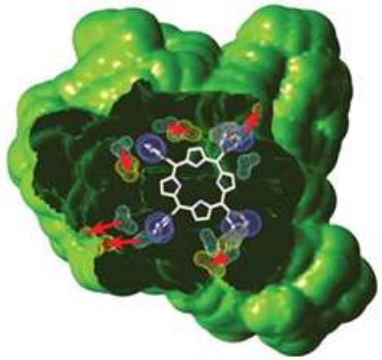
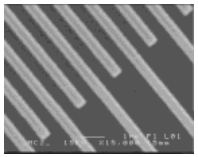
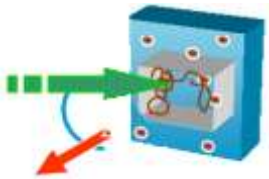
MOLECULARLY IMPRINTED POLYMERS for CHEMICAL SENSORS

Cristina Rusu - Senior scientist







Diaspora workshop “Micro-Nanoelectronica, Micro-Nanosisteme”
27 Septembrie 2012

Innovation for Growth

acreo

Technology Areas

Broadband Technology

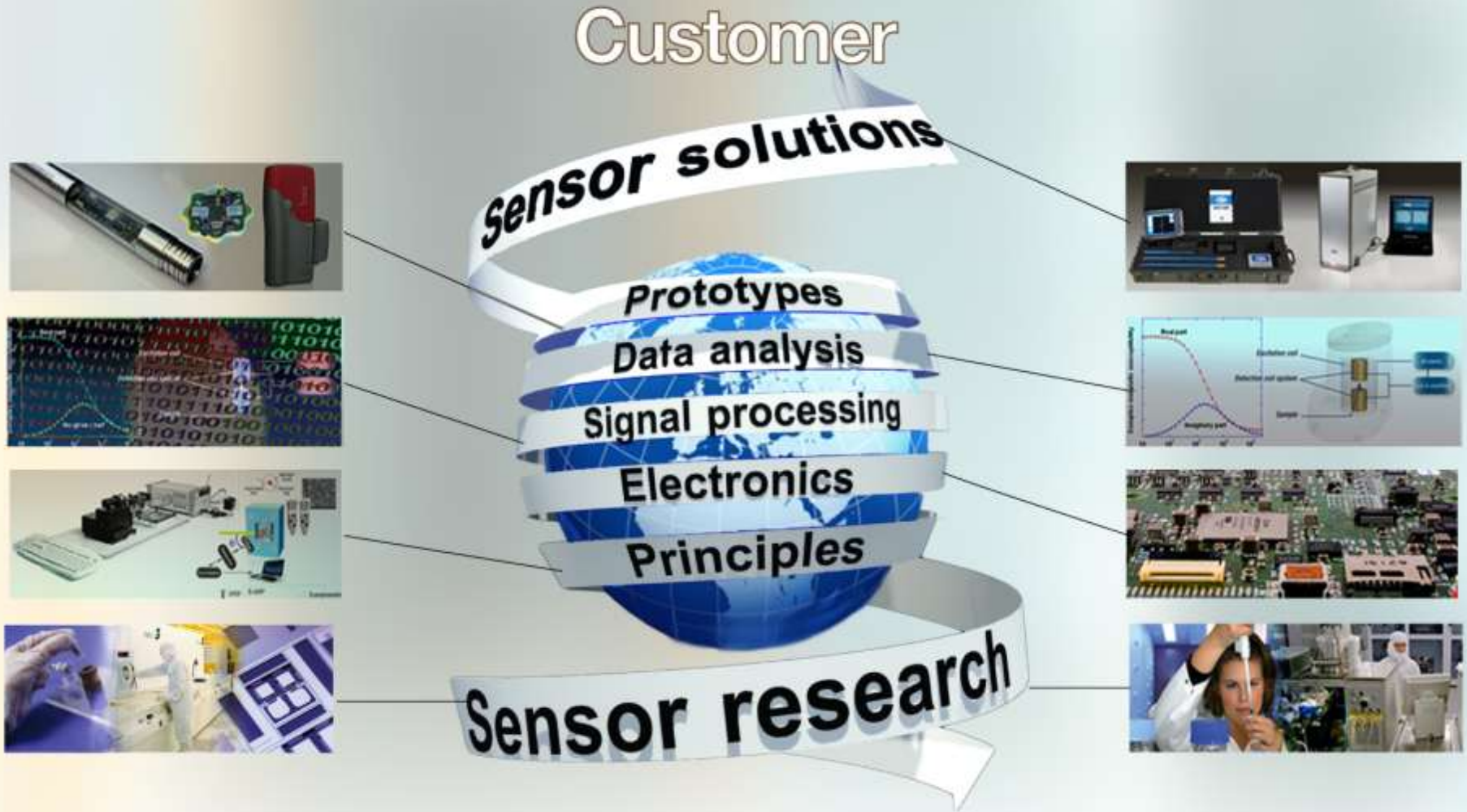
Nanoelectronics

Fiber Optics

Printed Electronics

Sensor Systems

Imego
department

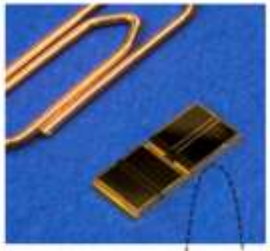


Advanced Technology for Demanding Measurements

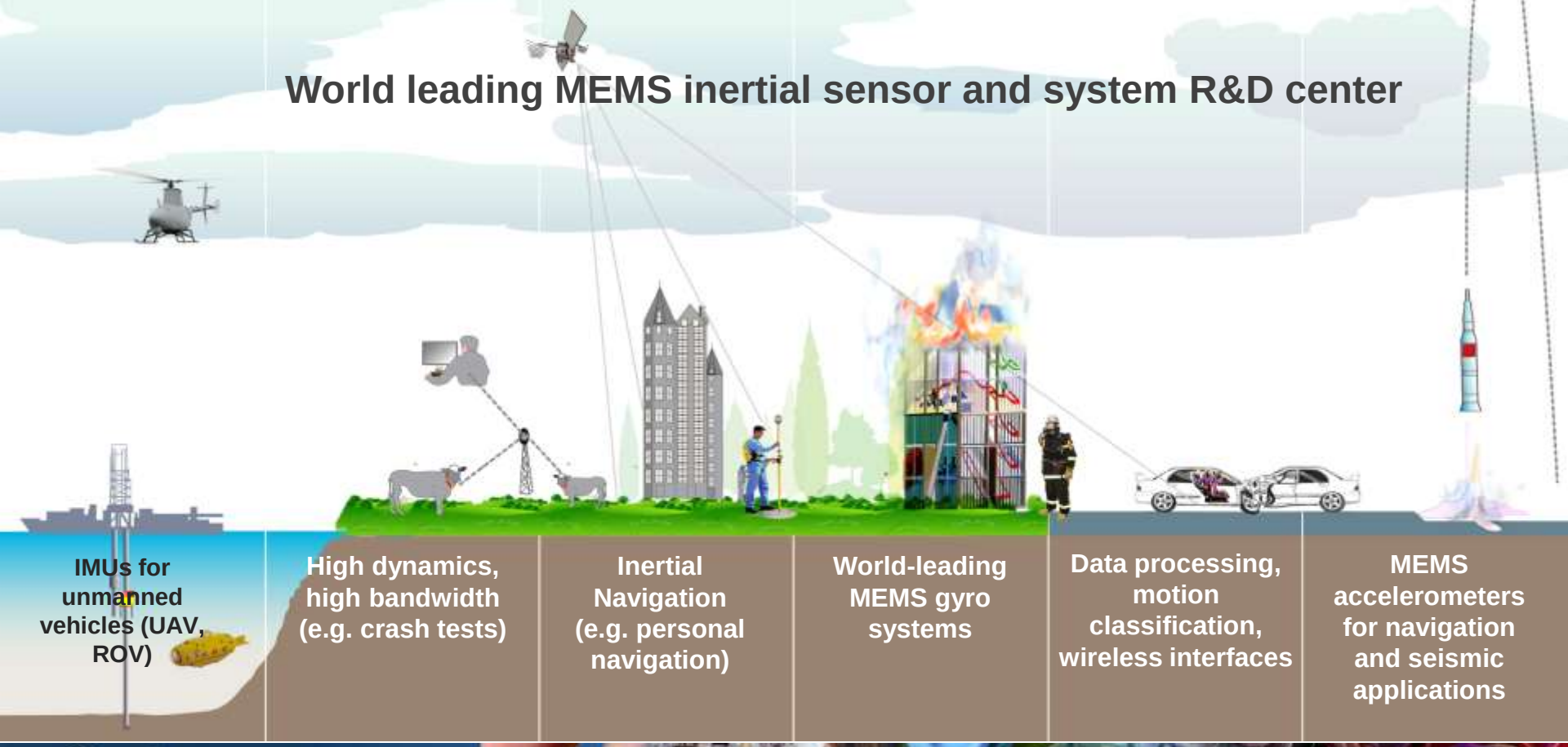
Inertial sensors and systems





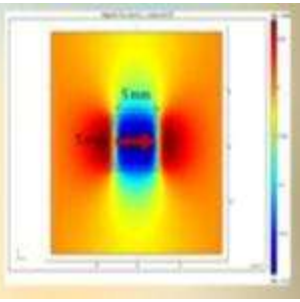
World leading MEMS inertial sensor and system R&D center



IMUs for unmanned vehicles (UAV, ROV)	High dynamics, high bandwidth (e.g. crash tests)	Inertial Navigation (e.g. personal navigation)	World-leading MEMS gyro systems	Data processing, motion classification, wireless interfaces	MEMS accelerometers for navigation and seismic applications

Electromagnetics sensors

Magnetic simulation



- Finite Element analysis

AC susceptometry

- The DynoMag system
- High frequency dynamic AC susceptometry

Magnetic sensor system

- Traffic detection

Magnetic analysis

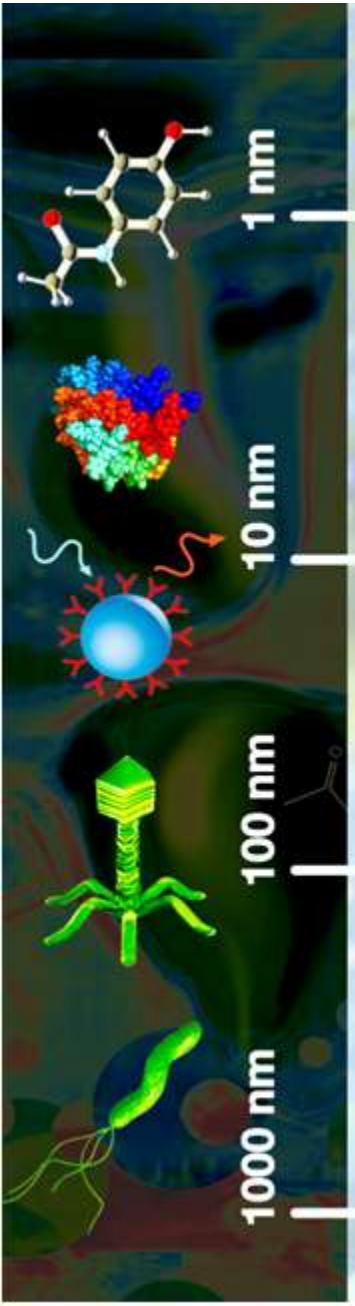
- Static and dynamic characterization
- Magnetic shielded room
- Magnetic consultants and lectures

Magnetic sensor system

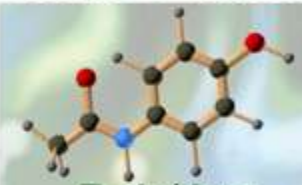
- Field scanning

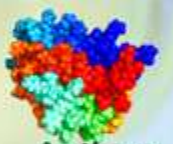
Bio-chemical sensors

From protocols to complete systems



What to detect

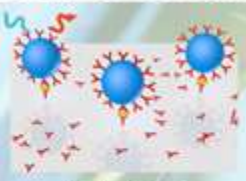

Toxin/drug

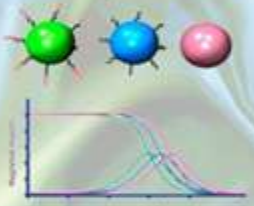

Antigen


Bacteria

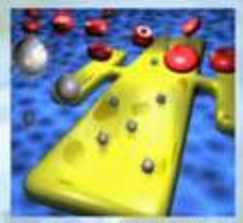

Biofouling

How to detect


Optical

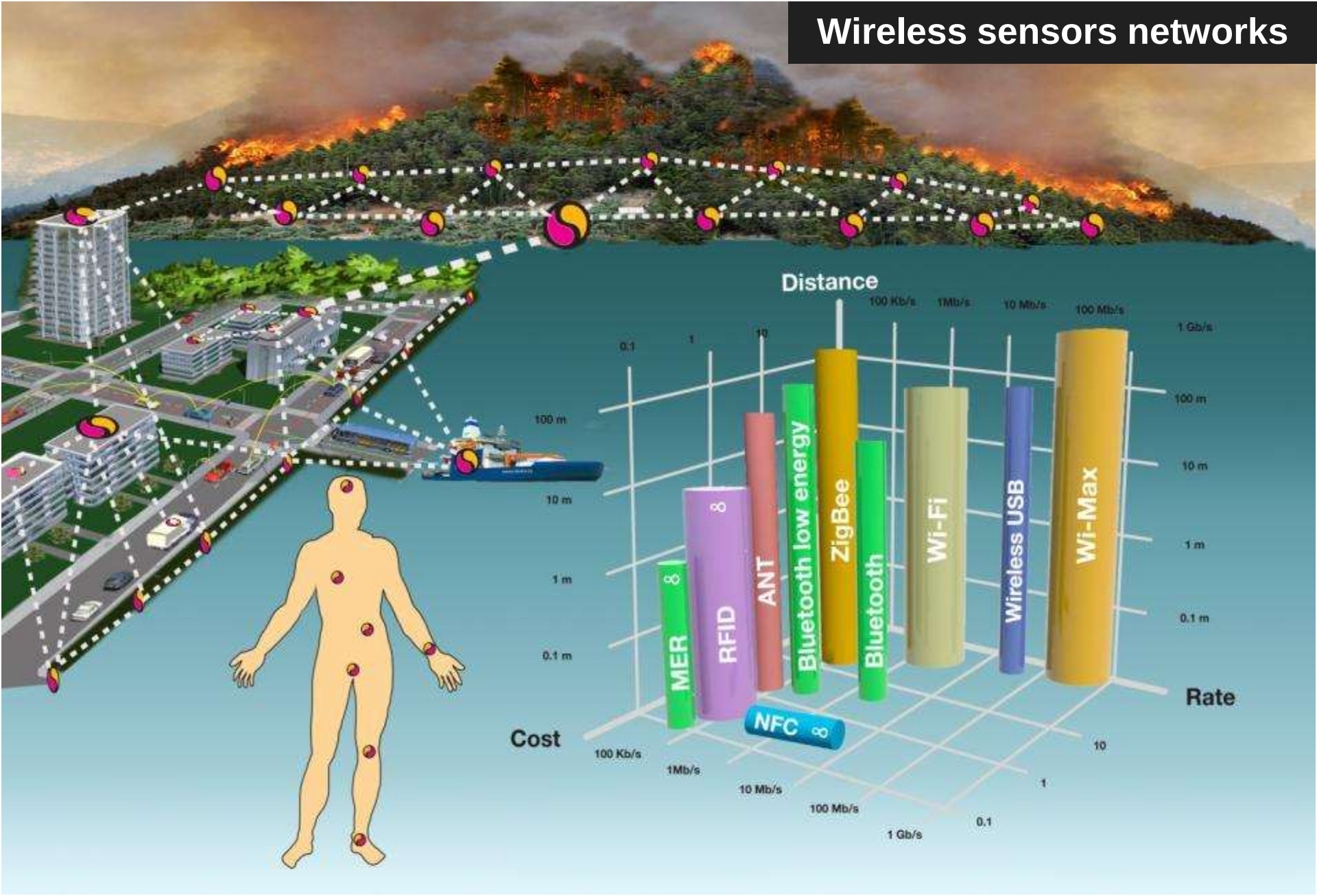

Magnetic


Electrochemical


Gravimetric

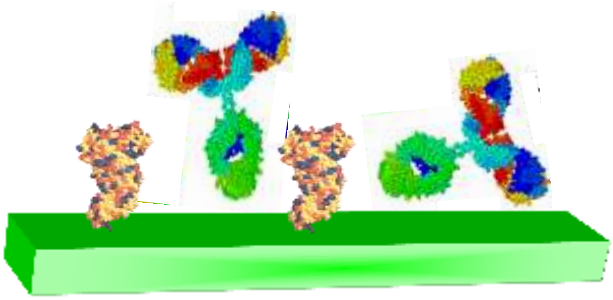
Solution / Prototype

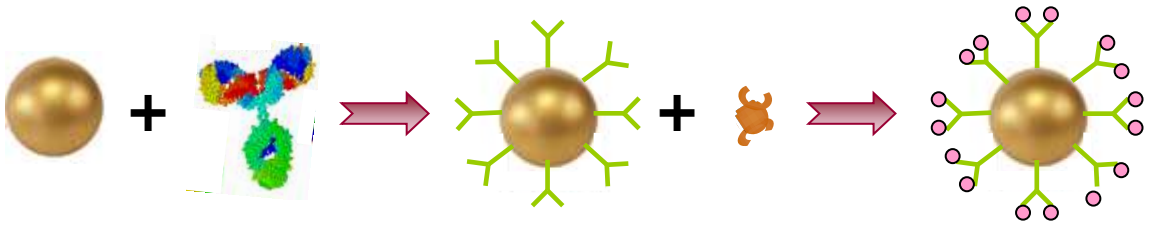
Wireless sensors networks

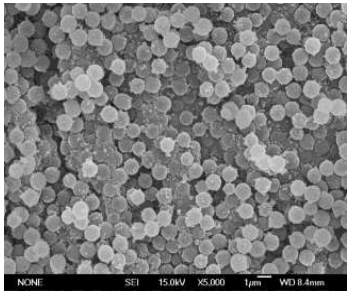


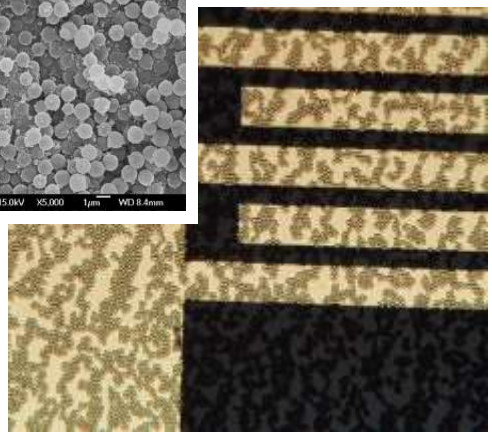
Bio-chemical applications

- Homogeneous assays
- Non-labelled sensing
- Nanoparticles & colloidal solutions
- Biomolecule – surface & receptor – ligand interactions









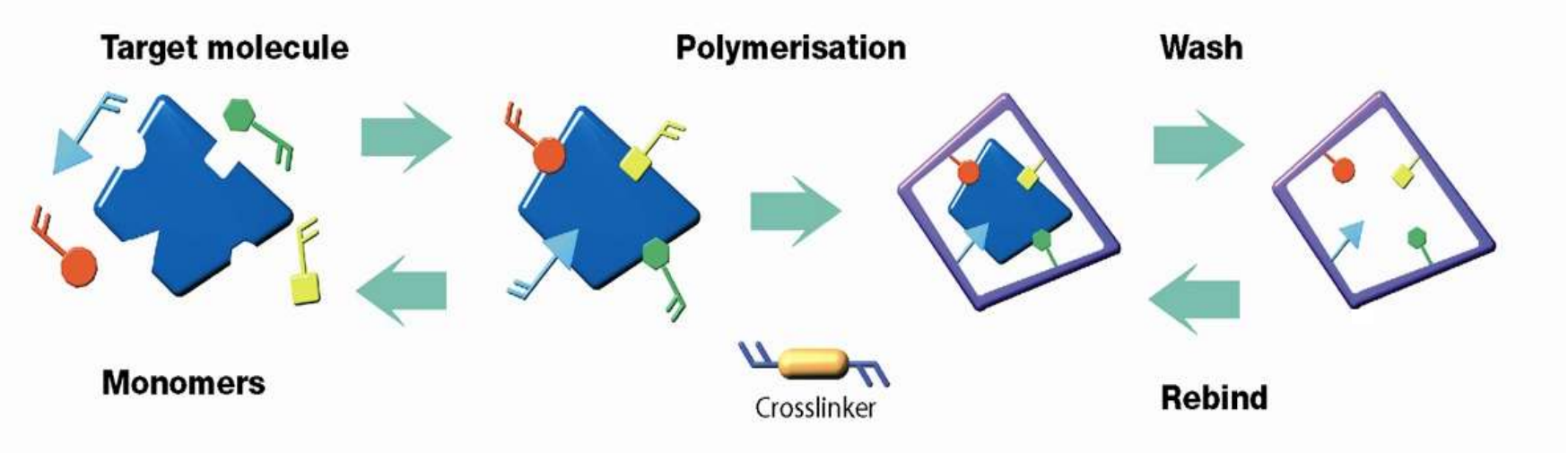
Molecularly Imprinted Polymers

Why Molecularly Imprinted Polymers?

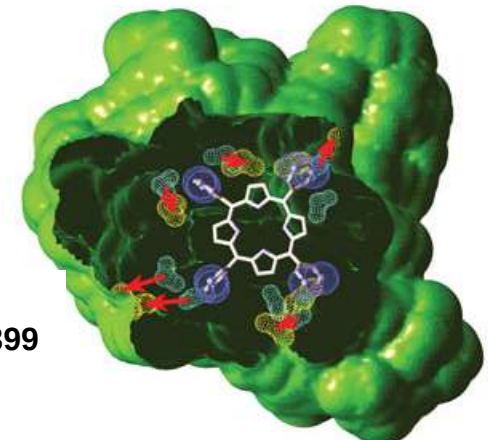
Problems Associated with Natural Compounds / Antibodies

- Low stability of the biomolecules
- High price of enzymes and receptors
- Poor performance in non-aqueous media
- Poor compatibility with micro fabrication technology, resulting in difficulties with design of sensors

The art of molecular imprinting



- Cross-linked polymer formed around a molecule that acts as a template, template subsequently removed.
- Imprints containing functional groups complementary to those of template are left behind



Zimmerman et al.
Nature (2002) 418, p. 399

Advantages of MIPs

Easily expanded for multiple detection of several analytes or families of chemically similar targets

Cheap industrial-scale production, long shelf-life, robust

Wide range of targets (virtually any compound with molecular weight, M_w, 0,05kDa < M_w< few kDa) *

Generic detection scheme is possible for the detection of a range of compounds

Disadvantages of MIPs

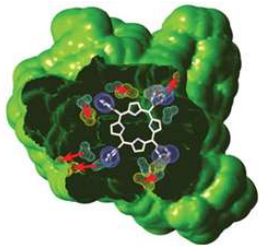
Specificity is lower than for natural antibodies → range of binding energies → requires careful choice of the detection scheme

High non-specificity → requires comparison with the non-imprinted polymer

Fairly complex system design

Detection in minutes rather than seconds; target dependant sensitivity

Application areas of MIPs



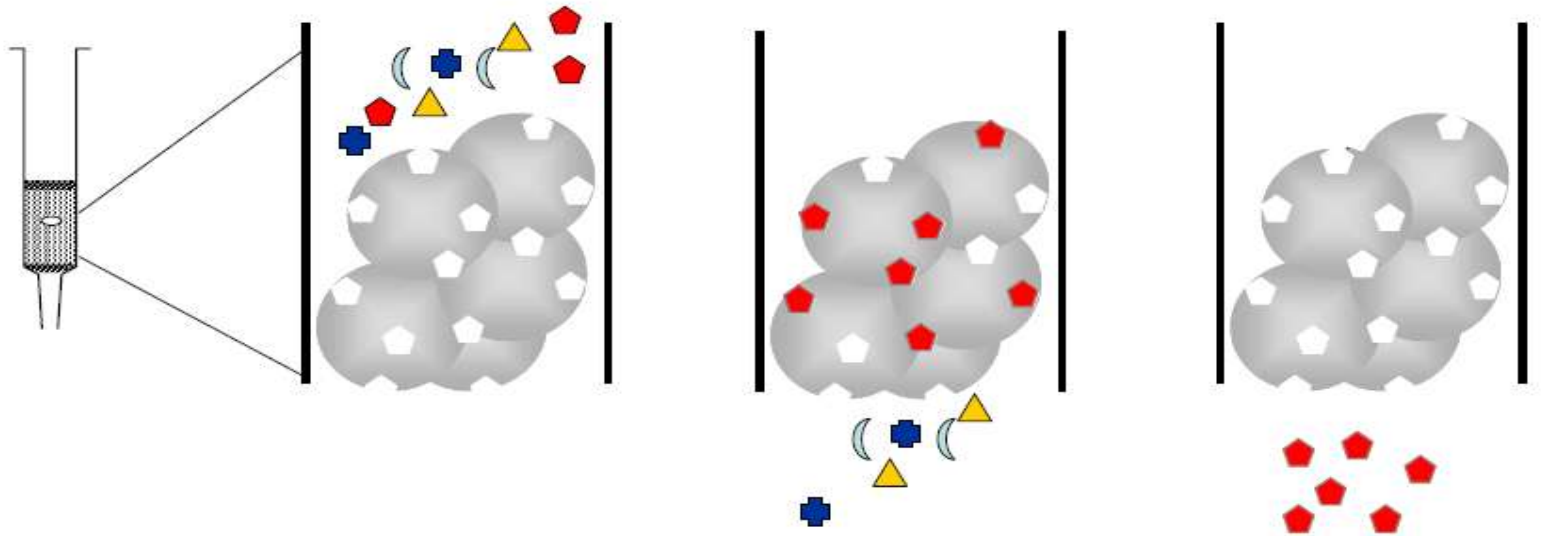
Target molecules

- Toxins, eg., marine toxins
- Narcotics
- Chemical warfare agents
- Explosives
- Peptides
- Pharmaceutical waste
- Tannins, caffeine
- Sugars, (sorbitol, glucose)

- **Pharmaceutical Industry**
- **Food Industry**
- **Veterinary Industries**
- **Doping Laboratories**
- **Monitoring Agencies**
- **etc.**

MIP Application: Selective Phase extraction

Selective extraction of low levels of target compounds in the presence of a mixture of potentially interfering matrix components.



1. Column conditioning

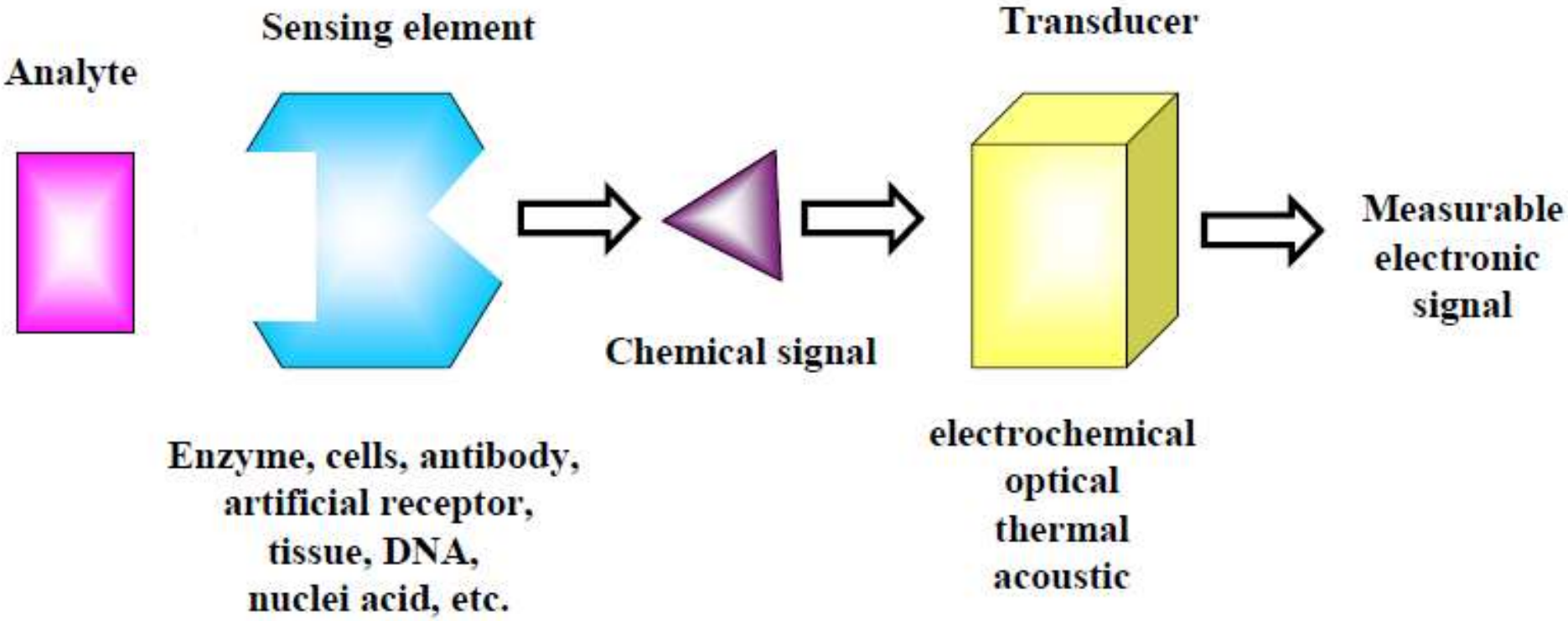
2. Sample Loading

3. Elution of interfering compounds

4. Elution

Clean and concentrated analyte!

MIP Application: Sensors



Our motivation of using MIPs

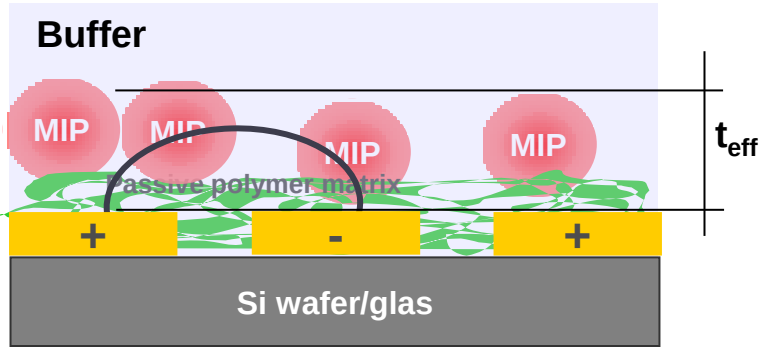
One of the very few techniques that allows one to detect *specific* contaminations in water / fluid *outside* the laboratory environment

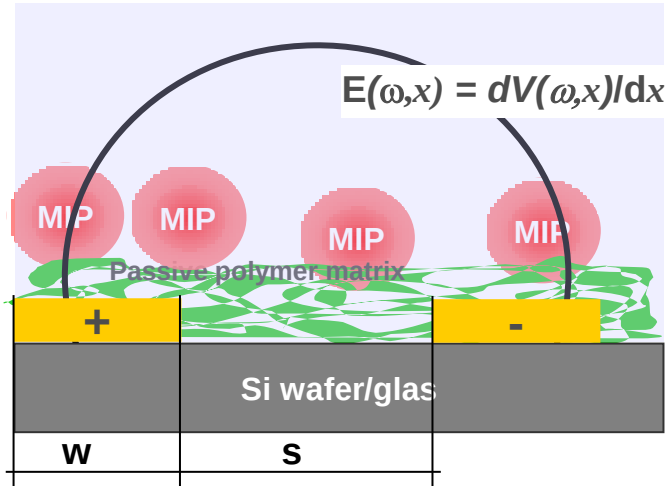
MIP-based sensors: Transductions

- **Volume changes upon imprint adsorption (swelling / shrinkage)**
  Changes of charge state ⇒ surface assay (QCMD, interdigital electrodes
- **Changes of charge states upon analyte binding ⇒ Reaction induced aggregation ⇒ homogeneous assay (PCS, Z-potential light scattering)**
- **Electrochemical Impedance Spectroscopy ⇒ surface assay, interdigital electrodes**

MIP- based sensor: detection by impedance spectroscopy (IS)

Impedance: Apply constant AC-voltage of different frequencies;
Measure AC - current amplitude and phase at each frequency.
Plot imaginary part of impedance (ImZ) vs. its real part (ReZ)





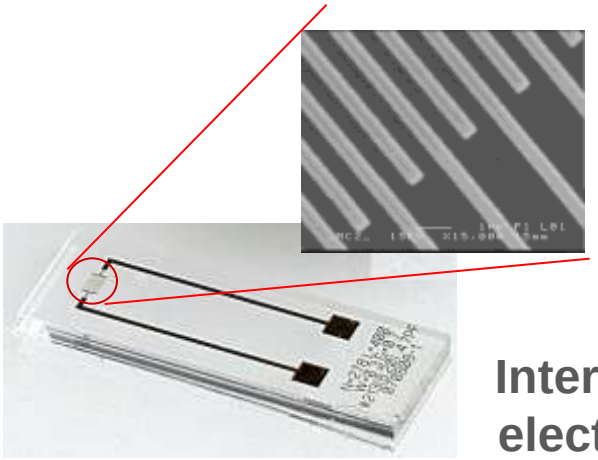
$C = Q(\omega)/V(\omega) = f(t,w,s,V,\varepsilon) \times (\varepsilon_0 \varepsilon_r A)/d$

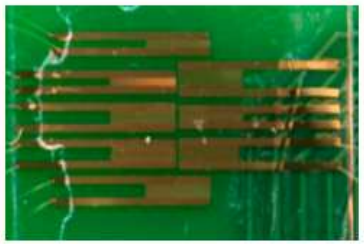
$I(\omega) = \int Q dt$

$\Rightarrow$ measure $Z(\omega) = \mathrm{Re}\, Z(\omega) + \mathrm{Im}\, Z(\omega)$

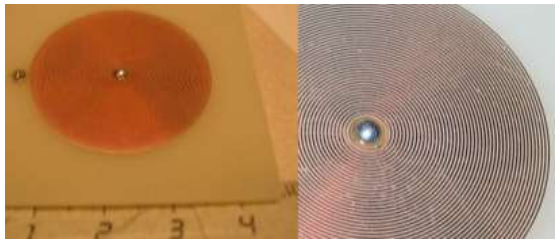
Microelectrodes = allows to vary penetration depth of the electric field inside the fluid

MIP-based sensor – IS setup

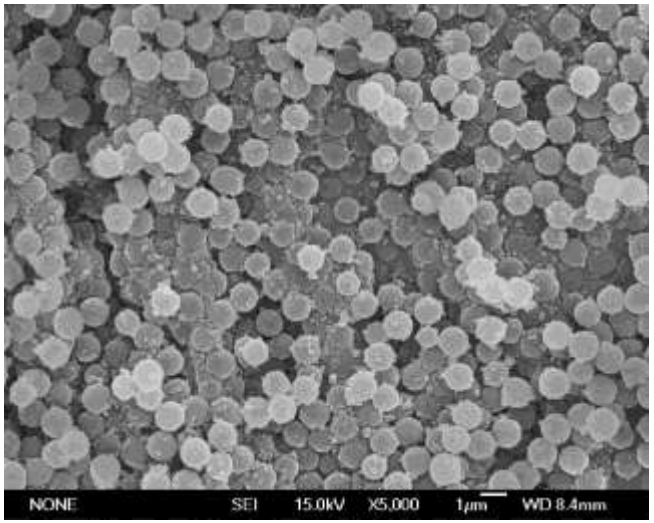




Interdigital electrodes

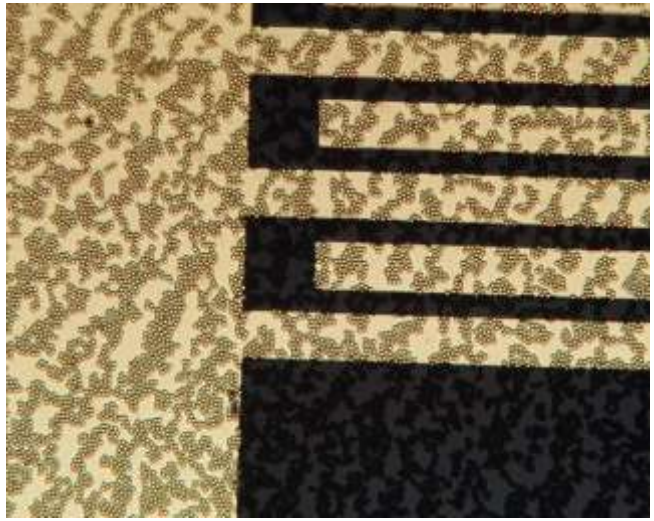


Planar coil electrode

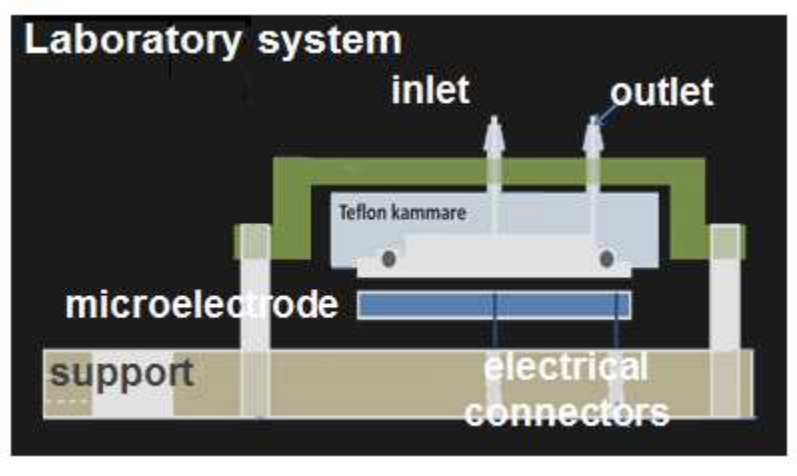


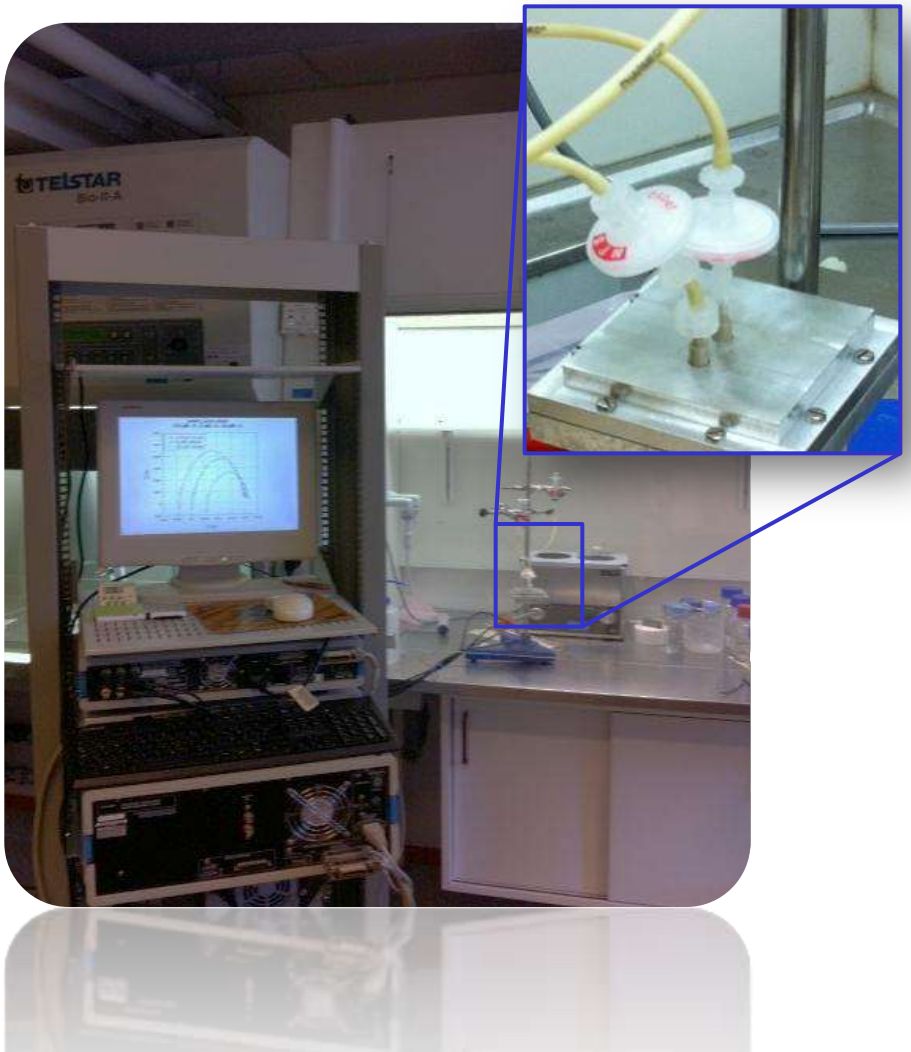
MIP particles sizes 170 nm – few μm

(Lund University)



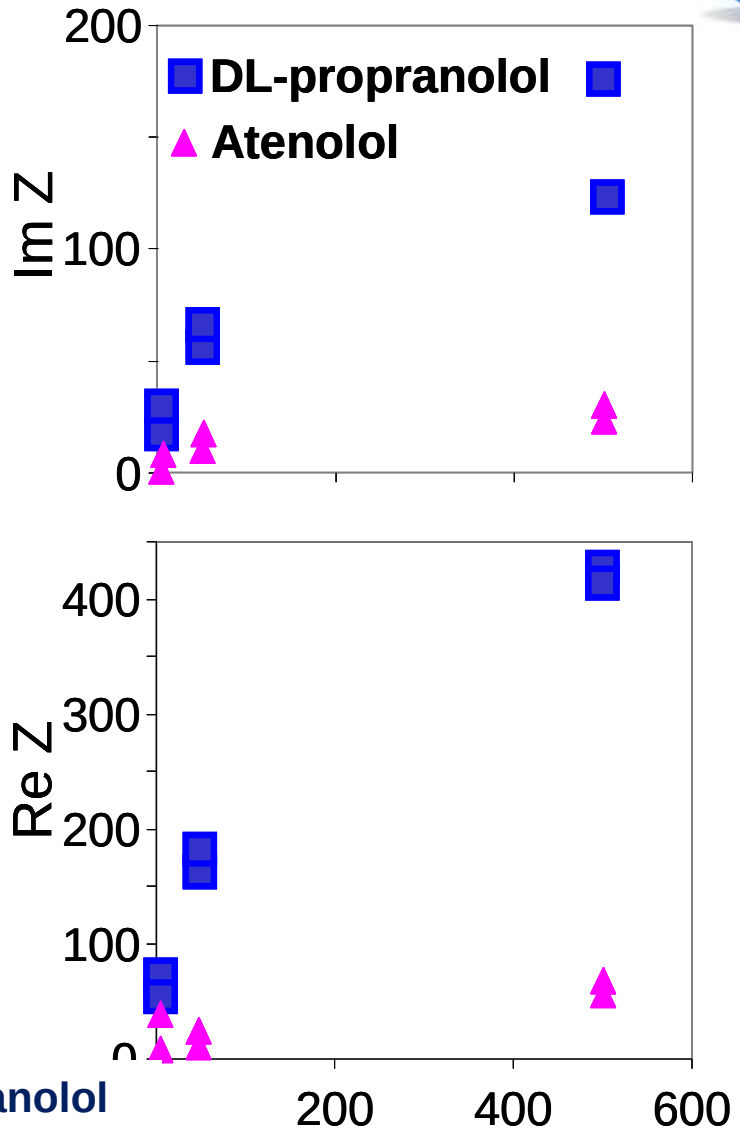
MIP-based sensor – IS setup





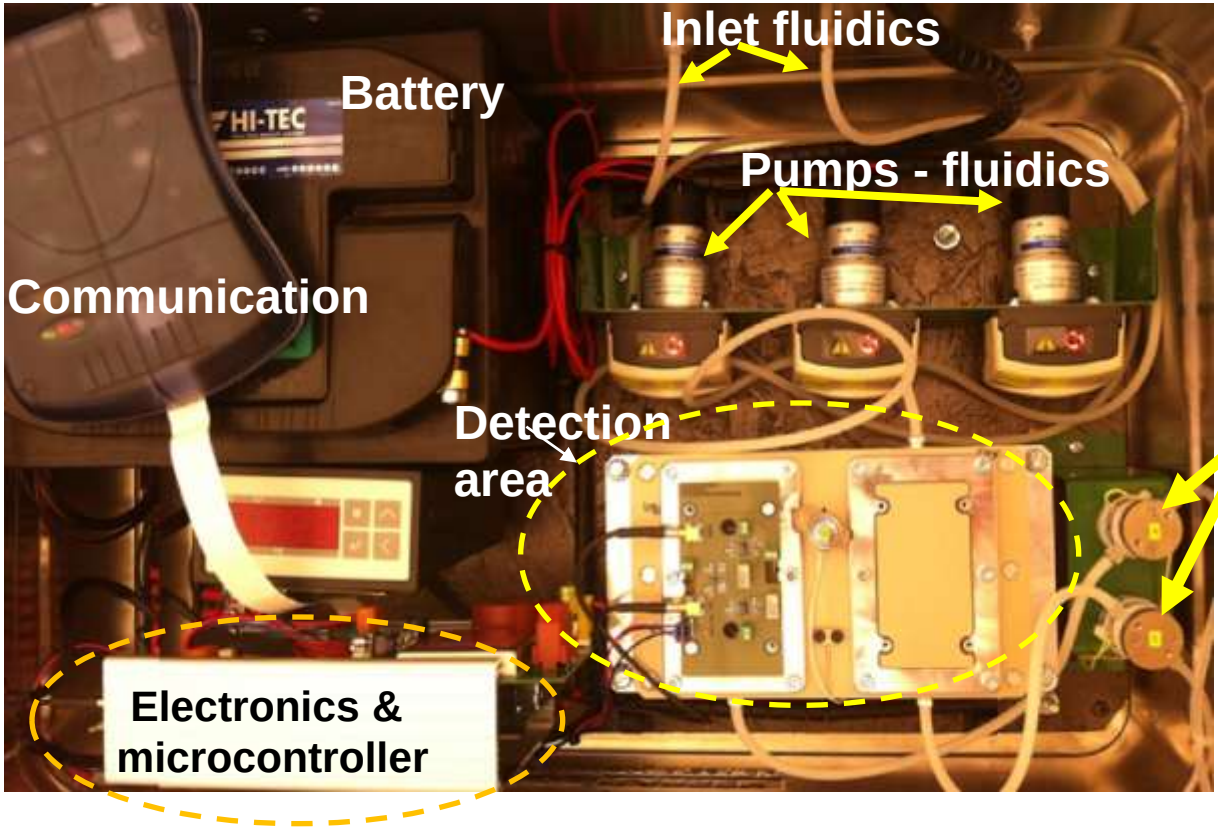
MIP imprinted against propranolol - IS

Interdigitated finger electrode
lowest concentration detected ≈ 10µM



Atenolol is chemically very similar to propranolol

MIP – field instrument



Top-view MIP system including detection system, fluidics, power supply, communication

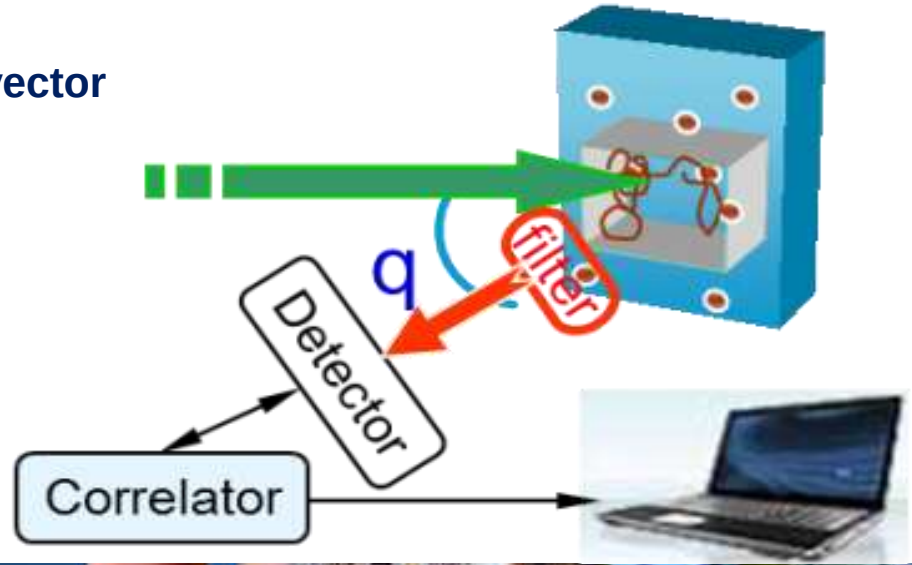
MIP imprinted against propranolol – optical detection

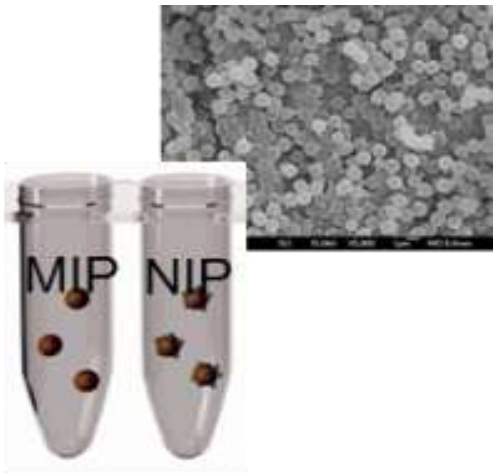
Size changes and agglomeration of MIP - propranolol upon target adsorption measured using *dynamic light scattering*.

Particle translational motion
⇒ Translational relaxation time, τ
⇒ Particle size distribution

$$\tau = \frac{6\pi\eta}{k_B T q^2} r$$

η – solvent viscosity
T – temperature
q – scattering wave vector
r – particle radius





CONCLUSIONS – Present & Future

☺ MIP-based sensing = quantitative detection

😐 Sample deposition ⇔ method of MIP manufacturing

😐 MIP / NIP signal analysis ⇔ MIP / NIP theory & modelling

☺ Optical detection seems ‘easier’

☺ NIP utilization ⇔ reduced false positive / negative

Field measurement system

⇔ Portable, low power

⇔ *Pre-concentration* of sample

⇔ Reliable

Multumesc pentru atentie

Acknowledgement

Andrea Astalan, Kristina Fogel, Anatol Krozer, Christer Johansson Fredrik Ahrentorp, Torbjörn Pettersson, John Roswell

EU-FP7 Emergency Support System www.ess-project.eu

EU-FP7 Total Airport Security System www.tass-project.eu

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