PROTON RANGE IN 2 CM THICK COPPER SIMULATION USING PHITS

SIMULASI RANGE PROTON DALAM KUPRUM BERKETEBALAN 2CM MENGGUNAKAN PHITS

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Abstract

PHITS is one of the Monte Carlo particle transport simulation code. It is being used in many studies in the field of accelerator technology, radiotherapy, space radiation, etc. This paper explains the simulation using PHITS for proton energies between 1 MeV and 6 MeV to determine the value of proton range in a 2 cm thick copper target material. The simulation value is compared to the existing value from NCRP 51. The similarities and the differences of these two values are also discussed.

Keywords/Kata kunci: Proton range, PHITS, proton interaction with matter.

Abstrak

PHITS merupakan salah satu kod simulasi pergerakan zarah Monte Carlo. Ia digunakan di dalam banyak kajian dalam bidang teknologi akselerator, radioterapi, radiasi angkasa dan sebagainya. Kertas kerja ini menerangkan simulasi dengan menggunakan PHITS bagi tenaga proton 1 MeV hingga 6 MeV dalam mencari nilai range zarah proton di dalam bahan sasaran kuprum berketebalan 2 cm. Nilai simulasi ini dibandingkan dengan nilai yang terdahulu dari NCRP 51. Persamaan dan perbezaan dari nilai simulasi dan NCRP 51 juga dibincangkan.

INTRODUCTION

In crossing a material, the charged particles will be ionized and consequently will lose energy in many steps until the energy is equal or approximate to zero. The distance taken by the charged particles to the maximum point is called the range of the particle. The unit of range is mass per unit area (g/cm^2). The range depends on the type of particle, the initial energy of the particles and the material to be passed by it. The study of this range is important to determine the distance or depth of a charged particle penetrating or crossing within a material or medium. For example in terms of radiation safety, the thickness of the shield to block the particles could be estimated. Similarly in the field of cancer therapy using proton particles, the range is very important to ensure that only cancer cells are radiated.

In modern technology, simulation is an important method in determining the various interaction of charged particles on a material. With the previous data, the simulation studies can be done successfully. The previous data from early experiment can be used as a guide and proof of successful of simulation. PHITS (Particles and Heavy Ion Transport code System) is one of the Monte Carlo codes that have been used in this study. The objective of this study is to simulate the values of the proton particles range in the 2 cm thick copper target material using the PHITS code. The values obtained from this simulation will then be compared to the previous values found in NCRP 51.

METHODOLOGY

By using PHITS Ver.3.02 simulation, five groups (where one group contains 10,000 particles) of the proton particles energy (E), where E is equal to 1 MeV, 2 MeV, 3 MeV, 4 MeV, 5 MeV and 6 MeV will be simulated and directed to a target material cylindrical (diameter 1 cm), which is 2 cm in thickness and density of 8.93 g/cm^3 as shown in Fig.1. The proton particles will penetrate within the target material of copper until the maximum distance R. Using tally of T-Track, this maximum distance (in cm unit) will be detected and measured from the surface of the target material to the maximum distance that protons penetrate the target material. These values of the maximum distance will be multiplied by the copper density value of 8.93 g/cm^3. Then, those values were compared to the previous values of NCRP 51.1977.

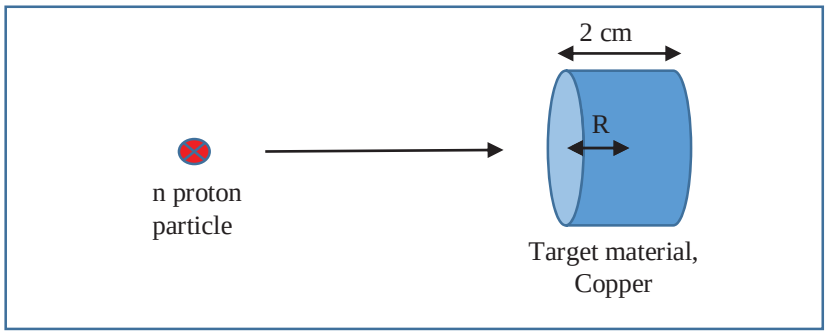

Figure 1. The simulation of PHITS

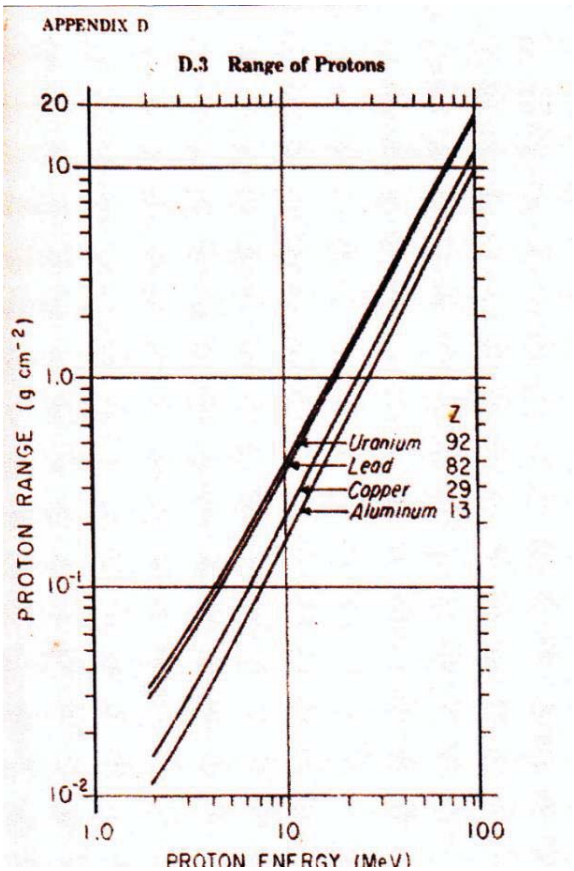

Figure 2. The Range of Proton in several types of materials from NCRP 51

RESULTS AND DISCUSSIONS

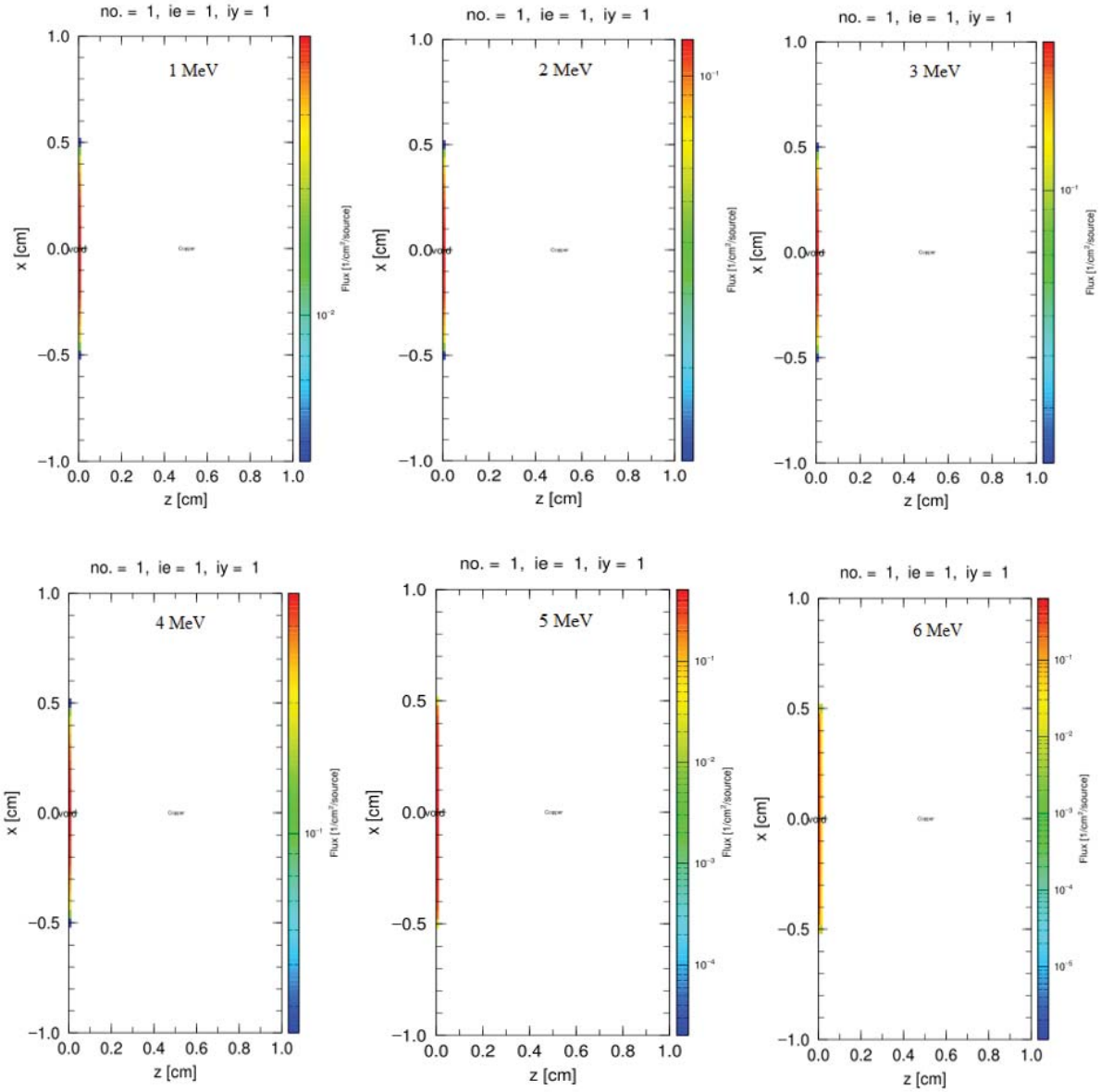

Figure 3. The T-Track output (X-Z axis) for a 1 MeV proton up to 6 MeV protons in copper target material.

From Fig.4, it is found that when proton's initial energy increases, the range of proton in copper also increases. These increasing values are the same as those obtained from previous values of NCRP 51. However, the range values for proton 1 MeV and 2 MeV have the same value of 1.786×10^{-2} g/cm^2 but have different particle flux of 9.0238×10^{-4} for 1 MeV and 2.3991×10^{-3} for 2 MeV. The values of the proton range in copper from the simulation were slightly higher than the previous value of NCRP 51. This was due to the parameters used in the simulations unlike the parameters considered in the experiment from NCRP 51.

In the simulation of PHITS, to simplify the simulations, many of the parameters are neglected such as the air medium while the empirical study is the actual situation of the study. Thus the data obtained from the simulation are usually not the same as the empirical data.

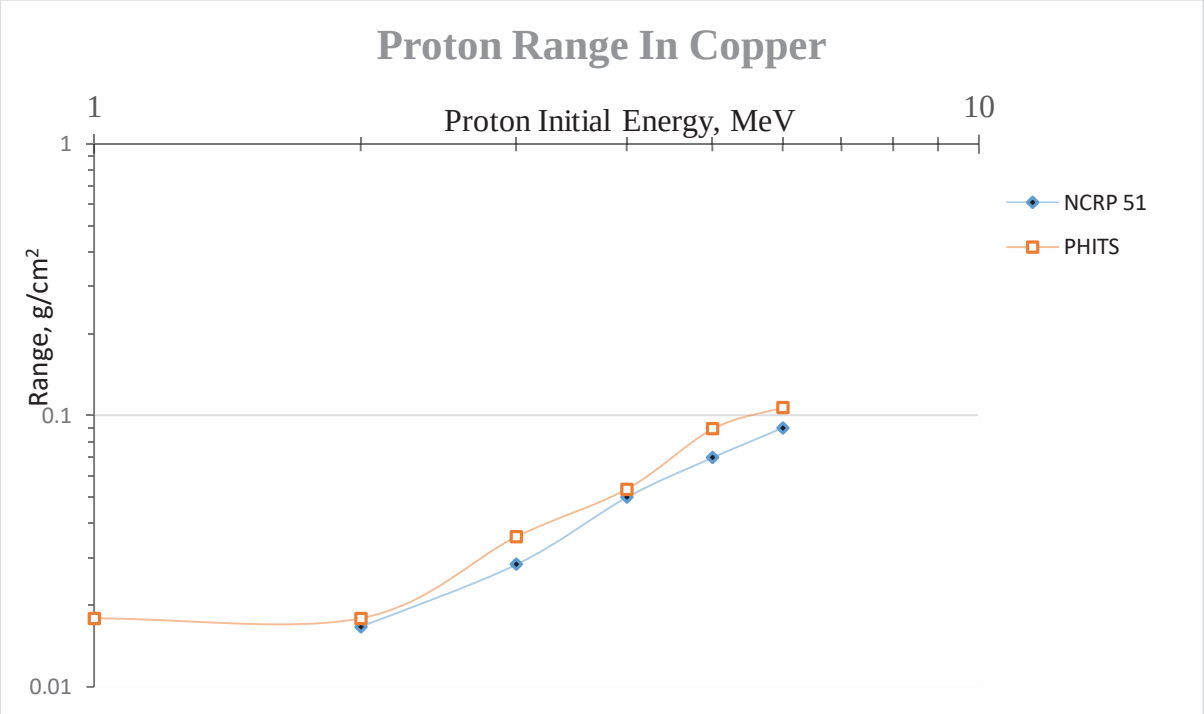

Figure 4. The Range value for Proton in Copper from 1 MeV to 6 MeV from PHITS and NCRP 51

CONCLUSION

From the simulation of PHITS that has been performed it is found that the range values obtained have the same characteristics in the range of NCRP 51. The simulation of proton range values in copper using the PHITS code has been successfully executed.

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