Versatile, compact and highly stable OPCPA seeder for modern LPA laser drivers

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Abstract

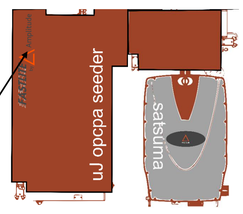
Recent developments in ultrafast Ytterbium lasers have triggered advances in light sources based on parametric processes, mostly due to their ability to generate a stable, broadband continuum by filamentation in a bulk crystal. The ability of these third-generation sources to produce optical pulses with cutting-edge properties like bandwidth, CEP stability and temporal quality make them ideal candidates for seeding high power amplifiers involving different technologies.

System architecture

µJ and mJ level seeder

Choice of a highly modular system architecture

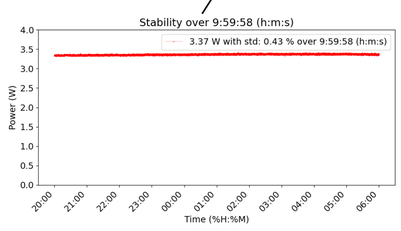
- We address most of the custom demands with tested modules
- Use of a **very low maintenance pump laser for first stages** → always a seed even at lower level
- Highly stable seed output parameters
- Motorized system for remote maintenance



1) µJ level system architecture

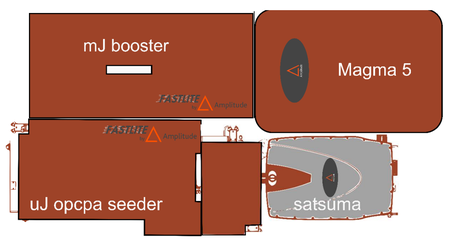
Satsuma:

- 40 µJ pulse energy
- < 300 fs pulse duration
- < 0,5% shot-to-shot and long-term stability
- All fiber laser for reliability
- Single shot to 500 kHz repetition rate



Magma:

- 5 mJ pulse energy
- < 500 fs pulse duration
- < 0,5% shot-to-shot stability
- < 1 % long term stability
- 100 Hz repetition rate
- Common oscillator to satsuma



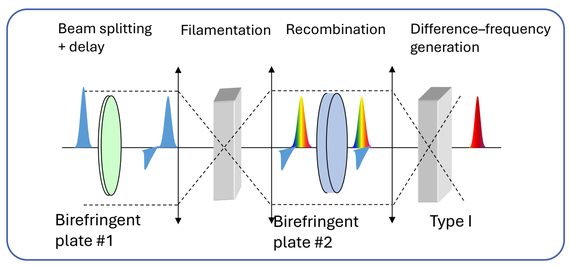
2) mJ level system architecture

Optical architecture: inline DFG

All optical delay management
→ **Good passive stability**

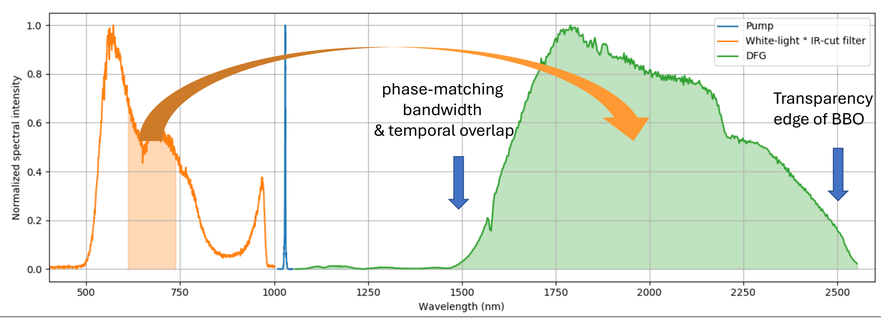
Difference frequency generation
→ **CEP + contrast**

Large bandwidth
→ **tunability, short pulses**



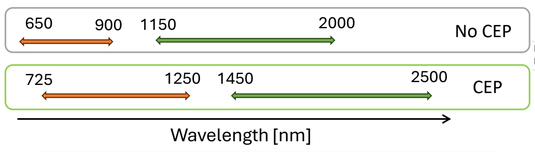
Patented design

Example #1: DFG in a type-I BBO crystal with the “visible” part of the white-light

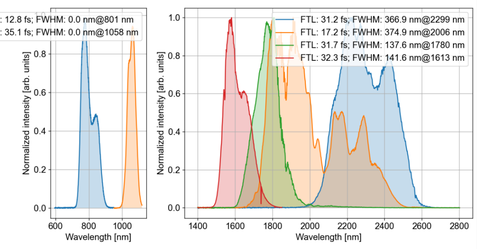


Spectral properties and stability

- Architecture compatible with seed generation from:

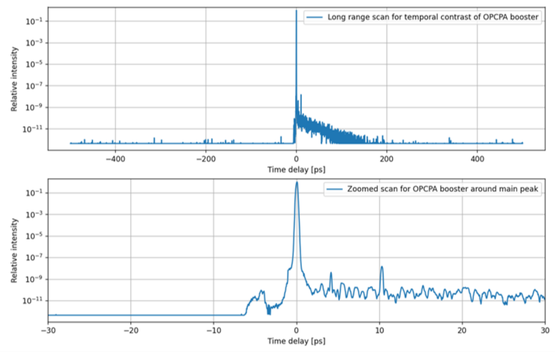


Central wavelength	Typical FTL pulse duration
800 nm	15 fs
1 µm	30 fs
1.5 µm – 2.5 µm	30 fs
2 µm	20 fs



Temporal contrast

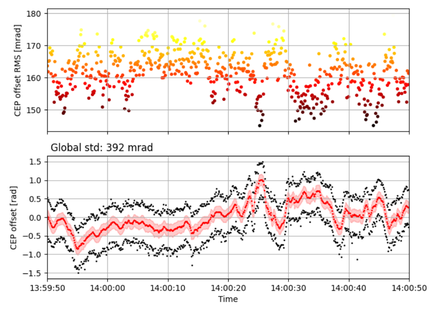
- Contrast measured with Sequoia device
- Dazzler included in amplification chain for high order phase term correction
- Output pulse energy : > 500 µJ



Spectral properties and stability

- Active stabilization between 2 pumps → fiber delay line between oscillator and magma
- No fast jitter
- Only slow drift due to thermal effects.

CEP stability



CEP measured at µJ seeder output

- (Top) : rolling (1000 shots) passive CEP noise
- (Bottom) : rolling (1000 shots) average of CEP offset (with std, min and max)
- Values shown here are **routinely obtained**!
- **No active stabilization**
- Part of the beam still not covered (turbulence)
- **Typical CEP between 150 mrad and 200 mrad at 800 nm**
- **Typical CEP noise in SWIR spectral range : 100 – 150 mrad**

Conclusion

We present a modular seeder with very high optical quality parameters aimed to seed large amplifiers of various technologies. It is considered as « universal » since it can adapt in terms of wavelength, spectrum and pulse energy to most of the amplifying technologies available today for ultrafast light sources. Its state-of-the-art temporal contrast makes it ideal for seeding high energy systems where temporal contrast is a key parameter for laser-matter interaction at high intensity. Its CEP stability (in tandem with a dazzler device) and short pulse duration is highly relevant for attosecond pulse generation.