CERN
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CERN Div./Group or Supplier/Contractor Document No.
EN/STI

EDMS Document No.
XXXXXXX

Date: 2010.06.04

Point 5 – Equipment inventory

Abstract

This document describes the equipments installed in the area UJ56, RR53, and RR57. The collected information will be used for the preparation of relocation studies of these LHC critical areas.

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History of Changes

Rev. No.	***Date***	***Pages***	***Description of Changes***

Contents

1. LAYOUT & RACK LOCATIONS

the following figures indicate the exact location of the racks listed in the previous table:

MISSING

2. TIMING AND REMOTE RESET [R. CHERY, C. DEHAVAY]

The timing and the remote reset systems are installed in the racks CYTIM01 and CYFRE01 respectively. They are located at UJ56 level 1 and manage the timing and the remote reset distribution for the front-end controls. Some equipment is also installed in the collimation rack TYCCR01.

Most of the users are resumed in Fig. 1. A failure of the system creates a lack of the timing distribution for the equipments related to the beam control. Therefore, the beam must be dumped.

The equipment is based on commercial devices and radiation tests were not performed. The racks can be relocated and the equipment owner is currently working on the specifications for that.

This system should be relocated.

CFP-UJ56-CRR1						
SOURCE RACK	*Nb de câbles*	*DESTINATION RACK*	*RESET SYSTEM*	*TIME*	*OUT*	*No Câble*
UJ56 CYFRE01	1	USC55 VY13	PLCVACLHCUSC55	5	1	1508970
UJ56 CYFRE01	1	UJ56 GYPOS01	Reserve for SURVEY	5	2	1508975
UJ56 CYFRE01	1	UJ56 GYPOS02	Reserve for SURVEY	5	3	1508976
UJ56 CYFRE01	1	USC55 CYCIP01	CFP-USC55-CIPAL5	5	4	1508971
UJ56 CYFRE01	1	USC55 CYCIP01	CFP-USC55-CIPLL5	5	5	1508972
UJ56 CYFRE01	1	USC55 CYCIP01	CFP-USC55-CIPXL5	5	6	1508973
UJ56 CYFRE01	1	UJ56 CYCIP01	CFP-UJ561-CIPXR5	5	7	1508977
UJ56 CYFRE01	1	UJ56 CYCIP01	CFP-UJ561-CIPAR5	5	8	1508978
UJ56 CYFRE01	1	UJ56 CYCIP01	CFP-UJ561-CIPLR5	5	9	1508979
UJ56 CYFRE01	1	UPS54 GYPOS01	Reserve for SURVEY	5	10	1508974
UJ56 CYFRE01	1	UPS56 GYPOS01	Reserve for SURVEY	5	11	1508980
UJ56 CYFRE01	1	UJ56 RYCA01	CFC-UJ56-RCAL12	1	12	1510227
UJ56 CYFRE01	1	USC55 RYCA01	CFC-UJ55-RCAL11	1	13	1510228
UJ56 CYFRE01	1	UCS55 QYC02	CRYO_PA_LSS5L	5	14	1511586
UJ56 CYFRE01	1	UCS55 QYC02	CRYO_ET_LSS5L	5	15	1511587
UJ56 CYFRE01	1	UCS55 QYC02	CRYO_PA_LSS5L_QUI	5	16	1511588
UJ56 CYFRE01	1	UCS55 QYC02	CRYO_ET_LSS5L_QUI	5	17	1511589
UJ56 CYFRE01	1	UJ56 QYC01	CRYO_PA_LSS5R	5	18	1511941
UJ56 CYFRE01	1	UJ56 QYC01	CRYO_ET_LSS5R	5	19	1511942
UJ56 CYFRE01	1	UJ56 QYC01	CRYO_PA_LSS5R_QUI	5	20	1511943
UJ56 CYFRE01	1	UJ56 QYC01	CRYO_ET_LSS5R_QUI	5	21	1511944
UJ56 CYFRE01	1	UJ56 TYCFL01	MDC-2-WT-012	5	22	1516215
UJ56 CYFRE01	1	UJ56 TYCFL01	MDC-1-NT-010	5	23	1516216
UJ56 CYFRE01	1	USC55 TYCFL01	MDC-1-NT-009	5	24	1516217
UJ56 CYFRE01	1	USC55 TYCFL01	MDC-2-WT-011	5	25	1516218
UJ56 CYFRE01	1	UJ56 EYC01/56	EFELUJ56	5	26	1516064
UJ56 CYFRE01	1	USC55 EYC01/55	EFELUSC55-1	5	27	1516214A
UJ56 CYFRE01	1	USC55 EYC01/55	EFELUSC55-2	5	28	1516214B
UJ56 CYFRE01	1	USC55 MYWIC01	CFP-USC55-CIWLR5	5	29	1519071
					30	
					31	
					32	
TOTAL	29					

Figure 1. Remote reset users

2.1 MISSING INFORMATION

Point out the difference between the timing and the remoter reset users
Type and number of cables for timing and remote reset.
Type of power line.

3. WORLDFIP EQUIPMENT [J. PALLUEL]

The WorldFIP equipment is installed in the racks CYFRE01 and GYPOS02/03 at UJ56 and in the RR53/57 (Table 1). There are end-line FipDiag, Cu/Cu (Copper copper) and optical repeaters. The power-is supplied from the rack EOK 105/56 and the repeaters normally use the UPS.

In case of failure of the WorldFIp repeaters, the next user agent cannot respond anymore. Therefore, the impact on the machine safety and operation depends on the criticality of the users that are specified in Table 1. In case of failure of the FipDiag, the proper working of the network cannot be checked.

Radiation tests were performed on the repeaters. A ^{60}Co source at CEA (Centre d'Energie Atomique) was used to irradiate the device under test (1MB/s) which stood up to 300 Gy. No major failure was observed. Two repeaters (2.5 MB/s) were tested by using a 60 MeV proton beam at Louvain. The samples received a total dose of 215 and 500 Gy respectively. The hadron fluence is not specified. The repeaters are under test in the CNGS radiation facility. According to the preliminary results, a repeater failed at a total dose of about 160 Gy when the hadrons fluence (> 20 MeV) and the neutron fluence (1 MeV_{eq}) were about of 1.1 x 10^{12} cm^{-2} and 1.7 x 10^{12} cm^{-2} respectively. Single Event Upsets were not observed till the device failed. A second repeater was tested and did not show any failure up to a total dose of 250 Gy.

1 and 2 VE2R cables are needed for each FipDiag and each repeater respectively. The relocation can be done and the maximum distance varies from 500m to 1000m depending on the system.

Performed radiation tests suggest that a relocation is not required from the P5 areas, a conclusion to be confirmed by the RadWG.

Area	**Equip.**	**Rack**	**User**	**Power**	**Rem. Com.**	**Failure**	**Relocation**
UJ56 1st floor	End line FipDiag	CYFRE01	Power	EOK 105/56	Fip 2.5 Mb/s	No Network Feedback	500 m 1 VE2R cable for fipdiag
UJ56 1st floor	2 End line FipDiag	GYPOS02 & GYPOS03	Survey	EOK 105/56	Fip 1 Mb/s	No Network Feedback	1000 m 1 VE2R cable for fipdiag
UJ56 1st floor	2 Cu/Cu repeater	CYFRE01	Power	UPS EOK 105/56	Fip 2.5 Mb/s	No bus for next user	500 m 2 VE2R cable for repeater

UJ56 1st floor	4 Optical repeater	CYFRE01	Cryo	UPS EOK 105/56	Fip 1 Mb/s	No bus for next user	1000 m 2 fibers and 1 VE2R cable for repeater
RR53 RR57	FipDiag	Wall	Cryo Power converter QPS	EOK103/57 EOK103/53 EOK102/57 EOK102/57	1Mbit/s 2.5 Mbit/s	No diagnostic	1000 m 1 VE2R cable for fipdiag
RR53 RR57	Repeaters	Wall	Cryo Power converter QPS	EOK102/57 EOK102/57	1Mbit/s 2.5 Mbit/s	No network for next users	500 m 2 VE2R cable for repeater

Table 1. WorldFip equipment.

3.1 MISSING INFORMATION

Do you have references/documents for the radiation tests carried out at CEA and Louvain?
Please provide a document summarizing the CNGS test results

4. POWER INTERLOCK CONTROLLER (PIC) [M. ZERLAUTH, B. TODD]

The Power Interlock Controller (PIC) is located in the rack CYCIP01 at level 1 of UJ56, RR53 and RR57. The control system is based on the *PLC* (installed in UJ56) from *Siemens* and remote IOs (installed in RR53 and RR57s) based on ANYBUS cards and XILINX CPLD 95144 (5 V type). It requires an UPS supply and its remote communication relies on the Ethernet connection for the PLC and ProfiBus for connecting the remote IOs with the PLC in UJ56 (power is supplied from the rack EOK104/56).

The main users are the LHC power converters, the Quench protection system and the Beam Interlock system for the transmission of the beam dump requests, whereas additional signals are transmitted via HW links (or direct PLC-PLC links) for the transmission of cryogenic conditions and the status of UPS systems and the AUG to the PIC. Following a failure of the PIC system, the beam must be dumped.

Radiation tests have been performed at Louvain on the ANYBUS modules. A 60 MeV proton beam with a flux ranging form 0.1 x 10^8 to 5 x 10^8 *protons/(cm^2·sec)* has been used. Two ANYBUS cards have been irradiated for a time period of about 75 minutes each, the first one up to a total dose of 125 Gy and a second one achieving a total dose of 326 Gy. No major degradation of the supplied output current for an active state of the output could be observed for either of the two irradiated boards. According to the irradiation time and considering the maximum flux of 5x10^8 *protons/(cm^2·sec)*, the fluence reached the value of 2.0 x 10^{12} *protons/cm^2*.

Radiation tests at CNGS showed promising results. The system uses CPLDs with a very small cross-section and they fail in a safe way. The Mean Time Beetwen Failure (MTBF) is about 7 years.

The relocation of the control equipment (PLC part of the system) is possible up to few 100s meters (limit of the PROFIBUS). The study for the relocation has been done for the area UJ56, UJ14, and UJ16 and the actual relocation could be done in 1 day (cables have already been ordered and new rack space allocated). For the remote I/O, the relocation is more difficult because it also involves the extension/relocation of tens of cables per system, connecting the QPS and Power converter systems.

It is suggested to relocate only the PLC equipment.

4.1 MISSING INFORMATION

Number and type of cables.
Do you have any references/documents for the radiation tests?

5. BEAM INTERLOCK CONTROLLER (BIC) [M. ZERLAUTH, B. TODD]

The beam interlock equipment is in the rack CYCB01 at UJ56, level 1. The Beam Interlock Controller (BIC) is composed of a single VME crate, with various VME boards and redundant Power Supplies. In addition, another Machine Interlock system is also present in the CYCIB01 rack: a FMCM unit (Fast Magnet current Change monitor). This one is in charge to monitor the RD1.LR5 magnet current (see Power Interlock Control).

The remote communication is based on Ethernet and the outlet numbers are 1507/01, 1507/02 & 1507/03. The power supply comes from EOK 104/56. The system uses 220VAC (0.5kVA) on UPS with P.F. = 0.7. The BIC is fully redundant and is using the fail safe concept. In case of radiation issue, the system will dump the beams and block further beam operation. In case of the FMCM, it will also provoke a Beam Dump request. The BIC system, used by the LHC operators, is linked by copper cables to other LHC equipments (named User systems). In the case of UJ56, the User systems are: Vacuum, Collimation, PIC, CMS and the Totem experience. Each one, via a dedicated Interface (named CIBU), delivers its own local permit for beam operation.

The BIS Interface (named CIBU) installed in the Users racks was tested at PSI by using a 60 MeV proton beam. In particular, tests were performed on the opto-coupler, the current regulator, the differential driver, the Schmidt trigger, and the system as a whole.

Device	**Fluence [*proton/cm^2*]**	**Dose [*Gy*]**	**Comments**
Optocoupler	4.8×10^{10}	62	40 glitches; no dependency on the dose
Current regulator	5×10^{10}	120	Drift of 4% of the current regulator
Differential driver	1.0×10^{11}	500	failure restored by means of a power cycle
Schmidt trigger	5.0×10^{11}	1000	No failure, No See
BICU (system as a whole)	6.0×10^{11}	150	CPLD (5V) failed during the test. After the cool down, the programming of the device could restore it.

Table 2. BICU test at PSI.

No operational limitations are imposed on the use of the CIBU due to radiation. Tests were carried out also at at CNGS on the BIC VME chassis which uses a small nmber of sensitive CPLDs. According to the test results, the Mean Time Beetwen Failure (MTBF) in the worst case is about 5.5 years.
As far as the relocation is concerned, one of the "Spare racks" has been already reserved in USC55. It has been named CYCIB02. The system uses 10 cables (8 x NE12 type and 2 CB50 type). They have been already asked to J-C Guillaume (EN/EL).
If it is reasonably feasible, it is suggested to relocate only the crates with the most sensistive CPLDs.

5.1 MISSING INFORMATION

Do you have any references/documents for the radiation tests at PSI?
Could you, please, verify if the total dose is correct in line 2 of table 2.
Could you, please, give details on the FMCM module? Has it already been tested under radiation?

6. BEAM POSITION MONITOR [E. GIRALDO CALVO, J. L. GONZALES]

The Beam Position Monitor electronics is placed in the rack BY01 at level 1 of UJ56 and in the racks BY01, BY02, BY03, BY04, BY05, BY06 at level 1 of RR53 and RR57. The BPM system has 1 power supply card (linear regulation with hard-radiation voltage regulator), 1 microfip card (old version: digital card: ASICs + antifuse FPGA), 1 intensity card: analogue card (BJT transistors + amplifiers + logic gates); 4 WBTN cards: analogue card (comparators, BJT transistors, amplifiers and logic gates). The system uses the UPS power supply from EOK 104/56. The consumption of each rack depends on the number of crates installed on each. Some crate settings like the sensitivity, and some controls for the calibration are received through the WorldFIP bus (32 kbit/s). The FIP gateways are placed at surface on the corresponding CYF racks. Generally, each crate is the read out for 2 Beam Position Monitors. As far as only 1 crate or (even a few consecutive) fail (and depending of the type of failure) the orbit system will lose some channels, but will continue working. There are no consequences from the point of view of safety.

The WBTNs cards where tested in TTC2 in 2001. They worked till the end of the test where the accumulated dose was of ~875Gy with no significant deterioration. The microfip card was tested in PSI up to 9.8e11p/cm^2 (~400Gy) where it stopped working. The acquisition/monitoring system was too slow for monitoring the SEE, but the functionality in general was ok. Tests were carried out at CNGS too. The WTBN cards and the power supply did not show any degradation. The intensity card suffered a serious problem that makes it not operative with a fluence relatively of low $3x10^{10}$ 1MeV eq n/cm^2 and $2x10^{10}$ h/cm2(>20MeV). Further studies should be done on this card to find out a solution that could be implemented in future shutdowns. 6 SEE over a fluence of $2x10^{12}$ 1Mev eq. n/cm^2 (3 of them took 1 min. in recover) were registered over the FIP. This means 0.5 SEE/ year·card, $5.2x10^{-6}$ SEE/s,that is 1 SEE/53h.

FIP is used only for sending the sensitivity settings of the WBTNs, launch calibrations, or monitoring the power supplies. All the errors seen consisted in return to a default state (calibration switched off, and high sensitivity). Then, the worst consequence is that 1 channel measures a high intensity beam with high sensitivity: 1 BPM channel will have for a few seconds (up to 1 minute) an offset of ~250µm. This effect is detected and can be compensated by the beam orbit feedback, that can also mask this BPM channel temporary.

The main users of the BPM are the operators for calculating the beam orbit. 2 redundant crates (x2 beams) will be used for the interlock system. This field bus and the general service of 220V are the only required for the system to work.

The maximum distance for relocation should be about some tens of meters of the beam position monitor itself. The longer the cable bringing the signals from the monitor, the worse the performance of the measure is, thus actually the reason why most of the electronics are right below the quads. The cables are: the CMC50 Ohm cables which should have exactly the same electrical length (<10ps) per groups of 4 and that requires many precise measures; 1 optical fiber per BPM plane (12 fibers per BPMD, and 8 BYPLM, and 6 per BPM); 1 or 2 microfip drops; 220V UPS.

The relocation can be avoided. In fact, the intensity card that failed at CNGS is used only for controlling the injection phase. The card will be analyzed to see which component failed and find out a possible solution. If the upgrade of the card will result extremely complicated, the relocation could be considered.

6.1 MISSING INFORMATION

Confirm that the equipment can stay as is.
Do you have any reports/documents for the TCC2 tests?

7. BEAM LOSS MONITOR [B. DEHNING, E. EFFINGER]

The beam loss monitor euipment is located at RR53/57. The equipment, made of custom electronics, aims at monitoring the beam losses. In case of failure the tuning of the machine is not possible and the beam must be dumped.

The electronic parts were tested and the system is considered radiation tolerant.

On this basis, the equipment can stay as is.

7.1 MISSING INFORMATION

Confirm that no relocation is required
If relocation is required, please, provide a more detailed description of the system, the power needs, the remote bus and the type and the number of the cables.

8. EQUIPMENT FOR SURVEY [A. MARIN]

The racks GYPOS01, GYPOS02, GYPOS03 for the Survey system are placed in UJ56, level 1. The equipments consist of the commercial drivers for step motors and the acquisition system for temperature and level sensors. Two level sensors, placed close to the door of the UPS area, on the side gallery, have an embedded conditioning electronics. Power is supplied from the rack EOK104/56 and two "reglettes" of 16 A power supply are needed for each rack dedicated to the motor controller and two "reglettes" of 10 A for the acquisition systems rack. The remote communication is based on a 32 kbit/s WorldFip bus. The equipment provides the alignment of the low beta magnets. In case of failure, the LHC beam must not be dumped but it will pose an issue for operations.

The step motors, installed in the tunnel, were tested by the supplier until 16000 Gray. Sensors can stand more than 16000 Gray (http://www.slac.stanford.edu/econf/C06092511/papers/WEPO16.PDF). Analogical components work fine up to about 250 Gray. The tests were carried out by using a ^{60}Co source and in TCC2 area. However, the hadron fluence values are not available. The acquisition systems was tested at the CNGS facility (RADWG CERN). Only 2 reset commands were required to recover the system.

The relocation is not possible for the sensors and the electronic conditioners placed in the tunnel. The acquisition systems and the control system for the step motors could be moved if requierd. The cables number is between 20 and 40 (MCA8 cables, NE18 cables, and NE4 cables).

According to the first preliminary results, the relocation can be avoided. However, a final decision will be based on the final report provided at the RADWG.

8.1 MISSING INFORMATION

Would you like to move the acquisition systems and/or the motor drivers?
If yes, provide a test document describing the results and conclusions, as well as more information on the cables as required (type and number).

9. CURRENT LEAD HEATERS [S. LE NAOUR]

The equipment control of the current lead heater is installed in the rack DYXF01, at UJ56-level 1, in the racks DYAI01, DYLD01 at RR53, and in DYAJ01, DYLE01 at RR57. They provide the temperature regulation of the top part of the current leads. There are 28 regulators and 28 solid state relays in UJ56 and 58 regulators and 58 relays for each RRs area. They are based on commercial electronics that act on the basis of the feedback signal of the temperature sensors installed on the leads. The power supply is a 230 V AC and it comes from the rack EBD223-56. There is no remote communication.

If the regulator or relay is down, no heating of the top part of the current lead is provided. If the temperature of the top part of the current lead is below a threshold (set to 280°C and controlled by the Cryogenic supervision system), the LHC power converter cannot start. In case of failure, the resistive part of the current lead could freeze if the current circulating in the circuit is low (current at injection level or no current). Therefore, a problem comes up only at the restarting of the machine. The alarm in case of malfunctioning is provided by the cryogenic control system.

Radiation tests were already carried out at CNGS in 2008 and 2009. One burnout at 1.3×10^{10}cm^{-2} for Neutron 1MeV equivalent (0.6×10^{10}cm^{-2} for hadrons with energy >

20 MeV) and 1 SEU at 3.2^{10}cm^{-2} for Neutron 1MeV ($1x10^{10}$cm^{-2} for hadrons with energy > 20 MeV))equivalent were observed.
The relocation of the system is feasible and there are no constraints on the maximum distance. The system uses 6 cables (2NG28, 2NE24T, 1 PJ12M, 1NE8T) for the UJ56 area and 22 cables (9 NE8T, 6PJ12M, 2NG18, 2NG28, 1PJ5SJ, 2NE24T) for each RR area (two racks).

It is suggested to relocate the system or allow for a functional modification so that it can remain in place (*e.g.*, ELMB-like solution, reset or similar).

9.1 MISSING INFORMATION

Verify that the list is complete.
Comment on the mitigation option other than relocation

10. COLLIMATOR CONTROL EQUIPMENT [A. MASI]

The collimator low-level control racks are the TYCFL01 and TYCCR01, located at level 1 of UJ56 area. The equipment consists of a National Instrument PXI equipped with ADC, DAC and FPGA cards, power Supply Custom electronics for excitation of LVDTs and resolvers (power buffer) and I/O modules compact RIO. The system requires AC 230V power supply coming from EBD 223/56, 2KW and an AC 230V UPS power supply (800W). The remote communication is based on the Ethernet protocol (TYCFL01 2537-1-0000 Outlets: 3607/01, 3607/02, 3607/03, 3607/04). In case of failure, the beam must be dumped. The system depends on the Beam Interlock System (CIBU in TYCFL01) Timing (Timing crate in Rack TYCCR01) and Remote Reset (from CYFRE01 rack).

A full collimator control system has been tested in the CERF facility. The entire control electronic received an equivalent high-energy hadrons fluence of circa 10^7 cm^{-2}, which corresponds at about 1.5 years of LHC operation. No SEU have been observed during the irradiation.

The system can be relocated up to a distance of 200 m because of the cable length limitation for sensor and stepper motor driver. The cables are NE48 for sensors (12 cables: 1514028, 1514029, 1514031, 1514032, 1514033, 1514035, 1514036, 1514037, 1514039, 1514040, 1514041, 1514043), NH48 for Motors (4 Cables: 1514044, 1514045, 1514046, 1514047), CB50 for remote Reset (2 Cables: 1516215, 1516216).

It is recommended to relocate the system because it is critical in terms of LHC operation safety.

10.1 MISSING INFORMATION

11. POWER CONVERTER [Y. THUREL]

The location and the rack names of the power converters are resumed in Table 3.

Location	Rack
UJ56 1st floor	RYHF01 (RQX LHC8kA/8V), RYHG01 (RQTX2 LHC6kA/8V), RYMCB01 (RTQX1 LHC600A/10V IT), RYCA01 (DCCT calibration rack), RYCA02 (DCCT calibration rack), RYMCB02 (LHC600A/10V), RYMCB03 (LHC600A/10V), RYMCB04 (LHC600A/10V), RYLC01 (LHC120A/10V), RYLB01 (LHC120A/10V), RYMCB05 (LHC600A/10V), RYSC01 (Powered spares), RYSA01 (Spares parts), RYSA02 (Spares parts), RYSA03 (Spares parts), RYSA04 (Broken modules)
RR53 and RR57; ground floor	RYHG01 (LHC6kA/8V), RYHG02 (LHC6kA/8V), RYHG03 (LHC6kA/8V), RYHG04 (LHC6kA/8V), RYHG05 (LHC6kA/8V), RYHG06 (LHC6kA/8V), RYHG07 (LHC6kA/8V), RYHG08 (LHC6kA/8V), RYHG09 (LHC6kA/8V), RYHG10 (LHC6kA/8V), RYHG11 (LHC6kA/8V), RYHG12 (LHC6kA/8V), RYHG13 (LHC6kA/8V), RYHG14 (LHC6kA/8V), RYHG15 (LHC6kA/8V), RYLB01 (LHC120A/10V),RYLC01 (LHC120A/10V).
RR53 and RR57; 1st floor	RYLB04 (LHC120A/10V), RYLB03 (LHC120A/10V), RYMCB03 (LHC600A/10V), RYMCB02 (LHC600A/10V), RYMCA02 (LHC600A/10V), RYMCB01 (LHC600A/10V), RYMCA03 (LHC600A/10V), RYMCA01 (LHC600A/10V), RYMCA04 (LHC600A/10V), RYLB02 (LHC120A/10V), RYSA01 (Spares parts), RYSC01 (Powered spares), RYSA02 (Spares parts), RYSA03 (Broken modules).

Table 3. Power converter equipment.

Generally, they contain the voltage source and the related Function Generator Controller, FGC, (communication module, processor module, I/O module, memory modules) with the associated DCCT (current sensor) conditioning electronics. In particular, the RYCA01 and RYCA02 are calibration racks. Moreover, they contain a PC with a screen, Sigma Delta converter, and DCCT electronic control. The power supply comes from EOD 116/56, ERK 106/56, ERK 104/56, ERK 105/56, ERD 103/56, EOK 103/56, and ERD 102/56. The systems require the 230 VAC and the UPS. The remote communication is based on the WorldFip bus (2.5 Mbit/s).

The failure of the power converters will cause the beam loss since the magnets are not supplied correctly and no redundancy is implemented. In case of failure, the power converter sends a signal to the interlock system (*Powering failure*). Viceversa, the action of the power converters can be disabled by the Interlock system (*PC_permit* and *PC_FastAbort* signals) on the basis of other alarms. The WorldFip for communication and control of the power converter, the AC Network (normal + UPS), the water cooling (LHC600A/10V, LHC4-6-8kA/8V) and the PIC systems are required to allow for proper working of the power converter system. The different type of FGCs (generic FGC, PSU FGC, and FGC DOC) use components like mosfet, memory, CPLD, that are known to be sensitive to radiations. Error mitigation is foreseen at software level for the generic FGC. Some parts are under test at CNGS facility.

As far as the relocation is concerned, the limiting factor is the cable resistance (the maximum output voltage of the power converter is 8 or 10V). More details concerning impact of failure, as well as mitigation constraints can be found in a dedicated summary summary document. [REF see link: http://r2e.web.cern.ch/R2E/Related/RadiationTesting/SummaryPCs_24june09_v4.pdf] as well as in the talks of the power-converter review (see link: http://indico.cern.ch/event/PowerConverterDay_2010) .

Owing to the dimensions of the equipments, a complete relocation is considered as very difficult without new civil engineering actions. Thus also other options (radiatio tolerant design, superconducting links) are considered in parallel.

A decision will be taken on the basis of the review.

11.1 MISSING INFORMATION

12. OPTICAL FIBERS [D. RICCI]

Patch panels for optical fibres are installed at UJ56, level 1, in the rack CYFIB01. It consists of passive elements such as optic fibres and connectors. The system does not need any power supply. The fibres are used by IT network, GSM, cryogenics, timing, quench protection system, power converter (WorldFip and Profibus), and other users. In case of failure, the users will be affected obviously.

The multimode fibres used by IT network are sensible to total dose and displacement damage only. Thus, the low dose expected in the considered areas should not pose any problem for the operation. The system uses about 20 cables and the relocation would require a high cost.

Therefore, the system itself can stay in place. A relocation can be required if it can make easier the relocation of the related network equipments (switches).

12.1 MISSING INFORMATION

Verify the list of the users.

13. NETWORK EQUIPMENT [E. SALLAZ]

The network infrastructure is located at UJ56, level 1. The racks CYNET01, CYNET02, and CYFIB01 include optical fibres, UTP (Unshielded Twisted Cable) cables, and switches.

A failure of the network system will affect all the users in the area. The systems using the network can change at any time. The list can be checked on the *netops* website.
The system can be moved as long as it can be re-installed in such a way to cover all the area. The main point concerns maximum lenght of the structured cabling infrastructure which is 90 meters from the star point.

It is suggested to relocate the network equipment since many users depend on it.

13.1 MISSING INFORMATION

The information was derived from point 8. Please verify.
Give the current list of the users.

14. ACCESS SYSTEM [R. NUNES, C. DELAMARE, J.F. JUGET]

The racks for the access system are YYACS01, YYACS02, YYACS03, YYACS04, and YYACS05. They are key-locked. They should contain control equipment which is known to be radiation sensitive and electro-mechanic switches that are not sensitive. Misbehavior could generate alarms and stops of the machine. Power-supply comes from the rack EOK104/56.

On the basis of these preliminary information, the equipment should be relocated.

14.1 MISSING INFORMATION

Please provide information on: System description; Failure consequence; List of systema that depend on your own equipment; list of the system required by your own system; power requirement; remote bus requirement. Type and numebr of cables for relocation – if possible. Alternatively, a survey can be filled on the web.
https://espace.cern.ch/info-r2e-documents/Lists/R2E%20Equipment%20Survey%20All%20Areas/overview.aspx

15. CRYOGENICS INSTRUMENTATION AND ELECTRONICS (FIP BUS) [G. PENACOBA]

The racks for the cryogenics control are QYC01 QYC02 QYC03. QYC01 contains Siemens unit power, QYC02 contains the acquisition system for temperature sensors and high voltage units; QYC03 contains Siemens modules. The power-supply comes from the rack EOK 105/56. The custom made cryogenic instrumentation electronics are: 1) Conditioners, measuring temperature, pressure, liquid helium level and digital valves status 2) Actuators, providing AC and DC power. In case of failure, the LHC cryogenics operations are affected; misbehaviors on the interlocks signals are also possible. The system requires the UPS power supply (~10 A), the WorldFIP bus at 1 Mb/s, the ethernet networks, and PLC and PVSS servers.

Radiation tests on the custom electronics have been done at CNGS and the results are resumed in Table 4.

On the basis of these results, the system can stay as is.

Card Type	**# Cards**
CT, CL, CV, MMW, CK, CJ, PA	42
CY	11
CH *	2

CNGS_09 tests: CT, CL, CV, MMW, CK, CJ, PA			
No Failures detected until	**TID (Gy)**	**NIEL (n/cm2)**	**>20MeV (p/cm2)**
	360	5.05E+12	2.62E+12
with safety factor 2	**180**	**2.53E+12**	**1.31E+12**
CNGS_09 tests: CY			
Failures detected at	**TID (Gy)**	**NIEL (n/cm2)**	**SEU cross section (cm-2)**
	126	1.77E+12	2.24E-09

with safety factor 2	**63**	**8.83E+11**	**4.47E-09**
CNGS_09 tests: CH *			
Failures detected at	**TID (Gy)**	**NIEL (n/cm2)**	-
	5	7.11E+10	-
with safety factor 2	**3**	**3.55E+10**	-

Table 4. Radiation tests for the cryogenoc instrumentation * CH cards are not needed for normal machine operation; needed only during cooling-down phase.

15.1 MISSING INFORMATION

Please, confirm that the relocation can be avoided.

16. CRYOGENICS INSTRUMENTATION (PROFI BUS) [P. GOMES, M. PEZZETTI]

The racks for the cryogenics instrumentation on PROFI bus are located in the racks QYC01 QYC02 QYC03. The racks contain valve positioners, remote I/O modules, and actuators. In case of failure, no inputs are given to the cryogenic control system and, consequently, a beam dump can be triggered.

Since the electronic parts of the system are supposed to be sensitive to radiations, it is suggested to relocate the equipment.

16.1 MISSING INFORMATION

Please, provide a more complete description of the system.
Do you have PLC too?
Could you better clarify the location of your equipment? Is it in the same rack as the cryogenics instrumentation on FIP bus (see par. 13)?
Which systems does your equipment need to work (power, ethernet?)?
Please, specify the number and the type of cables required by your equipment.

17. QUENCH PROTECTION SYSTEM AND ENERGY EXTRACTION [R. DENZ]

The equipment for the Quench protection system is installed in the racks DYPG01,DYPG02, and DYPG03 at UJ56, level 1 and at RR53/57. The DYPG01 contains the quench heater discharge power supply. The DYPG02 contains the acquisition monitor controller, the global quench detectors, the current leads quench detectors, and a quench heater discharge power supply. The power supply comes from the rack EBD 223-56. The WorldFip bus is required for the remote communication.

A failure of this equipment will prohibit the re-powering; a fast power abort sequence could be triggered; in rare cases, the protection for the magnets is not assured.

Most of the electronics has been tested or is under test.

A redesign of the weak parts is under investigation. Alternatively, the digital parts of the system could be relocated.

(Infomation was derived from the LHC layout database).

17.1 MISSING INFORMATION

Please, provide a more complete description of the system.
In case of relocation, specify the number and the type of cables required by your equipment.

18. GSM EQUIPMENT [F. CHAPRON]

GSM equipment, named GSP UJ56-28, is located in the rack CYRR01 at UJ56 level 0 in the safe-room. It consists of a GSM probe that monitors the availability of GSM services over time in this part of LHC tunnel. It needs a 220V, (50 W) power supply and the availability of the GSM services (provided by a GSM emitter located in SD5/6 and a leaky feeder cable infrastructure). The GSM emitter is located in SD5/6 and maintained by Sunrise.

The device is suspected to be sensitive to radiations but specific tests have not been carried out. In case of failure, the IT/CS group will loose the monitoring of the GSM service.

The relocation depends on the GSM signals propagation. Then, a site survey shall be made to determine the possibilities. The drawing of the leaky feeder cable infrastructure can be provided later.

Since the system is not so critical, the relocation could be possibly avoided.

18.1 MISSING INFORMATION

19. FIRE DETECTION (ODH) [S. GRAU, R. NUNES]

The control panel for the Fire detection of the machine and of the experimental area is located in the safe room at the ground level of UJ56. The rack name is SYFAD01 and the common equipment name is SFDIN-00297 CENTRALE INCENDIE ZS05. The system is based on a PLC-type device and is sensitive to Electromagnetic noise. A 230V secure power supply, not disabled by the Arret Urgence General (AUG), is needed. The communication is based on the Ethernet bus. In case of failure, the fire detection will not work anymore in the LHC REs and in the CMS experimental areas. The users of the system are the operators, the XCR and the Fire brigade.

The system could be relocated in the USC55 area.

The fire detectors are installed on the wall against the tunnel in the area UJ56 first floor, RR53 and RR57. The common equipment name is SFDEI-xxxx. Cables are needed to link the detectors to the central control system which provides the power supply as well. The communication is based on the Ethernet bus. In case of failure, a fire could not be detected in the RR and UJ areas.

In case of relocation, testing is necessary to move the stuff in a more safe location, and a pipe must be installed (2-3 inch diameter) in order to bring the air sample to the detector that is located further away. The routing of the pipe could pose an integration problem.

The relocation of the system is recommended for safety issues.

19.1 MISSING INFORMATION

20. ELECTRICAL SUPPLY AND DISTRIBUTION [G. BURDET, M. CODOCEO]

The EL equipment is located at UJ56, level 0. A brief description is given of all the kinds of racks.

- **EYU** AU Racks. These racks contain PCBs with the logic for the AU safety functions. There are some electronic components such as capacitors, diodes and integrated circuits. The safety logic is done via contacts and relays that in principle should not be affected by radiation.
- **EYP/ECU** racks (EYP) which contain the chargers (ECU) that power the safety lighting and that are placed either in the US safe rooms except US15, in the UJ56, UJ33 and UJ67 and RE zones. There are two type of brands, Victron and PROMEC (US85). They have sensible components as zener diodes (DZ18VAA0, DZ15VAA0), transistors (BC237, BD786), PCBs with integrated logics (74HC132), CMOS, thyristors.
- **EYC** These racks contain all of the equipment necessary to control and monitor the electrical equipment: DAUs, microcontrollers, switches, Ethernet…They are vital for our monitoring systems. These racks could be very sensible to radiation.
- **EYQ** Cryogenics 24VDC generation. These racks contain 24VDC PROMEC modules with electronic components sensible to radiation (EPROMs, diodes, MOS, microprocessors, transistors…).
- **EBS/ESS** UPS units (machine and cryogenics) which are very sensible to radiation since their logic depends on, transistors, CMOS, IGBTs, microprocessors and other electronics.
- **ESU/EAU** 48VDC generation and battery chargers. This equipment is mainly installed in the US (safe room) and RE. The chargers are manufactured by Ackermann and they have power electronics and sensible components such as zener diodes (Motorola 1N823, 1N754A1, IN747 A1, IN968 B1, 1N978A), diodes (Unitrode 1N4148, 1N5614, 1N5624, 1N4148), transistors (Motorola 2N3019, 2N3716), PCBs with integrated circuits (AXA 279.109, PMI IOP27CZ1), thyristor bridge (U5043/147, U5043/160).
- **EAD/EBD/ERD/ESD/EOD/EQD** They contain low voltage switchboards with fuses, bornes, switch breakers, which normally do not have electronics in their inside. Some of these racks contain voltage monitoring relays. We have not been able to find out which are the exact components in their inside. Anyhow, these relays do not realize any safety functions; they just enable our control system to detect the mains supply. In case they do not work properly our monitoring system will either have no alarm or a false alarm. We have as well monitoring equipment and displays (DIRIS) which do not realize any safety

function, if they do not work properly our monitoring system would not get the right measurements of the switchboard and we would lose the supervision of the switchboards.

- **EMD** medium voltage switchboards that do not contain equipment sensible to radiation.
- **EMT** medium voltage transformers whose "resine" isolation might decompose in the long term with radiation.
- **EYB** safety lighting chosen to stand radiation. This equipment does not contain any electronic components.
- **EJG** stands for battery racks for the UPS systems in the US15, RE, UAs of the LHC even points. Not affected by SEE.
- **ECJ/ECD** 48VDC distribution crates installed in the US, UW, UX, UJ and RE. Normally the distribution crates are made up of fuses or switch-breakers.
- **AU buttons** are all over the LHC underground and surface areas. These are mechanical buttons, with no electronics in their inside. The only problem presented so far, with the new technology AU buttons, is that they have a plastic component that is deteriorated by radiation. When this happens the button might set an AU safety function off. In any case, the safety of people is ensured. EN-EL is well aware of the problem. Annual tests of the AU system are carried out and campaigns of replacement of these AU buttons are foreseen.

The 48 V system generator is based on a technology presenting tirystor and ondulators for the anti panic light. This technology will be studied to understand his behaviour in presence of radiation.

Two UPS systems, EBS11 and EBS21 (120kVA) are installed. According to the other equipment informations, the UPS is required by the Vacuum, Cryogenics, Electrical distribution, FIP repeaters, PIC, BIC, Beam position monitor, Collimation, Power converters. Three racks EBD, EOD and ERD are isntalled at first floor of RR53 and RR57.

The relocation of the most critical racks (containing possibly sensitive components) should be done.

20.1 MISSING INFORMATION

Would it be possible to relocate only some racks (EYU, EYP, EYC, EYQ, EBS, ESS, ESU EAU)?
Or, are there strong interdependencies with the distribution racks (**EAD/EBD/ERD/ESD/EOD/EQD**)?
EJG are not installed in UJ56. Is that correct?
Can the loss of monitoring (see **EAD/EBD/ERD/ESD/EOD/EQD**) be tolerated for long periods (~time between two technical shutdowns)?

21. COOLING AND VENTILATION [H. JENA]

The ventilation unit was not on the plan of level 0 (Fig. 2).

Figure 2. Unit UIAO-00560. Ventilation UJ56, RR53, RR57. Automate UOWC-00560. Power supply from UIAC-00560.

21.1 MISSING INFORMATION

Could you, please, provide a description of this equipment?
Do you have equipments in RR53 and RR57?

22. SUMMARY TABLES UJ56, RR53/57

Equipment	Rack	Radiation test	Failure consequences	Option	Priority	Contact
Fire/ODH control	SYAFD01	Not tested Supposed very sensitive	No fire detection, no ODH detection Failure affects also the areas UJ US UX RE	Relocation	1 (Safety issue)	R. Nunes S. Grau
Fire/ODH detectors	SFDEI – xxxx	CNGS experience ~10^7 h/cm^2	No fire detection; if two more detectors are in fail mode, an evacuation is triggered	Relocation	1 (Safety issue)	R. Nunes S. Grau
AUG control	AU	Not tested	Loss of the AUG logic	Relocation	1 (safety) ?	A.Burdairon M. Codoceo
UPS	EBS/ESS	Not tested	Loss of Cryogenics, vacuum, QPS, Beam monitoring.	Relocation	1(many system depend on it)	A.Burdairon M. Codoceo
Electrical equipment	See text	Not tested Control part supposed to be sensitive	Loss of power supply and possible loss of the safety lighting	Shielding Relocation of the digital control parts	1	A.Burdairon M. Codoceo
Collimation control	TYCFL01 TYCCR01	CERF test ~10^7 h/cm^2	Beam dump	Relocation up to 200 m	1 (machine safety)	A Masi
Remote-Reset &	CYTIM01 CYFRE01	Not tested Supposed	Loss of timing Beam dump	Relocation Most of clients	2 (many systems depend on it)	R. Chery

Timing	TYCCR01	very sensitive		in safer areas such as USC(P5)		
QPS and Energy Extraction	DYPG01 DYPG02 DYPG03	Tested at CNGS-2008	Prohibited re-powering Possible fast power abort sequence No protection for the magnets (rare)	Redesign, or Relocation of the digital parts	2 (machine protection, redundant)	R. Denz
Power Converter	RYHF01 (RQX LHC8kA/8V), RYHG01 (RQTX2 LHC6kA/8V), RYMCB01 (RTQX1 LHC600A/10V IT), RYCA01 (DCCT calibration rack), RYCA02 (DCCT calibration rack), RYMCB02 (LHC600A/10V), RYMCB03 (LHC600A/10V), RYMCB04 (LHC600A/10V), RYLC01 (LHC120A/10V), RYLB01 (LHC120A/10V), RYMCB05 (LHC600A/10V), RYSC01 (Powered spares), RYSA01 (Spares parts), RYSA02 (Spares parts), RYSA03 (Spares parts), RYSA04 (Broken modules).	Tested at CNGS	Beam dump	Relocation with redesign (increase voltage) RadTol design d) SC link (feasibility)	2 (downtime)	Y. Thurel
Access System Control	YYACS01 YYACS02 YYACS03 YYACS04 YYACS05	Controls not tested. 60Co for switches	Misbehave could generate alarms and stop of the machine	Relocation	2 Downtime (Operation)	R. Nunes
Ethernet	CYNET01 CYNET02 CYFIB01	Tested in the past	Loss of the Ethernet connection for the clients	Relocation of the switches (max length structured cable 90 m)	2 (Many systems depend on it)	E. Sallaz
Cooling and Ventilation	Unit UIAO-00560	Sensitive (failure at CNGS)	No CV for Equipment Possible operational stop	Relocation	2 (Downtime)	H. Jena B. Jensen
Cryogenics Instrumentation and Electronics (PROFI bus)	QYC01 QYC02 QYC03	Tested at TCC2 Sensitive	No input for Cryogenic system that could drive a beam dump	Relocation	2 (down time)	P. Gomes M. Pezzetti
Power Interlock	CYCIP01	sensitive	Beam dump Users: Power converters, QPS, BIC, Cryogenics, UPS, AUG	Relocate PLC (up to 100 m)	2 (machine safety but the system is redundant)	M. Zerlauth P. Dahlen
Beam Interlock	CYCIB01	Total dose test at PSI for the CIBU Test at CNGS: Test at Louvain FMCM not tested	Beam dump Users: Vacuum. Collimation, PIC, CMS and Totem Exp.	Relocation of control part (VME rack) to be verified	2 (downtime/machine safety but the system is redundant)	B. Puccio B. Todd M. Zerlauth
Current Leads Heaters	DYAI0 DYLD01	Burn out at $\sim10^{10}$h/cm^2	No heating of the top part of the current lead. Pose an issue only for the machine restart	Relocation	3 (beam down time)	A.Ballarino S. Le Naour
Survey	GYPOS01	Acquisition system tested at CNGS Electronics tested Driver for motors not tested	No alignment for low beta magnets. Issue for operation	It can stay/relocation?	4	A.Marin
GSM Repeaters	CYRR01 **room**	Not tested. Supposed to	Loss of the GSM service in the	Relocation	4 (not intended for safety)	F. Chapron

		be sensitive	tunnel			
Beam Position Monitors	BY01	Problem on the intensity card. Not an issue for operation	Possible degradation of the beam orbit reading	It can stay Possible redesign of the intensity card.	4	Eva Calvo Giraldo Jose Luis Gonzales
Optical Fiber	CYFIB01	Insensitive to SEU Tested with 60Co	Radiation induces attenuation of light	Depend on the Ethernet switches		D. Ricci
AUG Buttons	**LHC underground**	Tested	Loss of full functionality	Annual test		A.Burdairon M. Codoceo
Cryogenics Instrumentation and Electronics (FIP bus)	QYC01 QYC02 QYC03	Tested at CNGS	No input for Cryogenic system that could drive a beam dump	It can stay?		J.Bremen E. Gousiou G. Penacoba
WorldFip	CYFRE01 GYPOS02 GYPOS03	Repeaters tested CNGS	Repeater: loss of the network for the next users FipDiag: Loss of the network diagnostic	It can stay Depend on the clients Power converter, Radmon, Experiment Survey, Cryogenics QPS		J. Palluel D. Caretti

Table 5. Equipments in UJ 56.

Equipment	Rack	Radiation test	Failure consequences	Option	Priority	Contact
Fire/ODH detectors		CNGS experience ~10^7 h/cm^2	No fire detection; if two more detectors are in fail mode, an evacuation is triggered	Relocation	1 (Safety issue)	R. Nunes S. Grau
Electrical equipment	ERD, EBD, EOD	Not tested Control part supposed to be sensitive	Loss of power supply and possible loss of the safety lighting	Shielding Relocation of the digital control parts	1	A.Burdairon M. Codoceo
QPS and Energy Extraction	DYPG01 DYPG02 DYPG03	Tested at CNGS-2008	Prohibited re-powering Possible fast power abort sequence No protection for the magnets (rare)	Redesign, or Relocation of the digital parts	2 (machine protection, redundant)	R. Denz
Power Converter	Level0 : RYHG01 (LHC6kA/8V), RYHG02 (LHC6kA/8V), RYHG03 (LHC6kA/8V), RYHG04 (LHC6kA/8V), RYHG05 (LHC6kA/8V), RYHG06 (LHC6kA/8V), RYHG07 (LHC6kA/8V), RYHG08 (LHC6kA/8V), RYHG09 (LHC6kA/8V), RYHG10 (LHC6kA/8V), RYHG11 (LHC6kA/8V), RYHG12 (LHC6kA/8V), RYHG13 (LHC6kA/8V), RYHG14 (LHC6kA/8V), RYHG15 (LHC6kA/8V), RYLB01 (LHC120A/10V),RYLC01 (LHC120A/10V) Level1 : RYLB04 (LHC120A/10V), RYLB03 (LHC120A/10V), RYMCB03 (LHC600A/10V), RYMCB02 (LHC600A/10V), RYMCA02 (LHC600A/10V), RYMCB01 (LHC600A/10V), RYMCA03 (LHC600A/10V), RYMCA01 (LHC600A/10V), RYMCA04 (LHC600A/10V), RYLB02 (LHC120A/10V), RYSA01 (Spares parts), RYSC01 (Powered spares), RYSA02 (Spares	Tested at CNGS	Beam dump	Relocation with redesign (increase voltage) RadTol design SC link (feasibility)	2 (downtime)	Y. Thurel

	parts), RYSA03 (Broken modules).					
Cooling and Ventilation	UIAO-00560	Sensitive (failure at CNGS)	No CV for Equipment Possible operational stop	Relocation	2 (Downtime)	H. Jena B. Jensen
Cryogenics Instrumentation and Electronics (PROFI bus)	QYC01 QYC02	Tested at TCC2 Sensitive	No input for Cryogenic system that could drive a beam dump	Relocation	2 (down time)	P. Gomes M. Pezzetti
Power Interlock (remote I/O)	CYCIP01	Test on Anybus card at TCC2, 60 MeV protons CNGS facility; (but it can have Latchups)	Beam dump Users: Power converters, QPS, BIC, Cryogenics, UPS, AUG	Ok for RR (remote I/O)		M. Zerlauth P. Dahlen
Current Leads Heaters	RR53 level 1: DYAI01 DYLD01 RR57 level 1 DYAJ01 DYLE01	Burn out at ~10^{10}h/cm^2	No heating of the top part of the current lead. Pose an issue only for the machine restart	Relocation	3 (beam down time)	A.Ballarino S. Le Naour
Beam Position Monitors	BY01, BY02, BY03, BY04, BY05, BY06	Problem on the intensity card. Not an issue for operation	Possible degradation of the beam orbit reading	It can stay Possible redesign of the intensity card.	4	Eva Calvo Giraldo Jose Luis Gonzales
Beam loss monitor		tested	No machine tuning Beam dump	Stay as is	4	B. Dehning
Cryogenics Instrumentation and Electronics (FIP bus)	QYC01 QYC02	Tested at CNGS	No input for Cryogenic system that could drive a beam dump	It can stay?		J.Bremen E. Gousiou G. Penacoba
WorldFip	Cable trays and walls	Repeaters tested CNGS	Repeater: loss of the network for the next users FipDiag: Loss of the network diagnostic	It can stay Depend on the clients Power converter, Radmon, Experiment Survey, Cryogenics QPS		J. Palluel D. Caretti

Table 6. Equipments in RR53 and RR57.