**HEDLA 2022**
13th International Conference on High Energy Density Laboratory Astrophysics
hedla@tecnico.ulisboa.pt

# Laboratory demonstration of rapid neutron captures: a quantitative feasibility study

Vojtěch Horný[1,2,3,†], S. N. Chen[4], X. Davoine[2,3], L. Gremillet[2,3], J. Fuchs[1]

[1] *LULI-CNRS, CEA, UPMC Univ Paris 06: Sorbonne Université, Ecole Polytechnique, Institut Polytechnique de Paris, F-91128 Palaiseau Cedex, France*

[2] *CEA, DAM, DIF, F-91297 Arpajon, France*

[3] *Université Paris-Saclay, CEA, LMCE, 91680 Bruyères-le-Châtel, France*

[4] *Horia Hulubei National Institute for Physics and Nuclear Engineering, 30 Reactorului Street, RO-077125, Bucharest-Măgurele, Romania*

[†] vojtech.horny@polytechnique.edu

The rapid progress seen in laser-driven neutron sources [1] makes them promising alternatives to larger-scale, accelerator-based spallation facilities or nuclear fission reactors. In fact, laser-based neutron pulses already outperform the latter conventional sources in terms of short duration, small size and huge instantaneous flux [2]. These features open prospects for attractive applications like non-destructive and isotope-sensitive material analysis [3]. On a more speculative side, owing to their very high brightness, laser-based neutron sources have also been proposed for laboratory studies of neutron capture processes under conditions relevant to heavy nucleosynthesis [4].
We will here present a numerical simulation method to quantify the isotope yield that laser-based neutron beams can generate within samples of various material types. Our approach consists of three stages. First, we perform particle-in-cell CALDER simulations of laser-driven ion acceleration from thin foil or double-layer targets [2]. Second, we employ the Monte Carlo FLUKA code [5] to describe neutron generation by nuclear reactions initiated by the fast ions in a secondary converter target. Third, the neutron areal density profile at the exit of the converter is used to compute the production of isotopes in a tertiary sample. The latter calculation is performed by generalizing the method proposed by Zagrebaev et al. [6].
When considering the laser parameters expected at the upcoming multi-petawatt facilities, our simulation chain suggests that rapid neutron captures leading to neutron-rich isotopes will not be realized experimentally in a foreseeable future. The opposite conclusions reached previously [2] were due to the overestimation of the neutron capture cross sections or of the areal density of the laser-driven neutron source.

## References

[1] M. Roth *et al.*, Physical Review Letters **110** (2013); I. Pomerantz *et al.*, Physical Review Letters **113** (2014); M. Günther *et al.*, Nature Communications **13** (2022).

[2] B. Martinez *et al.*, Matter and Radiation at Extremes **7** (2022); V. Horný *et al.*, arXiv:2202.06549 (2022).

[3] M. Zimmer *et al.*, Nature Communications **13** (2022).

[4] S. N. Chen *et al.*, Matter and Radiation at Extremes **4** (2019); P. Hill and W. Yu, Physical Review C **103** (2021).

[5] T. Böhlen *et al.*, Nuclear Data Sheets **120** (2014).

[6] V. I. Zagrebaev *et al.*, Physical Review C **84** (2011).