



WWFP #2

E-XFEL Power Coupler status

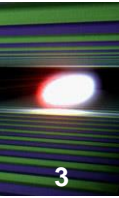
July, 12-13, 2016



- Status
 - Power couplers
 - Technical Interlock

- Technical problems
 - Pushrod leak
 - Conditioning

- Conclusion

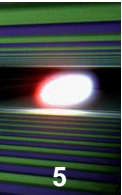


- Thales-RI (order placed 2010)
 - 670 units in the framework of the initial in kind contribution order
 - Delivery finished March 2016
 - strongly delayed because long copper plating development, low recovery rate of rejected parts and delivery delay of new parts

- Thales-RI (order placed Dec. 2015)
 - 10 coaxial units ordered to replace damaged couplers during assembly and test on modules
 - Delivery finished in April 2016

- RI (order placed 2012 because of difficulties with copper plating at the main contract)
 - 32 coaxial units
 - Schedule is very late because of plating problems (several companies and CERN have been involved)
 - Finally THALES was contracted by RI for the copper plating in Jan 2016
 - Delivery starts May 9th and will be finished in July 2016
 - Accessories ordered early 2016, delivery April and May 2016
 - Delivered up to now: 12, last delivery planned Aug. 5th
- CPI (order placed May 2014 because of late main contract)
 - 150 coupler units
 - Schedule is late
 - Delivery finished July 2016, few returns

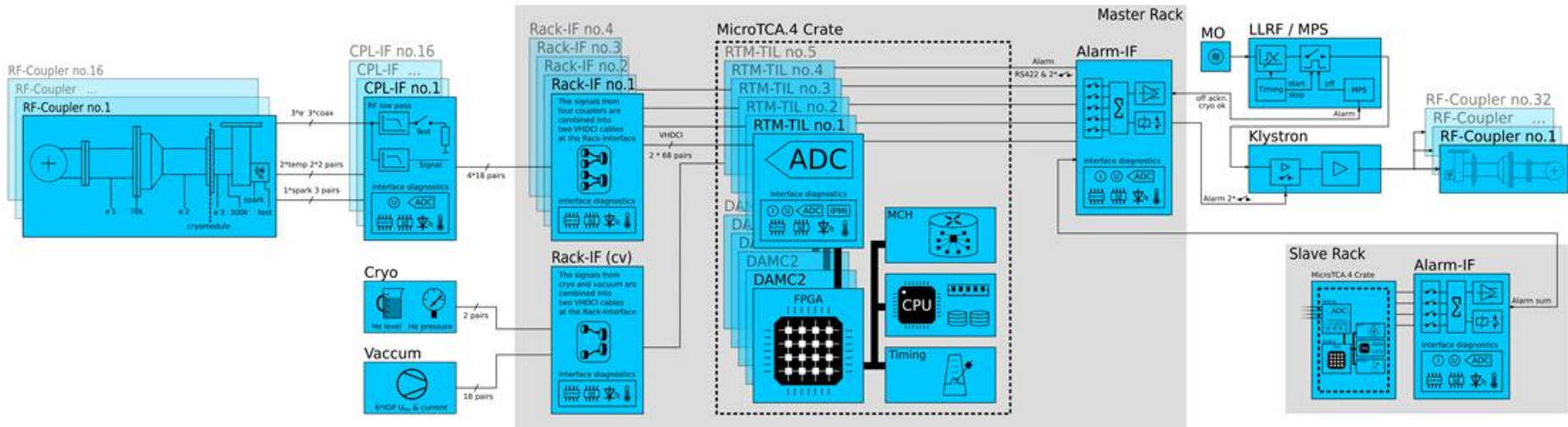
Technical Interlock (TIL)



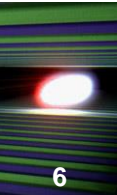
■ Signals for one RF station (32 couplers)

Count	Signal	Remark
96	e- sensor	current measurement with bias voltage
32	Spark	main coupler air side (waveguide)
64	PT1000	ceramic RF window (T70K, T300K)
12	analog	IGP vacuum and high voltage
2	analog	cryo signals (He level, He pressure)
1	contact	vacuum system status
1	RS422	cryogenic system status

■ Reaction time: <math><5\mu\text{s}</math>



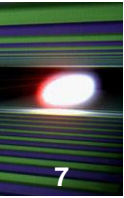
Status of Technical Interlock (TIL)



6

- Injector (3 TIL systems)
 - Gun TIL under operation
 - Injector module TIL under operation
 - Third harmonic TIL under operation
- RF station A2, A6 – A11 (7 TIL systems)
 - commissioned
 - Duration of commissioning for A6 - A11 was 48h only
- 16 more TIL systems are ready for installation or under installation
 - TIL hardware: 26 out of 28 TIL systems are finished (one TIL = two racks), ready for tunnel installation
- Module cabling: 89 all modules at DESY (89 modules) are fully equipped with TIL sensors and cabling





The pushrod (PR) function:

- It moves the coupler antenna in order to change the loaded Q.
- The PR bellow closes the coupler vacuum against the air.
- PR bellow has no RF function.

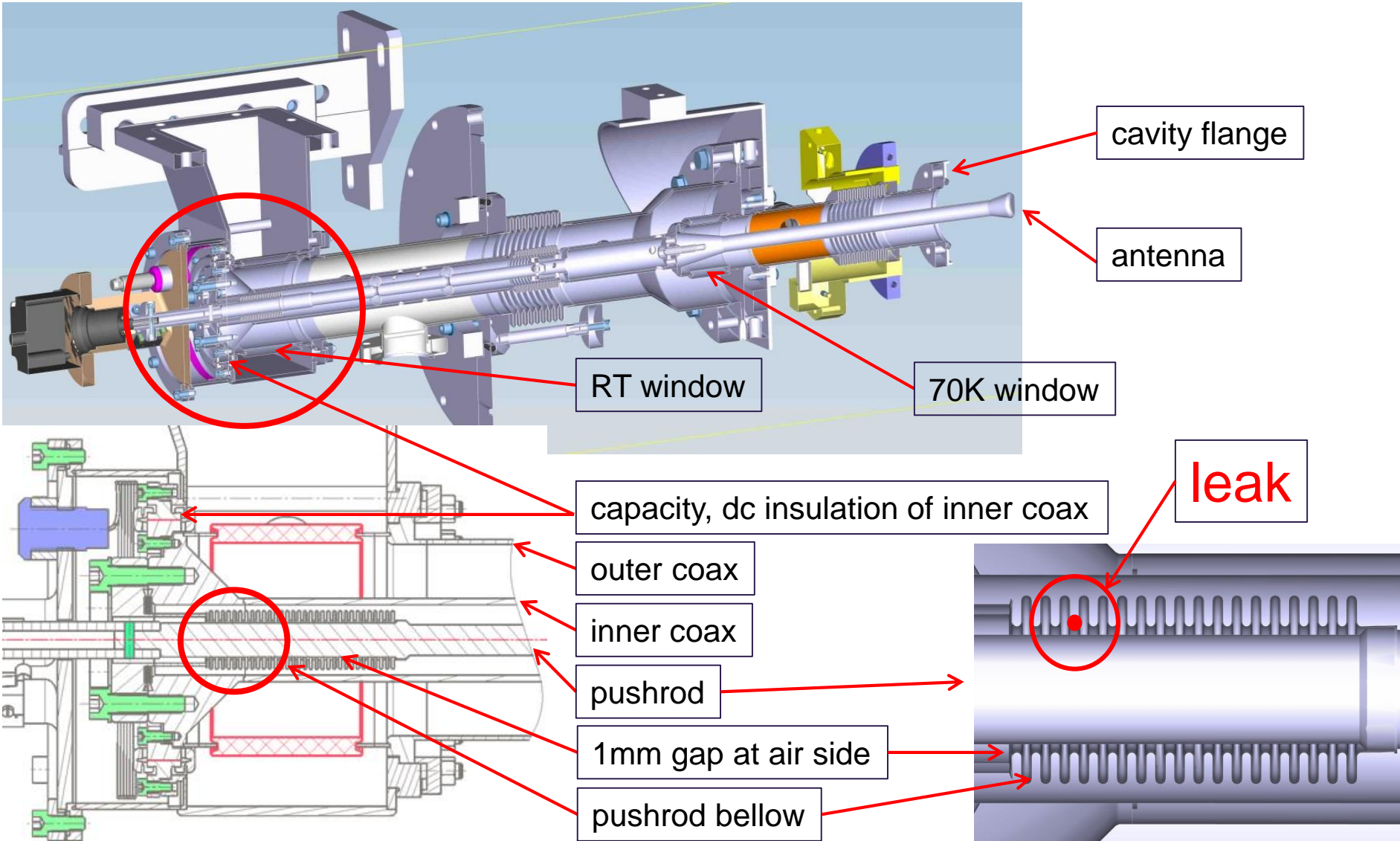
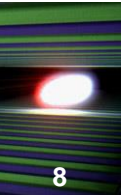
Problem:

- 26 PR's developed a leak in bellow between coupler vacuum and air
- leak appears during RF conditioning of modules
- Leak appears always near 12th (± 3) convolution on inside valley

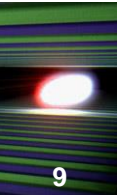
History:

- >40 TTF power couplers in FLASH are operated since many years without any defects
- change for XFEL power couplers:
 - PR bellow is 26mm longer
 - PR geometry is changed

Pushrod leak, location

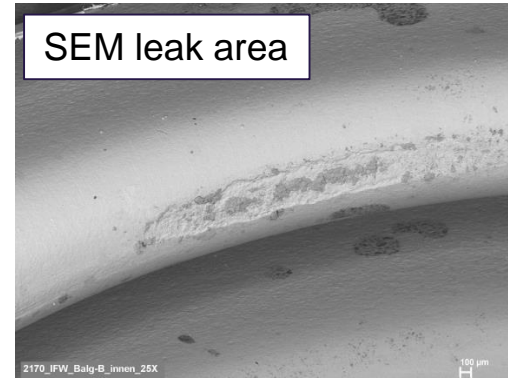


Pushrod leak, investigation

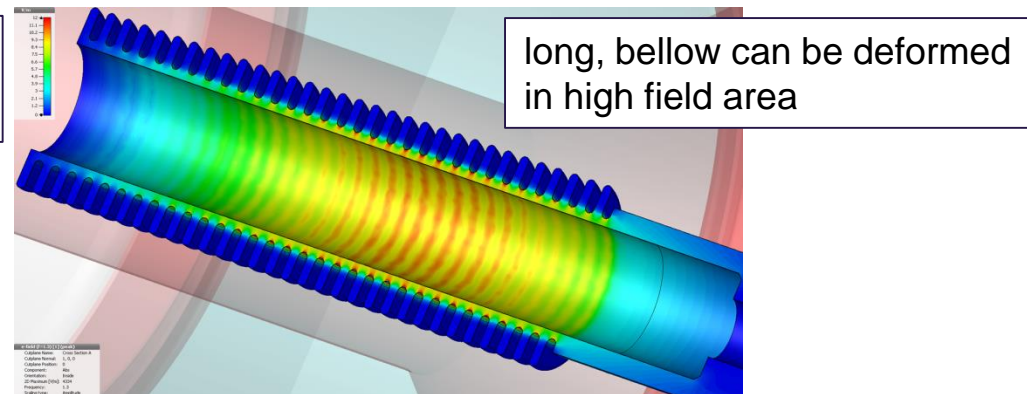
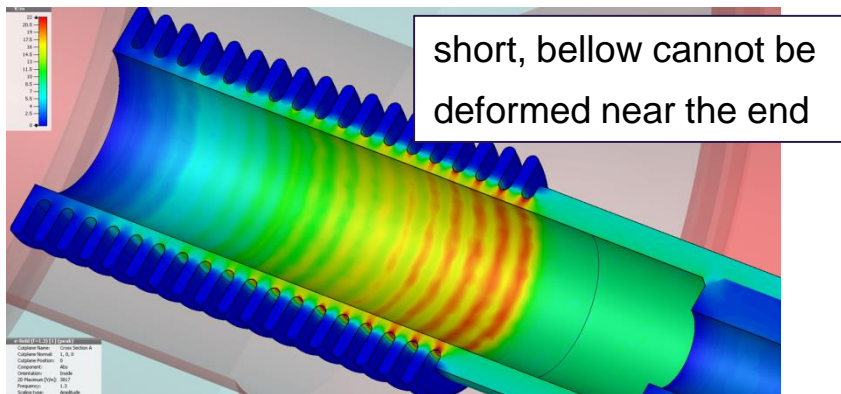
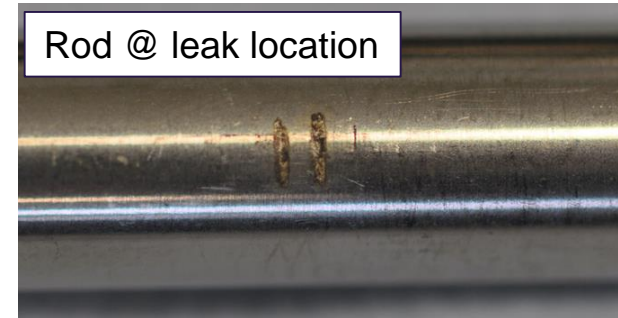


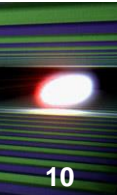
- bellow supplier SKODOCK investigation result:
 - steel structure is locally changed by overheating, carbide precipitation on grain boundaries causes stress corrosion cracking
- RF simulations (DESY, SLAC):
 - RF leak of the capacity leads to 15V/m @ 1W
i.e. for 200kW full reflection: 6.5V/mm
 - The breakdown voltage in air is 3kV/mm
- **Sparking is only possible when the bellow is deformed and touches the inner rod.**

SEM leak area



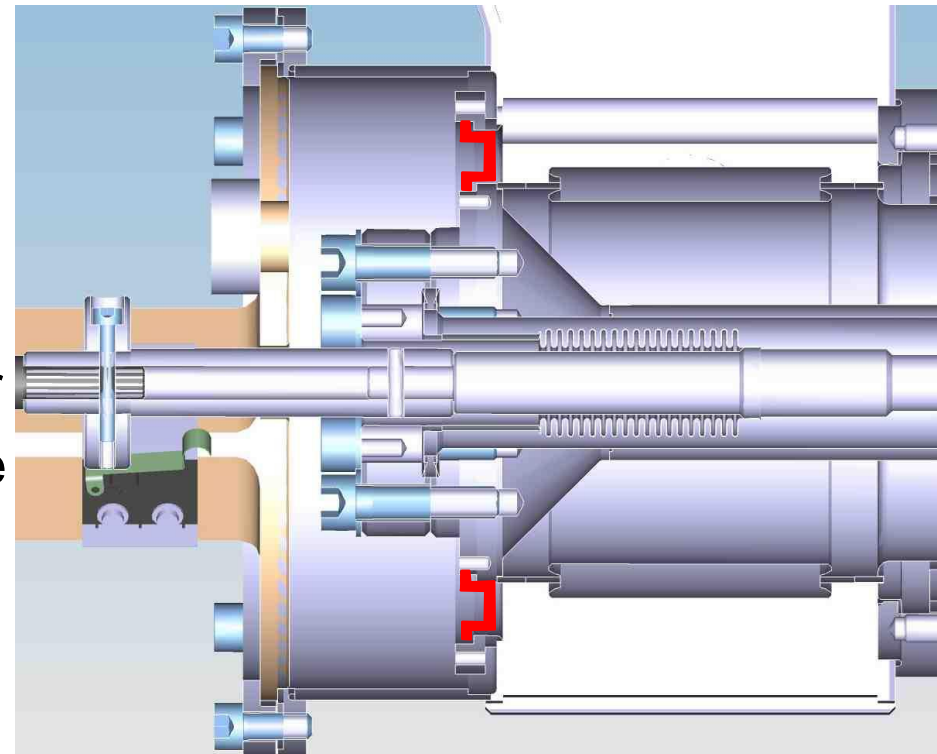
Rod @ leak location





The capacitor will be replaced by a short
 → the RF leak is suppressed

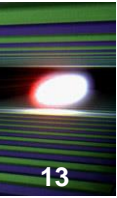
- The CPI coupler have no capacitor
 → no need for replacement
- Has to be done at all modules, also in the tunnel
- Coupler vacuum is not involved
- Material arrived at DESY, work has started
- No more RF operation with capacitor
- Exchange and commissioning will be still within time frame of XFEL
- The DC insulation of inner conductor is foreseen for bias application as multipacting remedy, was never needed in FLASH



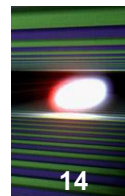
- Recently we faced overheating and strong light during conditioning on module test stands
 - All parts passed the RF test at LAL without any problems
 - Warm coaxial coupler parts had to be exchanged
 - Possible causes:
 - Copper plating quality
 - Surface contamination (RGA are OK)
 - Assembly problems with RF contacts at inner or outer conductor
 - ???
 - Under investigation

- Power coupler fabrication is still determining the XFEL schedule
- Additional work on power coupler on modules, also in the tunnel, necessary. Exchange of parts and commissioning will be still within time frame of XFEL

- TIL installation is in time
- TIL commissioning is faster than expected
 - TIL schedule depends from the tunnel cabling



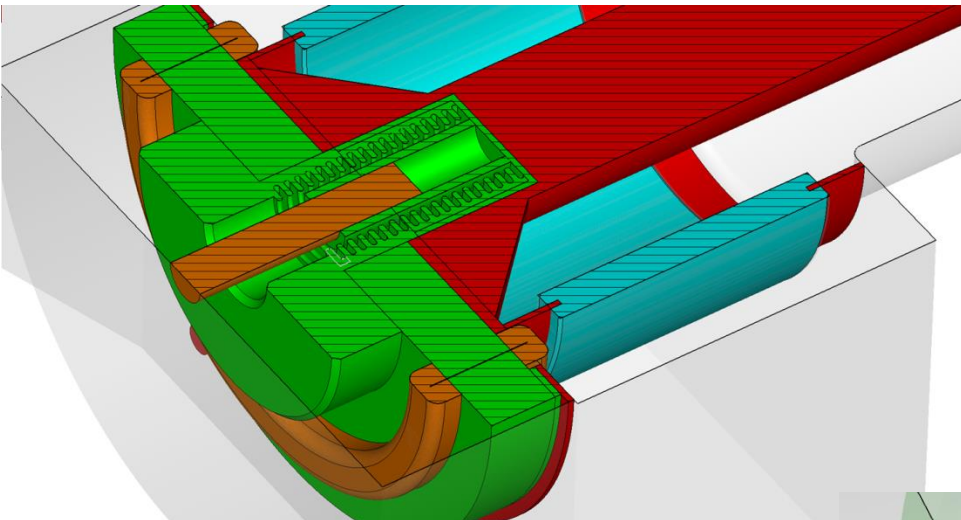
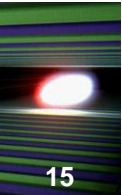
Thank you for your attention



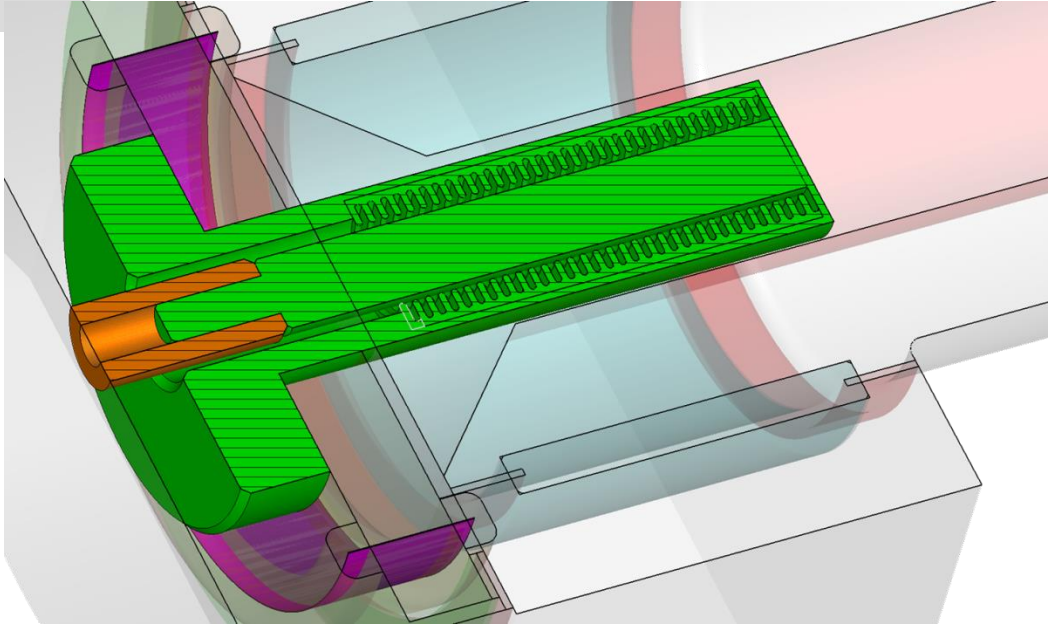
XFEL modules couplers parts problems. 01-07-2016.

N	module	pos.	Cold Part	Warm Part	problem	comment
1	XM80	2	THRI-CP-838	THRI-WP-320	WCC e-2/e-3 signals and cpl.vac not conditionable, mostly e-2. At cold high T70K (120K).	WP exchanged
2		4	THRI-CP-756	THRI-WP-758		WP exchanged
3	XM82	1	CPI-CP-061	CPI-WP-020	Very strong light (LUWG) signal (300Lx), high T300K (350K)	WP burned (near warm window) / exchanged
4	XM85	5	CPI-CP-063	CPI-WP-060	WCC e-2 signals and cpl.vac not conditionable, high T70K (345K). At cold high T70K (120K).	WP exchanged
5	XM87	4	CPI-CP-074	CPI-WP-079	At cold high T70K (120K) - phase independent.	WP exchanged
6	XM88	2	CPI-CP-083	CPI-WP-089	WCC e-2 signals and cpl.vac not conditionable, high T70K (345K). At cold high T70K (140K).	WP exchanged
7		4	THRI-CP-501	CPI-WP-084	Light not conditionable (15 Lux), slight T300K increase (+5K)	WP accepted with warning
8	XM89	8	CPI-CP-011	THRI-WP-834	T70K overheating (+20K)	WP exchanged
9		6	CPI-CP-086	THRI-WP-849	WCC MP-like discharge (200kW) high e-2 signal, e-1 present, no light and e-3 signals. High T70K (345K). High cpl. and cav.vac.	WP exchanged
10	7	CPI-CP-087	THRI-WP-891	WP exchanged		
11	XM90	6	CPI-CP-091	CPI-WP-091	T70K overheating (150K) at 2K operation.	WP exchanged
12	XM91	7	CPI-CP-095	CPI-WP-102	T70K overheating (150K) at 2K operation.	WP exchanged
13	XM92	5	CPI-CP-019	CPI-WP-106	WCC T70K overheating (350K), 190K at cold test	WP exchanged
14		6	CPI-CP-009	CPI-WP-100	WCC T70K overheating (335K), 136K at cold test	WP exchanged
15		7	CPI-CP-098	CPI-WP-103	WCC T70K overheating (330K), 124K at cold test	WP exchanged
16	XM93	5	CPI-CP-025	CPI-WP-086	WCC T70K overheating (350K), 120K at cold test	WP to be exchanged
17		6	CPI-CP-102	CPI-WP-099		WP to be exchanged
18	XM94	5	CPI-CP-103	CPI-WP-115	WCC T70K overheating (345K)	WP to be exchanged
19	XM95	7	CPI-CP-111	RIXF-WP-026	T70K overheating (120K, +20K) at 2K operation.	WP (inner screw) to be inspected
20	XM96	5	CPI-CP-036	CPI-WP-122	WCC T70K overheating (C5 - 350K), high e-2 signal and LUWG not conditionable (12V). WCC not successful.	WP to be exchanged
21		7	CPI-CP-112	CPI-WP-126		WP to be exchanged

TTF3 – XFEL PR comparison

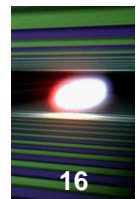


TTF3 coupler, short bellow, short PR, manual tuning

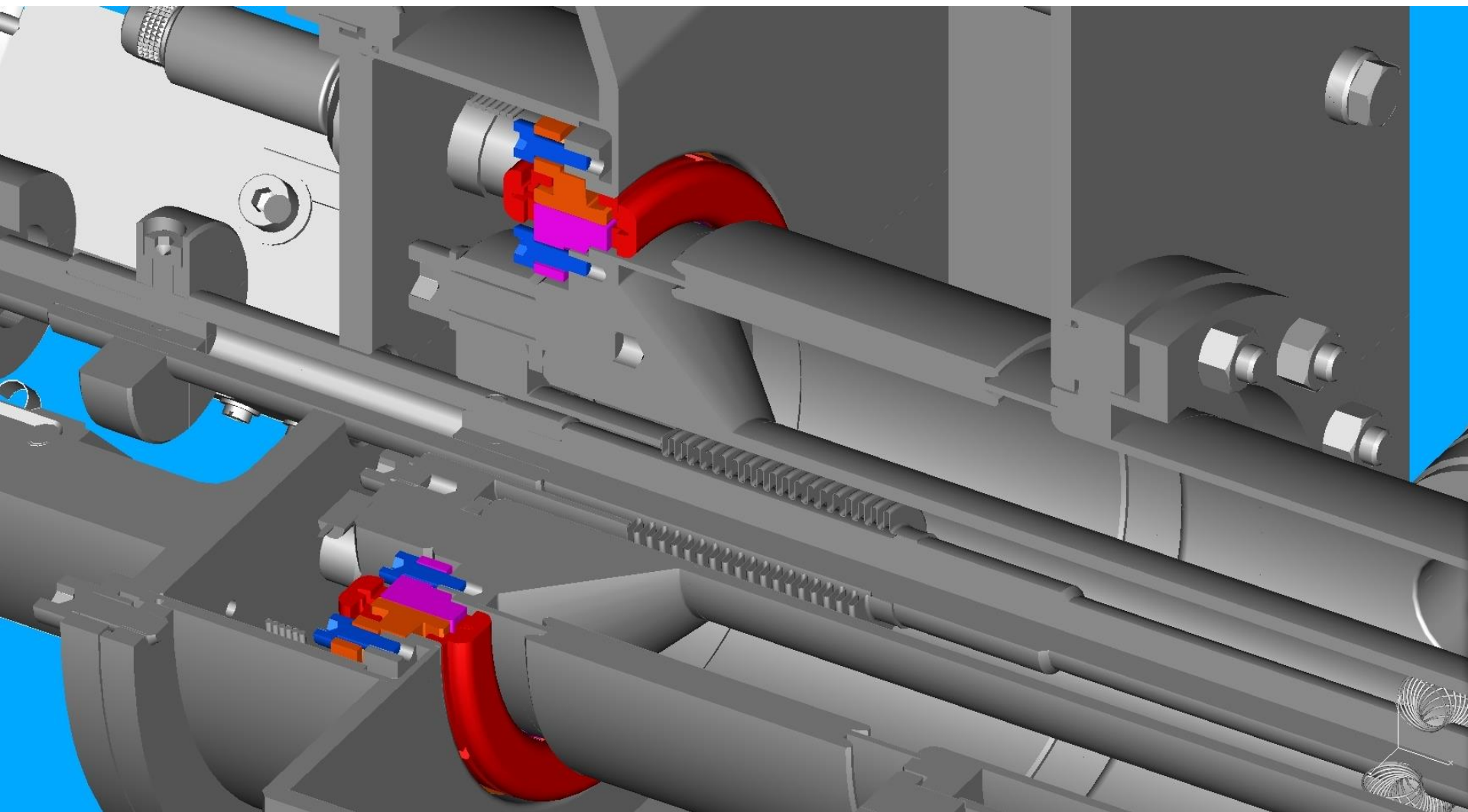


XFEL coupler, long bellow, longer PR, motor tuning

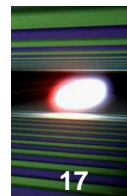
Replacement Installation



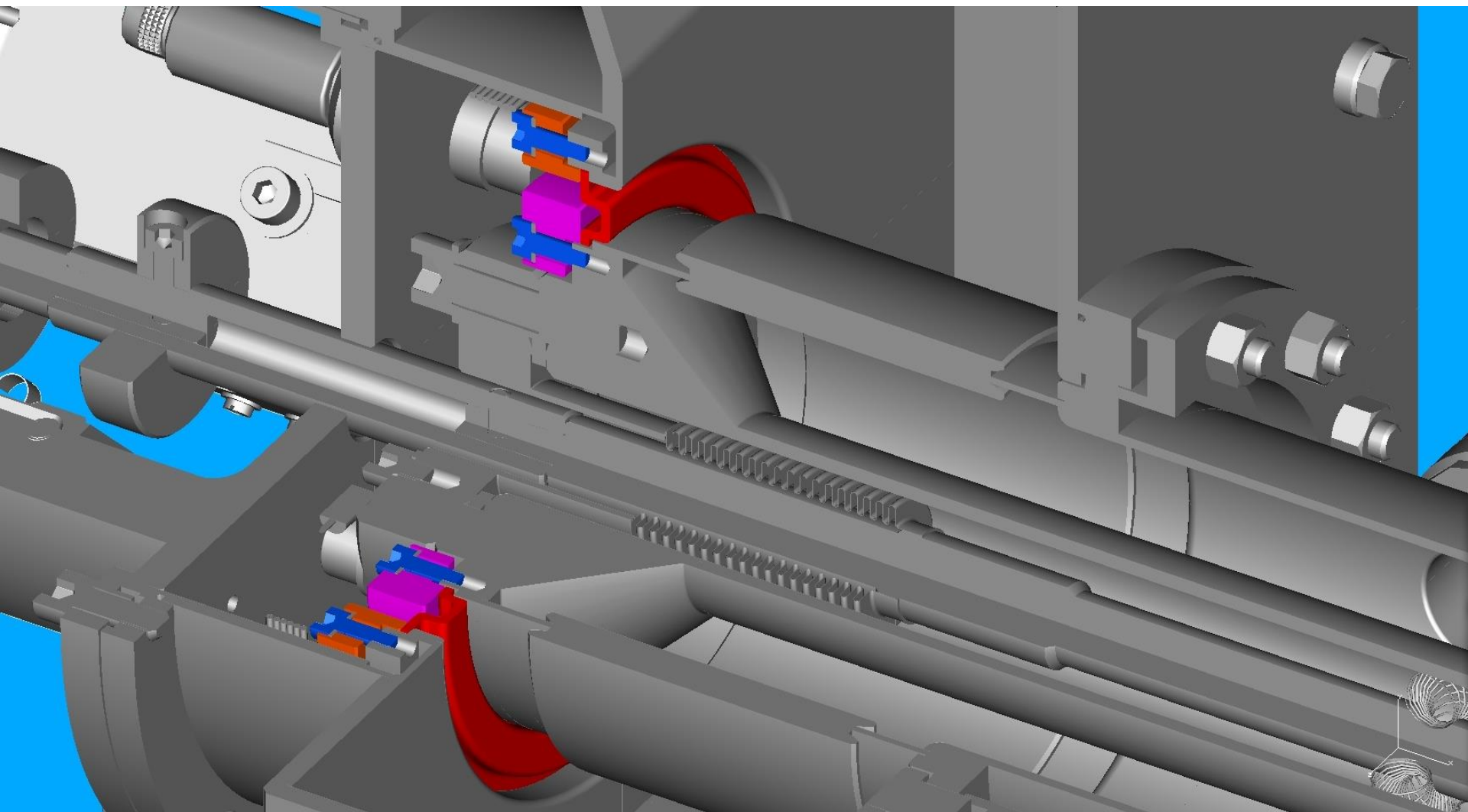
THRI coupler with capacitor



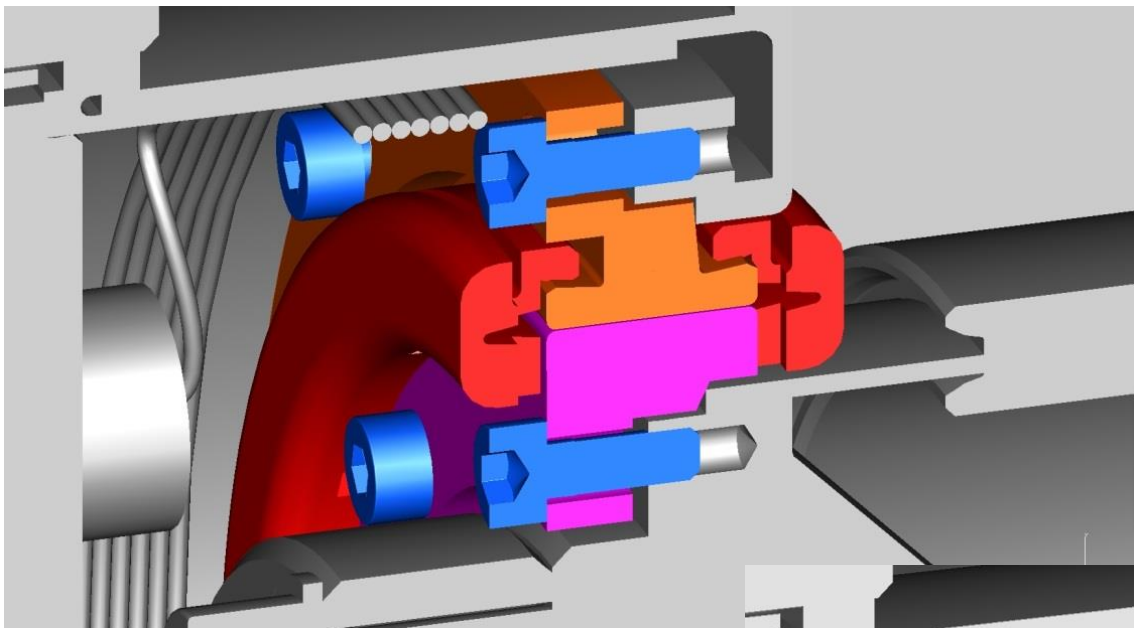
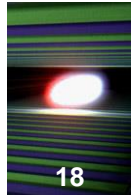
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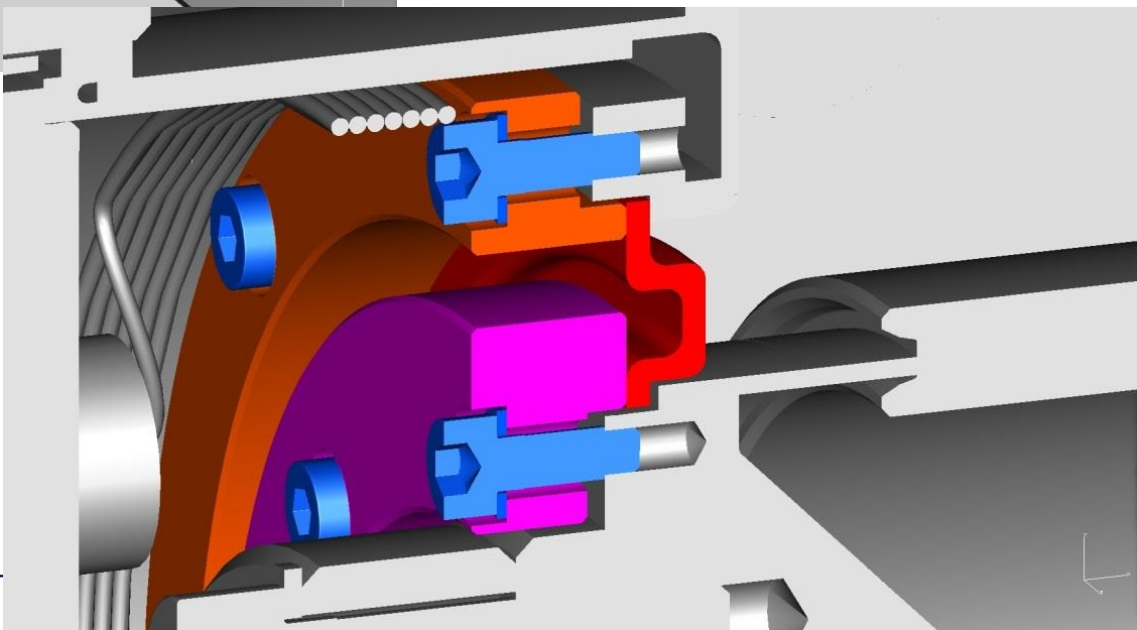
THRI coupler with coax gasket



Replacement Installation



Comparison



Capacitor replacement

