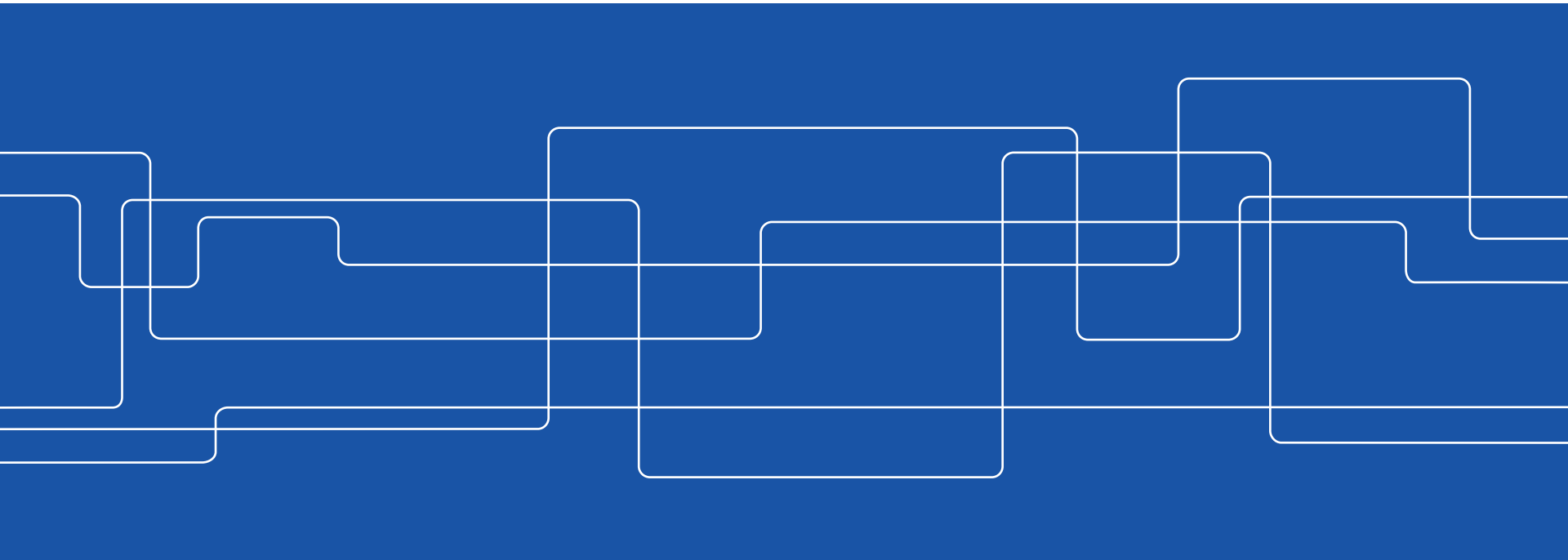
KTH ROYAL INSTITUTE
OF TECHNOLOGY

Tomography-assisted mechanics of materials

Department of Solid Mechanics



NFC foams

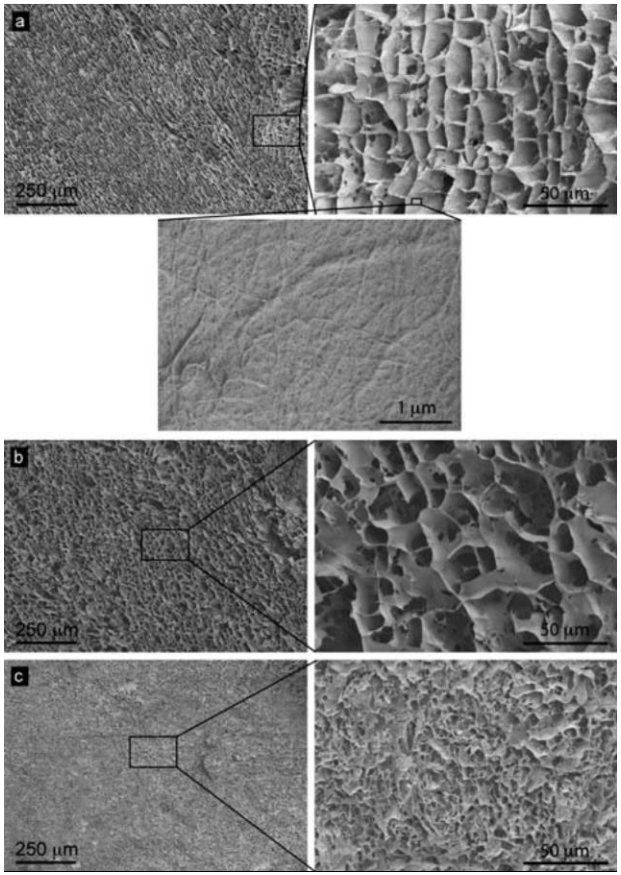
NFC foams [1]

Advantages:

- Low weight
- Wood-based

Features:

- Disordered inner structure
- Irregular thin sheets
- Small struts

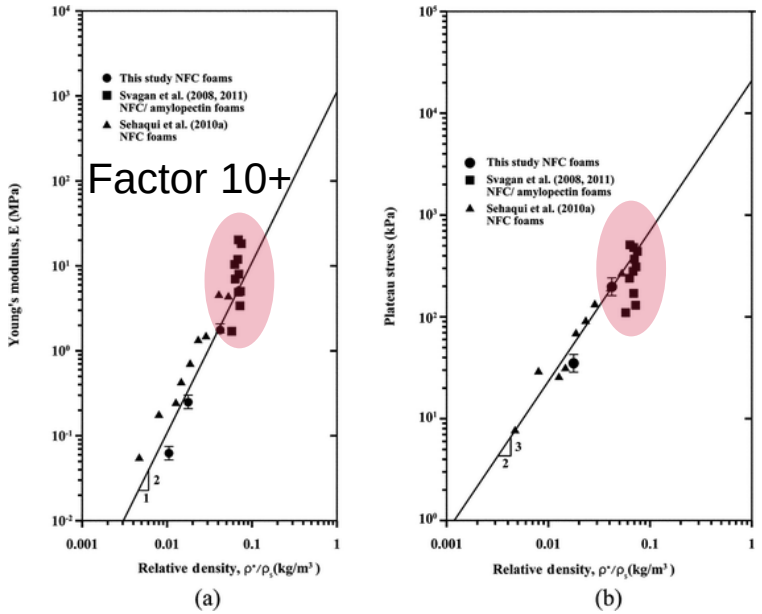


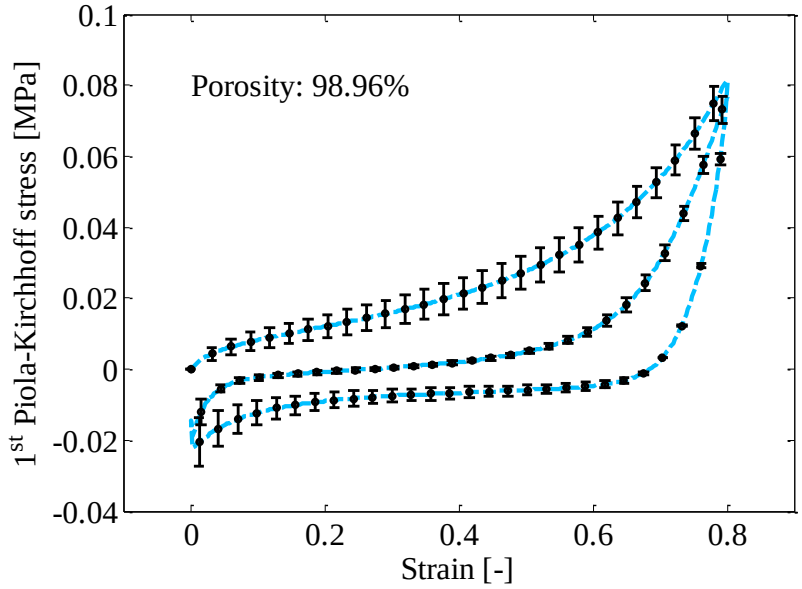
Hierarchical structure of NFC foams [2]

[1] Sievänen, J. and H.-P. Hentze, Morphological design of highly porous nanocellulose structures, in 2009 International Conference on Nanotechnology for the Forest Products Industry 2009: Edmonton, Canada.
[2] Sehaqui, H., Salajkova, M., Zhou, Q.,Berglund, L.A., “Mechanical performance tailoring of tough ultra-high porosity foams prepared from cellulose I nanofiber suspensions”, Soft Matter, Volume 6, 2010, pp. 1824-1832

Mechanical properties of foams
Why simulations?

Log scales!





Questions:

- Deviation from classical scaling laws
- Effect of micro-structure on macroscopic response
- The role of raw materials
- Source of large irreversible deformations

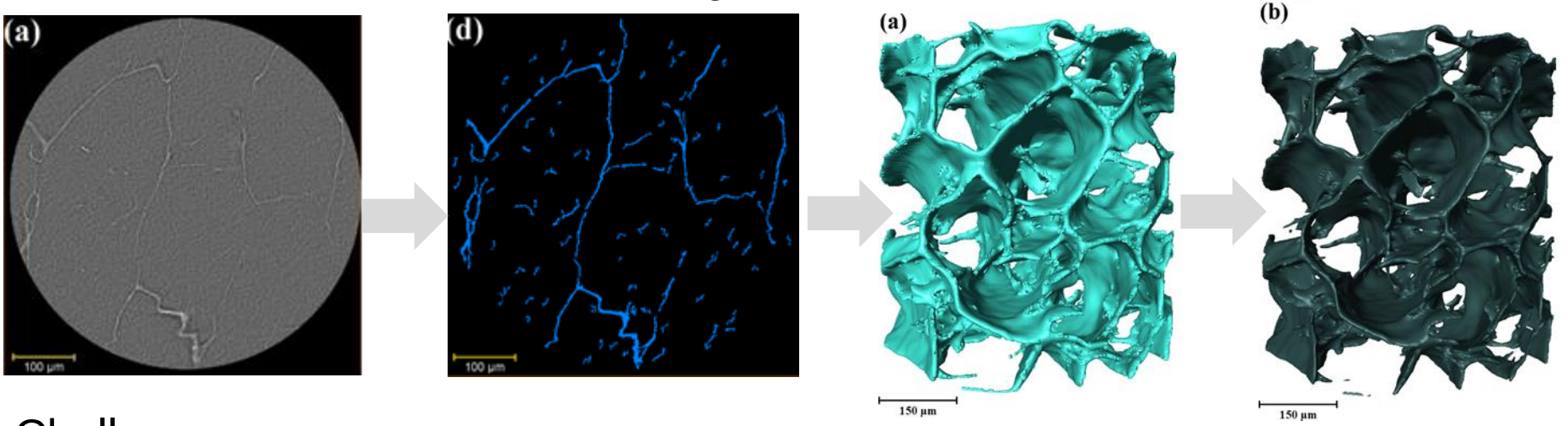
[1] Ali, Z.M., Gibson, L.J., 2013. The structure and mechanics of nanofibrillar cellulose foams. Soft Matter 9, 1580.
[2] Srinivasa, P., Kulachenko, A., Aulin, C., 2015. Experimental characterisation of nanofibrillar cellulose foams. Soft Matter 22, 3739

Reconstructing 3D structure of the foam

Thresholding

Reconstruction

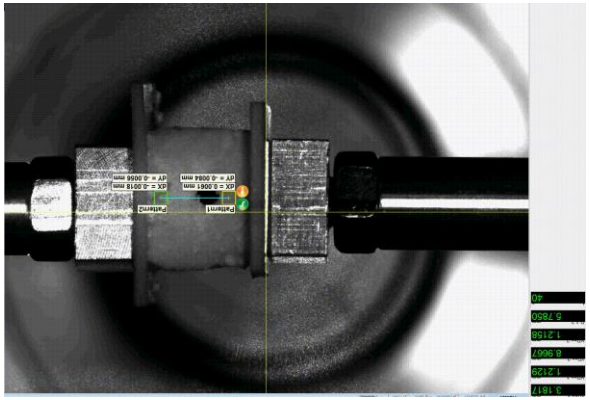
Dilatation/erosion

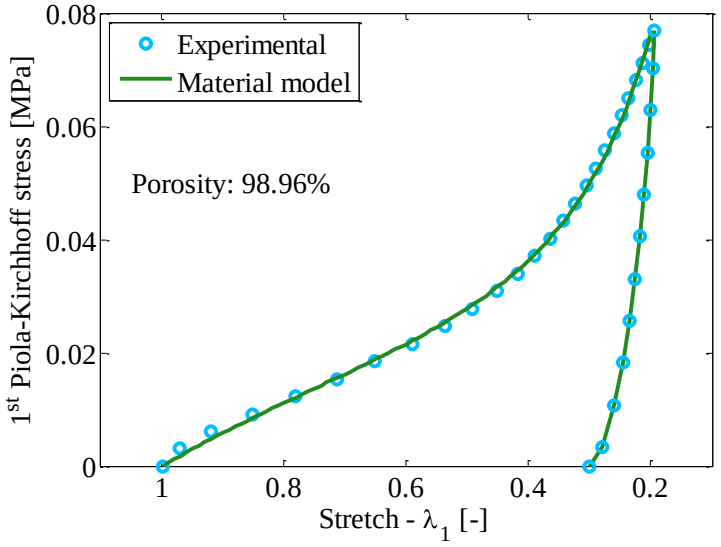


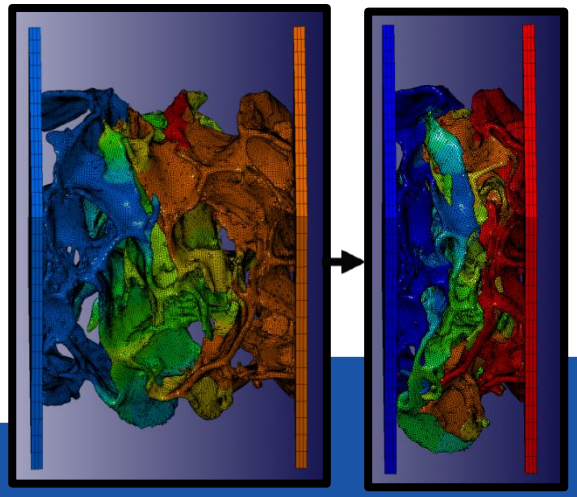
Challenges

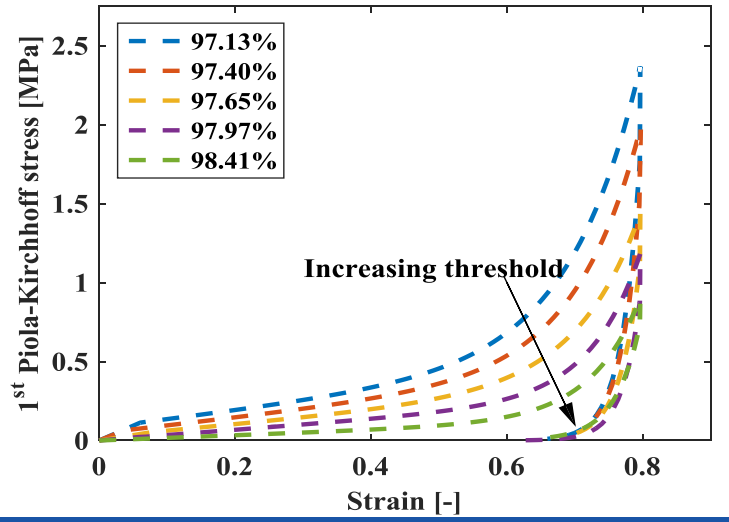
- Proper thresholding
- What is the real structure of the foam?
  - cell size
  - wall thickness
  - orientation
- In-situ testing

Micro-tomography based simulation









Summary

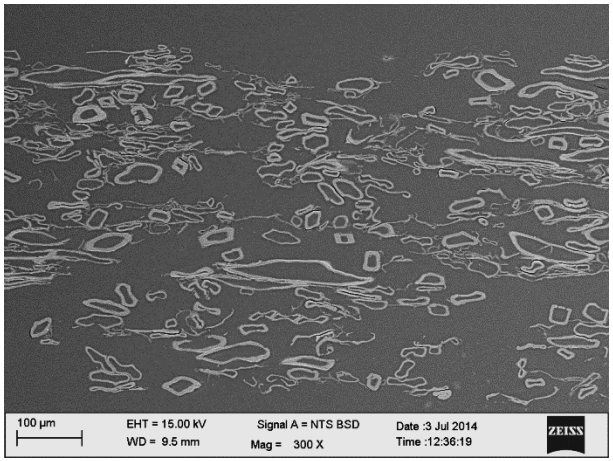
- Micro-tomography provides tools for extracting geometries of the inner structure

- The data can be used for verifying the reconstruction algorithms, which enable
  - size studies
  - parameter studies
  - coupling to the process

- **Problems**
  - **High noise level**
  - **Limited size**
  - **Too slow for in-situ**

Paperboard:
Ways to characterize the geometry

SEM (2D)

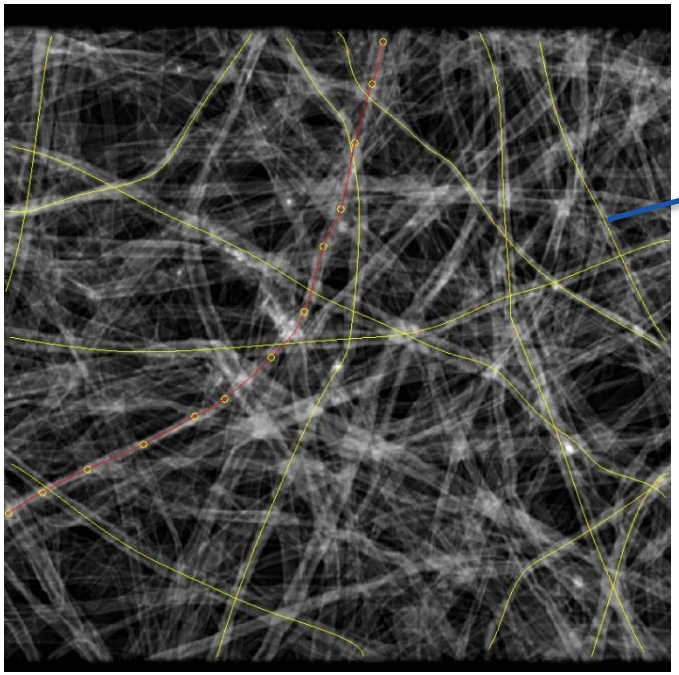


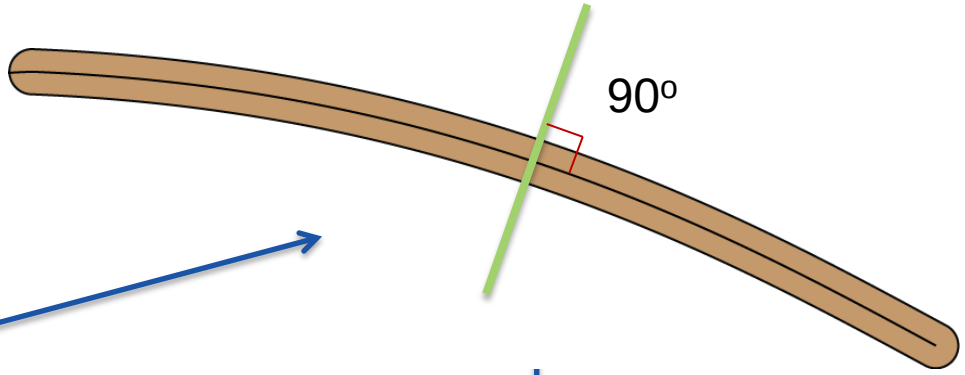
Micro-tomography

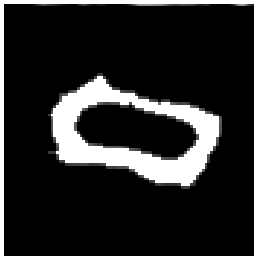
Micro Computed Tomography:

+ Three-dimensional reconstruction
+ Follow the fibers
+ Bonds

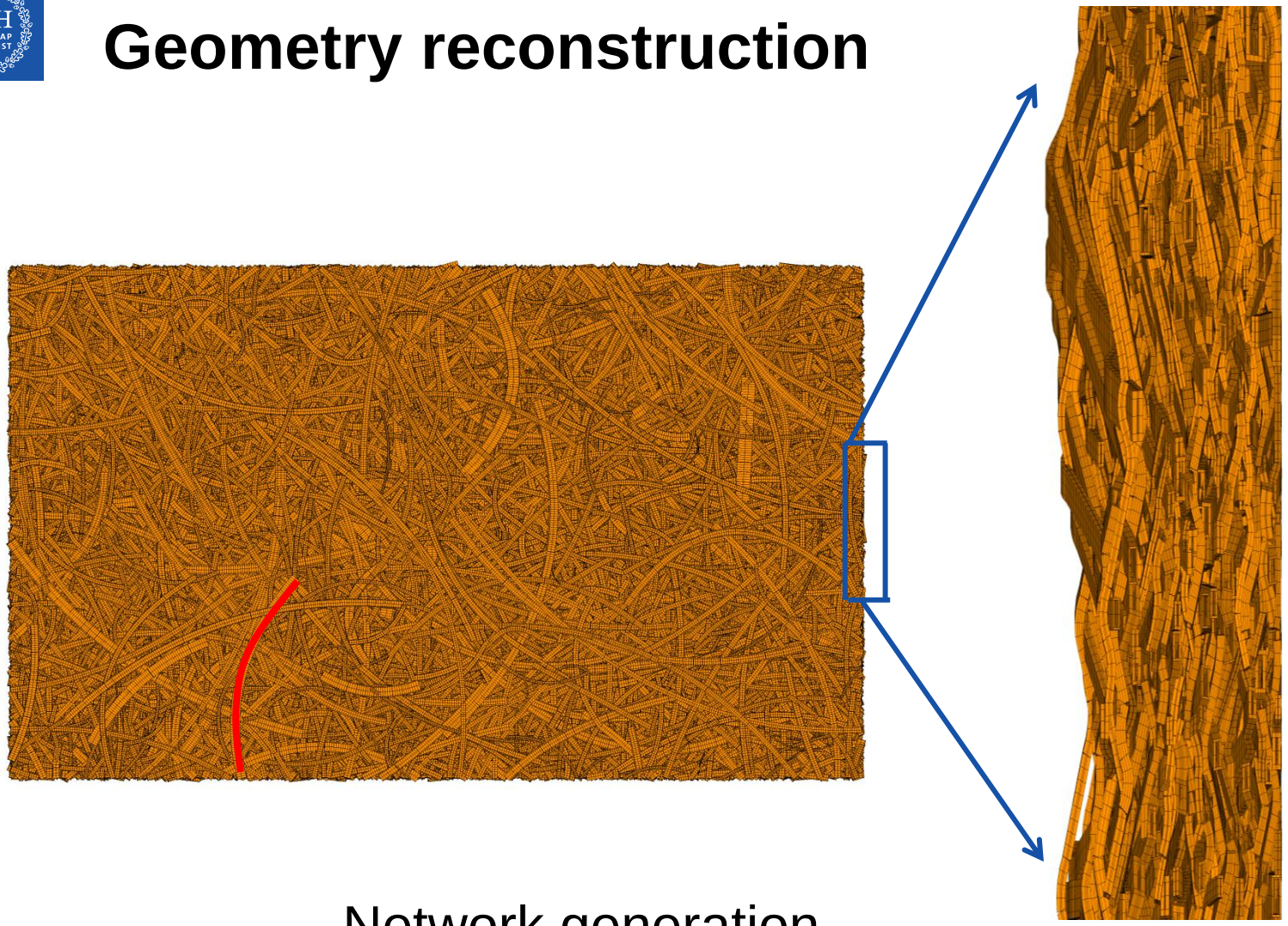
Cross-section extraction





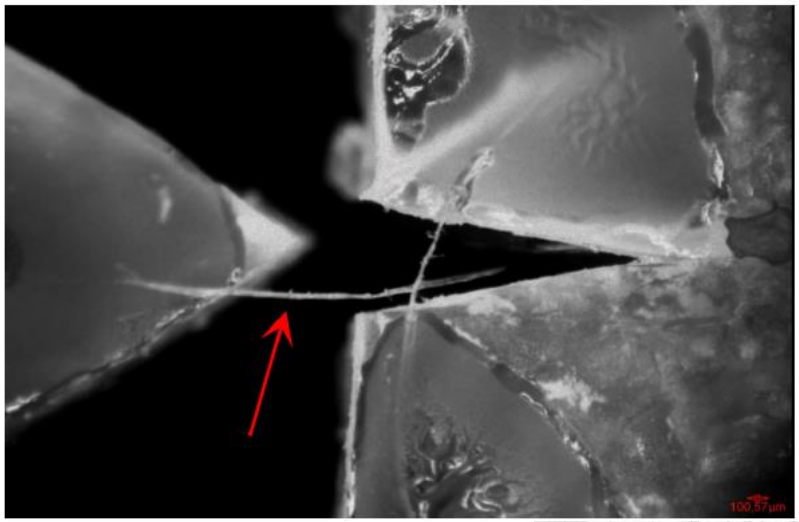


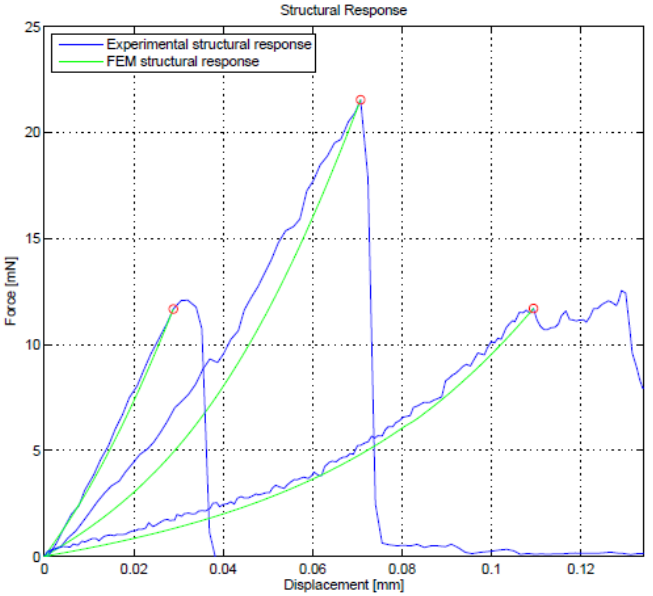
Geometry reconstruction

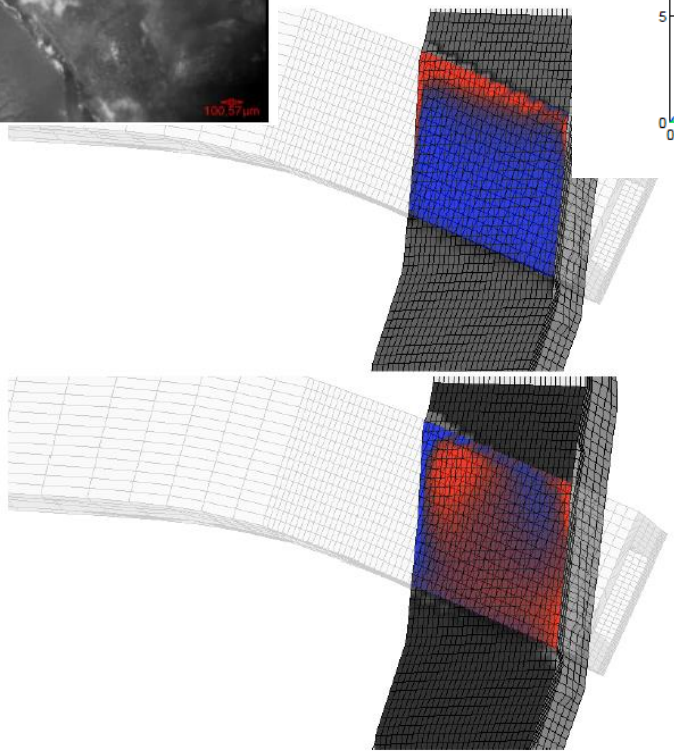


Network generation

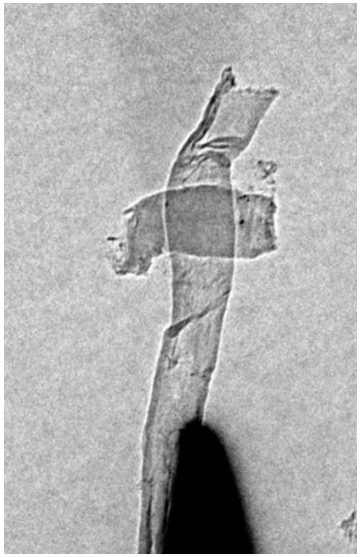
Fibre-fibre joints



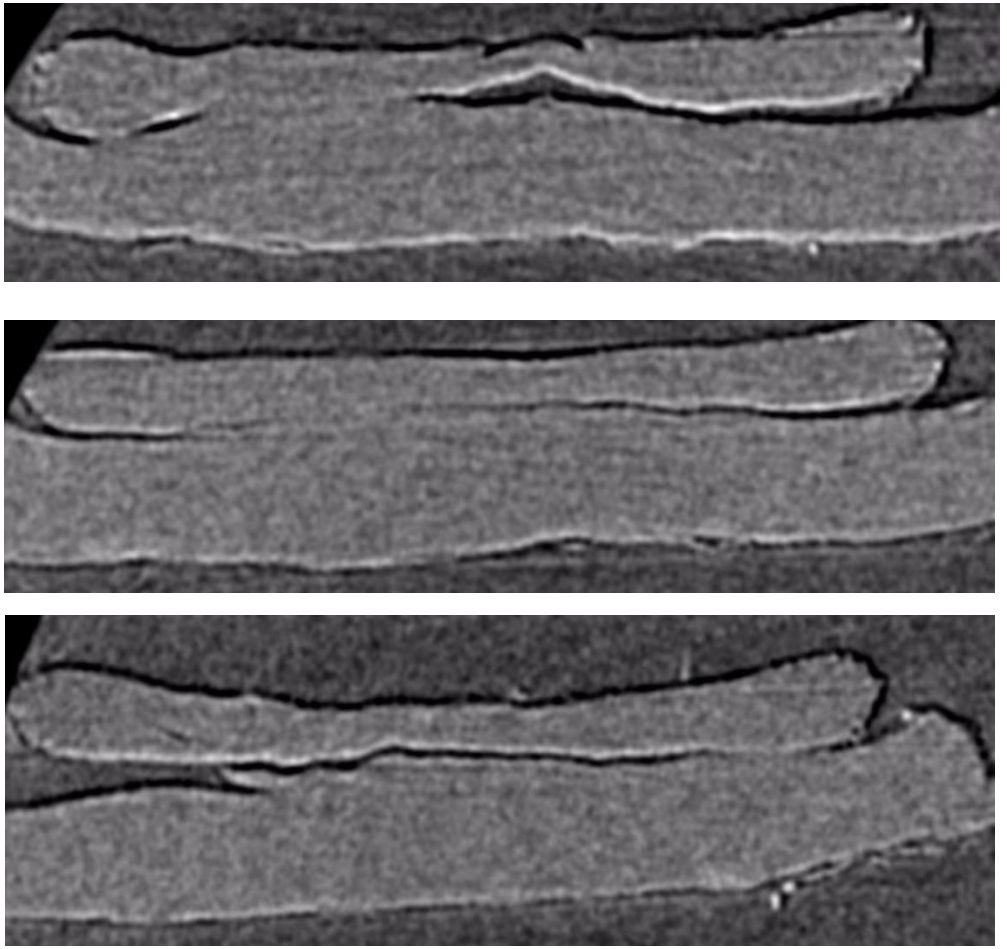




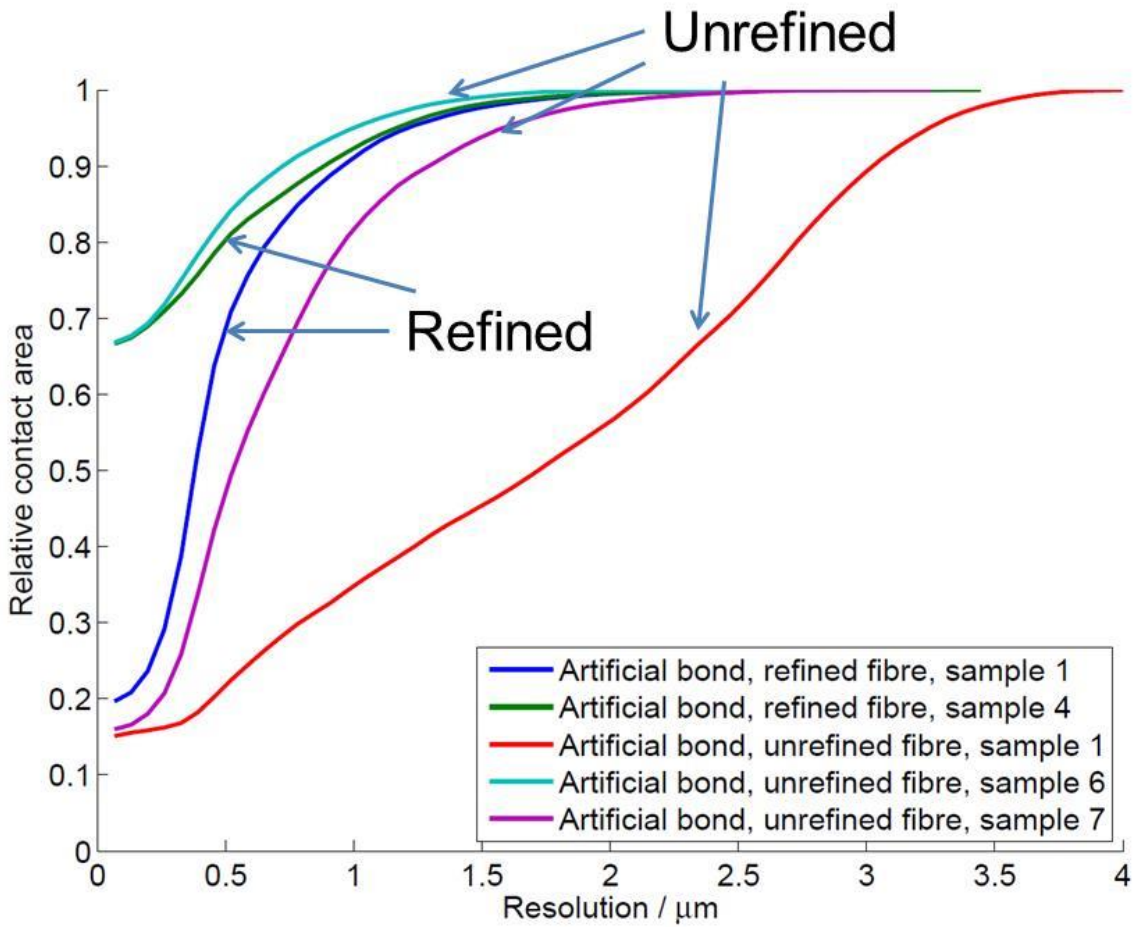
Refined fibres



Fractures and gaps within fibre wall and at interface



Contact area at different resolutions



Estimated bonded area of the overlapping area

0,20
0,67
0,15
0,67
0,16

Summary

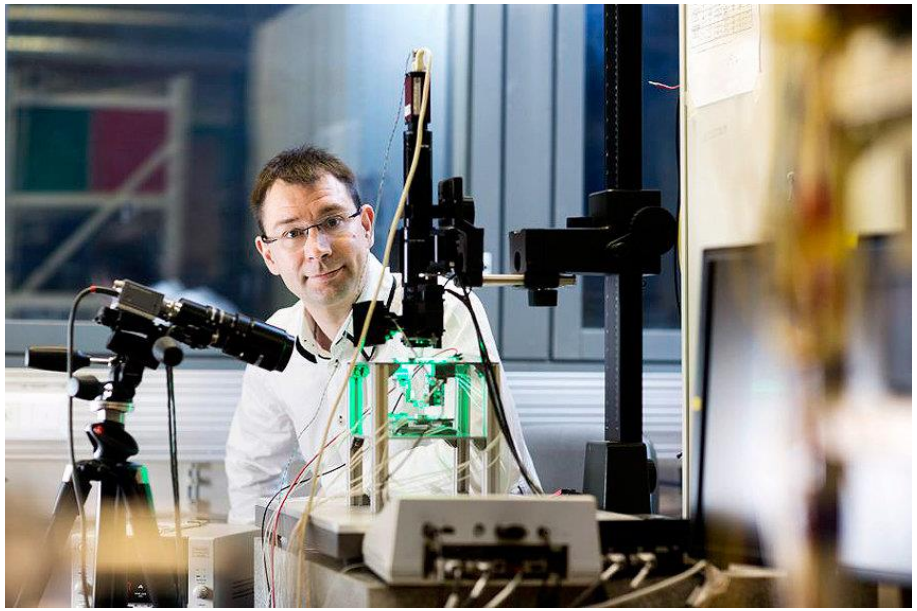
- Micro-tomography provides key features on the fiber and network morphology in the dry state

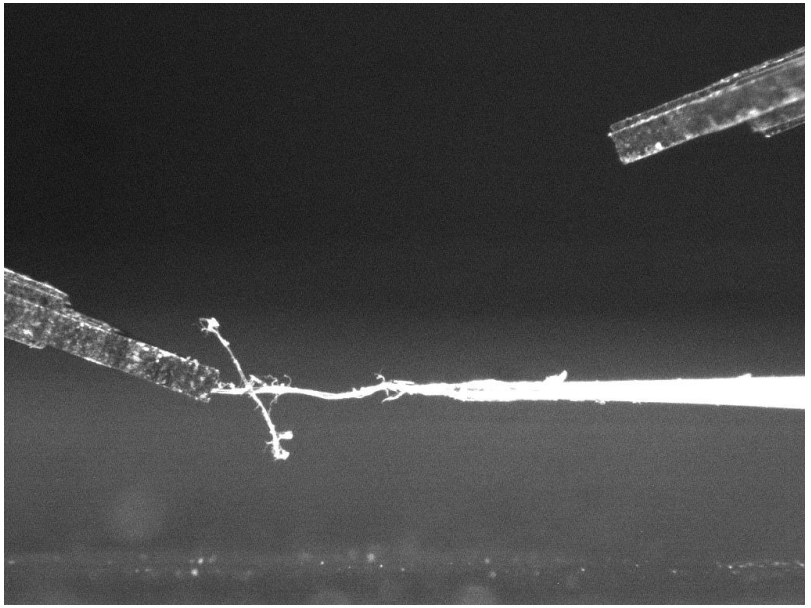
- Similar to foams, the data can be used for verifying the reconstruction algorithms size studies
  - parameter studies
  - coupling to the process

- **<u>Problems</u>**
  - **Resolution is insufficient to resolve individual joints**
  - **No automated and robust procedure for data extraction**

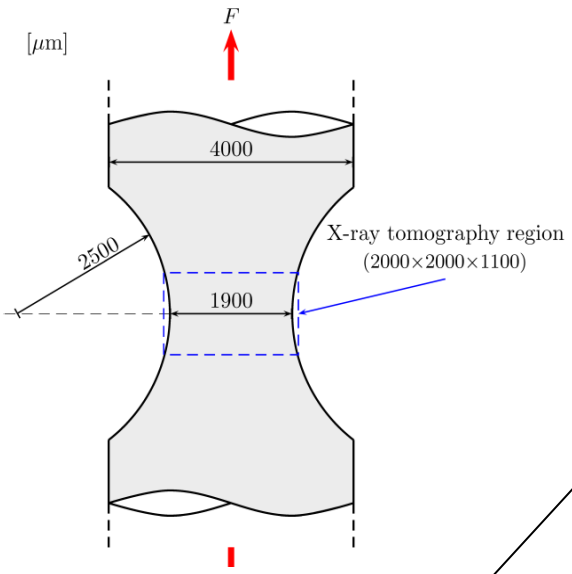
Micromanipulators with integrated force sensors

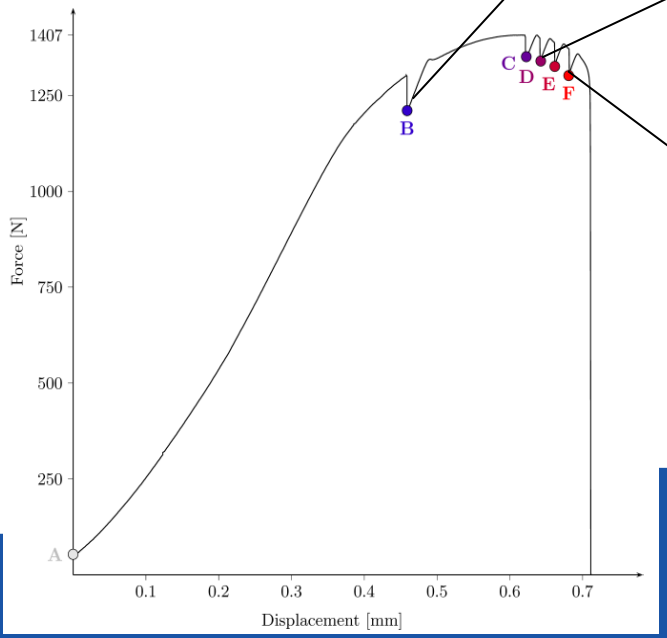
4D-testing of fibres, joints etc.

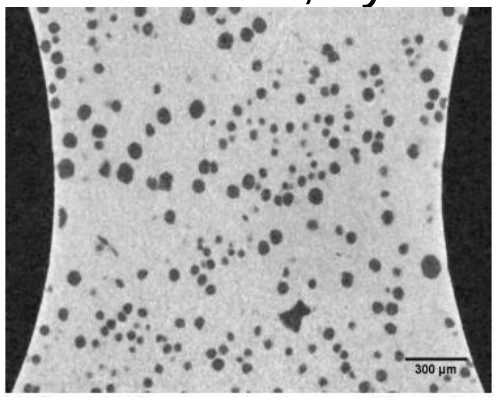


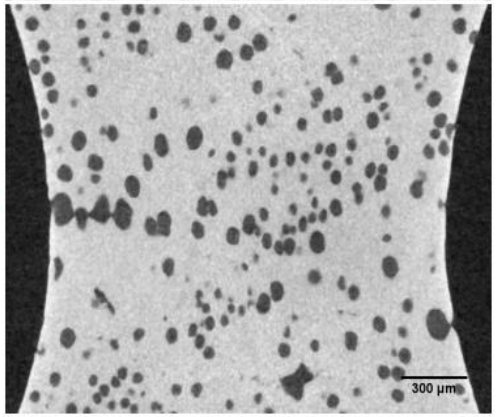


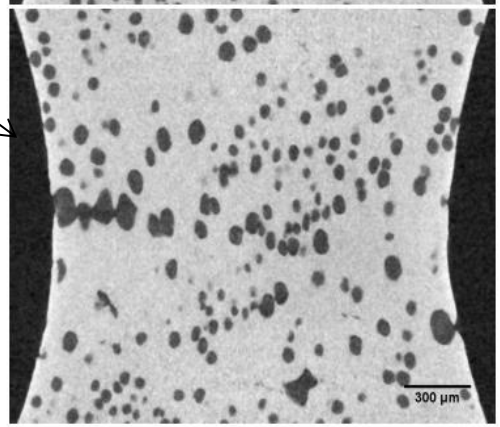
In-situ tensile test on nodular cast iron in an X-ray tomograph Collaboration with Eric Maire, Lyon











In-situ shear test on nodular cast iron