

Fiber Bragg Grating-Based Systems for Physiological Monitoring and Patient Safety Enhancement

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Associazione Ingegneri Clinici
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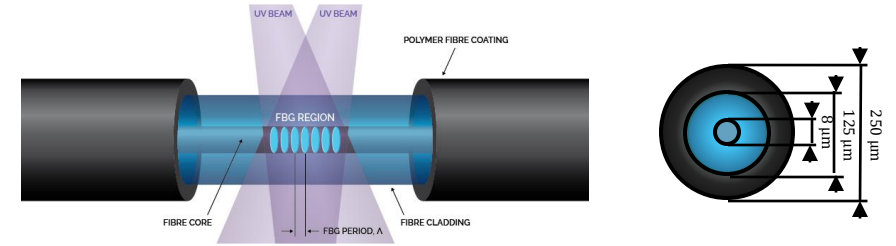
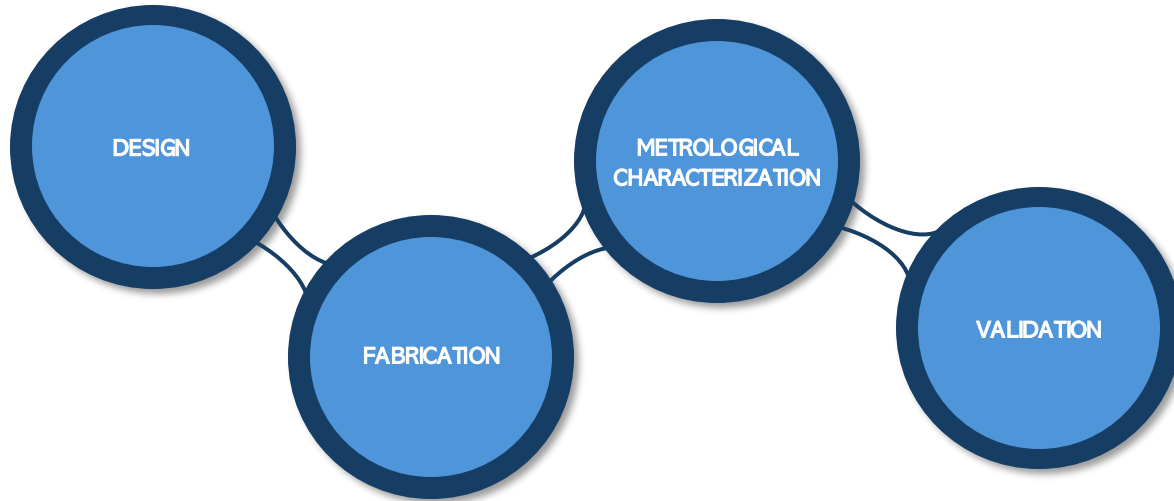


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Aim of the Ph.D. thesis



The Ph.D. thesis contributes to the ongoing evolution of the Health 4.0 revolution by investigating the crucial role of innovative sensing solutions

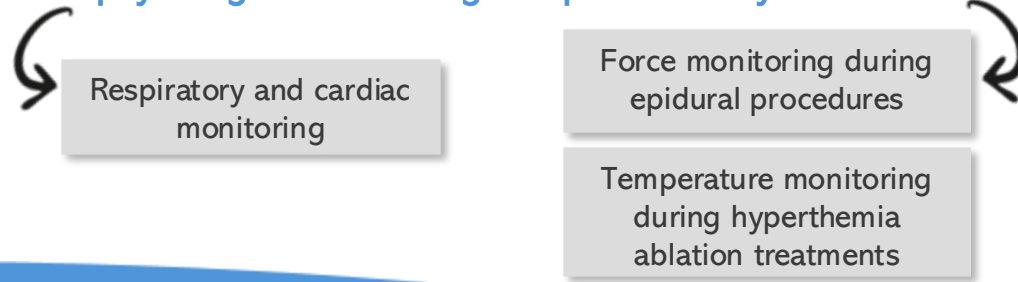


Advantages



- High sensitivity
- Small size
- Light weight
- Immunity to electromagnetic interferences
- Biocompatibility
- Temperature range -4 °C to 300 °C
- Ability to be multiplexed
- Long-lasting stability

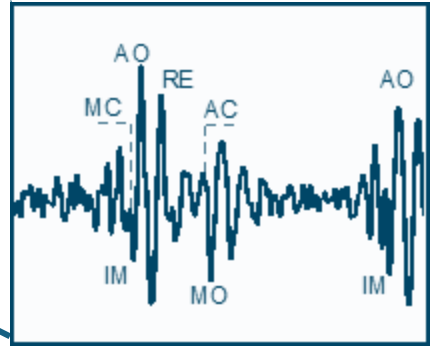
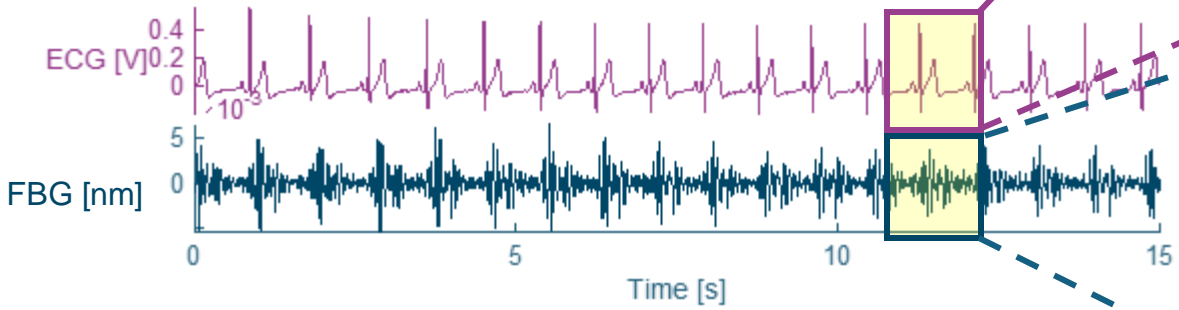
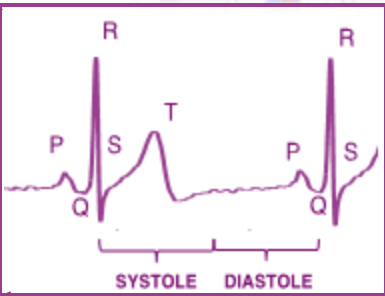
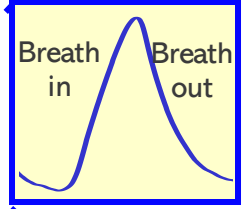
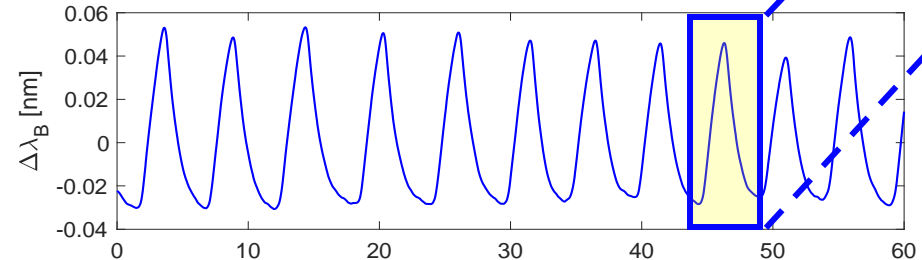
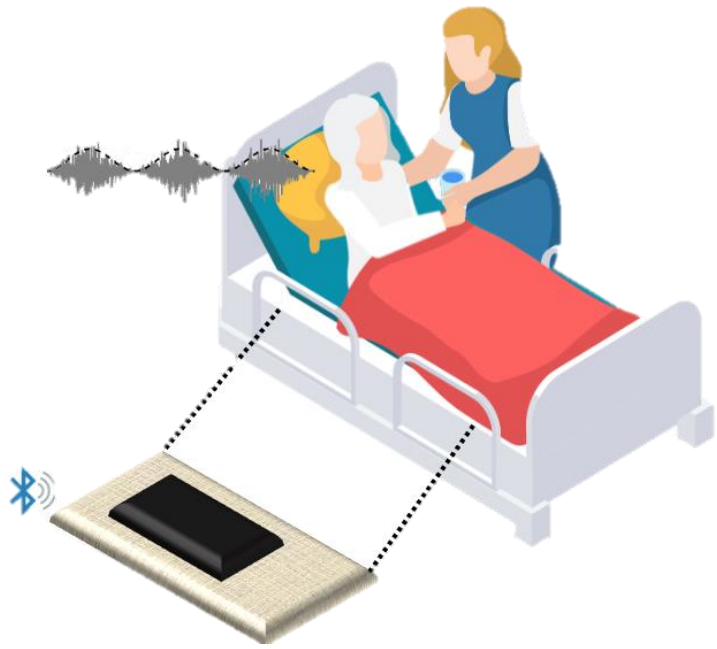
My research activity aimed at providing original contributions focusing on **FIBER BRAGG GRATINGS (FBGs)** and their applications in **physiological monitoring** and **patient safety enhancement**



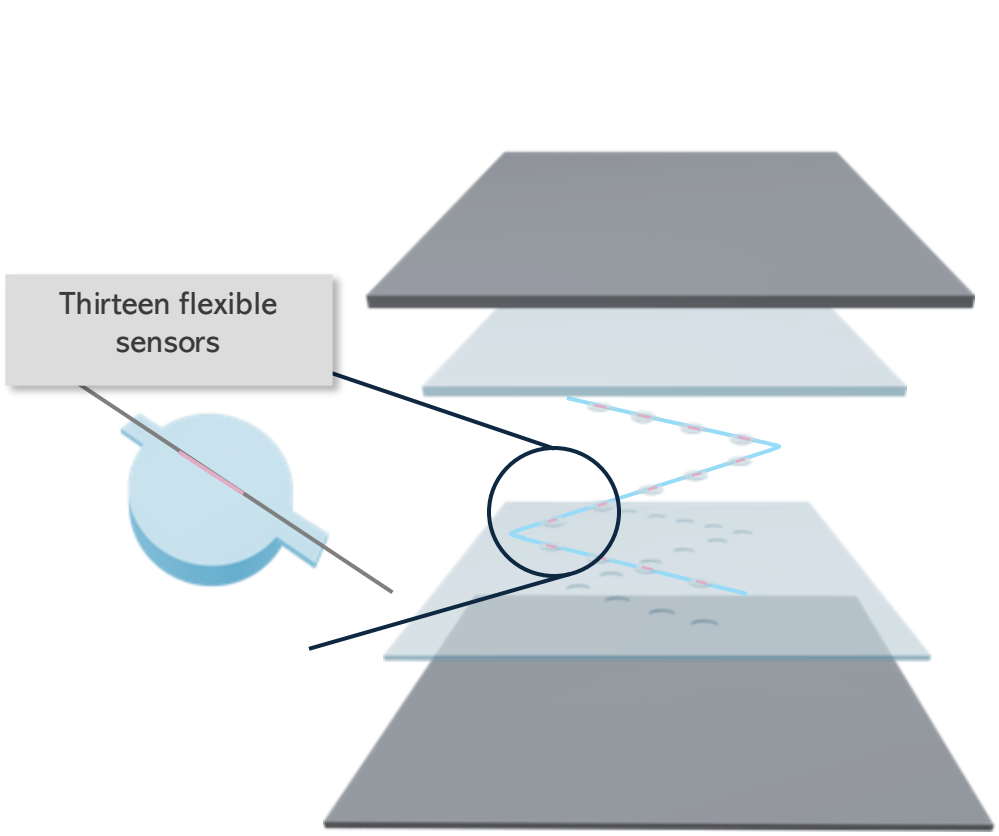
FBG-based Smart Mattress for Cardiorespiratory Monitoring



Nearable system



FBG-based Smart Mattress for Cardiorespiratory Monitoring

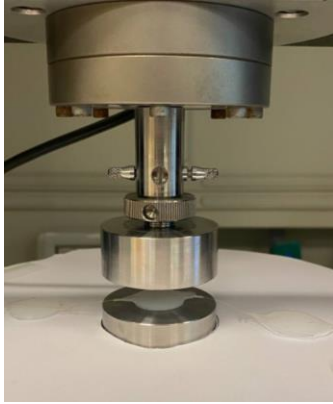


- Applicability
 - Sleep-related disorders
- Innovation
 - Distributed soft sensing elements
 - Mattress dimensions chosen considering body anthropometric proportions
 - Compactness and high robustness

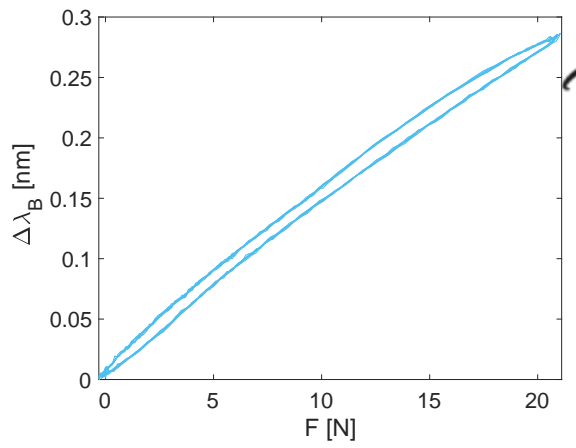
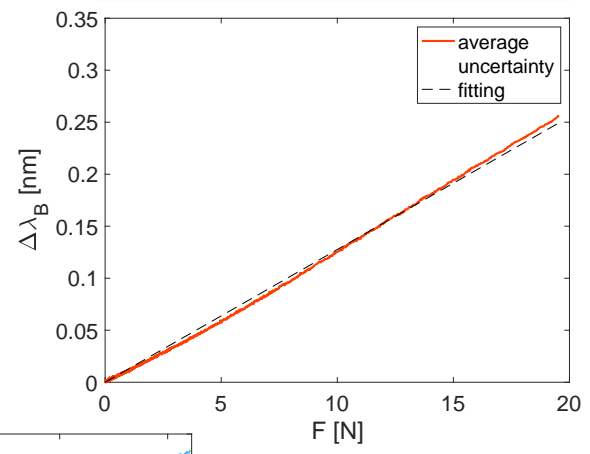


FBG-based Smart Mattress for Cardiorespiratory Monitoring

Metrological characterization

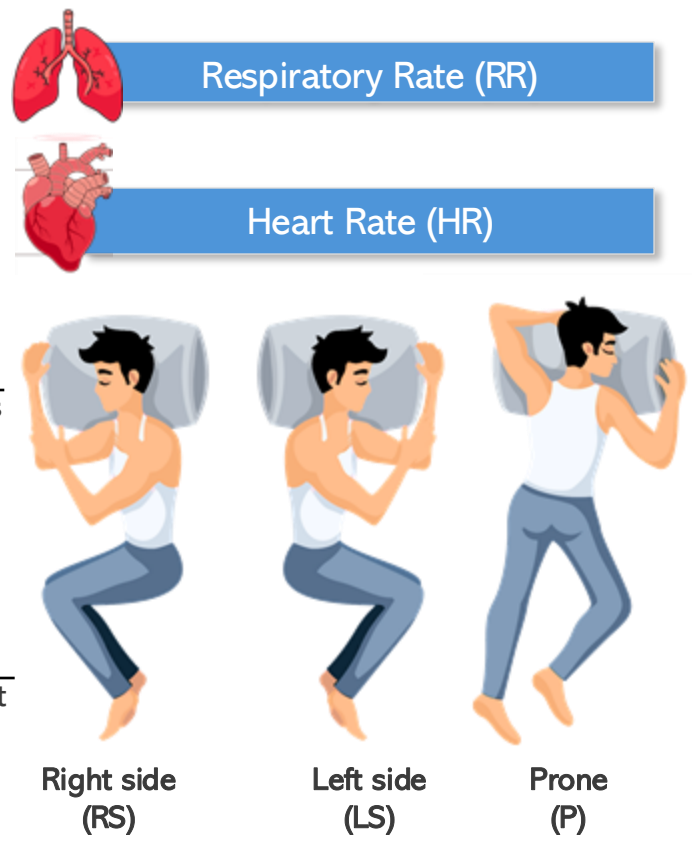
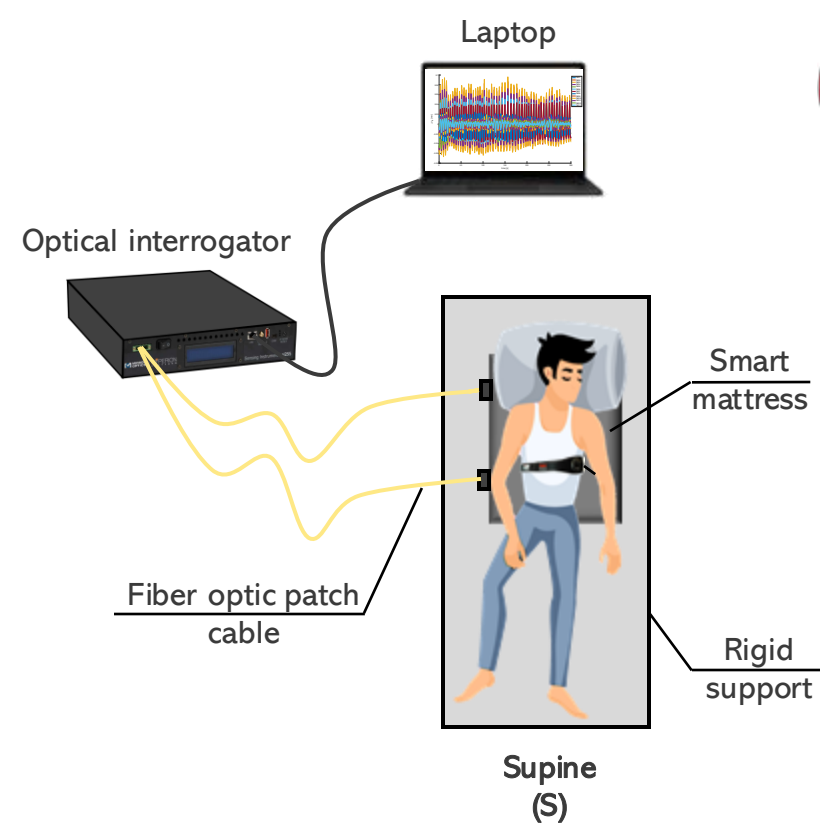


Force sensitivity (S_F)
Mean value $14 \text{ pm}\cdot\text{N}^{-1}$



Mean percentage hysteresis error
 $< 20\%$

In-lab validation

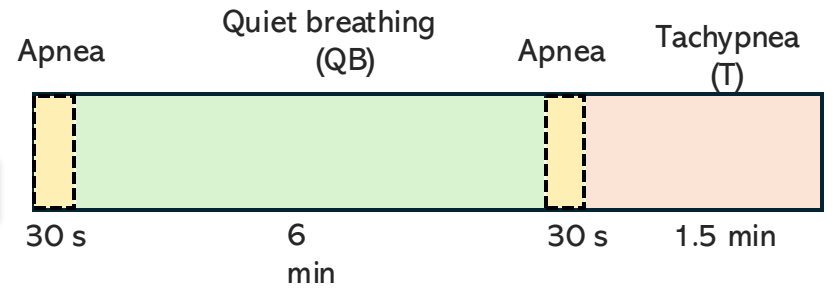


FBG-based Smart Mattress for Cardiorespiratory Monitoring

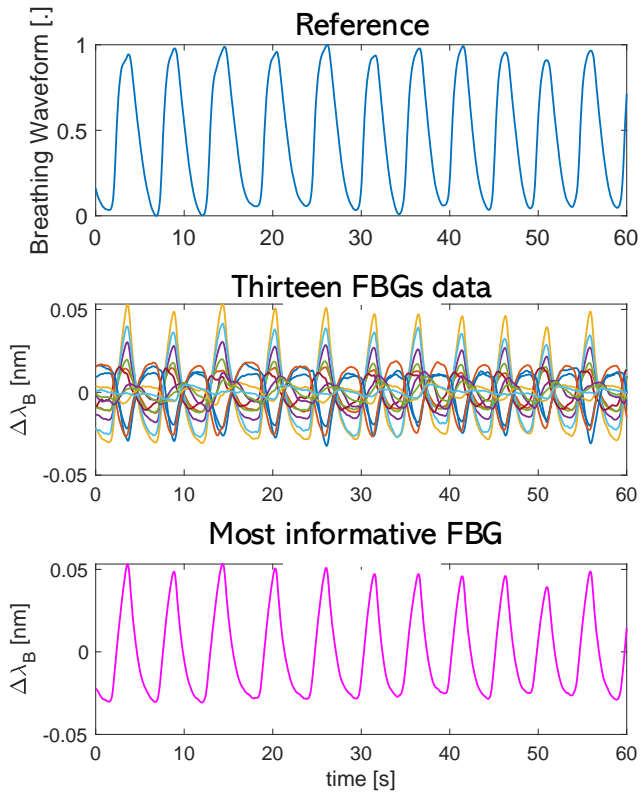
In-lab validation



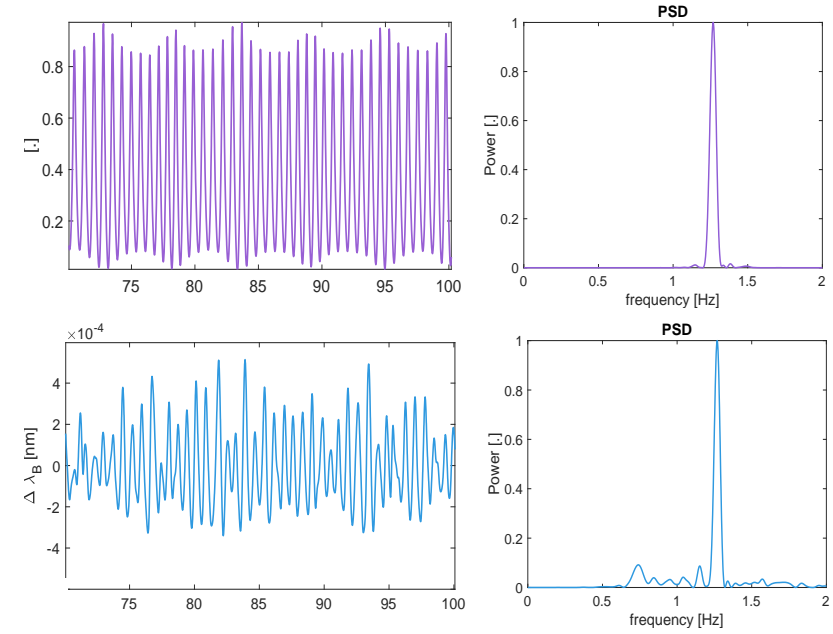
Respiratory Rate (RR)



Heart Rate (HR)



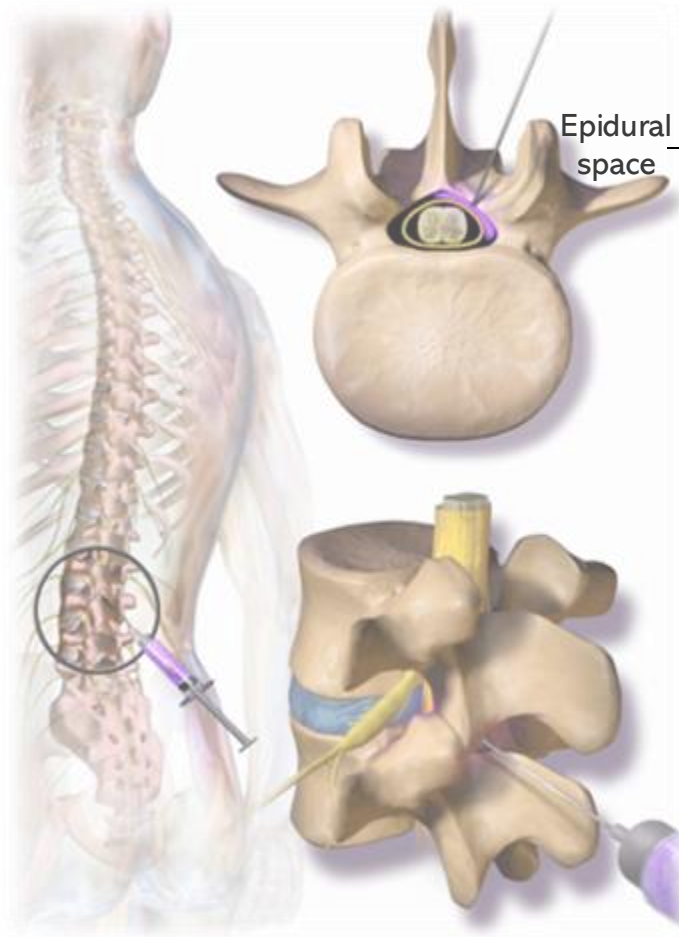
Results show a maximum MAPE of 1.6% in QB and 2.0% in T



Results show a maximum MAPE 1.1% for QB 2.7% for T



Solutions based on FBG for Epidural Anesthesia



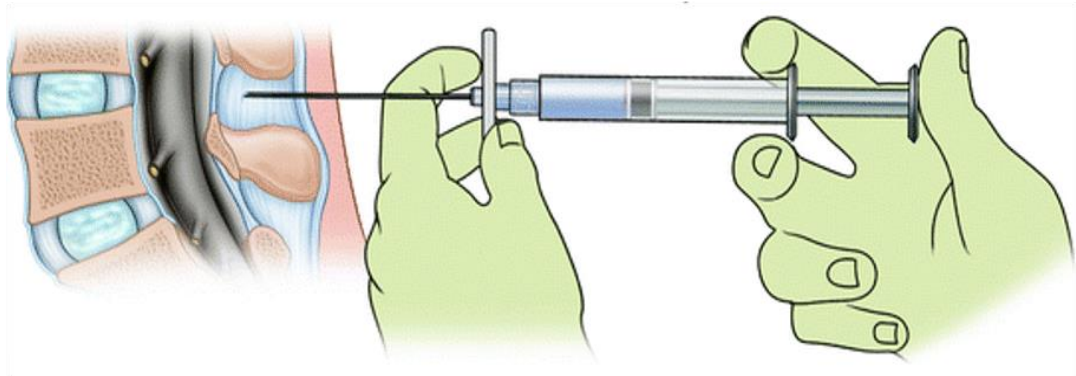
Epidural space

Located between the **ligamentum flavum** and the **dura mater**

Small size (ranging between 2 mm and 6 mm)

The procedure involves a **Tuohy needle** insertion between two lumbar vertebrae

Loss of resistance (LOR) technique



Broadly practiced technique for identifying the epidural space

Needle advancement is allowed by pushing the syringe plunger containing saline solution or air

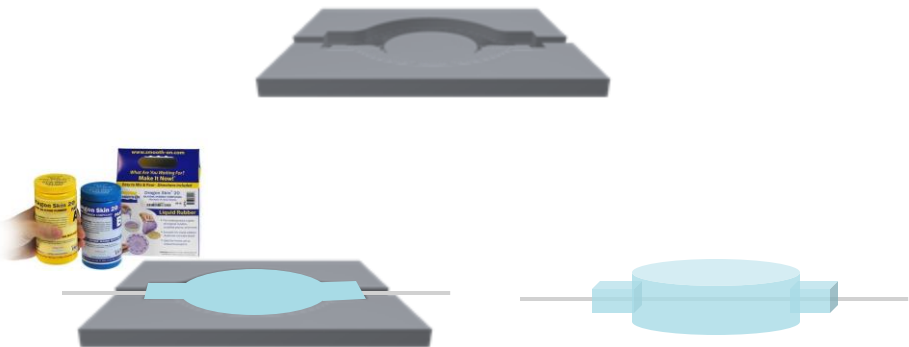
Based on the perceived perception of a drop in resistance

Its **success** is strongly **operator-dependent**, **time-consuming**, and **challenging**

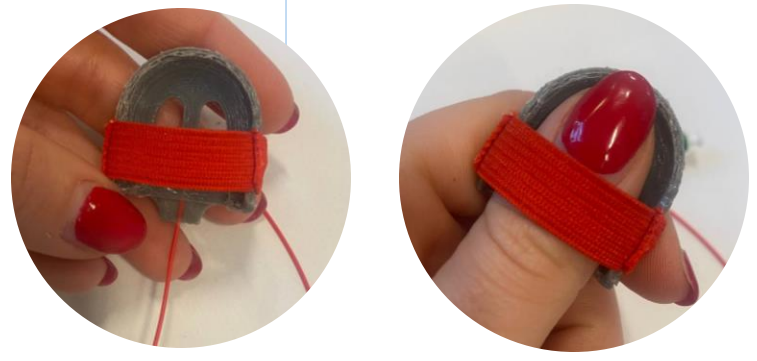
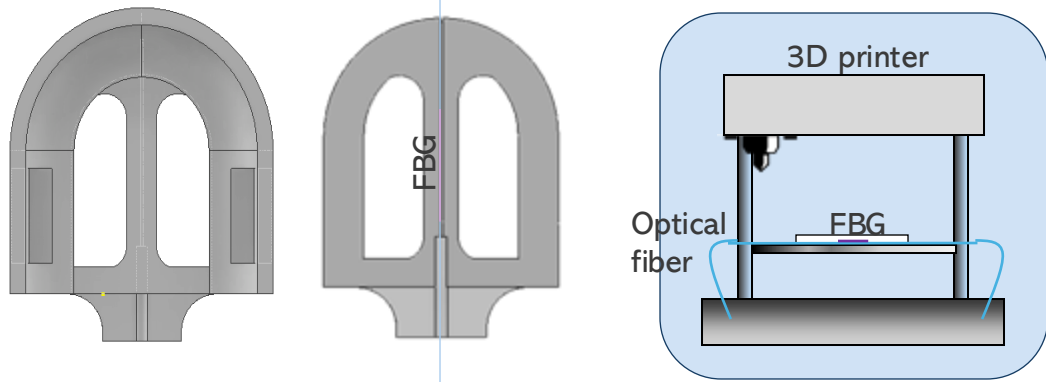


Solutions based on FBG for Epidural Anesthesia

Force sensor based on FBG conceived to fit the LOR syringe plunger

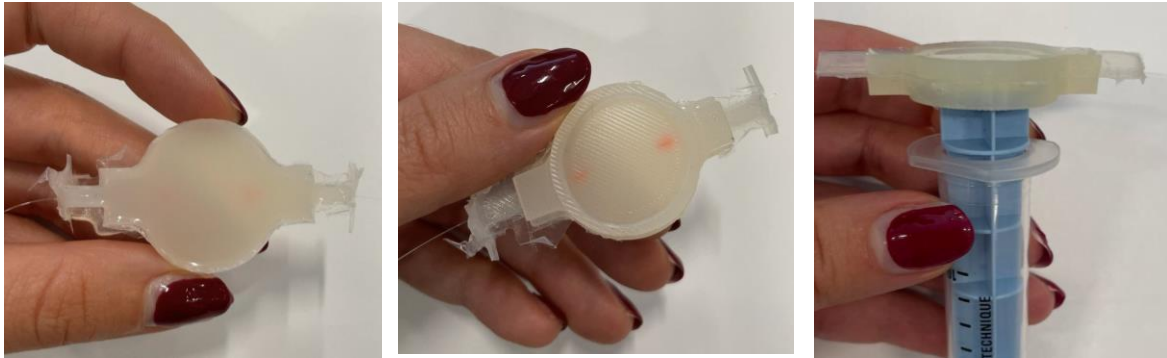


Wearable force sensor based on FBG conceived to fit the clinician's thumb

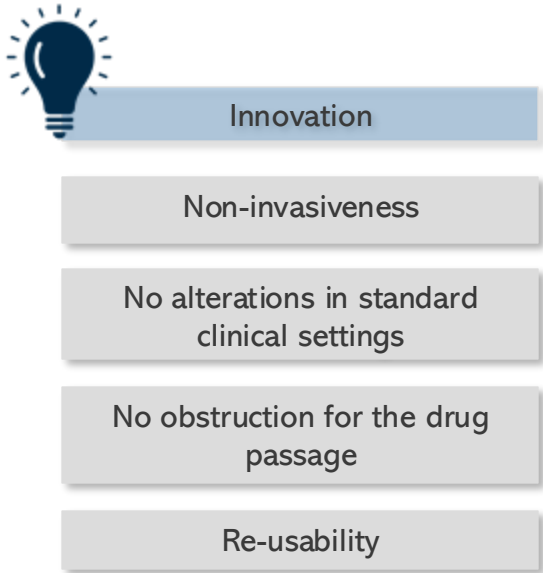
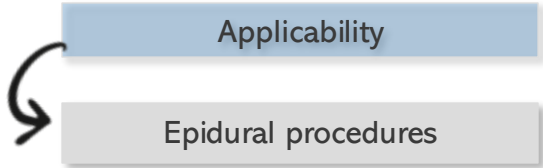
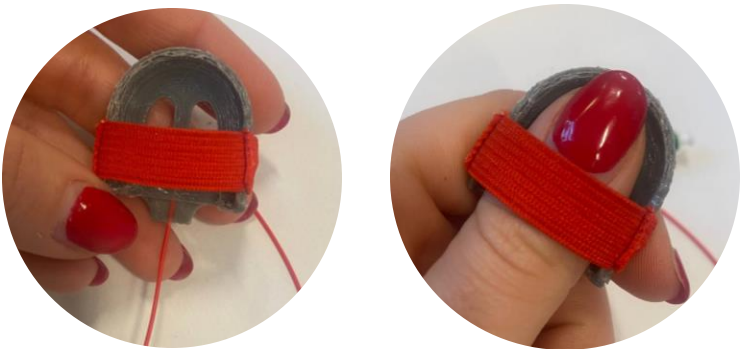


Solutions based on FBG for Epidural Anesthesia

Force sensor based on FBG conceived to fit the LOR syringe plunger

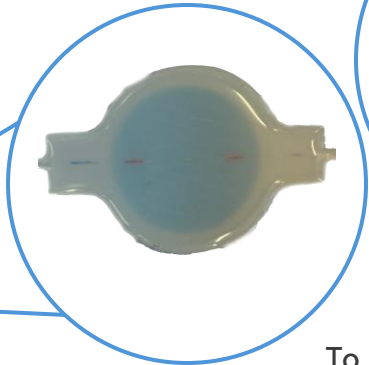


Wearable force sensor based on FBG conceived to fit the clinician's thumb



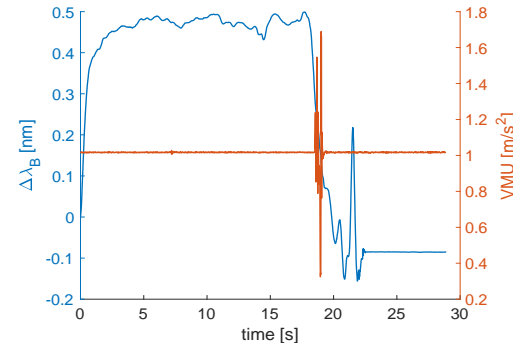
Solutions based on FBG for Epidural Anesthesia

Validation in real clinical scenario

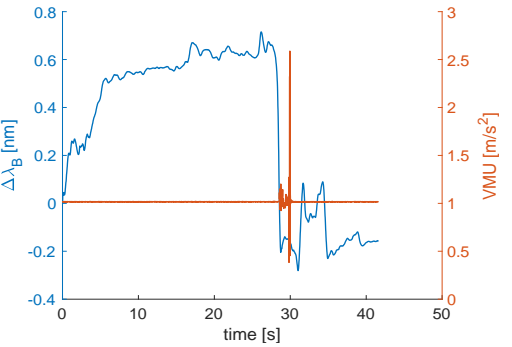


To relate the clinician's perception to the output of the flexible cap when the LOR occurred

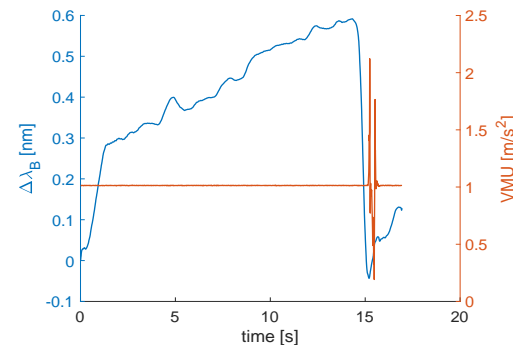
Patient 1



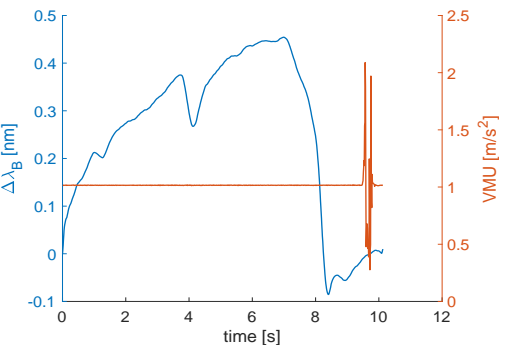
Patient 2



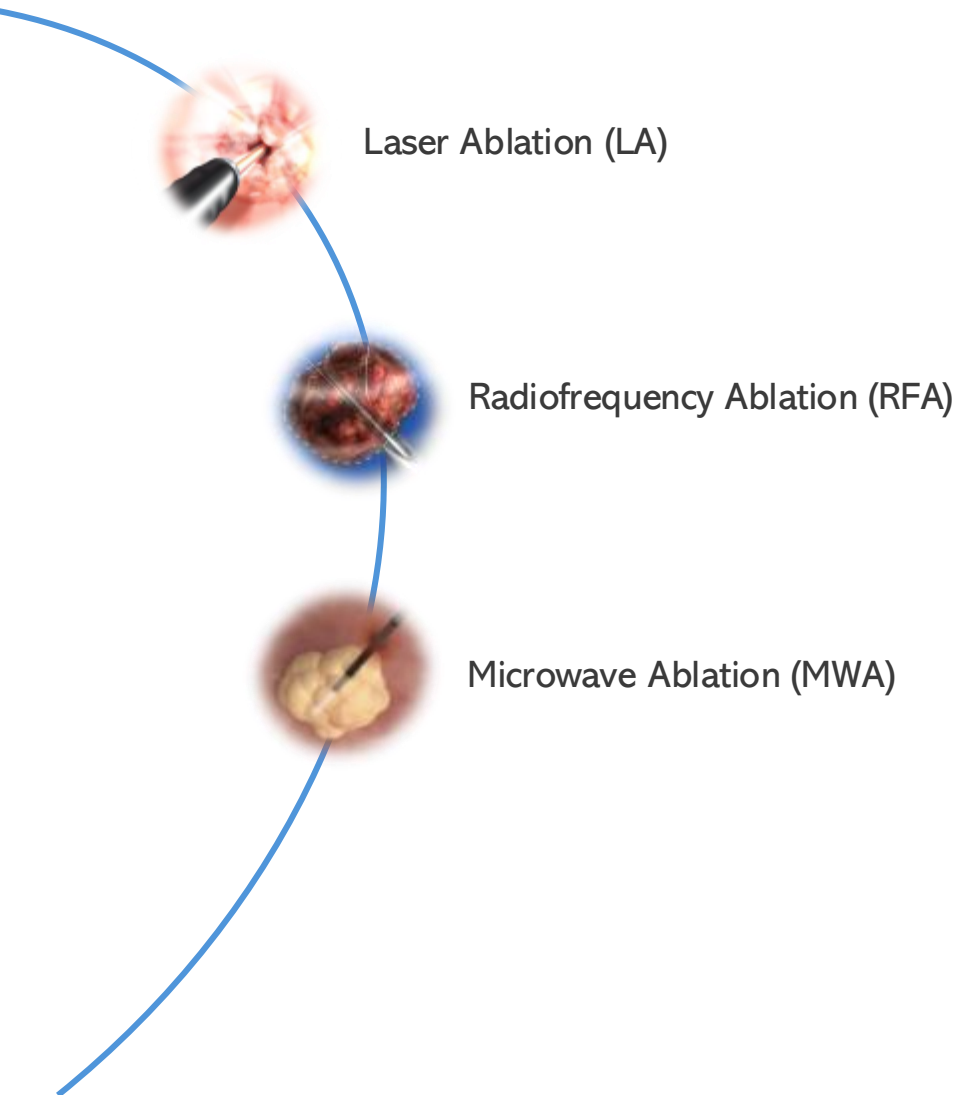
Patient 3



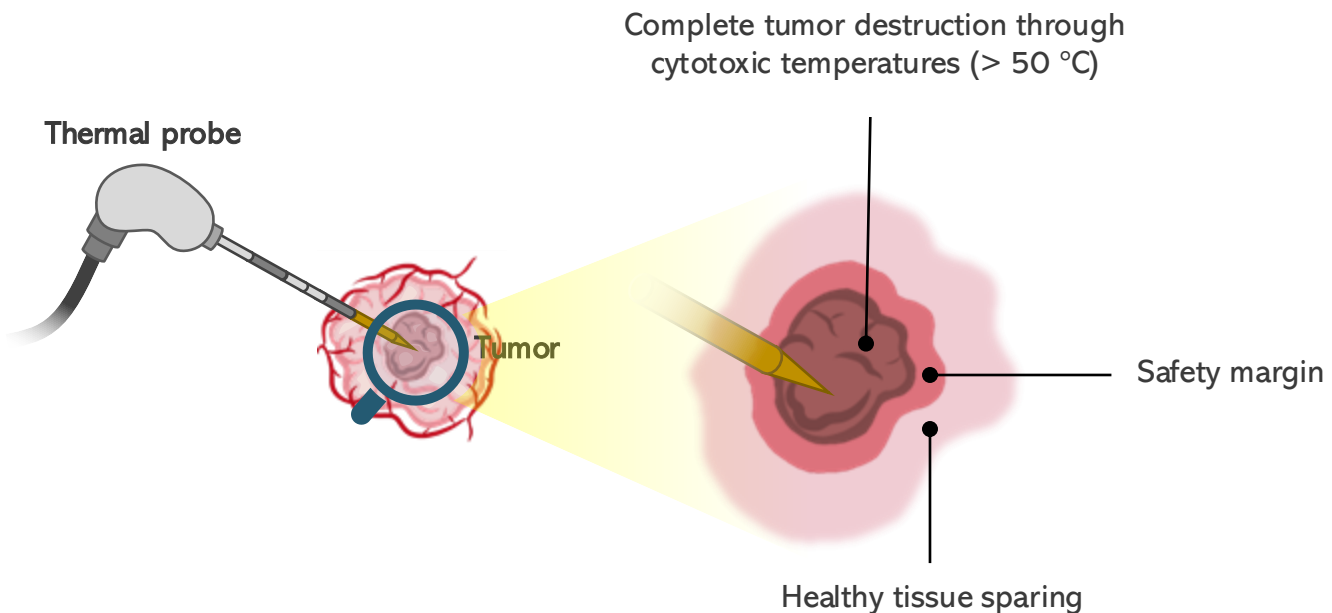
Patient 4



Solutions based on FBG for Epidural Anesthesia



❖ Thermal ablation goal:

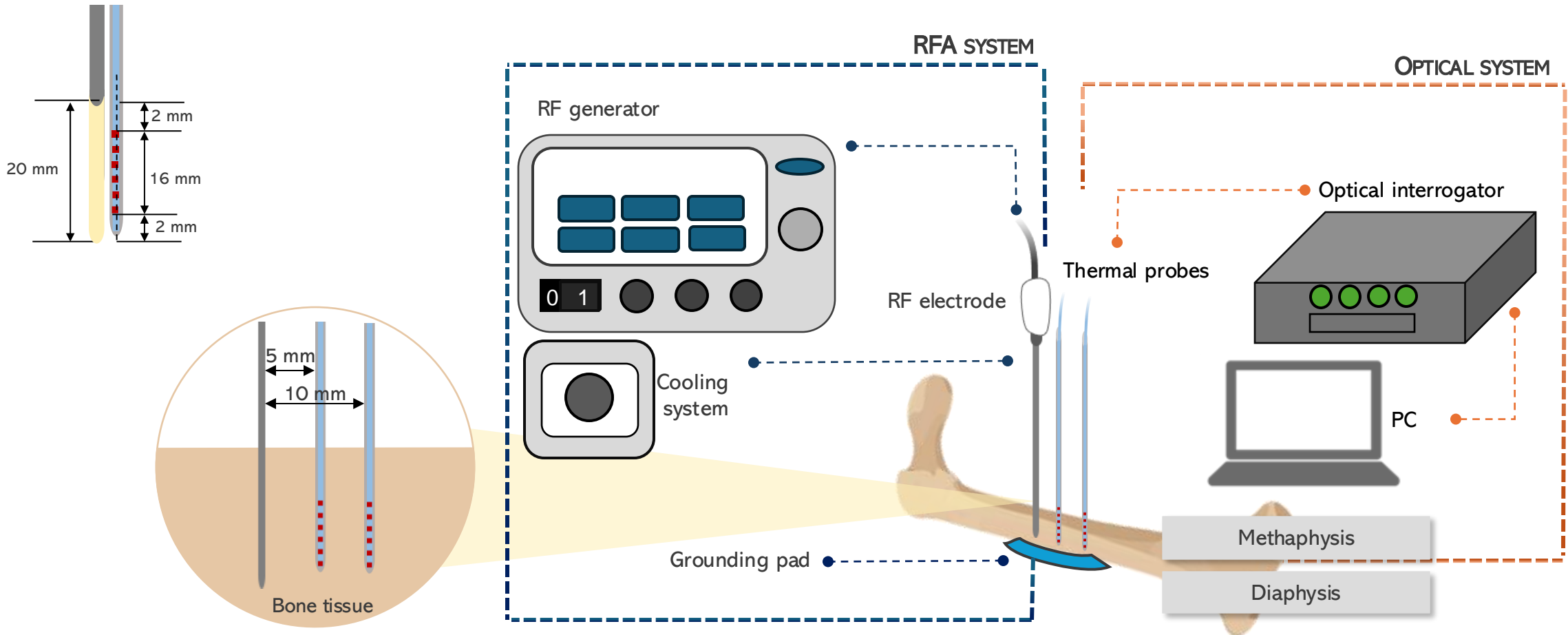


❖ Key problem: lack of selectivity

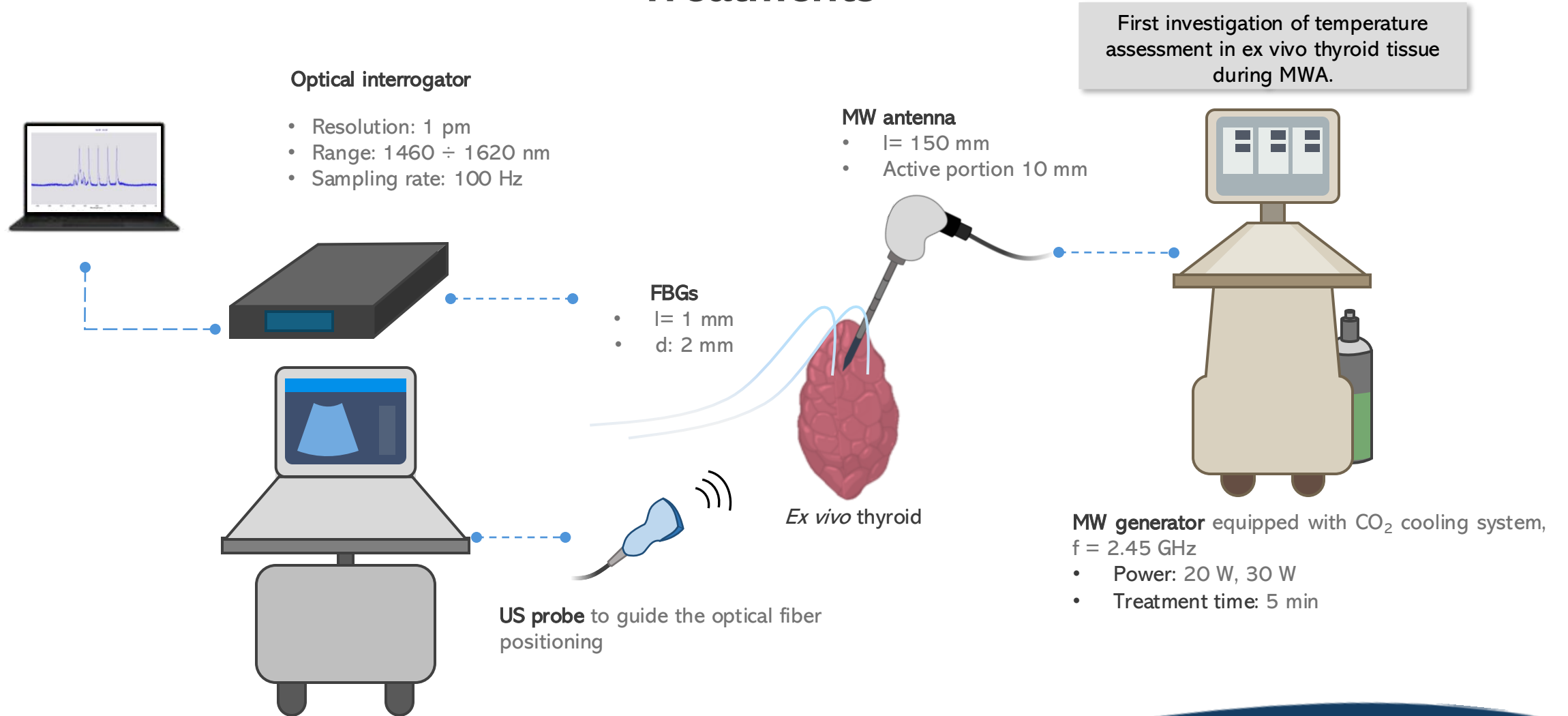
Temperature monitoring in HTTs is paramount to ensure damage to the tumor portion plus a reasonable safety margin while preserving healthy surrounding anatomical structures



FBG-based Solutions for Temperature Monitoring During Hyperthermia Treatments

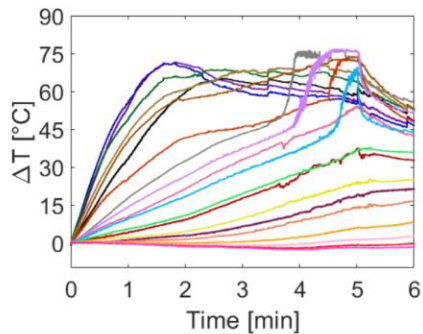
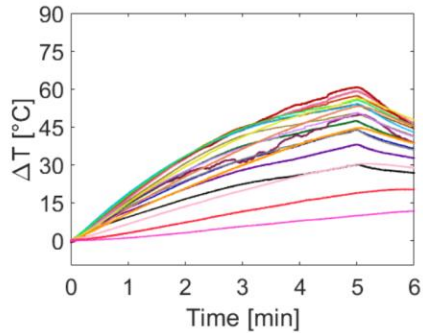


FBG-based Solutions for Temperature Monitoring During Hyperthermia Treatments

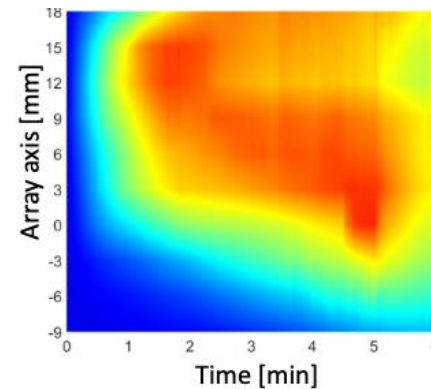
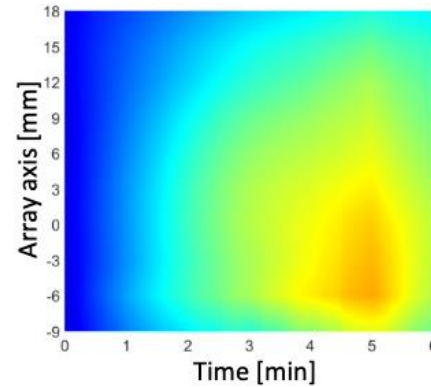


FBG-based Solutions for Temperature Monitoring During Hyperthermia Treatments

Temperature trend over time



Temperature map reconstruction



Applicability

Thermal ablation treatments for cancer removal



Innovation

Real-time feedback for clinicians performing the procedure

Multi-point temperature measurements

Temperature map reconstruction

Thank you for your attention!

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Co-supervisor: Prof. Massimiliano Carassiti

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