I-Tech – DESY Collaboration for the European XFEL LLRF and Special Diagnostics Systems.

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HELMHOLTZ ASSOCIATION

DESY

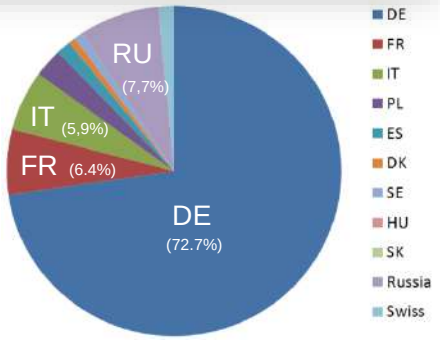
OVERVIEW

- Introduction
  - European XFEL accelerator
  - LLRF architecture for XFEL
- Piezo discharger and PZ16M: 16 channel piezo driver
  - Mass production of the piezo discharger
  - PZ16M pre-series production
  - PZ16M design update, status and plans
- TMCB: TeMperature and Controller Board
  - Pre-series production
  - Design update, status and plan
- Outlook
  - European XFEL commissioning
  - MicroTCA Innovation Labs.

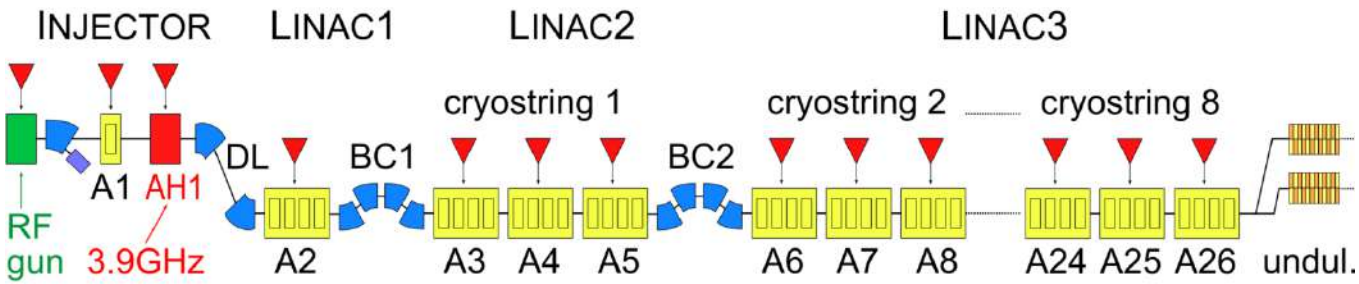
INTRODUCTION: the European XFEL

The European X-ray Free Electron Laser

- 17.5 GeV light source, Hamburg, Germany
- TESLA superconducting 1.3GHz RF cavities
- 1.4 msec pulses at 10 Hz
- e- beam 1.35 mA nom. - 4.5 mA max
- 2016: construction / commissioning
- 2017: first user operation



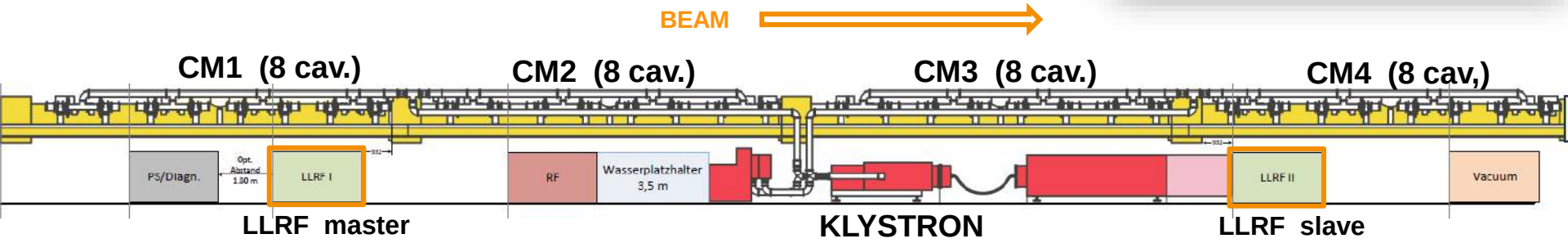
source: http://www.xfel.eu



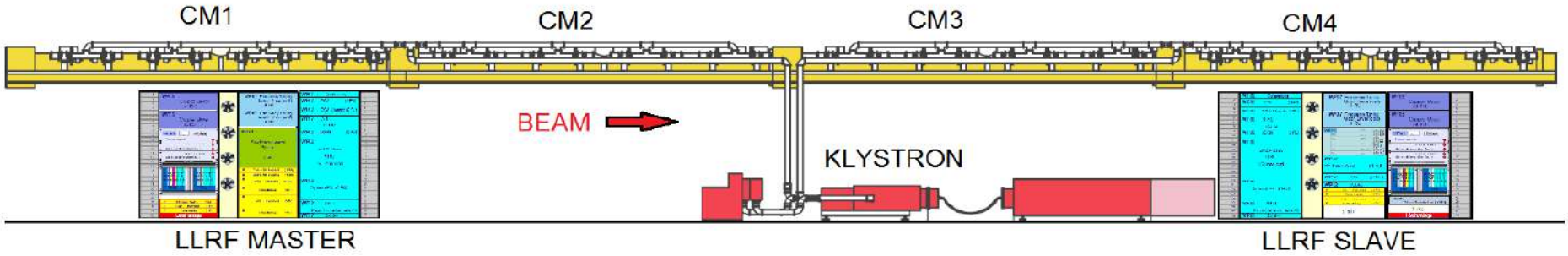
INTRODUCTION: LLRF for XFEL

- LLRF: DESY in-kind
  - 26 RF stations (808 cavities, 101 cryomodules)
  - MicroTCA.4 LLRF system, master / slave
  - Vector sum (32 cavities) RF control
  - Motorized cavity tuners
  - Motorized Q_L, one-time fixed power ratios

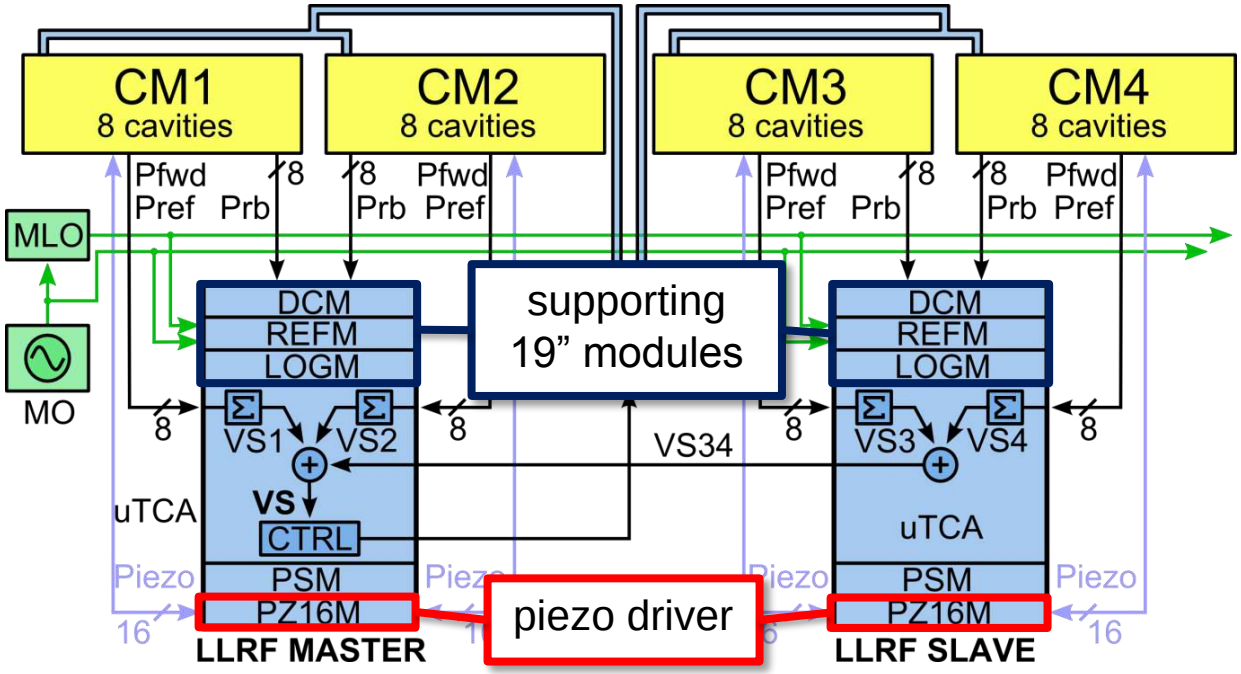
RF parameters:
- Pulse length 1.4msec (750 + 650 usec)
- Q_L = 4.6e6 (½ bw = 140 Hz)
- 10 Hz rep. rate
- ΔA/A = 0.01% ΔΦ = 0.01 deg.

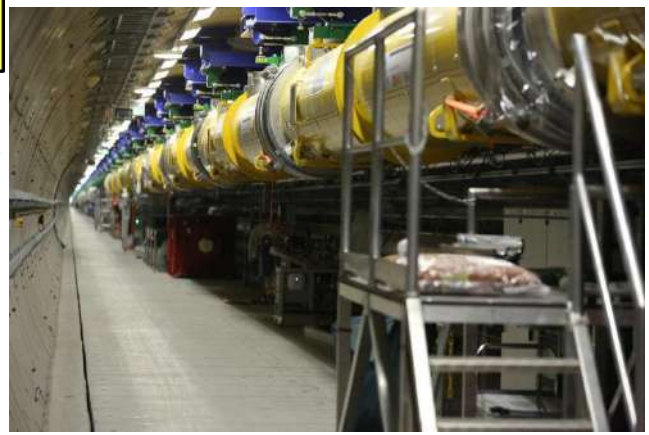


LLRF architecture for an RF station



RF station: semi-distributed LLRF system





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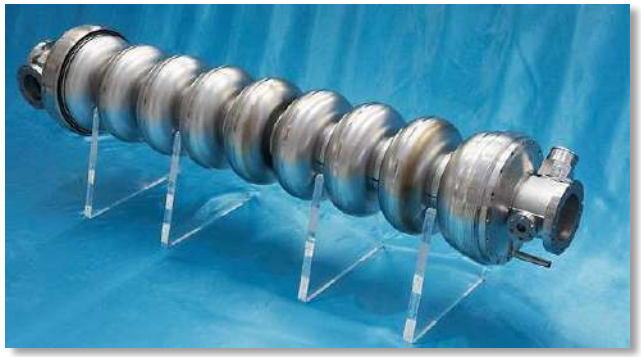
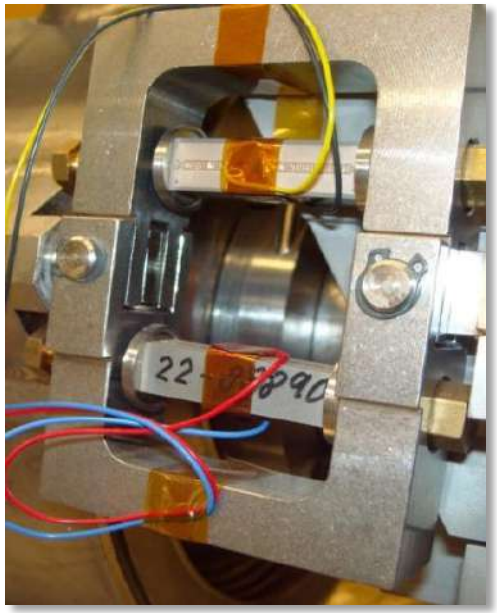
Piezo use in superconducting RF cavities



SRF 1.3 GHz cavity

Bracket cavity tuner



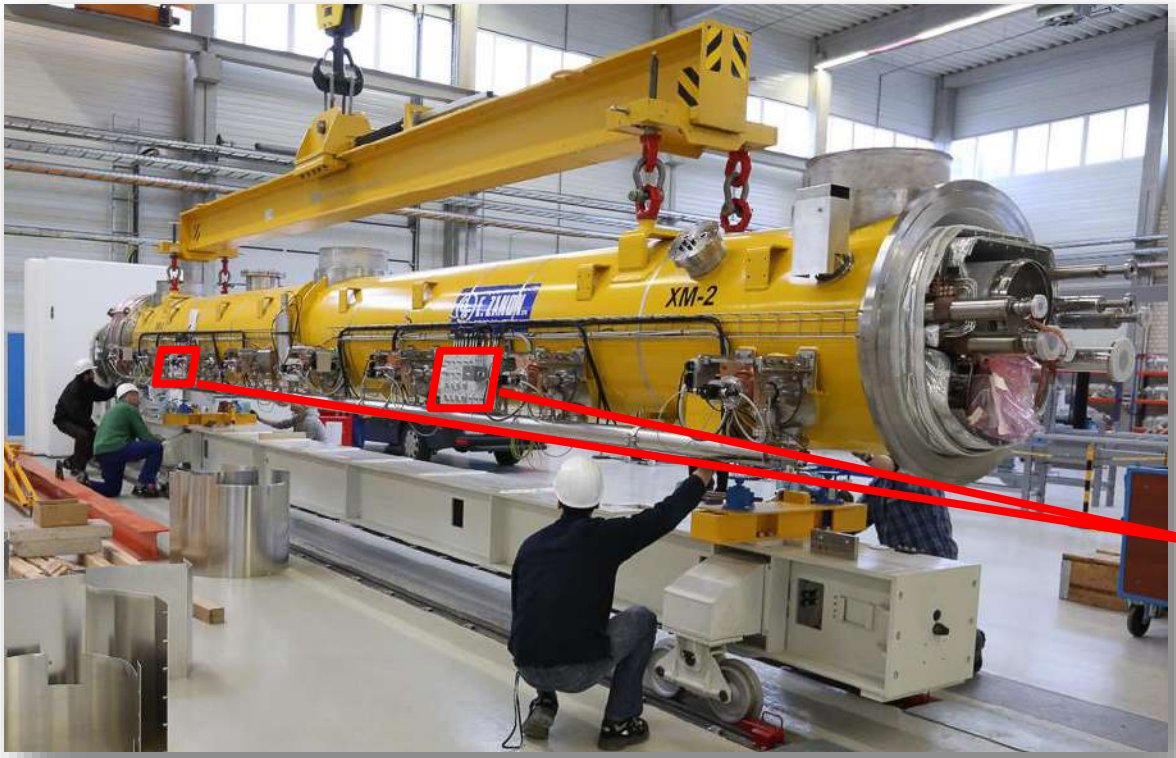
Double stack piezo

- TESLA cavity design and Saclay Tuner
  - Control SRF cavity resonant frequency with piezo-electric elements (piezo)
  - Every cavity tuner equipped with 2 piezos (sensor / actuator)
  - ➔ need for a piezo driver and sensor instrumentation for 16 piezos (i.e. 8 cavities)

Piezo discharger unit:

> Mass production of the piezo discharger

- 220 units produced and tested at ITech
- Protect the piezo against high currents
- Protects the user against electrical discharges

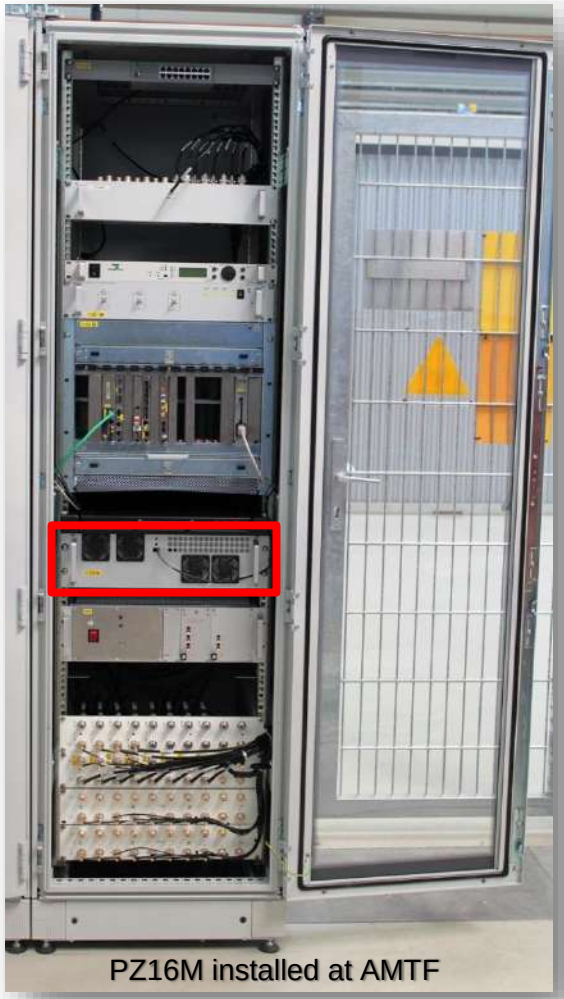


XFEL cryomodule equipped with piezo discharger

Piezo driver: PZ16M – Production history

- First prototype developed and produced at DESY
  - main PCB (produced at ITech)
  - First mechanical integration (DESY) (many shortcomings)

- First pre-series production:
  - 10 units produced by ITech (PCB, crate, assembly)
  - Routinely used at the cryomodule test facility at DESY (AMTF)
  - Installed and used at FLASH accelerator at DESY

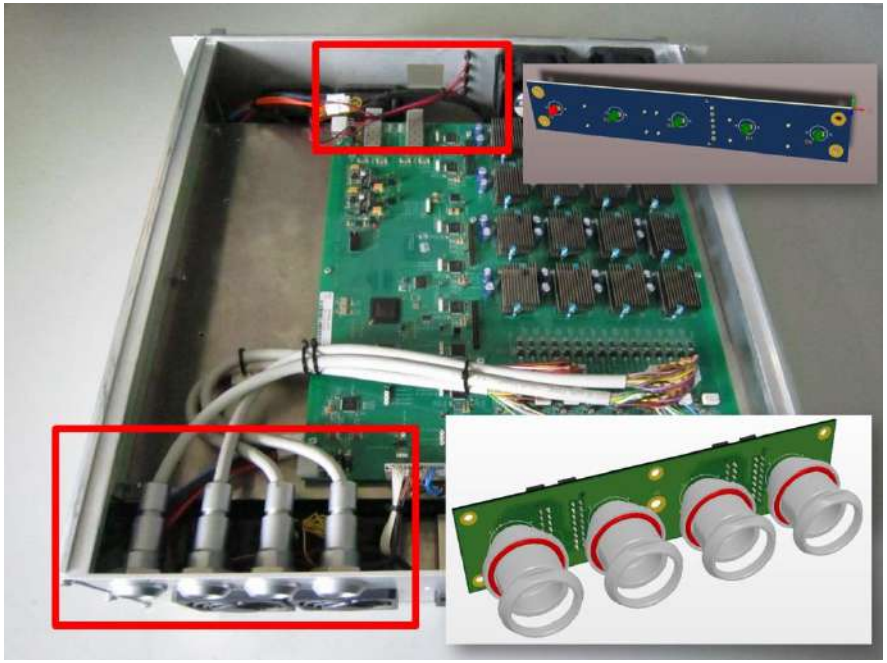


PZ16M installed at AMTF

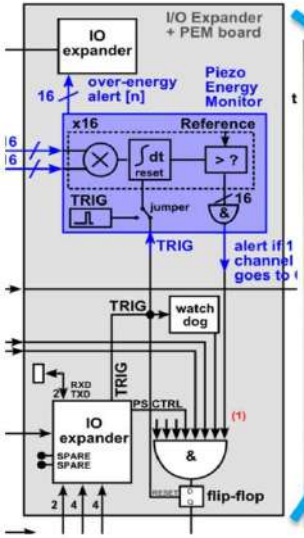
Piezo driver: PZ16M – Production history (continued)

- Preparation for the mass production for the XFEL
  - 60 units required

- Production feedback from ITech:
  - How to lower production cost by minimizing manual assembly work
  - Triggered new design at DESY
  - Standardized connectors
  - Simplify assembly by adding sub PCBs

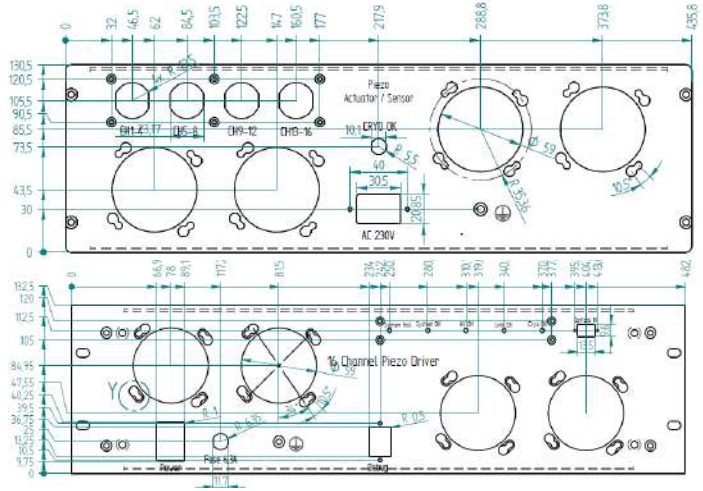


- Design improvement to protect piezos and protect the driver module
  - Short circuit detection and fast reaction
    → modification of main PCB
  - Piezo energy monitoring (PEM)
    → new PCB



Piezo driver: PZ16M – Production history (continued)

- Now: second prototype phase
  - New PCB produced by ITech
  - Mechanical assembly tested at DESY



- Mass production to start this year
  - Call for tender required by European regulation
  - Production in collaboration with ITech desired

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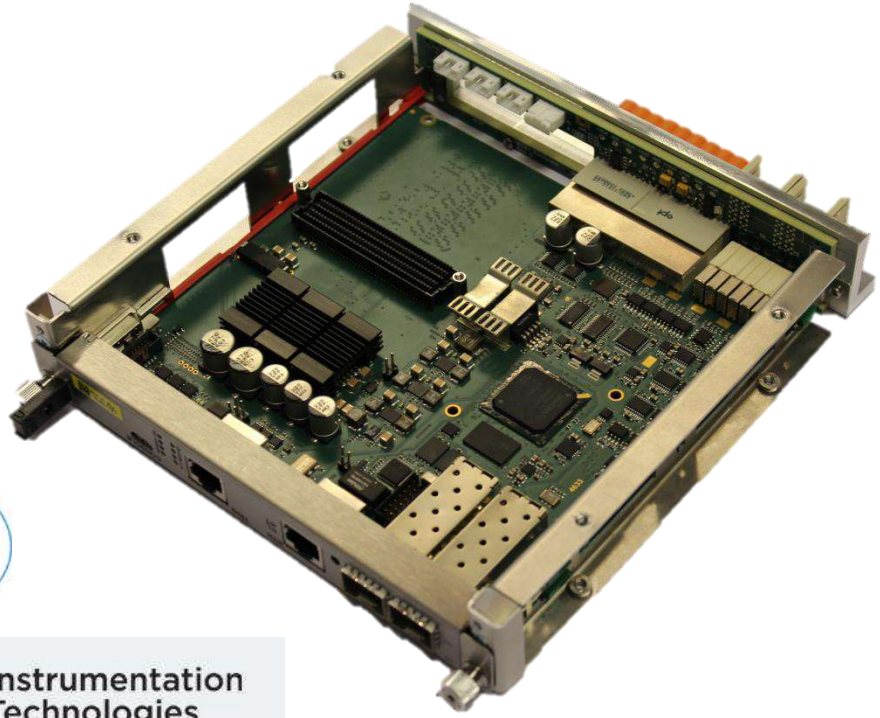
TMCB2 : Temperature Monitoring & Control Board

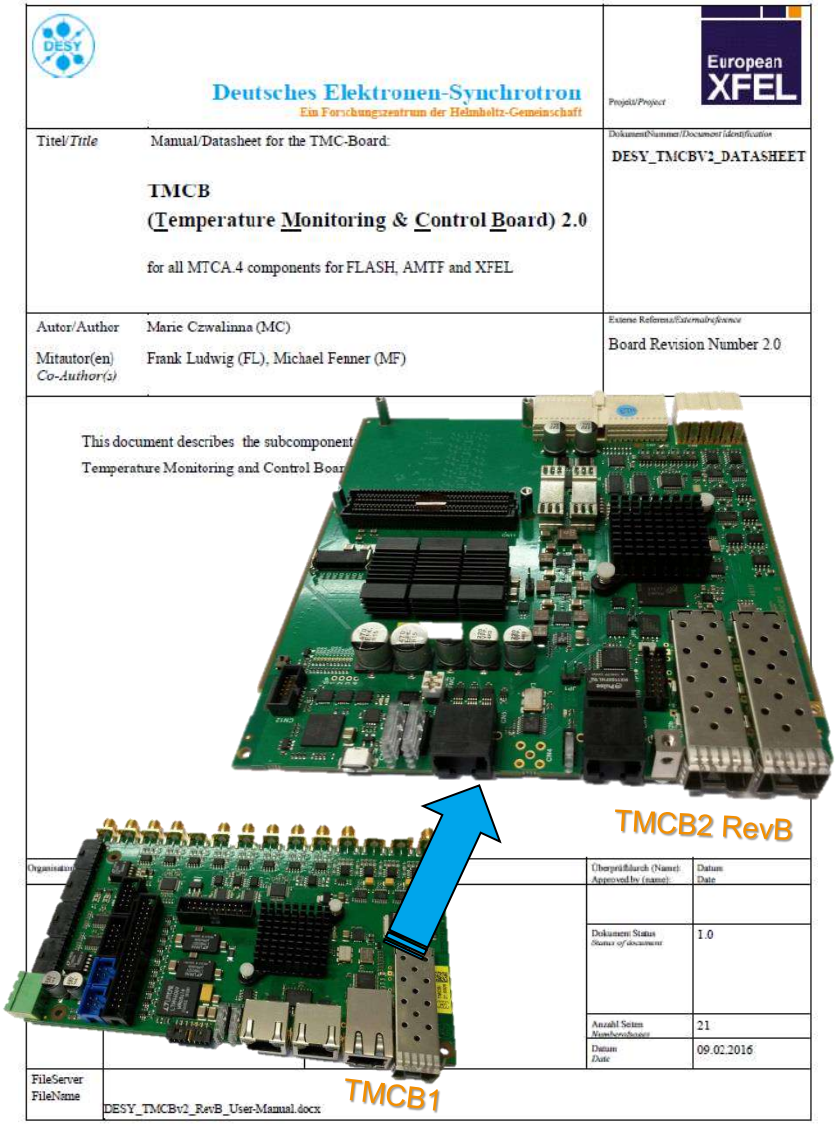
- TMCB2 : Stand-alone, multi-purpose I/O board
- with backplane (DESY)
- and with mechanical mounting frame (ELMA)



Features

- Laterally compliant with double width MTCA.4,
- Hot-plug functionality,
- Ethernet (10/100 Mbit) support,
- 2 SFP channels, up to 3.125 Gbps,
- 24 analog channels, different speeds & precision,
  - 14 ADC channels,
  - 10 DAC channels,
- 20 digital I/O GPIB, selectable directivity & level
  - 3.3V, ,
  - or 5V (TTL)
- Read-out of 4 external temperature sensors (PT1000; 3- or 4-wire connection),
- External clock inputs,
  - Analog input via front panel SMA,
  - Digital LVDS (3x) via RJ45,
- On board temperature sensor ,
- On board user I2C support,
- RoHS compliant

Project status of the TMCB2



History

- Started 2012 with the very first TMCB1 and made a big development step forward to TMCB2 (2013/14)

  Continuous improvements

  (functionality and signal integrity)

  +

  Board design evolved with advancing developments

  of target applications

  Rev.A → Rev.B → Rev.B, Pre-Series → Rev.C (now in production)

- Good cooperation & fruitful discussions during the past years

- Very well documented project:
  - Providing User Manuals (DESY)
  - Test Protocols (from I-Tech & DESY)
  - In mass production:
    - Automated board tests

      (Hardware, Firmware & Software provided by DESY)
    - 260 boards required up to now

Use of the TMCB

- Used as main diagnostic board for …
  - … most 19” supporting modules in the LLRF at XFEL and FLASH…

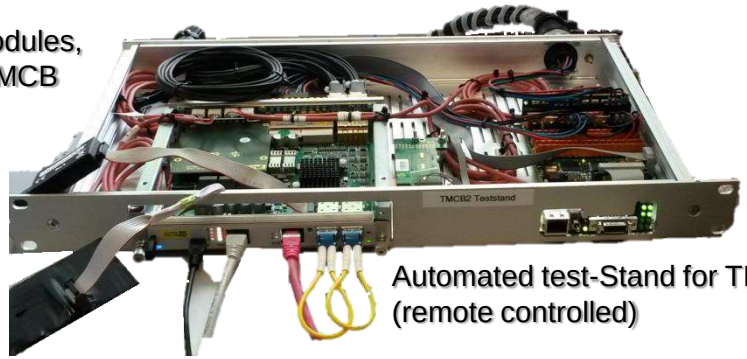
Master oscillator (MO)
Local oscillator and clock generation module (LOG)
Drift compensation module (DCM)
Reference distribution modules (REFM)
Optical reference synchronization module (REFM-OPT)

Drift compensation module (DCM) equipped with TMCB

  - … as well as in all Special Diagnostics 19” modules (XFEL and FLASH)

Generalized layout of special diagnostics modules, here for BAM application, with free slot for TMCB

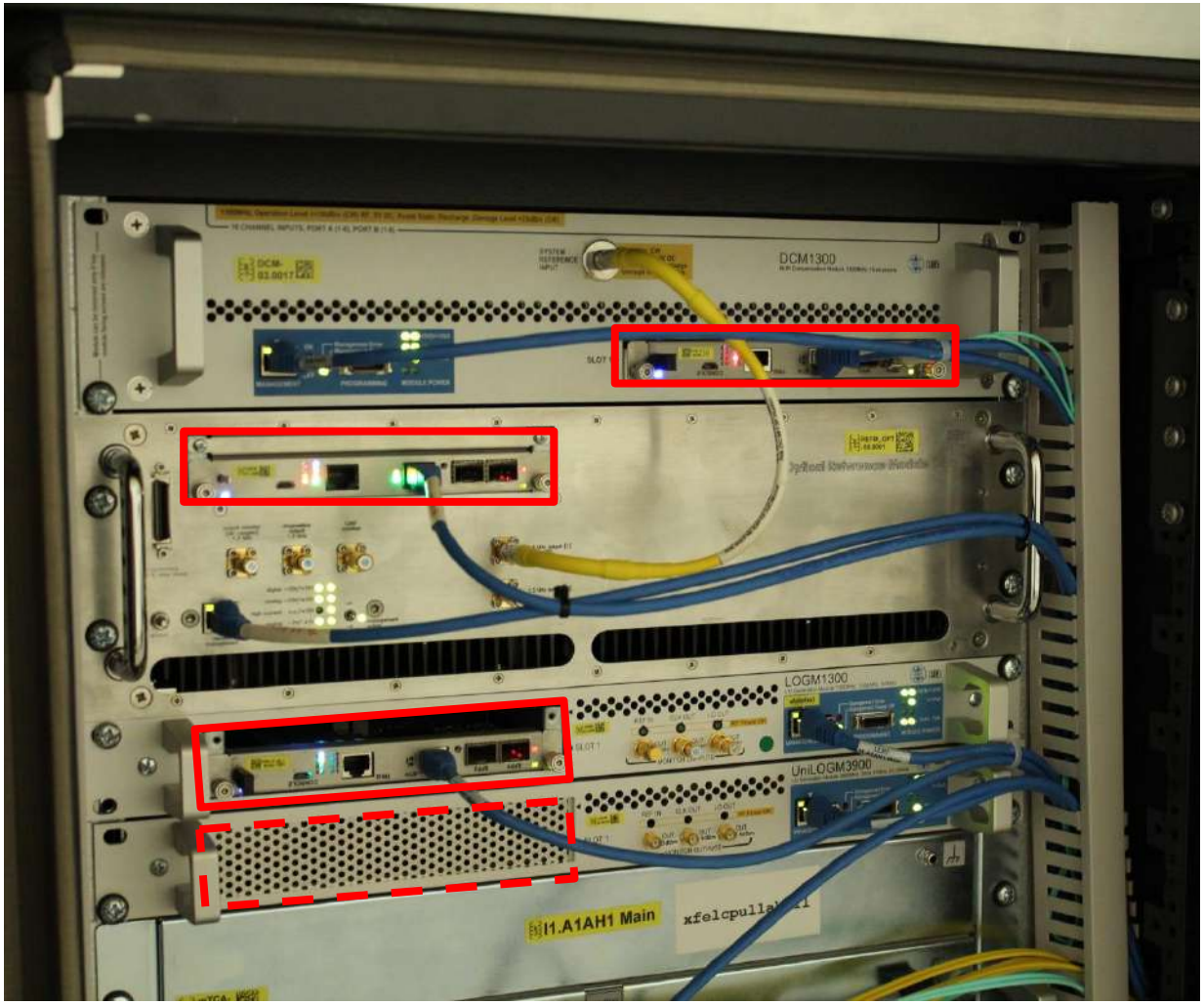
Bunch arrival time monitor (BAM),
Bunch compression monitor (BCM),
Electro-optical diagnostics (EOD),
RF Generation for transverse deflecting structure (TDS)



Automated test-Stand for TMCBs from mass production (remote controlled)

Use of the TMCB (Continued)

- AH1I1 XFEL station (first acceleration module and third harmonic)
- Each external 19” module uses a TMCB
- DCM
  - (mezzanine, ADCs, GPIOs, SFPs, Ethernet)
- REFM-OPT
  - (DACs, ADCs, Ethernet, GPIOs)
- LOGM , Uni-LOGM
  - (ADCs, GPIOs)



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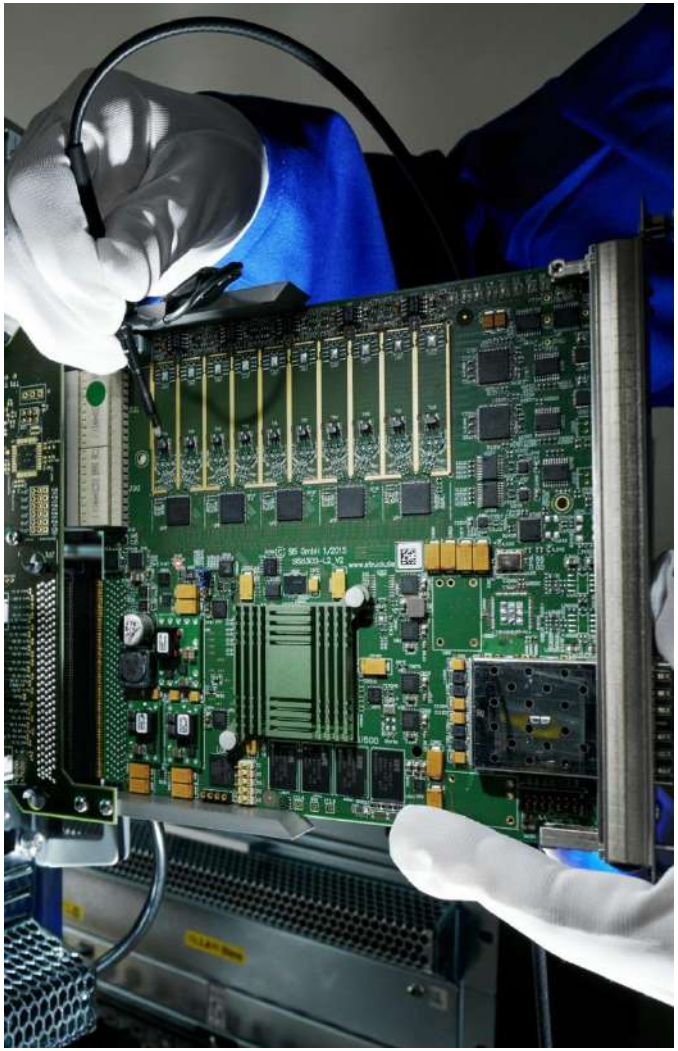
European XFEL commissioning

- Installation / commissioning of XFEL
  - Installation scheduled to finish end of September 2016
  - Commissioning of sub-systems already taking place
  - Installation of some sub-components such as PZ16M scheduled for late 2016, beg 2017
  - Cool down of the accelerator Oct. 2016
  - Cold commissioning → end of 2016
  - First beam operation in 2017

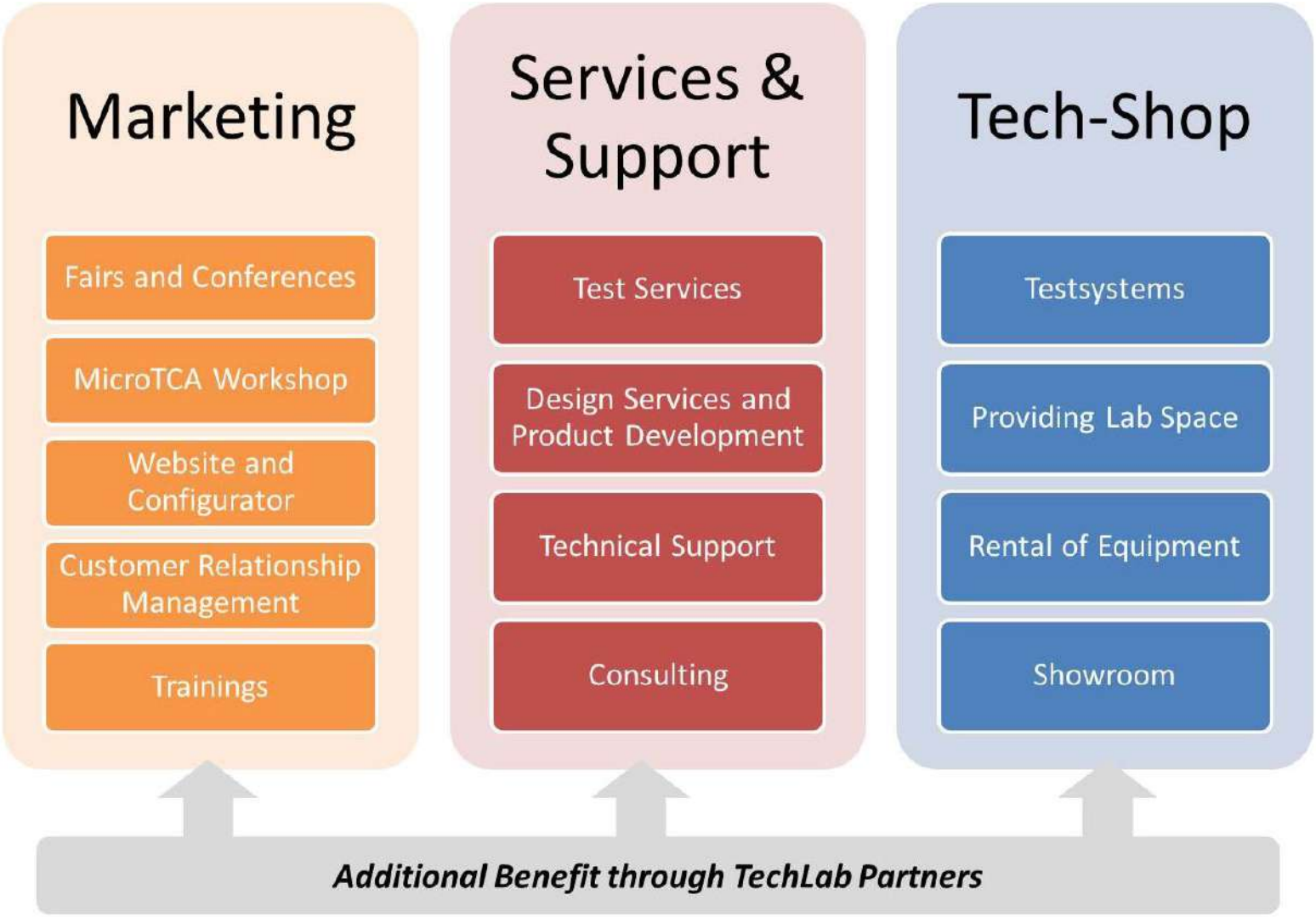
    PZ16M required for cavity resonance control with beam
    TMCB required for diagnostics (end 2016 – beg 2017)
    TMCB required earlier for module control in some applications (MO, BAM)
  - Full accelerator commissioning → mid of 2017

MicroTCA.4 Technology Lab

- DESY successfully **acquired funding** for building up a „User Innovation Lab“ for MicroTCA Technology.
- Investment of **5 Mio Euro during next 5 years** - together with partners (NAT, CAEN, Struck, PowerBridge,…).
- MicroTCA.4 Techlab will focus on **vendor-independent** design and integration **services** for users and producers.
- Provides **lab and office space** on DESY campus.
- Huge investment into **Lab equipment** (> 10 GHz) including a **MicroTCA Lending Pool** (Cutting-Edge HW).
- We will **hire six new persons**: 2x Marketing + 4x Developers (Software, Hardware, Firmware, Driver).
- Aims at providing integration services to allow users to **develop complete MicroTCA.4 products/systems** faster.
- Looking for new industrial partners.



MicroTCA.4 Technology Lab - Activities



Thank you for your attention