R2E RELOCATION AND SHIELDING ACTIVITIES

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Abstract

In the framework of the R2E (Radiation to Electronics) mitigation project, relocation and shielding campaigns will be performed during the next long shutdown in parallel in Points 1, 5, 7 and 8. About 15 groups will be involved in these R2E activities with work periods from few days to several months. The baseline for these relocations and shielding installations is today defined. The status of the integration studies and their constraints will be discussed aiming for the different teams to be ready for the 2012 shutdown. The impact on the work achievement of a possible delay of the R2E activities by one year will be presented.

INTRODUCTION

The R2E Mitigation Project assists LHC operation and equipment owners with expert knowledge and assessments of radiation-induced failures in electronics. It is responsible to implement a mitigation plan to minimise radiation induced failures in electronics and respectively optimise the LHC operation. To that purpose different working groups are related to the R2E Mitigation Project. Amongst them, there are the Monitoring and Calculation Working Group (MCWG) and the Radiation Working Group (RadWG). The MCWG discusses FLUKA simulations and early measurements of the radiation levels around LHC. The RadWG helps the equipment owners to estimate their equipment failure rate due to Single Event Effect (SEE) though irradiation tests campaigns and is the forum in which radiation tolerant solutions are discussed. For what concerns the R2E mitigation Project, a crosschecking of the results of the MCWG with the RadWG allows identification of the equipment to be relocated [1, 2, 3, 4] and ensures that the best new locations for the shielding and equipment are found. In the framework of the R2E Mitigation Project the EN/MEF group is in charge of the relocation and shielding activities integration and implementation tasks [5].

The level of flux of hadrons with energy in the multi MeV range expected from the collisions at the interaction Points 1, 5 and 8 and from the collimation system at Point 7 will induce Single Event Error in the standard electronics present in many of the control equipment. Furthermore, a risk of SEEs induced by thermal neutrons cannot be excluded. Such events would perturb the LHC, possibly leading to a stop of the machine. The R2E Mitigation Project foresees to shield or to relocate into safer areas the sensitive equipment, in terms of hadron fluence / SEE, installed in these critical areas. These mitigations activities will have to be performed in parallel in Points 1, 5, 7 and 8 during the next long shutdown.

This document describes the strategy in terms of shielding and relocation proposed for reducing the SEE risk associated to equipment installed around Points 1, 5, 7 and 8.

RELOCATIONS AND SHIELDING

The levels of radiation expected from the collisions at Points 1, 5 and 8 and from the collimation system at Point 7 have been simulated with the FLUKA code for the beam conditions foreseen for the LHC operation between 2011 and 2014 and for the LHC nominal operation conditions [6-10]. In 2011, in UJ14/16, UJ56, UJ76 and US85, the flux of hadrons with E>20MeV will exceed 10^7 cm^{-2}. It would exceed 10^8 cm^{-2} per year in the operational period after the next long shutdown and even exceed 10^9 cm^{-2} per year in nominal operation conditions. In the RRs adjacent to Points 1, 5 and 7 the flux of hadrons with E>20MeV could reach up to 10^7 cm^{-2} in 2011 and exceed 10^8 cm^{-2} per year afterwards. At such levels, one does not expect any radiation damage resulting from the total ionising dose (corresponding values range from 0.05Gy to a few Gy/year). However, single particle energy deposition can induce changes in the data state of a memory cell, register or flip-flop. For comparison, at CNGS, SEE failures leading to the stop of the facility were observed for hadrons with E>20 MeV fluences of the order of 10^7 cm^{-2} per year.

Point 1

Sensitive equipment, in terms of hadron fluence /SEE, has been identified in the UJs and RRs on both sides of Point 1 [1]. The sensitive equipment, today located in UJs14/16, will be relocated into the ULs14/16 (see Figures 1a and 1b). The sensitive equipment located in the RRs will stay there (except the fire detectors) but its shielding will be improved, replacing the concrete walls

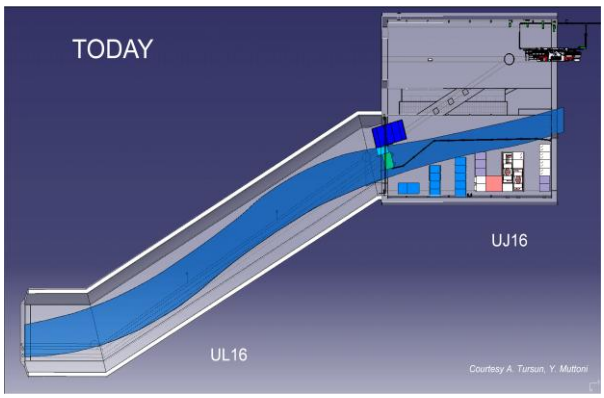

Figure 1a: Equipment location today in UJ16 (symmetric situation in UJ14).

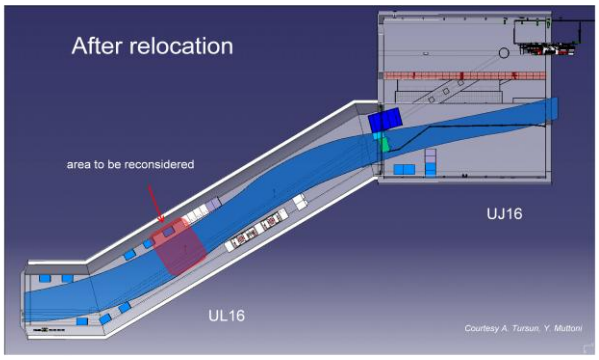

Figure 1b: Equipment after relocation in UL16 (symmetric situation in UL14).

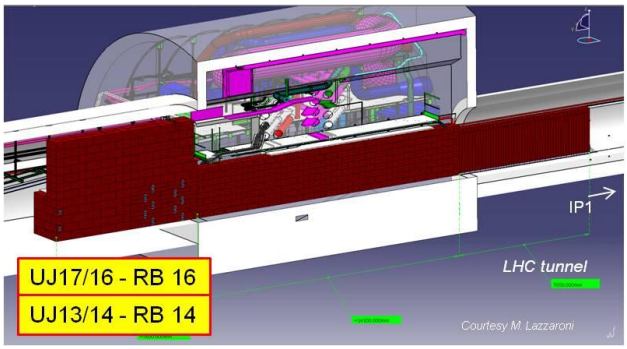

Figure 1c: New shielding implementation in UJs and RBs around Point 1.

by cast iron ones. 10 groups will be involved in the relocation activities at Point 1 during 7 months (see Table 1).

Additional cast iron shielding walls will be installed on both sides of Point 1 in the RBs and UJs (see Figure 1c). The overall shielding installation is estimated to 4 months for the EN/HE team. During the shielding activities in the RRs (3 weeks per RR), the access to RR and thus to the ARCs will not be possible.

Point 5

Most of the equipment installed on the first floor of the UJ56 and 5 racks of the UJ56 safe room (on the ground floor) has been identified as sensitive in terms of hadron fluence /SEE [2]. This equipment will be relocated inside the UJ561- bypass (see Figure 2). This relocation implies the following civil engineering work for cables and pipes passage; drilling 16m long ducts between the UJ56 first floor and the bypass; drilling holes between UJ56 first floor and LHC tunnel and drilling holes in the separation wall of the UJ561. 12 groups will be involved in the relocation activities of Point 5 during 15 months. This period estimation takes into account that the EN/EL team will work on a 2 shifts/day basis during 12 months (see Table 1).

Similar to Point 1, the existing concrete shielding walls in the RRs will be dismantled and replaced by cast iron ones. The overall shielding installation is estimated to take 2 months for EN/HE team. During the activities in the RRs (4 weeks per RR), the access to the RR and thus to the ARC will not be possible.

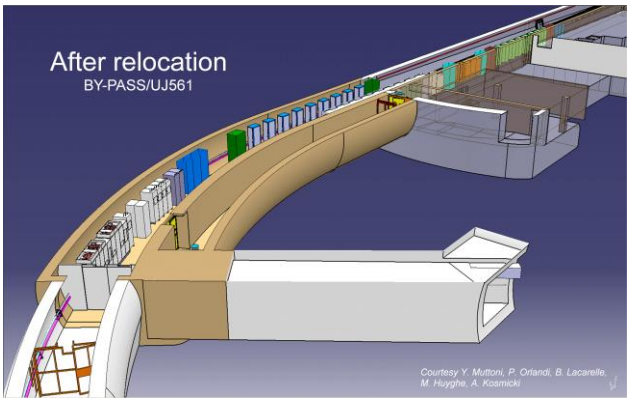

Figure 2: Equipment relocated in the by-pass/UJ561.

Point 7

Most of the equipment installed on the first floor of the UJ76 and 5 racks of the UJ76 safe room (on the ground floor) has been identified as sensitive in terms of hadron fluence /SEE [3]. This equipment will be relocated inside the TZ76 (see Figure 3). 11 groups will be involved in these relocation activities during 10 months (see Table 1).

Additional shielding walls have already been implemented in the UJ76 and in the RRs [11, 12].

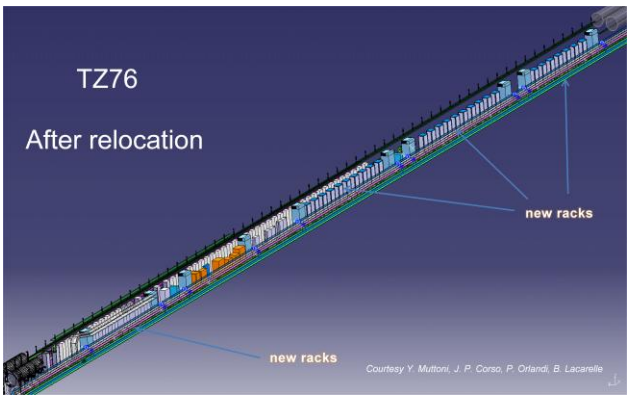

Figure 3: Equipment after its relocation in the TZ76.

Point 8

Equipment located in the US85 (on the first and second floors) has been identified as sensitive in terms of hadron fluence / SEE [4]. This equipment will be relocated in the US85 on ground floor, in the ULs84/86 and in the UA83. 7 groups will be involved in these relocations during 10 months (see Table 1).

An additional cast iron shielding wall with a movable chicane will be installed in the US85 at the ground floor (see Figure 4). It will protect the cooling and ventilation equipment located in the UW85 and cryogenics equipment relocated in the US85 on the ground floor. Due to technical constraints it was not possible to relocate this cryogenics equipment further away. The installation of the

Table 1: Teams involved into the R2E relocation and shielding activities with the estimated duration of their respective activities in Points 1, 5, 7 and 8 (as provided by the responsible groups).

	Equipment / activity	Point 1 activity [weeks]	Point 5 activity [weeks]	Point 7 activity [weeks]	Point 8 activity [weeks]
BE/APB	survey eqpt.	-	3	-	-
BE/BI	BTV, BLM	-	-	1	-
BE/CO	timing & remote-reset WorldFip	<1 -	<1 1	<1 1	<1 1
DGS/RP	RAMSES	-	-	2	-
EN/CV	cooling/ventilation eqpt	3	10	8	8
EN/EL	electrical eqpt & cabling activity	25	52 (2 shifts)	25	16
EN/HE	eqpt. transport shielding inst.	2 19	3 9	2 done	1 2
EN/STI	collimator control eqpt	6	5	-	-
GS/ASE	fire/ODH access	5 -	6 6	4 6	done -
GS/SE-CE	duct activities	-	11	-	-
IT/CS	ethernet	t.b.c.	2	t.b.d.	2
TE/CRG	cryogenics eqpt	7	6	6	4
TE/EPC	power converters	9	9	2	-
TE/MPE	QPS* PIC* current leads heaters BIS WIC	1 <1 6 - -	1 <1 3 <1 -	- - - - -	- - - - 3
TE/VSC	vacuum eqpt	-	-	9	-

* additional re-commissioning during the hardware re-commissioning and powering

shielding is estimated to 2 weeks for the EN/HE team.

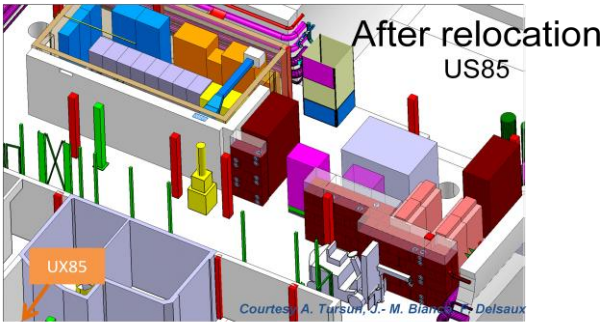

Figure 4: US85 after relocation and shielding installation.

OPEN ITEMS

Integration study update

During investigation into a possible direct contribution of the UX15 (ATLAS experimental cavern) to the radiation levels in the ULs the MCWG noticed that the wall thickness between UX15/ULs used in previous simulations (according to provided specifications) was thicker than the reality (3 m instead of the real 1.4 m). New simulations have thus been performed at the end of 2010 pointing out an area in the ULs with a hadron fluence above 10^7 cm^{-2} (see Figure 1b), in which SEE occurrence in sensitive equipment may be important [10]. To cross-check these simulation results, RadMon dosimeters have been installed in the UX at the end of 2010. Depending on the LHC operation, the first set of measurements will be available in June 2011. In the integration study performed in summer 2010, it has been proposed to relocate equipment in the ULs and especially in this sensitive area. To be ready for 2012 long shutdown, R2E has decided to review the integration study at Point 1, taking into account the removal of all equipment from this newly defined sensitive area. After the interpretation of the RadMon dosimeters measurements, most probably at the beginning of summer 2011, the relocation strategy will be chosen between the two available options. It may occur that the cables with require a long purchase delay would have to be ordered before the results of the measurements would be known.

'Safe rooms'

The AUG, anti-panic lightning and general electric network control equipment have been identified as sensitive in term of hadron fluence/SEE. This equipment, today located in the UJ56 and UJ76 safe rooms, has to be relocated in the UJ561- bypass and TZ76. Due to space constraints, the implementation of a 'safe room' in the existing TZ76 gallery is not possible. The only possibility would imply long and costly civil engineering work. Before launching such an activity, R2E together with DGS/SEE and EN/EL have launched studies to find out if the equipment could be relocated without the creation of an equivalent 'safe room'. It has been agreed that DG/SEE will study the existing fire risk in a safe room and in the TZ76, taking into account all the equipment to be relocated. EN/EL has agreed to study the technical feasibility of the relocation and the technical functionality after the relocation. The conclusions of both 'safe room' studies will be discussed within R2E and then a proposal for the relocation of the 'safe rooms' equipment will be submitted to the LMC. Once approved, R2E will provide a new updated integration solution for Points 5 and 7. Today a compromise has been found for Point 5 with the implementation of a 'mini safe room' with siporex walls which are fire resistant up to 2 hours.

CRITICAL DATES

Long shutdown in 2012

The ordering process of the water cooled cables for the power converters to be relocated drives the critical date for the activities in Points 1 and 5. EN/EL estimates this process to be 10 months long. To be ready for the 2012 long shutdown, the relocations integration studies of Points 1 and 5 have thus to be finalised by the end of February 2011.

Following the conclusions of the 'safe rooms' studies, the relocation integration study of Point 7 will have to be reviewed. If the decision is to relocate the racks to a location without a 'safe room' equivalent fire protection, the separation wall along the TZ76 would have to be removed to allow the relocation. This activity is categorised as 'minor' civil engineering work. GS/SE estimates that it will take 9 months to define the work, find a firm and be ready for intervention. Therefore to be ready for the 2012 long shutdown the integration study would have to be finalised by the end of March 2011 and the 'safe rooms' studies delivered before March 2011. If the decision is to relocate the racks to a location with a 'safe room' equivalent fire protection, a new excavation would be needed. This activity is categorised as 'major' civil engineering work. GS/SE estimates that it will take 18 months to define the work, find a firm and be ready for intervention. In this case, it is impossible to be ready for 2012.

All the remaining cast iron blocks required for the construction of the different shielding walls will be delivered to CERN by the end of 2011. The purchase process has already been launched.

Long shutdown in 2013

Even if the start of the long shutdown is postponed by one year, the R2E project has decided to keep 2012 as a target to be able to intervene if necessary all along 2012. An actions plan for the 2011-2012 'Christmas break' will be defined anticipating work. The goal is to anticipate when possible the relocation of the most sensitive equipment and already install shielding walls.

To be ready in Point 7 for the 2013 long shutdown the integration study of the 'major' civil engineering scenario has to be finalised by the end of June 2011 and the 'safe rooms' studies' conclusions have thus to be delivered before June 2011.

SUMMARY

The R2E relocation and shielding activities will be performed by 15 groups working in parallel in Points 1, 5, 7 and 8. The relocations activities in Point 5 are estimated to be the most important in term of time with 15 months of work. Due to a possible radiation leakage from the UX15 to the adjacent UL, the relocation integration study of Point 1 has to be reviewed. 'Safe rooms' studies by DG/SEE and EN/EL will impact on the relocations integration in Points 5 and 7. Without them a final optimised solution cannot be found in Point 7. Keeping the present work effort, R2E relocation and shielding activities may be performed during a long shutdown in 2012 in Points 1, 5 and 8. For Point 7, the conclusions of the 'safe rooms' studies are the driving factor. If 'major' civil engineering work is required then it will not be possible to implement the full relocation in Point 7 in 2012. The R2E project management keeps 2012 as its target even if the long shutdown is postponed to 2013.

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