Recommendations of the Brookhaven High Energy and Nuclear Physics Program Advisory Committee: RHIC Run 4

September 2003

Executive Summary:

The highest priorities for Run-4 are an extended high luminosity full energy Au-Au run ensuring a significant measurement of quarkonia production, and a polarized proton-proton machine development run. Additional priorities are a 63 A-GeV energy Au-Au run and a luminosity development run for polarized protons. A 27 week run will miss these additional significant physics opportunities. Therefore the laboratory should vigorously pursue efforts to obtain running for 37 weeks.

Recommendations:

The highest priority for heavy ions is a substantial running period of Au-Au at the highest RHIC energy of 200 A-GeV. It is important to integrate sufficient luminosity to open up the channel of heavy quarkonia studies for experimental and theoretical investigation. Measurements of the quarkonium channels are needed to characterize the system created and to complete our baseline program of exploring novel features of dense QCD matter such as the quark-gluon plasma. In addition, high quality measurements of low cross section processes will provide crucial constraints on the nature of the dense medium created.

We recommend that a benchmark of 300 inverse microbarns delivered luminosity be set for the Au-Au running period. We urge the laboratory to be flexible in time allocation so that a significant J/ψ signal in central Au-Au collisions is observed. Given variations in predicted machine performance, we can only estimate that this may take a full 5 weeks of setup and 14 weeks of physics running, including luminosity development during those 14 weeks.

The other priority is a minimum of 5 weeks of machine development with polarized protons. The RHIC spin program is the key element in the world wide effort to dissect the spin of the proton. Crucial tests of the gas jet target and other items must be performed this year in order to ensure the continued development of the spin program. The gas jet is essential for establishing the absolute polarization of the beam. The polarized proton program is at the early stages of development, and significant investments of time and effort are required for this novel accelerator program.

In the event of 27 total weeks of funding (including 2+1 for cool-down and warm-up), the recommendation is 5+14 for full energy Au-Au and 5 for polarized proton development. In this scenario, if the Au-Au luminosity goal is met at an earlier time, an exploratory run of Au-Au at lower energy 63 A-GeV should be considered. This lower energy run if allocated 2 + 2 weeks (2 for setup and 2 for running) should allow key measurements of the excitation function for elliptic flow, strangeness, intermediate p_T particles (4-8 GeV range), and global event characterization. This running does not preclude future lower energy running with higher integrated luminosity to measure high p_T particles (8-12 GeV range) and quarkonia.

Five additional weeks of polarized proton-proton running would allow for significant luminosity development by increasing beam intensity and exploring a new machine lattice. This time is necessary in order to minimize non-linearities in the machine optics at high interaction rates. At the same time it will be possible to obtain the first significant measurement of A_{LL}, which is sensitive to the gluon polarization in the proton.

It cannot be stressed enough that an extension of running time from 27 to 37 weeks buys enormous additional physics. Five weeks of additional heavy ion running ensures the low energy heavy ion run which maps the transition from lower energy CERN SPS physics to RHIC. Five weeks of additional polarized proton running ensures accelerator luminosity development critical for the future productive spin physics.