

# IrSens: QCL based MIR spectroscopy for fluids and gases

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**ETH**

Eidgenössische Technische Hochschule Zürich  
Swiss Federal Institute of Technology Zurich

**Objective:** Realization of a compact platform for spectroscopy of low concentration molecules in liquids and gases.

**Means:** Use of the strong absorption lines in the Mid-Infrared (MIR) due to fundamental vibrational and rotational modes of molecules.

**Targets for demonstrator:**

- Fluids: detection of cocaine in the saliva. Challenging goal due to the complex composition of saliva which can be different for every persons
- Gases: measurement of CO<sub>2</sub> isotopes. Challenging because of the very low concentrations involved.

**Collaboration:**

**ETH**  
Eidgenössische Technische Hochschule Zürich  
Swiss Federal Institute of Technology Zurich

**EMPA**  
Materials Science & Technology

**EPFL**  
ÉCOLE POLYTECHNIQUE  
FÉDÉRALE DE LAUSANNE

**n|w** Fachhochschule  
Nordwestschweiz

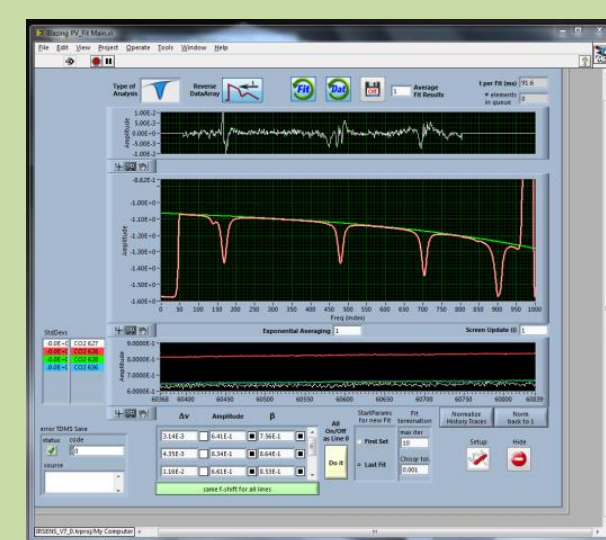
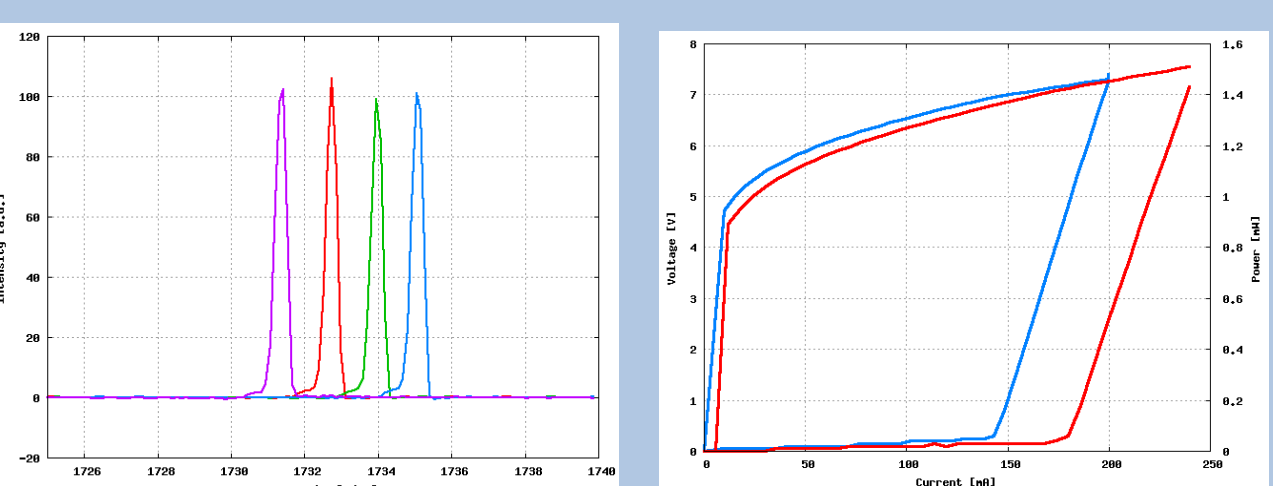
**unine**  
Université de Neuchâtel

## Systems and Components

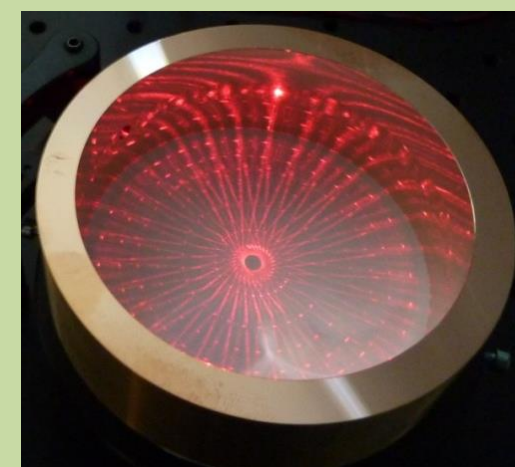


**QCL**

**ETH**  
Eidgenössische Technische Hochschule Zürich  
Swiss Federal Institute of Technology Zurich



**n|w** Fachhochschule  
Nordwestschweiz  
Analysis software,  
1kHz real time fitting

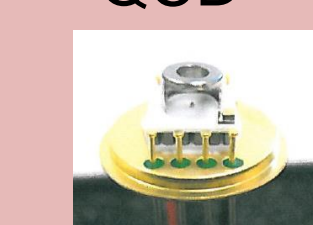


Cylindrical mirror cell

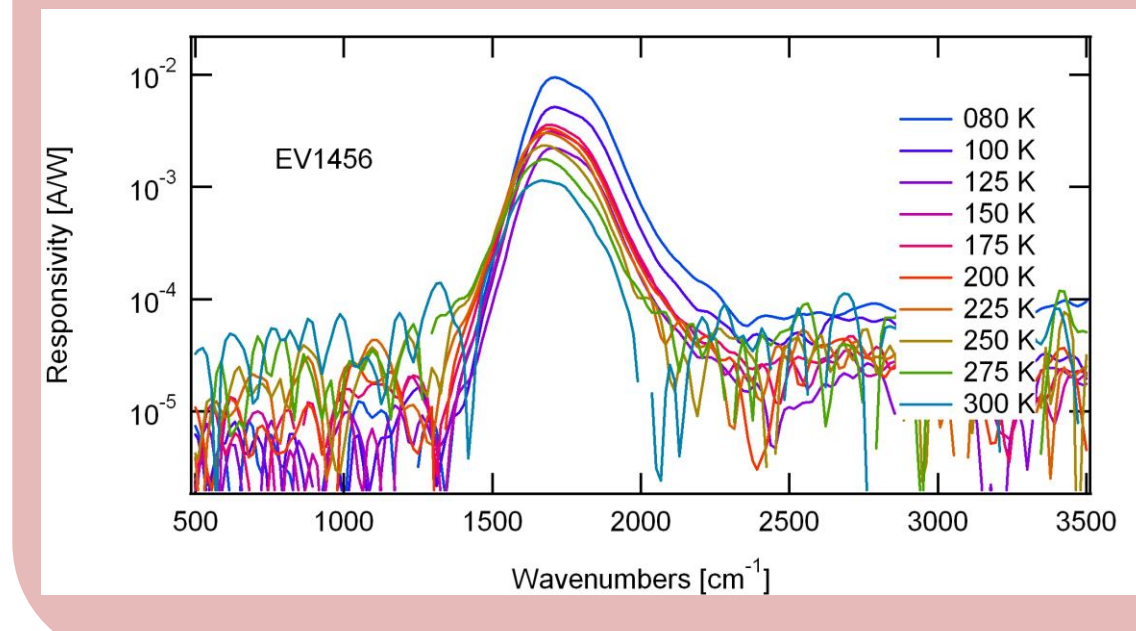
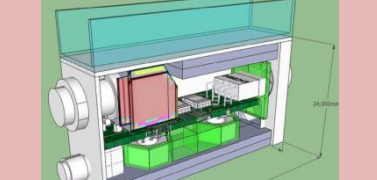
**Gas cell**

**Detector**

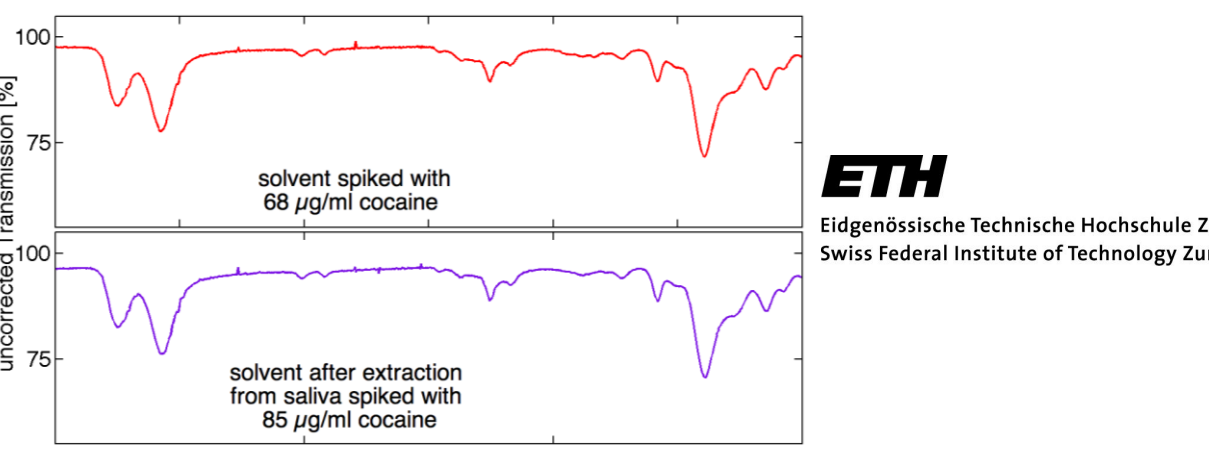
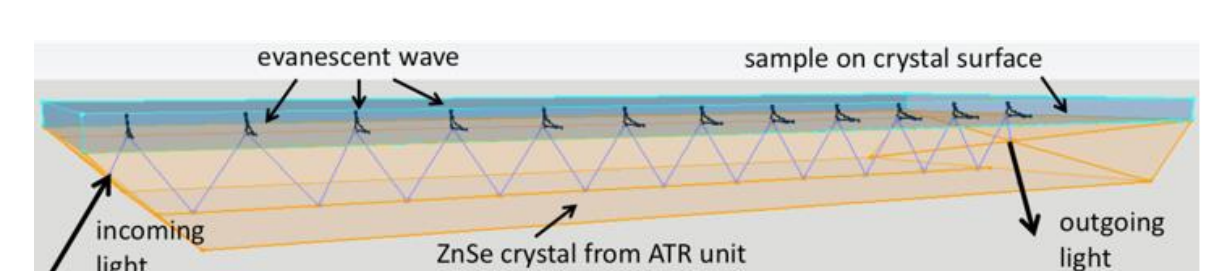
**QCD**



**Preamplifier**

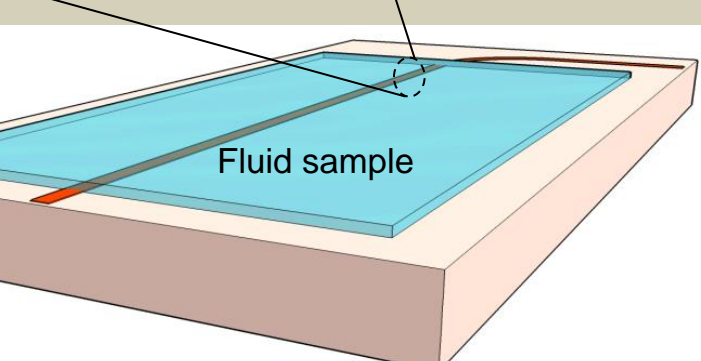


Benchmark measurements for the cocaine:



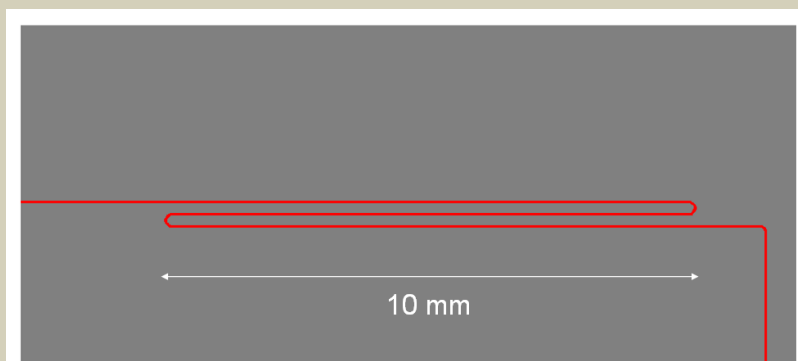
**Microfluidic cell**

Interaction region

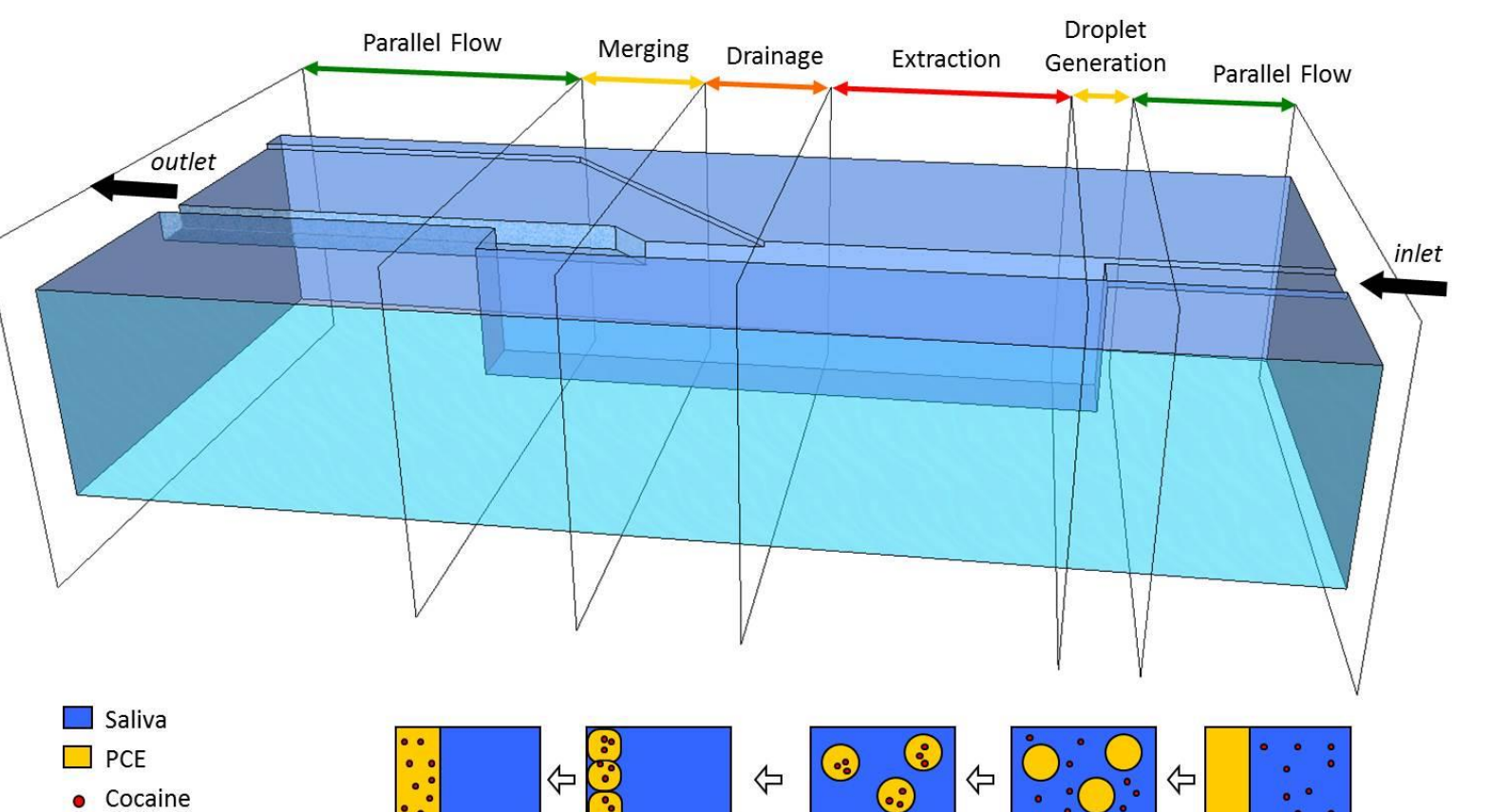


Evanescent wave from waveguide into liquid (ATR)

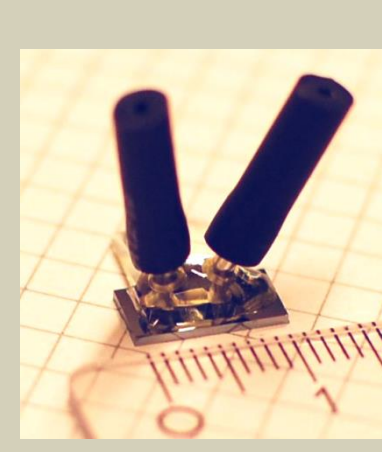
Waveguides



Microfluidic system for the cocaine extraction

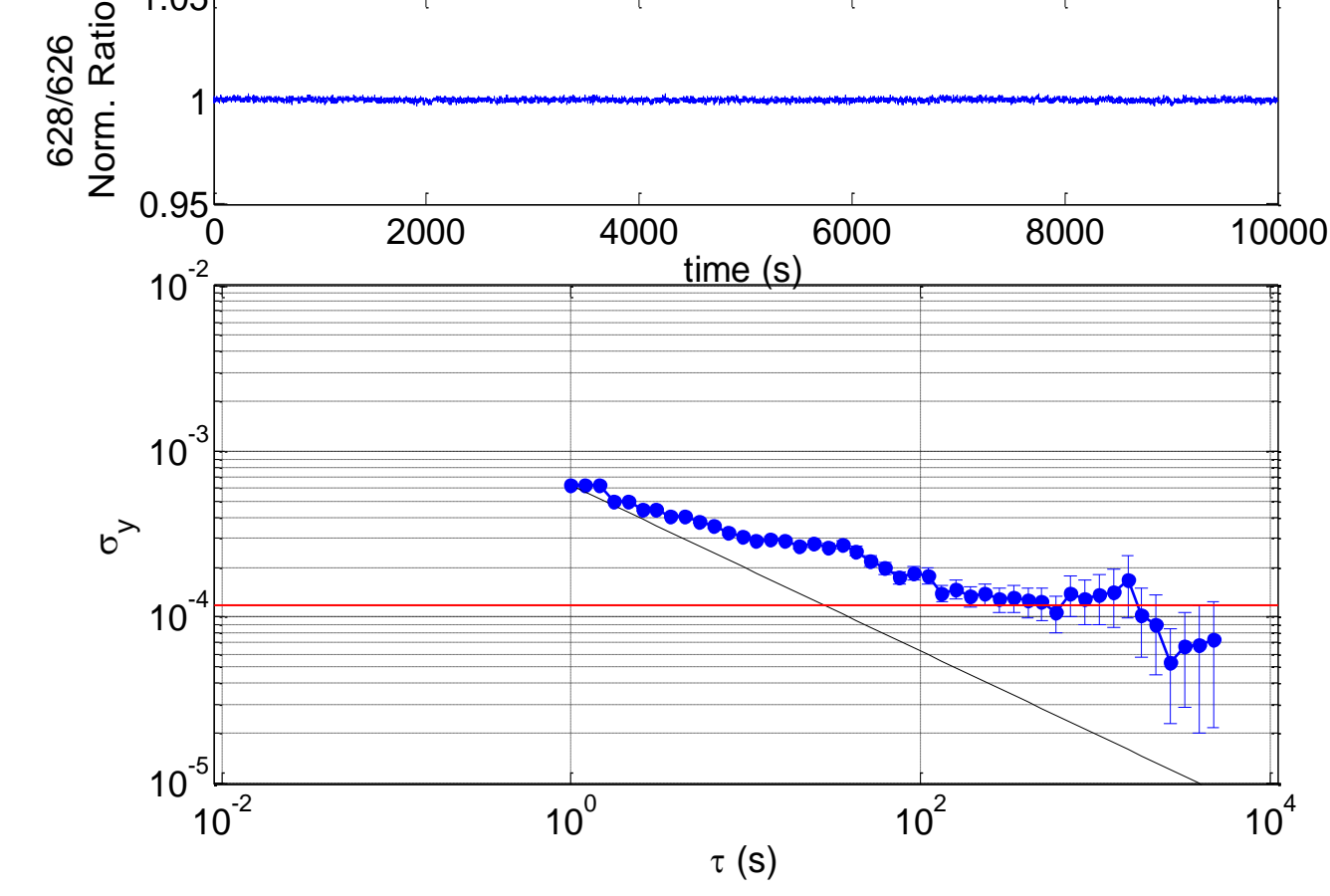


**EPFL**  
ÉCOLE POLYTECHNIQUE  
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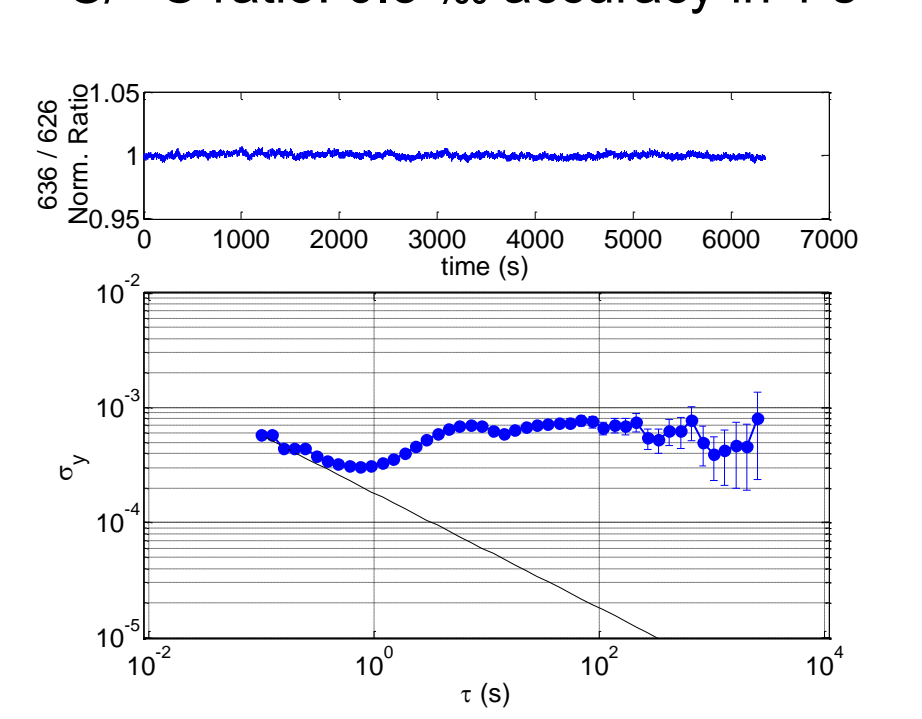


## Gas measurements: CO<sub>2</sub> isotopes

Quantum cascade detector:  
13C/12C ratio: 0.7 ‰ accuracy in 1 s  
0.07 ‰ in 1000s



Commercial MCT detector:  
13C/12C ratio: 0.3 ‰ accuracy in 1 s



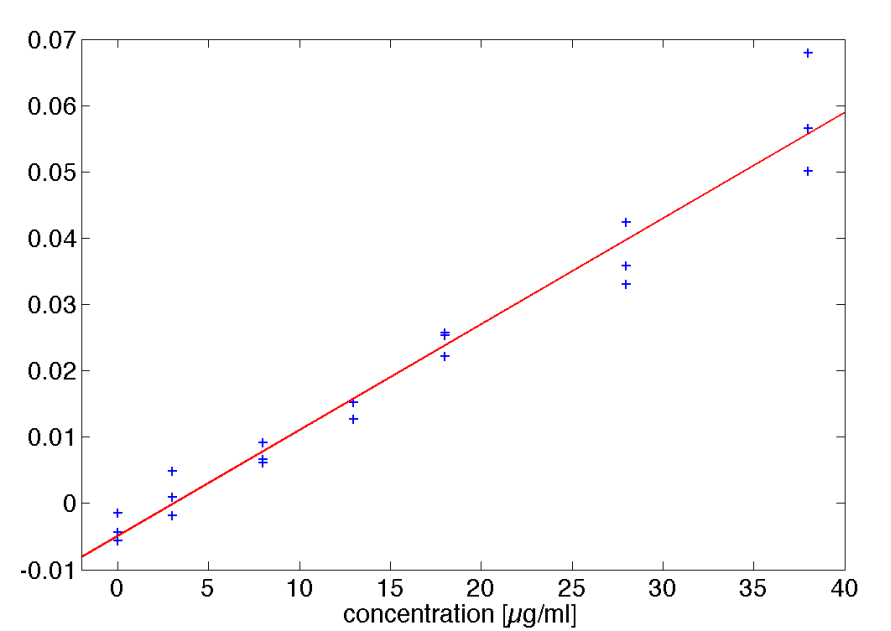
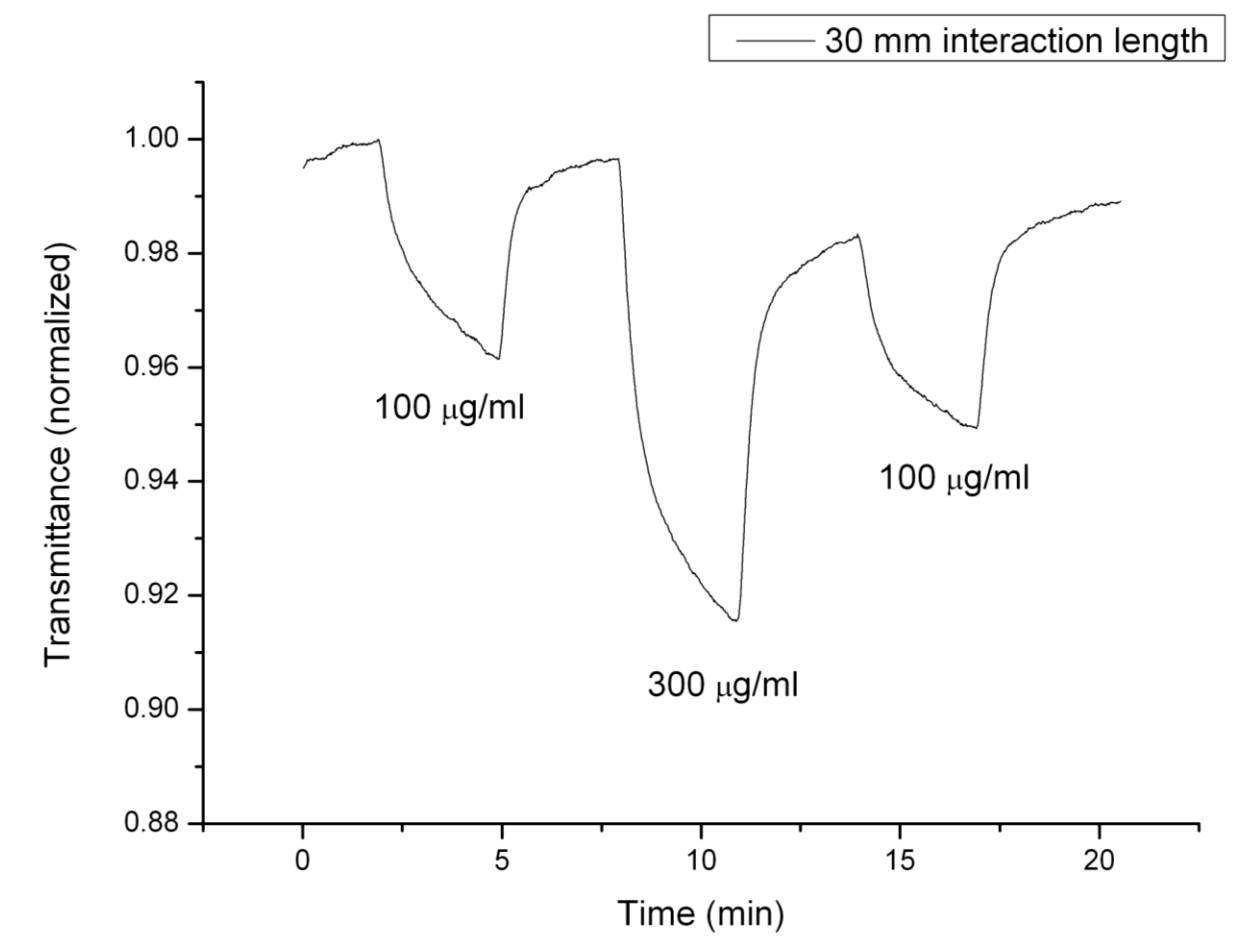
- High accuracy isotope measurements with toroidal cell achieved
- Goal of 0.1‰, necessary for health and environmental applications, is reached
- First successful combination of QCL with QCD: all III-V detection

Direct Absorption	Wavelength Modulation	Photoacoustics	Picarro (CRDS reference)
0.47	0.76	58.0	0.67
0.05 (250s)	0.07 (450s)	0.60 (8000s)	0.1 (300s)

1 sec (first line) and best precision values (last line, with integration time) in ‰ for different techniques with IrSens prototype 1<sup>st</sup> generation cell with commercial MCT detector, in comparison to commercial (Picarro) CRDS NIR system

Manninen et al., Applied Physics B (2012)

## Fluid measurements: cocaine

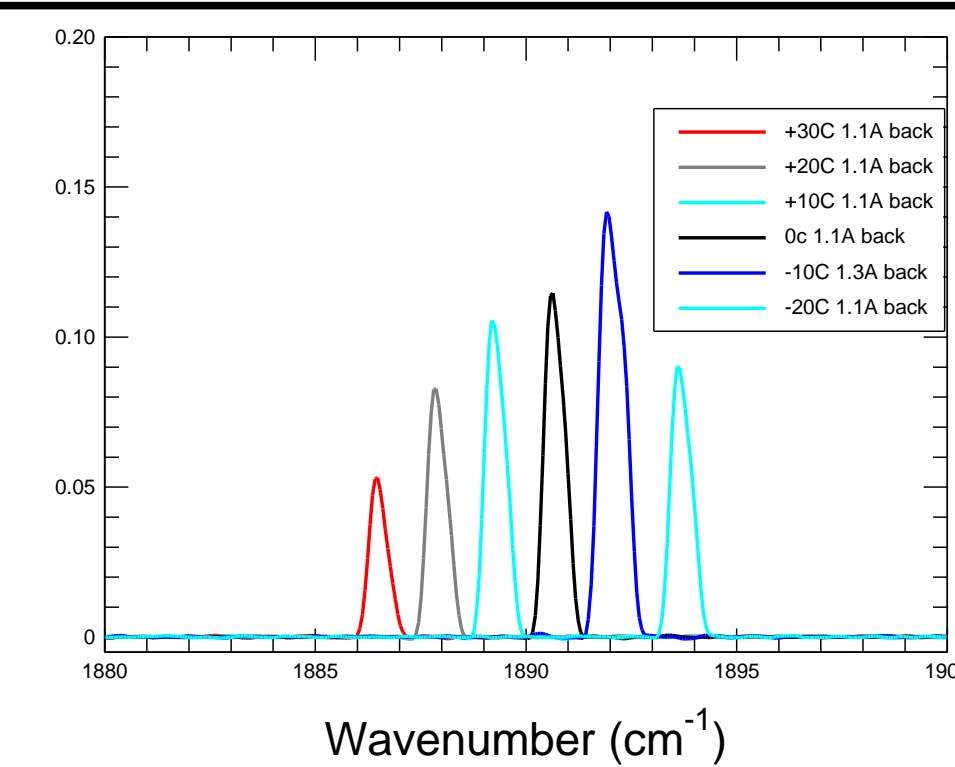
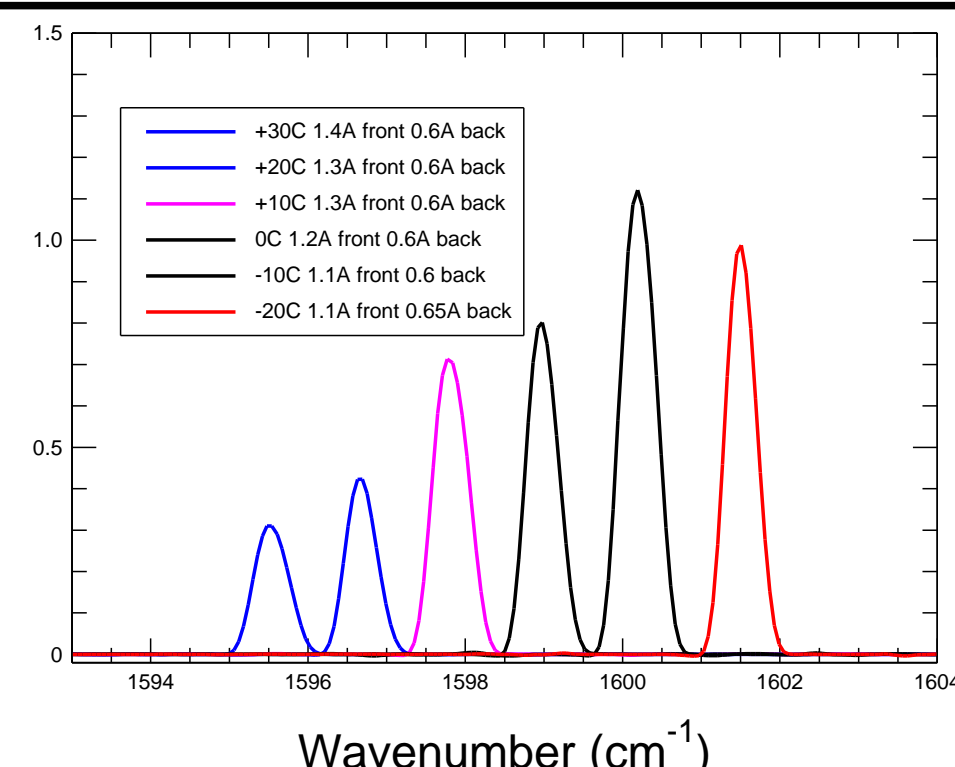
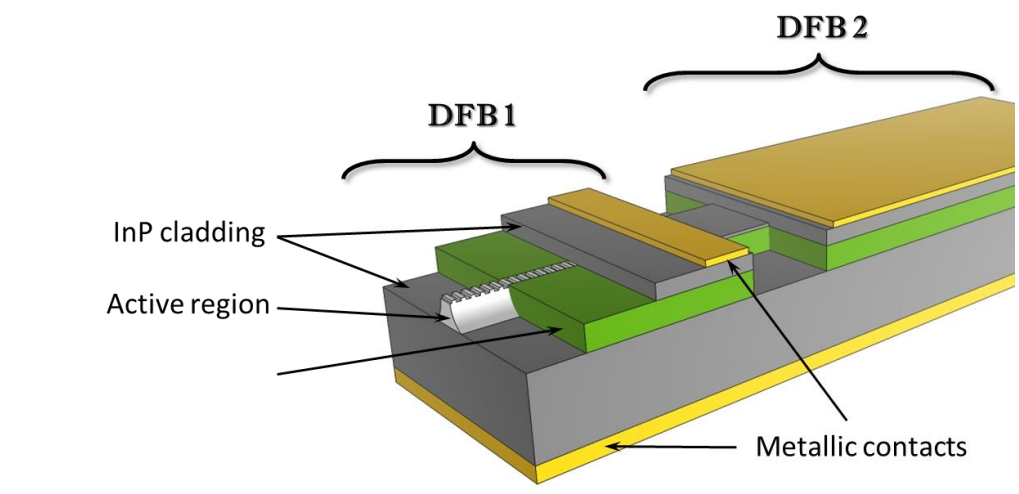


ATR limit detection with the FTIR below 5 µg/ml

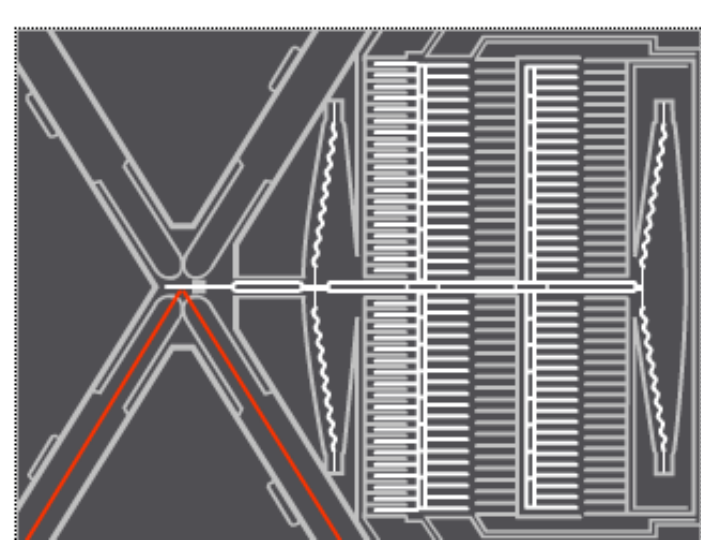
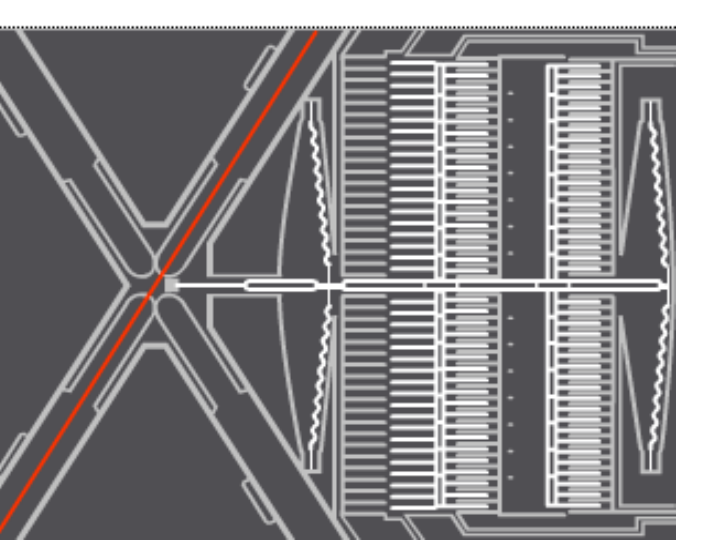
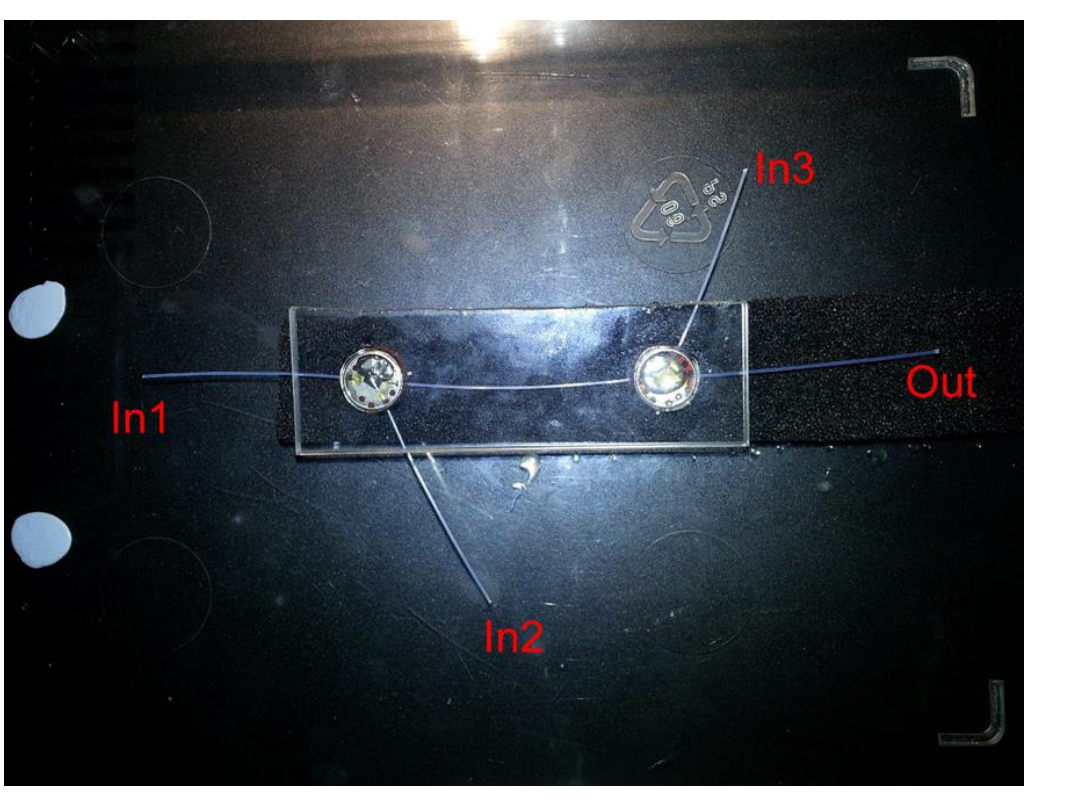
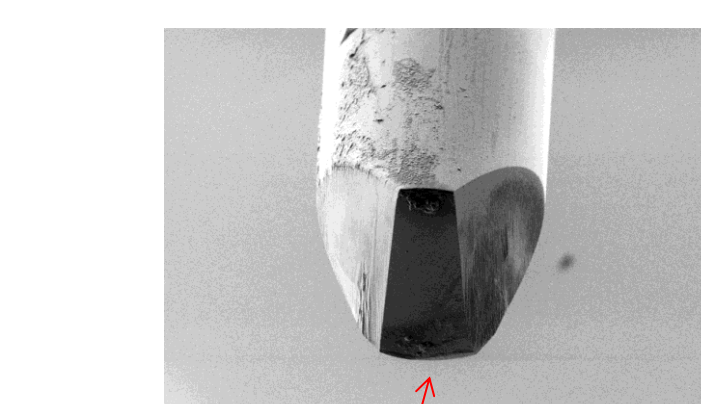
Absorption due to different concentrations of cocaine measured with the microfluidic system on top of the waveguide.

Concentration in saliva after one dose of cocaine ~500 µg/ml

## Twin DFB QCL:



## Optical switch: coupling of optical fibers



**serecalo**  
microtechnology ltd

## Add-on IrNox:

Approaches for single optical output of several independant single mode lasers

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