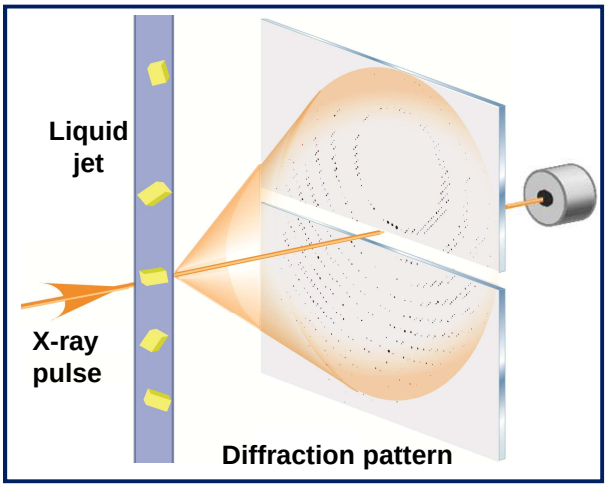
European XFEL Workshop

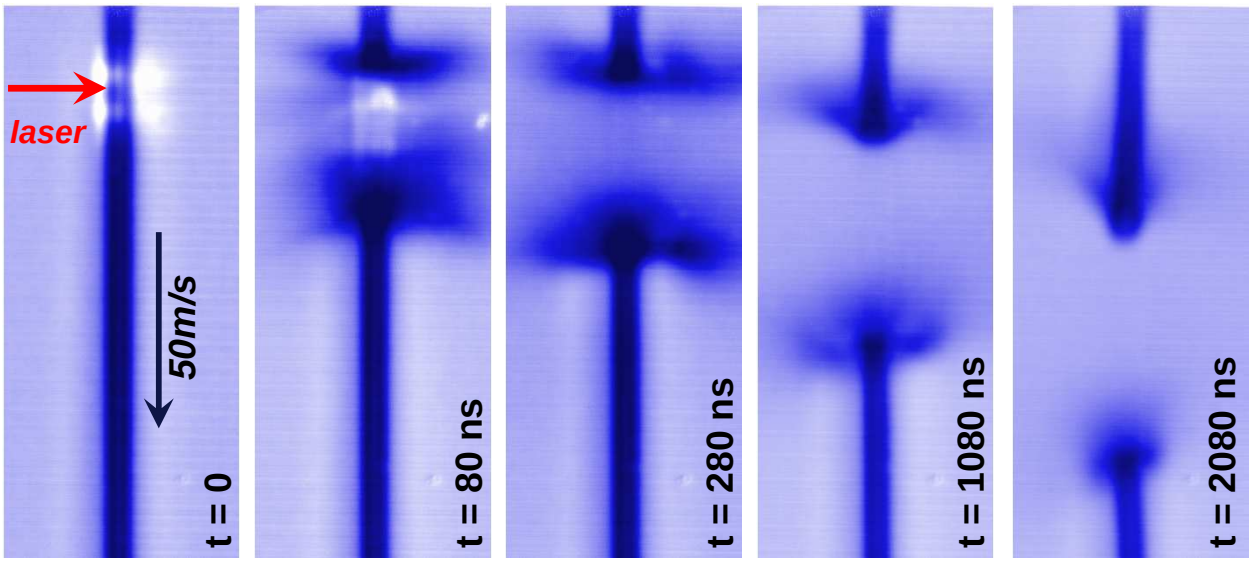
Opportunities for microfluidic devices at Free-Electron Lasers

15 June 2017 / European XFEL, Schenefeld, Germany

The recent developments on microfluidics for X-ray free-electron laser (XFEL) experiments open up the possibility to address new scientific questions. Novel micro-fabricated devices enable reactions initiation by **rapid mixing**, taking XFEL experiments beyond static structure solution into the realm of time-resolved structural science for a wide range of samples. The workshop will address further challenges on liquid sample delivery. **Sample consumption** is the bottleneck for experiments with precious samples and strategies for its reduction will be discussed. Moreover, the high repetition rate of European XFEL demands **rapid sample refreshment**, a challenge for all sample delivery methods.

We are pleased to announce a workshop on microfluidics for X-ray free-electron laser experiments, which aims to bring together developers of liquid sample delivery, using diverse microfabrication techniques and sample delivery approaches. The workshop intends to be a platform for discussing the latest developments and foster exchange of information and expertise.





European XFEL Workshop

Opportunities for microfluidic devices at Free-Electron Lasers

15 June 2017 / European XFEL, Schenefeld, Germany

Hosted by European XFEL

Speakers:

George Calvey, Cornell University

Daniel DePonte, SLAC National Accelerator Lab

Sebastian Göde, European XFEL

Michael Heymann, Max Planck Institute of Biochemistry

Daniel Langley, La Trobe Institute of Molecular Science

Adrian Mancuso, European XFEL

Dominik Oberthür, Center for Free-Electron Laser Science

Alexandra Ros, Arizona State University

Sébastien Teychené Laboratoire de Génie Chimique

Martin Trebbin, University of Hamburg

Organizers:

Rita Graceffa, European XFEL

Joachim Schulz, European XFEL

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08:15	Registration	
08:45	Welcome / Purpose and goals of the workshop	Serguei Molodtsov, Rita Graceffa European XFEL
Latest developments on liquid jets		
	Chair: Joachim Schulz, European XFEL	
09:00	Overview of the European XFEL and the SPB/SFX Instrument: Opportunities for microfluidic sample delivery (and more)	Adrian Mancuso European XFEL
09:30	Glass-based Microfluidic Injectors	Daniel DePonte SLAC National Accelerator Lab
10:00	Towards high throughput sample delivery for serial crystallography	Dominik Oberthür Center for Free-Electron Laser Science
10:30	Coffee	
11:00	Microfluidic crystallography: sample preparation and delivery	Michael Heymann Max Planck Institute of Biochemistry
11:30	Platform for cryogenic jet targets at the HED instrument	Sebastian Göde European XFEL
12:00	Lunch	
Mixing experiments		
	Chair: Katerina Dörner, European XFEL	
13:30	Watching proteins function: mixing injector for time-resolved crystallography at X-ray Free Electron Lasers	George Calvey Cornell University
14:00	Coupling droplet microfluidic and SAXS: from protein interactions to crystal nucleation	Sébastien Teychené Laboratoire de Génie Chimique
14:30	Microfluidic Droplet Generators and Mixers for Serial Crystallography	Alexandra Ros Arizona State University
15:00	Coffee	
15:30	Rapid Mixing Microfluidics for Time-Resolved X-ray Scattering	Martin Trebbin University of Hamburg
16:00	Rigid Materials for Photolithography Based Rapid Microfluidic Mixing and sample Delivery	Daniel Langley La Trobe Institute of Molecular Science
16:30	*Close-up session:* Microfluidics at European XFEL, current status and future perspectives	Rita Graceffa European XFEL
17:00	Guided tours of user laboratories and experimental hall	

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Opportunities for microfluidic devices at Free-Electron Lasers

Overview of the European XFEL and the SPB/SFX Instrument: Opportunities for microfluidic sample delivery (and more)

Adrian Mancuso[1]

[1] European XFEL GmbH, Schenefeld, Germany

The European X-ray Free-Electron Laser (XFEL) will offer first light to users in the second half of 2017 and promises to be the brightest source of hard X-rays available for a wide variety of experiments. This unique capability in turn promises to be extremely valuable to the determination of structure using scattering techniques—notably in crystallography, as well as providing the potential to determine the structure of single (non-crystalline) particles.

In this presentation, I will introduce the European XFEL and its instrumentation that supports structure determination experiments—the Single Particles, Clusters and Biomolecules and Serial Femtosecond Crystallography (SPB/SFX) Instrument. The basic components of optics, sample delivery and detector(s) will be described, with an outlook to the opportunities for microfluidics to exploit the high repetition rate of the European XFEL for new science.

European XFEL Workshop

Opportunities for microfluidic devices at Free-Electron Lasers

Glass-based Microfluidic Injectors

Daniel DePonte[1]

[1]SLAC National Accelerator Lab, Menlo Park , USA

Fluid based sample delivery is used for a little over half of the user operations shifts at the SLAC Linac Coherent Light Source. The sample injector devices are fairly task-specific with little demand for them elsewhere. As a result, there is little commercial interest in developing microfluid injectors and sample delivery efforts have progressed slower than other FEL subsystems. This presentation will discuss the efforts at SLAC and Stanford to produce standardized, manufactured, glass and silicon based fluid injectors.

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Opportunities for microfluidic devices at Free-Electron Lasers

Towards high throughput sample delivery for serial crystallography

Dominik Oberthüer[1]

[1] Center for Free-Electron Laser Science, DESY, Hamburg, Germany

Serial femtosecond crystallography (SFX) both required and enabled new sample delivery techniques. While for certain experiments the classic ways of how to get a crystal into the X-ray focus can still be used, it is often desired to replenish the sample at much faster rates, to be able to introduce much smaller crystals and to reduce the X-ray background from the sample carrier as much as possible. Initially gas-dynamic virtual nozzles (GDVN) were used for this purpose, since then a huge variety of sample delivery methods has been developed and used for SFX: viscous extrusion jets (LCP-jets), electrokinetic injection, conveyor belt injection, acoustic droplet ejection, piezo-electric droplet generation and various fixed target sample delivery systems. All of these approaches aimed to make sample delivery more efficient: reducing sample consumption and increasing the fraction of X-ray pulses that interact with the crystalline sample and give rise to indexable diffraction patterns. The original GDVN were produced in an artisanal fashion. The quality of a nozzle depended entirely of the capability of its producer and was neither reproducible nor predictable. For efficient sample delivery it is important to have nozzles that are all of the same high quality and that identical nozzles can be produced in large amounts. The most promising approach towards this goal is to make use of the microfluidic technologies developed the past decades. It's inherent advantage is the possibility of rapid prototyping, enabling a certain flexibility in design crucial for the handling of different samples. We combine 3D-printed microfluidics using a NanoScribe system with fluid-dynamics simulations to design, develop and produce GDVN, double flow focusing nozzles and mixing injectors for high throughput ultrafast SFX and time-resolved studies.

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Opportunities for microfluidic devices at Free-Electron Lasers

Microfluidic crystallography: sample preparation and delivery

Michael Heymann[1]

[1] Max Planck Institute of Biochemistry, Martinsried, Germany

There is no guarantee that a given protein has a crystalline phase, but even existence of an equilibrium crystalline phase is not sufficient for a crystal to form because the transformation of a protein solution to a crystal is governed by two non-equilibrium processes: nucleation and growth. Consequently, supersaturation kinetics play an essential role in crystallization and we argue that the optimal crystallization strategy should involve variables such as depth of supersaturation, duration of supersaturation, and sample volume.

Protein crystallization is a stochastic process; we experimentally optimize crystal nucleation and growth by generating hundreds of different kinetic paths simultaneously by varying both temperature and concentration of the protein solution. We have developed a phase chip technology based on emulsion microfluidics in which nanoliter volumes of protein solution are encapsulated in oil and stabilized by surfactant. This entails finding conditions on-chip for which one crystal is grown per drop and then isolating hundreds of drops for serial crystallography using an x-ray semi-transparent microfluidic device or via liquid jet injection.

Reliable sample delivery is essential to biological imaging using X-ray Free Electron Lasers. Continuous injection using the Gas Dynamic Virtual Nozzle (GDVN) has proven valuable, particularly for time-resolved studies. Yet, many important aspects of GDVN functionality have yet to be thoroughly understood and/or refined due to fabrication limitations. We use 2 high-resolution 3D printing to fabricate high-fidelity GDVNs with submicron resolution. This technique allows rapid prototyping of a wide range of different types of nozzles from standard CAD drawings and optimization of crucial dimensions for optimal performance.

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Opportunities for microfluidic devices at Free-Electron Lasers

Platform for cryogenic jet targets at the HED instrument

Sebastian Göde[1]

[1] European XFEL GmbH, Schenefeld, Germany

Target development has a significant impact on pushing the frontier in high energy density (HED) science, e.g. relativistic laser plasma physics or shock compression studies. Using liquid jets are of particular interest because they provide high repetition rate and debris free samples. Combining liquid jet and cryogenic technologies now pave the way to deliver ambient gas phase elements such as hydrogen, helium or methane at liquid/solid density. This talk will give an overview on recent activities on the development of cryogenic liquid hydrogen jets and their application at SLAC and DRACO. The performance of cylindrical jets with diameters in the range of 2-10 microns will be presented and compared with results from jets with planar geometry.

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Watching proteins function: mixing injector for time-resolved crystallography at X-ray Free Electron Lasers

George D. Calvey[1], Andrea M. Katz[1] and Lois Pollack[1]

[1] School of Applied and Engineering Physics, Cornell University, Ithaca, New York 14853, USA

Time-resolved crystallography at X-ray free electron lasers is poised to greatly advance enzymology and structure based drug design. The protein microcrystals used in SFX open up the opportunity to study chemically activated reactions. The small dimensions of these crystals allow short soaking times and observation of rapid reactions with atomic detail. We have developed a mixing injector for SFX that can capture transient states occurring milliseconds to seconds after introducing a reactant to the protein crystal [1]. The mixing device is integrated into a gas dynamic virtual nozzle, making it compatible with existing vacuum and atmospheric sample environments at XFELs. It has been successfully used at LCLS, and has proven to be robust and clog resistant, providing hit rates comparable to a standard GDVN. New all-glass construction techniques further improve the device, providing impeccable chemical compatibility and smooth contours to funnel even challenging samples through the mixer.

[1] G. D. Calvey, A. M. Katz, C. B. Schaffer, and L. Pollack, “Mixing injector enables time-resolved crystallography with high hit rate at X-ray free electron lasers,” Struct. Dyn., 3 (2016)

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Opportunities for microfluidic devices at Free-Electron Lasers

Coupling microfluidics and Small-Angle X-ray scattering to study the whole crystallization process of proteins in solution

Sébastien Teychené[1]

[1]Laboratoire de Génie Chimique, Toulouse, France

The combination of microfluidics and SAXS provides a powerful tool to investigate phase transitions at different molecular levels and relevant timescales. In droplet based microfluidics, the sample is compartmentalized inside droplets, each droplet acting as a microreactor in which the operating conditions can be finely tuned without cross-contamination. Several microfluidic platforms were developed in different BioSAXS beamlines (BM29 at ESRF and SWING at Soleil) to probe protein interactions in solution and phase transitions for nucleation and phase transition studies. The developed microfluidic systems generate droplets containing proteins, crystallization agents and buffer, carried by an inert fluorinated oil. In the microfluidic platform developed on BM29, the droplets are transferred from the microfluidic chip into the sample holder for exposure to the X-ray beam. The droplet flow is synchronized with SAXS measurements to probe protein form and structure factors while minimizing radiation damage. To this end, the experimental setup was used to successfully determine the form factor of three proteins. For instance, the experimentally obtained scattering curves of rasburicase fit well with their scattering curves determined from the crystal structure proving the structural stability of the protein in droplets and the absence of radiation damage. Subsequently, weak interactions of lysozyme solution were studied as a function of protein and salt concentrations. The obtained second virial coefficients values were found to be in good agreement with data previously reported in literature but using only a few milligrams of protein. In the microfluidic platform developed on SWING the microfluidic chips were directly inserted in the beam. In this setup, tens of droplets are stored in a capillary trap, allowing to follow the temporal evolution of the supersaturated lysozyme solution inside the droplets. The results obtained in this setup enable to demonstrate the existence of equilibrium clusters prior to crystal nucleation. The SAXS signal of supersaturated lysozyme solution exhibits some important features: a correlation peak appears at $q=0.16A^{-1}$ and a Guinier plateau, starting around $q=0.01A^{-1}$, is observed. The size of this clusters range from 60nm at the beginning of the experiment to 80nm at the end. The broad peak obtained at $0.16A^{-1}$ corresponds to a correlation length of 3.9nm compatible with one dimension of the crystal lattice of tetragonal lysozyme. Finally, the slope of -2 in the intermediate q region shows that the clusters are not spherical. These observations suggest a 2-setp nucleation process: first quickly after the temperature quench, large clusters are formed. In these clusters, the lysozyme molecules are in a disordered state but at a distance compatible with those of crystal structure. Afterwards, the formation of the crystal might be due to the reorganization of molecule within these cluster.

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Microfluidic Droplet Generators and Mixers for Serial Crystallography

Austin Echelmeier[1,2], Gerrit Brehm[1,2], Chelsie Conrad[1,2], Jesse Coe[1,2], Garrett Nelson[2,3], Dominik Oberthüer[4], Nadia Zatsepin[2,3], Uwe Weierstall[2,3], Richard A. Kirian[2,3], Henry N. Chapman[4], John C. H. Spence[2,3], Petra Fromme[1,2], Alexandra Ros[1,2]

[1] School of Molecular Sciences, Arizona State University, Tempe, Arizona, USA
[2] Center for Applied Structural Discovery, Arizona State University, Tempe, Arizona, USA
[3] Department of Physics, Arizona State University, Tempe, Arizona, USA
[4] Center for Free-Electron Laser Science, DESY, Hamburg, Germany

Serial femtosecond crystallography (SFX) with X-Ray Free Electron Lasers (XFEL) has evolved as a powerful technique for crystallography for proteins over the past years. Despite the recent advances in the field, limitations remain due to the restrictions in growing protein crystals sufficiently small in size (ideally sub-µm) for SFX, the requirement of highly concentrated crystal suspensions in the order of several milliliters, the limited tools for substrate-based time-resolved crystallography studies as well as the lack of *de novo* phasing approaches. The field of microfluidics has developed tools providing solutions to current challenges in SFX. To address the loss of precious protein crystals in liquid-jet injection technology typically achieved with gas dynamic virtual nozzles (GDVNs), we propose microfluidic droplet generation synchronized with the repetition frequency of currently available XFELs. Aqueous droplets of crystal suspensions can be intersected by an immiscible oil phase, thereby reducing the overall amount necessary for continuous injection with a GDVN dramatically. We demonstrate that microfluidic droplet generation can be coupled to traditional GDVNs and applied this approach to SFX of granulovirus. In addition, we explore microfluidic mixing based on hydrodynamic focusing and fast diffusive mixing for SFX. Mixing devices were developed both with photolithography as well as 3D printing approaches achieving sub-ms mixing times at flow rates compatible with GDVNs. Optimization of device geometry and flow rates allow the measurement of reaction time points ranging from several ms up to seconds. This mixing approach has been applied to study the reaction of the enzyme 3-deoxy-D-manno-2-octulosonate-8-phosphate synthase with its substrates phosphoenolpyruvate and arabinose-5-phosphate.

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Rapid Mixing Microfluidics for Time-Resolved X-ray Scattering

Martin Trebbin[1]

[1] University of Hamburg, Hamburg, Germany

Microfluidics in combination with microbeam X-ray scattering is currently being developed into a powerful experimental methodology suitable for the time-resolved investigation of nanostructures, particle alignment and serial protein crystallography at synchrotrons and X-ray Free Electron Lasers (XFELs). This experimental approach enables the in situ study of kinetics with nano- or atomistic resolution by using X-ray compatible microflow chips and rapid mixing microfluidic liquid jet devices [1-6]. We present lithography-based microfluidic devices (see Fig.1B) that produce liquid jets with µm-diameters (0.9 to 5 µm) at very low flow rates (150 to 1000 µl h^{-1}) under atmospheric or vacuum conditions [5]. This microfluidic liquid jet system with highly reproducible geometries is based on the gas dynamic virtual nozzle (GDVN) design suitable for structural biology at serial femtosecond X-ray nanocrystallography [6] as well as time-resolved rapid mixing experiments with mixing times within tens of microseconds and a very defined time-zero point [3,5].

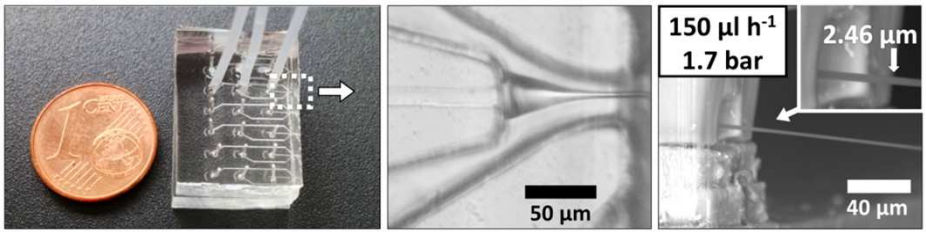

Figure 1 Microfluidic liquid jet device in operation [5].

[1] M. Trebbin, S. V. Roth, J. Thiele, S. Förster et al., Proc. Natl. Acad. Sci. USA 110, 6706–6711 (2013) doi:10.1073/pnas.1219340110.
[2] G. Benecke, M. Trebbin, S. V. Roth, P. Fratzl et al., J. Appl. Cryst. 47, 1797-1803 (2014) doi:10.1107/S1600576714019773.
[3] S. With, M. Trebbin, S. V. Roth, S. Förster et al., Langmuir 30, 12494−12502 (2014) doi:10.1021/la502971m.
[4] S. M. Taheri, M. Trebbin, S. Förster et al., Soft Matter 8, 12124 (2012) doi:10.1039/C2SM26777B.
[5] M. Trebbin, H. N. Chapman, S. Förster et al., Lab Chip 14(10), 1733-45 (2014) doi:10.1039/C3LC51363G.
[6] H. N. Chapman et al., Nature 470, 73–77 (2011) doi:10.1038/nature09750.

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Rigid Materials for Photolithography Based Rapid Microfluidic Mixing and sample Delivery

Daniel Langley[1]

[1] La Trobe Institute of Molecular Science, Melbourne, Victoria 3086, Australia

Sample delivery at X-ray free Electron lasers is complex and challenging field that continues to demand innovation and development. Initial work over the past two decades has firmly established the use of Gas Dynamic Virtual Nozzles (GDVN's) as an excepted standard for liquid sample injection. Current fabrication techniques associated with fused silica capillaries for the formation of GDVN's requires a highly manual fabrication process and has limited success rates and issues with reproducibility. In addition the use of fused silica capillaries restricts the possible combinations of geometry to sets of linear concentric channels.

Photolithography affords the advantages of parallel processing of multiple devices, high precision and reproducibility and also enables the formation of complex 2D and pseudo 3D geometries. To date the application of photolithography to the fabrication of GDVN's remains small even though success in planar PDMS devices has been demonstrated. This is in part due to the inherent limitations of PDMS as an elstomeric polymer, resulting in restrictions on the accessible working pressures and UHV compatibility issues.

In this presentation I will discuss the advantages and challenges associated with the fabrication of mixing devices and psuedo 3D structures in rigid materials including Silicon, Glass and SU-8. Some attention will also be given to potential methods for achieving rapid mixing in microfluidic systems.

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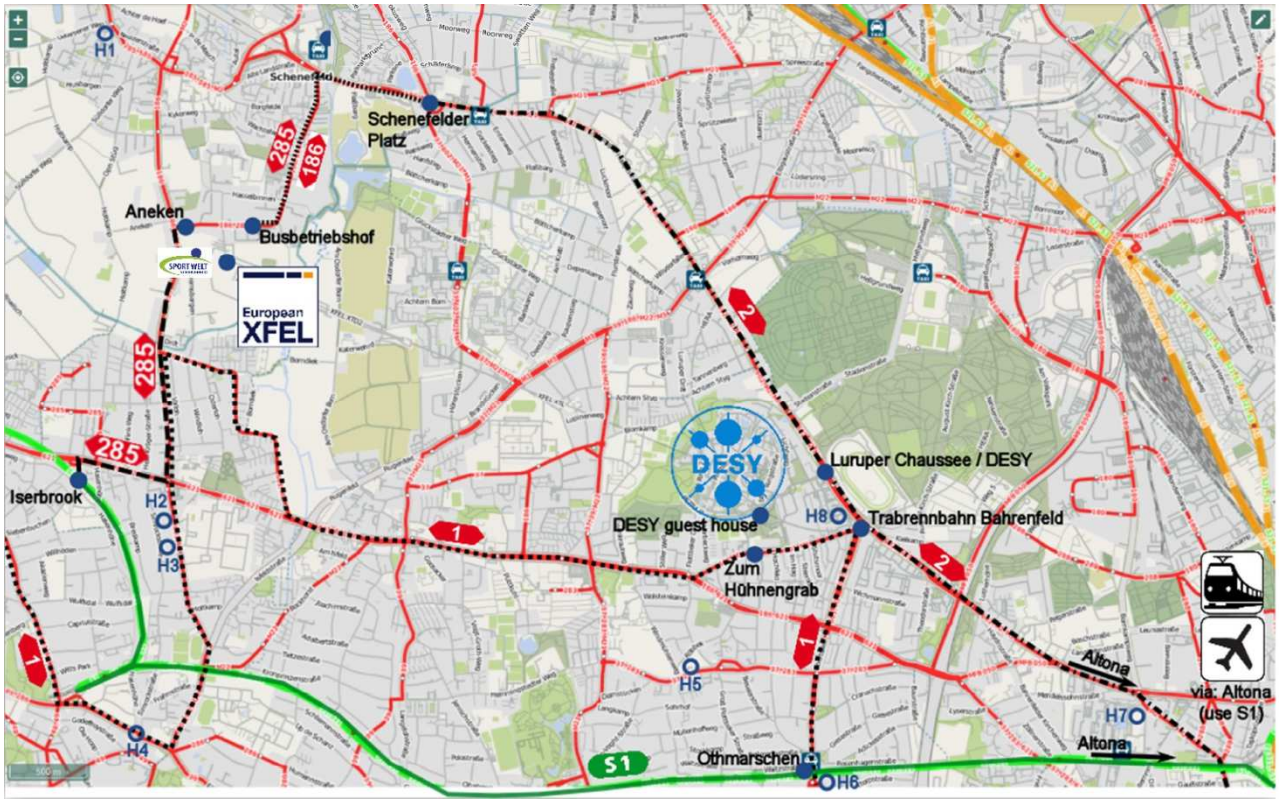
A Traveller's Guide to European XFEL



o H1	Hotel Klövensteen	Hauptstraße 83, 22869 Schenefeld
o H2	Hotel Blankenese	Schenefelder Landstraße 164, 22589 Hamburg
o H3	Hotel Hesse	Schenefelder Landstraße 139, 22589 Hamburg
o H4	Hotel Behrmann	Elbchaussee 528, 22587 Hamburg
o H5	Landhaus Flottbek	Baron-Voght-Straße 179, 22607 Hamburg
o H6	Hotel Schmidt	Reventlowstraße 60, 22605 Hamburg
o H7	Gastwerk Hotel Hamburg	Beim Alten Gaswerk 3, 22761 Hamburg
o H8	Hotel Mercure	Albert-Einstein-Ring 2, 22761 Hamburg

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How to get to XFEL

S-Bahn from **Hamburg Airport / Main Train station / Altona**

Take S-Bahn S1 in direction *Wedel* (goes every 20 min) travel until *Iserbrook* (S1 will change direction at station *Blankenese*, don't worry you are still going the right way). At *Iserbrook* walk down the stairs to the bus stop on the right. Take Bus 285 direction *Pinneberg* travel 2 stops and get out at *Aneken*. Walk along Osterbrooksweg in the same direction as the bus left but turn the next right on to Holzkoppel. Go straight until you reach the XFEL gate.

Bus from **DESY Guesthouse / Hotel Mercure**

From *Luruper Chausse* board Bus 2 direction *Schenefeld, Achterndiek* travel 8 stops (approx. 12 minutes) until *Schenefelder Platz.* At *Schenefelder Platz* change to Bus 186 (direction *Schenefeld Mitte*). Travel 5 stops (approx. 5 min) to *Busbetriebshof*. Walk along *Osterbrooksweg* the direction the bus drove and turn the next street left onto Holzkoppel. Go straight until you reach the XFEL Gate.

Alternatively, take the Bus 1 at *Trabrennbahn* or *Zum Hünengrab* (DESY) in direction *Rissen*. Get out at *Holtbarg* and change to bus 285 direction *Pinneberg* and get out at *Aneken*. Walk along Osterbrooksweg in the same direction as the bus left but turn the next right on to Holzkoppel. Go straight until you reach the XFEL gate.

Bus from **Hotel Klövensteen (ca 15 min)**

At *Uetersener Weg* take Bus 285 in directon *Reinheimerweg* travel 6 stops until *Busbetriebshof*. Walk along *Osterbrooksweg* the direction the bus drove and turn the next street left onto Holzkoppel. Go straight until you reach the XFEL Gate.

Alternatively, walk to bus stop *Schenefeld Mitte* (7 min, 500 m), from there take bus 186 in direction *S Othmarschen* and travel 2 stops until *Aneken*. Walk along Osterbrooksweg in the same direction as the bus left but turn the next right on to Holzkoppel. Go straight until you reach the XFEL gate.

Walking from **Hotel Klövensteen (ca. 25 min)**

Follow Hauptstraße right hand side till crossing Blankeneser Chaussee. Turn right and follow Blankeneser Chaussee till Osterbrooksweg (ca. 1,5 km). Turn left in Osterbrooksweg till Holzkoppel. turn right into Holzkoppel. European XFEL is at the end of the street.

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Opportunities for microfluidic devices at Free-Electron Lasers

XFEL → Hotel Klövensteen

Bus (ca 15 min)

Walk along *Holzkoppel* until *Osterbrooksweg*, turn right and walk to bus stop *Busbetriebshof*. Take bus 285 in direction *Bf. Pinneberg*, travel 6 stops to *Uetersener Weg*. Walk a bit back until you reach the traffic light. You should see the hotel across the roard (Peter's Bistro).

Alternatively, walk along Holzkoppel until Osterbrooksweg, turn left and walk to the bus stop *Aneken.* Take bus 186 direction *Schenefeld Mitte,* and travel 3 stops to *Schenefeld Mitte*. Here you can change to bus 285 in direction *Bf. Pinneberg* and travel 1 stop until *Uetersener Weg,* or you can walk back to *Hauptstraße* turn right and follow *Hauptstraße* until you reach the Hotel. Walking from *Schenefeld Mitte* to Hotel Klövensteen should take approx. 6 min.

Walking (ca. 25 min)

Walk along *Holzkoppel* until *Osterbrooksweg*, turn left and go straight until you reach a traffic light, at the traffic light turn right onto *Blankeneser Chaussee.* Follow *Blankeneser Chaussee* for 1.1 km until you reach *Hauptstraße*, than turn left and follow *Hauptstraße* until you reach the Hotel (400m).

XFEL → DESY Guesthouse/Hotel Mercure

Walk along *Holzkoppel* until *Osterbrooksweg*, turn right and walk to bus stop *Busbetriebshof*. Take bus number 186 direction *S Othmarschen* travel 4 stops until *Parkstieg*. Change to bus 2 direction *Bf Altona* travel 9 stops until *Luruper Chaussee (DESY).* Walk for approx. 200m in the direction the bus left until you reach Hotel Mercure. Or for DESY Guesthouse after you reach *Luruper Chaussee (DESY)* walk back approx. 100m until you reach the DESY side gate entrance.

Alternatively, Walk along *Holzkoppel* until *Osterbrooksweg*, turn right and walk to bus stop *Busbetriebshof.* Take bus number 285 direction *S Iserbrook*, travel for 2 stops until *Holtbarg*, change to bus 1 direction *Bf. Altona*, travel for 12 Stops until *Bahrenfeld, Trabrennbahn*, walk back to the traffic light and head straight for approx. 300m on *Luruper Chaussee* until you reach Hotel Mercure. Or for DESY Guesthouse get out 2 stops earlier at *Zum Hünengrab (DESY),* and walk 100m to the DESY main Entrance.

XFEL → Hamburg Airport / Main Train station / Altona

Walk along *Holzkoppel* until *Osterbrooksweg*, turn right and walk to bus stop *Busbetriebshof*. Take bus 285 in direction S *Iserbrook* (goes every 20 min). Travel 3 stops to station *S Iserbrook*, walk up the stairs to the trains and take the S-Bahn S1 to *Altona* (5 stops) or *Hauptbahnhof* (main train station) (11 stops), or continue on to Hamburg Airport (55 min, 22 stops). Note: for Hamburg airport please board one of the **last** three trains of six available (at S Bahn *Iserbrook* or at *Blankenese*), as only these go straight to the airport.

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WiFi access at European XFEL

1. ufluidic network

The WLAN network has been set for the workshop participants. Connect using the password: boocueHohk3i

2. Eduroam

For participants, whose home institutes are participating in the project eduroam, we offer this wireless guest network connection. For registered users this is a quick and easy way to obtain a secure access to the Internet without any further registration.

3. XFEL-Guest

Registration and Log in Procedure:

1. Enable Wi-Fi on your device and Connect to the XFEL-Guest network. You will be redirected to your browser, if not…
2. Open your browser and call up any **unencrypted webpage** (http://... **NOT** https://...), except desy.de (your browser will display the DESY homepage even if you have not completed the registration for the XFEL-Guest network).
3. You should have been redirected to the XFEL-Guest portal (https://guestnet-portal.desy.de).
4. Click on *"Receive your credentials by E-mail".*
5. Fill in your **First** and **Last name** and **Email**, accept the DESY data protection provisions and click on Register.
6. You now have **5 minutes access** to retrieve your *User Name* and *Password* from the Email address you entered.
7. After retrieving your login data go back to https://guestnet-portal.desy.de and disconnect the temporary connection.
8. You can now log in to the XFEL-Guest network with the credentials you received per E-mail.
9. Fill in "*Login*" (User name) and "Password" and accept the "*DESY Condition of Use*".
10. The account is now valid for 10 days and can be used with 5 different devices at the same time.