Fraunhofer
EMI

Fraunhofer Institute for High-Speed Dynamics,
Ernst Mach Institute, EMI

X-Ray Car Crash

Detect details from inside the crash with highly dynamic X-rays

Direct insight into the relevant processes during a crash
Until now, complex component structures and cladding have meant that much has remained hidden during the crash test. Now, high-dynamic X-rays provide unique insights.

X-ray crash with 1000 images per second: see what is really happening inside

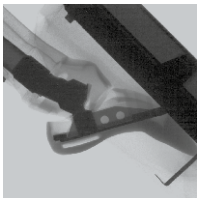
Crash tests are complex and expensive: the aim is to generate as much high-quality data as possible. The new X-CC X-ray crash test now makes it possible to look inside structures. It was developed at the Fraunhofer Institute for High-Speed Dynamics, Ernst Mach Institute, EMI.

Safety-relevant components are not always visible from the outside during the crash test using conventional methods. As a result, important experimental findings about the underlying deformation processes are missing. In order to be able to analyze the safety-critical processes inside vehicle structures, the institute combines its many years of expertise in high-speed dynamics with X-ray diagnostics: X-ray images can now be taken at 1000 images per second.

- ✓ More high-quality data per test
- ✓ Data from inside the vehicle during a crash
- ✓ For cases that are difficult to clarify
- ✓ Data that can be evaluated visually

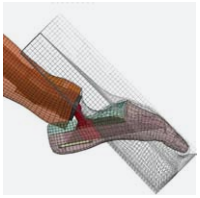
Opening up a new dimension with X-rays

The X-ray crash at Fraunhofer EMI combines high dynamics with X-ray technology. For the first time, it makes it possible to experimentally validate the behavior of internal components and subsystems during the crash.



Direct observation of critical processes
Until now, these processes could only be measured indirectly (e.g. using acceleration sensors) or reconstructed after the crash. High-dynamic X-rays make it possible to directly observe critical processes inside the vehicle. In the simplest case, the crash engineer can directly recognize the sequence of events in the X-ray video.

More high-quality data per test
The innovative research concept of X-ray simulation, X-ray crash and analysis provides unique data and views from inside the vehicle during a crash.



Millisecond-precise analysis and data feedback into the familiar working environment
The critical point in time at which a system tips over can be compared with the FE simulation with millisecond precision. If prominent areas in the X-ray image are tracked over time, it is possible to transfer the trajectories back to the evaluation software. This enables a quantitative comparison with the simulation in the user's familiar working environment.

Linking design, process and material
The material is analyzed before, during and after the processes. This data knowledge is used to automate the design using algorithms. By digitally linking design, process and material, solutions can be determined reliably and with maximum precision.

Applications
X-ray crash technology can be used to examine passive vehicle safety structures, analyze the behavior of safety-relevant subsystems, as well as in particularly demanding crash scenarios, such as the small overlap crash
.

I. X-ray Simulation

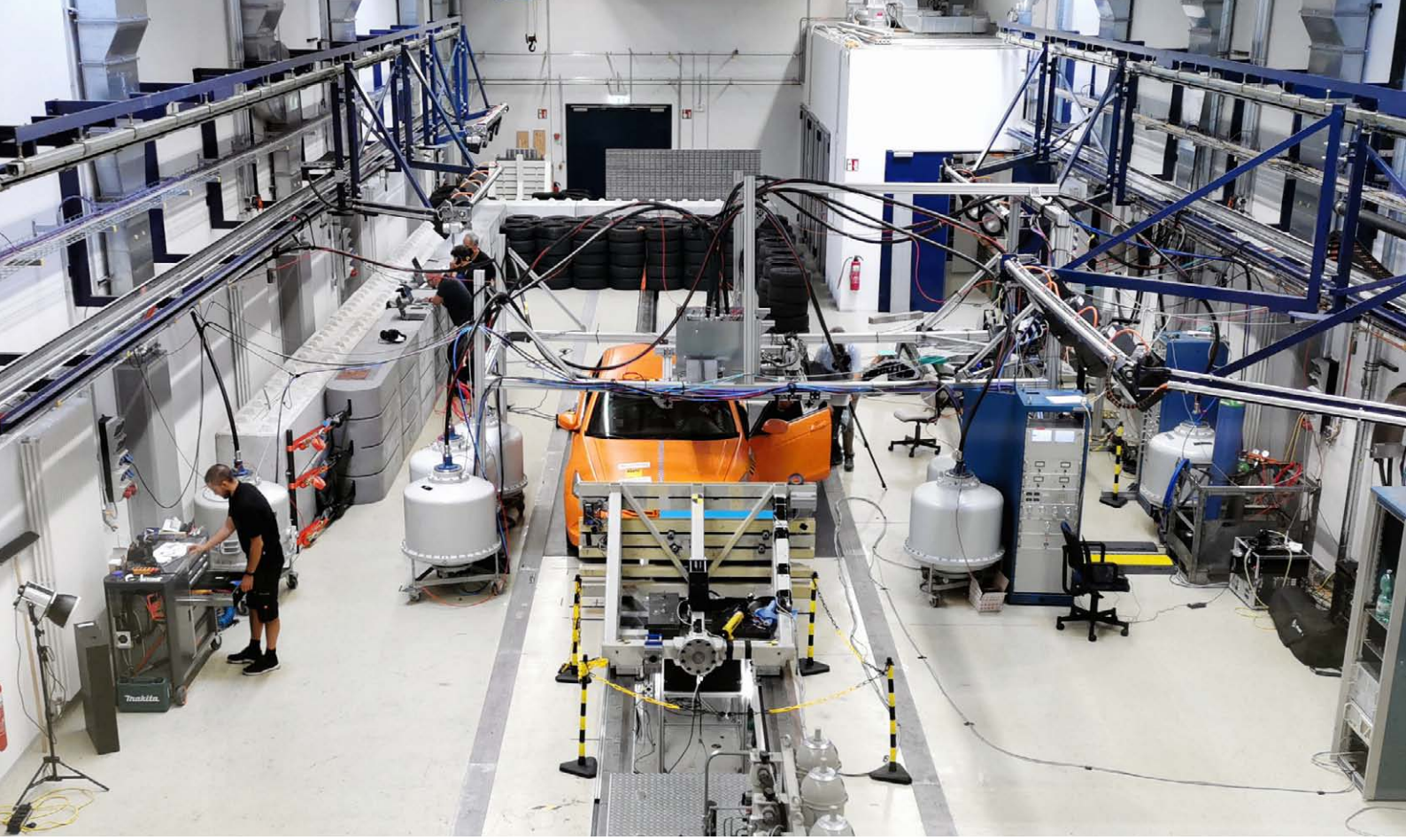
FE modeling
and virtual pre-testing

II. X-ray crash

Kilohertz high energy
radiation source,
crash system, crash measurement
technology

III. Analysis

3D point tracking in
X-ray data,
feedback in FE simulation



Research crash-test facility In the research crash-test facility, impact tests are carried out at component and complete vehicle level with impact masses of up to 3 tons and speeds of up to 80 km/h. Im Image: Complete vehicle test with the use of X-ray flash technology.

High-speed dynamics and X-ray: the technology in detail

Can you X-ray a car - like a doctor? And all this in the event of a high-speed collision?

A high-speed X-ray video is created during the vehicle crash at the Fraunhofer EMI research crash-test facility.

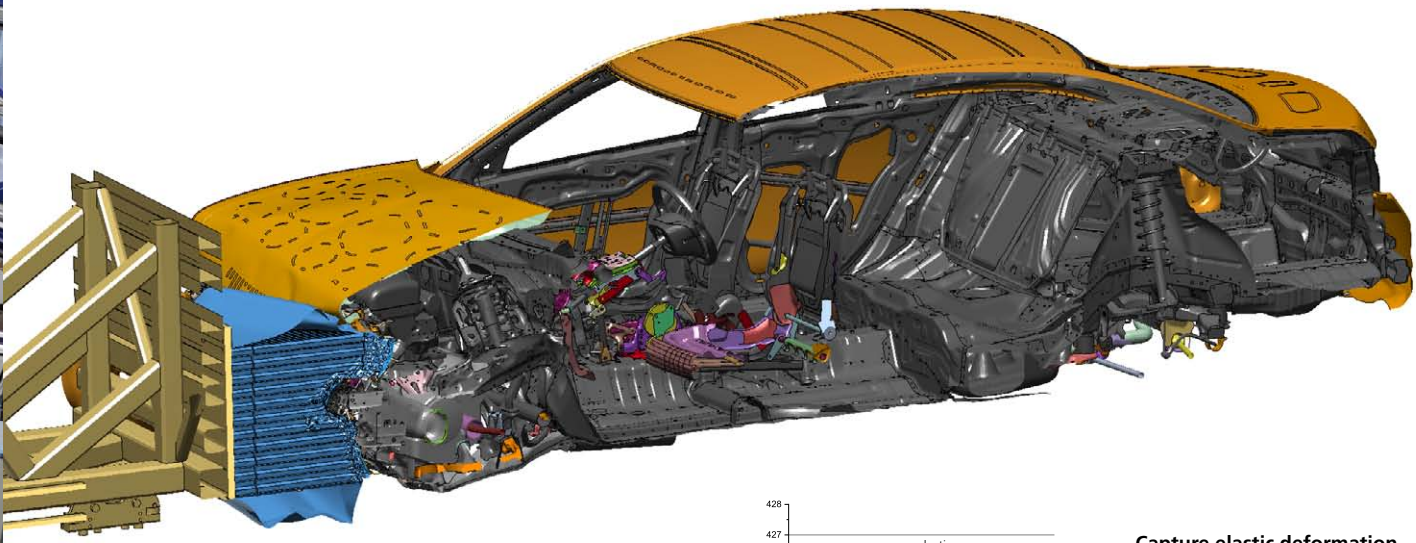
Using a priori data and simulations, defined areas and specific components inside the vehicle are examined in advance.

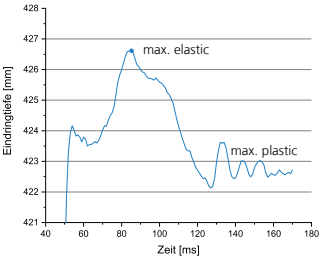
If FE simulation data is available, virtual preliminary tests can be carried out using the X-ray simulation developed in-house. This allows the experimental setup to be optimized. The observation window in space and time must be defined in such a way that important processes take place as transversely as possible to the direction of observation.

Markers are used for special questions - similar to those used in medicine. They are particularly easy to recognize in the X-ray image after imaging. Under these conditions, the results can be evaluated precisely.

An X-ray video is generated from the raw data using digital image processing algorithms. It is processed in such a way that internal processes can be easily understood. In addition, digital pattern recognition techniques can track features and record their trajectories quantitatively.

The Fraunhofer EMI uses the highly dynamic X-CC X-ray technology to investigate its customers' issues and provides on-site support for the implementation of X-CC technology.

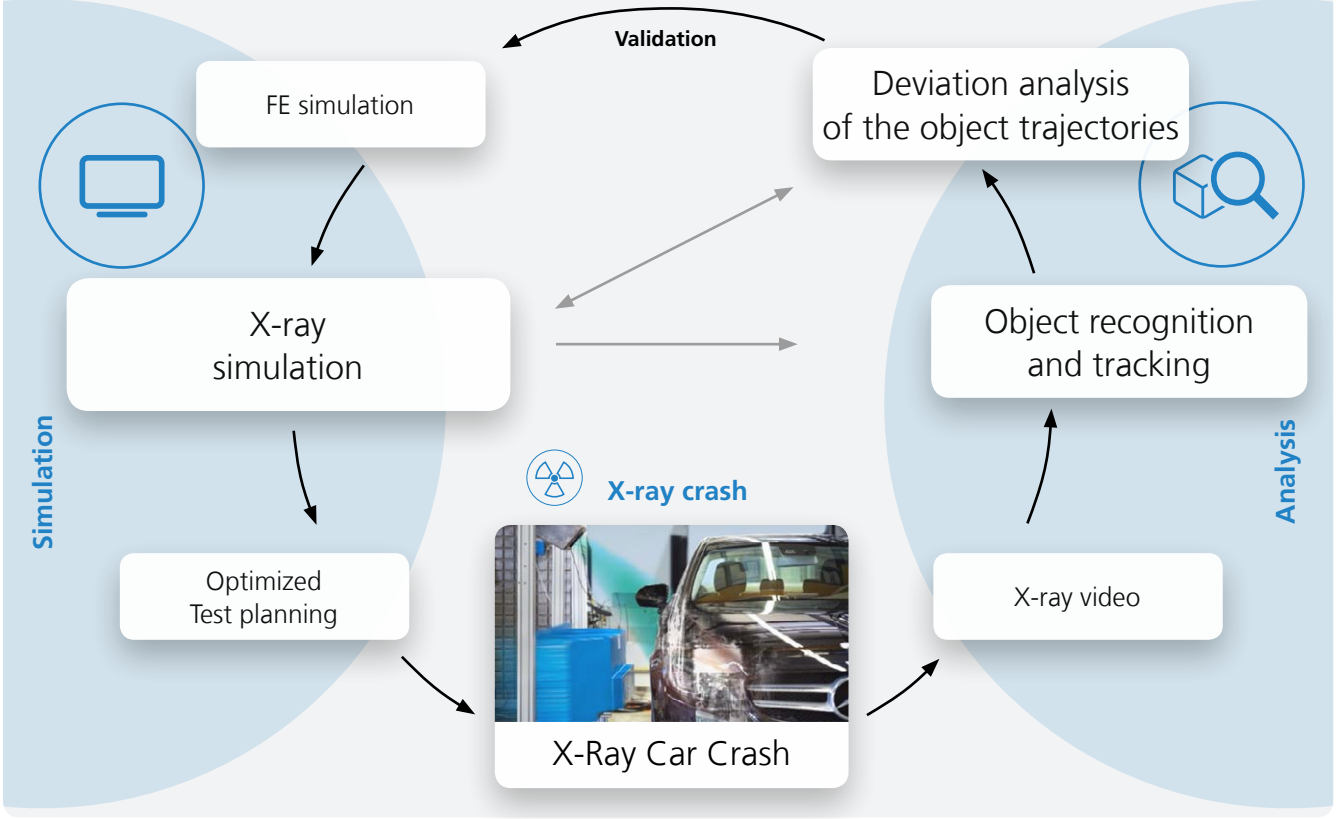




Capture elastic deformation directly during a crash
In the simulation, the front end penetrates deep into the honeycomb barrier. The elastic deformation goes beyond the plastic deformation. Both are difficult to measure in tests without X-rays.

Flowchart X-Ray Car Crash

Fusion between simulation and experiment Simulated X-ray images are generated for test planning on the basis of FE simulations. This data is used to optimize the test setup for maximum information gain. The X-ray video obtained in the experiment is subsequently analyzed. The data obtained enables the validation of the simulation models of previously invisible components.



Flexible test stand The test setup is customized depending on the requirements.

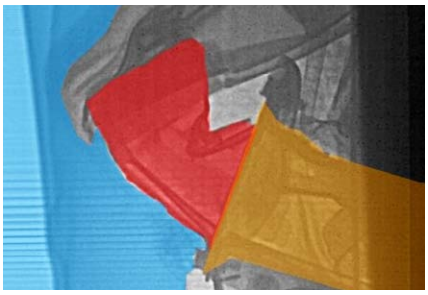
Application examples

The relevant crash processes are often hidden inside the vehicle. There are many reasons for this: complex component structures, overlapping multi-level protection concepts or cladding. With all these limitations, high-dynamic X-rays provide a direct insight.

Dummy head impact on the steering wheel

Accurate detection of the head position - despite airbags
A large number of airbags are deployed during a crash test of modern vehicles. The curtain airbags in particular block the view of the dummies inside the vehicle. Acceleration sensors, interior cameras and color markings only provide an incomplete picture. With the highly dynamic X-ray technology X-CC, the exact position of dummies in the vehicle can be filmed: How close has the head really come to the steering wheel? Are there elastic deformations that are no longer recognizable after the crash? X-CC is a useful addition to existing techniques.

Precise fine-tuning The Crash Center team advises on site on the final steps required for successful insurance implementation.



Recording the NCAP MPDB test more precisely

X-ray provides answers about the crash sequence
In the MPDB test, the front end of the car penetrates deep into the honeycomb barrier. During the evaluation, the plastic deformation is measured with millimeter precision after the crash. But how deep does the vehicle penetrate and when? When does deformation occur in the crash structure in the barrier? How large is the maximum elastic deformation? X-rays can provide the answers to these questions.

Complex, multi-layered crash structures

Investigate impact at the time of deepest intrusion
When protecting VRUs or occupants, dummies come into contact with multi-layered complex structures, such as the A-pillar. This deforms both the outer layers and the inner structures. However, it is no longer possible to tell after the test which elastic deformations of the deeper structures take place or when failure occurs. Highly dynamic X-ray technology can be used to examine the impact at the time of the deepest intrusion and clarify the relevant issues.

This is how you can cooperate with us:

Research and development order

The classic cooperation: For example, orders for material characterization, FE modeling, component or full-vehicle crash test.

Strategic Partnerships

Long-term collaboration to develop completely new technologies, testing methods, software and new materials.

Joint publicly funded projects

We work with you to apply for public research funding for a joint project idea. The projects are usually designed to run for three years.

Doctorates

A doctoral candidate conducts research at Fraunhofer EMI on a topic related to your company.

Contact person

Dr. Malte Kurfiß
Head of Crash Center

Fraunhofer Institute for High-Speed Dynamics,
Ernst-Mach-Institut, EMI
Am Klingelberg 1
79588 Efringen-Kirchen

Phone +49 7628 9050-712
malte.kurfiss@emi.fraunhofer.de

Team Crash Center

Location Freiburg

Location Efringen-Kirchen

Location Kandern

Fraunhofer Institute for High-Speed Dynamics, Ernst Mach Institute, EMI

Fraunhofer EMI is a world-leading research institute in high-speed dynamics.

The institute conducts research on fast processes through experiments and simulations, with a focus on enhancing safety and resilience.

Specifically, the research focuses on processes which occur within fractions of a second, such as car crash, battery explosion, or collision in space. Based on the observations, enhanced safety concepts are developed

Fields of research include safe mobility, battery safety, building protection, aircraft safety, satellite development, research for the German Armed Forces, safety in urban systems, and resilience of infrastructure networks.

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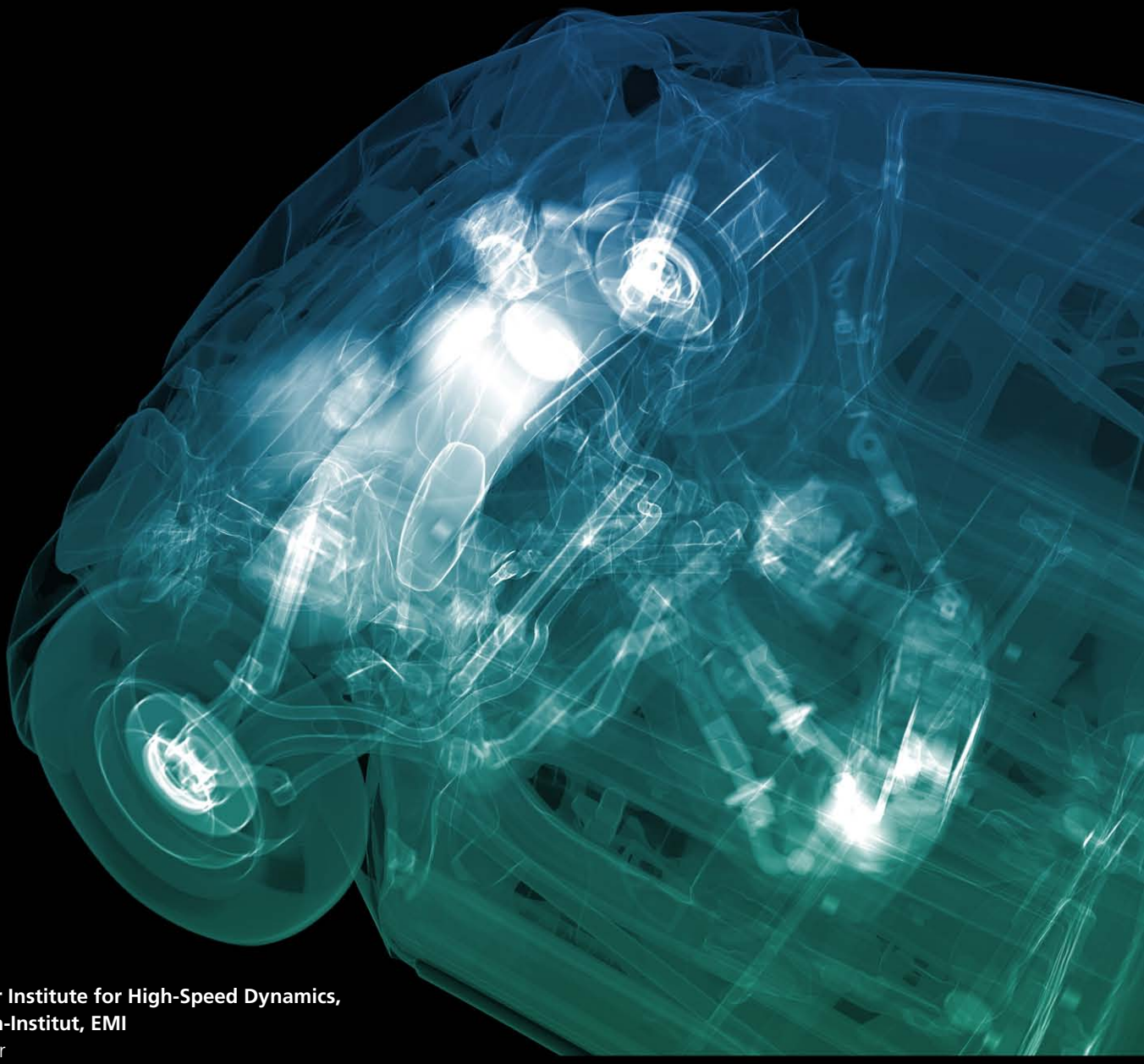
Ernst-Zermelo-Straße 4, 79104 Freiburg, Phone +49 761 2714-0, info@emi.fraunhofer.de, www.emi.fraunhofer.de



Fraunhofer Institute for High-Speed Dynamics,
Ernst-Mach-Institut, EMI
Crash center

Am Klingelberg 1
79588 Efringen-Kirchen, Germany
Phone +49 7628 9050-0
info@emi.fraunhofer.de
www.emi.fraunhofer.de

Locations:
Freiburg, Efringen-Kirchen und Kandern