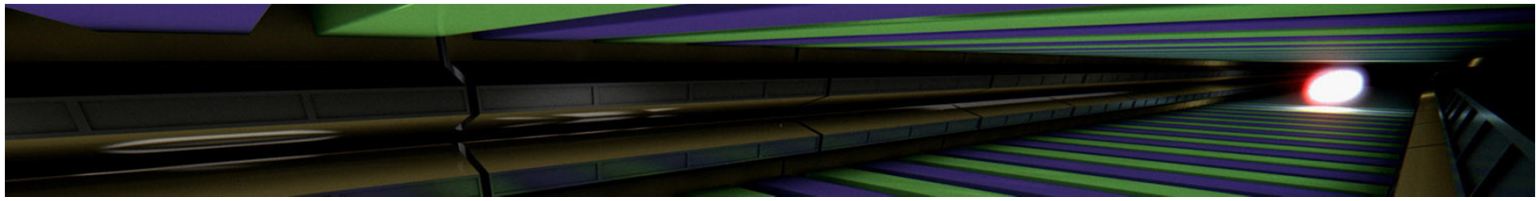
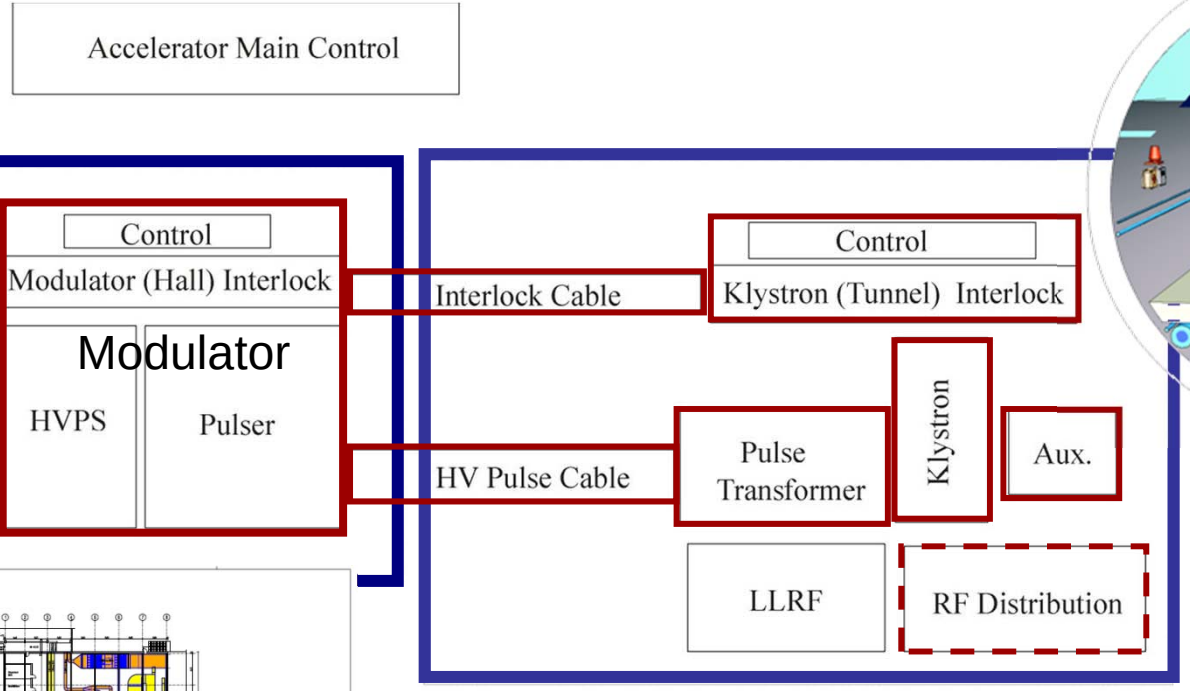


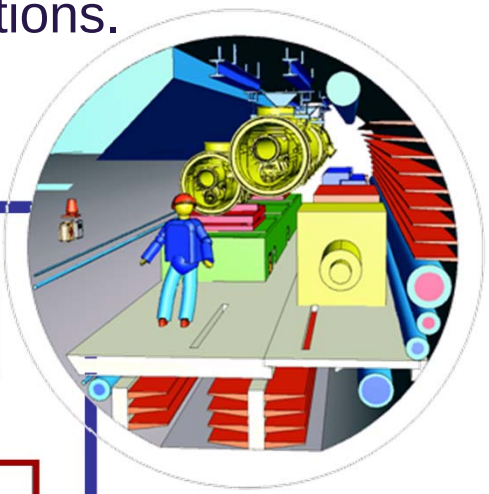
Status RF System - WP1

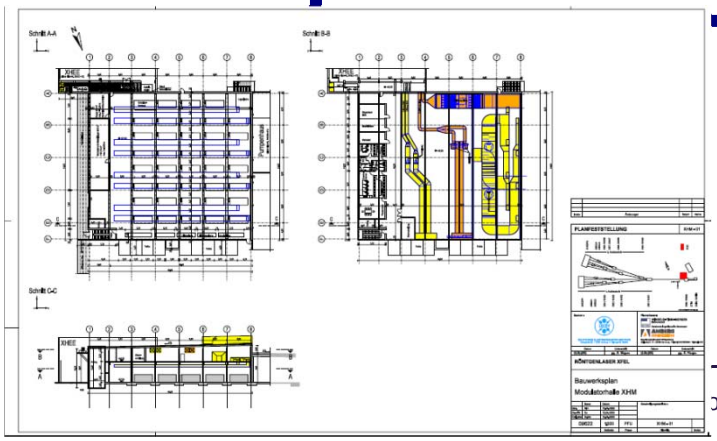
Presented by: Stefan Choroba (DESY / WPL1)

RF System Overview

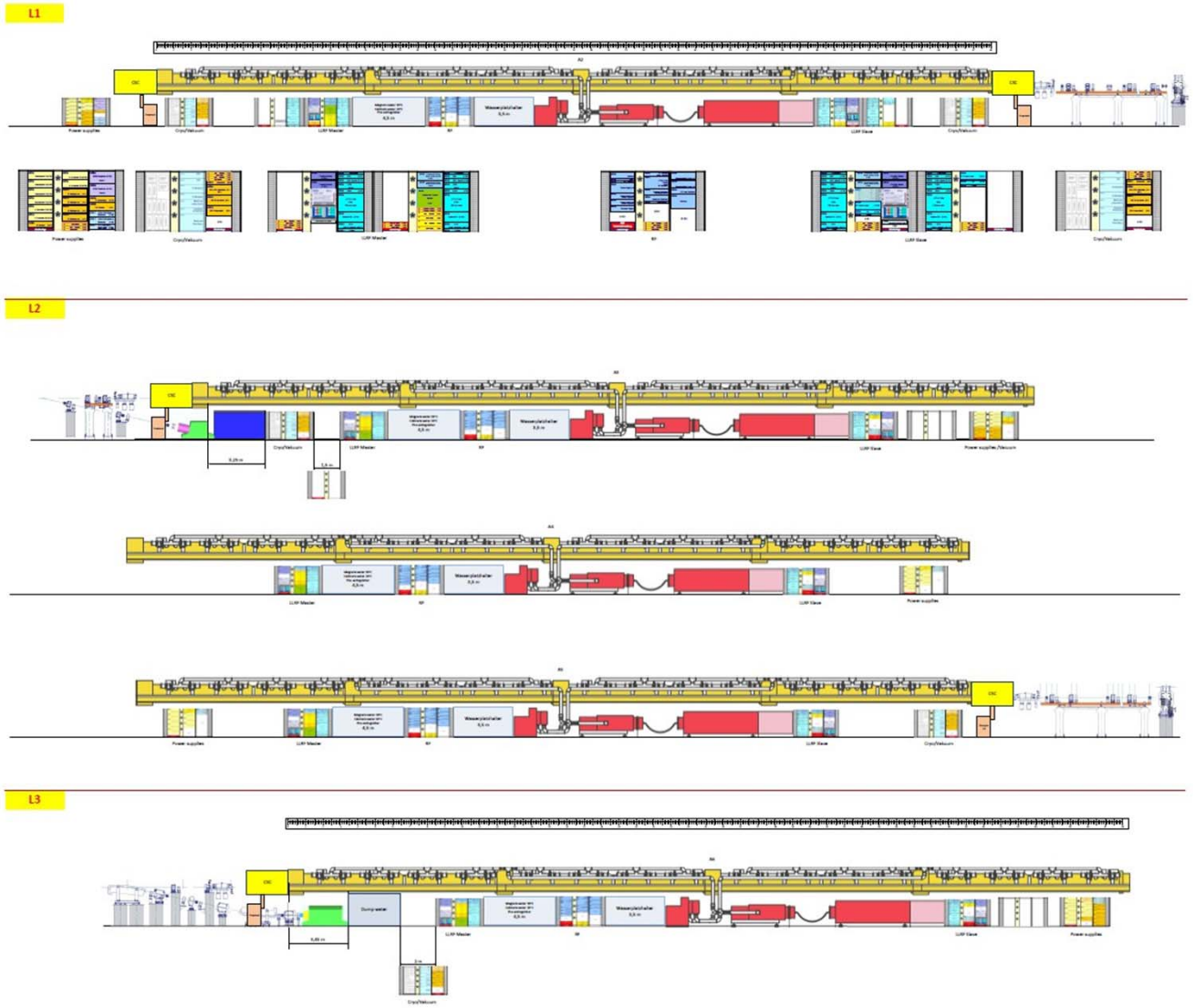
- The RF System converts AC line power to pulsed RF power and distrubutes it to the superconducting cavities of the XFEL main linac, injector and the RF gun. It consists of a number of RF stations.





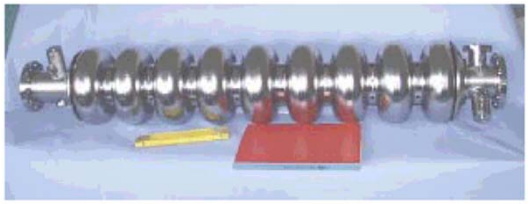


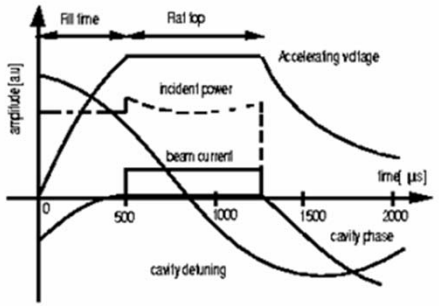
Main linac RF stations



RF System Requirements

- Number of sc cavities: 808 total for 17.5GeV
- Power per cavity: 122 kW
- Gradient at 17.5GeV: 23.6 MV/m
- Power per 32 cavities (4 accelerator modules): 3.9MW
- Power per RF station: **5.2MW** (including 10% losses in waveguides and circulators and a regulation reserve of 15%)
- Number of RF stations: **25** active **23**
- Number of RF stations for injector (1RF gun+1module): **2**
- Macro beam pulse duration: 650μs
- RF pulse duration: **1.38ms**
- Repetition rate: **10Hz (30Hz)**
- Average RF power per station: **72kW (150kW)**





Klystrons

Requirements

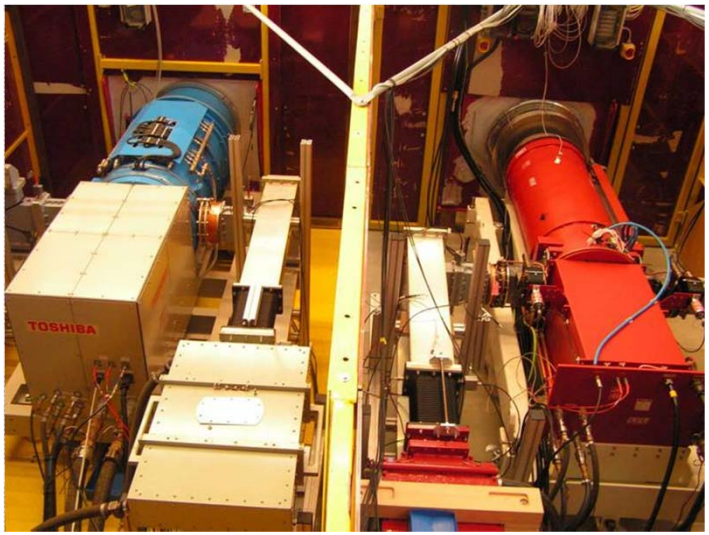
- Operation Frequency: 1.3GHz
- Cathode Voltage: < 120 kV
- Beam Current: < 140 A
- Max. RF Peak Power: 10MW
- RF Pulse Duration: 1.5ms
- Repetition Rate: 10Hz
- RF Average Power: 150kW
- Efficiency: 63%
- Solenoid Power: < 5.5kW
- Length: 2.5m

Thales TH1801

Multibeam Klystrons (MBK) have been chosen. Three vendors have developed and manufactured MBKs, meeting these requirements.

Horizontal MBKs

- Since vertical MBKs would not fit in the XFEL tunnel horizontal version have been developed.
- All three vendors of MBKs have developed and manufactured horizontal versions of their MBK.
- These klystrons have been successfully tested at the klystron test facility at DESY.



Horizontal multibeam klystron prototypes at the klystron test facility (KTF)

Klystron procurement

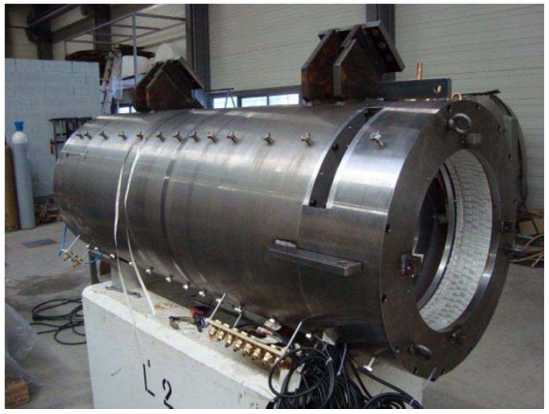
- After a CFT contracts have been awarded to 2 companies in May 2011
- 22 klystrons from Thales
- 7 klystrons from Toshiba
- Kick off meetings have been held in June 2011
- Both companies have to report each month on the status of production
- The klystrons will be delivered over a period of ca. 2 years (more than 1 klystron per month)
- Each klystron will be tested at the KTF and then stored before installation.

Status Thales

- 22 klystrons between June 2012 and July 2014
- Start delayed by 4 month due to vacuum leak and bad vacuum pumps

Klystron #1 before bake out

Girder for klystron #1



Solenoid for klystron #1

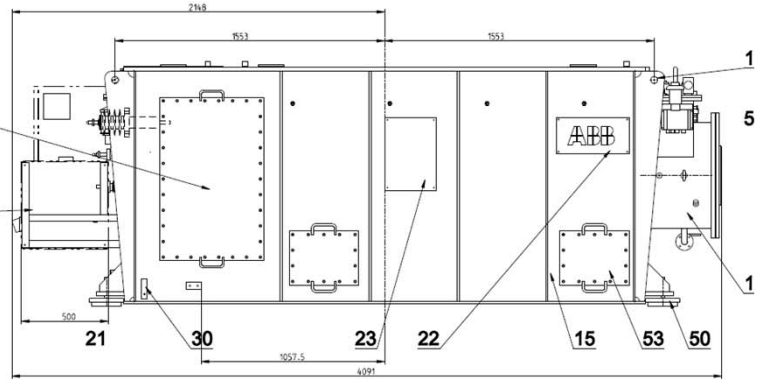
Status Toshiba

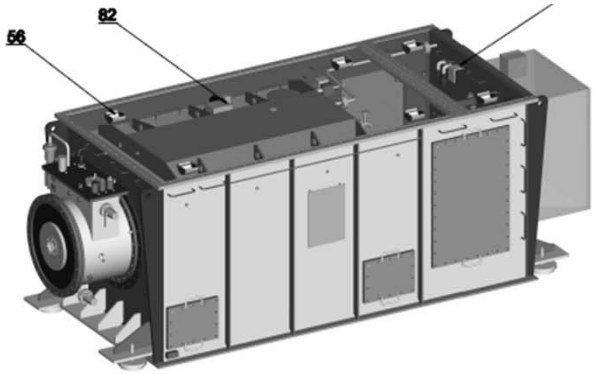
- Delivery of 7 klystrons between June 2012 and March 2013
- Start delayed by 3 month due to broken cathode filament

Solenoids and girder for 7 klystrons at Toshiba factory

Pulse Transformer

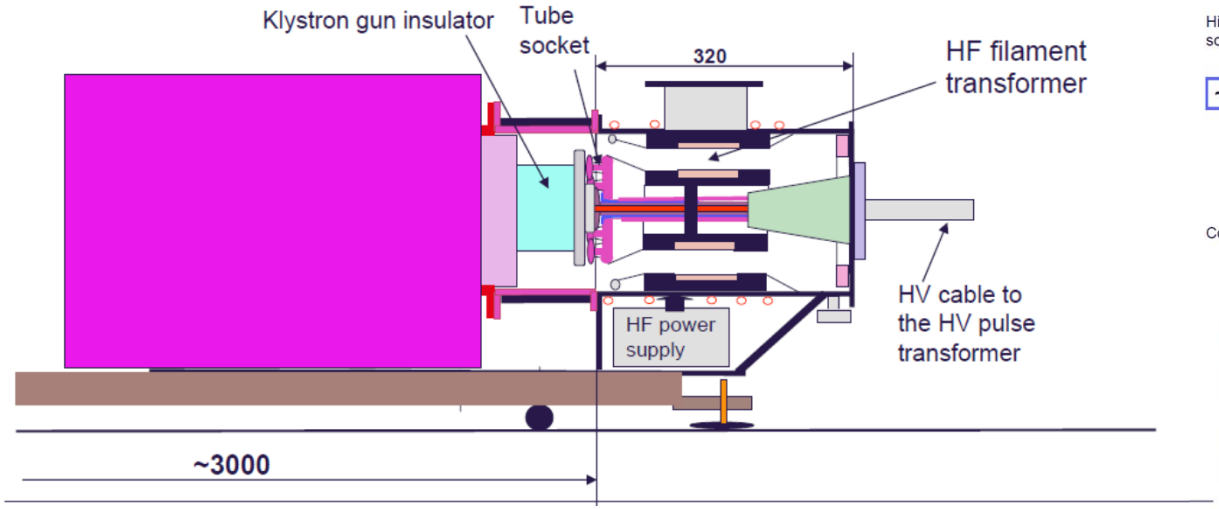
- The pulse transformer transforms the 10kV pulse voltage generated by the modulator to the 120kV required by the klystron.
- After a CFT a contract for 27 pulse transformers has been awarded to ABB (option for 3 more) in Feb. 2012.
- Kick off meeting has been held.
- Pulse transformers will be delivered between Aug. 2012 and Mar. 2014.
- Monthly status reports must be submitted by vendor.
- First three units will be tested at KTF.

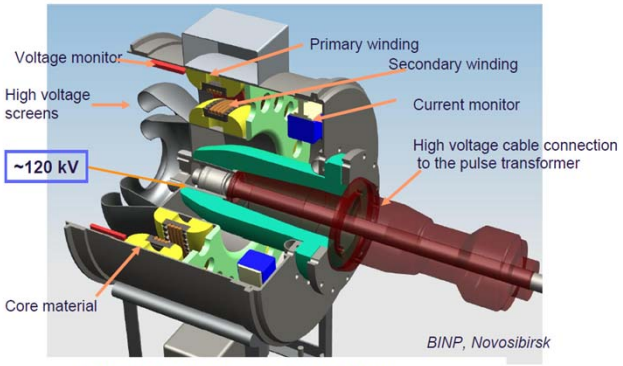




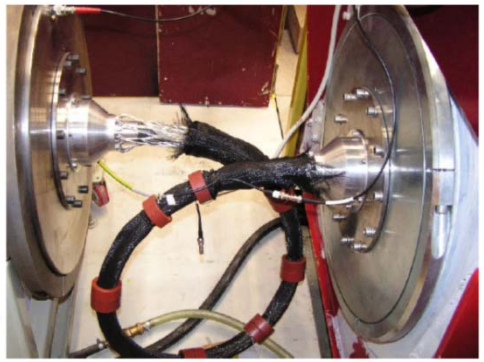
Connection Module

- The connection module allows for simpler connection of pulse transformer and horizontal klystron. Filament transformer, klystron voltage and current monitors are integrated in the module. Connection to pulse transformer will be done by 120kV cable.
- 27 connection modules will be manufactured by BINP Novosibirsk and delivered to DESY between June 2012 and March 2014.





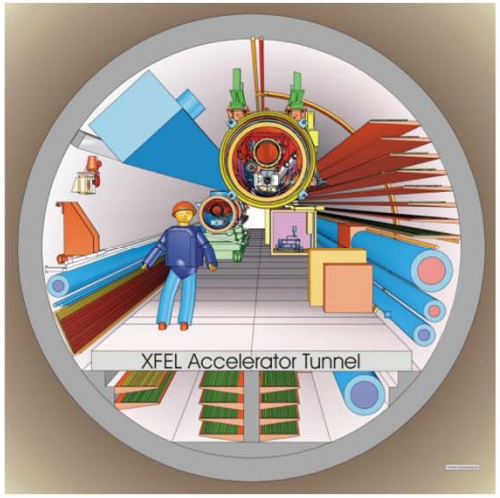
HV cable length 1.5 m, double shielded

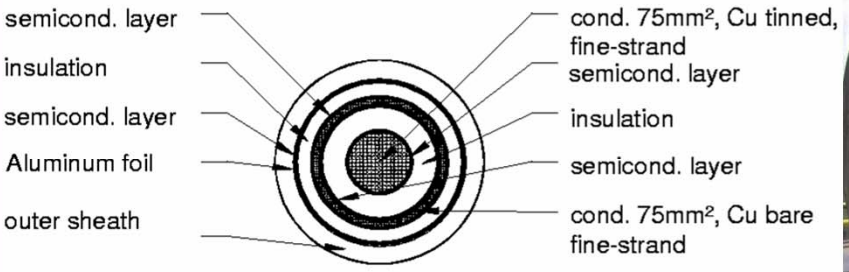


HV cable #2, leakage current ~ 50mA

Pulse Cable

- The pulse cables transmit 10kV/1.6kA pulses from the modulator in XHM to the pulse transformer in XTL. 4 cables in parallel (28Ohms each) per RF station.
- Prototypes have been tested succesfully at FLASH.
- After a CFT a contract for pulse cables has been awarded.
- Delivery of cables between July 2012 and Nov. 2012.
- CFT for pulse cable installation published.
- Matching Network (to be installed at the end of the cables in the transformer tank) under preparation.





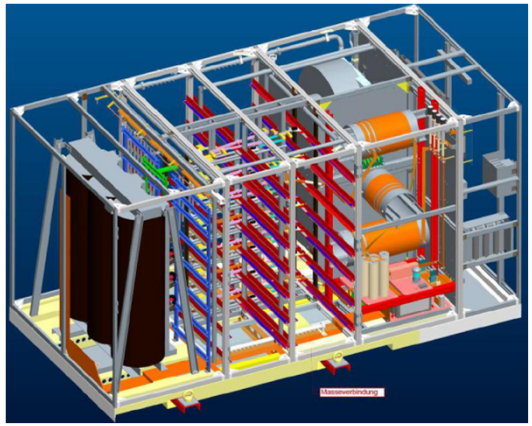
Modulators

- Modulators must generate HV pulses up to 10kV (=>120kV after Pulse transformer) and 1.6kA (=> 140A after pulse transformer), 1.57ms pulse length and 10Hz (30Hz) repetition rate.
- 2 Vendors have been qualified.

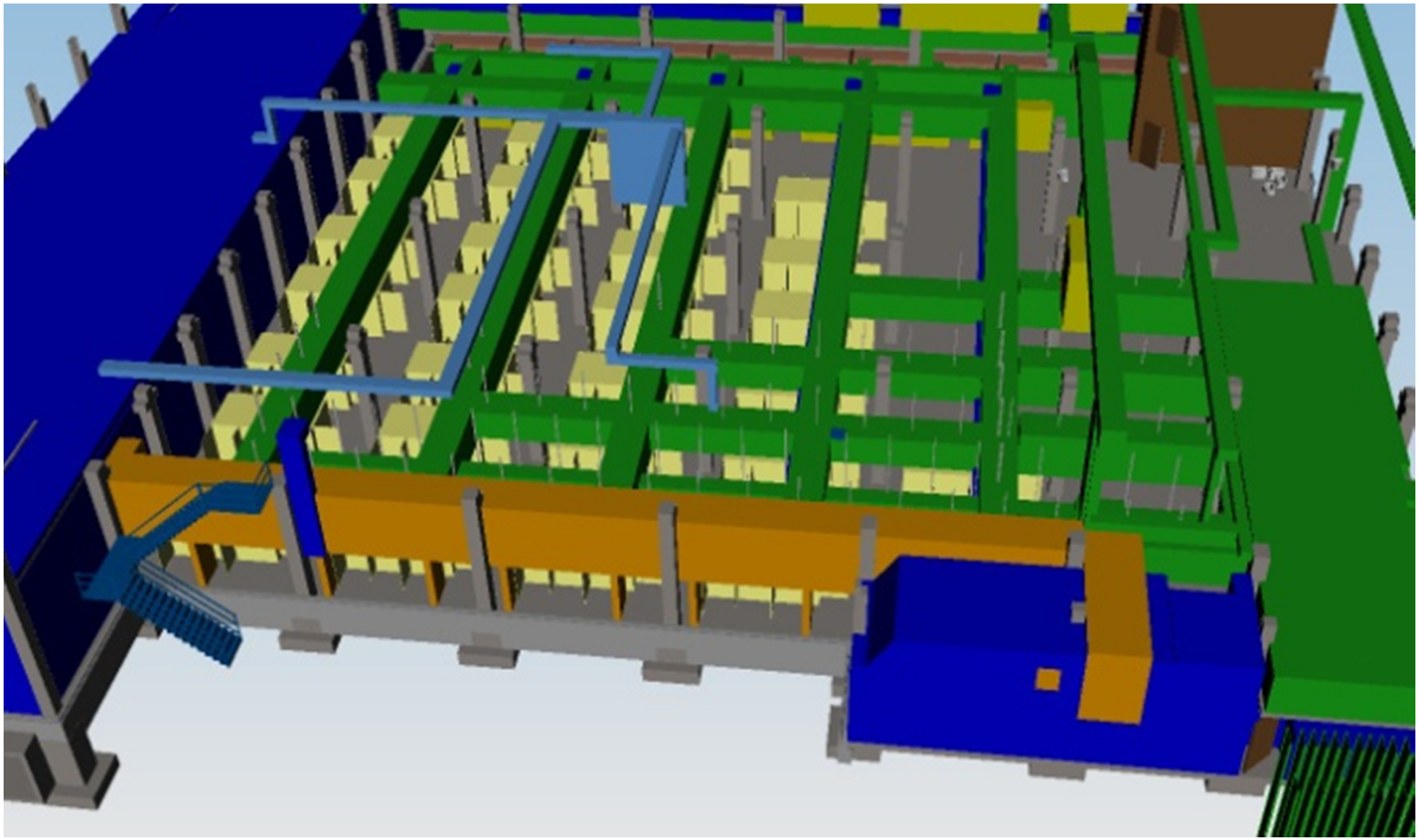
- One vendor constructed a modulator based on the bouncer principle. More than 17 modulators were built and most of them are in operation at FLASH and at test stands since several years.
- One vendor constructed a pulse step modulator. It has been succesfully tested at the MTF at Zeuthen. Operation time more than 5000h. Reliable operation.

PSM

- After CFT the Pulse Step Modulator by Thomson has been selected.
- 22 modulators were ordered in July 2011 (plus option for 5 more).
- Kick off meeting July 2011.
- Delivery time between Sep. 2012 and Dec. 2013 for 22 pieces (May 2014 for 27 pieces if option drawn before end 2012).
- Monthly status reports by Thomson.
- At present no delay.
- Site acceptance test in XHM.



XHM



Aux. PS and Racks

- Off the shelves PS will be used for the klystron solenoid, filament, vacuum pumps and pulse transformer core bias.
- CFT for Aux. PS under preparation.
- A semiconductor preamplifier will be used for amplification of the LLRF signals up to the klystron input level.
- RF Interlock protects and controls the RF station.
- Components will be installed in shielded racks in the tunnel. Racks will be ordered by TC.

Rack Layout

		Rack #1		Rack #2	Rack #3
mm	HE			Beispiel : Rittal 28HE = 1244,6mm	
1244,6	28	Platz f. Löschanlage		Platz f. Löschanlage	Platz f. Löschanlage
1200,2	27			Löschanlage/Elektronik	N - Patchfeld
1155,7	26	Vacuum		IT Patchfeld RJ45 12x	N - Patchfeld
1111,3	25				
1066,8	24	Bias Supply			Phaseshifter Crate #1
1022,4	23			uTCA Crate	
977,9	22	Filament Supply	AIRCOOLING UNIT	Timing, ADCs,	
933,45	21			RF Detektor	Phaseshifter Crate #2
889	20				
844,55	19	Öl Pump.Steuer. PT		Thomson Modulator	
800,1	18			Measuring System	
755,65	17			YAUI	WG preasure & compressor control unit ??
711,2	16	Focus Supply #1			
666,75	15	Thoshiba / Thales		Interlock (Zeuthen)	
622,3	14	Klystron			PreAmp
577,85	13			Distribution	
533,4	12			LWL Distribution	
488,95	11	Focus Supply #2		Platz für Hutschienen	Coupler Processing
444,5	10	Thales Klystron		24V Supply, Signal-	Interlock Module/CPIM
400,05	9			Umsetzung	MSK
355,6	8				
311,15	7				
266,7	6				
222,25	5				
177,8	4				
133,35	3				
88,9	2			LWL Splicebox /	
44,45	1			Patchfeld	

Rack #3
= 1244,6mm
Platz f. Löschanlage
N - Patchfeld
N - Patchfeld
WG preasure & compressor control unit ??
PreAmp

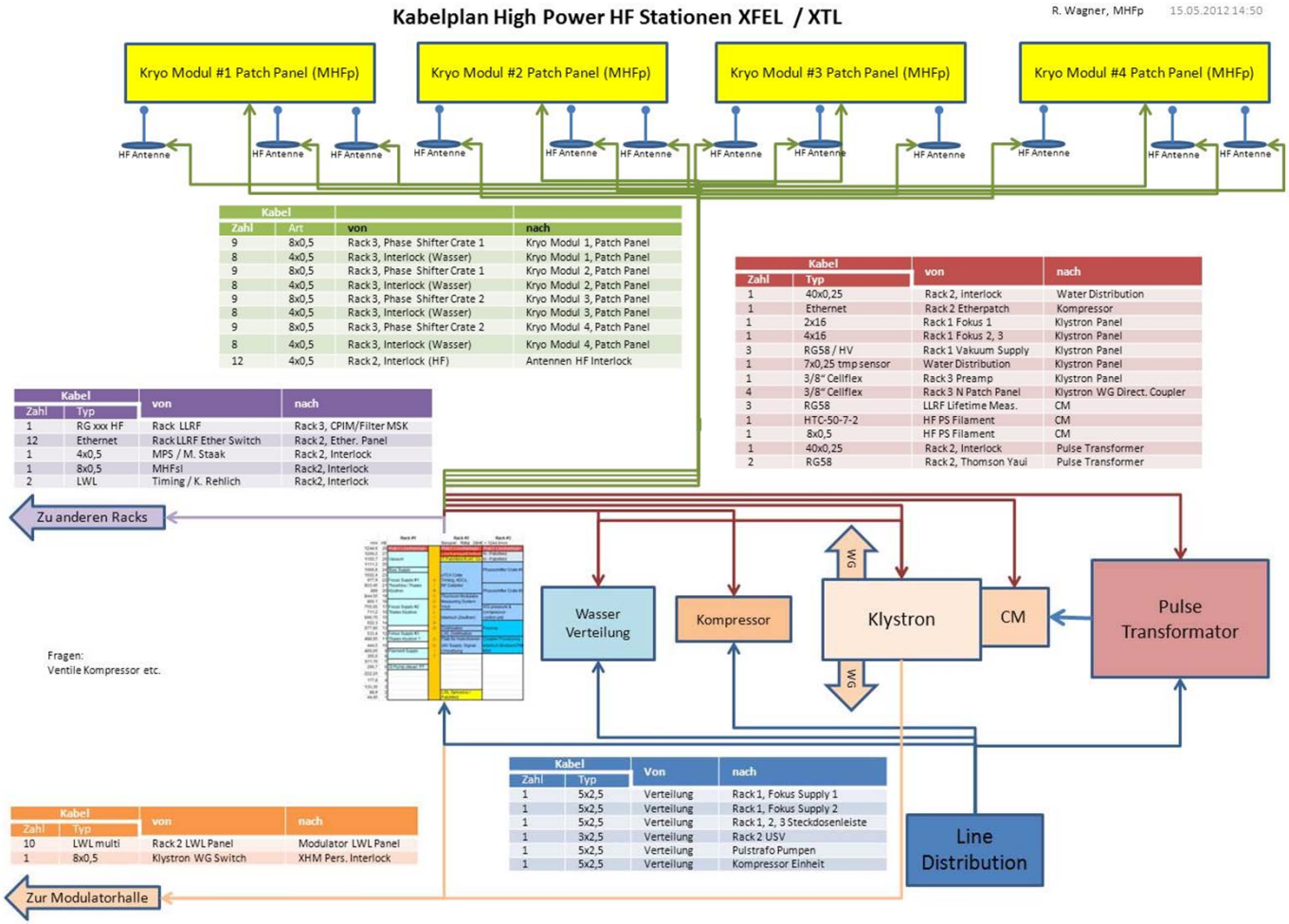
- Modified Rack #3
- Injector/GUN

Rack #3
= 1244,6mm
Platz f. Löschanlage
N - Patchfeld
N - Patchfeld
Phaseshifter Crate #1
WG preasure & compressor control unit ??
PreAmp
Coupler Processing Interlock Module/CPIM MSK

- Modified Rack #3
- Injector / 1. Kryo Module

- Rack Module containing the Racks #1, #2, #3 for the XTL RF Stations

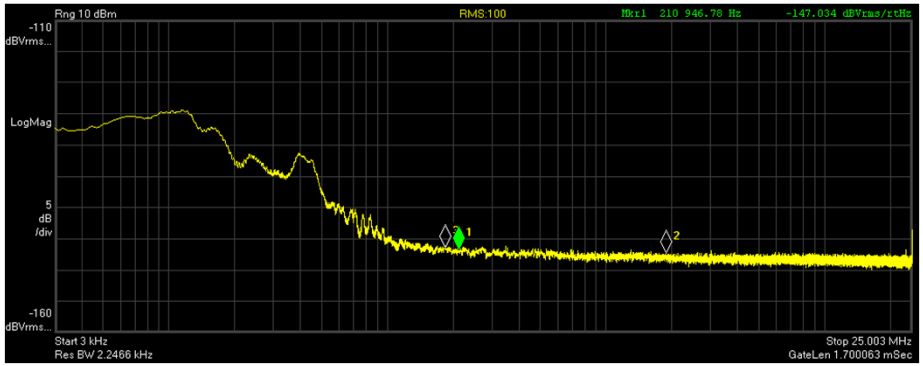
Cabling e.g. XTL RF station

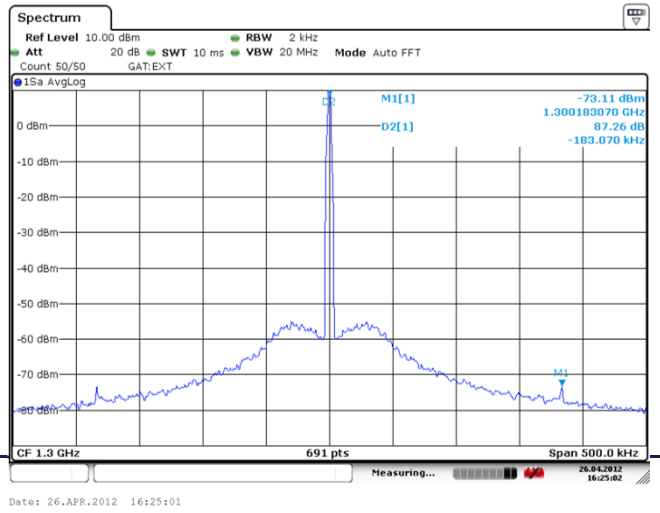


- Planning for cables ongoing

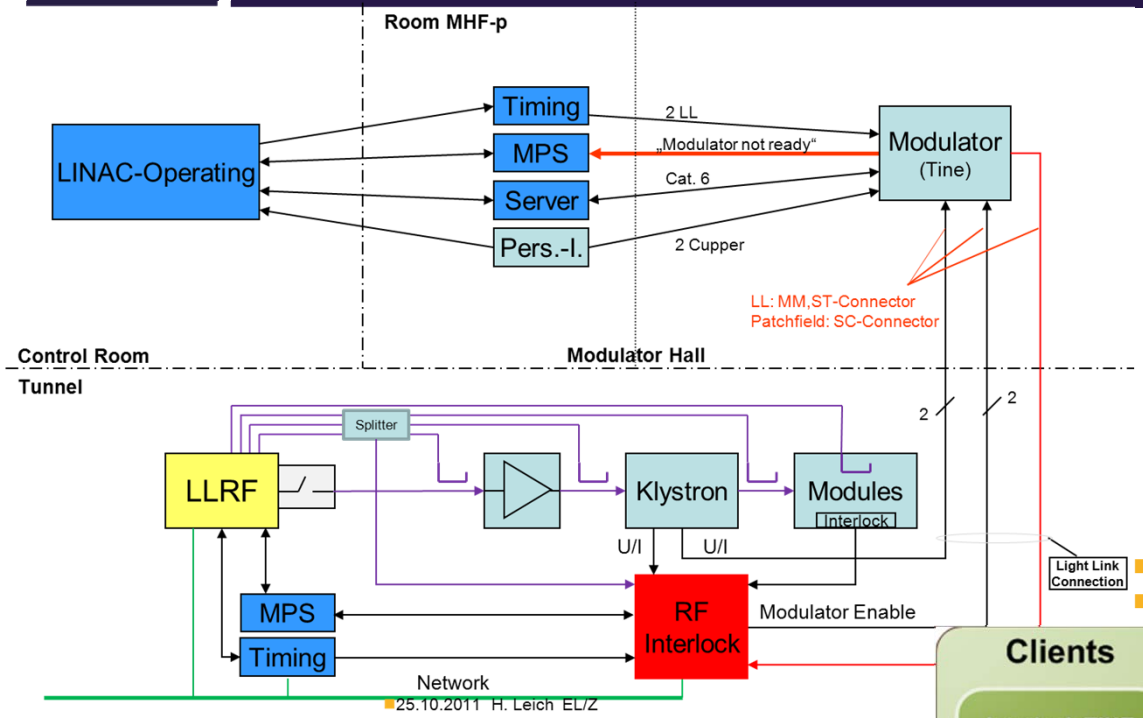
Preamplifier

- A semiconductor preamplifier will be used for amplification of the LLRF signals up to the klystron input level.
- Output power max. 400W at 1.3GHz.
- 22 preampfiers have been ordered (plus option for 5 or 8 more).
- First 4 preampliers have been delivered.
- At present acceptance test at Bruker and DESY.

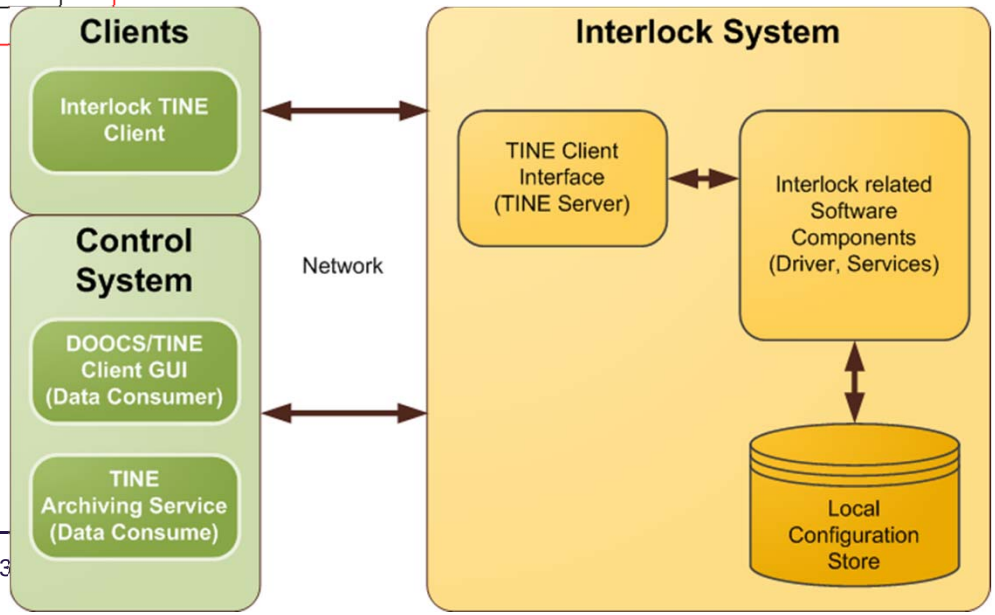




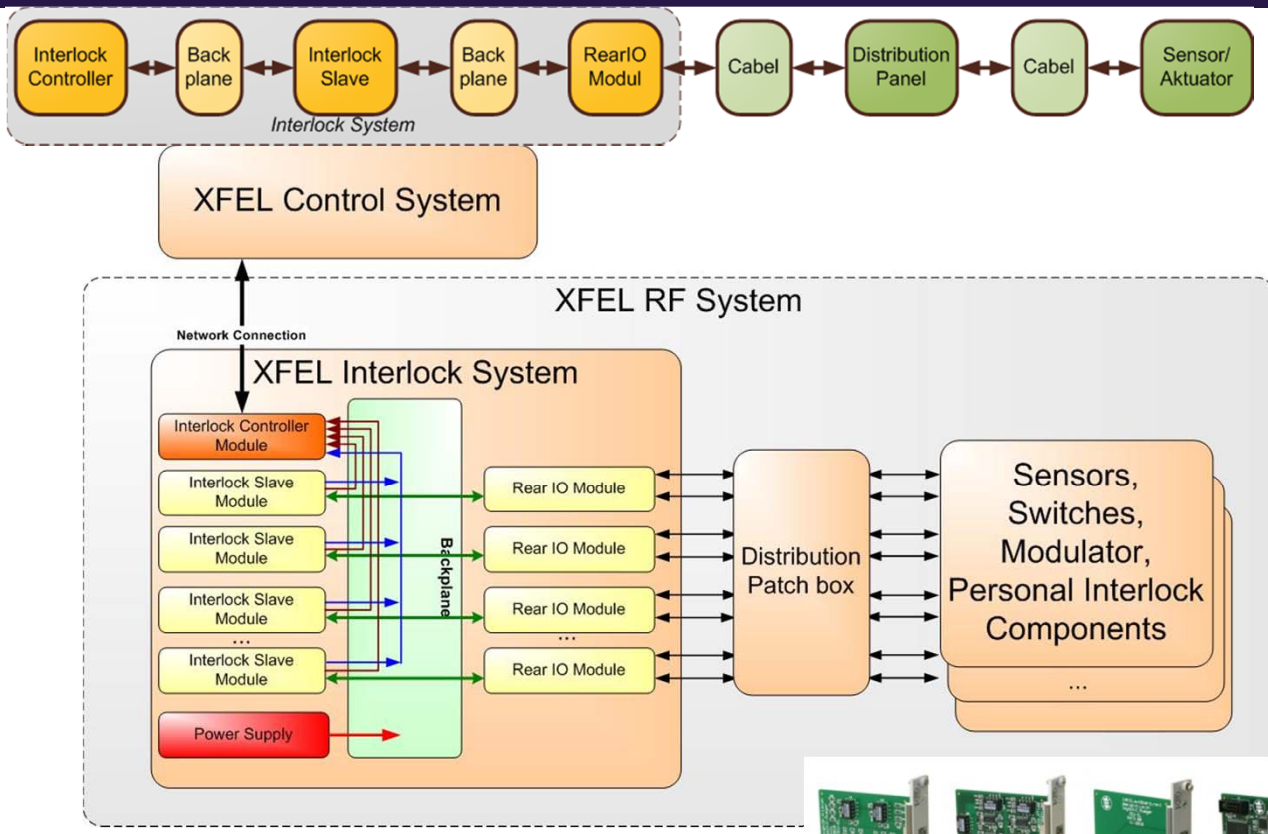
RF Interlock

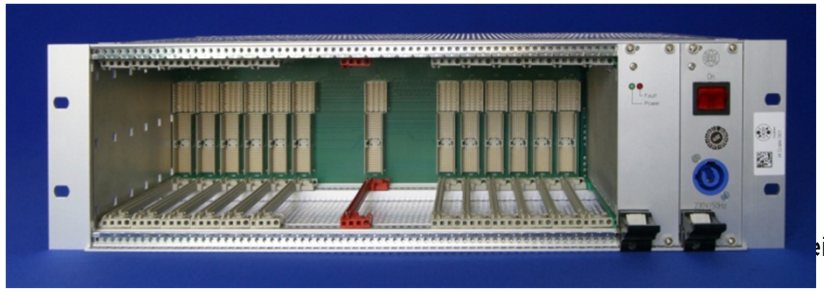


- TINE Server sends data to the control system and interested clients
- Interlock Software does not depend on network services



RF Interlock Hardware



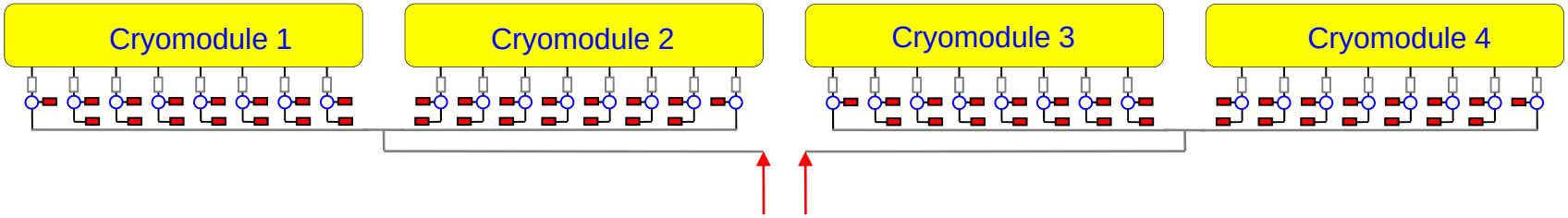


XFEL RF Interlock

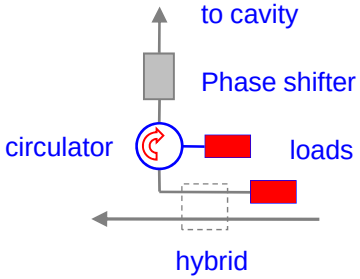
- Modulator interlock is integral part of the modulator
- RF interlock is a DESY Zeuthen/HH development
- Both parts are connected by glass fibers
- FPGA based
- Predecessors in use at PITZ and FLASH
- The interlock will be installed in shielded racks in the accelerator tunnel
- RF Interlock will be manufactured and tested in Zeuthen
- Components are being ordered
- First RF Interlocks ready end 2012

Waveguides

- Distribution of klystron output power to the superconducting cavities
- Protection of the klystron from reflected power
- Control of phase
- 2005 TDR: Linear Distribution System, assembly in XTL

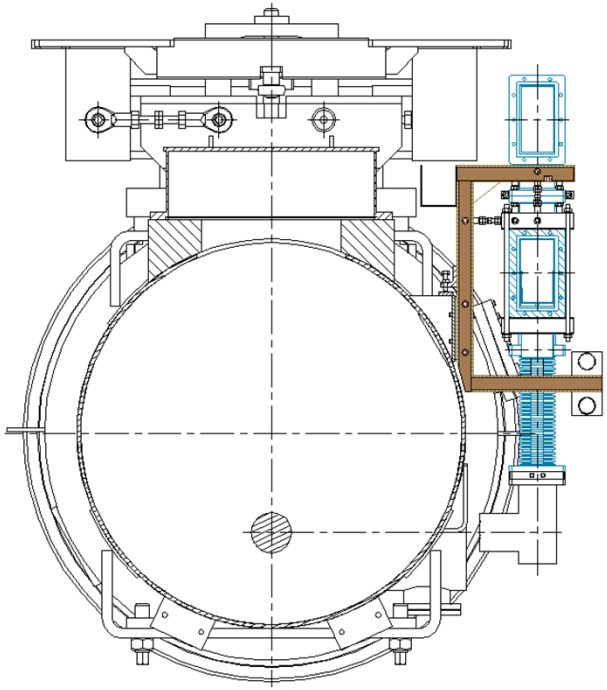


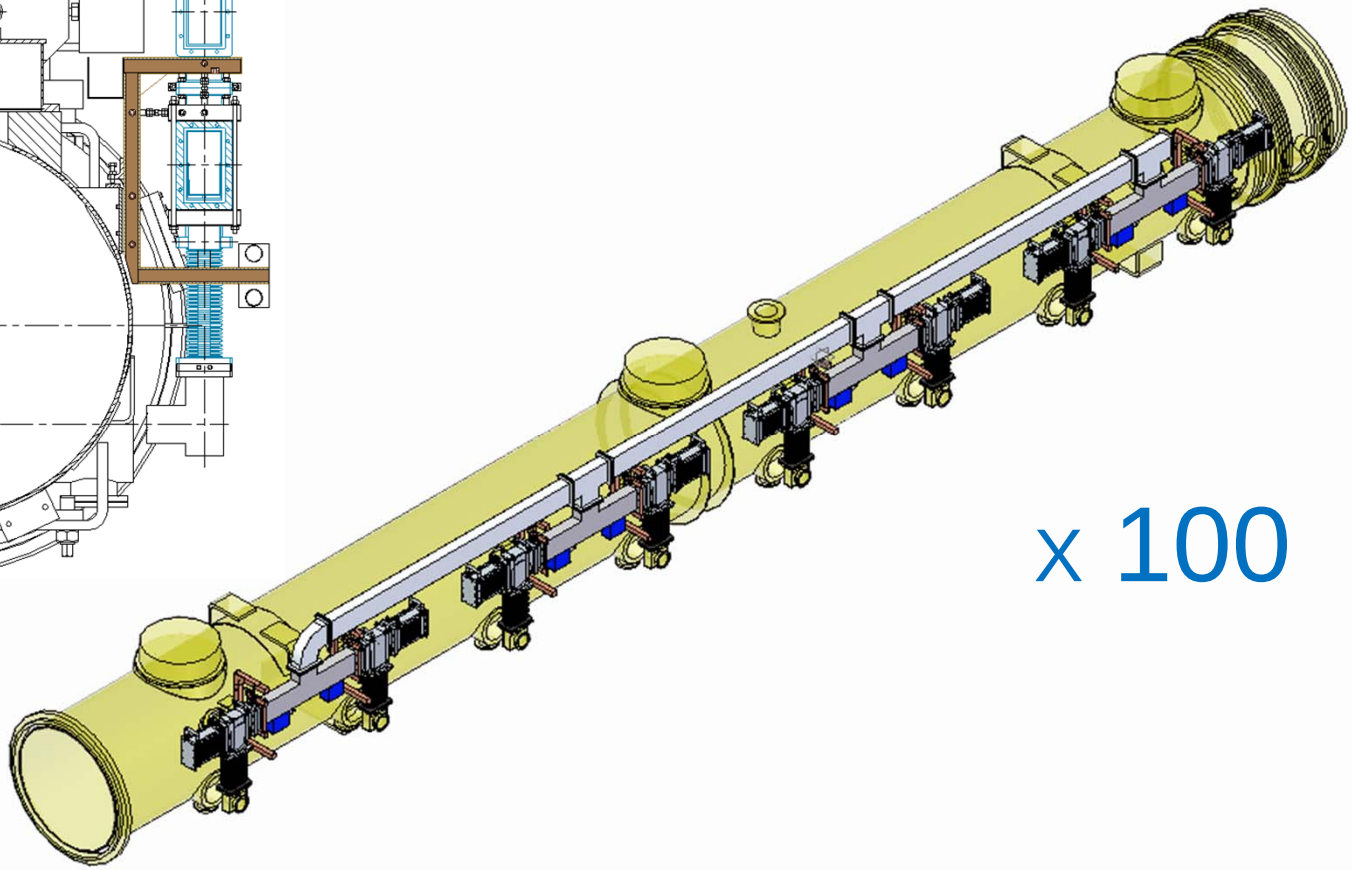
DETAIL



New Waveguide Distribution for Cryomodule

Compact size (2D system)





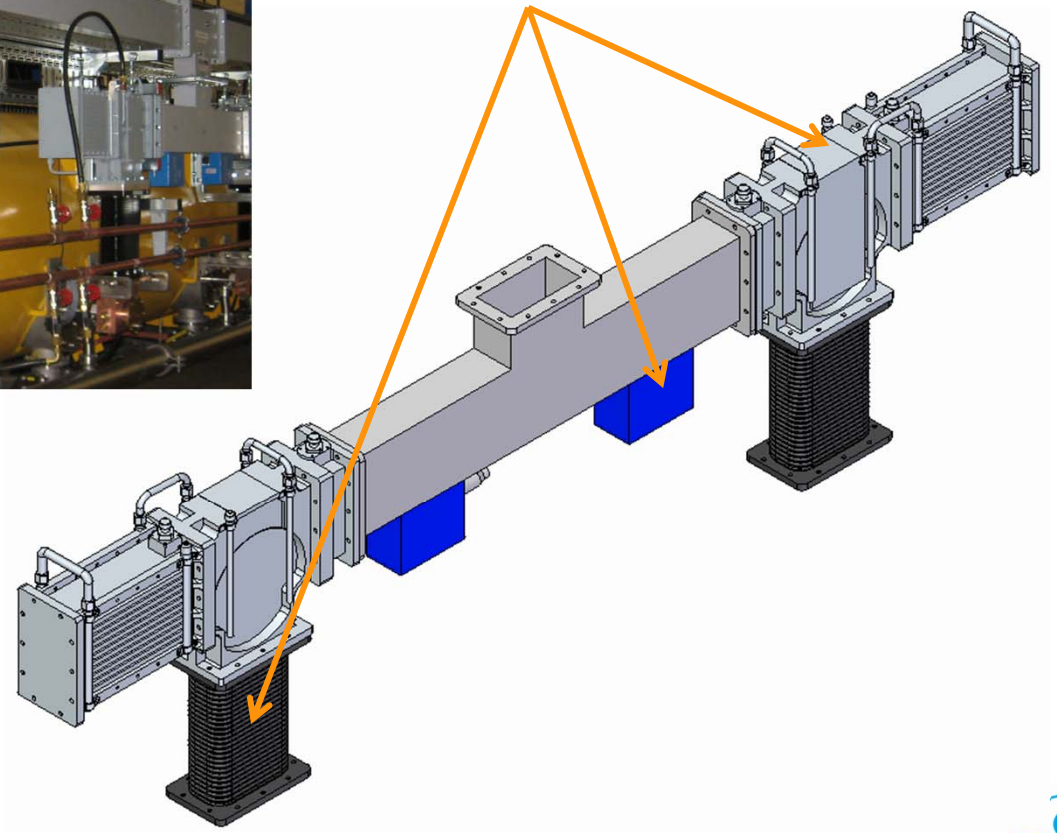
x 100

Example for one Key Waveguide Component

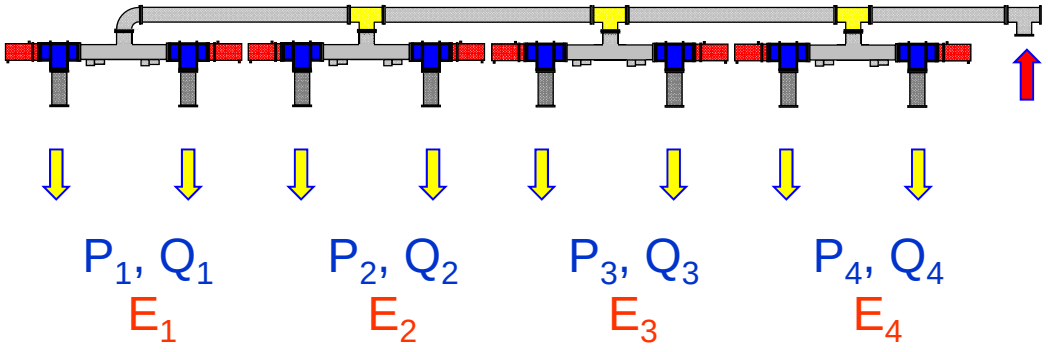
Based on a Binary Cell with integrated controlled phaseshifters and isolators

Binary Cell

Key waveguide component



New waveguide module distribution

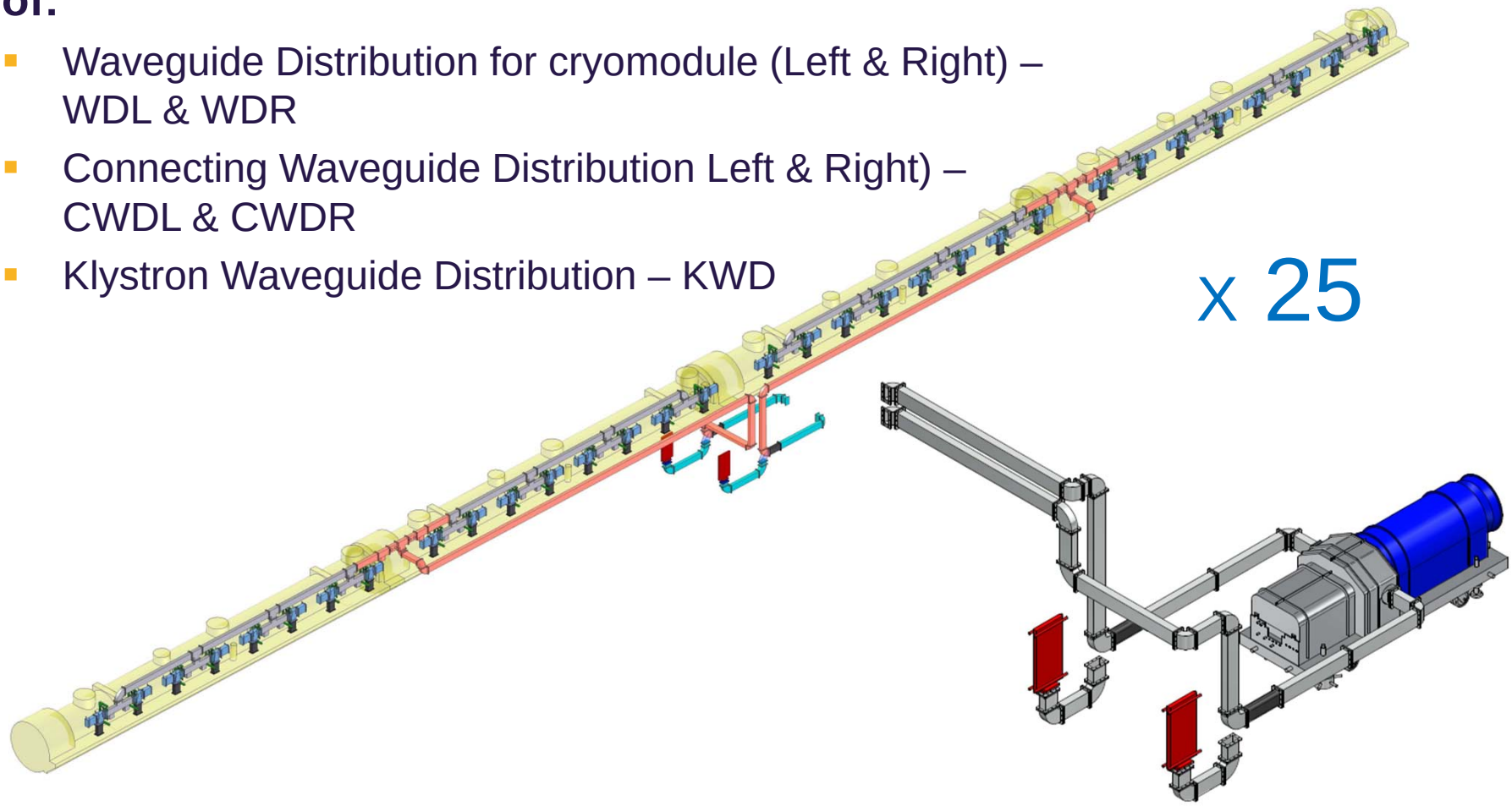


- Combined waveguide distribution as used for FLASH ACC6-7
- Distribution can be tailored for specific modules
- Assembly, test and installation on the module before transport to the tunnel
- Planning for cables ongoing

RF Distribution

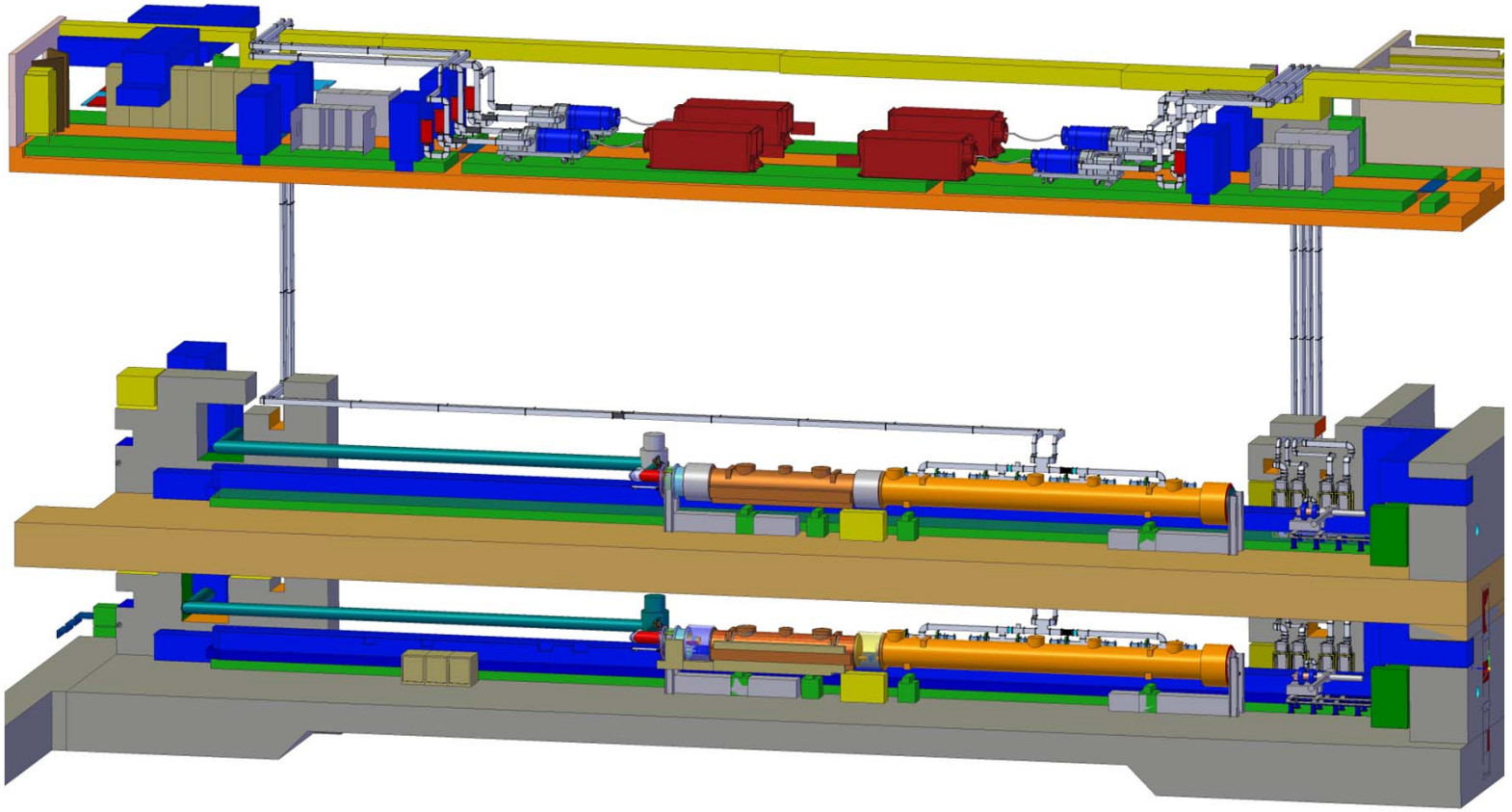
Linac Waveguide Distribution System consists of:

- Waveguide Distribution for cryomodule (Left & Right) – WDL & WDR
- Connecting Waveguide Distribution Left & Right) – CWDL & CWDR
- Klystron Waveguide Distribution – KWD

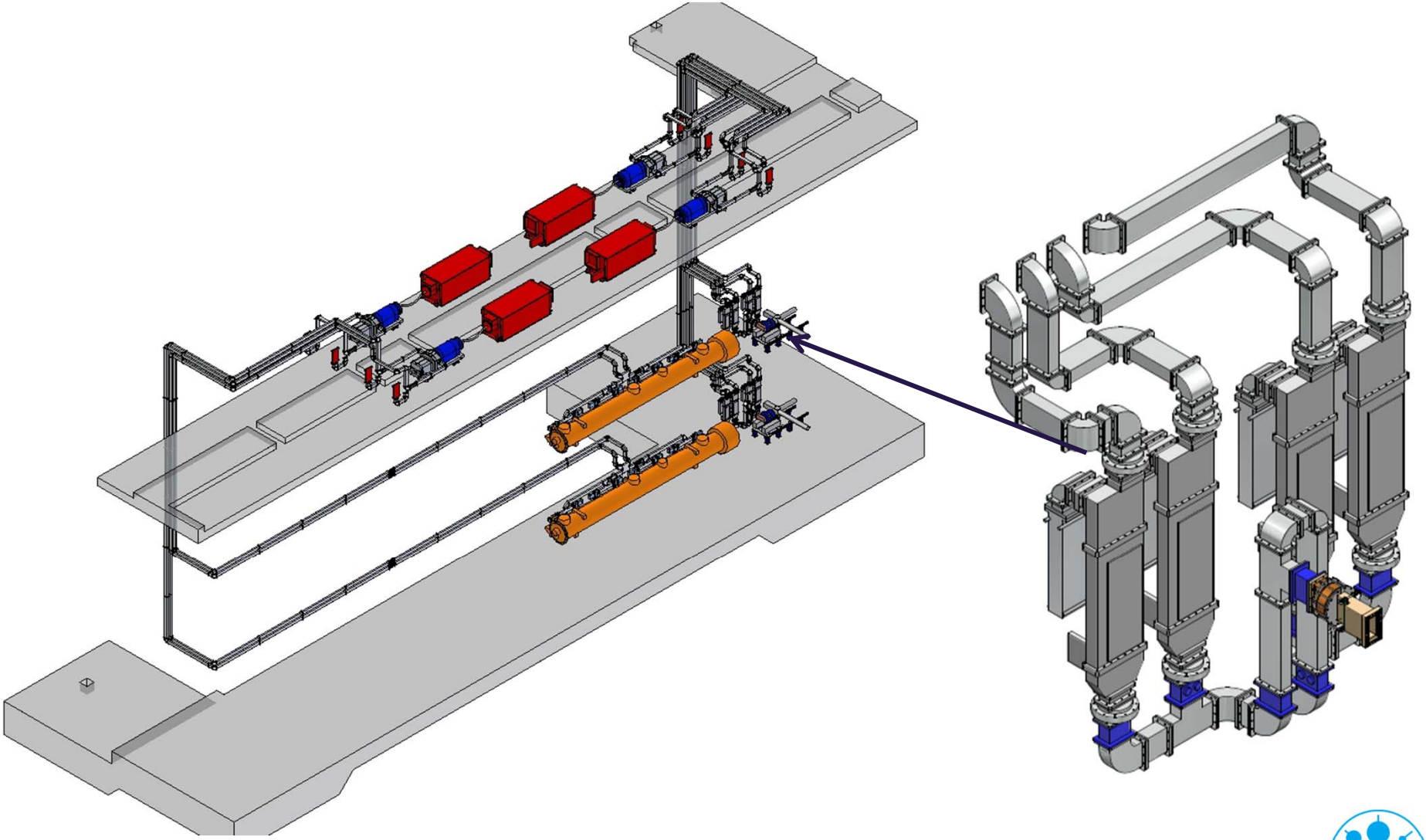


x 25

Injector Waveguide Distribution System

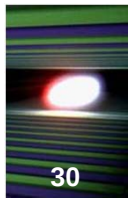


Injector Waveguide Distribution System



European XFEL

List of XFEL Waveguide Distributions



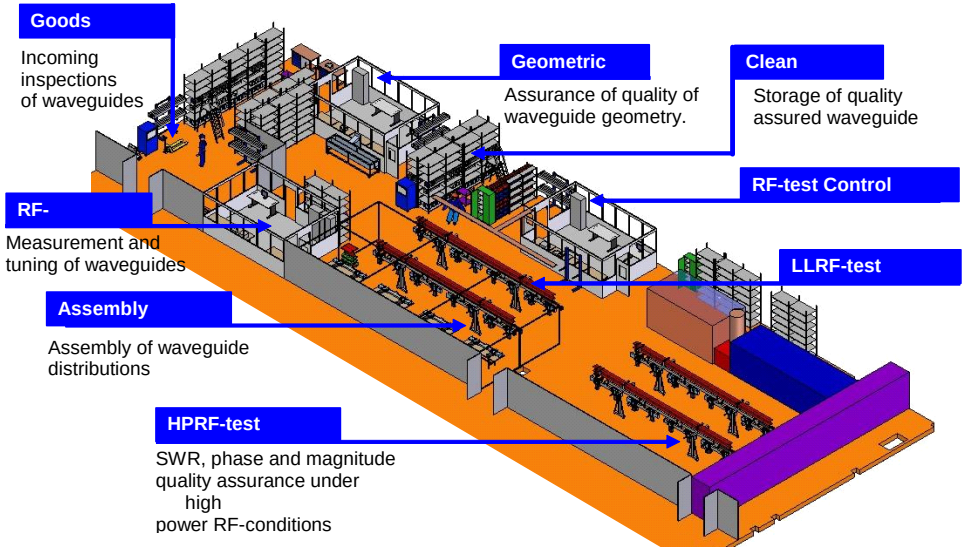
EQUIPMENT CODE	DESCRIPTION	
LWDS	**Linac Waveguide Distribution System**	
WDL	The waveguide distributions for cryomodule-Left (WATF)	**50**
WDR	The waveguide distributions for cryomodule-Right (WATF)	**50**
CWDL	Connecting Waveguide Distribution - Left	**25**
CWDR	Connecting Waveguide Distribution - Right	**25**
KWD	Klystron Waveguide Distribution	**25**
IWDS	**Injector Waveguide Distribution System**	**1**
IGWD7	Gun waveguide distribution at the 7 floor	**1**
IGKW7	Klystron waveguide distribution for Gun at the 7 floor	**1**
IGCW7	Connecting waveguide distribution for Gun at the 7 floor	**1**
ICWD7	Waveguide distribution for the first cryomodule of the injector(7 floor)	**1**
ICKW7	Klystron Waveguide Distribution for Cryomodule at the 7 floor	**1**
ICCW7	Connecting waveguide distribution for Cryomodule at the 7 floor	

Status Wavguides

- PRR December 2011
- Specifications ready, several hundreds of pages
- CFT under preparation at V4, several hundreds of individual waveguide components

Test Facilities

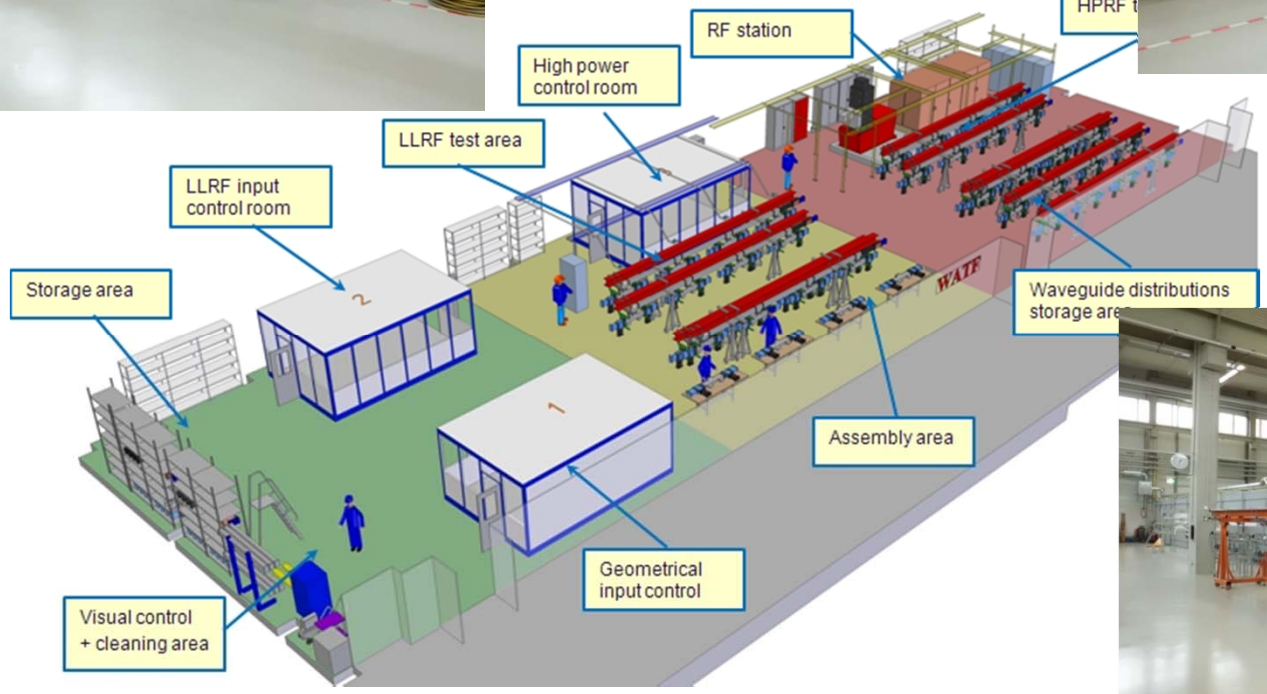
- Three test facilities were planned for test and assembly of RF system components.
- In the Modulator Test Facility (MTF) in Zeuthen prototype modulators have been tested. Series modulators will be tested and installed at XHM.
- In the Klystron Test Facility (KTF) klystrons, pulse transformers and other components will be tested.
- In the Waveguide Assembly and Test Facility (WATF) waveguides will be received, inspected, tested and assembled to distributions. The distributions will be tested at high power.



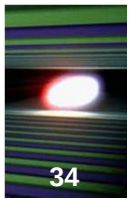
Layout of WATF

European XFEL

WATF



Status of WP01 QM System



Item	Description	Status
QA coordinator	• > 20 QM off-the-job-trainings attended – QM certificates achieved • Adequate qualification of WP01 QA coordinator ensured	
Agreement – Annex 1, Article 5 – Quality Management	Assignment of article 5.1 to DIN EN ISO 9001:2008 – QM system – requirements	
QM methods (according to the state of the art in quality management)	Selection of QM methods in order to satisfy QM system requirements, such as • Control of monitoring and measuring equipment • Complaint management (8D-report) • Audit • Risk analysis • …	
WP01 QM system	Process oriented QM system planned and documented	
WP01 QM system documentation	QM manual, quality plan, QA procedures and QA templates created	
Control of WP01 QM system documentation by EDMS	WP01 QM system documentation uploaded to EDMS	
WP01 QM system	Implementation, maintaining and continual improvement of QM system	
Process-oriented planning of RF system realization	Process map, process descriptions, inspection plans, inspection instructions, work instructions, checklists, inspection records, …	

To be done **In progress** **Completed**

May 2012, Frank Eints, WP01, DESY