Closeout Report on Instrumentation Grant DE-FG05-88ER75459

Polarized Hydrogen Gas Target

The purpose of the equipment was to produce a polarized gas target for use as an internal target in storage rings. The part funded under this grant was the construction of the atomic-beam apparatus. In addition to the \$300,000 award, \$13,267 from DOE operating funds and \$19,700 provided by the University was spent on the construction of the atomic beam apparatus. Certain other parts required for the experiments, like the target cell, the target vacuum chamber, and the detectors, were funded by the University of Wisconsin (in the amount of \$15,000). The cost for installation of the target in the cooler ring at the Indiana University Cyclotron Facility was \$2,400.

The equipment became operational for the first time in August 1992, after the sixpole magnets, the delivery of which was delayed by more than 6 months because of manufacturing problems, were delivered. There followed a period of measurements to optimize the atomic-beam intensity. The final value, 6.7×10^{16} atoms/sec into a 1cm diameter and 13cm long entrance tube of the gas target, exceeded the design specifications and significantly exceeds the performance of other similar devices built recently at other US laboratories. A paper on the performance of the atomic beam source has been published in the journal "Nuclear Instruments and Methods" (see list of publications related to the hydrogen gas target below).

In 1992, further work was done using other sources of funds to augment the performance of the polarized gas target by means of radiofrequency (RF) transitions intended to double the degree of polarization of the target. For this purpose, new RF transitions were developed and tested. After installation of these new RF transitions, the gas target was tested with a beam of 7 MeV protons at the tandem laboratory of the University of Wisconsin in the spring of 1993. The tests showed a target polarization of 75% and confirmed that the polarized gas target performed reliably over long periods of time, as required by the planned experiments in large storage rings. A paper on these target tests has been accepted for publication in Nuclear Instruments and Methods.

Immediately after the above tests, the polarized gas target equipment was shipped to Bloomington, Indiana where installation in the proton storage ring was completed in

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July 1993. A scale drawing of the target installation is shown in Fig. 1. The target has been used for preliminary measurements of spin correlation coefficients in proton-proton collisions at 200 MeV. Since during the experiments the target is located in a radiation area, work has continued to install remote control and remote readout devices.

The funding of this polarized gas target has had a great impact on the research program of the nuclear physics group of the University of Wisconsin and at Indiana University. Specifically, based on this novel equipment, a group of 12 scientists from three institutions has proposed four different large experiments to the program advisory committee at the Indiana University Cyclotron Facility (IUCF). Each of these experiments will add a new capability to measurements with polarized gas targets in storage rings. The title and identification number of these four experiments, all of which were approved by the Program Advisory Committee, are

CE - 35 : Measurements of pp spin correlation parameters at the Indiana Cooler

CE - 42 : Measurements of pp spin correlation parameters at $\theta_{cm}=90^\circ$ in the energy range between 100 and 500 MeV

CE - 44 : $pp \rightarrow pp\pi^0$ with polarized beam and polarized target

CE - 45 : Measurement of the spin correlation coefficient A_{zz} with the Indiana Cooler

The polarized gas target will be an invaluable piece of equipment to study spin dependences in proton storage rings for several years. It is planned to extend the usefulness by developing the equipment further to also serve as a target of spin-polarized deuterium atoms. Eventually, the target may be used at other accelerators (e.g. electron accelerators) as well. However, the target and the associated control and detection equipment is large and complex so that it is not easily moved, requiring roughly six months downtime and about two manyears of labor for relocation. Thus for at least two years, the equipment will be used for experiments at the present site.

Publications and Conference Reports

- 1) "Medium Field RF Transitions for Polarized Beams of Hydrogen and Deuterium"

A.D. Roberts, P. Elmer, M.A. Ross, T. Wise and W. Haeberli

Nucl. Instrum. Methods **A322** (1992) 6.

- 2) "Test of a Windowless Storage Cell Target in a Proton Storage Ring"
M.A. Ross, W.K. Pitts, W. Haeberli, H.O. Meyer, S.F. Pate, R.E. Pollock, B. v.Przewoski, T. Rinckel, J. Sowinski, F. Sperisen and P.V. Pancella
Nucl. Instrum. Methods **A326** (1993) 424.
- 3) "A High-Brightness Source for Polarized Atomic Hydrogen and Deuterium"
T. Wise, A.D. Roberts and W. Haeberli
Nucl. Instrum. Methods **A336** (1993) 410-422.
- 4) "Performance of a Polarized-Hydrogen Storage Cell Target"
M.A. Ross, A.D. Roberts, T. Wise, W. Haeberli, W.A. Dezarn, J. Doskow, H.O. Meyer, R.E. Pollock, B. v.Przewoski, T. Rinckel, F. Sperisen and P.V. Pancella
Nucl. Instrum. Methods A, accepted for publication.
- 5) "Development of a Clean High Intensity Polarized Atomic Beam Source for Hydrogen and Deuterium"
T. Wise, A.D. Roberts and W. Haeberli
Proc. of the Workshop on Polarized Gas Targets for Storage Rings, Heidelberg, Germany (1991) eds. H.G. Gaul, E. Steffens and K. Zapfe.
- 6) "Polarization Measurements of a Storage Cell Target"
M.A. Ross, A.D. Roberts, T. Wise, W. Haeberli, W.A. Dezarn, J. Doskow, H.O. Meyer, R.E. Pollock, B. v.Przewoski, T. Rinckel, F. Sperisen, and P.V. Pancella
AIP Conf. Proc. 293 (1994) p.14.
- 7) "Polarized H or D Target for Experiments on the Indiana Cooler: Development of the Atomic Beam Source"
A.D. Roberts, T. Wise and W. Haeberli
AIP Conf. Proc. 293 (1994) p.10.

FIGURE 1

Detail of ABS and Target Chamber