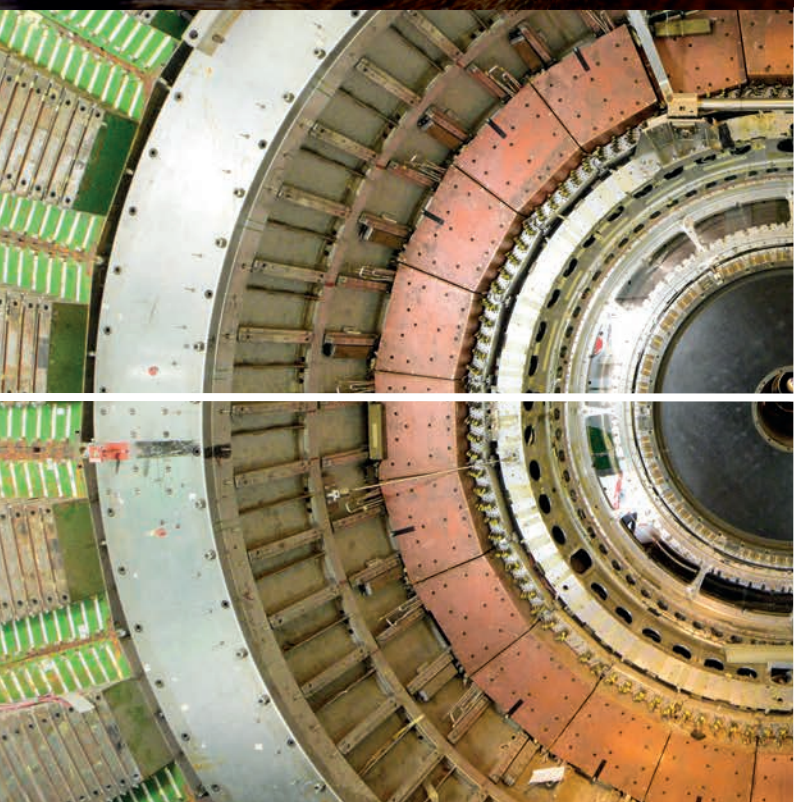
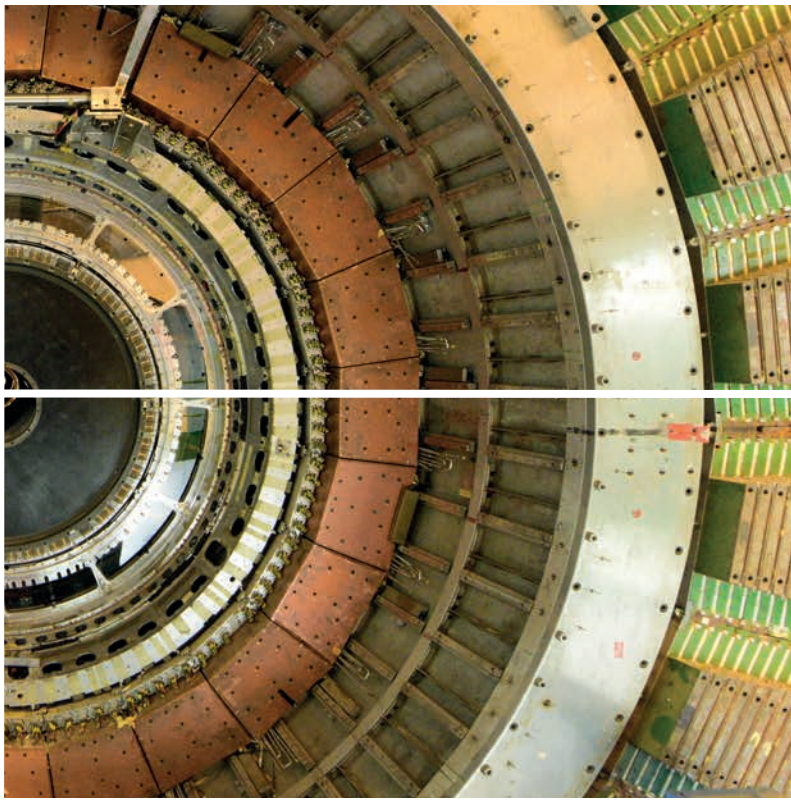
How we build reality

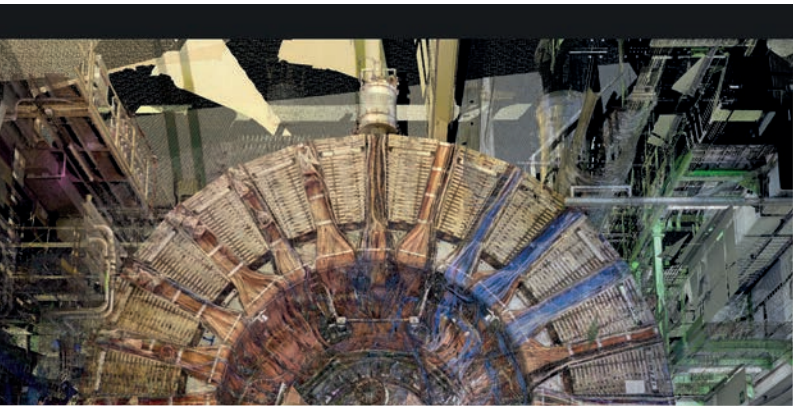
Zoller+Fröhlich

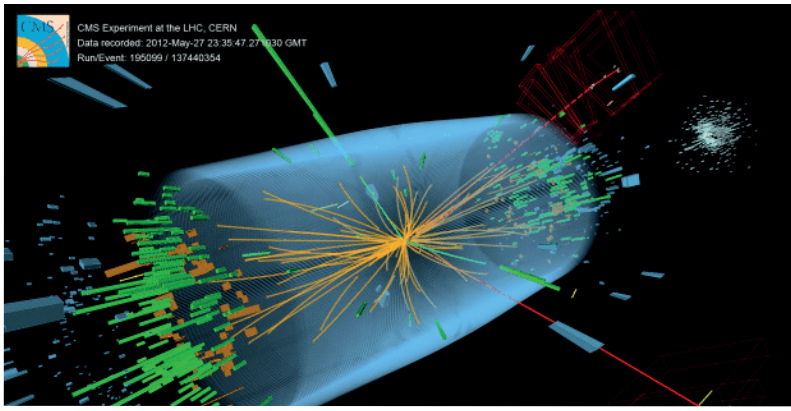


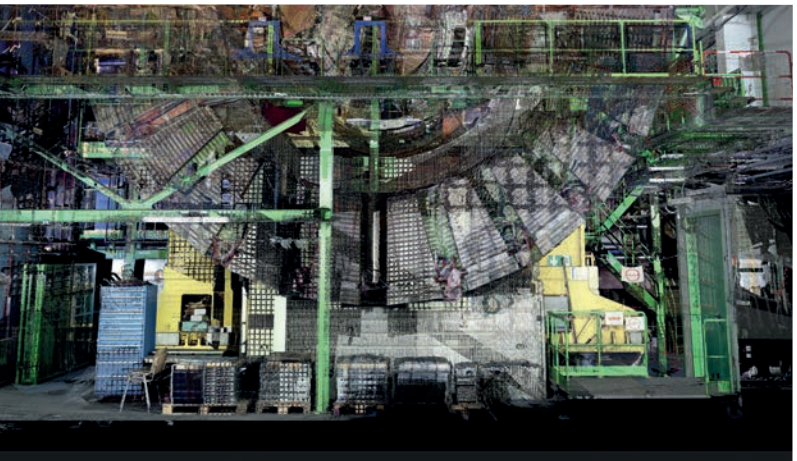


Case Study

3D survey of CERN
European Organization for Nuclear Research





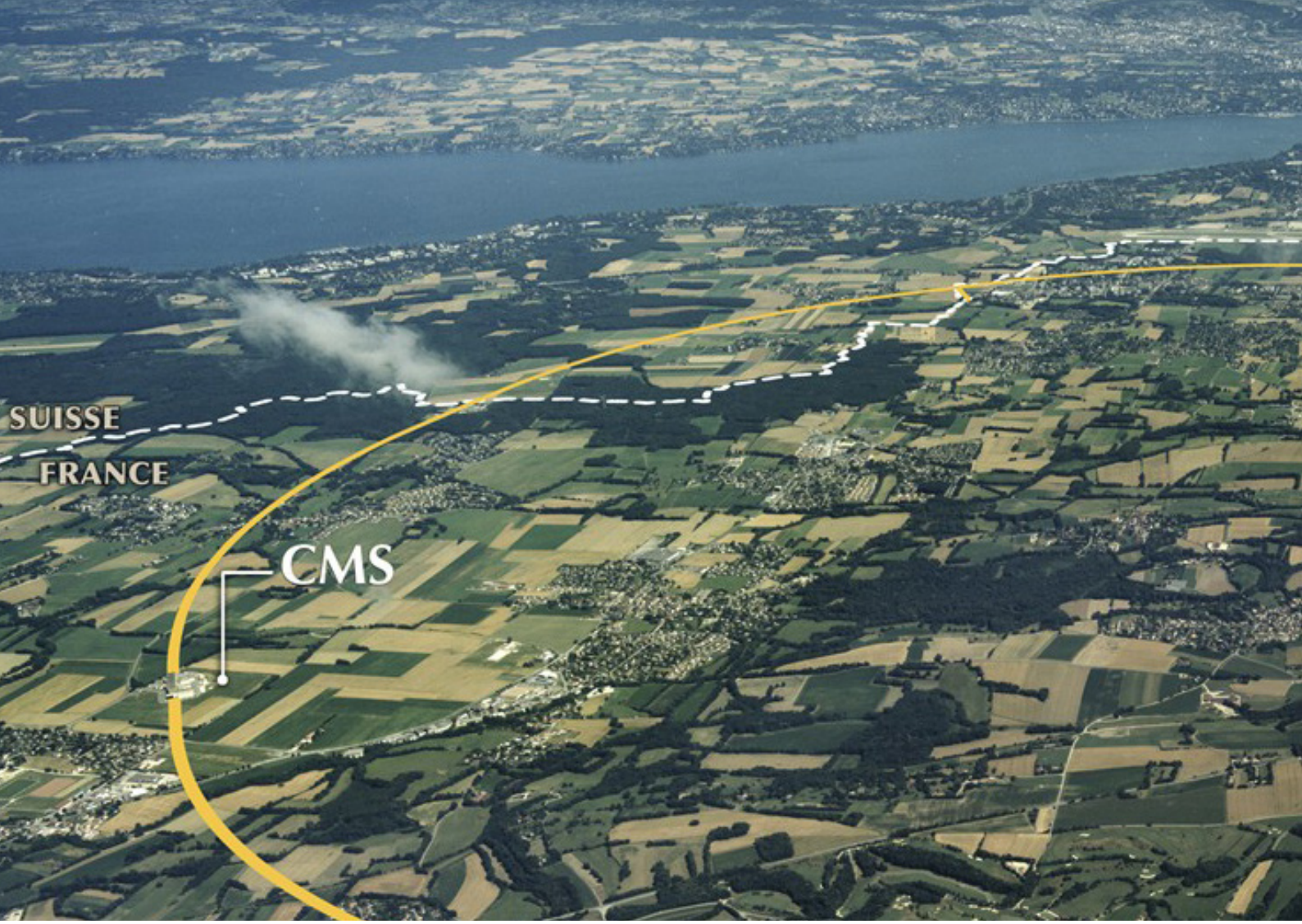


Company Overview

Z+F is one of the world's leading manufacturers in the field of non-contact laser measurement technology. Due to years of research, development and numerous successful engineering projects, Z+F is the forerunner in this field with a wealth of knowledge, experience and success.

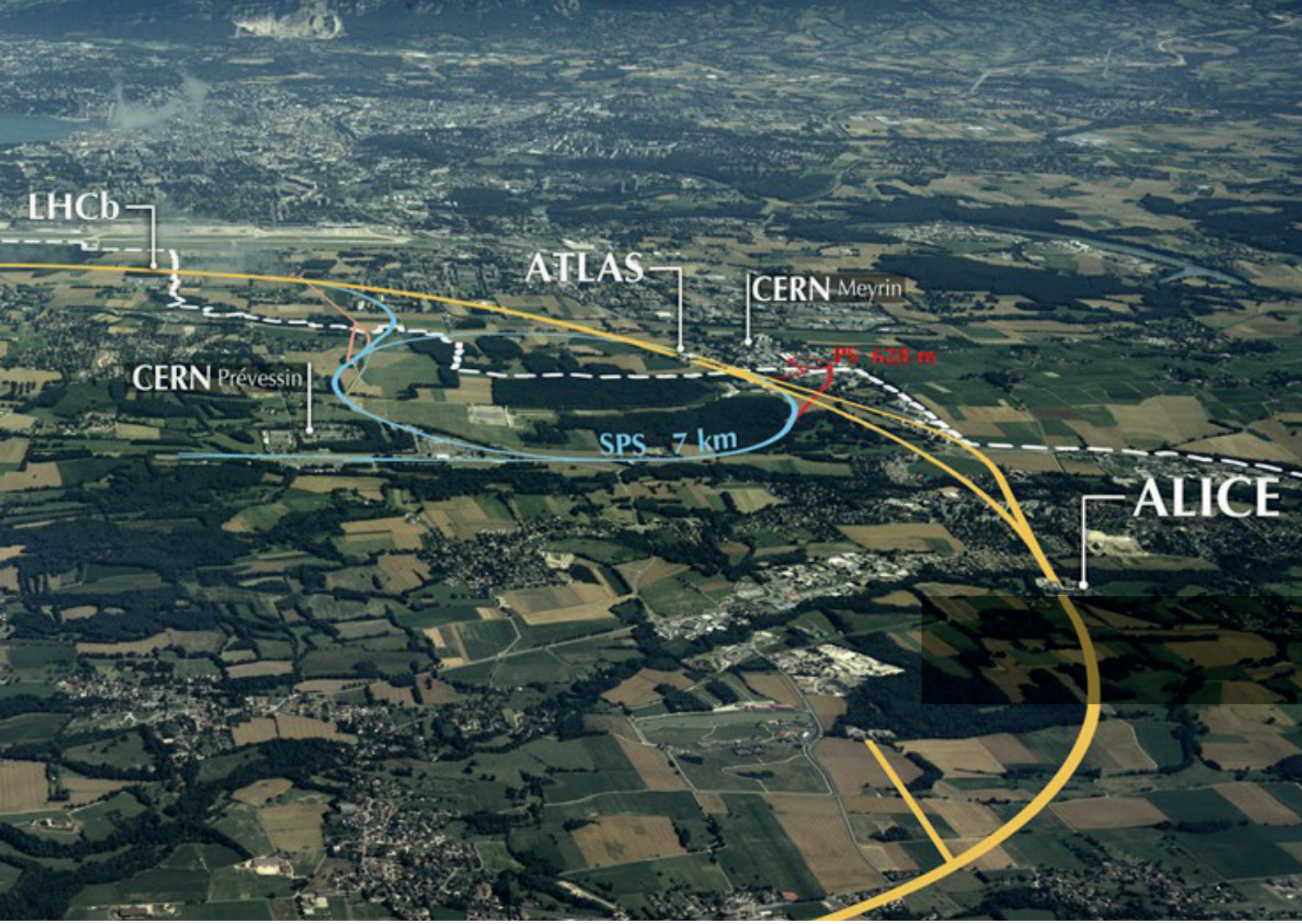
When it comes to implementing future developments Z+F has always encouraged innovative thinking and open-minds. Our loyal and long-standing customers appreciate our continual innovations, support and the services we provide.

In cooperation with School of Physics and Astronomy, University of Glasgow and AutoDesk Inc. San Francisco USA

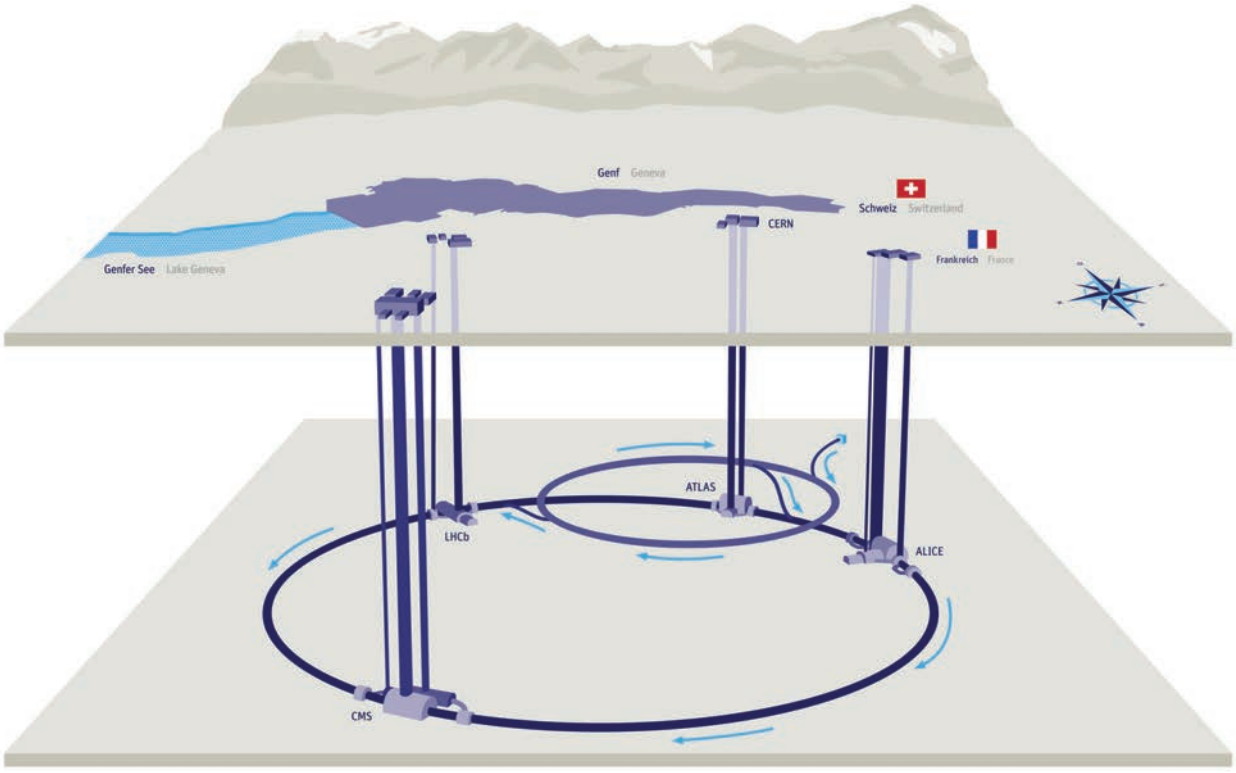


CERN

The European Organization for Nuclear Research, known as CERN, is a European research organization that operates the largest particle physics laboratory in the world. Established in 1954, the organization is based in a northwest suburb of Geneva on the Franco–Swiss border, (46°14 3 N 6°3 19 E) and has 22 member states. Israel is the only non-European country granted full membership. CERN is an official United Nations Observer.
The acronym CERN is also used to refer to the laboratory, which in 2016 had 2,500 scientific, technical, and administrative staff members, and hosted about 12,000 users. In the same year, CERN generated 49 petabytes of data.
CERN's main function is to provide the particle accelerators and other infrastructure needed for high-energy physics research – as a result, numerous experiments have been made at CERN through international collaborations. The main site at Meyrin hosts a large computing facility, which is primarily used to store and analyse data from experiments, as well as simulate events. Researchers need remote access to these facilities, so the lab has historically been a major wide area network hub. CERN is also the birthplace of the World Wide Web.



Aerial Image © CERN 2008

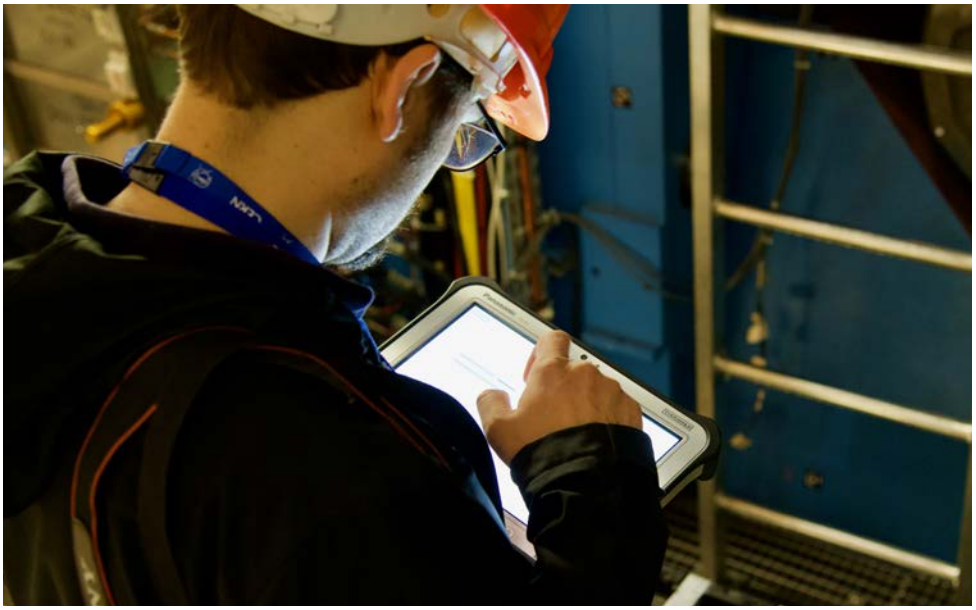


LageLHC © DESY 2008

Collaboration

Supported through the UK Engineering Research Council and the European Organization for Nuclear Research (CERN), researchers from the University of Glasgow precisely documented the Large Hadron Collider experiment at CERN using the latest terrestrial laser scanning and imaging equipment. The team consisted of physicists Dr Aidan Robson and Dr Paul Soler (U Glasgow), documentation expertise from Douglas Pritchard (Honorary Research Fellow, U Glasgow), and generous assistance through the involvement of Dennis Martin (Autodesk USA) and Chris Held (Zoller + Fröhlich).

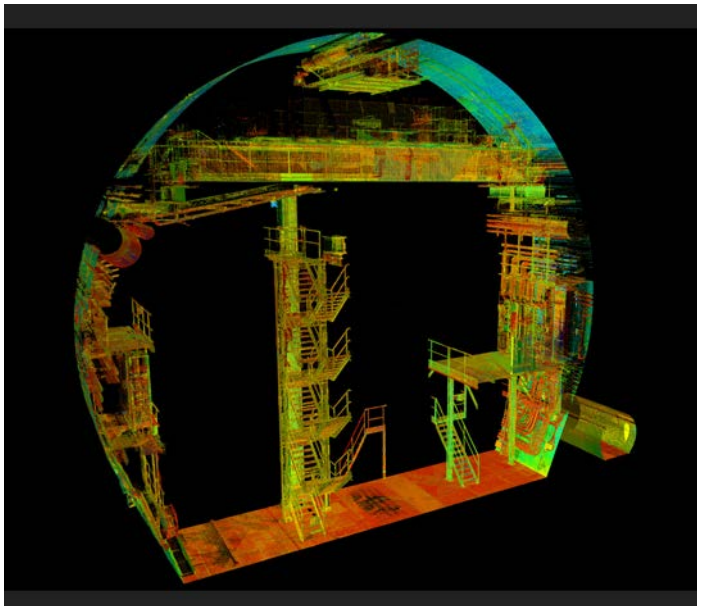
Given the international significance of CERN, the associated research achievements, and that the facility will be modified in the near future, it was important to create a comprehensive dimensional record for future scientists, researchers and industrial historians. The initial justification for the project was to document LHC as a scientific heritage site, moving the scanners and photogrammetric cameras throughout the entire cavern to capture as much dimensional information as possible. The deliverables for the project not only had to address the practical considerations of developing an exact 3D survey, but also the creation of multimedia and educational resources.

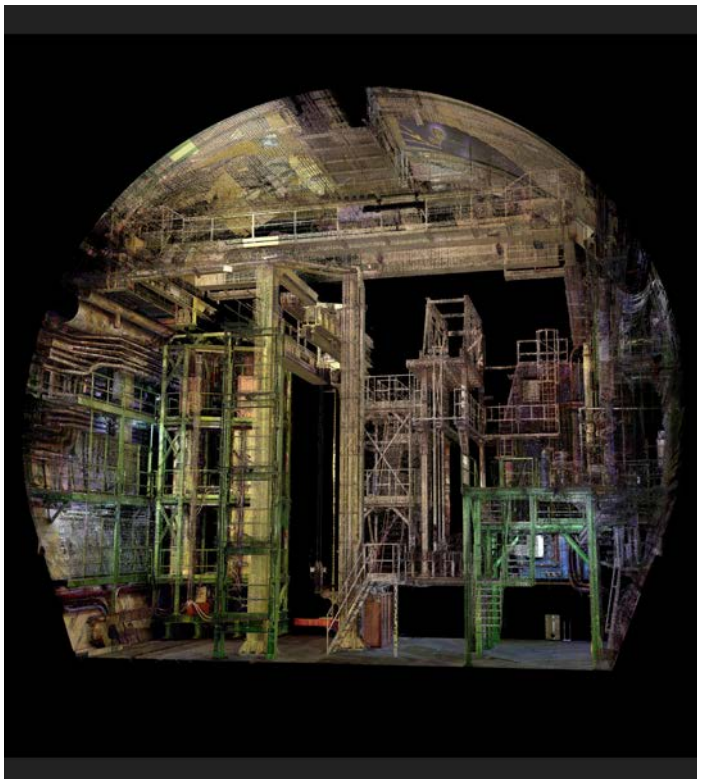


Chris Held from Zoller + Fröhlich on site

Project

The Large Hadron Collider (LHC) is situated 100 meters below ground at CERN and remarkably, it is considered the biggest single machine on the planet. It is also the location of one of the most important scientific achievements of this century, the Higgs boson.





A lateral cross section through the LHCb cavern

Equipment

Over 160 laser scans, as well as 360-degree images for enhanced photogrammetry, were taken over 5 days. All of the scanning was done with two Zoller + Fröhlich 5016 terrestrial scanners at a high-resolution setting (3mm@10m point spacing/resolution) and associated HDR imagery (80 MPixel).

Three features of the 5016 proved to be exceptionally beneficial for this type of project:

1. the quality of HDR imagery,
2. having a camera at the same nodal point as the laser sensor,
3. and the built-in LED lighting system.

This provided the team with the ability to position the scanners throughout the cavern, to capture both point and RGB data, including features that were dark or in poor light.

This configuration allowed the team to position and remotely operate the scanner within the focal point of the LHC experiment, the Beryllium beam pipe area. The heart of LHC consists of a long beryllium metal pipe that is surrounded by huge magnets and an array of sensors – the exact collision point of the subatomic particles.

The Z+F IMAGER® 5016 combines a compact and lightweight design with the latest laser measurement technology. All components are designed to guarantee excellent results. As a result, areas of application for the highest demands are made more flexible and expanded. In addition, the phase-based terrestrial laser scanner is equipped with an integrated positioning system and a HDR camera with lighting system.

Technical features of the terrestrial 3D laser scanner

Due to innovative developments, the maximum range of the new terrestrial 3D laser scanner Z+F IMAGER® 5016 has been extended up to 360 m (1,180 ft) - thus establishing new opportunities and applications. The maximum measurement rate of more than 1 Mio. points/sec. guarantees highly accurate results even with long distances.

Its 360° x 320° field-of-view assures great coverage of the scanned area, reducing the number of scan positions necessary to a minimum.

The scanner is classified as „eye-safe“ according to laser class 1 and can be used in public areas without any restrictions.

The Z+F IMAGER® 5016 is equipped with an integrated positioning system, which allows the automatic registration in the field, with or without targets or . All preprocessing tasks can be taken care on the fly, increasing efficiency. Please read the ”blue workflow®” section of this brochure for more information.

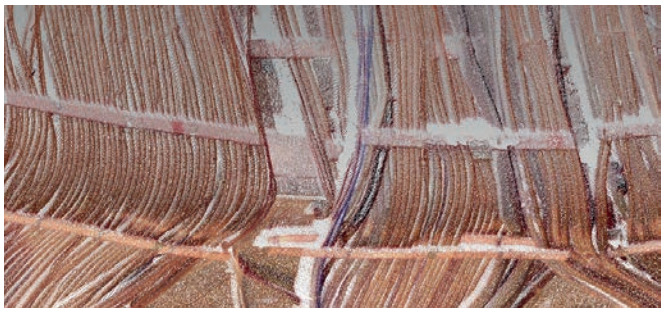
3D Point Cloud of DELPHI.
DELPHI was one of four large detectors on the Large Electron-Positron collider (LEP). It took 7 years to design and build, and it started up in 1989. After LEP was decommissioned in November 2000, DELPHI began to be dismantled, and dismantling was complete in September 2001.

Measurement results

The Z+F IMAGER® 5016 not only promises good results on the data sheet. The level of detail and the accuracy of the scanner are unmatched in use.

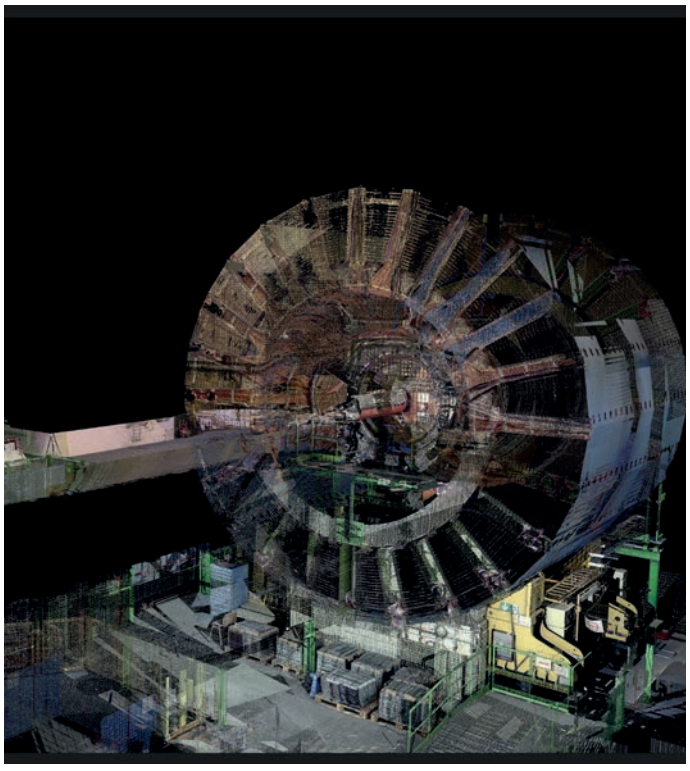
In addition to a very lifelike color reproduction, the scanner captures every visible structure. Each individual cable can be viewed and modeled in post-processing.

This allowed very detailed cross sections of the collectors with only a few scan positions.

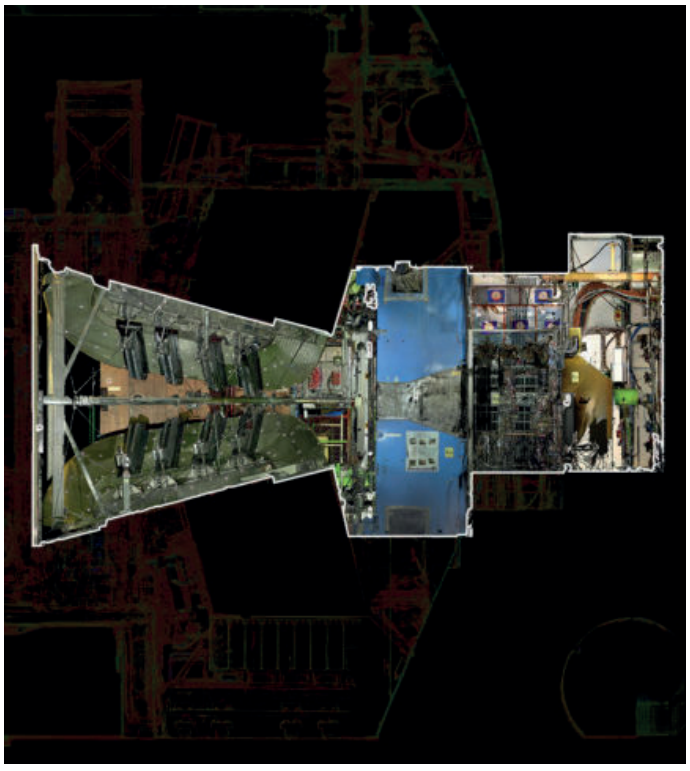


3D Point Cloud of cables installed in LEP

Cross section of some cables - details are detectable



A quick cut through the raw point data – showing the location of Large Hadron Collider beauty (LHCb) and the decommissioned DELPHI areas



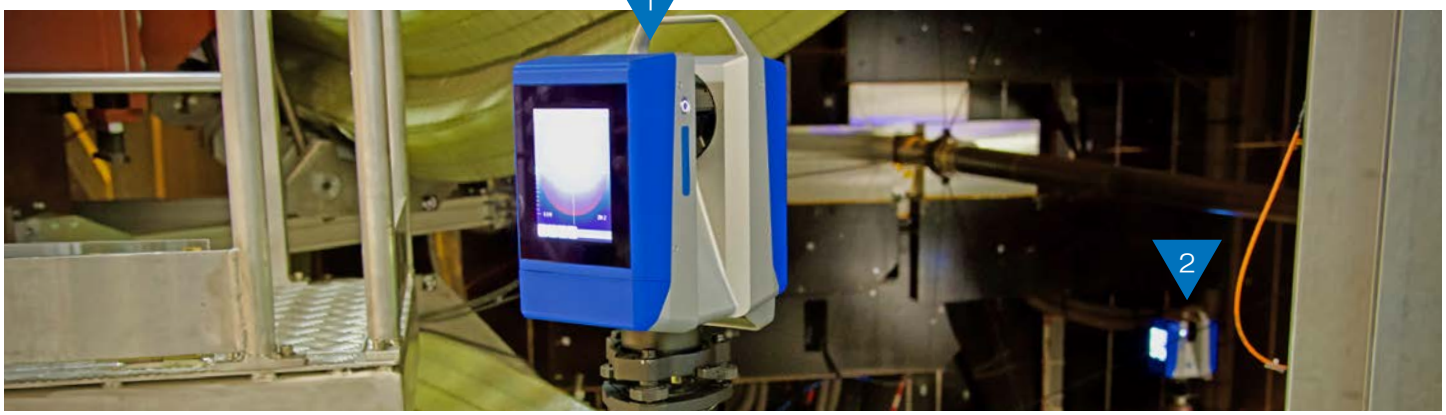
A lateral cross section through LHCb indicating the position of the Beryllium pipe and surrounding magnets

The **blue workflow®**

The blue workflow® describes a series of optimized work steps for measuring and processing measured data. The focus is on flexibility, data security and efficiency. With Z+F LaserControl® Scout and the laser scanners Z+F IMAGER® 5010X and 5016, point clouds can be registered, checked, processed and evaluated in real time in the field.
In addition, the user immediately recognizes problems in the project through immediate visualization and can intervene directly on site.

In detail, the blue workflow® allows the users to carry out the following work steps in the field:

- Registration of the point clouds
- Check the scanned targets
- Verification of data quality and quantity
- Direct integration of handheld scanner data
- Multi Scanning - the registration of point clouds created with multiple scanners (below scanner 1 and 2)

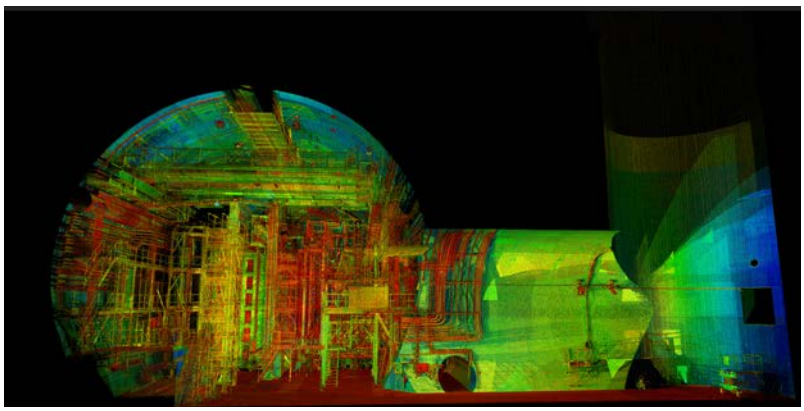


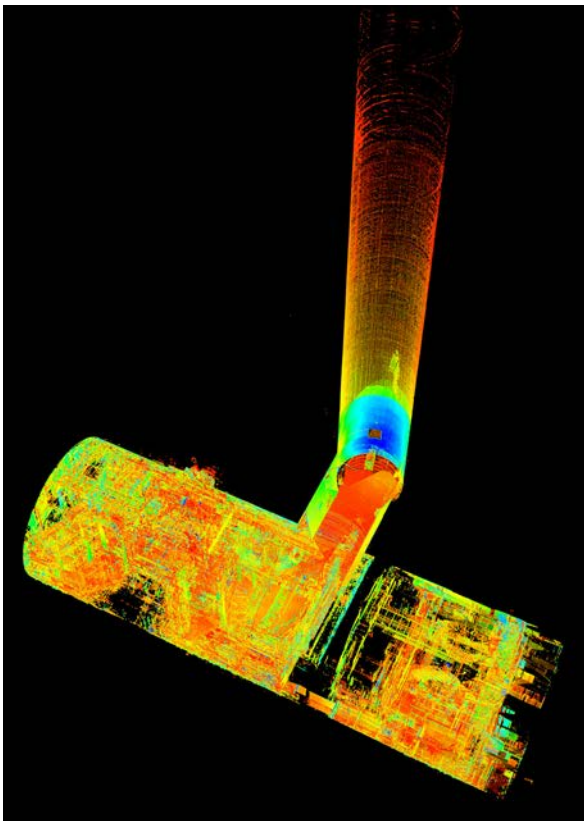
Registration and scanning with more than one Z+F IMAGER® 5016

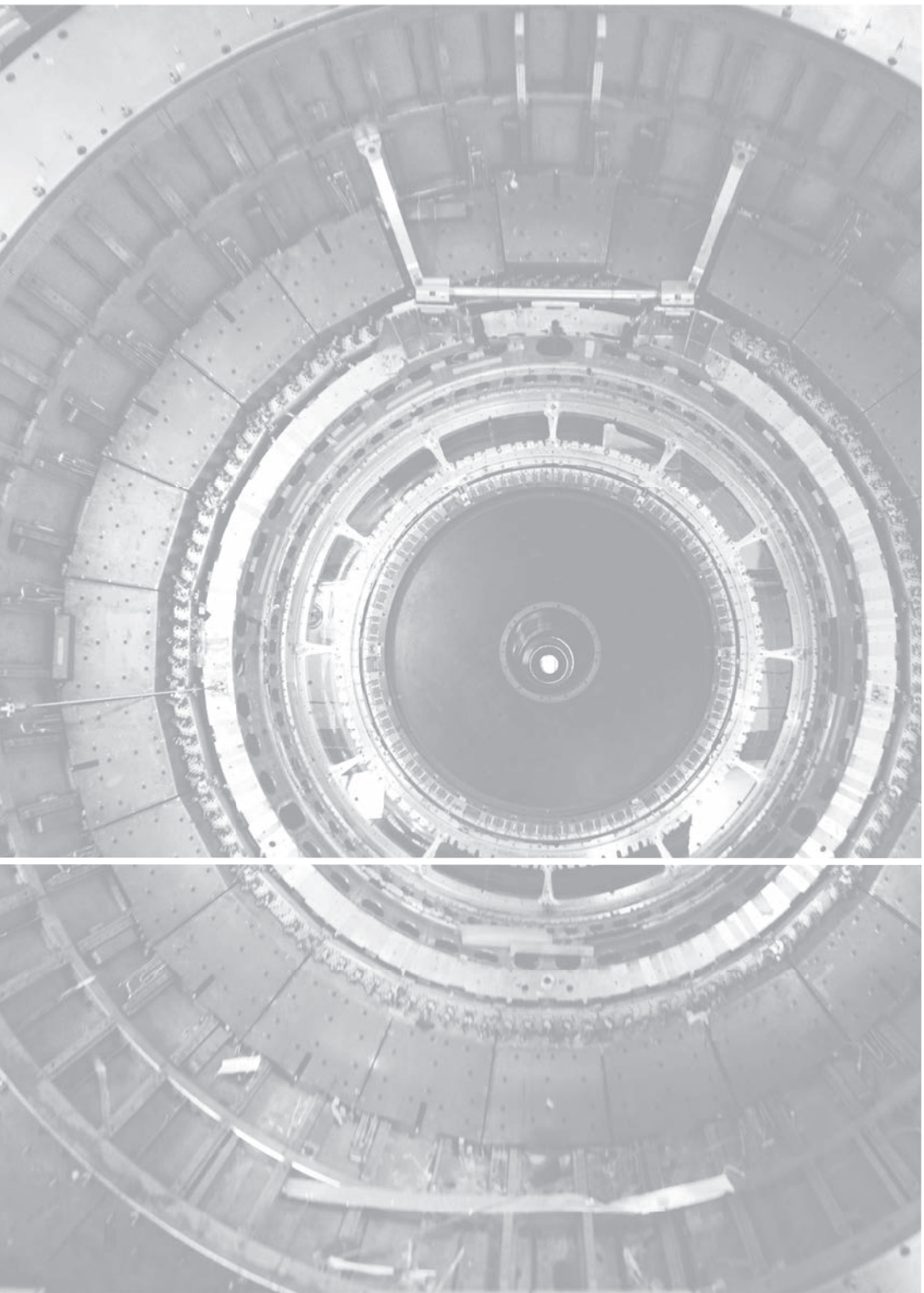
Challenge

Beryllium metal is ideally suited for the CERN experiments due to its low atomic number and low density, but it did pose a challenge to scan. Beryllium is an exceptionally rare element, difficult to manufacture and highly toxic if broken, therefore the area is highly restricted and accessible to only highly trained CERN staff. With the scanner carefully positioned, three high-resolution scans were taken within this area – apparently a world's first.

With the imagery and point data currently registered, the idea is that it will provide CERN with a precise three-dimensional CAD survey and also the foundation for the development of visually engaging, multimedia content for educators, engineers, researchers and visitors.







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