LWFA-Driven Photonuclear Reactions for Production of Medical Radionuclides

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Recent results of the production of the medical radionuclide ^{67}Cu using a laser wakefield accelerator (LWFA) will be presented. This emerging technique utilizes ultrashort, powerful laser pulses that are focused into a gas jet to create a plasma wake that traps and accelerates electrons to very high energies using the large accelerating gradients. Accelerated electrons interact with high-Z material to produce high-energy photons, which initiates photonuclear reactions via the ^{68}Zn (γ, p)^{67}Cu to produce ^{67}Cu.

^{67}Cu is considered ideal radioisotope for treatment of lymphoma and colon cancer [1]. This isotope has properties similar to the clinically used ^{177}Lu, but a slightly higher emission energy in addition to a conveniently shorter half-life ($t_{1/2}$:62 h).

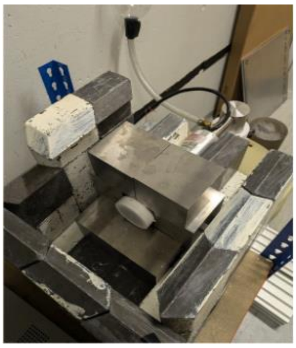

Figure 1. The passive background suppression system for the HPGe detector surrounded by tungsten and lead bricks

^{67}Cu is currently produced via ^{68}Zn (p, 2p)^{67}Cu reactions, which require medium-energy protons (~70 MeV) that are only available at limited number of facilities and often results in co-production of other Cu isotopes. Alternative methods using cyclotrons or nuclear reactors are limited by the natural abundance of target isotopes and the availability of fast-neutron reactors. The use of the LWFA for producing medical isotopes would be advantageous because of its compactness and cost-effectiveness, making its installation near hospitals easier, which would minimize transportation losses.

We present the experimental setup, maximizing electron pulse intensity by optimizing laser beam properties and target composition of gas jet. The gamma beam and the design of ^{68}Zn targets are optimized using FLUKA simulations (Figure 2). The produced radionuclides are identified and quantified using High Purity Germanium (HPGe) detector (Figure 1). We will also report on the development of detectors for online monitoring of the electrons and gamma beams.

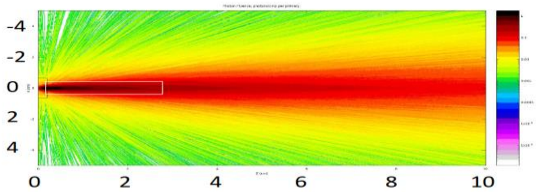

Figure 2. FLUKA simulation shows spatial distribution given with intensity of 2D photon flux after a 50 MeV electron beam interacts with a 2-mm Tungsten (W) converter followed by the natural Zinc target.

References

[1] G. Hao *et al*., Scientific Reports. **11**, 3622 (2021), doi: /10.1038/s41598-021-82812-1

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