RadMON Monitoring

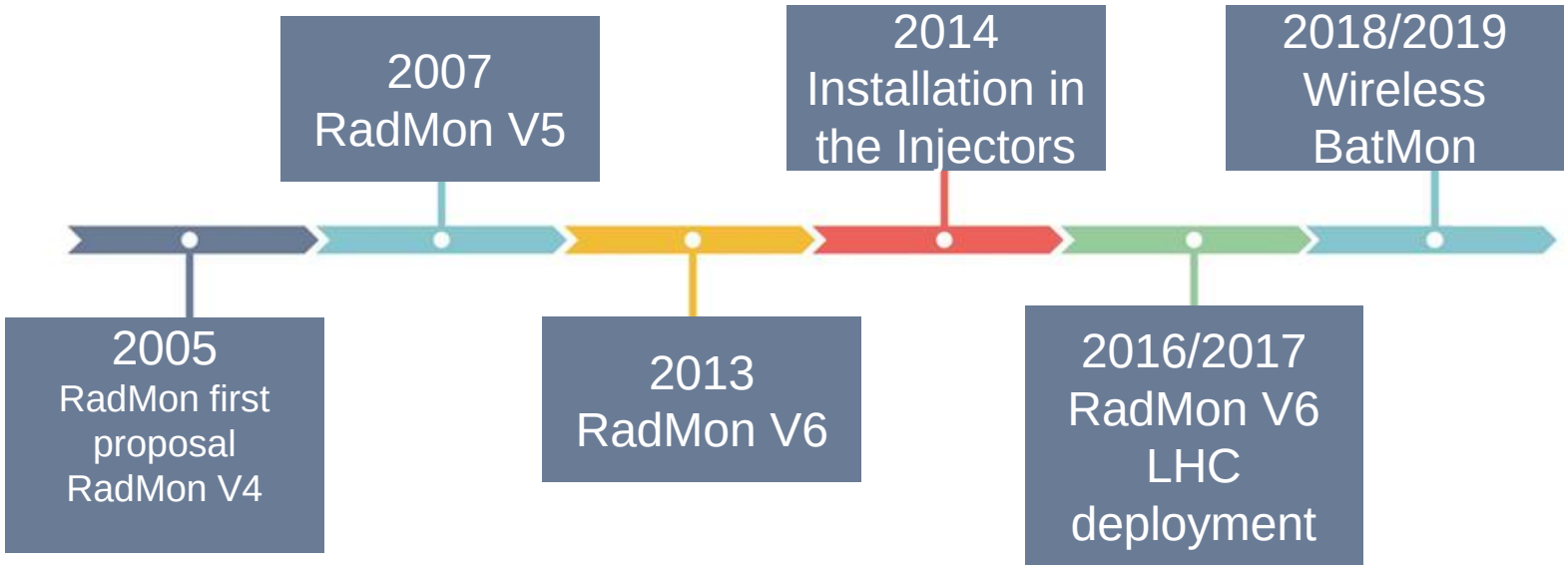
Salvatore Danzeca (EN/SMM-RME)

CERN | EN ENGINEERING DEPARTMENT

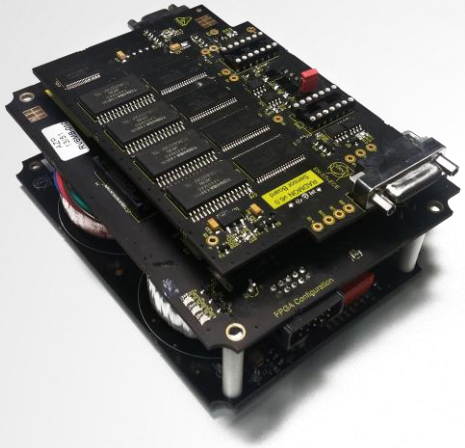
Overview

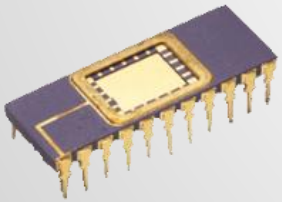
- RadMon ecosystem overview
  - V5 and the new V6
- RadMon installation in the LHC
- RadMon installation in the Injectors
- Other Passive solutions
- R&D in sensors and architecture

Historic Evolution of the RadMon



RadMon Ecosystem

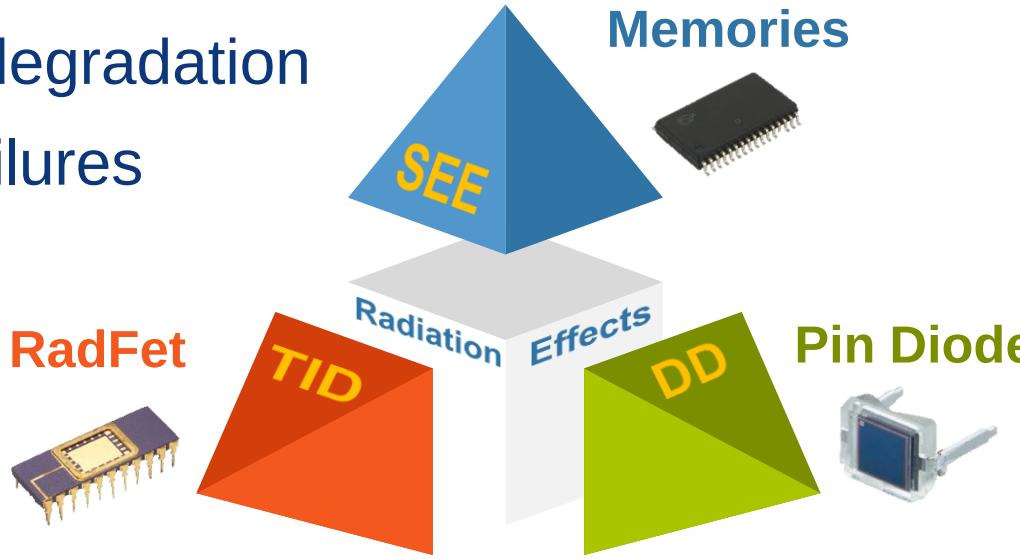




Scope of the RadMon

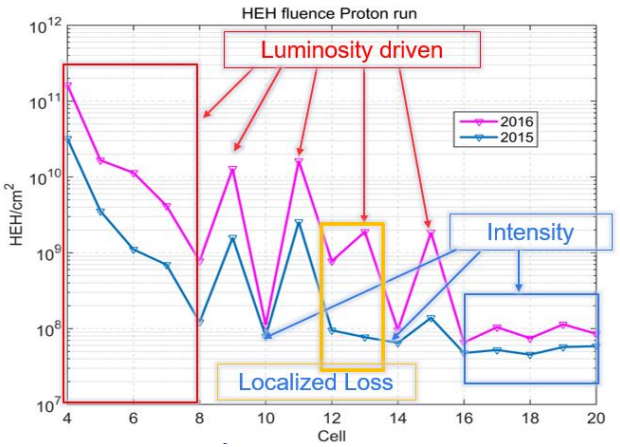
Measure the **Total Ionizing Dose** , the **Displacement Damage** and the **High Energy Hadron Fluence** in order to:

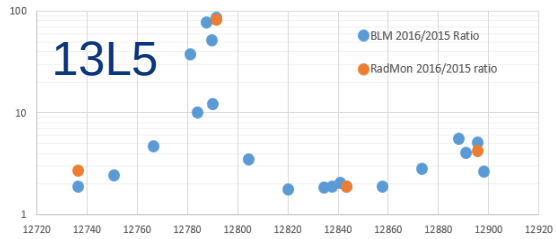
- Monitor the Radiation Level in the LHC tunnel
- Design and install new equipment
- Anticipate the electronics degradation
- Investigate the cause of failures
- Simulation benchmarking

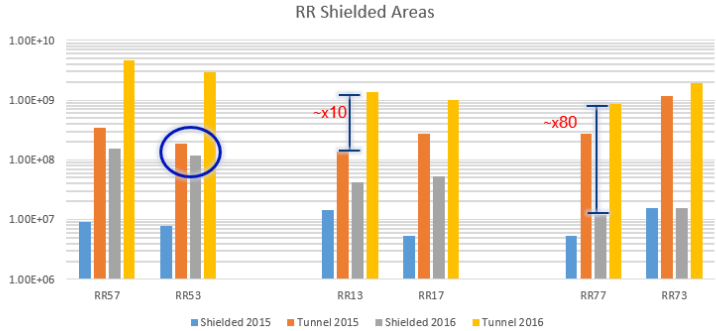


Usage example

- Comparison of the radiation levels every year and extrapolation for the future
- Measure the dose and the fluence in not expected localized high loss point
- Measurements in shielded areas for failure tracking and extrapolation
- Non conventional requests coverage with passive dosimeters and battery RadMon i.e FASER, LINAC4, RR53, UJ14…







RadMon Comparison

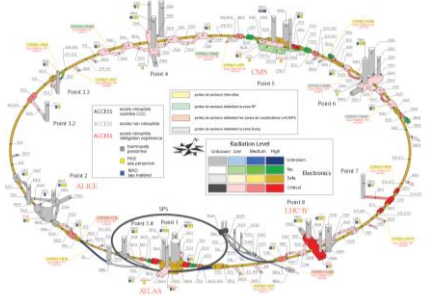
- Two versions of RadMon currently deployed
- V5: low monitoring resolution for the actual requirements, obsolescence of the components
- V6 is a full custom design
- V6 is more robust against radiation
- V6 communication fully compliant with the previous version
- Deported module foreseen in all the installations
- The V6 can be upgraded

Parameters	V5	V6
Communication	FIP	FIP
TID tolerance	80 Gy	200-250 Gy
Deported module	YES (50 mt)	YES (50 mt)
Reprogrammability	NO	YES
Modularity	YES	YES
Upgradability	NO	YES

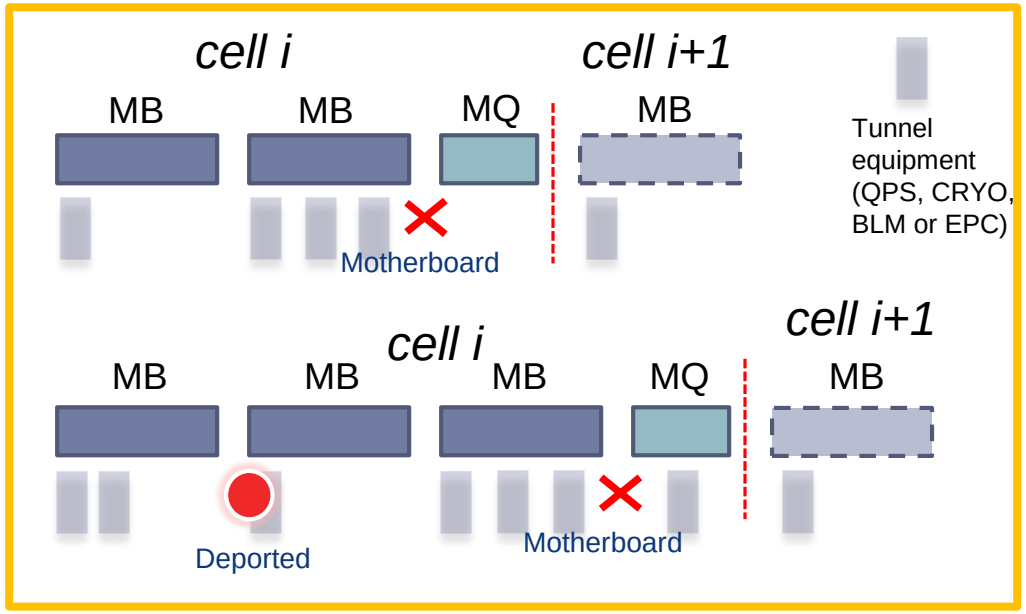
LHC installation plan for version V6

Points	Total Radmons	V5	V6	Installation
Point 1	43		43	Already Installed
Point 2	43		43	Already Installed
Point 3	32		32	Already Installed
Point 4	36	36		LS2
Point 5	42		42	Already Installed
Point 6	57	57		LS2
Point 7	41		41	Already Installed
Point 8	41		41	Already Installed
ALICE	12		12	Already Installed
ATLAS,CMS,LHCb	45	16+20+9		LS2
Total	**392**	138	254	

RadMon LHC installations



- LHC in all Points



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

In all points (apart from point 4 and 6) a deported module is attached to the equipment before the interconnection

Equipment below MB/MQ!

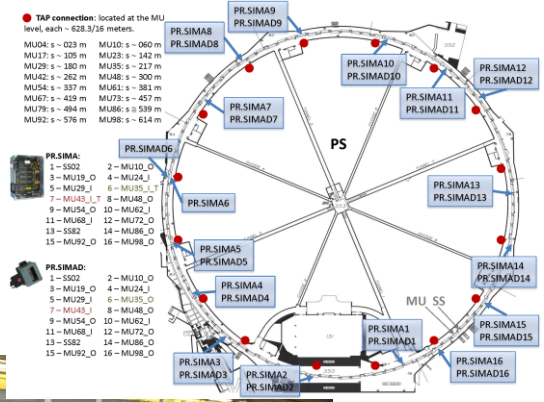
In the UJs, RR, UL, UAs in the tunnel side and internally

In LS2 the SMAC project will require the displacement of all the RadMons in the interconnections

At the end of the LS2 all the RadMon will be placed back in place

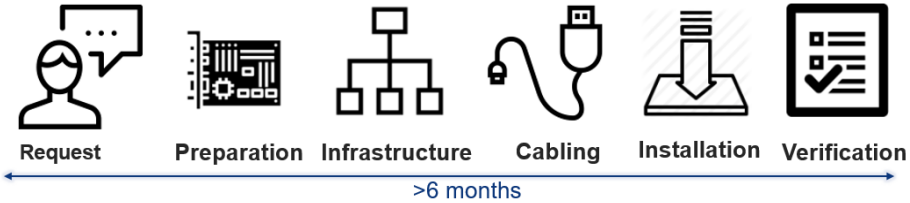
RadMon V6 in the injectors and Experiments

Installation points	Total V6 Radmons
Booster	8
PS	16
SPS	59
ALICE	13
NA62	11
HiRadMat	5
CHARM	7
AWAKE	3
Total	**122**

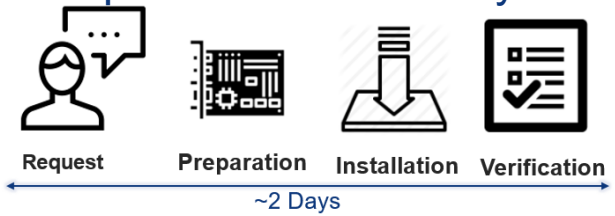


The origin of the idea

- Key idea is born around the RadMon
  - RadMon is a system of cabled devices with a well defined infrastructure inside the CERN (device management, gateways, logging etc..)
  - More than 500 devices are installed currently in the LHC

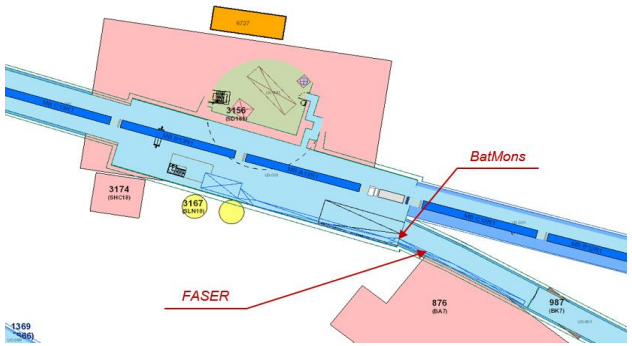


- What happen if one user want to monitor the radiation level in a place where RadMon are not available?
  - We have mainly only the technical stop (few days) for the installation
  - Usually the requests arrive few days before the access…



BatMons and Passive RadFets

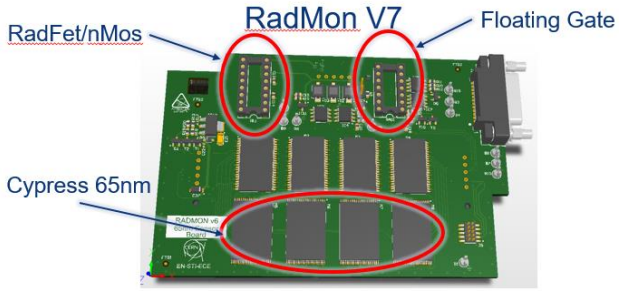
- Where there is no need or no possibility of having a fixed installation (mainly due to the FIP cabling) we use the BatMons
- Currently installed in:
  - Linac 4
  - TI12/TI18
  - RR53
  - UJ14/UJ17
  - US15
  - RA43
  - CMS Cavern
- 20 Passive dosimeters installed in ALPHA
- 200 Passive dosimeters installed in the SPS for monitoring the dose in the miniracks of BE-BI
- 40 Passive RadFet installed in the PSB for the RF cavities
- 100 Passive dosimeters installed in Point 1 and Point 5 for the 2018 BFPP
- **>40 interventions** during the 2018 Technical Stops for the installation of more than 50 BatMons and 100 passive dosimeters.



R&D New BatMon

- Development of the new prototype of BatMon
- Motivation:
  - few spares left
  - Obsolescence of several components
  - Local logging and wireless solutions
- The WBatMon: a Wireless BATttery radiation MONitor
  - Monitor and control radiation sensors
  - Modular
  - Battery powered
  - Reliable under radiation
  - Wireless communication over km range
  - Well known standard for IoT
    - Strong collaboration with IT/CS for the choice of the supported link
  - Same form factor as the actual RadMon
  - The first wireless radiation tolerant CERN development

2009



Conclusions

- RadMon ecosystem is an essential instrument (R2E eyes) for knowing the radiation levels in the LHC tunnel and shielded areas, injectors and experiments.
- The plan is to have for the end of LS2 all RadMon V6 installed in the LHC tunnel and experimental galleries
- Large work of SMAC project will require to move all the RadMon from the interconnection for re-installing them before the LHC start
- BatMon and Passive dosimeters deployed in the LHC, injector and in the experiments will be always supported
- WBatMon development in progress: the first radiation tolerant wireless development at CERN

Thanks to all the RadMon Team!!

RadMon V5 and V6 a quick overview

Feature	V4-V5	V6	Comments
ADC	12 bit	16 bit	
Controller	MicroFip	FPGA	V6 fully customizable
Health monitoring	2 Test points	12 Test Points	
Configuration	Manual Switches	FPGA re-programming	V5 access required to change conf
Dynamic Range	Limited by the +10V ADC	Programmable attenuator	

Reviewed location LHC part 1

Points	Start cell	End cell	Extension YETS	Shielded areas	Non standard installation
1 Left and Right	4	17	12-17	UJ16 UL16 UPS16 RR17 UJ14 UPS14 RR13	2R1.1RM03S **(out of UJ17)** 4R1.1RM19S **(LHCf)** 7R1.1RM11S **(out of RR17)**
2 Left and Right	8	20	9-20	UA23 UJ23 UJ22 RE22 UA27 RE28	4L2.2LM07S **(ZDC – close to the beam pipe)** 4R2.2RM21S **(on the wall of the first floor)** 8L2.2LM05S **(out of the UJ22)**
3 Right	4	20	NO	RE38 UJ32 RE32	
4 Left and Right	5	11	NO	UX45	SIMA.5R4.4RM14S **(BSRT Beam 1)** SIMA.5R4.4RM16S (BSRT Beam 1) SIMA.5L4.4LM14S **(BSRT Beam 2)** SIMA.5L4.4LM16S (BSRT Beam 2)
5 Left and Right	4	17	12-17	UPS54 UJ56 USC55 RR53 RR57	SIMA.4L5.5LM07S **(TAN)** SIMA.4R5.5RM05S **(TAN)**

Reviewed location LHC part 2

Points	Start cell	End cell	Extension YETS	Cavern	Non standard installation
6 Left and Right	4	20	NO	UJ64 UA63 UX65 RE62 UA67 UJ66 RE68	SIMA.17L6.6LM17S **(DUMP beam 1)** SIMA.17R6.6RM17S **(DUMP beam 2)**
7 Left and Right	4-7	20	NO	RR73 RE72	
8 Left and Right	4-7	20	9-20	UA83 RE82 UA87 UJ88 RE88	

LHC experiments: ATLAS, CMS, LHCb

- RadMon V4 installed in the 2009
- Atlas UX15 16 RadMons installed also on the balcony
- CMS UXC55 20 RadMons installed
- LHCb UX85 10 RadMons installed