# Waveguide-based external cavity semiconductor laser arrays: a smart optical systems project

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UNIVERSITY OF TWENTE.

LPNO Laser Physics and Nonlinear Optics

# Waveguide-based External Cavity Semiconductor Laser Arrays

*A Smart Optical Systems project*


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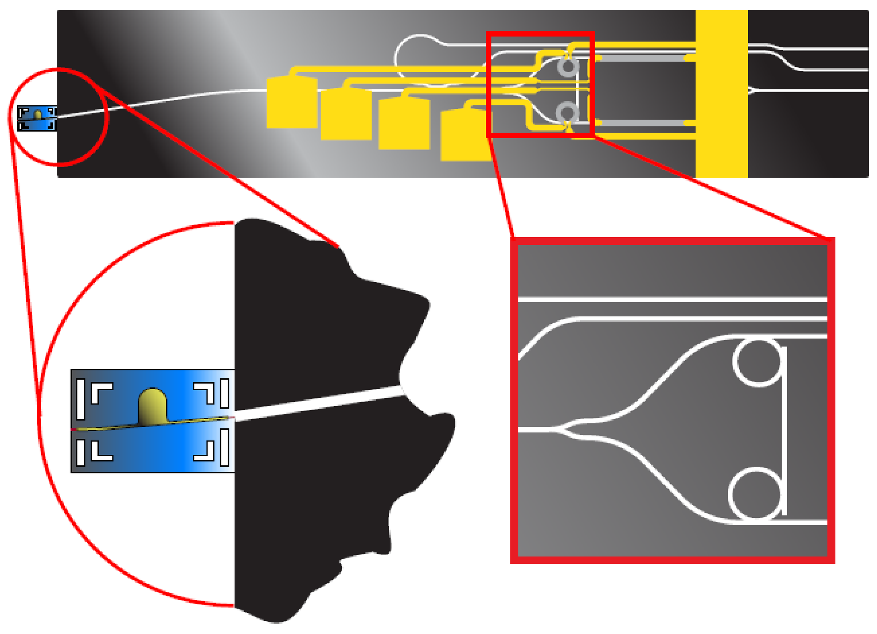
## Waveguide based external cavity semiconductor laser (WECSL)

### Goal

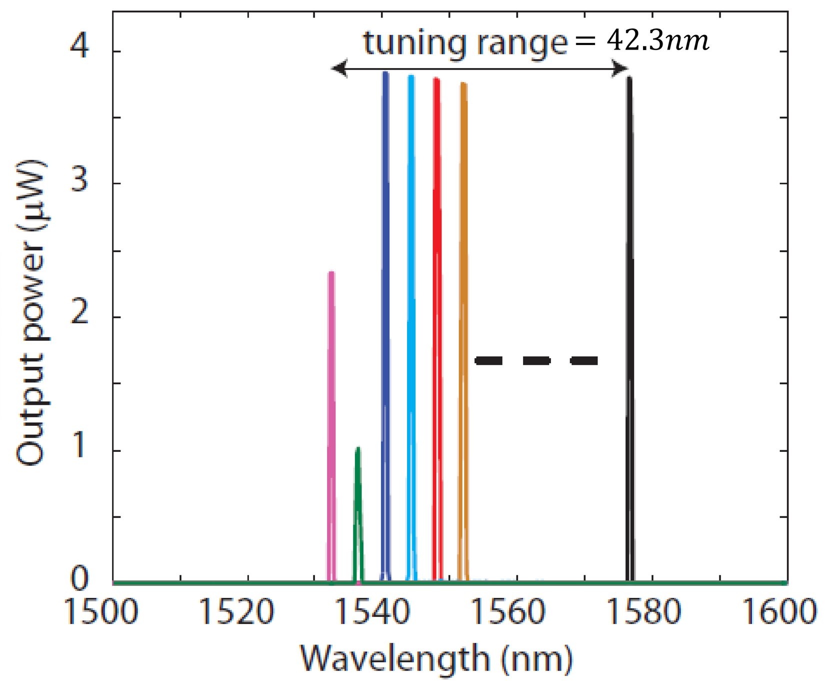
- Widely tunable
- Single longitudinal oscillation
- Narrow linewidth
- Small footprint (~mm$^2$)



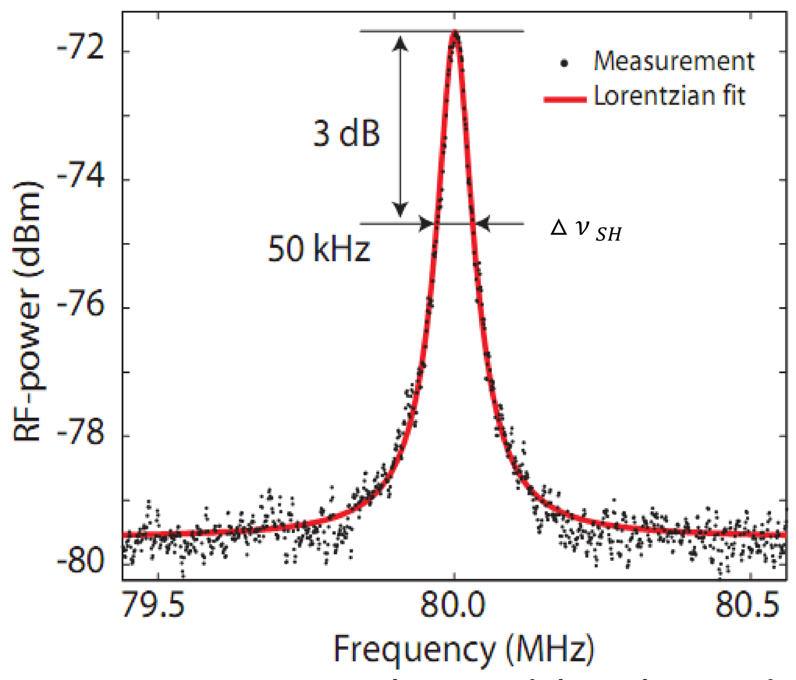
### Techniques

- Low loss external waveguide circuit
- Mirror-like device for spectrally filtered feedback (double-ring resonators)
- Hybrid integration of active material (InP) and passive material ($Si_3N_4$)

**Measured tuning WECSL output**




**Self-heterodyne measurement of line width**



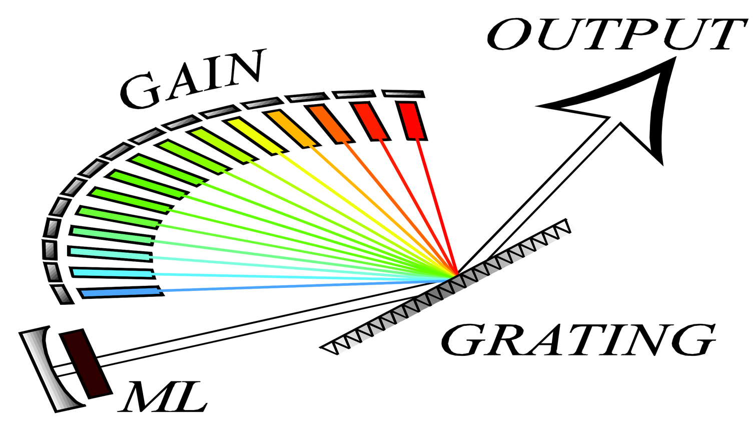

- Very narrow linewidth achieved

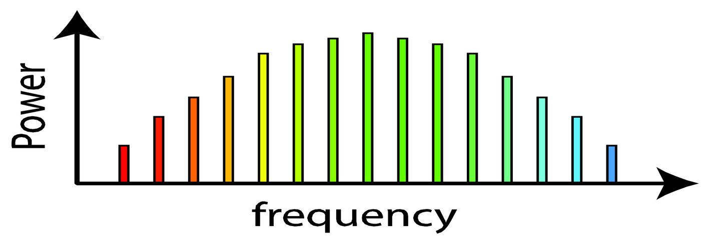
$$\Delta\nu = \frac{1}{2}\Delta\nu_{SH} = 25kHz$$

## Separate gain (SEGA) mode locking

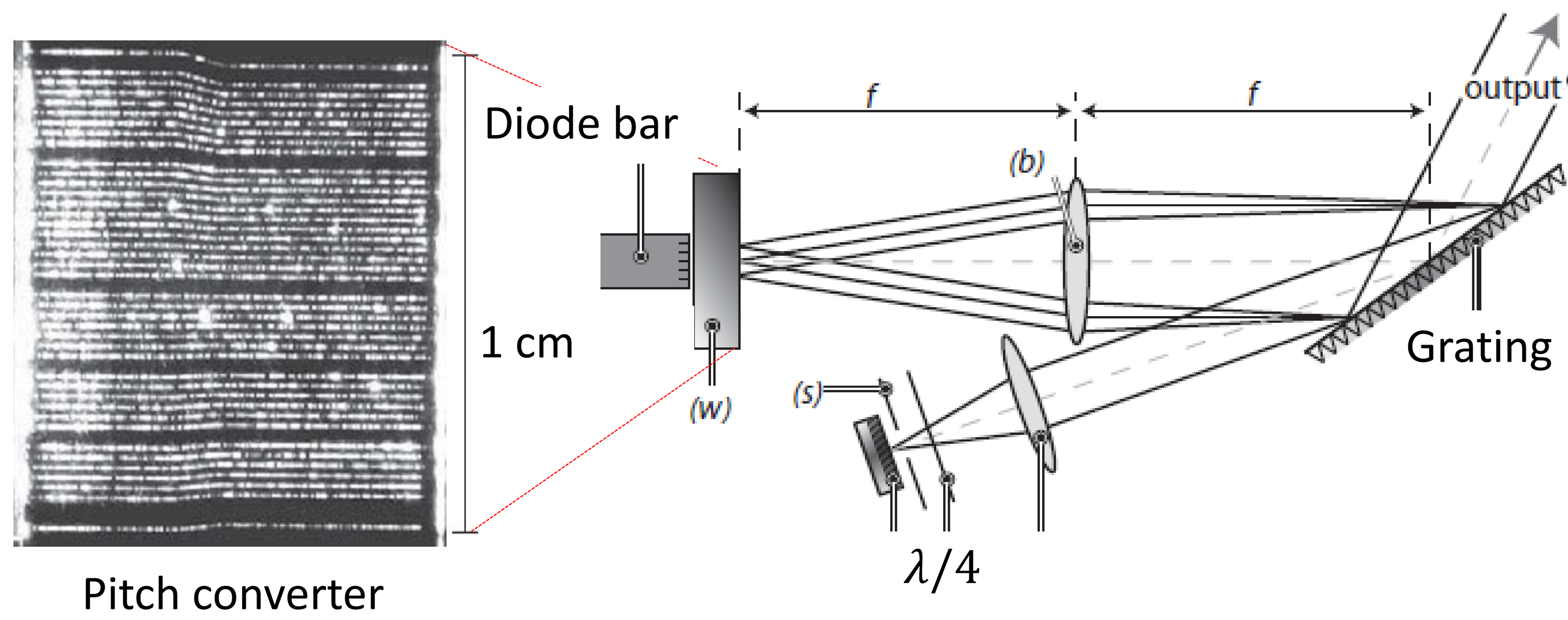
### Goal

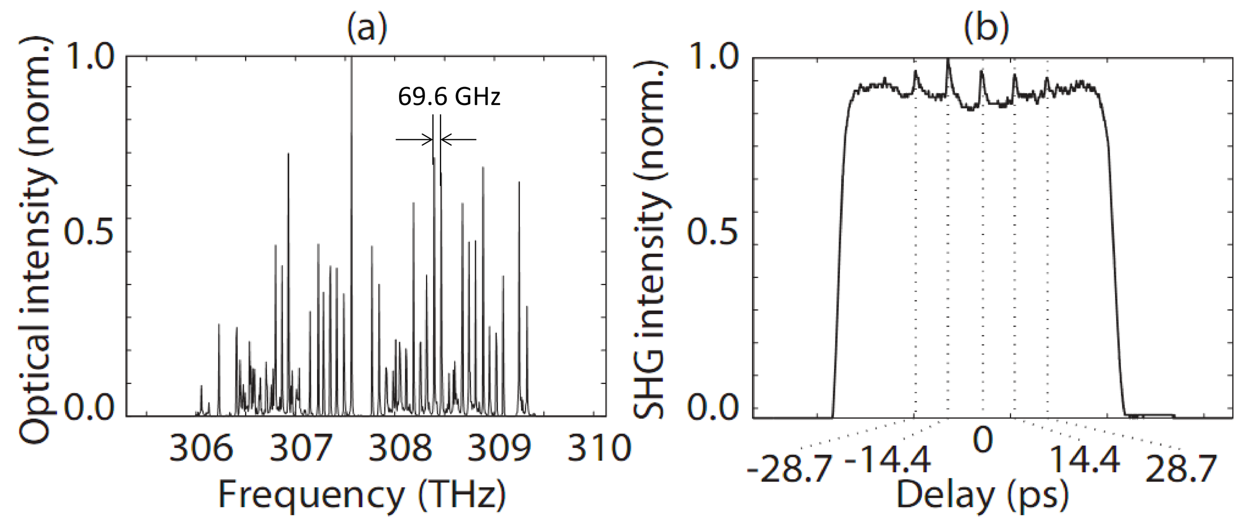
- High repetition rate mode lockied laser
- More elements = Higher output power
- Broader spectrum = reduced pulse duration




### Experiment setup



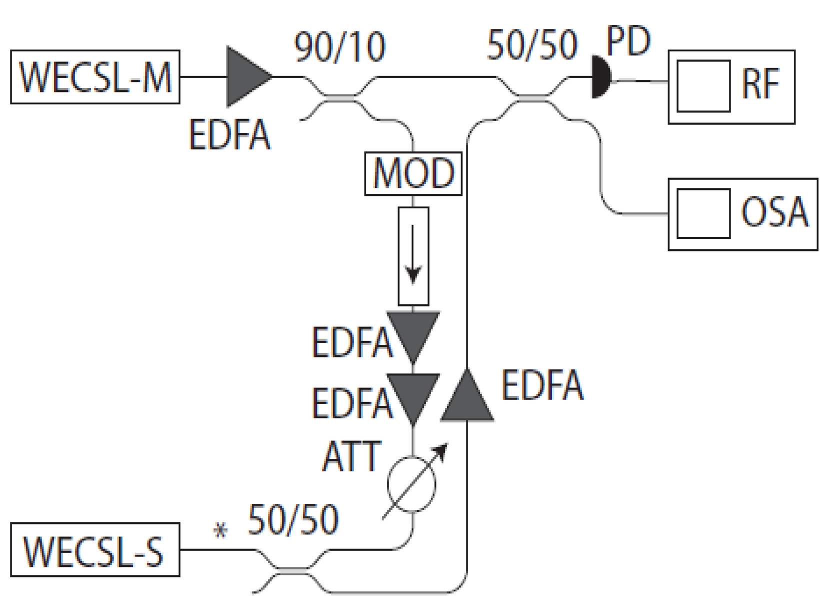

- Measured frequency comb, $\Delta f = 69.6\ GHz$
- Intensity autocorrelation

## Injection locking of a WECSL

### Goal

- Investigate the potential to build WECSL arrays with locked frequency and phase
- Verify injection locking as a tool to measure the Q-factor of complicated cavity with unknown losses.

### Experiment setup

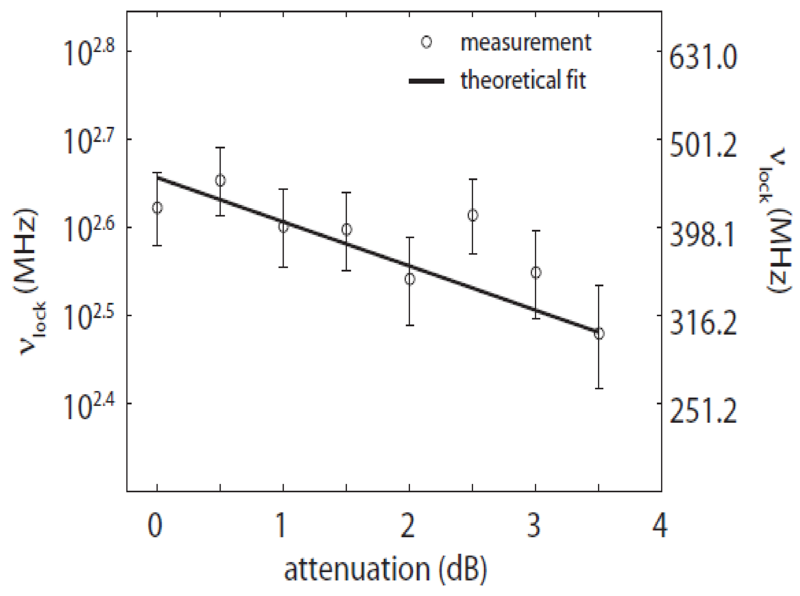



### Theory

- When subject to light injection from a Master laser, the frequency of the Slave laser could be locked within the range

$$\nu_{lock} = \frac{\nu_{SL}}{Q}\sqrt{\frac{P_i}{P_{SL}}}$$

### Main result




- Successful injection locking observed
- Estimated Q-factor = 7.7·10$^4$
- Q-factor inferred from measured WECSL linewidth = 1.5·10$^5$

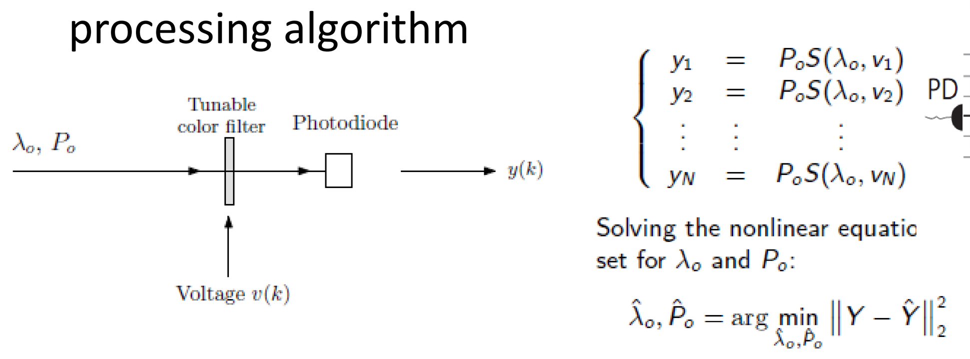
## High precision wavelength estimation

### Goal

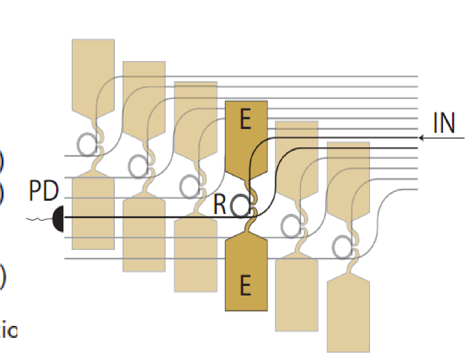
- Accurate wavelength monitoring devices for all integrated optics

### Method

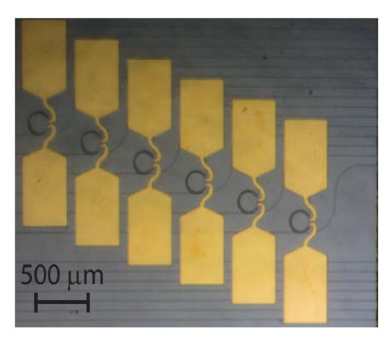
- Measuring detected signal from votage tunable microring resonator + smart signal processing algorithm

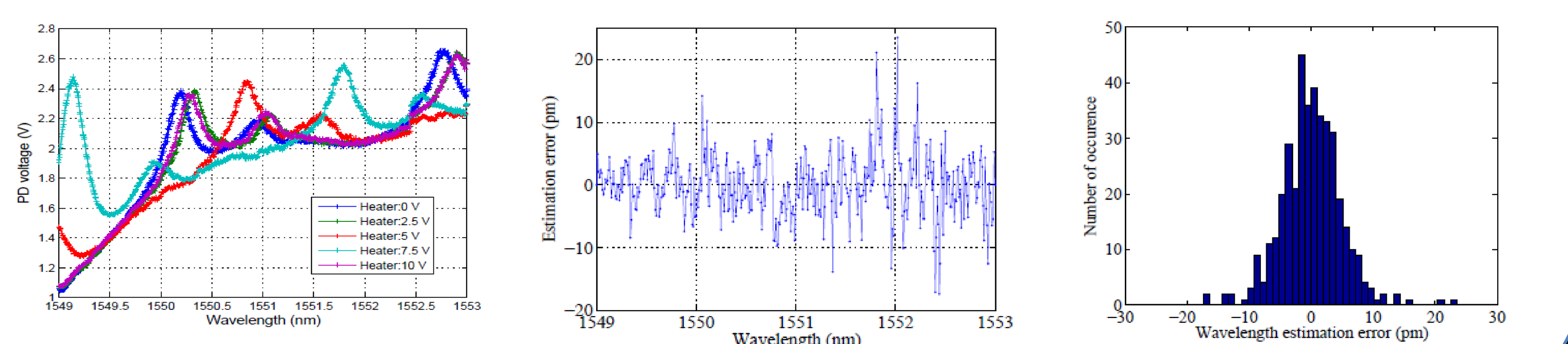



**Layout**




**Microscope picture**



- Spectral sensitivity by voltage tuning the microring resonator
- Wavelength estimation of high precision
- Histogram of the wavelength estimation error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