Neutrons are a unique tool to alter and diagnose material properties and excite nuclear reactions with a large field of applications. It has been stated over the last years, that there is a growing need for intense, pulsed neutron sources, either fast or moderated neutrons for the scientific community. Accelerator based spallation sources provide unprecedented neutron fluxes, but could be complemented by novel sources with higher peak brightness that are more compact. Lasers offer the prospect of generating a very compact neutron source of high peak brightness that could be linked to other facilities more easily.

We present experimental results on the first short pulse laser driven neutron source powerful enough for applications. For the first time an acceleration mechanism (BOA) based on the concept of relativistic transparency has been used to generate neutrons. This mechanism not only provides much higher particle energies, but also accelerated the entire target volume, thereby circumventing the need for complicated target treatment and no longer limited to protons as an intense ion source. As a consequence we have demonstrated a new record in laser-neutron production, not only in numbers, but also in energy and directionality based on an intense deuteron beam. This enabled the use in imaging applications with high temporal resolution as the neutron beam has a pulse duration of less than a nanosecond. The beam contained, for the first time, neutrons with energies in excess of 200 MeV and showed pronounced directionality, which makes them extremely useful for a variety of applications. Using short pulse lasers we have been able to get a radiograph of an unknown object using the hard x-rays of the laser matter interaction and neutrons of different energies. This allows also for determining the material composition of an object. The data thereby match the simulation data for our test samples. The results also address a larger community as it paves the way to use short pulse lasers as a neutron source. They can open up neutron research to a broad academic community including material science, biology, medicine and high energy density physics as laser systems become more easily available to universities and therefore can complement large scale facilities like reactors or particle accelerators. We believe that this has the potential to increase the user community for neutron research largely.

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