[^{18}O]Water Target Design for Production of [^{18}F]Fluoride at High Irradiation Currents

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Abstract

The current standard for [^{18}F]fluoride production is proton irradiation on a [^{18}O]water target. Heat removal is the main obstacle to achieve a higher production. The 16.5 MeV proton cyclotron at Risø has a maximum [^{18}F]fluoride production rate at an irradiation current of 55 μA. The aim of this target design is to irradiate at a proton current not below 100 μA while maintaining a [^{18}O]water volume close to 5 mL and a yield better than 80% compared with theoretical. The theoretical yield is calculated by cross section data [1] and using SRIM [2] H_2O stopping power calculation. At 55 μA the production yields 84% $\pm$ 4% of theoretical yield. This corresponds to an average of 140 GBq [^{18}F]fluoride for 1 hour of irradiation. A higher intensity beam will further reduce the efficiency of the [^{18}F]fluoride production. Still much remains in understanding the physics inside the currently used water target. However it is claimed that current water targets operating at maximum yield contain saturated steam vapor phase region(s) which are not constant in volume over time [3]. We propose a new target design which is a deep narrow cylindrical/cone shaped silver[i] target, see figure 1. The target has a depth of over 80 mm and width of about 10 mm near the target front. The width decreases as the target deepens. Its chosen shape is based on our model, which simulate the extent of the claimed steam/water matrix. This target is designed to operate at 30 bar of helium pressure and it is cooled by water at the sides and back and not by helium at the front. Introducting fins inside the target cavity will increase the [^{18}O]water-target wall surface and the heat transfer over this boundary is assumed to be the limiting factor in transfering heat from the [^{18}O]target water. Possible nucleate boiling heat transfer by conduction via convection may increase the heat conduction of up by a factor 10^2.

References

[1] E. Hess, S. Takacs, B. Scholten, F. Tarkanyi, H. H. Coenen, and S. M. Qiam. Excitation Function of the [O-18](p,n)[F-18] Nuclear Reaction from Threshold up to 30 MeV. *Radiochim. Acta 89, 357*, 2001.

[2] SRIM The Stopping and Range of Ions in Matter. Homepage: http://www.srim.org. World Wide Web.

[3] J. Michael Doster. New Cyclotron Targetry to Enhance F-18 Clinical Positron Emission Tomography. Homepage: http://www.osti.gov/bridge/servlets/purl/945375-HKLadR/945375.pdf. World Wide Web.

[i] Silver is chosen as target chamber material during this stage og modelling and prototype development, because of the good mechanical and thermal characteristics, its reasonable low price and universal availability. Once cavity design is optimized other target chamber materials will be used, i.e. noble metal plated silver.

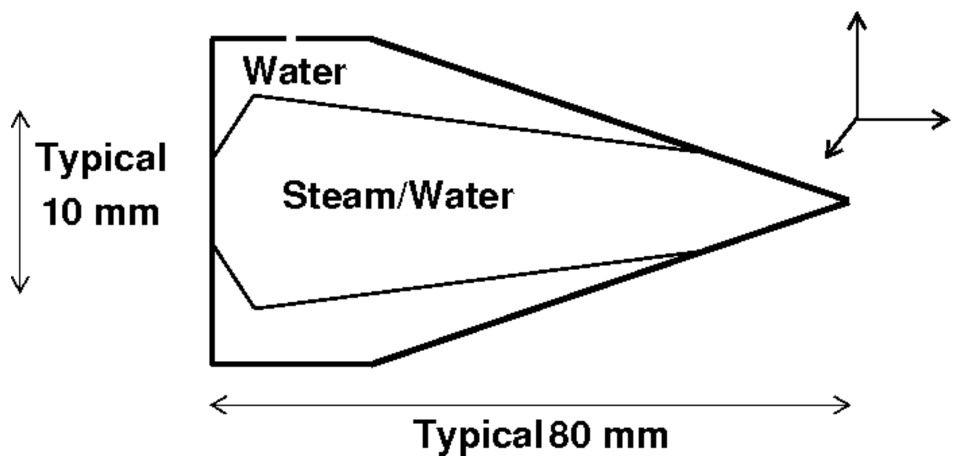

Figure 1: The target cavity of the [^{18}O]water target design is illustrated in the figure. The typical dimension of the target is 80 mm deep and 10 mm wide. A schematic extent of an assumed steam/water matrix (Steam/Water) is also shown. In the rest of the cavity is water.