# Imaging materials in motion: From sheared foams to human middle ear mechanics

Christian Schlepütz[1]

[1] *Paul Scherrer Institute, Switzerland*

**Presentation type:** Invited Talk **Presentation time:** 08:30-09:00

Seeing is believing. Yet, when it comes to the investigation of interacting microscopic objects and structures, it is even more: Seeing is understanding! This is particularly true when trying to unravel the nature of dynamic processes at length and time scales that are naturally inaccessible to the bare human eye.

Understanding dynamic processes in materials and biomechanical systems requires direct observation of their internal structural evolution at microscopic length and time scales. Since the properties and performance of both engineered and natural materials are fundamentally governed by their internal microstructure, transient phenomena occurring during formation, processing, or operation often determine their ultimate behavior. Most such processes typically occur within opaque materials or complex environments, rendering them inaccessible to conventional optical characterization techniques.

X-ray tomographic microscopy provides non-destructive three-dimensional visualization of internal structures with micrometer-scale resolution. By rapidly acquiring successive tomographic volumes, dynamic phenomena can be captured as time-resolved three-dimensional image sequences, effectively creating quantitative "4D movies" (3D space plus time). These datasets not only provide intuitive visualization of complex processes but also enable rigorous quantitative analysis of structural evolution, transport phenomena, deformation mechanisms, and dynamic interactions within materials and biological systems.

Realizing such experiments presents several key challenges: (i) matching imaging speed to the characteristic and often hierarchical time scales of the investigated processes, (ii) designing, controlling, and synchronizing experimental environments compatible with high-speed tomography, and (iii) processing and extracting meaningful information from the resulting large-scale 4D datasets.

This presentation will highlight recent advances in synchrotron-based dynamic X-ray tomography and showcase representative applications across materials science and biomechanics. Case studies include bubble rearrangements and stress relaxation in sheared liquid foams, transient flow dynamics in porous media, and motion analysis of auditory structures in fish and the human middle ear. Together, these examples demonstrate how high-speed tomographic microscopy enables unprecedented insight into dynamic processes, transforming visualization into quantitative understanding.