Part 1. Preliminary study for development of multi-modal breath analyzer

Part 2. Observation of supercontinuum light generation from PCF

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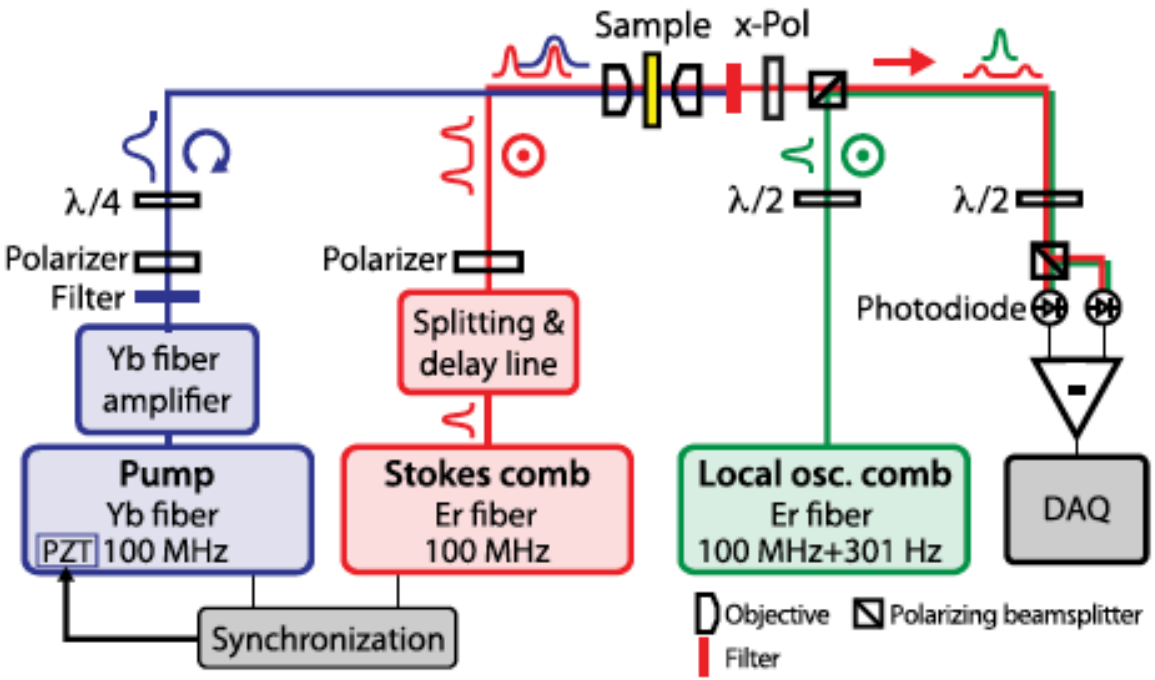
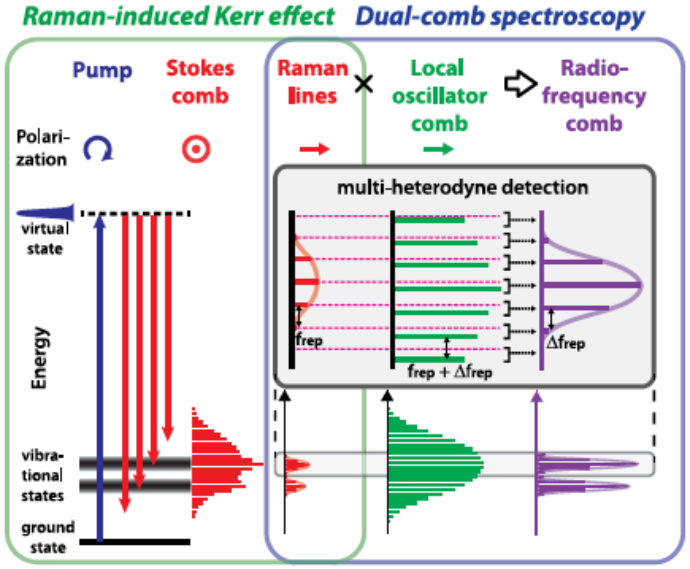
ERATO MINOSHIMA IOS PROJECT

Homework:
What is the advantage of using optical frequency comb for Raman spectroscopy?

Main advantages is **rapid acquisition** of **broadband spectra** for nonlinear coherent Raman spectroscopy with **high temporal** and **spectral resolution**





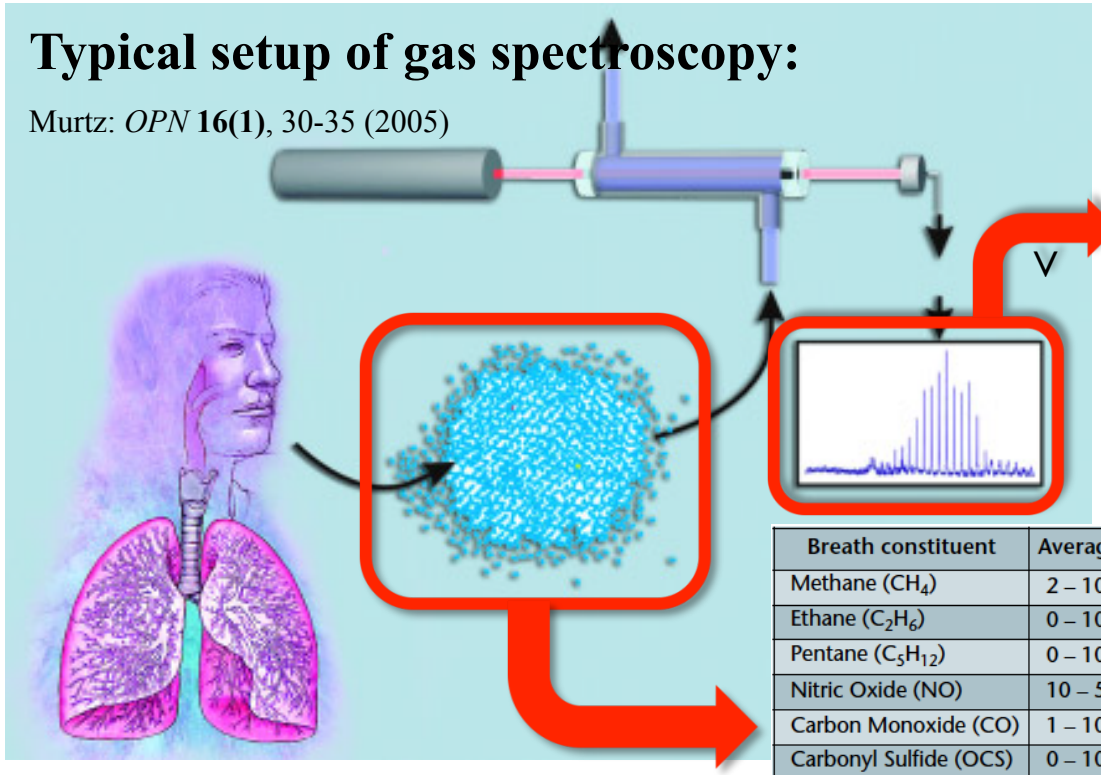
Ideguchi et al., *Opt. Lett.* **37(21)**, 4498-4500, 2012

Part 1.
Preliminary study for development of multi-modal breath analyzer

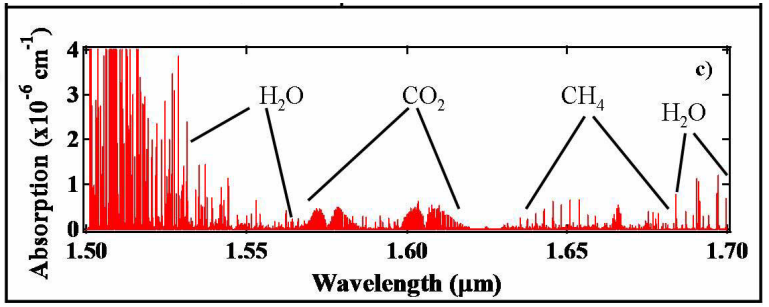
Breath analysis is a challenging application of gas spectroscopy in biomedical field for non-invasive monitoring and diagnosis

Typical setup of gas spectroscopy:

Murtz: *OPN* **16(1)**, 30-35 (2005)



Thorpe et al.: *Opt. Expr.* **16(4)**, 2387-2397 (2008)



Breath constituent	Average fraction
Methane (CH_4)	2 – 10 ppm
Ethane (C_2H_6)	0 – 10 ppb
Pentane (C_5H_{12})	0 – 10 ppb
Nitric Oxide (NO)	10 – 50 ppb
Carbon Monoxide (CO)	1 – 10 ppm
Carbonyl Sulfide (OCS)	0 – 10 ppb
Nitrous Oxide (N_2O)	1 – 20 ppb
Isoprene (C_5H_8)	50 – 200 ppb
Ammonia (NH_3)	0 – 1 ppm
Acetone ($(CH_3)_2CO$)	0 – 1 ppm

Murtz: *OPN* **16(1)**,30-35 (2005)

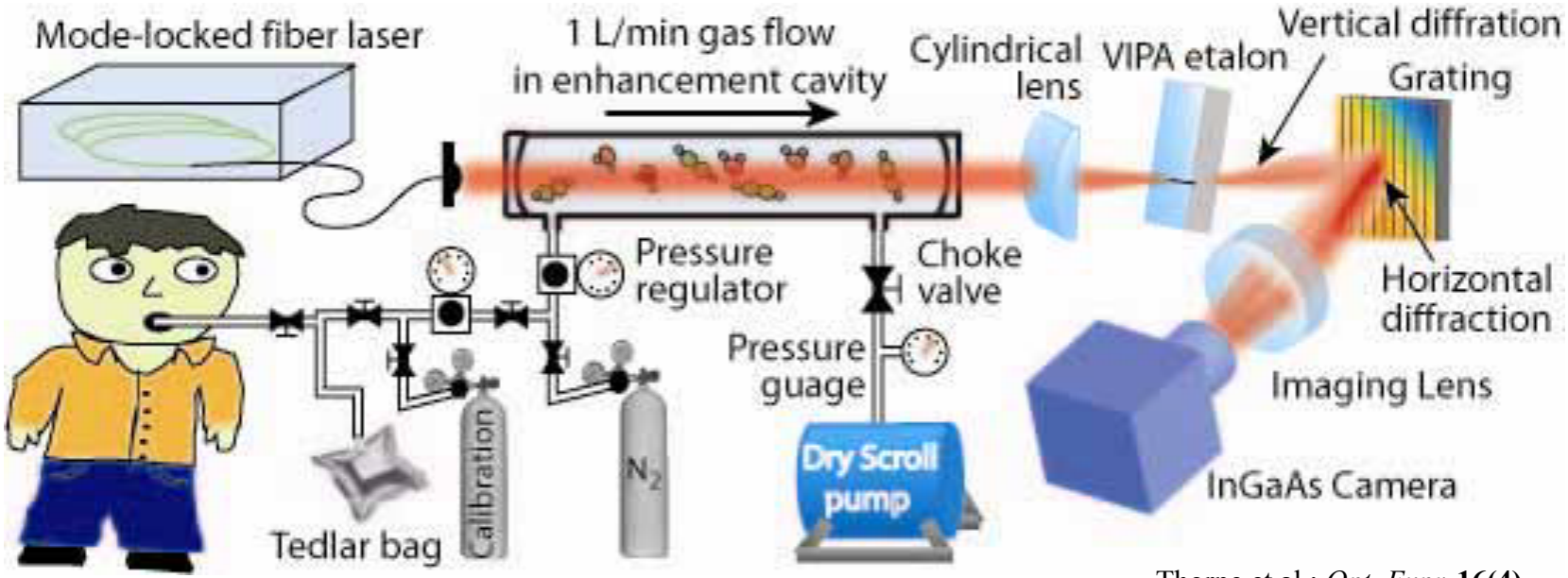
Breath components	Fraction
O_2	15-18%
CO_2	4-6%
H_2O	5%
NH_3	0.5-1 ppmv
Acetone	Hundreds ppbv
Methanol, Ethanol, other VOCs	pptv-ppbv level

Arslanov et al.: *Opt. Expr.* **19(24)**, 24078-24089 (2011)

Acetone: lung cancer, heart failure
Ammonia: asthma
Isoprene: blood cholesterol
- Wang & Sahay: *Sensors* **9**, 8230-8262 (2009)

Breath analysis is a challenging application of **gas spectroscopy** in **biomedical** field for non-invasive monitoring and diagnosis

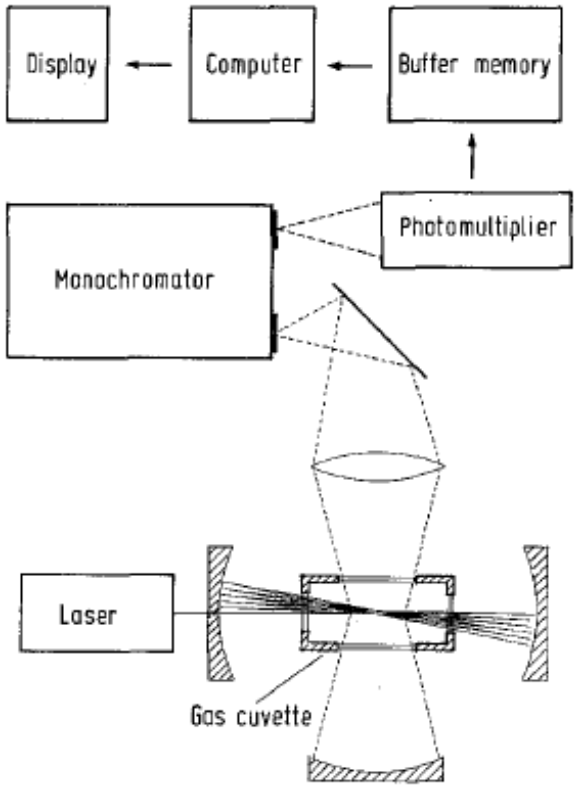
Optical frequency comb for breath analysis:
(with cavity-enhanced mechanism)



Thorpe et al.: *Opt. Expr.* **16(4)**, 2387-2397 (2008)

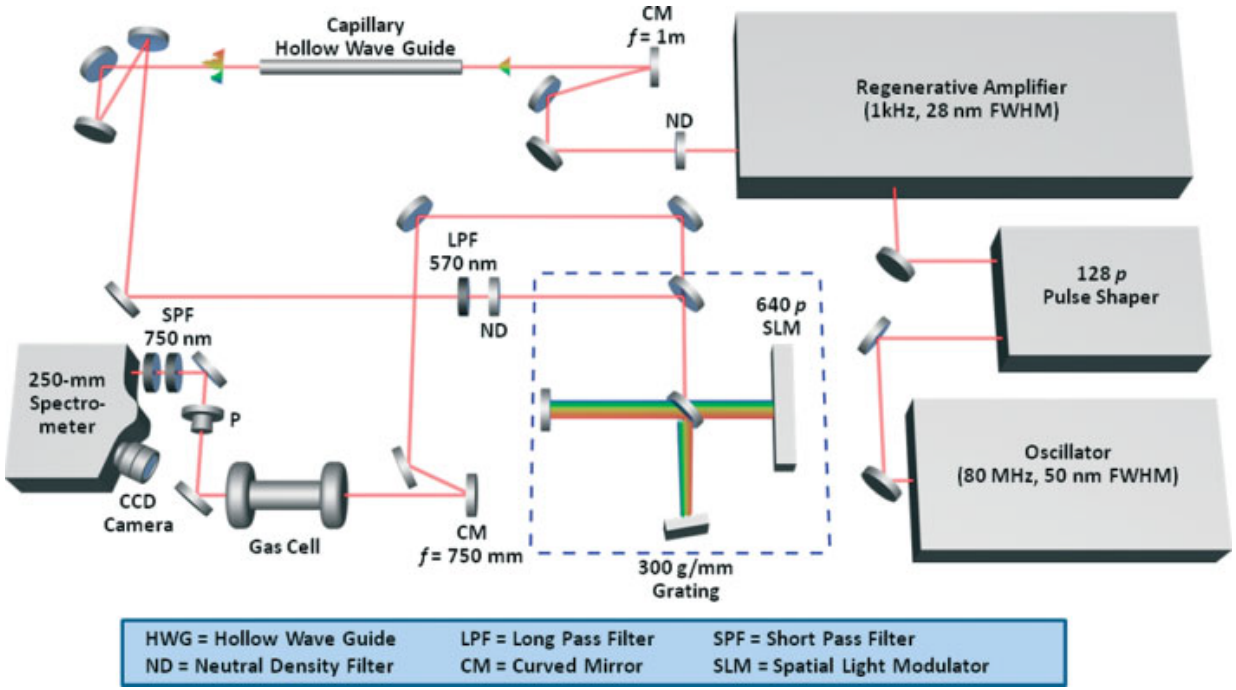
Raman-based spectroscopy offers an alternative method for **chemical-sensitive** and **non-invasive** detection, in this case: for gas analysis

Raman spectroscopy:



Schiel and Richter: *Fresenius Z. Anal. Chem.* **327**, 335-337 (1987)

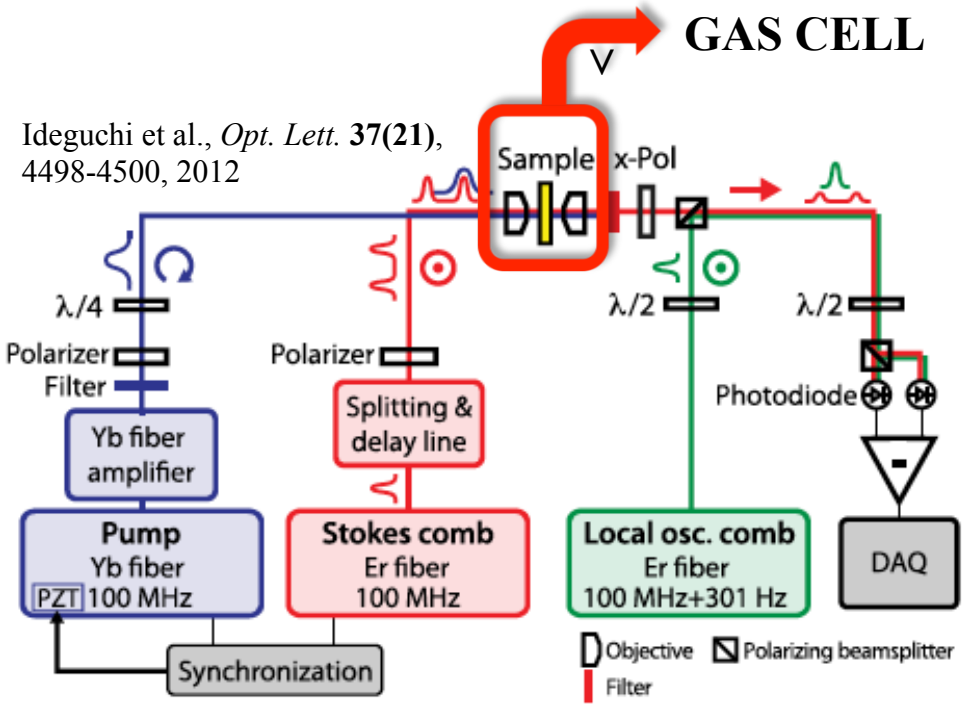
Nonlinear Raman spectroscopy:



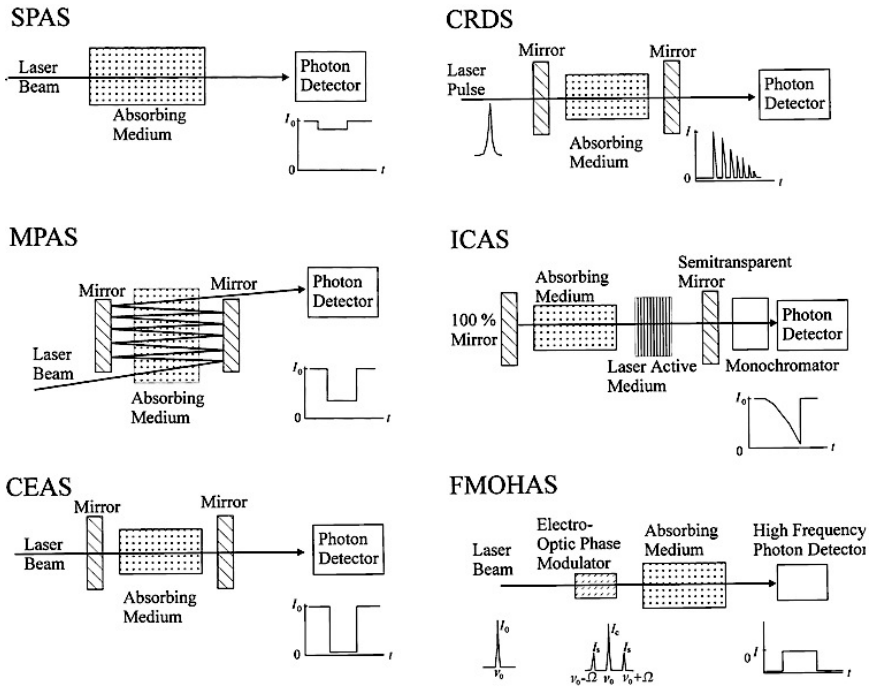
Roy et al.: *J. Raman Spectrosc.* **41**, 1194-1199, 2010

Possible development of multi-modal gas spectroscopy / breath analyzer (1)

Ideguchi et al., *Opt. Lett.* **37(21)**, 4498-4500, 2012



http://pubs.rsc.org/en/content/articlehtml/2000/ja/a910219l



SPAS:
Single pass absorption spectroscopy

MPAS:
Multi-pass absorption spectroscopy

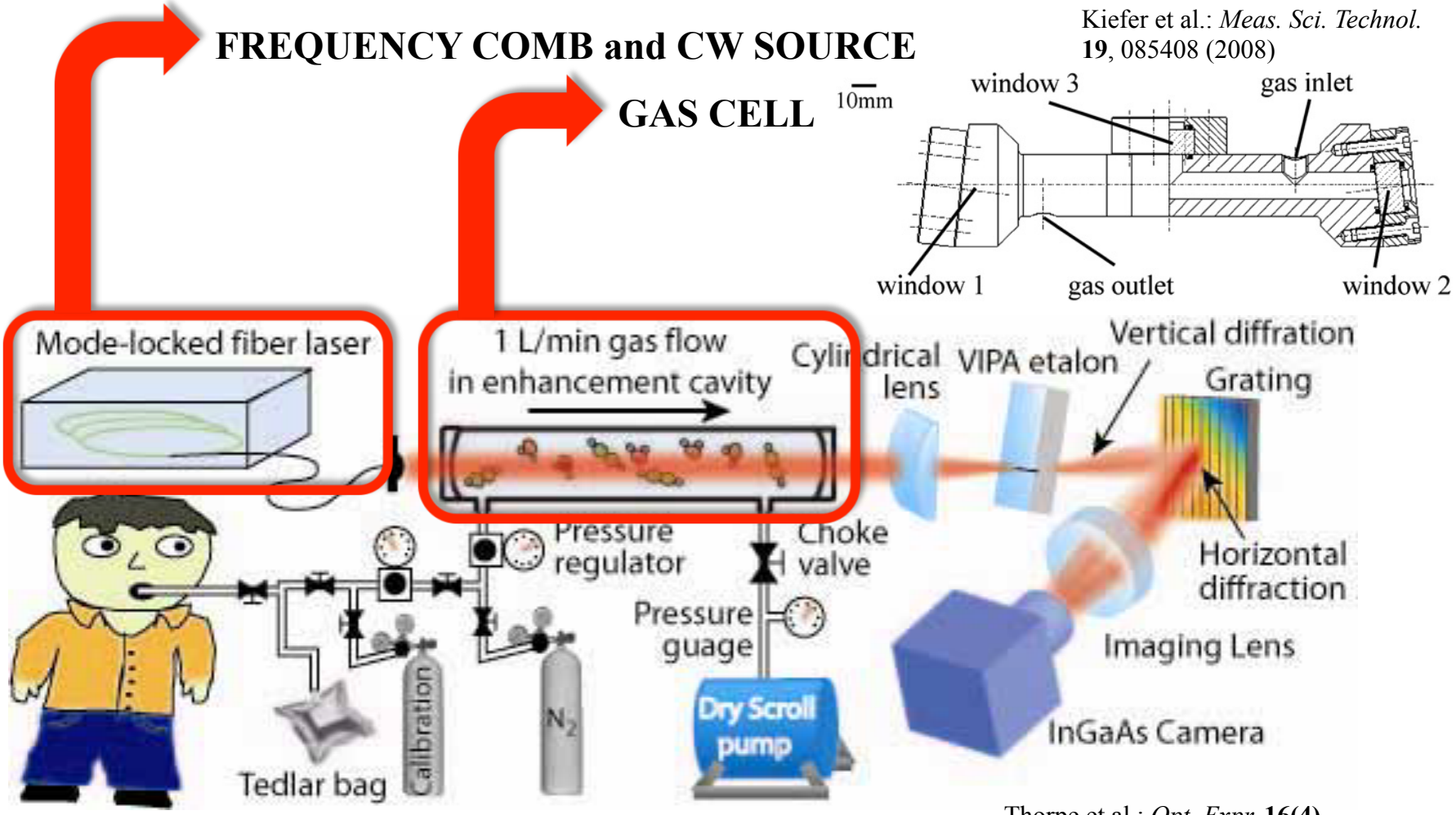
CEAS:
Cavity enhanced absorption spectroscopy

CRDS:
Cavity ring down spectroscopy

ICAS:
Intra-cavity absorption spectroscopy

FMOHAS:
Frequency modulation optical heterodyne absorption spectroscopy

Possible development of multi-modal gas spectroscopy / breath analyzer (2)



Kiefer et al.: *Meas. Sci. Technol.* **19**, 085408 (2008)

Thorpe et al.: *Opt. Expr.* **16(4)**, 2387-2397 (2008)

Part 2.
Observation of supercontinuum light generation from PCF

Experimental setup