

Development of a Prototype Compton Camera Simulation Code (CCSC) Based on GEANT4 Detector Simulation Toolkit

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1. Introduction

Our research group, along with others, has been interested, for several years, in a novel type imaging device, called Compton camera. The Compton camera has, in principle, several advantages over the conventional imaging devices such as Gamma camera, SPECT, and PET [1-4]. Based on detector simulations and limited experiments, the Compton camera has been characterized in detail. The improvement of the Compton camera has also been sought. The GEANT4 detector simulation toolkit [5] was considered as a suitable tool to model the Compton camera mainly because of its flexibility. However, because the GEANT4 toolkit was developed based on the C++ programming language providing only class libraries, the hard-coding is inevitable to model the detectors and experimental setup, which is usually very time consuming and error-prone. To address this problem, this study developed a user-friendly Monte Carlo simulation code for Compton camera, based on the GEANT4 simulation toolkit, in the form of a graphical user interface (GUI) by using MATLAB™.

2. Methods and Results

2.1 Methods

The developed prototype simulation code was named Compton camera simulation code (CCSC). Figure 1 shows main window of CCSC. The prototype CCSC has 4 categories as an input parameter as follows: (1) the geometrical configuration of the scatterer and absorber detectors, which includes inter-detector distance (IDD) and inter-detector angle (IDA), (2) the source description including photon energy, source position, and the number of source particles to run, (3) the specification of the scatterer detector including size, thickness, position, and material, and (4) the specification of the absorber detector. When compared with a hard-coding, CCSC can easily generate the source files of the GEANT4 toolkit for various physical conditions of the Compton camera.

The preparation for a GEANT4 simulation will be done just by entering the input data in the designated boxes and by clicking the 'Ready' button. If a user wants to change only one or two parameters, it can be easily done by selecting the 'user setup' after the selection of the 'default setup' which is based on the

current experimental setting. When all input parameters are defined, a user can confirm the geometry of the component detectors and the source position (Fig. 2).

The Cygwin environment, which is a Linux-like environment for Windows, is needed to compile the GEANT4 source files in the Windows operating system, because the GEANT4 toolkit is basically running in the Linux system. The Cygwin command window can be opened by clicking 'Cygwin' button in CCSC. Then, user can compile and run the GEANT4 model that is written by CCSC with the input data given by the user.

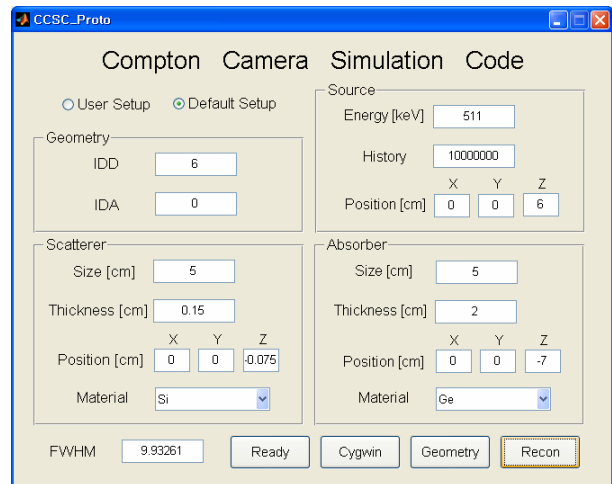


Figure 1. CCSC main window

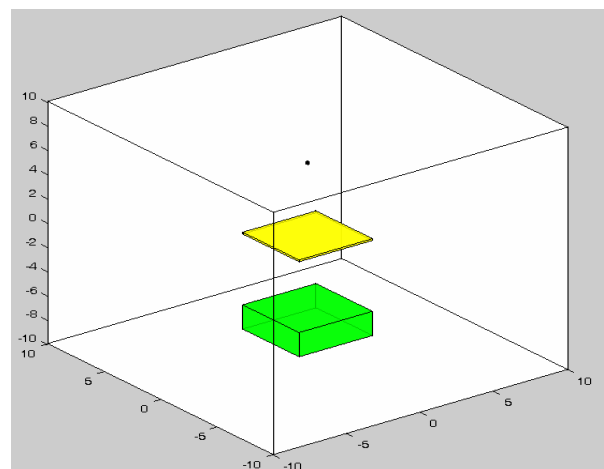


Figure 2. Three dimensional visualization of detector components in CCSC

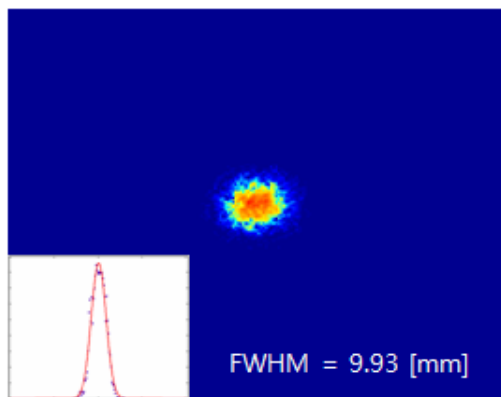


Figure 3. Reconstructed image and profile produced by CCSC with default setup (i.e., 511 keV source energy and 6 cm inter-detector distance in parallel)

After the completion of the Monte Carlo calculations in the Cygwin environment, the calculated data, which contains the interaction positions in the component detectors and the deposited energies are applied to the image reconstruction algorithm by clicking the 'Recon' button. Finally, user can get the reconstructed image and imaging resolution simply by clicking the 'Imaging' button, which is a toggle button in the same position of 'Recon' button. Figure 3 shows a Compton image and the profile generated by CCSC. The imaging resolution of the Compton camera is calculated by a Gaussian fitting of the profile and presented in the main window of CCSC.

2.2 Results

The prototype CCSC is easy to use and can significantly reduce the time and efforts to simulate Compton camera. In the previous methods to modify the parameters, a user has to find some associated source file in the GEANT4 code and modify it. To get the reconstructed image and the imaging resolution, a user also had to use a separate computer code and also a software Origin™. These previous procedures became very simple and easy by using prototype CCSC.

3. Conclusions

The prototype CCSC was developed with the MATLAB™ software to easily simulate Compton Camera. CCSC is very easy to use and significantly reduces the time and efforts to simulate Compton cameras and calculated data. It will be helpful to determine the optimal value of the detector parameter by conducting the large number of calculations. Even though a user is not very familiar with the Monte Carlo simulations, the user can easily simulate a Compton camera with CCSC. The number of parameters which can be controlled is limited in current version of CCSC. In the near future, an updated version of CCSC will be developed with more detailed options.

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