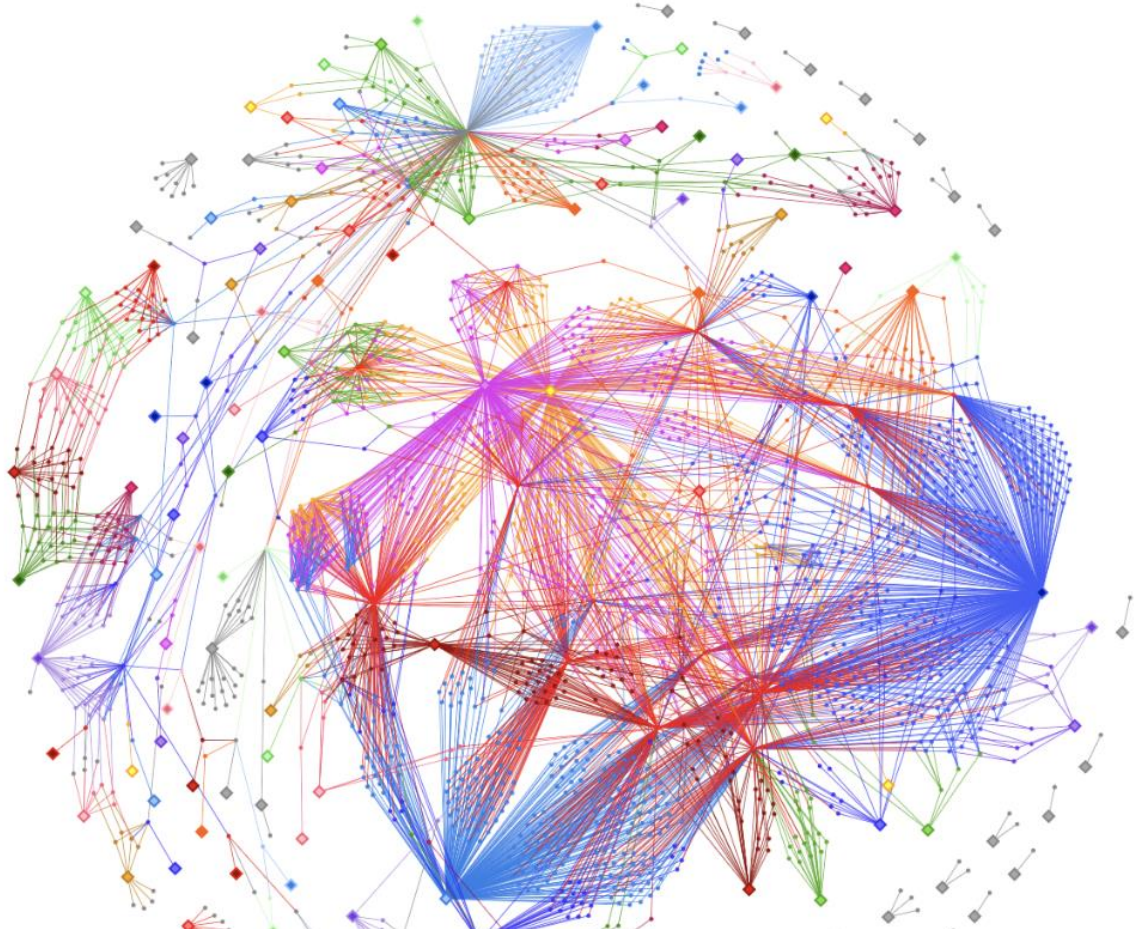
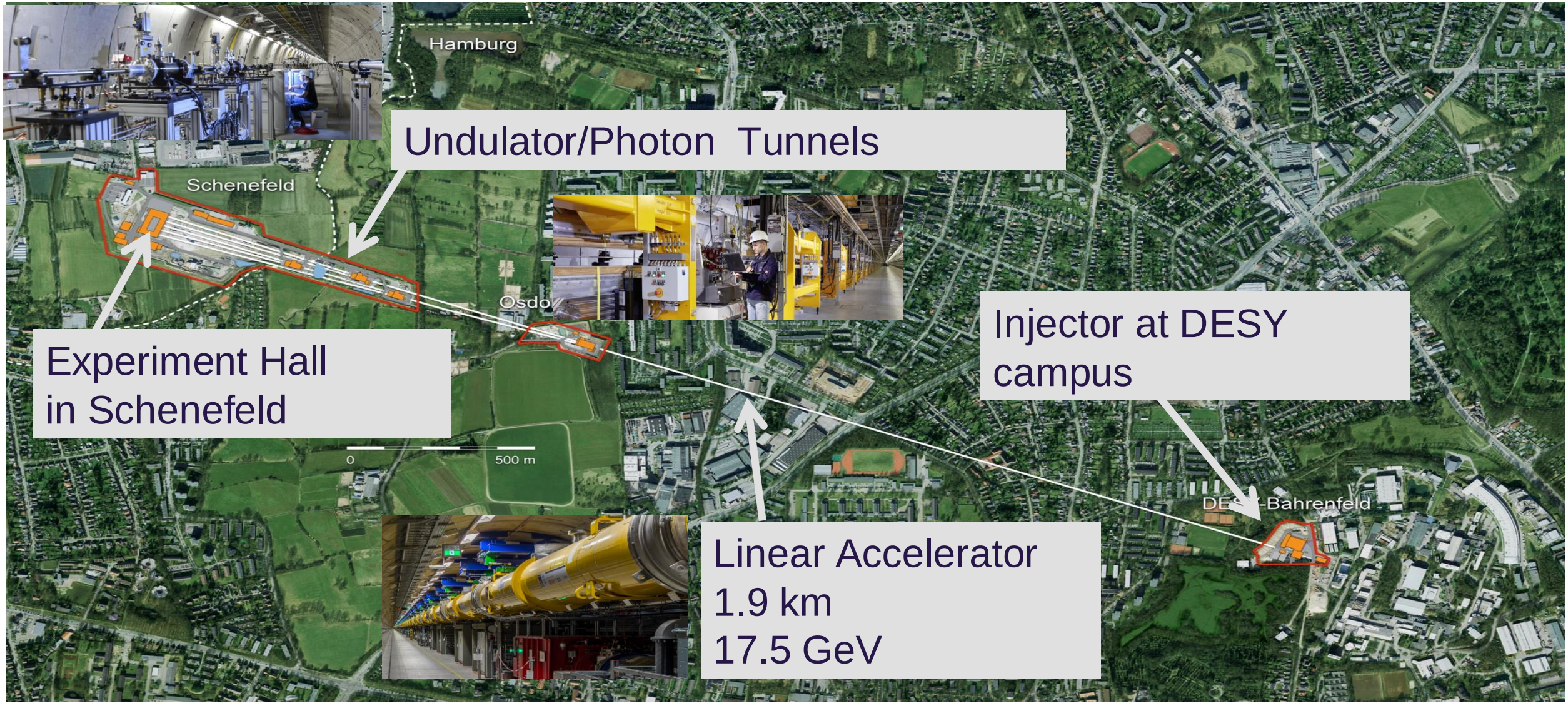
European XFEL – An Engineering (Challenges) Introduction

S. Hauf (steffen.hauf@xfel.eu)

EIROforum Workshop on Systems Enginnering,
February 5th and 6th, Schenefeld, Germany



The European XFEL – An X-ray Free Electron Laser



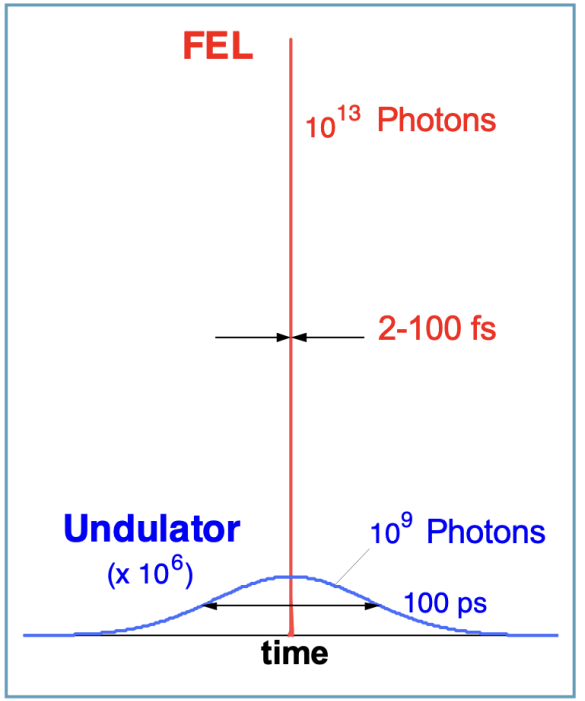
Undulator/Photon Tunnels

Experiment Hall in Schenefeld

Injector at DESY campus

Linear Accelerator
1.9 km
17.5 GeV

The European XFEL – An X-ray Free Electron Laser



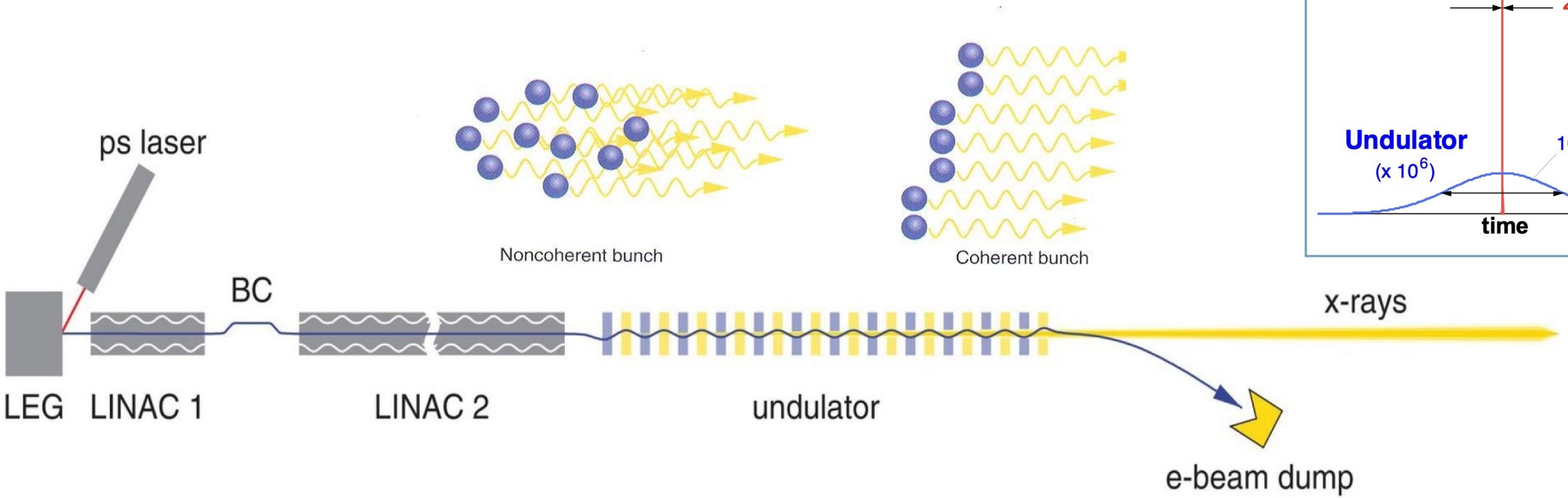
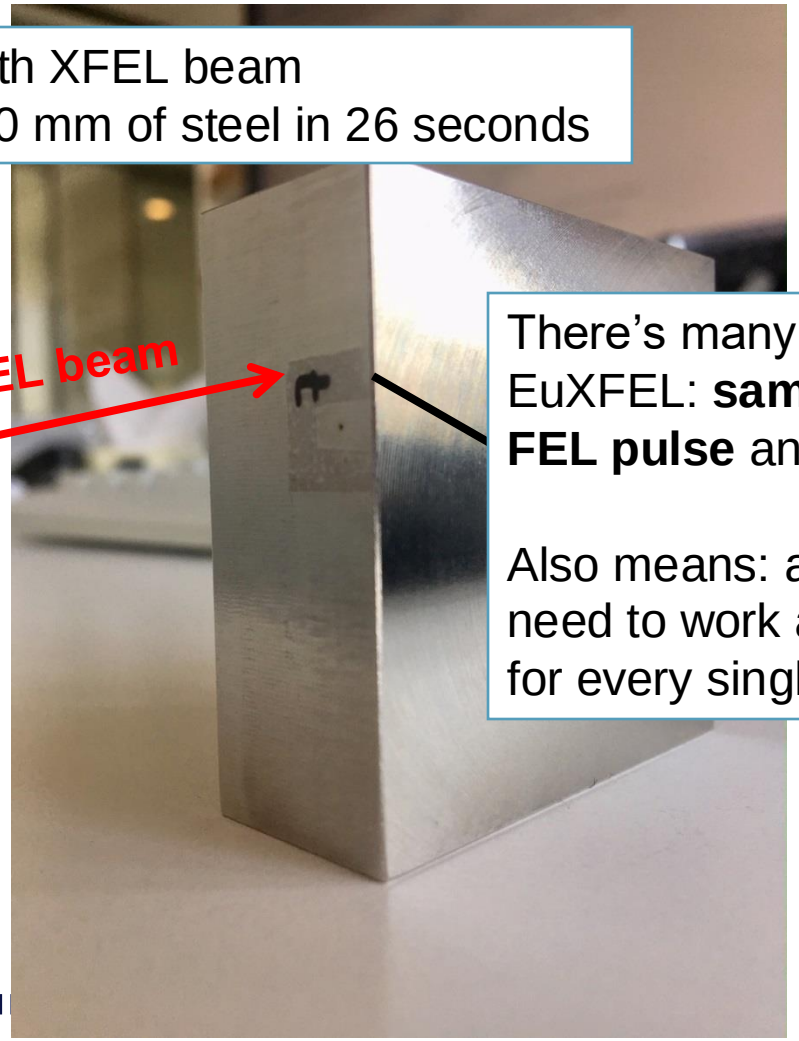


Figure 4.2 Schematic of XFEL facilities. Electron bunches are emitted from a low-emittance gun (LEG) irradiated by picosecond laser pulses. They are then accelerated in a short LINAC (LINAC 1), compressed longitudinally using one or more bunch-compressor magnet chicanes (BC), then further accelerated using a much longer LINAC (LINAC 2) before entering a long undulator, typically a few hundred metres in length. The SASE process along the undulator produces highly intense x-ray pulses with durations of the order of 50 fs. The electrons are deflected after the undulator using a bending magnet and subsequently dumped.

Courtesy R. Feidenhans'l

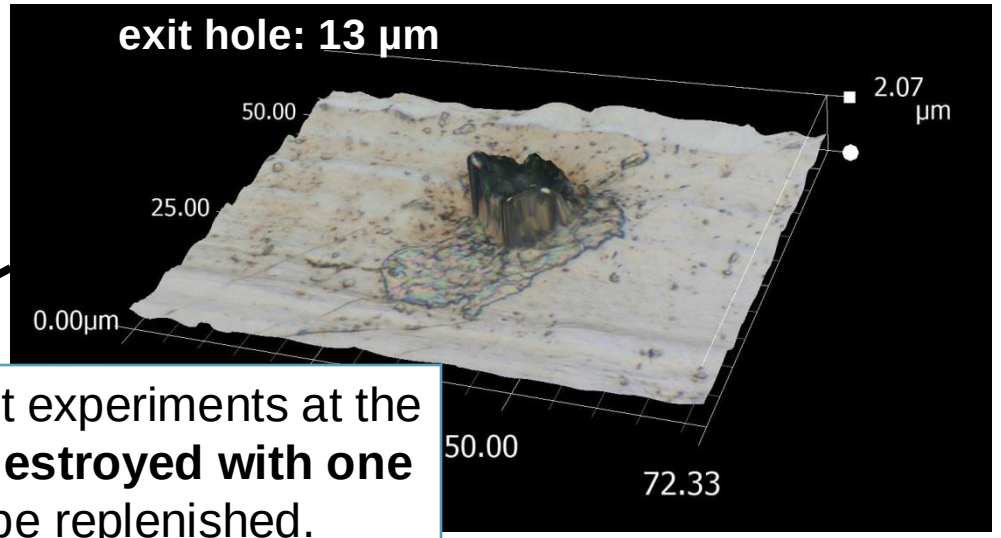
The European XFEL – An Exceptionally Strong X-ray Free Electron Laser

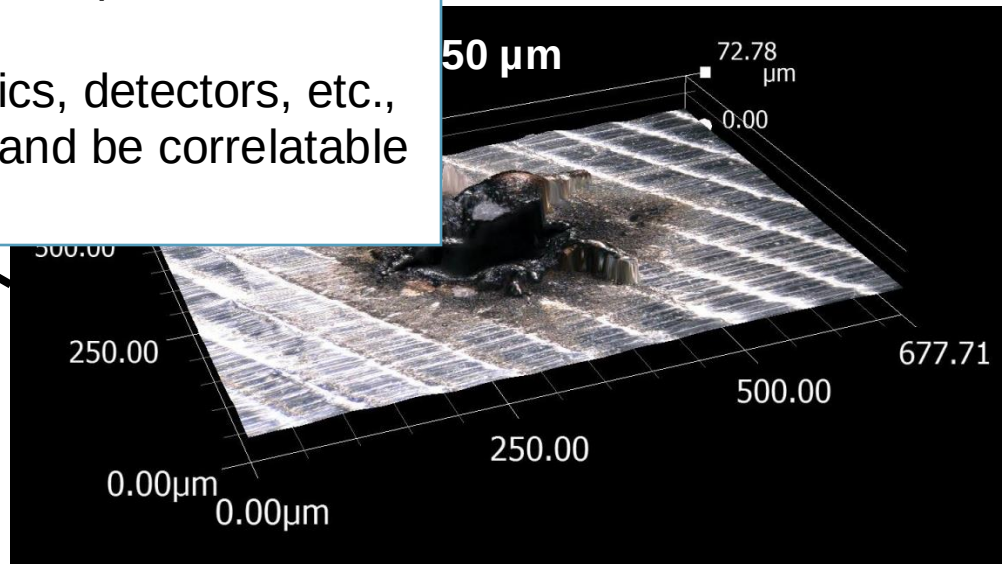
Drilling with XFEL beam
through 50 mm of steel in 26 seconds



There's many single-shot experiments at the EuXFEL: **samples are destroyed with one FEL pulse** and need to be replenished.

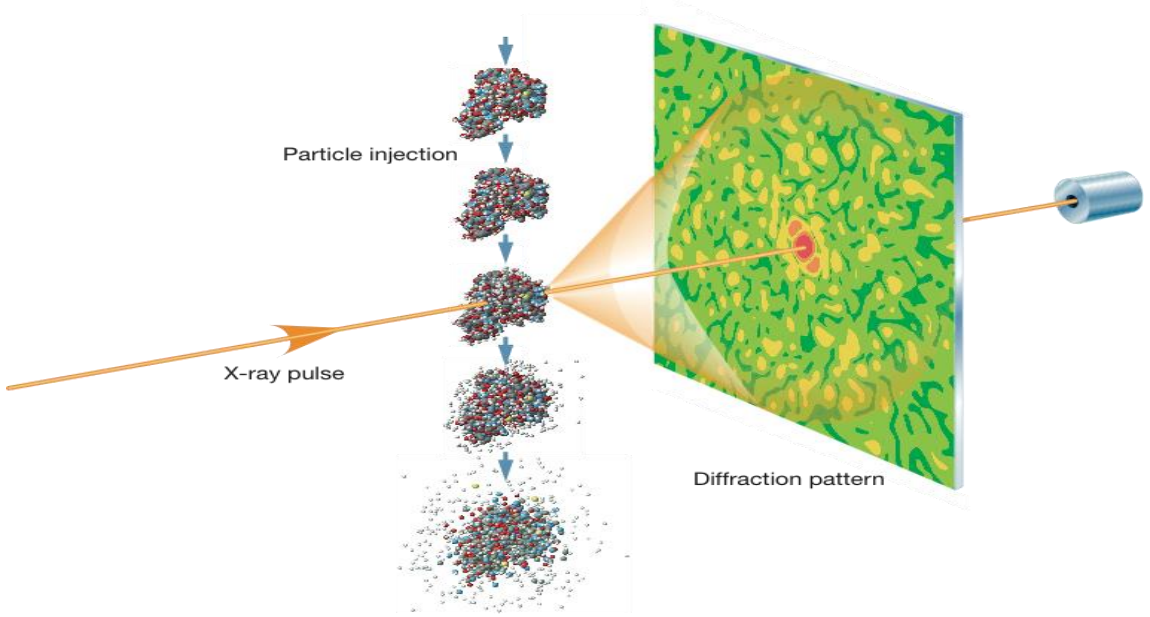
Also means: all diagnostics, detectors, etc., need to work accurately and be correlatable for every single pulse





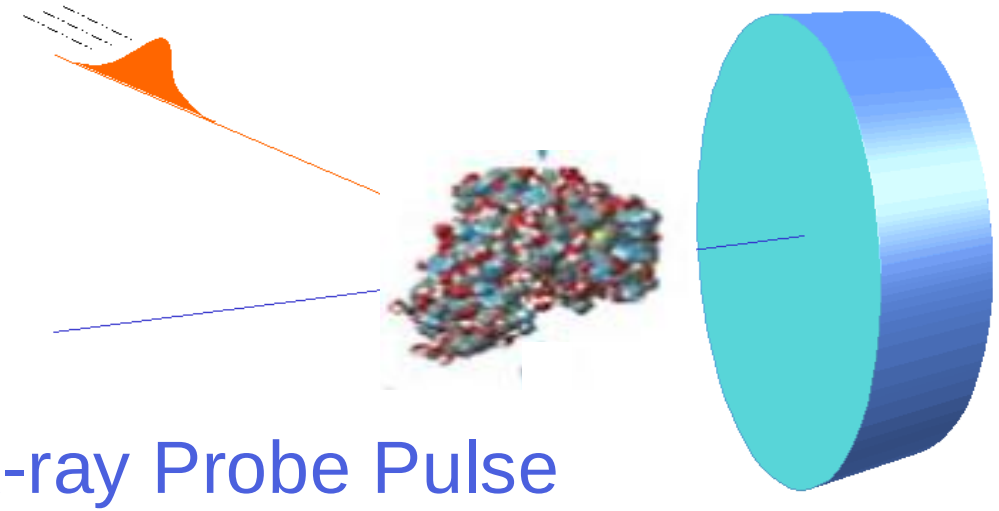
Courtesy Harald Sinn

The European XFEL – Science Case – Molecular Movies



Up to 3520 images/s
Up to ~ 15GB of data/s

Optical Laser Pump Pulse



X-ray Probe Pulse

10 times per second, with ps timing accuracy

Scientific instruments

SASE1

FXE (Femtosecond X-ray Experiments)

* Ultrafast dynamics of liquids and solid matter
* Combination of spec. & scat. techniques

SPB/SFX (Single Part., Bioimaging, & SFX)

- Coherent diffraction imaging from single part.
- Serial fs nano-crystallography

SASE2

MID (Materials Imaging & Dynamics)

- CDI from nano-structured samples
- XPCS of nanoscale dynamic

HED (High Energy Density science)

- Ultrafast dynamics of highly excited matter
- Combinations of scattering, diff. & spectroscopy

SASE3

SQS (Small Quantum Systems)

- Ultrafast dynamics of atoms, ions & clusters
- Combination of spec. & coh. scat. techniques

SCS (Spectroscopy & Coherent Scattering)

- Ultrafast dynamics of complex solids
- Combination of hr-inelastic spec. & coh.scattering

SXP (Soft X-ray Port)

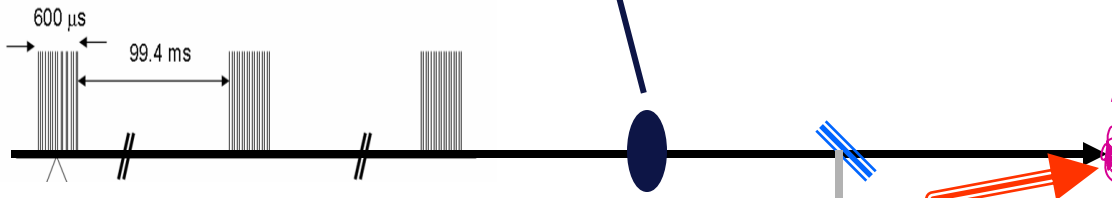
- Flexible port combining intense and tunable soft X-rays with versatile optical laser capabilities

The European XFEL – Complexity x 7 – Can change weekly!

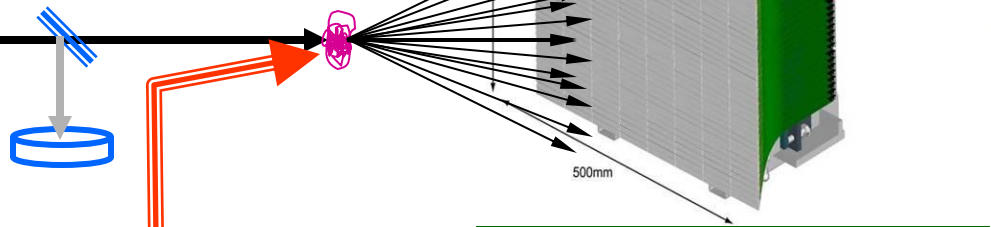
Controls

X-ray optics
Shape x-ray pulse
in space & spectrum

Sample delivery
Refresh & reposition
samples

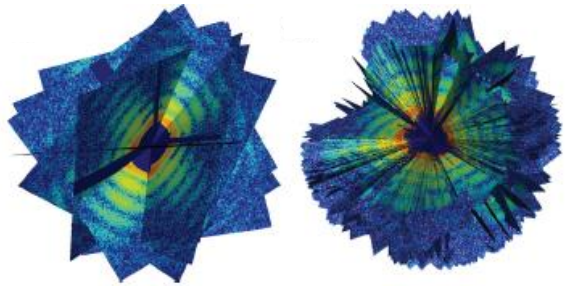


Photon diagnostics
Measure
x-ray pulse properties



Optical laser
Excite sample systems

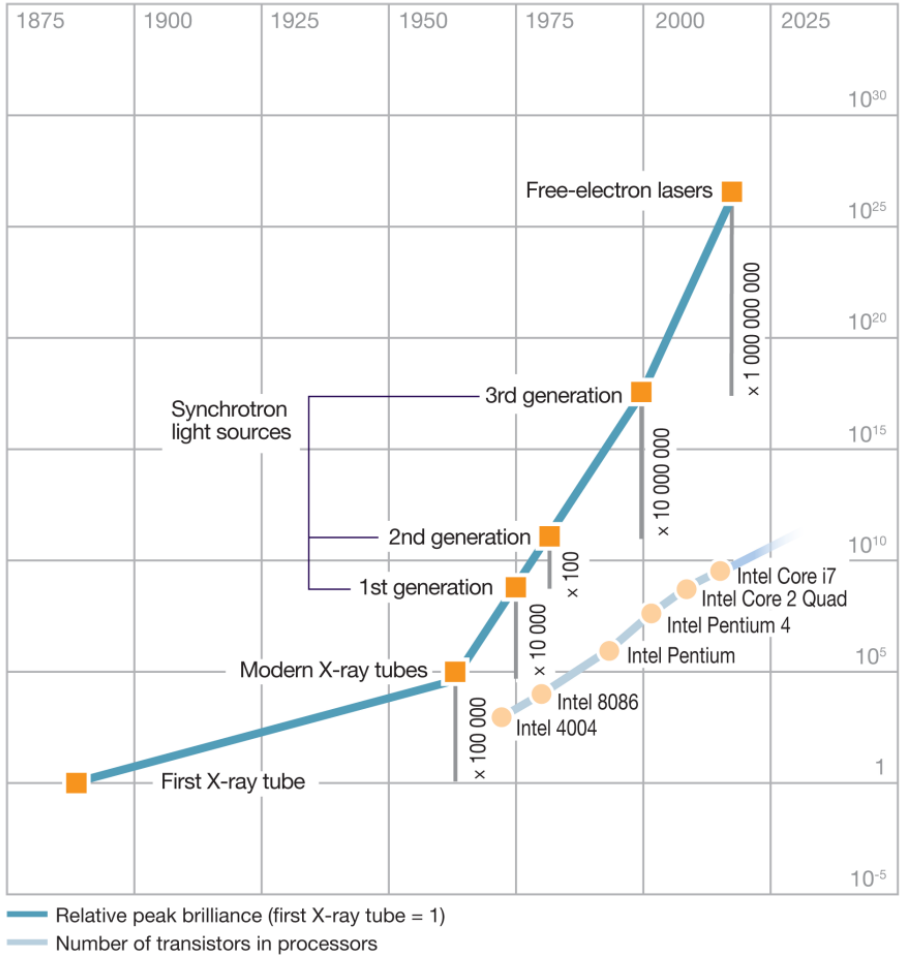
Detectors / DAQ
Take and store large number
of large data data sets



Data Analysis
Analyse immense amounts
of data

IT Infrastructure

The European XFEL - A Data Perspective



* The development of light source facilities has been faster than the increase in computer processing capacity (i.e., Moore's Law)

* We see this in the amount of data generated. For EuXFEL this can be multiple **PetaByte/week.** The Data Acquisition System is implemented in Karabo, as are the starting points of the online preview systems which support near-realtime processing of **>3kHz Mpixel images** .