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Ice Targets

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ICE TARGETS

by

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ABSTRACT

This report presents a description of ice targets that were constructed for research work at the High Resolution Spectrometer (HRS) and at the Energetic Pion Channel and Spectrometer (EPICS). Reasons for using these ice targets and the instructions for their construction are given. Results of research using ice targets will be published at a later date.

I. WHY ICE TARGETS?

Experimenters are interested in studying various oxygen isotopes such as ^{17}O, ^{18}O, and the normal ^{16}O. The ideal way of running these experiments is to have a target of uniform thickness in the beam line. The most practical way to construct a target of uniform thickness that will remain the same thickness throughout the experiment is to have the oxygen isotope in water and to freeze it. It is necessary to keep the H_2O frozen during the experiment.

It was also desired to conduct an experiment with ^{17}O, which is quite costly. By constructing an $H_2{}^{17}O$ ice target we can control and handle the ^{17}O so that our losses are minimal.

II. EXPERIMENTS AT LAMPF REQUIRING ICE TARGETS

A. EPICS

1. Experiment #229, "π^+ vs π^- Inelastic Excitation of Low-Lying Collective States in ^{28}N Nuclei," W. J. Braithwaite, University of Texas, Spokesman, used an ice target to investigate the isospin mixing effect in ^{16}O. C. L. Morris proposed this investigation of ^{16}O in collaboration with Dietrich Dehnhard, University of Minnesota.

2. Experiment #369 proposed a study of elastic and inelastic scattering of π^+ and π^- by ^{17}O, ^{18}O, and ^{19}F using the EPICS channel with $\sim$200 MeV pions. A ^{17}O target is especially

unique because it is the only stable nucleus, besides ^{209}Bi which consists of a single nucleon outside a double magic core.

Three ice targets were needed for Expt. 369, an ^{17}O, 3.175-mm thick target on loan to us by Tom Mills of Group CNC-4 and two ^{16}O targets were made for Expt. 369, one was 3.175 mm thick and the other 1.58 mm thick.

3. Experiment #310, "Double Charge Exchange" experiment requires a ≈1-cm thick ^{16}O ice target and one ≈1-cm thick ^{18}O ice target.

B. HRS

1. Experiment #431, "Cross Section and Analyzing Power for Inelastic Proton Excitation of Unnatural Parity States in ^{6}Li, ^{12}C, ^{14}N, and ^{16}O," requires a 1.58-mm thick ^{16}O ice target; a 3.175-mm thick target is ready for use.

2. Experiment #395 requires a 3.175-mm thick ice target 7.62 cm x 12.7 cm overall area with an active area of 1.27 cm x 8.89 cm ^{16}O water.

III. CONSTRUCTION OF ICE TARGETS

Most ice targets for EPICS experiments are made from 3.175-mm copper stock and are 14.61 cm x 27.31 cm overall size with holes around the perimeter to mount on the ice target refrigerator frame. There are also two compartments in the center of the ice target frame measuring 9.86 cm x 10.16 cm. There is a through hole from the outside of the frame top to each ice target compartment, tapped 9.52 mm deep for 4-40 MS. (See Fig. 1)

A phenolic target holder which fits on the EPICS target ladder was designed to hold the ice target at four points and to transmit the minimum heat. All targets for EPICS are designed to fit on this holder. (See Fig. 2 for assembly).

Different materials, such as Mylar, Kapton, etc., were tried for covering the ice targets. It was decided that a 0.025 mm copper sheet would be used because it has the best heat transfer. Epoxy and Eastman 910 adhesives were tried to adhere the copper foil to the copper plate. After much experimentation, it was found that soldering the 0.025-mm copper sheet in two steps, using two temperature solders worked best. Following is a description of the procedure for soldering the 0.025 mm copper foil on the ice target frame:

A. Place 27.31 cm x 14.61 cm x 3.175 mm copper ice target frame on 30.48 cm x 15.24 cm x 1.27 cm aluminum plate. Place aluminum plate and copper frame on hot plate (heat to ∿315.6-343.3°C).

B. Apply liberal amount of soldering flux, such as Nokorade #14000 to face of ice target frame. When ice target frame is hot enough to melt solder made from 60% Sn, 40% Pb, (∿232.2-260°C) solder one side completely. (See Fig. 3).

C. Place another 35.56 cm x 17.78 cm x 1.27 cm aluminum block with a 1.91 cm radius cut on one end on another hot plate.

D. Place a 0.025 mm copper foil measuring 50.80 cm long by 15.24 cm wide on top of aluminum plate. Clamp a steel bar measuring 2.54 cm x 0.64 cm x 17.78 cm on the opposite the 1.91 cm radius.

E. Turn on the hot plate to highest setting, then hang weight on the other end of the copper foil. (Two big "C" clamps or one medium bench vice clamped on two 17.78 cm x 2.54 cm x 0.64 cm steel bars will do the job). The weights are to keep the copper foil tight while the soldering is being done.

F. Place the ice target frame with tinned side down on top of copper sheet.

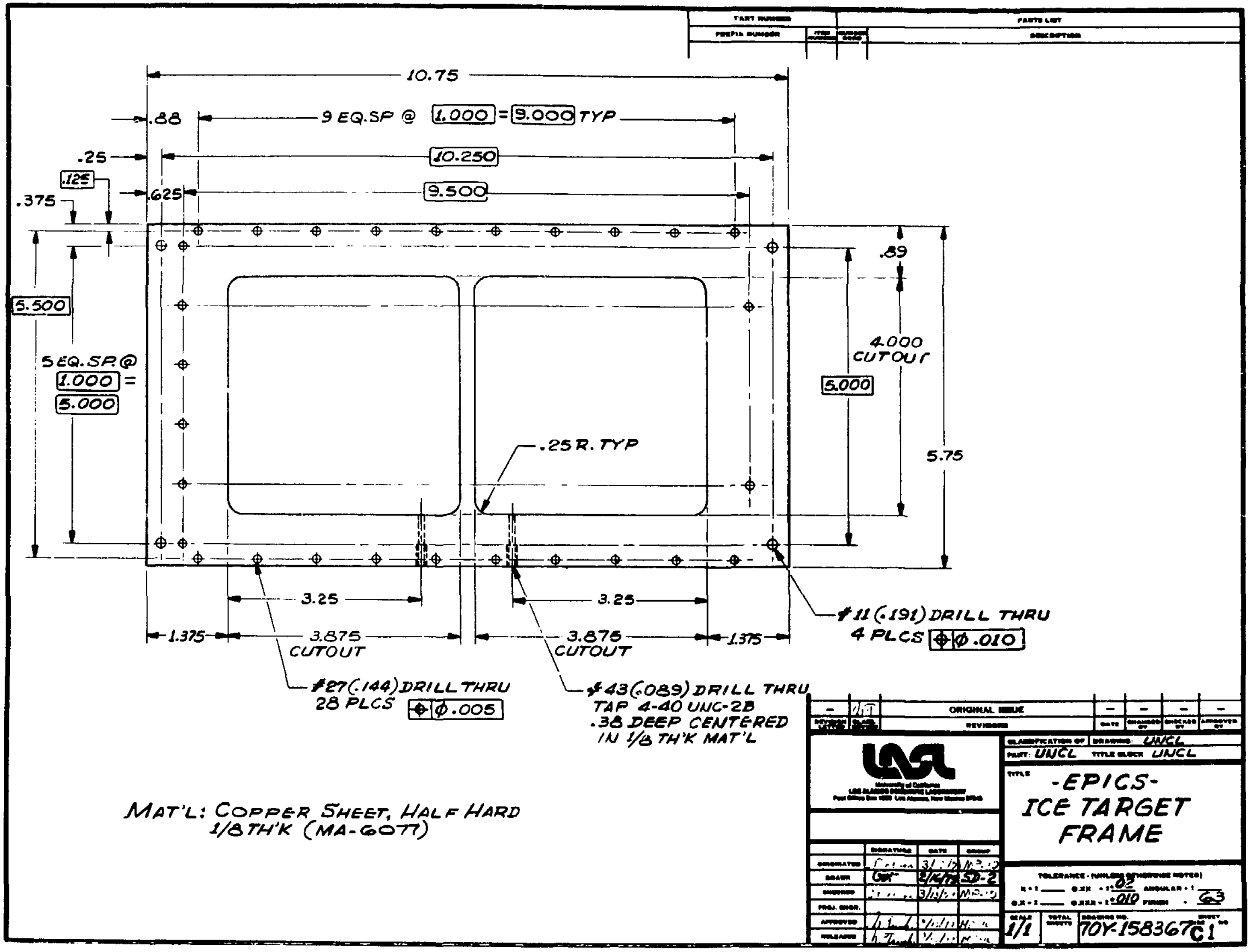

Fig. 1. EPICS Ice Target Frame.

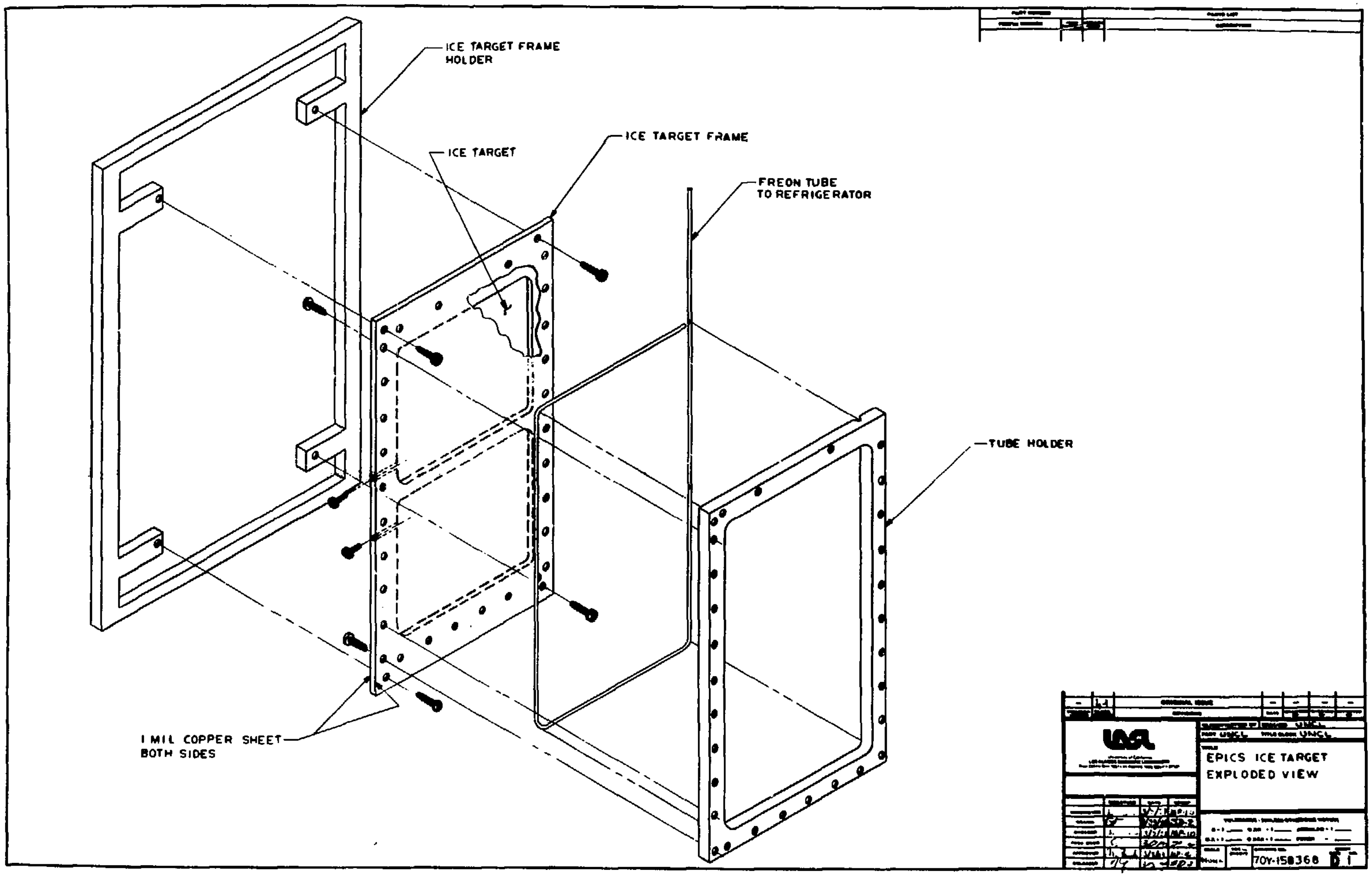

Fig. 2. EPICS Ice Target Exploded View.

(Use pliers as ice target frame will be hot). When the copper sheet and the frame are hot enough, run a bead of solder all the way around between the copper sheet and the frame.

G. Cool to ∿176.7°C to 204.4°C. The face of the frame facing up should be untinned. Wipe well with kimwipe and solder paste. Wet this side well with super speed solder (GS-4162/2P-59) which melts at 157.7°C. Allow everything to cool to room temperature.

Fig. 3: Ice target frame that has had solder melted on opposite side.

H. Take another 0.025 mm copper sheet measuring 50.80 cm x 15.24 cm. After removing ice target frame and trimming excess copper sheet, place a new copper sheet on the aluminum plate as in Steps C, D, and E except set hot plate to 176.7-204.4°C.

I. Heat the ice target frame to about 157.2-176.7°C. Place the ice target frame with the side that does not have a copper sheet face down on a new copper sheet.

J. When the ice target frame heats up enough to melt the super-speed solder, run a bead of super-speed solder all the way around between the ice target frame and the copper foil. Place the hot aluminum plate from the other hot plate on top of the ice target frame. Put lead brick on top of aluminum plate. (This insures that there are no wrinkles on the copper foil). Turn off the hot plates and let the frame return to room temperature.

K. After the ice target frame has cooled down, trim off the excess copper foil and file down to copper. Clear all mounting holes by using a drill.

L. Test frames by filling with distilled water and checking for leaks. Drain distilled water.

M. Fill with 180 proof Ethanol keeping Ethanol in the target for about 12 hours, then drain. Rinse out with distilled water three times.

N. Fill the target with the type of water required for the target. Clamp on the aluminum side plates especially for targets with "C" clamps. (To prepare 1.58-mm thick targets, aluminum plates have 0.894 mm plates epoxied being 6.35 mm smaller than the ice target area, thus making the active ice target area 1.58 mm thick). Screw 40-40 MS into the ice target frame; fill hole after putting three drips of "leak lock" to insure a good seal.

O. Put the ice target frame together with aluminum plates, "C" clamps, etc. in the refrigerator freezer compartment and leave them there overnight or until they are completely frozen.

The construction of a typical ice target frame for EPICS is shown in detail on LASL Drawing 70Y 158367 C1. For Experiment #310, the ice targets will be of 9.52-mm thick material instead of 3.175-mm thick material.

Figure 2 is an isometric blowup of the EPICS ice targets. Figure 4 shows a completed target frame mounted on a phenolic frame that mounts on the EPICS scattering chamber target ladder.

By much experimentation, we have made improvement in the design of the ice targets and the design of holders and cooling frames that keep the ice targets from melting. The old ice target frames were bulky and had valves to fill and drain the ice target chambers. The following photographs show how the present ice target evolved.

The first ice targets were covered with Mylar, which is $C_5H_4O_2$ and because of the carbon or hydrogen were not acceptable. Later 0.125 mm copper foil worked best.

Fig. 4: Finished ice target frame mounted on the phenolic frame that mounts on the EPICS scattering chamber target ladder.

IV. TESTING

Extensive testing was performed on both the refrigerator units and the ice targets themselves. In order to test the refrigerator and various targets, a vacuum chamber was used. A port to transfer the refrigerator tube, as well as a Cromel Alumel thermocouple was used in the chamber. This same port would later be used in the EPICS or HRS scattering chamber. (See Fig. 5, port to chamber).

A brown strip chart recorder was set up by E-1 for our use with a span of -200°C to +200°C. Several Cromel Alumel thermocouples were made for us. A test was made to check the temperature gradient from the center of the ice target to the edges where the coil runs. There was only 5° maximum temperature difference between the thermocouple touching the coil and the center

Fig. 5: Port into chamber. This port takes the refrigerator tube from the refrigerator unit to the ice target frame. It also takes the thermocouple wires from the ice target to the recorder through the vacuum.

of the target as long as the target and refrigerator coil made good contact.

In another test it was found that the temperature of an ice target could be held at -65°C. The temperature of the ice target was the same if the targets were orientated horizontal or vertical.

In another test it was found that insulating with super insulator (aluminized .00064-cm thick Mylar) around the target kept the ice target temperature down to -80°C. (See Fig. 6). In some experiments it was found undesirable to have Mylar between the beam line and the target so a more favorable way to insulate was desirable.

We lined the vacuum chamber with super insulator material by attaching it to the inside vacuum chamber with scotch tape. The temperature again dropped to -80°C. It was determined that an ice target could be kept to -80°C in the EPICS scattering chamber by lining the inside of the chamber with super insulator material. (See Fig. 7).

Alarm System

There are two Mercury switches on the Brown strip chart that can be set to change position at different set points. One of these switches was connected so that if the temperature of the ice target got any warmer than -30°C, it would activate a circuit that would sound an alarm. It could also have been incorporated into the run permit circuit which would not allow beam into the area if the target was not cold enough.

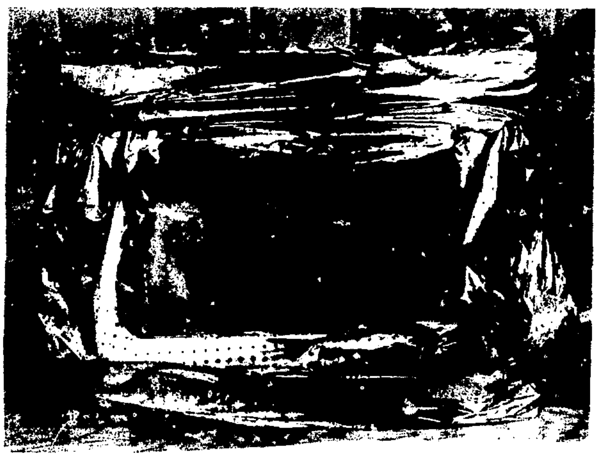

Fig. 6: Super insulation helps keep ice target below -60°C.

Fig. 7: Vacuum chamber lined with super-insulating material.