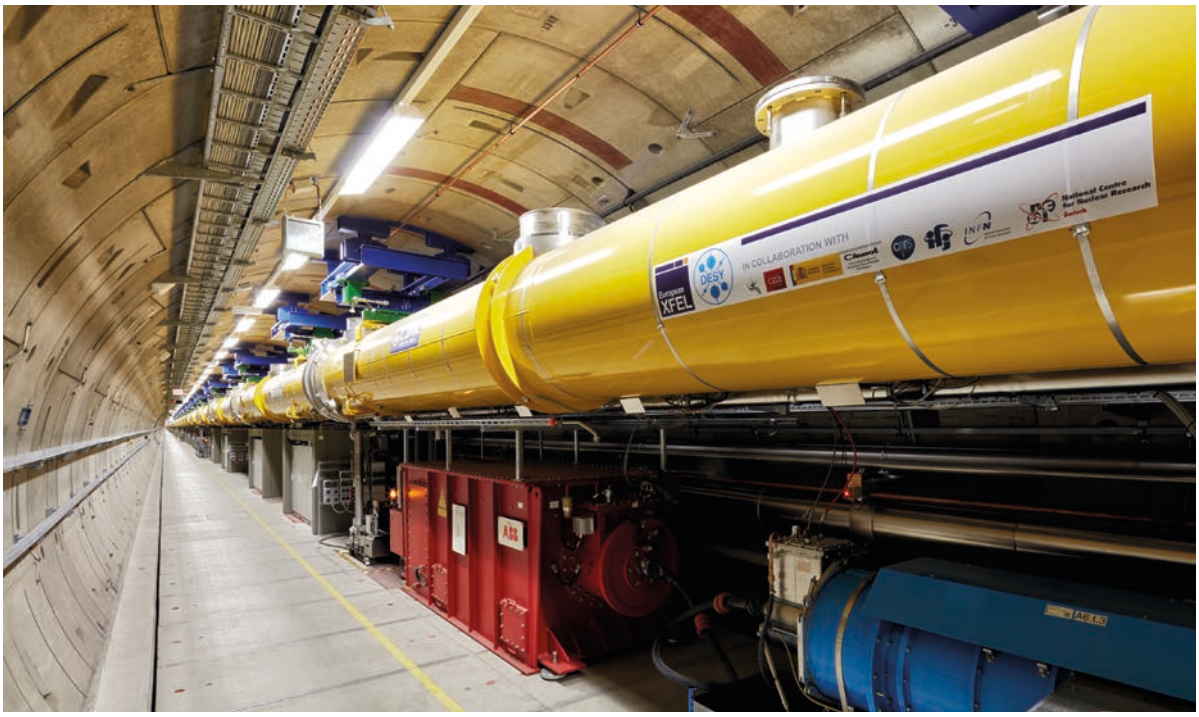
A Research Facility of Superlatives

Pfeiffer Vacuum supplies the European XFEL with vacuum solutions.

Fabian Frey



European XFEL / Heiner Müller-Elsner

View inside the XFEL accelerator tunnel

The beginning of September 2017 marked a milestone in the history of nanotechnology research: With the inauguration of the European XFEL (X-ray Free-Electron Laser), the world's largest and most powerful X-ray laser was officially put into operation. It will open new areas of research up and give insights into the nanocosm that were never achieved before.

The European XFEL is an international research facility, in which 12 European countries participate. The non-profit company European XFEL GmbH is responsible for the construction and operation of the X-ray laser. DESY (Deutsches Elektronen-Synchrotron), one of the worldwide leading centers for the investigation of the structure of matter and a long-term partner of Pfeiffer Vacuum, is the main share-holder. The facility starts at the DESY site in Hamburg and stretches to the town of Schenefeld in the German federal state of Schleswig-Holstein.

The interdisciplinary research at the European XFEL will deliver valuable insights into many areas of science. Experience shows that from this type of basic research, important applications develop. Many areas of science will profit from the new facility – among others, medicine, pharmacology, chemistry, physics, materials science, nanotechnology, energy technology, and electronics.

Using the unparalleled X-ray flashes of the European XFEL, scientists will be able to decipher the atomic details of viruses and cells, take three-dimensional images of the nanoworld, film chemical reactions or study processes such as those occurring deep inside planets.

To generate the X-ray flashes, bunches of electrons are first accelerated to high energies and then directed through special arrangements of magnets, so-called undulators (**Fig. 1**). Undulators are arrays of permanent magnets that are placed in an alternating pattern. They force accelerated electrons onto a slalom course. With every turn, the electrons emit X-ray light.

Because of the behavior of the X-rays in relation to the electrons and because of the pattern of the magnets in the undulator, the emerging light is laserlike, with all of its waves in phase with each other. Consequently, the European XFEL generates X-ray radiation with properties similar to those of laser light.

All these processes require ultra-high (UHV) or high vacuum (HV) conditions. Within several years of cooperation, Pfeiffer Vacuum developed matching solutions for the high vacuum applications inside European XFEL. All solutions were exclusively tailored to the specific

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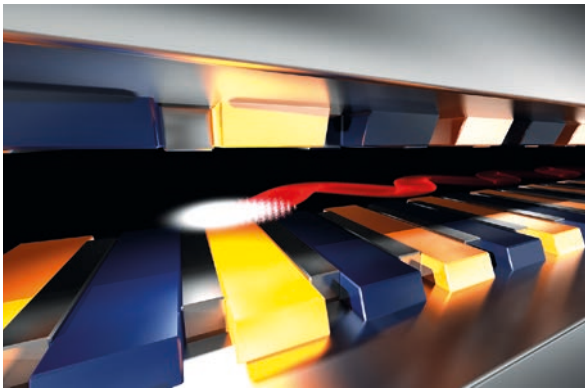
European XFEL

Fig. 1 X-ray laser flashes are generated in an undulator.

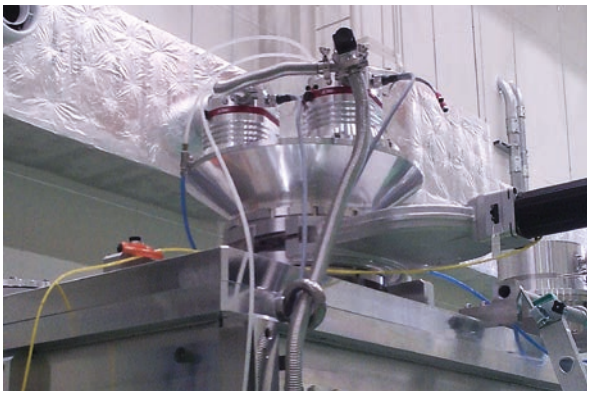

Fig. 2 HiPace turbopumps are installed at European XFEL.

needs and demands of these applications.

At the HED instrument of European XFEL, multiple turbopumps from Pfeiffer Vacuum are used to increase the pressure from UHV to HV (**Fig. 2**). There, ion getter pumps cannot be used. The whole beam line is windowless, so the differential pumping stage not only has to cope with the different vacuum levels, it also has to handle sudden or unexpected influxes of gas. Furthermore, the turbopumps have to maintain the UHV as a link on the side to the ion getter pumps so as not to trigger the machine protection valves and shut off the beam.

Pfeiffer Vacuum also developed and supplied the customized flange for the large interaction chamber (**Fig. 3**). The volume is about seven cubic meters. The solution from Pfeiffer Vacuum is specifically tailored to the needs of the application.

By using 800-liter pumps on two specially designed manifold flanges, the customer's demands were exceeded thanks to the higher compression of the pumps: the pumping speed can now be tuned to the user requirements with more or less pumping speed, depending on the type of experiment. Moreover, user safety was guaranteed and the down time was minimized.

The vacuum experts from Pfeiffer Vacuum recommended using more small pumps. The failure of a large pump is not only potentially dangerous but also puts the beam line out of operation until a replacement pump is fitted. With the current design, the pump can simply be replaced or a blank flange can be mounted and the normal operation can continue until a convenient time to replace the pump is found.

In further high vacuum applications at the European XFEL, HiPace 80, 300 and 800 turbopumps and associated controllers are used. Moreover, gauges as well as flanges, viewports and standard parts are in operation. Additionally, Pfeiffer Vacuum designed and manufactured customized parts and instruments for the HED instrument. The HiPace turbopumps allow an easy integration into the XFEL control system. Pfeiffer Vacuum modified the pumps according to the XFEL standards by enabling the option to use deionized water for cooling. In addition, Pfeiffer Vacuum supplied customized cables that matched the specific length of the XFEL standard connectors.

Solutions from a single source

Special vacuum components such as flanges and pipe components were developed for the use in European XFEL's electron beam lines. Moreover, the turbopumps and mass spectrometers were designed in close cooperation with the customer to match the requirements. Also special editions of leak detectors were delivered according to the customer's demands. Therewith, Pfeiffer Vacuum successfully provided tailored vacuum solutions from a single source for the UHV and HV at the European XFEL.


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Fig. 3 The interaction chamber at European XFEL is equipped with Pfeiffer Vacuum solutions.