(Some) Lessons Learned from the XFEL Project

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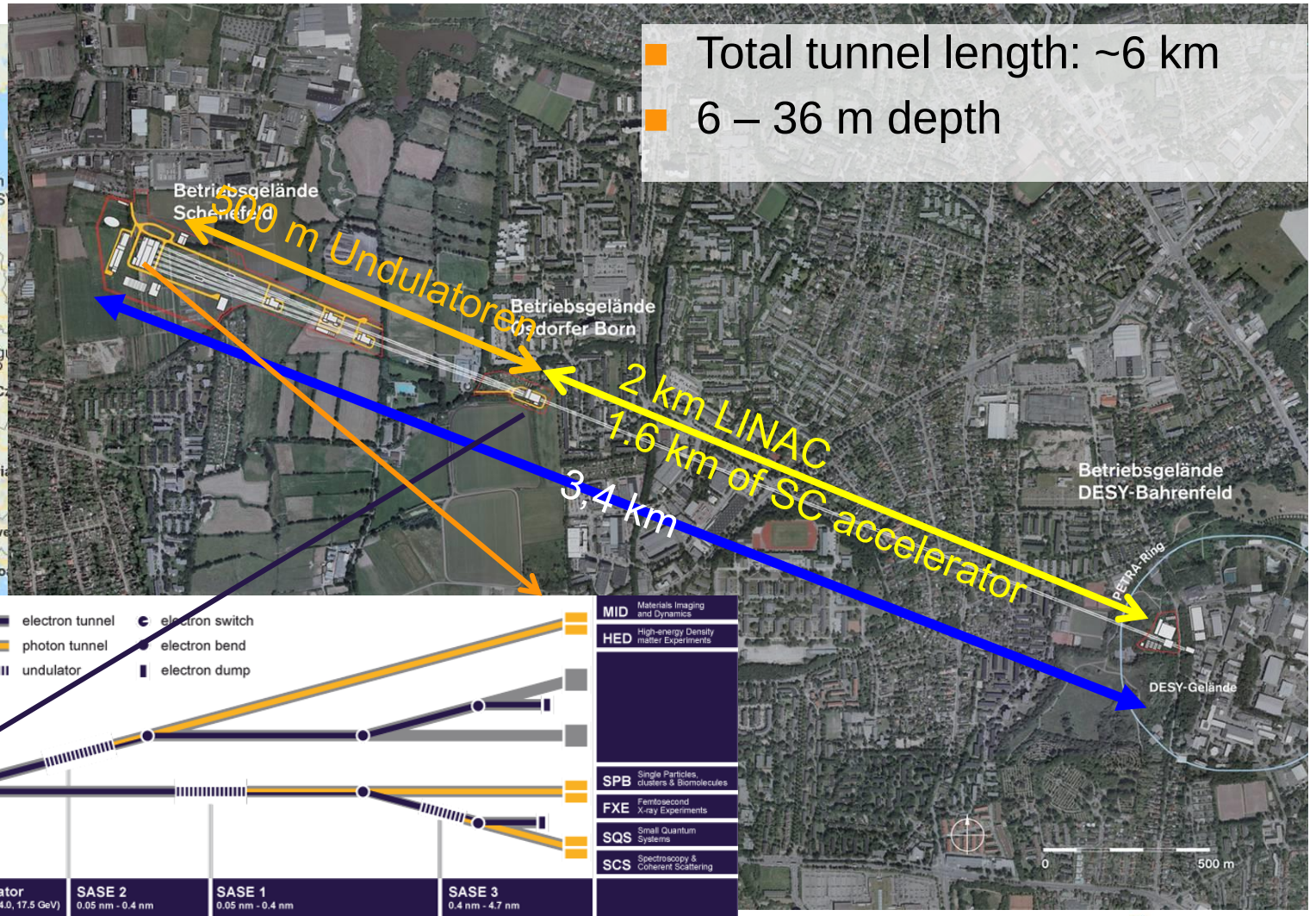
Accelerator-Industry Co-Innovation Workshop
Brussels, February 6th to 7th, 2018

Overview XFEL Facility

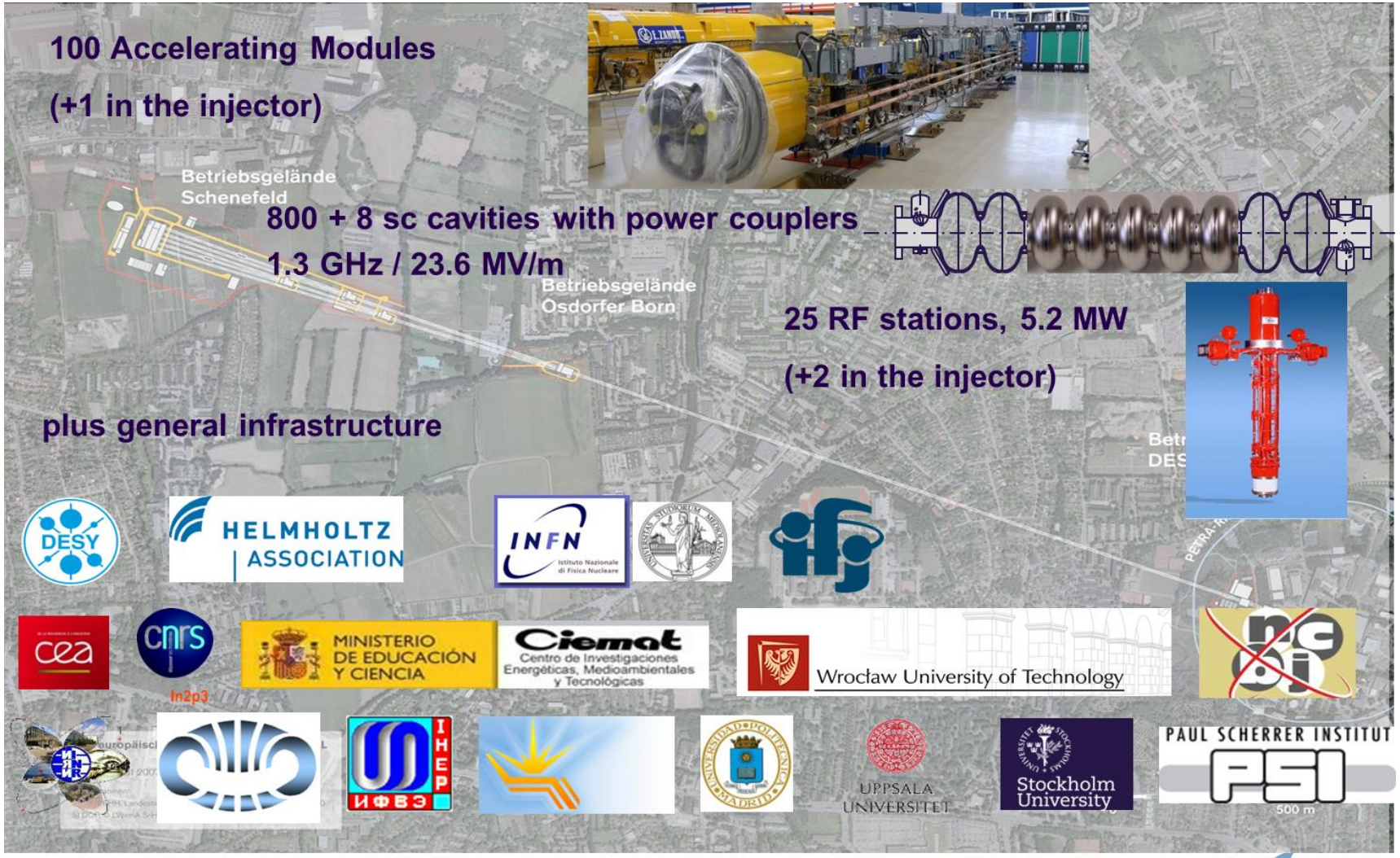


Time Line of the XFEL Project

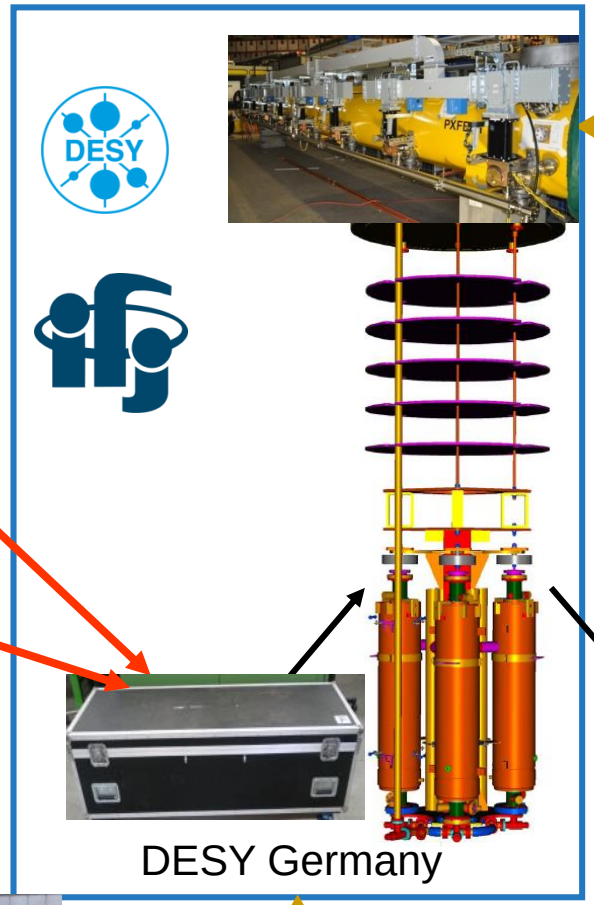
- 07/2006 TDR of the European XFEL published
- 01/2009 Start of underground civil construction
- 08/2014 Start installation of accelerator components
- 02/2015 First electron beam of the XFEL
- 12/2015 Start commissioning of XFEL injector
- 07/2016 Injector Commissioning finished
- 10/2016 Start cool-down of XFEL linac
- 05/2017 First laser light from the XFEL
- 07/2017 Start operation

Superconducting Linac

The XFEL Superconducting Linac – Work of Many in the Accelerator Consortium



Accelerator Modules – „Collaborative Effort“ between Science and Industry



Many more components

cea

E. ZANON
INFN
DESY

IHEP Beijing

E. ZANON

HELMHOLTZ GEMEINSCHAFT

DESY

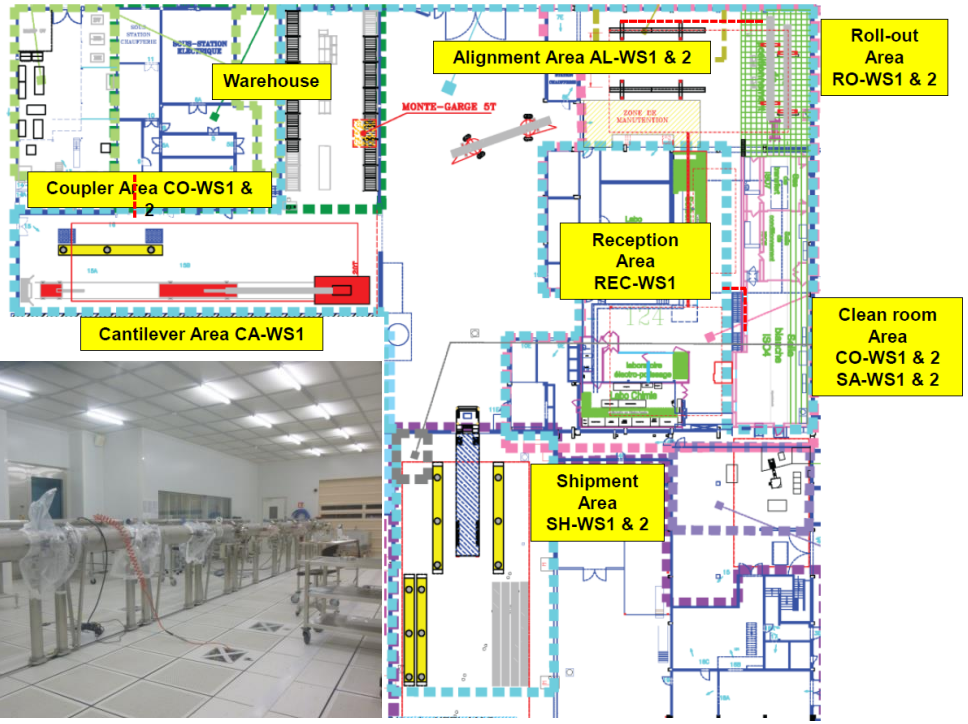
Contributions to the European XFEL Modules

BINP Novosibirsk, Russia	• cold vacuum bellows and coupler vacuum line
CEA Saclay / Irfu, France	• cavity string and module assembly • cold beam position monitors • magnetic shields, superinsulation blankets
CIEMAT, Spain	• superconducting magnets
CNRS / LAL Orsay, France	• RF main input coupler incl. RF conditioning
DESY, Germany	• cavities & cryostats • contributions to string & module assembly • coupler interlock • frequency tuner • cold vacuum system • integration of superconducting magnets / current leads / cold beam position monitors
INFN Milano, Italy	• cavities & cryostats • contributions to frequency tuners
Soltan Institute, Poland	• higher Order Mode coupler & absorber

Large Infrastructures at Research Centers and Industry (examples)

Cavity Production at Zanon

Accelerator Module Test Facility



Large Clean Room at CEA XFEL Village

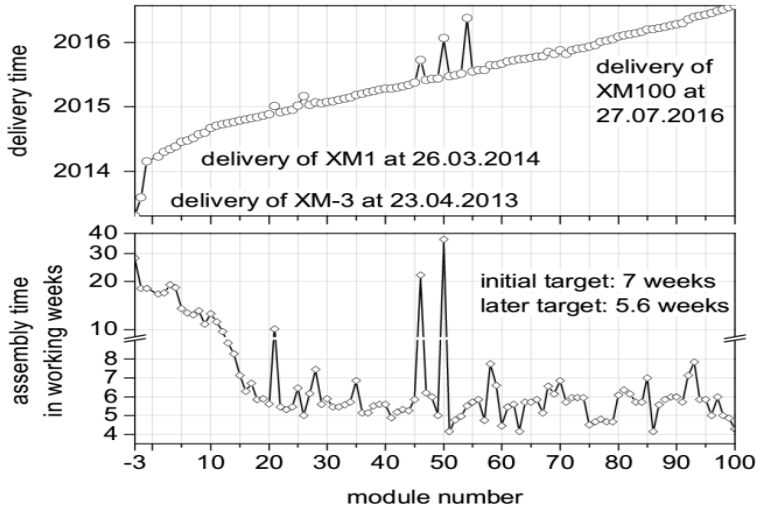
Cryostats for CavityTesting at DESY

Module Fabrication and Installation Summary

- Projected rate for module fabrication, test and installation

Target: 1 Module / week **Achieved: 96 modules in 103 working weeks**

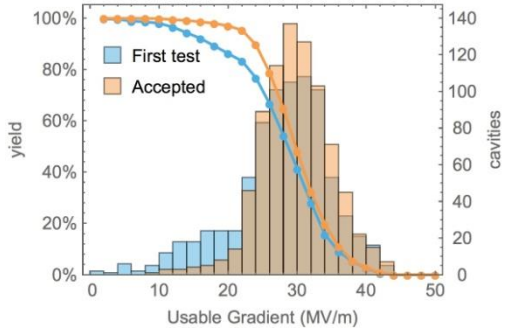
Assembly Rate



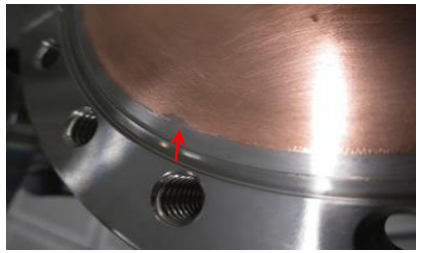
- **Knowledge transfer** from science to industry is **challenging and requires time**
- Throughout the entire production, problems had to be tackled by an **collaborative effort**
  - Often unexpected problems can be easier solved by the science partner
- Experience allowed significant speed-up of processes for production / assembly / test / installation

Examples of (Collaborative) Problem Solving

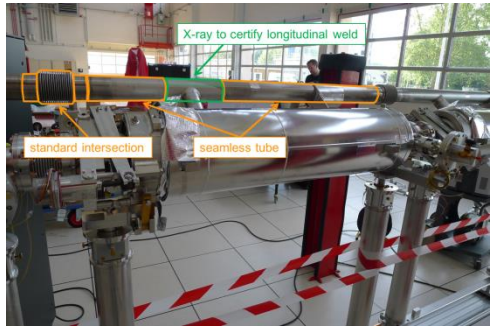
- **Retreatment of cavities**
  - Both at the manufacturer and at DESY
  - Gave significant improvement in energy gain (about 1.3 GeV)



- **Copper plating of power coupler**
  - Intense discussions and efforts by **all** involved experts
  - Variety of measures brought production rate up to sustain necessary module assembly rate

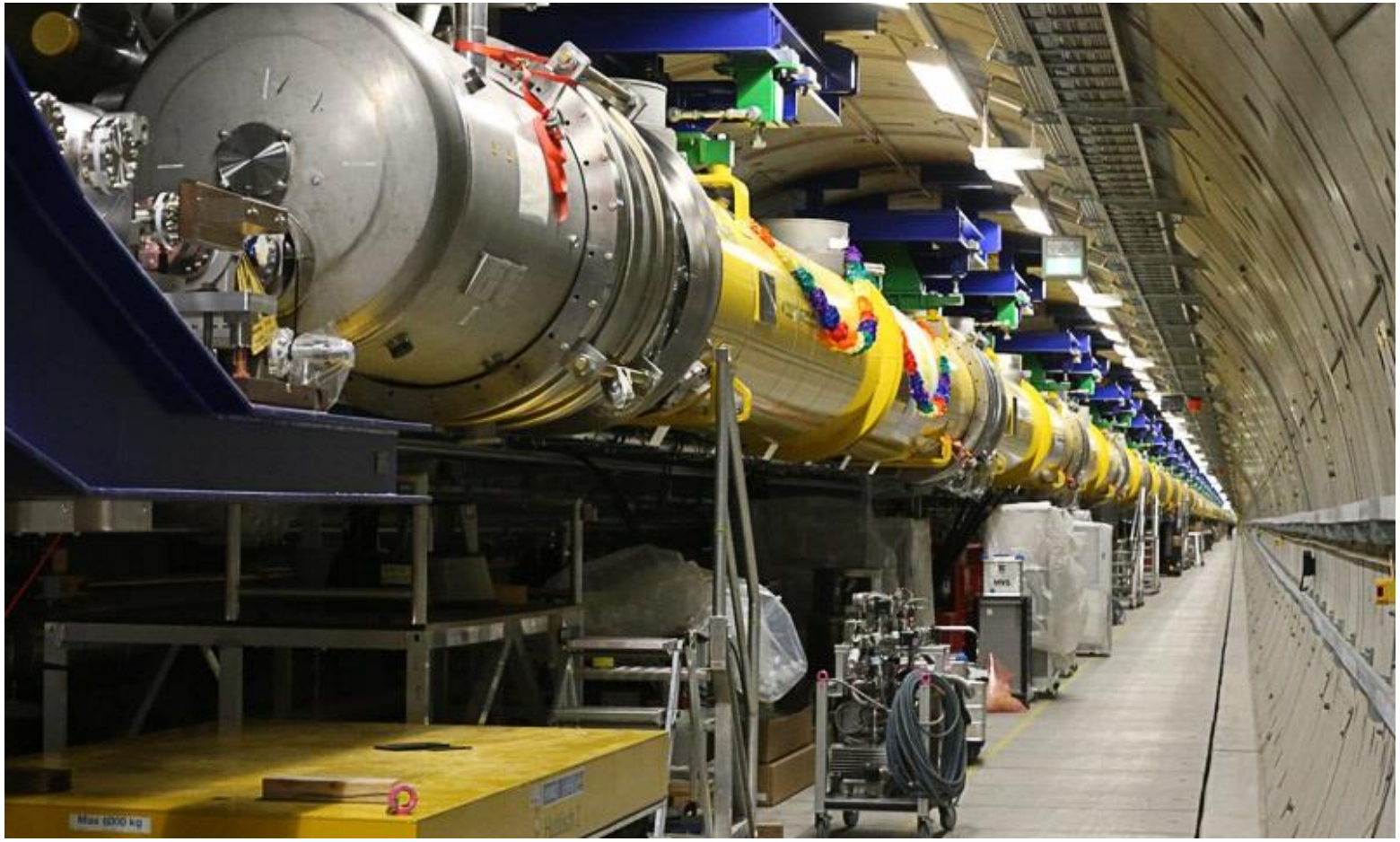


- **Systematic repair work on orbital welds and Ti tubes**
  - Unexpected discovery of pores on welds early in the module assembly ramp-up
  - Collaborative effort to improve welding technique and equipment
  - “on the fly” replacement with seamless Ti tubes



The Final Product: a 1.6 km Superconducting Linac

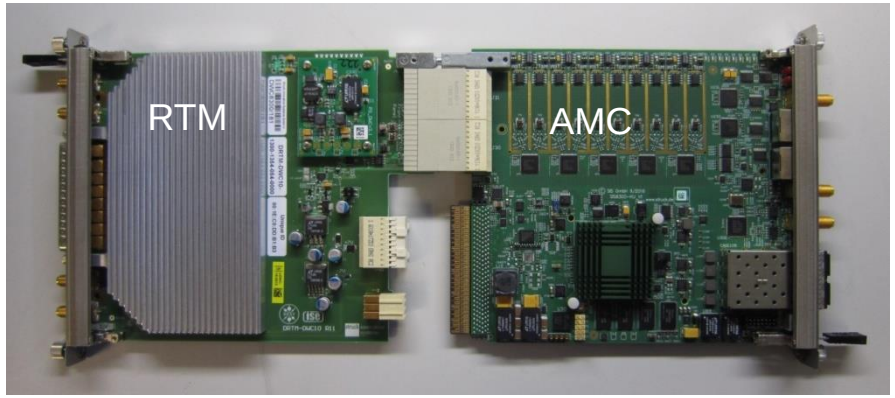
1st module July 1st, 2014 – last module (XM98) August 1st, 2016



µTCA Standard

Develop Industry Grade Standards

- Dec. 2007: Decision of µTCA and ATCA as standard for XFEL control system
- Mar. 2009: 1st PCI Industry Computer Manufacturer Group (PICMG) meeting „xTCA for Physics“
- Oct. 2011: Official announcement of PICMG Specification
  - µTCA.4 Enhancements for Rear I/O and Precision Timing
  - Open modular standard
  - Significant developments in the physics research community
    - ► **Fully managed components**
    - ► **Remote management**
    - ► Redundancy options
    - ► High–bandwidth digital signal processing
    - ► Compact, versatile formats



Rear **T**ransfer **M**odule (**RTM**)

Advanced **M**ezzanine **C**ard (**AMC**)

RTM

- rear side cable access
- mostly analog
- signal sampling and conditioning

AMC

- mostly digital
- latest FPGAs
- data processing

Cooperation and Innovation with Industry

- Growing µTCA community

Science

Standardization

PICMG µTCA®

Industry

ROHDE&SCHWARZ
PENTAIR
struck innovative systeme
powerBridge Computer
elspec group GmbH
CAENels Gear For Science
N.A.T.

- Mostly science driven but first indications for other application (e.g. industrial automation, medical, laser systems etc) of the µTCA technology
- **Need large (science) project like XFEL to establish new technology and provide an initial market**
  - **Successful start-up of facility is the best demonstration and marketing effort**
- Helmholtz funded µTCA TechLab @ DESY to ease / support access to the µTCA technology

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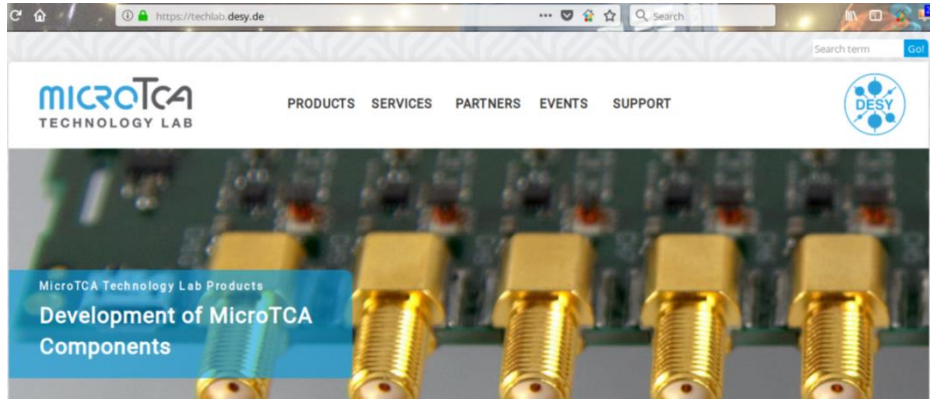
µTCA Tech Lab Hosted by DESY



- Fostering the widespread adoption of MicroTCA-based solutions
- Creating an “Enabling Space”
- Especially also in collaboration with industry:
  - Advance research and development for next generation MicroTCA systems
  - **Tutorials, trainings and workshops**
  - Joint marketing activities
  - Interoperability improvements
  - Provision of *Starter Kits* and Software *Framework / Tool Kits*
    - ► *AMC/RTM board templates ready to use*
    - ► *Open source tool kit device and control system independent*

ChimeraTK

Lessons Learned

- Building a large research infrastructure (like XFEL) requires good cooperation between science and industry
  - Large building and assembly infrastructures needed at labs and industry
  - Challenging technology requires **collaborative effort** between science and industry
  - **Knowledge transfer** is crucial, challenging and often (more) time consuming (than expected)

- Technological development for a large science project
  - Can **enhance industrial standards**
  - Has to potential to create **business opportunities beyond the scientific community**
  - **Creating a dedicated platform** helps to widespread technological innovations