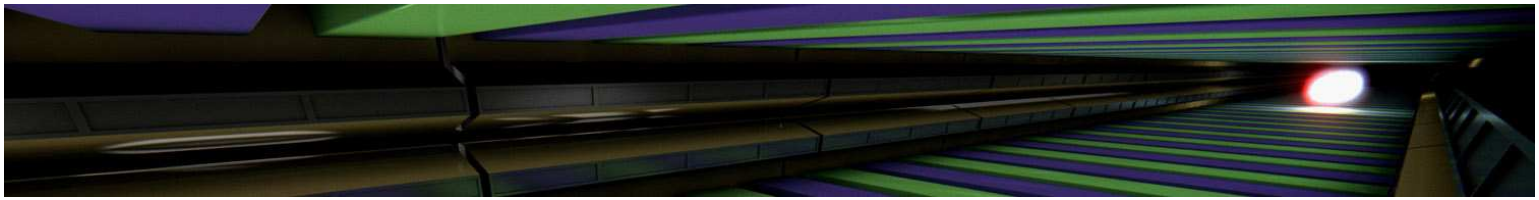


Operation modes

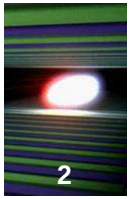
European XFEL Users' Meeting

January 29, 2014

Thomas Tschentscher for European XFEL

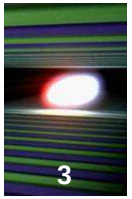
thomas.tschentscher@xfel.eu

Scope of this talk



- Overview
- From commissioning to full operation
- User program

European XFEL as User Facility



Scientific excellence

- Outstanding scientific research
- Framework for excellent science
- Peer-review access scheme

State-of-the-art instrumentation

- Cryogenic high repetition rate accelerator
- FEL modes and x-ray operation
- Scientific instrumentation
- Sample preparation facilities

Widen access possibilities

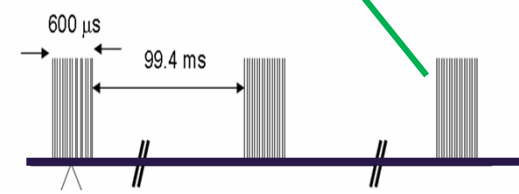
- Large number of experiment slots
- Efficient conduct of experiments
- Support of user groups

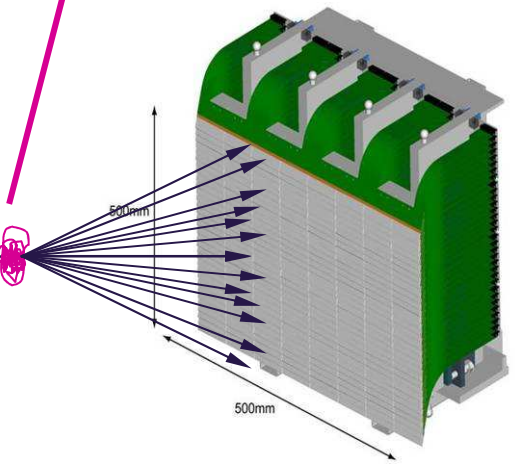
An experiment at European XFEL

Electron accelerator
Deliver highly defined pulses at user-defined pattern

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

Sample delivery
Refresh & reposition samples



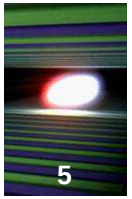


Photon diagnostics
Measure x-ray pulse properties

Optical laser
Excite sample systems

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

Overview of e$^-$-beam & FEL operation modes



Electron energy

- 8.5, 12, 14, 17.5 GeV
- ±1.5 % fast scanning

Bunch charge/compression → pulse duration

- 20 – 1000 pC → 2 - 100 fs

X-ray delivery pattern

- From pulse-on-demand to 4.5 MHz

Special

- Seeding
- Variable polarization
- and more …

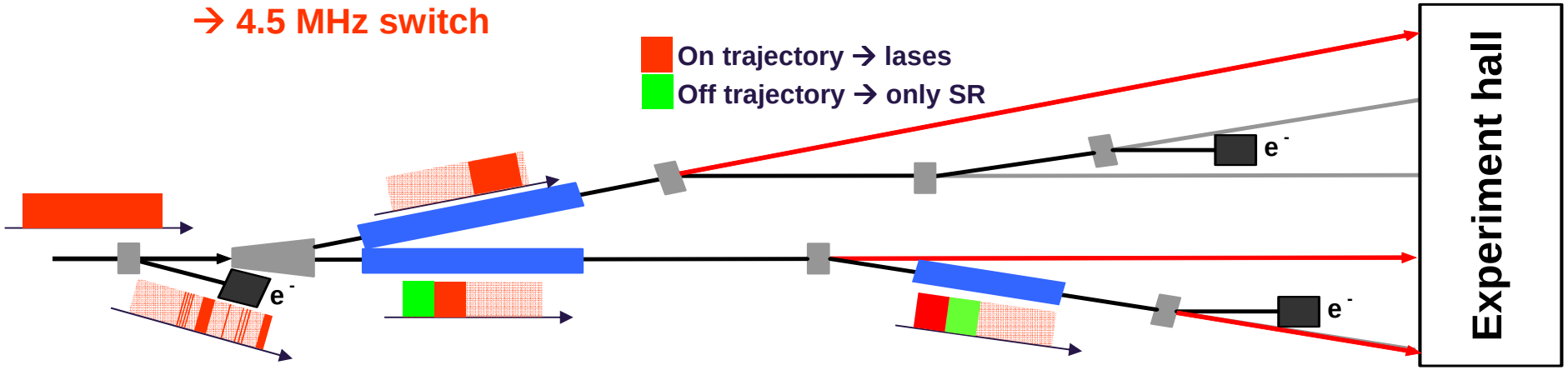
In addition: each instrument can determine x-ray settings

- Focus size
- Bandwidth
- Exact photon energy

Quasi-simultaneous operation of SASEs

Dedicate & distribute electron bunches to instruments

- Operate accelerator as continous as possible
  → **stability / performance**
- Distribute electron bunch train on two lines
  → **10 Hz switch (few µs duration)**
- Switch on/off lasing for SASE 1/ SASE 3 line (optional)
  → **4.5 MHz switches**
- Determine exact bunch pattern
  → **4.5 MHz switch**

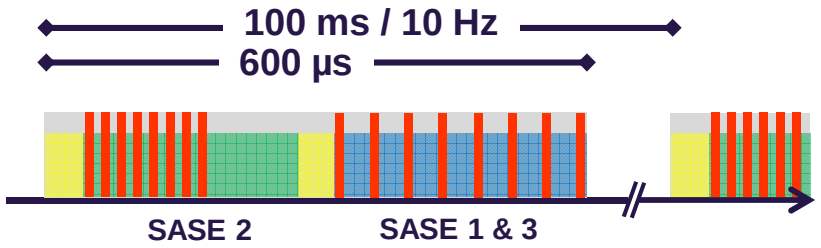


Electron bunch distribution : **27.000 bunches/sec to 3 (5) beamlines; in average 10-20 Hz and ~800 (500) pulses/train; using kicking methods to make bunches lase only in dedicated undulator**

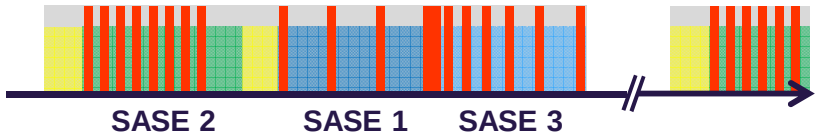
Electron bunch distribution

e-beam distribution to 2 beamlines

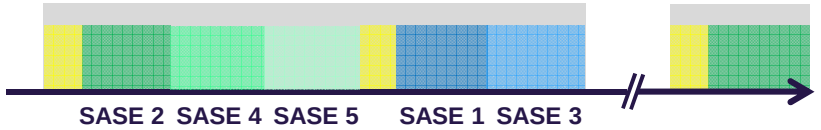
- Slots for feedback & switching
- Equal splitting on both e^--BL



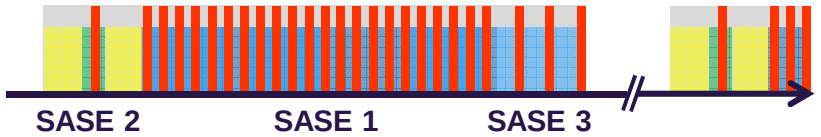
- Equal splitting on 3 undulators



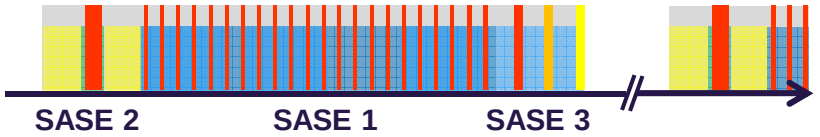
- Equal splitting on 5 und. (future)



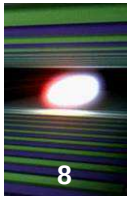
- Asymmetric splitting



- Specific electron bunch properties

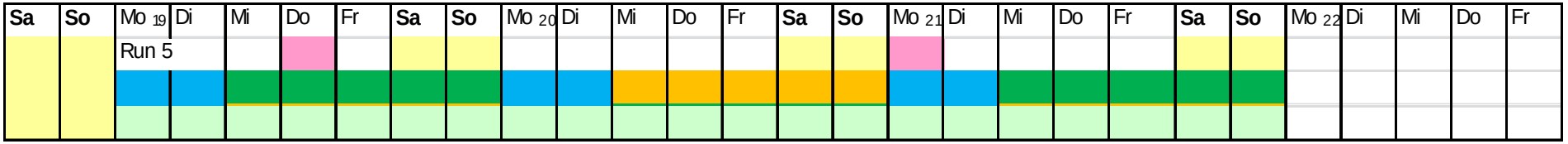


Operating two instruments per SASE beamline



Concept

- Typical experiment slot 5 days; start/end on machine day
- Share day with two 12 hrs shifts
- Setup /changes on machine days
- Major modifications during shutdown weeks



Example of 4 week slot at any instrument

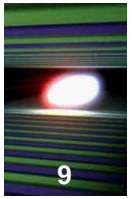
Day shift (12 hrs; e.g. 10-22 hrs)

Night shift (12 hrs; e.g. 22-10 hrs)

→ **Optimized instrumentation**

- dedicated setups & permanent installation where possible
- possibility to swap entire setups (chambers or interior) (only where applies)

A year at European XFEL



Annual operation

- **4800 hrs** accelerator operation for generation of x-rays
  - ➔ **Peer-reviewed proposals [4000 hrs]**
    - Review committees
    - UC prioritized time allocation
  - ➔ **Internal activities [800 hrs]**
    - Maintenance
    - R&D program & management contingency
- **~5600 hrs** total accelerator operation
  - ➔ **Dedicated machine time**
    - Maintenance (w. beam, short access) & tuning
    - R&D

Steady-state operation !

User experiments

- **12000 hrs** user time by operation of three instruments in parallel
- **~200 user experiments** / year

Some challenges

Accelerator operation

- First FEL facility to operate several FELs/instruments quasi-simultaneously. Initially 3, later 5 or even 10-15 instruments
- At the same time FEL electron beam delivery to undulator is much more individual than e.g. for a storage ring

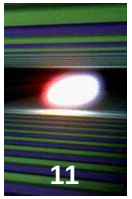
Maintain x-ray performance

- Size of facility leads to unprecedented long x-ray beam paths
- Coherence & wavefront preservation
- Effects of bunch train operation

User program

- Conduct complex experiments in relatively short user slots
- Fast switching between experiments (preparation, setup time)
- User support before, during & after experiments

Scope of this talk



- Overview
- From commissioning to full operation
- User program

From commissioning to operation

Commissioning aims

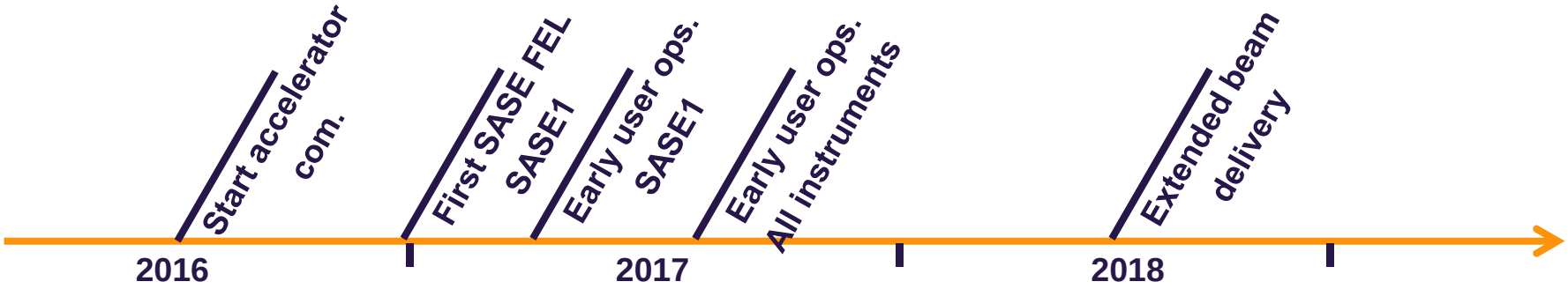
- Commissioning of electron beam to generate **hard x-ray SASE FEL radiation as soon as possible**
- Commissioning of x-ray instrumentation to launch **early user program**
- Continue development of e^--beam and instruments for ~1 ½ yrs to reach **extended electron and x-ray beam delivery**

Early user operation

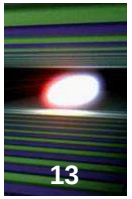
- Starts 14 weeks after first SASE and includes all instruments after 7.5 months

Full user program

- Provide full number of user hours when reaching the milestone of extended electron and x-ray beam delivery



Ramp-up of experiments



SPB & FXE (SASE1)

- First beam end 2016
- Early user operation from May 2017

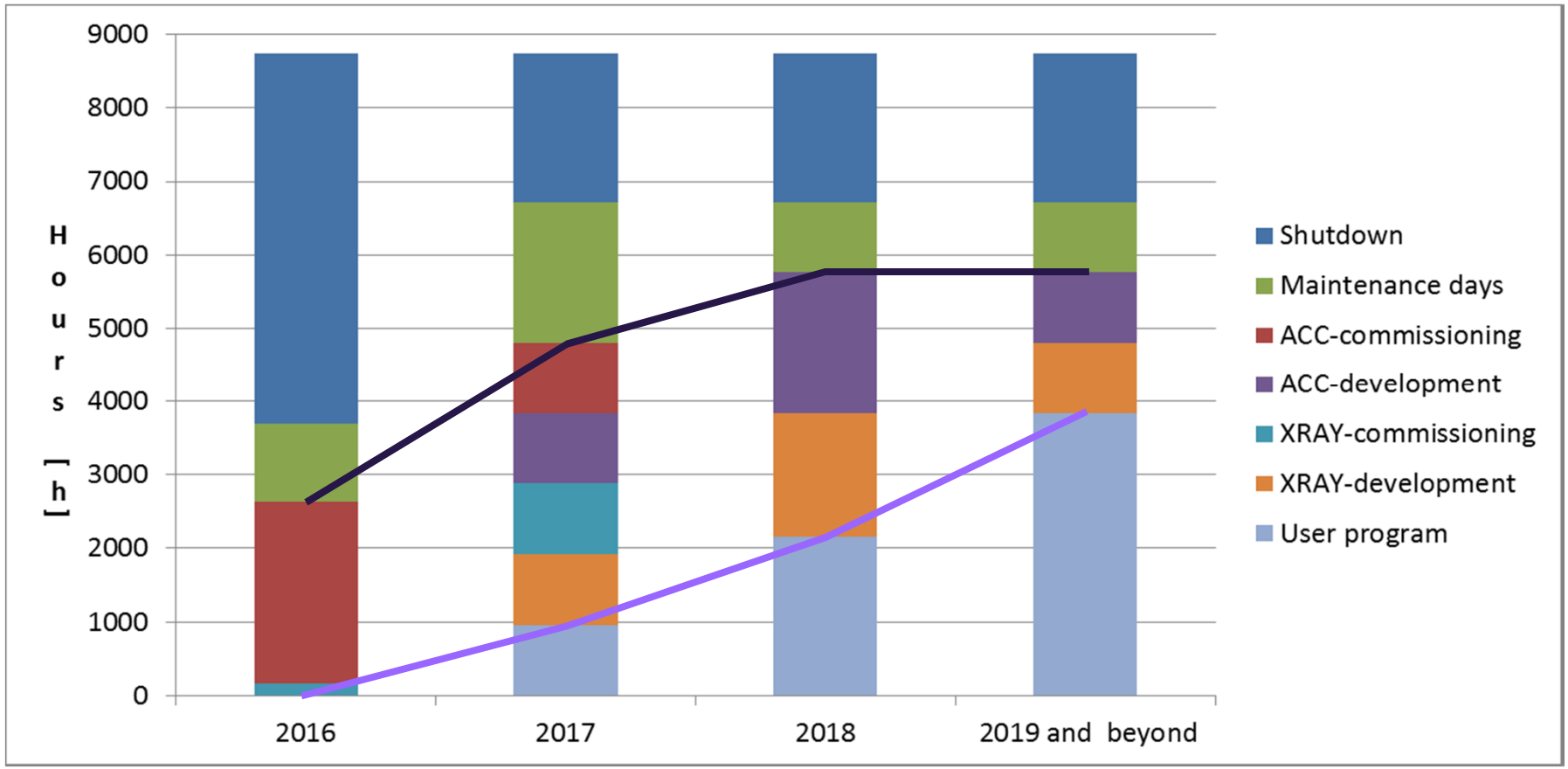
SQS & SCS (SASE3)

- First beam Feb 2017
- Early user operation from June 2017

MID & HED (SASE2)

- First beam Apr 2017
- Early user operation from August 2017

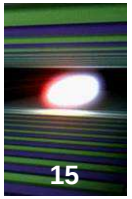
Ramp-up operation



If main accelerator commissioning starts summer 2016:

hrs	2016	2017	2018	>2018
Accelerator A	2500	4700	5600	5600
X-ray delivery T_x	<500	2800	3900	4800
Users ΣU_{NNN}	0	2 x 1000	3 x 2100	3 x 4000

Scope of this talk



- Overview
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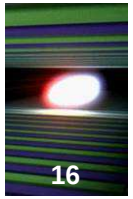
European XFEL as a user facility



User program

- Access to beamtime based on scientific peer-review
- Invitation for experiments following successful review
- User groups are on-site for few (1-8) days only. Successful conduct of the proposed experiments requires:
  - ➔ **Preparation**
  - ➔ **Performance (of accelerator and x-ray systems)**
  - ➔ **Support**
- For each group peak performance is what counts
  - ➔ **High availability of all sub-systems**

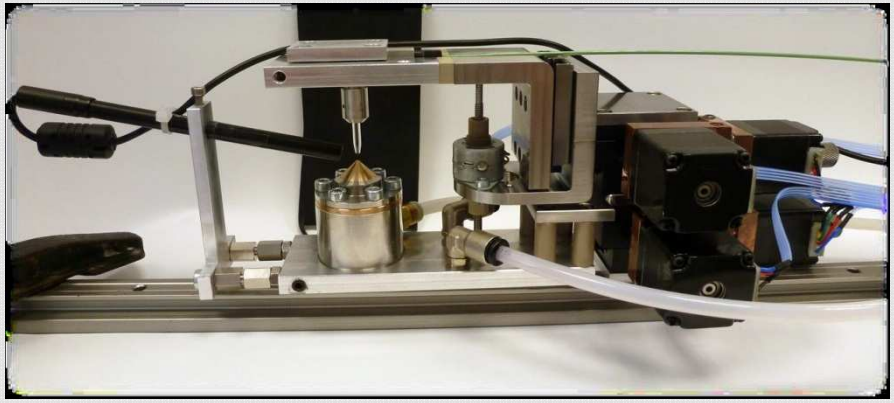
How to enable this

- Provide the infrastructures
- Provide the staff
- Provide the data management & scientific computing tools

Infrastructures for users

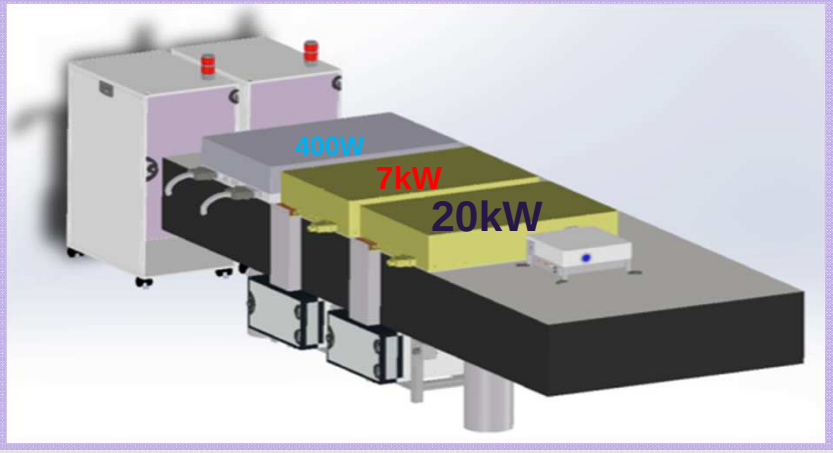
Sample injection/insertion

- Liquid jets and sample changer



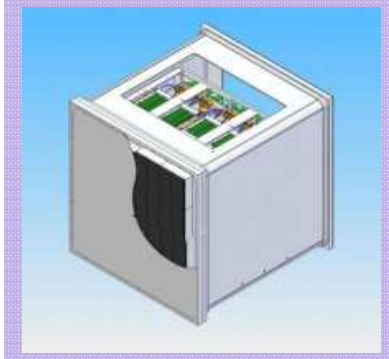
Optical lasers

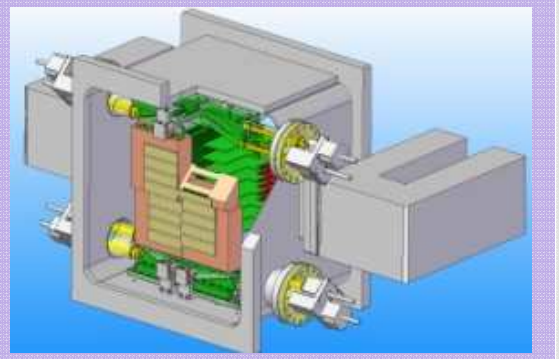
- MHz/mJ/fs laser pulses



Detectors

- MHz frame rate area detectors





Sample preparation

- 2x23m² chemistry wet labs
- 30m² x-ray lab for crystallography, SAXS, and reflectometry
- 30m² vacuum labs
- 44m² dry sample preparation
- 2x22m² Electron microscopy and nano-fabrication lab

User support at the instruments

Enable successful experiments

- Before : Preparation; setup
- During : Monitor instr. performance & change setup; optimize strategies
- After : Checkout (initial & final data analysis, publication)

Scientific instrument groups [MID, HED, FXE, SPB, SQS, SCS]

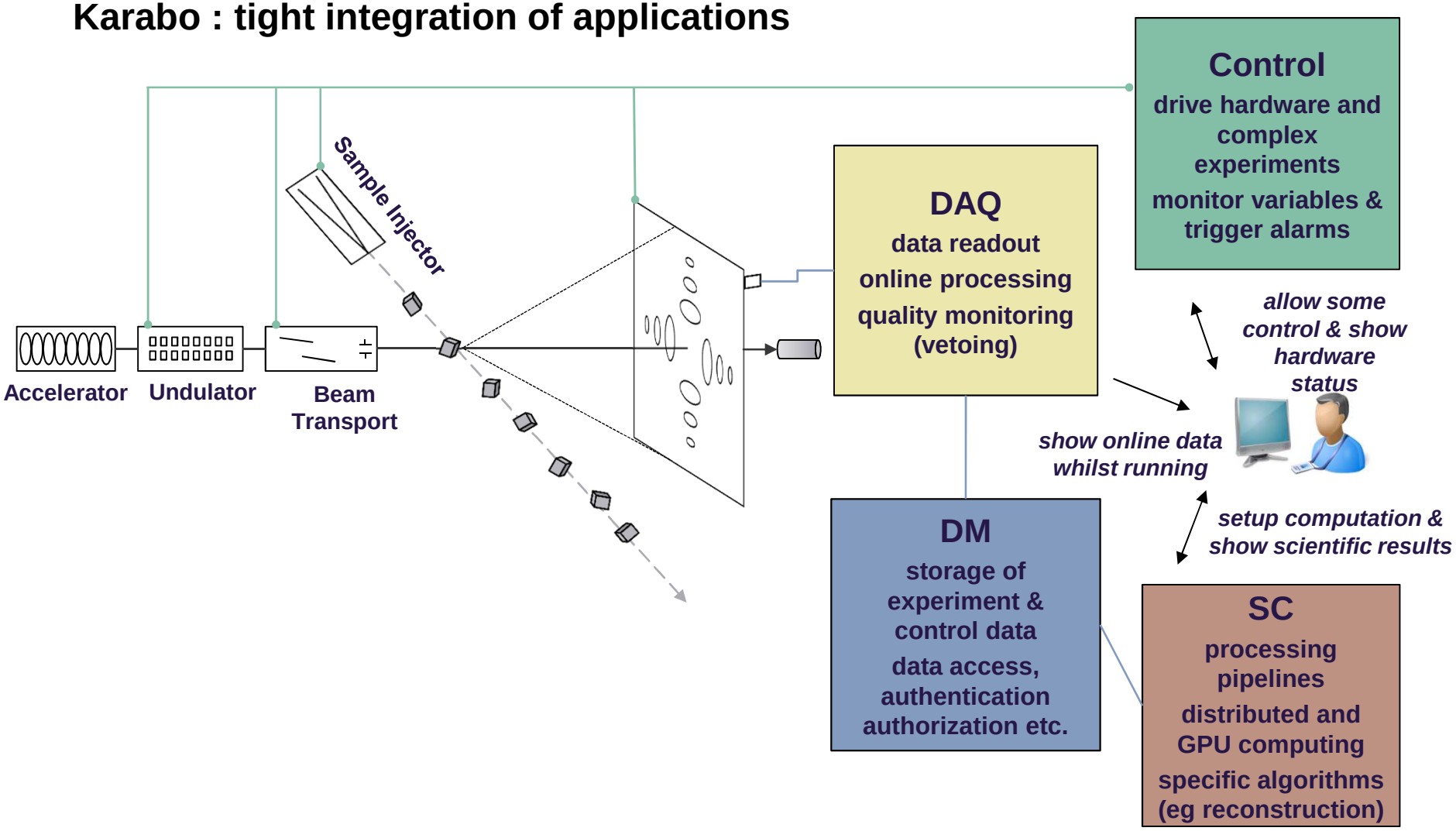
- Responsible for user program/instrument operation
- 3 teams of 4 scientists (always one team associated with an user group)
- Correspondent for Before/During/After periods
- Contact to experts (instrument support & development (ISD) groups)

Continuous presence of team member(s) during user experiments

- Enable highly efficient usage of beam time
- Involve ISD group members where required
- Plus: on-call service for ISD groups & hall operation group

IT/DM & software to support users

Karabo : tight integration of applications



Conclusion

Operation model of European XFEL is being established

- Ramp-up period of accelerator and x-ray delivery
- Increase operation for users over 3 yrs to final 4.000 hrs per annum
- Aim at operation of 3 science instruments in parallel → 12.000 user hrs

Facility operation

- Define accelerator operation modes
- Operation of accelerator & x-ray systems from different locations while maintaining a high level of collaboration and coordination
- Operation of scientific instruments for users over several weeks and at high level of support
- Learn from initial operation, evaluate and adjust where necessary

Thank you for your attention