

# High Power 130-fs-VECSEL

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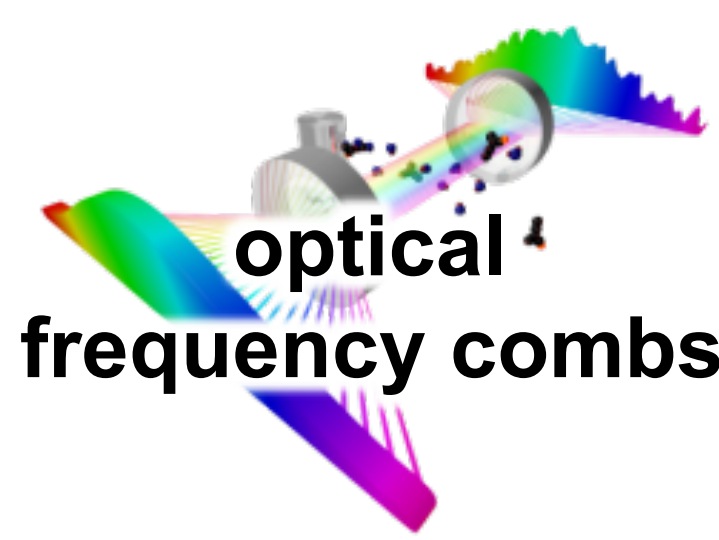
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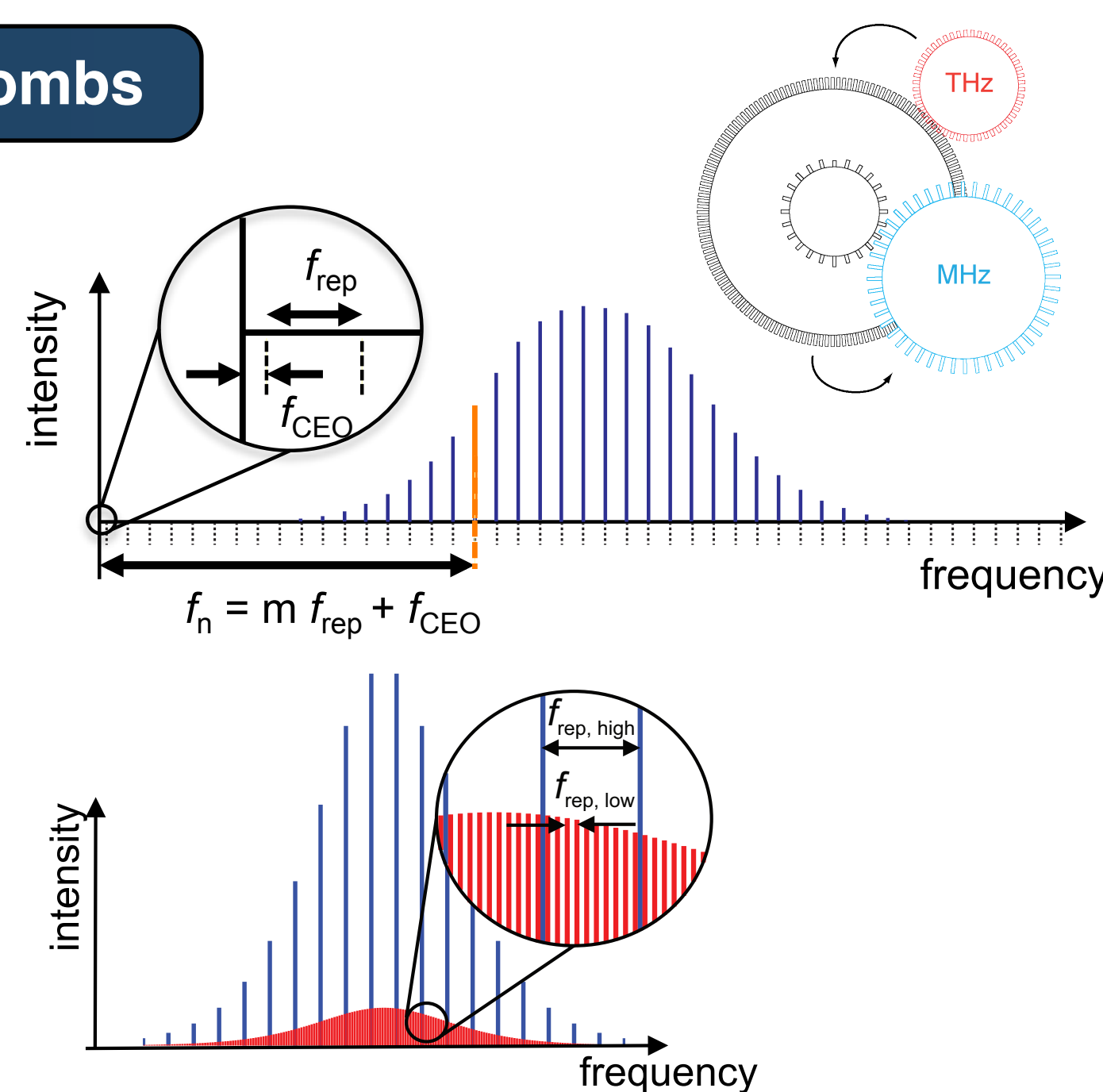
## Motivation

### Applications of Ultrafast Semiconductor Disk Lasers (SDL)



### Our Goal: Self-referenced frequency combs

- Down-convert optical signals (THz) into the microwave range (MHz/GHz)
- Need to stabilise:
  - Repetition rate
  - Carrier envelope offset frequency ( $f_{CEO}$ ) [1]
- Benefits from GHz repetition rates:
  - higher line spacing
  - high power per comb line
  - compact systems

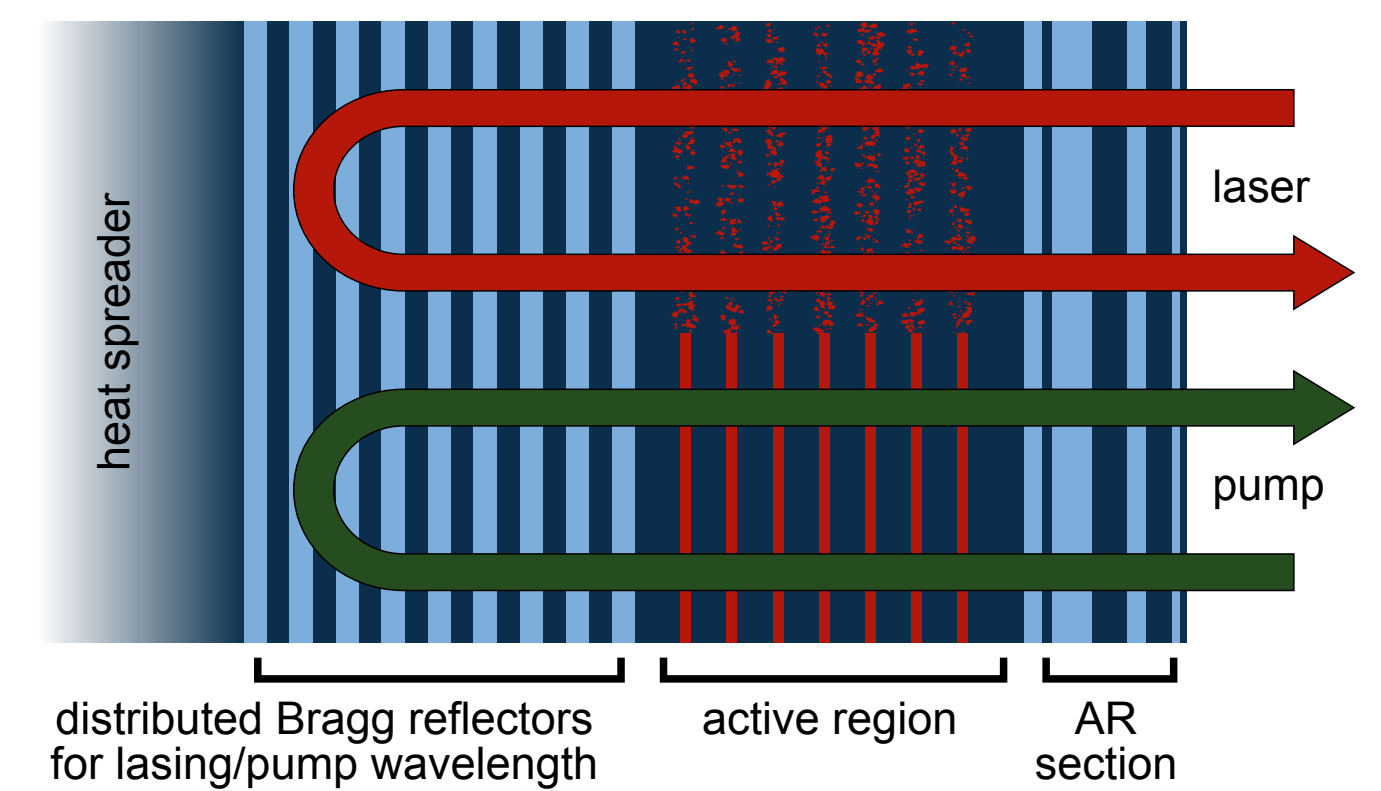


[1] H. R. Telle, G. Steinmeyer, A. E. Dunlop, J. Stenger, D. H. Sutter, and U. Keller, Appl. Phys. B **69**, 327-332 (1999)

## SESAM Mode-locked VECSEL

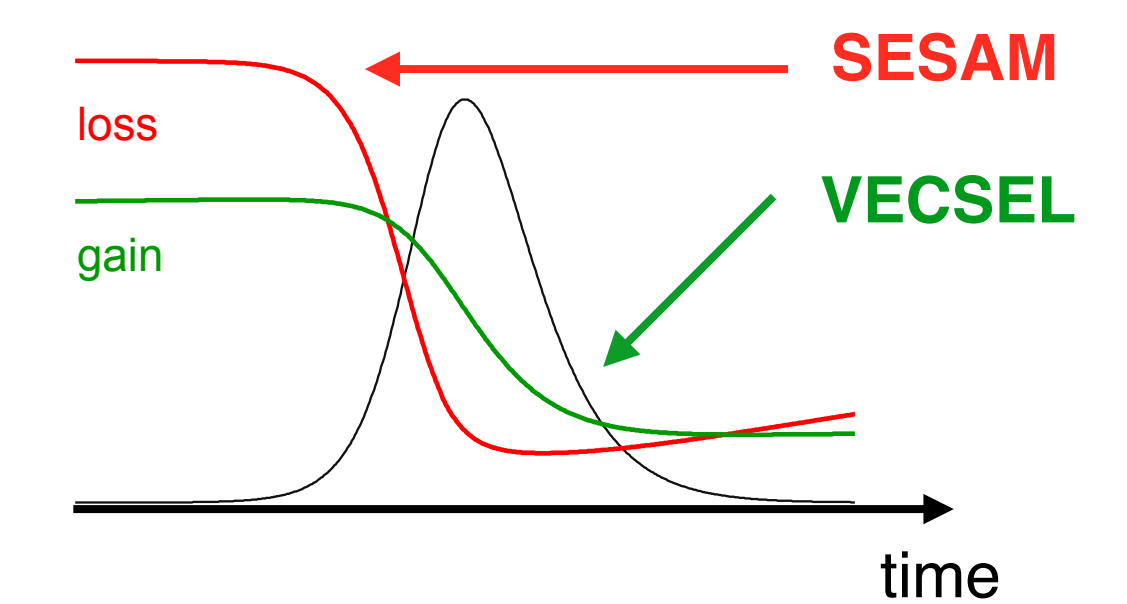
### VECSEL Gain Chip

- Distributed Bragg reflector (AlAs/GaAs)-pairs grown on GaAs for laser reflection
- Active region: Laser light amplification in quantum wells (QW)
- Antireflection-coating: Minimizing reflection and optimizing group delay dispersion (GDD)



### SESAM

- Semiconductor saturable absorber mirror
- Induce self-starting mode-locking operation with quasi-solitons [2]



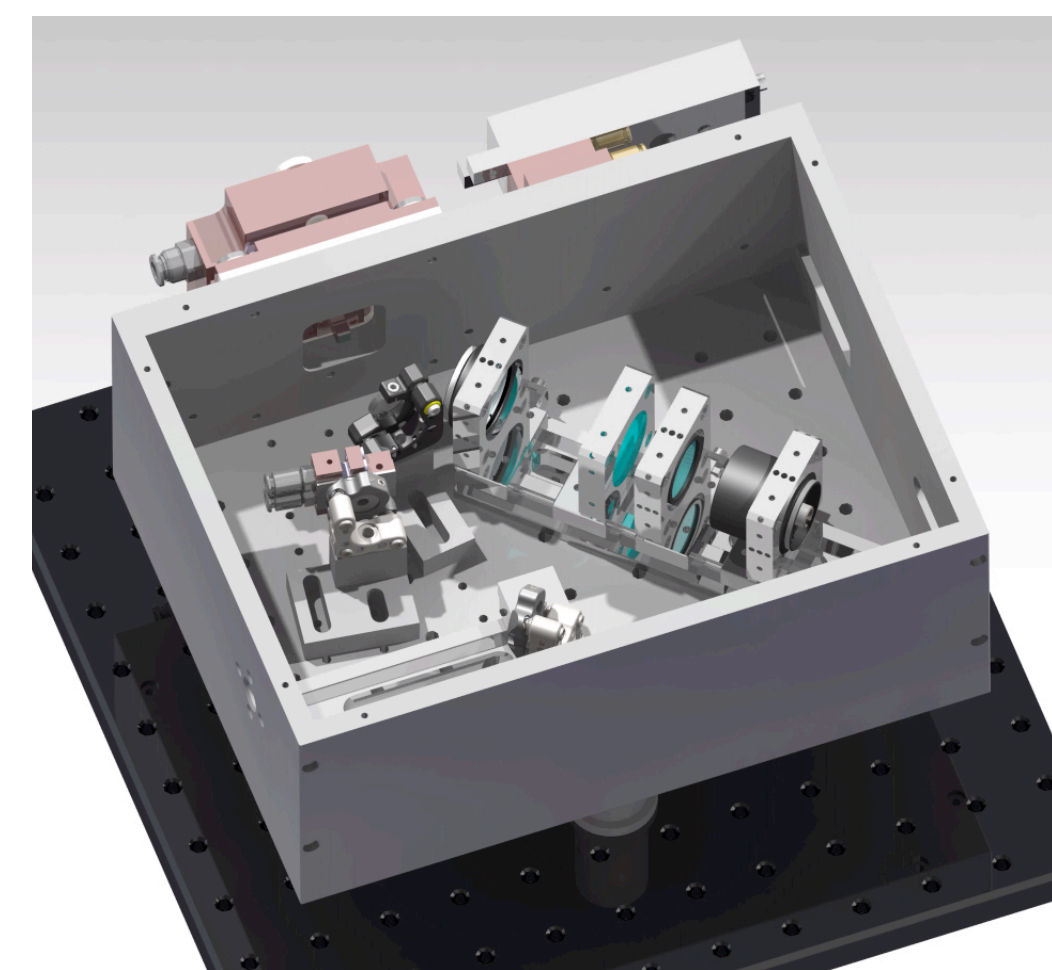
[2] R. Paschotta, R. Häring, A. Garnache, S. Hoogland, A.C. Tropper, U. Keller, Appl. Phys. B **75** (2002), 445

## VECSEL Prototype

### Prototype Housing

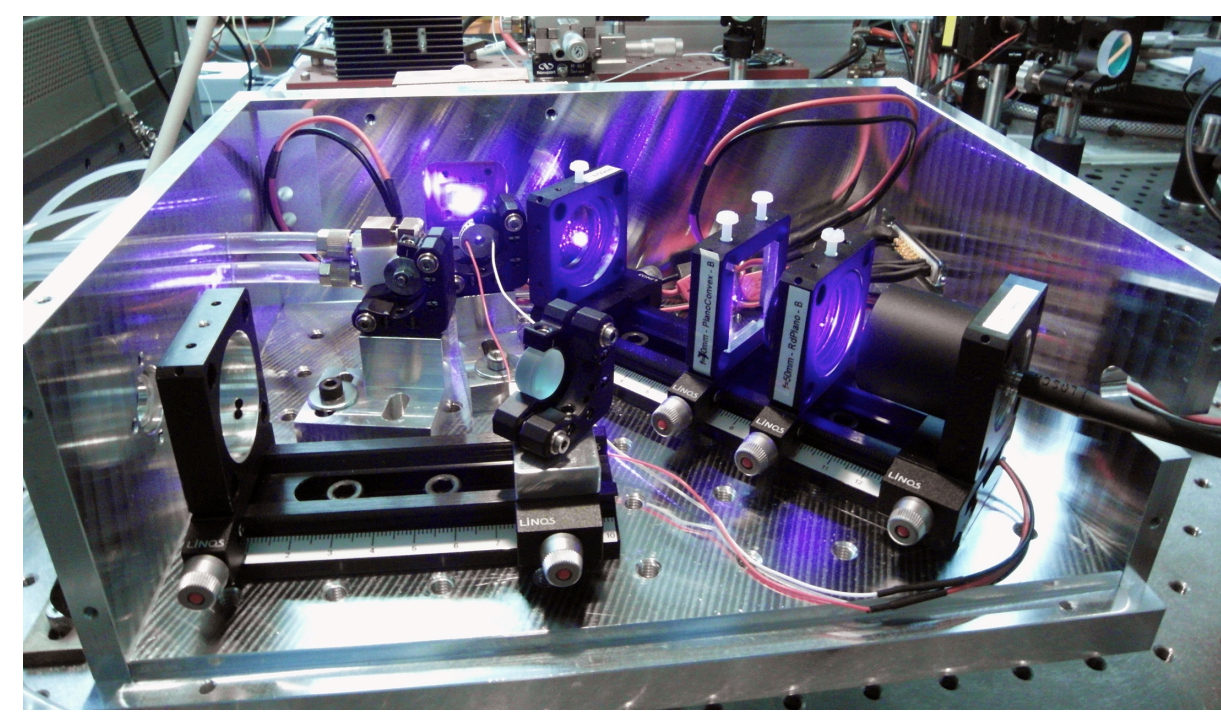
#### Data Sheet

- Aluminium housing
  - 19 cm x 25 cm x 11 cm
- Integrated pump diode
  - 808 nm, 40 W
- Temperature stabilized with water cooled Peltier element



#### Noise reduction

- Closed aluminium housing
  - prevent airflow
- Fixed mounted optics
  - minimize mechanical vibrations



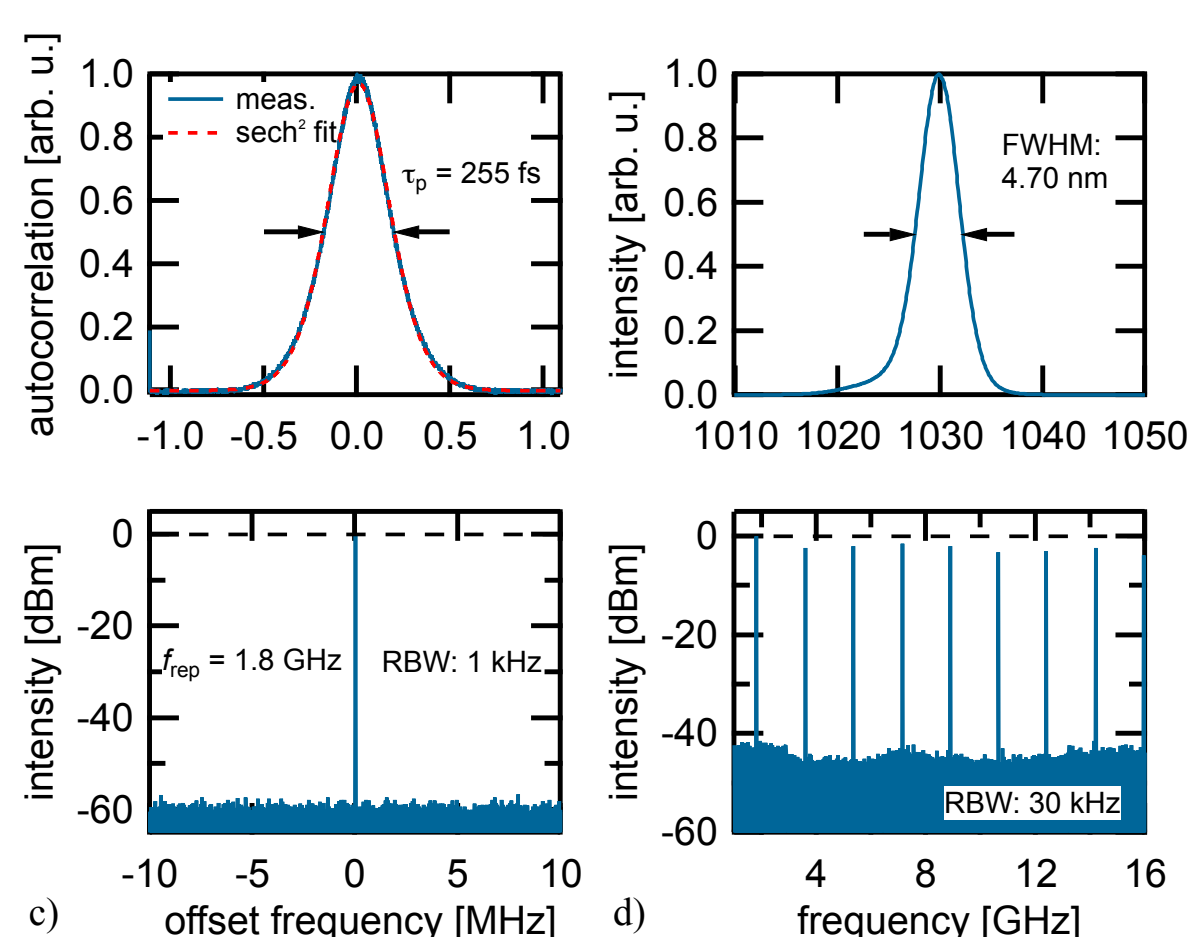
### Prototype UniNeuchâtel

Shipped to



#### Time and Frequency Laboratory

→ Characterisation & Stabilization



pulse duration	output power	repetition rate
255 fs	120 mW	1.77 GHz

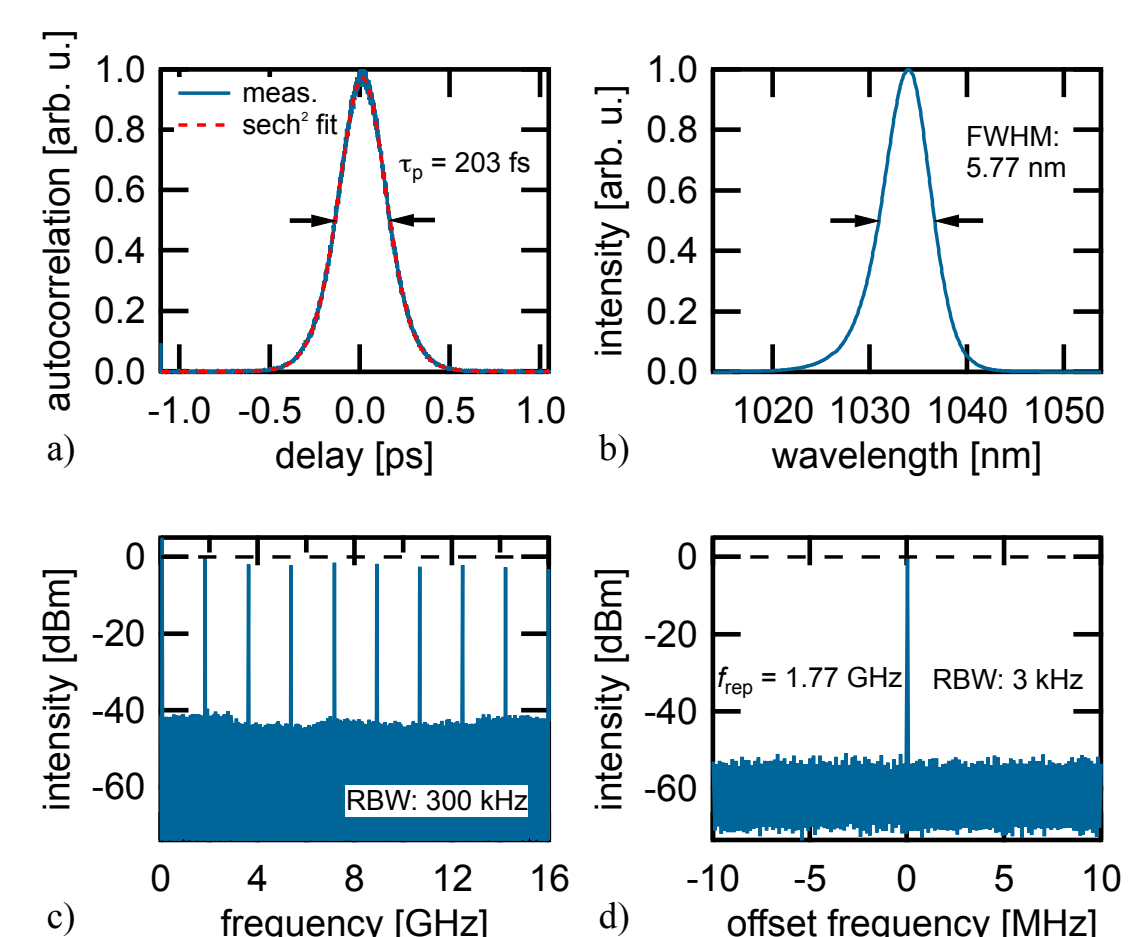
### Prototype METAS

Shipped to



#### Federal Institute of Metrology

→ Characterisation & Stabilization

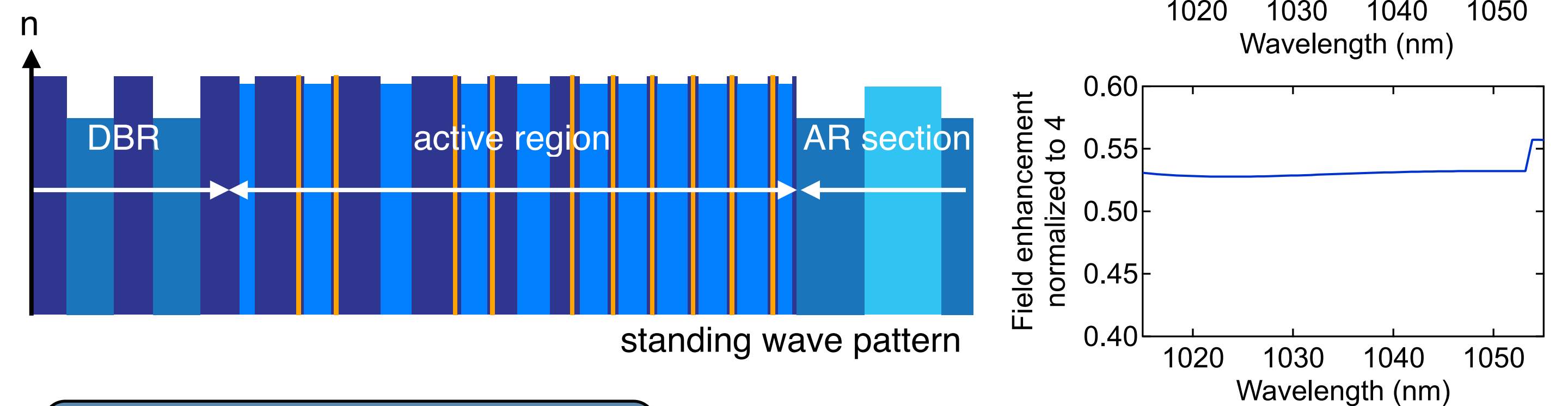


pulse duration	output power	repetition rate
203fs	80 mW	1.77 GHz

## 130-fs-VECSEL

### Structural Improvements

- Strain compensated active region for lasing at 1030nm
- Optimized AR section for reduced and flat dispersion
- Reduced and flat field enhancement

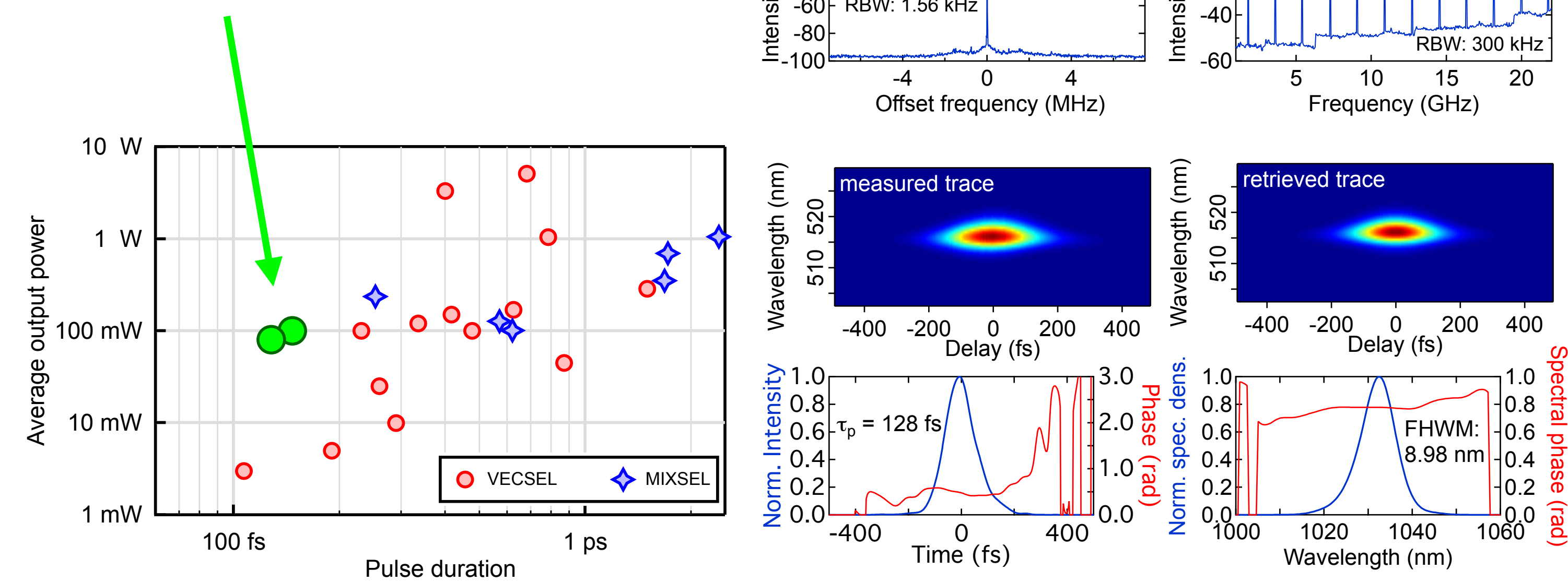
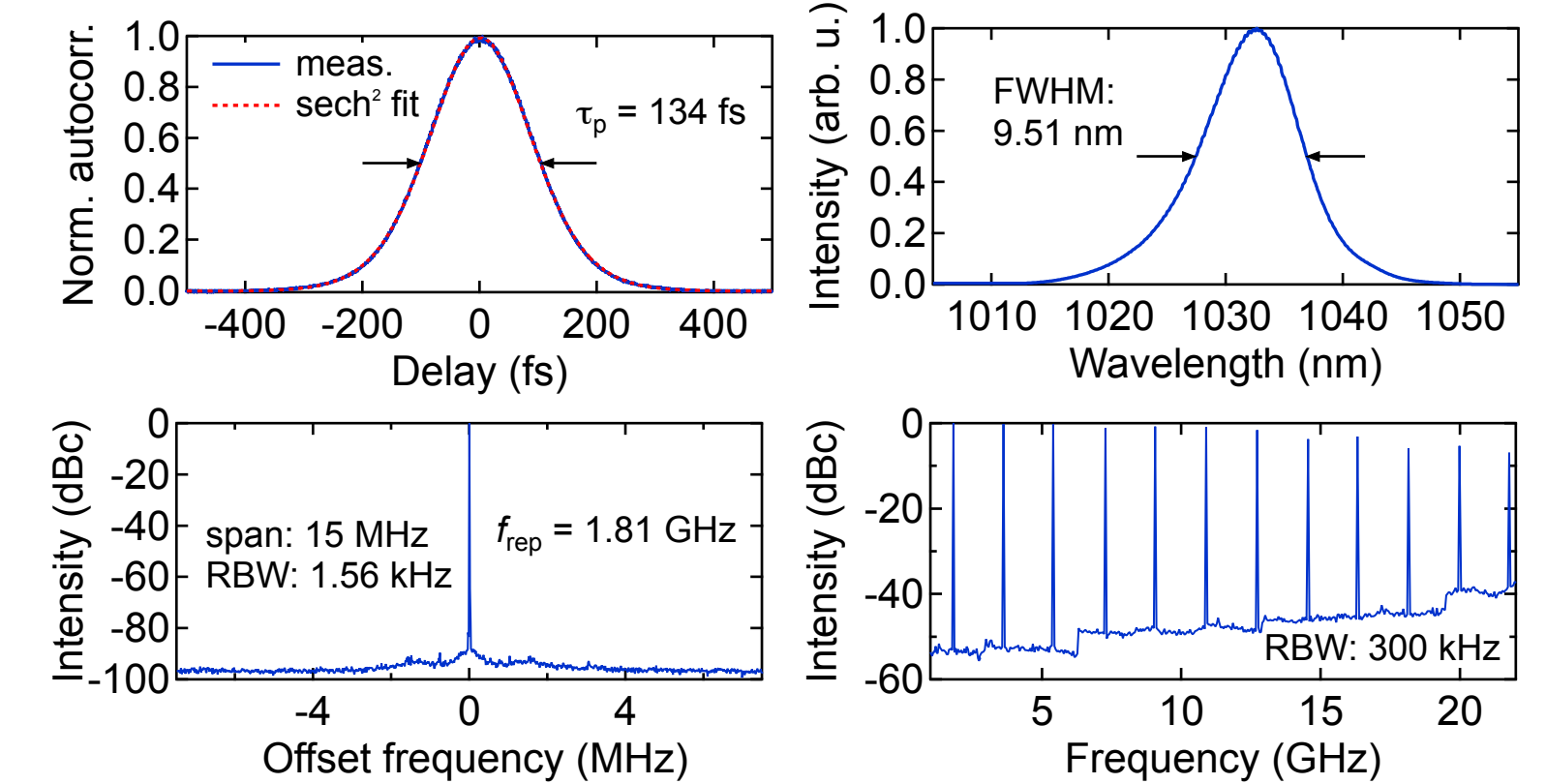


### Modelocking Performance

pulse duration	output power	repetition rate	peak power
147 fs	100 mW	1.82 GHz	328 W
128 fs	80 mW	1.81 GHz	304 W

### State of the art diagnostics to confirm clean, fundamental modelocking

- Microwave spectrum with minimal resolution bandwidth and high SNR
- Frequency Resolved Optical Grating (FROG)
- Shortest pulse duration from a VECSEL in the 100 mW regime



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## Outlook

**Next step:** Increasing the output power while maintaining the short pulses

**Ultimate goal:** Fully stabilized (repetition rate & CEO-frequency) frequency comb from a compact, low cost SDL

