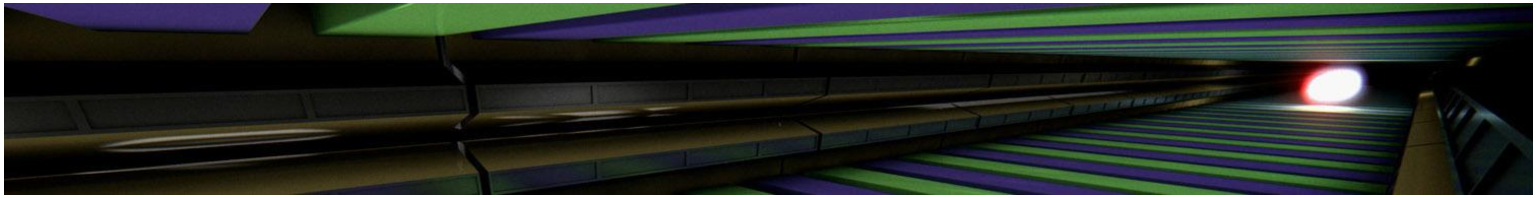


STATUS OF THE EUROPEAN XFEL

CONSTRUCTING THE 17.5 GEV SUPERCONDUCTING LINEAR ACCELERATOR

Winfried Decking, DESY

for the European XFEL Accelerator Consortium

- Up to 17.5 GeV SC Linac, 27000 pulses per second

[redacted]

- Up to 17.5 GeV SC Linac, 27000 pulses per second
- Three moveable gap undulators for hard and soft X-rays

- Up to 17.5 GeV SC Linac, 27000 pulses per second
- Three moveable gap undulators for hard and soft X-rays
- Initially 6 equipped experiments

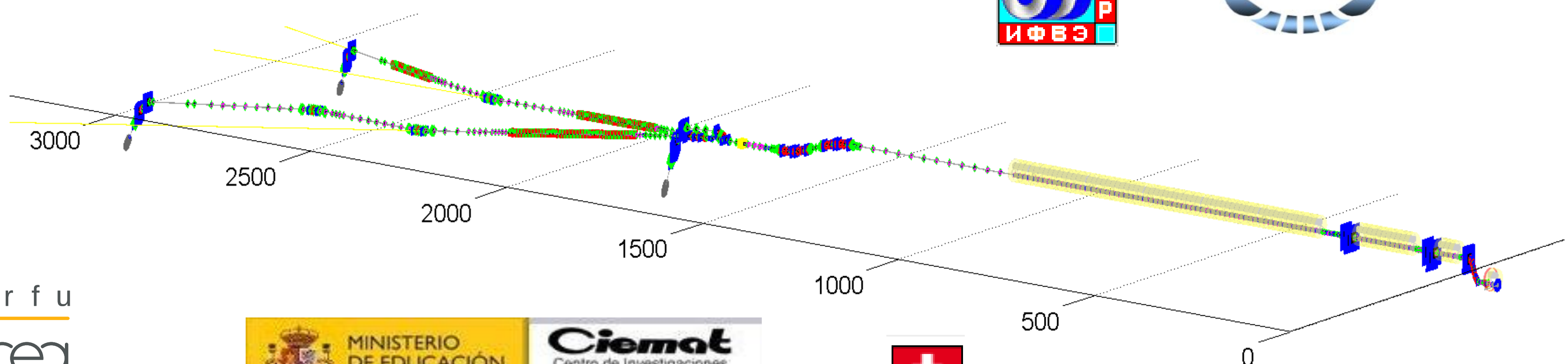
- Built by 12 European Nations at DESY, Hamburg
- Budget 1.150 MEuro incl. preparation and commissioning

Parameters

Quantity	Value
electron energy	10.5/14/17.5 GeV
macro pulse repetition rate	10 Hz
RF pulse length (flat top)	600 μs
bunch repetition frequency within pulse	4.5 MHz
bunch charge	0.02 – 1 nC
electron bunch length after compression (FWHM)	2 – 180 fs
Slice emittance	0.4 - 1.0 mm mrad
beam power	500 kW
# of modules (containing eight 9-cell superconducting 1.3 GHz cavities)	101
accelerating gradient for 17.5 GeV	23.6 MV/m
# of 10 MW multi-beam klystrons	27
average klystron power (for 0.03 mA beam current at 17.5 GeV)	5.2 MW
photon wavelength	0.05 – 4 nm

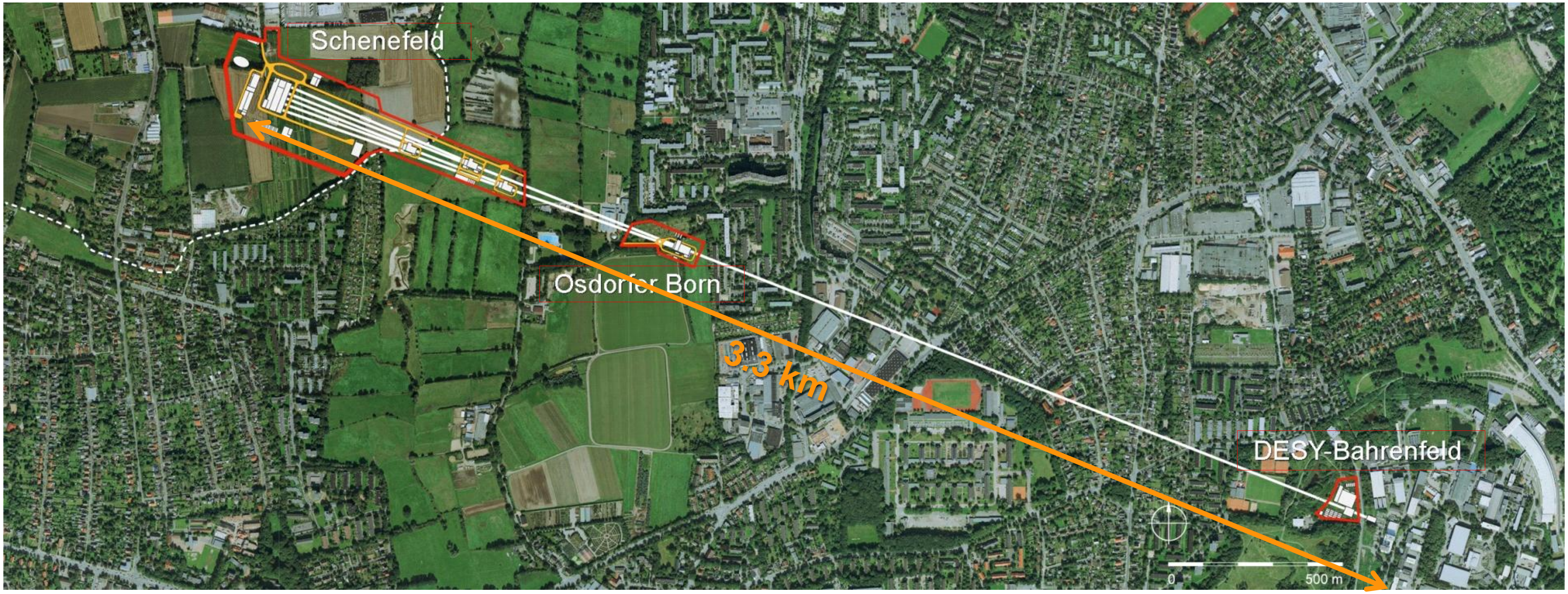
Accelerator Consortium: 16 Institutes that construct the Accelerator 'In-Kind'

DESY
HELMHOLTZ ASSOCIATION
Stockholm University
UPPSALA UNIVERSITET
ИФВЭ IHEP



irfu
cea
saclay
cnrs
In2p3
MINISTERIO DE EDUCACIÓN Y CIENCIA
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
UNIVERSIDAD POLITECNICA MADRID
PAUL SCHERRER INSTITUT
PSI
INFN
Istituto Nazionale di Fisica Nucleare
UNIVERSITAS STUDIORUM MEDIOLANENSIS
ifj
Wrocław University of Technology
NARODOWE CENTRUM BADAŃ JĄDROWYCH
Świerk

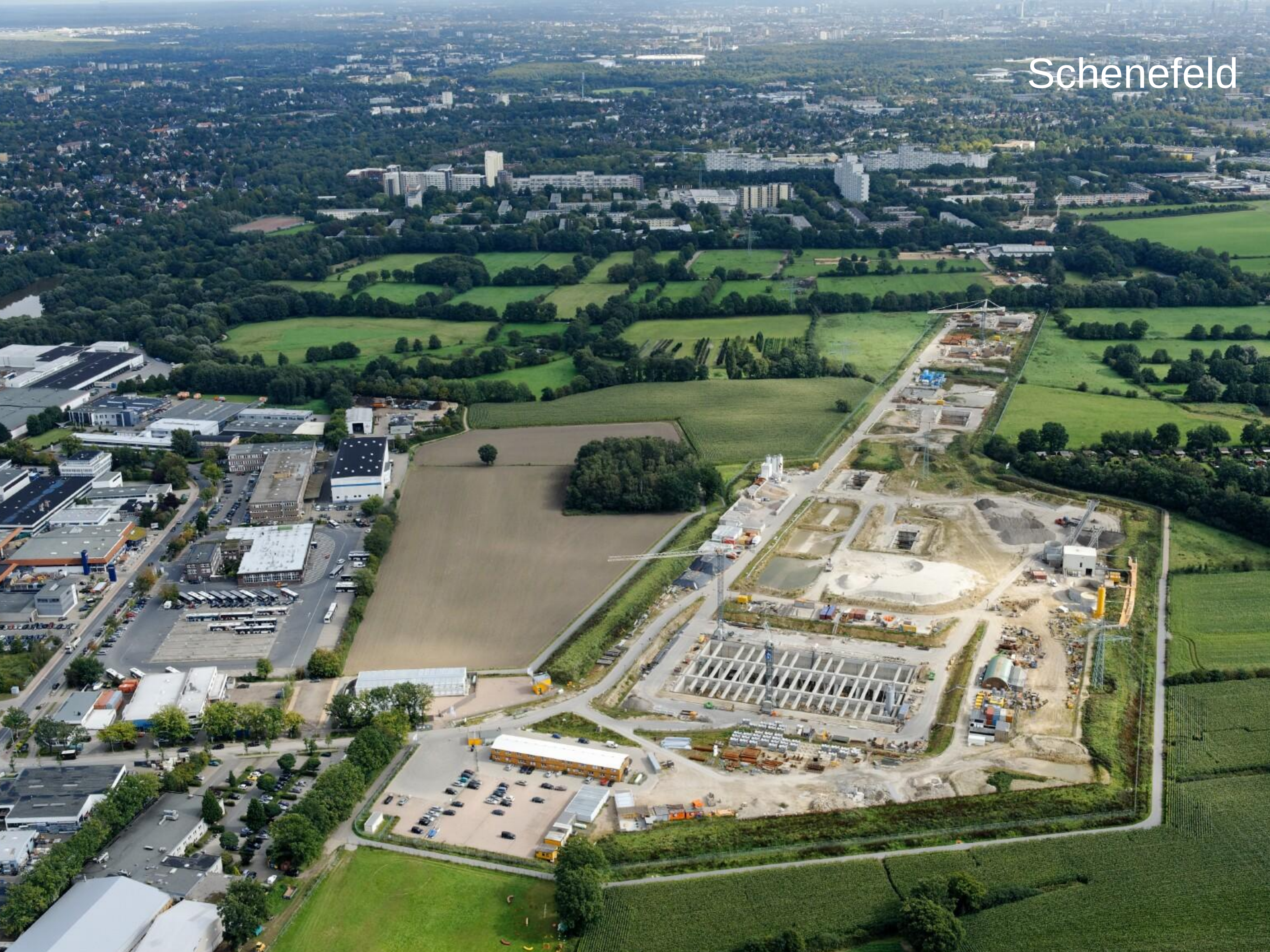
Civil Construction Status



- Three construction sites
- 5.8 km tunnels
- 12000 m^2 surface are buildings
- 150000 m^3 of underground building volume


DESY

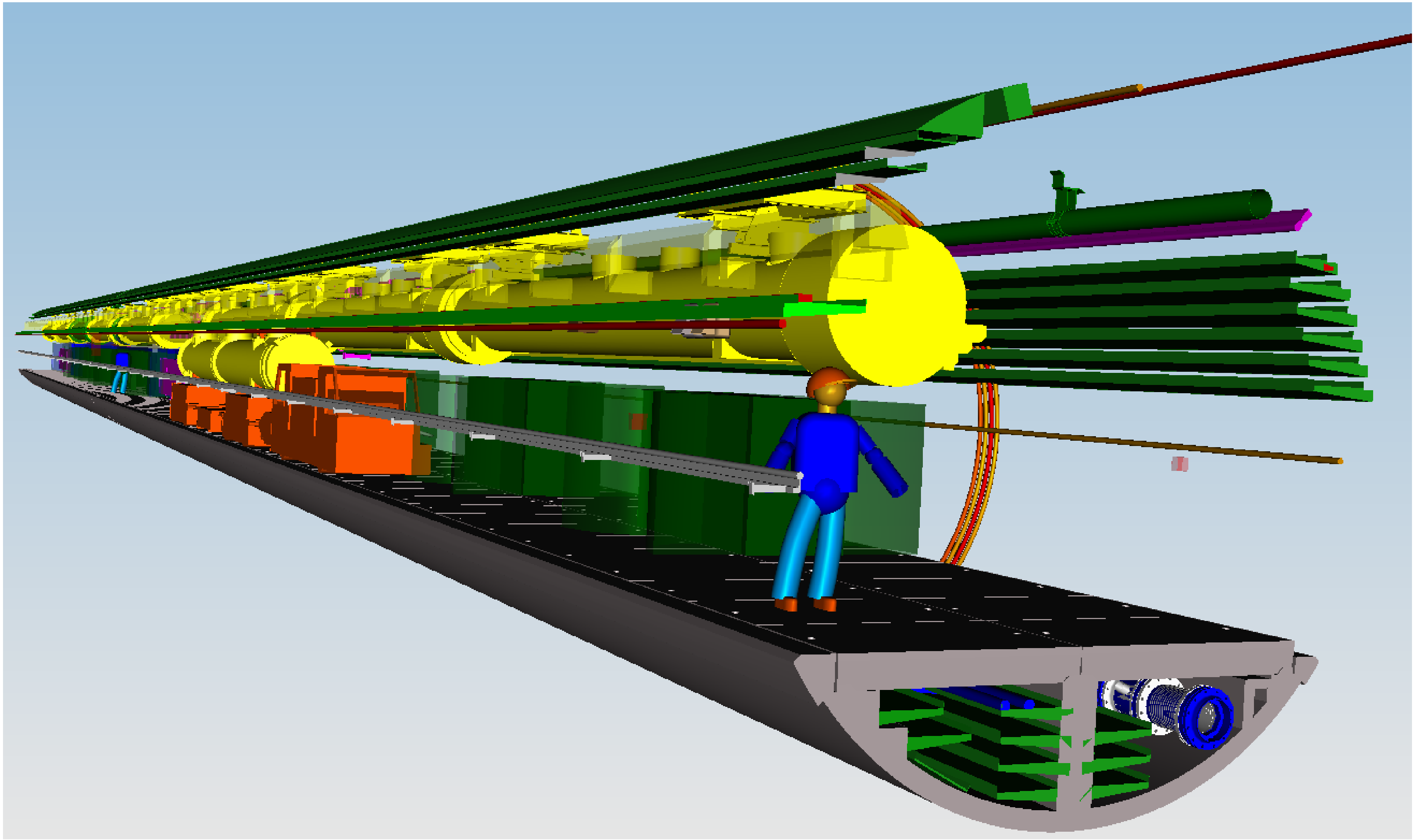

Osdorfer Born


Schenefeld

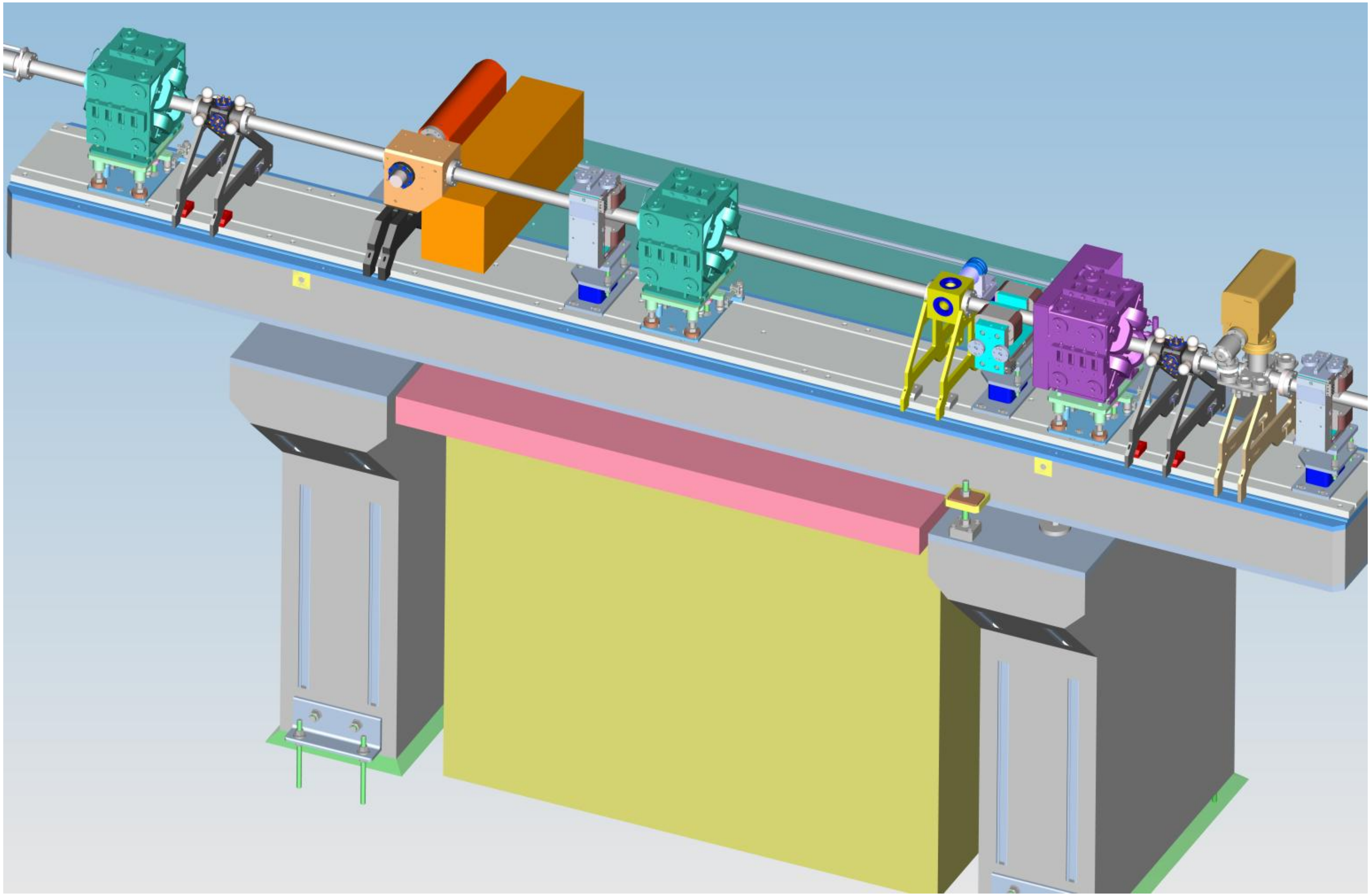

Schenefeld
Experimental Hall
BILFINGER BERGER
STARLIFT


4 June 2012
Tunnel breakthrough
All tunneling finished

CAD Model of LINAC installation

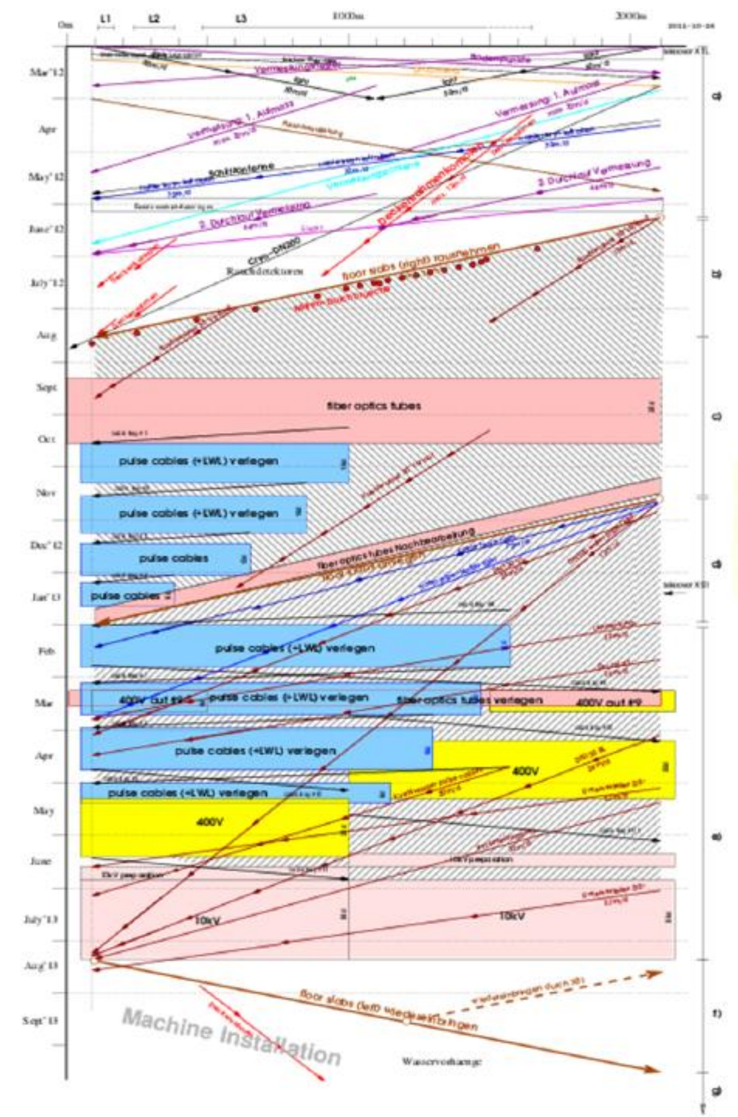


Accelerator Installation – Warm Beamlines



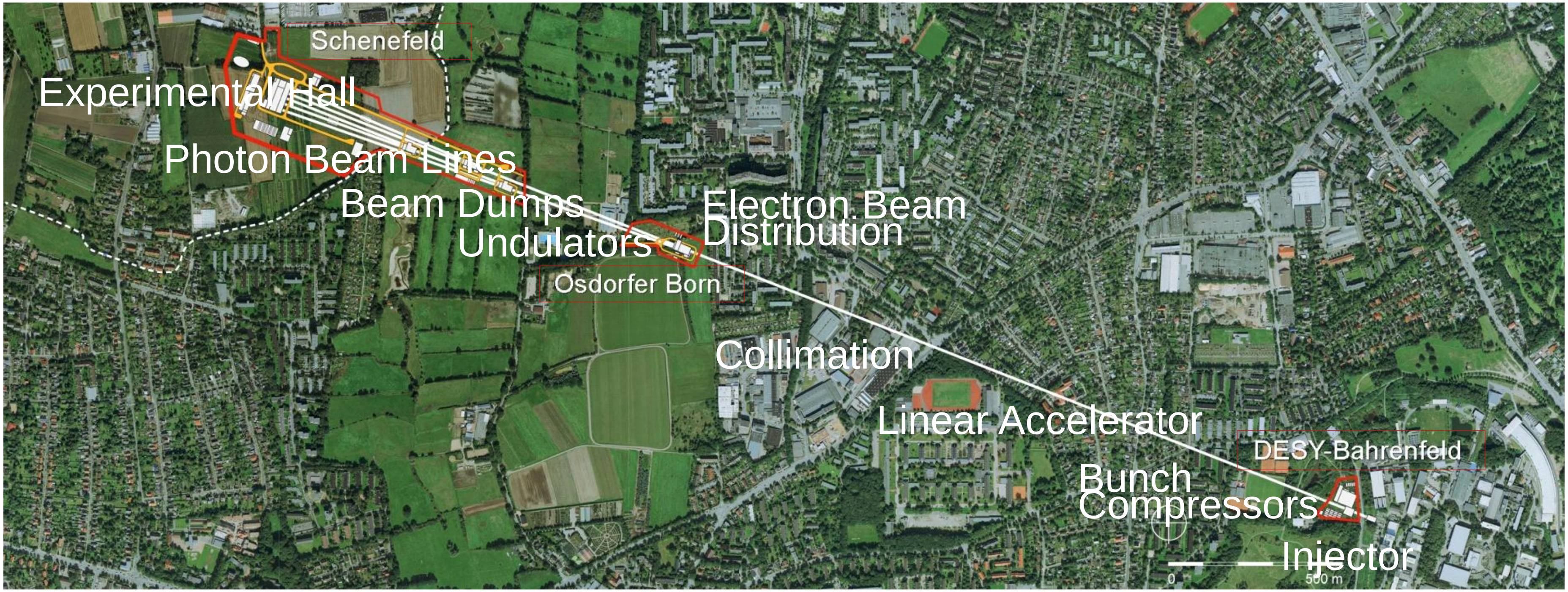
Technical Infrastructure Installation

- Detailed planning of needed infrastructure previous to tendering and installation
- Installation has started in main linac tunnel Q1/2012
- Planning diagram shows
  - when, where and how long a task takes place
  - which tasks can go on in parallel (or not)



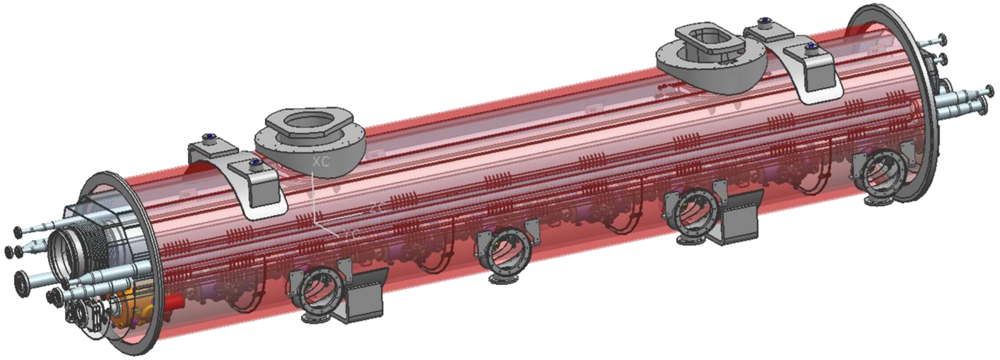
TUPB015 Markus Huening (DESY)
Warm Beamlines and Infrastructure in the European XFEL

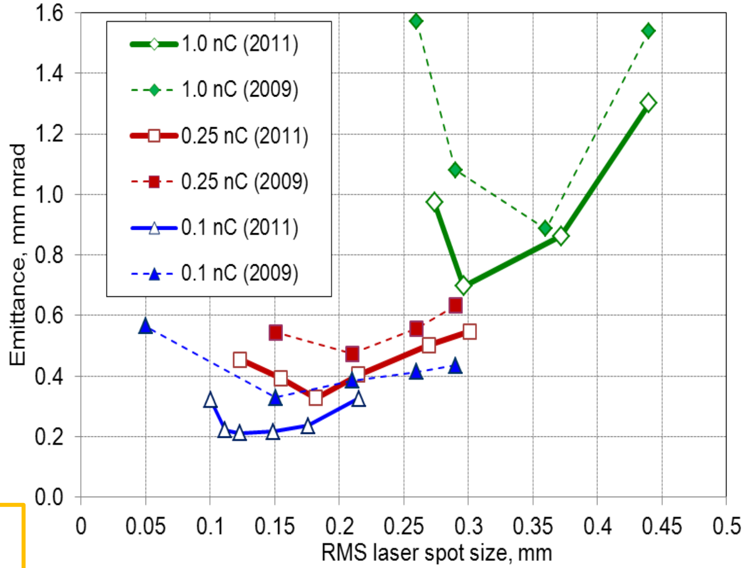
European XFEL at a Glance



Injector

- Gun development at PITZ, DESY Zeuthen
- New best values for emittance achieved
- XFEL gun cavity starts to be conditioned in autumn 2012
- 3.9 GHz accelerator module (for bunch length control), design finished, prototype cavities in test

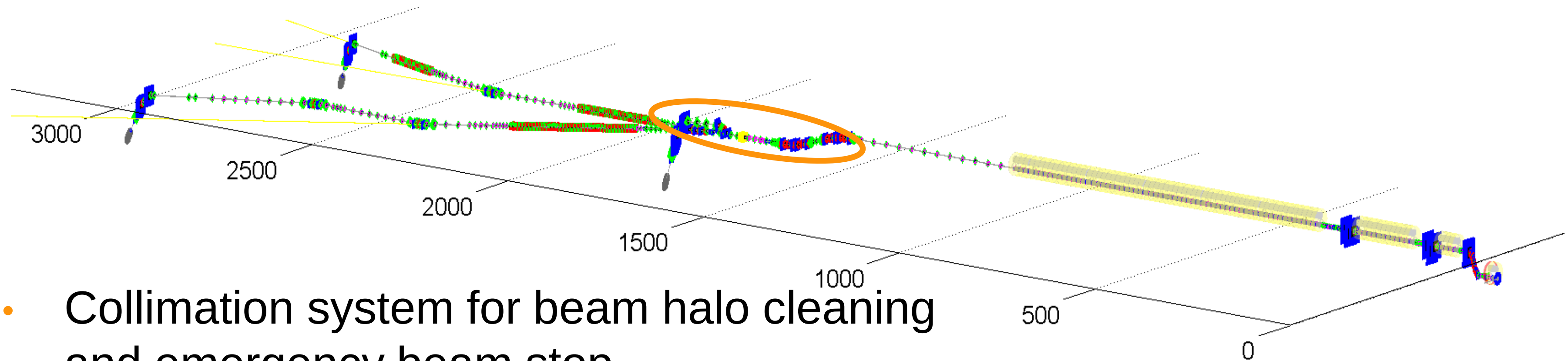




TUPB020 Elmar Vogel (DESY)
Status of the European XFEL 3.9 GHz system

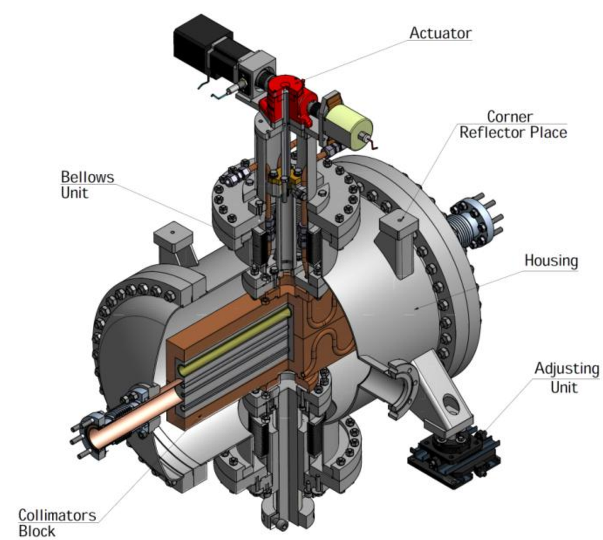
MOPB015 Igor Isaev (DESY)
Multipactor Discharge Simulation for the RF Photo Gun at PITZ

Collimation & Beam Distribution



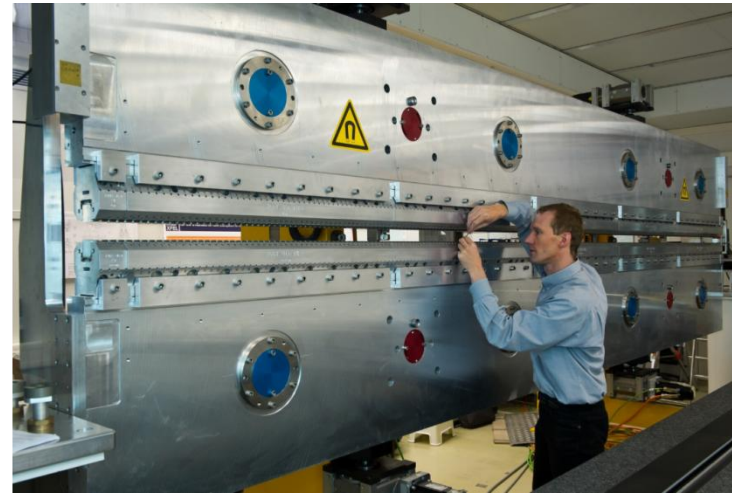
- Collimation system for beam halo cleaning and emergency beam stop
- Transvers Intra-Bunch Feedback
- Flexible beam distribution system for quasi-simultaneous operation of two primary electron beam lines

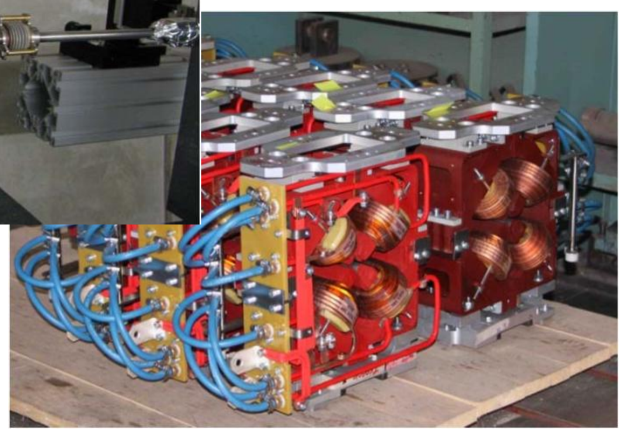
XFEL Collimator



European XFEL – Undulators

- Series production of 90 undulators started
- Focusing quadrupoles manufactured and precision fiducialization
- Series production of intersection components started





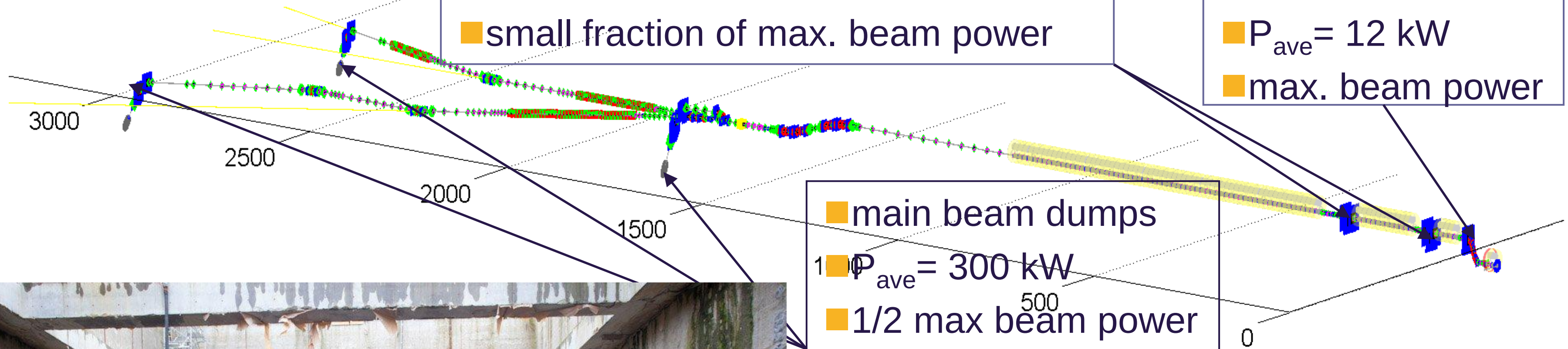
THPB089 Iván Moya (CIEMAT)
Magnetic Characterization of the First Phase Shifter Prototypes Built by CIEMAT for E-XFEL

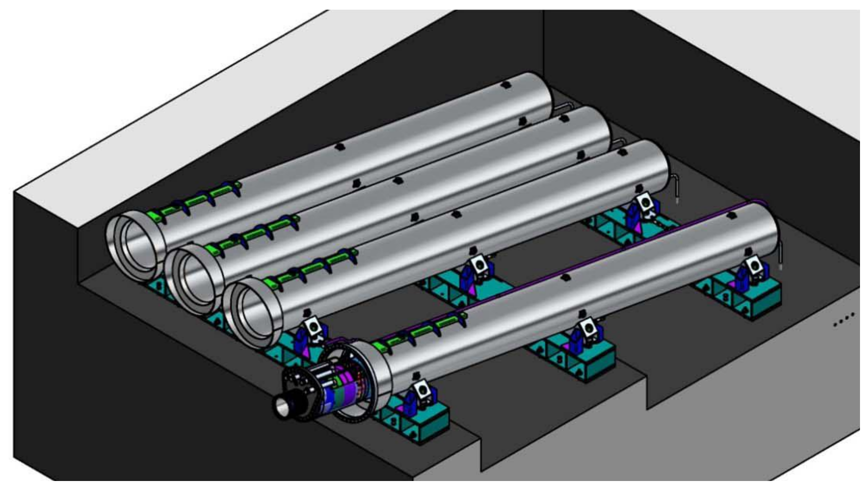
Beam Dumps

- bunch compressor diagnostic dumps
- 0.5 and 2.5 GeV
- small fraction of max. beam power

- injector dumps
- 130 MeV
- P_{ave}= 12 kW
- max. beam power

- main beam dumps
- P_{ave}= 300 kW
- 1/2 max beam power





Superconducting Cavities

Cavity Material Supply

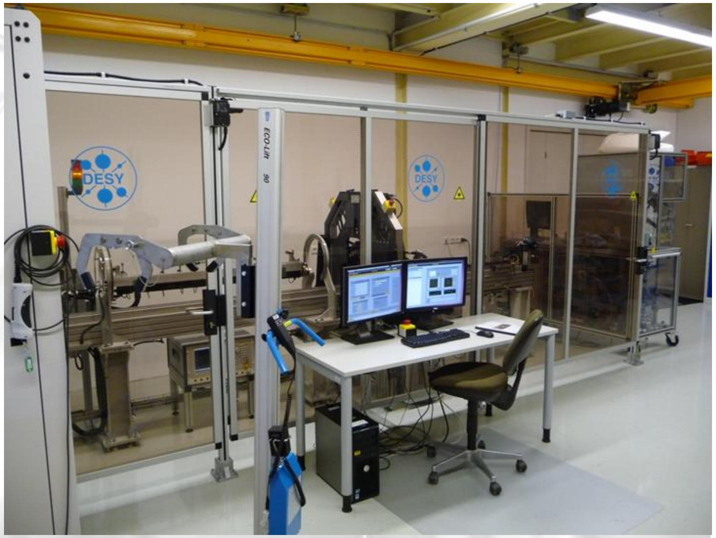
- Nb sheets and supplementing material purchased by DESY through 4 pre-qualified vendors
- **P**ressure **E**quipment **D**irective: Qualification of material, certification of QM, supervision of production through notified body (TUEV Nord)
- Quality inspection of all semi-finished parts at DESY prior to shipment to companies
  - eddy current scanning
  - tactile 3d measurements
- 70% - 100% material already delivered to companies

Acceptance of Nb sheets at Ningxia OTIC (courtesy of NOTIC)

Eddy current scan at DESY

Mechanical fabrication

- Mechanical fabrication at RI & Zanon
  - deep drawing of half cells
  - welding of dumb bells
  - rf measurements
  - e-beam welding of 9-cell cavities
- Process qualification through production of reference cavities (RC) and dummy cavities (DC)



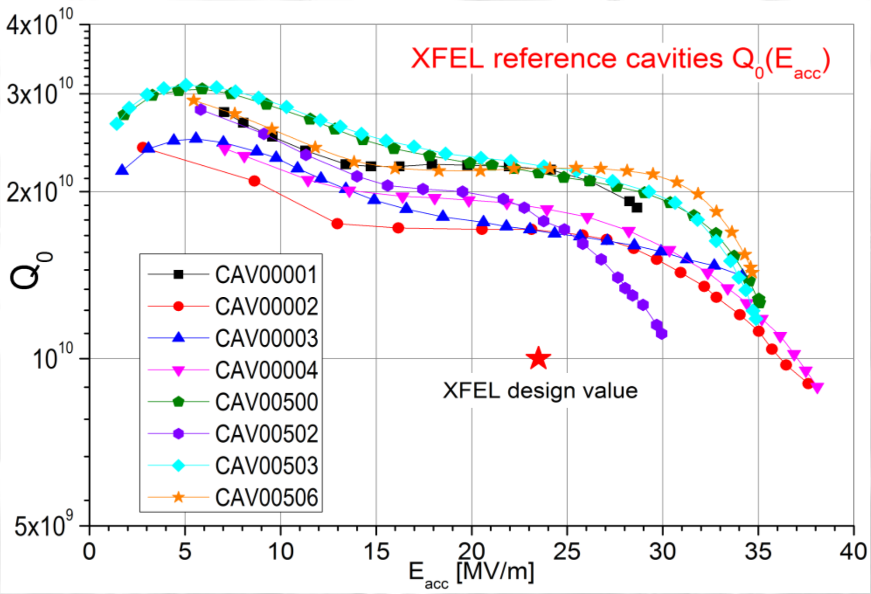
RF measurement and tuning equipment at RI

E-beam welding at Zanon (courtesy Zanon)

E-beam welding at RI (courtesy RI)

Mechanical fabrication

- All RCs and DCs produced and treated and RF tested at DESY



MOPB012 Alexey Sulimov (DESY)
First RF Measurement Results for the European XFEL SC Cavity Production

Fabrication of dumb-bells at RI (courtesy of RI)

Surface Treatment

- Installation of equipment for surface treatment at companies almost finished
- Qualification of surface treatment in multi-step process with intermediate RF tests at DESY this fall

Furnaces for 120º C baking (courtesy Zanon)

Ultrasonic Cleaning and BCP in ISO 10 clean room (courtesy Zanon)

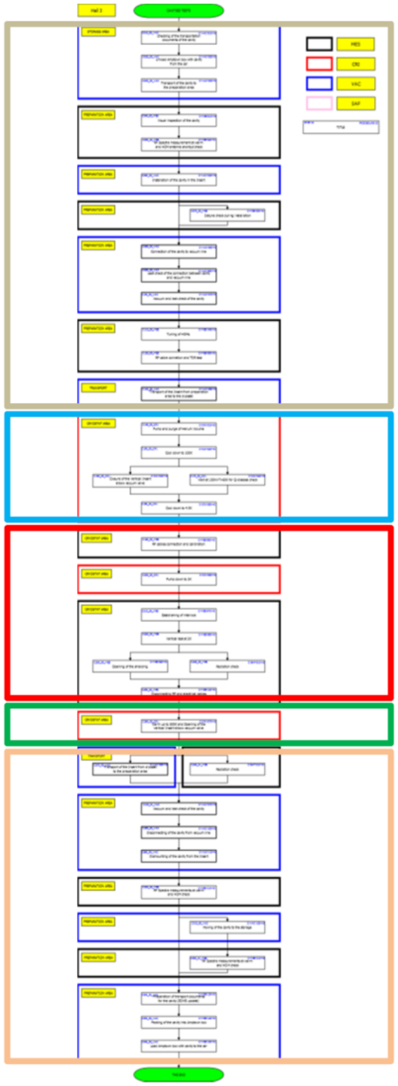
800º C annealing furnace (courtesy RI)

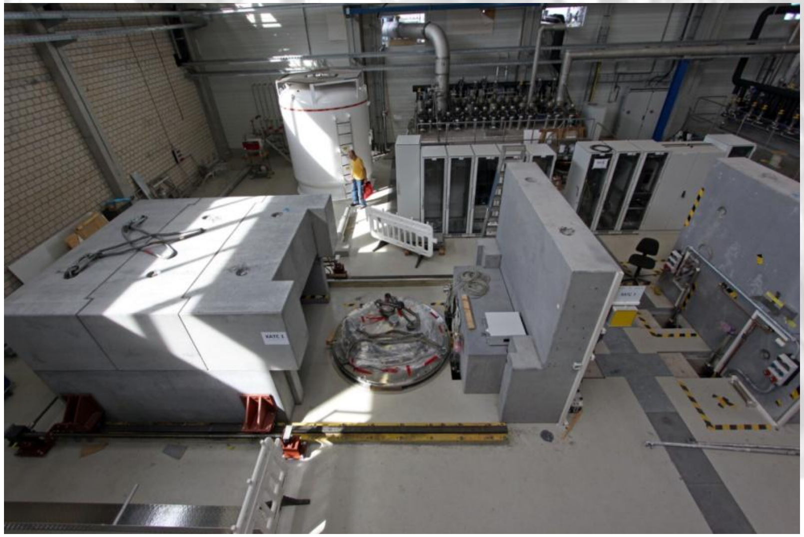
Cavity Measurements

- All 800 cavities CW power measured in vertical cryostat at AMTF
- Four cavities/cryostat
- Non-conforming cavities repaired at DESY infrastructure
- Conforming cavities shipped to Saclay

34 steps to perform

- Assembly
- Cool down
- RF test
- Warm up
- Disassembly





String Assembly

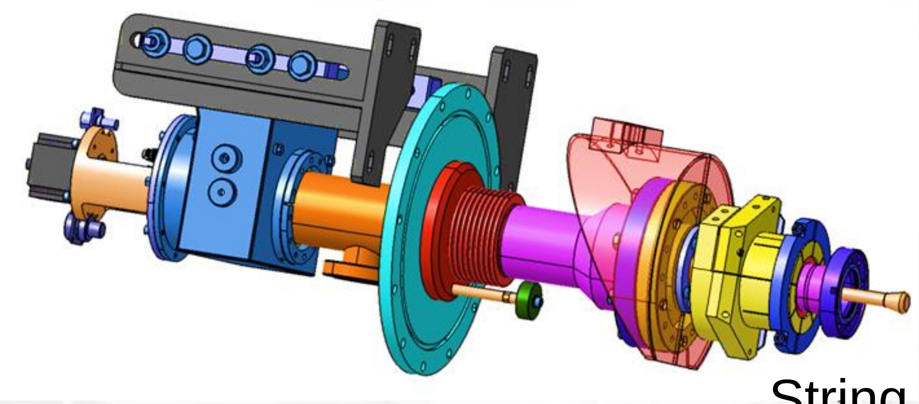
String Assembly

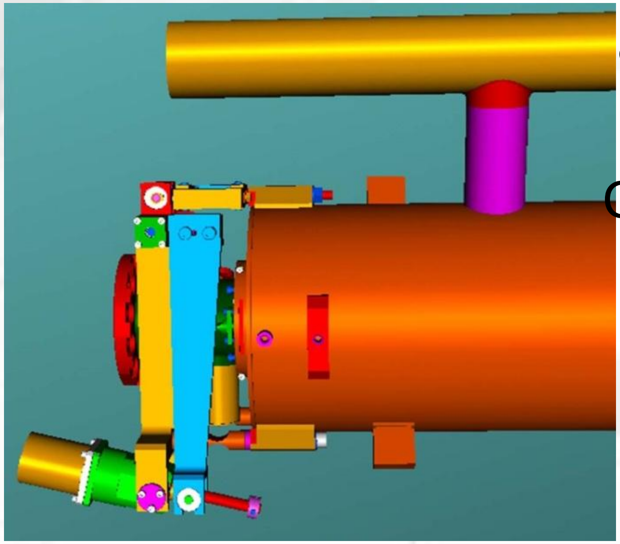
- Infrastructure installed at CEA Saclay (XFEL-Village) for string assembly
- Training of CEA staff with XFEL proto-type cavities
- Assembly will be performed by industrial operator
- Contract signed, training will start autumn this year

THPLB09 Thu 15:30 - 15:35,Catherine Madec (CEA Saclay)
Status of E-XFEL String and Cryomodule Assembly at CEA-Saclay

MOPB017 Elmar Vogel (DESY)
Integration of the European XFEL Accelerating Modules

String Assembly





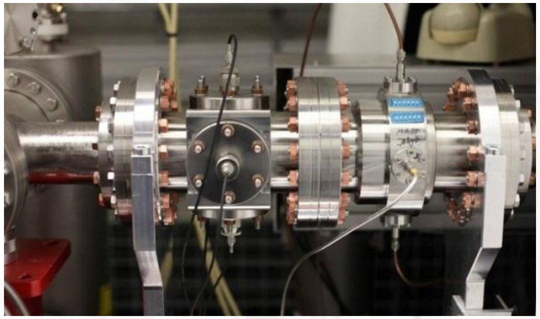
String Assembly

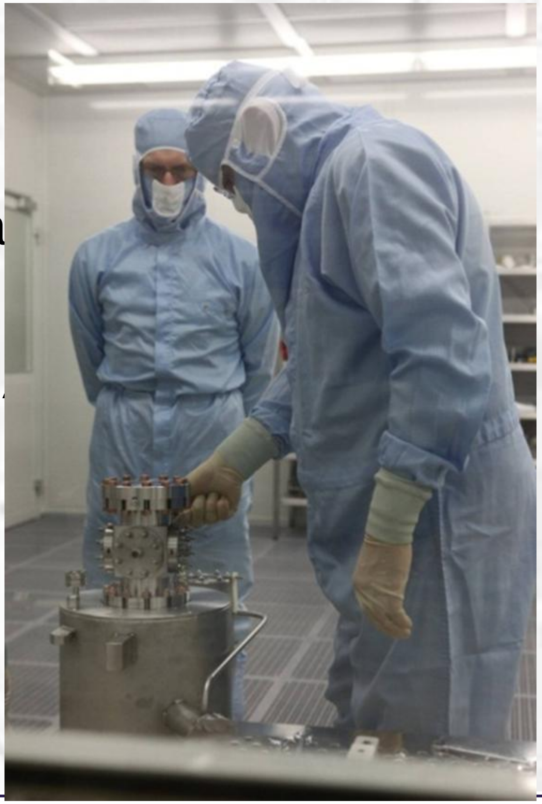
8 cavities

8 Power couples (LAL Orsa

8 Cavity tuners (DESY)

Quadrupole package (CIEM
Madrid & DESY

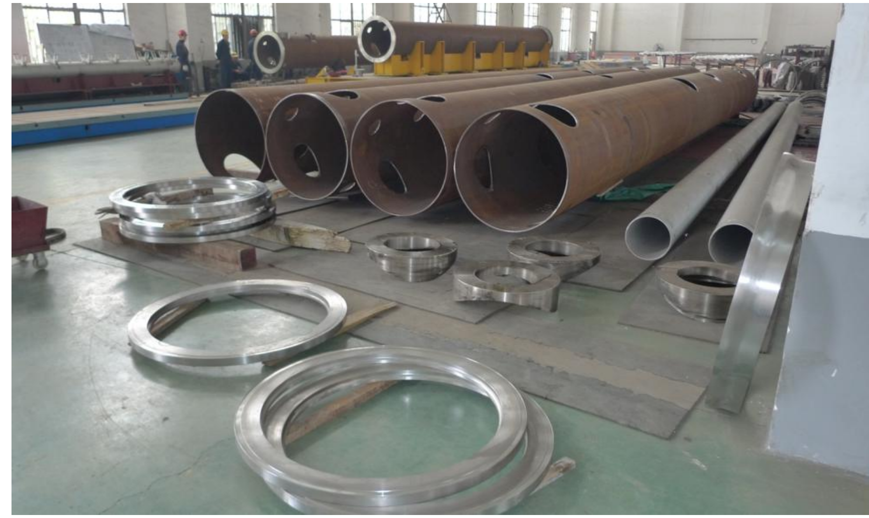




Module Assembly

Module Assembly

- Cold masses from IHEP and Zanon
- Assembly at CEA Saclay
- Tools and infrastructure ready
- Training of industrial operator starts autumn 2012



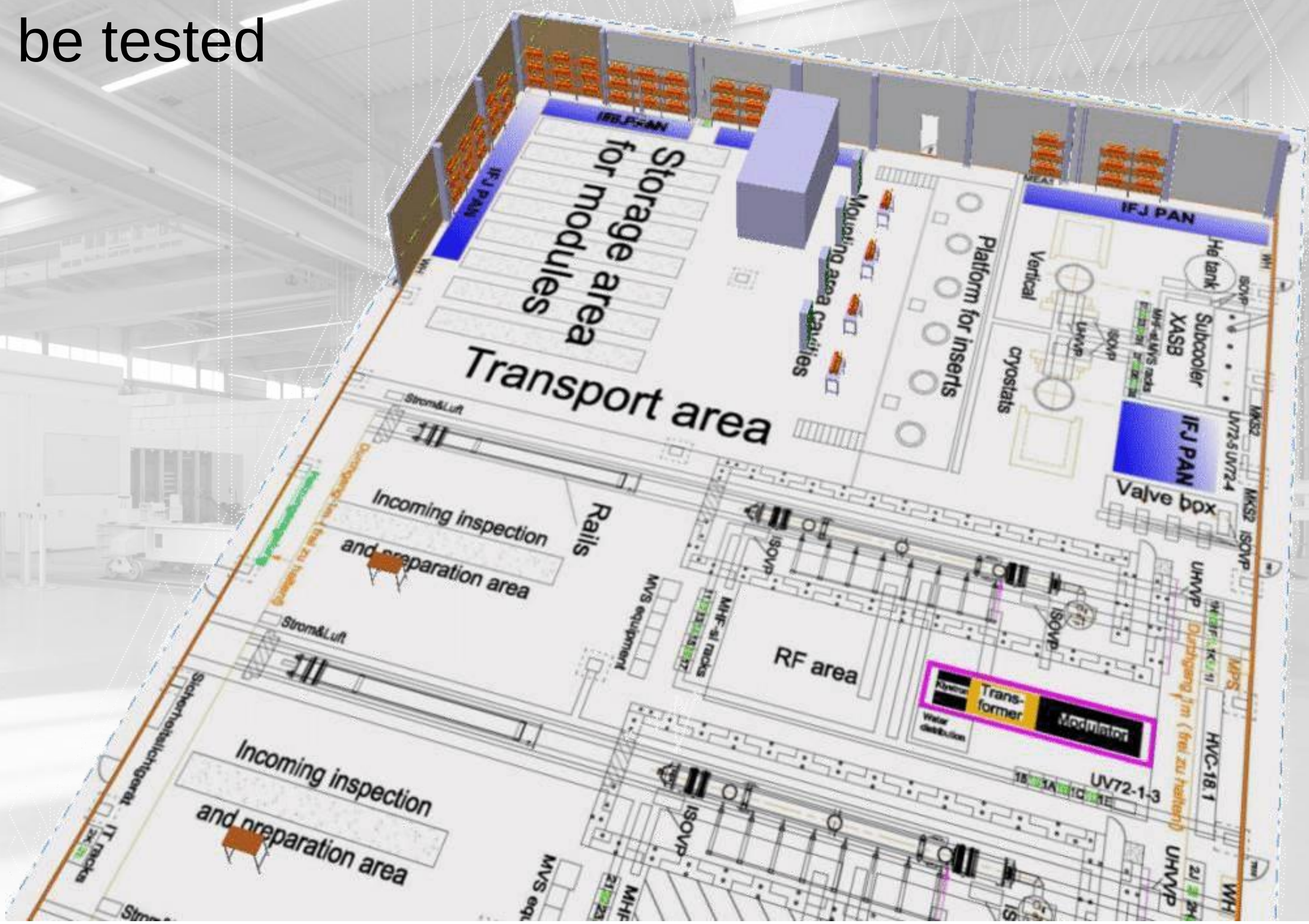
Module Assembly

- Assembly:
  - string connected to the He return pipe (cold mass)
  - components aligned
  - insulation and shields
  - insertion into cryostat
  - Assembly of warm coupler parts
  - transportation preparation: assembly of end-caps, nitrogen filling of the cavities and assembly of surveillance instrumentation
- Road transport from CEA Saclay to DESY for final testing

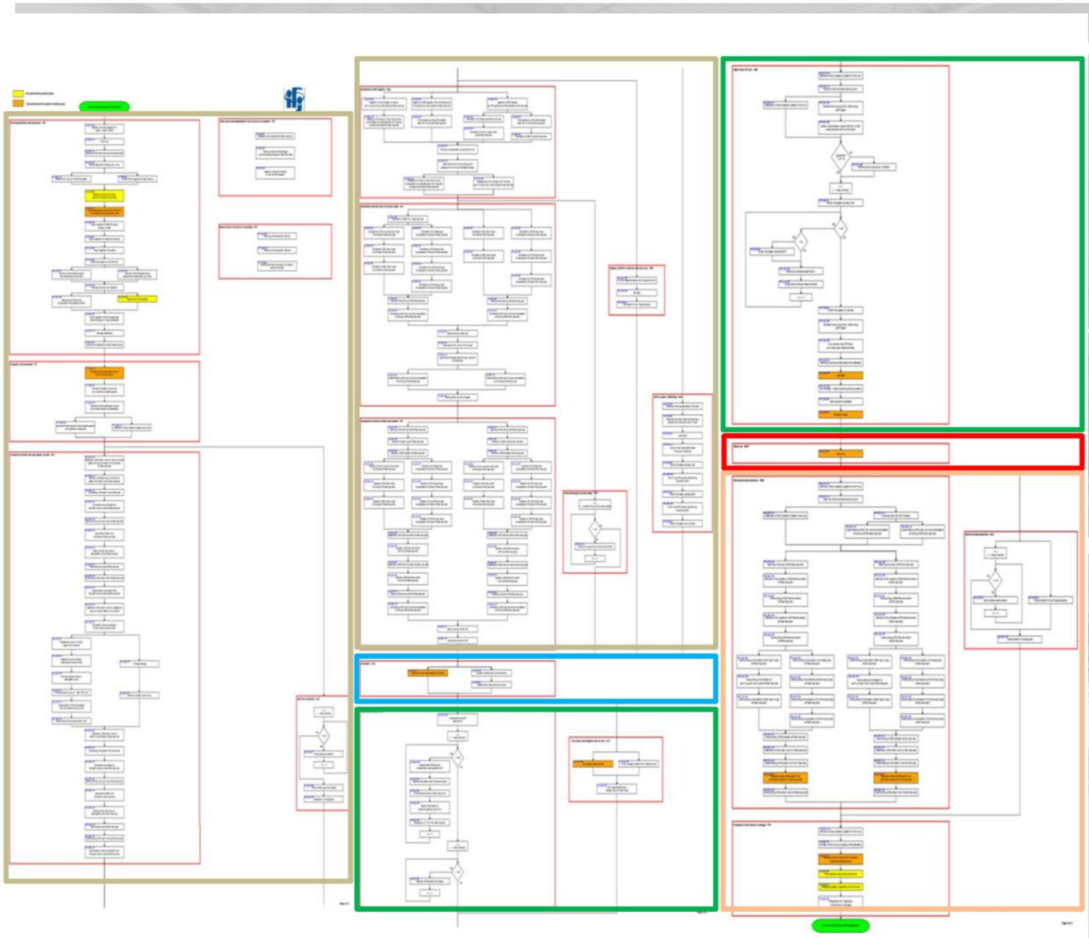
Module Testing

Accelerator Module Test Facility (AMTF)

- where the cavities and the modules will be tested



Flow Diagram of Module Test

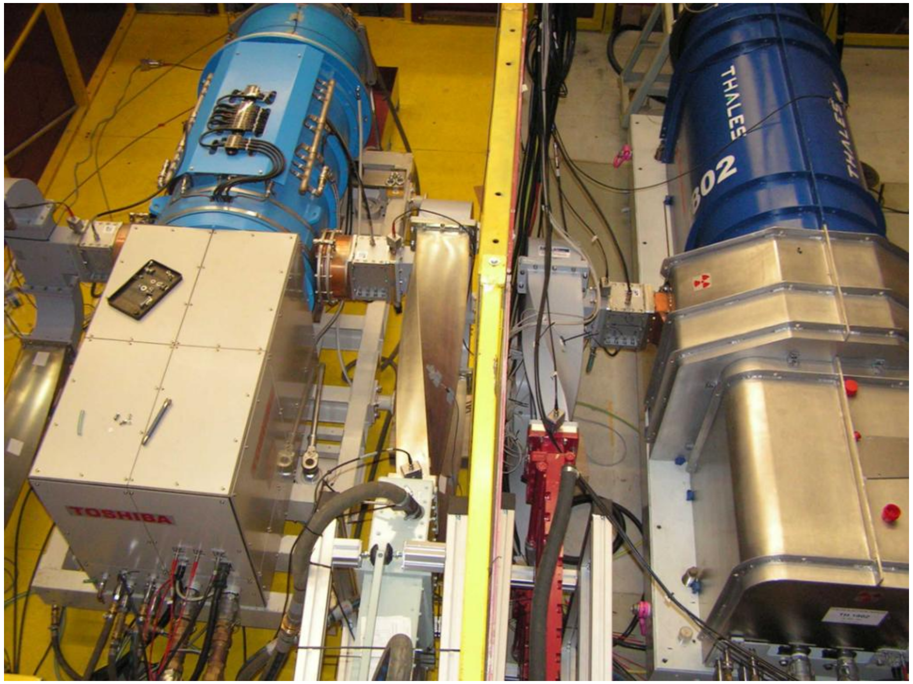


229 steps to perform:

- Assembly
- Cool down
- RF test
- Warm up
- Disassembly

- 2 weeks/module
- 3 test stands => 1 module/week tested
- Small fraction of non-conforming modules can be repaired at DESY

High Power RF System



- 10 MW multi-beam klystron
- Contract Awarded, first series klystrons delivered 8/2012

TUPLB04 15:05 - 15:10, TUPB004 Vladimir Vogel (DESY)
Results of Testing of Multi-beam Klystrons for the European XFEL

- Pulse Transformer and klystron installed in tunnel

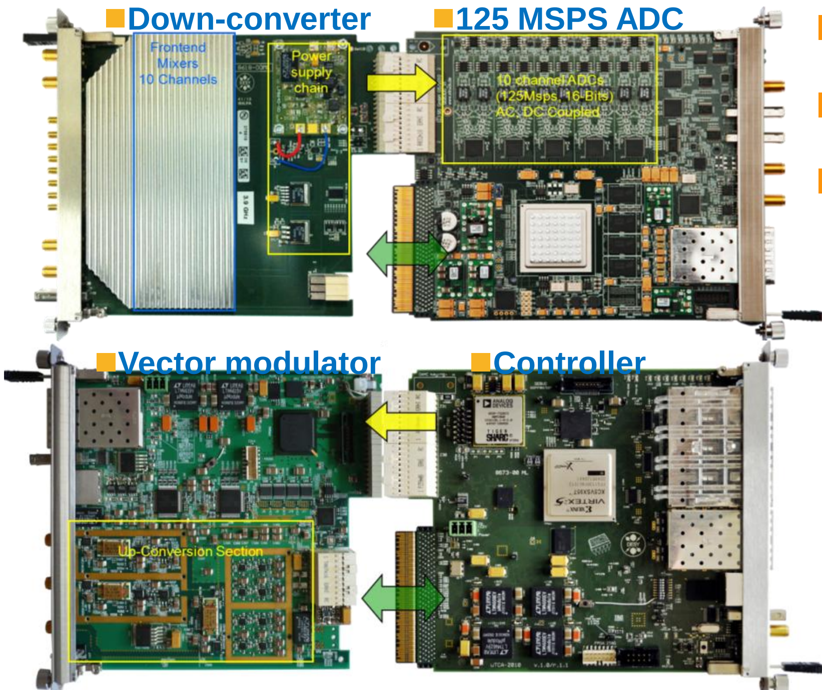
- Modulator installed on surface
- Connection with up to 2 km long pulse cables
- All components ordered, cable installation starts next month

Waveguide Distribution

- Pre-installed in AMTF
- AMTF wave-guide test are
- the call for tender started with specified delivery date of first waveguide distribution system in in autumn 2012

Low Level RF System

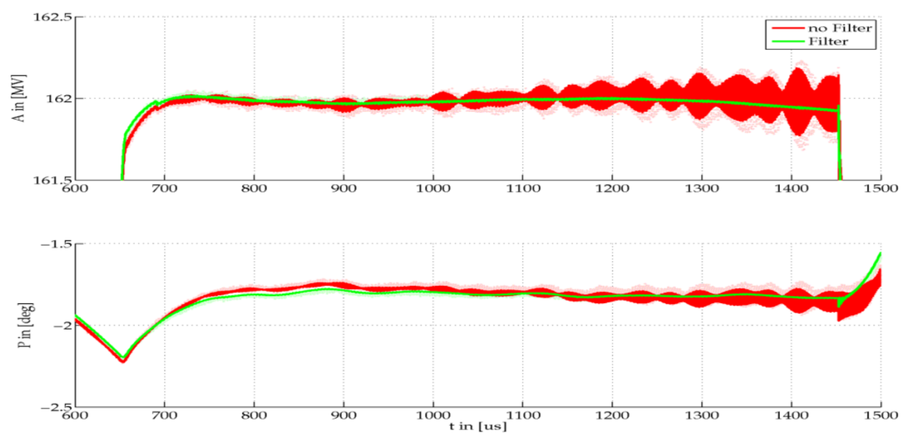
MicroTCA based LLRF system



Compact LO for crate

MTCA.4 Crate

- RMS amplitude regulation of 5 x 10−5
- Phase regulation of 0.009◦
- expected beam energy stability < 0.005%



THPB085 Julien Branlard (DESY)

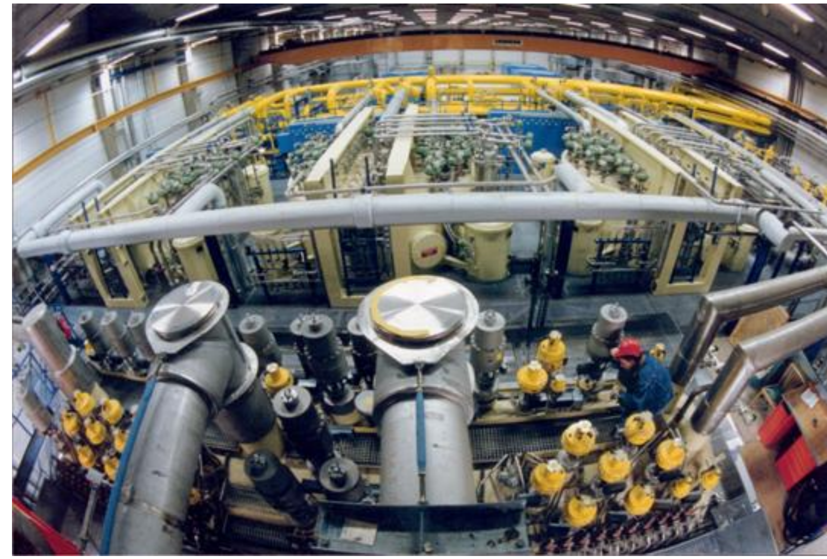
LLRF Automation for the 9mA ILC Tests at FLASH

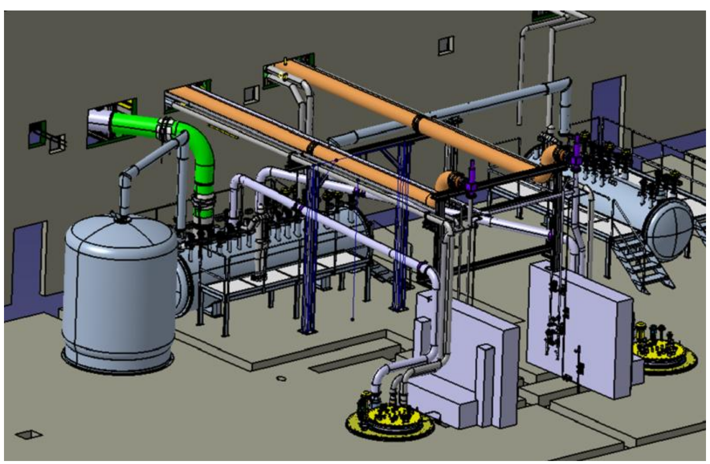
THPB086 Christian Schmidt (DESY)

Precision Regulation of RF Fields with MIMO Controllers and Cavity-based Notch Filters

Cold Linac Infrastructure

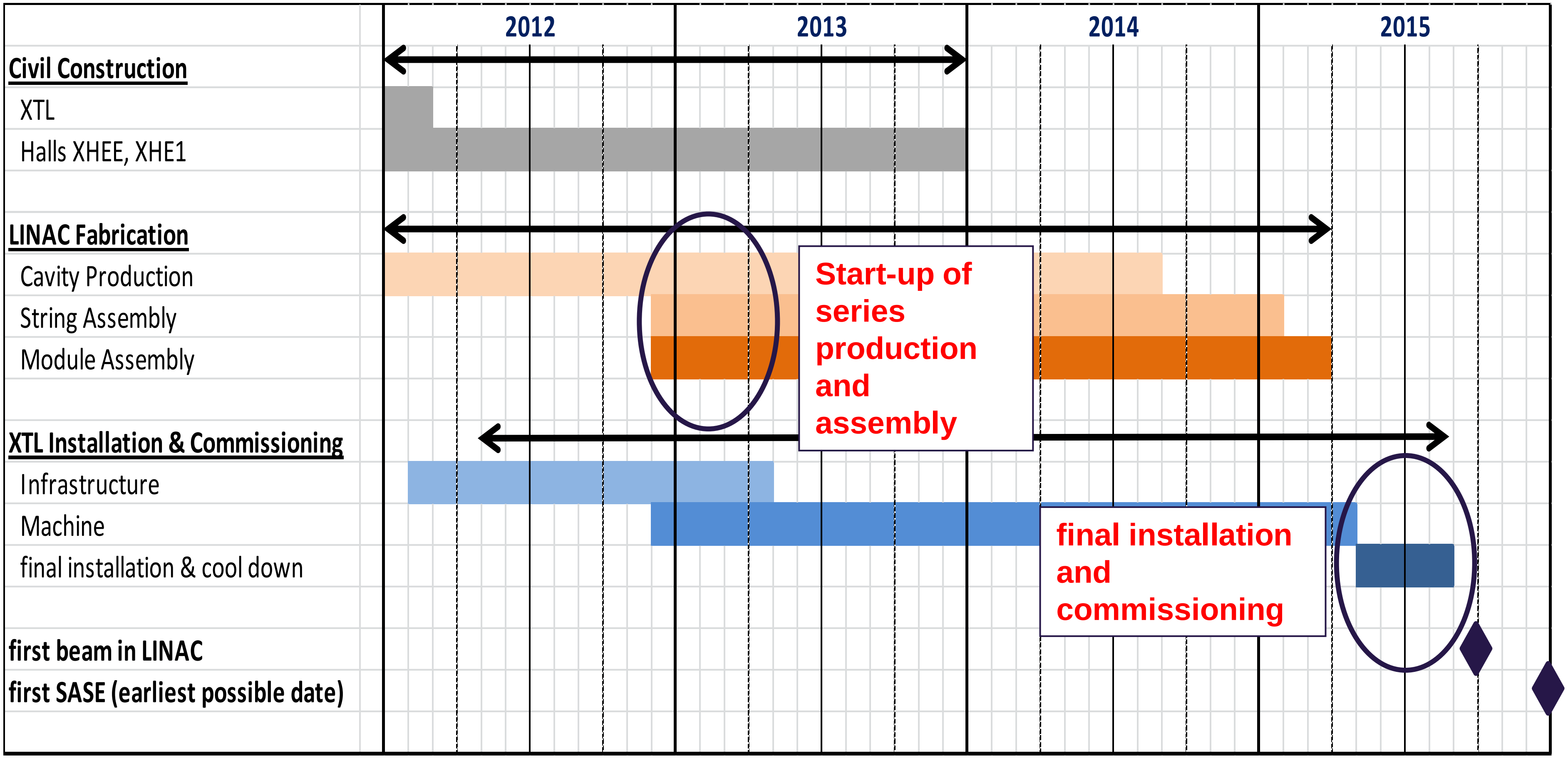
- Refurbishment of HERA cryo plant started
- Challenging schedule because of early operation start in 2014 to operate the XFEL injector
- Planning, production and installation of cryogenic equipment for accelerator and AMTF continued





European XFEL

Overall schedule – and its challenges



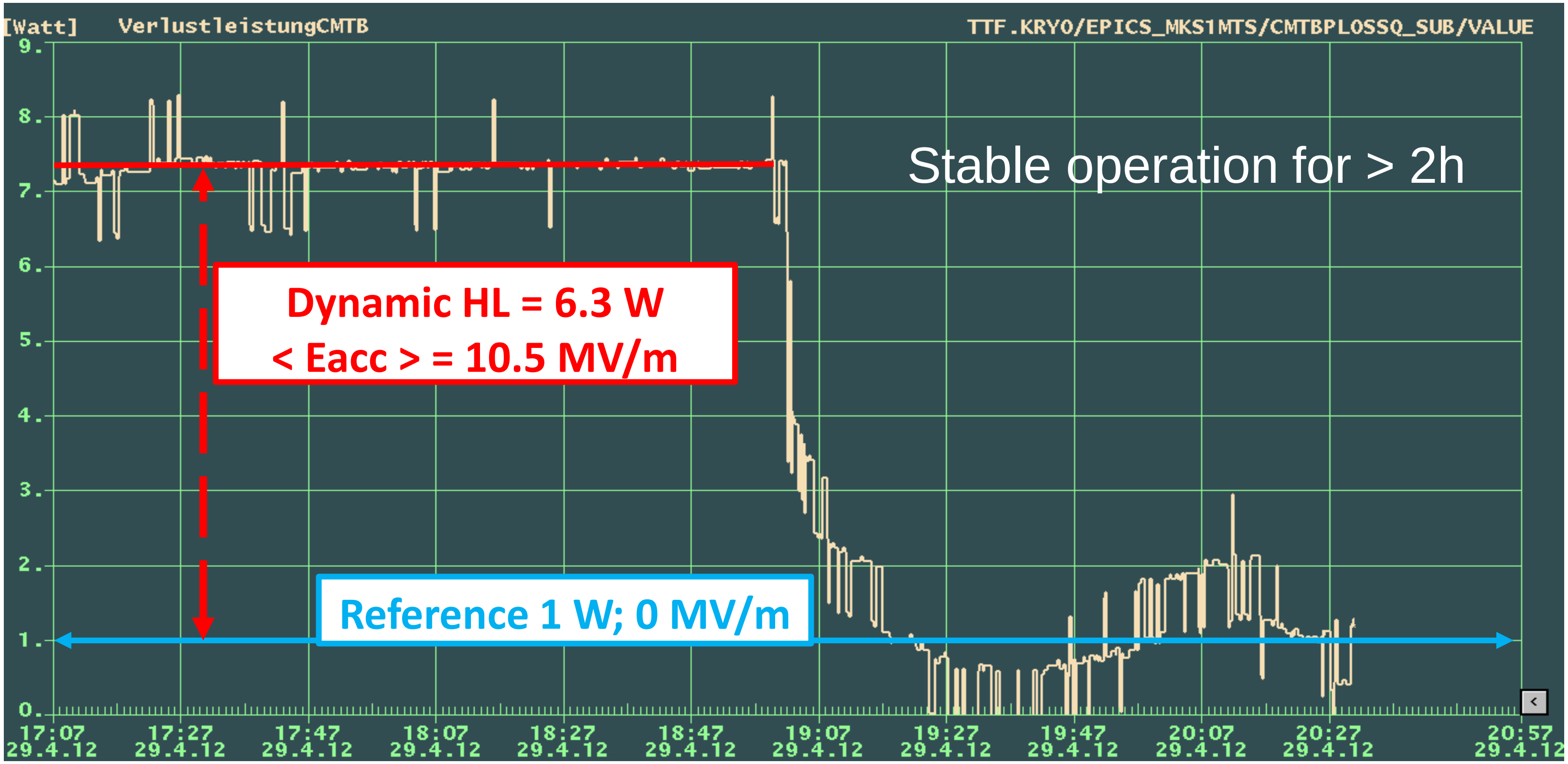
Last Words

- Progress on construction, infrastructure planning and ramp up of accelerator component fabrication
- Challenge to get the series production of accelerator modules started
- Working hard to finish installation in time for
  - start of injector commissioning mid 2014
  - start of linac commissioning mid 2015
  - observe first SASE by end of 2015

Thanks to all people contributing to this exiting project

Back Up

Detour: Long Pulse Operation

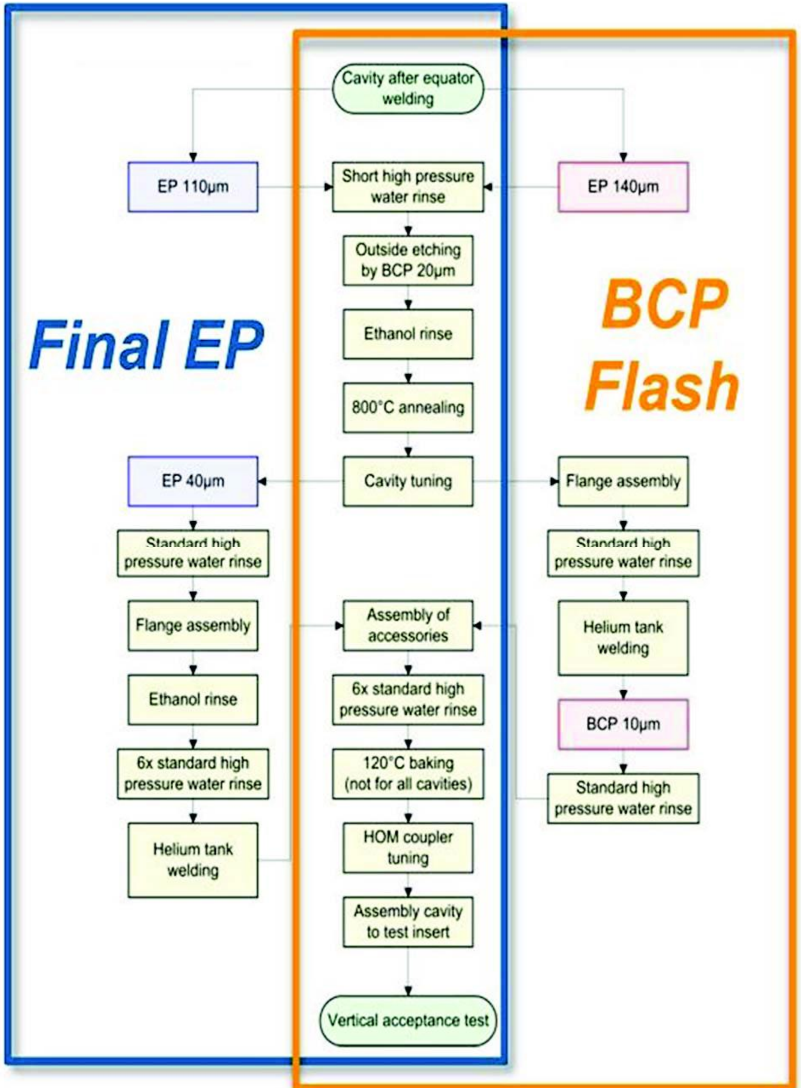


Conclusion:

Projecting to **8 cavities** operating at **1.8 K,** one should be able to reach **21.5 MV/m** at **DF=17% (flat-top 140 ms)** at**20 W/cryomodule**

TUPB019 Jacek Sekutowicz (DESY)
Second CW and LP Operation Test of XFEL Prototype Cryomodule

Surface Treatment



Prior surface treatment.

EP 110-140 m(main EP), ethanol rinse, outside BCP, 800°C annealing, tuning

Final surface treatment -two alternative options

1. Final EP of 40 m, ethanol rinse, high pressure water rinsing (HPR) and 120°C bake (RI)
2. Final BCP of 10 m(BCP Flash), HPR and 120°C bake (EZ).

Integration of the helium tank, assembly of HOM, pick up and high Q antennas before vertical RF test