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# Infrared laser spectroscopy as a versatile tool for environmental quality monitoring

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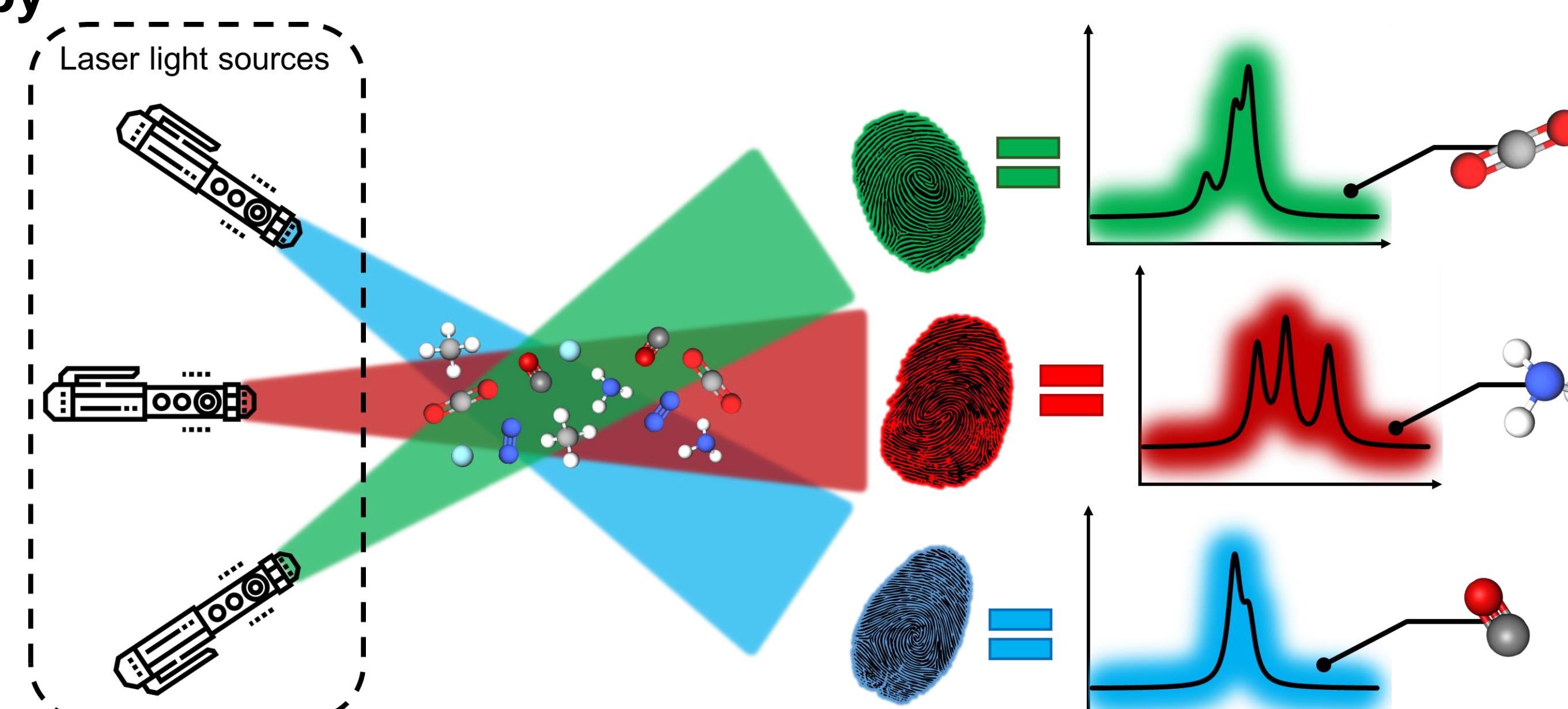
## Tunable Laser Absorption Spectroscopy

### Laser

→ High-brightness and purely monochromatic light source

### Tunable

→ Allows to precisely describe the absorption shape of the sample by scanning the laser wavelength



Absorption shape  
+ Associated wavelength  
= Specific to a single chemical species

Intensity of the absorption  
= Specific to a single chemical species

Beer-Lambert law  
→ Describe the absorption of the light

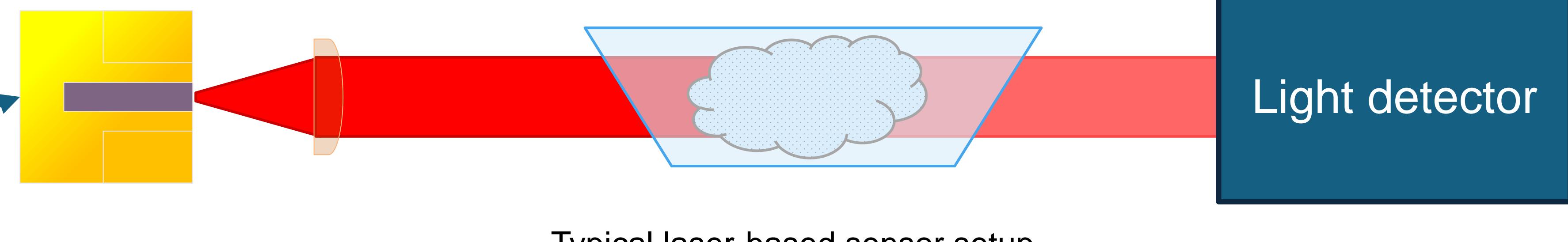
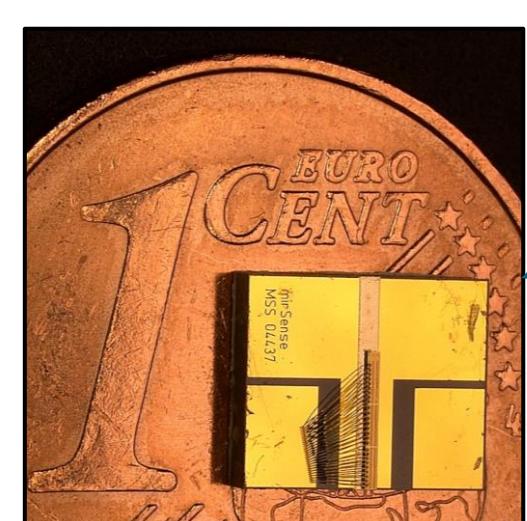
$$I = I_0 \cdot e^{-\alpha(\sigma)L \cdot C}$$

Absorption shape only rely on the chemical species  
Intensity only rely on molecular concentration and interaction length

→ Calibration free method

## Measurement techniques

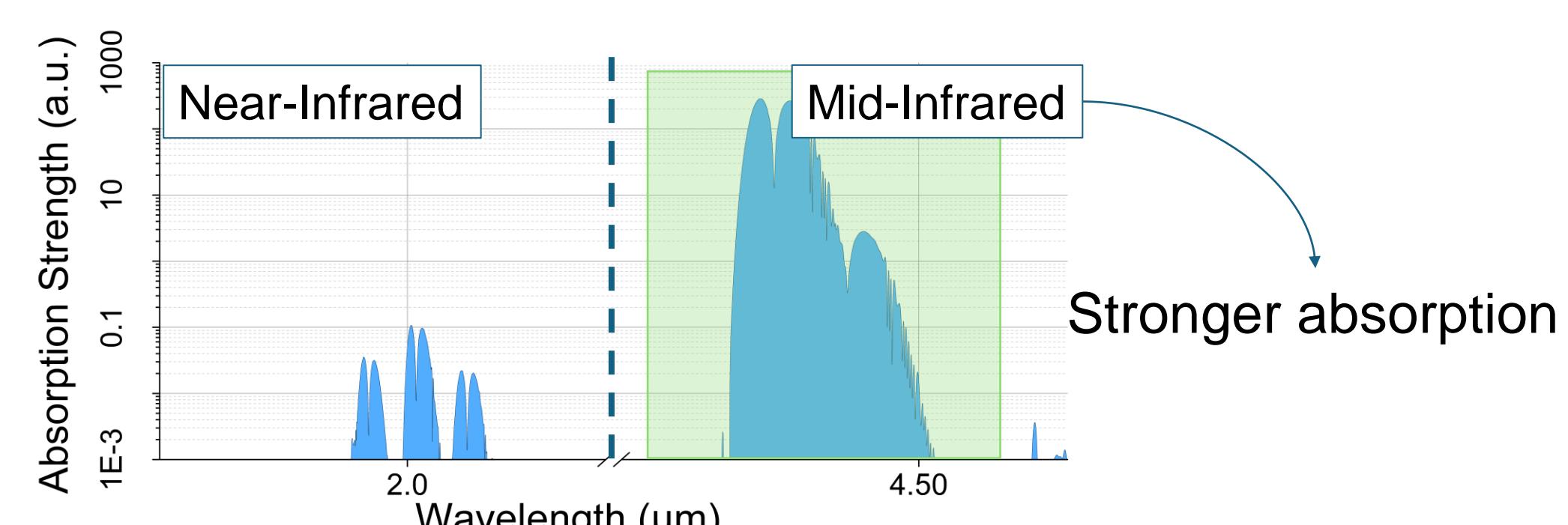
### Semi-conductor laser



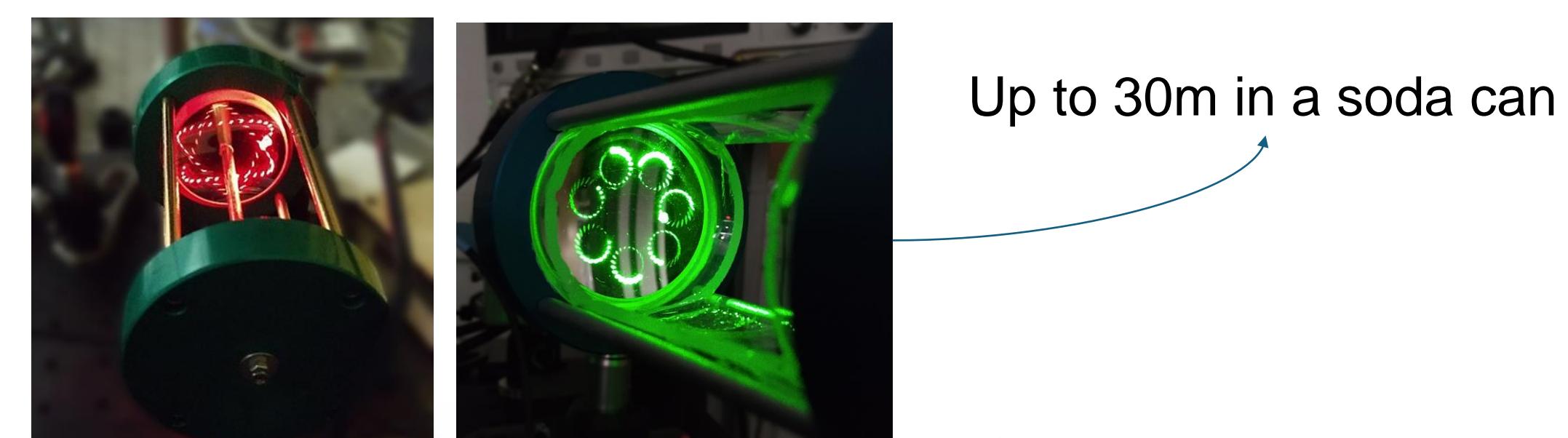
Typical laser-based sensor setup

Increasing sensitivity

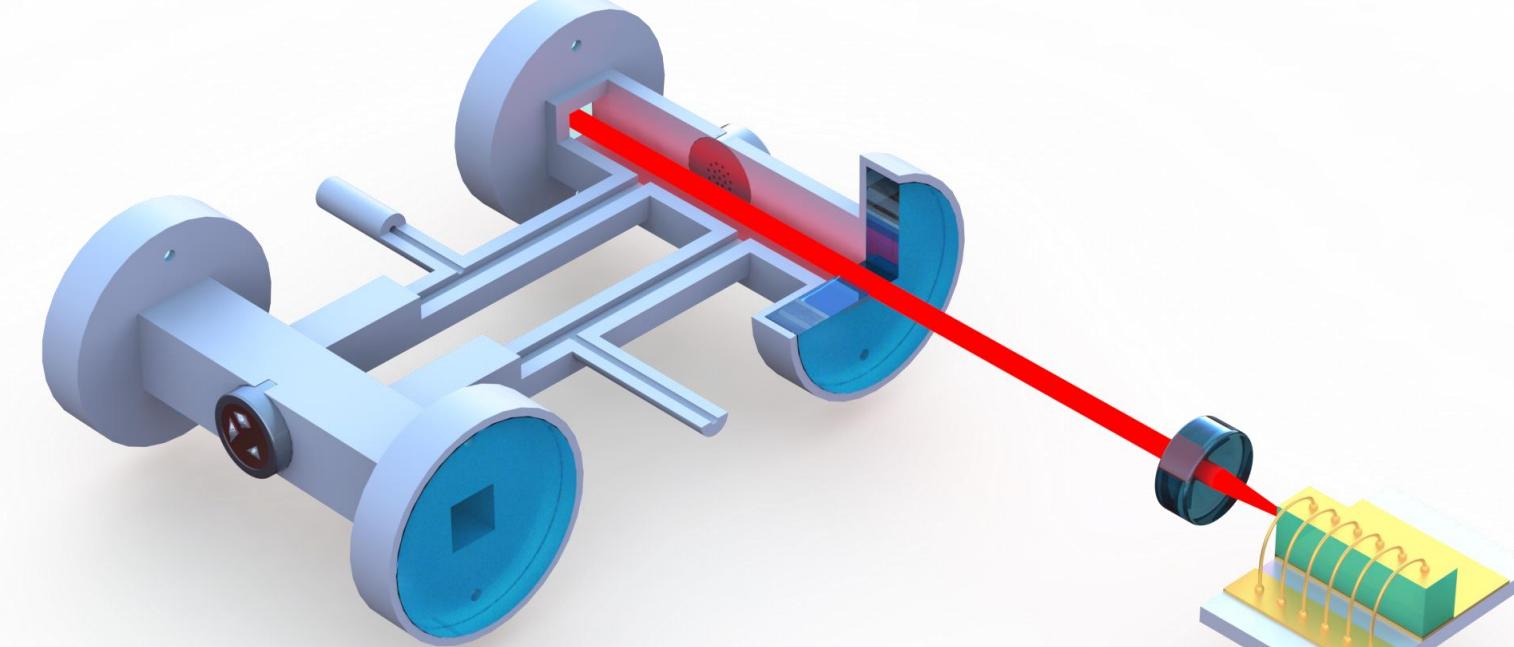
- Spectral region  
→ Infrared



- Interaction length  
→ Multipass cell



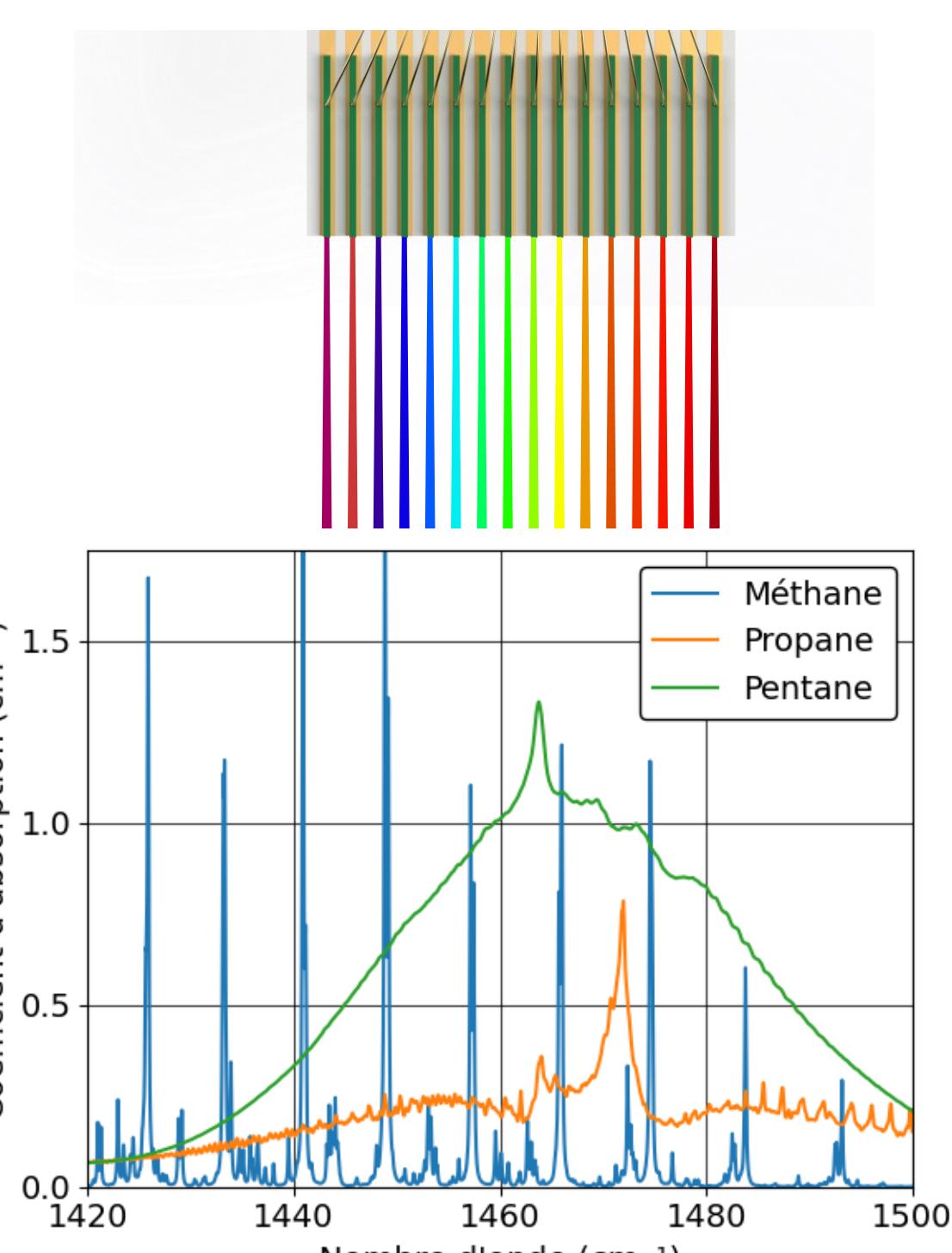
- Modulation techniques  
→ Wavelength Modulation  
→ Photoacoustic



Photoacoustic  
→ Turn light absorption into acoustic detection  
→ Low-cost detection

### Multiplexed laser source

1. Detect large number of species with narrow signature
2. Detect species with broadband signature  
→ Volatile Organic Compounds



→ Measurement methods can be adapted to a wide range of needs and constraints.

## Applications

- Long-term measurement  
→ Follow evolution and compare data with high reliability.

- Leak detection  
→ Detect and locate leaks of potential environmental pollutants.

- Large-scale sensor deployment  
→ Use these measurements to understand emission mechanisms through modeling.

### Example of outdoor measure campaign

