

LAB on Simulation

RD51 School

27/11/2023 – 01/12/2023

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Simulation Frameworks



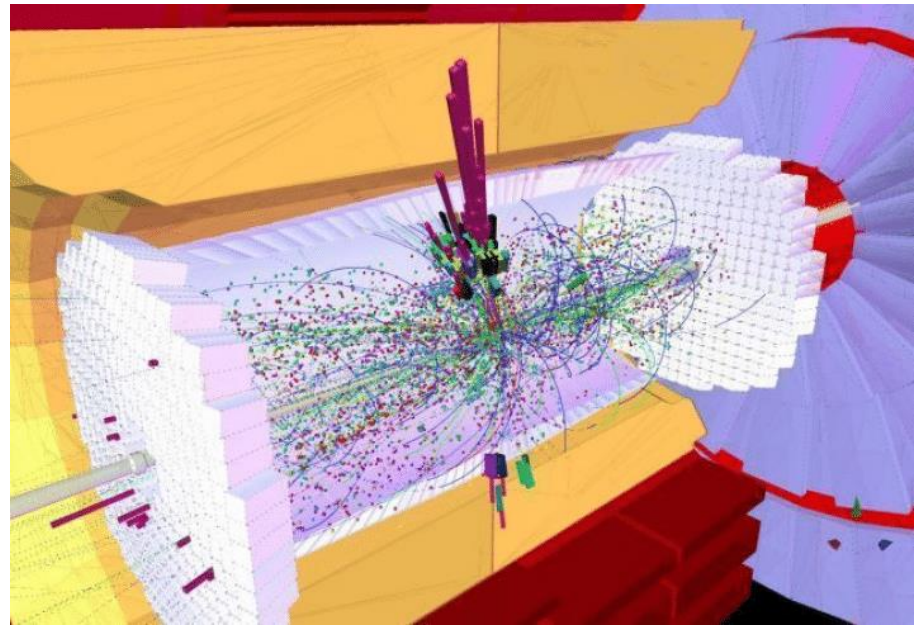
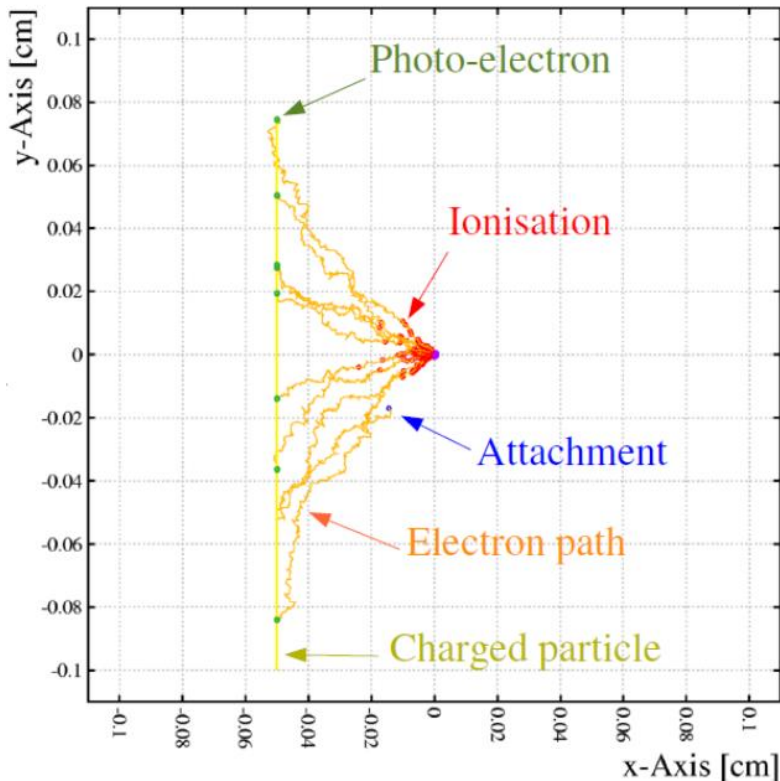
• Garfield

- Originally in Fortran
- Developed in '90ies by Rob Veenhof to simulate drift chambers
- Provides analytic solutions for Electric Field in 2D geometries
- Tracks electrons and ions in gas using v_{drift} , α , σ^+ , σ^- (gas properties from Gas table calculated with Magboltz)
- For MPGDs: Added Microscopic Tracking
- Rewritten in C++
- Interface with HEED (Primary Ionization) and Magboltz

• GEANT

- Originally in Fortran (GEANT 3) then C++ (4)
- Tracks particles through geometry with materials
- Calculates energy loss in materials
- Simulated Hit = Energy deposit in sensitive medium
- Maintained / developed by GEANT4 collaboration
 - Extensive validation
- Does not simulate what happens with electrons created in energy deposit

Simulation Frameworks



Simulation Toolbox

- Toolbox of Simulator / Physicist:



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ROOT
Data Analysis Framework



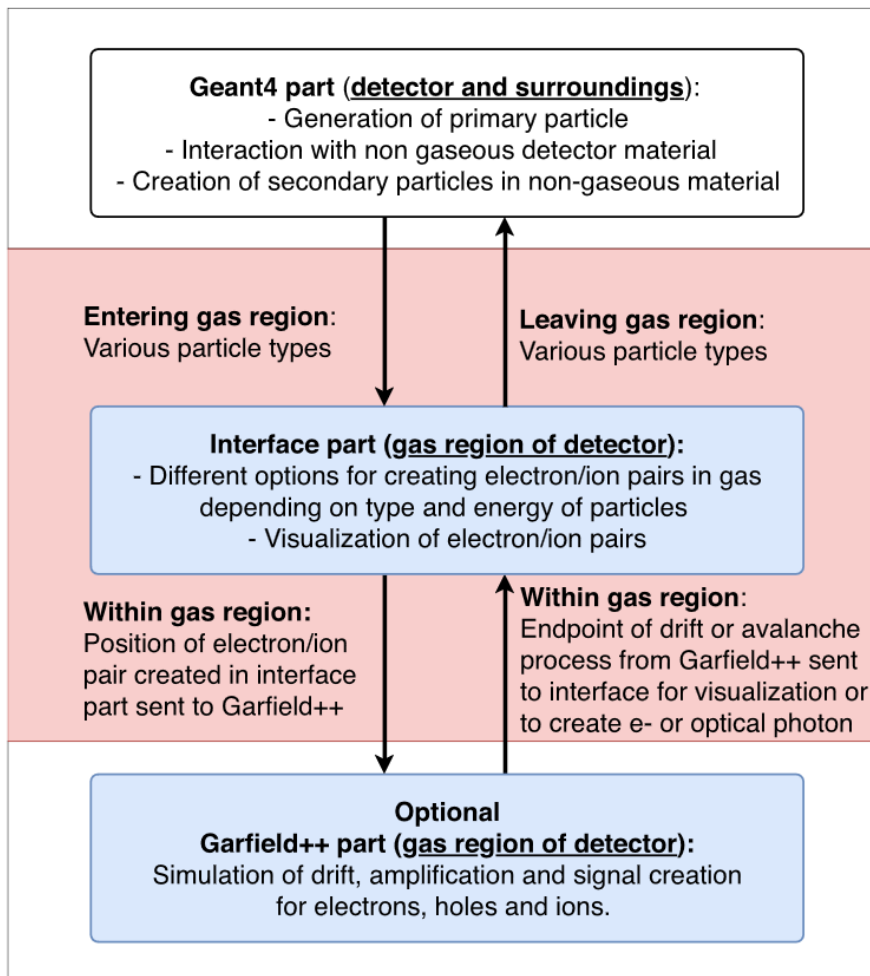
python™

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GEANT4
A SIMULATION TOOLKIT

Garfield – GEANT4 Interface




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Interfacing Geant4, Garfield++ and Degrad for the simulation of gaseous detectors

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User need to define when and how to hand over information from GEANT to Garfield

Useful for detailed simulation of:

- Testbeam environment (beam is not clean)
- Neutron / Photon detectors
- Not-understood effects in the detector assuming only muons / MIPs

Garfield++

- Open-source toolkit for detailed simulation of charge transport and signals in particle detectors
- Can now simulate also semiconductor devices
- Typical steps:
 - Calculate static electric fields
 - Simulate Primary ionization (electron-ion pairs)
 - Simulate the trajectories of Primary and Secondary e-
 - Including multiplication if field $>$ critical value
 - Calculate current induced on a readout electrode

Garfield++

material properties

- gases → Magboltz
- semiconductors

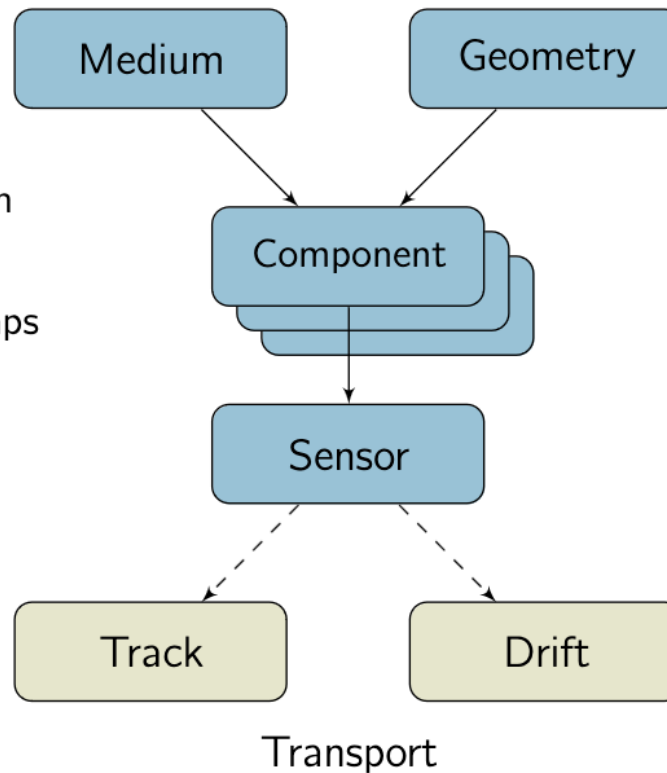
field calculation

- analytic
- field maps
- neBEM

primary ionisation

- Heed
- SRIM, TRIM
- Degrade

detector description



charge transport

- microscopic
- MC
- RKF

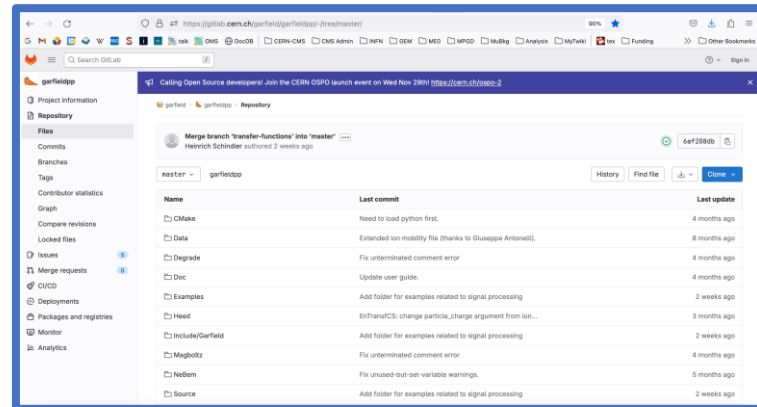
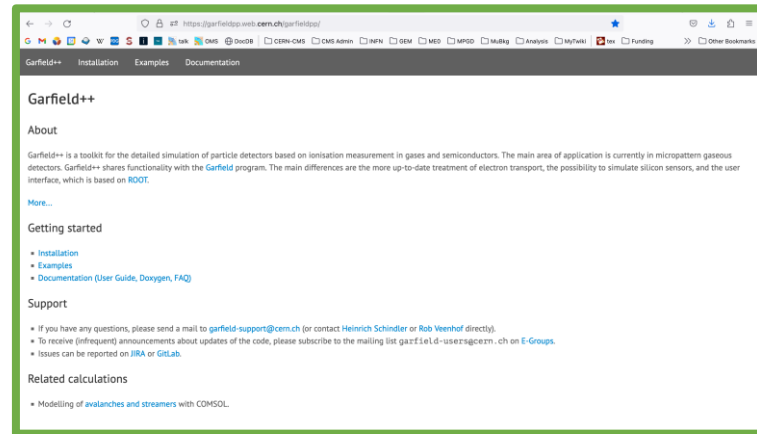
Your Friends:

Garfield++ User Guide



Version 2023.4

H. Schindler



Your best friends: the Holy Trinity: **The Manual**, **The Source Code**, **The Examples**

- *Maybe also your tutors - we will do our best 😊*
- <https://garfieldpp.web.cern.ch/garfieldpp/documentation/UserGuide.pdf>
- <https://gitlab.cern.ch/garfield/garfieldpp/-/tree/master/>
- <https://garfieldpp.web.cern.ch/garfieldpp/documentation/>

Prepared Exercises

- Exercise 1 :: install Garfield, Electric Fields (plot V , E)
- Exercise 2 :: Simulate Primary Ionization (calculate N_{prim})
 - *Homework: find the Bethe-Bloch function for energy loss*
- Exercise 3 :: Electron transport (plot v_{drift} , track e^- in detector)
 - *Homework: Evaluate the diffusion as function of the distance*
- Exercise 4 :: Gas Gain (simulate avalanche in Single-GEM)
 - *Homework: find the gain curve for a single-GEM detector*
- Exercise 5 :: Signal Induction in Parallel-Plate Avalanche Counter
 - *Homework: find the signal in a single-GEM detector*
- Exercise 6 :: Gain in a Triple-GEM detector
- Exercise 7 :: Parametrized simulation of a Triple-GEM detector

Contact - Questions

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