Geant4 One-Month Hands-On Exercise Plan

Overview

This plan provides six practical exercises to become familiar with Geant4 in one month, focusing on scoring, beam simulation, secondary particle tracking, and the effect of production cuts and physics lists. The suggested schedule is one exercise per week, with an extra week for final analysis and reporting.

Exercise 1 – Run and Modify a Basic Example

Goal: Understand the structure of a Geant4 application.

- Start with `/examples/basic/B1`.
- Change the detector material from water to PMMA and aluminum.
- Compile, run, and visualize geometry.

Deliverable: Screenshots of geometry for different materials.

Exercise 2 – Energy Deposition Scoring

Goal: Learn primitive scorers for dose.

- Use `/examples/basic/B2` or `/extended/medical/dosimetry`.
- Score *energy deposition* in a voxelized phantom.
- Change the number of voxels and compare results.

Deliverable: 2D heatmap of energy deposition using ROOT or matplotlib.

Exercise 3 – Beam Simulation

Goal: Configure a custom particle source.

- Use `G4GeneralParticleSource` to simulate:
  - 6 MeV photons
  - 10 MeV electrons
- Compare penetration depth and lateral spread.

Deliverable: Depth-dose curves for both beams.

Exercise 4 – Secondary Particle Tracking

Goal: Visualize and analyze secondary particles.

Method A: Using G4UserStackingAction

Record every newly created track:

```
// Inside ClassifyNewTrack in StackingAction
if (trk->GetParentID() > 0) { // Secondary
  auto* def = trk->GetDefinition();
  G4String name = def->GetParticleName();
  G4double ekin = trk->GetKineticEnergy(); // MeV
  G4ThreeVector pos = trk->GetPosition();  // mm
  G4String creator = trk->GetCreatorProcess()
                       ? trk->GetCreatorProcess()->GetProcessName()
                       : "primary";
  // Store data in EventAction for writing to ntuple
}
```

Method B: Using G4UserSteppingAction

Record secondaries created in the current step:

```
auto secs = step->GetSecondaryInCurrentStep();
for (const auto* trk : *secs) {
  auto name = trk->GetDefinition()->GetParticleName();
  auto Ekin = trk->GetKineticEnergy();
  auto proc = trk->GetCreatorProcess()
                ? trk->GetCreatorProcess()->GetProcessName()
                : "unknown";
}
```

Deliverable:

- Table of secondary particle types and counts.
- Energy spectra and angular distributions.
- Breakdown by creation process.

Exercise 5 – Angular and Energy Distribution

Goal: Extract kinematic distributions from interactions.

- Simulate electrons hitting a thin foil.
- Record:
  - Angular distribution of scattered particles.
  - Energy spectrum after the foil.
- Compare with multiple scattering theory.

Deliverable: Histograms for angular and energy distributions.

Exercise 6 – Effect of Production Cuts and Physics Lists

Goal: Understand how physics models and production thresholds affect accuracy, secondary generation, and runtime.

- Start from `/examples/basic/B4` or `/extended/medical/dosimetry`.
- Use a simple water phantom with a monoenergetic 5 MeV electron beam.
- Compare physics lists:
  - `FTFP_BERT`
  - `QGSP_BIC`
  - `QGSP_BIC_EMY`
- Vary production cuts:

```
/run/setCut 1 mm
/run/setCut 0.1 mm
/run/setCut 0.01 mm
```

- Record dose profiles, secondary yields, and runtime for each configuration.

Deliverable: Table and plots showing the trade-off between simulation accuracy and computational cost.

Suggested Schedule

Week	Task
1	Exercises 1 & 2
2	Exercise 3
3	Exercise 4
4	Exercises 5 & 6 + Summary Report