THE POLARIZED ^{3}He TARGET

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The polarized ^{3}He internal target[1] for CE-25 (Refs. 2 and 3) is based on direct optical pumping of the 2^3S_1 metastable state,[4] as is the case in the external target developed at Caltech[5] and used in the first measurement of spin-dependent electron scattering from ^{3}He at Bates.[6] If a weak electric discharge is maintained in a low pressure ^{3}He gas, a small fraction of the atoms ($\sim 10^{-6}$) will be in the long-lived 2^3S_1 metastable state. Circularly polarized pumping light at $\lambda = 1.083$ μm, incident upon the sample along a weak magnetic field, excites transitions between the 2^3S_1 and 2^3P_0 states. Angular momentum is thus transferred from the pumping light to the metastable atoms, which become polarized. Transfer of polarization to the ground-state atoms is achieved through metastability exchange collisions.[1] The polarization of the atoms in the pumping cell is measured by detection of the circular polarization of the 667 nm line.[7]

An infrared laser system[8] is used as source of 1.083 μm photons for optical pumping. The lasing medium is a $La_{85}Nd_{15}MgAl_{11}O_{19}$ (LNA) crystal, 4-mm diameter, 79-mm long, in a Lasermetrics 9550 YAG cavity. The laser beam is linearly polarized by passage through a polarizing beam splitter cube and then circularly polarized by passage through a Pockel cell. High voltage is applied on the Pockel cell to give $\lambda/4$ retarding, and its polarity can be reversed to give $\lambda/4$ advancing. The infrared laser system is set up about 2 m from the target. The laser beam is transported to the glass pumping cell by a series of AR coated lenses and mirrors. Three pairs of lenses are arranged at different locations to keep the beam spot well within the mirrors (2.5 cm diam.) and the Pockel cell (8.5 mm diam.). The last pair of lenses expands the beam coming out of the Pockel cell to almost the full diameter (6 cm) of the pumping cell, maximizing the optical pumping rate.

The target system, including the scattering chamber, was brought to IUCF in late 1991. It was first set up for preliminary testing outside the Cooler vault, and then, in April 1992, installed in the storage ring. Figure 1 shows a side view of the setup. The pumping cell is located at the center of Helmholtz coils that produce the 10 − 30 G vertical holding field. The laser beam coming down vertically into the glass pumping cell polarizes the ^{3}He atoms in the vertical direction. During the run the polarization direction was inverted by reversing the laser beam circular polarization.

Polarized ^{3}He atoms flow from the pumping cell through a glass capillary into the target cell below. The capillary tube and the target cell are coupled by means of a teflon sleeve that allows alignment of the cell on the beam axis. The target cell dimensions (40 cm long, 13.1 mm wide and 16.6 mm tall) correspond to horizontal and vertical Cooler acceptances of 30 and 35 $\pi\mu$m, respectively. (For later runs we may consider going to a

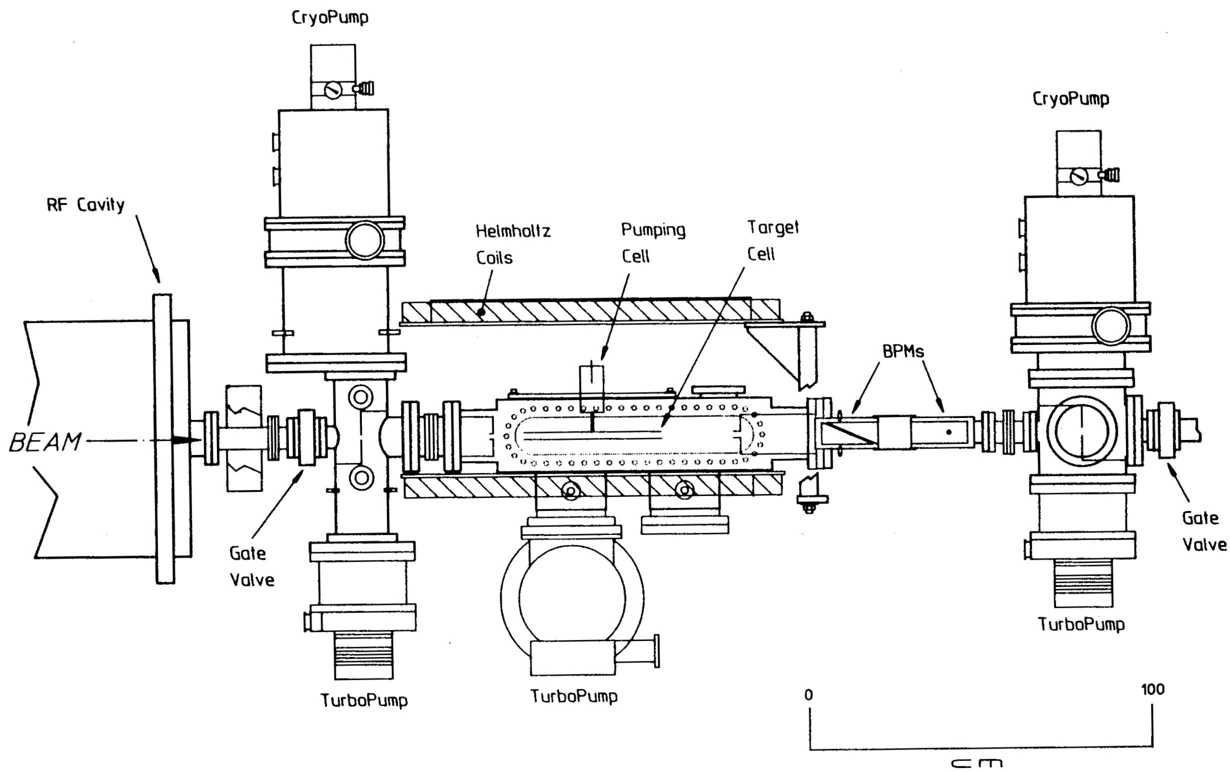

Figure 1. The polarized ^{3}He target setup for CE-25 setup in the Cooler A-section.

cell of smaller transverse dimensions in order to increase the luminosity.) The cell consists of a frame made from 0.2 mm aluminum with windows attached on each side. The top and bottom parts of the frame are channels 40 cm long by 6.3 mm tall and 12.7 mm wide. They are held apart by 5 mm $\times$ 5 mm $\times$ 30 mm long angle pieces attached at each corner of the cell with Torr-Seal low vapor pressure resin. The side windows of the cell were made from 1.5 μm aluminized mylar film attached to the cell frame with Torr-Seal. An additional 0.17 μm of aluminum was evaporated onto one side of the window material to block laser light that finds its way into the cell from reaching silicon micro-strip detectors just outside the cell.

The ^{3}He gas leaving the cell is differentially pumped with turbomolecular and cryogenic pumps. The former are used on the scattering chamber (Balzers TPH 2200) and on each first pumping stage up- and downstream (Balzers TPH 1500), while on the second stages, which couple the experimental area to the rest of the ring, we have cryo pumps (Leybold RPK 3000S12). The conductance limiters separating the differential pumping stages clear the beam with an acceptance of 35 $\pi\,\mu$m, both vertically and horizontally. Their position and length has been optimized such that the thickness of the ^{3}He gas outside the target cell amounts to only 2% of the target thickness.

In our first CE-25 run[3] we achieved 48% polarization at 0.5 Torr pressure in the pumping cell, resulting in a flow rate of 1.0 × 10^{17} atoms/s, and a target thickness of 1.3 × 10^{14} atoms/cm^2. At 0.37 Torr (5.0 × 10^{16} atoms/s) the polarization was down to 40%.

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THE H_2O JET TARGET

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An internal oxygen target is required for the study of the $^{16}O(p,n)^{16}F$ reaction in CE-19 (Refs. 1 and 2). We decided for an H_2O vapor jet for the following reasons. First, we would avoid possible corrosive effects that pure oxygen gas might have on the oil of the turbomolecular pumps. Second, the water molecule does not contain atoms that could create relevant background (low energy protons coincident with fast neutrons), or significantly reduce the beam lifetime and thus the luminosity. The presence of hydrogen in H_2O actually has very important benefits, because p+p elastic scattering has a relatively large and well known cross section. As has been done successfully in a number of Cooler experiments[3] with H_2 targets, normalized jet density profiles can be obtained with the use of position-sensitive recoil detectors. This makes it possible to center the beam on the jet relatively easily, as well as to monitor the luminosity.

After feasibility studies[4] and extensive testing in the Cooler G-section (during beam shutdown periods) the water vapor jet was installed in the T-section in April 1992. Figure 1 shows a side view of the setup with the 6° magnet. Water in a copper reservoir (not shown) is heated to a temperature corresponding to the desired vapor pressure, which in turn determines the flow rate through the nozzle and the jet thickness. A solenoid three-way valve allows for fast ($\sim$ 200 ms) turn-on and turn-off of the jet; the line to the nozzle can be switched either to the H_2O reservoir (jet on) or to a vacuum pump (jet off). The path of the vapor from the reservoir to the nozzle has to be kept at or above the temperature of the reservoir in order to avoid condensation.