High Beam Current ^{18}F-Fluoride Production and Fluoride Quality

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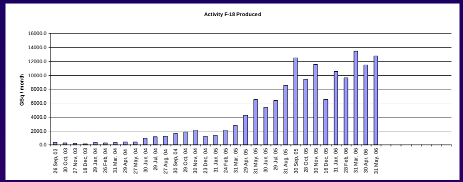
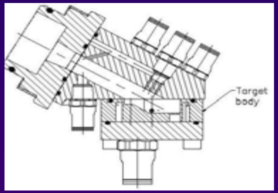
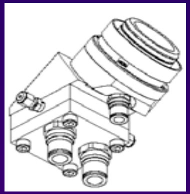
^{18}F Production

The cyclotron at the Edmonton PET Centre (EPC) is a TR19/9 from Advanced Cyclotron systems capable of producing 19 MeV protons and 9 MeV deuterons.

The EPC currently supplies FDG to hospitals as far away as 1300 km. Total shipping times of up to 5.5 hours have necessitated a very large production of FDG on site to offset decay losses.







The TR19/9 has two target stations and dual extraction capabilities. The new high current, low pressure niobium water targets introduced by ACS in 2004 have lead to a dramatic increase in ^{18}F production capabilities. An ^{18}F production yield of 15 Ci (555 GBq) in 1 hour was demonstrated on the niobium water targets when the beam was split and two targets were simultaneously irradiated.

1. Beam Characteristics

We observed that the ^{18}F production yield from the two target sides differed. In order to visualize the beam, a simple target was made up which consisted of a 2 mm thick quartz window mounted on a hollow 50 mm spacer and connected to a standard target nose piece which mounted onto the target port. A 0.025 mm aluminum foil was used as a vacuum foil between the nose piece and the spacer. Interaction of very low (3 uA) beam currents on the quartz window were observed by viewing a reflected image with a shielded USB camera.

It was observed that the beam shape on side 2 was much tighter than on side 1. Pictures of high current beam burn marks on the targets confirmed that the profile observed on the quartz window was maintained for much higher beam currents.

Side 2 Target

Side 1 Target

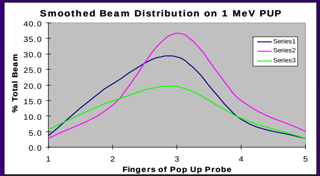
2. Target Preparation

High current production of ^{18}F has led to problems with the chemical synthesis of FDG. Chromatographic analysis of the ^{18}F produced showed only ionic fluoride however we have observed instances where there is a complete failure of ^{18}F to bind to a QMA resin cartridge. The lower and variable yields of FDG from ^{18}F produced with high beam intensity and longer duration of irradiation have been an ongoing challenge. Steps taken to improve ^{18}F reactivity are as follows:

- The niobium target was cleaned with Scotch-brite and then treated only with ethanol and water prior to foil replacement.
- Beam currents were reduced to a level that no burn mark was observed on the target body (75 mA).
- All o-rings were changed from EPDM to Viton and PEEK fittings and lines were changed to stainless steel.
- The irradiated water was passed through weak cation exchange resin prior to fluoride extraction
- The target was washed thoroughly with distilled water prior to each ^{18}F production run.
- Only target washing showed any effect to maintain moderate reactivity when target irradiations of 75 mA for 2 hours (9000 mA min) were performed.
- It was suspected that the prolonged intense irradiation of the Havar foil was the source of the problem.

3. Beam Shape

		PUP Fingers					
Rf (kV)	Inflector (Amp)	1 (uA)	2 (uA)	3 (uA)	4 (uA)	5 (uA)	% beam transmission
52.0	7.28	2.8	13.6	36.7	15.0	5.1	11.5%
50.0	7.28	3.8	20.4	29.1	9.0	2.8	10.2%
50.0	7.18	5.6	14.8	19.5	9.3	2.8	8.2%



Observations

- The TR 19/9 has a 5 fingered electronic probe which can be automatically inserted near the center of the magnet (1 MeV).
- A series of beam profile studies showed that the optimized beam had a very focused center region.
- It was possible to detune the beam to broaden the profile and to dissipate the heat on the foil.
- Beam transmission dropped from 11.5 % to 8.2 % on target however we have an surplus of beam generated in the ion source.
- The use of a slightly detuned beam led to an immediate and pronounced increase in FDG production yields.

Foils or Future Directions

Target designs which functioned adequately at low beam currents and were governed by a pressure threshold are being pushed to the limit now that pressure is no longer a constraint. New foil materials are being investigated which combine the strength found in traditional materials with the non reactivity of selected metal coatings (see related poster).

Acknowledgements

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