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Coherent Beam combining of 37 femtosecond fiber amplifiers

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For the last few years, coherent beam combining (CBC) has been drastically increasing the performances of ytterbium-doped femtosecond fiber amplifiers, up to more than 10 mJ output energy and to the multi-kilowatt level [1,2]. CBC consists in coherently adding the output beams of several independent amplifiers seeded by a common source. This method involves both an efficient combination process along with a phase detection and control technique applied on all the beams to combine. However, for femtosecond pulses to reach the Joule level and address applications such as particles acceleration, several thousands of fibers need to be combined. Thus, highly scalable CBC architectures along with adapted phase measurements techniques need to be investigated.

The XCAN project, a collaboration between Ecole Polytechnique and Thales, aims at demonstrating such a highly scalable CBC system in the femtosecond regime, involving 61 fibers as a target point. It consists in a tiled-aperture configuration where the fibers are stacked in a hexagonal array and collimated by a hexagonal microlens array. Besides, an interferometric phase measurement technique is implemented, which allows to determine the phase shifts of all the beams in one single frame acquired from a fast camera and to correct them with a kHz bandwidth feedback loop. This detection method has been demonstrated to be theoretically scalable up to about 10,000 fibers [3]. First proof of principles of the XCAN project have been published with 19 passive fibers and 7 high power fiber amplifiers [4,5]. In this paper, we report on the CBC of 37 fiber amplifiers in the femtosecond regime in the way towards our goal of 61 channels.

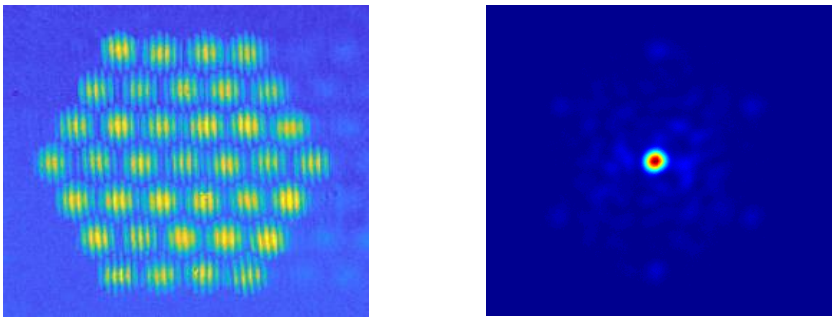

Fig. 1 Near field of 37 beams interfering with a reference plane wave for phase measurement (left) and corresponding far field (right).

In Fig. 1 is plotted the experimental near field (left), made of the juxtaposition of 37 amplified and collimated beams, interfering with a reference plane wave on a dedicated phase detection channel. The corresponding far field (right) is measured at the focal plane of a simple lens, when the fiber array is phase-locked. Preliminary results show excellent phase and beam pointing stabilities. The system is ready to be operated at various power and nonlinearity levels whereas the channel count is currently increasing towards 61. Further experimental results will be presented at the conference.

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