Hands on: detector simulation

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Detector simulation

- In this hands-on you will learn how to **simulate the interaction of a generated signal with the Muon Collider detector**
- All the instruction for this part can be found here: https://mcdwiki.docs.cern.ch/tutorial/simulation/
- The simulation is performed with the software ***ddsim***: it is part of the DD4HEP package, which uses the ROOT geometry package and the Geant4 simulation toolkit
- ***ddsim*** could be run with the following command:

```
ddsim --steeringFile <path_to_the_steering_file>.py
```

- The **steering file** contains all the user options. A baseline steering file can be found in

```
./mucoll-benchmarks/simulation/ilcsoft/steer_baseline.py
```

Steering file

```
import os

from DDSim.DD4hepSimulation import DD4hepSimulation
#from SystemOfUnits import mm, GeV, MeV, m, deg
from g4units import mm, GeV, MeV, m, deg
SIM = DD4hepSimulation()

## Path to the compact geometry desciption [XML file]
SIM.compactFile = os.environ.get('MUCOLL_GEO')
## Lorentz boost for the crossing angle, in radian!
SIM.crossingAngleBoost = 0.0
SIM.enableDetailedShowerMode = True
SIM.enableG4GPS = False
SIM.enableG4Gun = False
SIM.enableGun = False
## InputFiles for simulation .stdhep, .slcio, .HEPEvt, .hepevt, .hepmc files are supported
SIM.inputFiles = ["input.stdhep"]
## Macro file to execute for runType 'run' or 'vis'
SIM.macroFile = ""
## number of events to simulate, used in batch mode. -1 all
SIM.numberOfEvents = -1
## Outputfile from the simulation,only lcio output is supported
SIM.outputFile = "output_sim.slcio"
```

Detector geometry path (SIM.compactFile)

Enable/disable particle gun (SIM.enableGun)

Input file path (SIM.inputFiles)

Number of simulated events (SIM.numberOfEvents)

Output file name (SIM.outputFile)

Hands-on: simulate H→bb events

1. Create a directory: `mkdir sim_Hbb && cd sim_Hbb`

2. Run the simulation with the proper options

```
ddsim --steeringFile ../mucoll-benchmarks/simulation/ilcsoft/steer_baseline.py \
--inputFile ../gen_Hbb/mumu_H_bb_3TeV.stdhep \
--numberOfEvents 5 \
--outputFile Hbb_out.slcio
```

   or in alternative modify the the steering file and

```
ddsim --steeringFile ../mucoll-benchmarks/simulation/ilcsoft/steer_baseline.py
```

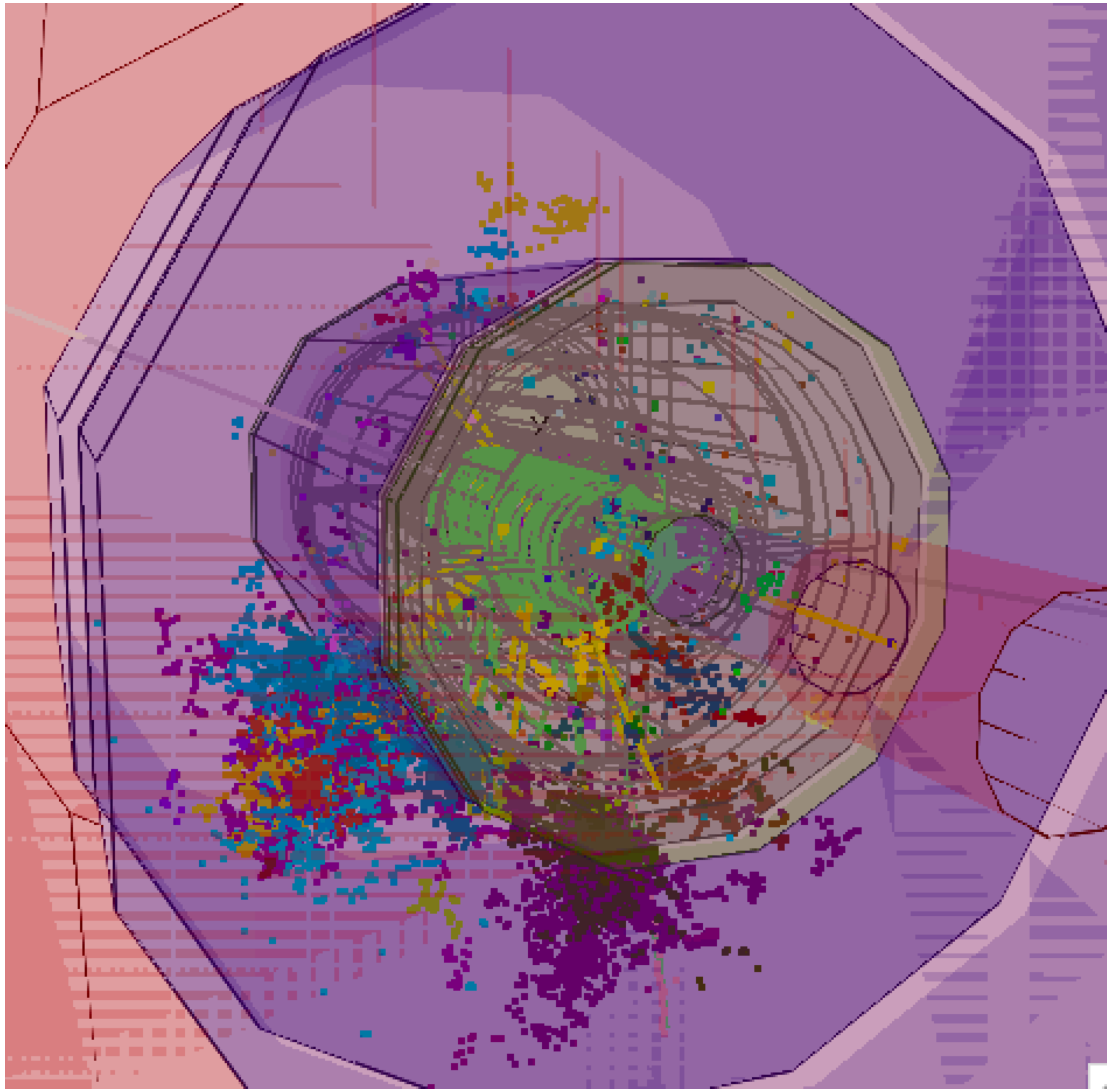
3. Visualize the simulated events with

```
ced2go -d $MUCOLL_GEO Hbb_out.slcio
```

   or inspect them with

```
dumpevent Hbb_out.slcio 1
```

Hands-on: simulate H→bb events



```
ced2go -d $MUCOLL_GEO Hbb_out.slcio
```

Particle gun

In this section of the steering file you can configure the particle gun

```
SIM.gun.particle = "mu-" # muon
SIM.gun.energy = 10.0*GeV  # fixed energy at 10 GeV
SIM.gun.distribution = "uniform"  # flat in theta distribution

SIM.gun.isotrop = True # isotropic distribution in Phi
SIM.gun.multiplicity = 1 # one muon per event
SIM.gun.phiMax = None
SIM.gun.phiMin = None
SIM.gun.thetaMax = 180*deg
SIM.gun.thetaMin = 10*deg
```

Hands-on: simulate single muons

1. Create a directory: `mkdir sim_muonGun && cd sim_muonGun`

2. Modify the parameters of the steering file `../mucoll-benchmarks/simulation/ilcsoft/steer_baseline.py` enabling the muon gun (it is already configured):

```
SIM.enableGun = True
```

3. Run the simulation:

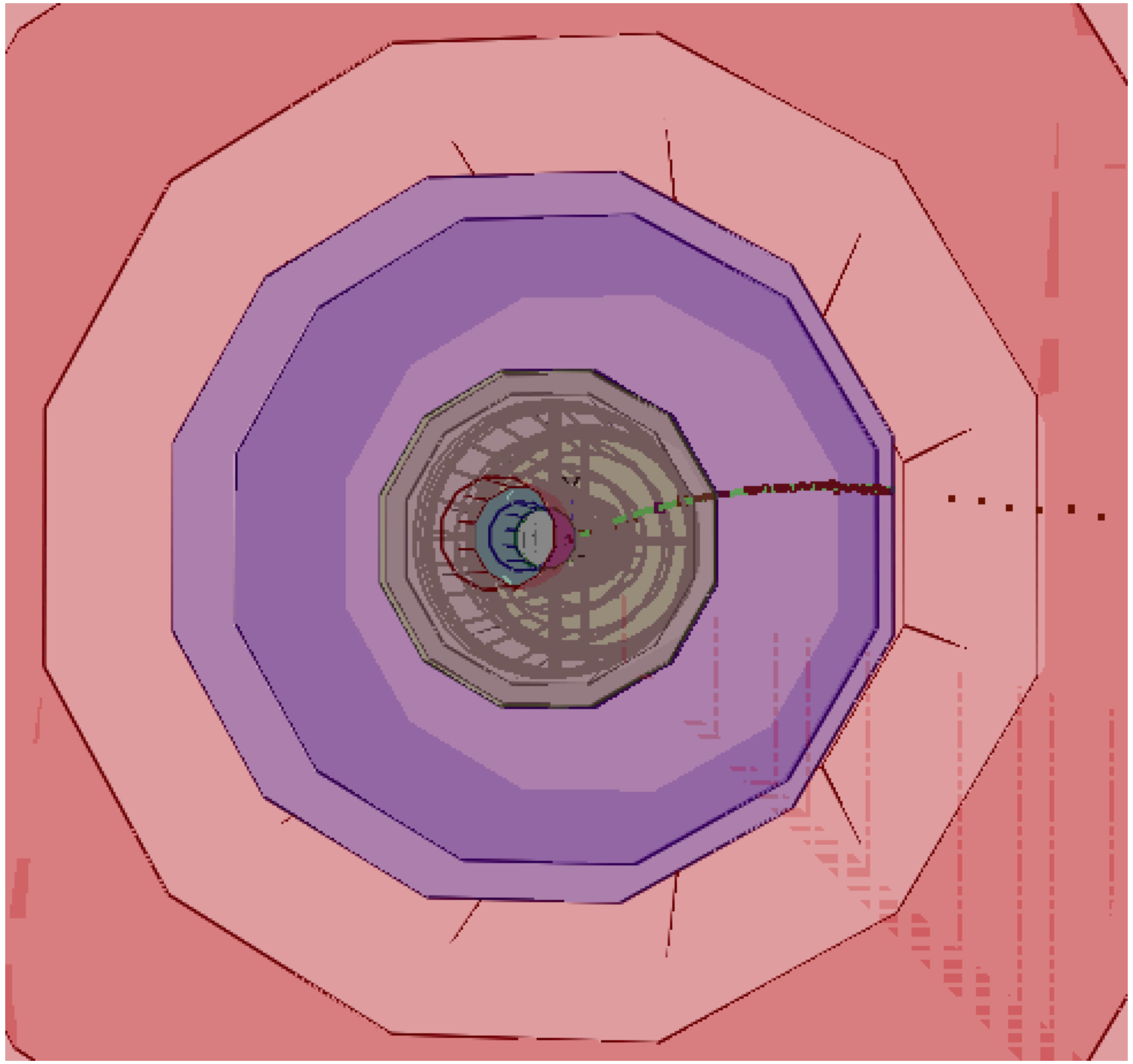
```
ddsim --steeringFile ../mucoll-benchmarks/simulation/ilcsoft/steer_baseline.py \
--numberOfEvents 5
```

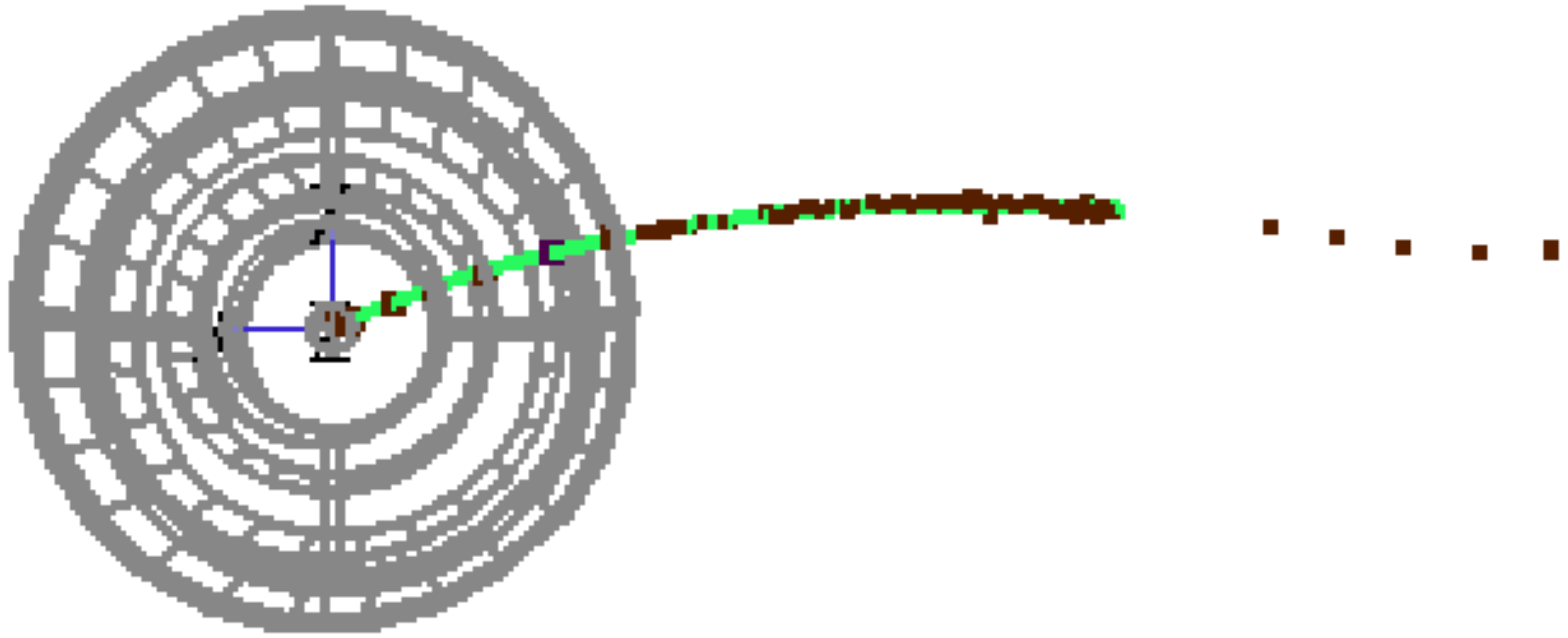
4. Visualize the simulated events with `ced2go -d $MUCOLL_GEO output_sim.slcio`

   or inspect them with

```
dumpevent output_sim.slcio 1
```

Hands-on: simulate single muons





And now ... hands on!!

Backup

Detector

hadronic calorimeter

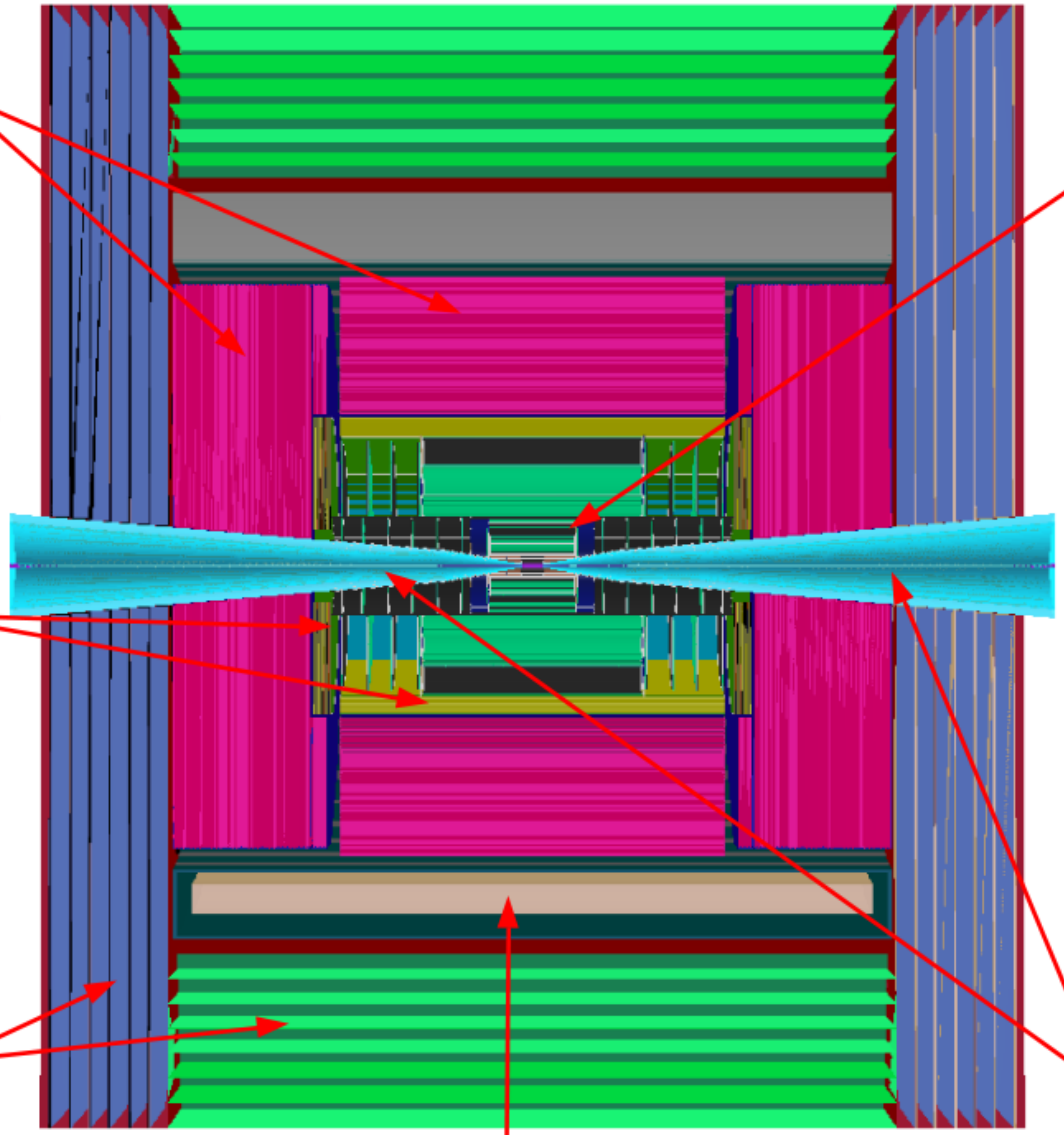
- 60 layers of 19-mm steel absorber + plastic scintillating tiles;
- 30x30 mm^2 cell size;
- 7.5 λ_I.

electromagnetic calorimeter

- 40 layers of 1.9-mm W absorber + silicon pad sensors;
- 5x5 mm^2 cell granularity;
- 22 X_0 + 1 λ_I.

muon detectors

- 7-barrel, 6-endcap RPC layers interleaved in the magnet's iron yoke;
- 30x30 mm^2 cell size.



superconducting solenoid (3.57T)

tracking system

- Vertex Detector:
  - double-sensor layers (4 barrel cylinders and 4+4 endcap disks);
  - 25x25 μm^2 pixel Si sensors.
- Inner Tracker:
  - 3 barrel layers and 7+7 endcap disks;
  - 50 μm x 1 mm macro-pixel Si sensors.
- Outer Tracker:
  - 3 barrel layers and 4+4 endcap disks;
  - 50 μm x 10 mm micro-strip Si sensors.

shielding nozzles

- Tungsten cones + borated polyethylene cladding.