X-ray Tomography. collaboration, perspectives, visions?

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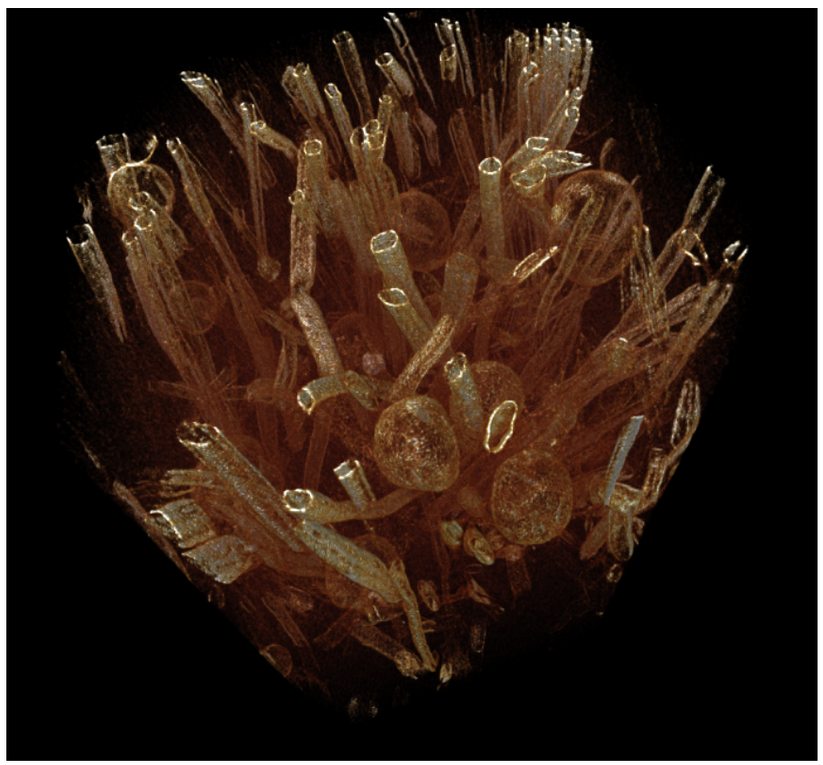
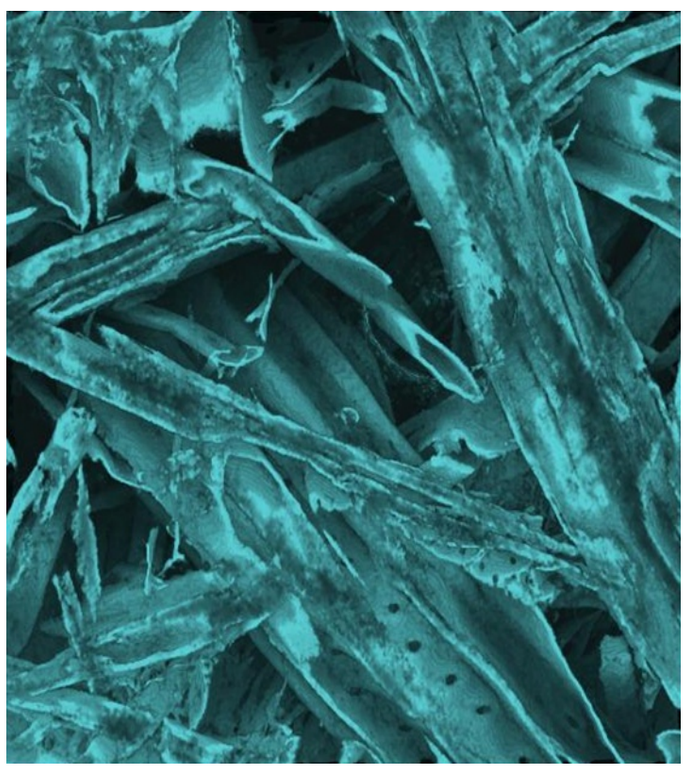
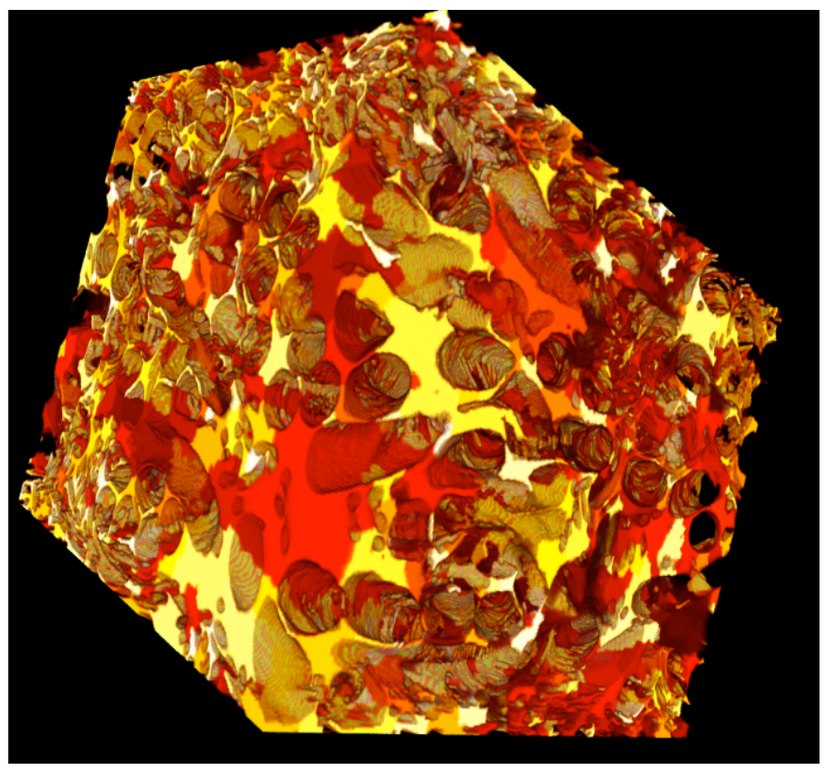






University of Jyväskylä, Department of physics (JYFL)

Main fields of research:

- Subatomaric physics
  - Nuclear physics (Accelerator laboratory)
  - Particle physics and cosmology
- Materials physics
  - Nanophysics (Nanoscience centre)
  - Complex materials (X-ray tomography lab.)

JYFL X-ray Tomography Laboratory. Facilites

1. Zeiss Xradia multiscale equipment.

- Micro/nanotomography
- Resolution 30 μm - 50 nm
- Sample size 40 mm - 15 μm

Vipuvoimaa EU:lta 2007–2013

LÄNSI-SUOMEN LÄÄNINHALLITUS

JYFL X-ray Tomography Laboratory. Facilites

2. SkyScan 1172 table-top scanner.

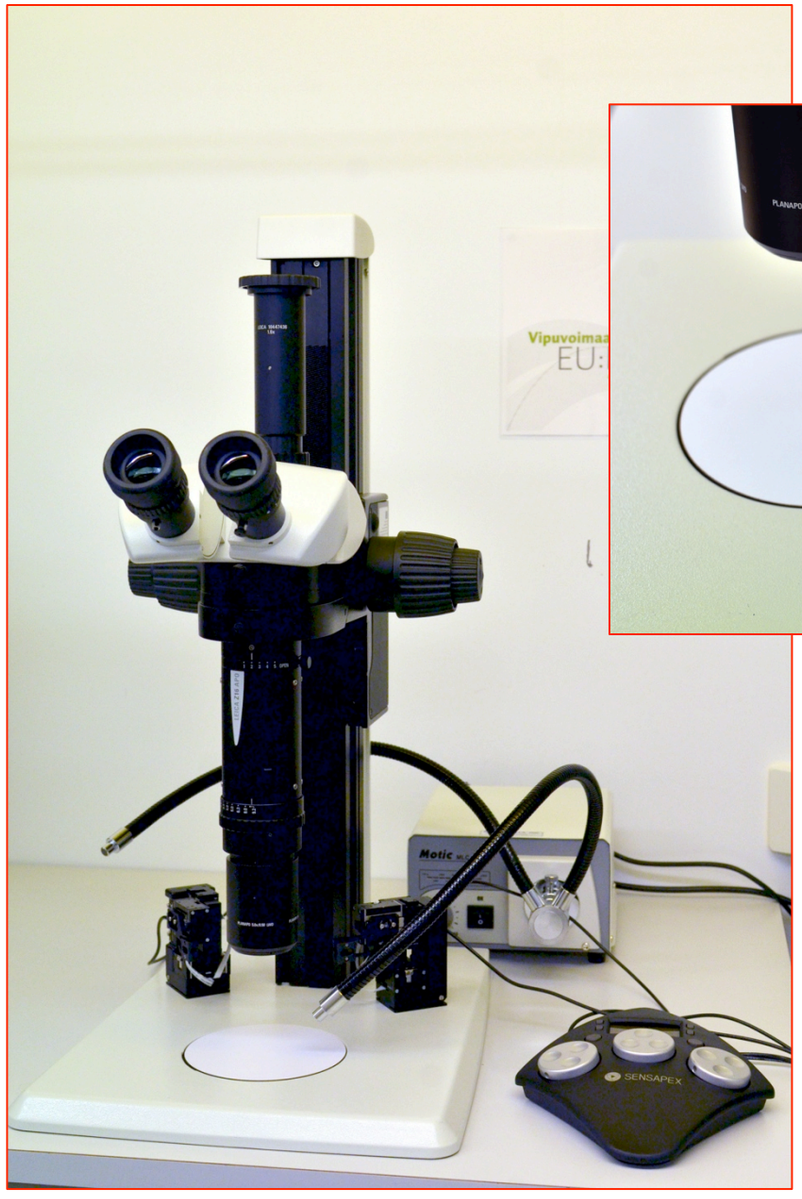
- Resolution 30 μm - 5 μm
- Sample size 50 mm - 2 mm
- 10 MB camera

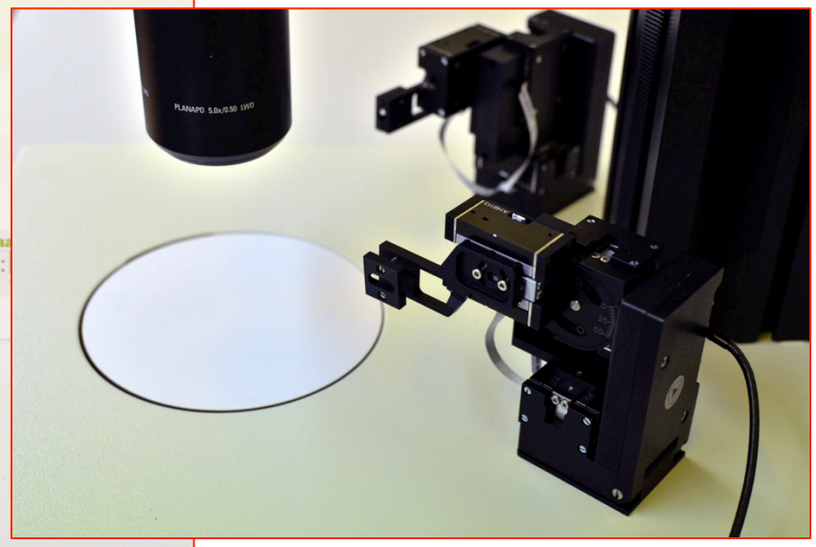
Facilities

3. Sample preparation equipment

Precision laser machining tool

Stereo microscope with micromanipulators





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Facilities

4. Sample conditioning equipment

Mechanical sample straining unit

Humidity controller

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Research profile: Complex materials group

X-Ray tomographic imaging and image analysis

- Non-destructive 3D imaging of material samples even in nm scale
- Structure and transport phenomena of heterogeneous materials
- Image analysis methods development

Heterogeneous materials research

- Structural properties
- Transport properties (4D imaging)
- Composites, biological materials, geological materials,...
- Hydromechanical behaviour of bentonite

Modelling and simulation

- Flow in porous media
- Transport phenomena
- Multiphase flows

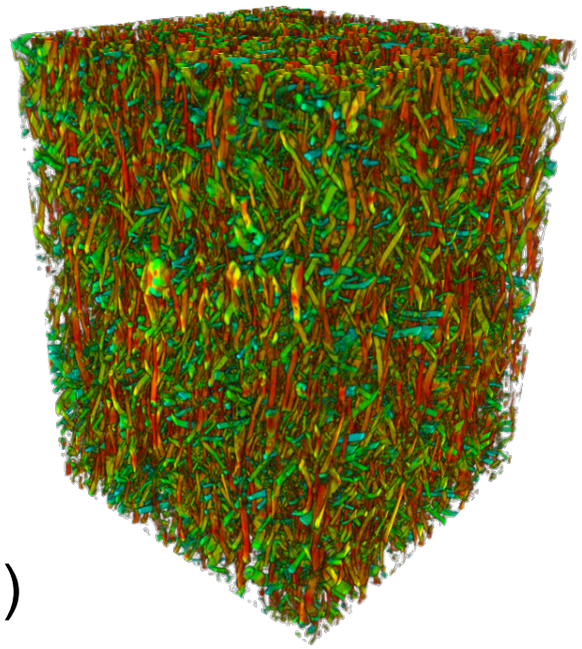
Industrial applications

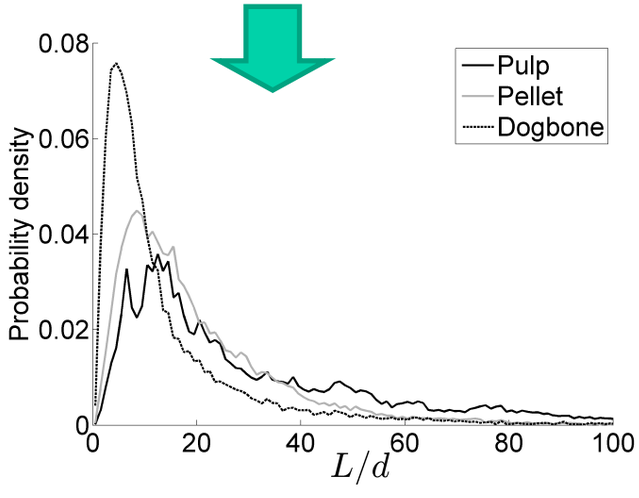
- Bio-based composites
- Strength, fracture and barrier properties of various materials

Methods development at JYFL:

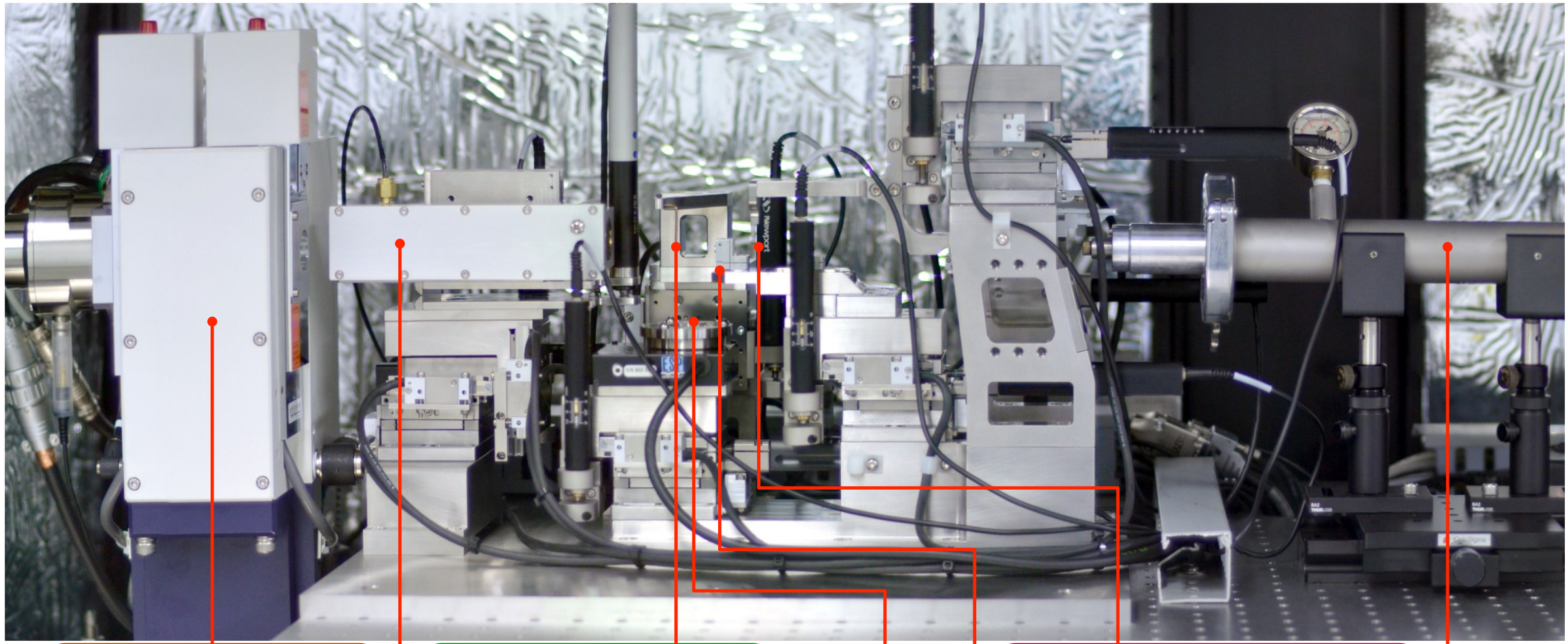
General goal: Quantitative measurement of heterogeneous materials properties based on 3D tomographic images.

- Image reconstruction
  - Filtered back-projection - and beyond
- Image post-processing
  - Denoising
  - Artefact removal
- 3D image analysis
  - Structural characteristics (porosity, surface area,…)
  - Pattern recognition (particles, fibres, single pores,…)
  - Orientation, sceletonization,…
  - …
- Numerical simulations based on true structrure
  - Flow properties in porous media
  - Orientation, sceletonization,…
  - …
- 4D tomography
  - Monitoring temporal change of internal structure
  - E.g.: water transport and deformations in wetting/swelling medium





Nanotomography



X-ray source
A copper anode, characteristic peak of 8 keV.

Pinhole
Used to exlude multiple reflected light.

Sample
At focal point

Phase ring
To block direct light (not diffracted by the sample) and to generate zernike phase contrast image.

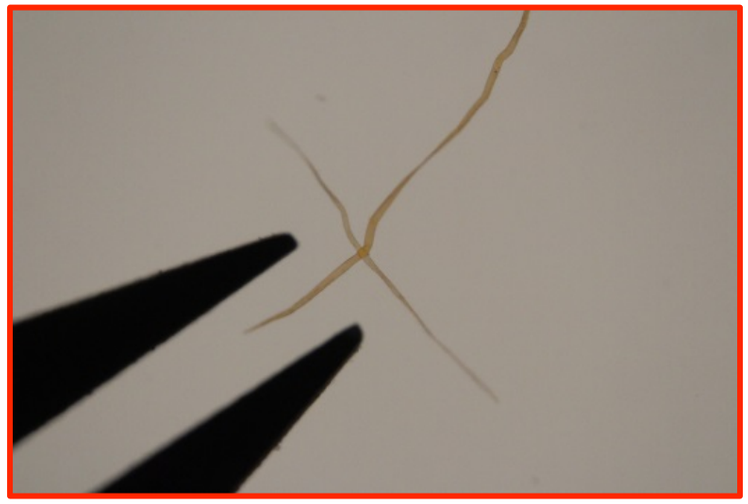
Condenser
An elliptical capillary lens used to focus X-rays into the sample.

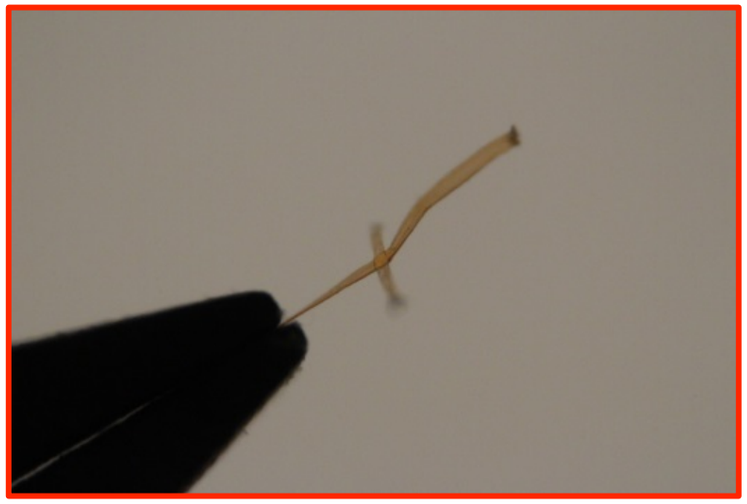
Objective Zone plate
Another focusing optics (Fresnel zone plate) to focus the image onto detector.

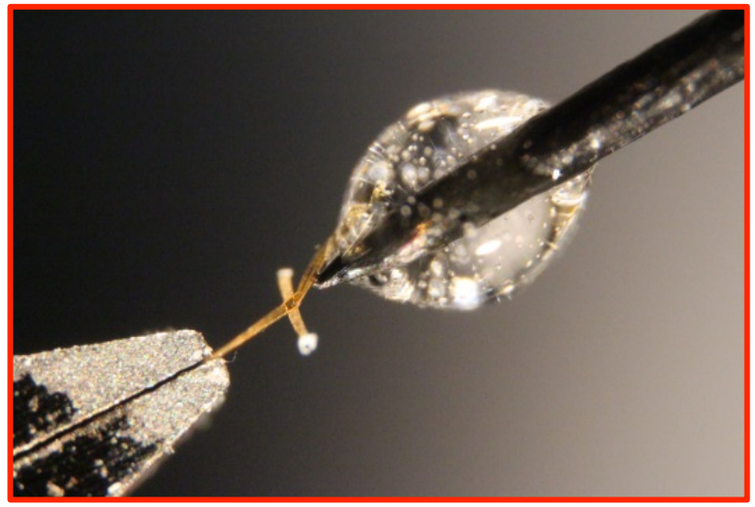
Flight tube and detector
He gas filled tube used to channel X-rays to the detector (CCD chip coupled with a scintillator)

XnCT example: contact between two wood fibres

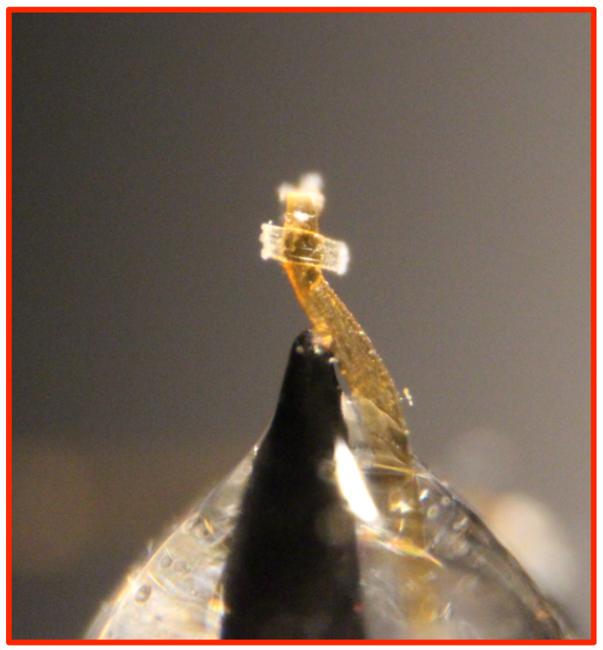
Sample preparation using micromanipulators and laser cutting



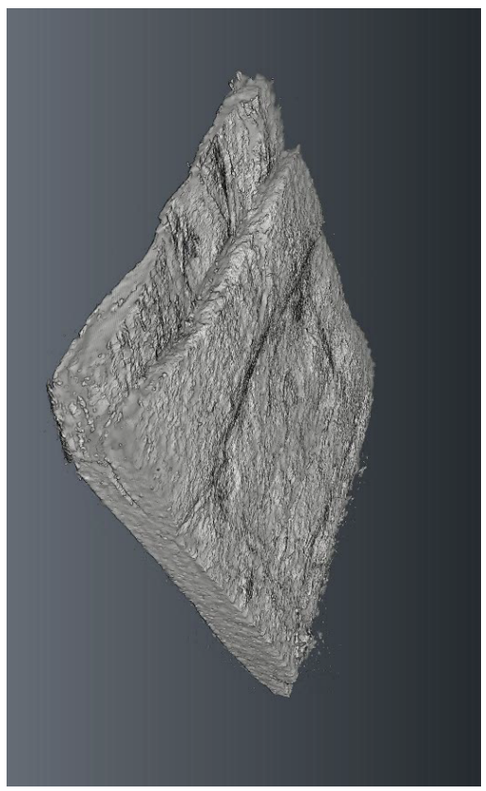




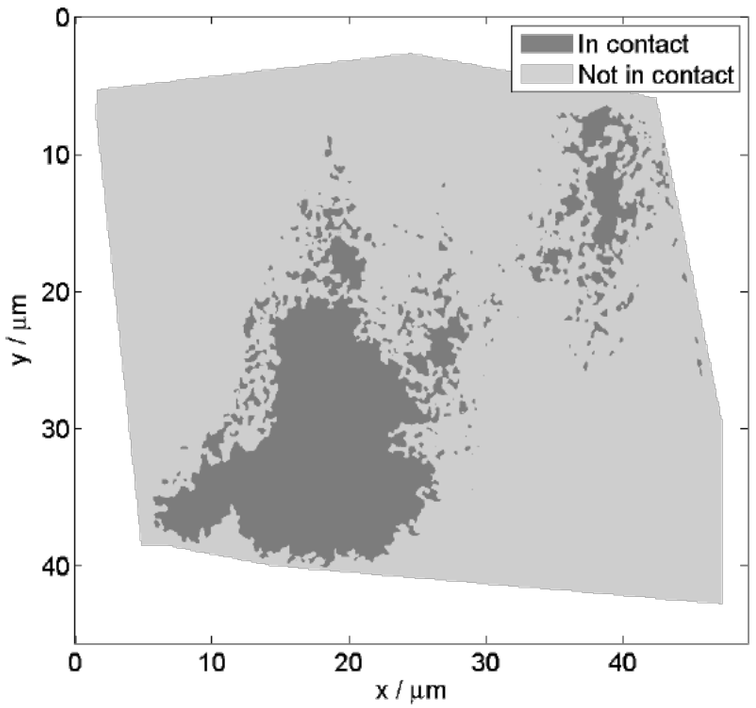
Sample ready for scanning



Nano-CT image of the contact



Contact area analysed



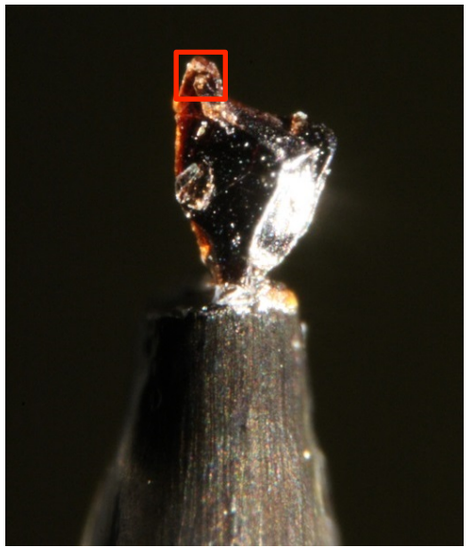
Collaborative opportunities
General perspective (FinTomo network)

- Joint research projects
  - E.g. participation in EU projects
- Joint infrastructure projects
  - FIRI, EU,...
- Subcontracting
  - Role as an external service provider in public or industrial projects.
- Sheared resources:
  - Facilities (device time)
  - Expertise
  - Knowledge
- Researcher training
  - PhD student exchange,
  - Summerschools,
- Mobility
  - Post-doctoral researcher exchange

... etc.

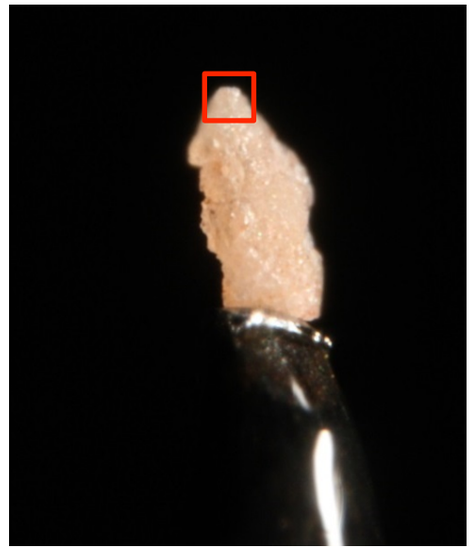
Practical example of GTK-JYFL collaboration: Geological samples imaged with nano-CT.

- FOV 60 μm, Pixel size 65 nm, Resolution 150 nm

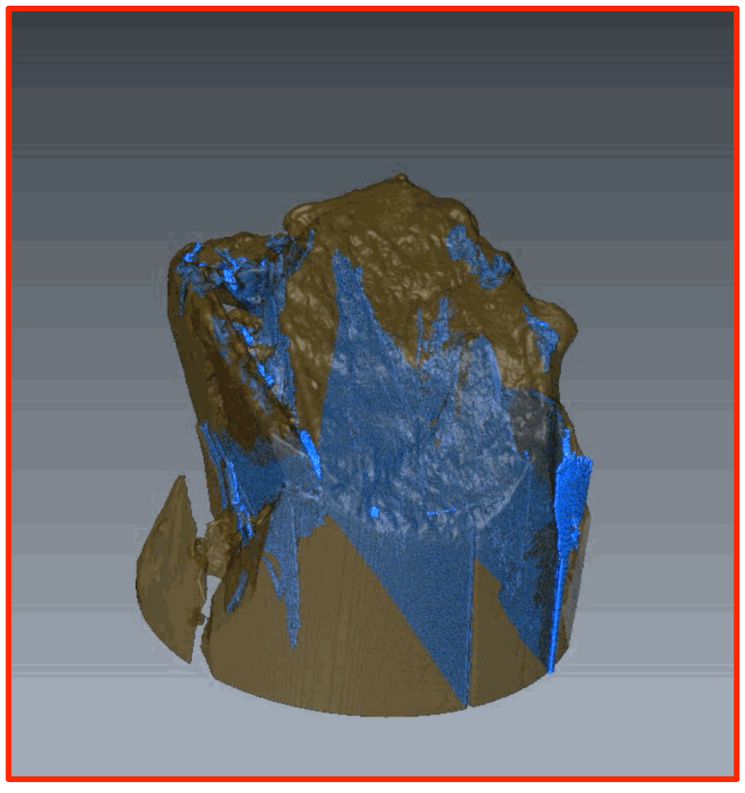


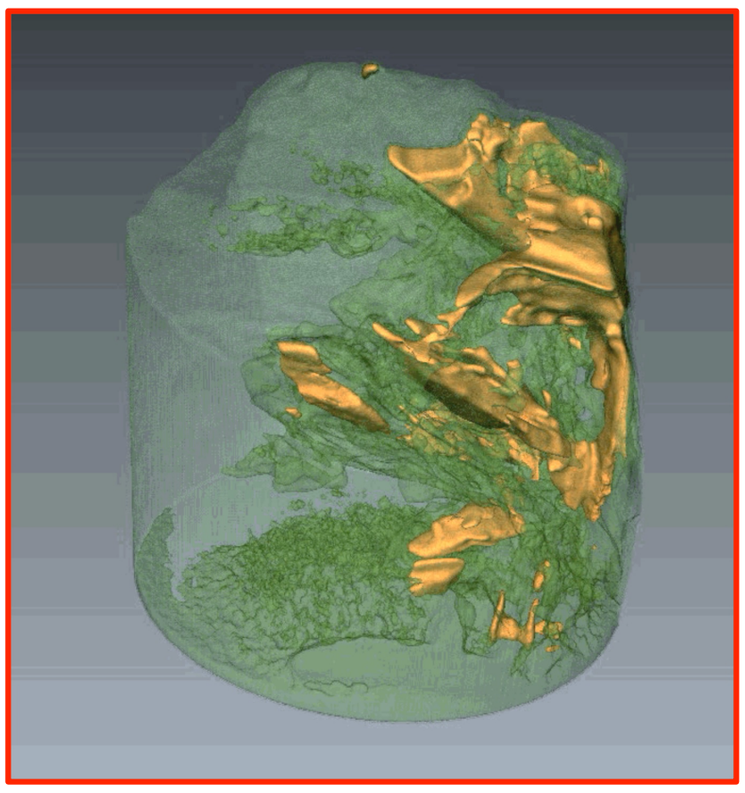
Biotite

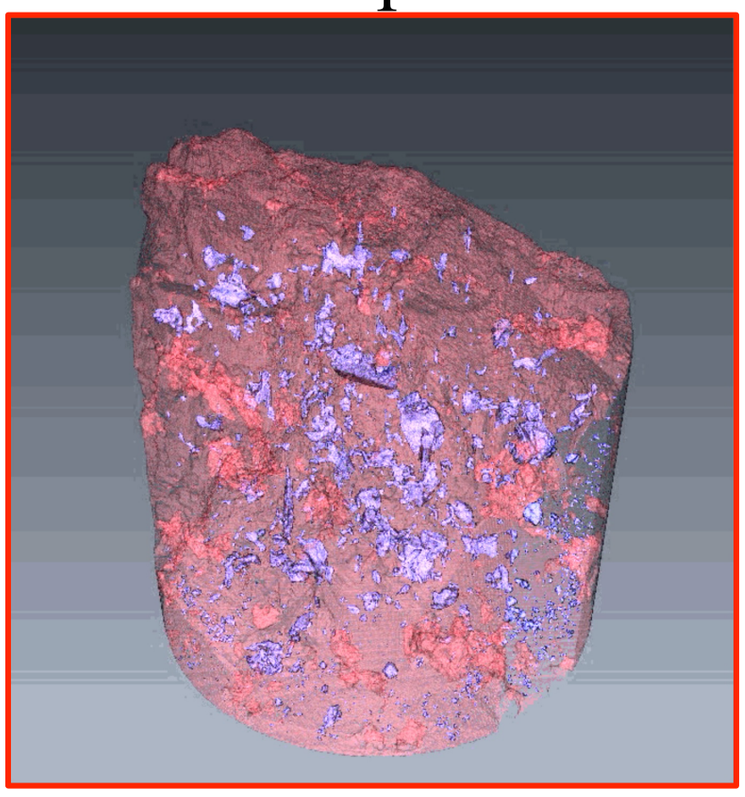
Cordierite



Feldspar

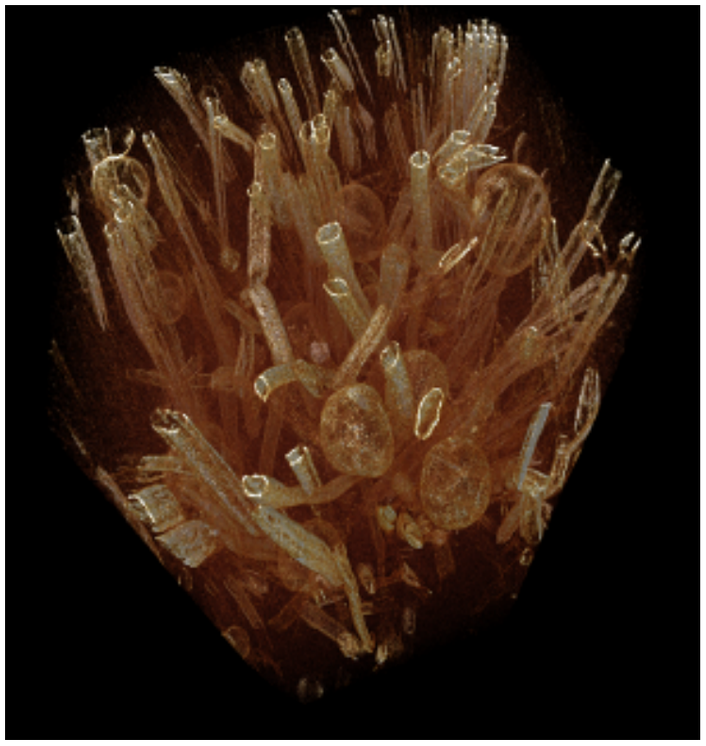




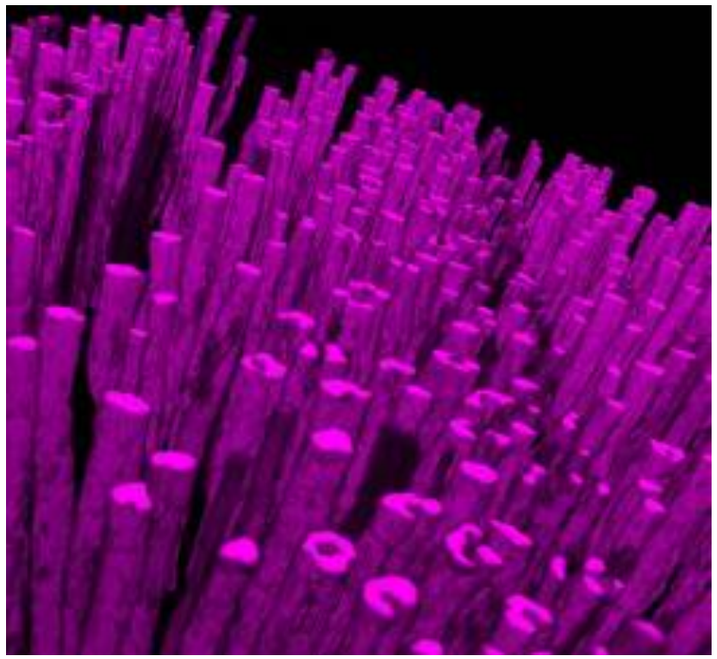


Tomographic art

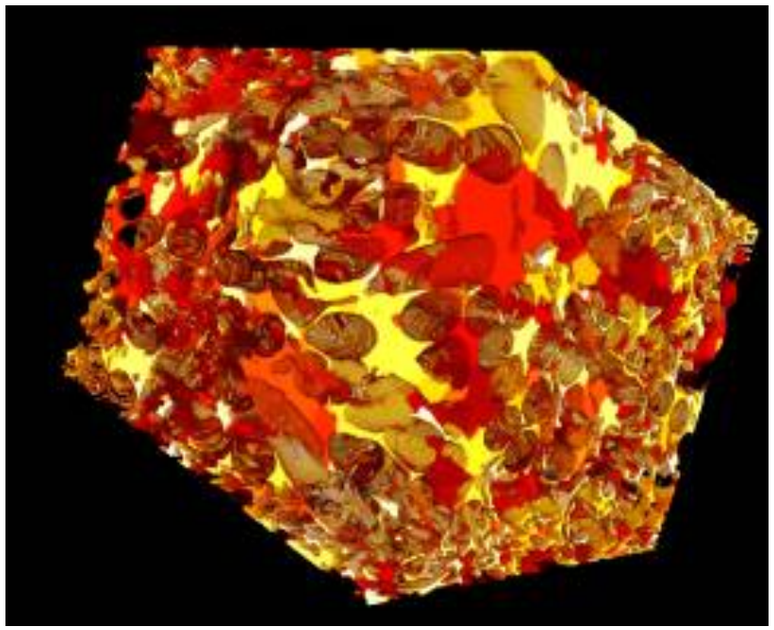
Wood fibres in a composite material



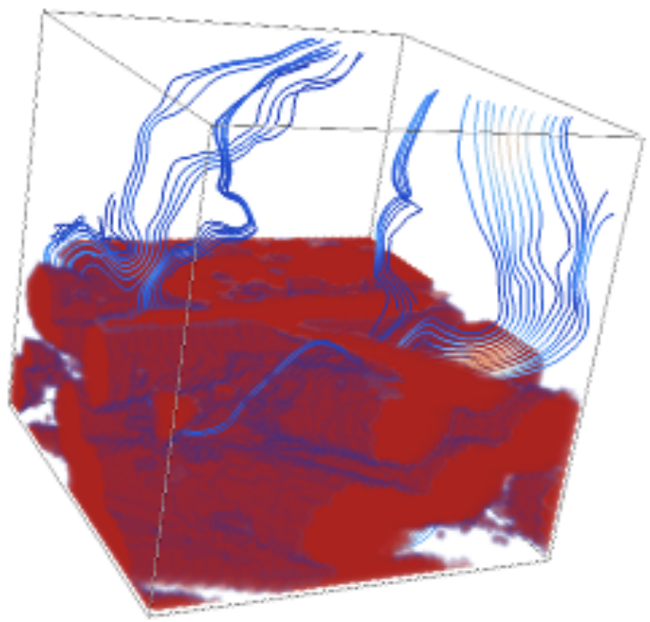
Tracheids of wood



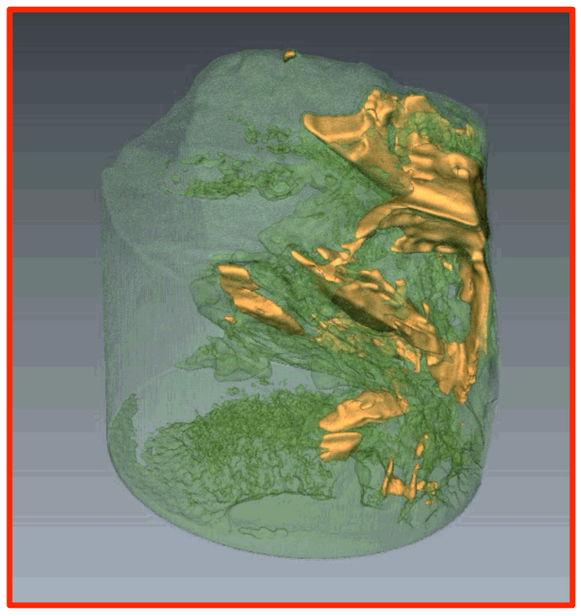
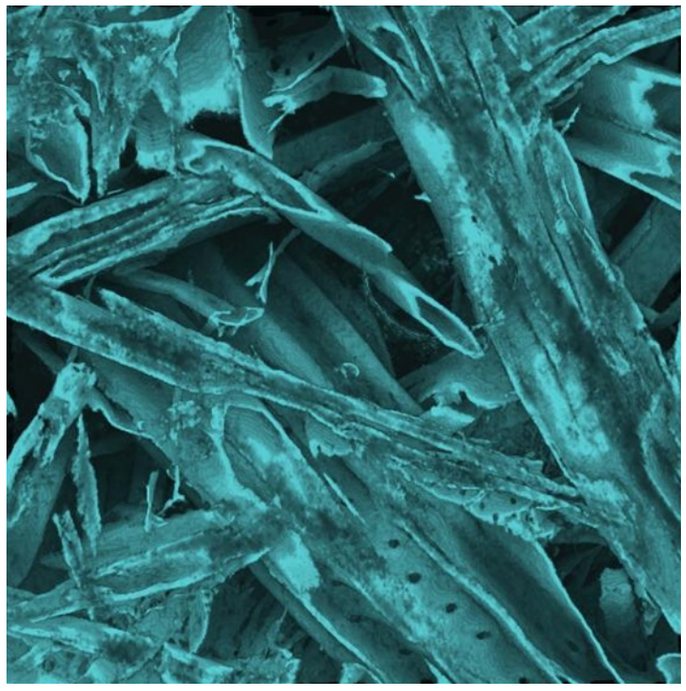
Pore space of a felt segmented into individual pores.



Numerically solved flowlines in porous material



Minerals in cordierite



Internal structure of cardboard