Longitudinally Polarized Electrons in a Storage Ring below 1 GeV

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Abstract. We report on the results of studies of the longitudinal electron polarization in the AmPS storage ring at NIKHEF. The ring was operated using a partial Siberian snake at the first magic energy, and a full Siberian snake between 440 MeV and 720 MeV. We have investigated the effect of high beam currents in the ring, and found that some of the electron polarization is lost if the beam current becomes larger than ≈ 120 mA.

In storage rings, electrons will become polarized by the Sokolov-Ternov self-polarization mechanism [1]. However, for the AmPS storage ring at NIKHEF the Sokolov-Ternov polarization build-up time is of the order of 10 h, while the beam lifetime during internal target experiments is of the order of 10 minutes. We obtained a stored polarized beam by injecting pulses from a polarized electron source [2]. It was used in combination with polarized internal targets [3,4] to perform spin-dependent electromagnetic studies of the nucleon and few body systems. The electron source used strained InGaAsP cathodes, which were illuminated with laser

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FIGURE 1. Electron polarization vs time for stored electrons with a beam energy of 665 MeV. The line is a fit to the data with the function $P(t) = P_0 e^{-t/\tau_p}$.

light to produce electron with a degree of polarization of up to 80%. The source used a pulsed high voltage power supply, which increased the lifetime of the cathodes from a couple of hours to 180 h. The electron polarization was measured at the source with a Mott polarimeter.

In order to maintain the longitudinal polarization at the internal target, a Siberian snake was implemented at the exact opposite side in the AmPS ring. The longitudinal polarization at the interaction point was determined with a Compton backscattering polarimeter [5]. The electron polarization of the stored beam was optimized by changing the orientation of the spin at the source with a Z-shaped spin manipulator and measuring the polarization in the ring. When the spin orientation in the accelerator was longitudinal, no depolarization was observed. However, up to 10% depolarization was observed when the spin was (partially) transverse to the momentum in the accelerator. This was probably due to the spin precession in the longitudinal magnetic field in the first sections of the accelerator and the spread in the energy of the electrons.

The polarization lifetime was measured with the Compton polarimeter at various beam energies and was always more than 4500 s, much longer than the beam lifetime when an internal target was present, see Fig. 1.

The polarized electron source produces pulses of about 5 mA. To obtain higher currents in the ring, 3-turn injection and pulse stacking is used. Currents in excess of 200 mA have been obtained. The effect of high beam currents on the electron polarization has been investigated using the Compton polarimeter and the internal target via the measurement of a spin correlation parameter. Here, the spin correlation parameter of the reaction ${}^3\text{He}(\vec{e}, e'n)pp$ at the quasi-elastic peak was used as a (relative) beam polarization analyzer [6]. The polarization of the ${}^3\text{He}$ target was monitored independently. Figure 2 shows the electron polarization as

FIGURE 2. Electron polarization vs injection current as measured with the Compton polarimeter (left) and spin correlation parameter vs injection current (right). The spin correlation parameter has been extracted, assuming no loss of electron polarization.

measured with the Compton polarimeter (left) and the extracted value of the spin correlation parameter with the online analysis, assuming no electron polarization is lost (right). The theoretical prediction was calculated using plane wave impulse approximation and the electromagnetic form factors of the neutron and is in good agreement with the extracted value for $I_{start} < 100$ mA. At higher currents, a clear depolarization of the electron beam is observed and a large discrepancy exists between the extracted and predicted spin correlation parameter, indicating a significant loss of electron polarization. This is probably due to a shift of the horizontal and/or vertical betatron tune in the storage ring.

In summary, we have presented studies of the behavior of polarized electrons in a medium energy storage ring. We have shown it is possible to inject and store polarized electrons in a storage ring with a spin lifetime, which makes it possible to use the polarized beam for internal target experiments.

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