Abstract 047

Three years experience in operation and maintenance of the [^{18}F]F_2 proton target at the Rossendorf Cyclone® 18/9 cyclotron

St. Preusche, F. Fuechtner, J. Steinbach
Forschungszentrum Dresden-Rossendorf, Institute of Radiopharmacy, P.O. Box 51 01 19, 01314 Dresden, Germany

Introduction

An increasing demand of radiopharmaceuticals based on electrophilic reaction with [^{18}F]F_2 gas (for instance [^{18}F]FDOPA) led to an upgrade of the IBA [^{18}F]F_2 gas target system in summer 2007. The more than 10 years operated [^{18}F]F_2 deuteron target [^{20}Ne(p,α)^{18}F] was not able to meet the increasing requirements in terms of activity anymore and was thus replaced by an IBA [^{18}F]F_2 proton gas target [^{18}O(p,n)^{18}F] based on the so-called "double-shot" 'irradiation method by R.J. Nickles [1]. The upgrade itself was done by IBA.
We run the Cyclone® 18/9 cyclotron in routine operation for more than 14 years. One of the specific features of the Rossendorf PET Center is the Radionuclide transport system (RATS) [2], 500 m in length that bridges the distance from the cyclotron to the radiopharmaceutical laboratories. The activity at the end of bombardment (EOB) is calculated taking in account the transfer time and experimental data of activity losses (about 30%) in the transfer tube [2].

The target and its supply

The [^{18}F]F_2 proton gas target is connected directly to the vacuum chamber of the cyclotron inside the return yoke. Target body: aluminium; target volume: 35 cm^3 of conical shape; target window: aluminium, thickness 500 µm; vacuum window: titanium, thickness 12.5 µm.
As target gases are used for the first bombardment: ^{18}O (enrichment: > 97%; cartridge volume: 75 ml, gas volume: 5250 ml, pressure: 70 bar, manufacturer: Cambridge Isotopes Laboratories, Inc./USA, distributor: ABX/Germany) and for the second bombardment: (Ne/2% F_2), filled up with pure Ne (both: Air Liquide/Germany) to achieve (N_2/0.45% F_2).

Experience in operation and maintenance of the target

First bombardment: $^{18}O_2$: 20 - 22 bar, 40 or 60 or 80 minutes at 22 µA target current
Second bombardment: Ne/F_2: 20 - 22 bar, 15 minutes in each case at 22 µA

Hints for operation:

- Keep the target cavity in standby always under (Ne/F_2) atmosphere
- Prior to the first bombardment of the [^{18}F]F_2 production a pre-irradiation (5 minutes, 10 µA) with (Ne/F_2) and transfer of the irradiated gas to the radiopharmaceutical laboratory for the conditioning of the target cavity and the transfer tube is useful.
- After deposition of the irradiated ^{18}O gas into the liquid nitrogen cooled trap: A careful pump down of the target cavity for some minutes is mandatory before filling it for the second bombardment to prevent the formation of [^{18}F]F – O species.
- One ^{18}O cartridge is sufficient for (100 – 120) irradiations. An average gas loss of less than 5% per bombardment has to be compensated by filling from the ^{18}O cartridge. It is possible to use the ^{18}O gas (from the cooling trap and the cartridge) until the residual pressure of the ^{18}O cartridge is around 10 bars.

A slight but permanent drop in the target yield is an indication for a target cleaning procedure to be necessary (see Fig. 1).
After target opening it is observed that the surface of the target cavity did not have a metallic sheen anymore. We added a grinding procedure of the cavity with very fine sand paper to the IBA cleaning procedure [3]. After the cleaning the surface of the cavity should look as metallic. We found this procedure necessary to be done after 100 to 120 runs and perform it once a year.
The handling of the target system is not easy because the results of any kind of changes are often not well reproducible. The highly-reactive [^{18}F]F_2 gas at the µmol level is difficult to handle due to the large surfaces of the target cavity, the transfer tube and the synthesis module.

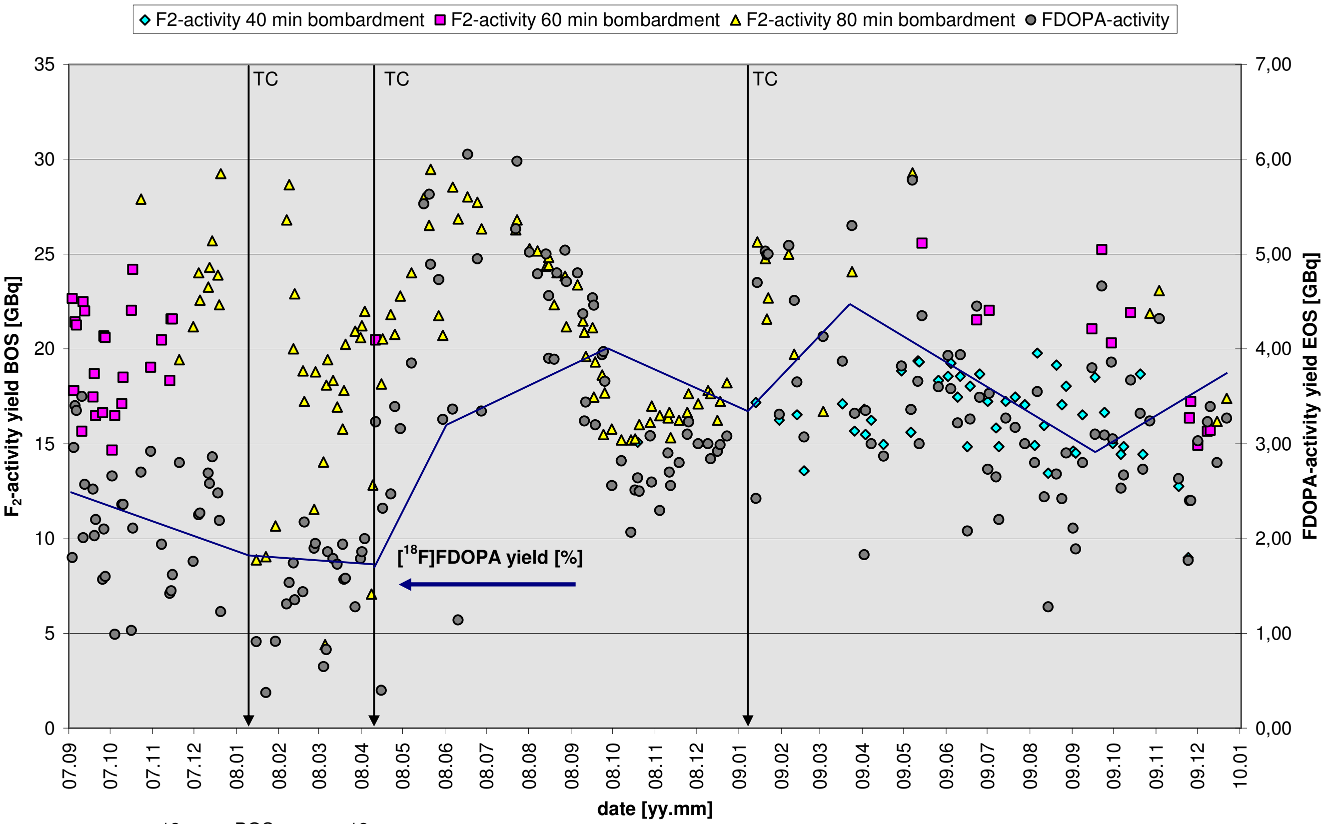

Fig. 1: $[^{18}F]F_2^{BOS}$ and $[^{18}F]$FDOPA activity yields in 2007 – 2009,
TC: target cleaning, line: $[^{18}F]$FDOPA yield

Results

- Dependence of produced $[^{18}F]F_2^{BOS}$ activity on the irradiation time of first bombardment: 40 minutes - 16 ± 2 GBq, 60 minutes - 20 ± 3 GBq, 80 minutes - 20 ± 5 GBq ➔ no increase of $[^{18}F]F_2^{BOS}$ activity increasing the irradiation time of first bombardment from 60 to 80 minutes,
- Besides the produced absolute $[^{18}F]F_2$ activity, the reactivity of the F_2 gas is important for the $[^{18}F]$FDOPA activity yields.
- Target cleaning is recommended if:
  - The absolute $[^{18}F]F_2^{BOS}$ activity yield drops down to about 15 GBq or
  - The $[^{18}F]$FDOPA yield is near or below 15 %.

The advantages of the new $[^{18}F]F_2$ proton target are:

- Higher efficiency in terms of $[^{18}F]F_2$ activity and resulting $[^{18}F]$FDOPA activity yields,
- Operating conditions far from limitations of the target current; that results in less wear of the cyclotron.

A comparison of the $[^{18}F]F_2$ deuteron and proton targets is given in the table.

	Deuteron target	Proton target
Max. target current	18 µA	30 µA
Irradiating conditions time average /common current	120 min 18 µA	First bombardment: 60 min Second bombardment: 15 min 22 µA
A^{EOB}, GBq	7 - 11	34 ± 5

References

[1] R.J. Nickles, M.E. Daube, T.J. Ruth; An $^{18}O_2$ target for the production of $[^{18}F]F_2$ Int. J. Appl. Radiat. Isot. 35 (1984) 117-122

[2] St. Preusche, F. Füchtner, J. Steinbach, J. Zessin, H. Krug, W. Neumann; Long-distance transport of radionuclides between PET cyclotron and PET radiochemistry, The Journal Applied Radiation & Isotopes 51 (1999) 625-630

[3] IBA, $[^{18}F]F_2$ proton target, maintenance procedure, 2007