

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



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Leading Scientist SPB/SFX Instrument

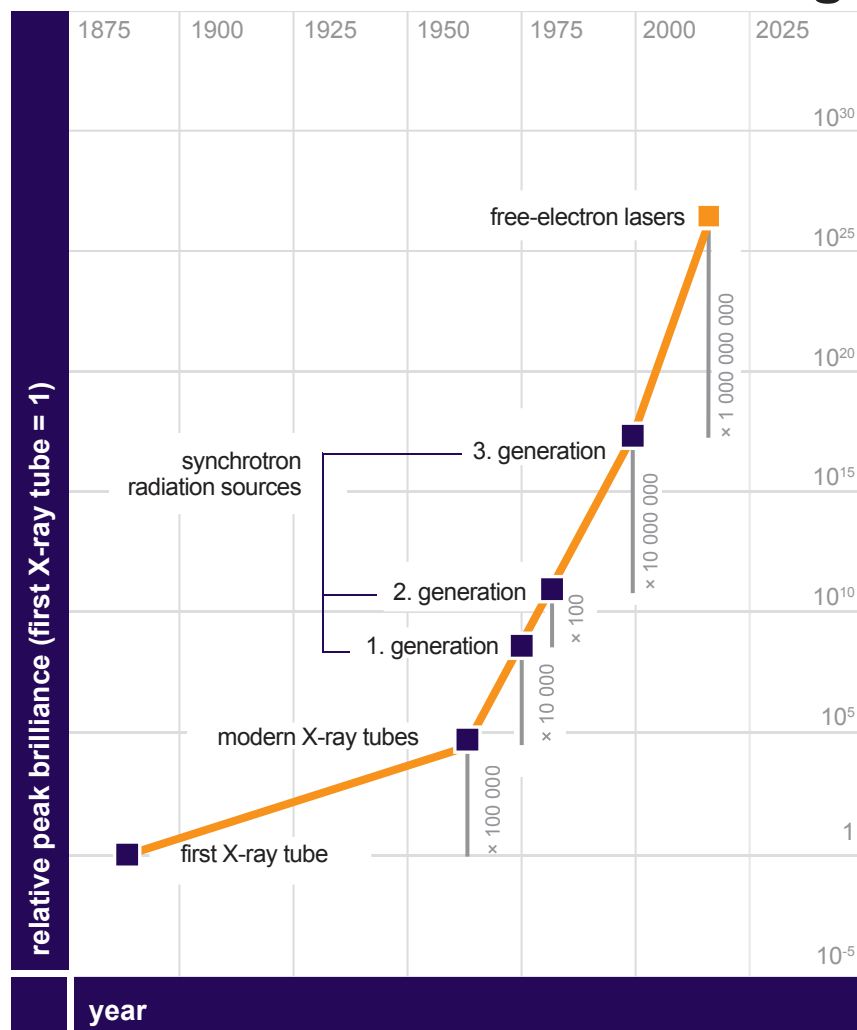
# Overview

■ A brief introduction to the XFELs and the European XFEL

■ The SPB/SFX instrument of the European XFEL

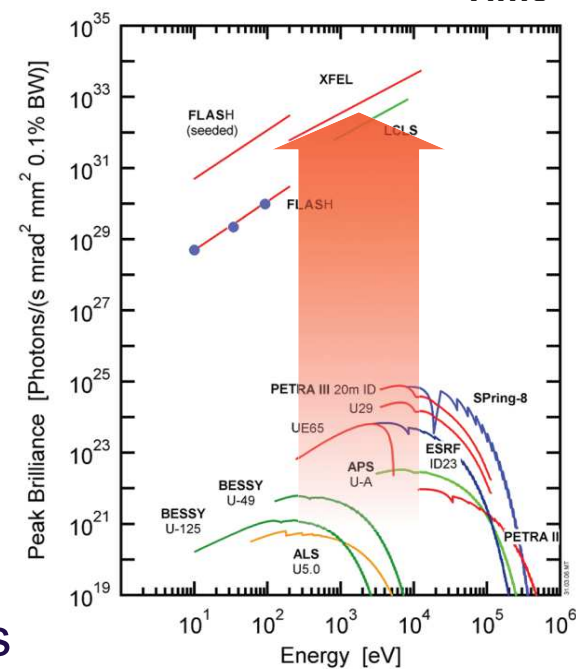
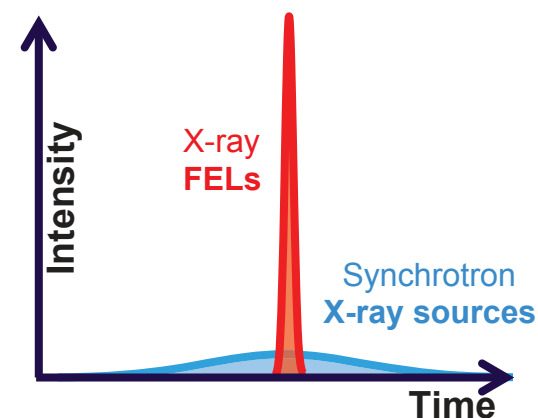
■ Key components of the SPB/SFX instrument (inc sample delivery)

# Free Electron Lasers are amazingly bright

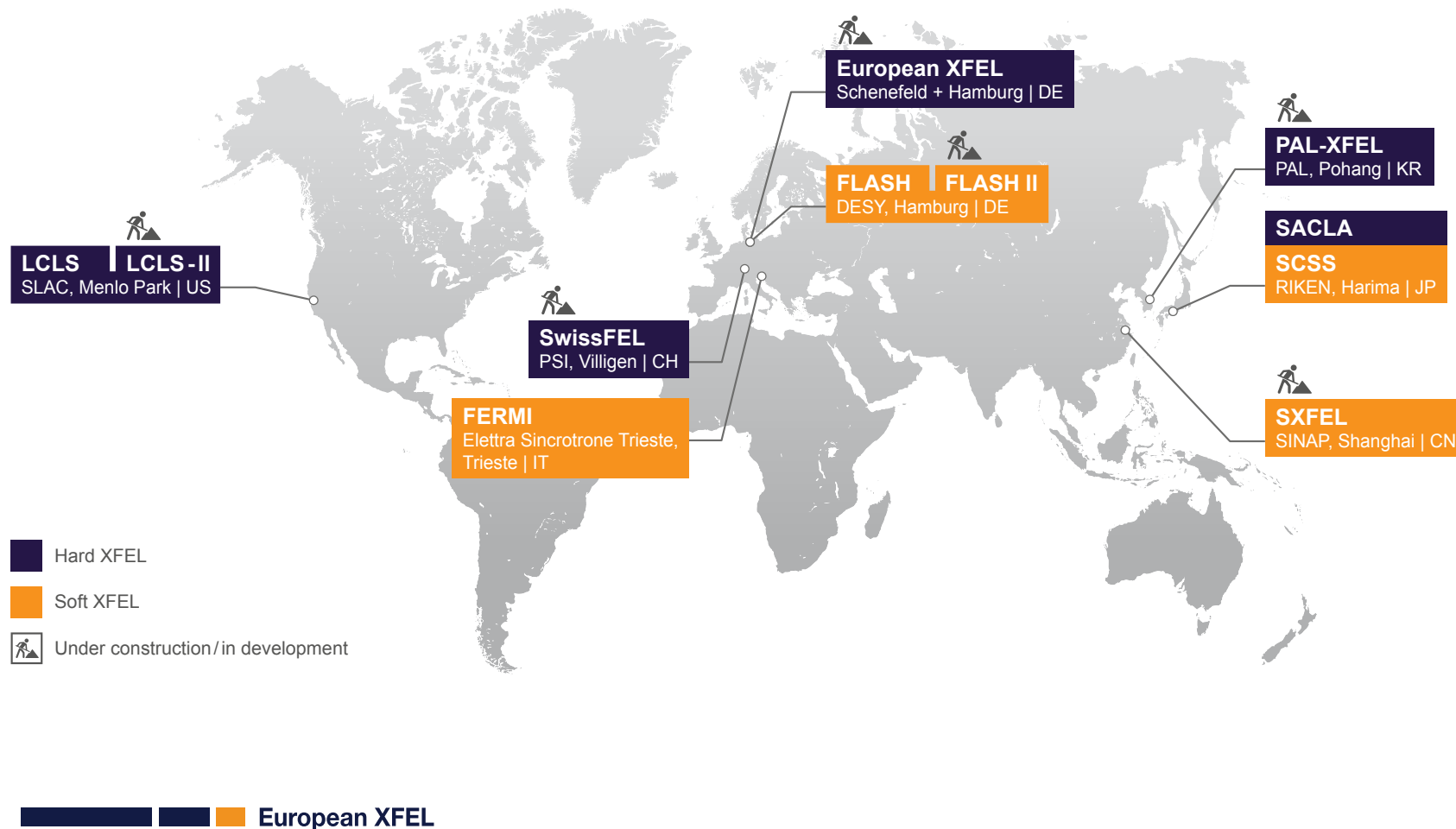


with pulse durations as short as femtoseconds

European XFEL



## Free electron lasers around the world





## The European XFEL at a glance



- Presently under construction in Hamburg, Germany



- A dozen (12) participating countries

- 17.5 GeV superconducting linear accelerator

- 3.4 km long facility

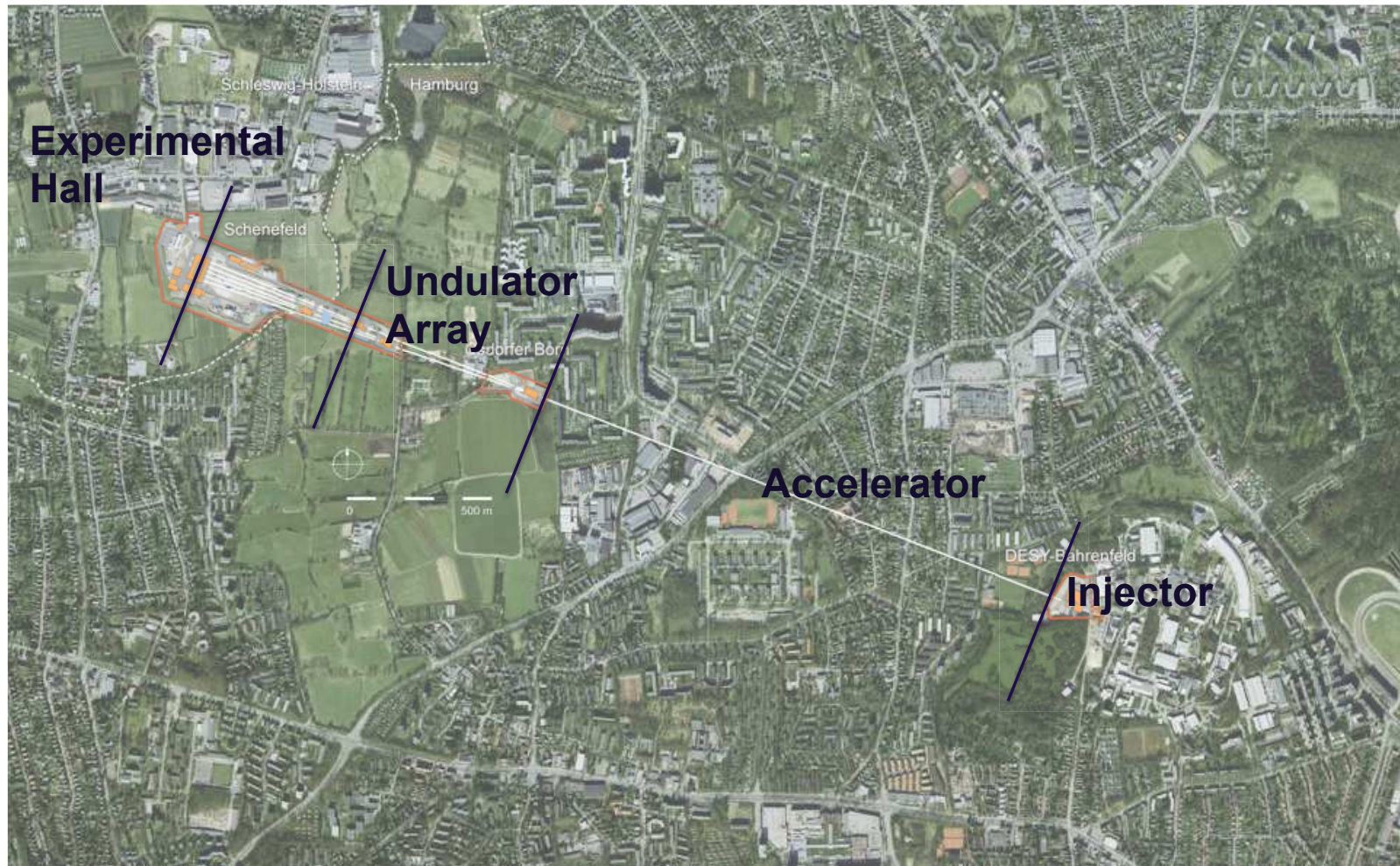
- Large scale project



- Accelerator consortium led by DESY



## The European XFEL from above



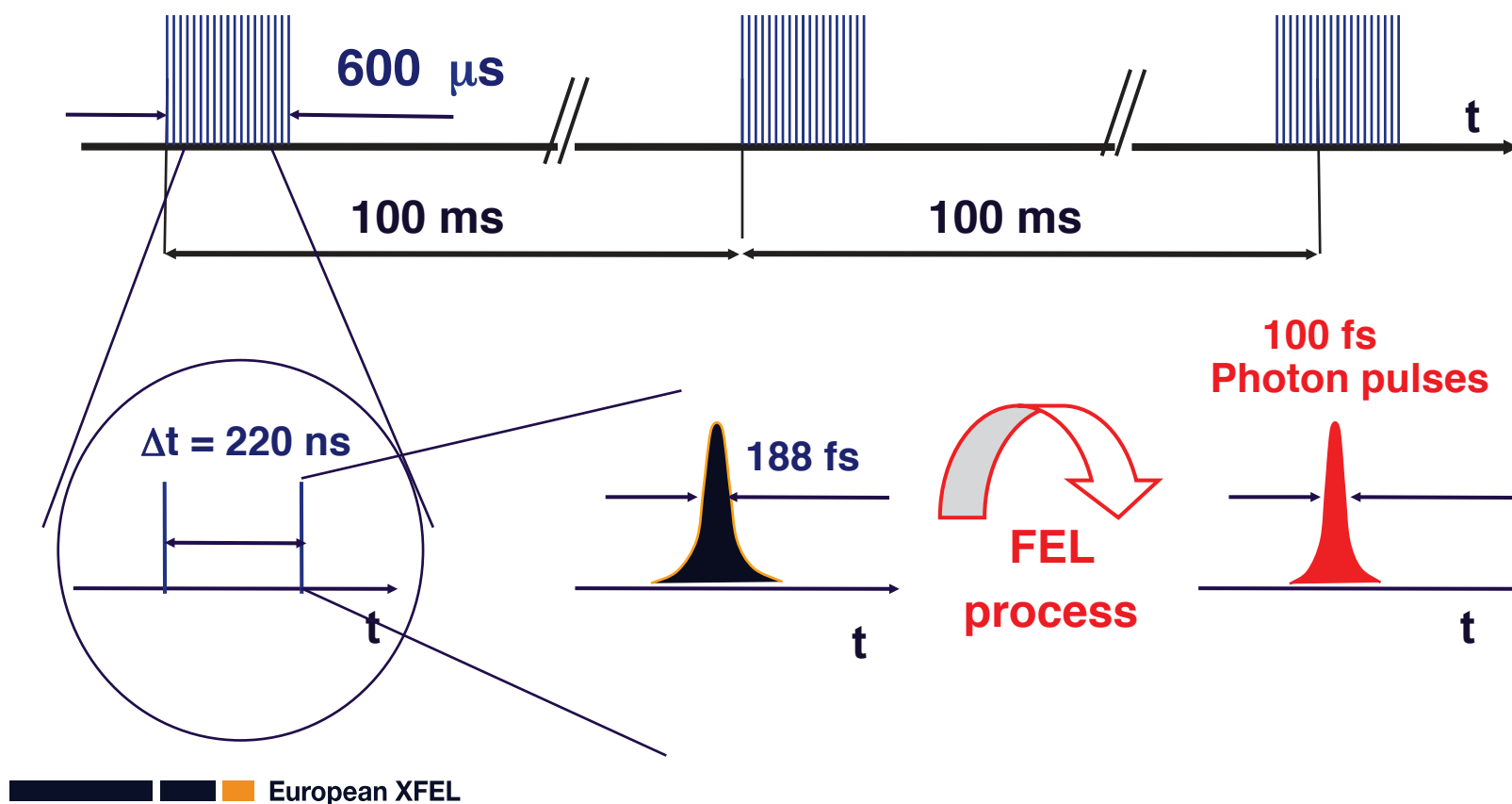
## What's special about the European XFEL?

	LCLS (USA)	SACLA (Japan)	European XFEL (Germany)
Max. e- Energy (GeV)	14,3	8	17,5
Max Photon Energy (keV)	~10	~20	> 24
Pulses/second	120	30	27000
Photons/pulse	$\sim 10^{12}$	$> 10^{11}$	$\sim 10^{12}$
First users	2010	2012	2017

- The European XFEL will operate over a wider range of energies and with more pulses per second than currently available XFEL sources


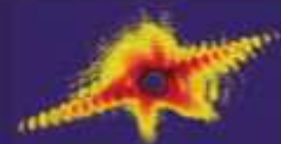
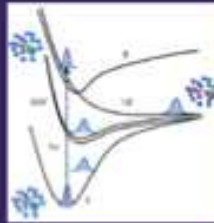
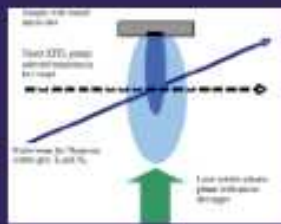
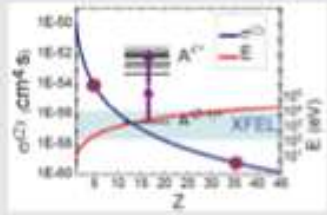

# The European XFEL's unique time structure

**Electron bunch trains**  
(with up to 2700 bunches à 1 nC)

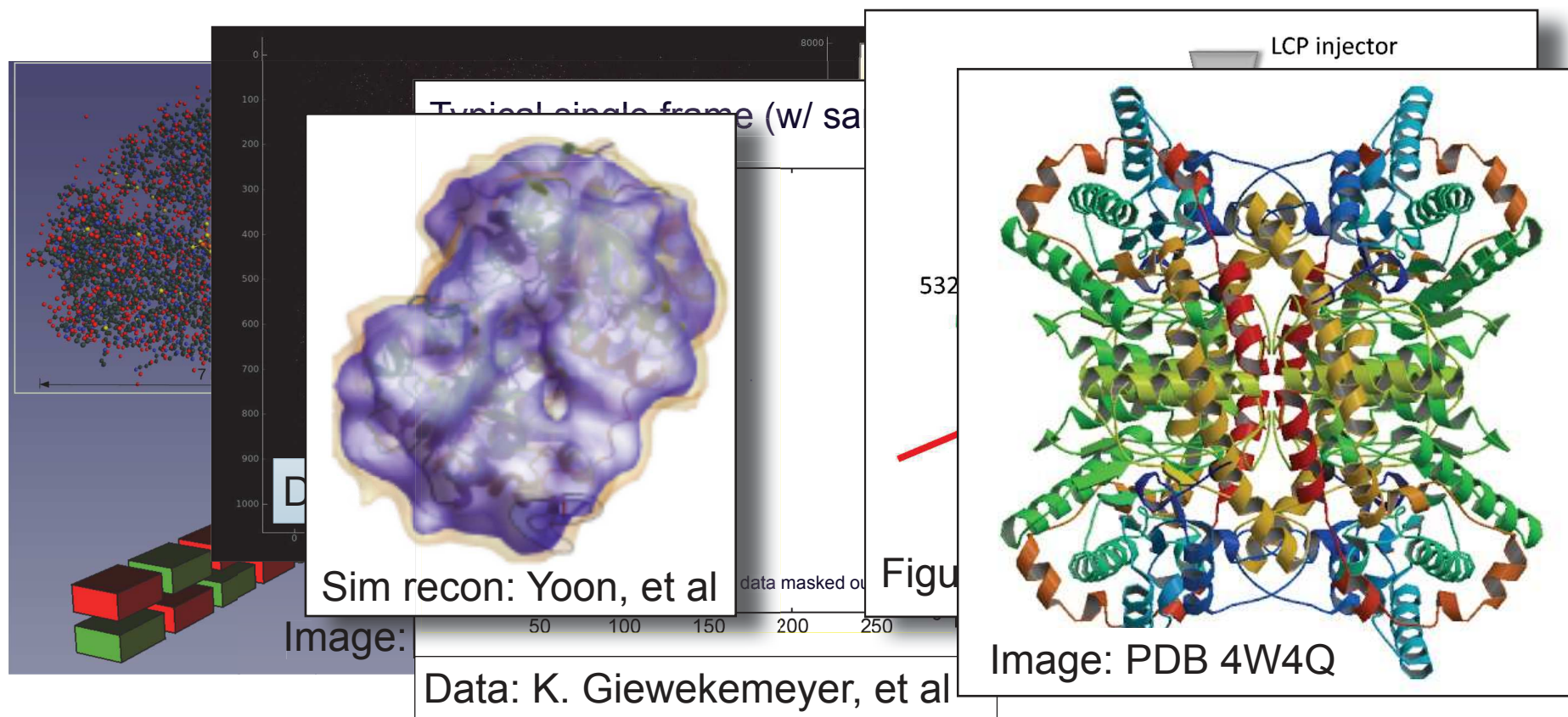




## Six initial scientific instruments

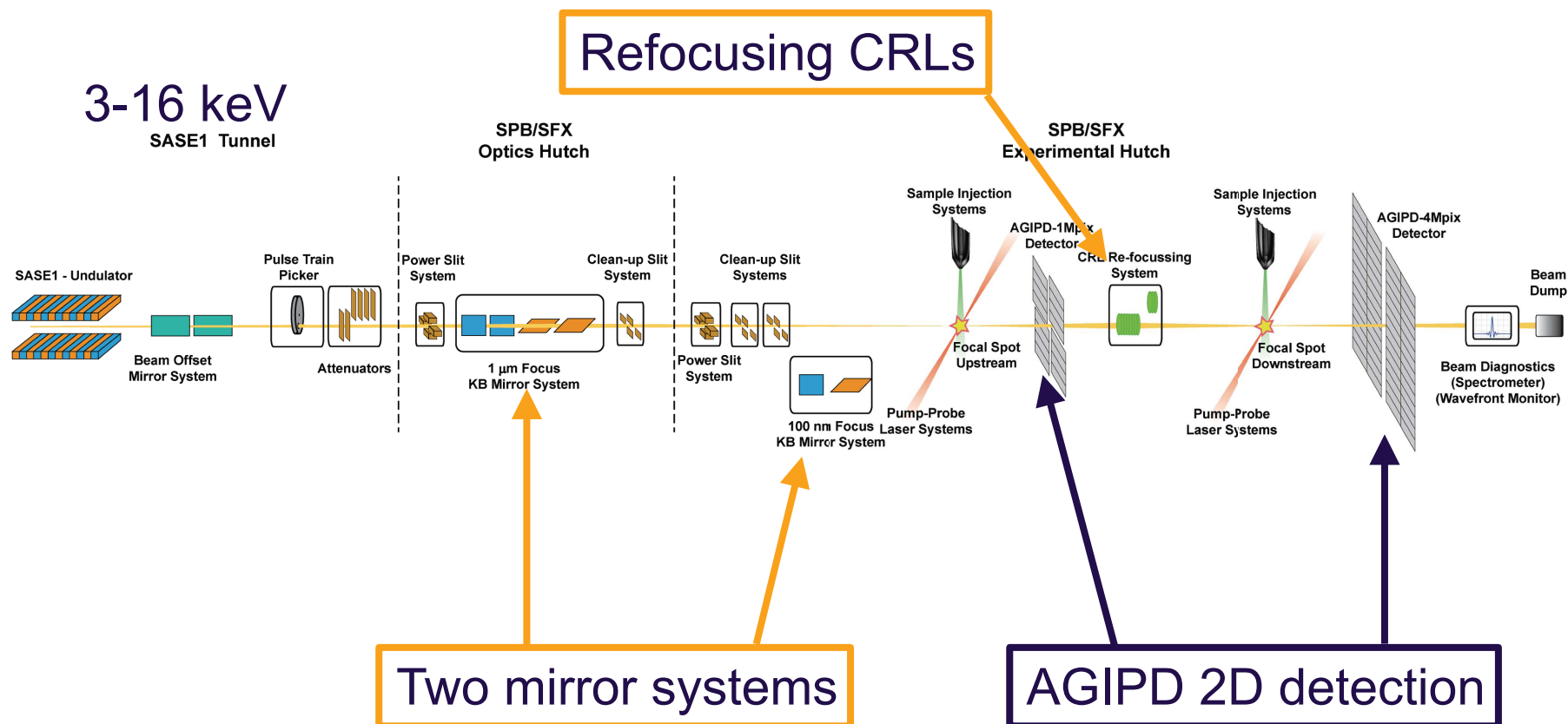
Hard X-rays	<b>SPB: /SFX</b>	<b>Ultrafast Coherent Diffraction Imaging of Single Particles, Clusters, and Biomolecules</b> Structure determination of single particles: atomic clusters, bio-molecules, virus particles, cells.		
	<b>MID:</b>	<b>Materials Imaging &amp; Dynamics</b> Structure determination of nano-devices and dynamics at the nanoscale.		
	<b>FXE:</b>	<b>Femtosecond X-ray Experiments</b> Time-resolved investigations of the dynamics of solids, liquids, gases		
	<b>HED:</b>	<b>High Energy Density Matter</b> Investigation of matter under extreme conditions using hard X-ray FEL radiation, e.g. probing dense plasmas		
Soft x-rays	<b>SQS: Small Quantum Systems</b>	Investigation of atoms, ions, molecules and clusters in intense fields and non-linear phenomena		
	<b>SCS: Soft x-ray Coherent Scattering/Spectroscopy</b>	Electronic and real structure, dynamics of nano-systems and of non-reproducible biological objects		

## Reminder: The scope of the SPB/SFX Instrument



Everything forward scattering—predominantly **Serial Crystallography** and **single particle imaging** of biological samples and including time resolved experiments

# Schematic overview of the SPB/SFX Instrument

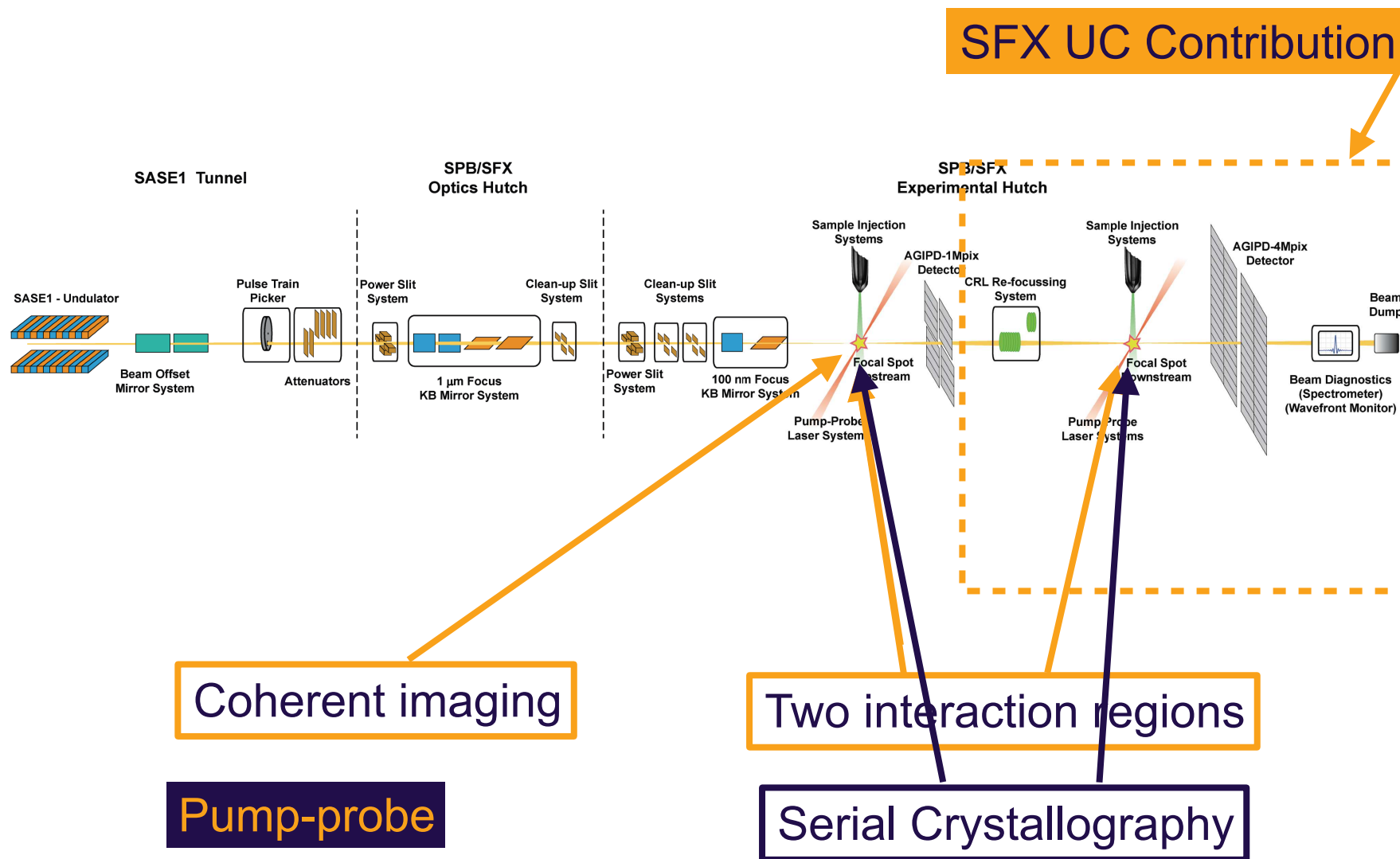


[1] A. P. Mancuso and H. N. Chapman, International Workshop on Science with and Instrumentation for Ultrafast Coherent Diffraction Imaging of Single Particles, Clusters, and Biomolecules (SPB) at the European XFEL (2011).

[2] A. P. Mancuso, Conceptual Design Report: Scientific Instrument SPB, 2011. [dx.doi.org/10.3204/XFEL.EU/TR-2011-007](https://doi.org/10.3204/XFEL.EU/TR-2011-007)

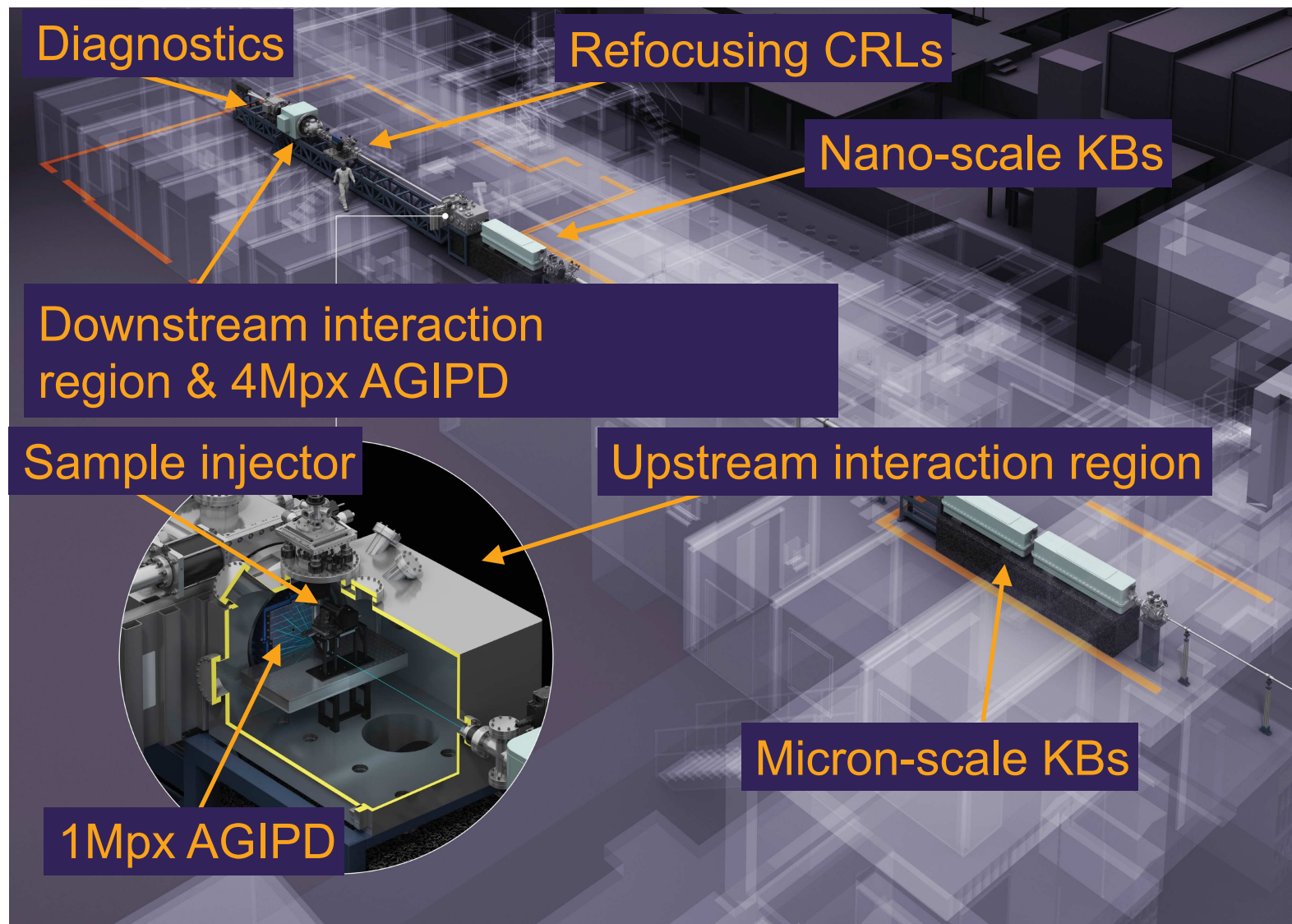
[3] A. P. Mancuso, et al, Technical Design Report: Scientific Instrument SPB, 2013. [dx.doi.org/10.3204/XFEL.EU/TR-2013-004](https://doi.org/10.3204/XFEL.EU/TR-2013-004)

# Schematic overview of the SPB/SFX Instrument

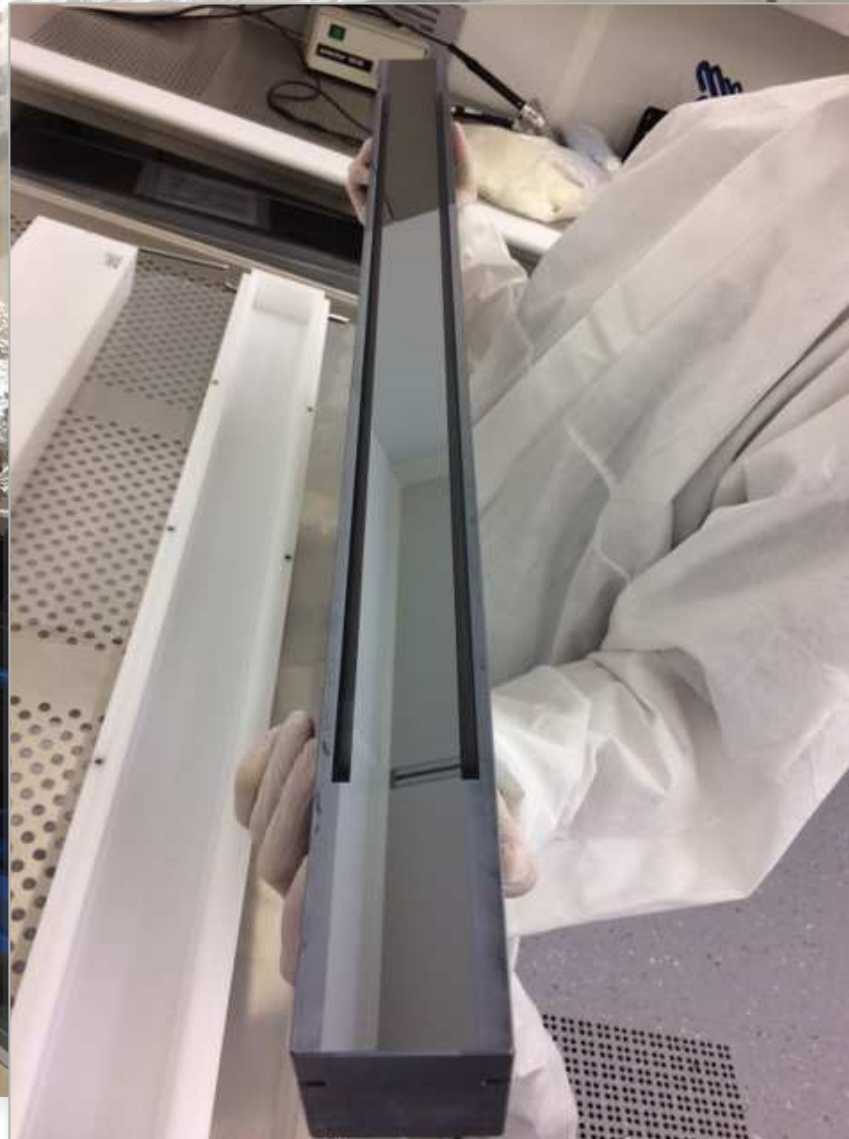




## Artist's impression of the SPB/SFX Instrument



Opti



## Beam and optics parameters

- 3 — 16 keV operation
- 100 nm scale and 1  $\mu\text{m}$  scale focal spot sizes from mirror optics
- High transmission optics (some few mJ per pulse most likely)
- Full train compatible
  
- For day one:
  - About 8.9 keV photon energy
  - 2.5  $\mu\text{m}$  diameter focal spot from CRLs
  - Moderate transition (as a function of photon energy)
  - 60 pulses per train maximum



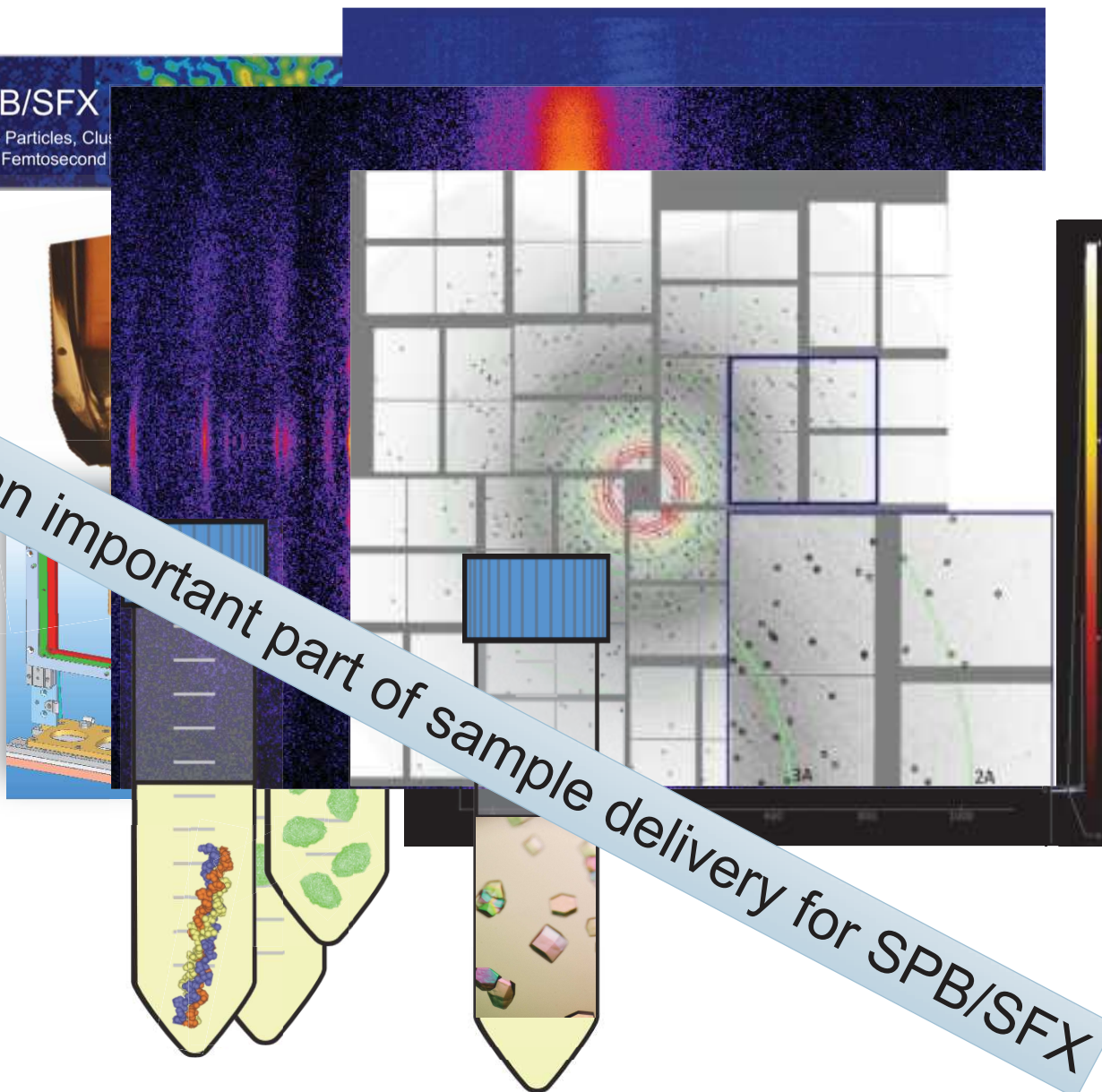
## Sample Environment



SPB/SFX  
Single Particles, Clusters  
Serial Femtosecond



Microfluidics are an important part of sample delivery for SPB/SFX



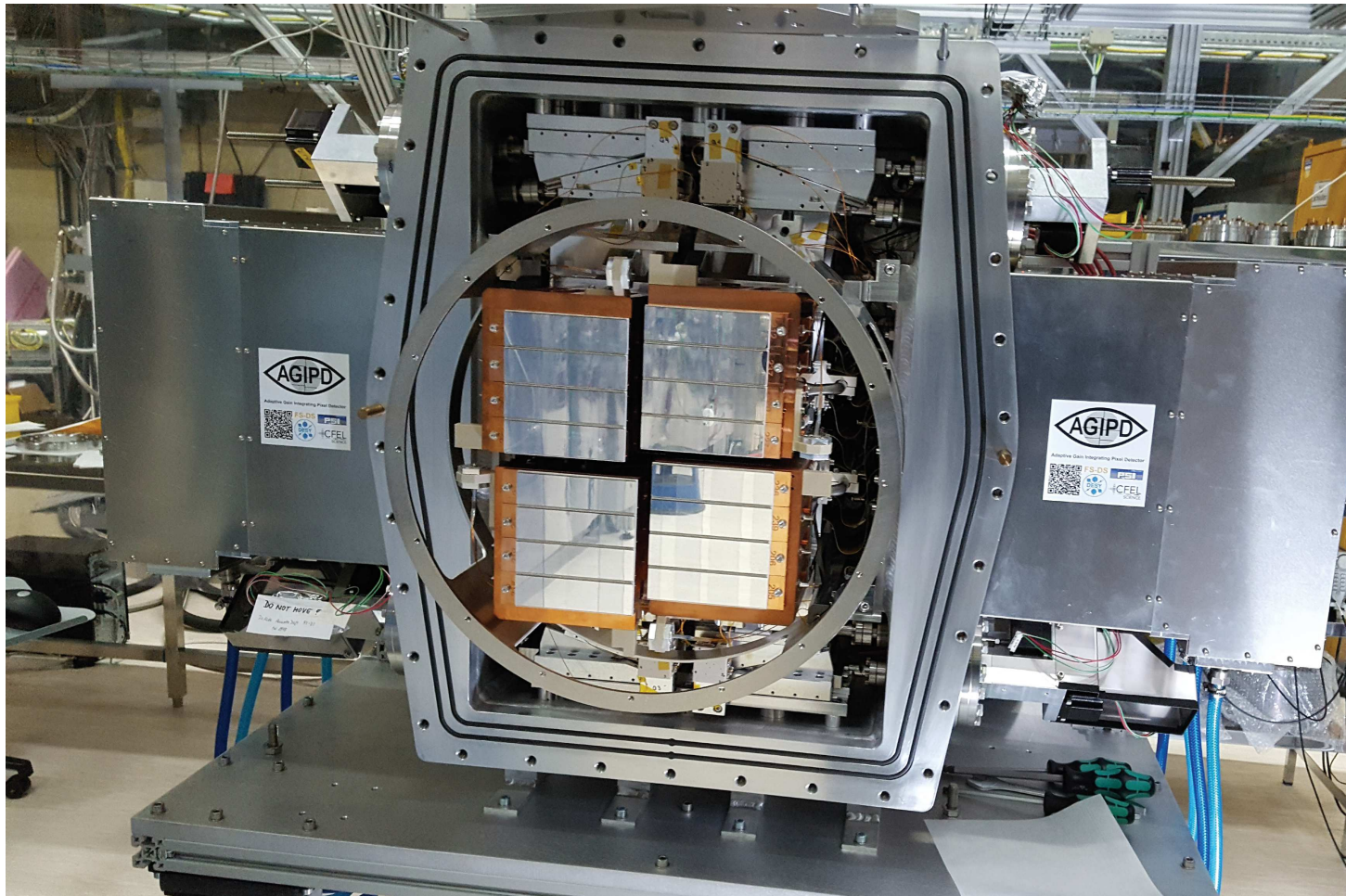
## Sample chamber overview



Many details can be obtained from Johan Bielecki (here today)  
as well as by looking in the windows during the tour later today

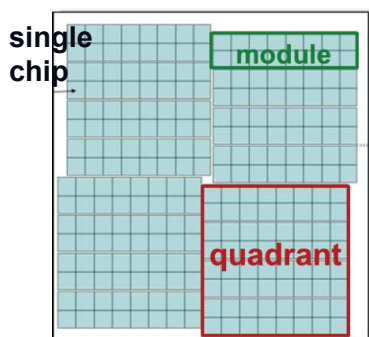


## AGIPD—the primary detector for SPB/SFX

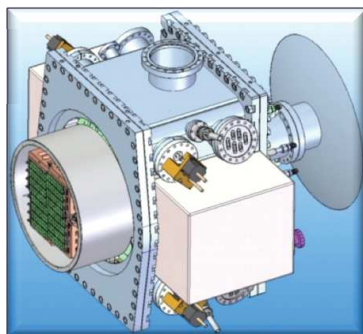


## AGIPD parameters

### ■ High repetition rate (4.5 MHz) 1MPix imaging detector



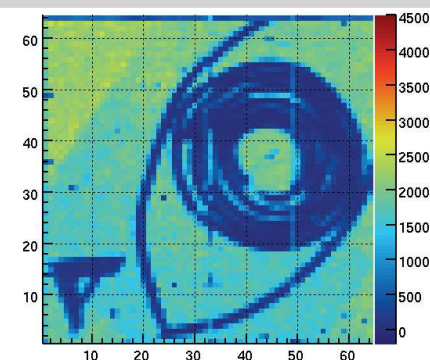
64x64 pixels/chip  
2x8 chips/module  
modules/quadrant  
4 quadrants/detector



Parameter	AGIPD
Energy Range	3-16 keV
Dynamic Range	$10^4$ ph @12 keV
Single Photon Sens	Yes → Noise ~350e- rms
Storage cells/pixel	352 (analog)
Pixel size	200x200 $\mu\text{m}^2$ (squared)
Variable hole	Yes → four independently movable quadrants
Veto capability	Yes

### Status

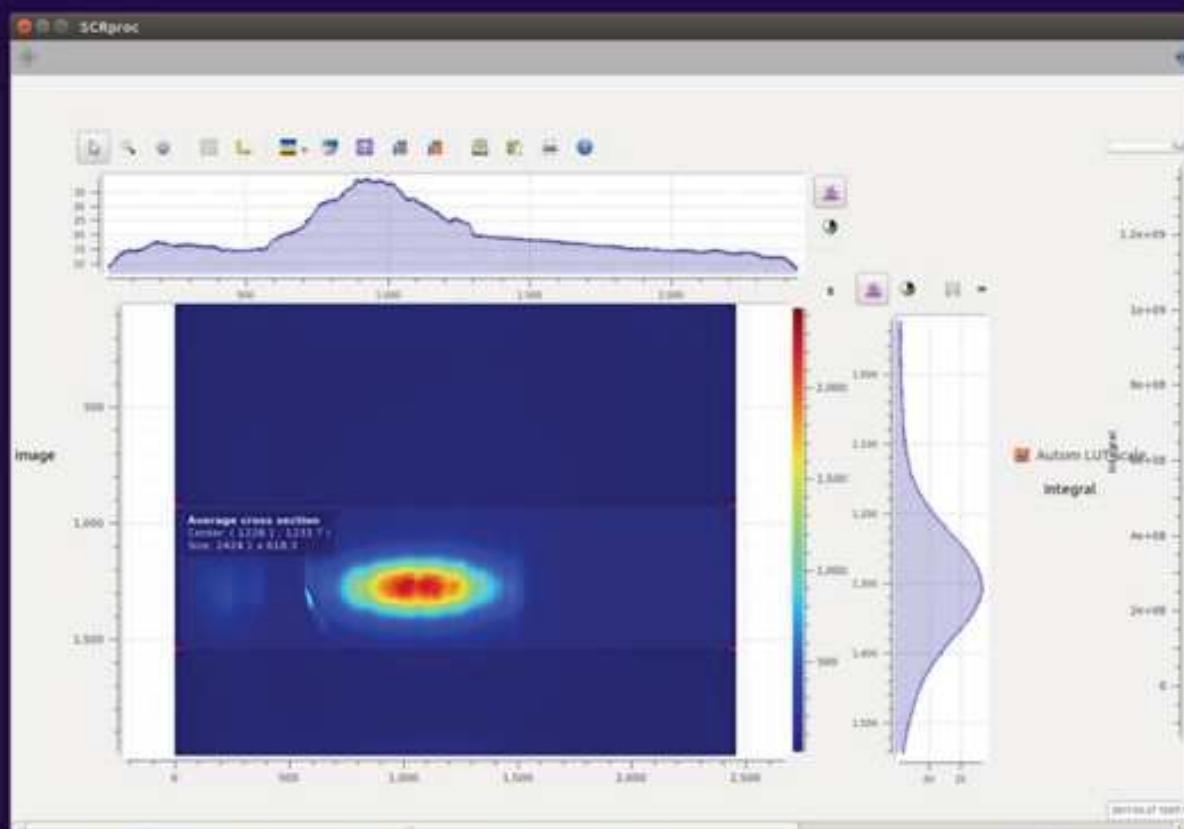
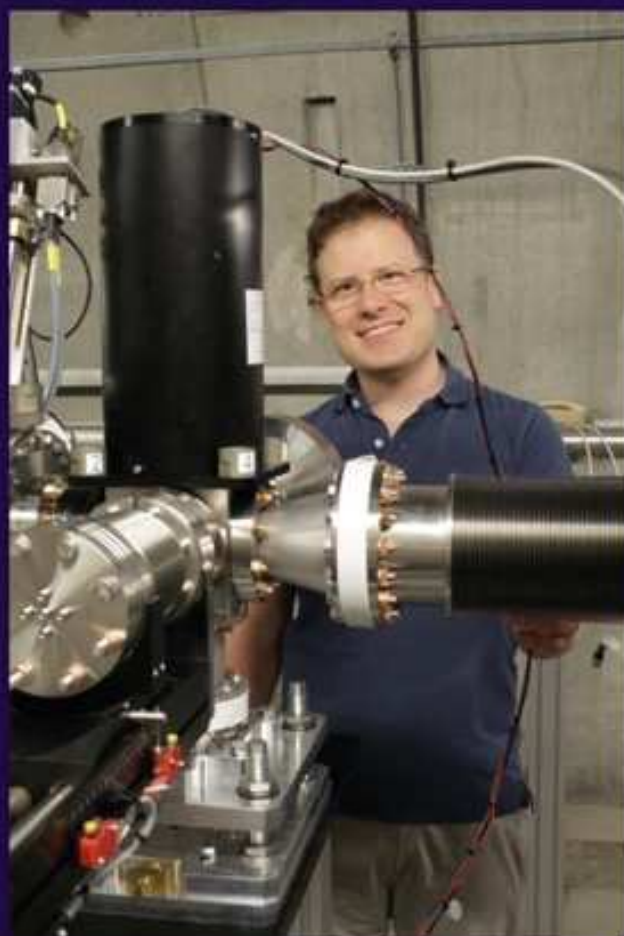
- The full scale chip **AGIPD1.0** exists
  - First test results show no major problems → very encouraging
  - Measured parameters within the specification
- **Mechanics** design for 1MPix detector in advanced state
  - Initial tests of movement system successful
- **Integration** of the detector in the XFEL beamlines in progress







# Commemorating European XFEL's first X-ray beam at the end of the tunnel. 27th May, 2017



Klaus Giewekemeyer, SPB/SFX Scientist



## Where to find more information

■ Your friendly local instrument scientist

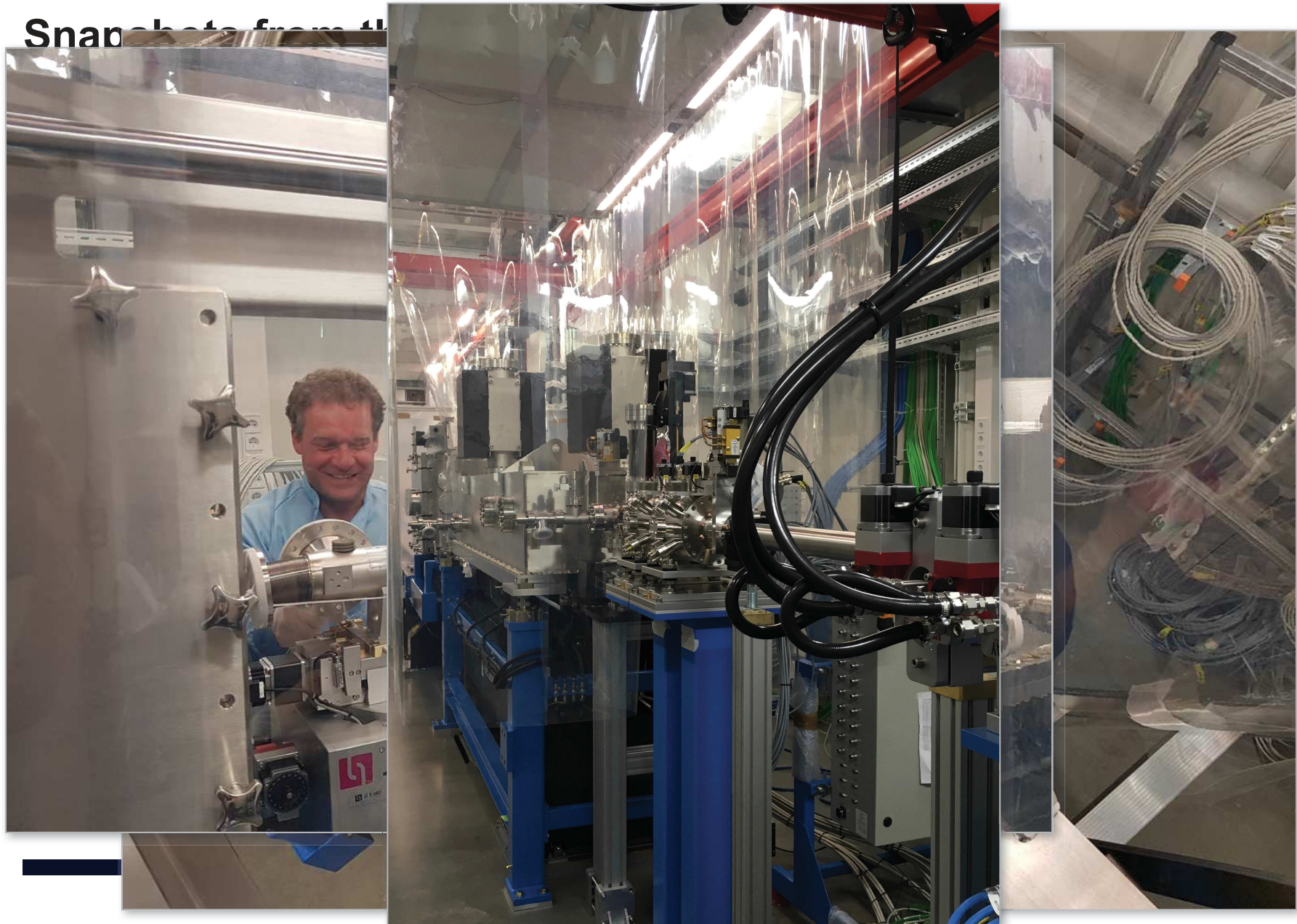
■ [xfel.eu/research/instruments/spb\\_sfx](http://xfel.eu/research/instruments/spb_sfx)

■ [xfel.eu/users](http://xfel.eu/users)

■ [http://www.xfel.eu/users/experiment\\_support/user\\_labs/index\\_eng.html](http://www.xfel.eu/users/experiment_support/user_labs/index_eng.html)



## Snapshots from the





[http://www.xfel.eu/research/instruments/spb\\_sfx](http://www.xfel.eu/research/instruments/spb_sfx)



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