

蒙地卡羅法 MCNPX 程式對醫用質子加速器之單層屏蔽研究

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摘要

質子加速器從 1990 年代發展至 2012 年底，全球已有約 36 座質子治療中心，已接受質子治療的病人則達 93,000 人，接受過質子治療的病人，其病情多能達到有效控制，療效相當顯著。然而，質子加速器之屏蔽數據目前則尚不足，且大多限定在特定幾何結構與能量條件。為解決此問題，本研究深入研究質子治療加速器輻射屏蔽的分析技術與方法。採用 MCNPX 蒙地卡羅程式，探討高能質子撞擊鐵、人體等效組織與石墨靶，產生之中子產率及其能量與角度分佈特性，計算其在混凝土屏蔽之遷移，並將結果以曲線擬合，求得射源項和衰減長度等屏蔽分析參數，也評估簡化衰減公式之準確性、適用範圍。使用 point-source line-of-sight 模型執行輻射屏蔽設計或劑量分析，所得到的效果與選用的參數是否有效與合適存在非常強烈的關係。以射源項與衰減長度為函數的數據庫，應用於單層屏蔽的使用方式非常簡單，只要掌握各參數的適用範圍，再依入射質子能量和靶材種類即可，這樣操作所得之結果本研究已證明是有效且可靠的。

關鍵詞：MCNPX，質子治療加速器，輻射屏蔽分析，射源項，衰減長度。

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The Study of Medical Proton Therapy Accelerator for Single-Layer Shield Using MCNP Monte Carlo Code

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Abstract

Since the medical proton therapy development from the 1990s to the 2012, there are already 36 proton therapy centers around the world. Patients who have received proton therapy amounted to 93,000 people, and their condition can be effectively controlled. The treatment effect is quite remarkable too. However, the medical proton accelerator shielding data are not enough. These shielding data limited to specific geometry and energy conditions. To solve the problem, this work study on the medical proton accelerator radiation shielding analysis techniques and methods. The first is using the MCNPX Monte Carlo code to investigate high-energy protons bombard on iron, tissue and carbon targets to produce neutrons with different energy and angle distribution. The second is calculation of these neutrons in concrete shielding transport and source terms and attenuation lengths will also be derived. Moreover, the accuracy of the simplified attenuation formula and the range of its application will be evaluated. Finally, using point-source line-of-sight model to execute radiation shielding design or dose analysis. There is a very strong relationship between Parameter selection and calculation of results. This work has demonstrated that this database is valid and reliable. If users understood the scope of each parameter.

Keywords : MCNPX, medical proton accelerator, radiation shielding analysis, source terms, attenuation lengths.