

SALONE DELL'ORIENTAMENTO 2026

CORSO DI LAUREA

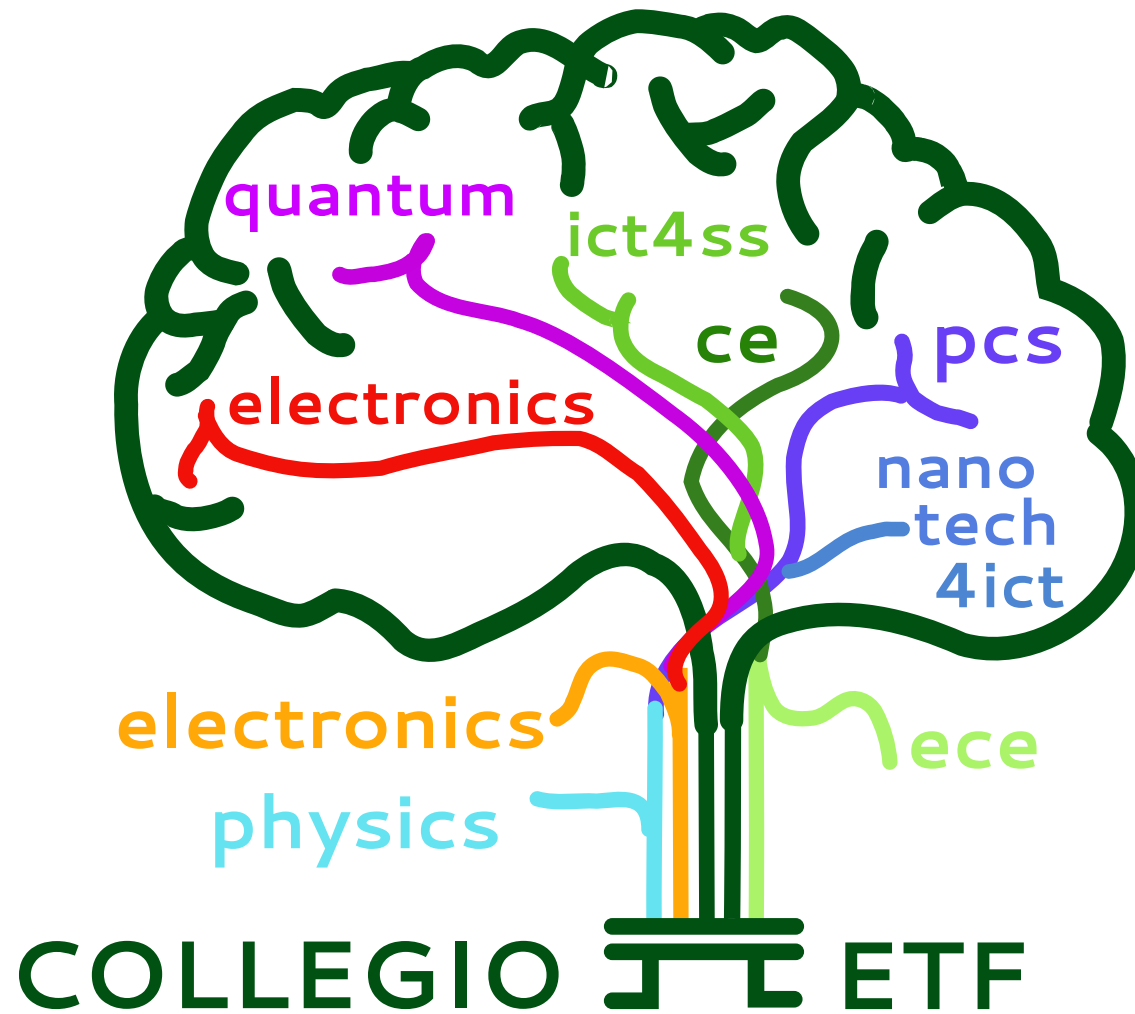
INGEGNERIA ELETTRONICA

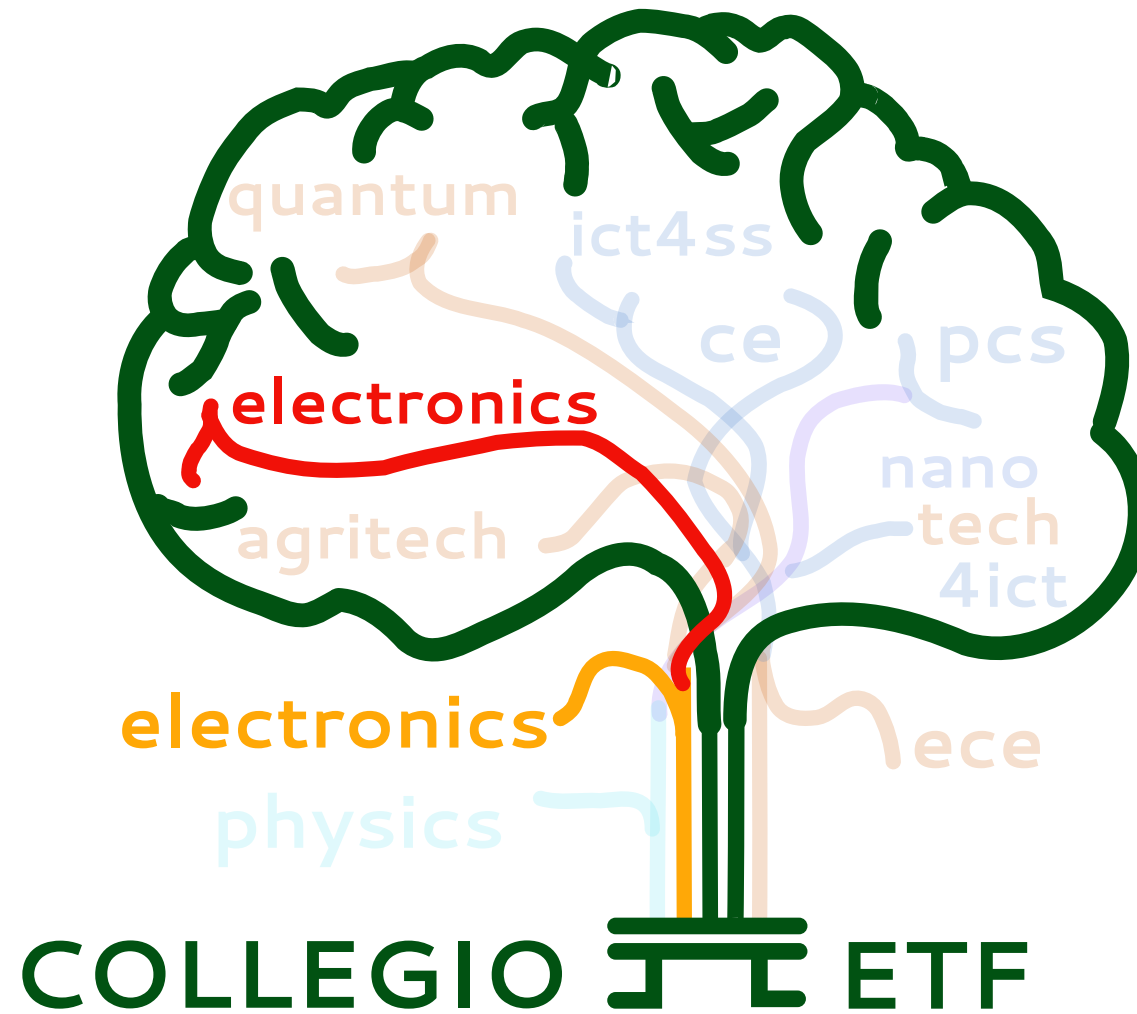


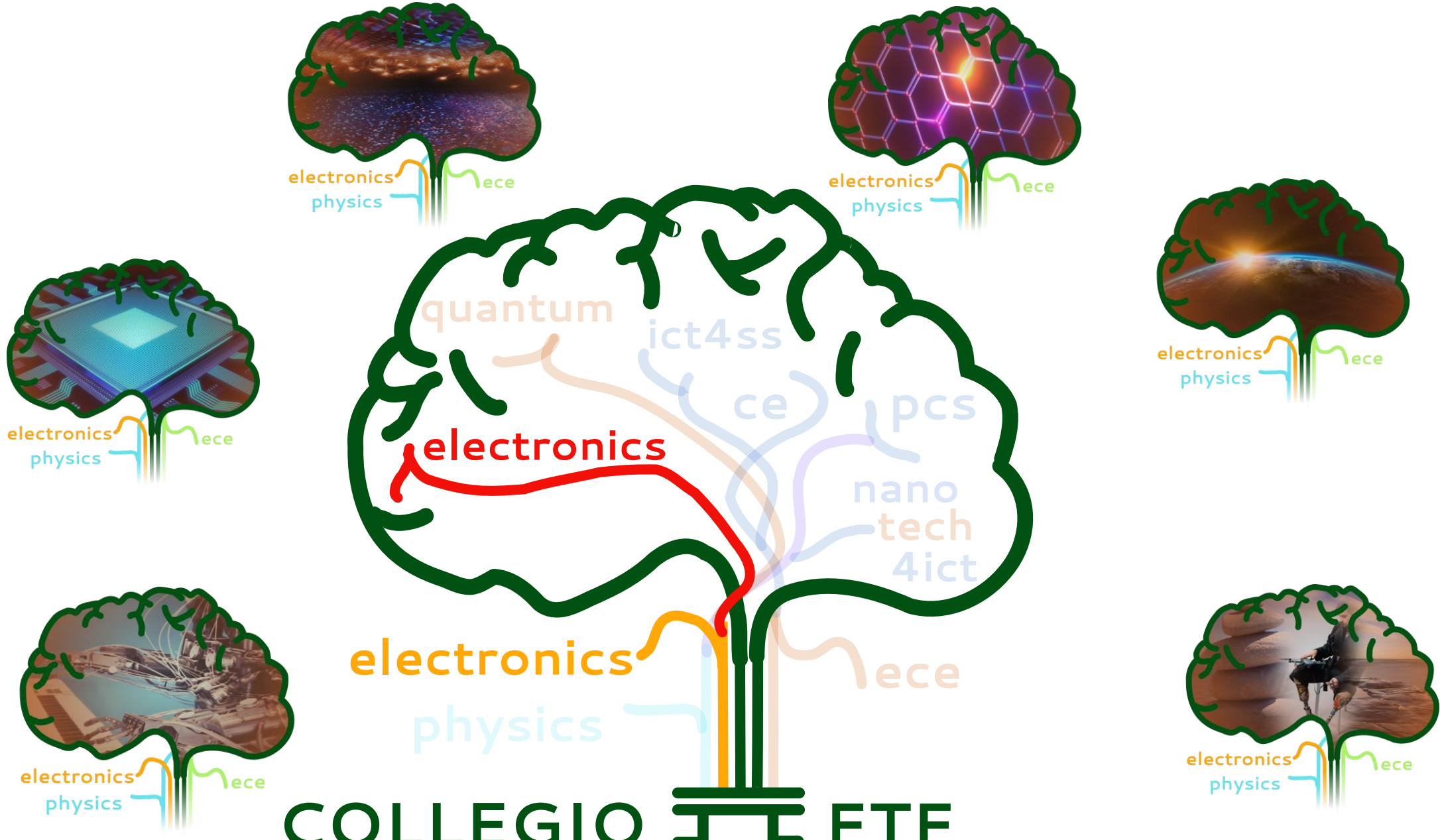
**Politecnico
di Torino**

**SCOPRI TUTTI I
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A.A. 2026/27
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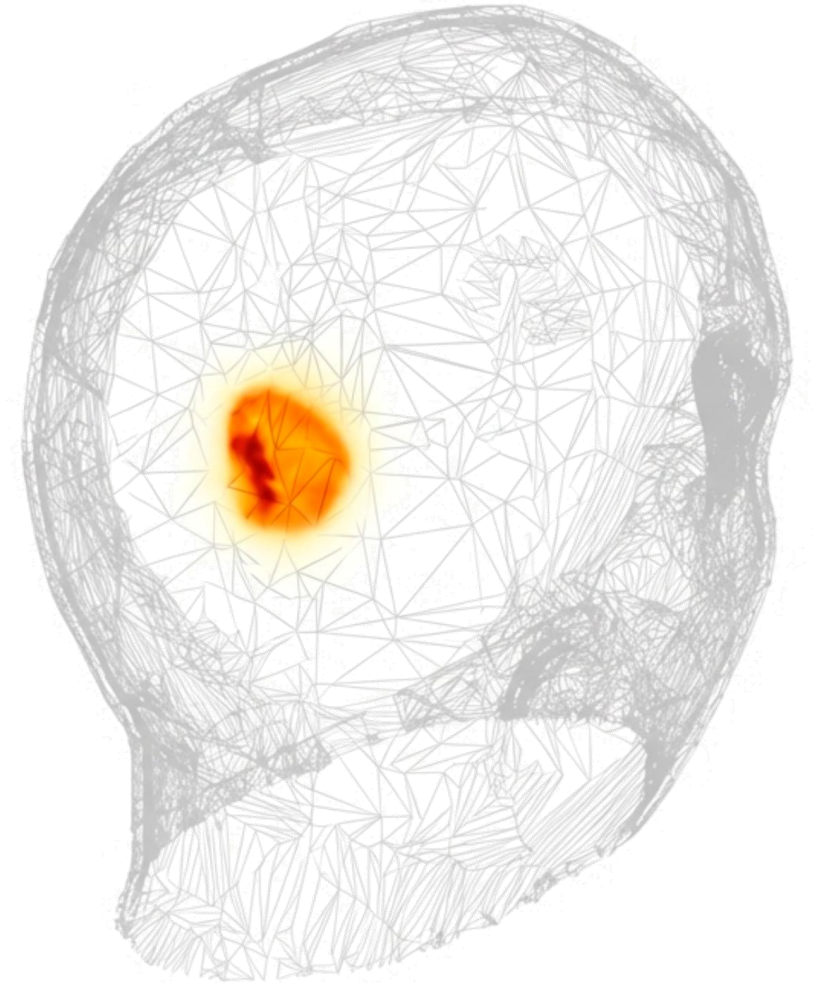






COLLEGIO I T L ETF

The Transparent Mind: real-time brain stroke monitoring via microwave imaging





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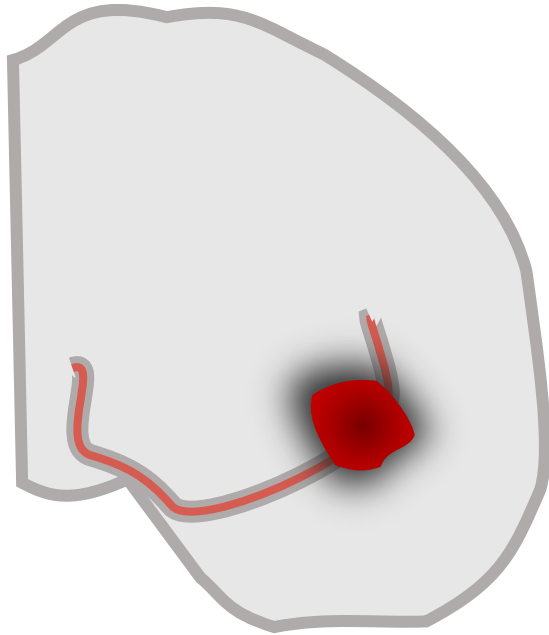
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Motivations

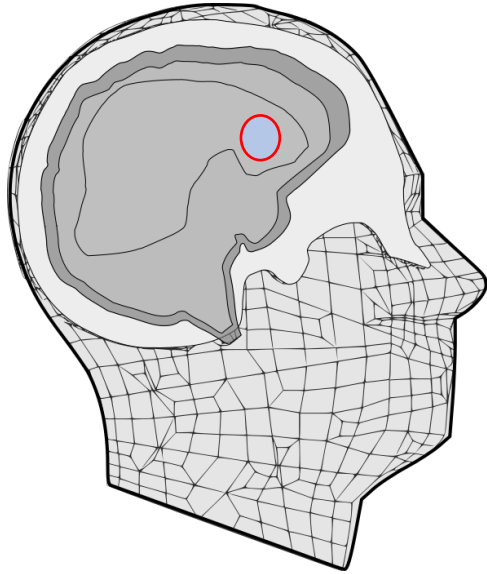
ISCHEMIA



HEMORRHAGE



Stroke Incidence



Someone has a stroke
every 2 SECONDS

Over 13M PEOPLE will have a
stroke each year

#2

Stroke is the No.2 cause of
death behind heart disease.



1 IN 6 PEOPLE

will have a stroke
in their lifetime.

33

MILLION PEOPLE WORLDWIDE

had a stroke in 2010.
Slightly more than half (16.9
million) were first strokes*.



Time is BRAIN

Death 25% Disability 50% Full-recovery 25%

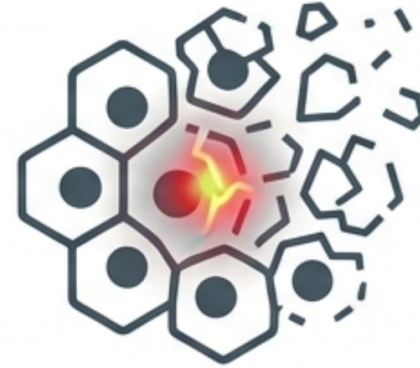
Clinical need

The Diagnostic Standard



MRI and CT scans are the gold standard for initial diagnosis. However, they utilise **ionising** radiation (CT), require complex patient transport, and cannot be deployed for continuous, bedside monitoring.

The Monitoring Gap



Stroke is a dynamic, evolving event. Brain tissues deteriorate rapidly due to disrupted blood flow (ischaemia) or vessel rupture (haemorrhage). Clinicians require a safe, non-ionising, and portable bedside tool to track stroke evolution after the initial onset.

**The Golden Hour
(Initial Diagnosis)**

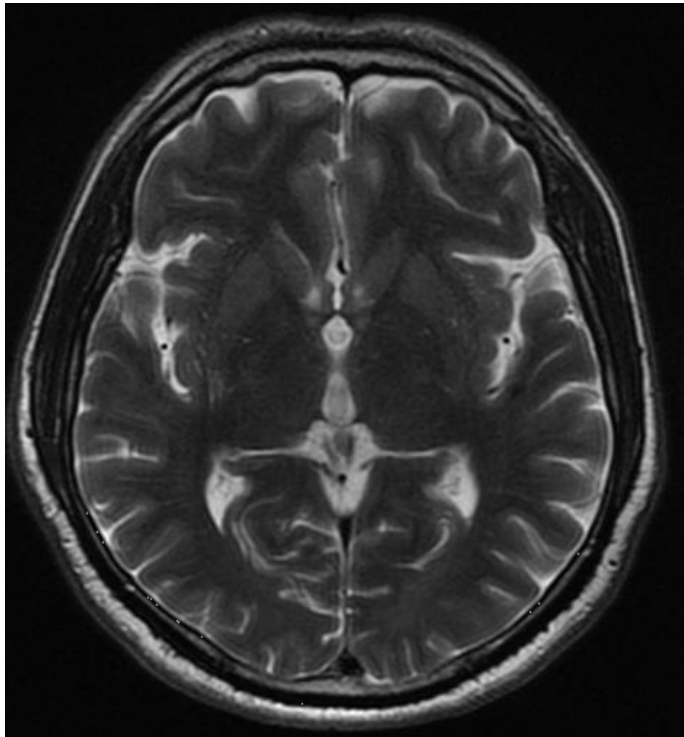
The Continuous Monitoring Gap

**Post-Treatment
Recovery**



Current technologies for Diagnostic/Imaging

Magnetic Resonance Imaging
(MRI)



Computerized tomography
(CT)

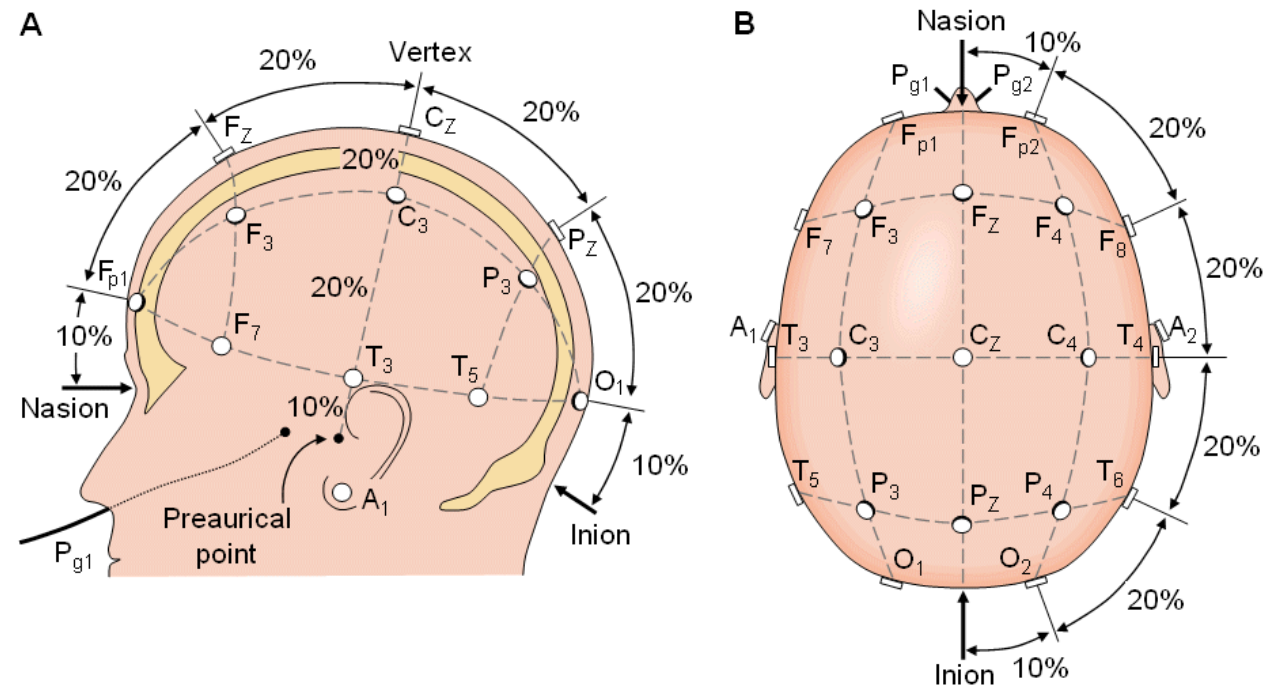
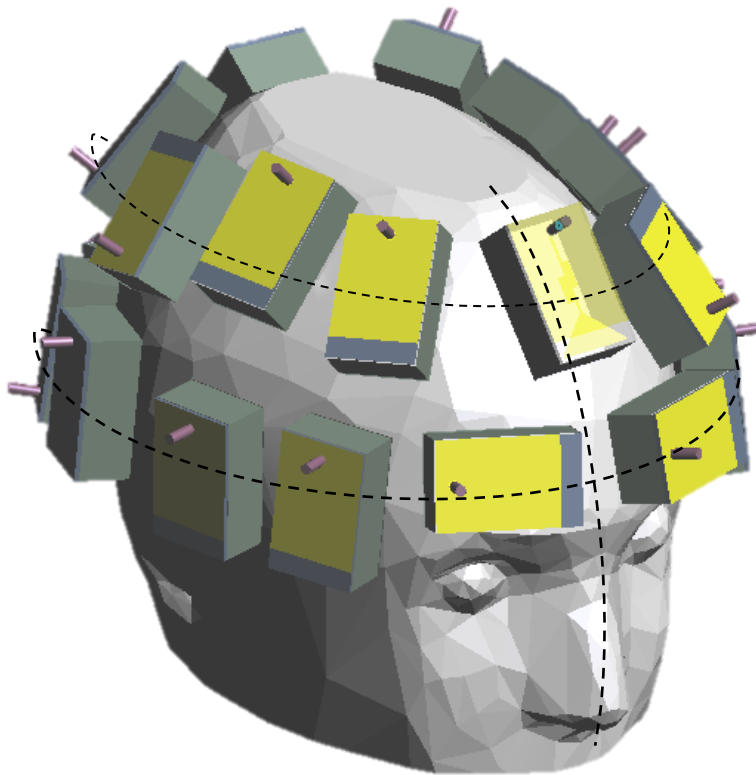


- Time consuming
- Not portable
- Costly
- Not available for bedside monitoring Harmful due to ionizing radiations (CT only)

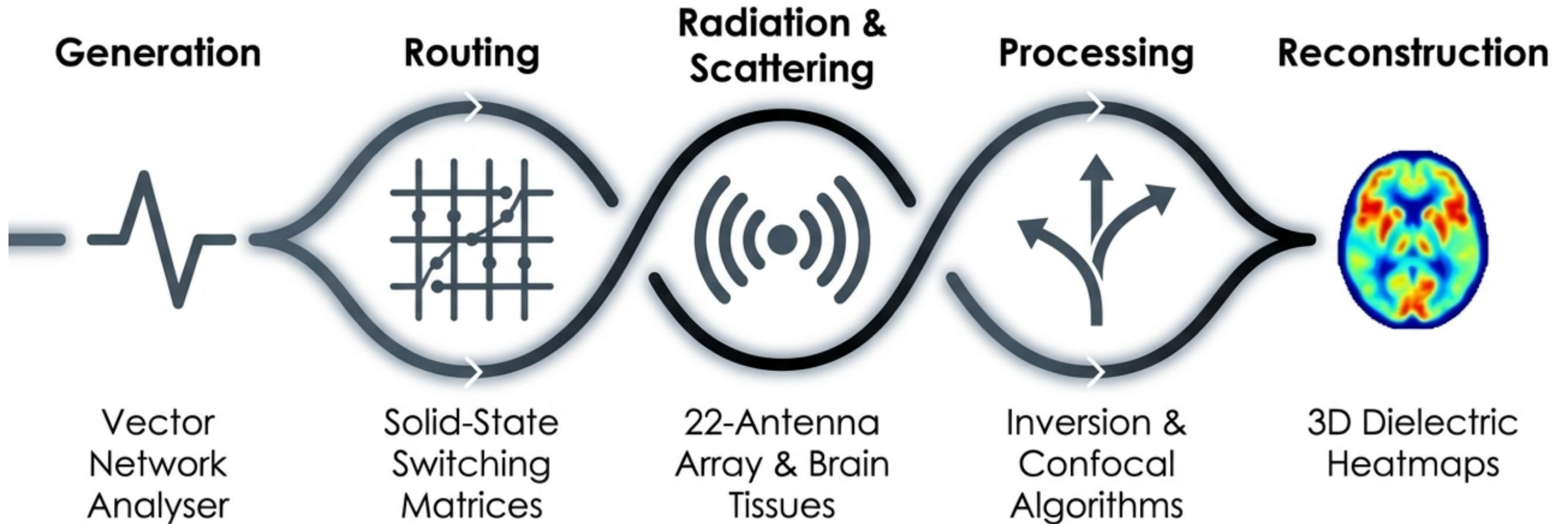
Microwave Imaging (MWI) is a complementary technology

Our solution: Microwave Imaging

A lightweight reference object worn continuously by the patient. The measurement device is attached only during scanning, aligned with the reference object.



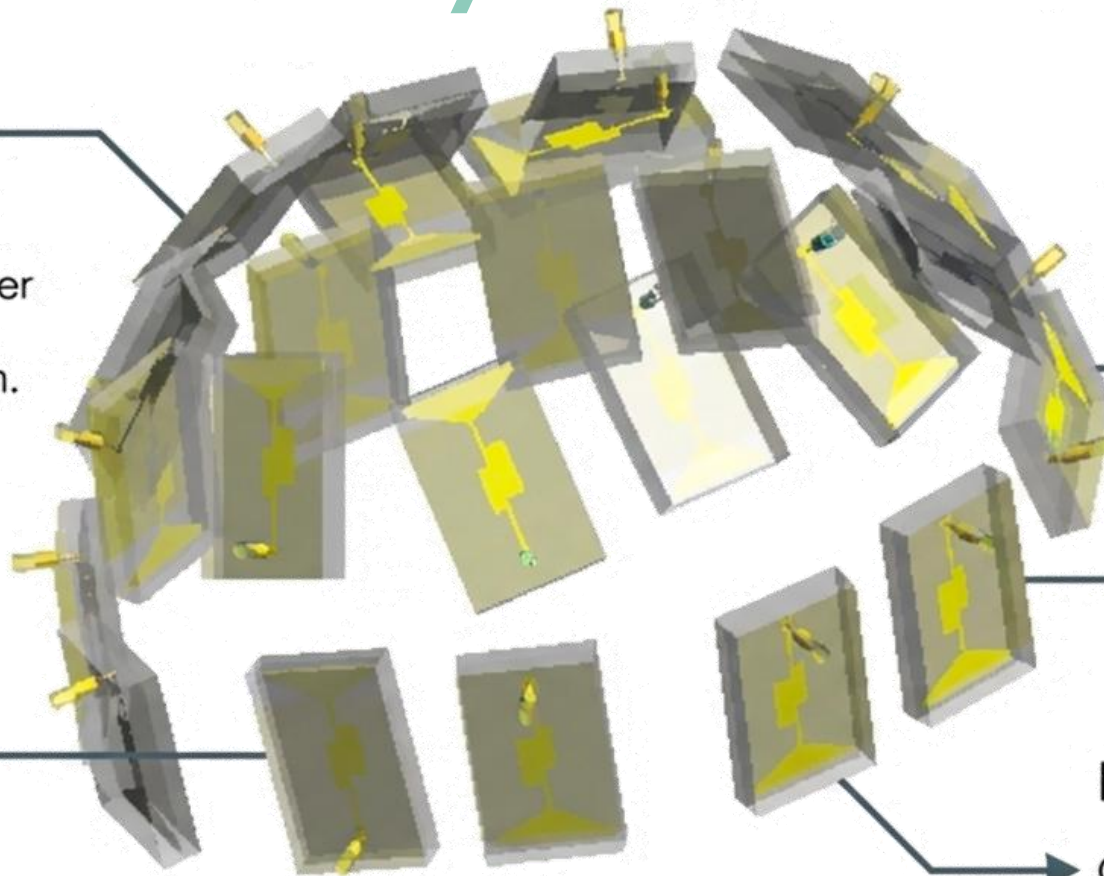
The signal's journey



22 Antenna Array

Configuration

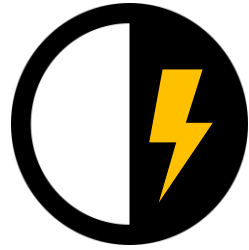
22 custom-made wearable antennas positioned conformally around the upper head, functioning as a multi-view transceiver system.



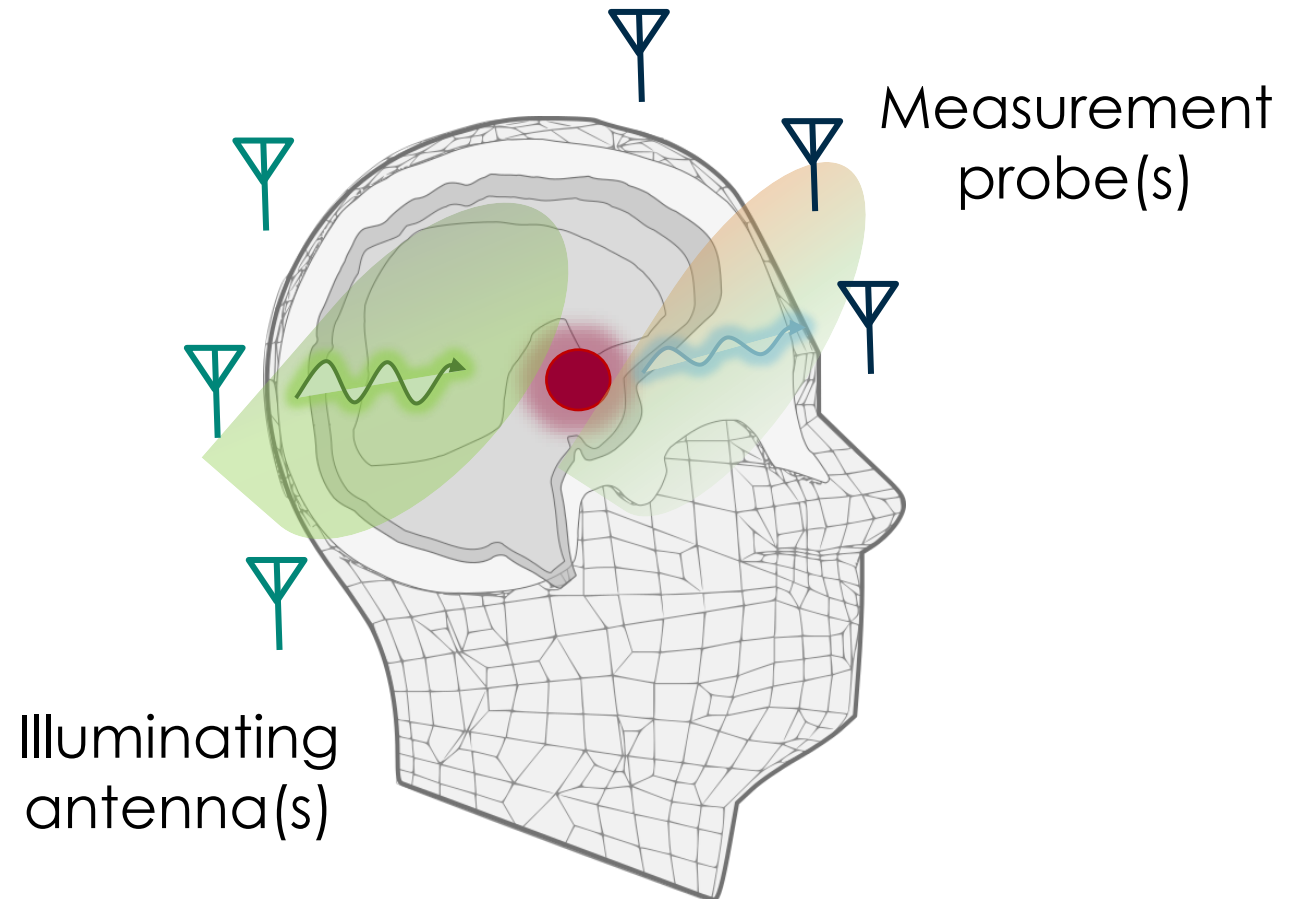
Frequency Trade-off

Operating at 1 GHz. This specific frequency provides the optimal mathematical trade-off between penetration depth (reaching deep brain tissues) and spatial resolution (detecting small lesion variations).

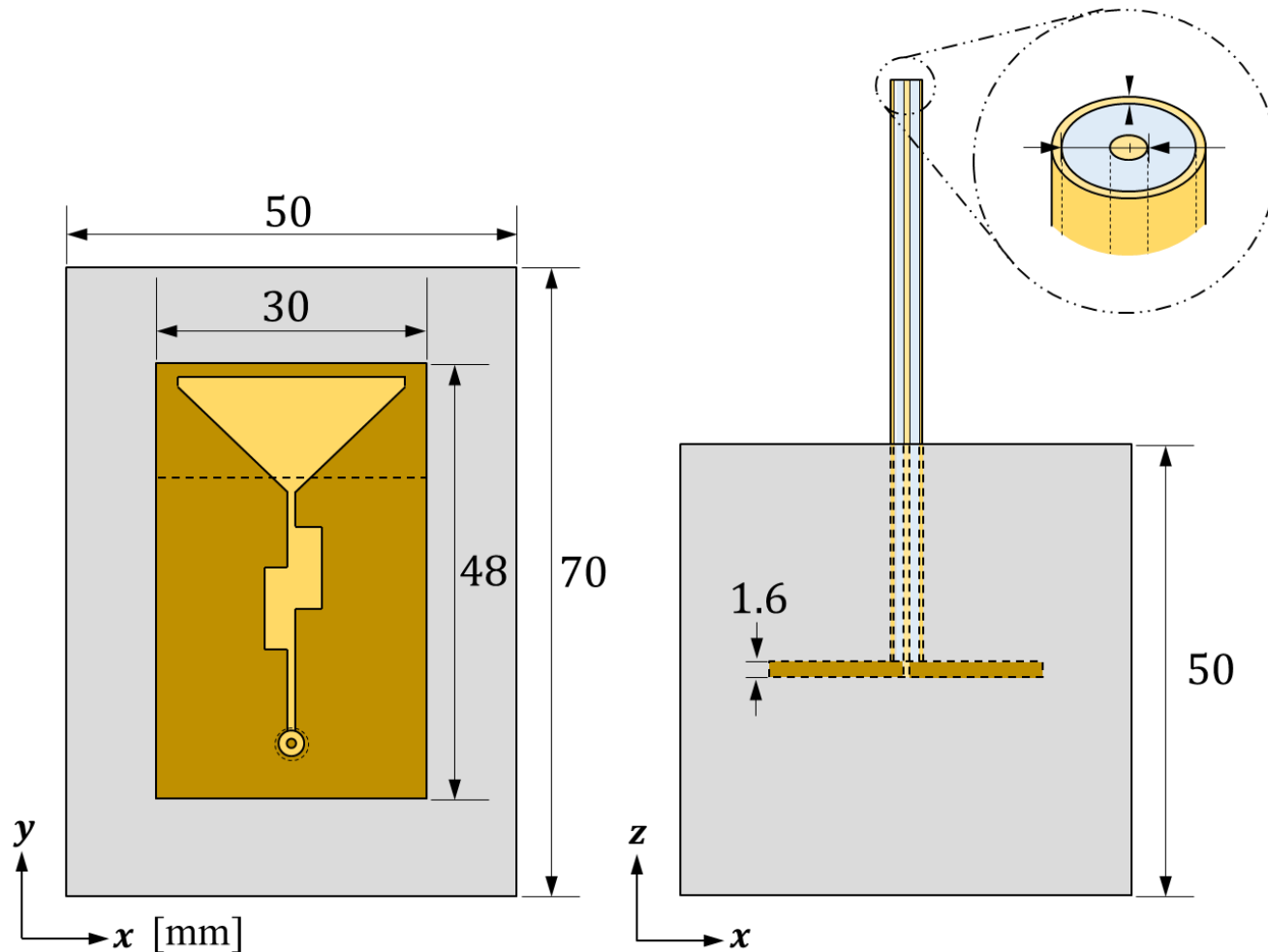
Principle



Electrical contrast
between the
healthy tissues
and stroke
affected zones



Antenna design

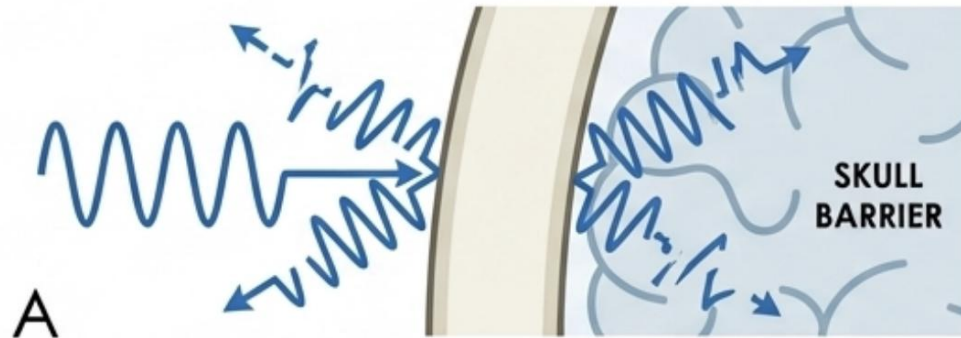


Working -10dB frequency band from 0.8 to 1.2 GHz, centered around 1GHz

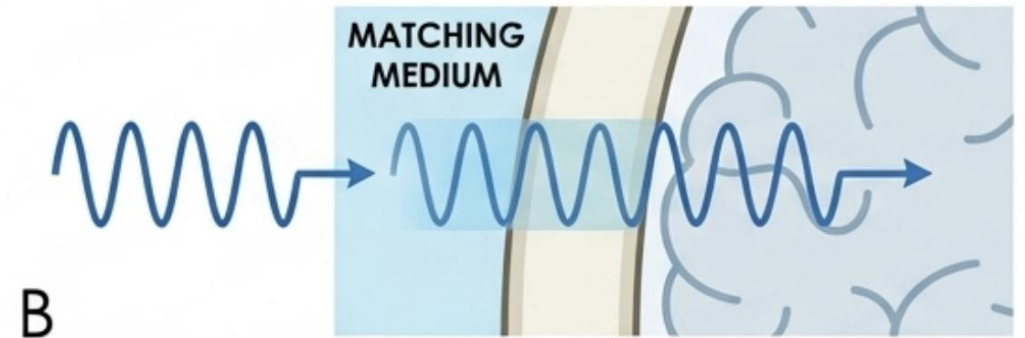
Semi-flexible and custom-permittivity coupling medium built with a mixture of urethane rubber and graphite powder. ϵ_r around 20

D. O. Rodriguez-Duarte et al., "Brick shaped antenna module for microwave brain imaging systems," IEEE AWPL, 2020.

Medium design



A Impedance Mismatch (No Medium)

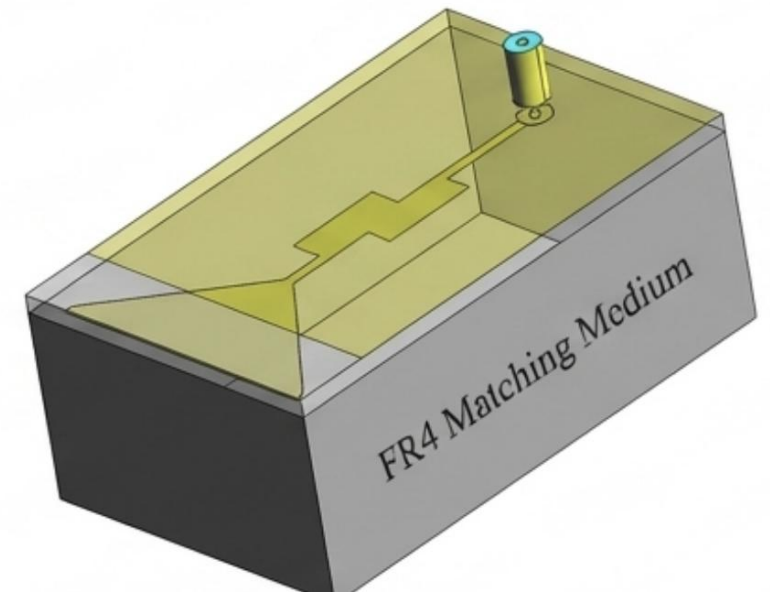


B Electromagnetic Coupling

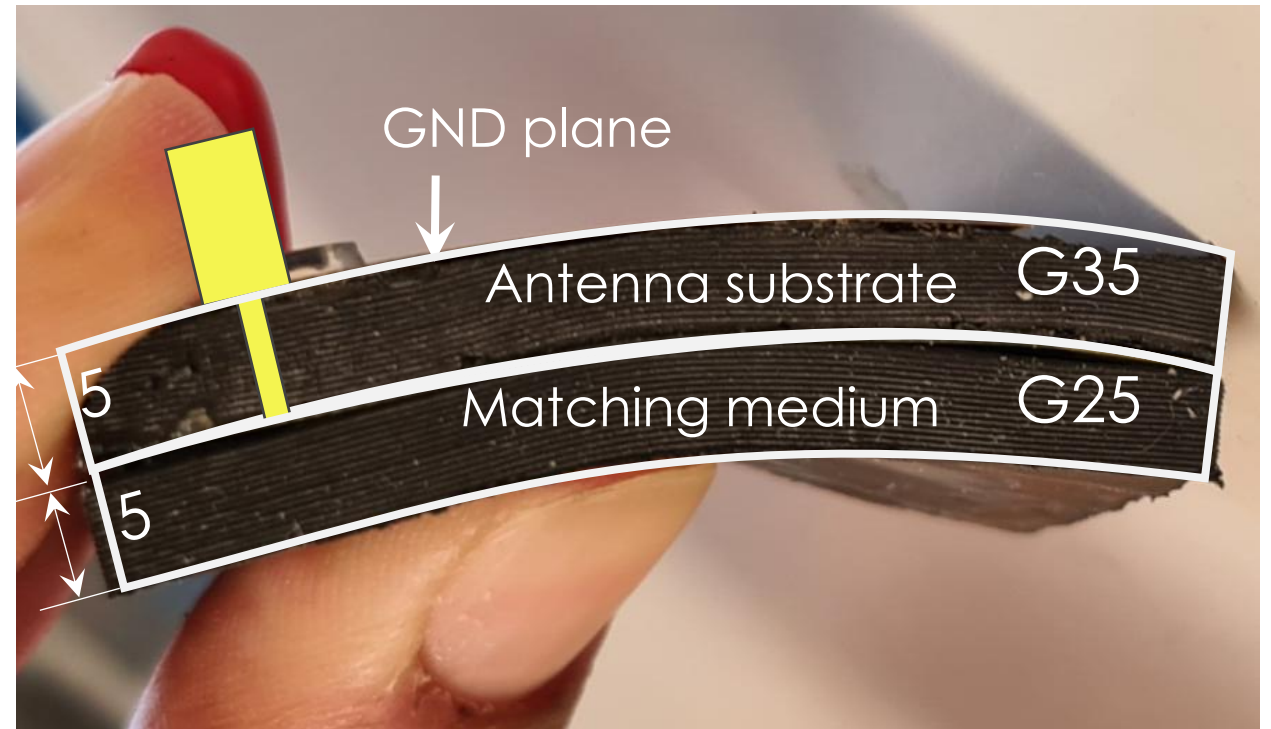
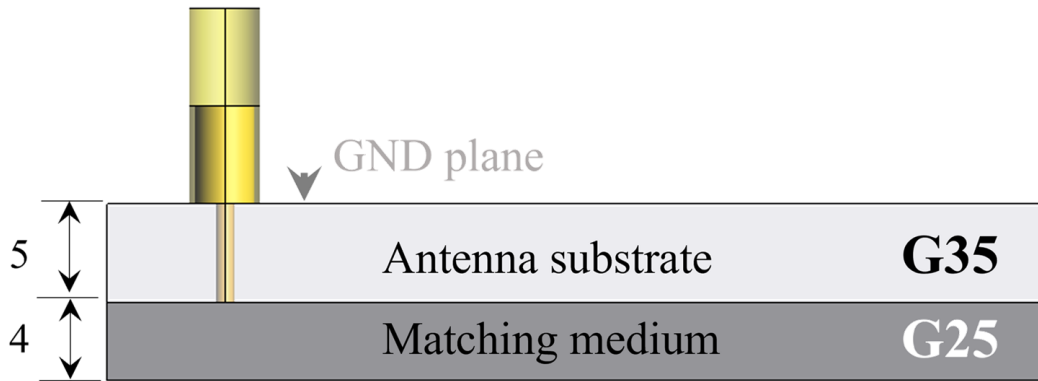
The Interface: Twenty-two custom-made, brick-shaped wearable antennas conformally positioned around the head.

The Physics: Without a matching medium, electromagnetic waves at 1 GHz reflect off the skin and skull.

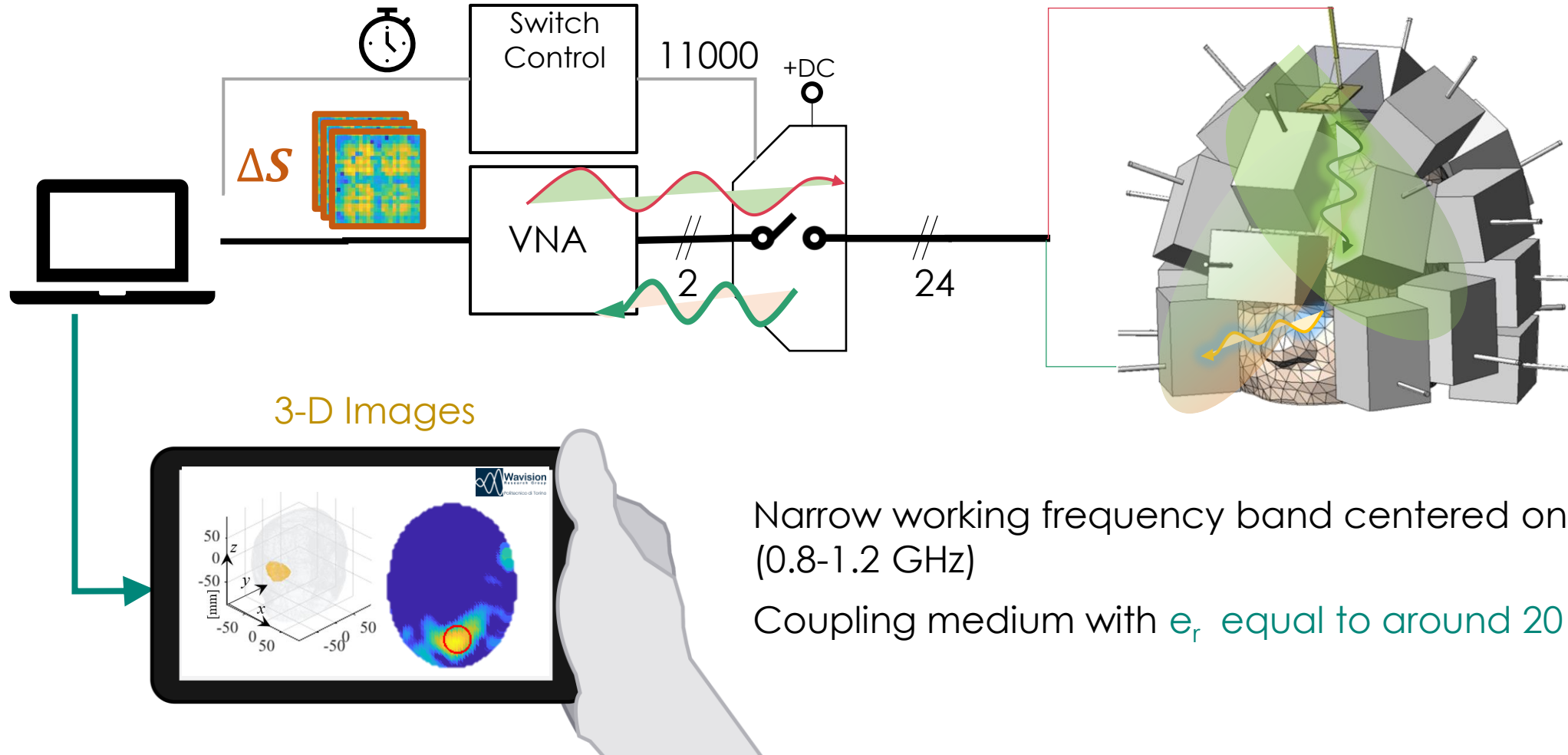
The Solution: Engineering an FR4 matching medium inside the antenna module forces electromagnetic coupling, allowing the signal to reach the brain.



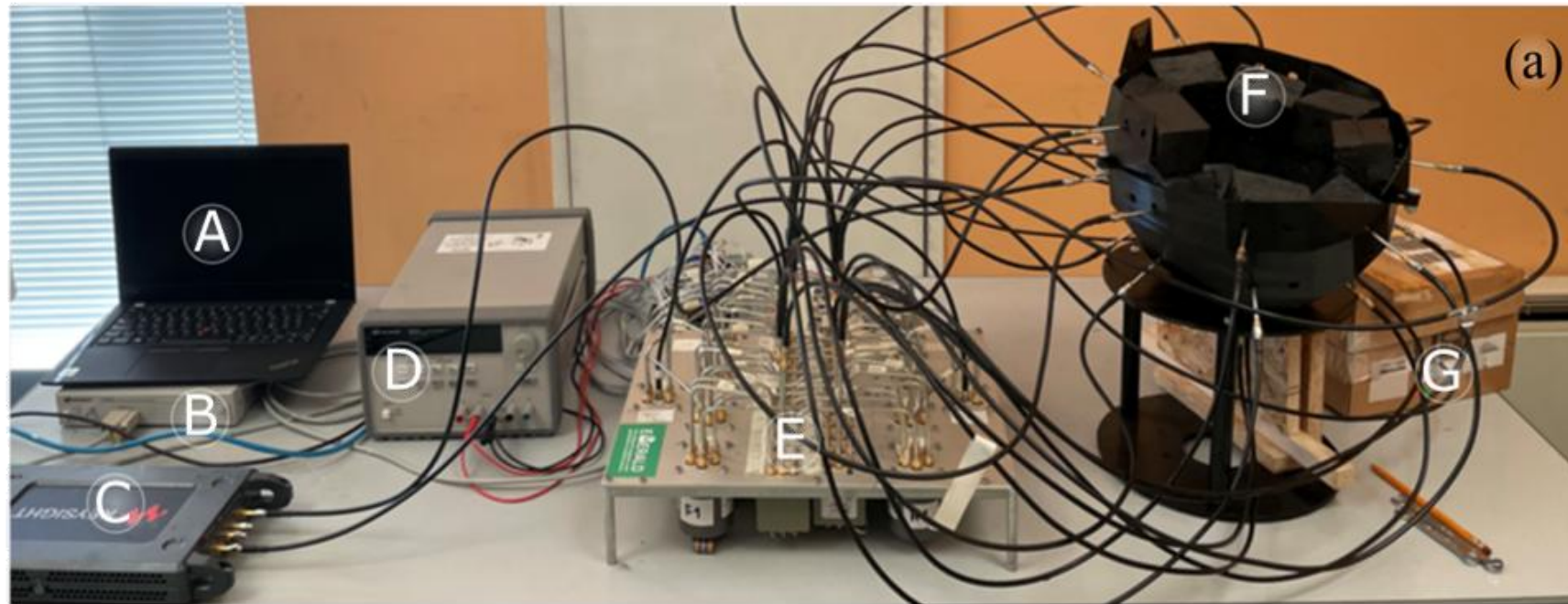
Matching medium



Validation and Lab Experiments

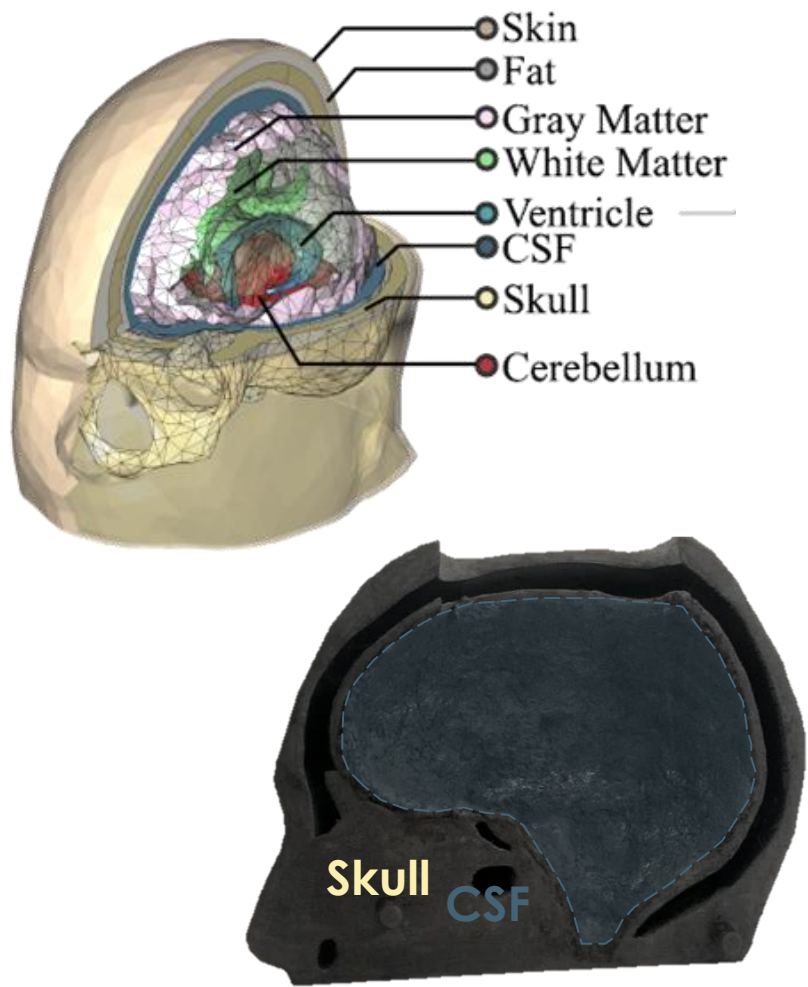



Experimental Setup



- Ⓐ Laptop
- Ⓑ Switch control
- Ⓒ VNA
- Ⓓ DC power source
- Ⓔ Switching matrix
- Ⓕ Brick antenna
- Ⓖ Reference channel
- Ⓗ Head phantom
- Ⓘ Average brain liquid

The phantom



 Drying time ~ 2-3h



Validation and Lab Experiments

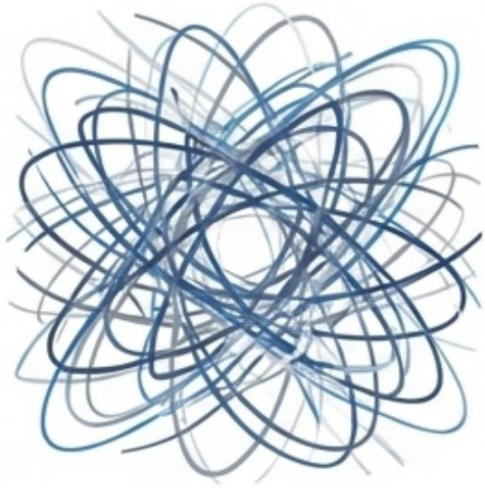
Homogeneous



Multi-tissue

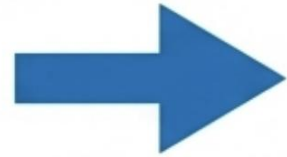


Extracting data



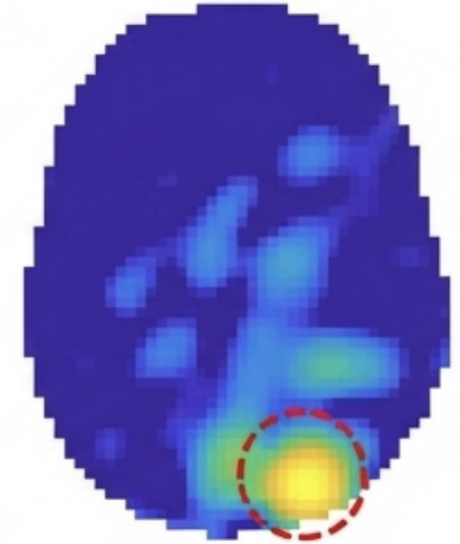
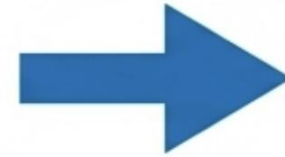
**Raw Scattered Signals
(Clutter)**

The Math: Translating scattering matrices into 3D dielectric maps is an ill-posed, non-linear inverse problem.



**TSVD / DS-DMAS
Inversion Kernel**

The Algorithms: We rely on the distorted Born approximation to linearise the problem, utilising Truncated Singular Value Decomposition (TSVD) and Double-Stage Delay-Multiply-And-Sum (DS-DMAS).

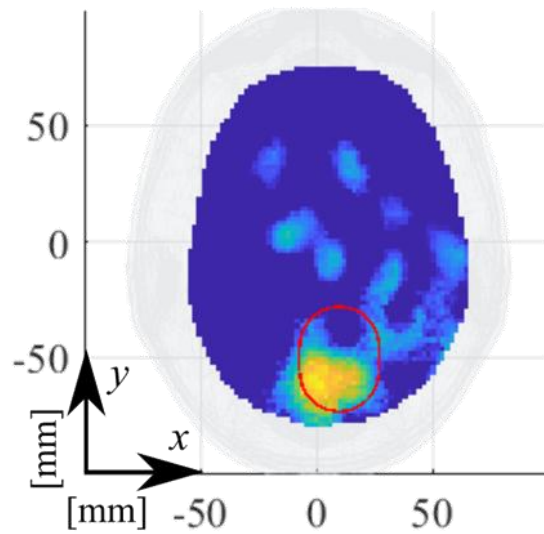


The Result: Complete suppression of signal clutter, isolating the localised temporal contrast variation caused by the stroke.

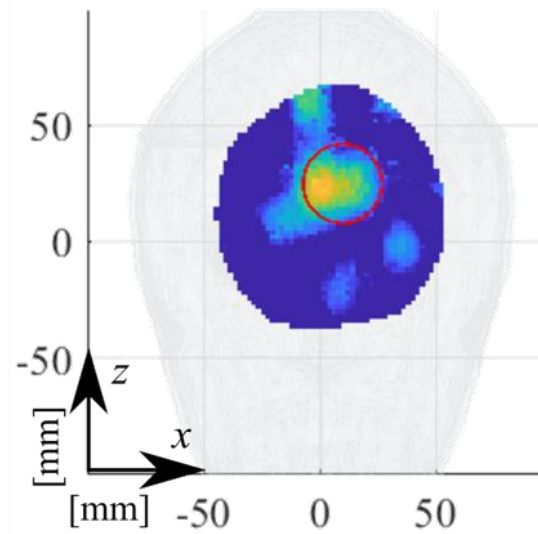
Validation and Lab Experiments



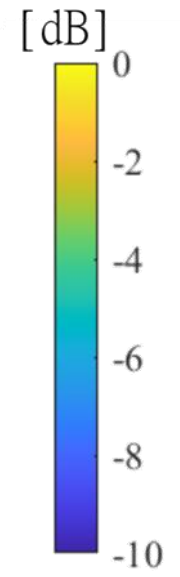
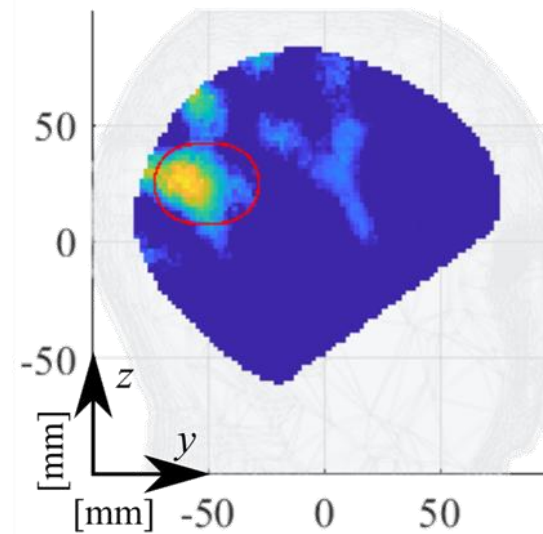
Frontal



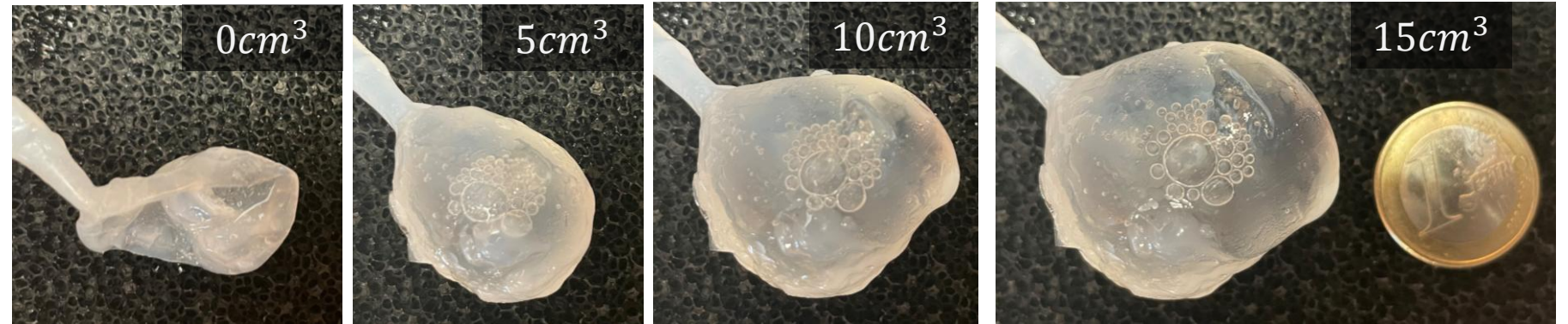
Transverse



Sagittal



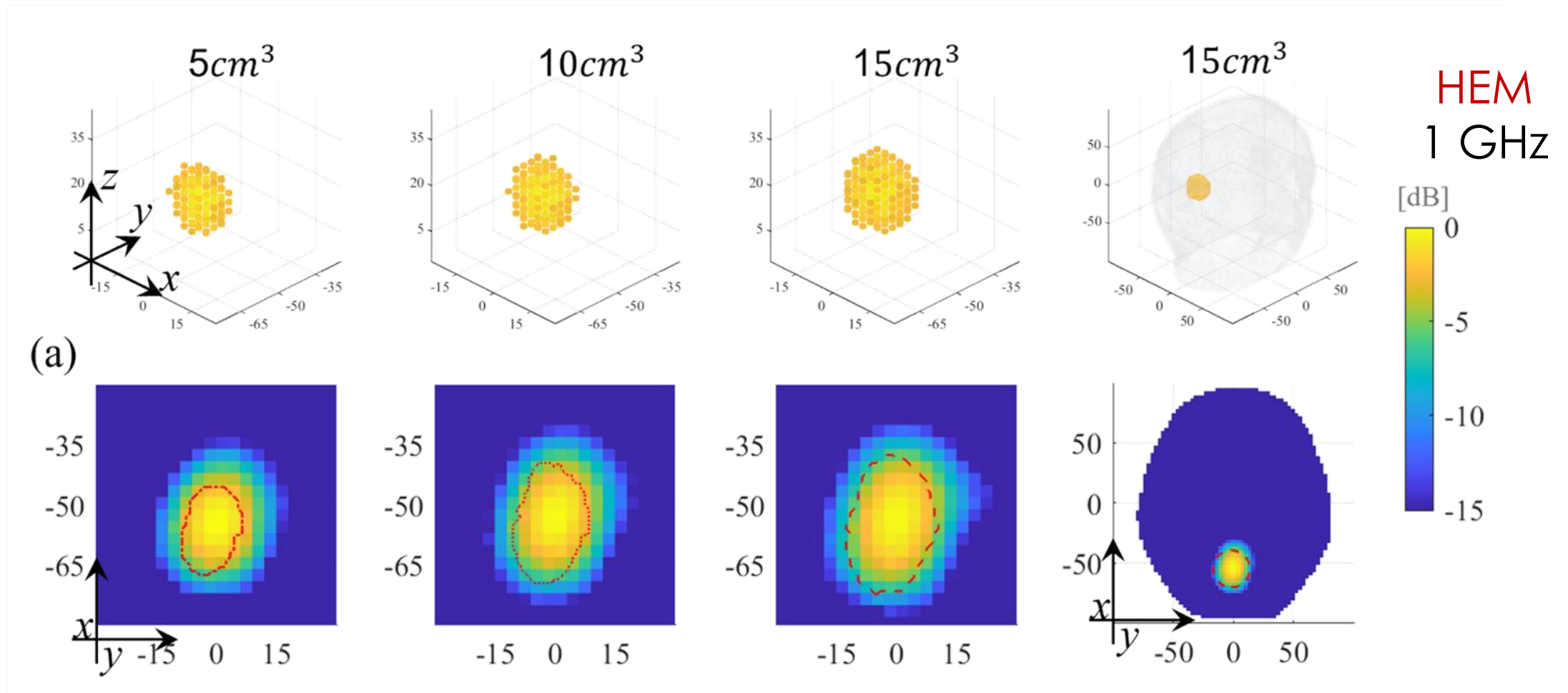
Numerical Validation: homogeneous head



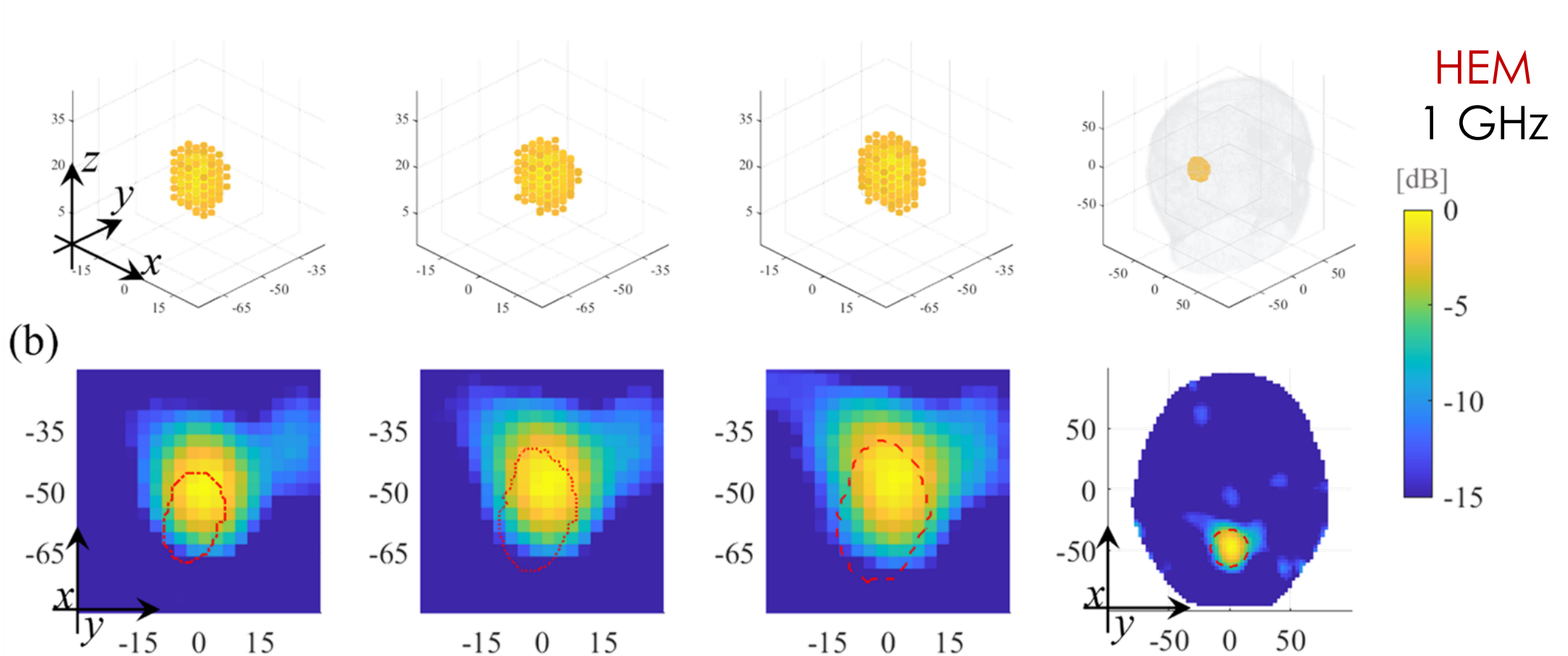
In collaboration with:



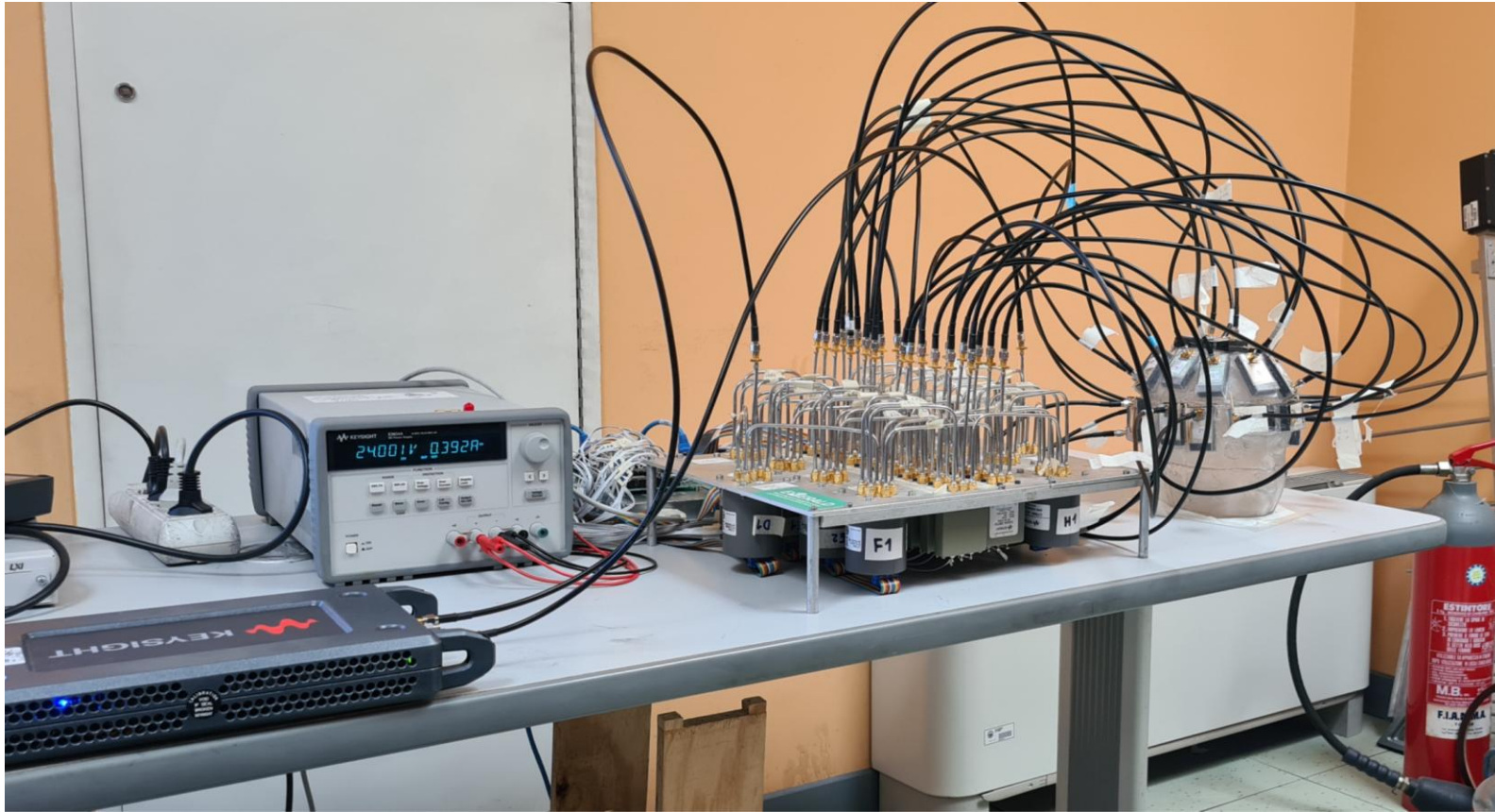
Numerical Validation: homogeneous head



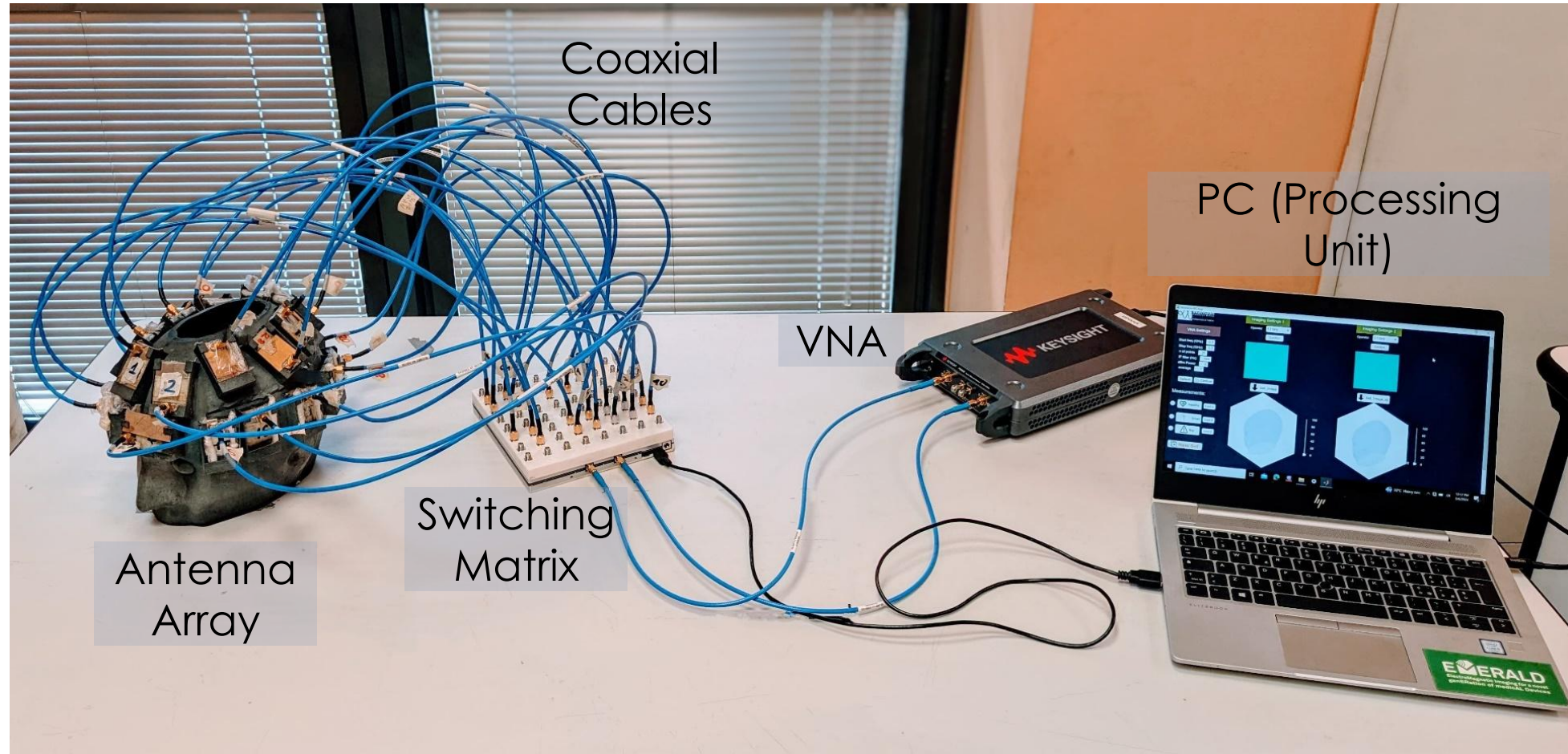
Numerical Validation: multi-tissue head



Always in renewal!



Always in renewal!



Always in renewal!



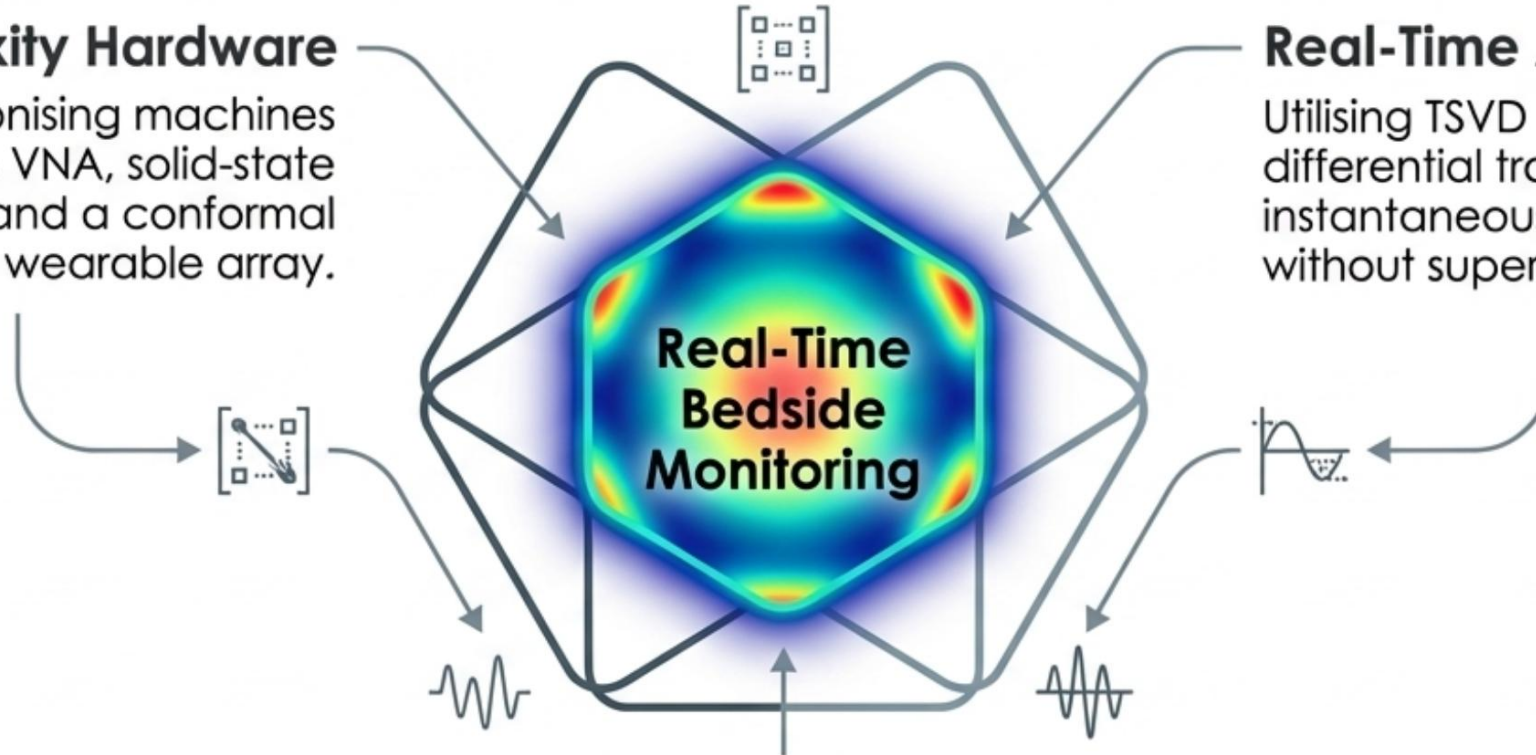
Conclusion

Low-Complexity Hardware

Replacing bulky, ionising machines with a portable VNA, solid-state switches, and a conformal wearable array.

Real-Time Algorithms

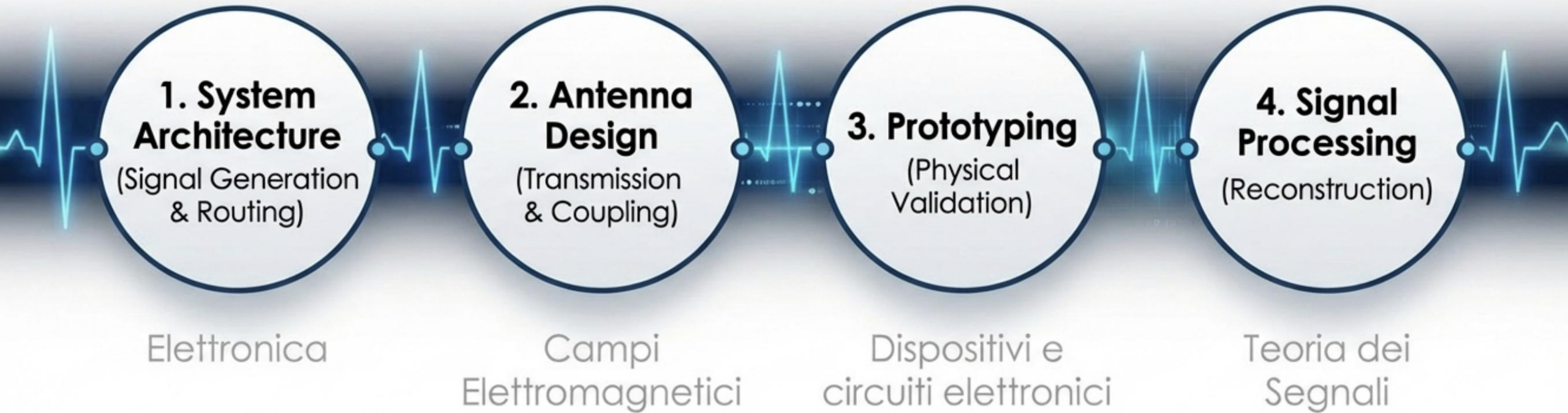
Utilising TSVD and DS-DMAS differential tracking to provide instantaneous clinical feedback without supercomputers.



Clinical Autonomy

Capable of operating robustly and accurately even with limited patient-specific anatomical data.

The electornic engineer job



THANK YOU!

Giovanna Turvani

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Solide basi di matematica, chimica, fisica ed informatica



Politecnico
di Torino

SALONE DELL'ORIENTAMENTO 2026



Dispositivi e
circuiti
elettronici



Misure
elettroniche

Elettronica
analogica e
dei sistemi
digitali

Controlli
automatici

Teoria dei
segnali

Campi
elettromagnetici



Politecnico
di Torino

SALONE DELL'ORIENTAMENTO 2026

**GRAZIE PER L'ATTENZIONE,
FELICE ORIENTAMENTO!**

Referente del Corso di Laurea in Ingegneria Elettronica
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