XFEL LLRF System installation proposal

&

Requirements to the infrastructure

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MSK Group, DESY

Wojciech Wierba[1]*, Krzysztof Oliwa*[1]

Abstract

This paper presents a current status of proposed LLRF system installation in XFEL Injector Complex and accelerator tunnel. System distribution, cables ducts, racks standard and occupation, AC power and cooling requirements and much more are discussed.

[1] Institute of Nuclear Physics Polish Academy of Sciences, Cracow, Poland

1. Introduction

The European X-ray Free Electron Laser XFEL is a 4th generation synchrotron radiation facility based on the SASE FEL concept and the superconducting TESLA technology for the linear accelerator. This multi-user facility will provide photon beams in a wavelength regime from 0.1nm to 5nm in three FEL beam lines and hard X-rays in two spontaneous radiation beam lines, serving in total 10 experimental stations in the first stage.

One of the major subsystems is the RF control system which stabilizes the accelerating voltage in the superconducting cavities - defined as the vectorsum of up to 32 cavities - within given tolerances of about 0.01% in amplitude and 0.01 deg. in phase. To achieve such a high degree of stability precision RF reference signals must be generated and distributed to the various accelerator subsystems and the user experiments.

The aim of this report is to present the current status of LLRF system installation proposal in Injector Complex and accelerator tunnel (XTL).

2. Installation in XTL – XFEL Tunnel

Installation of LLRF system in XFEL Tunnel is a very challenging task. Space for racks and cabling is extremely limited and need agreement with many other groups placing their equipment in the tunnel.

2.1 Centralized or Distributed LLRF System

There are three main concepts of LLRF system localization in one RF Station (4 CryoModules powered by 1 Klystron) in XFEL Tunnel. First, called "Centralized", will have one set of 3 racks 28 U height placed under last CryoModule of the RF Station. All electronics for one RF Station will be mounted in one place for that design. Second one, called "Distributed", will have four small racks over each CryoModule (there is no space for even small racks under each CryoModule). For that concept, the access to the electronics is quite difficult. The third concept, called "Semi-Distributed", will have two set (container) of racks (3 racks each) placed between CryoModule 1 & 2 and between CryoModule 3 & 4 for each RF Station. It means, that LLRF System will be distributed in two places in two set (containers) of racks – two ATCA or µTCA crates will communicate with two (redundant) Optical Gigabit Ethernet links.

2.1.1 Space in tunnel required for three concepts

The space for electronics racks in XFEL Tunnel is limited. The racks will be placed under CryoModules and can have height of only 28U (~half of standard rack).

The necessary space for "Centralized" and "Semi-Distributed" LLRF System is presented in Fig. 1. In Fig. 2. Proposed placement of "Distributed" system is presented.

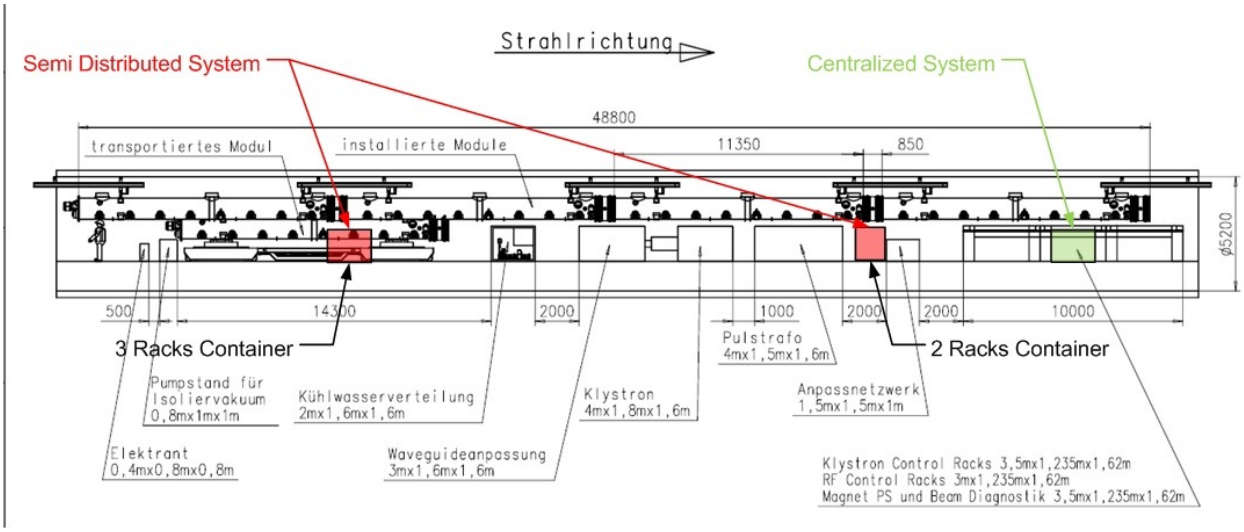


Fig. 1. “Centralized” and “Semi-Distributed” LLRF System placed along one RF Station in XFEL Tunnel.

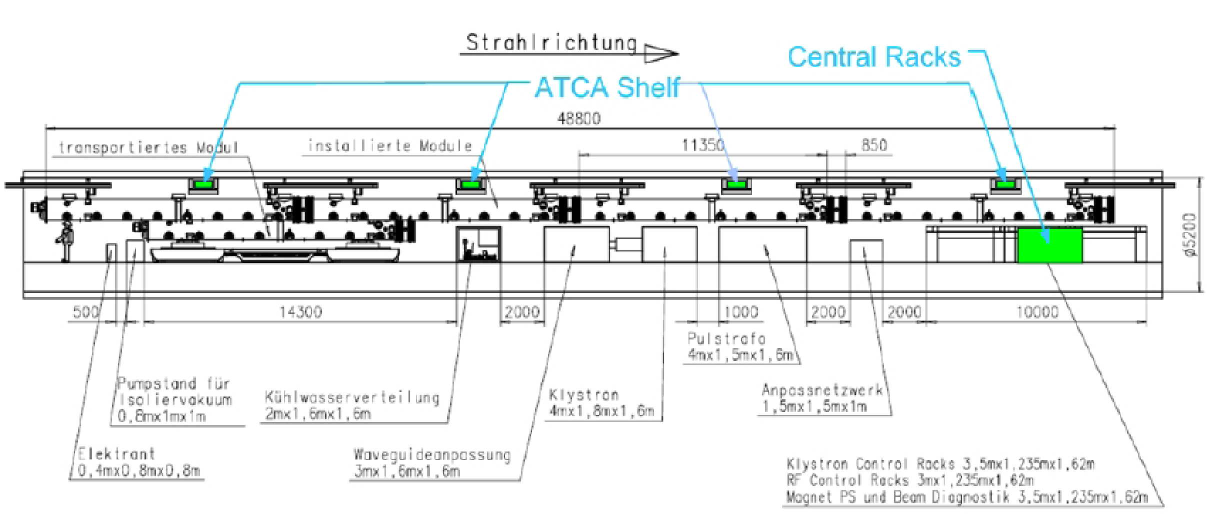


Fig. 2. “Distributed” LLRF System placement over CryoModules of one RF Station in XFEL Tunnel.

The cross section of XFEL Tunnel in Fig. 3. shows the position of LLRF racks for “Centralized” and “Semi-Distributed” concepts and in Fig. 4. for “Distributed” system.

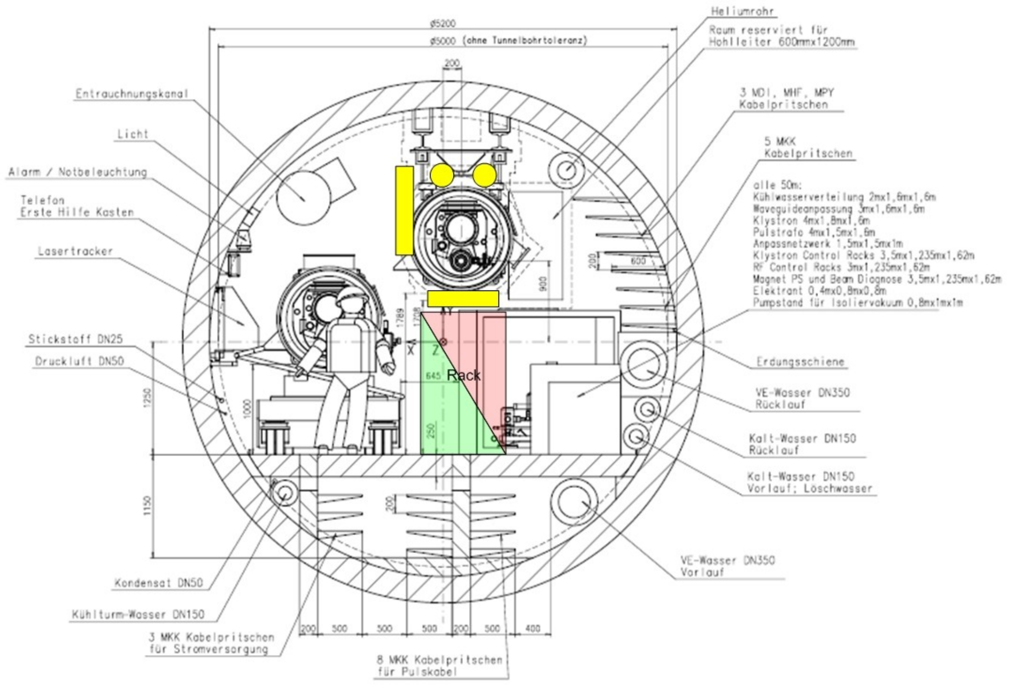


Fig. 3. XFEL Tunnel cross section with space for LLRF racks for “Centralized” and “Semi-Distributed” system.

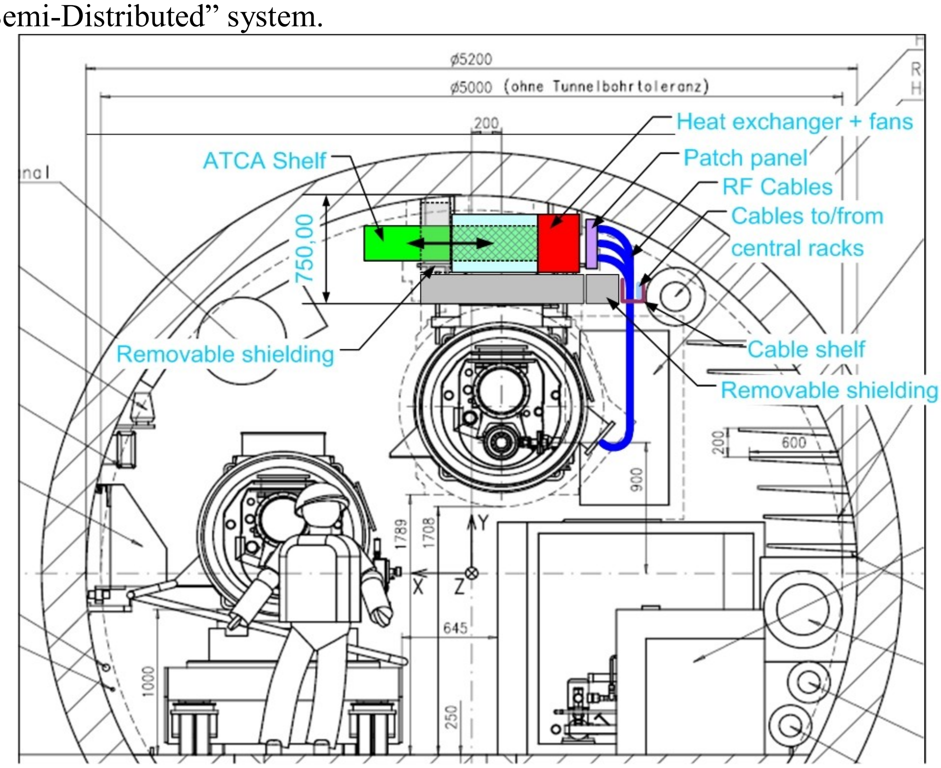


Fig. 4. XFEL Tunnel cross section with space for LLRF racks for “Distributed” system.

2.1.2 Advantage and disadvantage of designs

We have collected pros & cons for three designs in Table 1.

"Centralized"	**"Semi-Distributed"**	**"Distributed"**
Simple clock distribution	Low pickup noise	Low pickup noise
1 (?) ATCA crate per RF Station	Short RF signal cables	Short RF signal cables
Place in XTL reserved – no collisions	Small space for cables needed	Small space for cables needed
1 cooling water connection	Small patch panels	Small patch panels
1 AC power connection	Cabling of CryoModule possible outside XTL	Cabling of CryoModule possible outside XTL
Radiation shielding possible at reasonable costs	Quite simple clock distribution	
Easy access and maintenance	Radiation shielding possible at reasonable costs	
	Easy access and maintenance	
Long RF signal cables (cost)	Duplicated Master Oscillator Distribution system in racks	Complicated clock distribution
Pickup noise	2 ATCA crates per RF Station	Duplicated systems in racks
Space for cable shelves	2 cooling water connections	4 ATCA crates per RF Station
Large patch panels	2 AC power connections	4 cooling water connections
Cabling possible only in tunnel		4 AC power connections
		Radiation shielding difficult and expensive
		Difficult access and maintenance (electronics over CryoModule)

Table 1. Pros & Cons for "Centralized", "Semi-Distributed" and "Distributed" LLRF systems.

After many discussions we have concentrate on comparison between "Centralized" and "Semi-Distributed" systems.

2.1.3 Cost comparison

We have prepared the cost estimation for “Centralized” and “Semi-Distributed” LLRF systems. Most of items are estimated precisely (±10%), some, marked red, are only roughly estimated. The comparison is presented in Table 2.

Centralized System/Station			25 RF Stations		25 RF Stations	Semi-Distributed System/Station			
Quantity	Price	Total/ Station	k Euro	Item	k Euro	Total/ Station	Price	Quantity	Remarks
1	5000,00	5 000	125	3 racks 'container'	125	5 000	5000,00	1	ZPAS
0			0	2 racks 'container'	75	3 000	3000,00	1	estimated
1	100,00	100	3	Cooling water connection	5	200	100,00	2	estimated
1	4190,00	4 190	105	ATCA Shelf 13U (vertical, 14 slots)	210	8 380	4190,00	2	Shroff price
1	774,00	774	19	Spare Shelf Manager	39	1 548	774,00	2	Rittal price
4	3500,00	14 000	350	AMC Carrier Board (TJ)	350	14 000	3500,00	4	estimated*
2	1000,00	2 000	50	Timing Carrier Board	50	2 000	1000,00	2	
1	3550,00	3 550	89	ATCA CPU	89	3 550	3550,00	1	
0	2500,00	0	0	AMC CPU	63	2 500	2500,00	1	
14	2000,00	28 000	700	ADC_AMC	700	28 000	2000,00	14	
2	1000,00	2 000	50	Timing_AMC	100	4 000	1000,00	4	
2	2000,00	4 000	100	VectMod_AMC	100	4 000	2000,00	2	
1	1500,00	1 500	38	Radiation Monitor	75	3 000	1500,00	2	Ask D.Makowski
2	2500,00	5 000	125	PiezoCarrier Borad (contr.+drv.)	125	5 000	2500,00	2	estimated**
1	2400,00	2 400	60	Power Supply 48V	120	4 800	2400,00	2	Wiener price
0	1000,00	0	0	Local Oscillator Box + Peltier	0	0	1000,00	0	estimated
1	1000,00	1 000	25	Drift Callibration Box + Peltier	50	2 000	1000,00	2	estimated
1500	2,30	3 450	86	Cables 1/2"	31	1 242	2,30	540	RFS price
1500	2,00	3 000	75	Cabling	20	810	1,50	540	RFS price/ABB
0	4,25	0	0	Cables 7/8"	0	0	4,25	0	RFS price
0	5,00	0	0	Cabling	0	0	5,00	0	RFS price/ABB
192	11,00	2 112	53	HF Connectors	53	2 112	11,00	192	RFS price
1	5000,00	3 500	88	Container Shielding	175	7 000	3500,00	2	estimated
1	10000,00	10 000	250	Local Oscillator	250	10 000	10000,00	1	KC estimation
850	0,20	170	4	Piezo Cables	1	36	0,20	180	
850	0,50	425	11	Step Motor Cables	11	425	0,50	850	
13	500,00	6 500	163	Downconverters	175	7 000	500,00	14	Getta
4	600,00	2 400	60	RTM-DW	75	3 000	600,00	5	
1	2000,00	2 000	50	Ethernet Switch	100	4 000	2000,00	2	
		107 071	2 677		3 165	126 603			

Table 2. Estimated cost comparison of “Centralized” and “Semi-Distributed” LLRF systems.

It is clearly seen, that "Semi-Distributed" system will be ~20 000 € more expensive per one RF Station, but in estimation we have not included costs of cabling of RF Station in XFEL Tunnel for "Centralized" system, which can be more expensive, needs additional patch panels, connectors and space.

This a proposal from MSK group to focus our work on "Semi-Distributed" system and agreed personally with S. Simrock.

The cost estimation for the SemiDistributed System based on µTCA crate is presented in Table 3.

No.	Item	Quantity per one RF Station	Unit price [€]	1 RF Station	25 RF Stations	Remarks
1	3 racks container	2	10 000	20 000	500 000	
2	uTCA crate	2	4 000	8 000	200 000	
3	LO & distribution	2	6 000	12 000	300 000	
4	ADCM	2	3 000	6 000	150 000	
5	DWC8300 RTM	12	3 000	36 000	900 000	
6	SIS8300 AMC	12	5 000	60 000	1 500 000	
7	Controller AMC	2	5 000	10 000	250 000	
8	VM RTM	1	2 000	2 000	50 000	
9	CPU	2	4 000	8 000	200 000	
10	MCH	2	4 000	8 000	200 000	
11	Interlock	2	1 500	3 000	75 000	
12	Timing	2	2 000	4 000	100 000	
13	Radiation Monitor	2	2 000	4 000	100 000	
14	Step Motors Driver Coupler	4	3 000	12 000	300 000	
15	Step Motors Driver Resonance	4	5 000	20 000	500 000	
16	Power Supply	2	2 500	5 000	125 000	
17	Piezo Controller & Driver	2	4 000	8 000	200 000	
18	Ethernet Switch	2	2 000	4 000	100 000	
19	Fire Protection Unit	2	5 000	10 000	250 000	
20	N-type Connectors	192	11	2 112	52 800	
21	N-type Feedthrough	192	8	1 536	38 400	
22	Cables Cellflex 1/2"	540	3	1 620	40 500	
23	Burndy Connectors for Piezo	64	5	320	8 000	
24	Piezo Cable	180	1	180	4 500	
25	Cable tray	24	20	480	12 000	
26	Step Motors cables	850	3	2 550	63 750	
27				0	0	
28				0	0	
29				0	0	
30				0	0	

31				0	0	
32				0	0	
33				0	0	
34				0	0	
35				0	0	
36	AC power connection	2	100	200	5 000	
37	Cooling watre connection	2	200	400	10 000	
38	Container rad. Shielding	2	5 000	10 000	250 000	
	Total			**259 398**	**6 484 950**	
	Total excluding parts not belongs to WP02			148 768	3 719 200	

Table 3. Cost estimation for L2 and L3 LLRF Stations.

2.1.4 Requirements for space in XFEL tunnel

We have presented our LLRF requirements for space for racks and cables on CAD Integrations Meetings and discussions have started.

There is a proposal from MSK group presented 26.03.2009 on MSK Weekly Meeting and on 24.03.2009 on Technical Coordination Meeting. Presentations can be found:

https://svnsrv.desy.de/k5viewvc/MSK_Doc/trunk/users/Wierba/Presentations%202009

There will be a "Racks position in XTL Meeting", Thursday, 28. Jan. 2010, 14:00-15:30, Building 30b, seminar room 459 organized by E. Negodin.

2.1.5 LLRF position in XTL

After several discussions LLRF group has decided that Semi-Distributed System is the most promising solution. For that scenario the place in XTL for LLRF electronics has been reserved and included in 3D model. In Fig. 5. One section (RF Station) of L1, L2 or L3 is presented. The LLRF racks are under CryoModules close between CryoModule 1 & 2 and between CryoModule 3 & 4. There is a collision with Water Distribution Box placeholder for second set of racks in their optimal position (as close as possible to the interconnection between CryoModule 3 & 4). Discussion with Mr. Block (responsible for water in XTL) is in progress but there is a space shown in Fig.5. 6-7 m downstream far from the optimal one.
The crucial point is to place the set of racks as close as possible to the middle point between Cryomodule 1 & 2 and Cryomodule 3 & 4 (the patch panels on Cryomodules will be done 'left' and 'right'). This gives us the highest possible performance of LLRF System (shortest cables), low pickup noise, small space for cables needed, smaller patch panels and possibility to do almost all cabling outside XFEL Tunnel (reduce the necessary cabling work in XTL).
To fulfill our requirements, the water distribution system should be moved by ~3 m downstream the beam direction. This conflict has been discussed on the CAD

Integration meeting with Mr. Block and we agree to come to discussion when he will have more detailed design of water distribution system.
We have prepared a table with necessary shift of water distribution system presented in Table. 4.

Room Nr.	Cryostation Nr.	Z position of water boxes [m]	Begin of water box in Room [m]	Length move in Z [m]	Remarks
R01		~110	20	---	L1
R02	A2	~160	18,5	+ 6	L1
R03	----	~235	40	---	L2
R04	A3	~270	27,5	+ 3	L2
R05	A4	~320	23,5	+ 3	L2
R06	A5	~370	19,5	+ 3	L2
R07	----		15,5	---	
R08	A6	~470	25	-2 ? to add space	Beam dump
R09	A7	~510	6,5	+ 3	L3
R10	A8	~560	2,5	+ 3	L3
R10	A8	~605	50,5	+ 3	L3
R11	A9	~655	49,3	+ 3	L3
R12	A10	~705	45,3	+ 3	L3
					↓
R13	A11	~755	Should be at ~44	+3 m after puls trafo	No exact position of water “box” in 3D Model EDMS
R14	A12	~805	Should be at ~43	+3 m after puls trafo	
R15	A13	~855	Should be at ~39	+3 m after puls trafo	
R16	A14	~905	Should be at ~35	+3 m after puls trafo	
R17	A15	~955	Should be at ~34	+3 m after puls trafo	
R18	A16	~1000	Should be at ~30	+3 m after puls trafo	
R19	A17	~1050	Should be at ~26	+3 m after puls trafo	
R20	A18	~1100	Should be at ~25	+3 m after puls trafo	
R21	A19	~1145	Should be at ~21	+3 m after puls trafo	
R22	A20	~1195	Should be at ~17	+3 m after puls trafo	
R23	A21	~1245	Should be at ~16	+3 m after puls trafo	
R24	A22	~1295	Should be at ~12	+3 m after puls trafo	
R25	A23	~1345	Should be at ~09	+3 m after puls trafo	
R26	A24	~1395	Should be at ~07	+3 m after puls trafo	

R27	A25	~1445	Should be at ~03	+3 m after puls trafo	
R27	A26	~1490	Should be at ~51	+3 m after puls trafo	
R28	---				

Table 4. Necessary shift of Water Distribution Box for rooms in XTL

Without moving the Water Distribution System by ~3 m, the second set of LLRF racks will be placed at the end of RF Station as proposed by Thorsten Stoye in 3D model of XTL (Fig. 5).

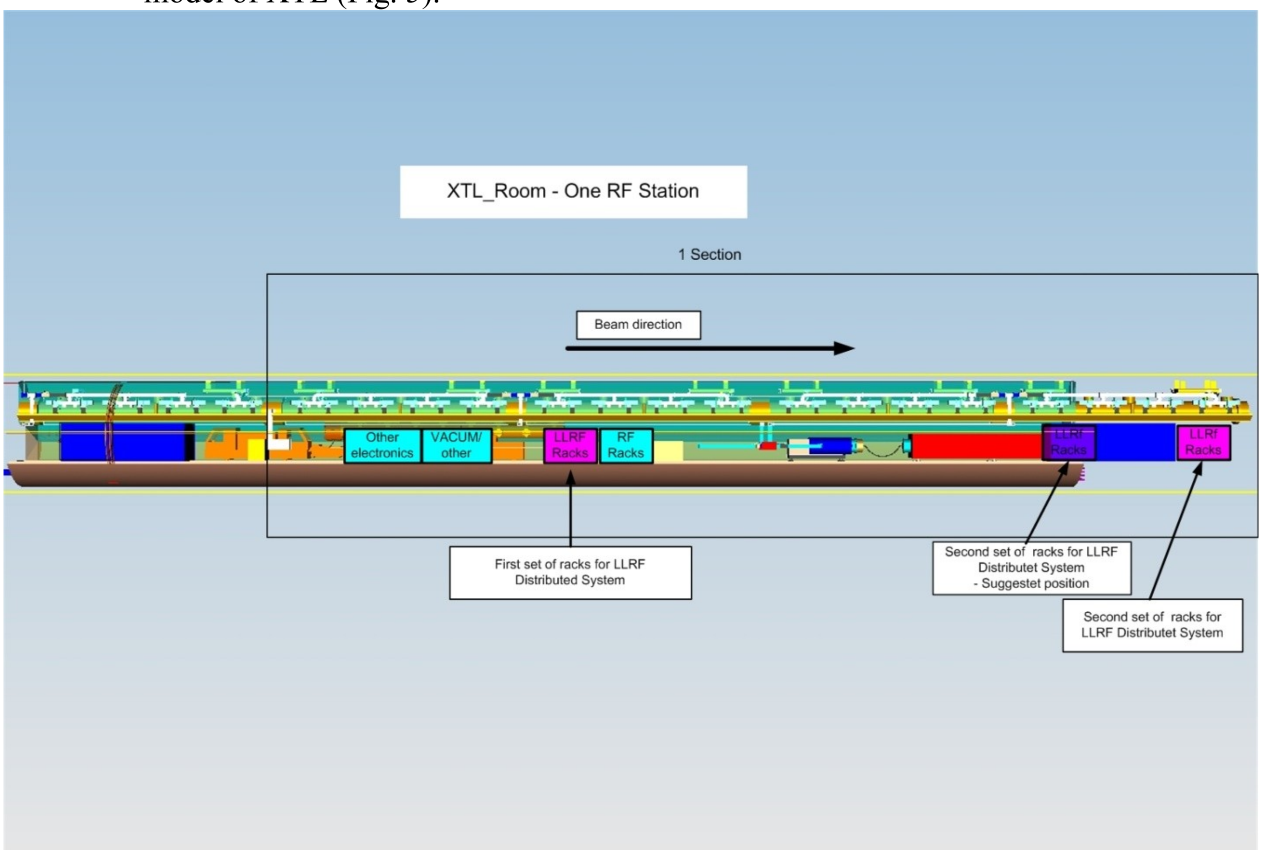


Fig. 5. One RF Station for L1, L2 and L3 with optimal and proposed place of LLRF Racks.

This ‘proposed’ position shifted by ~6-7 m from ‘optimal’ position will caused a few problems to the LLRF system. First, we have to count degradation of LLRF System performance by ~30% (without special drift calibration devices), second, the increase of cost of cables, cabling work, cables trays (+~2000€/RF Station). Additionally we will need some space under Cryomodule and over Water Distribution System to place cables trays for 48 Cellflex ½” cables.

We think, that the possibility of moving the Water Distribution System by ~3 m should be investigated.

The isometric view of LLRF racks in XTL is shown in Fig. 6.

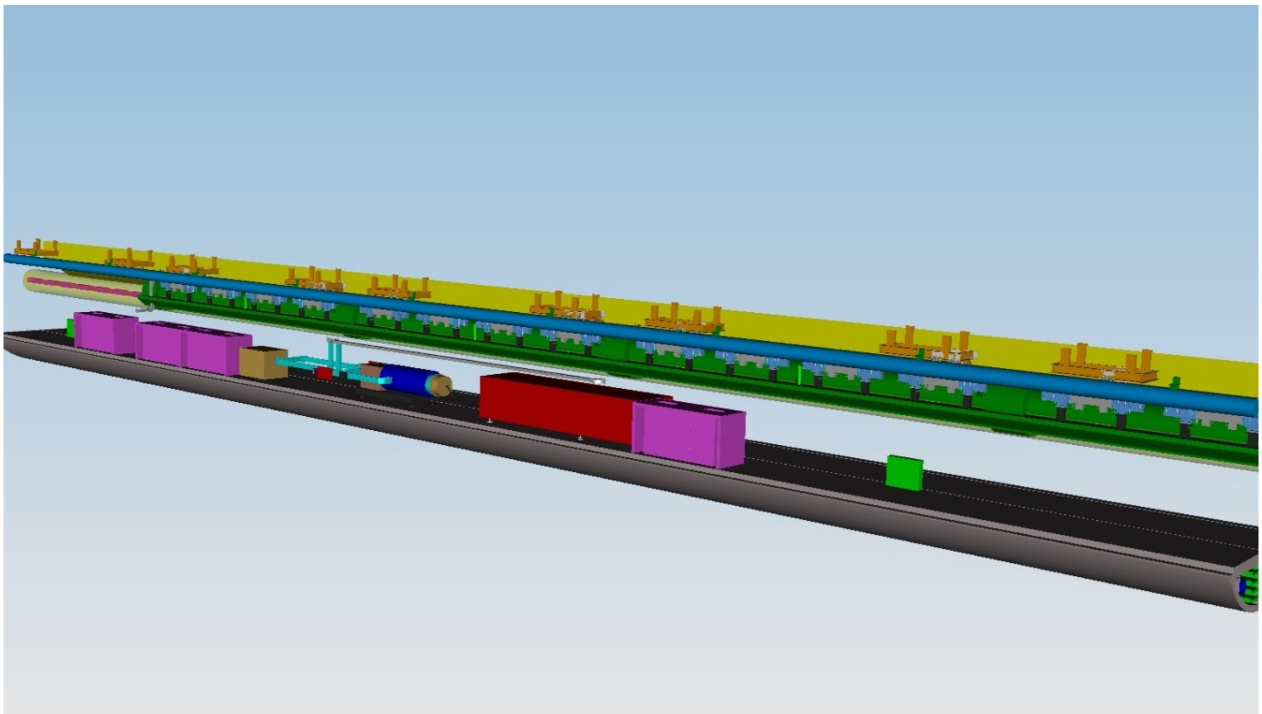


Fig. 6. Isometric view of the placement of LLRF racks in XTL for one RF Station.

2.2 Cables types

It is foreseen for LLRF System in XFEL Tunnel to use several types of cables for RF signals, piezzo actuators, step motors cavity tuners & phase shifters and for Ethernet connection. All cables should be fire resistant and halogen free.

2.2.1 Coax cables 3/8", 1/2" & 7/8" (probe, forward, reflected)

Cables for RF signals should have small attenuation, low temperature phase drift, sufficient bandwidth (1.3 GHz). Those requirements are very important for Master Oscillator signals.

For the tunnel purposes we have chosen coaxial cables Cellflex ½" for Probe, Forward and Reflected signals from each superconducting cavity.

This is a proposal from MSK group discussed a few times on MSK Weekly Meetings and agreed personally with S.Simrock.

Last measurements of phase stability versus temperature made by Krzysztof Czuba and his team gives us a recommendation to use for probe, forward and reflected signals coax cables Cellflex 3/8”. This type of cable seems to be the best. The attenuation of the signal on 1.3 GHz frequency is not important, there is sufficient RF power and we have to use attenuators of 10-15 dB in any case.
This will give us more freedom to cable the CryoModule because of smaller diameter and bending radius. This type of cables (Cellflex 3/8”) seems to be also suitable to make connections between patch panel on CryoModule and patch panel on the top of LLRF rack.

2.2.2 Master Oscillator cables

Master Oscillator signals will be feed through coaxial cables Cellflex 7/8” along the accelerator tunnel. We propose 4 cables (2 spare) running along tunnel from one RF Station to another.

This is a proposal from MSK group agreed personally with K. Czuba.

There will be a workshop on 25.11.2010 concerning the synchronization scheme and necessary cabling. We are prepared to fulfill different scenarios of synchronization from cabling and installation point of view.

2.2.3 Piezzo cables

Each cavity has two piezzo actuators so we recommend to use the cooper wire cable with two twisted pairs. It is not fixed yet, but as example cable Belden 9729 can be used.

This is a proposal from MSK group discussed personally with M. Grecki and T. Pożniak.

2.2.4 Step Motor cables

Cables for step motor phases should be discussed with MCS4 group – the design of cable ducts and shelves has started, but there is some delay from the Control Group side.
For L1, L2 and L3 accelerators we will use LYHCH(TP) 12x2x0.5 mm (diameter ~17 mm) cables (2 per CryoModule).
For J0 accelerator there will be 2 cables LYHCH(TP) 12x2x0.5 mm (diameter ~17 mm) and 8 cables LIHCH(TP) 4x2x0.5 mm (diameter ~11 mm).
For 3.9GHz there will be 2 cables LYHCH(TP) 12x2x0.5 mm (diameter ~17 mm) and 24 cables LIHCH(TP) 4x2x0.5 mm (diameter ~11 mm).

2.2.5 Ethernet cables

There will be two types of Ethernet cables: for outside connection two 10 Gbit fiber optics (LWL), for connection between racks in “Semi-Distributed” system two 1 Gbit fiber optics (LWL) and ~20 cooper wire 1 Gbit RJ45 in each LLRF rack. The type of cables will be provided by IT group.

This is a request from MSK group to IT. It has been discussed with T.Witt from IT at 12.01.2010. T. Witt will prepare solution to fulfill our needs.

We have to sacrifice some redundancy of Ethernet links because of shortage of budget. Thorsten Witt from IT is preparing the design of Ethernet connections in XTL.

2.2.6 Proposed cables with prices and remarks

Till now, we can only recommend coax cables from RFS:
Cellflex 3/8" – price ~1,20 €/m (for big order),
Cellflex ½" – price ~2,30 €/m (for big order),
Cellflex 7/8" – price ~4,25 €/m (for big order),
and
Belden 9729 – for Piezzo actuators.

2.3 Cables plant

The idea is to do as much as possible cabling outside XFEL Tunnel (XTL). For "Semi-Distributed" LLRF System it possible, only short cables connecting patch panel on CryoModule with LLRF System racks have to be installed in tunnel.

This is a proposal from MSK group discussed on MSK Weekly Meetings in 2009 and agreed personally with S. Simrock. The final decision depends on available space for "Semi-Distributed" system in XTL.
Presentations can be found:

https://svnsrv.desy.de/k5viewvc/MSK_Doc/trunk/users/Wierba/Presentations%202009/

2.3.1 Tunnel RF cables inventory

The cables per one RF Station for RF signals, Piezzo and Step Motors are mainly cabled on Cryo Modules, there are cables from Cryo Module patch panel to the racks also. In Table 5. the inventory of cables per one RF Station is presented.

LLRF Cables in RF station in XTL Rev.: 12.01.2010

	From	Via	To	Number of cables	Type of cables	Length [m]	Function & Number of cables	Remarks
1	Elektronik rack #1	patchpanel	Cryo Module 1 & 2	48	Cellflex 1/2"		2 x (8x3) Forward, Reflected & Probe	
2				16	Belden 9729		2 x 8 Piezzo Control	
3				16			2 x 8 StepMotorActuator	
4				16			2 x 8 StepMotor HF Actuator	
5	Elektronik rack #2	patchpanel	Cryo Module 3 & 4	48	Cellflex 1/2"		2 x (8x3) Forward, Reflected & Probe	
6				16	Belden 9729		2 x 8 Piezzo Control	
7				16			2 x 8 StepMotorActuator	
8				16			2 x 8 StepMotor HF Actuator	
9	Elektronik rack #1		Klystron station	1	Cellflex 1/2"		Klystron_Control	
10				4	Cellflex 1/4" ??		Klystron_Diagnostics	
11	Elektronik Rack #1 in XTIN Elektronik raum UG05/011	XSE Medienschacht	Whole XTL (Room 1 to 30 ?)	2+2	Cellflex 7/8"	?? 150-1600	Main Coax Drive Line	
12				24	MLO Fibers		Fibre-optic cable	
13								

Table 5. The inventory of LLRF cables for one RF Station.

2.3.2 CryoModule cabling

We have proposed several schemes of CryoModule cabling, after personal discussions with V. Katalev from MHF-p, the prototype for FLASH (ACC7) design have been fixed with agreement for patch panels and connectors. For XFEL it is necessary to discuss more detailed with MHF group patch panel on CryoModul to reserve the space for Piezzo and Step Motors connectors. It is presented in Fig. 7 and 8.

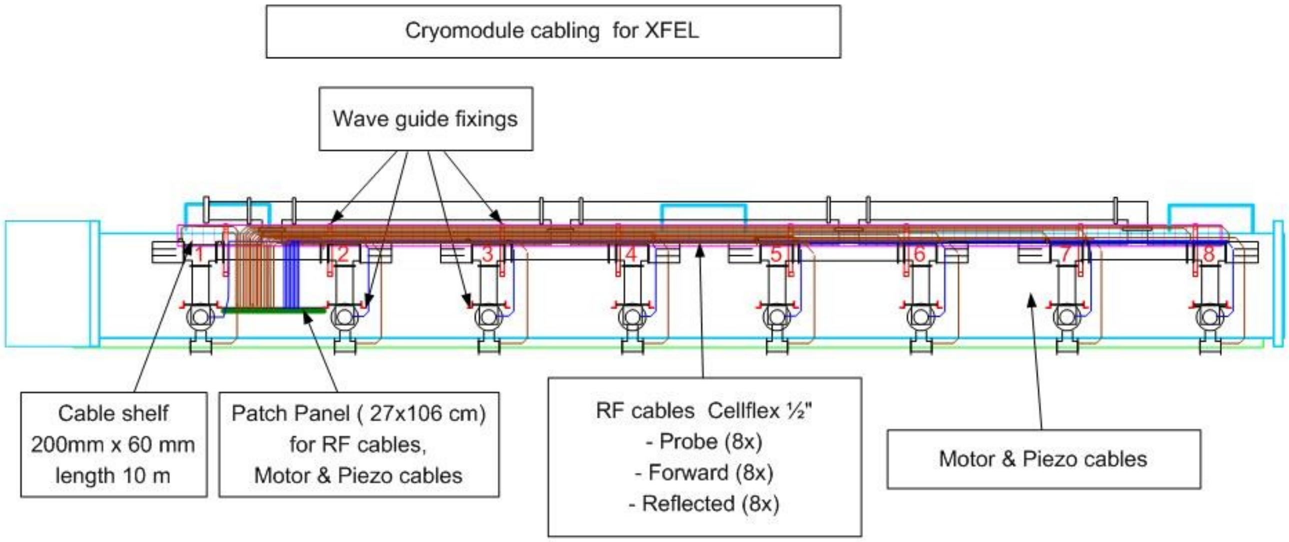


Fig. 7. Proposed cabling for one CryoModule.

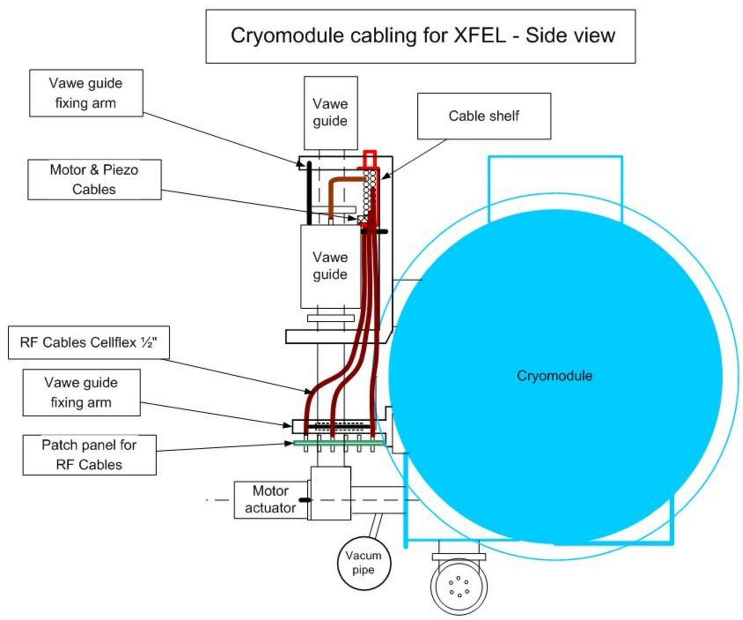


Fig. 8. Side view of proposed CryoModule cabling.

Most probably the cable shelf for coax cables on the CryoModule will be moved to the front of waveguides because for existing design there is a conflict with CryModule support (hanging). This is a small change in cabling design which will not alter much more our design.

2.3.3 Patch panels

The minimum space for patch panels for LLRF cables is shown in Fig. 9, 10 and 11.

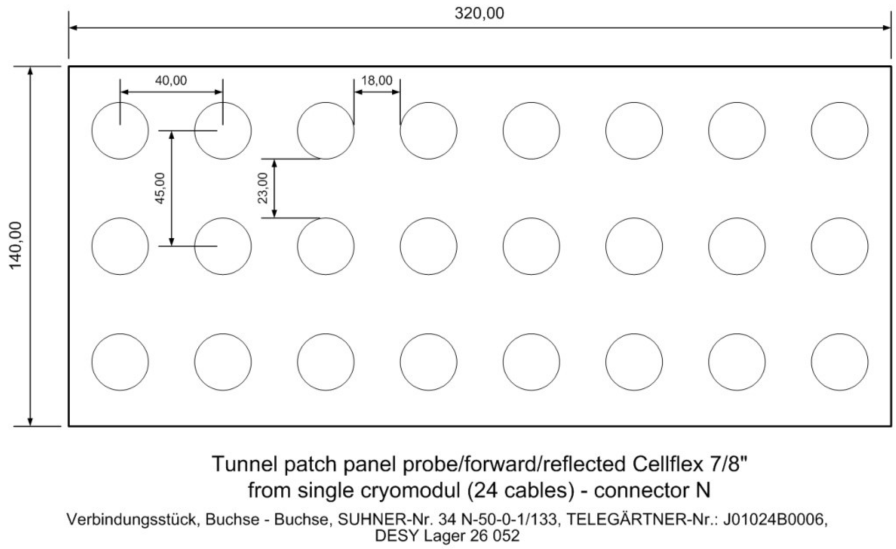


Fig. 9. Patch panel for RF signal for single CryoModule.

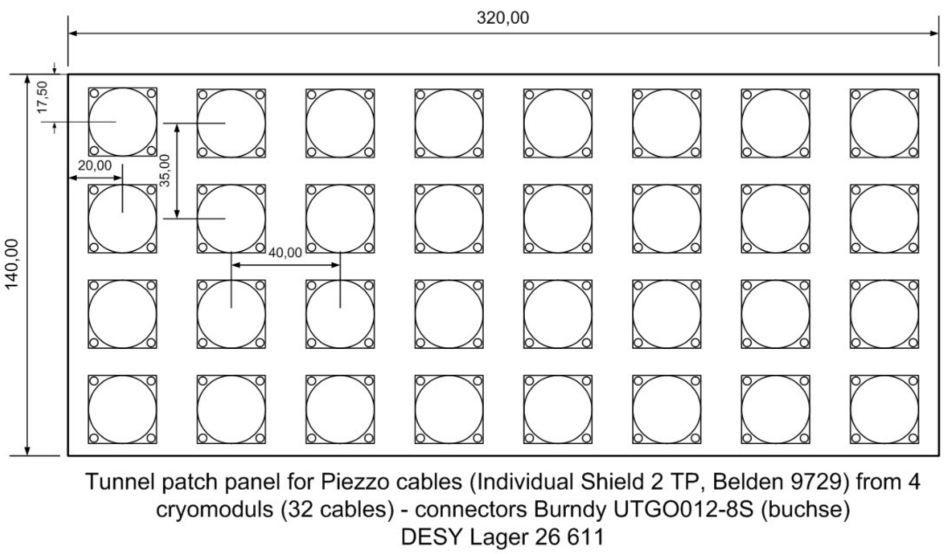


Fig. 10. Patch panel for Piezzo cables for one RF Station (4 CryoModules).

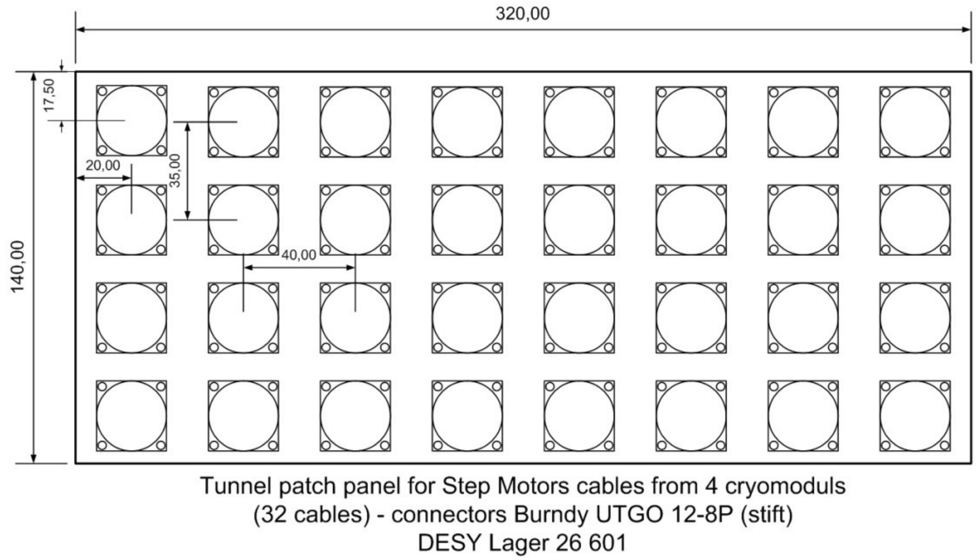


Fig. 11. Patch panel for Step Motor cables for one RF Station (4 CryoModules).

This is a proposal from MSK group.

For the Semi-Distributed system the RF patch panel will be a part of Calibration Box placed on the most upper place in LLRF rack. There will be 48 N connectors for Probe/Forward/Reflected signal for 2 (1/2 RF Station) Cryomodules. The top cover of Calibration Box is shown in Fig.12. and in Fig. 13 the photograph of (not fully assembly) top cover is presented.

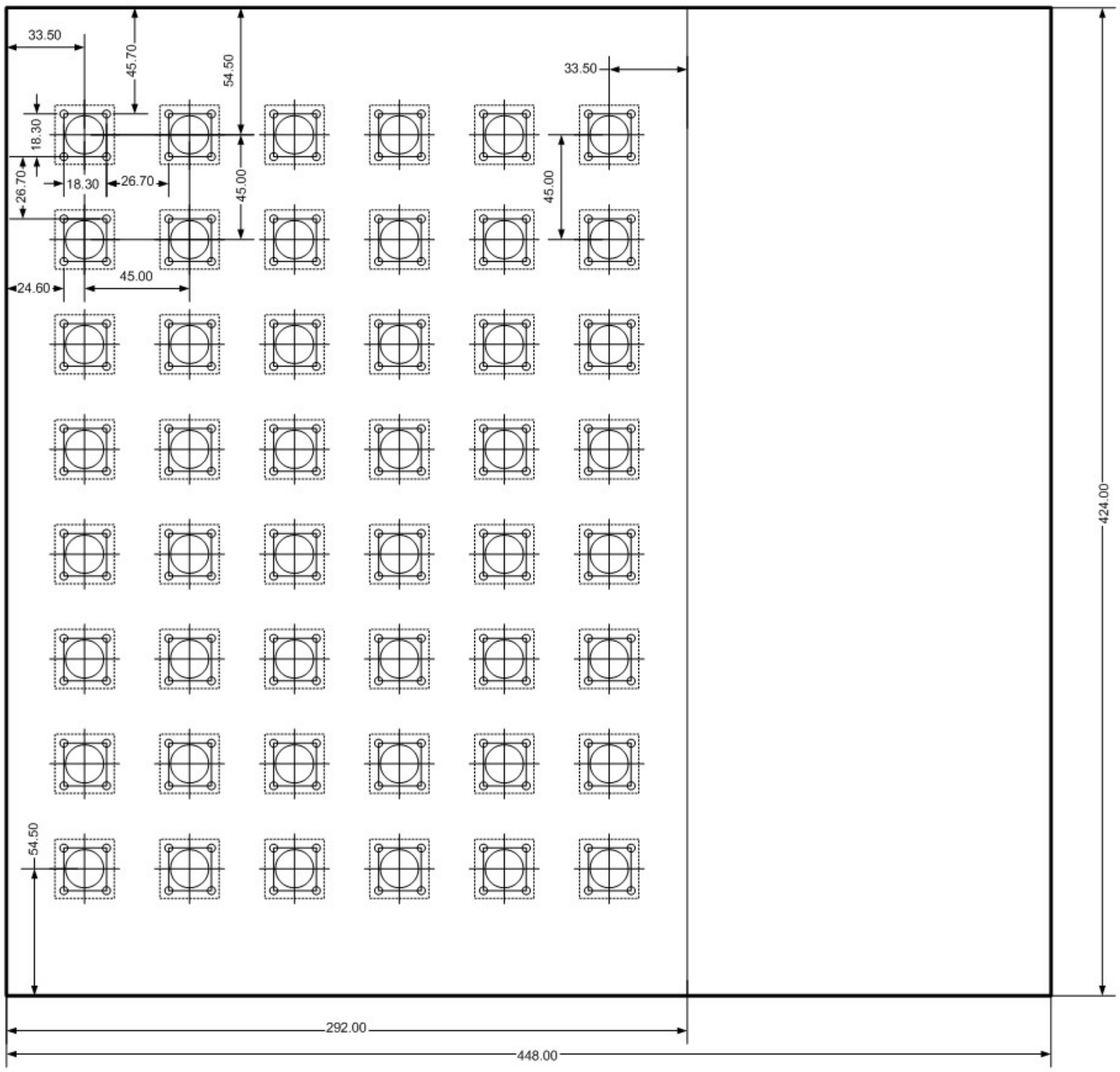


Fig. 12. Top cover of Calibration Box as RF signals patch panel for 2 CryoModules.

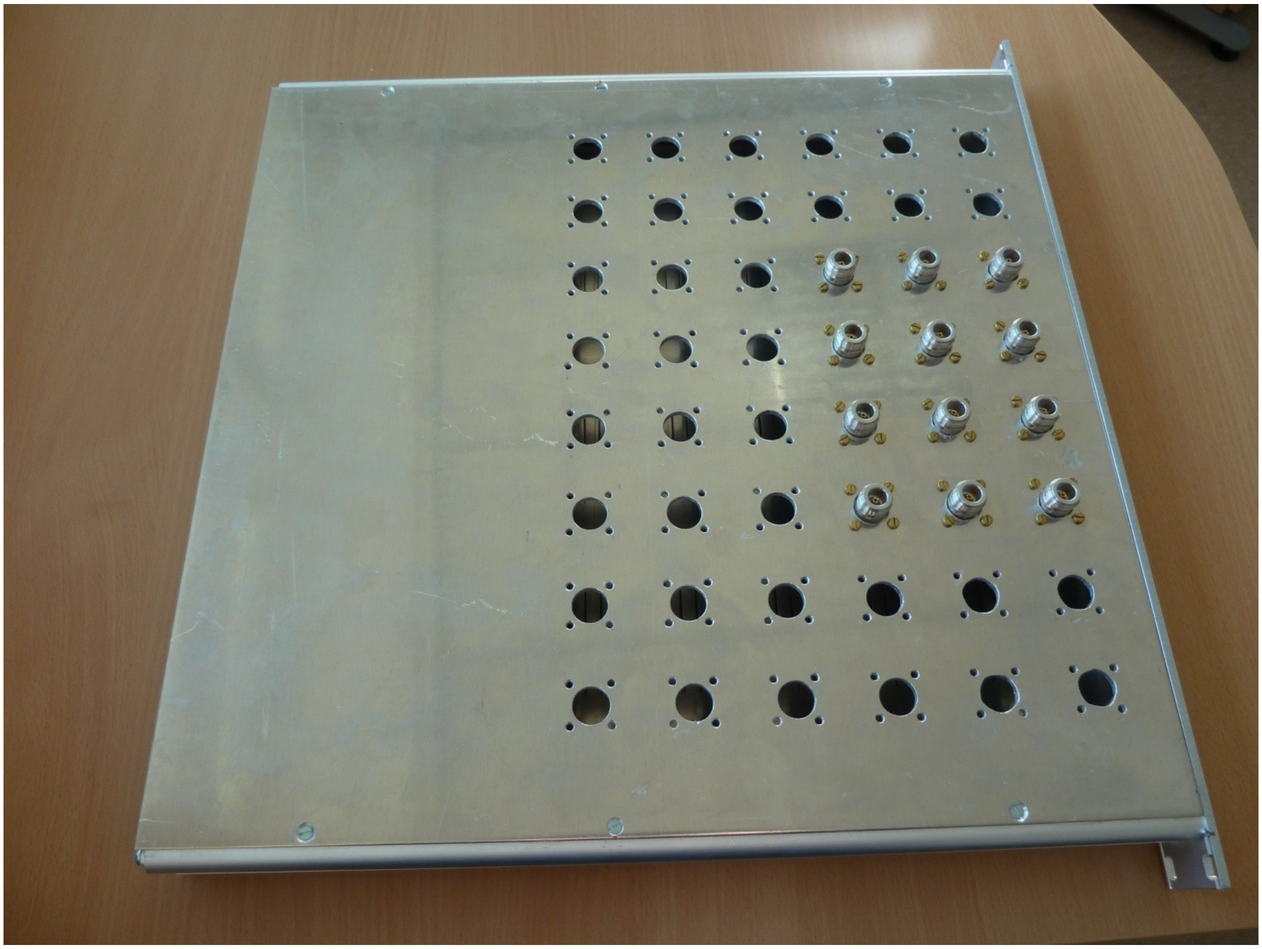


Fig. 13. Top cover of Calibration Box with N-connectors (not fully assembled).

2.3.4 Connectors

For RF signals we recommend N type connectors. On CryoModule there are N connectors for Probe, Forward and Reflected signals and same type of N connectors is used on patch panel. To avoid additional patch panel on LLRF racks, the interconnection between CryoModule patch panel to the rack will be done directly to the Calibration Box with N connectors.
After several discussions with connectors manufacturers we have decided to try special N-connectors from Compotek.
There are several scenarios how to solder or screw N-connectors to the calibration PCB. In Fig. 14 some possibilities are presented.

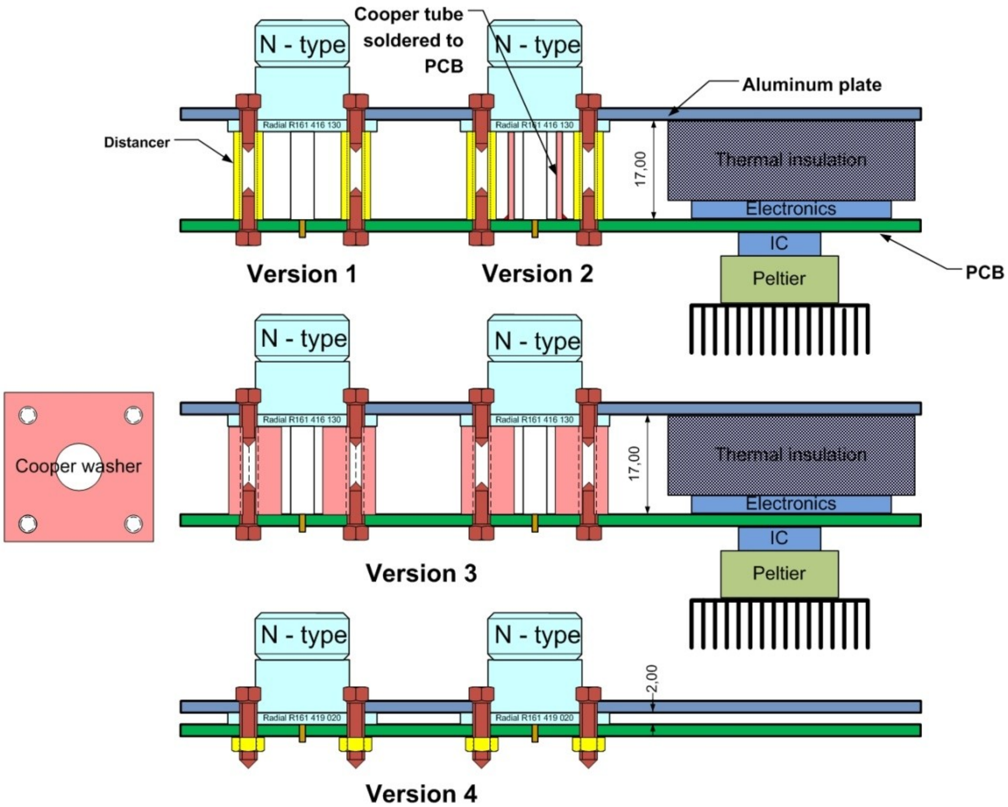


Fig. 14. Four versions of fixing the N-connector to the PCB.

This is a proposal from MSK group agreed personally with F.Ludwig and K.Czuba.

Till now, there is not clear which type of connectors will be used for cables connecting Calibration Box to the Downconverters on RTM in ATCA or μTCA crate. The discussion and tests of different types of connectors are in progress.

Piezzo actuators can be connected to the CryoModule with 4 pin special Lemo connector (type not known yet, depends on design of CryoModule for XFEL), for the CryoModule patch panel we propose 4 pin Burndy connector as well for the LLRF rack patch panel.

This is proposal from MSK group discussed personally with T. Poźniak and M. Grecki. The final decision not yet done.

The Step Motors can be connected using Burndy connectors (depends on MCS4).

This is a proposal from MSK discussed personally with K.Rehlich and P. Nommensen. The final decision not yet done.

2.3.5 Possible cabling layout

Interconnection from CryoModule to LLRF rack can be done from top but it is necessary to have a kind of meander to pass through the radiation shielding. This way is presented in Fig. 15.

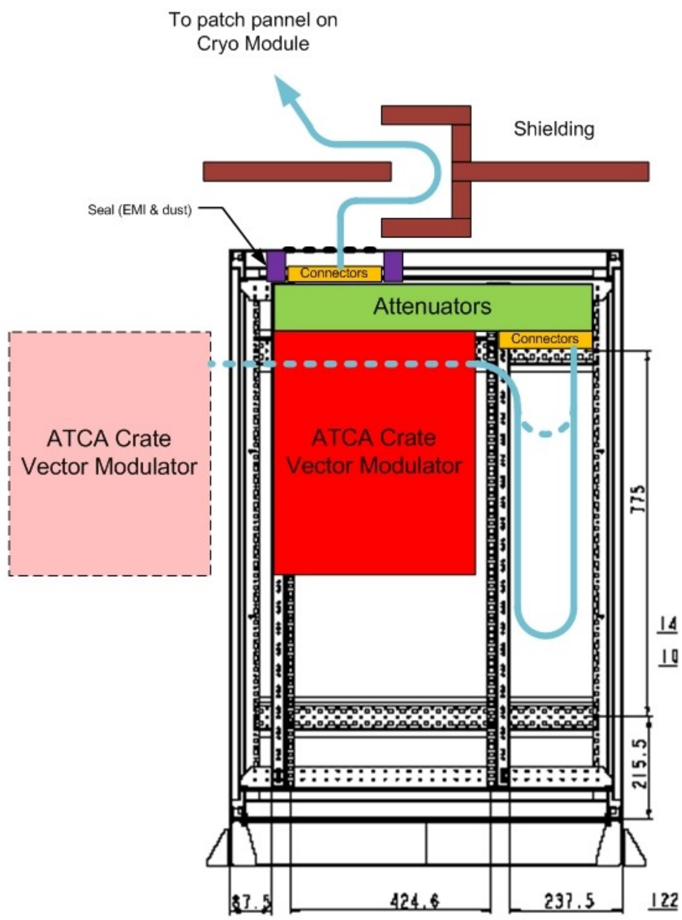


Fig. 15. Possible cables way from CryoModule patch panel to LLRF rack.

To avoid additional patch panel on the LLRF rack, the cables are directly connected to the Calibration Box.

This is a proposal from MSK presented on MSK Weekly Meetings and discussed within MSK group. The final decision not yet done, depends strongly on radiation shielding design.
Presentations can be found:

https://svnsrv.desy.de/k5viewvc/MSK_Doc/trunk/users/Wierba/Presentations%202009

2.3.6 Space for cables requirements

The space for cables on CryoModule is requested. The space for interconnecting cables is requested but strongly depend on place, where LLRF racks will be placed – not yet decided.
Along the XFEL Tunnel we have to feed 4 Cellflex 7/8” cables from one RF Station to the next one. We have requested a small cable shelf on top of another cable shelf. This shelf can be also used for the fiber optic cables for synchronization.

This is a proposal from MSK discussed personally with V. Katalev and K.Czuba. It is necessary to make a 3D model of cabling and implement it in XTL 3D model as placeholders.

2.4 Racks

LLRF racks will be placed in XFEL Tunnel on the floor under CryoModules. The rakcs will be smaller, approximately a half height of standard rack.

The racks requirements proposed below has been worked out with close cooperation with K. Rehlich. The preliminary status of “XFEL Standard Racks” can be found in his presentation on Technical Coordination Meeting 27.10. 2009 to which we have contributed.

Prototype of container with 3 racks 28U height has been ordered by two different vendors.

2.4.1 Container description

Special requirements for ‘container’:

- Fire protection panel in middle rack 1 (maximum 2) U height
- Dust free and air tight ‘container’ – washers in doors, sealed patch panels
- Separable doors
- Separable doors grounding (spring connectors for grounding)
- EMI tight doors – special cooper springs or mesh in doors
- ‘Ears’ on top of ‘container’ for transport (strength up to ~1 ton)
- Access from rear side of ‘container’
- Fluorescent lamp on the top of each rack inside container for maintenance purpose

We have designed a prototype ‘container’, ordered it in ZPAS firm. The ‘container’ is now equipped with one ATCA crate and placed in Mockup tunnel.
The ‘container’ is presented in Fig. 16 & 17.

This is a proposal from MSK discussed personally with K.Rehlich. The final decision not yet done.

Fig. 16. Prototype ‘container’ in Mockup tunnel.

Fig. 17. ‘Container’ with installed ATCA crate.

2.4.2 Rack standard

- Height of rack – 24-28(!)U (no base because of front-rear air circulation)
- Height of ‘container’ – 1200-1300mm (depends on radiation shielding thickness)
- Width of rack – 19”
- Depth of rack – min. 700 mm (crates (ATCA) needs less, but Fire Protection Unit needs ~700 mm)
- Depth of ‘container’ - ~800 mm (can be smaller)
- Length of ‘container’ for 3 racks - ~2160 mm
- Length of ‘container’ for 2 racks - ~1456 mm

This is a proposal from MSK discussed personally with K.Rehlich. The final decision not yet done.

2.4.3 Rack power

We have estimated for one set of racks in XFEL Tunnel (one ‘container’) the AC power needs for 3,5 – 5 kW.

This is a proposal from MSK discussed internally. The final decision not yet done.

2.4.4 Rack cooling

- Air-to-water heat exchangers
- Two (redundant) air-to-water heat exchangers or one heat exchanger with redundant fans (2-4). Fans are the most critical part of heat exchanger.
- One emergency cooling system (fans) to the tunnel air (emergency system **must not** be activated when fire extinguished system has been released). Opening to the tunnel air should be dust tight for ‘normal’ operation.
- Cooling power - ~3-5 kW per ‘container’ for inner temp. ~25°C (cooling water 18°C)
- Temperature stability - ~±1.0°C (better ~±0.5°C)
- Heat exchangers placed inside container in space between racks.
- Front to rear cooling air direction
- Air condition control panels placed in space between racks
- Thermal insulation of ‘container’ (i.e. 25 mm thick, nonflammable, halogenfree foam). If the air temperature in XTL will be ~30-35˚C and we want to have ~25˚C inside the rack, the rack should be thermally insulated because in other case we will ‘cool’ tunnel. The heat transfer for ~10˚C gradient for 3 racks ‘container’ is roughly ~500÷1000 W.

This is a proposal from MSK discussed internally.

2.4.5 Rack air-conditioning

It was decided to have front-to-rear cooling air flow and the heat exchanger should be place in space between racks inside ‘container’ as shown in Fig. 18.

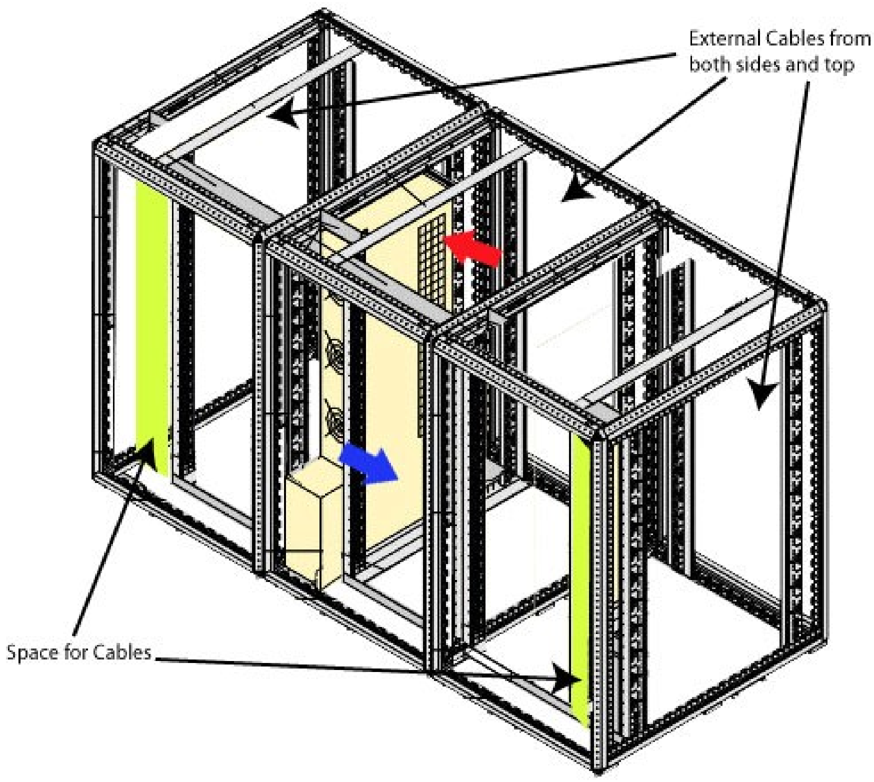


Fig. 18. Air flow in container.

2.4.6 Rack EMI

The ‘container’ should be EMI tight so doors should have special cooper springs or mesh in doors. Water connection should be done with cooper or stainless steel pipes. All patch panels have to be designed as EMI tight.

This is a proposal from MSK discussed personally with H.Weddig.

2.4.7 Rack patch panels

Phase sensitive signals in coax cables will go directly to the Attenuator box (as shown in Fig. 10.). We only foresee the patch panels for Piezzo and Step Motor cables.

This is a proposal from MSK discussed internally.

2.4.8 Rack connections

- Water connection from one side of ‘container’
- AC Power (3 phase) connection from one side of ‘container’
- ‘Containers’ should be equipped with AC distribution system – 8 sockets per rack, two sockets per rack in front for diagnostic equipment (not controlled)
- Ethernet connection – side or top of ‘container’

- Master Oscillator and Synchronization – top of the ‘container’
- RF cables – top of the ‘container’ (from patch panel on Cryo Module)

This is a proposal from MSK discussed internally.

2.4.9 Rack occupation

Preliminary LLRF racks occupation diagram for L2 and L3 is shown in Fig. 19.

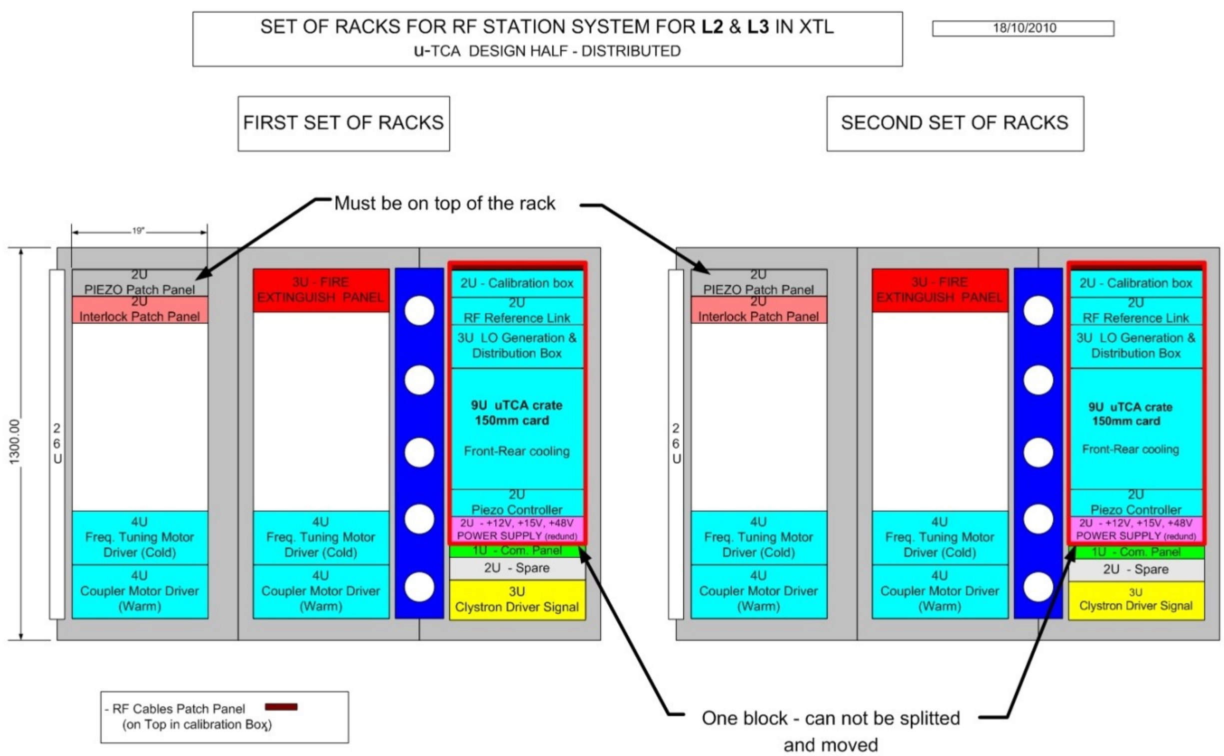


Fig. 19. LLRF System racks occupation for “Semi-Distributed” system for L2 & L3.

Preliminary LLRF racks occupation diagram for L1 (redundant system) is shown in Fig. 20.

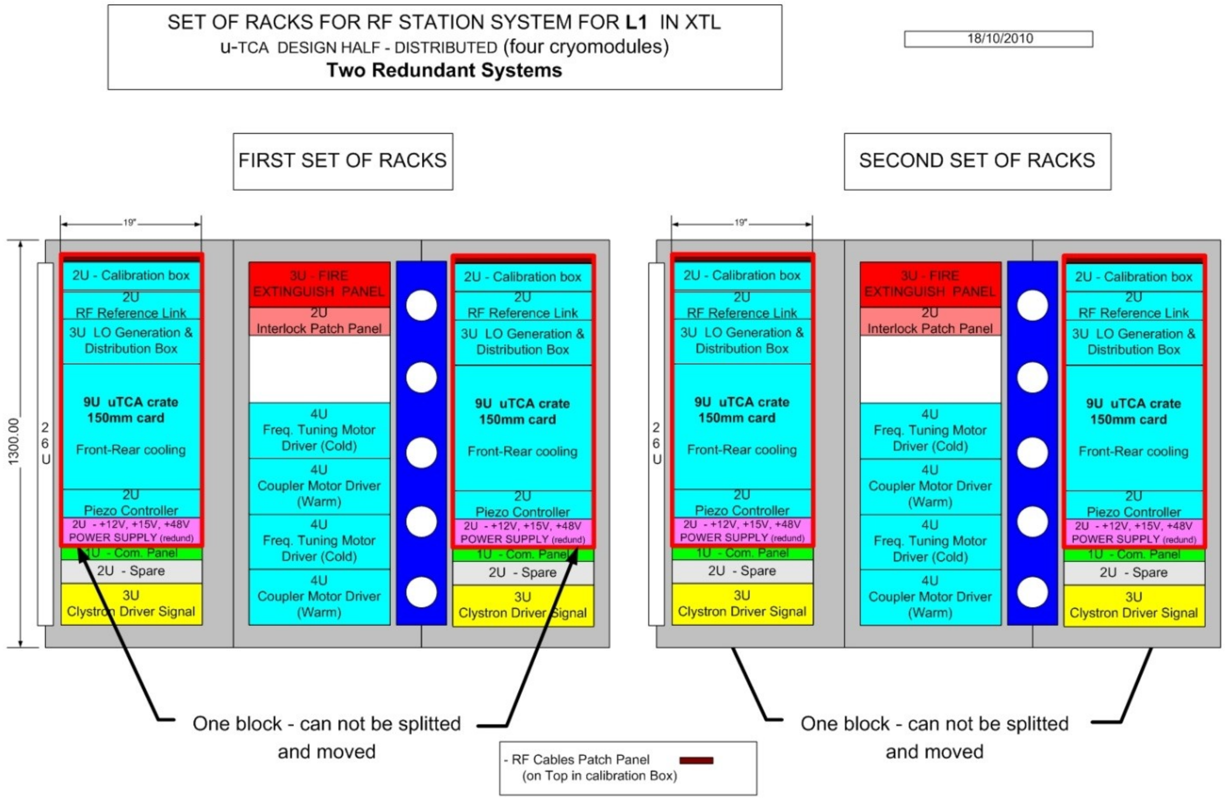


Fig. 20. LLRF System racks occupation for "Semi-Distributed" system for L1.

This is a proposal from MSK discussed internally.

2.4.10 Requirements for space for racks in tunnel

Place in XTL:

1. One 3 racks 'container' placed under the end of Cryo Module 3 and beginning of Cryo Module 4 (counted in beam direction) for each RF Station
2. One 3 racks 'container' placed under the end of Cryo Module 1 and beginning of Cryo Module 2 (counted in beam direction) for each RF Station
3. For 25 RF stations of Main Liniac LLRF needs 25 'containers' with 3 racks and 25 'containers' with 2 racks

There is a proposal from MSK group presented 26.03.2009 on MSK Weekly Meeting and on 24.03.2009 on Technical Coordination Meeting (presentations can be found in SVN).
There will be a "Racks position in XTL Meeting", Thursday, 28. Jan. 2010, 14:00-15:30, Building 30b, seminar room 459.

After many discussions and agreements we have come to the design presented in Fig. 21 and 22.

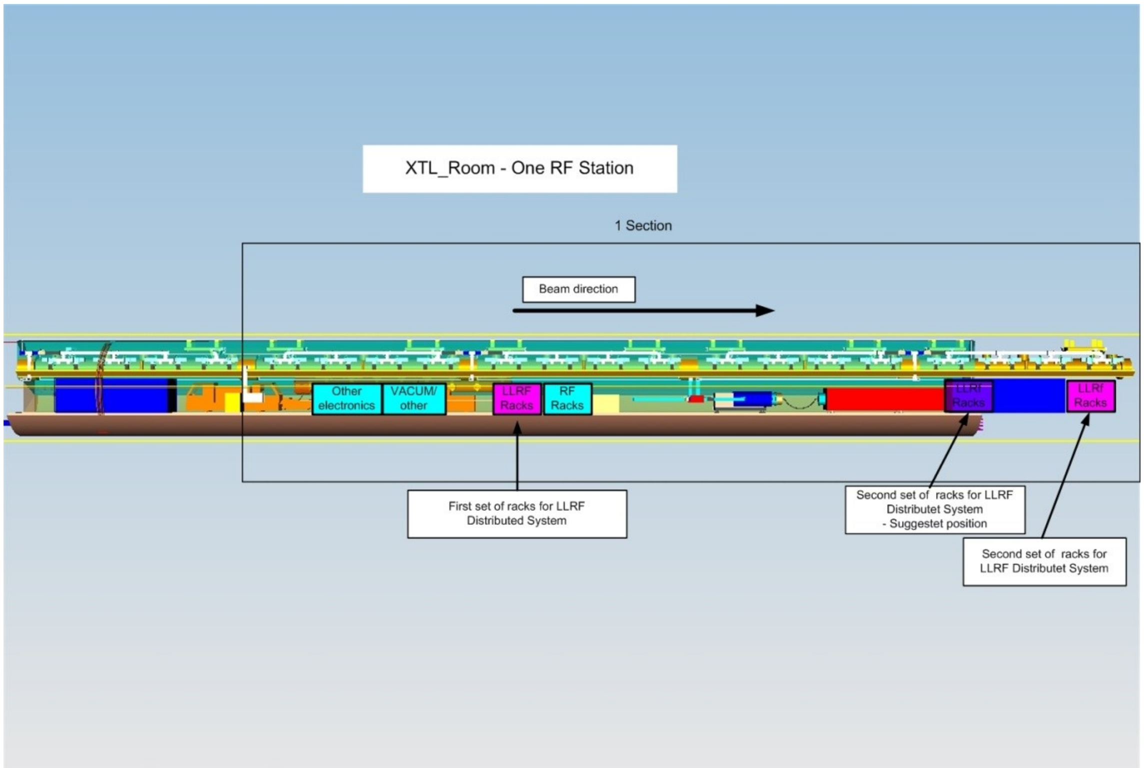


Fig. 21. Position of LLRF set of racks for one RF Station for L1, L2 and L3.

There is still a discussion about 'suggested' position of the second set of racks (optimal) but there is a collision with water distribution system. Finally, most probably, the water distribution system can be shortened and the second set of racks for one RF Station can be placed in 'optimal' position.

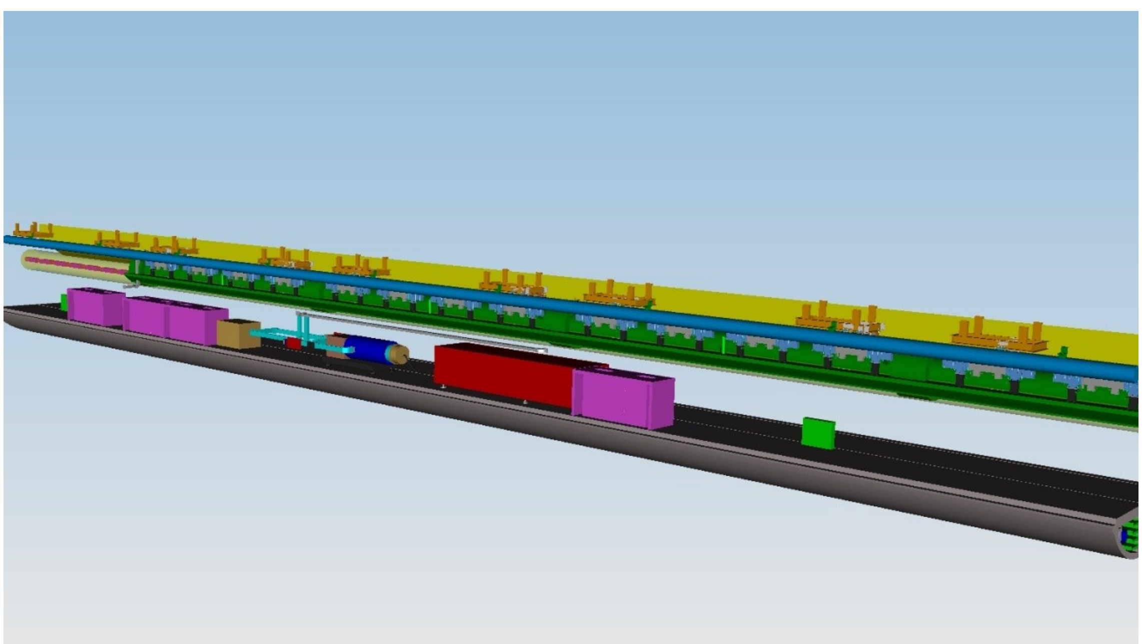


Fig. 22. ‘Optimal’ position of LLRF racks (violet) for one RF Station.

2.5 Crates

It is proposed to use ATCA crate standard for LLRF System. Some devices cannot be integrated in ATCA (i.e. Local Oscillator) and are foreseen to be build in special housing. In 2010

2.5.1 ATCA 13U, RTM, ATCA occupation

ATCA crate has 14 slots for electronic cards. The slots will be occupied as follow.
Crate in 3 racks ‘container’ (Master):

- 1 * CPU
- 1* Switch
- 4* ATCA Carrier Board *(2*AMC-ADC Probe, 2*AMC-ADC Forward, 2*AMC-ADC Reflected, 2* Timing, 1*AMC-ADC Diagnostic, 2*AMC-Vector Modulator, 1*AMC-DSP)*
- 1* ATCA 16 Ch. Piezzo Driver
- 1* Radiation Monitor

Crate in 3 racks ‘container’ (Slave):

- 1 * CPU
- 1* Switch
- 3* ATCA Carrier Board *(2*AMC-ADC Probe, 2*AMC-ADC Forward, 2*AMC-ADC Reflected, 2* Timing, 1*AMC-ADC Diagnostic)*
- 1*AMC-DSP
- 1* ATCA 16 Ch. Piezzo Driver
- 1* Radiation Monitor

In each ATCA crate there are 6 slots free – there is an idea to integrate Step Motors Drivers in to ATCA standard (i.e. 2 boards of 16 channels each).
Downconverters will be placed as RTM’s.

This is a proposal from MSK group agreed personally with T. Jeżyński.

2.5.2 xTCA occupation

End of 2009 the design of XFEL LLRF system has switched to the µTCA crate platform. Chosen model of µTCA crate from ELMA vendor is shown in Fig. 23.

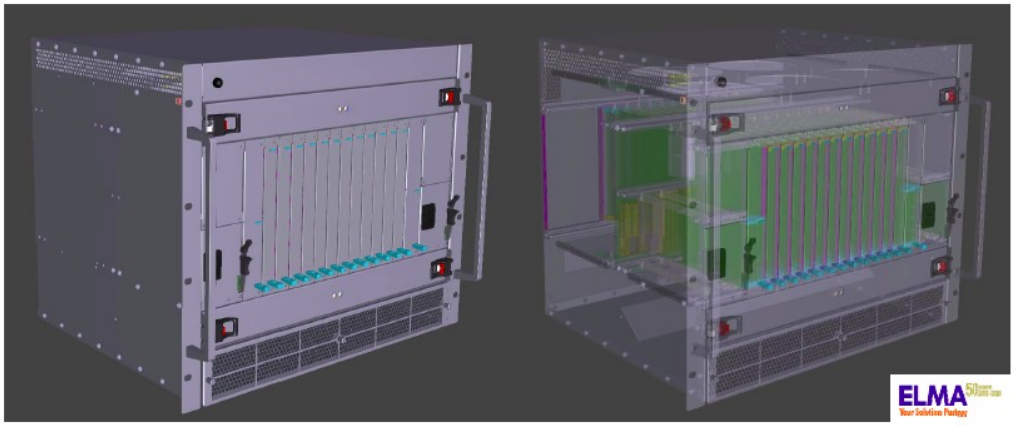


Fig. 23. ELMA crate (courtesy: ELMA).

μTCA crate has 12 slots for electronic cards. The slots will be occupied as follow.
Crate in 3 racks ‘container’ (Master):
front side

- 1 * CPU
- 1 * Interlock
- 1 * Timing
- 1 * LLRF Controller
- 7 * ADC

rear side

- 1 * Klystron Driver
- 7 * DWC (downconverter)
- 1 * LO-Generation

Crate in 3 racks ‘container’ (Slave):
front side

- 1 * CPU
- 1 * Interlock
- 1 * Timing
- 1 * LLRF Controller
- 7 * ADC

rear side

- 1 * Klystron Driver
- 7 * DWC (downconverter)
- 1 * LO-Generation

Proposed crate occupation is presented in Fig. 24 and 25.

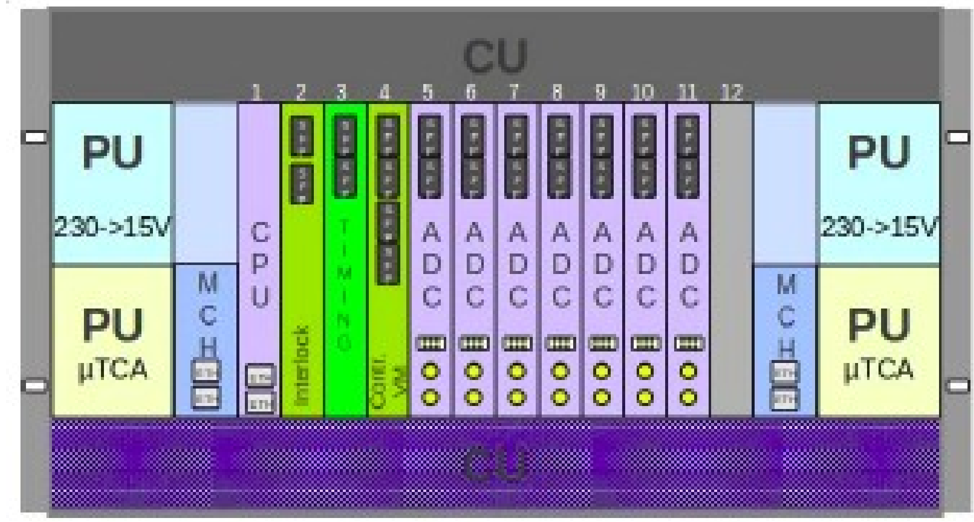


Fig. 24. µTCA crate front occupation (courtesy: T.Jeżyński)

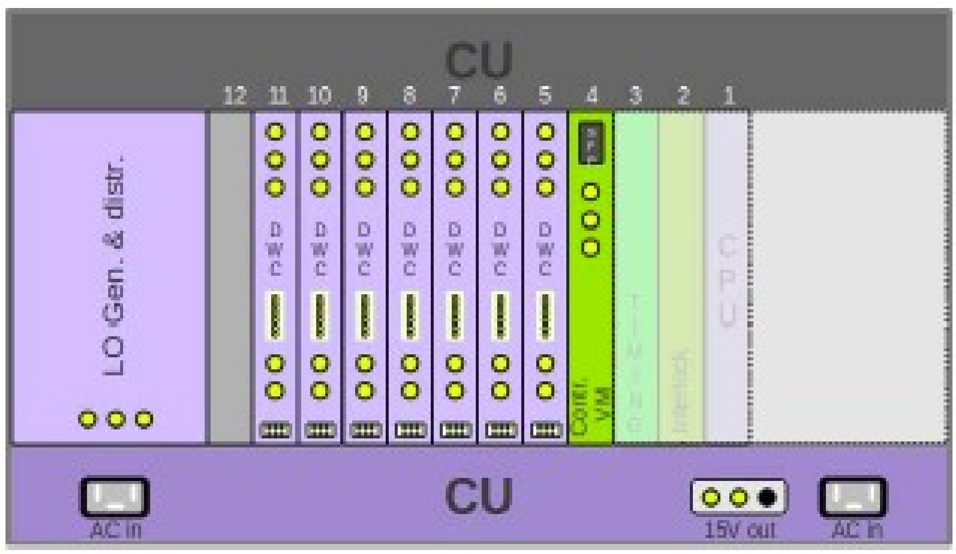


Fig. 25. µTCA crate rear occupation (courtesy: T.Jeżyński)

2.5.3 Power Modules for ATCA (redundant)

The requirements for DC Powers Supply for ATCA are:

- -48 V DC (or floating output ±10 V)
- ~3 kW power
- Low noise < 20 mV_{RMS}
- 2U- 88,9 mm (max. 3U-133,35 mm) – housing height
- Standard 19" rack mounting
- Ethernet (TCP/IP) control
- PS must be redundant

We have ordered the PL508 Power Supply System from Wiener. It has 5 power modules 48 V, 13,5 A, 650 W each. Total power is 3250 W. The housing has 3U height and standard 19" width. Channels can operate in master/slave mode for

paralleling outputs which fulfill redundancy requirement. The special price of PL508 was 2326,00€ in September 2008. This Power Supply is now under tests.
We have chosen another Power Supply from Aspiro. It has 4 power modules 48 V, 18,2 A, 837 W each. Total power is 3,3 kW. The housing has 2U height and standard 19” width. Channels can operate in master/slave mode for paralleling outputs which fulfill redundancy requirement. The standard price of Aspiro 0609G011 was 3500,00€ in December 2009 – for order around 50 pcs. the price can be lowered to 2550,00€/pcs. This power supply we want to order in January 2010 and test it in first quarter of 2010.

This is a proposal from MSK group agreed personally with T. Jeżyński. After tests we will chose the better PS for our purposes.

2.5.4 Transient Detection

There is foreseen 6U crate for Transient Detection device, the Gain Controlled Amplifiers can be placed at the rear side of the crate.
The Transient Detection unit is under design and no detailed information is available now.

This is a proposal from MSK group agreed personally with P. Morozov.

Most probably the Transient Detection Device will be skipped.

2.5.5 Local Oscillator

We have reserved a space of 3U for Master Oscillator Receiver and 3U for Local Oscillator. The special low noise DC 12 V power supply for MO and LO should be discussed carefully (not yet finalized).
The MO and LO are under design and no more detailed information is available now.

This is a proposal from MSK group agreed personally with K. Czuba.

2.5.6 Piezo Controller & Drivers

Piezo Controller & Drivers to compensate the Lorenz force will be placed in one 2U box. It is recommended to use Burndy 4 pin connectors for piezo cables.

This is a proposal from MSK group agreed personally with T. Poźniak.

2.5.7 Drift Calibration

There is foreseen 3U box for Drift Callibration device and 3U box for RF Calibration Distribution unit. The DC and RF CD units are under design and no detailed information is available now.

This is a proposal from MSK group agreed personally with F. Ludwig.

2.5.8 Box standards for LO & DC

To standardize the boxes for RF components we recommend to use in all system 19“, 2U or 3U height boxes with maximum depth of 700 mm.

2.5.9 Standards for Step Motor Drivers

The Step Motor Drivers will be delivered by MCS4 group. The current status of design (similar to the FLASH) shows the huge consumption of space. One Step Motor Drivers unit for 16 warm motors has a 4U height. For cold motors (in Helium) one 4U box can control only 8 motors. We need to control 32 warm and 32 cold motors per one RF Station. That means, that we need 2 times 4U boxes for warm and 4 times 4U boxes for cold motors – together Step Motor Drivers will occupied 24U = one full tunnel rack.

This is a proposal from MSK discussed personally with K.Rehlich and P. Nommensen. The final decision to reduce the height of Step Motor Drivers not yet done.

In framework with EuCard we are preparing a design of integration step motor drivers in to the ATCA crate (16 channel board, universal for warm and cold motors) for FLASH. It will be a good opportunity to test the new design during FLASH operation.

This is a proposal from MSK discussed personally with M. Grecki and E. Kielar.

2.5.10 Requirements for Crates and Power Supplies

The work on requirements for Crates, boxes, power supplies is in progress, ATCA crates and power supplies from different manufacturer are under tests or will be tested soon.

2.5.11 LLRF system layout

There are foreseen two steps in LLRF System design based on µTCA crate. First step to prove the design will have separated LO-Generation box of 3U and LO-Distribution box of 2U. The LLRF System layout is shown in Fig. 26.

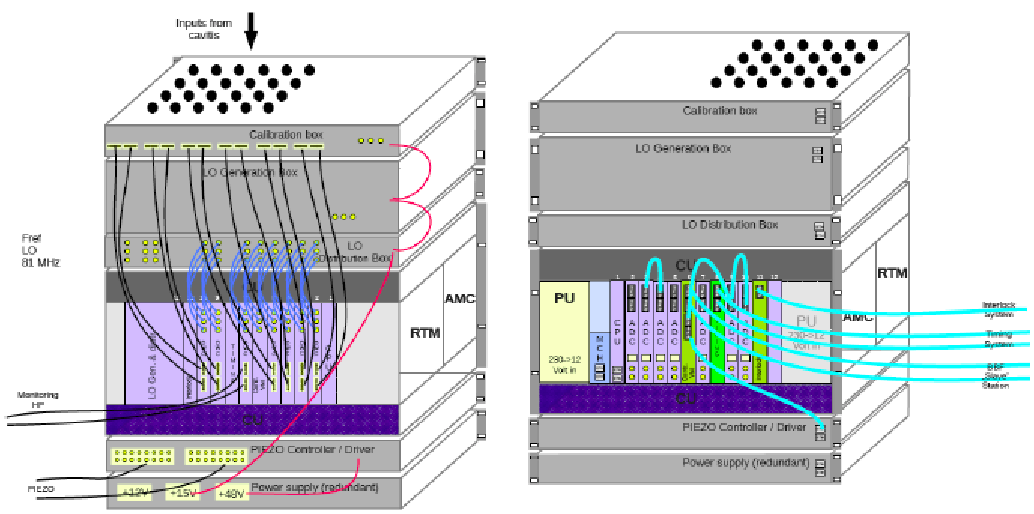


Fig. 26. LLRF System layout for the first design step (courtesy T.Jeżyński).

The prototype LLRF System will be tested at FLASH in first quarter of 2011. Tests of the prototype will give a opportunity to make necessary changes to the design. In next step the design will be focused on more compact layout and clock distribution via backplane (reduce of cables). The proposed final layout is presented in Fig. 27.

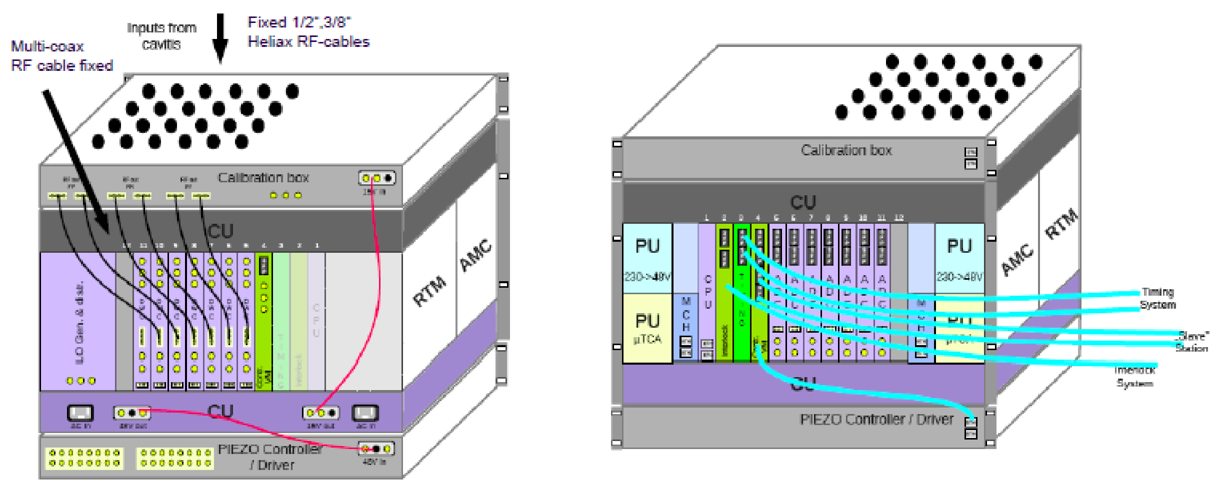


Fig. 27. Final LLRF System layout (courtesy T.Jeżyński).

For the space reservation we currently assume the ‘prototype’ version.

2.6 Infrastructure

We have filled the TGA for ‘rooms’ in XFEL Tunnel (XTL). More detailed information can be found in TGA file.

TGA file for MSK requirements in XTL can be found:

https://svnsrv.desy.de/k5viewvc/MSK_Doc/trunk/users/Wierba/TGA/

2.6.1 Request for IT connections

For all XFEL Tunnel ‘rooms’ where RF Station will be placed we have requested two redundant Ethernet connection 10 Gbit. For the LLRF racks there is foreseen 16 (32) Cu-RJ45 copper wire 1 Gbit connection and two fiber optic links 1 Gbit between “Semi-Distributed” system racks.

2.6.2 Request for AC Power (UPS, Emergency Off)

For all XFEL Tunnel ‘rooms’ where RF Station will be placed we have requested three phase AC power with 3 kW permanent consumption and service socket one phase AC with 500W (1% duty factor).

2.6.3 Request for Cooling Water

For all XFEL Tunnel ‘rooms’ where RF Stations will be placed we have requested cooling water with input temperature of 18˚C. The nominal cooling power is 3 kW with maximum of 4 kW. The flow and temperature sensors have been also requested.

2.6.4 Request for telephones

For all XFEL Tunnel 'rooms' where RF Station will be placed we have requested one IP phone connection. Wireless headphones with microphone are advised.

2.6.5 Request for Security

For all XFEL Tunnel 'rooms' where RF Station will be placed we have requested one smoke detector and evacuation signs.

2.7 Radiation Shielding

Radiation shielding of electronics racks in XFEL tunnel is necessary to avoid damages of electronic circuits during 10 years of operation.

This is a proposal from MSK discussed internally made to induce the discussion. It is foreseen to have a preliminary radiation shielding design made by N. Meyners in first quarter of 2010. DESY is preferring heavy concrete blocks but the space is very limited. Our proposal is contradictory to DESY solution (in 2009).

2.7.1 Radiation simulations in XFEL tunnel

We have not seen any results of MC simulations of radiation in XFEL Tunnel. In our Institute of Nuclear Physics PAN there is a group who can do such a job.

2.7.2 Radiation measurements in FLASH

Radiation measurement in FLASH has been done by Bhaskar Mukherjee in 2007. (http://flash.desy.de/sites/site_vuvfel/content/e870/e2267/infoboxContent2283/Flash-Seminar-181207.pdf

2.7.3 Shielding design

Basing on radiation measurements in FLASH we have proposed a radiation shielding of electronics racks in XFEL Tunnel. The idea is to have a stack of 1 cm steel + 1 cm of Boron Rubber Sheet BR-287 (rather 3 mm thick) + 1 cm of steel (must be checked by experts in radiation transport). There is also another possibility, because the BR-287 is very expensive, to have a stack of 1 cm steel + 1 cm tiles glue (cement) with Boron added + 1 cm of steel (must be checked by experts in radiation transport and tested). The second solution seems to be quite cheap and needs less space than heavy concrete blocks.
Possible solution of radiation shielding is presented in Fig. 28, 29, 30.

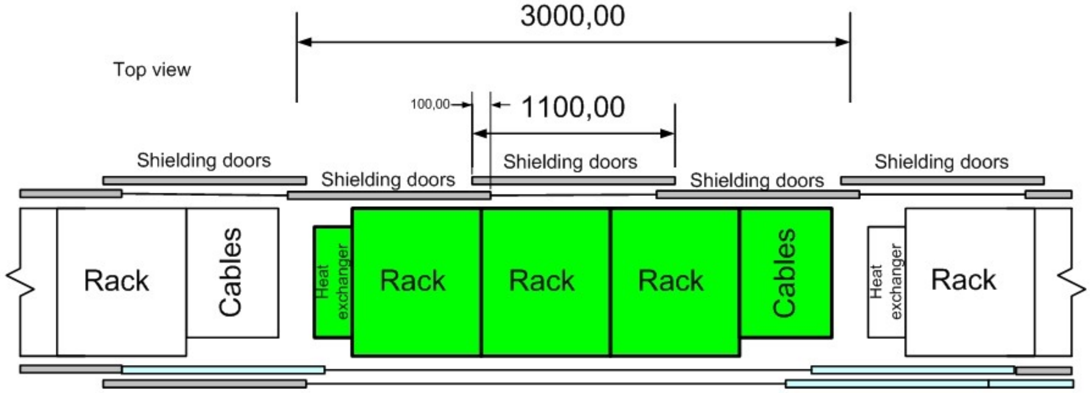


Fig. 28. Top view of set of racks with sliding doors closed and opened.

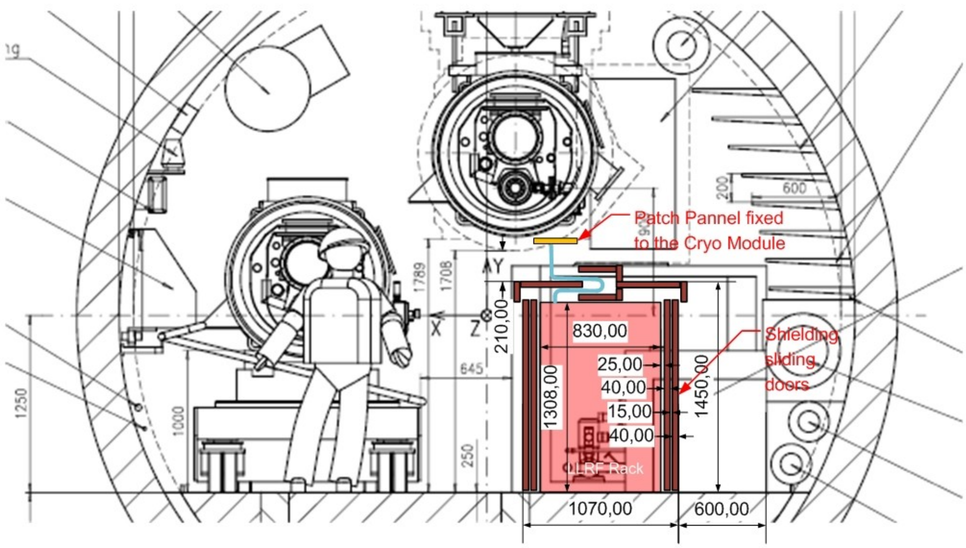


Fig. 29. Tunnel cross section with proposed radiation shielding and cables meander.

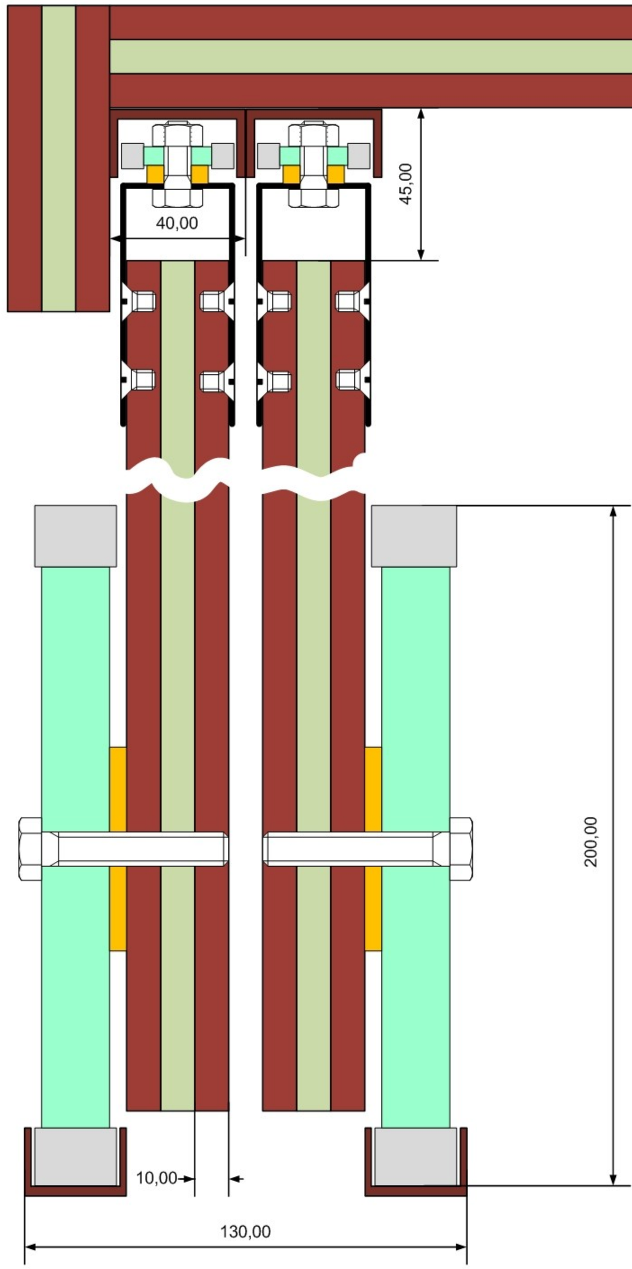


Fig. 30. Sliding doors details.

At the end of 2010 the design of radiation shielding has started. We are in contact with F.Czempik, who is responsible for this task.

2.7.4 Request for space for shielding in tunnel

In first quarter of 2010 it is foreseen to have a preliminary design of heavy concrete radiation shielding. Then we will see how much space is necessary. But we will strongly advice to reduce the amount of space required for radiation shielding. The rear access to racks will be very helpful.

This is a proposal from MSK discussed internally.

3. Installation in Injector Complex – XTIN & XSE

Installation of LLRF System in Injector Complex is a challenging project, specially the design of cable ducts from UG05 to RF Gun, J0, 3,9 GHz System and L1.

3.1 LLRF System for RF Gun, Injector (J0) & Booster (L1)

Installation of LLRF System for RF Gun, J0, 3,9 GHz System and L1 in Injector Complex strongly depends on the system concept. The availability of LLRF System seems to be a main requirement and induce a redundancy of the system. Additionally, the requirements for RF phase stability are for the injector components much more narrow than for the main accelerator.

There are three concepts for LLRF System structure in Injector Complex.

3.1.1 Concept I

All LLRF Systems for RF Gun, J0, 3,9 GHz System and L1 placed on 5th floor (UG05) of Injector Complex which gives full time accessibility and maintainability. There is foreseen to have Main and Spare LLRF System for each injector component, in some cases also a LLRF Development System. The disadvantage of this concept are long RF signal cables which may degrade the system performance. The RF cables to RF Gun, J0 and 3,9 GHz System have acceptable length of 50-70 m but the cables for L1 have length of 150-190 m which will have strong influence on phase drifts and signal delay.

3.1.2 Concept II

Main LLRF Systems for RF Gun, J0, 3,9 GHz System and L1 placed close to the units respectively, Spare and Development Systems placed on 5th floor. This concept gives very good performance for Main Systems, high availability is covered by Spare system with lower performance and maintainability is moderate.

3.1.3 Concept III

Main and Spare Systems for RF Gun, J0, 3,9 GHz System and L1 placed close to the units respectively, Development Systems placed on 5th floor. This concept gives very good performance and high availability for Main and Spare Systems. Maintainability is reduced only to maintenance days or controlled accesses.

Realization of proposed concepts strongly depends on available space. After several discussions and negotiations, small change in J0 CryoModule support design, the space in Injector Complex for Concept III has been found. We have concentrated on Concept III because of its very good performance and high availability. There is not foreseen to have a Development System in XFEL, all tests of new upgraded systems will be done at FLASH.

3.2 Cables types

LLRF System in Injector Complex will use several types of cables for RF signals, piezzo actuators, step motors cavity tuners & phase shifters and for Ethernet connection. All cables should be fire resistant and halogen free.

3.2.1 Coax cables 1/2” & 7/8“ (probe, forward, reflected)

Cables for RF signals should have small attenuation, low temperature phase drift, sufficient bandwidth (1.3 GHz). Those requirements are very important for Master Oscillator signals.

For the cabling purposes of the RF Gun, CryoModules for J0, 3,9 GHz System, L1 we have chosen coaxial cables Cellflex ½” for Probe, Forward and Reflected signals from each superconducting cavity. For the cables going from RF Gun, J0, 3,9 GHz System, L1 to the electronics racks on 5th floor (UG05) where the redundant and development systems will be placed, we have chosen coaxial cables Cellflex 7/8” for Probe, Forward and Reflected signals.

This is a proposal from MSK group discussed a few times on MSK Weekly Meetings and agreed personally with S.Simrock.

For the Concept III, the cables will be much shorter, so it is possible to use Cellflex 3/8” for Probe, Forward and Reflected signals. Tests made by K.Czuba show very low phase drift versus temperature for this type of cable, even better then for Cellflex ½” and 7/8”.

3.2.2 Master Oscillator cables

LLRF System racks will be placed near RF Gun, J0, 3,9 GHz System, L1 and in two rooms on 5th floor (UG05) of Injector Complex. There is necessary to provide Master Oscillator signals to all electronics. Those signals will be feed through coaxial cables Cellflex 7/8” from Master Oscillator (placed on UG05) down to the RF Gun, J0, 3,9 GHz System, L1 and along the accelerator tunnel.

This is a proposal from MSK group agreed personally with K. Czuba.

3.2.3 Piezo cables

Each cavity has two piezzo actuators so we recommend to use the cooper wire cable with two twisted pairs. It is not fixed yet, but as example cable Belden 9729 can be used. The long Piezzo cables from UG05 to L1 should have thicker cooper wires because of voltage drop over ~150 m. It has to be investigated.

This is a proposal from MSK group discussed personally with M. Grecki and T. Pożniak.

Fot the Concept III the piezo cables will be much shorter.

3.2.4 Step Motor cables

Cables for step motor phases will be quite long. For the Concept III, due to lack of space in the racks near cavities, the step motors drivers have to be placed in electronics racks on UG05. Proposed types of cables are:
LYHCH(TP) 12x2x0,5mm , diameter max 17mm,
LIHCH(TP) 4x2x0,5mm diameter max 11mm

3.2.5 Ethernet Connection

There will be two types of Ethernet cables: for outside connection two 10 Gbit fiber optics (LWL) per each LLRF localization (2 rooms on UG05), for connection between two groups of racks in room 11 & 22 two 1 Gbit fiber optics (LWL) is foreseen. Depends on concept, ~48 cooper wire 1 Gbit RJ45 in each LLRF rack room. The type of cables will be provided by IT group.

This is a proposal from MSK group not yet discussed with T.Witt from IT.

3.2.6 Proposed cables with prices and remarks

Till now, we can only recommend coax cables from RFS:
Cellflex 3/8" – price ~1,20 €/m (for big order),
Cellflex ½" – price ~2,30 €/m (for big order),
Cellflex 7/8" – price ~4,25 €/m (for big order),
and
Belden 9729 – for Piezzo actuators.

3.3 Cable plant

Cables ducts design in Injector Complex seems to be the most difficult work done in 2009. A very limited space, a lot of conflicts with other infrastructure (i.e. water pipes, cryo pipes, AC cables etc.). After more than 10 designs and many discussions we have come to the final solution.
Decision for Concept III made in 2010 simplifies the cable plant in Injector Complex. There are not so many cables necessary from UG05 to the RF Gun, J0 and L1. The reserved cables ducts will be used for MO cables, Step Motors cables and Klystron Control cables.

3.3.1 Cables inventory in Injector Complex

The foreseen LLRF cables in Injector Complex are summarized in Table 6.

Cables in XTIN Complex Building Rev.: 12.01.2010

	From	Via	To	Number of cables	Type of cables	Length [m]	Cross-section [mm]	Function & Number of cables	Remarks
1	**Elektronik Rack #1 in XTIN Elektronik raum UG05/011**	**UG05/012, XTIN Medienschacht**	**XTIN1** UG07/008	55	Cellflex 7/8"	~75m - Gun ~60m - J1 ~55m - 3.9	with thermal insulation, **(6x10x32) 400x200 mm +100mm insulation**	RF_Gun-2, J1-24, 3,9_GHz-24, Spare-2	With common thermal insulation both cable duct **500x500 mm** on 5th floor or **500x600 mm** with Klystron Control cables (Entry to XTIN Medienschacht)
2				18	Belden 9729			J1_Piezzo-8, 3,9_GHz_Piezzo-8, Spare_Piezzo-2	
3				18				J1_StepMotorActuator-8, 3,9_GHz_StepMotorActuator-8, Spare_Step-2	
4				18				J1-StepMotor HF Actuator - 16 J1_Spare - 2	
5	**Elektronik Rack #1 in XTIN Elektronik raum UG05/011**	**UG05/012, XTIN Medienschacht**	**XTIN2** UG06/008	55	Cellflex 7/8"	~70m - Gun ~55m - J1 ~50m - 3.9	with thermal insulation, **(6x10x32) 400x200 mm + 100mm insulation**	RF_Gun-2, J1-24, 3,9_GHz-24, Spare-2	
6				18	Belden 9729			J1_Piezzo-8, 3,9_GHz_Piezzo-8, Spare_Piezzo-2	
7				18				J1_StepMotorActuator-8, 3,9_GHz_StepMotorActuator-8, Spare_Step-2	
8				18				J1-StepMotor HF Actuator - 16 J1_Spare - 2	
9	**Elektronik Rack #1 in XTIN Elektronik raum UG05/011**	**UG05/012, XTIN Medienschacht,** UG03/009	**XTIN Klystron - stationen** UG03/010	7	Cellflex 7/8"	~50-75m	**260x100 without** thermal insulation, **400x200 with** thermal insulation	Klystron_Control-6, Klystron_Control_Spare-1	With thermal insulation cable duct **400x200mm**
10				28	Cellflex 1/2"			Klystron_Diagnostics-(6x4=24), Klystron_Diagnostics_Spare-4	
11	**Elektronik Rack #2 in XSE Klystron stationen UG05/022**	**XSE Medienschacht**	**XTL Room 1 & 2**	98	Cellflex 7/8"	?? 150-190m	**(12x11x32) 400x400 +100mm insulation**	L1-(4x24=96), L1_Spare-2	With thermal insulation cable duct **500x500 mm**
12				34	Belden 9729			L1_Piezzo-(4x8=32), L1_Piezzo_Spare-2	
13				34				L1_StepMotorActuator-(4x8=32), L1_Spare-2	
14				34				L1-StepMotor HF Actuator (4x8=32) L1_Spare - 2	
15	**Elektronik Rack #2 in XSE Klystron stationen UG05/022**	**XSE Medienschacht**	**XTL Room 1 & 2**	2	Cellflex 7/8"	~150-190m		Klystron_Control-1, Klystron_Control_Spare-1	
16				5	Cellflex 1/2"			Klystron_Diagnostics-4, Klystron_Diagnostics_Spare-1	

Table 6. The inventory of LLRF Cables in Injector Complex.

The detailed list of cables is also available.

3.3.2 Patch panels

Patch panels are agreed to be placed on CryoModules and RF Gun. The LLRF racks near devices will have direct connection of RF signals (Probe, Forward, Reflected) to the Attenuator box. There will be only the patch panels for Piezzo and Step Motor cables.

This is a preliminary proposal from MSK group, needs discussion on spliters etc.

3.3.3 Possible cables ducts

Depends on chosen concept, the amount of cables going from UG05 rooms 11 & 22 to the RF Gun, J0, 3,9 GHz System, L1 and to the Klystrons on UG03 will change. We

have design the cable ducts for the 'worst case' – the maximum number of cables for each concept.
In the Fig. 31 the simplified schematics of LLRF cables in Injector Complex and to the L1 in XTL is presented.

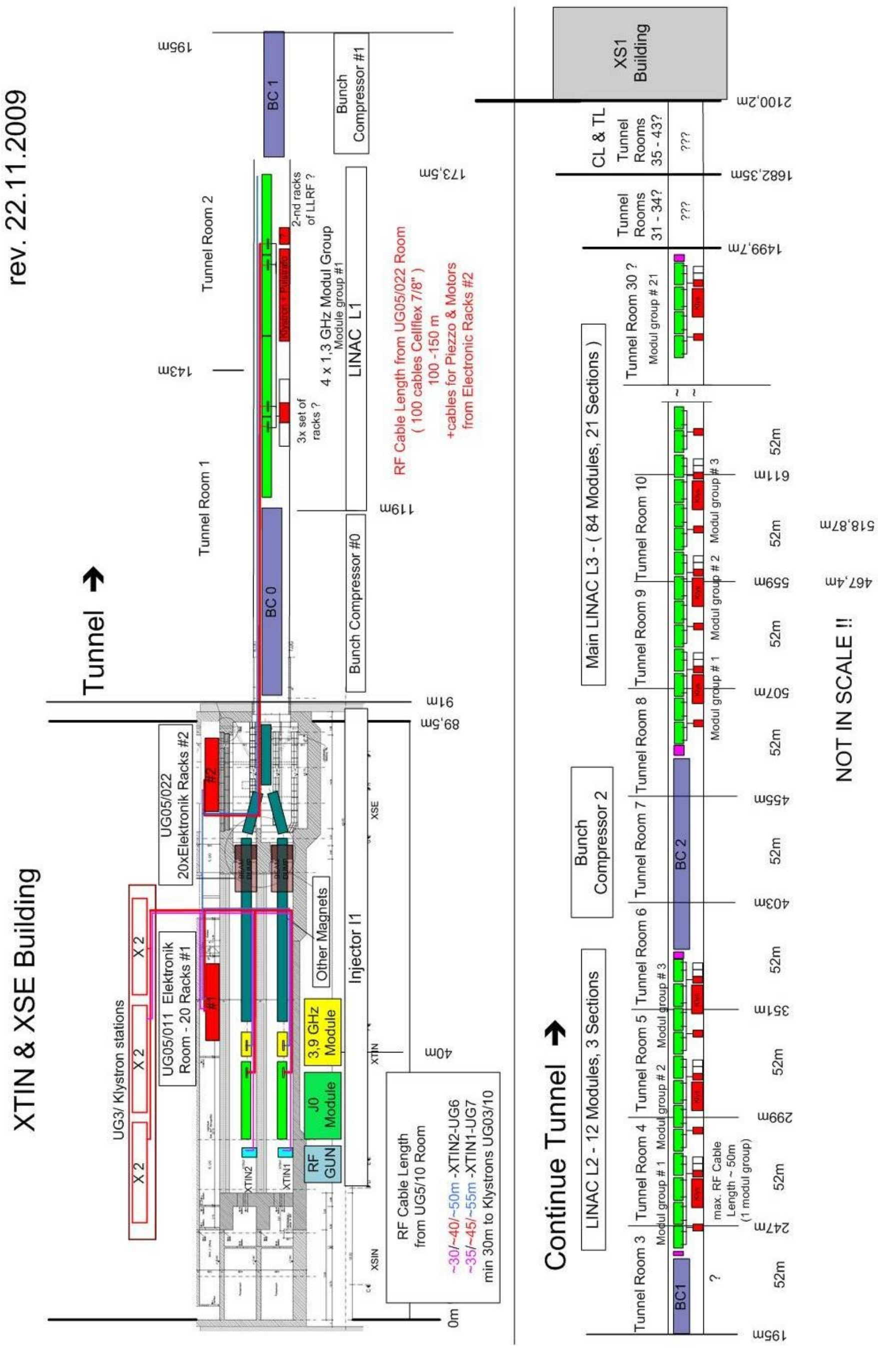


Fig. 31. Simplified schematics of LLRF cables in Injector Complex. More detailed design of cables ducts can be found in Fig. 32.

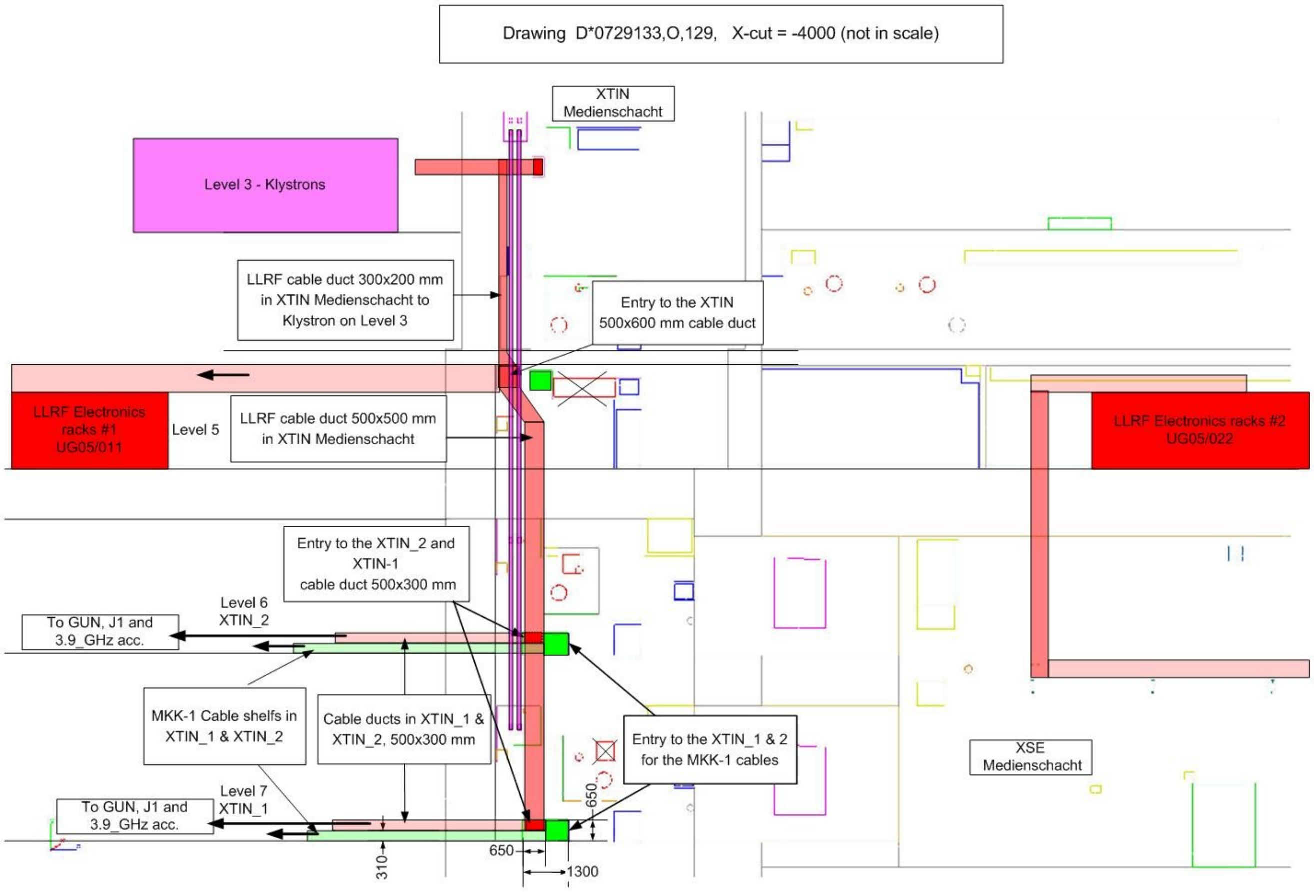


Fig. 32. Detailed side view of LLRF cable ducts in Injector Complex.

The LLRF racks will be placed in two rooms 11 & 22 on the 5th floor UG05 and it is necessary to have a interconnection between this two places for Master Oscillator and control signals. The top view of LLRF racks on UG05 is shown in Fig. 33.

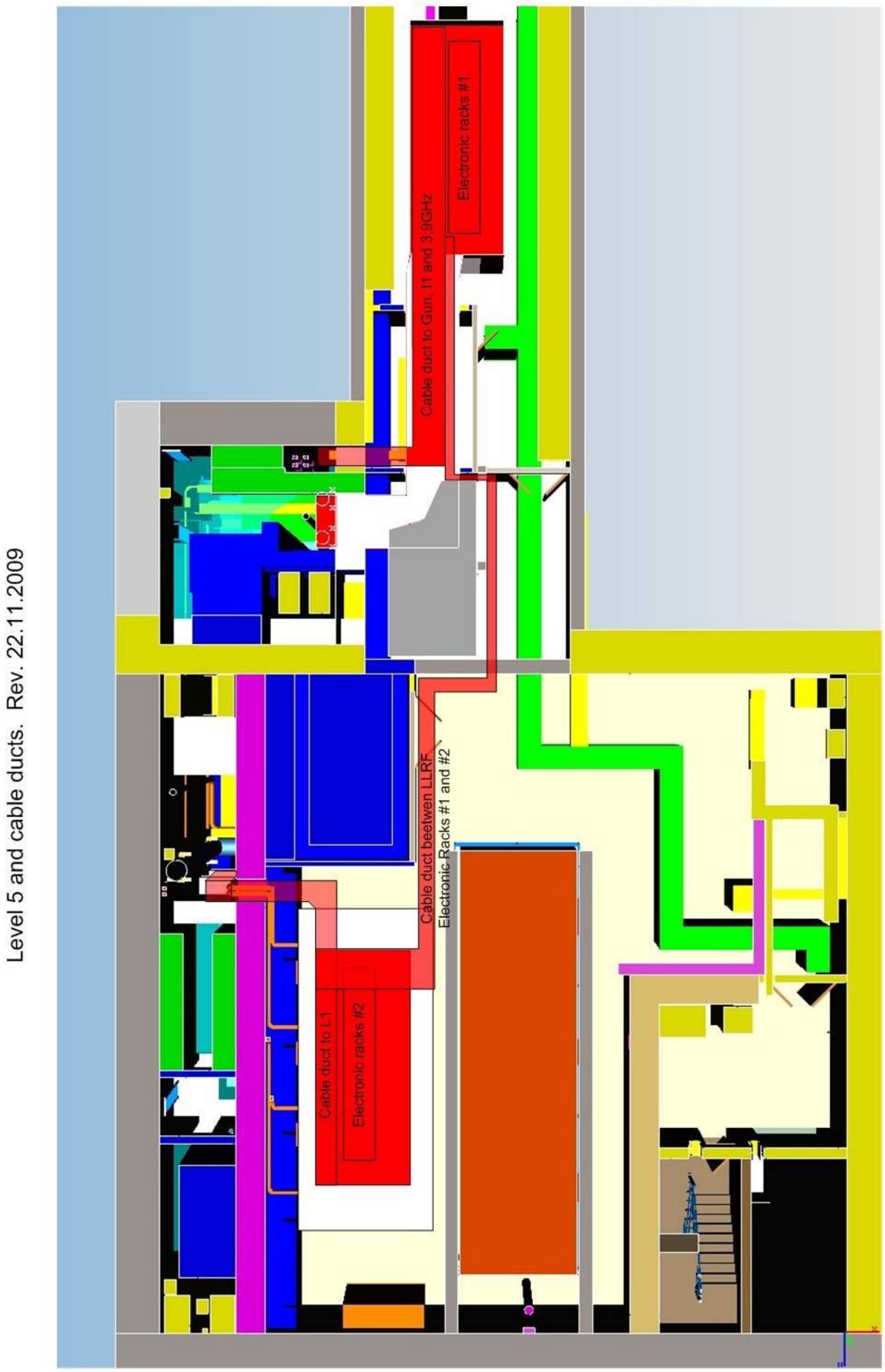


Fig. 33. Top view of UG05 with place reserved for LLRF racks and cable duct between room 11 and 22.

There is foreseen also a space on UG05 for additional LLRF racks in room 21. Reserved for LLRF racks space is shown in Fig. 34.

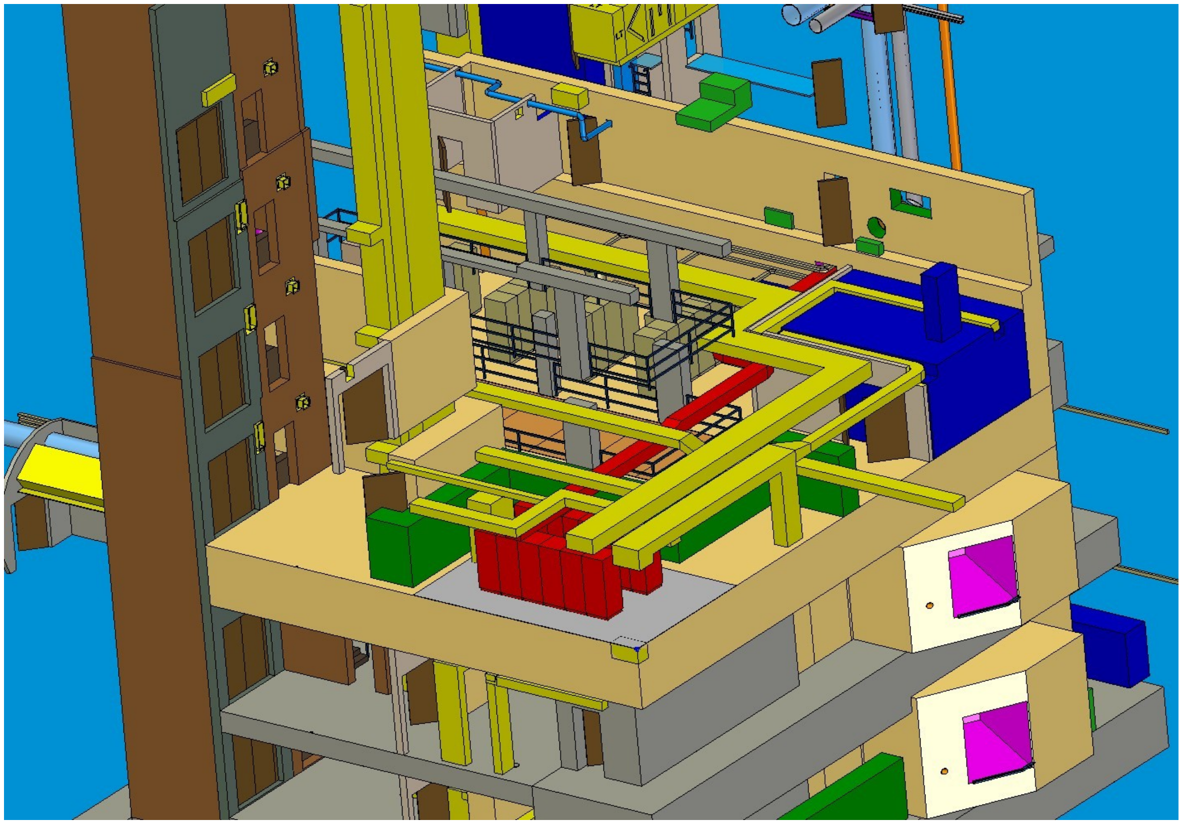
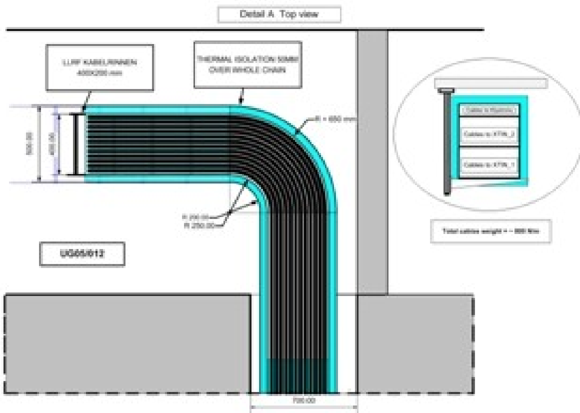
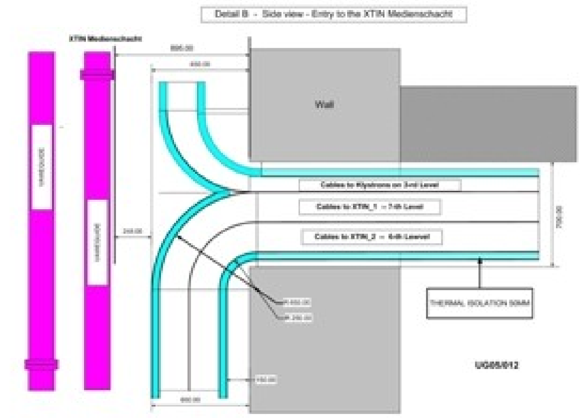


Fig. 34. Additional space for LLRF racks UG05/21 and possible cables ducts (red).

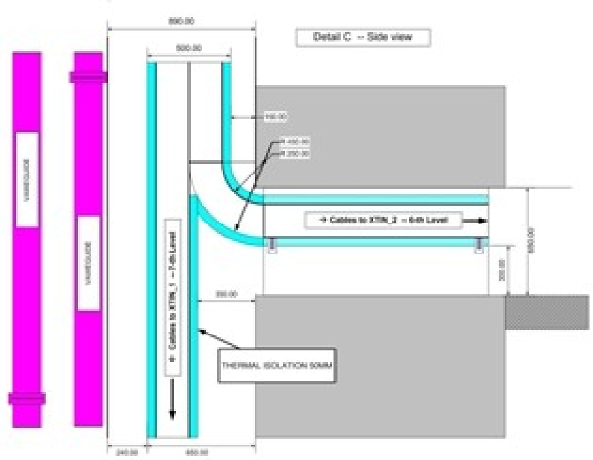
Because the coax cables Cellflex 7/8” have a minimum bending radius we have to design cabling more carefully. In Fig. 35 the proposed cabling with bending details is presented.



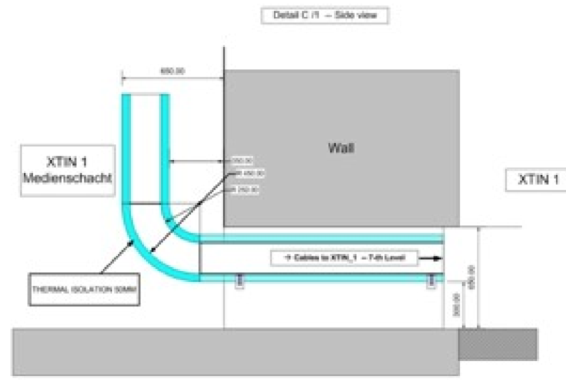
Detail A Top view
LLRF KABELRINNEN
400X200 mm
THERMAL ISOLATION 50MM
OVER WHOLE CHAIN
R = 650 mm
R 200.00
R 250.00
UG05/012
Cables to XTIN_2
Cables to XTIN_1
Total cables weight = ~ 800 N/m
700.00



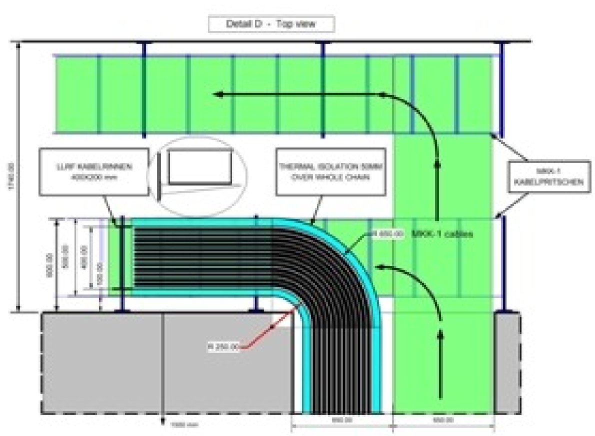
Detail B - Side view - Entry to the XTIN Medienschacht
XTIN Medienschacht
890.00
Wall
Cables to Klystrons on 3-rd Level
Cables to XTIN_1 -- 7-th Level
Cables to XTIN_2 -- 6-th Leavel
700.00
THERMAL ISOLATION 50MM
UG05/012
650.00



Detail C -- Side view
890.00
500.00
R 450.00
R 250.00
→ Cables to XTIN_2 -- 6-th Level
650.00
← Cables to XTIN_1 -- 7-th Level
THERMAL ISOLATION 50MM
240.00
650.00



Detail C /1 -- Side view
650.00
Wall
XTIN 1
Medienschacht
XTIN 1
R 450.00
R 250.00
→ Cables to XTIN_1 -- 7-th Level
THERMAL ISOLATION 50MM
650.00
300.00



Detail D - Top view
1740.00
LLRF KABELRINNEN
400X200 mm
THERMAL ISOLATION 50MM
OVER WHOLE CHAIN
MKK-1
KABELPRITSCHEN
R 650.00
MKK-1 cables
R 250.00
600.00
500.00
400.00
650.00
650.00
1000 mm

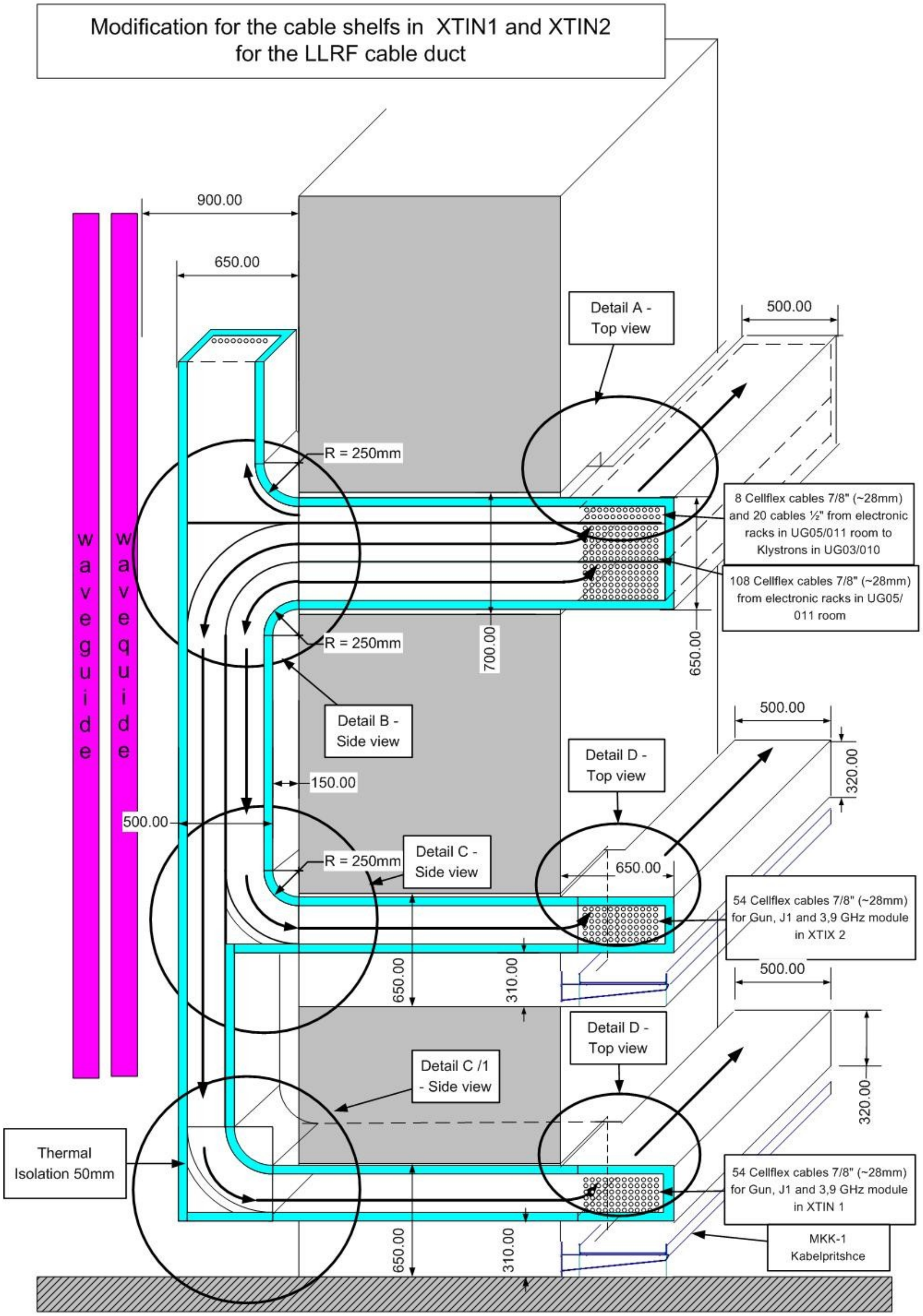


Fig. 35. Details of cable shelves with bending requirements.

3.3.4 Space for cables requirements

The proposed LLRF cables ducts in Injector Complex have been implemented in 3D model as place holders and all collisions with other equipment have been fixed.
The 3D model of injector Complex can be found in EDMS –D*729133,S,1,37 and an example is shown in Fig. 36.

XTIN & XSE Injector Complex with LLRF Cable ducts EDMS Doc No: D00000000729133,S,1,37

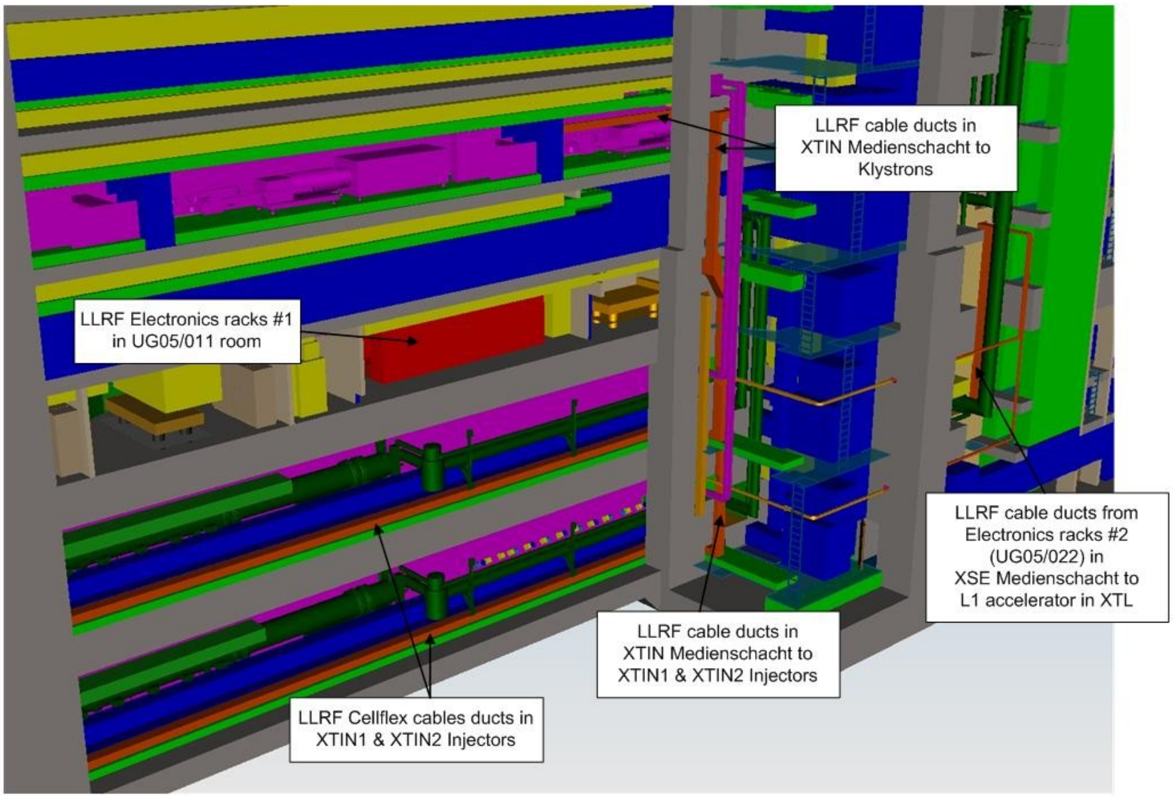


Fig. 36. View of the LLRF cables ducts and space for racks in Injector Complex.

This is a proposal from MSK implemented in 3D model of IC. The space for LLRF cables and racks has been reserved.

3.4 Thermal stabilization of coax cables

Requirements for phase stability in injector devices (RF Gun, J0, 3,9 GHz System, L1) are very narrow. Because the RF signal cables are quite long (for the Concept I, see chapter 3.1.1.), thermal drift of signal phase in cables can significantly degrade the system performance. Active or passive thermal stabilization of coax cables is necessary.

This is a proposal from MSK group discussed on MSK Weekly Meetings to achieve better phase stability of RF signals specially for Injector Complex and quite long cables.

3.4.1 Phase drift in Cellflex cables

Temperature dependent signal phase shift in coax cables Cellflex ½” and Cellflex 7/8” can be found in Fig. 37 and Fig. 38 respectively.

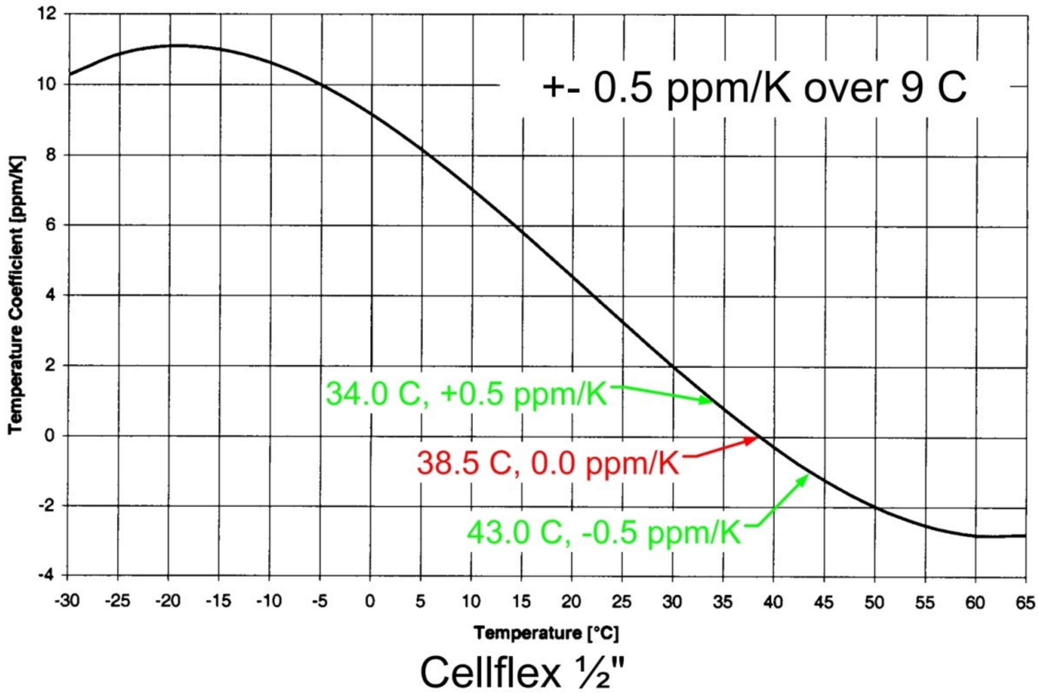


Fig. 37. Signal phase drift in Cellflex ½” versus ambient temperature.

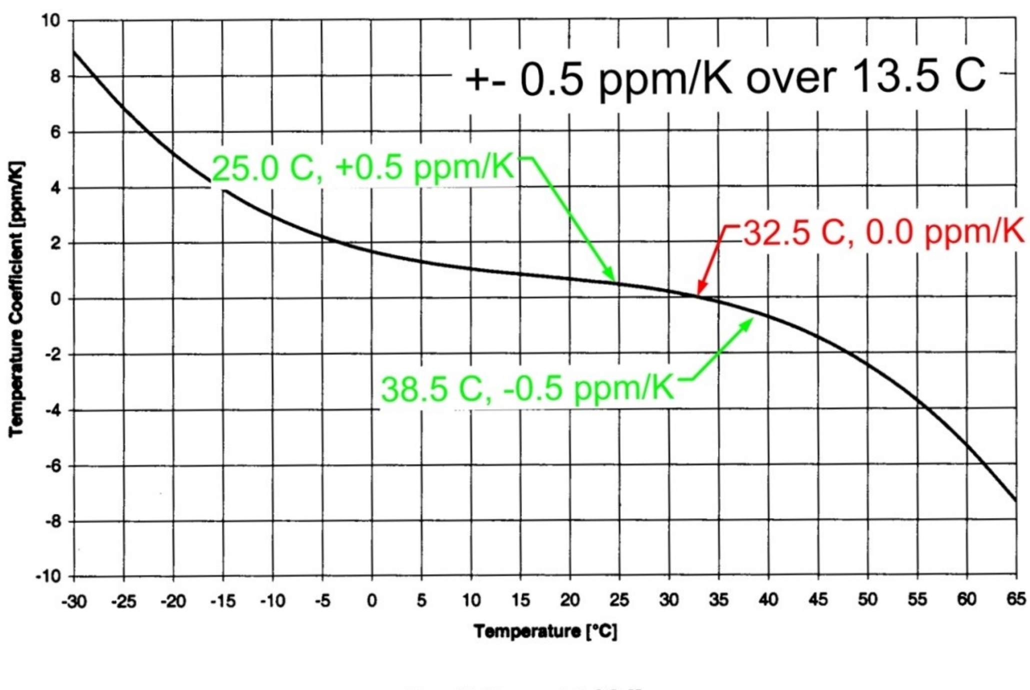


Fig. 38. Signal phase drift in Cellflex 7/8” versus ambient temperature.

It is clearly seen, that the best temperature for phase stabilization is 38,5 ˚C for Cellflex ½" and 32,5 ˚C for Cellflex 7/8".

3.4.2 Concept of thermal stabilization of cables

We plan to use cables shelves (220 mm * 400 mm) for LLRF cables in Injector Complex and for cable ducts to L1 in XTL. Cable trays will be used as radiator heated by floor heating cables (cheap cable) and insulated with 5 cm of halogenfree foam. Aluminum shelf seems to be better for this purpose but steel is cheaper and acceptable. The cable trays will be divided in to 5-10 m long sections with individually controlled temperature. All temp. controllers will be connected via CAN link with XFEL Control.

The power needs for all LLRF cables temperature stabilization can be estimated to ~ 20 W/m * ~400 m = 8 kW. We intend to use Wiener Power Supplies 48 V (same as for ATCA crate) 4-6 pcs.

3.4.3 Prototype design

For the proof of concept basis we have designed and build a 4 meter long temperature stabilized chamber where 133 m of coax cable Cellflrx ½" has been installed. The inner chamber is placed in additional outer chamber, also temperature stabilized, to simulate ambient temperature changes. The simplified drawing of prototype chamber can be found in Fig. 39.

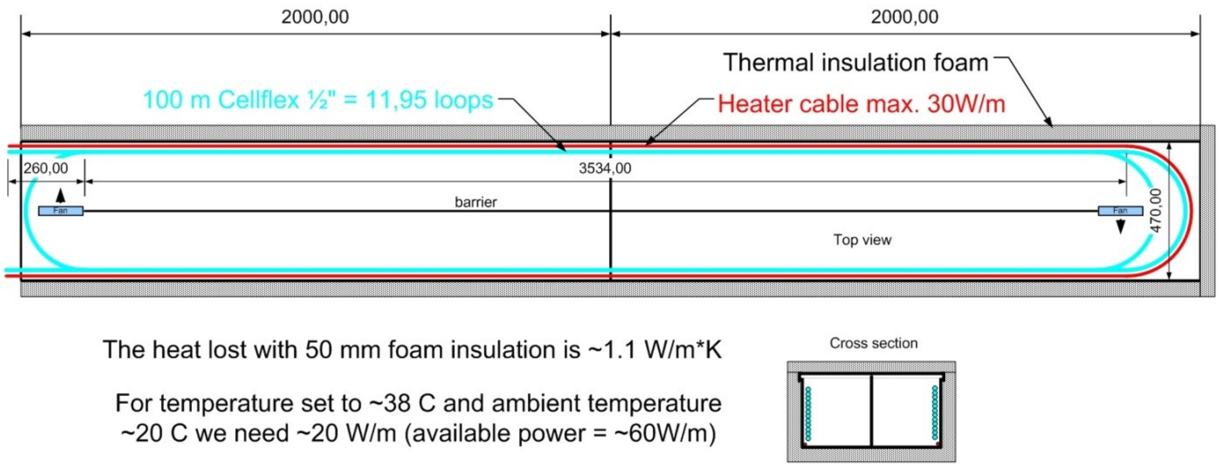


Fig. 39. Prototype chamber for coax cable temperature stabilization.

In the prototype chamber we have a possibility to test the phase drift versus temperature with and without fans 'melting' the air inside chamber – for final solution we don't want to use fans because of possibly vibrations and fan fault.

3.4.4 Temperature controller

To stabilize the temperature of inner and outer chamber we have designed and build a temperature controller.

Controller hardware should have:

- communication via CAN bus with other controllers (for a set of controllers along one cable path it is foreseen a converter CAN to TCP/IP to integrate with DOOCS – for prototype interface CAN-USB will be used),
- up to 16 temperature sensors to be read for prototype, finally ~2-4 sensors,
- 2 ADC inputs to measure voltage and current of heater,
- 1 DAC or PWM output to control current in heater,
- power stage for proportional control heat dissipation.

Software for controller should provide:

- PID control of temperature inside cable box based on various combinations of temperature sensors readings (mean value, weighted etc.),
- communication via CAN bus with CAN-TCP/IP converter (status, voltage/current of heater, temperature readings, set of temperature).

We intend to use a resistive cable with silicon insulation designed for floor heating. The resistance for such cable is 12 Ω/m, max. power 30W/m, max. voltage 500V and operating temperature up to 200°C. The cost of such cable is ~0.5 €/m (~2 €/m with additional screening).

Hardware

The schematics of designed controller is presented in Fig. 40 – 44.

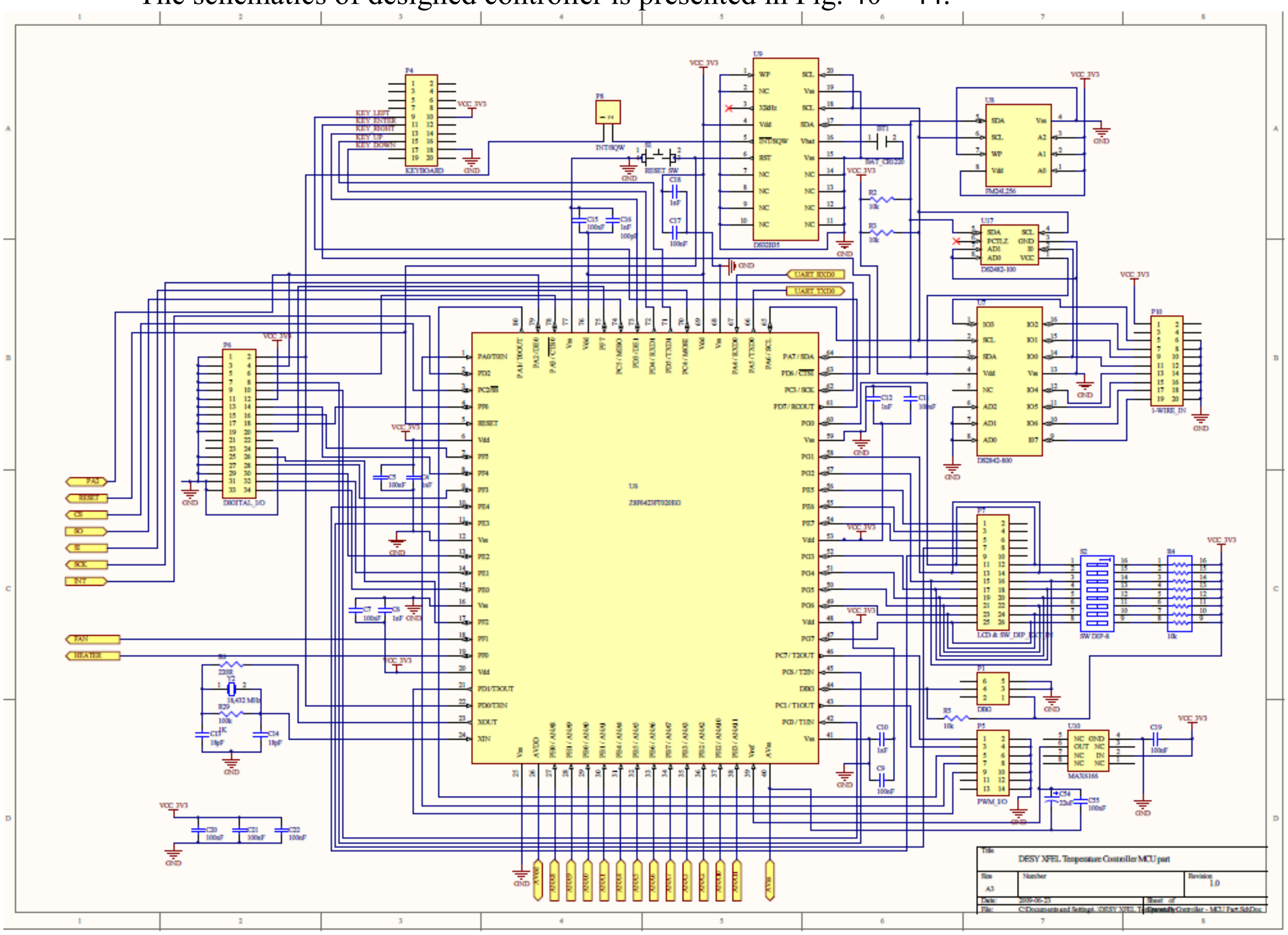


Fig. 40. Schematics of Temperature Controller.

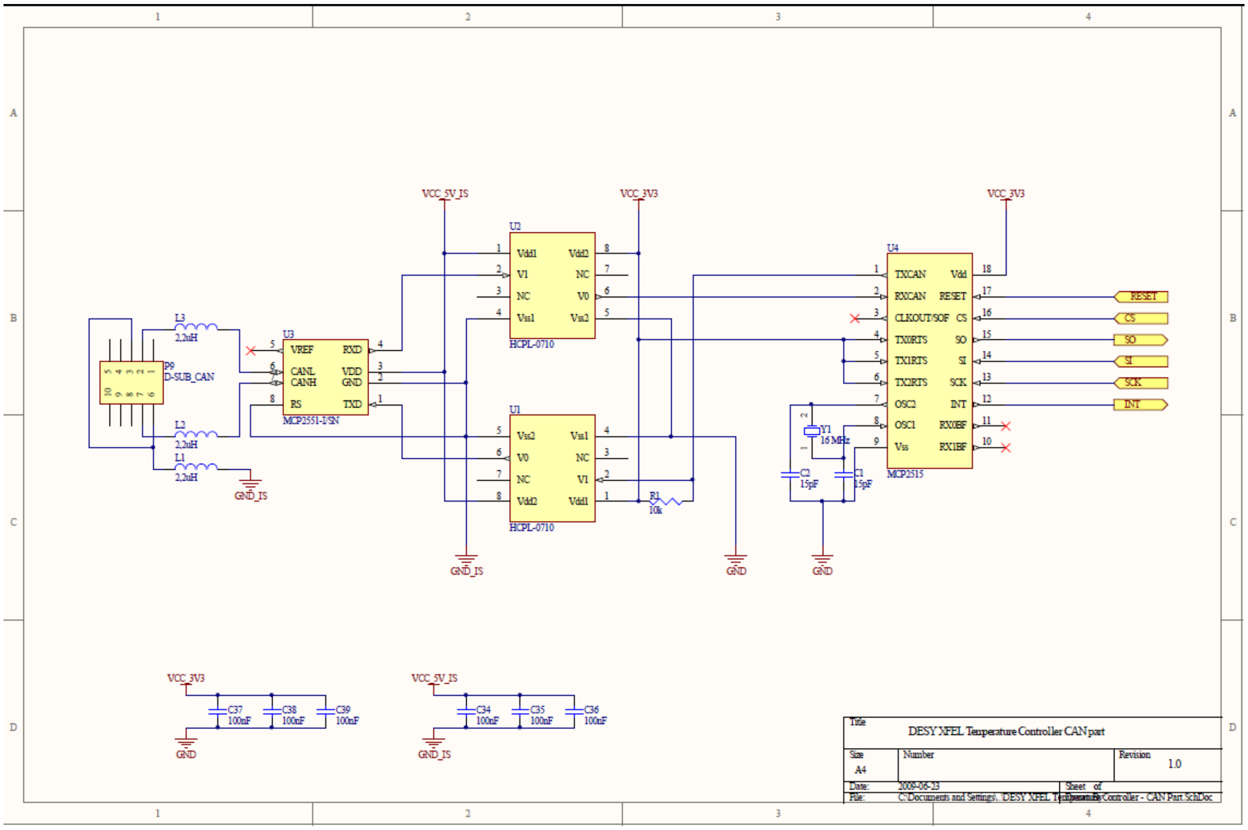


Fig. 41. CAN Interface.

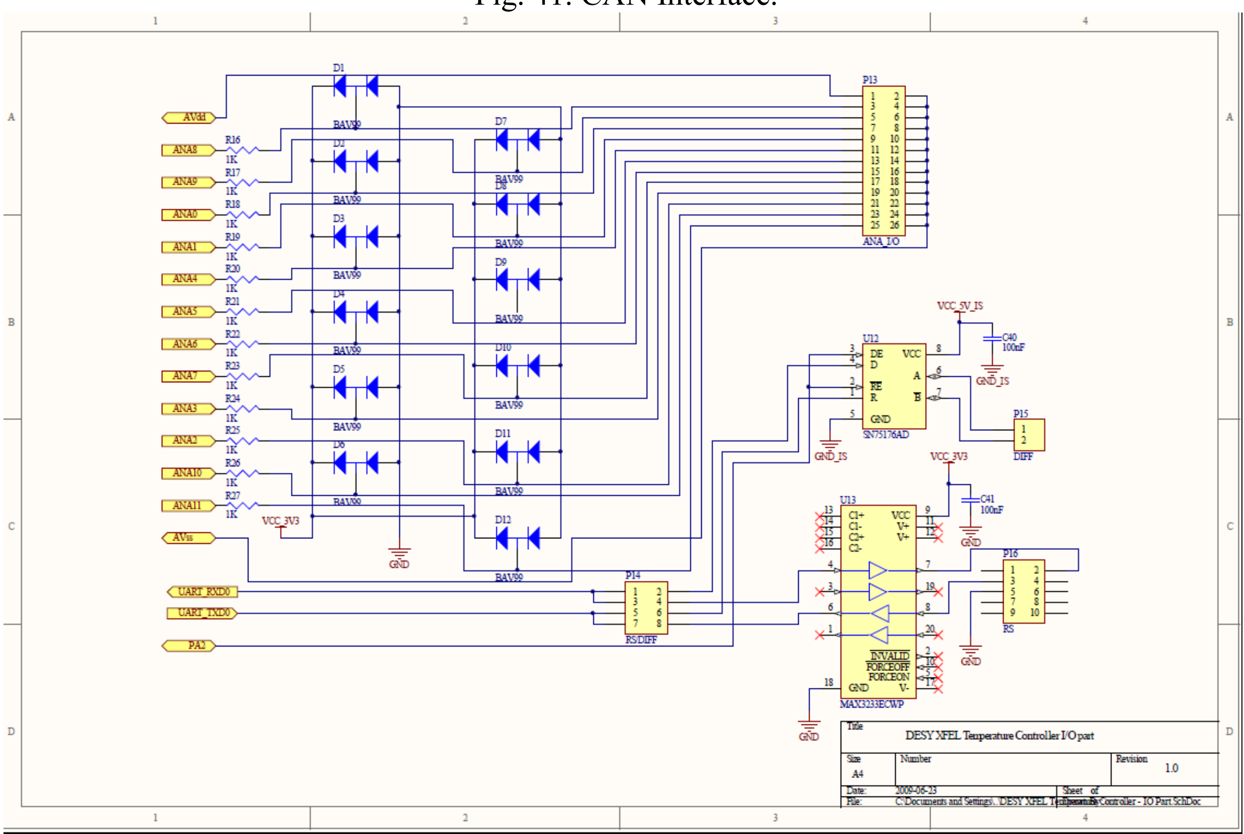


Fig. 42. I/O for Temperature Controller.

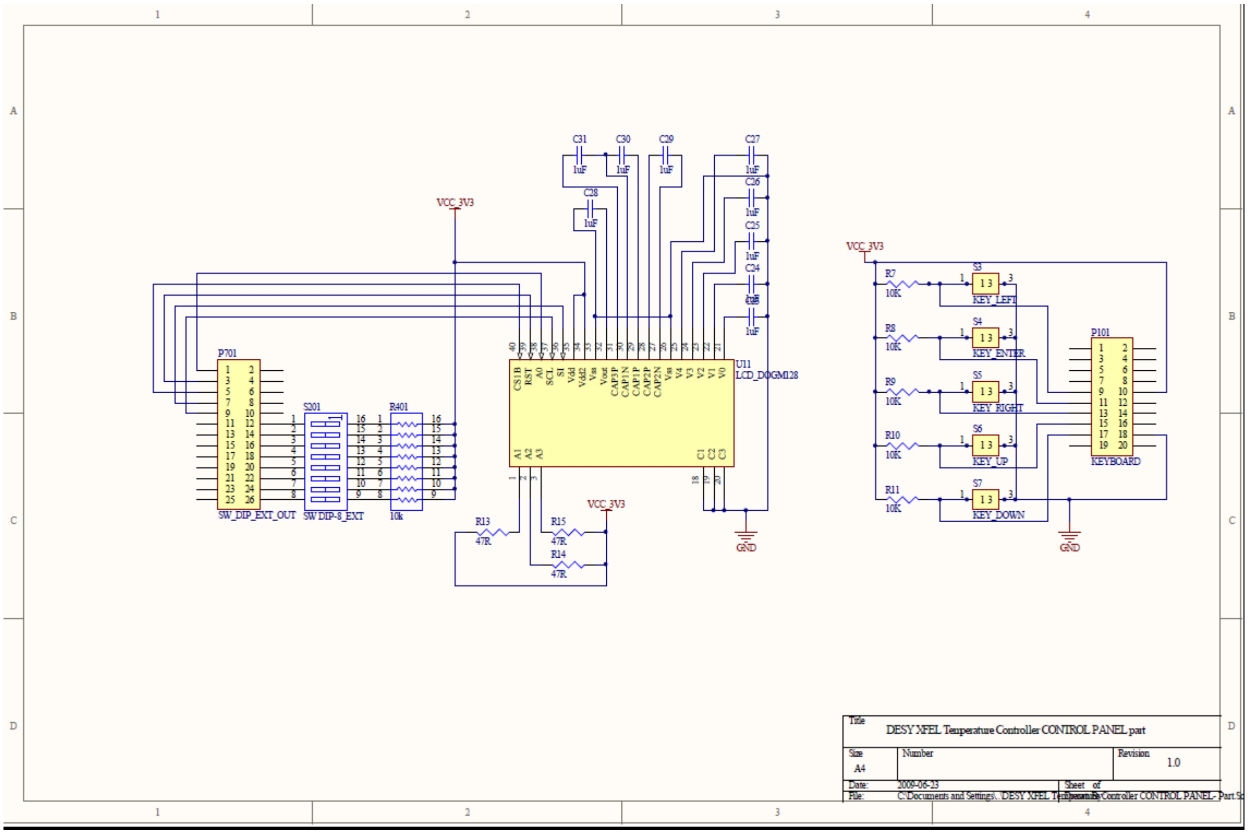


Fig. 43. Display and 'joystick' switches for Temperature Controller.

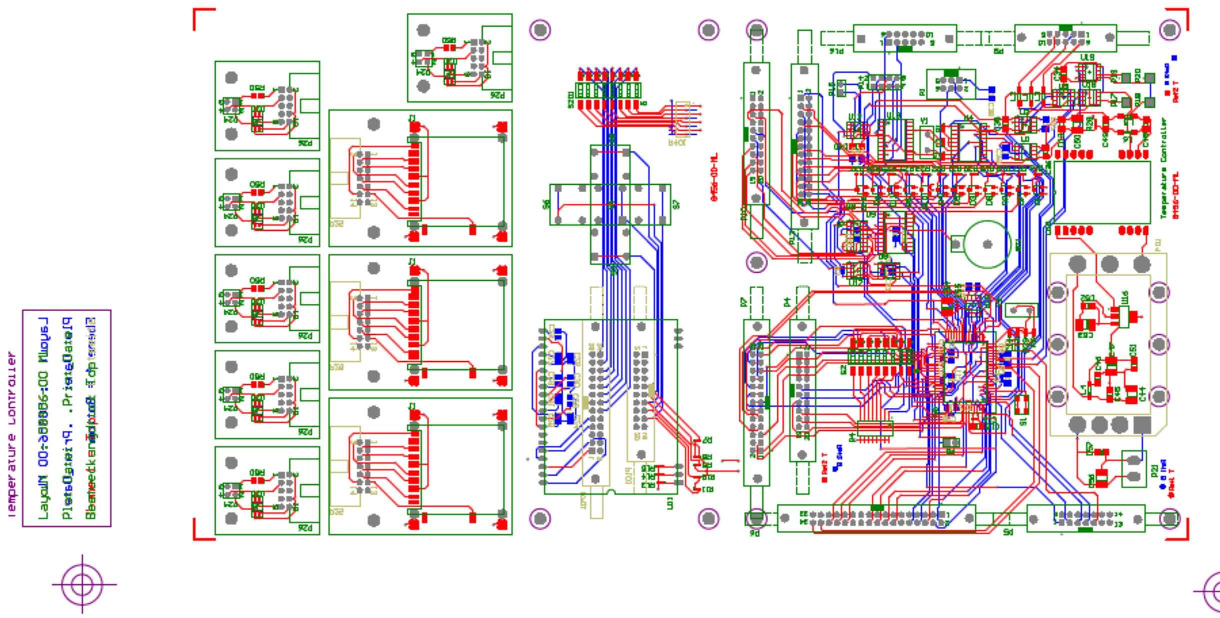


Fig. 44. PCB design.

Four Temperature Controllers have been assembled, one is currently used for coax cable chamber control, other Temperature Controllers are foreseen to be used as Data Loggers for cooling of racks tests.

Altium project files can be found:

https://svnsrv.desy.de/k5viewvc/MSK_Doc/trunk/users/Wierba/Temperature%20Controller%20-%20Sch%20%26%20PCB/

Software

This chapter describes the firmware for the Dual Channel Temperature Controller. In the next sections a brief overview of the firmware functionality and main features are presented. Also list of the project source files with some hints for the maintenance or further development are included. The last section shows the PC program used for tests as well as used interfacing hardware.

DUAL CHANNEL TEMPERATURE CONTROLLER FIRMWARE OVERVIEW

The firmware, dedicated to Zilog Z8F64 Encore microcontrollers, implements two independent ON/OFF temperature control loops with programmable hysteresis. Set points for each control channel can be defined as a weighted average of any of 16 temperature sensors. Current temperature values are displayed on controller's LCD display, as well as sent to the host computer. Communication with the host utilizes the CAN bus, which can be shared by up to 32 such controllers. The communication with host allows also setting of the control loop parameters: set point, hysteresis value and weight factors for each temperature sensors.

Temperature sensor readout

The controller reads chain of up to 16 temperature sensors DS28EA00. The sensors, produced by the Maxim Integrated Products, measure temperatures from -40C to 85C with resolution of 0.1C and send digital result over the 1-WIRE bus. These sensors offer additionally an unique feature of the sequence detection, providing an easy way of mapping readouts to the physical location of the sensor in the chain.
The 1-WIRE bus protocol is not handled directly by the firmware. The firmware sends via the I2C interface high-level commands to the 1-WIRE bus master (DS-242-800, Maxim) which takes care about bus timing and bit-level communication details.

Controller – Host Communication

Communication with the controller is provided by the CAN interface. The external CAN controller (MCP2515, Microchip), connected to the Zilog microcontroller via SPI port, is used. Due to the high costs of protocol stack no standard application layer has been implemented. However, some subset of the CANopen functionality is provided by the firmware. Implemented are: NMT commands, boot-up message and heartbeats, SDO (expedited and segmented only), PDO (internal timer triggering only). All controller configuration parameters as well as process data are available as Object Dictionary entries. These approach permits to use standard CANopen software tools in order to setup the controller, read measured temperatures or system debugging.

LCD display and Serial Console

Temperatures, measured by the controller, are displayed on the controller's LCD. The values are displayed on two screens, switched by a user by pressing any of front panel buttons. The first screen shows temperatures of sensors 1..8, the second one - temperatures of sensors 9-16. Although setting of controller parameters as well as data readout is done via the CAN bus, the screen provides users with a quick check of controllers behaviour. In addition, for debugging purpose, the console (ex. PC terminal emulators like TeraTerm, Hyperterminal) can be connected to the controller's serial port.

PROJECT NOTES AND LIST OF FIRMWARE SOURCE FILES

The firmware was written for the Zilog Z8F64 Encore microcontroller family, using the ZDS-II, the standard Zilog IDE tool for PC computers. The IDE is available for a download from the Zilog web site. The IDE offers a simple editor, ANSI C cross-compiler, linker, in-circuit debugger and microcontroller flash programmer. The Smart Flash Programmer, which comes along with the cheap (~$40) Z8F64 development system, was used to connect PC to the controller board for debugging and flash programming.

List of the source files:

thermoControl.zdsproj	project file for the Zilog ZDS-II IDE.
can.c	basic CAN and some CANopen functions
canMsgQueue.c	queues for CAN messages
control.c	control loop functions
dogm128.c	LCD handling functions
ds28ea00.c	temperature sensors specific functions
i2c.c	I2C controller functions
keys.c	handling of front panel keys
main.c	main program – entry point
mcp2515.c	Microchip's external CAN controller handling
od.c	access to parameters and process variables
onewire.c	ds2482 commands and some 1-wire functions
sdo.c	SDO protocol handling
spi.c	SPI interface
temperaturemeasurement.c	measurement of temperatures
timers.c	timing tools
abrtCode.h	list of used abort codes for SDO protocol
can.h	CAN low-level function prototypes

canMsgQueue.h	message queues function prototypes
control.h	declarations of control loop parameters
dogm128.h	LCD function prototypes
ds28ea00.h	temperature sensor function prototypes
errorRegister.h	definition of error register bits
i2c.h	I2C manipulation function prototypes
keys.h	mapping of front panel keys
mcp2515.h	external CAN controller definitions
od.h	Object Dictionary access function prototypes
oneWire.h	1-wire function prototypes
processdata.h	process data declarations
sdo.h	SDO protocol handler definitions
spi.h	SPI interface function prototypes and definitions
temperatureMeasurement.h	temperature measurement control function
prototypes	
timers.h	timing functions prototypes
tools.h	serial port selection function prototype

PC SOFTWARE

As it was mentioned above the firmware implements some subset of the CANopen protocol functionality. Therefore any CANopen compliant configuring/monitoring tool can be used in order to access controller parameters or temperature readouts. For the preliminary tests the CANopenMonitor program, available at DESY (written by the MCS-1 group programmers) was used. In order to log readouts of all temperature sensors over the long period of time (up to 12 h), as well as to provide more convenient setup of dual channel controller parameters, a dedicated software, the CANnet, was written.
The screenshot in Fig. 45 shows the control loop parameters setup panel.

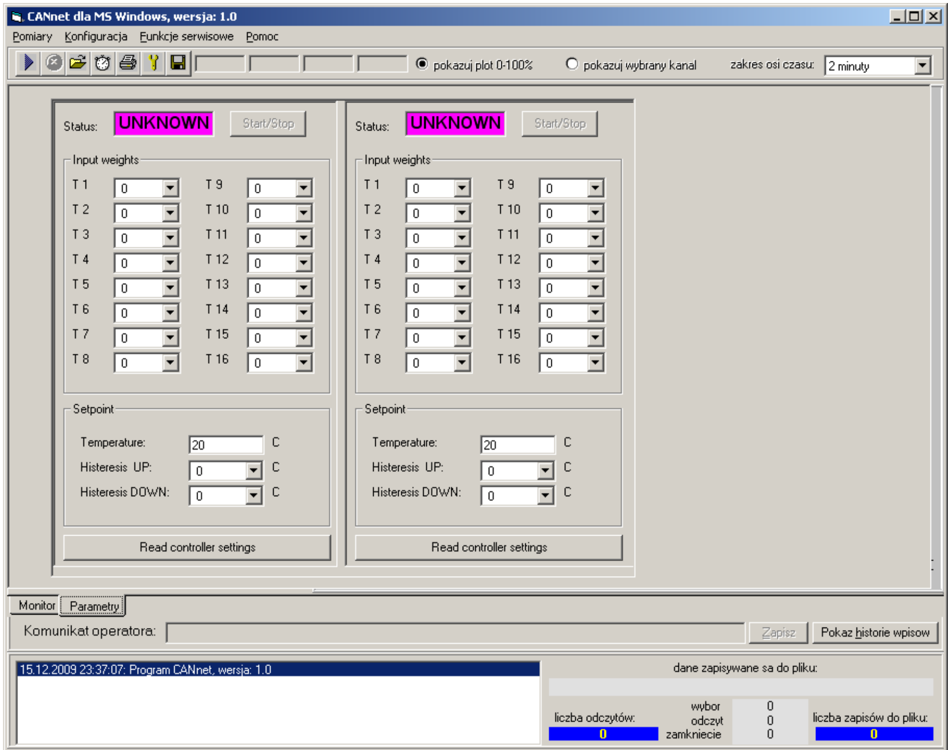


Fig. 45. Screen shoot from the control loop parameters panel.

Both programs run under Windows XP and use the USB-CAN interface, provided by the Peak Company (see http://www.peak-system.com).

Software source code can be found:

https://svnsrv.desy.de/k5viewvc/MSK_Doc/trunk/users/Wierba/Temperature%20Controller%20-%20Software/

3.4.5 Results

At first we have checked, that temperature in inner chamber set to 37,8 ˚C is stabilized very well. The measurement proofs, that the temperature in inner chamber changes ±0,25 ˚C with fans on and ±0,5 ˚C with fan off for the outer chamber temperature change from 26 – 34 ˚C. Typical results are shown in Fig. 46.

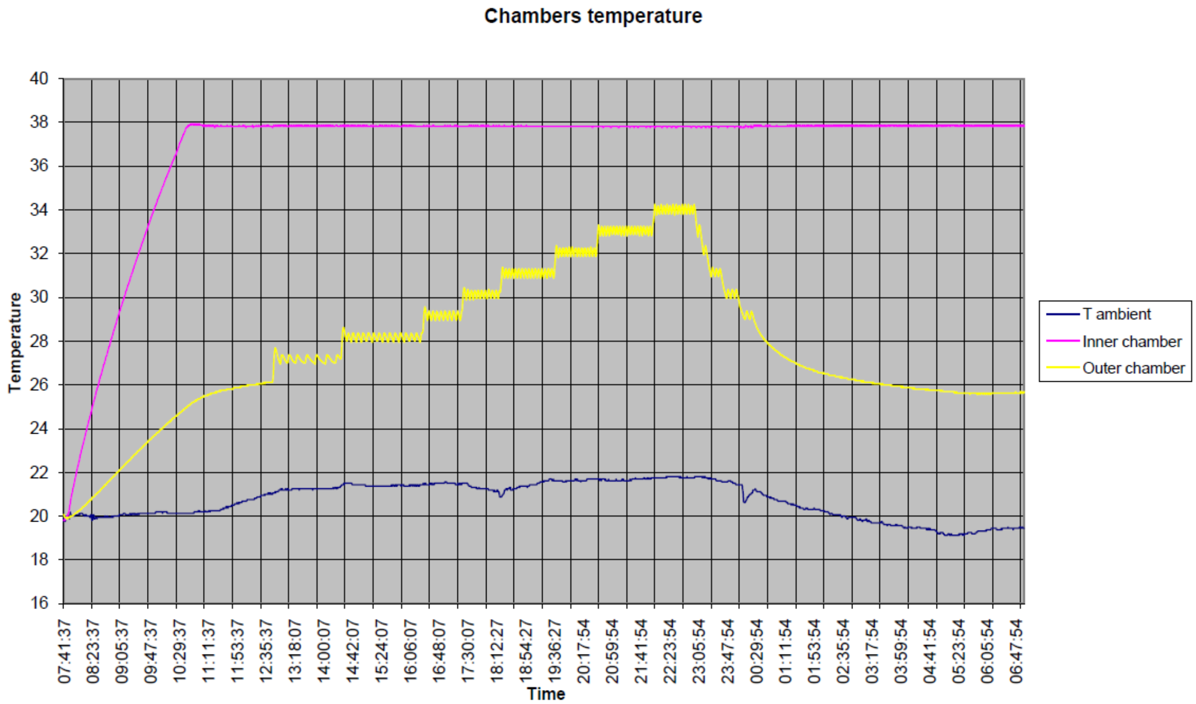


Fig. 46. Temperature stabilization in chambers.

The signal phase drift have been measured in 133 m long coax cable Cellflex ½". We have found, that most probably, the phase shift we have observed comes from temperature instability of phase sensitive amplifier and connecting cables. Corrected with ambient temperature results are presented in Fig. 47. The temp coefficient can be calculated to be roughly 5,3 fs/m*K. We have to repeat the phase drift measurements with better setup.

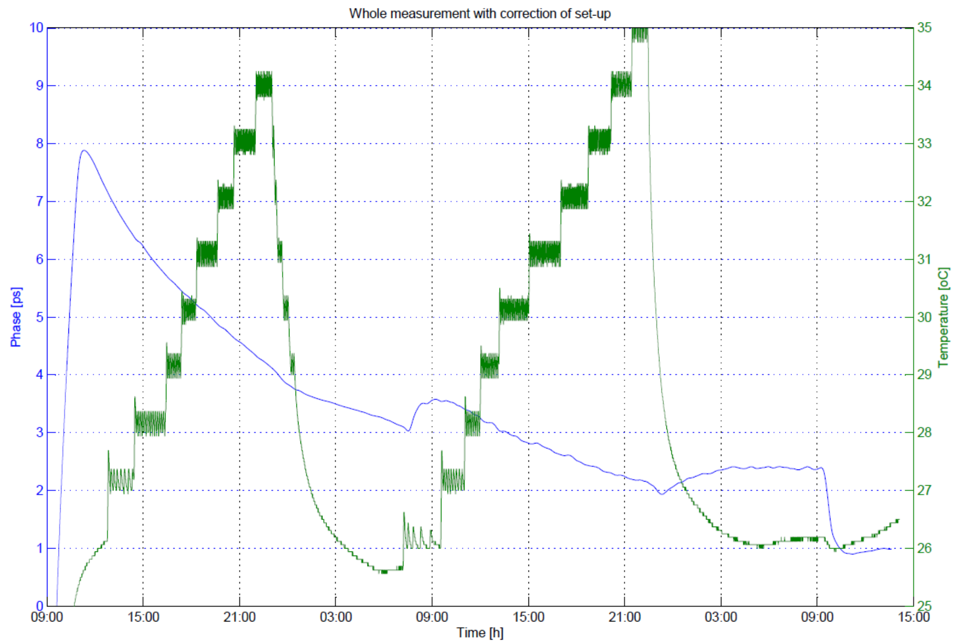


Fig. 47. Phase drift in Cellflex ½" coax cable stabilized to 37,8 ˚C versus outer chamber temperature.

We have proved that concept of temperature stabilization of coax cables works and all cables ducts in Injector Complex are designed for that purpose (larger space reserved to cover thermal insulation).

3.5 Racks

That was temporary decided by the Rack Committee (K. Rehlich), that for Injector Complex the subcomponents have a freedom to chose appropriate to their needs racks. We have preliminary chosen the racks called Data Center from firma ZPAS for the electronics placed on UG05. For the Concept III we will need special racks 16U height to place them under the CryoModules for RF Gun, J0 and 3.9 GHz.

3.5.1 Data Center

Data Center is a expandable set of racks (in our case 2 rows of 8 racks each) covered from top with sliding doors on both sides of corridor. Such a solution gives us an possibility to work on LLRF Systems without changing the temperature in racks (the corridor is also air conditioned). Sliding doors provide us with controlled access to the systems.

The Data Center is presented in Fig. 48.

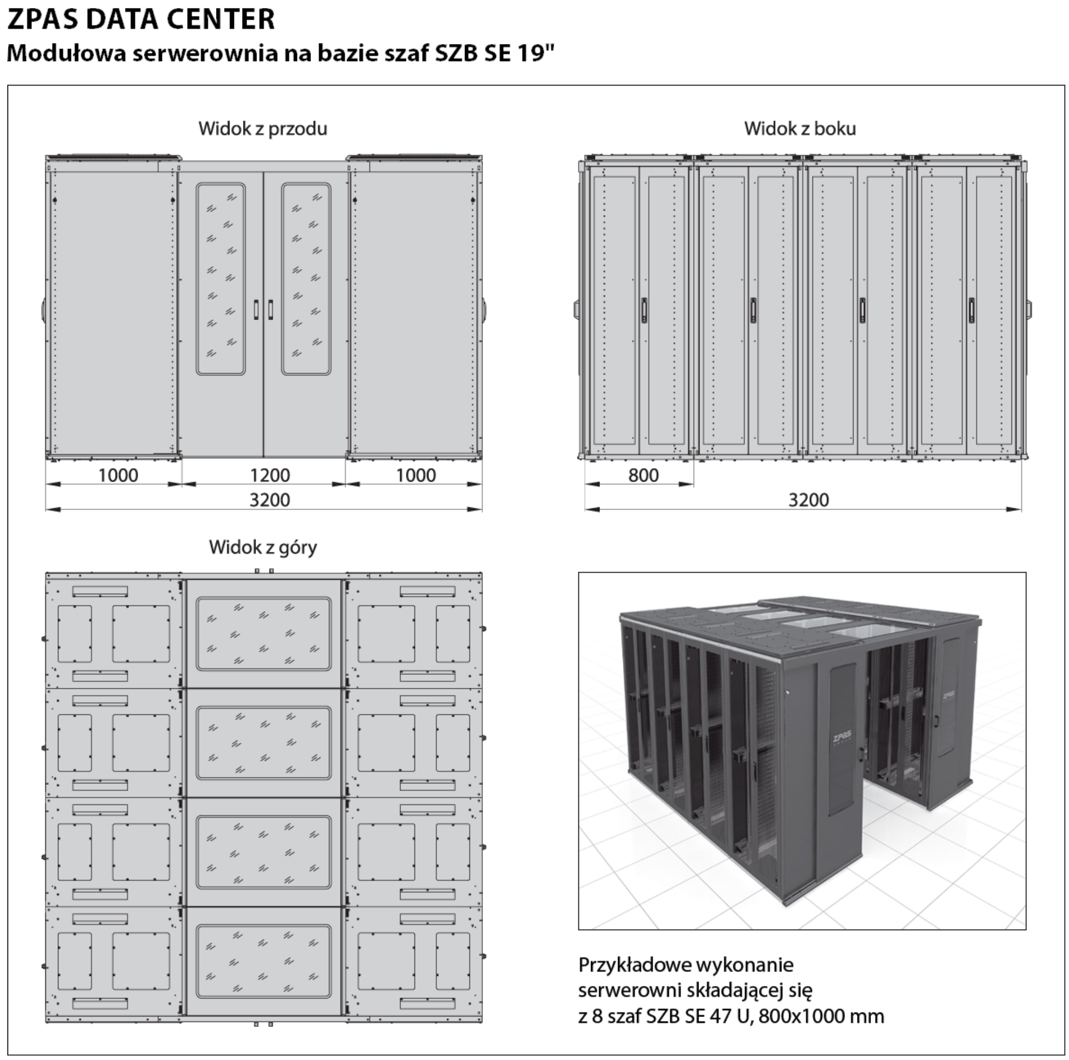


Fig. 48. Data Center from ZPAS.

This is a proposal from MSK group discussed on MSK Weekly Meetings.

3.5.2 Rack standard for UG05

Data Center will be equipped with standard 42U height 19" racks. The air-to-water heat exchangers will be placed in Data Center between racks.

This is a proposal from MSK group discussed on MSK Weekly Meetings.

3.5.3 Rack standard for Injector

LLRF Sytems (Main & Spare) will be placed in 3 and 2 racks 'containers' 16U each.

- Height of rack – 16U (no base because of front-rear air circulation)
- Height of 'container' – 1200-1300mm (depends on radiation shielding thickness)
- Width of rack – 19"

- Depth of rack – min. 700 mm (crates (ATCA) needs less, but Fire Protection Unit needs ~700 mm)
- Depth of 'container' - ~800 mm (can be smaller)
- Length of 'container' for 3 racks - ~2160 mm
- Length of 'container' for 2 racks - ~1456 mm

The design of LLRF 'container' has started but the final solution strongly depends on radiation shielding design.

3.5.4 Rack power

We have estimated for LLRF racks Data Center the maximum AC Power to be less than 3 kW per rack.

This is a proposal from MSK group discussed on MSK Weekly Meetings.

For Injector we have estimated the maximum AC Power to be less than 3 kW for 3 racks 'container' and 2 kW for 2 racks 'container'.

3.5.5 Rack cooling UG05

- Air-to-water heat exchangers
- In Data Center there will be a few air-to-water heat exchangers with redundant fans (2-4). This will fulfill the redundancy requirement.
- Emergency cooling system (fans) to the IC air. Opening to the outside air should be dust tight for 'normal' operation.
- Cooling power - ~3 kW per rack for inner temp. ~25°C (cooling water 18°C)
- Temperature stability - ~±1.0°C (better ~±0.5°C)
- Heat exchangers placed inside Data Center in space between racks.
- Front to rear cooling air direction
- Air condition control panels placed in space between racks

This is a proposal from MSK group discussed on MSK Weekly Meetings.

3.5.6 Rack cooling in Injector

- Air-to-water heat exchangers
- Two (redundant) air-to-water heat exchangers or one heat exchanger with redundant fans (2-4). Fans are the most critical part of heat exchanger.
- One emergency cooling system (fans) to the tunnel air (emergency system **must not** be activated when fire extinguished system has been released). Opening to the tunnel air should be dust tight for 'normal' operation.
- Cooling power - ~3 kW per 'container' for inner temp. ~25°C (cooling water 18°C)
- Temperature stability - ~±1.0°C (better ~±0.5°C)
- Heat exchangers placed inside container in space between racks.

- Front to rear cooling air direction
- Air condition control panels placed in space between racks
- Thermal insulation of ‘container’ (i.e. 25 mm thick, nonflammable, halogenfree foam). If the air temperature in XTL will be ~30-35˚C and we want to have ~25˚C inside the rack, the rack should be thermally insulated because in other case we will ‘cool’ tunnel. The heat transfer for ~10˚C gradient for 3 racks ‘container’ is roughly ~500÷1000 W.

3.5.7 Rack air-conditioning (airflow, controller)

It was decided to have front-to-rear cooling air flow. The Controller should be placed in the space between racks and be controlled via TCP/IP.

This is a proposal from MSK group discussed on MSK Weekly Meetings.

3.5.8 Rack EMI

The ‘containers’ should be EMI tight so doors should have special cooper springs or mesh. Water connection should be done with cooper or stainless steel pipes.
All patch panels have to be designed as EMI tight.

This is a proposal from MSK group discussed on MSK Weekly Meetings and personally with H. Weddig.

3.5.9 Rack patch panels

Patch panels in Data Center racks are foreseen on top of each rack. Over the Data Center there will be a cable trays.

This is a proposal from MSK group discussed on MSK Weekly Meetings.

There will be no patch panels on the top of racks in Injector, the RF signals will come directly to the Calibration Box placed in the most upper position of the rack.

3.5.10 Rack connections to infrastructure

- Water connection probably from top of the Data Center.
- AC Power (3 phase) connection from top of the Data Center.
- Data Center should be equipped with AC distribution system – 8 sockets per rack, two sockets per rack in front for diagnostic equipment (not controlled)
- Ethernet connection – top of Data Center
- Master Oscillator and Synchronization – top of the Data Center.
- RF cables – top of the Data Center.

This is a proposal from MSK group discussed on MSK Weekly Meetings.

3.5.11 Rack occupation on UG05 for Concept I & II

Very preliminary LLRF racks in Injector Complex occupation is presented in Fig. 49.

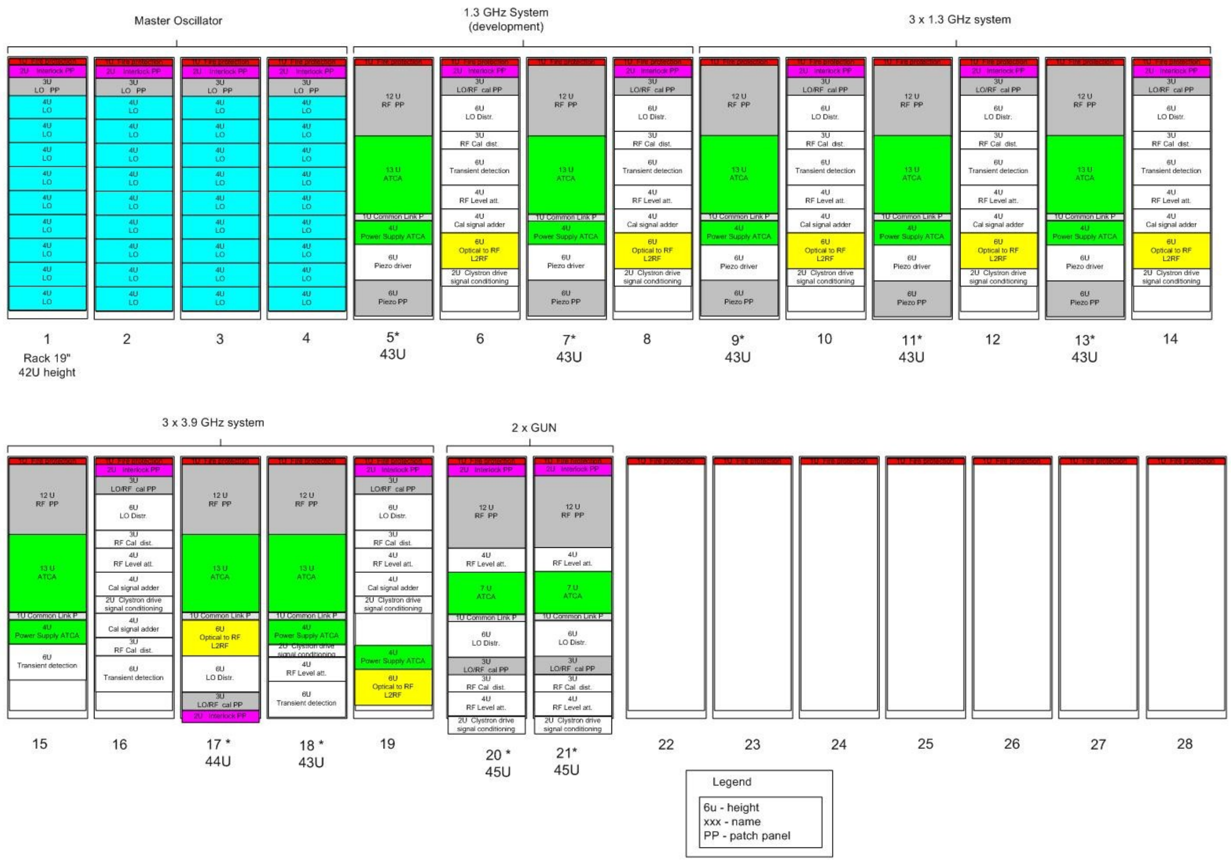


Fig. 49. Preliminary LLRF racks in Injector Complex occupation.

This is a proposal from MSK group discussed on MSK Weekly Meetings.

3.5.12 Rack occupation for RF Gun for Concept III

There is a very limited space for RF Gun LLRF System. The proposed occupation is shown in Fig. 50.

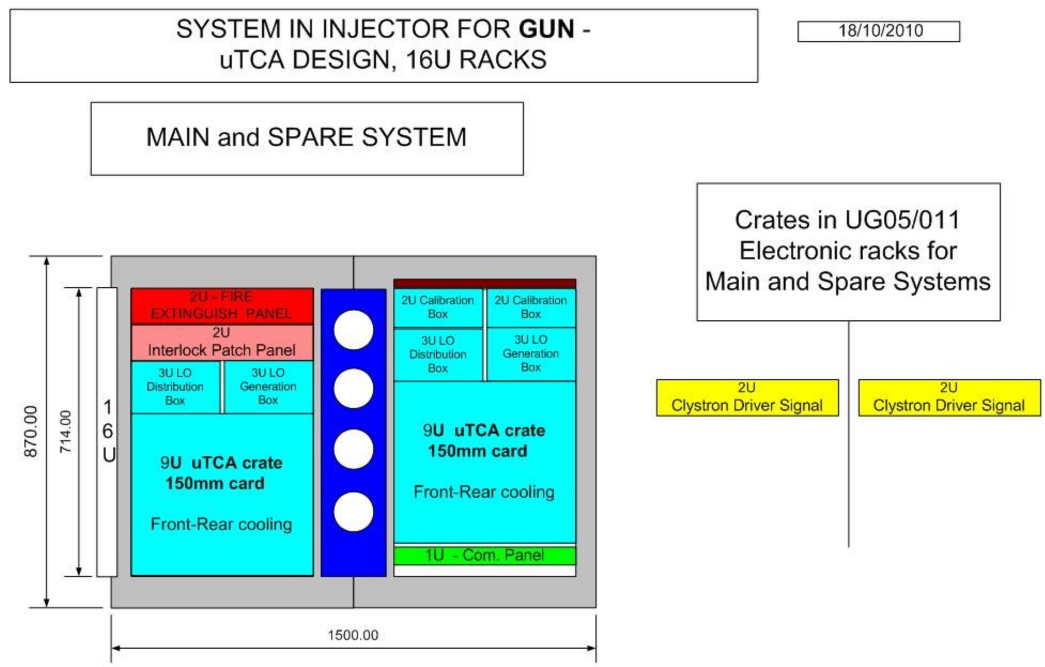


Fig. 50. Racks occupation for RF Gun.

For the RF Gun spare system it is difficult to feed the RF cables because of Fire Extinguish Panel which must be placed on the top in the rack. Fortunately, for RF Gun only a few RF signals are necessary. It is also possible to have RF Gun LLRF System placed in µTCA crate dedicated for J0.

3.5.13 Rack occupation for J0 for Concept III

The proposed occupation is shown in Fig. 51

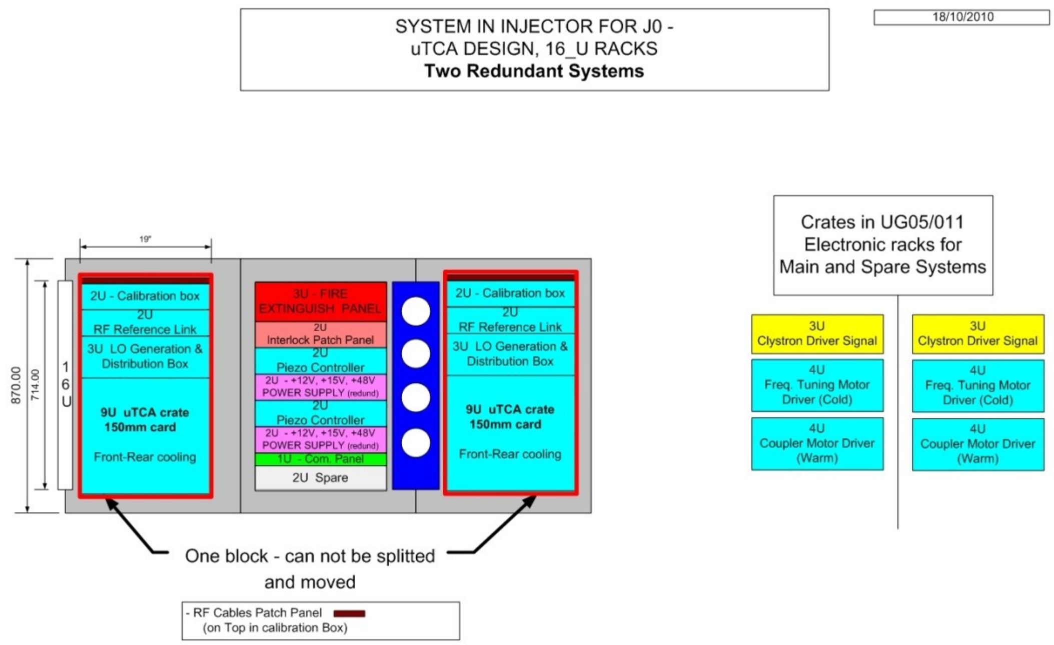


Fig. 51. Rack occupation for J0.

3.5.14 Rack occupation for 3.9 GHz for Concept III

The proposed occupation is shown in Fig. 52.

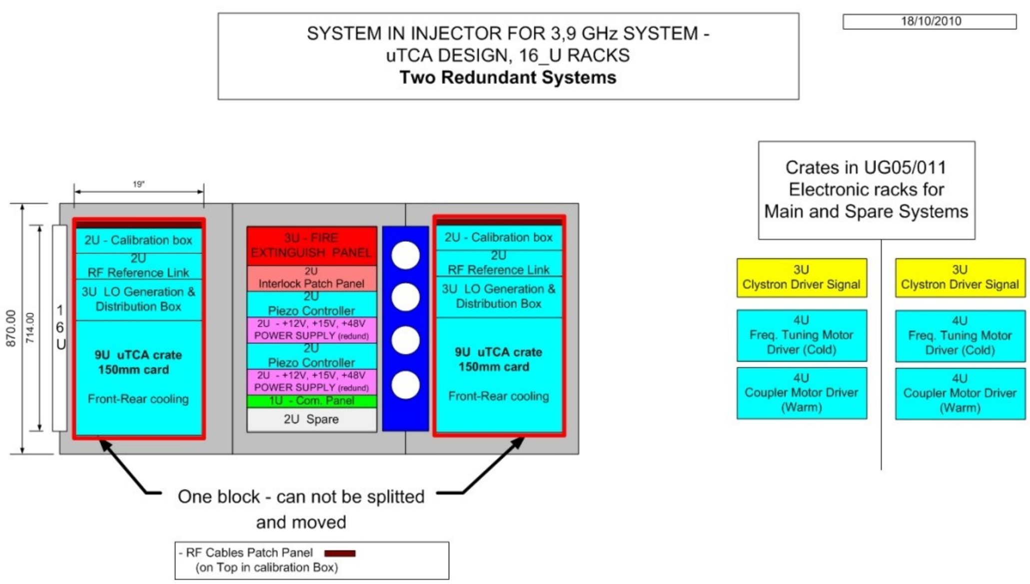


Fig. 52. Rack occupation for 3.9 GHz.

3.5.15 Rack occupation for L1 for Concept III

The proposed occupation is shown in Fig. 53.

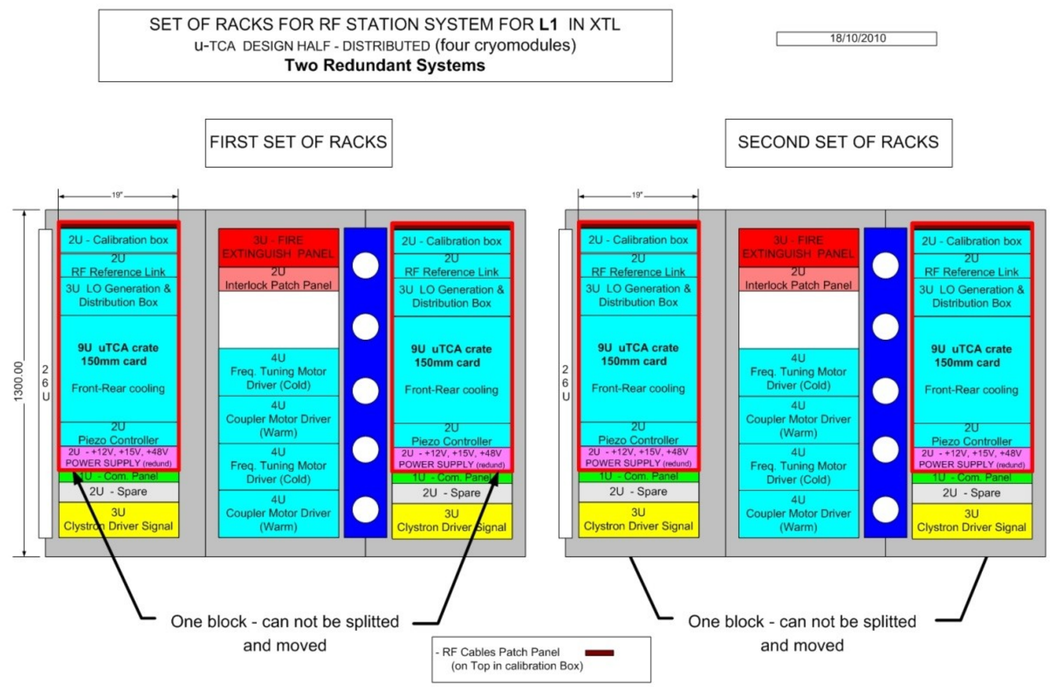


Fig. 53. Rack occupation for L1.

3.5.16 Requirements for space for racks in UG5/010XTIN & UG5/020/XSE

The space for LLRF racks have been negotiated and agreed. The racks will be placed on 5th floor of Injector Complex (UG05) in rooms 11 and 22. The LLRF racks in Injector Complex have been implemented in 3D model as place holders and all collisions with other equipment have been fixed.

This is a proposal from MSK group discussed on MSK Weekly Meetings. The space for LLRF racks in Injector Complex is reserved as place holders on 5th floor.

There are three concepts of placement of LLRF electronics in Injector Complex (3.1). For the Concept I, all LLRF systems will be placed on 5th floor but the length of RF signal cables can significantly degrade the system performance. For the Concept II & III (and all sub modifications), there is foreseen a space for LLRF electronics near the RF Gun, J0, 3.9 GHz and L1 accelerators.
The request for space has been presented on CAD Integration Meeting 08.03.2010 and implemented in 3D model. Reserved space for LLRF racks in Injector is shown in Fig. 54, 55, 56, 57.

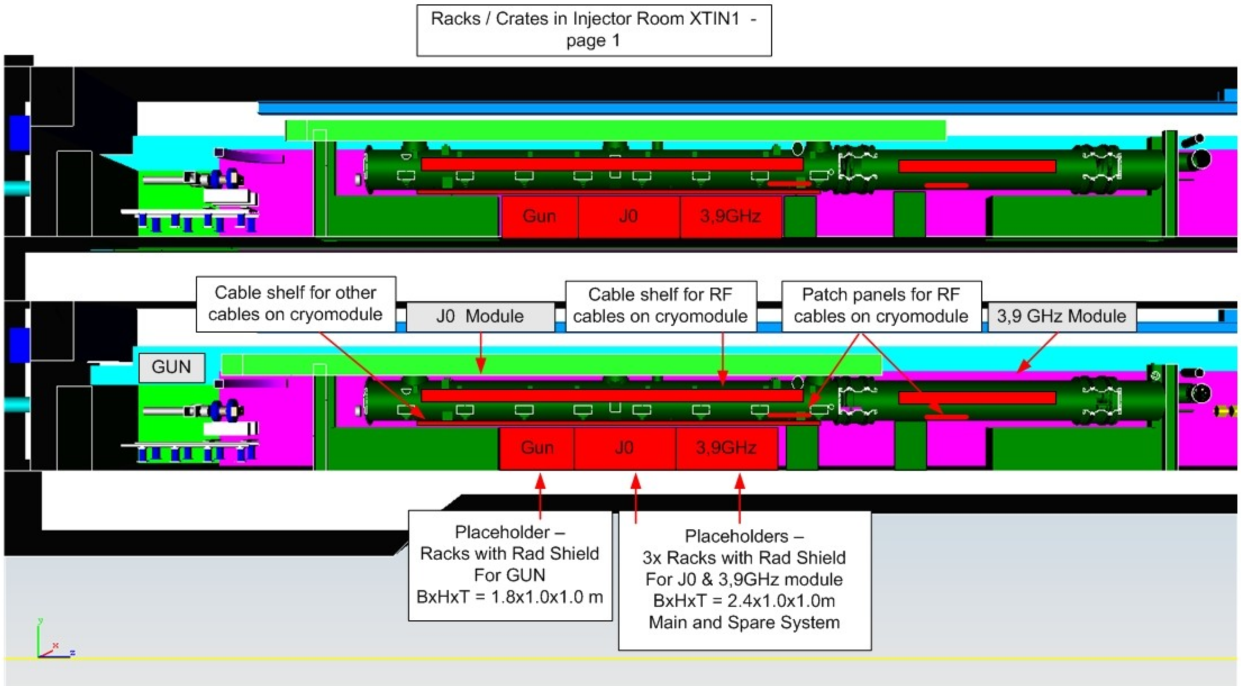


Fig. 54. Side view of proposed space for LLRF electronics In Injector Complex.

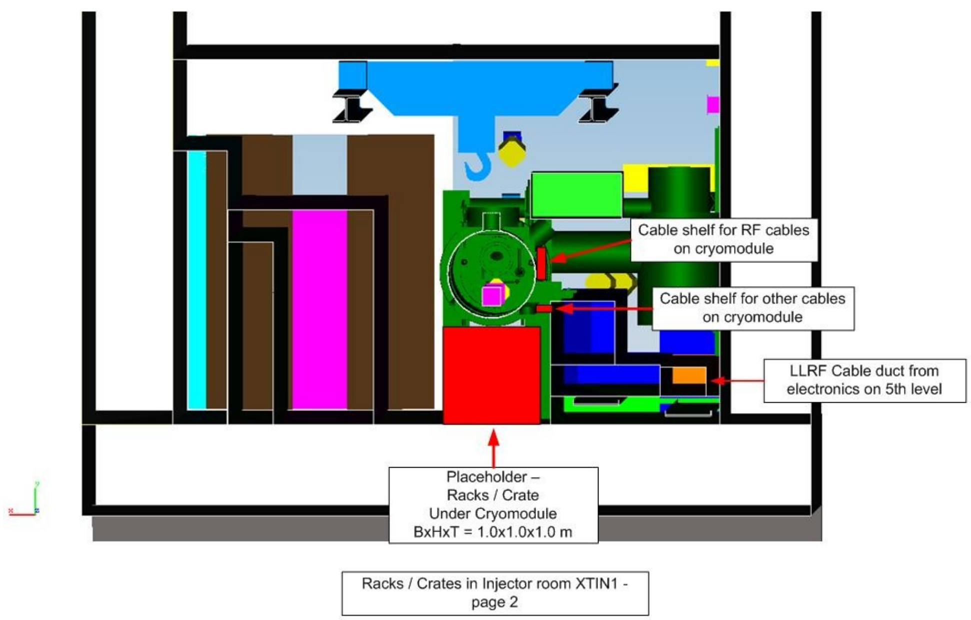


Fig. 55. Cross section of proposed space for LLRF electronics In Injector Complex.

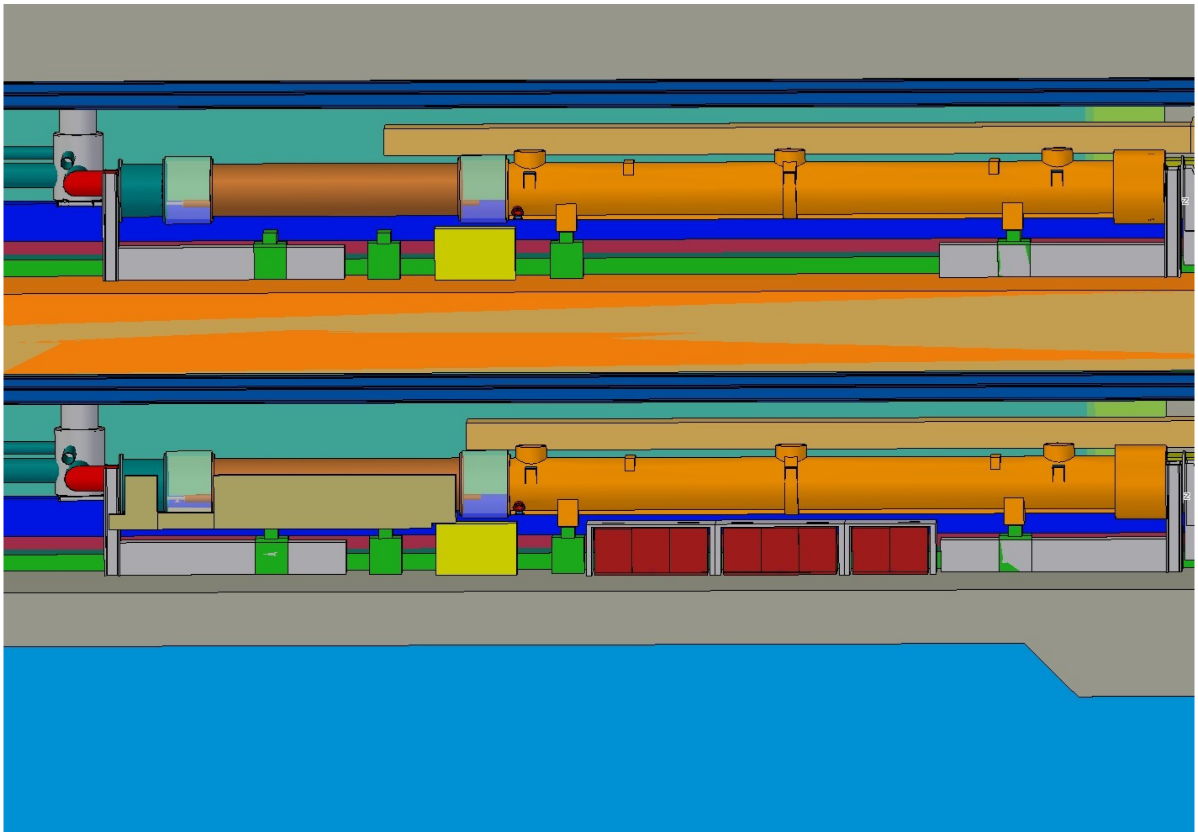


Fig. 56. View of the Injector area with LLRF racks.

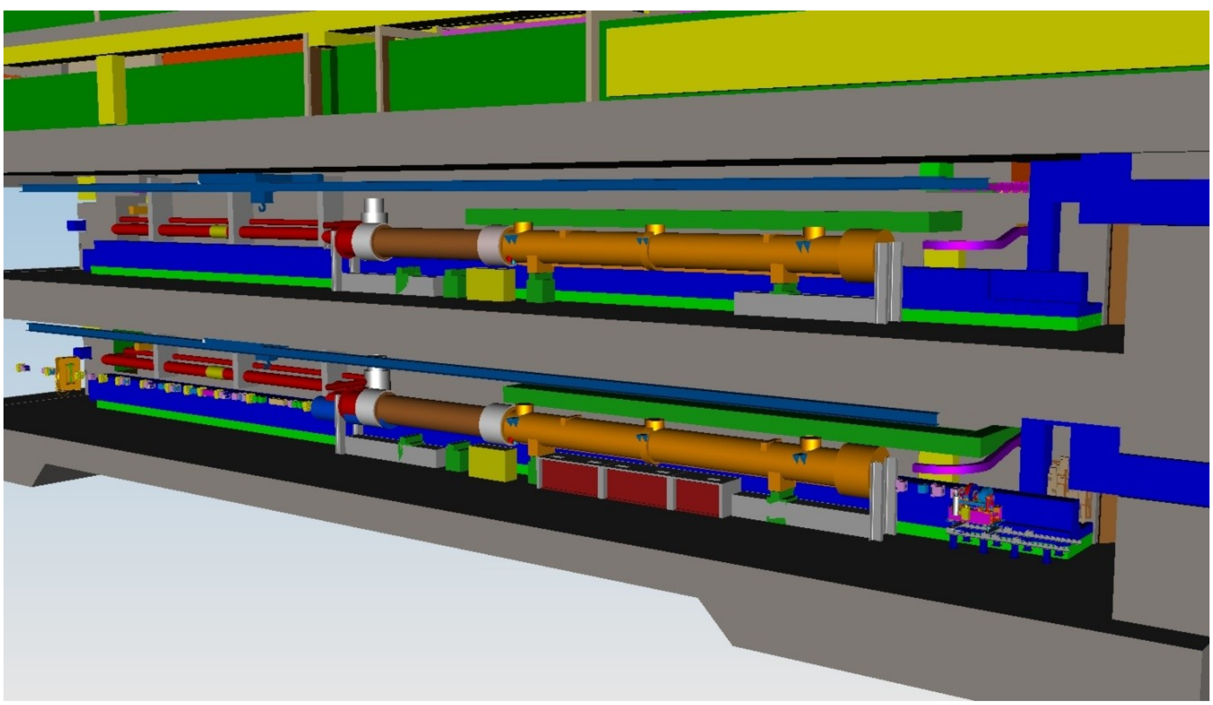


Fig. 57. Isometric view of the Injector area with LLRF racks.

3.6 Crates

It is proposed to use ATCA or µTCA crate standard for LLRF System. Some devices cannot be integrated in a crate (i.e. Master Oscillator, Drift Calibration) and are foreseen to be build in special housing.

3.6.1 ATCA 13U, RTM, ATCA occupation

ATCA crate has 14 slots for electronic cards. The occupation of crate depends for which system (RF Gun, J0, 3,9 GHz System, L1) is designed, but in 'worst case' for L1 accelerator still some slots are free. For RF Gun, J0, 3,9 GHz System the occupation of ATCA crate is smaller.

This is a proposal from MSK group discussed on MSK Weekly Meetings not finally decided, needs more detailed discussion.

3.6.2 µTCA occupation

µTCA crate has 12 slots for electronic cards. The slots will be occupied as follow.

RF Gun:
Crate in 2 racks 'container':
front side

- 1 * CPU
- 1 * Interlock
- 1 * Timing
- 1 * LLRF Controller
- 1 (2) * ADC

rear side

- 1 * Klystron Driver
- 1 (2) * DWC (downconverter)
- 1 * LO-Generation

(6 slots free)

J0:
Crate in 3 racks 'container':
front side

- 1 * CPU
- 1 * Interlock
- 1 * Timing
- 1 * LLRF Controller
- 4 * ADC

rear side

- 1 * Klystron Driver
- 4 * DWC (downconverter)
- 1 * LO-Generation

(4 slots free)

3.9 GHz:
Crate in 3 racks 'container':
front side

- 1 * CPU
- 1 * Interlock
- 1 * Timing
- 1 * LLRF Controller
- 4 * ADC

rear side

- 1 * Klystron Driver
- 4 * DWC (downconverter)
- 1 * LO-Generation

(4 slots free)

L1:
Crate in 3 racks 'container' (Master):
front side

- 1 * CPU
- 1 * Interlock
- 1 * Timing
- 1 * LLRF Controller
- 7 * ADC

rear side

- 1 * Klystron Driver
- 7 * DWC (downconverter)
- 1 * LO-Generation

(1 slot free)

Crate in 3 racks 'container' (Slave):
front side

- 1 * CPU
- 1 * Interlock
- 1 * Timing
- 1 * LLRF Controller
- 7 * ADC

rear side

- 1 * Klystron Driver
- 7 * DWC (downconverter)
- 1 * LO-Generation

(1 slot free)

3.6.3 Power Modules for ATCA

The requirements for DC Powers Supply for ATCA are:

- -48 V DC (or floating output ±10 V)

- ~3 kW power
- Low noise < 20 mV_{RMS}
- 2U- 88,9 mm (max. 3U-133,35 mm) – housing height
- Standard 19" rack mounting
- Ethernet (TCP/IP) control
- PS must be redundant

We have chosen a PS from Wiener and from Aspiro – see Chapter 2.5.2.

This is a proposal from MSK group agreed personally with T. Jeżyński. After tests we will chose the better PS for our purposes.

3.6.4 Transient Detection

The Transient Detection system will be placed in 6U crate, the Gain Controlled Amplifiers can be placed at the rear side of the crate.
The Transient Detection unit is under design and no more detailed information is available.

This is a proposal from MSK group agreed personally with P. Morozov.

3.6.5 Local Oscillator

We have reserved a space of 3U for Local Oscillator and 2U for Local Oscillator Distribution. The special low noise DC 12 V power supply for LO and LOD should be discussed carefully (not yet finalized).
The LO and LOD are under design and no more detailed information is available now.

This is a proposal from MSK group agreed personally with K. Czuba.

3.6.6 Drift Calibration

There is foreseen 3U box for Drift Callibration device and 2U box for RF Calibration Distribution unit. The DC and RF CD units are under design and no detailed information is available now.

This is a proposal from MSK group agreed personally with F. Ludwig.

3.6.7 Box standards for LO & DC

To standardize the boxes for RF components we recommend to use in all system 19", 2U or 3U height boxes with maximum depth of 700 mm.

This is a proposal from MSK group.

3.6.8 Standards for Step Motor Drivers

The Step Motor Drivers will be delivered by MCS4 group. The current status of design (similar to the FLASH) shows the huge consumption of space. One Step Motor Drivers unit for 8 warm motors has a 4U height. For cold motors (in Helium) one 4U box can control only 8 motors. We need to control 32 warm and 32 cold motors for L1. That means, that we need 4 times 4U boxes for warm and 4 times 4U boxes for cold motors – together Step Motor Drivers will occupied 32U.

This is a proposal from MSK discussed personally with K.Rehlich and P. Nommensen. The final decision to reduce the height of Step Motor Drivers not yet done.

In framework with EuCard we are preparing a design of integration step motor drivers in to the ATCA crate (16 channel board, universal for warm and cold motors).

This is a proposal from MSK discussed personally with M. Grecki and E. Kielar.

3.6.9 Requirements for Crates and Power Supplies

To establish requirements for Crates, boxes and Power Supplies, it is necessary to have more detailed information about LLRF sub systems. Because the most of subsystems for LLRF in Injector Complex are in development stage, there is small progress.

3.7 Infrastructure

We have filled the TGA for rooms in Injector Complex.

TGA file for MSK requirements in Injector Complex can be found:

https://svnsrv.desy.de/k5viewvc/MSK_Doc/trunk/users/Wierba/TGA/

3.7.1 Request for IT connections

For room UG05/011 we have requested:

- 8 LWL Ethernet connection 10 Gbit/s
- 80 cooper wire RJ45 1 Gbit/s
- 1 WLAN – service

For room UG05/022 we have requested:

- 12 LWL Ethernet connection 10 Gbit/s
- 120 cooper wire RJ45 1 Gbit/s
- 1 WLAN – service

3.7.2 Request for AC Power

For each room UG05/011 and UG05/022 we have requested:

- 27 AC power 230 V/2 kW
- 1 AC power 230 V/2 kW (UPS)

3.7.3 Request for Cooling Water

For all Injector LLRF rooms we have requested 28 connections of cooling water with input temperature of 18˚C. The nominal cooling power is 2 kW with maximum of 3 kW. The flow and temperature sensors have been also requested.

3.7.4 Request for telephones

For all LLRF rooms in Injector Complex we have requested 4 IP phone connection. Wireless headphones with microphone are advised.

3.7.5 Request for Security

For all LLRF rooms in Injector Complex we have requested 2 smoke detectors, 4 security lamps and evacuation signs.

4. Conclusions

The aim of this paper is to present the current status of installation design of LLRF system in XFEL. This report will be used as a frame for future enlargement together with design progress.
Additionally, in 2009 we have prepared a proposal for cabling of FLASH ACC7 module, cabling in FLASH Tunnel and request for cabling. The cabling has been done under our supervision.
The proposals and cabling order can be found:

https://svnsrv.desy.de/k5viewvc/MSK_Doc/trunk/users/Wierba/FLASH%20Cabling/

5. List of presentations in 2009

a. 22.01.2009, MSK WM, W.Wierba, K.Oliwa, "Concepts of coax cable temperature stabilization in Injector Complex"
b. 29.01.2009, MSK WM, W.Wierba, K.Oliwa, "LLRF Cables in Injector Complex"
c. 02.02.2009, CAD IM, W.Wierba, K.Oliwa, "LLRF cables in Injector complex"
d. 24.03.2009, TCM, W.Wierba, K.Oliwa, "LLRF system racks in XFEL tunnel"
e. 26.03.2009, MSK WM, W.Wierba, K.Oliwa, "LLRF System Racks in XFEL Tunnel"
f. 06.07.2009, CAD IM, W.Wierba, K.Oliwa, "LLRF Cables in Injector Complex - space for LLRF rackks in XTL"
g. 13.07.2009, CAD IM, W.Wierba, K.Oliwa, "LLRF cables in Injector Complex, entrance to the XTL"
h. 16.07.2009, MSK WM, W.Wierba, K.Oliwa, "Space for LLRF System in XTL"
i. 16.07.2009, MSK WM, W.Wierba, K.Oliwa, "LLRF Cables in Injector Complex"
j. 28.09.2009, CAD IM, W.Wierba, K.Oliwa, "LLRF cables in Injector Complex - new ducts"
k. 09.11.2009, CAD IM, W.Wierba, K.Oliwa, "LLRF cables temperature stabilization"

Presentations can be found:

https://svnsrv.desy.de/k5viewvc/MSK_Doc/trunk/users/Wierba/Presentations%202009/