R2E and Availability for P7 – report from workshop

D. Wollmann

with input from M. Brugger, R. Losito, L. Rossi, R. Schmidt, B. Todd, S. Uznanski

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Full summary reported to 4th Joint HiLumi LHC-LARP Annual Meeting (18.11.2014)

- Slides available in INDICO.
- Organizers: M. Brugger, L. Rossi, R. Schmidt, B. Todd, J. Wenninger, D. Wollmann
- 20 – 65 participants during the sessions

Session 3 – Cleaning insertions IR3 - IR7

Radiation damage issues and equipment maintenance planning.

Future radiation levels and their measurement.

- Possible **operational scenarios** and respective loss distributions – B. Salvachua
- Prompt **radiation levels** at critical locations – E. Skordis
- Radiation **monitoring**: what do we have and what do we need – M. Brugger
- Activation constraints, residual dose rate maps and **intervention scenarios** – C. Adorisio
- Assisted and **remote handling** options and tools – M. di Castro

Impact on equipment lifetimes, maintenance procedures, etc.

- **Vacuum** equipment, optimization of dose/intervention times – V. Baglin
- **Magnet** lifetimes, optimization and dose/intervention times – P. Fessia
- **Cryo** equipment, optimization of dose/intervention times – S. Claudet
- **Collimator** equipment, optimization of dose/intervention times – O. Aberle
- **Cables, Optical Fibers & Lights** (including safety LEDs) – J. Devine
- **Alignment** systems & requirements – J.-F. Fuchs
- **Enclosed** section and affected equipment – I. Efthymiopoulos

Session 2 – Equipment exposed to radiation

Ongoing developments, plans for the next 5 years and requirements beyond.

The Big 4

- RF: Current Systems + Damper – W. Hoefle
- RF: New Systems – R. Calaga
- Power Converters: Control – S. Uznanski
- Power Converters: Power – Y. Thurel
- **Cryogenics** – J. Casa-Cubillos
- **QPS** – J. Steckert

Protection

- **Interlock Systems** – M. Zerlauth
- LHC Beam Dumping System – V. Senaj
- **BLM** – B. Dehning

Close to Machine

- **Beam Instrumentation** – T. Lefevre
- **Vacuum Systems** – P. Krakowski
- Survey and Alignment – M. Sosin

Infra-structure

- WorldFIP – E. Gousiou
- Electronics in the RE – G. Spiezia

LHC Cleaning insertions (IR3-IR7) – summary

- Activation in IR7 will become **comparable to hottest region in injectors** for HL-LHC (35x LS1).
- FLUKA calculations predict **~1MGy / 40fb^{-1}** up to LS3 on **MBW and MQW**.
- **No** known **lifetime issues** until LS3 for the equipment, but first **problems encountered** in cables/connectors (profibus) for vacuum equipment.
- General interest and **support for robotics** solutions (survey, vacuum, …) → **data transmission** as bottleneck.
- **Better understanding** of losses in IR7 required and their **dependency** on operational parameters.
- **2015/16** radiation data essential **to refine the predictions** → improved monitoring required (including radical and ozone levels).
- Better understanding of **future radiation levels** important for the choice of replacement date of MQWs/MBWs → activation levels should still **allow interventions** on them.

Radiation levels

ANNUAL RADIATION LEVELS	Assumptions for various periods:	based on measurements as reported in 2012 summary then used with calculations for scaling				similar to 2012 bit less lumi higher energy 25ns +scrubbing (x2 for ARC/DS)		50fb-1y-1 6.5TeV IR3/7: ~$1x10^{16}$ ~$2\text{-}3x10^{14}$ p.		100fb-1y-1 7TeV IR3/7: ~$2x10^{16}$ ~$3\text{-}4x10^{14}$ p. scaled with lumi		200fb-1y-1 7TeV IR3/7: ~$4x10^{16}$ ~$6x10^{14}$ p. scaled with lumi		400fb-1y-1 7TeV IR3/7: ~$5x10^{16}$ ~$6x10^{14}$ p. scaled with lumi	
Location	Area Assumptions	HEH Fluence [$cm^{-2}y^{-1}$]	Dose [$Gy\,y^{-1}$]	HEH Fluence [$cm^{-2}y^{-1}$]	Dose [$Gy\,y^{-1}$]	HEH Fluence [$cm^{-2}y^{-1}$]	Dose [$Gy\,y^{-1}$]	HEH Fluence [$cm^{-2}y^{-1}$]	Dose [$Gy\,y^{-1}$]	HEH Fluence [$cm^{-2}y^{-1}$]	Dose [$Gy\,y^{-1}$]	HEH Fluence [$cm^{-2}y^{-1}$]	Dose [$Gy\,y^{-1}$]	HEH Fluence [$cm^{-2}y^{-1}$]	Dose [$Gy\,y^{-1}$]
		RUN-1				RUN-2				RUN-3		HL-LHC			
		2011		2012		2015		[2016; 2018]		[2020; 2022]		[2025; 2035+]			
Tunnel ARC MQ	beam-gas ~10^{15}			3E+08	0.5	5E+08	1.0	5E+08	1.0	1E+09	2.0	2E+09	4.0	4E+09	8.0
Tunnel ARC MB	beam-gas ~10^{15}			1E+08	0.2	2E+08	0.4	2E+08	0.4	4E+08	0.8	8E+08	1.6	2E+09	3.2
Tunnel DS MQ				3E+09	5.0	5E+09	10.0	5E+09	10.0	1E+10	20.0	2E+10	40.0	4E+10	80.0
Tunnel DS MB				1E+09	2.0	2E+09	4.0	2E+09	4.0	4E+09	8.0	8E+09	16.0	2E+10	32.0
Tunnel DS Worst	worst RadMon/BLM			5E+09	10.0	1E+10	20.0	1E+10	20.0	2E+10	40.0	4E+10	80.0	8E+10	160.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RRs P7		1E+07	NIL	4E+07	NIL	4E+07	NIL	1E+08	0.1	2E+08	0.2	5E+08	0.4	1E+09	0.8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UJ/RE32	based on RadMon on tunnel side			1E+06	NIL	2E+06	NIL	2E+06	NIL	4E+06	NIL	8E+06	NIL	2E+07	NIL
UJ56		3E+07	NIL	2E+08	0.1	2E+08	0.1	5E+08	0.9	9E+08	1.8	2E+09	3.6	4E+09	7.2
UJ76		1E+07	NIL	8E+07	0.1	8E+07	0.1	2E+08	0.5	5E+08	1.0	1E+09	1.9	2E+09	3.8
ULs P1 start equ.	where 1st PCs are					2E+06	NIL	6E+06	NIL	1E+07	NIL	2E+07	NIL	5E+07	NIL
ULs P1 end equ.	towards US									1E+06	NIL	2E+06	NIL	4E+06	NIL
UPS P1/5 Corner	no equipment					2E+09	5.0	6E+09	12.0	1E+10	24.0	2E+10	48.0	5E+10	96.0
UPS P1/5 Behind	+UX contribution									1E+06	NIL	2E+06	NIL	4E+06	NIL
UX45		2E+06	NIL	2E+07	NIL	4E+07	NIL	4E+07	NIL	8E+07	0.1	2E+08	0.2	3E+08	0.4
UX65						1E+06	NIL	1E+06	NIL	2E+06	NIL	4E+06	NIL	8E+06	NIL
UX85(b)		2E+08	0.2	3E+08	0.3	3E+08	0.3	6E+08	0.6	1E+09	1.2	2E+09	2.4	5E+09	4.8
US85		2E+07	NIL	1E+08	0.1	1E+08	0.1	2E+08	0.2	4E+08	0.4	8E+08	0.8	2E+09	1.6
UW85	shielding as efficient as designed					2E+06	NIL	4E+06	NIL	8E+06	NIL	2E+07	NIL	3E+07	NIL
US45								1E+06	NIL	2E+06	NIL	4E+06	NIL	8E+06	NIL
REs	shielding as is							1E+06	NIL	2E+06	NIL	4E+06	NIL	8E+06	NIL
UJ23 (next UA23) UJ87 (next UA87)	injection losses remain comparable	2E+06	NIL	3E+06	NIL	6E+06	NIL	6E+06	NIL	1E+07	NIL	2E+07	NIL	5E+07	NIL
Mazes (e.g, UA23, UA83)	streaming based on RadMon reading			1E+06	NIL	2E+06	NIL	2E+06	NIL	4E+06	NIL	8E+06	NIL	2E+07	NIL
TZ76 (1^{st} 15m), UA63/67 (behind ducts) UJ33	ok, but to be monitored during operation					1E+06	NIL	2E+06	NIL	4E+06	NIL	8E+06	NIL	2E+07	NIL
All Other	ok														

Colour Codes				
HEH			TID	
low	1.00E+06		low	0.1
mid	1.00E+07		mid	1.0
high	1.00E+08		high	10.0

Vacuum systems P. KRAKOWSKI

- **5 R2E failures** in P7 in run1 (2 blocked PLCs, 3 burned switching PC) → **relocation** of vacuum equipment to UJ76.
- Arcs: only **passive devices**, all intelligent devices in safe areas.
- Total does objective: **Vacuum controls** equipment **should stand 500Gy** for HL-LHC (e.g. 24V power supplies for pumping groups) .
- **Possible relocation** for future: relocate controllers of 96 Turbo molecular pumps (use long cable connections).
- **Fluctuation of penning** readings in P7 due to radiation → source (HV cable, gauge, controller?) **to be identified**; mitigation for LS2.
- Long term exposure to radiation: of cables, connectors, flexible connection for compressed air, bearings, carbon coating, ….
- **Obsolescence is an issue**, new designs required.
- Improving **availability**: **improvement expected since relocation**, learn with time.

Cryogenic systems Juan CASAS-CUBILLOS

- Overall availability > 91.9%
- **Commercial equipment** in general (re-)located out of radiation areas.
- **R2E faults** have only share of **14%** → not dominant and 2012 most of the **SEE/SEU were transparent** to LHC operation.
- Other effects: humidity, em-interference, aging, ….→ **loss of cryo-maintain** 3x per year.
- **Part** of sensors and actuators are **exchangeable**. Duplications of some **critical thermometers**.
- Temperature sensors not exchangeable: **qualified for high radiation** (300Gy).
- Tunnel electronics has been **designed to 1000Gy** → ok for HL-LHC.
- **Consolidation** of electronics: electrical power supply, insulated temperature card for current leads → final tests to be performed in CHARM.
- Temperature monitoring for new Inner Triplets to be addressed

QPS

J. Steckert

- **Equipment in RR P7**: crate controller/field bus coupler, quench detector 600A, quench detector IPQ, IPD, IT.
- **Radiation tolerant** quench detectors for **600A circuits** and individual powered magnets were developed and installed in LS1.
- No need to relocate equipment from remaining RRs (RR13, RR17, RR53, RR57, **RR73, RR77**) as **moderate dose** (0.8Gy/y) expected for HL-LHC.
- Improved remote maintenance (e.g. power cycles).
- Quench heater discharge monitoring.

Interlock Systems M. Zerlauth/I. Romera

- Beam Interlock System (**BIC**)
  - **Not rad-tolerant** → installed in protected areas (Uas, US), apart from client user boxes (CIBUs).
  - Some 10 out of 250 **CIBU** (UX85, UX45, **RR73, RR77**) can be affected during Run3 and HL-LHC.
- Powering Interlock System (**PIC**)
  - Used **COTS** components **not rad-tolerant**.
  - Few remote **I/O modules** in low radiation areas (RRs in P1/5/7) → components tested up to ~300Gy, opto-couplers & CPLDs to 150 Gy.
- Warm Magnet Interlock System (**WIC**)
  - **COTS** components not considered rad-tolerant and hence installed in protected areas.
  - Exceptions are **remote I/Os** installed in TI2/TI8 → **tested up to 250Gy**, Magnet boxes to 1MGy.
- Fast Magnet Current Change Monitors (**FMCM**)
  - Not rad-tolerant → installed in radiation free areas.

High Luminosity LHC

Beam Instrumentation T. Lefevre/B. Dehning

- **BLM front-end** electronics (below MQ, in RRs, UAs, UJs) qualified **to 500Gy** (life time limited by optical Laser diode).
- Replaced cables/fibres for BLMs in collimation regions.
- New radiation tolerant **front-end for BLMs** (with ASICs) under **development**.
- **BI** front- and back-end design approach (e.g. new fast wire scanners, MOPOS, …):
    - Design goal: 100Gy/y, total dose of 1kGy.
    - Analog and digital front-end in tunnel.
    - Transmission via fiber over long distances.
    - Acquisition and control systems in surface buildings or protected areas.
- New **collimators** equipped **with button BPMs** → rad-hard front-end to reduce local cabling in IP7?

END