
EXPLORE THE POTENTIAL OF
INTEGRATED SILICON PHOTONICS
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SILICON PHOTONICS FOR MEDICAL APPLICATIONS

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INTRODUCING THE SPEAKER: ROEL BAETS

- To be completed

OUTLINE

- Silicon photonics for medical applications: why, how
- Cardiovascular medicine
- H2020-CARDIS project: results
- H2020-InSiDe project: prospects

HEALTH CARE

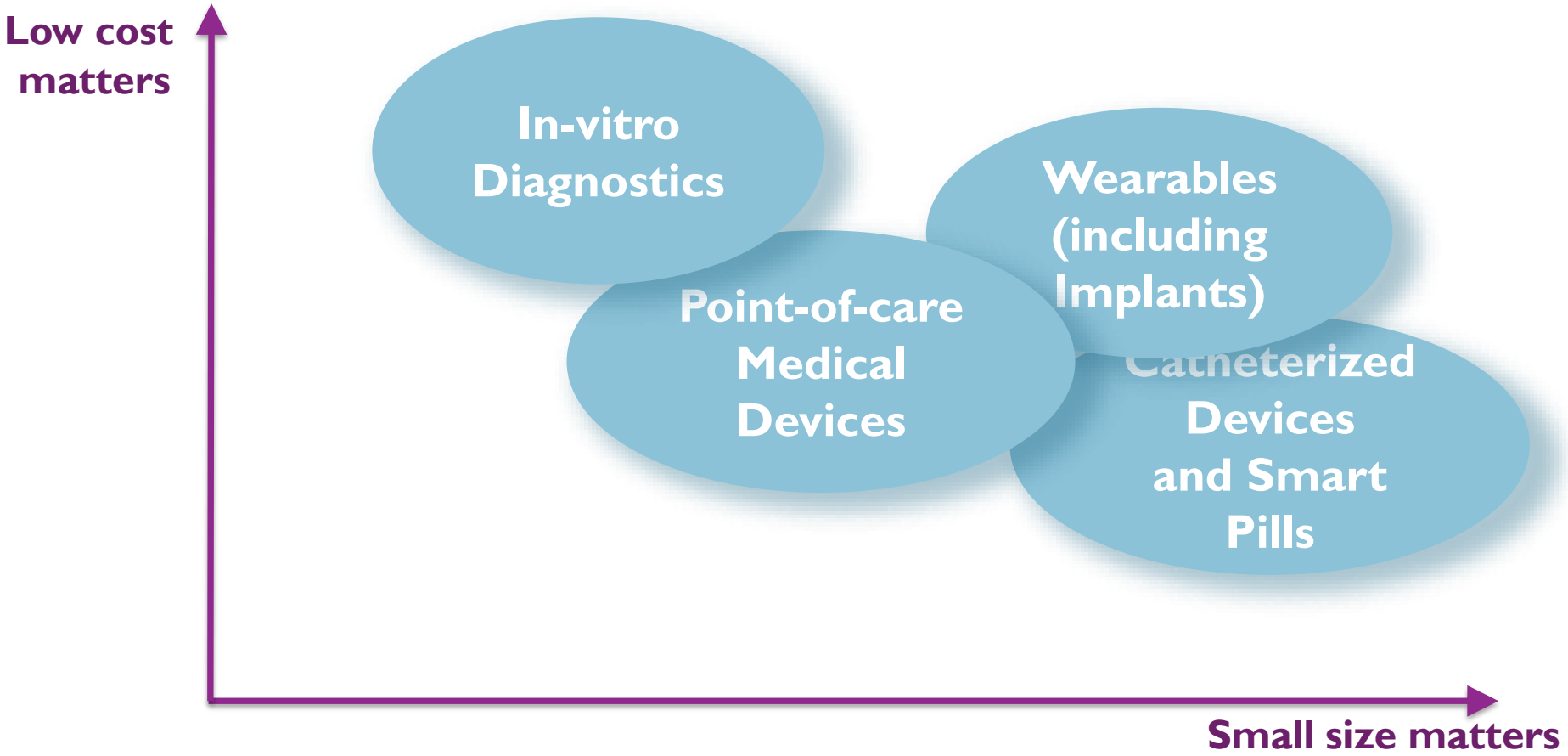
- Enormous challenges:
  - Ageing society
  - Keep ever more performant health care affordable for society
  - More focus on preventive medicine

- Technology can help:
  - Low-cost personal, bed-side and point-of-care medical devices
  - Minimally invasive devices (cathetered approaches, implants, electronic pills)
  - Rapid diagnostics (immuno-assays based on disposable use-once chips)

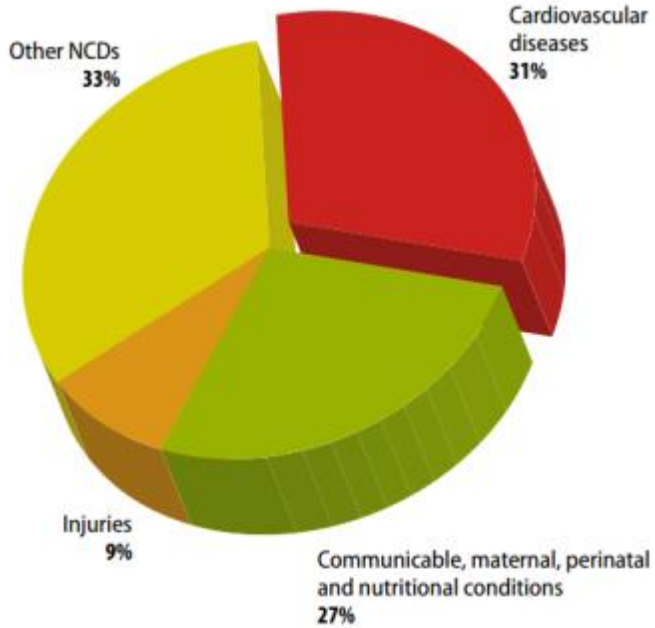
ASSETS OF SILICON PHOTONICS FOR MEDICINE AND HEALTH CARE

- Rich set of sensing modalities
- Low cost (even in moderate volume)
- Very compact devices
- Can address needs from visible to mid IR
- Mature supply chain

MAIN APPLICATIONS OF SILICON PHOTONICS IN MEDICINE



CARDIOVASCULAR DISEASES (CVD)



Distribution of major causes of death including CVDs (WHO 2011)

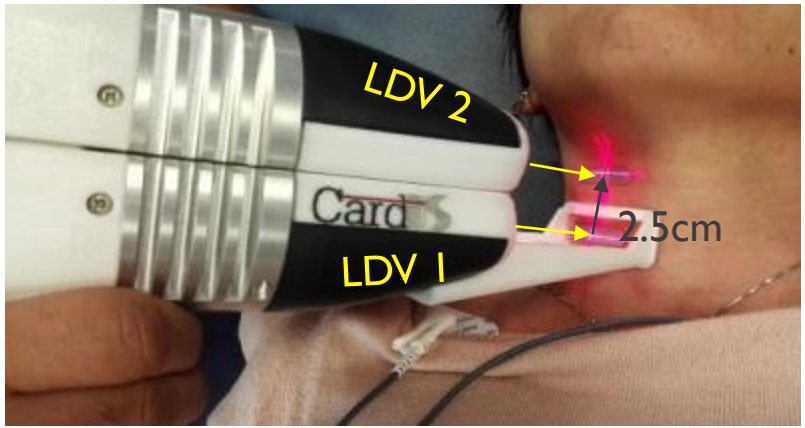
Cardiovascular disease: The biggest killer in the world, responsible for **30%** of deaths (WHO, 2011)

CARDIOVASCULAR DISEASE (CVD)

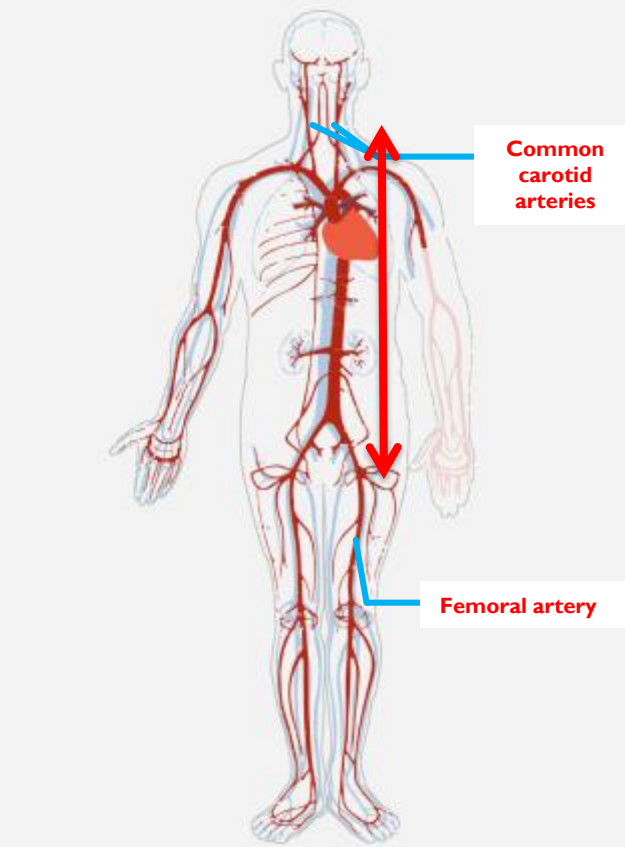
- Resistant hypertension
- Arteriosclerosis: stiffening of arterial walls
- Atherosclerosis: deposition of plaque on the inner arterial walls
- Stenosis: abnormal narrowing in a blood vessel
- Heart dyssynchrony: left and right part of the heart are not triggered synchronously
- Valvular diseases

A map of the skin displacement above arteries can help for early diagnosis or follow-up of these pathologies.

- Method: laser Doppler vibrometry
- Technology: silicon photonics
- Use: by general practitioner



PULSE WAVE VELOCITY (PWV): MARKER FOR ARTERIAL STIFFNESS



Pulse Wave Velocity: speed by which the pressure wave caused by a heart beat travels in the arteries

$$PWV = \frac{pulse\ travel\ distance}{pulse\ travel\ time}$$

Larger PWV

⇓

Higher arterial stiffness

⇓

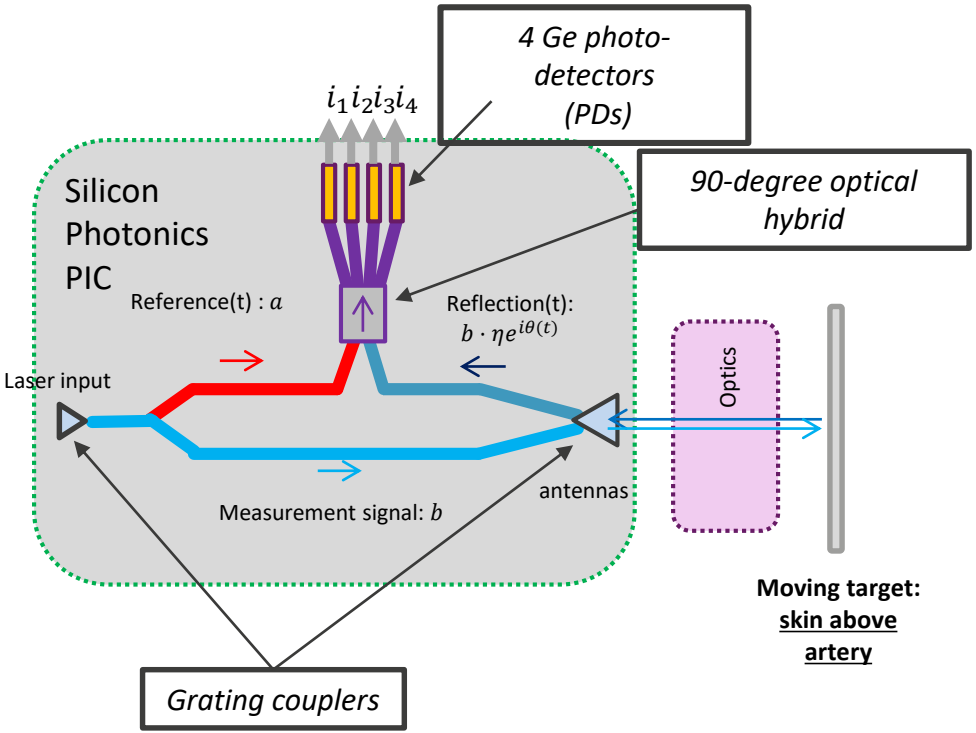
Higher risk of cardiovascular events

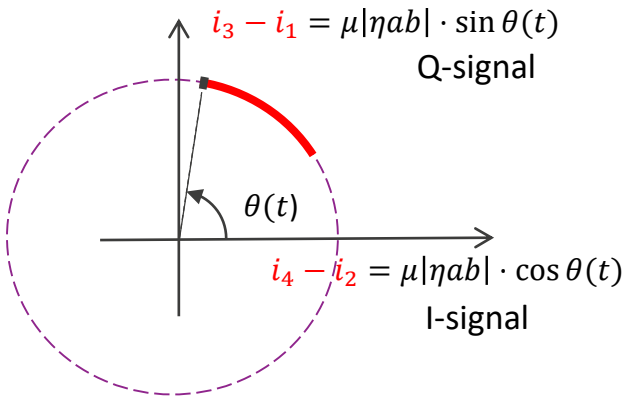
THE H2020 CARDIS PROJECT (2015-2019)

Objectives

- develop a proof-of-concept device for cardiovascular screening
- based on silicon photonics
- execute a clinic evaluation study

WORKING PRINCIPLE OF LDV: HOMODYNE DETECTION

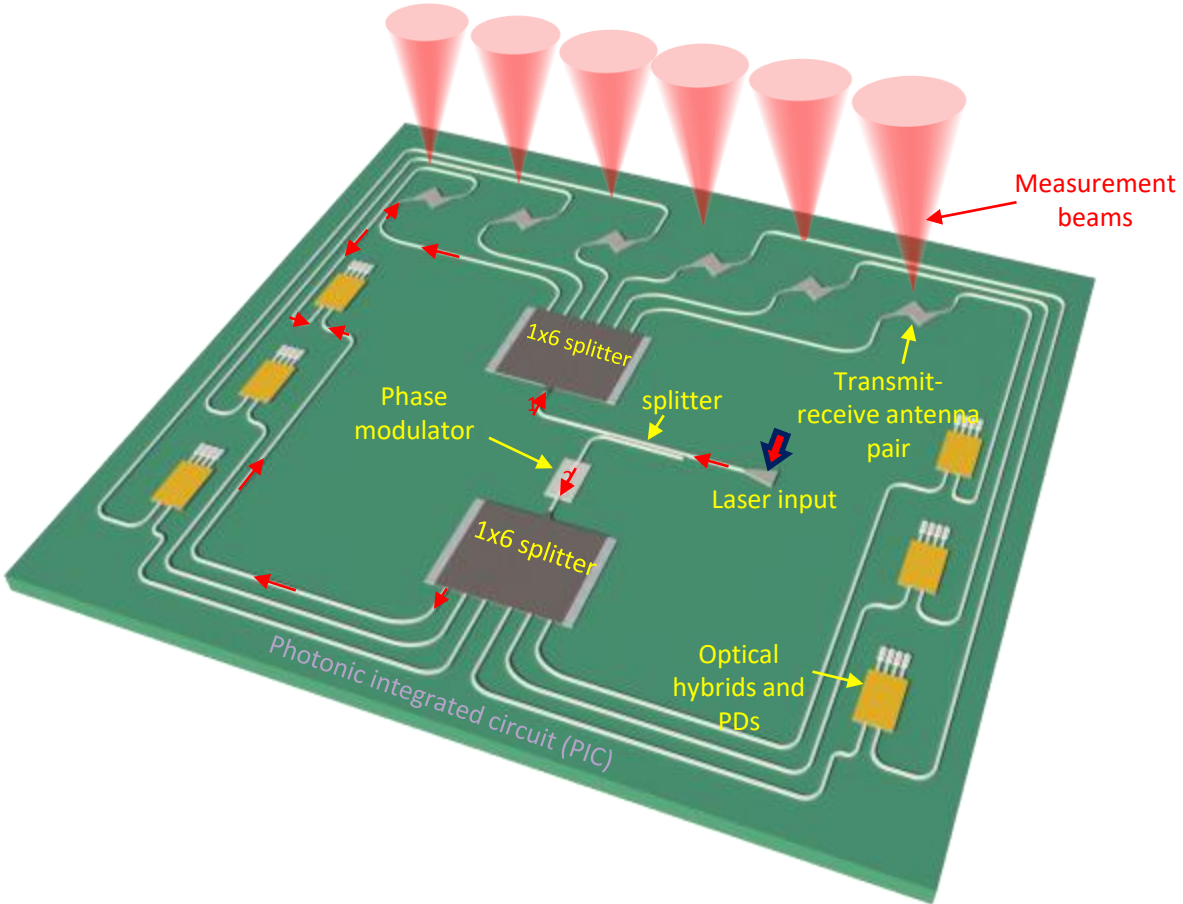




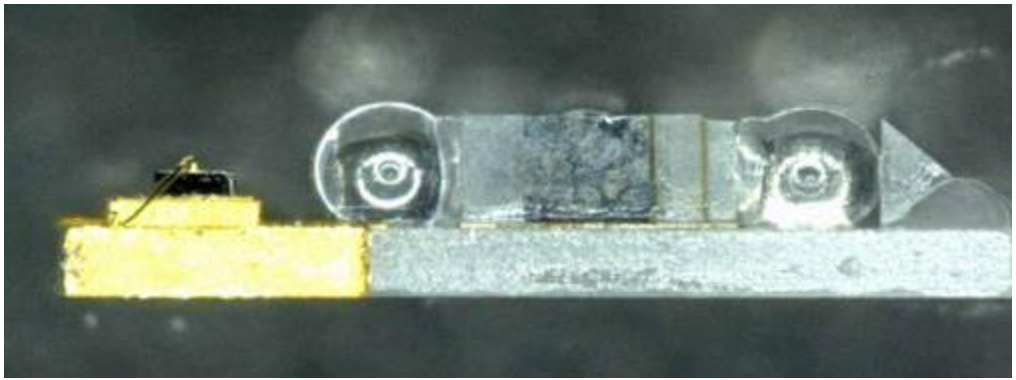
Demodulation method:

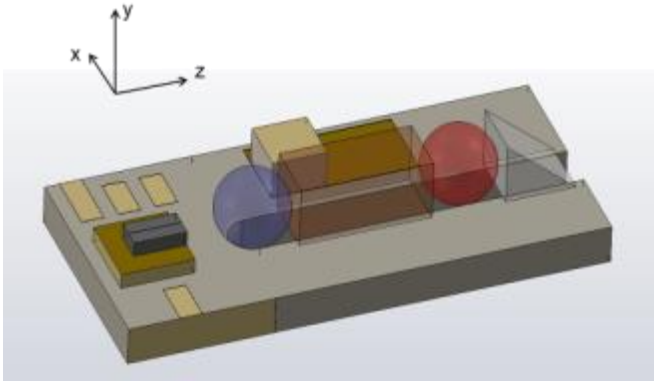
$$\theta(t) = \arctan\left(\frac{i_3 - i_1}{i_4 - i_2}\right)$$

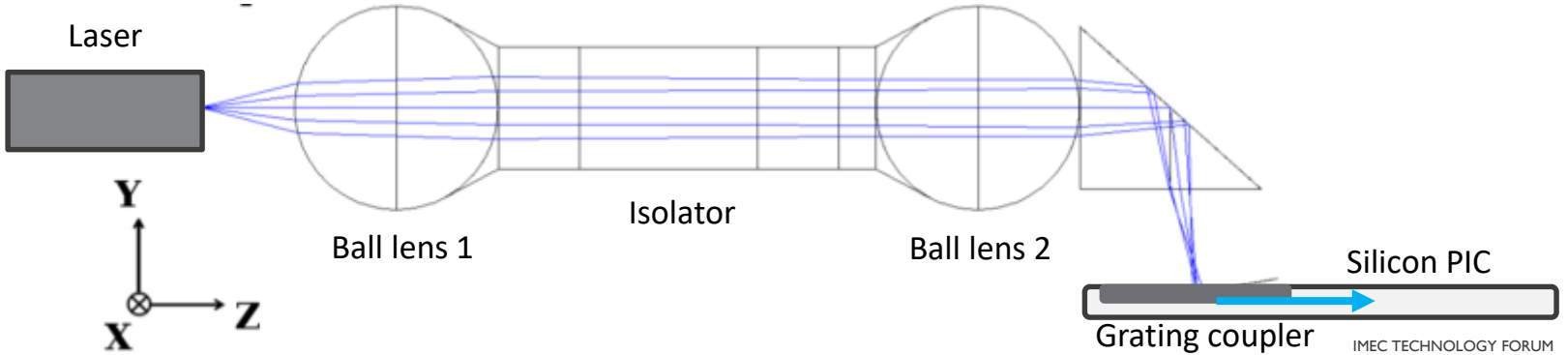
SIX-BEAM LDV ON SILICON CHIP (ISIPP50G)



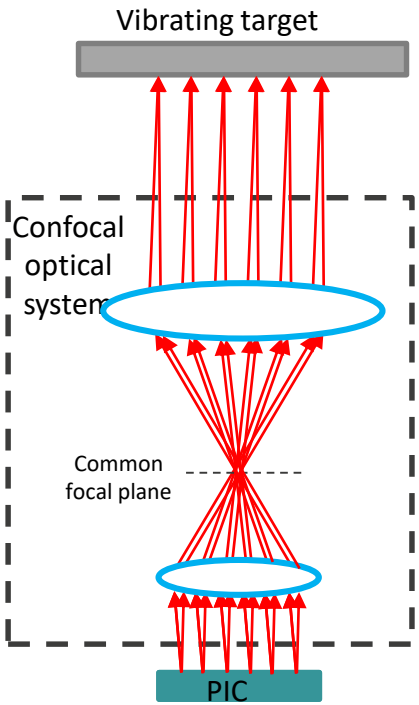
HYBRID LASER INTEGRATION: MICRO-OPTIC BENCH APPROACH



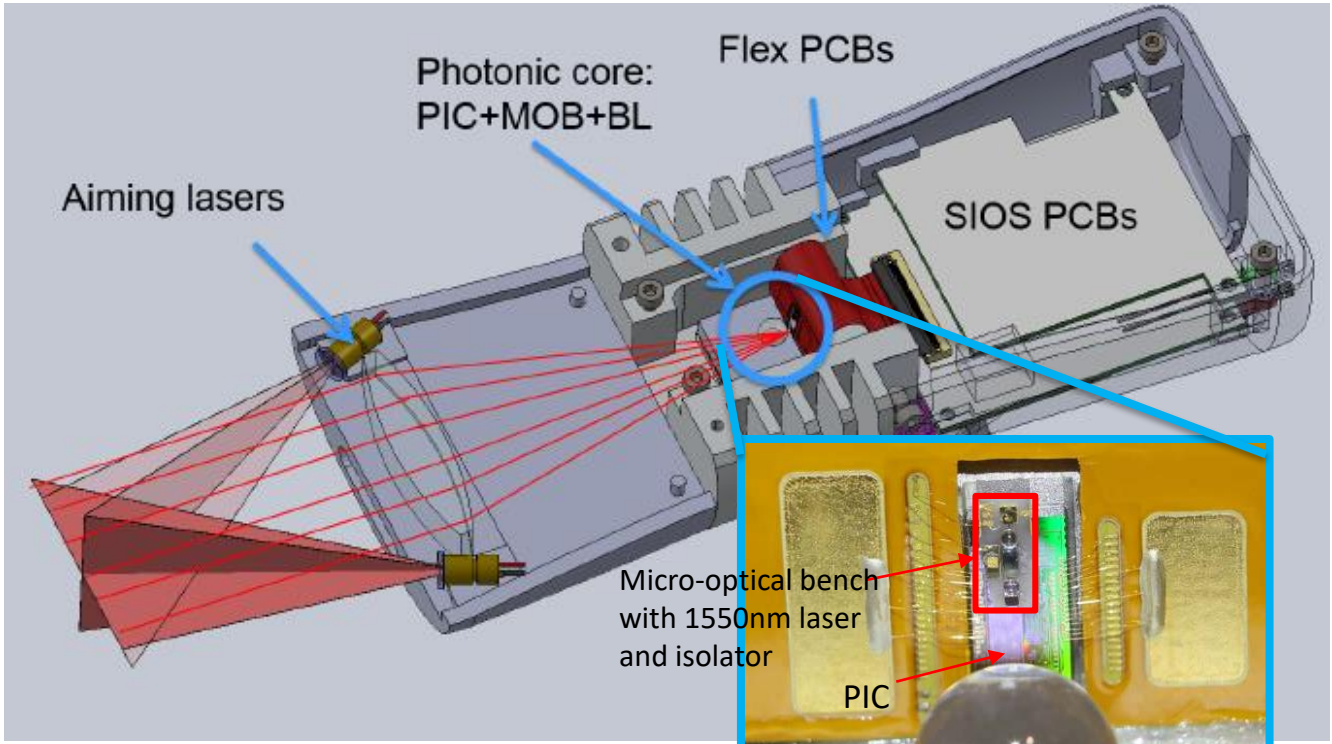




ASSEMBLY OF THE 6-BEAM LDV

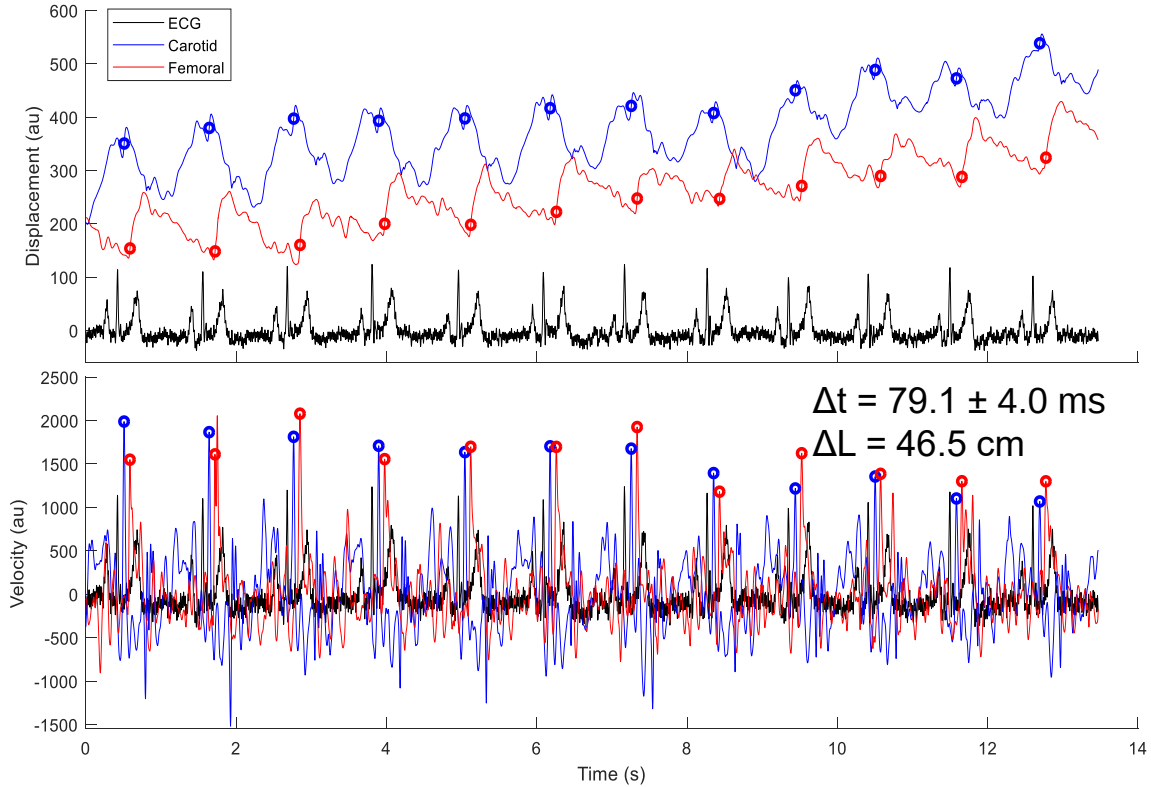


PIC and external optics



CLINICAL FEASIBILITY STUDY AT INSERM, PARIS

CAROTID-FEMORAL (CF) PWV MEASUREMENT



The cf-PWV is obtained with the 1st derivative signal on a healthy subject.

Sensor	cf-PWV
CARDIS LDV	5.88 ± 0.30 m/s
Commercial cf-PWV meter (Sphygmocor)	5.96 ± 0.40 m/s

The cf-PWV measured by the CARDIS LDV is very similar to that measured by a commercial PWV meter.

THE H2020 INSIDE PROJECT (2020-2023)

InSiDe

HORIZON 2020

Objectives

- develop next generation of silicon photonics based prototype
- fully wireless, more compact, more ergonomic
- no patches on skin
- algorithm development for extraction of robust medical data
- five distinct clinic evaluation studies (targeting different CVD cases)
- first steps towards industrial scaling of device manufacturing

much weaker reflection (diffuse reflection from skin)
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redesign of silicon photonics chip

imec Medtronic Microsemi a Microchip company Argotech Tyndall GHENT UNIVERSITY Maastricht University Inserm POLITECNICO DI TORINO

IN SUMMARY

- Health care
  - many needs for cost-effective point-of-care or personal devices
  - for early diagnosis and follow-up of therapy
- Silicon photonics
  - rich set of functionalities
  - ultra-compact
  - low-cost
  - supply chain getting ready for volume manufacturing
- Cardiovascular diseases
  - leading cause of death, but 90% preventable
  - we have developed a proof-of-concept silicon photonics device with excellent potential to help doctors diagnose and monitor CVDs

THANK YOU FOR YOUR ATTENTION