Tutorial #5: FCC-ee Noble Liquid Calorimeter Full Simulation

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FCCSW Hands on tutorial
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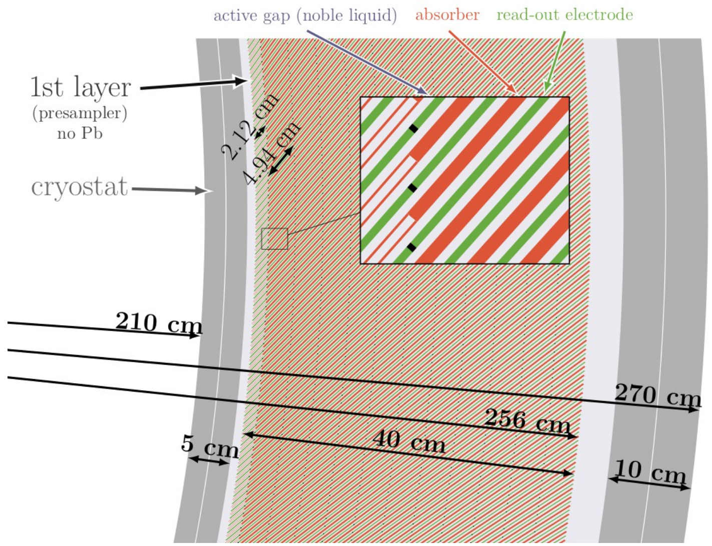
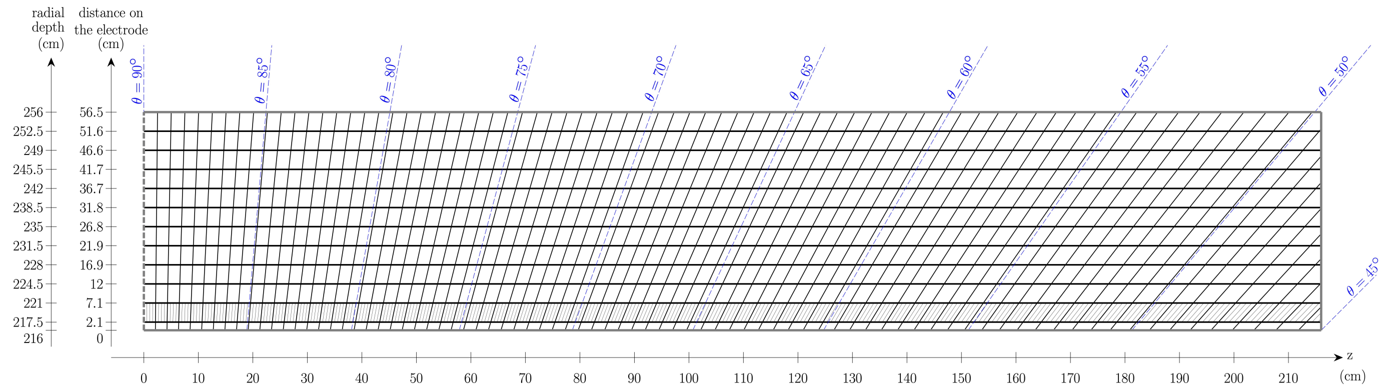
What is tutorial #5 about?

- Detector **requirements** can be determined to a large extent via **parametrized/fast simulations**
- **Full simulation** is THE way to evaluate the **performance** of a detector design and **optimize** it
- Tutorial #5 is about running various aspects of the **Full Sim** framework used to **optimize** the **FCC-ee noble liquid calorimeter**
- You will learn how to
  - **Generate** particle gun events
  - **Run** the calorimeter **reconstruction**
  - Evaluate **performance**
  - Apply **corrections**
  - Simulate **noise**
  - **Modify** the detector **geometry**
  - **Profile** the code (per module computation time)
  - …

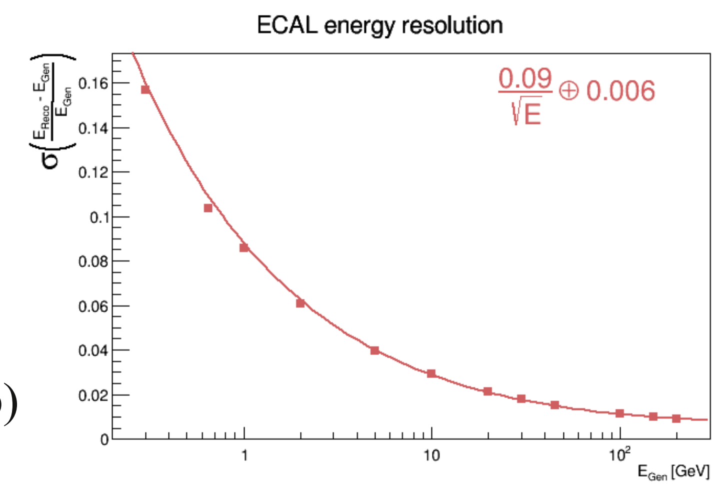
Detector Geometry

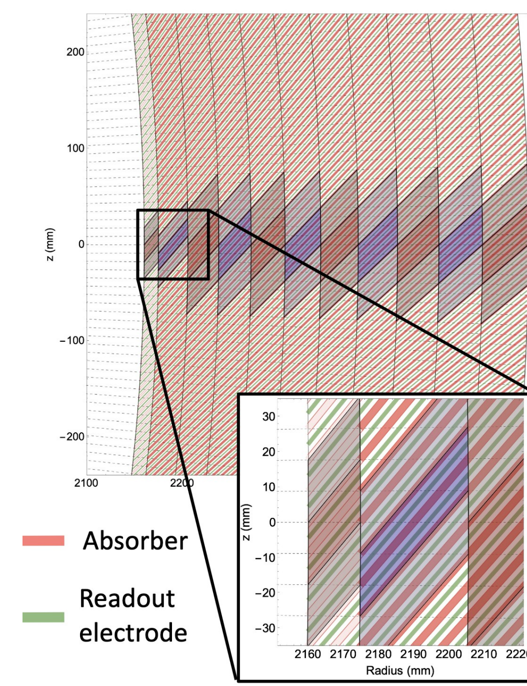




FCC-ee High Granularity Noble Liquid ECAL Barrel

- Sampling calorimeter
- 1536 **straight inclined** (50°) 1.8 mm **Pb** absorber arranged in Φ
- **1.2 - 2.4 mm LAr** sensitive media
- 40 cm deep (22 X_0)
- $\Delta\theta$ = 10 (2.5) mrad for regular (strip) cells, $\Delta\Phi \geq$ 8 mrad, 12 longitudinal compartments (Δr=3.5 cm)
- Aluminum cryostat (5 cm inner, 10 cm outer)

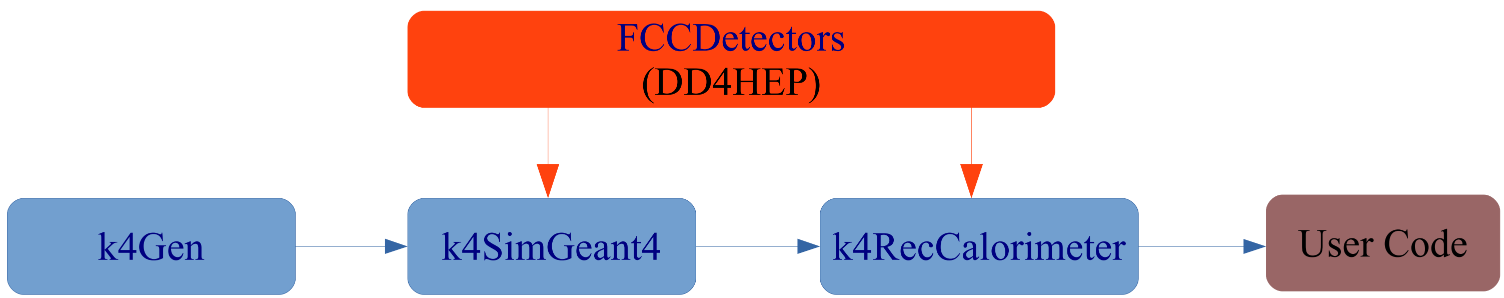




Simple simulation and performance

Exercises 1 to 4

- Various Key4hep repositories will be at play
  - Produce 10 GeV γ gun events, run calorimeter reconstruction on it and produce energy resolution plots
  - Modify detector geometry xml to replace liquid Argon by liquid Krypton
  - Assess the difference between the two scenarios and witness the need for correction



k4Gen:

Monte Carlo Generation

Physics collision or Particle Gun

k4SimGeant4:

Detector description

Particle interaction and propagation

Energy deposits

k4RecCalorimeter:

Energy deposits per physical cells/readout channel

Noise

Corrections (sampling fraction, dead material correction)

Clusterings

User Code:

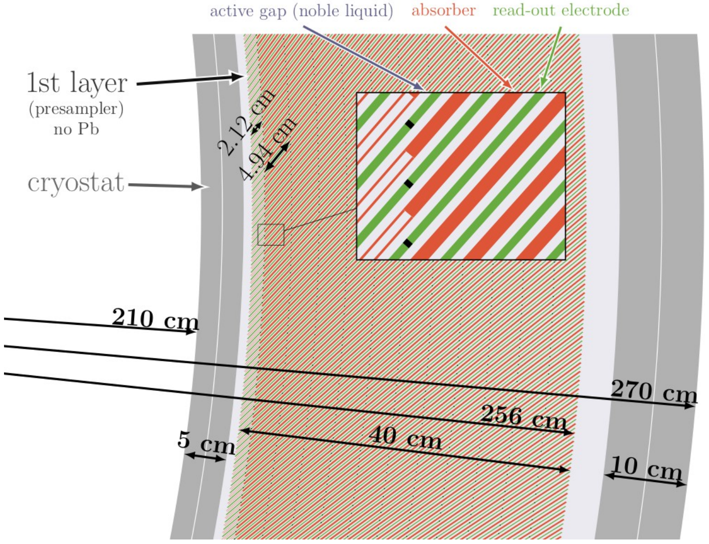
Performance studies

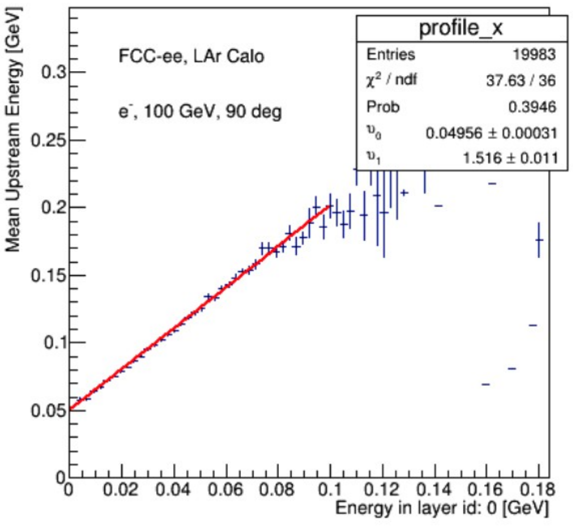
Partially provided

Applying corrections

Exercise 5

- Some energy is deposited in non-sensitive regions
  - Simple scaling can recover the correct energy response but
  - Stochastic nature of the amount of energy deposited in a given region smears the energy response and degrades the energy resolution
  - With a finely segmented calorimeter, we can do better!
  - **Strong correlation** between energy in first(last) sensitive layer and energy deposited upstream(downstream)
- You will learn how to apply this event by event correction for energy deposited in dead (non sensitive) material and witness its effect
  - Adding new algorithms to the sequence
  - Modifying the content of the output collection





Going further

Exercises 6, 7 and bonus

- Apply **noise** and evaluate its impact
- Generate **π^0 events**
  - Those samples will be used for tutorial #6 (π^0/γ identification)
  - Make sure you follow tutorial #5 if you want to attend tutorial #6
- Learn how to exploit calorimeter longitudinal segmentation
  - Produce **shower longitudinal energy profile**
  - Compare π^0 and γ profiles
- All in all you will
  - Get a first contact with **realistic detector optimization software**
  - Set the ground to become an active contributor
- Exercise documentation with quiz: LINK

See you all on **Friday morning!**