European XFEL facility developments

Thomas Tschentscher

Workshop *Future detectors for the European XFEL*
Hamburg, 18-19 September 2023

thomas.tschentscher@xfel.eu

Content

- European XFEL Strategy 2030
- Mid-term development of the facility
- Long-term: Upgrade European XFEL
- Needs for detectors
- Summary

European XFEL Strategy 2030

- European XFEL started operation in 2017, and reached full scope early 2022.
- 2022 first year of full operation scope (full yr operation, 6 science instruments, ~100 user experiments)

➔ **Time to develop and implement a strategy how to further develop European XFEL**

- Vision for European XFEL strategy
  - **Keep a lead in the area of high energy and high repetition rate FEL facilities**
  - **Develop new scientific opportunities by using attosecond time resolution and very high photon energy FEL pulses**
  - **Become a leader in data science for FEL-type installations**
- Strategic decisions
  - **Focus for this decade on harvesting science using the investments made and efforts spent**
  - **Develop new capabilities to keep a lead in FEL science**
  - **Develop the technology and the know-how needed to prepare a facility upgrade in the 2030s**

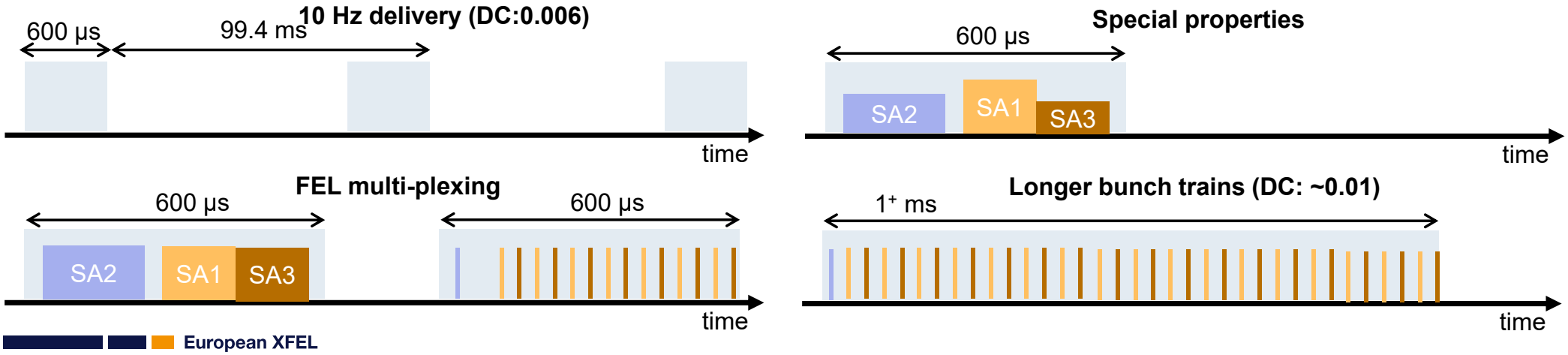
Strategy 2030 – Timeline with different strategic phases

Facility parameters in the medium-term (until ~2030)

- Accelerator
- FEL sources
- Science instruments

Facility parameters in the medium-term (until ~2030)

- Accelerator
  - **High repetition rate delivery will occur using pulsed RF.**
  - **More tailoring of the bunch patterns to match exp. needs**
  - **Some potential to deliver longer bunch trains: O (1 – 2 ms) → provide more bunches at reduced rep.rate**
- FEL sources
- Science instruments



Facility parameters in the medium-term (until ~2030)

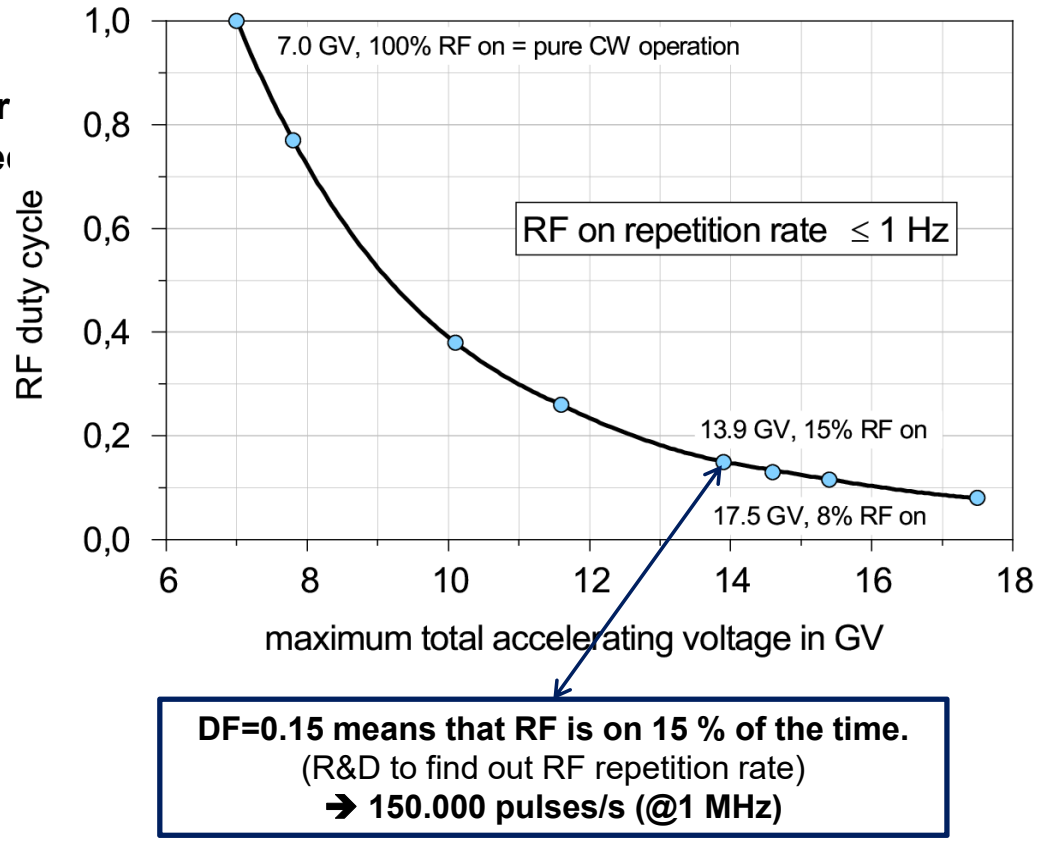
- Accelerator
- FEL sources
  - **Attosecond sources – tweak electron bunch to provide ultrashort (0.2 – few fs) x-ray pulses**
    - ► New science applications in soft and hard x-ray regime
    - ► New delivery and diagnostics schemes
    - ► Complexity expected on timing side; so far no particular requirements for area detectors issued
  - **Very high photon energy sources**
    - ► New material science applications
    - ► Using high-harmonic schemes photon energies O(30 keV) may be accessible
  - **Special modes: self-seeding, 2-pulses, variable polarization**
  - **No. of FEL sources: 3** (constant)
  - **XFELO**(@SA1)**: at proof-of-principle stage**
- Science instruments

Facility parameters in the medium-term (until ~2030)

- Accelerator
- FEL sources
- Science instruments
  - **No. of instruments: increase from 7 to 8**
  - **new *High photon energy X-ray Scattering* (HXS) at SA2 to switch on 2026/7; scientific instrument: 2028+**
    - ► One focus: use and development of high photon energy FEL radiation experiments
  - **Refurbishment of existing instruments**
    - ► Multi-channel detection (e.g. diffraction & spectroscopy)
    - ► Dynamics imaging
    - ► X-ray photon correlation spectroscopy
    - ► High resolution inelastic x-ray scattering
    - ► Attosecond science
    - ► S(Q)-scattering
    - ► THz pumping

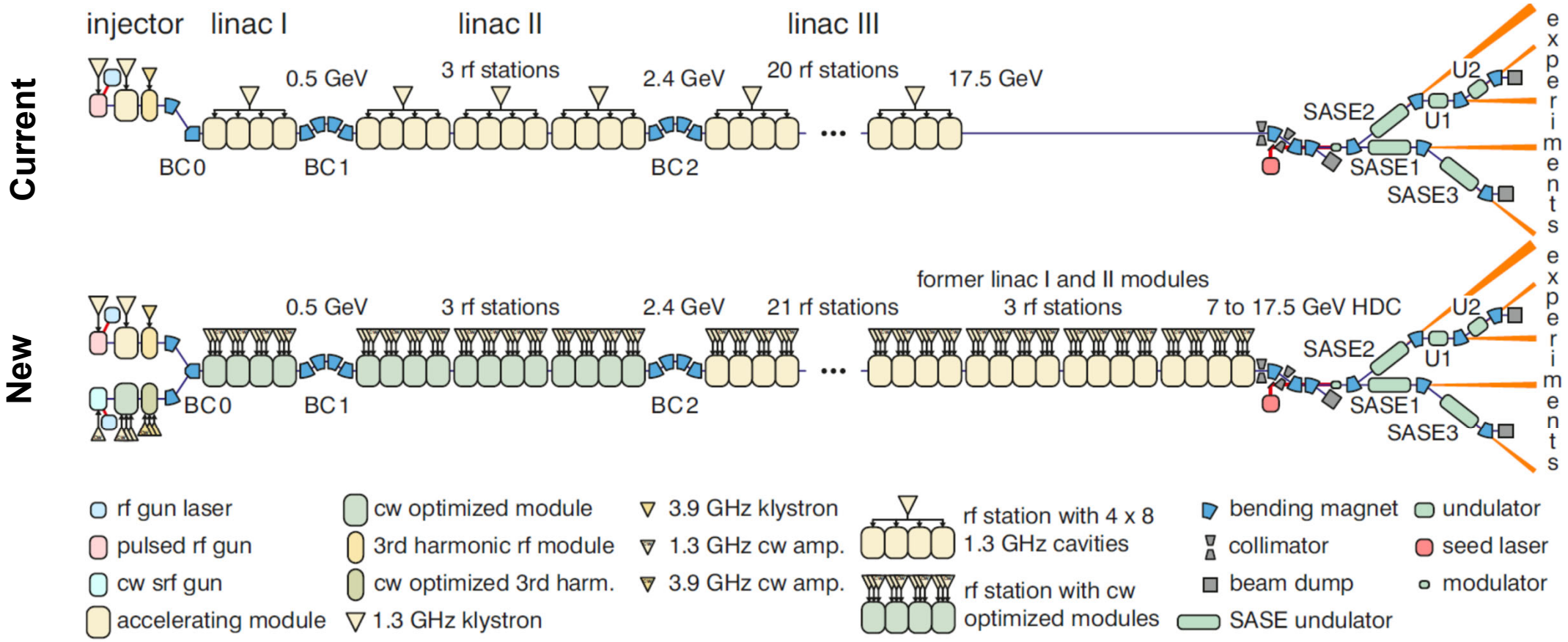
Long-term (beyond 2030)

- Accelerator
  - **Continue burst-mode vs. switching to cw-type deliver**
  - **New idea: High duty cycle operation using refurbishe accelerator**



(unpublished, results under review; Courtesy**: DESY**)

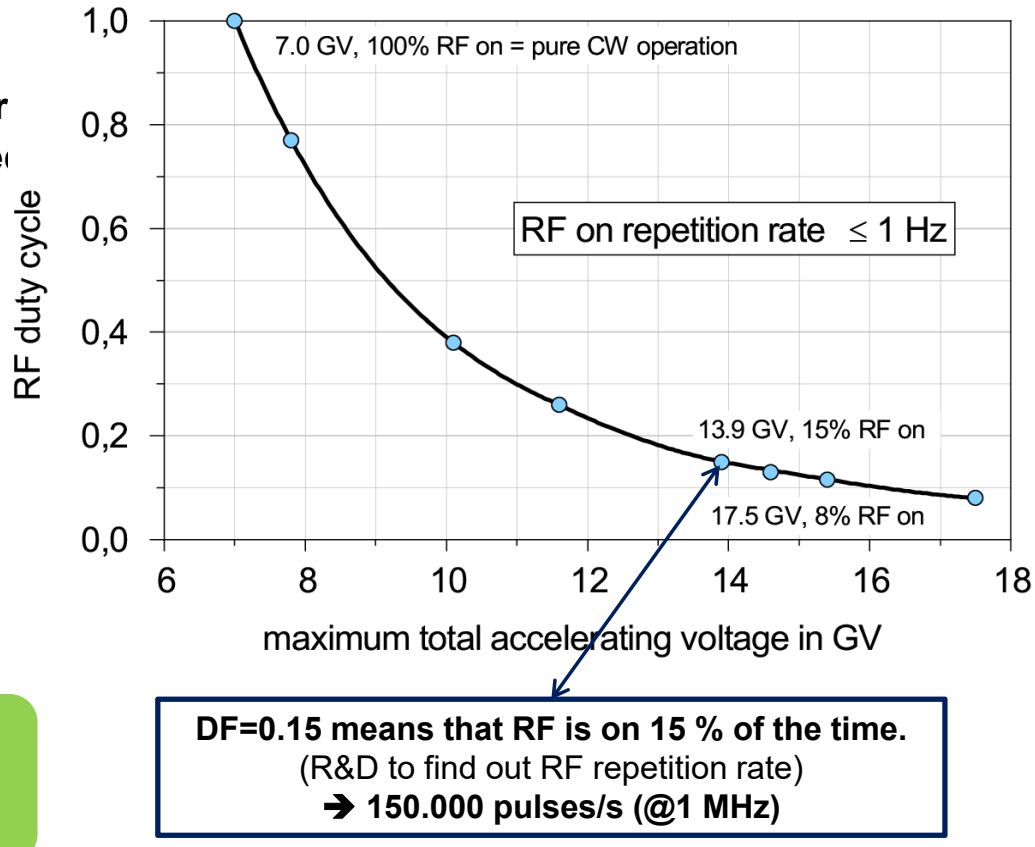
Major modification of the accelerator



Courtesy: **E. Vogel (DESY)**

Long-term (beyond 2030)

- Accelerator
  - **Continue burst-mode vs. switching to cw-type deliver**
  - **New idea: High duty cycle operation using refurbishe accelerator**
- FEL sources
  - **Complete existing fan (SA4, SA5)**
  - **Build new fan**
  - **Refurbish existing FELs**
- Science instruments
  - **Add. instruments for SA4, SA5**
  - **New experiment hall w. new instruments**
  - **Refurbishment of existing science instruments**
- How to prepare in present strategy (- 2029) ?
  - **R&D on technology**
  - **CDR and TDR to prepare for a decision vs. 2028/29**



(unpublished, results under review; Courtesy: **DESY**)

Summary

- *European XFEL 2030 Strategy* focuses on harvesting as much science as possible from facility in its present realization.
- The beam parameters will stay similar to the present ones, with chance to prolong the bunch trains and to provide even more flexibility for the properties of individual electron bunches, resp. X-ray properties
- In parallel, new capabilities shall be developed and the preparations for future upgrades be performed.
- A proposal for a facility upgrade is envisaged for 2028.
  - **Extended Burst-mode operation**
  - **High duty cycle operation**
  - **Cw-type delivery**
  - **With corresponding proposals for FEL sources and science instruments**