The Design of Beam Monitoring System of the Xiamen Humanity Hospital BNCT Center

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Introduction

In order to accurately estimate and control the dose delivery to patient during irradiation, this study designed and developed a reliable and robust beam monitoring system for the Xiamen Humanity Hospital BNCT Center. The monitoring system is a subsystem of the Neuboron AB-BNCT System.

Materials and Methods

The design of the monitoring system considered the following aspects: 1) good discrimination between neutrons and gamma rays; 2) good linearity over the full power range; 3) satisfactory statistical output; 4) free of patient back scattering influence; 5) consist of redundant channels/detectors; 6) capability of detecting special information as well as energy information; 7) compliance of ISO-13485 and other IEC requirements. In short, the system must deliver trustworthy measurement result that can accurately reflect the true beam intensity as well dose rate reliably under different conditions.

For the 1st consideration, fission chamber is considered as our first choice due to its good performance and long-term stability. However, the fission chamber is a controlled nuclear item/material in many countries as well as in China. Furthermore, its fission products causes high residual activity after irradiation. As a result, this study considered boron-based detectors, i.e. boron lined detector and the BF_3 proportional counter. For the 2nd and 3rd consideration, a good control of counting rate must be carefully evaluated and controlled. This involves the positions where the detectors are deployed and the local neutron intensities as well as spectra. A range of counting rate is chosen from 4500 counts per second to 15000 counts per second at full power. Additional neutron moderators/absorbers, such as regular PE, boron-containing PE, Cd, and B_4C, were evaluated to create different response to different energetic neutrons, as well as to control the counting rate at desired range. Monte Carlo code was used to evaluate the ideal response function of the designed detectors.

Results

Although the boron lined detector has a much better neutron detection efficiency than the BF_3 counter, BF_3 does has a better performance in signal discrimination. Furthermore, because of the powerful beam intensity, the expected counting rate is at order of 10^4 – 10^5 counts per second using

BF_3 counter. Thus, the BF_3 counter was chosen as the main detector used in the monitoring system. Sleeves made of B_4C were applied on the detectors to generate desired responses. Three BF_3 counters were placed at 3 different locations in the BSA with ideal responses falling within the desired counting rate range. Based on the calculation results, we found the patient back scattering contributed a slight additional counts to the readings. Further works are now under going to minimize the patient back scattering influence.

Conclusion

An on-line neutron monitoring system has been designed and proposed for the Xiamen Humanity Hospital BNCT Center. The system consists of three BF_3 proportional counters with B_4C covers on them to create different responses to neutrons. The system will be tested in a real installation by the end of 2019, and will be adjusted according to the real readings.