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RadMon: a versatile, integrated radiation monitoring system for accelerators and experiments electronics at CERN

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The Radiation Monitoring System (RadMon) for CERN accelerator complex measures radiation levels in the accelerator tunnels, adjacent shielded galleries and experimental areas. This allows the correlation of observed radiation-induced equipment failures with the respective accumulated radiation levels. The main component of the system is the RadMon device, a compact detection and communication system capable of measuring Total Ionizing Dose (TID), Displacement Damage (DD) in Silicon, High Energy Hadrons (HEH) and thermal neutrons fluence. A separate, smaller sensor module, connected to the main RadMon device, allows measurements in less accessible locations, as large experiment caverns and inner detectors.

Summary (500 words)

The Radiation Monitoring System (RadMon) for the CERN accelerator complex, is designed to measure the radiation effects on the electronics in the tunnels, adjacent shielded galleries and experimental areas. The main hardware component of the RadMon system is the RadMon device, a compact detection and communication system capable of measuring the Total Ionizing Dose (TID) in Silicon dioxide by means of Radiation-sensing Field-Effect Transistors (RadFETs), the Displacement Damage (DD) in Silicon by means of p-i-n diodes, and the High Energy Hadrons (HEH) and thermal neutrons fluence by counting Single Events Upsets (SEU) in SRAM memory.

Currently, more than 500 RadMon devices are in operation in the CERN accelerator complex, continuously acquiring and logging data once per second. Moreover, remote installations include J-PARC complex in Japan.

Different measurement techniques are exploited by the RadMon system for the different radiation field components. RadFETs exploit the build-up of positive trapped charge in the gate silicon oxide layer of the transistor under ionising radiation, causing threshold voltage shift (Vth) of the transistor as a function of the dose. Silicon p-i-n diodes are used in forward bias to monitor 1-MeV equivalent neutron fluence (Φeq). Such quantity is measured by the variation of the forward threshold voltage induced by defects from particle interactions, during the injection in the silicon p-i-n of a short pulse current. Hadron fluence measurement with SRAM memories exploits the state change of a single cell, that can be induced by single particle induced ionisation, commonly referred to as a Single Event Upset (SEU). The number of SEUs induced in the SRAM memory is proportional to the incoming particle fluence.

In RadMon devices, two SRAM types are used, that are mainly sensitive to either High-Energy Hadrons (above 20 MeV), or to thermal neutrons (due to boron passivation processes during manufacturing).

A separate, smaller sensor module hosting RadFETs and PIN diodes can be connected to the main RadMon device, and located up to 40 m away from it. This increases the monitoring use cases for the RadMon system to less accessible locations, as large experiment sub-detectors and front-end electronics.

The main settings of each device are stored in a Database. The RadMon controls software communicates with the monitoring devices located in the

underground tunnels over a WorldFIP fieldbus. Acquired data are stored in the NXCALS database system, where both raw and processed data are logged. This allows users to retrieve dosimetry data directly from NXCALS or through the TIMBER application, easily integrating on-line comparison with other CERN-sourced

data.
RadMon system's main scopes include:
Radiation to electronic measurements and extrapolation for future scenarios, exploiting knowledge of the radiation source terms, for reliable design of future installations;
Fault troubleshooting in operation, by correlating observed radiation induced equipment failures with the respective accumulated radiation levels;
Simulation benchmarking of accelerator and experiments environment;
Site investigations to verify the radiation environment before installations.

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