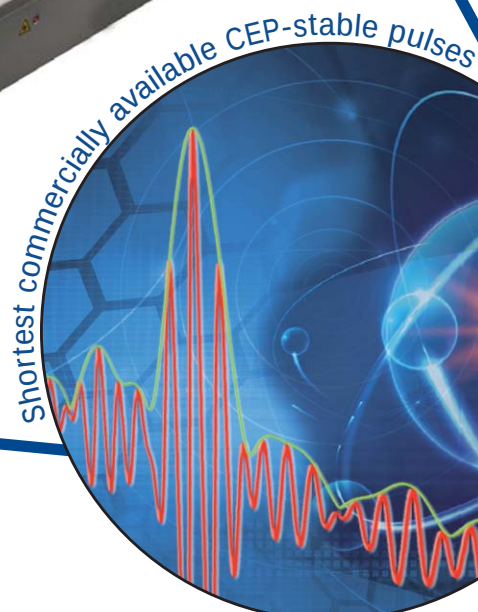
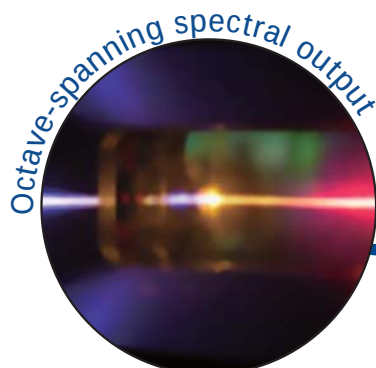
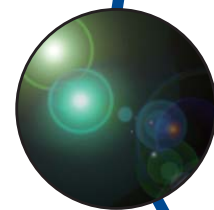
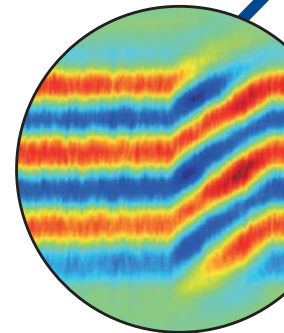
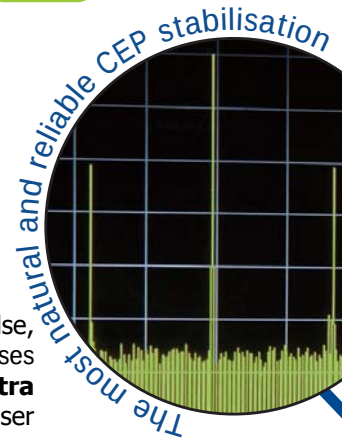


- Pulse duration <5.5 fs (FTL), <6 fs (measured)
- Average output power ~220 mW
- Fully configured CEP locked laser
- Integrated pump laser with CEPLoQ™ technology

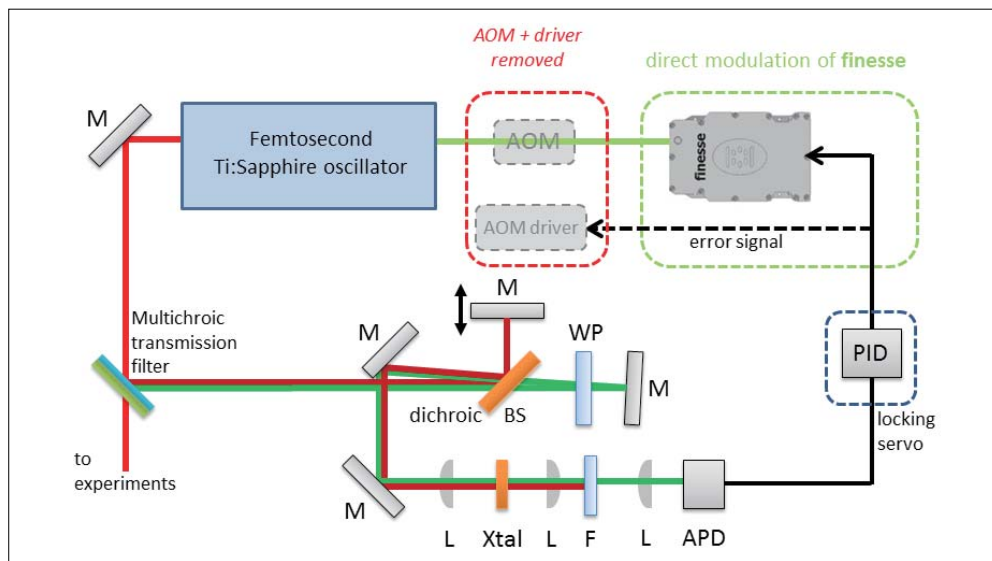
Overview

The **venteon CEP5** is a fully configured ultra-short pulse, carrier envelope phase (CEP) stabilised laser system that utilises the exceptional spectral characteristics of the **venteon ultra** oscillator, for a direct realisation of sub-two cycle CEP stable laser pulses, with less than 50 as timing jitter. Comprising the **venteon ultra** octave spanning laser, the **venteon CEP5** system includes an f-to-2f interferometer for f_{CEO} beat generation and the ultra-low noise **finesse pure CEP** pump laser featuring CEPLoQ™ technology that enables CEP stabilisation without AOM power modulation and all the associated electronic controls.

The spectral bandwidth of the **venteon ultra** laser system supports pulse durations well below 5 fs directly from the oscillator. Its octave-spanning output is sufficiently broad for a direct CEP stabilisation of the pulses, realising the f-to-2f beating without any additional spectral broadening by either a PCF or PPLN device. Only 10% of the output power is used by filtering the edges of the output spectrum, leaving more than ~220 mW and sub-6 fs pulses available for subsequent experiments. This is the most natural, direct and reliable approach for realising a CEP stabilisation without distorting the laser output beam and giving an excellent long-term locking performance.



The second advancement is the feedback system that inputs the processed signal directly into the pump laser using CEPLoQ™ technology rather than an AOM system, placed before or after the oscillator. This is achieved by directly controlling a $\pm 1\%$ power modulation of the pump laser, covering a range of DC to 1 MHz, with better than 90 degrees phase behaviour up to 700 kHz, leading to a more stable locking bandwidth than traditional methods. The combination of these two innovative technologies delivers a CEP stabilised laser using the most direct and natural scheme possible today, with true sub-two cycle sub-5.5 fs pulses in an unaffected high quality output beam in a compact housing that requires minimal maintenance.

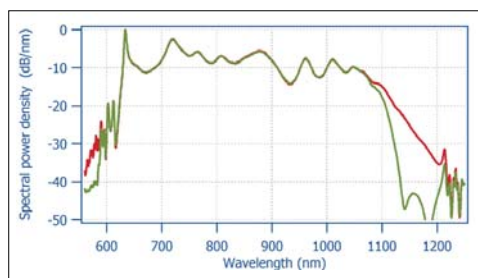


Schematic of CEP5 locking scheme with **finesse pure CEP** using CEPLoQ™ technology.

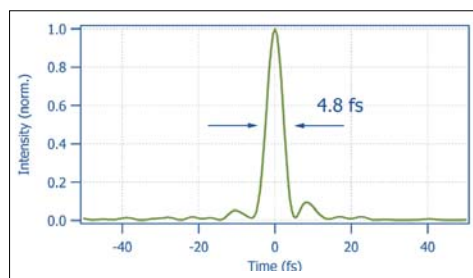
Typical venteon CEP5 data

The modular realisation of the laser system allows for an easy separation of laser oscillator and f-to-2f module. If CEP stabilisation is not required, the f-to-2f module can be detached and the full oscillator characteristics, comparable to the **venteon ultra**, can be applied. This ensures the maximum flexibility for many ultrafast applications.

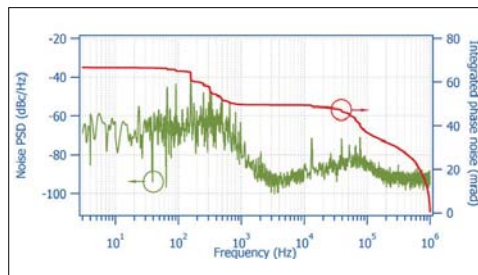
Laser Quantum supports clarity in reporting pulse duration and detailing whether our figures are theoretical values based on Fourier transform calculations or actual measured durations using **SPIDER** technology and instrumentation. In the case of the **venteon CEP5**, the Fourier transform specification is < 5.5 fs, with a measured pulse of < 6 fs. The small difference between these two values demonstrates the excellent phase control of the laser.



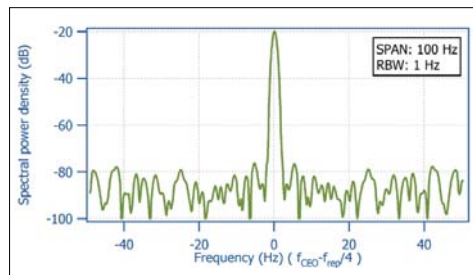
Full oscillator output spectrum (red) and usable **venteon CEP5** output spectrum (green) where the spectral wings for realising the CEP stabilisation have been filtered.



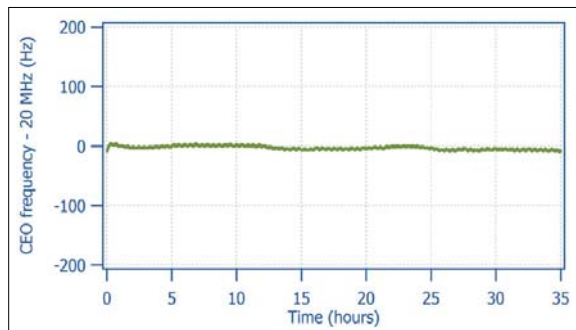
Typical few-cycle pulse with a duration as short as 4.8 fs (measured with a **SPIDER**).



Integrated phase noise of the stabilised beat note featuring 68 mrad (1 MHz - 3 Hz).



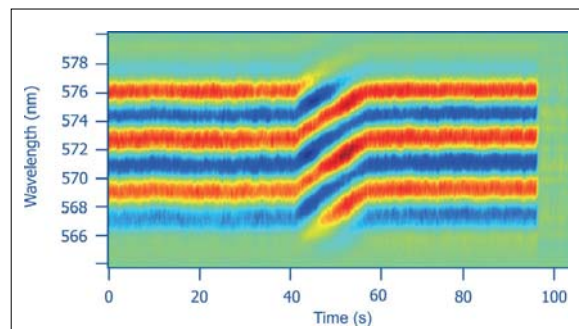
Zoomed-in stabilised CEP beat note recorded with 1 Hz resolution bandwidth.



Long-term tracking of the stabilised CEP beat; The automated wedge control enables the **venteon CEP5** to operate CEP locked over days.

Options and upgrades

The **venteon CEP5** can be ordered with a CEP-zero option to stabilise the carrier-envelope-offset frequency to zero, generating a pulse train with constant CE phase (versus every fourth in standard configuration). This system allows for field sensitive experiments at full oscillator power and repetition rate without the need for sophisticated pulse picking.



Out-of-loop measured interference of 10^{11} oscillator pulses proving an excellent CEP-lock. The CEP is tuned by inserting glass wedges in the extra-cavity beam as shown in the middle part of the picture.

Rausch et al. Optics express 17,20282-20292 (2009)

Related systems

The **venteon dual** laser system represents the ideal front-end for broadband few-cycle OPCPA applications. The spectral bandwidth of this laser allows for the generation of broadband sub-5.5 fs pulses as a signal for a NOPA stage and additionally provides sufficient pulse energy for seeding a Yb-based amplifier pump stage. The pulses are provided by two separate output ports and are intrinsically self-synchronised with ultra-low timing jitter. If a CEP stabilised laser system is required for realising a CEP-stable OPCPA, the **venteon dual** laser system can be ordered with a CEP option featuring the CEP5 stabilisation technology and performance.

PST option: Preparation for repetition rate stabilisation, including a slow and fast piezo/stepper motor unit to add fine control of cavity length and repetition rate.

TL-1000 timing stabilisation: Locking electronics, photodiode, RF analyser and oscilloscope needed for full timing stabilisation of the laser system (requires PST option).



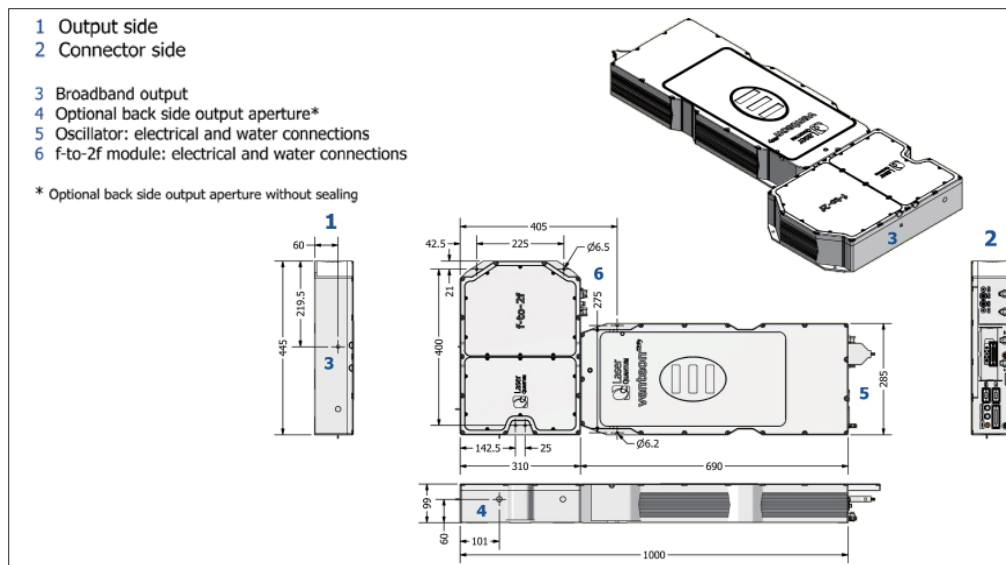
CEPLoQ™ technology that directly modulates the pump power to maintain phase stabilisation without the use of an AOM, allowing faster responses than the traditional method.



The **venteon CEP5** laser system features a set of remote control capabilities including remote starting, adjustment and dispersion control. Together with the provided user-control software, the laser system can be handled, monitored and maintained on a day-to-day basis without manual intervention. Upon installation, our service engineers will provide detailed training on the laser system and all associated components. If service is required, the user control software allows our service engineers to connect to the laser system to remotely check and optimise the laser, ensuring speedy and efficient help and support.



Dimensions (mm)



Drawings are for illustrative purposes only. Please contact Laser Quantum for complete engineer's drawings.

Other information

- Water cooling included
- System chiller included
- Locking electronics included
- All required measurement equipment included (oscilloscope, RF analyser)
- Weight 50 kg
- 2 year warranty

Specifications*

	venteon CEP5
Average power output	~220 mW
Pulse energy (@80 MHz)	~2.75 nJ
Central wavelength ¹	830 nm +/- 30 nm
Spectral bandwidth (@-10 dBc)	>380 nm
Pulse duration (Measured) ²	<6 fs
Pulse duration (FTL)	<5.5 fs
RMS noise ³	<0.1%
Integrated pump	finesse pure CEP 6 W
Divergence	<1 mrad
CEP phase noise ⁴	<100 mrad
SNR for f _{ceo} -beat (@100 kHz RBW)	>30 dB
M-squared	<1.2
Power stability (Over 24hrs)	<1% RMS
Repetition rate	80 MHz +/- 100 kHz

* Laser Quantum operates a continuous improvement programme which can result in specifications being improved without notice.

¹ Measured as the spectral centroid

² Achieved using optional extra cavity dispersion compensation

³ Noise bandwidth 1 Hz to 10 MHz measured using finesse pure pump laser

⁴ Noise bandwidth 3 Hz to 1 MHz derived from RF side-band analysis

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