The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2018-20

Winter College on Optics in Environmental Science

2 - 18 February 2009

Environmental, combustion and medical diagnostics and their connection

Svanberg S.
Lund University
Sweden

Winter College ICTP 2009

Environmental, combustion and medical diagnostics

–

and their connection

Sune Svanberg
Lund Laser Centre
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Sweden

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LUND INSTITUTE OF TECHNOLOGY
Lund University

Lund Present and recent Collaborators:

G. Ahlgren, M. Andersson, S. Andersson-Engels, K. Barup, M. Brydegaard, M. Cassel-Engquist, J. Hällström, R. Grönlund, Zuguang Guan, K. Jakobsson, A. Johansson, L. Persson, G. Somesfalean, J. Swartling,T. Svensson, K. Svanberg

Lund Previous Collaborators:

Ch. Abrahamsson, H. Edner, J. Sandsten, M. Sjöholm, P. Weibring

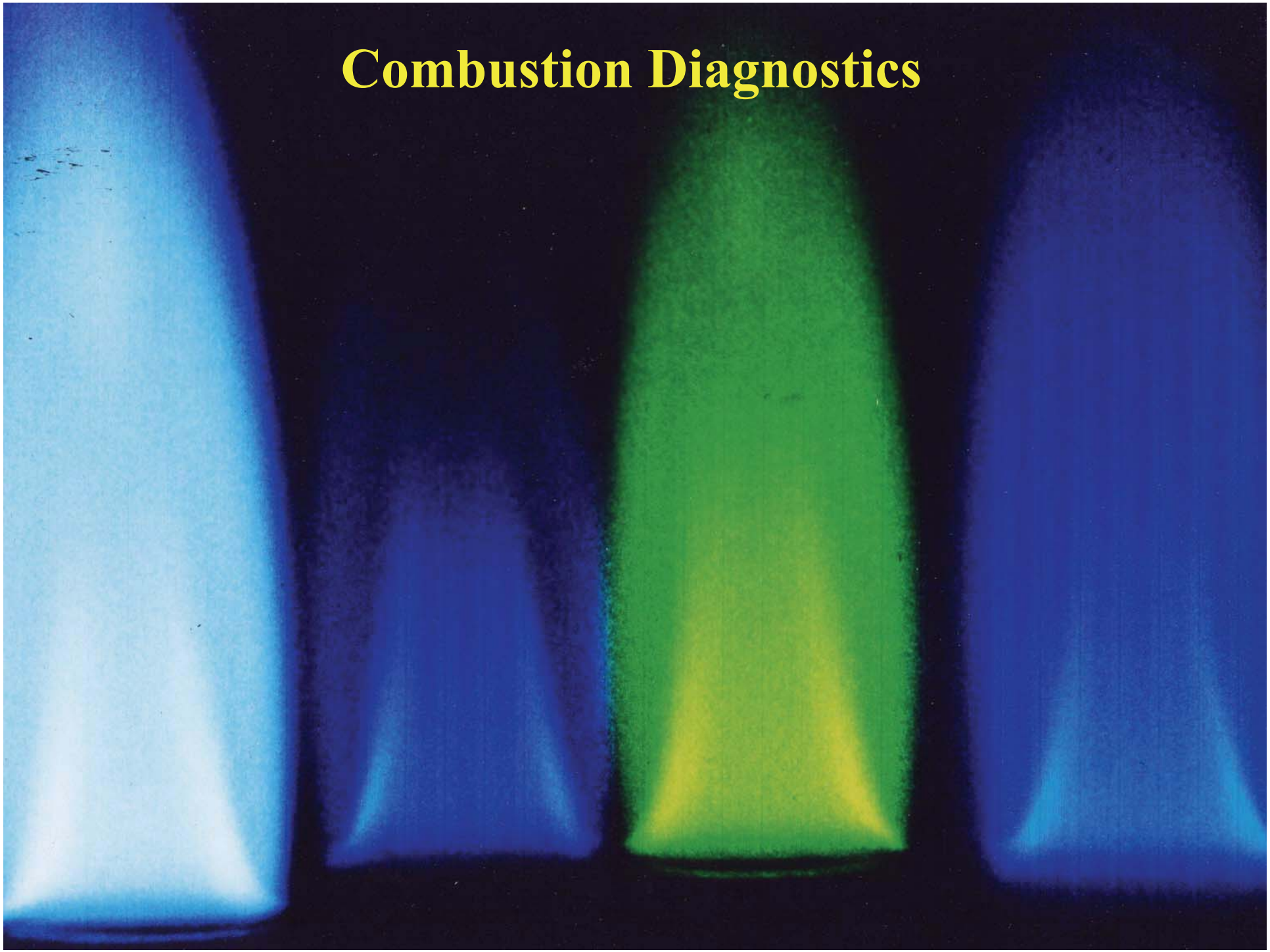
International Collaborators:

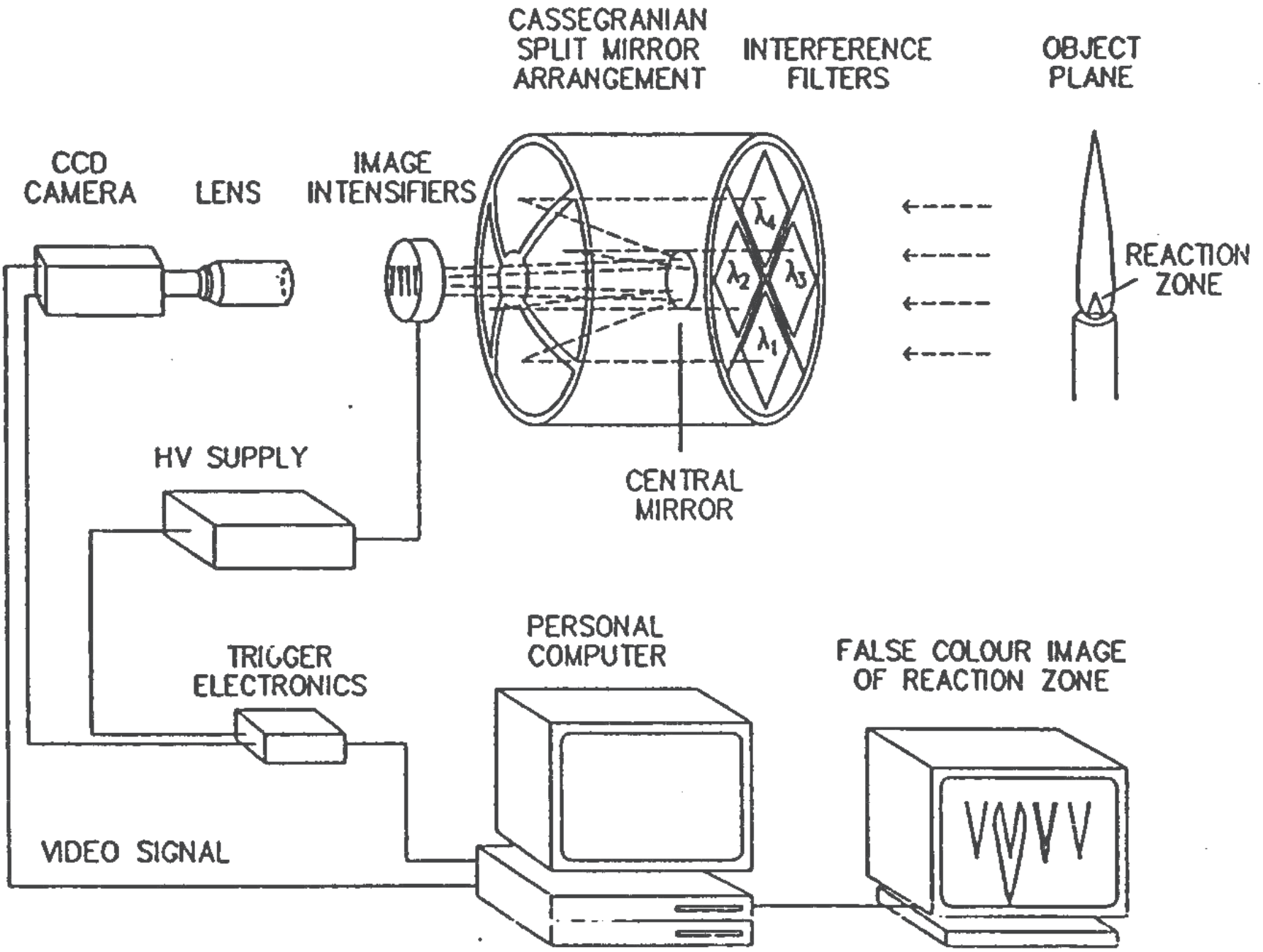
Z.G. Zhang, Harbin, S.L. He, Hangzhou, G. Cecchi, Valentina Raimondi et al., Firenze; African LAM Network

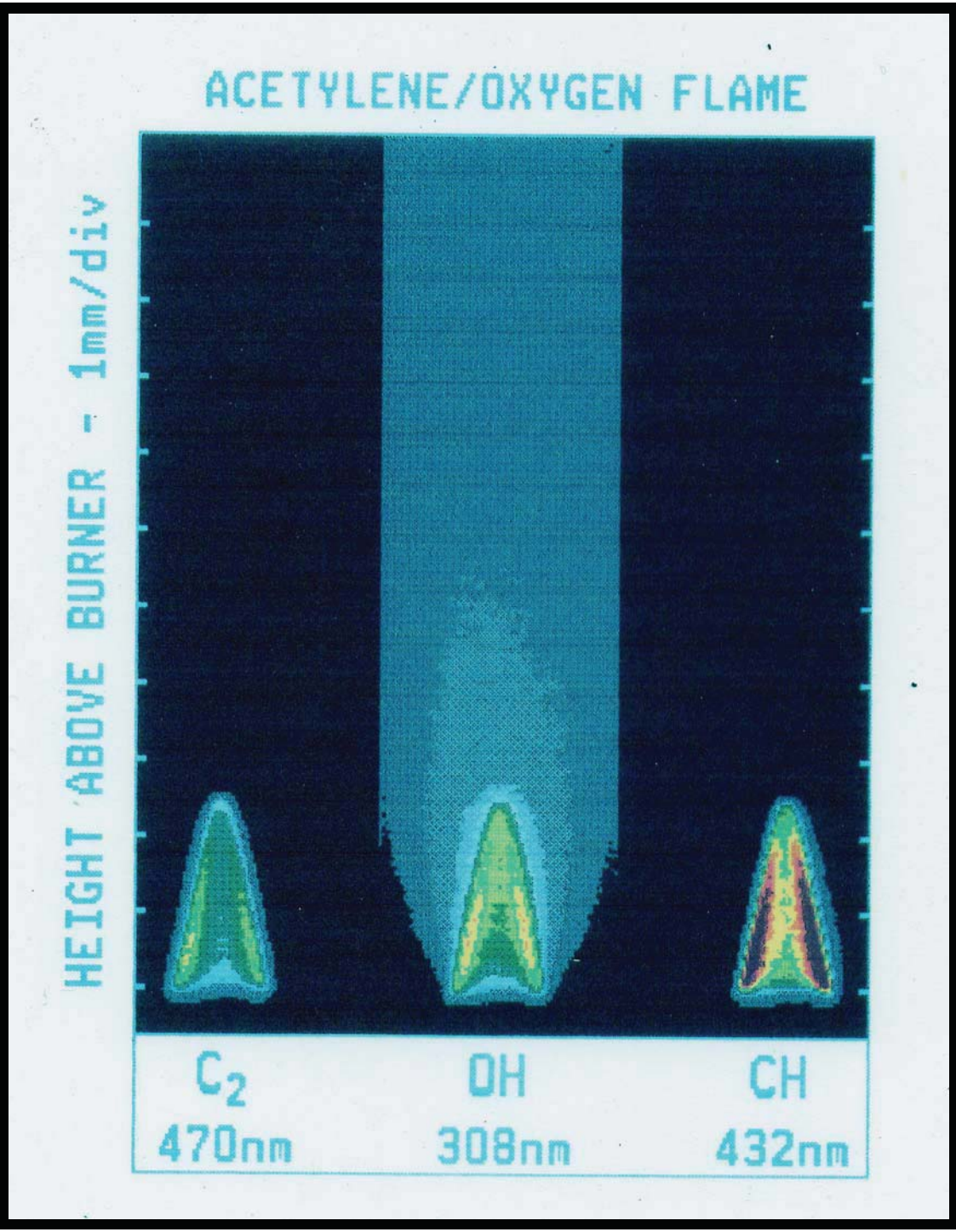
Lund Laser Centre

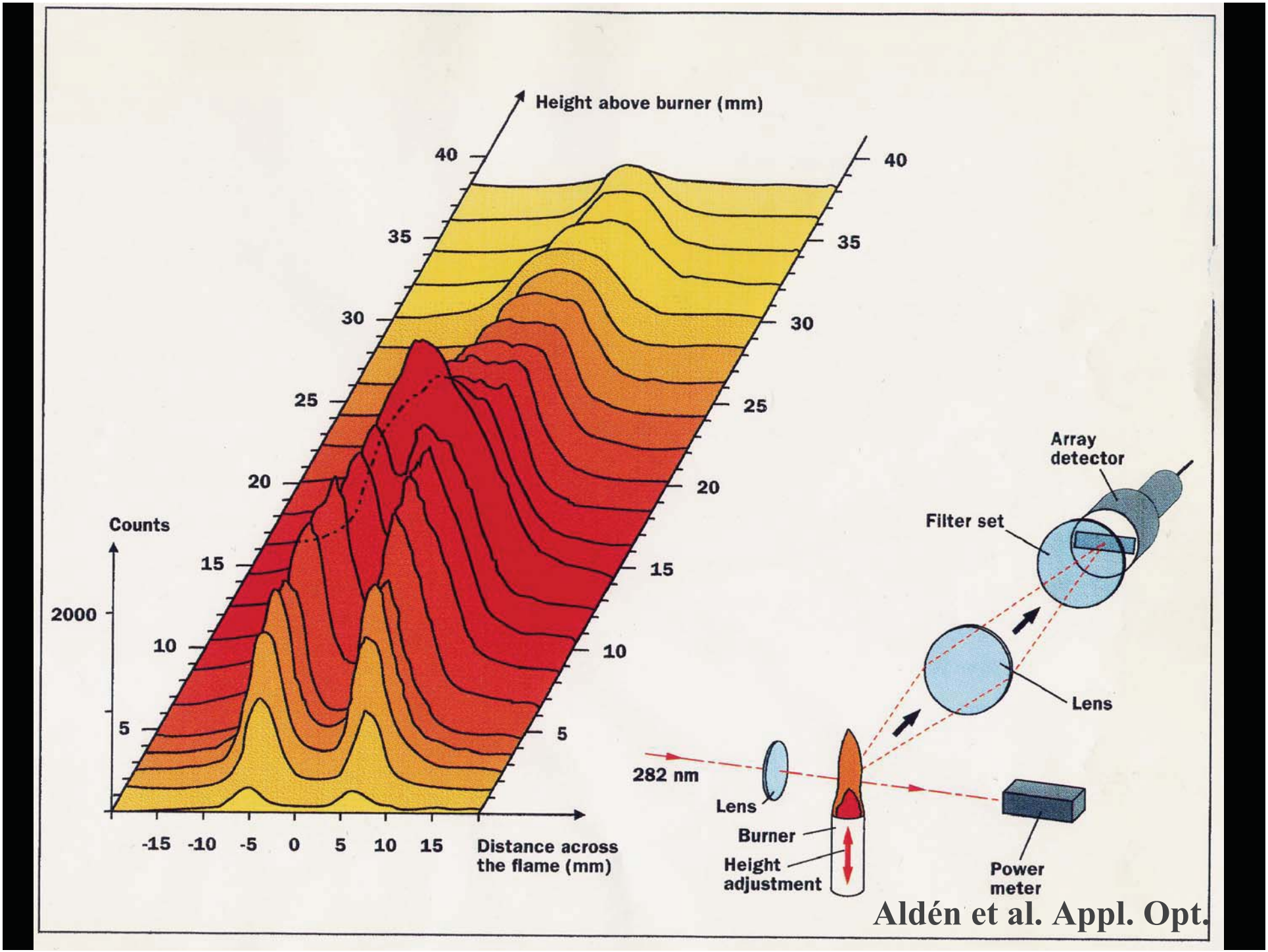
Lund Institute of Technology
Lund University

Combustion Diagnostics

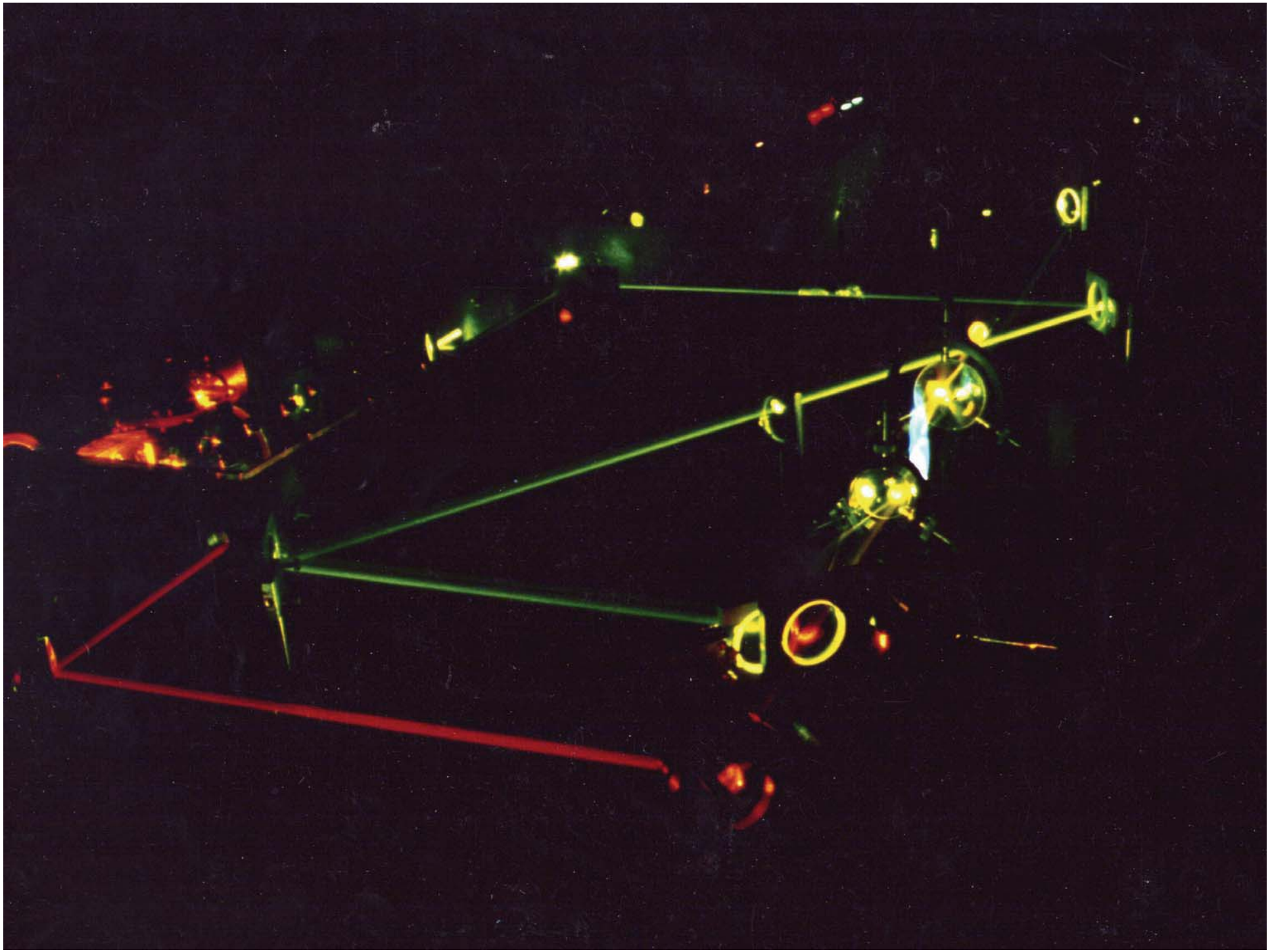


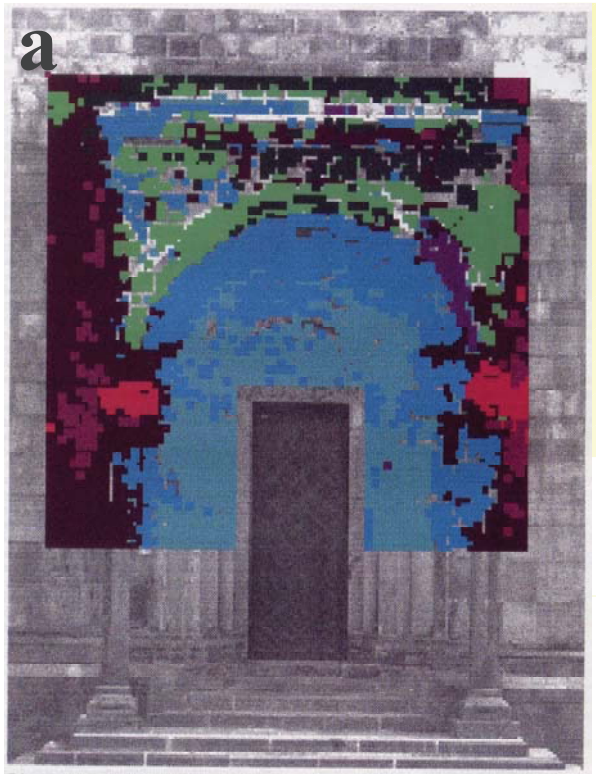

CASSEGRANIAN SPLIT MIRROR ARRANGEMENT
INTERFERENCE FILTERS
OBJECT PLANE
CCD CAMERA
LENS
IMAGE INTENSIFIERS
λ_4
λ_2
λ_3
λ_1
REACTION ZONE
HV SUPPLY
CENTRAL MIRROR
PERSONAL COMPUTER
TRIGGER ELECTRONICS
FALSE COLOUR IMAGE OF REACTION ZONE
VIDEO SIGNAL

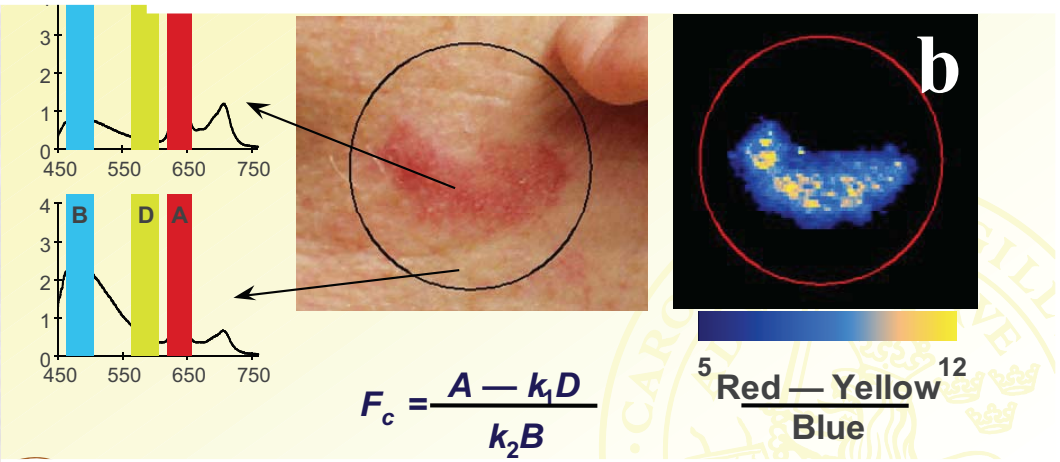

ACETYLENE/OXYGEN FLAME
HEIGHT ABOVE BURNER - 1mm/div
C2
470nm
OH
308nm
CH
432nm



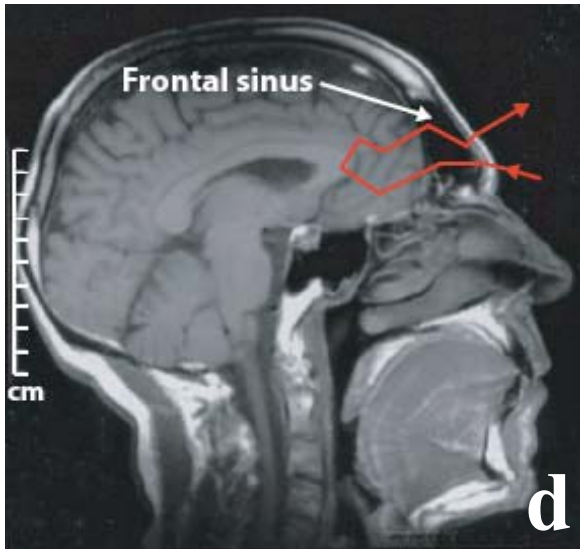
Aldén et al. Appl. Opt.



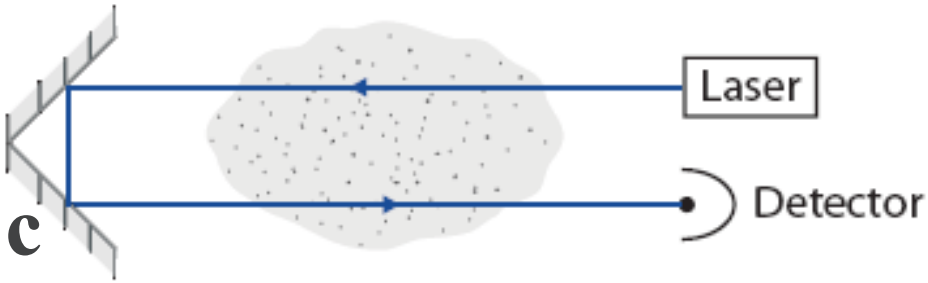


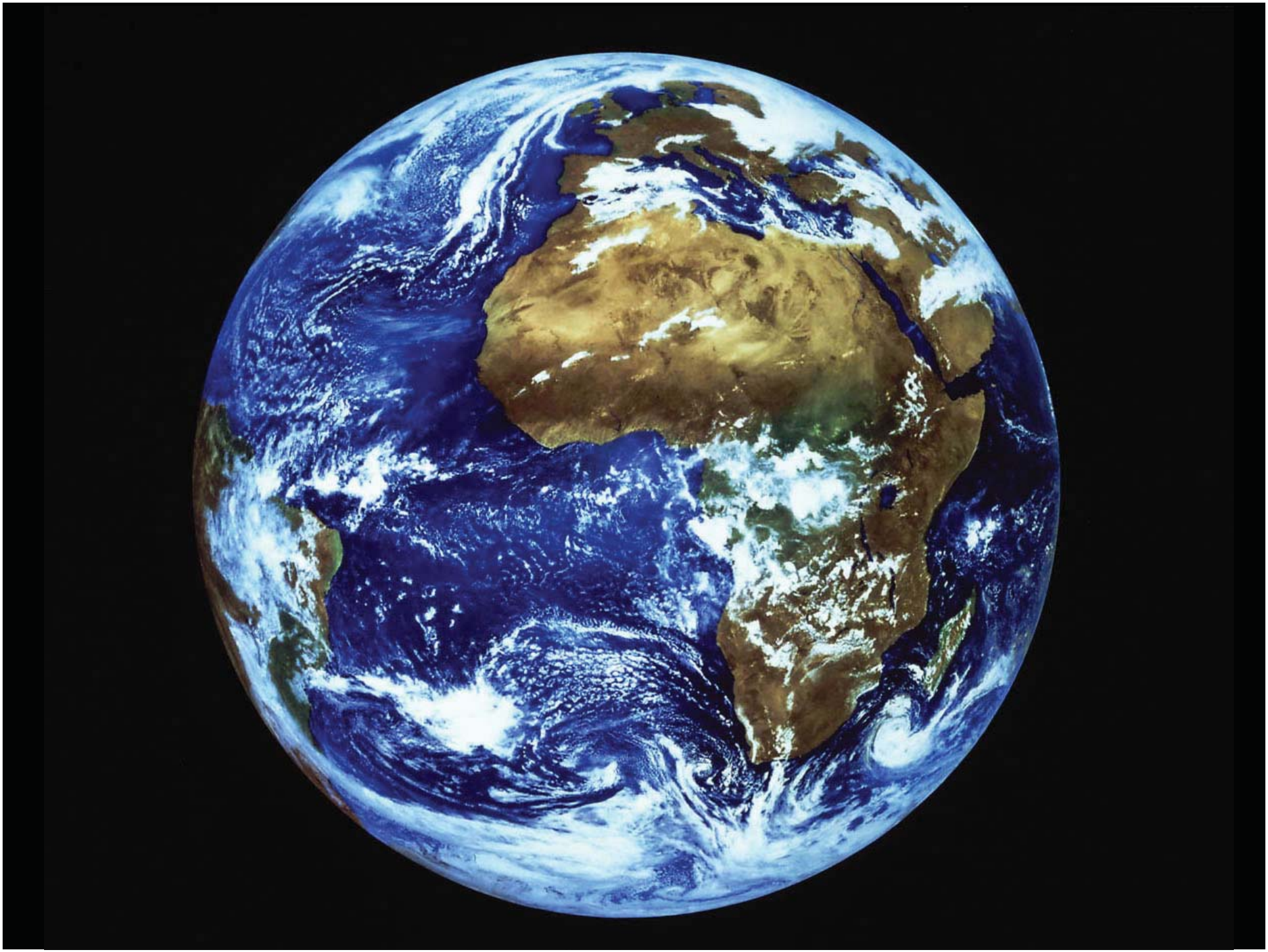


Medicine

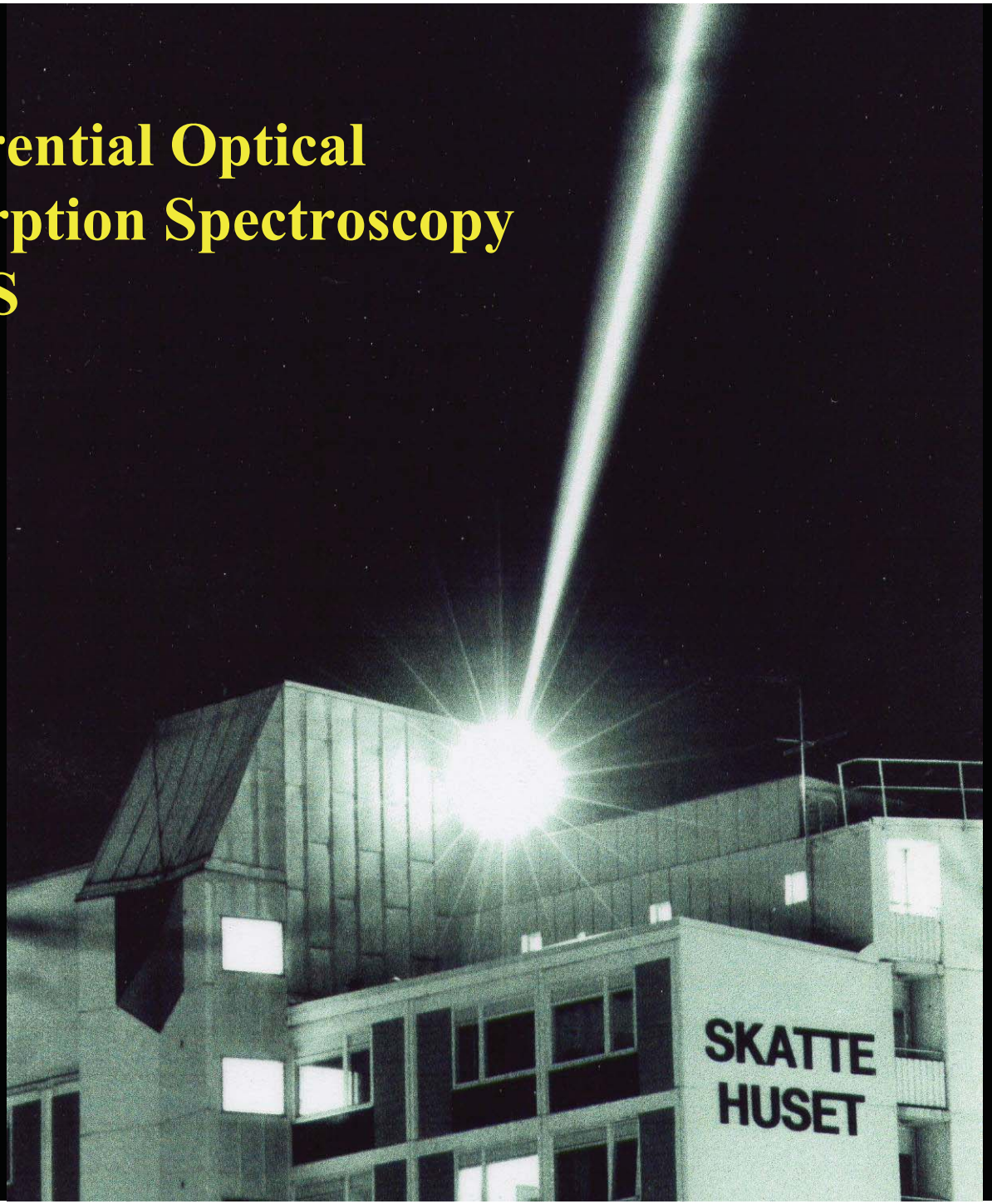


Environment



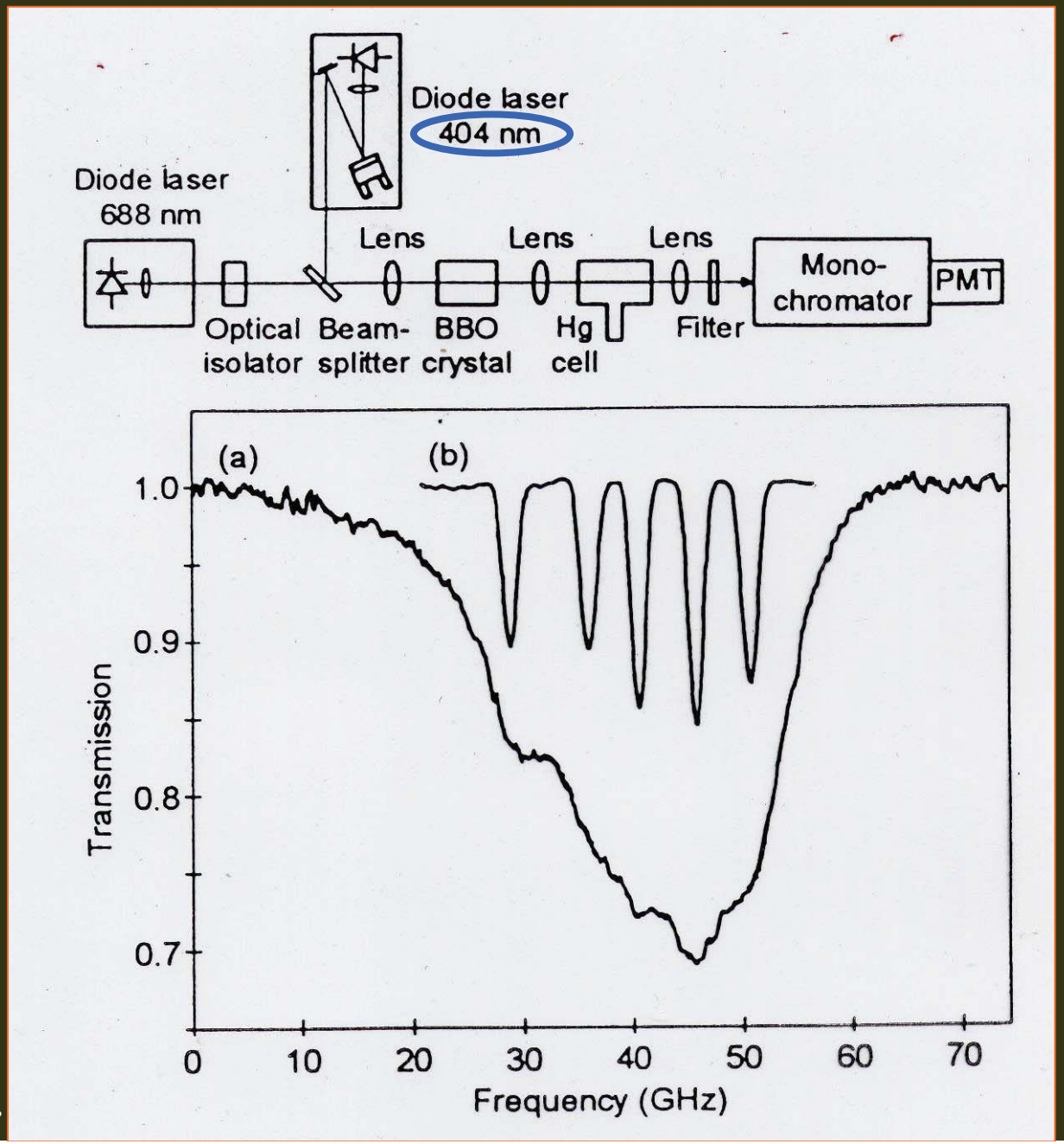


Differential Optical Absorption Spectroscopy DOAS

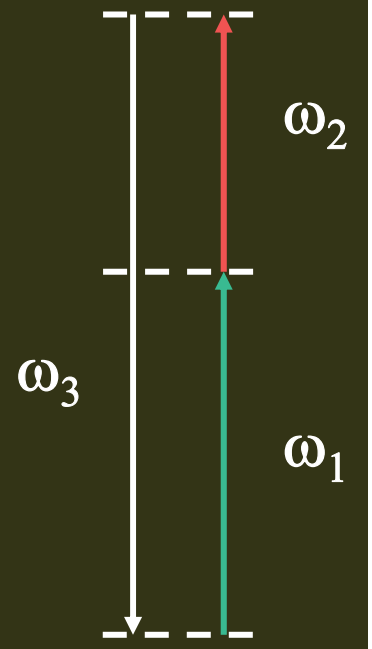


Opsis AB

Sum-frequency generation to 254 nm: Hg

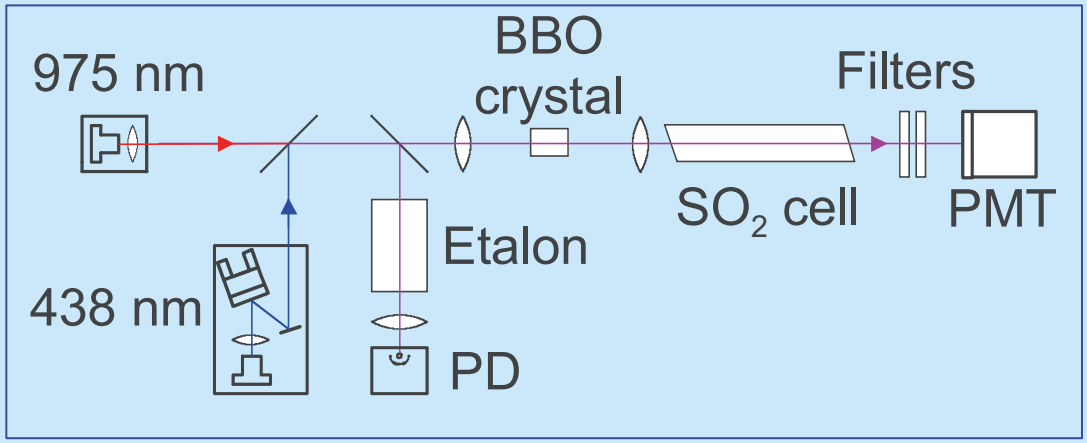


$\omega_3 = \omega_1 + \omega_2$

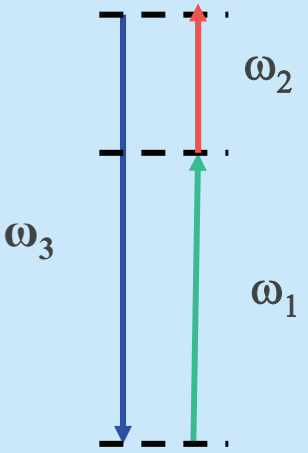


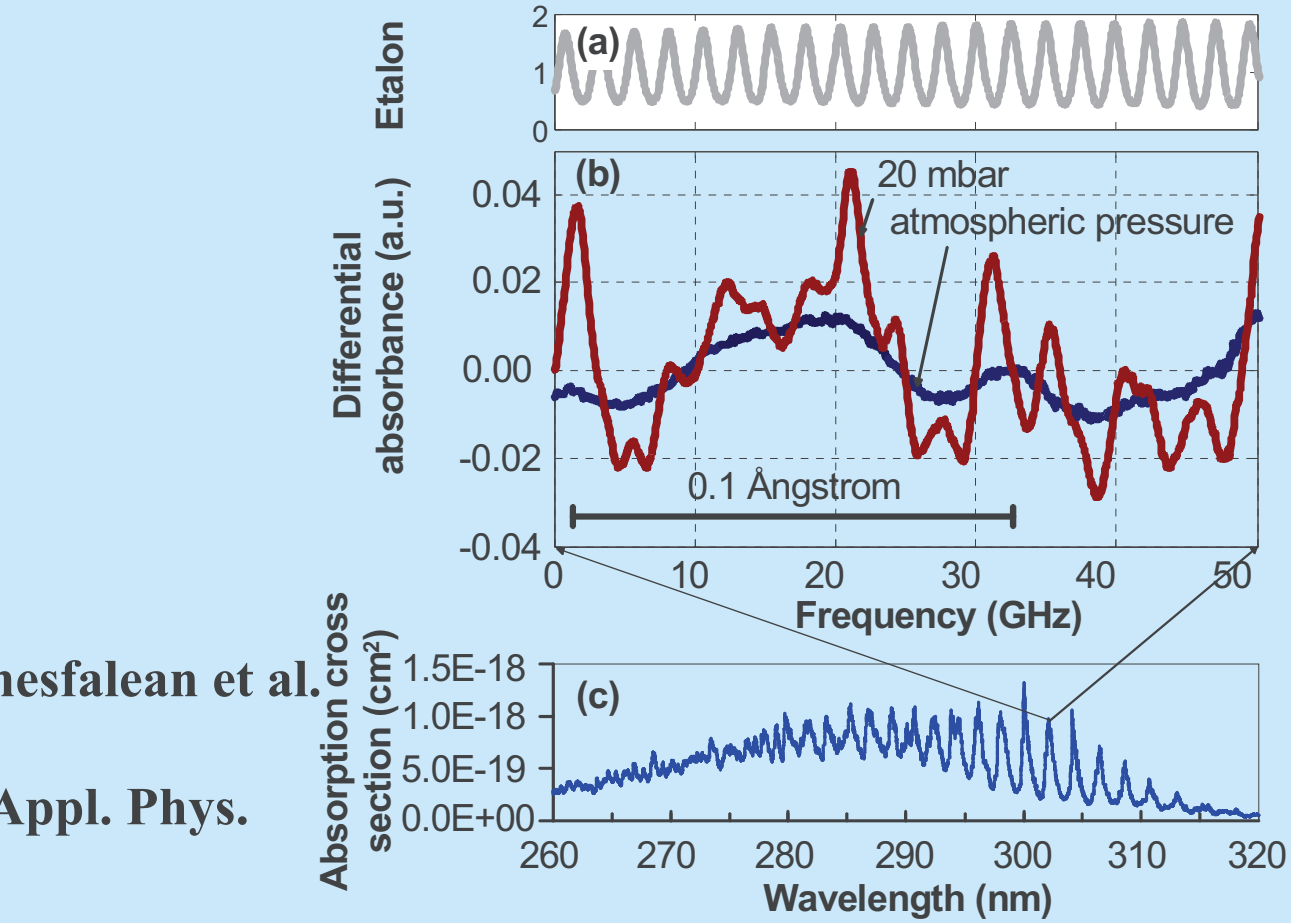
Also:
SO_2, NO_2
H_20

Alnis et al.
Appl. Phys. Lett.



$\omega_3 = \omega_1 + \omega_3$





SO_2
NO_2
H_2O

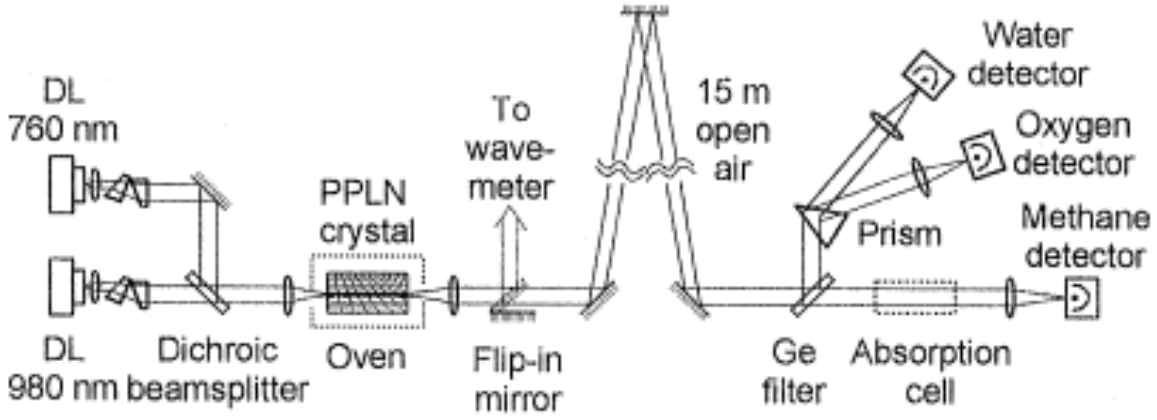
Somesfalean et al.

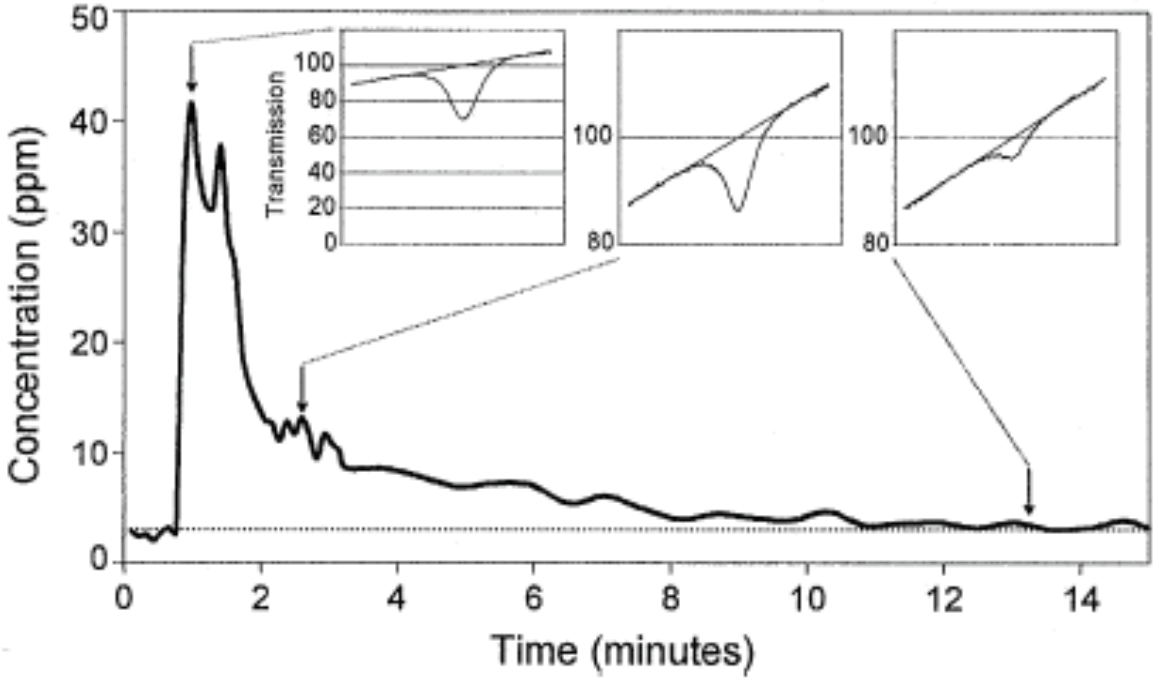
Appl. Phys.

Diode laser difference frequency generation

Simultaneous monitoring of Oxygen, Water vapour and Methane

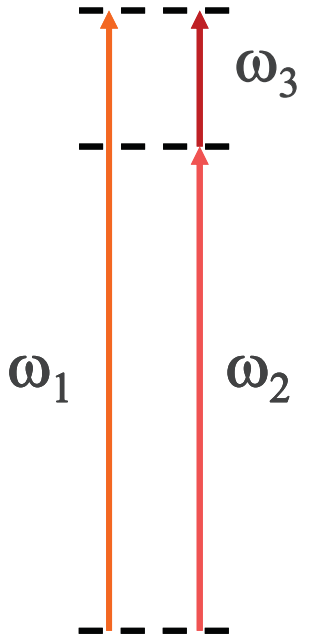
ω_1 ω_2 ω_3





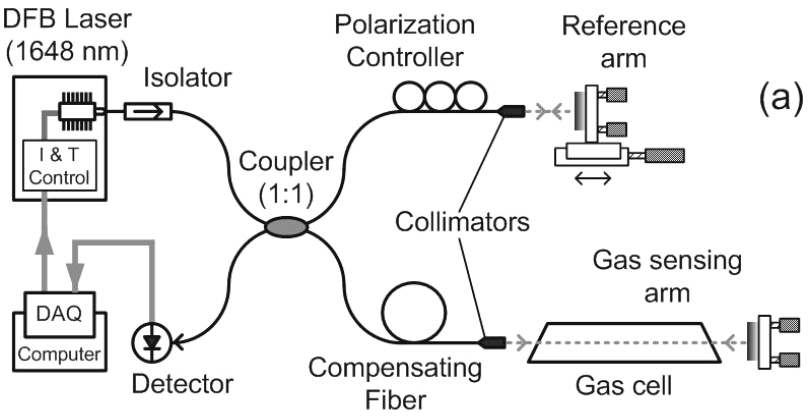
Gustafsson et al. Appl. Phys. B

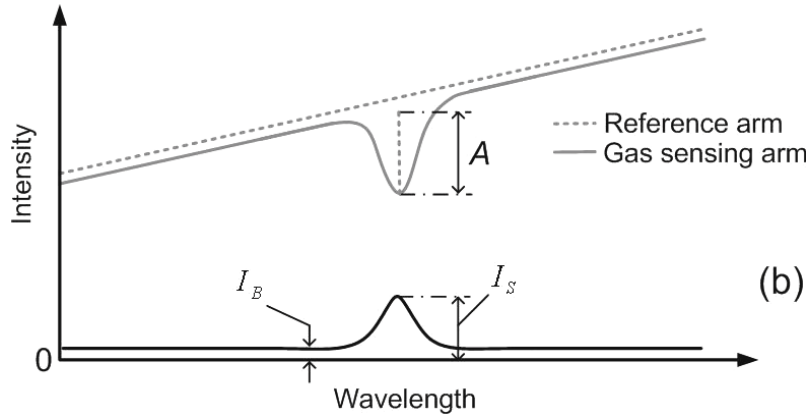
$\omega_3 = \omega_1 - \omega_2$

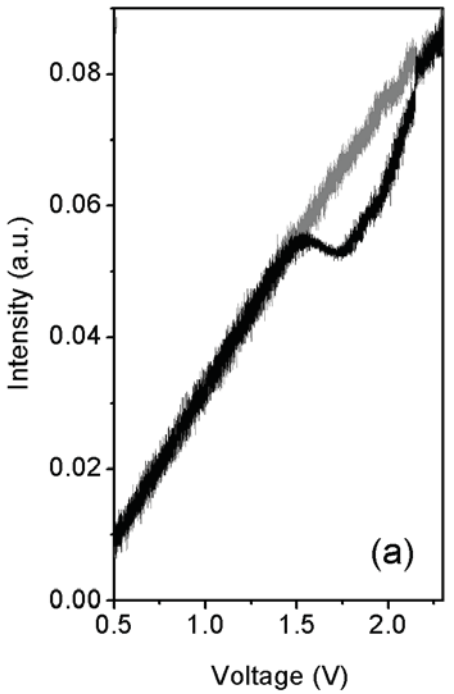


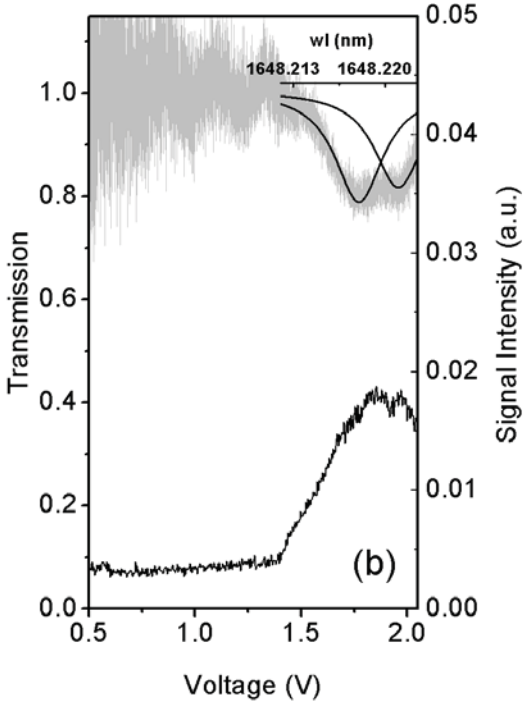
Zero background TDLAS in a balanced Michelson interferometer

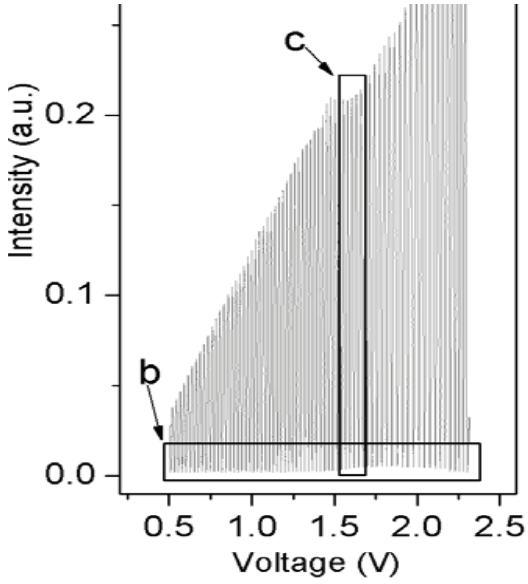
Guan et al. Optics Exp.

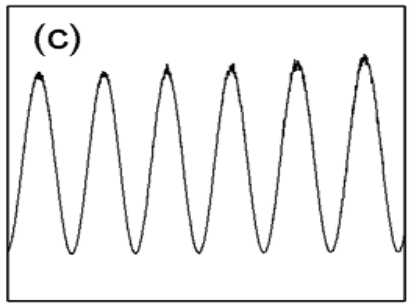




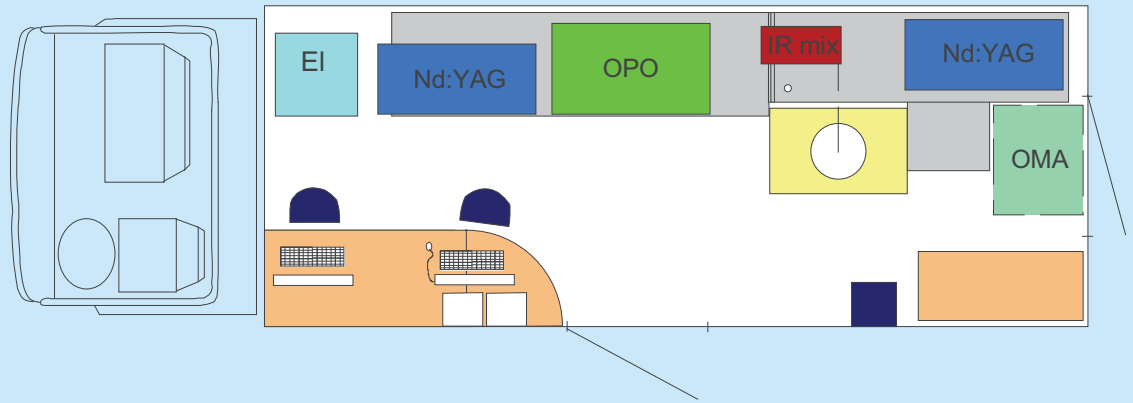


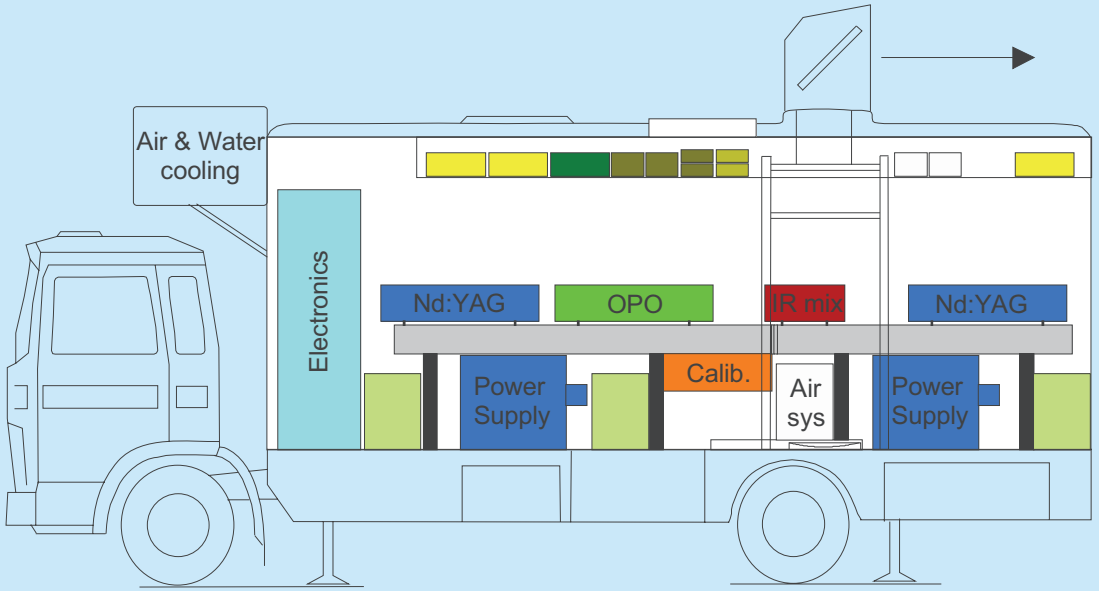






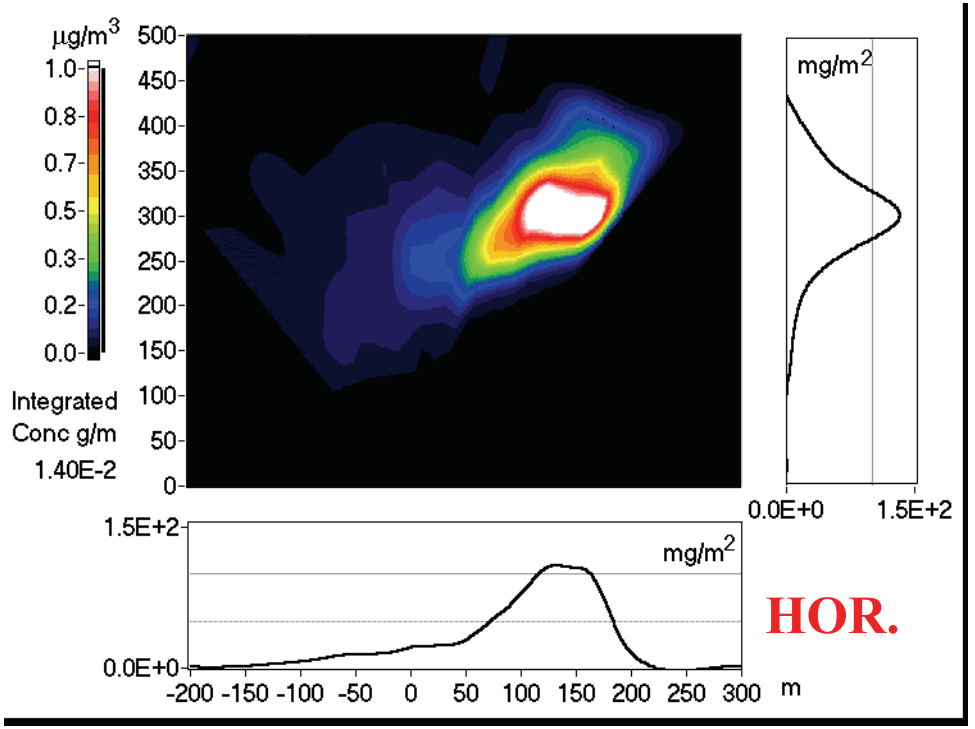
Lund mobile Lidar system

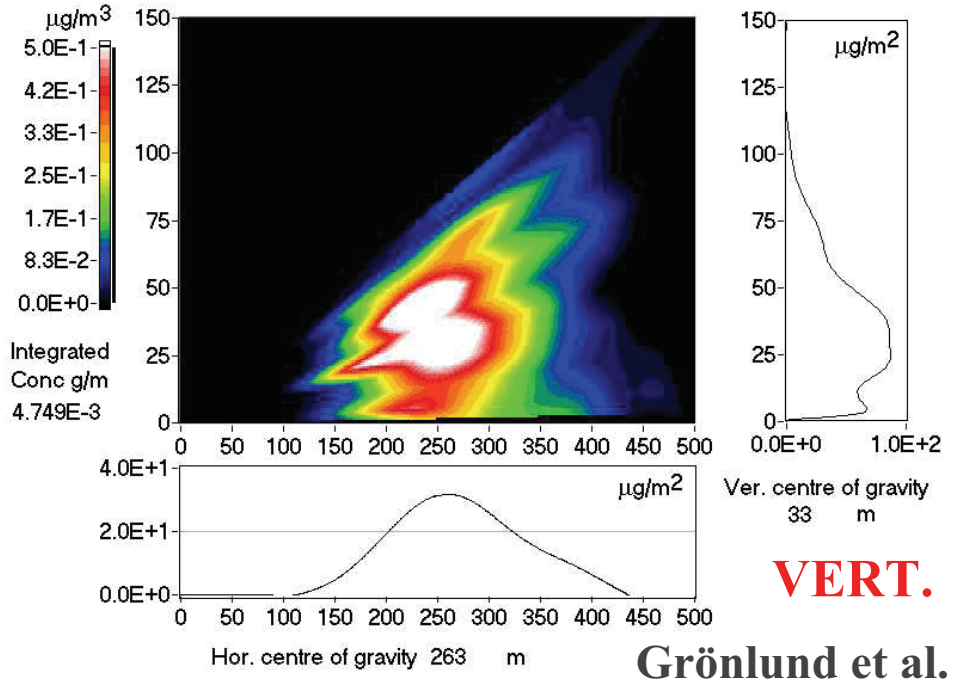




Atomic Mercury Lidar Mapping and Flux Measurement

Rosignano Solvay, Italy

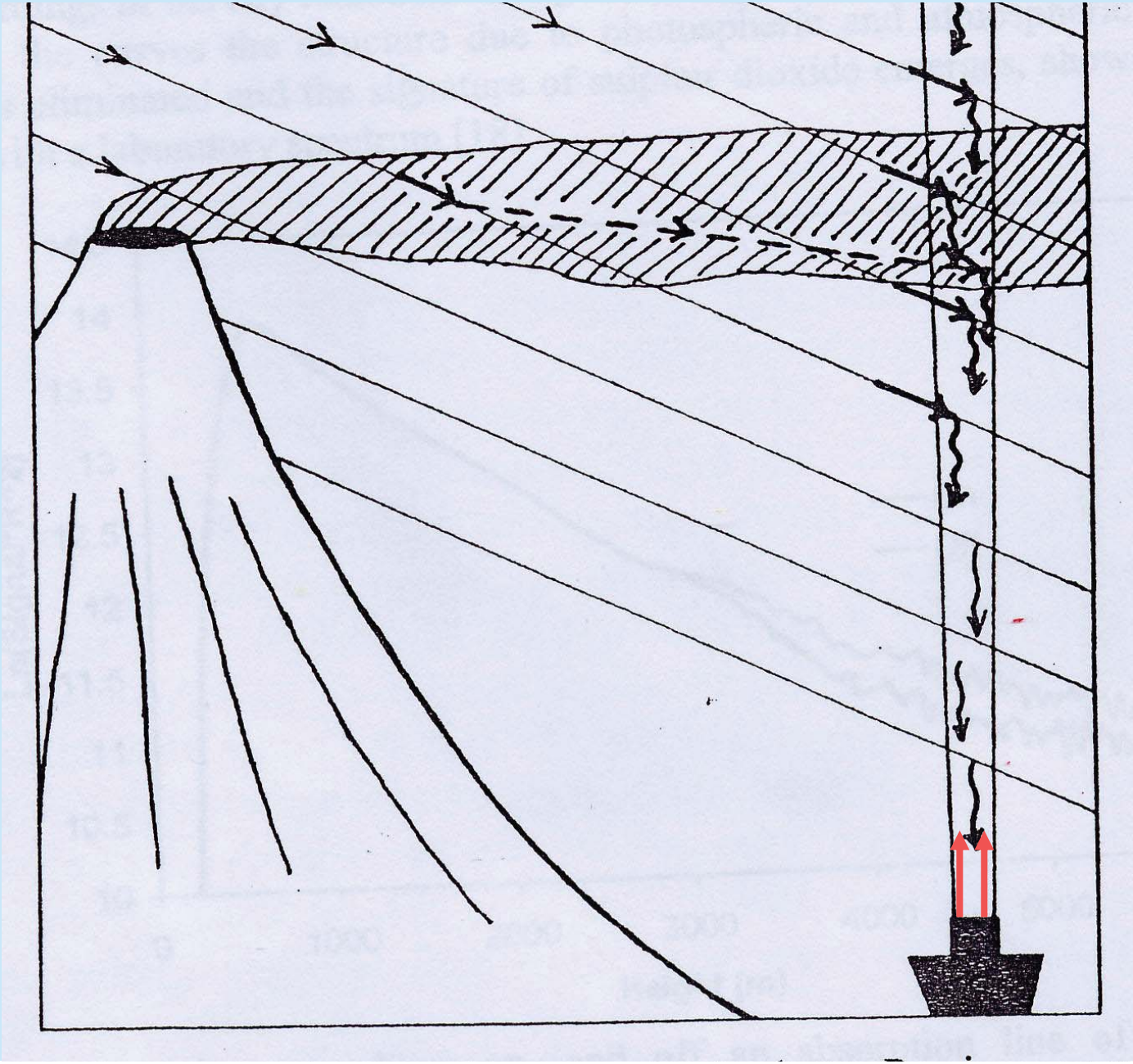


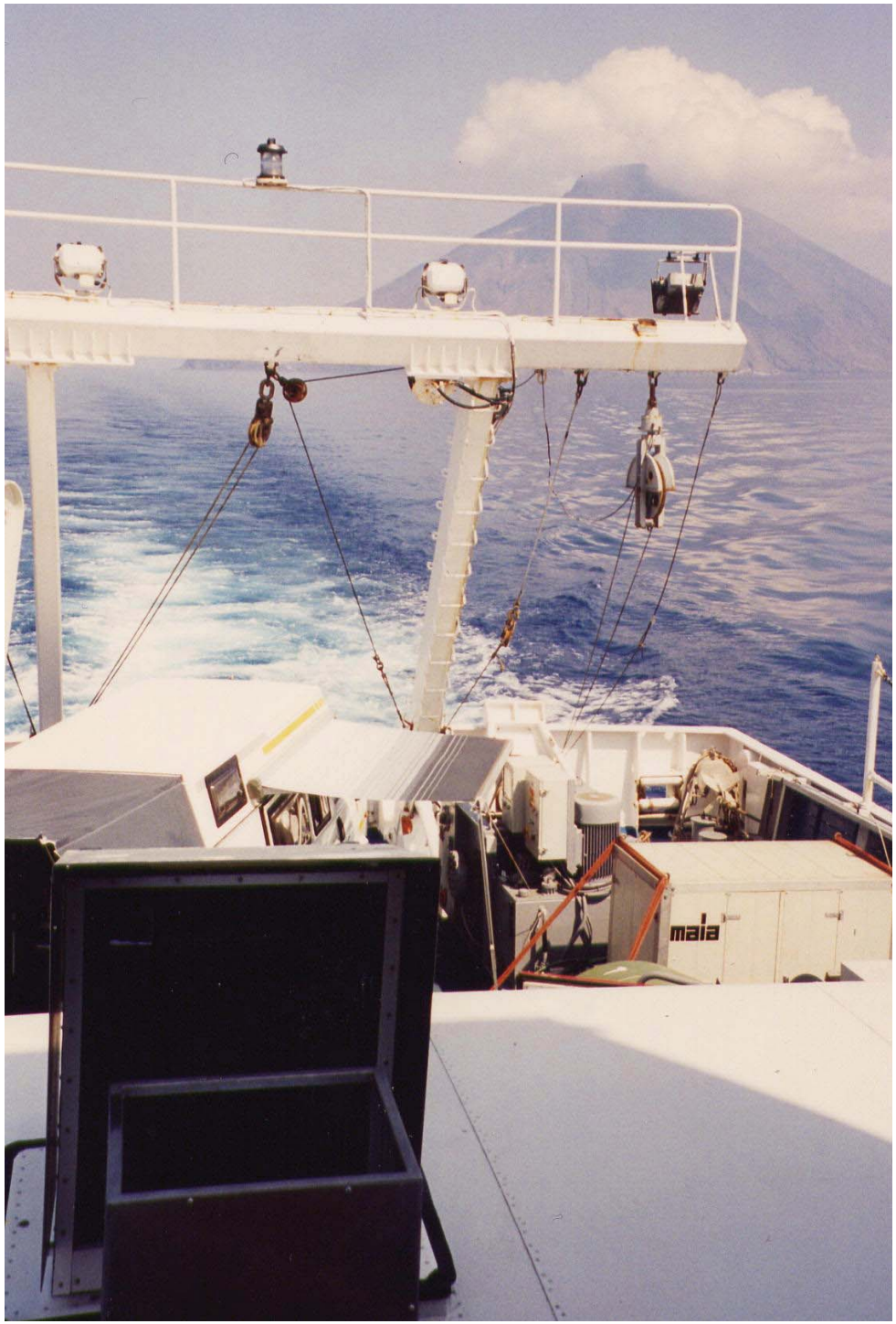


Grönlund et al.

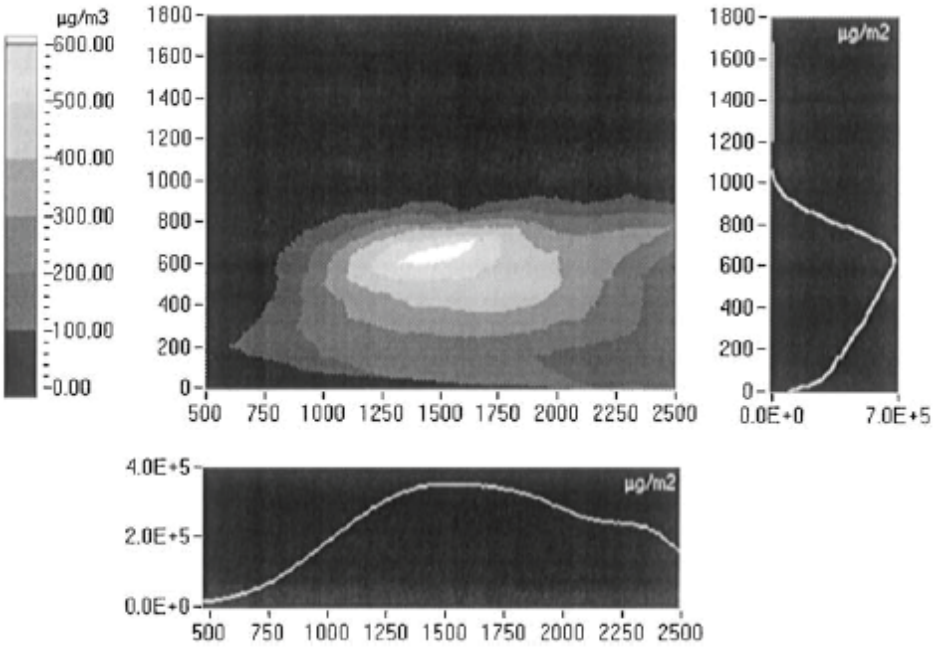
RV Urania and the Lund Lidar system in the port of Bari

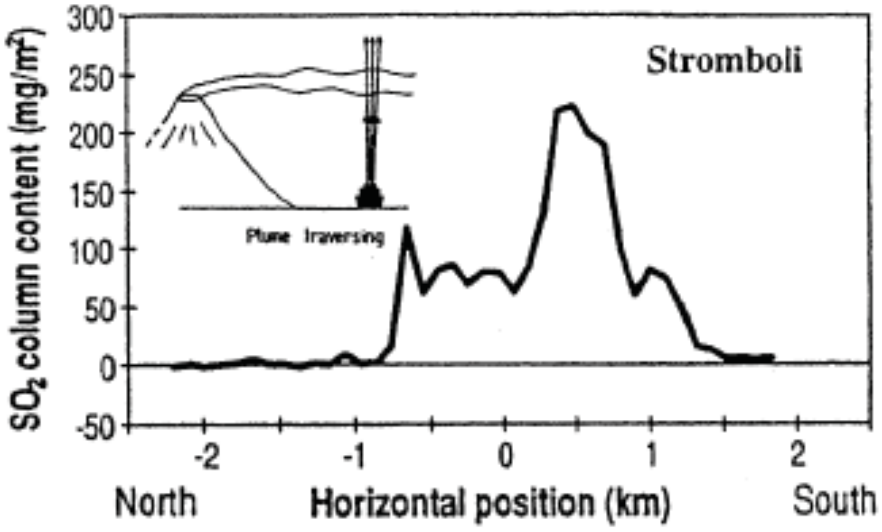
Volcanoe Monitoring

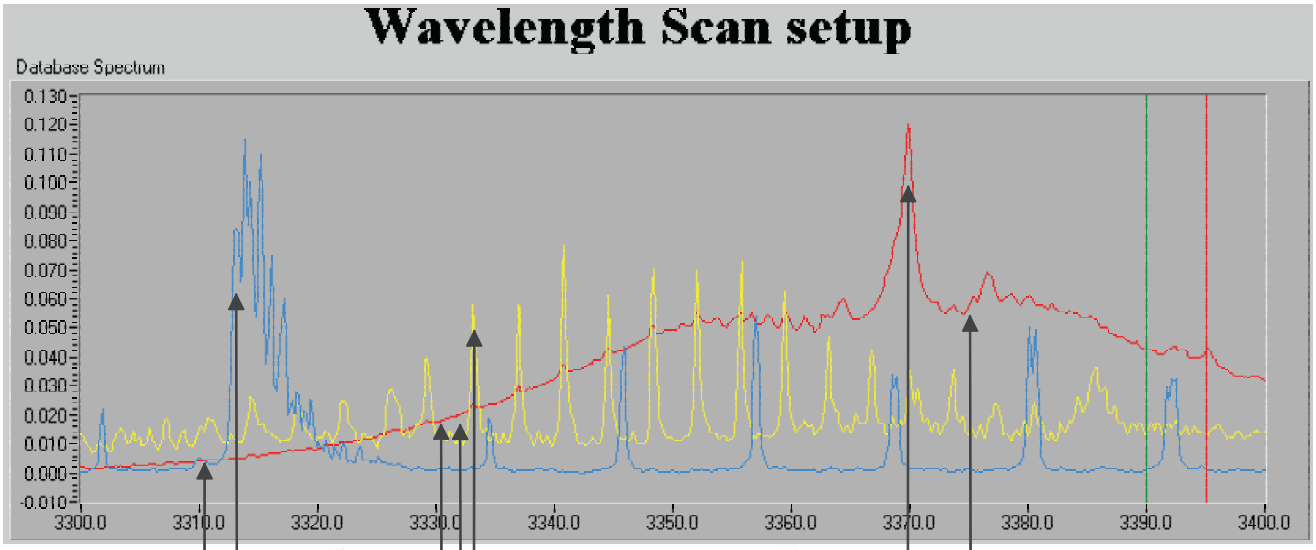




Lidar monitoring of SO_2 at Stromboli

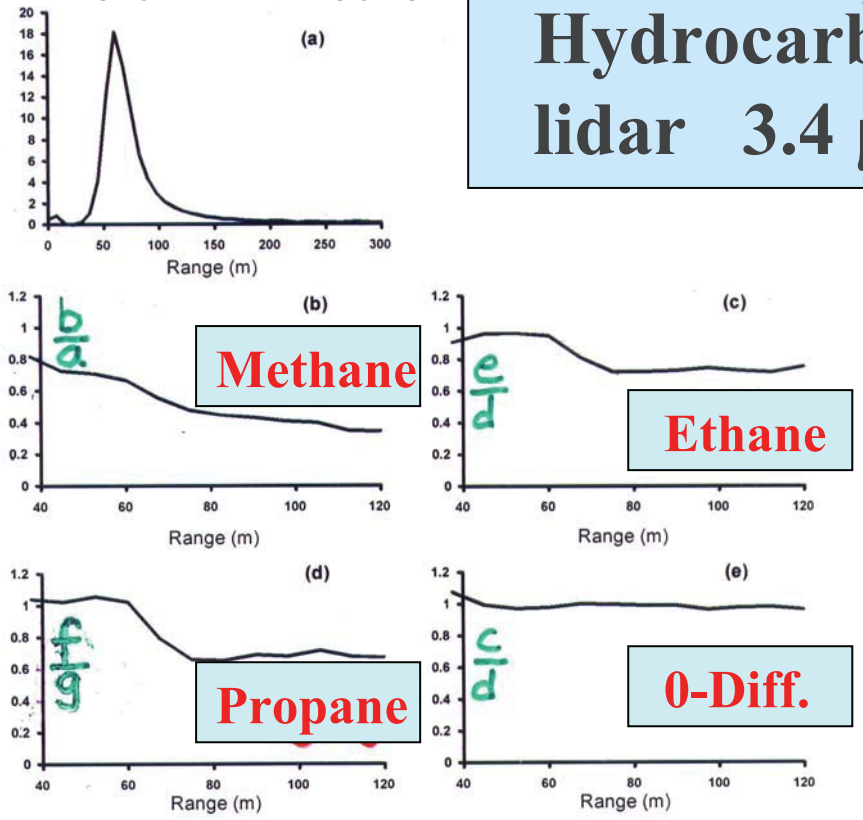






Lidar extension To hydrocarbons

Hydrocarbon lidar 3.4 μm

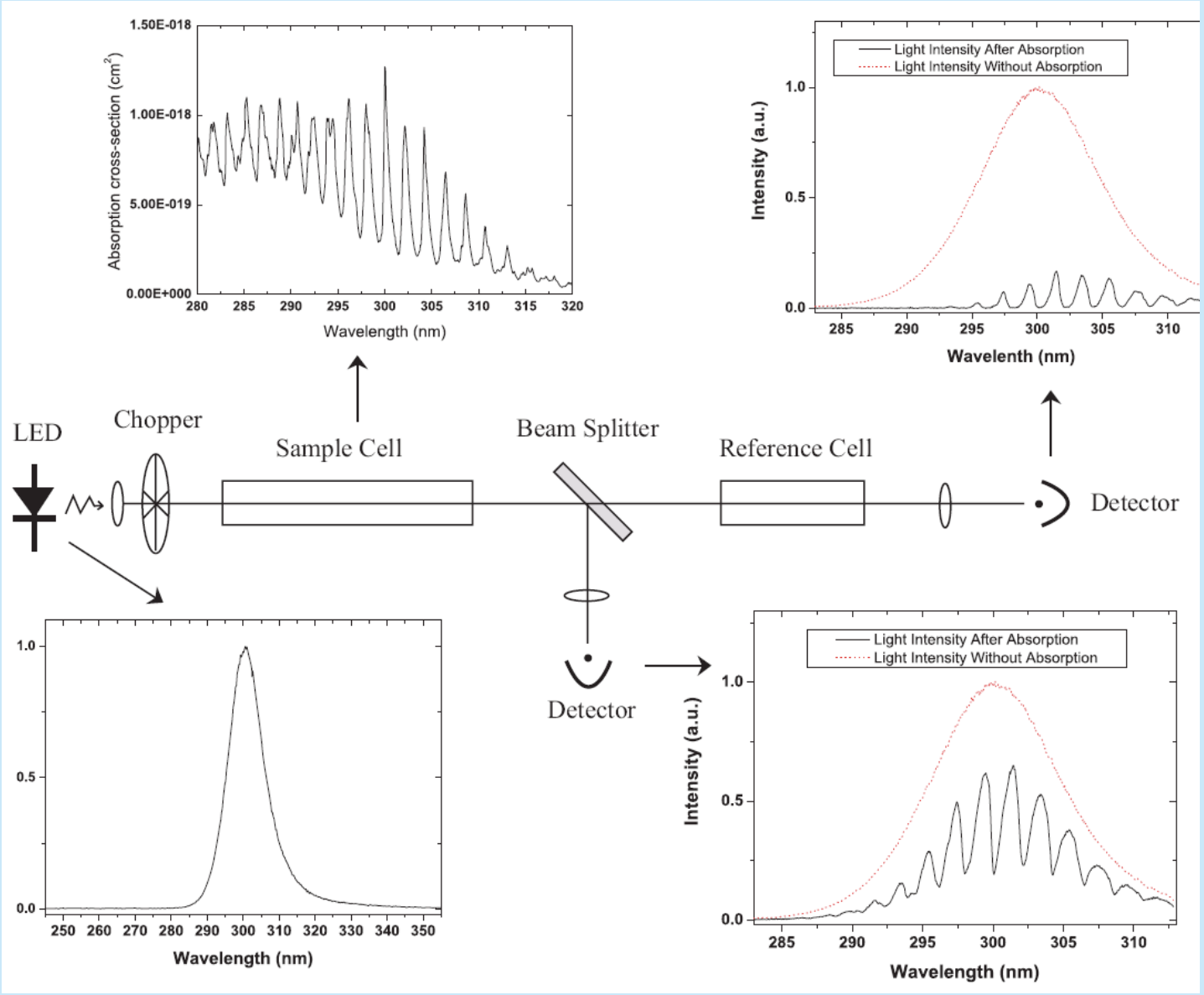


Weibring et al.

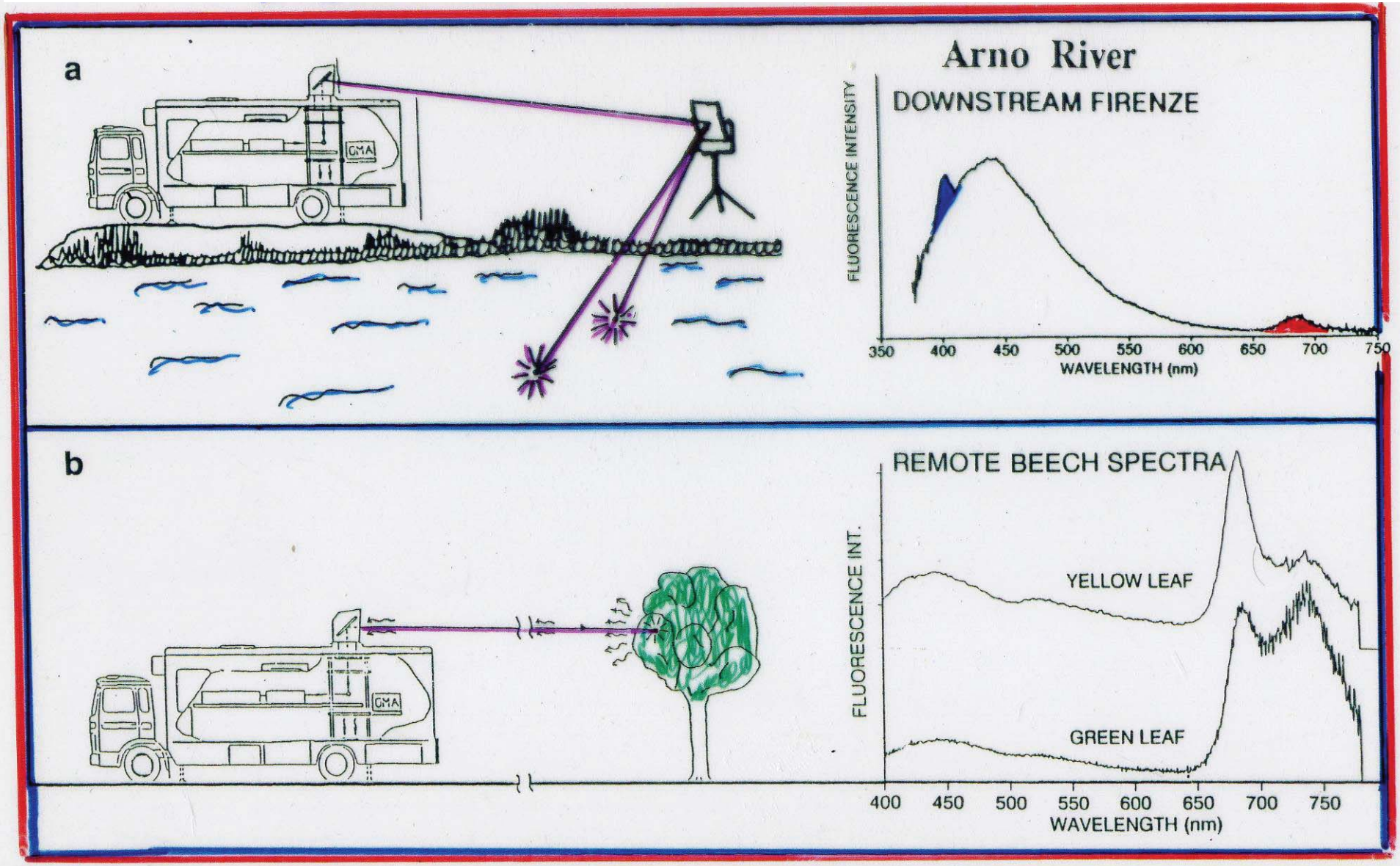
Gas correlation imaging in the infrared


Gas cell
Dual image
Cassegrainian
telescope
CCD
IR camera with
spectral filtering
PC with real-time
image processing
GVS
Installation at
Statoil Kårstö
Norway

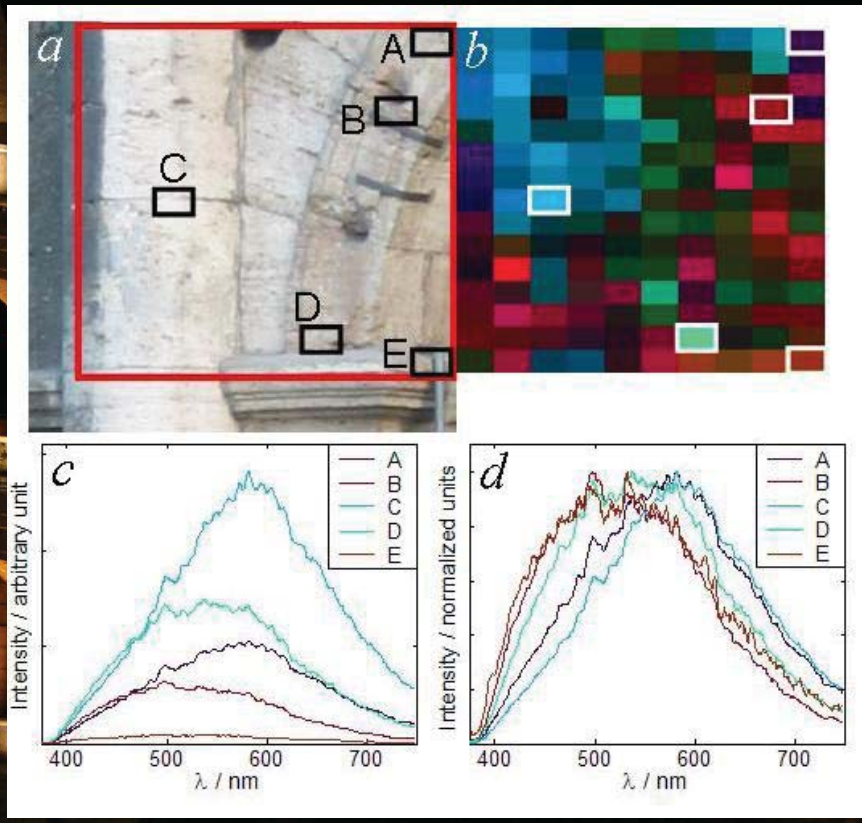
Gas correlation spectrometer based on UV LED
Luo et al. Harbin – Lund Collaboration. Appl. Phys. B

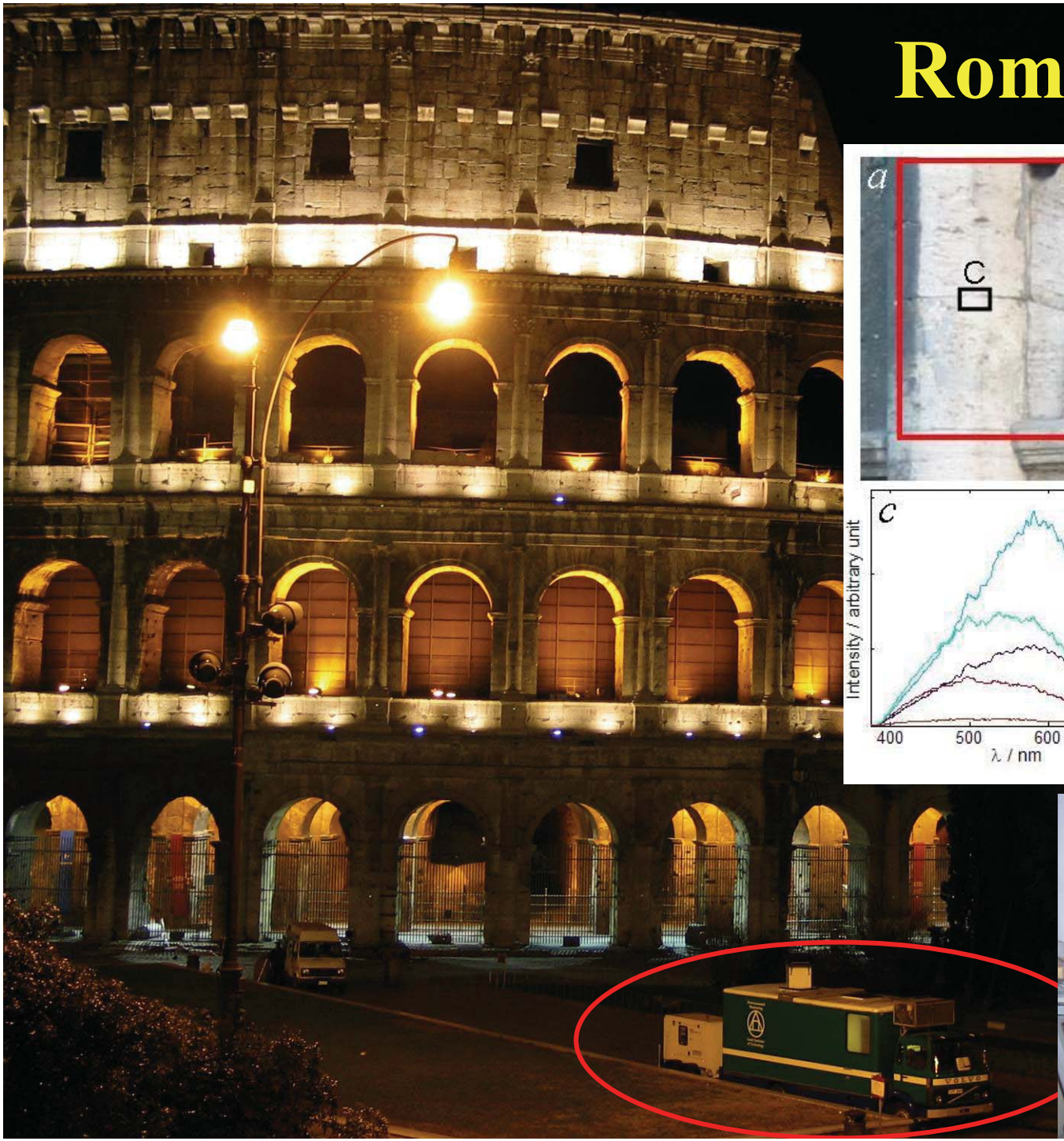


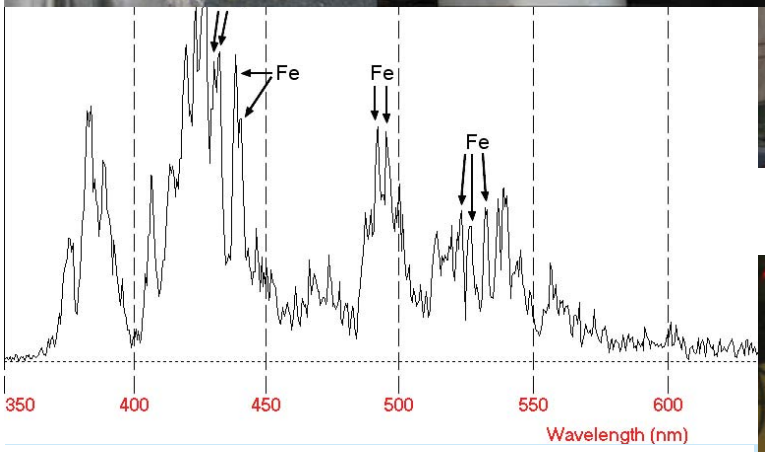
LIDAR REMOTE FLUORESCENCE MONITORING

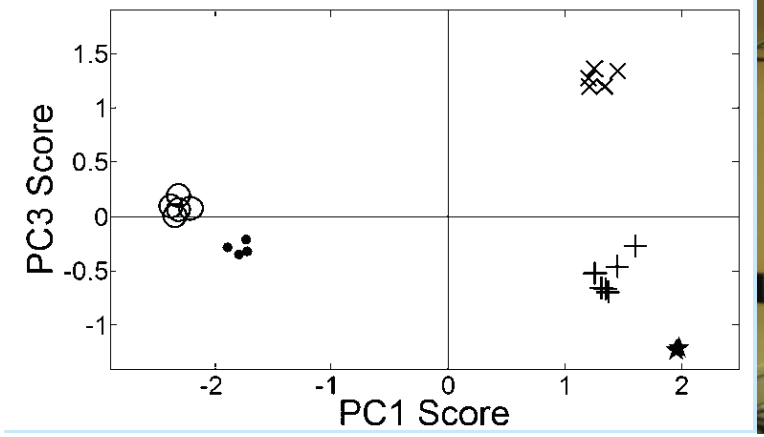


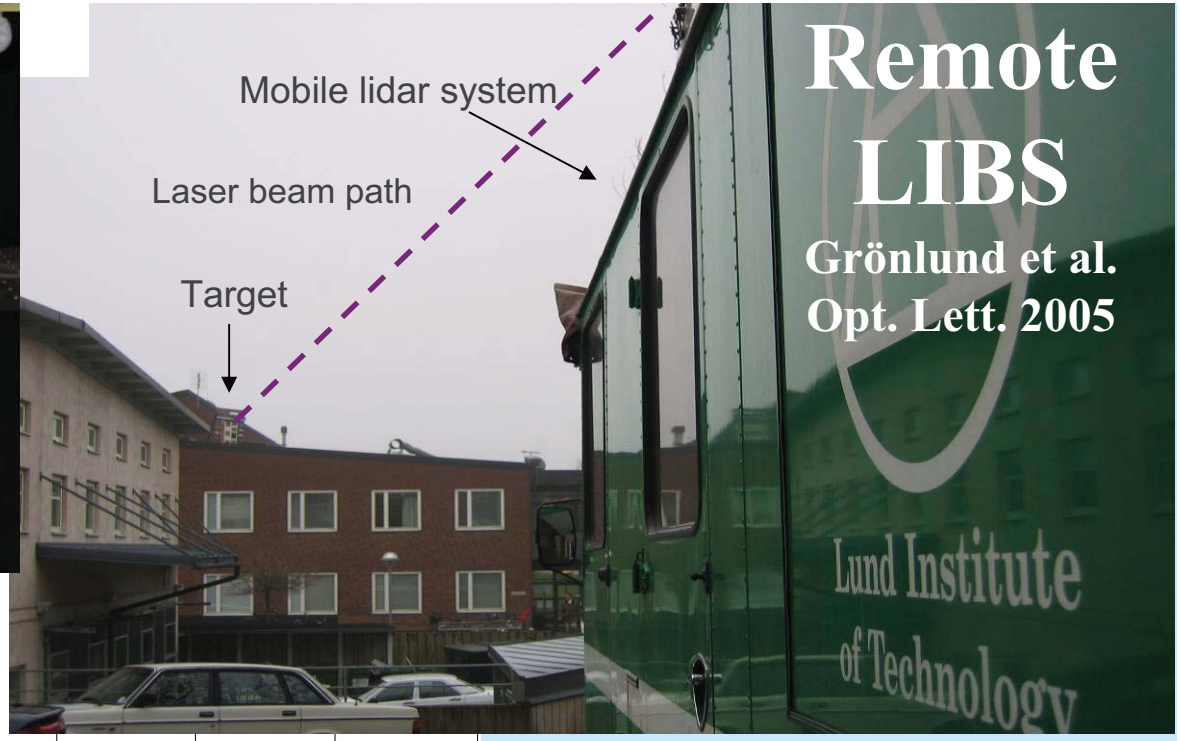
Rome Coliseum





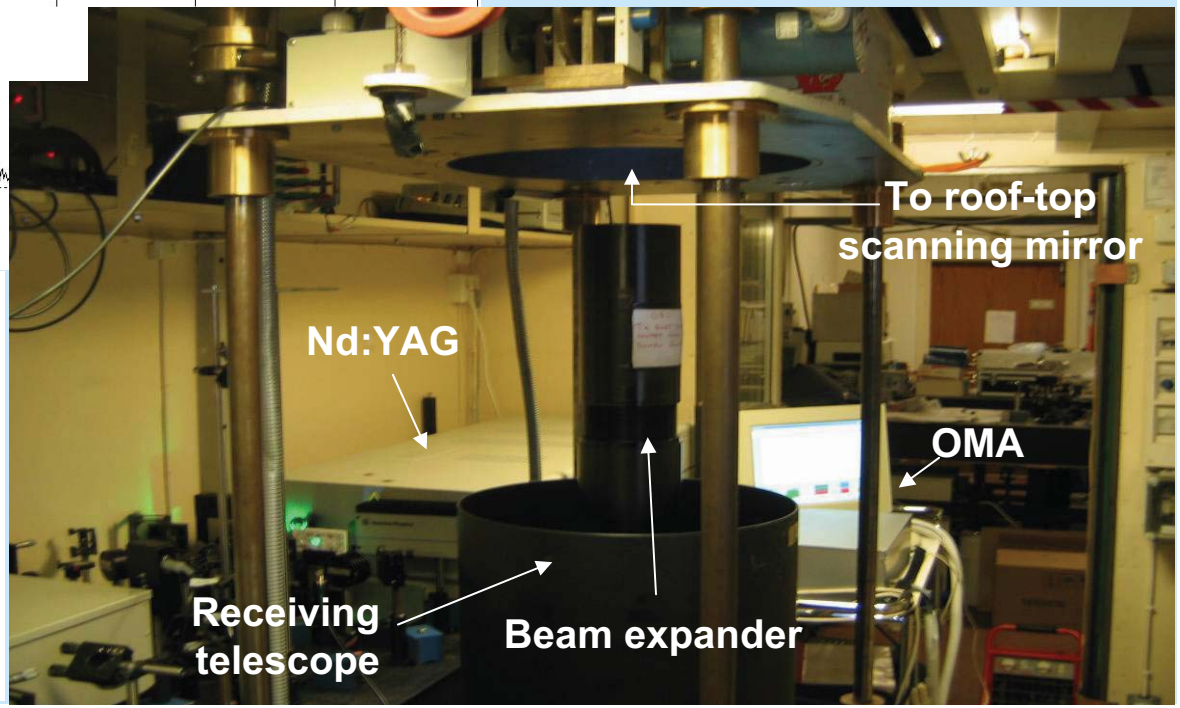






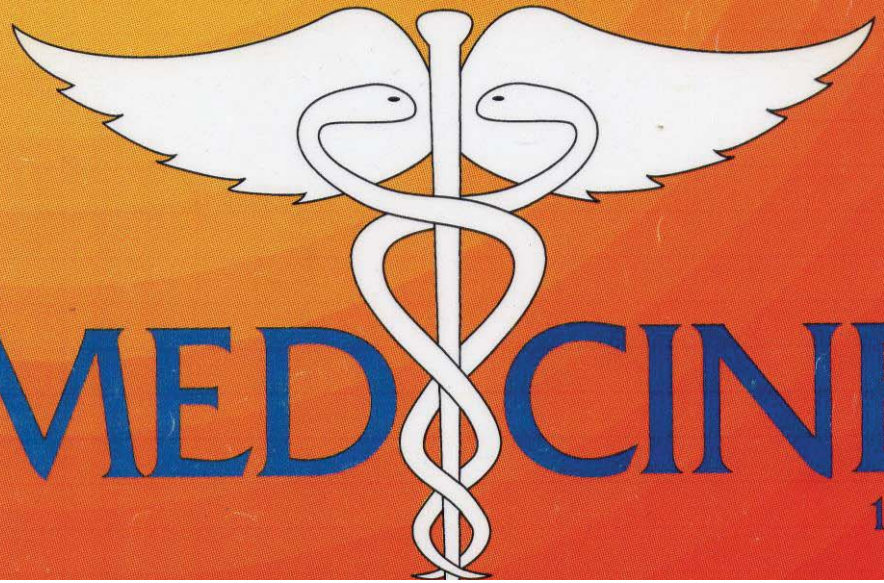
Remote LIBS

Grönlund et al.
Opt. Lett. 2005

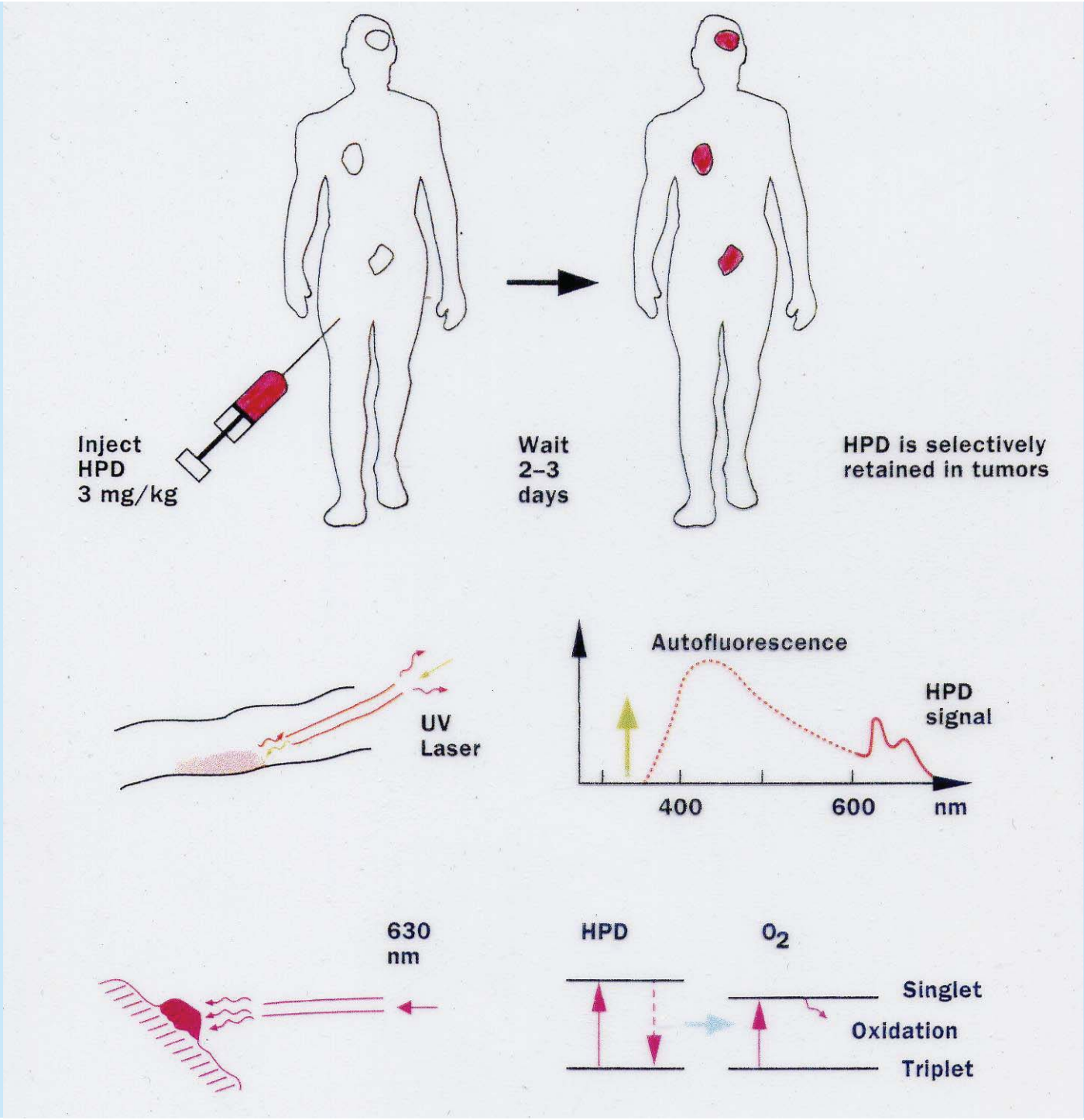


Analytical CHEMISTRY

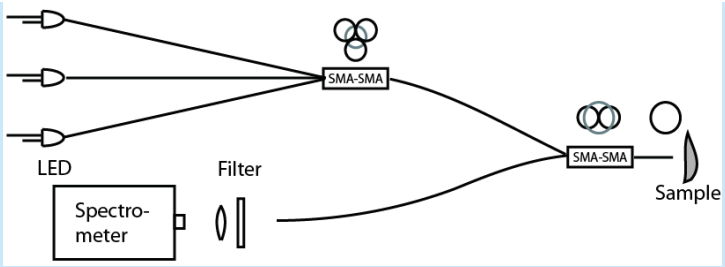
LASERS in MEDICINE



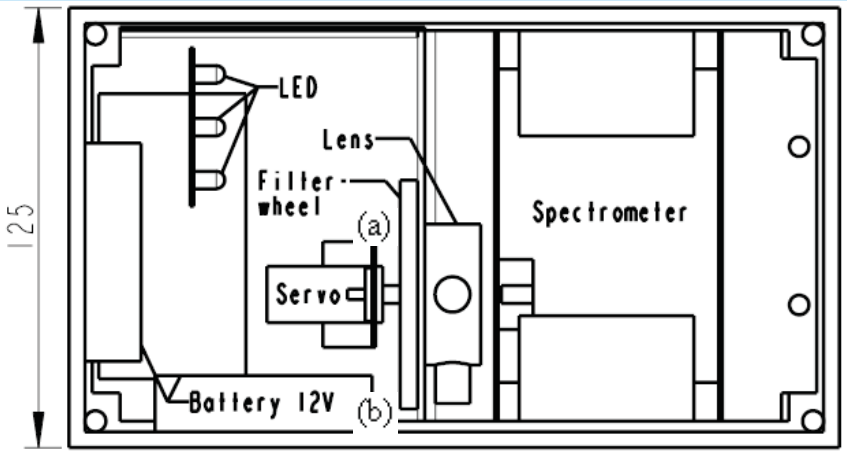
19A

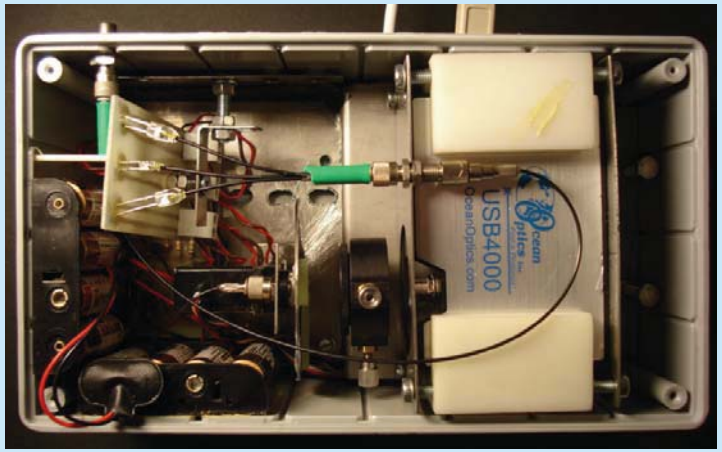

Inject
HPD
3 mg/kg
Wait
2–3
days
HPD is selectively
retained in tumors
UV
Laser
Autofluorescence
HPD
signal
400
600
nm
630
nm
HPD
O_2
Singlet
Oxidation
Triplet

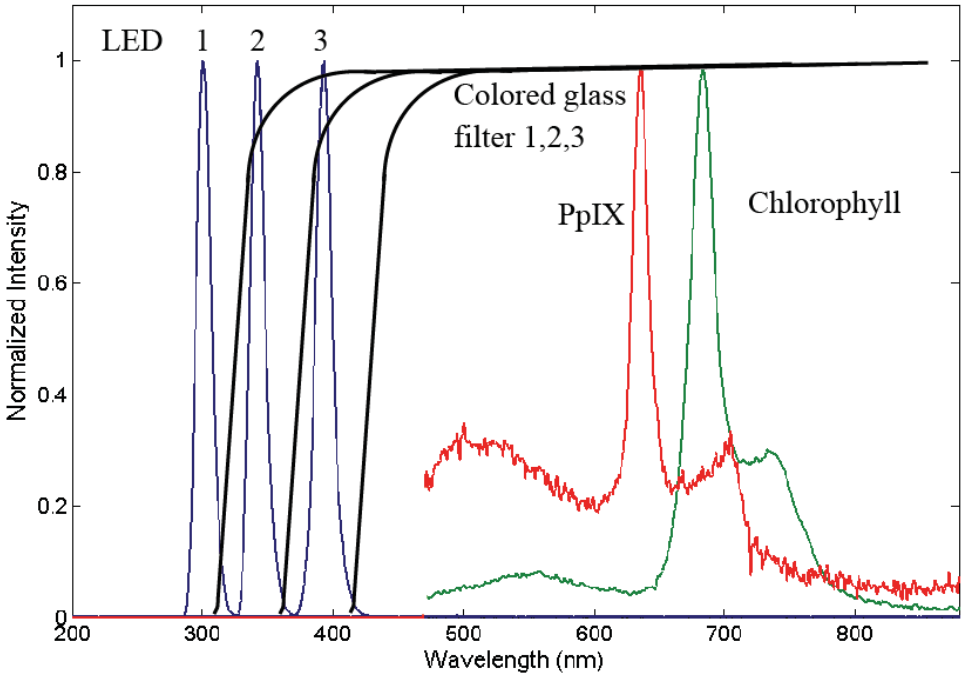
Compact UV LED Based Fluorosensor

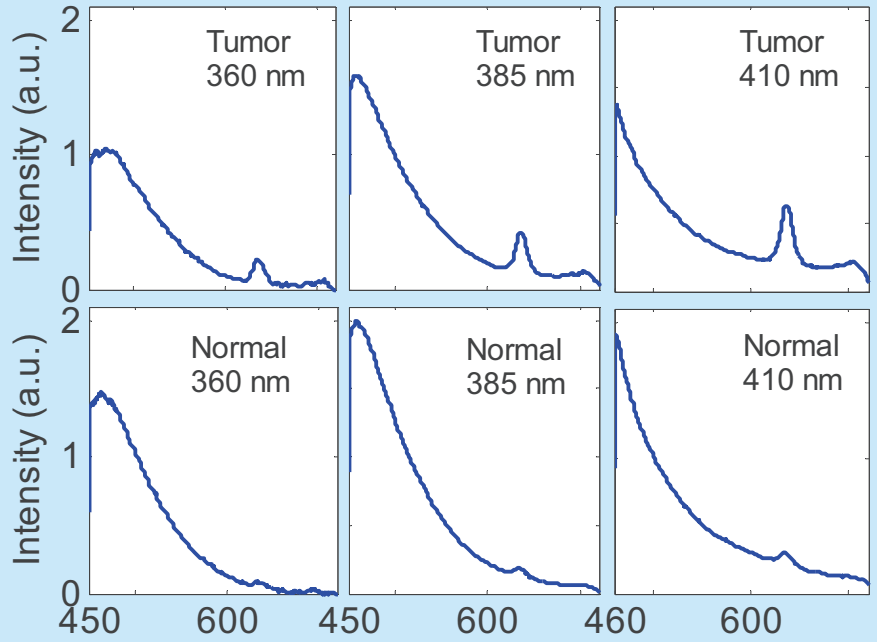


S. Ek et al.
Spectrochim Acta A
2007

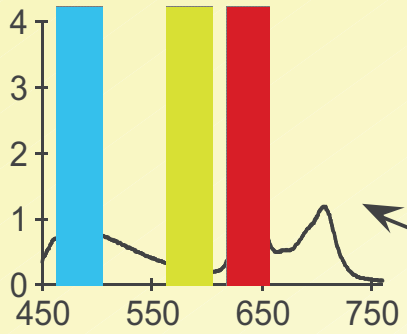


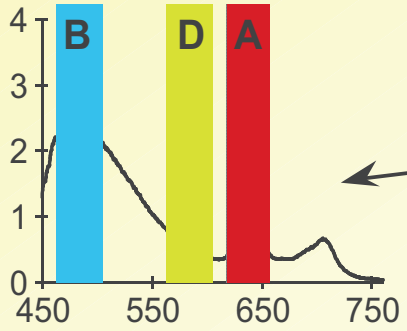


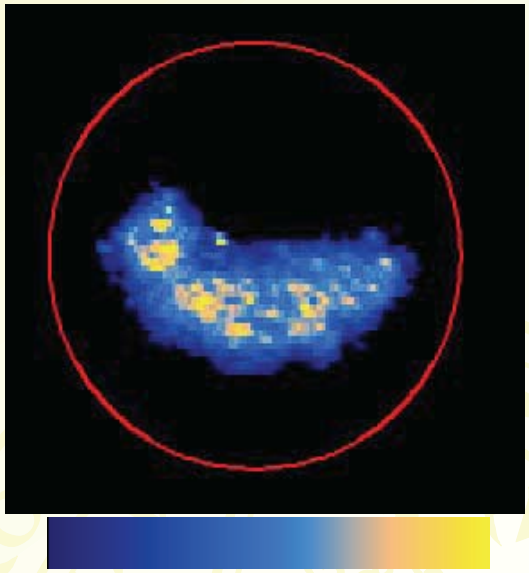




Multicolour Fluorescence Imaging





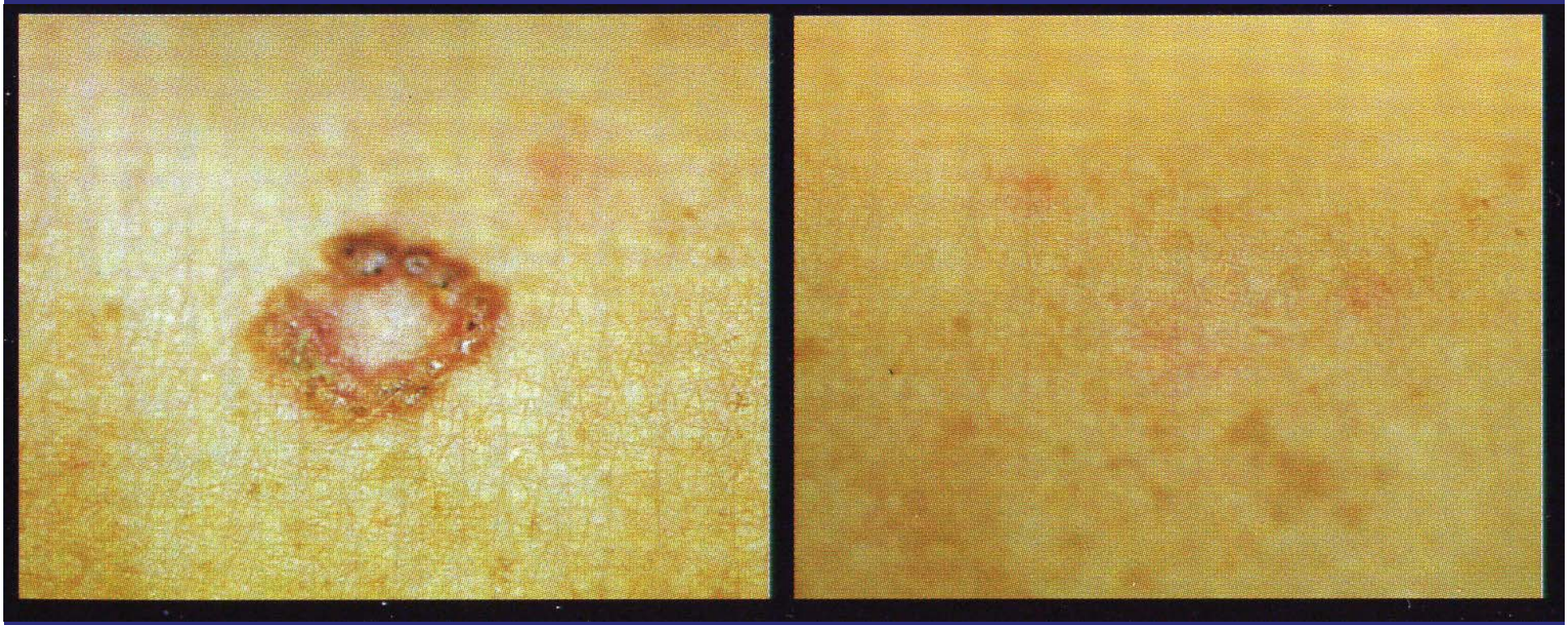


$$F_c = \frac{A - k_1 D}{k_2 B}$$

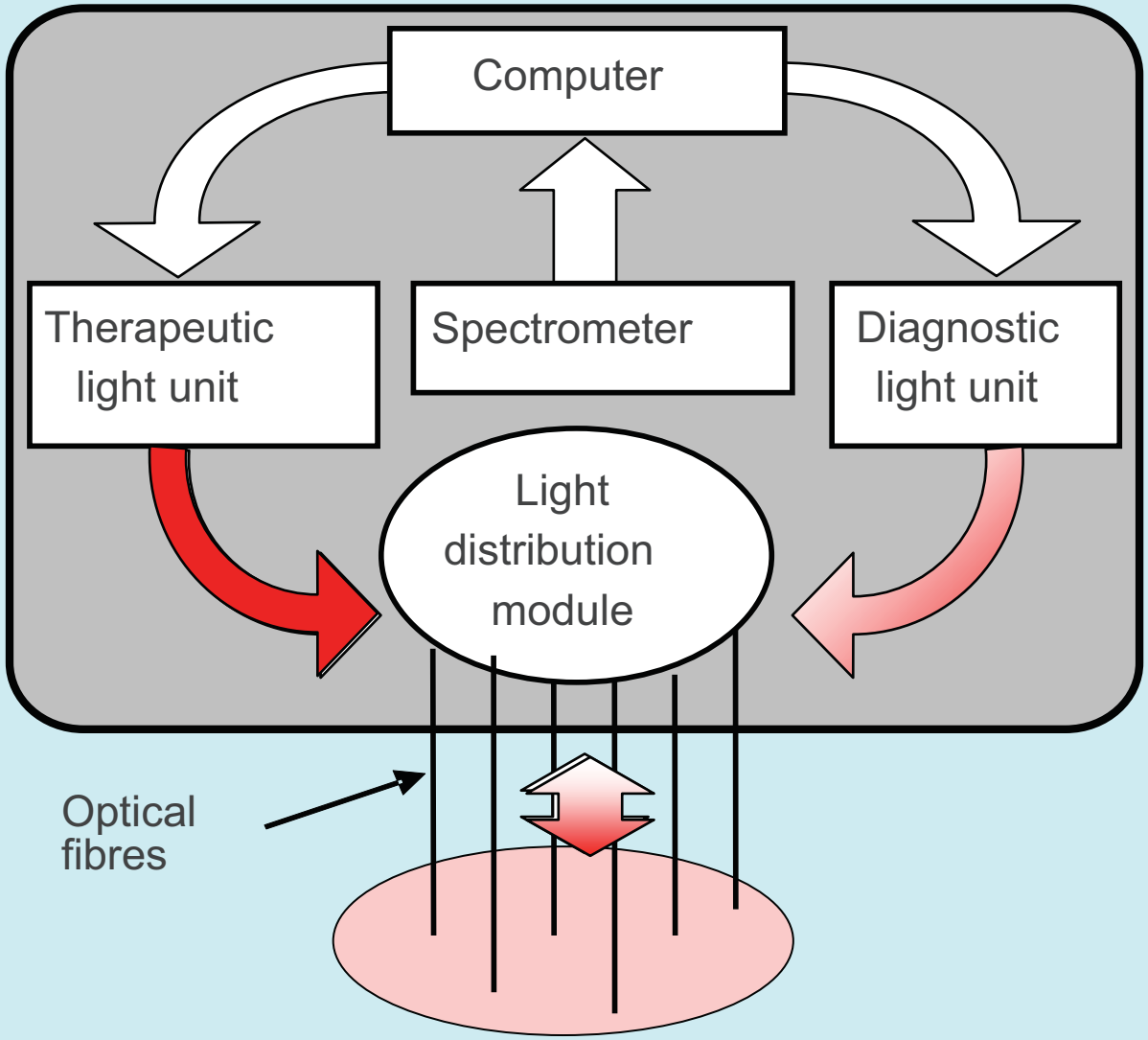
$$\frac{\text{Red} - \text{Yellow}}{\text{Blue}}^{12}_{5}$$

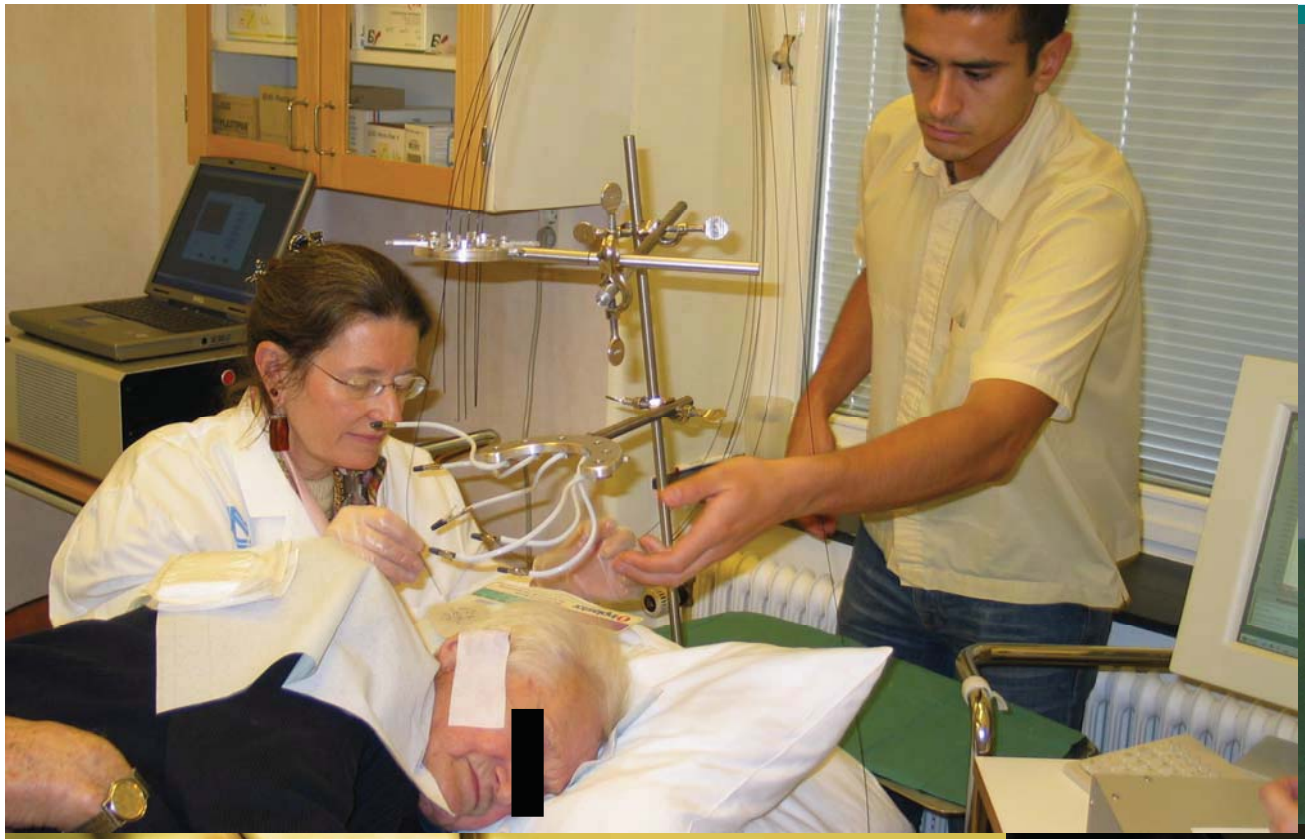
Andersson-Engels *et al.* LSM (2000)

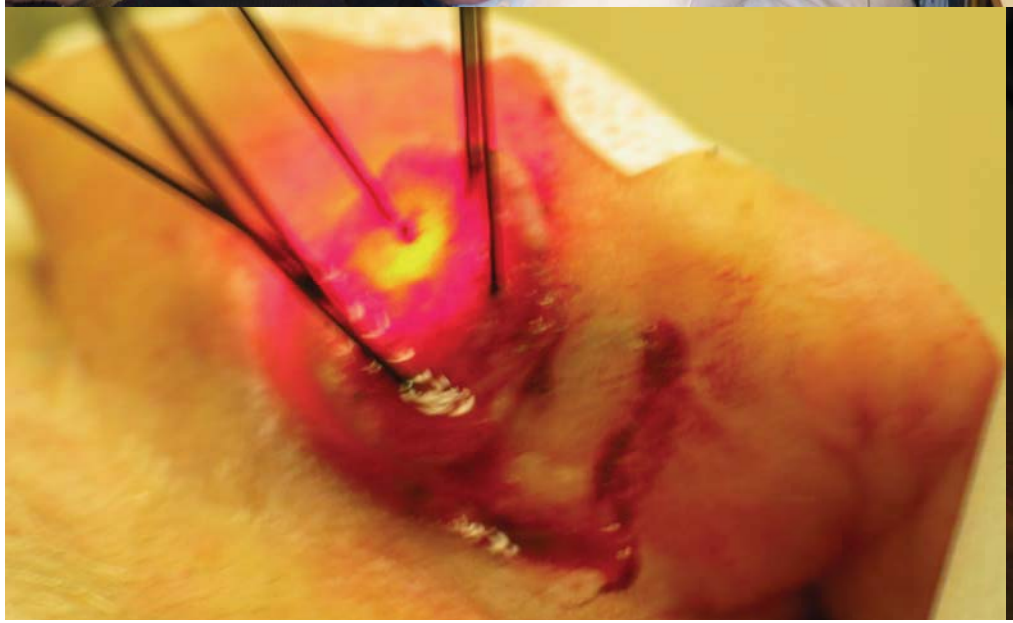
ALA PDT Treatment of Basal Cell Carcinoma

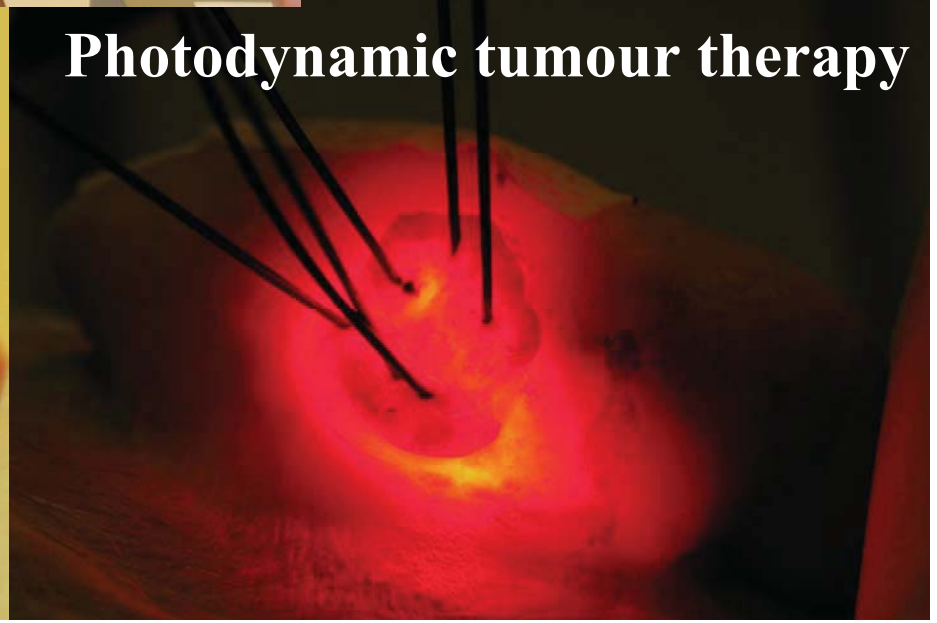


Challange: Deep-lying tumours
Fiber-based interstitial system





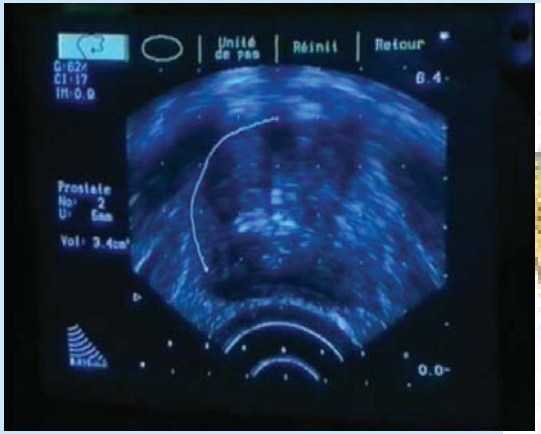


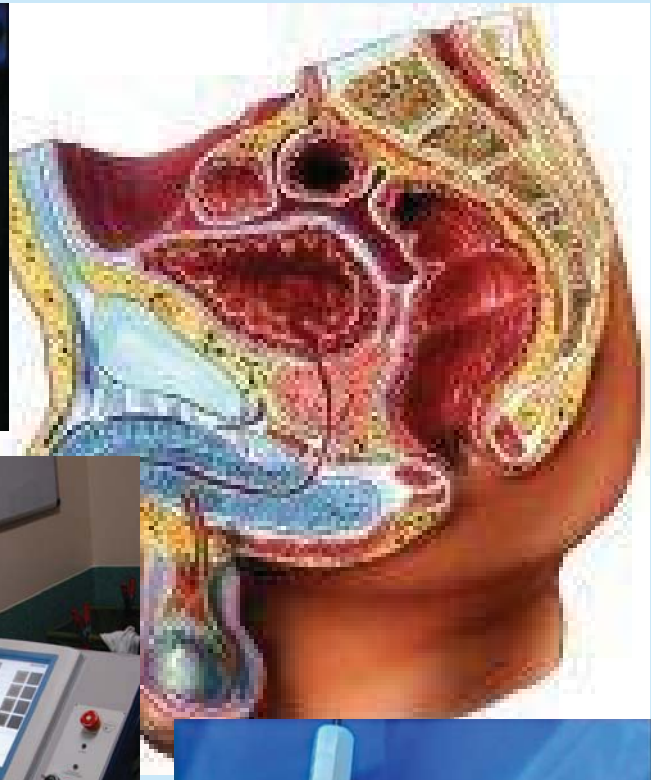


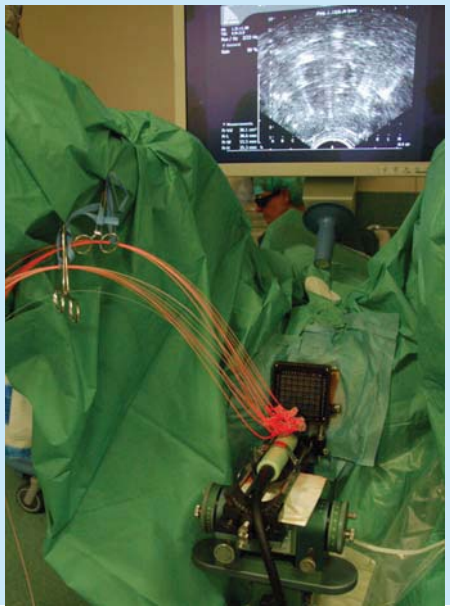
Photodynamic tumour therapy

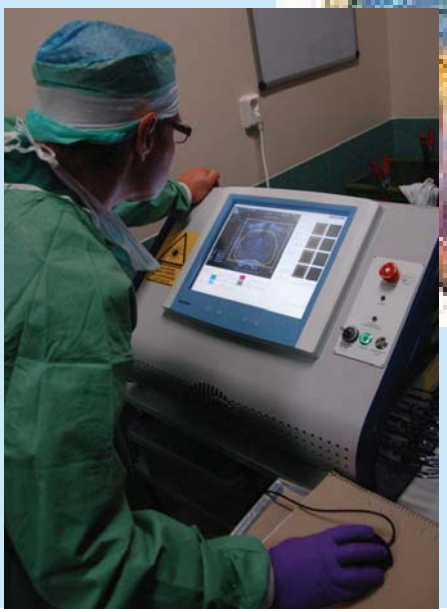
Example of clinical applications - prostate cancer

Lund collaboration with SpectraCure AB, Karolinska Hospital and Malmö University Hospital

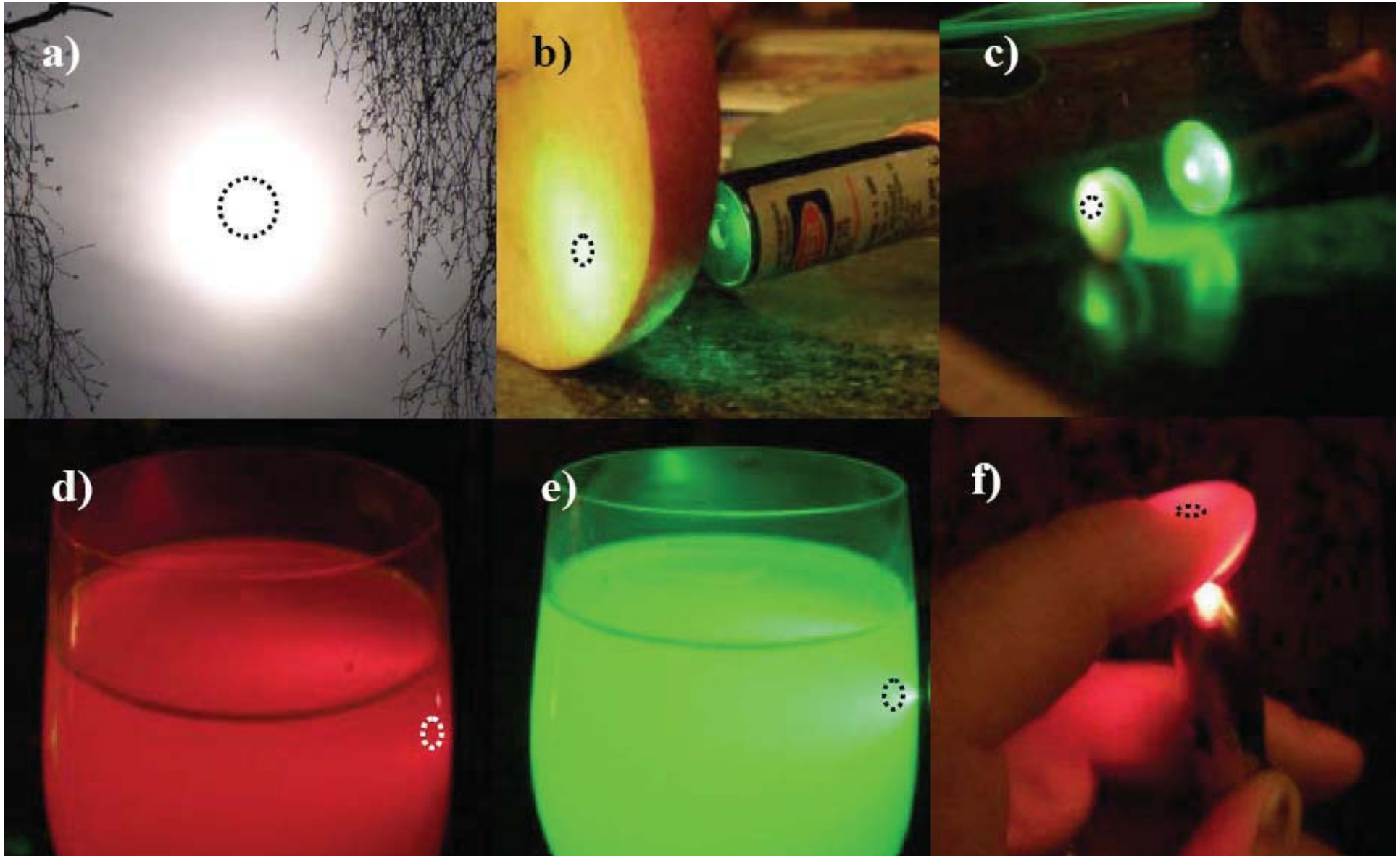


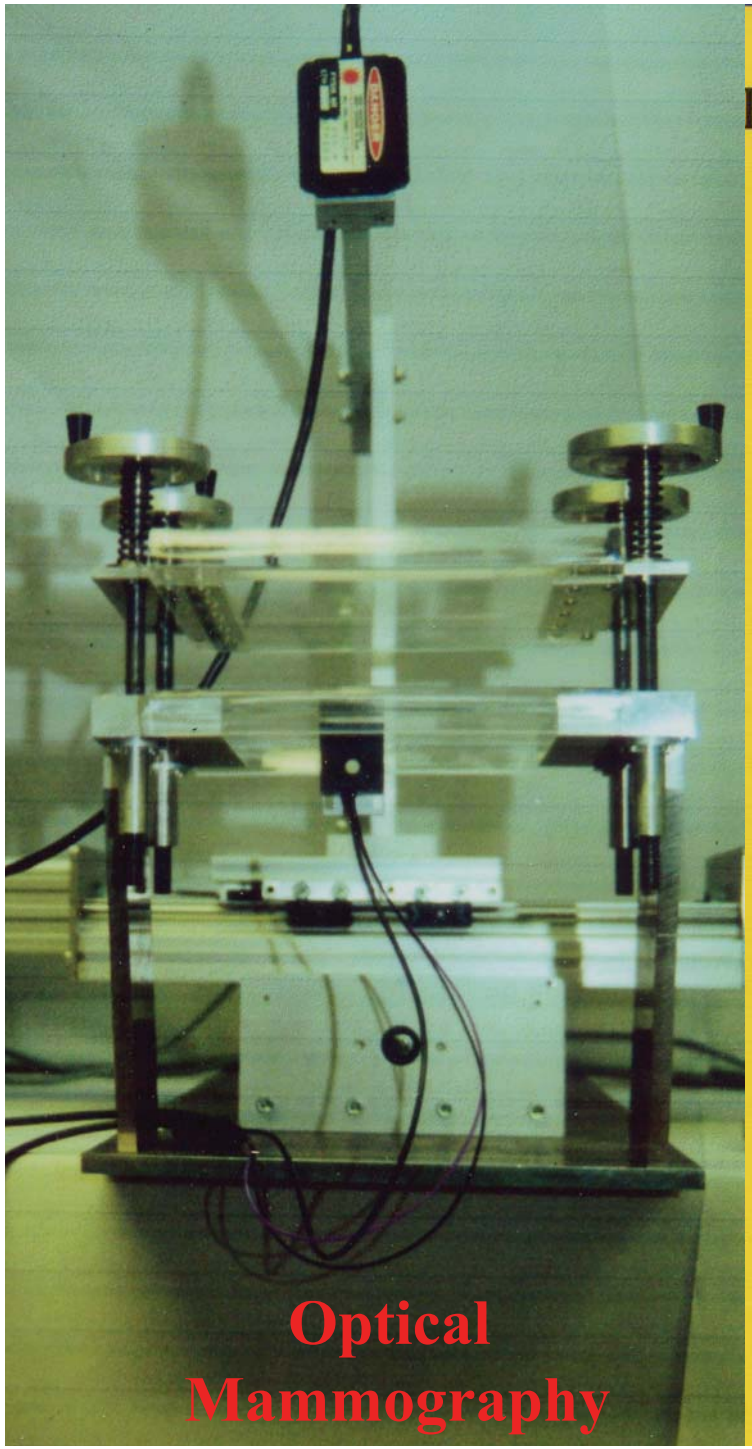






Light propagation in scattering media

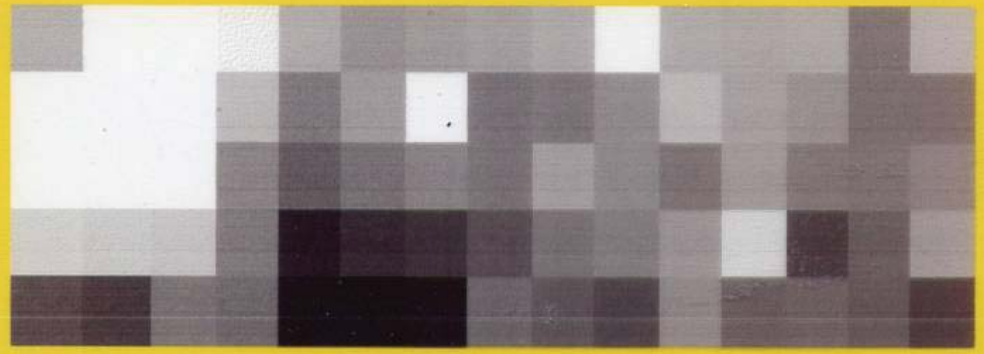




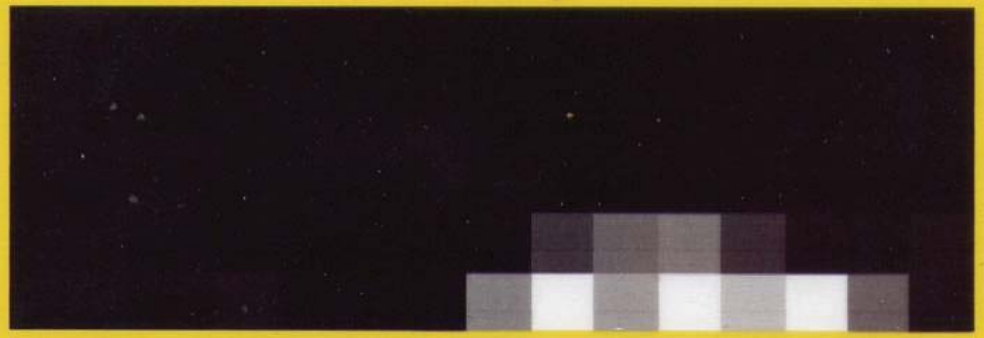
Picosecond Diode Laser Transillumination

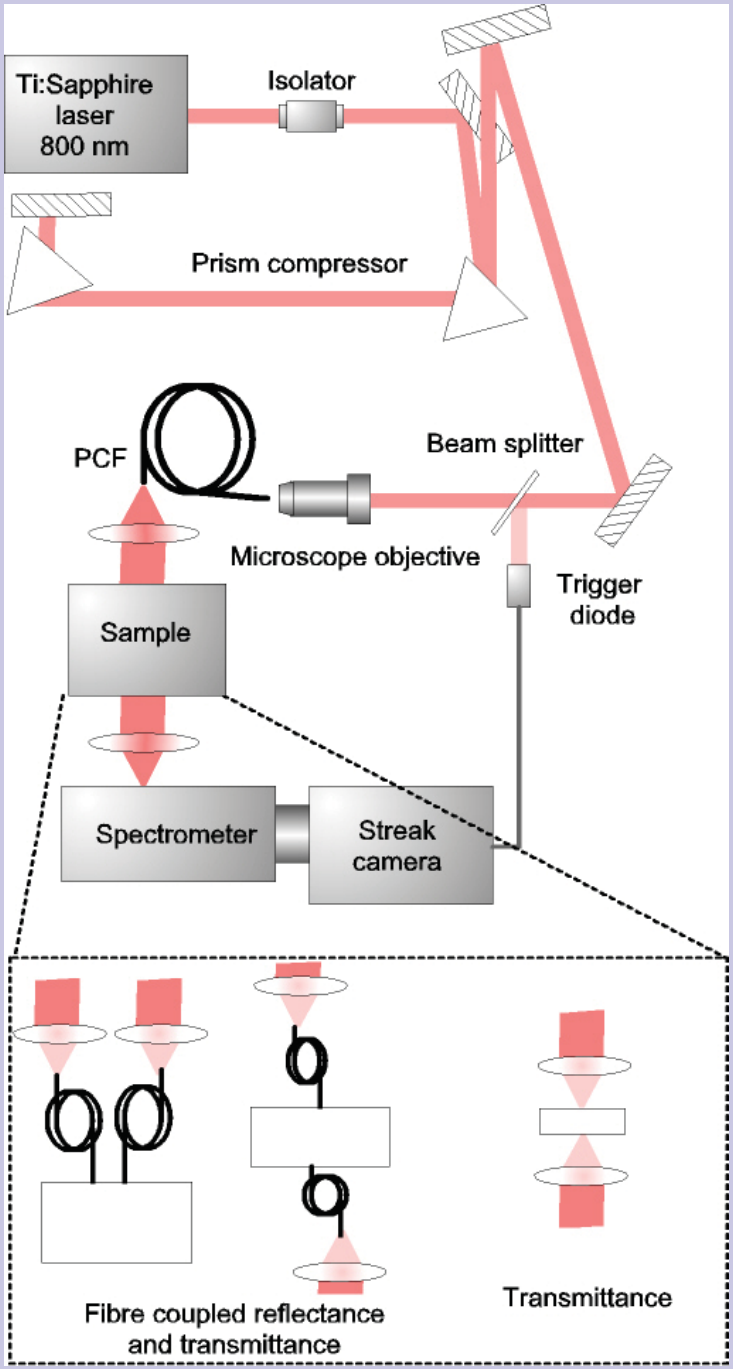
Image of ductal cancer in female breast

Total



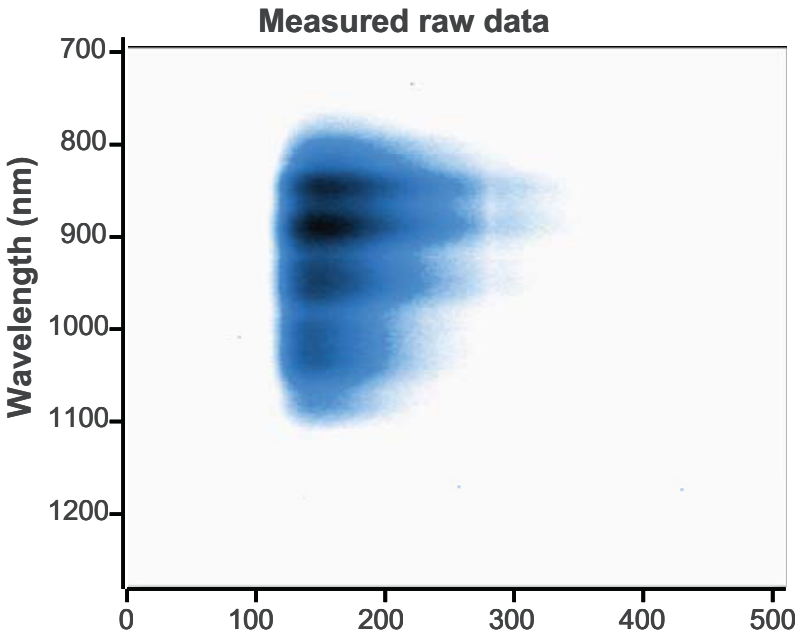
Early

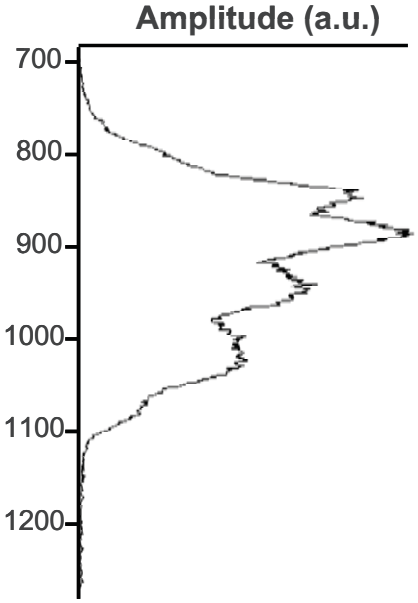


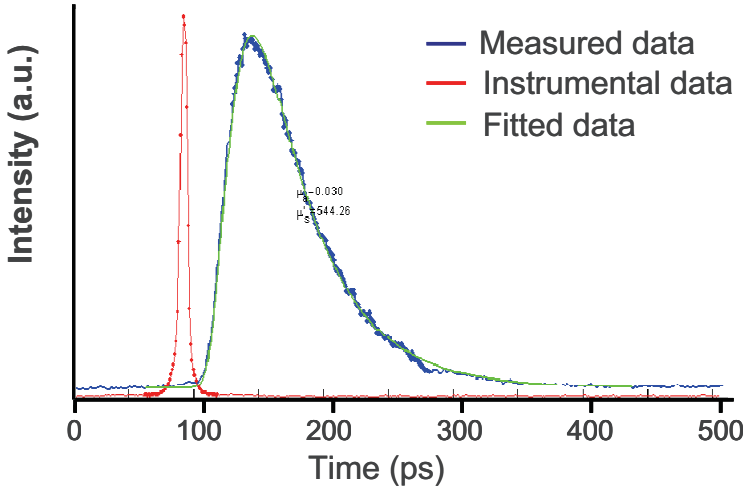


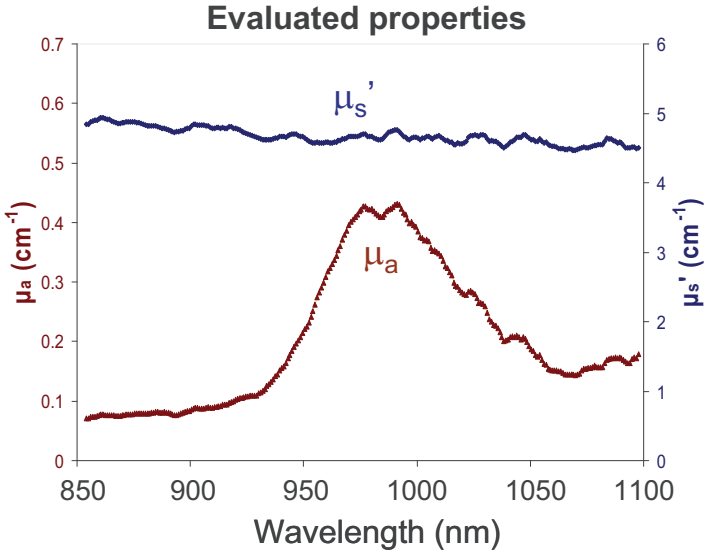
White light time-resolved transillumination for analysis of constitutents in scattering media

Applications:
Human tissue
Fruits
Pharmaceuticals





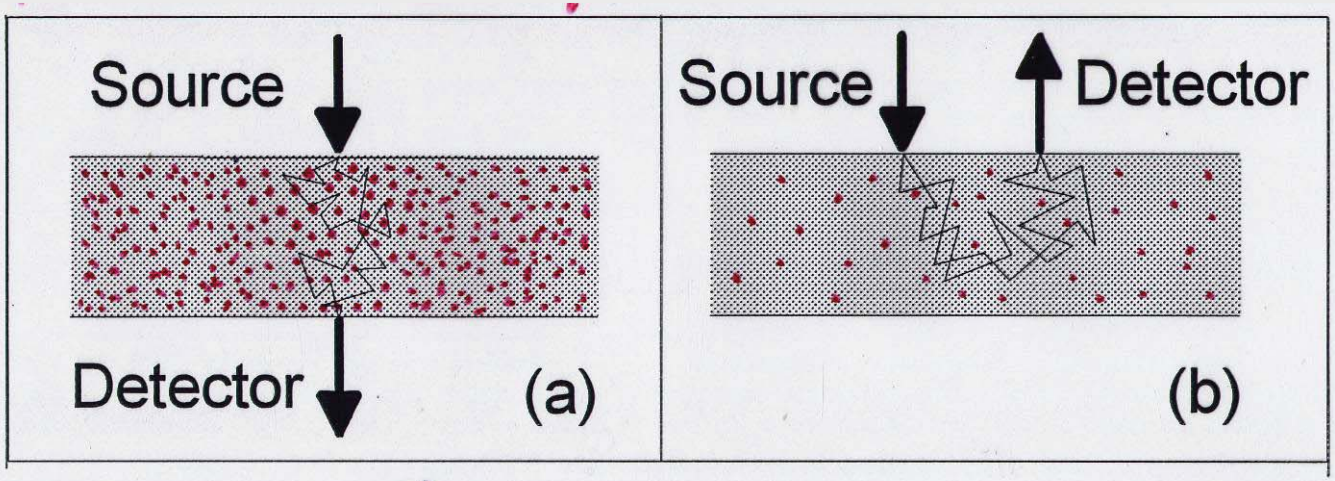


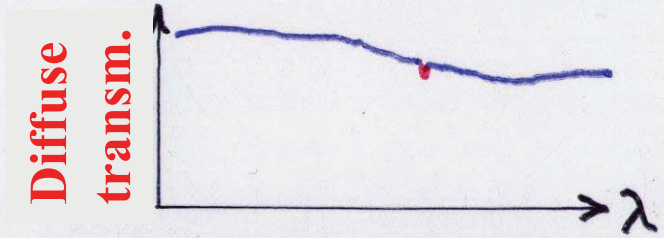


Abrahamsson et al.

Gas in Scattering Media Absorption Spectroscopy
GASMAS

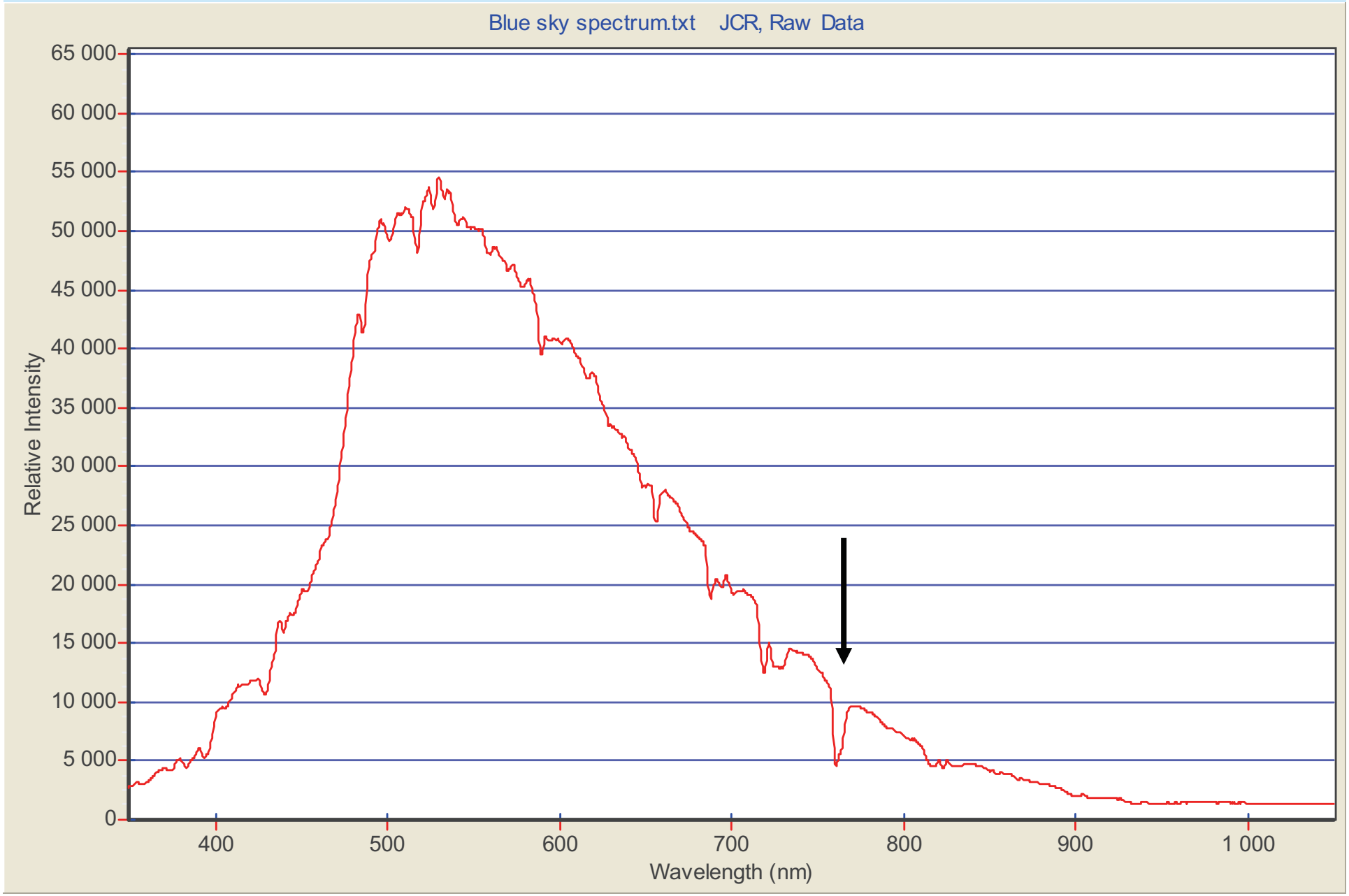
Signature of free gas in a solid/liquid:
Extremely sharp line on a broad background
Retrievable by WM or FM diode laser spectroscopy
TDLS ↔ DIAL ↔ Opt. Mammography



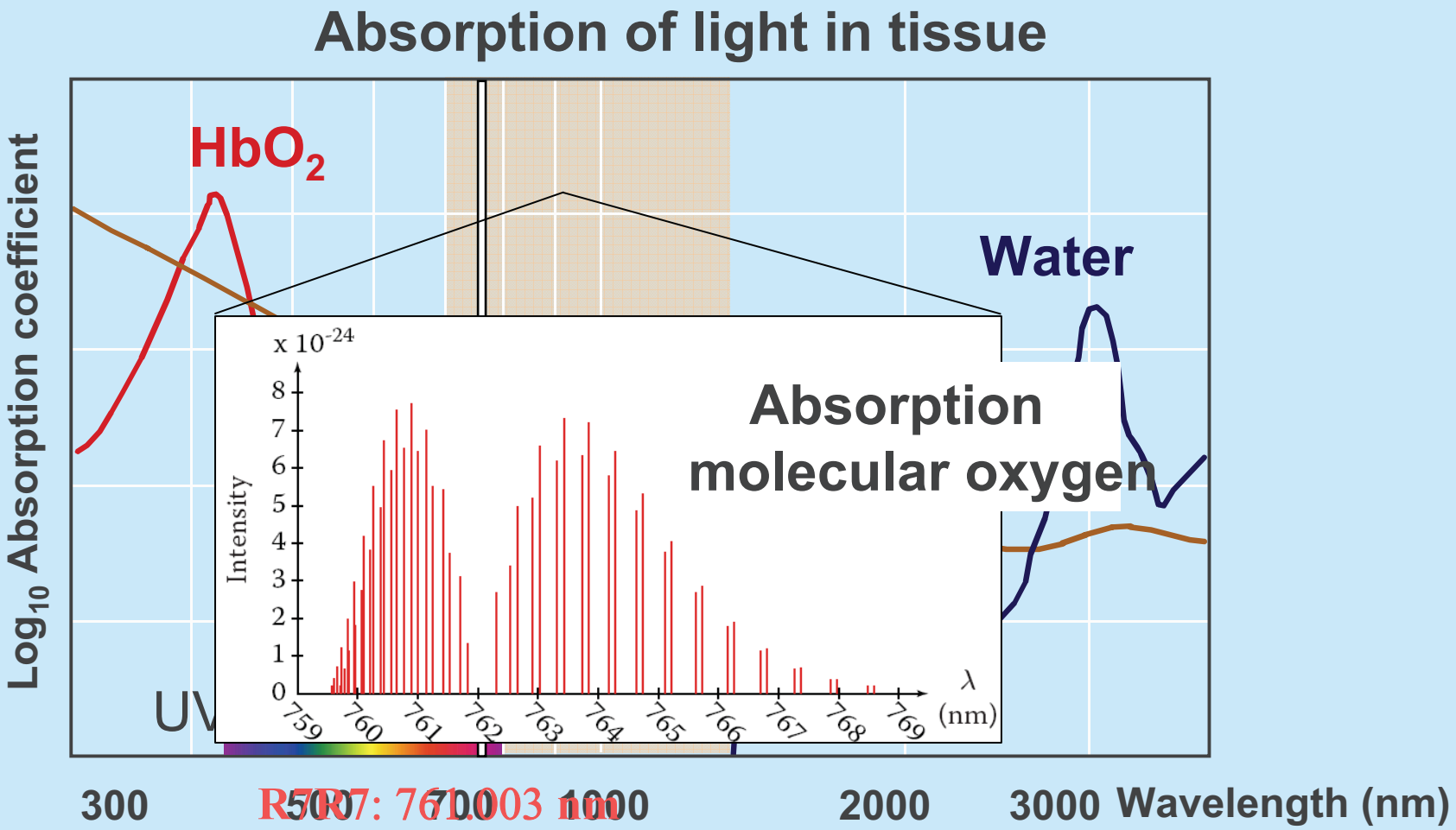


Line width
0.01-0.001 nm

Blue sky spectrum with Fraunhofer lines, including Oxygen A

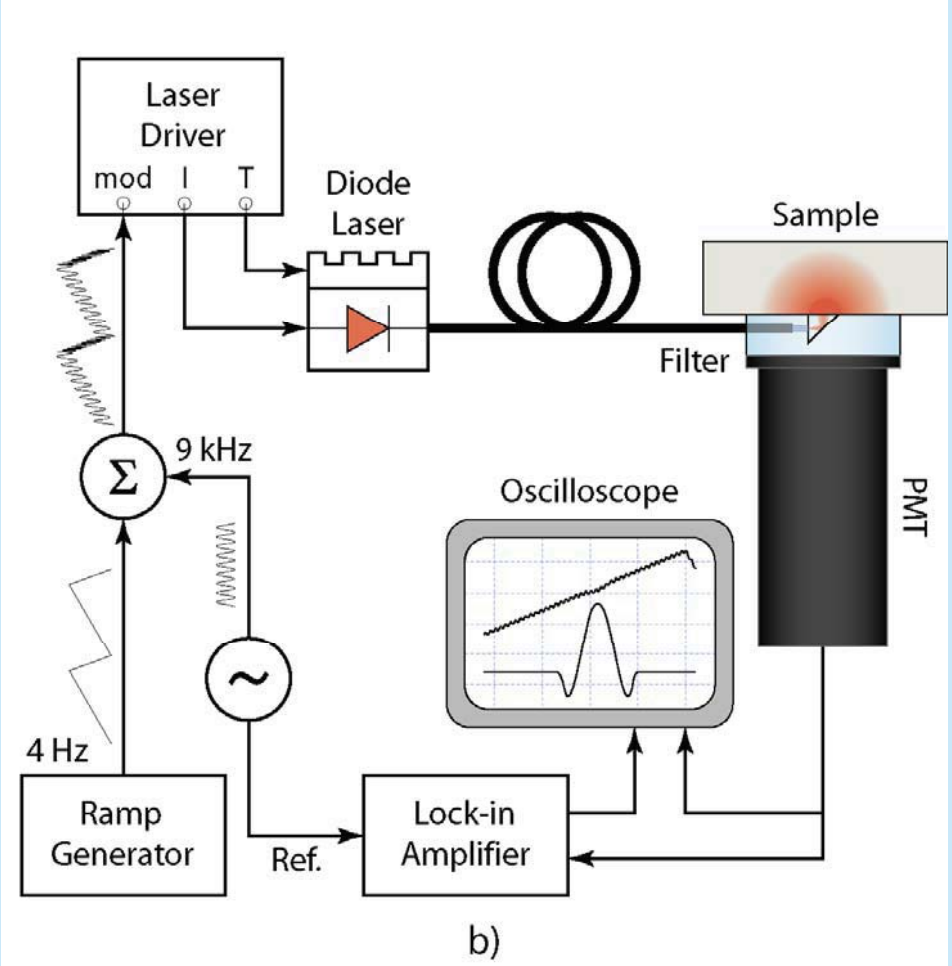


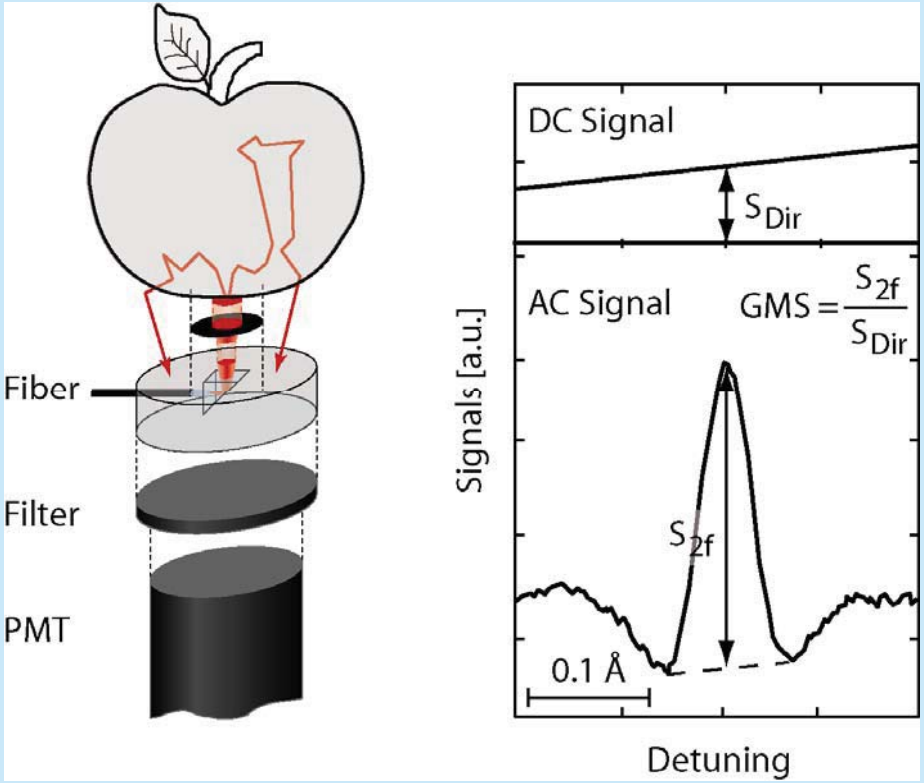
Tissue Absorption



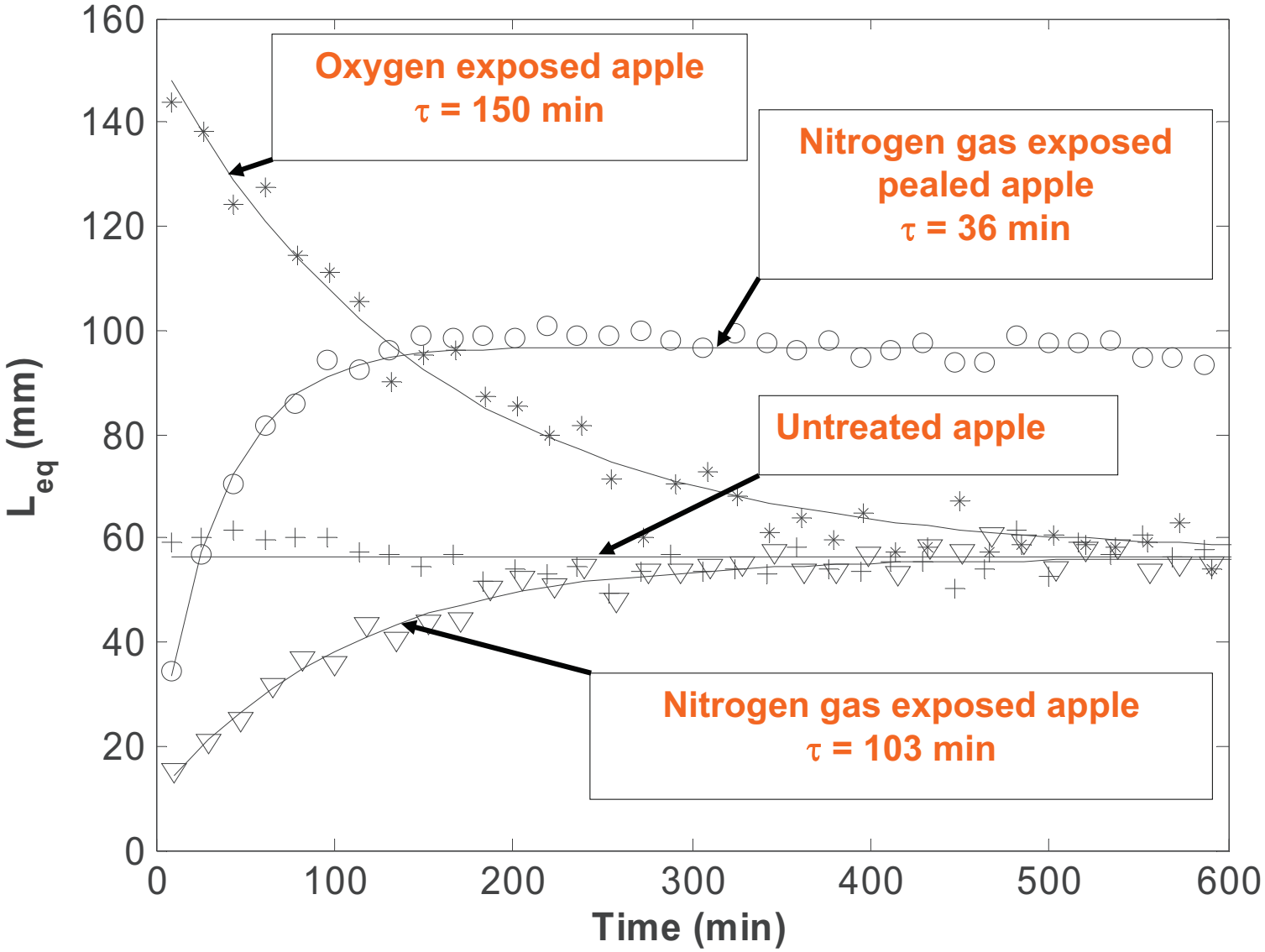
R7R7: 761.003 nm

GASMAS set-up and oxygen signal

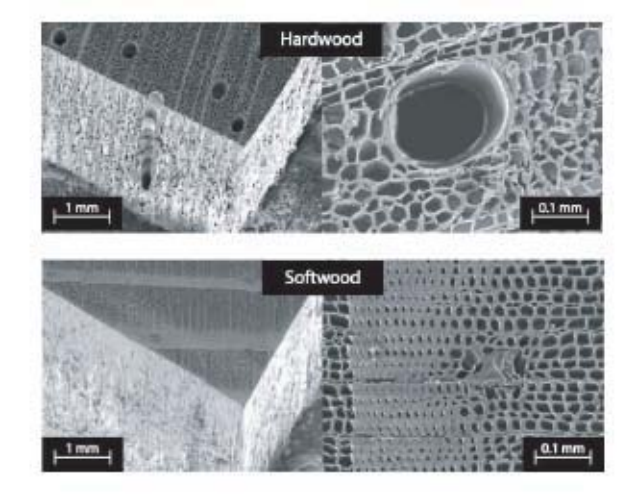


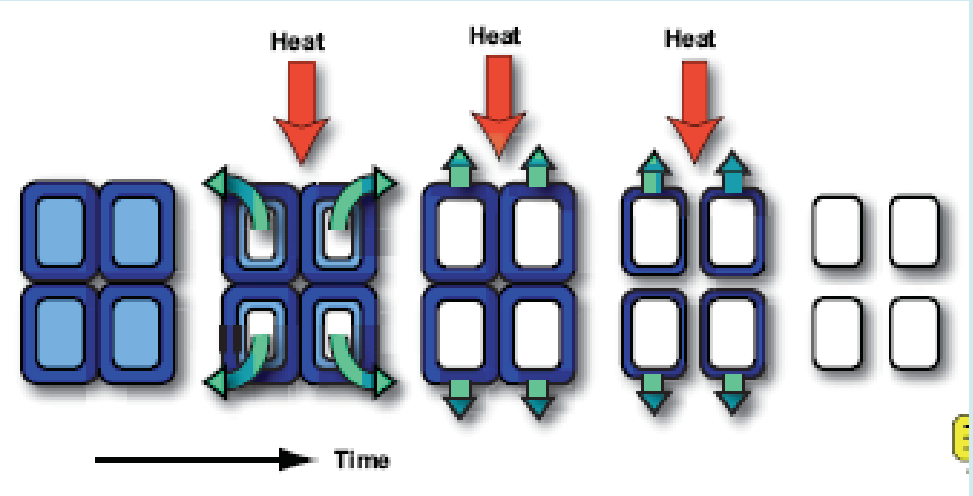


Gas transport in materials (apples)

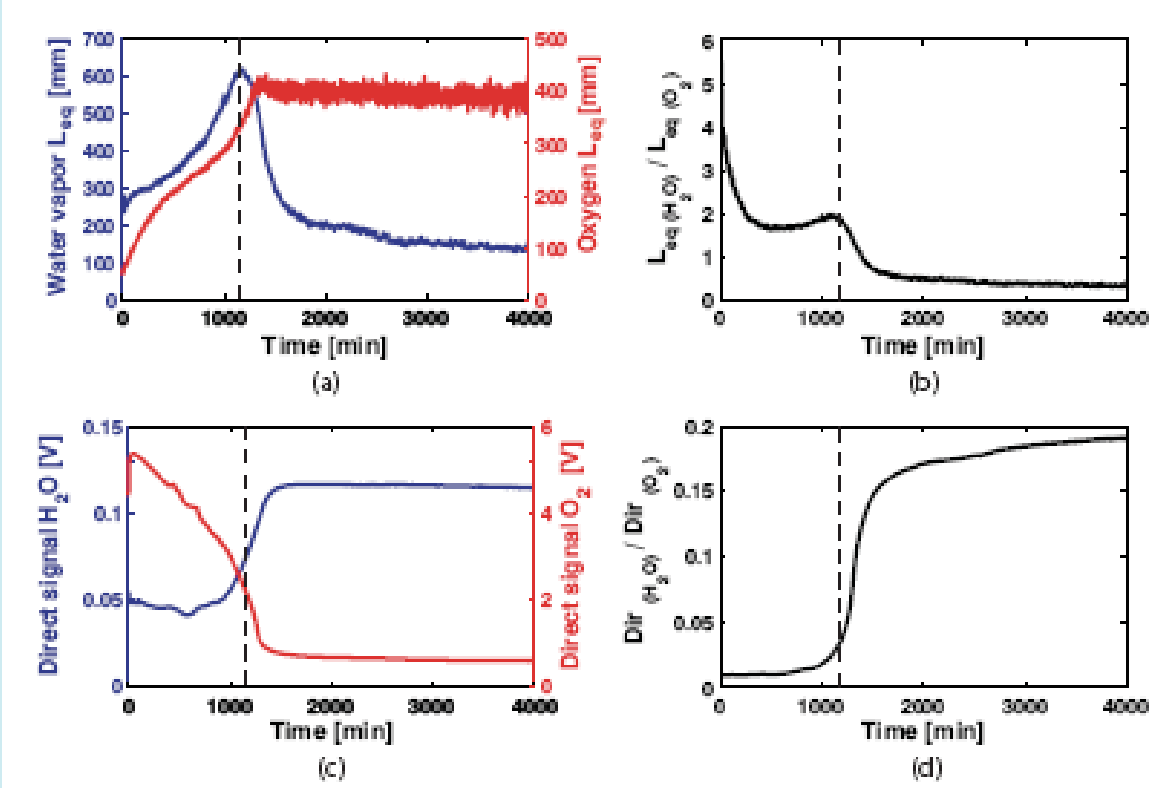


Drying of wood



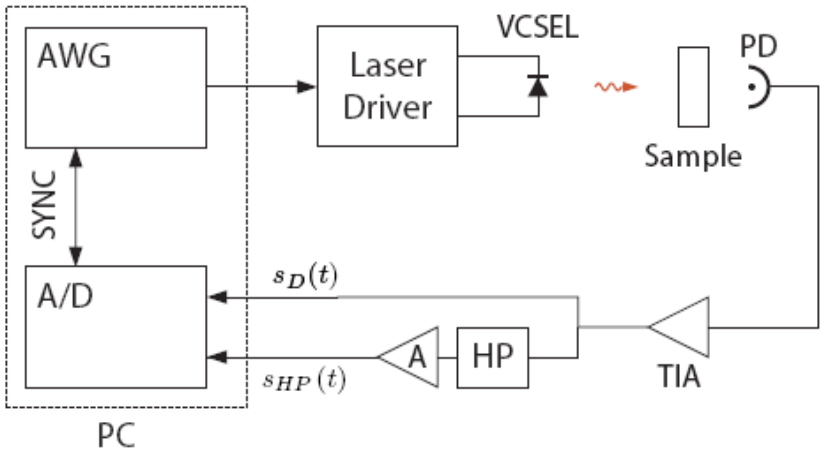


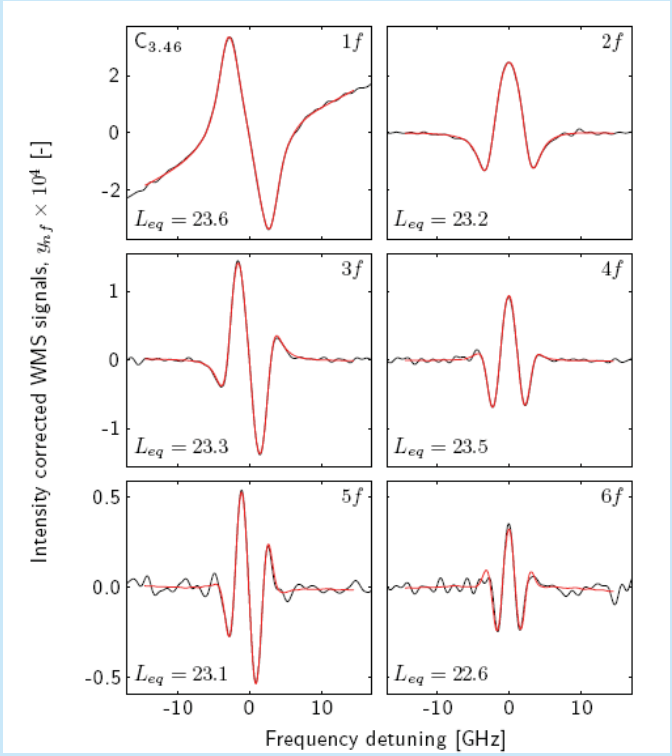
Oxygen
Water



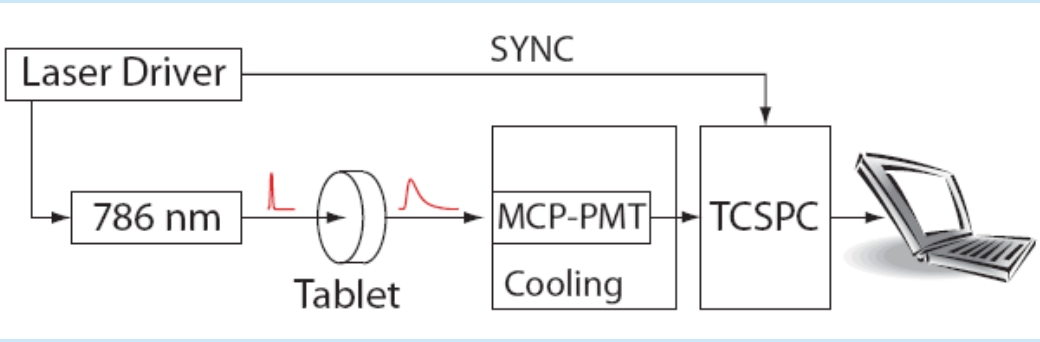
Farmaceutical tablets

Frequency domain

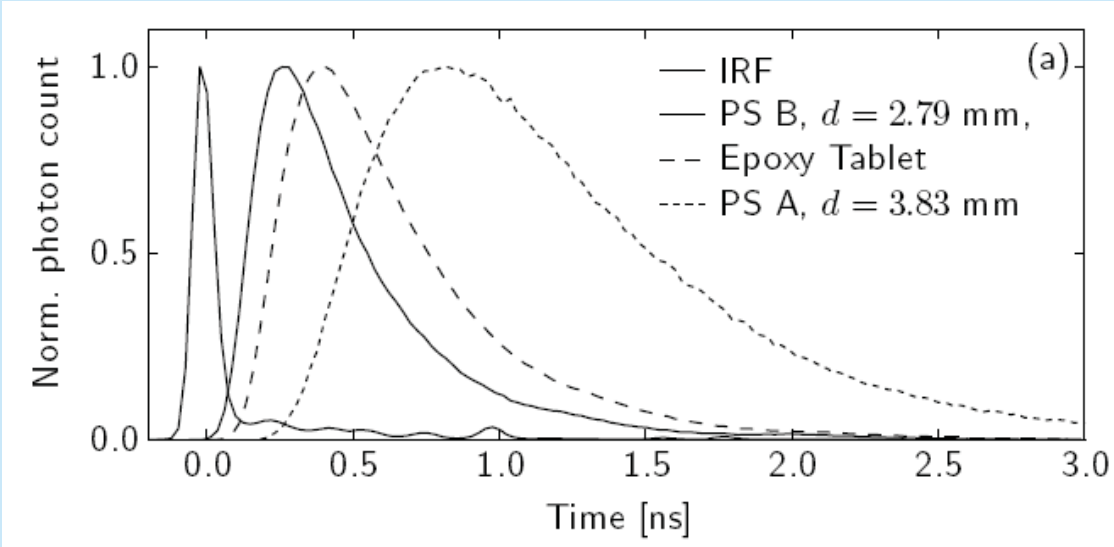




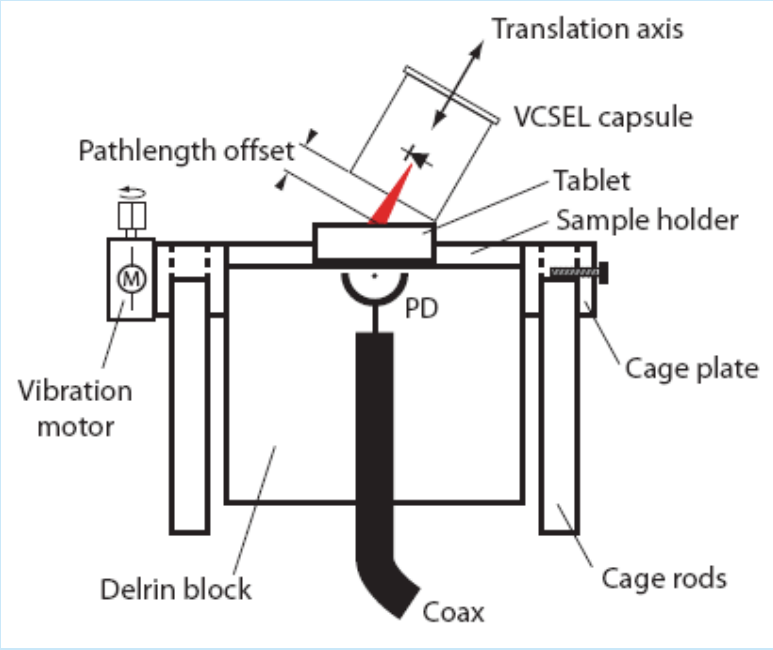
Time domain

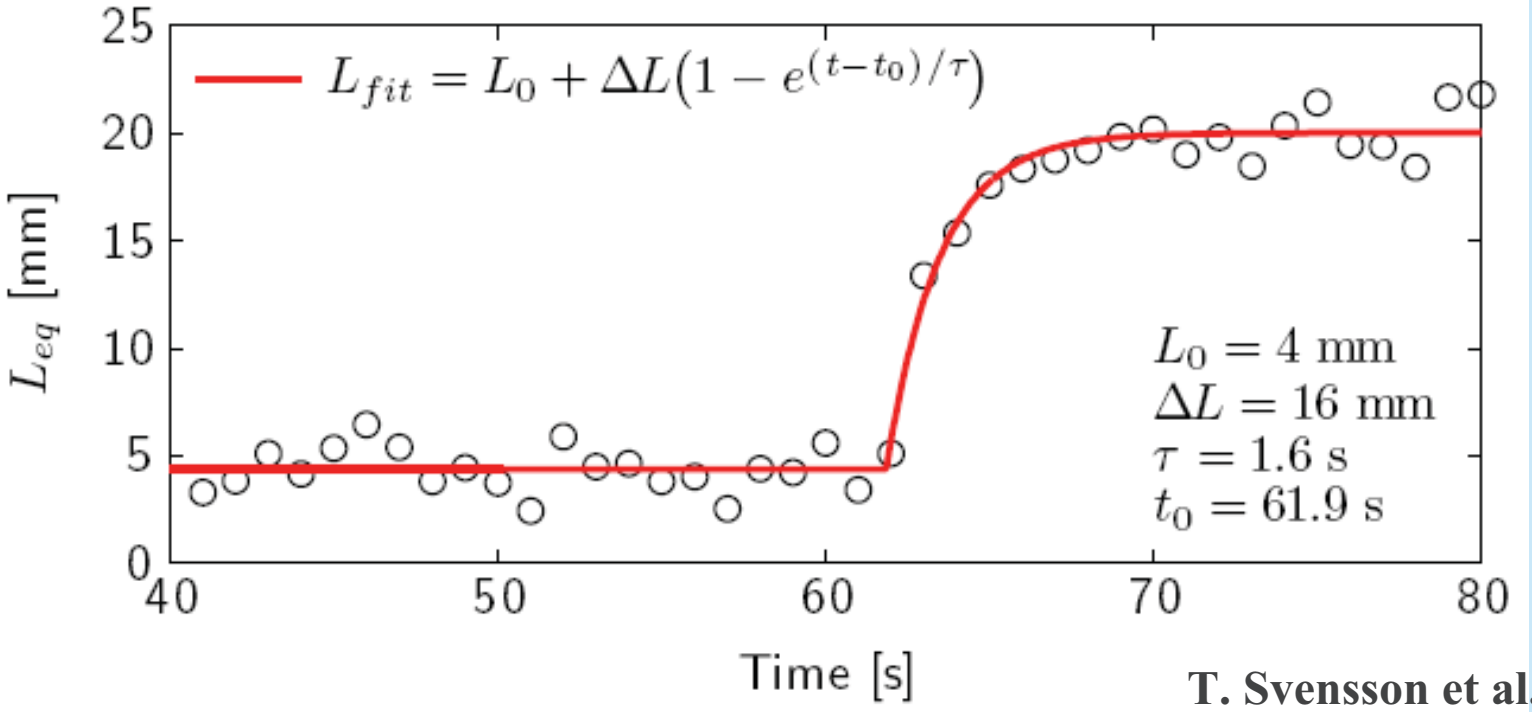


T. Svensson et al. 2007



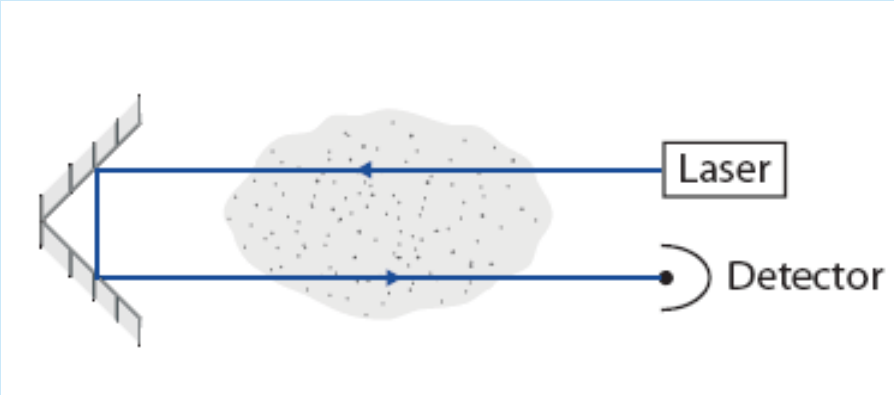
Measurements on farmaceutical Tablets (with AstraZeneca)



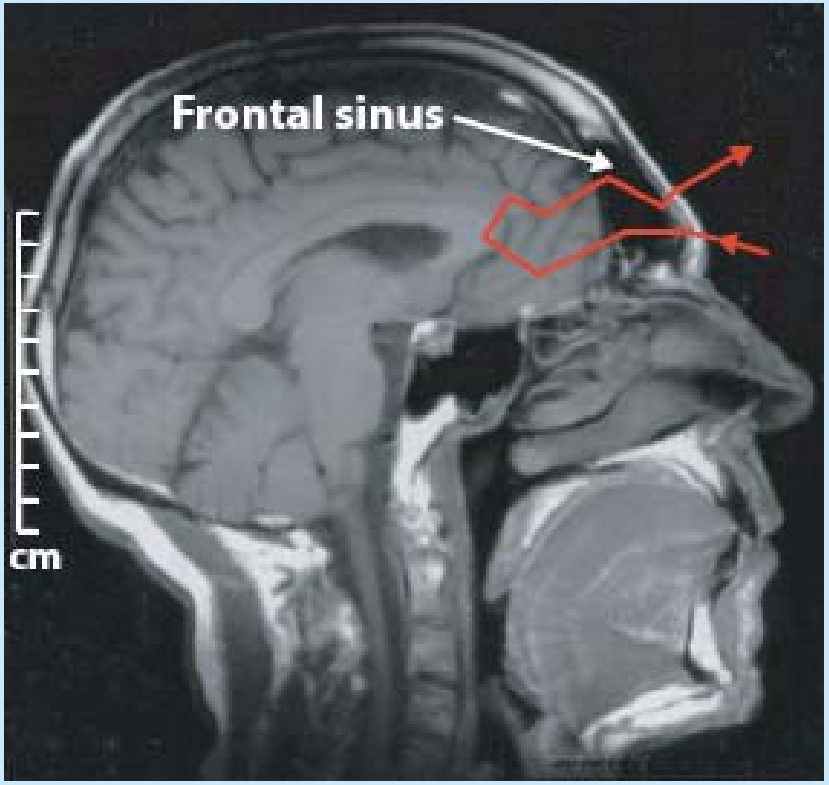


T. Svensson et al. 2007

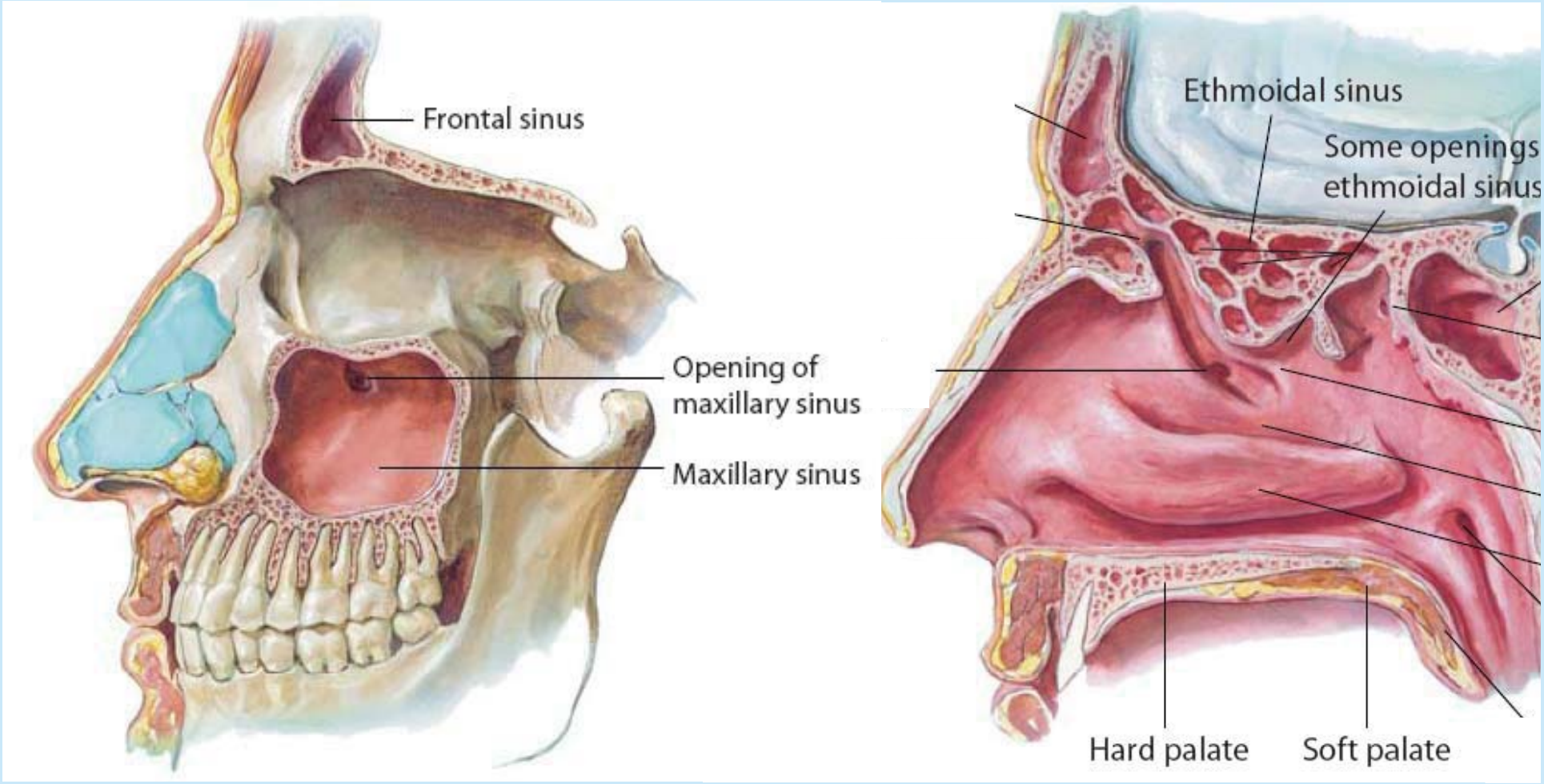
Environment

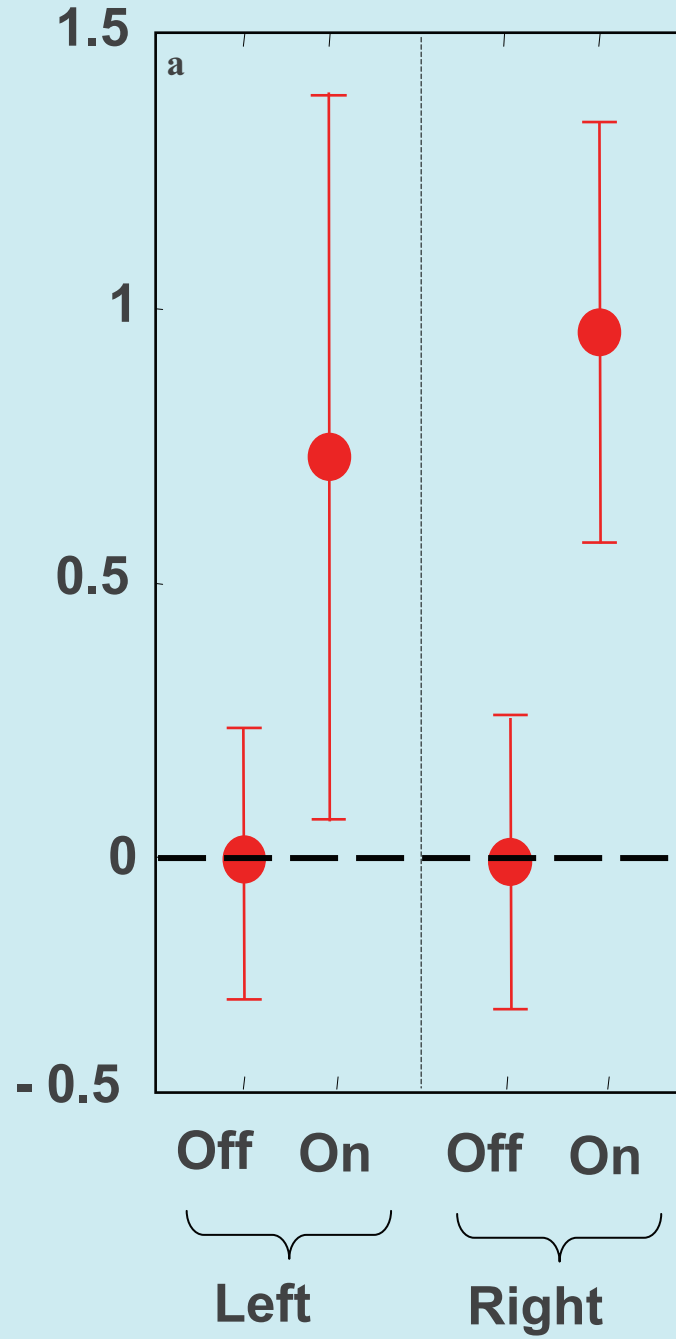


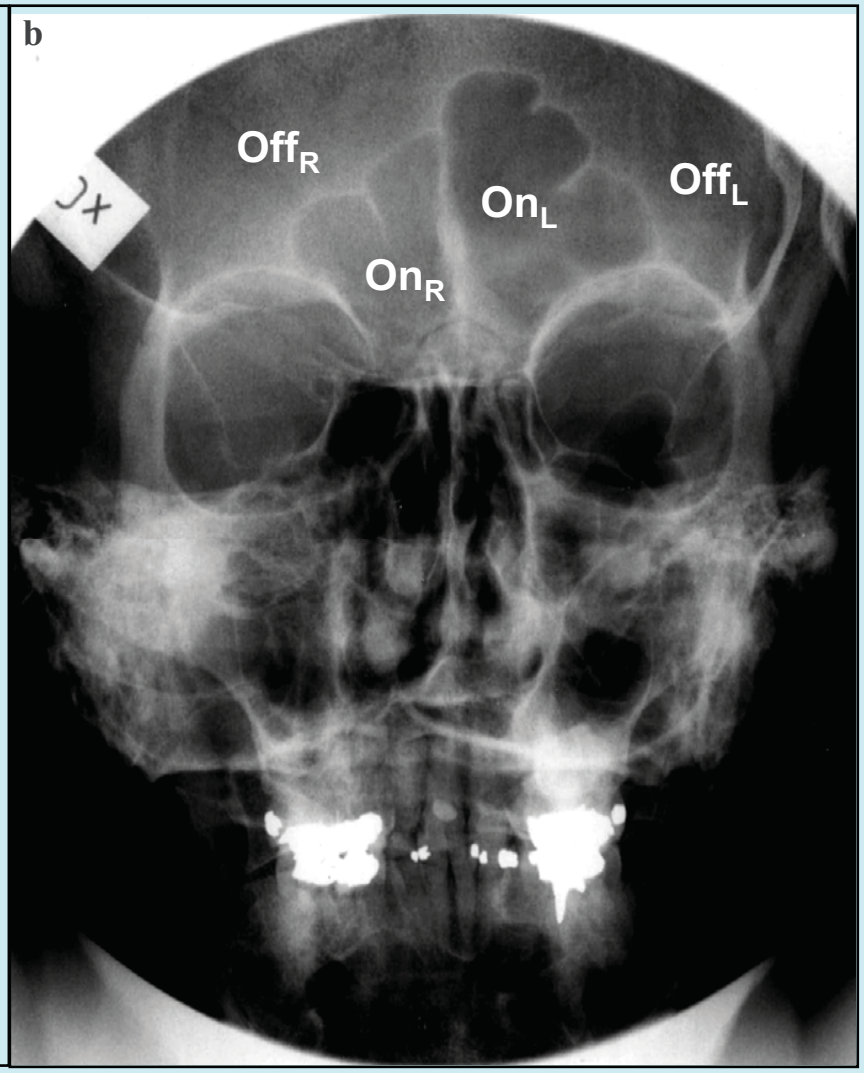
Medicine



Paranasal Sinuses

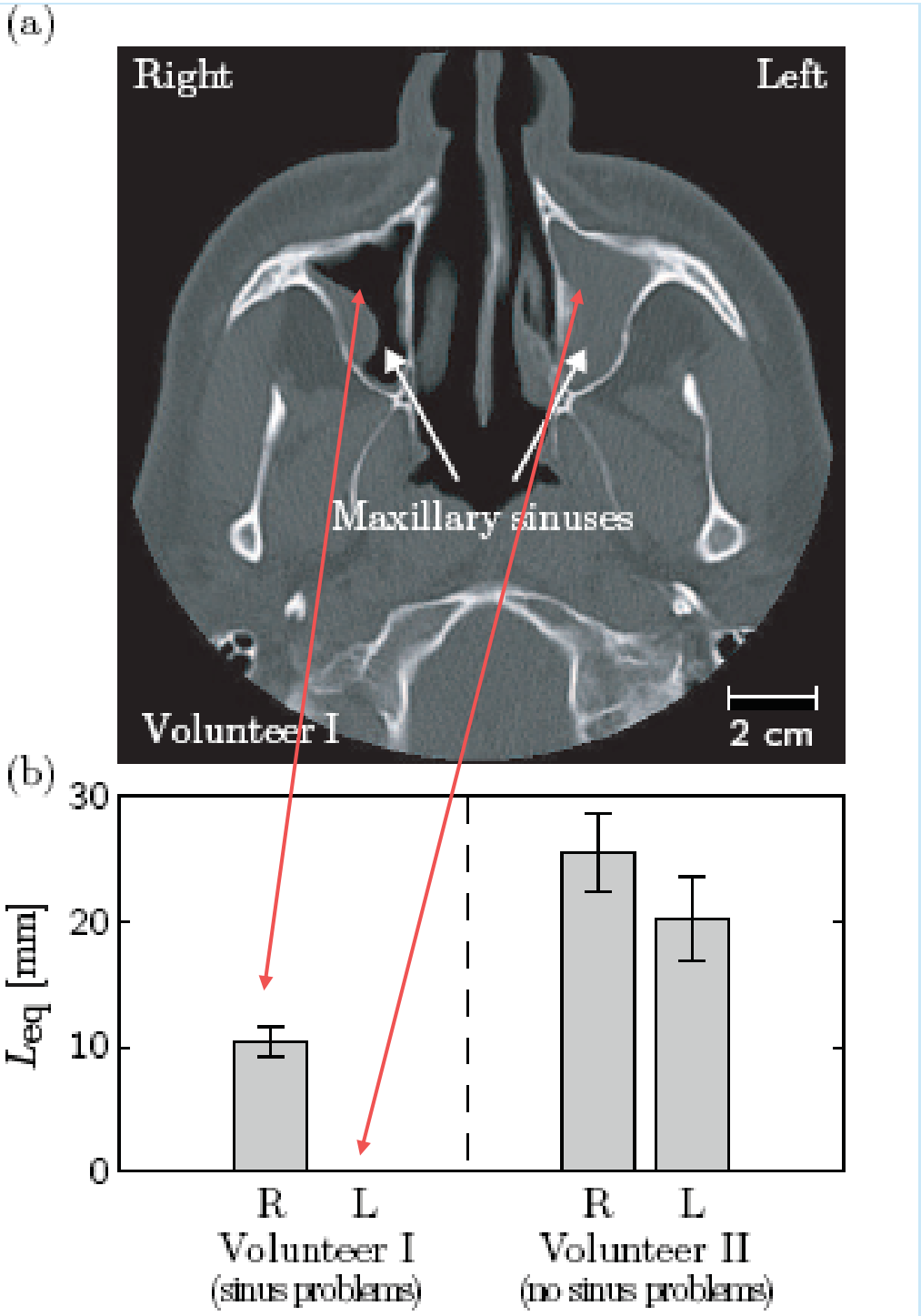




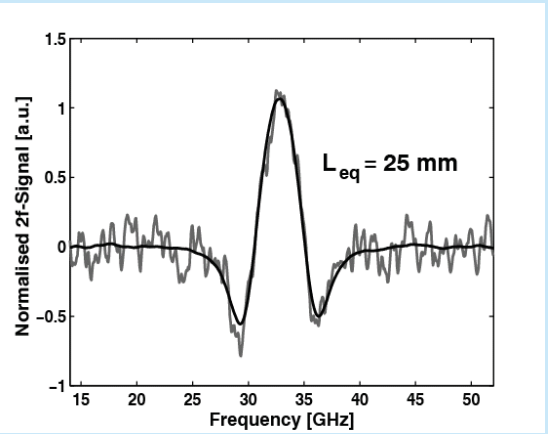


Healthy volonteer

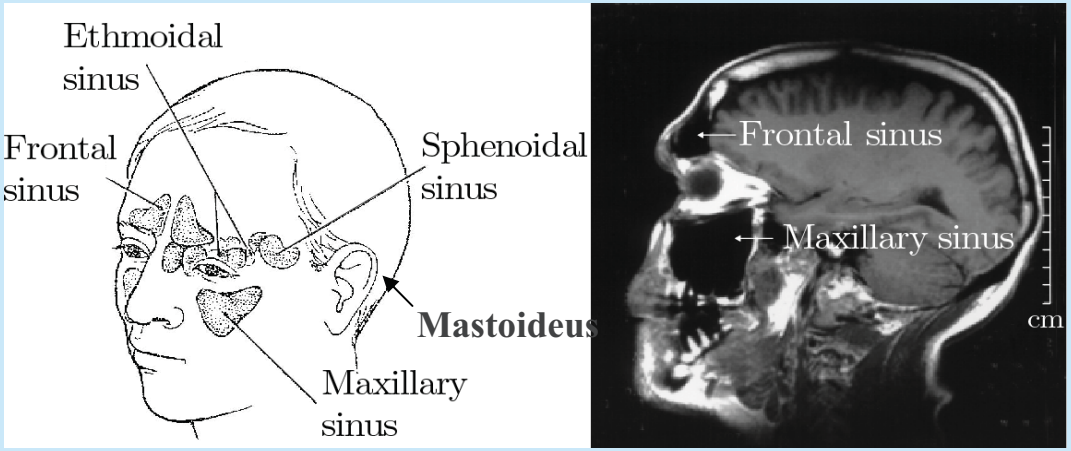
Me !



Maxillary sinuses

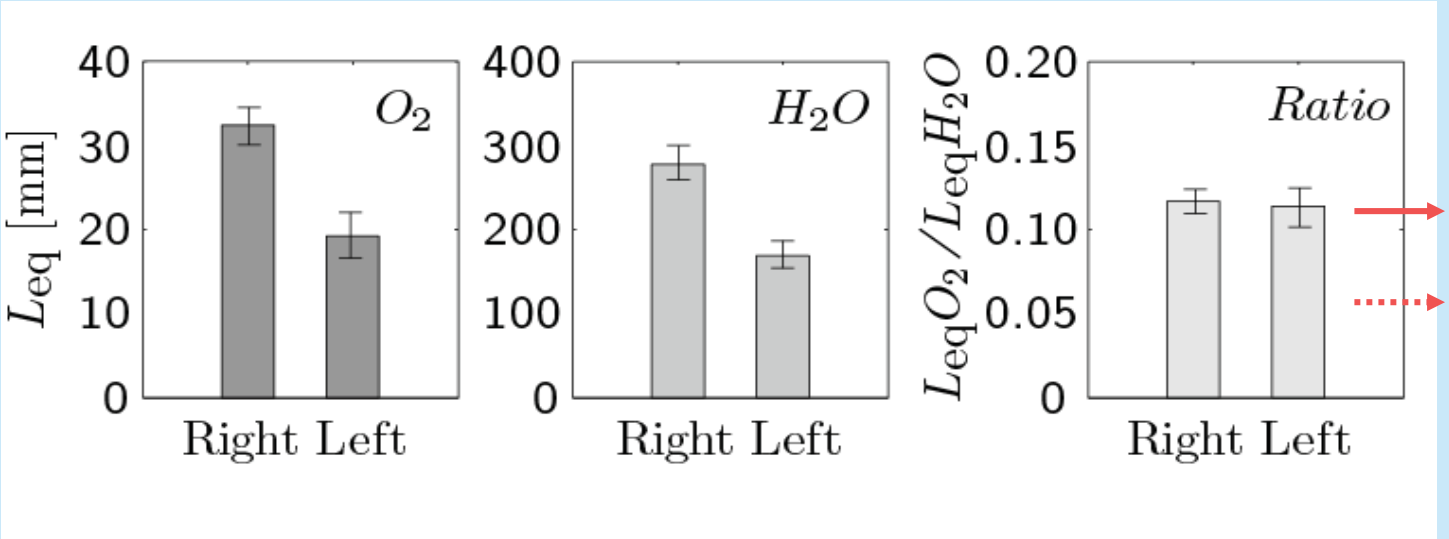


Maxillary sinus
Oxygen (760 nm) normalization on Water vapor (935 nm)

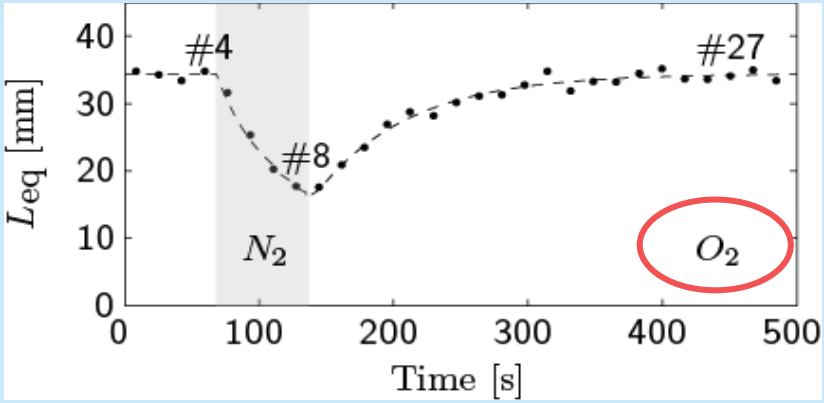


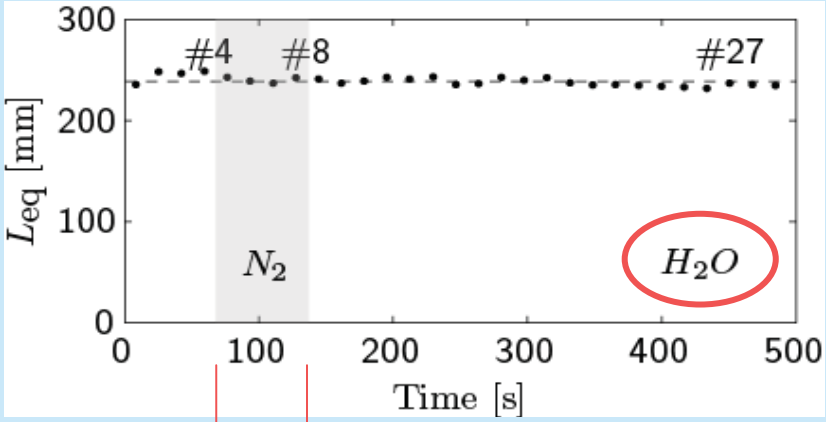
Density of H_2O determined by temperature

Thermostate at 37 C

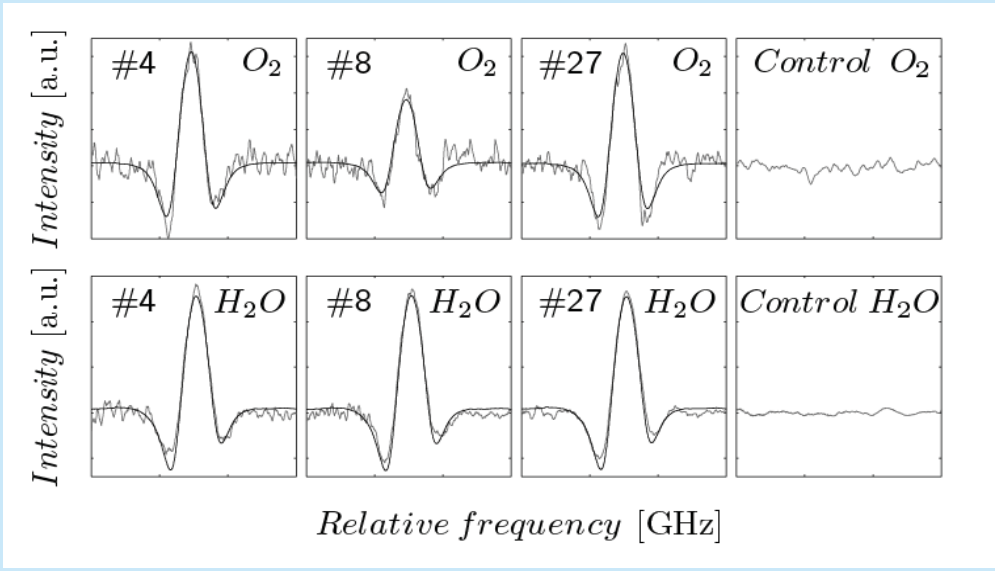


Gas Exchange Study – Maxillary





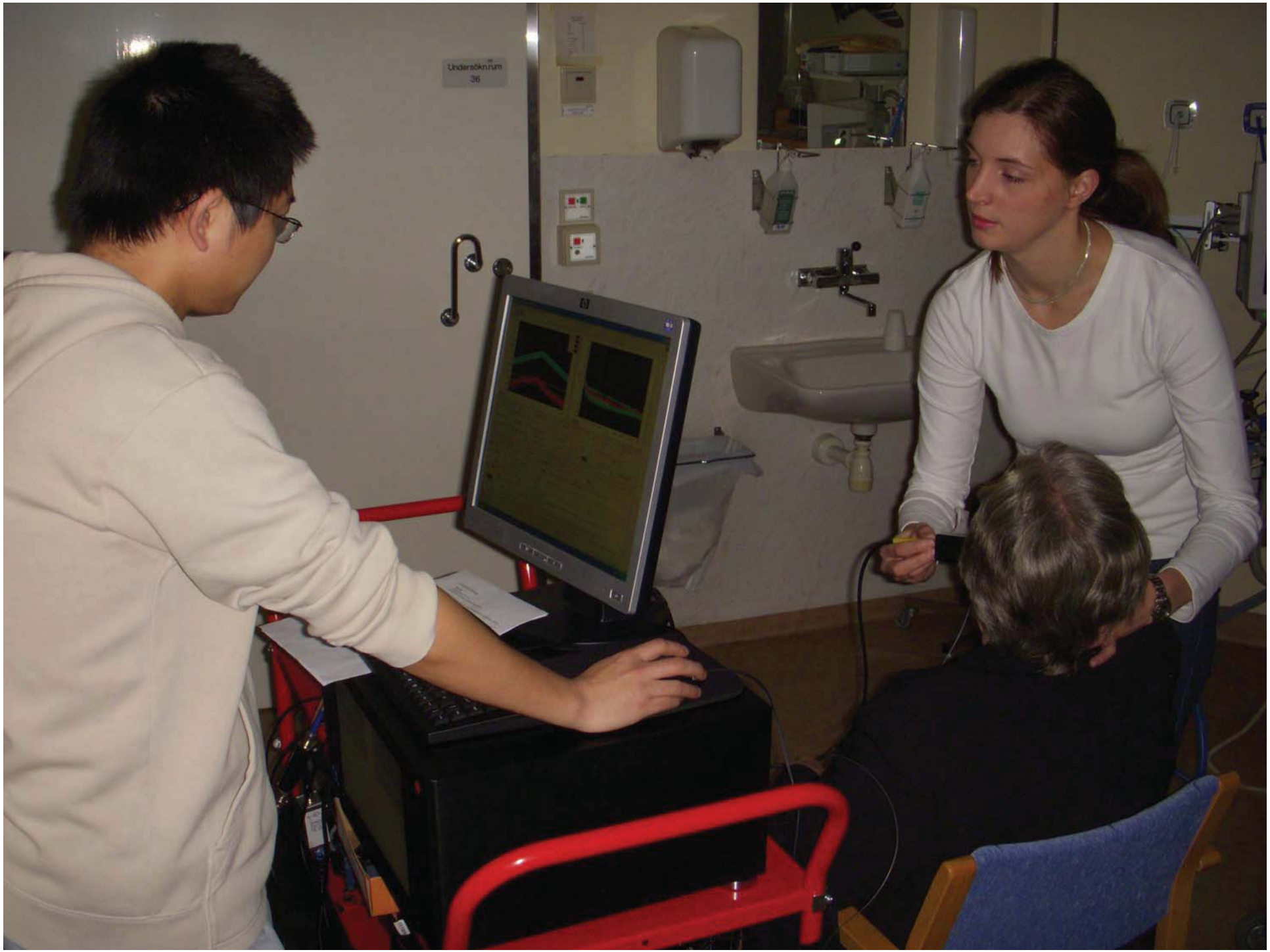
Nitrogen flushing



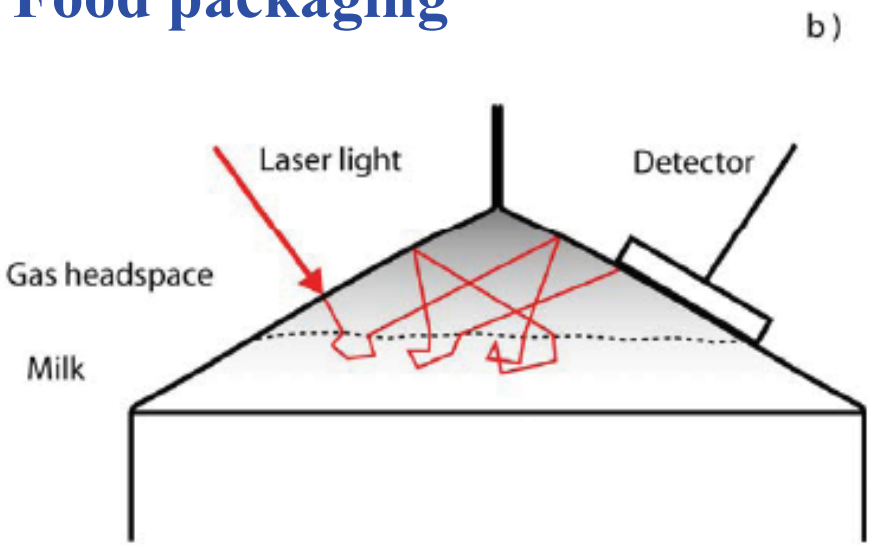
Clinical trial ongoing:

Maxillary, frontal, mastoideal Sinuses

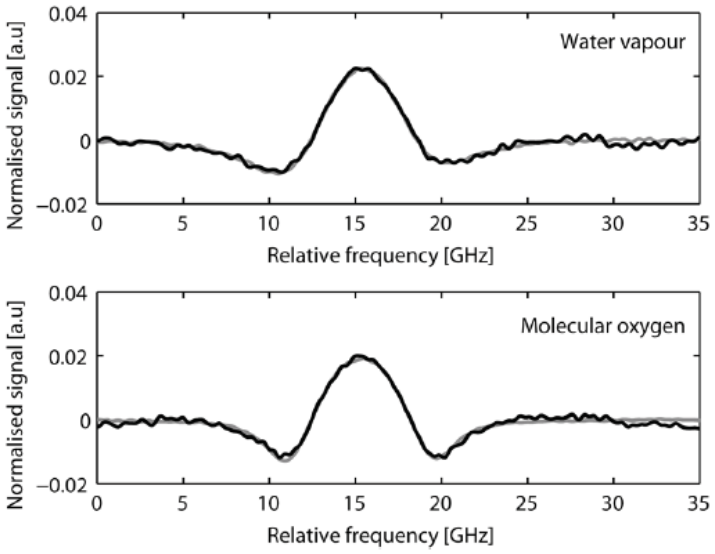
New tool for fast ENT diagnostics


Undersökningsrum
36

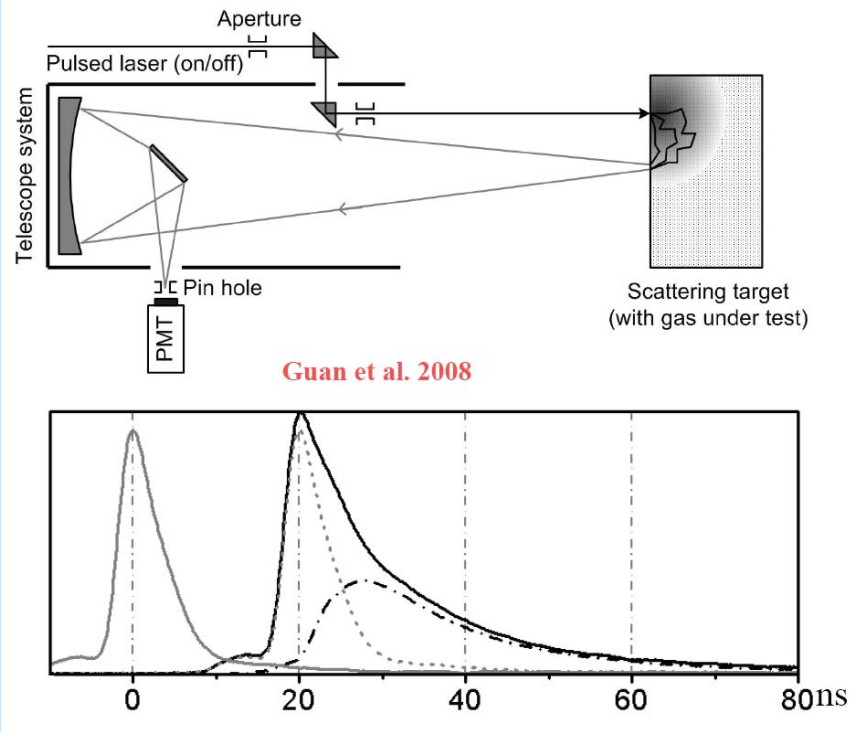
Food packaging

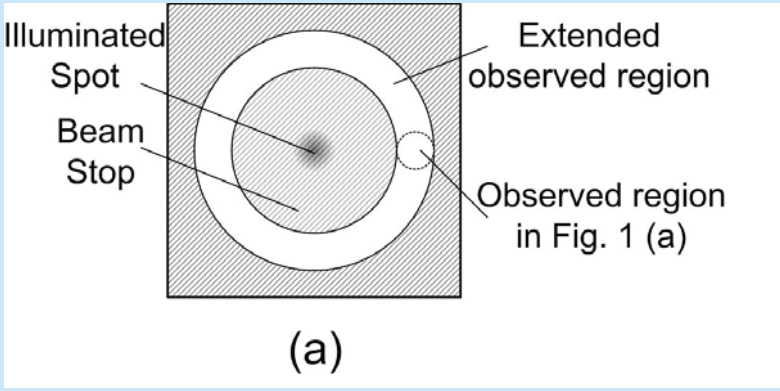


Lewander et al., Appl. Phys. B 2008

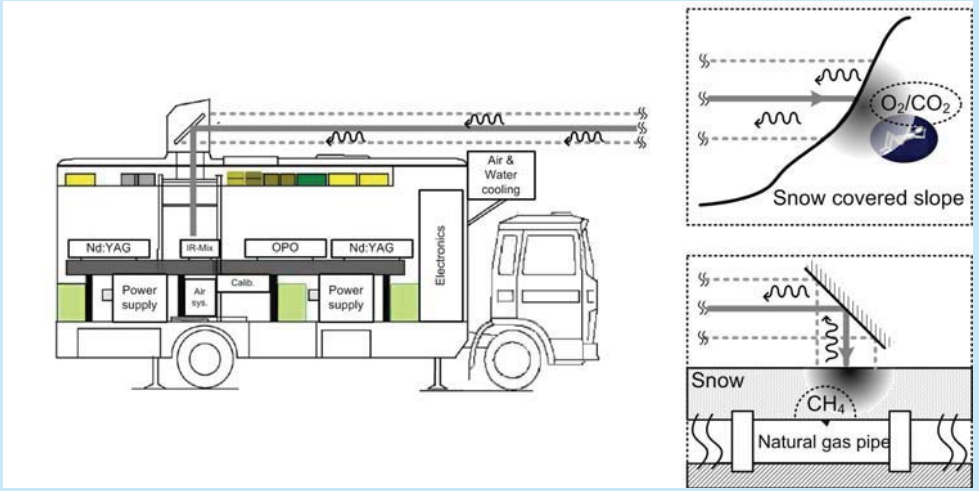


Large-scale GASMAS – Multiple scattering LIDAR





Guan et al. Appl. Phys. B 2008



Environmental and medical applications are very similar !

–

Just a matter of scales, spatially and temporally!


Thanks to all enthusiastic collaborators!
Thank you for your attention !