Development of the dosimetry technique for FLASH radiotherapy with nuclear emulsion

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Introduction

FLASH radiotherapy is a kind of proton therapy, which deliver a high dose of radiation in a very short time. Early research suggests that FLASH radiotherapy reduces side effects compared to conventional proton therapy. To understand biological mechanisms that create the FLASH effect and reach a reliable clinical translation of FLASH radiotherapy, an accurate dosimetry is needed. However, Detectors that are employed for dosimetry of conventional proton therapy suffer from saturation effects caused by ultra-high dose rate. We attempt to use a nuclear emulsion as a gamma camera [1] for dosimeter to solve this saturation problem.

Experimental Procedures

A nuclear emulsion can detect pair productions and it may avoid the saturation problem by separating pair productions from other gamma rays reactions. We can know arrival direction of gamma ray to measure momentum of electron-positron pair because momentum of the gamma ray is converted into momentum of electron-positron pair. This time, we develop a method to measure energy of electron created by pair production using Monte Carlo simulation and neural network. First, we simulated tracks of electrons created by pair production and positions of silver grains caused by the electrons in emulsion with GEANT4. Next, we calculated a scale of scattering from simulation silver grains' positions and a neural network model trained a relation between an electron's energy and its scale of scattering. We employed a GRU-based neural network model to process time-series data.

Results and Discussion

After the model trained, we simulated 1 mm length tracks of 2 MeV electrons and evaluate the trained model by predicting the electrons' energies from their scattering scale data. The model predicted the electron's energy with an accuracy of 13 % and this level of accuracy was sufficient for our purpose. This result suggests that GRUs are effective for this task and could achieve the limits of statistical precision. In future work, we plan to simulate to estimate the arrival direction of gamma ray and conduct experiment using electron or gamma ray sources with specific energies.

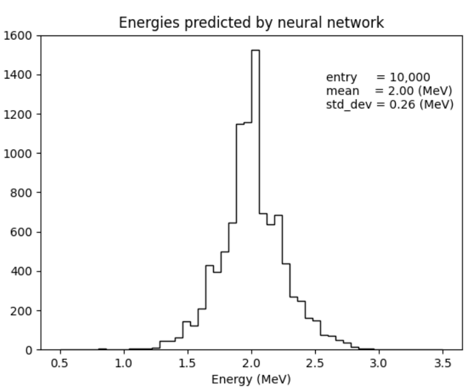

Figure 1 The histogram of predicted energies.

References

[1] T. Toshito et al., JSPS KAKENHI, Grant-in-Aid for Scientific Research Report [16K15349]