Roadmap on IR Photonics for Medical Diagnostics and Therapy

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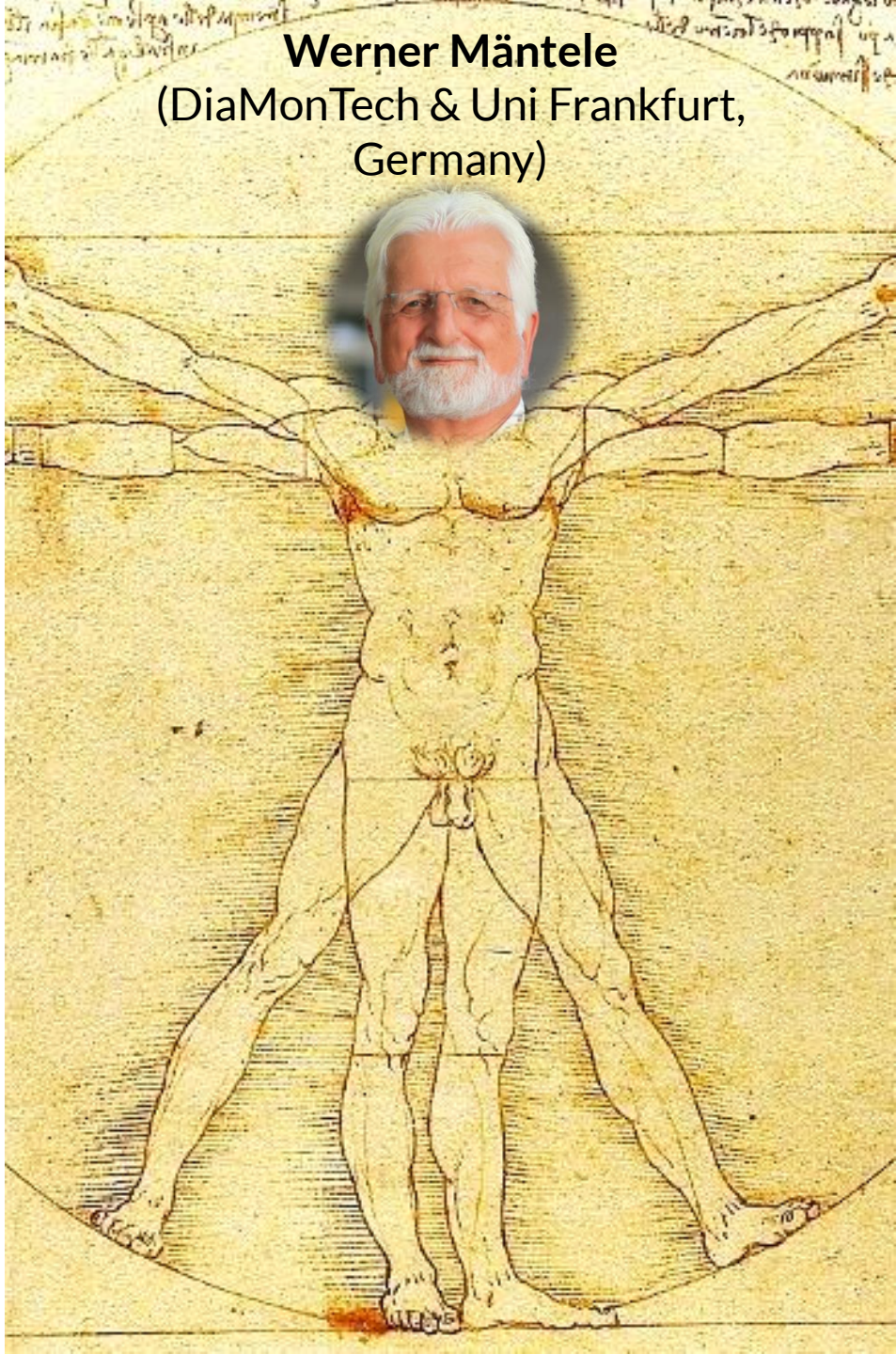


The Vitruvian Man (Da Vinci 1490)

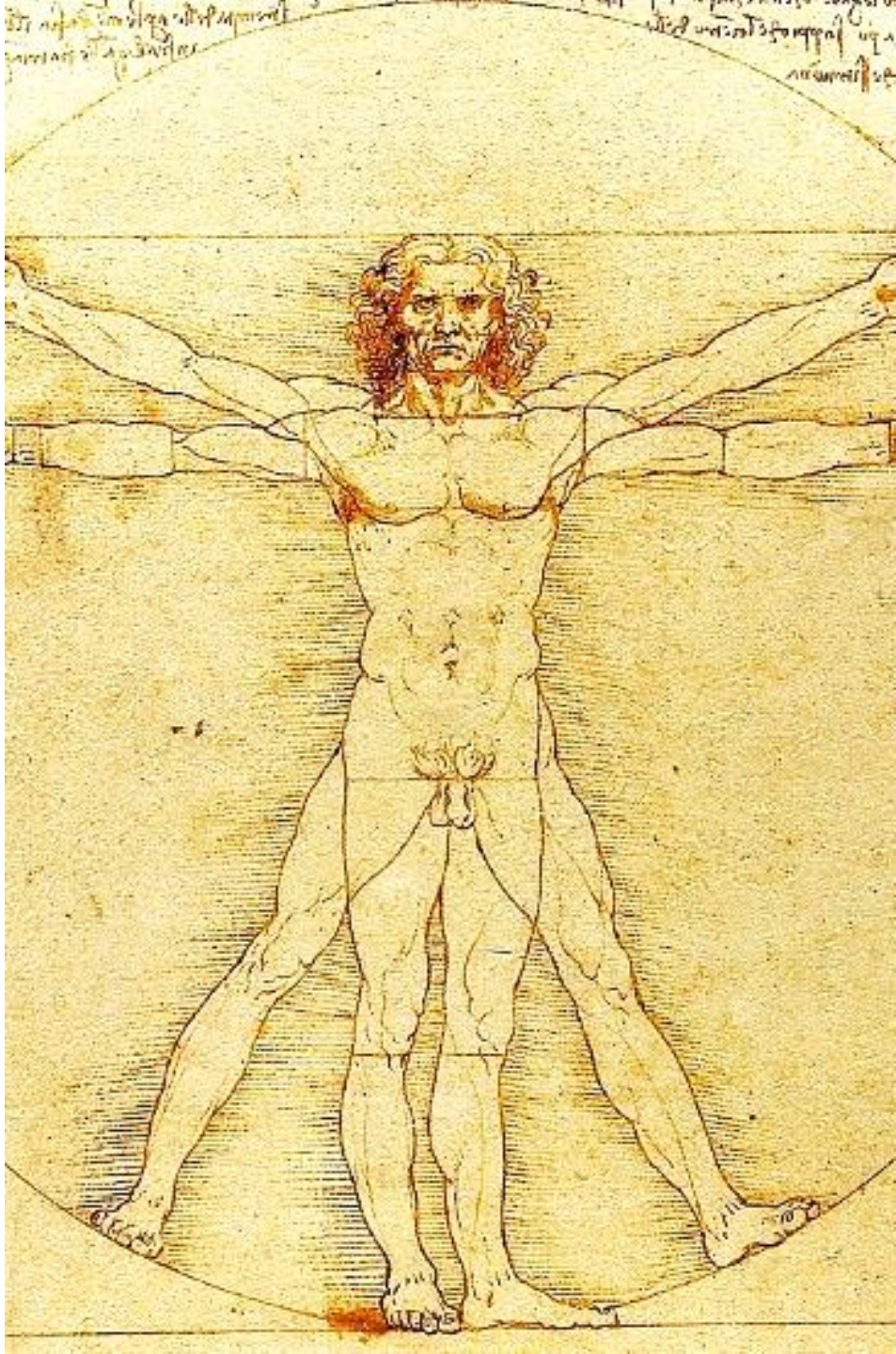
Nude male figure in **two overlapping poses**

Inspired by Roman architect **Vitruvius**

Idea: human body should perfectly **fit in square AND circle**

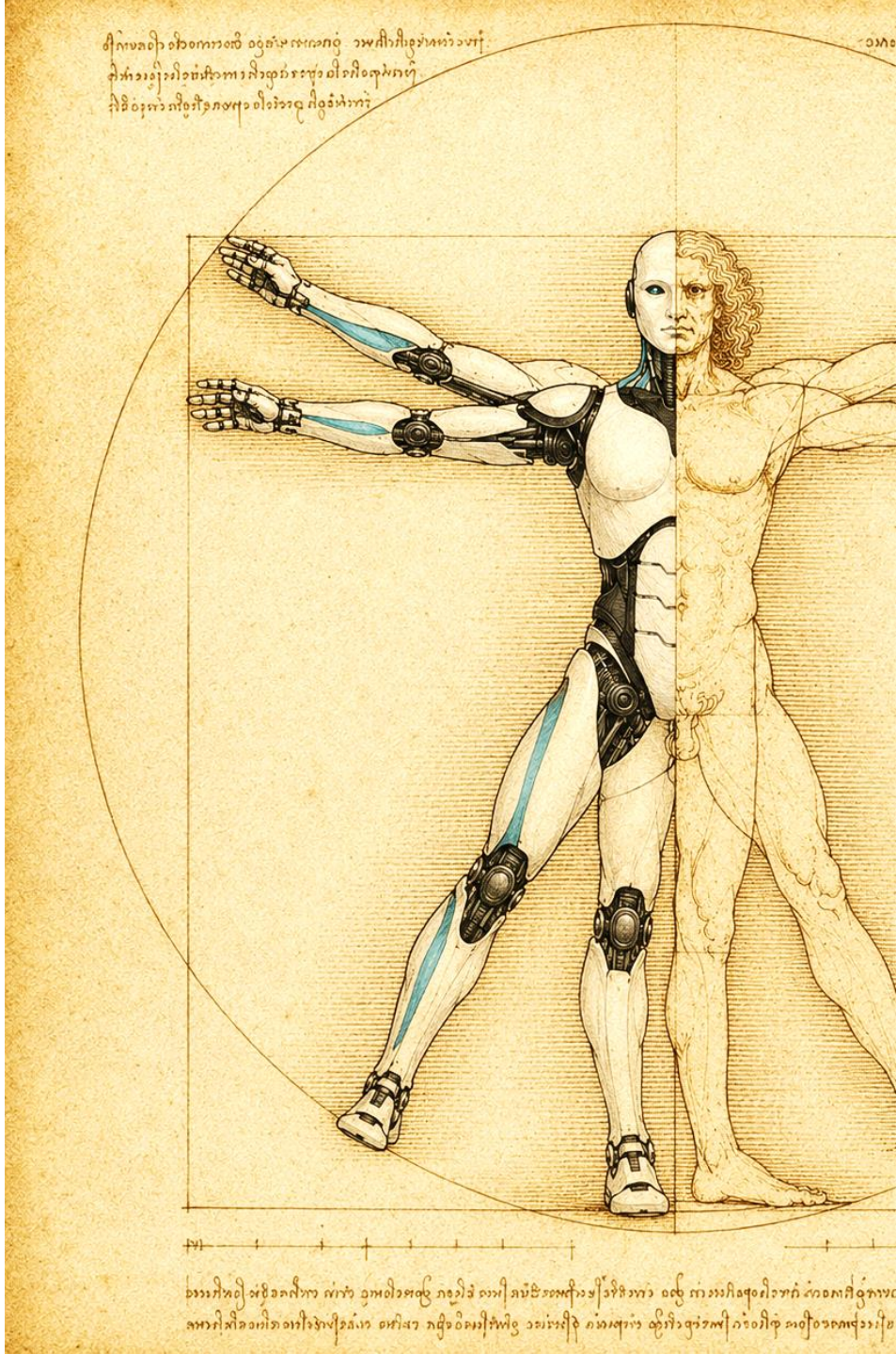
Navel at **center** of circle and outstretched **arms forming square**

Representation of ideal human proportions



The Vitruvian Man (Da Vinci 1490)

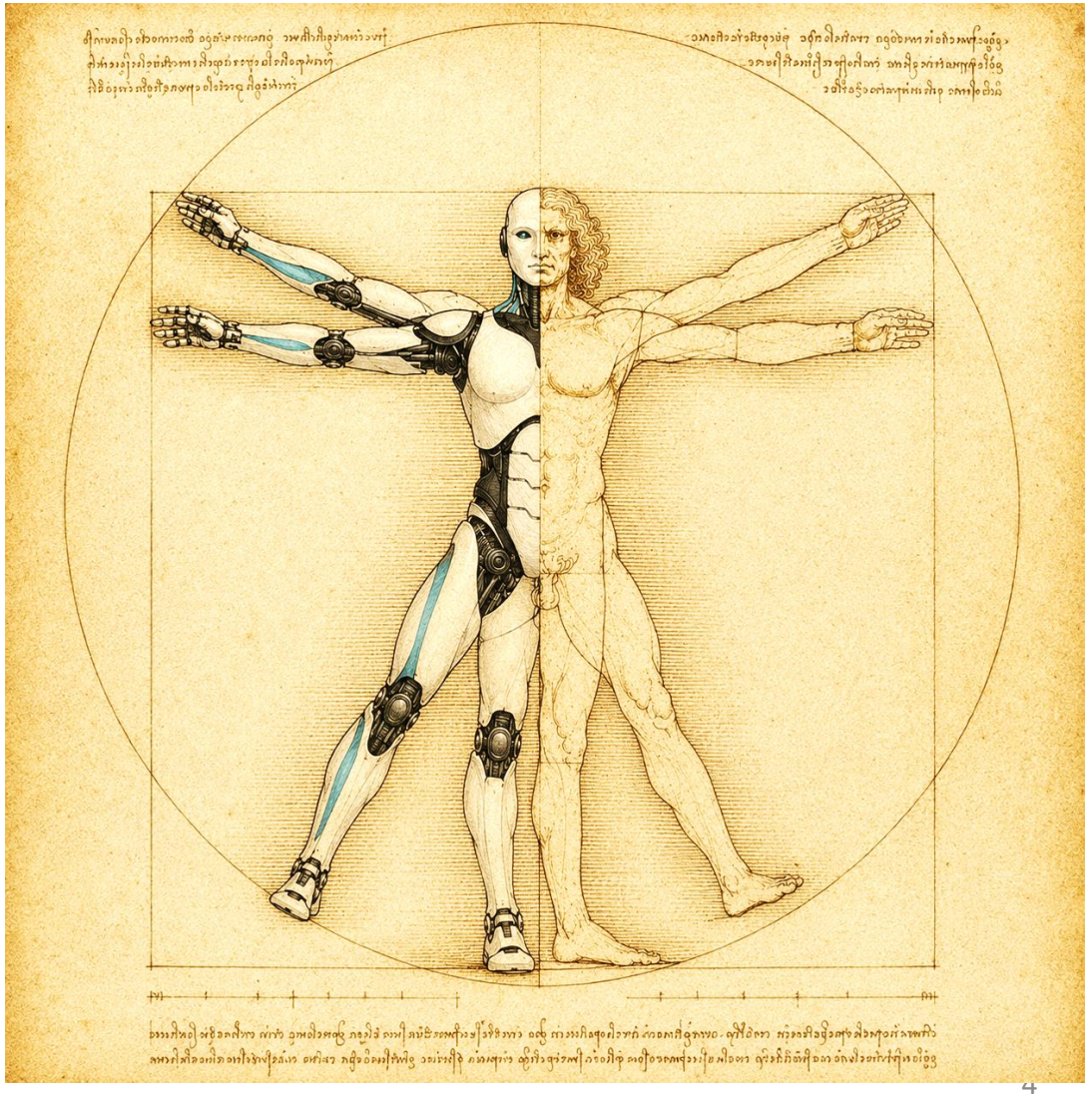
Progress in technology has enabled the creation of robots, in particular humanoids



From Human Sensing to Artificial Perception

The **senses of a robot:**

- **Camera**
- **LiDAR**
- **Radar**
- **Microphones**
- **Temperature sensor**
- **Tactile sensors**



From Human Sensing to Artificial Perception

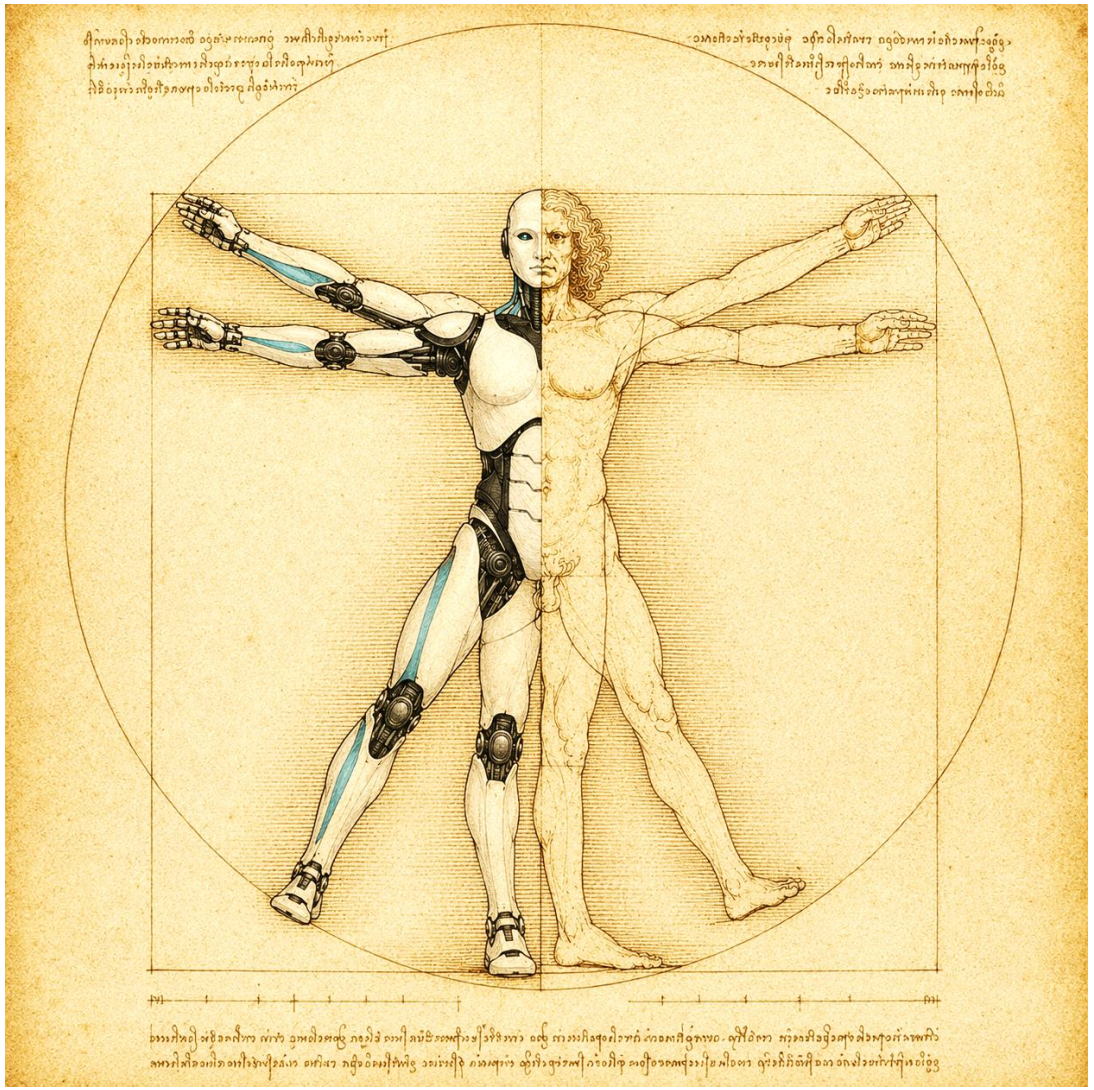
Vision

Distance

Temperature

Motion

Sound



Blood Chemistry

Breathomics

Tissue composition

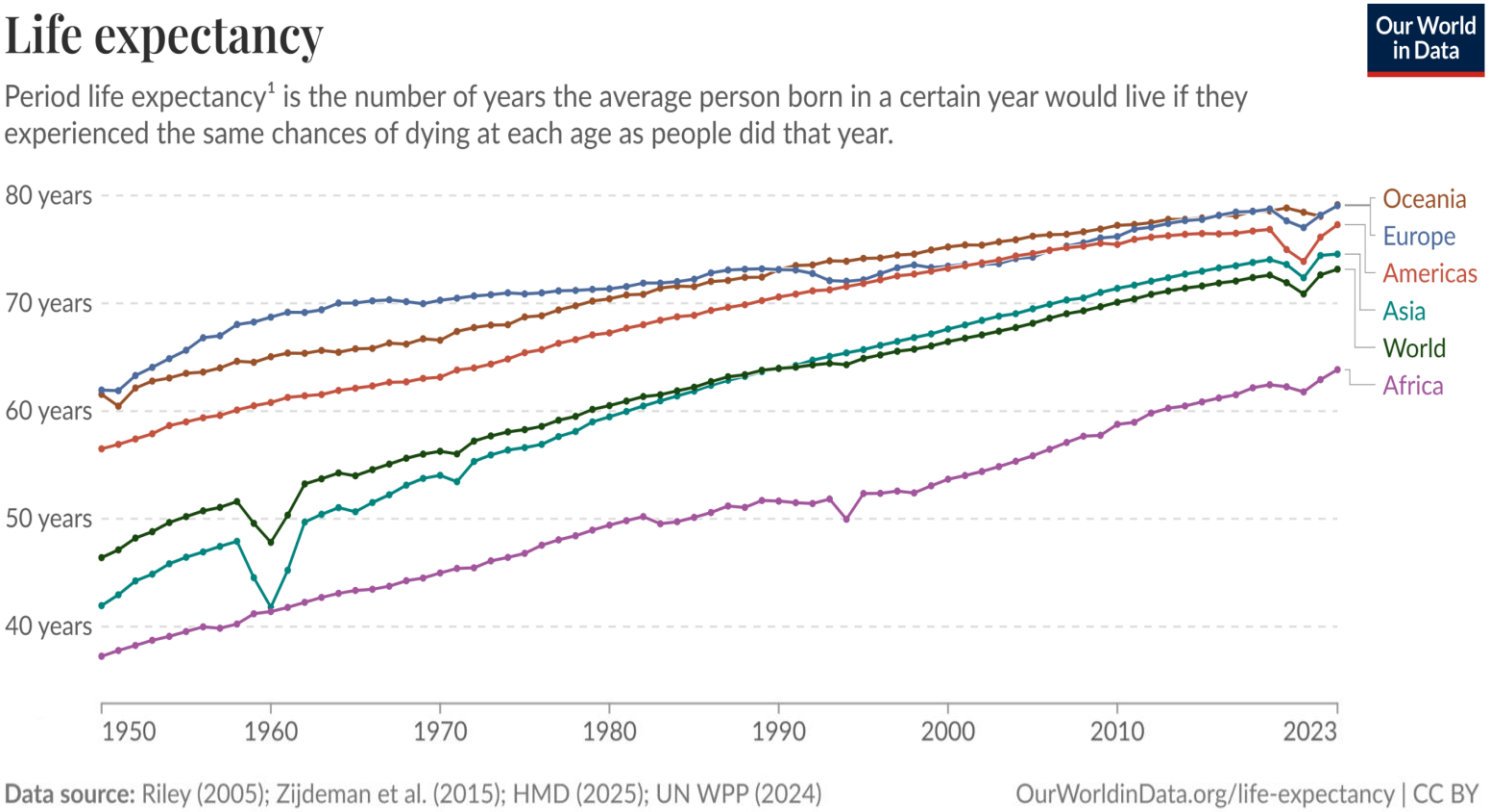
Metabolism

Inflammation

Biomarkers

Microbiome

Why? Motivation



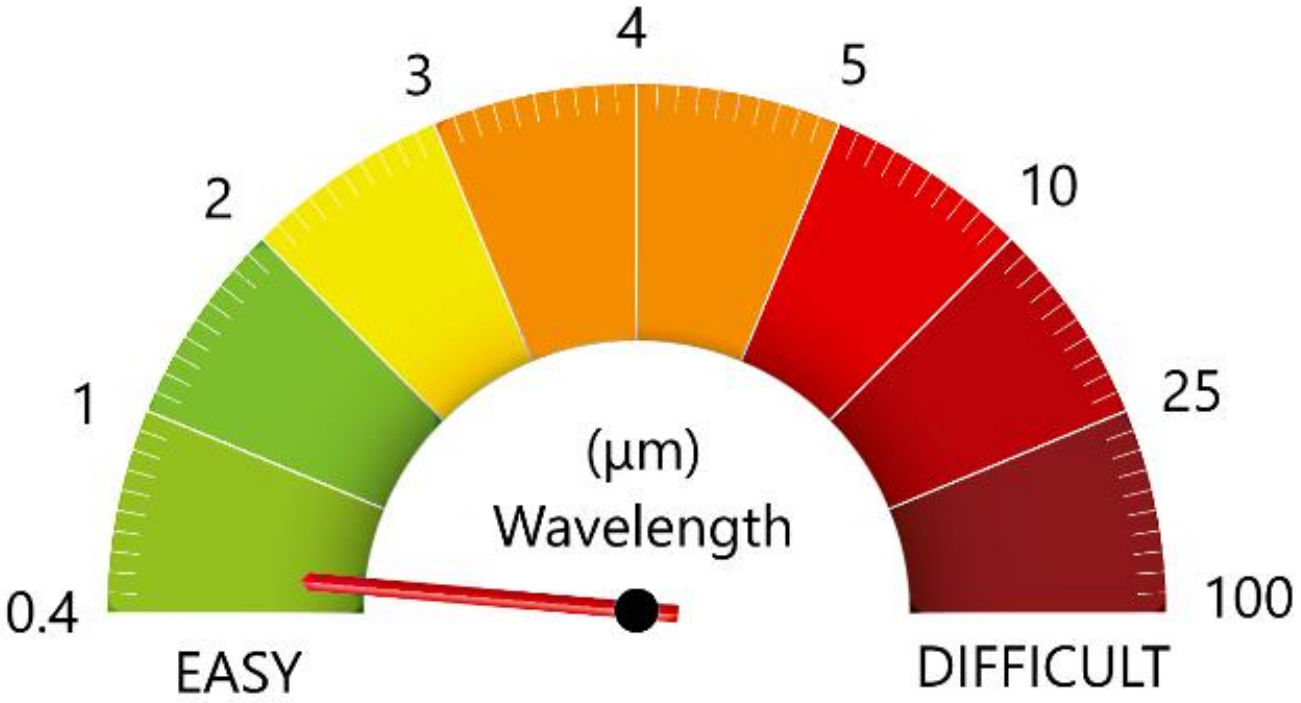
Increase in life expectancy = ageing population

Proactive & predictive healthcare moving from "**who can afford it**" to "**requirement for the broader population**"

The unique features of IR spectroscopy for healthcare

WHY INFRARED?

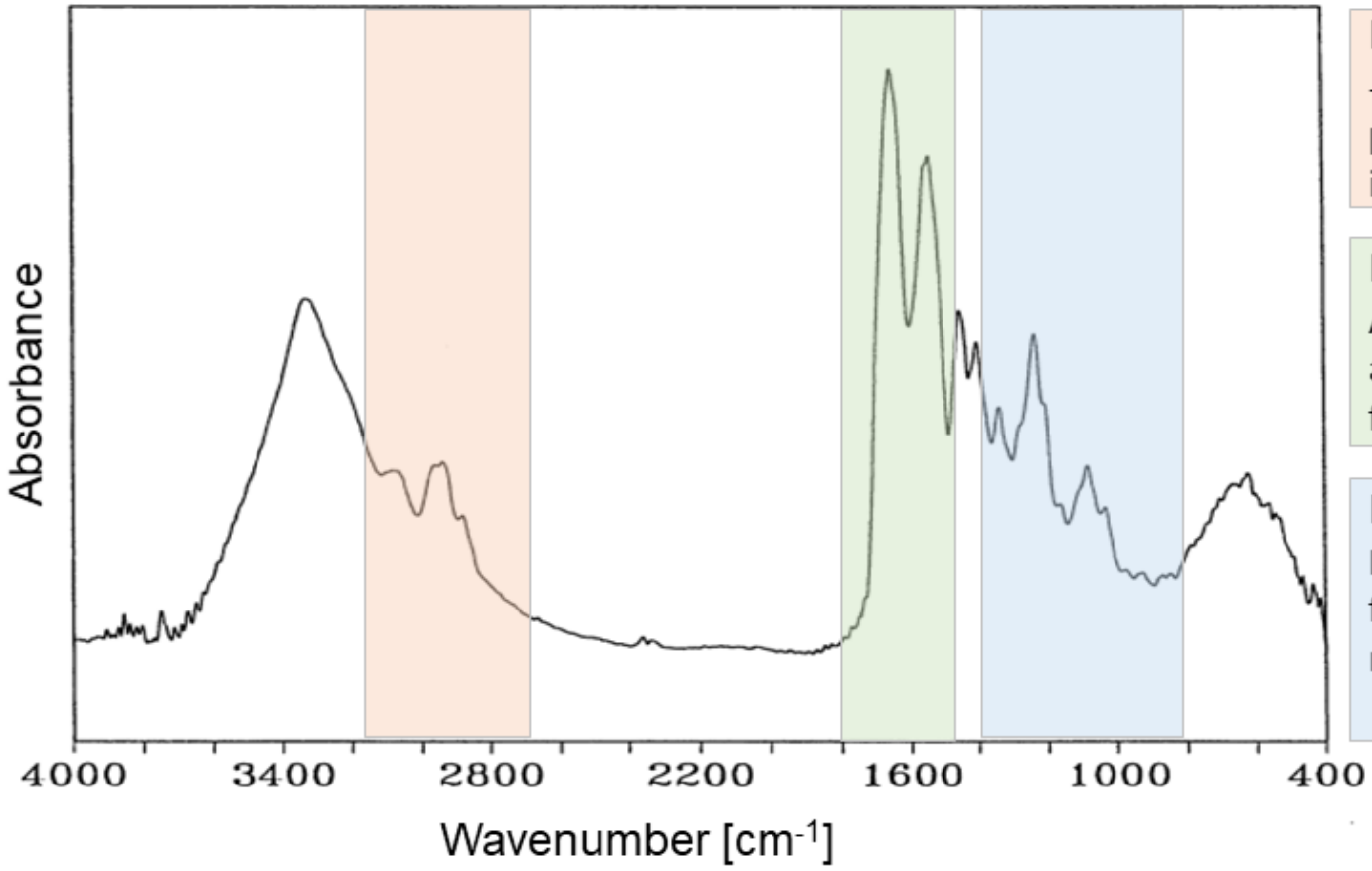
~2.5 to 20 µm (4000 – 500 cm^{-1})



Inspired by J. Kunsch's idea

- Transitions of **almost all molecules relevant in biological systems**
- **Extremely high specificity** for molecules, their conformation, and molecular interactions
- An **ideal tool for biomedical analysis**.

WHY MID-INFRARED?

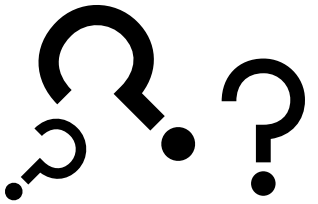


Lipid region (approx. 3200-2700 cm^{-1}):
-CH, $-CH_2$, $-CH_3$ modes are specific for membrane properties, protein-lipid and protein-membrane interactions.

Protein region (approx. 1800-1500 cm^{-1}):
Amide I and Amide II modes of the peptide bond are specific for secondary structure, protein folding, and misfolding (e.g. amyloid structures).

Fingerprint region (approx. 1400-800 cm^{-1}):
Region specific for molecular conformation and for the identification and quantification of small molecules (e.g. glucose, lactate, cholesterol).

WHY ANOTHER ROADMAP?



- **Fragmentation** in the IR field & CROSS fields:
  - Great concepts and prototypes → barely "**full supply chains**" to commercial devices available (~TRL3 - >TRL8)

- Many healthcare/medical suitable **technologies** individually demonstrated
- BUT: **Missing common vision**
- **Natural progress:** sources, detectors, components, optics, procedures, applications

- "**The hunt for the killer application**" (which gets a completely new meaning when speaking about medical/healthcare)
  → Could it be in the medical field?

THE COMMUNITY BEHIND THE ROADMAP

arXiv

Infrared photonics for healthcare: A roadmap for proactive and predictive health management

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Hinkov, Kunsch, Mäntele, Sterczewski et al., arXiv:2602.08248 (2026).

KEY FACTS

86 co-authors from 19 countries, from 48 institutions worldwide & 5 continents

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IRELAND UK FRANCE GERMANY POLAND

USA AUSTRIA SWITZERLAND JAPAN

SPAIN SAUDI ARABIA TURKEY

BRAZIL HUNGARY CHINA

ACADEMIA & INDUSTRY

Cross-discipline: Photonics, Optoelectronics Materials & Devices, Medicine, Chemistry, Clinical Research, …

The InfraM(R)ed Alliance

Currently under foundation.

InfraMRED Alliance

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DIAMONTECH

Nanosystems and Technologies GmbH nanoplus

VIGO PHOTONICS

13:47

InfraMRED Alliance

ABOUT

The InfraM(R)ED Alliance is a global initiative and platform founded by spectroscopists and device manufacturers united by a common goal: To bring infrared photonic advances into medical practice as rapidly as possible.

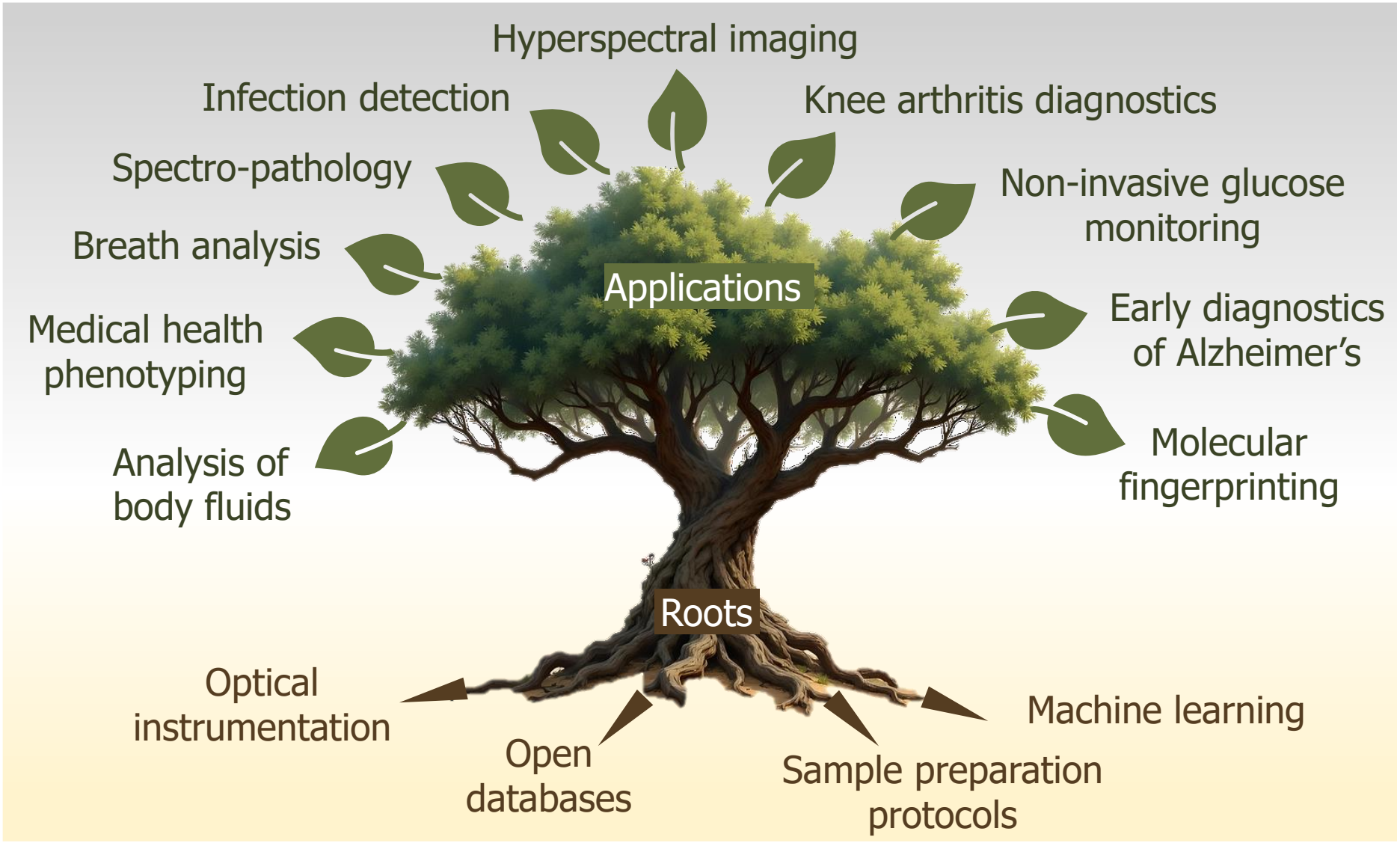
WORK IN PROGRESS

Textbook for medical people (2027)

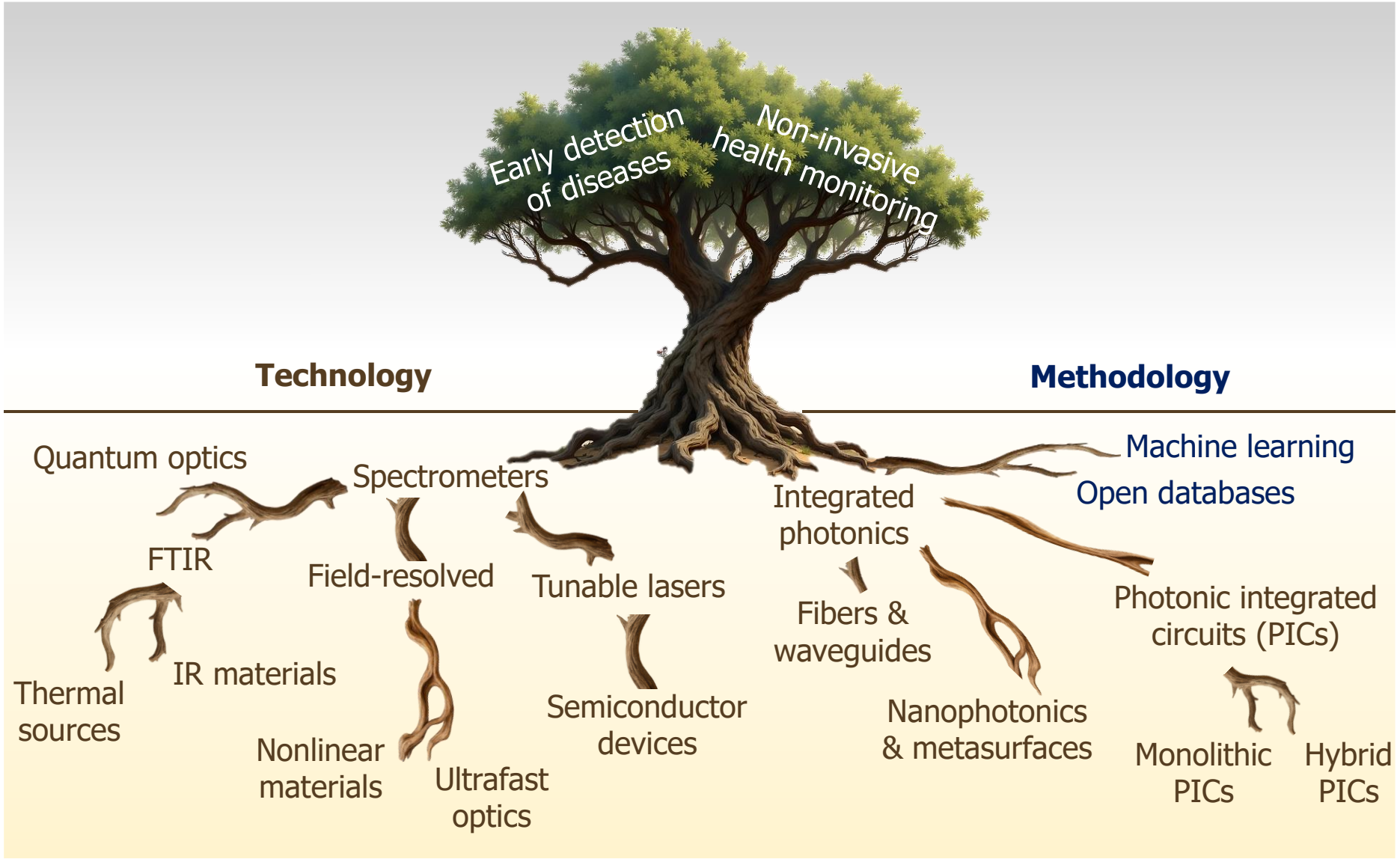
Special WORKshop: Wroclaw, Oct 16th, 2026

Medical Congress (2028)

APPLICATIONS ARE ROOTED

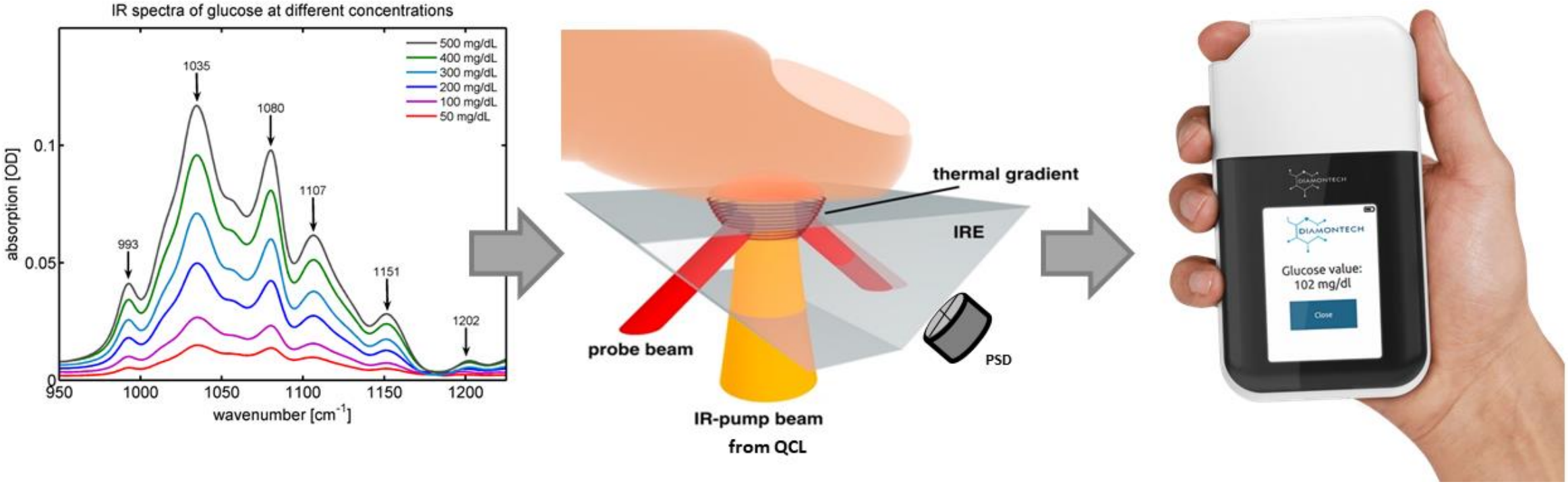


DEPENDENCE ON …

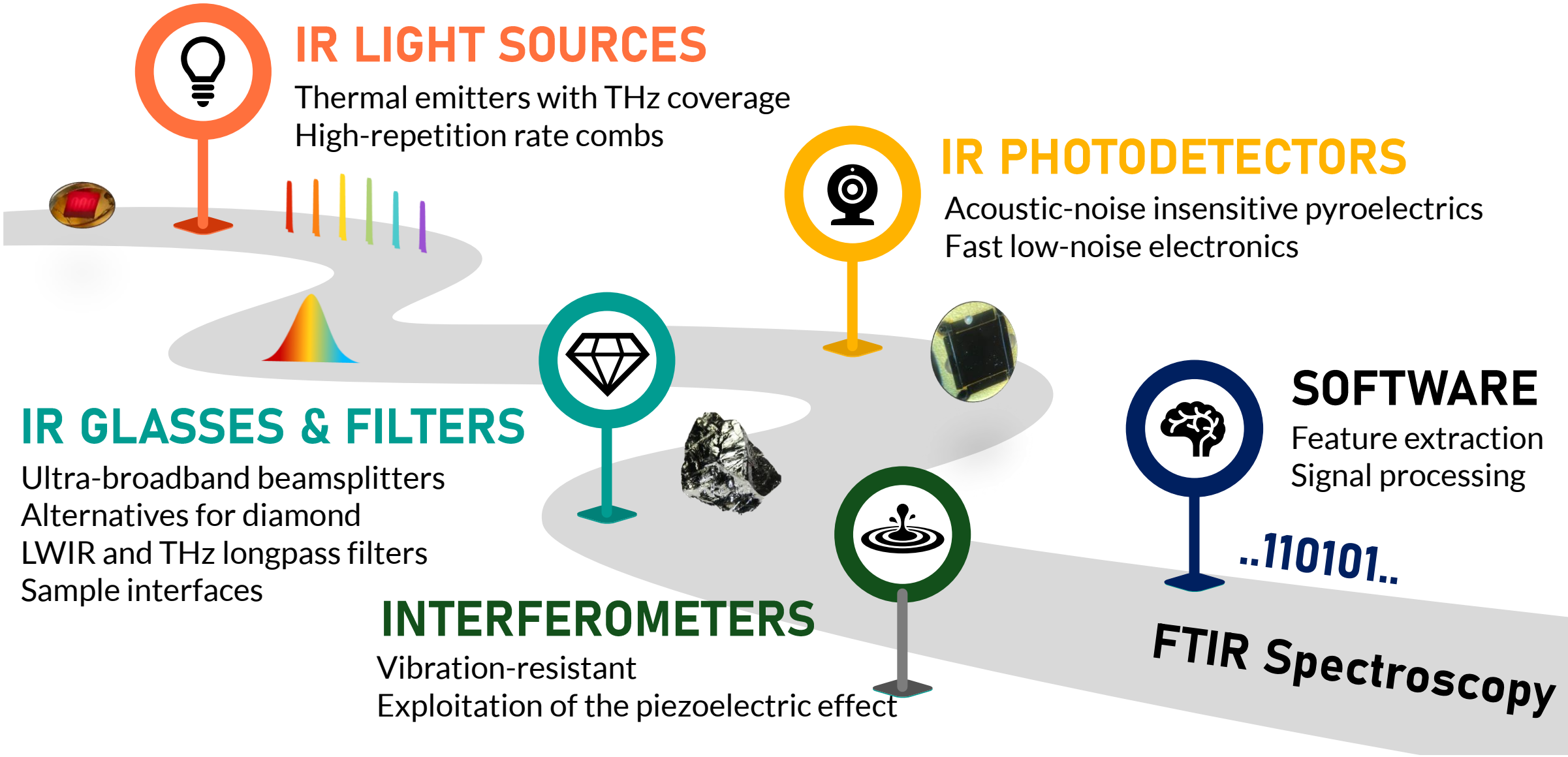


NON-INVASVE BLOOD GLUCOSE MONITORING

Werner Mäntele[1,2], Michael Kaluza[1], Sergius Janik[1], Mattia Saita[1], Lars Melchior[1], Thorsten Lubinski[1]



DIRECT MEANING OF A ROADMAP



IR LIGHT SOURCES

Thermal emitters with THz coverage
High-repetition rate combs

IR PHOTODETECTORS

Acoustic-noise insensitive pyroelectrics
Fast low-noise electronics

IR GLASSES & FILTERS

Ultra-broadband beamsplitters
Alternatives for diamond
LWIR and THz longpass filters
Sample interfaces

INTERFEROMETERS

Vibration-resistant
Exploitation of the piezoelectric effect

SOFTWARE

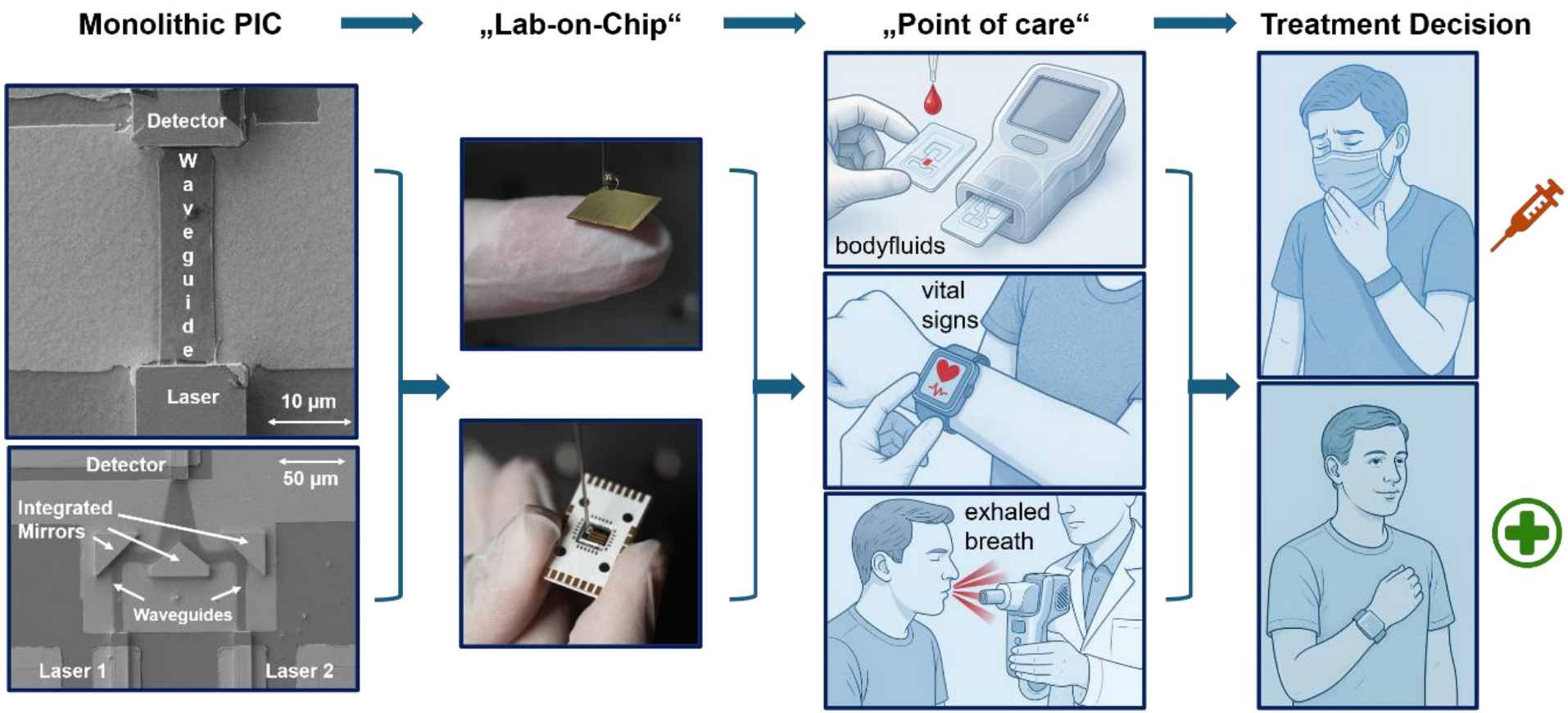
Feature extraction
Signal processing

..110101..

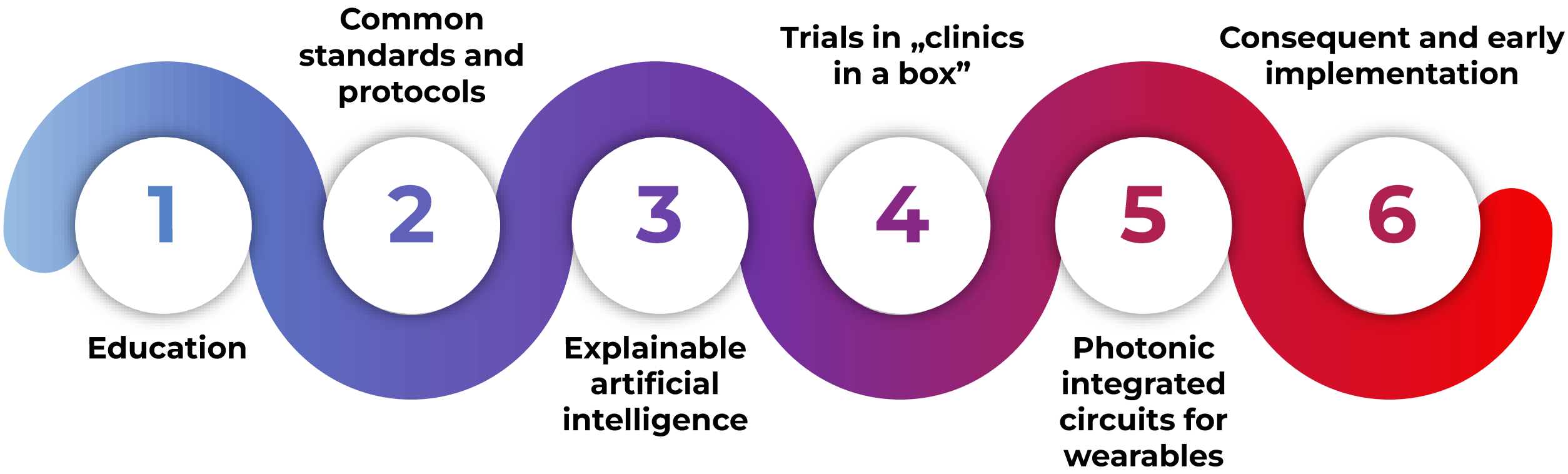
FTIR Spectroscopy

PICS FOR COMPACT MEDICAL DEVICES

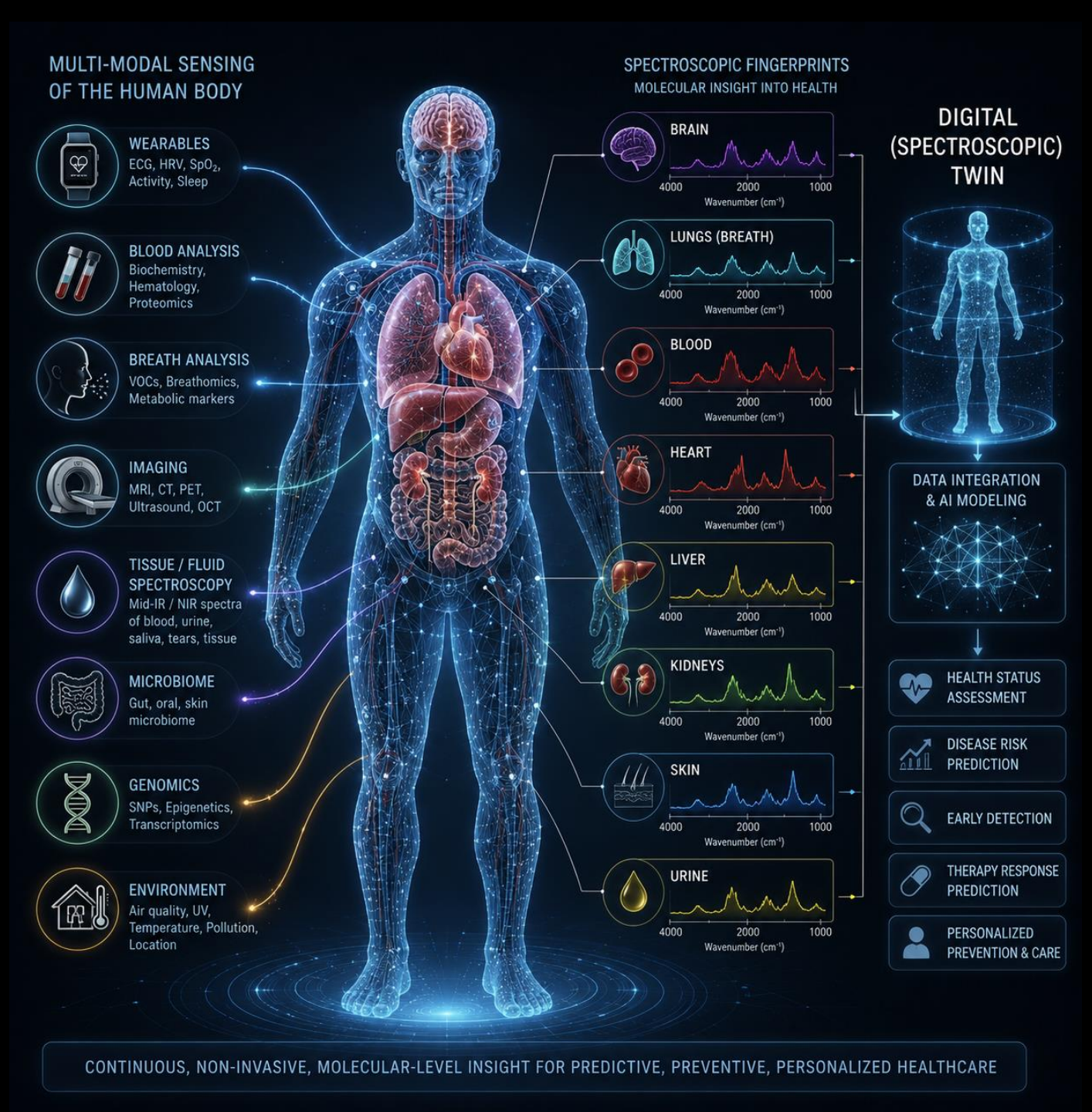
Borislav Hinkov[1] and Felix Jaeschke[1,2]



BOOSTING THE PHOTONIC REVOLUTION



THANK YOU!

Become part of our initiative!

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