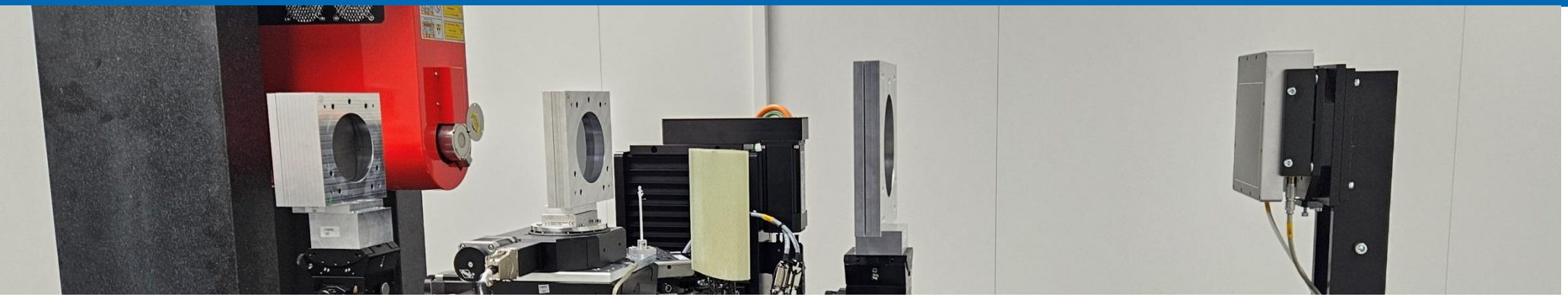
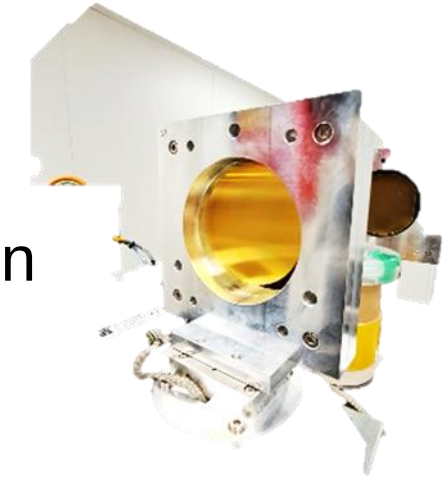


FASERINSTITUT BREMEN

Testing and Research Platform for Advanced X-ray Applications



New insights into material characterization

Supported by:

Federal Ministry for Economic Affairs and Climate Action

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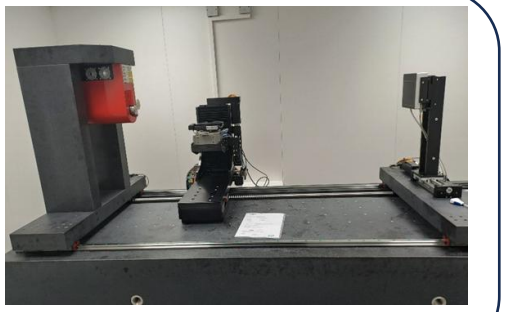
X-ray radiation protection cabin

Advantages:

- Walk-in radiation protection cabin with large experimental platform.
- Open, Python-based software.
- Enables integration of additional detectors and X-ray sources, or control of in-situ experiments.
- Integration and control of a Talbot-Lau grating interferometer (TLGI).
- TLGI: delivers three contrast modes: conventional absorption (AC), differential phase (DPC) and dark-field (DFC).
- Limitations of conventional X-ray CT are overcome.

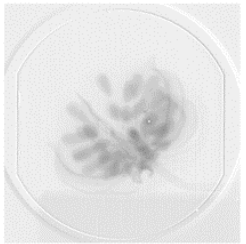
Size: 4500 × 2500 × 2200 mm



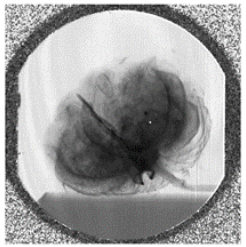
Size: 2500 × 1000 × 400 mm

TLG-Interferometer

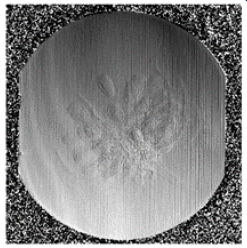
Cotton-seed



AC



DFC



DPC

X-ray radiation protection cabin: Optical Setup

Sample manipulator

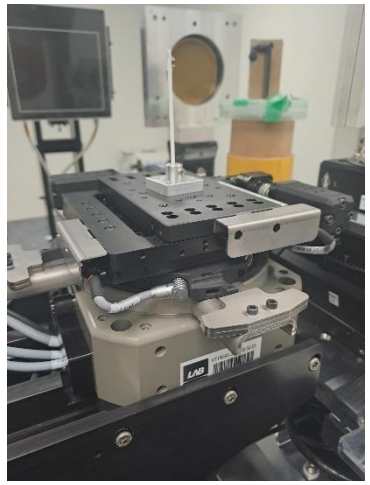
- High-precision, air-bearing rotation stage.
- Two translational degrees of freedom on and two below the rotation axis,
- enables the measurement of relevant areas outside the axis of rotation.

Properties of the X-ray source

- Maximum voltage 150 kV / 75 W.
- Focal spot size / resolution => 3 µm.

Properties of the X-ray detector

- Flat-panel detector; detector size 140 x 120 mm.
- Measuring field extension to 280 x 240 mm.
- Max. component size 250 x 220 mm.
- Read-out rate at least 40 fps.



X-ray radiation protection cabin: Image Analysis

VG-STUDIO MAX 2025/2

T-bracket

- Short-fiber injection molding
- Outer shape: CAD vs. CT Data (a)
- Inner quality: pores (b)

Non-woven fabric (natural fibers)

- Color-coded fiber-orientation (c)

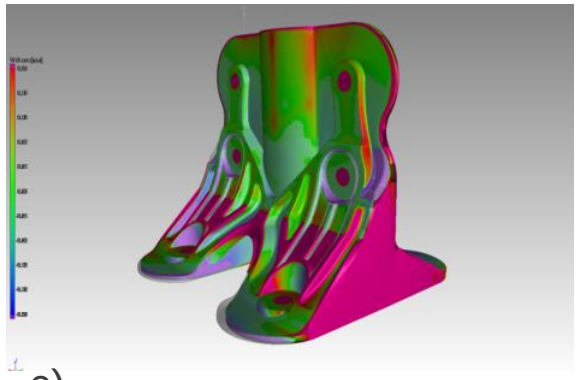
Foam

- Color-coded displacement comparison (loaded vs. unloaded) (d)
- Digital volume correlation (in-situ-application)

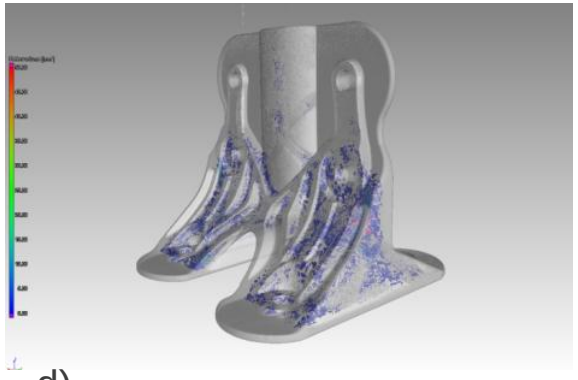
Bi-component polymer fiber

- Color-coded wall thickness
- Fiber-diameter 200µm (e)

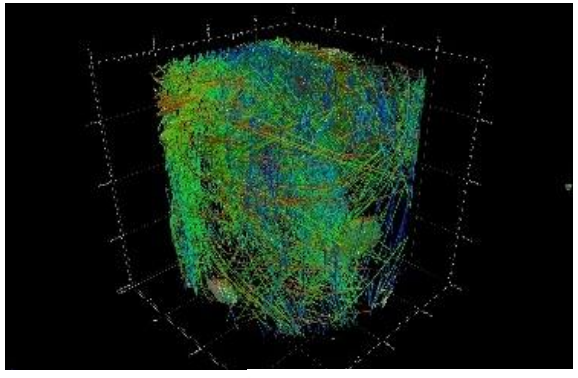
a)



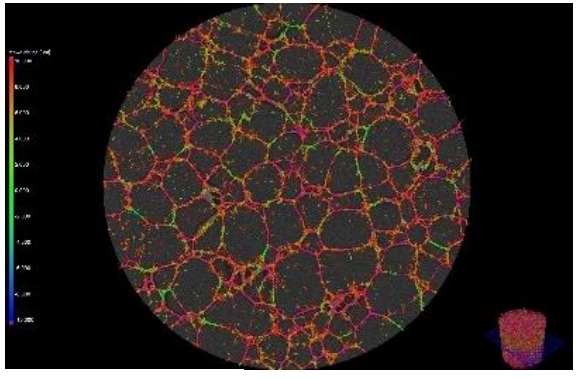
b)



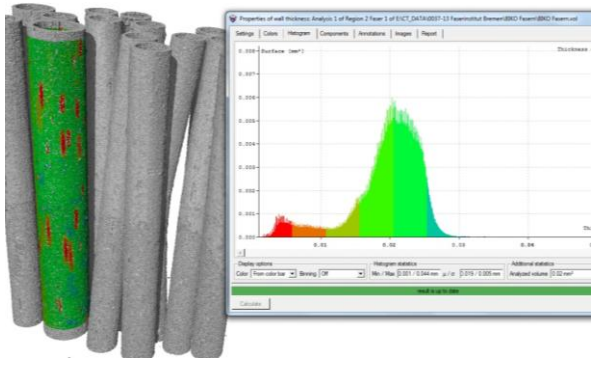
c)



d)



e)



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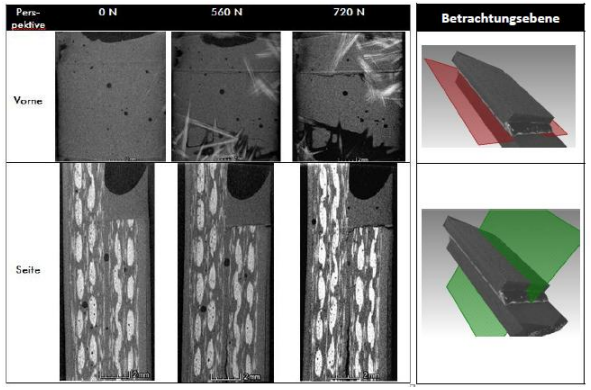
X-ray radiation protection cabin: Experimental Platform

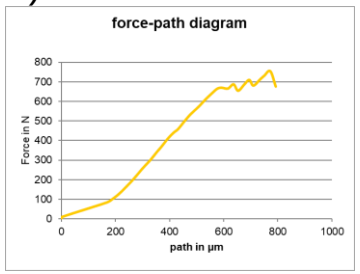
In-Situ Experiments:

- Compression, tensile, and 3- / 4-point bending tests
- Failure testing of bonded joints (a).
- Real-time crack detection based on acoustic emission (AE).
- Further customized experiments possible
  - E.g. thermal loading,
  - Environmental chamber for long term creep-studies,
  - …

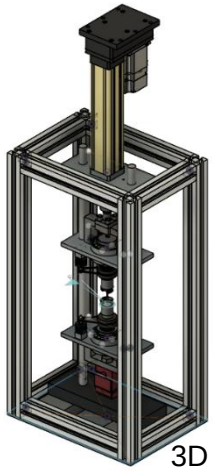
a)



b)



a) Position of the sectional views is shown in the right-hand section.
b) Load on the GFRP bonded joint was gradually increased until failure.



3D view

- newly designed, revised in-situ unit
- specimen's field of view is unrestricted
- acoustic emission

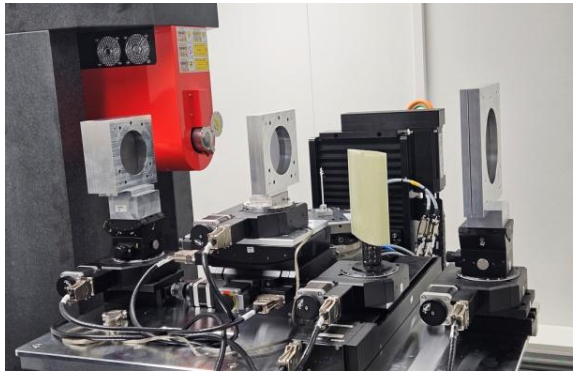
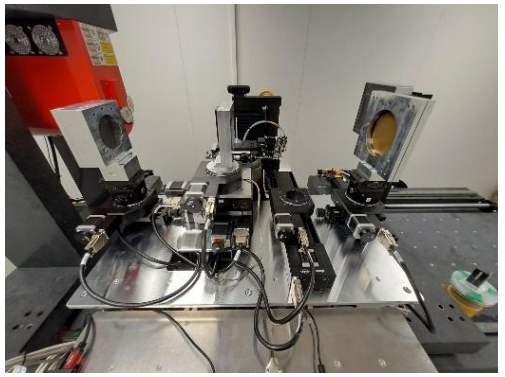
Talbot-Lau-Grating Interferometer (TLGI)

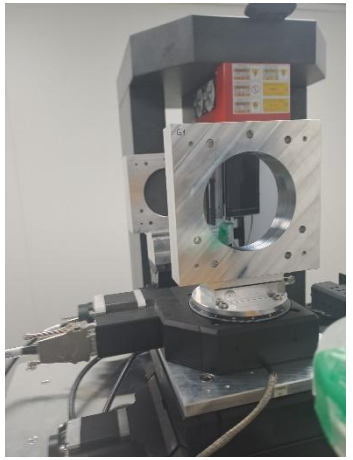
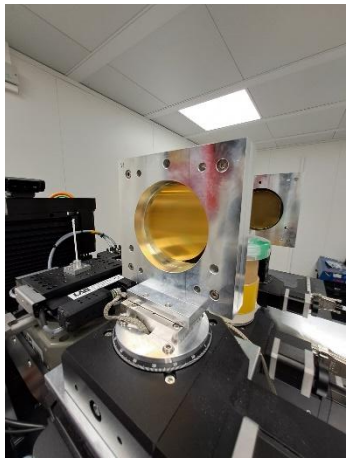
Software (RosCT, EZRT)

- Standardized measurement software for CT and TLGI mode
- Reconstruction software for
  - CT applications
  - phase-contrast tomography
  - dark-field tomography
- Python based

Interferometer

- Quick switch between X-CT and TLGI mode

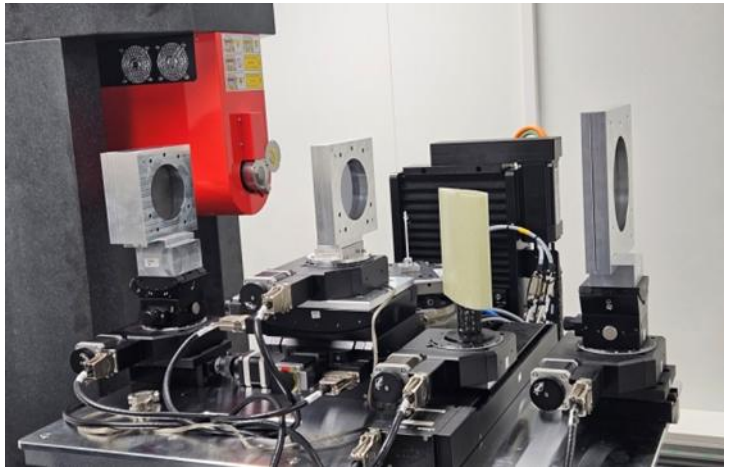



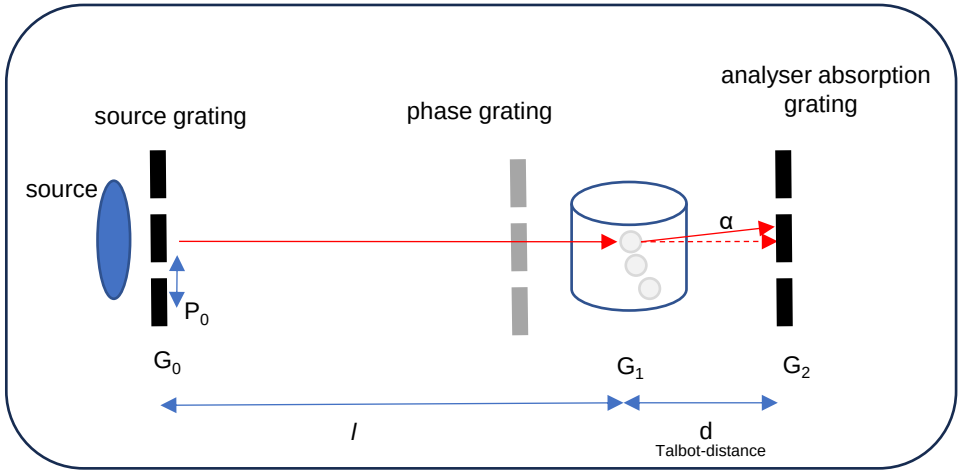



Talbot-Lau-Grating-Interferometer (TLGI)

Interferometer setup

- Three line gratings (G_0, G_1 and G_2),
- G_1 – G_2 are arranged at a fixed distance (Talbot-Lau configuration)
- G_2 can be moved stepwise perpendicular to the optical axis
- realizes a phase shift
- leads to three contrast modes being achieved from a single measurement:
  - Conventional Absorption Contrast (AC)
  - Differential Phase Contrast (DPC)
  - Dark Field Contrast (DFC)



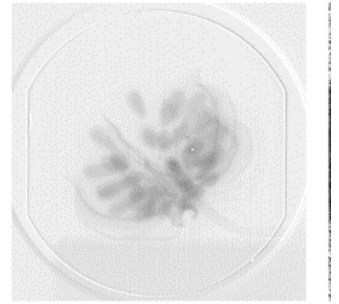


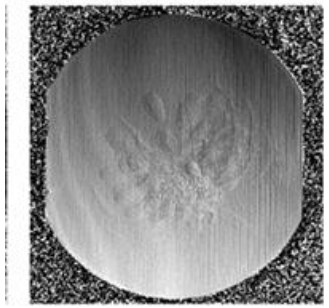
Talbot-Lau-Grating-Interferometer: Contrast Modes

Contrast Modes and Applications

- **AC:** conventional X-ray imaging.
- **DPC:** differentiation of materials with similar attenuation.
- **DPC:** reduced sensitivity to metal artifacts in CFRP components.
- **DFC:** detection of microstructural scattering (pores, fibers, cracks).
- High sensitivity to delaminations and fiber orientation.
- Measurement volume up to 40 mm^3.
- **Conventional CT:** measurement volume limited to 2 mm^3.

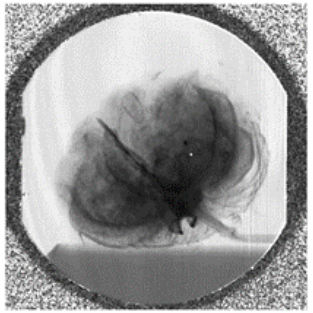
AC





DPC

Cotton-Seed

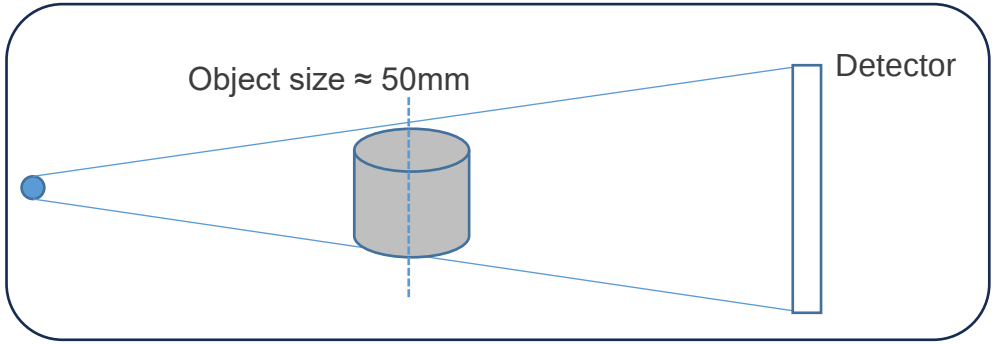


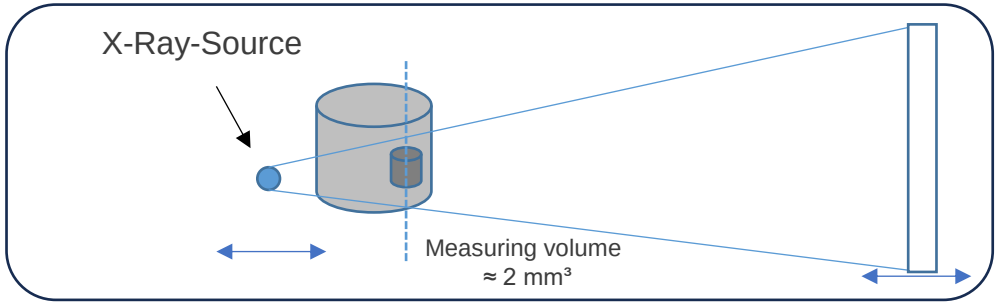
DFC

X-ray radiation protection cabin: Measuring modes

CT Mode

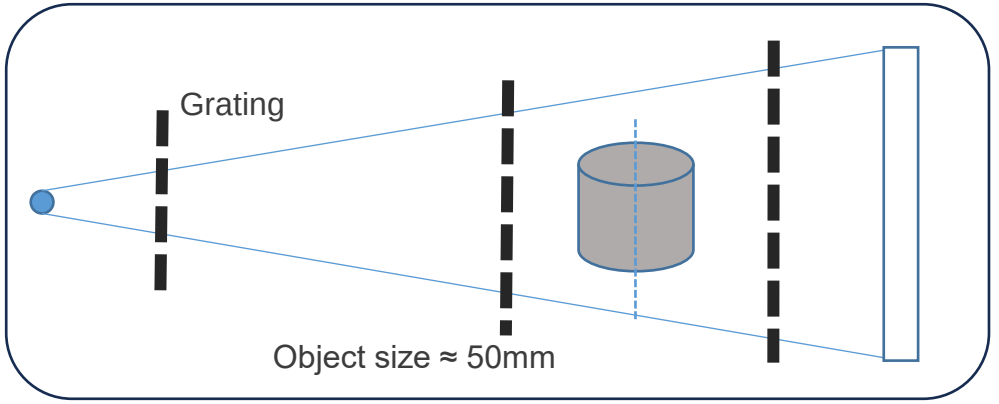
- Geometrical magnification
- Meso and macro ranges
- Structure and pore analysis
- Flexible region-of-interest measurement
- In-situ experiments

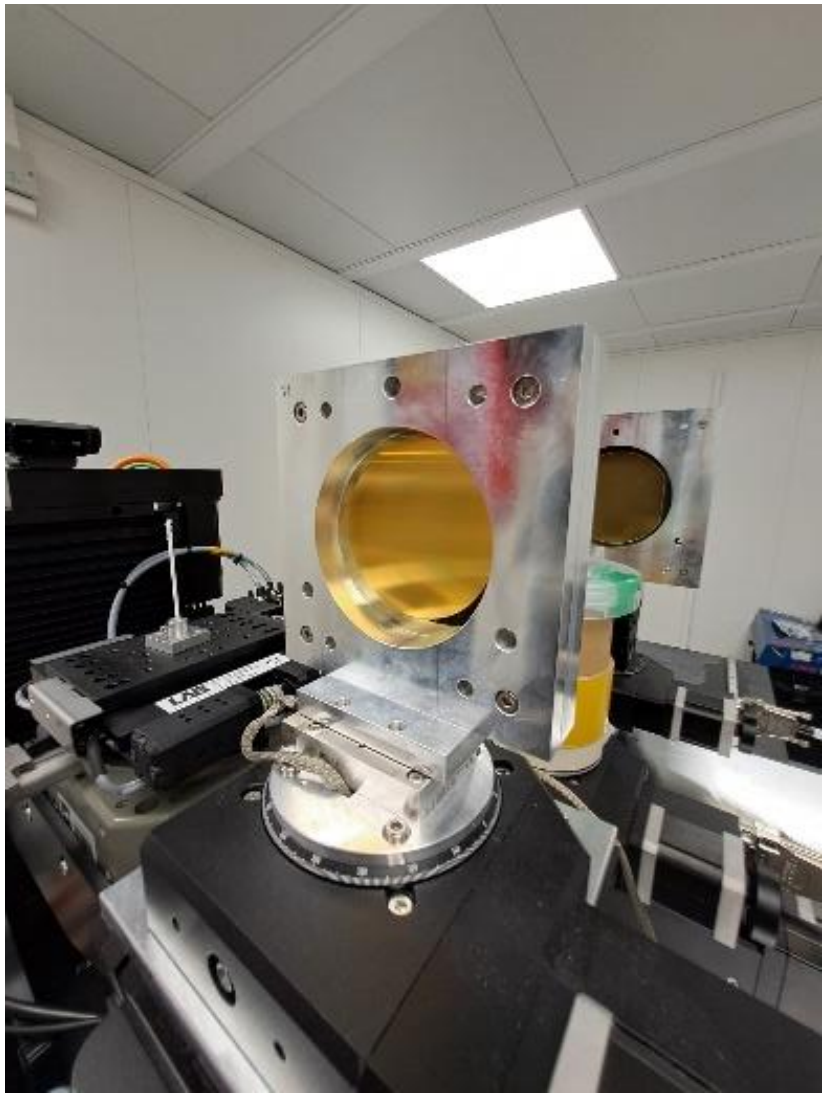




TLGI / XTT

- X-ray tensor tomography (XTT)
- Sensitive to micro-cracks and
- Fiber orientation





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Dipl.-Phys. Oliver Focke
Faserinstitut Bremen e.V.
focke@faserinstitut.de
www.faserinstitut.de
+49 421 / 218 58655