FIELD–IMMERSED TARGETS (CE-30)

M. Klasen, J. Lash, R. Pollock, T. Sloan
Indiana University Cyclotron Facility, Bloomington, Indiana 47408

An experiment to develop and explore the potential of a charged particle trap as a target in a cooling ring has been initiated. A solenoid magnet of 48 pancake coils and a steel frame, with interior diameter 0.24 m, length 0.83 m and field 0.23 T has been constructed and field-mapped. The outer 4+4 coils are excited from a separate power supply, allowing the field to be adjusted either for maximum uniformity or with a mirroring enhancement at the ends. Pancakes are assembled with a 72° azimuthal phase advance between the current leads of adjacent pancakes. This results in a five-fold symmetry that reduces the effect of conductor cross-over length of 0.50 m. Field lines in this central region are found to differ from a straight line by less than 0.3 mm.

A bakeable cylindrical vacuum chamber with several ports for feedthroughs has been constructed. A vacuum of 20 nTorr has been reached when pumping with a small turbo-pump, and 8 nTorr when installed in the S region of the Cooler ring with no pump closer than 3 m.

In a first application of this system, an electron gun, a set of electrostatic deflectors and steerers, and position-sensing collectors have been installed within the chamber. A 10 eV-0.1 μA electron beam from a hairpin Tungsten filament is guided onto a path which can be made to coincide with a stored ion beam. The electromagnetic interaction between the beams is observed as a position shift at the collector. In a five shift run ending 6 May 1992, it was demonstrated that the position and intensity of a coasting stored cooled beam of 45 MeV protons could be monitored with this setup. (The normal beam positioning pickups only function when the beam has rf structure imposed.) A 30 keV decrease in the stored beam energy which occurred during each cooled stripping injection phase was discovered through a small position shift (4.2 m dispersion) at this detector and later confirmed with Schottky scans. An electron beam of smaller diameter is being developed to permit non-destructive monitoring of the cooled beam emittance.

The system will be reconfigured for electron accumulation studies as an anharmonic Penning trap with a bathtub-shaped longitudinal confinement potential. The system is a synchrotron analog, and particles may be captured by an rf modulation below transition energy and decelerated onto a stack. Transverse multi-turn accumulation may also be possible using an rf signal applied to steerer fields. A small enclosure north of the S region has been fitted out as an off-line test area for these trap studies.

A long-term goal is to be able to store a quantity of electrons sufficient to serve as a free electron target for the Cooler. Studies of loss processes (CE-17) have shown that electrons bound to atoms in internal targets can be a significant cause of beam heating and loss. Electrons bound to the field lines of a trap have a larger Coulomb logarithm. Their effect on the beam should be observable at thicknesses of order $10^{12}/cm^2$. However the stability of a dense cloud of trapped electrons interacting with a stored beam is uncertain. Certainly the ion beam will undergo a tune shift from the collective electric field of the electron lens, and may serve as a useful diagnostic for the trap.

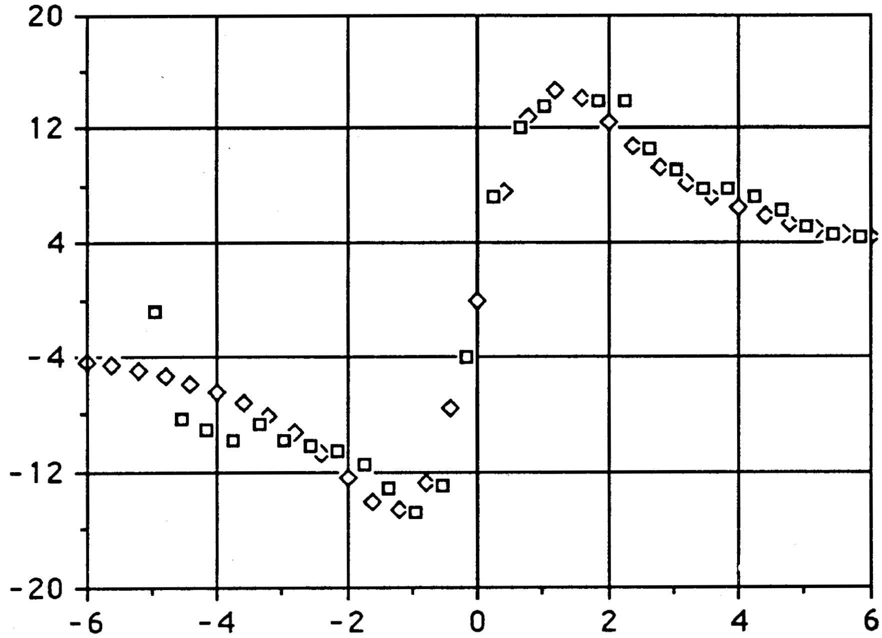

Figure 1. The diamond symbols show the expected in-plane electric force exerted on a charge by a stored beam with a Gaussian density profile. The square symbols are data from CE-30 on May 6, 1992 showing the difference between the outputs of two logarithmic amplifiers connected to a split-plate collector. The abscissa is proton beam position spanning about 30 mm. The ordinate reflects horizontal beam deflection. The data are corrected to a typical proton current of 0.5 mA.