRAHMS experiment measures only charged particles the net-baryons must be derived from simulations of the neutron and hyperon contributions.

Figure 2 shows the rapidity loss from $\sqrt{s_{NN}} = 62.4$ GeV Au+Au collisions together with results from AGS [5], SPS [6] and RHIC [7]. From SPS energies ($\sqrt{s_{NN}} = 17$ GeV) and upwards the rapidity loss seems to saturate or at least vary slowly with energy. An attempt has been made to estimate the expected rapidity loss at LHC. As can be seen from the figure we estimate $2 < \delta y_{LHC} < 3.4$.

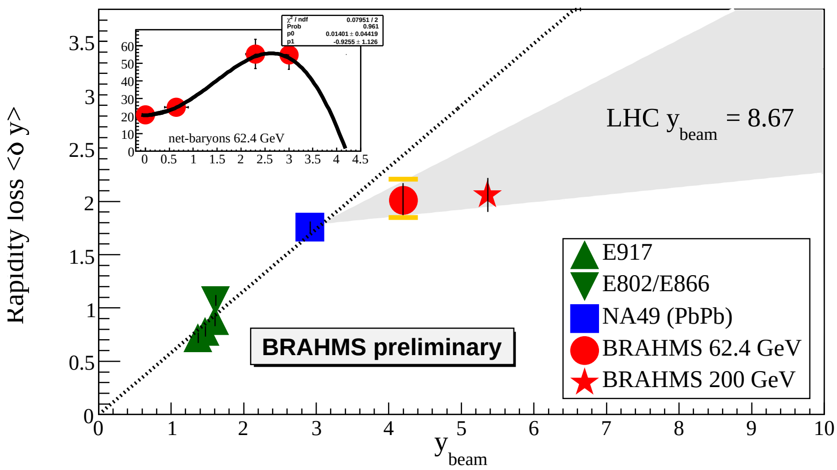

FIG. 2: Rapidity losses from AGS, SPS and RHIC as a function of rapidity. The inset shows a 6'th degree polynomial fit used to estimate the net-baryon distribution. The band represents the expectation for LHC, consistent with the $\sqrt{s_{NN}} = 200$ GeV data. Also included is the linear fit to AGS and SPS data from [3]. The scaling is clearly broken already at $\sqrt{s_{NN}} = 62.4$ GeV.

III. NET-BARYONS

In the Bjorken collision scenario [4] the midrapidity region is net-baryon free. Figure 3 shows net-baryons from AGS, SPS and RHIC including this new measurement at $\sqrt{s_{NN}} = 62.4$ GeV. It is seen that even at $\sqrt{s_{NN}} = 62.4$ GeV and $\sqrt{s_{NN}} = 200$ GeV the midrapidity region is not net-baryon free. The black curves in the figure show a Bjorken inspired fit function. A simple extrapolation of this fit function to the LHC energy gives the curve in the bottom panel of the figure. It is worth noting that the rapidity loss calculated from the LHC extrapolation is consistent with the prediction given in Figure 2.

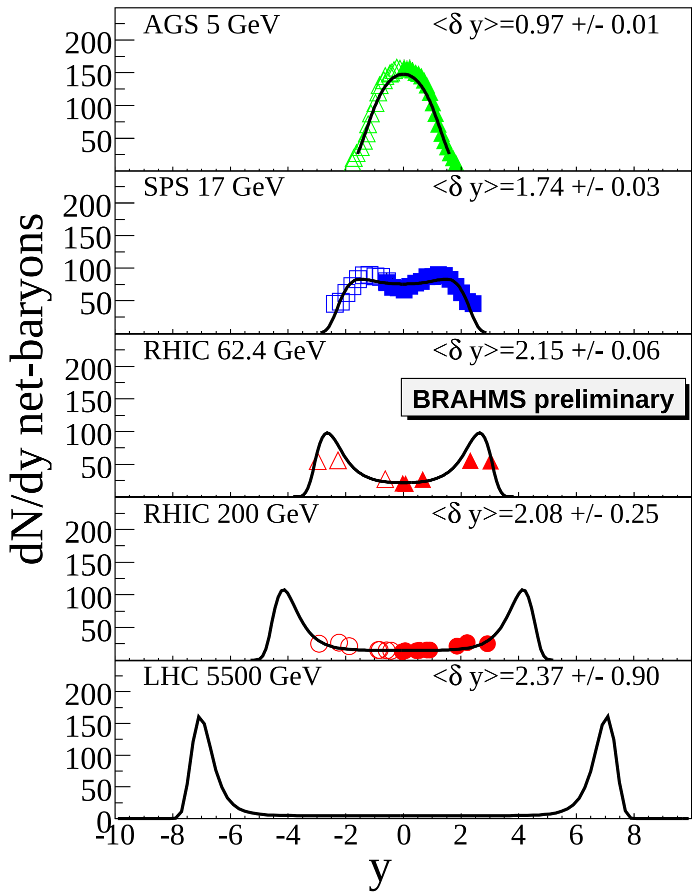

FIG. 3: The top four panels show the net proton rapidity distributions from AGS, SPS and RHIC ($\sqrt{s_{NN}}$ = 62.4 GeV and $\sqrt{s_{NN}}$ = 200 GeV) [5–7] obtained as described in the text. The average rapidity losses are listed. The bottom panel shows the prediction for the Large Hadron Collider (LHC)

IV. LONGITUDINAL SCALING

In order to compare net-baryons at SPS and RHIC we consider the net-baryon distribution to consist of two parts: The 'projectile' distribution from one nucleus and the 'target' distribution from the other. The two contributions overlap and form $\frac{dN_{B-\bar{B}(y)}}{dy}$. We want to study the rapidities $0 < y < y_{beam}$ or the 'projectile' side of the collision. We use the variable $y' = y - y_{beam}$. Thus,

$$\frac{dN_{B-\bar{B}(y)}}{dy'} = \frac{dN_{projectile}}{dy'} + \frac{dN_{target}}{dy'} \Rightarrow \frac{dN_{projectile}}{dy'} = \frac{dN_{B-\bar{B}(y)}}{dy'} - \frac{dN_{target}}{dy'} \tag{2}$$

In this study we have used a simple linear rapidity distribution to remove the 'target' net-baryons. Work is in progress to include a more realistic study using a baryon transport model [8]. The result is shown in Figure 4. It is seen that there seems to be a longitudinal scaling of net-baryon 'projectile' distributions from SPS to RHIC energies.

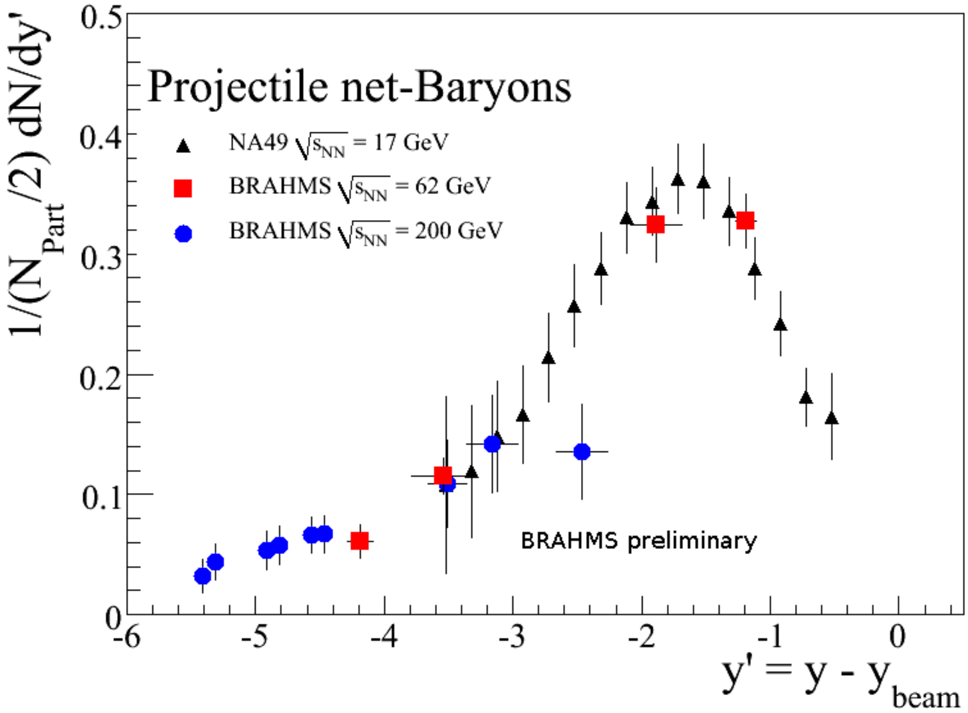

FIG. 4: The figure shows $(1/N_{part}/2)dN/dy'$ from SPS and RHIC after subtraction of the target net baryon contribution. A 'longitudinal scaling' is clearly visible through two orders of magnitude in $\sqrt{s_{NN}}$.

V. SUMMARY

Measurements from BRAHMS of $\sqrt{s_{NN}} = 62$ GeV Au+Au collisions at RHIC expand the study of stopping systematics from SPS to RHIC. Through extrapolation the rapidity loss at LHC is estimated and a longitudinal scaling behaviour observed. The rapidity loss seems to saturate at higher energies indicating the onset of a new collision regime.

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