

Preparing RI for the Mechanical Manufacturing and Surface Preparation of 300 XFEL Cavities

Michael Pekeler

RI Research Instruments GmbH

Friedrich-Ebert-Str. 1

51429 Bergisch Gladbach

Core Competences and Markets

Quality Management according to DIN EN ISO 9001:2008, KTA

Technologie

- RF, Accelerator
- Superconductivity
- Cryogenics
- Vacuum
- Integr. System Control
- Specialized Manufacturing
- Surface Treatment
- System Integration

Products / Services

- Linear Accelerators,
- RF Cavities, Couplers
- SRF Accelerator Modules
- Electron and Ion Sources
- Beam Diagnostic Elements
- Particle Beamlines
- Precision Manuf. Components

Markets

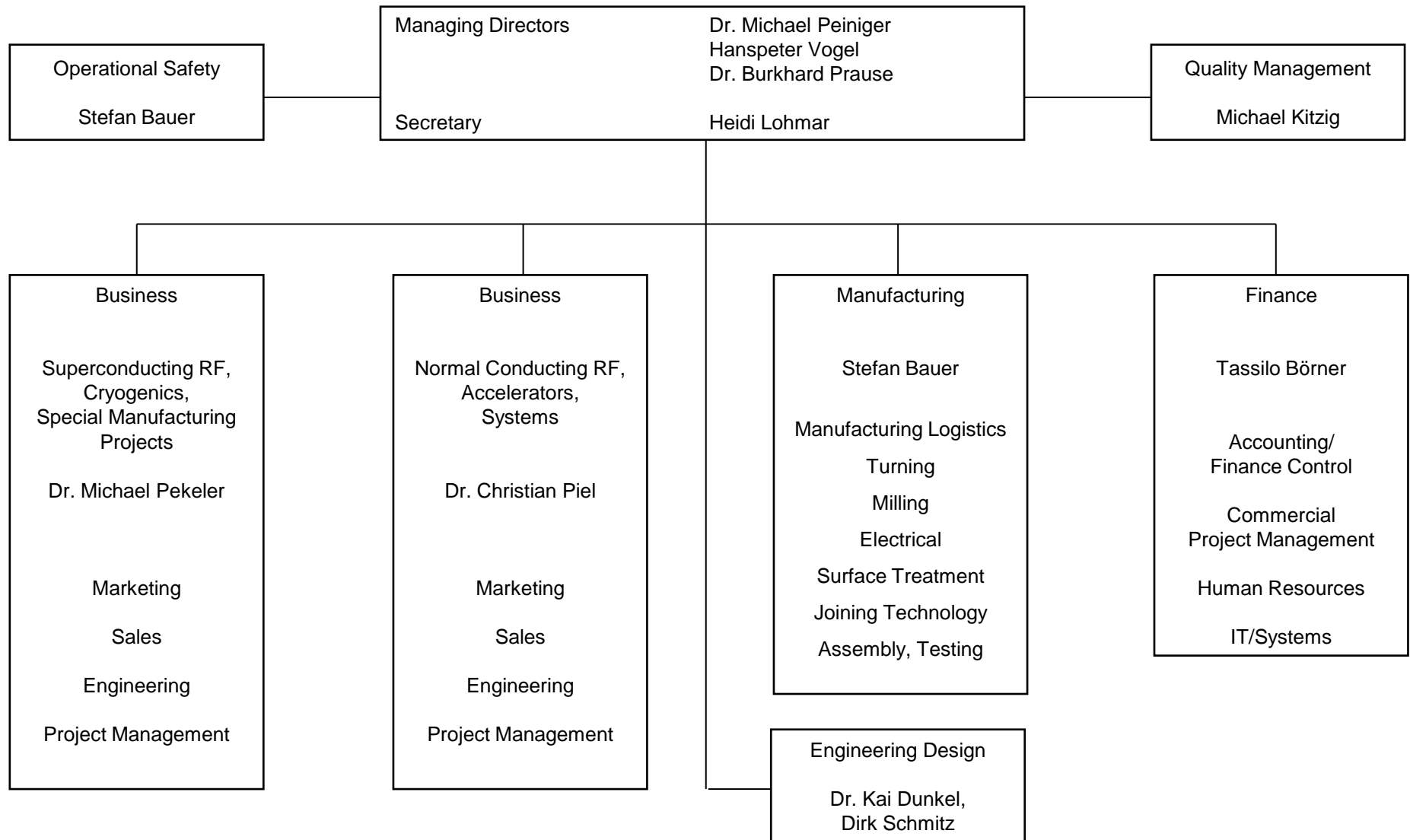
- Fundamental Physics
 - Applied Research
 - Medical/ Particle Therapy
 - Energy/ Nuclear
 - Advanced Technology Industry
- Including:
Inspection,
Solar,
Live Science

physics layout – engineering – design – manufacturing – assembly – testing – service

Visit us at the booth and take one of our new brochure to learn more about our capabilities and accomplished projects. RI is a project oriented company.

RI Research Instruments GmbH

Company Organisation (January 01, 2011)



RI employs about 100 people, 60 manufacturing specialists, 30 physicists and engineers, 10 employees with administrative or commercial/financial duties

RI Research Instruments GmbH, Bergisch Gladbach

Advanced Technology Devices and Turn-Key System Supplier for Research, Industry and Medical worldwide



RI Research Instruments GmbH
at the Technologiepark Bergisch Gladbach, 15 km away from Cologne

A former activity of ACCEL Instruments GmbH

51% of shares by Bruker EST, Inc.

Management holding a significant equity stake of the company

More than 25 years history in superconducting and normal conducting RF cavity manufacturing through Siemens, ACCEL and RI

Manufacturing premises of RI (before XFEL project)



Main building for turning, milling, brazing, EB welding, assembly, clean room, RF measurements, dimensional control, leak check

- 2 Electron beam welding machines
- 2 Vacuum brazing furnaces

- 11 Turning machines
- 10 milling machines

- 1 clean room class 100 (40 sqm)
- Assembly space (1500 sqm)

- Leak checking
- Pressure test

- RF measurement and tuning

- Cold test facility (1 MeV)

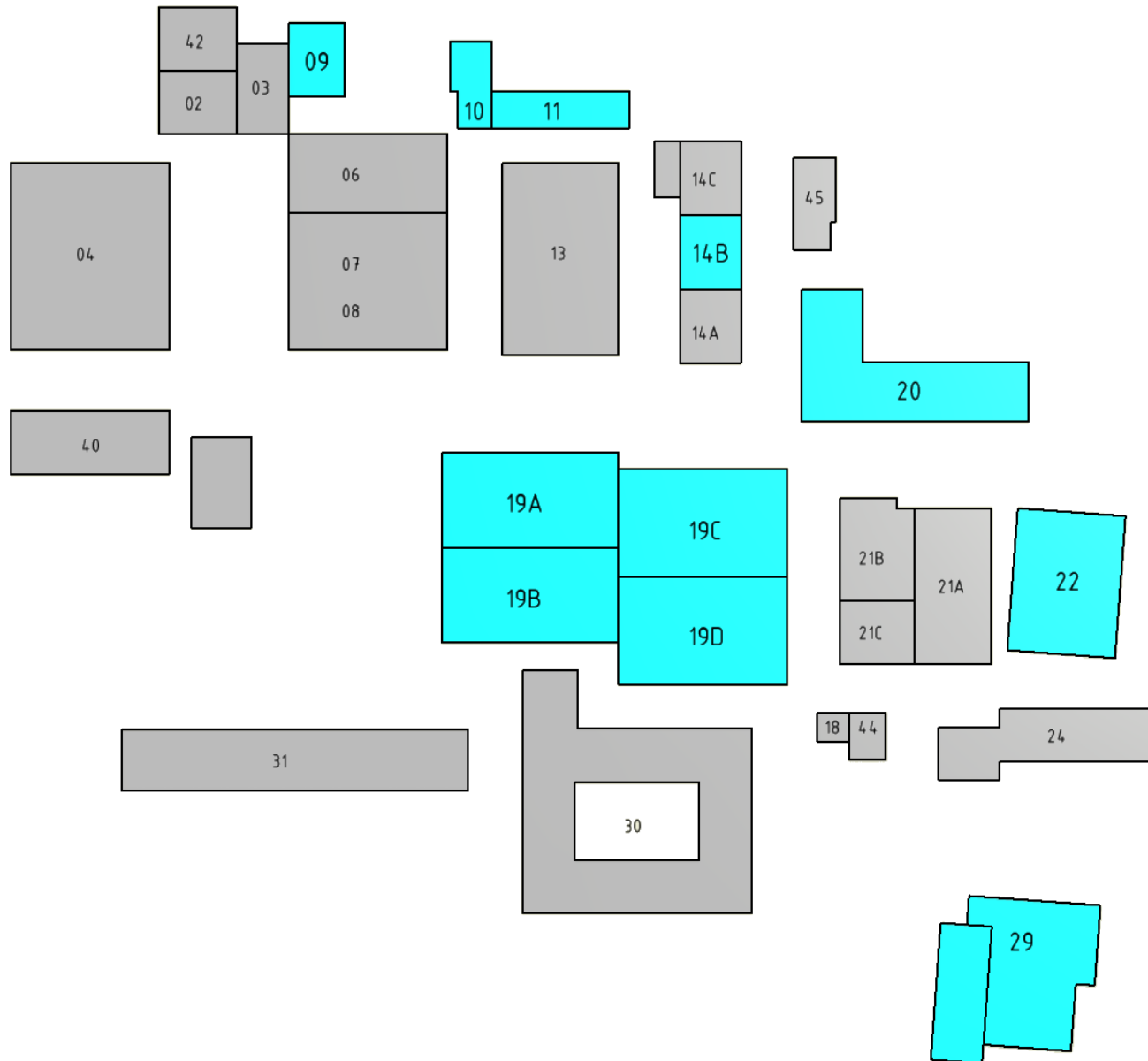
- TIG welding

- 3 US degreasing bathes

- 1 BCP facility
- 1 EP facility

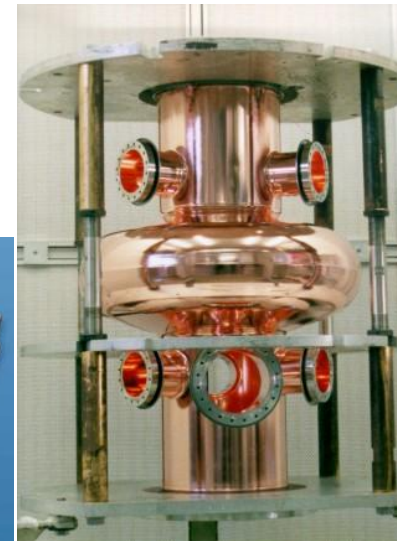


Buildings rented by RI at the Technology Park in Bergisch Gladbach



- 9** FAT of cryo modules
- 10** BCP plant
- 11** Grinding facility
- 14 B** TIG welding
- 19 A** Turning
- 19 B** Milling, dimensional control
- 19 C** RF measurement, other assembly
- 19 D** Brazing, EB, 800°C , leak test
- 20** Office
- 22** Receiving, storage
- 29** EP, degreasing, grinding

Superconducting cavities – prototypes, small series, larger series production



1200 SRF Cavities produced so far, about 40 SRF cavities/year in average over the last 25 years

RI production capability for JLAB upgrade cavities

RI's scope included purchasing of niobium, cavity manufacturing, bulk chemistry and RF tuning (fundamental mode and HOM couplers).

- RI received an order for 86 pieces 1.5 GHz 7-cell cavities in July 2009
- The niobium was at RI premises in November 2009.
- Original schedule:
First article to be delivered in June 2010, last cavity to be delivered middle of 2011
- Achieved schedule:
First article delivered July 2010, **84 cavities delivered in November 2010, one year after niobium supply**, 2 last cavities delivered in March 2011 (lack of niobium material, additional material had to be ordered for the last two cavities).

Schedule improved by 2 shift operation on turning, milling and electron beam welding machines.



European XFEL cavity production at RI

Order for 300 cavities received from DESY in September 2010



Niobium and
helium vessel supplied by DESY

RI scope:

- Mechanical manufacturing of cavity, respecting the pressure vessel code
- Complete Surface preparation and helium vessel welding
- Shipping to DESY under vacuum and “ready for vertical test”
- Extensive documentation and QA is crucial and will ensure that cavities are manufactured and treated according to detailed DESY specification. No performance guarantee.

DESY:

- Cavities will be cold RF tested at DESY (vertical test) with helium vessel already welded
- After successful test, DESY will ship the cavities under vacuum to CEA for module assembly

European XFEL cavity production time schedule

2011-07-15_XFEL-CV_Time_Schedule																						
Nr.	description	start	finish	2010				2011				2012				2013				2014		
				Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
1	Infrastructure for mechanical series fabrication	Do 23.09.10	Mi 29.06.11																			
11	Infrastructure for series preparation	Do 23.09.10	Mi 08.02.12																			
39	Mechanical Engineering	Do 23.09.10	Mi 17.11.10																			
41	PED related work (two test pieces)	Do 28.10.10	Fr 30.09.11																			
65	Fabrication of 4 DCVs (dummy cavities)	Mo 13.12.10	Fr 09.09.11																			
69	Fabrication of 4 RCVs (reference cavities)	Mo 13.12.10	Mi 02.05.12																			
76	Fabrication of 280 Series Cavities and 12 HiGrade Cavities	Mi 29.06.11	Do 10.04.14																			

- Two test pieces for pressure vessel qualification
- Four dummy cavities stay at RI for implementing infrastructure
- Four reference cavities, will be treated and tested at DESY first, if test is ok, then mechanical manufacturing of series cavities can start. The reference cavities will then be retreated by RI in RI infrastructure. If test also ok, the series surface preparation can start

Status: Dummy and reference cavities on track
 First series material will arrive End of July at RI
 Mechanical Infrastructure finished
 Infrastructure for series preparation on schedule

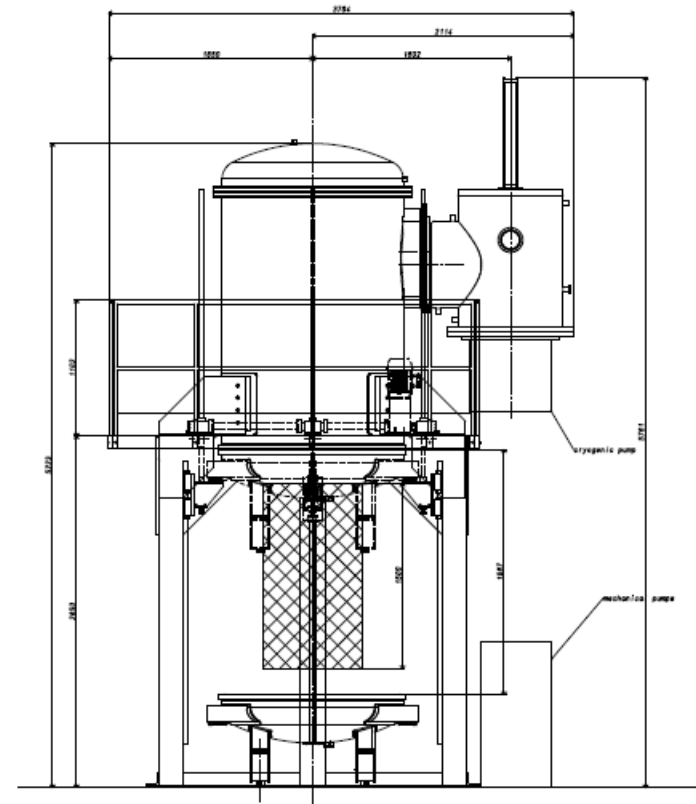
New infrastructure at RI for XFEL production



- 60 kV EB welder from Pro Beam
- Replaces our old small EB welder
- Pallet system
- Lock chamber (1E-3 mbar)
- Weld chamber (1E-6 mbar)
- Turbo pumps

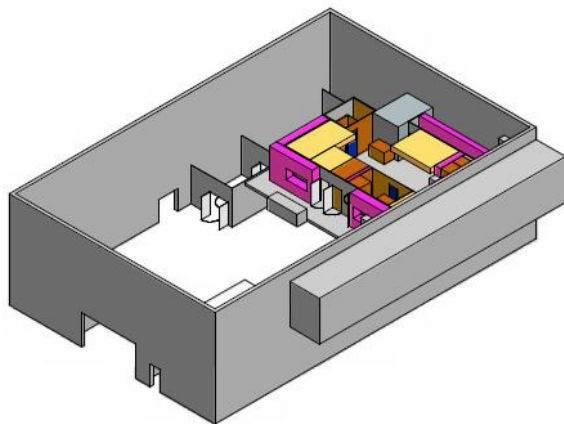
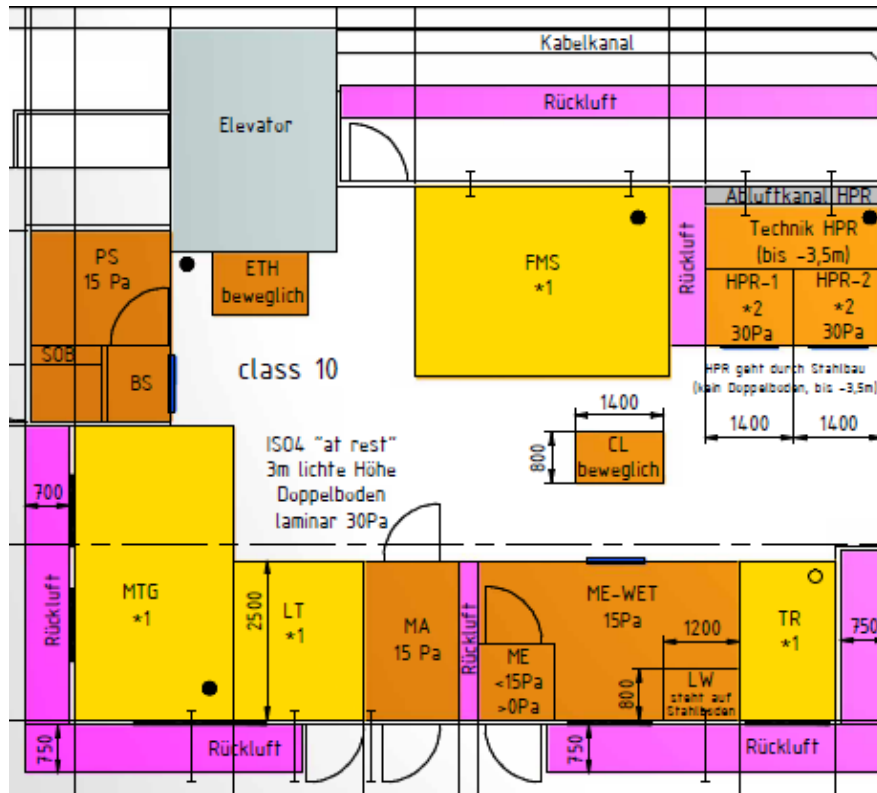
- One more turning machine
- One more milling machine
- Two 120° C baking chambers
- 4 pumping stations including RGA for SRF cavities and dry leak checker

Tuning machine and HAZEMEMA (half cell measurement machine) supplied by DESY



- 800° C all metal annealing furnace from TAV, Italy
- Diameter 800 x 1500 high
- 4 cavities in vertical position per run
- Cryo pump

New clean room at RI for XFEL cavity surface preparation



- 120 sqm ISO4 clean room
- 2 HPR systems including UPW system
- 2 assembly spaces
- 1 leak checking area
- 2 rinsing stations
- 1 ethanol rinse
- 1 personal lock
- 1 area for cavity drying

Test pieces for pressure vessel code verification

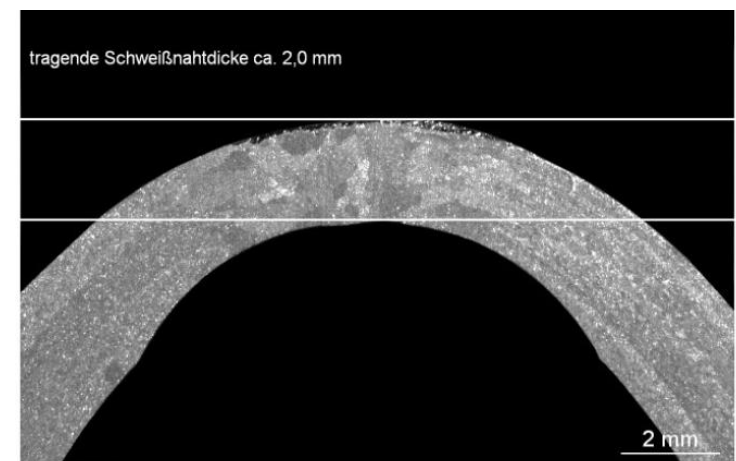
- The cavity must be produced according to European pressure vessel code
- DESY and TÜV Nord have worked out a „simple“ qualification procedure
- Test piece (2 cell with helium vessel, without end groups), representing all pressure bearing parts is built using exactly the same manufacturing methods and welding parameters, that will be later used in the series production
- Test piece parts are dimensional controlled and welds are inspected by X-rays, visual control and leak check (witnessed by TÜV Nord)
- Pressure test
- Cut test piece, micrographs of welds by TÜV Nord.
- During the series, RI applies exactly the same welding procedures as during the test piece production
- TÜV Nord might want to inspect some welds by visual control
- Pressure test on cavities might be witnessed by TÜV Nord.

RI will produce 2 test pieces:

- Test piece one: EB welding machine 1 and TIG welder 1
- Test piece two: EB welding machine 2 and TIG welder 2

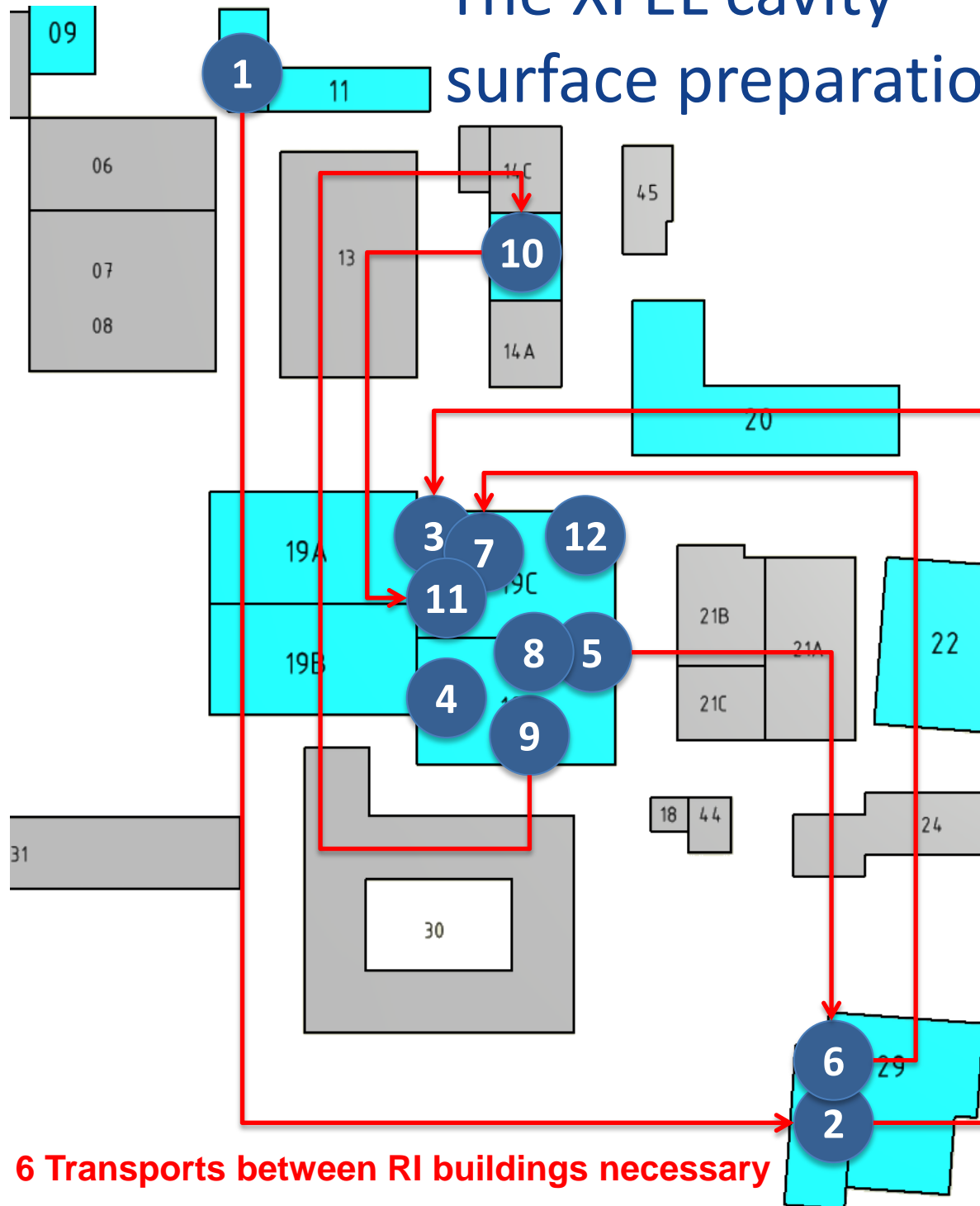


First test piece finished



Micrograph of test piece iris weld

The XFEL cavity surface preparation recipe



1. Outside BCP
2. Weighting, US-degreasing, Electropolishing (110 μm), rinsing
3. Cleanroom (1 x HPR, ethanol rinse, drying, weighting)
4. 800 ° C annealing
5. Tuning
6. Electropolishing (40 μm), rinsing
7. Cleanroom (1 x HPR, ethanol rinse, assemble blank flanges, leak check, 6 x HPR, drying, install FMS (field measurement system), leak check)
8. Check field profile (ev. tuning)
9. EB welding of ring and bellow
10. TIG welding of helium vessel
11. Cleanroom (disassemble FMS, install antennas (pick-up, HOM. High Q for vertical testing), leak check, 6 x HPR, assemble last flange, leak check and RGA)
12. 120° C baking, leak check
13. Transport under vacuum to DESY for vertical test

Outlook: Mechanical manufacturing and surface preparation capabilities

	XFEL				post XFEL			
	Shifts	Working days	For 200 cavities/year	Installed at RI for XFEL	Shifts	Working days	For 600 cavities/year	Additional needed at RI
Recources (mechanical)								
Turning machine	2	5	5	5	3	7	7,5	3
Milling machine	2	5	1	3	3	7	1,5	-
Dimensional control place	2	5	1	3	3	7	1,5	-
Metal working station	2	5	1	3	3	7	1,5	-
BCP barrel	2	5	1	1	3	7	1,5	1
Degreasing bath	2	5	1	3	3	7	1,5	-
EB welding machines	2	5	1,5	2	3	7	2,5	1
Leak checker	2	5	0,5	3	3	7	1	-
RF control	2	5	0,5	1	3	7	1	-
Grinding place	2	5	0,5	2	3	7	1	-
Press	2	5	0,5	2	3	7	0,5	-

	XFEL				post XFEL			
	Shifts	Working days	For 200 cavities/year	Installed at RI for XFEL	Shifts	Working days	For 600 cavities/year	Additional needed at RI
Recources (preparation)								
Degreasing bath (clean room)	2	5	1,5	2	3	7	2,5	1
Ethanon rinse	2	5	0,5	1	3	7	1	-
BCP outside bath	2	5	0,5	1	3	7	1	-
Leak check station, clean room	2	5	1	1	3	7	1,5	1
Tuning machine	2	5	0,5	1	3	7	1	-
Clean room assembly	2	5	2	2	3	7	3	1
EP station	2	5	1	1	3	7	1,5	1
800 °C oven (4 cavities per run)	3	7	0,5	1	3	7	1,5	1
HPR	2	5	2	2	3	7	3	1
Drying places	2	5	4	8	3	7	12	4
EB welding	2	5	0,5	0,5	3	7	0,5	-
120°C Oven	3	7	2	2	3	7	3	1
Leak check, pressure check	2	5	0,5	1	3	7	0,5	-
TIG welding	2	5	1	1	3	7	1,5	1

Challenges in mechanical Manufacturing and surface treatment

Mechanical manufacturing

- All working steps are good established at RI (about 100 cavities produced before within the last 15 years)
- The main resources for mechanical manufacturing are:
Turning, EB welding, BCP and degreasing and grinding before EB welding
- There are 62 EB welds and 75 different turning steps on the XFEL cavity
- This work has to be piped through limited turning machines and only 1 or two EB welding machines
- Therefore logistics to generate a constant cavity output is the main challenge beside keeping the quality standards high in two or three shift operation

Surface preparation

- Not so much experience with the individual preparation steps at RI
- Close collaboration with DESY during the first preparations of reference cavities and series cavities is mandatory
- The work flow through the different stations and the clean room seems to be smooth, logistics manageable (diploma work in progress, mechanical engineering production planning, Fachhochschule Aachen)
- The main challenge will be to establish and maintain a high quality of the work and find the right parameters to measure and control the quality

Summary

- RI is good prepared for XFEL cavity production
- Infrastructure for mechanical manufacturing is completed
- Infrastructure for surface preparation will be installed at the end of the year
- One test piece for pressure vessel code is finished, second running, dummy cavities and reference cavities mechanically finished in September
- First material for series fabrication expected end of this month from DESY
- Upgrade to 600 cavities per year production seems possible, requires probably 24/7 operation
- Experience learned from XFEL production will be very fruitful for future even larger scale projects like ILC