Generation of alpha particles by $p+^{11}B$ fusion driven by high-repetition-rate PW-power lasers

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The $p+^{11}B \rightarrow 3\alpha + 8.7$ MeV fusion reaction can be triggered by the interaction of high-power laser pulses with matter. Not only it represents a potential alternative to tritium-based fuels for fusion energy production [1,2], but it is attracting also for many applications such as astrophysics [3] and alpha-particle generation for medical treatments [4]. One possible scheme for laser-driven $p+^{11}B$ reactions is to direct a beam of laser-accelerated protons onto a boron sample (the so-called "pitcher-catcher" scheme). This technique was successfully implemented with energetic lasers yielding hundreds to thousands of joules per shot. This is possible on a few large installations and for a limited number of shots. An alternative approach is to exploit high-repetition rate laser-systems at PW-power scale [8], allowing to explore the laser-driven fusion process with hundreds (up to thousands) of laser shots (at more moderate energy), leading to an improved optimization of the diagnostic techniques and an enhanced statistics of the obtained results. Moreover, this approach potentially paves the way to applications where a constant stream of alpha particles is needed. In this work we describe the experiments recently performed on PW-power-scale laser facilities, capable of delivering laser pulses at high-repetition-rate, namely the L3 ELIMAIA laser system at ELI-Beamlines and the VEGA III laser system at CLPU. We aim at providing a detailed insight of the effectiveness of the laser-driven $p+^{11}B$ fusion for alpha particle production. We will discuss the challenges of implementing this experimental scheme, highlight its critical aspects, in terms of detection of fusion products and assessment of its performance as laser-driven alpha particle source[5,6]. We will also show applicative results that indicate that this scheme is potentially viable for the production of radioisotopes for medical purpose [7,8].

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