a new front wirechamber (X-Y with 0.125-inch wire spacing and 128 wires), 45° scintilators and a VME computer front end. Currently the new E2 detector is being installed (6-inch thick plastic scintilator in four quadrants with 17-inch radii). These improvements are in preparation for the completion of CE42 and CE44 ($\vec{p}\vec{p} \to pp\pi$)

G-region

The G-region, with its large target chamber, the thin exit window and the rails to mount detectors, is currently being setup as the Cooler polarimeter. This location makes possible a measurement of the polarization of beam that would be longitudinal in the A-region. This polarimeter is much simpler in design that the CE01 detector system which is currently used as the Cooler polarimeter.

Installed in the G-straight section, is the RF-solenoid. Besides being able to create depolarizing resonances for ring spin-dynamics studies (CE20), this solenoid can "flip" the spin of the beam in the ring on a relatively fast time scale. This sytem is was used routinely for the production data taking in CE35 as a way to minimize systematics in polarized beam experiments.

DECELERATED BEAM IN THE COOLER

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Experiments with polarized protons in the Cooler Ring need a method to determine the polarization of the stored beam, since it cannot be assumed that the polarization is conserved during the injection process. So far, $p+^{12}C$ and p+p elastic scattering both have been used as analyzers. A very clean experimental signature distinguishes p+p scattering (when both outgoing protons are detected in coincidence), and several active or proposed nuclear physics experiments (e.g. CE42, CE44, CE45) make use of this process to measure the polarization of the stored proton beam. All of these experiments use a polarized hydrogen target which also serves as the analyzer.

Despite the fact that p+p elastic scattering is commonly considered to be well known, the absolute normalization of existing analyzing power data is often not known to better than about ± 0.05. Predictions from various phase shift analyses are normally spread over a similar range.

In a preparatory experiment we have measured the analyzing power A_y in p+p elastic scattering at 183 MeV and Θ_{cm}=18.1° with high accuracy.[1] This datum serves as a calibration point: it is now possible to determine the stored-beam polarization absolutely for beam energies near 183 MeV.

We plan to use the following method to export this calibration to energies T' other than 183 MeV. First, the asymmetry is measured at, or near 183 MeV (which establishes the beam polarization), then the beam is accelerated and the asymmetry is measured at T′ (which establishes the new analyzing power $A_y(T')$), and finally the beam is decelerated and the asymmetry is measured again at, or near 183 MeV (which establishes that the beam polarization was the same at both energies).

The ability to decelerate the stored beam has a second advantage. For accelerated-beam operation so far, protons are injected into the Cooler, accelerated and then used for data taking. At the end of the cycle, the remaining beam is discarded when the magnets are reset to their values at the injection energy. With the availability of deceleration it is no longer necessary to discard the beam before establishing injection conditions. This "cycle-to-cycle accumulation" results in a considerable increase in the time-averaged luminosity, a benefit for all experiments using accelerated beam.

During the past year, deceleration in the Cooler has been developed. Extensive changes in the software that governs the timing sequences of the machine during a cycle now allow up to three individual "ramps", either for deceleration or acceleration. The development was driven mainly by the requirements of the CE42 experiment (described elsewhere in this report). The goal of this experiment is a precise measurement of the energy dependence between 200 and 450 MeV of the spin-correlation coefficients in p+p scattering, and it is planned to make use of the method described above to export the A_y calibration.

Although beam acceleration was part of the Cooler design from the beginning, deceleration was not foreseen, and a number of steps have been necessary to obtain this mode of operation. For example, all the ring magnets were field-mapped on the rising portion of the hysteresis curve, except for the main dipoles for which complete loops were recorded. It has been necessary to develop a model of the magnet hysteresis for other elements and to extend the computational algorithms for loading ramping "slope-endpoint" arrays into the control hardware to the down-ramping case. Flux integration on a representative ring quadrupole has been employed to check the hysteresis model and to extend it to the small loops corresponding to small energy changes.

Extensive revision and extension of the control software have been required to permit strings of ramps to be executed in succession. For example the "G3" tables containing small corrections to the computed ramp shapes triple in number so that independent corrections are available for each of three ramps. Cooling must be provided at each flat-top (or "flat-bottom") so the cool-ramp-cool process is also extended. Separate timing controls are made available for each ramp, so that the automatic tune measurement can be triggered to monitor betatron tune at any point on any ramp. Flattop ramps, which are used by the experimenter to make small beam adjustments at a target, are also needed after each ramp. The software changes have been under development over the past year, interspersed with beam studies which provide useful feedback for the controls evolution.

So far, beam has been successfully accelerated up to 450 MeV and decelerated back down to 200 MeV during runs in December 1994 and January 1995. The beam current during a typical cycle is plotted as a function of time in Fig. 1. At first, 200 MeV proton beam is injected. After about 25 s, during which the experiment is taking data, the beam is accelerated (while the beam current increases due to the increase in the velocity of the stored particles). After the energy ramp is completed, the beam is used by the experiment

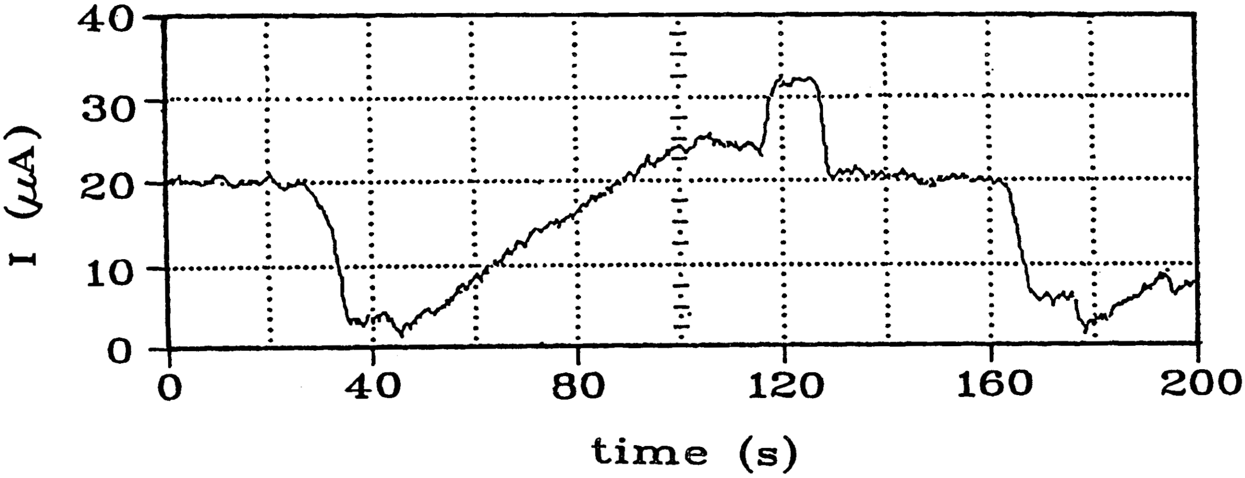
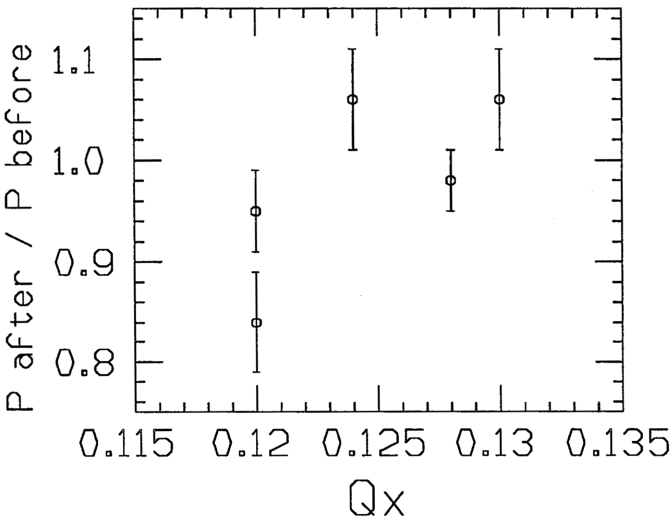


Figure 1. Beam current as a function of time. At the beginning of a cycle beam is injected (~ 40 s – ~ 100 s). During the upramp (~ 115 s) an increase of beam current is observed. During the downramp (~ 130 s) the corresponding decrease in beam current is seen. At about 170 s the magnets are reset. Before, between and after the two ramps the beam is used by the experiment.

Figure 2. Ratio of the beam polarizations before and after the two ramps as a function of the fractional horizontal betatron tune.



for another 25 s before being decelerated back to injection energy. It can be seen that the beam current before and after the two ramps is nearly the same. Such a high transmission efficiency for both ramps is required before this scheme can be used for cycle-to-cycle accumulation.

The experiment was carried out with polarized beam from the HIPIOS source. Before and after the two ramps the beam polarization was measured and the ratio of the two polarizations was calculated.

Figure 2 shows this ratio as a function of the fractional horizontal betatron tune, Q_x. It can be seen that within the statistics, this ratio reaches unity, indicating that the beam

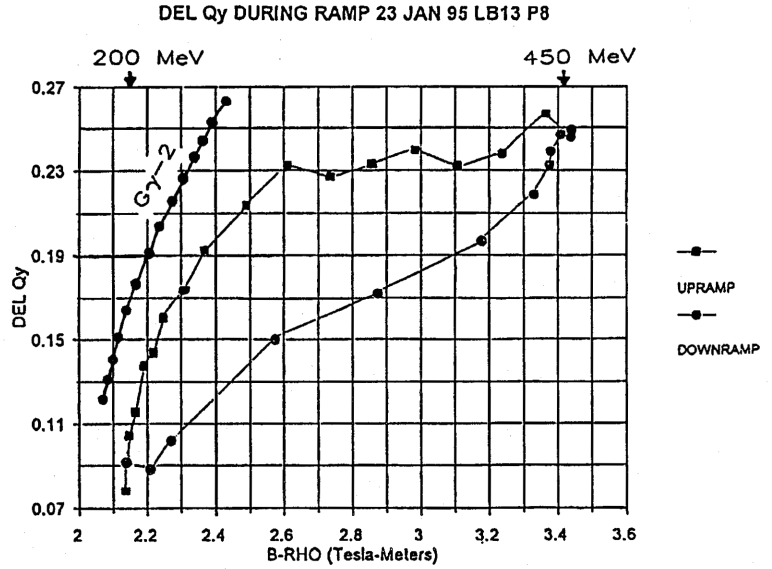


Figure 3. Fractional vertical betatron tune as a function of magnetic rigidity during the upramp (squares) and downramp (shaded circles). The solid circles indicate the location of the intrinsic resonance.

polarization was preserved during the double ramp. The fact that for certain values of Q_x the polarization after the ramp is smaller than before can be understood on the basis of the nearby intrinsic depolarizing resonance, assuming coupling of the vertical and horizontal tunes.

Depending on the machine tune, the injection energy of 200 MeV is close to the one intrinsic depolarizing resonance in the Cooler energy range. If the tune is not carefully controlled, beam depolarization may result. This is especially critical at the very beginning of the up-ramp and at the very end of the down-ramp. At present a lengthy, and largely empirical, optimization procedure is required to control the tunes during the ramps. Figure 3 shows the fractional vertical betatron tune as a function of magnetic rigidity (or energy) during both ramps. As in Figs. 1 and 2, the beam was ramped to 450 MeV. The location of the intrinsic resonance is also shown. The fact that the dependence has loop-like character is due to hysteresis effects that were not yet corrected. An upgrade of the Cooler software, containing an improved ramp algorithm with corrections for hysteresis in the quadrupole magnets, is expected to remedy the tune variations during the ramps. The new software will be tested in an upcoming experiment. The tune is now stable during both ramps and easily changeable by a single tune quadrupole for each, the vertical and horizontal tune.

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1. B. von Przewoski, H.O. Meyer, P.V. Pancella, S.F. Pate, R.E. Pollock, T. Rinckel, F. Sperisen, J. Sowinski, W. Haeberli, W.K. Pitts, and S. Price, Phys. Rev. C 44, 44 (1991).