The European XFEL –
A lightsource facility preparing to use the powerful electron for experiments

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DESY, Hamburg, January 27, 2025

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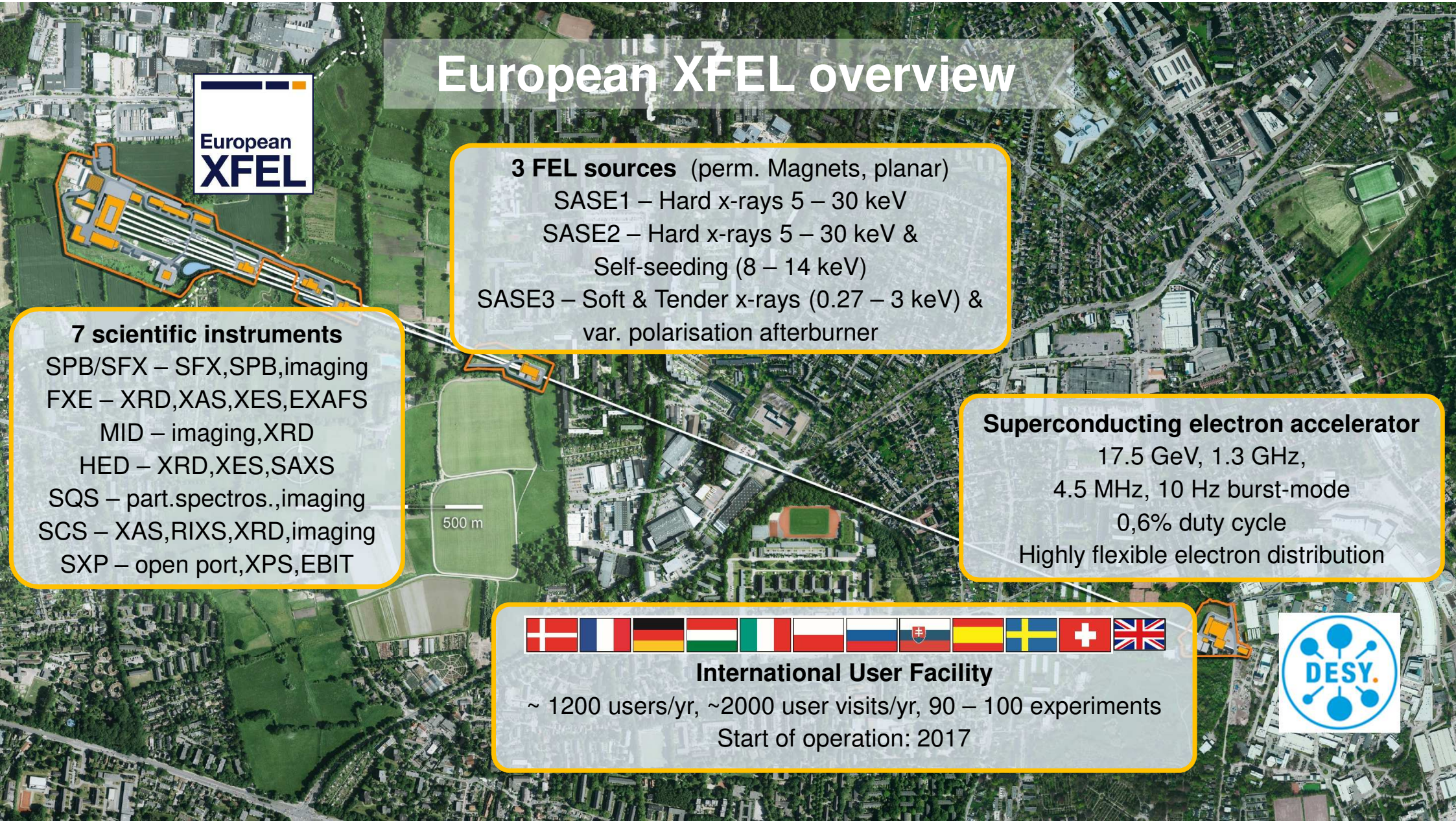
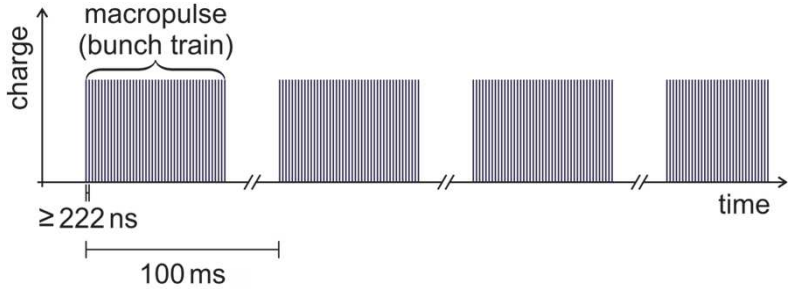

European XFEL overview
European XFEL
3 FEL sources (perm. Magnets, planar)
SASE1 – Hard x-rays 5 – 30 keV
SASE2 – Hard x-rays 5 – 30 keV &
Self-seeding (8 – 14 keV)
SASE3 – Soft & Tender x-rays (0.27 – 3 keV) &
var. polarisation afterburner
7 scientific instruments
SPB/SFX – SFX,SPB,imaging
FXE – XRD,XAS,XES,EXAFS
MID – imaging,XRD
HED – XRD,XES,SAXS
SQS – part.spectros.,imaging
SCS – XAS,RIXS,XRD,imaging
SXP – open port,XPS,EBIT
500 m
Superconducting electron accelerator
17.5 GeV, 1.3 GHz,
4.5 MHz, 10 Hz burst-mode
0,6% duty cycle
Highly flexible electron distribution
International User Facility
~ 1200 users/yr, ~2000 user visits/yr, 90 – 100 experiments
Start of operation: 2017
DESY.

High repetition rate

European XFEL superconducting 17.5 GeV electron accelerators (TESLA technology)

- FLASH, European XFEL – Burst mode



  - **Similar pulse performance as RT FELs**

- LCLS-II, SHINE – cw-mode
  - **Continuous electron bunch delivery**
  - **Rates are 100 kHz to 1 MHz**
  - **Modified pulse performance (smaller charge)**

Super-conducting accelerator

- Worlds first long sc accelerator, 17.5 GeV, ~1000 m acc. length, 768 Nb cavities, 96 cryo-modules

X-ray FEL undulators

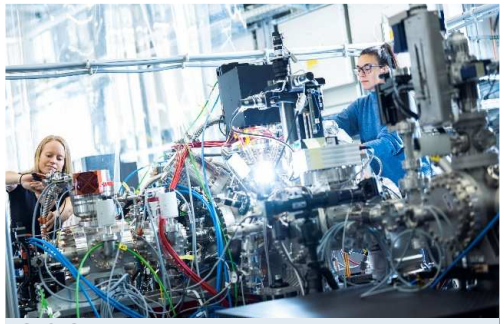
- 450 m total length, 5 m segments, 92 segments, 3.5 cm period → ~54.000 single magnets

Seven scientific instruments

FXE (start Sep 2017)

SPB/SFX (start Sep 2017)

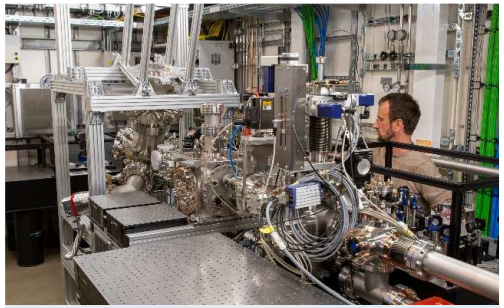
SCS (start Nov 2018)



SQS (start Nov 2018)

MID (start Apr 2019)

HED (start May 2019)



SXP (start summer 2023)

A user facility for the application of x-ray FEL radiation

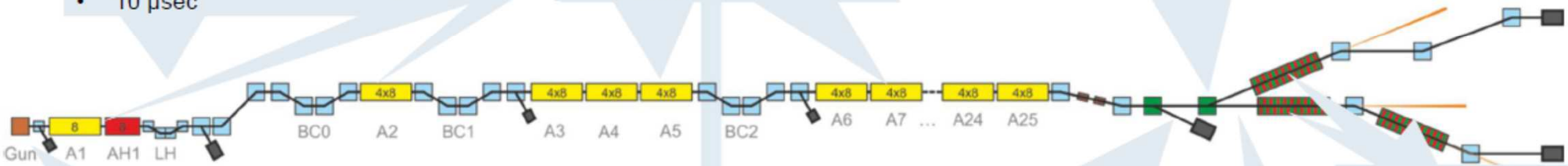
- **European XFEL vision** is to provide to the international scientific community a world-leading research facility for pushing forward the frontiers of scientific knowledge, opening new scientific avenues, thus enabling to solve major societal challenges.
- **Users** from universities, research centers and industry propose experiments and will invited to perform these following positive evaluation (peer-review process).
- The **user facility** supports **user experiments** by x-rays, instruments, data services, personnel & expertise.

An electron accelerator with extreme flexibility

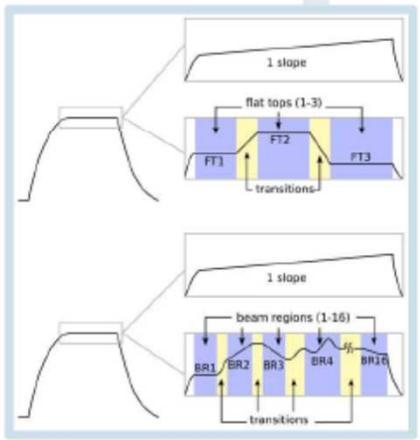
Position in laser heater
- Vary slice energy spread
- 10 µsec

RF parameters
- Beam energy
- Phase space
- Pulse length
- 10 µsec

Beam distribution North/South
- Divide bunch train
- 10 Hz / 10 µsec, flexible bunch number and position



Injector laser
- vary charge
- Up to 4.5 MHz
- In development, fully available 2024



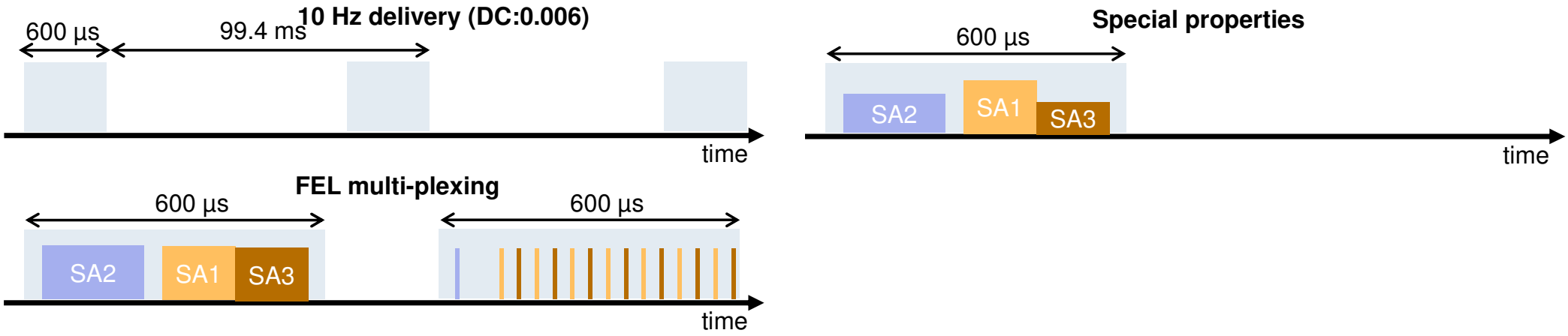
Beam distribution Dump
- Kick out single bunches
- Customizes bunch pattern for each SASE
- Up to 4.5 MHz

Variable gap
- Energy selection
- BW
- Intensity
- Source point

Corrugated Structure
- Phase space manipulation
- 10 Hz / 10 µsec
- In commissioning

DESY.

Flexible electron bunch and x-ray pulse delivery patterns



European XFEL & DESY (only technical and operational)

- DESY
  - **Operates the electron accelerator and all its sub-systems**
  - **Operates the technical infrastructure for the facility**
  - **Develops further the accelerator and its sub-systems**
  - **Room responsibilities for the tunnel sections & accelerator levels of shaft buildings**
  - **System responsibilities for accelerator systems**
  - **Radiation protection responsibility for areas around electron accelerator**
- European XFEL
  - **Owns and operates the entire facility and thus has overall responsibility**
  - **Operates the undulator systems, x-ray beamlines and scientific instruments**
  - **Operates the User program of European XFEL**
  - **Operates the buildings (surface, shafts and tunnels)**
  - **Develops further the undulator systems, x-ray beamlines and scientific instruments**
  - **System responsibility for the buildings and civil construction matters**
  - **Radiation protection responsibility for areas with x-ray beam**

Governance

Operation Agreement (Contract)

Governing Board (Oversight, major issues)

Operation Board (daily matters, operation issues, trouble shooting)

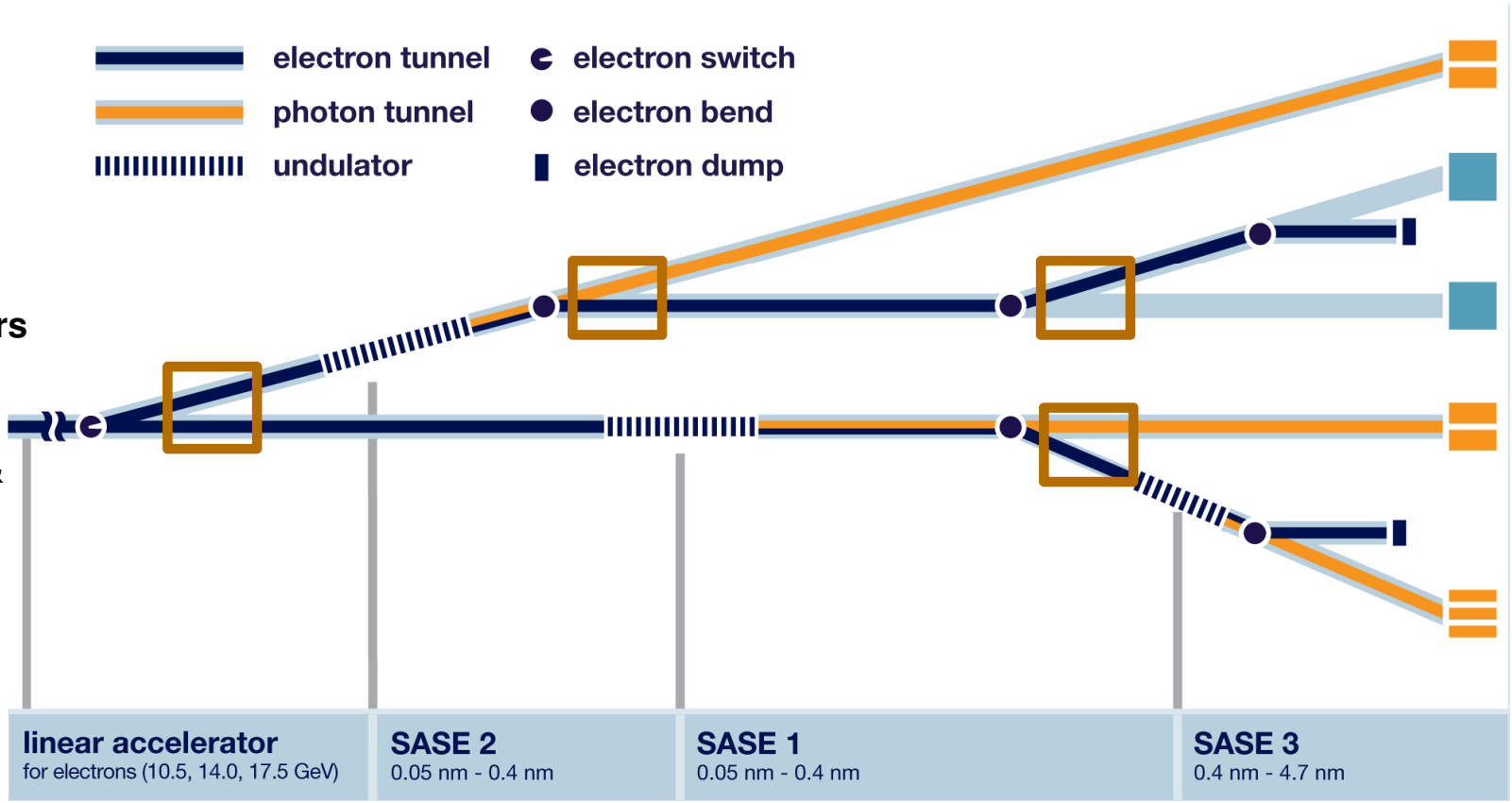
Accelerator operation: Winfried Decking, MXL+

Photon system operation: MB (TT), DO groups (Technical Services)

Access to the electron beam

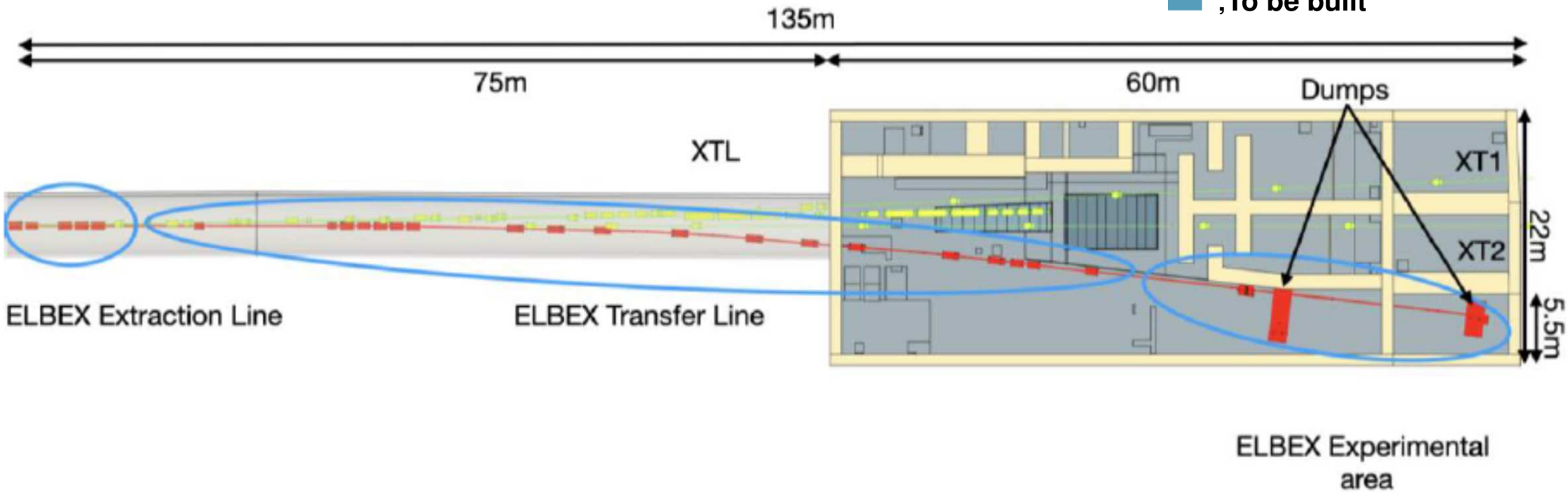
- Facility purpose (so far)
  - **Accelerate electrons**
  - **Provide photons for experiments**
- Electron beam areas
  - **No accessible for users**
  - **No ‚experiments‘**
  - **Beam delivery, x-ray generation, electron & x-ray diagnostics**

Shaft/access bldg.s



XS1 – Distribution of electron beam

- 3 electron beamlines exist
  - **North – towards SASE1 & SASE3**
  - **South – towards SASE2**
  - **Dump – towards XTL dump**
- Access
  - **Only when no electron beam is operated & magnets in safe s.**
  - **Special regulations apply**
- Infrastructure
  - **Power, water**
  - **Laser rooms**
  - **At upper/surface levels**
  - **‚To be built‘**



European XFEL role within ELBEX

- Enable the infrastructure availability for ELBEX
  - **Coordination, support and oversight of**
  - **Technical infrastructure preparation**
    - ► requirements,
    - ► design,
    - ► procurement,
    - ► Implementation
- 45 PM

Work package WP4 – Service infrastructure

Work Package Number	WP4	**Lead Beneficiary**	2 - EUROPEAN XFEL
Work Package Name	Service infrastructure		
Start Month	1	**End Month**	60

Objectives
Support preparation, procurement and implementation preparation of infrastructure necessary to install the ELBEX facility in the tunnel and annex shafts of the XS1 building at Osdorfer Born.

Description
WP4 consists of the design, procurement and implementation preparation of new technical infrastructure installations at Osdorfer Born, necessary to prepare installation of the ELBEX facility. This includes support by technical service group experts on civil construction, building service infrastructure and electrical installation. The main European XFEL role is the coordination, support and oversight of these activities. The DESY contribution to WP4 is the implementation and commissioning of the infrastructure modification in the tunnel area to house the ELBEX facility. This includes works on the existing tunnel doors, as well as the design, manufacturing and installation preparation of mounting structures for all magnets and vacuum system (use of XFEL standard ceiling mount and concrete floor mount components foreseen). The overall responsible for work package 4 is European XFEL.

European XFEL role within ELBEX

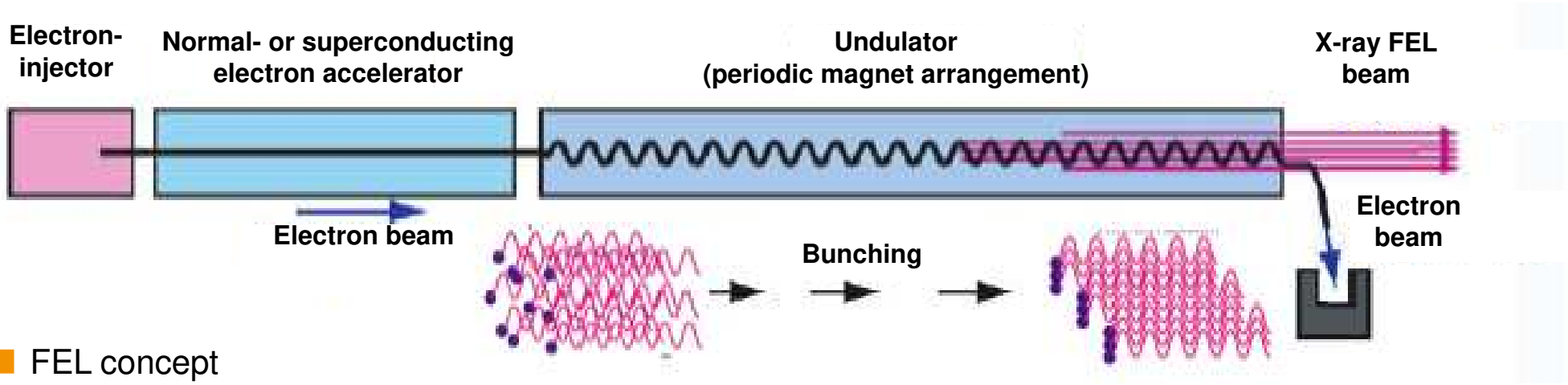
- (Scientific) Coordination of integration of ELBEX (and eventually LUXE) into European XFEL facility
  - **Acting as the interface to ELBEX and LUXE teams**
  - **Coordinating with European XFEL technical expert teams for building infrastructure**
  - **Collecting requirements for the installation & operation, and communicating to infrastructure groups**
  - **Promoting LUXE science case and further applications at European XFEL**

- Execution
  - **Scientific Director (in charge of Developments & Operation)**
  - **Operation team**
  - **Expert groups at European XFEL and DESY**

- Status
  - **Clarification of roles largely achieved**
  - **Additional resources required expected to start Q2 2025**

Thank you for your attention

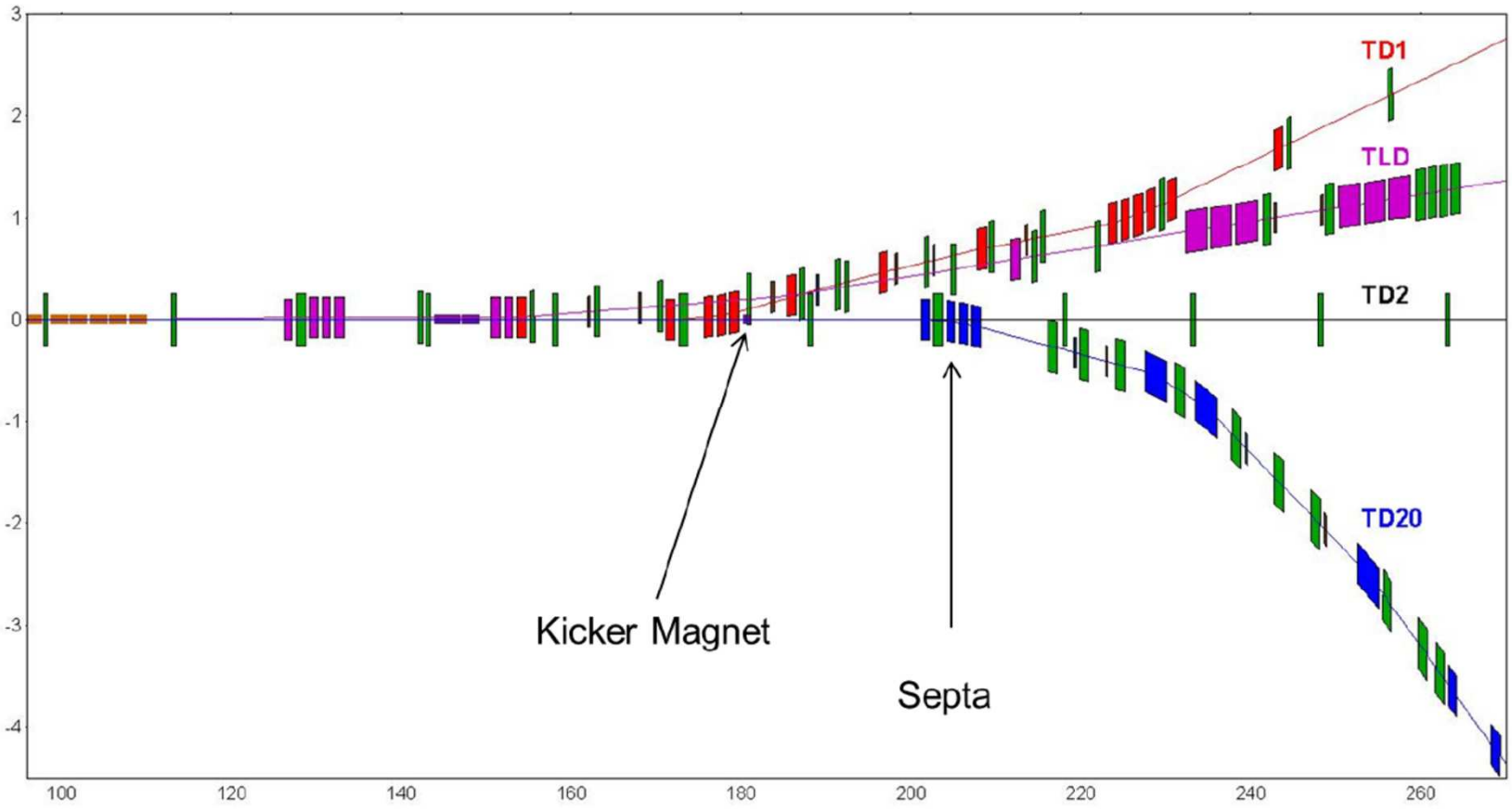
X-ray Free-Electron Laser (FEL) radiation



- FEL concept
  - J.M.J. Madey, J. Appl. Phys. 42, 1906(1971)
- SASE FEL radiation
  - **High Gain Single Pass regime:** A.M. Kondratenko, E.L. Saldin, Part. Accel. 10, 207 (1980)
  - **Collective instability and self-organization**: R. Bonifacio, C. Pellegrini, L.M. Narducci, Opt. Communications 50, 373 (1984)

- Properties of SASE x-ray FEL radiation
  - **Ultrashort duration (sub-fs – 100 fs)**
  - **Very high pulse energies (0.1 – 10 mJ)**
    - ► Few 10^{12} photons at 0.1 nm (10^{14}@1 nm)
  - **Full transverse coherence (<10 keV)**
  - **Limited longitudinal coherence**
  - **Single pass generation / fluctuations**

Details electron beamlines (XS1)



XS1 – Conceptual layouts of underground levels

XS1 Shaft with LUXE