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A fast neutron source driven by an 80W average-power laser and its application in radiobiology

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A laser-based neutron source was commissioned using the 1kHz repetition rate SYLOS3 laser of ELI-ALPS, delivering 80mJ, sub-10 fs laser pulses on a heavy water sheet. The accelerated deuterons induced a 2H + 2H fusion reaction on a rotating disk of deuterated polyethylene, resulting in neutrons with a mean kinetic energy of 3.5MeV in the forward direction. We maximized the neutron yield per laser shot by tuning the dispersion, and hence the temporal shape of the laser pulse. At the optimum neutron yield of 7×10^4 neutron/shot, the cutoff energy of the forward accelerated deuterons well exceeded 2MeV, while its average power was around 4W. However, due to the degradation of the surface of the deuterated polyethylene disk, the yield continued to drop continuously over 4 hours of operation. The average neutron flux on target exceeded 2×10^7 neutron/cm2/s, while the flux rate of a neutron pulse was estimated around 10^{12} neutron/cm2/s.
In an irradiation session of four hours, a total of 1.6 Gy dose was delivered on zebrafish embryos. The density of apoptotic cells as well as double-strand breaks in the zebrafish embryos was similar to that of the control group irradiated with cyclotron-generated neutrons. However, photomotor responses showed differences.

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