# Simulations work plan for 2025 Test-Beam

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# Simulations for testbeam

## goal, method, steps

- Goal:
  - simulations of the testbeam, foreseen to evaluate sensors and experimental setups performances.
- Method
  - stand-alone application in Geant4 / frameworks used in Ecal community
  - Fluka simulations (?)
- Steps:
  - implementation of various configurations geometries;
  - evaluate various physics lists and check their influence;
  - collect quantities of interest (eg. hits position, energy deposition);
  - correlate the sensor response to the energy deposition;
  - digitize the detectors response;
  - evaluate the first physical observables.

# Simulations supports

## hardware, software

luxe.spacescience.ro

### Hardware

- *CPU model/make:* AMD EPYC 7713P 64-Core Processor
- *CPU Core:* 64
- *Thread per core:* 2
- *Total threads:* 128
- *Total memory:* 258 G
- *Storage :* 6 x 12 T drives in RAID6
- *Total storage:* 44T / 8.8T free (also for the calibrated test-beam data )

### Software

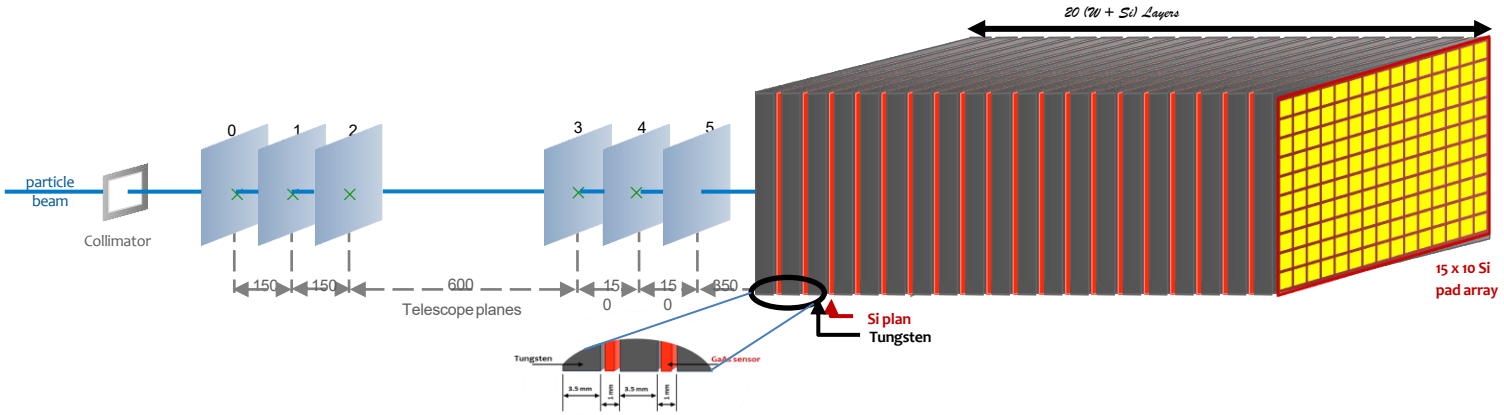
- *Access via SSH using Public Key Authentication*
- AlmaLinux
- CernVM File System (cvmfs) *installed*:
  - Geant4.11.2.2
  - Root 6.34.02
  - Dd4hep
- Corryvreckan version v2.0

# 1. Design geometry and materials

## investigated setups (layouts)

### A. Create detector geometry

- *~ 20 configurations used in test-beam*
- *each configuration will have its own geometry file;*
  - *selection of each configuration will be done through Geant4 macro commands;*
- *easy to change between configurations;*




### B. Assign material properties

- *materials must be accurately defined with their physical properties.*

### C. Visualize geometry setup

- *using OPENGLX Geant4 visualizing engine it is possible to visualize the detector and also some events and control simulations via commands:*
  - Idle> /gun/particle e-
  - Idle> /gun/energy 5000 MeV
  - Idle> /run/beamOn 3

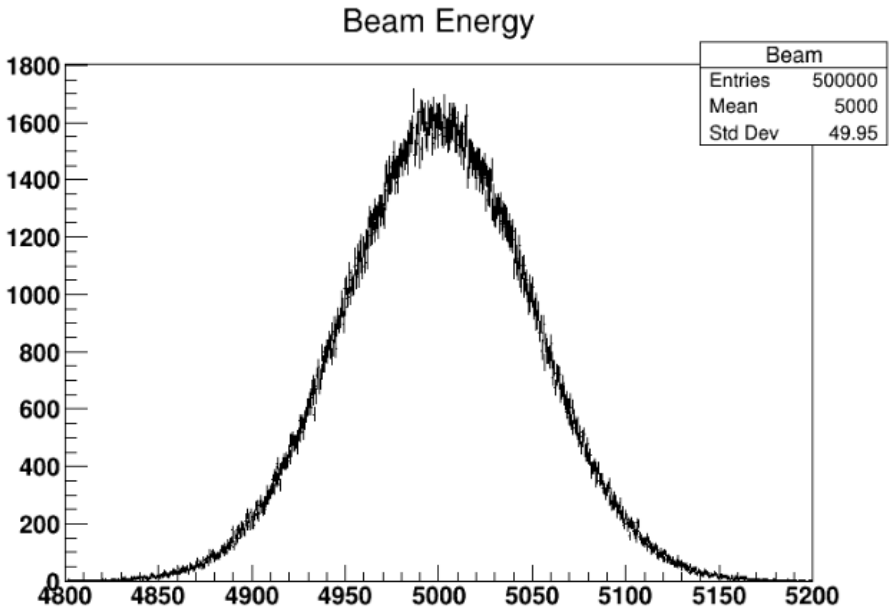
- Expected completion:
  2 weeks

# 2. Primary particle generation & Actions

## GPS source, G4RunAction, G4EventAction

### A. Particle source

- *define type, energy, position, and direction of primary particles.*
- *use GPS type source*
  - *easier to control via macros and commands*
- *create 'diverging' beam*
  - *the beam will have some divergence and shape*
  - *12 x 12 mm2 collimator -> square source (??)*
  - *gaussian energy distribution with 0.1% spread*




### B. Event handling

- *Implement actions for run, event, and tracking to control simulation flow and data collection*

- Expected completion:
  2 days

# 3. Physics list

## G4VUserPhysicsListPhysics, G4VModularPhysicsList

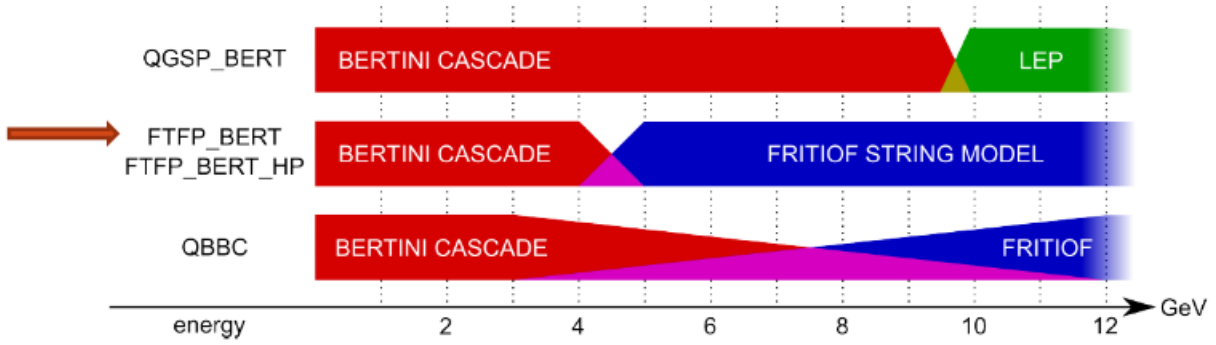
- FTF_BIC
- FTFP_BERT
- FTFP_BERT_HP
- FTFP_BERT_TRV
- FTFP_BERT_ATL
- FTFP_INCLXX
- FTFP_INCLXX_HP
- FTFP_QGSP_BERT
- LBE
- NuBeam
- QGSP_BERT
- QGSP_BERT_HP
- QGSP_BIC
- QGSP_BIC_HP
- QGSP_BIC_AllHP
- QGSP_FTFP_BERT
- QGSP_INCLXX
- QGSP_INCLXX_HP
- QGS_BIC
- Shielding
- ShieldingLEND

### Select relevant physics models

*a) used in the last test-beam simulations: QGSP_BERT / FTFP_BERT with one of the _EMV, _EMZ, _EMY additions;*

*b) Geant4 collaborators introduced G4HepEm*

- *a solution to reduce the computing performance bottleneck experienced by the High Energy Physics (HEP) detector simulation applications;*
- *targets the most performance critical part of the HEP detector simulation applications, i.e. the EM shower generation covering e – / e + and γ particle transport*




- Expected completion:
  1 day for case a)
  1 week for case b)

# 4. Sensitive detectors and hits

## sensitiveDetector, DigitizerModule

### A. Define sensitive volumes

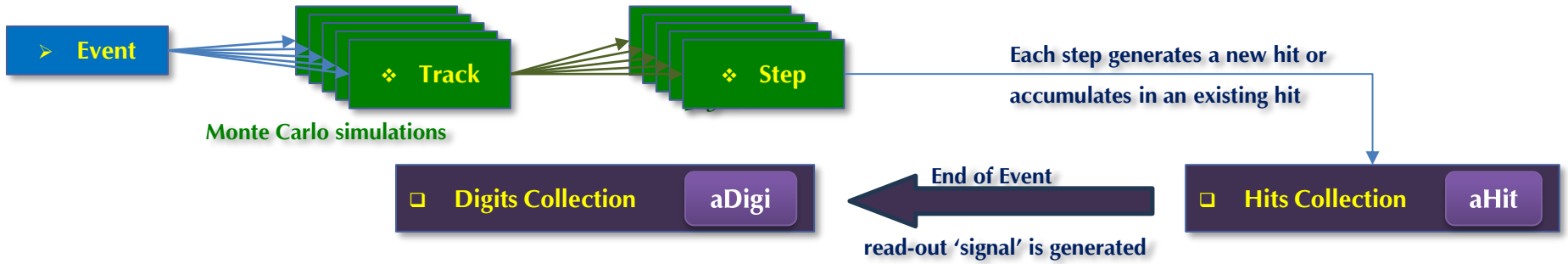
- *each silicon sensor is defined as a sensitive volume;*
- *energy deposited within silicon sensors is registered in the sensitive detector;*

### B. Record particle interactions

- *record each particle that has reached a sensitive volume*
- *No digitization has been applied to simulations performed for the previous test-beams*

### C. Digitize the signal

- *digitization is performed at the end of the event;*
- *it accumulates the energy deposits within pads, taking into account the time cut on the arrival of signal (global time of energy deposit); by default no time cut is applied which means all the deposits are counted.*
- *electronic noise can be applied together with all instrumental effects*



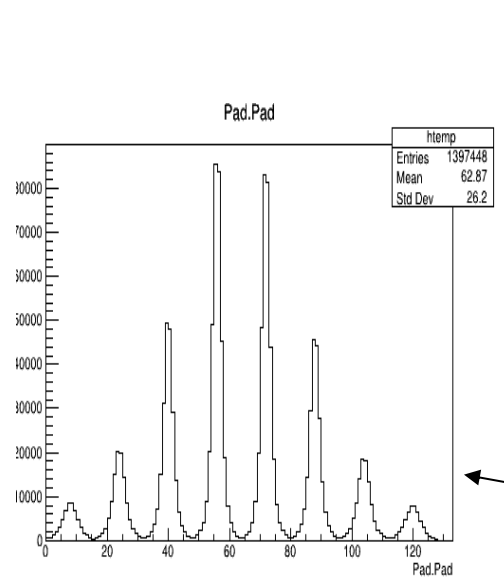

- Expected completion:
  - 2 days for B
  - 2 weeks for C

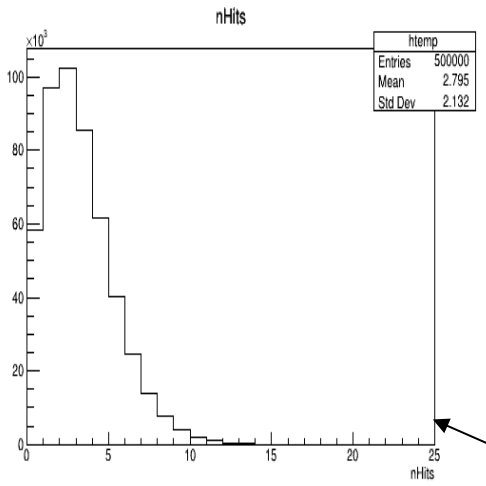
# 5. Hits collection

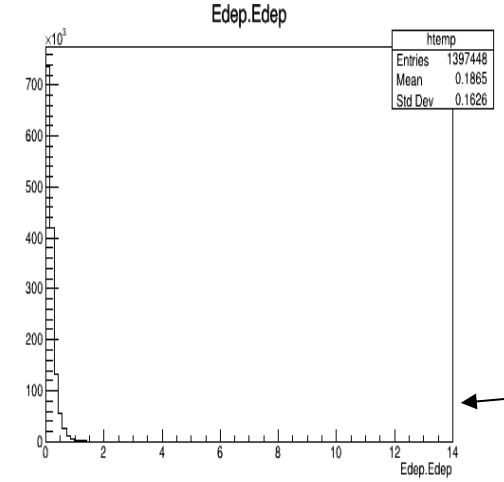
## sensitive detector

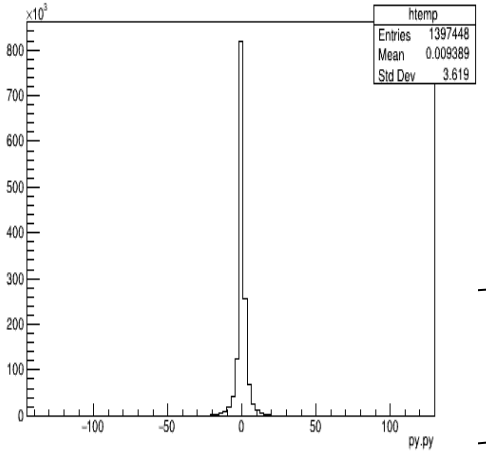
### 7 observables

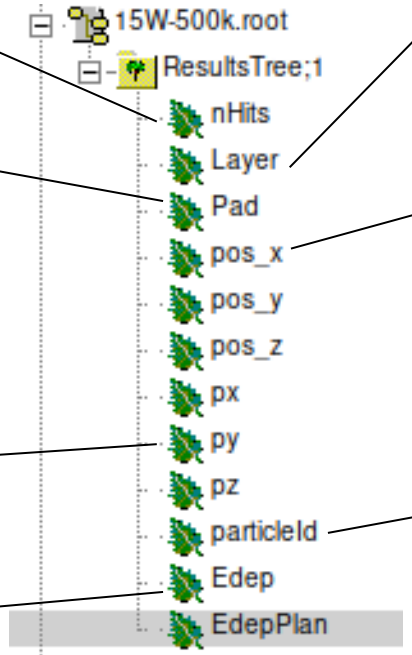
- Number of hits
- Pads hits
- Position of hits (x, y, z)
- Hits momentum (px, py, pz)
- Particle identification
- Total energy per event
- Total energy of hits

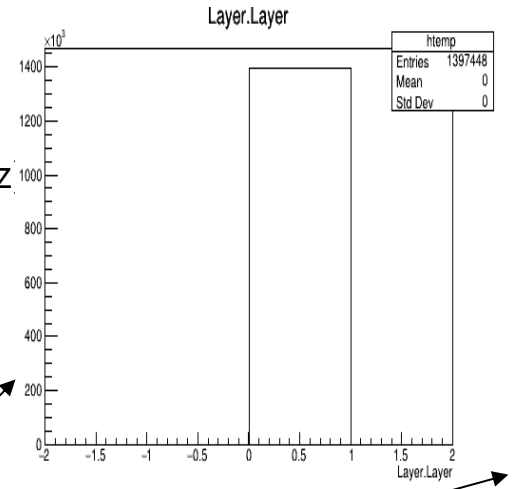


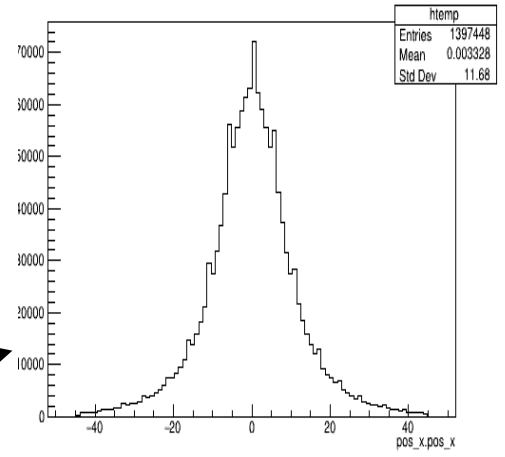



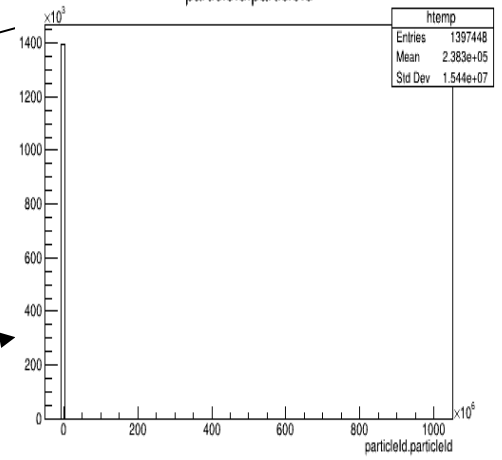



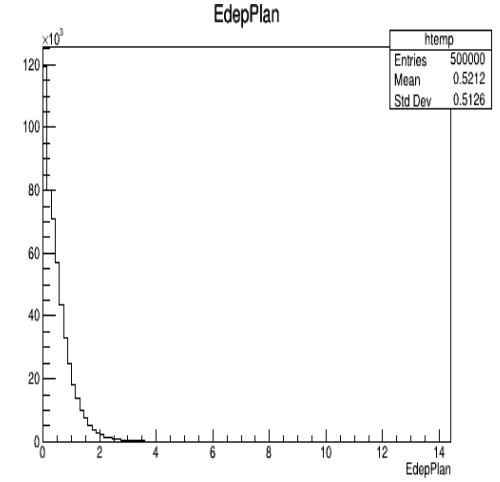



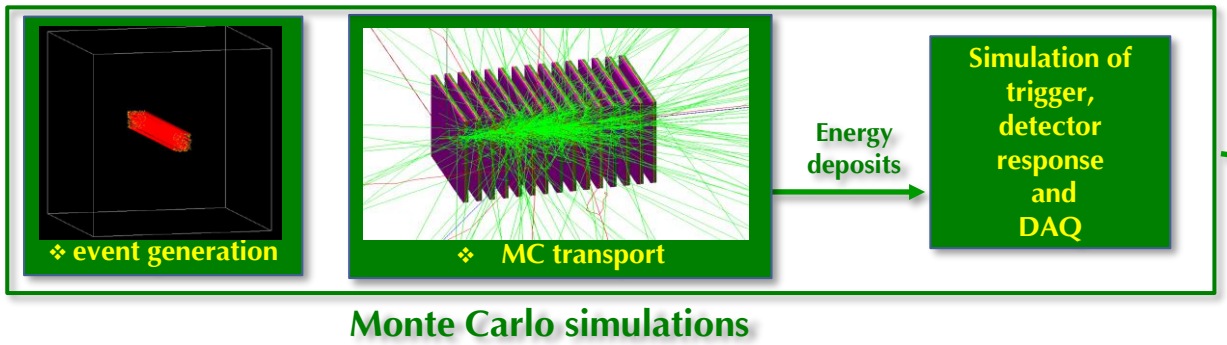



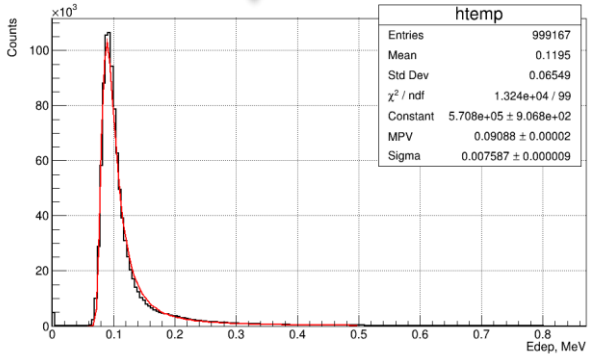




- Expected completion: 1 day

# Data workflow in simulations




- Expected completion:
  - 2 weeks + 2 days + 1 day + 2 days + 1 day ≈ 3 weeks for simplest case
  - 2 weeks + 2 days + 1 week + 2 weeks + 1 day ≈ 5.5 weeks for more complex case

~~FreeCAD~~ → GEANT4 → ROOT Data Analysis Framework

- ***experimental setups*** with individual files for each configuration

  challenge: switch between experimental layouts
- ***full response of the sensor*** and the test beam setup with high statistics

  challenge: choose/construct physics list, write data to file
- ***data analysis*** of the sensors is performed using **ROOT** framework

  challenge: extract physical quantities matching foreseen experimental data