Overview

For this assignment, you will produce a “radiograph” of a tungsten T using a parallel radiation beam. You will need to build the T and detector out of G4Box solids and modify the PrimaryGeneratorAction (PGA) to produce parallel particles.

You will use our “basic” Geant4 code, which now has all the key components needed to run some general simulations and record the results. The code can be found here: https://github.com/micahfolsom/g4-ne697

To analyze the output, you may use the code demonstrated in class, but you are encouraged to write the plotting code yourself.

Code Submission

Create a folder in your Github repository called **assignment6/**. Here, you should copy the code demo’d in class as your starting point, then modify it. Delete the .git/ folder when you clone the repo, before copying it into your own.

For each part of the questions below (where applicable), create a separate .mac file to accomplish the task, just like in Assignment 5. Place your .mac files in the **scripts/** sub-folder so they get copied to the build directory when you run CMake.

This assignment will be due by **Tuesday, November 16th at midnight Pacific Time.**

Geometry Details

All coordinates are specified as (X, Y, Z), and full lengths. Don’t forget that G4Box takes half lengths for its arguments.

The “world” should stay as a 2x2x2 m^3 G4Box made of G4_AIR

The T will consist of 3 parts: the central pillar, then the 2 wings. All are G4Box solids

- Central pillar: 10x2x40 cm^3, centered at (0, 0, 0)
- Wings: 10x2x10 cm^3

This will create a 2-cm thick T in the X-Z plane at the origin. Use “G4_W” (tungsten) as the material.

The radiation detector panel will be a 50x5x50 cm^3 G4Box placed 30 cm behind (-Y direction) the T made of “G4_SODIUM_IODIDE”.

Source Details

The beam type (non decaying) particle sources will start at fixed positions and go a fixed direction unless otherwise altered. We would like a parallel beam where the positions are randomly selected to mirror the extent of the radiation detector on the other side.

Modify the PGA to generate particles in the (0, -1, 0) direction and to randomly start in the XZ plane at Y=30 cm.

To get random numbers, you'll need to #include "Randomize.hh". Then, you can call **G4UniformRand()** to get a floating point number between 0.0 and 1.0. From here, you can scale it to the desired range (e.g. 50 cm), allowing you to generate random positions (don't forget the units!). It's ok to hard-code the 50 cm here, instead of getting it programmatically.

Runs

You will run with some different particles and energies to demonstrate the different physics occurring. For each, run with 100,000 particles. Make sure to remove any lingering code that prints to the terminal every event - the repeated printing to the terminal will slow down the simulation a lot!

run1.mac
- gamma, 5 MeV

run2.mac
- gamma, 1 MeV

run3.mac
- gamma, 10 keV

run4.mac
- neutron, 10 MeV

run5.mac
- neutron, 1 eV

Again, please save your .mac files to **scripts/** so that they get copied when CMake is run and I can easily execute them when I use your code.

Radiographs

Create an **images/** directory in your repo for your plots of radiographs, named run1.png (or .jp[e]g), run2.png, etc. Use 100 bins in each dimension (50x50 cm^2).

Do not save your hits.csv files to the repo - these will be large!

In the real world, you'll want to be very diligent and thorough when processing the data, to make sure you're extracting the right quantities and that they behave as expected. For this assignment, don't worry *too* much about the details - just grab the position of the first hit from each event in the hits.csv file. Since we use a SensitiveDetector, they're guaranteed to be in the correct volume if the simulation is set up correctly.

Bonus Exercises

If you have extra time, then try selecting on "e-" particles produced with "phot" (photoelectric) and "compt" (Compton scattering), and plot the energy deposited spectra.

After selecting “e-” events produced with “phot” or “compt”, put an energy deposited cut on the data from run1 of 4.5 MeV. This should select on events that didn’t scatter, or underwent shallow scatters before hitting the detector panel, producing an image with higher contrast.