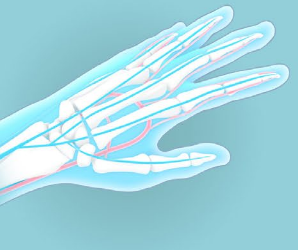
HAND ARM VIBRATION



International conference

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Nancy, France

Factoring muscle activation and anisotropy in modelling hand-transmitted vibrations: a preliminary study

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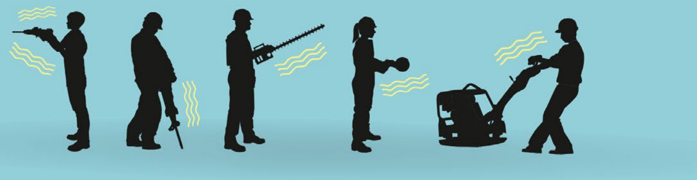


Hand-arm vibration in France

Prolonged exposure
+ high level

2.2 M workers
17% for more than **10 h/week**

Hand-Arm Vibration Syndrome

Regulation/standardization

✓ Maximum exposure limited

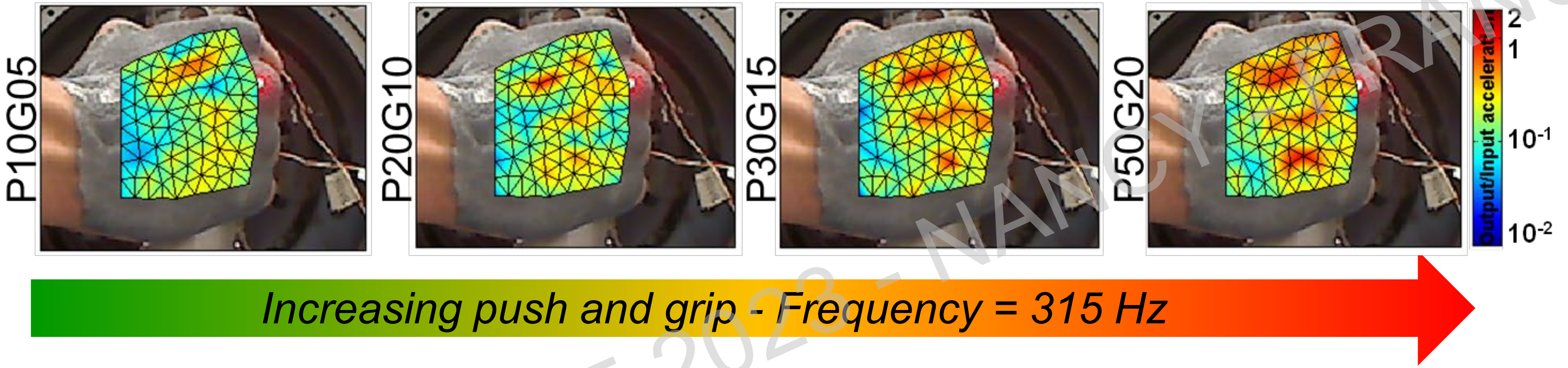
ISO 5349: Exposure assessment

✗ **Push** and **grip** forces

High frequency (>50 Hz)

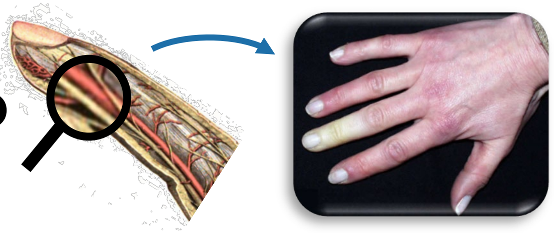
General framework of research

Do grip and push forces affect vibration transmissibility? **Yes**



Why? **Passive and active stiffening of soft tissues**

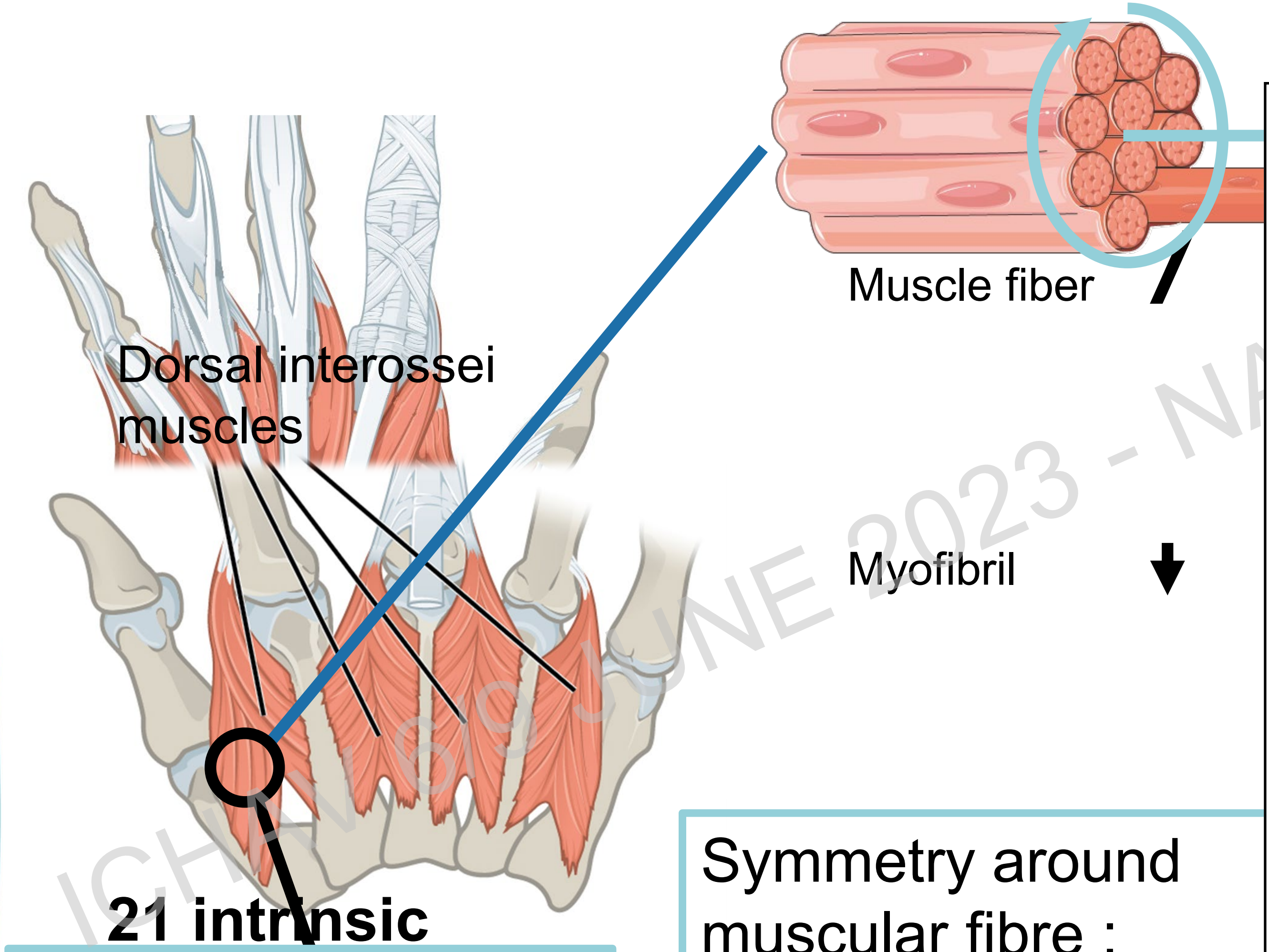
Are measurements outside the hand sufficient? **No**



Approach : Develop a finite element model for mimicking grip and push

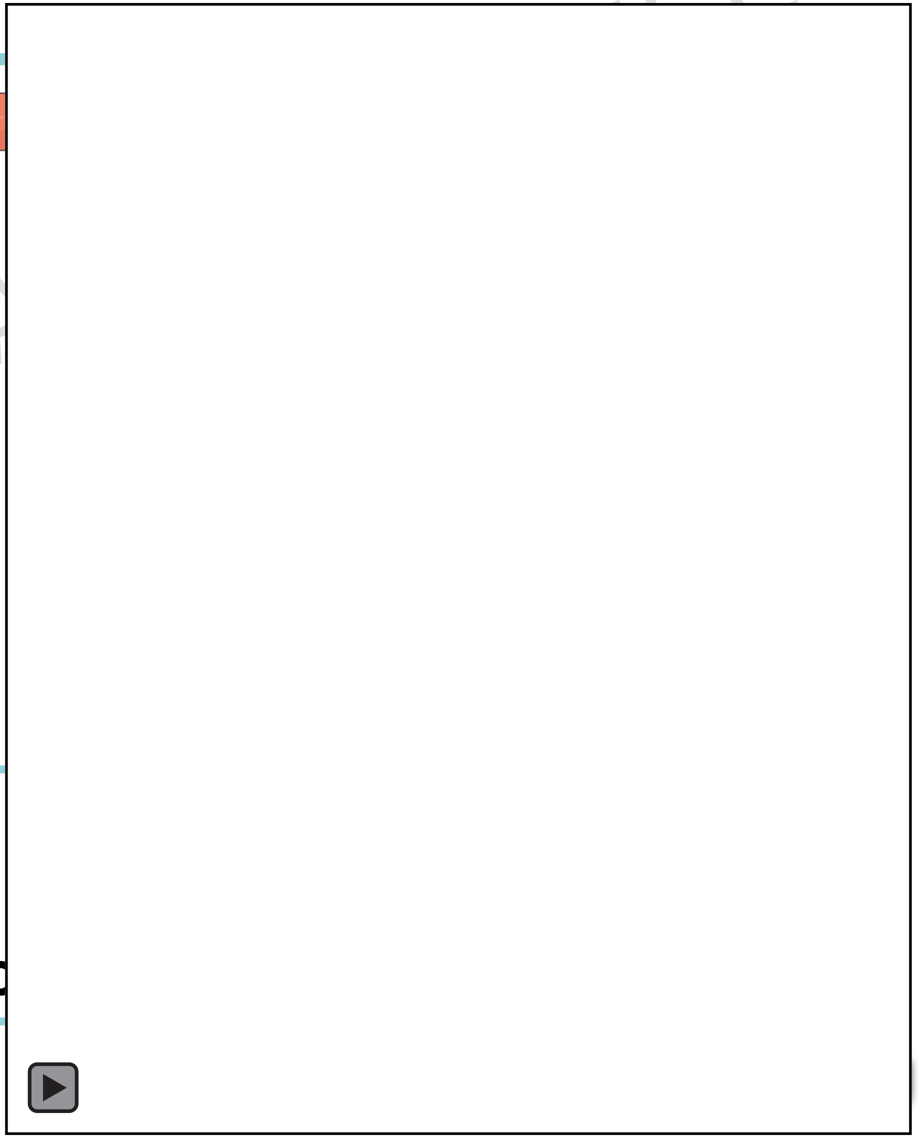
First step : Factoring muscle properties into the model

Skeletal muscles properties

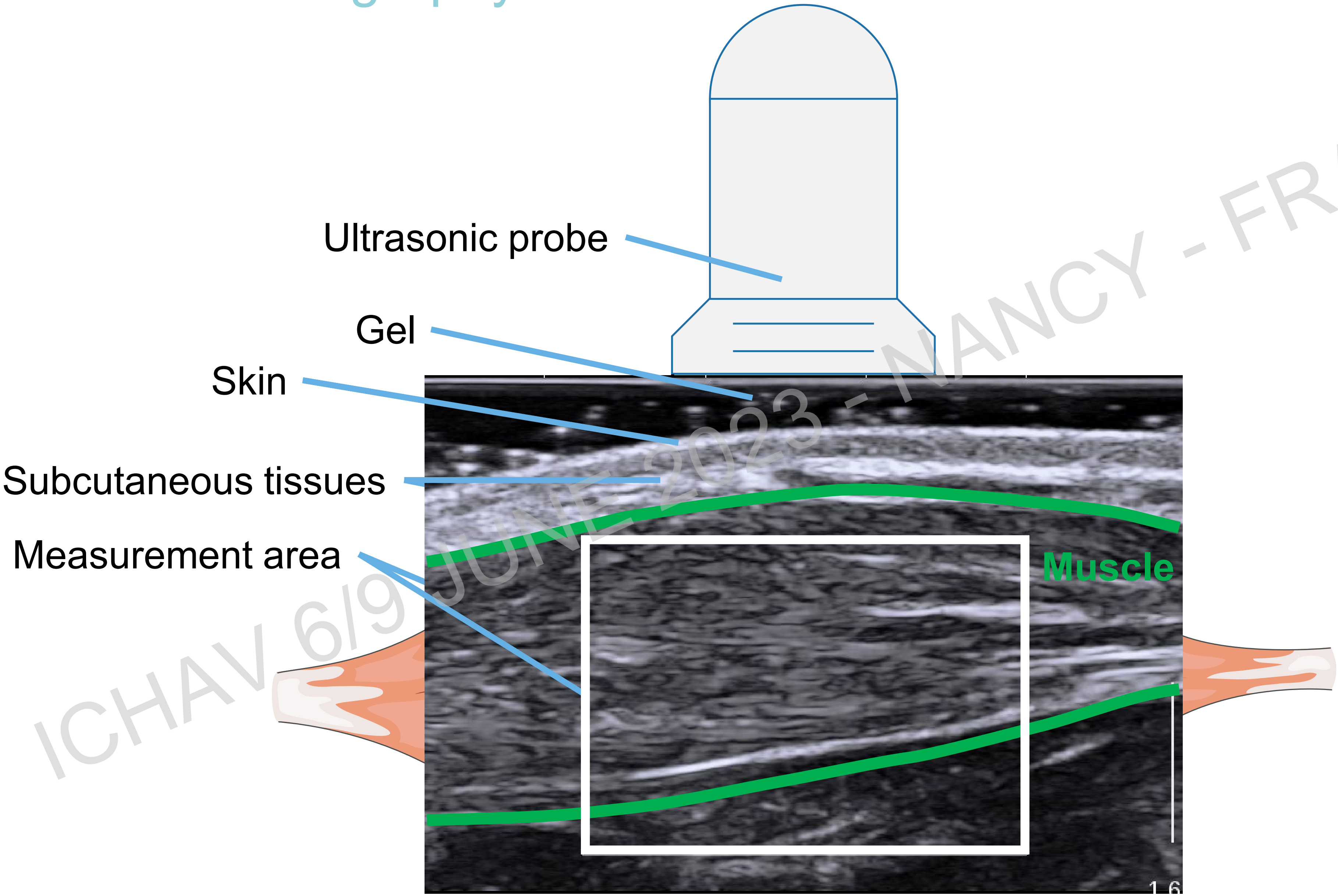


Measurement area

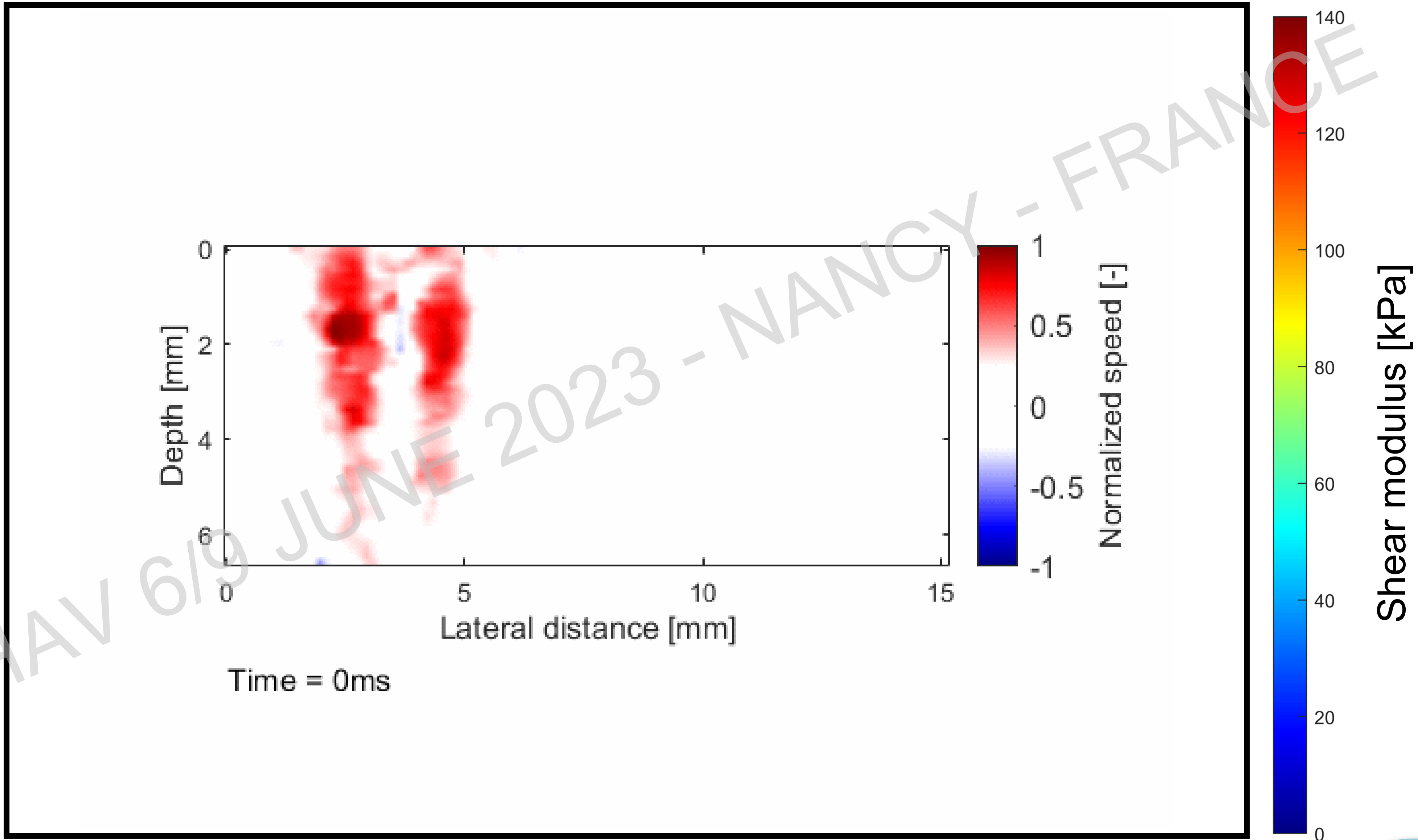
Symmetry around muscular fibre :
Transversally isotro



Shear-wave-elastography measurements

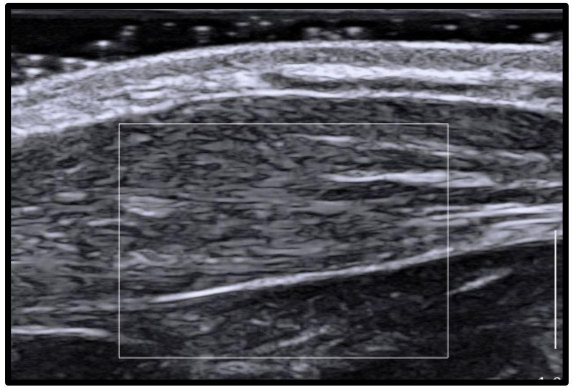


Ultrasonic probe



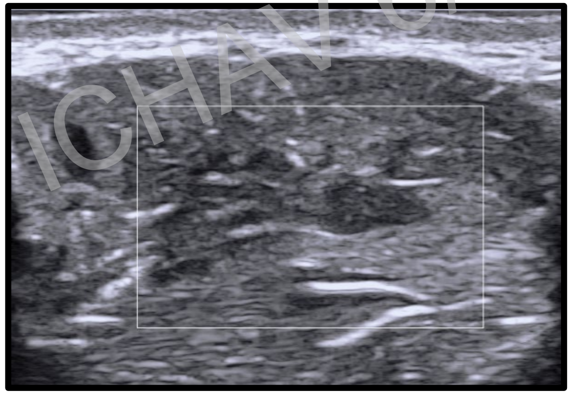
Set-up for measuring shear modulus

Longitudinal

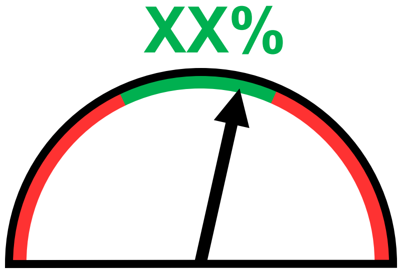


Ultrasonic probe

Transverse



Instructions : 0 to 30% maximum gripping force



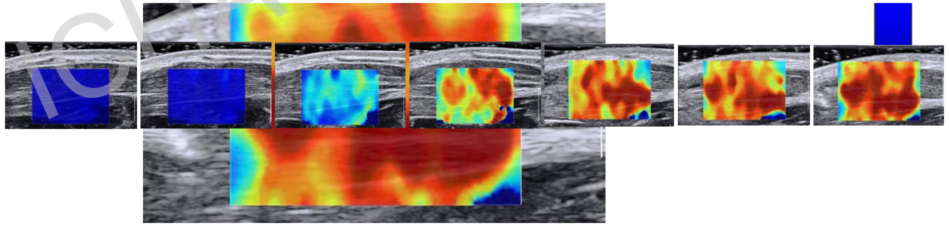
Force gauge

Instrumented handle

Results from elastography

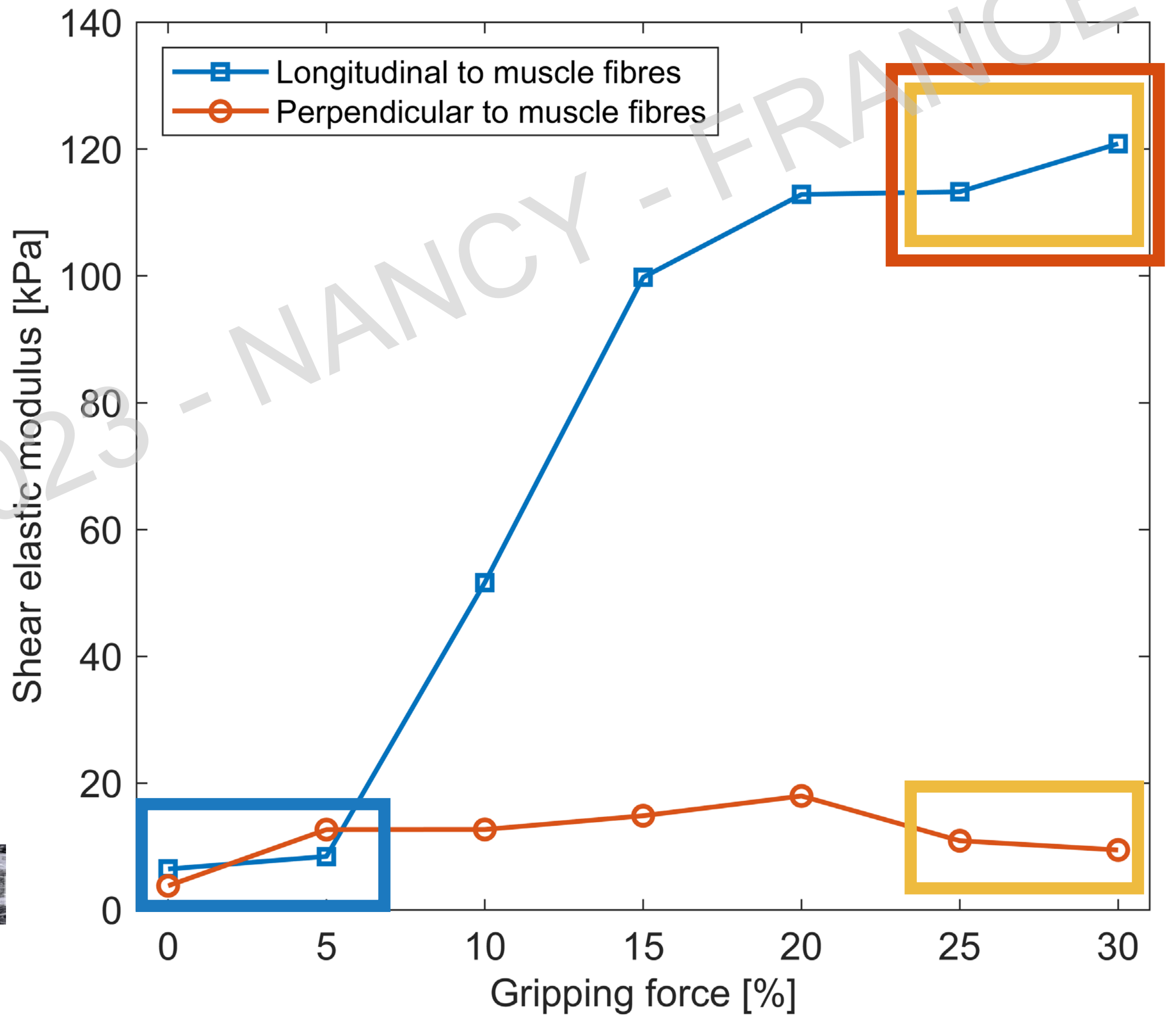
Longitudinal shear modulus maps

- Longitudinal modulus increased with force
- Local dispersion increased with force
- 3 cases included in the model : min isotropic, max isotropic, max anisotropic



30 %

Mean modulus inside 5 x 5 mm² region-of-interest



Finite-element model of the hand

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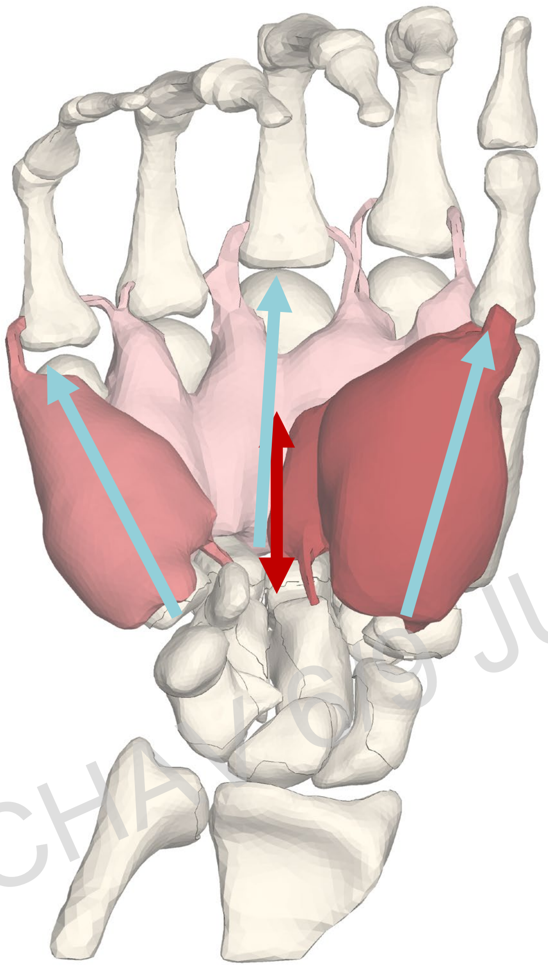
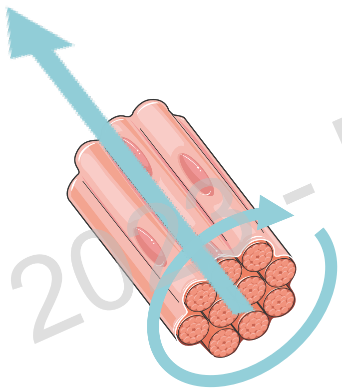
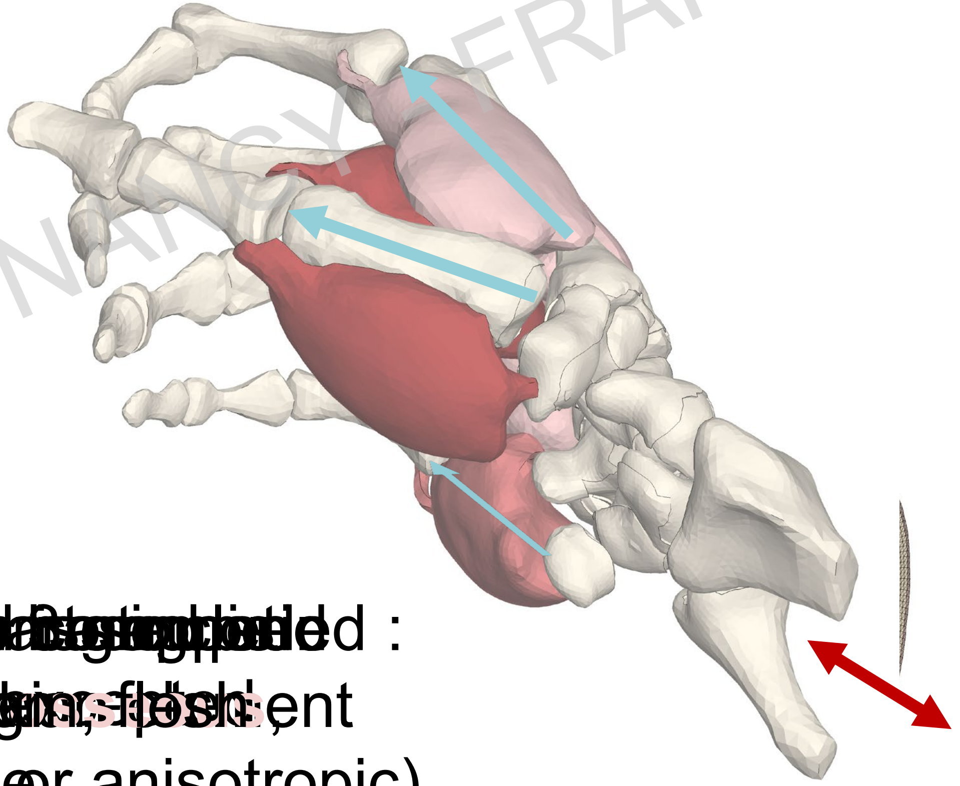
[illegible] :
calculation:







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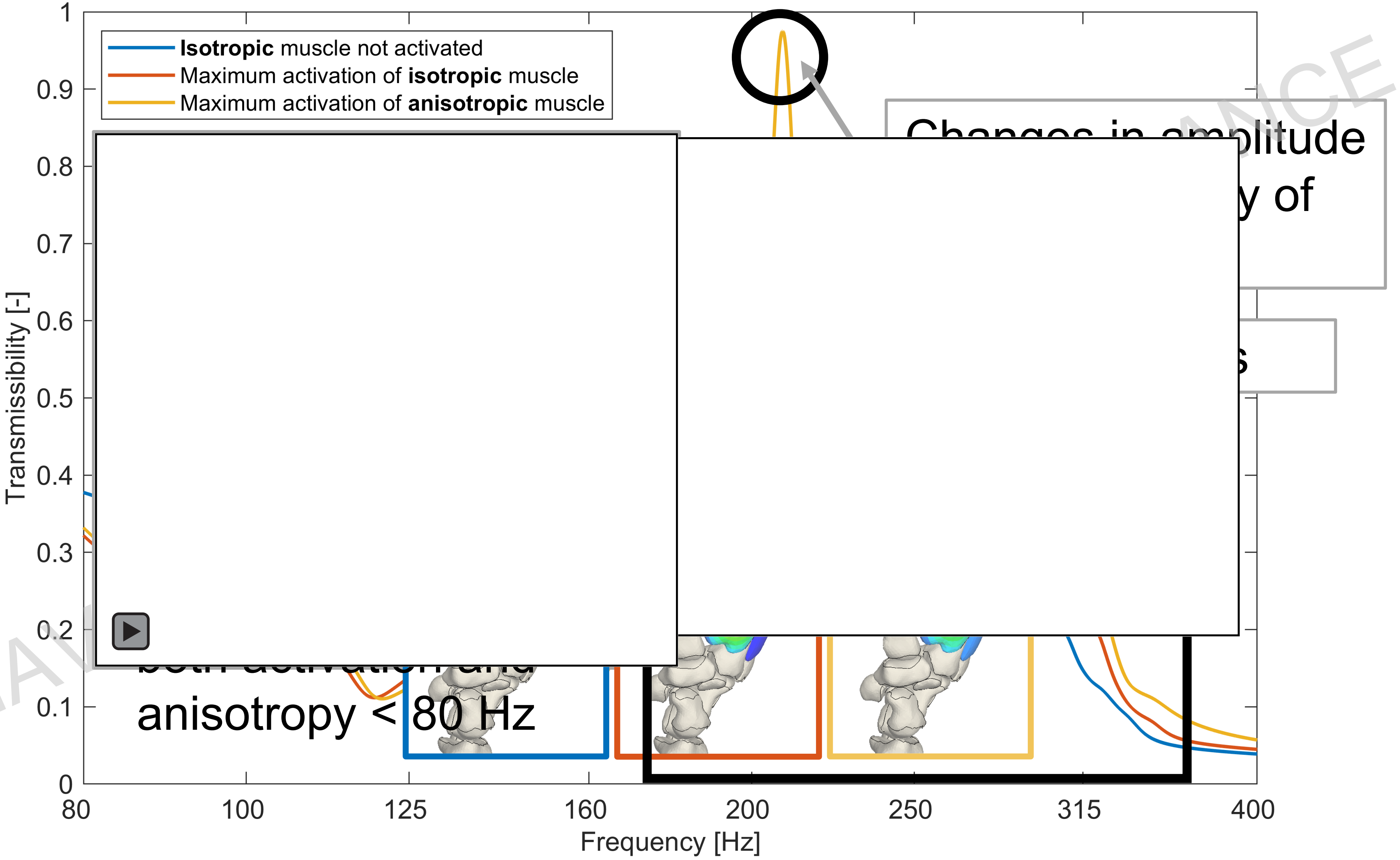
Mean transmissibility inside the first dorsal interosseous muscle



Conclusion

- **Elastography measurements:**
  - ✓ Simultaneous elastography and force measurements
  - ✓ Relationship between muscles stiffness and griping force established
  - → Extend to a cohort of subjects
  - → Characterize the visco-elastic properties of muscles
- **FE modelling:**
  - ✓ Transform elastography results to FE-compatible data
  - ✓ Muscle activation impacts the hand biodynamical response
  - → Add realistic boundary conditions and initial stress due to tightening
  - → Add hyperelasticty and visco-elasticity constitutive laws for soft tissues
- **Prevention:**
  - ✓ Muscle transmissibility over 80 Hz depends highly on muscular activation due to gripping
  - → Better realistic modelling of the biodynamical response of the hand would help defining new biomarkers for risk assessment

Our job: making yours safer

Thanks for your attention

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