E16-2018-38

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

Submitted to "Acta Physica Polonica B"

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Хлопик А. и др. E16-2018-38
Прототип дозиметрической системы для защиты
электронного оборудования по проекту Slow Control NICA

В ходе работы многоцелевой детектор (MPD), входящий в состав ионного коллайдера NICA, основанного на нуклотроне в Дубне, может сломаться в результате случайного облучения, вызванного отказом NICA или его ненормальным функционированием. Это может привести к радиационному облучению в помещении, где будет установлено электронное оборудование Slow Control. Таким образом, существует риск разрушения электроники, вследствие чего аварийное отключение аппарата NICA может стать невозможным. В статье описан метод предотвращения такой ситуации путем непрерывного дозиметрического контроля в камере замедленного контроля и оповещения при превышении радиационного порога.

Работа выполнена в Лаборатории физики высоких энергий им. В. И. Векслера и А. М. Балдина ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна, 2018

Chlopik A. et al. E16-2018-38
The Prototype Dosimetry System to Protect NICA
Slow Control Electronic Equipment

During the work the Multi-Purpose Detector (MPD), which is a part of the Nuclotron-based Ion Collider fAcility (NICA) located in Dubna, can burst in an accidental irradiation caused by 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 will be installed. Thus, there is a risk of destroying the electronics, and as a consequence the emergency switch off of the NICA apparatus might become impossible. The article describes the method of prevention of such a situation by the continuous dosimetry monitoring in the Slow Control chamber and alarming when the radiation threshold is overrun.

The investigation has been performed at the Veksler and Baldin Laboratory of High Energy Physics, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna, 2018

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 this 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 (see Fig. 1). The vulnerable spot is when the radiation exposure in the MPD chamber will 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 the determined level is reached there, an alarm should be triggered and special procedures should take place to stop the NICA operation until Slow Control electronics is working.

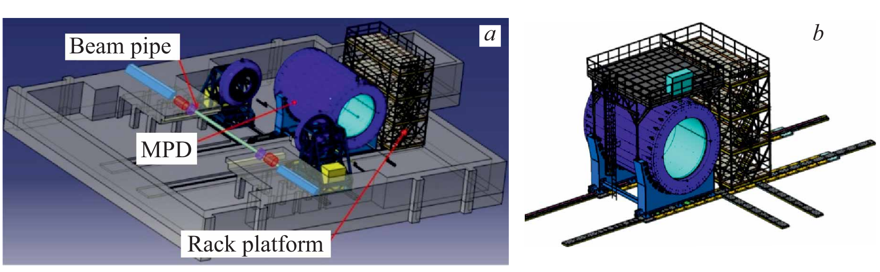

Fig. 1. *a*) Room for the MPD detector; *b*) MPD detectors and platform for the MPD electronic racks [1]

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 expect gamma rays mostly. Thus, we should create 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 is exceeded.

It is planned to design such a dedicated dosimetry system. There are two scientific institutes involved in this project — National Centre for Nuclear Research in Świerk and Physics Department of Warsaw University of Technology. We want to create 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 in Dubna.

The dosimetry system should continuously monitor the ionizing radiation level in the chamber with taking into account two factors: the safe level for people working in that chamber and the level which can destroy the electronic devices 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, the first measuring low doses of radiation and second measuring higher ones. The former is made for protecting people working in the chamber from radiation. These probes will be mounted on the chamber walls, for example. The latter 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 a low radiation level dosimeter EKO-C (or EKO-D) dosimetry probe can be used [6] (see Fig. 2, *a*). It uses 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.

Fig. 2. *a*) EKO-C and EKO-D dosimetry probe [6]; *b*) UM-EGM wide-range gamma probe [7–8]

The second dosimetry probe chosen for prototype tests is EGM-104 (Fig. 2, *b*) [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 12–24 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 dosimeters mentioned above can be connected together in one RS-485 bus. This allows us to use the Programmable Automation Controller from National Instrument [9] called c-RIO to control these devices and read out the measured data (see Fig. 3). The c-RIO model chosen for the prototype is c-RIO-9065. The 4-port RS-485 C-Module NI-9871 is placed 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.

Fig. 3. c-RIO controller and NI-9871, RS-485 module [9]

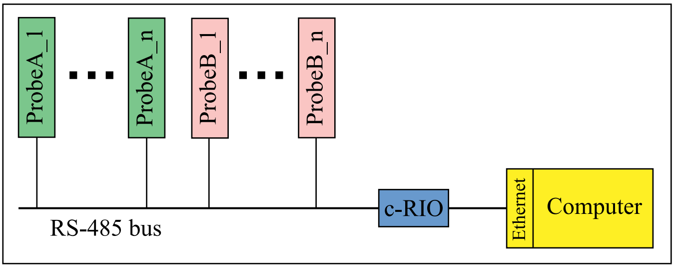

Fig. 4. The schematic view of the prototype dosimetry system for protecting MPD Slow Control electronics from unexpected irradiation

We are going to use the National Instrument LabVIEW [10] suit as a control and data visualizing software. It has to bring about 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 the 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 ports. The module is placed into 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.

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 compared to the prototype. If the detailed tests of the prototype dosimetry system for protecting MPD Slow

Control electronics from unexpected irradiation show that the probes selected for prototype are inconvenient, they should be replaced with new ones.

Acknowledgements. This work is partially supported by Research Program for the research group at JINR and research centres in Poland 2018. This work is a part of Polish Consortium for NICA program (NICA-PL).

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Received on July 12, 2018.

Редактор *Е. И. Крупко*

Подписано в печать 20.08.2018.
Формат 60 × 90/16. Бумага офсетная. Печать офсетная.
Усл. печ. л. 0,68. Уч.-изд. л. 0,88. Тираж 175 экз. Заказ № 59493.

Издательский отдел Объединенного института ядерных исследований
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