

# Calculation of the photon pair production cross section by artificial neural network

Aydin Ghalehasadi  
*University of Tabriz*

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# ABSTRACT

Photon pair production is the most likely photon interaction at high energies. Many efforts have been performed in pair production cross section calculation. Artificial neural networks have emerged with successful applications in nuclear physics as well as in many fields of science in recent years. In this paper, the artificial neural network was used to calculate photon pair production cross section. Multilayer perceptron feedforward artificial neural network model was used to fitting the reference values for pair production cross section. Results show a good agreement with the experimental values. Also, other statistical tests were examined to show the accuracy of the proposed method.

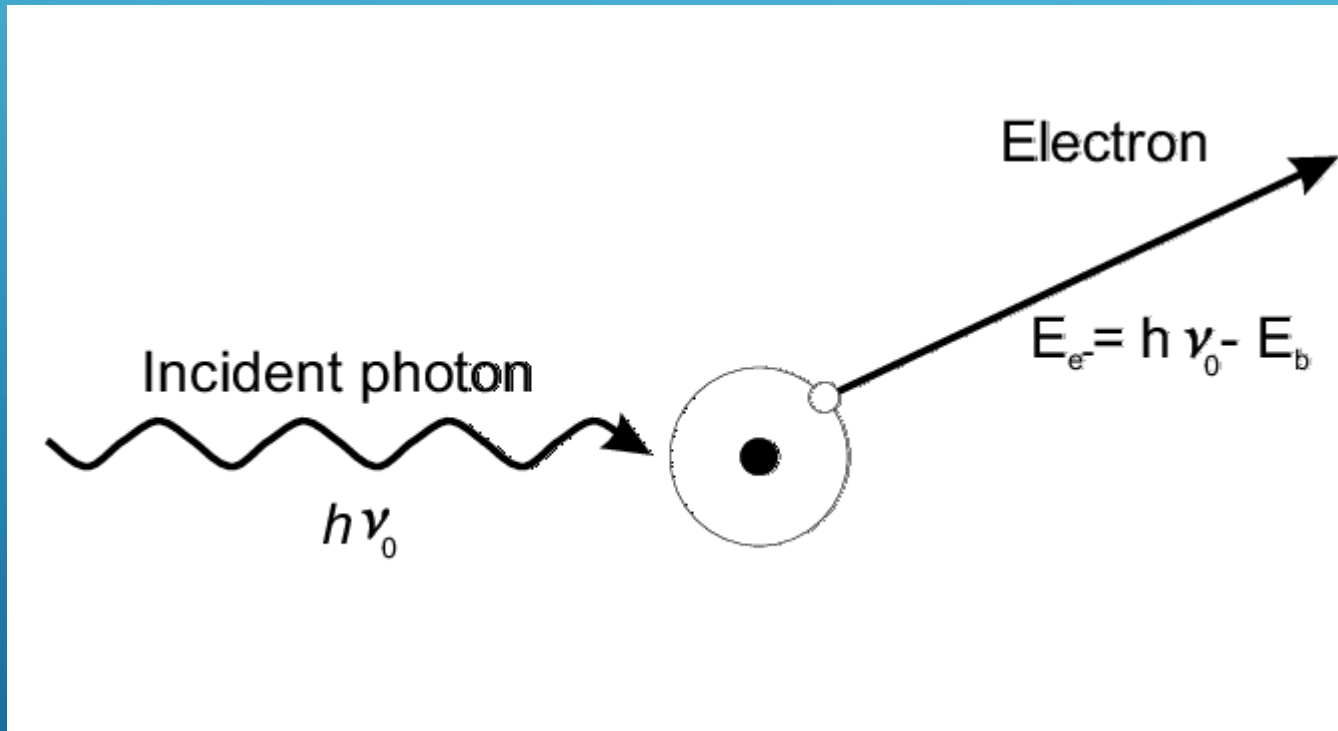
# PHOTON INTERACTIONS WITH MATTER

*a) Photoelectric absorption*

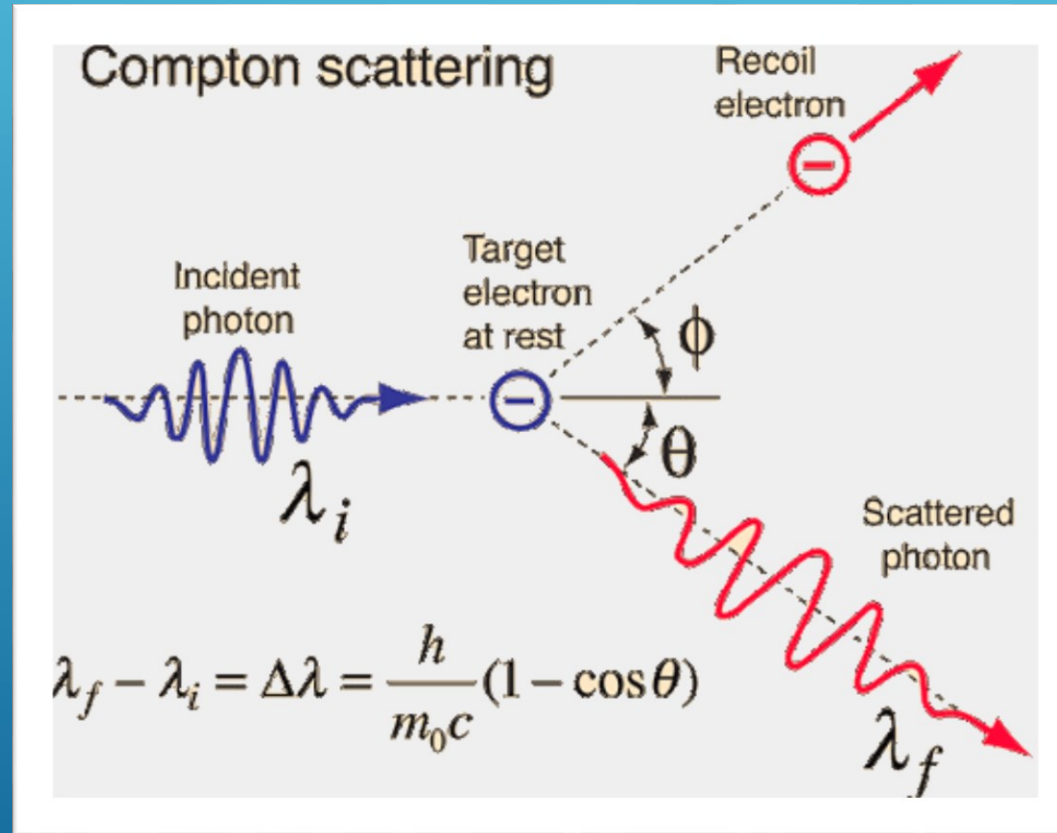
*b) Compton scattering*

*c) Pair production*

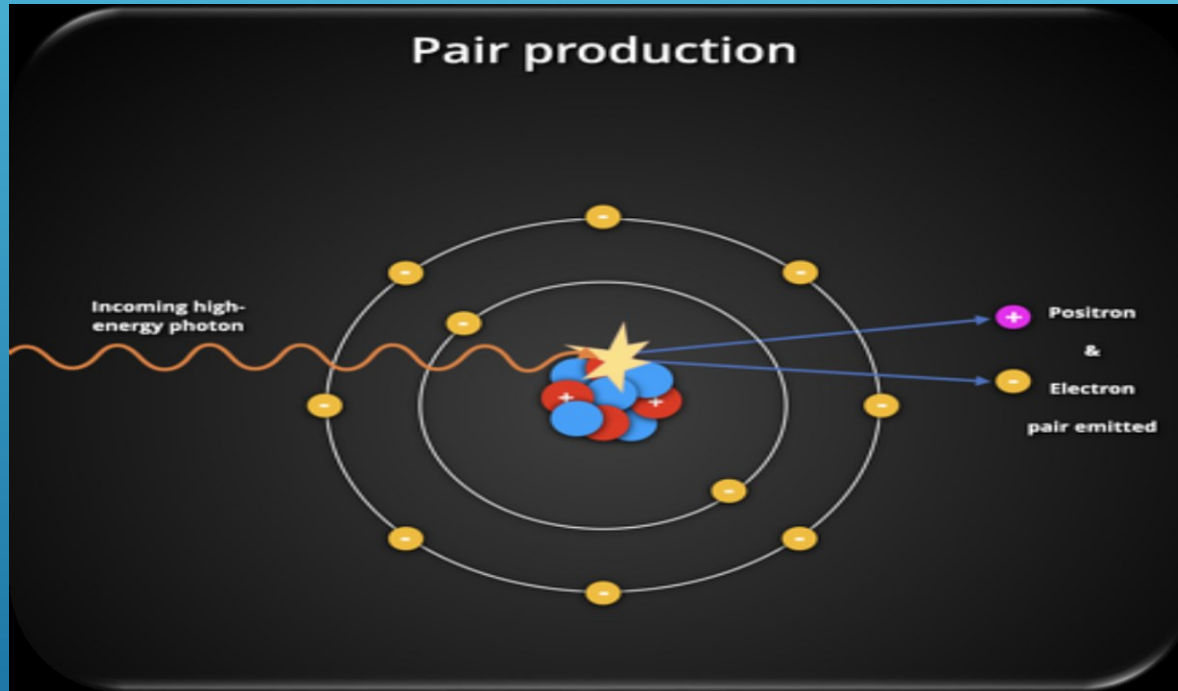
# PHOTOELECTRIC ABSORPTION

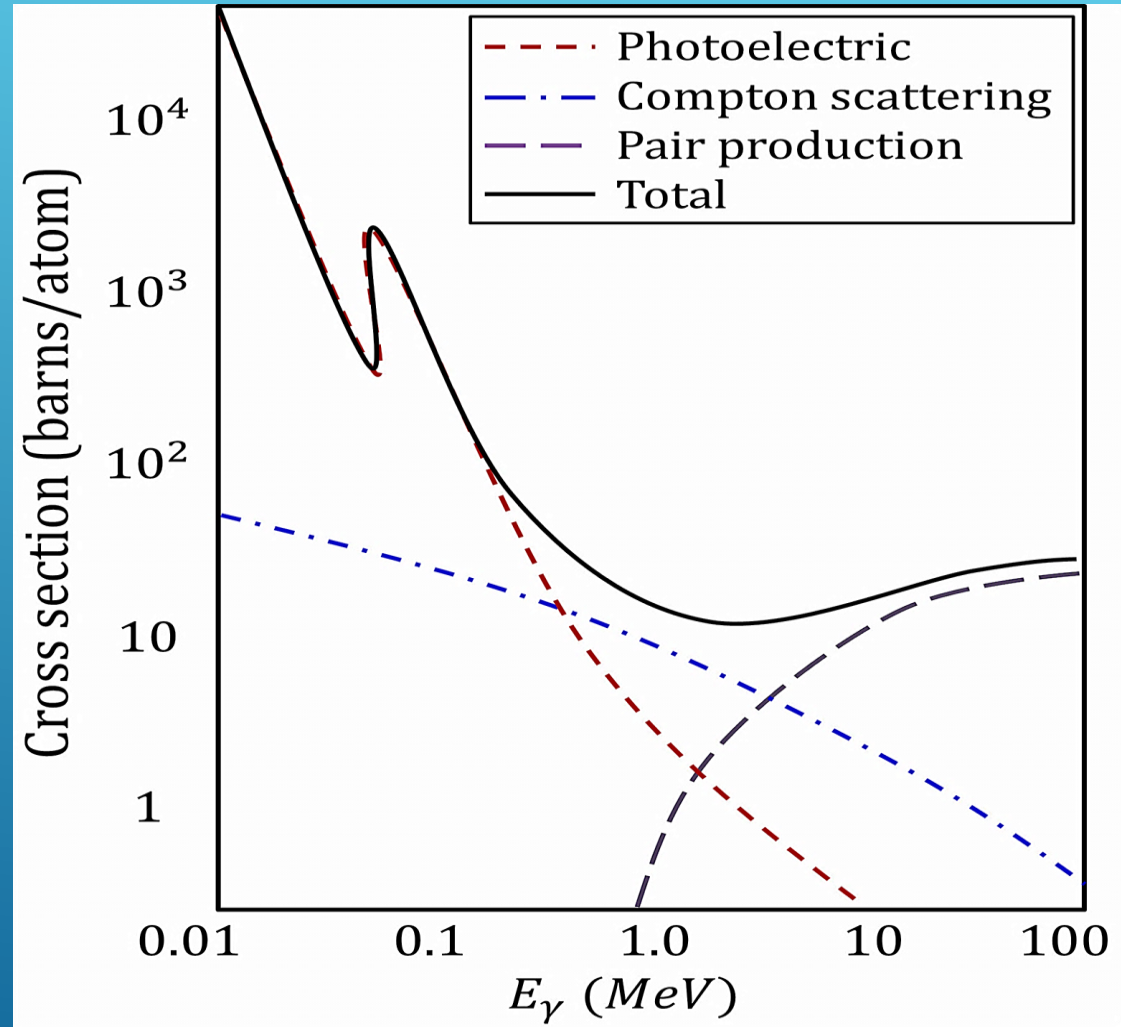


# COMPTON SCATTERING



# PAIR PRODUCTION









# PAIR PRODUCTION

In this interaction a gamma photon disappears in the presence of a nucleus and an electron-positron pair is created. To create the pair, energy of photon should be at least 1.022MeV. The pair production cross section depends on the energy of photon and atomic number of the matter . For the photon energies in the range of several Mev it can be written in the form as:

$$\sigma_{pp} = \frac{4Z^2 r_e^2}{137} \left( \frac{7}{9} \ln\left(\frac{2E_\gamma}{0.511}\right) - \frac{109}{54} \right)$$

where Z is the atomic number and  $r_e$  is the classical electron radius ( $r_e^2 = 0.079$  barn). According to equation the cross section of the pair production interaction increases logarithmically with gamma-ray energy, so that at high energies the cross section for this process is much greater than that of photoelectric and Compton scattering interactions.

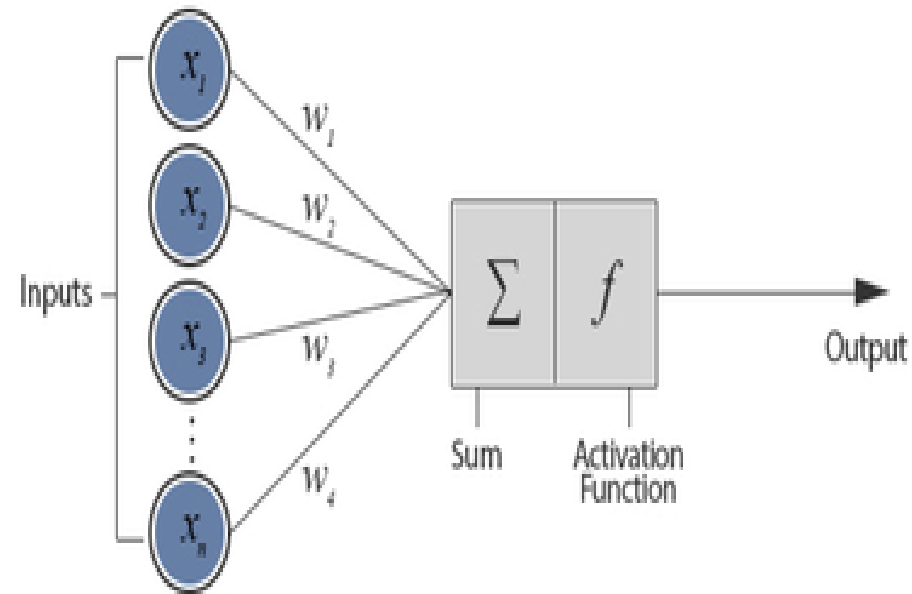
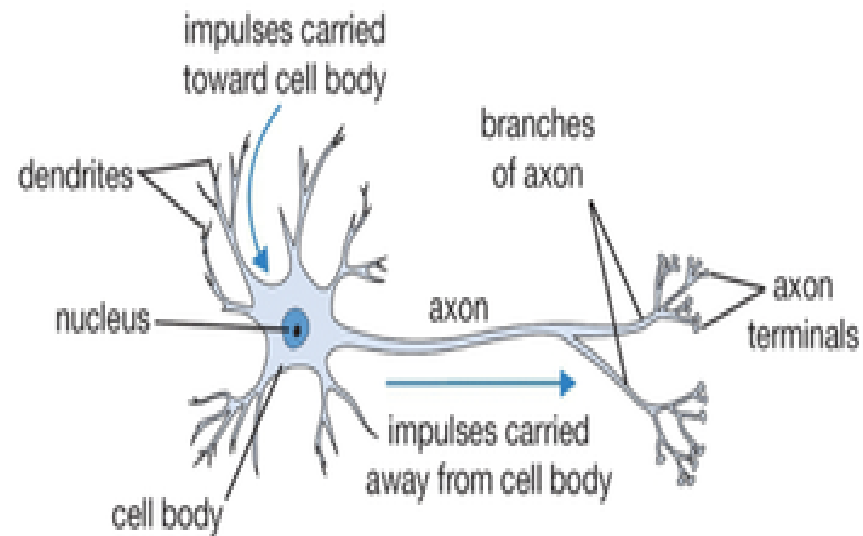


Considering the importance of silicon element in the fabrication of high energy photon detectors, careful determination of the pair production cross section for this element is necessary.



# ARTIFICIAL NEURAL NETWORK

## Biological Neuron versus Artificial Neural Network

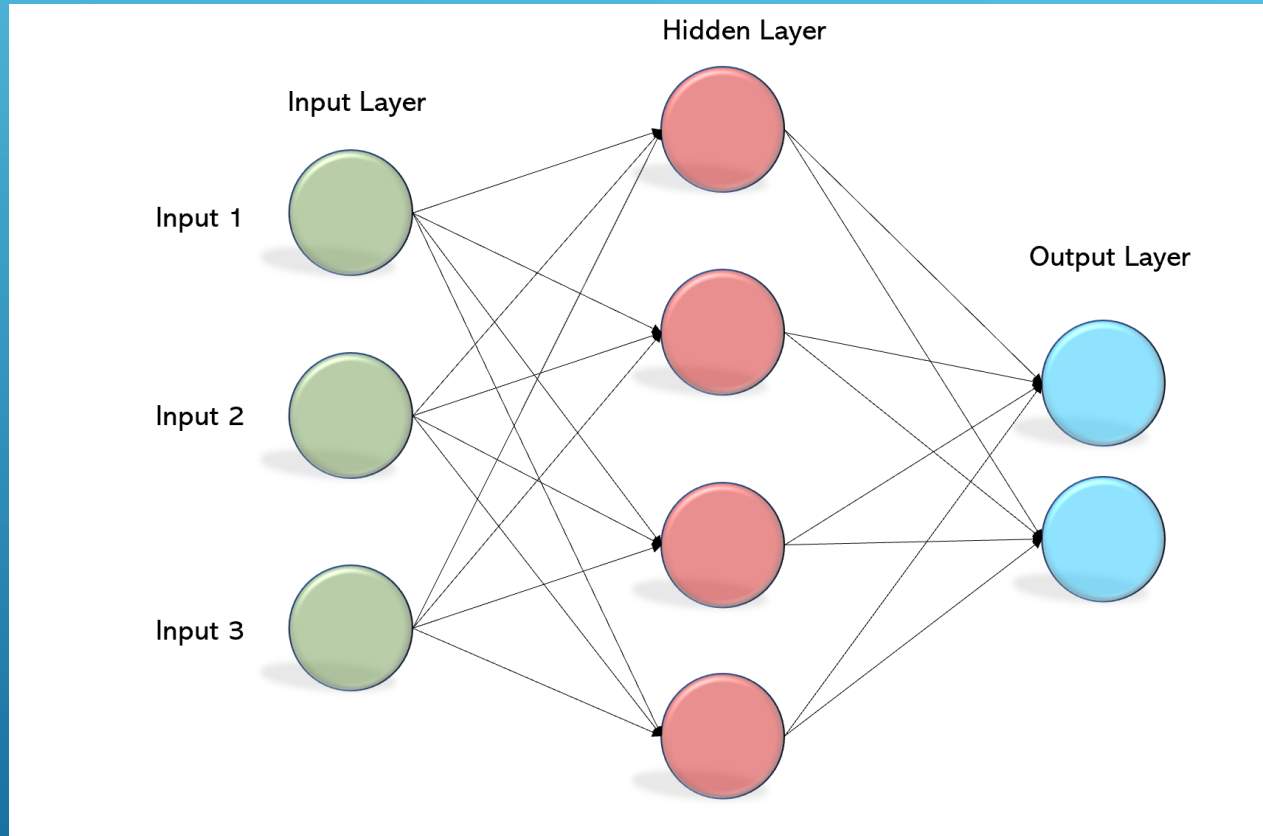




# ARTIFICIAL NEURAL NETWORK

Traditionally neural network was used to refer as network or circuit of biological neurones, but modern usage of the term often refers to ANN. ANN is mathematical model or computational model, an information processing paradigm i.e. inspired by the way biological nervous system, such as brain information system. ANN is made up of interconnecting artificial neurones which are programmed like to mimic the properties of biological neurons. These neurons working in unison to solve specific problems. ANN is configured for solving artificial intelligence problems without creating a model of real biological system. ANN is used for speech recognition, image analysis, adaptive control etc. These applications are done through a learning process, like learning in biological system, which involves the adjustment between neurones through synaptic connection. Same happen in the ANN.

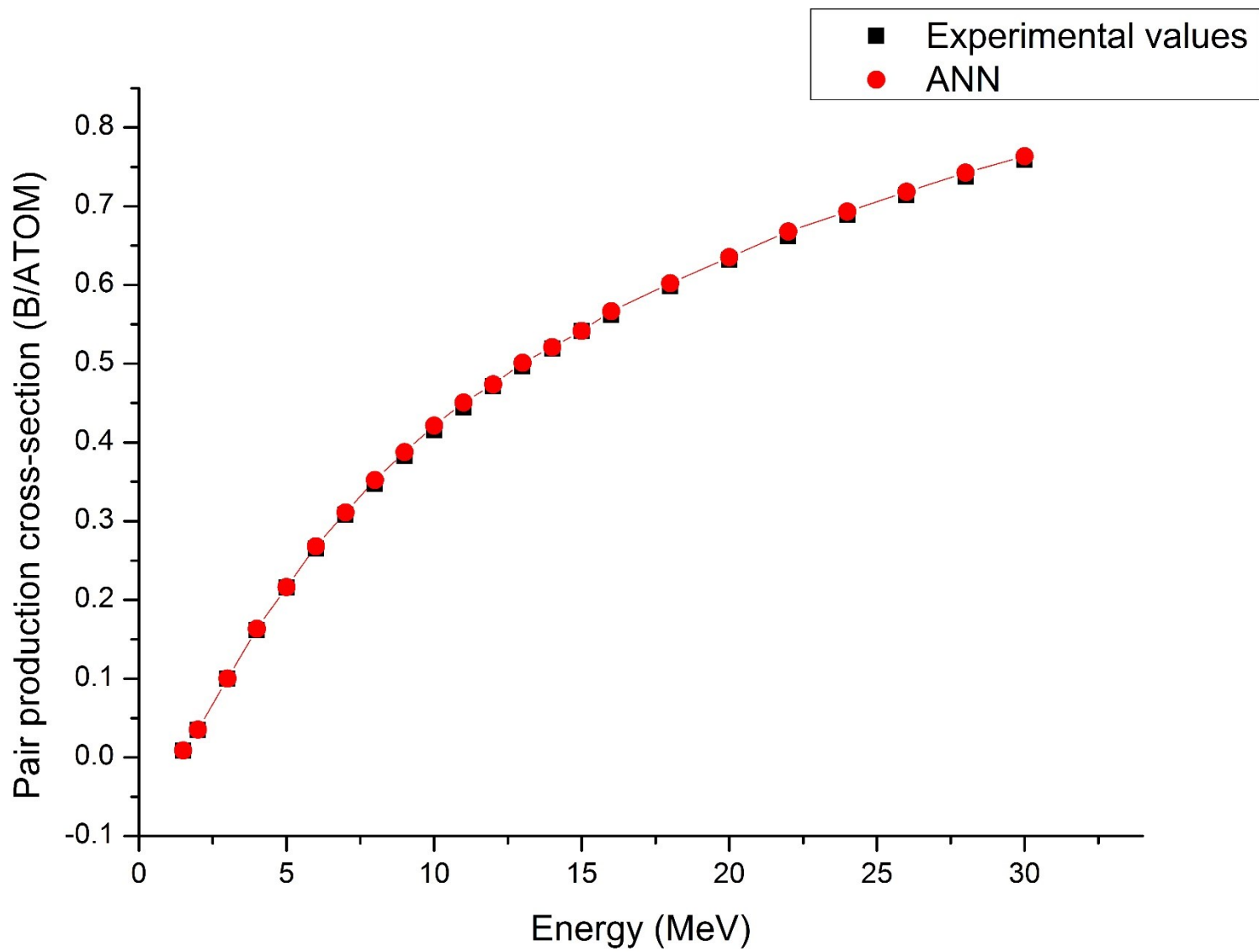
# MULTI LAYER PERCEPTRON (MLP)



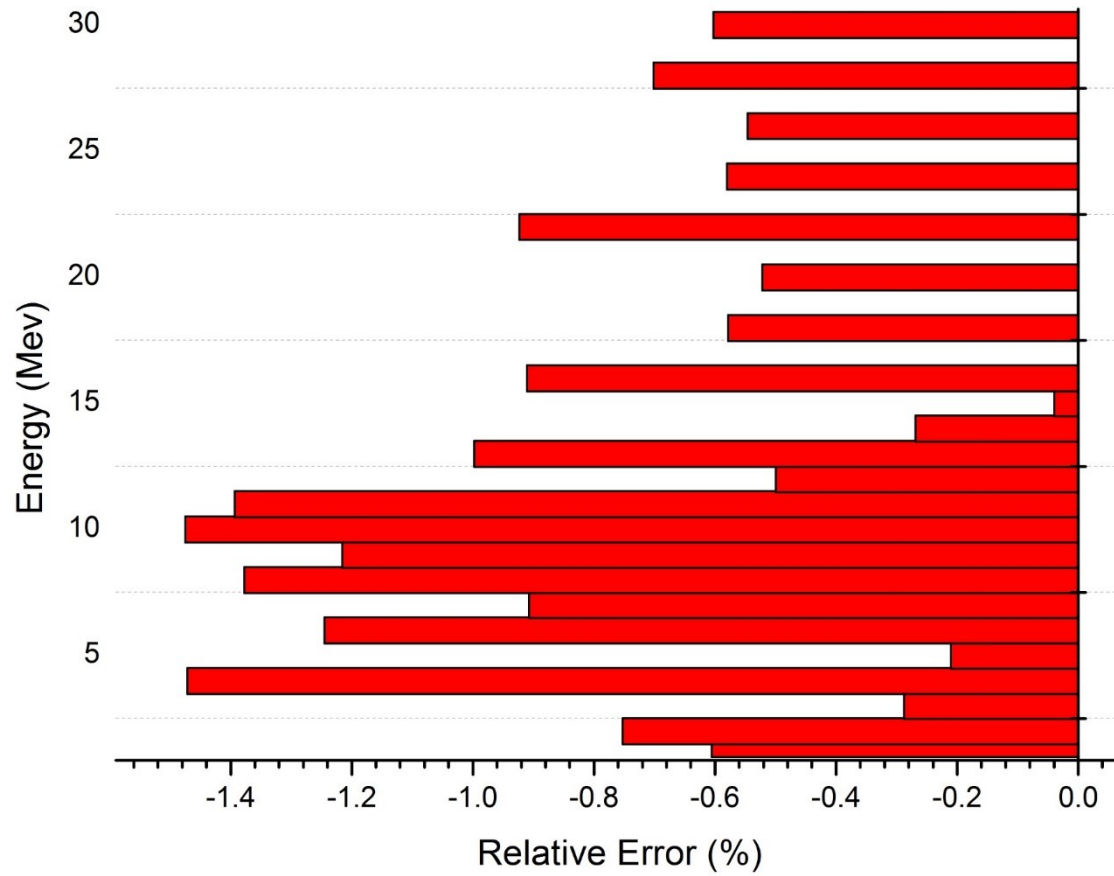
# EXPERIMENTAL VALUES

Energy (MeV)	Cross-section values
1.5	0.008917
2	0.03513
3	0.09978
4	0.1612
5	0.2159
6	0.2648
7	0.3083
8	0.3475
9	0.383

Hubbell, J. H., Gimm, H. A., & O/verbo/, I. (1980). Pair, triplet, and total atomic cross sections (and mass attenuation coefficients) for 1 MeV-100 GeV photons in elements Z= 1 to 100. *Journal of physical and chemical reference data*, 9(4), 1023-1148.









# CONCLUSION

According to the figure, it can be seen that the proposed artificial model predicts cross-section values with an error of less than 1.47% and is able to predict the cross-section and can be used with confidence in estimating the cross-section values.

Thank  
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