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Study of the Variation of Material layer Compotition and Thickness Related Neutron Flux and Gamma Radiation

Yuliana Dian Nirmalasari[1], Suparmi[1], Y. Sardjono[2]

[1]Physics Department of Graduate Program Sebelas Maret University,
Jl. Ir. Sutami 36A Kentingan Jebres Surakarta 57126, INDONESIA

[2]PSTA-Batan Yogyakarta

E-mail: yulians.dn@gmail.com

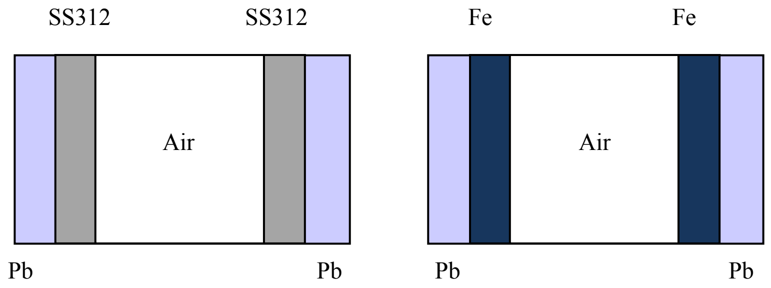
Abstract. Optimation of simulation design of collimator is corresponding to 30 MeV cyclotron generator. The simulation has used the variation of the thickness materials layers that was applied at treatment room's door. The purpose of the variation and thickness of the material in this simulation to obtain optimum results for the shielding design in the irradiation chamber. The layers that we used are Pb-Fe and Pb-SS312. Simulation on cancer treatment is used with monte carlo simaulation MCNPX. The spesifications that we used for cyclotron is the spesification of the HM-30 Proton Cyclotron from Sumitomo Heavy Industries Ltd. The variation of the thickness materials layers that was applied at treatment room's door are Pb remains 4cm while Fe and SS312 varies between 2 cm, 4 cm, 6 cm respectively. This simulation of Fe layer on Pb was give good result in measurement simulation at 4 cm thickness.

1. Introduction

Radiation in its development has been widely applied in various fields, one of which is in the field of health as in the pilot plant Boron Neutron Capture Therapy (BNCT). BNCT is a method of cancer therapy which is the development of long-established NCT. BNCT is a combination method of chemotherapy and radiotherapy that was first tested in 1951 [1]. Radiation is the emission energy generated by an unstable transformation of atoms or nuclei. Radiation of energy emitted by radiation sources, can cause changes in physical, chemical and biological properties in its path [2]. The spread of radiative energy can occur through materials and spaces in the form of electromagnetic waves or particles. Radiation of charged particles can ionize the material either directly or indirectly because the radiated energy of charged particles exceeds the ionise potential energy material [3 - 5].

It is well known that nuclear reactions are divided into several types depending on the type of bombarded particles. The following reactions may occur: by the action of neutrons n, proton p, deuteron d, heavier particles and α particles, and γ-rays [6]. Photons (energy above some MeV) that can stimulate the nucleus and (γ, n) interactions can cause radiation protection problems. Photonuclear interactions do not depend on dosimetry. The power of photon radiation increases as the plasma is rich in baryon [7]. Photon interacts with the material (as an x-ray beam or gamma radiation that passes through a material) and will be completely absorbed by depositing its energy, it will penetrate the material part without any interaction, or will interact and spread or bend from the original. In this research used lead (Pb) because Pb can hold radiation well and used variation of Ferit (Fe) and 312 of Stainless Stell type (SS312) that coating material because this material is considered easy to have economic value.

2. Material and Methode



(a) (b)

Figure 1. Treatmen room's door materials (a). With SS312 layers, (b). With Fe layers

The design optimization of the collimator simulation corresponds to the 30 MeV cyclotron generator and 1 mA proton current. Simulations have used a variety of layers of thickness materials applied to the treatment room door. The layers we use are Pb-Fe and Pb-SS312. Simulations on cancer treatment are used with the monte carlo version X (MCNPX) simaulation code. Monte Carlo simulation is a very helpful tool for investigating complex radiation fields [8]. The specifications we use for cyclotron are the specifications of HM-30 Proton Cyclotron from Sumitomo Heavy Industries Ltd. The thickness of the thickness material applied to the treatment room door is fixed Pb 4 cm for each segment, this thickness was given better absorb for neutron flux whereas Fe and SS312 vary between 2 cm with the air segmen is 242 cm, 4 cm with the air segmen is 238 cm and 6 cm with the air segmen is 236 cm for each segment layer. The neutron flux and gamma radiation were tallied using F4:n and F4:p, while the dose rate was tallied with the DE and DF tallies.

3. Result and Discusion

Figure 2. discribe the spectrum energy that producd by the simulation with Alumunium (Al) moderator and its can be seen, the neutrons flux that produced by HM-30 almost in epithermal energy range with the maximum energy of 3,8 MeV.

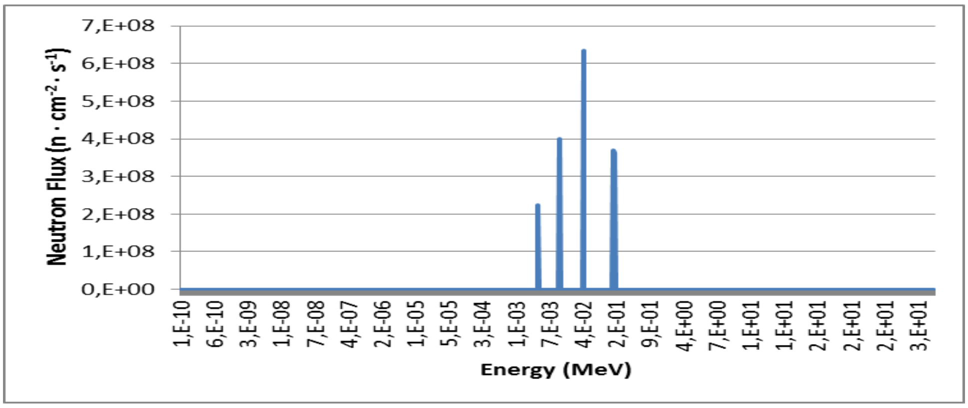
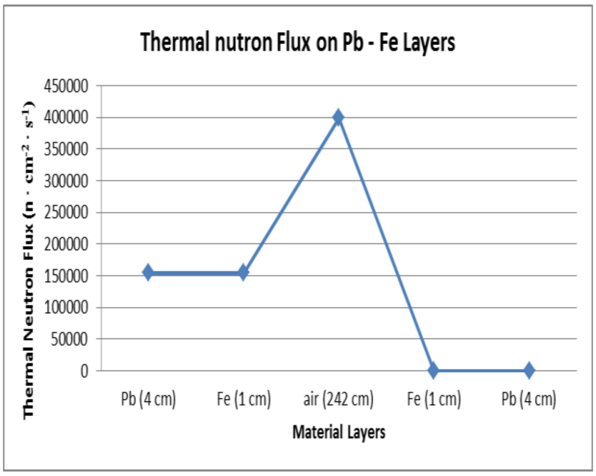
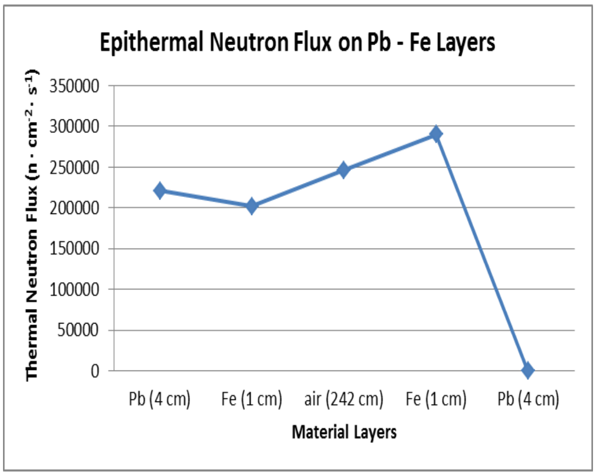


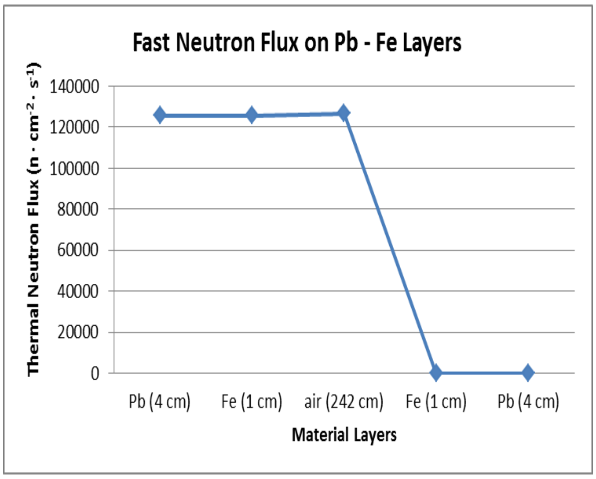
Figure 2. Neutron energy spectrum produced by 1 mA 30 MeV



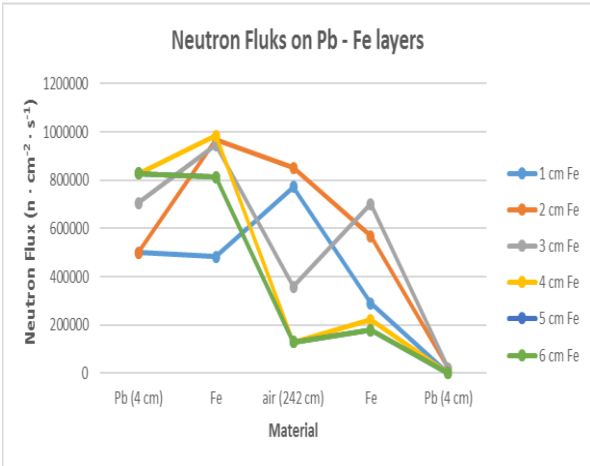
(a)



(b)

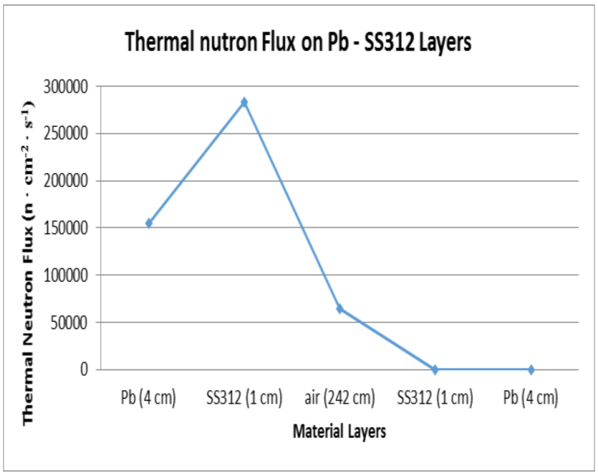


(c)

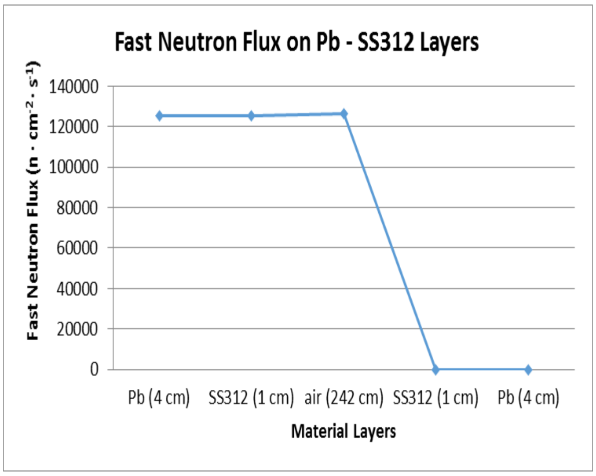


(d)

Figure 3. (a), (b), and (c) Neutron flux on energy range in Pb – Fe material layers, (d) total neutron fluxes on Pb – Fe layers



(a)



(b)

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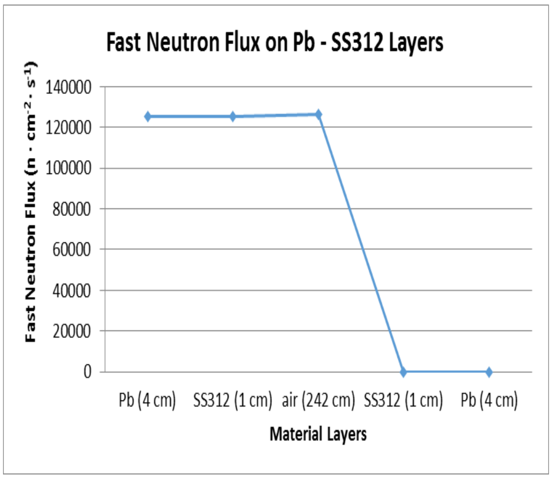
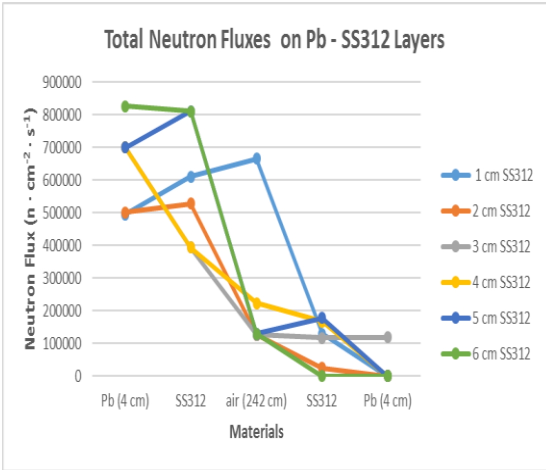


(c)



(d)

Figure 4. (a), (b), and (c) Neutron flux on energy range in Pb – SS312 material layers, (d) total neutron fluxes on Pb – SS312 layers

The Neutron flux passing through the Pb-Fe door averages a significant decrease as it reaches the Pb door in the second segment (Fe-Pb). On the other hand the value of neutron flux that passes from this material is zero.

From the comparison the figure 2 and figure 3, it can be concluded that the SS312 layers can absorb neutrons better than denan using Fe layers. With 4 cm SS321 neutron layer that reaches the second Pb layer has a value of zero while using a 4 cm Fe layer there is still a neutron escaped that is 2.03484 x 10^4 n. cm^{-2} s^{-1}. For neutron flux, which is detected through the majority Pb layer is a slow neutron.

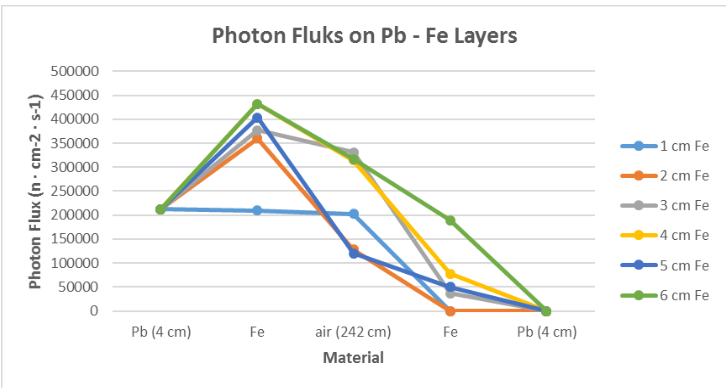


Figure 5. Total photon Flux for Pb – Fe layers with Fe variation of thickness

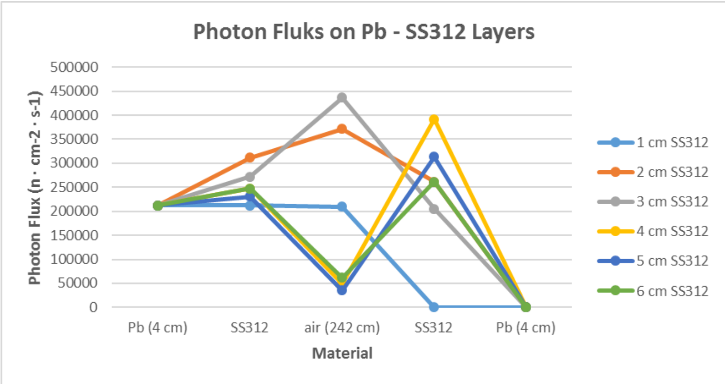


Figure 6. Total photon Flux for Pb – SS312 layers with Fe variation of thickness

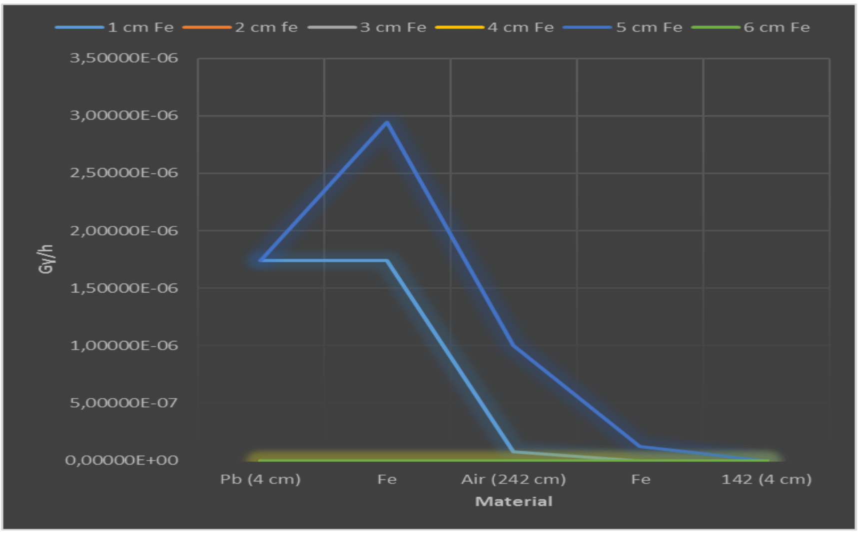


Figure 7. Gamma dose of Pb – Fe layers, for 2,3 and 6 cm Thickness of Fe, the line are looks stacked

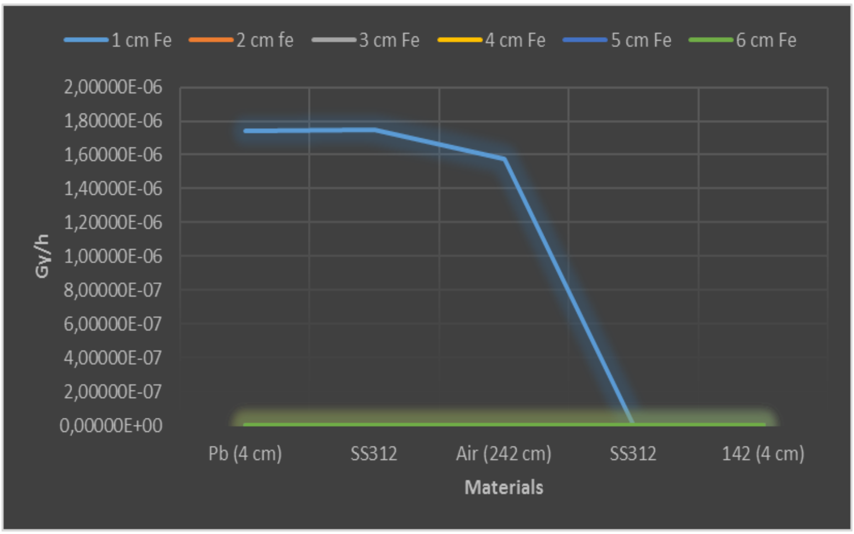


Figure 8. Gamma dose of Pb – Fe layers, for 2 - 6 cm Thickness of Fe, the line are looks stacked

For Photon flux, it can be absorbed on coatings both for SS312 and for Fe, but from the simulation results, the comparison of these two coating materials is best shown by the Fe coating. A review is required for this flux photon. Associated with the gamma dose rate emitted at the time of irradiation, with this coated Pb material obtained, the best value of this simulation is with Fe layer is on the first layer of Pb (6 cm of Fe) is 5,12862 x 10^{-22} Gy/h and on the second layer of Fe is 3,40739 x 10^{-22} Gy/h, while the gamma dose rate on the second of Pb layers is zero. However, it is necessary to re-examine gamma absorbing doses that escape from other shielding parts such as concrete walls and gamma filters in the moderator section to reduce the risk for radiation workers outside the room.

4. Conclusion

From this simulation that has been done can be concluded that the layer material Pb door treatment room obtained that Fe coated Pb has been able to reduce neutron flux and photon flux. However, for gamma-rate doses emitted in the therapy room it is necessary to review again even if the gamma dose can also be absorbed so that no gamma escapes. Then the use of Fe to coat Pb can be applied.

Acknowledgments
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