The Radiation Shielding Design of Xiamen Humanity Hospital BNCT Center

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Introduction

For the design of any radiation facility, the radiation safety always comes first, and radiation shielding plays an extremely important part of it. For conventional radiotherapy facilities, the primary penetrating radiation source is gamma ray and some may take into account the contamination of secondary neutrons induced by high-energy gamma rays (> 6 MeV); these facilities use high-Z material such as lead to shield gamma rays and low-Z materials like polyethylene to shield neutrons. However, for a BNCT facility, the situation is totally the other way around – neutron is the primary penetrating radiation source and gamma ray is the secondary source. The shielding design philosophy is thus very different from the gamma-ray based facility, and it requires a much more sophisticated consideration.

The Xiamen Humanity Hospital BNCT Center is the 1st accelerator-based BNCT facility built in Great China, and it consists of 2 horizontal neutron beams and 1 vertical one; the center is built on a green field with limited space. The complication of the center makes the radiation shielding design much more challenging than other known BNCT facilities. The Xiamen BNCT Center requires new shielding material and design to satisfy the radiation safety and corresponding regulations.

Materials and Methods

The primary radiation shielding was chosen basing on the following four considerations: 1) the material should has a good performance in removing neutrons and gamma rays; 2) it should have a good mechanical performance to serve as the main structure material as well; 3) the material should be of high density to minimize the wall thickness; 4) it should be non-activated or low-activated after neutron irradiation. Based on the abovementioned considerations, a special borated barite concrete was invented and created successfully.

The core facility was arranged as Y shape at the primary floor, which can provide better protection to the accelerator and decrease the wall thickness around the high-energy beam line room. The whole core facility was analyzed using PHITS [1].

Results

A given percentages of boron was used as additive into barite concrete to increase the capability of neutron absorption. Several different boron contained barite concretes have been made and tested, in order to find a satisfactory combination. One combination reached a strength of C40 standard, and had a much more effective neutron removing capability than a conventional one. The new borated barite concrete was therefore used as the primary shielding material in the core facility. It is found that the shielding design of the Xiamen BNCT Center satisfied the Chinese GB standard [2]. The main shielding wall is only 1 meter, and it could be further decreased to 0.8 m if the ICRP-103 [3] dose limit guideline is applied. More details will be given and discussed during our presentation.

Conclusions

The Xiamen BNCT Center has been carefully designed and calculated with full 3D model. The final design satisfy all the GB standards, while the size of the facility remain compact. The demonstration site will be the standard model for all the following BNCT facilities built by Neuboron.

References

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