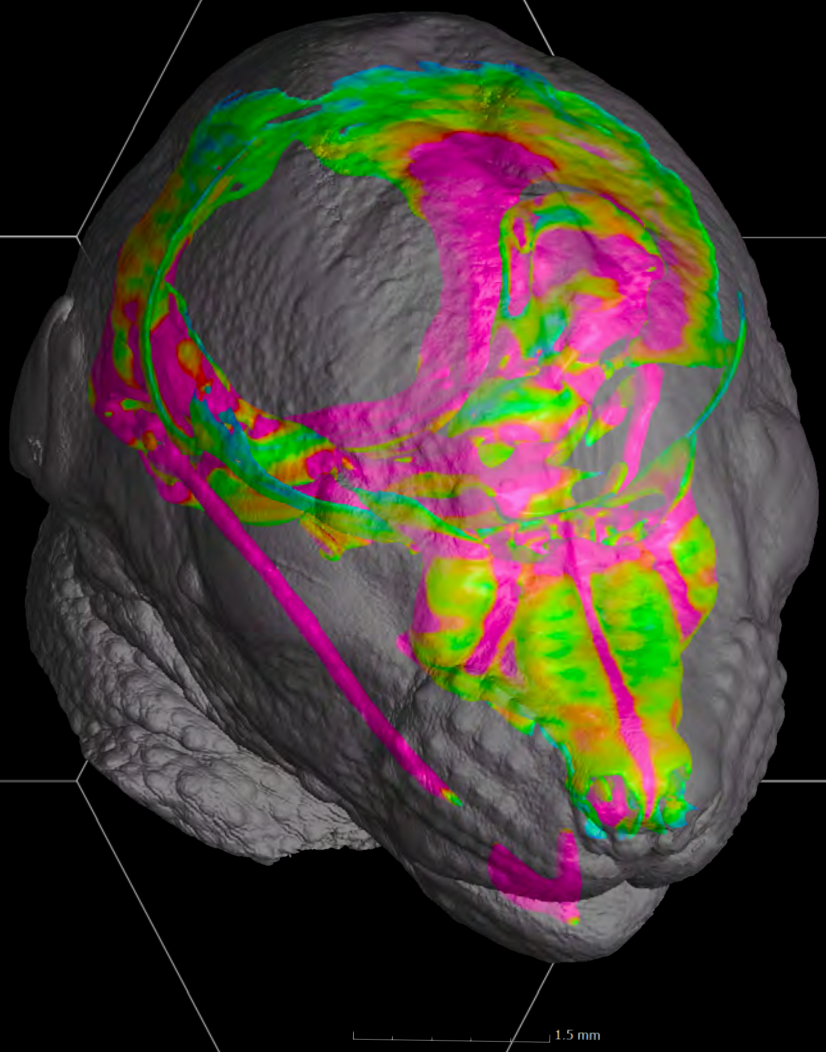
CEITEC CTLAB

BRNO UNIVERSITY OF TECHNOLOGY




The mother's protein intake during pregnancy can affect facial development. More on page 7.

# NEWSLETTER SPRING 2024

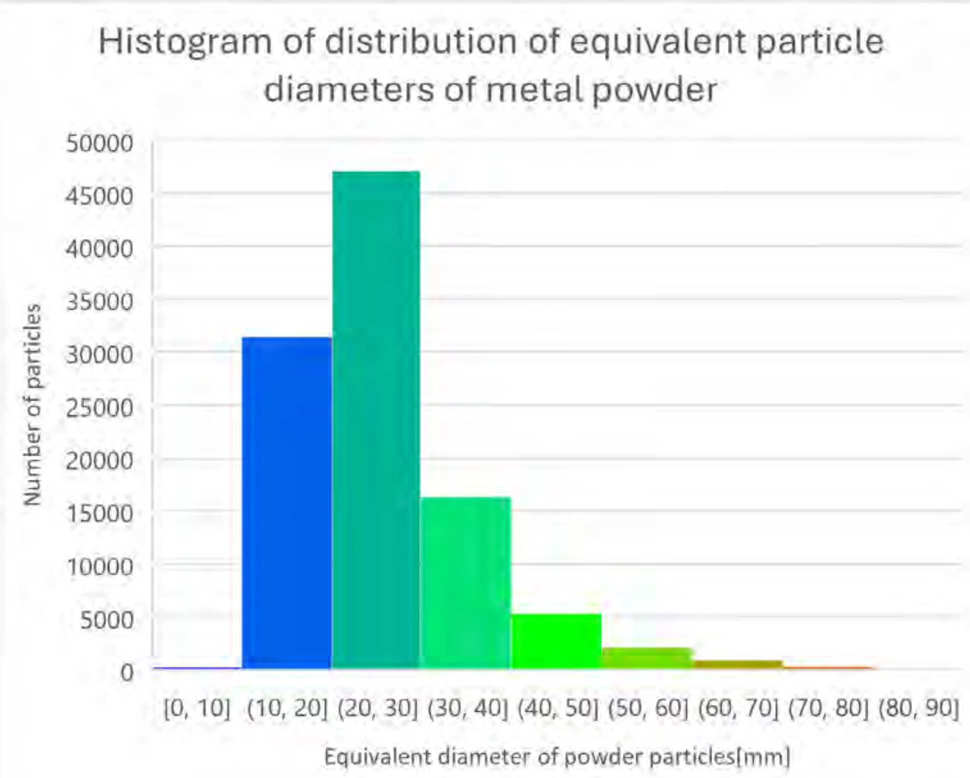
It is a pleasure for me to present you with a new issue of the newsletter of our Laboratory of X-ray Micro and Nano-Computed Tomography at CEITEC BUT. You can read about some of our recent explorations, including evaluation of metal powder for additive manufacturing according to space industry standards, up to CT characterization of self-healing alloys.

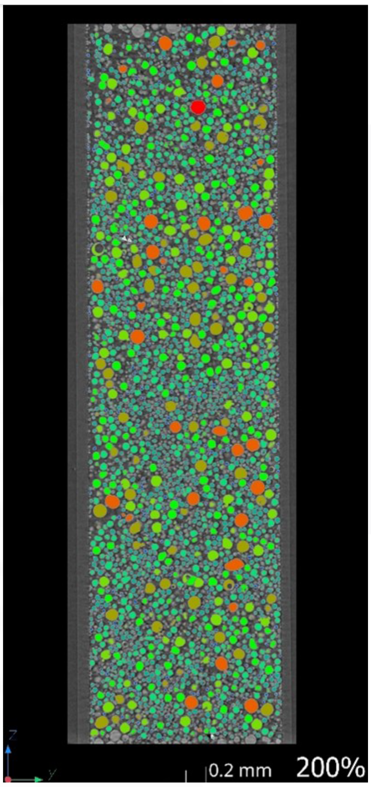
Enjoy reading!

**Tomáš Zikmund**
**Head of the laboratory**

# EVALUATION OF METAL POWDER FOR ADDITIVE MANUFACTURING ACCORDING TO SPACE INDUSTRY STANDARDS

The inspection of the input raw material (powder) is the initial analysis in the additive manufacturing process. The size of the powder particles, their shape or presence of air pores can affect the manufacturing process and the quality of the final product. Such inspections serve to verify the supplier of new powders, but they are even more important in the case of reused powders* by which manufacturers minimize production costs.




Graph 1: Histogram of distribution of equivalent particle diameters of analysed metal powder.

Fig. 1: Longitudinal tomographic cross-section through analysed particles, coloured according to their equivalent diameter.

We had the opportunity to familiarize ourselves with the issue in detail during the analysis of AlSi10Mg alloy powder for the mini satelitte body. The aim of our analyses was to define the distribution of powder particles according to their diameter and sphericity and to find out portion of internal porosity.

The analysis procedure was designed in accordance with the ECSS Q-ST-70-80C standard (Space product assurance: Processing and quality assurance requirements for metallic powder bed fusion technologies for space applications). The powder we tested had particles in the order of tens of micrometres in size, see graph 1. In order to be able to achieve the necessary resolution, it was needed to scan a very small volume. The powder for CT analysis was therefore placed in a thin tube made of light material with an internal diameter of 1 mm, see Fig. 1. Even in such a small volume however, it is possible to image more than 100,000 particles.

* powder taken from the chamber after production and sifted through sieves.

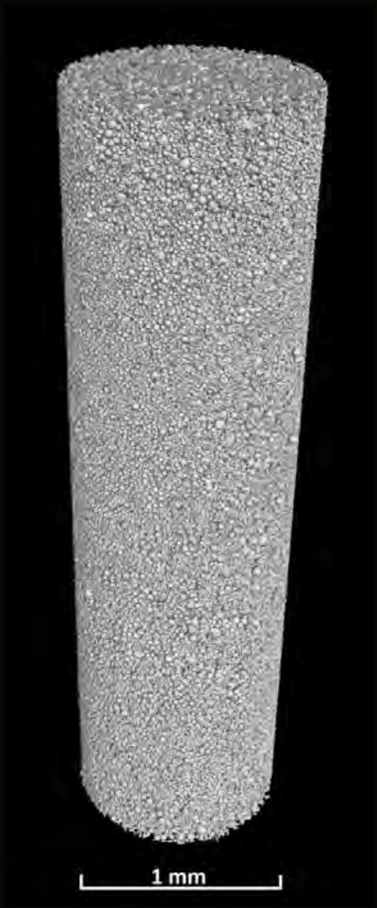



Fig. 2: 3D visualization of scanned particles.

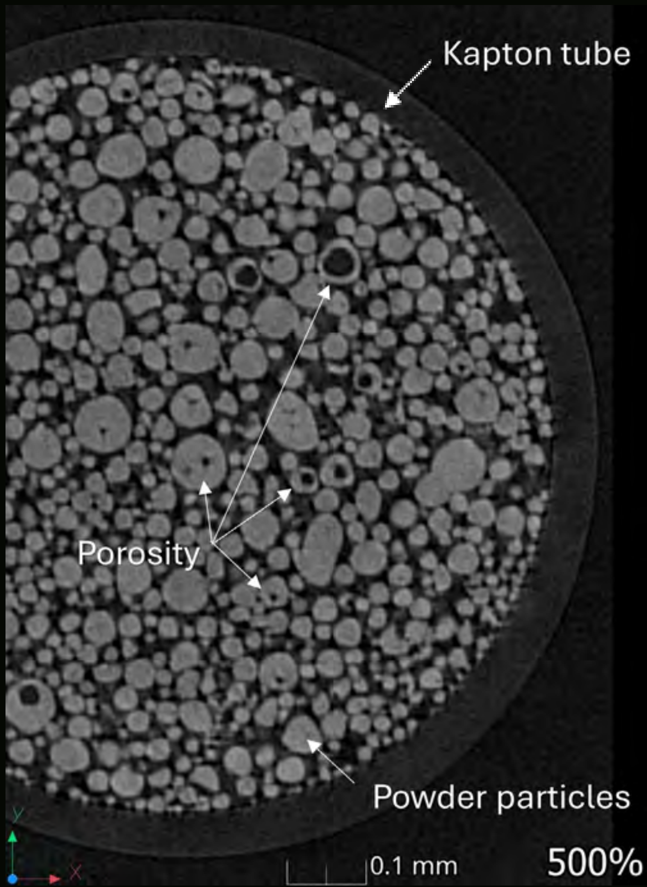



Fig. 3: Tomographic cross-section of aluminium powder particles.

# BENEFITS OF UNROLL VIEW IN VGSTUDIO MAX SOFTWARE

In certain situations, compared to standard orthogonal views, it can also be beneficial to use non-standard, so--called non-planar views when inspecting data in the VGSTUDIO MAX software. One such view is the unfolding of a curved element into a plane. Various geometrical objects can be the basis for this unfolding, for example a curved line, circle, cylinder, cone, sphere, etc. Various irregular shapes and curves can also be used.

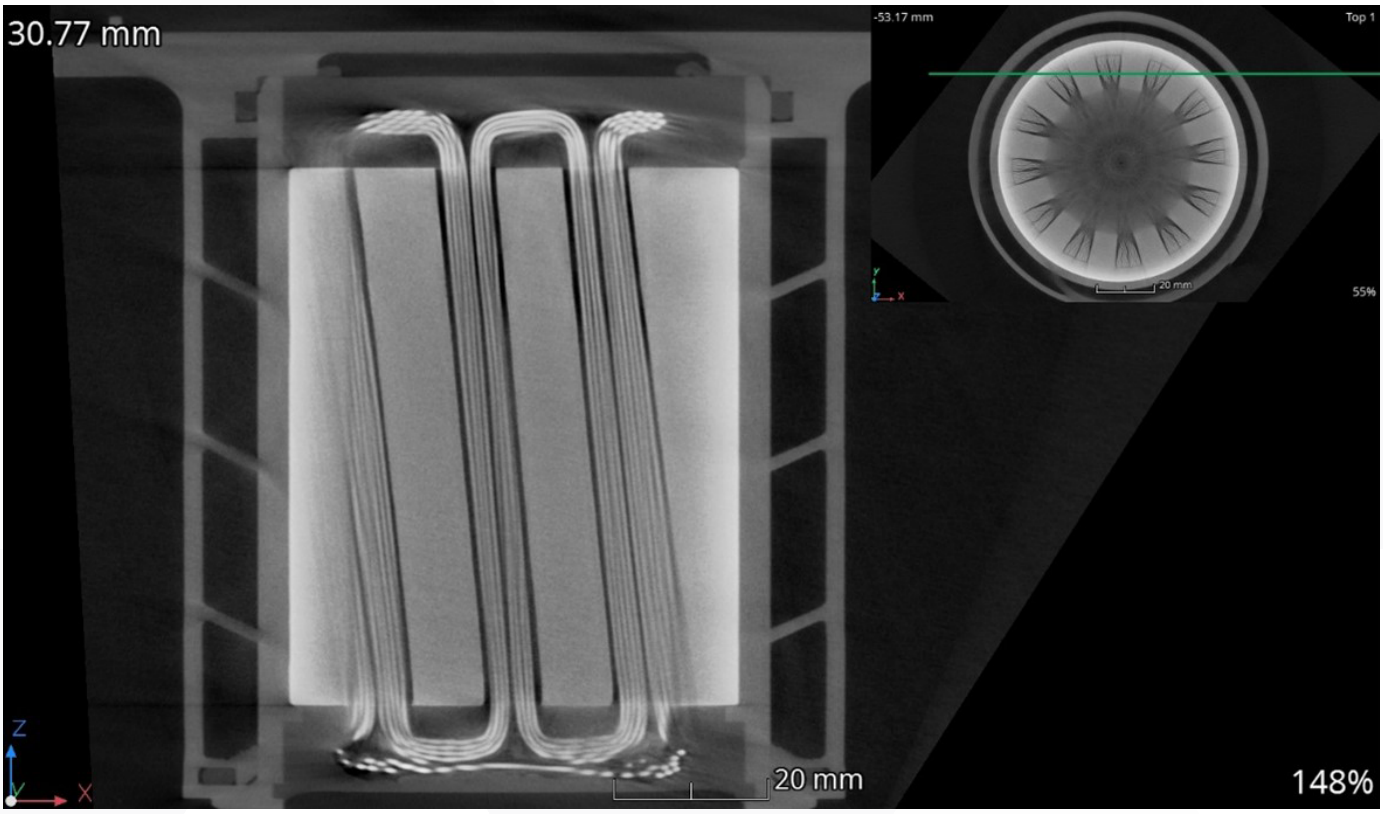



Fig. 4: Example of a classic orthogonal cross-section through the stator.

The analysis of an electric motor stator can be a concrete example of using this view in the data. The inspection of the geometric dimensions of the stator, including the inspection of the winding, was the main motivation for scanning of the sample. Winding inspection is a great example where using a non-planar view can be beneficial.

Using conventional orthogonal views (as shown in Fig. 4), we are able to capture an area approximately the size of two loops of copper winding at most. Due to the shape of the winding, it is also not a very suitable cross-section. On the other hand, with unroll view, which respects the rotating shape of the stator, we are able to display the winding in its entire length and constant depth from the axis of rotation of the stator (as shown in Fig. 5). In this case, a cylinder defined by the outer surface of the stator body was used to define the view (see Fig. 6). The view subsequently works with cuts in an infinite number of smaller (or larger) outer surfaces of this cylinder and develops these into a planar view (see Fig. 5).

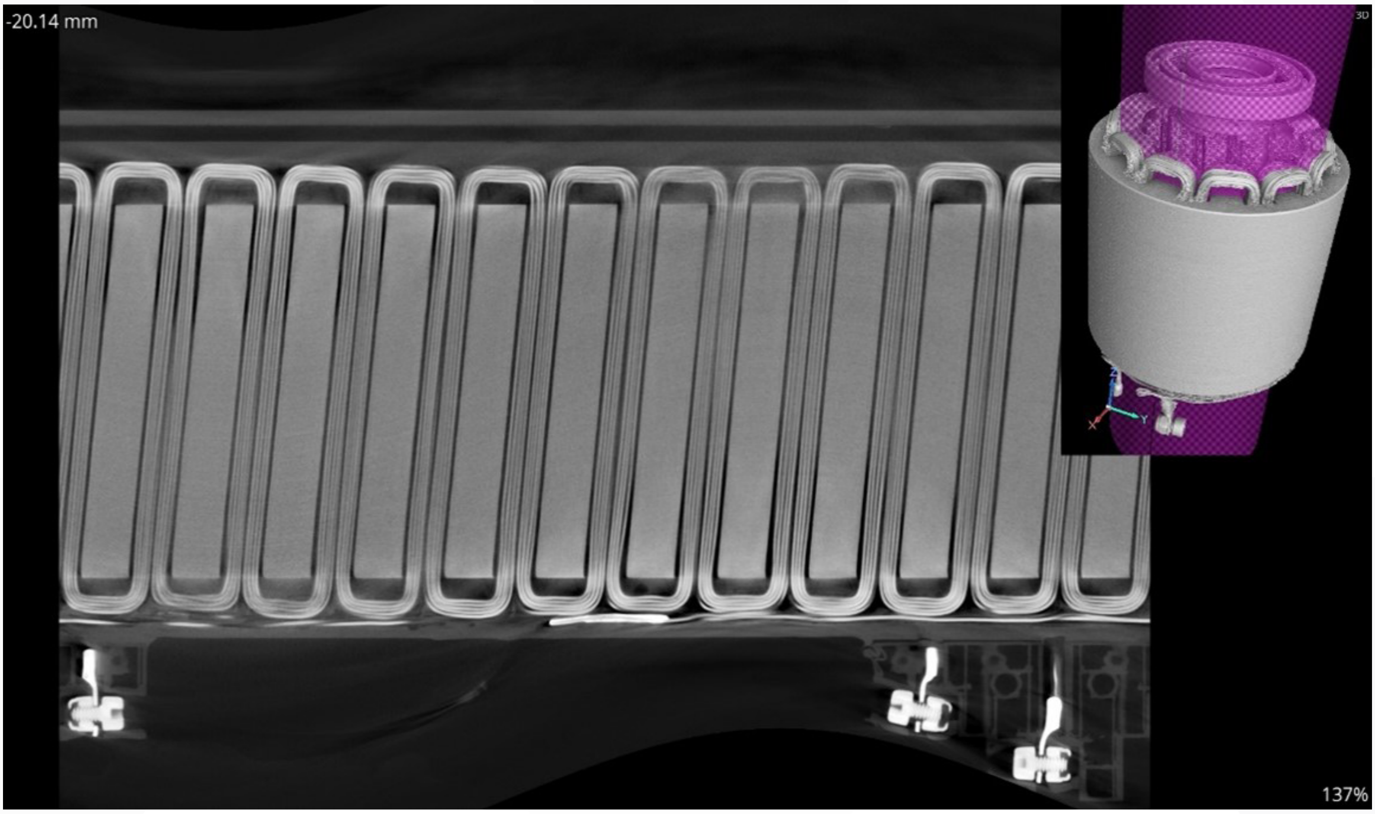



Fig. 5: Unroll view of the inner winding of the stator.

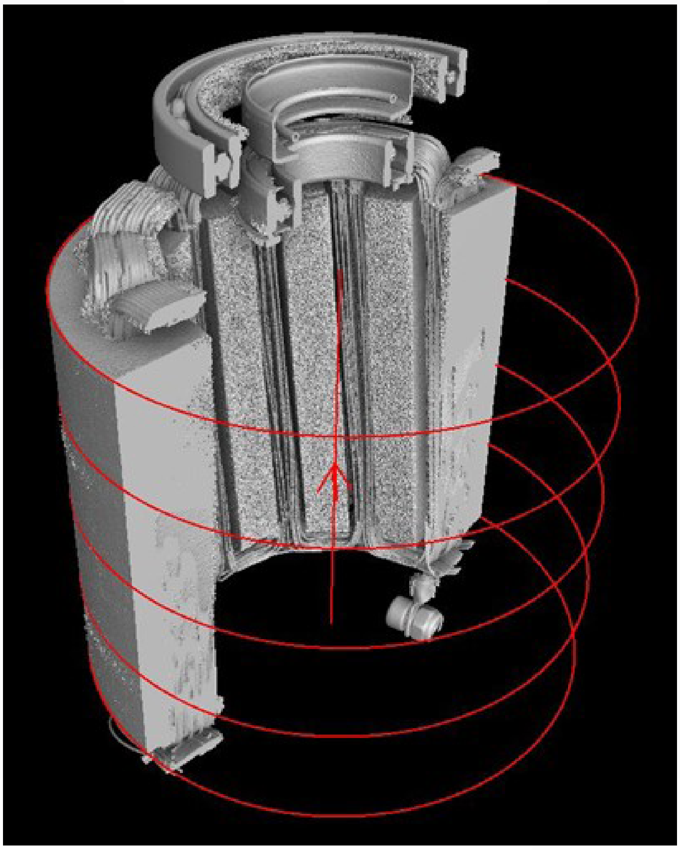


Fig. 6: Geometric element (cylinder) used for unroll view definition.

# EXPLORE THE FUTURE OF MATERIALS: SELF-HEALING ALLOYS

Self-healing alloys are relatively new and rapidly evolving materials of the future. These are alloys of materials that have the ability to repair their own damage, most often through the action of heat, pressure or both (Fig. 7). Industrial parts made from self-healing alloys promise increased strength and longer lifespan compared to standard alloys. These properties are achieved through the ability to heal porosity in the material created during manufacture, and to facilitate easy repair of cracks created during use. Utilizing 3D printing, complex geometries can be created from these alloys, as well as replacing the full volume of material with a support structure, so that the printed shape is lighter and uses less material. 3D printed aluminium alloys thus have the potential to be used in the aerospace and defence industries for the construction of load-bearing structures and components due to their strength and relatively low weight.

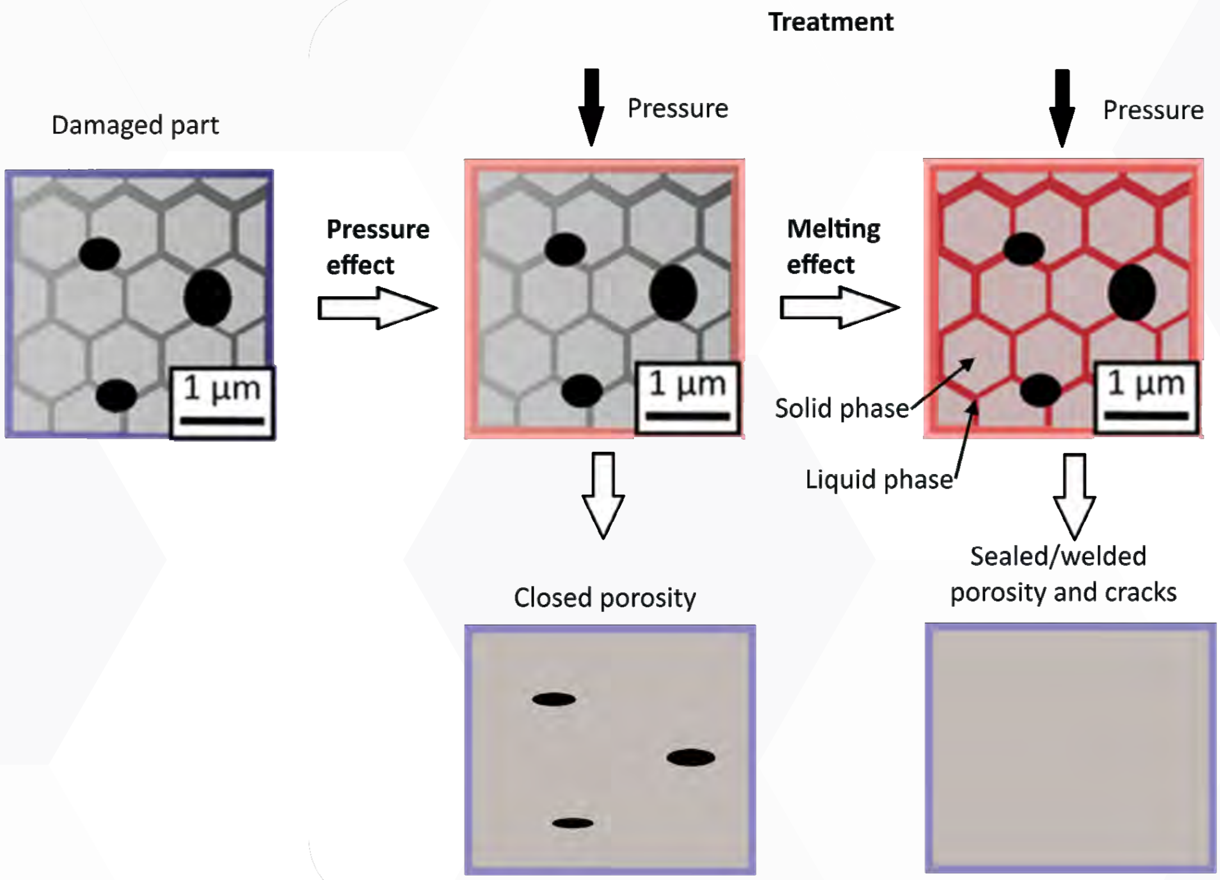



Fig. 7: Self-healing process diagram. On the left, a diagram of the damaged part of the printed sample. In the middle, a diagram of healing after pressure application. On the right, a diagram after the application of both pressure and temperature. Amended from: [https://doi.org/10.1016/j.scriptamat.2023.115512](https://doi.org/10.1016/j.scriptamat.2023.115512)

With the support of the M-ERA.NET project, our laboratory is working on the characterization of these aluminium self-healing alloys. Specifically, in collaboration with the University UC Louvain, we focus on the characterization of the internal structure of printed parts using micro and nano CT. CT analysis allows for precise determination of the amount of porosity inside the printed part and provides the possibility to assess changes in the internal structure before and after the self-healing process. This approach can verify the effectiveness of the self-healing process and optimize both, the composition of the printing powder and the printing process itself.

Author: Jakub Lázňovský

# THE MOTHER'S PROTEIN INTAKE DURING PREGNANCY CAN AFFECT FACIAL DEVELOPMENT

Scientists from our laboratory participated in a multidisciplinary study suggesting a possible connection between the face of the offspring and protein intake during pregnancy. This study led by prof. Andrei Chagin from the Swedish University of Gothenburg, was published in the prestigious journal Nature Communications. The study was conducted on mice, or mouse embryos. Specifically, they focused on the mTORC1 signaling pathway, which has a key role in the regulation of various cellular processes, including growth and metabolism. However, whether the protein content of the pregnancy diet can influence mTORC1 and play a role in the formation of facial bone structure was not yet known. Scientists from our laboratory created 3D models of cartilage tissue (Fig. 8), which is the basis for the subsequent development of the face. Differences between embryos from mice fed with different protein diets were noticeable. An enlarged nasal cavity or an elongated jaw were observed, for example. The study thus shows that the amount of protein in the diet can affect mTORC1 and thus the subsequent musculoskeletal development. In mammals, the shape and features of the face are influenced not only by genetics, but also by the mother's lifestyle during pregnancy. In what direction, i.e. how to use this newly discovered knowledge in practice, is a matter of further research.

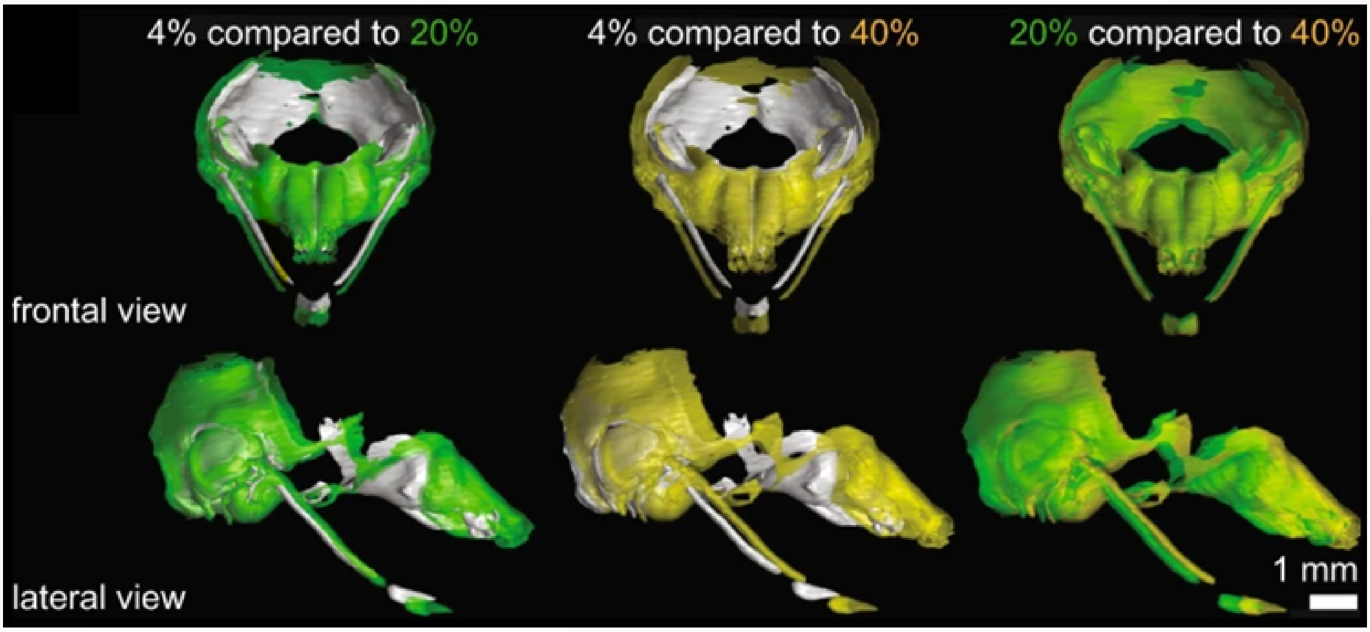



Fig. 8: 3D models of cartilage tissue of mouse embryos created using X-ray computed microtomography. The different colors of the models represent different protein diets.

Link to the article: https://www.nature.com/articles/s41467-024-46030-3

Author: Markéta Kaiser

# FOREIGN SCIENTISTS WILL USE OUR FACILITIES

Starting from April 1st, 2024, the CT laboratory together with the LIBS laboratory has become a part of the EXCITE2 Network. This European infrastructure dedicated to advancing research and innovation in the areas of Earth and environmental material sciences is connecting 18 partners from Europe and Australia, providing researchers from Europe and associated countries the access to cutting-edge facilities including techniques such as electron microscopy, X-ray computed tomography, laser-induced breakdown spectroscopy and more. This initiative was established to enhance the international collaboration within the scientific community and to address challenges such as environmental factors affecting human health, healthy oceans and waters, nanoscience and nanotechnology, climate-change risks, renewable energy, and sustainable Arctic and polar regions. A free-of-charge transnational access to the participating institutions can be achieved after a proposal submission.

For more information see the website.

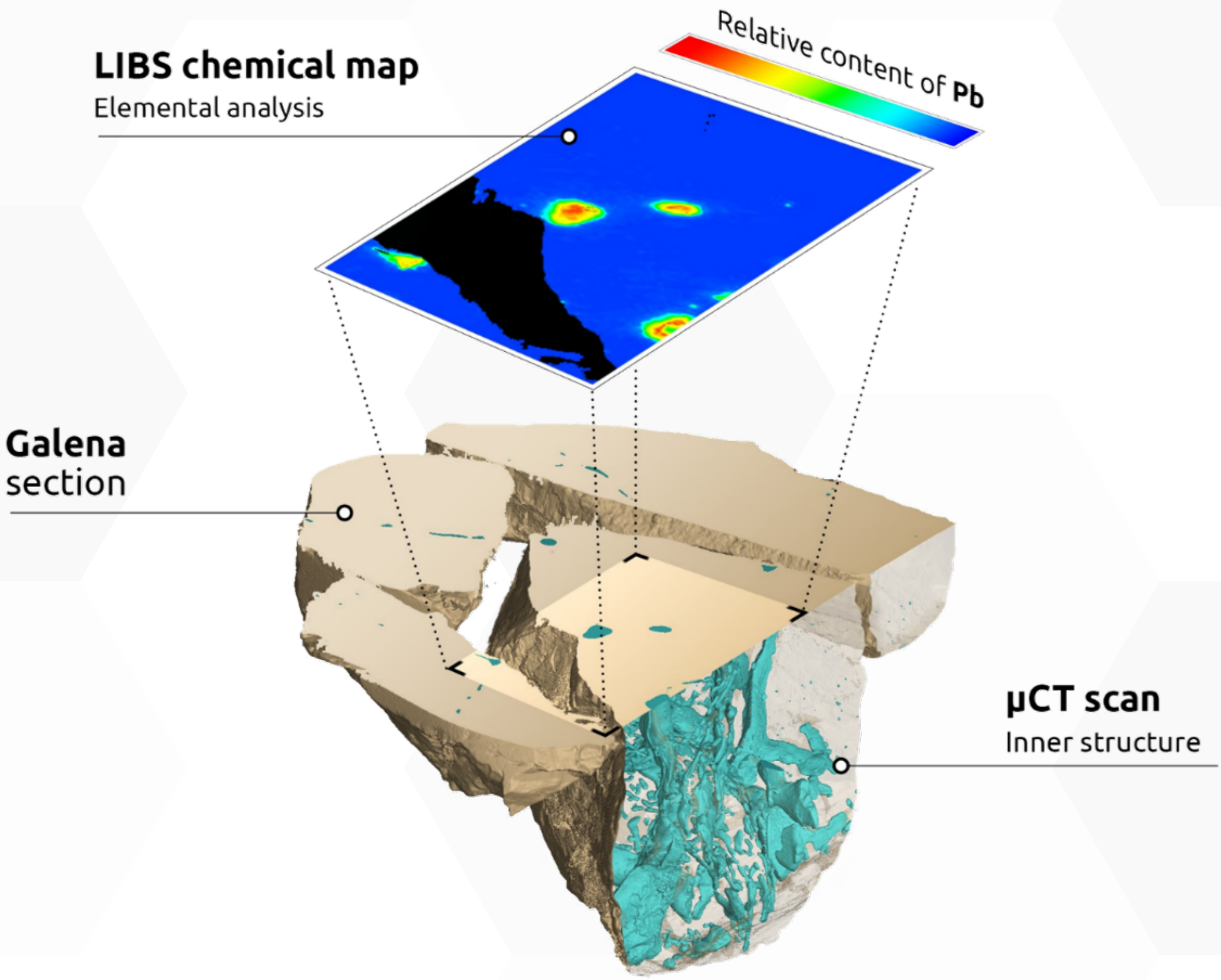



Fig. 9: 3D rock model with a combination of LIBS analysis.

Author: Tomáš Zikmund

# CZECH BATTERY CLUSTER

Our laboratory is a member of the Czech Battery Cluster (ČBK), which aims to ensure a partnership between the public and private sectors, supporting the cooperation of private companies, the research sphere and the public sector. This cooperation focuses on real projects for the development of an emission-free economy, technological changes in industry, scientific and technical projects, support for innovative business and international cooperation.

On February 26th - 27th, 2024, the 1st members' meeting of the ČBK was held. New members of the cluster were introduced and interesting topics from the field of energy storage and others were discussed.


Fig. 10: Members of ČBK.

Author: Michaela Škaroupková

# MEMBERS OF OUR LABORATORY IN V4SDB

Participation in V4SDB (Visegrád Group Society for Developmental Biology) conferences has already become a regular part of our laboratory. The involvement of X-ray computed tomography in biological research is one of the scientific directions of our laboratory. To strengthen this research direction and strengthen further cooperation, we decided to join the initiative of short and long-term research internships for other members of this membership. We offer students and other researchers the opportunity to spend some time in our laboratory, where we will introduce scientists from the biological environment not only to measurements, but also to the processing of biological data, which offers certain specificities. We believe that this step will contribute to breaking down the barriers between the technical world and biological research and will lead to interesting scientific discoveries.

Author: Markéta Kaiser

# ICT CONFERENCE 2024

The 2024 iCT conference was launched in Wels, Austria, at the beginning of February, where the 13th edition of this important event in the field of industrial computed tomography was held. The conference is characterised by the networking of companies involved in the development of CT systems and the scientific community, which processes and analyses CT data. Among the main points of the program were intriguing lectures given by Pavel Blažek with the theme „Improving resolution through variable magnification trajectory in X-ray computed tomography for decomposition of low-atomic number materials". The conference had a diverse programme covering various aspects of industrial CT, with artificial intelligence being a major theme. The participants also enjoyed a tour of the laboratories hosted by the University of Applied Sciences Upper Austria. Organisers of @University of Applied Sciences Upper Austria, our heartfelt thanks and we look forward to next year's iCT 2025 in Antwerp, Belgium.


Fig. 11: The team of our laboratory, from the left Markéta Tkadlecová, Pavel Mikuláček, Assoc. Prof. Tomáš Zikmund (Head of the laboratory), Prof. Josef Kaiser (Research group Leader), Zuzana Stravová, Pavel Blažek a Marek Zemek.

Author: Pavel Mikuláček

# INTERNSHIP IN SASKATOON, CANADA

Our PhD student Viktória Parobková currently represents our institution at the University of Saskatchewan in Saskatoon. She joined the research group of Dr. Heather Szabo-Rogers, who specializes in the study of craniofacial cartilage development. Her internship includes the preparation and scanning of biological samples, as well as many biological analyses, including histology, immunohistological staining, western blotting, genotyping and microscopy. In addition, Viktória has the opportunity to explore the operation of the synchrotron - Canadian Light Source, where they have a beamline intended for imaging biological samples (BMIT). The interesting thing is that the measurements can also be adapted for CT scanning of large animals, thanks to their specially designed CT system, which is not common with classic CT systems.

Author: Viktória Parobková

# SCIENTIFIC MISSION TO CANADA AND THE USA

The January scientific mission to Canada and the USA was successfully launched at the Waterloo Institute for Nanotechnology, where the executive director of WIN, prof. Sushanta Mitra, announced the launch of a Joint Seed Funding Initiative with CEITEC - Central European Institute of Technology to promote international collaboration in interdisciplinary research. The next stop was the Winter Conference in Plasma Spectrochemistry 2024, where the head of our research group, prof. Jozef Kaiser and head of the LIBS laboratory, Assoc. Prof. Pavel Pořízka. We had the opportunity to meet with colleagues from the University of Arizona and the University of Nevada, Reno. We are pleased with the possibility of international cooperation between our institutes and look forward to its continuation.


Fig. 12: Plasma Spectrochemistry Winter Conference in Tucson, Arizona. From the left: Jozef Kaiser, Michaela Škaroupková, Michaela Kuchyňka, Lucie Teperová, Gabriela Kalčíková and Pavel Pořízka.

Author: Michaela Škaroupková

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