Rapidity density deviations in Pb+Nb and Ni collisions at 158 A GeV/nucleon beam energy

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(Received 31 January 2010; accepted 16 May 2010)

Abstract

Phenomenological models used, for comparison with the experimental observations, for a long time. This comparison slowly modified the structure of these models. They have contributed significantly in planning the future experiments, in addition to pointing out deviations, which needs other experiments. In this work, a Rapidity distribution in heavy ion interactions is studied, and comparison between simulated results with actual experimental data using several targets to look for deviations from the general trend.

Keywords: Rapidity density, deviations, Pb+Nb, Ni interactions.

Resumen

Durante mucho tiempo han sido utilizados modelos fenomenológicos, para compararlos con las observaciones experimentales. Esta comparación lentamente ha modificado la estructura de estos modelos. Han contribuido de manera significativa en la planificación de los experimentos futuros, además de señalar las desviaciones, que las necesidades de otros experimentos. En este trabajo se estudia una Rápida distribución en la interacción de iones pesados, y la comparación entre los resultados reales simulados con datos experimentales con varios objetivos para buscar las desviaciones de la tendencia general.

Palabras clave: Densidad rapidez, desviaciones, Pb + Nb, interacciones en Ni.

PACS: 25. 75. D, 11.30.Rd, 29.25.Lg, 29.25.Ni **ISSN 1870-9095**

I. INTRODUCTION

Nuclear physics went through revolution and its connection to particle physics and statistical physics become more apparent, so that relativistic beams of heavy nuclei become available at several places in the world. In the mid 1980s the heavy ions injected into some of the highest energy proton accelerators, such as the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory (BNL) and the Super Proton Synchrotron (SPS) at the European Center for Nuclear research (CERN). By the early 1990 s the injection of heavy ions had already been studied at the planning phase of the new accelerators, as in the case of the Large Hadron Collider (LHC) of CERN. Nuclear physics become so much the center of interest because heavy ion reactions are the only means to compress and heat up nuclear matter in laboratory. Which lead to the exploration of the quark-gluon plasma (GQP). Studying the Ultra-relativistic heavy ion Pb+Nb and Pb+Ni collisions is the major motivation to search for the (QGP), a potential new state of matter where colored quarks and gluons no longer confined into hadrons and chiral symmetry restored. To study such a complicated system one wish for a probe that is not equally complicated in itself. The production of hadrons are governed by the strong interaction and therefore adds to the complication, as the probability of rescattering processes, which modify the properties at later stages, is high. One possible way out might be the study of hard processes where Quantum chromodynamics (QCD), the theory of strong interaction, enters the perturbation regime and is calculable. The other avenue involves a particle that suffers only electromagnetic interaction: Photons — both real and virtual — should be an ideal probe. For previous reviews on this topic, see Refs. [1, 2, 3, 4].

Study of photon production in heavy ion interaction gives us general trends of variation of various parameters. A comparison of the experimental observations with the results of phenomenological models allows us to know the domains of deviations. A detailed investigation of these deviations is very important. This suggests modifications of some simulation models.

II. PHOTONS PROBE

At the Relativistic Heavy Ion Collider (RHIC), nuclei are collided at ultra-relativistic energies to create a new state of matter the (QGP) [5]. Emitting particles that only interact through the electroweak interactions are very unlikely to interact again despite the dense medium, which created. Thus, they are able to carry the detectors information about the state of the system at the time they created [6]. Photons and leptons thus constitute a unique class of penetrating probes. The two most interesting sources of photons are those where the plasma is directly involved in the emission. These are the thermal radiation from the hot QGP [6] and the radiation induced by the passage of high energy jets through the plasma [7, 8, 9]. Both may be produced e.g. by processes like quark-gluon Compton scattering or quark- antiquark annihilation see (figure 1).The thermal radiation is emitted predominantly with low transverse momentum pT and has to compete with photon emission from the hot hadronic gas at later times [10, 11]. Photons from jets are an important source at intermediate pT where they compete with photons from primary hard scatterings among partons of the nuclei [12]. They probe the thickness of the medium: the longer the path of the jet, the more photons emitted.

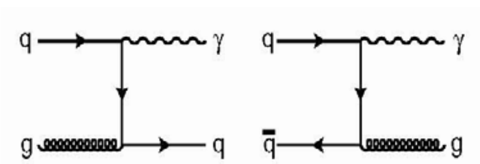


FIGURE1. Lowest order processes for photon production in QCD. Left: quark-gluon Compton scattering; right: quark-antiquary annihilation.

III. DATA SELECTION

Analysed data collected during Pb interaction with other targets run in WA98 heavy ion experiment at CERN SPS. Information from Many factors like collected energy at particular angle, multiplicity of the projectile and targets fragments and number of created particles chosen to classify the selected events. The heavy ion collision can be divided into peripheral, not so central (Quasi central) and central collision. In central collisions, the production of heavier fragments reduces drastically due to complete overlapping of the two nuclei. We used data from trigger detectors, *i.e.* MIRAC and zero degree calorimeter (ZDC) measures energy in the very forward one. The coverage of MIRAC and Photon Multiplicity detector (PMD) is almost same. We use E_T observed in MIRAC as the selection parameter of the events. The range for different class of E_T is ≥ 291.65.These events are also termed as central events.

The PMD, with its fine granularity, is able to measure the spatial distributions of photons of high multiplicity events. A rapidity density distribution for photons produce in Pb+Pb interaction at 158 A GeV is studied [13], and Pb-Ni, Nb. The values of transverse energy and multiplicities of produced particles observed in central collisions show that energy density sufficient for QGP formation might have stained over a large nuclear volume. The observed pseudprapidity distributions for all targets analyzed with reference to Number of participant nucleons (N_{part}) in the interactions [14]. The observe parameters e.g. total photon multiplicity change smoothly with N_{part}.

IIV. RESULT AND DISCUSSION

Photon multiplicity distributions for minimum bias sample as well as sample of central events have been studied [15]. For minimum bias sample charged particle multiplicity distributions are analyzed in terms of negative binomial distributions (NBD) by [16] (figure 2a, 2b and 2c), was shown that photon multiplicity distributions for minimum bias using Ni and Nb sample can be parameterize as NBD. As well as the photon, multiplicity for central reactions studied in terms of Gaussian distributions. It observed that, comparing different sample it is illustrious to plot normalized photon multiplicity Ng /< Ng> [15] (figure 3).

With a different window range ($\Delta\eta$ = 0.05, 0.1 and 0.2 units of rapidity), we have analyzed the rapidity density distributions for central Pb-Ni, and Nb interactions in detail e.g. and comparison made between different targets based on VENUS code, for central events analyzed (Et≥291.65). The number of events analyzed for Pb was 3019 and for Ni and Nb was 2840 for the range 3.0-4.2 with different window sizes.

Result on rapidity density for central Pb+Pb collisions between real data and simulated data studied by [15]. Phenomenological models been used, for comparison with experimental observations, for a long time. This comparison has slowly modified the structure of these models. They have contributed significantly in planning the future experiments, in addition to pointing out deviations, which need other experiments.

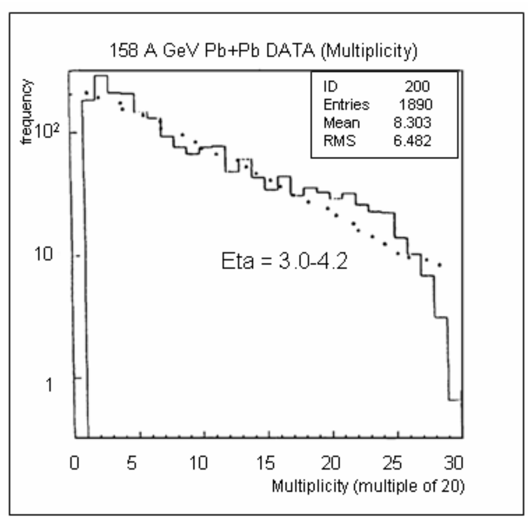


FIGURE 2a. Multiplicity distribution of photons in the limited rapidity interval of 3-0 – 4.2 for Pb+Pb.

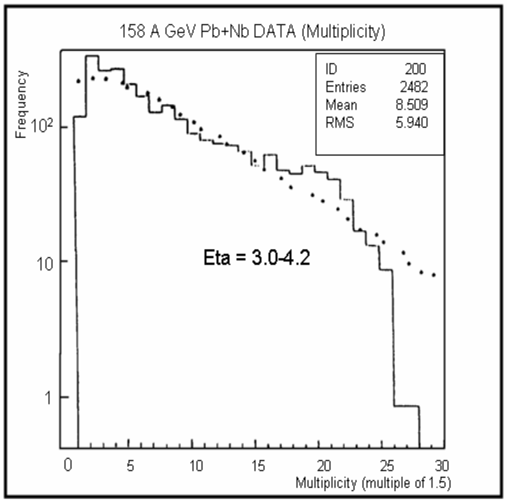


FIGURE 2b. Multiplicity distribution of photons in the limited rapidity interval of 3-0 – 4.2 for Pb+Nb.

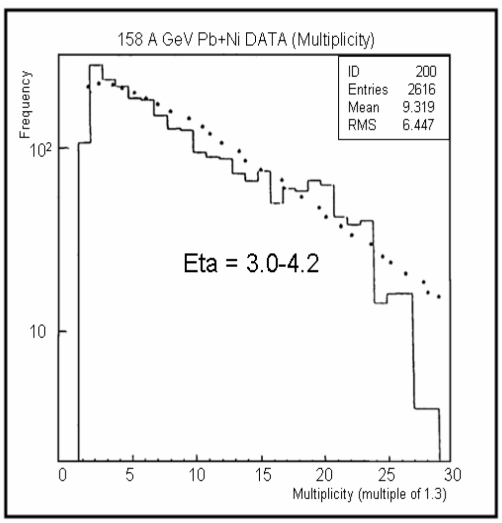


FIGURE 2c. Multiplicity distribution of photons in the limited rapidity interval of 3-0 – 4.2 for Pb+Ni.

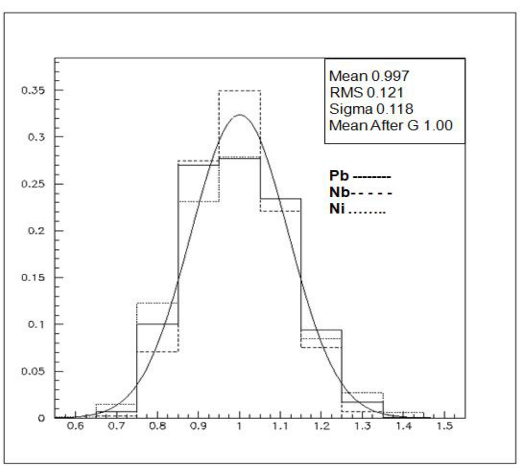


FIGURE 3. Gaussian fit for data Pb-Pb, Nb And Ni interactions.

In this article, comparison of rapidity density distributions measured at 158 A GeV in WA98 experiment using several targets. The general shape for the distributions observed is almost similar to all targets. (Figures 4(a, b), 5(a, B)) show the rapidity distributions for 0.05 sizes of windows of rapidity, where the mean of Pb is raised to that of Nb and Ni, it was clear after the normalization to the same <Nγ>. Deviation around η=3.4 for the Pb data and Ni as well as for Nb becomes more apparent while the similarity of the remaining distribution is clearly observed.

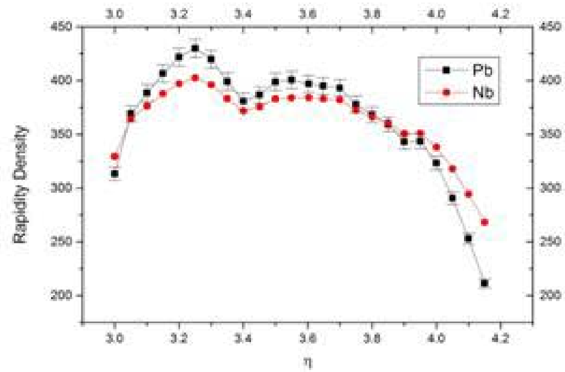


FIGURE 4(a). Normalized rapidity density for inclusive photons in Pb+Nb collisions at 158 A GeV/ nucleon beam energy with wide $\Delta\eta = 0.05$.

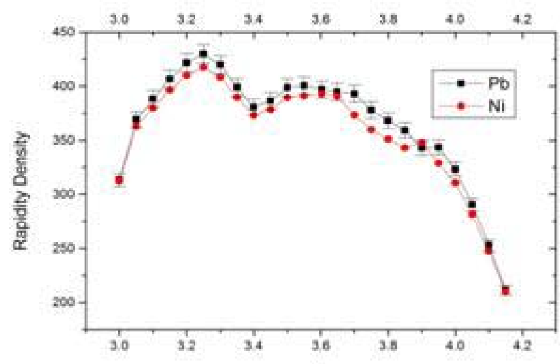


FIGURE 4(b). Normalized rapidity density for Pb+Ni collisions.

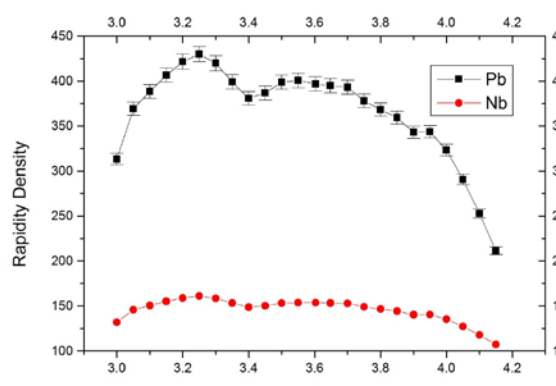


FIGURE 5 (a). Non normalized rapidity density for inclusive photons in Pb+Nb collisions at 158 A GeV/ nucleon beam energy with wide $\Delta\eta = 0.05$.

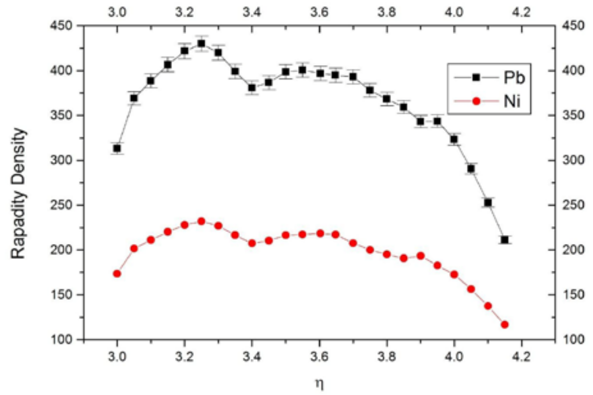


FIGURE 5 (b). Non normalized rapidity density for inclusive photons in Pb+Ni collisions at 158 A GeV/ nucleon beam energy with wide $\Delta\eta = 0.05$.

By looking for the mean value for Pb+Nb and Ni interactions, will become closer if we increased the η window to 0.1. As will the deviation will decrease, and that is more clear in Ni and Nb targets if we increase the η window to 0.2, as shown in (figures 6 (a, b),7 (a, b), 8 (a,b) and 9(a, b)), for the same rapidity density with a different window sizes.

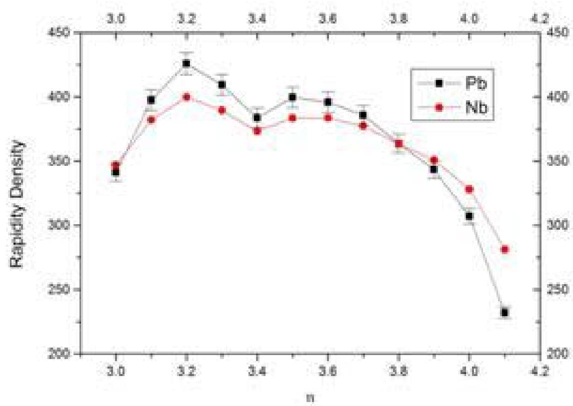


FIGURE 6(a). Normalized rapidity density for inclusive photons in Pb+Nb collisions at 158 A GeV/ nucleon beam energy with wide $\Delta\eta = 0.1$.

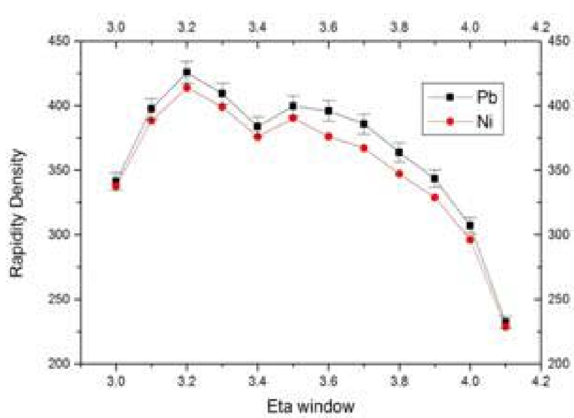
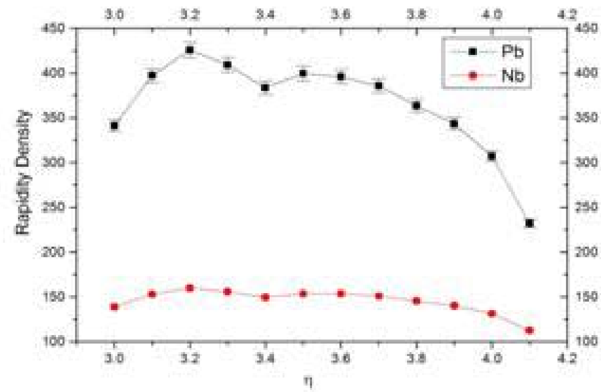
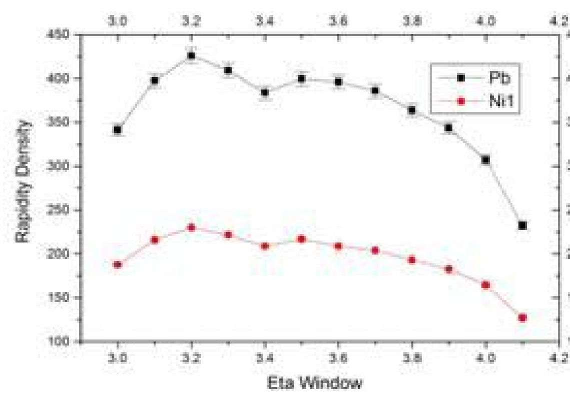


FIGURE 6 (b) Normalized rapidity density for Pb+Ni collisions.



FIGURES 7(a). Non-normalized rapidity density for inclusive photons in Pb+Nb collisions at 158 A GeV/ nucleon beam energy with wide $\Delta\eta = 0.1$.



FIGURES 7 (b). Non-normalized rapidity density for inclusive photons in Pb+Ni collisions at 158 A GeV/ nucleon beam energy with wide $\Delta\eta = 0.1$.

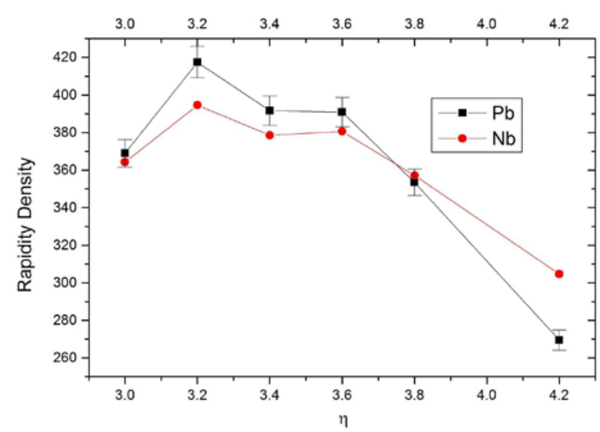


FIGURE 8 (a). Normalized rapidity density for inclusive photons in Pb+Nb collisions at 158 A GeV/ nucleon beam energy with wide $\Delta\eta = 0.2$.

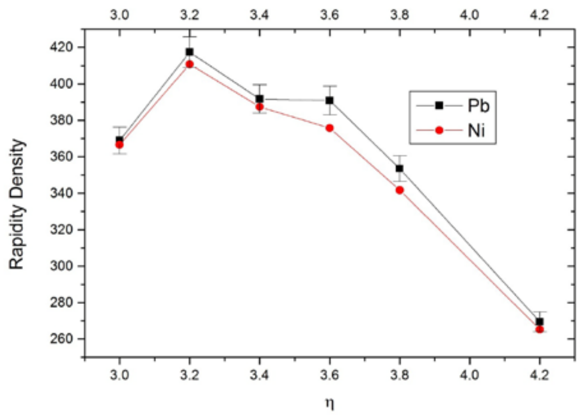
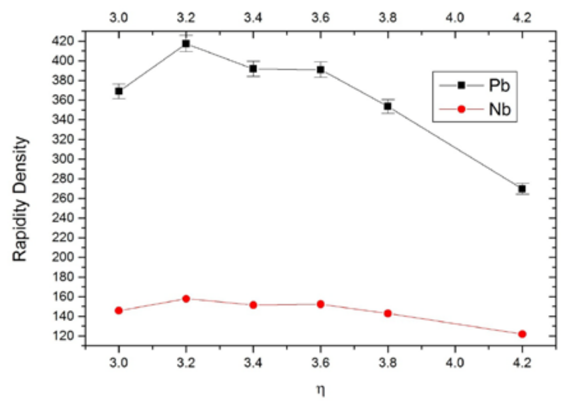
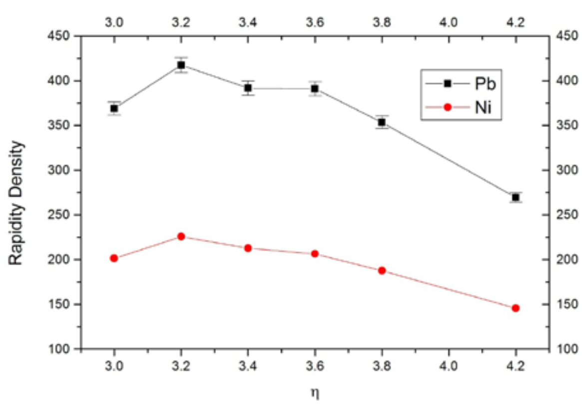


FIGURE 8 (b). normalized rapidity density for Pb+Ni collisions.



FIGURES 9(a). Non-normalized rapidity density for inclusive photons in Pb+Nb collisions at 158 A GeV/ nucleon beam energy with wide Δη = 0.2.



FIGURES 9(b). Non-normalized rapidity density for inclusive photons in Pb+Ni collisions at 158 A GeV/ nucleon beam energy with wide Δη = 0.2.

V. CONCLUSIONS

Phenomenological models been used, for comparison with the experimental observations; this comparison allows us to know the domains of deviations. By comparing the rapidity distributions Pb+Nb and Pb+Ni interactions for a different windows sizes, shows a little deviation near η=3.4 for all targets. This study of systematic suggests modifications of simulation models; thus make productions useful for planning future heavy ion experiments. A complete transparency expected at LHC energies for a large rapidity range.

VI. ACKNOWLEDGMENT

This work supported by WA98 experiment (India group). As well, the help from Prof. Khalil alTaeef, Prof. A. Al badawi and Prof. Abu Samak was the way to this accomplishment.

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