nano-tera.ch

Swiss Research Program
Engineering Multi-Scale Systems
in Health and the Environment

Nanosystems for Health and Environment

Giovanni De Micheli

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Nano-Tera.ch: Mission

Research, Design & Engineering of complex tera-scale systems using nano-scale devices and technologies

Foster research and crossbreeding of technologies

Main application domains are Health and Environment with transversal themes such as Energy and Security

- Develop new markets
- Improve living standards
- Better the quality of health and environment
- Foster a vision of engineering with social objectives
- Promote related educationl programs

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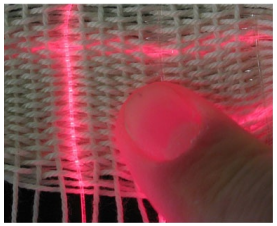
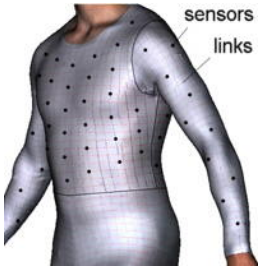
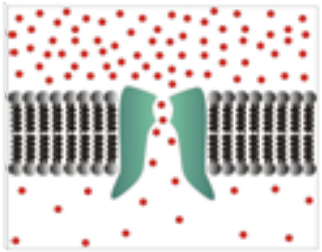
Health

- Body monitoring
  - Biosensors
  - Body area networks
  - Smart textiles
- Clinical support
  - Remote diagnosis
  - Drug delivery
- Prevention
  - Monitoring nutrition
- *Challenges:*
  - *Non-invasiveness*
  - *Safety and security*







Environment

- Monitoring heat, wind, vibration
  - Earthquake, flood prediction
  - Movement of glaciers
- Controlling pollution
  - Water, air purity
  - Bio-contamination
- Emergency relief control
  - Real time support for reaction
- *Challenges:*
  - *Seamless presence and biodegradability*
  - *Autonomous and adaptive operation*

Nano-Tera.ch evolution

- First phase 2008-2012:
  - Research and develop enabling technologies and experimental systems
- Second phase: 2013-2016:
  - Integrate new technologies into systems, demonstrating the possibilities of new products and markets
- Third phase: 2017-2020:
  - Consolidation of results and deliverables of those projects that have a strong societal and industrial impact

Nano-Tera.ch: key figures

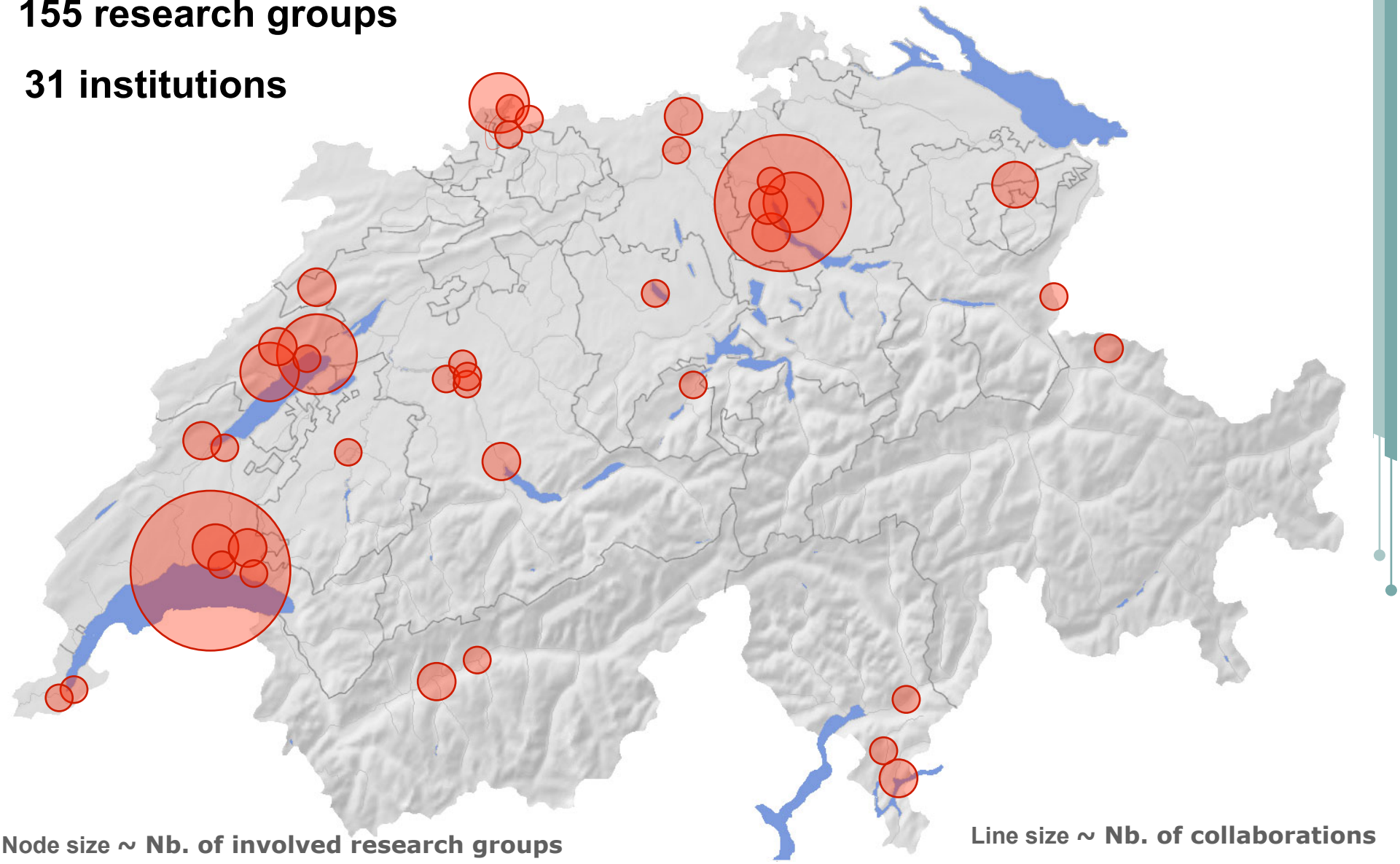
- **97** projects (**22** projects starting in 2013)
- **30** MCHF/year (approximatively 50% in cash + institutional matching)
- **31** Swiss research institutions involved (2008-2012)
- **155** research groups
- **~700** researchers
- **~180** PhD thesis supported
- **~ 575** papers published
- **~ 1000** presentations

	Current reporting period (2012)			TOTAL since beginning of the program		
	Journals, books	Conf. Proceedings	Total	Journals, books	Conf. Proceedings	Total
RTD 2009	48	69	**117**	144	133	**277**
RTD 2010	44	77	**121**	82	147	**229**
RTD add-on	1	3	**4**	1	3	**4**
NTF	6	10	**16**	14	36	**50**
SSSTC	6	9	**15**	6	9	**15**
	105	168	**273**	247	328	**575**

Distribution of research groups

155 research groups

31 institutions



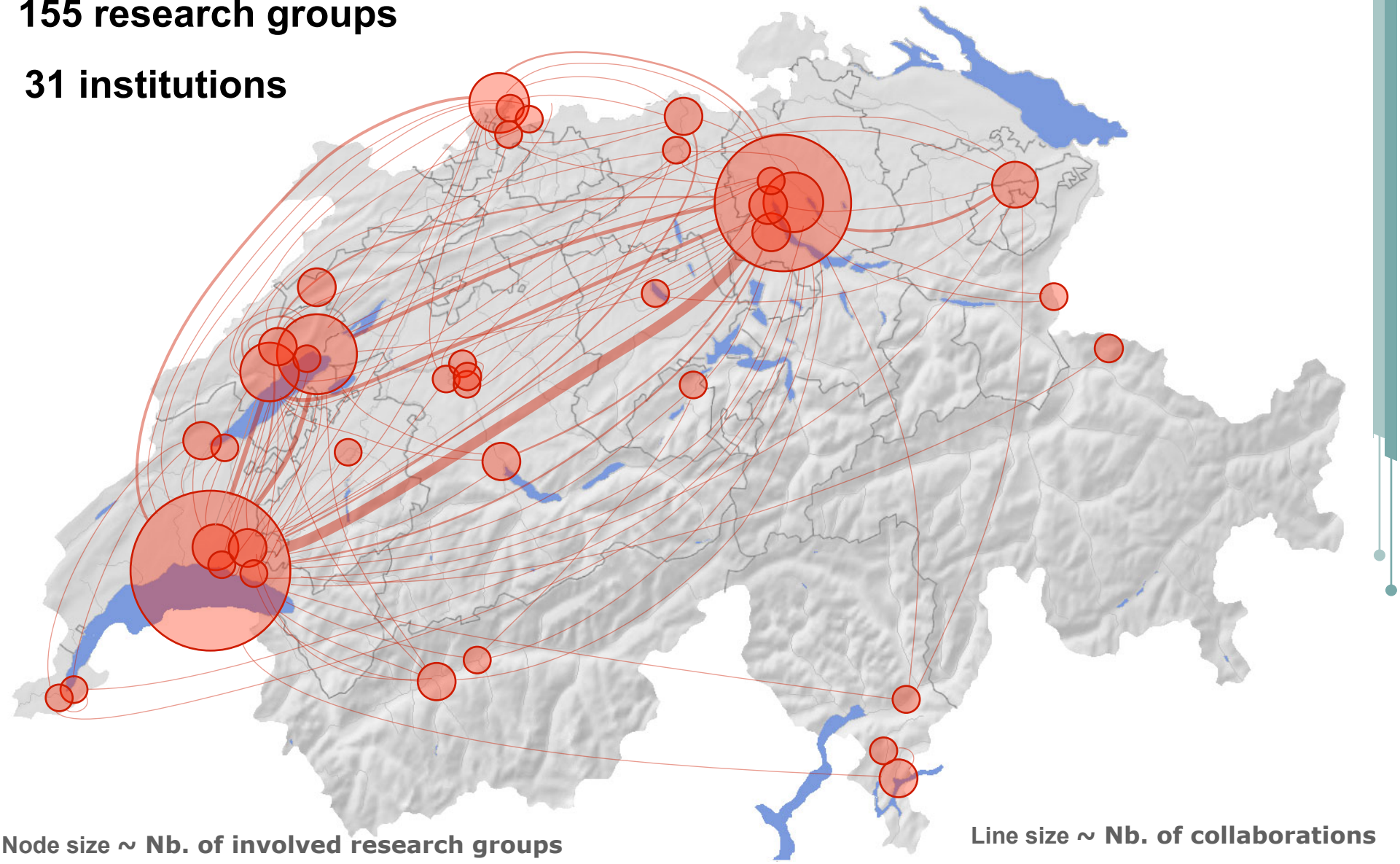
Node size ~ Nb. of involved research groups

Line size ~ Nb. of collaborations

Distribution of research groups

155 research groups

31 institutions



Node size ~ Nb. of involved research groups

Line size ~ Nb. of collaborations

31 Swiss participating institutions
(2008-2012)

Part of ETH-Board

- EPFL – École polytechnique fédérale de Lausanne
- ETH – Eidgenössische Technische Hochschule Zürich / Swiss Federal Institute of Technology Zurich
- EMPA
- PAUL SCHERRER INSTITUT – PSI

Part of OPET (BBT)

- Hes·so – Haute Ecole Spécialisée de Suisse occidentale – Fachhochschule Westschweiz – University of Applied Sciences Western Switzerland
- n|w – Fachhochschule Nordwestschweiz
- FHO Fachhochschule Ostschweiz

Part of SUK / CUS

- Universität Zürich
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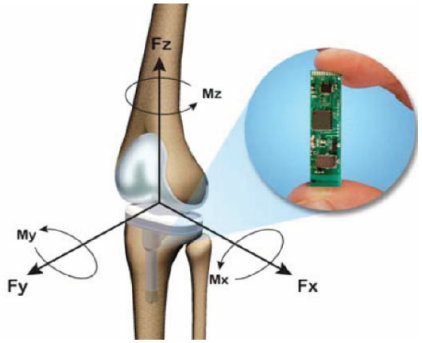
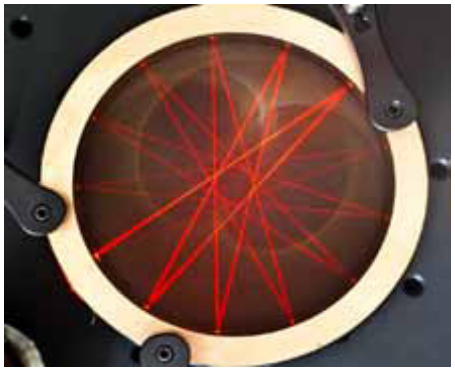
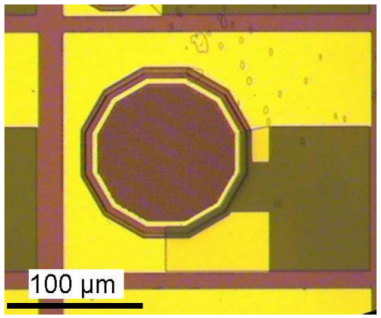
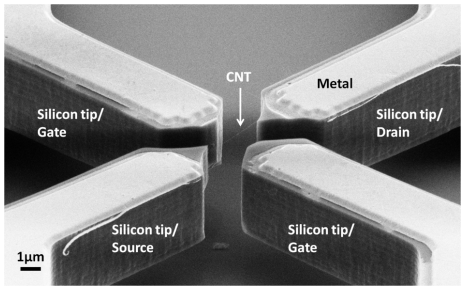
- rr!
- SYMBIOS
- csem
- Centre Pluridisciplinaire d'Oncologie
- UniversitätsSpital Zürich
- icare
- CHUV
- Swiss Paraplegic Centre
- Federal Department of Economic Affairs DEA – Agroscope Liebefeld-Posieux Research Station ALP
- Schweizerische Eidgenossenschaft / Confédération suisse / Confederazione Svizzera / Confederaziun svizra – Swiss Confederation – Federal Office for the Environment FOEN
- IBM
- fsrm – Crossroads of Microtechnology
- IDQ – From Vision to Technology
- ist
- GAMMA REMOTE SENSING

Examples of research projects





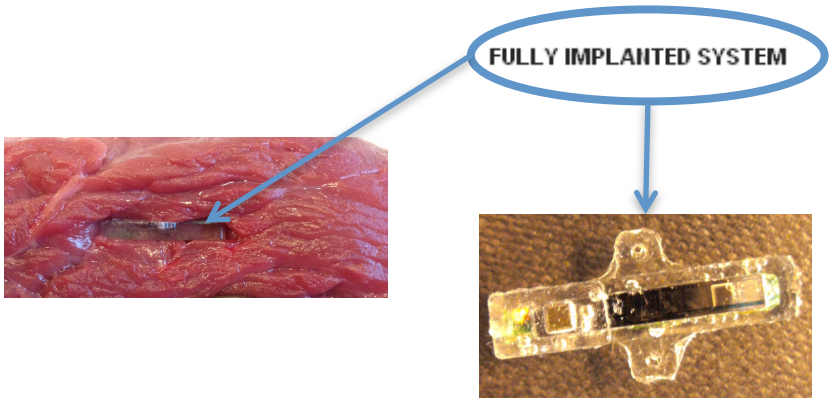


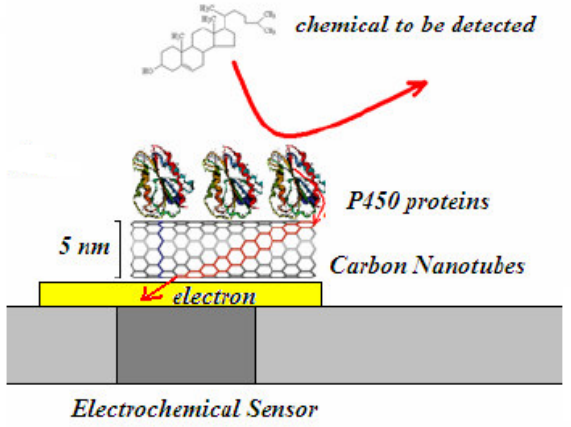


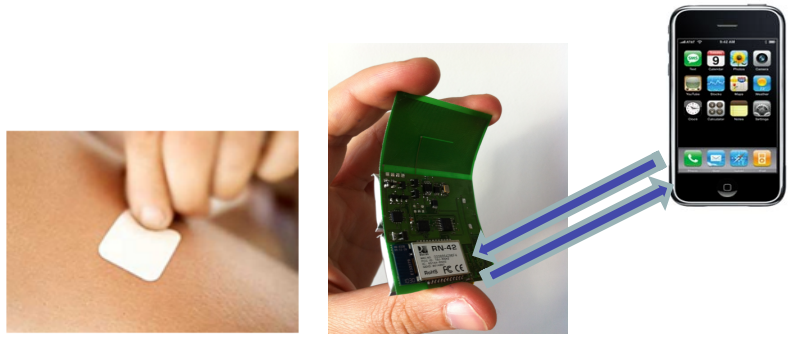
Remote Monitoring Metabolic Conditions in human fluids

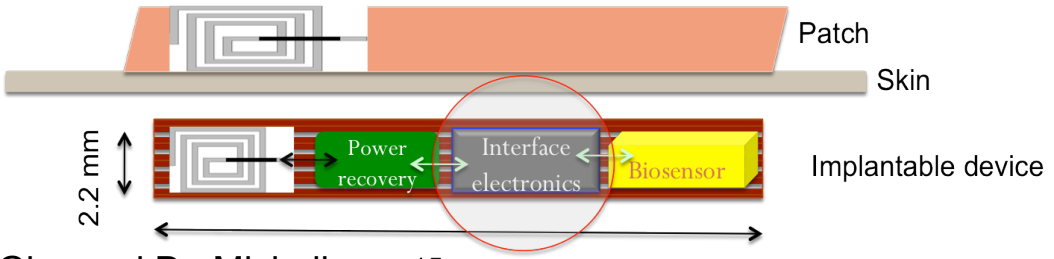
Giovanni De Micheli (EPFL)

Implant: cylinder about 2 mm in diameter and below 20 mm in length

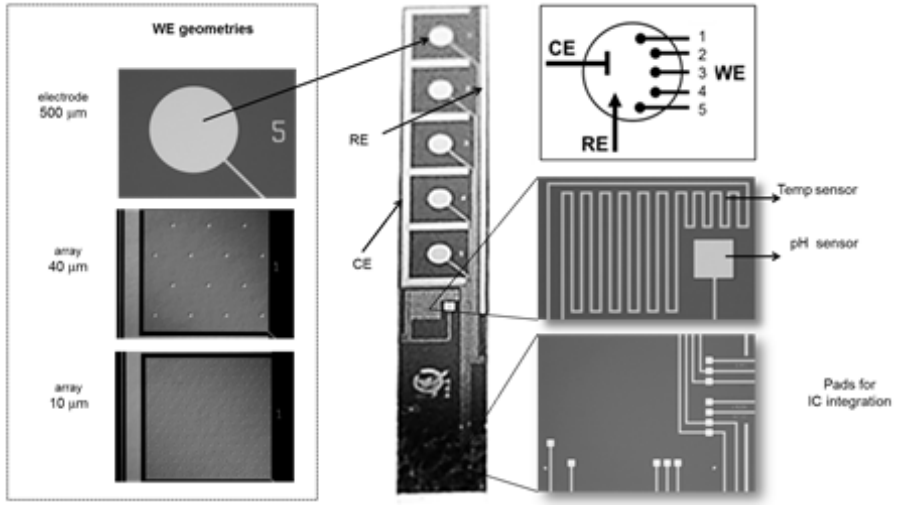


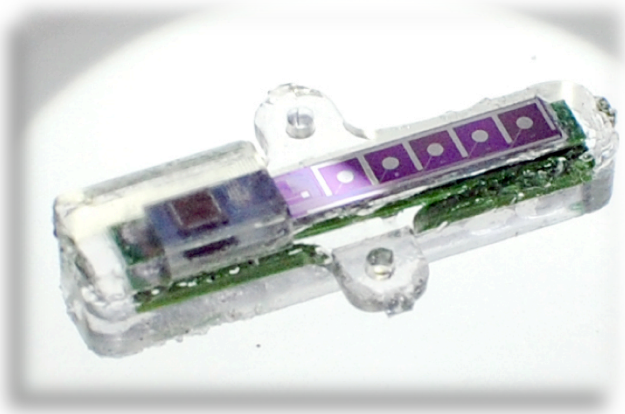


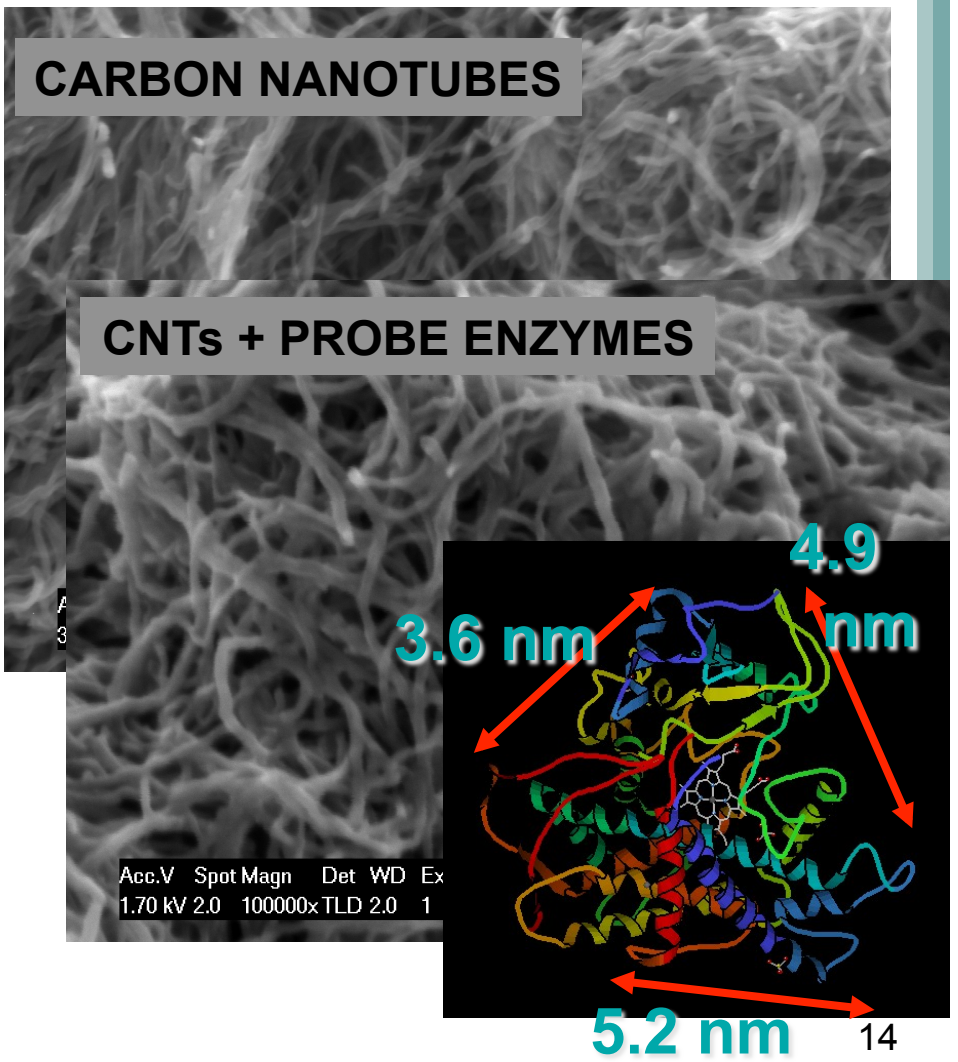




i-IronIC


WE geometries
electrode
500 µm
5
array
40 µm
array
10 µm
RE
CE
CE
1
2
3 WE
4
5
RE
Temp sensor
pH sensor
Pads for
IC integration




CARBON NANOTUBES
CNTs + PROBE ENZYMES
Acc.V Spot Magn Det WD Ex
1.70 kV 2.0 100000x TLD 2.0 1
4.9
nm
3.6 nm
5.2 nm

TecInTex

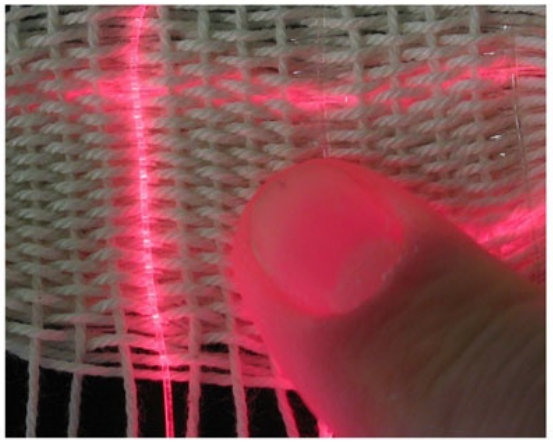
Technology integration into textiles: empowering health

Gerhard Tröster (ETHZ)

Sensing capabilities close to the human body ➡ monitor activity, motion, health…

Incorporate built-in technological elements in our everyday textiles & clothes

Existing E-textiles: low processability, wearing comfort, washability…



➡
- **design & manufacture truly wearable functional clothes**
- **electronic fibers**
- **optical fibers**
- **transducer between optical & electrical signals**

Near infrared spectroscopy sensing

Peripheral vascular diseases: 30% of adults

Early detection possible (near IR spectroscopy), but conventional sensors are cumbersome

Light wearable system in sock to monitor tissue oxygenation continuously & non-invasively

Tec InTex

Intelligent underwear for paraplegic people

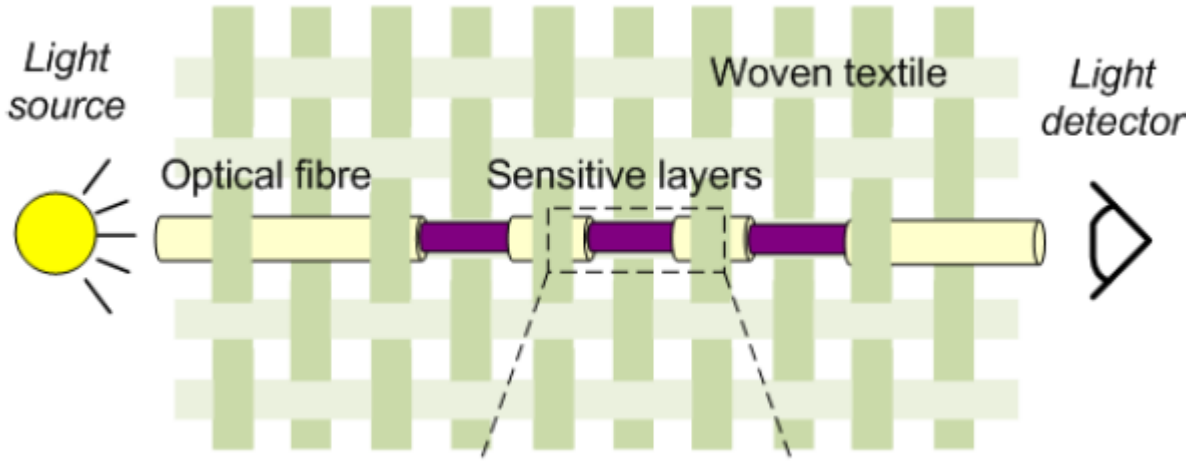
Pressure ulcers are serious problems for paraplegic and bed ridden patients

➡ **Build a comfortable device to detect the risk for pressure ulcers in order to enable preventive measures**

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich · EMPA · csem · UniversitätsSpital Zürich · Swiss Paraplegic Centre

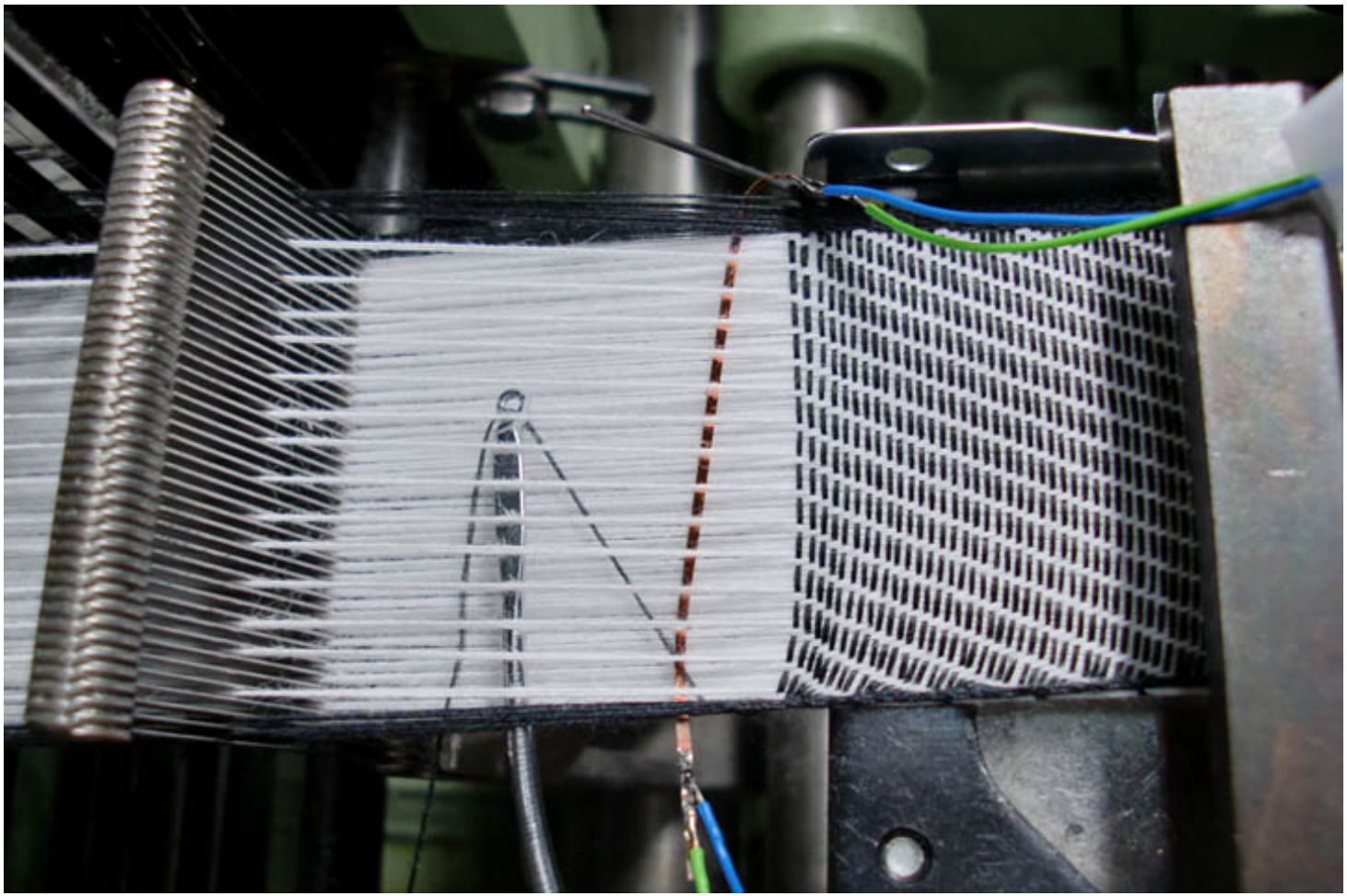
Woven optical sensor

- Modify optical fibers with sensitive porous layer
  - Specific to biomarkers
  - pH sensors (variation in color)
- Detection based on variation of light absorbance
- Fibers, detectors and light sources into fabric

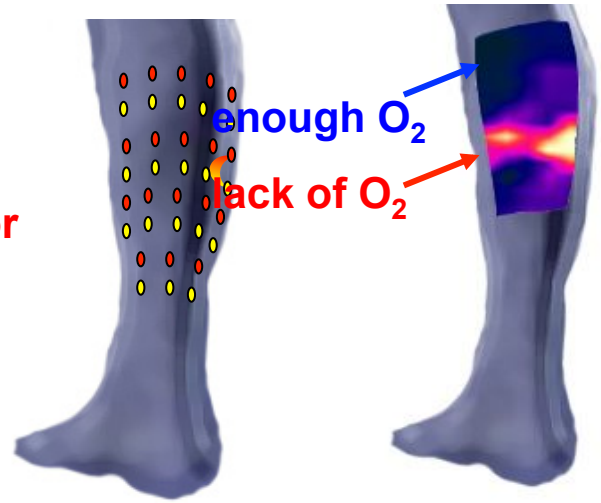


TecInTex

Loom



- NIRS (Near Infrared Spectroscopy) in socks
  - Early detection and treatment of peripheral vascular disease (PVD)



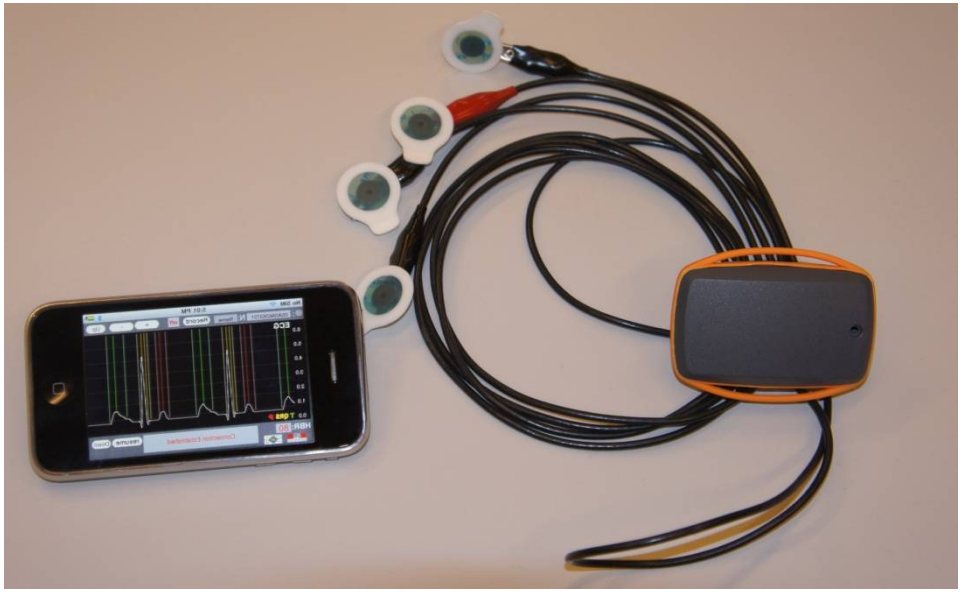
- Intelligent underwear for paraplegic people to prevent and to treat ulcer

BioCS-Node

Pierre Vandergheynst, David Atienza (EPFL)

Target: Continuous heart monitoring
Technology: Compressed sensing

Autonomous tool that automatically identifies anomalies in heart-rate and alerts doctors in seconds, helping them treat patients more quickly



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Part of complete coverage on CNN Labs

CNN LABS

Smartphone detects danger in a heartbeat

By **Matthew Knight**, CNN
October 24, 2011 -- Updated 1614 GMT (0014 HKT) | Filed under: Mobile

Electrode sensors on the skin link to a chip and radio module clipped to a patient's belt sending continuous data to a smartphone.

STORY HIGHLIGHTS

- New invention to help doctors respond to heart problems more quickly

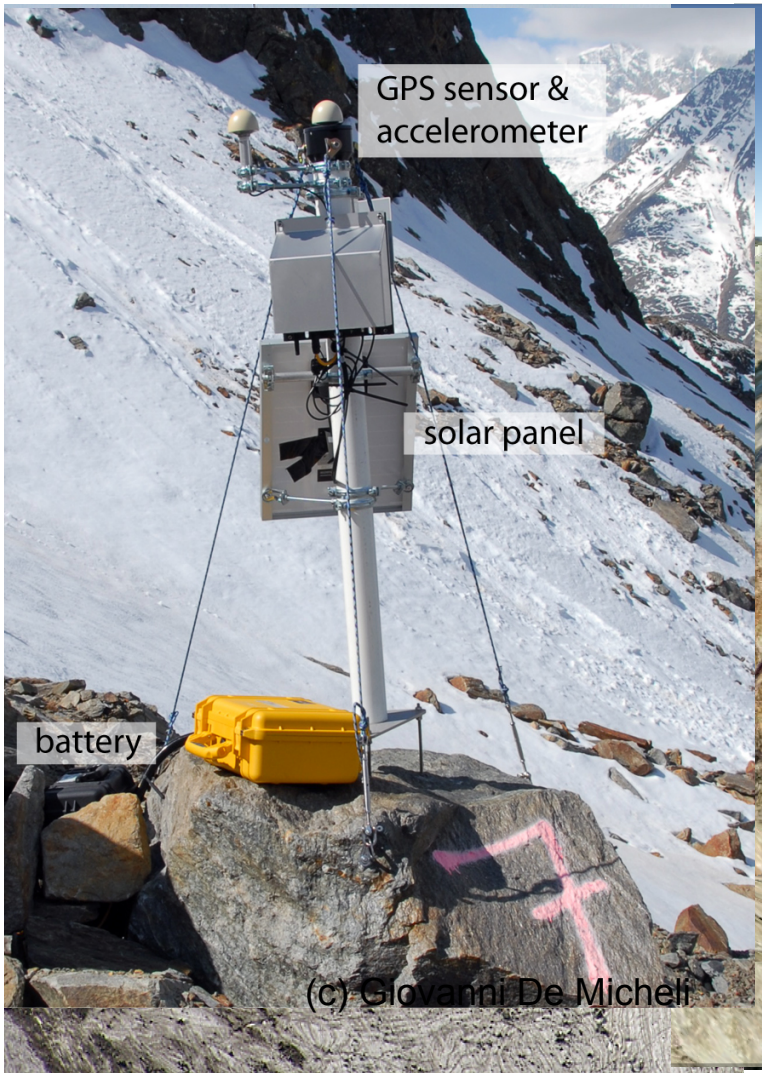
London (CNN) -- A new medical invention which harnesses the power of smartphone technology could revolutionize the treatment of heart patients, according to researchers in Switzerland.

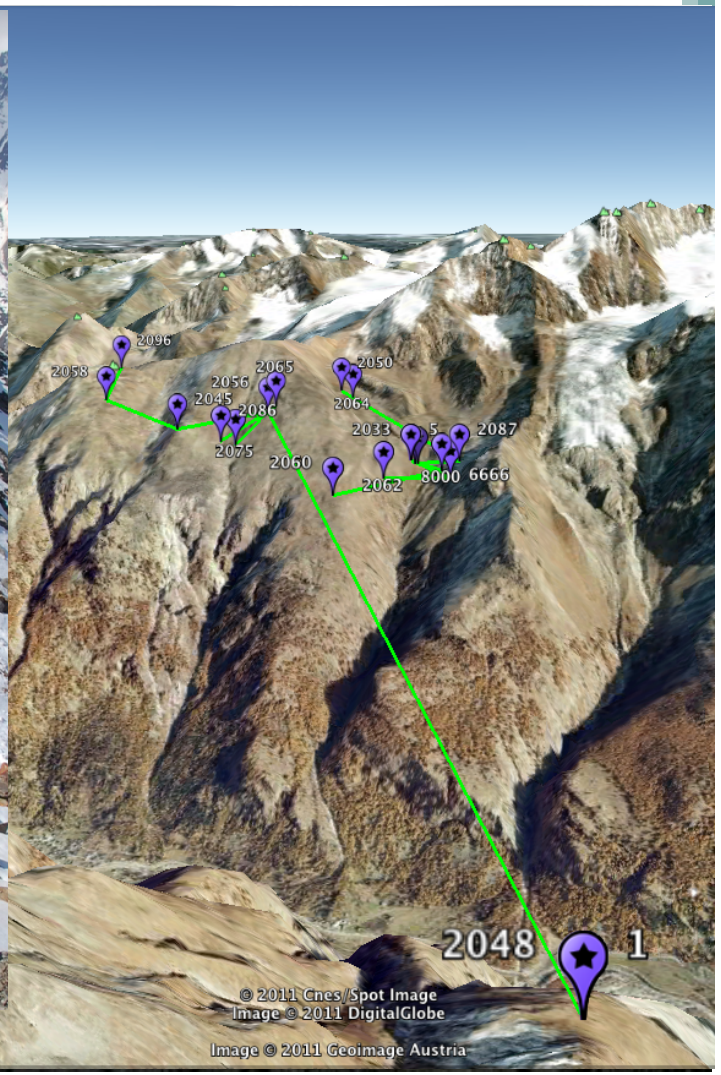
X-Sense

Monitoring alpine mass movements at multiple scales

Lothar Thiele (ETHZ)

Target: Safety in an alpine environment
Technology: Networked stations for rock/ice movement





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Swiss Federal Institute of Technology Zurich

Universität Zürich

GAMMA REMOTE SENSING

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Office for the Environment FOEN

OpenSense

Open sensor networks for air quality monitoring

Karl Aberer (EPFL)

Community driven, large-scale air pollution measurement in urban environments

- Few monitoring stations measure pollutants
- **Important technical opportunities & challenges**
- **Massive measurements that exploit:**
  - **wireless sensor networks**
  - **mobile stations**
  - **community involvement**
- **More data, more noise… also more redundancy**
  - **Can we produce better quality data?**

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Swiss Federal Institute of Technology Zurich

OpenSense

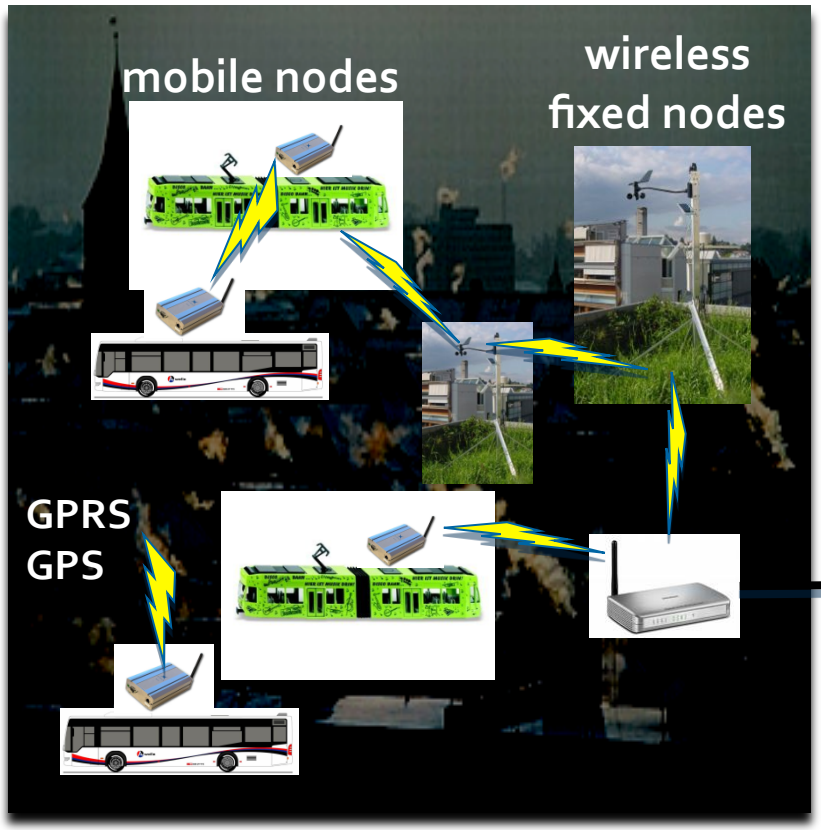
Challenges

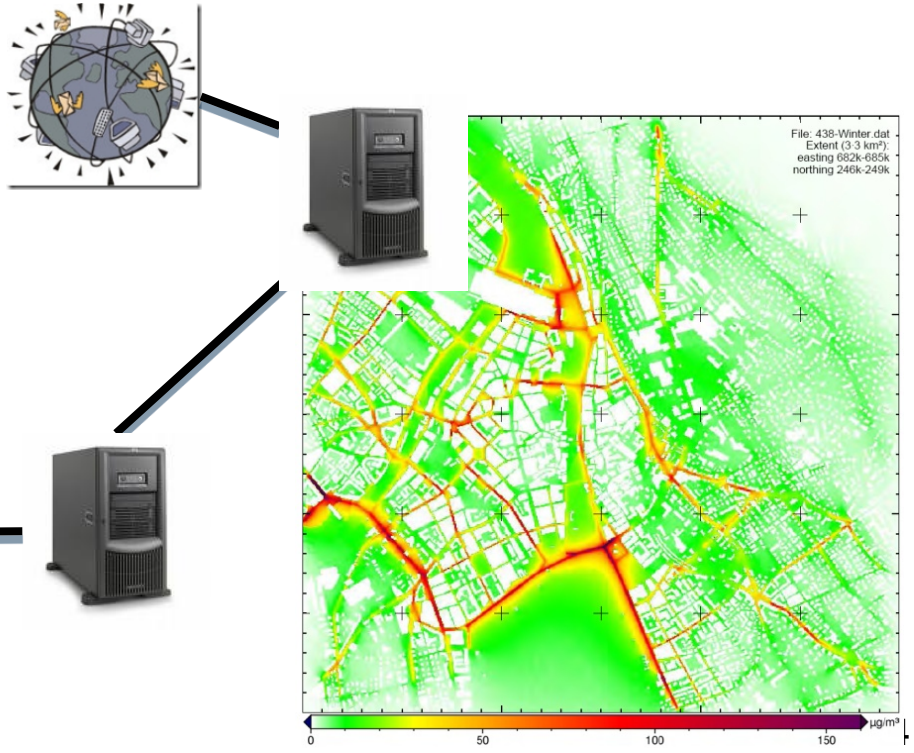
NANO

SENSING SYSTEM
From many wireless, mobile, heterogeneous, unreliable raw measurements …

INFORMATION SYSTEM
… to reliable, understandable and Web-accessible real-time information

TERA

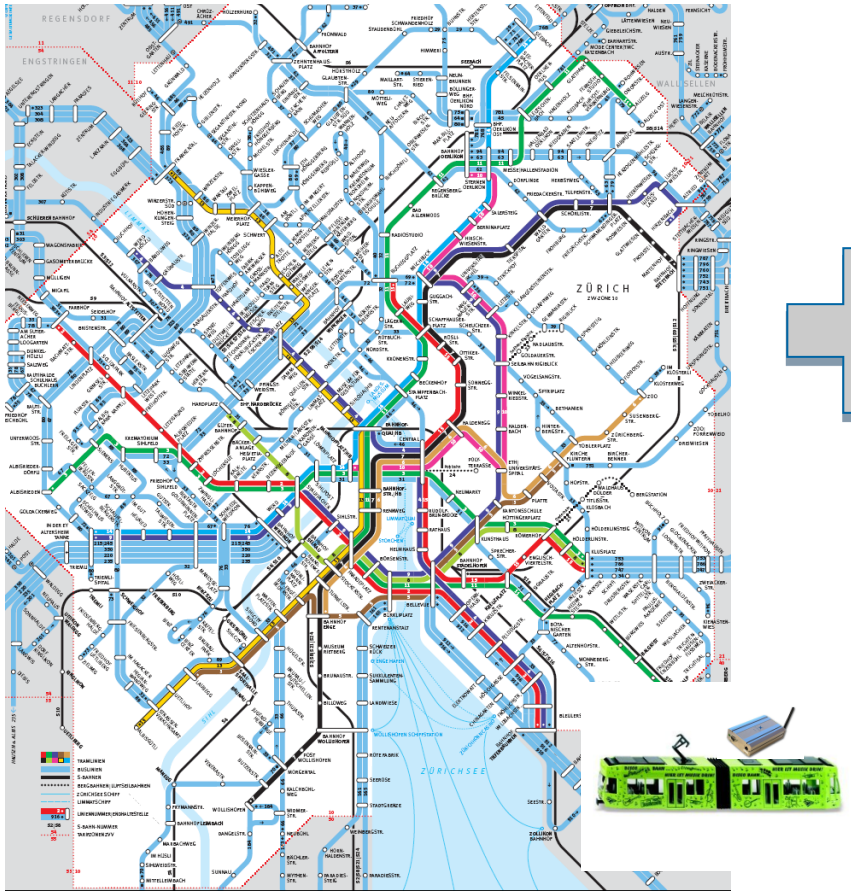




OpenSense

Sensing infrastructure

Mobile sensor nodes on public transportation and private mobile devices



Wireless sensing and communication infrastructure

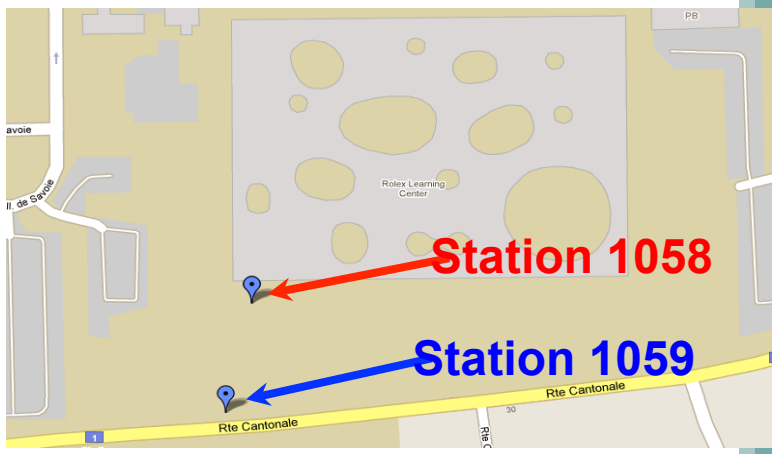
OpenSense

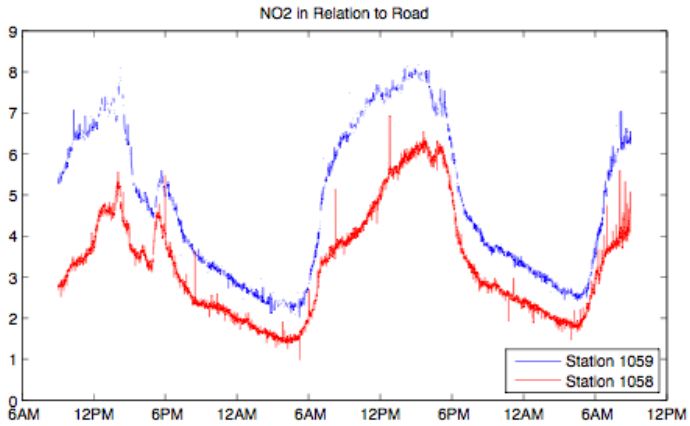
Lausanne: stationary

- 2 prototype stationary stations
  - NO2 (2 sensors), CO (2 sensors), Humidity, Temperature
  - Solar panel powered
- 1 station next to Nabel
- 12 stations deployed in 2012

EPFL campus

Lausanne Nabel station



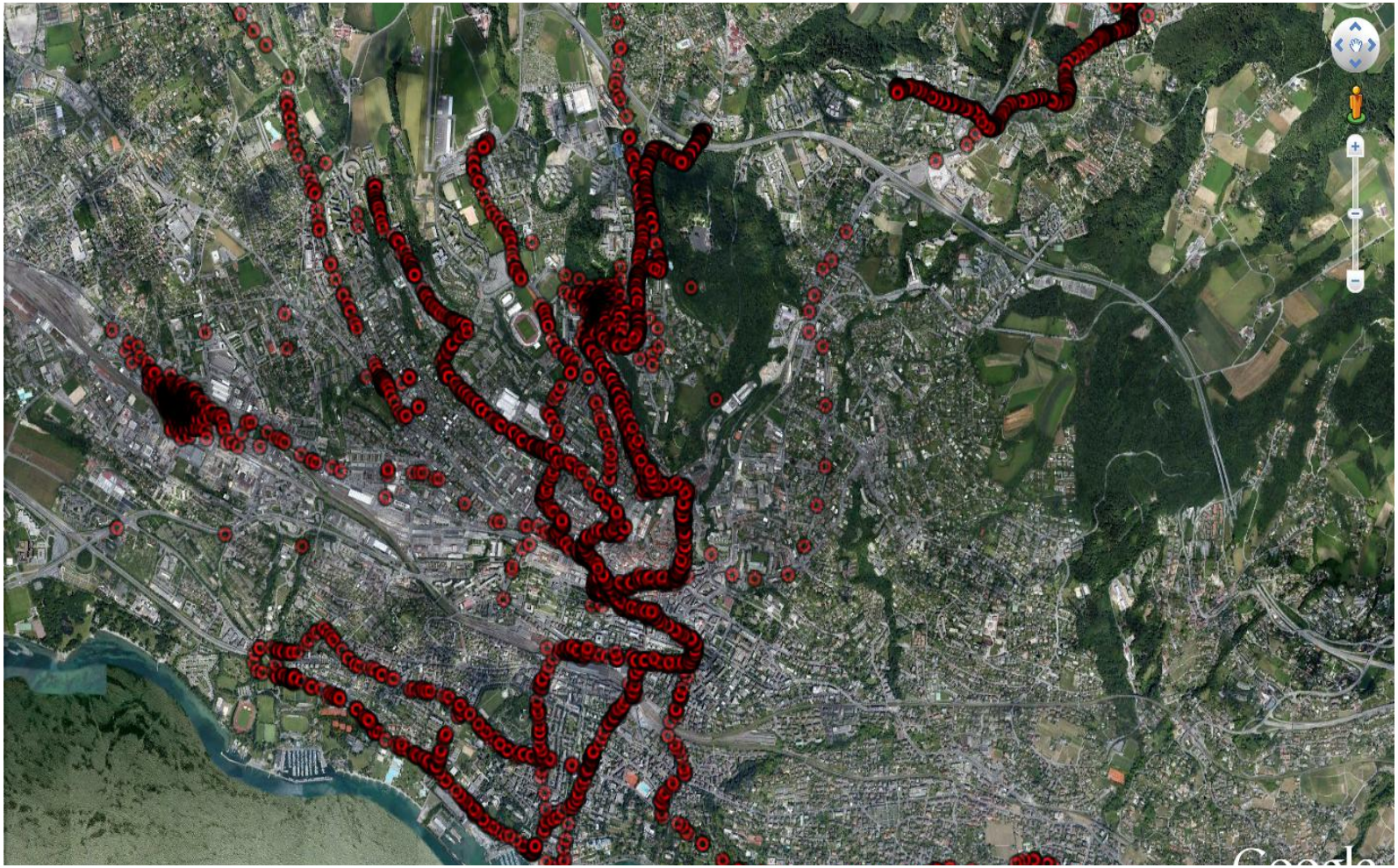


10 m distance result in significant difference

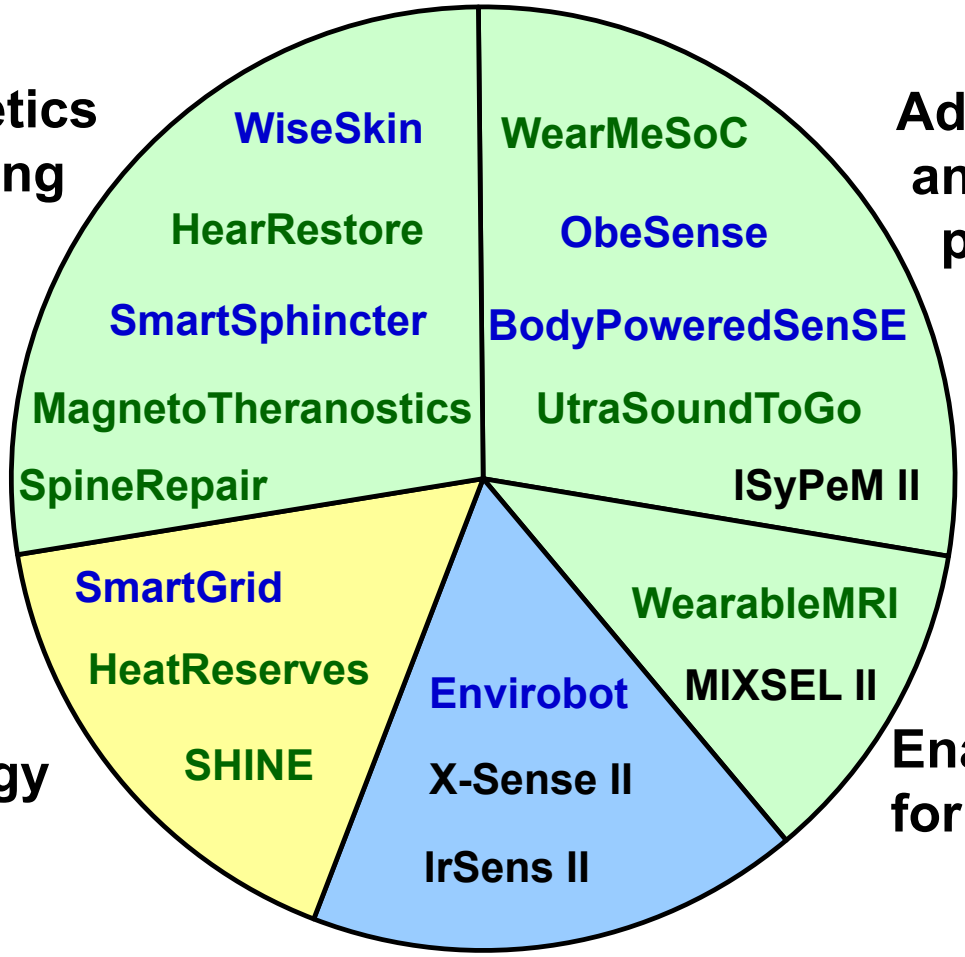
Lausanne: mobile

- 1 prototype station mounted on bus
  - NO2, CO (2 sensors), CO2, Humidity, Temperature
  - Positioning module
  - Powered by bus
- 8 mobile stations being deployed

OpenSense Lausanne coverage



New starting projects: 2013



RTD call 2011
RTD call 2012
RTD continuation

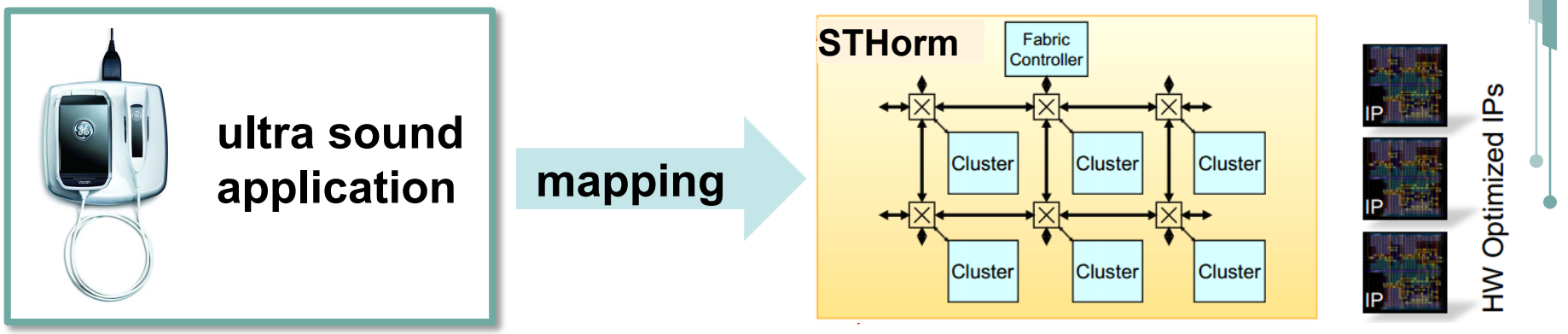
UltraSoundToGo

High performance portable 3D ultrasound platform

Giovanni De Micheli (EPFL)

Medical breakthroughs:

- Portable imaging device with capabilities of current large and stationary systems
- Enable 3D imaging
  - Support for telemedicine: sonologist/doctor can be remotely located



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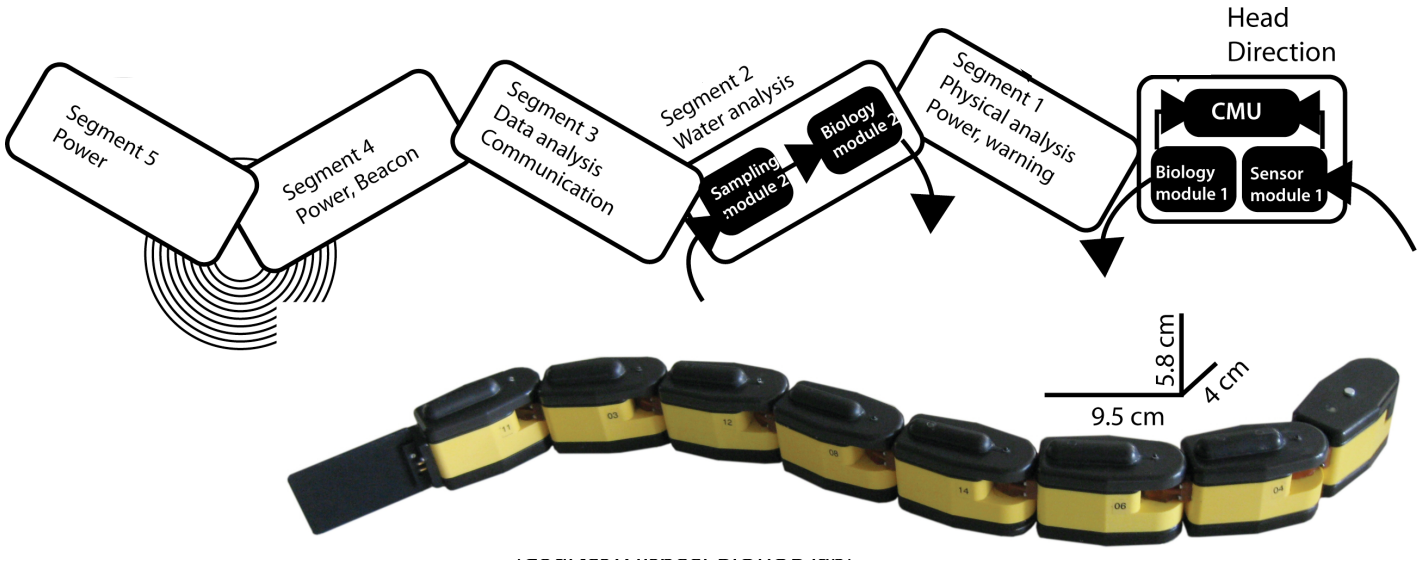
Envirobot

Automated surveying of surface water quality by a sensor equipped anguilliform robot

Jan van der Meer (UNIL)

- **Build a robot platform to measure surface water quality parameters with optical/physical/chemical/biological sensors**
- **Platform based on existing segmented anguilliform robots,** with adaptations for energy use & efficiency, sensory decision programming, and communication possibilities
- **2 modes:**
  - **Autonomous surveying:** Robot analyzes water bodies according to a preset path
  - **Autonavigation :** Robot guides its movement & sampling based on the sensory input



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UNIL | Université de Lausanne

eawag aquatic research

Hes·so Haute Ecole Spécialisée de Suisse occidentale Fachhochschule Westschweiz University of Applied Sciences Western Switzerland

Conclusions

- Nano-Tera.ch exploits **new technologies** and devices:
  - *Silicon nanowire* and *carbon nanotube* devices
  - *Integrated electronics* and *sensors*
- With the objective of building **heterogeneous** systems:
  - Monitor health in patients, disabled and elderly
  - Monitor the environment for pollution and to prevent disasters
- And with the final goal of increasing the **well-being** of individuals and communities
  - Key contribution of engineering to coping with complex societal and economic problems
  - Requiring large and collaborative intellectual effort


Thanks for your attention !
www.nano-tera.ch