An Automatic Focalization System for Enhanced Radioisotope Production with Solid Targets

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Abstract

A research program aimed at the production of novel radioisotopes for theranostics is ongoing at the 18 MeV cyclotron laboratory in operation at the Bern University Hospital (Inselspital). A method based on the bombardment of isotope enriched materials in form of compressed 6 mm diameter pellets was specifically developed. To accomplish this challenging scientific goal a new automatic compact focalization system was conceived and constructed to optimize the irradiation procedure.

Introduction

The University of Bern is equipped with an IBA 18/18 HC medical cyclotron for both routine production of radiopharmaceuticals and scientific research (Fig. 1).

Fig. 1 The Bern medical cyclotron

The production of novel radioisotopes for theranostics, in particular, is carried out using solid targets in form of 6 mm diameter pellets. The beam has to be focused and kept fixed on the pellet during the whole irradiation.

To achieve a reliable and optimized production, a new Automatic Focalization System (AFS) has been developed and installed at the Bern medical cyclotron [1]. AFS operating principle as well as preliminary tests are presented in this work.

Materials

We perform the production of new radioisotopes for theranostics by irradiating solid targets contained in a specifically designed target coin made of two Al halves held together by permanent magnets (Fig. 2). The overall thickness of the coin is 2 mm.

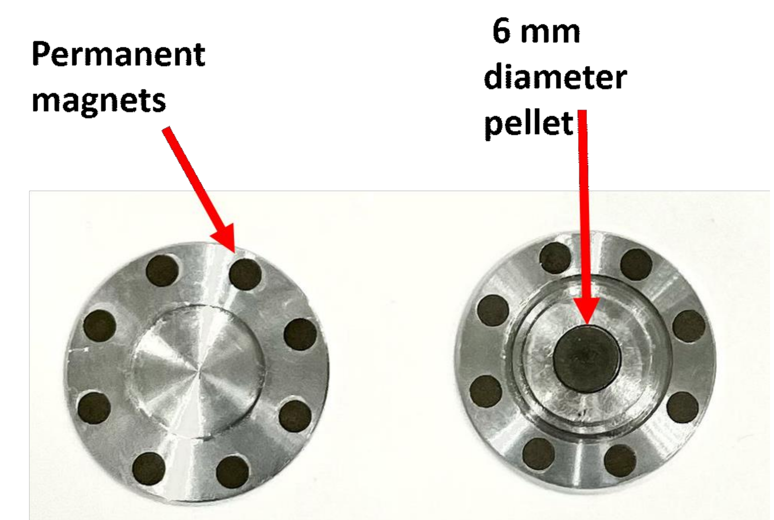

Fig. 2 Target coin with permanent magnets and the 6 mm diameter pellet indicated by arrows.

The AFS comprises of three main components: a Mini-PET Beamline (MBL), a UniBEaM detector and a feedback control system. The MBL is a 50 cm long structure with two quadrupole and two steerer magnets produced by the company D-Pace. The UniBEaM is a two-dimensional beam profiler based on scintillation optical fibers, developed by our group [2]. The feedback control system adjusts the MBL currents on the basis of the beam profiles measured by the UniBEaM detector. The AFS has been installed on the outport of the cyclotron dedicated to the irradiation of solid targets (Fig. 3).

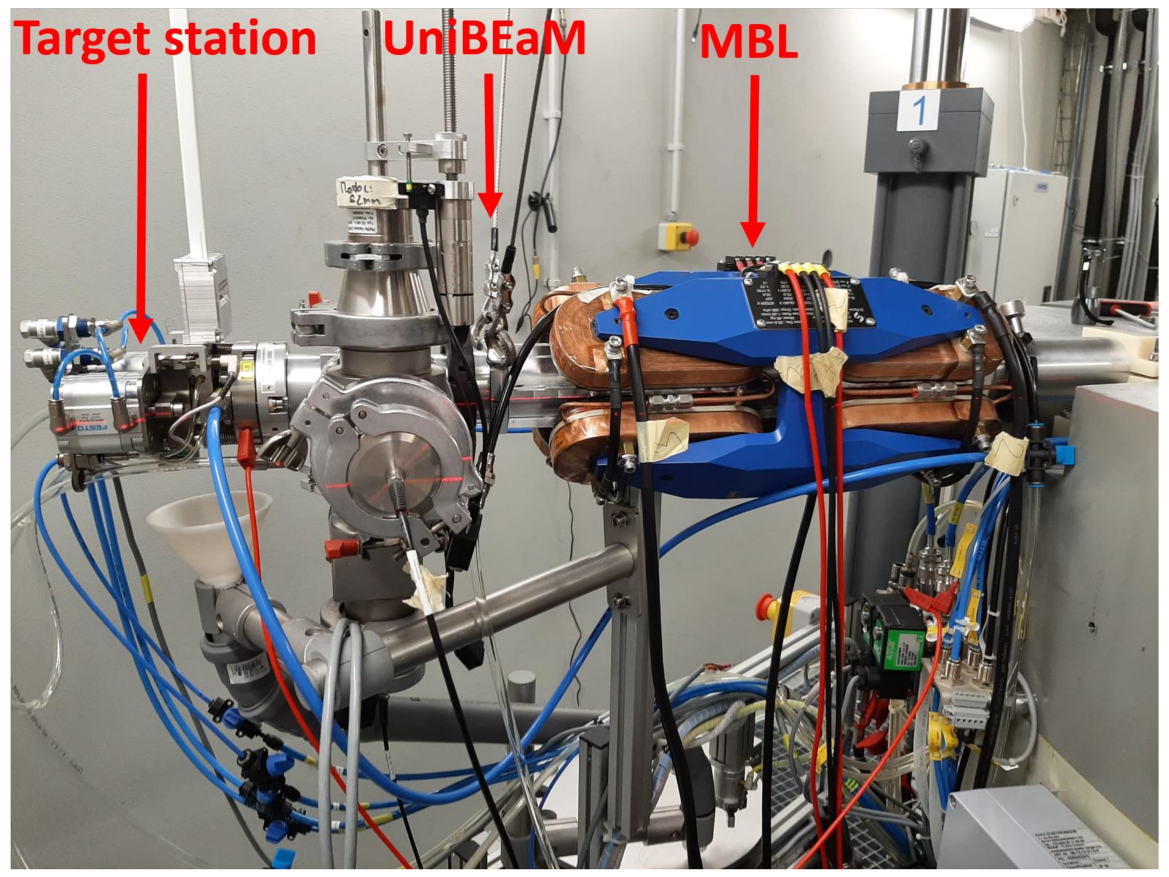

Fig. 3 Beam line for the production of novel radioisotopes for theranostics at the Bern medical cyclotron.

Methodology

The AFS is based on iterative procedures. It adjusts the MBL currents with the feedback given by the beam monitor. In particular, UniBEaM

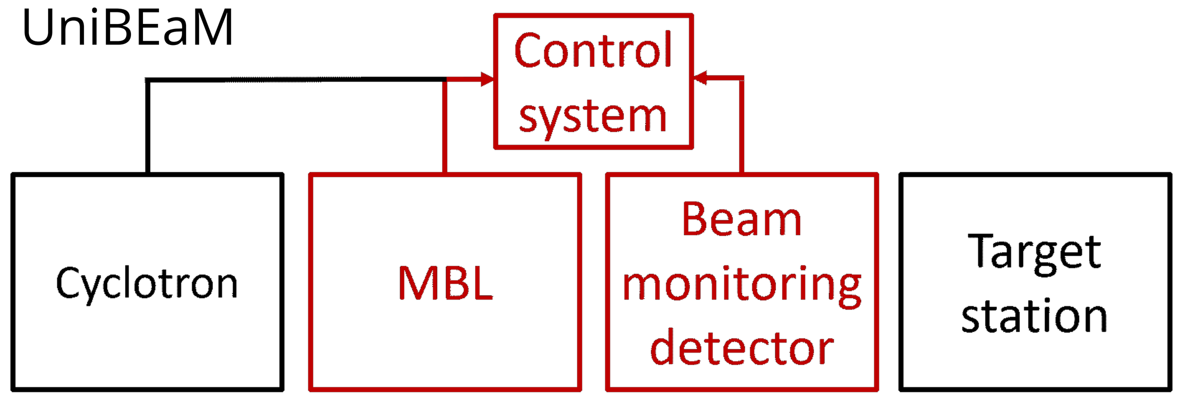

Fig. 4 Schematic of the AFS.

X and Y profiles are recorded; optimization parameters (OPs) are defined as functions of the centroid and FWHM of each profile. The OPs are compared to those of the target region (position of the pellet in the target station). Thus, the MBL currents are varied and new OPs are compared to those of the previous profile. The automated procedure ends when the difference between the OPs of two consecutive beam profiles is less than a defined tolerance.

Results

Based on scintillation optical fibers, the UniBEaM measures the light intensity, which is proportional to the beam current, and the corresponding fiber position, thus providing accurate beam profiles [2]. Beam profiles on target are calculated from the UniBEaM profiles. To verifiy the goodnes of this calculation we measured beam profiles with another UniBEaM placed in the position of the target (Fig. 5).

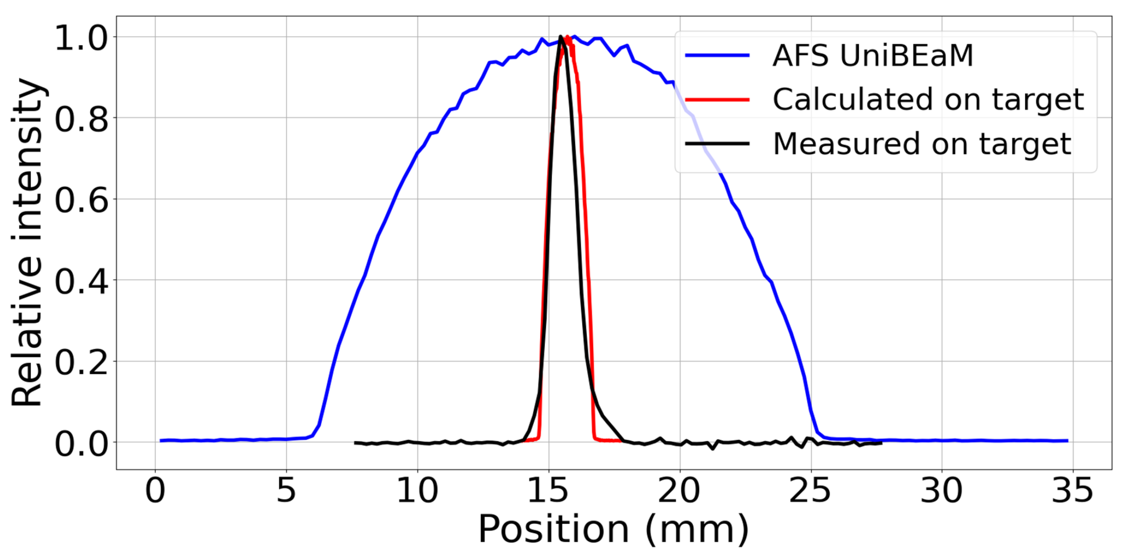

Fig. 5 Measured and calculated profiles on target as well as profile measured by the AFS UniBEaM.

AFS focusing capabilities have been proved by visualizing the beam spot on the π^2 detector, a novel beam monitor developed by our group, based on a scintillation Y_2SiO_5 foil read-out by a CCD camera (Fig. 6). In order to test the AFS

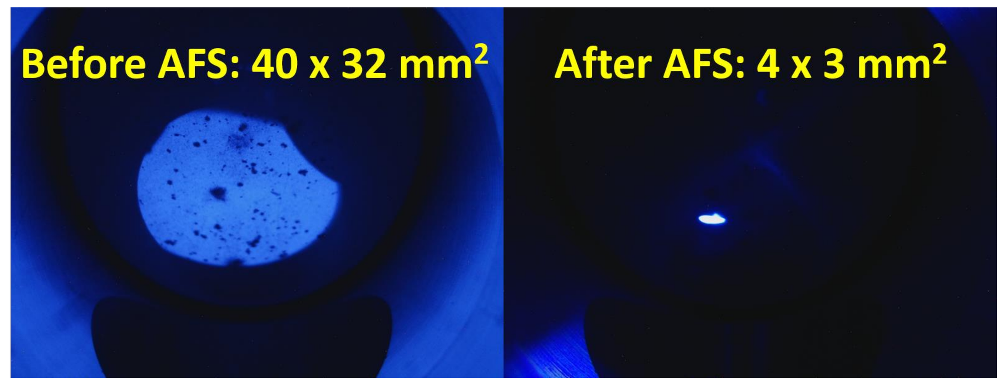

Fig. 6 Beam spot before (left) and after (right) the optimization procedure.

capabilities, we performed a slight perturbation of the beam, by acting on the steerers (Fig. 7), thus we started the AFS procedure.

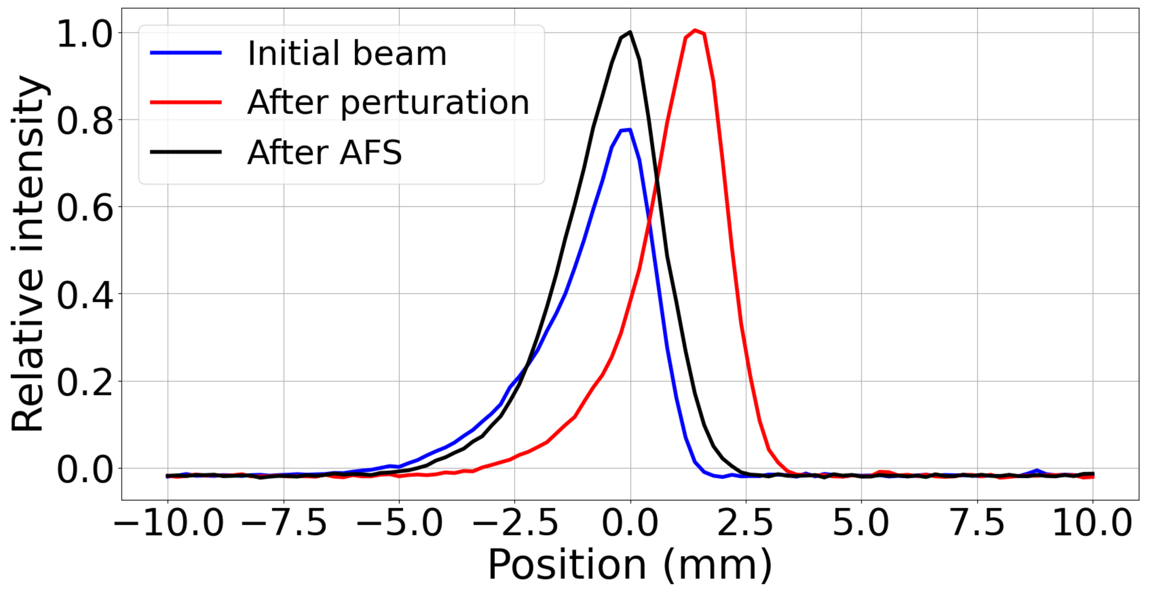

Fig. 7 AFS capabilities in recovering the beam after a perturbation was intentionally performed.

Conclusion

A novel Automatic Focalization System (AFS) has been developed to enhance the performance of the radioisotope production with solid targets. The AFS is able to focus the beam on a 4 mm diameter and to recover the beam on target after a change of the profile. The system is compact and allows to be installed in facilities with limited space such as in low-energy medical cyclotron.

References

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