

# Novel Wearable Photonic Sensors as Enablers for Scaled Sensor Fusion (PhotonWear project)

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# Scaled sensor fusion and photonic wearables

## Bittium's Veturi Roadmap

### Scaled sensor fusion:

- *Sensor and data fusion technologies especially in medical domain.*
- *Sensor data handling methods, algorithms and models.*
- *Improved quality of measured vital signal for example, enable fast feedback systems by utilizing sensor fusion.*
- *ML/AI algorithms development for fast and accurate analysis.*

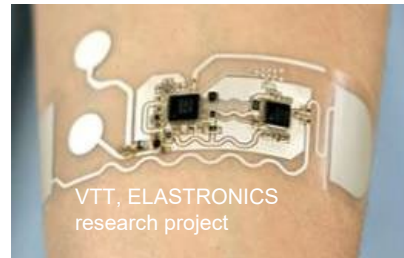
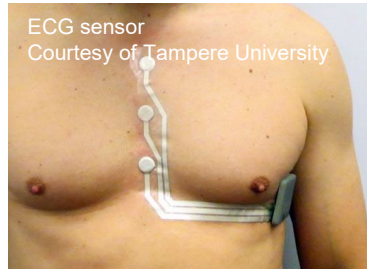
- Photonic wearable sensors for medical and wellness domains:
  - Same technologies and R & D tools can be utilized in both domains
- Optical modelling and algorithm development required – digital twin of a human being.
- Signal quality improvement of measured vital parameters and finding novel measurement methods, as well integration of multi-parameter sensors into one platform for sensor fusion.
- Interfaces with ML/AI tools.

# Motivation

- Demographic change and the need for cost-effective solutions for health and elderly care is one of the biggest global challenges.
- Wearable sensors are fundamental to monitoring of health and wellness for their inherent advantages:
  - Non-invasive measurements
  - Continuous data collection
  - Wireless connectivity
- Market need for pushing the boundaries of what can be measured non-invasively with light.

# The future of patient monitoring in healthcare

- Wearable, flexible, conforming
- Wireless
- Multi-parameter
- Cloud connected
- Remote viewable



**Portrait™ Mobile (Courtesy of GE Healthcare)**

# Towards personal, wearable measurements



Peake et al *Front. Physiol.*, 28 June 2018

## Multi-modal analysis:

- ECG
- Optical HR/HRV
- SpO2
- Temperature
- Respiration rate
- Activity
- Non-invasive blood pressure



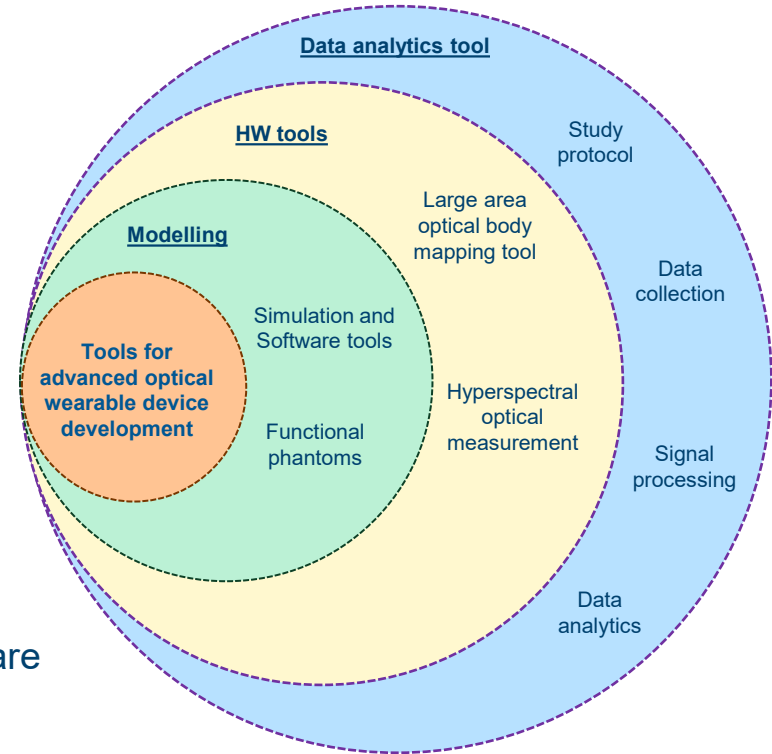
Lou et al

Materials Science & Engineering R 140 (2020) 100523

# Wearable Technologies for Photonic Sensors (PhotonWear)

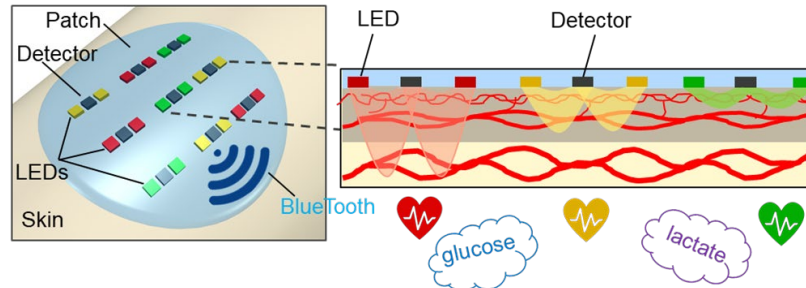
- Business Finland co-innovation project; part of the Bittium's Veturi program
- Duration: 24 months, starting from Nov 2023
- Budget : ~8 M€
- 6 partners in the consortium
  - VTT
  - Oulu University
  - Bittium
  - GE Healthcare
  - Oura
  - EIFys

PhotonWear will focus on optical non-invasive measurement of different physiological parameters and biomarkers, using ultra-comfortable sensors for healthcare and wellness applications, such as patient monitoring, apnea detection, heart health and metabolic monitoring.

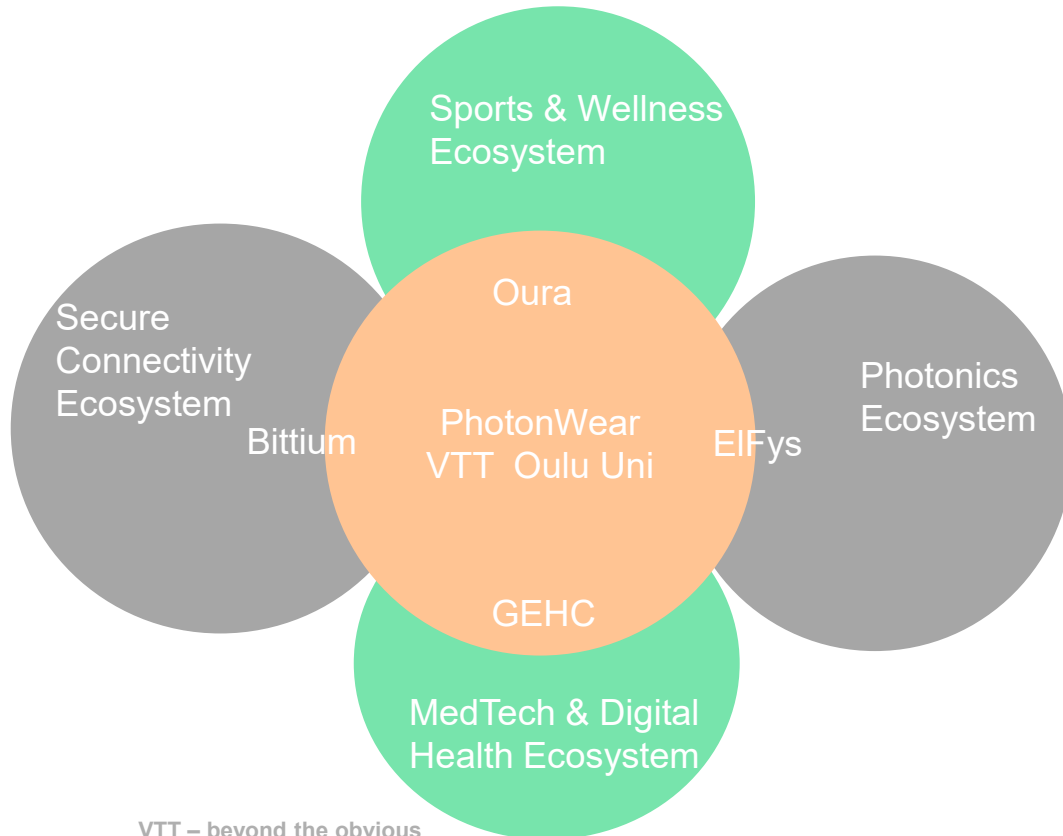


# PhotonWear aims

1. Optical modelling toolset - digital twin:
  - Optical model of human tissue by simulation toolset
  - Realistic physical models of human skin and body parts
2. Research tools and procedures for high-accuracy (medical quality) multispectral optical measurements
3. Demonstrator sensors measuring HR/HRV, SpO2 and blood pressure validated with human volunteers
  - Ultra-comfortable, soft, flexible/stretchable skin patches
4. Proof-of-concept novel optical measurement of lactate and glucose
  - High risk, high reward innovation track



# PhotonWear as a part of Bittium's Veturi and other ecosystems

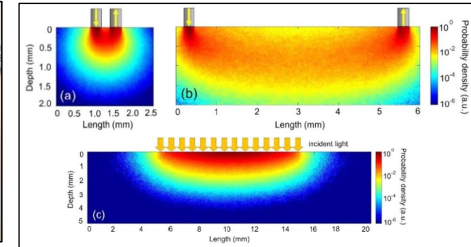
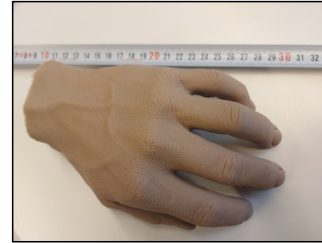


- Cross-fertilization through open work shops, seminars and events such as PrintoCent.
- Active dissemination in international events such as Medica, Photonics West etc.
- Over-arching research themes.

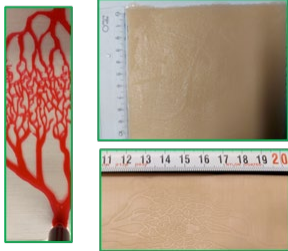


# Research themes – phantoms and simulations

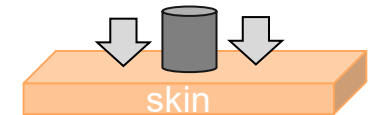
- Virtual optical model (digital twin) of skin by highly developed simulation models.
- Physical broadband skin mimicking phantoms.
- Speeds up the R & D of photonic sensors.



## Functional phantom



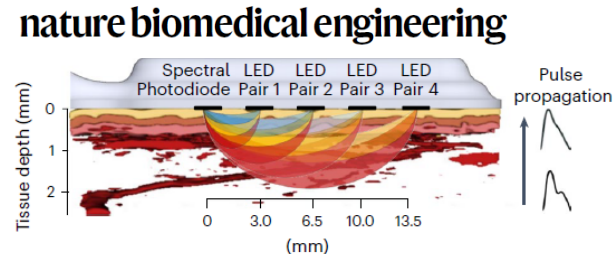
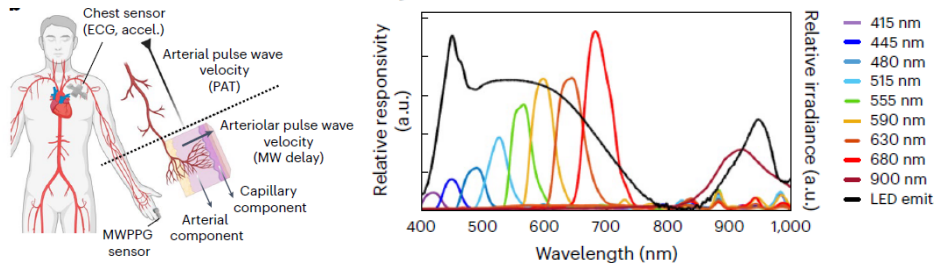
Effect of skin tone (skin type)



Effect of pressure

# Research themes – multi-spectral measurements

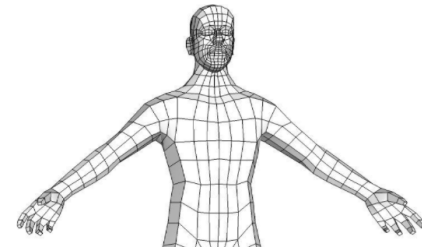
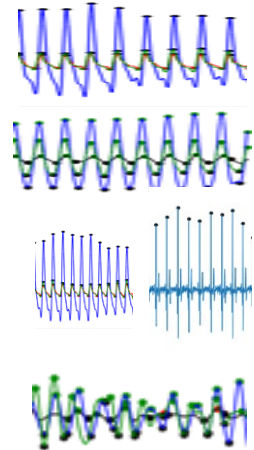
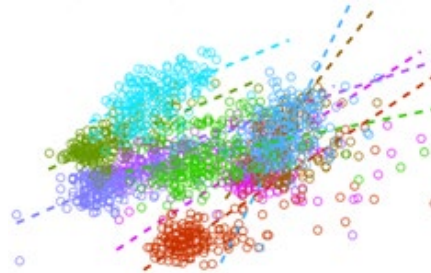
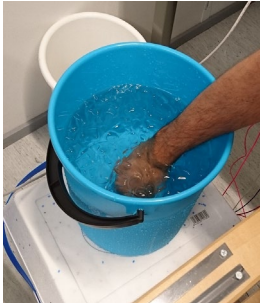
- Light with different wavelength probes tissues with varying penetration depth.
- Possibility to extract spatial PPG information -> separation of arterial and peripheral components.
- Potentially comprehensive picture of homeostasis (biomarkers such as glucose and lactate) can be obtained.



2023 <https://doi.org/10.1038/s41551-023-01098-y>

# Research themes – data analysis and modelling

- Sensor attachment analysis.
- Lab measurement protocols.
- Signal quality estimation.
- Biomarker modeling (non-invasive blood-pressure etc.).



# Research themes – manufacturing and integration

- State-of-the-art devices are based on conventional electronics and optical sensing element are embedded into rigid mechanical structure of the device housing.
- Integration of optical components on soft and conformal substrates.
- High-throughput manufacturing and integration processes.



# Conclusions

- Photonic wearable sensors are key enablers for scaled sensor fusion in both medical and wellness domains.
- PhotonWear brings together most important Finnish players within photonic wearable sensors and build bridges between different ecosystems.
- Important research topics are:
  - Optical modeling and physical phantoms.
  - Multi-spectral measurements.
  - Data-analysis and modeling.
  - Flexible and stretchable electronics manufacturing and integration.

# bey<sup>0</sup>nd

## the obvious

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