

**Research Infrastructure Consortia Network Meeting  
Brussels, February 21, 2020**

**What can Laser (and other) Infrastructures  
provide  
in Solving the Grand Challenges?**



**LUNDS  
UNIVERSITET**

*Sune Svanberg*



*LASERLAB-Europe*

[www.laserlab-europe.eu](http://www.laserlab-europe.eu)



## **General statement:**

**Our Research Infrastructures may mostly do basic research  
but ....  
without basic research you very quickly run out  
of good ideas!**

**Good basic research** promotes  
**good applied research**, which in turn leads to  
**industrial development** and **improved living conditions !**

# Specific Challenges to Discuss:

## MISSION AREAS:

Soil health and food



Adaptation to climate change, including societal transformation



Climate-neutral and smart cities



Cancer



Healthy oceans, seas, coastal and inland waters

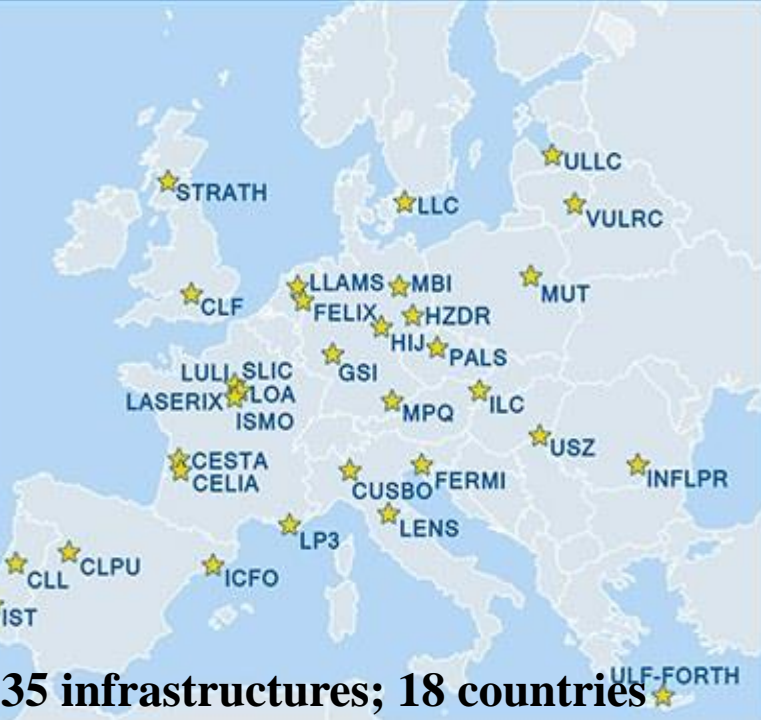


#HorizonEU

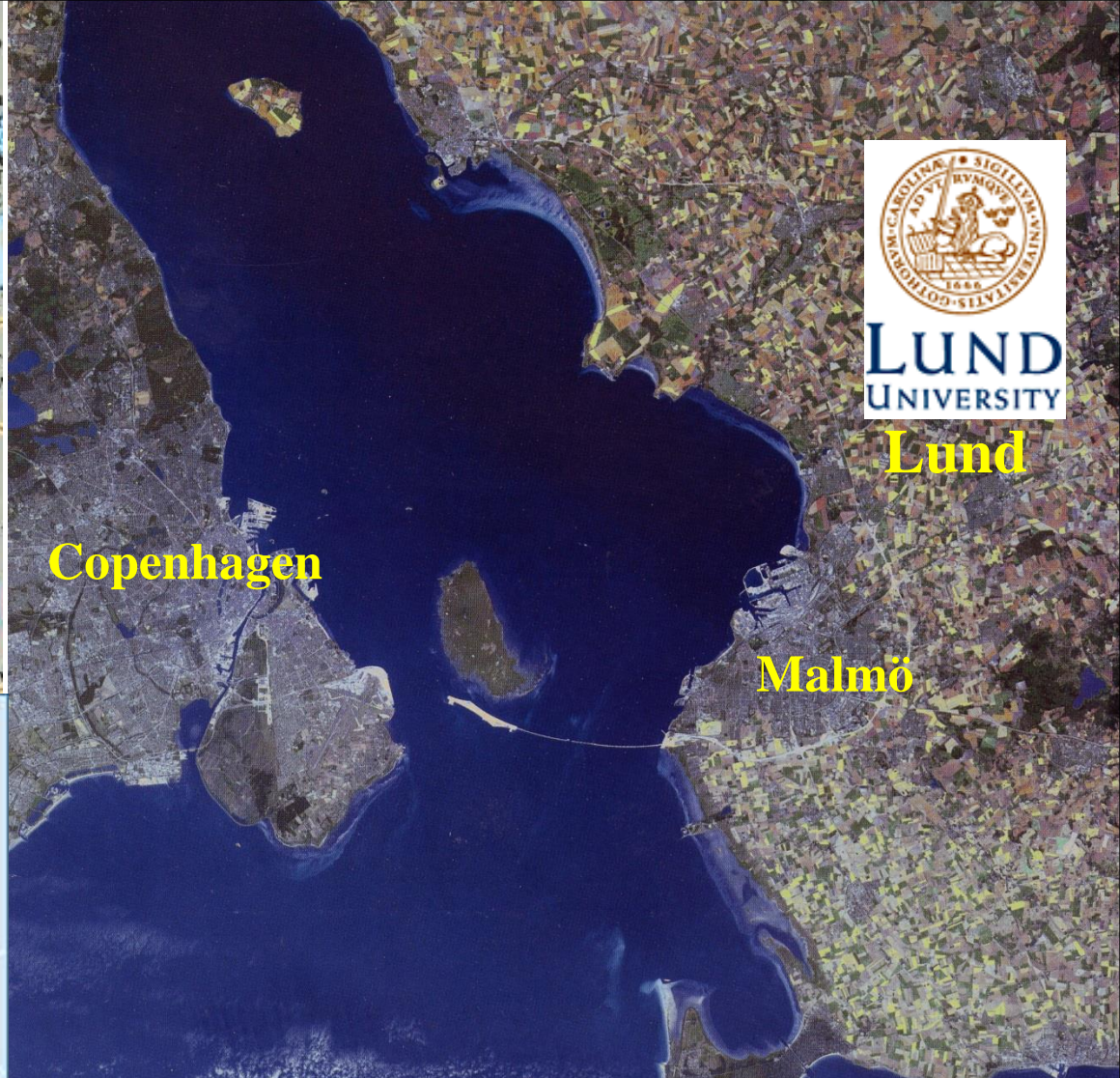


European Commission





35 infrastructures; 18 countries



LUND  
UNIVERSITY

Lund

# LASERLAB-Europe

Coordinator: C.G. Wahlström, LLC

Administration Head: D. Storzno, MBI

# Lund Facilities:

## MAX IV

### Synchrotron Radiation Source

3 GeV linear accelerator  
1.5 + 3 GeV storage rings  
Short Pulse Facility



# European Spallation Neutron Source ESS

2.5 GeV protons  
5 MW – 2 BEuro

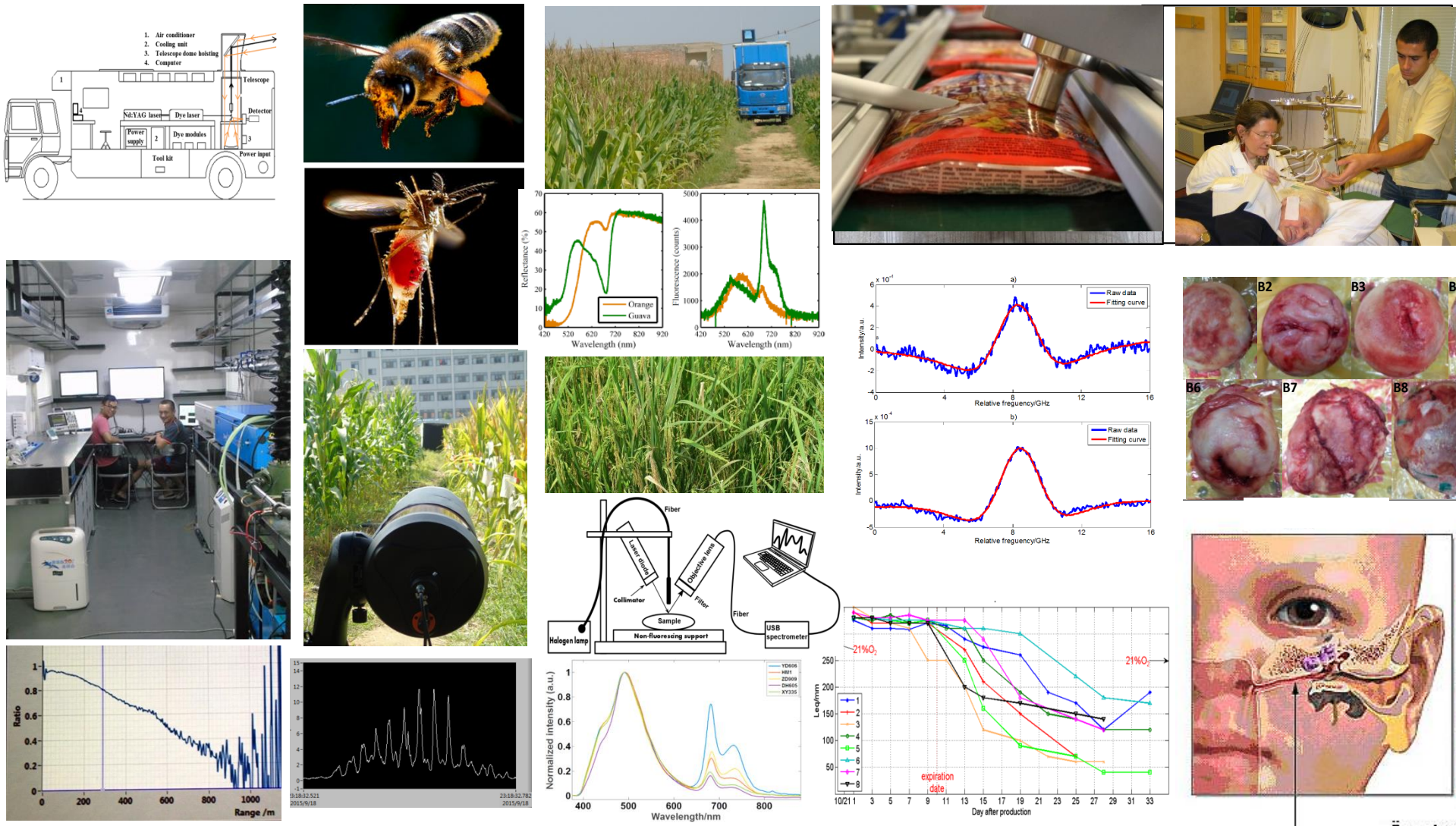


# Laser-based Science is very Interdisciplinary

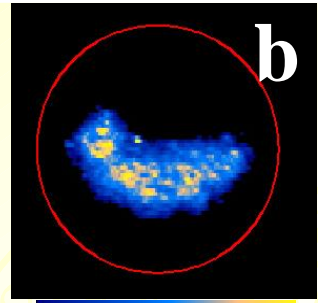
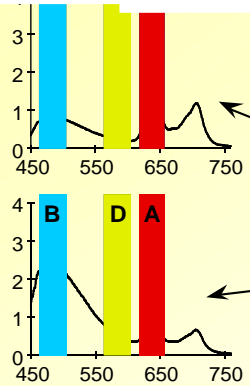
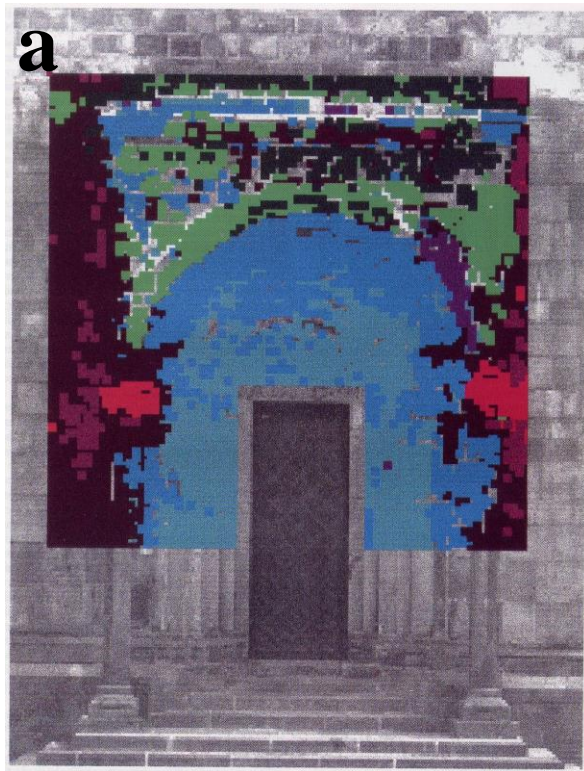
## Example: Applied Laser Spectroscopy

Very similar approaches to many different areas !

**Environment - Ecology - Agriculture - Food Safety - Biomedicine**



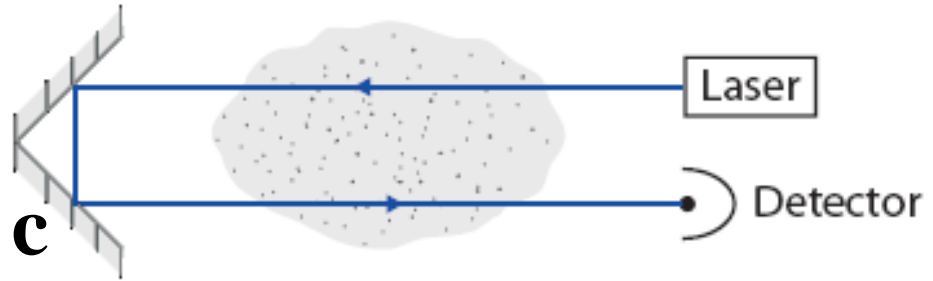
# Environmental Monitoring - Biophotonics



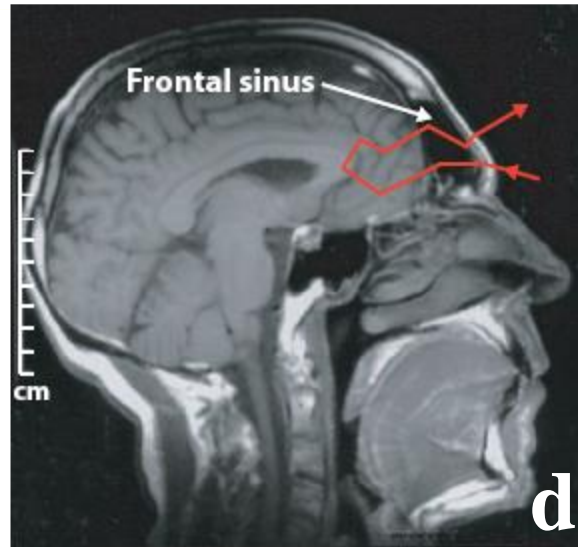
$$F_c = \frac{A - k_1 D}{k_2 B}$$

5 Red — Yellow 12  
Blue

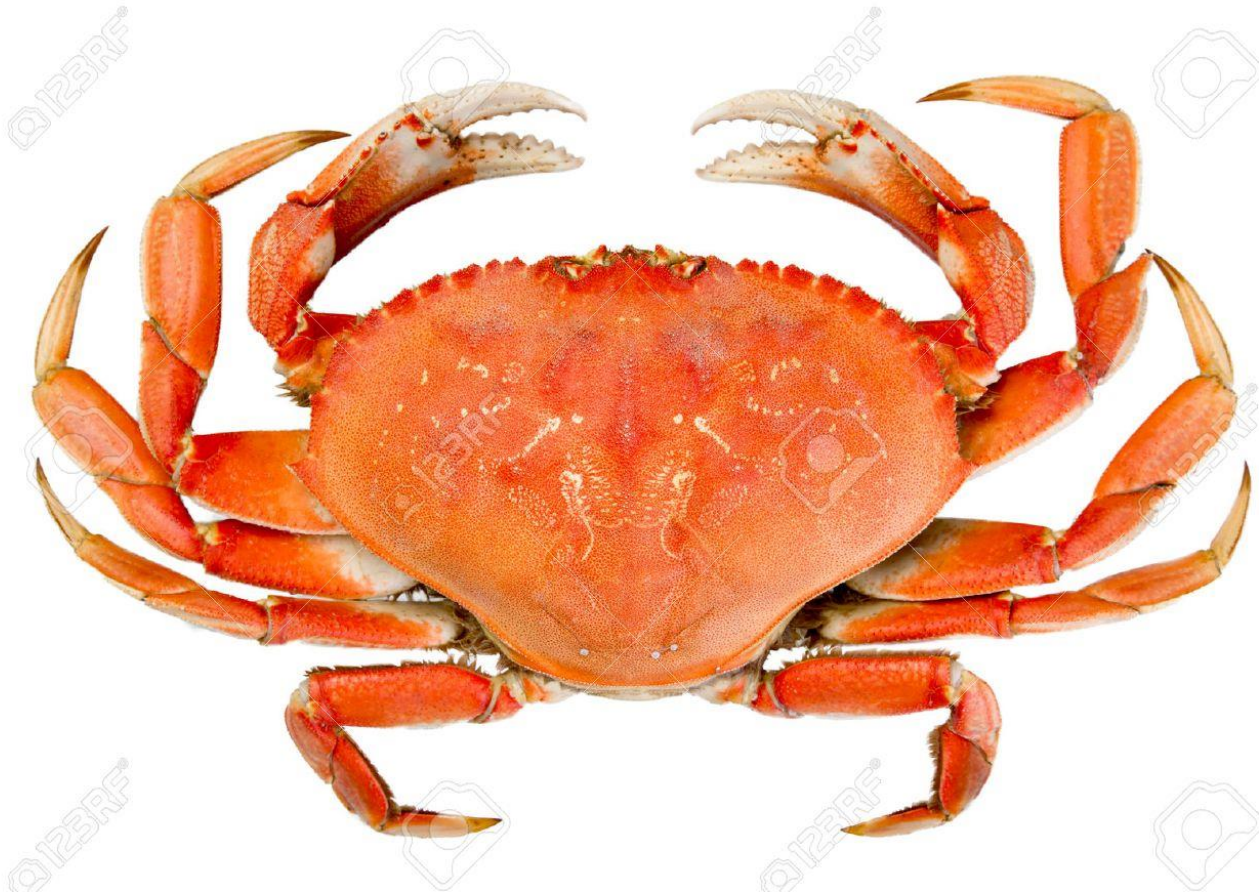
## Environment



## Medicine



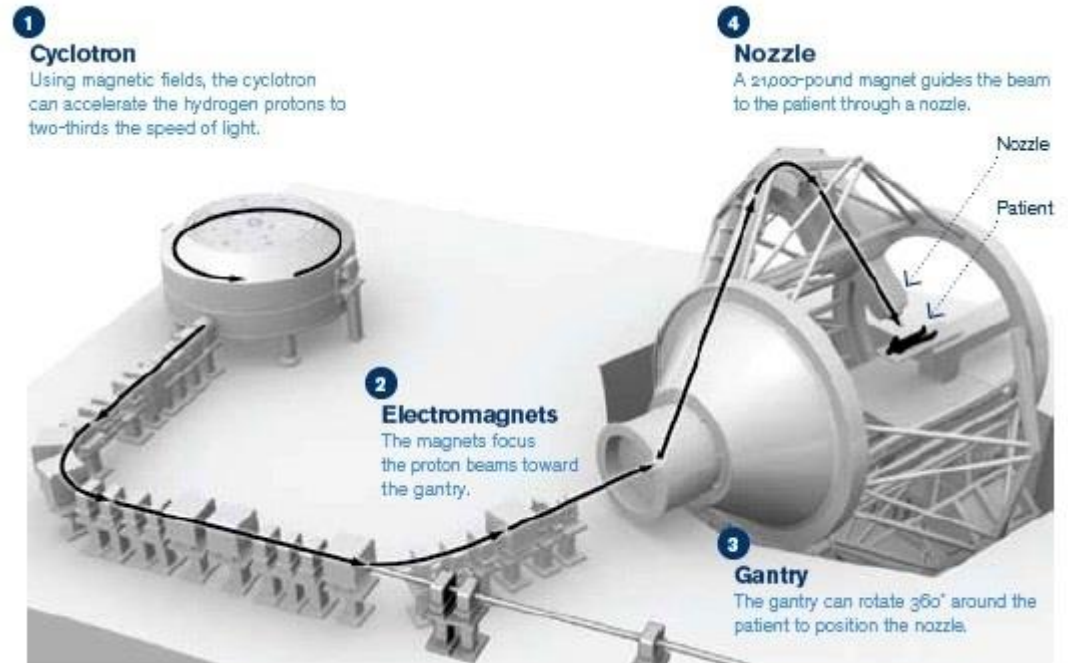
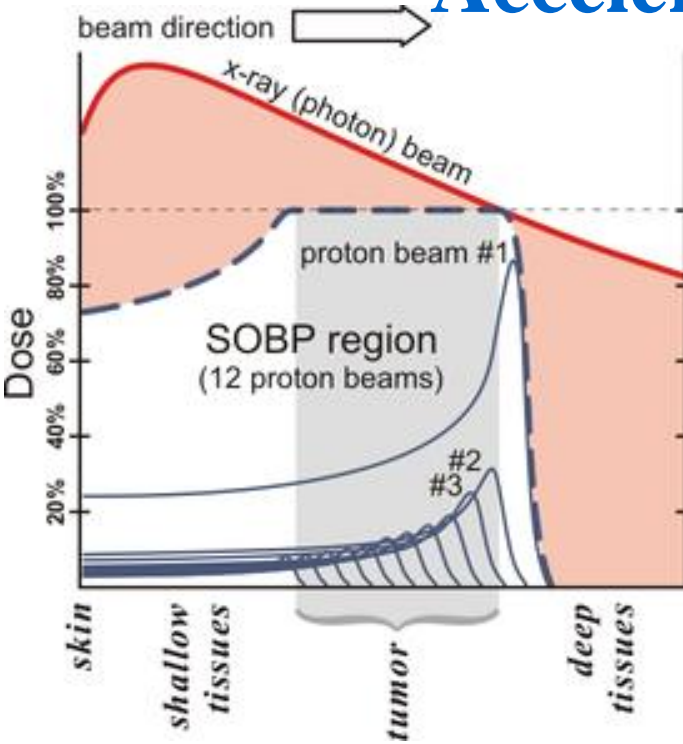
# Cancer



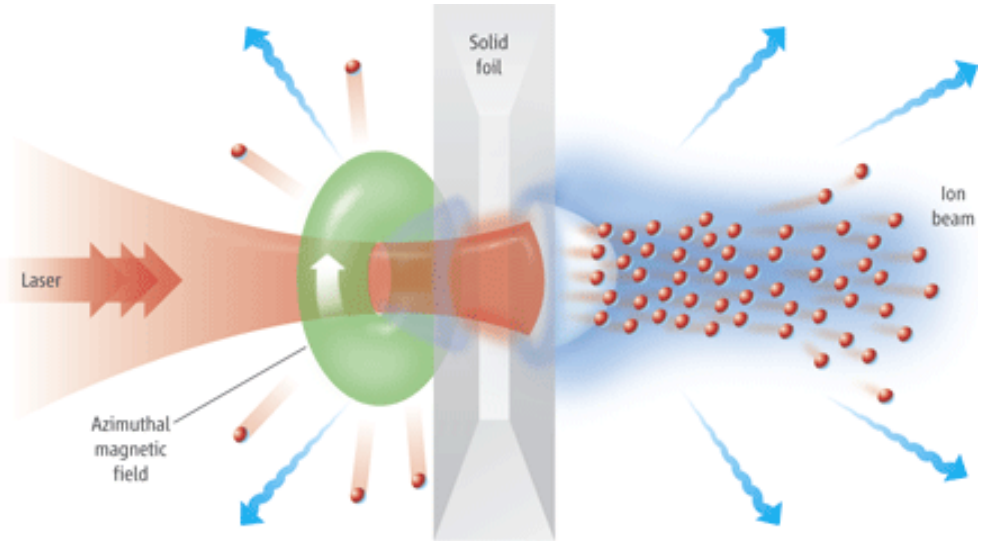
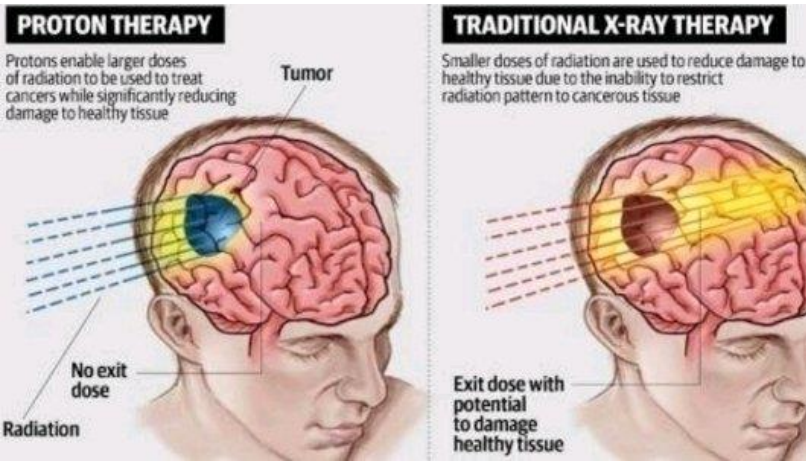


# Cancer – Proton therapy

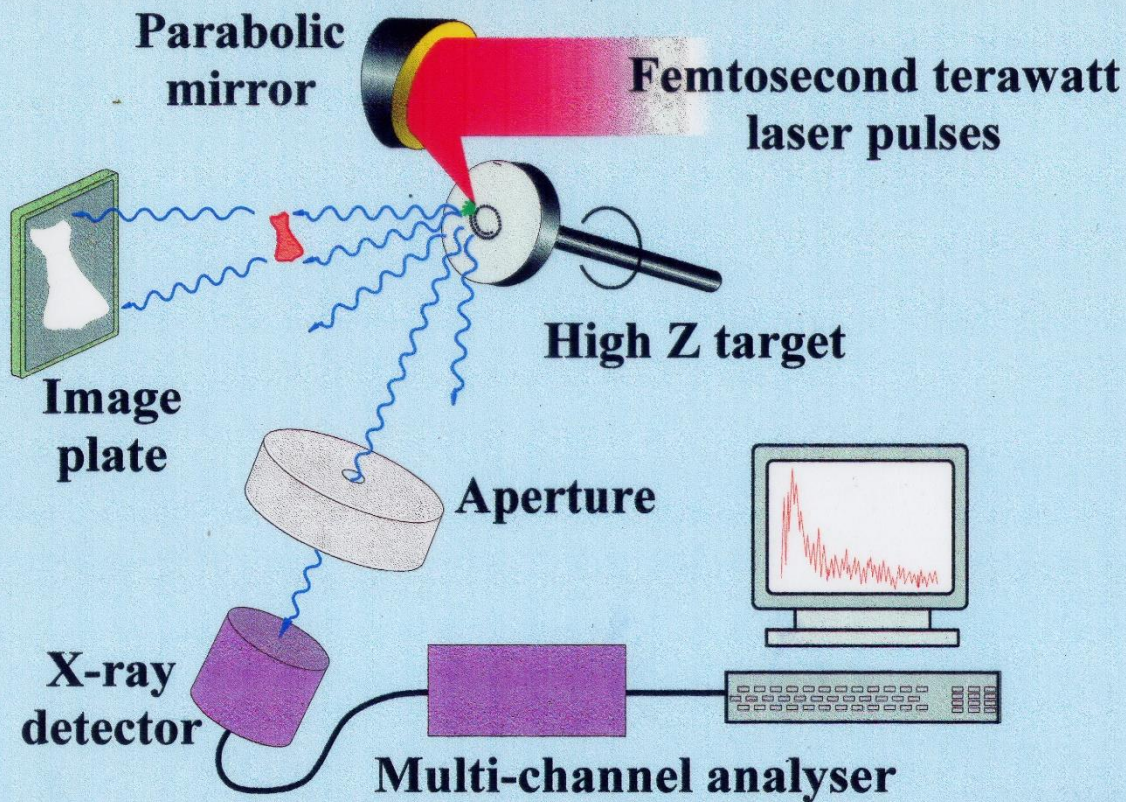
## Accelerator based - Laser based



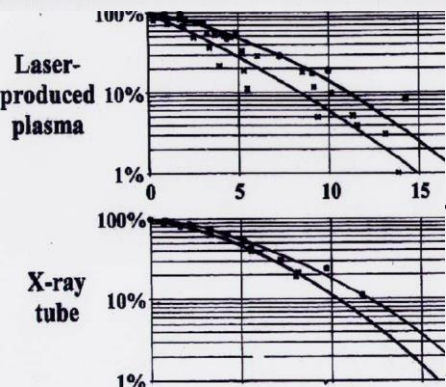
## Figures retrieved from the web



# Laser-produced hard X-rays

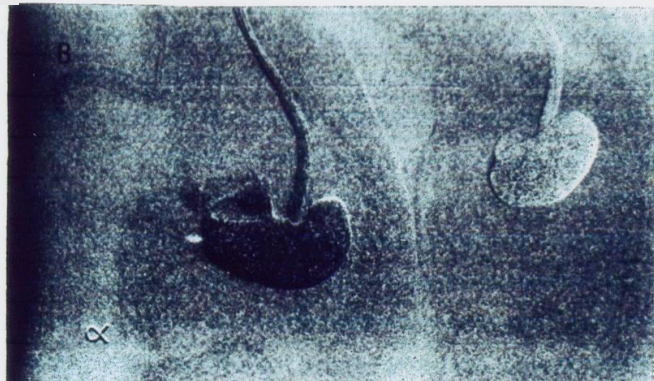
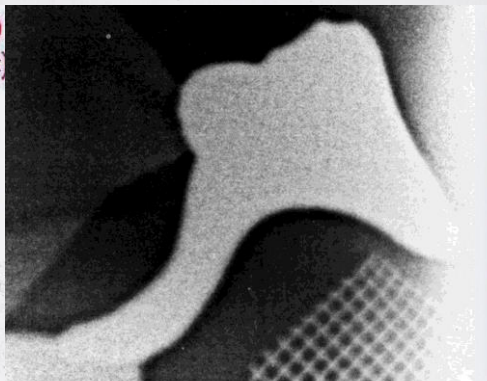


Carl Tillman 1994

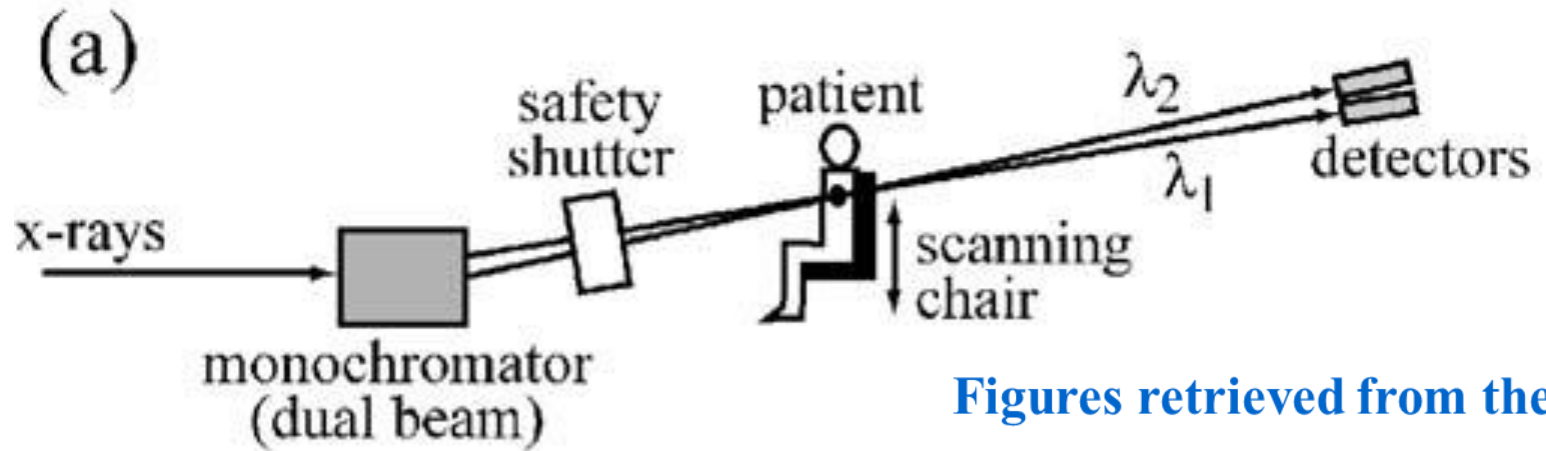


body phantom (12 cm)  
Hard X-rays (Ta-target)

lead-shadow



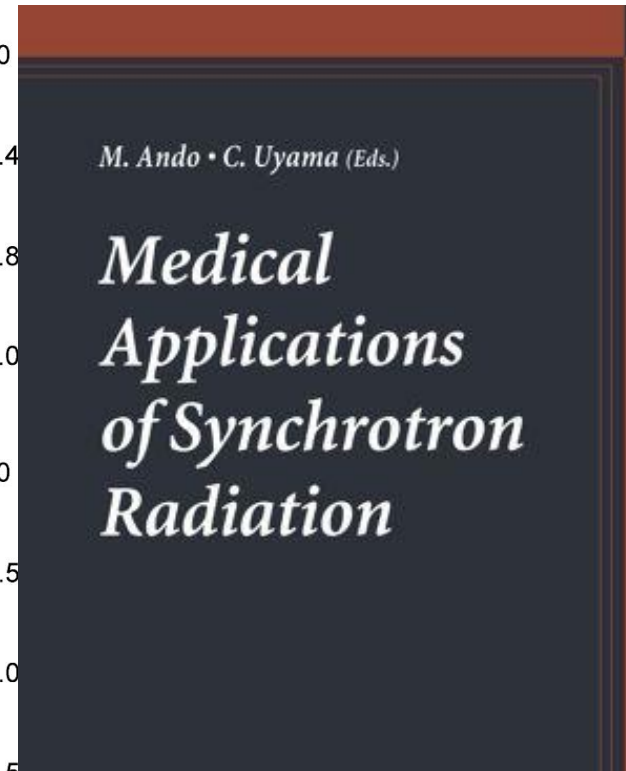
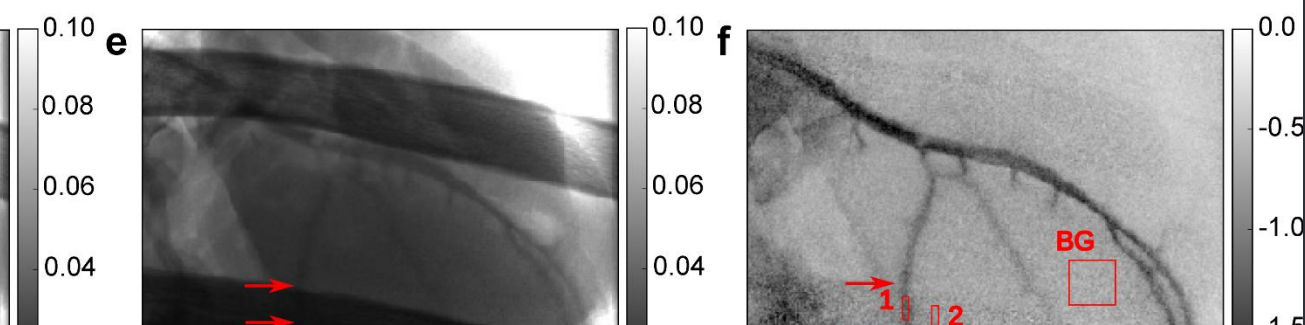
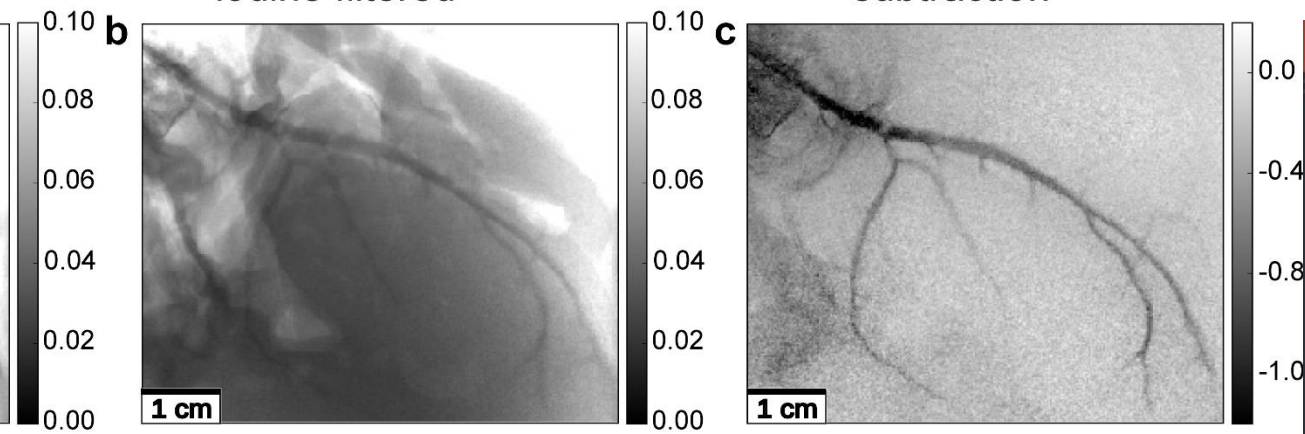
# Synchrotron K-edge subtraction coronary angiography



Figures retrieved from the web

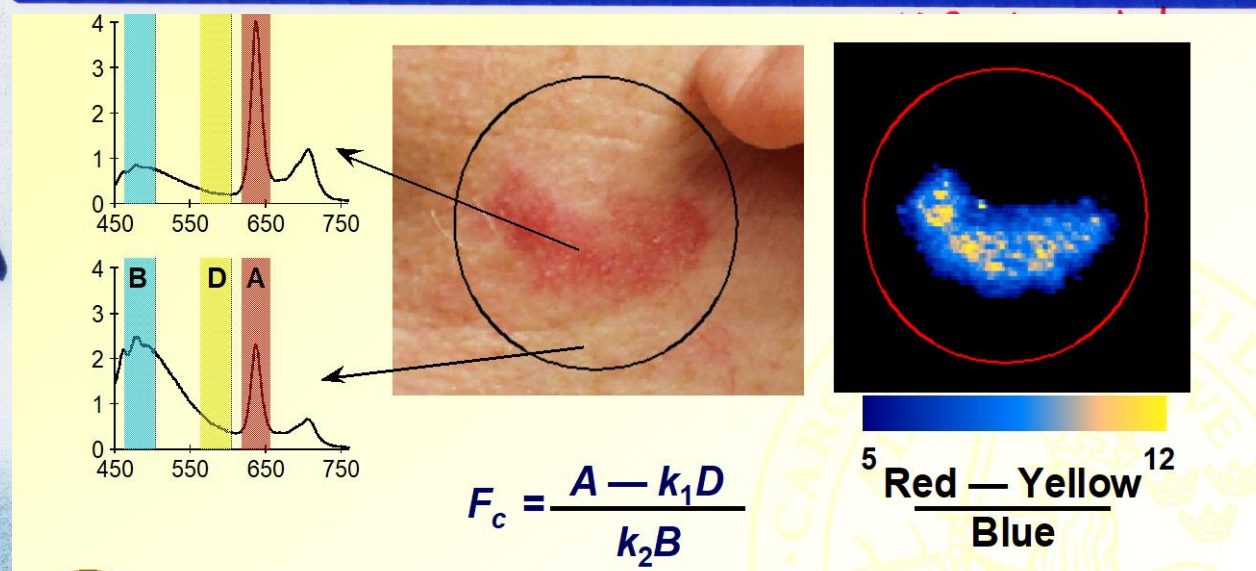
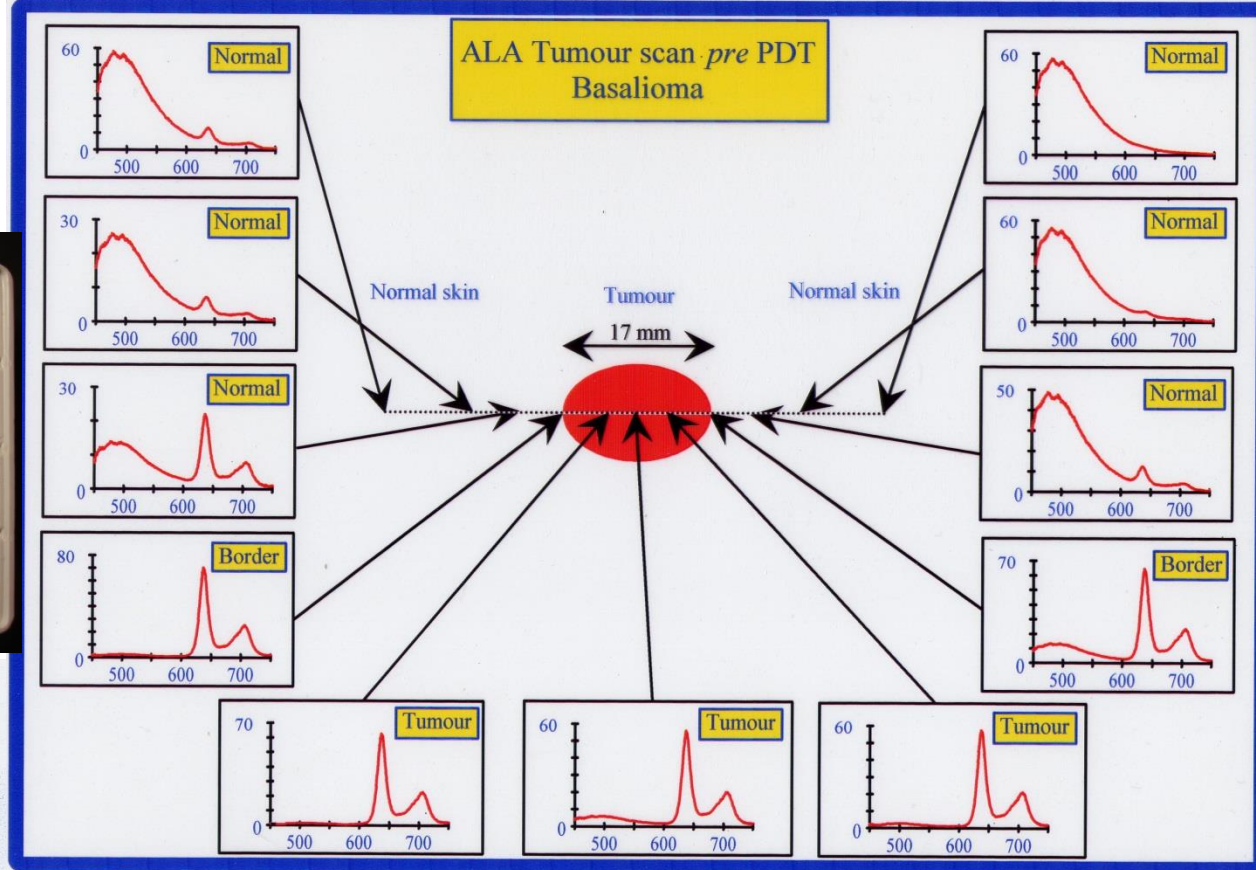
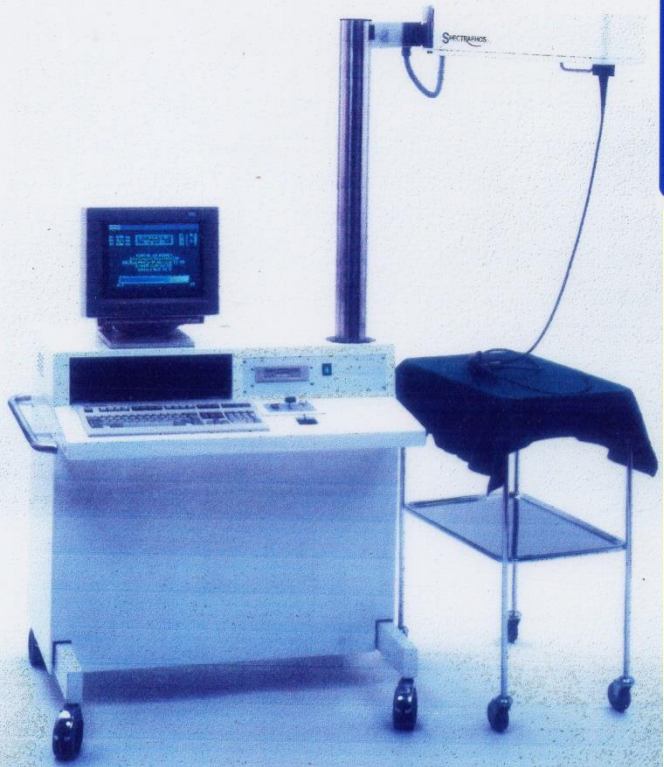
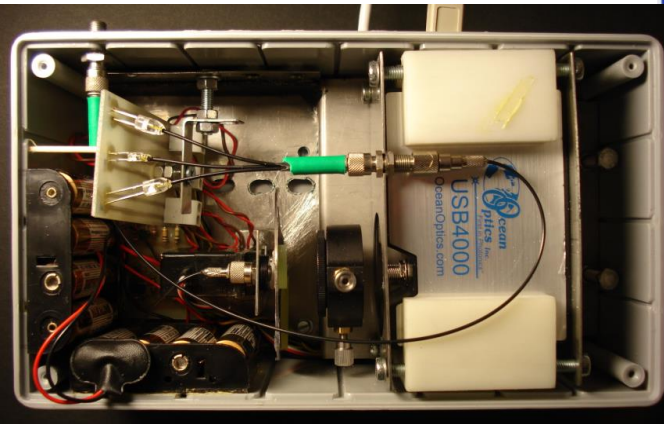
iodine filtered

subtraction

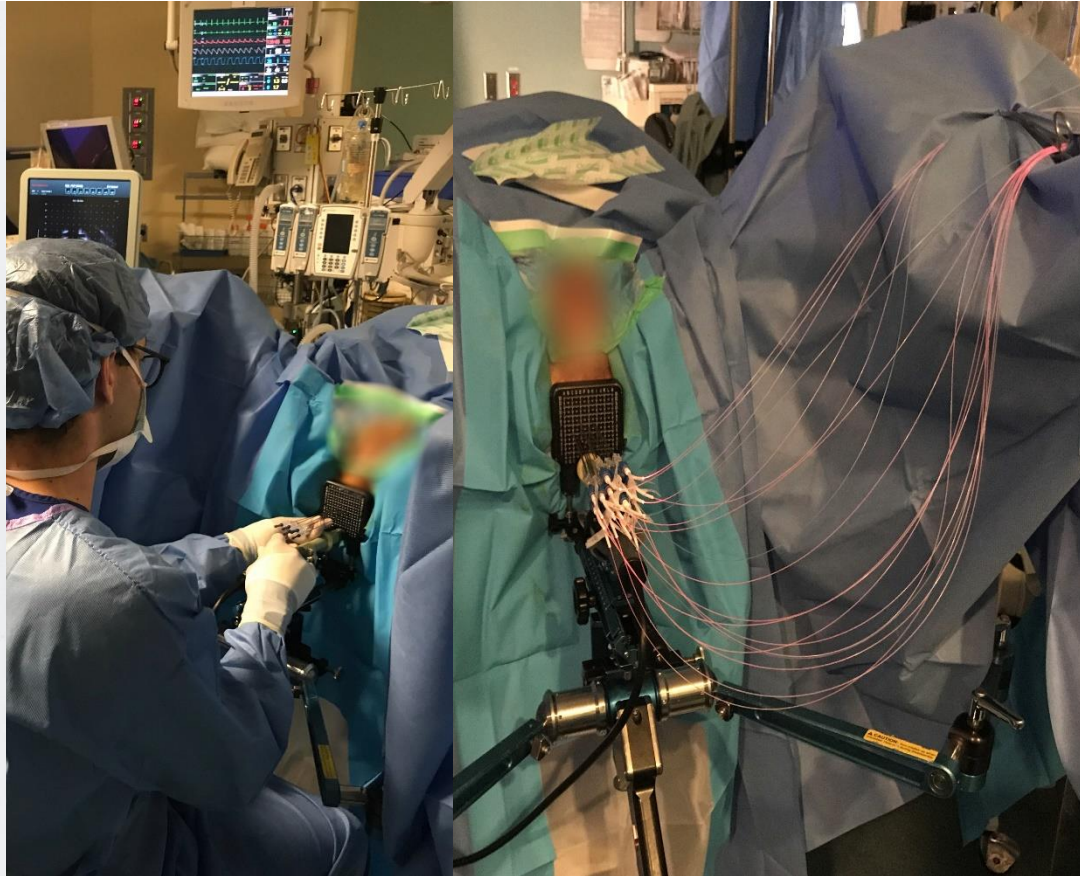
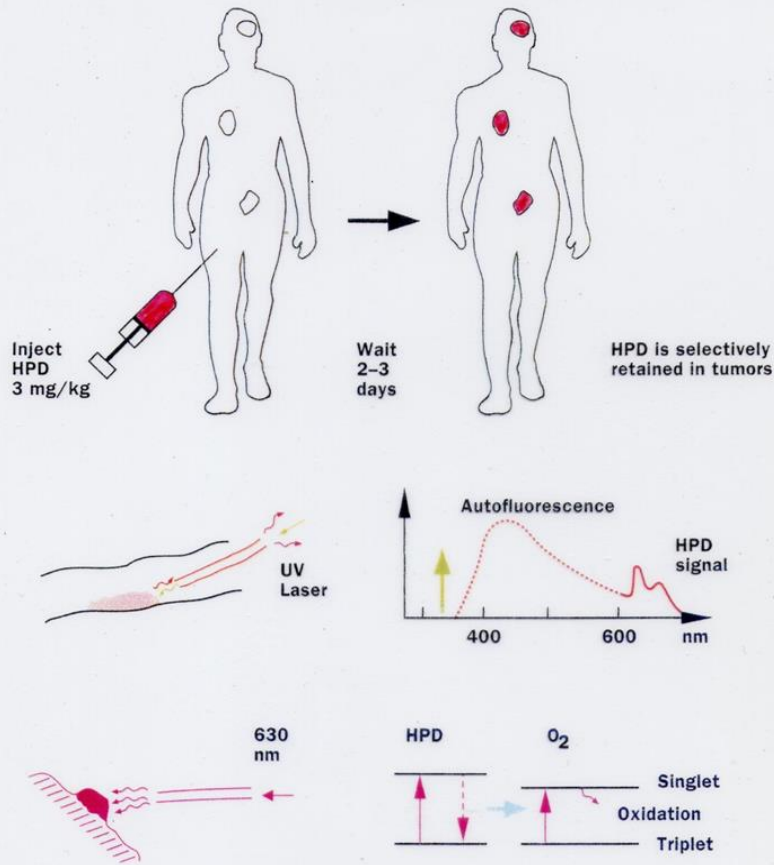


# Localizing Malignant Disease

**KEY: Early detection!!**



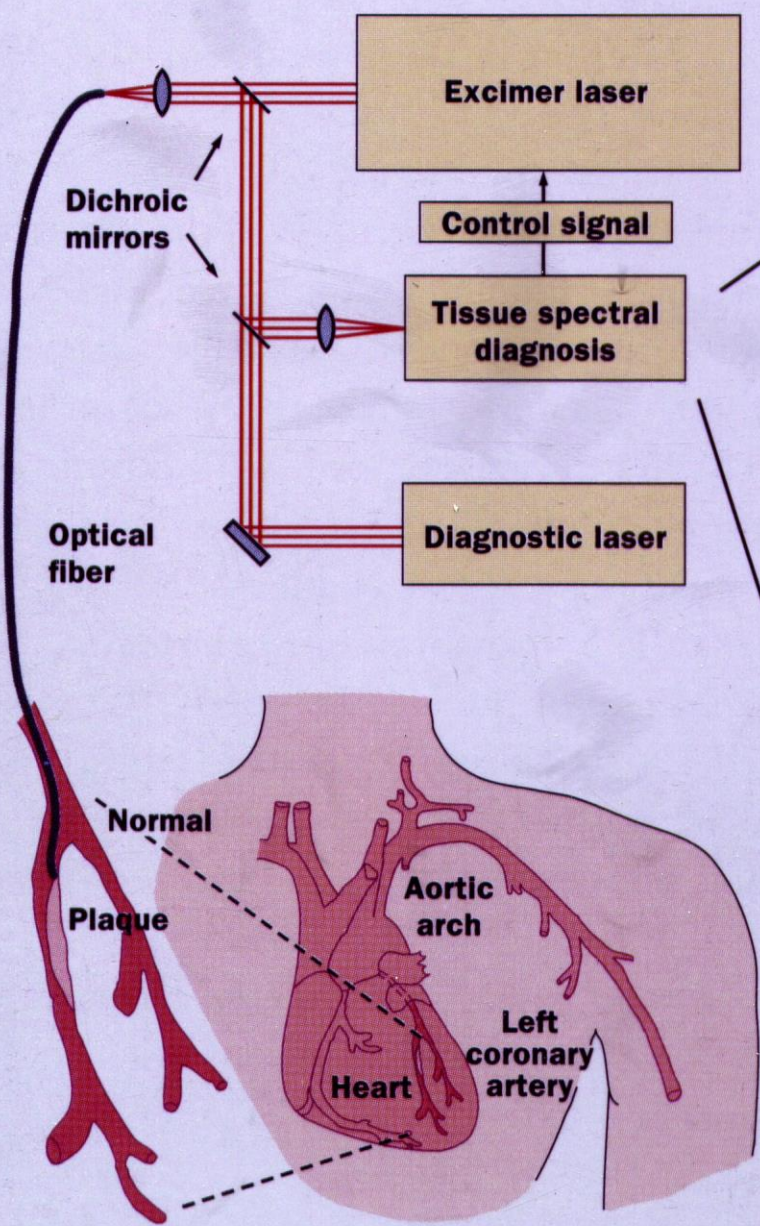
# Treating Recurrent Prostate Cancer using Interstitial Photodynamic Therapy



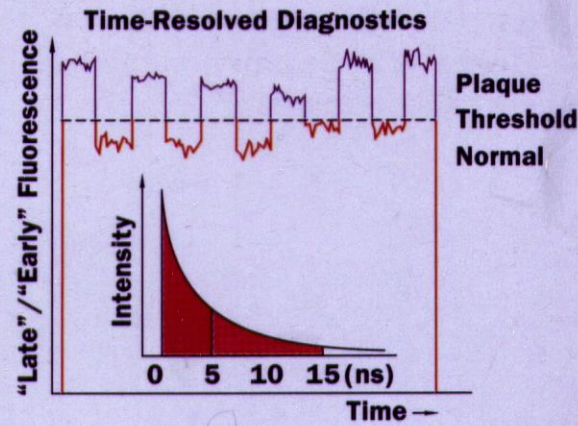
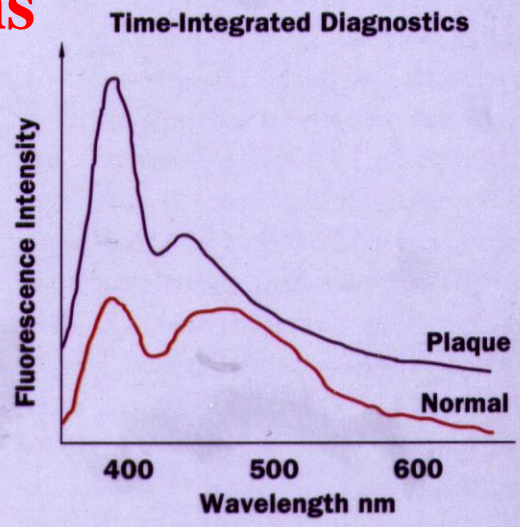
**Interactive Diagnostics and Treatment  
Prostate, ENT, Breast, Brain .....**

**Also: Optical mammography reducing X-ray use**

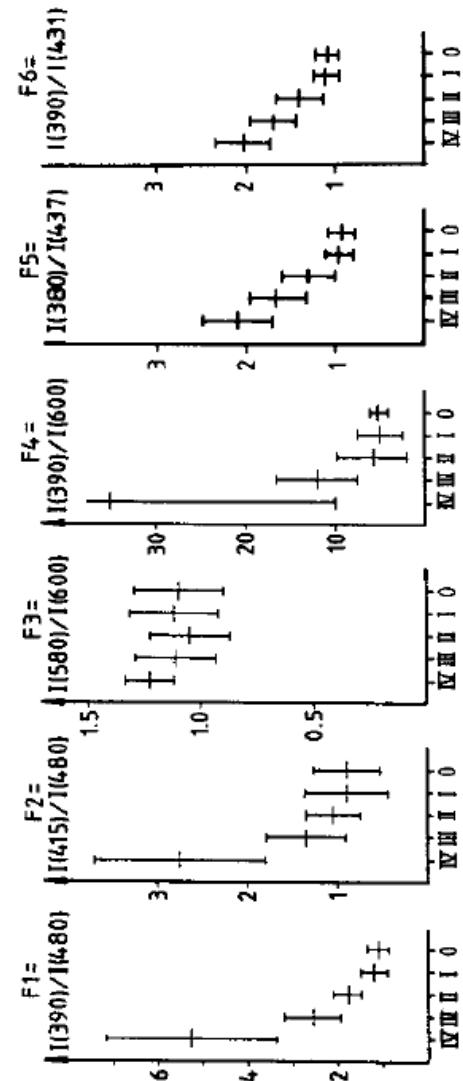
# Cardiovascular applications



## Integrated diagnostics and treatment



## Vessel spectroscopic diagnostics



# Climate-Neutral and Smart Cities

Megacity Air Pollution: Houston, TX – We also have our share in Europe.

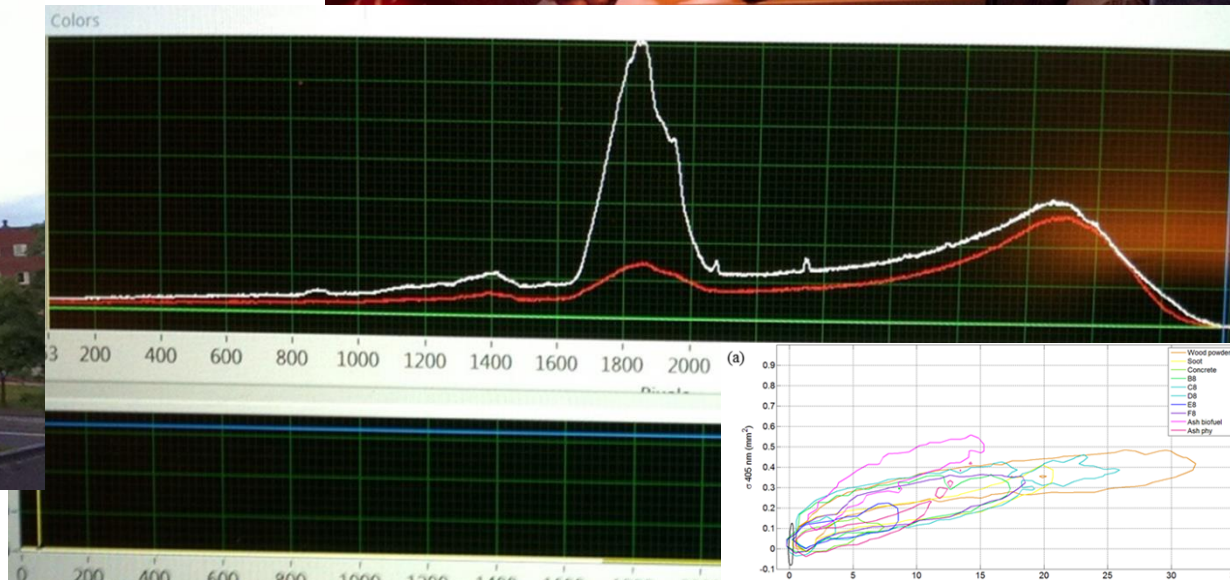


F. Tittel

8/21/2000

# CW lidar soot monitoring

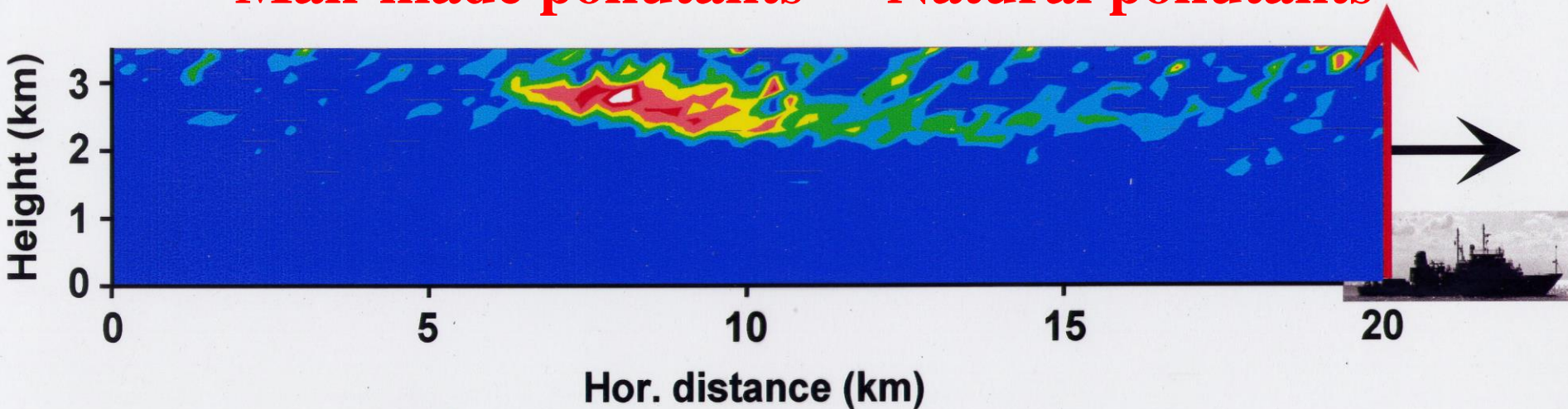
Zhao et al. 2016



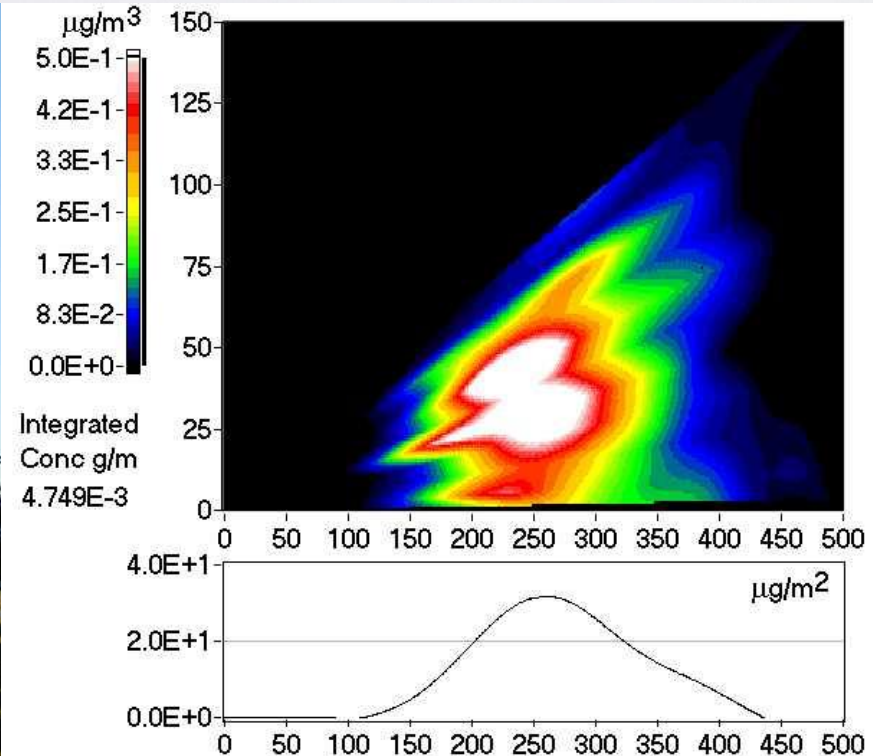


**Sulphur dioxide plume from Etna - Flux: 50 tonnes/h**

**Man-made pollutants - Natural pollutants**

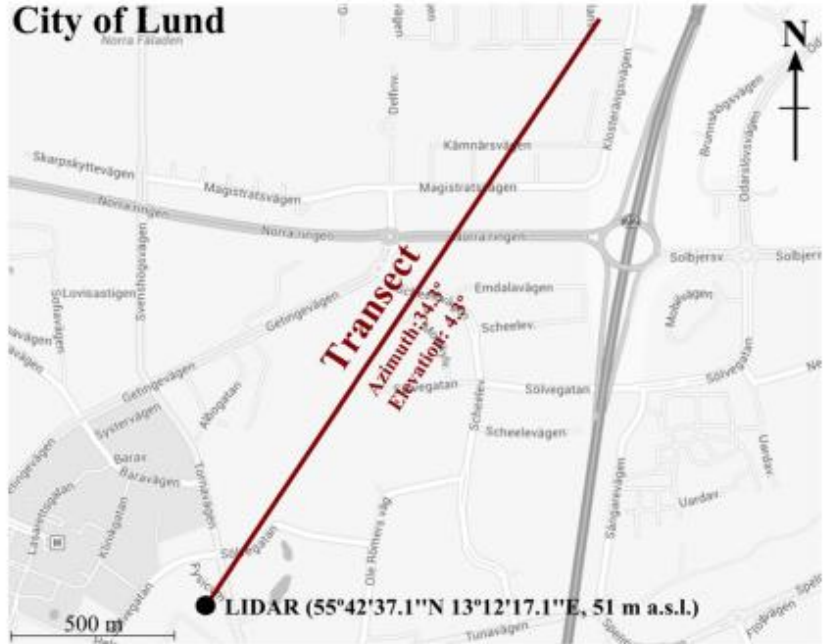


**Mercury monitoring**



# Adaption to **Climate Change**



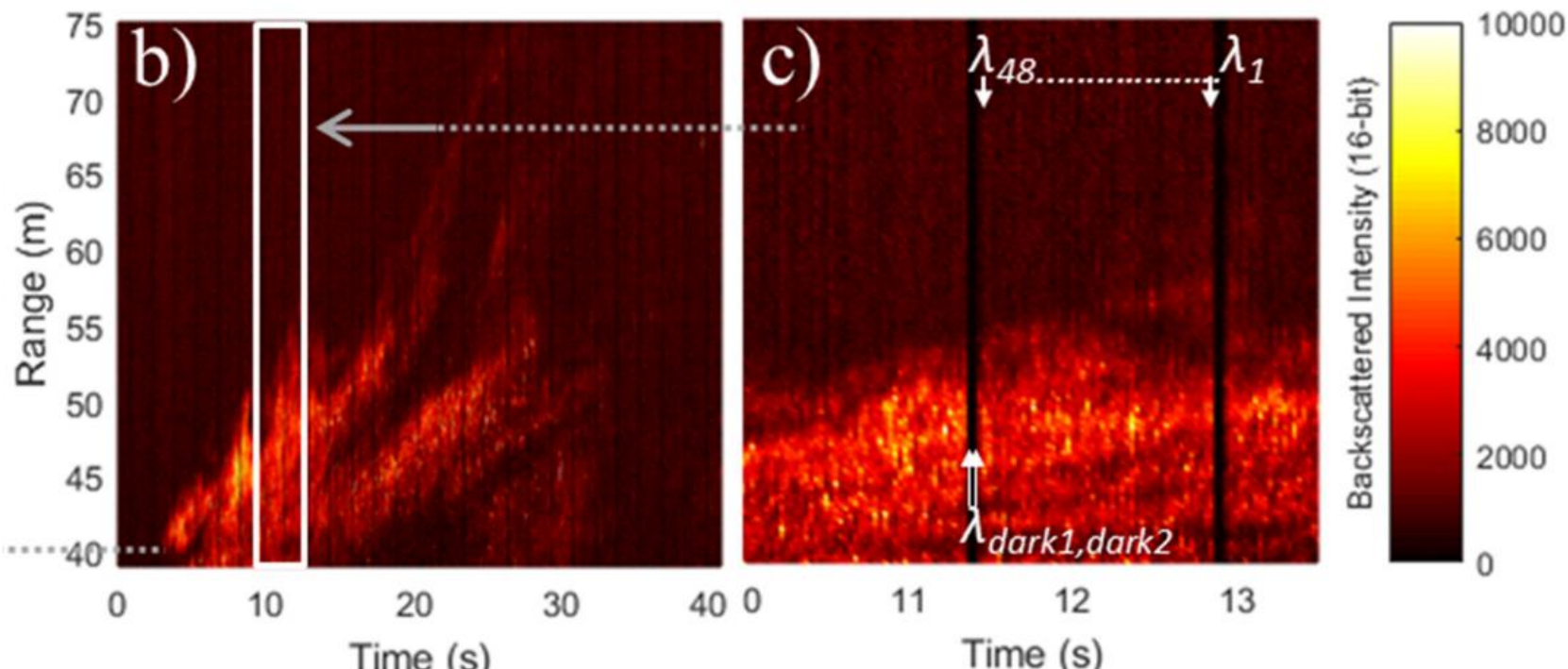


# Managing Green-House Gases

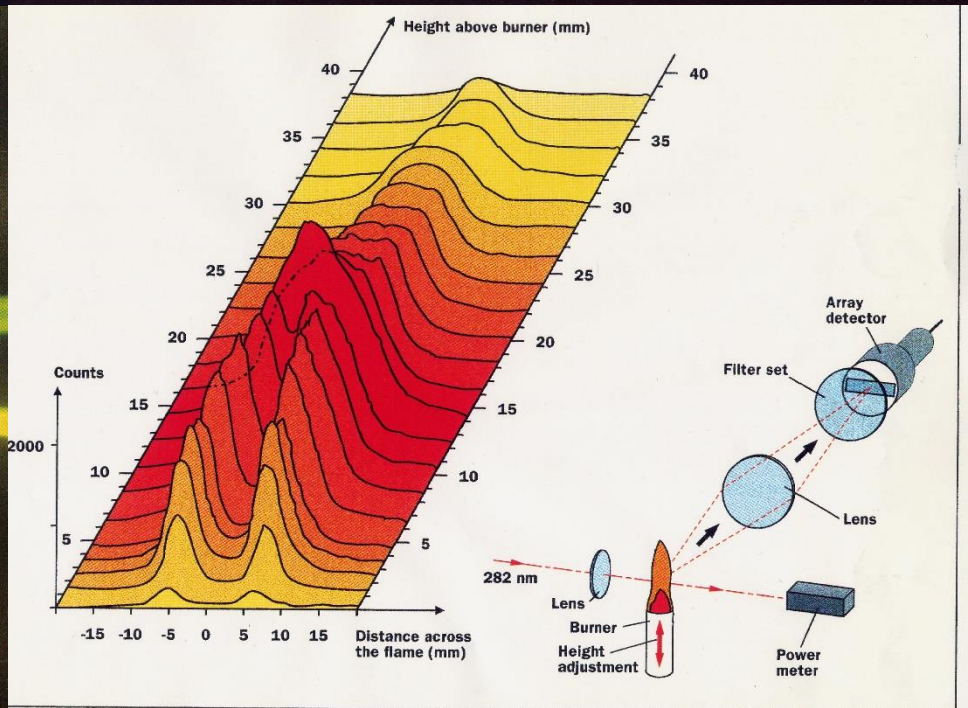
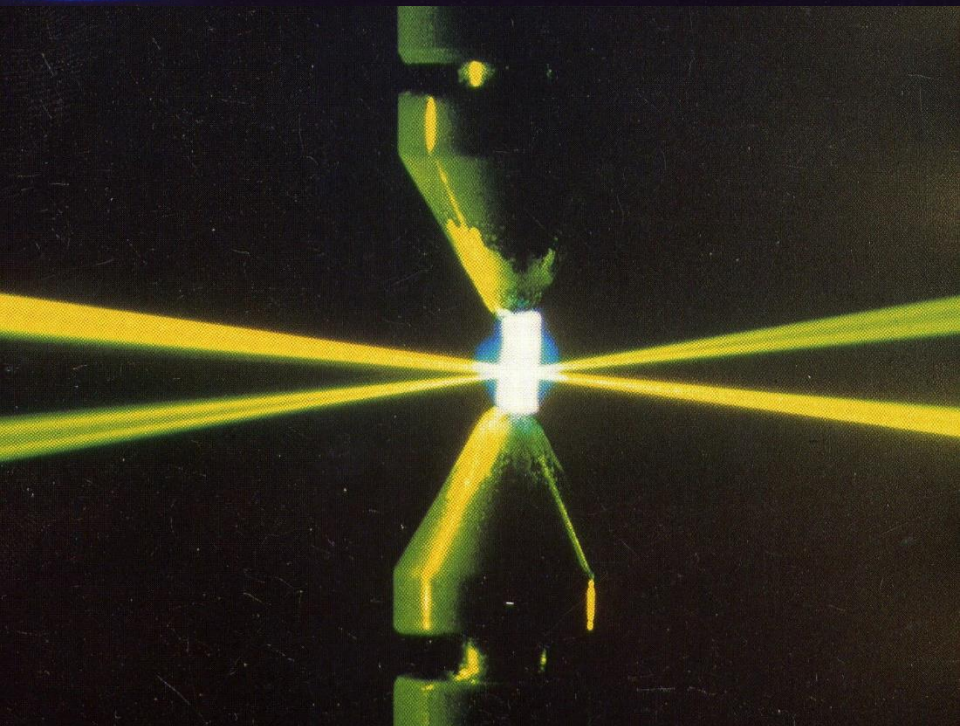
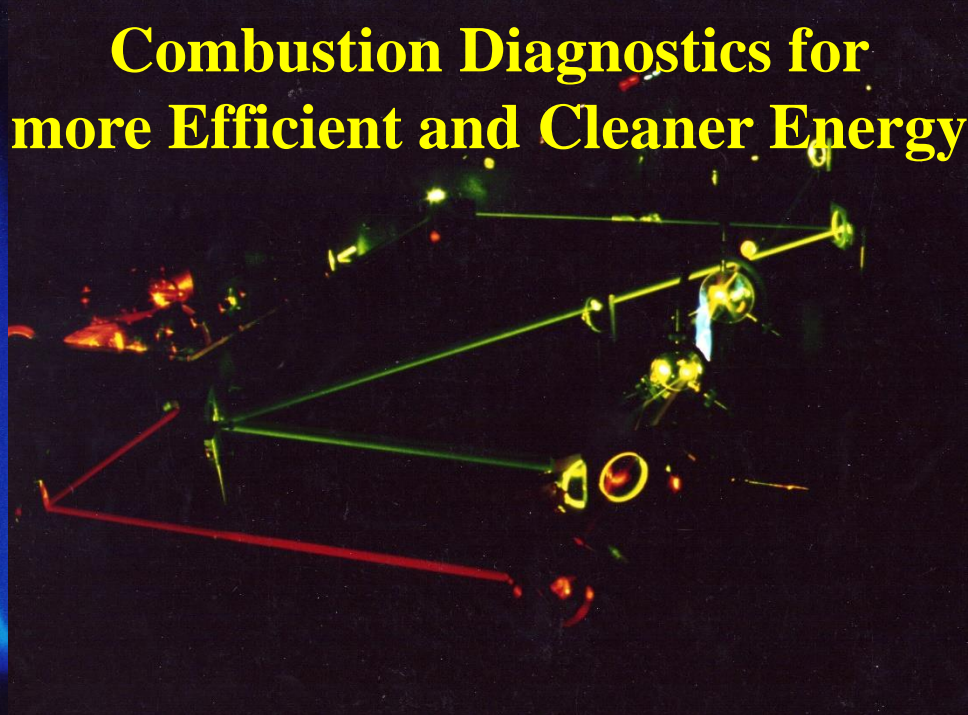
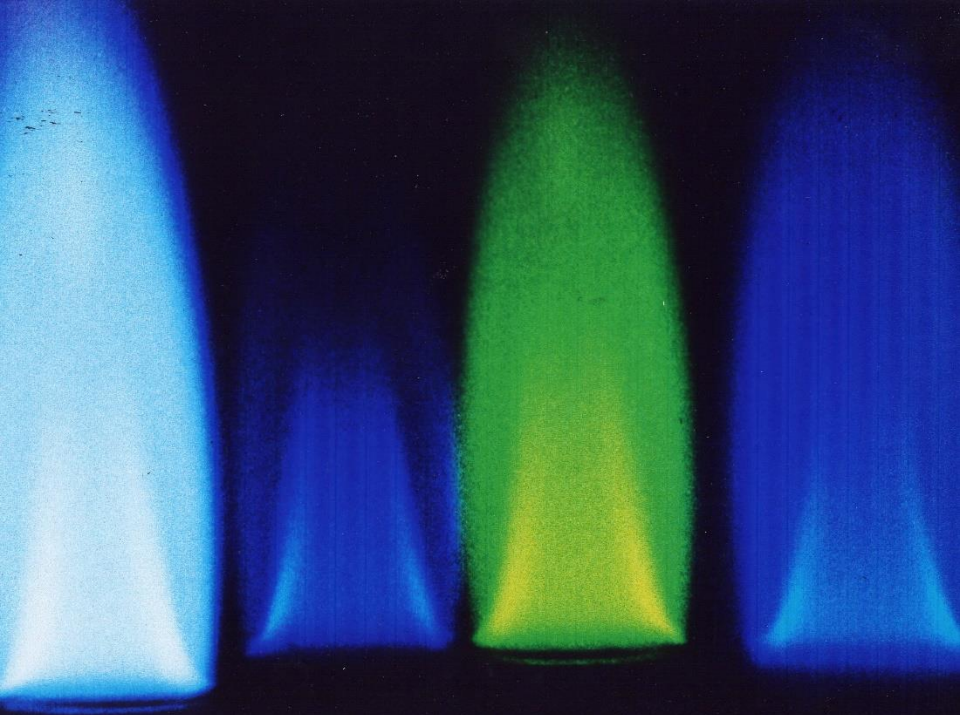
## New way to monitor the carbon-dioxide distribution

Atmospheric CO<sub>2</sub> sensing using Scheimpflug-lidar based on a 1.57- $\mu\text{m}$  fiber source

Jim Larsson et al. Optics Express (2019)



# Combustion Diagnostics for more Efficient and Cleaner Energy



# **Photovoltaics – Artificial Photosynthesis**

**Perovskites for cheap and efficient electricity production ?**

**Mimicking the plants !**

**Processes must be better understood – ultrafast dynamics enabled by lasers !**

**This is a topic at several laser infrastructures**

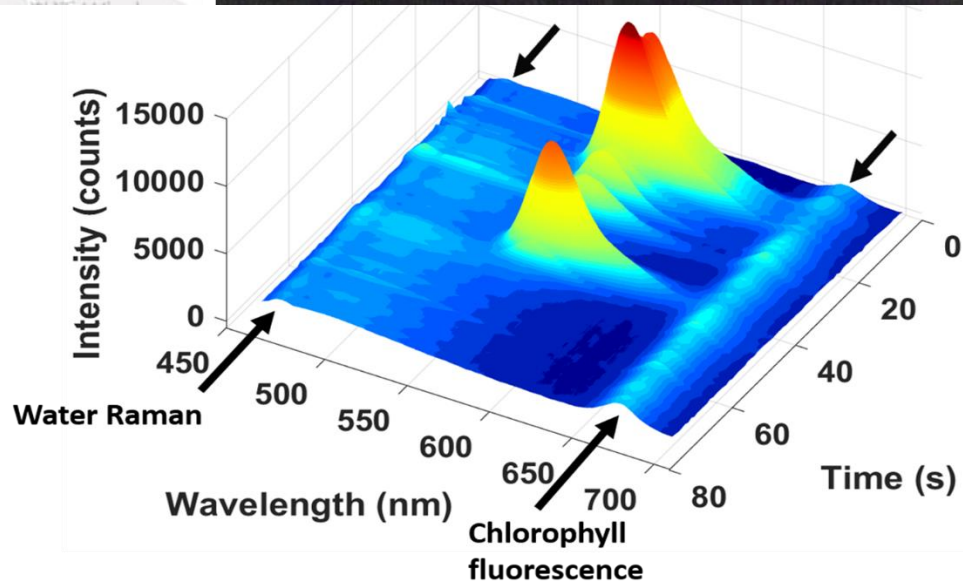
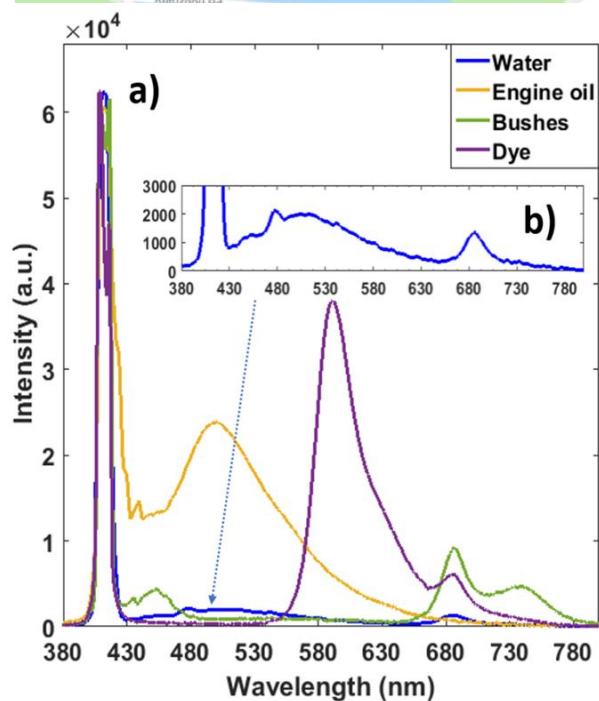
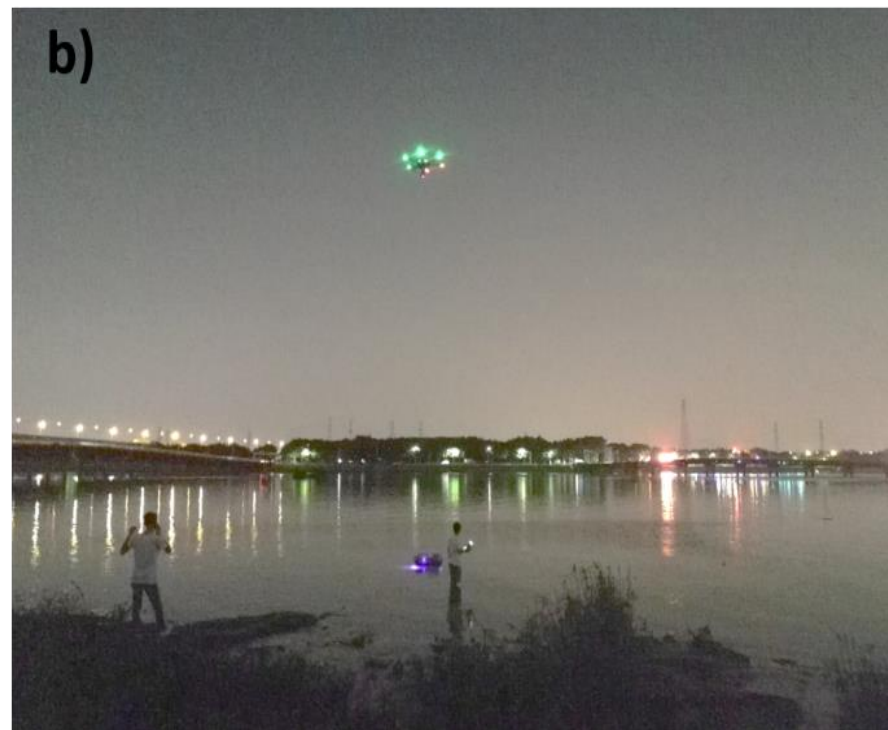
# Healthy Oceans, Seas, Coastal and Inland Waters

Unfortunately, plastics and garbage everywhere, even in open sea!



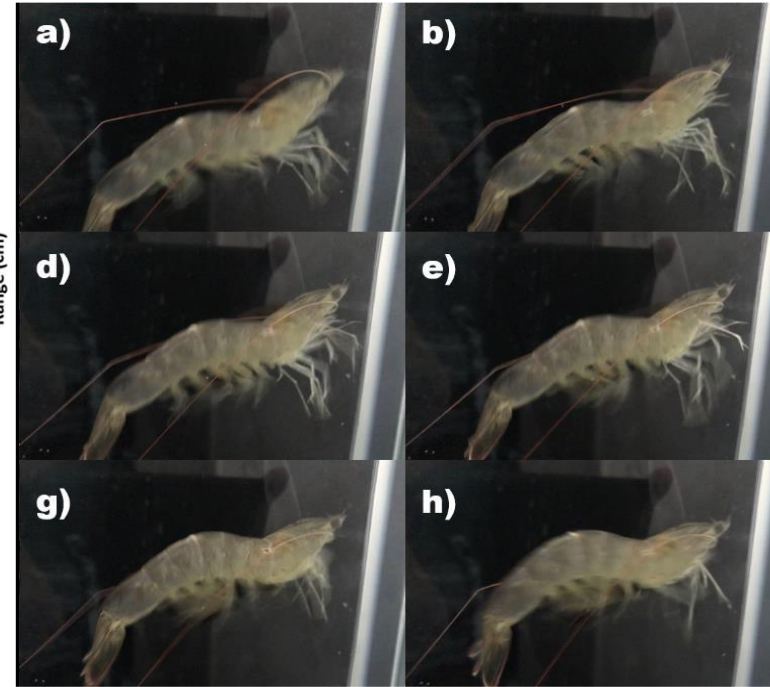
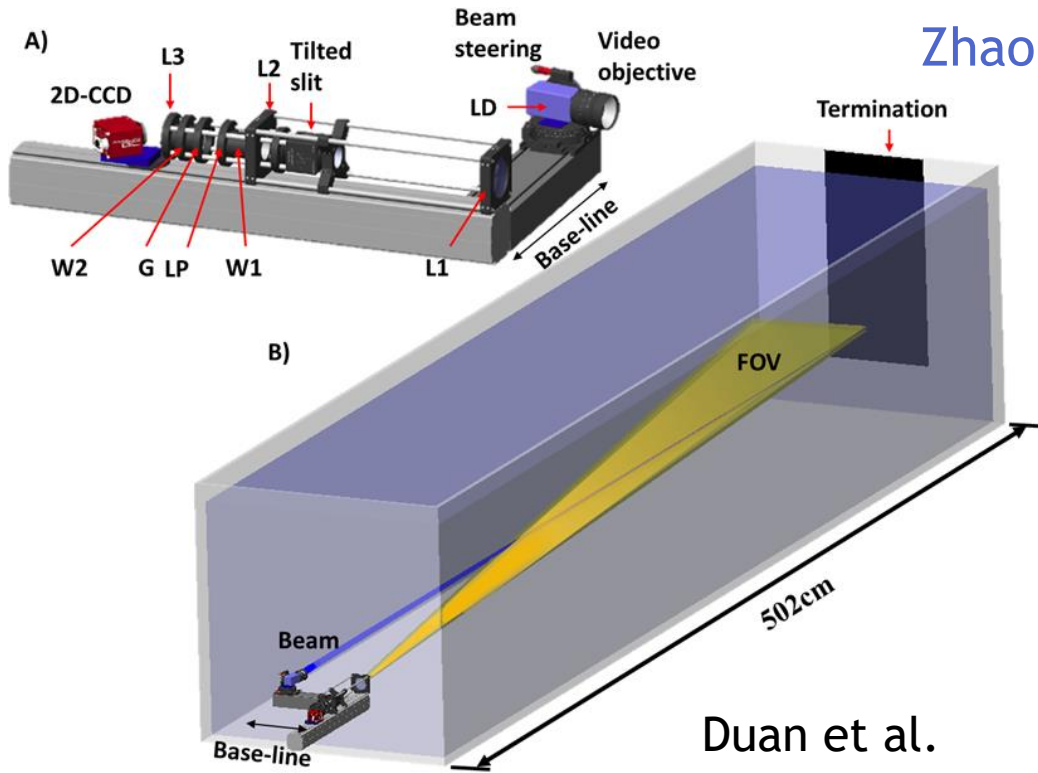
# Drone with laser-based fluorosensor flying over polluted river

Duan et al. (2019)

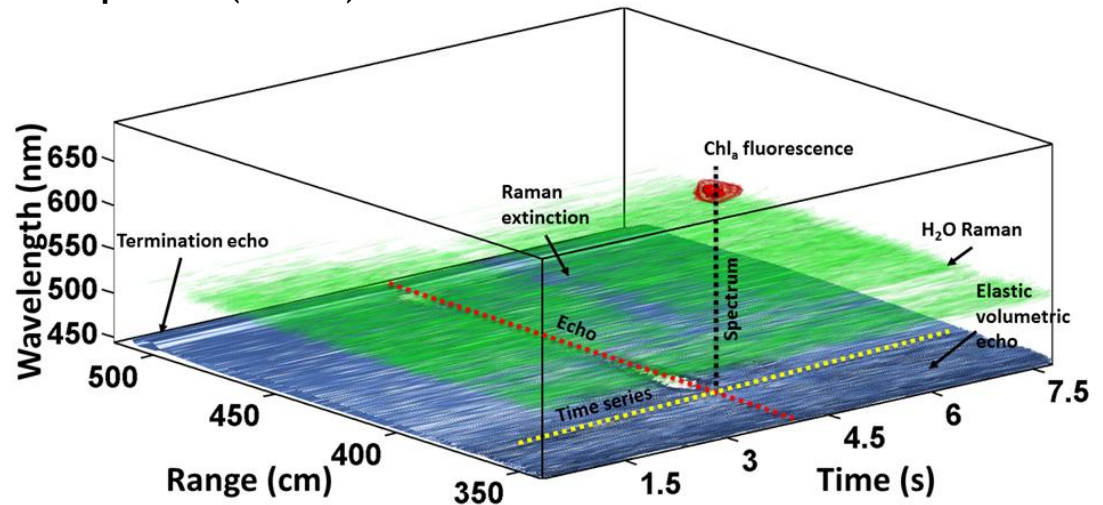
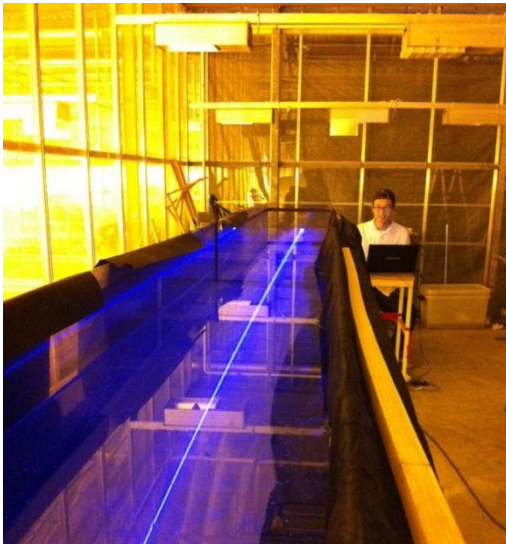


# Underwater CW multispectral aquatic lidar

Zhao et al. L&PR (2016)



Duan et al.  
Optics Express (2019)



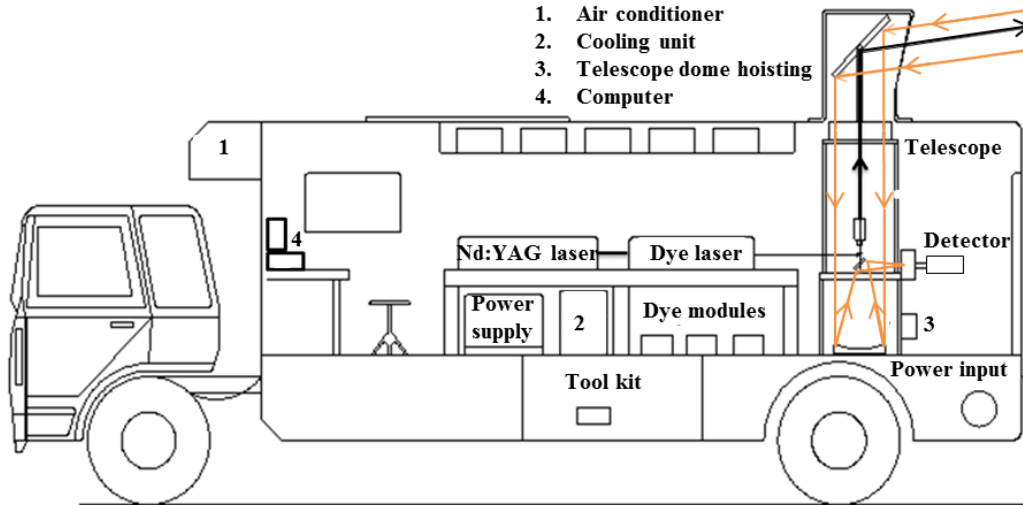
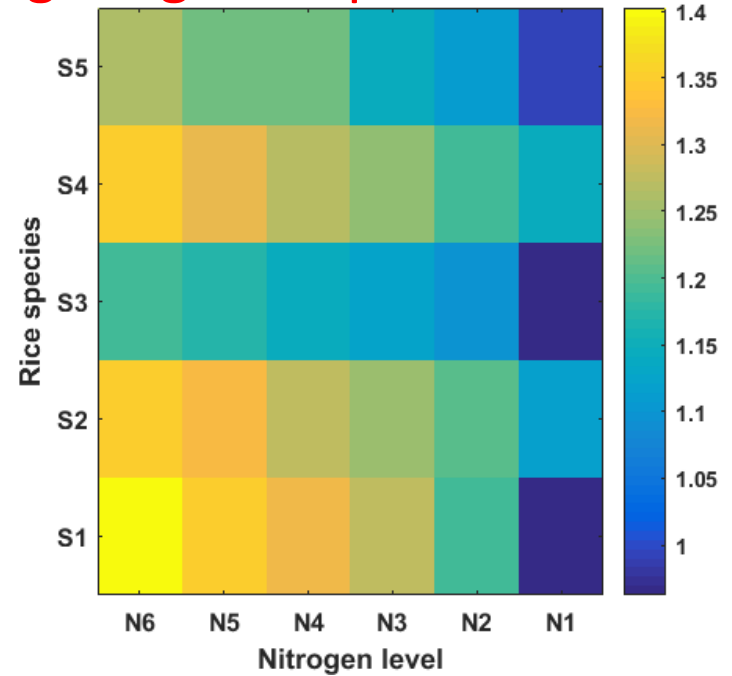


# Soil Health and Food

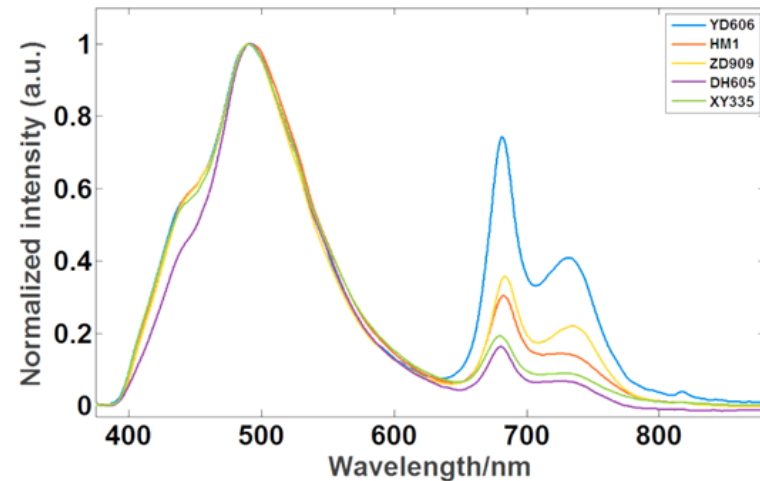


# Agricultural Spectroscopy – Nitrogen contents

## Optimizing crop yield – Fighting eutrophication



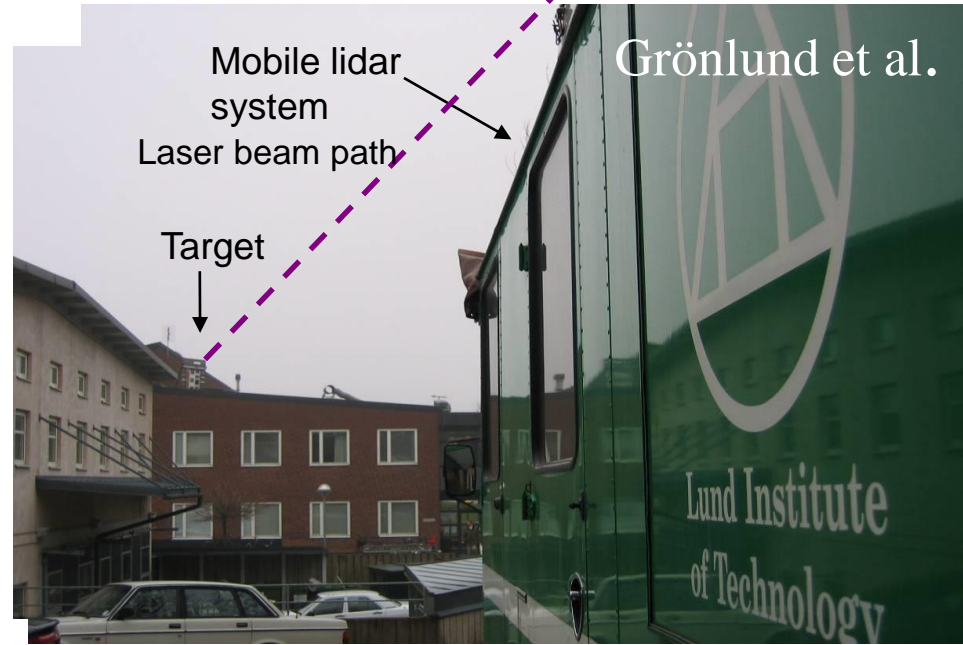
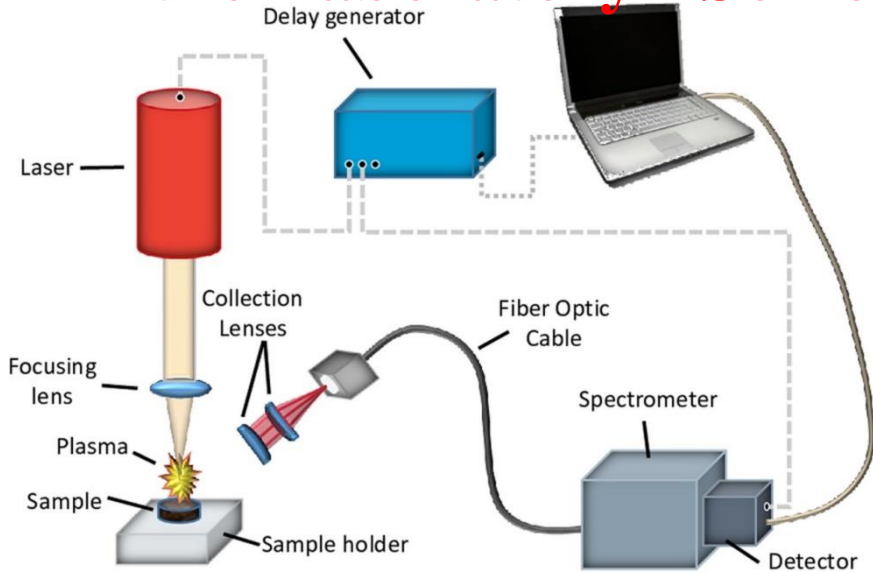
**Zhao et al.; Duan et al.**



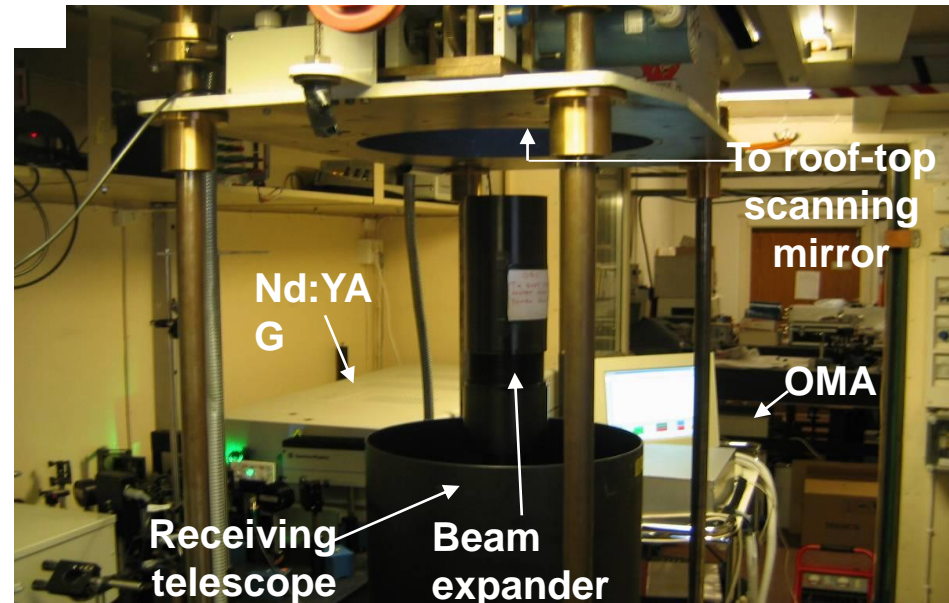
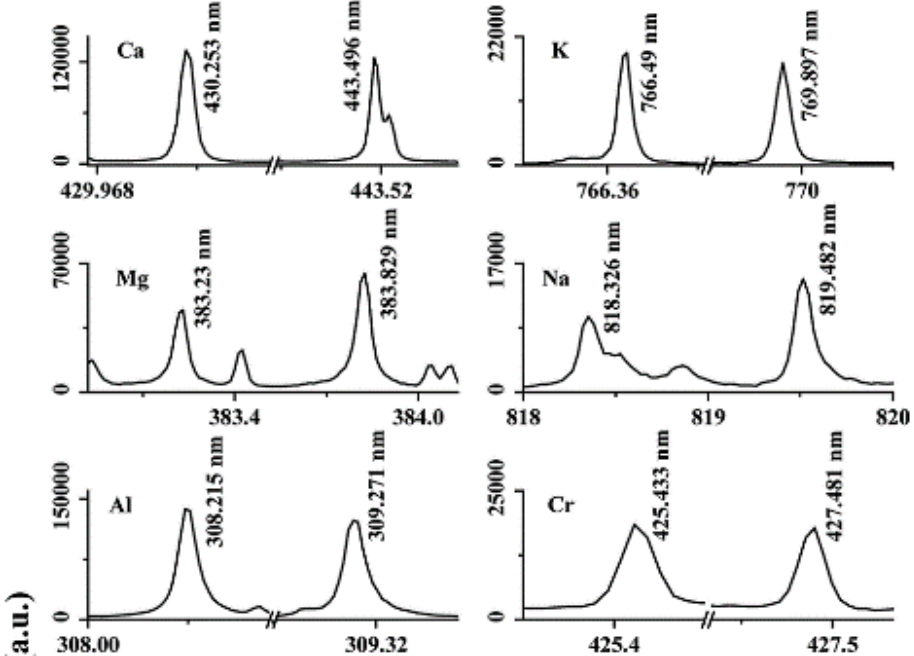
# Laser-induced break-down spectroscopy (LIBS)

## In the Laboratory - Soil contaminants

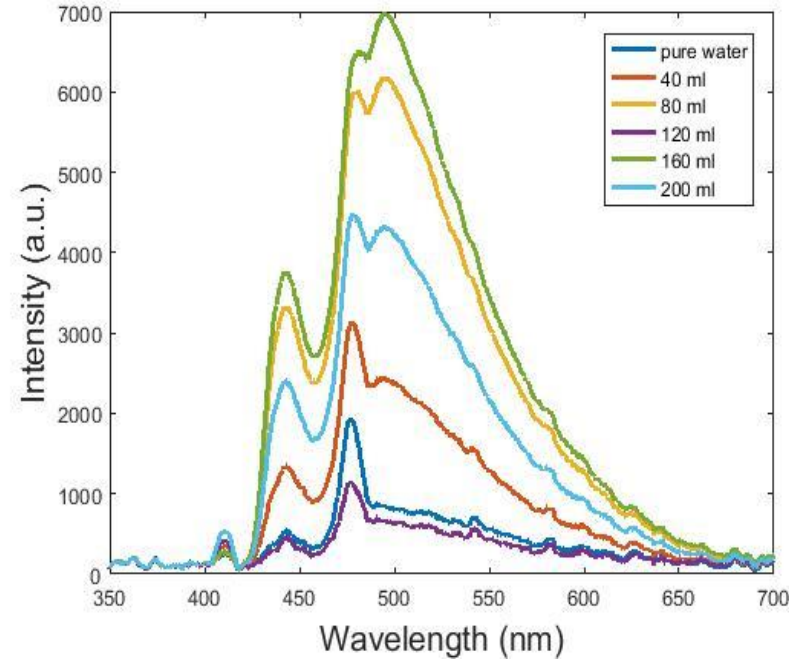
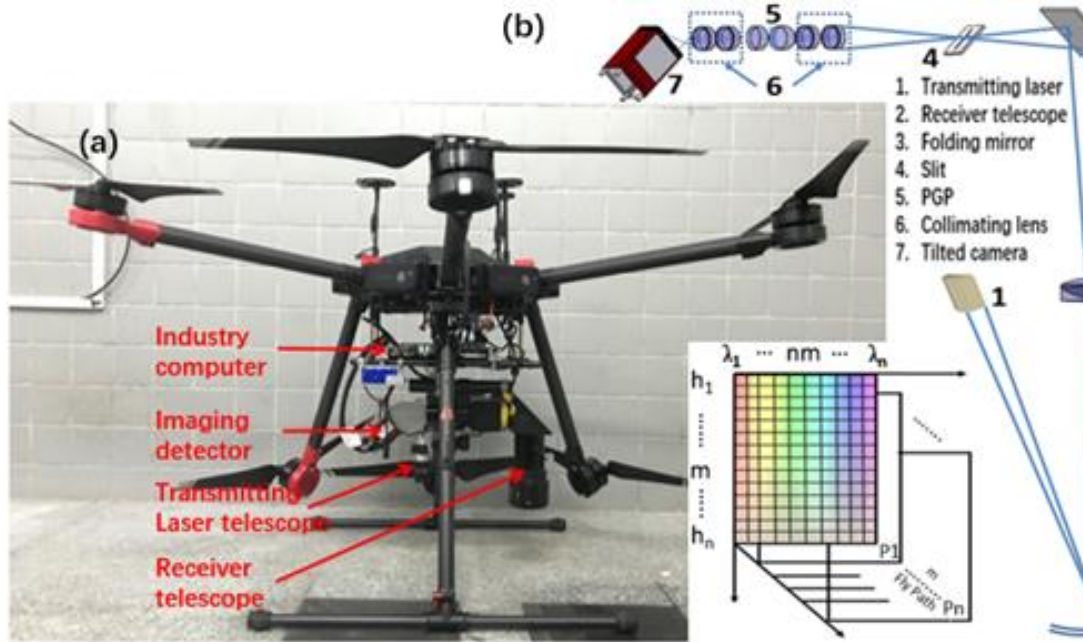
## Remote



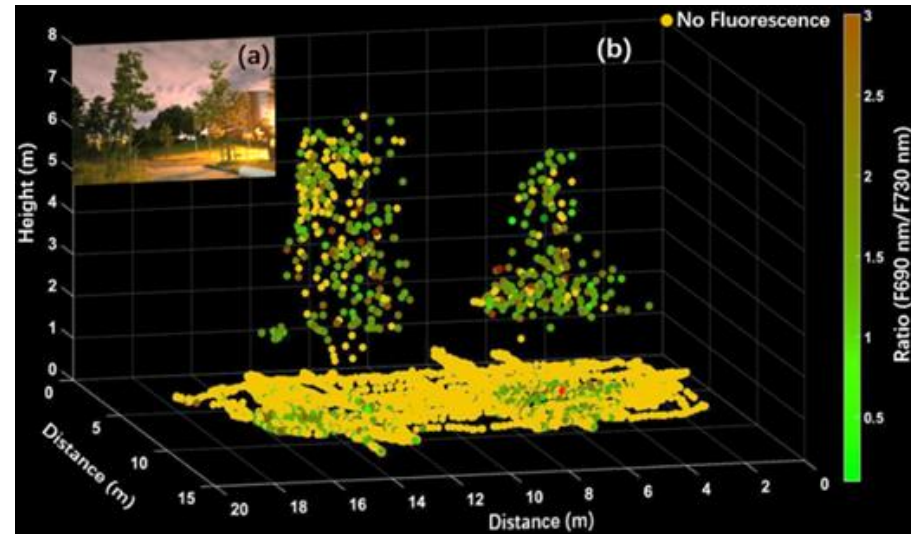
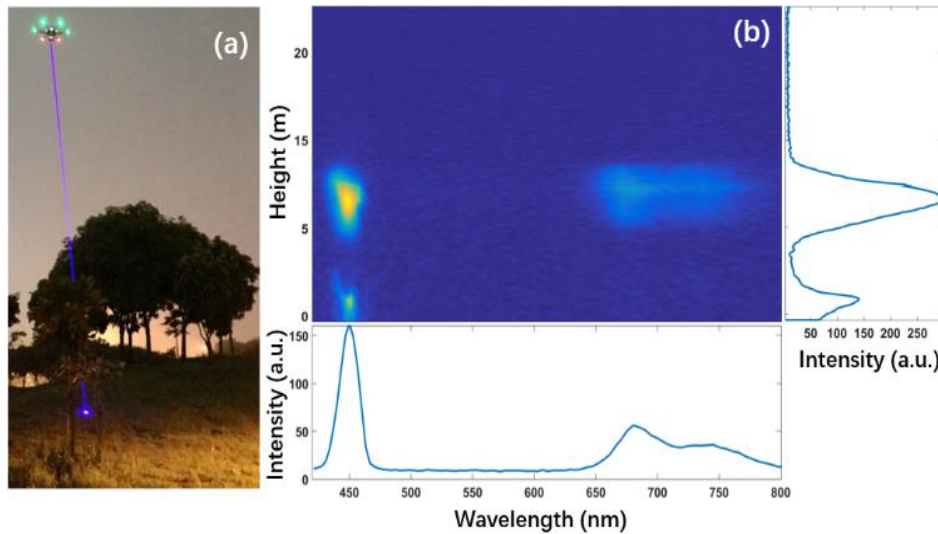
Villas-Boas et al. (2019) Guo et al. (2019)

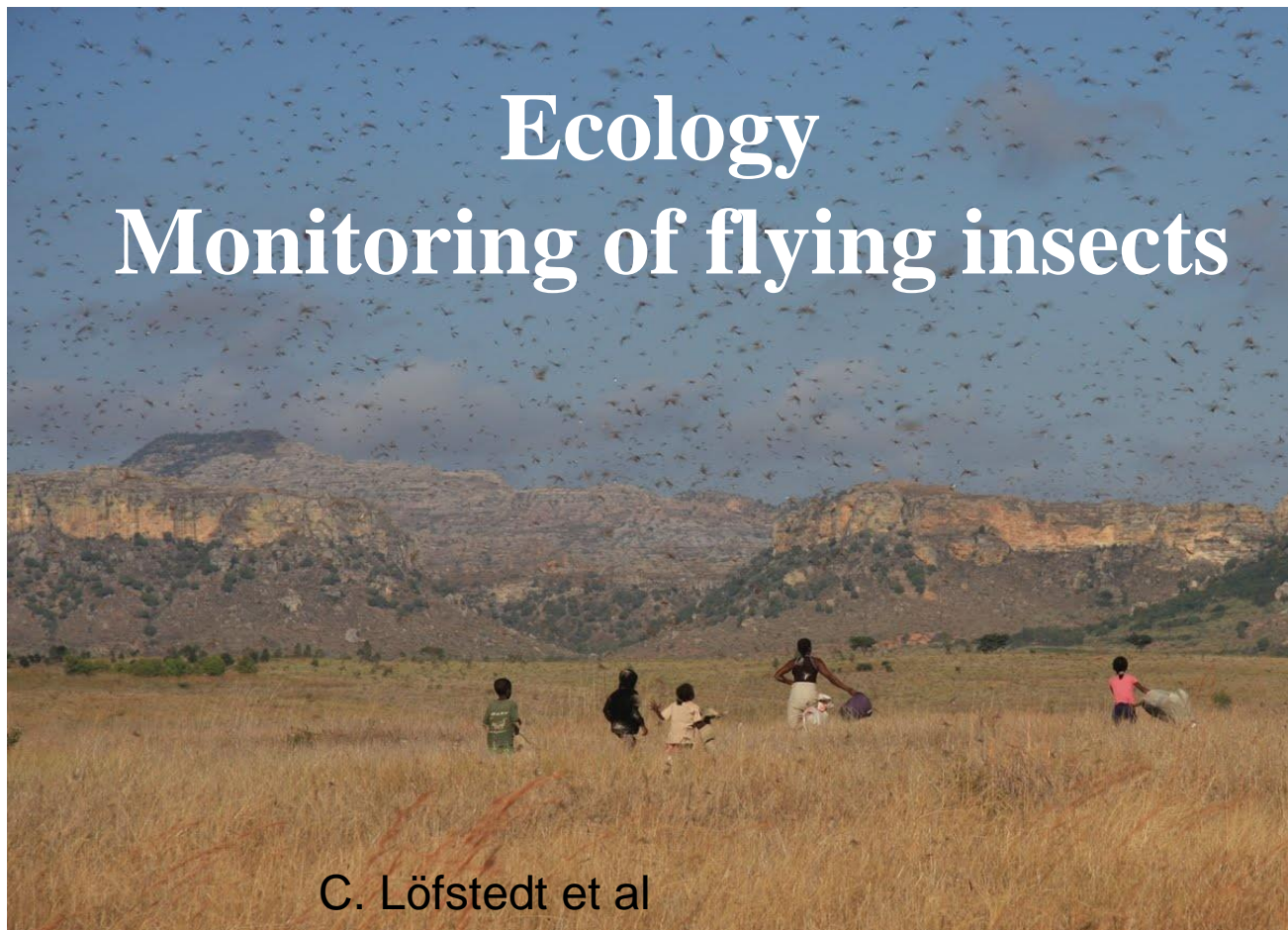


# Drone-based laser-induced fluorescence in vegetation



X. Wang et al. 2018





# Lidar in Ecology



*Calopteryx splendens*



# Food safety





# Non-intrusive monitoring of food and food packages

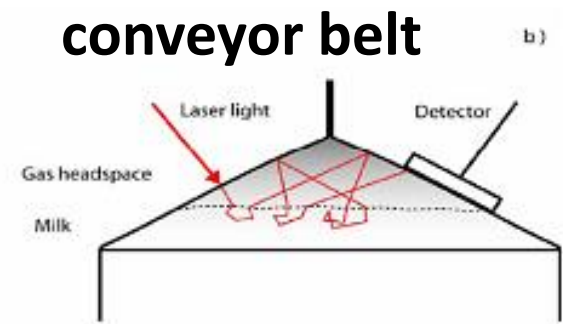
## Technology

- Tuneable diode laser absorption spectroscopy (TDLAS)
- Gas in scattering media absorption spectroscopy (GASMAS)
- Gases of interest: O<sub>2</sub> (760 nm), CO<sub>2</sub> (1.6 μm)

### Partners & Project data

- 1 CONSIGLIO NAZIONALE DELLE RICERCHE, ITALY
- 2 GASPOROX, SWEDEN
- 3 NORSK ELEKTRO OPTIKK, NORWAY
- 4 FT SYSTEM, ITALY
- 5 LUNDS UNIVERSITET, SWEDEN
- 6 L PRO, ITALY
- 7 TEKNOLOGISK INSTITUT, DENMARK
- 8 SANTA MARIA, SWEDEN
- 9 LATTERIA DI SOLIGO, ITALY
- 10 MAREL, ICELAND

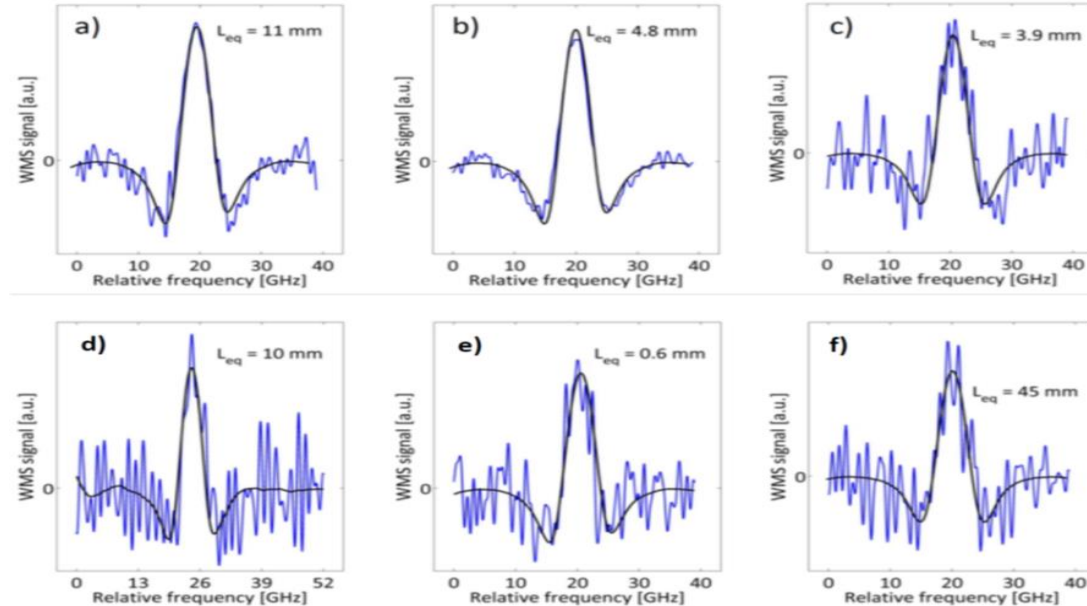
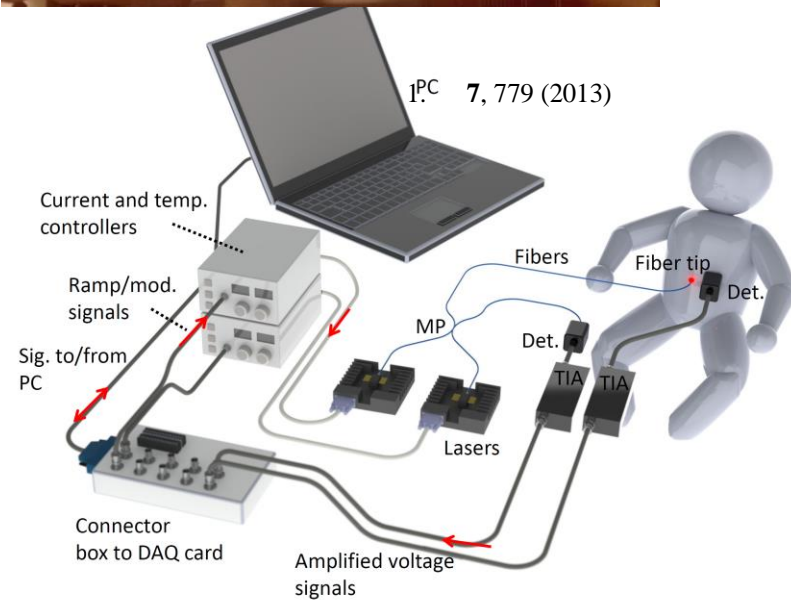
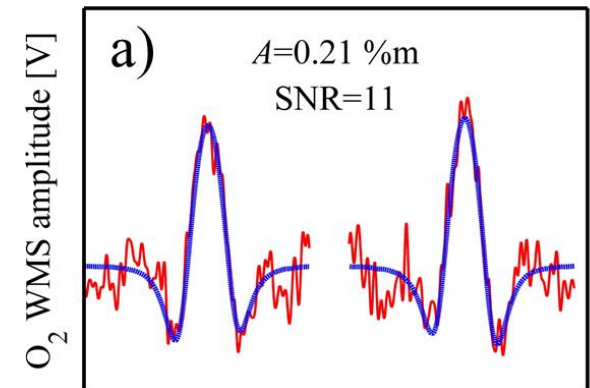
Food is packed in modified atmosphere to achieve longer shelf-life. Equipment is being developed to measure the gas in every single package on the conveyor belt



# 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)



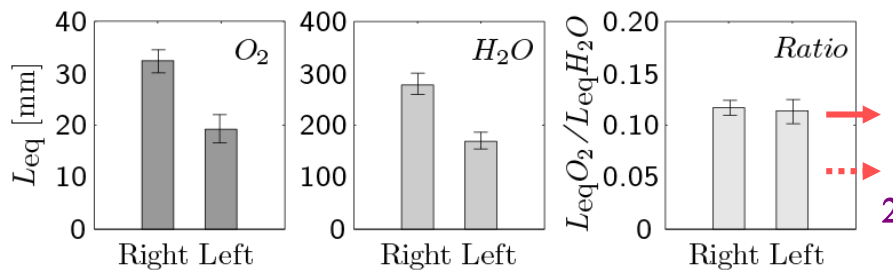
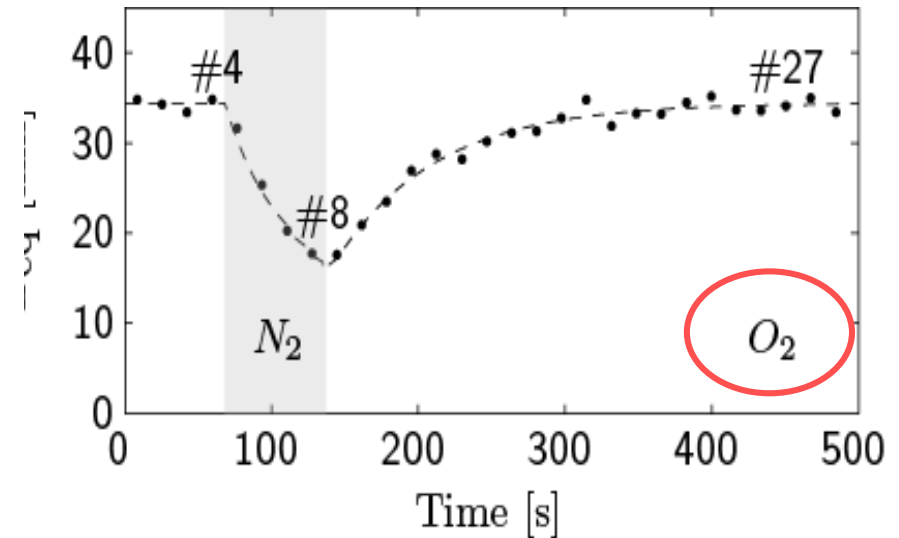
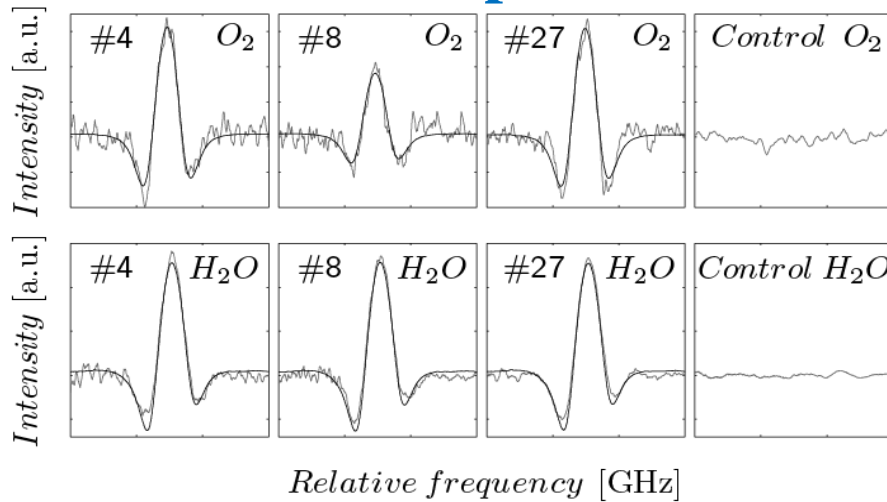
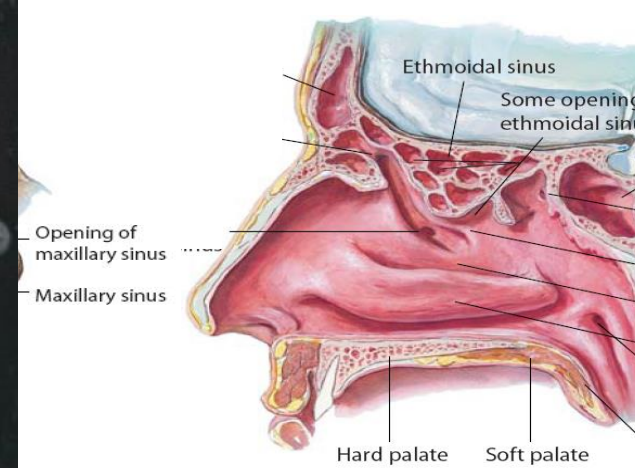
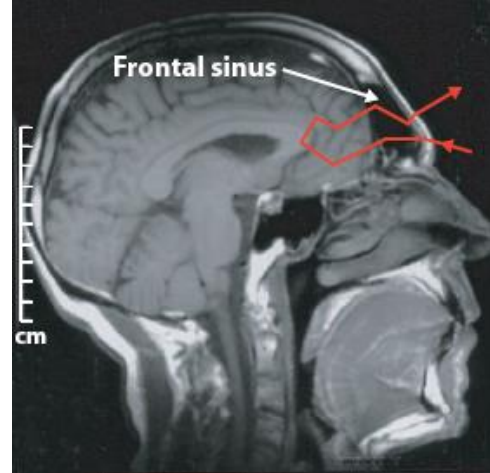
**GASMAS Reviews:** S. Svanberg, *Laser and Photonics Reviews* 7, 779 (2013)

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

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

# Fighting Antibiotics Resistance

Sinusitis diagnostic by laser-spectroscopic measurement of oxygen and water vapour

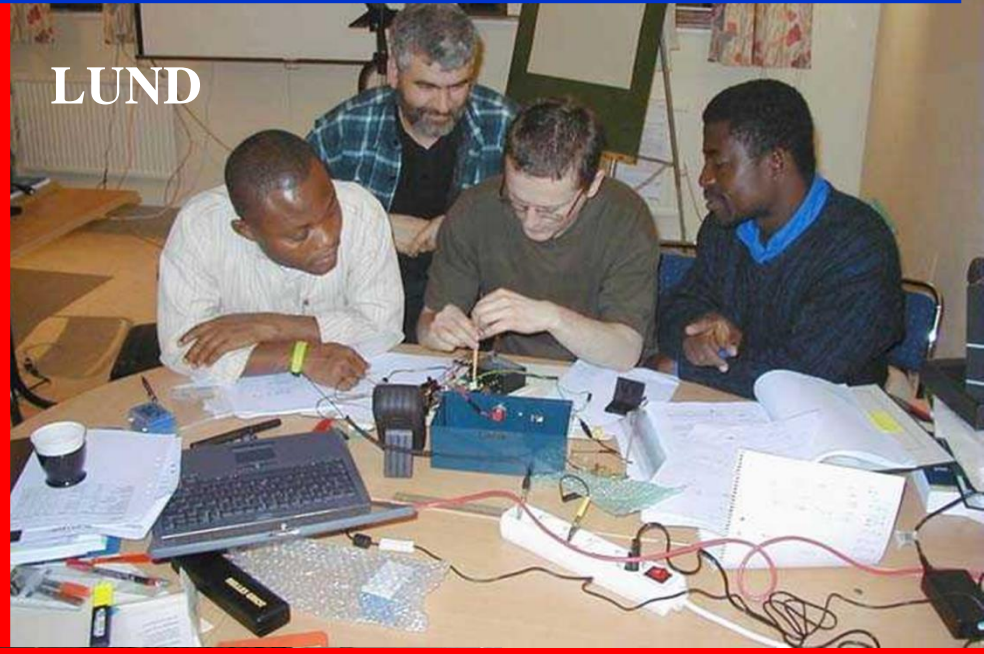


# Realistic Applications for the Developing World

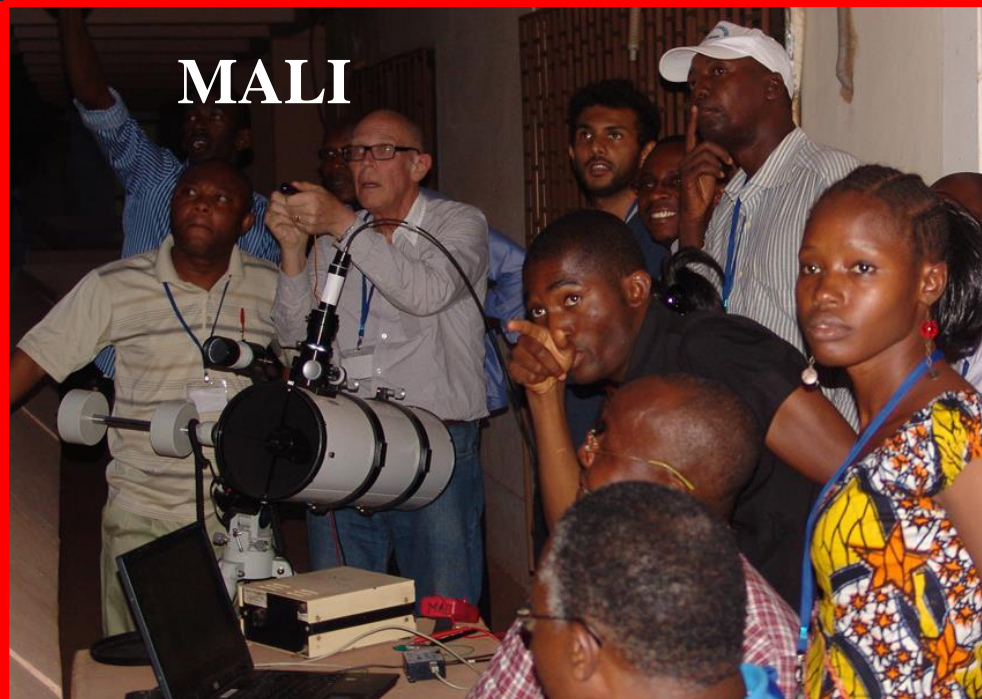
KENYA



LUND



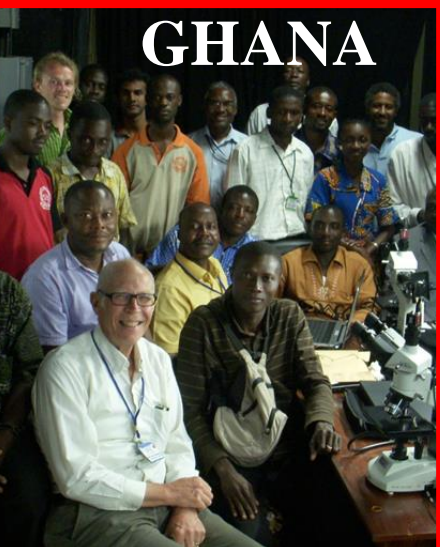
MALI



GHANA



GHANA





*Complex problems can be attacked by combining different expertises, and different advanced techniques, available and being developed at **Research Infrastructures** !*