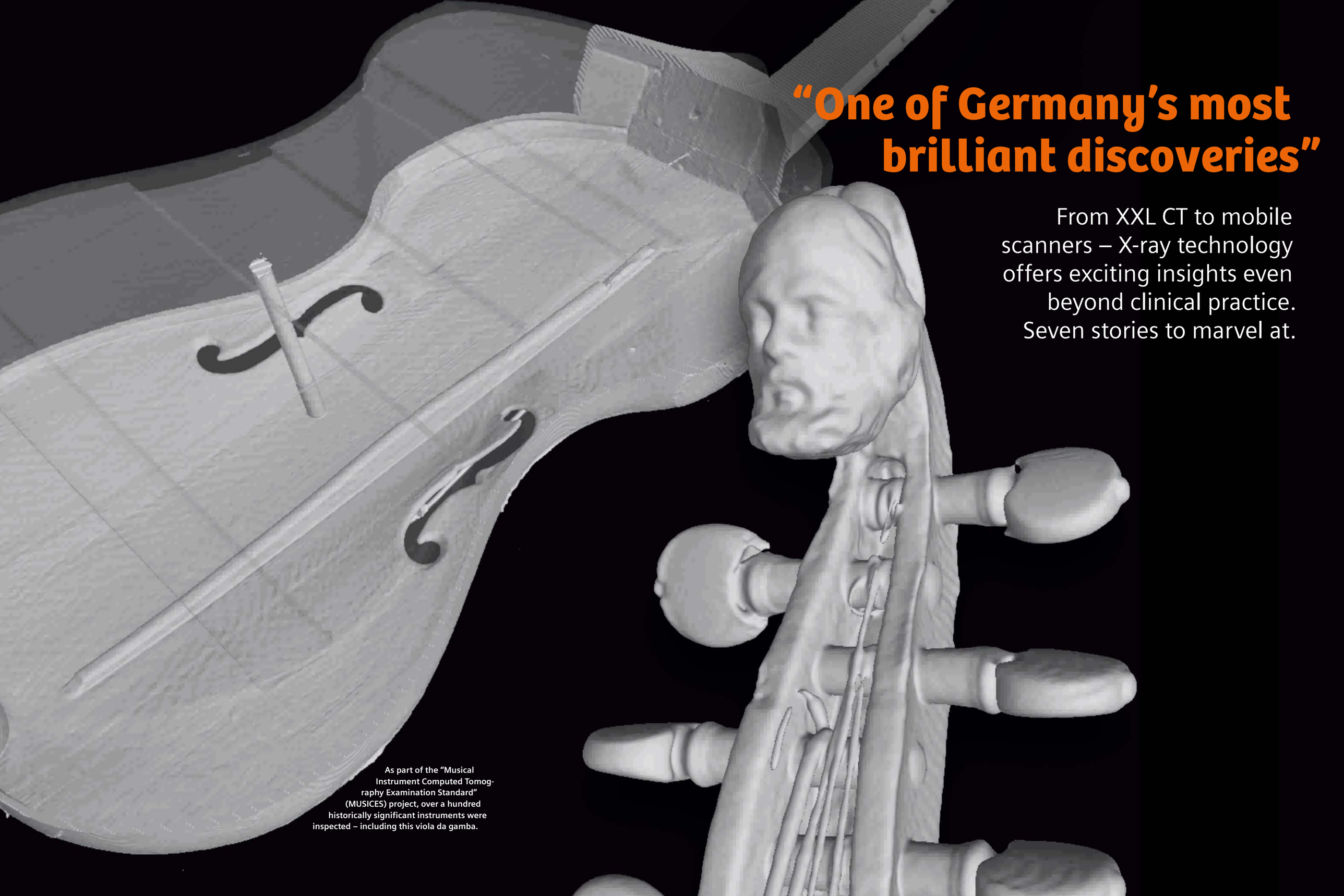

"One of Germany's most brilliant discoveries"

From XXL CT to mobile scanners – X-ray technology offers exciting insights even beyond clinical practice. Seven stories to marvel at.

As part of the "Musical Instrument Computed Tomography Examination Standard" (MUSICES) project, over a hundred historically significant instruments were inspected – including this viola da gamba.

Analysis of electric cars after a crash test: Keep away from the battery

Wilhelm Conrad Röntgen was reportedly an introverted character. He channeled his entire efforts into his discoveries, which he felt should be "publicly available and not reserved for individual companies through patents, license agreements etc." Although he was always aware of the significance of the X-rays that he had discovered, he could not even begin to imagine how many different fields this technology would benefit, even beyond clinical use. From XXL computed tomography scanners with which electric cars can be analyzed safely after a crash to the mobile mini CT scanner with which researchers illuminate ice cores in Greenland – the discoveries that have been made with X-ray technology are considerable. It is precisely this ability to see below the surface that fascinates Michael Salamon, Group Leader at the Development Center X-ray Technology (EZRT), a division of the Fraunhofer Institute for Integrated Circuits (IIS) in Fürth. Together with his colleagues, Salamon is addressing the challenges that face our society today, saying "X-ray technology is one of Germany's most brilliant discoveries." He recounts seven exciting stories to show how this is true.

Until now, computed tomography, particularly in the high-energy field, has been limited to small, simple objects. Results from existing large CT systems were mediocre because no suitable reconstruction algorithms were available. Michael Salamon and his, to use his words, "inquisitive colleagues" have developed a technique for scanning very large objects from which high-resolution 3D images can be generated. The X-ray source used by the researchers is a linear particle accelerator (LINAC) developed by Siemens Healthineers combined with an X-ray detector. Large objects such as automobiles and airplanes are rotated on a turntable housed in a specially built hall at the EZRT. The detector and X-ray source then scan the object line by line, acquiring it from many different angles, and so provide the basis for detailed representation in 3D.

Analysis of electric cars after a crash test: Keep away from the battery

One important application of the mega system is the analysis of motor vehicles after a crash test. Previously, the wreckage had to be taken apart in a time-consuming procedure in order to be able to analyze its structures. Using non-destructive X-ray inspection at the EZRT, previously inaccessible structures and materials can now be analyzed – for example, the battery module of an electric car. "After a crash, ideally the battery in an electric car is not touched by anyone because it is never clear what damage has occurred to the structure and what its effect might be. With our X-ray inspection, we can design a safer and more efficient crash test and provide our industry partners with results with which they can vastly improve safety standards for drivers," says Michael Salamon.

Radiography in the production hall: Detecting faults that cannot be seen

Engineers can gain yet more safety-related information in the production of automobiles when X-ray technology is used in quality inspection. Michael Salamon explains: "If we scan every safety-related aluminum component in the vehicle, we are really improving safety on our roads. By the time a vehicle leaves the production line, various components have been inspected radioscopically. In that way, we can ensure that they have just the strength they need to really be road worthy."

Inspecting sea freight: Scanning the non-intrusive way

Quite a different purpose is pursued by the third application of XXL X-ray – the inspection of shipping containers. Two-dimensional X-ray imaging of their cargo has already been in use in the world's ports for some time. Using the 3D technology developed at the Fraunhofer Institute, police and customs officers can now also clearly visualize small objects inside the container. The technology developed by IIS makes it possible to digitally unload the container, providing the security authorities tasked with searching containers for explosives or weapons the view necessary to fight smuggling.

Airplane under the scanner: The war machine and its peaceful twin

XXL CT scanning is not only used in processes in the present day – the technology can also be used to analyze cultural objects without dismantling them. "We recently generated the digital twin of a World War II rocket-powered interceptor. The aircraft was scanned with wings removed in the XXL CT system," Salamon explains. The rare specimen is part of the collection in Munich's Deutsches Museum where the curators are hoping that the images of the interior of the ME163

Collaboration project between X-ray aces

A large dose of energy is needed to scan large radiodense objects. To make this possible, the test hall of the Development Center X-ray Technology (EZRT) at the Fraunhofer Institute at Fürth-Atzenhof is equipped with a linear particle accelerator. It was developed by Siemens Healthineers especially for the XXL CT and made available as a demonstration object. Many sectors benefit from this method.

"What our colleagues at Siemens Healthineers and we have in common is our enthusiasm for the invisible. Every working day brings something new because there are so many hidden things still to discover."

Michael Salamon, Group Leader, Development Center X-ray Technology (EZRT), Fraunhofer Institute for Integrated Circuits (IIS) Fürth, Germany

Messerschmitt – nicknamed "Kraftei" – will provide fresh insights into the history of the rocket-driven interceptor, which was the first to break the 1,000 km/h barrier. And visitors will benefit, too: At the aviation exhibition opening at the Deutsches Museum in 2020, the ME163 Messerschmitt can be experienced in augmented reality (AR) applications.

Looking inside the drum: Insights into historical instruments

Infinitely more fragile than rocket-powered interceptors are the historical objects that took restorers of the Germanisches Nationalmuseum to Atzenhof. They wanted to investigate the internal workings of historical trumpets, drums, and flutes. For old musical instruments in particular, it is often not entirely clear how the inaccessible parts are constructed or whether they have been damaged by storage or many years of use. Dismantling them is simply not an option. And that is where computed tomography comes in.

As part of the project "Musical Instrument Computed Tomography Examination Standard" (MUSICES), Salamon's colleagues have scanned over one hundred historically significant instruments in three dimensions and even compiled guidelines for scanning musical instruments.

Dino meets linear accelerator: Discoveries even before excavating

"By far the oldest object that we have ever had in the scanner is the skull of a Tyrannosaurus rex," recalls Michael Salamon. The remains of the female dinosaur are estimated to be 66.4 million years old. During the X-ray process, the 500-kilo skull was kept in a box still embedded in the original soil in which the paleontologists had found it. It required the combination of the Fraunhofer expertise and technology from Siemens Healthineers to allow researchers to look inside the internal structures without breaking the skull. Any fractures could be reliably detected beforehand and taken into account during processing. The X-ray data generated can now be used to make faithful replicas of the skeleton by 3D printing. "The dinosaur scan showed up a bone that previously could not be correctly identified," reports Michael Salamon and adds: "It is surprises like this that make the work so fascinating for us."

CT scanner on tour: Off to the permanent ice

A complete change of scene for story number seven: We're off to Greenland. "Polar ice cores are climate archives that hold vast environmental information providing us with indicators of how the planet has developed. As an archive of atmospheric air, the dust particles and air bubbles locked inside them provide information about long-gone eras. Onsite, an X-ray unit was installed in a tent and enabled scanning of fragile snow structures. "With the CT installed at Alfred-Wegener-Institute in Bremerhaven, Germany, the microstructure of ice from more than 3,000 meters depth can be analyzed," says Michael Salamon. With this so-called "Helix-CT" and a dedicated X-ray detector, the one-meter long ice cores can be scanned in its entirety without having to stop the motion.

The applications are many and varied: Whether on a micro or macro scale, findings from the Cretaceous period or revelations about climatic change that affect our future, from safety-related testing in industry to exciting insights for historians: "X-ray technology is a major economic factor for Germany and highly relevant to our society today," says Michael Salamon. Unfortunately, the enormous value that these invisible rays have is all too often just that, invisible, he continues. If there is anything that those following in the footsteps of the quiet Wilhelm Conrad Röntgen would like to change, it's this: "X-rays are invisible. But we want to make clear the many brilliant and versatile ways in which they drive progress."

Michael Salamon

Michael Salamon personally refers to himself as a "home-grown Fraunhofer". He has worked at the institute for 13 years. Why? "It's just so interesting" – he says. He is Group Leader at the EZRT and can understand and explain the relationship between pure physics and applications. As an interviewee for non-physicists, there's no one better.

To perform the scans directly on site at the research station in Greenland, the CT had to be easily transportable.

XXL X-rays in figures

The 14-meter high test hall houses the two eight-meter high manipulation towers, a three-meter wide turntable, the three-tonne X-ray source and a four-meter long detector. The objects, which are positioned on the turntable by a heavy-duty crane, effect a complete rotation about their own axis and are scanned line by line. The X-ray energy is varied to the material and size of the object. A maximum of nine megaelectronvolts (MeV) can be achieved. This is roughly 20 times that of conventional industrial X-ray systems.