



Summary of the radiation levels of the equipments at CNRAD

- RF MosFETs
- Cryogenics
- TE/EPC
- LED warning system
- BPM
- QPS
- RadMON V.6
- Acquisition crate BE/ABP
- IT beacon
- Other tests
- Equipments tested during 2012

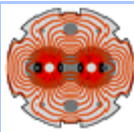
Radiation levels

• RF MosFETs

○ Motivation

- Having a deeper understanding of their behavior and limits
 - ✓ **Used in the PS Booster over the last 20 years** → $10^5 - 10^6$ Gy without major failures
- Installed inside the **target area (hottest test location)** since beginning of slot 3.

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot 3	4.385e3	6.2e13	2.8e13
Slot4	4.3e3	6.05e13	2.75e13
Total	8.7e3	1.23e14	5.6e13



Radiation levels

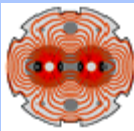
• Cryo - MosFETs

○ Motivation

- **Validate the design of a new power supply for the LHC beam screen heaters**
- Required dose: **Up to 1 kGy** → To validate up to the DS level
- Installed at position 451 since beginning of slot 3.

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot 3	354	3.5e12	2.5e12
Slot4	347.5	3.4e12	2.4e12
Total	701.5	6.9e12	4.9e12

- At the DS locations (close the quadrupole magnets (nom. Operation)), this corresponds to:
 - ϕ_{eq} : 17 years
 - ϕ_{HEH} : 50 years
 - Dose: \approx 4 years



Radiation levels

• TE/EPC - Puls AC/DC Power Supply

○ Motivation

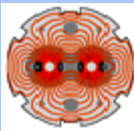
It has been found that those AC-DC modules were delivered in 2 versions

- One using IR MosFET
- The second one using another type of MosFET from ST (which does not stand radiations).
- Test of the PSU using IR MosFET

Installed at position 453

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot 3	157	1.6e12	1.1e12
Slot4	154.2	1.5e12	1.1e12

- During slot 3 and 4, PSUs failed at around **100 times higher HEH fluence ($\approx 1e11 \text{ cm}^{-2}$)** compare to the model designed with ST MosFET.



Radiation levels

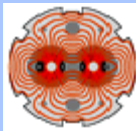
• LED Warning System – Position 451 (without monitoring)

○ Motivation

- New prototype to be tested based on lessons learned from last year:
 - Safety lighting system powered by voltage transformer + Graetz bridge
 - Power LED technology

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot 1	160.2	1.6e12	1.1e12
Slot 2	245.9	2.4e12	1.7e12
Slot 3	354	3.5e12	2.5e12
Slot4	347.5	3.4e12	2.4e12
Total	1.1e3	1.1e13	7.7e12

- At the DS levels (close the quadrupole magnets (nom. operation), this corresponds to:
 - ϕ_{eq} : 27 years
 - ϕ_{HEH} : 77 years
 - Dose: 5 years
- Check during the next access if still alive



Radiation levels

- **LED Warning System (position 453 – Monitored)**

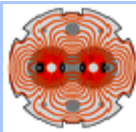
- Installed since the beginning of the year.

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot 1	71	7.1e11	5.1e11
Slot 2	109.1	1.1e12	7.9e11
Slot 3	157	1.6e12	1.1e12
Total	423.1	3.4e12	2.4e12

- **New system** Type **400 W metal iodide**, Installed in **TCC2** → Several died

- x-check with the radiation level measurement (end of TS#4)

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot 4	154.2	1.5e12	1.1e12

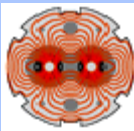


Radiation levels

• BPM

- Installed at position 451 since beginning of last slot 2011
- Several components have been tested (Transceivers, LogAmps, ADC drivers ...)

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot6 (2011)	15	1.5e11	1e11
Slot 1	160.2	1.6e12	1.1e12
Slot 2	245.9	2.43e12	1.7e12
Slot 3	354	3.5e12	2.5e12
Slot4	347.5	3.4e12	2.4e12



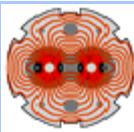
Radiation levels

• QPS

- Installed since 2011. Positioning at various positions

		Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
2011	Slot4 (TSG46-464)	9.5	1.1e11	7.7e10
	Slot5 (TSG46-464)	7.9	9.1e10	6.4e10
	Slot6 (TSG46-463)	1.7	1.3e10	9.4e9
2012	Slot1 (TSG46-463)	18.4	1.4e11	1e11
	Slot2 (TSG46-463)	28.3	2.2e11	1.6e11
	Slot3 (TSG45-453)	157	1.6e12	1.1e12
	Slot4(TSG45-453)	154.2	1.5e12	1.1e12
Total		377	3.7e12	2.7e12

- In terms of HEH fluence, *we reached 27 years of LHC operation in the DS* (close to quadrupole magnets)



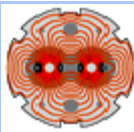
Radiation levels

• RadMON V.6

○ Motivation:

- Test of 2 prototypes of the **next version of the RadMON**.
- Same used during the **H4 test** → They already get around **50 Gy** (No failure observed)
- Tests have been performed at **PSI** up to ≈ 300 Gy → No failure observed
- **Target dose: 200/300 Gy** → Installed in TSG45, position 451.

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot4	347.5	3.4e12	2.4e12



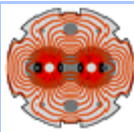
Radiation levels

• Acquisition crate – Position 453

- **Motivation**
- They are installed in shielded area in P5 (2) and P2 (2). **After LS1, more will be installed**
 - **IP1** (US15) , **IP2** (UA23 & UA27), **IP5** (>LS1: IL55), and **IP8** (UA83 & UA87) → **Each IP : 2 crates**
- Target dose: **100 Gy** → Position 453
- Acquisition system composed by several semiconductor devices:
 - CMOS, MOSFET driver, FPGA (Xilinx CPDL), 12 bit DAC ...)

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot 4	154.2	1.5e12	1.1e12

- This is corresponding in the UAs to more than 100 years at nominal intensity



Radiation levels

• IT beacon – Position 463

- **Motivation**
- Will be installed everywhere in the **LHC tunnel**.
- 15 beacons installed **in TSG46** (data transmission monitored on-line)

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot 4	40	3.1e11	2.2e11

- At the ARC locations, this corresponds to:

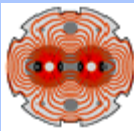
- ϕ_{eq} : 77 years, ϕ_{HEH} : 220 years, Dose: \approx 20 years

- 5 beacons installed **in TSG45** – position 453 (off-line). **Check if still working** at the end of the slot

	Dose (Gy)	1-MeV fluence (neq/cm ²)	HEH fluence (cm ⁻²)
Slot 4	154	1.5e12	1.1e12

- At the DS levels (close the quadrupole magnets (nom. operation), this corresponds to:

- ϕ_{eq} : 4 years, ϕ_{HEH} : 12 years, Dose: \approx 9 months



Other tests

• Ethernet switches

○ Evaluation of the radiation levels that the new type of switches can tolerate.

○ The data traffic has been monitored

▪ Preliminary conclusions for the 1st Slot measurements :

✓ All the 3 Ethernet switches died

❖ Dose : 0.0162 Gy

❖ $\Phi_{eq} = 1.25e8 \text{ cm}^{-2}$

❖ HEH = 8.9e7cm⁻²

○ During second slot

▪ Old Ethernet switches model have been installed for comparison

✓ All switches died in few hours

❖ Dose : 0.0165 Gy

❖ $\Phi_{eq} = 1.29e8 \text{ cm}^{-2}$

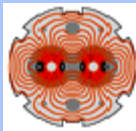
❖ HEH = 9.1e7cm⁻²

○ Lessons learned

▪ Old model is not better than the new one

▪ **Ethernet switches need to be protected from radiation** (Usually it is already the case)

Test report
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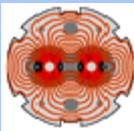


Other tests

• Wifi

- Test of wireless access points from HP
 - Preliminary conclusions for the 1st Slot measurements :
 - ✓ Both AP failed during the slot
 - ✓ **The first AP failed at :**
 - ❖ **Dose : 0.45 Gy**
 - ❖ **$\phi_{eq} = 3.5e9 \text{ cm}^{-2}$**
 - ❖ **HEH = 2.5e9 cm⁻²**
 - ✓ **Second AP failed at :**
 - ❖ **Dose : 9.2 Gy**
 - ❖ **$\phi_{eq} = 7.2e10 \text{ cm}^{-2}$**
 - ❖ **HEH = 5.06e10 cm⁻²**
- The surviving time is really random but it is interesting to know
- No more tests have been performed during the 2nd slot

Test report
missing



Equipments tested in 2012

- **BPM components**
- **LED warning system**
- **QPS**
- **Ethernet Switches**
- **Wifi access points**
- **Cryo power supply**
- **TE/EPC components**
- **Acquisition Crate load sensors (BE/ABP)**
- **IT beacons**
- **RadMON version V6**

