Update European XFEL

E. Elsen
at ILC PAC Meeting, Nov 11-12, 2010

Slides almost exclusively from H. Weise
Talk at IWLC2010, Oct. 2010
Topics

- Construction status of European XFEL
- Parameter update
- SRF
  - Cavities
  - Couplers
  - Modules
  - Assembly
Experience from the European XFEL

Tunnel and Borer Christening Ceremony

Saint Barbara
Patroness of the Miners
480 m within the First two Months

- Start of excavation of main linac tunnel beginning of 2011
- Arrival at DESY Bahrenfeld (injector) in summer 2011
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The Injector Building on DESY Site
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Accelerator Complex with New Parameters

- **80** accelerator modules
- **640** accelerating cavities
  - 1.3 GHz / 24.3 MV/m
- **20** RF stations
  - 5.2 MW each

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Cavities
Cavity Call for Tender was published on July 2nd, 2009 following a Production Readiness Review.

- **Production and preparation** in industry.
- **Contracts** to be allocated by DESY and supervision of cavity production by DESY/INFN.
- **Negotiations with vendors** in two iterations.
- **Funding** politically complicated.
Two schemes for the final surface treatment (*Final EP* and *BCP Flash*) were studied with cavities from two different vendors.

The preparation strategy to go for a final treatment with the cavity already welded into the He-vessel was investigated.

Results are:
- yield curves for the different schemes
- yield curves for the different vendors
- a preparation strategy allowing two different final treatments

Some tooling will come from DESY

DESY procedures and experience described in much detail in the CFT specification will be made available to the SRF community towards end of 2010.
Both machines ready for use at the companies (CE certified).
- Machines may be operated by non-RF-experts.
- Considerably shortened measurement / tuning time.
- Automated measurement with documentation included.
Research Instruments and E. Zanon were contracted to produce each

- 4+4 pre-series cavities
- 280 XFEL type series cavities
- 12 ILC-HiGrade cavities, initially used for quality assurance, later available for further investigations & treatments (high gradient R&D towards ILC)
- Nb / NbTi to be supplied by DESY
- Production to follow the specifications which also include the exact definition of infrastructure to be used
- Final treatment after bulk electro-polishing (EP): EP for RI / flash BCP for Zanon
- No performance guaranty by vendors, i.e. the risk of unexpectedly low gradient or field emission is with DESY (responsibility for re-treatment); goal: average usable XFEL gradient of 24.3 MV/m
- Additional 80 cavities will be ordered as an option; contract to be placed after the evaluation of the successful start of the series production
- First series cavities beginning of 2012; all cavities to be delivered within two years; He-vessels for RI cavities to be supplied by DESY
- Both contracts have a volume of almost 25 M€ each
Building and commissioning automated optical scanner
- full cartography of cavity inner surface
- automated feature extraction

2nd sound technique to localize quench in vertical test stand
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**XFEL RF Power Coupler – LAL Orsay Contribution**

- **TTF3 coupler type**

**LAL Orsay** has assumed the responsibility for the XFEL RF power coupler production.

**Conditioning** of the couplers will take place at LAL Orsay.

The **coupler interlock** system was developed and will be contributed by DESY.

- Contract for the **production of 640 couplers** recently placed at a consortium of **THALES & Research Instruments**. Kick-off Meeting on Sep.13, 2010.

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Conditioning rate of **8 couplers per week** with max. 5 MW RF power.

- Either pairs (4 x 2 couplers) or units of 4 couplers (under study).
- Schedule integrated in overall project schedule.

- Direct delivery to near-by assembly site at CEA Saclay.
Three XFEL prototype modules were built and tested.
Assembly procedures improved during assembly training with new teams.
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PXFA - Modules from Different Vendors

PXFA1:
cryostat: IHEP Beijing

- $\langle E \rangle = 36$ MV/m; 32 MV/m in module
- operated at FLASH with $\langle E_{acc} \rangle = 30$ MV/m using the XFEL waveguide distribution.

PXFA2:
cryostat: duro felguera

- $\langle E \rangle = 31$ MV/m; 30 MV/m in module
- 3rd cavity dropped from 30 to 19 MV/m

PXFA3:
cryostat: Thales

- $\langle E \rangle = 30$ MV/m; 25 MV/m in module
- 3rd cavity dropped from 27 to 16 MV/m and neighboring cavities show field emission
- possibly an assembly issue; cavity had been used as a training sample

Cavities gradient limits

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All PXFEL cryostats seem to be acceptable. Demonstration of a **successful technology transfer.**

There are now **four experienced vendors** including E. Zanon who produced all previous cryostats.
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PXFEL2 – Traveled from DESY to Saclay to DESY to Saclay ... as an Exercise ...
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... and a Test of the Transportation Tools

Feed-cap side

End-cap side

Accelerometers
Permanent leak check etc.
DESY takes care of installation / dismounting of cavities into / from test insert
Transport to CEA in transport boxes
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Transport Simulation

- Sweep (0.1 g), Transport simulation (up to 2 g) 1200 km with shocks applied up to 6 g
- Final test done without external dampers, only internal foam elements.

- Eigen frequencies
- Field flatness
- Cavity gradient
Using experience gained at DESY and results of industrial studies, the assembly facility for all XFEL modules will be set up at the CEA-Saclay site.

CEA (IRFU), CIEMAT, DESY, INFN-Milano, LAL Orsay, Swierk assume responsibility for the cold linac.
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Module Assembly - Workstations

- Roll-out Area RO-WS1 & 2
- Alignment Area AL-WS1 & 2
- Shipment Area SH-WS1 & 2
- Warehouse
- Coupler Area CO-WS1 & 2
- Cantilever Area CA-WS1

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All cavities with He tank, coupler cold parts and the quadrupole-BPM units will be cleaned and dried externally before entering ISO4 area.
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Infrastructure for Cavity String Assembly
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Infrastructure for Cavity String Assembly

ISO 7
(class 10,000)
28 m²

ISO 5
(class 100)
38 m²

ISO 4
(class 10)
112 m²

15.6 m

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Module Assembly Halls at CEA Saclay

- Three Assembly Halls and Services (offices, dressing rooms, warehouse, central courtyard, etc...) have been refurbished:

  - Hall n°1 is ready
    - Roll-out Area (RO-WS1, RO-WS2)
    - Alignment Area (AL-WS1, AL-WS2)

  - Hall n°2 is ready
    - Cantilever Area (CA-WS1)
    - Coupler Area (CO-WS1, CO-WS2)
    + offices and warehouse

  - Hall n°3 is ready
    - Shipment Area (SH-WS1, SH-WS2)

Assembly Hall and Services ready: April 2010
Central courtyard new surface in June 2010.
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Refurbished DESY Clean Room

- State-of-the-art
- Now used for assembly training
- Later available for repair work
- Increased ISO4 assembly area
- Chemistry and ultra sound infrastructure now in ISO6/5 instead of ISO7/6
- New rotational clean room airlock

- Two independent air systems
- Improved energy balance
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Accelerator Module Test Facility (AMTF)
Including Single Cavity Tests

- Includes cavity / module & waveguide assembly / test
- Commissioning
  - cavity tests late fall 2011
  - module tests end 2011
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Many More Components, e.g. Cold Magnets, 3.9 GHz Acceleration, RF Systems ...

- The first **cold magnet** in the test cryostat.
- The **3.9 GHz FLASH accelerator module** as prototype.
- **RF system R&D at DESY.**

- **Approx. 100 undulators** with 585 m total length.
- **Undulator beam pipe extr.** Al 15 mm x 8.8 mm ellipsoid
- **Sophisticated intersections** incl. Quad / Phase Shifter / BPM

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Many Contributions to the Accelerator Complex
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Summary of aspects relevant for ILC

- Production of components now handed to industry together with detailed instructions (and tools)
  - Cavities
  - Couplers
  - Modules

- Vendors document QA wrt to specification

- Full QC and performance tests remain with laboratories, e.g. gradient or $Q_0$

- Production deemed appropriate for high gradient cavities but requires additional
  - diligence and
  - monitoring

- Expect valuable learning experience for ILC