Beam Request
on

Do unpolarized electrons affect the polarization of a stored proton beam?

(ANKE and $\mathcal{PAX}$ Collaborations)

Jülich, March 2007

Beam Request
on
Do unpolarized electrons affect the polarization of a stored proton beam?

(ANKE and $\mathcal{PAX}$ Collaborations)

Abstract

Understanding the interplay of the nuclear interaction with polarized (anti) protons and the electromagnetic interaction with polarized electrons in polarized atoms is crucial to progress towards the PAX goal to eventually produce stored polarized antiproton beams at FAIR. Presently, there exist two competing theoretical scenarios: one with substantial spin filtering of (anti)protons by atomic electrons, while the second one suggests an almost exact self-cancellation of the electron contribution to spin filtering. The existing experimental data from the FILTEX experiment allow neither an unambiguous discrimination between the two scenarios nor do they give a direct constraint on the rôle of the spin-flip scattering in spin filtering as discussed recently by Walcher et al.

In addition to the measurements proposed with a ^{4}He target, the collaborations have confirmed the possibility to perform as a next step after the machine studies (scheduled in the last two weeks of June, 2007) a first measurement of the polarization lifetime using two Silicon Tracking Telescopes (STT) and to pursue the commissioning of the second STT at ANKE using the Deuterium cluster-jet target bombarded by a polarized proton beam at injection energy of $T_p = 45$ MeV. The analyzing powers in *pd* elastic scattering are large, and using the point-like cluster target a similar significance of the depolarizing effect can be reached compared to the extended ^{4}He storage cell target.

Spokesperson:

Dieter Oellers
Institut für Kernphysik, Forschungszentrum Jülich, Germany
E–Mail: di.oellers@fz–juelich.de

for the ANKE and $\mathcal{PAX}$ Collaborations

Contents

1 Beam Depolarization with the Deuterium Cluster Jet Target

The COSY program advisory committee granted in session # 32 two weeks for machine studies for experiment #169 [1], which we will use to carry out the necessary preparatory investigations with respect to improvements of the beam lifetime. These two weeks have been meanwhile scheduled in the end of June, 2007. With the present request, the collaborations would like ask for two more weeks of beam time towards the end of 2007 to carry out a first measurement of the polarization lifetime.

We have applied the formalism outlined in Sec. 3.5 of ref. [1] to estimate the depolarizing effect of the target electrons, based on the Meyer-Horowitz (MH) approach [2]. For this, we have chosen the following standard set of parameters:

Parameter	Value
Target Thickness	$2 \cdot 10^{14}$ cm^{-2}
Beam Intensity	$2 \cdot 10^{10}$ stored protons
Initital Beam Polarization	0.8
Beam Lifetime	2700 s
Beam Polarization Lifetime	45000 s
Beam Energy	45 MeV

Table 1: Standard set of parameters to evaluate the depolarizing effect of the electrons in a Deuterium cluster target.

The Figure of Merit for *pd* elastic scattering, FOM = $\mathrm{d}\sigma/\mathrm{d}\Omega(\theta_{\mathrm{cm}}) \cdot A_y(\theta)^2$ has been evaluated based on available experimental data [3, 4]. The experimental setup forsees two Silicon Tracking Telescopes (STT) left and right of the target area. The detectors are placed to cover the region, where the FOM exhibits a maximum, i.e. near $\theta_{\mathrm{lab}}^{\mathrm{proton}} = 80^\circ$ (see Fig. 1). The count rates have been determined using a Monte Carlo simulation.

In order to evaluate the relevance of the different parameters, the parameter set in Table 1 was fixed, except for one quantity, which was varied. As shown in Fig. 1, it is most crucial to provide a large lifetime of the beam polarization. The other parameters enter linearly into the significance, defined as $\tau_p^{\mathrm{MH}}/\Delta\tau_p^{\mathrm{Target}}$, where τ_p^{MH} denotes the polarization lifetime based on the (MH) interaction with the target electrons, and $\Delta\tau_p^{\mathrm{Target}}$ is the measurement error of the polarization lifetime. Since in the scenario outlined above no storage cell will be utilized, the number of polarized protons, stack-injected and accumulated into COSY at injection energy can be increased from 2 to $3 \cdot 10^{10}$, which would yield a significance of about 6 standard deviations.

With optimum ring settings, the dominating beam loss mechanism is single Coulomb scattering of particles beyond the ring accpetance. The beam lifetime is inversely pro-

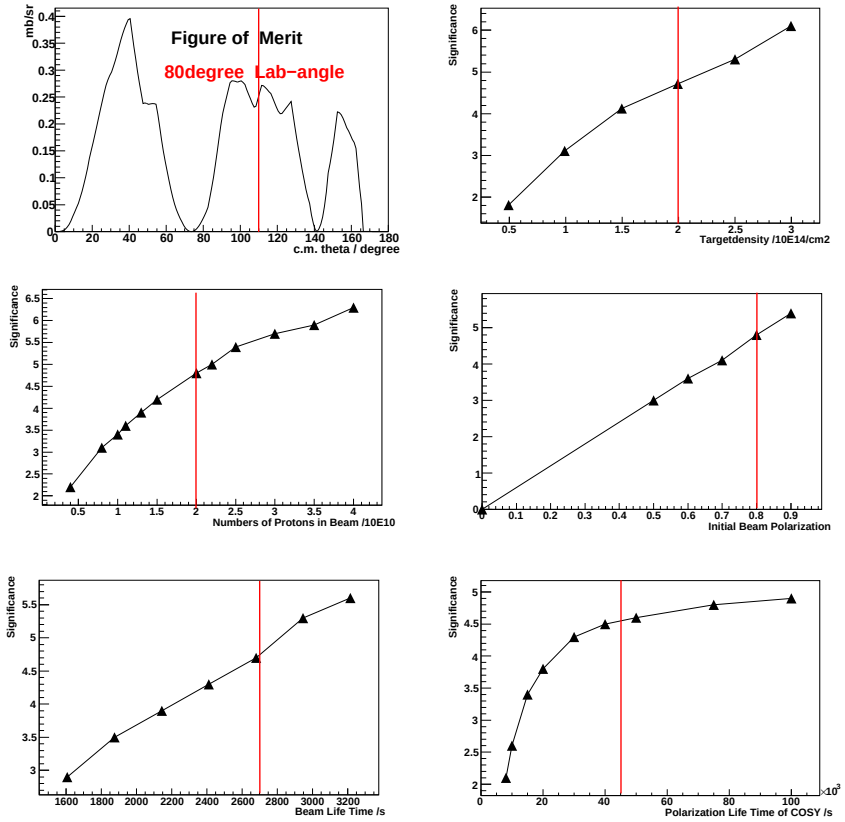

Figure 1: The top-left panel shows the FOM for *pd* elastic scattering at the COSY injection energy of $T_p = 45$ MeV. The other five panels show the significance as function of the target density (top-right), beam intensity (middle-left), initial beam polarization (middle-right), beam lifetime (bottom-left), and polarization lifetime (bottom-right). (The red vertical lines indicate the standard parameters, as listed in Table 1.)

portional to the square of the charge of the target nuclei [5], thus when instead of a ^{4}He target of thickness $2 \cdot 10^{14}$ cm^{-2}, a Deuterium target of the same thickness is used, the beam lifetime is increased by a factor of four. This we have indicated in Fig. 2, where the statistics of a four week measurement is summarized together with the optimized target on- and off-times.

2 Beam Request

- **We request two weeks of beam time with polarized protons**. **ONE** week will be used for machine development, and **ONE** week for commissioning of the detector system and a first measurement of the COSY polarization lifetime in the second half of 2007.

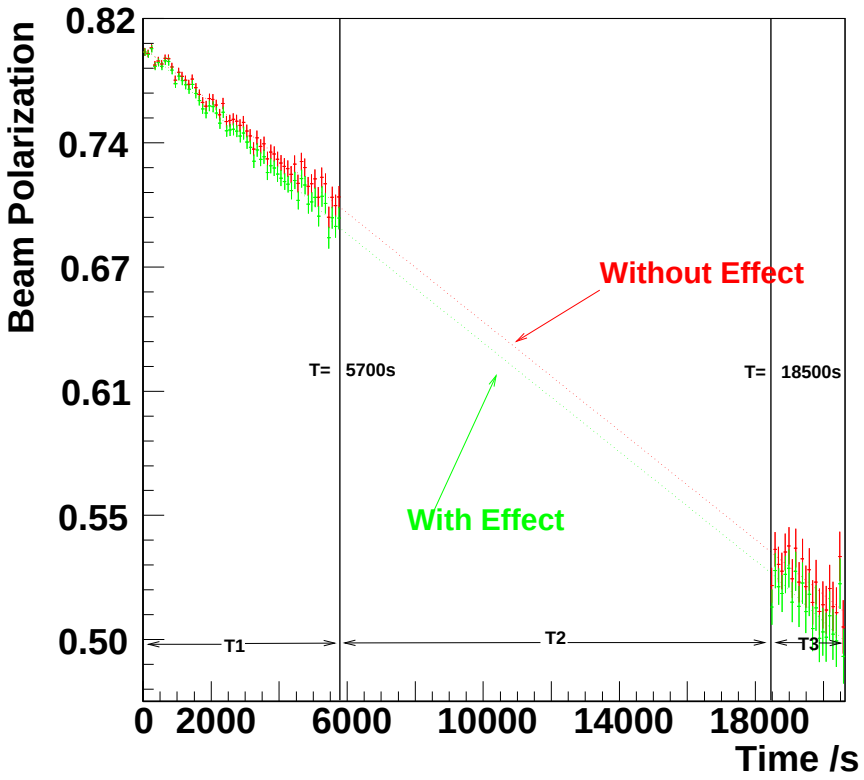

Figure 2: Plot of the measured beam polarization vs time in the cycle. The cycle is composed of three parts of duration $T = T_1 + T_2 + T_3 = 20600$ s, target-off times are 5700 s $< t <$ 18500 s. The observed beam polarization with(out) the Meyer-Horowitz depolarization is shown in green (red).

References

[1] Proposal #169 to the COSY PAC on *Do unpolarized electrons affect the polarization of a stored proton beam?*, ANKE and PAX Collaborations, spokesperson: Dieter Oellers (Forschungszentrum Jülich), available from the PAX website `http://www.fz-juelich.de/ikp/pax`.

[2] H.O. Meyer, Phys. Rev. E **50**, 1485 (1994).

[3] A.R. Johnston et al., Phys. Lett. **21**, 309 (1966).

[4] S.N. Bunker et al., Nucl. Phys. A **113**, 461 (1968).

[5] F. Hinterberger and D. Prasuhn, Nucl. Instrum. Methods A **279**, 413 (1989).