HOW INDUCED ACTIVATED ACCELERATOR PARTS HAVE AN IMPACT ON THE RADIATION SAFETY OF A PROTON THERAPY FACILITY

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I. Introduction

Residual activity induced in particle accelerators is a radiation safety concern as the long-lived radionuclides produced by fast or moderated neutrons and impact protons can cause problems of radiation exposure. Staff involved in maintenance of the proton therapy installation or in the quality control measurements done for evaluation of the beam output need to be aware of this.

This study presents dose rate and energy spectrum-based measurements done on 1) phantoms used during quality control measurements; 2) on the accelerator components that become activated due to the backscattered neutrons from the target and also due to the direct proton interactions and their secondaries. As a part of this study, a correlation is made between de continuously monitored neutron and gamma dose rate measurements in the cyclotron vault and the registered beam-on time. In this way we can evaluate how quickly the dose rate, measured at contact of these activated parts, goes down to a safe level after irradiation.

These measurements are used to assess operator exposure and to evaluate the need for specific radiation safety measures during maintenance and regular quality control.

II. Material and methods

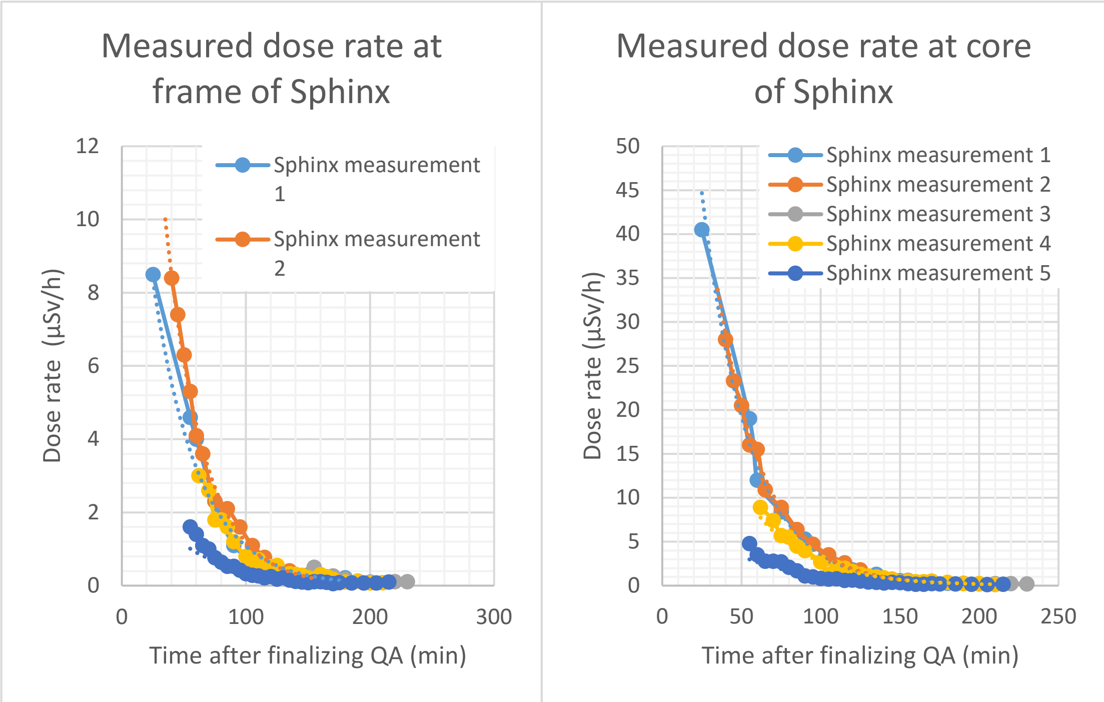
Measurements were carried out at ParTICLe, the proton therapy facility of UZ Leuven, which consists of a Proteus®ONE (IBA) compact proton therapy system using the latest generation Pencil Beam Scanning.

2 IBA Dosimetry products (Sphinx and Lynx) used for quality control and removed metallic parts during maintenance (cooling cylinders, beam flanges,…) were selected for this activation study. Dose rate measurements were done using the LB134 (Berthold) and Babyline 81A (Mirion) dose rate meters. Hot spots were detected by using a LB124 scintillation monitor (Berthold).

III. Results and discussion

Measurements performed at contact on the grid of the detector for 2D-dosimetry, i.e. Lynx, showed no significant increase in dose rate measured 30 minutes after finalizing the QA measurements. However, at the end of life of these devices it is necessary to investigate if cumulated activation over time is still below legal release limits.

Irradiations on the Sphinx resulted in elevated dose rates inside the core of the Sphinx, but these dose rates are also significant at the positions where the Sphinx is held during manipulations. Based on the exponential extrapolation of these performed measurements a dose rate above 100 µSv/h can be expected at the core of the Sphinx immediately after finalizing the QA measurements. The cumulated dose for staff related only to the daily manipulation of the Sphinx immediately after the morning QA during one year is estimated to be 2% of the Belgian public yearly dose limit.



Spectrum-based measurements performed on activated metallic parts of the accelerator show the presence of Co-57 and Co-60. Dose rates at contact can vary significantly, from a few µSv/h up to 1 mSv/h for the most activated components.

IV. Conclusions

Activation was significant after long irradiation sessions, resulting in instantaneous dose rates up to 1 mSv/h at contact of accelerator components where the highest beam losses are expected. Therefore specific radiation safety measures are necessary during maintenance operations.

Some of the investigated quality control devices may also cumulate activity in time, depending on the scenario of periodic irradiation in routine clinical practice.

Results of this study will help to determine which specific radiation protection measures need to be taken during maintenance and quality control measurements.