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.

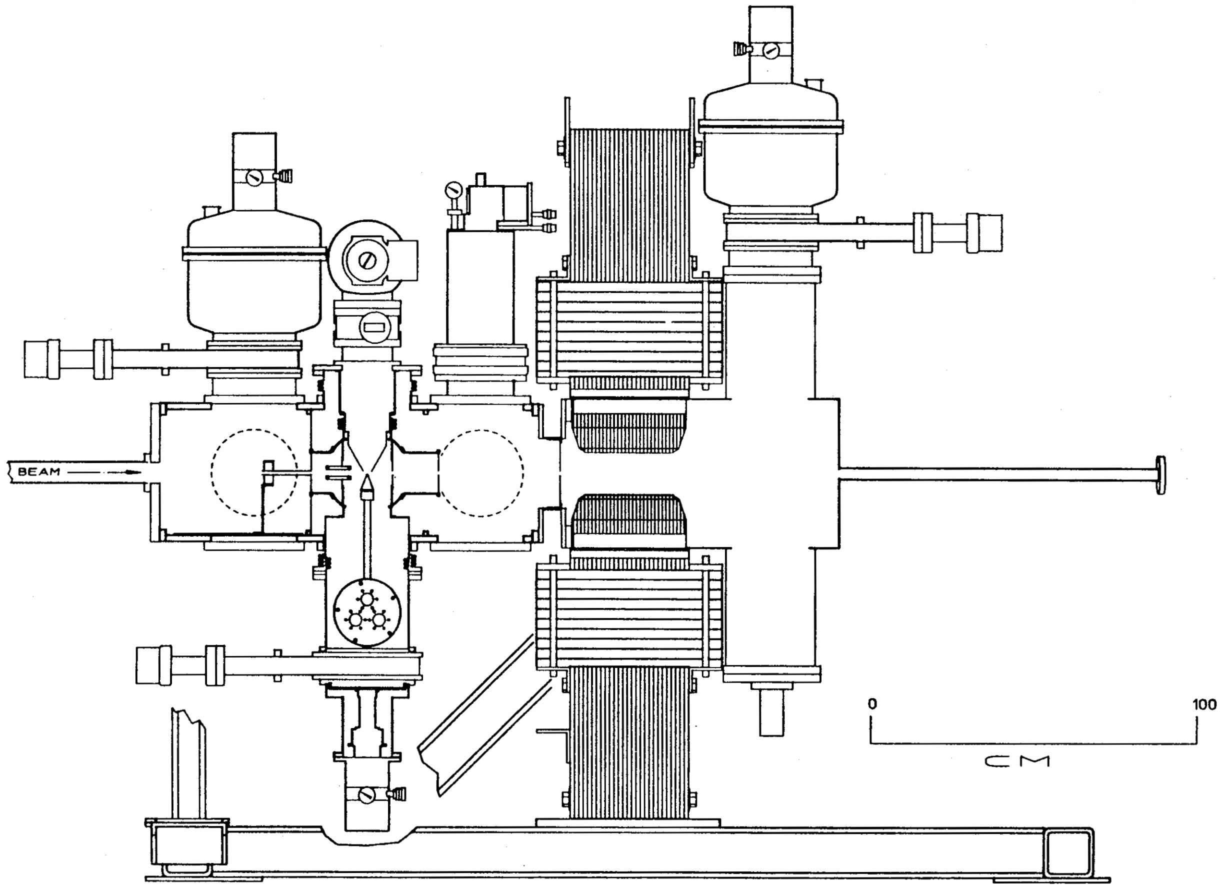

Figure 1. The H_2O vapor jet target setup with the 6° spectrometer magnet in the Cooler T-section.

The nozzle, the catcher (in the center of the target chamber, see Fig. 1), and the differential pumping system are similar to that of the conventional gas jet target.[5] About 65% of the jet is caught by the catcher; the remainder of the gas is differentially pumped along the Cooler beam. The first pumping stage, surrounding the nozzle, is pumped cryogenically by a copper disk, cooled to 150 °K by a closed cycle He expander. Its H_2O pumping speed was found to be about 4000 l/s, much more than that of the turbo pump in this place of the conventional gas jet target. A total of four turbos are used in the second and third pumping stages. All of them, plus the one on the catcher, are backed by one common fore pump. To prevent water vapor from condensing in the fore pump, a liquid nitrogen cold trap is used.

For initial centering of the beam on the jet and detector, tune-up hydrogen jets (both H_2 and D_2) are desirable. They can be run with considerably higher luminosity than the H_2O jet, and with a D_2 jet one gets a copious source of nearly mono-energetic neutrons.

Unfortunately, the H_2O target setup is not ideal for running with hydrogen because the cryo pump (cold copper disk) on the first stage does not pump H_2. Therefore, for hydrogen operation, this pump has to be replaced by a turbo pump. This can be done while leaving the chamber under vacuum due to the gate valve there.

In our first CE-19 run we ran H_2, D_2 and H_2O jets. For the latter the water reservoir was kept at 50 °C (90 Torr vapor pressure), resulting in a jet thickness of about 2×10^{13} molecules/cm^2. The Cooler beam lifetime was unusually low, only about 12 s, which is an order of magnitude less than what should be expected.[6] With the Cooler running well, the optimum target thickness will be about 4×10^{14} molecules/cm^2. This, with 300 μA ramped beam, is expected to result in an average luminosity of roughly 2×10^{29} cm^{-2}s^{-1}.

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UPDATE ON THE JET TARGET

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Aside from minor modifications, a significant improvement of the jet target system has been the implementation of the PC based monitor and control system, TRIPS. All remote readouts and controls are now done from the PC keyboard, except for the jet flow which is normally controlled by the experimenter's data acquisition computer. The interlock conditions can be programmed flexibly; they typically include fore and high vacuum pressures as well as turbo pump speeds. Any violation of these conditions causes all turbo pumps to turn off and all valves to close. The PC also controls the nozzle temperature at a level set by the user.

A continuing problem are the frequent failures of the turbo pumps[1] (Balzers mod. TPU/H 1500). We have begun replacing them with a redesigned model with improved bearing lubrication. However, failures have continued even with these new pumps. To reduce the risk for more break-downs, we will now install even the new pumps with the