

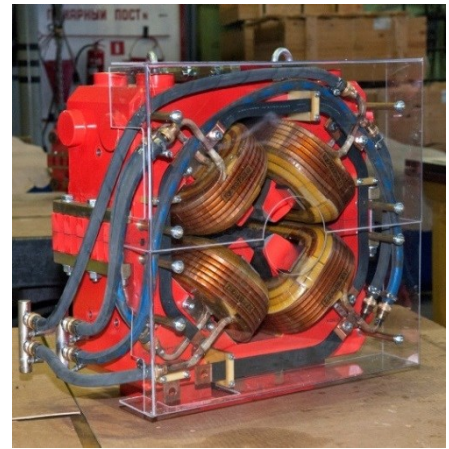
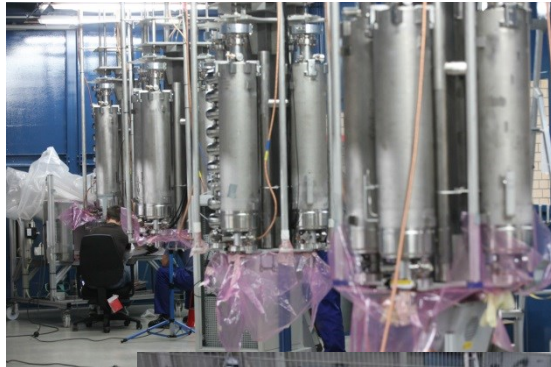
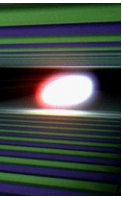
Status of the European XFEL Accelerator

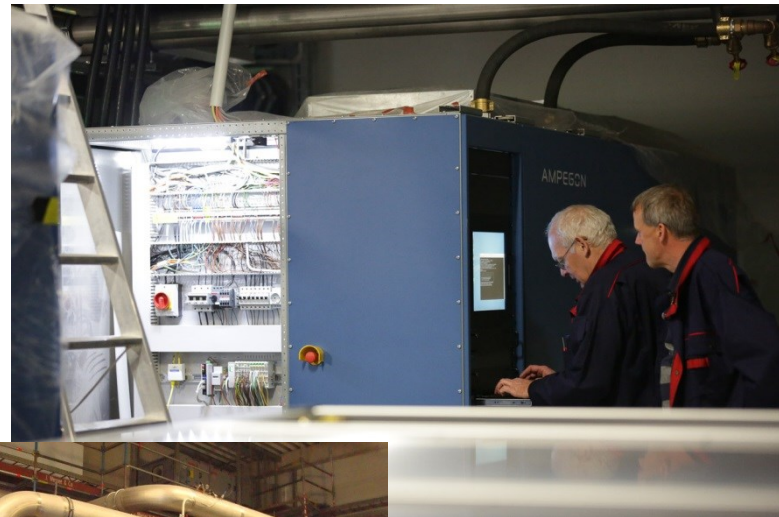
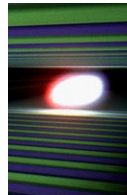
Presented at the
2014 European XFEL Users' Meeting
January 29, 2014

Hans Weise

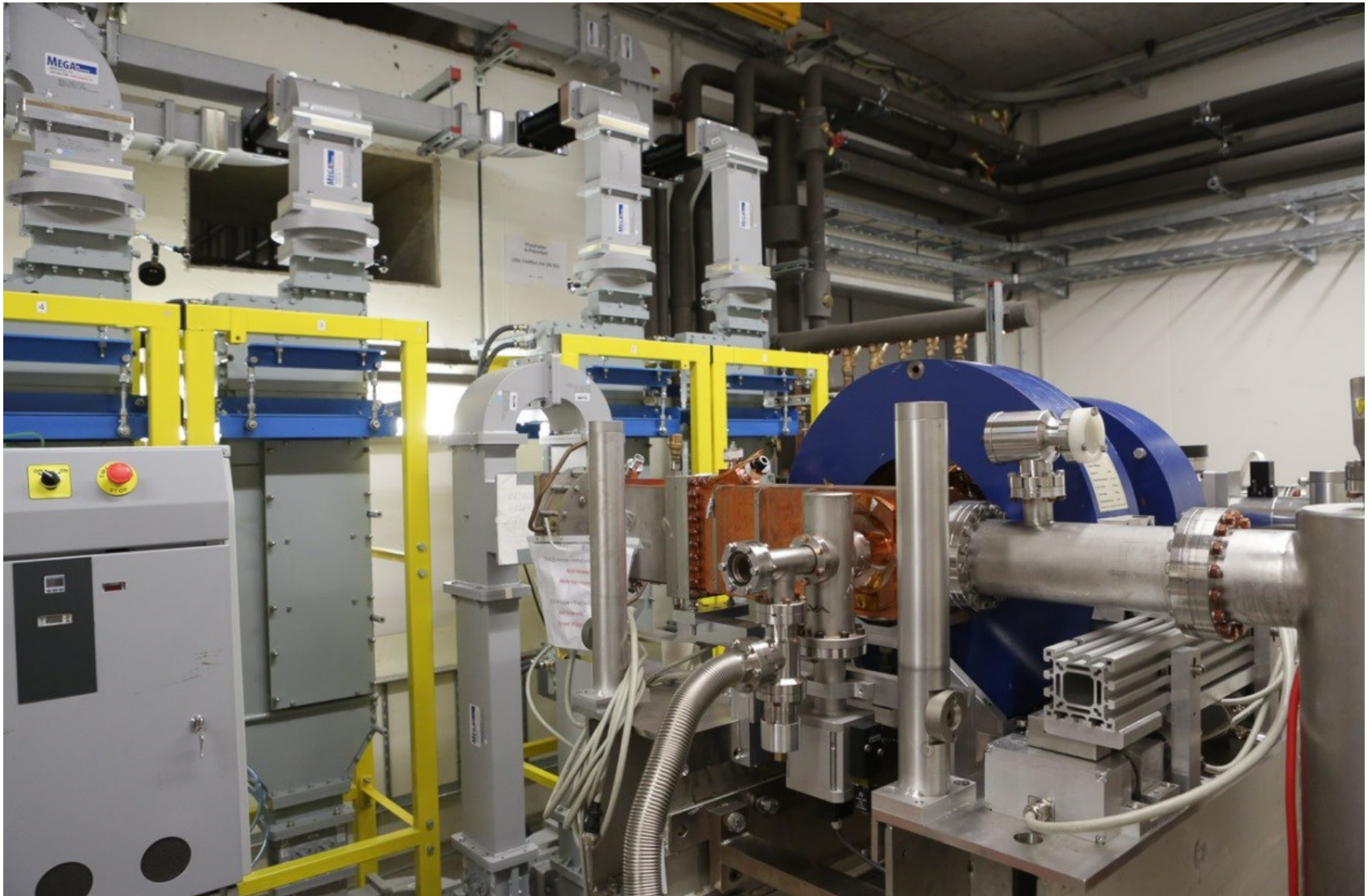
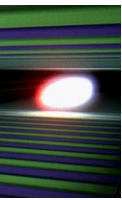


Production of Accelerator Components

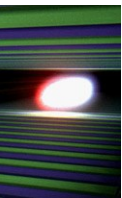




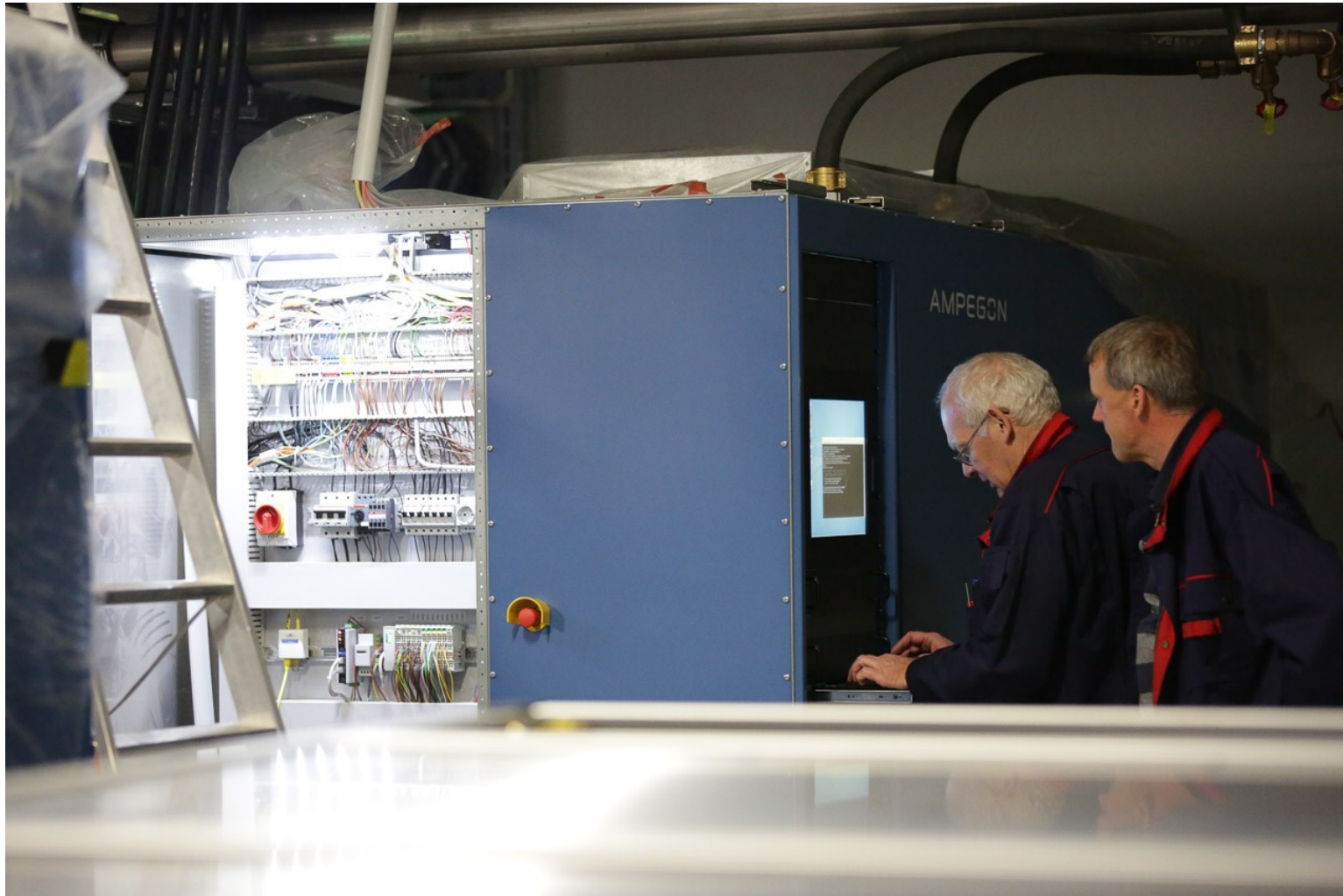
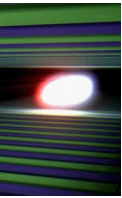
XFEL RF Gun Installed in the Tunnel



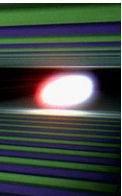
Multi Beam Klystron in the Injector Building



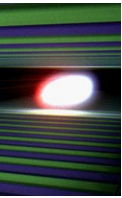
RF Power Modulator Commissioning



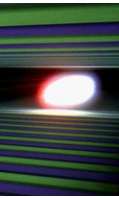
RF Gun Waveguide Installation



Storage of Accelerator Components

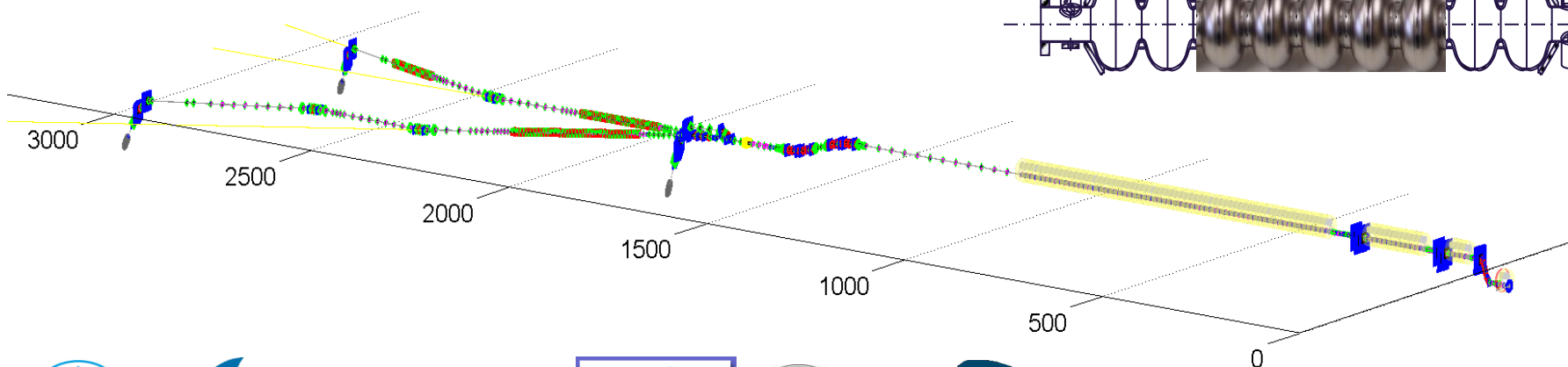
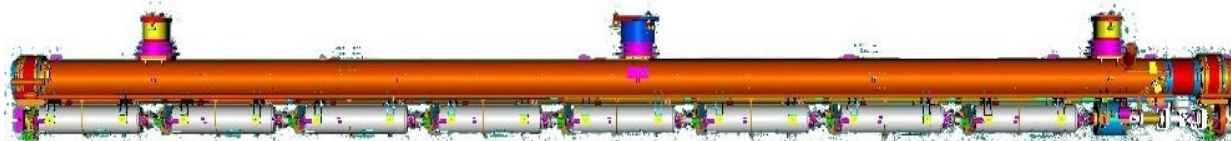
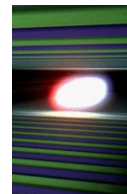


Production of Accelerator Components in Full Swing



- many challenging tasks were solved
- today mostly (but not only) logistics challenges
 - **Guaranteed delivery dates**
 - Can we keep the delivery rate constant?
 - How to cope with varying delivery rates?
 - How to deal with slight deviations from the specification?
 - Quick but **reliable quality control(QC)**
 - QC requires sufficiently high test rates. Do we achieve it at AMTF? How about other test stands? In general: is the incoming inspection sufficiently well established?
 - Storage place; a daily asked question...
 - **Component integration** is the on-going challenge
 - Accelerator module assembly started
 - Integration of electronics in combined racks to be done
 - Integration of warm beam line sections

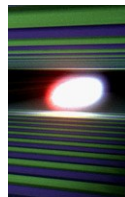
Contributors to the XFEL Accelerator



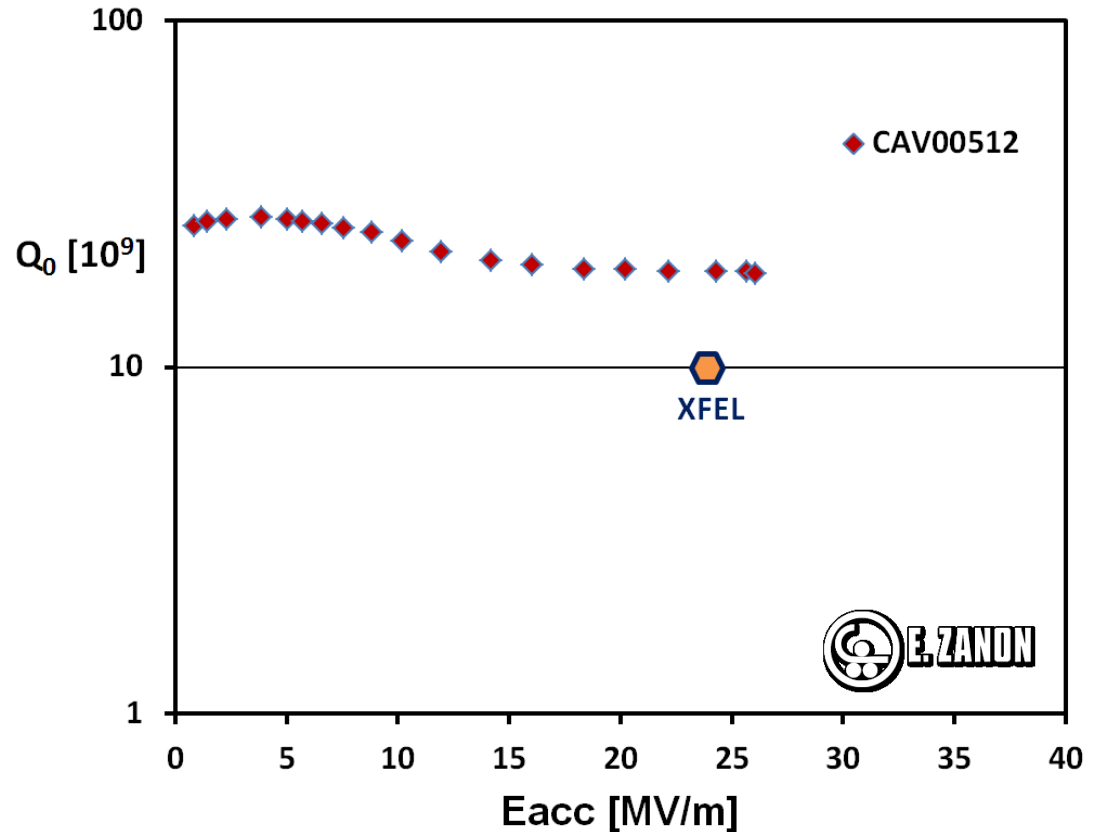
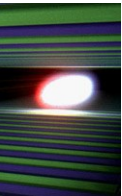
Wroclaw University of Technology



Cavity Production



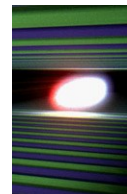
Successful Technology Transfer – A Year ago



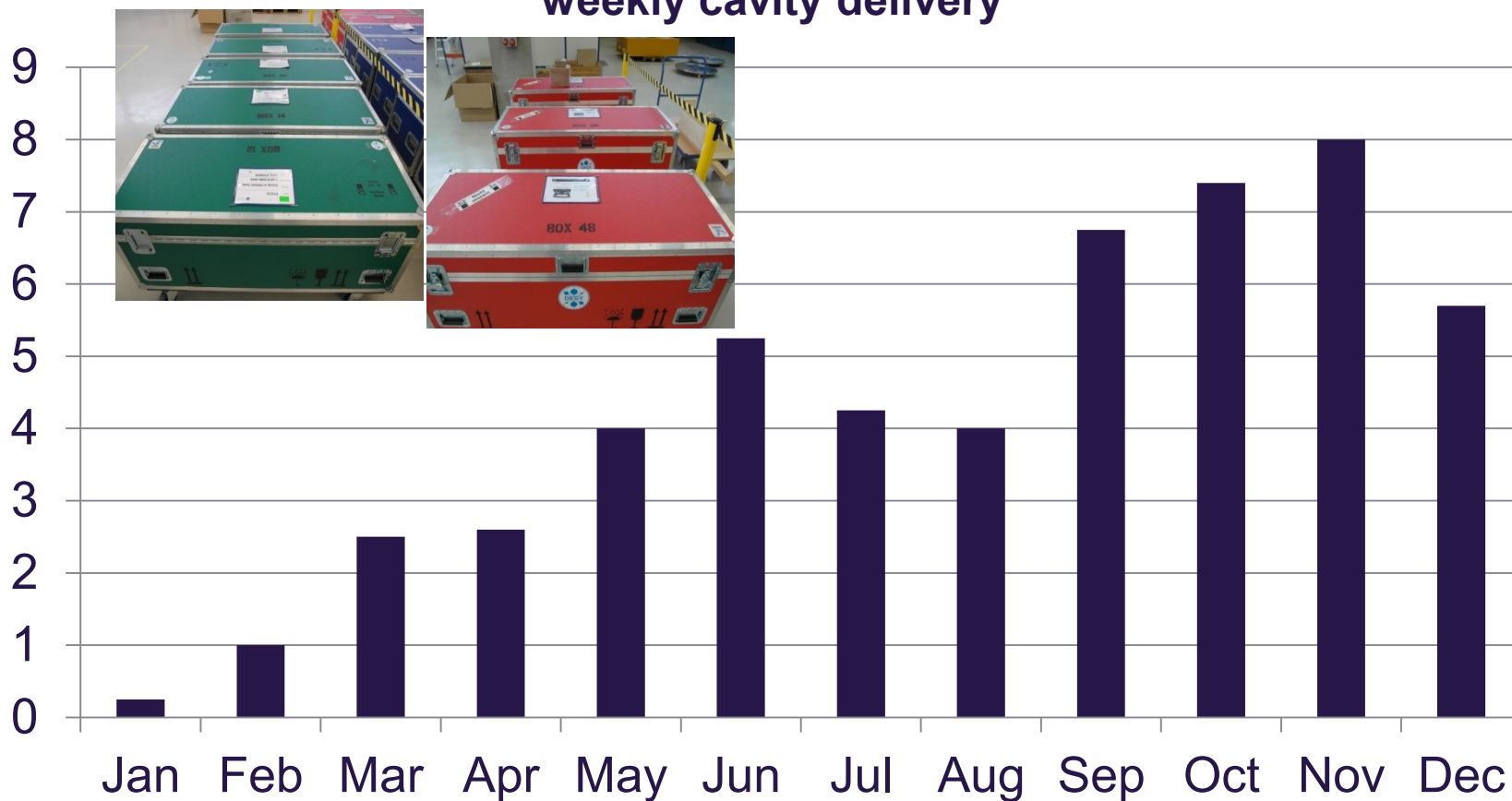
The first bulk Niobium cavity completely produced in industry was delivered in 12/2012.

- mechanical production
- surface preparation as well as final cleaning

Weekly Cavity Delivery

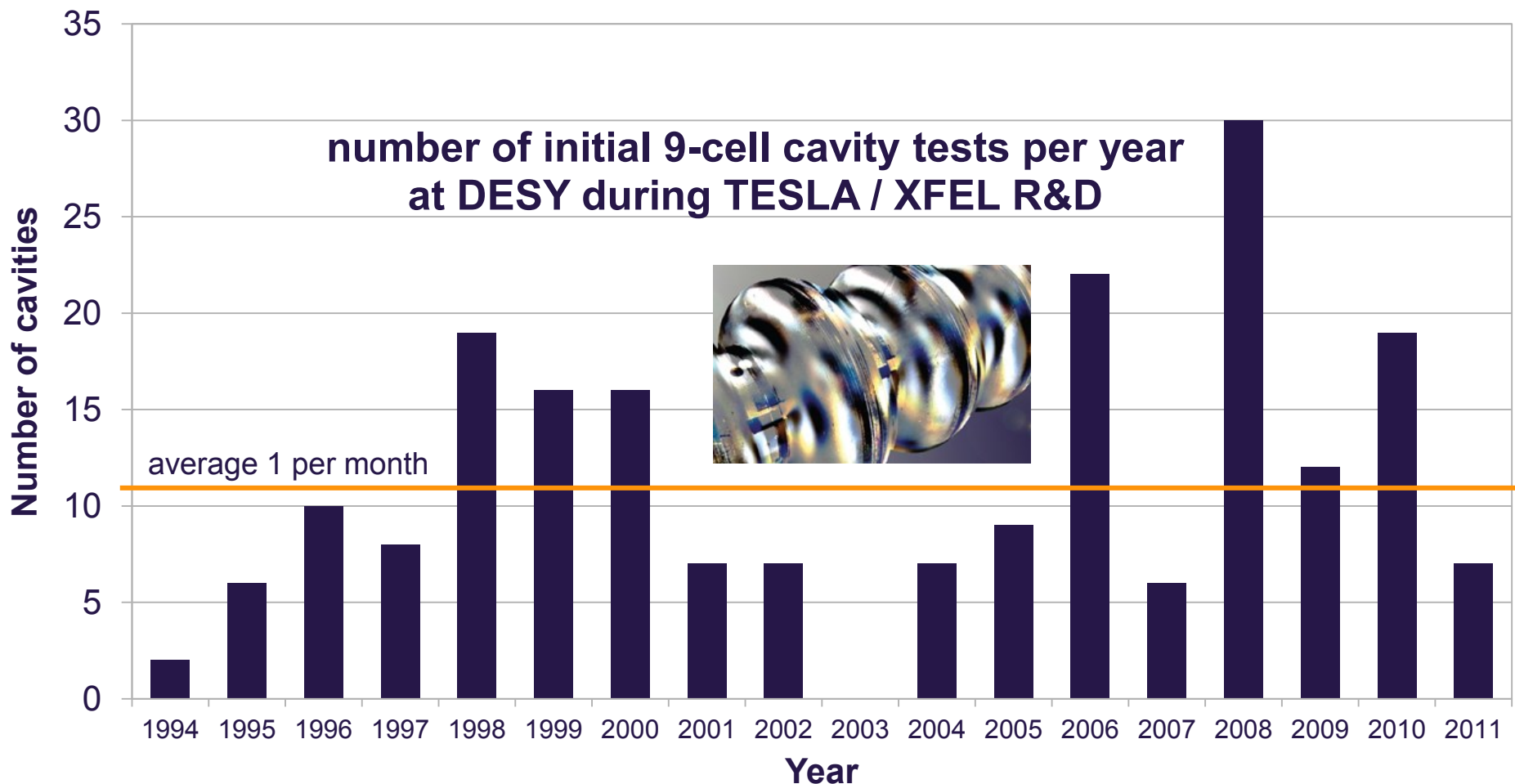
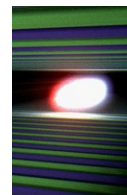


weekly cavity delivery

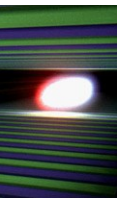


■ the task for 2014: stay at 8 cavities per week

Comparison - 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

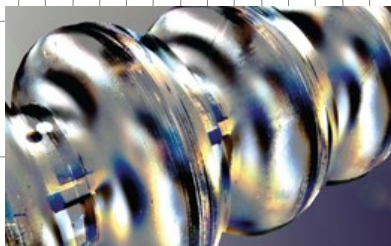
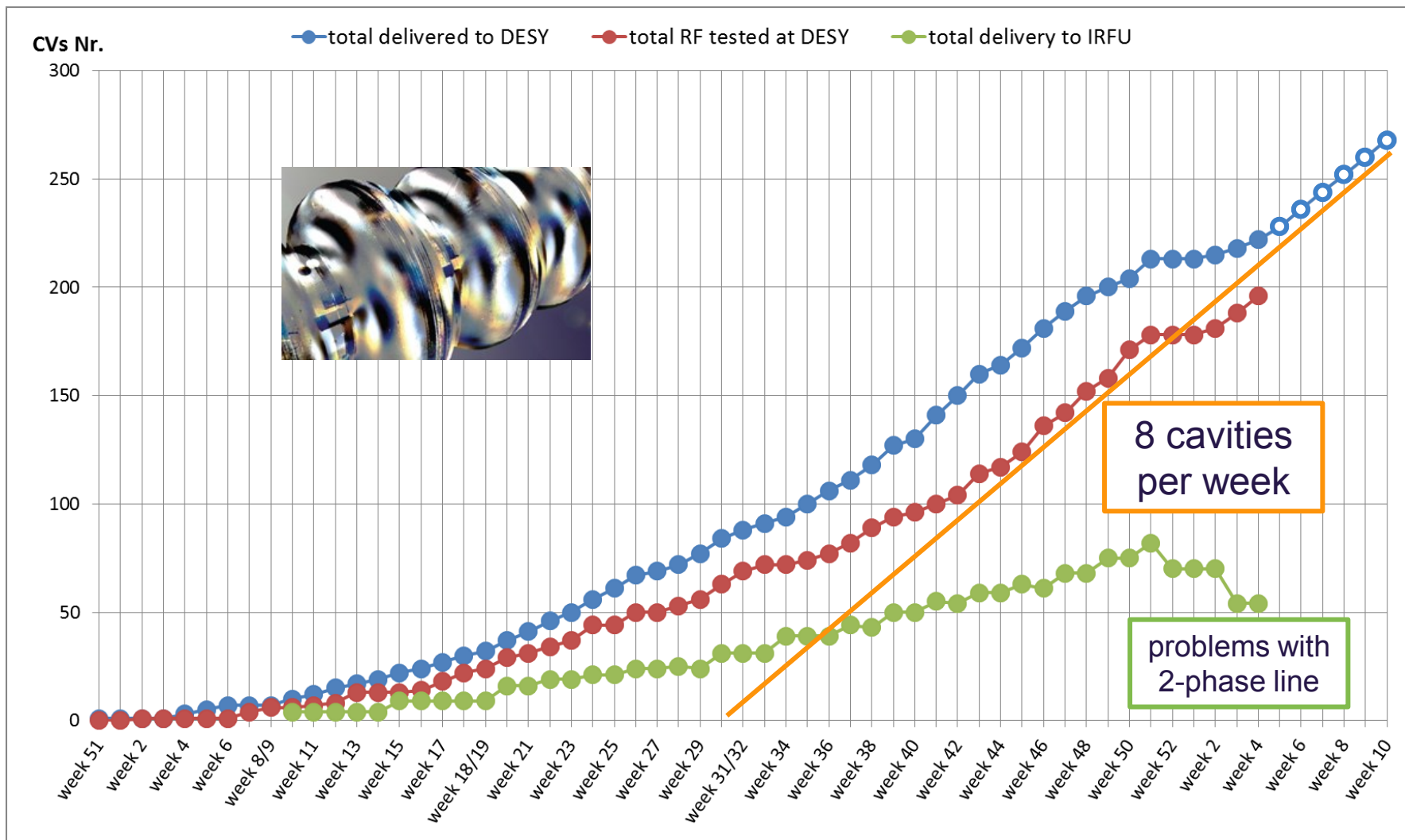
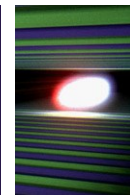


Cavity tracing																	
1																	
2	week 2																
3	year																
4	month																
5	calendar week	September				Oktober				November				December			
6		week 38	week 39	week 40	week 41	week 42	week 43	week 44	week 45	week 46	week 47	week 48	week 49	week 50	week 51	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										500 / 14.11.			506 / 05.12.				
12												658 / 05.12.					
13																	
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												
24																	
25	weekly delivering to DESY	7	9	3	11	9	10	4	8	9	8	7	4	4	9	0	
26																	
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	
29																	
30	total delivered to DESY	118	127	130	141	150	160	164	172	181	189	196	200	204	213	213	
31																	
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	
34																	
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



Cavity Delivery Status as of 1/2014



Vertical Acceptance Tests for XFEL Cavities

	delivered	rejected	tested
Zanon	89	5	
RI	71	9	
total	160		113

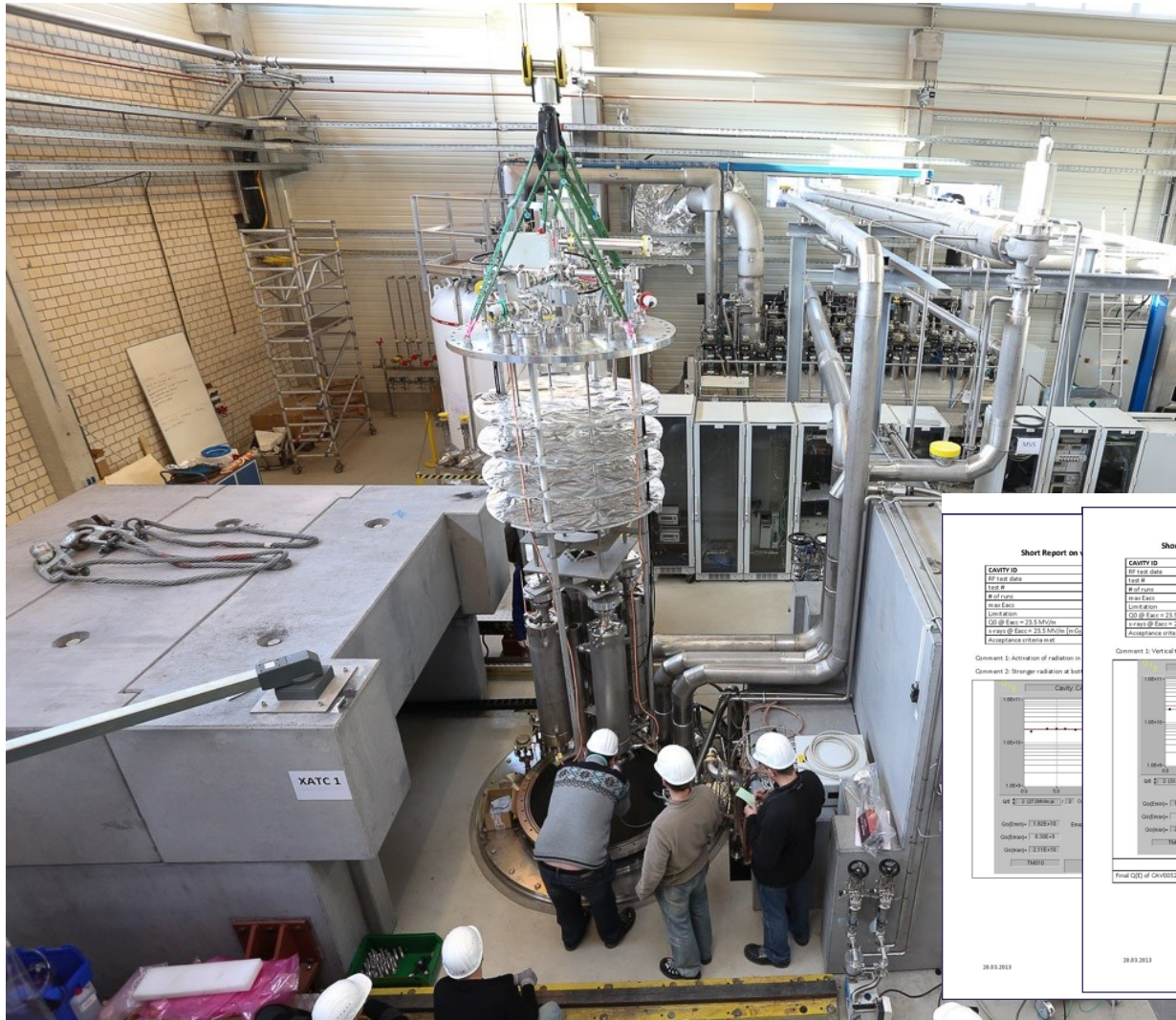
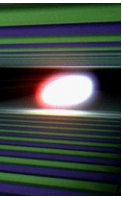
- Rejected cavities can be re-worked
- So far not a single cavity which cannot be used due to bad performance

Analysis done in 11/2013

	25.10.13	accepted w/o re-treatment	re-treatment done / to be done	as received		after re-treatment	
				Emax	usable gradient	Emax	usable gradient
Zanon	67	40	18 / 9	(27,7 +- 7,5) MV/m	(24,4 +- 7,3) MV/m	(30,0 +- 5,0) MV/m	(27,6 +- 5,1) MV/m
RI	46	32	5 / 9	(32,6 +- 7,1) MV/m	(27,7 +- 7,1) MV/m	(34,3 +- 4,8) MV/m	(30,4 +- 4,4) MV/m
total	113	72	20 / 18				

- Electro-polished cavities have **higher gradients** (+ 3 MV/m)
- Re-treatment increases the usable gradient by approx. 3 MV/m
- At present approx. 2/3 can be accepted as delivered; this statistics includes ramp-up phase
- Detailed analysis will be given after 40-50% of all cavities (5/2014)**

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

Short Report on vertical test

CAVITY ID	CAV00526
RF test date	27.03.13
Test #	1
Exp. #	2
max. Exc.	27 MV/m
Exc. rate	2000 Hz
Limitation	Quench limit
CD @ Exc = 23.5 MV/m	1.4 x 10 ⁻⁶
Exc. @ Exc = 23.5 MV/m	none
Acceptance criteria met	Yes

Comment 1: Vertical test without problems
Comment 2: Filling line bend => OK, if cavity is visible

Final Q(f) of CAV00526, test 1

28.03.2013

Short Report on vertical test of CAV_FEM00526, test 1

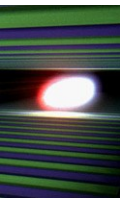
CAVITY ID	CAV00526
RF test date	27.03.13
Test #	1
Exp. #	2
max. Exc.	27 MV/m
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Exc. @ Exc = 23.5 MV/m	none
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Final Q(f) of CAV00526, test 1

28.03.2013

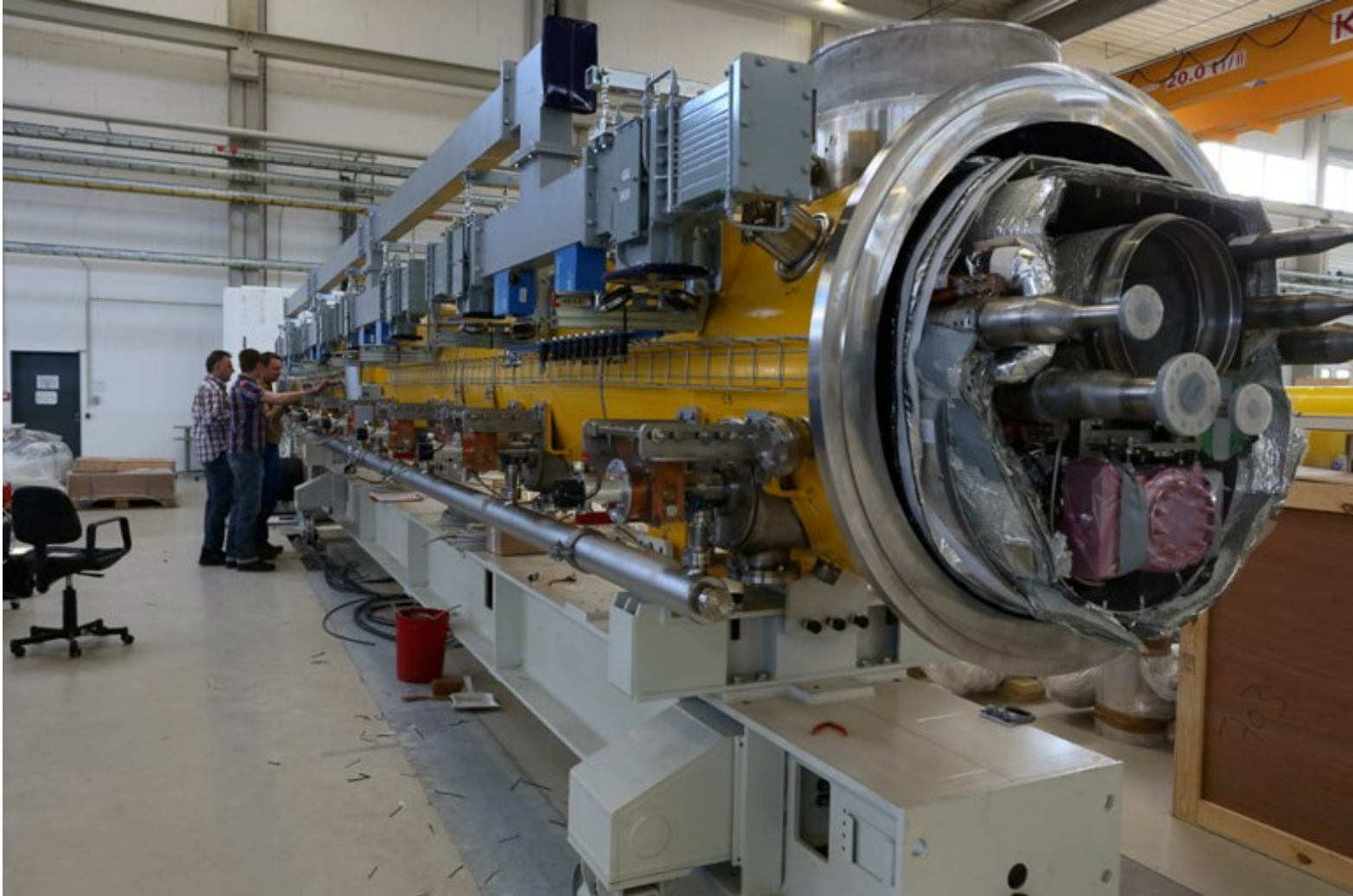
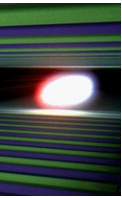
AMTF Cavity & Module-Tests



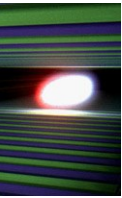
- cavity tests are routinely done
- in Q4/2013 we reached a test rate of 8-12 cavities per week; great!
- two out of three module test stands are ready for operation
 - the third one will be coming soon
 - we are gaining experience with the module testing; the testing rate still has be confirmed
 - starting end of 3/2014 we expect the delivery of one module per week



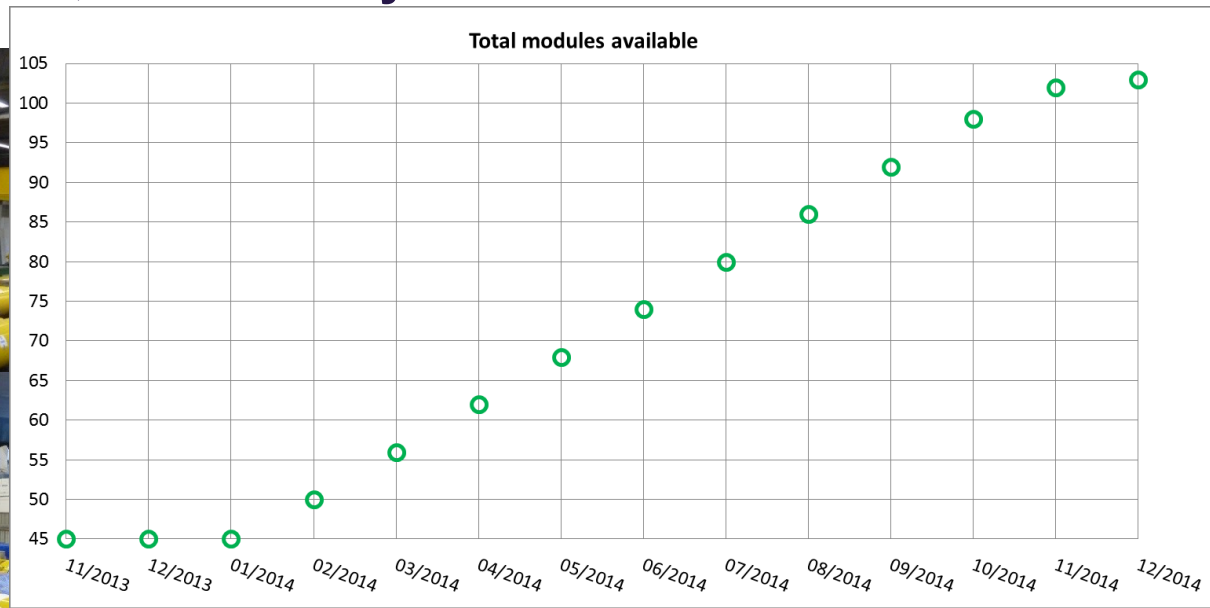
Tailored Waveguide System after AMTF Test



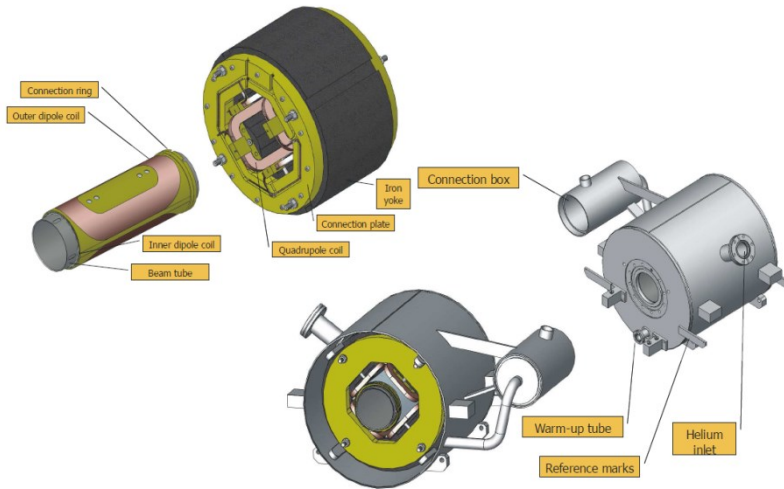
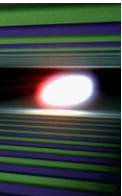
Many Cryostats and Cold Masses Available



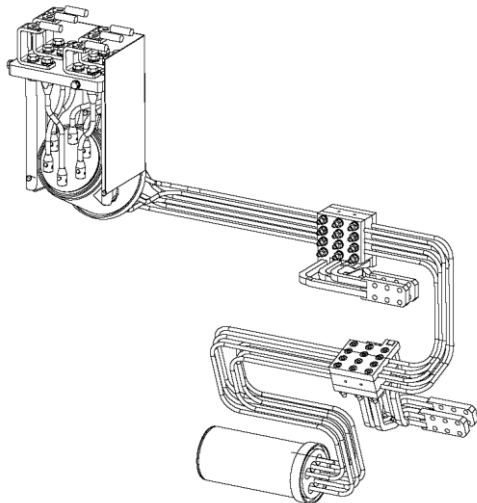
- a total of 25 cryostats & cold masses delivered by E. Zanon
- 20 units delivered by IHEP but 7 need re-work due to non-conformities
- some minor re-work of Zanon units will take place at CEA Saclay
- overall delivery schedule ok; **last delivery in 12/2014**



Cold Magnets and Current Leads

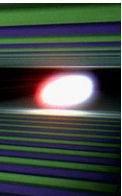


- 65 magnets delivered (CIEMAT IKC)
- 55 cold tested at DESY (IFJ-PAN IKC)
- 45 current leads (DESY IKC) tested
- only minor non-conformities; all accepted
- special magnet for 3.9 GHz module exists



- 14 quad packages assembled

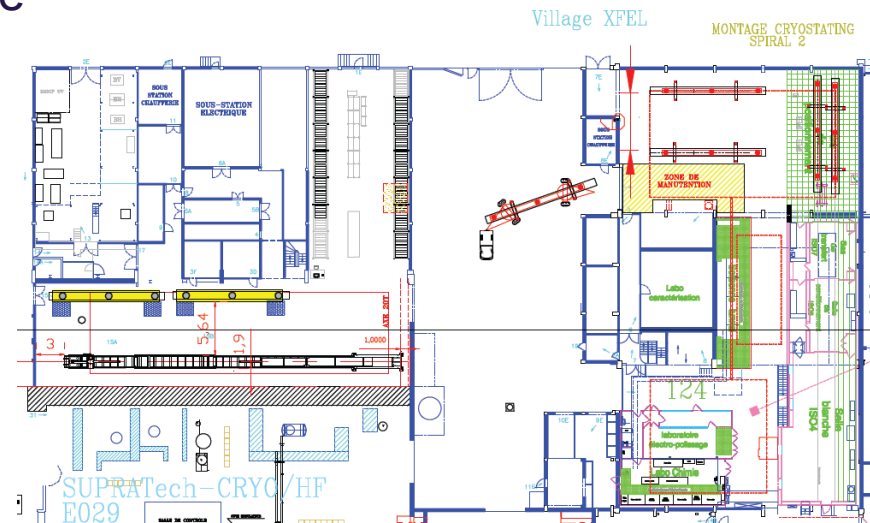
String and Module Assembly



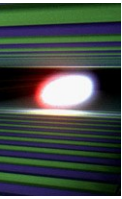
- company ALSYOM contracted by IRFU / Saclay
- ALSYOM colleagues were trained using pre-series modules
- ALSYOM colleagues are now assembling first series modules

BUT

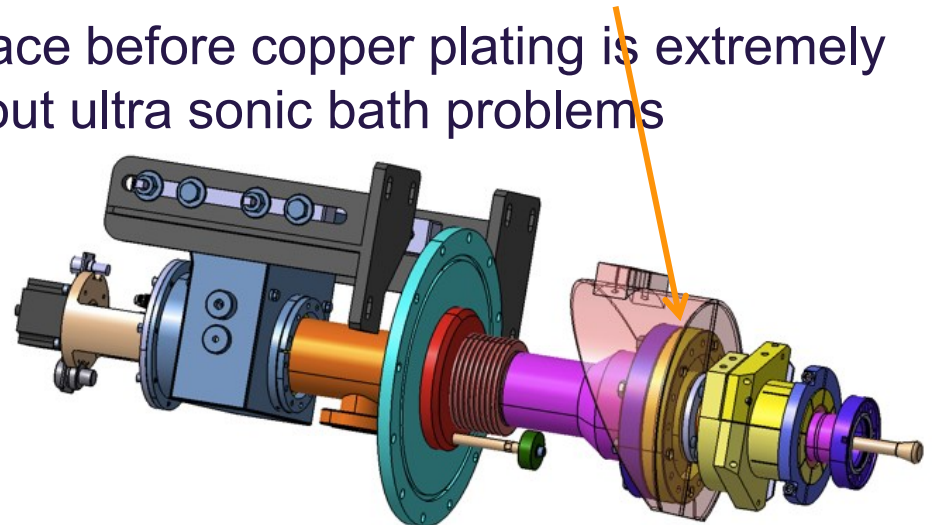
- work on first series module XM1 was expected in 5/2013 and actually started in Q4/2013, this due to the challenging interfaces
- beginning of 2013 we hoped for a reduction of already visible delays; today we know that w/o extra additional effort module #100 will be available in spring 2016
- RF power coupler availability is still the issue



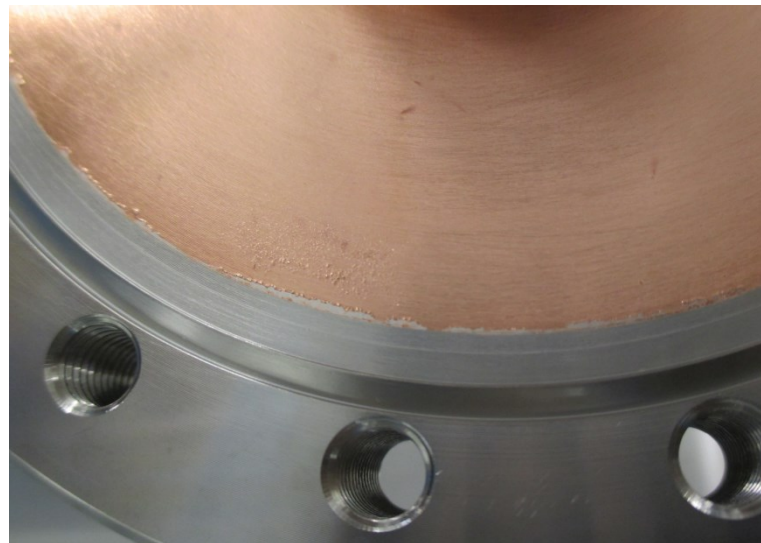
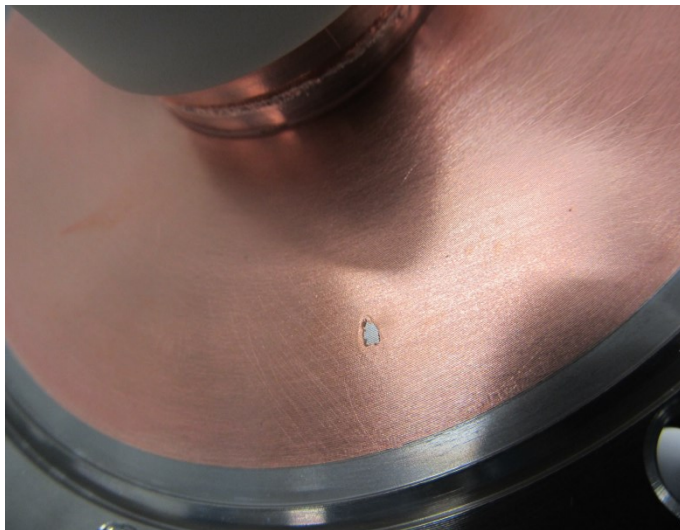
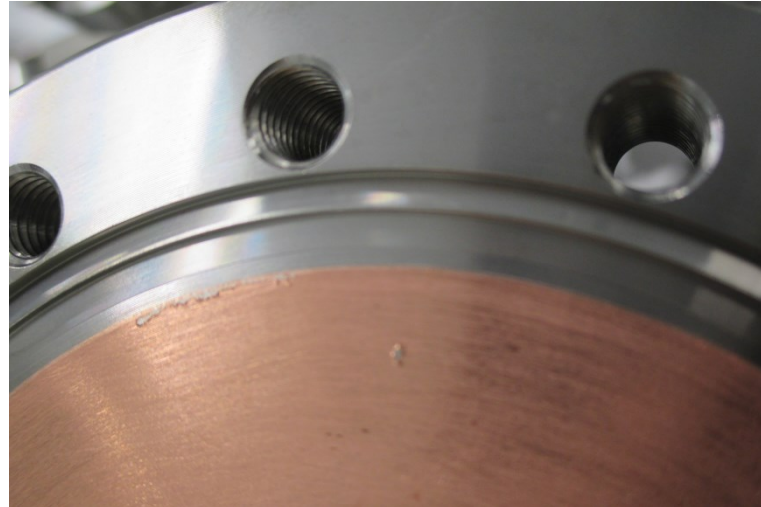
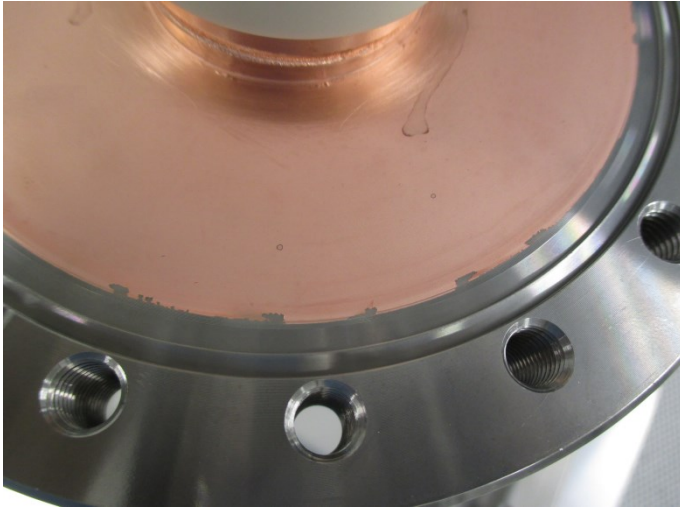
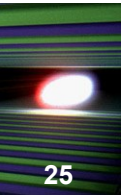
do we get the RF power couplers in time?



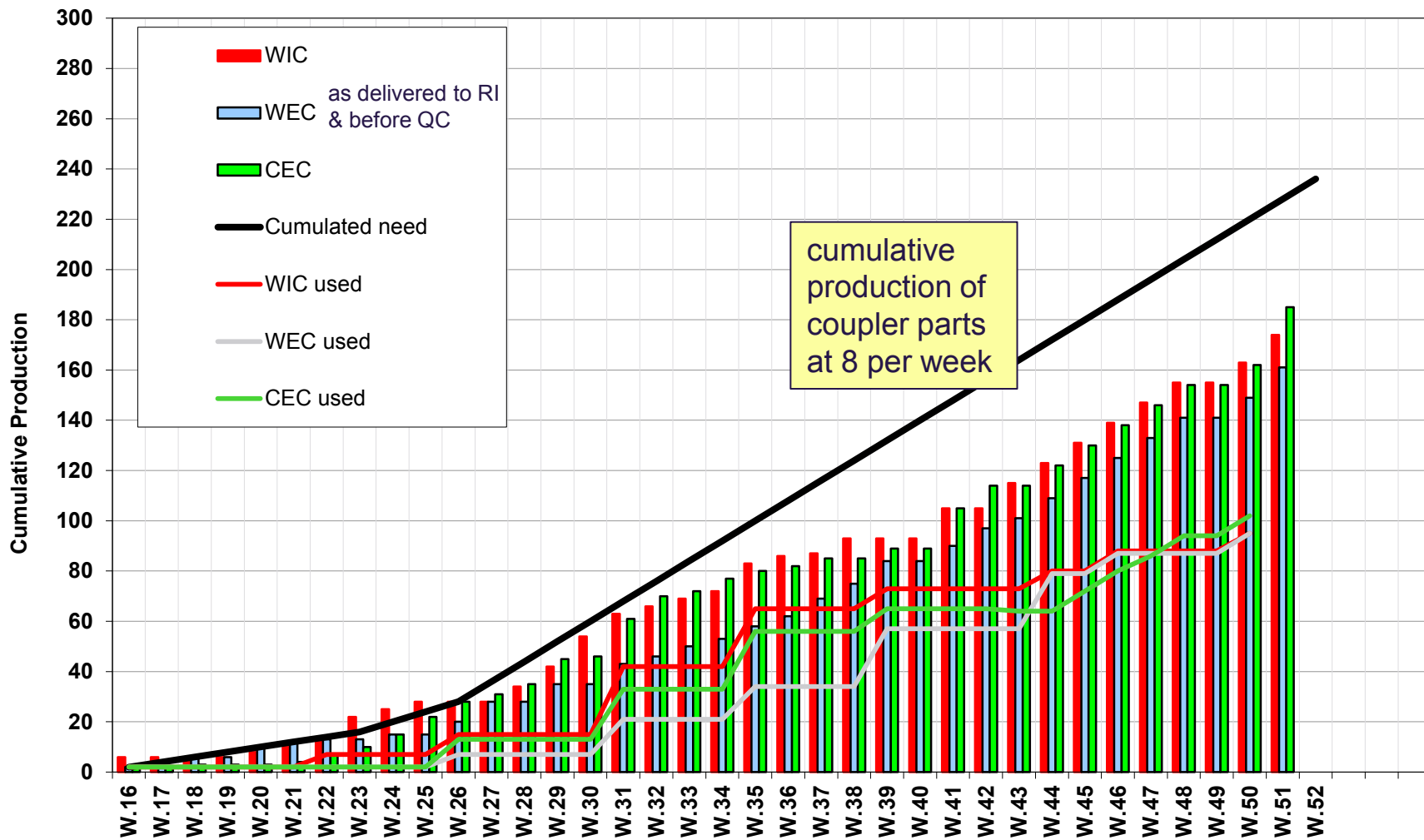
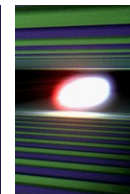
- almost 50 first XFEL couplers produced by Thales / RI are successfully conditioned
- the **production started**; coupler for four modules were delivered to IRFU and more to come soon
- a **delivery rate of 4 per week** to LAL was reached in December 2013; an increase of 6 per week is expected for 1/2014; hopefully 8 per week soon
- **infrastructure at Thales and RI** upgraded to produce 8(+) per week
- **THE problem in 2013** was with copper flaking off from CF100 flange;
- cleanliness of stainless steel surface before copper plating is extremely critical and measurements pointed out ultra sonic bath problems
- in general excellent **quality control** is required to reject bad parts early during production; then the production can be adopted to the yield of the individual steps even if it costs additional money



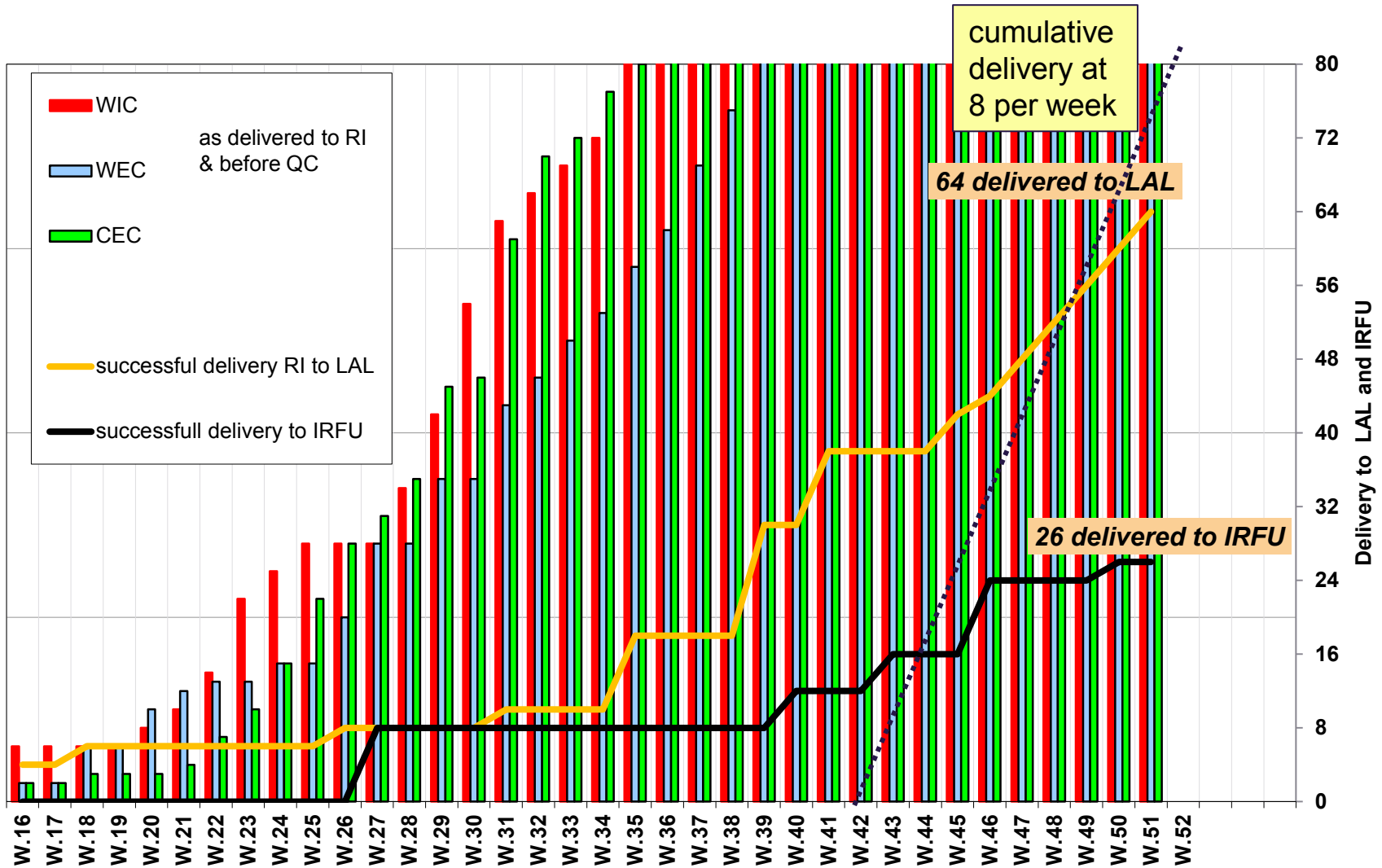
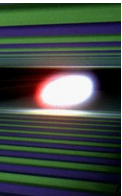
Pictures CF100 Flange Cold Coupler



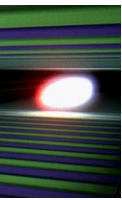
XFEL Coupler Production Chart 2013



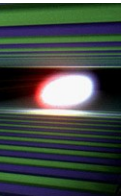
XFEL Coupler Production Chart 2013



LAL Clean Room with RF Conditioning Set-up

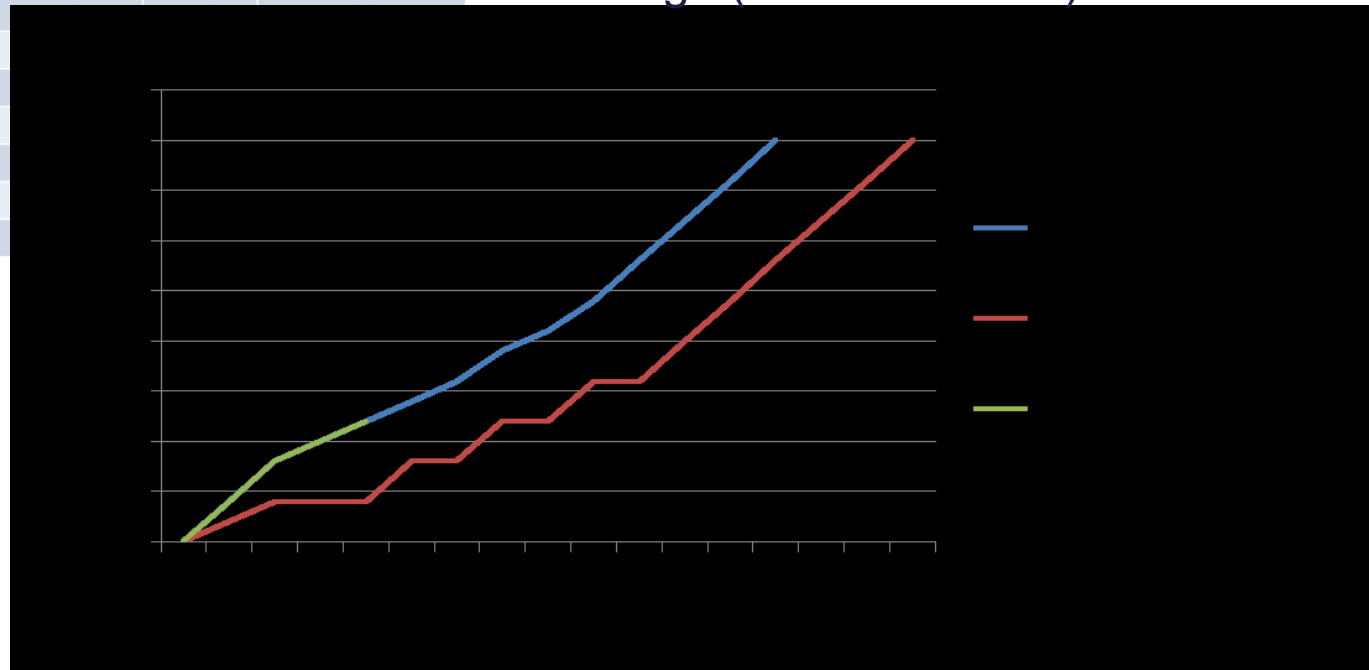


RF Power Coupler Availability in 2014

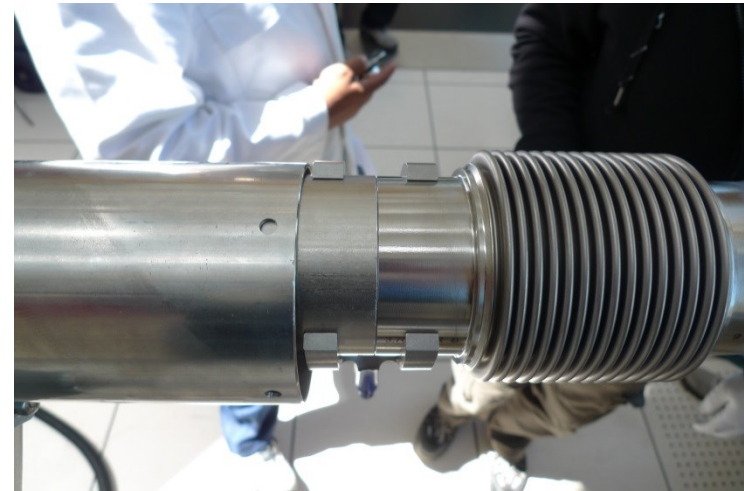
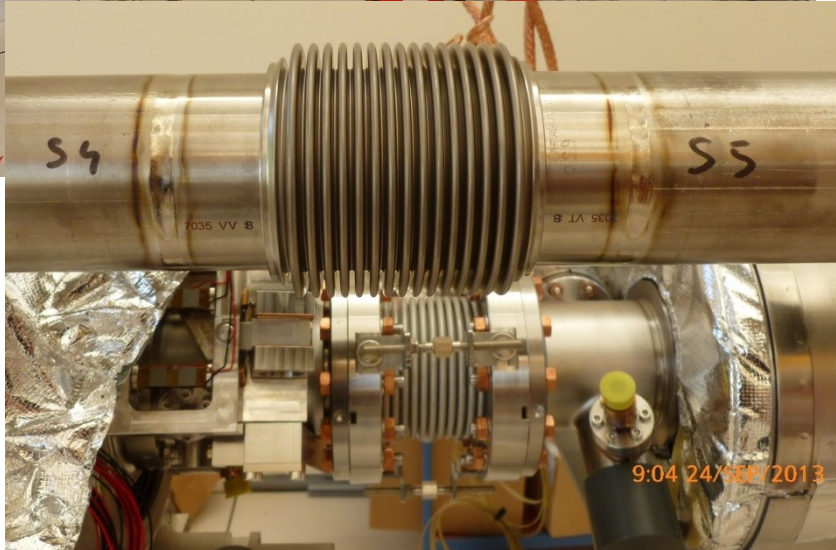
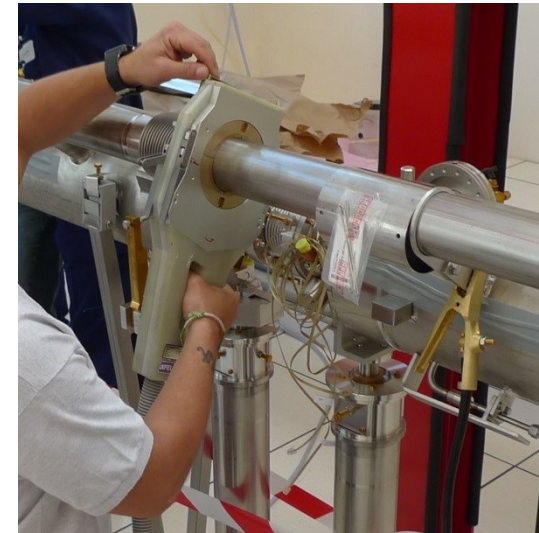
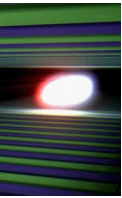


Pairs	Delivery to LAL	Baking	RF Cond	Ready for IRFU	Used / Needed	Module
					W27	XM-1
TTF-III					W36-49	XM1
				W40-50	W40-50	XM2
				W46-51	W46-51	XM3
21, 23, 24, 26	2013			W2	W2 / 3	XM4
22, 27, 29, 28	2013		W3	W3	W6	XM5
31, 32,33	W52 (2013), W2	W3	W3	W4	W8	XM6
36	W3	W4	W4	W5	W8	XM6
30B,37	W4	W5	W5	W6	W10	XM7
2 pairs	W5	W6	W6	W7	W10	XM7
3 pairs	W6	W7	W7			
2 pairs	W7	W8	W8			
3 pairs	W8	W9	W9			
4 pairs	W9	W10	W10			
4 pairs	W10	W11	W11			
4 pairs	W11	W12	W12			
4 pairs	W12	W13	W13			

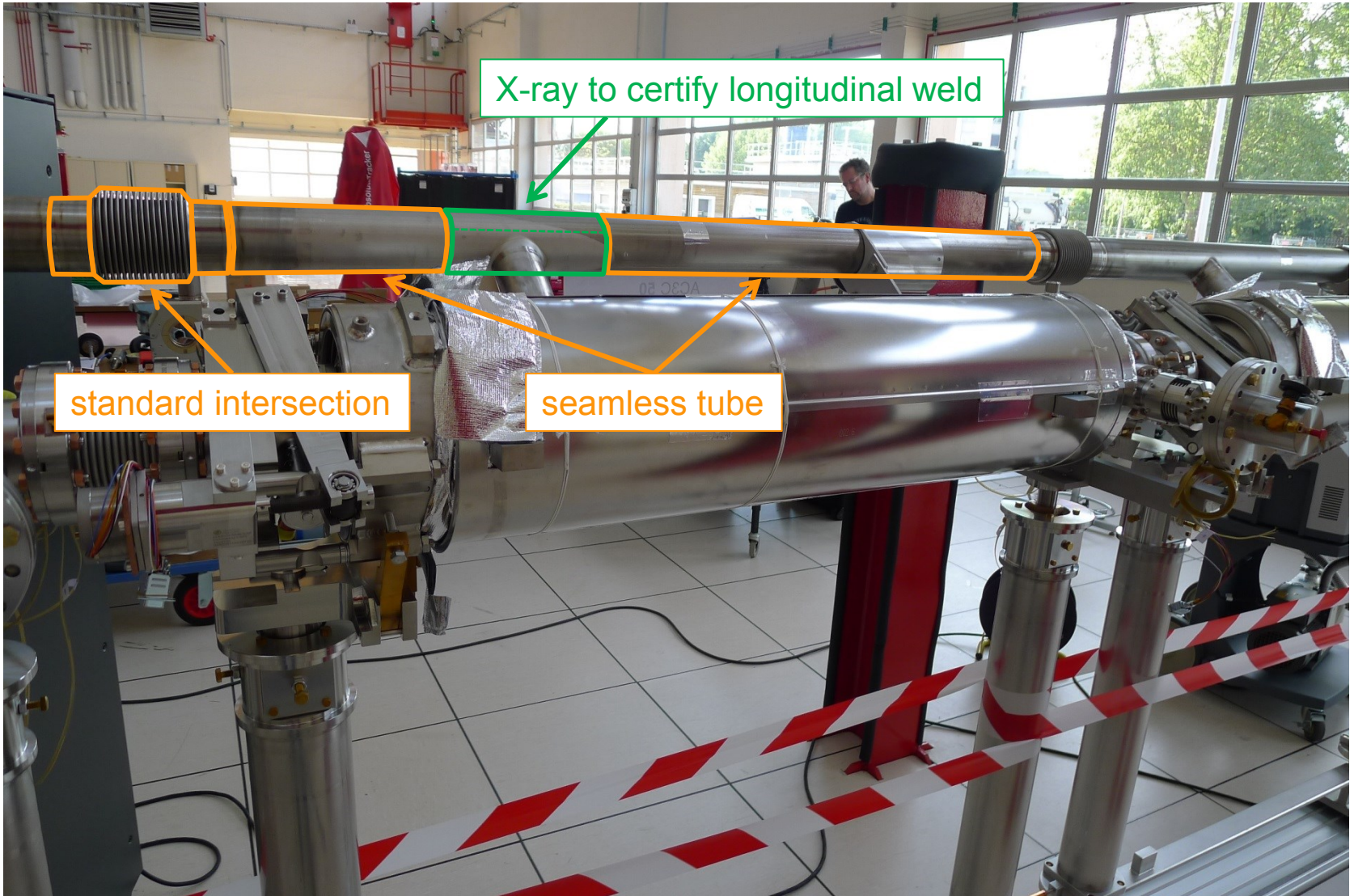
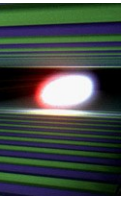
- availability of RF power couplers is want counts
- for the next few modules it could work
- further ramp-up is a must!
- at present the coupler production clearly profits from another technical challenge (see next slides)



2-Phase Line Titanium Tube Welding



2-Phase Line Repair Work

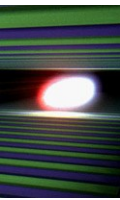


X-ray to certify longitudinal weld

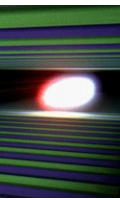
standard intersection

seamless tube

Recent Challenge with 2-Phase Line Welding



- during the assembly of module XM-1 a **completely unexpected problem** occurred
 - After string assembly the 2-phase line sections of the individual cavities need to be connected which includes orbital welding of Titanium tubes.
 - X-ray pictures of the welds pointed out large pores which are not acceptable due to PED requirements.
 - An action plan with constantly updated items was developed and many sample welds were done at DESY & CEA; tough-minded cleanliness (surface, welding gas, gloves, ...) is the issue.
 - During the course of our investigations we found non-acceptable pores in the longitudinal welds; as a consequence replacement of all 2-phase tubes is required; remaining short sections are to be X-rayed.
- The welding problem was blocking the assembly of further modules. Such a problem causes a complete stop of the assembly of the module series and thus has **direct impact on the project schedule!**



■ delivery status of major components

- 13 klystrons
- 18 modulators
- 24 pulse transformers
- 27 connection modules
- 100% pulse cables installed
- all 30 preamplifiers
- continuous delivery of waveguides, e.g. 450 circulators



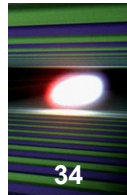
■ **some delay in klystron delivery** due to testing capabilities at vendor and some non-conformities

■ some delayed start in modulator delivery due to availability of electronic parts

■ **no schedule risk**

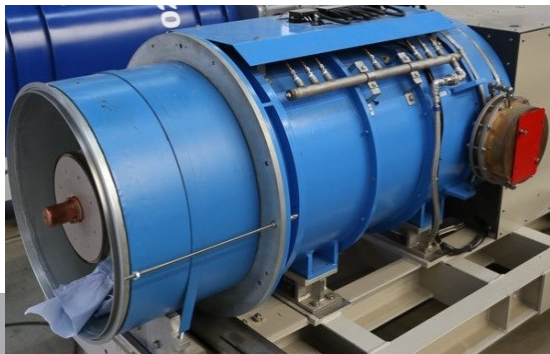


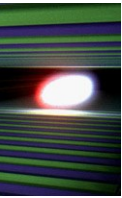
Klystron overboard! – an unexpected schedule risk...



34

- a Toshiba Klystron was on board of this vessel... and is finally lost; replacement by Toshiba within schedule is possible.





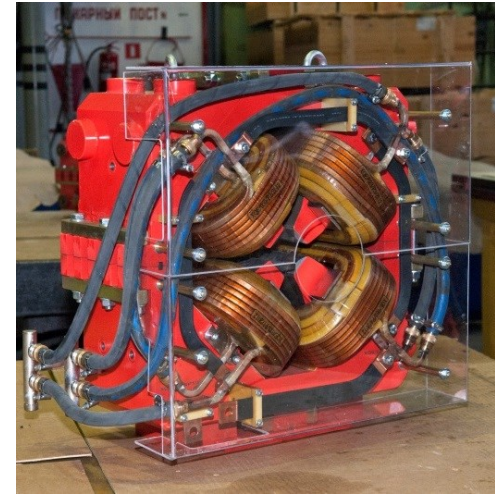
- **53% of 715 magnets delivered**, i.e. magnet fabrication in full swing



correctors



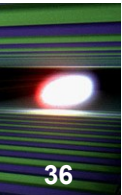
XSC



XQE

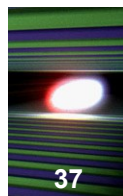
- quality control / magnetic measurement started at DESY; required magnetic field quality confirmed
- all magnets required for the injector are available

XHM - Modulator Hall Infrastructure



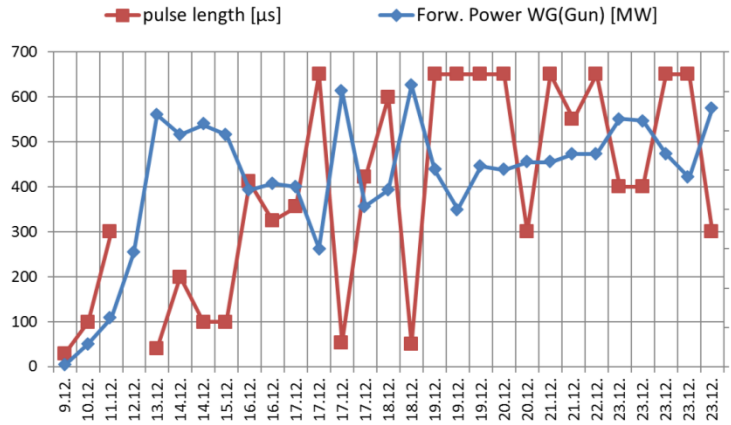
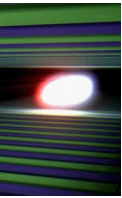
■ Modulator Hall infrastructure ready

XHM - Modulator Installation

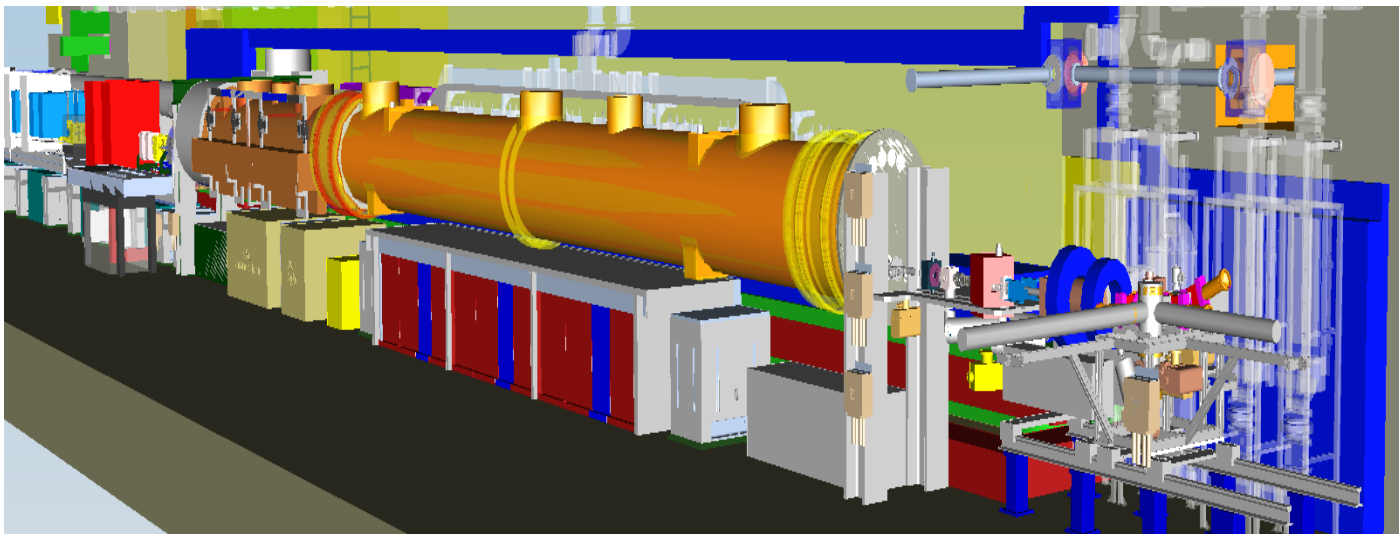


- 18 out of 27 modulators delivered
- installation on-going
- all pulse cables in place
- first modulator in operation for RF gun

First RF Gun Experience

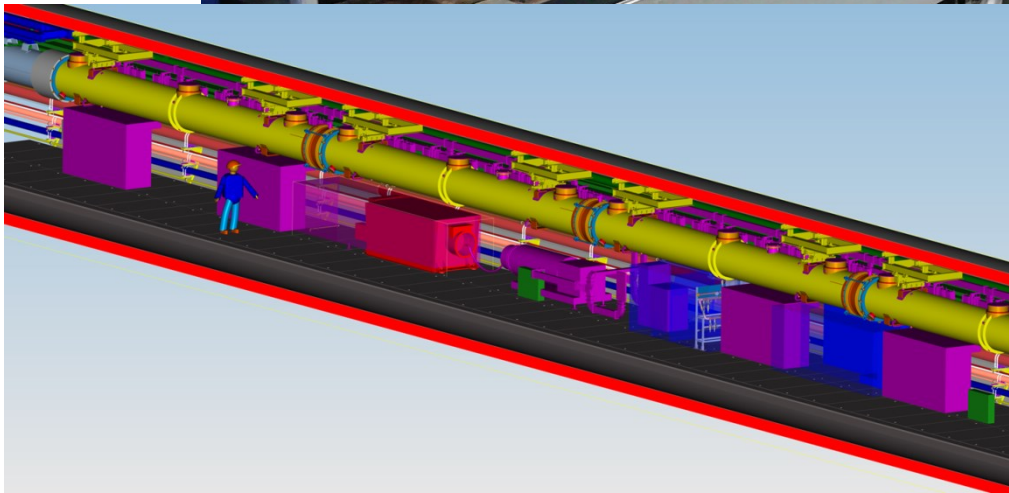
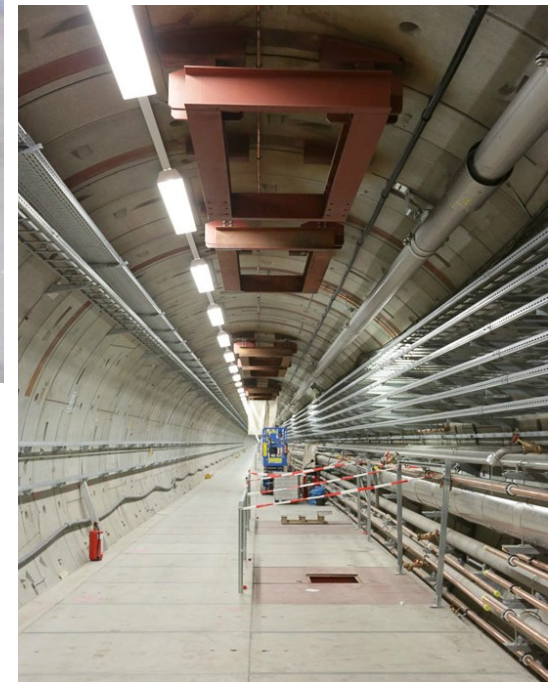
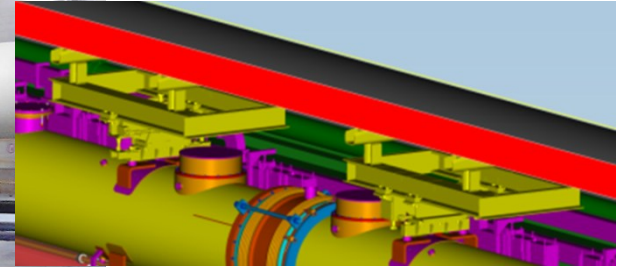
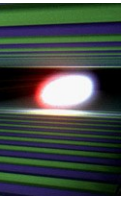


- The at DESY, Zeuthen pre-conditioned RF gun was operated in 12/2013
- close to specs but some open issues at the RF window; needs further studies

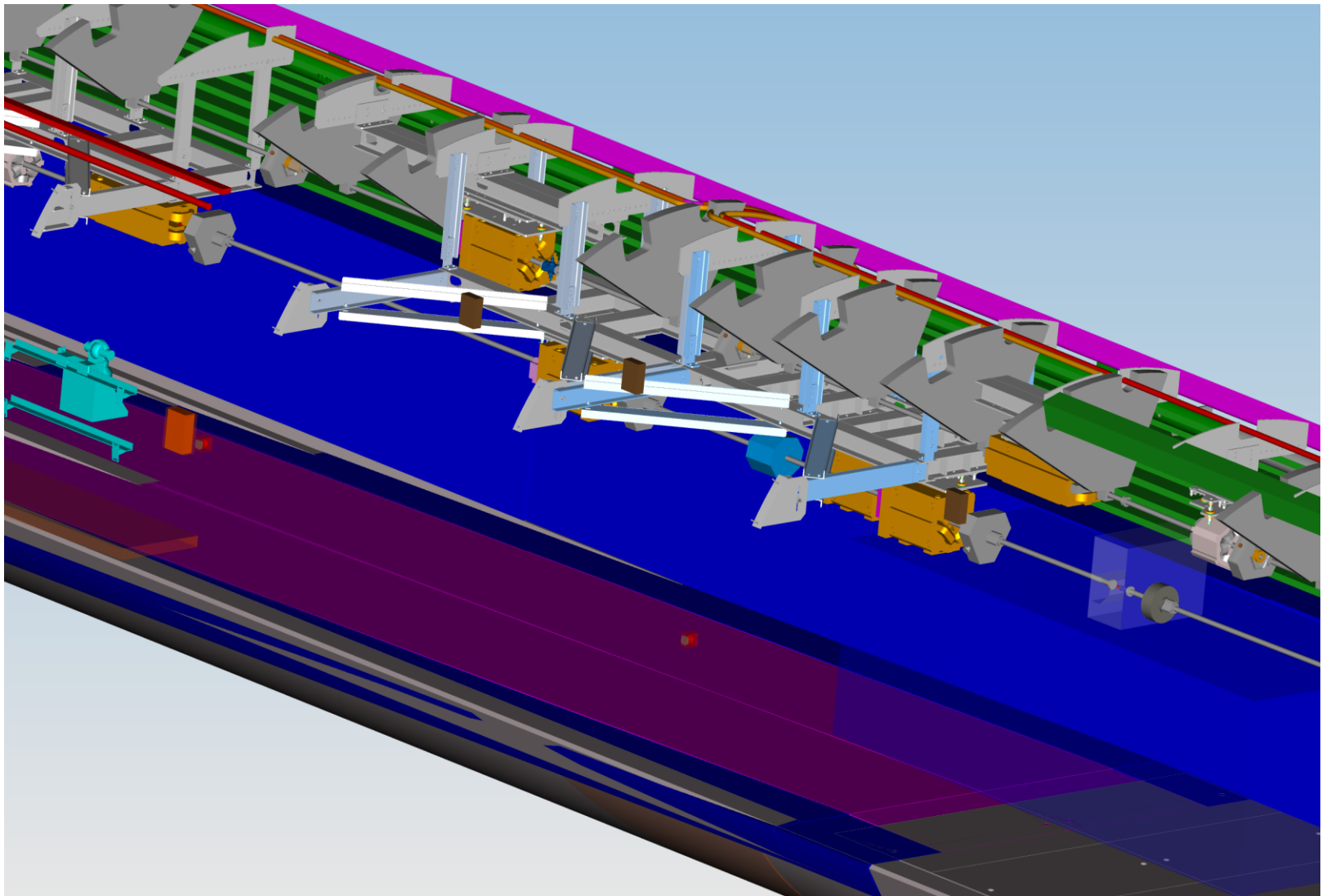
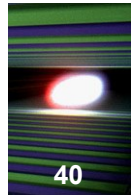


- injector girder integration will be followed by complete installation
- 3.9 GHz module will come late

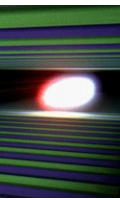
Suspension Frames for Accelerator Modules



Beam line Suspension



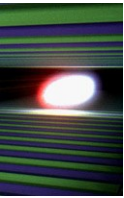
Risks and Challenges Remain



- do we get the RF power couplers in time?
- we need to demonstrate module assembly rate in Q1/2014



- sophisticated interplay between work packages continues to require careful steering
- we need to minimize schedule impact (also cost)



The end