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^{11}C Gas Target Yield Increase of KOTRON-13 Cyclotron

W. K. LEE *, S. K. CHAE , B. O. CHO, J. H. KIM, K. H. YANG, S. Y. LEE
Samyoung Unitech Co.,Ltd., Dong Yeon B/D 3F, 106-4, Yangjae-Dong, Seocho-Gu, Seoul, Korea
**Corresponding author:lwk75@naver.com*

1. Introduction

Lately, using range of positron emission tomography is utilized to a tumor and a wide variety of diagnosis in many fields and with the change of those, positron emission isotopes covered with varied positron emission isotope is developed.

Positron emission tomography isotopes are ^{18}F, ^{11}C, ^{15}O, ^{13}N and etc. ^{15}O, ^{13}N out of those isotopes are limited for utilization due to their short half-life which are 2min and 9.9min but ^{18}F, ^{11}C is mainly using for composing varied compound since those half-life are longer as 109.7min and 20.4min than ^{15}O, ^{13}N.

As for PET of those radiopharmaceutical used for cancer diagnosis, generally glucose synthesized with fluorine, called 2-[^{18}F] Fluoro-2-deoxy-D-glucose (FDG), is used but in case of diagnostic medical images like brain or heart, using gas isotope like ^{11}C has high confidence for diagnosis.

Gas isotope ^{11}C used to PET is producing a proton beam from cyclotron and it is produced with nuclear reaction, $^{14}N(p,\alpha)^{11}C$, by irradiating a produced proton beam to stable isotope, N_2[1].

2. Methods and Results

KOTRON-13 cyclotron high yield ^{11}C target withstands increasing pressure of ^{11}C cavity while a proton beam is entering and it consists of three parts which are grid making ^{11}C cavity pellicle be water cooling, cavity saving ^{11}C gas and water cooling cavity part having ^{11}C gas be cool.

2.1 Design for grid of high yield ^{11} C target

Firstly, a proton beam bordering onto the part is grid and this grid consists of 2.8mm. Also the shape is arranged from the center as hexagon. Spaced hexagon 0.2mm apart and thickness of grid is designed to 8mm. Its material is copper and designed inside diameter is 18mm and external diameter is 70mm.

This designed grid beam efficiency is approximately 85% and it is designed for possible to be cool by water cooling around grid for cooling of N_2 cavity foil which is connected by grid part and grid heated by proton beam[2]. Fig.1 shows high yield ^{11}C target grid.

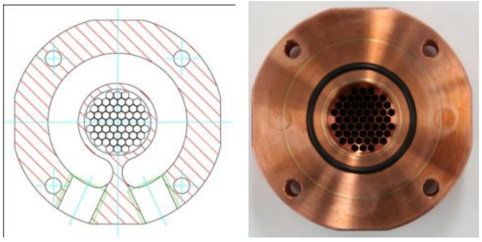

Fig.1. High yield ^{11}C Target grid

2.2 High yield ^{11}C target N_2 cavity design

N_2 cavity part is arranged with 40 ㎛ HAVAR foil in the front and the part shielding N_2 is designed for 18mm wide and 160mm depth, 190mm depth.

In this case, the inside bulk is approximately 90 ㎖, 100 ㎖. After proton beam energy reacts to N_2, on account of possibility to remaining proton beam, the back part of thickness regarding extinction of all proton beam energy for 13MeV should be 1.0mm.

High yield ^{11}C target N_2 cavity shape is that proton beam becomes more scattering while it is moving from the inside to rear-end and also sectional area is bigger. Since the shape of total proton beam is bigger as conical shape in rear-end, it is designed by reflecting this phenomenon and it is also designed as hemicycle shape in order for maximally maintaining nuclear reaction from occurring of the second spawn in the back part of N_2 cavity due to the inside spawn.

Used ^{11}C cavity material is titanium and external diameter is designed as 70mm. Fig.2 shows high yield ^{11}C target N_2 cavity.

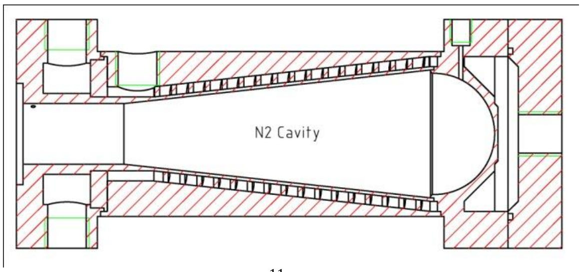

Fig.2. High yield ^{11}C target N_2 cavity

2.3 Water cooling cavity design

Water cooling cavity has N_2 cavity be cool by rotating cool water. Its direction is from the back part of the center in a straight and makes the back part which generates the most heated part be cooling and then its body could be cooling with rotating in a spiral.

Ascended cooling is designed for flowed to upper part of N_2 cavity.

High yield ^{11}C target let heat accumulation from target middle part generating heat chilled by force and designed for improving thermal efficiency than previous method by rotating cool water. Designed high yield ^{11}C cooling heat volume is maximum 1,000W and it is possible for KOTRON-13 to irradiate up to proton beam 80uA. Used coolant material is titanium and aluminum. Its external diameter is 70mm.

Fig.3. shows high yield ^{11}C target water cooling cavity.

Fig.4. shows high yield ^{11}C target assembled

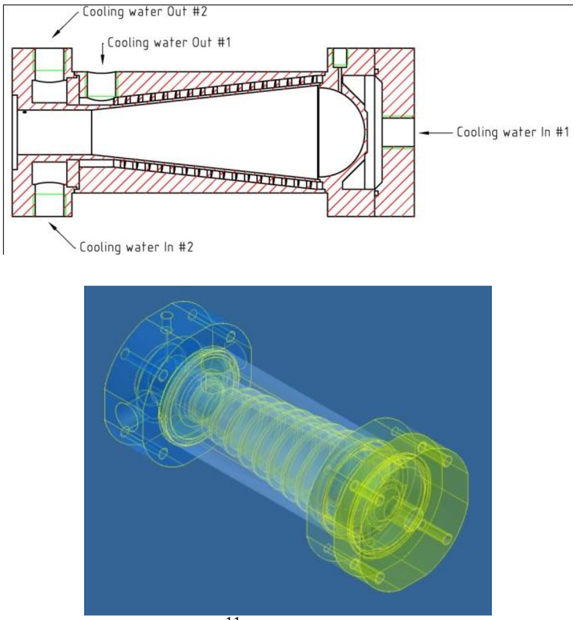

Fig.3. High yield ^{11}C target water cooling cavity

Fig.4. High yield ^{11}C target

2.4 Result

The test from KOTRON-13 cyclotron investigates proton beam as average current 50 μA (maximum 60 μA), 60 μA for 30min. Fig.5 shows the result of irradiation ^{11}C target to KOTRON-13 cyclotron through experiments in 10 times.

If the average current of proton beam 50 μA, thermal capacity is 625W and the average current of proton beam is 60 μA, it is 750W from KOTRON-13 cyclotron. During the plan, the maximum thermal capacity considered is 1,000W.

160mm ^{11}C target produces maximum 2,200mCi when the proton beam is average 60 μA and 190mm ^{11}C target produces maximum 1,900mCi when the proton beam is average 60 μA. It shows the great performance of thermal capacity and production about beam current. Fig.5. is shows high yield ^{11}C target.

Fig.5. is shows ^{11}C target yield (EOB) of KOTRON-13 cyclotron.

Fig.6. is shows ^{11}C target yield (SAT) of KOTRON-13 Cyclotron.

Fig.7. is shows ^{11}C target of KOTRON-13 Cyclotron.

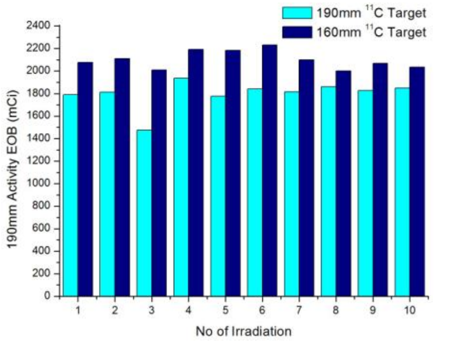

Fig.5. ^{11}C Target Yield (EOB) Result

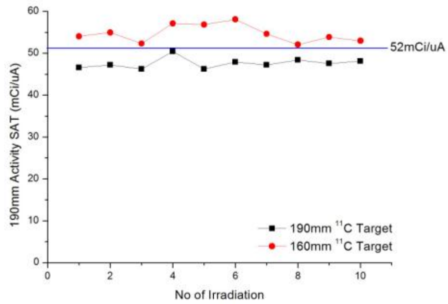

Fig.6. ^{11}C Target Yield (SAT) Result

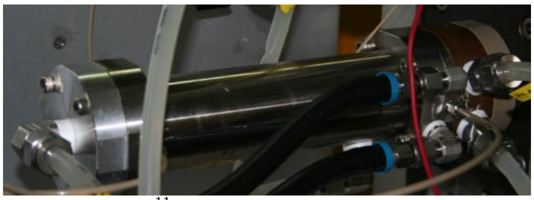

Fig.7. High yield ^{11}C target of KORTRON-13 cyclotron

3. Conclusions

As a result of above test, high yield ^{11}C target is a great performance of cooling and production from KOTRON-13 cyclotron.

At present, HAVAR foil lifetime is being tested, and if the design becomes optimization from now on, the production of target is expected to markedly increase in the future.

REFERENCES

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[2] B. W. Blackburn, M. S. Thesis, Massachusetts Institute of Technology, 1997.