RHIC Beam Use Proposal

For FY 2002 running

BRAHMS Collaboration

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Abstract

The 2000 running period at RHIC with Au-Au collisions at $\sqrt{s_{NN}}$=130 GeV and an integrated luminosity of an a few μb^{-1} albeit with a very large diamond size, enabled BRAHMS to record a significant dataset, that so far has lead to two publications.
In the ongoing FY2001/02 run the primary BRAHMS physics goal is to study Au+Au collisions at $\sqrt{s_{NN}}$ =200 GeV. Emphasis will be placed on studying the process of stopping of the incoming baryons by measuring proton rapidity and p_t distributions and on basic reaction mechanisms of particle production by measuring rapidity and transverse momentum distributions of produced pions and kaons as a function of reaction centrality. The rapidity region will be $0<y<4$, the coverage in transverse momenta will be from .2 to about 1.5 GeV/c for the full rapidity range.

For the next run period the request is for i) completion of the ongoing program and ii) complementing with higher statistics measurements at larger pt values (2-4GeV/c) for a smaller set of selected rapidities.
As its second priority BRAHMS requests a significant running period with a lighter system (Si-Si or Cu-Cu) at the same $\sqrt{s_{NN}}$ of 200 GeV as measured with the Au-Au system.
As the third goal is to perform the comparison pp measurements

[As a last priority we request a run period (~4 weeks) at the previous energy of $\sqrt{s_{NN}}$ =130 GeV to complete measurements at the lower energy.] ??

Introduction

The Brahms experiment has unique capabilities in terms of precise momentum determination and particle ID. The forward spectrometer (FS) covers a rapidity range up to about 4 , and a large momentum and transverse momentum range . The excellent Particle Identification (PID) in Mid-Rapidity Spectrometer (MRS) complements measurements by other RHIC detectors, and allows for comparisons to higher rapidities.

The BRAHMS experiment took its first Au-Au data during the summer 2000 run at RHIC. Data was obtained using the mid-rapidity and front forward spectrometers, and the initial commissioning of the back forward spectrometer was accomplished. Since the run last summer the experiment has been upgraded and ithe experiment is now ready to explore heavy ion collisions at the top RHIC energy with symmetric Au beams. These conditions should lead to the highest energy densities that can be achieved at RHIC.

The upgrade included the addition of a power substation at the 2 O'clock area, which allows all of the BRAHMS magnets to be powered to full field and particle production can be explored at the most forward and highest momenta of the design acceptance.
On the detector side the Drift Chambers in the back spectrometer was fully instrumented with electronics and readout multiplexing. The Time-Of-Flight wall in the mid-rapidity spectrometer was extended and now records positive and negatively charged hadrons simultaneous.

Summary of 2000 run.

Most data were recorded in the last month of the running period. Spectrometer data were recorded at angle settings of 90, 45 and 40 degrees using the Mid-Rapidity spectrometer with two field settings at both polarities. The forward spectrometer was run at 4 and 8 degrees with one magnetic field setting (both polarities). The data were analyzed yielding physics results for p-bar/p ratios as function of rapidity and centrality, particle ratios vs pt near mid-rapidity, and dN(ch)/d(eta) measurements vs. centrality in the –5<eta<5 region using the global detectors.

FY200/021 Detector configuration

The BRAHMS detector situated in the 2 O'clock IR consists of 3 major spectrometer components.

- 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 is used in combination with the FFS to measure the angular range from 2.3 to 15 degrees. Only one of the Forward Spectrometer drift-chambers (T3) was commissioned during last years run. The other chambers T4, and T5 were installed and has now been commissioned. The magnets will be able to operate at full field.
- The Mid Rapidity Spectrometer (MRS) consisting of a single magnet D5 and associated detectors is moveable from 30 to 95 degrees ,and was augmented with additional Time-of-Flight panels allowing for simultaneous measurements of both sign charged hadrons.

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

- The Centrality detector consists 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 provides 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, provides luminosity information, and neutron multiplicity at 0 and 180 degrees.

The spectrometers will be able to cover their full design angular and momentum range. One component from the CDR that was not funded for the baseline program BRAHMS detector is a Cherenkov detector for the mid-rapidity spectrometer. This detector could extend the PID up ~5 GeV/c, and would greatly enhance the physics from BRAHMS.

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/π ratio vs. centrality is an important measure for the strangeness chemical potential.

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 and cascade models to shed light on collective effects. The size of the system at freeze out can be investigated from HBT measurements and 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.

The initial parton scattering plays an increasing important role in the heavy ion collision as the beam energy increases. The study of particle spectra in intermediate p_t range of 1-4 GeV/c will help in the understanding of initial scattering (Cronin effect), shadowing and jet quenching. The importance of these processes depends on energy, rapidity and collision system.

Expectations for the ongoing 12 weeks running period.

At the time of this writing the first 3.5 weeks of this period has been completed. The beam availability, the lack of 200 MHz re bunching, still implies as for the 2000 run that only a small integrated luminosity has been collected. It is though also clear that the accelerator performance is improving, the number of ions/bunch increasing which sets the stage for a productive run-period.
The initial detector commissioning was done mainly with few intermittent periods with beam in the time from first collisions up the first week of ‘production running’. At this time trigger development continues in parallel with physics data taking. We estimate that data are recorded close to 90% of the time beam is stored and cogged, and with DAQ deadtimes of approximately 50-60%.

The goal is to perform a systematic survey of identified charged hadron rapidity distributions from Au on Au collisions at transverse momenta between pt= .2 and ~1.3 GeV/c (i.e. the soft physics) at many rapidities between 0 and 4. This requires a fairly large number of angle settings, each with 4 field values and 2 polarities (4 setting per angle). A mixture of minimum bias trigger and a central collision trigger is used to stay below the DAQ event rate limit of about 100 ev/sec. The goals will be set to achieve satisfactory statistics for central collisions (~15% trigger cut, 5% software cut). One of the aspects that are emerging is the importance of comparing peripheral collisions to central, and comparing mid-rapidity to higher rapidities. This will then in addition set as a goal to have good statistics for the more peripheral events. To complete this measurement we need to record ~150 microb(-1), i.e. within the +-20cm near the nominal collision point.

Polarized Proton running (5 weeks)

In last years beam proposal Brahms stated that the experiment was not equipped to take full advantage of this pp running period. Comparison to pp will be important both for the soft physics as well as for the understanding of the development of mini-jets with pt. BRAHMS though, is not yet in a position to utilize pp beams fully. The pp2pp experiment has constructed a set on inelasticity counters that will be useful for BRAHMS too in so far by providing an efficient inelasticity trigger. At present the spectrometers arms are not instrumented with detectors that can provide a good start time for the time-of-flight measurements a needed ingridence for the full pp comparison program. The aim for the proton running period is

1. Commission the detector for pp running by integration of inelasticity counters, develop spectrometer triggers, and collect data at a

2. Exploring possibilities for a spin program (high x_F, transverse polarization) for transversity measurements. This will be initiated in 2001/2002 with collaboration with the RHIC spin group and would take place during the 1 week scheduled time with transverse polarized protons. A longer period for high statistics is highly desired for later pp running.

2002/2003 running

As noticed in the call for RBUP the start of the following data period is dependent of additional funds for RHIC running. This might take place as additional running time in the period January through April. Such a running period is not optimal from the point of view of Brahms, both in regard to collect data and to analyze the data being collected in the previous 12+5 weeks.
The request described is never the less based on the assumption of about 17 weeks of running, and does also reflect our best present request should this run fall into a subsequent running period.

The first request is a completion of the ‘soft’ physics program already underway with Au-Au at sqrt(snn)= 200. Though it is envisioned that much of this program would be completed in the ongoing program it is wise to assume that an additional set of measurements will be needed for this, both to make up for missing angle/field setting and to repeat runs (settings) where the first analysis identified problems. This is hard to quantify but would likely require 2 weeks of running.

These measurements will be complemented by runs at selected rapidities to study high p_t (i.e 1-4 GeV/c) devoted to a study of spectral shapes, and aiming to understand mini-jet production and its characteristics. This segment requires a large integrated luminosity, as well as implementation of a forward spectrometer setting. Such a forward spectrometer trigger will be commissioned during the 2001/02 run. One of the aspects that are emerging is the importance of comparing peripheral collisions to central, and comparing mid-rapidity to higher rapidities. This will then in addition set as a goal to have good statistics for the more peripheral events. The higher p_t studies can be carried out at y~2 y~3 (at angle settings of ~10-15 deg, and high magnetic field settings). The request for this is 200 microbarn(-1) [recorded] for the central collisions high p(t). This will assuming the spec trigger working give a half the statistics for peripheral collisions.

At the same time we will collect a large statistics data sample near mid-rapidity for HBT studies. (give micorb (-1) 10M central collisions recorded.

The second priority is for measurements with a lighter projectile. Our choice from a physics point of view is Si . Much lower energy data exists at AGS and CERN for this collision system (S at SPS). In addition when considering the number of participants in the reaction such a light system gets access to a region that cannot really be measured by peripheral Au-Au collisions. These measurements should be done at the same energy as Au-Au i.e. $\sqrt{s_{NN}}$=200 GeV. For this system the focus will be on central collisions where trigger and global detectors will be fully efficient.

III proton-proton running

Based on a positive experience (hopefully) with the commissioning run we see this as the third request for running. This can both give the comparison running for pp, and may be very useful for the transverse polarization measurements.

Shorter access periods, on the order of hours will (based on experience) also be required on a weekly basis to fix minor problems and/or make small adjustments to electronics in the IR. We strongly support the notion of weekly/bi-weekly maintenance days that has proven valuable

Summary of Run Plan

System	Weeks	Luminosity	Physics	Note
Au-Au at 200	**6**	**~400 μb^{-1}**	**High pt, heavy clusters** **HBT at y~0**	**Rate limited by DAQ**
Si-Si at 200	**4-6**	**??**	**Survey of soft** **physics**	**Rate limited** **By DAQ**
pp at 200	**6**	**~150 μb^{-1} ??** **~50%**	**Comparison measurements**	**Spectrometer triggers will be implemented.**

Summary

Comments on p/dA
Lower energy running?