Tunable VECSELs for MIR optical gas sensing

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Innovative Laser Technology

Novel laser modules for the precise analysis of gas mixtures

- Advanced gas detection
  - Multiple gases simultaneously
  - Works in rough environment
- Unique Silicon-based technology
- Low integration costs

Company History

ETH Zurich / Hans Zogg

- 30+ years research experience of infrared materials and devices
- Unique laser technology
  - First publication 2007
  - 35+ man-years

Phocone AG

- Founded Oct. 2011
- Series A financing round
- ETH Pioneer Fellowship, NCCR QP, CTI

Camlin Technologies (Switzerland) AG

- Exit: 100 % subsidiary since Dec. 2013

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

spinoff ETH Zürich

phocone
Laser Precision for Gas Detection

CAMLIN TECHNOLOGIES

The Camlin Group

- Companies dedicated to energy, transport, gas & oil, medical and security technologies
- Privately owned and self financed
- > 150 full time engineers and physicists across 6 global centres of excellence
- World leading product design in Smart Grid applications, fault location, breaker monitoring, transformer monitoring
- Leading research in sensor technology, mid infrared lasers, plasma physics
- Construction of custom LV test network for rapid development and real-life field test conditions
- Significant growth plans
- 13 locations worldwide … to date

CAMLIN

KELVATEK

- LV Automation
- Smart Grid applications
- Fault Management
- Fault Location

CAMLIN POWER

- MV/HV Asset management
- Transformer monitoring
- Dissolved Gas Analysis
- Partial Discharge
- Tan delta
- Breaker Monitoring
- PD – HV cables

CAMLIN RAIL

- Network automation
- Signalling power supply
- Fault location

CAMLIN TECHNOLOGIES

- R&D
- Manufacturing
- Engineering Development


Headquarters
Lisburn, N. Ireland
Customer Services
Nuneaton, England
Engineering Design
Glasgow, Scotland
R & D
Birkerød, Denmark
Engineering Design
Krákow, Poland
Engineering Design
Bologna, Italy
Sales & Support
Dortmund, Germany
Research & Design
Zurich. Switzerland
Engineering Design
Quebec, Canada
Sales & Support
Chicago, USA
Sales & Support
São Paulo, Brazil
Sales & Support
Chengdu, China
Sales & Support
Shanghai, China
Sales & Support
Sydney, Australia

Current Products

BIDOYNG

FUSEMATE

REZAP FAULTMASTER

PROFILE P3

SIGNET

DELTA V

New Products

Lynx

Totus and Intego

Weezap

Reflekt

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Our VECSEL Technology

IV-VI semiconductors

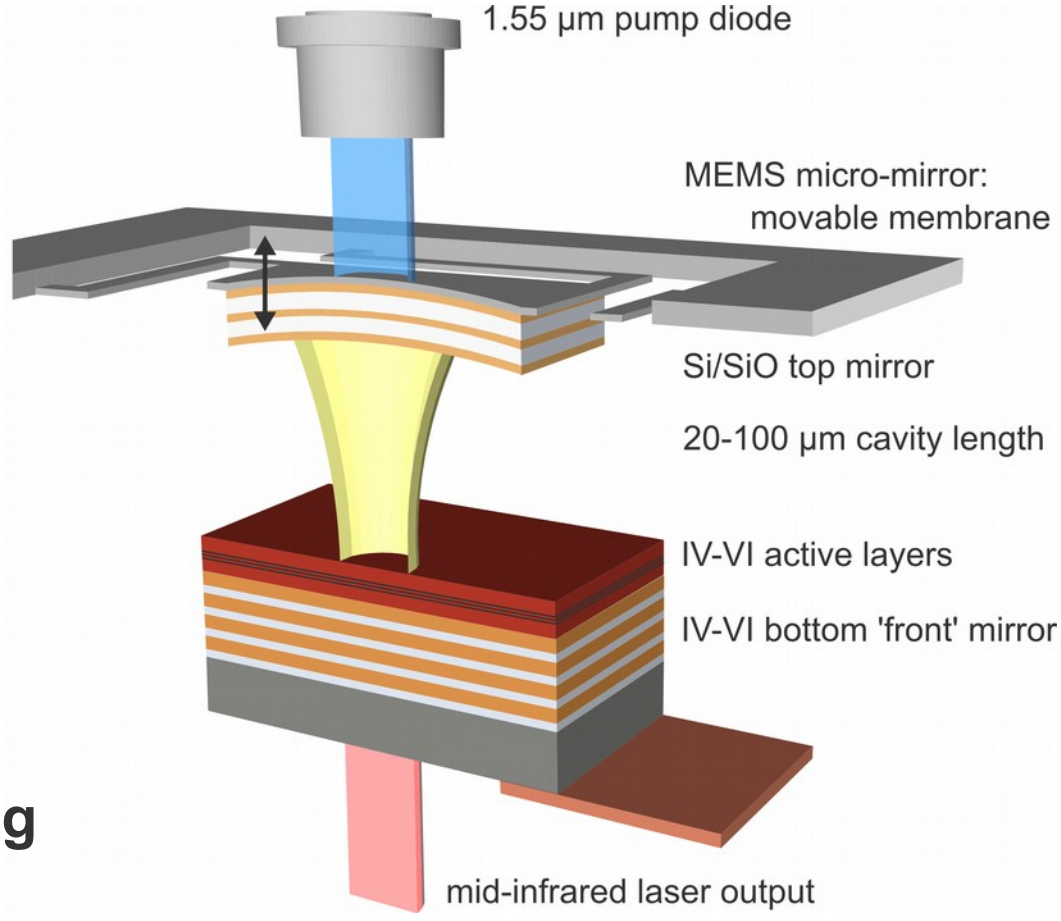
- Direct MIR band-gap
- Chemical band-gap tuning
  < 3 µm to > 10 µm
- Silicon substrate

Movable top mirror

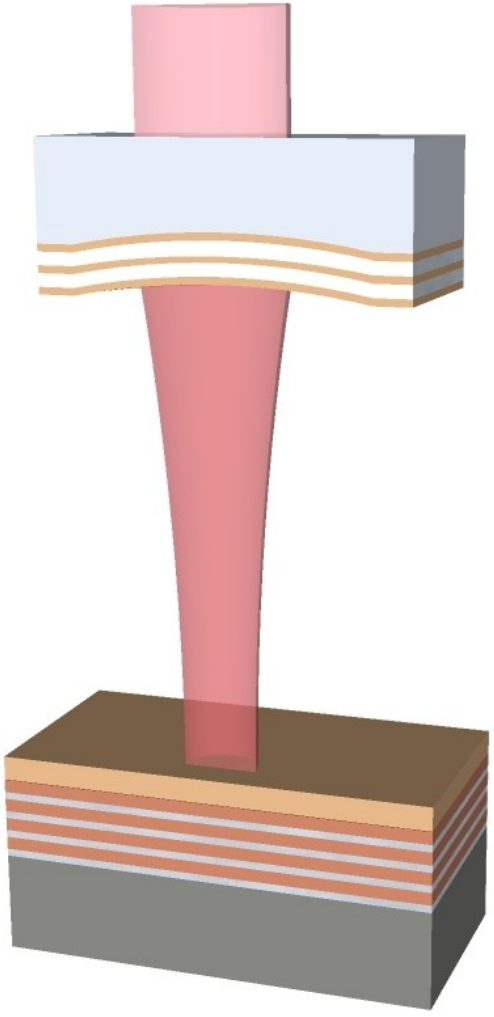
- Si/SiO DBR
- Piezoelectric actuator, or
  MEMS micro-mirror

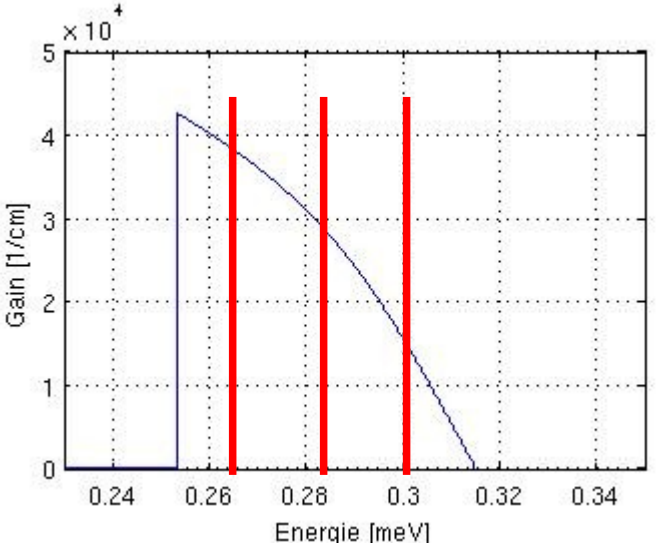
→ **Mono-mode emission**

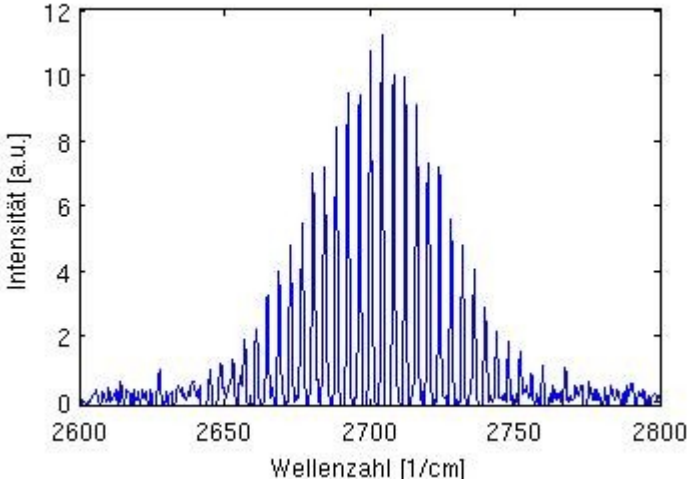
→ **Continuous wavelength tuning**



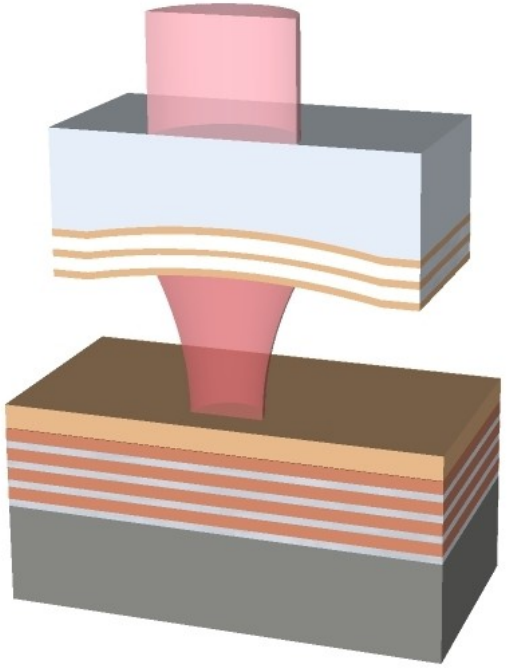
Multimode → Monomode Emission

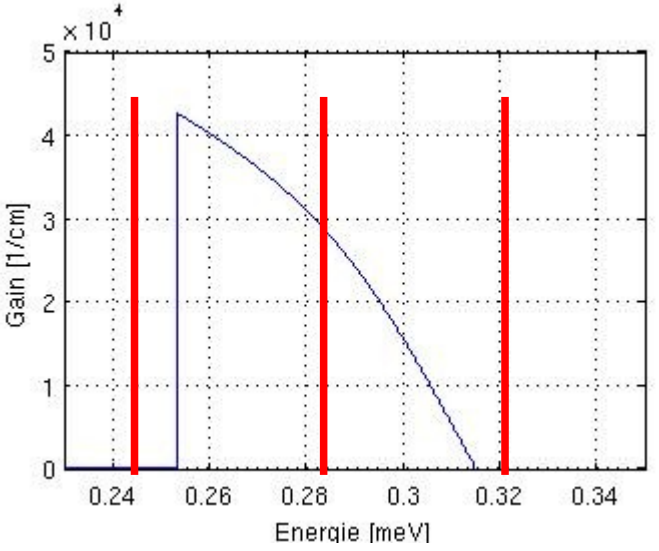


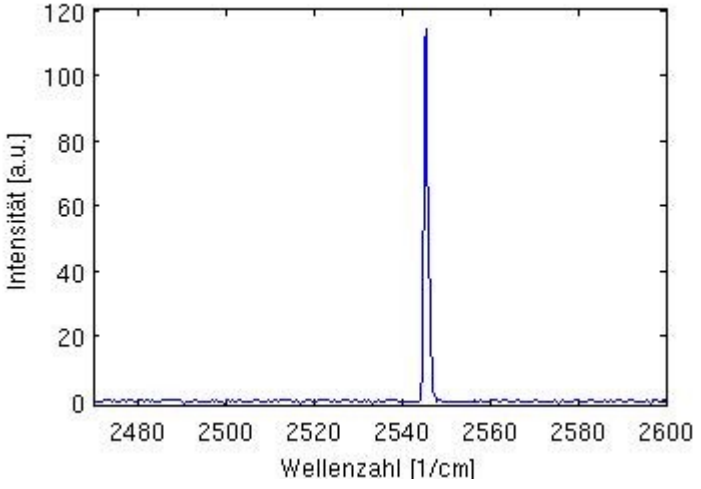




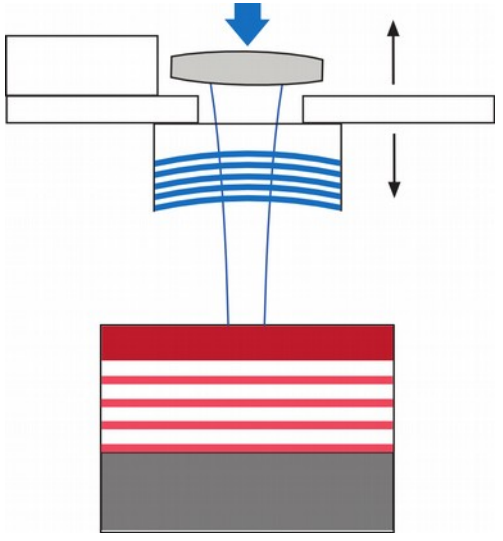
Multimode → Monomode Emission

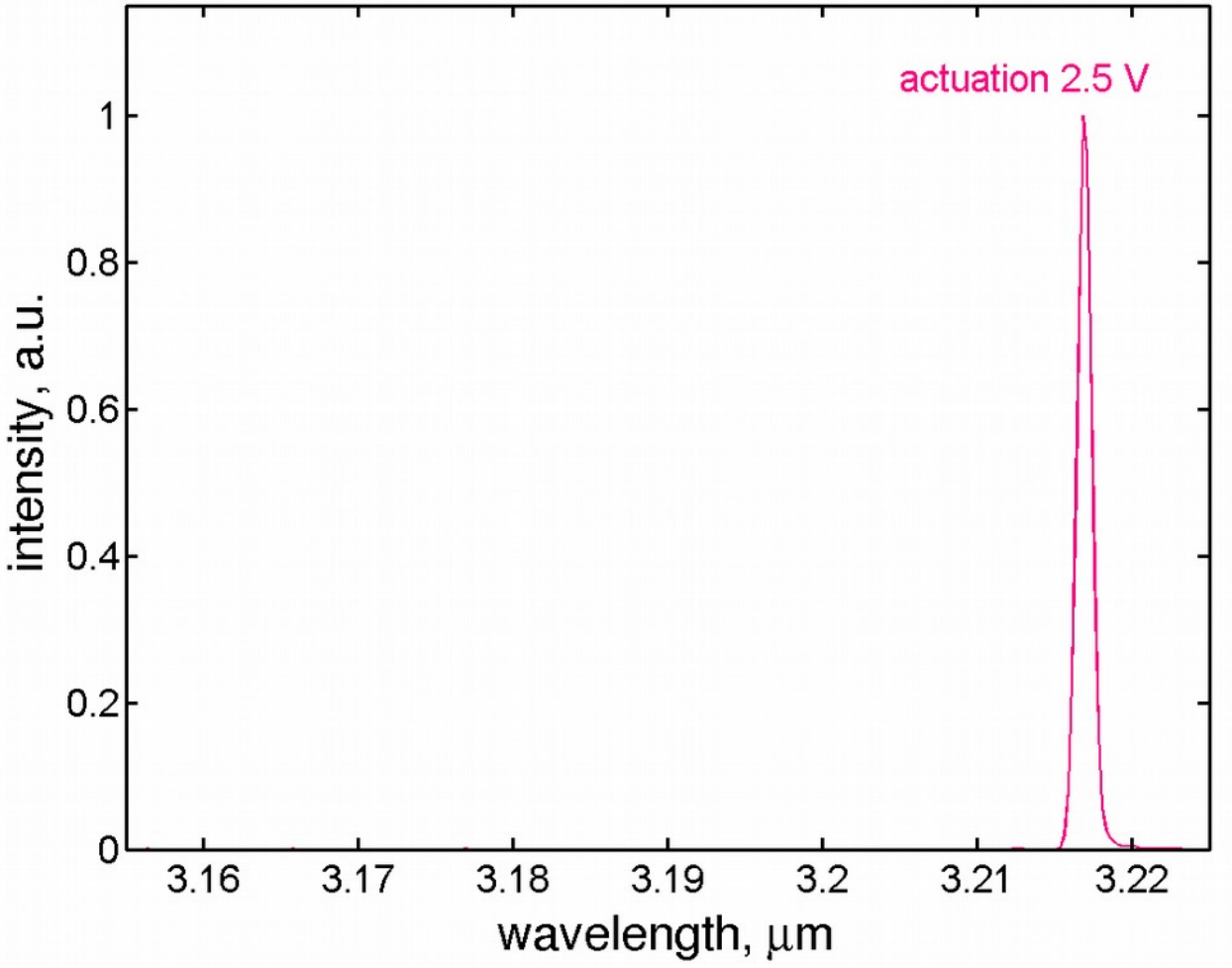




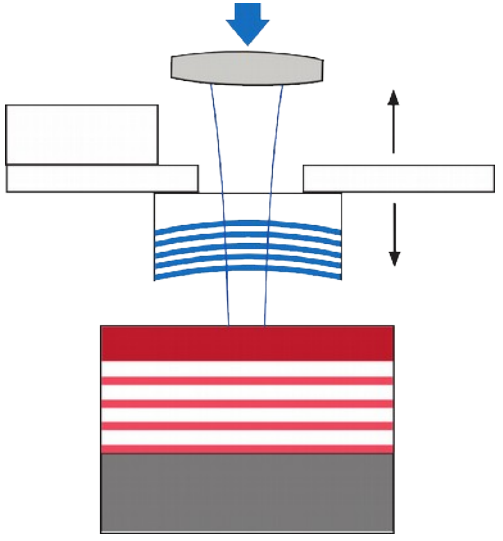


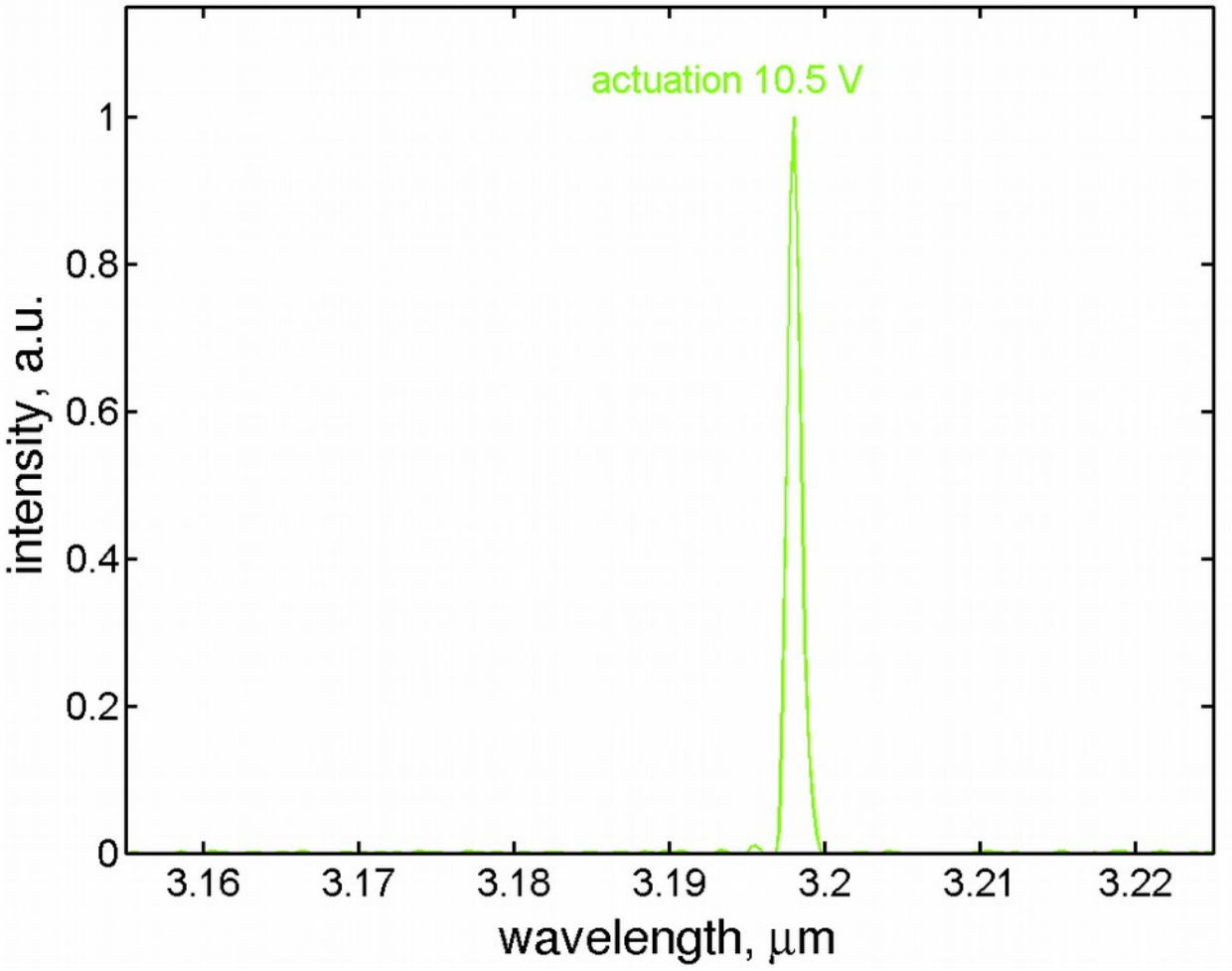
Continuous Mono-mode Tuning





Continuous Mono-mode Tuning

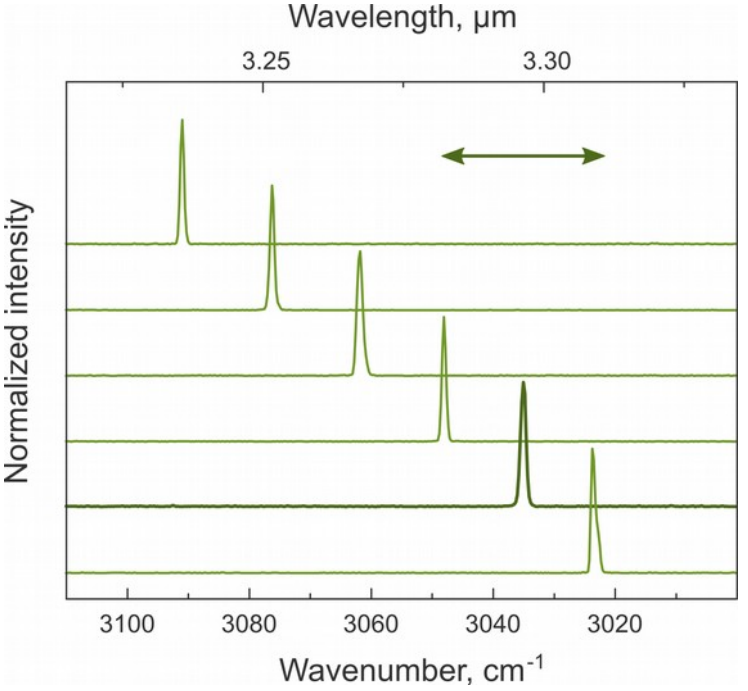




CAMLIN TECHNOLOGIES

Continuously Tunable Laser Modules

- Single-mode emission
- Continuous wavelength tuning
  > 100 nm / ~3%
- Output peak power > 10 mW_{peak}
- Operated in pulsed mode
  125 kHz repetition rate
- Thermo-electric stabilized
- Plug&Play control electronics
- Initial batch available

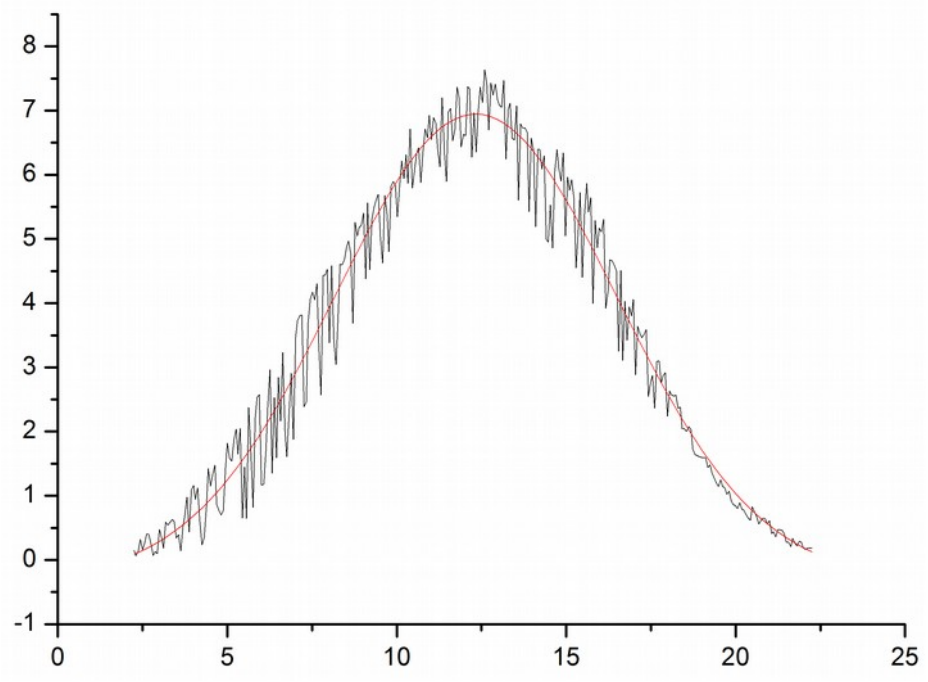


M. Fill et al, APL 103, 201120 (2013)
M. Rahim et al, APL 94, 201112 (2009)

Emission Beam, TEM_{00}

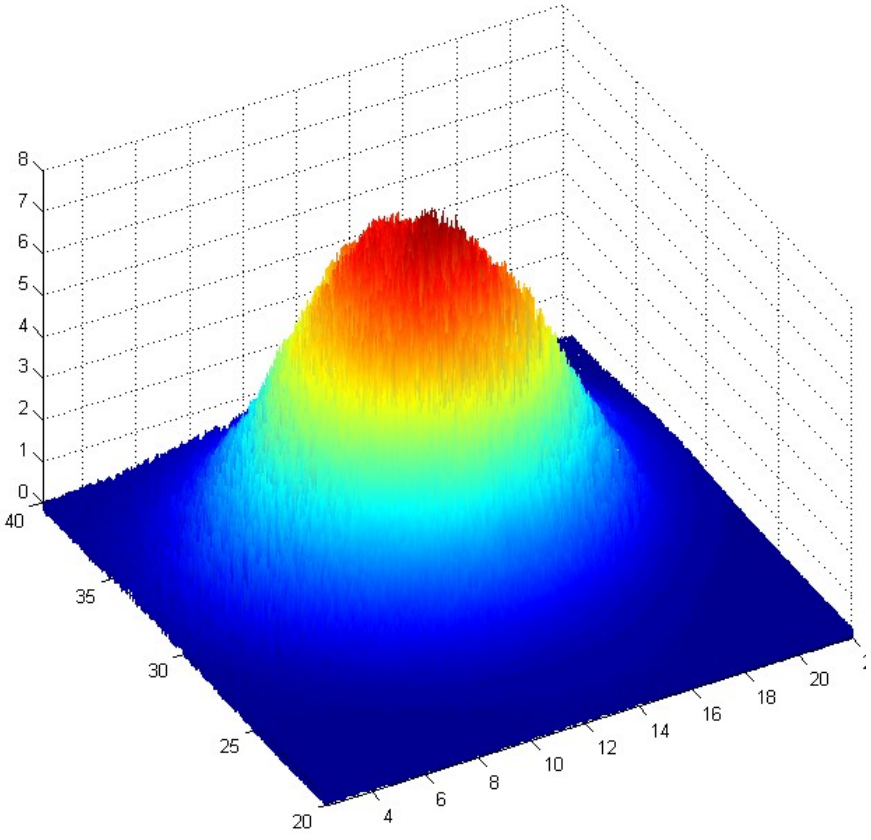
Aperture r = 80 µm

- θ = 1.73°
- M^2 = 1.14
- Diffraction limited

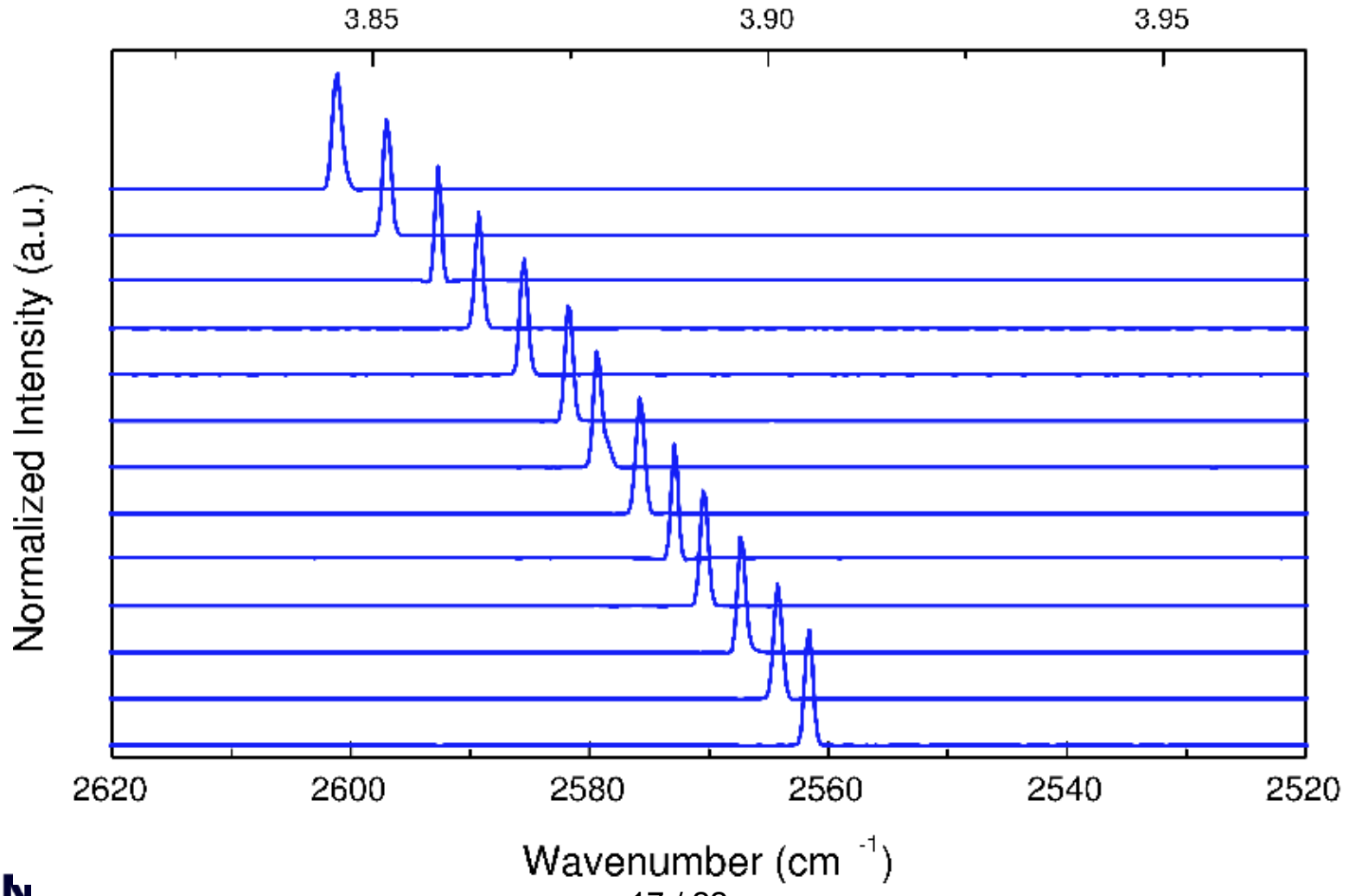


Aperture r = 40 µm

- θ = 3.3°
- M^2 = 4.3

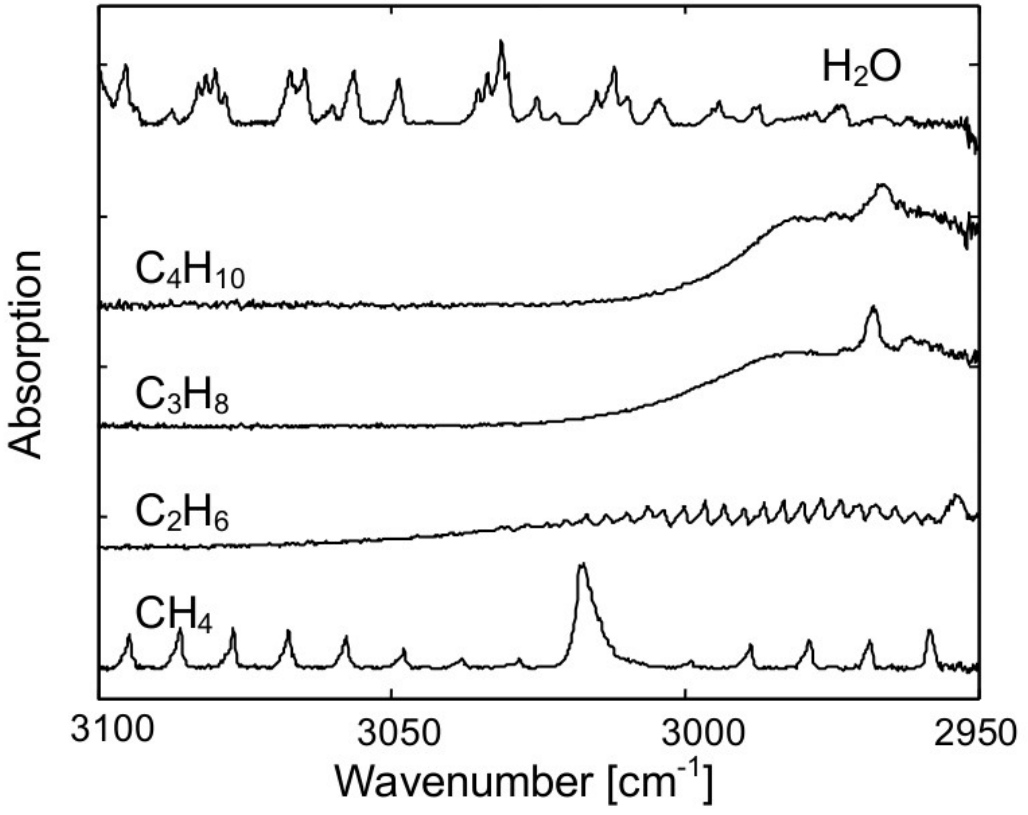


Tunable VECSEL @ 3.9 µm



Hydrocarbon Multi-Gas Sensing

- Application in oil- & gas-industries
- Direct absorption spectroscopy
- Simultaneous detection of
  - Methane
  - Ethane
  - Propane
  - Butane
  - … independent of water background



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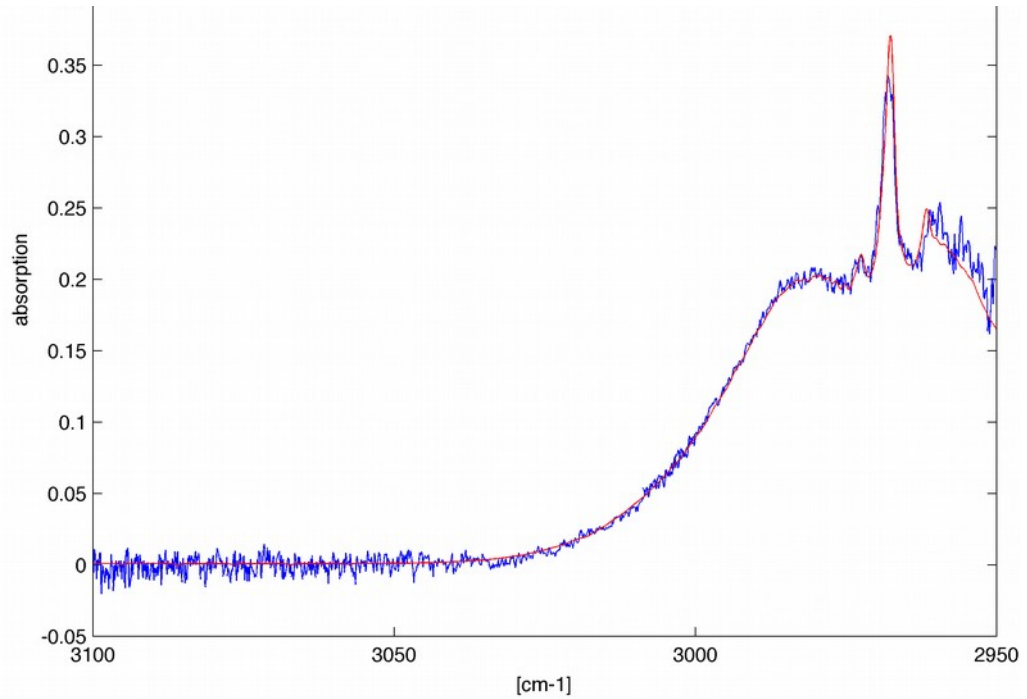
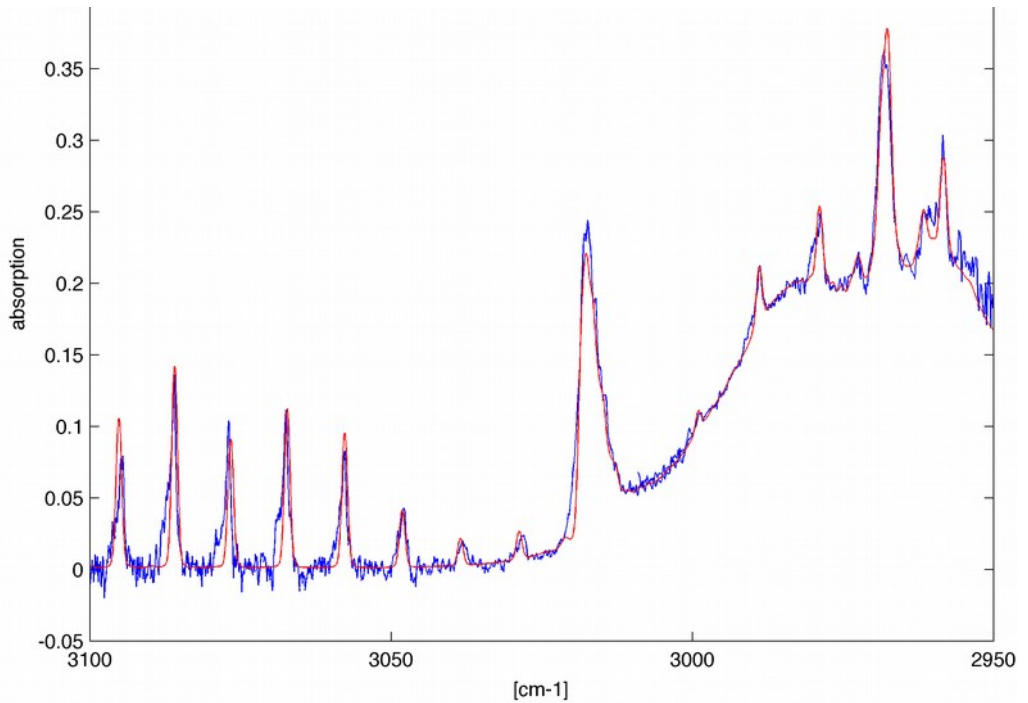
J. M. Rey et al, APB 117, 3 (2014)

Hydrocarbon Multi-Gas Sensing



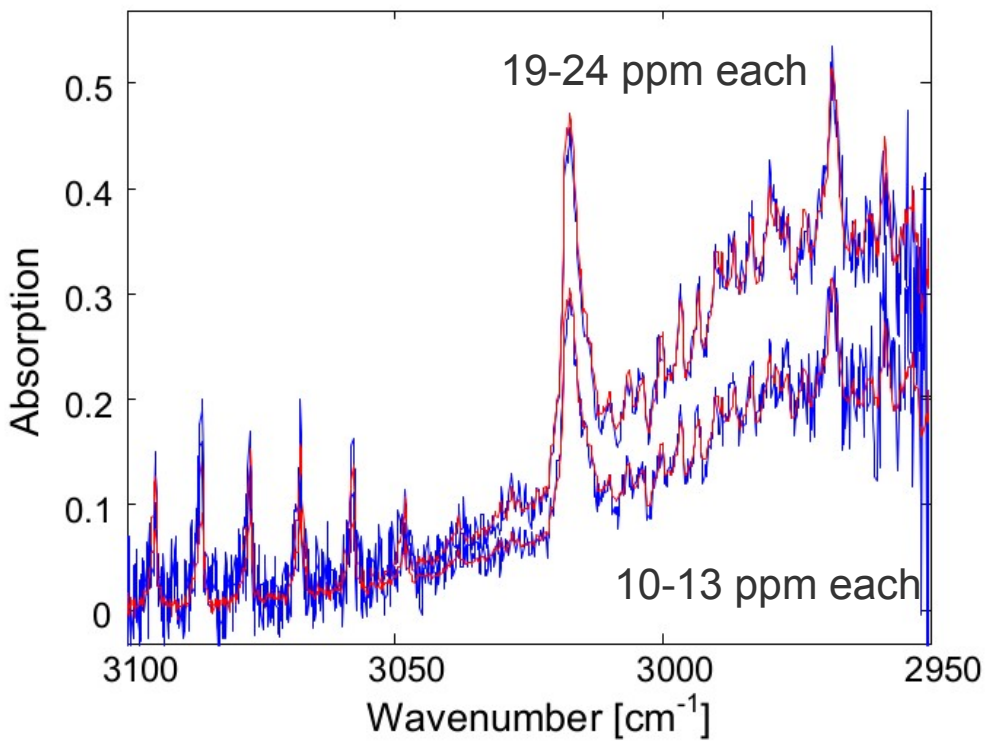


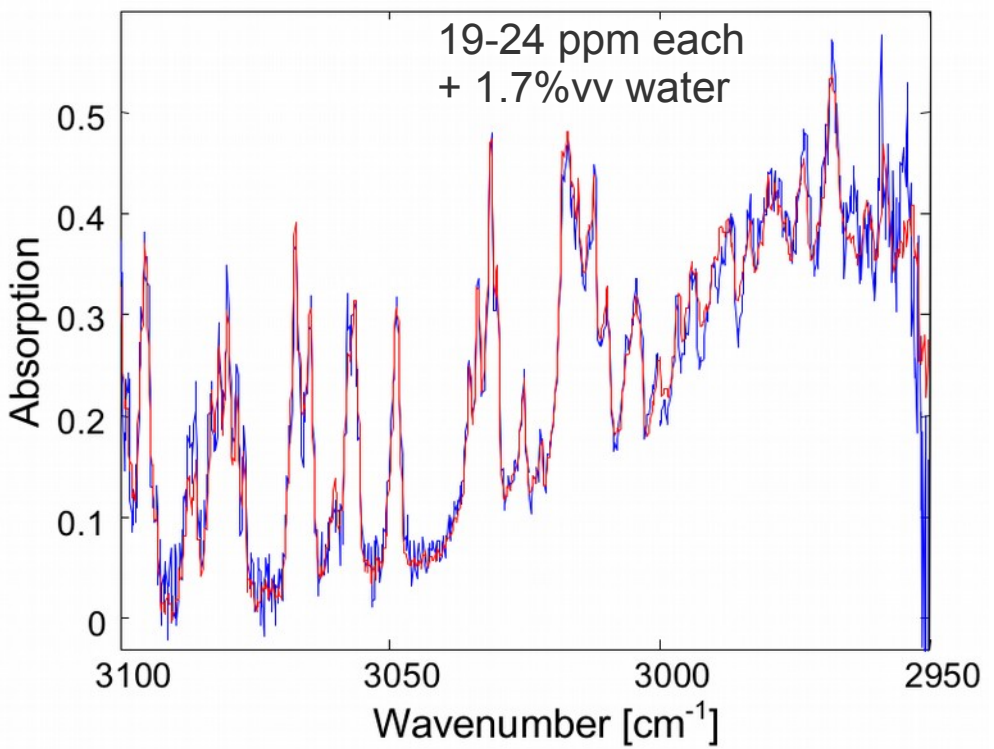
J. M. Rey et al, APB 117, 3 (2014)

CAMLIN TECHNOLOGIES

CH4, C2H6, C3H8 Multi-Gas Sensing

- 14 m absorption path
- Detection limits < 0.3 ppm
  ~0.6 ppm with water background





J. M. Rey et al, APB 117, 3 (2014)

Continuously Tunable Laser Modules

Mid-infrared emission for multi-gas analysis

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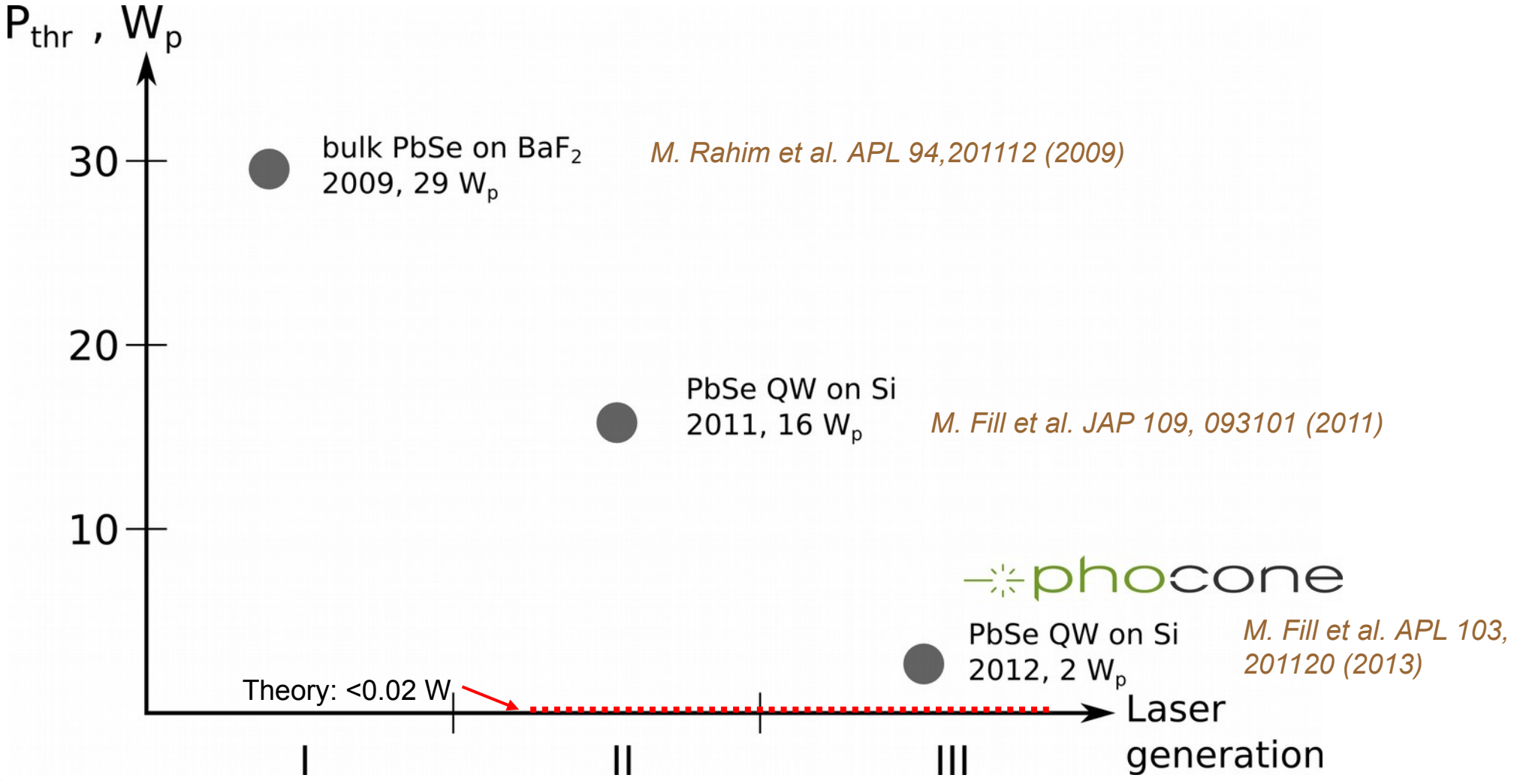
Road to CW: P_{th} at RT



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