

## Development of the Polarized Proton Target for RHIC

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In early December, 2002, a review was held at Brookhaven National Laboratory to discuss the progress and plans for the calibration of the circulating proton beam at RHIC. This calibration is being treated as an experiment that will also provide some information on the analyzing powers and spin correlation parameters for proton-proton elastic scattering in the energy region of RHIC. This experiment calls for the construction of an atomic beam source (ABS) that will provide a target to be placed at the 12 o'clock intersection point. The polarization of this atomic beam will be monitored after it crosses the RHIC beam by a Breit-Rabi polarimeter (BRP) located opposite to the source. Proton-proton scattering will be observed in the Coulomb-nuclear interference (CNI) region where the analyzing power goes through a relative maximum and the cross section is very large. By measuring the ratio of the asymmetries generated when either the atomic beam or the circulating beam is polarized, the value of the atomic beam polarization can be transferred to the RHIC proton beam. With the atomic beam as an absolute standard, the present polarimeters that make use of proton-carbon scattering in the CNI region can be calibrated.

At the time of the review, there was a design for the ABS and BRP, including the size and location of the sextupole magnets and the RF transition units. The timetable presented at the review called for the construction of these two major components to take place during FY2003. The source and polarimeter would be placed in the RHIC rings in the fall to check for any installation problems, then removed again to continue work on the optimization of their operation while the heavy-ion program was underway. When the time came to switch to polarized proton running in the spring of 2004, the source and polarimeter would be returned to the RHIC rings.

The review committee expressed concern that the timetable could be met without a more aggressive management approach, and recommended that there be a full-time project manager and a separate liaison among the various polarimeter efforts at Brookhaven. Yousef Makdisi subsequently assumed the role of project manager, and Haixin Huang agreed to provide coordination among the polarimeter groups (CNI at both RHIC and the AGS, as well as lower-energy and calibration polarimeters). Regular reports were generated for DOE review.

Early in calendar 2003, an ambitious schedule was adopted, beginning with procurement for the vacuum vessels and pumping that would be needed for the source and polarimeter. Additionally, the design of the holding field magnet was completed and construction started on the magnet. This magnet, besides defining the polarization direction for the target, also makes it possible to avoid depolarization by the RF structure of the circulating RHIC beam. A plan was drawn up for scattering chambers that would extend about 1 m on either side of the target position. Construction started on the silicon detectors needed to observe the CNI recoil protons, and on the waveform digitizers that will be used to record the silicon detector data. A part of the linac building at Brookhaven was remodeled to contain a crane so that it could be used as a construction area for the source and polarimeter. Anatoli Zelenski assumed the responsibility for

detailed supervision of the construction, and several technicians were added to the team. Power supplies were gathered, and a control system based on Brookhaven standards was set up. The University of Wisconsin undertook to provide the RF transition units. Changes to the civil construction in the 12 o'clock region necessary to allow the source and polarimeter to be moved in and out easily got underway. Plans were made for cable runs to a nearby counting house that would house the controls and data acquisition equipment.

During the spring and summer of 2003, progress on procurement and construction was rapid. By the end of August, the jet target and the polarimeter were both fully assembled. Several racks of controls and power supplies were assembled so that the source and polarimeter would be fully operational in their location in the linac building.

By the beginning of October, beam was running. The center of the beam was less than 0.7 mm from the original alignment axis of the source. Tests showed that the fringe field at the location of the RF transitions met the adiabatic conditions necessary for a large polarization. Initial polarization measurements with the BRP of 0.94 and 0.95 were recorded for holding field strengths of 1.0 and 1.2 kG respectively. These values are within 1% of the theoretical maximum at those field strengths, which are only about a factor of two above the proton critical field.. This performance is excellent.

The next step, taken on October 8 and 9, was to move the source and polarimeter to the 12 o'clock region and begin the process of making sure that the installation there is functional. It is expected that with some optimization of the procedures, the move from the linac building to the RHIC ring could be completed in one day. It is still necessary to do a detailed analysis of the atomic beam to determine its molecular fraction and to search for the presence of water, something that may wait until the ABS and BRP come back to the linac (before the 12 o'clock region closes for beam operations).

During the review process, IUCF provided information on the analysis techniques needed to obtain reliable information on the RHIC beam and atomic target asymmetries when both beam are polarized simultaneously. We will continue to be involved with the testing of the p+p elastic scattering data acquisition system and the study of systematic effects in the extraction of the calibration information.