VENTEON Company Introduction

MEDEA Kickoff Meeting

20.1.2015

Thomas Binhammer
VENTEON Laser Technologies GmbH
Hollerithallee 17
30419 Hannover
www.venteon.com

Company Information

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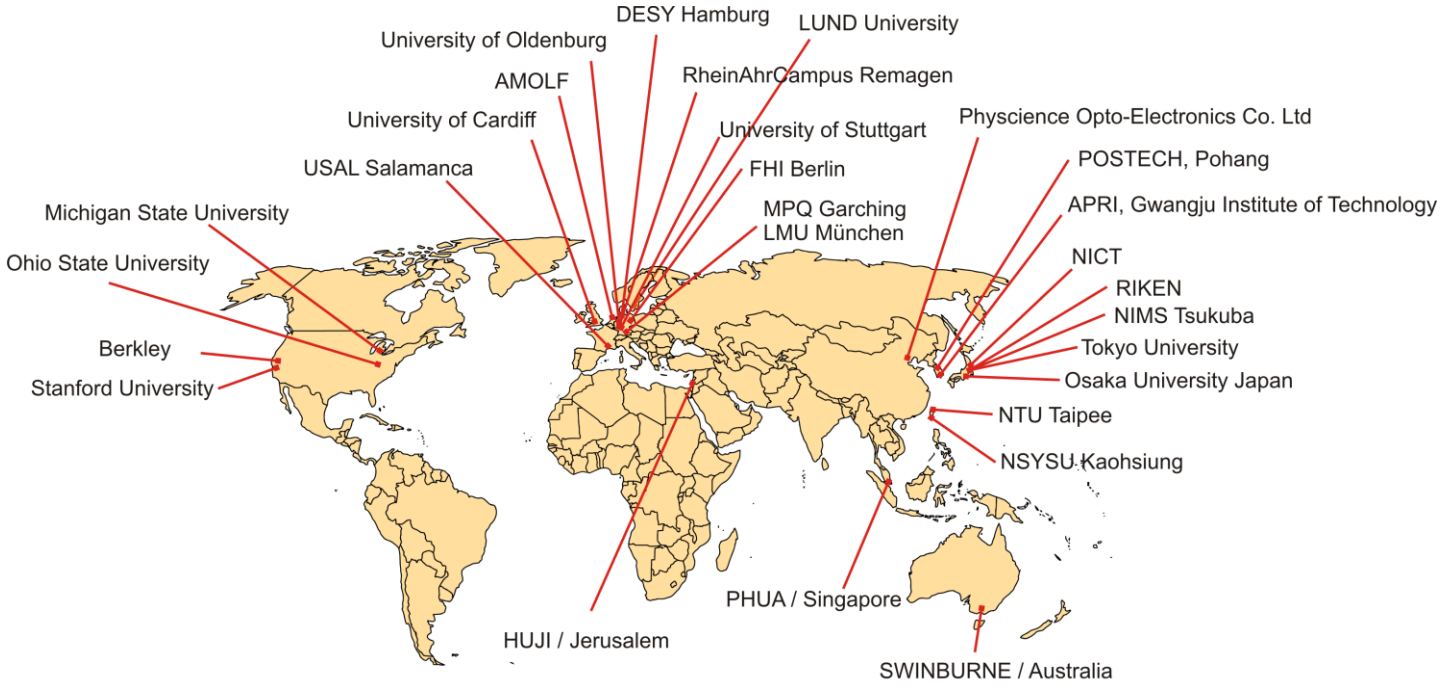
- **VENTEON Laser Technologies GmbH** was founded in 2008
- First laser systems in the market since 2004 (Nanolayers /MIT)
- Located in Hannover, Germany
- Small, but focussed on ultrashort pulses, scientific market

Selected customers worldwide:



Company Overview

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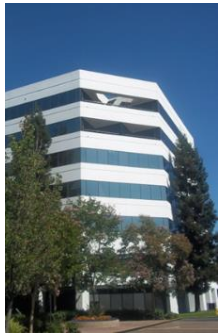
In 2014, after many years of close collaboration, VENTEON eventually became a member of the Laser Quantum group!

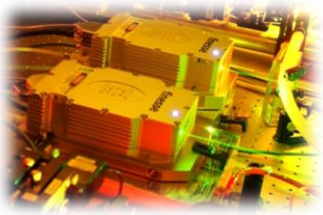
Laser Quantum Ltd

Venteon GmbH

Laser Quantum
INNOVATIVE RELIABLE INTELLIGENT

Laser Quantum Inc





Laser Quantum GmbH

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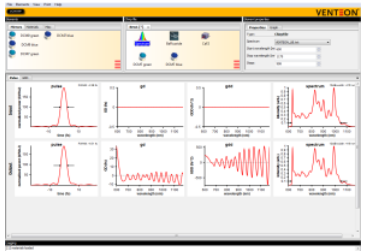
Pulse characterization

Ti:sapphire laser systems

Fiber laser technology

<6fs



Dispersion calculation

Optics & accessories

OPCPA - amplified systems

Laser systems overview:

	BASIC	POWER	ULTRABROAD	CP	OPCPA SEED
Pulse duration	< 8 fs	< 8 fs	< 6 fs	< 6 fs	< 6 fs
Pulse energy (@ 80 MHz)	> 2 nJ	> 7 nJ	> 3 nJ	> 3 nJ	> 2.5 nJ
Average output power	> 200 mW	> 560 mW	> 240 mW	> 240 mW	> 200 mW
Spectral bandwidth	> 200 nm	> 200 nm	> 400 nm	> 400 nm	> 350 nm
Repetition Rate (MHz)	80 MHz	75 - 150 MHz	75 - 150 MHz	75 - 150 MHz	75 - 150 MHz
Additional 1030 nm output	-	-	○	○	●
Pump laser included	●	●*	●*	●*	●*
CEP stabilization	-	○	○	●	○
Repetition rate stabilization	-	○	○	○	○
Dimensions (mm)	260 x 600 x 114	475 x 600 x 165	475 x 600 x 165	750 x 600 x 165	750 x 600 x 165

● standard ○ optional - no option

*also available without pump laser or integration of customers pump laser

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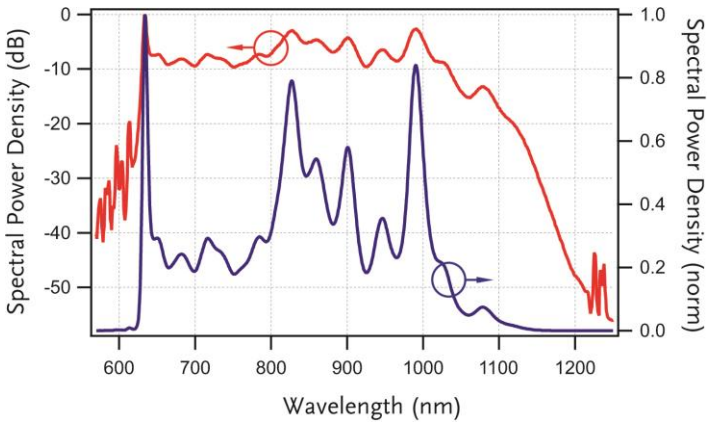
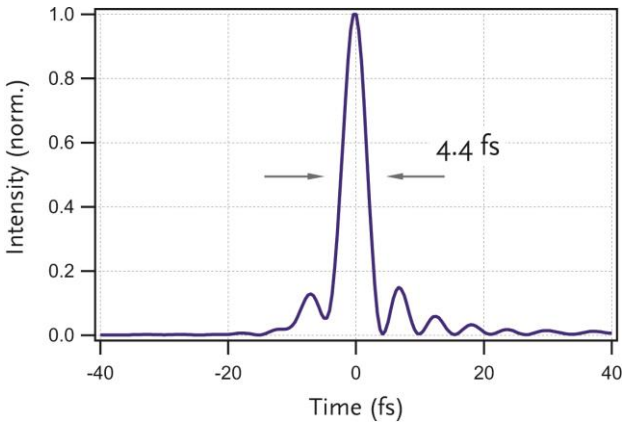
ULTRA BROAD

Spectrum:



Pulse duration: < 8 fs



Benefits and Applications

- Shortest pulses commercially available with typical pulse duration below 5 fs!
- Ultrabroadband spectrum spanning one optical octave
- Direct CEP stabilization possible
- High power at 1030 nm for direct Yb amplifier seeding
- Direct OPCPA seeding with upgrade option for timing stabilization and CEP stabilization

Ultrabroad System running live at the Laser Munich 2013 with sub-5fs measured on-site for the full time of exhibit!

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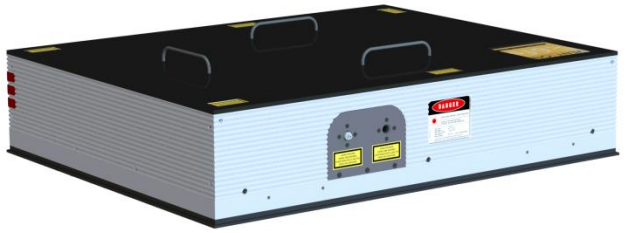
OPCPA SEED – Front-end Laser System for OPCPA seeding

- Based on the Ultrabroad Edition (UB) femtosecond oscillator
- **Dual output** for broadband signal seed pulses < 6 fs and narrowband 1030 nm radiation
- **Octave-spanning spectral bandwidth** supports pulse durations **< 6 fs** directly from the oscillator.
- Sufficient **power @ 1030 nm** directly form the native laser spectrum for **seeding high-power amplifiers**
- Bandwidth sufficient for a direct CEP stabilization without any additional spectral broadening by either a PCF or PPLN device.
- Low-noise DPSS pump laser and the *f*-to-*2f* interferometer directly on a monolithic all-water cooled breadboard.



OPCPA SEED

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Specifications

- **Broadband OPCPA Output (after filtering)**
  - Spectral bandwidth > 350 nm (@ - 10 dBc)
  - Pulse duration **< 6 fs**
  - Repetition rate: 80 MHz
  - Average output power **> 200 mW**
  - Pulse energy **> 2.5 nJ**
  - CEP-lock without additional spectral broadening (optional), specifications above remain
- **Pump-Amplifier Seed Output**
  - Center wavelength: 1030 nm, Spectral bandwidth: 10 nm (FWHM)
  - Spectrally filtered directly from the original VENTEON laser spectrum
  - Pulse energy: free-space: **> 30 pJ** (> 2.4 mW) / fiber-coupled: > 12 pJ (> 1 mW)
  - FC/APC fiber port at the laser enclosure for easy seed pick-up
  - Pre-amplified for optimal amplifier seeding (optional)
  - Pulse duration < 200 fs (Fourier-limited)

OPCPA SEED

VENTEON OPCPA

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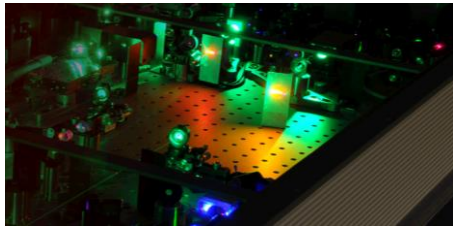
First commercial OPCPA system < 8fs *

Shorter pulses and higher repetition rate than multi-pass amplifier systems



- **Benefits and Applications**
  - Compact and robust design
  - High repetion rate up to 1 MHz
  - Ultrashort pulse duration < 8 fs
  - Low-noise, seeded by
  - CEP stable with slow feedback
  - Ideal source for high harmonic generation or ionization and multi-photon experiments!

* In cooperation with Lund University

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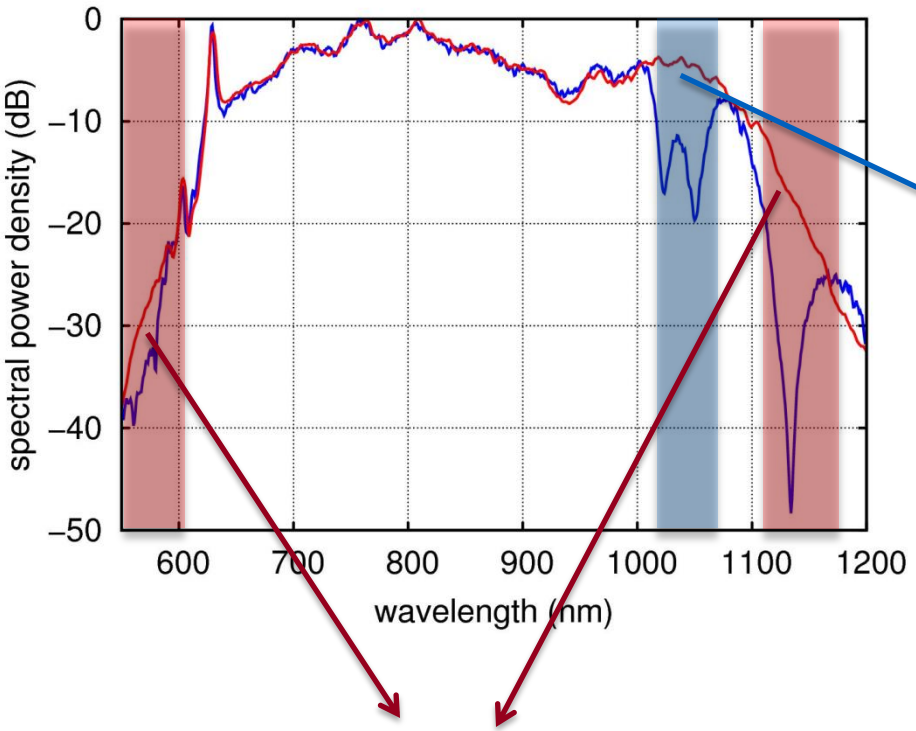
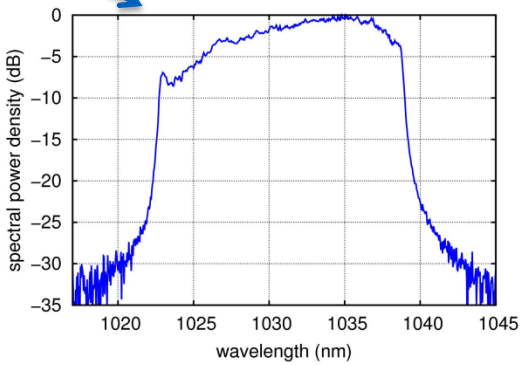
Benefits of an ultrabroadband starting spectrum:



measurement of the CEP beat



spectrum @ 1030nm

- No external spectral broadening necessary!

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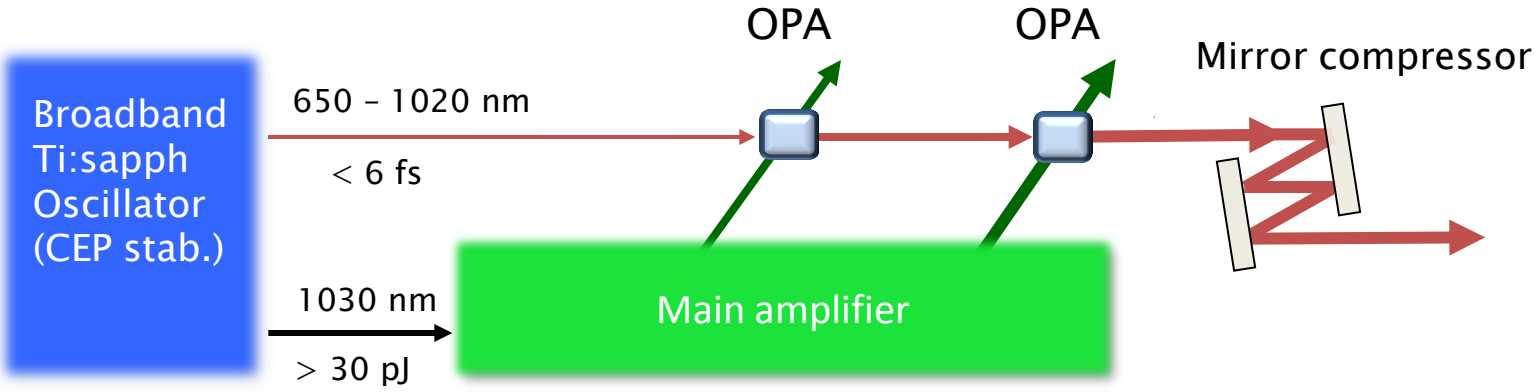
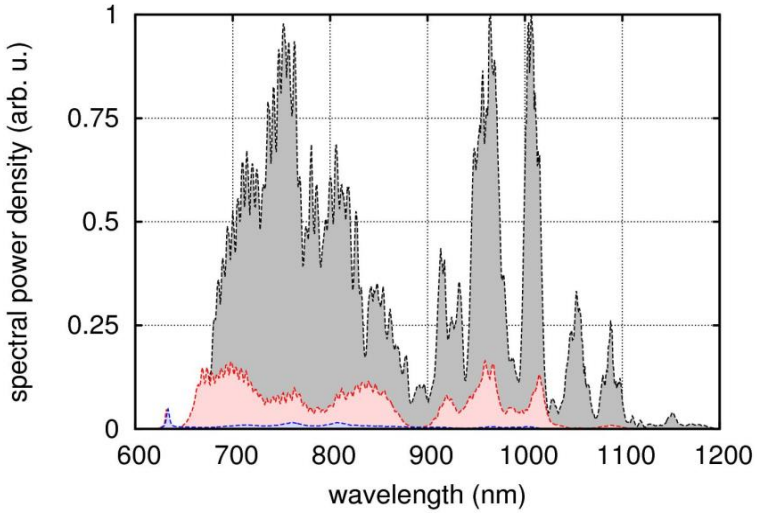
Schematic setup:

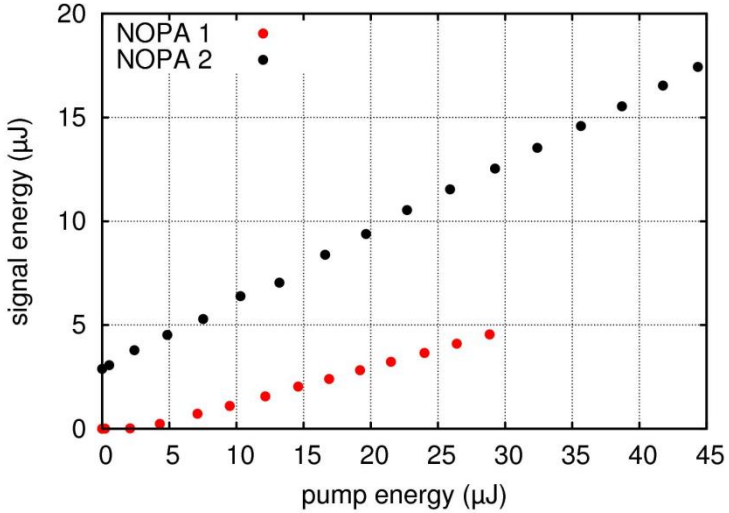


Main advantages:

- Simple, robust setup
- Oscillator bandwidth supports <6 fs pulses
- No nonlinearity needed for seed generation
- Intrinsically low noise and minor timing jitter
- Excellent CEP stability

VENTEON OPCPA



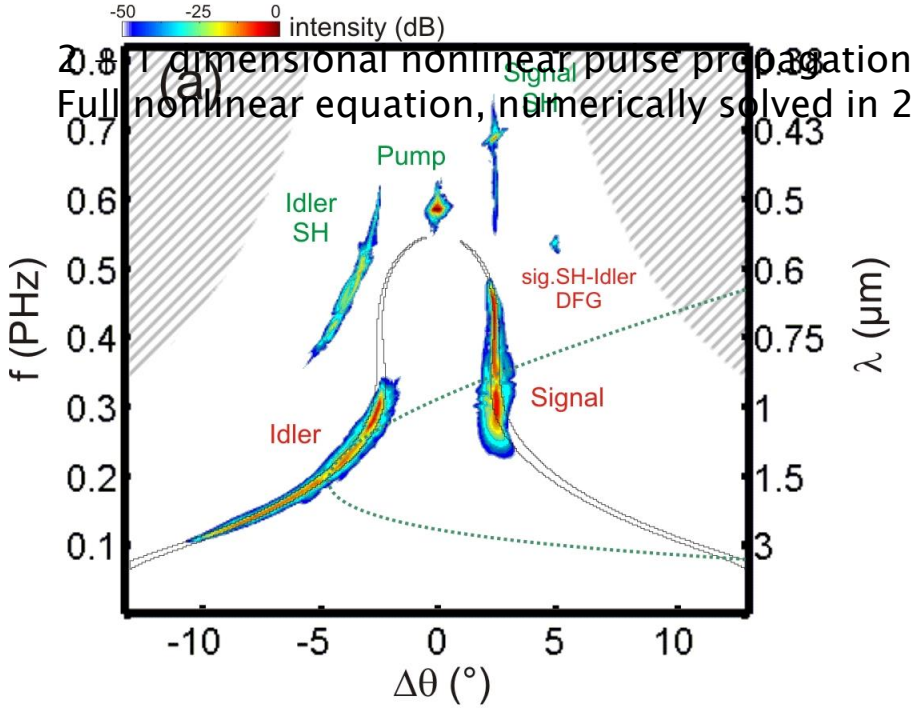


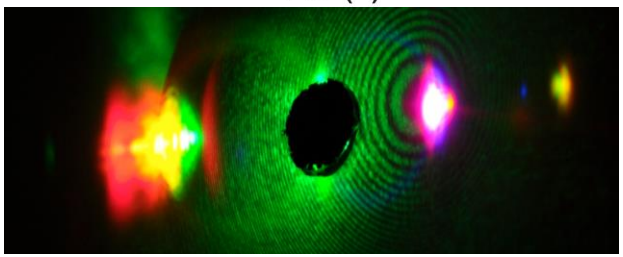
- **first parametric amplification stage:**
  - 5 mm BBO, PVWC geometry, alpha = 2.4°
  - seed energy 1.25 nJ → amplification to 4.5 µJ

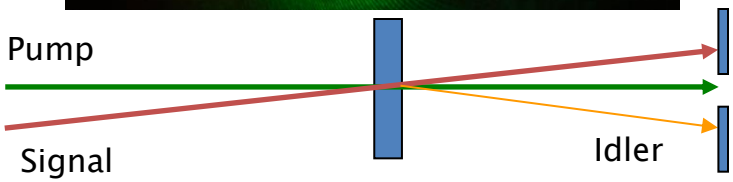
- **second parametric amplification stage:**
  - 5 mm BBO, PVWC geometry, alpha = 2.4°
  - seed energy 3.4 µJ → amplification to 17 µJ

Numerical model for OPCPA

2+1 dimensional nonlinear pulse propagation r
Full nonlinear equation, numerically solved in 2 s







[1]: "Impact of temporal, spatial and cascaded effects on the pulse formation in ultra-broadband parametric amplifiers", Lang et al., Optics Express 21, 949-959 (2013)

Numerical model for OPCPA

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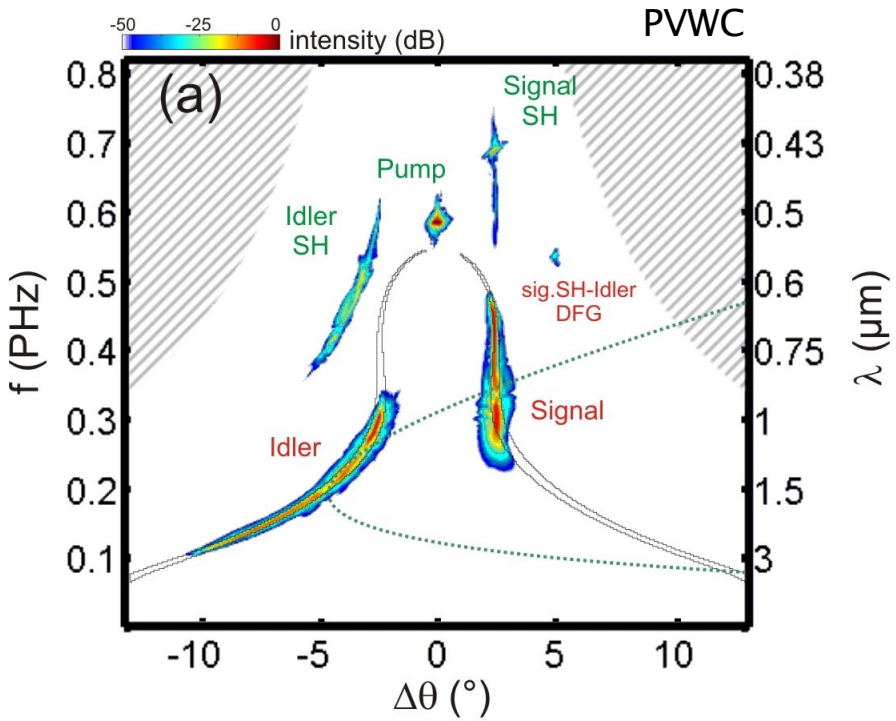
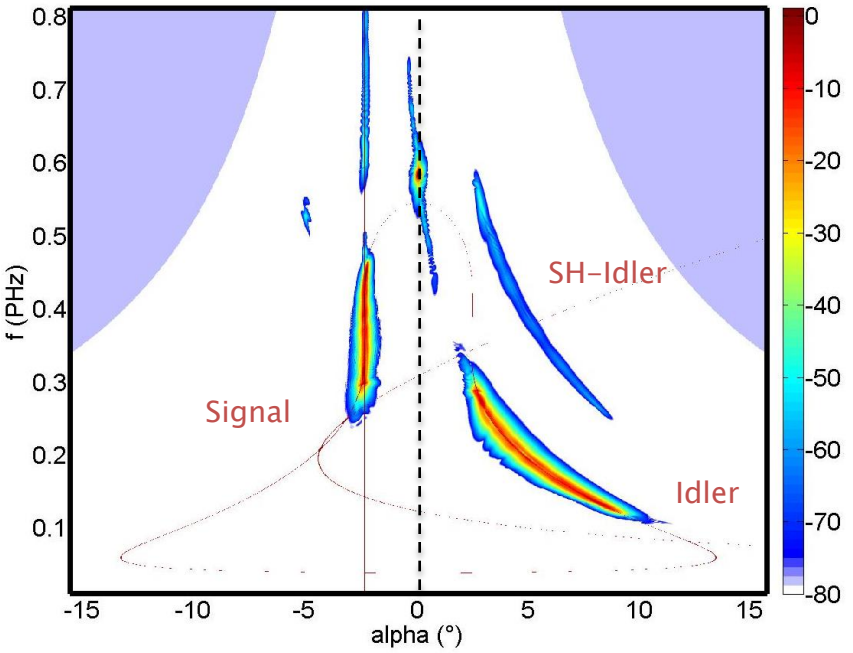
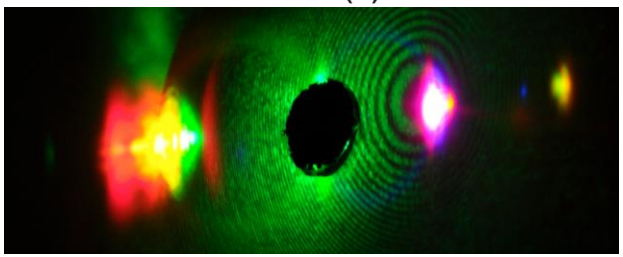
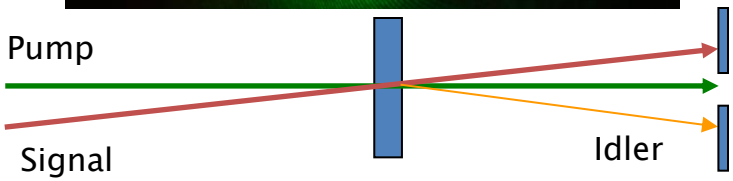
PVWC



Tangential







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Numerical model for OPCPA

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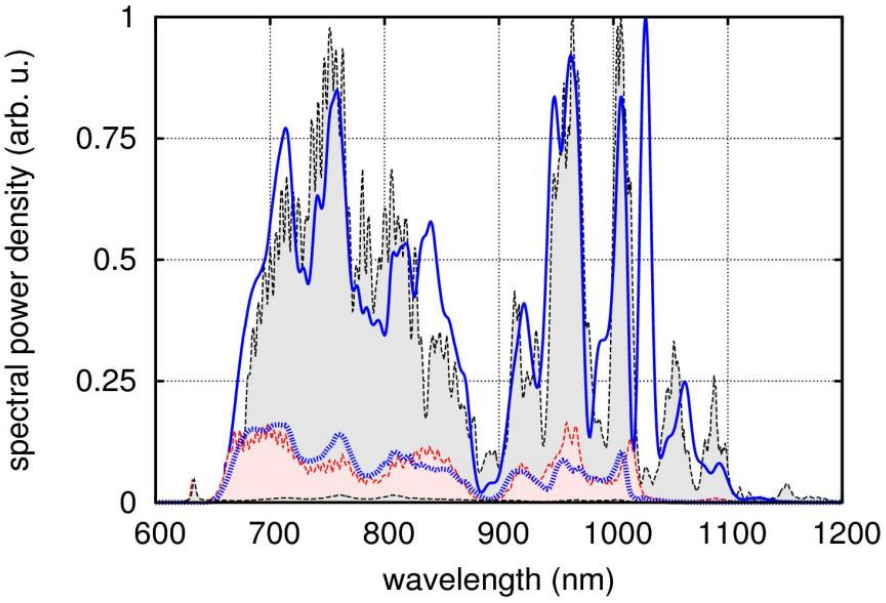
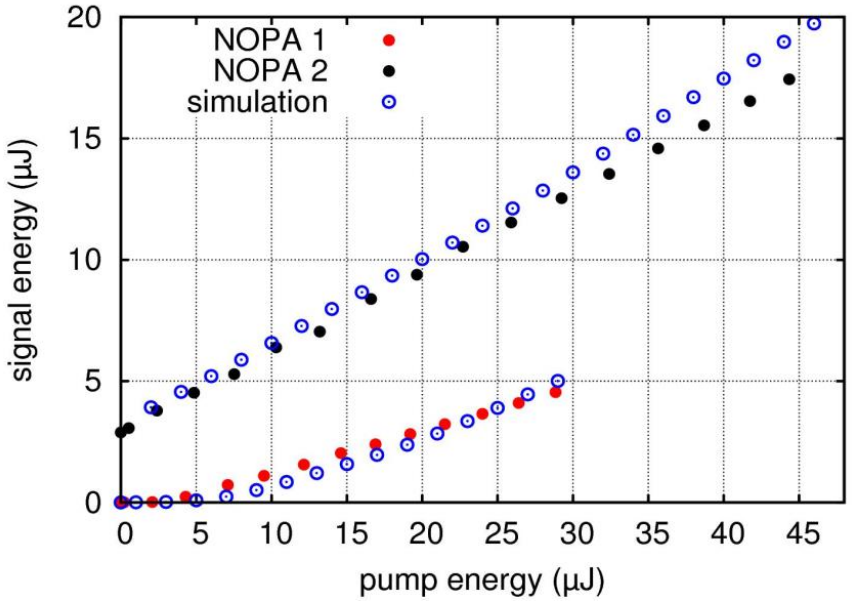
Comparison with experimental data





- excellent agreement with the experiment
  - predictions for OPCPA systems with smaller foci sizes
  - scaling of the pulse energy
  - important for scaling to higher repetition rates

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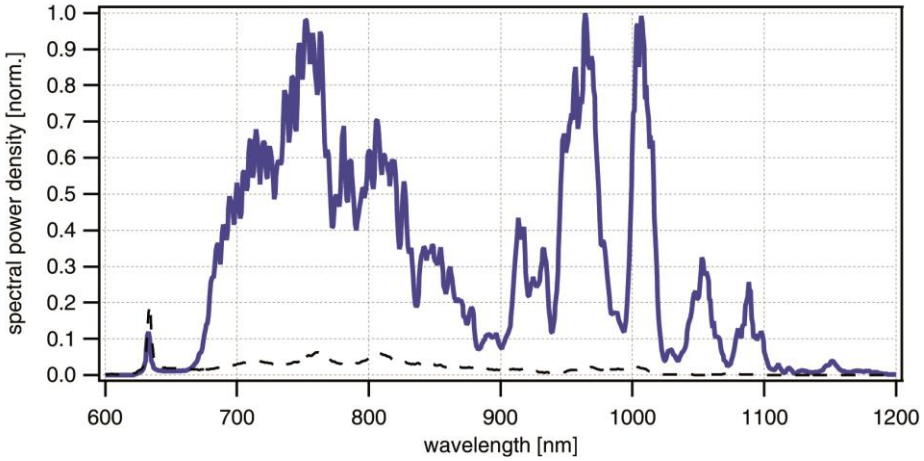
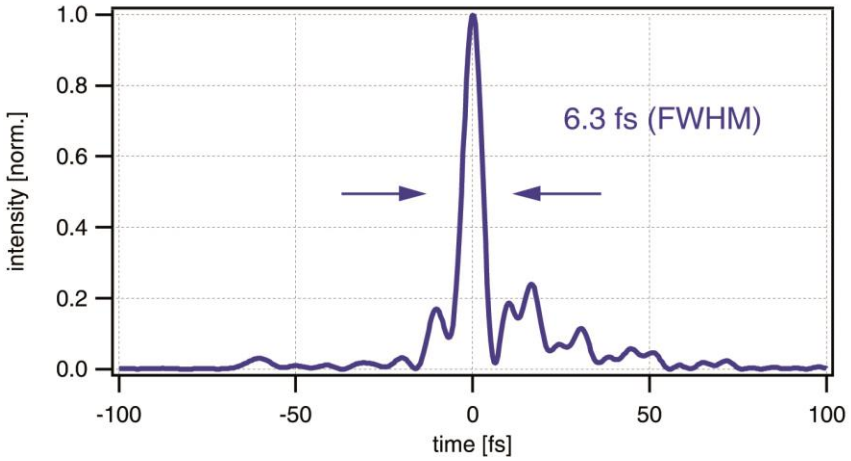
Ultrabroad bandwidth



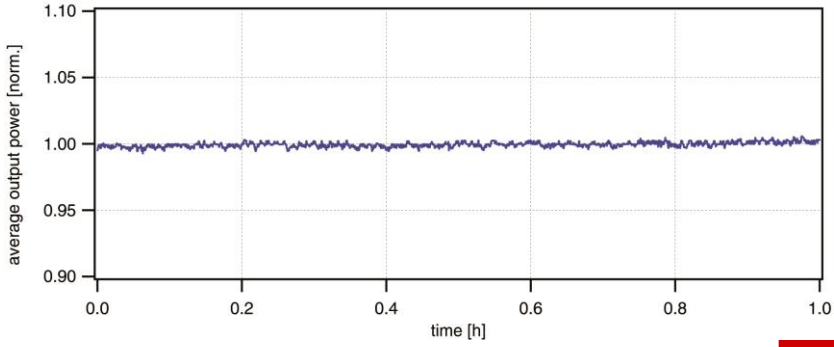
Ultrashort pulses



- **Output parameters:**

Pulse energy:	10 µJ
Pulse duration:	6.3 fs
Rep. rate:	200 kHz
Peak power:	800 MW
Low noise:	<0.5% (rms)

Very low noise



OPCPA AMPLIFIER

CE-phase stabilization

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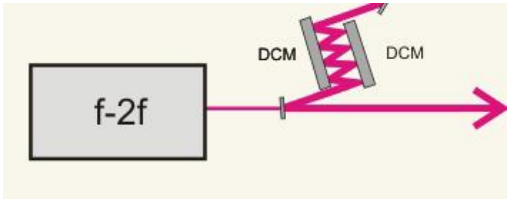
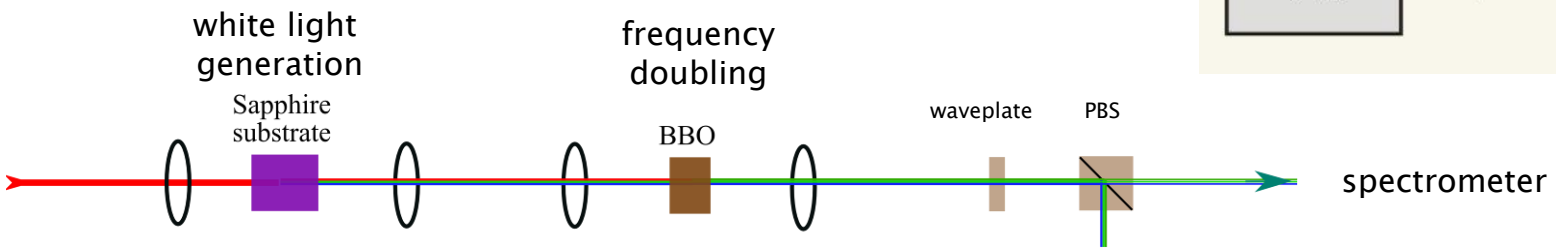
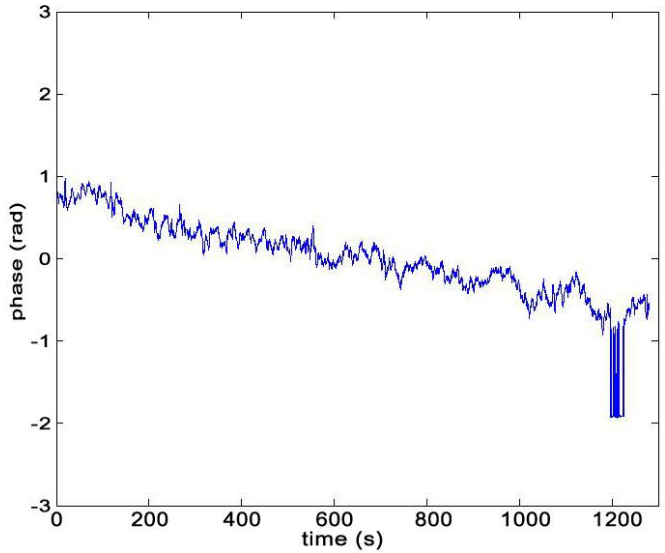
spectral f-to-2f interferometer (~ 0.2 µJ):

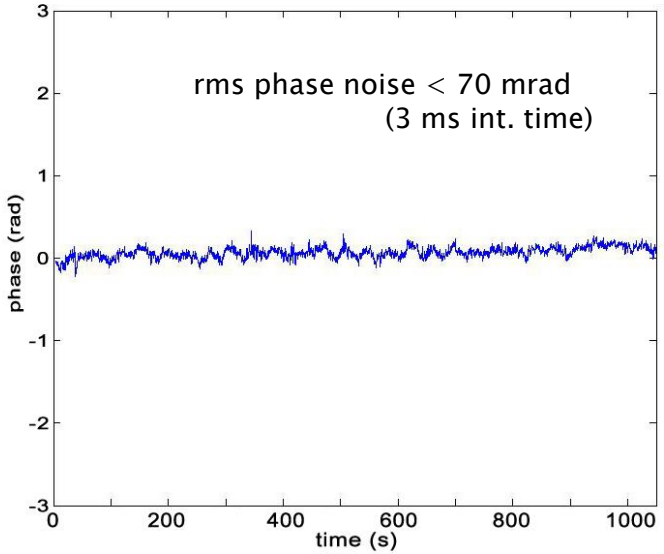




open loop



closed loop



VENTEON MEDEA

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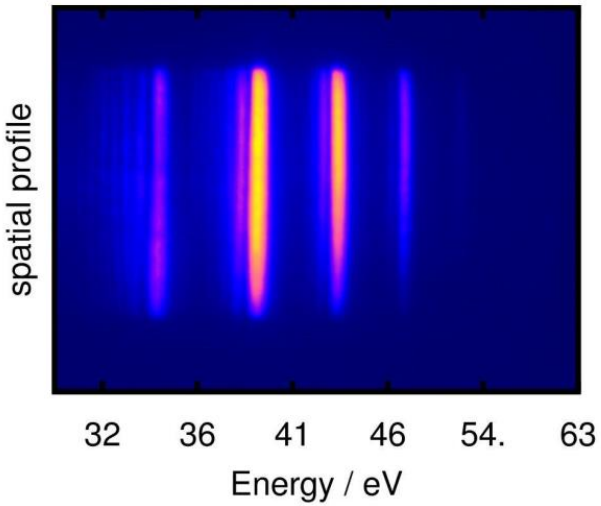
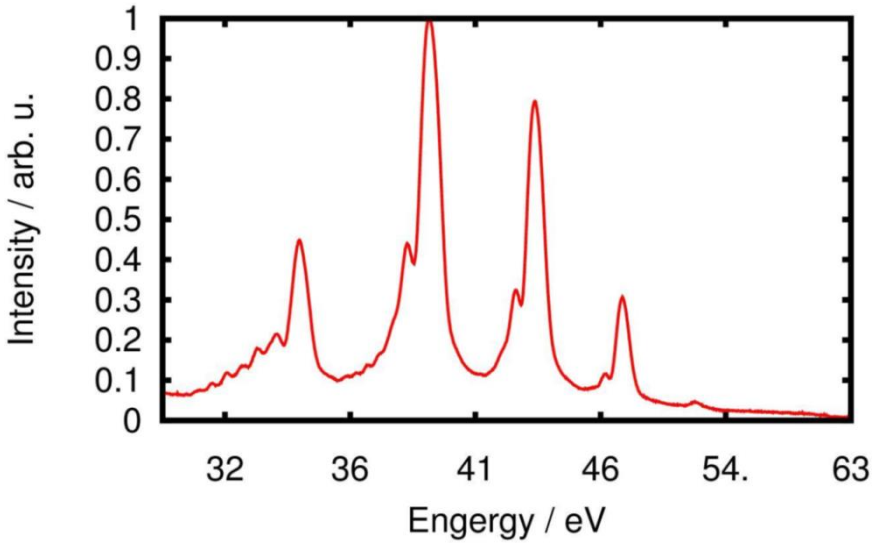
High repetition rate, few-cycle laser for HHG, XUV spectroscopy, PEEM…





**data courtesy of C. Arnold, Lund University*

Goals MEDEA

- Planned secondment with Lund
- increase level of cooperation
- Scaling-up of system to higher energy and photon flux

LUND UNIVERSITY

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Thank you for your attention!

We have moved to
new lab and office space:

Technologie-Zentrum
im Wissenschaftspark
Hollerith-Allee 17
30419 Hannover