Dependence of W-derived photons and MoO_3-derived photons on W thickness

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Abstract

In order to improve the ^{99}Mo production yield of a W-MoO_3 target system, photon generation at a W converter and photon generation at a MoO_3 target were investigated as functions of the W thickness. The two separate sets of results were then analyzed to find the W thicknesses that lead to improved ^{99}Mo yields.

Keywords: ^{99}Mo/^{99m}Tc, bremsstrahlung, electron linear accelerator, PHITS, `phitar`

1. Introduction

Production of ^{99}Mo using an electron linear accelerator and the ^{100}Mo(γ,n)^{99}Mo reaction is a promising alternative to the fission production of ^{99}Mo. In a target system where a separate converter material is used, the photon fluence measured at a Mo target results from (i) photons generated at the converter by incident electrons, and also from (ii) photons generated at the Mo target by converter-penetrated electrons. In order to increase the sum of (i) and (ii) and thereby the ^{99}Mo yield, we investigated the dependence of (i) and (ii) on the converter thickness using Monte Carlo (MC) simulations.

2. Monte Carlo simulations

MC simulations were performed on a W-MoO_3 target system using PHITS [1] with our program `phitar` [2] used as the frontend. Electron beam energies of $E_{e^-} = 20$–50 MeV, and W thicknesses of 1.0–7.0 mm were simulated.

First, photon fluences were measured in the region of a MoO_3 target, with the MoO_3 target set to be void. These fluences represent W-derived photons. Next, dummy electron sources entering a nonvoid MoO_3 target were obtained, which were then simulated on a new nonvoid MoO_3 target. This resulted in MoO_3-derived photons. Finally, the W thickness at which the largest sum of the two photon fluences were calculated. Results for $E_{e^-} = 35$ MeV are presented in Table 1.

Table 1. Photon fluences measured at MoO_3 targets and integrated over $E_\gamma > 8$ MeV. The electron beam energies were all $E_{e^-} = 35$ MeV. t_W denotes the W thickness.

t_W (mm)	Photon fluence (cm^{-2} $electron^{-1}$)		
	W-derived	MoO_3-derived	Total
1.0	0.2474	0.0397	0.2871
1.5	0.2866	0.0222	0.3088
2.0	0.2989	0.0124	0.3113
2.5	0.2962	0.0070	0.3032
3.0	0.2852	0.0038	0.2890

3. Summary

The relative contributions of W-derived and MoO_3-derived photons to the total photon fluence were investigated as functions of the W thickness. The W thicknesses that can increase the ^{99}Mo yields were then calculated. The detailed calculation methods and results will be presented in the talk.

References

[1] T. Sato et al. Features of Particle and Heavy Ion Transport code System (PHITS) version 3.02. *Journal of Nuclear Science and Technology* 55 (2018), 684–690. DOI: 10.1080/00223131.2017.1419890.

[2] J. Jang. *phitar - A PHITS wrapper for targetry design (v1.02)*. Zenodo. 2019. DOI: 10.5281/zenodo.3235364.