



*Biophonet*



# Biosensor Technology - an overview

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October 6. 2005

# Bioneer in short



- **Contract Research and Development within Biotechnology & Biomedicine**
  - Molecular detection
  - Vaccine technology
  - Enzyme technology
  - Mammalian cell technology
  - Recombinant production
  - Contract manufacturing
- **Owned by the Technical University of Denmark**
- **22 scientists, 15 Tech & Adm**
- **Funding:**
  - Contract research
  - Company-University collaborations



Some danish activities.....

bioner

~~BIOPHOTONET~~

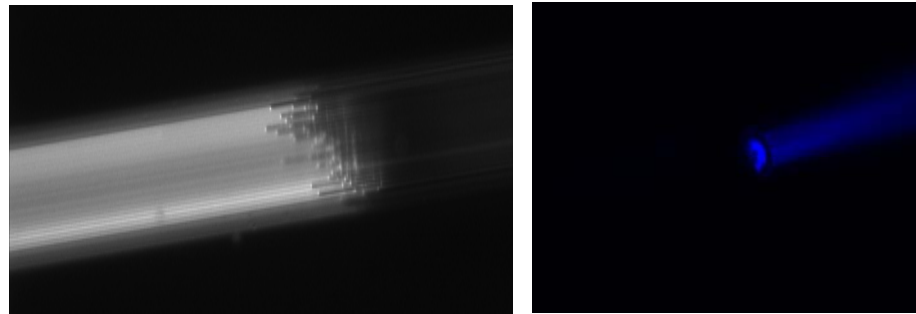
**Danish High Technology Network for Biophotonics**  
– headed by Risø National Laboratory with participating  
Danish industry and research institutions

**Danish Sensor Initiative**  
STC A/S & companies & research  
Center for Biochips  
Center for optical sensors



**Center for biomedical  
Optics and New laser  
systems**

# Biosensor technology – a overview



- **FACTS**
  - What's a .....
  - A finite number of concepts and applications....
  - A boost to development - market
  - Validation criteria
  
- **FUTURE (near and distant)**
  - Telemedicine
  - Nanophotonics
  
- **CONCLUSION**

## Sensor

A device that provides information about the state of a physical system

Compact and robust

**Matched to the system - not the other way around**

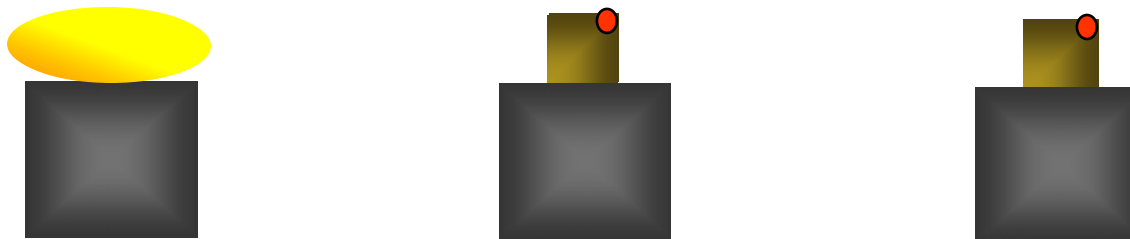
## Biosensor

**A device that provides information about the state of a chemical/biochemical/biological system.....**

# A finite number of concepts and applications....

# A finite number of concepts and applications 1

- chemical sensors – ions often electrode sensors
- bioconversion sensors - an organic molecule sensor (glucose sensor) – often electrode sensors
- biochemical affinity sensors - a molecular binding event (receptor ligand), **often waveguides, acoustic sensors**
- Invasive/non-invasive – optical coherence tomography, MR etc





# A finite number of sensors 2 - Chemical sensors - measurement of ions

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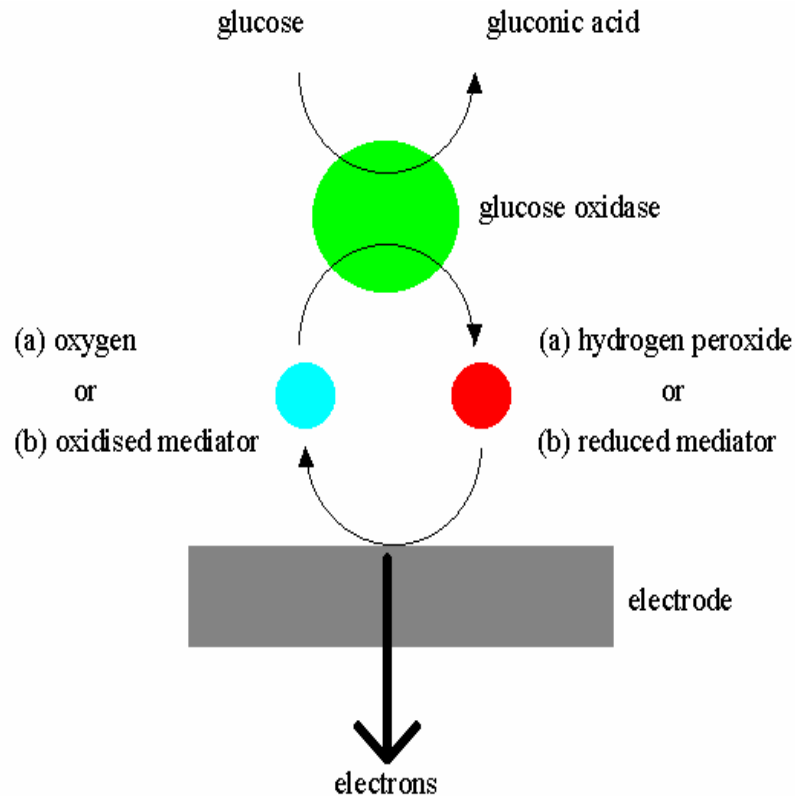


Chemical electrodes  
Microbial sensors

<http://www.unisense.dk/products/products.html>

**Main applications: Analysis of inorganic molecules**

# A finite number of sensors 3 - Enzyme electrodes I



To measure the glucose concentration, three different methods can be used:

1. Measure oxygen consumption by an oxygen sensor
2. Measure acid (gluconic acid) production by a pH sensor
3. Measure production of  $H_2O_2$  by a peroxide sensor.

**Main applications: Analysis of organic molecules**

# A finite number of sensors 4 - Enzyme electrodes II

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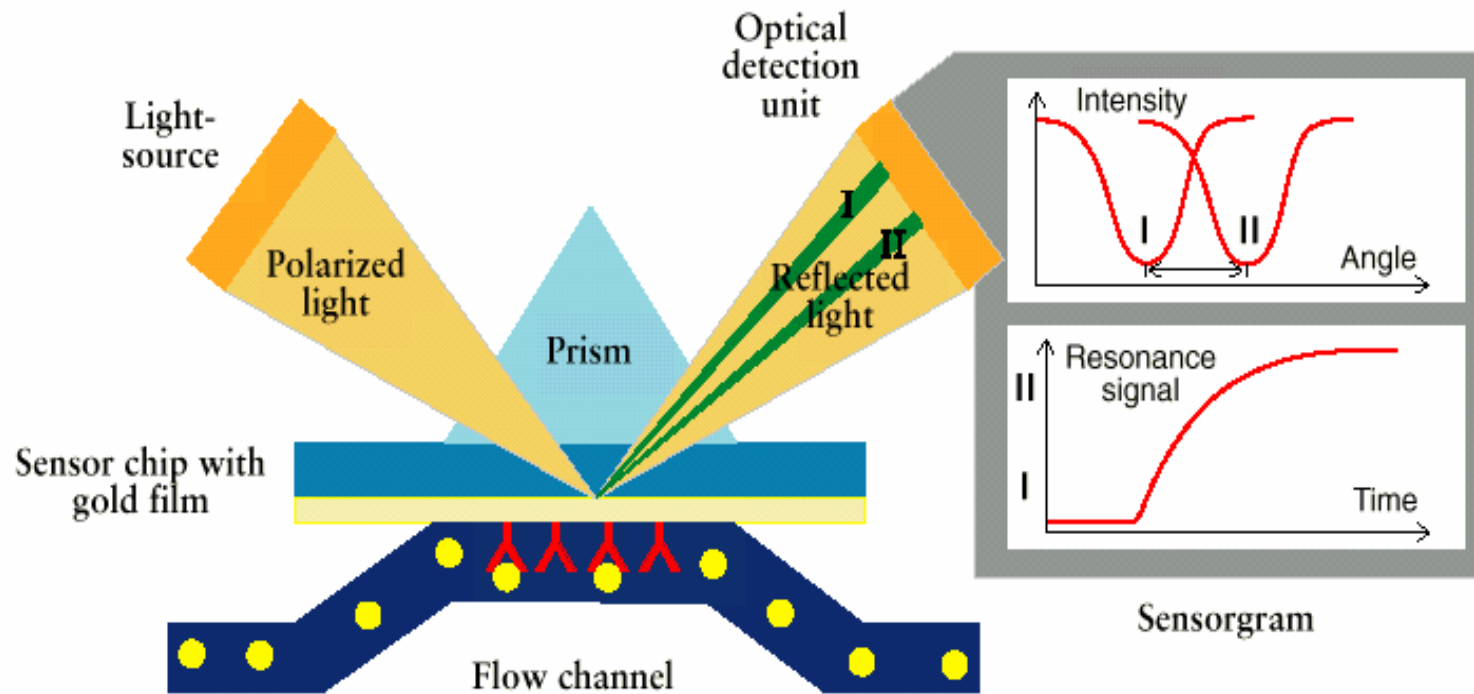


## **MediSense: Home Blood Glucose**

Invented, designed & developed  
at Cranfield with Oxford Univ.

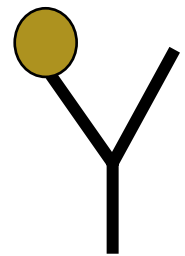
**i-Stat Hand-held Critical  
Care Monitor** – Multianalyte  
Silicon-based technology  
cholesterol

# A finite number of sensors 5 - Molecular binding events I



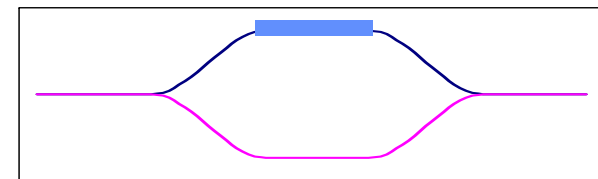
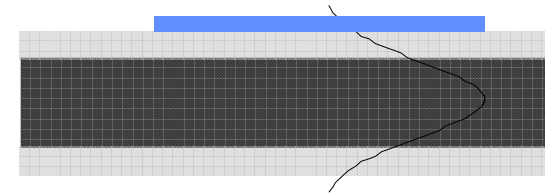
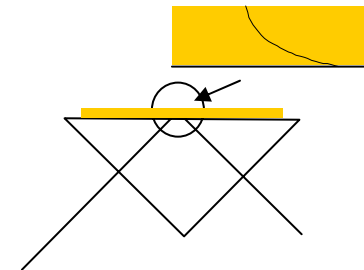
Surface Plasmon Resonance, (Biacore)

## Main applications: Molecular binding analysis



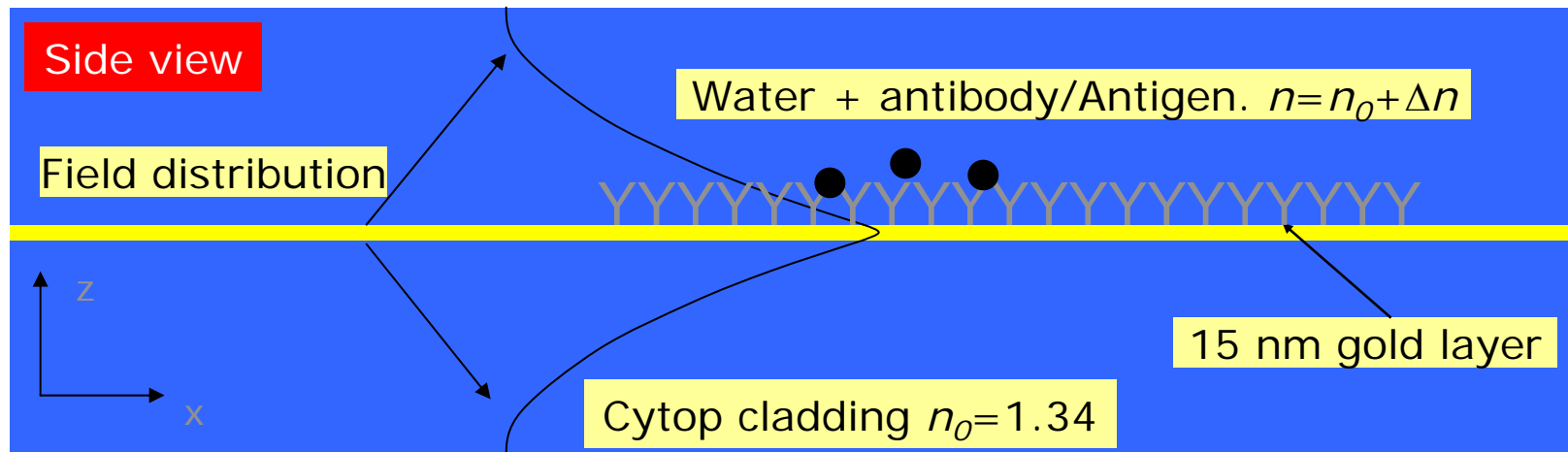
# A finite number of sensors 6 - Molecular binding events I

- A way of separating the optics and the target (e.g. with a TIR prism)
- Waveguiding can be exploited
- Can be combined with interferometric methods – making it possible to detect extremely small phase delays
- Very small sensing region



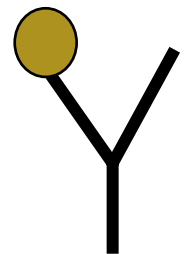
# A finite number of sensors 7 - Molecular binding events II

## Long-range surface plasmon-polariton waveguides



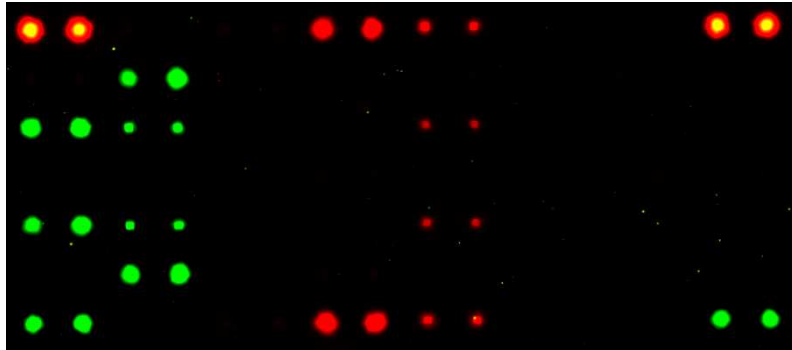
and other guiding principles: ultrasound guides

## Main applications: Binding analysis



Thomas Nicolaisen, Lars Lading, Bonni Kryger, Lars H. Pedersen

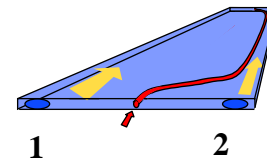
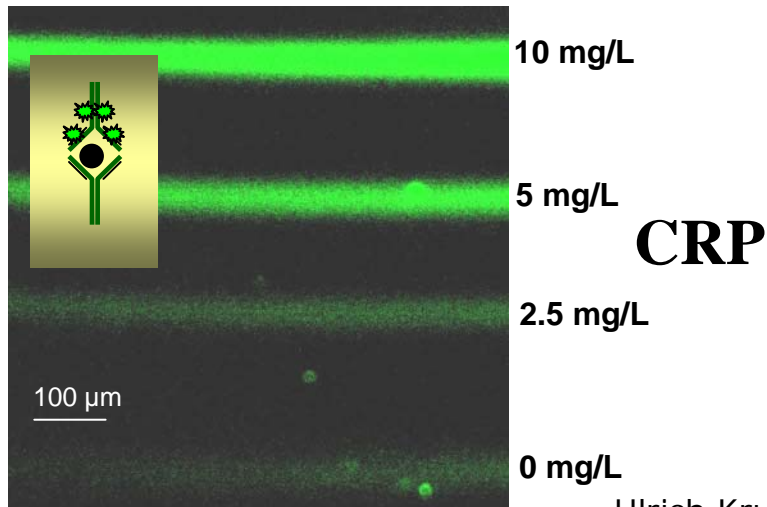
# A finite number of sensors 8 - Molecular binding events III



## Pattern analysis, DNA chip

- *E. avium*
- *Bifidobacterium infantis*

Kim Holmstrøm, Poul Erik Høiby, Pernille Skouboe



Unique flow system

whole blood analysis

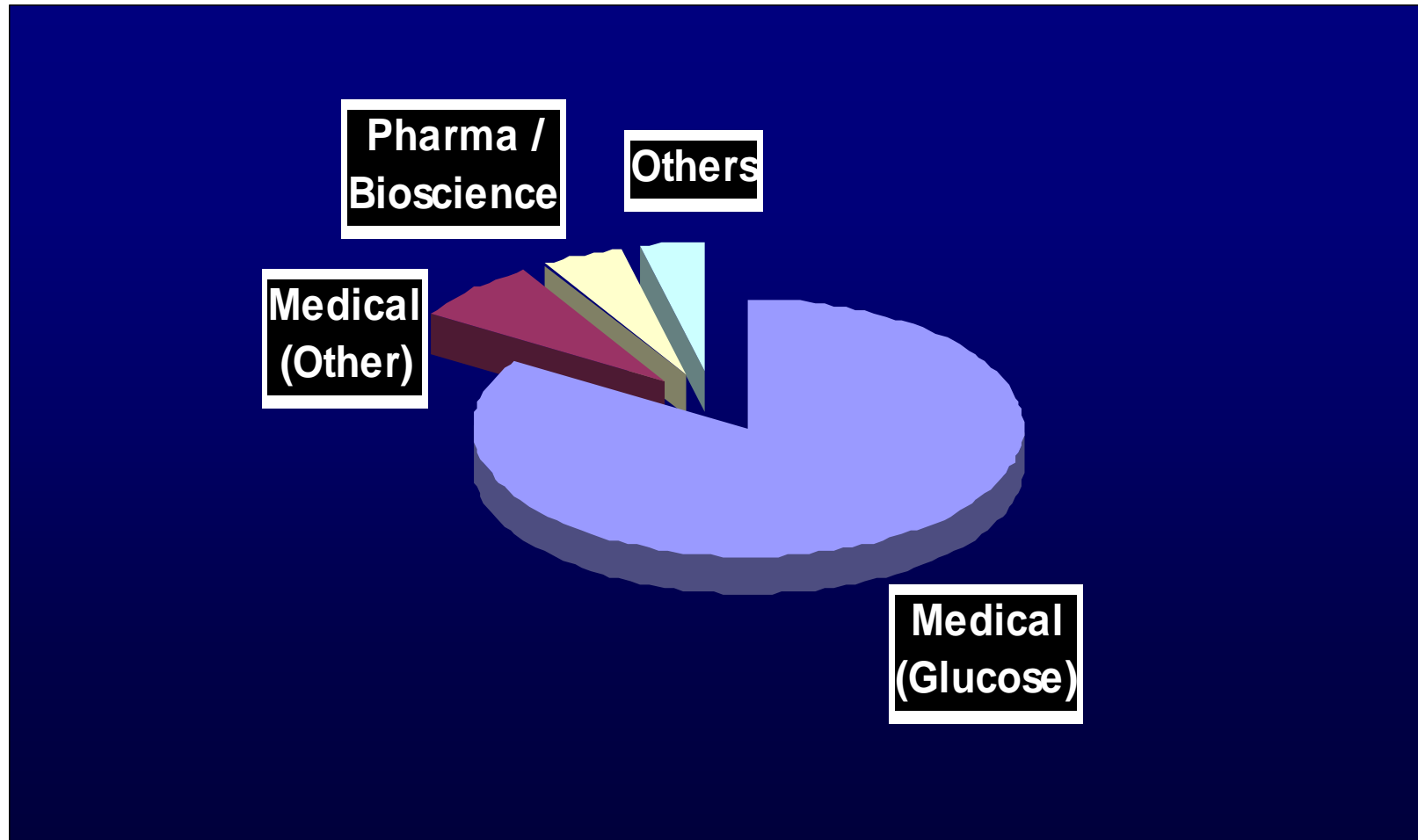
Ulrich Kruhne, Technological Institute (Celtor Biosystems)  
Rachel Kahn, Lars H. Pedersen, Thomas Brevig

## Multiplex on chip molecular signatures

## A boost to development - markets

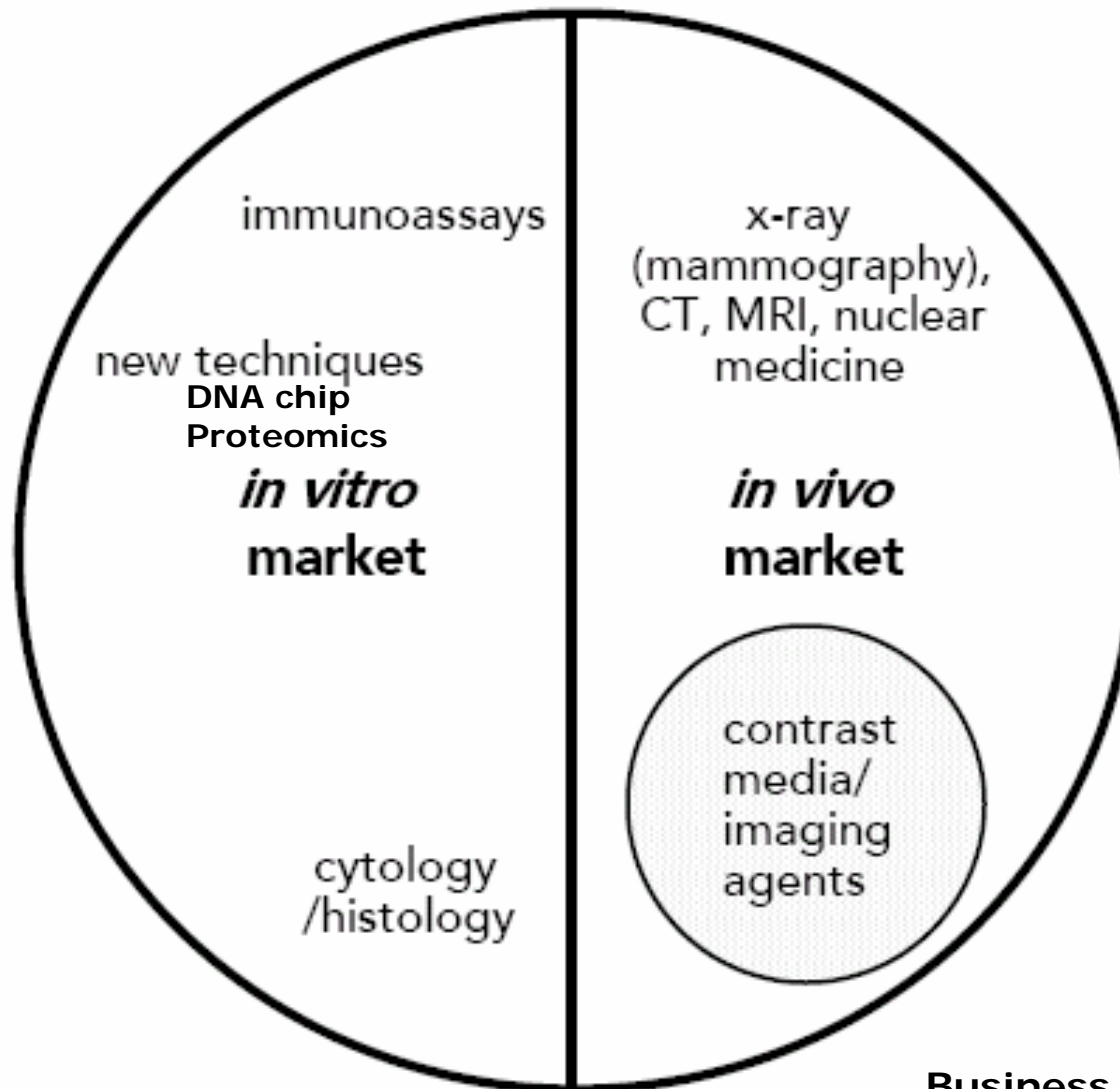


# A boost to development 1 – Market 2002 .....



**Total World Market in 2002 = \$2.1b**

# A boost to development 2 – In vitro and in vivo market



Business Insight, 2004

- **Point of care, (estimated 115000 units in US alone)**
  - Physicinas office
  - Clinics
  - Emergency rooms
  - Operating rooms
  - Intensive care units
  
  - **Tests include**
    - Blood components
  
- **Patient self testing,**
  - Infections (strep throat)
  - Pregnancy
  - Blood pressure
  - Cholesterol,
  - Glucose
  
  - **To come .....soon**
    - HIV
    - Faecal blood tests
    - Urinary tests

new market drivers .....

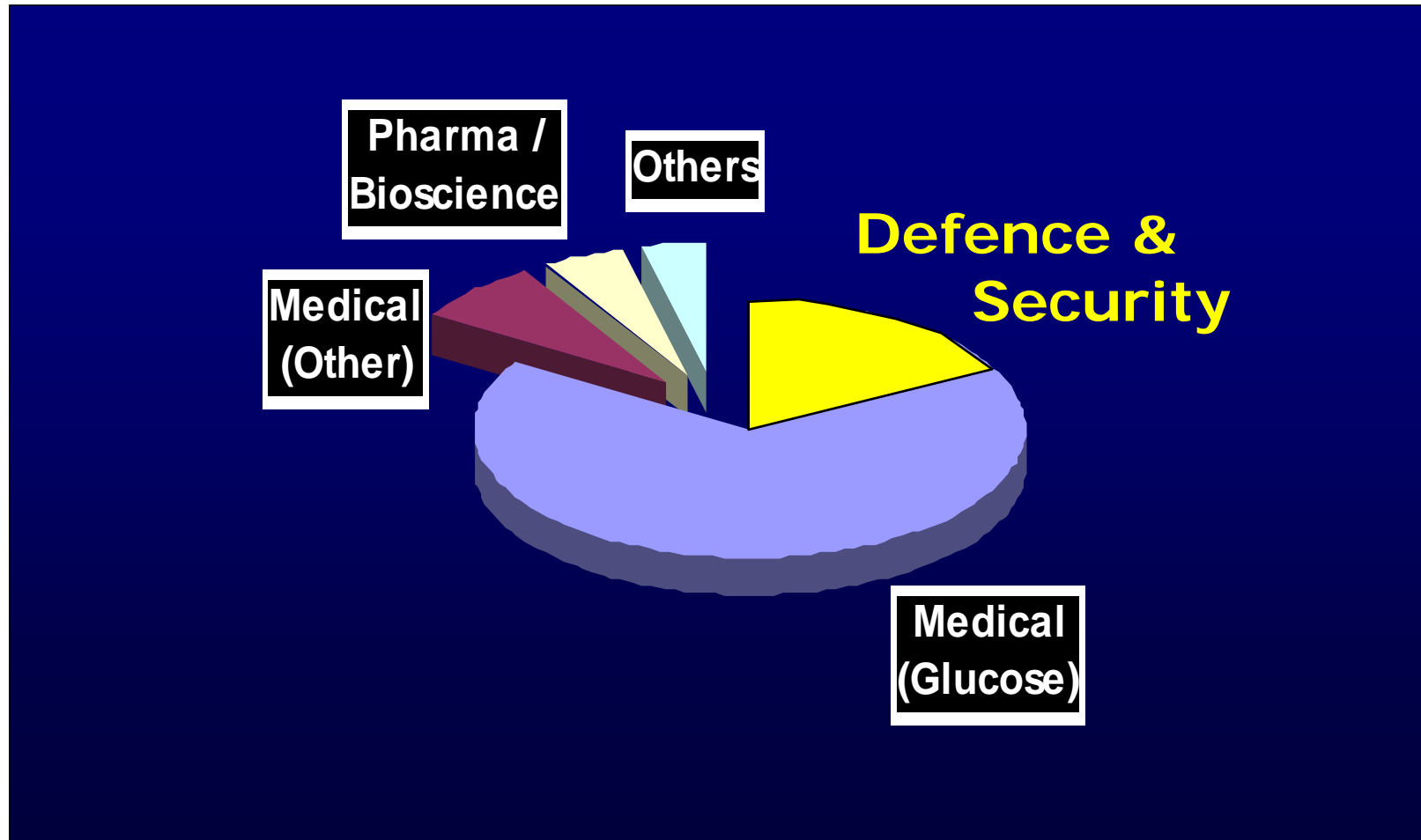
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FBI homepage

A boost to development 4..new  
emerging opportunities.....

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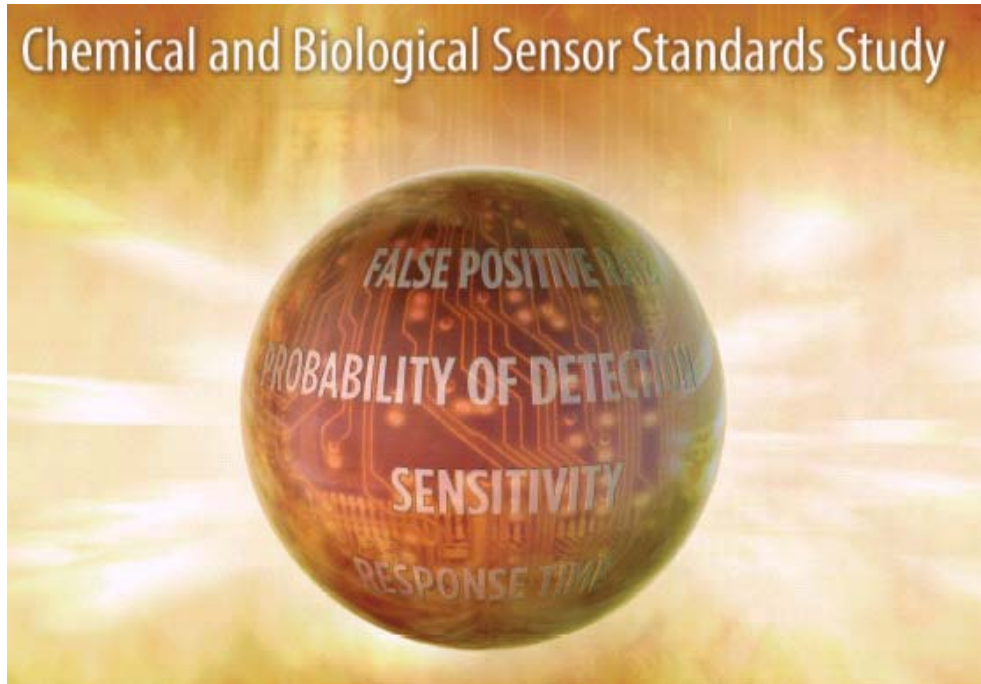
**Total World Market in 2010 = \$ 4b ?**

## Validation criteria

# Validation criteria 1



## Chemical and Biological Sensor Standards Study

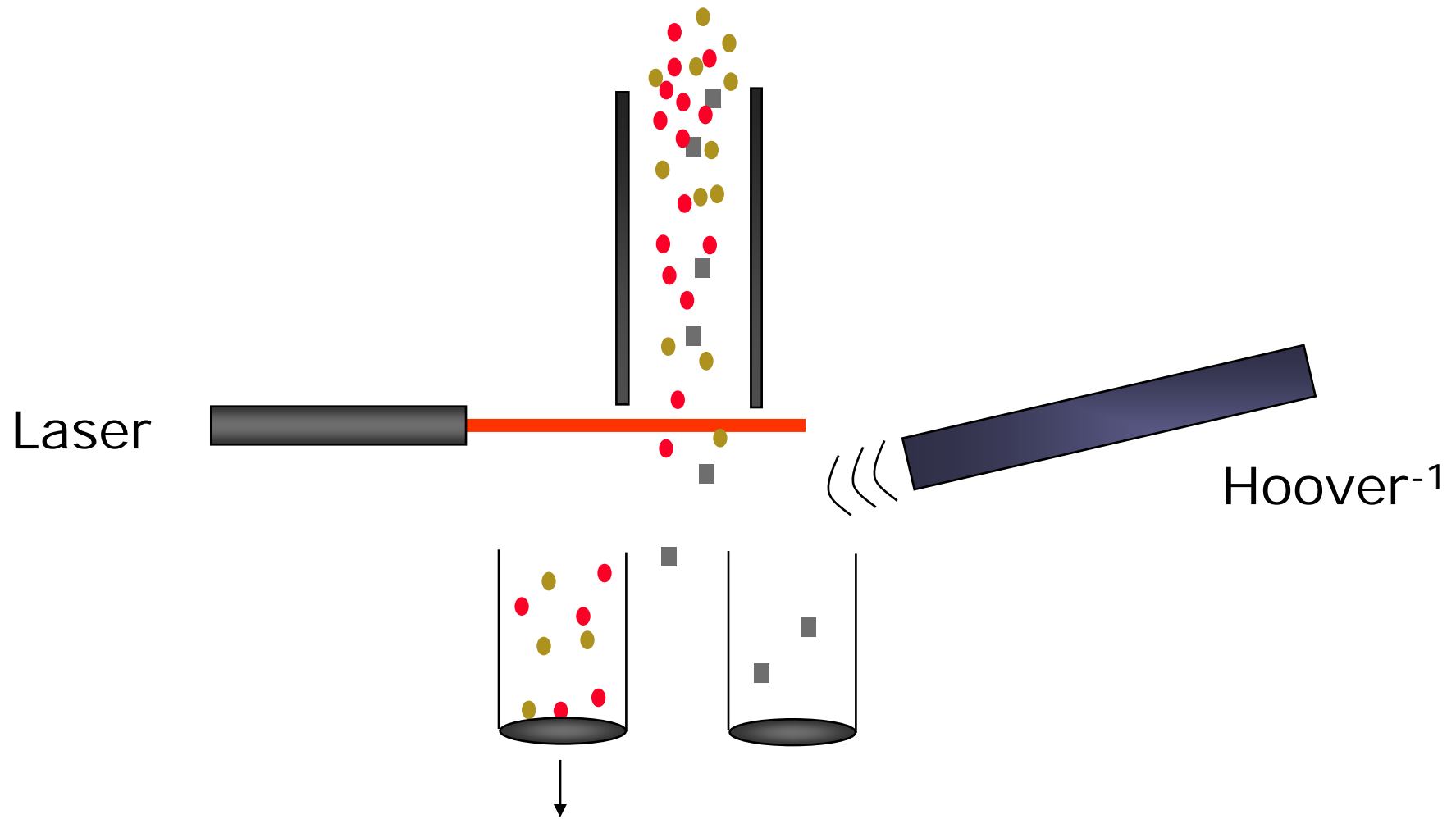


## Chemical and Biological Sensor Standards Study

Defense Advanced Research Projects Agency

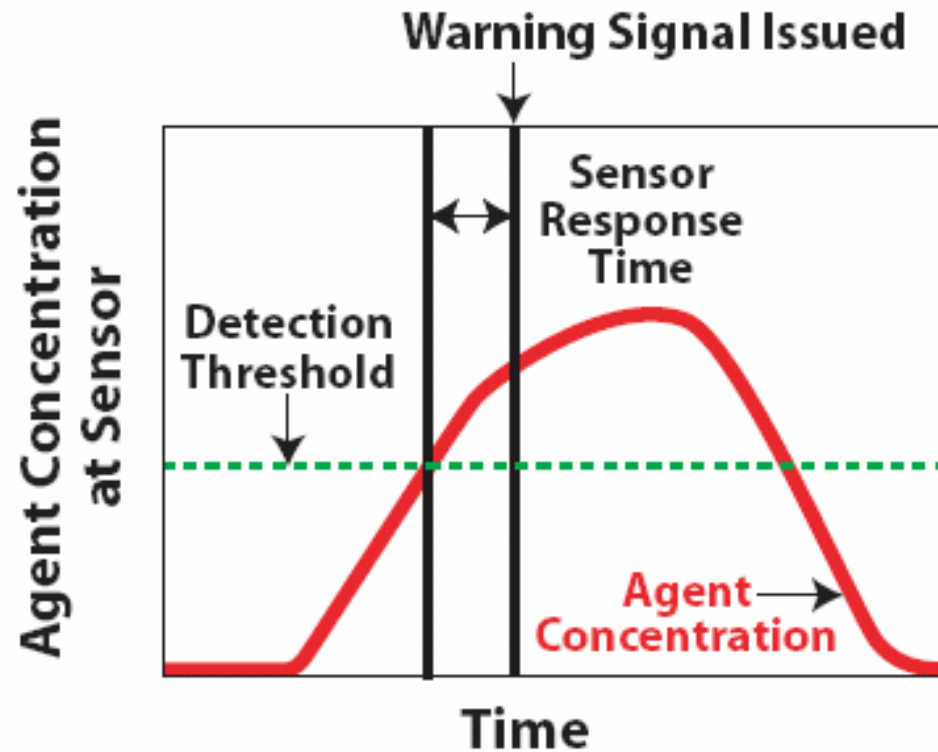
**LTC John Carrano, Ph. D.**  
**Study Chair**

Program Manager, Microsystems Technology Office



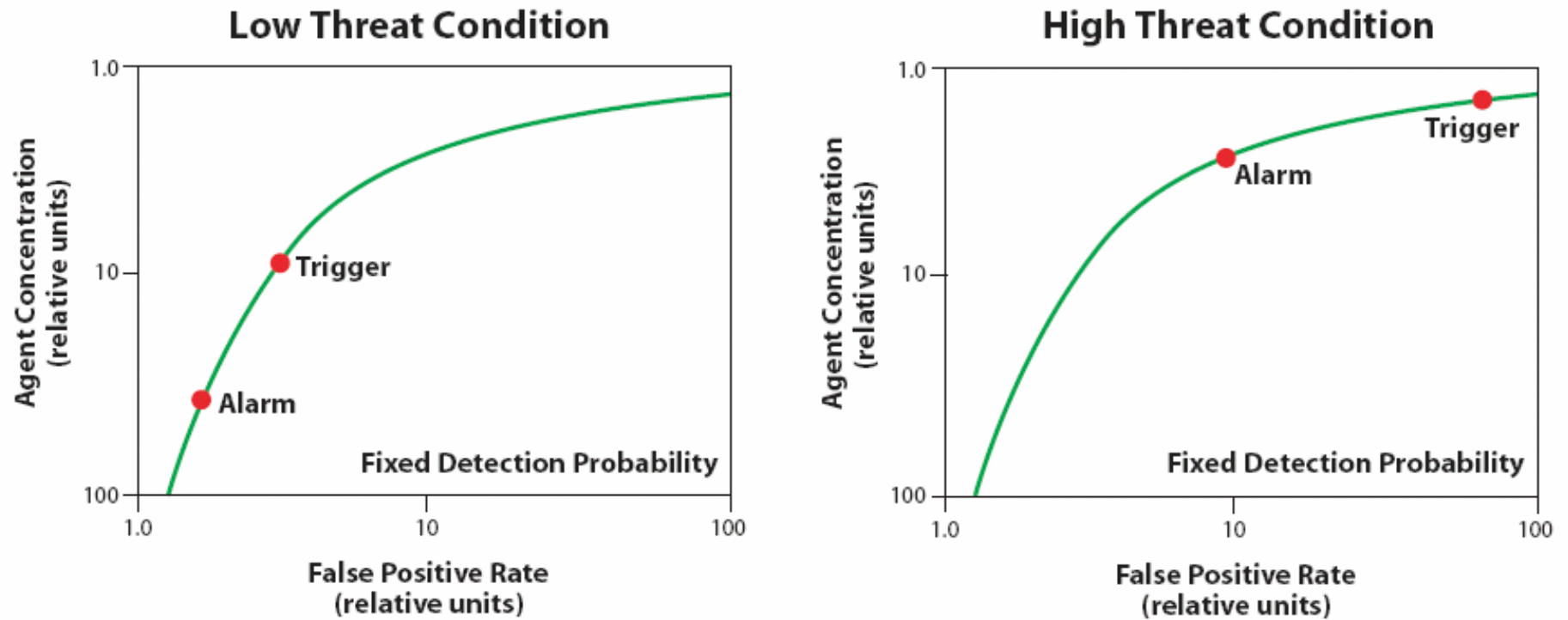
Which bacterium ? Ultrafast techniques are required





*Figure 5. The sensor response time is the time interval between when the agent concentration reaches the sensor's specified sensitivity (or detection threshold) and the time that the sensor issues a detection signal.*

Carrano et al, 2004

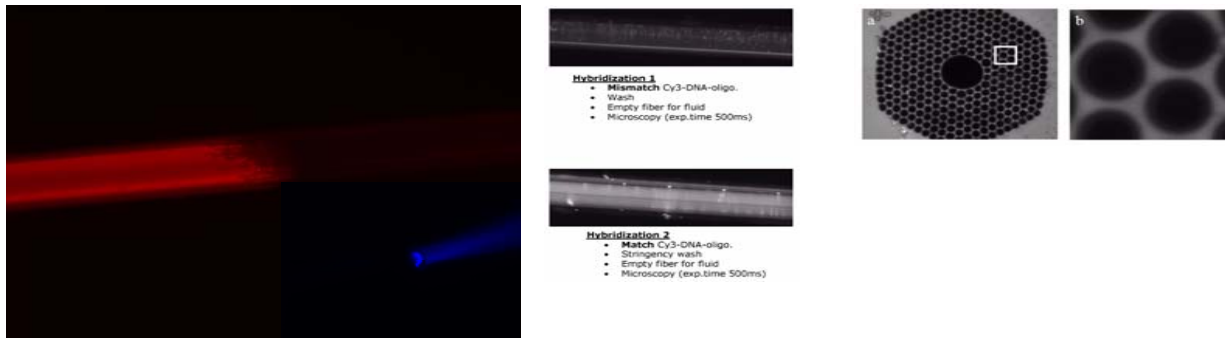


**Figure B.** *Dependent upon the threat condition, the sensor trigger and alarm thresholds should be adjustable along the sensor ROC curve. In the context of this report, an alarm refers to an event that results in a high disruption action, and a trigger is an event that results in a low disruption action.*

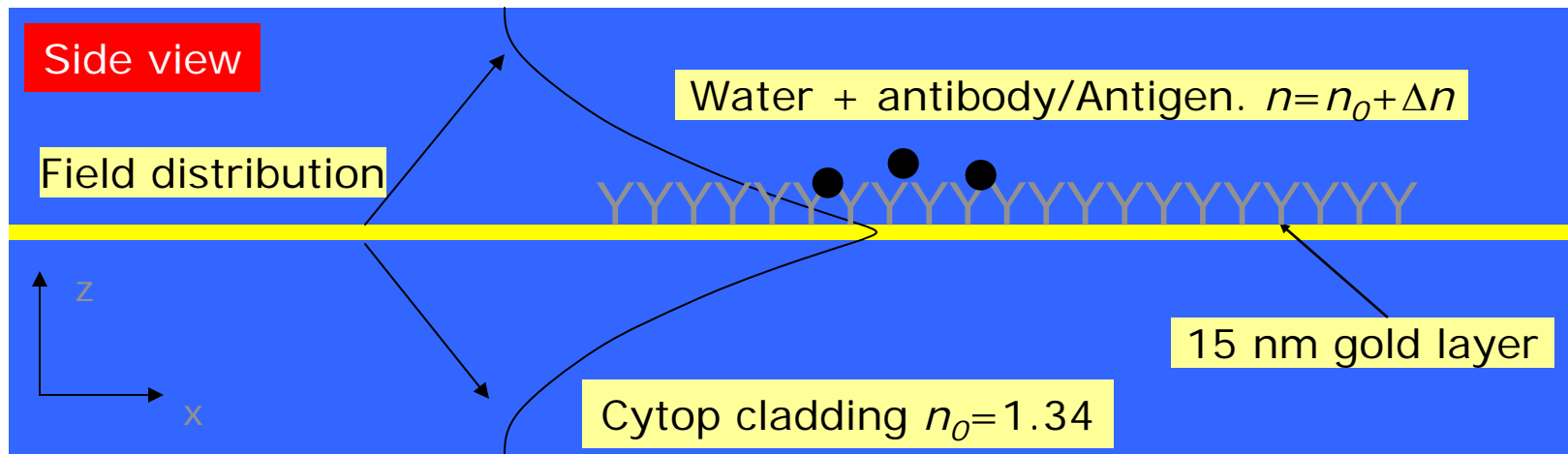
Carrano et al, 2004

## Future perspectives

# Near future – fiber sensors, waveguides



Fiberoptical sensing in photonic crystal Structures. JB Jensen et al. & others



A number of wave guide technologies is emerging/will emerge

### Telemedicine:

- Surveillance/analysis of patients at home (some possibilities are realized)
- Dosage of medicine

### Sensors

- on the body
- in the body
- passive/active

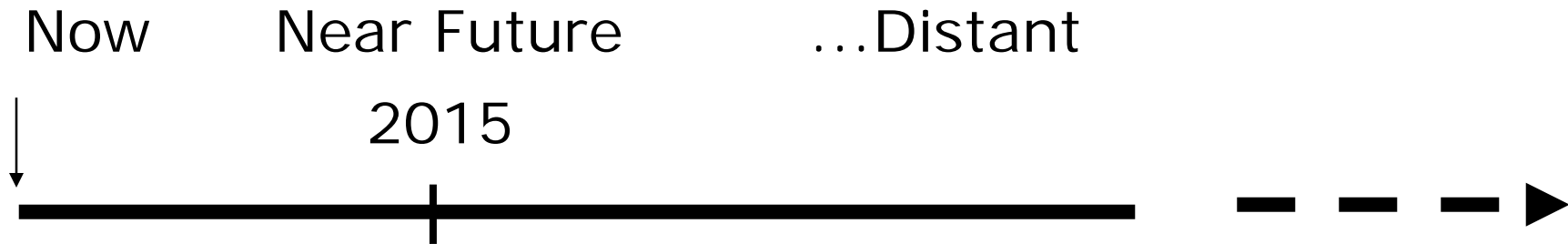
**FUTURE**

**bioner**

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# Multicolor Nanophotonics

## Nanowire/tube nanosensors



Bio-Sensors with elements from.....  
Microtechnology

Nanostructures (biosurface modelling)  
Nanophotonics sensors (wires)  
Nanolasers elements etc

# Conclusion and challenges biosensors



- **Sample:**
  - conditions
  - preparation
- **Molecules**
  - Stability and immobilization of molecules
  - Source of molecules (antibodies, biomimics, enzymes)
- **Performance**
  - in non-aqueous media and complex media
  - Response times & Regeneration
  - Specificity
  - **Validity – Receiver operating Conditions**
- **Sensors on body...in body**
- **Pattern recognition**
- **Cost of goods/analysis**



## Acknowledgments



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**Jesper Bo Jensen & Anders Bjarklev, COM**

**Lars Lindvold,**

**Jimmy Bak & Peter E. Andersen, Optics and Plasma Physics, Risø**

**Thomas Nicolaisen, Rene Kristiansen, Crystal Fibre A/S**

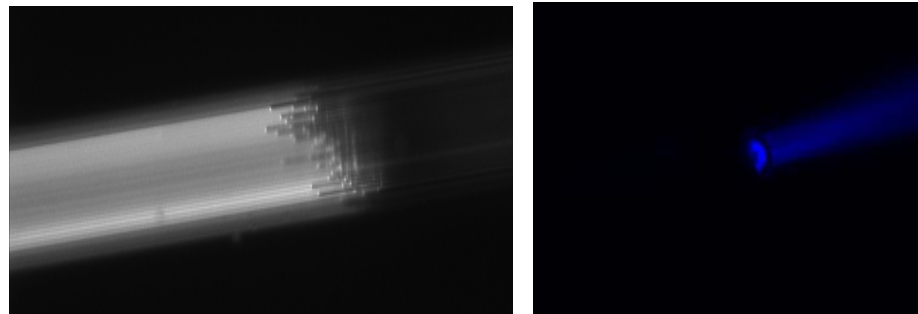
**Bonni Kryger, Micro Manganese Photons A/S, Lumisense**

**Ulli Kruhne, Teknologisk Institut**

**Kim Holmstrøm, Poul Erik Høiby Bioneer A/S**

**Thomas Brevig, NUNC A/S**

**and many more.....**



**Thank you !**

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