Simulation of the NEBULA detector using Geant4
Presentation 3.

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Achievements

## Goals and progress made so far

✓ Installing and setup Geant4 and other softwares and libraries needed

✓ Testing the configuration by running the examples provided in the Geant4 install

✓ Automate the complete setup pipeline of the environment for Geant4

– Implementing the NEBULA detector geometry in Geant4 using smsimulator

✓ Implementing the simplified NEBULA detector geometry in Geant4

✓ Create neutron beam runs with real physical parameters

✓ Create macros for the project

✓ Create the data analysis and explore the distribution of the energy deposit of neutrons in the detector rods

✗ Test the finalized detector with pre-defined particle beams originating from real physical processes (built-in in Geant4)

Making NEBULA rods susceptible for neutrons

Structure of the simulated detector

- 2×10 plastic scintillator rods in two layers
- Dimensions of rods are $12\text{cm} \times 12\text{cm} \times 180\text{cm}$
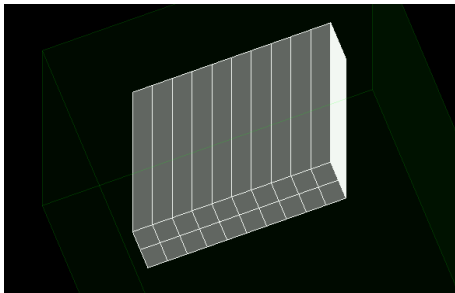
Making NEBULA rods susceptible for neutrons

G4SteppingAction

- Handles the individual tracking of each particle in the simulation

G4LogicalVolume : Initialized in G4DetectorConstruction

- Geant4's G4SteppingAction can use this type of volume to identify the mother volume of the particle's position in the current step
- This type of volume contains the methods used for particle tracking

G4Accumulable : Initialized in G4RunAction

- Stores "accumulable" quantities (eg. energies) during the whole simulation
- The G4AnalysisManager reads values from this type of object

Geant4 Analysis pipeline

G4AnalysisManager

- Geant4 has no built-in analysis tools
- This library handles the creation, filling and I/O of user defined datasets
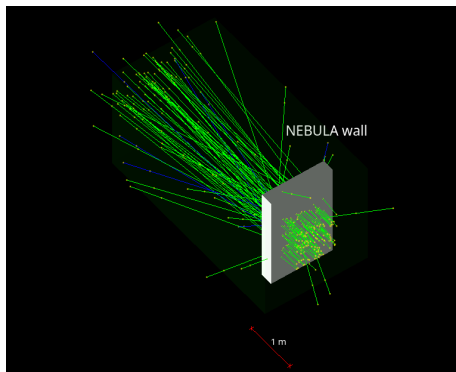- Able to output `XML`, `CSV` or `ROOT` files

Analysis

- Using the `G4AnalysisManager` I've saved the accumulated energies for each rods in `CSV` format
- For the analysis I've used `Python 3.9`

Analysis of simulation results

- All neutrons are set to have the same amount of energy at the start (tested for 20, 100, 200 and 300 MeVs)
- The NEBULA rods measure the deposited energies for each particles penetrating them

Figure 1: Heatmap of the total deposited energy in the NEBULA detector rods during a test run of 1000 neutrons of 100 MeV.
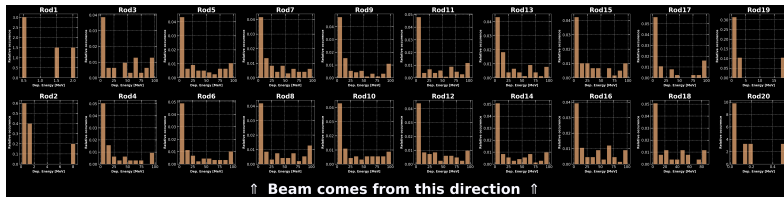

Figure 2: Histogram of the deposited energies for each NEBULA detector rods during a test run of 1000 neutrons of 100 MeV.