Performance of IBA new Conical shaped Niobium [^{18}O] water Targets

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Introduction

Because of an ever increasing demand for Fluoride-18 (^{18}F$^-$), efforts are made to increase the performance of the ^{18}F-target systems. Moreover, given the particularly high cost of ^{18}O enriched water, only a small volume of this target material, at the very most a few milliliters, is desired.

NEW ^{18}F- Conical Target

When designing this new conical shaped Niobium insert#, the objectives were multiple:

- reduce the enriched water volume;
- improve the cooling of this insert;
- increase the produced activity;
- reduce and improve auxiliary parts.

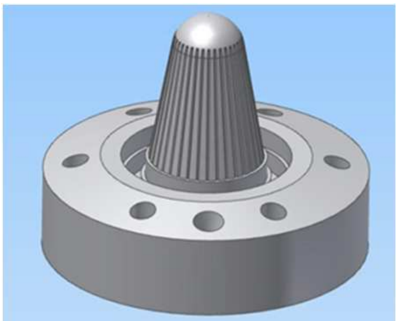


Figure 1: new conical shaped Niobium insert #

The cooling has been improved thanks to the drilled channels on the outside of the insert chamber. Another deep channel has been foreseen to be able to cool the beam strike area next to the target window (Figure 3, green circle).

Maintenance has been simplified with less pieces and o-rings. The insertion of the flow lines is now done directly inside the Niobium (Figure 3, blue circle). This solution improves the purity of the 18F-Fluoride, because there is no contact between the product and small o-rings as it was the case with the old cylindrical design (Figure 2, red circle). The maintenance interval is expected to be longer.

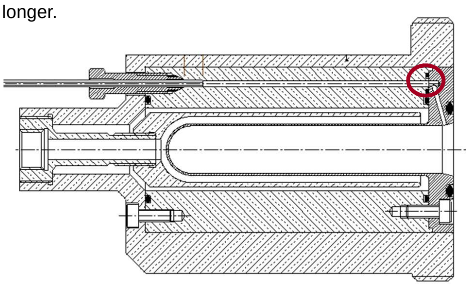


Figure 2: old cylindrical design

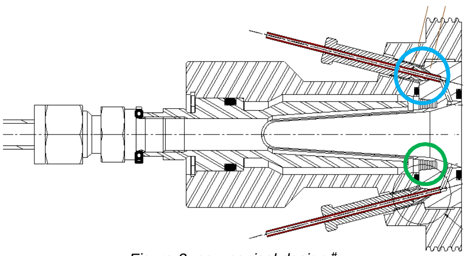


Figure 3: new conical design #

Another benefit of this conical shape is that it sends the [^{18}O]-water back to the beam strike area, and when emptying the target at the end of the shot, the water flows naturally to the transfer line making the remaining activity inside the target as low as possible.
In operation, 35 µm Havar® target window are used instead of 50 µm, reducing the power loss in the window and cooling needs.

Tests and results

Four conical shaped targets with different target chamber sizes (Conical 6 – 2.4 ml; Conical 8 – 3.4 ml; Conical 12 – 5 ml; Conical 16 – 7 ml) were tested using IBA Cyclone® 18 MeV cyclotrons.

The insert volumes of the new Conical targets are identical to the cylindrical insert volumes: LV – Conical 6; XL – Conical 8; 2XL – Conical 12; 3XL – Conical 16.

The targets were filled with different volumes of enriched ^{18}O water (enrichment >92%) and irradiated with 18 MeV protons on target with beam currents up to 145 µA for 30–150 minutes.

Pressure curves were completed.

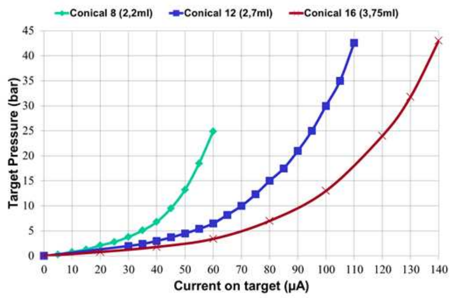


Figure 4: target pressure curves for given filling volumes

Even though the new target body is made of Niobium and a Havar® window (35 µm) is used, the radionuclidic impurities were determined in the ^{18}F-solution.

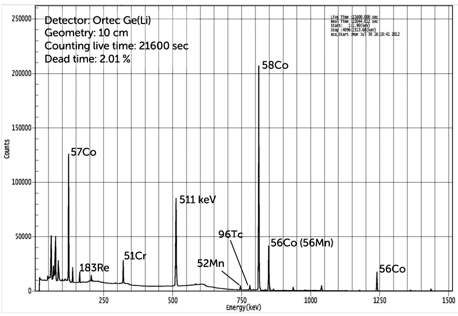


Figure 5: radionuclidic impurities in ^{18}F-solution (Conical 8)

Amount in kBq @ EOB				
Radionuclidic impurities	MEX-AMS-001	MEX-AMS-002	MEX-AMS-003	MEX-AMS-005
Cr-51	5	6	11	13
Mn-52	23	3	14	2
Co-56	7	8	18	7
Co-57	3	3	7	3
Ni-57	32	4	7	ND
Co-58	34	36	80	34
Tc-96	1	1	1	3
Re-183	ND	ND	ND	1
F-18	258 GBq	264 GBq	314 GBq	276 GBq

Table 1: radionuclidic impurities (beam time 2h, current 65 µA)

The tests aimed to find an optimal filling volume, allowing:
- Minimal use of enriched water;
- Keeping good Fluoride-18 saturation activity yields;
- Maximizing activity output.

	Conical 6	Conical 8	Conical 12	Conical 16
Insert volume	2.4 ml	3.4 ml	5 ml	7 ml
Filling volume	1.8 ml	2.3 ml	2.7 ml	4.2 ml
Max current**	45 µA	65 µA	100 µA	130 µA
Average yield @ sat	230 mCi/µA 8.5 GBq/µA	224 mCi/µA 8.3 GBq/µA	228 mCi/µA 8.4 GBq/µA	235 mCi/µA 8,7 GBq/µA
Activity output (2h)	5.5 Ci 203 GBq	7.7 Ci 285 GBq	12.1 Ci 448 GBq	16.2 Ci 599 GBq
Target pressure	40 bar	30 bar	30 bar	30 bar

Table 2: result summary

Conclusions

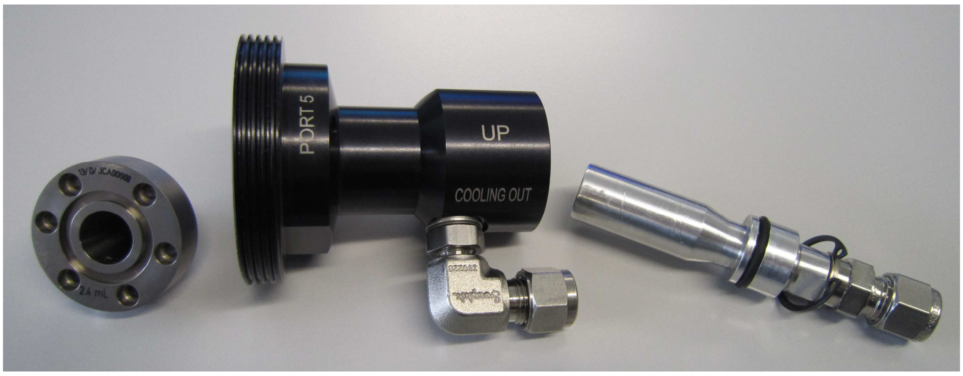
With this new range of 18F- conical targets, we observe a switch in the performance compared to cylindrical ones with lower water consumption and higher activity output.

The global activity output per ml enriched water has increased: from 2.8 Ci/ml to respectively 3 and 3.5 Ci/ml for the smallest targets (Conical 6 and Conical 8); and from 3 Ci/ml (111 GBq/ml) to over 4 Ci/ml (148 GBq/ml) for the biggest targets (Conical 12 and Conical 16.)

Conical 6 and Conical 8 inserts will be slightly redesigned to increase the insert volume to achieve the targeted output activities (respectively 6 Ci and 8 Ci).

Nirta Cylindrical	LV		XL		2XL		3XL	
	1.8ml 5Ci		2.5ml 7Ci		3ml 9Ci		4ml 13Ci	
Nirta Conical		Conical 6		Conical 8		Conical 12		Conical 16
		1.8ml 5.5Ci		2.3ml 7.7Ci		2.7ml 12Ci		4.2ml 16Ci

Table 3: cylindrical versus conical performances



New conical design #: Niobium insert, target body, one piece water diffuser

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