THE BRAHMS EXPERIMENT AT RHIC
Day-1 Physics

FLEMMING VIDEBÆK
Physics Department, Brookhaven National Laboratory,
Upton, NY 11973-5000, U.S.A.

The BRAHMS experiment is designed to measure semi-inclusive spectra of charged hadron over a wide range of rapidity. It will yield information on particle production, both at central rapidity and in the baryon rich fragmentation region. The physics plans for measurements in the first year of running at RHIC are discussed.

1 Introduction

The main motivations for the RHIC experiments are the search for and the investigation of the quark-gluon plasma. At RHIC with energies $\sqrt{s} = 200GeV/c$ per nucleon pair, which is above the stopping regime presently being explored at AGS and SPS, a baryon poor region with a high energy density is expected to be created at mid-rapidity. The region near the initial nuclei i.e. at high rapidities, will be baryon rich at relatively high temperature. This gives experimental opportunities to study experimentaly both regimes at RHIC and search for the quark-gluon plasma under several different conditions.

The Broad RAnge Hadron Magnetic Spectrometers (BRAHMS) experiment is designed to gather basic information in heavy ion reactions on momentum spectra and yields for various emitted particles as function of transverse momenta, p_t, and rapidity, y. These yields as function of rapidity are important indicators of the densities reached in the collisions and of the produced entropy. The spectral shapes and their y-dependence reveal the reaction dynamics and the degree of thermalisation attained. The high p_t parts of the spectra carry information from the early times in the reaction. The centrality measurements are an integral part of the experiment, and systematic studies are needed to establish an understanding of the reaction dynamics.

The BRAHMS spectrometers are small solid-angle devices so the measurements will be semi-inclusive; i.e. the average spectra for given event classes as determined by the centrality detectors will be measured. This contrasts to the large RHIC experiments where event-by-event information can be collected. BRAHMS has a unique place in the RHIC experimental program with its wide coverage in rapidity and p_t. The coverage is essentially limited by the accelerator structures, the size of the experimental halls, and the modest budget.

2 First year Physics Goals

The dominant part of the particle spectra is the soft part with transverse momenta $p_t \leq 1\ GeV/c$. Particle spectra have been studied in elementary pp ($p\overline{p}$) over a wide range of energies covering the RHIC energy regime. Even with this knowledge in hand it is not trivial to extrapolate to nucleus-nucleus collisions. It has been learned from heavy ion reactions at AGS and SPS that heavy ion collisions cannot be considered a super-position of elementary nucleon-nucleon collisions, but that multiple collisions and collective effects are important to a proper description of the experimental data. At the much higher energies considered here it is likely that additional many-body effects, even for a pure hadronic description, have to be taken into account. Understanding of the reaction mechanism will clearly come from systematic studies of pp to p-nucleus and nucleus-nucleus reactions.

One basic question is the amount of stopping, i.e. the mean rapidity shift of projectile nucleons, see e.g. ref.[1], and to what degree this transfers energy to the central rapidity region, and the magnitude of the net baryon density is in the central region of Au+Au collisions. Recent theoretical interest in this subject has also risen with the high quality data from AGS and SPS. The higher energy regime will allow to address the question on importance of the baryon junction mechanism for stopping (see e.g. ref.[2]) The predicted mean rapidity losses from many models are in the range of 1.7-3.1. The coverage of BRAHMS is not complete, i.e. the fragmentation region as observed in pp (i.e. y $\approx$ 4-5) is outside the range. The measurements do though cover the region $y \leq 3.8$ sufficiently to map and study the stopping in nucleus-nucleus collisions at RHIC.

The predictions for meson production in central collisions from various models varies quite a bit ranging from about 500 to close to 1200 charged pions per unit rapidity at mid-rapidity. Brahms will will essentially cover the expected rapidity distribution for π and K, and can address details of the shape and particle yields.

3 The Spectrometers

This section gives only a brief description of the BRAHMS detectors. For more detailed information the reader is referred to in references [4,5,6].

The very different experimental conditions, momenta, and particle densities at mid-rapidity and forward angles has lead to the design with two moveable magnetic spectrometers. The Mid-Rapidity Spectrometer (MRS) covers the angular region $30^o \leq \Theta \leq 95^o$ ($-.1 \leq \eta \leq 1.3$) and the forward spectrometer (FS) the region $2.3^o \leq \Theta \leq 30^o$ ($1.3 \leq \eta \leq 4.0$). FS consists of

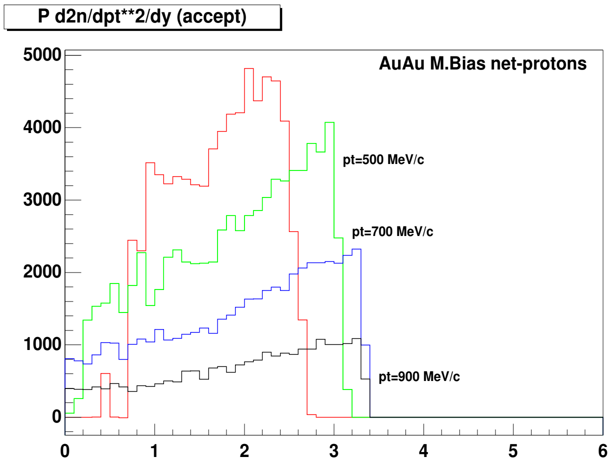

Figure 1: Acceptance (invariant yields) for different values of p_t for protons as can be measured in first year of running. The prediction is base on the Fritiof 7.2 Model[3]

4 dipole magnets (D1-D4), two time projection chambers (T1,T2) and three drift chamber packages (T3-T6). The particle identification is done by combining time-of-flight measurements in the hodoscopes H1 and H2 with measurements in the threshold Cherenkov counter C1 and the Ring Imaging Cherenkov Counter (RICH). This allows for particle identification in the momentum range 1-20 GeV/c in the forward spectrometer. The mid-rapidity spectrometer has two TPCs, a dipole magnet (D5) for momentum measurements, and a time-of-flight wall. The momentum resolution is typically $\delta p/p \leq 0.01p$, which is sufficient for tracking considerations and the spectral measurements.

Three event characterization detector systems will provide global information, namely the Beam-Beam counters, a multiplicity detector and a Zero-Degree calorimeter (ZDC). A set of Beam-Beam counters provide the initial trigger and vertex information as well as the start time for the time-of-flight measurements. A multiplicity detector will be characterize the centrality of the collisions in the mid-rapidity region covering the pseudo rapidity range of $-2.2 \leq \eta \leq 2.2$. Zero-Degree Calorimeters, that will be a common devices for all RHIC experiments, are situated behind the two DX beam magnets. They will partly be used to measure the luminosity in Au Au collisions, and partly to measure geometric collision conditions by measuring forward going neutrons. Together the three systems will provide centrality coverage in the mid-rapidity region $-2.2 \leq \eta \leq 2.2$, in the region $3.2 \leq |\eta| \leq 4.3$ and at zero degree.

4 Status and Plans for first year Running

Even though the BRAHMS experiment was first considered part of the RHIC program by approval of the Letter of Intent in 92, only since August 97 has it been an approved RHIC DOE construction project. As of today (May 99) the initial construction is nearing completion. The magnets D1, D2 and D5 are all installed on the platforms. D3 and D4 have been assembled, mapped and installed on the back platform. They will be made operational inn the fall before the start of the year 1 run. TPCs have been completed, instrumented and installed. Time-of-Flight systems are of fairly conventional design. H1 is completed and will be used in the commisioning run. The C1 detector is completed and mounted on the platform. The RICH construction has started. The beam-beam counters, the ZDC are in place, and the multiplicity detector will be partly installed for this summer.

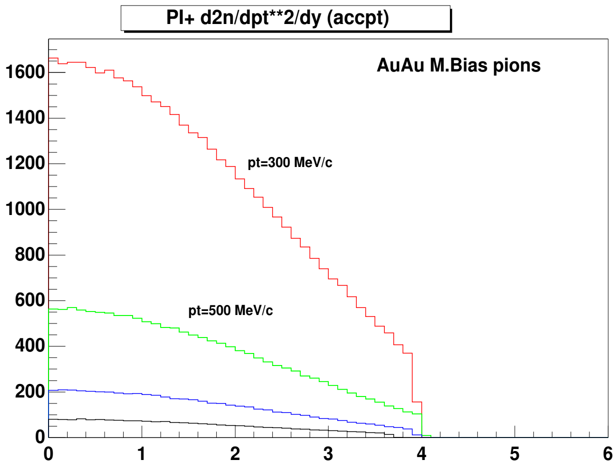

Figure 2: Acceptance for different values of p_t for π as can be measured in first year of running

Despite the compressed construction schedule, significant parts of the detector will be ready for the RHIC commisioning run in June 99. The mid-rapidity spectrometer, and the front part of the forward spectrometer will be in place, together with ZDC and beam beam counters for this short running period. It is expected that the back end of the forward spectrometer with its detectors will be ready for the first year of RHIC running with the startup on November 99.

During the first year of RHIC running, significant time will be spent on machine studies and detector commisioning. The inital instantaneous luminosity will be about 1% rising toward 10% of the design luminosity at the end of the year. The early activities of the experiment will clearly be in commisioning the detector, understanding spectrometer settings, trigger conditions, and backgrounds.

Some of the first physics results will come from the global detectors, yielding multiplicity distributions. From the spectrometers is planned a survey of p_t distributions for selected rapidities y=0, 0.5, 1, 1.5,2 and 3 up to p_t of $\approx$ 1GeV/c restricted by magnetic field, PID, and luminosity capabilities in the first year of running. This should yield high quality spectra of $\pi^{\pm}$,$K^{\pm}$ and $p^{\pm}$ as function of centrality at selected transverse momenta. This will address the issues of baryon stopping, thermalization, transverse and longitudinal expansion.

Summary and Acknowledgments

The BRAHMS experiment construction is supported by a collaboration consisting of about 50 physicist from BNL, CRN-Strasbourg, The Niels Bohr Institute, Texas A&M, New York University, Harbin Technical University, U.C. Berkeley Space Sciences Laboratory, the University of Kansas, and the Jagelloian University-Krakow, the University of Oslo, the University of Bergen, the University of Bucharest, and the University of Lund. This work was supported by the US Department of Energy under contract with BNL (DE-AC02-98CH10886).

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