Prospective of multiple stages mJ energy level and ultrashort pulses OPA generation at Extreme Light Infrastructure-Nuclear Physics (ELI-NP)

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In the last decade, there was a significant progress in the femtosecond high power laser technology, which materialized in a couple of PW class laser systems that were worldwide installed. High Power Laser System (HPLS) of ELI-NP (Extreme Light Infrastructure - Nuclear Physics) research infrastructure delivers up to 10 PW laser pulses in two beamline arms. Output beams of 1 PW/1 Hz and 100 TW/10 Hz are available too [1].

Femtosecond laser pulses with more than 10 mJ energy at 1300 nm wavelength are necessary for experiments of dark matter search using four wave mixing, proposed at ELI-NP [2]. High-energy near-infrared (NIR) femtosecond laser pulses can be obtained in multi-stage optical parametric amplification (OPA) systems with nonlinear crystals pumped by femtosecond pulses at 800 nm. BBO crystals represent a good solution for NIR fs laser pulses OPA [3]. Because of intrinsic growth issues, the clear aperture of BBO crystals is restricted to 20 mm diameter. Due to limitations imposed to the LIDT fluence, the energy of amplified 1300 nm fs laser pulses in BBO crystals is restricted to few-mJ. For the generation of more than ten-mJ 1300 nm fs laser pulses, nonlinear crystals with larger than 50 mm clear aperture are necessary. 100-mm size YCOB crystals with good nonlinear optical properties can be grown [4]. The type I collinear OPA at 1300 nm in *xy* plane of YCOB crystals, has some significant features which contribute to a broad parametric gain bandwidth, an increased parametric interaction length and a high conversion efficiency, allowing an efficient amplification of 20-fs signal laser pulses.

A tiny fraction of the 100 TW Ti:sapphire femtosecond laser pulses is focused into a sapphire plate [5] to generate seed pulses by white-light generation in the NIR spectral range. The wavelength selection in the 1300 nm spectral range occurs in the first BBO OPA stage by adjusting the phase-matching angle in the crystal. The seed energy is boosted up to more than 10-mJ in the final OPA stage using a large diameter YCOB crystal, pumped by 800 nm femtosecond laser pulses of several-ten mJ – 100 mJ energy at ~100 GW/cm^2 intensity. The timing synchronization between seed and pump pulses play a critical role and must be achieved using precise delay lines with femtosecond temporal resolution.

In this contribution, the preparatory experimental set-up with multiple OPA stage configurations using different nonlinear crystals (BBO and YCOB) and the key experimental challenges will be discussed.

References

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