A polarized scintillator target

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We report on the development of an "active" polarized proton target and its first operation in particle scattering experiments. A block of 18×18×5 mm scintillating polymer has been doped with TEMPO and polarized dynamically in a vertical dilution refrigerator at 2.5 T. Proton polarizations well above 60 % have been routinely achieved. A 12 mm diameter lightguide transports the scintillation light from the target in the mixing chamber to a photomultiplier outside the cryostat.

The availability of dynamically polarized nuclei in a scintillating substance opens a wealth of new possibilities for the measurement of spin-dependent observables in nuclear and particle physics. The coincident detection of the low energy recoil proton in the target itself allows to suppress background scattering significantly, which is essential when measuring at forward angles[1,2], but until recently, a "polarized scintillator target" was not available.

We have been able to demonstrate with a prototype [3,4] the feasibility of such a target, which was thought impossible for a long time, in a test experiment on a pion beam [5]. Since then, several significant improvements on different components of the system have been achieved which increased its performance significantly and enabled us to carry out two scattering experiments successfully.

The light output and the polarization in the scintillator are determined by the doping and production process. In both respects, the diffusion method [3,6] poses severe limitations. A homogeneous distribution of the TEMPO free radical is difficult to achieve and concentration gradients are observed in platelets of thicknesses of more than a few tenths of a millimeter. Furthermore, from

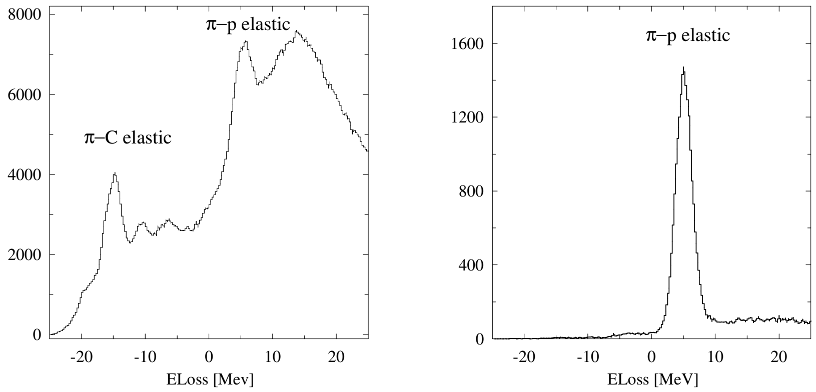

Figure 1: Pion energy loss spectra for the scintillating target taken with the **L**ow **E**nergy **P**ion **S**pectrometer at PSI. Left: Trigger requirement LEPS only. Right: Trigger LEPS∗recoil proton detected in the polarized target.

the point of view of light output, a block target is preferable over a stack of thin platelets having the same effective thickness, as used in the prototype.

The investigation of different alternative production processes has led to solid samples of ca. 4 cm^3 and we achieve now routinely well above 60 % polarization in blocks of $18\times18\times5$ mm at 2.5 T and below 0.3 K. A full account of the production process will be given in a forthcoming publication [7]. The scintillation characteristics of the blocks have been studied with a ^{90}Sr-source and with protons of energies ranging between 5 and 12 MeV at a tandem accelerator. The light output of the new probes reaches 25 % of the unpolarizable reference material.

Furthermore the light extracting system was investigated with a raytracing program and the optimum shape and dimensions of the different components deduced. According to these findings, a new target holder was constructed, based on the design of the prototype [3]. By increasing the diameter of the light-guide from 8 to 12 mm, machining it from a low attenuation material (Bicron BC800) instead of ordinary plexiglass and redesigning the quarz intermediate piece coupling the target to the guide, almost a factor of 4 could be gained in light transmission. Together with the better scintillation properties of the probes themselves, this added up to an overall improvement of a factor 20 compared to the original setup.

With this new insert integrated in our standard polarized target dilution refrigerator [8] we could reach a temperature below 70 mK. The system has been operated recently in two scattering experiments[1,2] over a period of two months, proved to be very robust and reliable and no deficiencies in the design have been noticed. It was run in continuous polarizing mode as well as in frozen spin mode at fields of 0.8 T and 1.2 T, with polarization values around 60 %. Both experiments would have been impossible to perform without additional information on the scattering event. Figure 1 illustrates the kind of background suppression that can be achieved with the coincidence detection of the low energy recoil proton inside the target.

References

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