EN Engineering Department

Radiation Levels & Monitoring: status report

R2E Extended Project Meeting

23rd October 2012

M. Calviani for the MCWG, P. Mala, G. Spiezia and P. Peronnard (EN/STI)

Outline

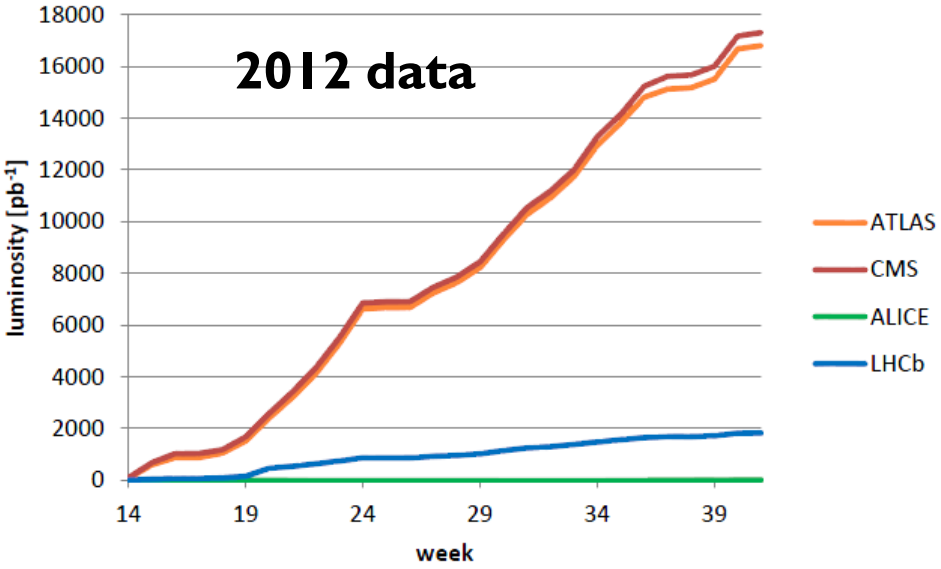
- Review of R2E 2011 Review open points
- Review of radiation levels in the LHC and perspectives
- Summary of RadMon v6 development

Comments on the R2E Review 2011

- **R2E Review 2011 – *Monitoring & Calculation***
  - Dedicated neutron spectra measurements in LHC *not clear*
  - Dedicated thermal neutron sensor in RadMon *on-going*
  - 2nd generation RadMon development – high priority *on-going/ok*
  - Cypress memories calibration to be improved *on-going*
  - Additional alternative monitor locations (Xmas 2012/2013) *ok*
  - DS losses during ion operation to be studied *on-going*
  - 25ns scrubbing period for gas densities DS/ARC *postponed*
    - *Not clear if useful either according to present configuration*
  - IR3/7 loss sharing *on-going*

Luminosity overview and prospects

Cum lumi (fb^{-1})	2011	2012 (W42)	*2012 (estimated)*
ATLAS	5.3	17.7	*~22*
CMS	5.4	17.7	*~22*
ALICE	4.8 (pb^{-1})	4.9 (pb^{-1})	*~6.3 (pb^{-1})*
LHCb	1.2	1.7	*~2.1*



- Prospects for cumulated lumi ~1.5x larger than initially foreseen for 2012

UJ overview

High Energy Hadron fluence (#/cm^2)					Comments
Area	2011	2012	*2011/fb^{-1}*	*2012/fb^{-1}*	
UJ14	2.8*10^8	1.4*10^8	*5.1*10^7*	*7.9*10^6*	*Physics deb.*
UJ16	2.2*10^8	1.1*10^8	*4.2*10^7*	*6.2*10^6*	*Physics deb.*
UJ23	1.5*10^6	2.6*10^6	*2.8*10^5 (*)*	*1.5*10^5 (*)*	*Injection*
UJ56	3.9*10^7	1.3*10^8	*7.2*10^6*	*7.3*10^6*	*Physics deb.*
UJ76	6.4*10^6	6.0*10^7	*1.2*10^6 (*)*	*3.4*10^6 (*)*	*Collimation*
UJ87	3.0*10^6	2.6*10^6	*5.7*10^5 (*)*	*1.5*10^5 (*)*	*Injection*

(*) = ATLAS/CMS luminosity

- **P1**: decrease by factor of 6x, due to additional shielding
- **P7**: increase due to tight collimator settings
- **P2/8**: reduction due to cleaner injections in the LHC

RR overview

High Energy Hadron fluence (#/cm²)					Comments
Area	2011	2012	*2011/fb^{-1}*	*2012/fb^{-1}*	
RR13	7.2*10^6	1.4*10^7	*1.4*10^6*	*7.9*10^5*	*Physics deb.*
RR17	8.4*10^6	2.0*10^7	*1.6*10^6*	*1.1*10^6*	*Physics deb.*
RR53	1.2*10^7	2.0*10^7	*2.3*10^6*	*1.1*10^6*	*Physics deb.*
RR57	1.0*10^7	2.0*10^7	*1.9*10^6*	*1.1*10^6*	*Physics deb.*
RR73	7.7*10^6	4.2*10^7	*1.5*10^6 (*)*	*2.4*10^6 (*)*	*Collimation*
RR77	1.1*10^7	2.1*10^7	*2.1*10^6 (*)*	*1.2*10^6 (*)*	*Collimation*

(*) = ATLAS/CMS luminosity

- **P1/5**: decrease up to a factor of 2x (1.5-2x) due to TCL.4 closure
- **P7**: asymmetry L/R

UX overview (4/6/8)

High Energy Hadron fluence (#/cm^2)					Comments
Area	2011	2012	*2011/fb^{-1}*	*2012/fb^{-1}*	
UX45	2.6*10^6	1.4*10^7	*4.3*10^5 (*)*	*8.2*10^5 (*)*	*Beam-gas*
UX65	N/A	~1*10^6	*N/A*	*N/A*	*Beam-gas*
UX85	2.1*10^8	2.8*10^8	*1.7*10^8 (**)*	*1.6*10^8 (**)*	*Physics deb.*
US85	4.4*10^7	7.0*10^7	*3.7*10^7 (**)*	*4.1*10^7 (**)*	*Physics deb.*

(*) = ATLAS/CMS luminosity
(**) = LHCb luminosity

- **P8**: 2012 equivalent to 2011
  - Increase with LHCb luminosity
- **P4**: increase, beam-gas coupled with higher cumulative current in the machine
  - Potentially weak point in view of 25ns operation

Observations compare with prediction

Critical LHC Areas	High-Energy	
	2011	2012
UJ14/16	2.1E+08	1.3E+08
RR13/17	7.0E+06	2.1E+07
UJ56	3.5E+07	1.1E+08
RR53/57	1.1E+07	3.3E+07
UJ76	5.4E+06	1.6E+07
RR73/77	8.1E+06	2.4E+07
UX85b	1.7E+08	2.1E+08
US85	3.5E+07	4.4E+07

2012 prediction

2012 measurements

$1.1\text{-}1.4*10^8$

$1.4\text{-}2.0*10^7$

$1.3*10^8$

$2.0*10^7$ lower loading (TCL)

$6.0*10^7$ tight collimation

$2.1\text{-}4.2*10^7$

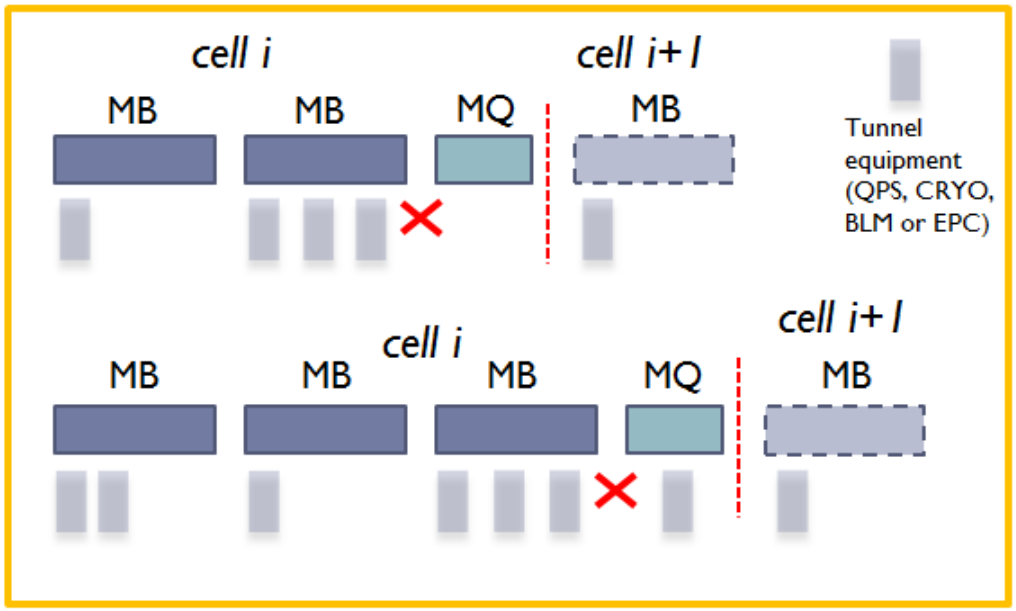
$2.8*10^8$

$7.0*10^7$ higher predicted lumi

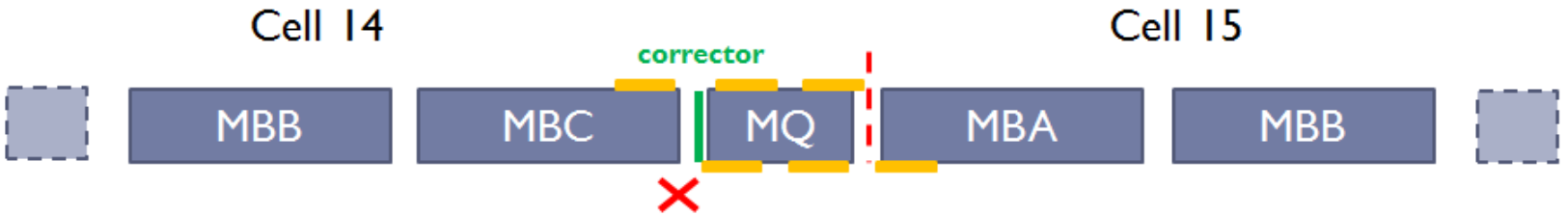
P4/P6 comments and weak points

- **UX45** cavern values are starting to be worrying, especially as 2012 vs. 2011 is higher than expected
  - TE/CRG failures triggered actions to displace the sensitive object
  - ***How the situation will evolve with 25ns operation?***
- **UX65** still calm, as no particular object from a beam-gas pressure point of view is present in the tunnel section
  - Monitoring has been added but still below significance at the moment (2 counts @3V, $\leq 10^6$ HEH/cm^2)

RadMons in the LHC

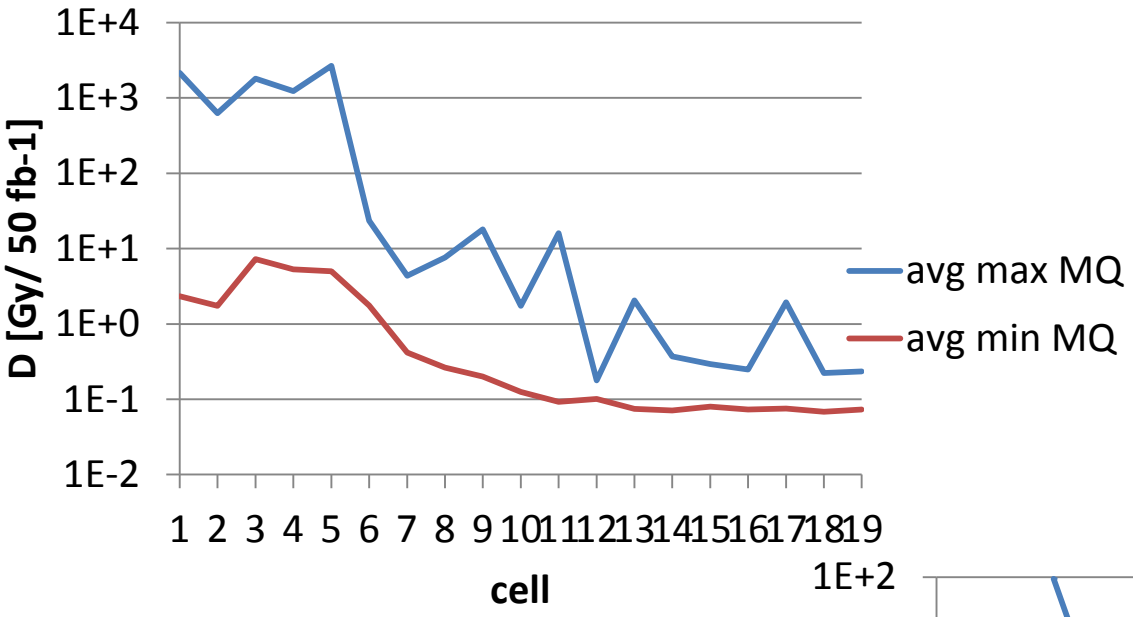


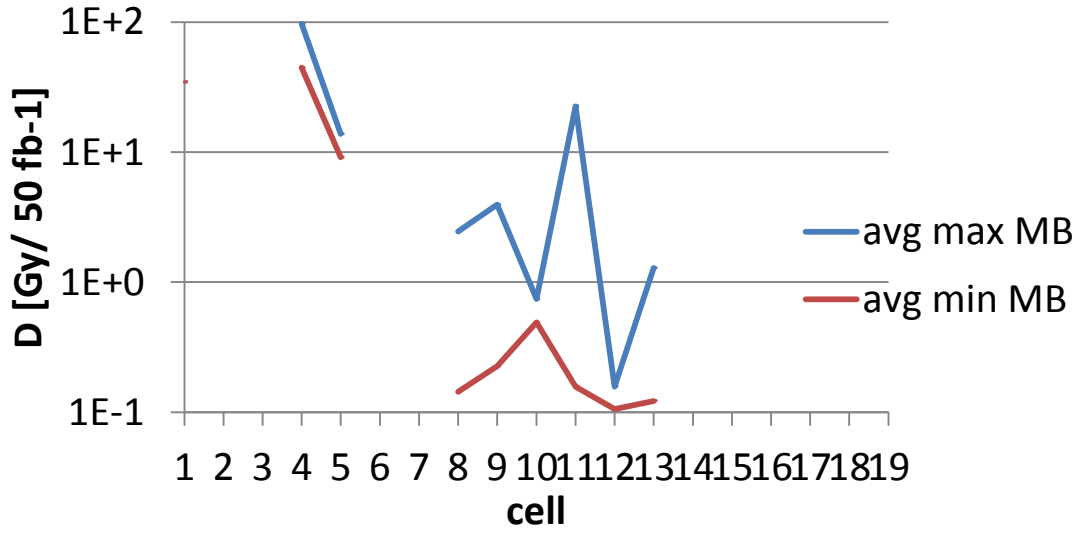
- DS/ARC (from cell 7 to 20)
  - RadMon are placed below the interconnect between the last MB/MQ of a given cell
  - Equipment below MB/MQ!



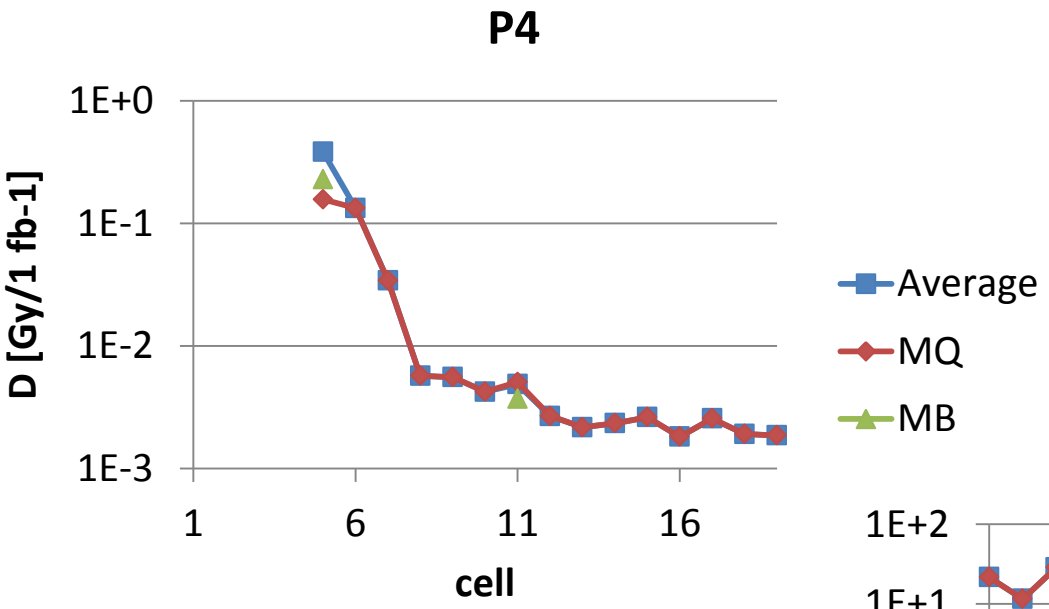
- Dedicated LHC-MD → extraction of an operative ratio between BLM dose and expected HEH from RadMons = **~1 SEU count/mGy**

DS/ARC MB/MQ evolution



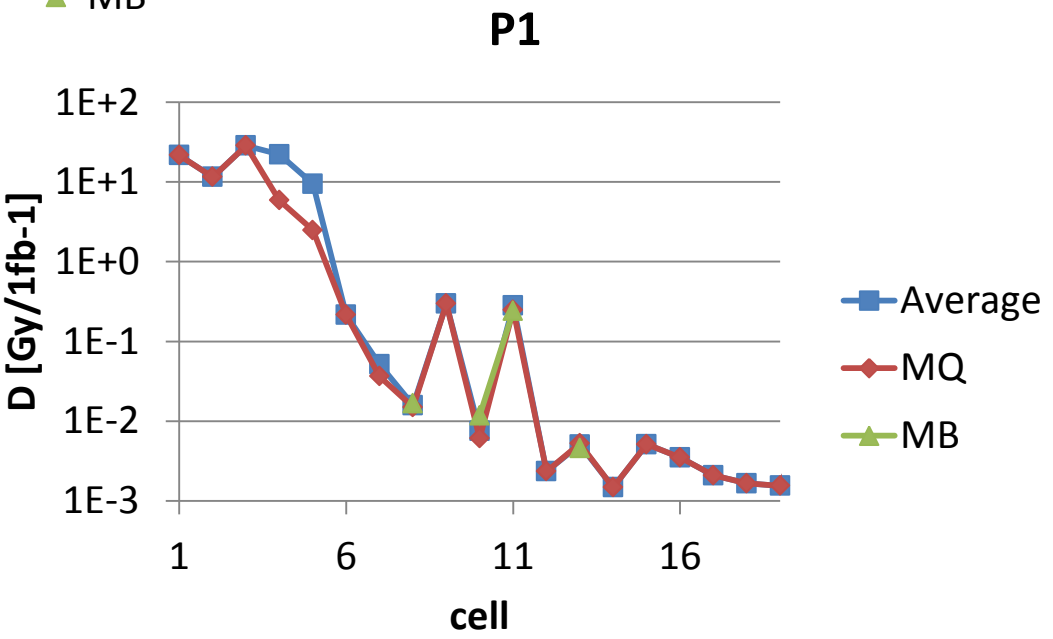


DS/ARC main conclusions



- Dose/HEH levels in the DS/ARC based on BLM data

- ~100 mGy/2012 in ARC
  - $2*10^8$ HEH/cm^2/2012
- ~1 Gy/2012 in DS P1
  - Few 10^9 HEH/cm^2/2012

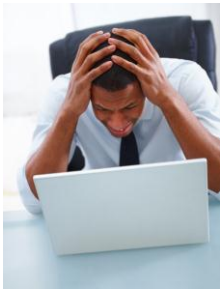


Long-term projections

- Observed radiation levels are still compatible to those predicted for the Chamonix 2012 presentations (link)
  - Slightly lower load for the RRs P1/5
  - Slightly higher load for P7
  - Still no confirmation for ARC/DS behaviour with 25ns operation
- Cumulated dose in the DS during 2013 p-Pb and 2015 Pb-Pb runs (action from R2E 2011 Review)

25 ns uncertainties

- Evolution if beam-gas levels during **25ns operation** (nominal) is **still to be fully clarified**
- During Chamonix 2012 it was stated that pressure will not increase more than factor of 2x with respect to 50ns operation
  - However operational experience shows that pressure variation depend strongly on real operational parameters
- 2012 25ns test run (with ramp) – if confirmed (***before Xmas***) – will help to shed some light



Still an open point

Monitoring status and needs

- **RadMon coverage after LS1**
  - Additional monitors will be deployed in LS1…
  - Start covering the injector chain if resources available
  - Increase the covering of LHC ARC/DS
- **RadMon v6 development**
  - Increase functionalities and flexibility with respect to the present version
  - Proper calibration and cross-checks

RadMon interventions for LS1

Location	Work	Priority	Status
P7-TZ76	Displacement	0	Approved
P8-US, UL	Displacement	0	Approved
P1-UJ14/16	Displacement	0	Approved
P8-Right	Extension up to REs	1	*To be approved*
P1-Right	Extension up to cell 17	1	*To be approved*
P5-Right	Extension up to cell 17	1	*To be approved*
P2-Left	Extension up to REs	2	*To be approved*
P1-Left	Extension up to cell 17	2	*To be approved*
P5-Left	Extension up to cell 17	2	*To be approved*

RadMon interventions for LS1

Location	Work	Priority	Status
PS-EASTAREA	New Installation	0	Approved
n_TOF	New Installation	0	Approved
AD	New Installation	1	Approved
SPS	New Installation Locations to be clarified	1	To be approved
PS	New Installation Locations to be clarified	2	To be approved
PS Booster	New Installation Locations to be fixed	2	To be approved

- **Injectors: installation not yet confirmed**

RadMon v6 – requirements

- **Requirements for the new system**
  - Improve the sensitivity for the HEH fluence measurement (*)
  - Improve the measurement of thermal neutrons (*)
  - Clarify the uncertainty of the RadFETs for the TID measurements
  - Additional flexibility with respect to RadMon v5 (configuration and settings)
  - Increased TID resistance with respect to v5

** = inputs from R2E 2011 Review*

RadMon v6 – Status & Tests

- **Hardware status:**
  - Components selected and tested: FPGA, ADC, Regulators, current sources, switches, transceivers
  - Component to be selected: potentiometers
- **Radiation tests:**
  - Components tested at PSI. Lowest limit 200 Gy (ADC)
  - 3 full systems tested at PSI at ~300 Gy total dose
  - 2 full systems tested at H4IRRAD at 70 Gy total dose
  - 2 full systems being tested at CNRAD:
    - Monitor1 voltages out of specification (main power problem)
    - Monitor2 still working (~200 Gy)

RadMon v6 – sensors

- **Sensors:**
  - RadFET 100 nm and 1600 nm
  - Pin Diode BPW
  - Cypress memories
    - 1 SEU count/2*10^5 HEH/cm^2 @230 MeV (*)
    - Response not flat in the range 30-230 MeV
  - Toshiba memories (already used)
  - Sensors for thermal neutron detection (*)
    - Diode back-to-back difficult to use (high voltage) and buy
    - Other methods under investigation

** = inputs from R2E 2011 Review*

RadMon v6 – sensors

- **Sensors calibration:**
  - Gamma calibration for RadFETs on-going
  - CEA calibration for Pin Diode BPW on-going
  - PSI test for Cypress memories on-going (*)

** = inputs from R2E 2011 Review*

RadMon v6

Conclusions

- There are **still few open points** from the follow-up of the R2E 2011 Review
  - Many points are related to on-going actions
  - Some aspects have not (or not fully) clarified yet (25ns, IR3/7 sharing, ion in DS)
- Radiation levels for most of the areas are **under control** and **in-line with predictions**
  - Still weak points in UX45 and UX65
  - Unknowns for 25ns operation
- Development station of RadMon v6 well undergoing