

# **RHIC Beam Use Proposal**

For Year 1 running  
**BRAHMS**

## **Abstract**

The primary BRAHMS physics goal for the first year of RHIC running is to study Au+Au collisions at  $\sqrt{s} = 200$ . Emphasis will be placed on the process of stopping of the incoming baryons by measuring proton rapidity distributions. The basic properties of particle production will also be investigated by measuring rapidity and transverse momentum distributions of produced pions and kaons as a function of centrality. The rapidity region will be  $0 < y < 3.5$  and the coverage in transverse momenta from .3 to about 1.2 GeV/c. An integrated luminosity of about  $50 \mu\text{b}^{-1}$  is requested for these measurements.

## **Introduction**

The BRAHMS experiment (R3) was approved by the AGS/RHIC PAC in April 95, with the conceptual design report (CDR) approved by the TAC in June 95. Because of a reduction in the planned funding of the experiment from 6.5 to 5.5 M\$ the collaboration agreed to a reduction in the initial scope for BRAHMS and received strong encouragement that the deferred parts be implemented later. In particular the forward spectrometer will not be able to operate at full power and the particle identification in the Mid-Rapidity Spectrometer is reduced in coverage. The management plan was approved in August 1997. Although the Day-1 configuration is consequently reduced compared to the project approved in 95, it is still well matched to the capabilities of RHIC in the first year of running with expected luminosity in the range of 1-10% of the nominal value. The proposed first year measurements do not, in fact, require large integrated luminosity.

## **Day-1 Detector configuration**

The BRAHMS detector situated in the 2 O'clock IR consists of 3 major spectrometer components (see Fig. 1). The forward spectrometer will be fully instrumented with its detectors, but the available power limits the magnets to about half field strength thus restricting the coverage in phase-space. The Mid-Rapidity Spectrometer will have only half the time-of-flight wall instrumented, thereby restricting any given measurement to one sign of the charge. The spectrometers will be able to cover their full design angular range.

- The Front Forward Spectrometer (FFS) consisting of 2 magnets D1 and D2, and associated detectors is moveable from 2.3 to 30 degrees.
- The Back Forward Spectrometer (BFS) consisting of 2 magnets D3 and D4 and associated detectors can be used in combination with the FFS to measure the angular range from 2.3 to 15 degrees.
- Mid Rapidity Spectrometer (MRS) consisting of a single magnet D5 and associated detectors is moveable from 30 to 95 degrees.

The BRAHMS detector has a set of global detectors that are used for event characterization, triggering and timing measurements.

- The Centrality detector consisting of an inner layer of Si-detectors and an outer

- layer of large scintillator tiles covering the range of about  $-2.2 < \eta < 2.2$ .
- The Beam-Beam counter array that will provide accurate start timing information to the experiment, rough vertex determination, and multiplicity measurements at high  $\eta \sim 3-4$ .
- The Zero Degree Calorimeters (ZDC), a common device to all RHIC experiments, will provide luminosity information, and neutron multiplicity at 0 and 180 degrees.

## ***Physics Program***

The first task at RHIC is to establish an energy budget for Au+Au collisions and to determine how that energy is partitioned between particle production and transverse and longitudinal momenta. Secondly the "chemistry" of the system can be tied down by measuring the fraction of strange to non-strange particles and the yield of baryons.

The amount of nuclear stopping of the incoming baryons determines the energy deposition in the reaction volume. An estimate of the energy density in the initial stage of the collision is of prime importance for the understanding of reaction dynamics. The rapidity shift and the energy loss can be determined by the measurements of the proton rapidity distributions over a wide range in  $y$ .

Pion and kaon spectra measure the basic properties of particle production. An enhancement of strangeness production has long been predicted to be an important signature of the color de-confined phase of nuclear matter. The integrated kaon yield, measured over a wide range in  $y$  and  $p_t$ , can be regarded as a measure of the total strangeness production, and a change in  $K/\pi$  ratio vs. centrality is an important measure.

The freeze-out properties, e.g., collective transverse and longitudinal expansion, of the hot nuclear system formed in the reactions will be established by measuring the transverse momentum spectra of pions, kaons, and protons. The yields will be measured at several rapidities and at several transverse momenta so that the expected average momentum of each species will be covered. Comparisons will be made with thermal models, and cascade models to shed light on collective effects. The size of the system at freeze out can be investigated from studies of small baryonic clusters (e.g. deuterons, tritons and their anti-clusters).

The centrality dependence of these data, as measured by the multiplicity array, may or may not show discontinuities, but in either case this information will be vital to understanding what is going on in this new regime.

## ***First year run plan***

When the beam first turns on in November 1999 it will be the first time the Day-1 complement of detectors will be in place and see beam. Therefore a significant but yet to be determined amount of time will be spent in the first part of the run period as a commissioning and engineering run. Our current estimate is that 8-10 weeks will be required to make the detector fully operational. The specific first year goals are:

- Commissioning of the full detector system, in particular the detectors on the BFS i.e. Drift Chambers, the H2 hodoscope and the RICH.
- Characterization of the detector systems. Before physics measurements can be performed it is necessary to understand the operation of the detector system under stable beam conditions and to study and evaluate in particular the

- Beam-beam collisions, beam-gas background
  - Detector backgrounds at different spectrometer settings
  - Trigger (Beam-Beam counters and Multiplicity array) and DAQ.
- Initial physics Running. During this period a single measurement should not extend for more than a few days, at least until the machine stability and conditions are better understood. It is not only the integrated luminosity that matters but also the beam stability. A small amount of integrated luminosity obtained over a very long period will be much less valuable than the same amount obtained with a higher instantaneous rate (later in the year).
  - The first physics measurements will be
    - Global multiplicity distributions
    - A first survey of charged hadron rapidity distributions from Au on Au collisions at selected transverse momenta e.g.  $p_t = .3, .5$  and  $.7$  and  $.9$  GeV/c and at a small number of selected rapidities. This can be achieved with only a few angle and magnetic field changes. A minimum bias trigger will be employed, but goals will be set to achieve satisfactory statistics for central collisions (5-15% software cut). An example of expected distributions obtained within the Brahms coverage is shown in figure 2a and 2b.
    - A set of higher statistics runs to obtain more complete  $p_t$ -spectra and extending to higher  $p_t$ . This will aim to get high statistics spectra of both central, minimum bias and peripheral collisions for protons, kaons and pions at selected rapidities and  $p_t$  up to about 1-1.2 GeV/c.
  - An open period of about 1 week some time in the later half of the running period will be required to move the spectrometer to the most forward angle (2.3 degrees) for which a special adjustment of the beam pipe is necessary. The stands and beam-pipe is constructed with this in mind (movement of 1 cm), but manual intervention and coordination with the RHIC operation group is required. Following this change the forward angle measurements (at 2.3-3.5 degrees) can be made. This period will also be used to install additional shielding of the detectors necessary at the most forward angles.
  - Shorter access periods, on the order of hours, will be required to change the angle settings and the spectrometer configuration, particular during this first year of running. Such periods, may also be required to fix minor problems and/or make small adjustments to electronics in the IR.

### ***Data taking conditions***

During most of the first year of running the data taking is not limited by the DAQ (assuming reasonable beam-gas background rates), and we will record minimum bias data with a simple trigger defined by the beam-beam counters. At about 10% of the nominal luminosity, additional multiplicity and spectrometer triggers will become essential for event selection.

### ***Manpower for the experiment.***

The very long anticipated running periods will put a severe strain on the collaboration, a strain that is not helped by the inadequate funding for several of the Brahms collaborating groups.

To maximize the resources it is the intention to man the data taking shifts in the following way.

- During beam conditions when physics data can be taken, the experiment will man 3 shift per day with 2-2-1 persons (i.e. 5 per day).
- During machine studies (50% at year start, 20% at year end) a single shift-supervisor will perform shift checks, but will otherwise be on call .

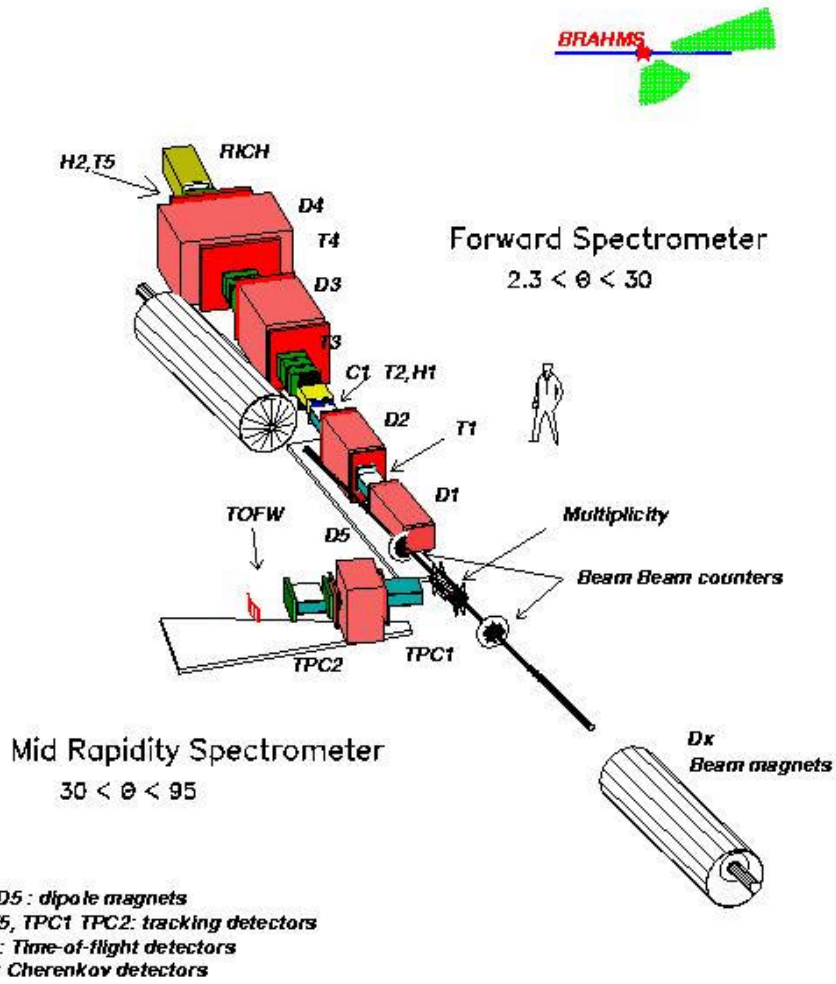
The collaboration has provided input to evaluate the available manpower for running and analyzing data from the experiment. The resources are summarized in the table below indicating the number of people assigned to BRAHMS from each institution, the number of planned shifts manned (measured in months) , and man months for data analysis. Both for manning the shifts and for the data analysis sufficient manpower is available (40 shift months are needed for 8 months of running) under the assumption that funding from DOE and foreign funding agencies continues at the present level.

Institution	person total	Data taking shift months	Daata Analysis Data Analysis
BNL	6.5	12	20
Bergen/Oslo	4	5.6	22
NBI	5	8	28
TAMU	5	4.2	17
U.Kansas	2	2.5	8
J.Hopkins	1	1.8	2
NUY	2	3	10
U.Cracow	5	2.8	12
U.Bucharest	5	3.5	12
<b>Total</b>		<b>43.4</b>	<b>131</b>

## Summary

BRAHMS wants Au+Au at full energy and a minimum of  $50 \mu\text{b}^{-1}$  integrated luminosity for the first year to make a first survey of particle spectra over a wide range of rapidity. BRAHMS will need to upgrade magnet power and PID in MRS to be ready for year 2, to extend the survey for Au on Au to high pt and larger rapidity range.

**Figure 1. Schematic layout of BRAHMS detector**



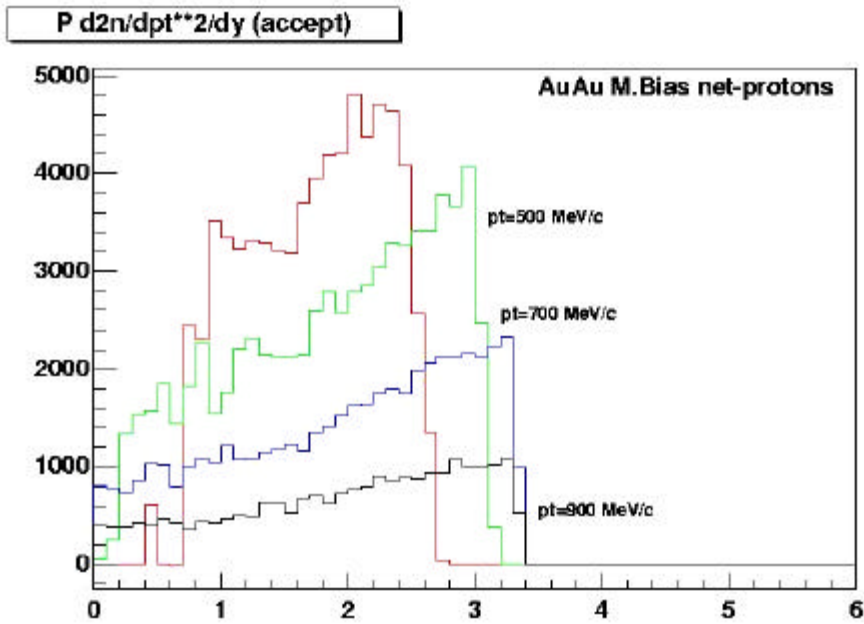


Figure 2a Model predictions based on Fritiof 7.02 for Minimum bias Au on Au collisions at 200 GeV/c. The invariant cross section is shown for a 50MeV/c  $p_t$  bin at 300, 500 , 700 and 900 MeV/c for rapidities accessible by Brahms.

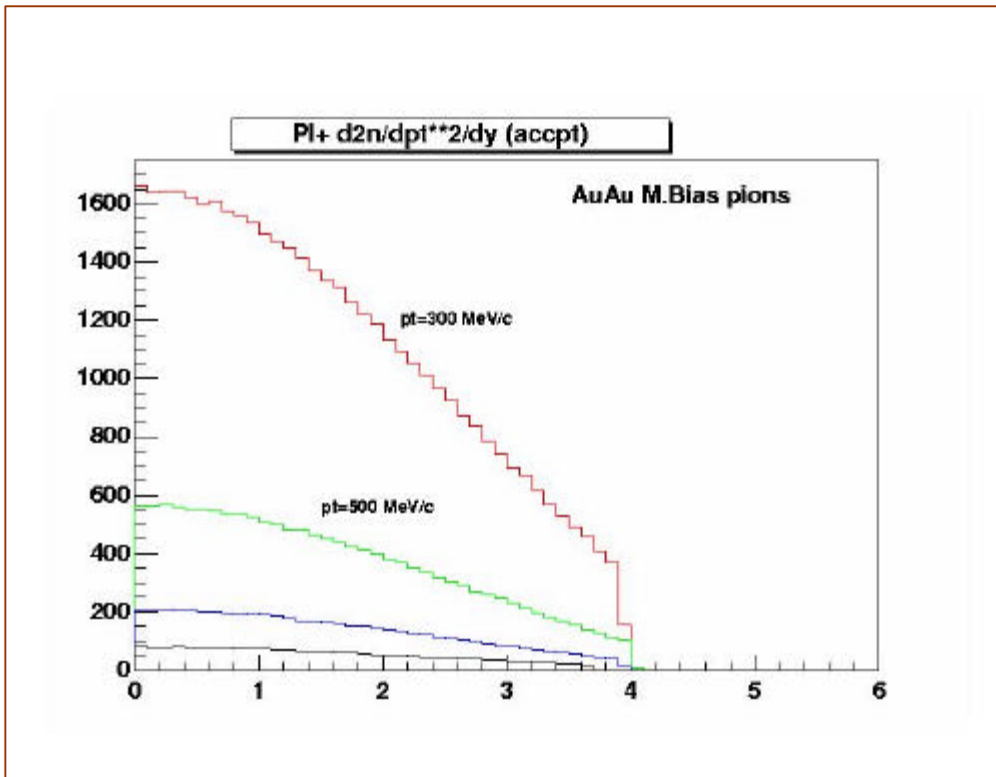


Figure 2b As Figure 2a but for pions