Optical Gas Sensing, 15 January 2015

High-precision MIR trace gas analysis for environmental applications

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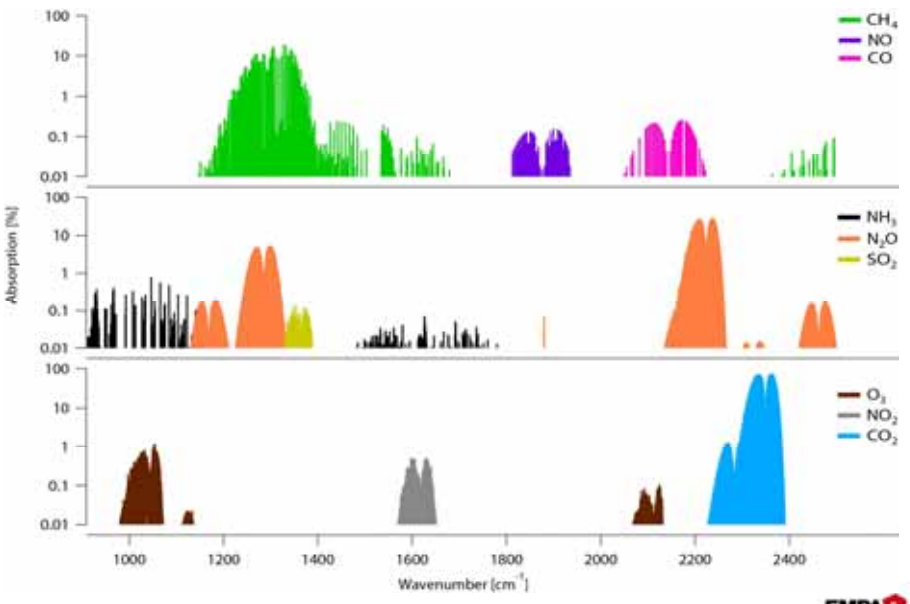
Air pollutants / GHG absorbtion in the MIR



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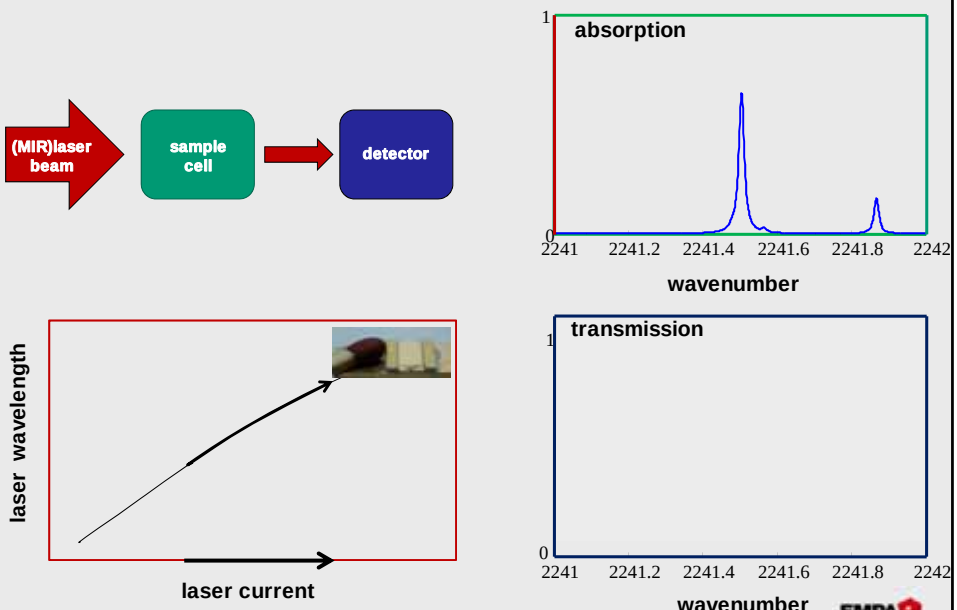
Very simple: direct absorption spectroscopy



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Examples and prospects

selective

CO_2 and its four stable isotopes

sensitive

NO_2 and NO at ppt mixing ratios

small

towards mobile sensing

direct absorption QCL spectroscopy

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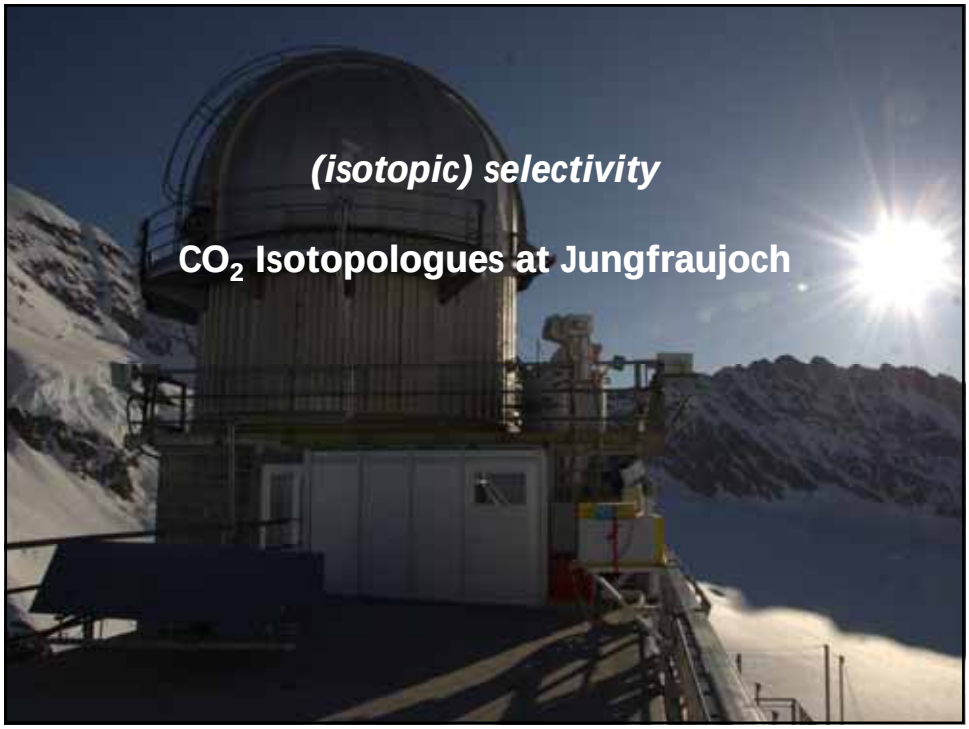
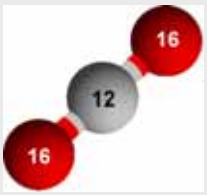
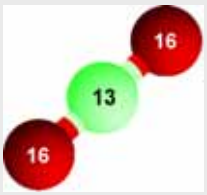
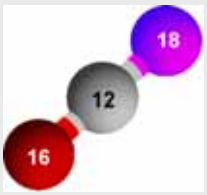


CO_2 isotopologues

626	636	628
		
0.98	0.01	0.003

natural abundance

$$\delta^{13}C = \left(\frac{\alpha_{13,s} / \alpha_{12,s}}{\alpha_{13,ref} / \alpha_{12,ref}} - 1 \right) \cdot 1000‰$$

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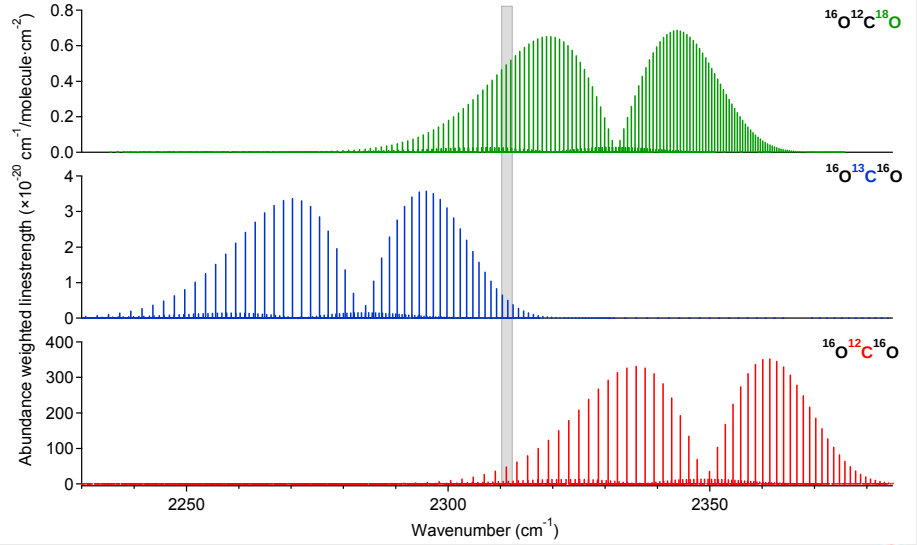
Simulated ν_3 ro-vibrational bands of CO_2 based on Hitran



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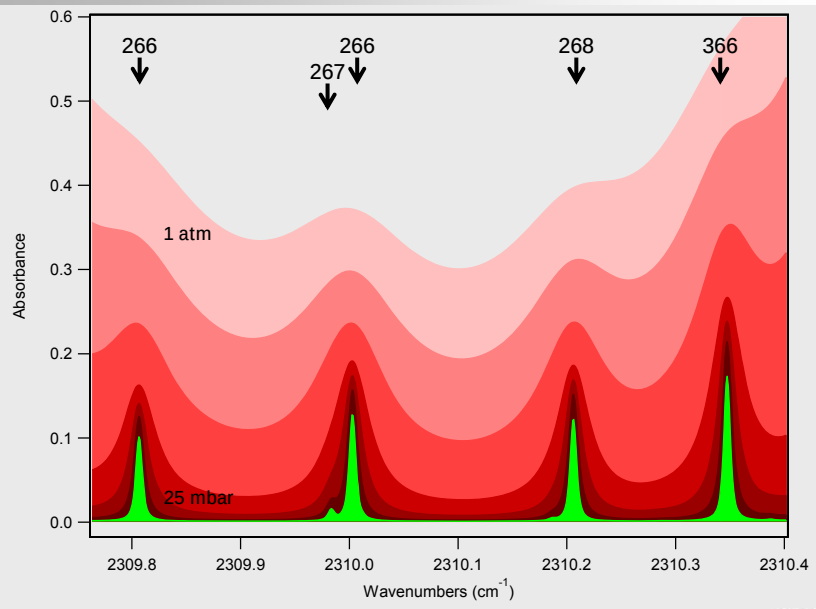
Peak Separation – Resolution and Pressure



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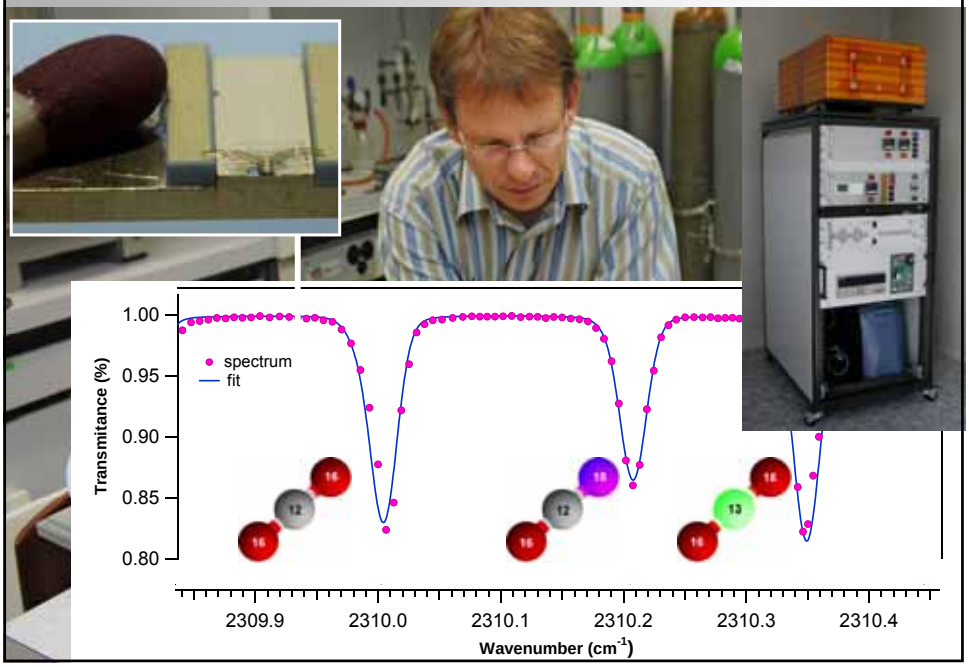
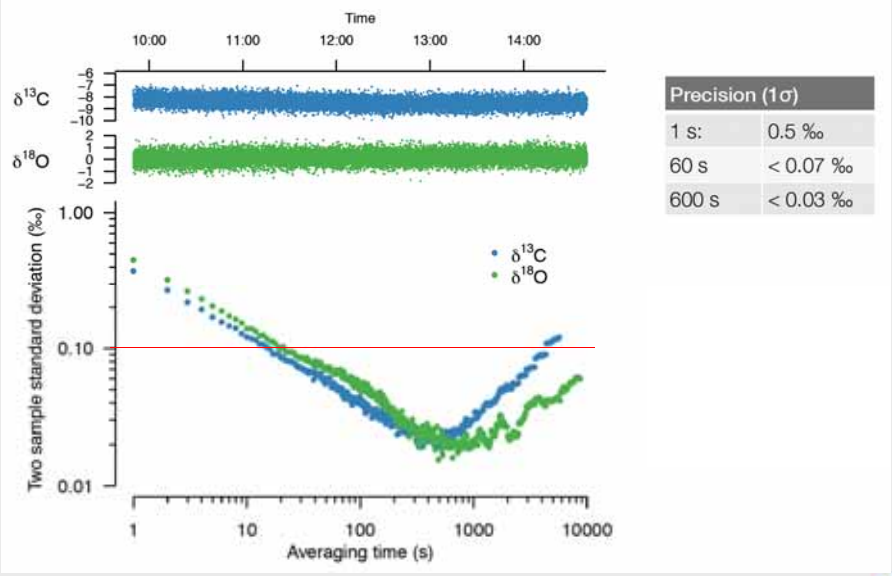
Quantum Cascade Laser Spectroscopy for Stable CO_2 Isotopes



Precision & Stability (Allan plot)



Precision (1σ)	
1 s:	0.5 ‰
60 s	< 0.07 ‰
600 s	< 0.03 ‰

Sturm et al., ACP (2013)

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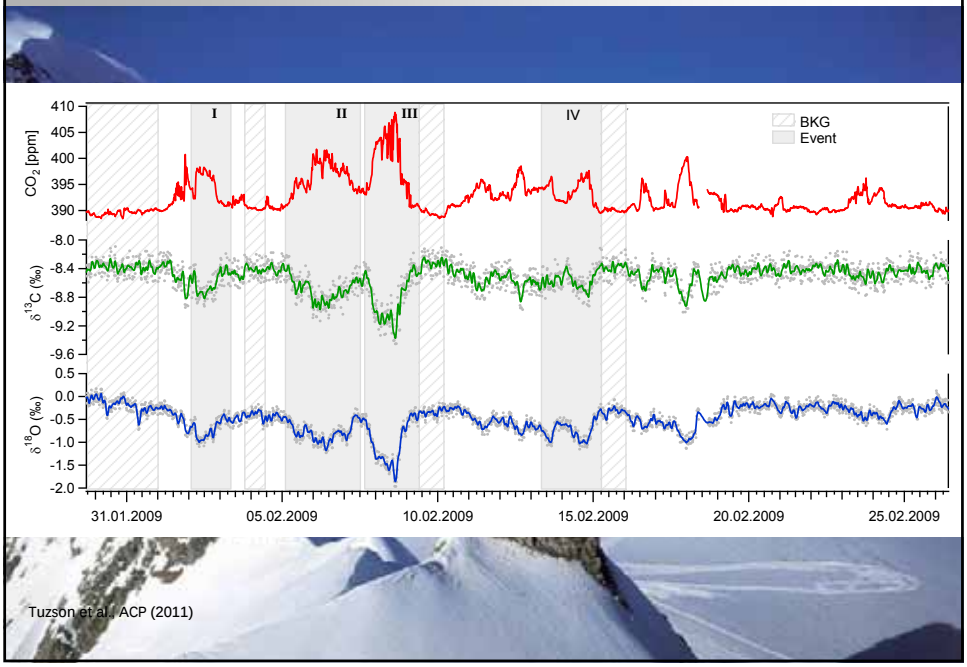
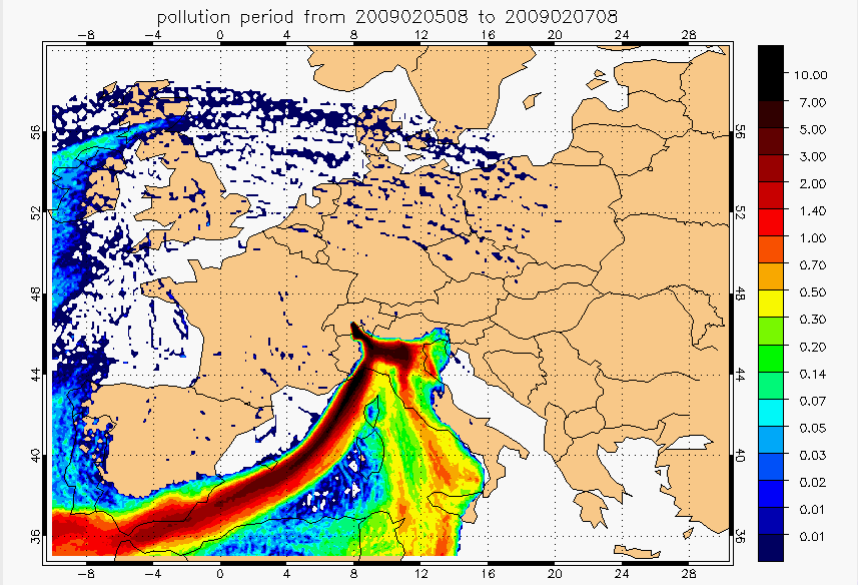
(Isotopic) variations at Jungfraujoch, 3580 masl



Tuzson et al., ACP (2011)

Regional Pollution Events



Tuzson et al., ACP (2011)

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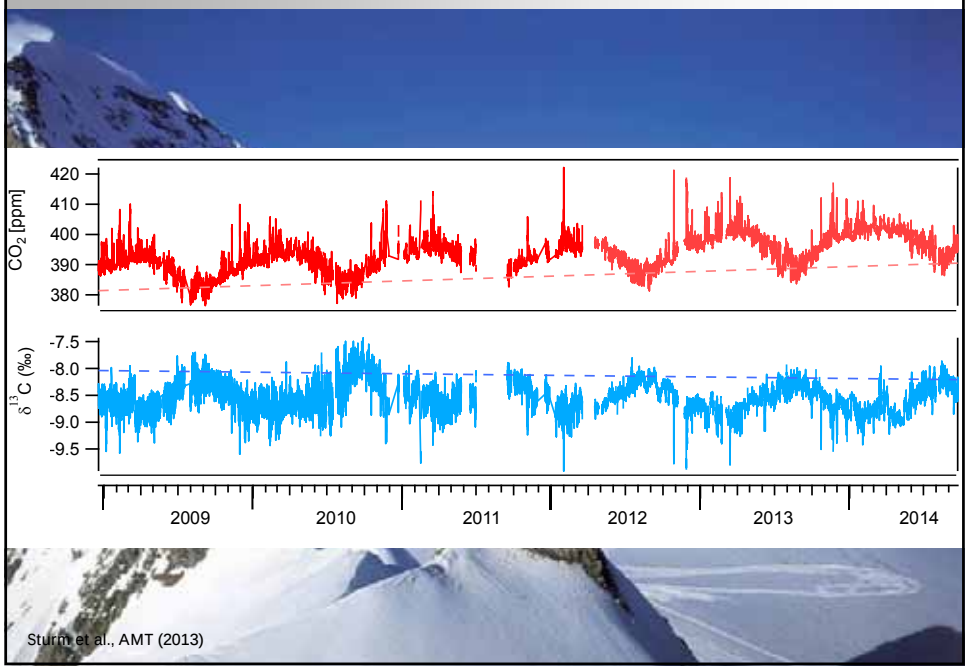
(Isotopic) variations at Jungfraujoch, 3580 masl

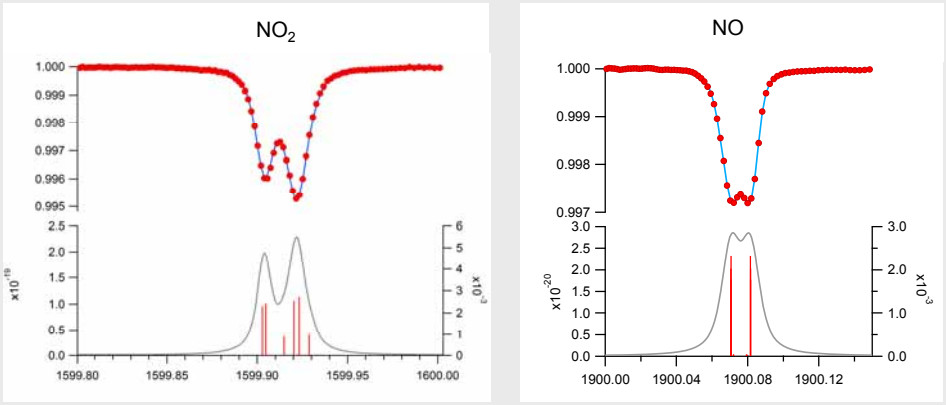


Sturm et al., AMT (2013)

sensitivity

NO_2 and NO measurements at Jungfraujoch

Selective measurement of NO and NO_2 at ppt mixing ratios



1 s average of 5 kHz spectra at at 50 hPa; simulation (lower part) based on HITRAN
RT cw QCL from Alpes Lasers

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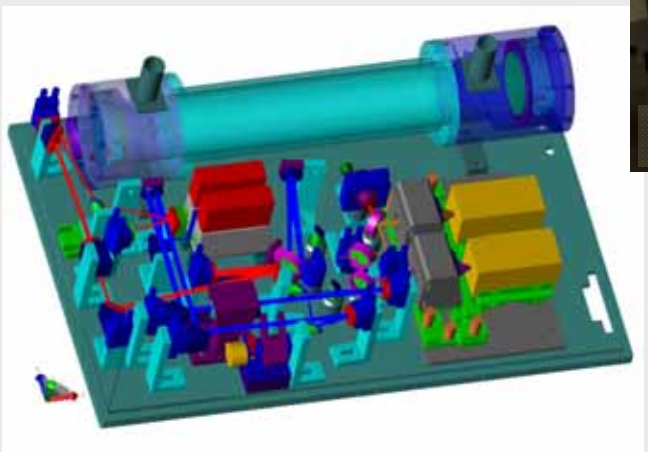
Direct measurements of NO and NO_2 by QCLAS



McManus et al., Applied Optics, 2011

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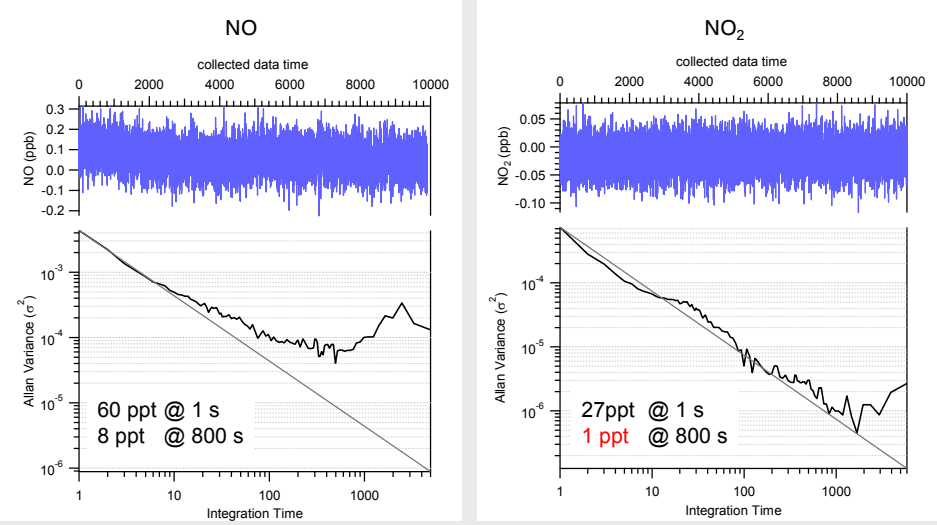
Precision (Allan plot)



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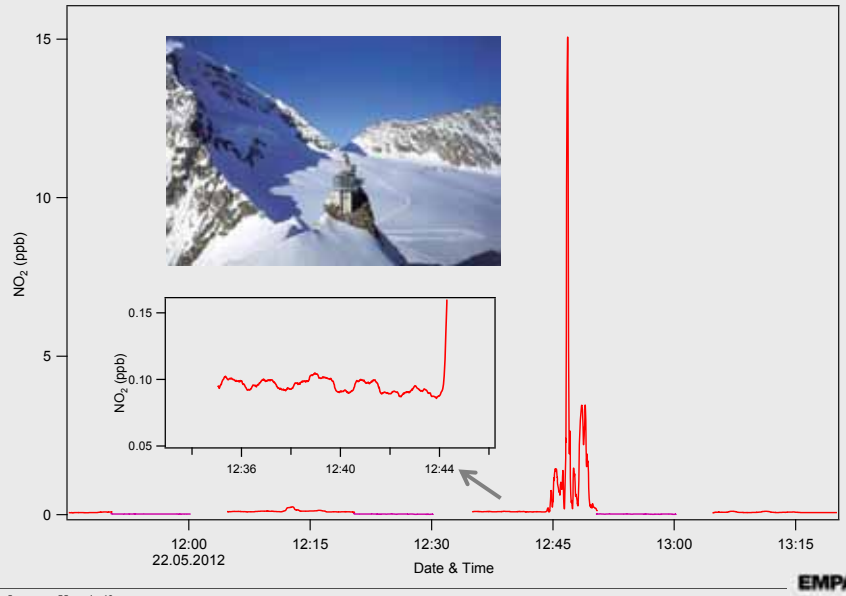
Beware of the unexpected!



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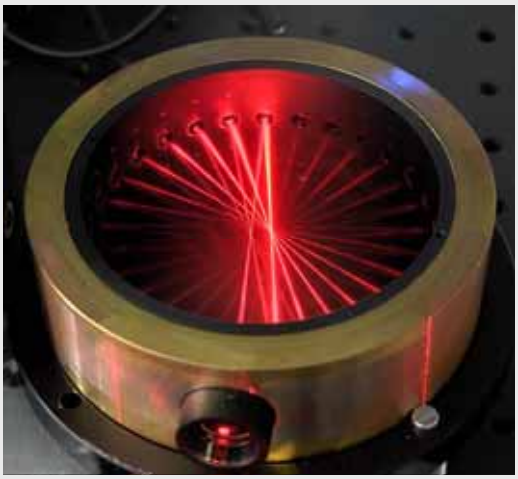
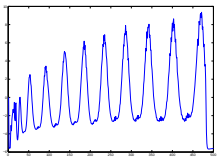
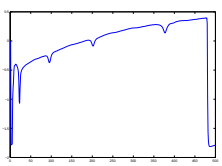
Toroidal Cell with cwQCL and «Fringe Killer»



-> interference, fringes



with absorption mask



M. Mangold et al., PCT/EP2013/070805

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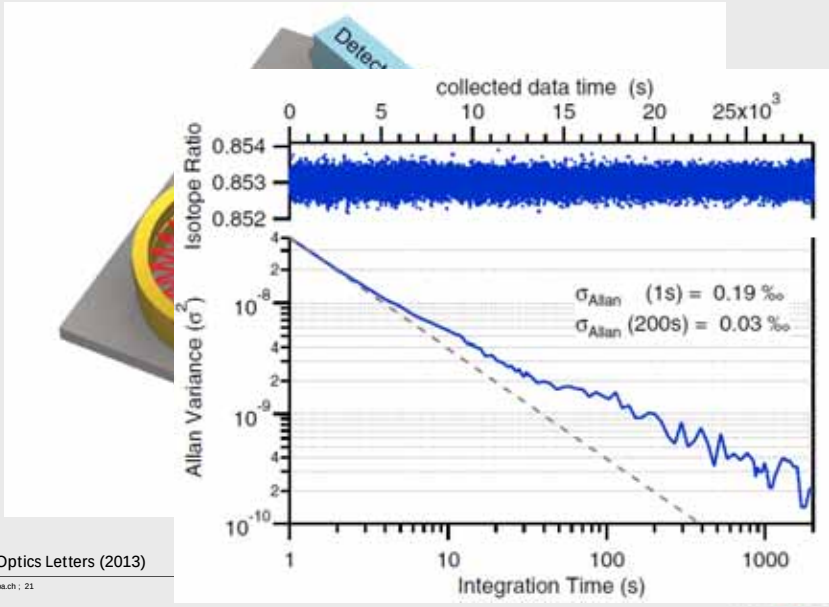
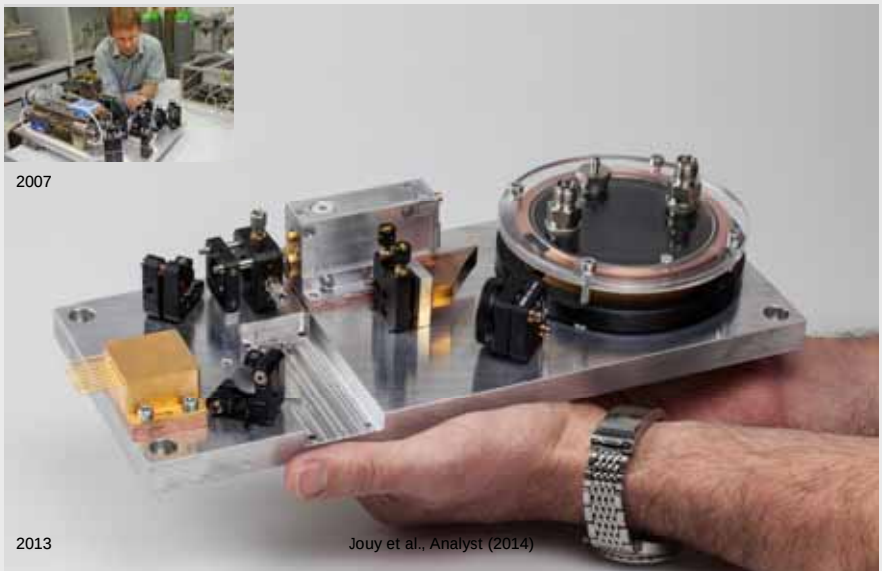
Application of the toroidal cell for CO_2 isotopes



Tuzson et al., Optics Letters (2013)

Optical setup exclusively based on QC technology



2007

2013

Jouy et al., Analyst (2014)

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

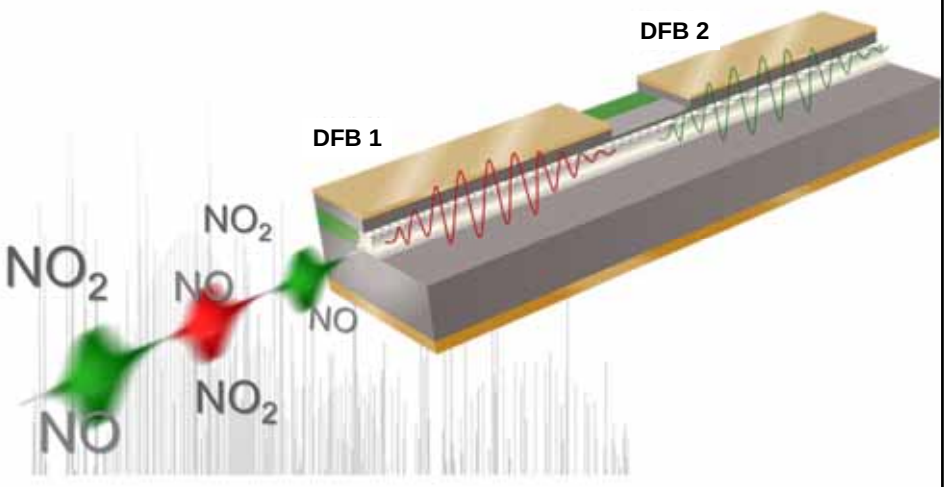
n|w Fachhochschule Nordwestschweiz

ALPES LASERS

EPFL

Université de Neuchâtel unine

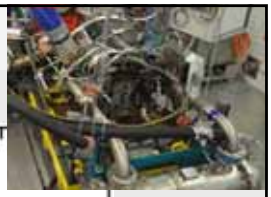
Two Colour QCL

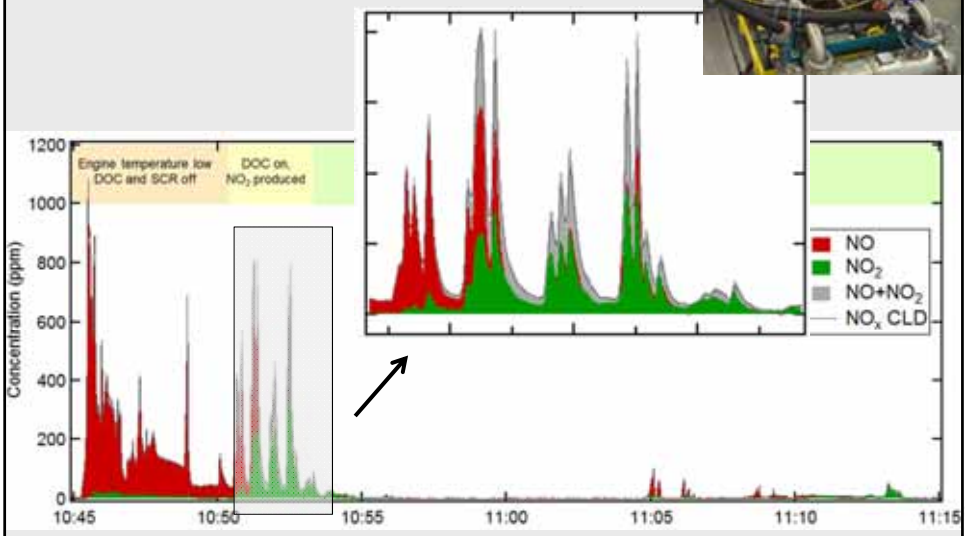


Jágerska et al., Appl. Phys. Lett. (2014)

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

Dynamic diesel engine measurements of NO and NO_2





Jágerska et al., Optics Express (2015)

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