Experimental characterization of mechanical behavior of *in vivo* human skin by suction test

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Outline

Skin introduction

Layers, properties, research goals

Test description *(Ring suction test)*

Experimental device, camera output

Digital Image Correlation (DIC)

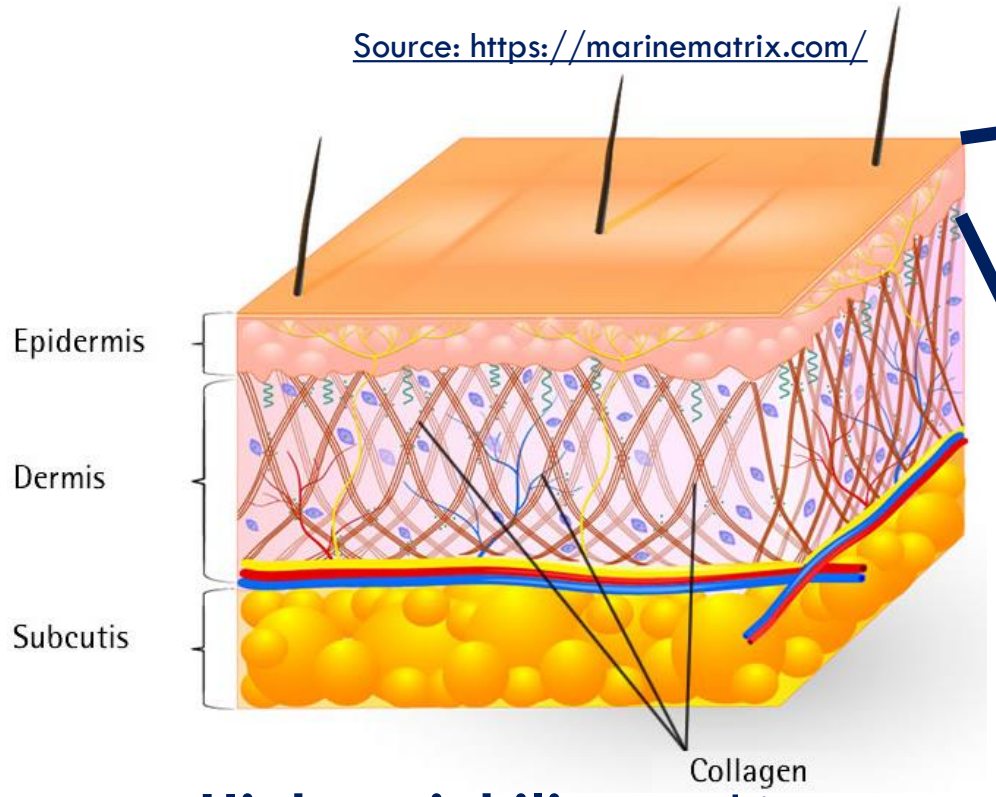
Displacement fields, resulting curves

Finite Element Model

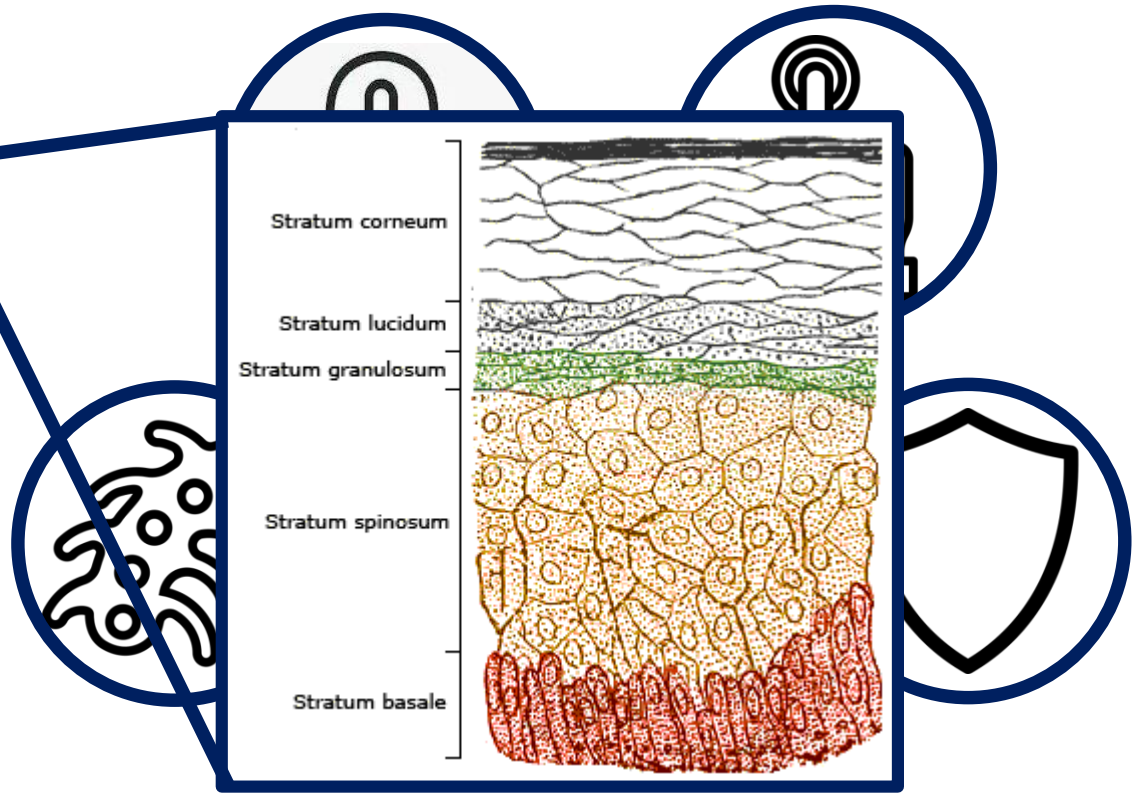
Description, first results

Skin introduction: Layers / Properties

Source: https://marinematrix.com/



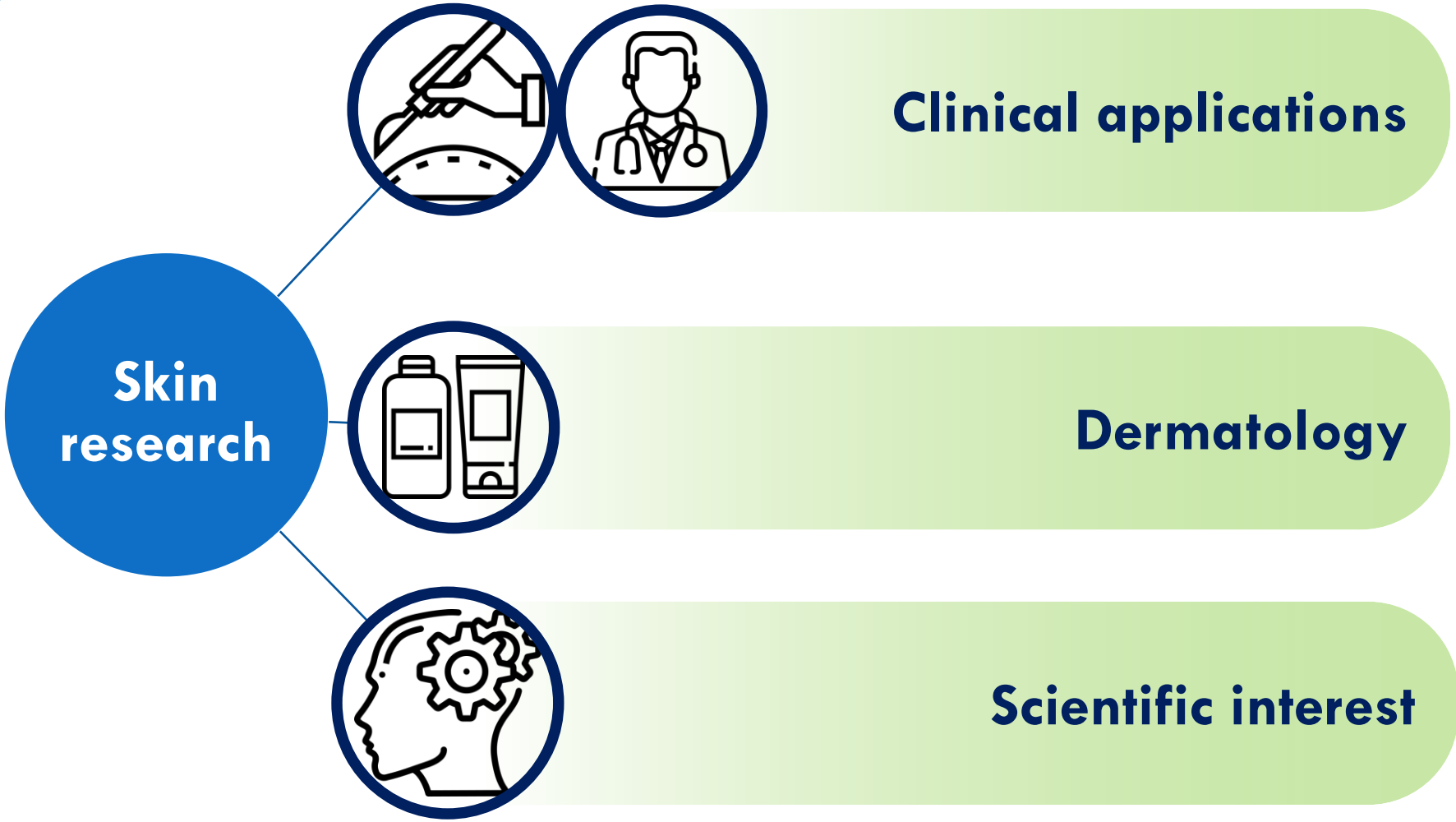
High variability on skin



Skin multiphysic properties:

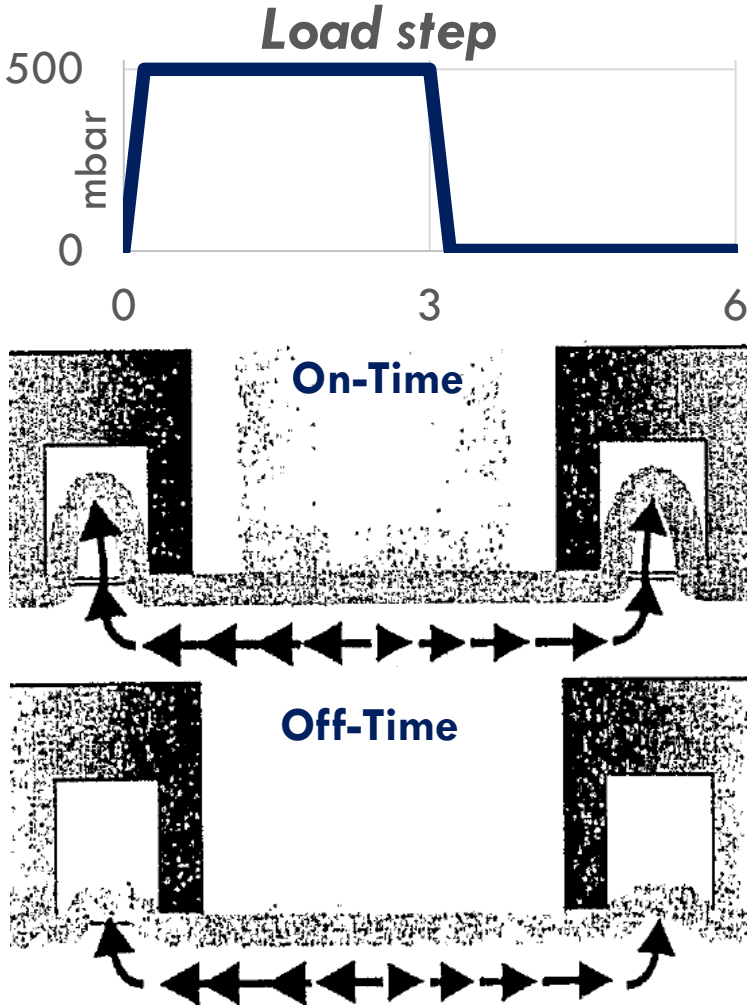
Biological / Thermal / Chemical / Mechanical

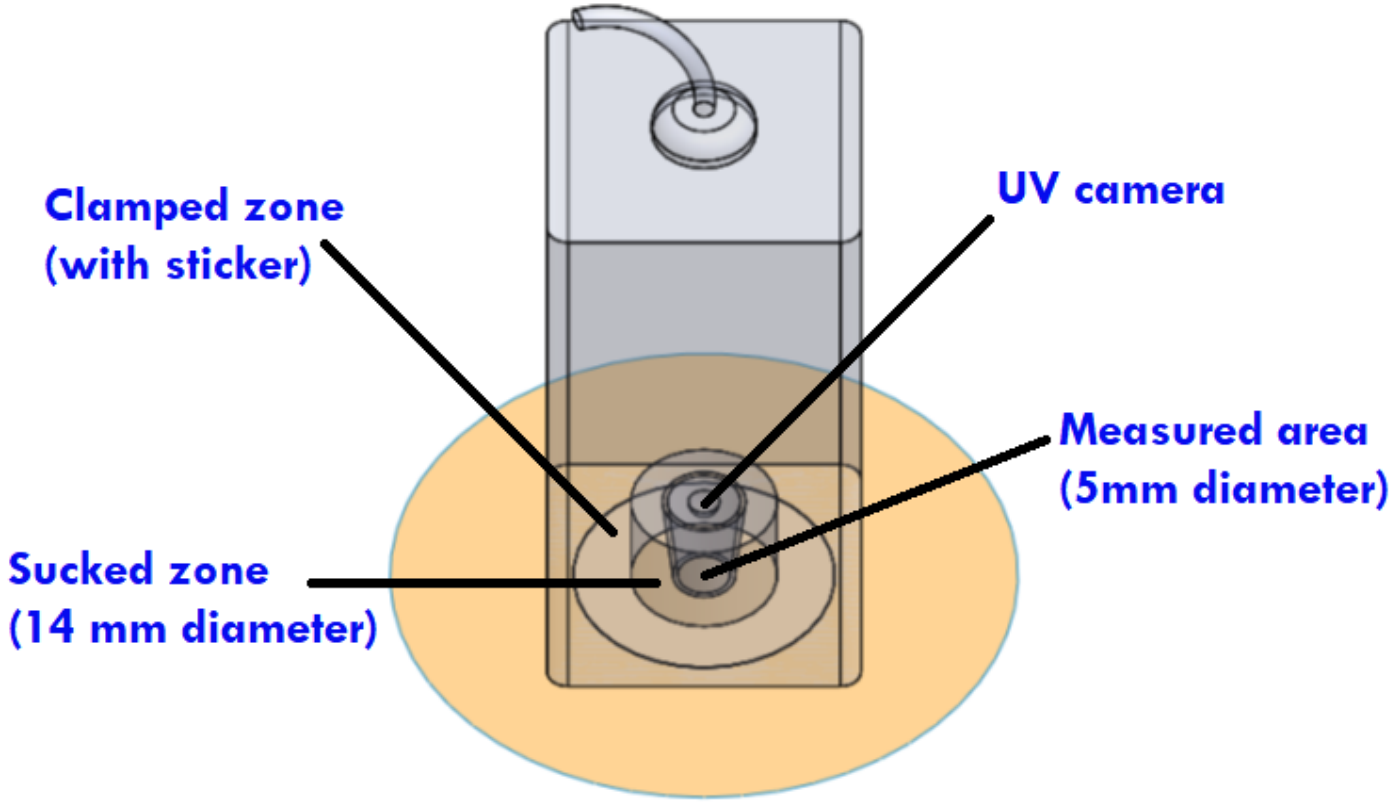
Skin introduction: Research goals



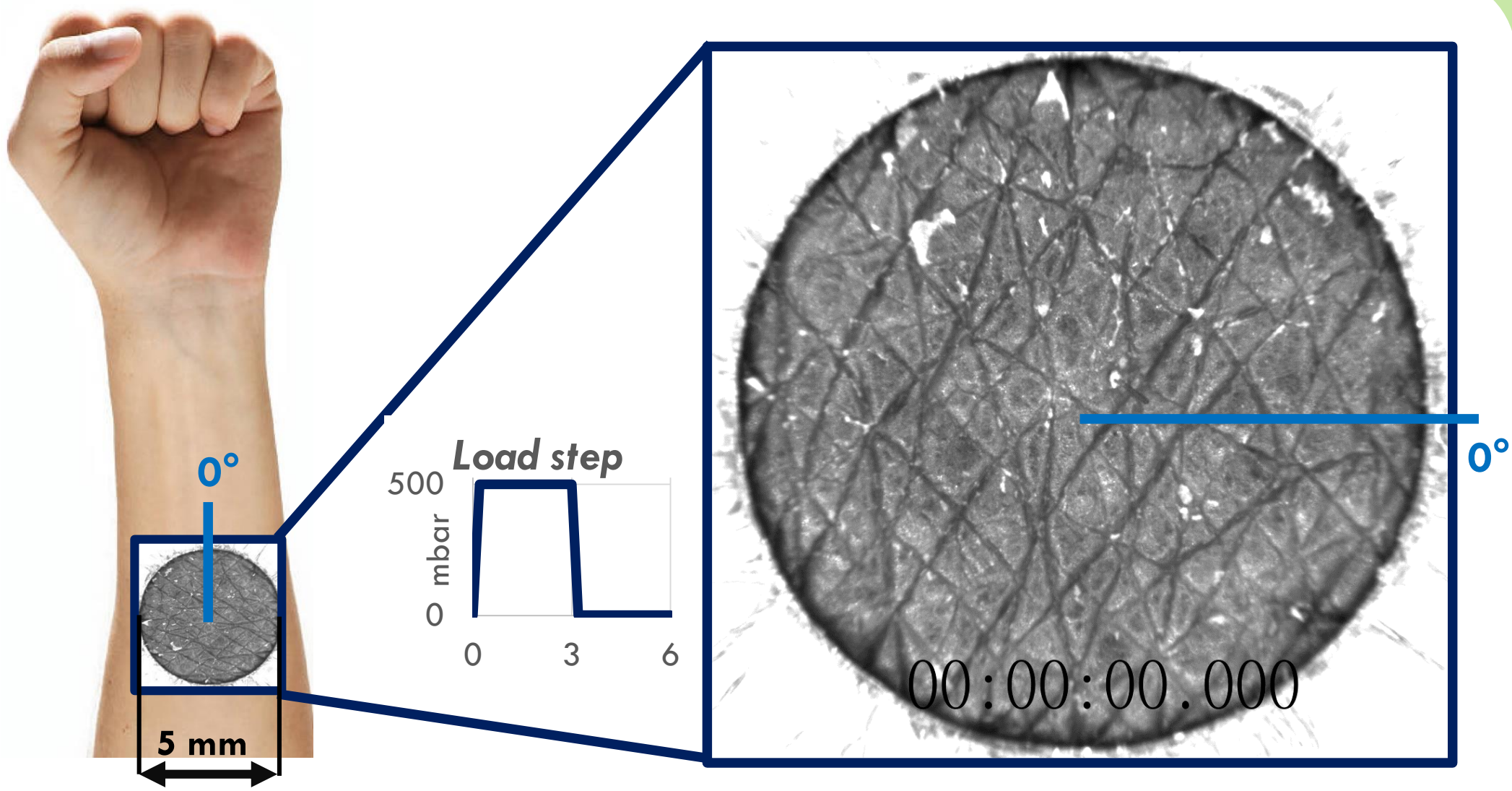
Experiment : Ring suction test

Courage+Khazaka Cutiscan CS100® device (Patent: EP1513445 / 2002)





Experiment : Camera output



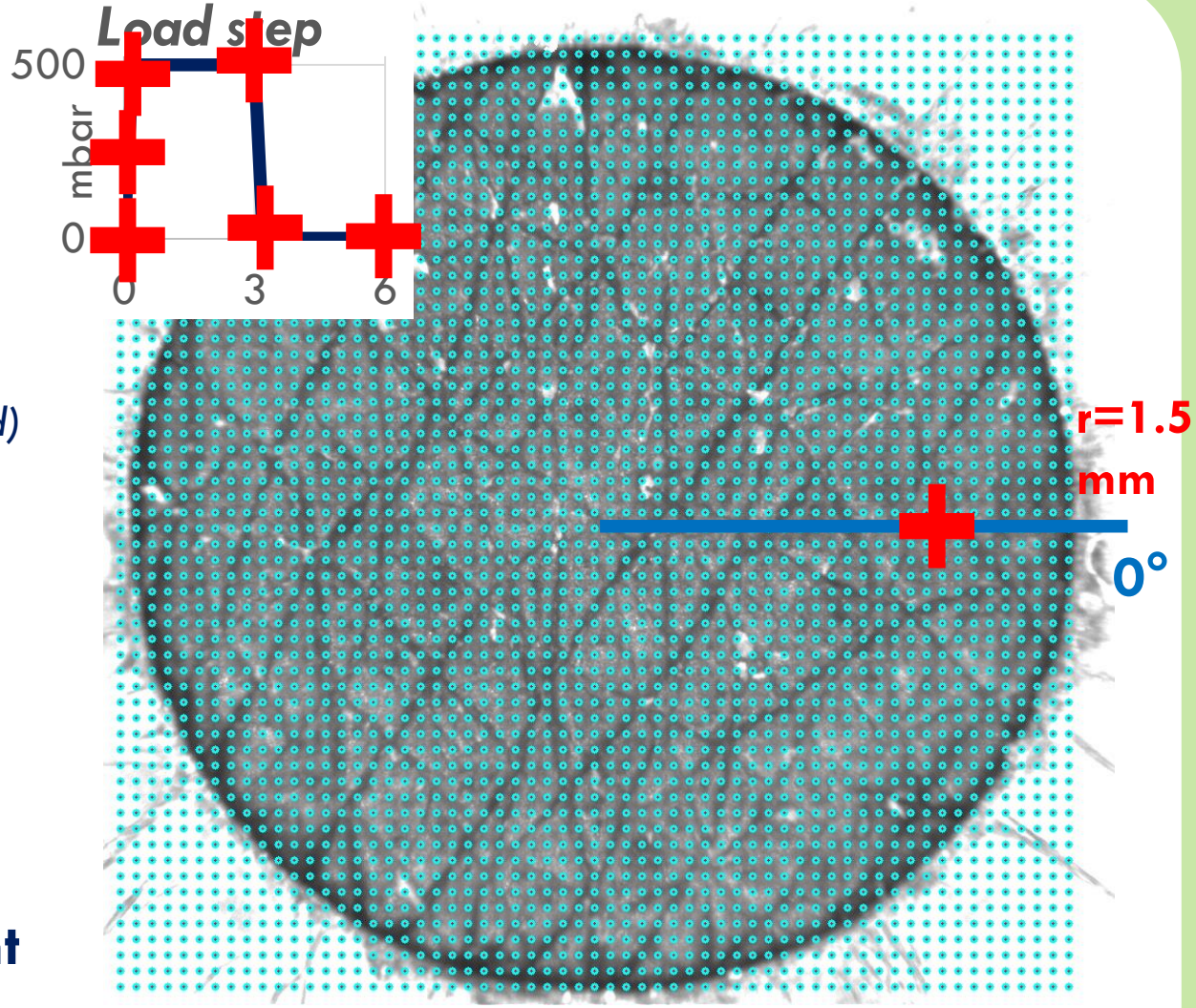
DIC: Displacement field

- **Automation of an algorithm available in the open-source library PyDic** *(D. André – Univ. Limoges)*

- **Lucas-Kanade method**
  - *Optical flow estimation*
  - *Purely local method (pixel neighbourhood)*
  - *Least squares criterion solving*

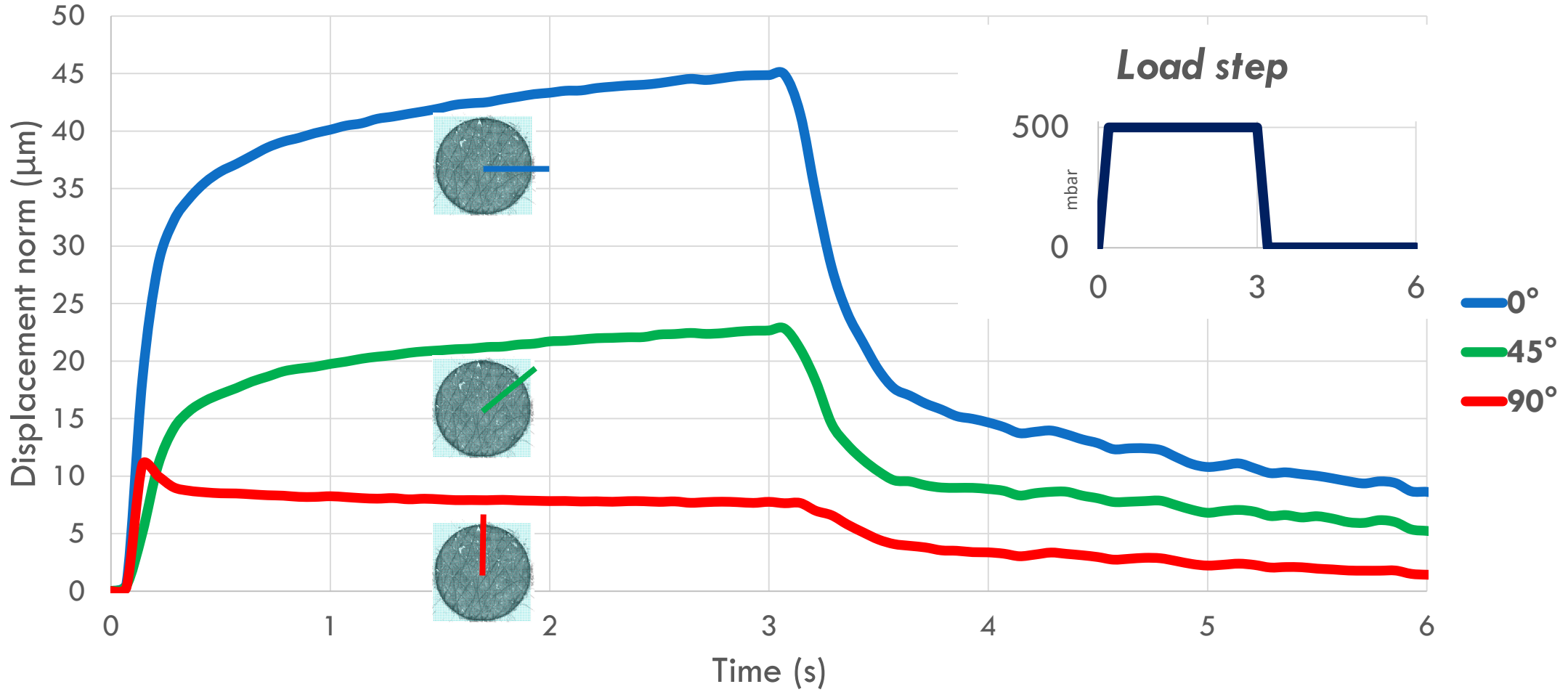
- **Adapted choice of correlation windows**
  - *Size*
  - *Spacing*

- **Brightness threshold adjustement**

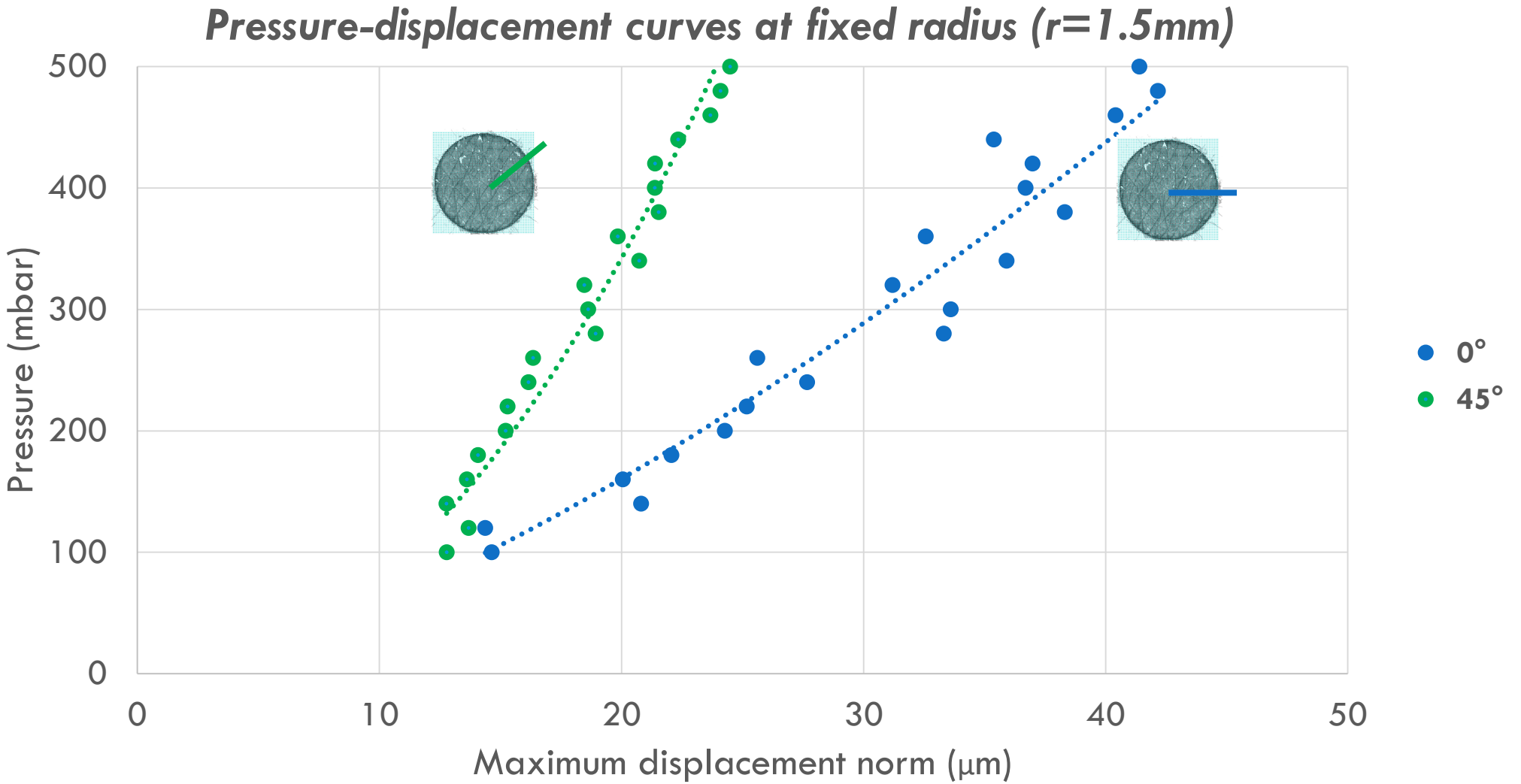


DIC: Angle influence

Displacement-time curves at fixed radius (r=1.5 mm)



DIC: Angle influence

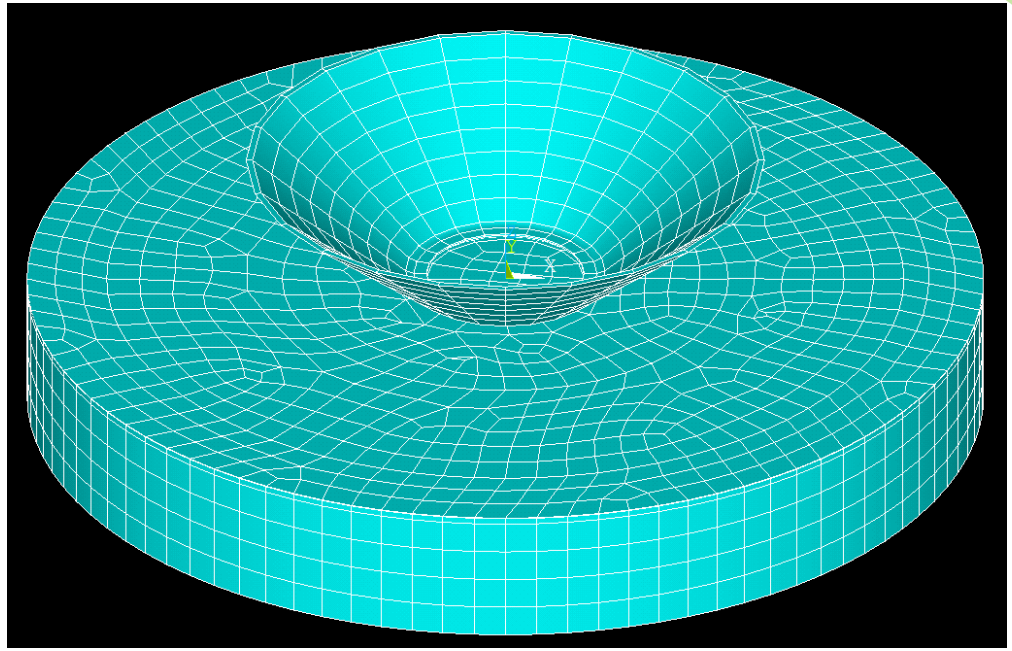


FEM: Description

- **Elastic isotropic behavior with geometrical non-linearities**
- **4 layers**

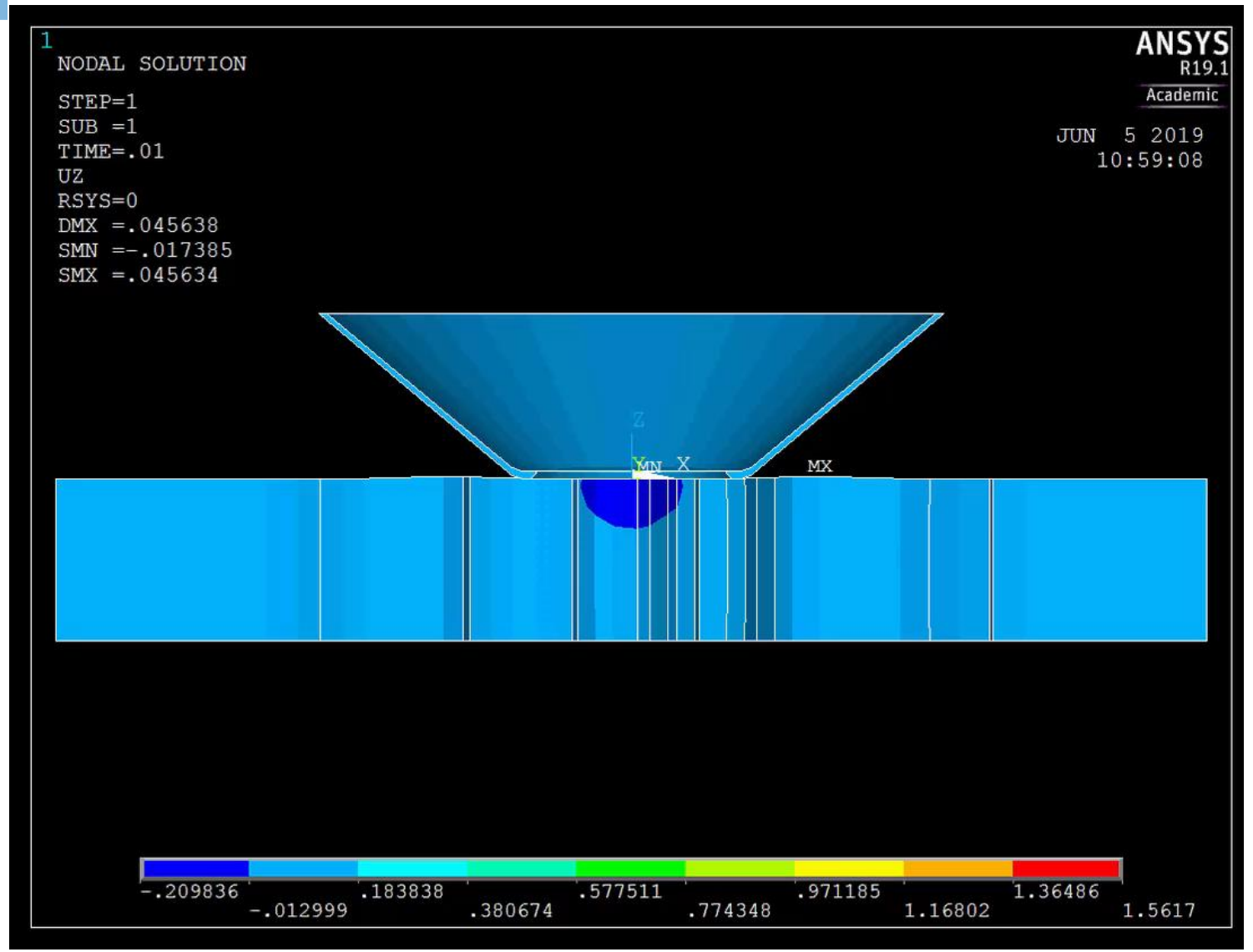
Layer	Stratum corneum	Epidermis	Dermis	Hypodermis
Thickness (mm)	0.02	0.2	1	3
E (MPa)	5	0.5	0.05	0.01

- **ANSYS 3D model**
- **Friction skin-device** *(0,42)*
- **500 mbar on sucked zone**
- **Boundary conditions**
  - *No displacement outside*
  - *No displacement on clamped area*



5388 quadratic elements (SOLID186 20-node)

FEM : Preliminary results



Z-axis displacement

(max 1.56 mm at 500mbar)

Conclusion

Experimental comprehension

- *Complex structural test to understand*

DIC

- *Optimisation and rich information available*

FEM to evolve

Future Work

More complex skin mechanical behavior

- *Hyperelasticity / Viscoelasticity / Anisotropy for FEM*

Sensitivity analysis

- *Influence of parameters (layers thickness / mechanical properties…)*

Inverse identification (FEMU)

Thank you
Any questions ?

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