# Radioisotopes production using lasers: from basic science to applications

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Laser technologies have advanced significantly with the understanding of Chirped Pulse Amplification (CPA), which allows energetic laser beams to be compressed to tens of femtoseconds (fs) pulse durations and focused to a few micrometers (μm). Protons with energies of tens of MeV can be accelerated using methods such as Target Normal Sheath Acceleration (TNSA) and focused on secondary targets. Under these conditions, nuclear reactions can occur, producing radioisotopes relevant for medical purposes. High repetition lasers can produce sufficient isotopes for medical applications, making this approach competitive with conventional methods that rely on accelerators.

The production of the $^{67}$Cu, $^{63}$Zn, $^{18}$F, and $^{11}$C were investigated [1] at the 1-petawatt (PW) laser facility at Vega III in Salamanca, Spain. These radionuclides are used in positron emission tomography (PET) and other applications. The reactions $^{10}$B(p,α)$^{7}$Be and $^{70}$Zn(p,4n)$^{67}$Ga were also measured to further constrain proton distributions at different angles and the reaction $^{11}$B(p,α)$^{8}$Be, which is relevant for energy production. The nuclear reaction products were investigated using the pitcher-catcher method, with protons produced by an aluminum target and impinging on various targets in both the forward and backward directions relative to the laser.

Angular distributions of radioisotopes in the forward (with respect to the laser direction) and backward directions were measured using a High Purity Germanium Detector (HPGE). Our results, presented in detail in Rodrigues et al. [1], are reasonably reproduced by numerical estimates following the approach of Kimura et al. [2]. The theoretical production of different nuclei was also estimated and assumptions for cross sections were made in energy regions where they have not been measured. The TNSA mechanism should be studied in more detail and adjusted to various physical scenarios. In particular, the role of electrons must be clarified and, if possible, used to favor nuclear reactions in the plasma. This may be crucial if this method is applied to neutron less reaction energy production. The predictions in Table I from ref. [1] are confirmed by the experimental data. The reaction $^{11}B(p,\alpha)^{8}Be$ will be discussed in more detail in a new publication [3]. The values obtained [1] are too small for self-sustained reactions, and the catcher may need to be compressed [4,5].

Laser technologies are mature enough to compete with accelerators for production. While costs for construction, space, maintenance, etc., may attest to their competitiveness, the results suggest that this may be a winning technology.

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