HIGH CURRENT SALT TARGETS FOR 70-86 MeV PROTON BOMBARDMENT

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Molten salt targets were designed to operate up to 25 μA, using 70-86 MeV protons. Sodium iodide was chosen to produce I-123 and Xe-122. Lithium bromide was chosen for the production of radiokryptons and their daughter radiobromines (Br-75 and Br-77).

The noble radiogases are continually "swept" from the target during bombardment by a flow of xenon or krypton doped helium gas. To efficiently release the Xe and Kr, the targets are operated above the melting point of the salt. These operating conditions require a primary target container to operate in a corrosive molten salt environment at 670° C and a variable cooling method to maintain this temperature with varying beam power.

The targets consist of an upstream carbon collimator, a beam halo and density monitor, the target material primary container, a containment vessel surrounding the target container, water cooling lines, radiogas lines, forced helium cooling lines and a thermocouple in the target material (see Figures 1 and 2).

Primary Target Container

The primary target container is fabricated from Type 347 stainless steel to avoid chromium carbide precipitation at the operating temperature of 670° C. The windows are 0.2 mm (.008") thick Type 347 stainless steel, gold plated, and TIG welded to the body. The gold plating (inside only) is necessary to protect the stainless steel from corrosion by the molten salts. A corrosion lifetime test was conducted. A target container, identical to the "as installed" container, was filled with NaI, placed in an oven at 700° C, evacuated, and periodically helium leak tested. After 71 days (or 1,704 hrs.) there was no corrosion or helium leak observed. This is equivalent to 2.7 years operation with our proposed production schedule.

The NaI target operates at 670° C (the melting point of NaI is 651° C) to facilitate the release of Xe-123. From heat transfer tests, using cartridge heaters in a model target, the following sequence is expected (see Figure 2). As the beam current is increased the NaI will become molten and attain a temperature of 700° C at about 12.5 μA. At point "A", forced helium cooling is initiated to keep the temperature at about 700° C. From the tests, it is predicted that the maximum beam current the heat transfer equipment can accommodate is 20-30 μA. All temperature measurements were made with the thermocouple in a stationary position. Since NaI is such a poor thermal conductor, the temperature measurements of Figure 3 are somewhat arbitrary; a 1 mm movement of the thermocouple in molten NaI resulted in a temperature change from 494° C to 610° C. However, the figure does indicate the significance of forced helium cooling.

The closed loop forced helium cooling system consists of a reservoir and sealed bellows pump. Both the pressure and flow rate of the helium cooling can be adjusted (0-10 PSIG and 0-36 /min).

Containment Vessel

The containment vessel consists of a 10 cm stainless steel beam pipe with edge water cooled, copper clad, Inconel windows at both the beam entrance and exit points. The target is welded into the beam pipe. The 6.35 cm diameter windows are electron beam welded to an annular water channel on the window body. The composition is 0.13 mm Inconel with 0.13 mm copper electroplated onto each surface. The addition of copper increases the energy drop across the window from 0.62 MeV (Inconel only) to 2.03 MeV (composite window) with a 70 MeV beam, an increase of 327%. However, the thermal conductivity of the window is increased from 0.21 W/cm° K (Inconel only) to 2.68 W/cm° K (composite window), an increase of 1100%. This addition of copper to the Inconel window does increase the heat load from 37 W to 122 W at 60 μA. However, the computed maximum window temperature is significantly lower, 300° C for the composite window and 1100° C for bare Inconel (60 μA and 70 MeV protons).

An electron beam welder was employed to simulate beam heating effects on these composite windows (see Figure 4). With a 4 mm diameter electron beam, the copper began to splatter at a power level of 637 W/cm° C. Since it is intended not to allow the proton beam diameter to become smaller than 1 cm, we estimate that these windows could accommodate a heat load of 246 μA of protons at 70 MeV.

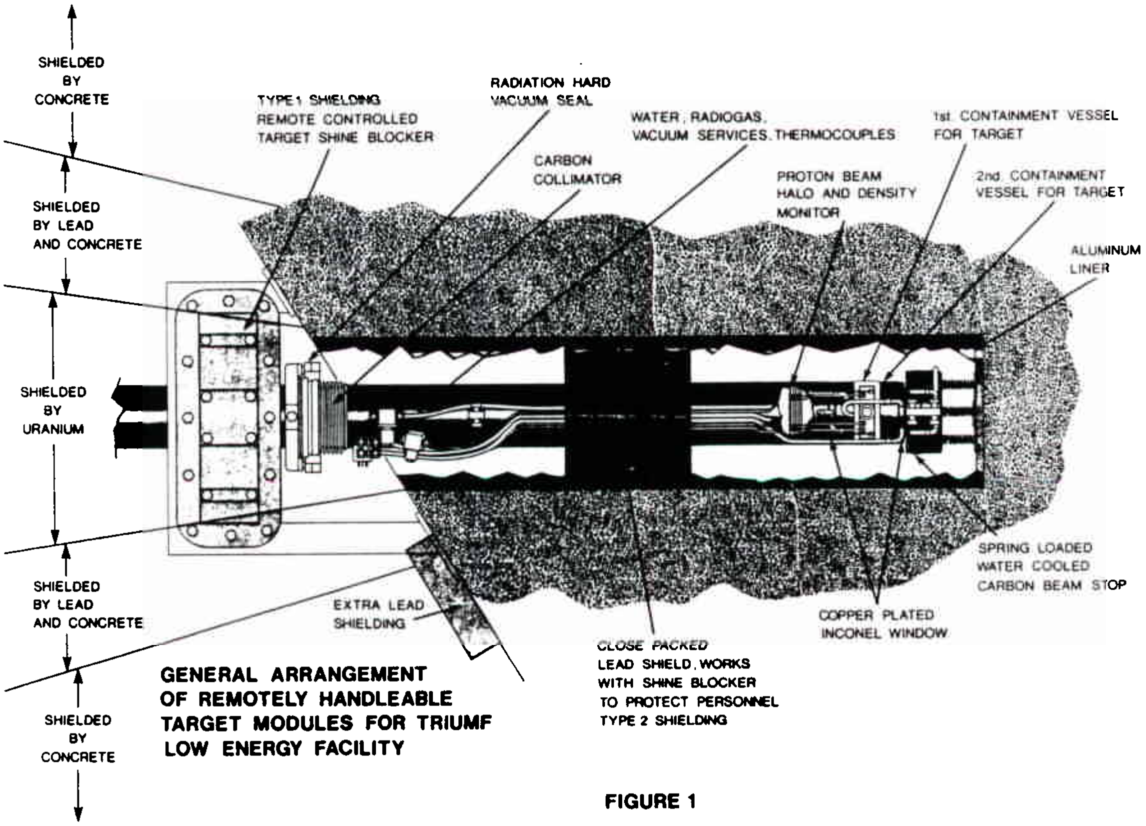
A carbon beam stop was chosen to reduce the residual radiation field. The carbon is cooled by contact with a water cooled copper plate. The results of a heat test are shown in Figure 5.

By choosing the target thickness and energy of the incident proton beam one can minimize the production of undesirable isotopes. As an example for the NaI target an increased purity of the desired Xe-123 product was achieved by bombarding with 71 MeV protons (to minimize Xe-122 production) and choosing the NaI thickness (3.5 gm/cm) such that the exit energy was 50 MeV (to minimize Xe-125 production). If Xe-122 production is chosen, the entrance and exit energies are 82 and 63 MeV.

Figures 6-10 show the calculated time history of xenon, iodine and tellurium isotopes from a NaI target. As yet, these production targets have not been tested with a proton beam.

REFERENCES

1.Lundquist, et al., International Journal of Applied Radiation and Isotopes, v. 30 (1979), pp. 39-43.



GENERAL ARRANGEMENT OF REMOTELY HANDLEABLE TARGET MODULES FOR TRIUMF LOW ENERGY FACILITY

FIGURE 1

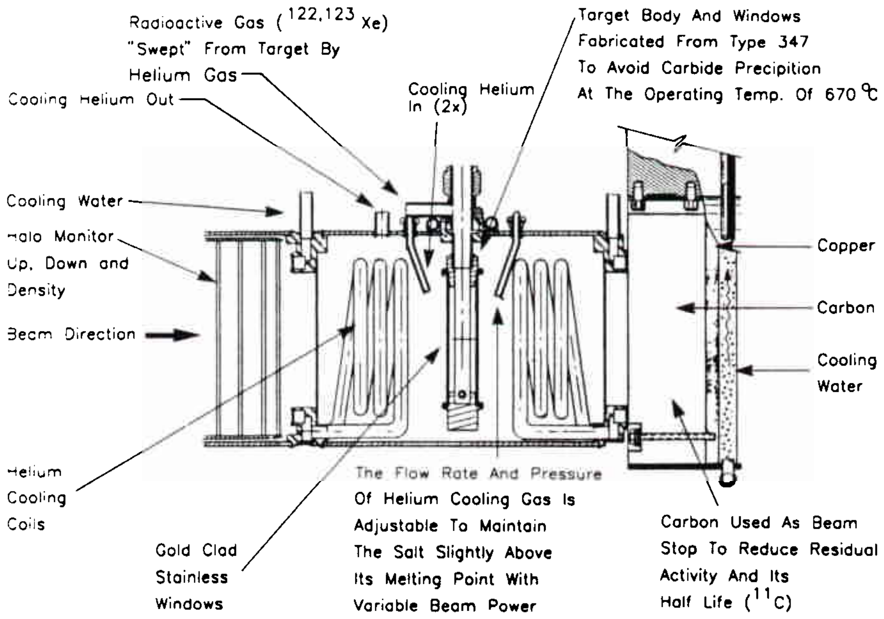


Fig. 2. NaI (or LiBr) Target

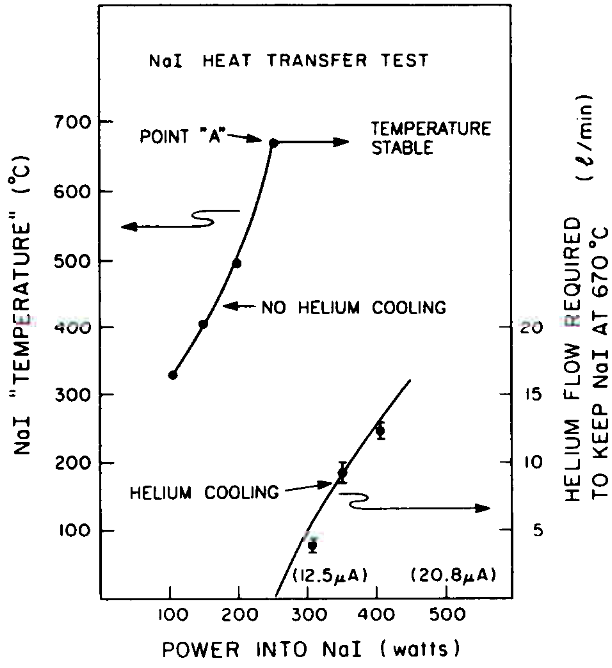


Fig. 3. NaI Target Heat Test (Equivalent Current Points Assume 70 MeV Protons)

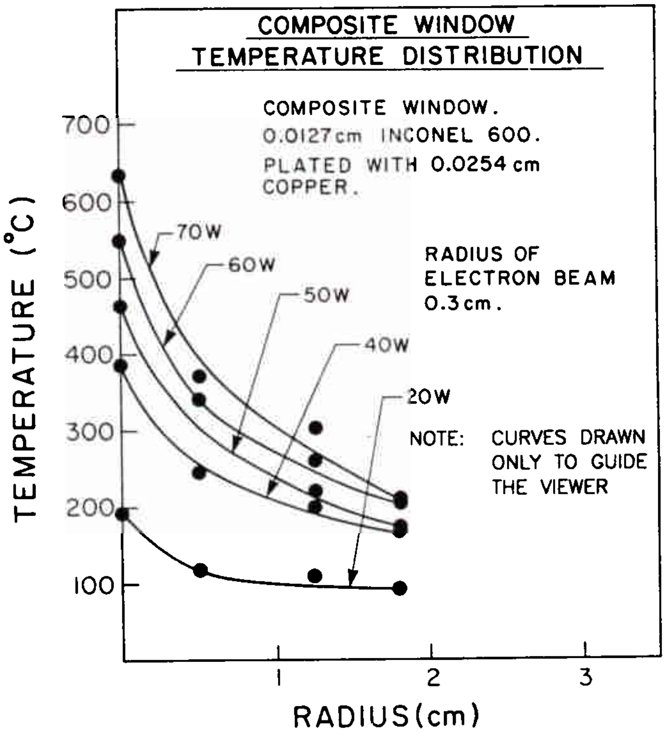


Fig. 4. Composite Window Thermal Test

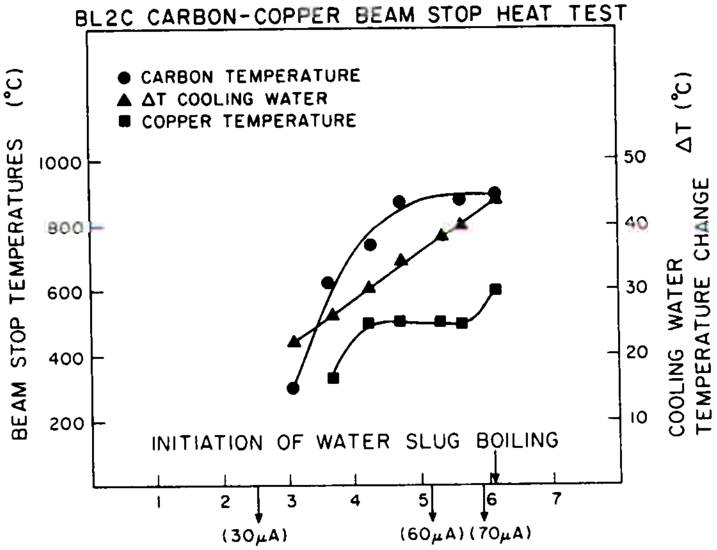


Fig. 5. Power Extracted By Water Cooling (KW) (Refer to Fig. 2 Equivalent Currents Assume 70 MeV Protons)

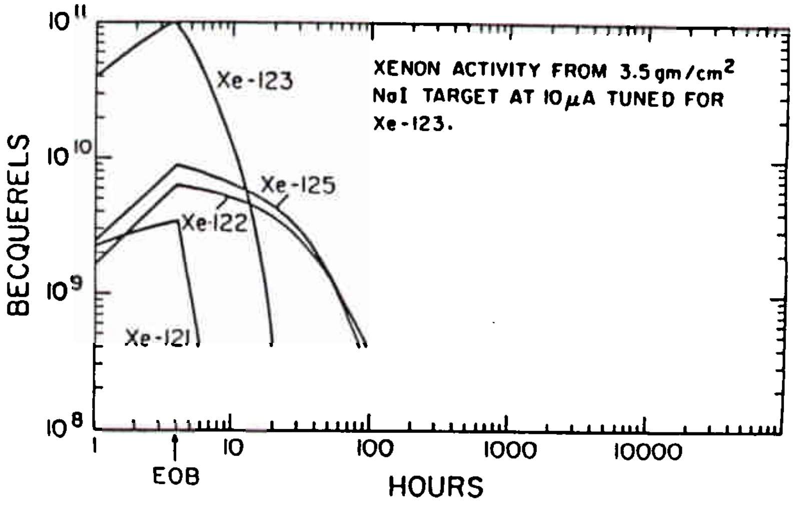


FIGURE 6

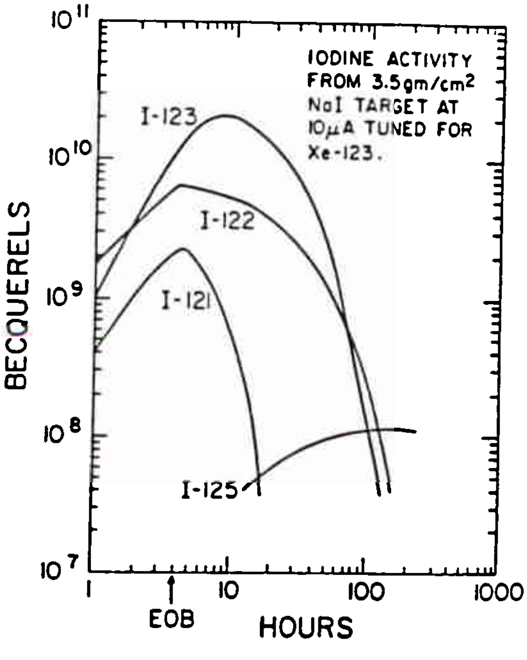


FIGURE 7

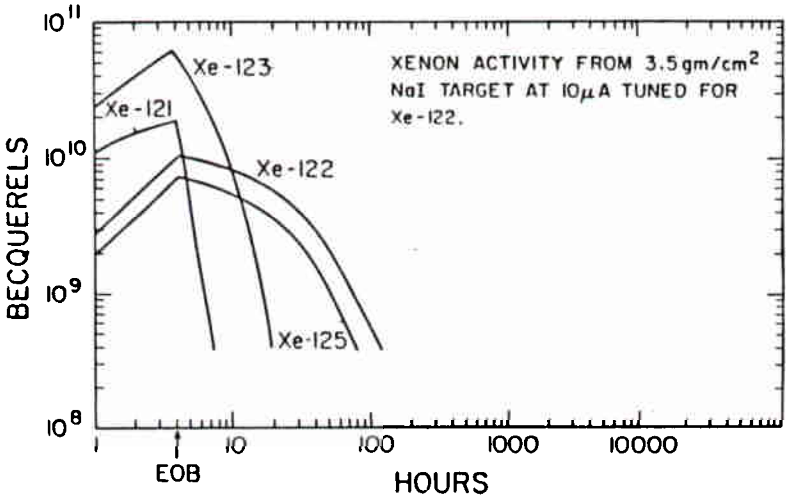


FIGURE 8

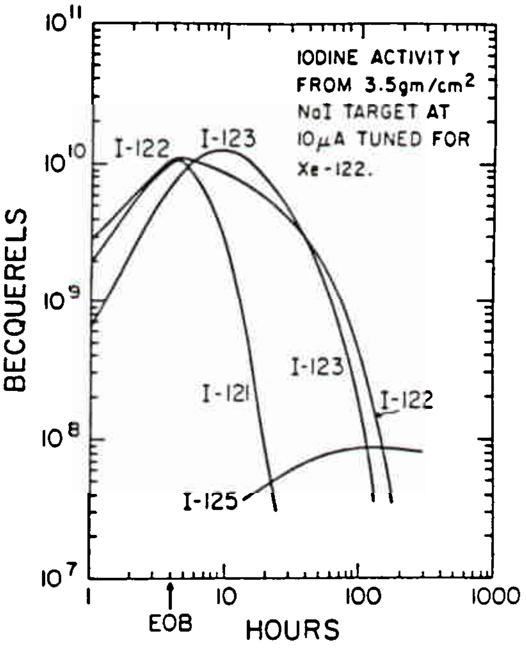


FIGURE 9