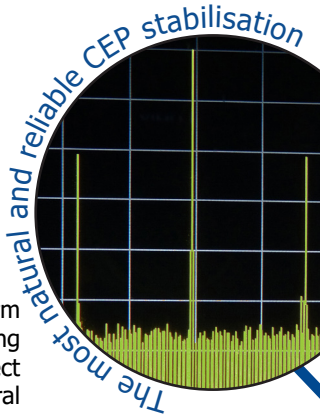
# venteon CEP5

5.5 fs CEP stabilised laser system

Laser Quantum
A Novanta Company

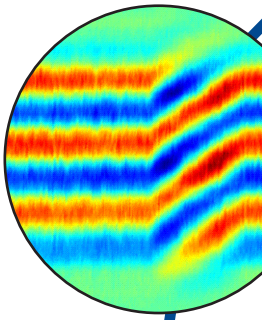
- Pulse duration <5.5 fs (FTL), <6 fs (measured)
- Average output power >220 mW
- Fully configured CEP locked laser
- Integrated pump laser with CEPLoQ™ technology



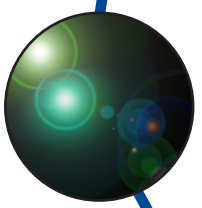

## Overview

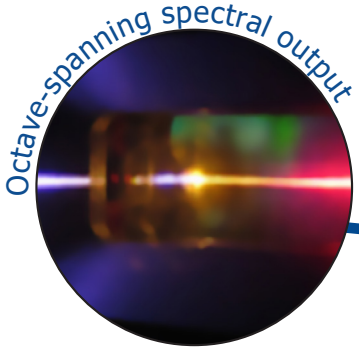
The **venteon ultra** oscillator directly delivers Fourier-transform limited (FTL) pulse durations well below 5.5 fs. The corresponding octave-spanning spectrum is sufficiently broad for a direct CEP stabilisation of the pulses without any additional spectral broadening by either a PCF or PPLN device.

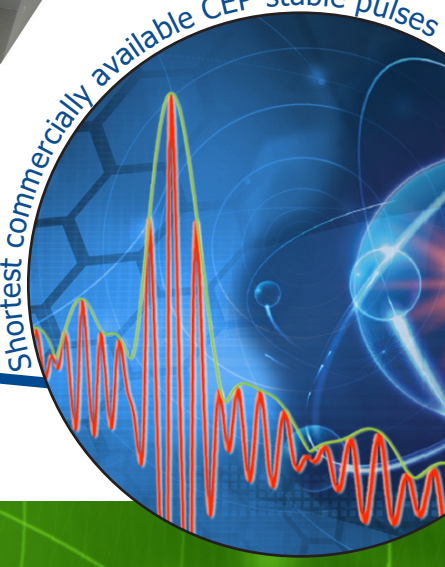
In the **venteon** f-to-2f interferometer, f- and 2f components are spectrally filtered from the octave-spanning spectrum for f-to-2f beating, leaving more than 220 mW output power and <5.5 fs FTL pulse duration available for subsequent experiments. This is the most natural, direct and reliable approach for realising a CEP stabilisation without distorting the laser output beam and giving an excellent long-term locking performance.



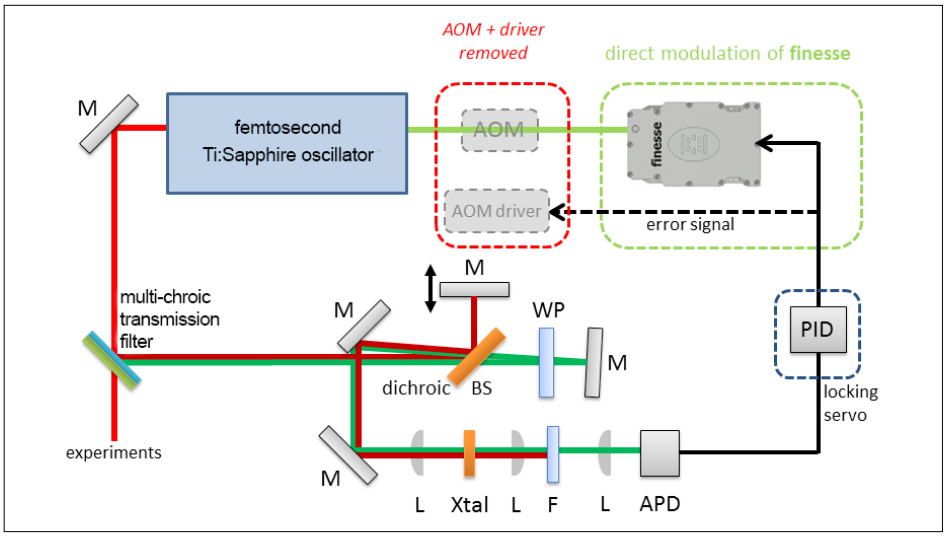
In addition to the advantage of direct f-to-2f beating, the feedback signal for CEP stabilization can be directly applied to the **finesse pure** CEP pump laser using using CEPLoQ™ technology rather than an acousto-optic modulator placed before or after the oscillator. This is achieved by directly controlling a ±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 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 ±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 <6 fs pulses in an unaffected high quality output beam within a compact housing that requires minimal maintenance.

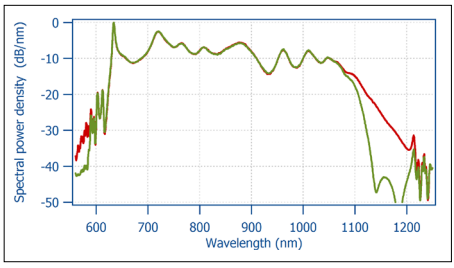



Schematic of CEP5 locking scheme with **finesse pure CEP** using CEPLoQ™ technology.

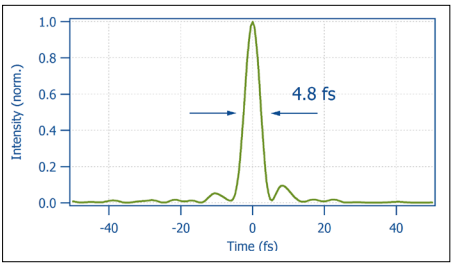
## Typical venteon CEP5 data

The modular realisation of the **venteon CEP5** laser allows for an easy separation of **venteon ultra** oscillator and **venteon** f-to-2f module. If CEP stabilisation is not required, the **venteon** f-to-2f interferometer module can be detached and the full oscillator characteristics can be used for experiments. This ensures the maximum flexibility for many ultrafast applications.

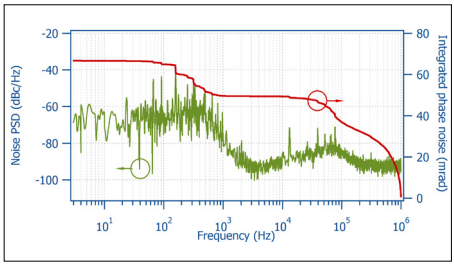
Laser Quantum supports clarity in reporting pulse duration and detailing whether our figures are theoretical values based on Fourier transform calculations or actual measured durations using **SPIDER** technology and instrumentation. In the case of the **venteon CEP5** laser, the Fourier transform specification 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.



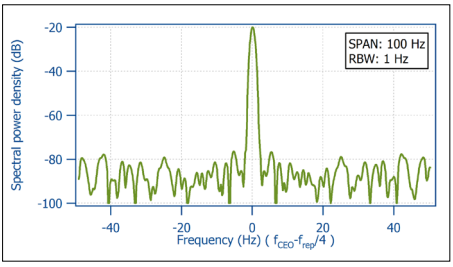

**venteon ultra** oscillator output spectrum (red) and CEP-stabilised output spectrum (green) of the **venteon CEP5** laser. Spectral wings are filtered and used for CEP-stabilisation.




Typical **venteon CEP5** output pulse, measured with **SPIDER** after external pulse compression.



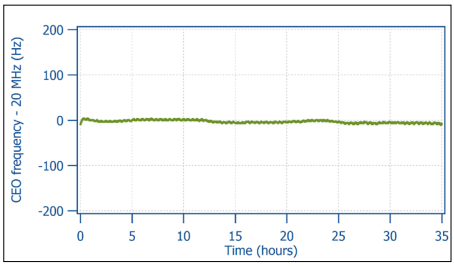

Integrated phase noise of the carrier envelope offset beat signal featuring 68 mrad (1 MHz - 3 Hz).



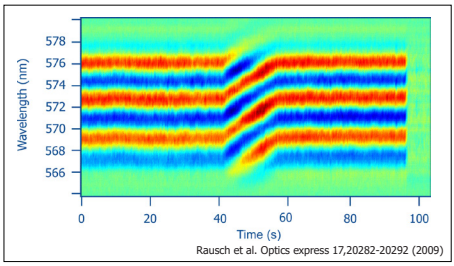

Zoomed-in stabilised carrier envelope offset signal featuring 1 Hz resolution bandwidth.

# 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.




Long-term tracking of the carrier envolope offset frequency, locked to a quarter of the repetition rate. Automated dispersion control enables the **venteon CEP5** to operate CEP locked over several days.




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.

# Related systems

The **venteon dual** laser represents the ideal front-end for broadband few-cycle OPCPA applications. The spectral bandwidth of this laser allows for the generation of broadband (<5.5 fs) pulses as a signal for a NOPA stage and additionally provides sufficient pulse energy for seeding an 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 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.

## Other information

- Weight (head + f-to-2f module only): 47 kg
- Cooling system included
- 2 years/5000 hours (PSU 'on' time) full specification warranty
- Locking electronics included
- All required measurement equipment included (oscilloscope, RF analyser)

# venteon CEP5

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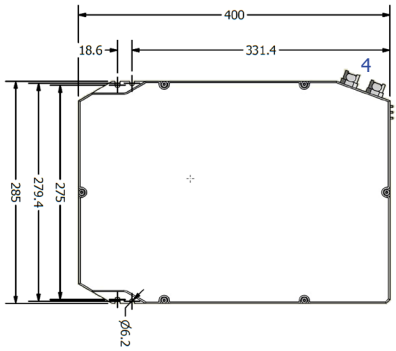
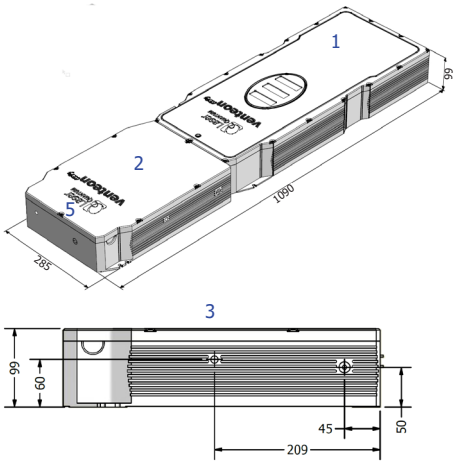
## Dimensions (mm)

1 **venteon** oscillator
2 **venteon** module
3 Broadband output
4 Electrical and water connections
5 Alternative front-side outputs (choose upon order)







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

## Specifications*

| | venteon CEP5 |
|---|---|
| Average power output | >220 mW |
| Pulse energy | >2.75 nJ |
| Central wavelength[1] | 830 nm ± 30 nm |
| Spectral bandwidth (@-10 dBc) | >300 nm |
| Pulse duration[2] (Measured) | <6 fs |
| Pulse duration (FTL) | <5.5 fs |
| RMS noise[3] | <0.05 % |
| Beam diameter[4] | 1.2 mm ± 0.3 mm |
| Divergence | <3 mrad |
| M-squared | <1.2 |
| Power stability (RMS within 24 hrs) | <1 % |
| Repetition rate[5] | 80 MHz |
| SNR for fceo-beat (@100 kHz RBW) | >30 dB (>27 dB with CEP zero option) |
| CEP phase noise[6] | <100 mrad (<150 mrad with CEP zero option) |
| Polarisation direction | horizontal |
| Polarisation ratio | >100:1 |
| Operating temperature | 21 °C +/- 3 °C |
| Warm-up time | <20 min |
| Weight (head only) | 30 kg |

*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 1 MHz
[4] FWHM beam diameter at laser exit
[5] Repetition rate accuracy +/-100 kHz. Other repetition rates available upon request
[6] Noise bandwidth 3 Hz to 1 MHz derived from RF side-band analysis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