

## **SRF2015**

17th International Conference on **RF Superconductivity** Whistler Conference Centre September 13-18 2015



# **Recent Progress with EU-XFEL**

## Detlef Reschke – DESY for the EU-XFEL Accelerator Consortium







- European XFEL Linear Accelerator
- Vertical Acceptance Test
- Cryomodule Test
- 3.9 GHz Third Harmonic System
- Injector + Cryomodule Installation and Commissioning





DES







### **XFEL** Accelerator Complex for 17.5 GeV





#### 808 accelerating cavities 1.3 GHz / 23.6 MV/m

















#### European Reminder: Cavity Surface Preparation

- Two schemes for the final surface treatment:
  - E. Zanon:
  - Final 10µm BCP ("BCP Flash") - Research Instr.: Final 40µm EP
- Cavity after equator welding Short high pressure EP 110µm EP 140um water rinse Outside etching by BCP 20µm BCP Ethanol rinse Final EP Flash 800°C annealing EP 40µm Cavity tuning Flange assembly Standard high Standard high pressure water rinse pressure water rinse Flange assembly Helium tank welding cavity fabrication pro-Ethanol rinse Assembly of BCP 10um accessories 6x standard high pressure water rinse 6x standard high Standard high pressure water rinse pressure water rinse Helium tank welding 120°C baking RF-measurement: packaging Transportation to DESY

## Successful mechanical production and surface preparation at both vendors!

Close **supervision** of infrastructure and processes by DESY + INFN Milano

#### No performance guarantee results in:

- the risk of unexpected low gradient or field emission is with DESY
- responsibility for <u>re-treatment</u> at DESY (good cooperation with both vendors)





## **XFEL** Statistics of Cavities + Vertical Acceptance Tests

- Mechanical production (nearly) finished
- Last cavities expected in Oct 2015
- Delivered: ~785 cavities (Aug 31)
- Status of vertical tests analysis: Aug 01, 2015 (~740 cavities)
- Analysis of vertical acceptance tests includes
  - Series Cavities
  - ILC "HiGrade"-Cavities (w/o He-tank; QC)
  - NO infrastructure commissioning tests
- Stable average vertical test rate ~40 tests/month
- Vertical tests to be finished end of 2015





**MOPB086** 





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## **FEL VT-CM comparison: USABLE GRADIENT**



### **Vertical Test – min of**

- Maximum gradient (quench, RF power)
- FE limit (top/bottom X-ray)
- Q<sub>0</sub> limit (= 10<sup>10</sup>)

Cryomodule – min ofMaximum gradient (quench)

**FE** limit (front/back X-ray)

RF power limit at 31 MV/m

- Acceptance criteria for "Usable gradient" in vertical test
  - INITIAL: > 26 MV/m (10% margin to required average design operating gradient)
  - NOW (after analysis of retreatment results in May 2014):
     > 20 MV/m (for optimized number of retreatments and retests)









- Both vendors well above Spec
- RI shows ~ 3MV/m in average more than EZ:
   a) final EP
  - b) low gradient quenches at EZ
- In general, first re-treatment is a standard High-Pressure Rinse (or "special" handling at vendor)
- Several cavities with < 20 MV/m accepted, especially if
   a) limitation = "bd" +
   b) no FE

### "Missing" 75 cavities? Not included in "as record

Not included in "as received", because "retreatment at vendor" necessary before first RF test





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# Recent Progress with EU-XFEL TTC 2014: Trend of Usable Gradient "As received" increasing?



European













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#### European More Cavity related topics

- MOPB086 **MOPB075** Retreatment: very successful

Optical inspection of defects + surfaces | MOPB072

"Warm" RF measurements + tuning during cavity fabrication => WEBA02 THPB066 THPB031 THPB068

- HOM coupler notch filter tuning
- He 2-phase line does not fulfill PED-requirement
- **TUPB117** THPB039 Documentation + Data Base THPB032 THPB038
- Second Sound on Cavities with He-tank





**THPB025** 

TUPB085



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THPB067



**TUPB079** 

## XFEL Cryomodule Test at AMTF

#### August, 31: 59 modules arrived with ~55 modules rf tested (XM-3 excluded)











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## **XFEL** Statistics of Cryomodules + Cryomodule Tests

- Cryomodule assembly covered in separate talk
- Analysis of cryomodule tests: Aug 31, 2015 (~54 cryomodules) MOPB080

- Improved and optimized test procedure since June 2015 TUPB118
   => typical test duration reduced to < 15 days (assuming no non-conformities!!!)
- Non-conformities (causing significant delay):
  - (cryogenic + vacuum) leaks (mainly at temporary connections to test stand)
  - warm coupler part





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#### Recent Progress with EU-XFEL Cryomodule – Vertical Test comparison: MAX GRADIENT



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individual cavity comparison

European

(upper limit due to 31 MV/m limit in module test)



17<sup>th</sup> International Conference on RF Superconductivity Detlef Reschke, DESY





when making comparisons,



INFN

# EuropeanVertical Test - Cryomodule comparison III:XFELUSABLE / OPERATIONAL GRADIENT











# EuropeanRecent Progress with EU-XFELEuropeanVertical Test - Cryomodule comparison IV:XFELQ\_0-values at ~ 23MV/m









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## **XFEL** 3.9GHz third harmonic system (DESY+INFN MI IKC)

- One 8-cavity module is ready for XFEL Injector [+1 full spare in fabrication]
  - Fabrication of cavities (10 done+10 ongoing) @ E.Zanon
  - Vertical qualification tests at INFN MI (first 10 batch)
    - All cavities above specs
  - Horizontal RF test of a fully equipped 3.9 GHz cavity
    - Cavity package validated (tuner, coupler, WG tuners)









**MOPB076** 



European

## **FEL** 3.9GHz Module preparation for Injector

- Cryomodule Vessel and Cold Mass derived by INFN from XFEL design, manifactured by E.Zanon
- String and Module Assembly Infrastructure at DESY adapted for 3.9 GHz
- Module is ready for tunnel installation in Mid September (W37)
  - 2 weeks string assembly from Mid June, (W26)

 $\sim$  10 weeks from roll-out to module from July, (W28) **TUPB018** 





**TUPB105** 









- Gun and gun diagnostics already tested first beam on Feb 10<sup>th</sup> 2015
- Single accelerating module (27 MV/m) installed in May '15
- start of injector commissioning in Nov. '15 after installation of 3.9 GHz module





## **XFEL** The finished L1 section







Armin Brand XFEL TC - Office

04.09.2015

## **XFEL** Installation + Commissioning

- Cryomodule installation
  - Automatic welding of all the cryo pipes (with PED certification)
  - Installation of the Beam Line Absorber under clean conditions
  - Leak test of a complete string of 12 modules and 2 feed/end components

**TUPB108** 

- First RF station under warm commissioning
- New developed technical coupler interlock with remote diagnostics
   THPB080
- Tunnel closing June 30, 2016





#### Micro TCA™ Rear Transition Module









## **FEL** Thanks to all colleagues of:

- IFJ-PAN Krakow
- CEA Saclay
- INFN Milano
- E. Zanon
- Research Instruments
- Daher Transkem
- Alsyom
- DESY









