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A Laser-Accelerated Th Beam is Used to Produce Neutron-Rich Nuclei Around the N=126 Waiting Point of the r-Process Via the Fission-Fusion Reaction Mechanism

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Radiation Pressure Acceleration (RPA) with solid state density ion bunches, which are about $1E15$ times more dense than classically accelerated ion bunches, allow for a high probability that generated fission products fuse again, when the thorium beam strikes a second close Th target. The fission fragments have a $1/\sin(\Theta)$ angular distribution and thus are predominantly emitted in beam direction and stay within the cylinder volume defined by the small spot diameter of the first Th target. In this double reaction neutron-rich light fission fragments of the beam fuse with neutron-rich light fission fragments of the target and we can reach more neutron-rich nuclei than with classical radioactive beams only. The produced beam of new radioactive nuclei will be analyzed with a classical velocity filter, where the technical optimization is well known. The small repetition rate of the 30 PW APPOLON lasers of about 0.02 Hz with very short production pulses is stretched by the Beta-decay half-lives of the produced nuclei to counting rates acceptable to nuclear detectors. Very neutron-rich nuclei still have small production cross sections, because weakly bound neutrons are evaporated easily. The velocity filter has to suppress the many fused nuclei close to the valley of stability. Here we want to look specifically for nuclei close to the waiting point at N=126 of the r-process, which is decisive for the astrophysical production of heavy elements and was not accessible until now. We estimate sufficient rates for these interesting nuclei. We envision having behind the velocity filter a gas stopping cell and a Penning trap to measure accurately the masses of these nuclei.

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