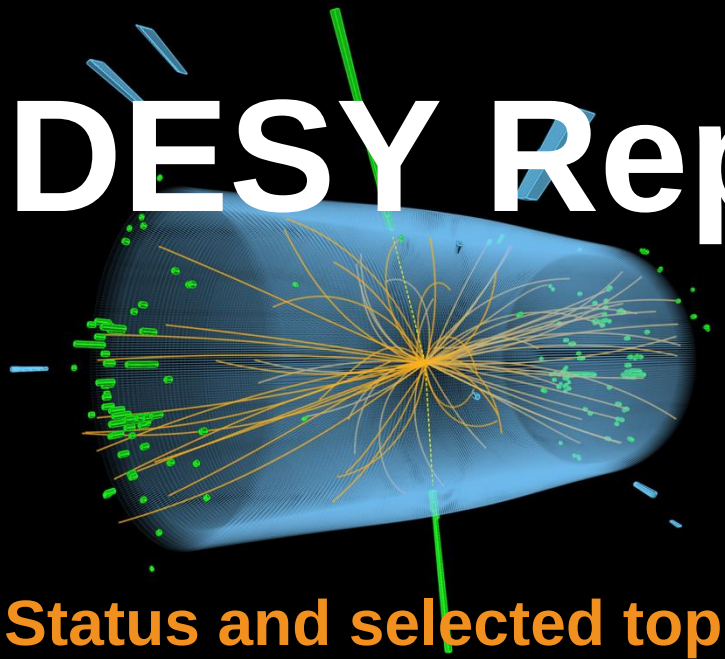
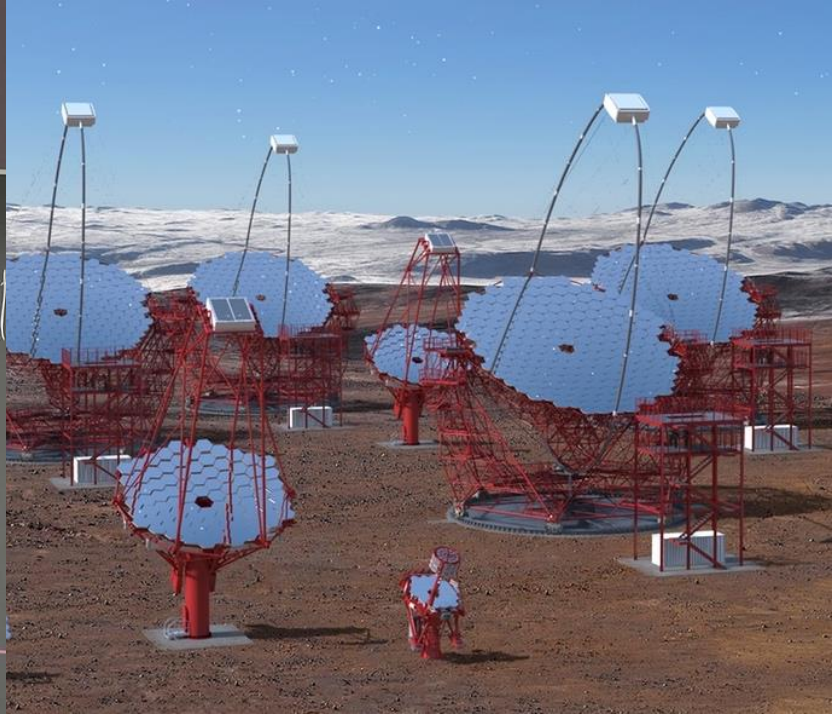
DESY Report





Status and selected topics

Joachim Mnich (DESY)
Plenary ECFA Meeting
19 July 2018

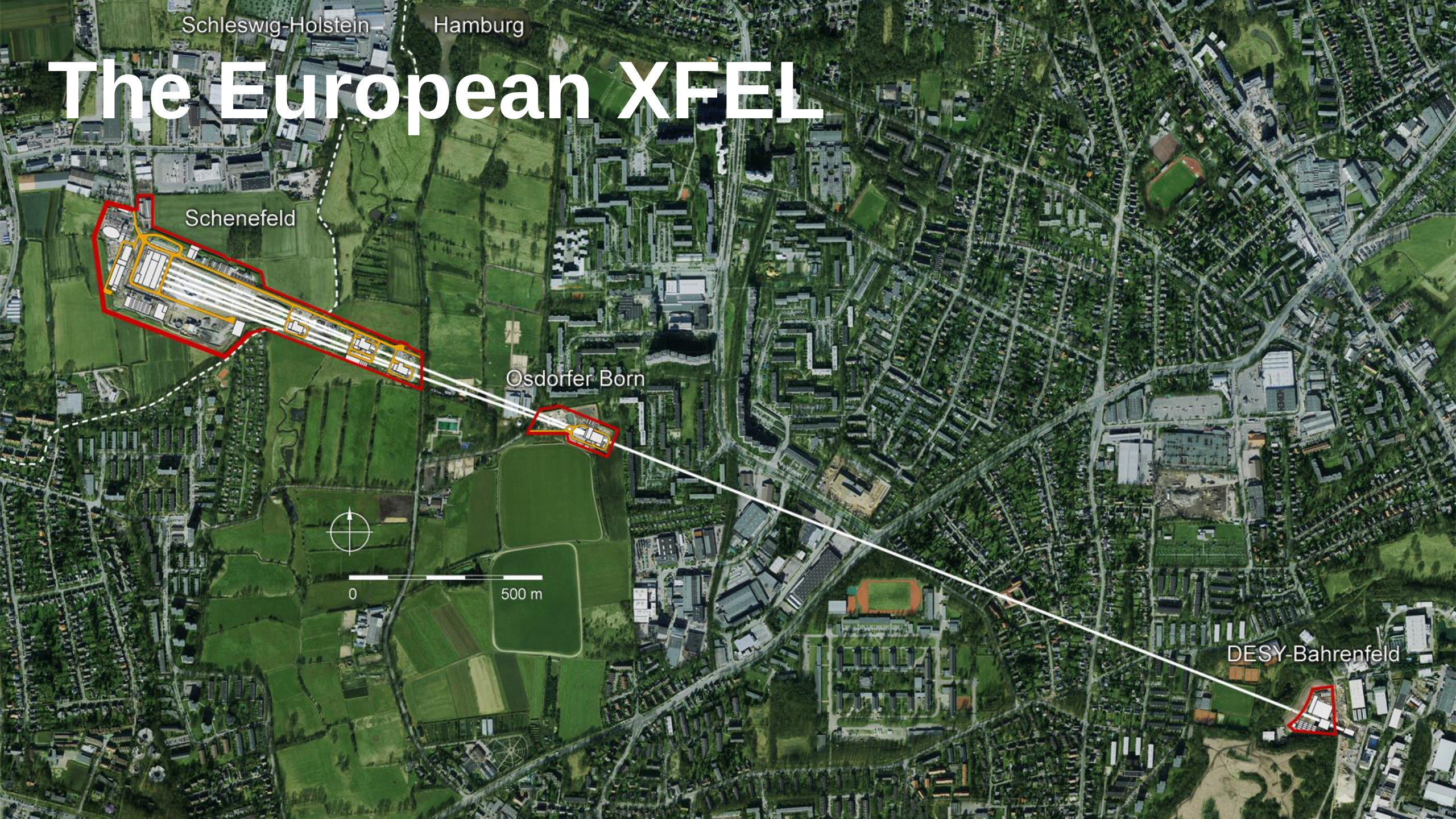
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

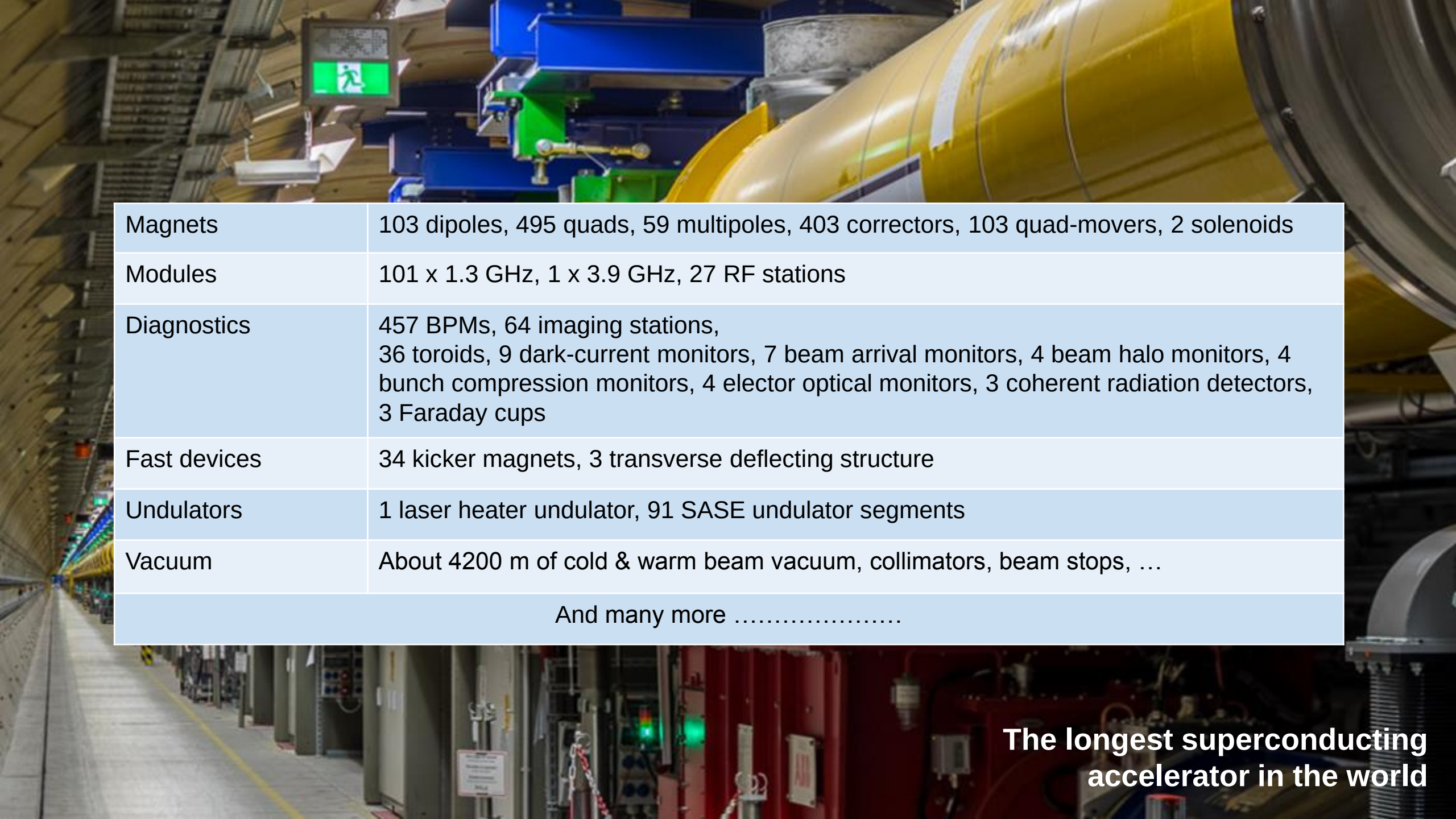
DESY.

The European XFEL

entering routine user operation

The European XFEL



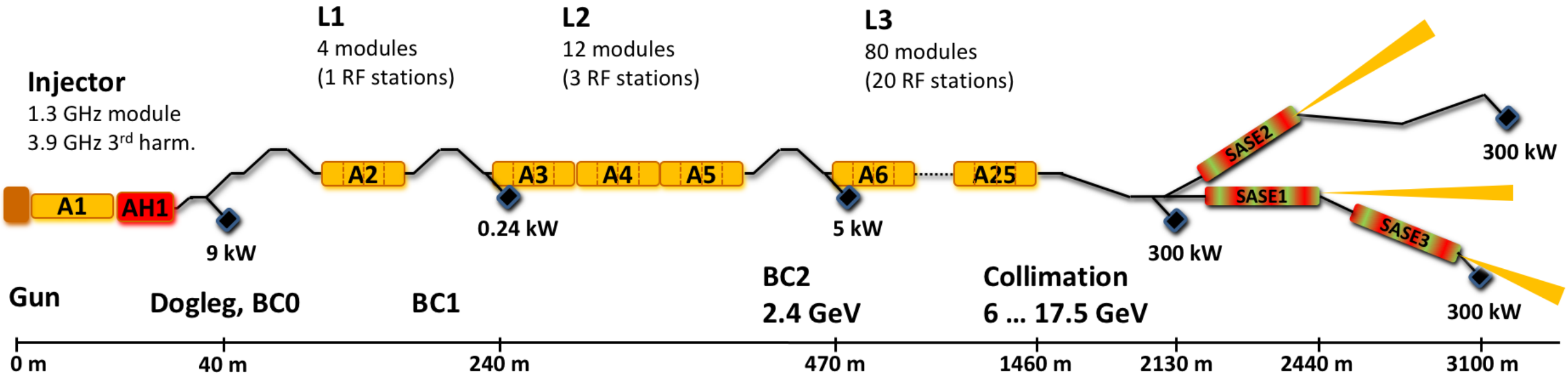


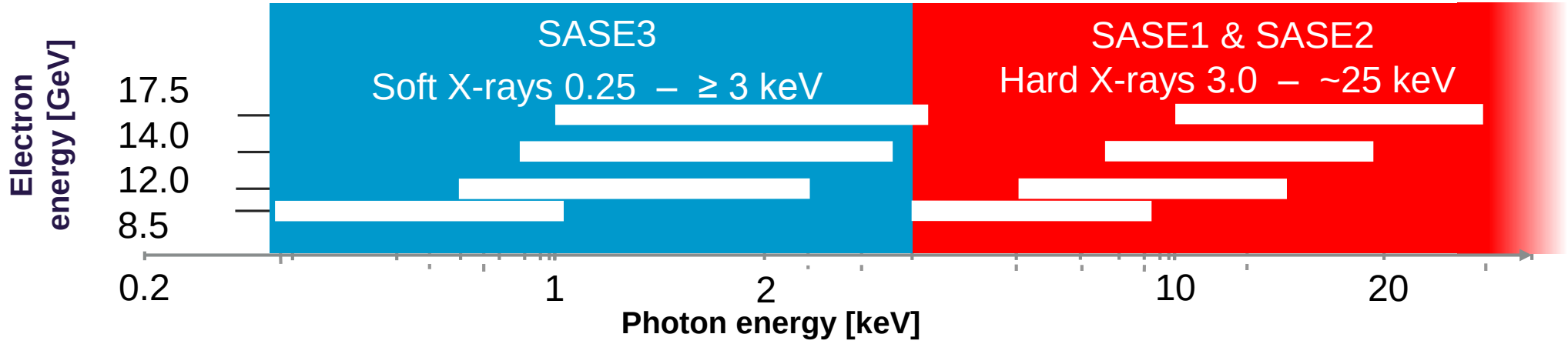
Magnets	103 dipoles, 495 quads, 59 multipoles, 403 correctors, 103 quad-movers, 2 solenoids
Modules	101 x 1.3 GHz, 1 x 3.9 GHz, 27 RF stations
Diagnostics	457 BPMs, 64 imaging stations, 36 toroids, 9 dark-current monitors, 7 beam arrival monitors, 4 beam halo monitors, 4 bunch compression monitors, 4 elector optical monitors, 3 coherent radiation detectors, 3 Faraday cups
Fast devices	34 kicker magnets, 3 transverse deflecting structure
Undulators	1 laser heater undulator, 91 SASE undulator segments
Vacuum	About 4200 m of cold & warm beam vacuum, collimators, beam stops, …
And many more ……	

The longest superconducting accelerator in the world

European XFEL

Schematic overview: photon energies from 0.25 – 25 keV



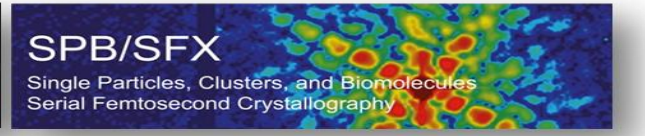


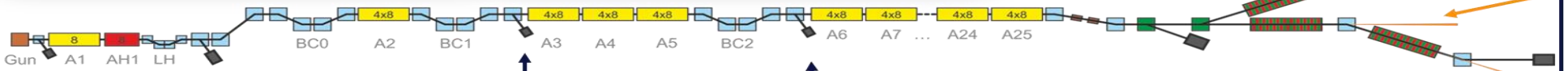
European XFEL

Commissioning and Operation

Commissioning timeline

First user runs started in September 2017



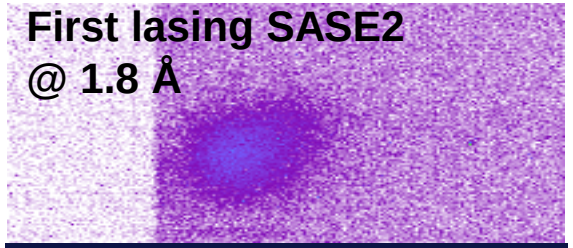


Jan 13, 2017

Jan 15, 2017 @ 130 MeV
Jan 19, 2017 @ 600 MeV

Feb 2, 2017 @ 600 MeV
Feb 22, 2017 @ 2.5 GeV

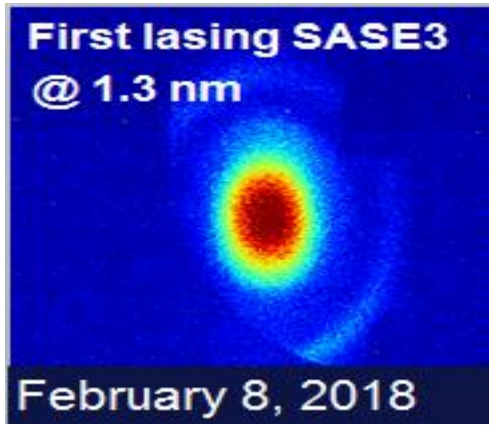
Feb 25, 2017@ 2.5 GeV
March 19, 2017 @ 6 GeV
April 8, 2017 @ 12 GeV
Oct 23, 2017 @ 14.9 GeV



May 1, 2018

May 2-3, 2017

April 27, 2017



February 8, 2018

European XFEL

User statistics PRP round 1 and 2

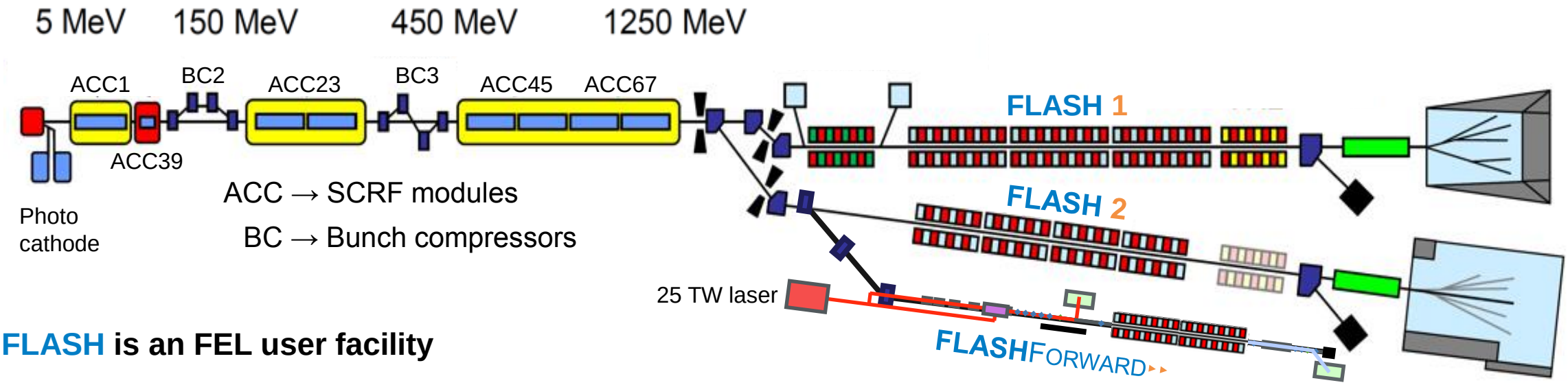
Beamtime Allocation Period	201701 (Sep.-Dec. 2017)	201801 (Aug.-Oct. 2018)
Proposals submitted	63	61
Total proposers	505	440
User shifts requested	275	341
Proposals for FXE Beamtime allocated	37 7	42 6
Proposals for SPB/SFX Beamtime allocated	26 7	19 6
Users in Sep.-Dec.		
Users visits Schenefeld	463	
Remote access users	41	
Individual users	341	

FLASHForward

Plasma Wakefield Acceleration Experiment at FLASH

FLASH Drives Free-electron Laser and Accelerator Research

Superconducting, high average power system feeds multiple beam lines simultaneously



FLASH is an FEL user facility

FLASHForward is a beam line/experiment for plasma wakefield accelerator research

Both share the same superconducting accelerator based on ILC/XFEL technology.
Typical electron beam parameters:

- ≲ 1.25 GeV energy with a few 100 pC at ~100 fs rms bunch duration
- ~2 µm trans. norm. emittance
- up to 800 bunches (≲ MHz spacing) at 10 Hz macro-pulse repetition rate, up to 30 kW average beam power
- parallel **FLASH 1**, **FLASH 2**, **FLASH**Forward operation

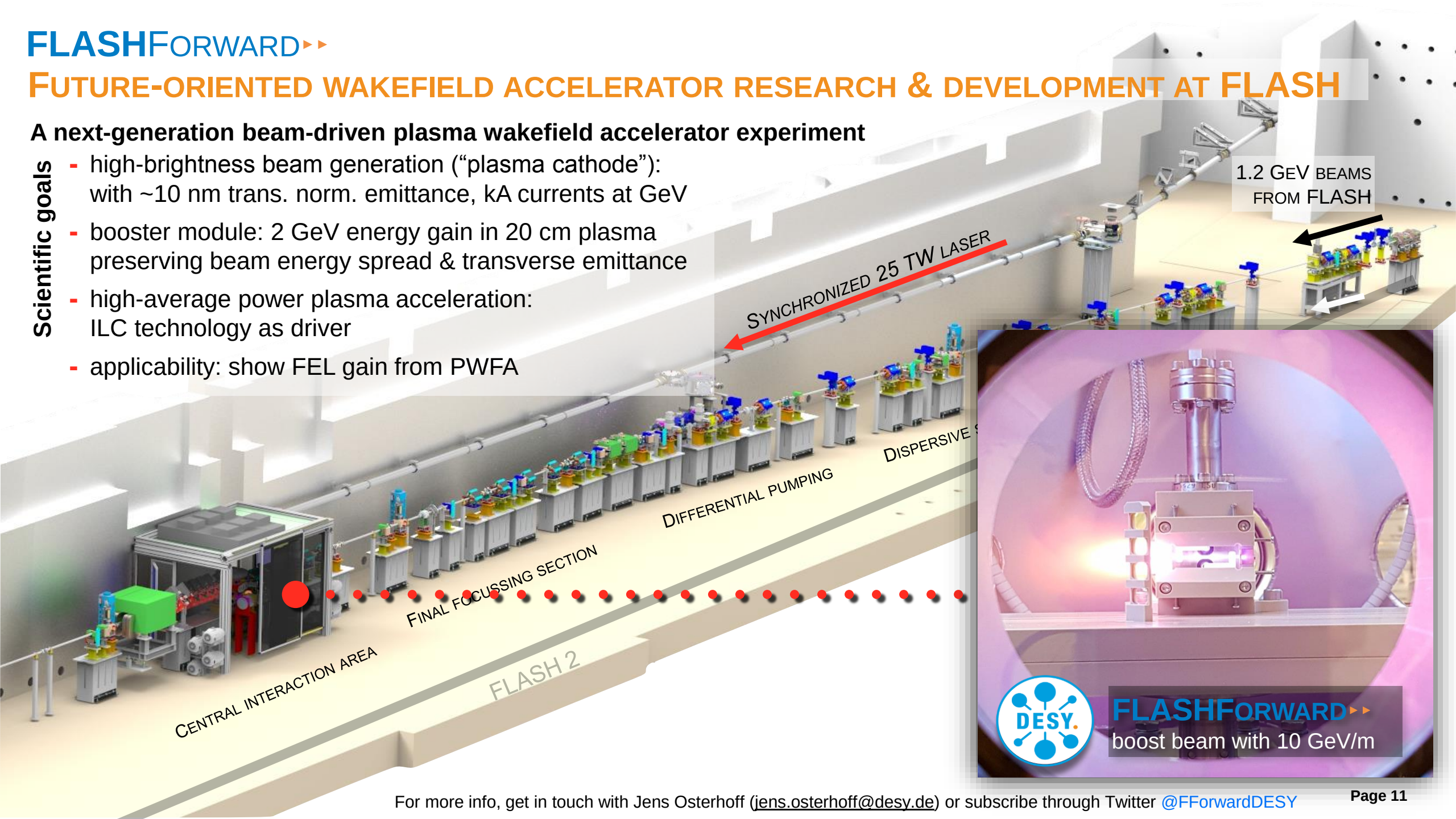
FLASHFORWARD

FUTURE-ORIENTED WAKEFIELD ACCELERATOR RESEARCH & DEVELOPMENT AT FLASH

A next-generation beam-driven plasma wakefield accelerator experiment

Scientific goals

- high-brightness beam generation (“plasma cathode”): with ~10 nm trans. norm. emittance, kA currents at GeV
- booster module: 2 GeV energy gain in 20 cm plasma preserving beam energy spread & transverse emittance
- high-average power plasma acceleration: ILC technology as driver
- applicability: show FEL gain from PWFA



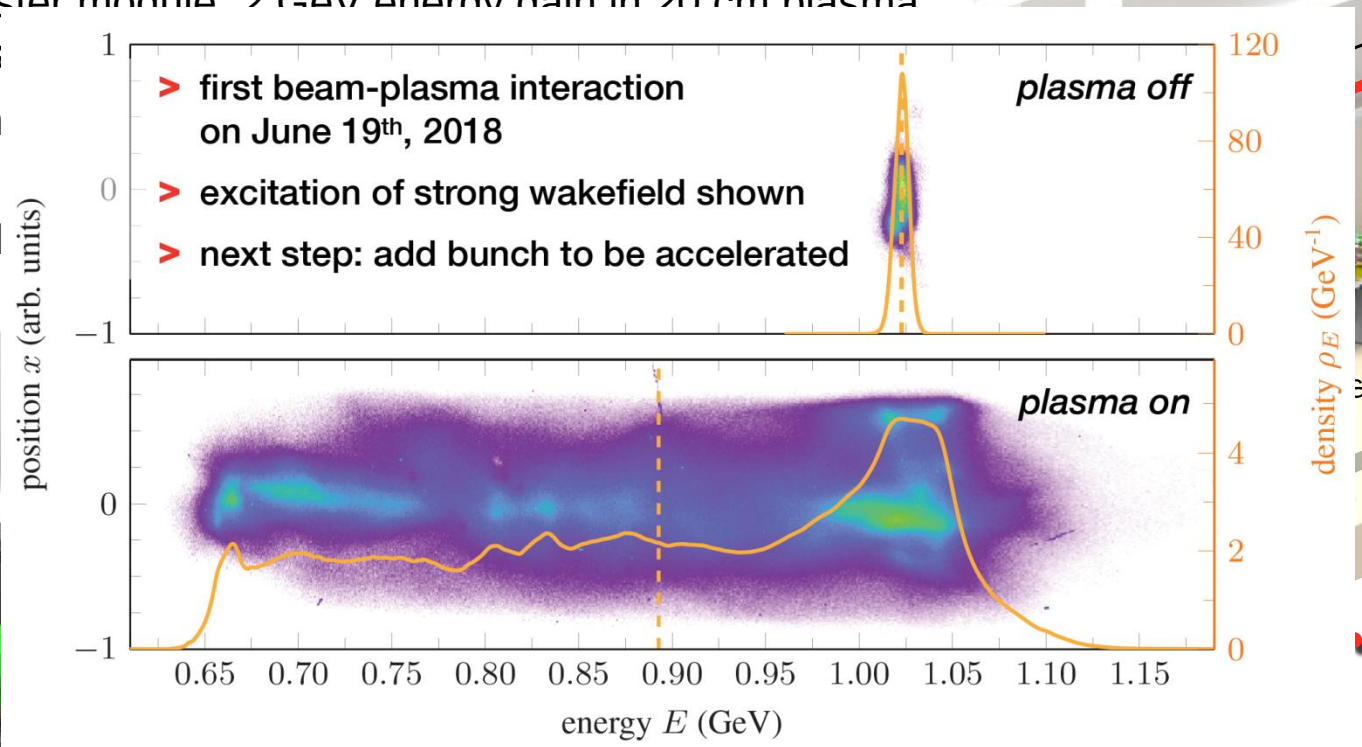
FLASHFORWARD

FUTURE-ORIENTED WAKEFIELD ACCELERATOR RESEARCH & DEVELOPMENT AT FLASH

A next-generation beam-driven plasma wakefield accelerator experiment

Scientific goals

- high-brightness beam generation ("plasma cathode"): with ~10 nm trans. norm. emittance, kA currents at GeV
- booster module: 2 GeV energy gain in 20 cm plasma
- pres
- high ILC
- appl



> (12.3 ± 1.7) GV/m wakefield generated in 30 mm plasma cell

> 12.7% total energy loss to plasma wakefield
→ complete beam-energy depletion in 23.5 cm plasma expected

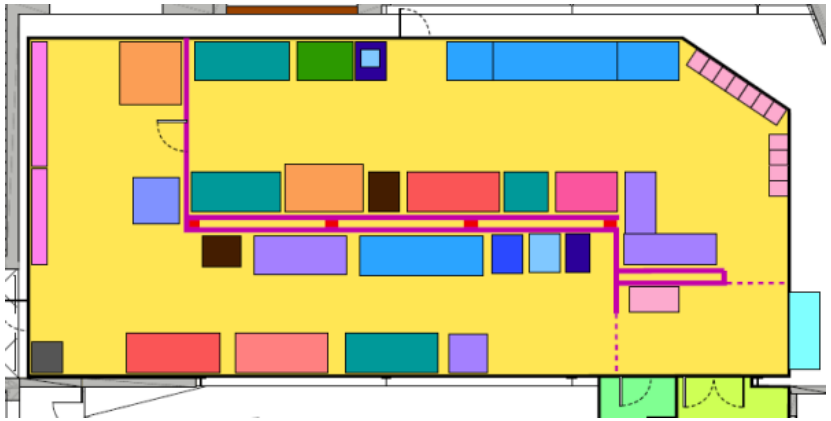
Particle Physics Activities

at DESY

– LHC and upgrades
– Belle II
– ALPS II
– Other on-site experiments
– Test beam facility at DESY-II

Detector Assembly Facility (DAF) - I

Building 25c



DESY: 10 MEUR investment in infrastructure for LHC upgrades

- Buildings 25c and hall 1

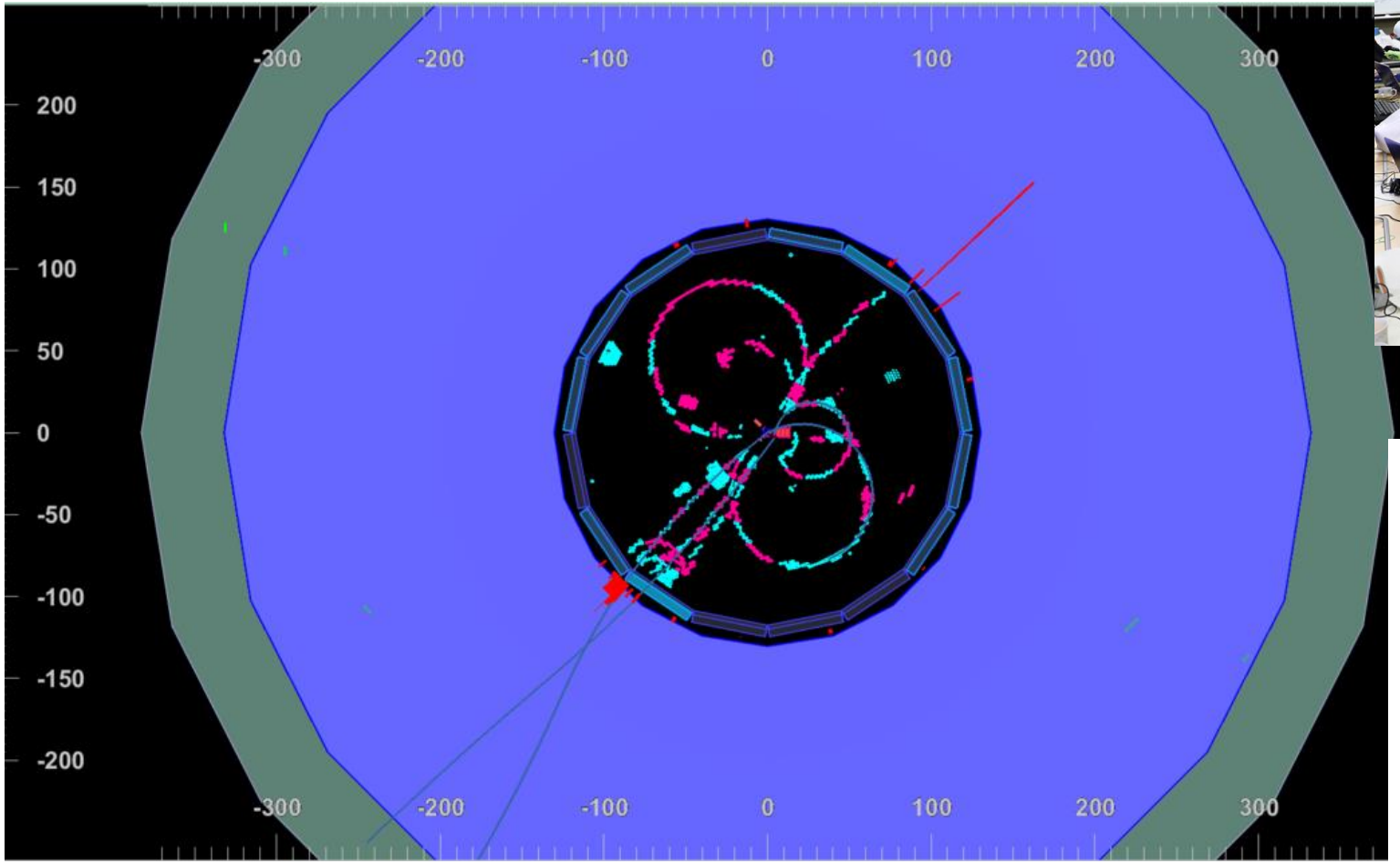
Building 25c infrastructure & cleanroom (ISO-6) ready

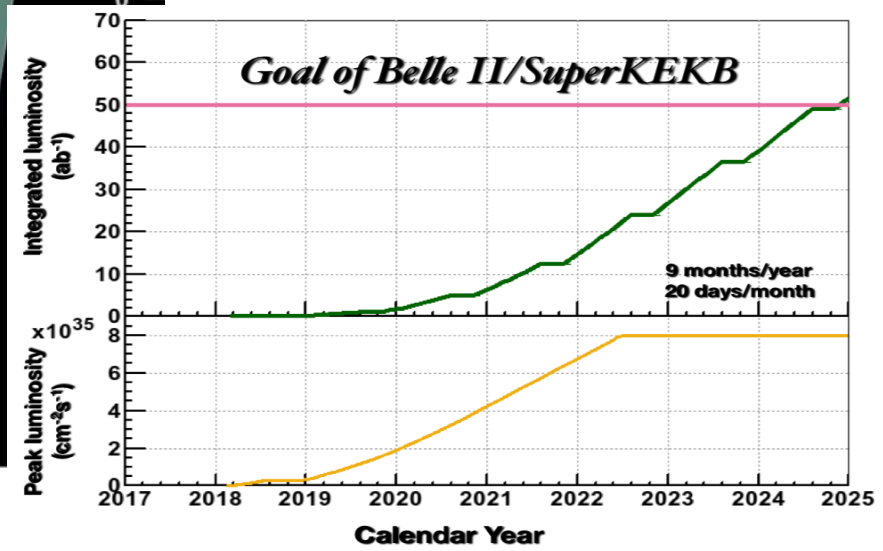
- Commissioning has started
- Will be fully operational by July 2018

View of CMS cleanroom area with microscope (left) and wire bonder (right). Used for module R&D, pre-production, production.

Belle II: First Collisions Recorded

25 April 2018; SuperKEKB ramping up towards design lumi





Belle II: PXD Commissioning at DESY

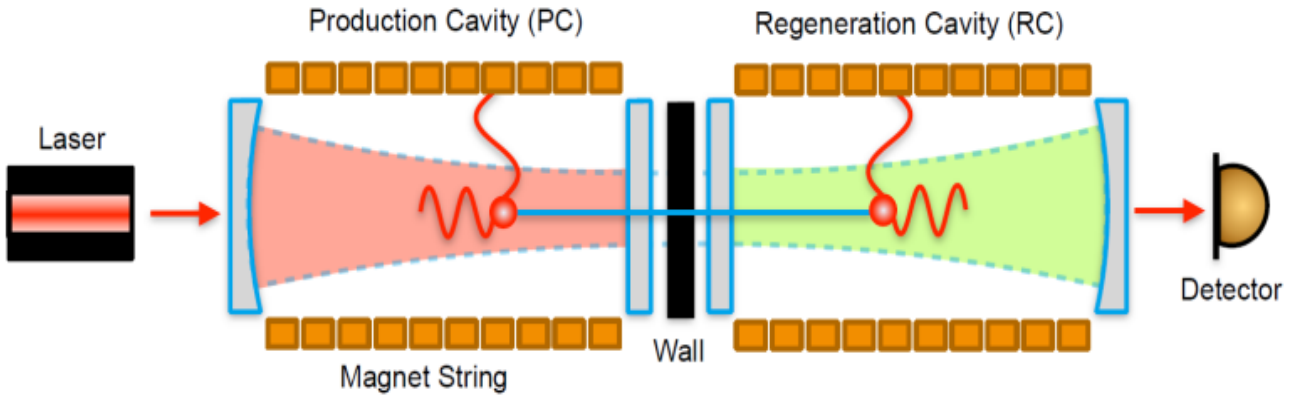
1st PXD half-shell with final layer 1 ladders completed end of April 2018

Tight PXD Schedule

- Several technical issues caused additional delay
- PXD on critical path for Belle II completion

ALPS II Progress at DESY

Here: bending of HERA dipole magnets



10+10 dipole magnets from the HERA proton accelerator.
Production cavity and regeneration cavity, mode-matched.

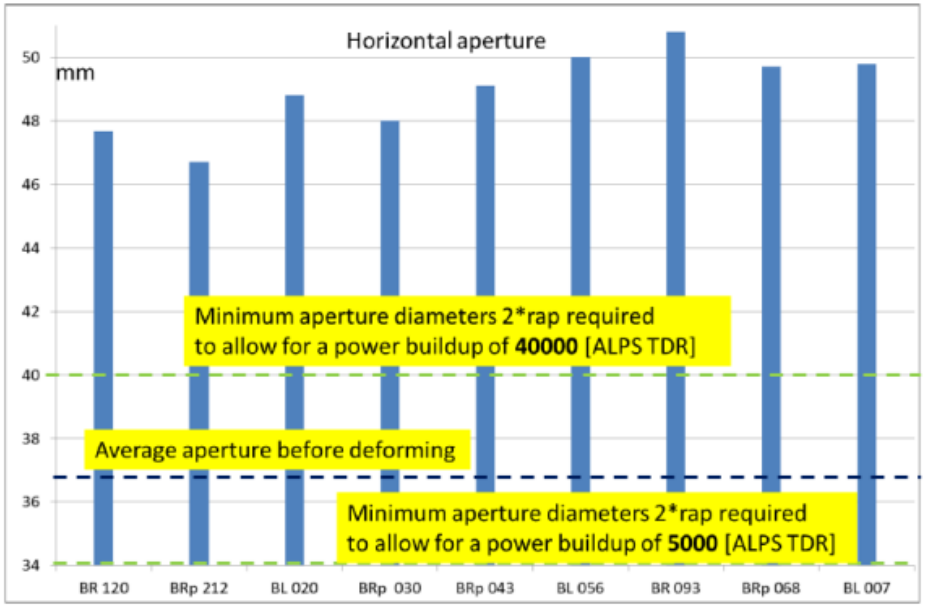


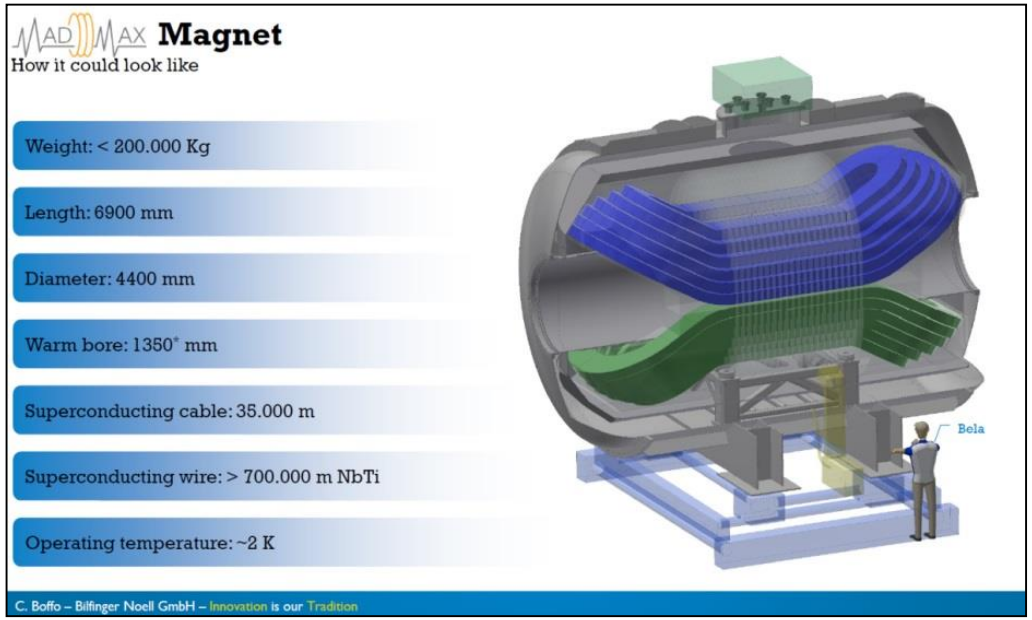
Figure 6.2: Horizontal aperture of HERA dipoles after straightening

Magnet bending progressing well:

- 10+10 dipoles from HERA, each 5.3 T on 8.8 m.
- To be straightened to achieve ≈ 50 mm aperture.
- Aperture and quench current goals achieved.
- 11 magnets modified successfully (out of 11).
- HERA tunnel is being cleared.
- Start experiment in 2020.

On-Site Experiments – Future

MADMAX – search for dark matter axions



MADMAX (dark matter)

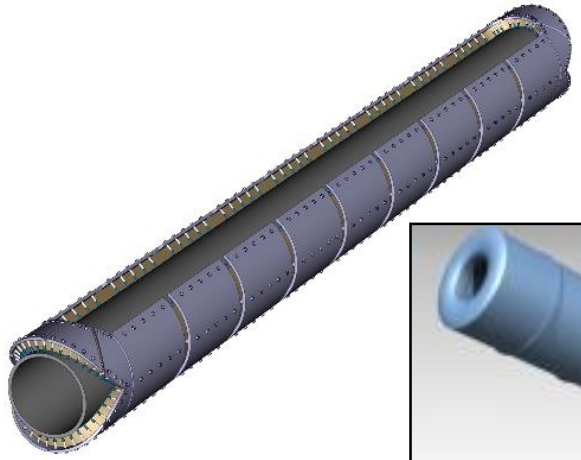
- Conversion of axion to microwave in 10 T field; 80 di-eletric discs made of LaAlO3 with ε = 25
- Oct. 18th founding at DESY: Aachen, DESY, Hamburg, MPI, Saclay, Tübingen, Zaragoza

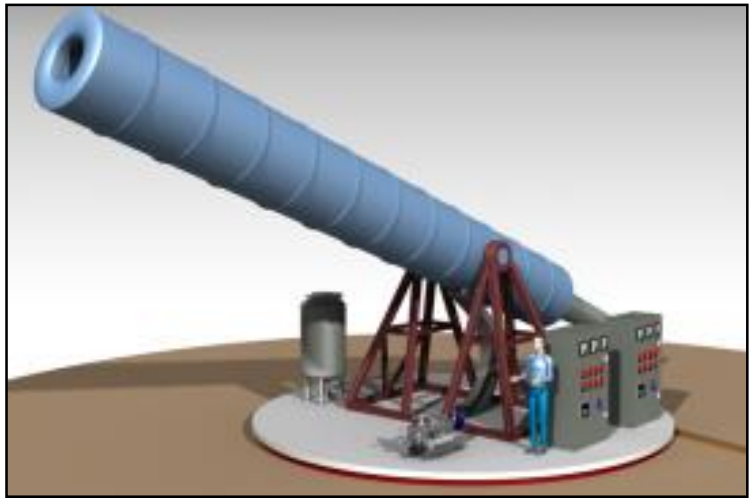
MADMAX collaboration

- Collaboration founded at DESY in 2017; selected DESY site: north hall (H1) area
- Site now being prepared
- Magnet studies by Bilfinger-Noell and CEA Saclay, aim for magnet decision in late 2018

On-Site Experiments – Future

IAXO – search for solar axions





U. Schneekloth, 2017

IAXO:

- CAST principle with larger aperture, use of ATLAS-like toriods, satellite-like X-ray optics: aims to detect axions emitted by sun
- Magnet studies for babyIAXO ongoing at CERN.
- Aim for magnet decision in summer 2018

IAXO location at DESY:

- 4 July 2017: founding of IAXO collaboration at DESY: 16 institutions from 9 countries + CERN
- Strong support from German and Europ. community to host IAXO at DESY.
- Location under discussion – several possible locations under discussion

LUXE

QED at extreme conditions

QED thoroughly tested in perturbative regime

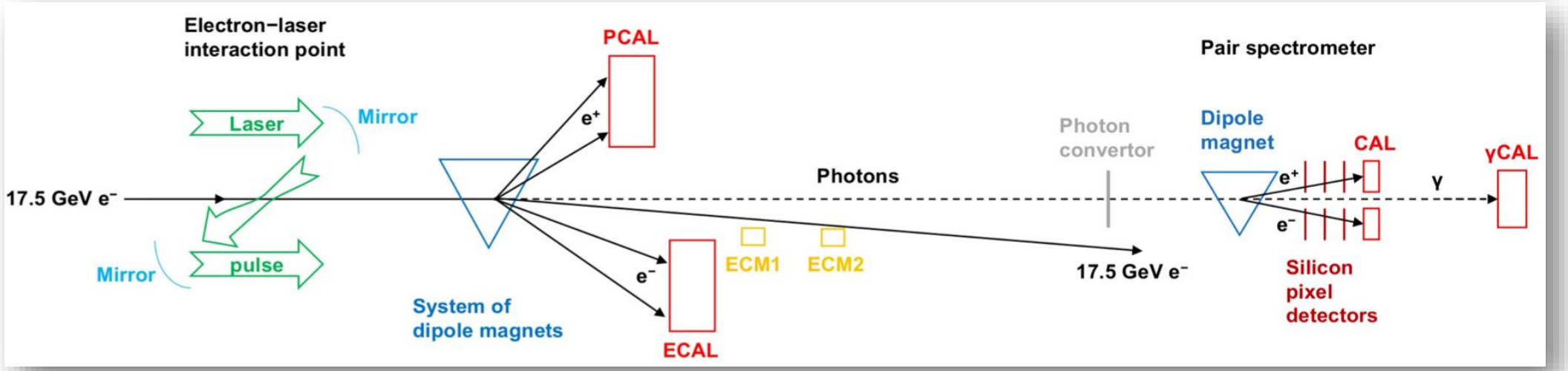
- But little known about strong-field QED in non-pert. regime

LUXE:

- Testing QED in the strong-field (so-called Schwinger) regime $E \sim 1.3 \cdot 10^{18}$ V/m (calculated 80 years ago!)
- Install laser to collide photons ω with XFEL electron beam
- Two reactions of interest: $e^- + n\omega \rightarrow e^-\gamma$ and $e^- + n\omega \rightarrow e^-e^-e^+$.
- Detect photons, electrons and positrons

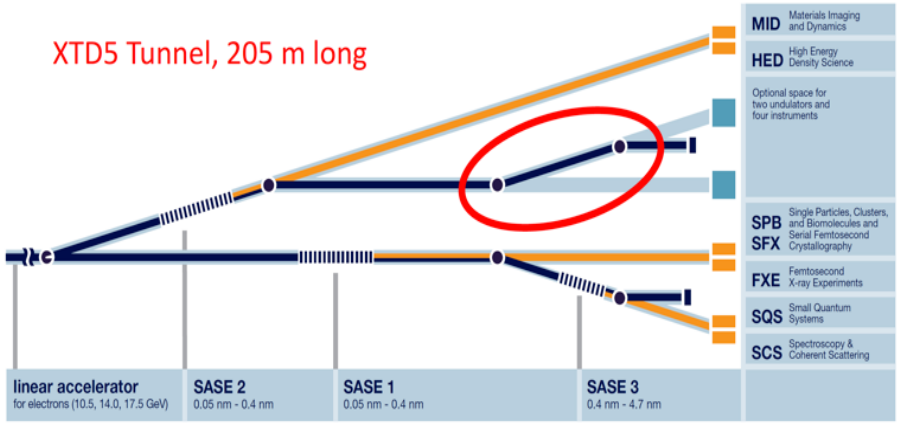
Features

- DESY unique: high-intensity high-energy electron beam
- Parasitic to XFEL operation
- Laser requirements: 500 nm with 10^{21} W/cm^2
- Dimensions: 50 m long, 1.2 m wide
- LUXE will exceed previous measurements (E144 at SLAC) by one order of magnitude
- Feasibility/design study just started



LUXE

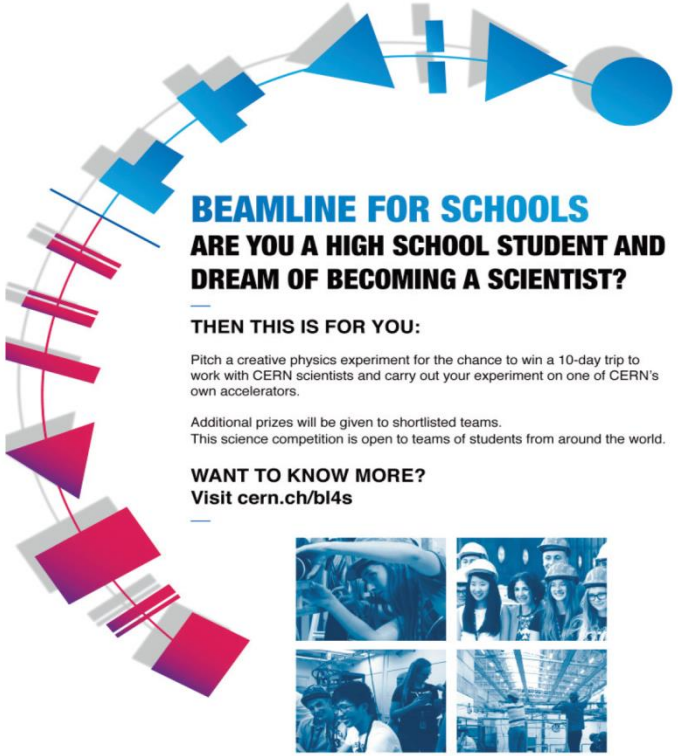
Tentative Location and schedule

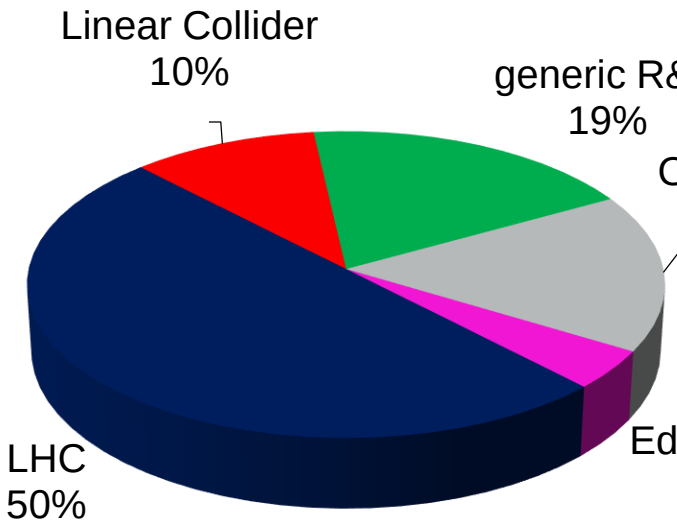


Installation of first phase of LUXE experiment in the XFEL tunnel planned for 2021.

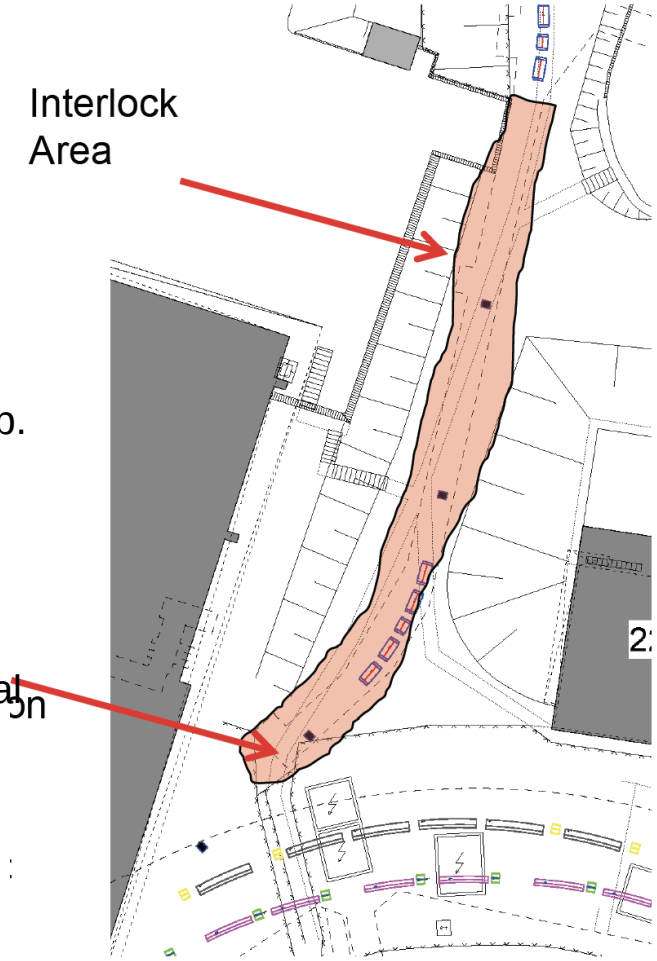
Test Beam Facility at DESY II

6 GeV electrons with superb service





Distribution of beam time 2018 over projects



- 2019/20: CERN LS2 → DESY will host Beamline4Schools
- Teams of pupils compete with their experiments (so far 10000 participants at CERN)
- Complement to other outreach activities

- 2018 so far : 75 weeks of beam time allocated
- Beamline usage between 25-100%
- Requiested infrastructures: 75% of all groups want telescope

- Idea for a „direct extraction“ beamline with electrons with high rate or other particles
- Currently proof-of-principle work – different options (“R-Weg“, hall 2, …)
- Attraktive and very visible

Strategy Developments

at DESY

Strategy DESY-2030

For particle physics

Explore the LHC and beyond

- Upgrade ATLAS and CMS for HL-LHC
- Prepare leading participation in future global collider project

Harvest at Belle II

- Data taking and analysis until ~2027

On-site experiments

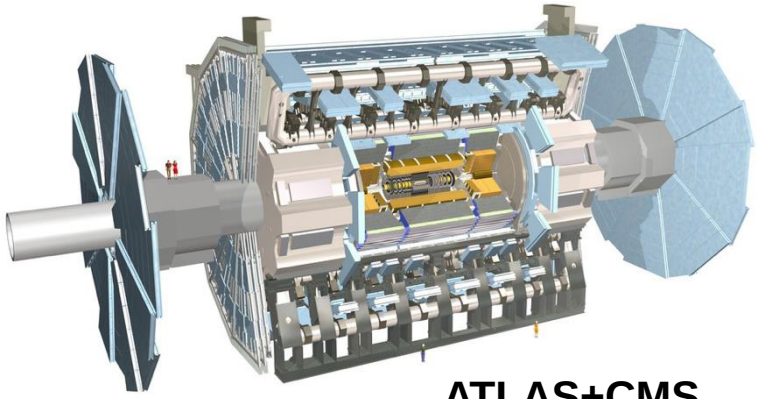
- Prepare a future on-site experiment after ALPS-II
- Detector R&D & testbeam operation

Theory:

- Maintain broad spectrum of research topics and world-leading expertise

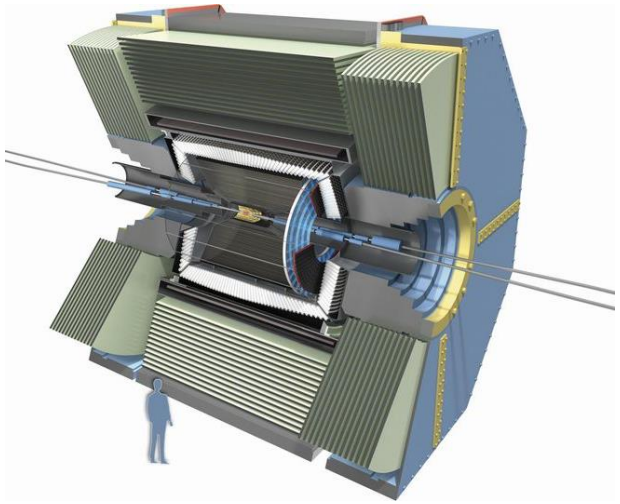
DESY as a “hub”:

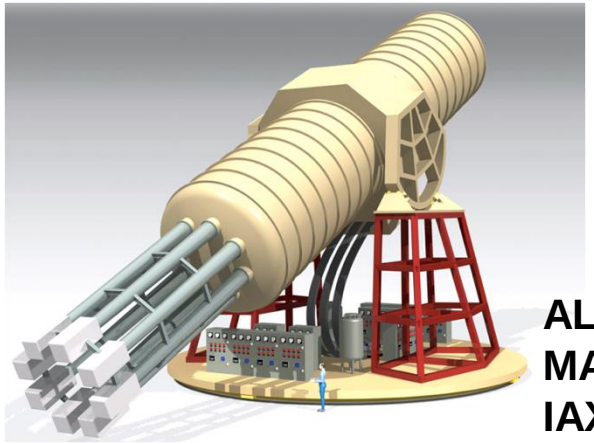
- Support projects with large German participation



ATLAS+CMS

Belle II





ALPS-II
MADMAX
IAXO

Backup

Outline

European XFEL

- Entering phase of routine user operation

Particle Physics strategy

- German contribution to European strategy update
- DESY strategy (“DESY-2030”)

Particle physics activities at DESY

- LHC detector upgrades
- Belle II
- ALPS II
- Future on-site experiments at DESY (IAXO, MADMAX, LUXE)
- Testbeam facility

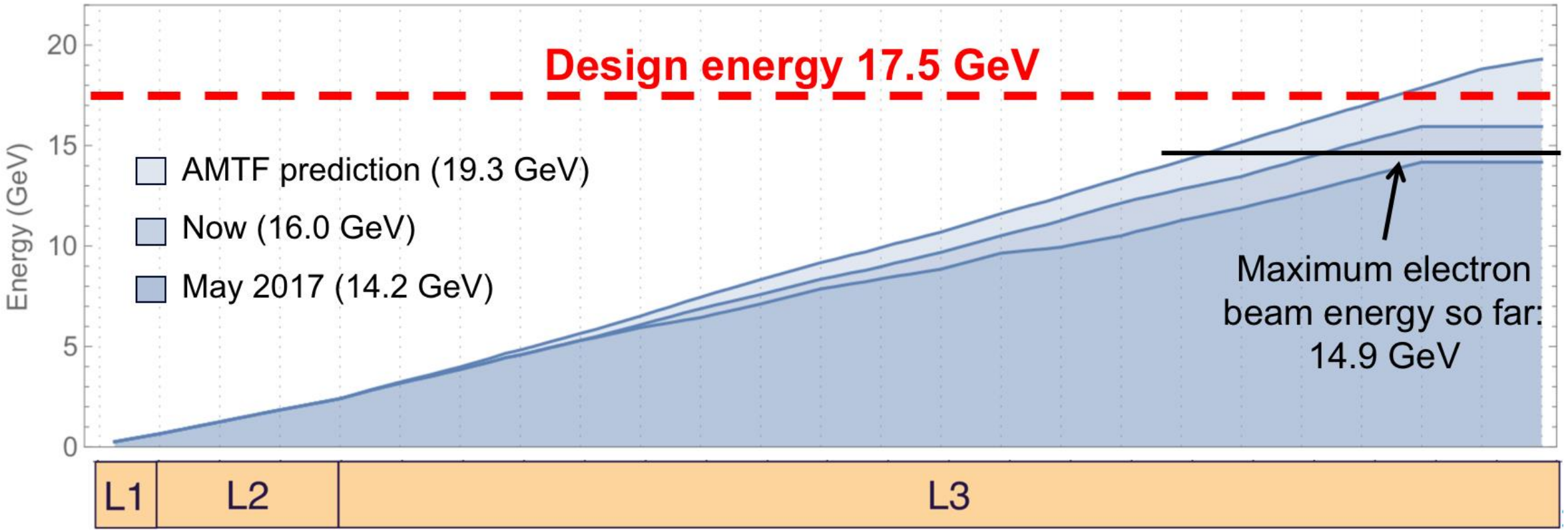
Conclusions

European XFEL

RF commissioning: process and results

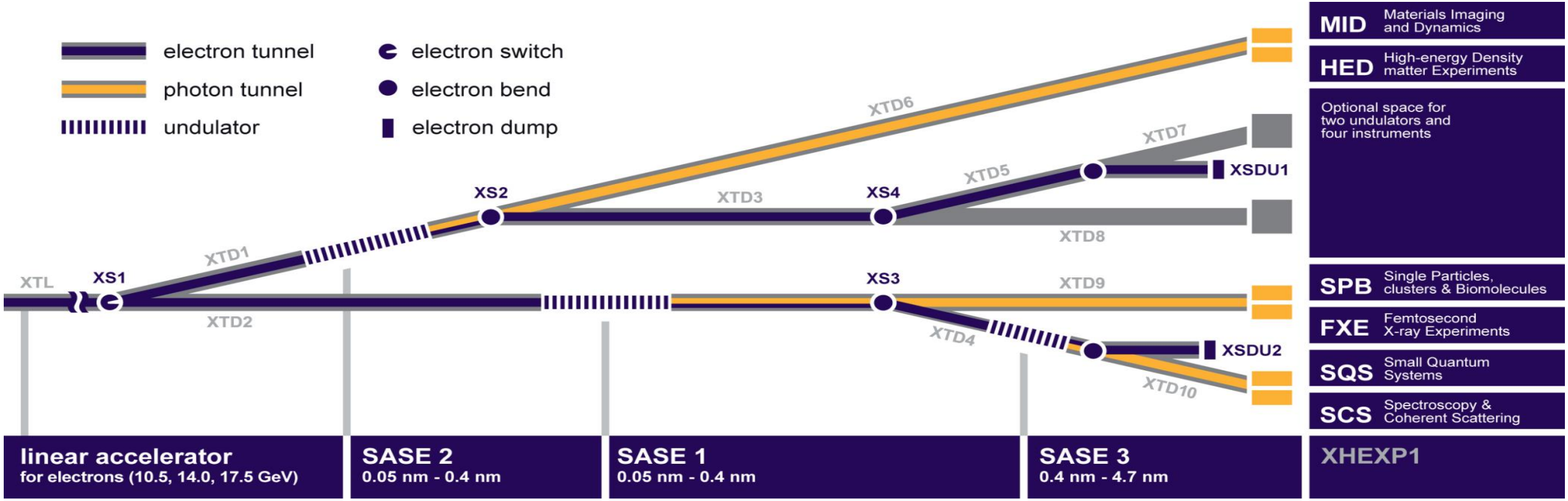
About 3.5 months initial commissioning time with up to three teams in parallel

- With and without electron beam in parallel to other beam commissioining
- 23 out of 25 RF stations initially commissioned
- Operation automated: energy goal for 2017/18 reached with 1-2 stations in reserve

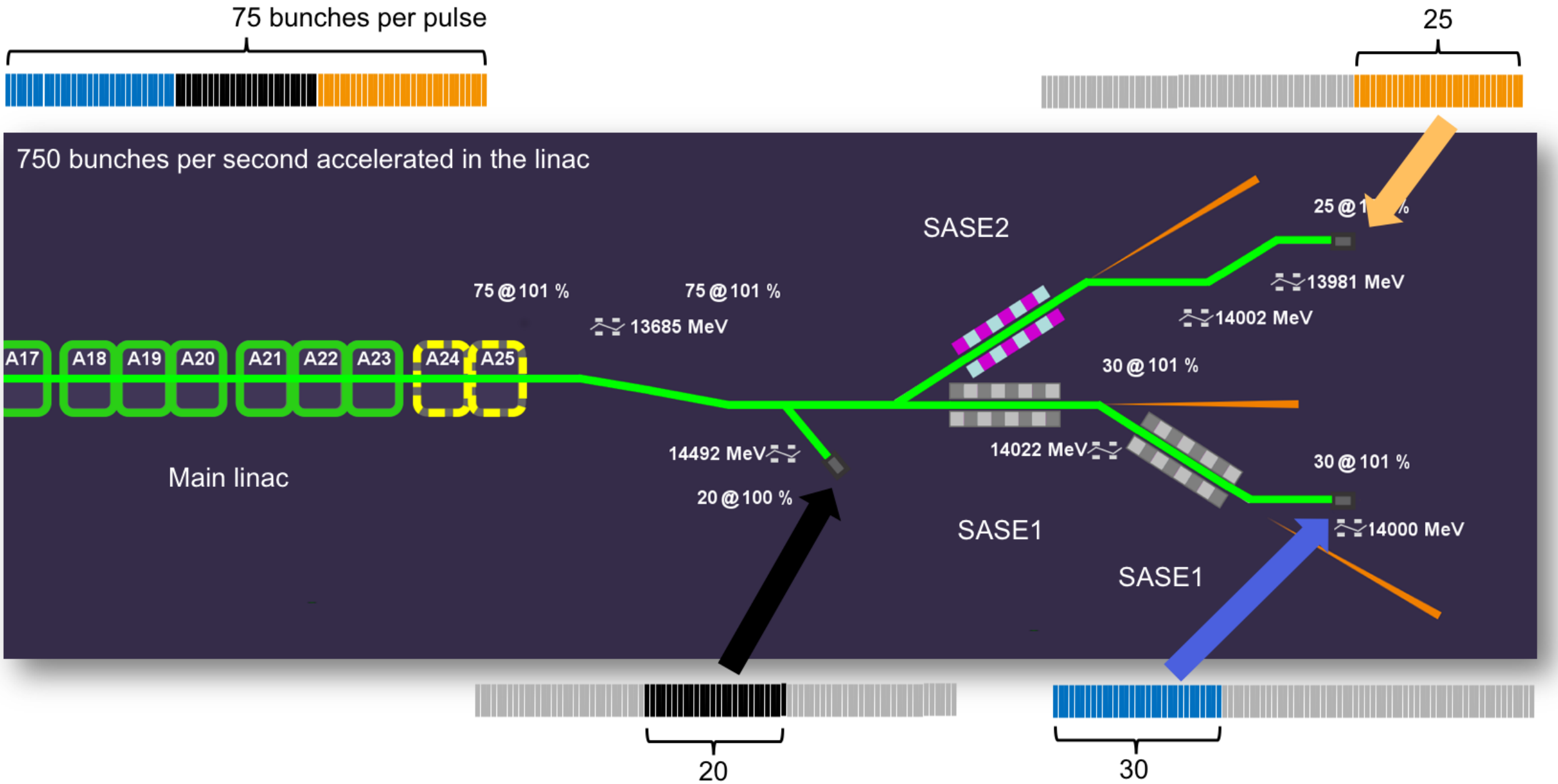


European XFEL

Layout of photon tunnels and experiment regions



Parallel operation of three beamlines

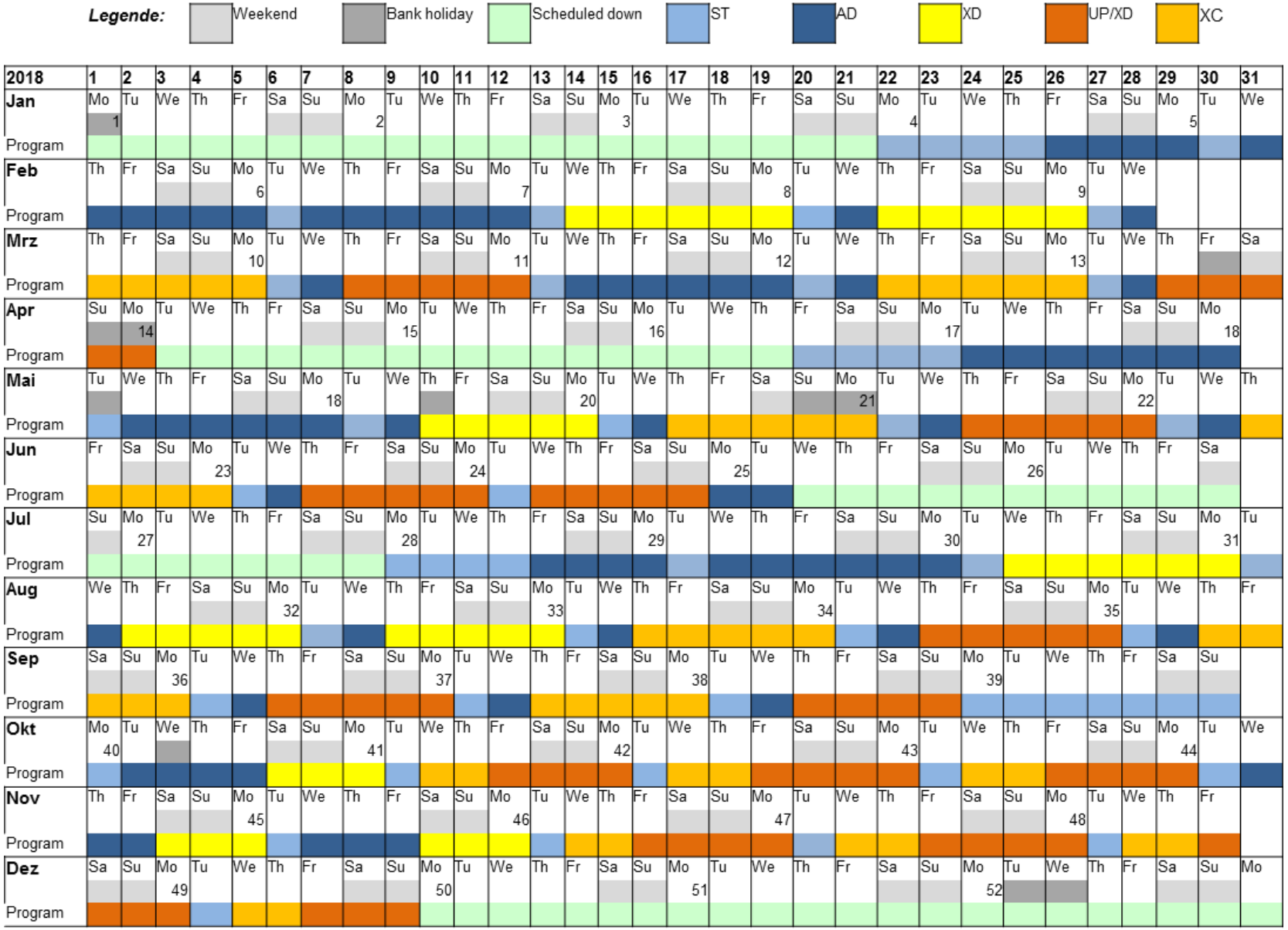


European XFEL

User operation schedule 2018

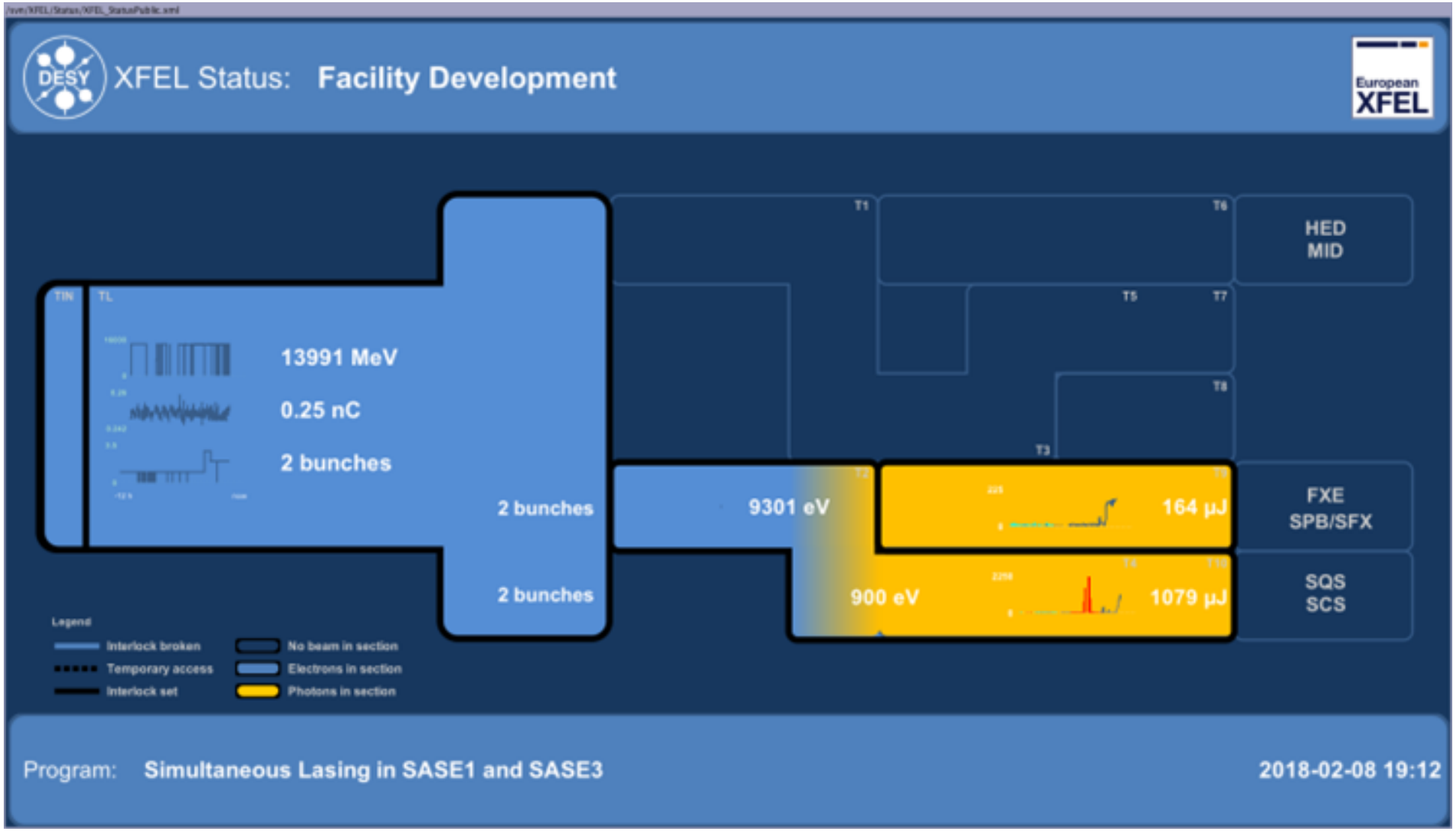
SD	Scheduled Down	1896
ST	Access, Setup, Tuning	1320
AD	Accelerator development	1800
XD	X-ray development	984
XC	Experiment commissioning	1176
UP	User Program	1584

About 6800 hours of operation



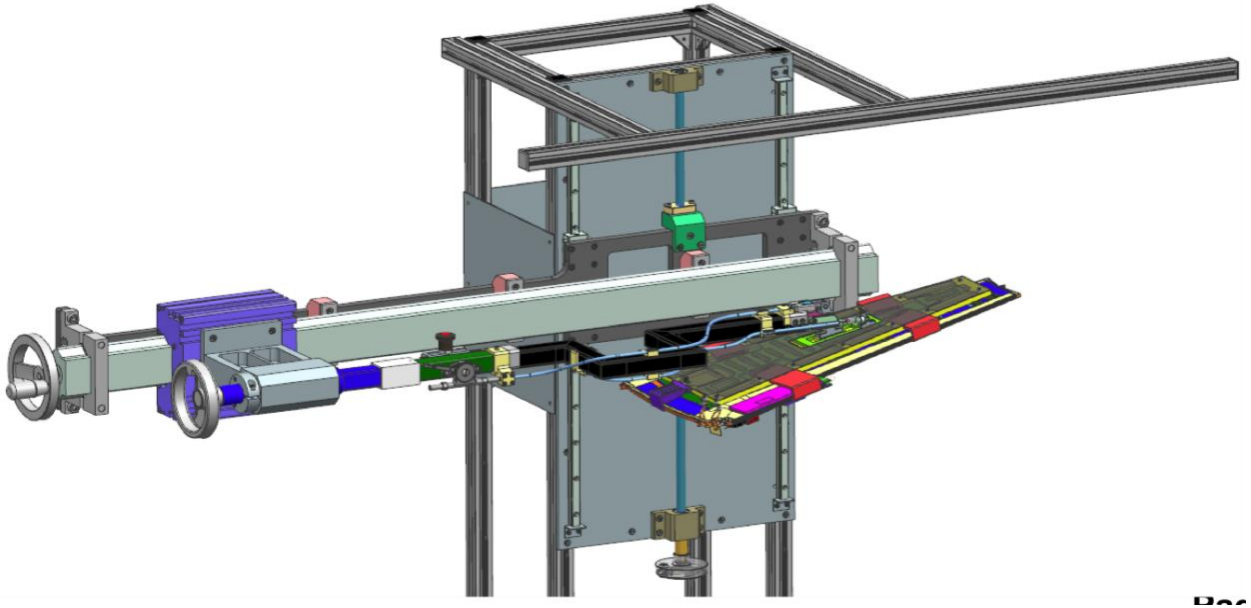
European XFEL

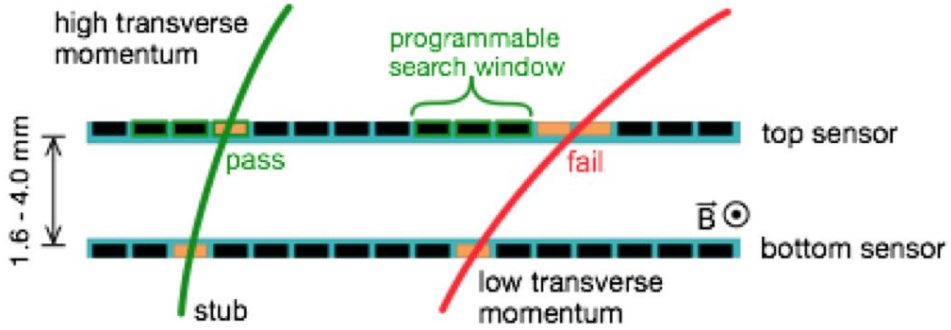
Regular operation

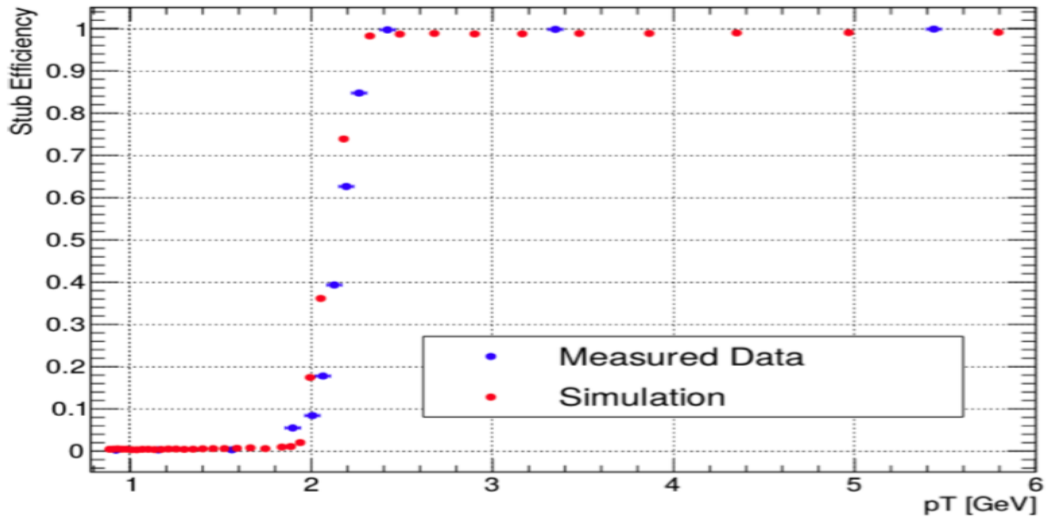


DESY LHC Highlights

Hardware achievements for HL-LHC upgrades







ATLAS petal insertion tool

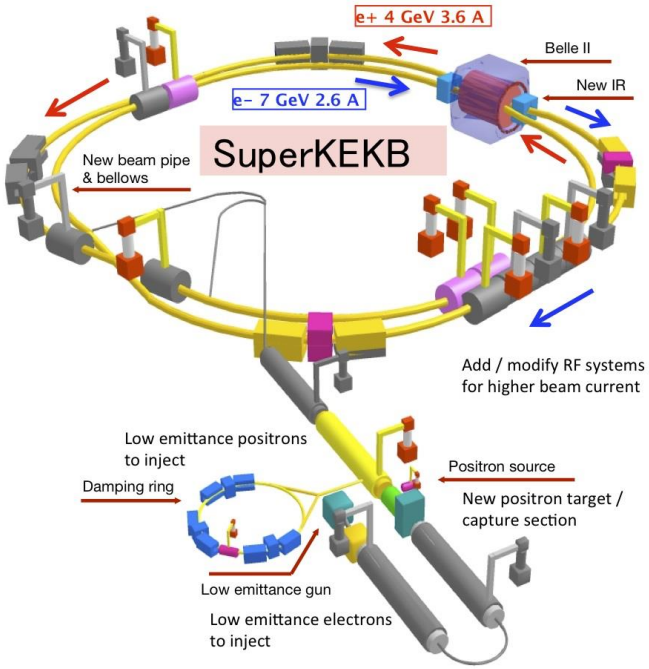
- ATLAS group moving from fundamental R&D towards assembly and installation concepts for tracker endcap.
- Insertion tool for modules into petal structures as important milestone. .

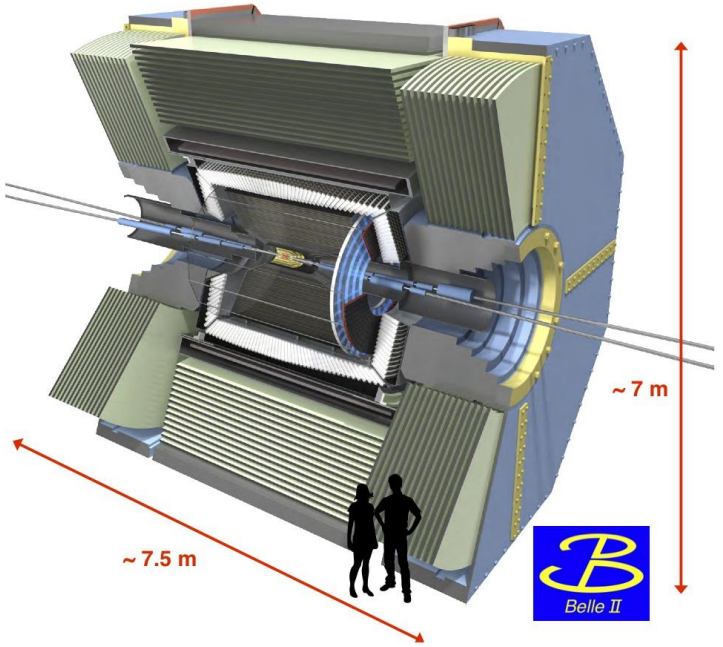
At HL-LHC triggering important, also using tracker

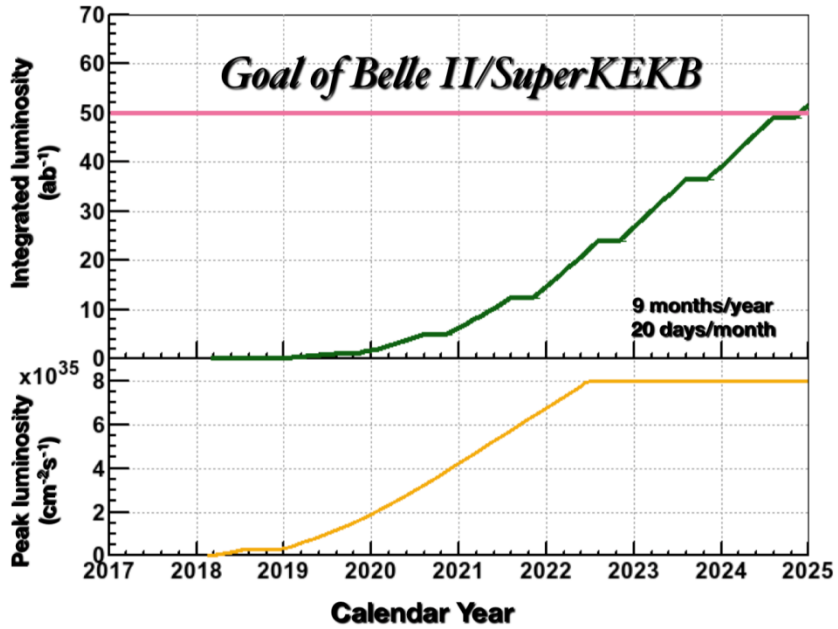
- First results from CMS for triggering capabilities of new tracker using „stubs“.
- Results from testbeam campaigns at DESY & CERN
- p_T-Triggering capabilities demonstrated.

The Belle II Experiment

Utmost precision for discovery in the flavour sector







SuperKEKB e+e- collider:

- Complete refurbishment
- First collisions earlier this year
- Currently ramping up luminosity
- Background issues

Belle II experiment:

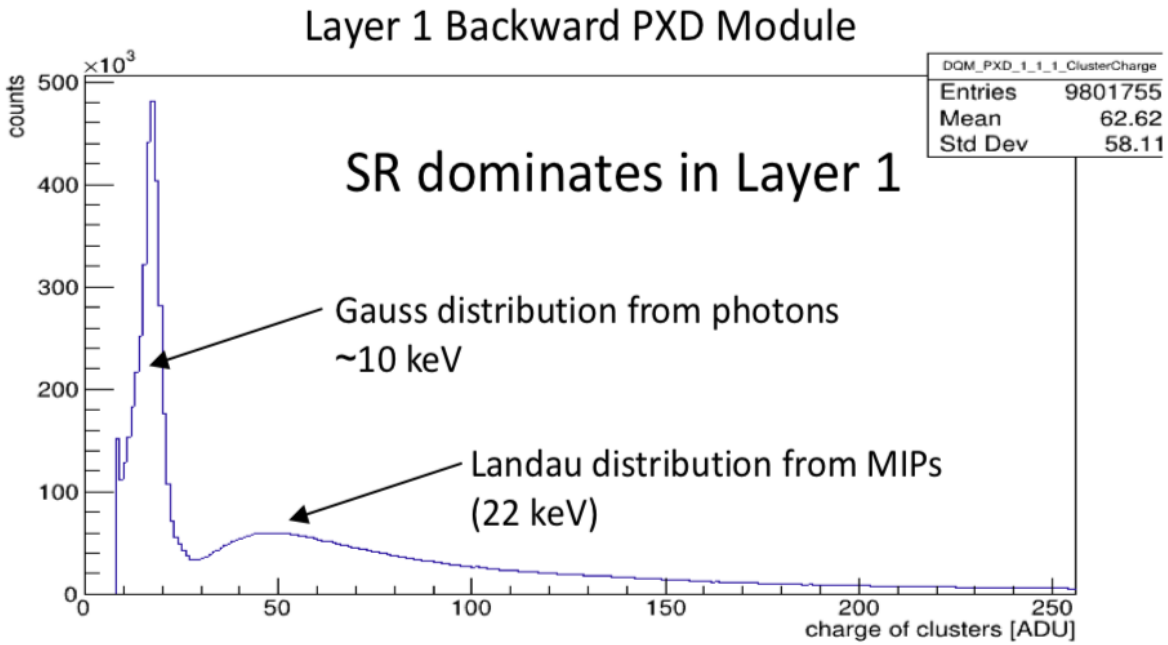
- Successor of former Belle experiment
- Upgrades to important components, notably the vertex / tracking system (PXD in DEPFET etc.)

High physics expectations:

- Lumi increased by factor 50 compared to Belle (1)
- Precision physics, e.g, Bs decays, LFU violation, LFV, …
- Dark sector: dark photons etc.

Belle II

Risks and challenges



Tight PXD Schedule

- Several technical issues caused additional delay
- PXD on critical path for Belle II completion
- Center of activity has to shift to KEK in August

First measurements of background in Belle II

- Background larger than expected (synchr. rad?) Needs to be understood.
- Very early days – still orders of magnitutde below design luminosity!

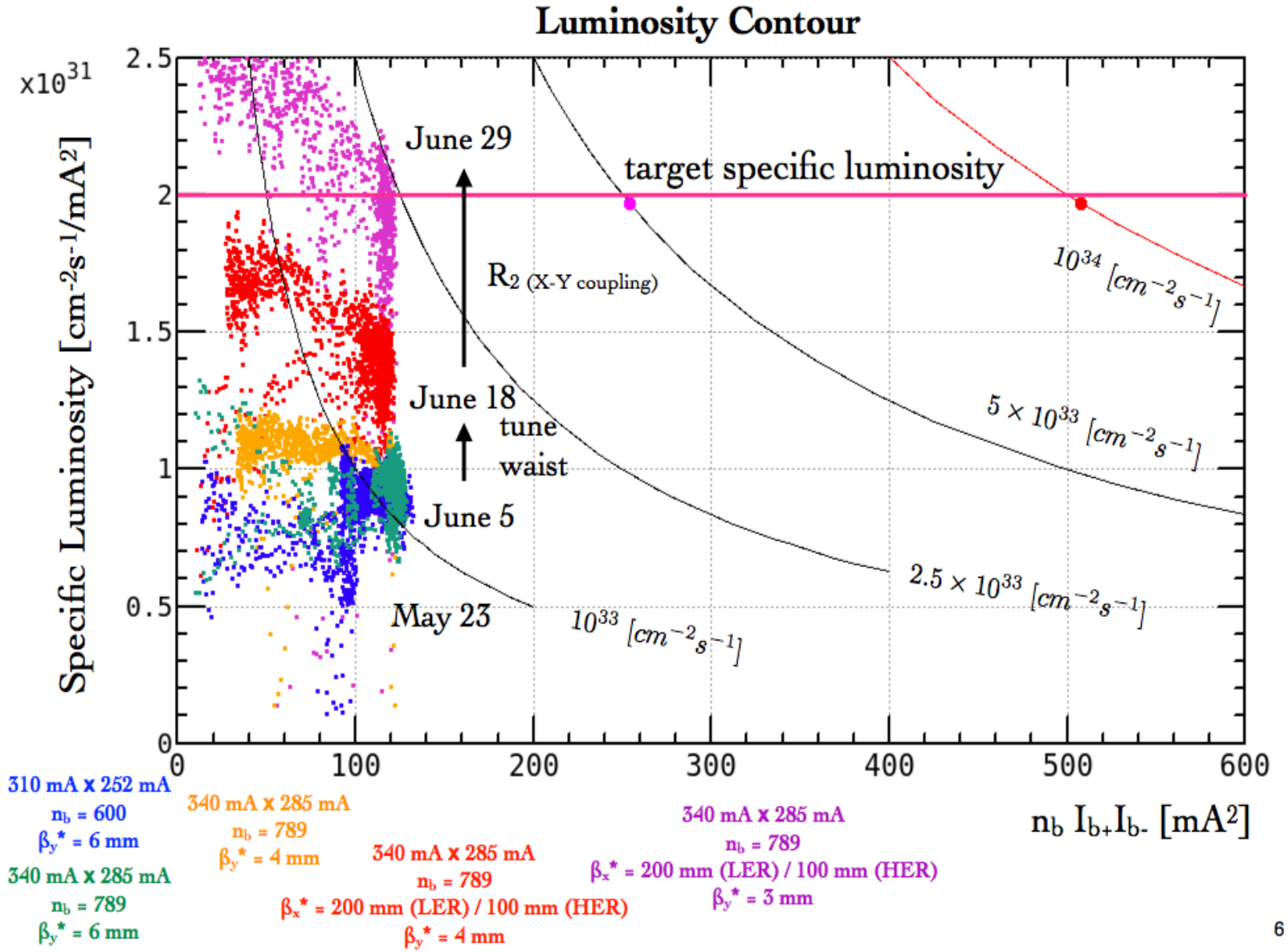
Belle II: Commissioning

Machine gradually ramping up!

Ramping up beam currents
and peak luminosity

Goal of phase 2:
$L \approx 10^{34} cm^{-2}\ s^{-1}$ (KEKB design)

In parallel:
Comprehensive background studies using BEAST II detector (commissioned at DESY in 2017)



AXION and WIMPs

Small-scale experiments for the low-mass regime

Axions – Goldstone boson of Peccei-Quinn symmetry that explains strong CP problem:

- Name „axion“ introduced by F. Wilzcek 1978.
- Hot candidates for cold dark matter.
- Not observed so far, but ...

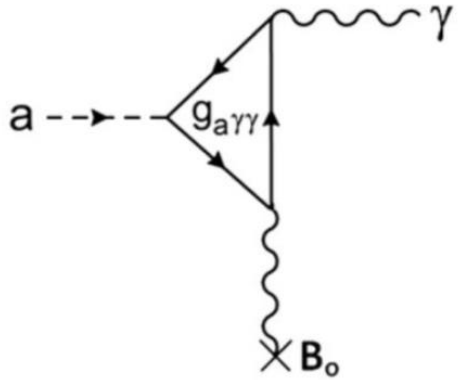
Numerous ways to search for them

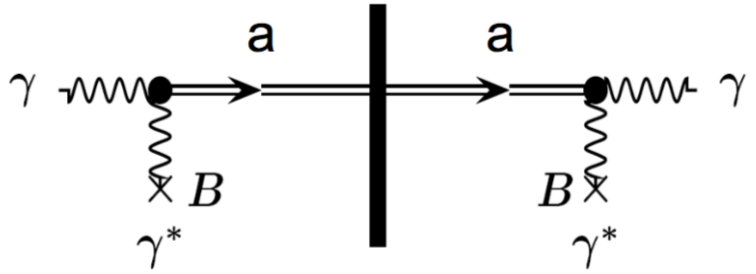
- Primakoff-like axion conversion in B field
- „Light-shining-through-a-wall“

➔ LSW, helioscopes, haloscopes

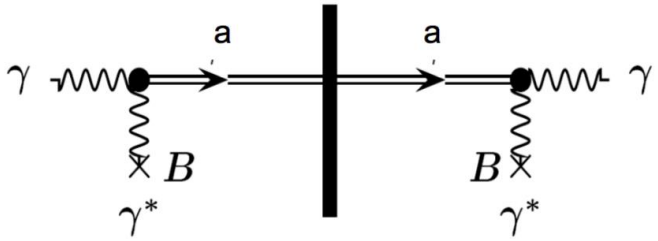
And many new experiments on the way ...

- See next slide!

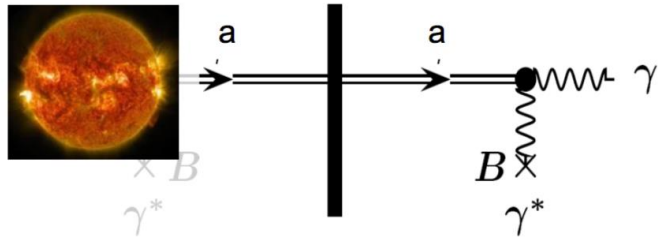




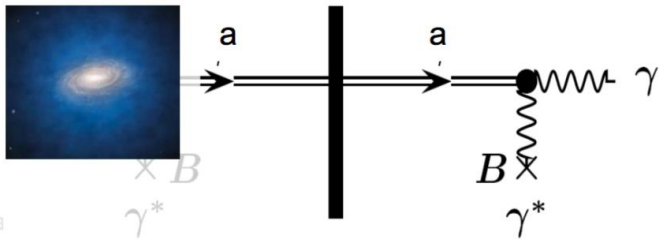
- Purely laboratory experiments
  “light-shining-through-walls”,
  optical photons



- Helioscopes
  ALPs emitted by the sun,
  X-rays,

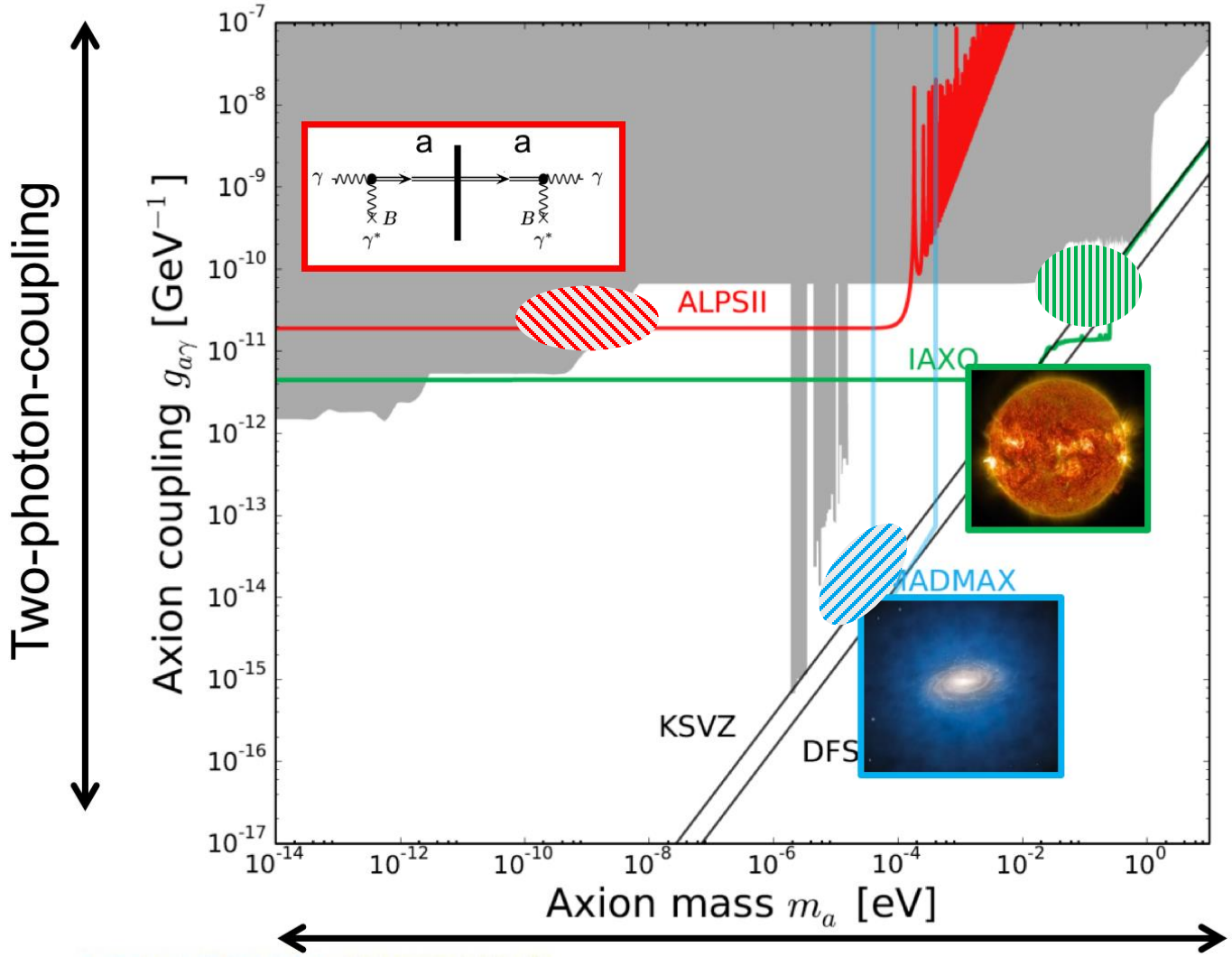


- Haloscopes
  looking for dark matter constituents,
  microwaves.



ALPS II + Other On-site Axion Experiments)

Reminder: Axion hotspots followed up at DESY



Three main regions of interest:

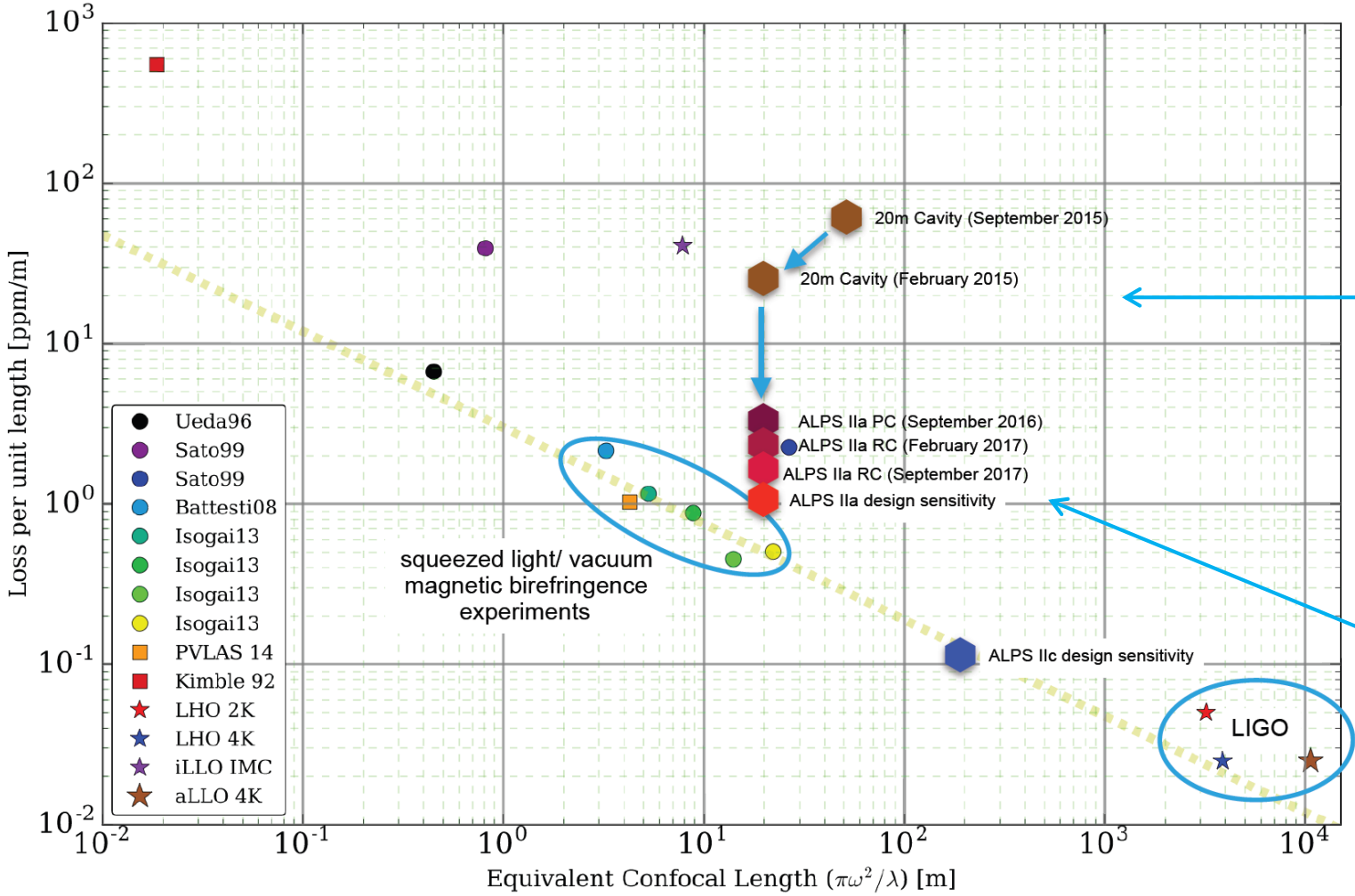
- Axion-like particles:
  TeV transparency, stellar evolution,
  $m_a < 10^{-7}$eV, $g_{a\gamma} = O(10^{-11}\text{GeV}^{-1})$,
  ALPS II.

- QCD axions:
  CP, stellar evolution, (dark matter),
  $m_a = O(10^{-3}\text{eV})$, $g_{a\gamma} = O(10^{-11}\text{GeV}^{-1})$,
  IAXO.

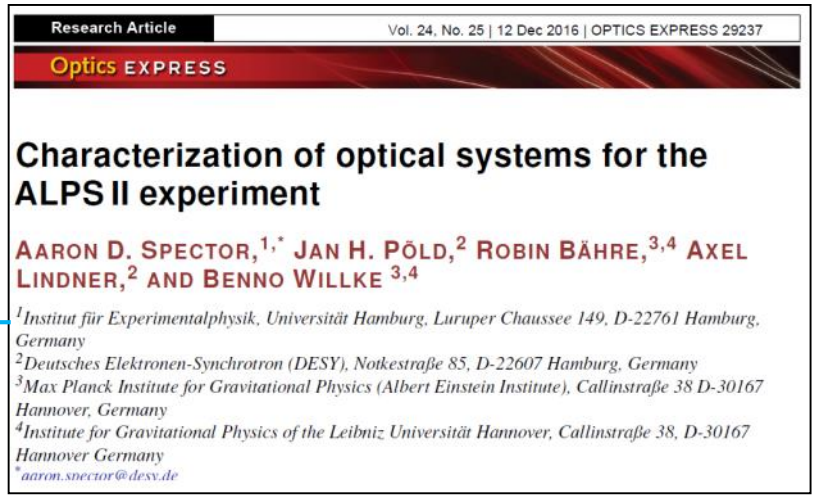
- QCD axions:
  CP, dark matter,
  $m_a = O(10^{-5}\text{eV})$, $g_{a\gamma} = O(10^{-14}\text{GeV}^{-1})$,
  MADMAX

ALPS II Progress at DESY

Optics status



plot from LIGO T-1400226-v6



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Characterization of optical systems for the ALPS II experiment

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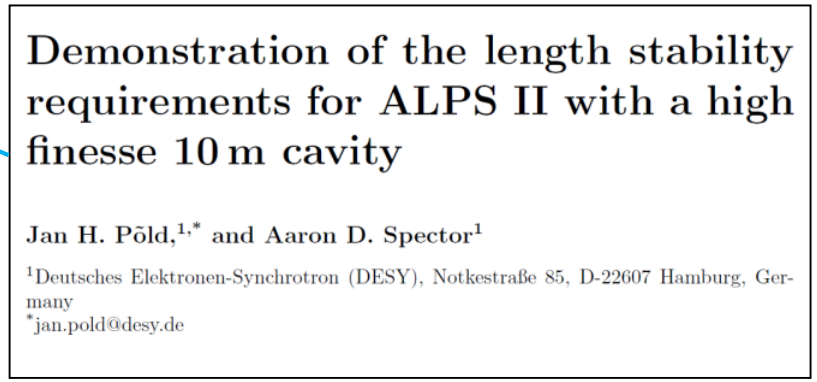

Demonstration of the length stability requirements for ALPS II with a high finesse 10 m cavity

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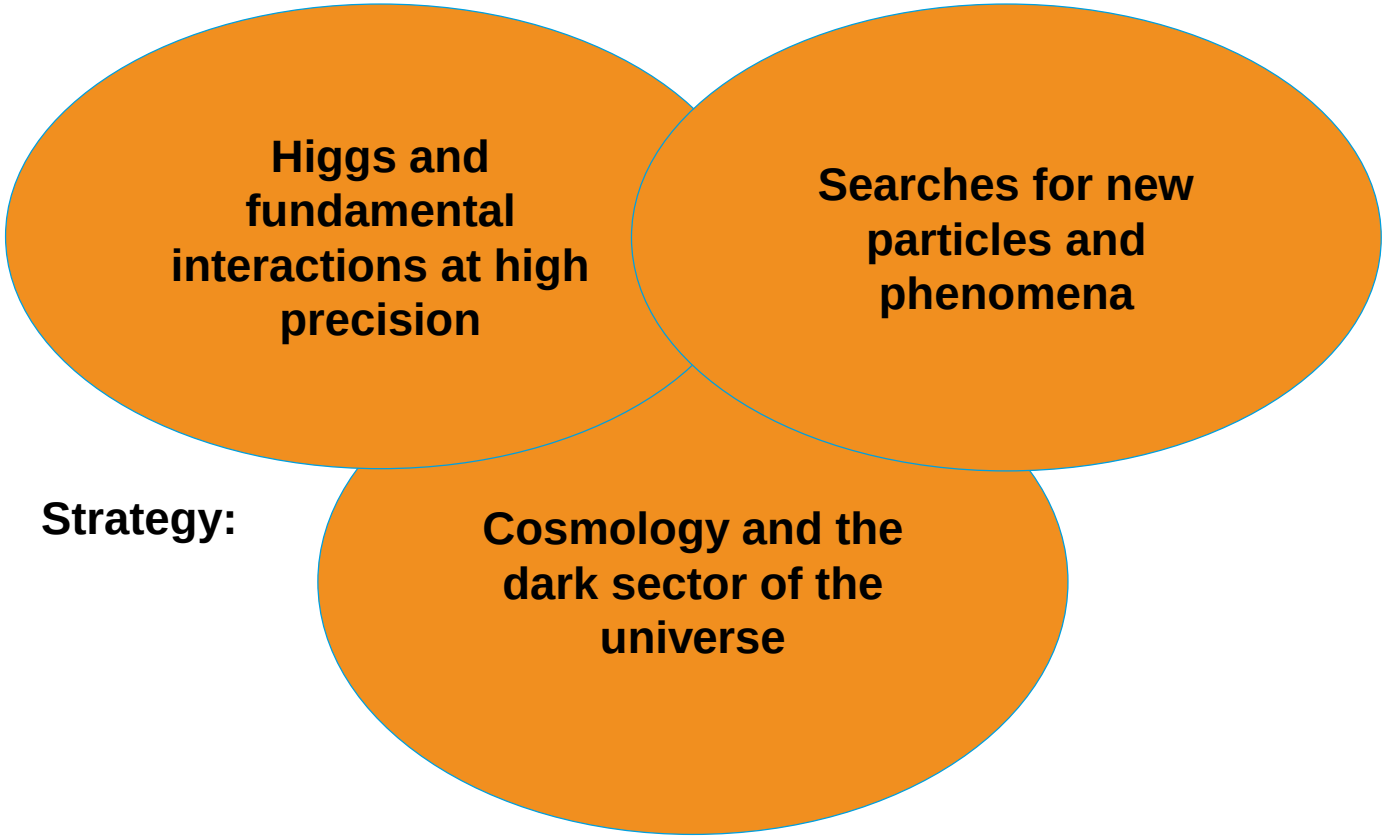
Strategy DESY-2030

Particle Physics in the next funding period (2021 -2027)

Science drivers:

- Structure of the vacuum
- Nature of the Higgs boson
- Theory beyond SM
- Dark matter
- (Anti)Matter asymmetry

Strategy:



Conclusions

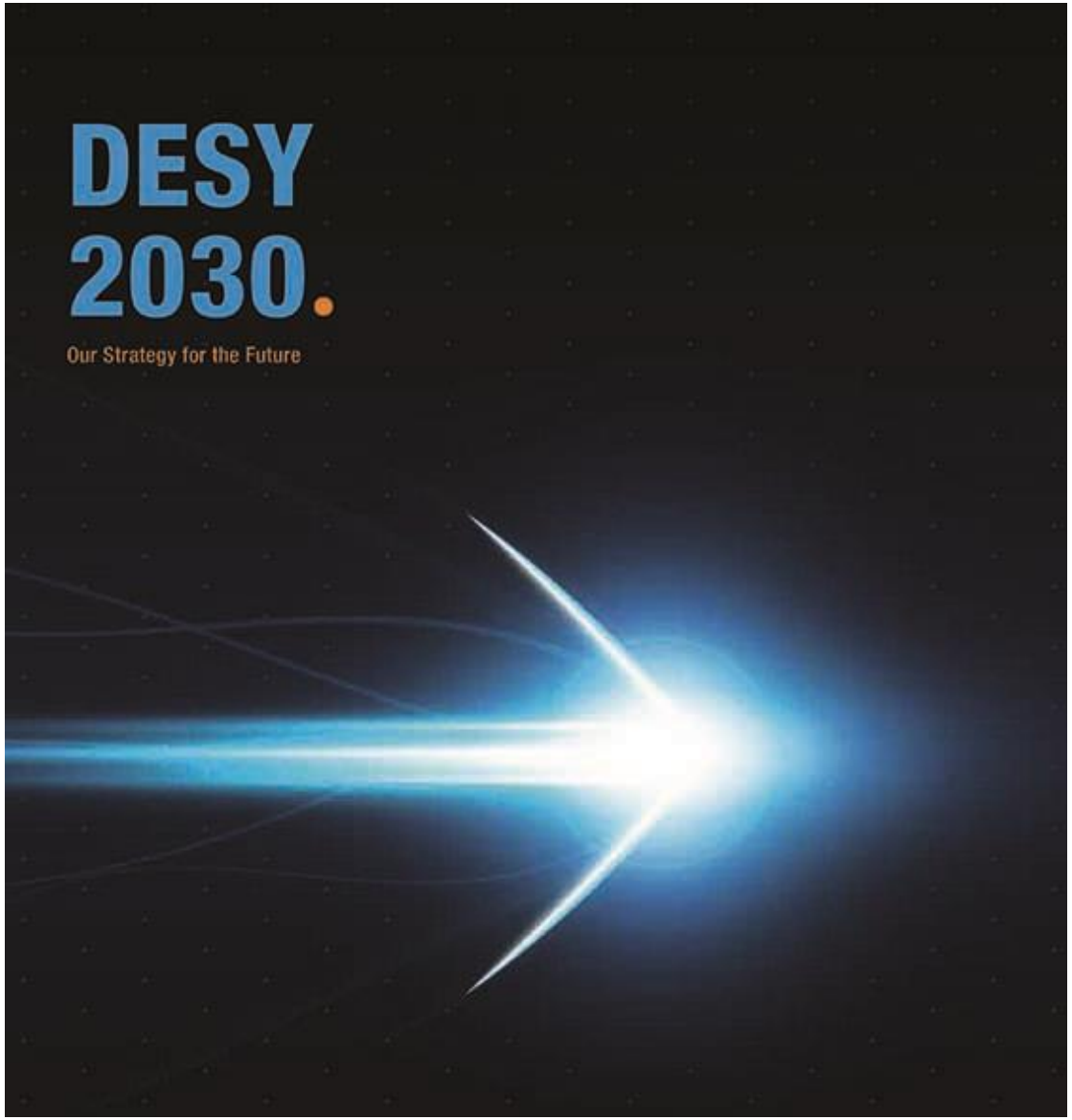
XFEL regular user operation started

DESY strategy process DESY-2030 finalised

- well aligned with outcome of German particle physics strategy process
- Eagerly waiting for European strategy process and for signal from Japan on the ILC

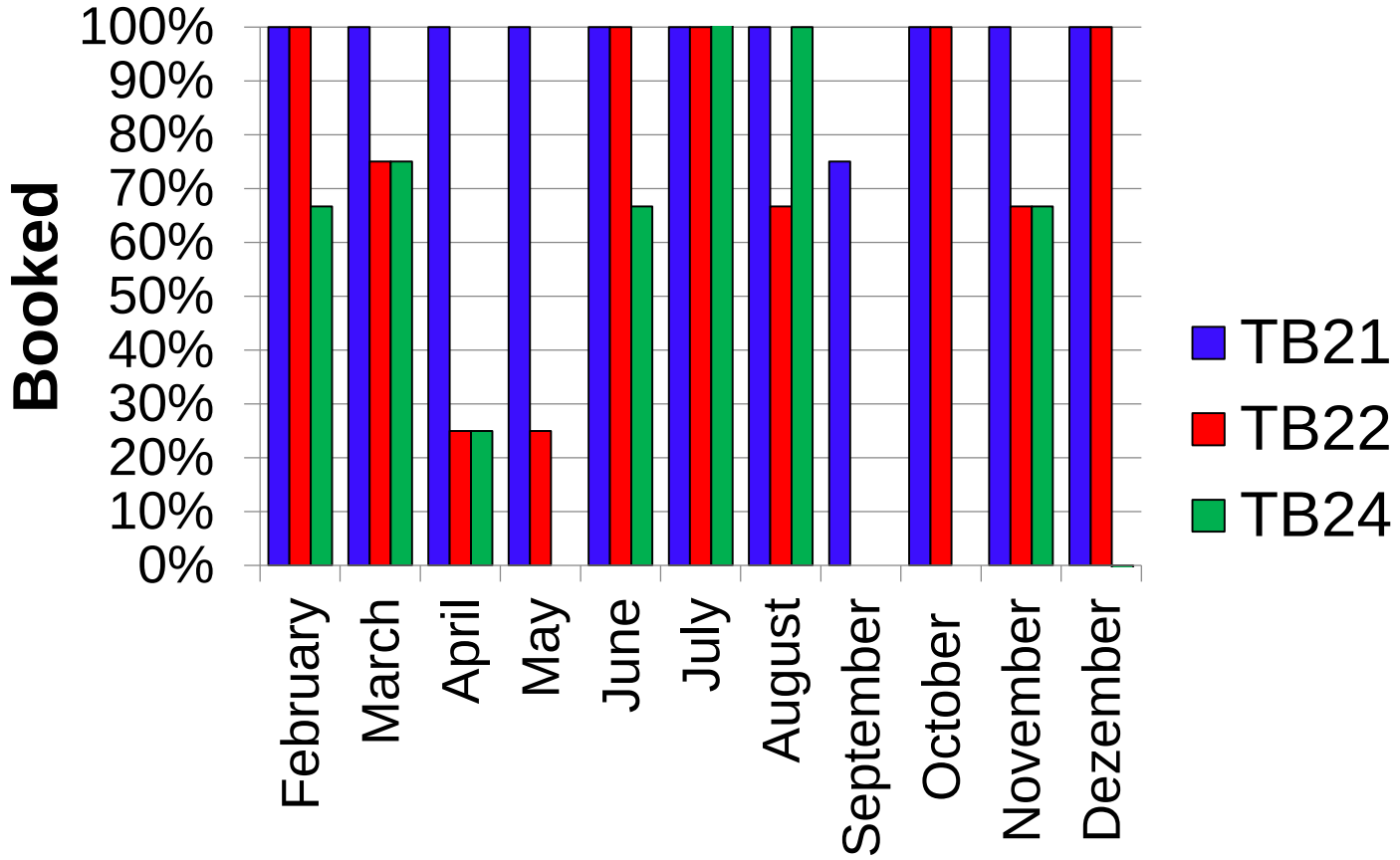
In detail:

- LHC upgrades and DAF proceeding as planned
- ALPS II well on the way for data taking in 2020
- DESY II testbeam:
  - New ideas for high-rate particle beams
- Ideas for future experiments getting more concrete, particularly on axions & QED tests
  - IAXO, MADMAX, LUXE
  - ILC, DUNE

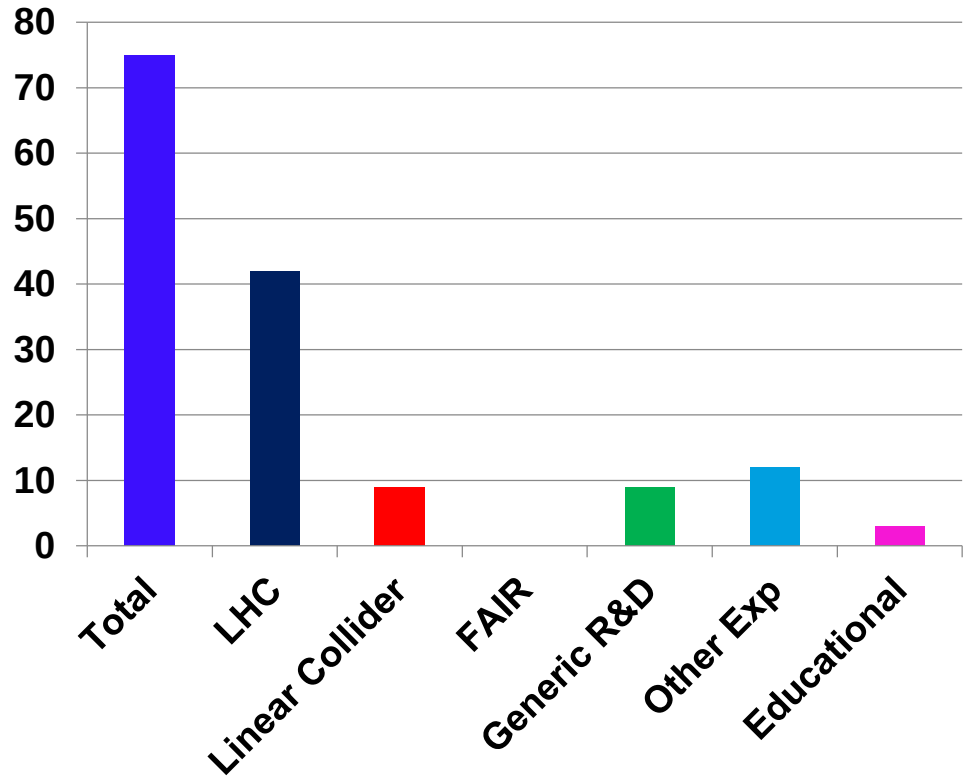


Test Beam Facility

Some more statistics …



Beam line usage per beam line



Allocated weeks in 2018