Concepts for high power targets of thorium and uranium

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In recent years the high power Radioactive Beam community has had a renewed interest in actinides targets that has sparked several research activities around the world. In the USA, despite the FRIB (Facility for Radioactive Ion Beams) project not having, in the DOE approved form, an ISOL station, the studies of high power actinide targets continue to be of high priority for the research community. In Europe, with the EURISOL project among others, also there is a great interest in high power actinide targets. The development of thorium and uranium targets that can withstand beam powers of 100-400 kW is of high interest for the community. Targets with fast release characteristics are also of high interest. Currently there is a project funded by DOE to produce thin plates of uranium and thorium to be used in a tilted or multi-foil target. The primary candidate for this kind of targets is compressed powder with some pore former. Several pore formers are under consideration and the literature for HTGR fuel elements has a number of experiments performed with successful pore formation and structural soundness of thin samples.

The production of rare isotopes using a tilted target is an option being pursued for a few years. The two greatest advantages of this approach are: (a) a short path for the produced rare isotope to reach the plate surface for desorption, and (b) a large area to radiation heat transfer to the enclosure. Using a tilted angle of 6^o it is possible to have the distance from any production point to the nearest surface roughly 20 times smaller than the thickness of the plate seen by the beam particles. The use of porous material facilitates the release of the produced rare isotopes. The porosity of the plate cannot be high because it has to be structurally sound and have good thermal conductivity.

Another option is to have very thin plates, in the sub-millimeter range, stacked as it is done in ISAC and ISOLDE. This approach facilitates diffusion out of the plates but the heat transfer to the enclosure is limited to the surface area of the cylinder. However, this concept would also profit from having thin plates with controlled porosity to stack them in available target enclosures.

Another area of interest is the production of radioisotopes for medical, industrial, and other applications. Actinide targets are seen as a good option for the production of several isotopes of interest. There are proposed configurations to directly irradiate uranium targets with proton beams to harvest ^{99}Mo and other radioisotope of interest [1]. The cooling of the plates becomes an important issue in those systems and new approaches are necessary to produce the isotopes while efficiently removing the heat deposited.

In this area of application active cooling of the plates is possible, in contrast with radioactive beam applications, because the produced isotopes, in most of the cases, should be kept inside the material for post-irradiation processing. Foam products that have a complete structure of interconnected pores with pore volume percentage ranging from 85 to 50% are of interest and commercially available. The large internal surface area of metallic, carbide, or oxide foam material presents an attractive feature for heat transfer and cooling (Fig. 1). The large internal surface area per unit volume for heat transfer makes it possible to extract large amounts of heat without a large increase in temperature of the coolant or target material. The application of the foam fabrication technique to actinide targets is one of the goals of this project of actinide target development.

As an alternative to the foam target structure, a stack of thin foils of sub-millimeter thickness tilted at an angle of about 6^o to the beam direction (Fig.2) can be used. The plates can be actively cooled by forced flow of a liquid or gas through sub-millimeter channels that separate the plates. The same advantage of the one-plate tilted can be accomplished with the added advantage of the active cooling to reach high power levels.

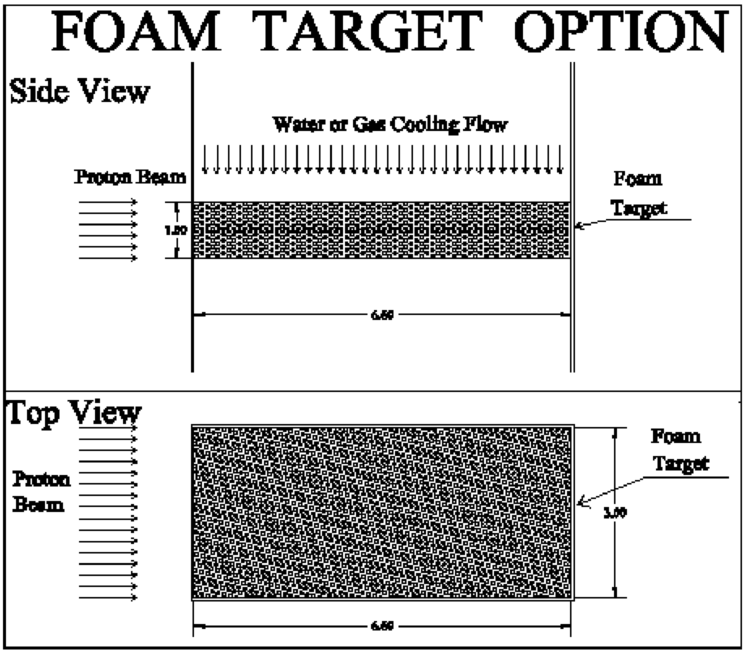

Fig. 1. Schematic representation of the Foam Target model with cooling across the porous media.

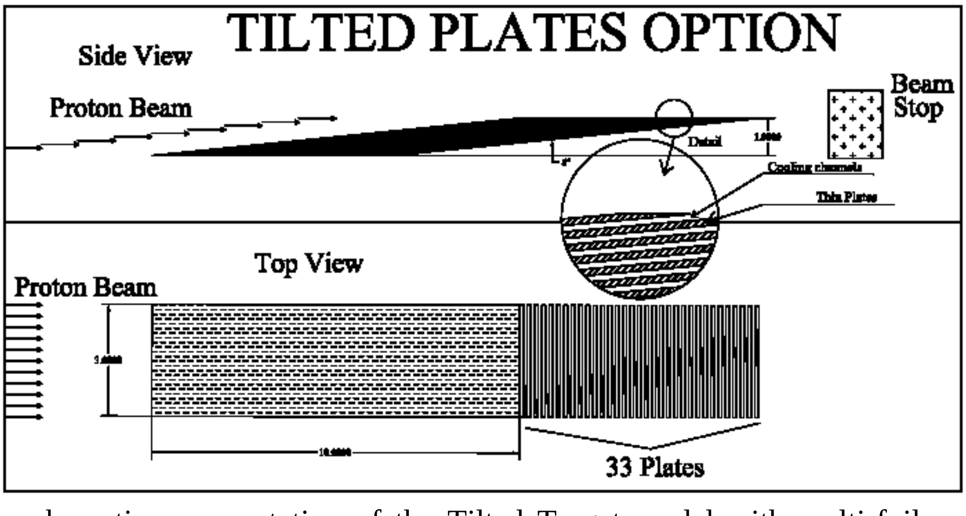

Fig. 2. A schematic representation of the Tilted Target model with multi-foil and cooling channels; the plates are tilted 6^o from the beam direction in this model.

References

[1] Y. Jongen, "A cyclotron driven neutron multiplier for the production of ^{99}Mo," at the 37th European Cyclotron Progress Meeting, Groningen, The Netherlands, October 29, 2009.

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