CEITEC CTLAB

BRNO UNIVERSITY OF TECHNOLOGY

NEWSLETTER AUTUMN 2023

More about the satellite on page 2.

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 activities that our team have prepared for you, including the scanning of a unique test satellite.

Enjoy reading!

Tomáš Zikmund
Head of the laboratory

DEVELOPMENT OF A MINIATURE SATELLITE BODY USING 3D PRINTING

Small satellites in the shape of a cube or cuboid and approximately 10 cm in size and 2 kg in weight, which are called CubeSats, are launched into orbit in several pieces at once, each with a different functionality and determination. Typical purposes are, for example, Earth observation or amateur radio. Any technology sent into space must always meet the highest quality standards. CTLAB with the company ONE3D participated in the development of the support structure of the test CubeSat* through additive manufacturing from aluminum alloy, which has indisputable advantages over standard machining.

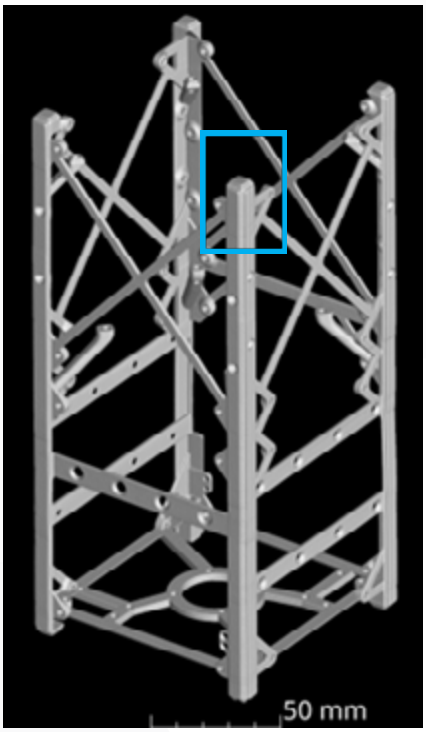

Fig. 1: 3D render of tomographic data of the entire CubeSat structure. The blue box marks one of the areas analysed with better resolution (see Fig. 2).

CT analyses were involved throughout the development of the CubeSat body, i.e. inspection of the input metal powder for 3D printing, verification of the manufacturing process through reference smaller prints and inspection of the final CubeSat body (Fig. 1). All these steps were carried out in accordance with European standards for ensuring the quality of space products manufactured by powder layer sintering technology (ECSS Q-ST-70-80C **).

For most of these measurements, it was necessary to choose a suitable compromise between the size of the scanned area and the resolution of the resulting data. For this reason, the resulting construction was scanned both in its entirety with a lower resolution, and also selected critical areas in greater detail. Figure 2 shows one of these areas, scanned with 15 µm/voxel resolution. The results of the performed porosity analysis were also displayed in the form of a cubic grid, where the percentage porosity in each volume element of the grid superimposed over the sample is evaluated. Among other things, this makes it possible to better emphasize places with local clusters of small porosity, which can weaken the mechanical properties of the part.

The development of this prototype CubeSat allowed us to adopt quality control procedures for additively manufactured parts for space industry.

* Grant OP PIK Development of components for the space industry using additive technologies, number CZ.01.1.02/0.0/0.0/21_374/0027340

** Processing and quality assurance requirements for metallic powder bed fusion technologies for space applications.

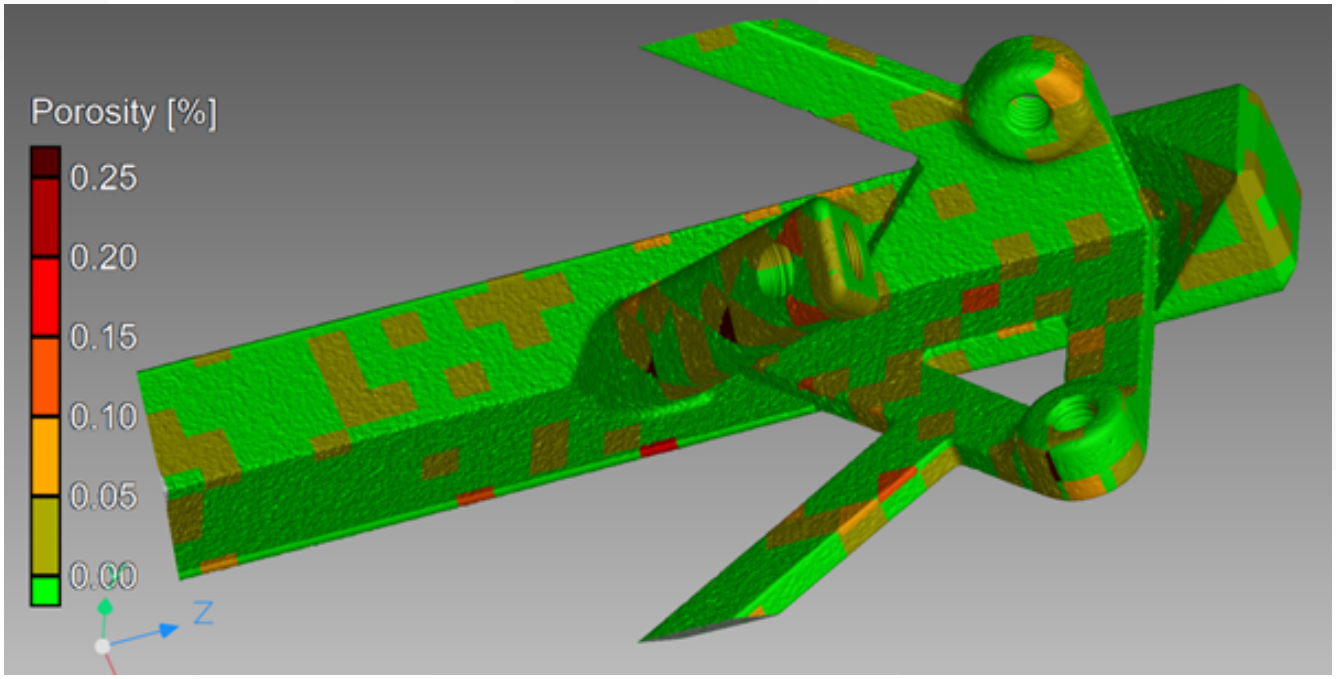

Fig. 2: Visualization of the results of the porosity analysis of a smaller region of the CubeSat, projected onto a cubic mesh of side 2 mm.

Author: Martin Kareš

CT INSPECTION OF A HISTORICAL SWORD SCABBARD

Fig. 3: Real photo of the sword of Jan of Rottal. Source: idnes.cz

The ceremonial sword of the Moravian provincial governor Jan z Rottal is a unique early Baroque monument of great cultural and historical importance, which is part of the collection of the Holešov Municipal Museum and Gallery. The sword was a symbol of the supreme power of the Moravian Margraviate and the representative of the sovereign. The sword is dated to 1650 and since then it has already seen the ravages of time, especially on the scabbard of the sword consisting of a wooden body covered with silk velvet, complete with a tip and a hilt made of silver alloy.

Computed tomography imaging was used to assess the condition of the wooden body of the scabbard, on the basis of which the construction of the scabbard and the extent of damage were determined. Significant cracks were discovered (see Fig. 4) in the structure caused by material drying and mechanical stress. The obtained results brought valuable information to complement the comprehensive material survey and will help in choosing a suitable and effective restoration intervention procedure.

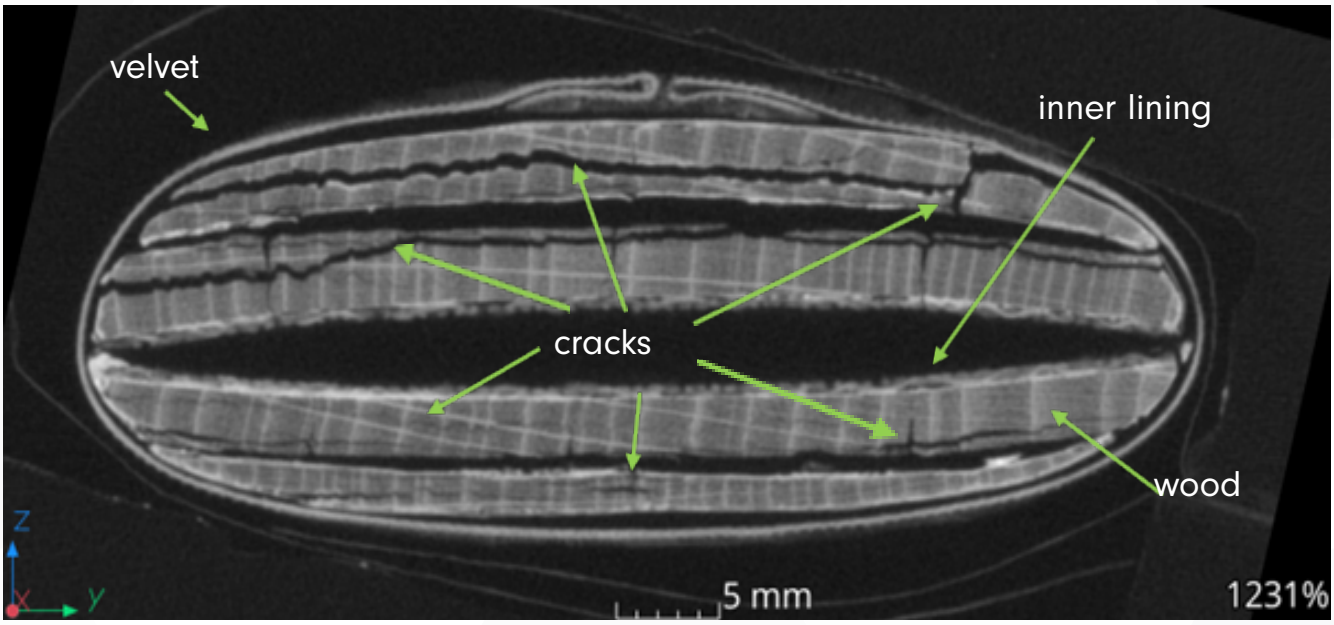

Fig. 4: Cross section of the wooden part of the sword scabbard.

CT ANALYSIS OF METEOROIDS

The rotation of meteoroids that travel through interplanetary space is among the so far unsolved questions concerning the physics of small bodies in the solar system. Similar to their larger companions, the asteroids, the solar radiation also has a significant effect on their rotation, which under certain conditions can be so significant that it leads to the splitting of the meteoroid. For better modeling of these phenomena, it is crucial to know the shape of the investigated bodies. Unfortunately, in the case of meteoroids, their shape cannot be determined directly from observation. To solve this challenge, the formation of meteoroids was simulated by the collision of meteorites and terrestrial rocks at high speeds.

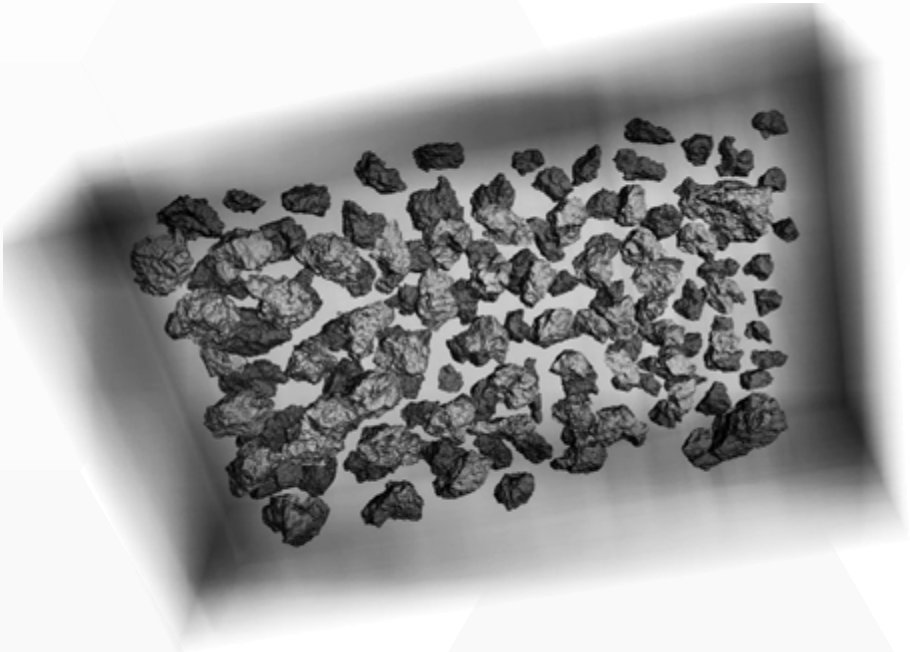

Fig. 5: 3D visualization of one of the groups of scanned fragments. There are 171 fragments of size 3 - 23 mm in the measured volume.

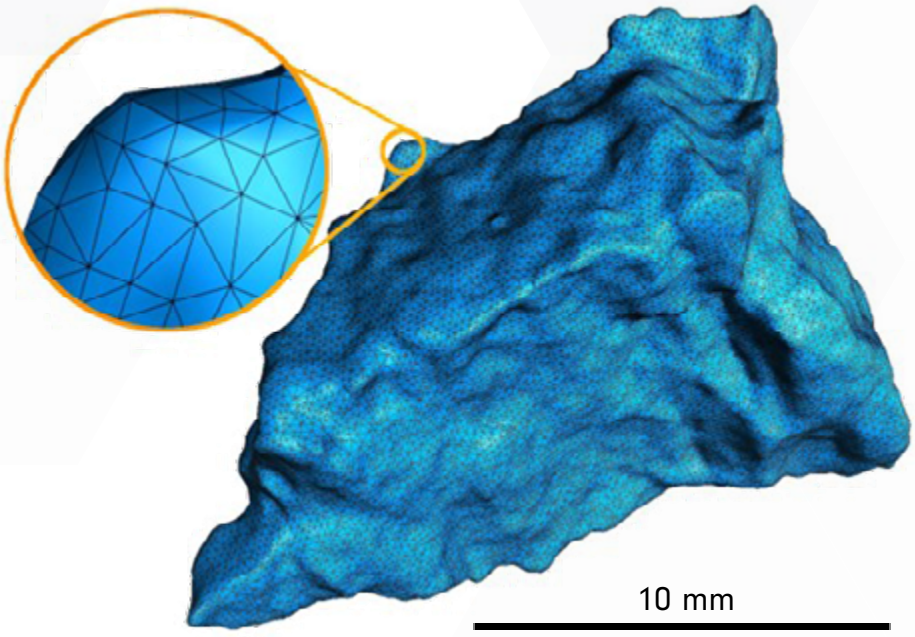

Fig. 6: Digitized fragment surface in STL format with high mesh fineness.

The morphology of suitable fragments from these simulations was then digitally visualized in our CT laboratory. Scanning of almost two hundred fragments was a real challenge for several reasons. It was necessary to prepare them for measurement in the smallest possible volume so that they do not touch each other. Furthermore, it was necessary to fix the samples only with light materials that would not absorb too much X-ray radiation. This could complicate the already rather demanding segmentation of individual samples, which had to be automated, taking into account the number of fragments. Another challenge was to determine the surface of the scanned fragments as accurately as possible and export it to STL format with a very fine structure of up to 100,000 triangles (Fig. 6), so that the resulting shape corresponds as closely as possible to reality. The generated models supplemented the already existing database of shape-like fragments, thanks to which it is now possible for the first time to study the rotations of shape-different populations of meteoroids, and thus to understand the significance of rotational splitting and the observed rapid oscillation of meteor brightness.

Author: Martin Kareš

EXTENSION OF THE RIGAKU APPLICATION LABORATORY

As part of a long-term cooperation with a Japanese company Rigaku Corporation and its European branch Rigaku Innovative Technologies Europe we already became an application laboratory in 2015, which carries out demonstration measurements and participates in development projects on the device nano3DX. This year, we are following up on these activities with a flexible desktop microCT scanner CT Lab HX130 (Fig. 7) with an X-ray source with a power of 130 kV / 39 W and a voxel resolution of up to 2.1 μm, which allows scanning even the entire smartphone or 3D printed objects. This device was temporarily borrowed from the Rigaku Europe SE, in order to use the experience CEITEC VUT in the field of X-ray computed tomography and involve him in demonstration measurements and technical support with the presentation of the device.

Fig. 7: CT Lab HX130 in our laboratory.

RESEARCHERS' NIGHT

In October, we opened the doors of our CT laboratory to the public as part of the nationwide event Researchers' Night. Visitors could view our machinery, hear how X-ray computed tomography works and look at interesting CT data via virtual reality or on a holographic projector. An interesting part of the program was the scanning of objects that the visitors themselves brought (Fig. 8) and we revealed their hidden inner structures to them.

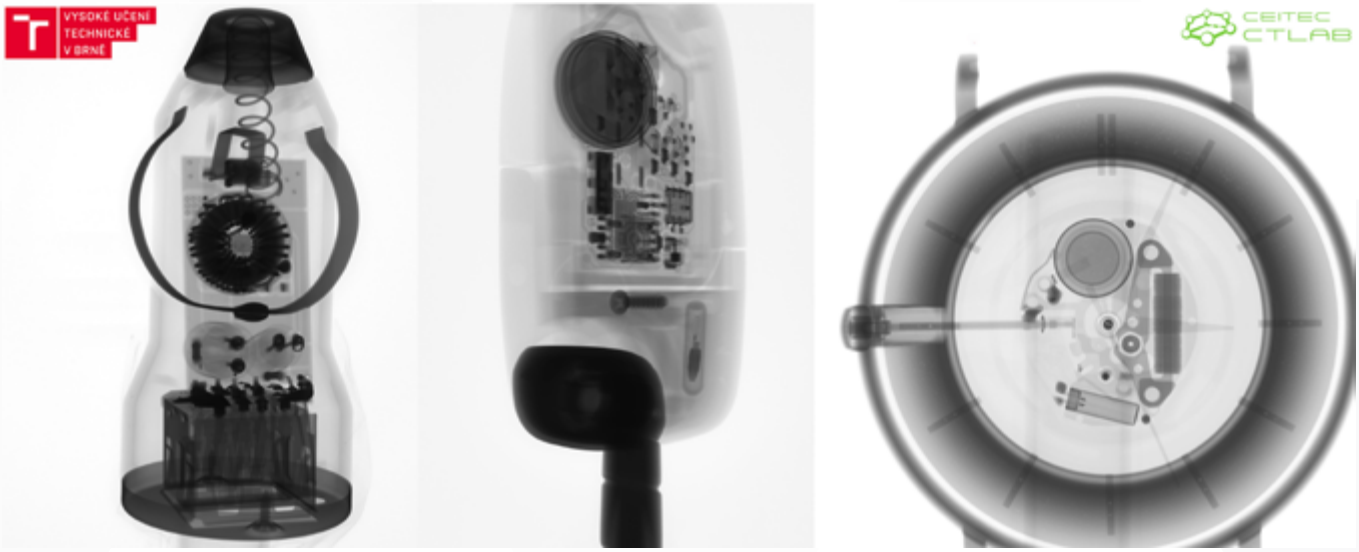

Fig. 8: X-rays of objects brought by visitors. From left, charger, car keys and watch.

Fig 9: Open laboratory to the public as part of the Researchers' Night.

OUR STUDENT'S METHOD WILL HELP TO BETTER IDENTIFY MICROPLASTICS IN THE BODY

Our student's method will help to better identify microplastics in the body. In her research, Viktória Parobková deals with possibilities of detecting microplastics in the human body using various methods. In the future, he hopes that knowledge about the presence of microplastics in the human body could help change the approach to the use of plastics in everyday life.

She is currently working on optimizing the entire procedure, as well as determining the limits of the method. For example, how large particles of microplastics can be found in the body. „We want to be sure that if we apply this protocol to the tissue in which the particle is located, we can detect it. And not only to locate them, but ideally also to determine what type of polymers they are," explains the student. „We will also combine tomographic and spectroscopic techniques and investigate how best to identify microplastics," confirms Viktória, adding that she would like to follow up her work with a project mapping the specific effects of microplastics in the human body.

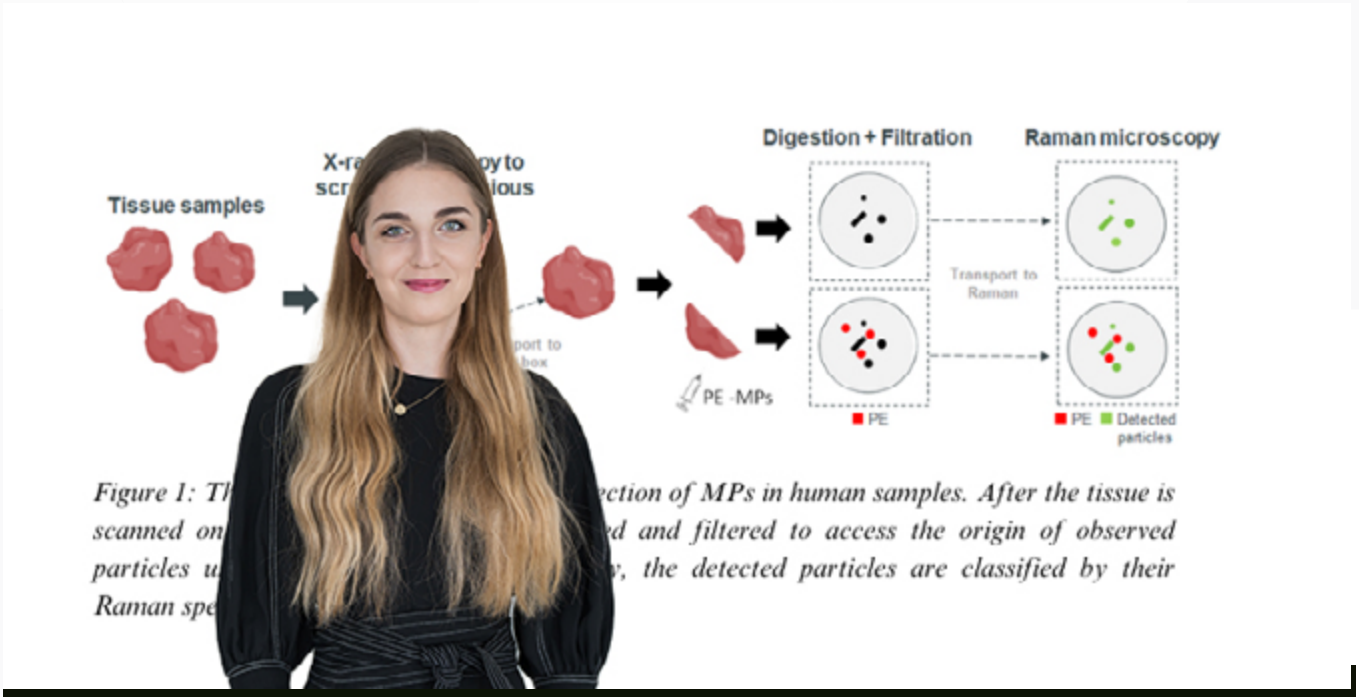

Fig. 10: Viktória Parobková.

INNOVATIVE METHODOLOGY FOR OBJECTIVE EVALUATION OF VERTEBRAL FUSION SUCCESS

Our researcher Jakub Lázňovský is developing software that could one day help doctors with CT data processing. In one of his recent publications in a scientific journal Computers in Biology and Medicine, he presented an automated software that allows an objective and accurate assessment of the success of vertebral fusion of the porcine spine in 3D (Fig. 11). This innovative methodology has the potential to influence clinical practice and in the future help doctors determine the quality of fusion and evaluate the success of treatment in patients with spinal problems.

You can read more information here.

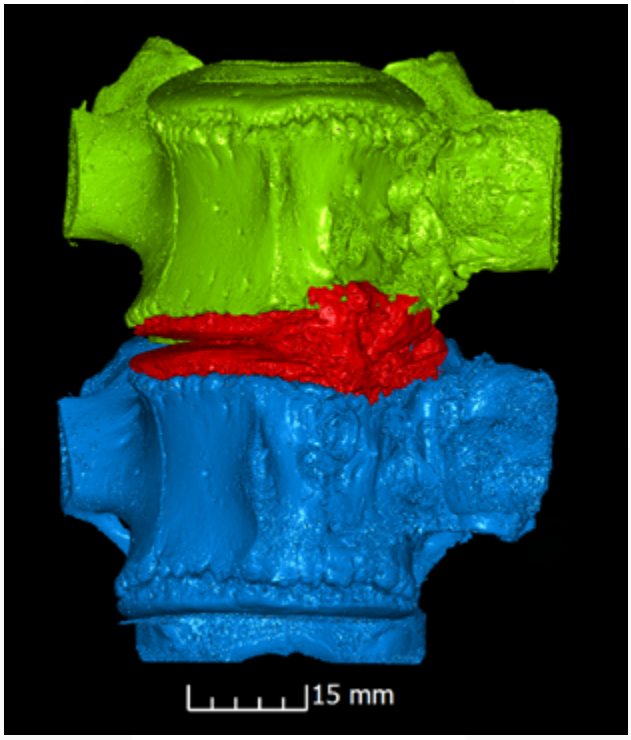

Fig. 11: Front view - 3D render. Green: L2 (2nd lumbar) vertebra, blue: L3 vertebra. The red area marks the intervertebral fusion site.

Fig. 12: Jakub Lázňovský.

PHYSICS OF DETECTION AND DETECTORS COURSE

In October, our laboratory organized a Physics of Detection and Detectors course. Course speakers talked about X-ray detection and applications of state-of-the-art X-ray detectors. The course was accompanied by associate professor Ladislav Pina from CTU, Ph.D. Luca Brombal from the University of Trieste, Dipl.-Ing Michael Salamon from the Fraunhofer Institute and Ph.D. Josef Uher from Advacam. We thank all these speakers.

Fig. 13: Graduates of the course with one of the lecturers, associate professor Ladislav Pina (in the middle.)

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