

Passive Measurement of Joint Angle Using a Printed Dipole Antenna: Proof of Concept

ORTHOPEDIC SURGERY

2

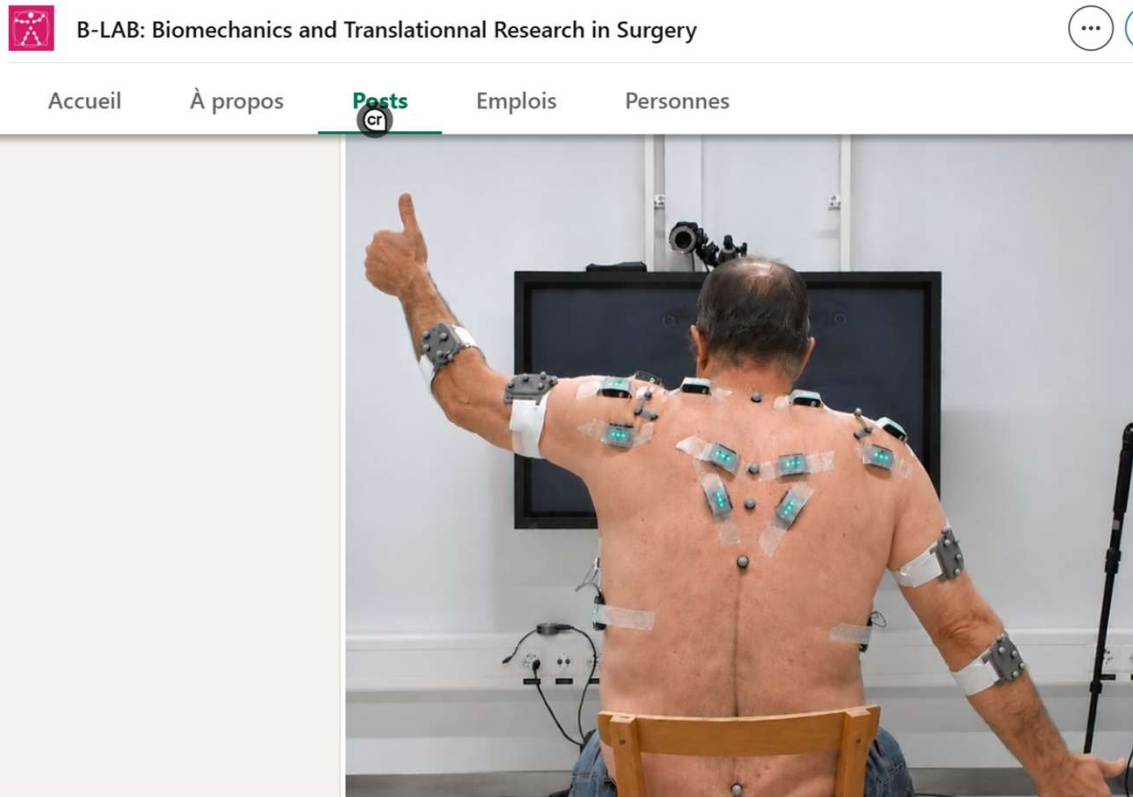
- 2024 → 30.5* million orthopedic procedures (+4.5% compared to 2023)
- 2nd most common type of surgical procedure
- Rehabilitation is required after surgery
- ⇒ Joint angle measurement: observable



*Source: <https://www.lifesciencemarketresearch.com/insights/market-dive-orthopedic-surgery>

MOUVEMENT Measurement...

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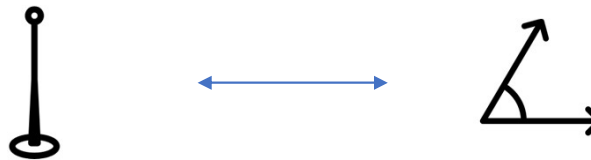
- **Need**
 - **Sport**
 - **Aging**
- **Few solutions**

Our proposition

- Printed Antenna(s)

Bio-degradable TATOO Hypothesis

It's possible to correlate antenna's parameters to angle of a joint.



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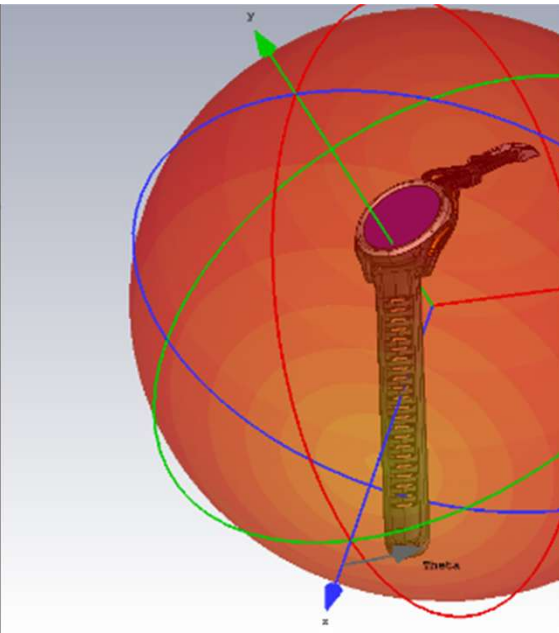
Printed electronics vs. as we always do

Conventional electronics processes <i>Photolithography, vapor deposition</i>	Printed electronics processes <i>Inkjet, screen-printing, stamping, coating...</i>
+ High performances + High miniaturization ability - Expensive - Complex implementation - Rigid substrates - Time consuming - Waste producing	+ Large areas + Flexible and rigid substrates + Low cost + Easy implementation - Lower performances - Lower precision



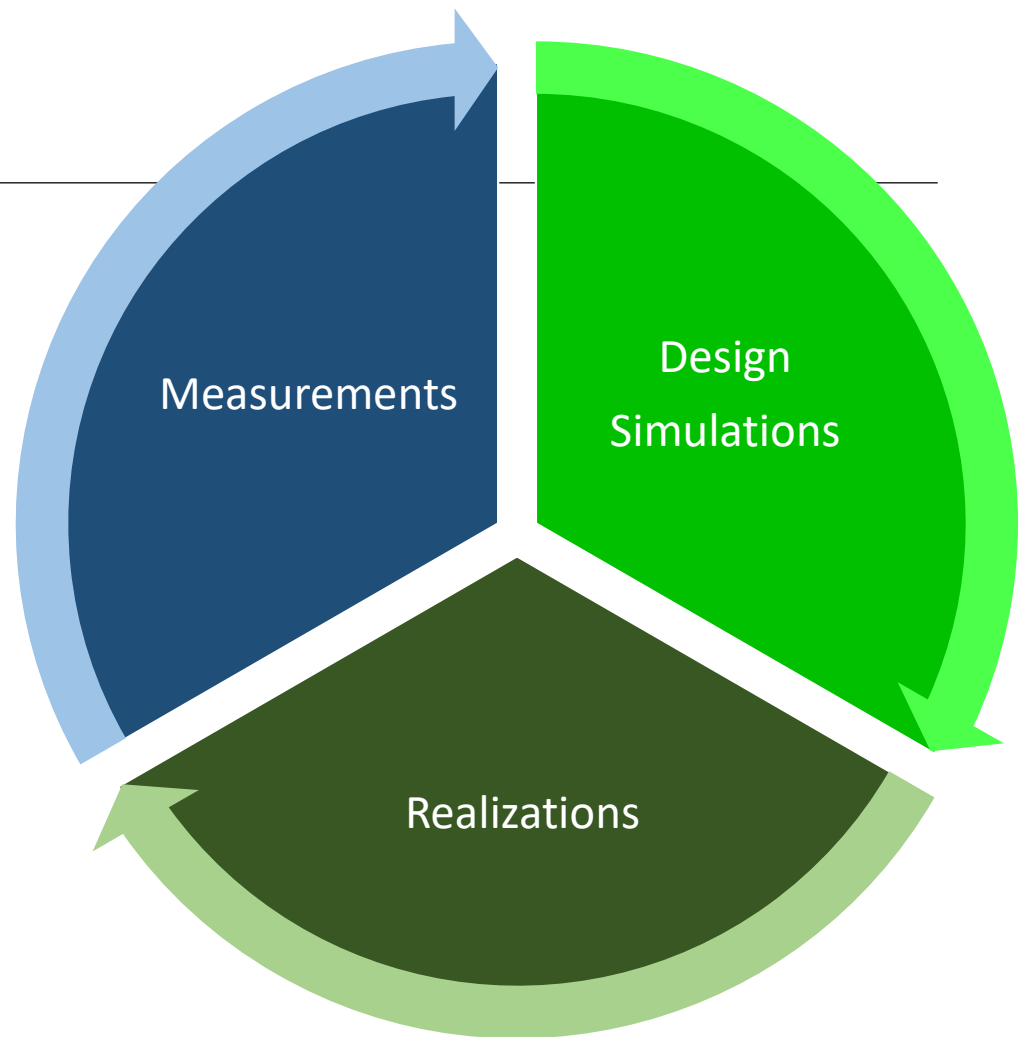
- Amonbofis ! Il faut changer l'eau des crocodiles c'est une infection.
- Ah, je sens rien moi. Non, pourtant j'ai installé l'évacuation des eaux usagées comme on le fait tout le temps.
- C'est bien ça le problème avec vous Amonbofis, vous faites toujours comme on fait tout le temps.
- Oui bah on a tout le temps fait comme ça...

Astérix et Obélix : mission Cléopâtre, Cléopâtre et Amonbofis.

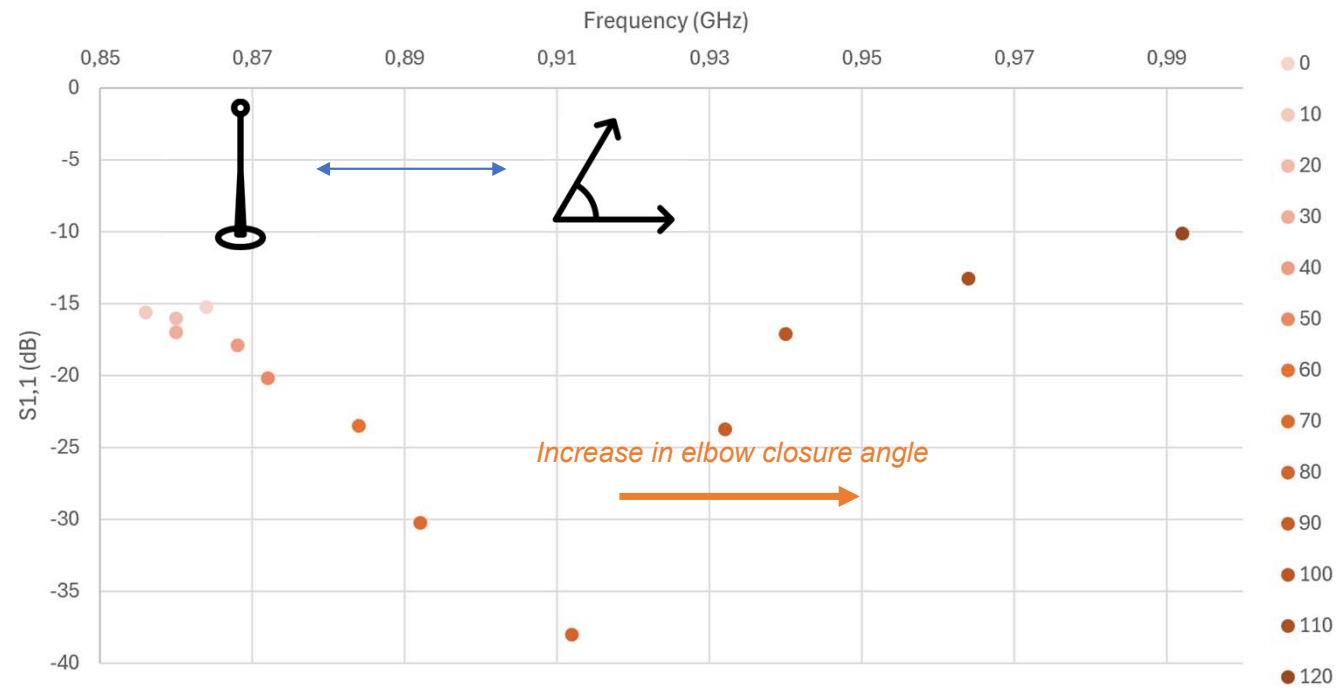


How we work

Crédit: @Joanna Kunikowski



ANTENNA SIMULATIONS



Evolution of antenna characteristics according to elbow angle into the void

Link between the antenna and elbow rotation?

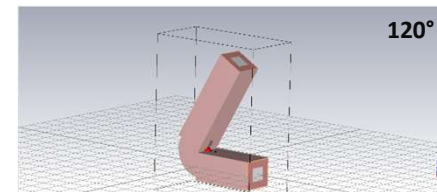
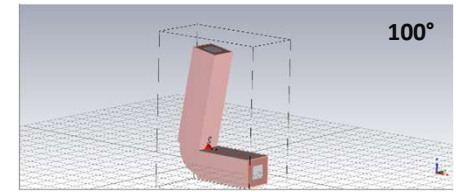
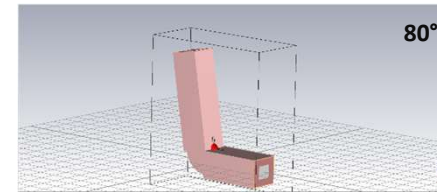
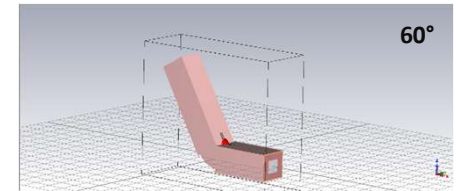
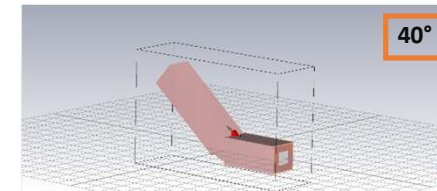
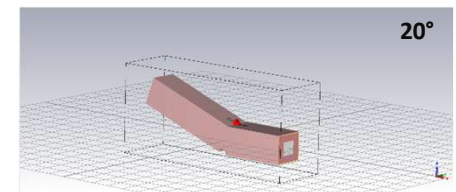
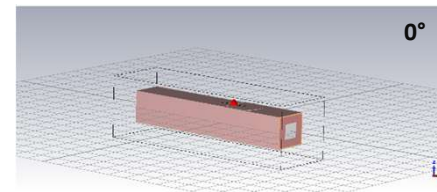
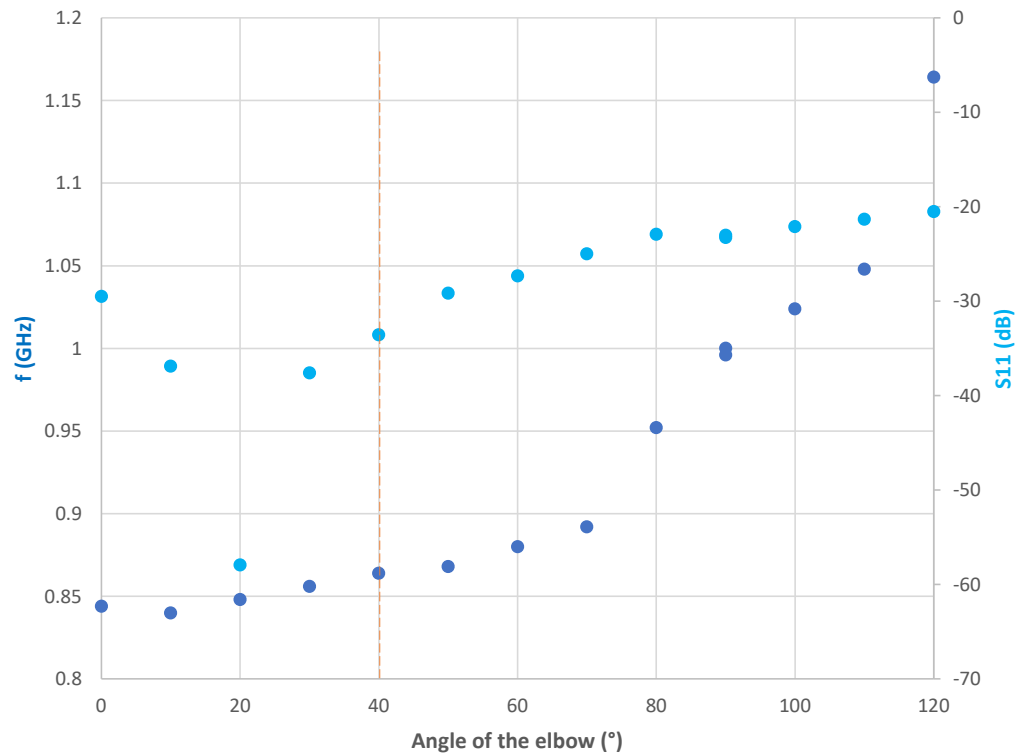
Yes! 😊



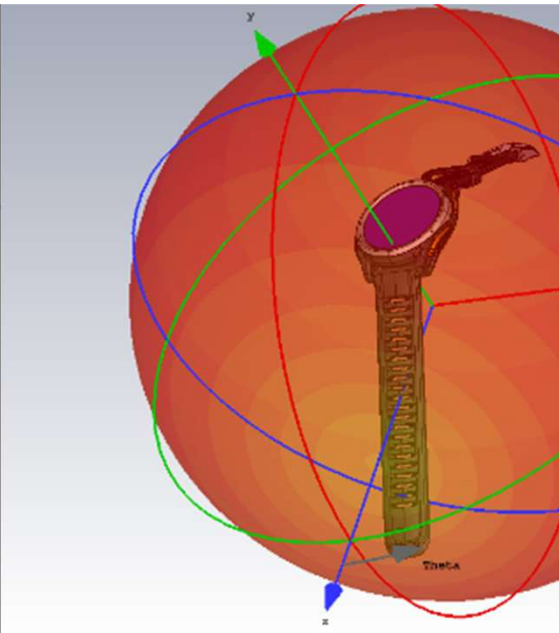
ANTENNA SIMULATIONS



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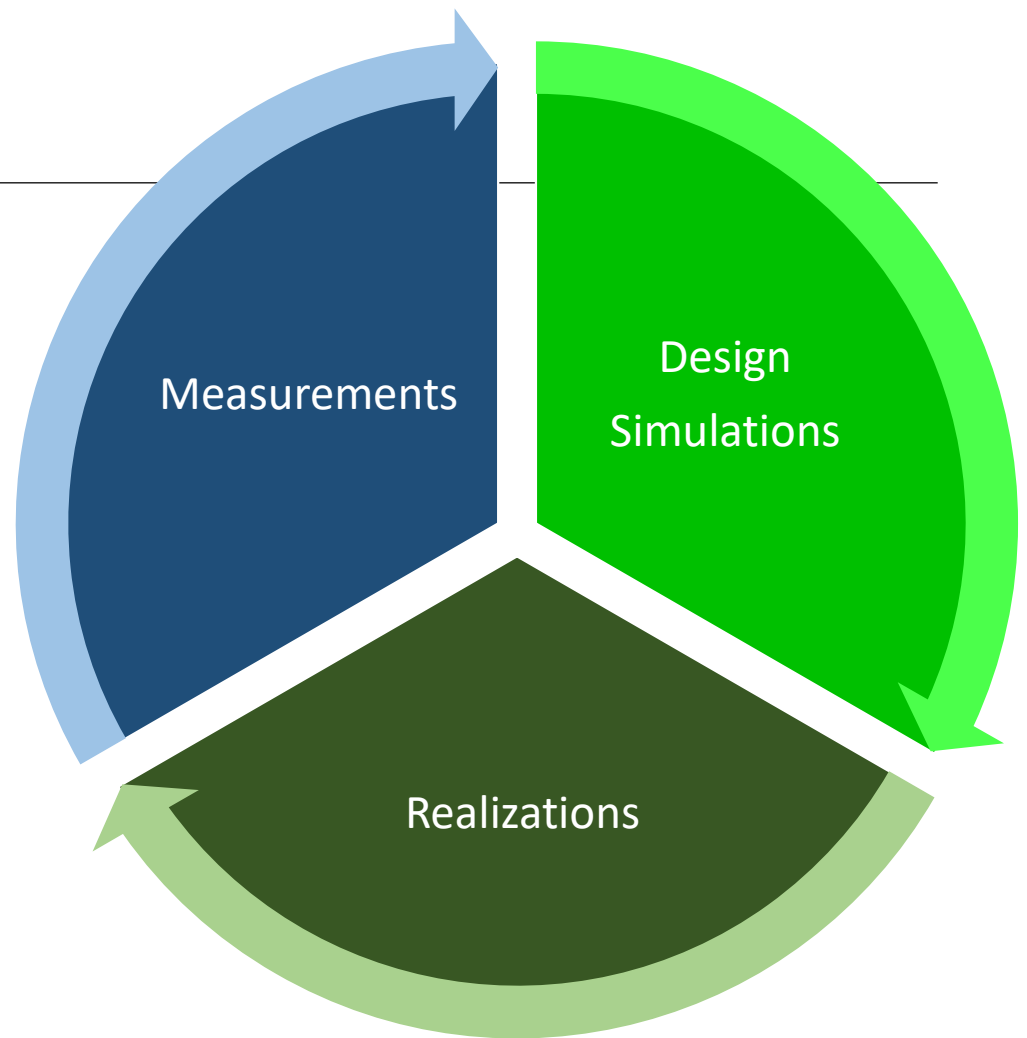


During the angle variation, significant frequency shift.

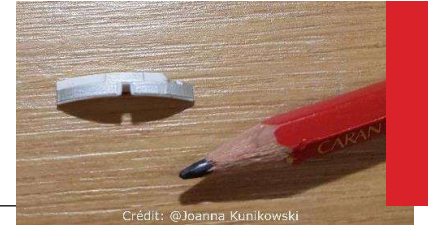


How we work

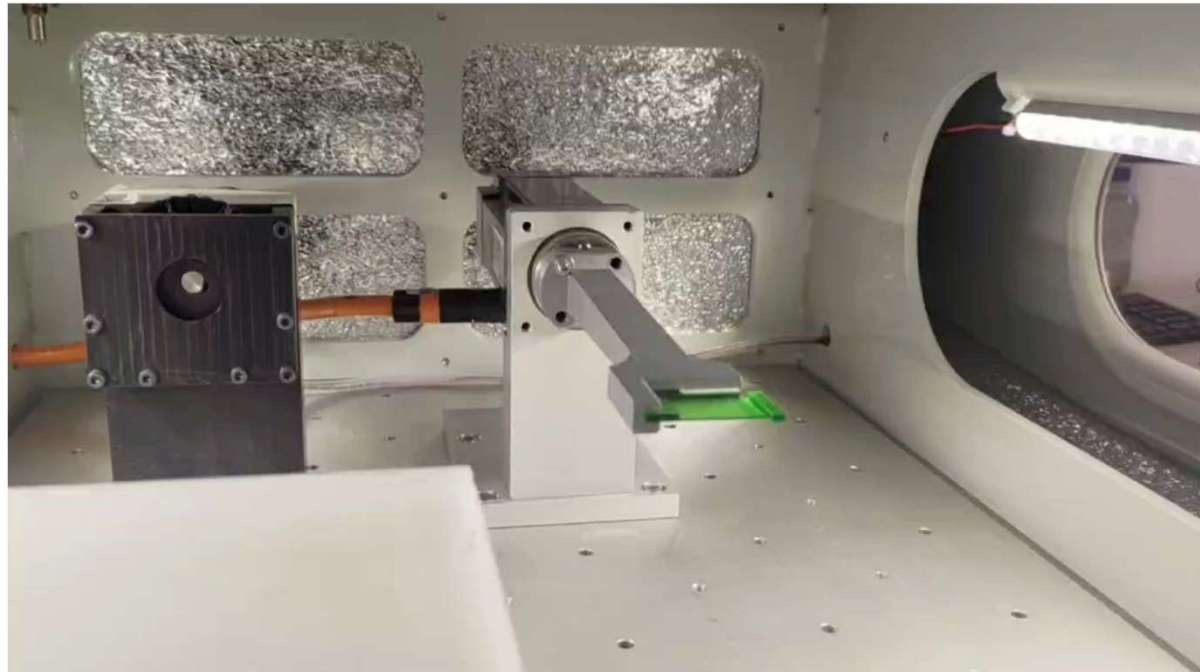
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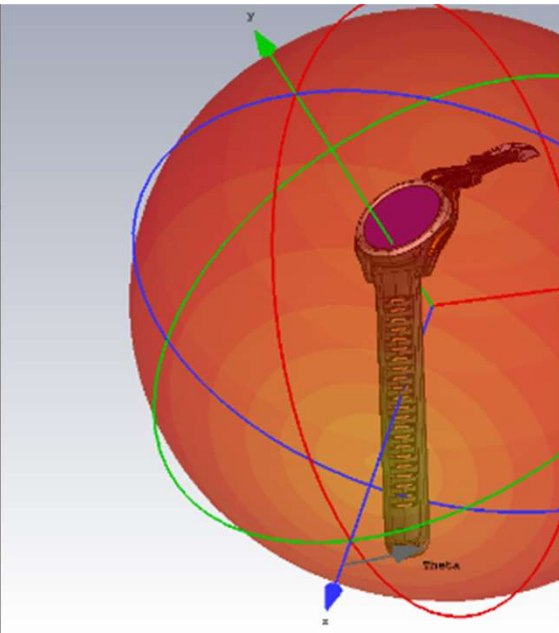


3D Realization

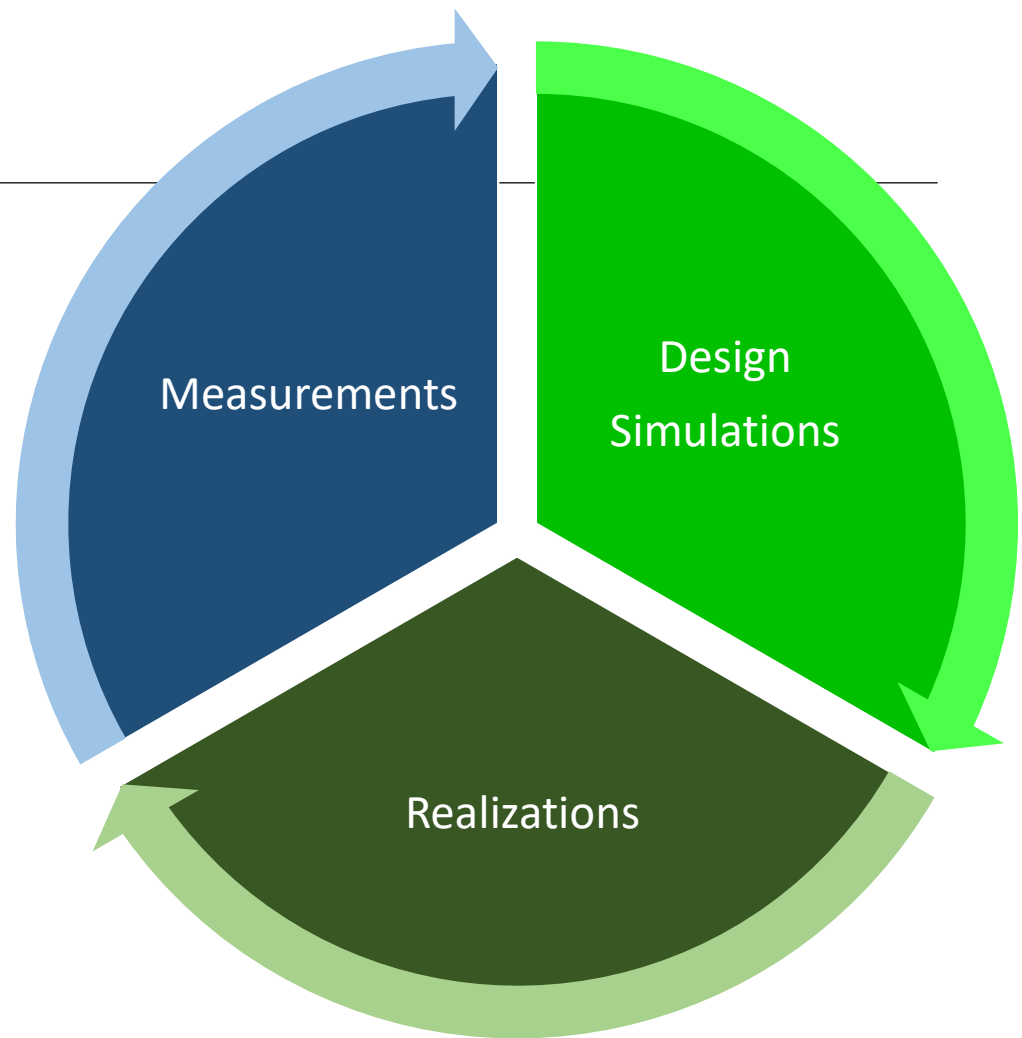


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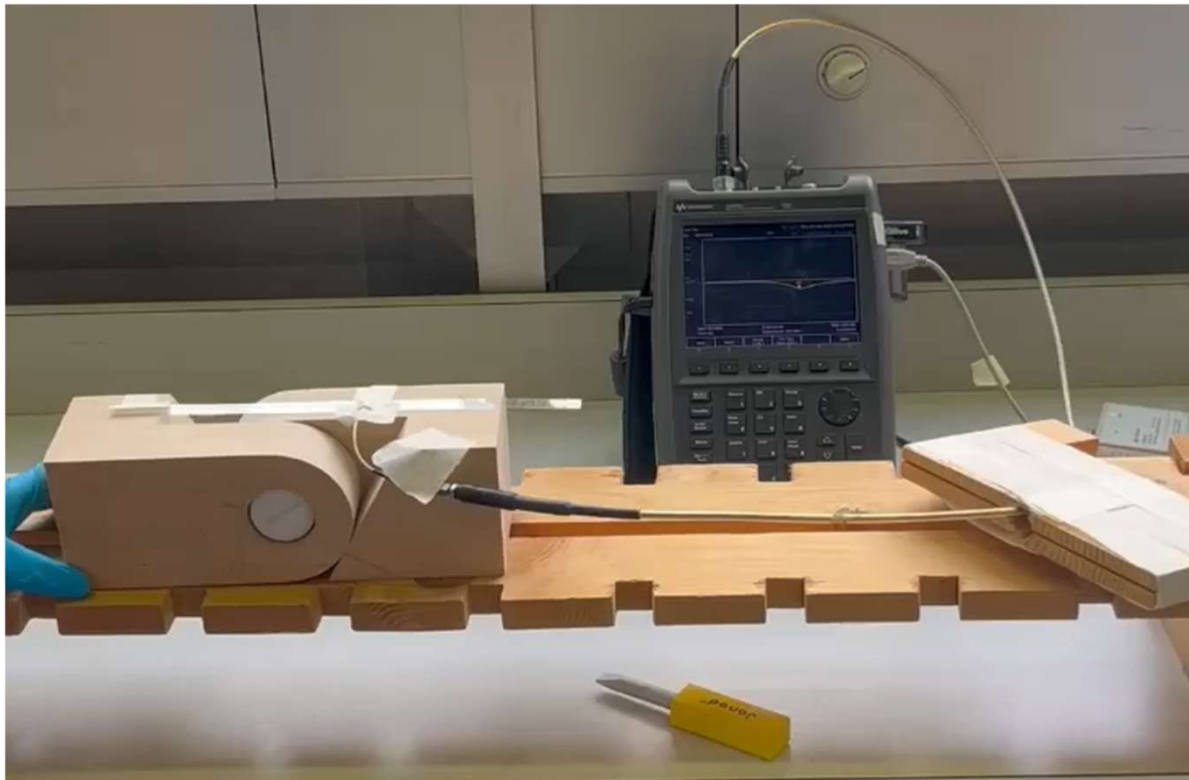
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ANTENNA MEASUREMENTS



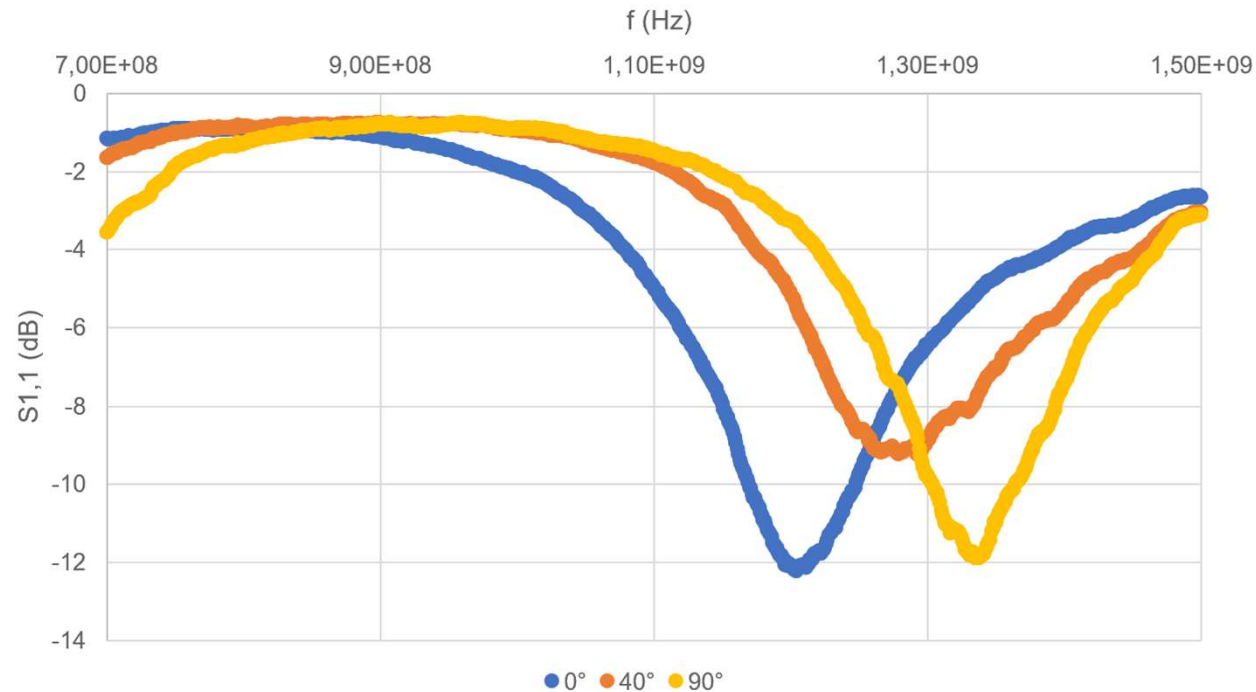
12



ANTENNA MEASUREMENTS



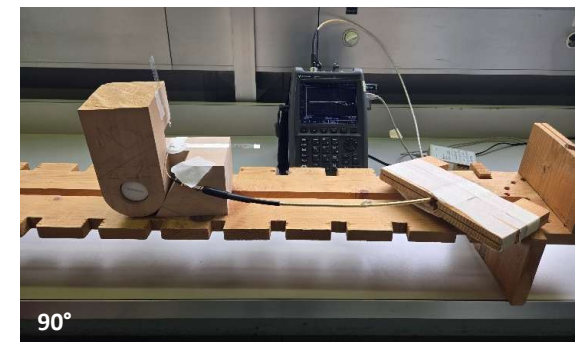
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Printed antennas (silver ink) placed on a wooden arm

-> antenna parameters shift vs. angle of the joint

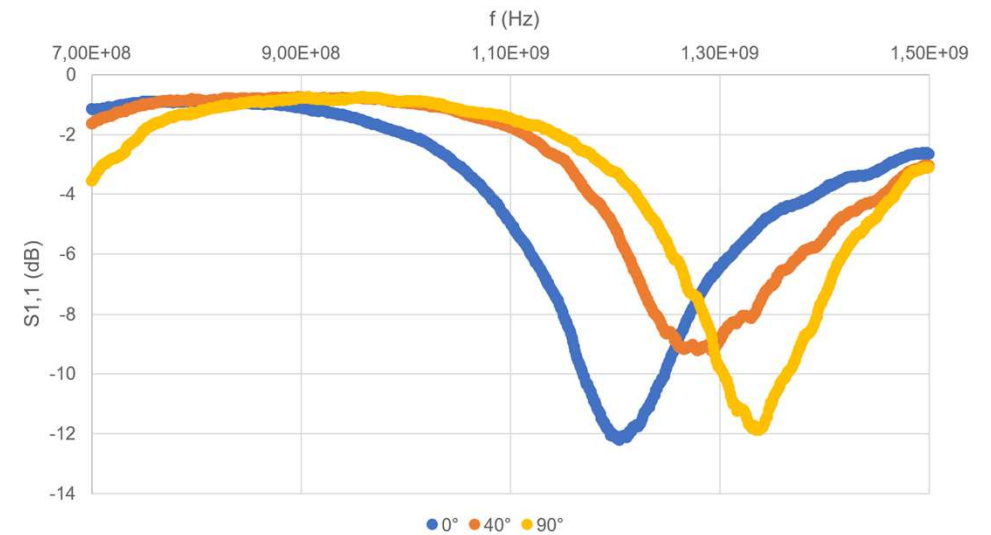
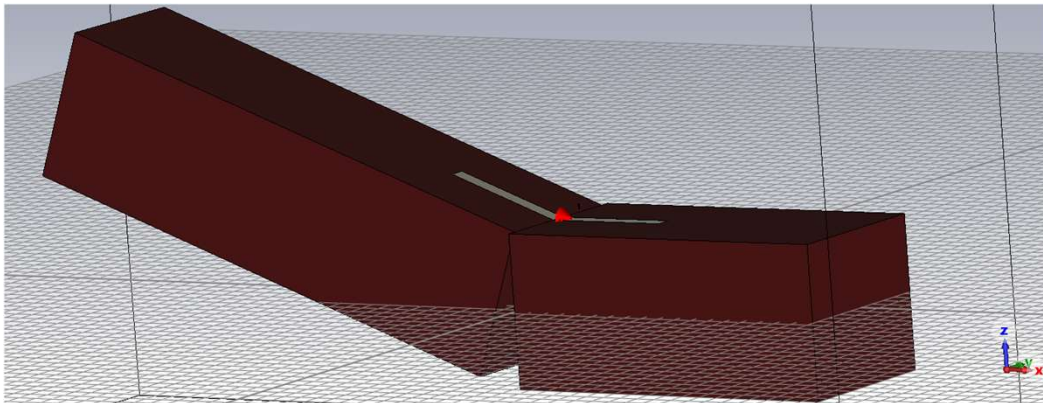
=> The hypothesis verified.



ELBOW Movement → FREQUENCY/S11 CHANGES

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$0^\circ \rightarrow 150^\circ$



WHAT WE DEMONSTRATE

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- Correlation angle/antenna
- Band 1,5–2,5 GHz
- Key angles : 0° - 45° - 90° - 135°
- Antenna = sensor



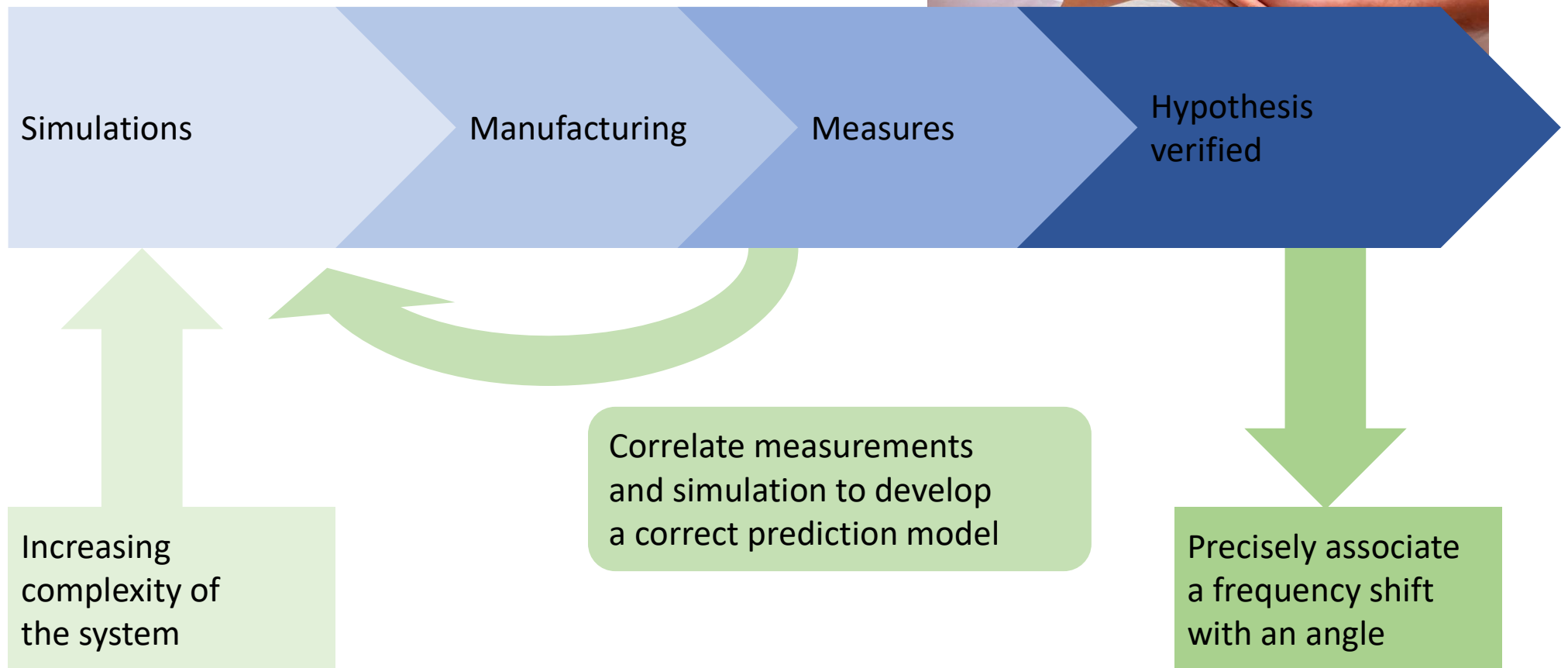
COMING NEXT

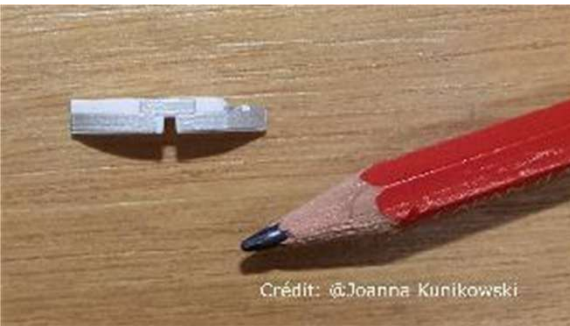
Rehabilitation · IHM

Next step: prototype + IA



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ALPEES

CoRES | Communicating
Reconfigurable
Embedded Systems

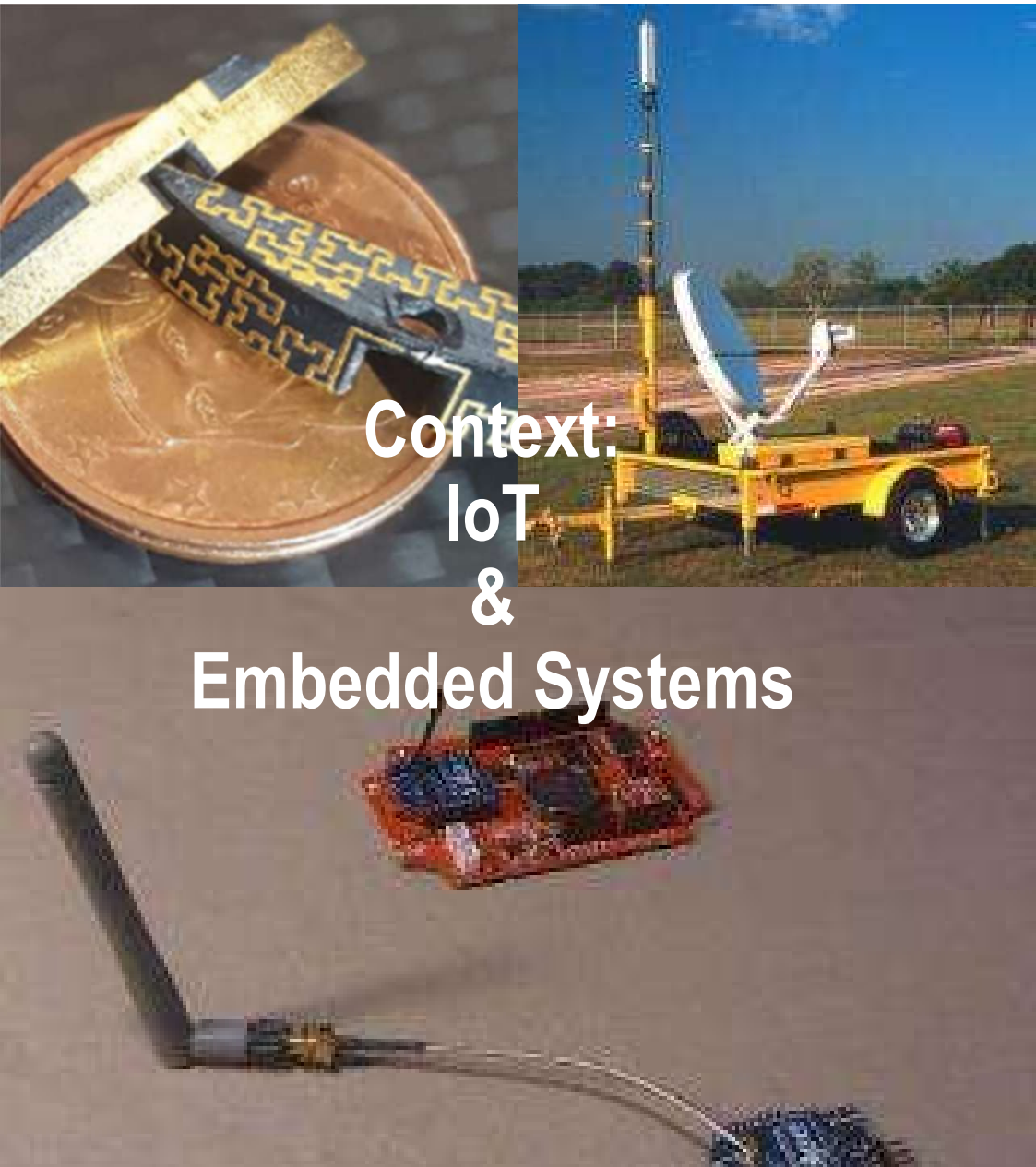


Antennas Lab & Printed Electronics
for Embedded Systems

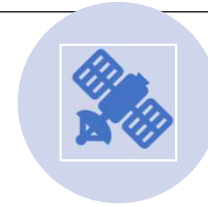


h e p i a

Haute école du paysage, d'ingénierie
et d'architecture de Genève



Context:
IoT
&
Embedded Systems



ANTENNAS



ENERGY



EFFICIENCY

h e p i a

Haute école du paysage, d'ingénierie
et d'architecture de Genève

h e d s

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Merci de votre attention

Une antenne imprimée, sans batterie, pour mesurer le mouvement articulaire

J. Seignard, M.-A. Petit, F. Moissenet, J.-Y. Beaulieu, G. Déprès, N. Reverdy-Bruas, D. Bechevet

FEDRIGONI



HUG



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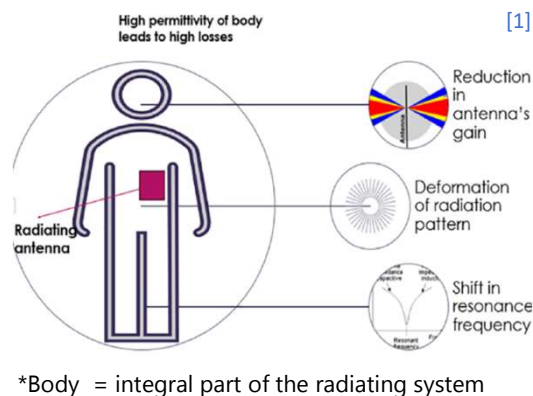
State of the art

Antennas as passive motion sensors

Body movements $\Leftrightarrow$ electrical signals

Mechanisms used : mechanical deformation, sliding of conductive elements, resonance shift, impedance matching and frequency tuning

On-board antennas and morphological sensitivity



Optimized antennas for body coupling

Antennas $\rightarrow$ dielectric properties of tissues = performance

Techniques used : genetic algorithm optimization, dynamic impedance matching, and phantoms



Passive and textile sensors based on RFID antennas

Measures : impedance converted into a variation in the power of the return signal



Design $\neq$ not adapted to the on-body environment

Diapositive 20

JS1

Slide pas très jolie je ne sais pas comment la mettre en page

Juliette SEIGNARD; 2025-09-05T10:07:11.053

State of the art: Gaps identified

Antennas as passive motion sensors

On-board antennas and morphological sensitivity

Studies $\approx$ use RSSI, path loss, or signal intensity

$\neq$ antenna's internal properties as a mechanism for fine motion detection

Optimized antennas for body coupling

Passive and textile sensors based on RFID antennas

Analyses $\neq$ antenna adaptation to body geometry, effective permittivity, and dynamic behavior

Our project $\Rightarrow$ complementary and innovative approach

Antenna simulation

Study of the influence of
antenna parameters –
Into the void

Study on wooden arm

Study on human arm
with elbow

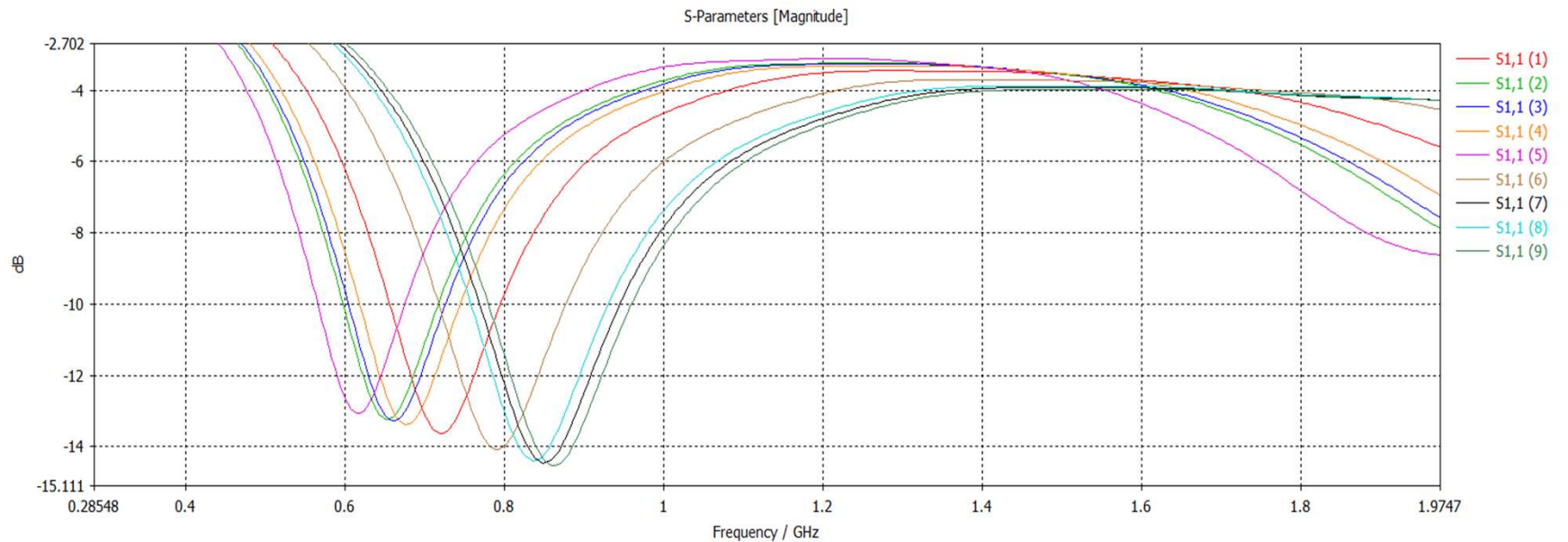
Study with several antennas
on wooden arms

Study of the
influence of:

Antenna length

Antenna width

Port position



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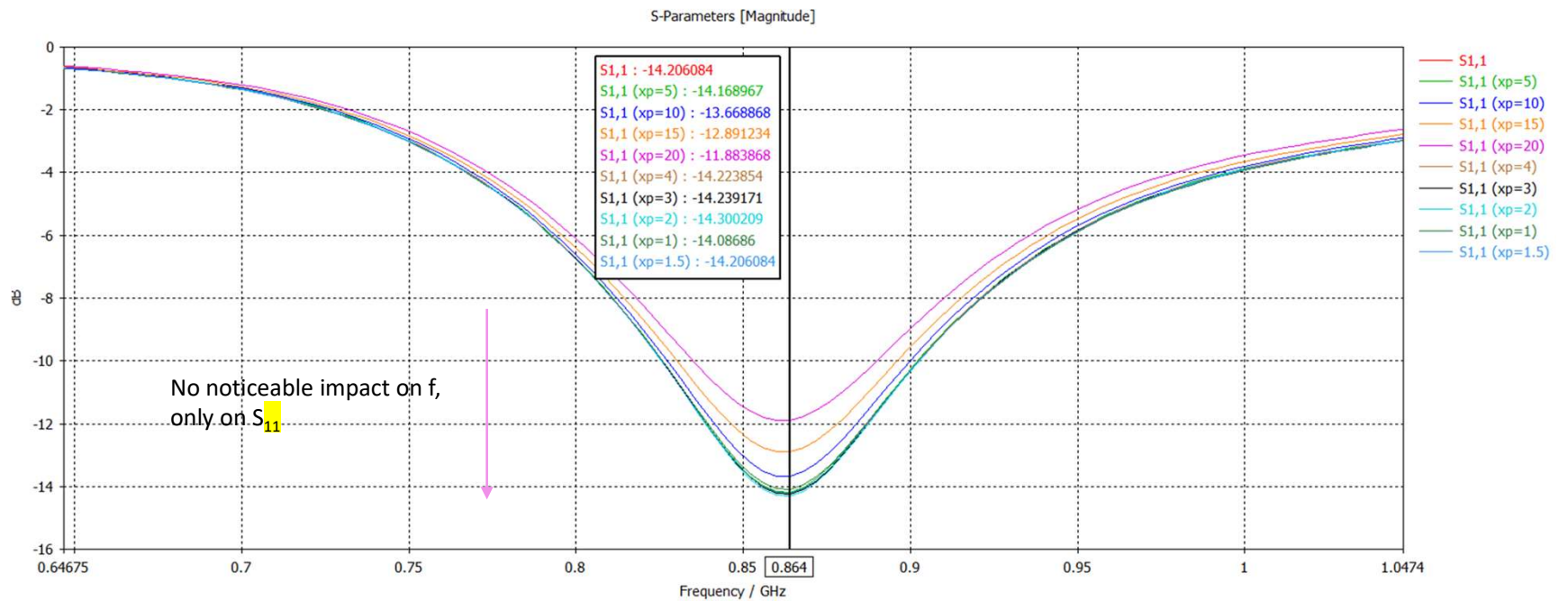
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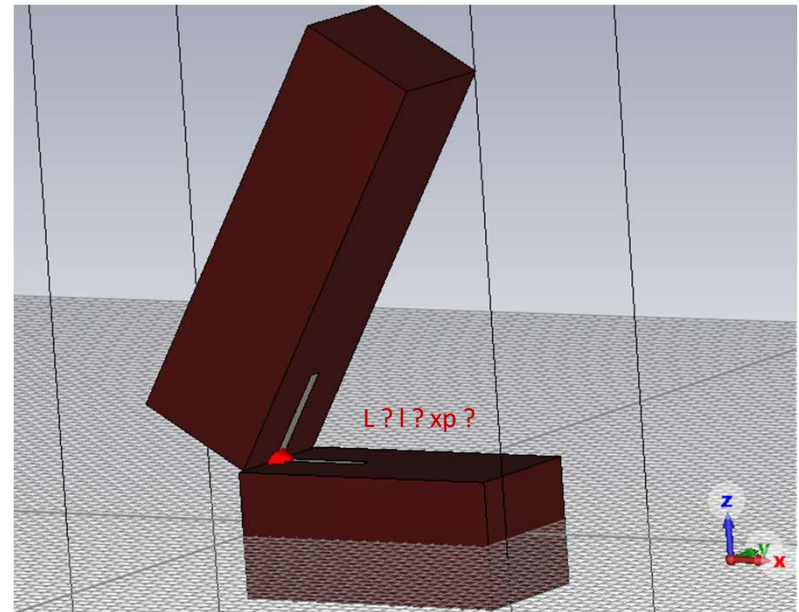
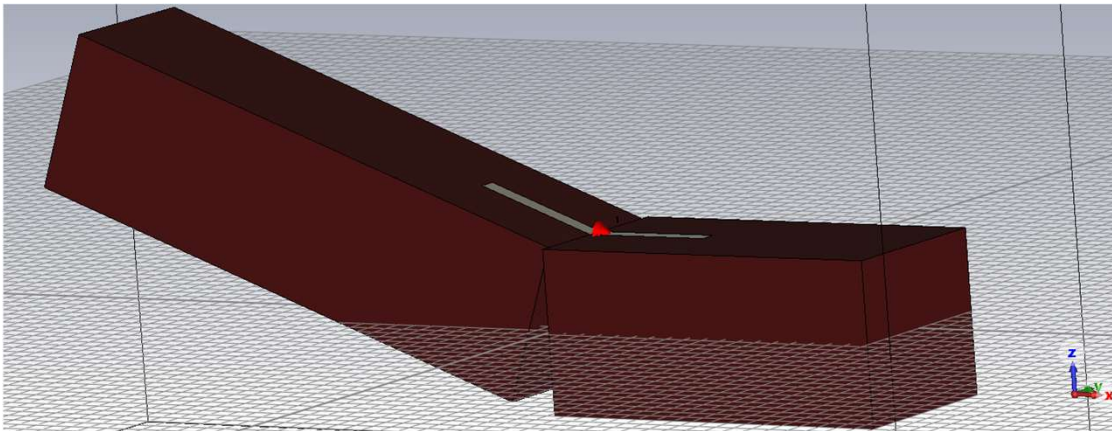
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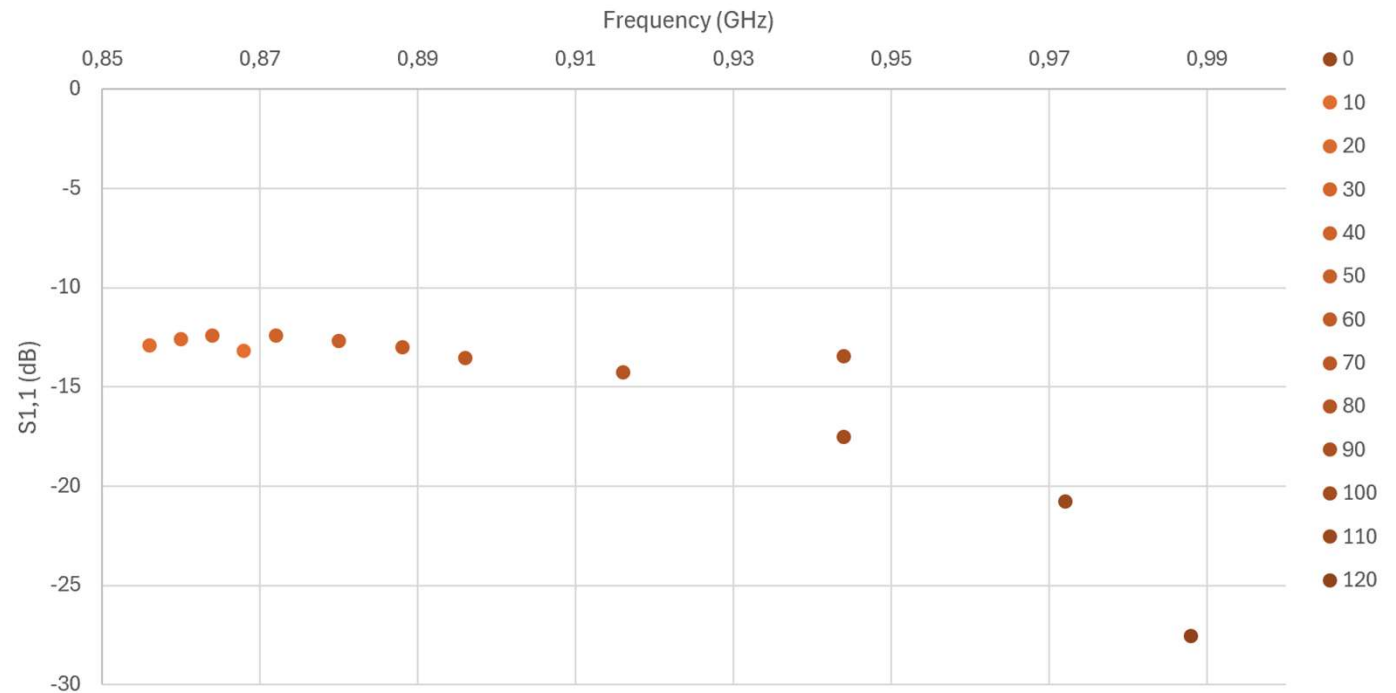
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Study with several antennas on wooden arms

S_{11} propagation interval smaller than that in a vacuum -> permittivity of wood

Once again, we observe a variation in the antenna's characteristics when the angle changes.



Evolution of antenna characteristics according to elbow angle on a wooden arm

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