成均館大學校
SUNGKYUNKWAN UNIVERSITY
1398

Unique Origin
Unique Future

Study of Geant4 simulation for cyclotron radioisotope production in various target size

SangChul Mun[1], Ho Namgoong[1], Mitra Ghergherehchi[1], Jong-Seo Chai*,
College of Information & Communication Engineering, Sungkyunkwan University, Suwon, KOREA
Jongchul Lee[2], Hui-Su Kim[2], Department of Energy Science, Sungkyunkwan University, Suwon, KOREA

21st International Conference on Cyclotrons and their Applications, Sep 11-16, Zürich, Swiss

Abstract

The application of radioisotopes in medical radiology is essential for diagnosis and treatment of cancer. The fabrication of radioisotopes has main factors that maximize the fabrication yield and minimize the costs. An effective method to solve this problem is that the usage of Monte Carlo simulations before experimental procedure. This paper studies the simulation and presents cyclotron models for the energy 13 MeV with moderate beam intensity are used for production of ^{11}C, ^{13}N, ^{15}O, and ^{18}F isotopes widely applied in positron emission tomography. SKKUCY-13 cyclotrons with high beam intensity are available on the market for production of most medical and industrial isotopes. In this work, the physical and technical parameters of different models are compared. Overall, this confirms the applicability of Monte-Carlo to simulate radionuclide production at 13 MeV proton beam energy.

Modeling

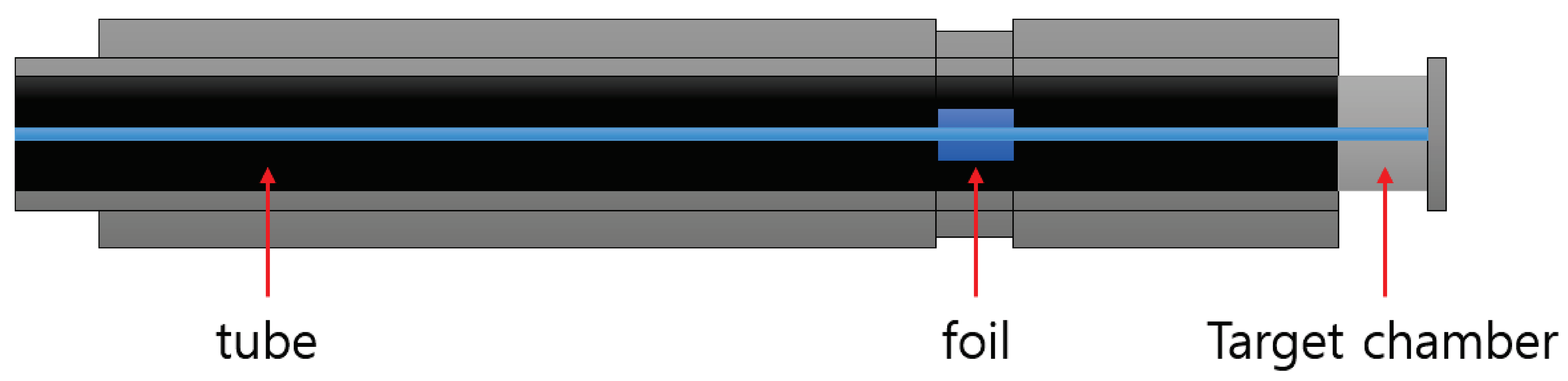
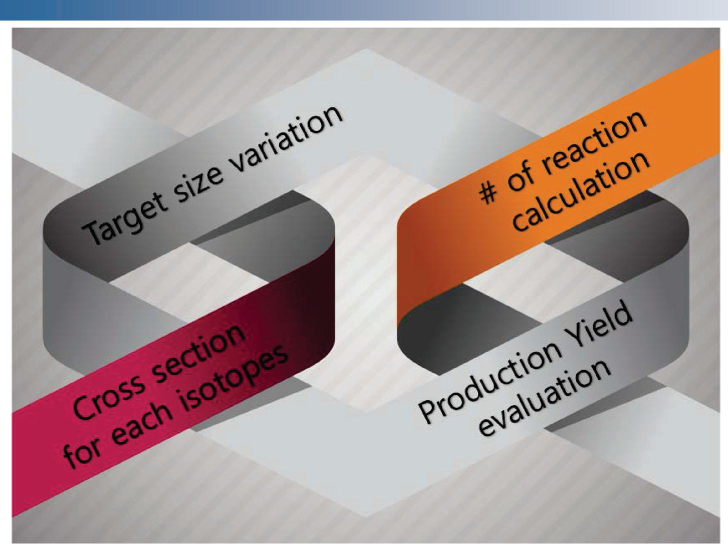


Fig.1 Geometry for radioisotope production target system

- Cylindrical shape target chamber and target body that can modulate the energy of the beam and a target at the end of the fixed chamber.
- The target is made for optimization of target shapes which allows the selection of the thickness.
- The low-energy (p, n), (p, α), (d, n) and (d, α) nuclear reactions cross section values were calculated for energies at 13 MeV.
- On average, around 10000 events were calculate to achieve good precision.

Conclusion



Minimize the Cost for diagnosis and treatment

- A GEANT4 toolkit for simulation of a medical cyclotron solid beamline has been developed and described in details
- Agreement between simulated yields and theoretical yields varied with reaction types
- This is a cost efficient approach to studying new isotope production mechanisms before investing in costly experimental studies

Results

Number of reactions for isotope production

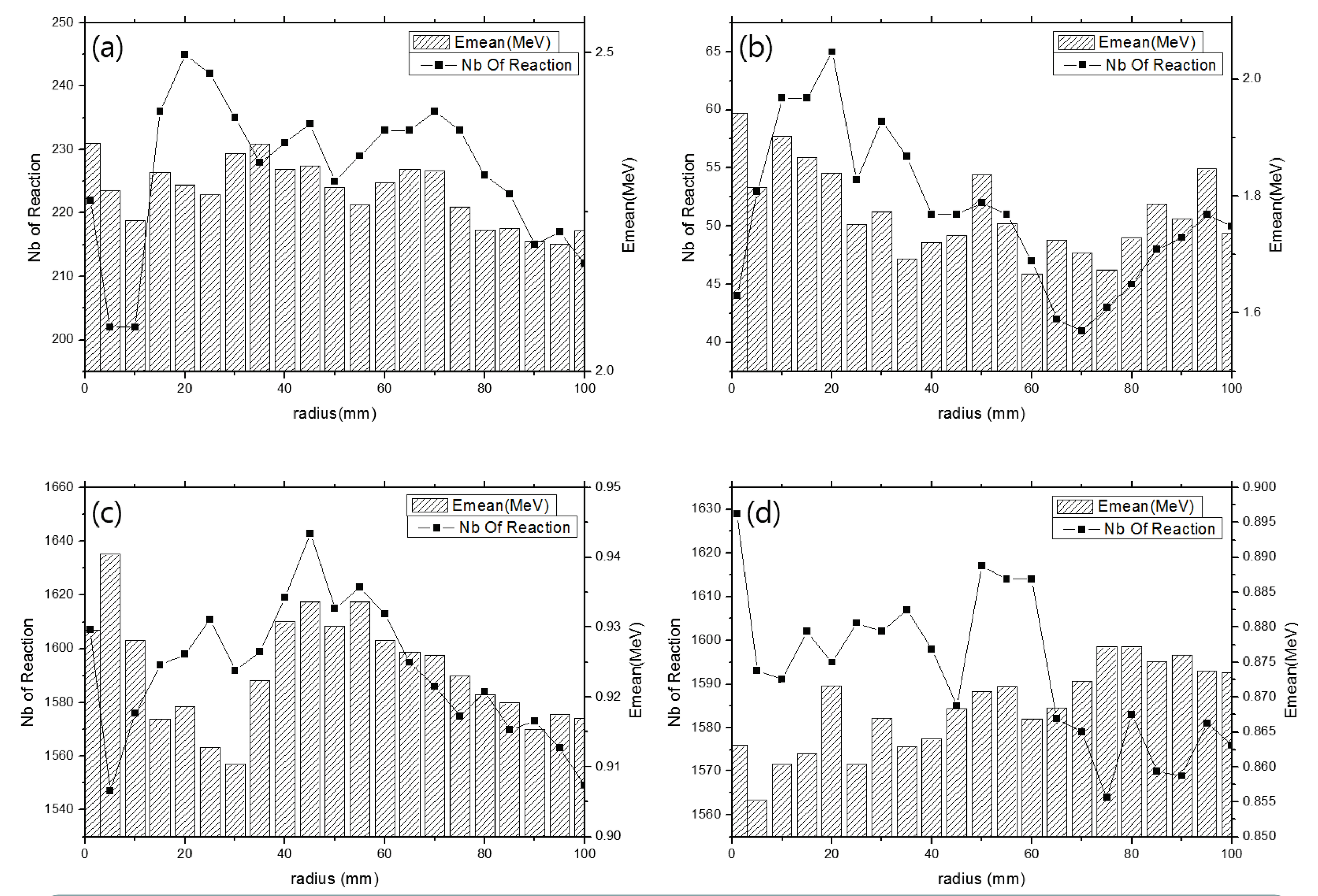


Fig.2 Number of Reactions and mean Energy for (a) 11C, (b) 13N, (c) 15O and (d) 18F at thickness range from 1 mm to 100mm

- The isotope number of reactions relative to ^{11}C, ^{13}N, ^{15}O and ^{18}F production was shown
- The relative simulated result shows the comparison of number of reaction and mean energy at 13 MeV
- The results show that unreliable properties for radioisotopes production at various thickness

Production yield from simulation

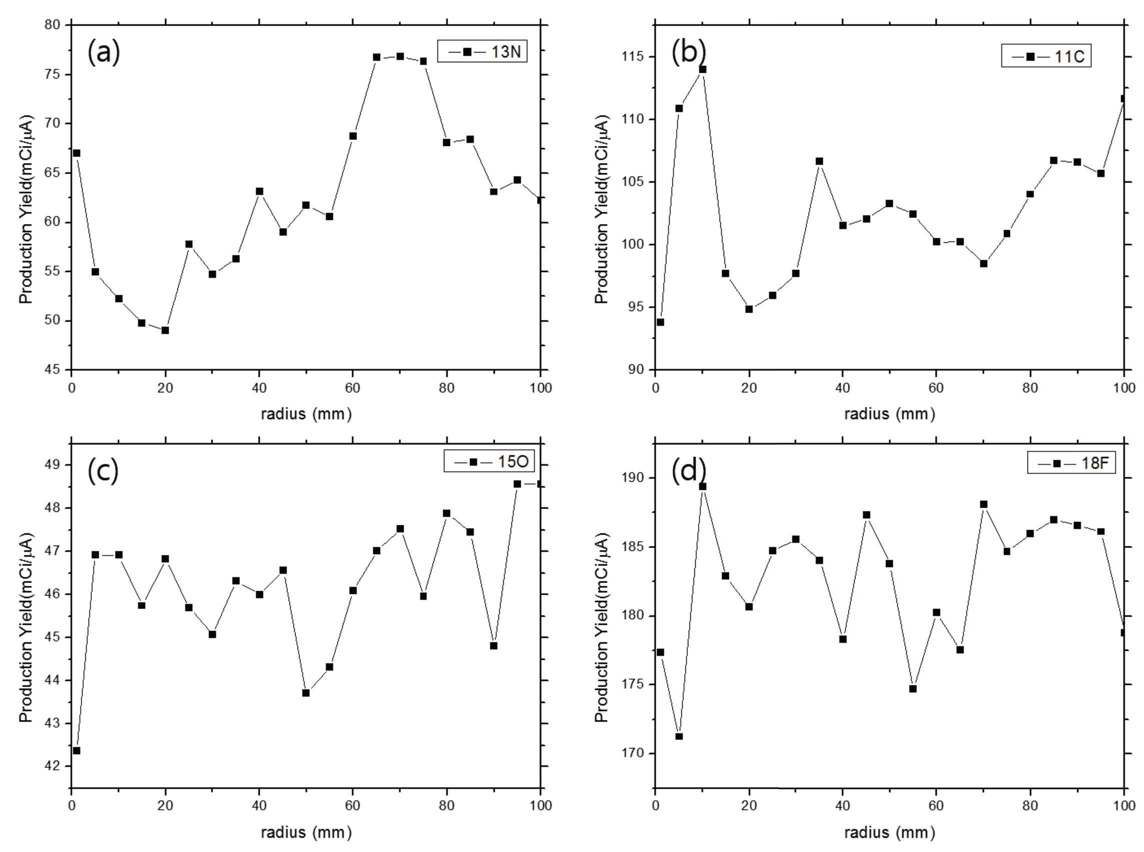


Fig.3 Production yield calculation result for (a) 11C, (b) 13N, (c) 15O and (d) 18F at various thickness

- The simulation tends to overestimate the saturation yield with 103 ± 10 mCi/μA for 11C a thickness range from 1 to 100 mm, with protons reaching the target with an energy of 13 MeV.
- The theoretical yield is 100mCi/μA and the simulated yield is 103 ± 10mCi/μA, giving an overestimation of 10% compared to theory.
- For a whole range of thickness, the theoretical yield and the simulation yield are in good agreement.

Cross section of the reaction

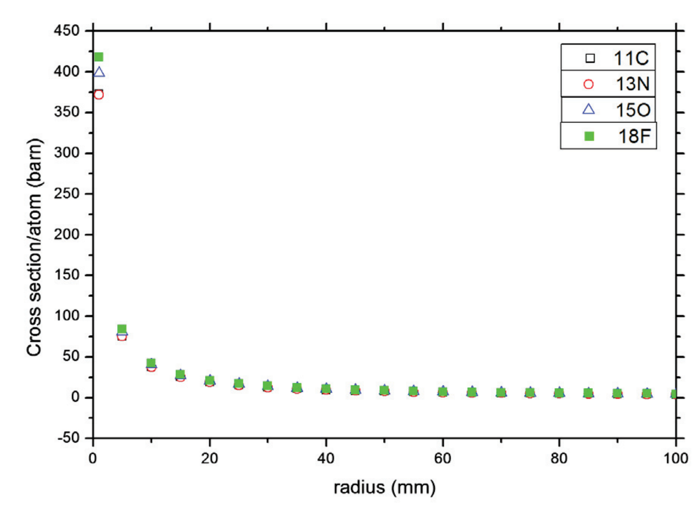


Fig.4 Cross section for each isotopes at various thickness range

- The cross section of the reaction was calculated through the simulation using the QGSP_BIC_AllHP physics model and the TENDL library
- The graph shows good agreement each isotopes cross section simulation results
- They were in reduced value with some error due to the uncertainty of the simulation.

* Corresponding Author, jschai@skku.edu

IT Accelerator Engineering Research Center
ITAEC
SKKU