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A HIGH-INTENSITY HE-JET PRODUCTION SOURCE FOR RADIOACTIVE BEAMS

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ABSTRACT

The use of a thin-target, He-jet transport system operating with high primary beam intensities is explored as a high-intensity production source for radioactive beams. This method is expected to work well for short-lived, non-volatile species. As such the thin-target, He-jet approach represents a natural complement to the thick-target ISOL method in which such species are not, in general, rapidly released. Highlighted here is a thin-target, He-jet system that is being prepared for a $500^{+}\mu$A, 800-MeV proton demonstration experiment at LAMPF this summer.

1. Introduction

As the community prepares the scientific and technical case for a high-intensity, high-quality, broad-mass-range radioactive beam facility, such as the IsoSpin Laboratory (ISL), one of the most critical questions regards the ability to scale-up the target/ion source system to higher beam intensity. More specifically for the ISL initiative, can the thick-target approach be scaled-up to operate reliably with 100 μA primary beams? And given that many species are not readily released from thick-target matrices, what alternatives are available? These and other questions are being explored by the radioactive beam community (see for example Ref. 1 and 2). Herein we describe an alternative, yet complementary production approach, that of a thin-target, He-jet system and describe our R&D plans to test such a system at high primary beam intensity using the Los Alamos Meson Physics Facility (LAMPF).

2. Key Features of the Thin-Target, He-jet Approach

The thin-target, He-jet approach offers a rapid transport mechanism that enables the target region to be decoupled from the ion source. Based on the attachment of recoiling activities to aerosols suspended in the stopping helium gas, this method is best suited to nonvolatile species which have high attachment probabilities. In fact these high attachment probabilities are what prevents nonvolatile species from rapidly diffusing out of thick target matrices. In this respect the thin- and thick-target approaches are natural complements of one another.

The decoupling of the production target from the source offers several potential advantages to the He-jet method. Given that the target does not have to operate at high voltage and high temperatures as in the thick-target, integrated ion source system, a more robust target is possible. The aim would be to make a target which is capable of lasting several months in the beam. Moreover, since the ion source is removed from the high radiation field of the target, the source does not have to be discarded with each target. This will enable more sophisticated and hands-on optimizable and maintainable sources to be employed.

Questions about the thin-target, He-jet approach are: (1) can competitive production rates (at least for nonvolatile species) be achieved with thin targets given their thickness disadvantage, (2) do the fixed delay time and other losses which occur during He-jet transport pose serious problems, and (3) can ion sources be developed to operate efficiently under the load of helium gas and aerosols introduced by the He-jet? On the latter point there has already been a fair amount of success and several groups are continuing to make improvements (see Ref. 3 and 4). Thus we have tailored our initial investigations to concentrate on the former two points.

Concerning the first issue, that of lower production rates due to target thickness, this problem can be offset to some extent by the use of multiple targets and by operating at higher primary beam intensities. For comparison sake consider a typical ISOLDE thick target system of 200 gm/cm^2 operating at a beam intensity of 2 μA and a multiple, thin-target system of 40 mg/cm^2 operating at 1000 μA. Assuming that both systems have identical efficiencies (an admittedly oversimplified viewpoint), one notes that the thick target has a 5000x advantage in target thickness, but since it operates at only 1/500th of the beam intensity, the overall production rate advantage of the thick target over the thin target is only a factor of 10.

One way in which the thin target can make up this production shortfall is through its different release and transport time properties compared to that of a thick-target system (i.e., relating to the second point mentioned above). In a recent paper[5] we compared a thin target system with equal capillary transport (t_c) and target sweep out (t_s) times to two extremes of a thick-target system, namely for solid and liquid targets having a release time, t_r. Figure 1 shows that for activities with relatively short half-lives the thin target system can achieve a considerable yield advantage over a thick target for the same integrated beam flux - target thickness. For example in the case of a 1 s activity, a He-jet system characterized by $t_c = t_s = 0.5$ s is estimated to give 20x to 600x the yield of a $t_r = 1000$ s, solid or liquid thick target, respectively.

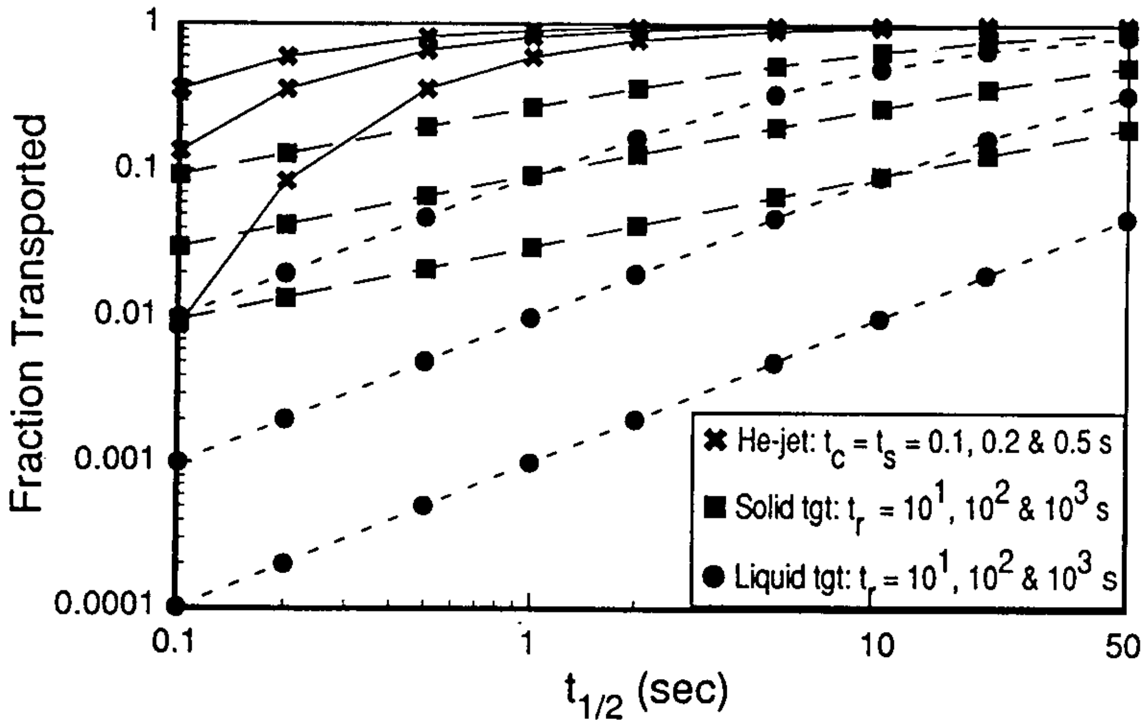

Fig. 1: Fraction of activity transported (released) versus half-life for a thin-target, He-jet system compared to two types (solid and liquid) of thick target, integrated ion source systems (t_c = capillary transit time, t_s = sweep out time of the target chamber, t_r = release time from thick target). Taken from Ref. 5.

Given that such systems are far more complicated than are assumed here, we are preparing to demonstrate and characterize the performance of a thin-target, He-jet system operating at high primary beam intensities.

3. LAMPF Thin-Target, He-jet Demonstration Experiment

A sketch of the He-jet target chamber is shown in Figure 2. The chamber consists of two thin-walled (0.7 mm) stainless steel coaxial tubes which are actively cooled by high-pressure water passing between the inner and outer tubes. The system has been designed to withstand beams up to 1-mA with beam deposition powers of 5 kW. Finite-element stress and temperature calculations indicate that surface temperatures will be kept to below 170°C in order to reduce potential collection losses from gas turbulence. The main production target consists of a thin (15 mg/cm^2) coating of $^{238}U_2O_3$ which has been electroplated onto the inside surface of the inner tube. Provisions for adding additional self-supporting targets have been made. Fission and spallation products which recoil out of the targets are stopped in the surrounding helium gas, attach themselves to aerosols suspended in the helium, swept out of the target chamber, and are entrained in one to seven differentially pumped capillary tubes. The activity is then transported some 30 m, in times on the order of one second, to a moving-tape collection and detection station where the various activities are measured. Gas-flow, smoke studies on a plastic model of the target chamber have been performed to optimize the design.

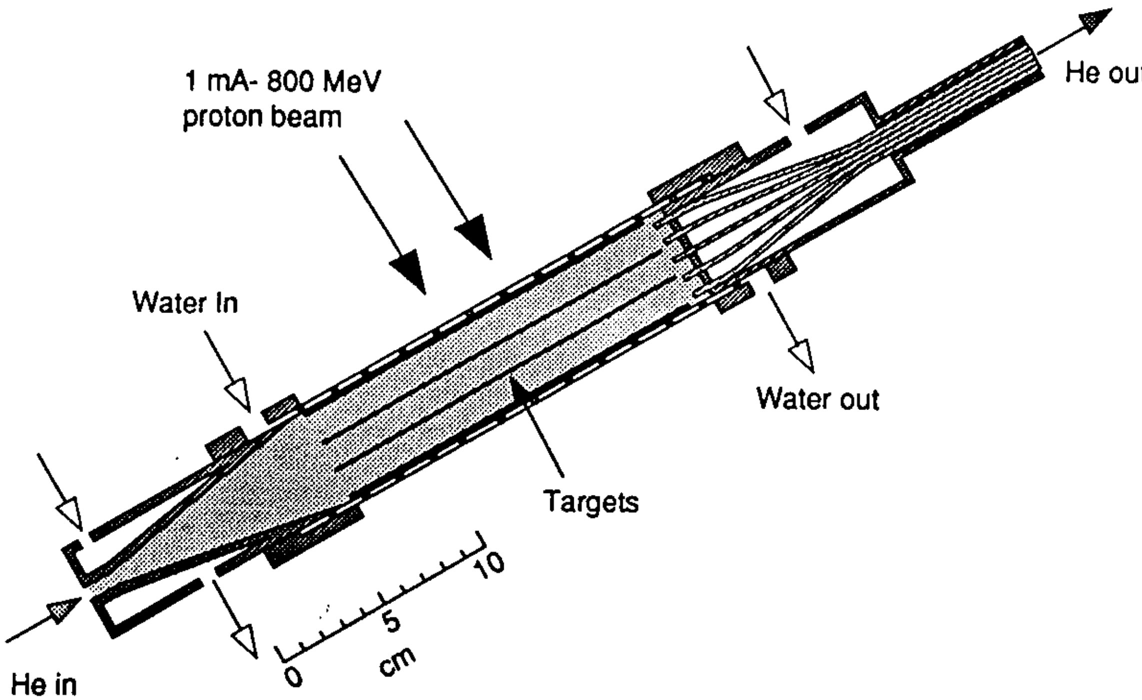

Fig. 2: Sketch of the LAMPF He-jet target chamber.

A gas recirculating system (see Fig. 3) will be used to contain radioactive gas emissions and to facilitate operation at high flow rates. This system which consists of several pumps, purifying filters, cold trap, and an evaporative-type aerosol generator is fully computer controlled. It is designed to operate at target pressures of up to 6 atm. and at flow rates of 1 std. l/s or less.

All components are being assembled or installed at this time. The short- and long-term performance of this system will be tested in the main beam stop of LAMPF during the summer of 1993 with primary beam intensities of 500 μA. In particular, we will explore the dependence of He-jet yields on target pressure, gas flow, aerosol density, transit times, number of capillaries used, number of targets used, beam position, and beam intensity. Altogether as much as 4 Ci of activity are expected to be present in the vicinity of the collection chamber. Radioisotopic yields will be extracted using a combination of on-line and off-line counting techniques.

If successful, such a high-intensity, thin-target, He-jet system would make a powerful and complementary addition to existing radioactive beam production sources.

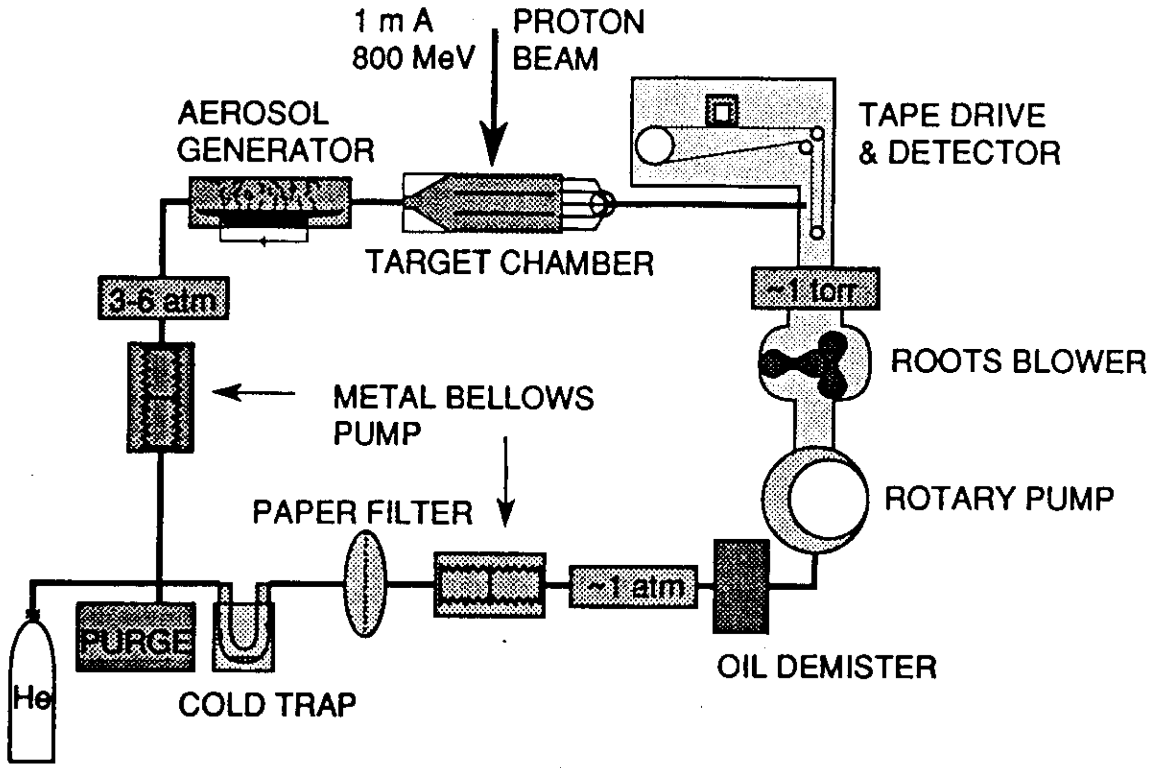

Fig. 3: Schematic of the He-jet gas recirculation system.

4. Acknowledgements

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5. References

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