THE PROTOTYPE DOSIMETRY SYSTEM TO PROTECT NICA SLOW CONTROL ELECTRONIC EQUIPMENT*

A. Chłopik[a], A. Bancer[a], M. Bielewicz[a,b], D. Dabrowski[c,b]
A. Dudziński[a], E. Jaworska[a], M. Milewicz-Zalewska[a,b]
M.J. Peryt[c,b], M. Pietrzak[a], K. Roslon[c,b], J. Rzadkiewicz[a]

[a]National Centre for Nuclear Research, A. Sołtana 7, Otwock-Świerk, Poland
[b]Joint Institute of Nuclear Research, Joliot-Curie 6, Dubna, Russia
[c]Warsaw University of Technology, Pl. Politechniki 1, Warszawa, Poland

(Received July 23, 2018)

During the work, the Multi-Purpose Detector (MPD) which is a part of Nuclotron-based Ion Collider fAcility (NICA) located in Dubna, can burst in an accidental irradiation caused by the NICA's failure or its abnormal functioning. It can result in the presence of the radiation exposure in the room, where the Slow Control electronic equipment is installed. Thus, there is a risk of destroying the electronics and, in the consequence, the emergency switch off of the NICA apparatus might become impossible. The article describes the method of prevention of such situation by the continuous dosimetry monitoring in the Slow Control chamber and alarming when the radiation threshold is overrun.

DOI:10.5506/APhysPolBSupp.11.745

1. Introduction

The Multi-Purpose Detector (MPD) [1] is a part of the Nuclotron-based Ion Collider fAcility (NICA) [2], a new accelerator complex designed at the Joint Institute for Nuclear Research in Dubna to study properties of dense baryonic matter. The MPD is located in the specially prepared concrete room. The work of MPD is controlled and monitored by big amount of electronic equipment called Slow Control. All these electronics can finally occupy approximately 60–120 racks. The racks will be located on the platform designed for this purpose and standing near the MPD (Fig. 1). The vulnerable spot is when the radiation exposure in the MPD chamber will

* Presented at the II NICA Days 2017 Conference associated with the II Slow Control Warsaw 2017, Warsaw, Poland, November 6–10, 2017.

occur in case of any NICA's failure or its abnormal functioning. The radiation can go through the walls and irradiate the Slow Control electronics. That can destroy it and the NICA control would be lost. This can lead to unexpected behavior of MPD and even cause some accidents. To prevent the MPD malfunctioning, continuous monitoring of the level of radiation in the Slow Control room is needed. When it reaches the determined level, an alarm should be triggered and special procedures should take place to stop the NICA operation until Slow Control electronics is working.

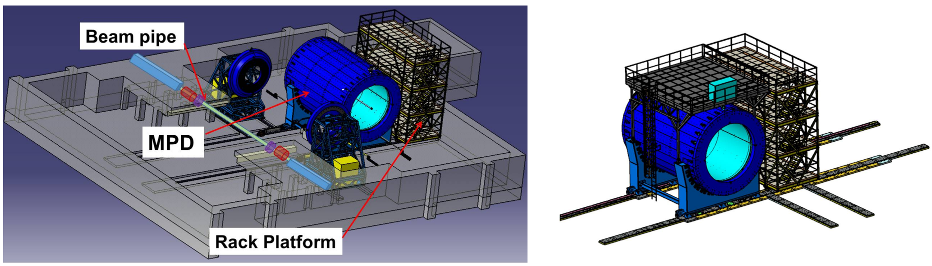

Fig. 1. Left part: Room for MPD detector. Right part: MPD detectors and Platform for MPD electronic racks [1].

2. System description

The process or method of measuring the dosage of ionizing radiation by means of a dosimeter is called dosimetry. The dosimeter is an instrument for measuring and monitoring exposure to doses of radiation, such as X-rays or gamma rays. In our case, we mostly expect gamma rays. Thus, we should build the dosimetry system which could constantly monitor the radiation in the room with the Slow Control equipment [3–5] and start the alarm when the permissible dose would be exceeded. It is planned to design such a dedicated dosimetry system. There are two scientific institutes involved in this project — the National Centre for Nuclear Research in Świerk and the Physics Department of Warsaw University of Technology. We want to build a prototype apparatus at the first step of the project to demonstrate a possibility of monitoring the radiation level using four racks filled with electronics which are currently at Dubna. The dosimetry system should continuously monitor the ionizing radiation level in the chamber taking into account two factors: the safe level for people working in that chamber and the level which can destroy the electronic devices being located in the chamber. The measurements will take place in the fixed time intervals. The results have to be displayed on a computer screen instantly in the graphical manner (*e.g.* a chart or graph) and they should also be archived. When the measured doses exceed the threshold determined for electronics, a supervisory system should be automatically informed and proceed to switch off the devices successively with the specific procedure. It will allow us to avoid dangerous and unpredicted damages which can happen in the accelerator thus avoiding serious disaster. The dosimetry system should also inform selected people via SMS or e-mail about the overrun of the fixed radiation level. We are going to use two different types of dosimetry probes, one measuring low doses of radiation and second measuring higher doses. The first one is made for protecting people working in the chamber against radiation. These probes will be, for example, mounted on the chamber walls. The second one is designed to protect the electronics of Slow Control equipment. They will be placed somewhere on the racks. Both of them should provide continuous monitoring and show the measurement results on the screen instantly. The safe radiation threshold can be different for people and electronic equipment. They have to be precisely determined during prototype tests. As the low radiation level dosimeter, an EKO-C (or EKO-D) dosimetry probe [6] shown in Fig. 2 (left) can be used. It uses the mica window Geiger–Müller counter as a detector and measures gamma rays in the range from 10 nSv/h to 999,9 μSv/h. EKO-C is small, light (500 g) and handy, and communicates with master computer via RS-485 interface. Fixing this dosimeter on a wall is easy and it can be powered from a battery. The second dosimetry probe chosen for prototype tests is EGM-104 (Fig. 2 (right)) [7, 8]. It consists of three Geiger–Müller counter chambers. Each of them has a different range of measured doses and they are switched automatically depending on the radiation rate. The probe can measure the ambient dose equivalent rate H*(10) from 10 nSv/h to 10 Sv/h in total. It needs to be powered from external DC switching power supply with output voltage in the range of 12 V–24 V and the power of 0.3 W. The communication with master computer is performed via one of RS-485, RS-232 or USB interfaces. The mentioned above dosimeters can be connected together in one RS-485 bus. This allows us to use the

Fig. 2. Left: EKO-C and EKO-D dosimetry probe [6]. Right: UM-EGM wide range gamma probe [7, 8].

Programmable Automation Controller from National Instrument [9] called c-RIO to control these devices and read out the measured data (Fig. 3). The c-RIO model chosen for prototype is c-RIO-9065. There is placed the 4-port

Fig. 3. cRIO-9065 with NI-9871 module [9].

RS-485 C-Module NI-9871 inside c-RIO. The c-RIO has the built in National Instrument Linux Real-Time Operating System and is equipped with powerful Field Programmable Array chip. We are going to use the National Instrument's LabVIEW [9] suit as a control and data visualizing software. It has to realize the following tasks:

- send control commands to probes (*e.g.* to perform setup),
- receive data from probes,
- display graphs on the screen,
- analyze the data,
- send alarms and messages to MPD supervisor and indicated persons (SMS and/or e-mail),
- archive the data.

The LabVIEW suit is installed on a PC computer to be equipped with an Ethernet card. The schematic diagram of the whole prototype system is presented in Fig. 4. It shows a number of two types of probes (ProbeA and ProbeB) gathered into one RS-485 bus which is connected to one of the NI-9871 C-Module port. The module is placed into the c-RIO-9065 slot.

The read data are sent to a PC computer via Ethernet connection. There is LabVIEW suit installed on the PC which visualizes and analyzes the collected data and alarms specified persons when the determined radiation thresholds are overrun.

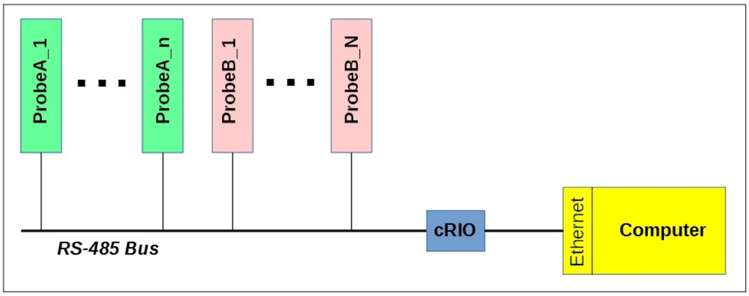

Fig. 4. The schematic view of the prototype dosimetry system for protecting MPD Slow Control electronics against unexpected irradiation.

3. Summary

We plan to accomplish the following tasks during the prototype tests:

— investigation of ionizing radiation influence on the different types of electronic devices,

— defining of the exact level of radiation dose triggering an alarm informing supervisor and other people,

— development of the managing software prototype for the dosimetry system.

We want to continue this project in the future and build the final dosimetry system. It will have the extended number of probes when compare to the prototype. If the detailed tests of the prototype dosimetry system for protecting MPD Slow Control electronics against unexpected irradiation will show that the probes selected for the prototype are inconvenient, then they should be replaced with new ones.

This work is partially supported by the Research Program for the research group at JINR and research centres in Poland 2018.

REFERENCES

[1] V. Golovatyuk *et al.*, *Eur. Phys. J. A* **52**, 212 (2016).

[2] http://nica.jinr.ru/complex.php

[3] D. Dabrowski *et al.*, *Acta Phys. Pol. B Proc. Suppl.* **9**, 203 (2016).

[4] M.J. Peryt, T. Traczyk, *Acta Phys. Pol. B Proc. Suppl.* **9**, 293 (2016).

[5] K. Roslon *et al.*, *Acta Phys. Pol. B Proc. Suppl.* **9**, 299 (2016).

[6] Technical documentation: http://www.polon-ekolab.com.pl/ekoc/ekoc.htm

[7] Technical documentation: http://nuvia-group.com/en/blog/product/components/nudet-detectors-and-probes/nudet-egm/

[8] Technical documentation: https://nuvia.cz/ke-stazeni/en/products/radiometric-systems/nudet-egm.pdf

[9] Technical documentation: http://www.ni.com/en-us/shop/select/compactrio-controller