



Contribution ID: 50

Type: Poster

Simulation study on SOI based electron tracking Compton camera using deep learning method

Monday, 8 July 2019 17:17 (2 minutes)

SOI (Silicon On Insulator) based pixel detectors are promising as a scatterer in Compton imaging because of its thick sensitive area ($\sim 500 \mu\text{m}$) and small pixel size up to less than $10 \mu\text{m}$. SOI based electron tracking Compton camera are fabricated and tested in the previous study [1][2]. Electron tracking could improve the signal to noise ratio in the reconstructed image. One of the issues in electron tracking Compton camera is the complexity in estimation of ejected direction of Compton recoil electrons. In this study the capability of direction estimation using deep learning method are simulated and validated with Geant4 Monte Carlo simulation for different pixel sizes of $10 \mu\text{m}$ and $30 \mu\text{m}$. The thick silicon detector up to 80 mm is assumed and irradiated by the source of Cs-137 with the energy of 662 keV . The Compton image is reconstructed with and without electron tracking information. The initial direction angles of alpha along the detection surface and beta with the detection surface are estimated by this method. The alpha and beta are divided into 8 classes and 80000 data and 40000 data are used for teaching and testing. The accuracies with the pixel size of $10 \mu\text{m}$ and $30 \mu\text{m}$ are 61% and 47% for alpha angles and 48% and 49% for beta angles. The calculated FWHM of SPD (Scatter Plane Deviation) is approximately 68 degree in $10 \mu\text{m}$ by $10 \mu\text{m}$ pixel and 81.2 degree for $30 \mu\text{m}$ by $30 \mu\text{m}$ and $10 \mu\text{m}$ pixel detector show a slightly better resolution of SPD. The SNR of reconstructed image with and without electron tracking estimation is 3.99 and 4.83 and electron tracking shows a better SNR in the reconstructed image. The estimation method could be used for fast determination of ejected angle of Compton electron in the Compton imaging system.

[1] Shimazoe, K., et al. "Electron Pattern Recognition using trigger mode SOI pixel sensor for Advanced Compton Imaging." *Journal of Instrumentation* 11.02 (2016): C02030.

[2] Yoshihara, Y., et al. "Development of electron-tracking Compton imaging system with $30\text{-}\mu\text{m}$ SOI pixel sensor." *Journal of Instrumentation* 12.01 (2017): C01045.

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Session Classification: Poster Exhibition 1: Posters ID 1 - 80, chair: Christer Frojdh

Track Classification: general