Simulation of neutrino events in a fine grained scintillator detector

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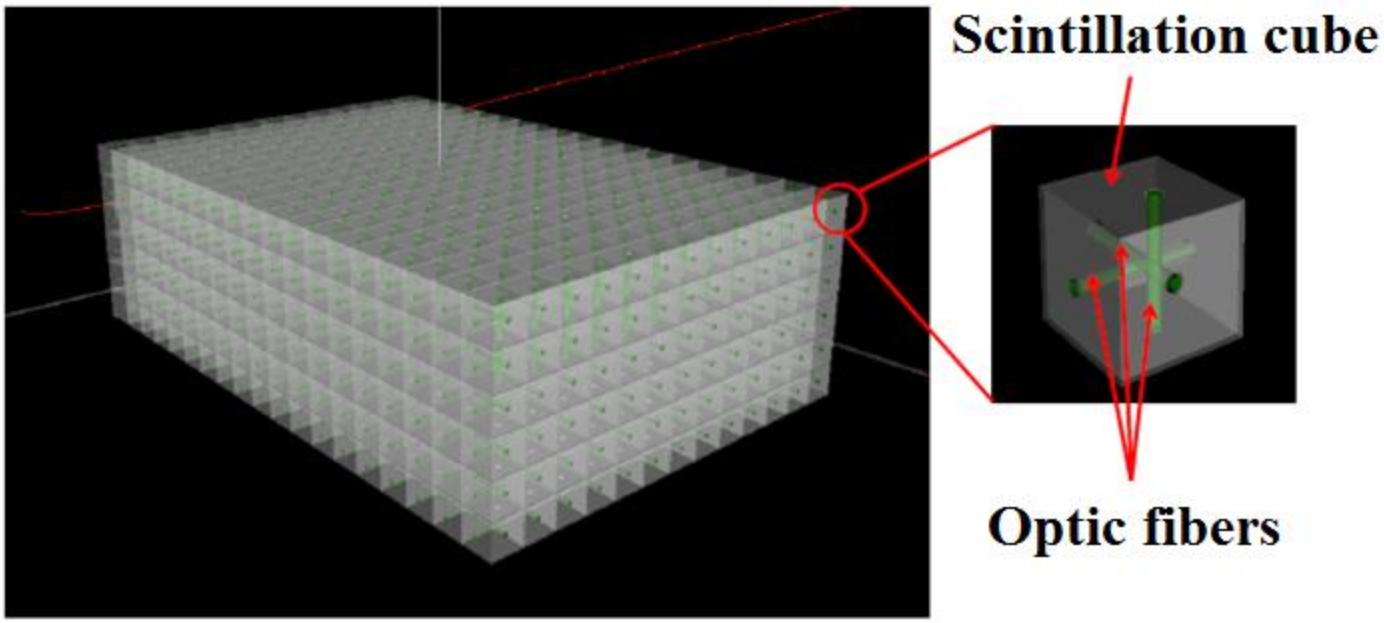
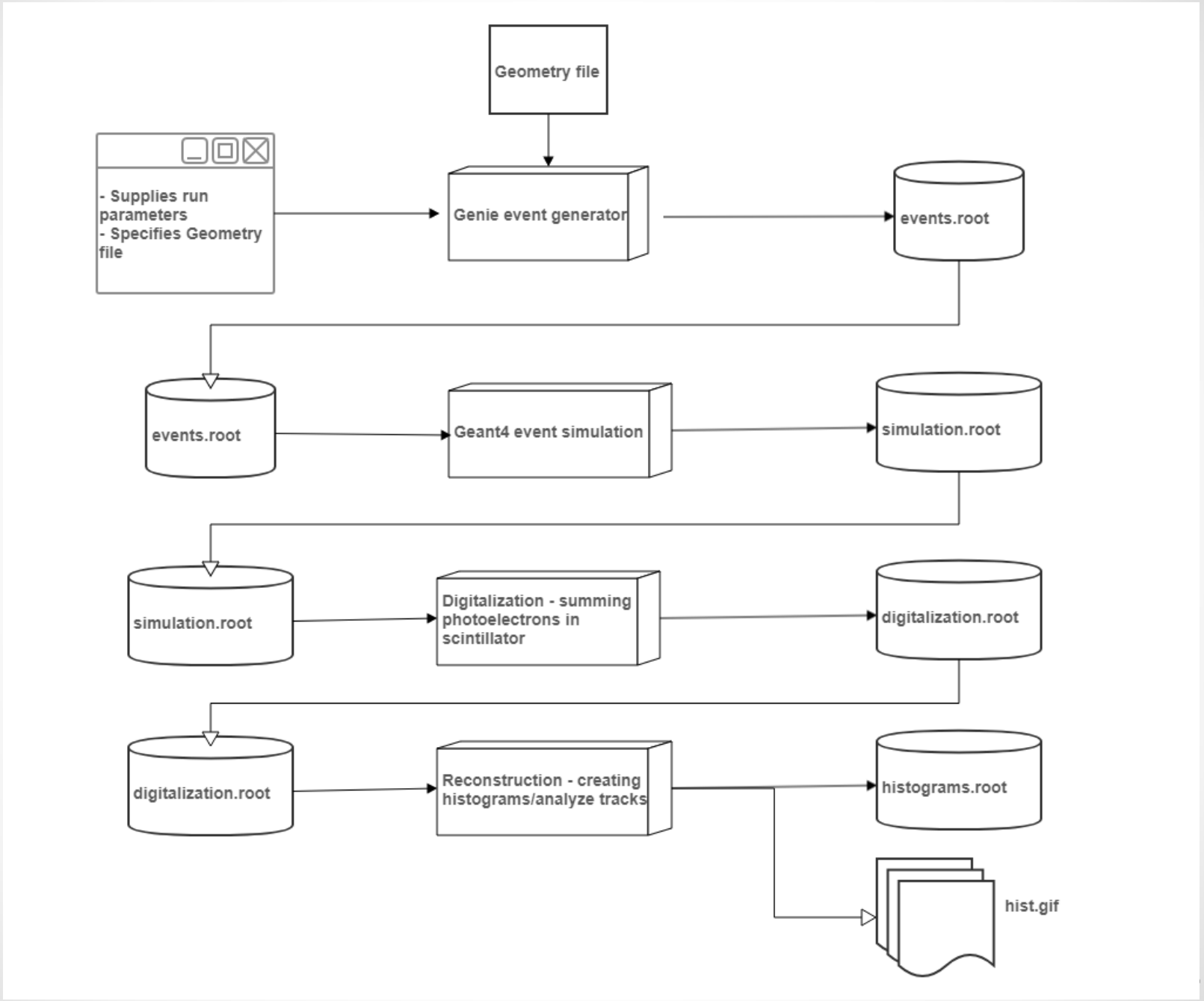
SuperFGD



Used platforms

- GENIE – neutrino event generator
- CERN ROOT – library for data analysis
- Geant4 – platform for simulating interactions of charged particles with matter
- Pythia6 – Monte Carlo generator

The software is build to run on OS Linux Mint 18.2 (or higher version)


Geometry file
- Supplies run parameters
- Specifies Geometry file
Genie event generator
events.root
events.root
Geant4 event simulation
simulation.root
simulation.root
Digitalization - summing photoelectrons in scintillator
digitalization.root
digitalization.root
Reconstruction - creating histograms/analyze tracks
histograms.root
hist.gif

4 executables are build

- nfevgen– used to generate the neutrino events and creates an events.root file
- nfsim – reads the events from the events.root and uses Geant4 to simulate the neutrino events, creates the simulation.root file
- nfdigit – reads the simulation.root file and digitizes the information according to the requirements, outputs digitalization.root file.
- nfrecon – generates histograms (creates picture files for the moment) of the interaction.

EventGenerator

- A class is implemented (NFFluxdriver) that inherits from GFluxI

A main file is created with the following flow:

1. Passed arguments are read – detector dimensions, neutrino energy etc.
2. Initialize cross section xml data
3. Initialize detector geometry
4. Initialize FluxDriver
5. Initialize Genie neutrino event generator and pass the fluxdriver
6. Initialize an Ntuple Writer to save GHEP records into a Ttree
7. Generates events and saves them into a file

Geant4 simulation

Specific classes are implemented for the simulation based on the detector parameters and materials – inherited classes include:

1. G4VPVParameterisation
2. G4VUserDetectorConstruction
3. G4VSensitiveDetector
4. G4UserEventAction
5. G4VUserPrimaryGeneratorAction
6. G4UserRunAction
7. G4RunManager
8. G4UserSteppingAction
9. G4VUserPhysicsList

Geant4 simulation flow

1. Reads cmd arguments
2. Construct the default run manager
3. Detector construction – detector is the same as in the Genie event generator
4. Physics list
5. Primary generator action
   - Can be either the genie output file
   - Primary particle generator – for test purposes
6. Initialize Stepping action
7. Initialize Event action
8. Initialize Run action
9. Initialize G4 kernel
10. Run the simulation

Digitalization step

From the run simulation in the G4VSensitiveDetector we extract the necessary data – energy deposited in each cube and convert into generated photons with a conversion formula. We do not use the Geant4 photon simulation since this will reduce the performance significantly.

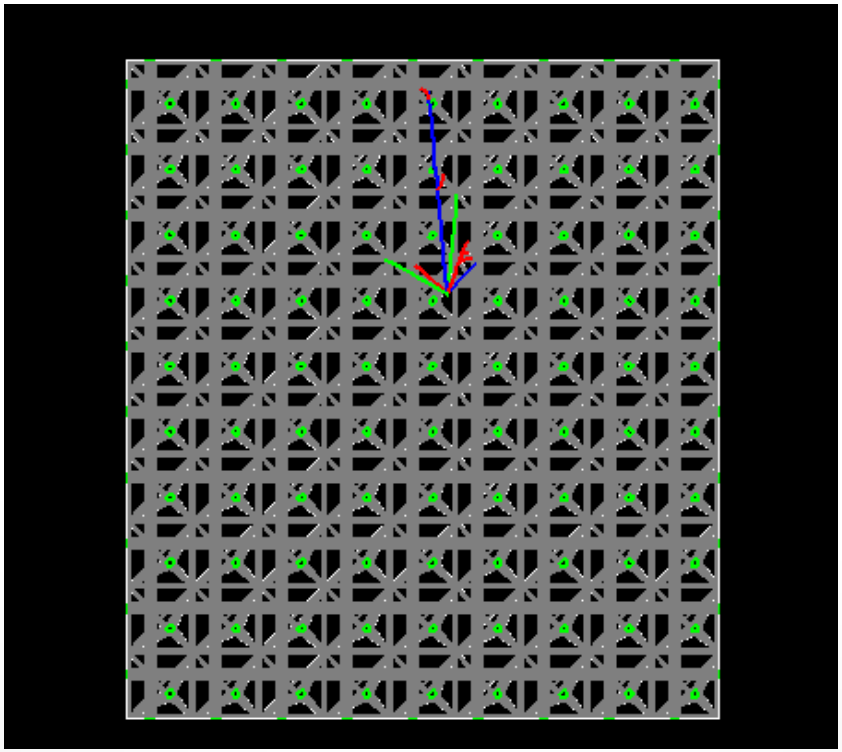
The digitalizations sorts and sums the generated photons per cube and the output file basically is the information of only the number of generated optical photons per cube.

Reconstruction

The reconstruction for (the moment) reads the output file from the digitalization step and generates 3 views - one from X and Y, one from X and Z, and one from Y and Z axis; for each event.

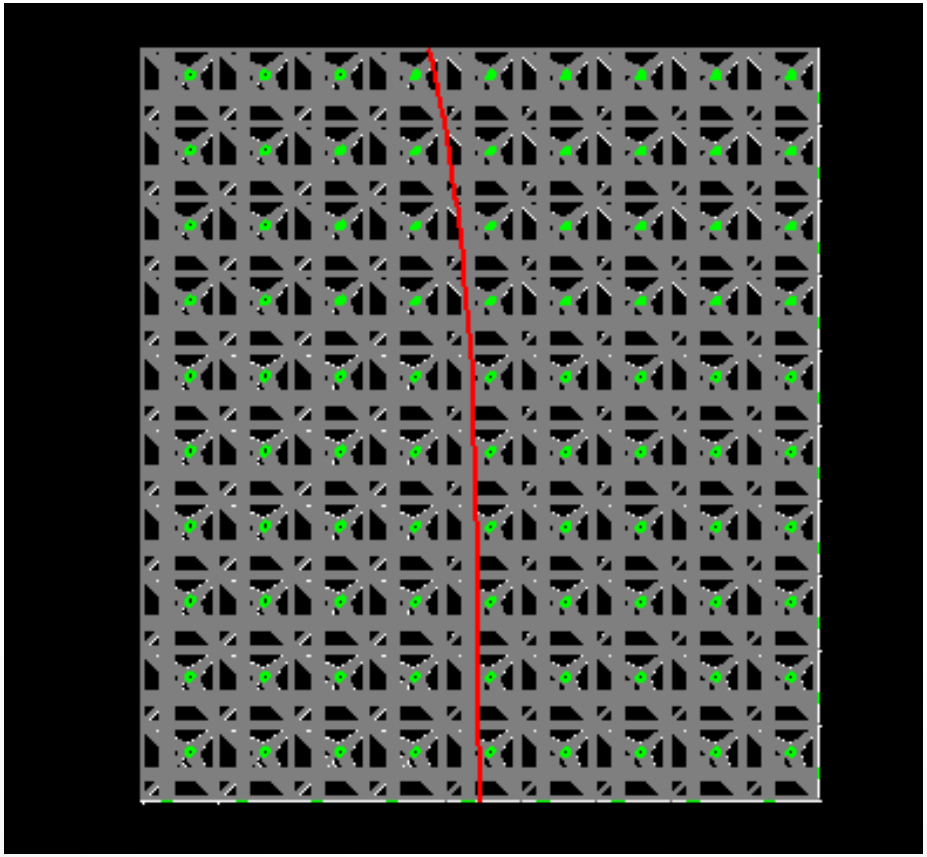
Simple simulation

Generated image in a scintillation detector using Geant4 [muon neutrino interaction with energy of 7.5GeV, view from X and Z axis, magnetic field is parallel to Y=0.5 T (into the screen), number of cubes per acis X=9, Y=1, Z=10]



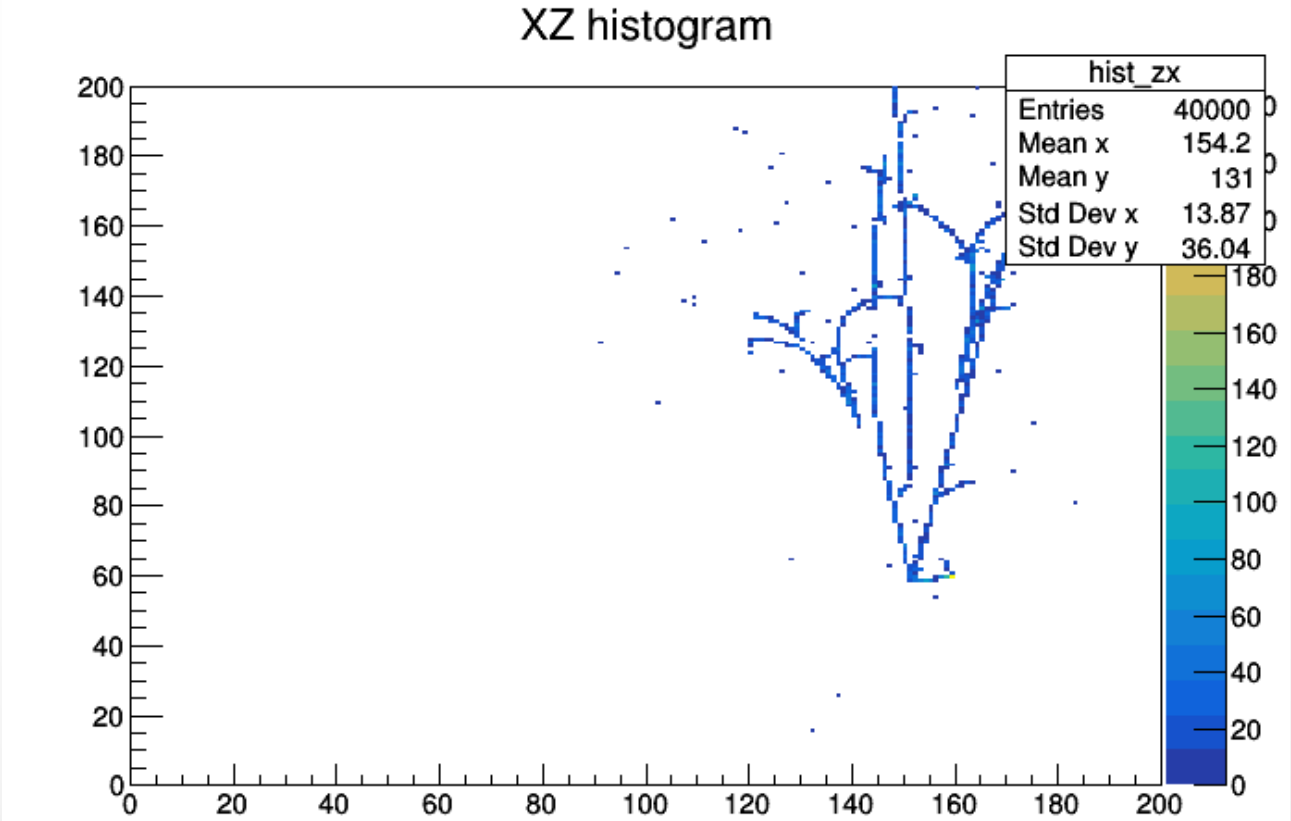
Simple simulation

Generated image of a muon with energy of 0.05GeV, view is from X and Z axis with an applied magnetic field in Y axis of 0.5 T, detector dimensions are 9 by 1 by 10 cubes



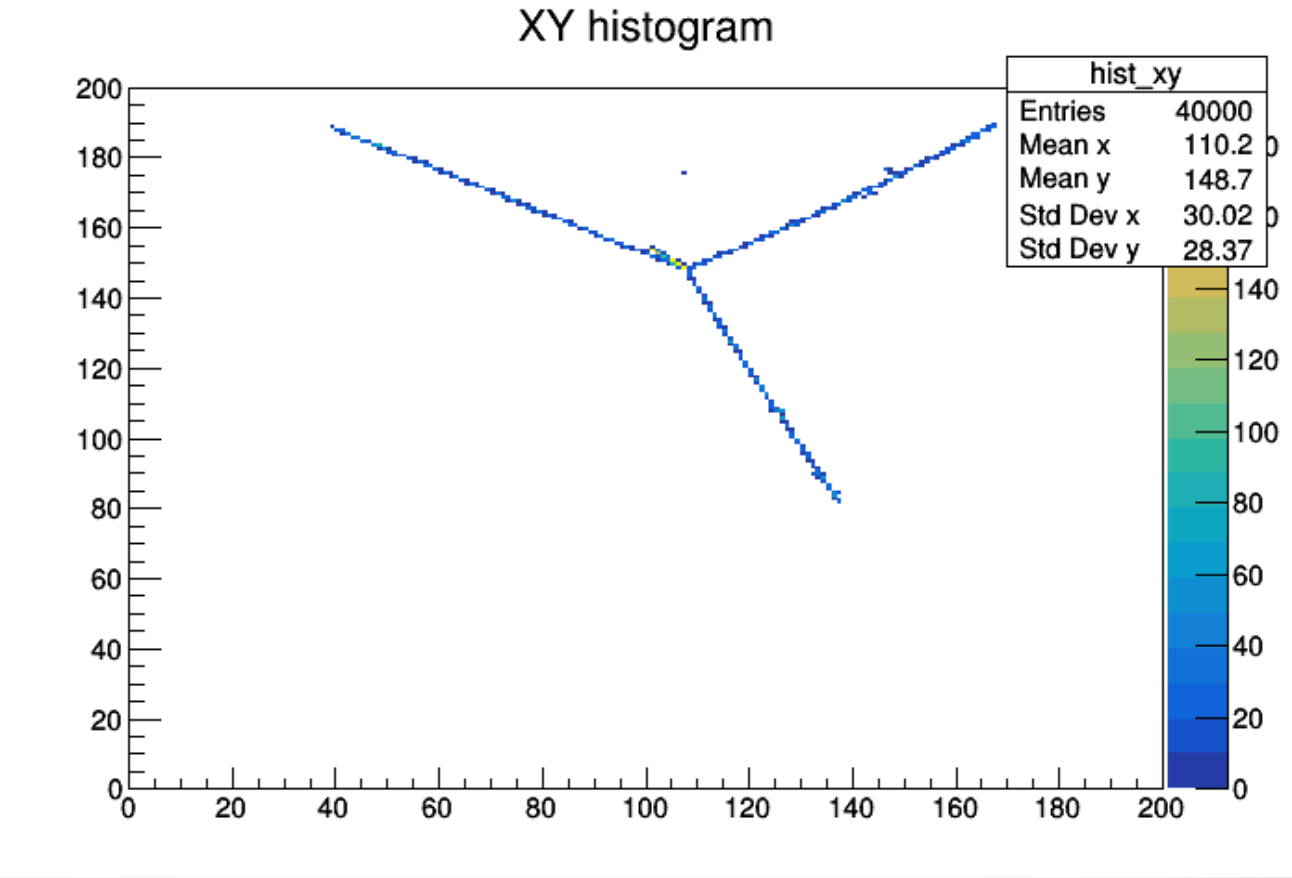
Simulation reconstruction

Reconstruction of a neutrino event with E=7.5 GeV and an applied magnetic field in the Y axis with 0.5 T in a granular detector with dimentions of 200x200x200 cubes [View is from the X and Z axis]



Simulation reconstruction

Reconstruction of another neutrino event with E=7.5 GeV and an applied magnetic field in the Y axis with 0.5 T in a granular detector with dimentions of 200x200x200 cubes [View is from the X and Y axis]



Future work

- Simulation of the whole detector – scintillation and cerenkov detector
- Adding the newest version of Geant4
- 4 executables can be run in parallel (multithreaded application can be made for faster data processing)
- Reconstruction of the whole event based on the registered tracks

Questions?

Thank you for your attention!