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simulation of neutron and proton particles collision with various targets in the plasma focus device for production the Fertilizer radioisotopes

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ABSTRACT: In this study, Uncharged particles (neutrons) and charged (protons) is used to Collision with cube made of N, Xe, C and B in a plasma focus device in order to the production radioisotopes such as ^{14}C, ^{15}O, ^{18}F and $^{123124}I$. This radioisotopes have short half time. With the development of nuclear technology (in different countries), the use of isotopic tracers has a special place in agricultural sciences. In this study with MCNPX code and GEANT4 , the particle flux & Cross section Collision of neutrons and protons in plasma focus device is simulated. The particle energy in the input of the program is 1MeV to 10MeV. The results in this study shows, The particle flux in these increases but it is not linear because of differences in absorption and resonance cross sections. After the energy of MeV10, this slope is almost constant due to the constant cross section.

***Keywords*:** Plasma focus, Radio Isotope, Deposit Energy, Flux, MCNPX2.7, GEANT4

INTRODUCTION

It should be noted that the physical properties of the nucleus of radioactive elements determine their value as a sample trace. Three major characteristics [half-life, type of radiation, decay energy] make it possible to select the type of tracer. Short half-life radioisotopes are radioisotopes that have a half-life of about a few seconds, a few minutes, or several hours, For this reason, these radioisotopes should be consume at the production place. Preceding studies conducted in the Radioisotope Production of plasma focus devices have shown that most of these research activities will be summarized on a production of short half-life radioisotopes of nuclear fusion.[1] The production of radioisotopes, radio nuclides, and radio drugs and their various compounds for the use of nuclear medicine is an essential part of nuclear activity. In this study the production of radio isotopes by the particles in plasma focus device As an accelerator is simulated by GEANT4 codes and MCNPX.

Description

In this study, geometrical dimensions of the problem and characteristics of the interacting particles are defined. Then It was simulated with MCNPX and GEANT codes.

The particle Source (Neutron & proton) in this study to simulation the amount of radiation for the production of medical radioisotopes such as 11C, 15O, 18F and 123124I in a focal plasma device, has designed in a disk with 4 cm radius, The energy of these particles is considered

1 MeV to 10 MeV also Source is located 10 cm from the target cube.[2]

In this research, according Figure 1-1 a cubic with 15 × 15 cm^2 and 7 mm thick Dimensions is considered as target. At first this cube made of nitrogen and then replaced with xe, c and B. Outside this cube, a sphere with radius 30 cm with air is placed [3,4].

This research is simulation by Geant 4 too and showed in figure 2-1.

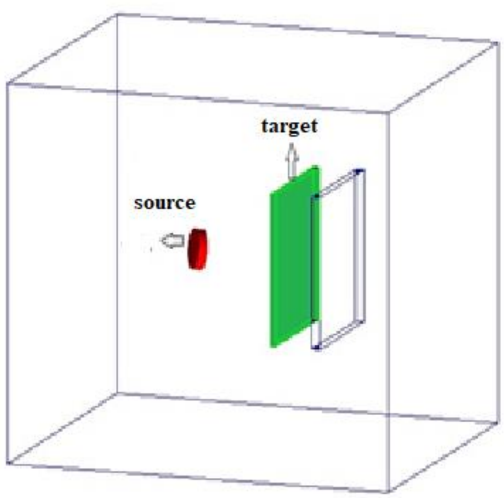

figure-1-2- Cube target shape simulated by Geant4 code

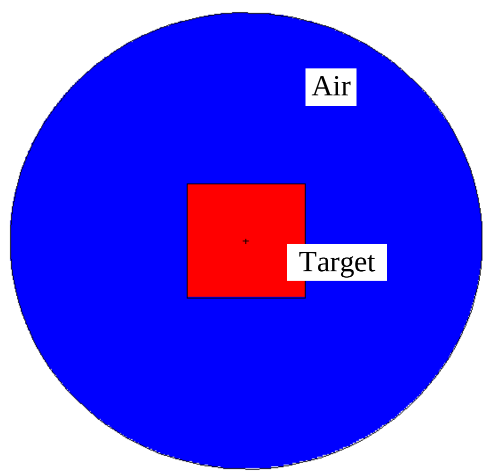

figure -1-1 - Cube target shape simulated by MCNPX code

Figure 1. simulated by the MCNPX code for producing radioisotopes in a plasma focus device.

Figure 2. Shows the simulation of the path of the particles are produced in the plasma focus device.

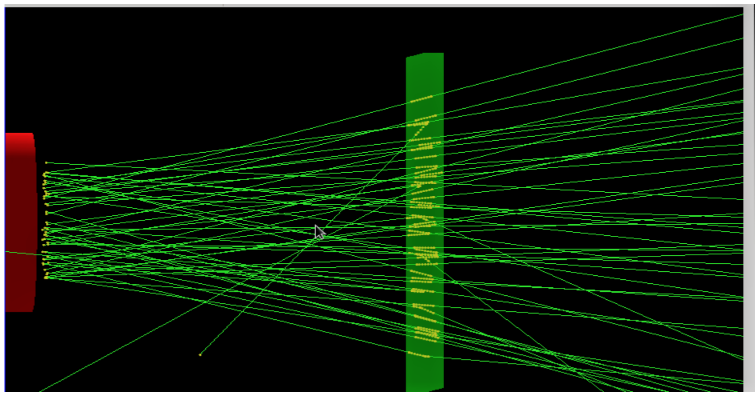

Figure 2. Simulation pass particles generated in plasma focus devices

Figure 2 shows that the particles are absorbed, reflected or passed

In this study, cross-section of solid target based on the energy source of neutrons and protons were examined.

Figure 3 shows the cross-sections of neutron interaction with a nitrogen target. As shown in this figure, in less energies than 1MeV , the total cross-sectional values and elastic dispersion are high.

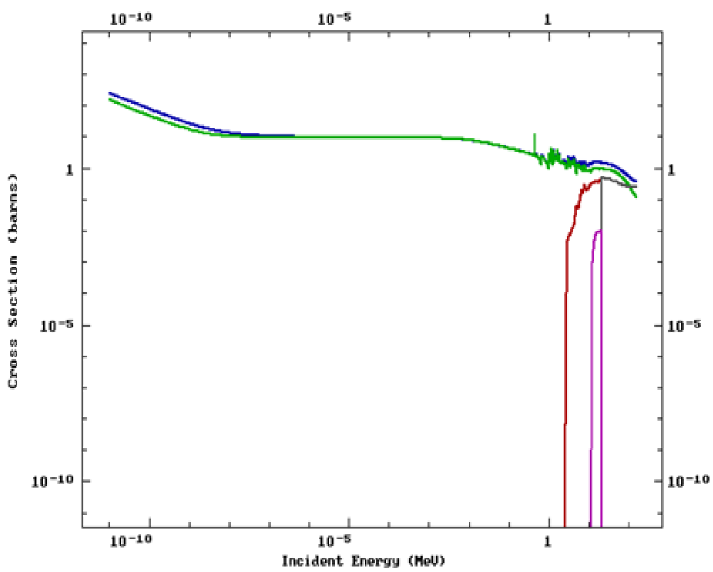

Figure 3. The cross section of the interaction of neutrons with the nitrogen target in terms of energy include: cross section (blue), scattering cross section of elastic (green), scattering cross sections, inelastic (red), absorption cross section (gray) and cross-section of capture (n, 2n)

Figure 4 also shows the cross-sectional area of the interaction of the proton with the nitrogen target. The shape shows that the cross-sectional amount of all proton energy is less than one baron.

The maximum cross-sectional area is in MeV 20, which is about 0.6 bar. After this energy, the cross-sectional area decreases.

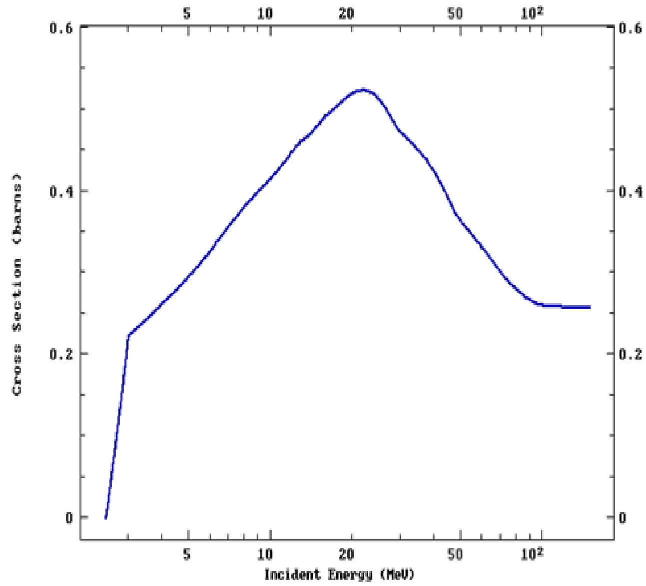

Figure 4. Proton interaction cross-section with a nitrogen target in terms of energy

The cross-section of the interaction between neutrons and protons with a target of xe, c and B were showed in figures 5,6,7,8 ,9& 10.

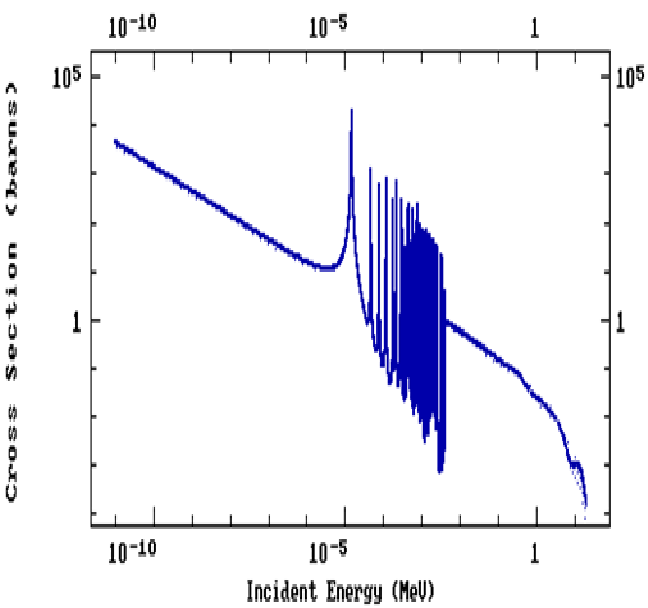

Figure 6. Proton interaction cross-section with a xe target in terms of energy

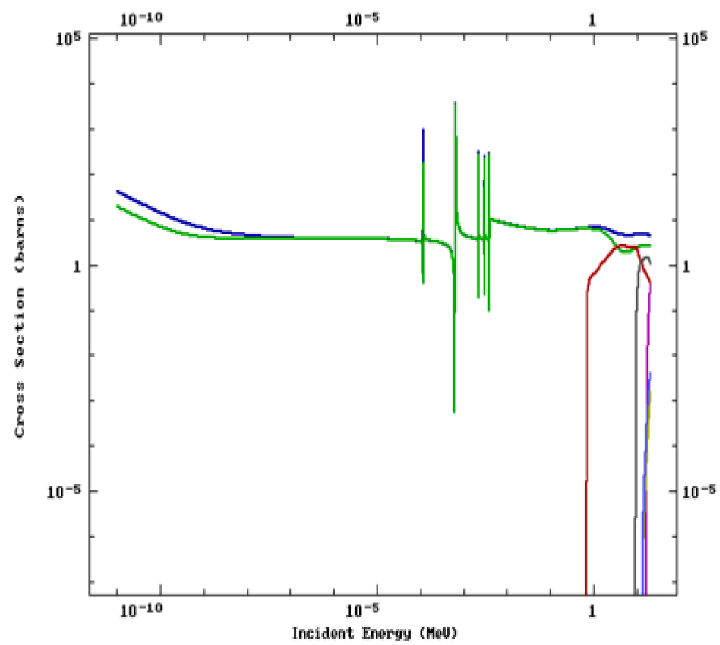

Figure 5. The cross section of the interaction of neutrons with the xe target in terms of energy include: cross section (blue), scattering cross section of elastic (green), scattering cross sections, inelastic (red), the cross section of capture (n, 2n) (gray), cross-trap (n, 3n) (violet), proton (n, p) (blue) and cross-sectional alpha (n, a) (olive)

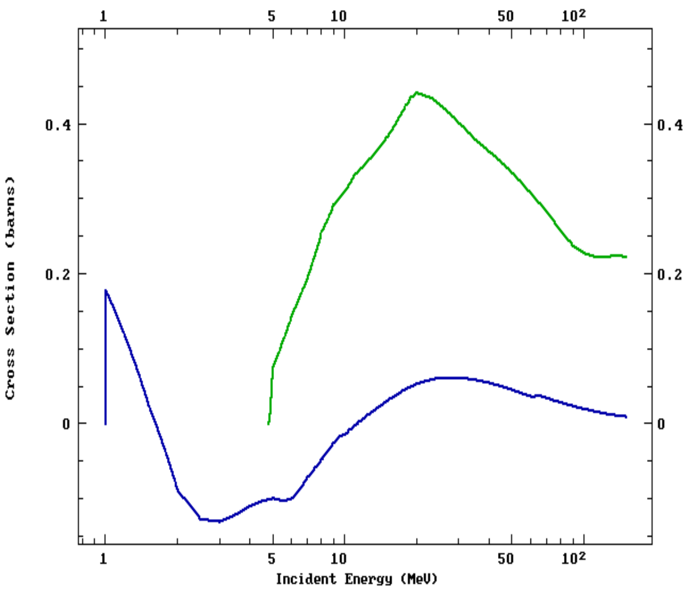

Figure 8. Proton interaction cross-section with a c target in terms of energy

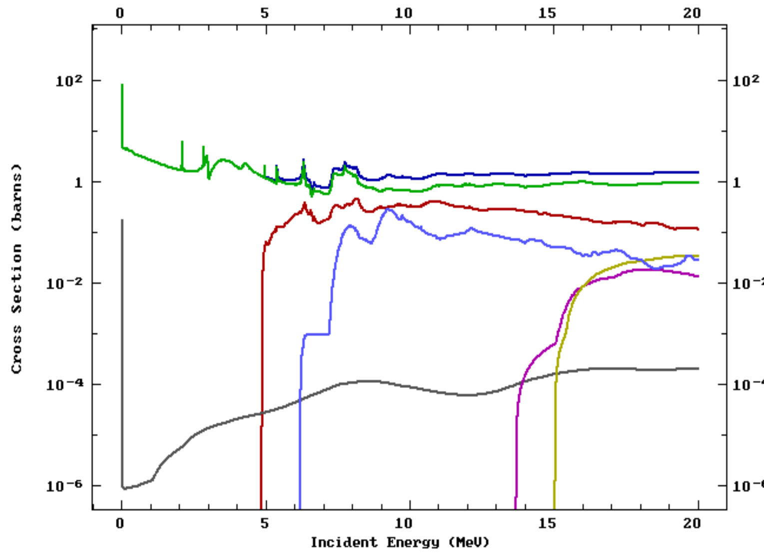

Figure 7. The cross section of the interaction of neutrons with the c target in terms of energy include: cross section (blue), scattering cross section of elastic (green), scattering cross sections, inelastic (red), the cross section of capture (n, 2n) (gray), cross-trap (n, 3n) (violet), proton (n, p) (blue) and cross-sectional alpha (n, a) (olive)

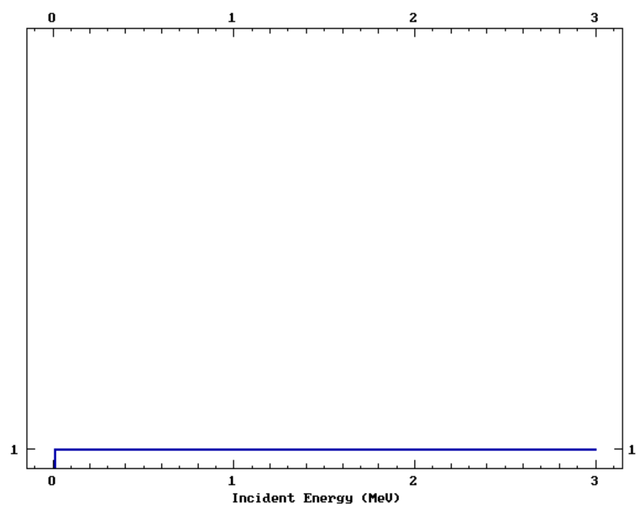

Figure 10- Proton interaction cross-section with a B target in terms of energy

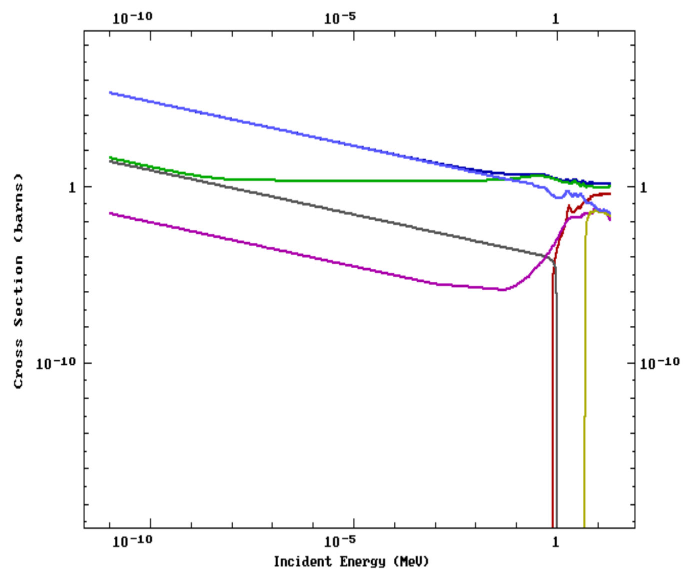

Figure 9. The cross section of the interaction of neutrons with the B target in terms of energy include: cross section (blue), scattering cross section of elastic (green), scattering cross sections, inelastic (red), the cross section of capture (n, 2n) (gray), cross-trap (n, 3n) (violet), proton (n, p) (blue) and cross-sectional alpha (n, a) (olive)

Calculate the particle flux of neutrons and protons that ejected from the target, in energy terms:

In this research, first, the collision of neutron with solid with energies from 1 MeV to 14MeV in order to calculate flux particles, is simulated.

Then, in the next step, the proton source with the same, but with energies from 3MeV to 10MeV, is repeated to calculate the mentioned parameter. [5,6]

The results obtained from the comparison of this two codes are shown below.

Figures 11 and 12 show that with increasing energy of neutrons in these , the amount of gradient flux of neutrons is fixed due to neutron Unwanted Exitat high energies in the of B and xe.

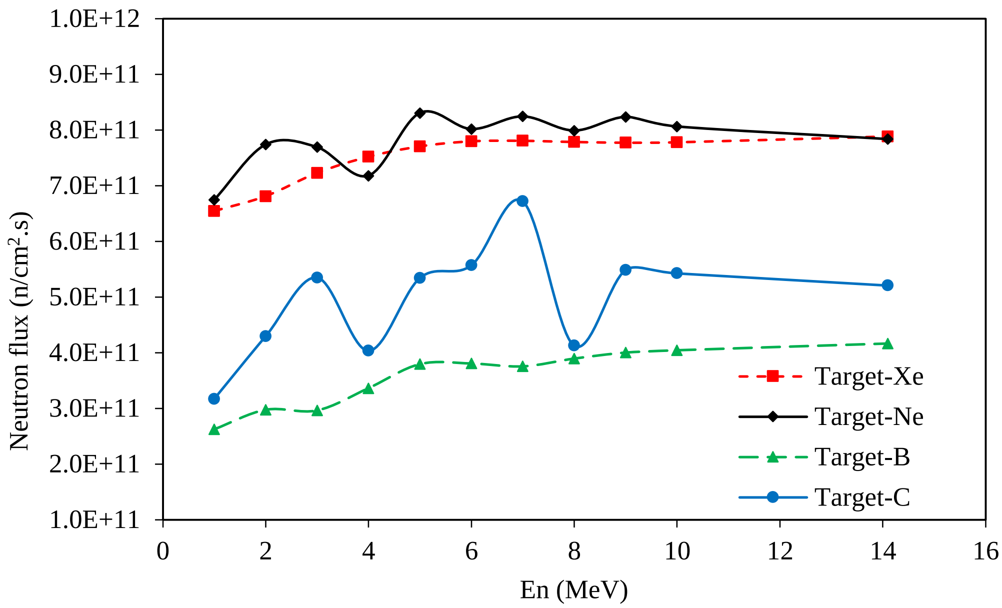

Figure 11. The values of the neutron flux emitted from the solid cube of nitrogen, zeinan, carbon and boron for the neutron source in terms of energy with MCNPX code

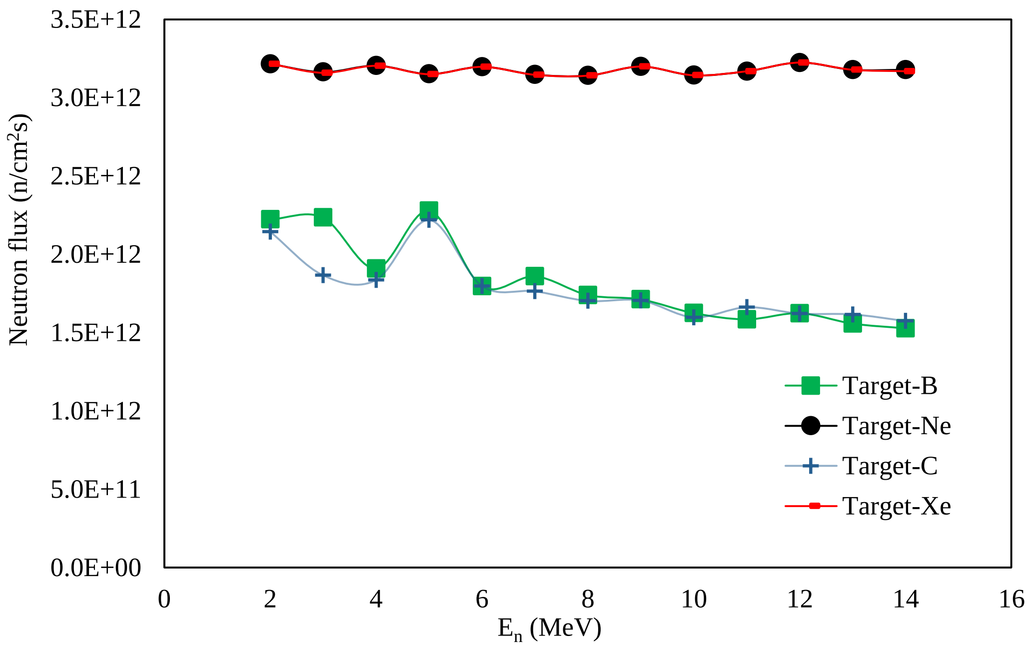

Figure12. The values of the neutron flux emitted from the solid cube of nitrogen, zeinan, carbon and boron for the neutron source in terms of energy with Geant4 code

In this study, the flux quantities of proton excreted from these for the proton source are calculated in terms of energy, as shown in Figures 13 and 14. These figures show that with increasing energy of protons, the flux of protons increases.[7,8]

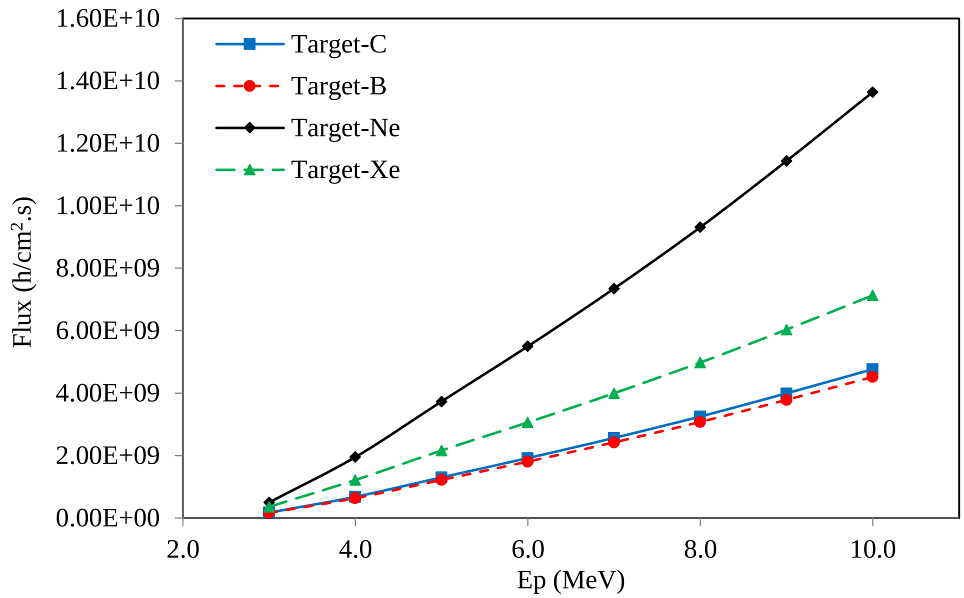

Figure 13. The values of the proton flux emitted from the solid cube of nitrogen, zeinan, carbon and boron for the proton source in terms of energy with MCNPX code

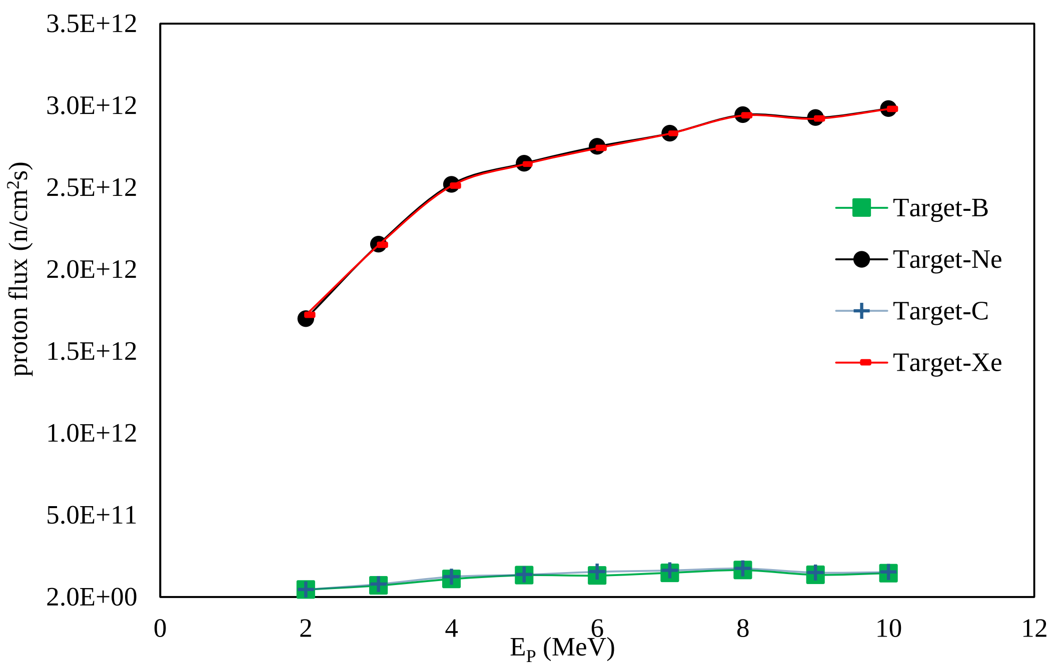

Figure 14. The values of the proton flux emitted from the solid cube of nitrogen, zeinan, carbon and boron for the proton source in terms of energy with Geant4 code

Calculation of activity

Amount of radiation of an element is called activity, which means the decay rate of an element in one second from a radioactive nucleus sample.

If the produced isotope has a low half-life, then in the process of production, a considerable amount of them will have production and destruction. Figure 15

$A=R\lambda\ (1-e^{-\lambda t})$ (1)

t is the time and λ, the probability of collision in barren, A is equal to activity, R is the radioactive nuclei per second.

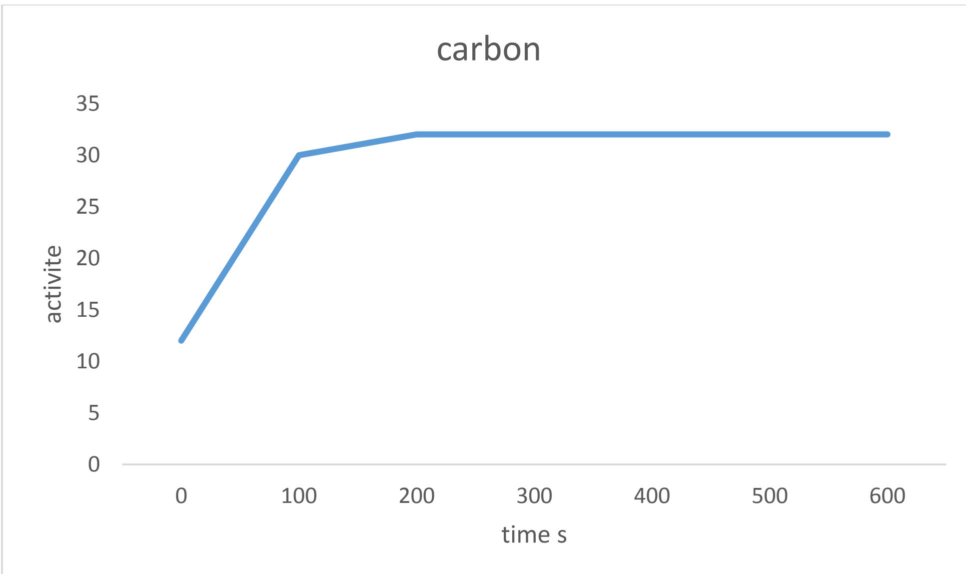

Figure 15. Carbon activity in terms of passed time

Conclusion

1. The neutron collision cross-section with radioisotopes in a plasma focus device is simulated.

2. Parameters of Flux for neutron and proton are calculated and compared with using the two MCNPX and GEANT codes for research applications in the plasma focus device.

For example Figures 15 and 16 compare the results of flux of neutrons and protons passed from nitrogen target with both GEANT & MCNPX code. Maximum energy of neutron is considered 14 MeV.

Figure 16 shows that with increasing neutron energy, at first the neutron flux gradient had different absorption and resonance because of difference in cross sections for this material that showed in figure 3,5,7& 9. But then it increases with a constant amount.

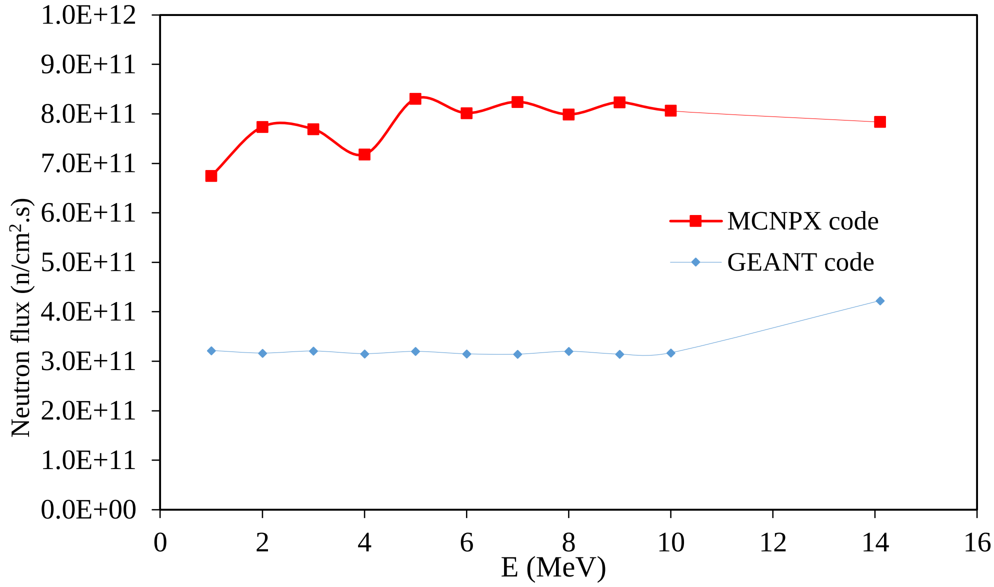

Figure 16. Comparison of spectrum of neutron flux exits from the cubic nitrogen target for the neutron source in terms of energy by MCNPX and GEANT codes

Figure 17 also shows that with increasing energy of protons in this target, the flux of protons increases linearly. As we know, with increasing proton energy, its flux increases.

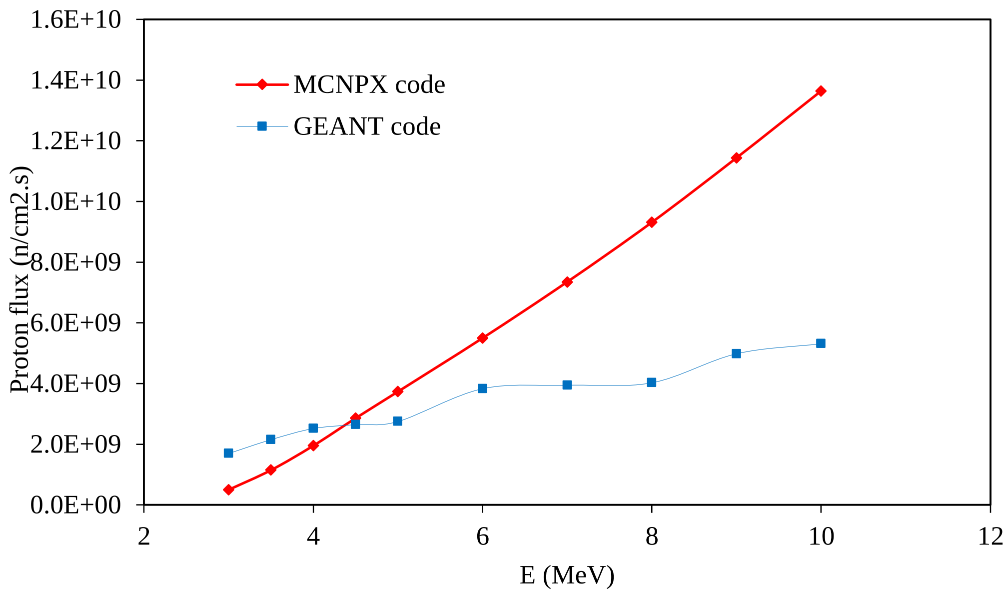

Figure 17. Comparison of spectrum of proton flux exits from the cubic nitrogen target for the proton source in terms of energy by MCNPX and GEANT codes

3- For example, Radioactive of carbon that is produced in the plasma focus devices is shown in figure 15.

4- If the half-life is too short build tracer compounds labeled with the problem and also due to time constraints it is difficult to measure decay But physical risks in using the isotope with a short half-life time is less

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