

The photon system of the European XFEL : diagnostics and optics for an intense X-ray laser beam



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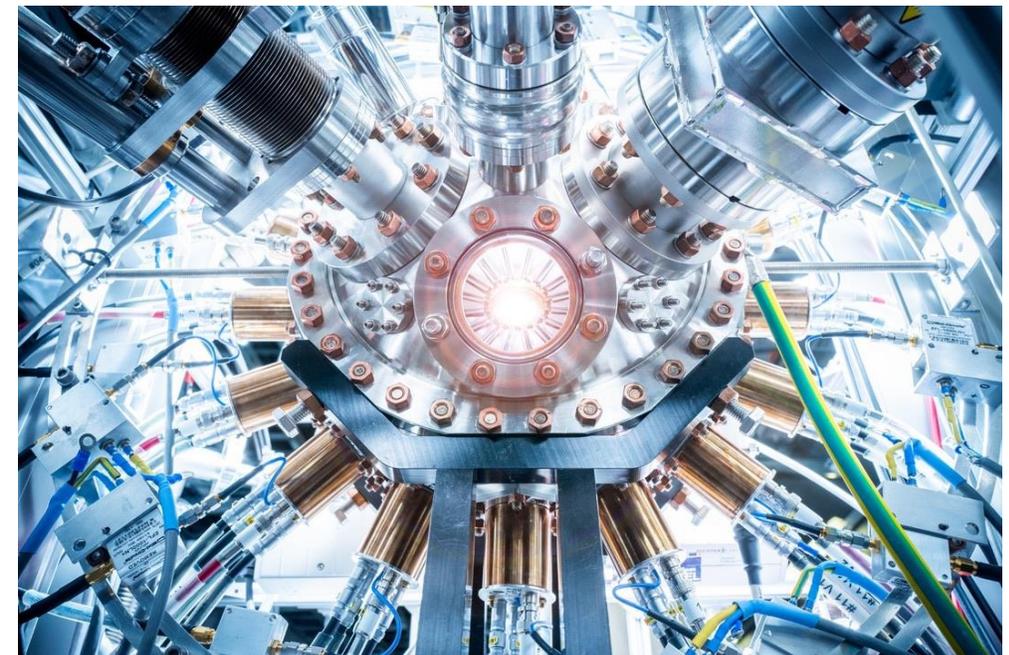
X-ray Photon Diagnostics

Staff Scientist and Group Leader

**Big Science
Business
Forum
2022**

Granada, Spain

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Enlightening Science

General layout of the European XFEL



European XFEL in Euros



■ Non-profit corporation 2009

Mission: design & construct & operate the free-electron laser facility

■ Construction budget from 11 partner countries (now + UK):

■ Germany 58%, Russia 27% , others 1–3%

■ 1220 Mio € (2005 prices) total construction budget

▶ 600 Mio € in cash, 600 Mio € in-kind contributions

▶ X-ray Photon Diagnostics : ~ 9 M€ during 8 years

■ In user operation since 2017

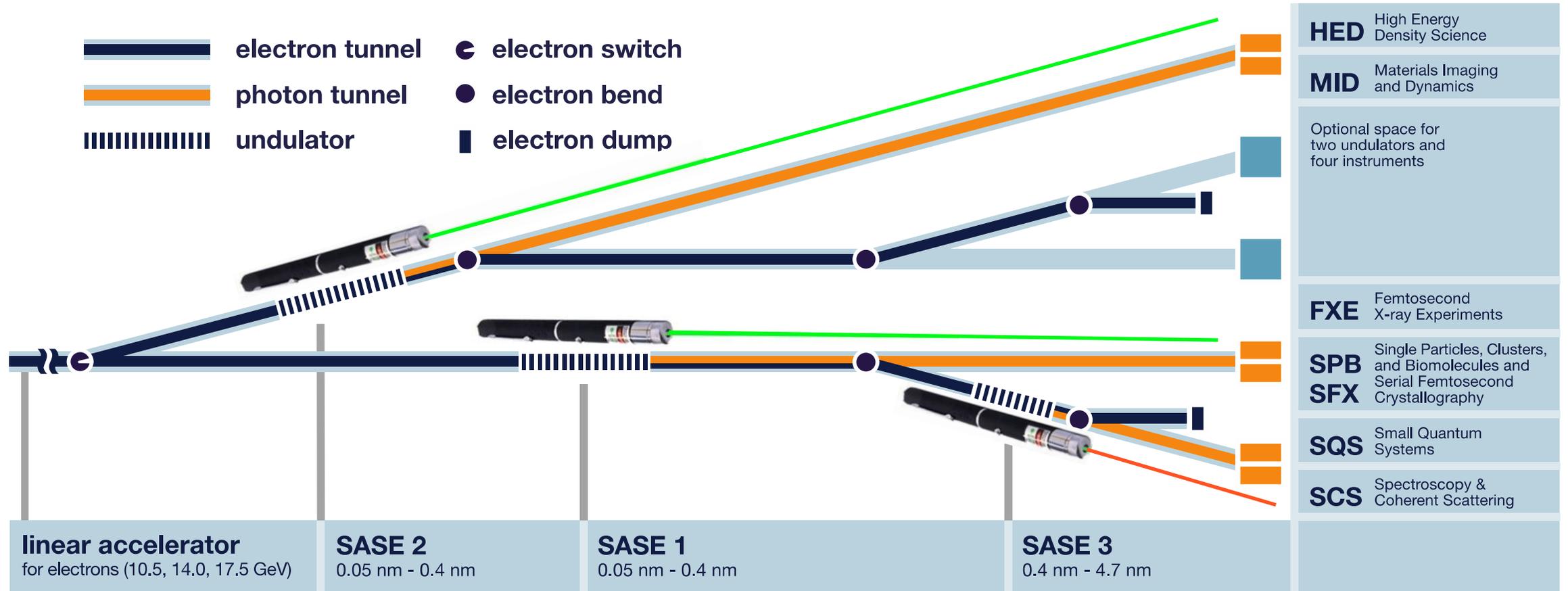
■ Yearly Operation Budget : ~ 120 M€



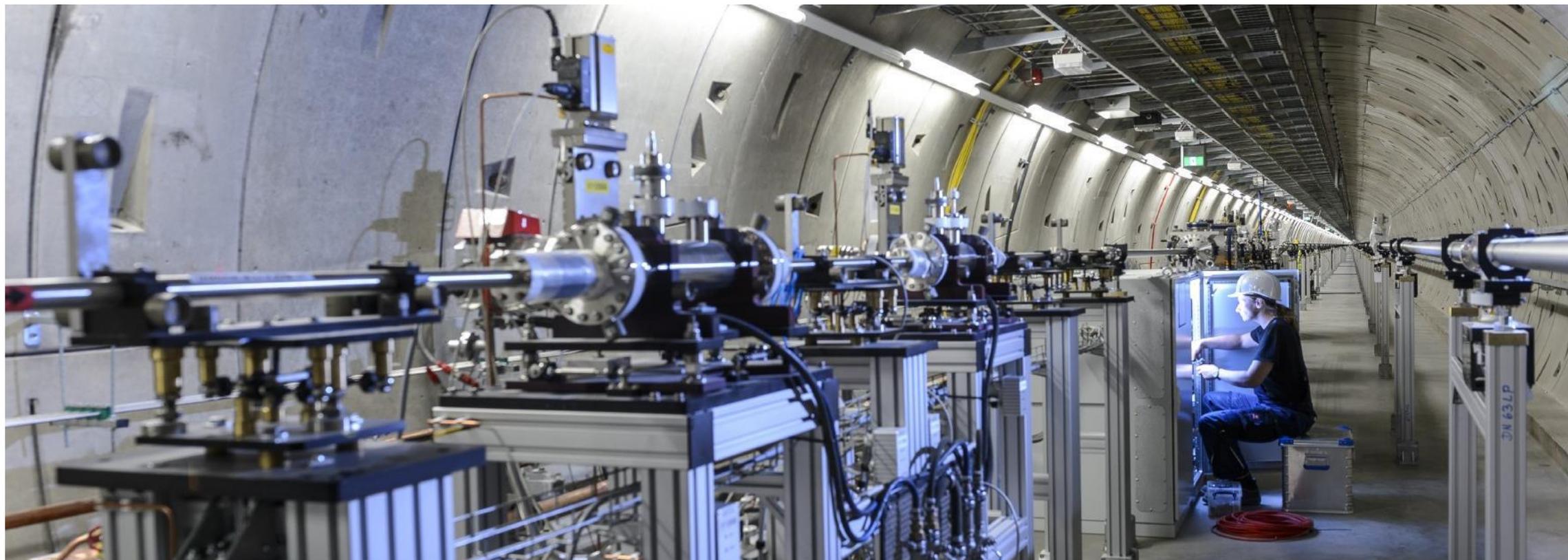
XFEL: The European X-Ray Free-Electron Laser Technical Design Report

ISBN: 978-3-935702-17-1
(2006)

Beamline layout and experiment stations



Photon beamlines

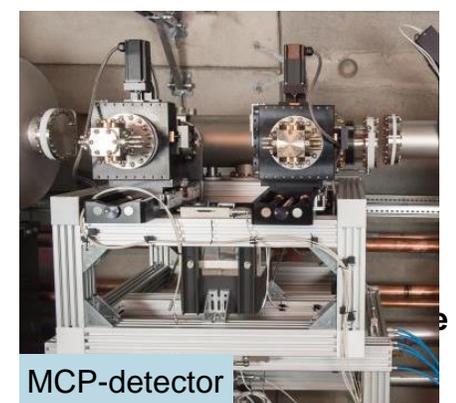
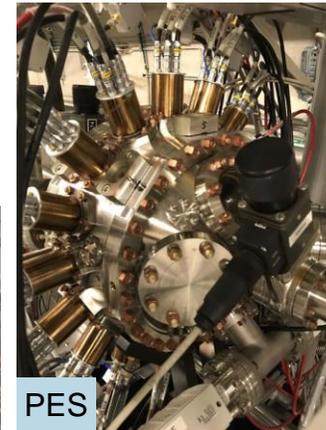


X-ray photon diagnostics at the European XFEL

- Diagnostics at EuXFEL is split into
 - Electron beam diagnostics
 - X-ray photon beam diagnostics

- **Photon Diagnostics components** are the hardware in the tunnels which measure the photon beam properties, whereas **instruments** are the scientific endstations, where users perform experiments

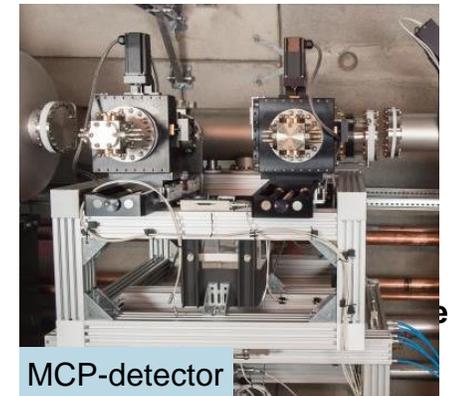
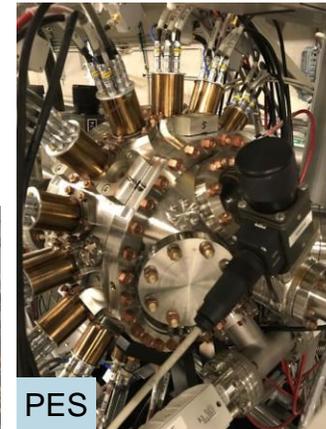
- Monitored **beam parameters** (e.g.):
 - pulse energy
 - wavelength / spectrum
 - polarization
 - arrival time
 - pulse duration
 - beam position / shape
 - wavefront



X-ray photon diagnostics at the European XFEL

- We often
 - design and assemble (particle-free) inhouse.
 - procure off-the-shelf and custom-made parts.

- Sometimes we tender complete systems based on detailed specification documents.



SASE1 photon diagnostics



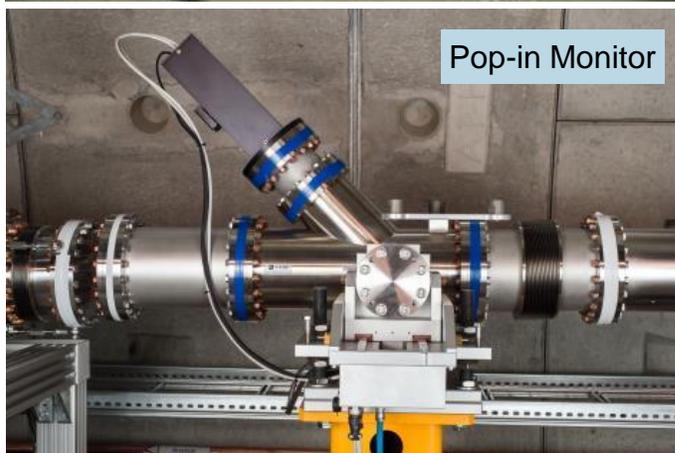
Filter Ch. & IMGTR



XGM



Gas supply



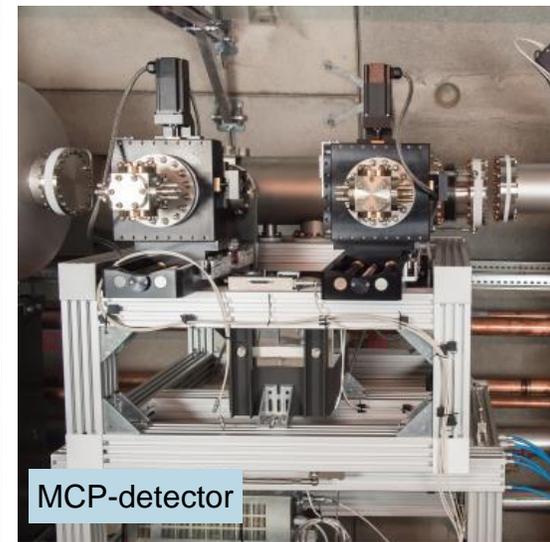
Pop-in Monitor



IMGSR



K-mono



MCP-detector

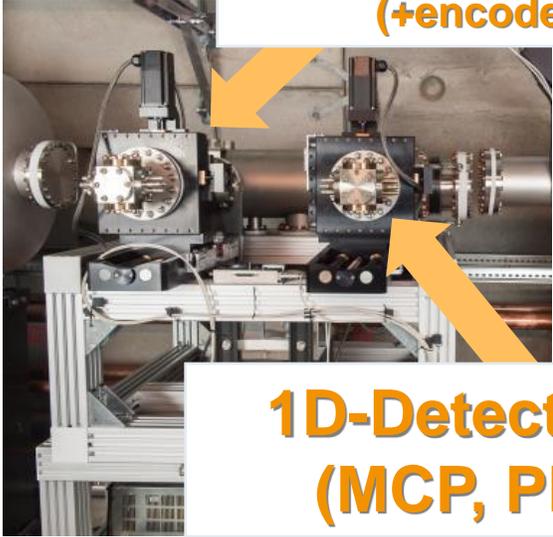
What we need in diagnostics:

Handling & supply of high purity gases



Ultra-high vacuum systems (particle-free)

Motion systems (+encoders)



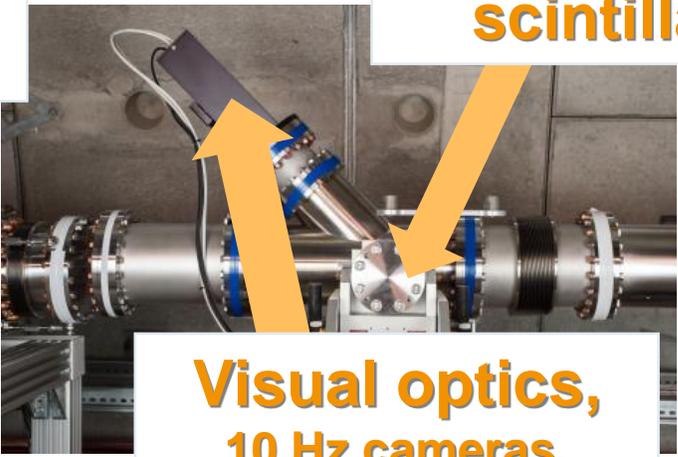
1D-Detectors (MCP, PD)



Absorption Filters



Crystals / scintillators



Visual optics, 10 Hz cameras, high-speed cameras

Power supplies (HV & LV)

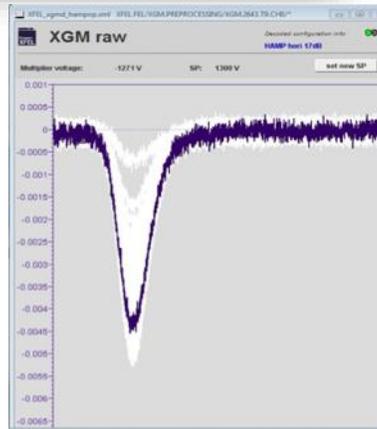
What we need in diagnostics:

Cables, cables, cables

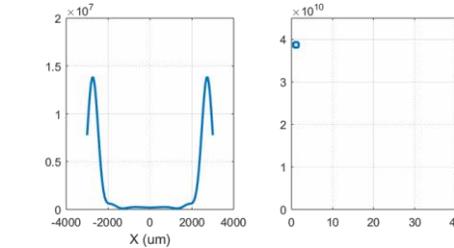
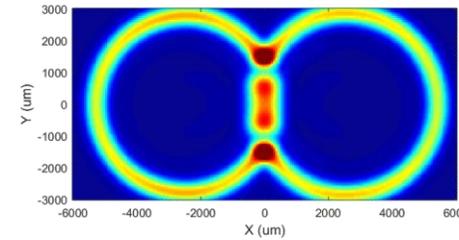
High voltage supplies

**Fast DAQ electronics
(GHz, GS/sec,
micro-TCA standard)**

**Analog electronics
(amplifiers...)**

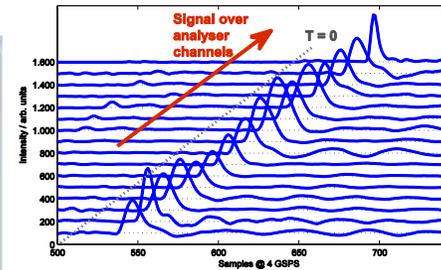


Simulation software



Diagnostics automation

Software for big-data analysis



optical fs-laser technology

Industry involvement

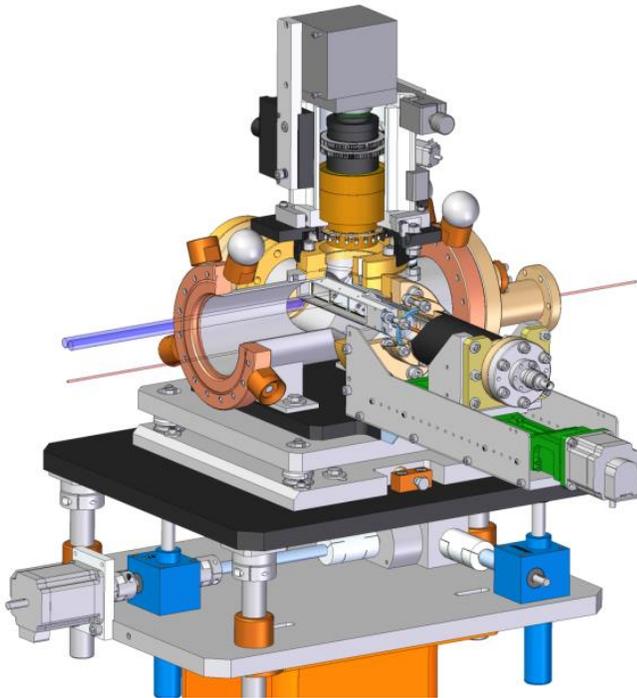
- Newcomer companies could first ...
 - ... look with us at previous projects before engaging in new tenders.
 - ... understand the very formalized tender process (German & European public tender laws).

- Type of contracts
 - Mostly open procurements or limited tenders
 - Build-to-spec, build-to-print, joint development,...

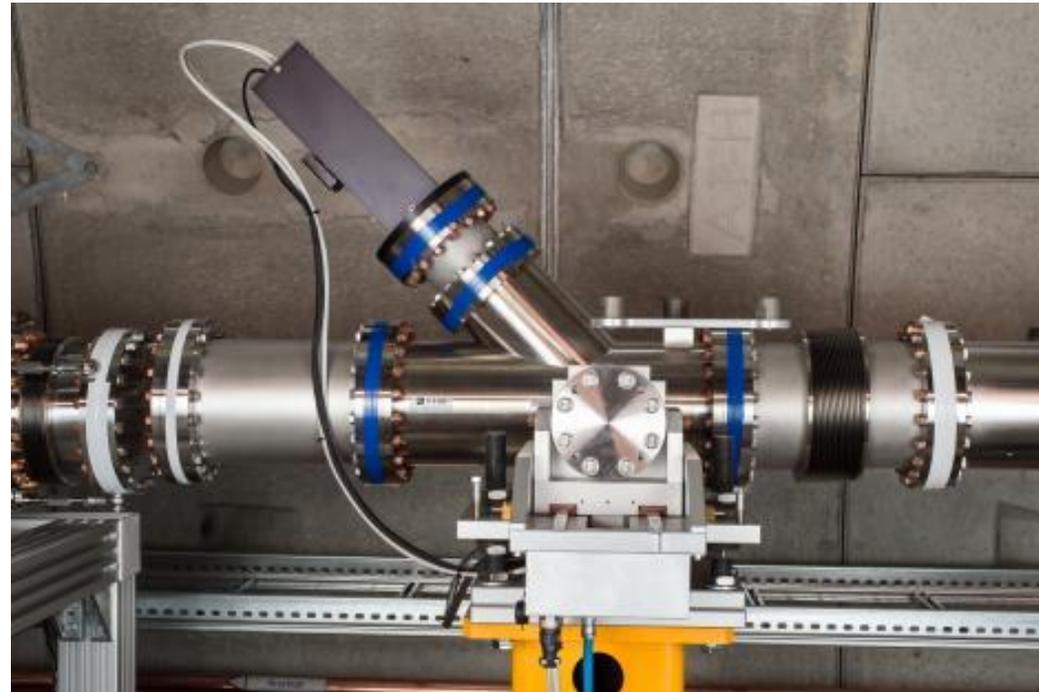
- Main construction phase was 2009 – 2016. Now procurements for
 - maintenance & spare parts & repairs
 - subcomponent upgrades
 - new projects (R&D for additional diagnostic capabilities)

- Projected annual volume of procurements (only photon diagnostics):
 - 500 – 700 k€
 - including 1 - 2 large tenders (200-300 k€)

Success stories of co-development with companies (examples)

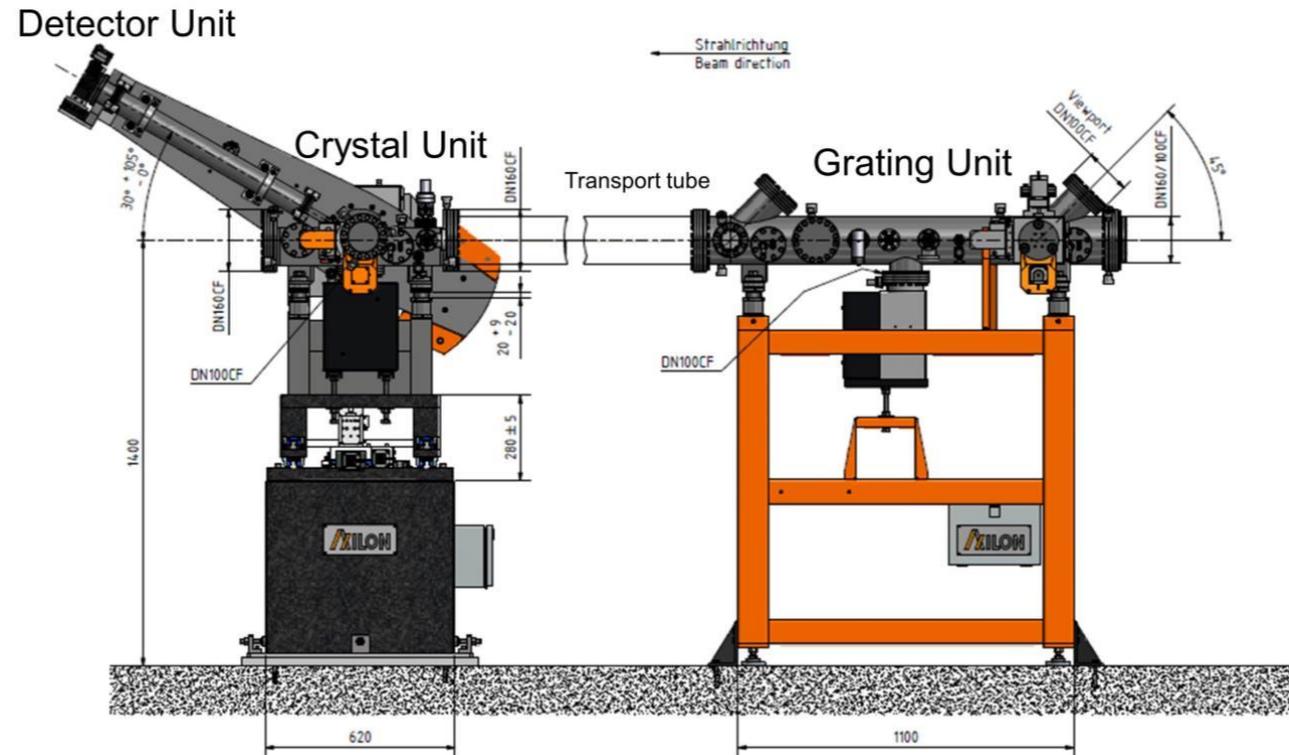


■ SR-Imager with FMB Berlin



■ Pop-in monitors with JJ-Xray, Denmark

Success stories of co-development with companies (examples)



■ HIREX (diagnostic spectrometer)
with AXILON, Cologne



Lessons learned from past experiences

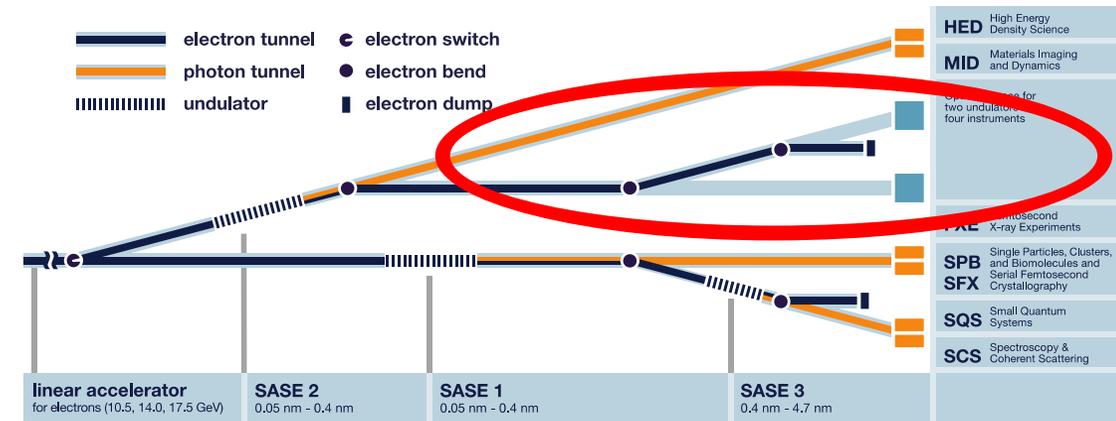
- Instrumentation for cutting-edge research pushes the limits of technical feasibility
 - custom-made, complex specs
 - must have
 - ▶ very close communication
 - ▶ designated project-managers on both sides

- Often only few suppliers exist with the specialized knowhow
 - New players are always very welcome ! (but must learn a lot)
 - Joint developments are common and mutually beneficial

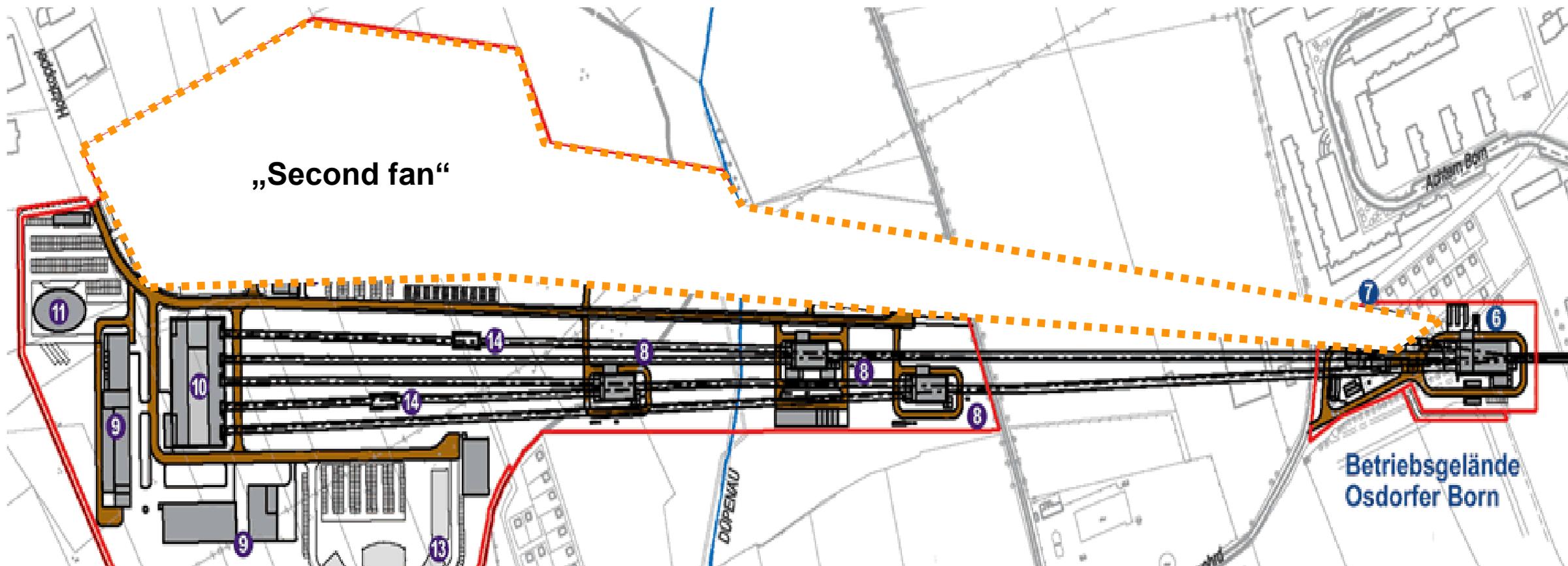


Upgrades / future constructions

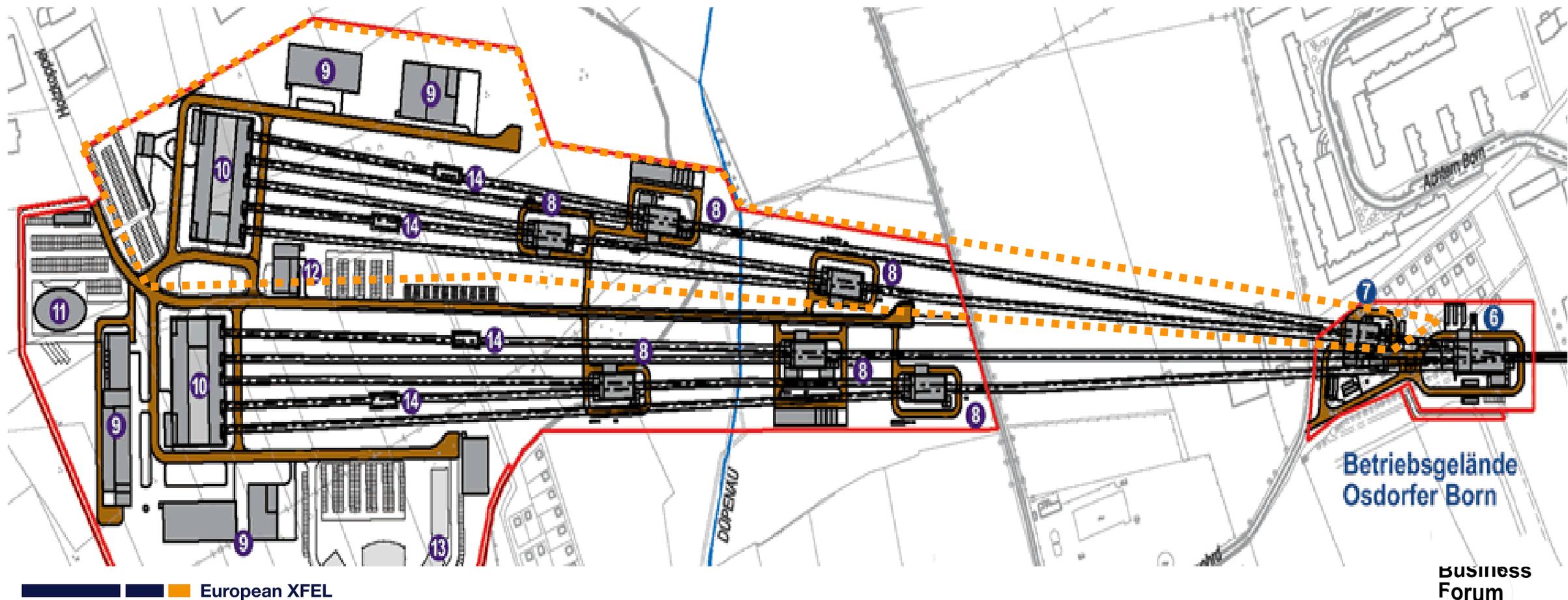
- **Smaller upgrades** during operation
 - Example: gated cameras for the imagers
- Mid-term (~ 2030):
 - fill the empty tunnels (SASE4+5)**
 - Investment ~2/3 of original photon systems budget (e.g. ~ 5 M€ for diagnostics)
- Long-term (beyond 2030):
 - European XFEL II**
 - „cw“ operation (continuous beam rate)
 - „Second fan“ of tunnels



Upgrades / future constructions



Upgrades / future constructions



Betriebsgelände
Osdorfer Born

More infos:
google-find us with “XPD diagnostics”

Thank you for your attention

