Beam Use Proposal for Extended Operation of RHIC in 2001-2002
The STAR Collaboration

September 2001

1 Overview

At the November 2000 Program Advisory Committee Meeting, STAR requested with highest priority 12 weeks of data-taking with collisions in the Au + Au system at $\sqrt{s_{nn}} = 200$ GeV for heavy ion studies. Next in priority was 6 weeks in the p + p system at $\sqrt{s_{nn}} = 200$ GeV for transverse and longitudinal spin studies and measurements, including 50 million minimum bias events as reference data for the heavy ion program. Beyond that, STAR requested Au + Au at lower energies and a lighter system Cu + Cu at $\sqrt{s_{nn}} = 200$ GeV in order to initiate a survey in the RHIC physics program.

The November 2000 proposal was formulated for 32 weeks of data-taking (as per guidance from the Lab), with data-to-tape rates estimated from the Summer 2000 run. This rate was 2 Hz (9 Hz) for central (minimum-bias) trigger(s) for 200 GeV Au + Au. In addition, a combined STAR detector plus RHIC collider efficiency of 50% was assumed (incorporating guidance from the Collider Department).

At present our priorities are to complete the data-acquisition for our first two priorities above, with a slight reduction in the number of events accumulated in Au + Au (detailed below) due to reduced availability of collisions (compared to last year's expectations), and then to initiate a survey with lower energy Au + Au and a lighter system at full energy. It is essential for STAR to first accumulate sufficient statistics to complete our initial investigation of Au + Au at the highest RHIC energy prior to measurements in other systems. It is anticipated that measurements of various observables over a range of beams and energies are required in the longer term, for a thorough search and investigation of the deconfinement and chiral phase transitions. A comparison of the most central Cu + Cu collisions with a less central trigger in Au + Au collisions will provide a cross-check for determination of the participant number as a function of collision centrality, which is important for understanding the data accumulated so far with the heavier ion beams. A comparison of different systems at $\sqrt{s_{nn}} = 200$ GeV, eventually including proton (or deuteron) - nucleus interactions will allow a thorough investigation into hard scattering processes and parton propagation.

2 Summary of Data Anticipated from the 2001 RHIC Run

2.1 $\sqrt{s_{nn}} = 200$ GeV Au + Au

The physics goals of STAR for the $\sqrt{s_{nn}} = 200$ GeV Au + Au run, as requested at the November 2000 Program Advisory Committee Meeting, called for the acquisition of

5 million minimum bias events and 5 million central events in 12 weeks of data-taking. This time estimate assumed an efficiency of 50%, and included an initial efficiency of 25% during the first 4 weeks for new detector commissioning and studies. This is STAR's highest priority for the run.

We have refined our estimates of the STAR data-to-tape rates from the present run. These are presently 2-3 Hz for central (10-15 Hz for minimum-bias) trigger(s) for $\sqrt{s_{nn}} = 200$ GeV Au + Au. It is difficult to project the number of events to anticipate without knowing the efficiency of the collider for the remainder of the run. If we assume a time-averaged, overall efficiency for collisions and data-taking of 40%, which corresponds to the projected efficiency for the remaining beamtime from present CAD guidance, our anticipated data accumulation for this 12-week run will be 5 million minimum bias events and 4 million central events (with 8% of the geometrical cross section). These statistics are slightly lower than our original proposal, but have been determined to be just sufficient to complete our initial physics program for full energy Au + Au. It should be emphasized that successful accumulation of these numbers of events for $\sqrt{s_{nn}} = 200$ GeV Au + Au depends upon the collider providing long, stable fills (with at least 40% availability for collisions, as in the present projections of the CAD) and a collision rate of one-half design luminosity with a collision diamond of $\pm$ 20 cm, at which point the STAR level 3 trigger becomes data-rate limited.

2.2 $\sqrt{s} = 200$ GeV p + p

The next highest priority is successful commissioning of RHIC to provide highly polarized proton beams (beam polarization greater than 50%) at 100 GeV/c and a collision luminosity of 5×10^{30} cm^{-2}s^{-1}. Next is the demonstration that some measurement of the polarization magnitude can be made for polarized proton beams at 100 GeV/c, since an accurate determination of the magnitude of the beam polarization will not be available until the calibration experiment (gas-jet target and p + p elastic scattering experiment) is ready in FY 2003. The highest priority after these commissioning tasks is the first measurement of a spin asymmetry in a polarized proton collider. STAR expects to be able to measure a non-zero value for the transverse single-spin asymmetry, A_N, with an integrated luminosity of 1.5 pb^{-1}. A statistically significant signal for Feynman x values in the range $0.25 \leq x_F \leq 0.5$ are anticipated with this luminosity. In addition to the scientific value of learning how to make beam-spin asymmetry measurements in a collider, these measurements are of interest physics-wise to the international spin physics community.

During this run, a concurrent measurement will be made of the transverse single-spin asymmetry for hard scattering events near mid-rapidity with a statistical accuracy of 1% for A_N for mid-rapidity charged particles with transverse momenta up to $p_T \sim 5$ GeV/c using the minimum bias trigger. A high-p_T trigger sample of mostly neutral pions can provide comparable statistical accuracy for A_N up to a transverse momentum of at least 10 GeV/c using the 24-module barrel EMC patch. That sample can be obtained concurrently with the minimum-bias data. Inclusive leading particle detection at mid-rapidity is expected to result in $A_N \to 0$ for increasing p_T.

The longer-term STAR spin physics goals are best met by having the first three weeks of the scheduled five week polarized proton run with vertical polarization. This should provide adequate time for the necessary commissioning of STAR for polarized proton operation, time to understand how to make the relative luminosity measurements to the required accuracy, and time to collect the necessary statistics for the forward π^0 asymmetry measurement. We expect that a publication will result from the STAR spin measurements.

The 5 weeks of collisions of polarized protons at $\sqrt{s} = 200$ GeV will also serve to provide concurrently reference data for heavy ion collisions. It is anticipated that minimum bias and π^o trigger events will be accumulated for this purpose. The requirements for the heavy ion reference data acquisition are consistent with the integrated luminosity requested for spin physics.

3 Priorities for Data-Acquisition for RHIC Run 2001-2002

The priorities for STAR in the entire RHIC 2001-2002 run follow. Details of the physics motivation for each data set and the anticipated measurements can be found in the November 2000 Proposal.

- The highest priority is to accumulate 4 million central events (corresponding to 8% of the geometrical cross section) and 5 million minimum bias events for $\sqrt{s_{nn}} = 200$ GeV Au + Au.

- The second highest priority is to commission and collide polarized protons at $\sqrt{s} = 200$ GeV. Of primary interst is achieving an integrated luminosity of 1.5 pb^{-1} and a beam polarization of 50% for collisions of transversely (vertical) polarized protons and the remaining polarized proton time utilizing longitudinally polarized protons for spin measurements. In addition, up to 50 million minimum bias events will be accumulated concurrently for heavy ion reference data.

- The third highest priority for data-taking is to initiate an energy and system-mass survey, and accumulate approximately 2 million events in the central and 5 million events in the minimum-bias trigger modes with the beam-energy combination of $\sqrt{s_{nn}} = 60$ GeV Au + Au. This corresponds to approximately 4 weeks of data-taking. The physics motivation for this survey and specifically this data set is to understand the energy and system-mass dependence of particle (strange, nonstrange, and resonance) production, spectra, correlations, flow, and fluctuations.

- The fourth highest priority for data-taking is to accumulate approximately 2 million events in the central and 5 million events in the minimum-bias trigger modes with the beam-energy combination of $\sqrt{s_{nn}} = 200$ GeV Cu + Cu. This corresponds to a minimum of 4 weeks with a preference for a total of 8 weeks of data acquisition with $\sqrt{s_{nn}} = 200$ GeV Cu + Cu. The primary physics reasons for this data set are to provide a cross-comparison with the Au + Au system in the determination of the participant number as a function of collision centrality, and to investigate the path-length dependence of parton energy-loss. By varying the size of the colliding nuclear system, the path-length and participant number dependences can be studied in a controlled fashion.

- If there is any additional running time during this period, our next priority would be to continue our survey and physics measurements at lower energy with 4 weeks of data-taking at $\sqrt{s_{nn}} = 20$ GeV Au + Au for comparison with the CERN-SPS heavy ion data. This can be started and expected to yield results, even if only 2 weeks of data-taking is available.

As a comment, STAR anticipates continuing the survey in 2002 utilizing Au + Au at the lower energies (mentioned in the previous paragraphs), Cu + Cu at 200 GeV (and possibly lower energies), 200 and 500 GeV polarized p + p, and 200 GeV Au + Au again. All of this will depend upon the physics results from the 2001 run.

4 Recent and Future Additions to STAR

During the 2001 shutdown, STAR installed 24 barrel electromagnetic calorimeter (20% of the full barrel EMC) modules covering $0 \leq \eta \leq 1$ and $0 \leq \phi \leq 0.8\pi$, the silicon vertex tracker, forward time projection chambers, level 3 trigger processors, and a forward π^o detector. The level 3 trigger is currently being used to select rare events (such as events with high P_T tracks in the RICH detector, events with anti-nuclei, or ultra-peripheral collision events) online in STAR. The EMC will measure the π^o spectrum and provide high p_T triggering, while the forward π^o detector will be used for the single-spin asymmetry measurements. Additional forward trigger detector systems, with acceptance $2 \leq \mid \eta \mid \leq 5$, will be installed prior to the p + p run for triggering in p + p and in lower energy Au + Au.