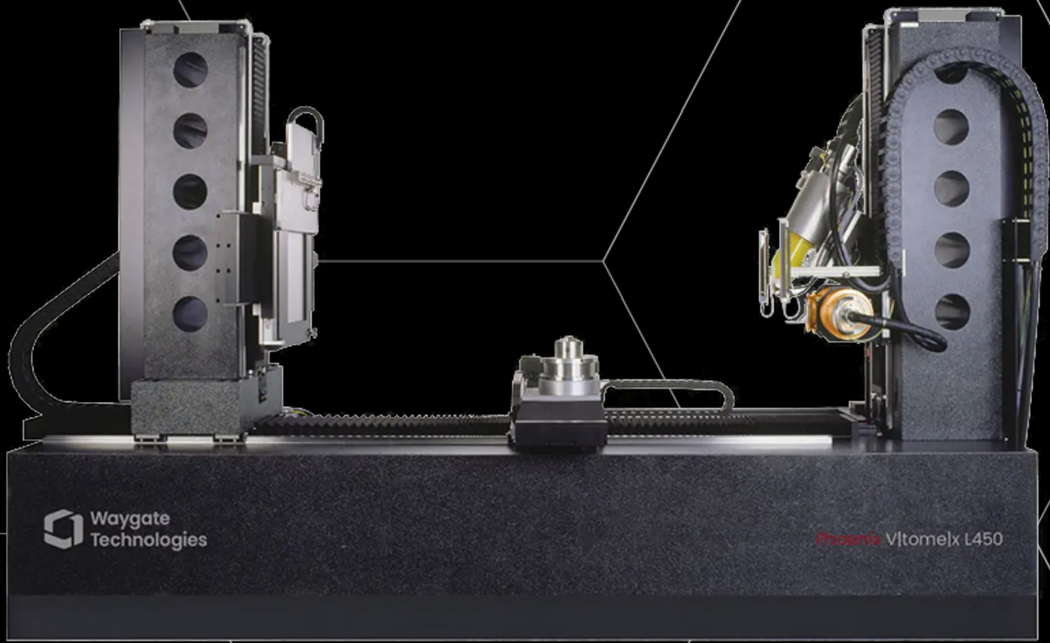
CEITEC CTLAB

BRNO UNIVERSITY OF TECHNOLOGY



More information about Phoenix v|tome|x L450 on page. 2.

NEWSLETTER AUTUMN 2025

It is a pleasure for me to present you with a new issue of the newsletter of our Laboratory of X-ray Micro and Nano-Computed Tomography at CEITEC BUT. You can read about some of our recent explorations, including introduction of our new CT with 450 kV x-ray source.

Enjoy reading!

Tomáš Zikmund
Head of the laboratory

NEW CT SYSTEM WITH 450 KV SOURCE

In the last newsletter, we shared the measurement of the student formula in the Waygate Technologies Phoenix v|tome|x L450 device at the manufacturer in Germany. Now we are pleased to announce that this device is already installed in Brno, in a completely unique configuration, aimed at pushing our capabilities towards larger and heavier samples. At random, we can mention a 7-axis manipulator with a sample load capacity of up to 200 kg, an internal space of almost three meters, the possibility of virtually expanding the scanned area by moving the detector up to 3 times, and most importantly, two sources with an acceleration voltage of 450 kV (Fig. 1).

The first X-ray tube is from the mini-focusing category and will offer a power of up to 1,500 W. It will thus become the most powerful source in our portfolio, capable of irradiating up to 7 cm of steel in cumulative thickness. The second X-ray source has a relatively new meso-focusing technology, which allows a relatively small spot size to be maintained even at higher power. Thanks to this, even at the maximum applied voltage, it is possible to achieve a resolution of the order of tens of micrometers. A more detailed comparison with our largest device to date can be found in the table below.

Instrument parameters	L240	L450
Maximal voltage / power	240 kV / 320 W	450 kV / 1500 W
Minimal spot size	~1 µm	63 µm
Maximal focus detector distance	1580 mm	2810 mm
Flat panel detector shift	2×	3×
Cabinet dimensions	4100×2600×2800 mm	6400×3900×4300 mm
Maximal cumulative wall thickness of materials:		
Steel / Inconel	40 mm	70 mm
Al, Ti, Zn, Mg	<150 mm	<250 mm
Plastic Composites	<250 mm	<450 mm

Tab. 1: Comparison of key limits of our laboratory's largest CT system to date (L240) with the newly acquired one (L450).

For handling larger samples, the device has a barrier-free entrance and its own crane inside the shielding cabinet. The cabinet is also equipped with an extra labyrinth connecting the interior and exterior of the cabinet, which allows the samples to be connected to any device that simulates operating conditions. Other interesting features of our new CT system are advanced scanning trajectories or advanced hardware correction of scattered radiation, but more on that next time.

NEW CT SYSTEM WITH 450 KV SOURCE

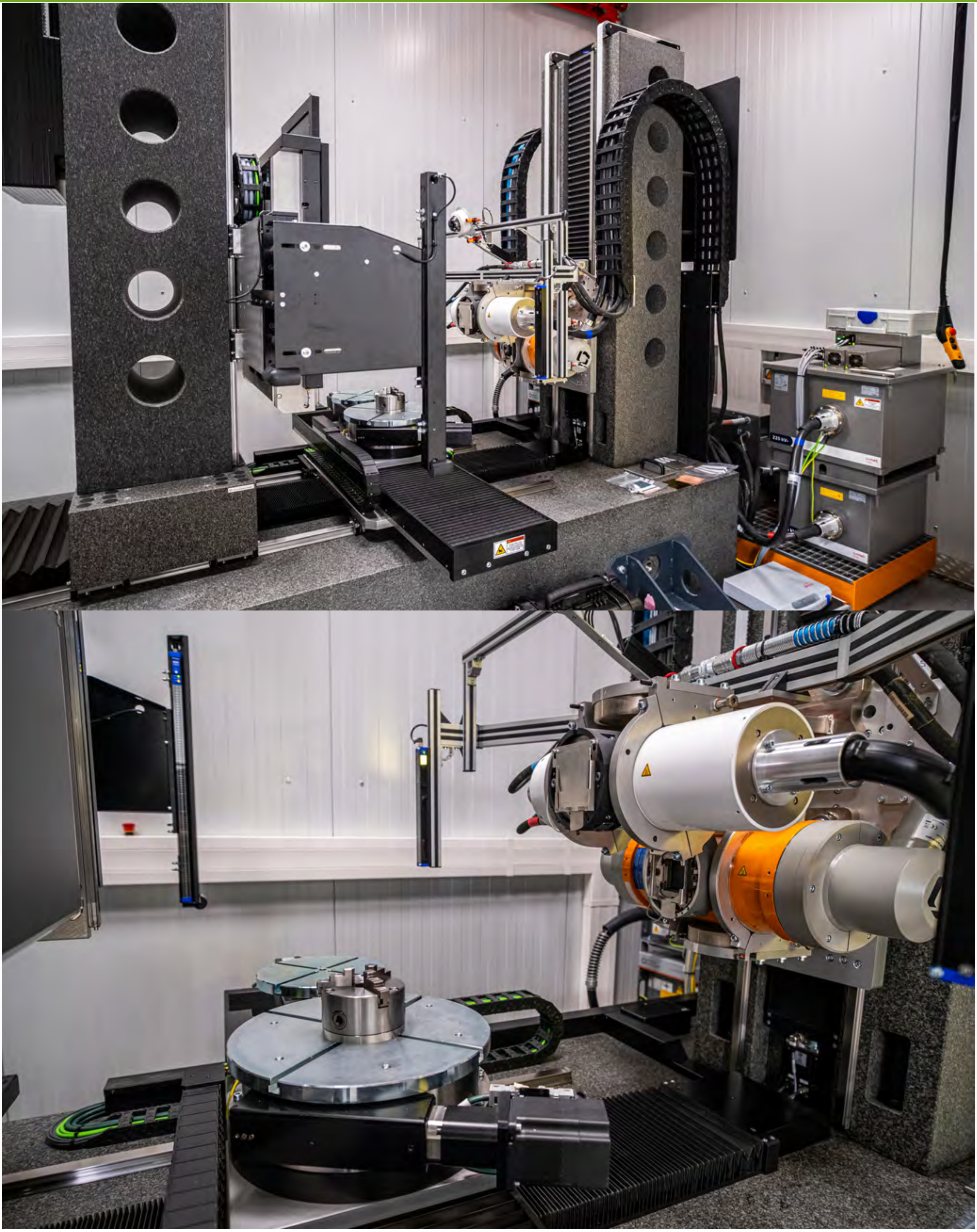


Fig. 1: Interior of Phoenix v|tome|x L450 protective cabinet.

Author: Martin Kareš

HIGH-RESOLUTION CT STUDY OF ANCIENT, CARBONIZED MAYA FOOD REMAINS

In archaeology, the study of food remains reveal how simple ingredients were transformed into complex dishes and sheds light on ancient culinary traditions. Analyzing their microstructure can help us reconstruct recipes and gain a broader understanding of past environments, societies, and health.

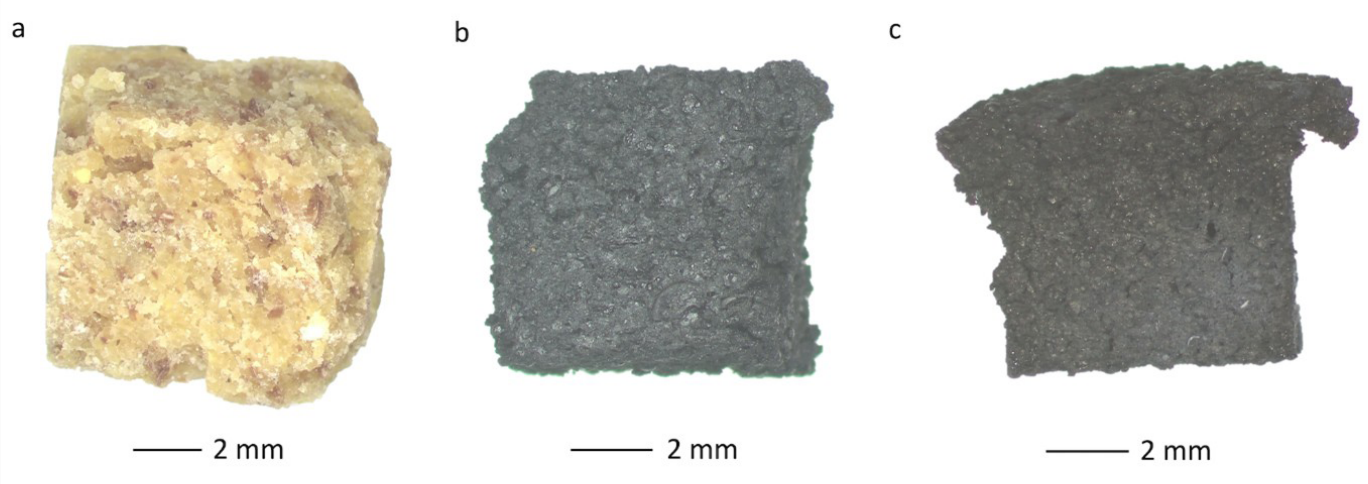


Fig. 2: Experimental sample composed of maize dough and bean flour, heated at different temperatures: a) 80°C for 24h; b) 300°C for 60 minutes; 500°C for 15 minutes.

The present study focused on foods processed by the ancient Maya during the Classic period (AD 250-900). The aim of our CT analysis was to identify the presence of maize kernels and other seeds in small, amorphous carbonized organic fragments (see Fig. 3). We compared both archaeological remains and experimental food composed of maize dough that underwent several types of heat treatment to simulate the conditions of the archaeological samples (see Fig. 2). While more detailed findings are yet to be analyzed, this study confirms that micro-CT technology (with a nano-focus tube) can achieve sufficient resolution to replace synchrotron systems for similar tasks.

These measurements were performed as part of the Excite project, which connects scientists and state-of-the-art laboratories, such as ours, to provide high-quality science techniques to applicants. We thank Clarissa Cagnato, Ph.D. from Ca' Foscari University of Venice for this experience and opportunity to share these insights with you.

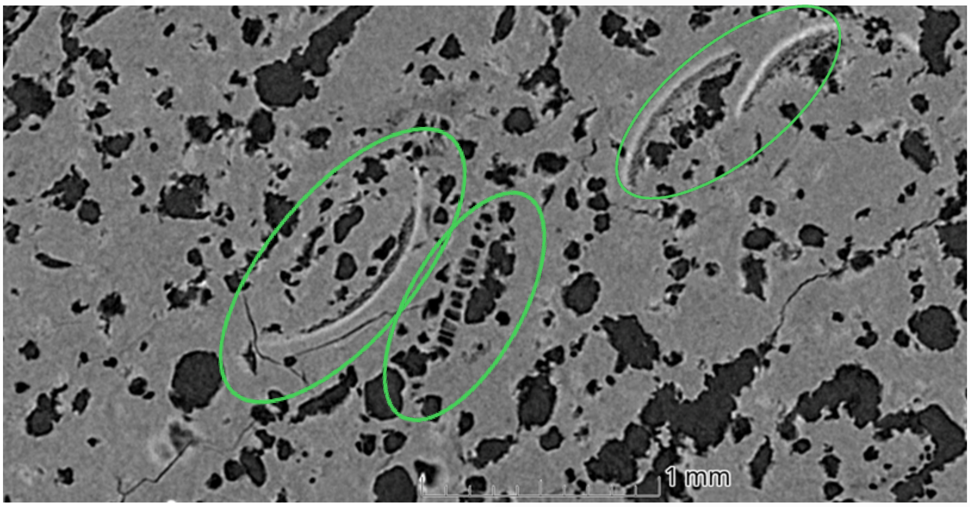


Fig. 3: Tomographic cross-section showing examples of identified food structures in experimental sample.

Author: Martin Kareš, Clarissa Cagnato

SUBMICRON CT ANALYSIS OF POLYMERS

Plastic polymers and composite materials play a crucial role in many modern industrial sectors, from the automotive industry to medical applications. Their microstructure fundamentally affects the mechanical properties, making detailed analysis essential for research, development, and quality control in manufacturing processes. Submicron computed tomography (submicron CT) has emerged as an ideal and powerful method for this demanding task. Conventional methods for polymer analysis often encounter significant limitations. Traditional CT systems lack sufficient resolution to detect microstructures on the micrometer scale. Moreover, polymers frequently exhibit similar X-ray attenuation values, making them difficult to distinguish.

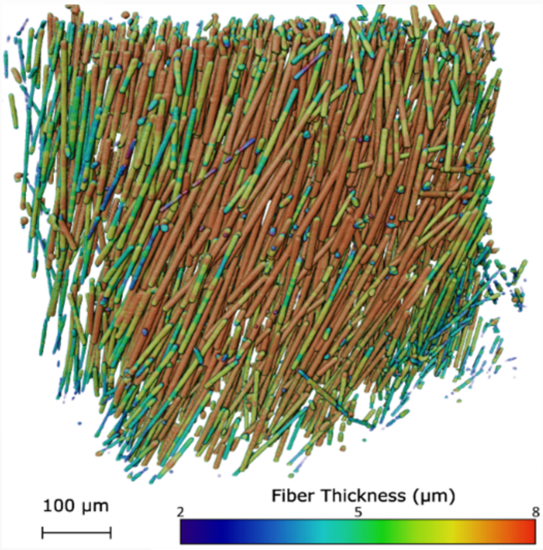


Fig. 4: Thickness analysis – fiber thickness in a CFRP sample.

Thanks to the Rigaku nano3DX X-ray microscope with phase-contrast capability, we can analyze the fiber thicknesses of carbon-fiber-reinforced composites (CFRP) in the range of 2 to 8 µm with submicron resolution (see Fig. 4), and to identify up to four different materials within the sample based on grayscale values (see Figs. 5 and 6). The nano3DX even enables us to distinguish polymers with very similar densities, such as HDPE (0.93 g/cm³) and LDPE (0.91 g/cm³), which is a challenge for conventional CT systems.

This level of detail enables quality control, prediction of mechanical properties, and the development of new polymer blends and composites. It allows not only the detection of defects and inhomogeneities, but also for the quantification of microstructural parameters such as fiber orientation, the presence of impurities, cracks, and material irregularities. Submicron CT analysis thus becomes a key tool for materials development and research.

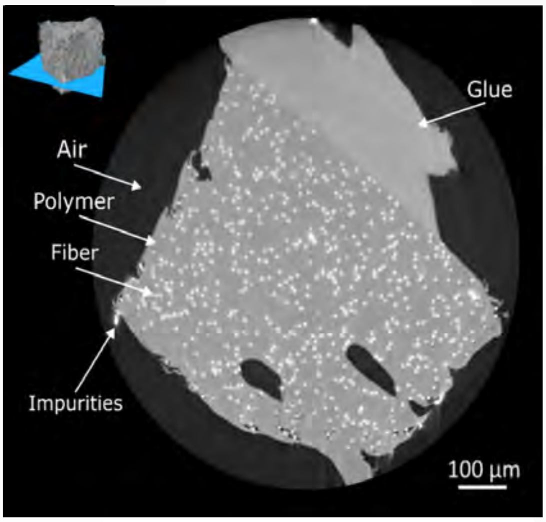


Fig. 5: CT cross-section of a CFRP sample showing five different phases (air, polymer, fibers, impurities, and glue).

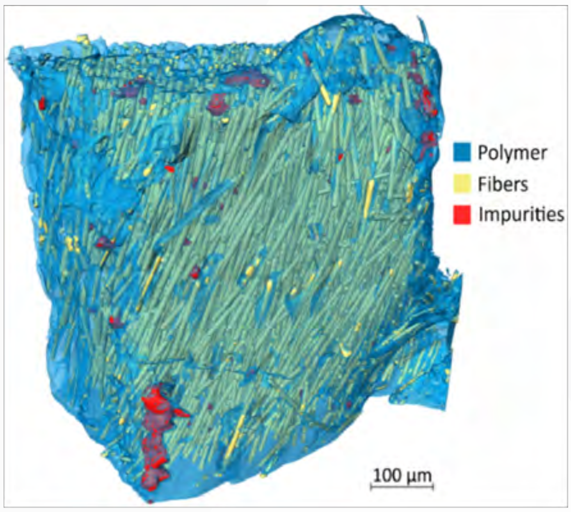


Fig. 6: 3D render of a CFRP sample (polymer composite) visualized into a semi-transparent polymer matrix, fibers, and impurities.

Auhor: Lukáš Maleček

CRYOGENIC CT FOR IMAGING MUSCLE FIBERS

Muscle fibers are the basic functional unit of muscle tissue. Their spatial organization, diameter, and mutual arrangement directly determine the mechanical properties and function of the tissue. Any changes in their architecture are therefore of fundamental importance for physiological development and for the onset and progression of disease. The problem is that commonly used methods cannot accurately capture this architecture – histological sections provide only a limited 2D view, and even conventional micro-CT cannot adequately image muscle fibers (Fig. 7).

A breakthrough has been achieved with a method known as cryo-CT, which combines standard procedures with rapid freezing of the sample and subsequent scanning at low temperatures. The resulting scan then allows individual muscle fibers to be displayed in a true-to-life 3D image, providing not only qualitative insight into the structure of biological samples (Fig. 7) but also enabling quantitative analysis of selected morphological parameters such as their diameter, density, or orientation, in an almost native state, preserving the natural architecture of the tissue. To introduce this method in our laboratory, we collaborated with CactuX, s.r.o. to modify their in-situ box, which allows samples to be measured in a frozen state and maintains a temperature of -35°C throughout the scan. Cryo-CT thus enables detailed study of the development and structural changes of muscle tissue and is used in studies of regeneration, degenerative changes, the influence of genetic interventions, pharmacological therapies, and physiological or biomechanical analyses.

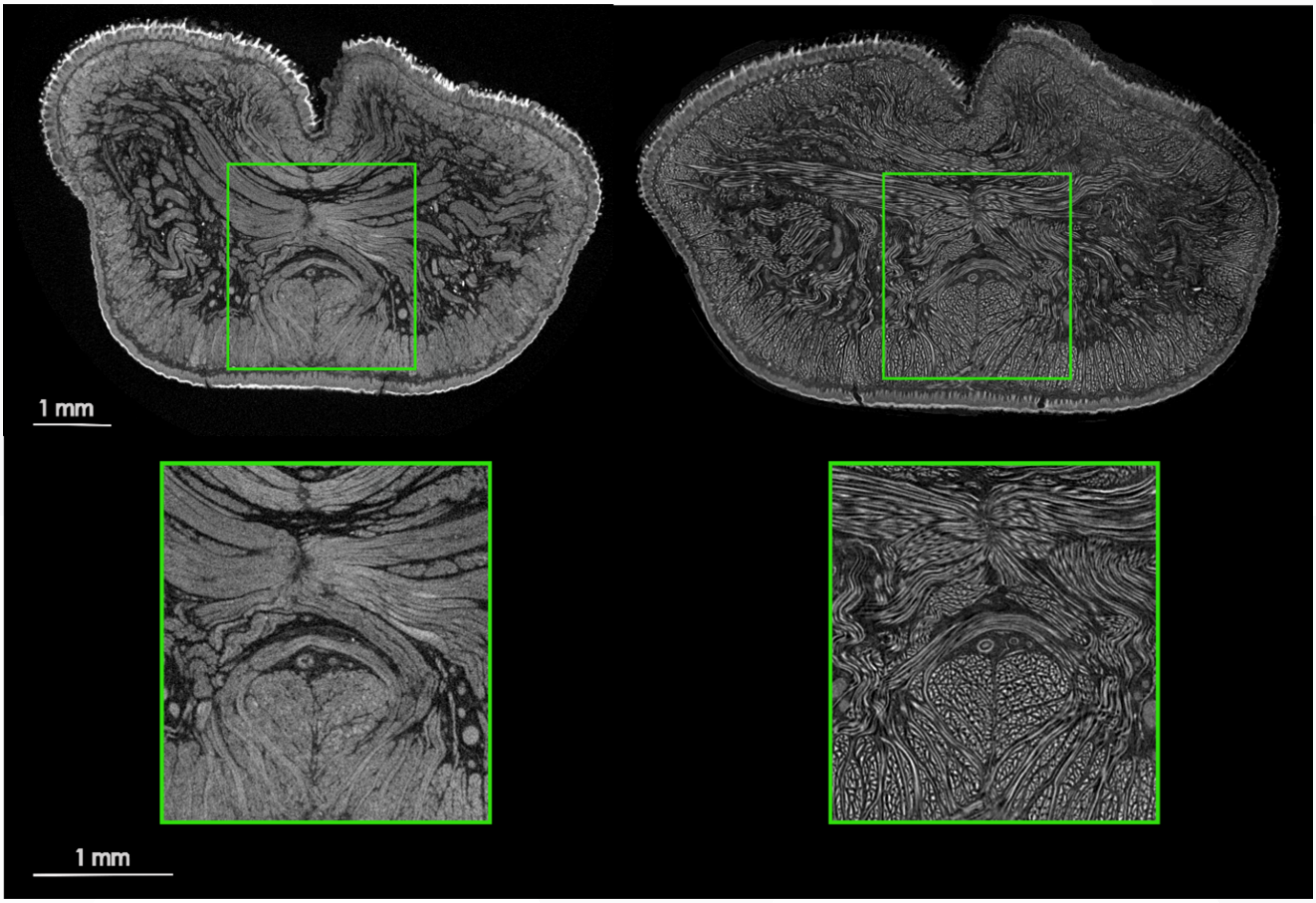


Fig. 7: Cross-section showing detail of rat tongue in standard CT (left) and cryo-CT at -35°C (right). Voxel size 3 μm.

Author: Petra Procházková

EXPANDING QUALIFICATIONS FOR X-RAY EXAMINATION IN THE AVIATION INDUSTRY

In recent years, our laboratory has been striving to provide expertise based on known standards. In addition to the evaluation standards themselves, it is also necessary to comply with the required procedures and parameters of non-destructive X-ray testing. In addition to the current qualification according to **ČSN EN ISO 9712**, covering non-destructive testing in general across various applications, we now also have a qualification according to **ČSN EN 4179**, focused on the evaluation of welds and castings from the field of aviation and astronautics.

Thanks to both of these certifications, we are able to more precisely evaluate the admissibility of defects in analysed samples and determine its resulting classification into the appropriate quality class. Imaging can be performed both on tomographic stations and on a specialized Microme|x device, the acquisition of which we wrote about in the previous issue.

Author: Martin Kareš

EXPO OSAKA 2025

EXPO 2025 in Osaka was visited by doc. Zikmund (Fig. 8), the key point was the renewal of the Memorandum between Rigaku and CEITEC BUT.

Our laboratory has been serving as their application laboratory for 10 years, this partnership has now been extended for another three years - the agreement includes joint research and student exchange. The signing took place in the ceremonial environment of the Czech House at the aforementioned EXPO 2025.

Fig. 8: From the left T. Zikmund, K. Omote, P. Oberta, Y. Takeda.

Author: Michaela Škaroupková

WOOSUK UNIVERSITY AT CEITEC VUT

FEEC, Brno University of Technology signed a five-year memorandum of cooperation with Woosuk University (Korea). The agreement opens up new opportunities for research, education and technological development. As part of its visit, the Korean delegation also visited CEITEC - Central European Institute of Technology, where CTLAB presented the possibilities of cooperation in the field of non-destructive testing (NDT). The visit was organized by the Mechanical Engineering Testing Institute (SZÚ). The partnership will focus primarily on hydrogen technologies, batteries and other advanced areas in energy and electronics - areas that are key to the global transition to clean energy and cutting-edge solutions.

Fig. 9: Delegation from Woosuk university, members of the SZÚ and members of CTLAB.

Author: Michaela Škaroupková

CONTACT US

Assoc. Prof. Tomáš Zikmund
tomas.zikmund@ceitec.vutbr.cz
+420 541 142 846

www.ctlab.ceitec.cz
ctlab@ceitec.vutbr.cz
+420 541 142 875

CEITEC BUT
Brno University of Technology, Central European Institute of Technology
Purkyňova 656/123, 612 00 Brno