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Estimation of bremsstrahlung photon fluence from aluminum by artificial neural network

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Background: As bremsstrahlung photon beam fluence is important parameter to be known in a photonuclear reaction experiment as the number of produced particle is strongly depends on photon fluence. ***Materials and Methods:*** Photon production yield from different thickness of aluminum target has been estimated using artificial neural network (ANN) model. Target thickness and incoming electron energy has been used as input in ANN model and the photon fluence was output. ***Results:*** The results were estimated using ANN model for three different thickness and compared with the results obtained by EGS (Electron Gamma Shower) simulation. ***Conclusion:*** It can be concluded from this work that the bremsstrahlung photon fluence can be obtained using ANN model. **Iran. J. Radiat. Res., 2012; 10(1): 63-65**

Keywords: *ANN, EGS, photon fluence.*

INTRODUCTION

Nuclear structure is still one of the main research area of physics even its hundreds year old of its history. It can be investigated by several ways including nuclear reactions. The photon is one best probe to be used in nuclear reactions as it can be described by Quantum electro dynamic (QED) which is well known theory in physics. The photon can be obtained in different way including bremsstrahlung processes. De-accelerating an electron beam through an electric medium can produce photon beam called as bremsstrahlung (breaking radiation). The obtained bremsstrahlung photon beam fluence depends on incoming electron beam energy, target thickness and also type of target materials (1). In order to choose material type and thickness, the photon beam fluence would be estimated. A number of codes such as FLUKA or EGS can be used for these purposes. In this paper, the bremsstrahlung photon yield from Aluminum target in different thickness has been estimated by ANN model.

MATERIALS AND METHODS

Artificial neural network (ANN) has been used to estimate photon fluence from three different Aluminum targets. Artificial neural network (ANN) is a simple model and similar to the human brain. It has some powerful characteristics in information processing. The ANN were proposed in 1943 for the first time and it started to be used in a variety of different fields since than. Development of computer technology in recent year has made ANN model popular. The inputs and outputs are considered as information processing systems that have the abilities to learn, recall and generalize from training data. An ANN consists of several layers of a large of highly interconnected computational units. Each of those units is called neurons. In figure 1 the general structure of a three-layer feed-forward ANN is shown. The neural network contains one input layer, one or more hidden layers, and one output layer. Process parameters that are normalized in the interval of [0, 1] are fed to the nodes of the input layer. As shown in figure1 target thickness and incoming electron beam energy is inputs in this study and fluence was the obtained output. The results used as input parameter were obtained by EGS

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calculation. The EGS calculates photon fluence as a function of incoming electron energy, target thickness.

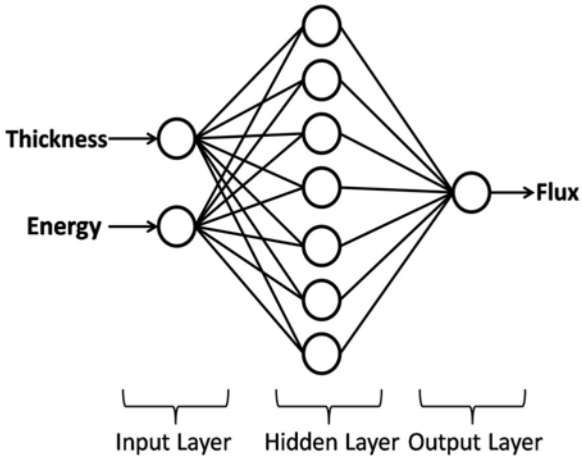

Figure 1. A neural network structure shows three-layer.

The number of nodes in the input layer equals the number of parameters in the process. The output layer represents the quality responses of the product. The hidden layer represents the interactions between the input and output layers [(2)]. Multi-layered sensor networks operates according to trained learning strategy. The ANN model consists of two steps: the first step is to train the network; the second step is to test the network with data, which were not used in training step. Neural networks have been trained to perform complex functions in various fields of application including pattern recognition, identification, classification, speech, vision, and control systems [(2, 3)]. The network needs a set called training set is determined both the inputs and the outputs, and occurred from samples. Learning rule used is to reduce minimum the difference between produced outputs during training of the network and needed to produce outputs by distributing the weights. During learning, firstly inputs are presented to network and the corresponding outputs for these inputs are produced and then, the expected output is compared with the output produced and the weights are changed by distributing backward error between them.

RESULTS AND DISCUSSION

The photon fluence from Al target in different thickness has been estimated using developed ANN model. The end point electron energy impinges into the Al target is 15 MeV. The photon fluence was obtained using ANN model for 0.1 cm Al target and displayed in figure 2 where it has been compared with the photon fluence obtained using EGS code. In figures 3 and 4 the photon fluence obtained using ANN is displayed as a function of bremsstrahlung photon energy for 0.2 and 0.3 cm thickness have been displayed respectively. It can be seen from those figures that the photon fluence vary with the incoming electron (thus created photon) energy and it is stopped at end point energy which is 15 MeV in this case. In same figures the obtained results were compared with the photon fluence obtained by using EGS computer code. It can be seen from those figures that the photon fluence obtained by ANN and EGS are in good agreement. It is also clear from those figures that the end point energy of created bremsstrahlung photon is 15 MeV. It can also clearly be seen in those figures that a good correlation has been obtained between predicted results by ANN and calculated results by EGS. This agreement can also be seen in the correlation between the results of EGS and ANN. This is displayed in figure 5 where R^2=0.99 has been obtained. The variation of photon fluence as a function of target thickness has been obtained for three different incoming electron energies of 3, 8 and 13 MeV. This is displayed in figure 6 where it can be seen that the photon fluence increases with the increasing target thickness for all energies. On the other hand the sharpness of the increasing is related non-linear with the incoming electron energies.

It can be concluded from this figure that bremsstrahlung photon yield can be estimated using developed models of ANN.

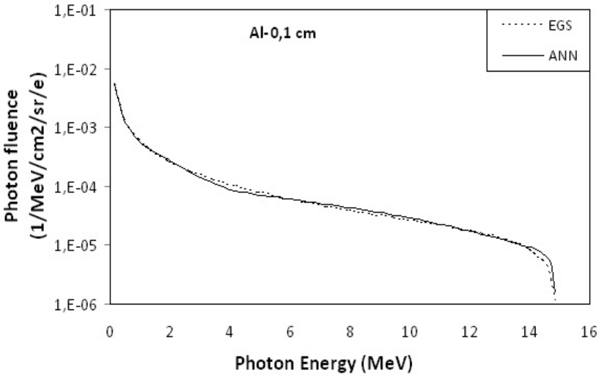

Figure 2. Photon fluence estimated by ANN for 0.1 cm Al target and comparison with the EGS results.

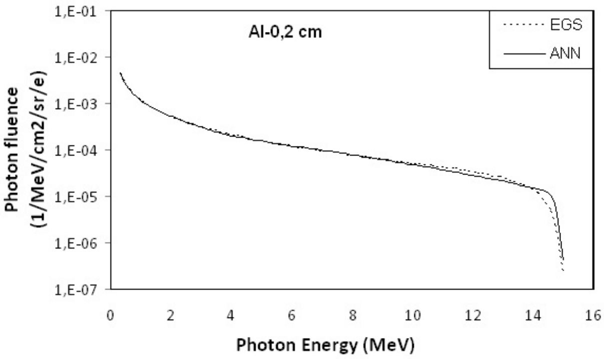

Figure 3. Photon fluence estimated by ANN for 0.2 cm Al target and comparison with the EGS results.

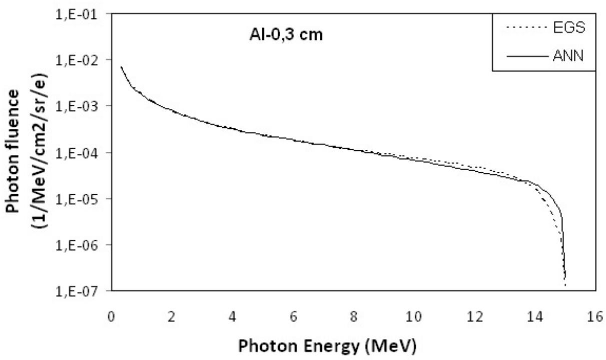

Figure 4. Photon fluence estimated by ANN for 0.3 cm Al target and comparison with the EGS results.

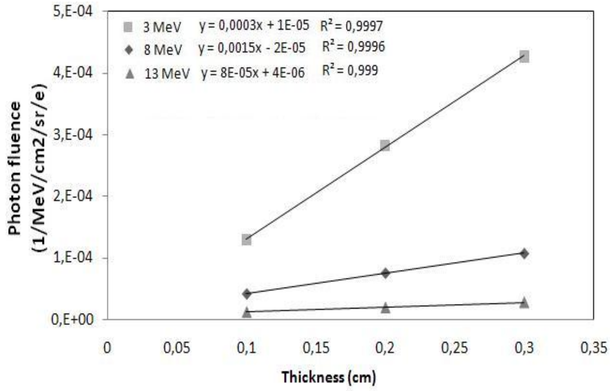

Figure 6. Variation of photon fluence as a function of target thickness.

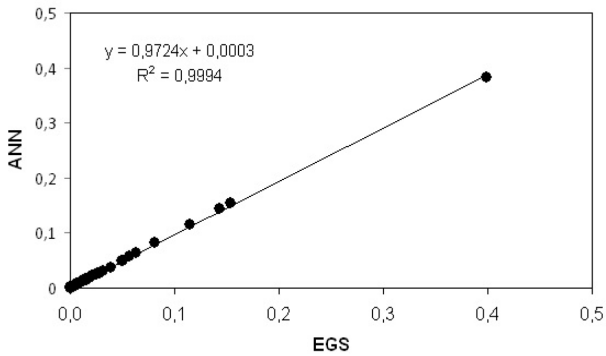

Figure 5. Correlation between ANN model and EGS.

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