

**SPIE Photonics West  
Biophotonics Hot Topics 2018**

**Biophotonics Applications  
of  
Gas in Scattering Media  
Absorption Spectroscopy (GASMAS)**

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Sweden***

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Guangzhou***



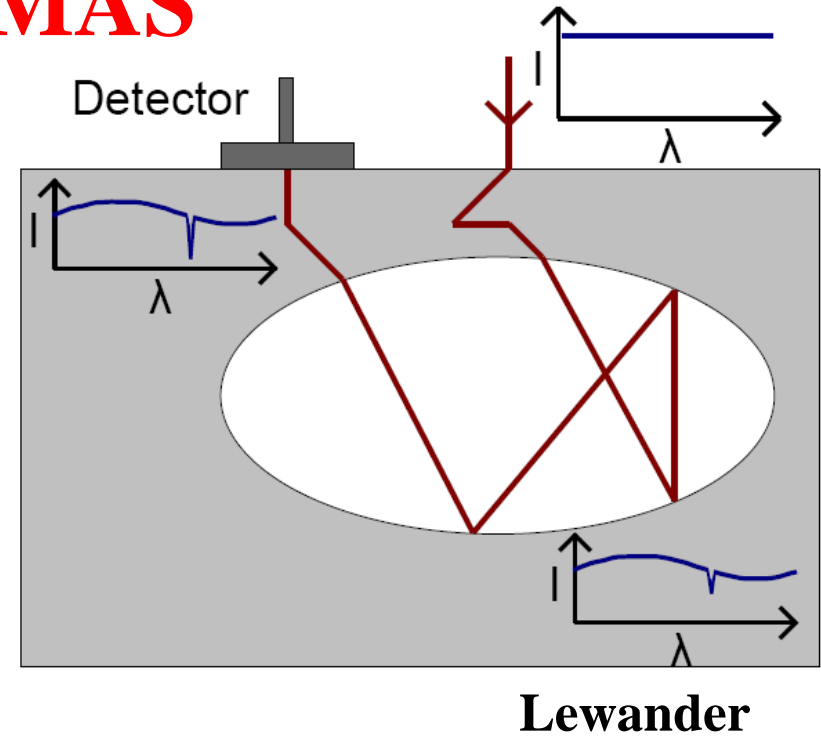
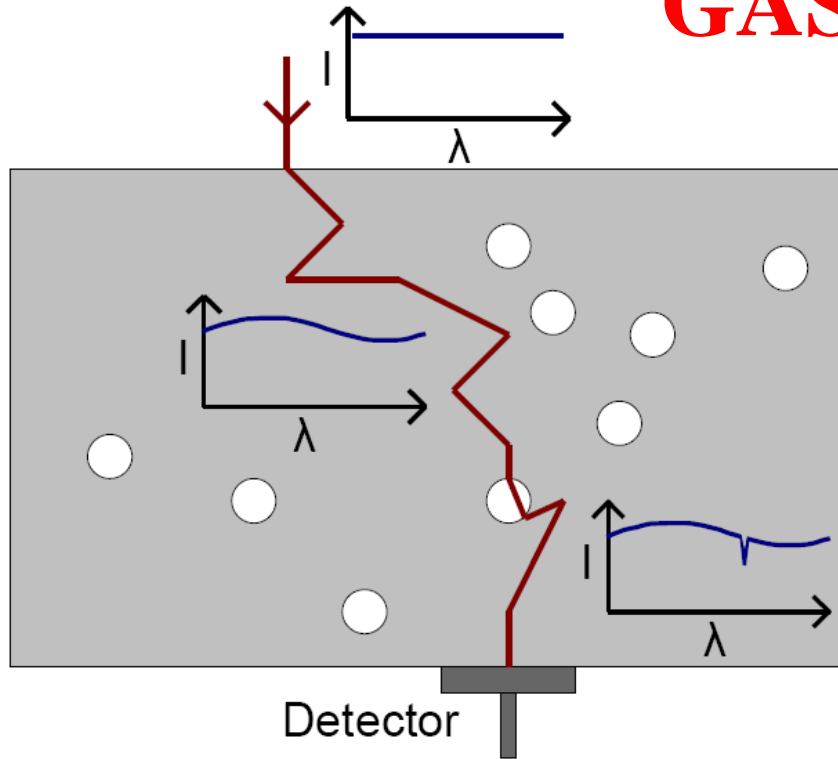
**LUNDS  
UNIVERSITET**



TRANSMISSION

**GASMAS**

BACKSCATTERING

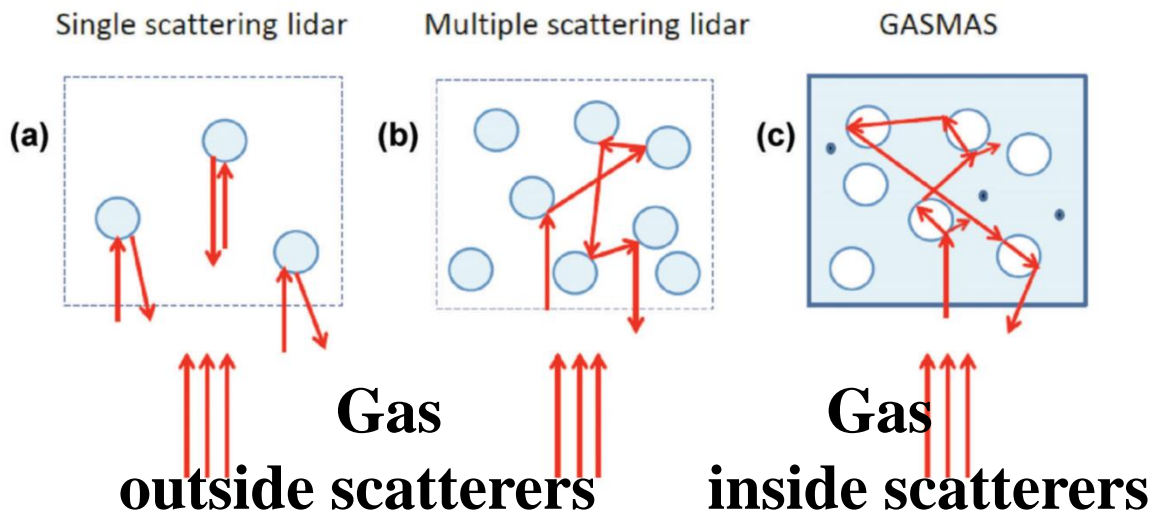
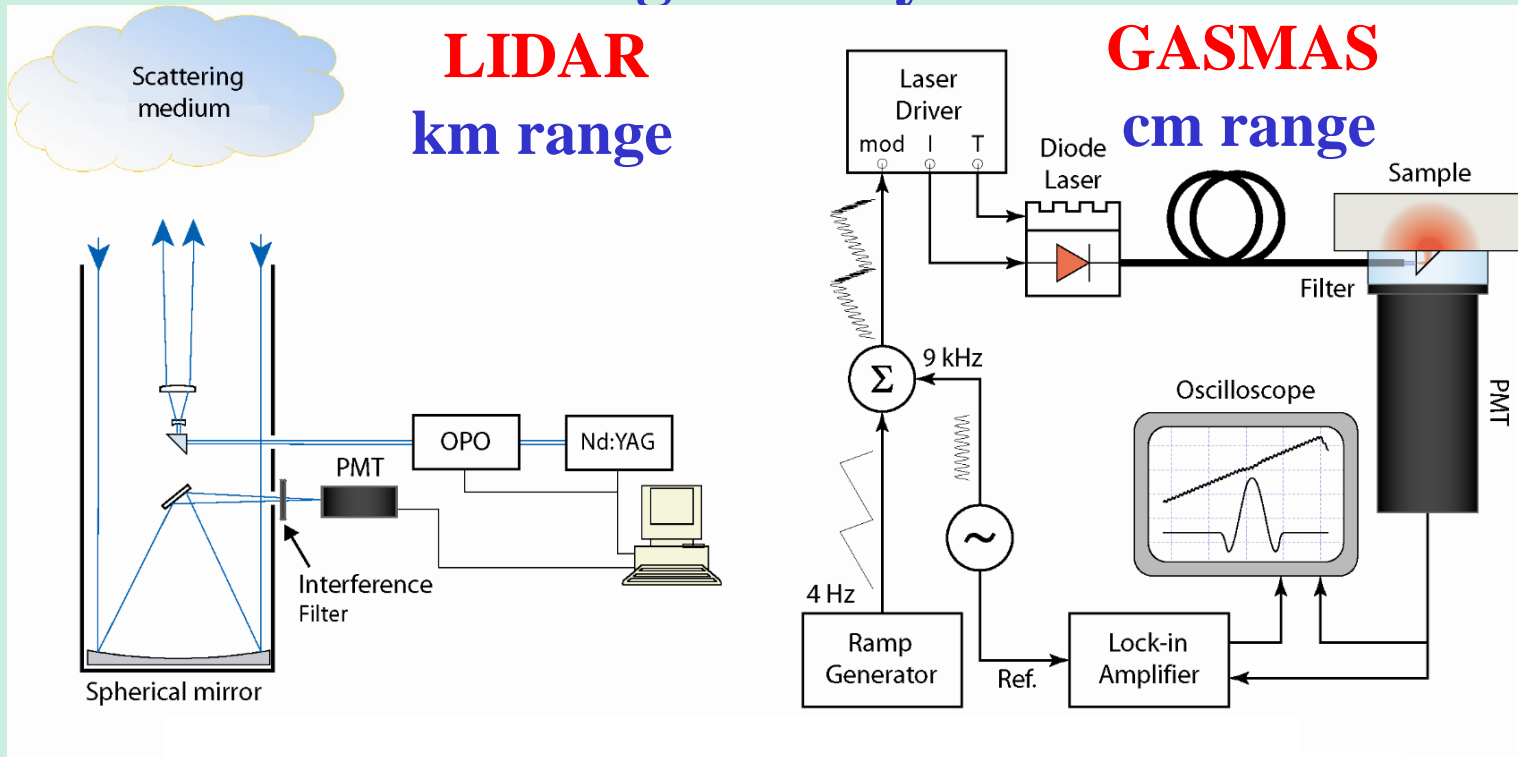


**Materials, pharmaceuticals, food stuffs and packages, biomedicine ...**  
**How to handle the path-length problem? Normalize on water vapor!**

**Collaborators in Sweden and China**

**M. Andersson, S. Andersson-Engels, P. Chen, D.L. Chen, V. Fellman, W. He, L.N. Hu, J. Huang, E. Krite Svanberg, J. Larsson, M. Larsson, T.Q. Li, W.S. Li, Y. Li, H.Y. Lin, M. Lewander, P. Lundin, S. Lindberg, L. Mei, L. Persson, R. Siemund, G. Somesfalean, T. Svensson, C. Xu, H. Zhang**  
**Spin-off: GASPOROX AB**

# Large- and small-scale sensing for gas analysis

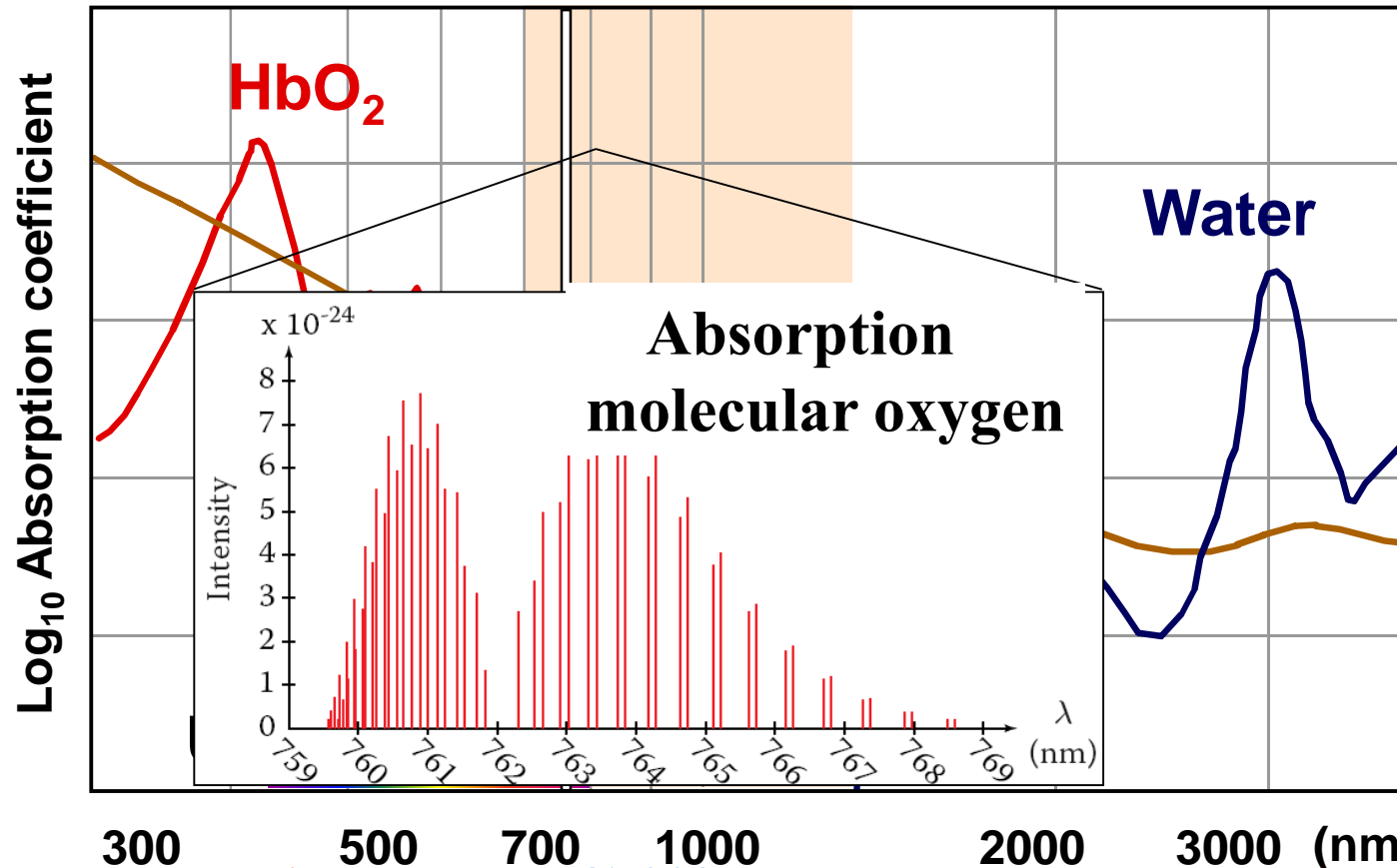


# Tissue and Free Gas Absorption

Key to GASMAS:

10,000 times difference in linewidth!

Use lock-in wavelength modulation spectroscopy !  
Absorption of light in tissue



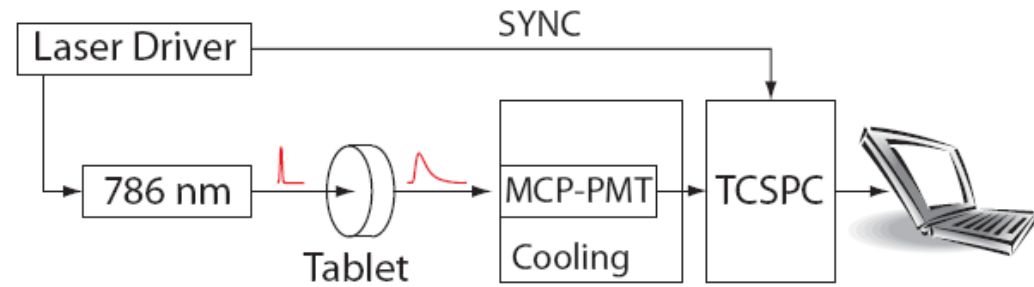
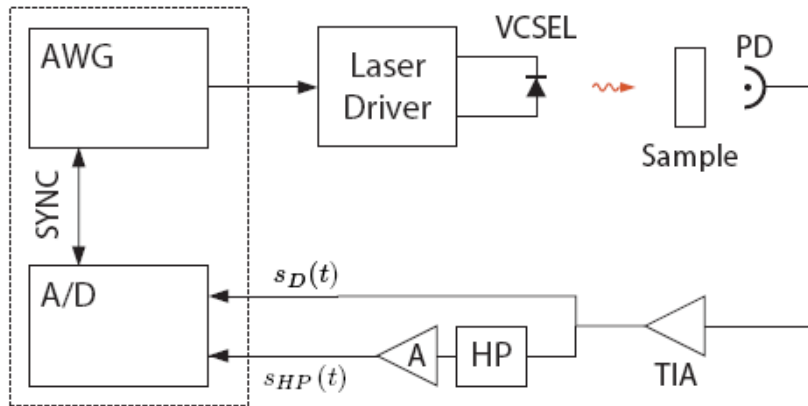
Strongest oxygen line: R7R7: 761.003 nm - We must be correct in the 6<sup>th</sup> digit!

# Spectroscopy on Pharmaceutical Tablets – Coll. AstraZeneca

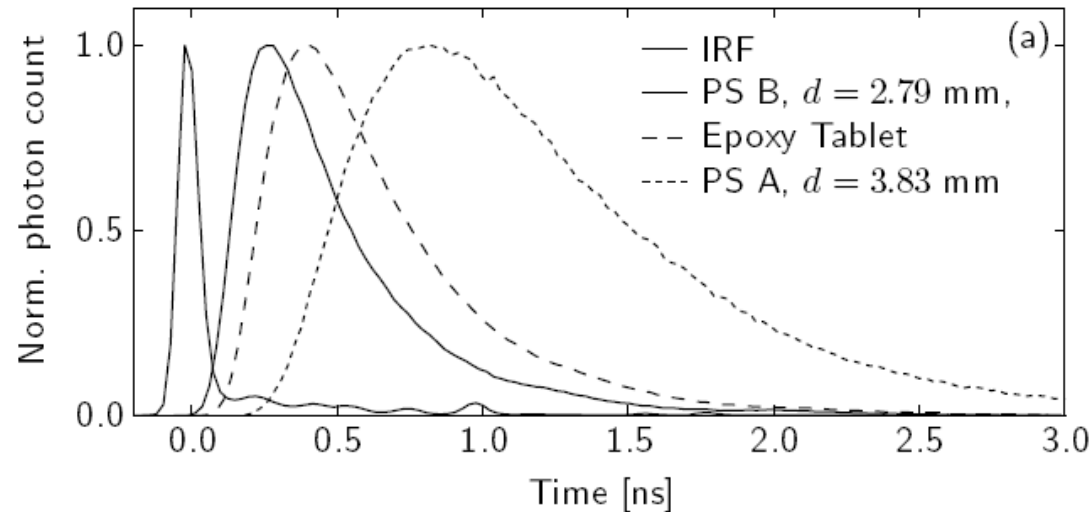
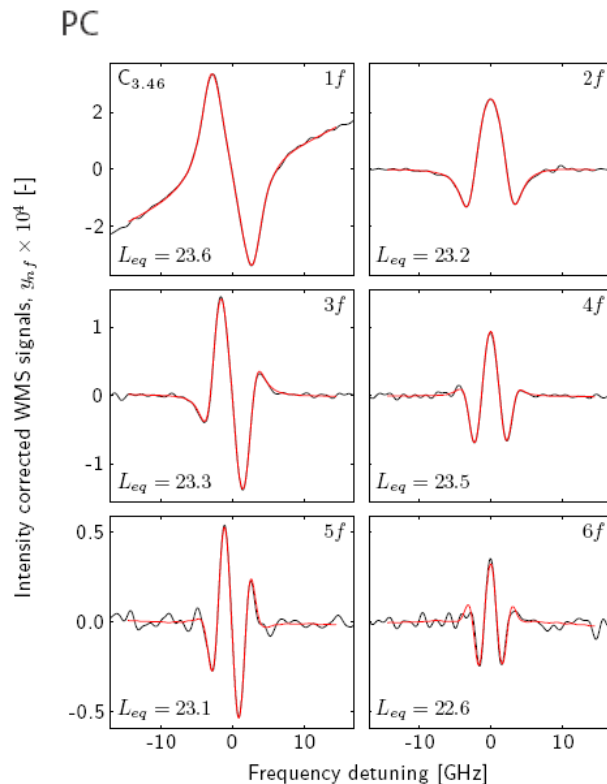
## Porosity studies/delayed release

Frequency domain, oxygen

Time domain, TOF/Lidar



*T. Svensson et al.*



**Follow-up: Alignment-free multi-pass gas cell made of nanoporous ceramics -750 times path enhancement !!**  
*Svensson et al. PRL (2011)*

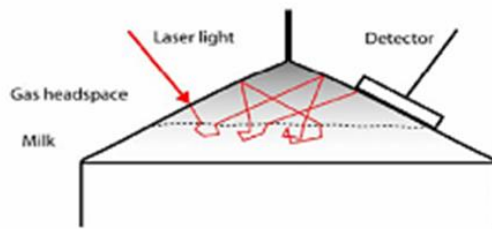
# FOOD MONITORING – FOOD SAFETY - FRESHNESS

Most food is packed  
in modified atmosphere  
(low O<sub>2</sub>, high N<sub>2</sub>, CO<sub>2</sub>)

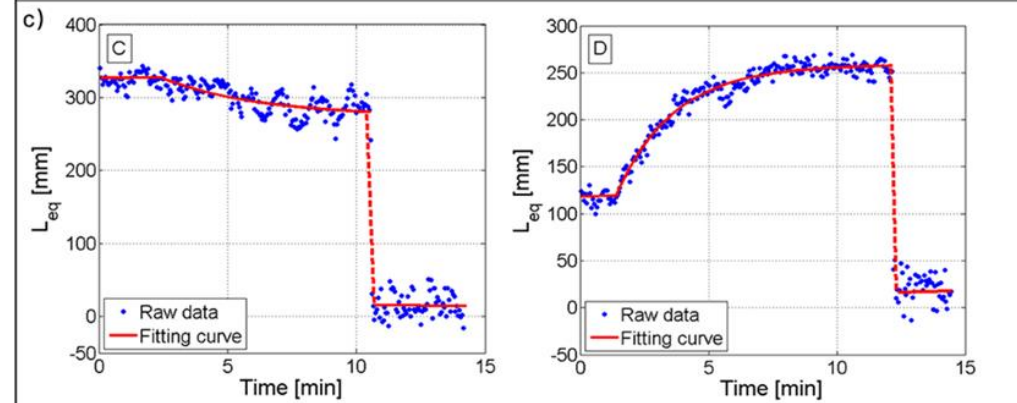
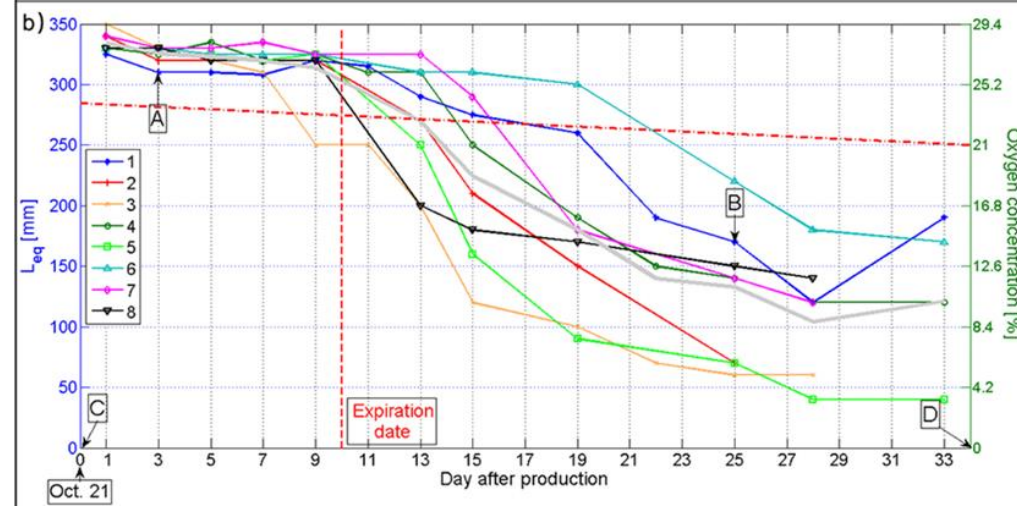
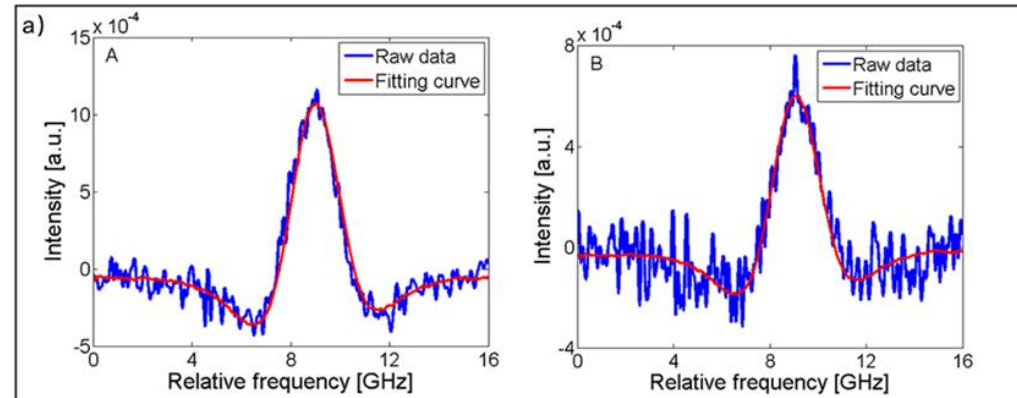
Milk, bread, meat, eggs ..



Lewander *et al.*; Li *et al.*



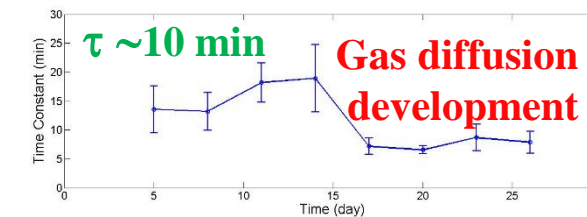
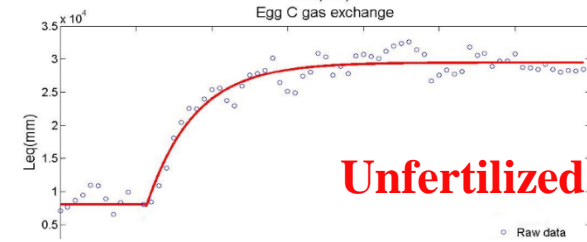
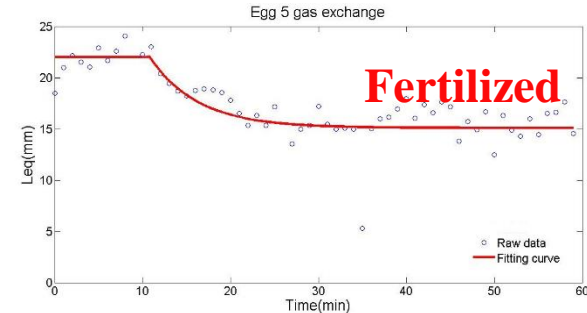
European SAFETYPACK project



# Detection of free oxygen and water vapor in hen eggs

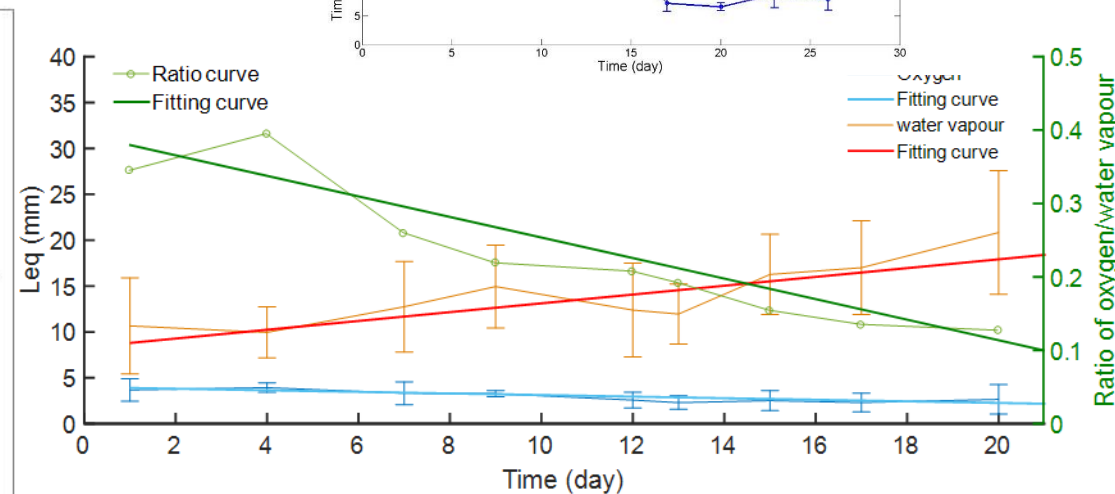
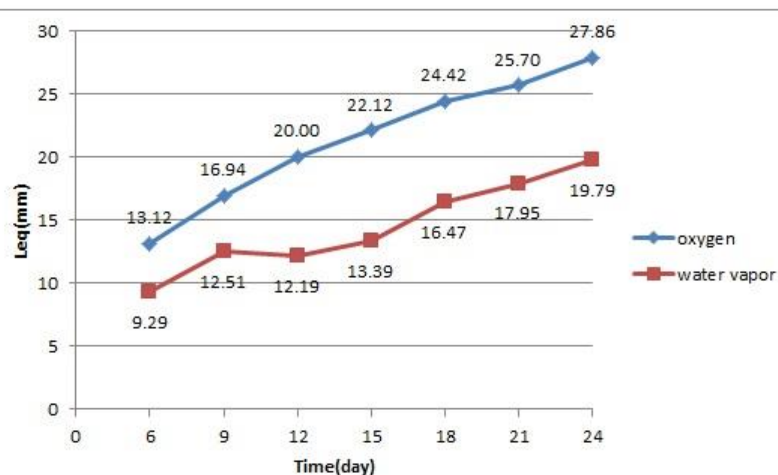
## Exploration of diagnostics possibilities

Li *et al.* J. Biophotonics 2017



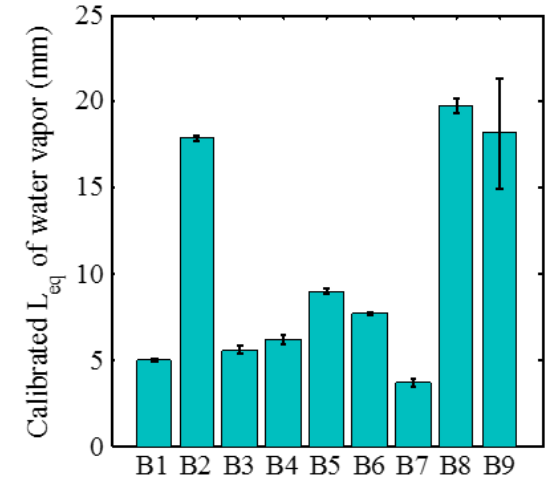
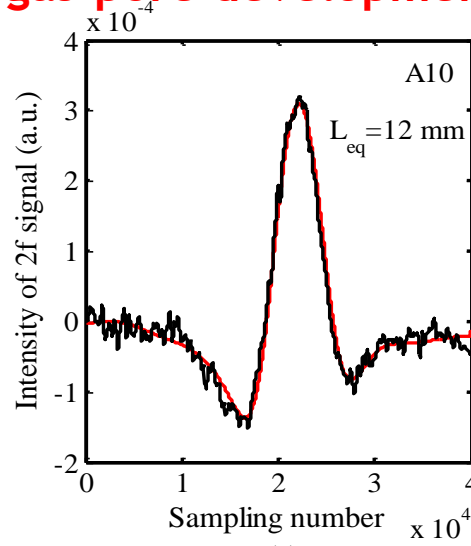
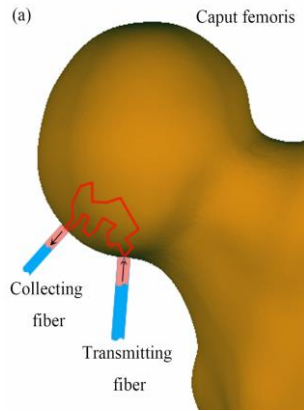
**Unfertilized**

**Fertilized**

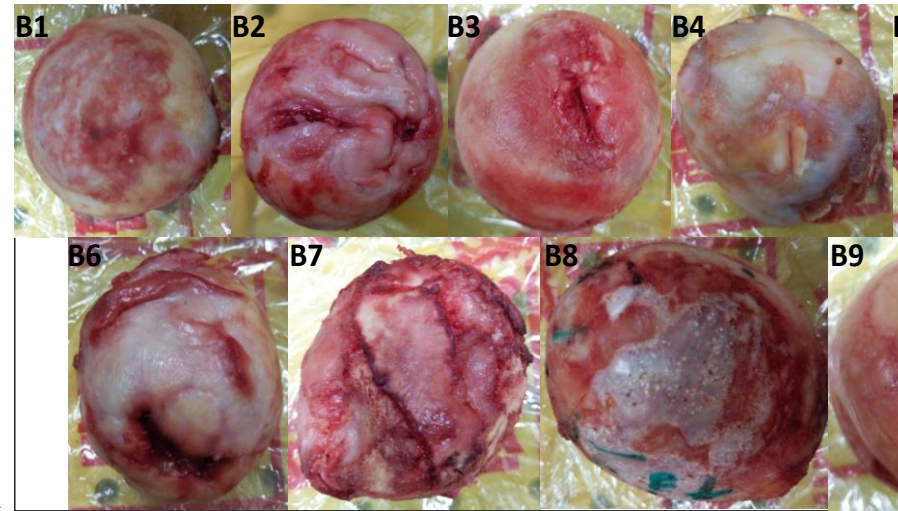
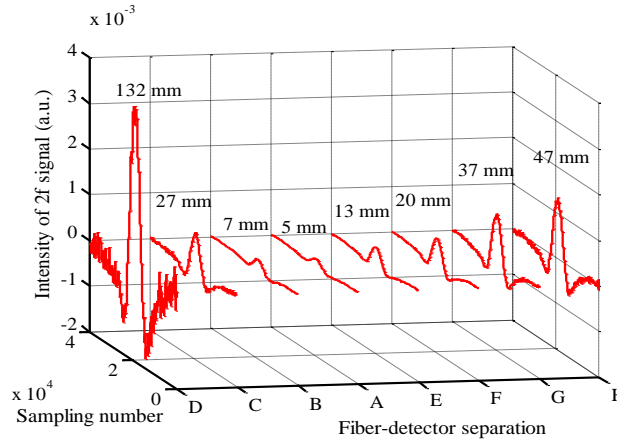
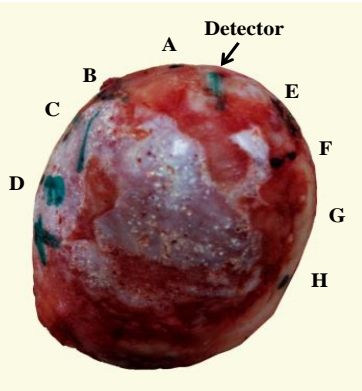


# Hip replacement - developing GASMAS for diagnostics

Degradation is accompanied with gas-pore development and impaired blood flow



Lin *et al.* J. Biophotonics (2017)



Combine with Laser Doppler Blood Flow Measurement:

Comes for free!

$$\frac{\Delta f}{f} = \frac{v}{c}$$

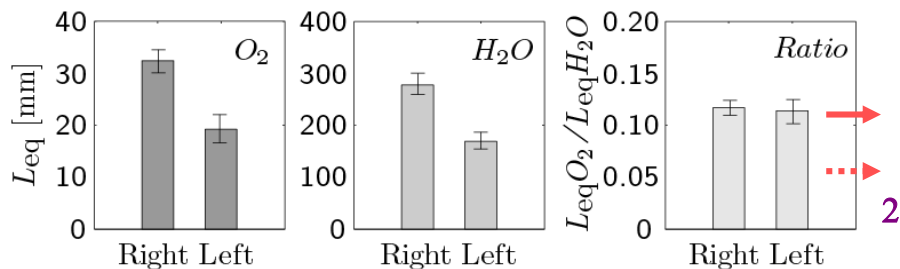
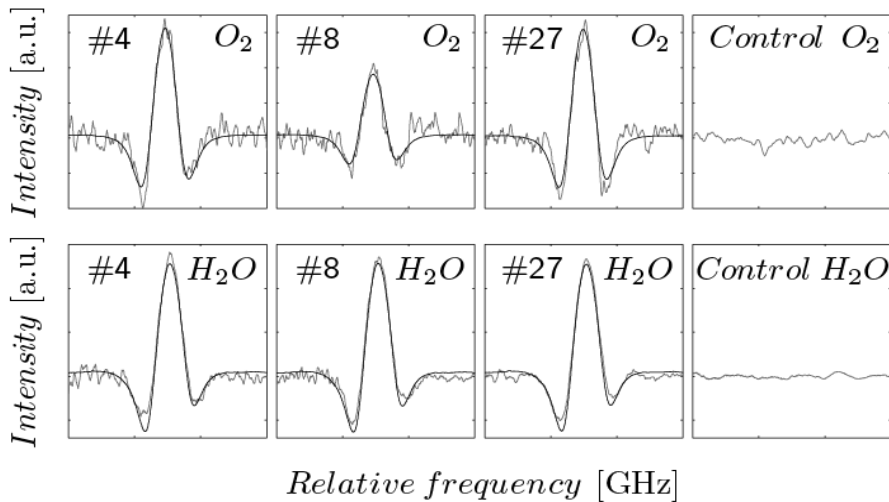
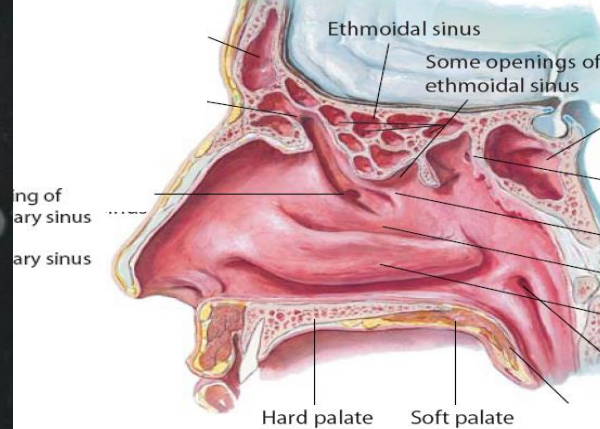
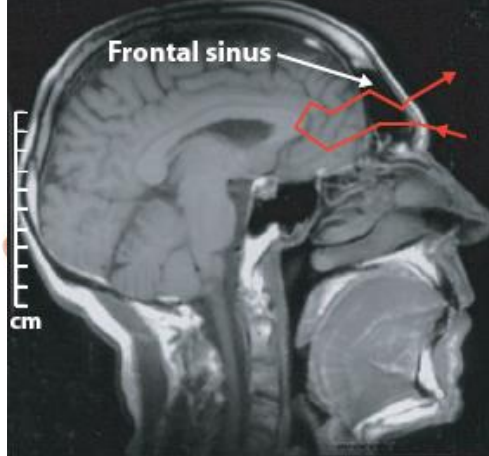


# Fighting bacterial antibiotics resistance!

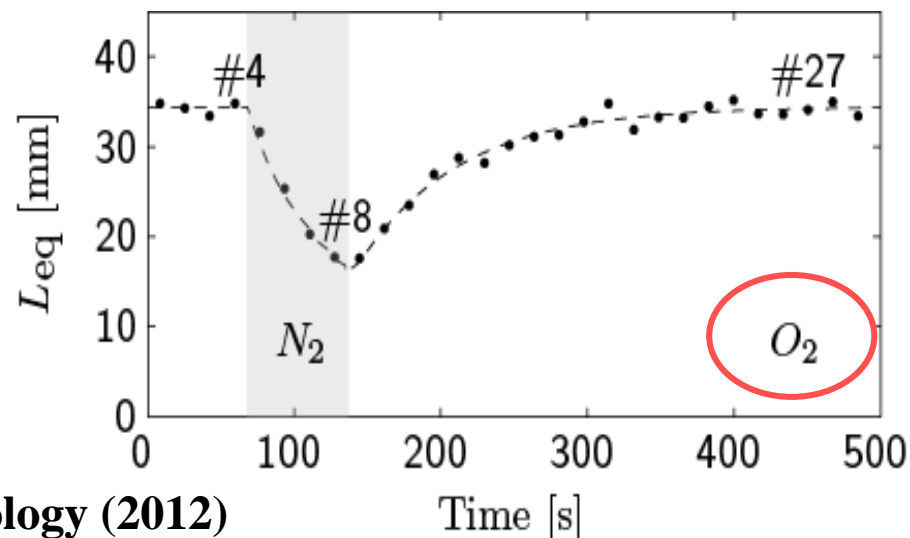
## Worldwide concern!

## Sinusitis diagnostics

### Frontal, maxillary, mastoideal

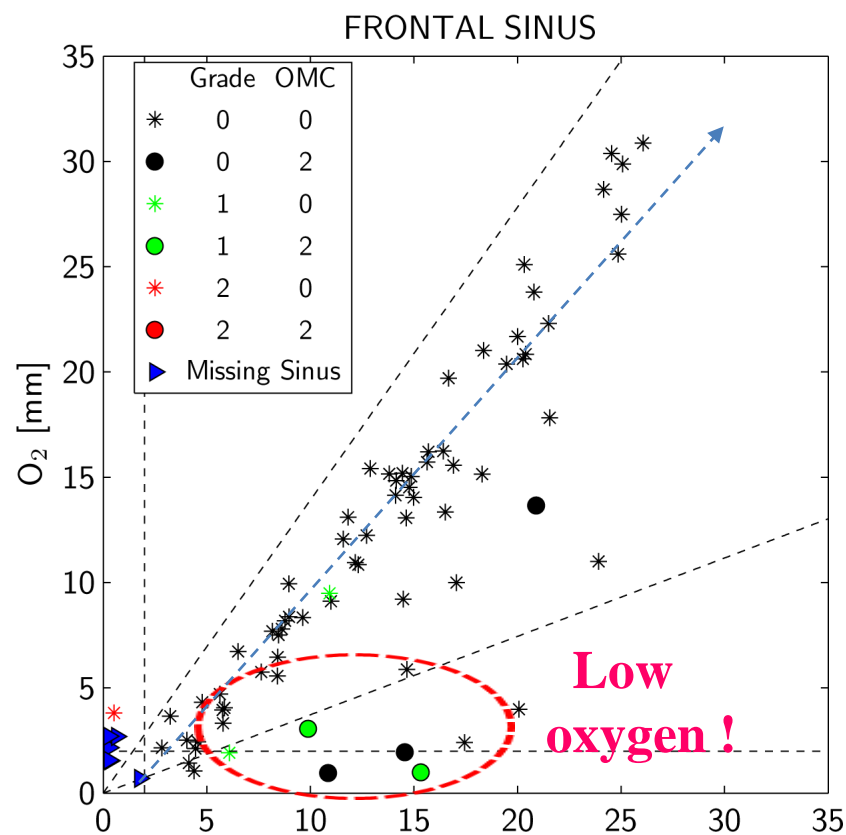
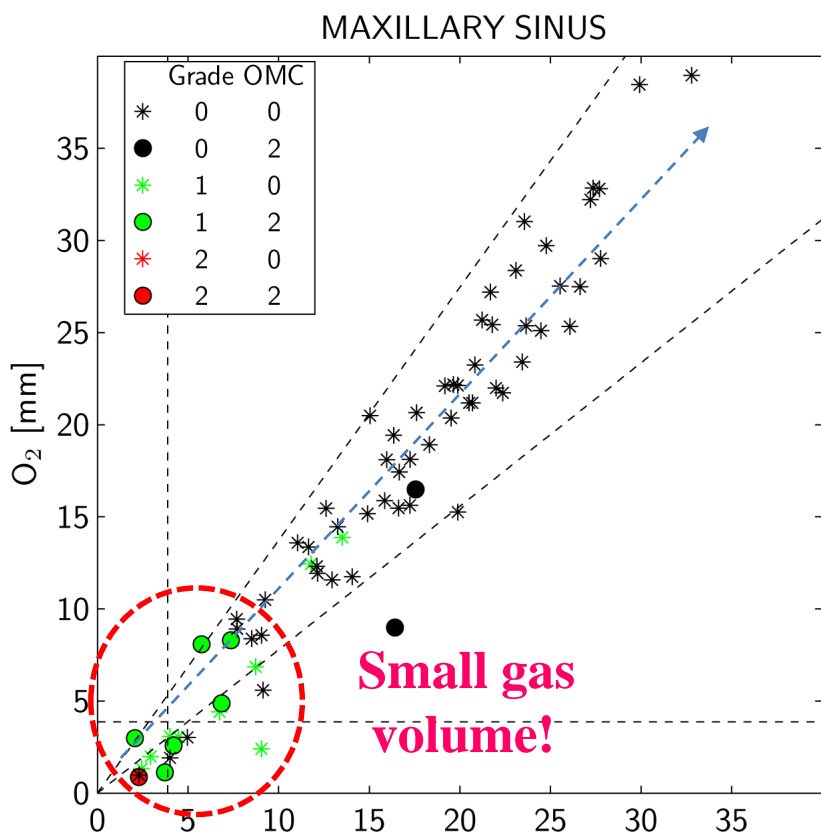
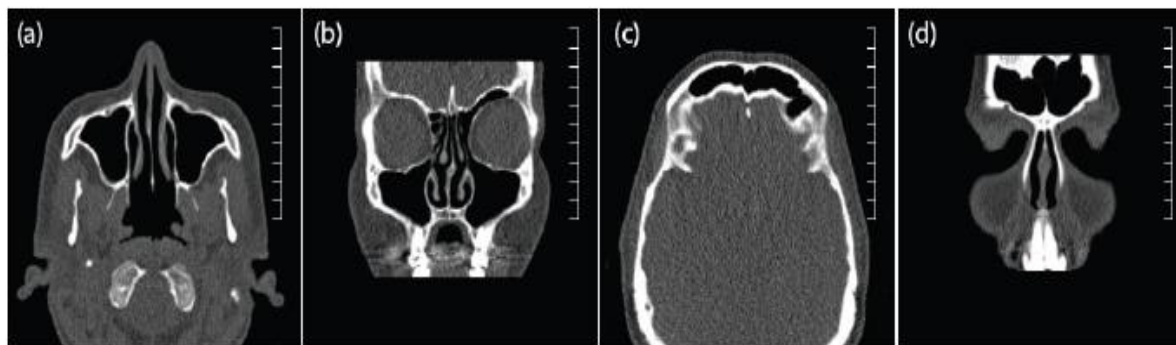


**Fleming  
Nobel  
Prize  
1945**

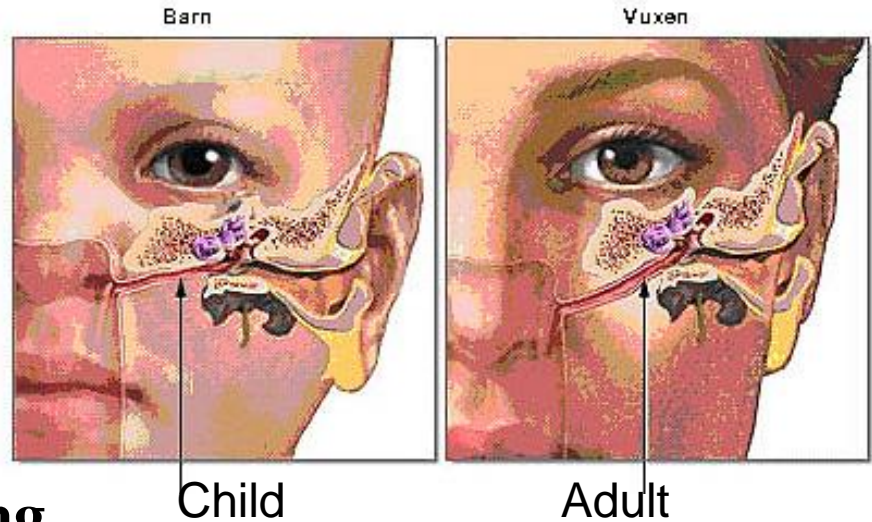


# Clinical study on 40 patients

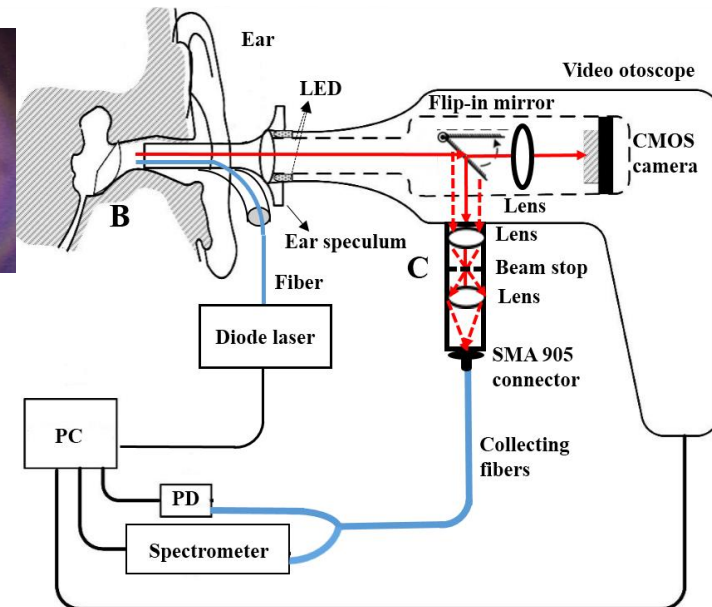
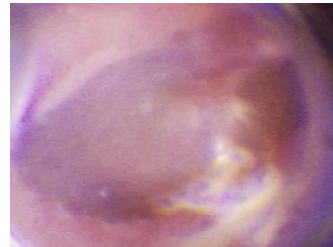
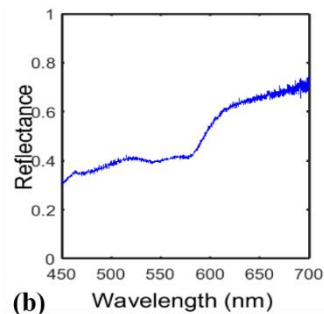
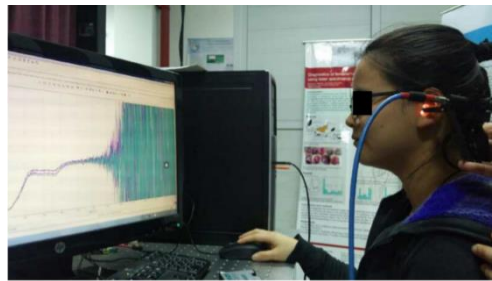
Lewander *et al.* Rhinology (2012) – Results comparable to CT



# Middle ear infection (otitis)

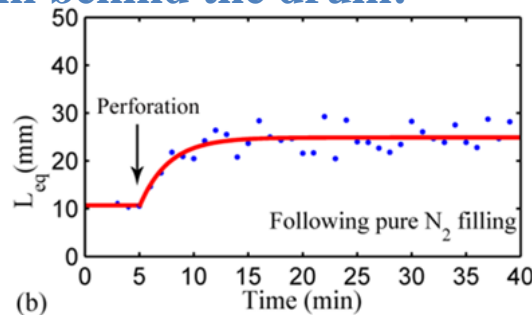
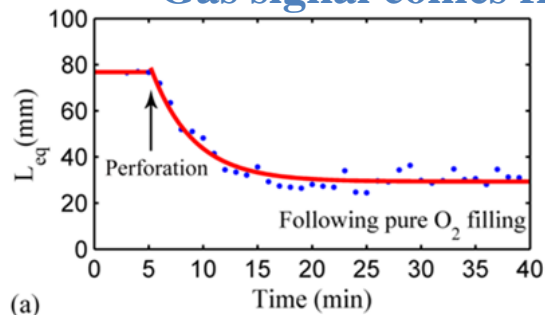


## Ear-drum color monitoring



## GASMAS Phantom experiments: Zhang *et al.* 2016

Gas signal comes from behind the drum!

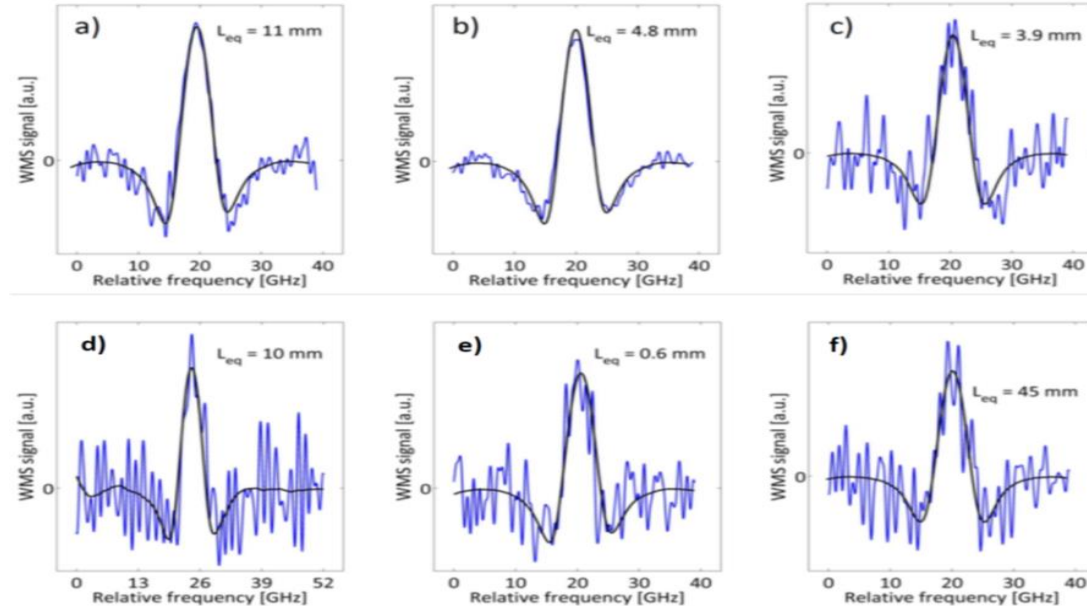
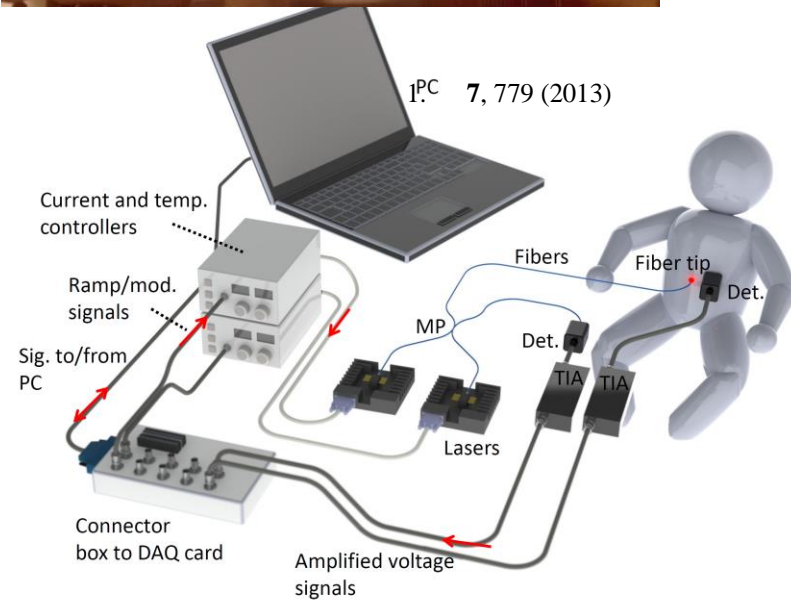
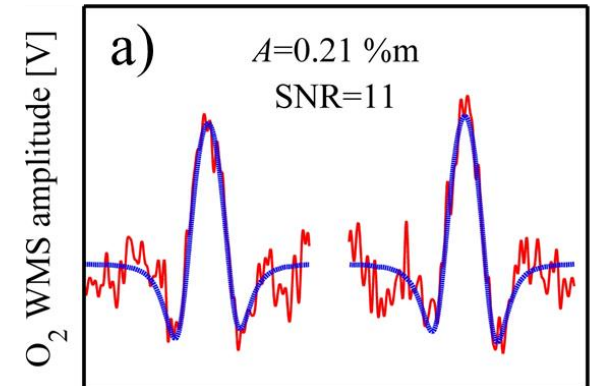


Li *et al.* 2018

# Neonatal/Premature child monitoring

Lack of surfactant – lung problem! Eliminate X-rays! 24 h cot-side monitoring of O<sub>2</sub>

Lundin et al., Krite-Svanberg et al. (2015)



**GASMAS Reviews:** S. Svanberg, Laser and Photonics Reviews 7, 779 (2013)

K. Svanberg, S. Svanberg, in *Frontiers in Biophotonics for Translational Medicine*,

U.S. Dimish and M. Olivo (eds) (Springer, Singapore 2015) 307-321