SRF Technology at DESY

Activities and technologies relevant for ESS

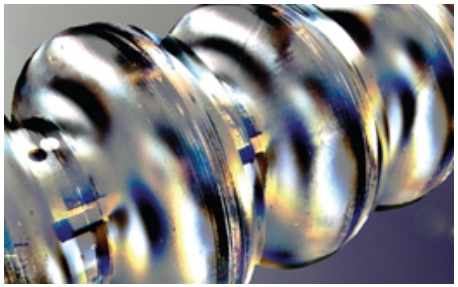
January 22nd, 2014

Hans Weise / DESY

EUROPEAN SPALLATION SOURCE

HELMHOLTZ ASSOCIATION

Knowledge Exchange between DESY and ESS



- Based on the experience with the European XFEL and the long time history of Superconducting RF Technology (TESLA, FLASH, TTC, ILC R&D) DESY is clearly able to provide expertise to the ESS Accelerator Team.

- Support and knowledge exchange within the SRF community is well established.
- The ACCSYS construction phase of ESS will start after the European XFEL accelerator is built.
- As contribution to the ESS Design Update Phase, DESY already started to provide assistance in the field of accelerator technology.

  Accelerator Module Design / Test Facility Study / Project Organization

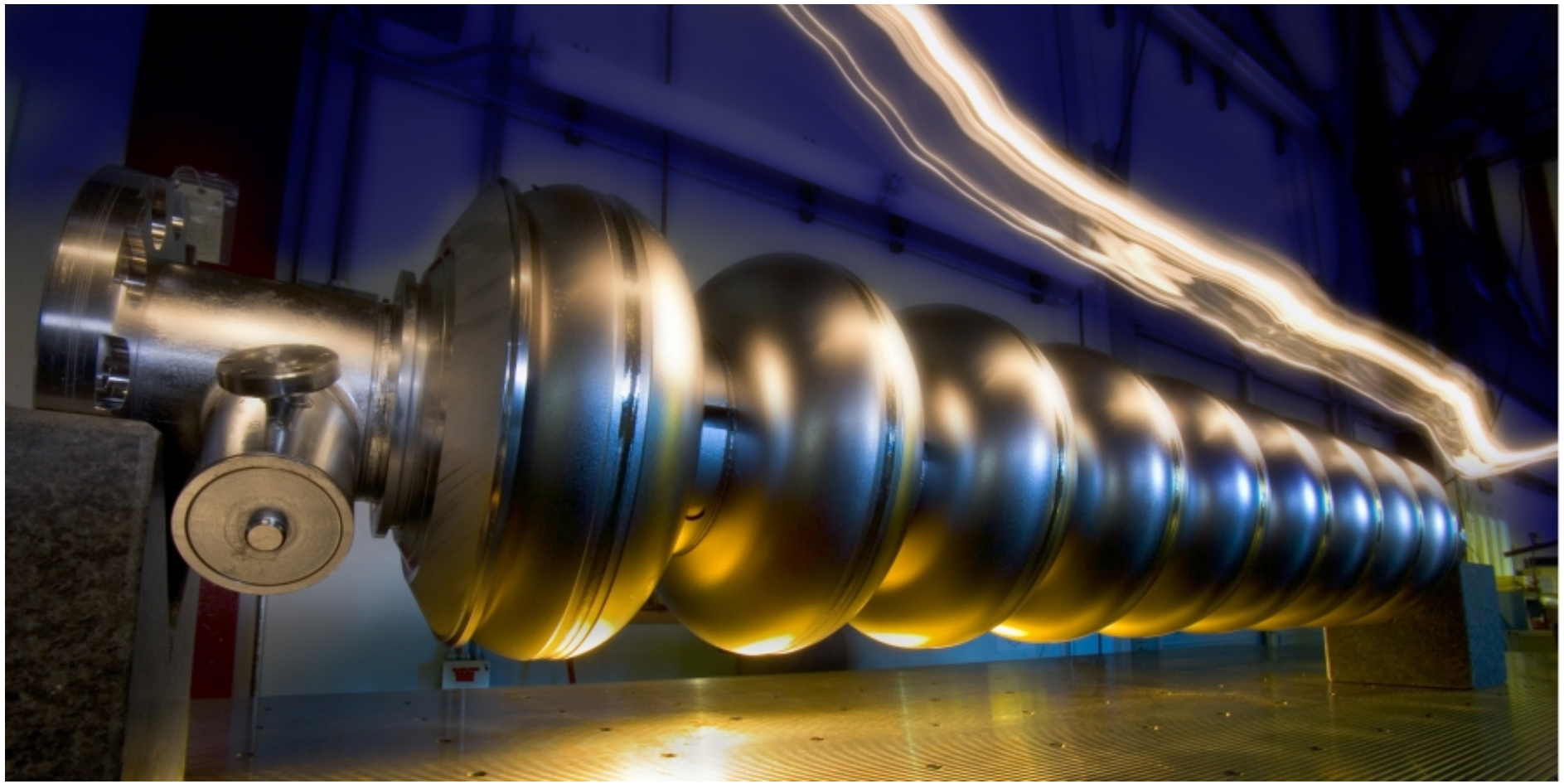
- A continuation of the good collaboration established within the SRF community and used for the European XFEL would be appreciated by all partners (research institutes & industry).

Recent Activities

- Technical advice in different fields has been given over the last year
  - SRF cavities
  - Cavity testing
  - Cryogenics (cryoplant / transfer lines)
  - Beam diagnostics
  - LLRF based on MTCA technology
- Several meetings / visits were used to exchange knowledge between DESY's XFEL Project Group and the ESS project management
  - participation in technical reviews (incl. specs. & CFT evaluation)
  - discussions with emphasis on project structure for the accelerator systems, In-kind contributions, project partners, common tools etc.
- DESY provided help in the cryogenic design, provided specifications and studied the possible use of existing DESY / XFEL infrastructure perhaps available after the installation of the European XFEL.

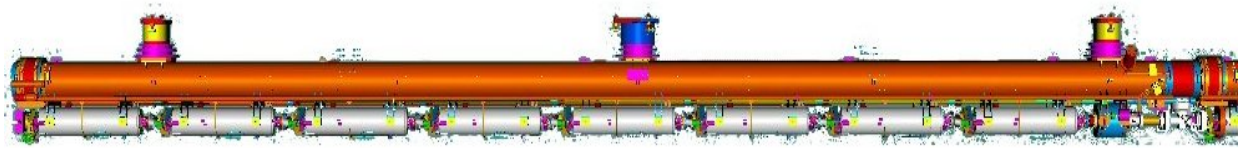
SRF Technology at DESY – Activities and Technologies Relevant for ESS

SRF Technology Industrialized for the European XFEL at DESY



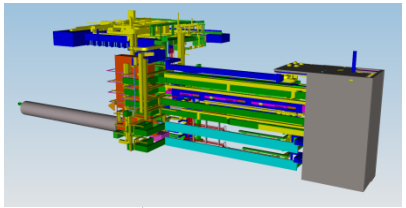
European XFEL
An Accelerator Complex for 17.5 GeV

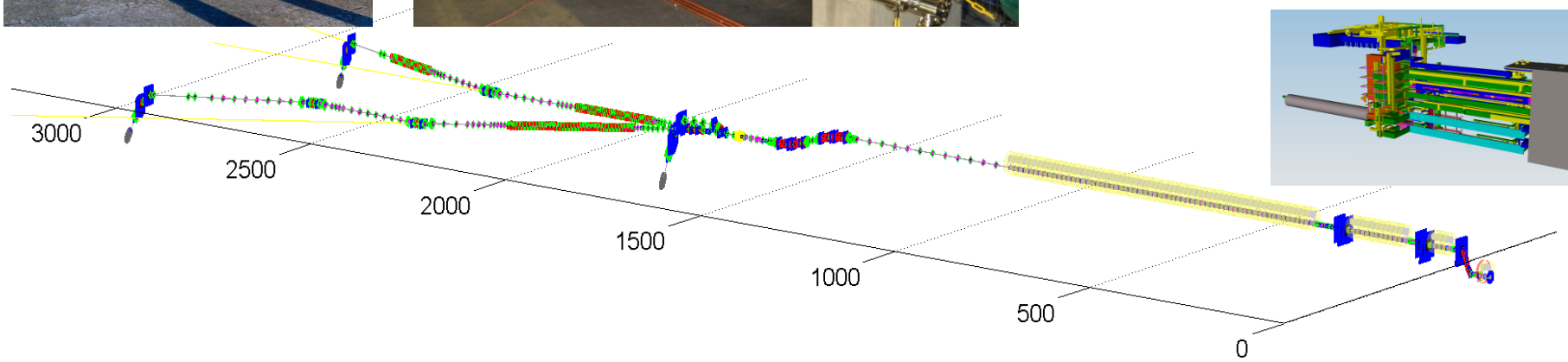
100 accelerator modules



800 accelerating cavities
1.3 GHz / 23.6 MV/m

25 RF stations
provide
5.2 MW each



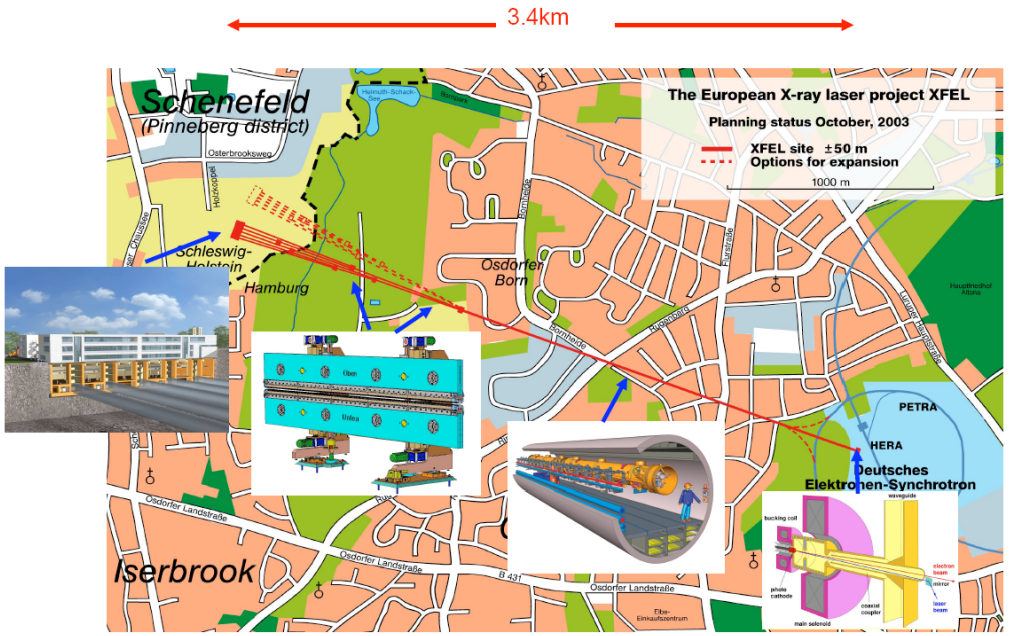


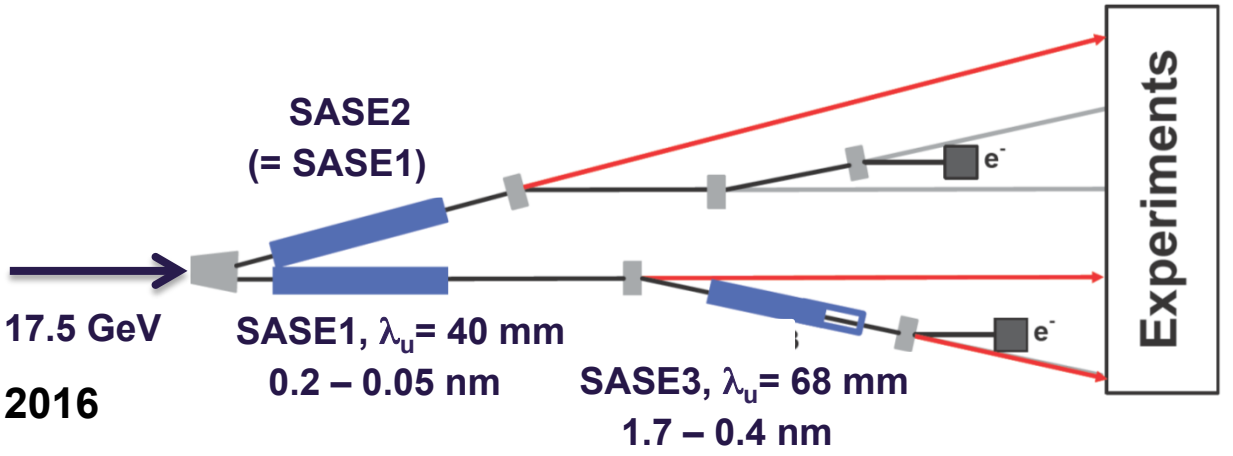
The European XFEL
Built by Research Institutes from 12 European Nations

Some specifications

- Photon energy 0.3-24 keV
- Pulse duration ~ 10-100 fs
- Pulse energy few mJ
- Superconducting linac. 17.5 GeV
- 10 Hz (27 000 b/s)
- 5 beamlines / 10 instruments
  - Start version with 3 beamlines and 6 instruments
- Several extensions possible:
  - More undulators
  - More instruments
  - …….
  - Variable polarization
  - Self-Seeding
  - CW operation

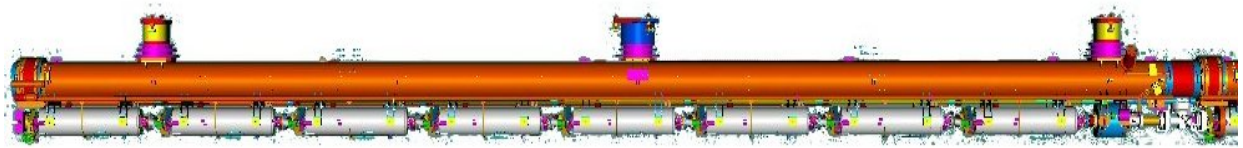
First electron beam 2nd half of 2016



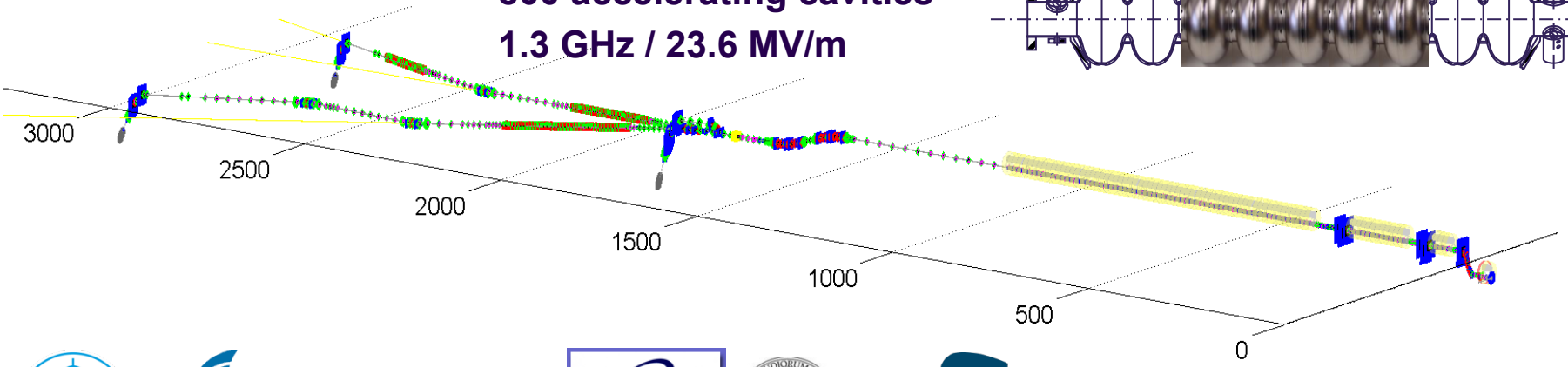


Contributors to the XFEL Accelerator

100 accelerator modules

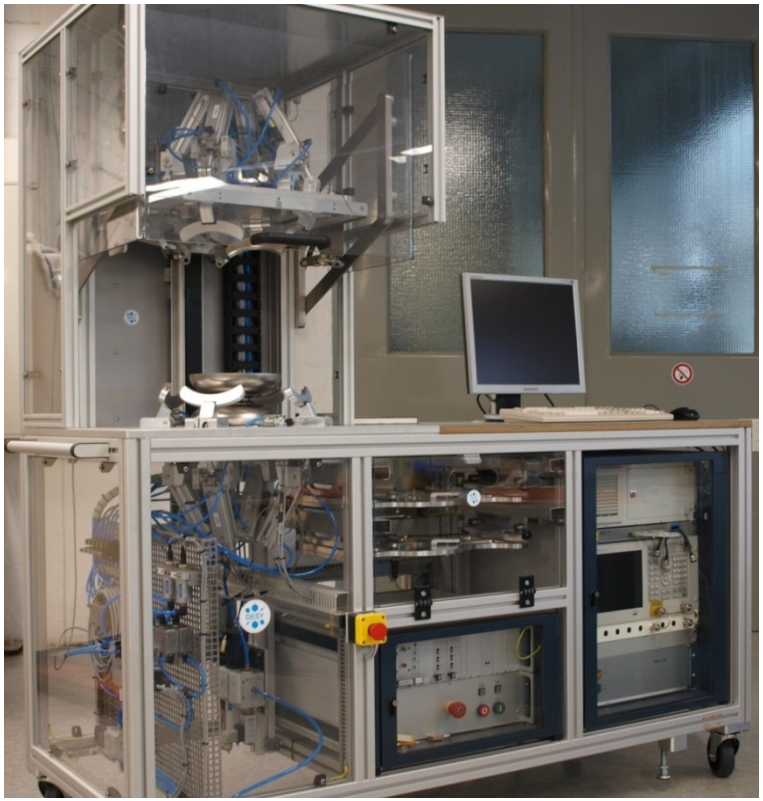


800 accelerating cavities
1.3 GHz / 23.6 MV/m



Established DESY Technology (developed during the last two decades)

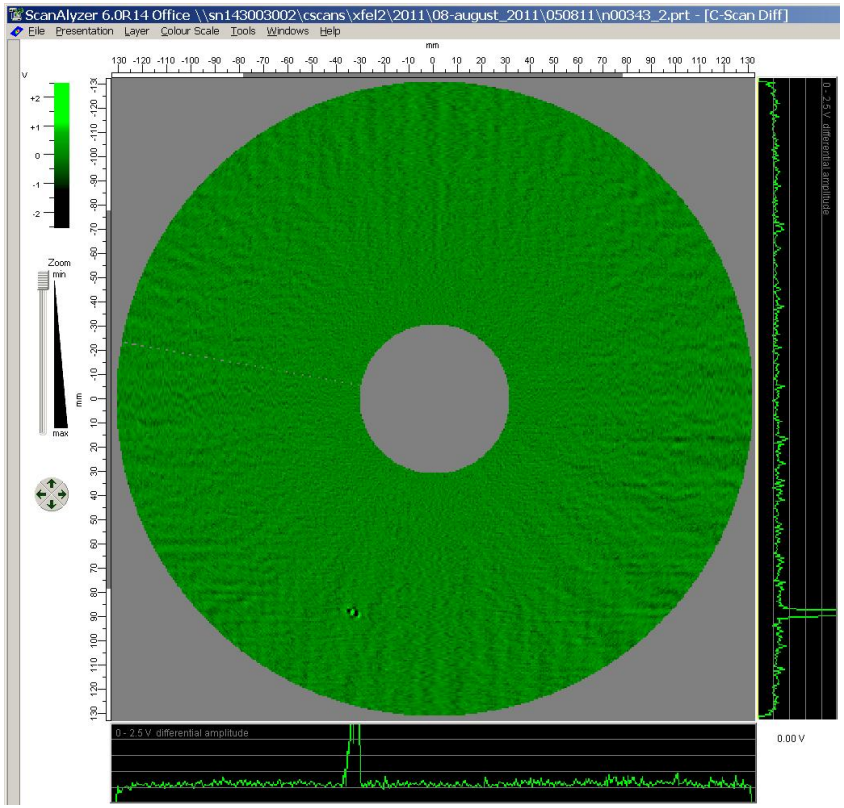
Industrial Cavity Production Relies on DESY Supervision



- Special CE certified machines were developed and given to industry.
- Since accelerator cavities are delivered without performance guarantee, very detailed specifications are used.
- Many productions steps are supported and partly supervised by DESY.
- Several QC steps are established. Very detailed documentation.

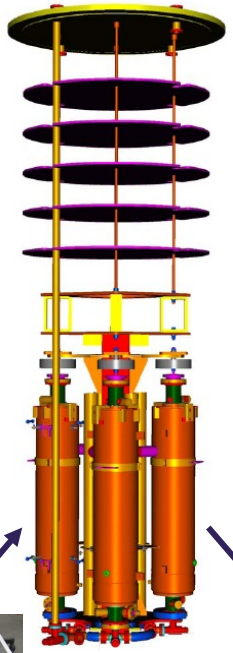
Niobium Material Bought and QC-ed by DESY

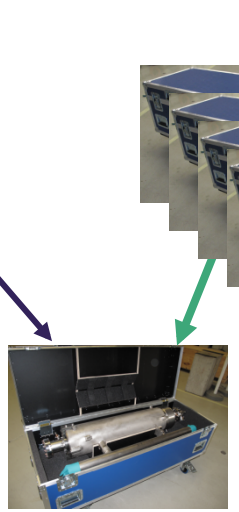
- All Nb / NbTi material (24,420 single parts!) were procured by DESY.
- Detailed quality inspection was developed and carried out.
- Last Delivery end of 2013. All material available to cavity vendors.

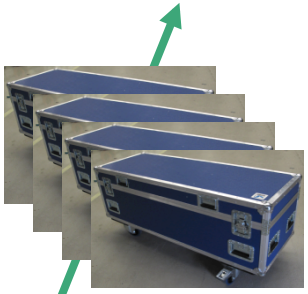


800 XFEL Cavities Travel Through Europe

DESY Germany



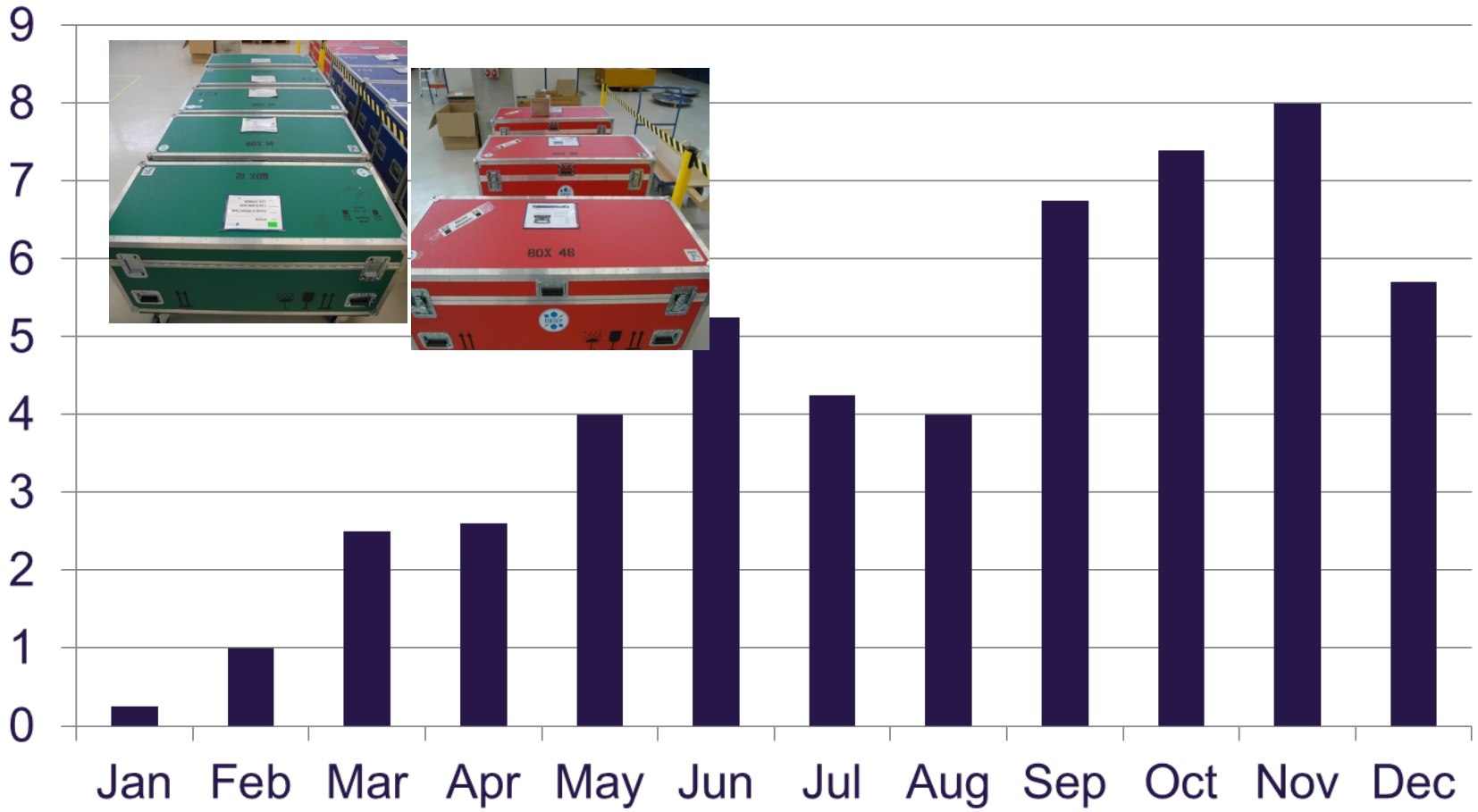




IRFU /CEA France

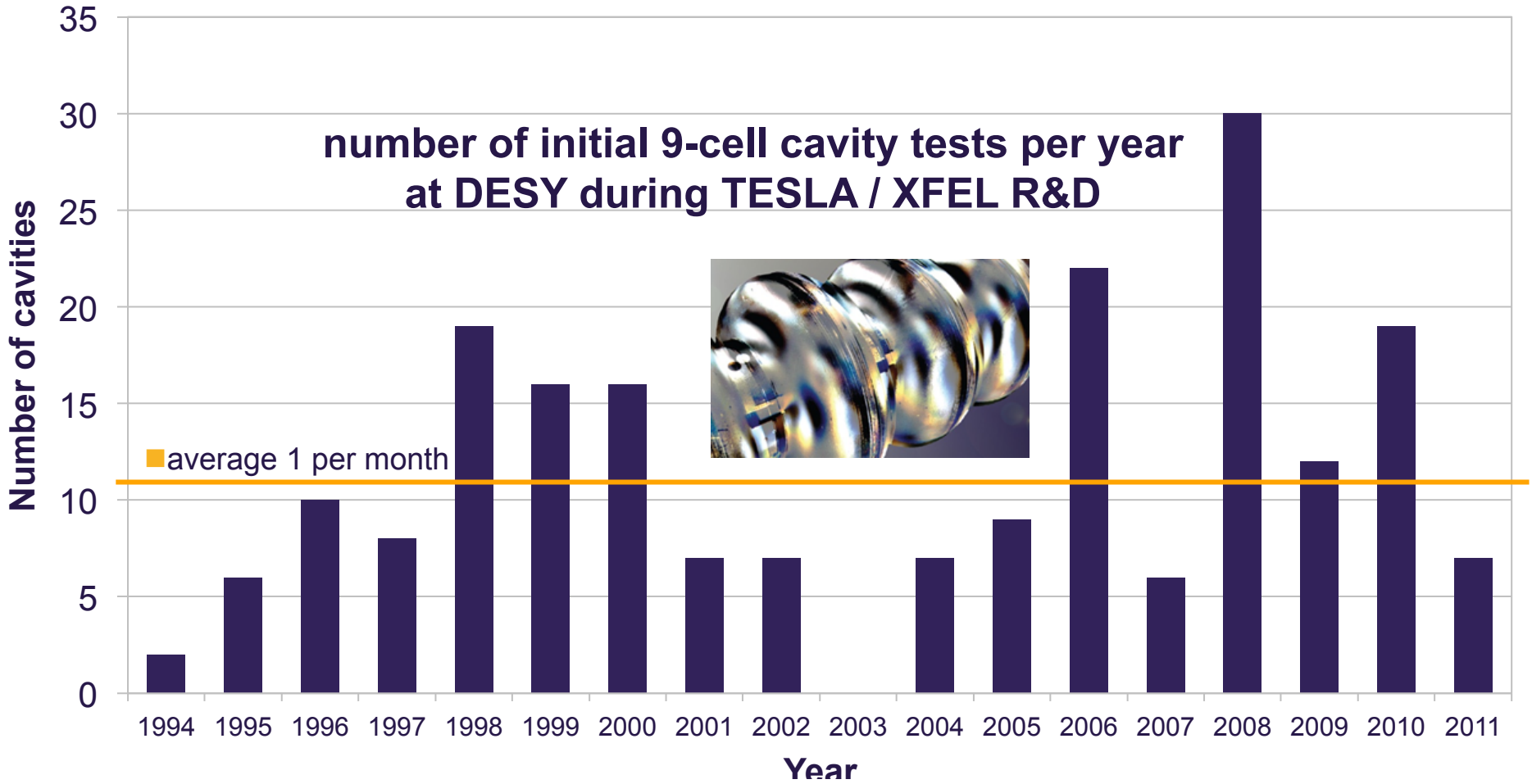
irfu
cea
saclay

Weekly Cavity Delivery for Euroepan XFEL



- Task for 2014: continuous delivery of 8 cavities per week

New Cavities per Year

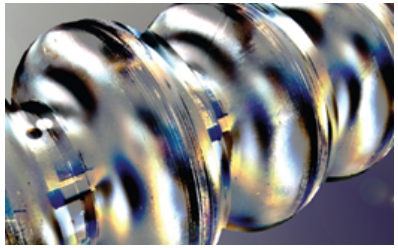


- during TESLA / XFEL R&D phase we worked on up to 30 cavities per year
- the European XFEL requires approx. 400 cavities per year

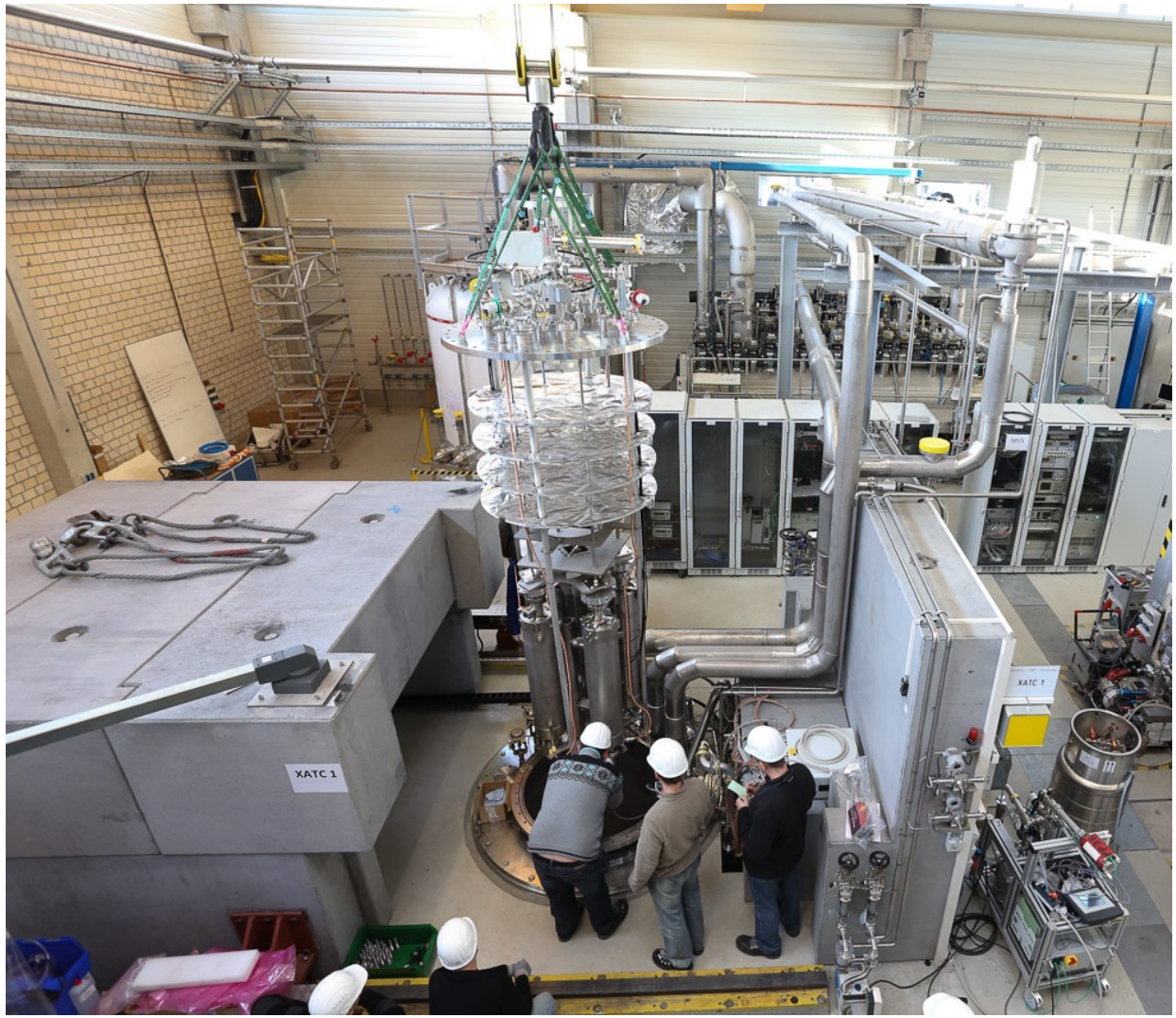
Cavity Delivery

	Cavity tracing															
2	week 2															
3	year															
4	month	ember		Oktober					November				December			
5	calendar week	week 38	week 39	week 40	week 41	week 42	week 43	week 44	week 45	week 46	week 47	week 48	week 49	week 50	week 51	week 52
7	EZ CVs Nr./ date	588 / 19.09.	591 / 26.09.	592 / 2.10.	613 / 9.10.	606 / 16.10.	506 / 24.10.	617 / 31.10.	621 / 07.11.	605 / 14.11.	627 / 21.11.	603 / 28.11.	636 / 05.12.	640 / 12.12.	643 / 19.12.	
8		589 / 19.09.	610 / 26.09.	587 / 2.10.	614 / 9.10.	590 / 16.10.	594 / 23.10.	618 / 31.10.	597 / 07.11.	623 / 14.11.	624 / 21.11.	632 / 28.11.	598 / 05.12.	641 / 12.12.	648 / 19.12.	
9			612 / 26.09.	593 / 2.10.	582 / 9.10.	586 / 16.10.	596 / 24.10.	619 / 31.10.	609 / 07.11.	625 / 14.11.	604 / 21.11.	631 / 28.11.	637 / 05.12.	645 / 12.12.	649 / 19.12.	
10						607 / 16.10.	611 / 24.10.	620 / 31.10.		626 / 14.11.	622 / 21.11.	634 / 28.11.	638 / 05.12.	646 / 12.12.		
11							615 / 24.10.			500 / 14.11.			506 / 05.12.			
12							616 / 24.10.						658 / 05.12.			
14	RI CVs Nr./ date	053 / 20.09	010 / 27.09		067 / 07.10	074 / 18.10	084 / 25.10		088 / 08.11.	093 / 15.11.	049 / 19.11.	033 / 26.11.	096 / 03.12.		107 / 20.12.	
15		060 / 20.09	049 / 27.09		069 / 07.10	080 / 18.10	085 / 25.10		089 / 08.11.	097 / 15.11.	065 / 19.11.	062 / 26.11.			110 / 20.12.	
16		063 / 20.09	059 / 27.09		071 / 07.10	081 / 18.10	086 / 25.10		092 / 08.11.	099 / 15.11.	066 / 19.11.	068 / 26.11.			112 / 20.12.	
17		064 / 20.09	062 / 27.09		028 / 07.10	082 / 18.10	090 / 25.10		095 / 08.11.	100 / 15.11.	079 / 22.11.	073 / 26.11.			113 / 20.12.	
18		065 / 20.09	066 / 27.09		018 / 07.10	083 / 18.10	087 / 25.10		096 / 08.11.	101 / 15.11.	102 / 22.11.	069 / 29.11.			114 / 20.12.	
19			068 / 27.09		072 / 11.10						103 / 22.11.	078 / 29.11.			116 / 20.12.	
20			070 / 27.09		073 / 11.10						104 / 22.11.	094 / 29.11.				
21					075 / 11.10						105 / 22.11.	098 / 29.11.				
22					078 / 11.10							106 / 29.11.				
23					079 / 11.10											
25	weekly delivering to DESY	7	**9**	3	11	9	10	**4**	8	9	8	**7**	4	4	9	**0**
27	total delivered from EZ	71	**74**	77	80	84	89	**93**	96	**100**	104	**108**	112	116	119	**119**
28	total delivered from RI	47	**53**	53	61	66	71	**71**	76	81	85	**88**	88	88	94	**94**
30	total delivered to DESY	118	**127**	130	141	150	160	**164**	172	181	189	**196**	200	204	213	**213**
32	weekly RF testing at DESY	7	**5**	2	4	4	10	**3**	7	12	6	**10**	6	13	7	
33	total RF tested at DESY	89	**94**	96	100	104	114	**117**	124	136	142	**152**	158	171	178	**178**
35	delivery to IRFU	-1	**7**		5	-1	5		4	-2	7		7		7	**-12**
36	total delivery to IRFU	43	**50**	50	55	54	59	**59**	63	61	68	**68**	75	75	82	**70**

- average delivery of 8 cavities per week reached
- in total 213 delivered cavities until end of 2013
  - still some non-conformities, i.e. some rejected cavities (<10%)
  - 30+ new cavities still to be tested
  - test of re-treated cavities adds to the weekly work load
    - re-treatment (mostly only HPR) successful and done for all cavities showing some gradient potential, i.e. even if European XFEL specs. are met
- approx. 70 cavities delivered to CEA Saclay; average usable gradient almost 30 MV/m

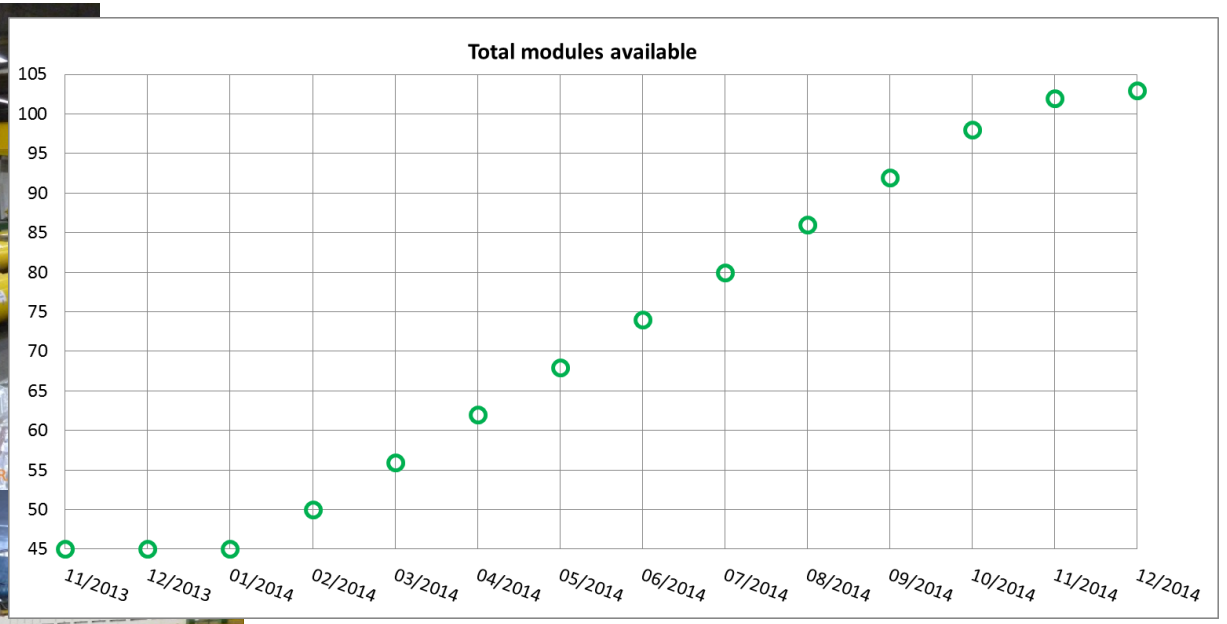


Vertical Test of Accelerating Cavities at DESY

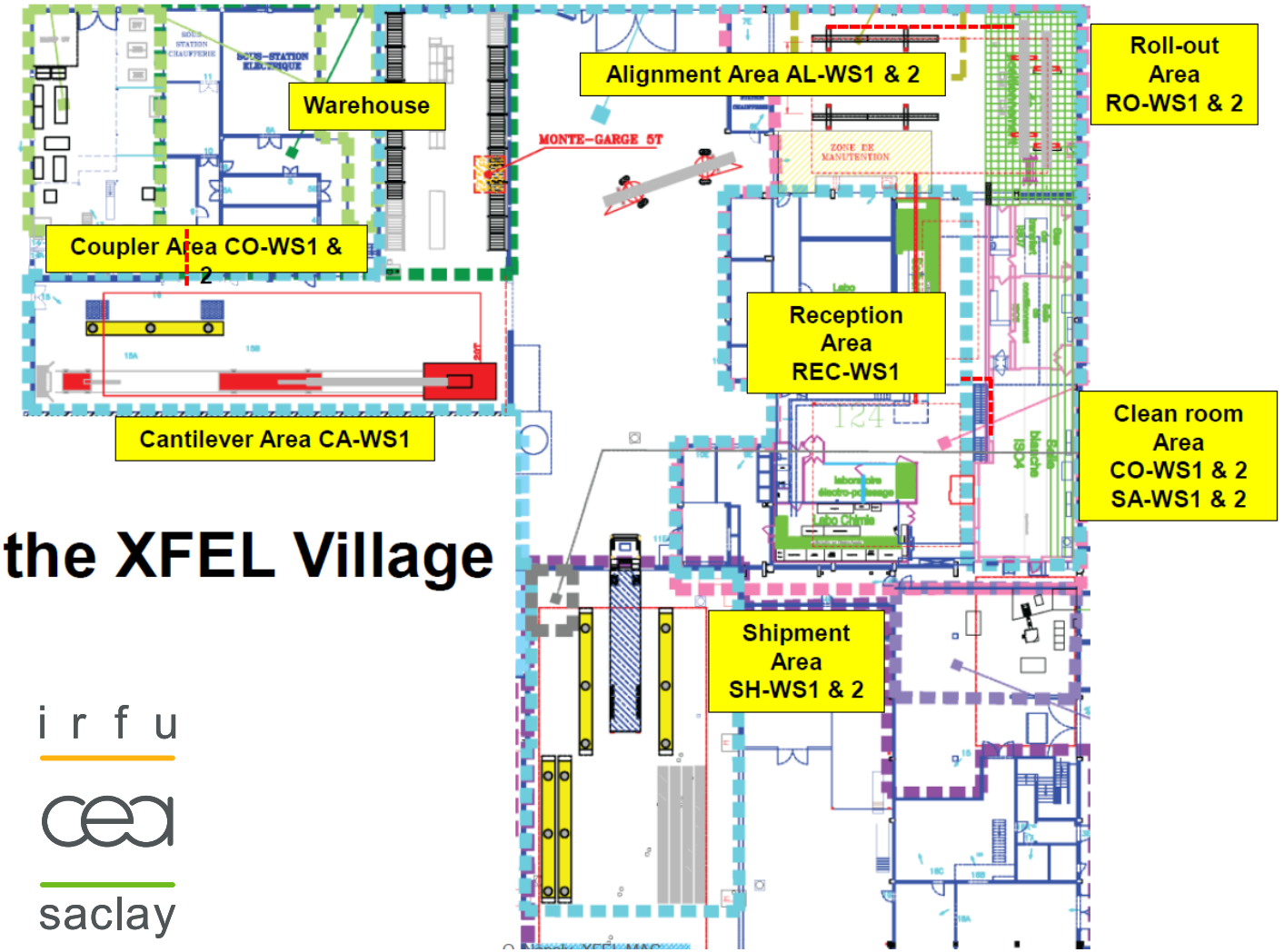


- all RF test related procedures developed
- two vertical dewars are used to test up to 12 cavities per week
- documentation required to trace all parts used for the s.c. linac

103 Cryostats and Cold Masses Needed also s.c. Magnets and Diagnostics



XFEL Village at IRFU / CEA Saclay used for Accelerator Module Assembly



the XFEL Village

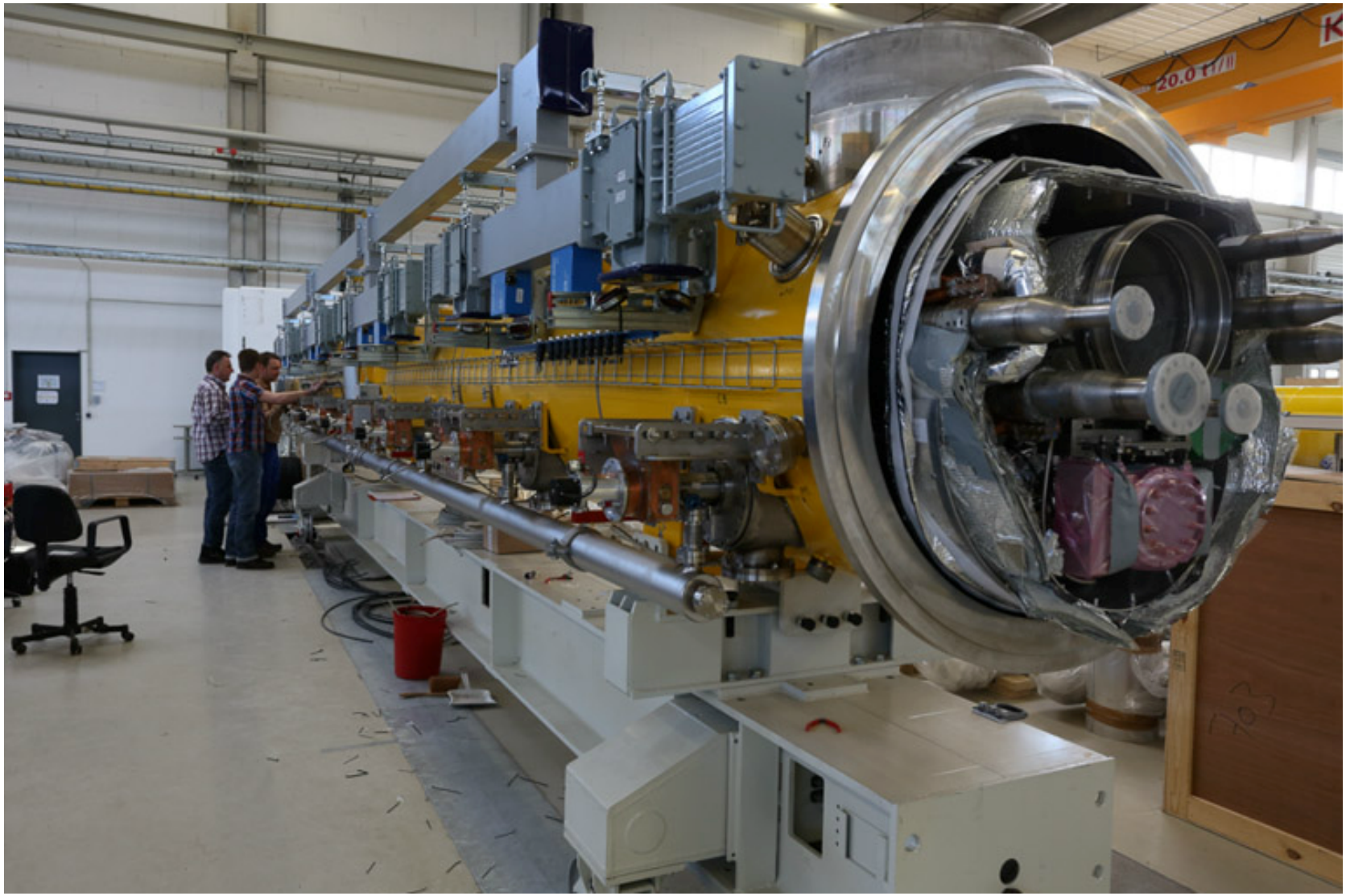
irfu cea saclay

Mounting of RO Power Coupler Cold Part

Cavity String Assembly at IRFU / Saclay

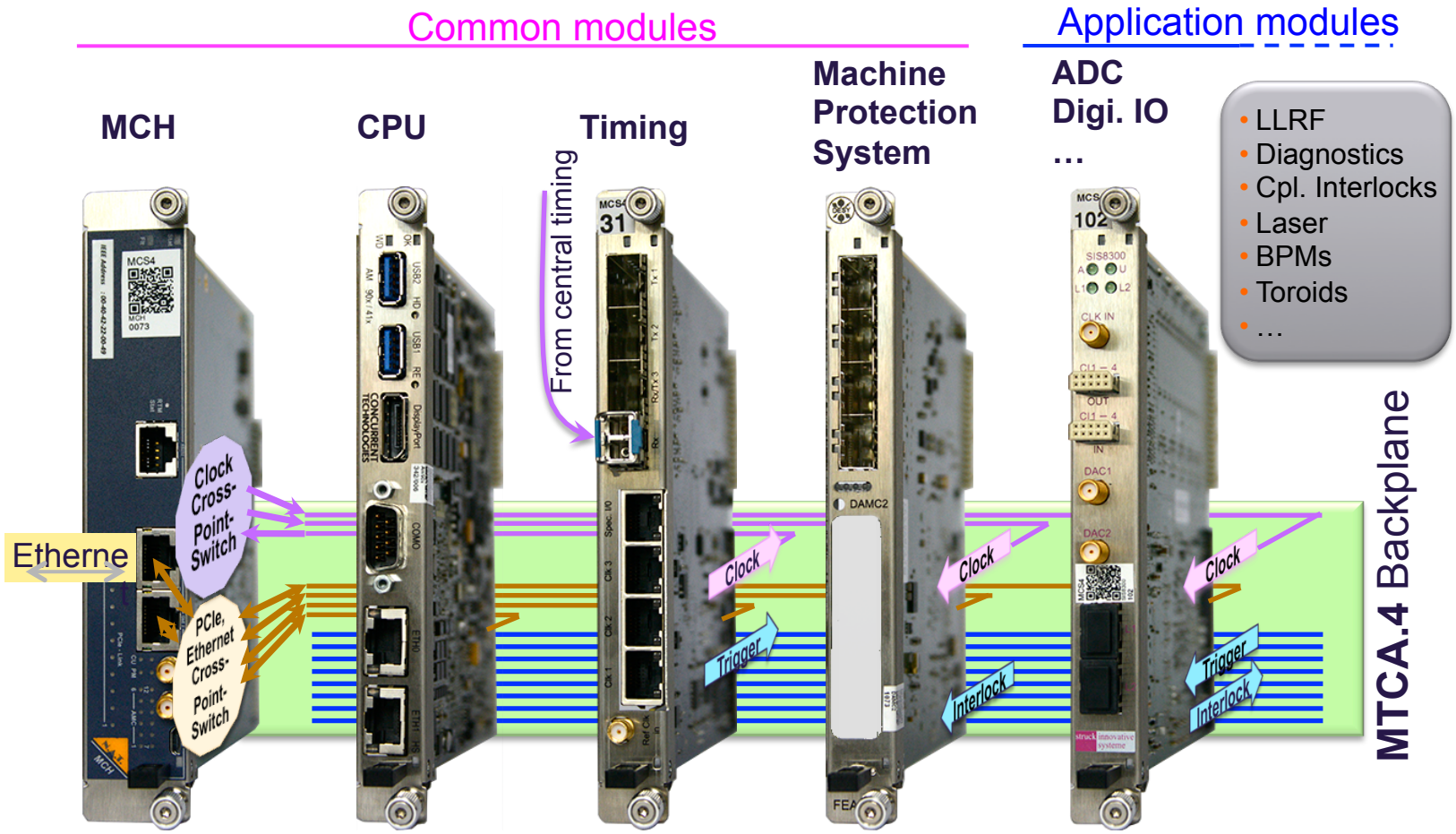
Accelerator Module Testing at DESY

Tested Accelerator Modules are Prepared for the Tunnel Installation

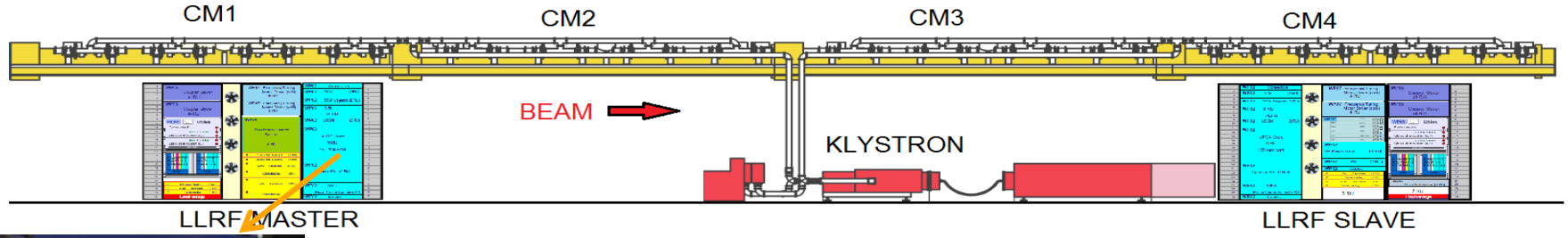


Modern front-end controls based on MicroTCA

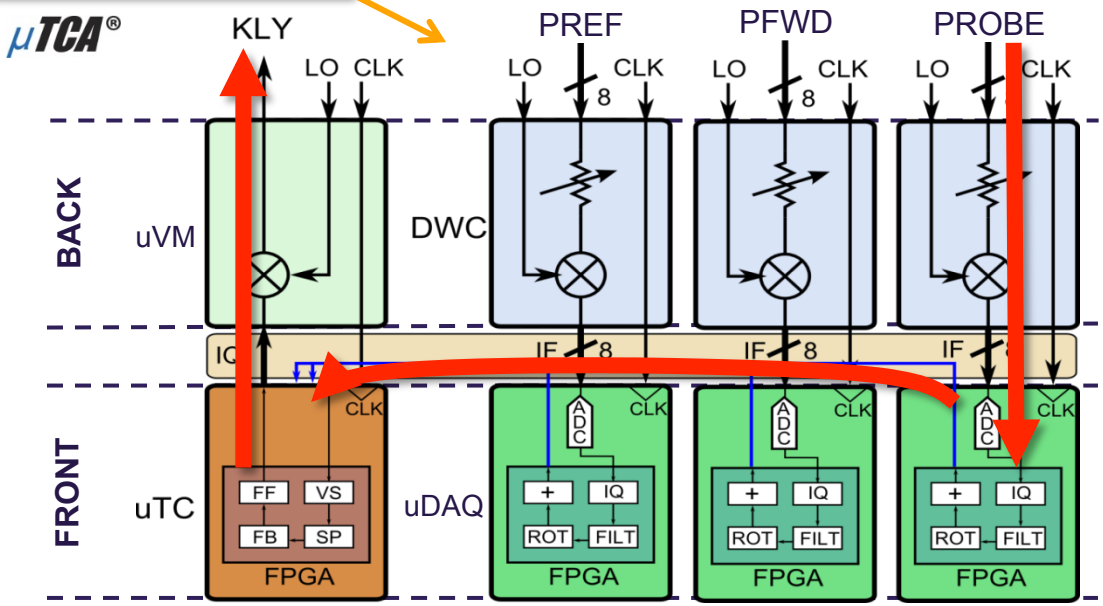
- High availability
- Configurable
- Modular incl. AMC/RTM
- Excellent analog performance
- High data throughputs
- Hot swap



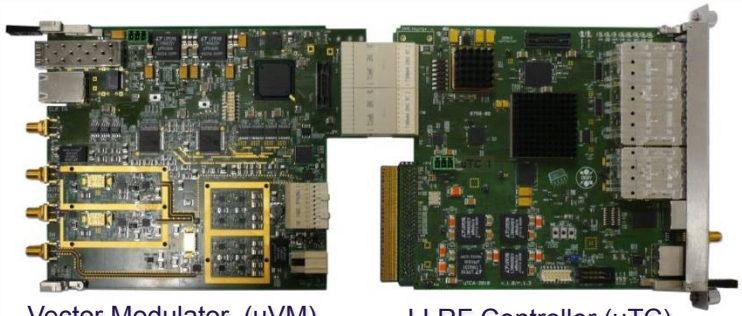
Low Level RF controls for 800 SRF cavities



- 32 cavity per 10 MW Klystron
- 3000 RF signal to be processed
- <0.01% and 10 mdeg stability

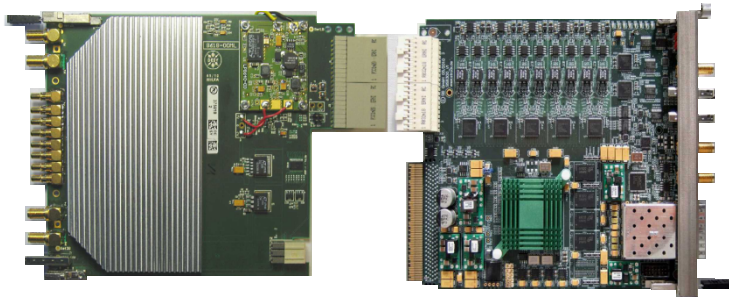


LLRF modules for XFEL



Vector Modulator (uVM)

LLRF Controller (uTC)



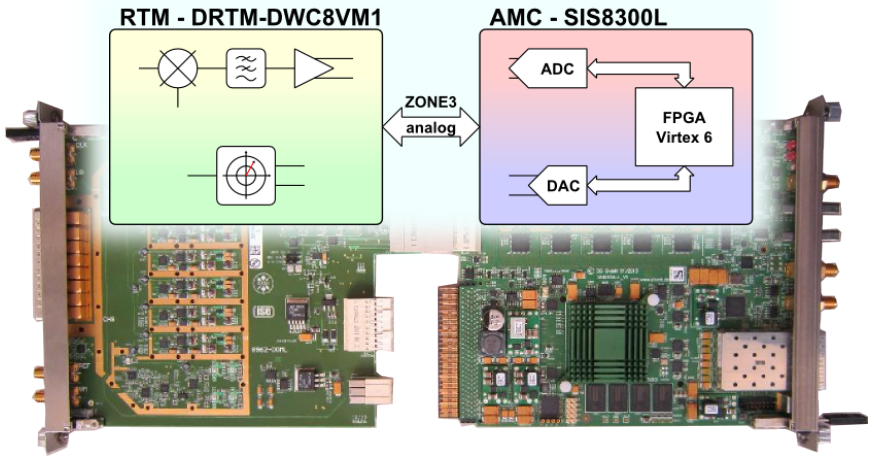
Down Converter (DWC)

Digitizer (uDAQ)

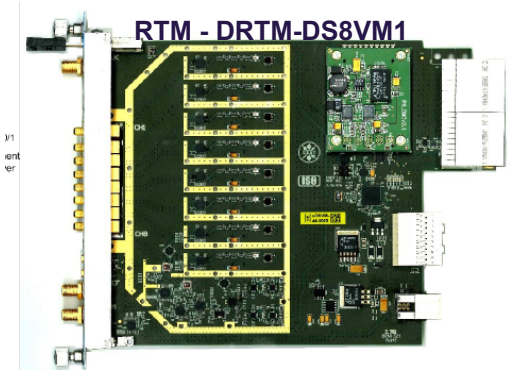
… and for single cavities operation…

- cost and performance optimized …

Frequency range 700MHz – 6 GHz



Frequency range 10MHz – 500 MHz

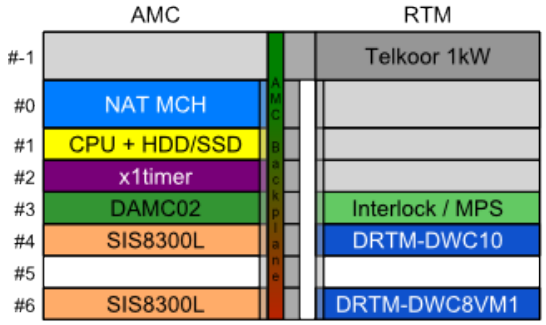


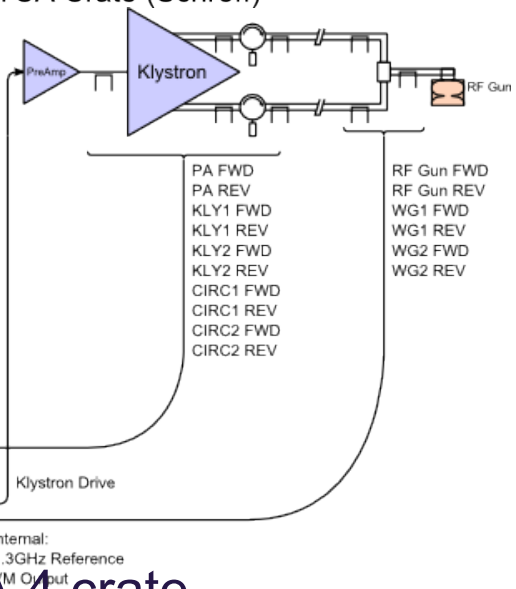
XFEL RF Gun
LLRF System

2HE 6 Slot MTCA Crate (Schroff)

- HZDR
- TARLA
- FLUTE
- Candle
- …

PITZ RF Gun





- .. with up to 8 cavity regulation in one 12 slot MTCA.4 crate

Possible DESY Involvement in ESS Accelerator Construction

- The ESS Accelerator Team has recently delivered a *Wish List* to DESY which describes possible cooperation in the fields
  - Niobium and cavity procurement (elliptical cavities)
  - Cavity testing
  - Advice for module testing to be carried out at Lund
  - Participation in commissioning of cryogenic systems
  - Low-Level RF control for accelerator systems
  - Beam diagnostics
- The ACCSYS construction phase of ESS will start after the European XFEL accelerator is built. Thus the ESS schedule matches with the XFEL schedule.
- Based on ESS funding, work on several of the above listed tasks could be started and DESY knowledge be made available to ESS and its industrial partners.

The end