

Complete simulation of multi-TW laser pulse post-compression close to single-cycle in multiple thin plates

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Efficient post-compression of linearly polarized pulses down to single-cycle duration has been already demonstrated by spectral broadening through a sequence of multiple thin plates [1]. Extending the method to the multi-10 mJ regime requires significant efforts regarding the spatial beam characteristics. In the meantime, understanding of the key physical processes in post-compression requires advanced simulation techniques, which provide the possibility to optimize the experimental arrangements after validation with measured data.

To capture the important physical mechanisms and spatio-temporal couplings in high energy thin plate post-compression, we developed a full 3+1D numerical code, which can handle long distance propagation with large aperture beams. We implemented a highly efficient propagation model using the advanced Fourier transform [2]. After validation with results from the literature, capabilities of the simulation code were tested by investigating the post-compression of the SYLOS Experimental Alignment (SEA) laser of ELI-ALPS [3]. We took the 12 mJ and 12 fs pulses, which are obtained after spatial filtering, and propagated through the optical system consisting of consecutive focusing and collimating mirrors, and three 200 μm thick fused silica plates as the nonlinear media. The intensity on the plates was tuned by translating them along the optical axis in respect to the focus.

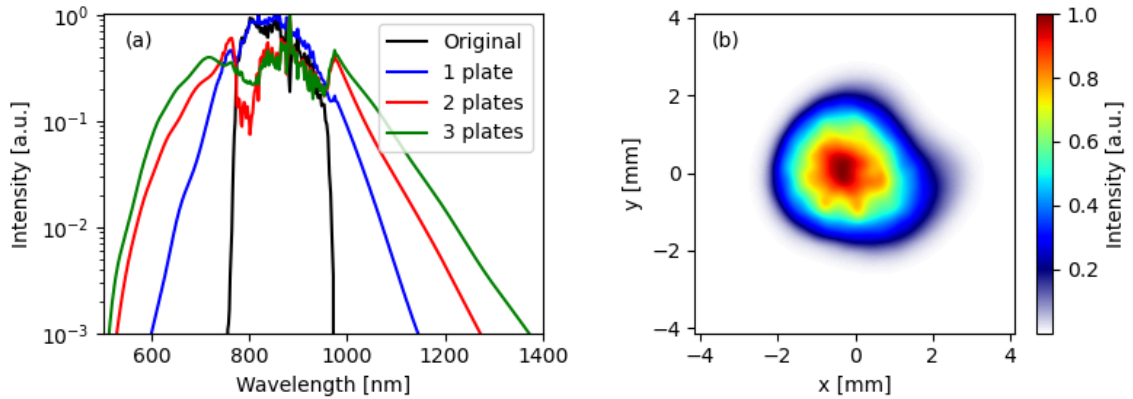


Fig. 1. Spectral (a) and spatial (b) intensity distribution of the spectrally broadened pulses on the last collimating mirror.

The results of the numerical simulations were compared to experimentally obtained data, after each plate, and a good agreement in the output spectra and spatial profiles was found. Upscaling of the method to 100 mJ and 1 J is also under consideration.

References

- [1] M. Stanfield et al, Opt. Express 29, 9123-9136 (2021).
- [2] Sz. Tóth, PhD thesis, University of Szeged, (2021).
- [3] Sz. Tóth et al, J. Phys. Photonics 2 (2020) 045003.