HF RADMON STATUS AND UPGRADE PLANS

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Review of the status, recent results, problems, solutions and upgrade plans of the system of the radiation condition monitoring in the HF (Hadron Forward) CMS calorimeter area are described.

1. INTRODUCTION

The HF functions under the worst radiation conditions of all CMS subdetectors. The estimated absorbed dose and neutron irradiation in the fiber system, photomultipliers and readout electronics during the lifetime of the experiment are close to the upper limits for these devices [1]. Therefore, the close monitoring of the neutron fluxes and dose rates is extremely important. Also the neutron flux data can provide additional information on stability of the running conditions. Consequently the goals of the radiation monitoring system are:

- long term monitoring of the absorbed dose and neutron flux to estimate degradation of fibers, electronics, PMTs, etc.;
- measurements of the shielding efficiency;
- possibility of some additional monitoring of beam losses, luminosity, etc.

2. HF RADMON SYSTEM COMPOSITION AND CONSTRUCTION

The HF radiation monitoring system includes neutron counters MNR-14 (8 per every HF) to measure the neutron fluence and dosimeters KG-18 (2) and KG-21 (2) measuring the total ionization dose due to the γ-quanta and charged particles [2]. The KG-21 counters are placed inside the HF shielding in the area between absorber and PMTs. The KG-18 counters and neutron monitors are positioned in the vicinity of the readout boxes (RBX) and electronics racks. Parameters of the radiation monitors are shown in Table 1.

The drawing of the neutron monitor is shown in Fig. 1. Monitors are designed to operate autonomously for the long periods of time. Neutron detection is based on the neurton capture reaction by the boron with the

Table 1. HF RADMON system components

Detector	Location	Number	Detected radiation	Sensitivity
MNR-14	RBXs/racks	8/8	Neutrons (up to 11 MeV)	1–2 neutron/ cm^2/count
KG-21	Fibers&PMTs	4	γ-quanta and charged particles	$4.4–6.1 \cdot 10^{-5}$ Gy/count
KG-18	RBXs	4	γ-quanta and charged particles	$4.4–4.6 \cdot 10^{-4}$ Gy/count

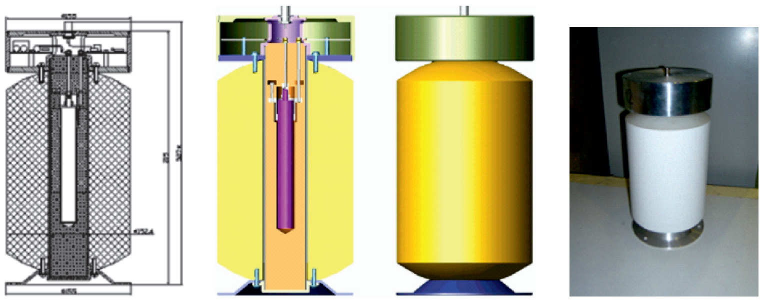

Fig. 1. Construction and view of the MNR-14 neutron monitor based on the SNM-14 B^{10} proportional counter

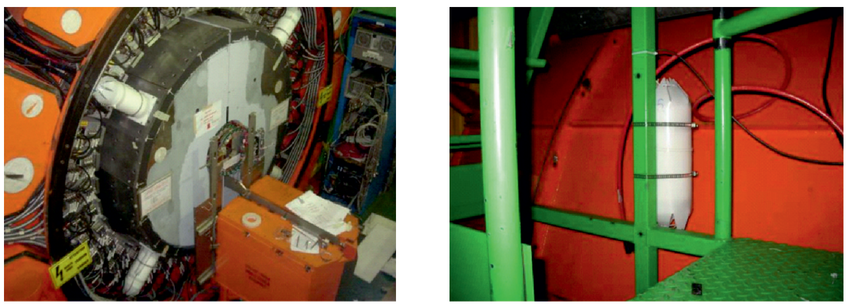

Fig. 2. MNR-14 neutron monitor mounting on the backplane of the HF and out of the HF shielding

emission of the α-particle induced by the slow neutrons in the argon-filled proportional counter surrounded by the 6 inch dia polyethylene moderator. The electronics container includes the Cockroft–Walton voltage multiplier and signal conditioning unit. Each detector is connected to the readout electronics with single cable (for both signal and power supply).

The signals from the detectors go to the custom made adapters where the signal is separated and shaped. The readout electronics also includes the ADCs for the detector performance monitoring, and scalers. The whole system is controlled by the DIM server running under Windows OS. The elements of the system have been tested and calibrated with the radioactive source and on the beam tests [3, 4].

Mounting and location of the neutron monitors are illustrated on the photos in Fig. 2.

3. RESULTS OF THE MEASUREMENTS

The system started in November 2009, first neutron signals were observed from beam loss events. First neutron signals from collisions were observed in March 2010.

During the first two years of the system exploitation the neutron fluxes have been measured in the RBX and electronics areas of the both of HFs. The estimations of the neutron fluxes per the unit of the instant luminosity at 7 TeV proton beams are shown in Table 2.

Table 2. Estimations of the neutron flux in the HF area (neutrons/μb^{-1}/c)

HF+		HF−	
RBXs	Racks	RBXs	Racks
$2.6 \pm 0.7 + 0.5$	$0.27 \pm 0.07 + 0.04$	$15 \pm 4 + 1$	$0.4 \pm 0.1 + 0.04$

The significant difference was observed of the neurton fluxes between plus and minus ends of the CMS due to so-called "CASTOR effect" (factor 5.8 ± 2.2 in the RBX area and factor 1.9 ± 0.6 in the rack area). The direct measurement of the shielding efficiency is 38 ± 10 and 9.6 ± 3.6 in the RBX and rack areas correspondingly.

During the long time of the measurements, the neutron detector stability and linearity vs. luminosity were shown (Fig. 3).

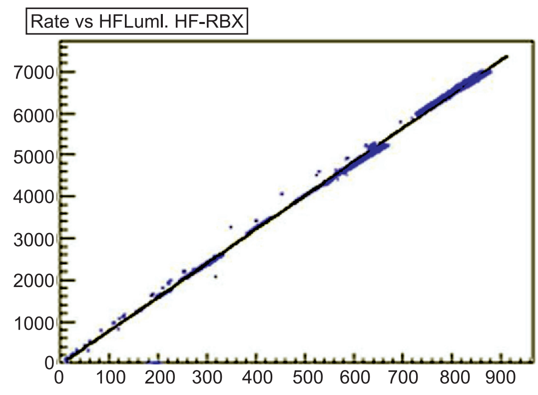

Fig. 3. Long term measurement of the neutron monitor count rate vs. luminosity in the HF – RBX area (counts/μb^{-1}/c)

4. HF RADMON PROBLEMS, UPGRADES AND UPGRADE PLANS

The first step of the HF RADMON upgrade was done in 2010. In December 2009 after the CMS magnet start we found strong instability of the MNR-14 operation under magnetic field. The reason was that 0.10–0.15 T magnetic field in the HF area is close to the critical value of the ferromagnetic hardness. The most critical element was changed in January 2010, and finally the problem was fixed during 2010 by scheme upgrade to exclude both of ferromagnetic elements.

One can see in Fig. 3 the indication of the problem of the saturation effect starting from 300 kHz. The reason of saturation was low dynamic range for counters (we had to run with pre-scalling). Also the 1-wire readout itself was too slow. As temporary solution we proposed to use the set of the NI modules including NI PCI-6224 — 32-channel 16 bit ADC and NI PCI-6602 — 8 32-bit counters. The quality of the system operation is illustrated by the neutron monitor response during the fills of the LHC (Fig. 4) and neutron monitor response during the Van-der-Meer scan (Fig. 5).

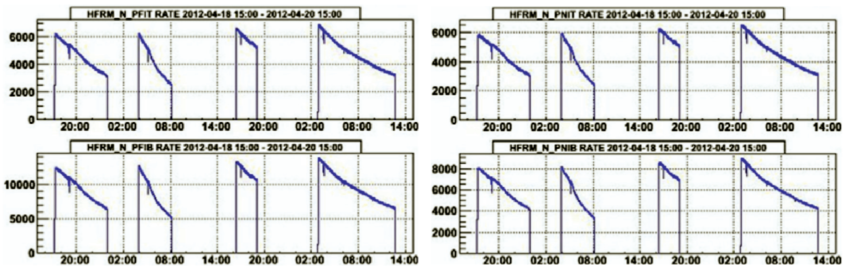

Fig. 4. Neutron monitor response in the HF + RBX area vs time during fills in April 2012

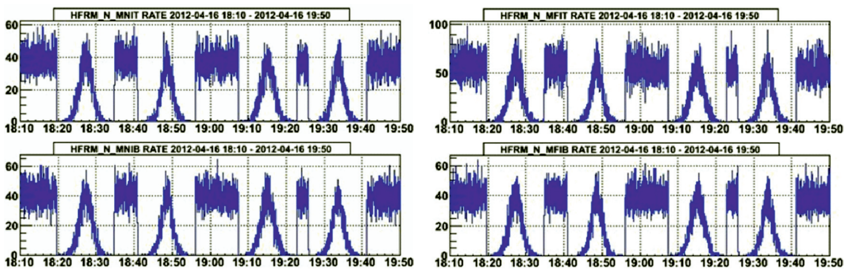

Fig. 5. Neutron monitor response in the HF – RBX area vs time during VDM scan in April 2012

By using the mentioned electronics we avoid the saturation problem (in 2012 up to 6000 $\mu b^{-1}/c$). But the readout does not fully conform to the current CMS guidelines and it is considered only as a temporary solution till the LS1.

The other problem is a number of the systematic uncertainties concerning the measurement of the absolute value of neutron flux (calibration coefficients, spectrum corrections, anisotropy effect, etc.). Therefore, we propose during the LS1 the re-calibration of the monitors with the reference neutron field. Also we need the detail simulation of the neutron field in the measurement points.

Finally, the upgrade plans for LS1 include:

• final upgrade of the HF RADMON readout electronics for the long-term neutron field measurements and independent monitoring of the highest luminosity;

• full integration of the HF RADMON data in CMS beam radiation monitoring system;

• re-calibration of the neutron monitors.

Optionally we consider a possibility of the following additional upgrades:

• increasing of the number of the points of measurements to reproduce the neutron field in the UXC;

• modification of a number of the neutron monitors for neutron spectrum estimation;

• upgrade of the system for ionizing radiation measurements and modification of the gamma-counters for the measurements in the electronics area.

REFERENCES

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