Organizzato da

ILO Network Italia
Rete Industrial Liaison Officers

CENTRO ESTERO INTERNAZIONALIZZAZIONE PIEMONTE, Agency for Investments, Export and Tourism
Promoted by Regione Piemonte and Chambers of Commerce

Finanziato da

TORINO CHAMBER OF COMMERCE
INDUSTRY CRAFTS AND AGRICULTURE

Con il patrocinio di

REGIONE PIEMONTE

European XFEL

IOD – INDUSTRIAL OPPORTUNITY DAYS
Torino, 12 – 13 giugno 2025

Opportunità nel settore dell'infrastruttura tecnica e impiantistica a European XFEL

Antonio Bonucci
Head of Industrial Liaison Office and
In-kind Contributions Supply Chain

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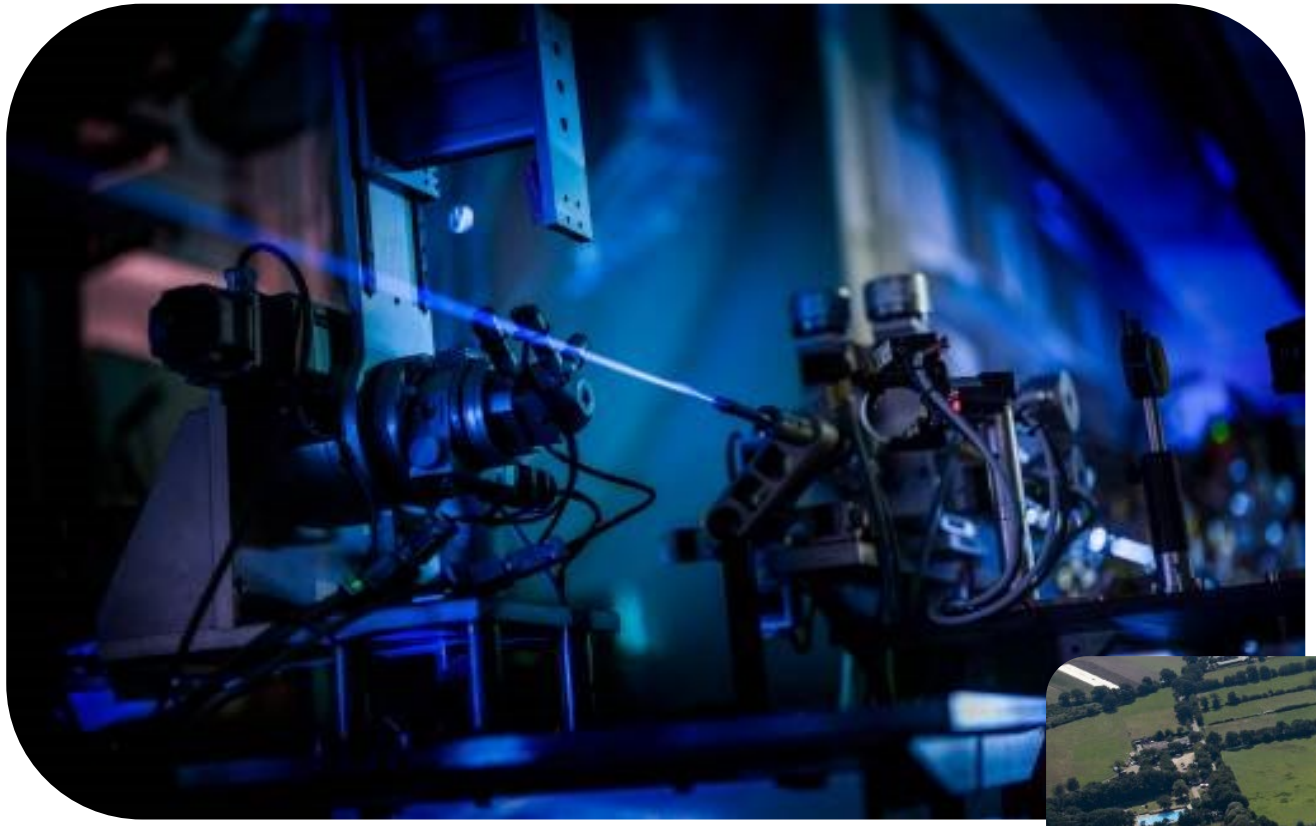
European XFEL—a leading new research facility

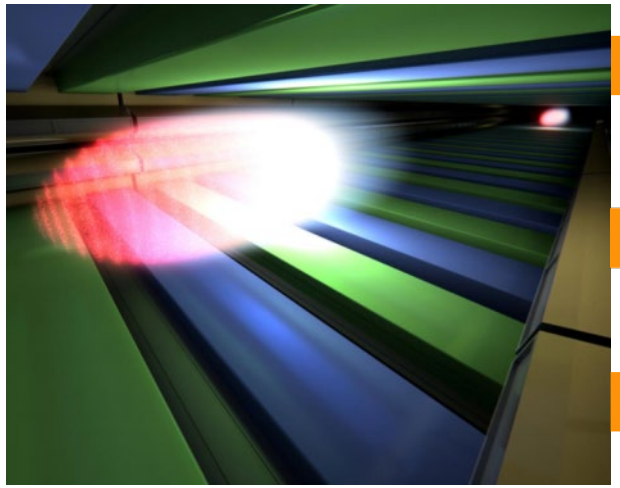


The European XFEL is a new research facility that uses high-intensity X-ray light to study the structure of matter.

- User facility with more than 500 employees (+250 from DESY)
- Location: Hamburg and Schenefeld, Germany

Schenefeld research campus on 14 August 2017

What can the European XFEL do?



X-ray light
See samples at atomic resolution

Ultrashort flashes
Film (bio-)chemical reactions

Intense X-ray pulses
Study single molecules or tiny crystals

About European XFEL

- Organized as a non-profit corporation in 2009 with the mission of design, construction, operation, and development of the free-electron laser
- Supported by 12 partner countries
- Total budget for construction (including commissioning)
  - 1.25 billion € at 2005 prices, about 140 M€ operating budget
  - 600 M€ contributed in cash, over 550 M€ as in-kind contributions (mainly manufacture of parts for the facility)

European XFEL—Entwicklung einer Einrichtung

We need a strategy for the next phase

Prof. Dr. Massimo Altarelli

2009–2017
Construction

- Increased efficiency
- Increased capacity
- Increased quality
- Investment in science
- Science- and challenge-driven experiments

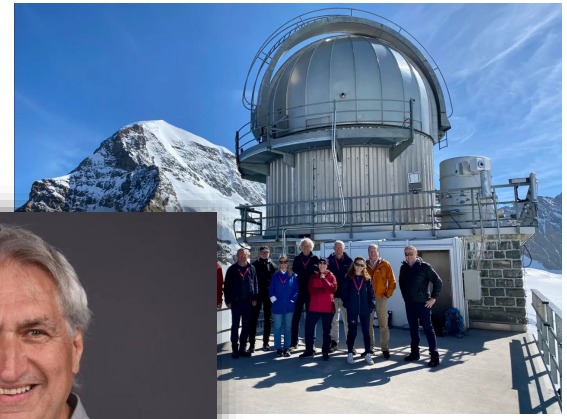
2024–2030
Harvesting

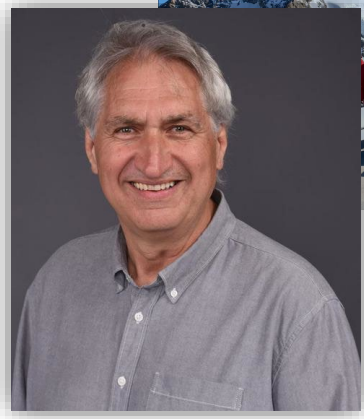
Prof. Dr. Thomas Feurer

2018–2023
Startup

Prof. Dr. Robert Feidenhans'l

- Start of operation
- First science programme
- Many proof-of-concept experiments
- 2022 – First year of full user operation (<8 000 instrument hrs)
- New developments needed to keep competitive





European XFEL

2017 - 2022

Three years of operation including the pandemic situation

2448

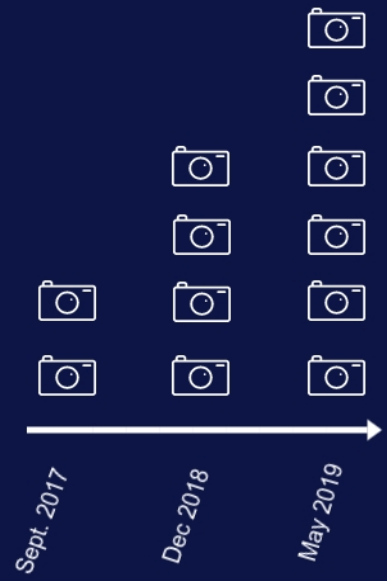
users from across the world have visited European XFEL for their experiments since operation began in September 2017.

247

experiments have been carried out at the facility.

After 2022, we started a steady-state operation with an average of 1,223 users per year and 9,000-10000 hours of beamtime.
40-50 Peta bytes for year

From **2 to 6** operational **instruments** in 2 years.

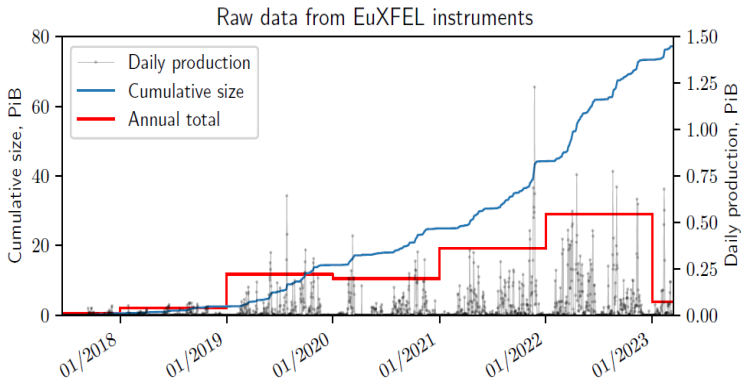


19 944
Hours of beamtime
provided for user experiments since operation began.

19 (2020), **80** (2023)
Petabytes of data
produced during user experiments.

55
User publications
published in peer-reviewed journals during the first three years. Many more are in preparation.

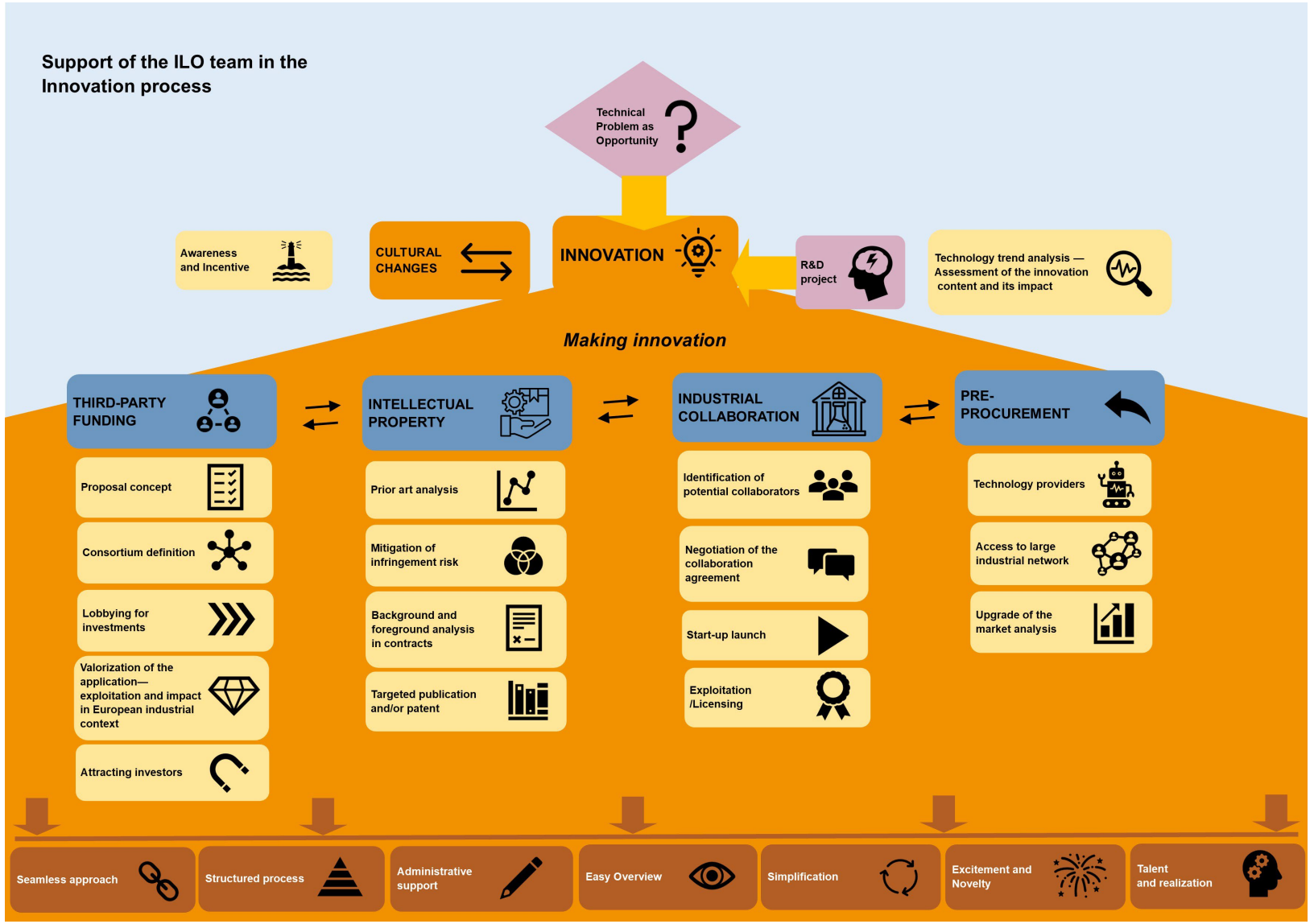
Data profile



instrument	dtype	proc	raw	bytes total
SPB		3.2 PiB	8.5 PiB	11.6 PiB
MID		2.7 PiB	4.6 PiB	7.2 PiB
SCS		352.9 TiB	2.7 PiB	3.1 PiB
FXE		1.2 PiB	1.3 PiB	2.5 PiB
SQS		59.0 TiB	429.4 TiB	488.4 TiB
HED		18.4 TiB	25.6 TiB	44.0 TiB
total		7.5 PiB	17.5 PiB	25.1 PiB

Project	FLASH	LCLS CuRF (USA)	LCLS-II SCRF (USA)	SACLA (Japan)	European XFEL	SwissFEL (CH)	PAL-XFEL (S. Korea)	SHINE (China)	FERMI (Italy)
Max. electron energy (GeV)	1.35	15	5.0	8.5	17.5	6.2	10	8	1.55 GeV
Wavelength range (nm)	3.4-90	0.05–5.0	0.25–5.0	0.06–0.3 /8-30	0.05–4.7	0.1–7	0.06–5.0	0.05–3.1	4-100 (1.7-4)
Photons/pulse	~10^{11}-10^{14}	5 x 10^{13}	0.5 - 5 x10^{12}	~5 x 10^{11}	~10^{12} (typical at 12.4 keV)	5 x 10^{11} (HX) 1.2 x 10^{14} (SX)	10^{11}–10^{13}	10^{10}–10^{13}	3x10^{11}-10^{14} (~10^{7}-10^{8})
Peak brilliance	1 x 10^{31}	4x10^{34} (measured at 10 keV)	2 x 10^{33} (simulated at 1.25 keV)	~5 x 10^{33}	3 x 10^{33} (8.3 keV simulated at saturation without seeding)	1 x 10^{32}–1 x 10^{33}	1.3 x 10^{33}	1 x 10^{33}	2x10^{32}
Average brilliance		5 x 10^{22}	3x10^{25}		2 x 10^{24} (8.3 keV simulated at saturation without seeding)				
Pulses/second	8000	120	1 000 000	60	27 000	100	60	1 000 000	50
Experiment Stations (parallel Operation)	7(2)	9 (3)		7 (3)	7 (3)	5 (2)	3 (2) Instruments 7 (2)	10 (3)	6(2)
Date of first beam	2005	2009	2023	2011	2017	2016	2016	2025	2010

Support of the ILO team in the Innovation process



Outline

- General presentation of European XFEL
- Main description of the facility
- Highlights on typical technologies in the experimental hall
- Information about procurement procedures, hints on new internal procedures
- Technologies of interest

3.4 km from Injector to Experimental Hall.

Injector (Hamburg - DESY)

SC-LINAC (1,9 Km; 17,5 GeV)

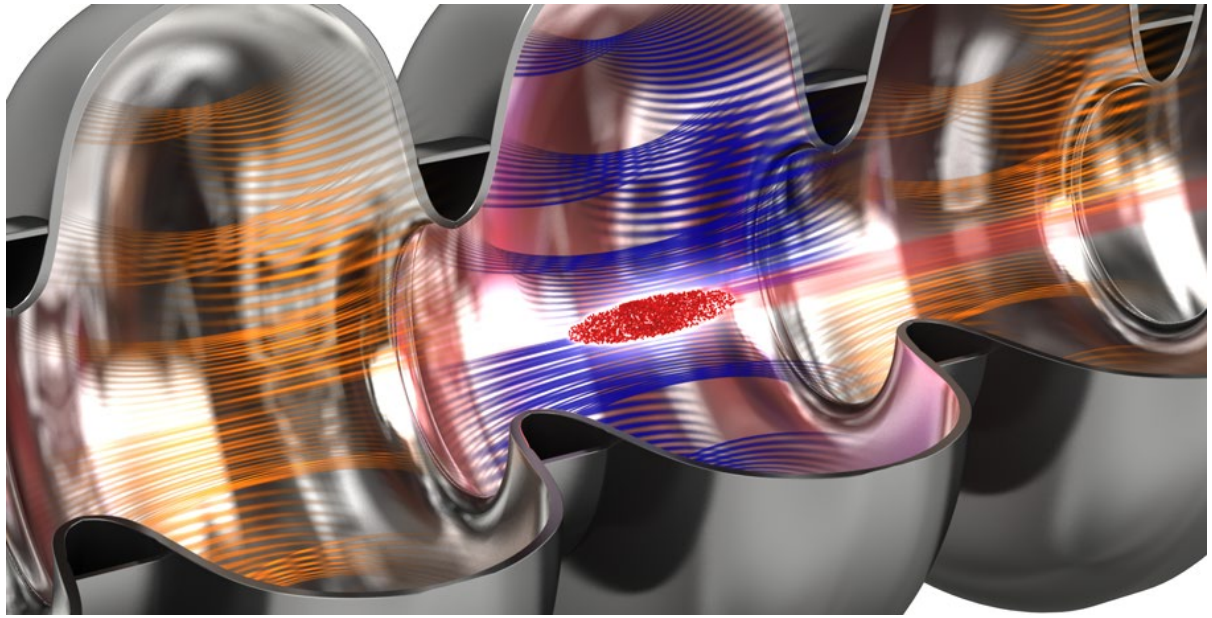
Undulators Sector

Undulators Sector

Photon Beamlines

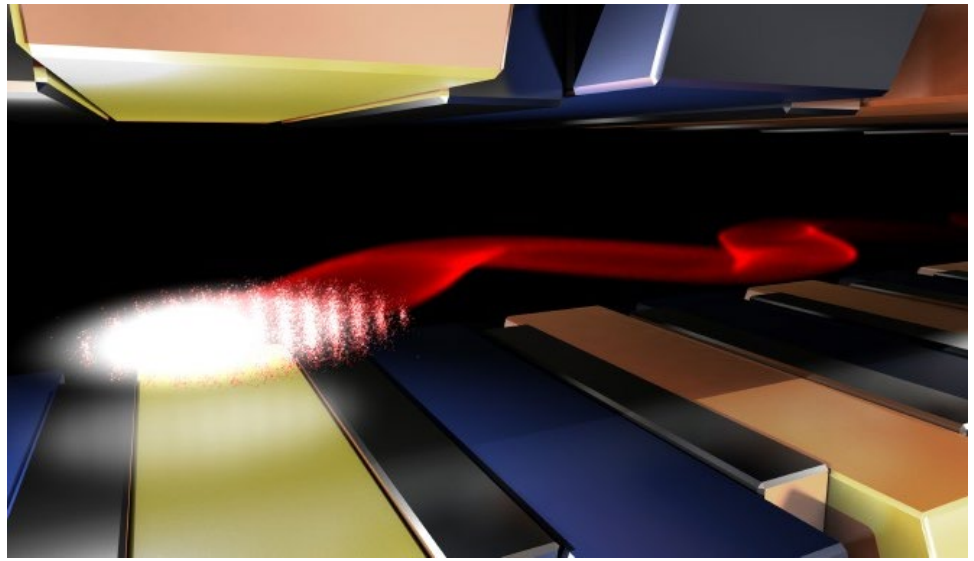
Instruments (Schenefeld)

Accelerator: electrons at close to light speed

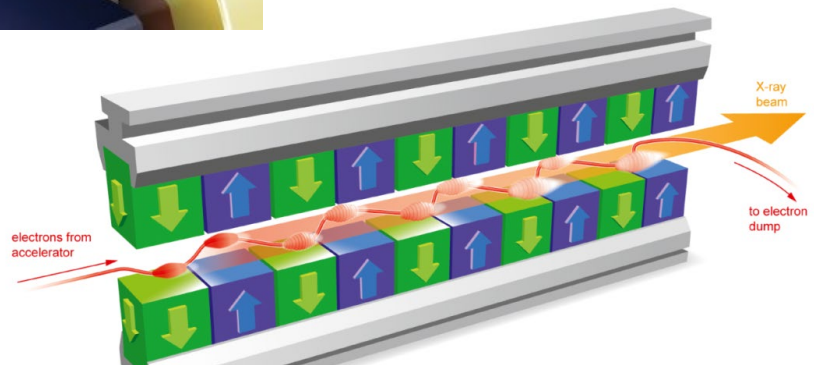


- Superconducting niobium cavities powered by intense radio frequency accelerate electrons
- Ninety-six accelerator modules over 1.7 km bring the electron bunch to near light speed and high energies

SASE (Self Amplified Spontaneous Emission) undulators: inducing electrons to emit X-ray light

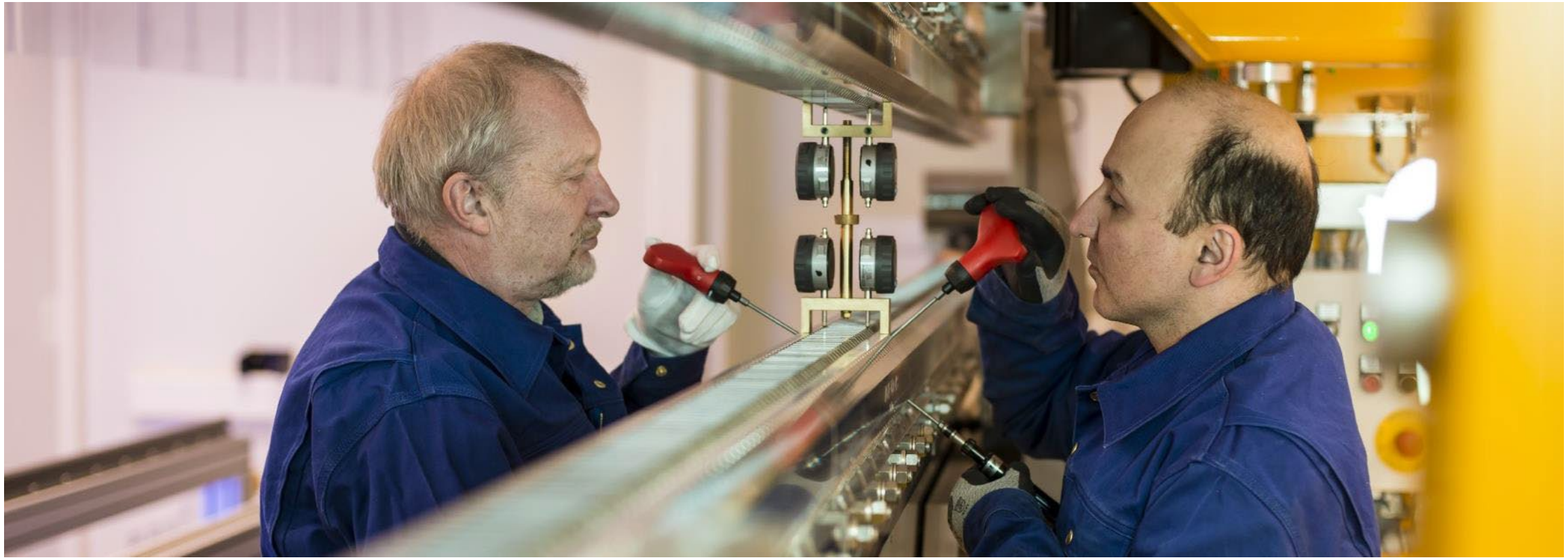


- Alternating magnetic fields cause electrons to take “slalom” course
- Electrons release X-rays with each turn
- SASE process builds intense, laser-like flashes



The European X-Ray Free-Electron Laser **Technical design report**
https://xfelbau.desy.de/technical_information/tdr/tdr/

Tuning undulators



Procurement regulation

Please have a look at https://www.xfel.eu/organization/procurement/legal_and_regulatory_information/index_eng.html#laws_and_regulations

- Threshold EU international call for tender

The EU threshold for construction contracts was set at 5.35 M€ and for all other supply and service contracts at 221 k€

- Rules of Procedure for the award of public supply and service contracts below the EU thresholds

https://www.xfel.eu/sites/sites_custom/site_xfel/content/e35152/e46557/e47200/e47206/xfel_file47209/UVgO_Englisch_eng.pdf

- Procurement Ordinance

https://www.xfel.eu/sites/sites_custom/site_xfel/content/e35152/e46557/e47200/e47206/xfel_file86104/VgV-ordinance-award-of-public-contracts_eng.pdf

Call for tender

- The European XFEL GmbH is a public-equivalent body and is therefore subject to special legal regulations concerning the award of contracts and placement of purchase orders. This includes, for example:
  - **the VOB** ("Verdingungsordnung für Bauleistungen“, regulations for civil construction contracts),
  - **the VOF** (“Verdingungsordnung für freiberufliche Leistungen“, regulations for freelance and professional services contracts)
  - **the VOL** (“Vergabe- und Vertragsordnung für Leistungen“, regulations on contract awards for public supplies and services),

https://www.xfel.eu/organization/procurement/legal_and_regulatory_information/index_eng.html

- The award of contracts and placement of purchase orders fall under the responsibility of the Procurement Group

General Purchase Conditions

- Due to the fact that we are a goverment-funded organization, we are not allowed to accept other terms and conditions than these. Please read them carefully and include them as part of your public tender documentation.

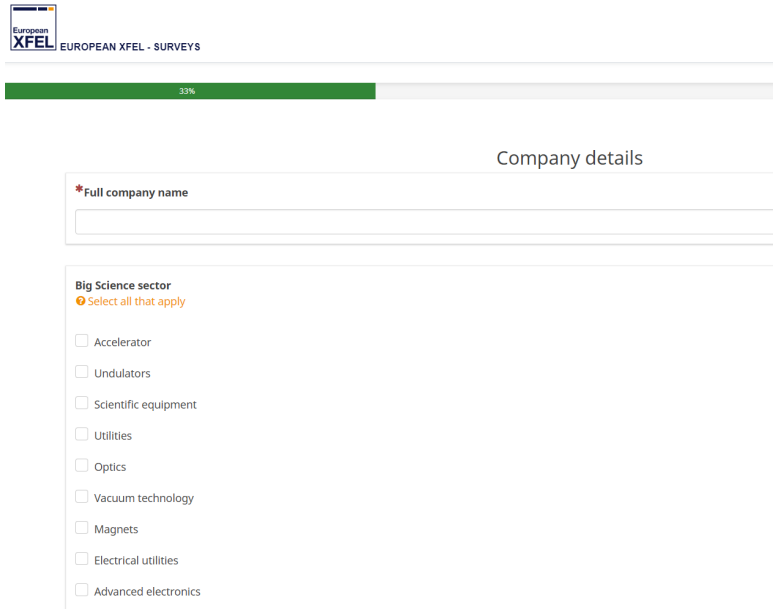
https://www.xfel.eu/sites/sites_custom/site_xfel/content/e35152/e46557/e47200/e47202/xfel_file47204/EuXFEL_GeneralTermsandConditionsofPurchase_20250325_en_eng.pdf

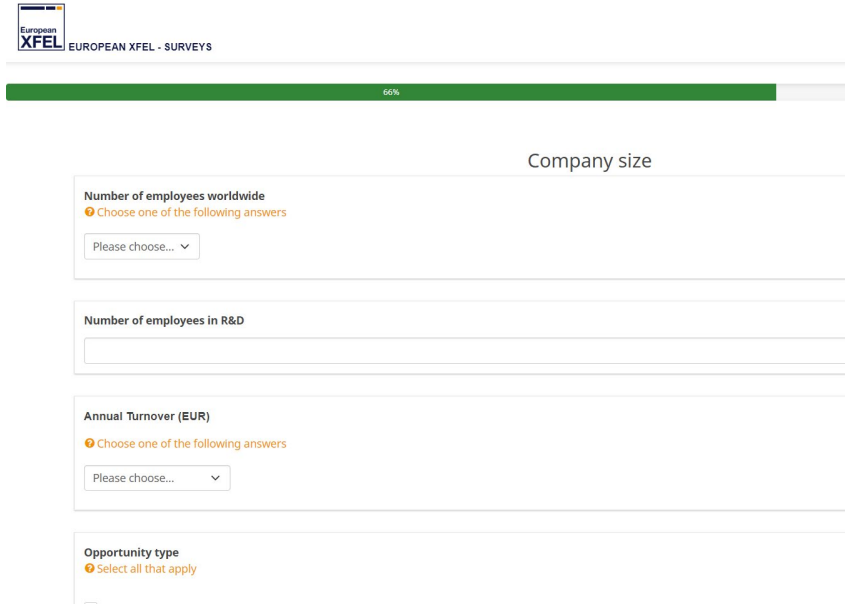
Innovation procurement workflow





Technology provider contact database





https://in.xfel.eu/thesurvey/index.php/782712

Outline

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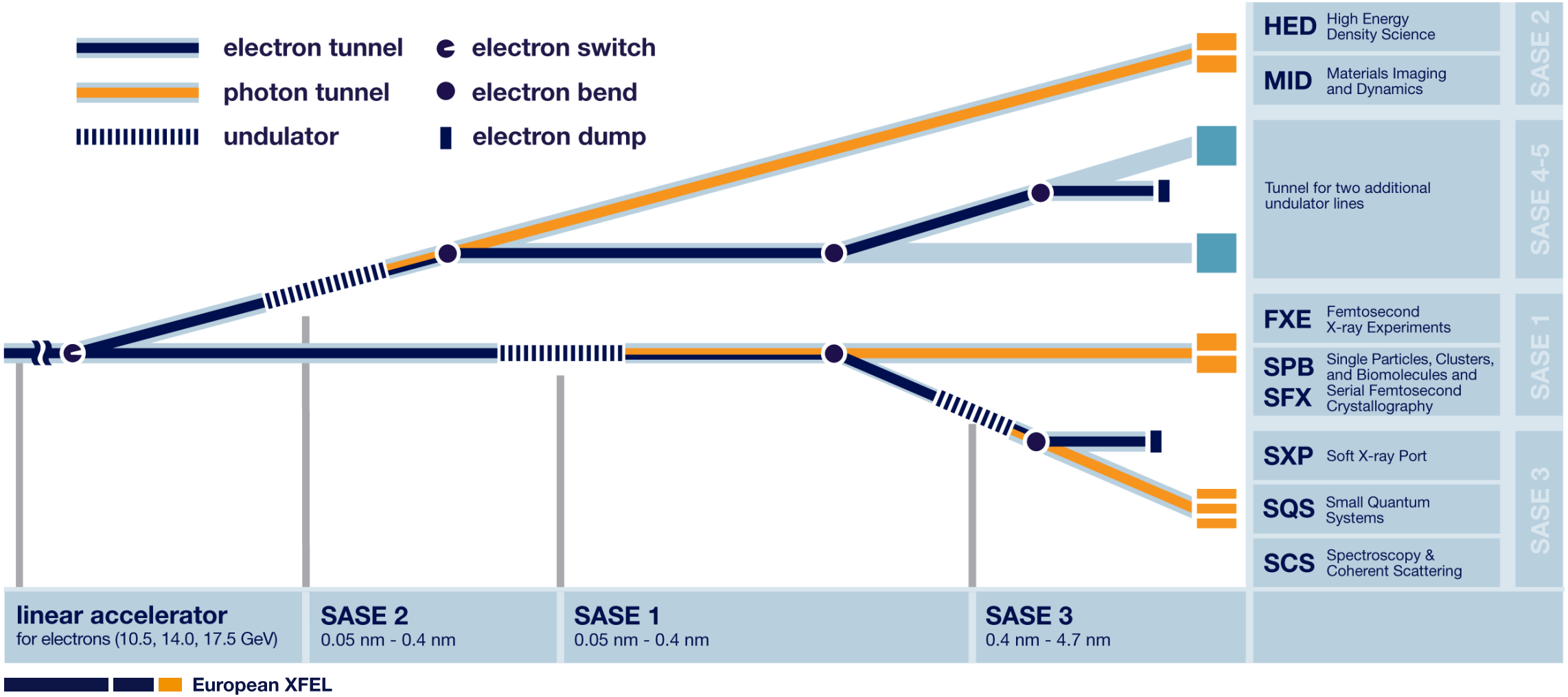
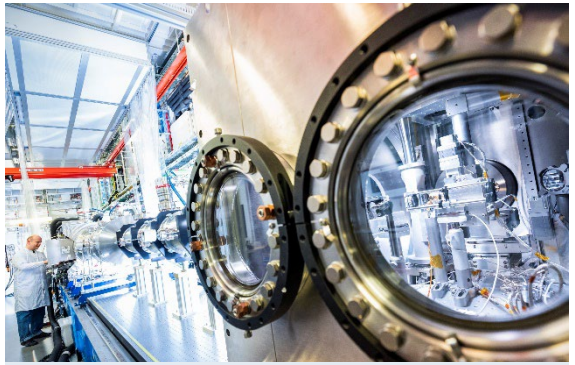
Beamline layout and experiment stations

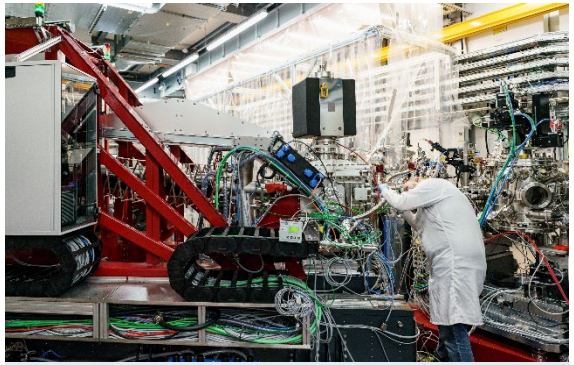


Seven scientific instruments

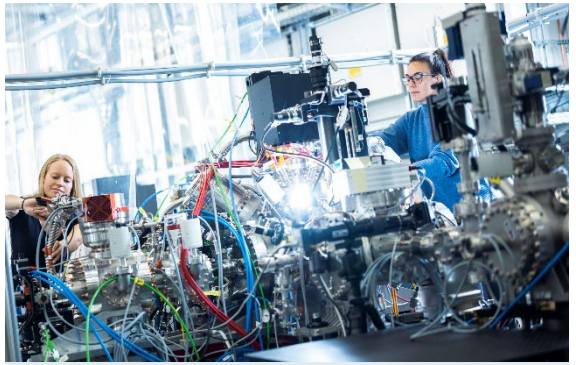
FXE (start Sep 2017)



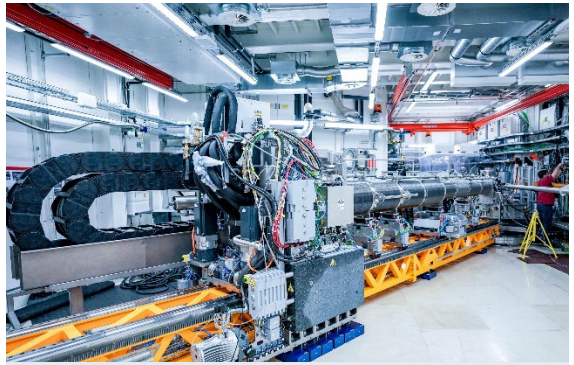
SPB/SFX (start Sep 2017)



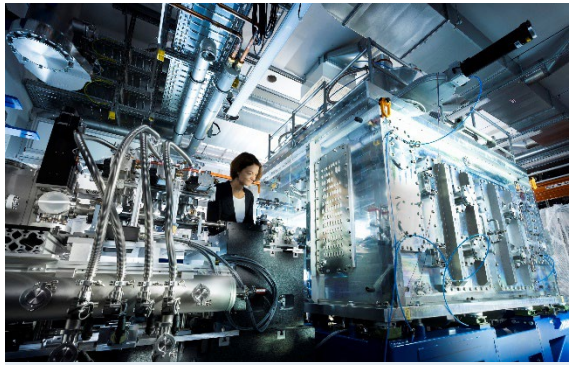
SCS (start Nov 2018)



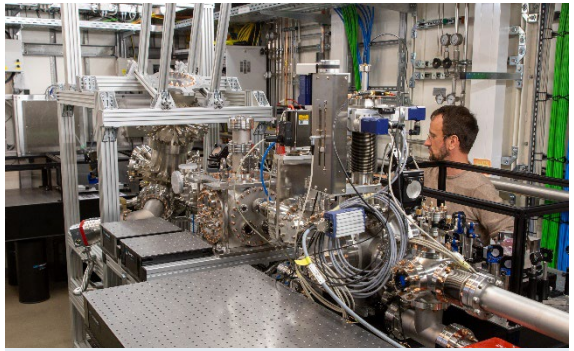
SQS (start Nov 2018)



MID (start Apr 2019)



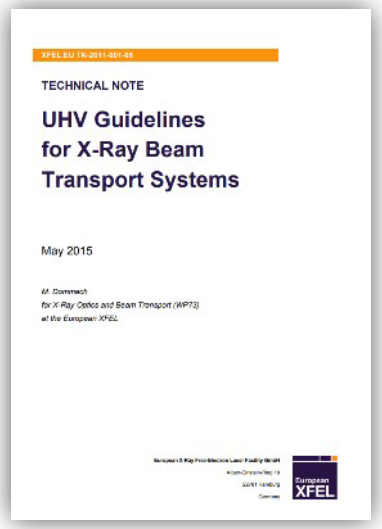
HED (start May 2019)

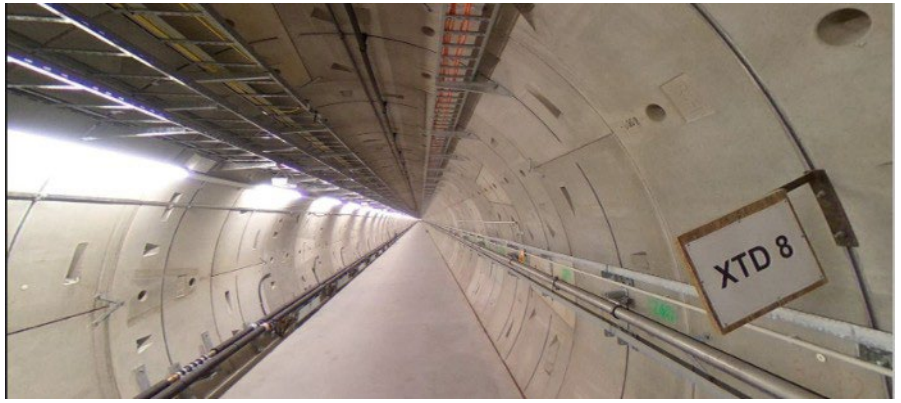


SXP (start summer 2023)

Photon Beam Transport System

- According to XFEL UHV Guidelines.
- Outsourced manufacturing and cleaning.
- “Particle free“ specifications (ISO Class 5/6).
- Sectorization & Mobile clean tents.
- In-situ conditioning (specific cases): wet-cleaning, baking, plasma cleaning…
- Hundreds of meters beampipe (flanged and in-situ orbital-welded sectors)
- Standard vacuum components:
  - Pumping Stations
  - Beamline Pumping equipment (mechanical, SIP’s, NEG’s)
  - Controller for pumps, gauges…
  - Gauges, RGA‘s,…
- PLC Control system (racks, terminals, interfaces).
  - PLC terminals
  - Power supplies, connectors, cables
  - Controller for pumps, gauges…





HED Instrument

https://www.xfel.eu/facility/instruments/hed/index_eng.html

- Combining hard X-ray FEL radiation and the capability to apply extreme conditions of pressure, temperature or electric field using the FEL, high energy optical lasers, or pulsed magnets.

https://www.xfel.eu/virtualtour/#node42

- Diamond Anvil Cells (available)
  dynamic DAC; pulsed laser heated DAC; double-stage DAC
- Powerful optical lasers (2020-2021)
  100 J 15 ns 10 Hz; 400 TW 30 fs 10 Hz
- XFEL split&delay line (2021) x-ray pump-probe, 0-20 ps delay
- 60 T pulsed magnetic field coil (2021)
  cryogenic sample environment, superconductivity (s for condensed matter studies at high fields)

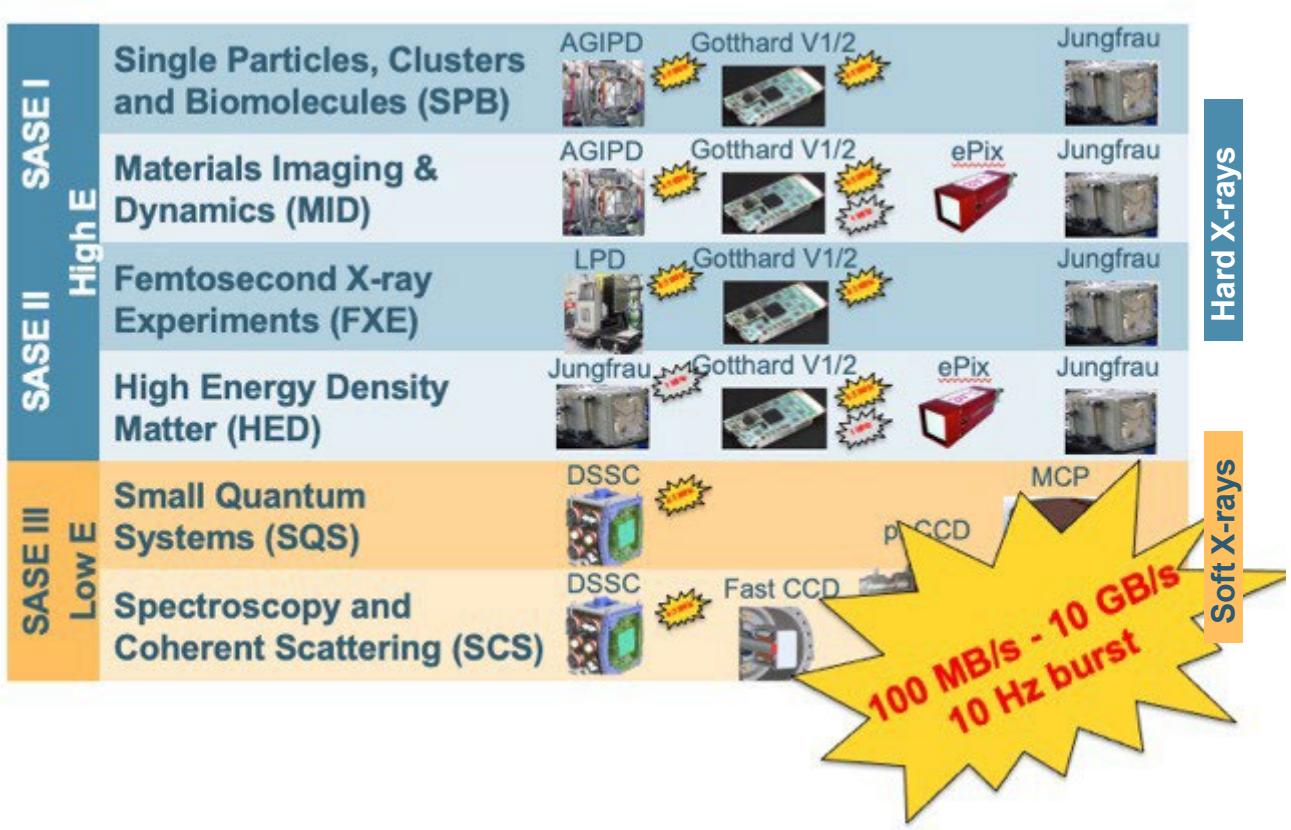
The goal will be to achieve pressures of 1 TPa and temperatures up to 10 000 K using 5 ns, frequency-doubled 50 J pulses from the DiPOLE100X laser focused to 100 μm

Additional laser

	Abbreviation	Repetition [Hz]	Wavelength [nm]	Pulse energy	Pulse duration	Max. power or B field	Remarks
Pump–probe laser	PP-OL	4.5 M	~ 800	0.2 mJ / 4.5 MHz 5 mJ / 200 kHz	15–00 fs	10–250 GW	NOPA
		200 k	~ 1030	100 mJ	0.8 ps or 0.5 ns	~ 100 GW	Yb amplifier
High-energy laser	HE-OL	1–10	1057 or 1064	~ 150 J/ω ~ 100 J/2ω	2–20 ns	~ 75 GW	Nd-glass or Nd-YAG
		< 1	528 or 532	> kJ	2–20 ns	> 500 GW	Beyond 2016
Ultrahigh-intensity laser	UHI-OL	10	~ 800	3–5 J	~ 30 fs	~ 100 TW	Ti-sapphire
		~ 1		10–30 J	~ 30 fs	~ PW	Beyond 2016
High-field pulsed magnet	HFM	0.1 – ~ 0.01	—	~ 30 kJ	> 100 μs	> 30 T	—
		< 0.01	—	> MJ	—	TBD	Beyond 2016

Handling Data and Complexity

X-Ray Detectors at EU.XFEL Instruments



Custom FPGA-based Data Producers at EU.XFEL

MicroTCA Crates
Large 12 slot 9U and small 6 slot 2U (including MCH, Power Supply and CPU)

X2Timer
XFEL Timing System module for synchronization (clocks and triggers) and pulse parameters from NAT

DAMC2
Required for Clock & Control system for fast 2D detectors, VETO System, Machine Protection System and photon beam loss monitors from DESY

SIS8300
Fast 125MSPS ADC with 10 channels and 16bit resolution for diagnostics an
etectors from
ovativ

ADQ412/ADQ14/ADQ7
High-speed digitizers from 1.8GSPS to 10GSPS with 12 to 14 bit resolution from Teledyne SP Devices

1 MB/s - 1 GB/s
10 Hz burst

Example of Technology of interest of 2025

- **Femtosecond laser system, including a laser and an optical parametric amplifier :**
  - A femtosecond laser system with a pulse duration of <300 fs.
  - Capability to operate in both kHz (~1 kHz–10 kHz) and MHz (1 MHz) repetition rate regimes. At kHz operation, a pulse energy of approximately 1–2 mJ is required, while at MHz operation, a more flexible range of 0.05–0.1 mJ per pulse is acceptable.
  - The laser should be compatible with an OPA, which will be purchased as part of an integrated laser + OPA system. The OPA should have a tuning range of approximately 350–2000 nm, delivering >0.02 mJ per pulse across all required spectral ranges in kHz operation. For MHz operation, pulse energy and tuning range requirements are more flexible in terms of power.

- **High-pressure, high-temperature diamonds:** with impurity concentrations below 0.1 ppm. Boron contamination should be minimized as much as possible. The material should have a dislocation density of less than 10e2 cm-2, ideally be defect-free, and exhibit single-sector growth. We require multiple slices for instance with dimensions of **more than 5 mm*5 mm and with a thickness less <0.2 mm³**.

- **Two vacuum chambers:**
  - The provider will be responsible for manufacturing two complete chambers, each consisting of a chamber body and three blank flanges.
  - The chamber body is a welded structure with approximate dimensions of 500–600 mm per side. The material specified for the body is AISI 316L, while the flanges welded to the body are made of AISI 316LN ESR.
  - The primary flanges to be welded on the body include 2x DN300CF and 1x DN250CF. Precise positioning and orientation (well below 0.1 mm tolerance) of these flanges are critical.

Example of Technology of interest of 2024

Alignment Table:

- Dimensions: Length/Width between 800-1200 mm, height between 500-950 mm.
- Translation: 80-100 mm along two main axes, resolution of 1 micron.
- Rotation: 8-12 degrees, precision <0.02 degrees.

Cryocooler System:Temperature

- Stability: ±0.02K at the sample.
- Cooling Power: 1st Stage >15W, 2nd Stage >1.5W at 4K.T
- Temperature Range: 4K - 325K.

Gas Mixers:

- Mixed gases: Argon and Neon.Input pressure: ~7-9 bar;
- Mixed pressure: ~4-6 bar. Adjustable mixing ratio: 0-100%,
- Withdrawal rate: <<1 to ~50 Nl/min.

High-Frequency Piezo Disks:

- Diameter: 5-12 mm, Thickness: 1-2 mm. Frequency: 1-5 MHz, material suitable for wire soldering.
- X-Ray Spectrometer:Designed for nonlinear soft X-ray spectroscopy.Grating chamber with up to three gratings, and motorised rotation with microradian accuracy.

Technology of interest - 2023

- **(piezo) actuators with controllers** that are encoded, UHV compatible, with low magnetic permeability (< 1.01μr), few Newton force and with nanometric resolution
- 50-100 pieces of **compound refractive lenses made of pure beryllium**
- **High time resolution, 4 channel real-time oscilloscope** with more than 25 GHz bandwidth, more than 70 GS/s sample rate and more than 13 Gb/s serial trigger Sensitivity is requested better than 3 mV-1 V/div.
- **Linear stage** that moves in horizontal direction a static load more than 2500N

Technology of interest – extract of 2022

- **UHV vacuum chambers in Aluminum alloy**, with bi-metallic flanges, without use of welding, in the direction of the beam.
- **Polycrystalline CVD diamonds** (chemical vapour deposition)
- Mechanical design and delivery of **optical holding systems** and its **large UHV chamber** with manual and remote micrometric control adjustment.
- **UHV compatible linear translation stages** moving in the vertical/horizontal axis by a travel range of more than 2 cm till 7 cm, with a spatial movement resolution less than 0,1 um
- **X-ray coatings of X-ray coatings** in B4C, metals (for instance Platinum, Gold, Chromium) for mirrors and gratings (made typically by silicon)
- **X-ray mirrors** large about 1 m (or even more) with a substrate in Silicon single crystal <100>, Meridional radius >200 Km, surface height error <20 nm peak to valley.

Conclusion

- European XFEL is an international big science large facility
- The construction is completed but there are a lot of opportunities to collaborate on new devices

For any question please write to **ilo@xfel.eu**

antonio.bonucci@xfel.eu

General Purchase Conditions

If the delivery or service resulting from a works contract is carried out in accordance with the contractual conditions, it will be accepted. If a test run is agreed, the delivery or service is deemed accepted by means of a joint acceptance report after a flawless test run.

In addition, the Goods to be delivered must comply with the applicable safety regulations (e.g. EU Directive 2006/42 on machinery, EU Directive 2014/35 on the market of electrical equipment designed for use within certain voltage limits, EU Directive 2014/30 relating to electromagnetic compatibility, EU Directive 2014/68 on the market of pressure equipment, EU Directive 2011/65 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, German Product Safety Act (ProdSG - Act on making products available on the Market)and be provided with all prescribed markings (e.g. CE mark), declarations (e.g. declaration of conformity, declaration of incorporation) and documents (e.g. operating instructions, assembly instructions, safety data sheets). Protective devices, markings, declarations, and documents required according to such regulations shall be taken into account in the Contractor's calculation and shall be part of the scope of delivery, even if they are not requested separately by the Client.

General Purchase Conditions

The Contractor shall keep all images, drawings, calculations, and other documents and information (hereinafter referred to as "Confidential Information") received for the execution of the Purchase order strictly confidential and to disclose them only to employees who have been obliged to treat them confidentially. Confidential Information may only be disclosed to third parties with the prior written consent of the Client, which must be granted in the event of proven judicial or statutory claims for disclosure. The obligation to maintain confidentiality shall also apply after the termination of this contract; it shall expire - unless otherwise agreed - five years after the conclusion of the contract or if and to the extent that the Confidential Information has become public domain.

Property rights

The Contractor is liable for ensuring that no third-party property rights are violated during the execution of the contract and during the delivery and use of the delivered item or service. Upon first written request, the Contractor shall indemnify the Client against any third-party claims arising from any property right infringements.

The Client is entitled to obtain the necessary authorization for delivery, commissioning, use, resale, etc. of the delivery item or service from the owner of such property rights at the Contractor's expense if the Contractor is unable to obtain such rights, finally refuses such subsequent performance, or is in default with subsequent performance.

The Contractor shall grant the Client free-of-charge a non-exclusive and irrevocable license to all domestic and foreign property rights, applications for property rights, and inventions, insofar as they have arisen during the performance of this contract. Furthermore, the Contractor shall grant the Client free-of-charge an irrevocable and non-exclusive right to use all know-how and every innovation and improvement, insofar as these have arisen during the performance of this contract. The Client is entitled to transfer licenses and rights of use within the meaning of the above paragraph to its shareholders. This shall also apply beyond the term of this contract. The Contractor shall expressly agree the above rights with its subcontractors for the benefit of the Client.

General Purchase Conditions

The Contractor shall, no later than two weeks after placing the Purchase order, notify the Client independently and in writing for each individual item of all information and subsequent changes thereto required by the Client for compliance with foreign trade and payments law in the case of export, import, and re-export, in particular:

3.2. All applicable export list numbers, in particular in accordance with Annex AL to the German Foreign Trade and Payments Regulation (AWV) or comparable list positions of relevant export lists including the "Export Control Classification Number" in accordance with the "US Commerce Control List" (ECCN), if the Goods are subject to the "US Export Administration Regulations" (EAR);

3.5. All information of the Contractor required by the Client for the fulfillment of its obligations under the EU Regulation 2023/956 establishing a carbon border adjustment mechanism; and