NUCLEUS-NUCLEUS COLLISIONS
AT ULTRA-RELATIVISTIC ENERGIES:
STATUS AND PROSPECTS *)

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Received 2 February 1995

Physics with ultra-relativistic heavy ions at three different accelerators SPS at CERN and AGS and RHIC at BNL is reviewed. The physics discussed ranges from global event characteristics through direct photon production, proton-proton correlation studies to Quark Gluon Plasma (QGP) phase transition signatures via dileptonic, photonic and hadronic signals.

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1 Introduction

This paper is based on three lectures presented at the Prague Seminar on Relativistic Heavy-Ion Physics in September 1994. The first lecture, following a general introduction, focuses on three different aspects of the CERN experiment WA80. I first present results on global event characteristics deduced primarily from measured distributions of transverse energy and of forward energy [1]. The purpose is to introduce the main general features of nucleus-nucleus reactions at the highest energies currently available. I highlight the role of projectile-target geometry, discuss the degree of nuclear stopping, and estimate the energy densities attained in these reactions. This discussion is followed by a presentation of one of two topics that are unique to the WA80 experiment and which are not addressed by any of the other CERN collaborations that study nucleus-nucleus reactions: direct measurements of photons [2]. The second topic unique to WA80, measurements of photons...
proton-proton correlations in the target-fragmentation region [3], is covered in the first part of the second lecture. The remainder of the second lecture is devoted to a selective overview of results obtained at the AGS accelerator of Brookhaven National Laboratory (BNL). The third lecture is devoted to a discussion of the two main experiments, STAR and PHENIX, planned for the Relativistic Heavy Ion Collider, RHIC, under construction at BNL.

2 Global event characteristics at CERN SPS energies

Global event properties are studied by determining, on an event-by-event basis, the number of particles emitted and/or the energy they carry. No attempt is made to identify particles, and the results are presented as a function of pseudorapidity, $\eta$. The WA80 data were obtained from a number of CERN/SPS runs between 1986 and 1990. The initial beams available were $^{16}$O nuclei at 60 and 200 GeV/nucleon. Later runs made use of $^{32}$S ions at 200 GeV/nucleon. The availability of two different projectile nuclei and two different bombarding energies, together with the use of a number of different targets, enables us to study the gross features of the reactions in a systematic way. Our results are obtained from measurements of the energy detected in the forward direction, $E_F$, and the transverse energy, $E_T$, which is defined as the sum of the transverse masses of all interacting and produced particles. Both energies are, in some sense, a measure of the degree to which an interaction has (or has not) taken place, and as may be expected, they are strongly anti-correlated. Both $E_F$ and $E_T$ were measured by means of sampling calorimeters [4,5].

The main reaction features can be understood on the basis of a schematic “clean-cut” geometry picture in which colliding nuclei are regarded, to first order, as colliding spheres. At any given impact parameter, all nucleons that are contained in the overlap region of the two spheres are considered to be participants, while nucleons outside of this region are spectators. On the assumption that $E_F$ depends monotonically on the impact parameter $b$, it is possible to deduce $b$ on an event-by-event basis. Furthermore, based on Glauber theory [1,6], it is also possible to deduce, for each event, the number of projectile nucleons participating in the collision, $W_p$, as well as the number of target participants, $W_T$. As will be seen below, the determination of the total number of participants provides us with a valuable tool which enables us to obtain a unified quantitative description of the various reactions studied by WA80.

Transverse energy measurements were performed with the Midrapidity Calorimeter MIRAC [5]. $E_T$ measurements are important because results can be used to estimate energy densities that might have been attained (see below) and because they provide us with an indication of the degree of nuclear stopping that has taken place. Most $E_T$ distributions, including those of WA80, are measured in a limited pseudorapidity region. Comparisons between different experiments (and between results from the same experiment at different energies) can be made in terms of $dE_T/d\eta$ distributions. Such distributions from $^{32}$S interactions with various target nuclei are shown in Fig. 1. It can be seen (and it is confirmed by numerous other