High energy X-ray computed tomography at CEITEC

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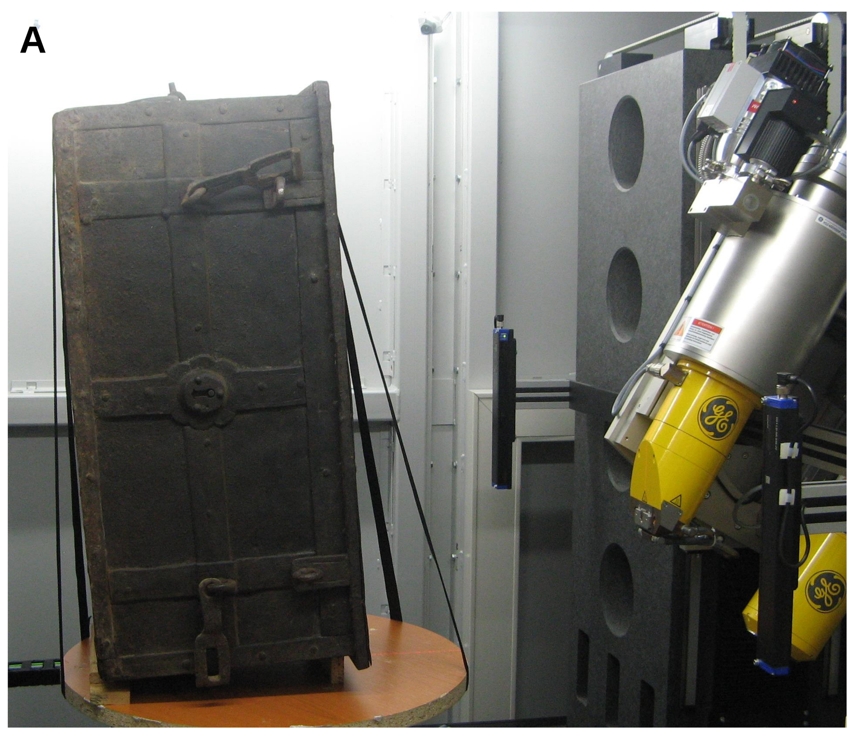
Introduction

High energy X-ray computed tomography (CT) is powerful non-destructive imaging technique used to investigate the internal structure and surface of precious and delicate objects represent a very important and consolidated research field in the scientific domain of **cultural heritage knowledge and conservation.** The volumetric capabilities of high-resolution X-ray CT modalities have been recently used in the study of cultural heritage items to reveal internal structures unseen from the outside of precious objects as papyrus, pottery, and coins. In addition, it provides a unique 3D visualization of the internal structures of the imaged object that is not possible with other methods.

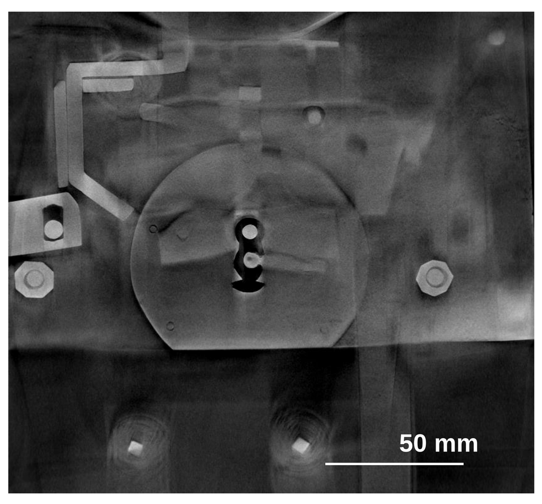
At CEITEC, this technology enables high-resolution imaging at microscales offering insights into the internal structures of a variety of samples, including composites, biological tissues, industrial and other samples. **CEITEC focuses on high-energy X-ray CT**, which enables precise imaging of dense and heterogenous materials. This technology also **opens up new possibilities for the study of cultural heritage objects** such as ancients artifacts and artworks, **by revealing hidden features, internal degradation, and the materials used without damaging the specimens**.

Waygate v|tome|x L240

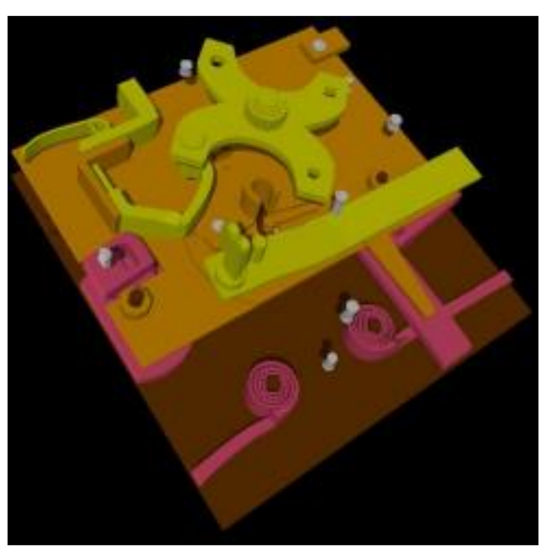
A



B



C



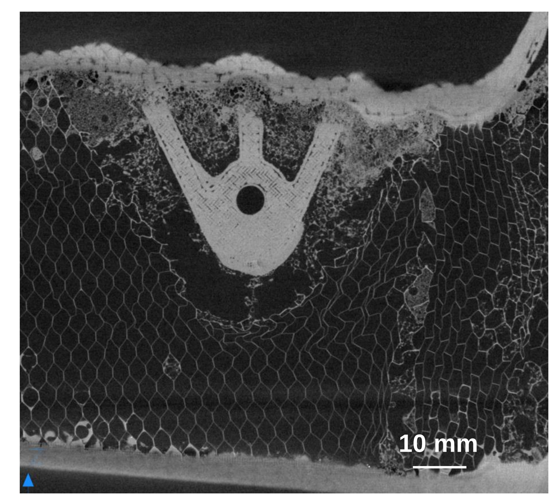
A: illustration of a chest fixation in the CT system
B: illustrative transverse cross-section, (linear voxel size 102 µm)
C: 3D view of lock mechanism of a historical chest

X-ray CT was used to examine and carefully open a locked chest from 19th century. This non-destructive analysis provided detailed insights into the lock´s lever and bolt system, enabling the creation of a new key while also revealing two secret protective mechanism and existing damages.

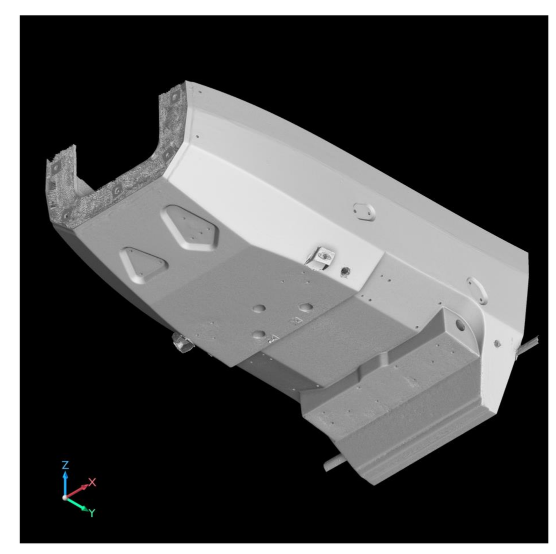
Waygate v|tome|x L450

A

B



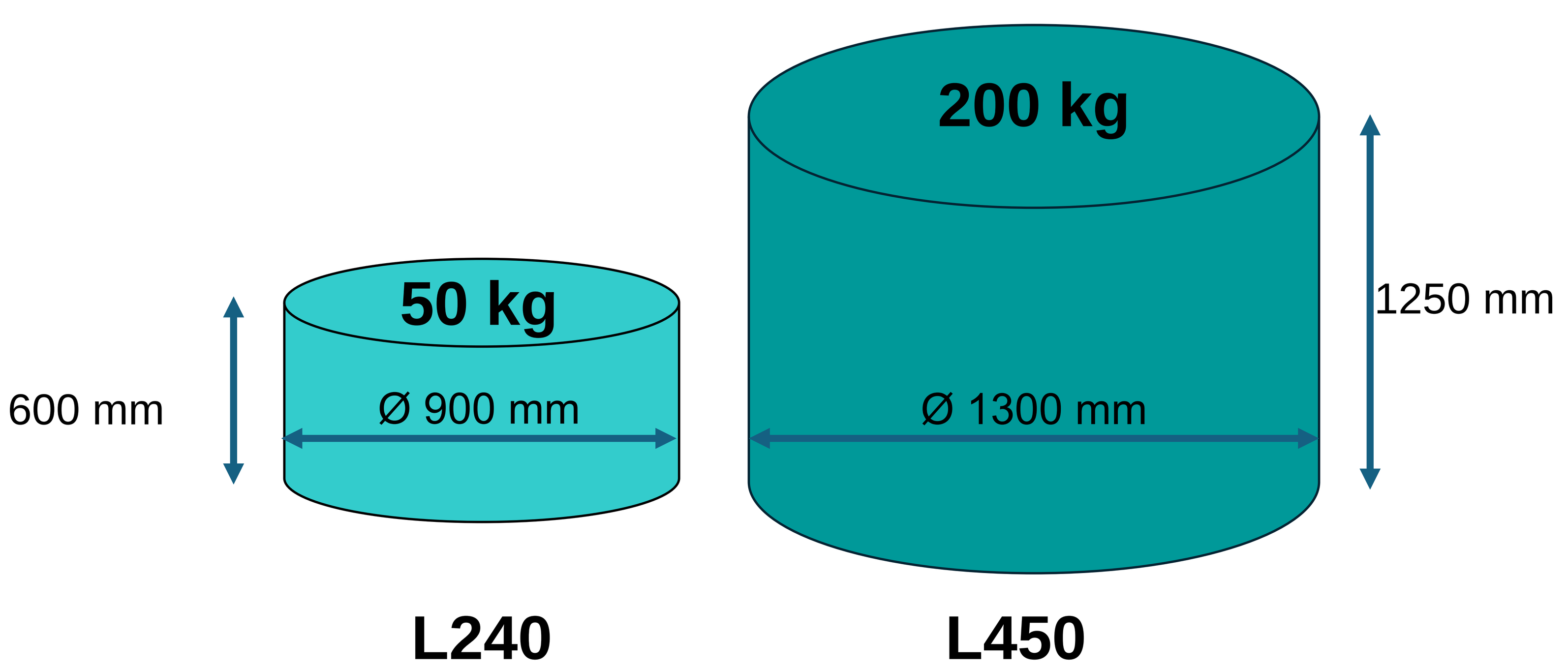
C



A: illustration of a formula fixation in the CT system
B: illustrative cross-section (linear voxel size 80 µm)
C: 3D view of monocoque at the front axle suspension point

X-ray CT was used to detect damage and deterioration of the student electric formula monocoque after the racing season. The stress-concentrated area at the suspension arms and joints were selected for X-ray CT examination. As in the case of chest, only selected areas of interest were scanned.

Maximal sample size



Instrument parameters	L240	L450
Maximal voltage / power	240 kV / 320 W	450 kV / 1500 W
Maximal focus detector distance (FDD)	1580 mm	2810 mm
Flat panel detector shift	2x	3x
Cabinet dimensions (without console and switch cabinet)	4100 x 2600 x 2800 mm	6400 x 3900 x 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

Conclusion

X-ray CT is widely used technique in heritage science due to its non-destructive nature and ability to provide detailed 3D structural visualization. Micro-CT systems, commonly found in laboratories, offer high-resolution imaging down to few microns. However, the compact dimensions of cabinet and fine X-ray source limit the size of analyzable samples. Standard 450 kV X-ray source provides greater penetration appropriate for larger or metallic objects, however, at the cost of low resolution.

In comparison with currently available **CT equipment at CEITEC BUT** (Waygate v|tome|x L240), the new CT system **Waygate v|tome|x L450** with a new generation of **mezzo-focus** (450 kV / 1500 W) **X-ray source** now **combines** both **high power and fine resolution**, overcoming these limitations. In addition, this system allows scanning with an **additional mini-focus X-ray source** (450 kV / 1 500 W). Also, bigger cabinet dimensions allow us to visualize up to **heavier and bigger samples**.

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