

ЯДЕРНАЯ ФИЗИКА,
ЭЛЕМЕНТАРНЫЕ ЧАСТИЦЫ И ФИЗИКА ВЫСОКИХ ЭНЕРГИЙSTUDY ON CU-64 PRODUCTION
USING Ni-64 AND Zn-68 TARGETSQiuying Liang¹, Xunchao Zhang², Guanghui Yang²

This study employed the Monte Carlo method to simulate the production of ^{64}Cu using a low-energy proton cyclotron, which is essential for identifying cost-effective production strategies. Two target materials, ^{64}Ni and ^{68}Zn metals, were considered. The SRIM code was used to calculate the proton ranges in these two target materials. Based on the available experimental cross-section data provided by the IAEA, the effects of target material type, target thickness, and incident angle of the proton beam on the target surface on the production yield of ^{64}Cu and associated impurities were also analyzed using the PHITS software. The results indicated that proton-induced reactions on ^{64}Ni and ^{68}Zn targets can achieve desirable yields of ^{64}Cu within incident proton energy ranges of $12 \rightarrow 9$ MeV (for ^{64}Ni target) and $28 \rightarrow 25$ MeV (for ^{68}Zn target), respectively. Appropriately reducing the incident angle of the proton beam on the target surface can improve the utilization efficiency of the proton beam. Consequently, under the same target thickness, the yield of ^{64}Cu is increased while the impurity yields remain relatively stable. Furthermore, as the incident angle decreases, the optimal target thickness required to achieve the maximum ^{64}Cu yield is correspondingly reduced.

Keywords: ^{64}Ni target, ^{68}Zn target, ^{64}Cu yield.

¹ Advanced Energy Science and Technology Guangdong Laboratory, Huizhou 516000, China; e-mail: yangguanghui@impcas.ac.cn.

² Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China.

1. *Introduction.* The radioisotope ^{64}Cu has a half-life of 12.7 hours and exhibits three decay modes: emission of β^- particles (0.579 MeV, 38.48%), β^+ particles (0.653 MeV, 17.85%), and Auger electrons (1.675 MeV, 43.53%) [1]. The β^- particles and Auger electrons released during its decay can kill or damage cancer cells, thereby achieving therapeutic purposes, while the β^+ particles are suitable for high-spatial-resolution positron emission tomography (PET) [2, 3]. Compared to two other commonly used β^+ emitters in PET, ^{18}F and ^{11}C , the longer half life of ^{64}Cu endows it with two major advantages: firstly, it can meet the requirements of dynamic PET imaging for slow biochemical processes such as protein metabolism; secondly, it supports nuclear medicine imaging research and clinical applications in institutions far from radionuclide production facilities [4]. Additionally, ^{64}Cu exhibits excellent coordination chemistry properties, enabling easy labeling with biological carrier molecules such as monoclonal antibodies and peptides [5]. These characteristics make ^{64}Cu -based radiopharmaceuticals highly promising for applications in nuclear medicine diagnostics and tumor radiotherapy. Currently, Cu DOTATATE has been approved for marketing [6]; moreover, a variety of other radiotracers are under clinical development [7].

The production pathways for ^{64}Cu primarily involve two methods: reactor-based production and accelerator-based production [8]. In the reactor-based route, ^{64}Cu is typically generated by irradiating ^{63}Cu or ^{64}Zn targets with high-flux thermal neutrons via neutron capture reactions. The advantage of this method lies in its lower cost; however, the produced isotopes often suffer from low specific activity and high carrier content, which is unfavorable for subsequent biomolecular labeling [9–12]. Additionally, with the gradual phase-out of high-flux reactors worldwide and the continuously growing demand for radioisotopes, reactor-based production alone can no longer meet the market needs for medical isotopes. Therefore, accelerator-based production has increasingly become an important supplementary method. Among accelerator technologies, cyclotrons have emerged as one of the core facilities for efficiently producing various radioisotopes, owing to their ability to accelerate multiple types of particles, wide energy range, and high average beam intensity [13]. In the accelerator-based production of ^{64}Cu , proton beams are commonly used to bombard ^{64}Ni or ^{68}Zn targets, generating the target nuclide via the $^{64}\text{Ni}(p, n)^{64}\text{Cu}$ and $^{68}\text{Zn}(p, x)^{64}\text{Cu}$ reaction pathways, respectively. The $^{64}\text{Ni}(p, n)^{64}\text{Cu}$ pathway achieves high ^{64}Cu yields at relatively...

Поступила в редакцию 2 октября 2025 г.

После доработки 12 апреля 2026 г.

Принята к публикации 17 апреля 2026 г.