

MIR

direct absorption

Multi-component laser spectroscopy: on the way to the all-in-one laser sensor

Lukas Emmenegger

Empa, Air Pollution / Environmental Technology Lab



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Materials Science & Technology

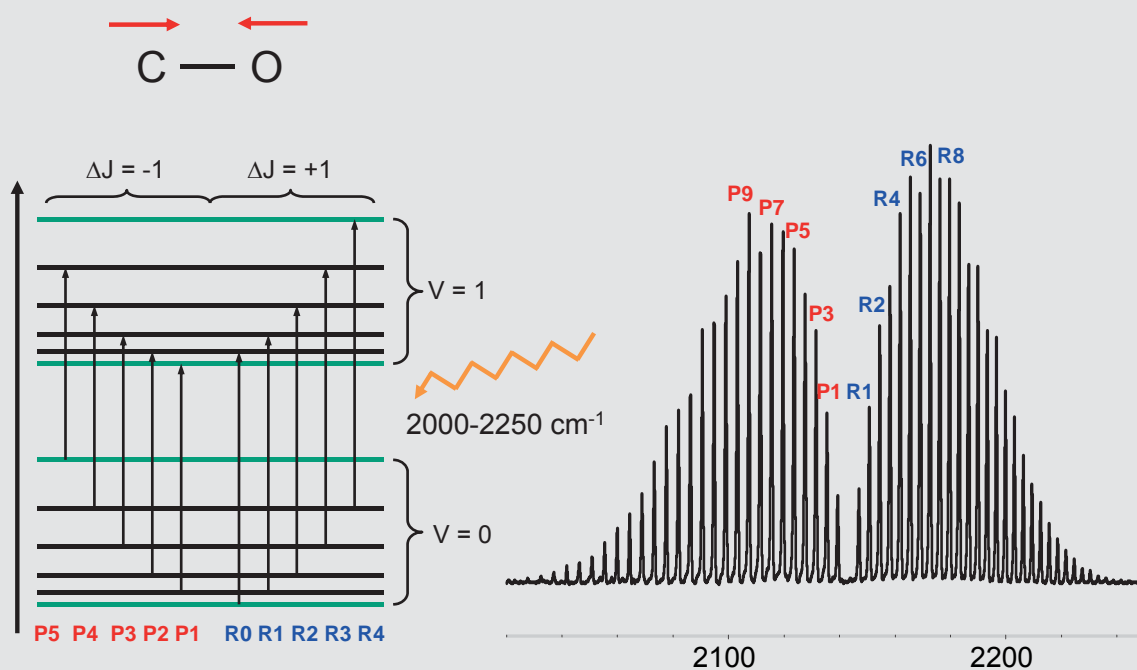
Overview

1. Introduction to (quantum cascade) laser spectroscopy
2. Example: CO₂ isotopes with <0.1 ‰ precision
3. Miniaturization
4. Outlook

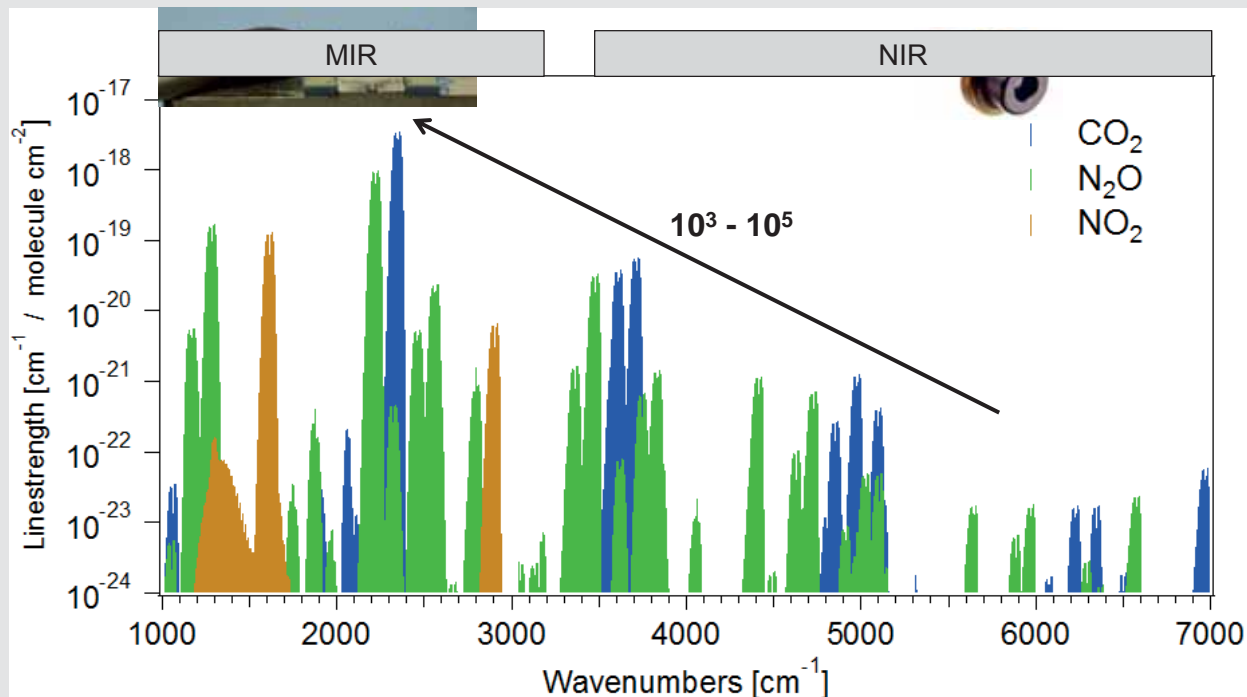
Direct Absorption Laser Spectroscopy



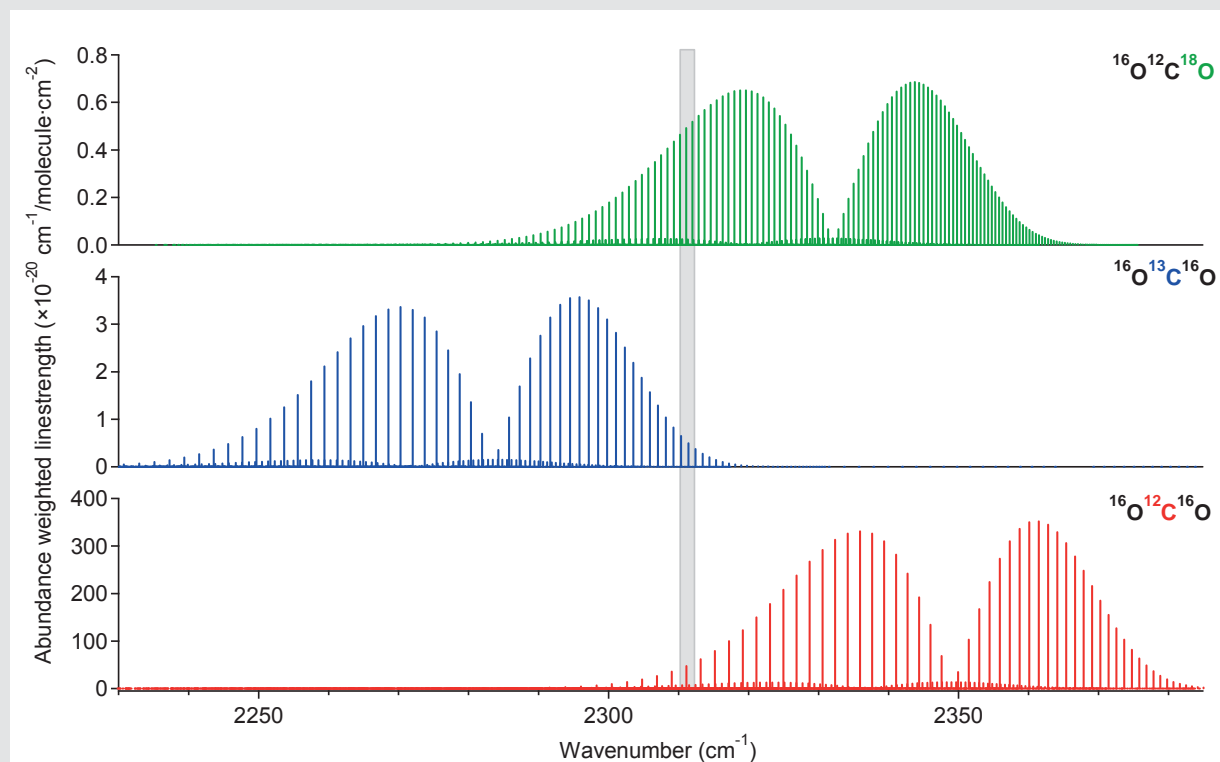
Ro-vibrational transitions in the MIR



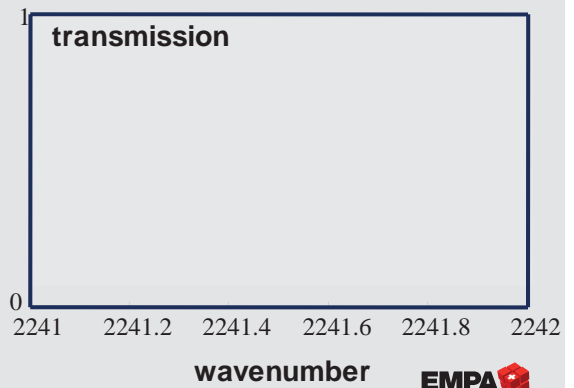
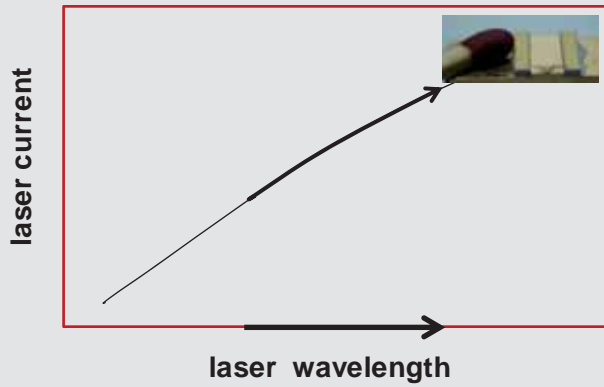
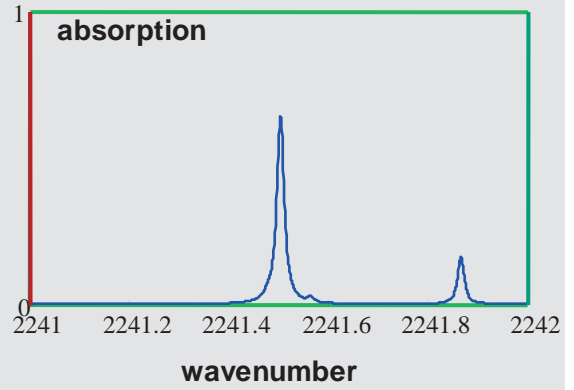
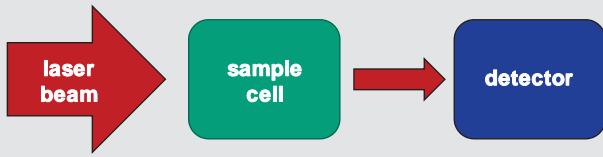
Linestrength and light sources



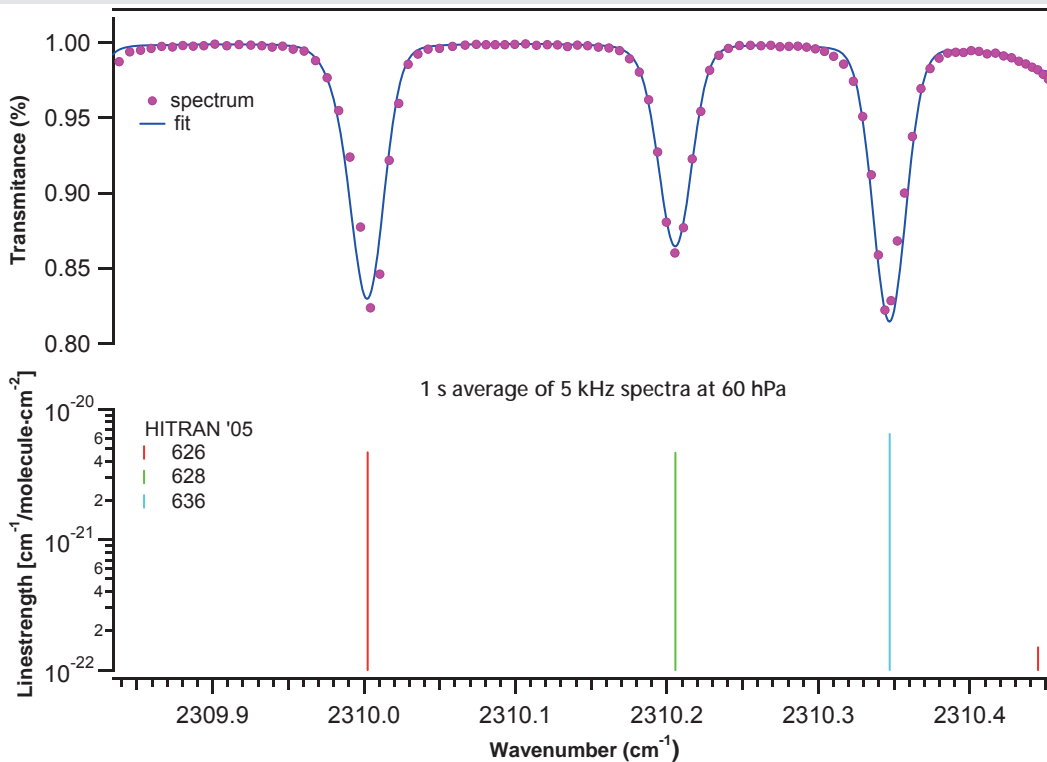
Simulated ν_3 ro-vibrational bands of CO₂ based on Hitran



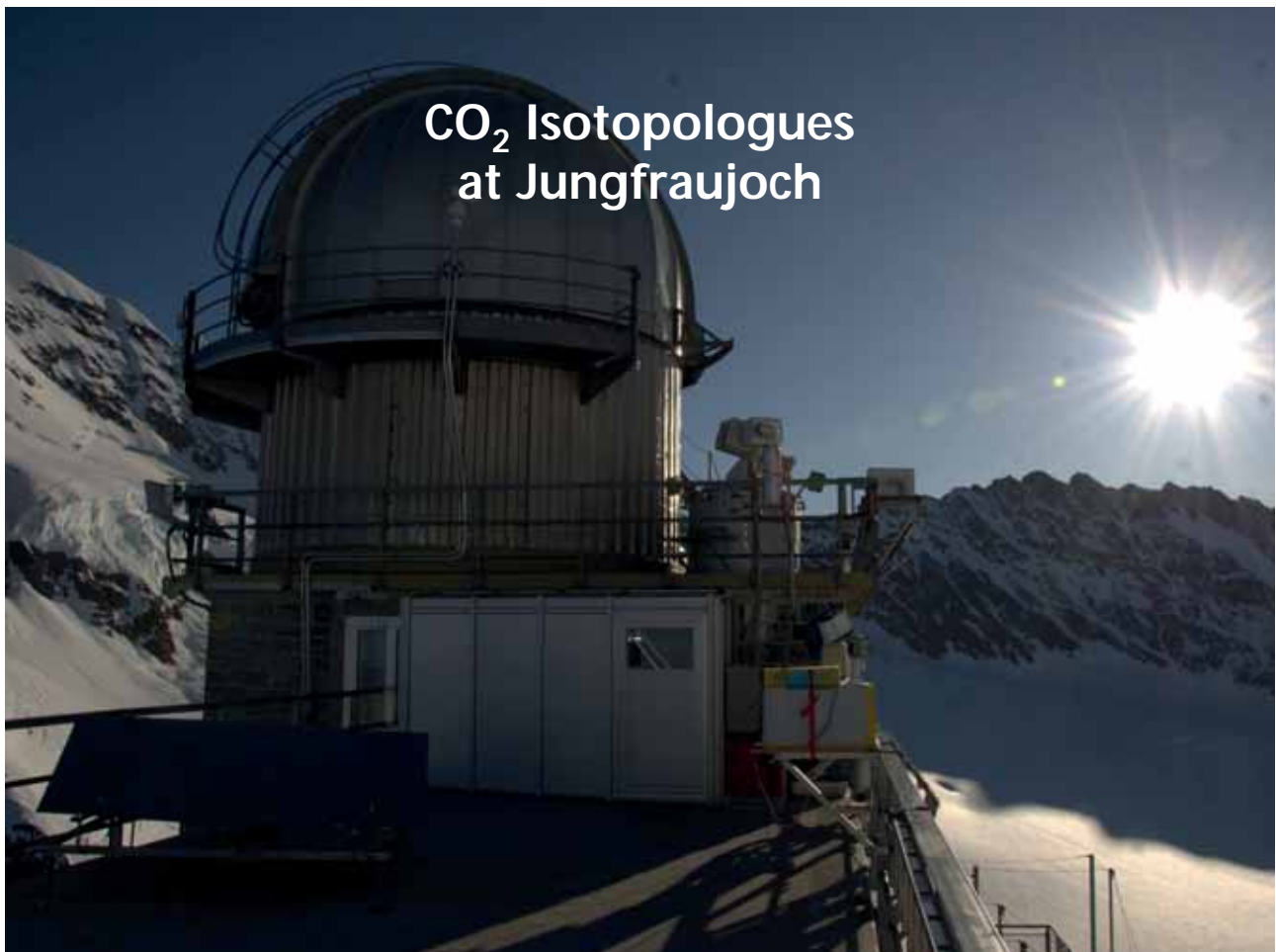
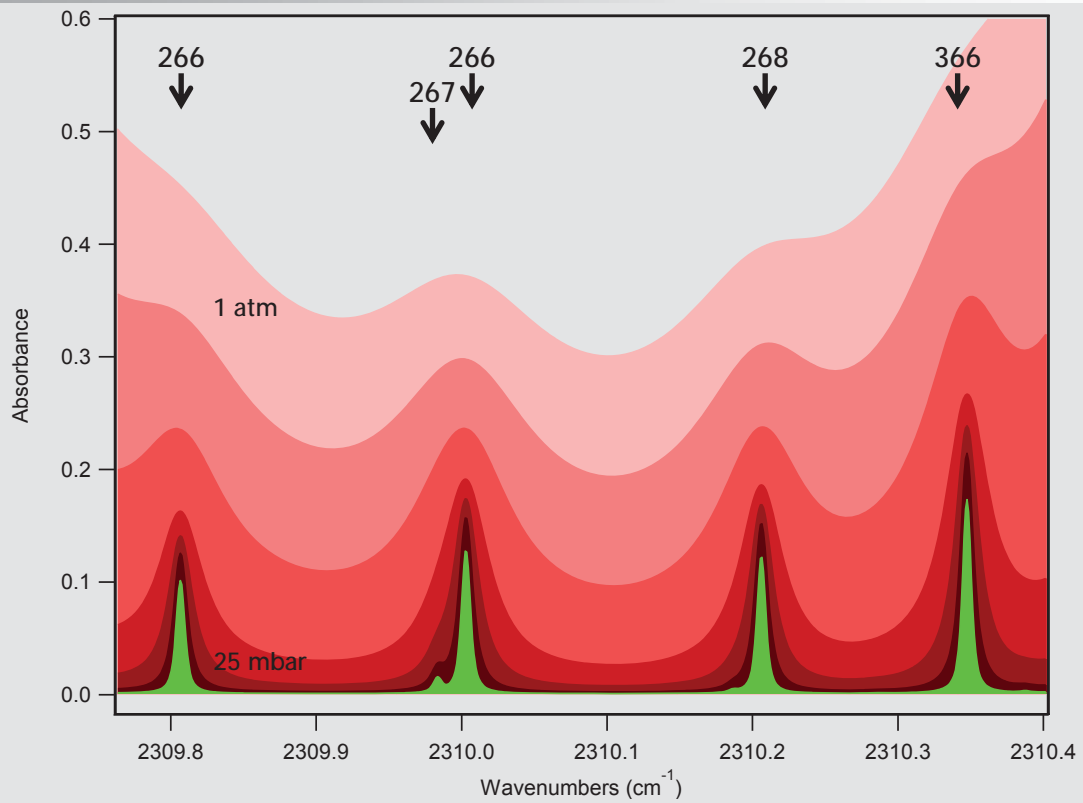
Direct absorption spectroscopy



Measured and Simulated Absorption Spectrum of CO₂



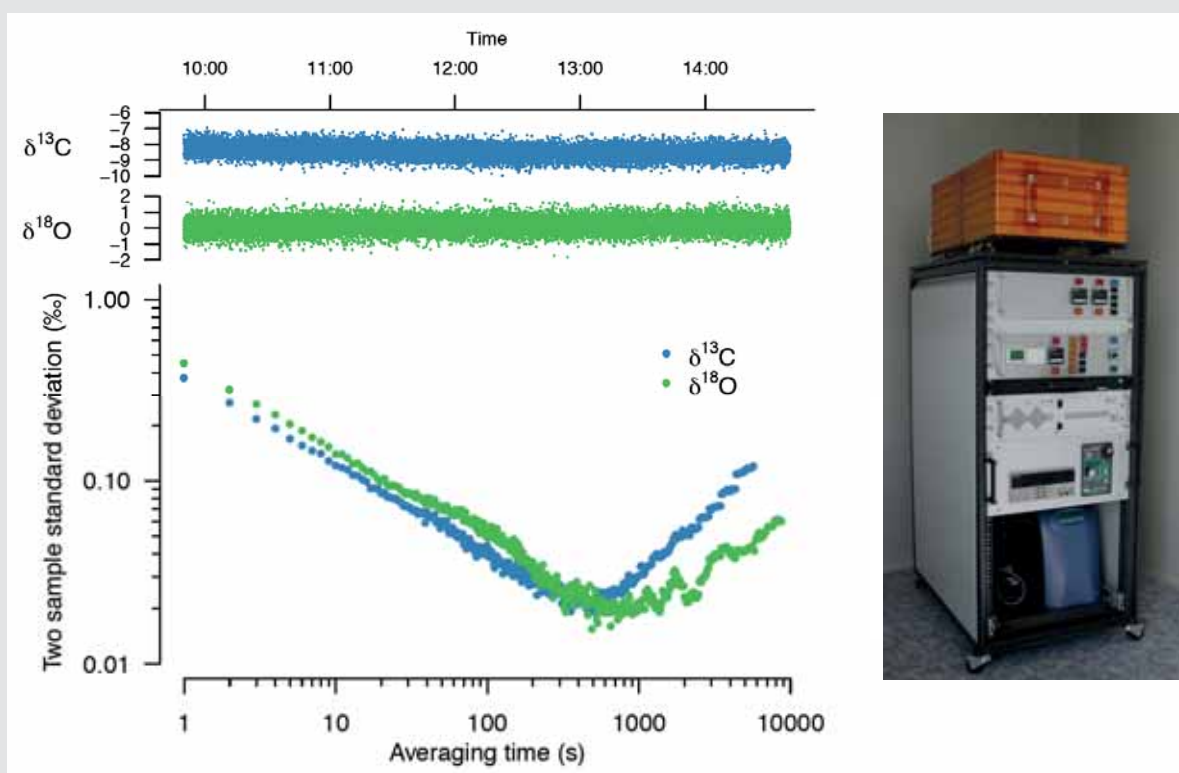
Peak Separation – Resolution and Pressure



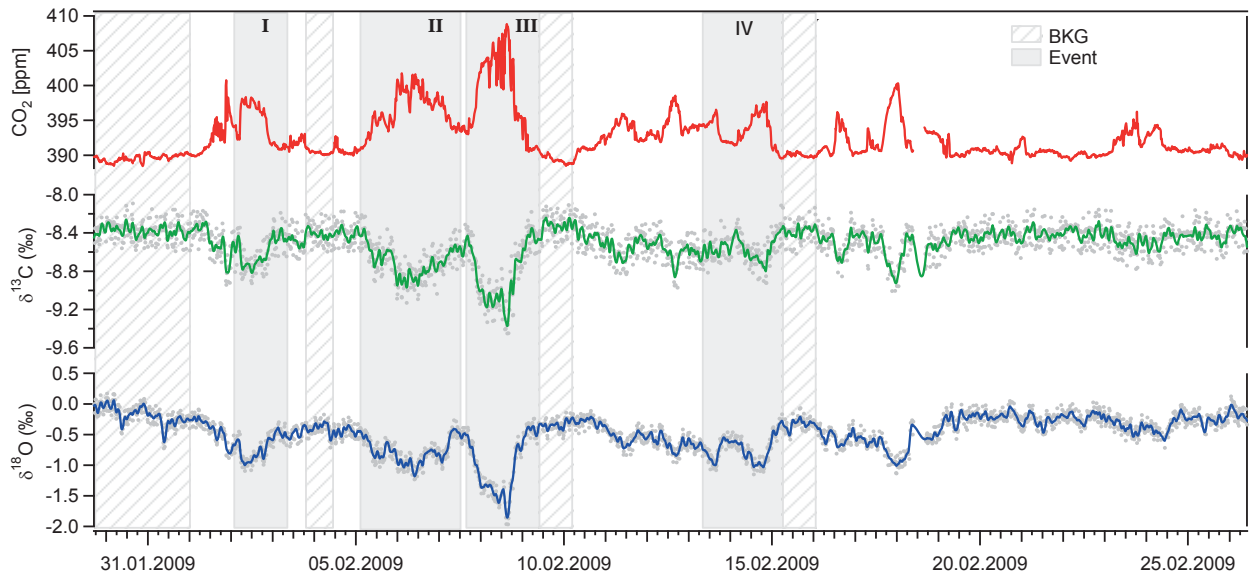
Optics for high-precision measurements



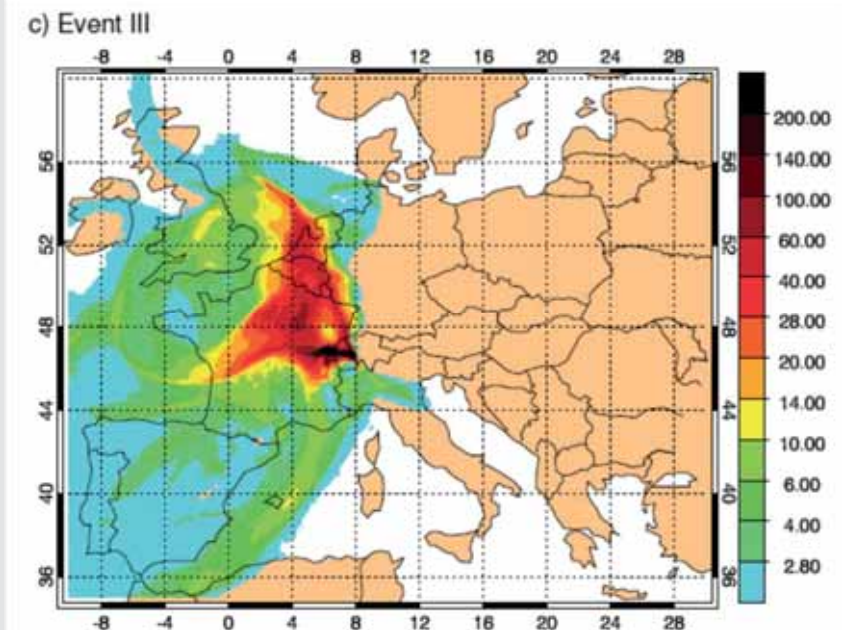
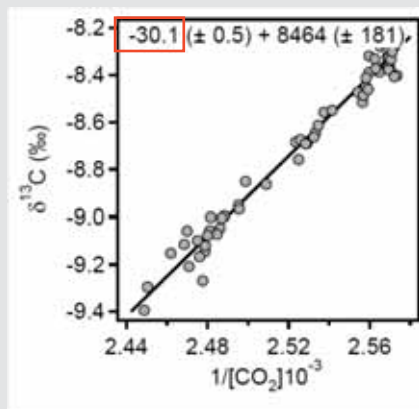
Precision & Stability (Allan plot)



Short-time variations @ Jungfraujoch, 3580 masl

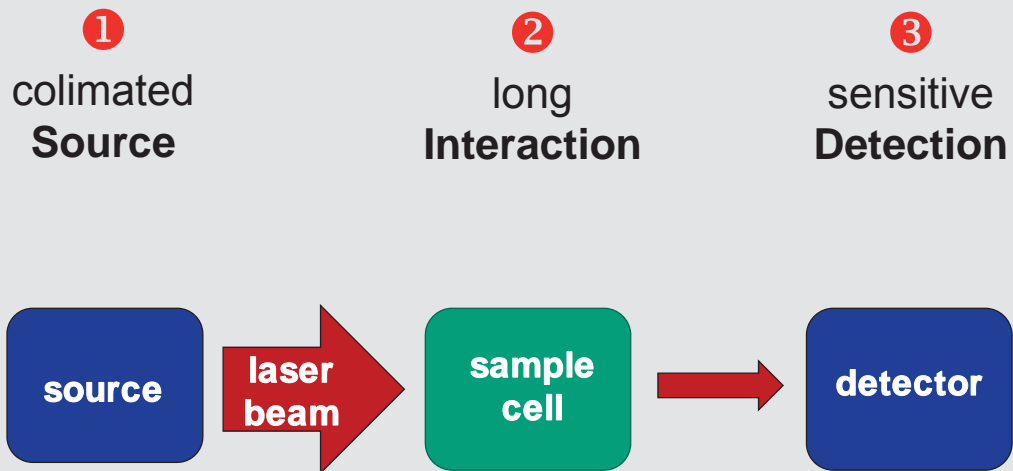


Event III : $\delta^{13}\text{C}-\text{CO}_2$

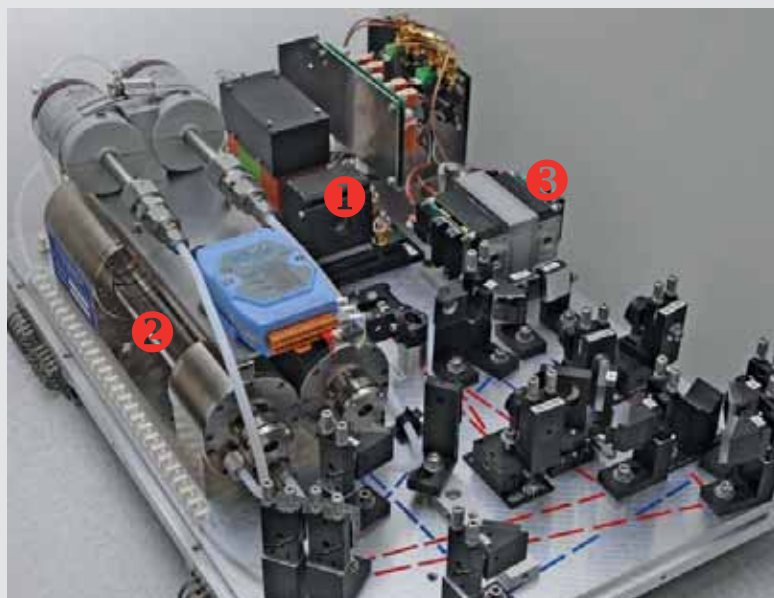
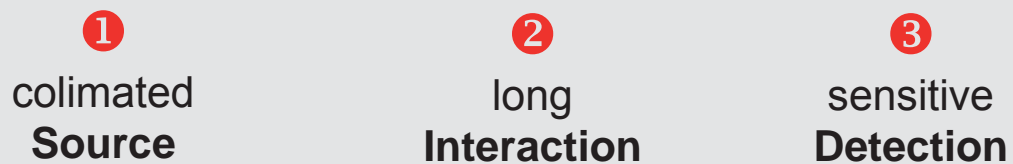


Tuzson et al., ACP (2011) ; Sturm et al. AMTD (2013)

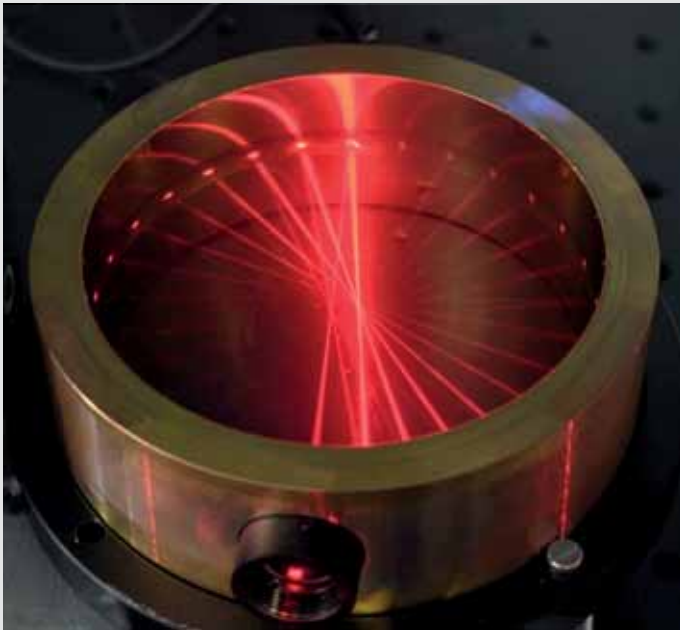
Main optical elements of a direct absorption gas sensor



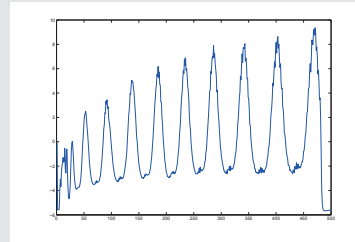
Main optical elements of a direct absorption gas sensor



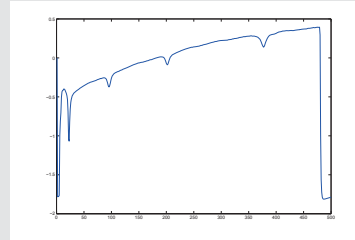
Toroidal Cell with «Fringe Killer»



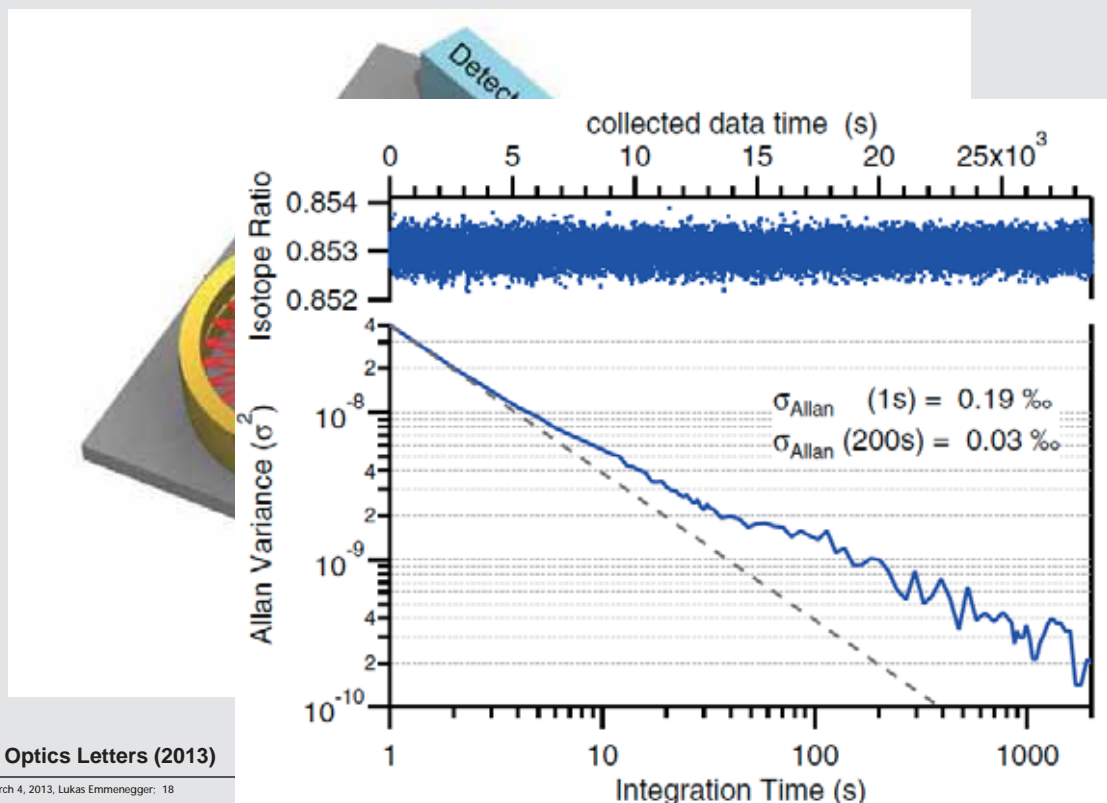
-> interference, fringes



with absorption mask
(patent pending)



application of the toroidal cell for CO₂ isotopes



Current size of main optical elements

1

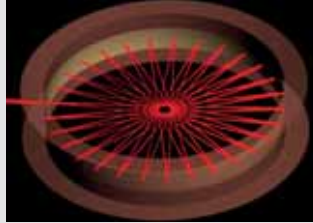
colimated
Source



x 1
(: 10)

2

long
Interaction



x 7
(: 8)

3

sensitive
Detection



x 1
(: 2)



ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

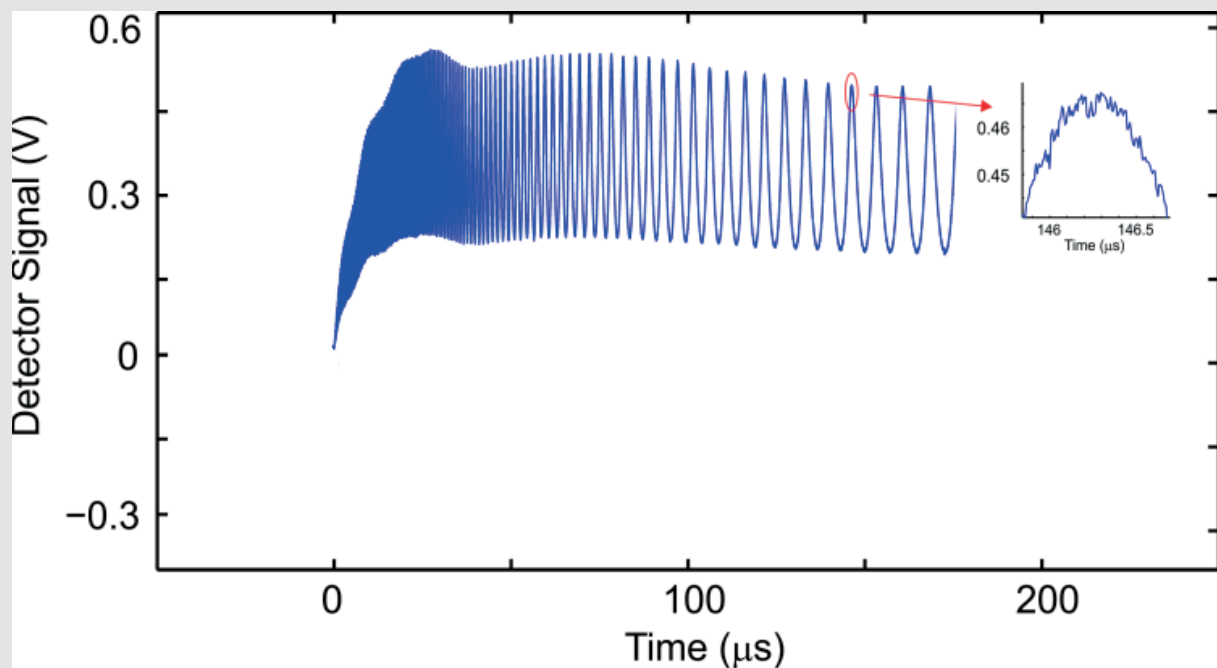
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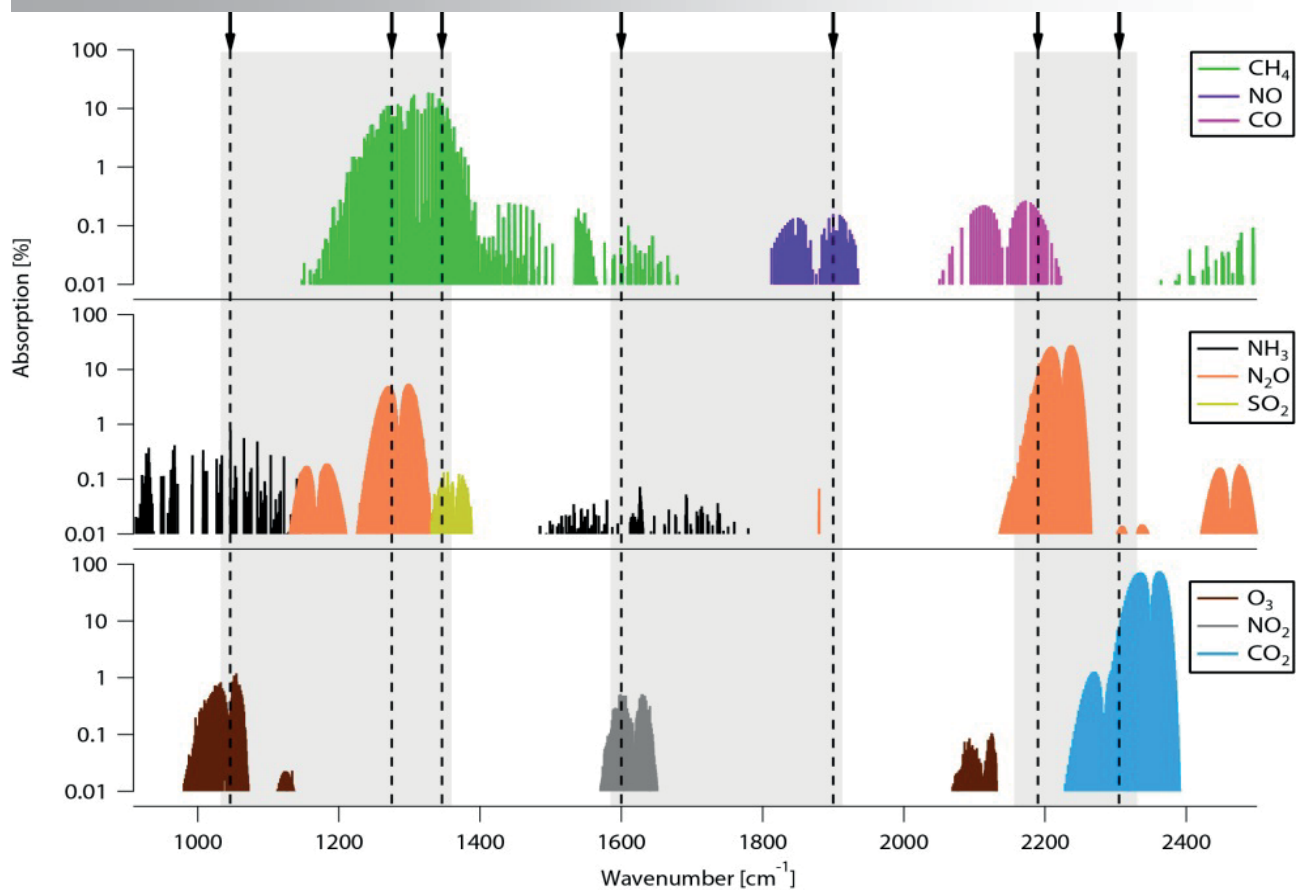
Increasing AD frequency → reducing energy consumption (and size)



Outlook



The all-in-one sensor ?



Acknowledgements

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