ECFA LC2013

ECFA LC13 SRF Technology Summary

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HELMHOLTZ ASSOCIATION

ECFA Study
Physics and Detectors for a Linear Collider

DESY

Overview

- European XFEL challenges and experience
  - Industrialization of the cavity fabrication
  - testing and test results
  - Module assembly
  - High grade program
- Cavity R&D
  - Materials, welds and surfaces
  - Shapes
- RF high power coupler status and development
- Frequency cavity tuner

We have had high quality presentations and intense discussions

XFEL challenges experience, cavity fabrication

- The principles of technology transfer are followed and completed
- Contracts for two times 400 cavities have been placed to the companies: Research Instruments and E. Zanon (plus 24 ‘High grade cavities’ for ILC research and XFEL quality control)
- Jointly supervision team of DESY and INFN (Milano) was formed
- Pressure vessel code: test pieces have been build and investigated, procedure is implemented
- Niobium material provided by DESY to both companies
- Infrastructure at industry is qualified by extra cavities (8 for each company)
- Quality control and documentation scheme is defined and working (mechanical, RF and preparation)
- Data aquisition and processing in progress

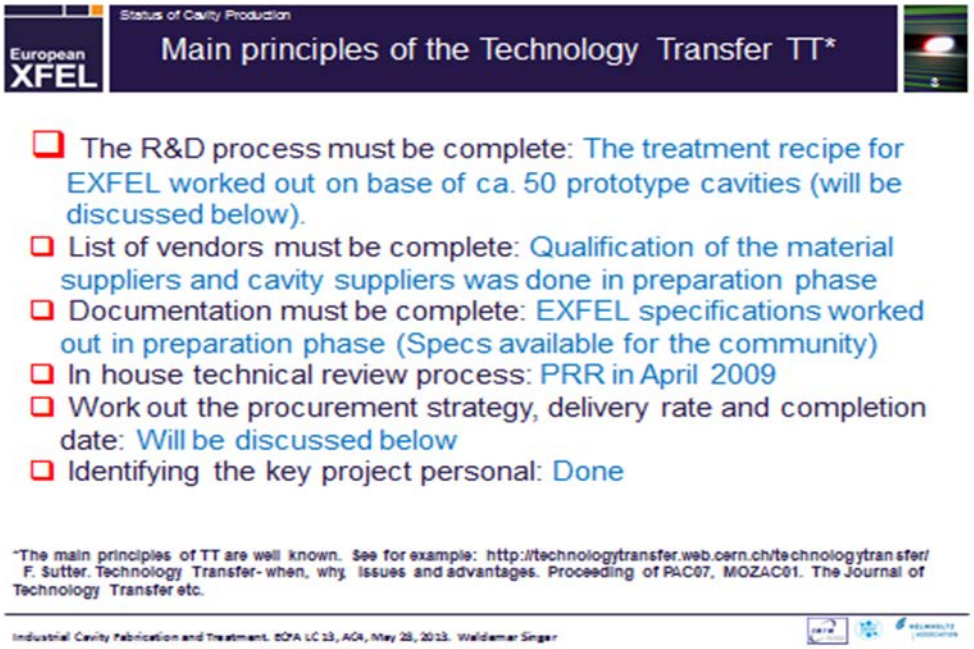
XFEL challenges experience, cavity fabrication

> Delivery status:

Cavities	EZ	RI	Total
Delivered to DESY:	37	4	41
Measured (RF):	28	1	29
Delivered to Saclay:	15	0	15

> Waldemar concludes:

"First experiences of the European XFEL demonstrate that industry is in position not only mechanically produce SC Cavities, but also do the complete cavity preparation up to vertical RF test."

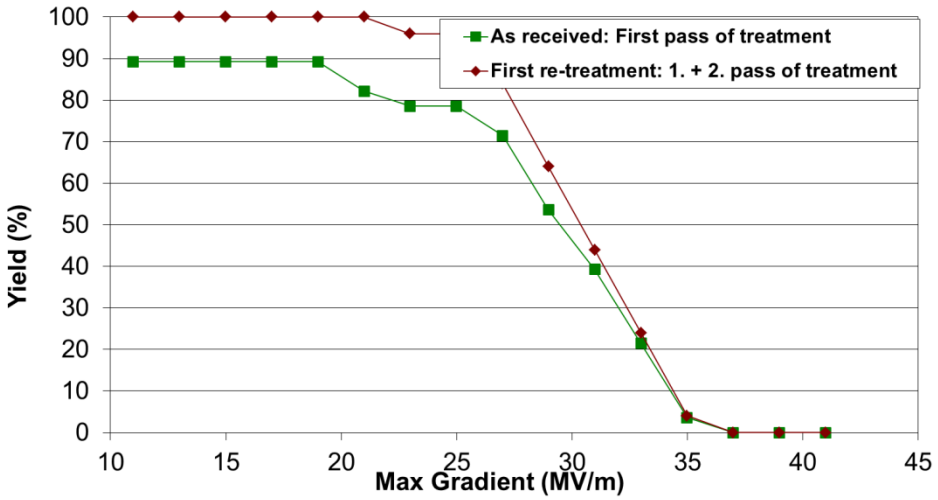


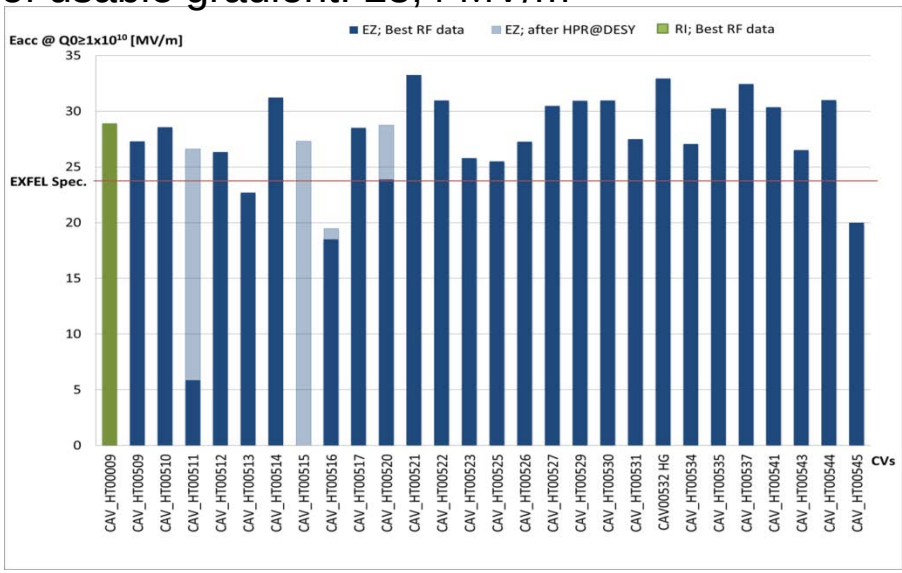
XFEL challenges experience, test facility

- New test infrastructure has been build:
  - Cold RF test of all XFEL superconducting cavities before cryo module assembly, 800 cavities, rate 6/week, 2 of 2 vert. test stands under operation
  - Complete cold performance test of all XFEL cryo modules before tunnel installation: RF, vacuum, cryo-losses, tuner, quad, 100 cryo modules, rate: 1/week, 1 of 3 test stands in cryo commissioning
  - Cold test of all superconducting magnet packages before cryo module assembly 100 magnets, 1/week, 1 of 1 stand under operation
  - Assembly and tests of RF Waveguides at Waveguide Assembly and Test Facility, under operation

XFEL challenges experience, test results

- Vertical acceptance test done on 27 cavities equipped with He-tank and HOM feedthroughs + 1 HiGrade Cavity w/o He-tank, but with HOM feedthroughs
  - 21 cavities meet specification w/o re-treatment
- Re-treatment by High Pressure Ultra-Pure Water (HPR) rinsing =>
  - 3 cavities successful done at DESY + 1 cavity in preparation
- 3 cavities with quench between 19 MV/m - 22 MV/m => add. BCP in preparation
- Average of max gradient: 29.8 MV/m; average of usable gradient: 28,4 MV/m



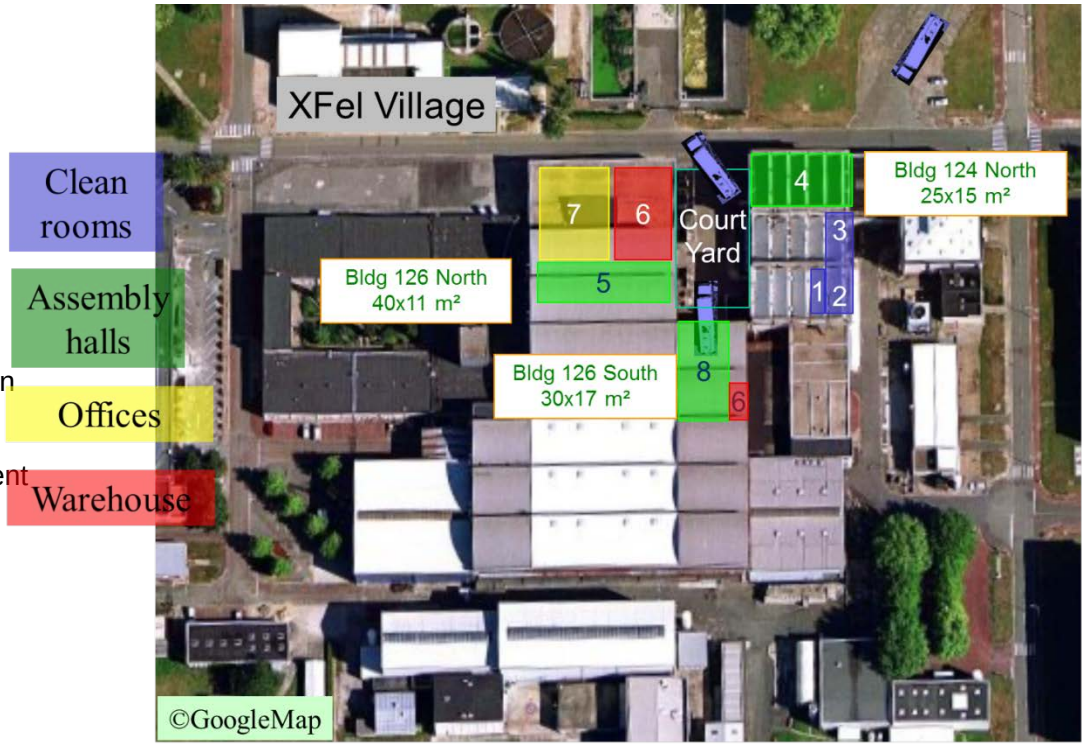


Yield of max. and usable gradient based on 28 cav.
25 cavities OK for add. 3 HPR so far (3 need BCP, changes every day)

XFEL challenges experience, module assembly

New and complex infrastructure build at CEA, Saclay

1. **Clean Room Cold Coupler Area** (IS04-CC-WS1)
   - Cold coupler assembly
2. **Clean Room String Assembly Area** (ISO4-SA-WS1, ISO4-SA-WS2)
   - String connections (1 gate valve + 8 cavities + 1 Qpole unit)
3. **Roll-out Area** (RO-WS1, RO-WS2)
   - HOM tuning, magnetic shielding, tuners,…
   - 2Ph-tube welding, cold-mass connection
4. **Alignment Area** (AL-WS1, AL-WS2)
   - Cavity and quadrupole fine alignment
   - Coupler shields and braids, tuner electric tests
5. **Cantilever Area** (CA-WS1)
   - Welding of 4K and 70 K shields, super insulation
   - Quad current lead
   - Insertion into vacuum vessel and string alignment
6. **Coupler Area** (CO-WS1, CO-WS2)
   - Warm couplers + coupler pumping line
   - Control operations (electrical, RF)
7. **Shipment Area** (SH-WS1, SH-WS2)
   - CEA-Alsyom “acceptance test”
   - End-caps closing, N2-insulation, loading.



In full production, this chain of workstations will be fully occupied with 7 cryomodules (XM_{n-6} @ WS1,…, XM_n @ WS7) stationed for one week.

XFEL challenges experience, module assembly

Tender process: ALSYOM, lowest bidder / best technical offer, has been selected by CEA.

Up to 29 people will be on Saclay site during ~2 ½ years

After 9 months collaboration, these people are GOOD and the CEA-Alsyom collaboration is EXCELLENT !

As one example of challenge: Tooling vs. Industrial Contract

- Ideally the tooling definition should be included in the industrial contract.
- This was impossible with our project timeline
- The contract specifies that the Industrial Operator is only responsible of the standard tools, while CEA is responsible for the specific tools and their maintenance.
- *The contract is essentially 'Man and Engineering Power'*
- As a consequence, the industrial operator will criticize the infrastructure layout and the tooling made available to him:
- *Some of the criticisms come too early, missing the global scheme.*
- *Some of the criticisms will lead to a better optimized production.*
- ⇒ Negotiation and improvement is on the way

XFEL challenges experience, High grade program

> Program serves as quality control (QC) samples for the XFEL cavity fabrication
- extracted regularly ~one cavity/month: first cavity arrived!
- after the normal acceptance test will be taken out of the production flow, than intense investigation

XFEL/ILC HiGrade program

R&D program @ DESY derived from global effort for ILC and well in phase with effort elsewhere

- Our goal
- European XFEL/ILC-HiGrade program
- Results of cold RF test of the first XFEL/ILC-HiGrade cavity
- Additional R&D instruments to be applied
  - Centrifugal Barrel Polishing
  - OBACHT optical inspection
  - Second sound upgrade
  - Local grinding
  - Replica
- HiGrade Lab

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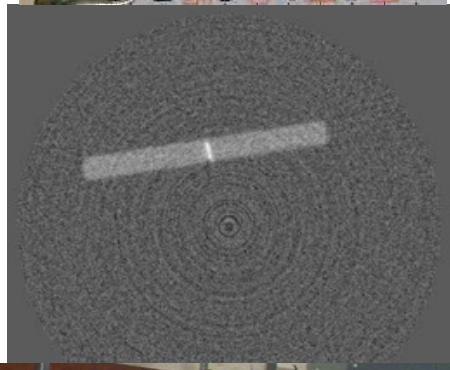
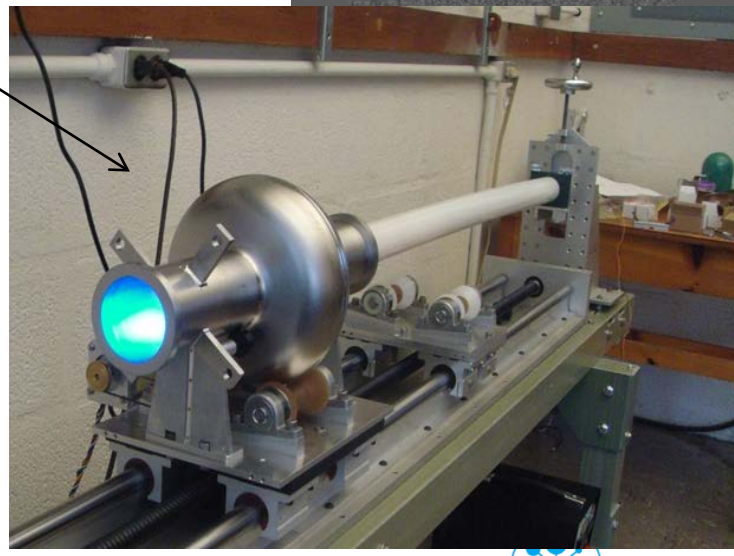
SEVENTH FRAMEWORK PROGRAMME
CRISP
Bundesministe für Bildung und Forschung
Alexander von Humboldt Stiftung/Foundation

Cavity R&D, materials, welds, surfaces, shapes

- Defect detection on bulk Niobium and cavity welds; Comparison of inspection methods have been discussed:
  - Optical, Neutron imaging, X-ray Imaging



- There is continued interest in developing large-grain niobium cavities for higher performance in gradient and in Q0
- Synergies with activities for the CW activities (high Q) have to be used
- New activities on Nb_3Sn coating at Cornell
- Low surface field shape for smaller H_{pk}/E_{acc}

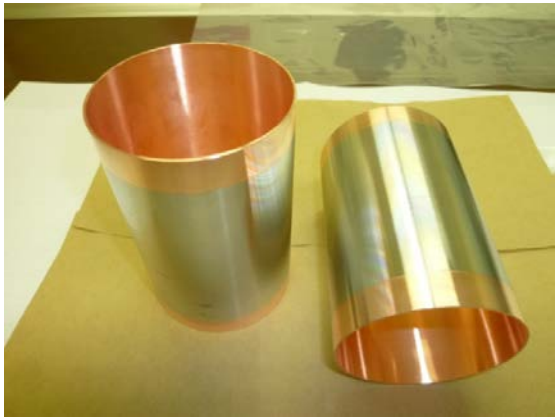


Work from different labs

Jlab

RF high power coupler status and development

- Analysis coupler performance KEK, Fermilab, DESY from S1 global experiment were given.
- Copper plating is still a problem (RRR, adhesion) KEK starts investigation
- New series of improved coupler are build at KEK



- Discussion on cavity coupler port size: new analysis, workshop planned in fall 2013

Cavity Frequency Tuner

- Variety of tuners for 1.3 GHz elliptical cavities have been built and tested and compared in ILC/S1G tests at KEK in 2010

  Each demonstrated excellent performance following compensation

- Variety of control algorithms have been implemented and tested
  - Feed-forward LFD compensation and resonance stabilization against He pressure variations are now well understood
  - At narrower bandwidths microphonics becomes more important

    Feedback may be useful
  - No fundamental reason detuning from all sources can't be controlled to 1Hz or better
- Tuner represents only a few percent of overall cryomodule cost
- Selection of tuner for collider cavities should focus on lifetime and reliability
  - Required reliability can be achieved
- Tuner reliability evaluation and improvement program should be initiated and completed well before commencement of procurement and production

- XFEL tuner fabrication progress and quality control was presented

Charge for the WG 4, SCRF Technology

- Working group AC 4 should present plans for strengthening links between the ILC - SCRF group and the EU-XFEL project. We expect the EU-XFEL cavity and cryomodule industrial production rate to reach its peak in the next year or so and the ILC – SCRF group must plan a practical (and mutually beneficial) working relationship to take advantage of the information generated through this substantial activity.
  - High grade program is established with dedicated cavities from mass production
  - Extensive data taking from fabrication process and performance measurements is implemented, analysis is planned, expert are invited to take part
- SCRF linac supporting technology (for example HLRF generation and distribution) studies should be reviewed and progress should be reported.
  - No progress, but planned experiments (budget)
- Following up on recommendations made in the December 2012 Project Advisory Committee report, the working group should develop a program to study and improve coupler and tuner performance and cost.
  - Workshop on coupler performance and design is planned

List of presentations

Many thanks to all who have presented excellent talks and partissipated in the intense and fruitfull discussions.

Link: https://ilcagenda.linearcollider.org/sessionDisplay.py?sessionId=14&confId=5840#20130530

- SINGER, Waldemar, Industrial Cavity Fabrication and Treatment -Challenges of the Knowledge Transfer to Industry
- SULIMOV, Alexey, RF Measurements and Documentation for the Industriel Fabrication of SC Cavities
- PETERSEN, Bernd, XFEL Cavity and Module Test Facility AMTF
- WIENCEK, Mateusz, XFEL AMTF Cavity and Module RF Measurement Procedures
- RESCHKE, Detlef, First XFEL Cavity RF Test Results
- NAVITSKI, Aliaksandr, XFEL/ILC High Grade Program
- IWASHITA, Yoshihisa, Update on Detection and Study of Welding Porosity in Niobium EBW (effort at JLab, KEK and perhaps FNAL?)
- FURUTA, Fumio, Update on the Development of Alternative Shape Cavities (9-cell re-entrant cavity at Cornell, 9-cell low-loss shape at IHEP, 9-cell low-surface-field shape at JLab).
- GENG, Rongli, Update on Raising Q0 at Ultra-High Gradient via Large-Grain Niobium Material (1-cell cavity as well as 9-cell cavity results)
- POSEN, Sam, Update on Development of Coated Cavities (new results from 1-cell cavities at Cornell and JLab
- ALL, Comparison of Different SC Cavity Treatment Strategies (hor. EP/ vert. EP/ BCP/ tumbling/ repair/ large grain)
- KAKO, Eiji, High Power Coupler Development for the ILC at KEK
- KAZAKOV, Sergey, Can we avoid copper coating for 1.3 GHz ILC coupler?
- ADOLPHSEN, Chris, Developments on High Power Generation and Distribution
- LI, Yongming, Update on Instrumentation and Results of X-ray Mapping for Understanding of Field Emission in 9-cell Cavities (effort at JLab and KEK).
- KOSTIN, Denis, Analysis of Cavity Performance Degradation During Vertical RF Test at High Fields (is there a need to limit the gradient during vertical RF tests?)
- LILJE, Lutz, Fabrication and Quality Control of Frequency Tuner for the XFEL
- SCHAPPERT, Warren, A Review of Fast and Slow Tuners for 1.3 GHz Elliptical Cavities
- ALL, General discussion on tuner implementation for ILC
- NAPOLY, Olivier, Industrial String and Module Assembly -Challenges of the Knowledge Transfer to Industry
- ALL, Strategies Towards a Better Quality Control During String Assembly (how to preserve the cavity gradient)
- YAMAMOTO, Yasuchika, Explosive Events during Vertical Testing at KEK