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Optimization Dose BNCT of Skin Cancer with SHIELD-HIT 12A PROGRAM

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A B S T R A C T

Study aims to determine the optimum dose of cancer therapy Boron Neutron Cancer Therapy (BNCT) in skin cancer using the SHIELD-HIT 12A program. The steps taken are to define the geometry and components of the skin as the object being studied and boron-10 as the source of radiation used. The output obtained from SHIELD-HIT 12A is in the form of radiation length in each skin forming a constituent of skin. Medium 1 is a bone tissue with a radiation length of 10.416 cm; medium 2 is muscle tissue with radiation length 20.089 cm; medium 3 is skin tissue with radiation length 34.25 cm and medium 4 is cancer tissue with radiation length 9.639 cm. In this study the dose of BNCT has not been detected by the SHIELD-HIT 12A program.

1. INTRODUCTION

Cancer is a generic term for a group of diseases that can affect any part of the body. Another term for this disease is a malignant tumor or neoplasm. Characteristic of cancer is the quick growth of abnormal cells that can grow and spread to adjacent body parts (metastasize). Metastasis is the leading cause of cancer deaths which is the second leading cause of death in the world. There were approximately 14 million new cases in 2012, and it is estimated that number will increase to 98 million new cases over the next two decades. By 2015 cancer had caused 8.8 million deaths (WHO, Media Center 2017).

Overall, the prevalence of cancer continues to increase, in the United States alone about 1,665,540 people suffer from cancer and 585,720 of them died from the disease in 2014. In men, the highest percentage of cancers occur in the prostate, lung and bronchial, colon and rectum, as well as the bladder. In women, the highest prevalence is breast, lung and bronchial, colon and rectal cancers, uterine corpus and thyroid. These data suggest that prostate and breast cancer are a major part of cancer for men and women. For children, the highest percentage of cancer types is blood cancer, cancer associated with the brain and lymph nodes. Cancer occurs by a series of successive mutations in the gene so that these mutations alter the function of the cell of a chemical compound that has the role of mutating the gene and cancer cells (Hassanpour & Dehghani, 2017).

Cancer has many types, but this paper focuses on skin cancer. A large number of people worldwide are exposed to skin

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cancer. Skin cancer accounts for significant morbidity and mortality (Walocko & Tejasvi, 2017). According to the World Health Organization (WHO), about 2-3 million cases of non-melanoma and 132,000 cases of melanoma occur every year globally. The highest rates of skin cancer occur in Australia and New Zealand, which are four times higher than Canada, the United States and the United Kingdom. Skin cancer commonly occurs in the epidermal and dermal layers. It is often categorized into melanoma and non-melanoma. Among all types of skin cancer, melanoma metastasizes quickly and causes the majority of deaths. So, it is important for the melanoma to be detected as early as possible before the cells start to attack and spread (Bhowmik, Repaka, Mulaveesala, & Mishra, 2015). Accurate documentation of the date of cancer diagnosis is important for clinical and research care as it is the starting point for disease identification and treatment. In cancer epidemiology, the date of cancer diagnosis is the data element required in the calculation of morbidity measures (Porter, Chao, Quinn, Hsu, & Jacobsen, 2014). Non-melanoma (NMSC) and melanoma skin cancer are the two most common forms of cancer diagnosed in the United States and around the world. 1,2 NMSC is much more common but melanoma has a greater lethality potential (Glazer, Rigel, Winkelmann, & Farberg, 2017). Recent studies have found that NMSC incidence increased 35% between 2006 and 2012, from 4,013,890 to 5,434,193 cases / year. For context, the estimated incidences of all other forms of cancer combined in 2017 were 1,688,780 cases / year. Thus, 3 of 4 cancers diagnosed in the United States are NMSC (Wang, Morgan, Besaw, & Schmults, 2017).

One method of cancer diagnosis is using invasive biopsy. In addition to biopsies, optical techniques such as Raman Spectroscopy have been implemented as a real time vivo tool for use (Zhao, Zeng, Kalia, & Lui, 2017). Reflective Confocal Microscopy (RCM) is an innovative, non-invasive diagnostic technique in the 21st century that allows visualization (Haroon, Shafi, & Rao, 2017). Electrical impedance spectroscopy (EIS) is a non-invasive method for diagnosing skin cancer in the differential electrical impedance between normal and abnormal skin (Braun et al., 2017), and diagnosis using dermatoscopy is a non-invasive diagnostic technique that is widely used for single non pigmentation lesions (Sinz et al., 2017). The current methods of cancer therapy are surgical methods, chemotherapy, radiotherapy (with protons, neutrons, gamma, electrons, x-rays), and BNCT. The best therapeutic method is BNCT, because Boron Neutron Capture Therapy (BNCT) is based on Boron-10's non-radioactive isotope capability to capture thermal. This nuclear reaction produces two high Linear Energy Transfer (LET) particles (He-4 and Li-7). BNCT combines the principles of chemotherapy and radiotherapy. The principle of chemotherapy is based on the presence of Boron-10, Sodium Borocaptate (BSH) or Boronophenylalanine (BPA) compounds that are inserted into the patient's body prior to irradiation. The radiotherapy principle is included because the patient is irradiated with a neutron source (Rosidah, Sardjono, & Sumardi, 2017).

The dose study in BNCT determines the success rate in cancer therapy. For that a Monte Carlo-based computer program such as MCNP, MCNPX, PHITS, PENELOPE, GEANT-4, FLUKA, EGSnrc, EGS4, BEAMnrc, and SHIELD-HIT 12A (Faqqiyah, Sardjono, & Bassler, 2014) is needed. Monte Carlo (MC) has demonstrated a suitable technique for evaluating cell-level microdosimetric parameters for BNCT (Karaoglu, Arce, Obradors, Lagares, & Unak, 2017). Because of the limitation of MCNP system for dosage calculation in BNCT, the SHIELD-HIT 12A

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(Heavy Ion Therapy) is used, which has the advantage in calculating dose of BNCT (Faqqiyyah, Sardjono, & Bassler, 2014).

2. MATERIALS AND METHODS

2.1 Materials

Laptops, Software used Microsoft Office Word 2016, Microsoft Excel 2016, Software SHIELD-HIT 12A, notepad. Materials with journals and books related to BNCT and SHIELD-HIT 12A.

2.2 Methods

The methods used are reference and simulation by programs SHIELD-HIT 12A.

1. Search and collect references.

This research begins with searching and material results on BNCT, skin cancer and SHIELD-HIT 12A program.

2. Literature study.

Literature study is done by using the journals and books that have been sought as a reference and by asking people who understand BNCT and SHIELD-HIT 12A.

3. Analyze data using SHIELD-HIT 12A program.

After doing literature study, the data have been analyzed using program SHIELD-HIT 12A.

4. Write a report.

After all the process is passed then a report is written about the results of the research.

3. RESULTS AND DISCUSSION

The SHIELD-HIT 12A input codes used are as follows:

1. Mat.dat

Mat.dat contains codes that are chemical compositions that exist in the target zone. For skin cancer there are 4 tissues reviewed, namely cancer tissue, skin tissue, bone tissue and muscle tissue. The materials of the four networks are as follows:

a. Material for cancer tissue: H, C, N, O, P.
b. Material for skin tissue: H, C, N, O, Na, Mg, P, S, Cl, K, Ca, Fe, Zn.
c. Material for bone tissue: H, C, N, Mg, P, S, Ca.
d. Material for muscle tissue: H, C, N, O, Na, Mg, P, S, K.

(Setyadi, Sardjono & Darmawan, 2016).

The code used on the SHIELD-HIT 12A program for tissue reviewed skin cancer is as follows.

Table 1. Code used in the program SHIELD-HIT 12A for cancer tissue.

Cancer elements	Material code SHIELD-HIT 12A
H	ICRU 1
C	ICRU 6
N	ICRU 7
O	ICRU 8
P	ICRU 15

For skin tissue, there is a special material code that is ICRU 250, so the constituent elements need not be elaborated.

Table 2. Code used in the program SHIELD-HIT 12A for bone tissue.

Elements of bone tissue	Material code SHIELD-HIT 12A
H	ICRU 1
C	ICRU 6
N	ICRU 7
O	ICRU 8
Mg	ICRU 12
P	ICRU 15
S	ICRU 16
Ca	ICRU 20

Table 3. Code used in the program SHIELD-HIT 12A for muscle tissue.

Elements of muscle tissue	Material code SHIELD-HIT 12A
H	ICRU 1
C	ICRU 6
N	ICRU 7
O	ICRU 8
Na	ICRU 11
Mg	ICRU 12
P	ICRU 15

S	ICRU 16
K	ICRU 20

Each code of the network is input into one notepad and the file is named mat.dat.

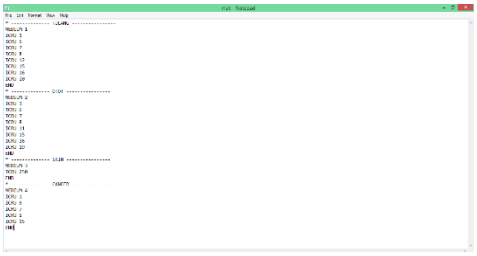

Fig 1. File input mat.dat.

2. Beam.dat

This section contains various parameters such as projectiles, statistics, and others. The beam.dat in this case is the following:

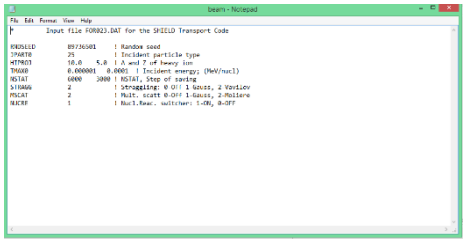

Fig 2. File input beam.dat.

The input above illustrates that the type of particle used as a projectile is heavy ion, specifically the boron which has the mass number (A) 10 and the atomic number (Z) 5. Because of its target skin tissue, the energy used is ranged from 1 eV (0 , 000001 MeV) up to 10 keV (0.001 MeV).

3. Geo.dat

In modeling this skin cancer an RCC-shaped cancer geometry was made with the following conditions:
r1 (cancer radius) = 0.03 cm
r2 (skin fingers) = 0.5 cm
r3 (muscle radius) = 1 cm
r1 (bone radius) = 2 cm
P1 (cancer length) = 5 cm
P2 (skin length) = 15 cm
P3 (muscle length) = 15 cm
P4 (bone length) = 15 cm
So the input geo.dat is as follows.

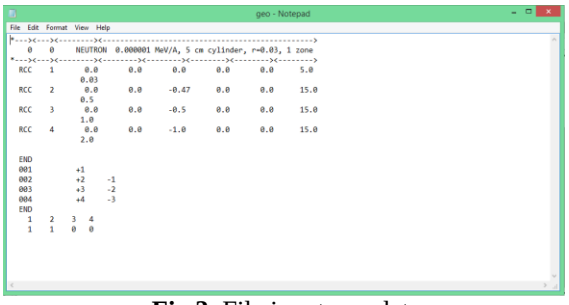

Fig 3. File input geo.dat.

4. Detect.dat

Detect.dat is an optional input for the simple assessment of physical quantities in independent geometry. This analysis used a detect.dat file in the simple file example.

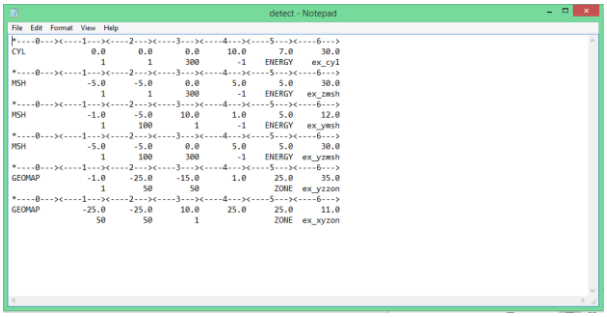

Fig 4. File input detect.dat.

Once the input file is completed, then it is saved in one folder and saved in the example file to run in command prompt.

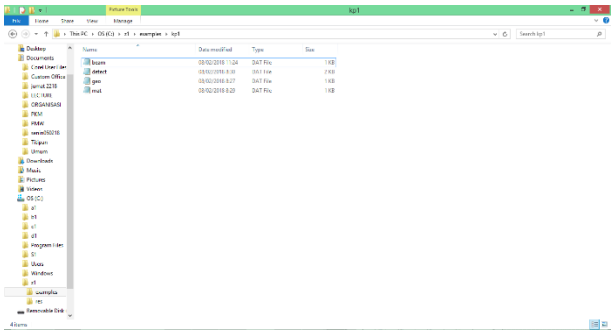

Fig 5. Folder kp1 contains the input file

Running process

The running process is shown in the following figure 6-8:

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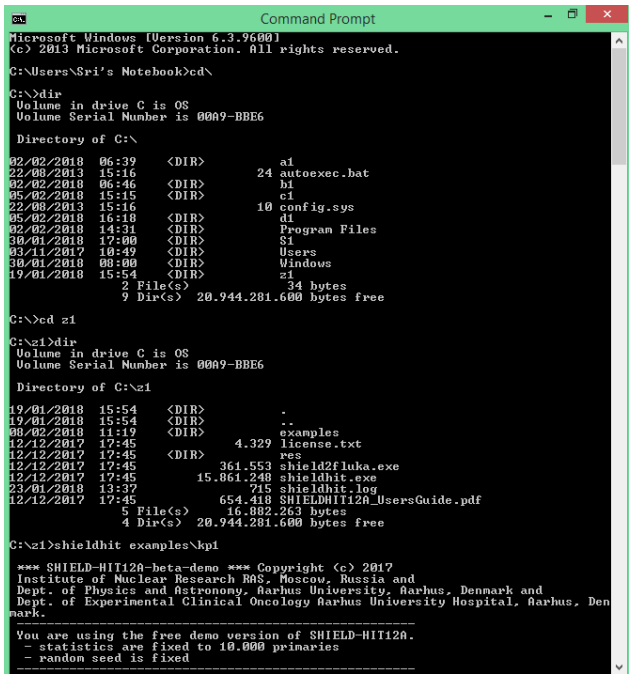

Fig 6. Running process

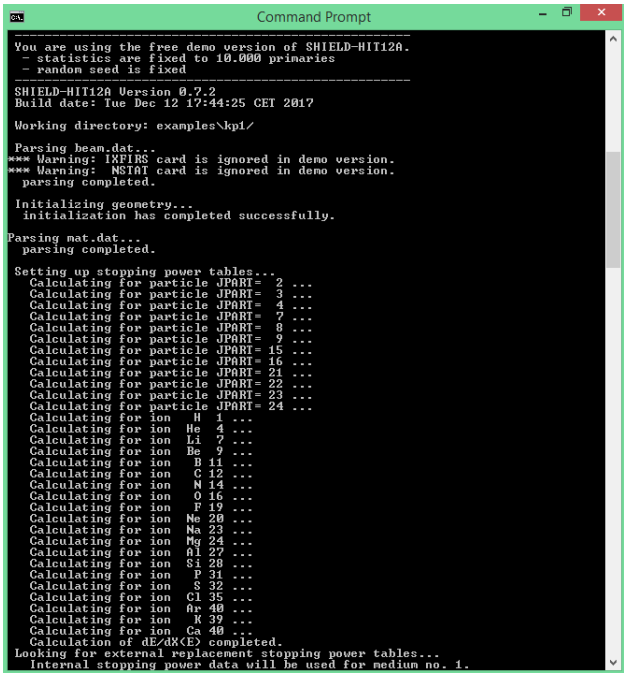

Fig 7. Running process

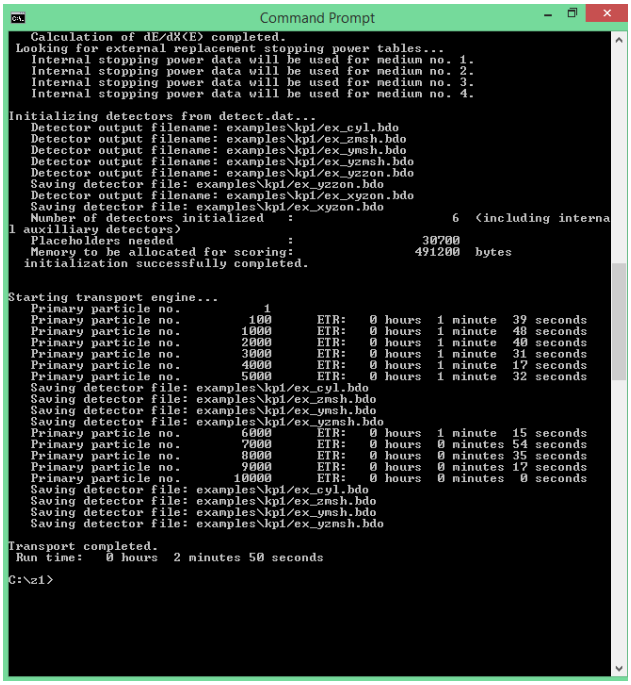

Fig 8. Running process

Running result:

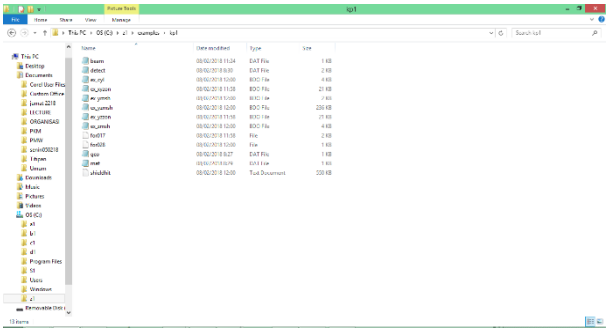

Fig 9. Additional files after running

The picture above shows the output of the SHIELD-HIT 12A program. The running results are described in full on the "shieldhit" file.

This result highlights the length of radiation on the medium. These results can be seen in the graph below.

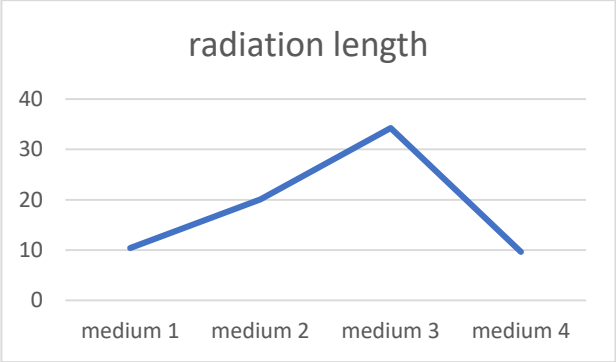

Fig 10. Radiation length of each medium

The graph describes the length of radiation on each medium, where medium 1 is a bone tissue with a radiation length of 10.416 cm; medium 2 is muscle tissue with radiation length 20.089 cm; medium 3 is skin tissue with radiation length 34.25 cm and medium 4 is cancer tissue with radiation length 9.639 cm.

4. CONCLUSION AND REMARKS

The output obtained from SHIELD-HIT 12A is in the form of radiation length in each medium under review. Medium 1 is bone tissue with a radiation length of 10.416 cm; medium 2 is muscle tissue with a radiation length of 20.089 cm; medium 3 is skin tissue with a radiation length of 34.25 cm and medium 4 is cancer tissue with a radiation length of 9.639 cm. In this study the dose of BNCT has not been detected by the SHIELD-HIT 12A program. Therefore, further research or analysis is needed so that the dose value can be determined.

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