The quest for high repetition rate PW lasers: record 750TW @ 10Hz

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We present here the latest results achieved in the development of High Repetition Rate Petawatt lasers. It is by now apparent that besides the ultrahigh peak power, the users demand also higher and higher repetition rates in a user-friendly and robust system configuration. Increasing the repetition rate in high energy lasers requires mastering several parameters, with thermal management and the stability playing a key role.
Amplitude has recognized early on the need for such user-friendly lasers that go beyond just achieving the one-time record for peak power. Towards this end, we engaged in the necessary development, notably in the frame of two important European projects: the HF laser for ELI-ALPS in Hungary and the ReLaX laser for HIBEF in Germany. We present the developments necessary to reach simultaneously the highest repetition rate for lasers in this class, e.g., specific pump lasers (50J@10Hz), high average power cryogenic cooling. We will then show the achieved results which already constitute a record for such systems (750 TW @ 10 Hz).
The HF laser system at the ELI ALPS user facility in Szeged, Hungary is a unique laser system (Figure 1) to provide in its final configuration 2 PW @ 17 fs, at 10 Hz. The design of the HF laser system follows the typical architecture based on an OPCPA front-end (R&D program with FASTLITE, Institut d'Optique, CEA) which seeds the PW-class CPA Ti:Sapphire laser with broadband pulses and ultra-high temporal contrast. Simultaneously, an additional output with 1 mJ, 10 fs @ 100 Hz is provided.

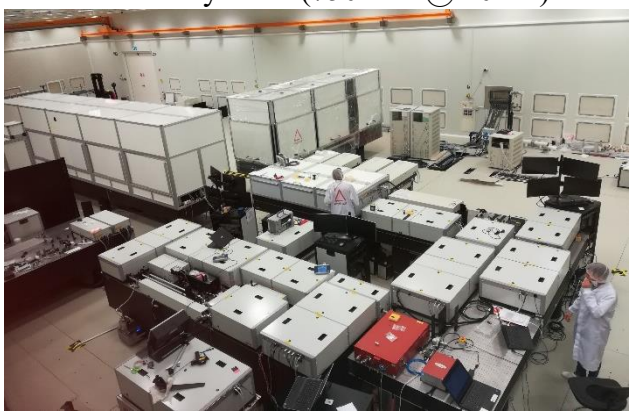

Figure 1: The HF laser system @ ELI-ALPS

With no appropriate pump laser solution available for achieving 50 J @ 10 Hz (before compression), we successfully developed a new generation of pump lasers – the Premiumlite which delivers 50 J @ 10 Hz in one beam as we will show. The unique design of this laser also allows its integration in high-energy OPCPAs. Record breaking output specifications for the system have already been achieved: 750 TW @ 10 Hz - the highest average power demonstrated in an ultrafast PW-Class laser.
The unprecedented power for a laser in this class requires also careful downstream handling - the beam transport line and experimental setup. Hence, ELI ALPS will operate the HF laser around 500 TW @ 2.5 Hz, 22 fs for the first five-days-a-week campaigns to start in 2023.
The quest for high repetition rate PW lasers goes on, and we will share in this presentation our future roadmap for increasing the peak power @ 10 Hz and the repetition rate up to 100 Hz and beyond. Such developments are recognized as necessary for establishing laser-based accelerators as viable tools for the user communities.

[1] http://www.eli-hu.hu/