Simulation of IDEA

Lorenzo Capriotti
on behalf of the IDEA software group

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Fast and full simulation

DELPHES

- Modular framework for a parametrised detector response
- Fast simulation, fully implemented

GEANT4

- Classic simulation software
- Standalone simulation fully interfaced to Key4HEP
- Full simulation, almost fully implemented

DD4HEP

- A more modern framework
- Can be used also for trigger, reconstruction, alignment...
- Full simulation, implementation in progress

DELPHES

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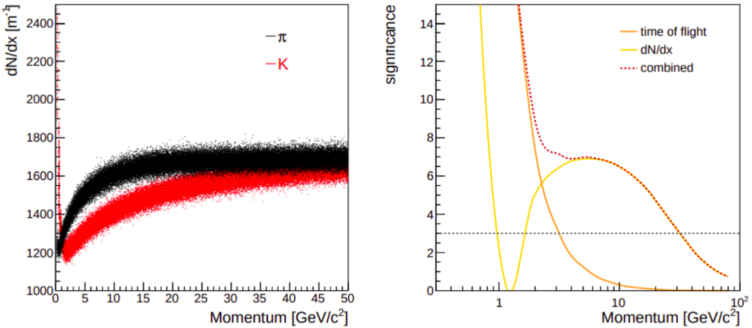
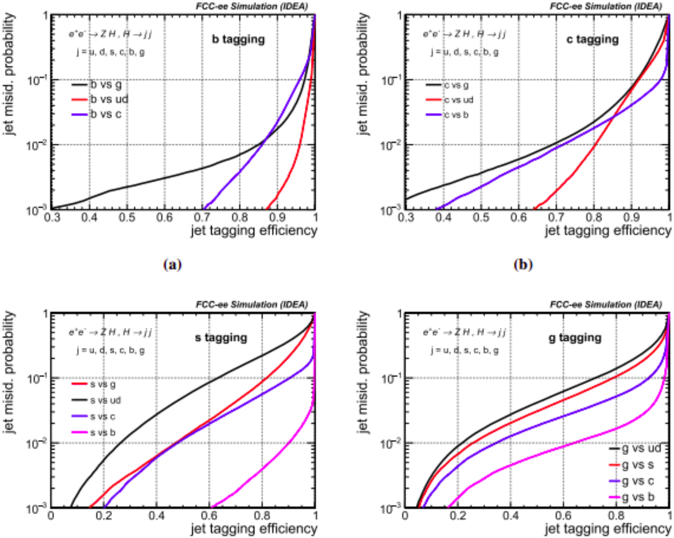
IDEA detector fully implemented in DELPHES

- On average $O(10^4)$ times faster than full simulation
- Track Smearing included to simulate material impact
- Track Covariance module included to calculate the full covariance matrix
- PID tools (dE/dx and dN/dx, timing) included
- Durham Jet Clustering implemented, using the Valencia algorithm



DELPHES: flavour tagging

Nice flavour tagging algorithm implemented, see [EPJ C 82, 646 (2022)]



GEANT4: tracking system

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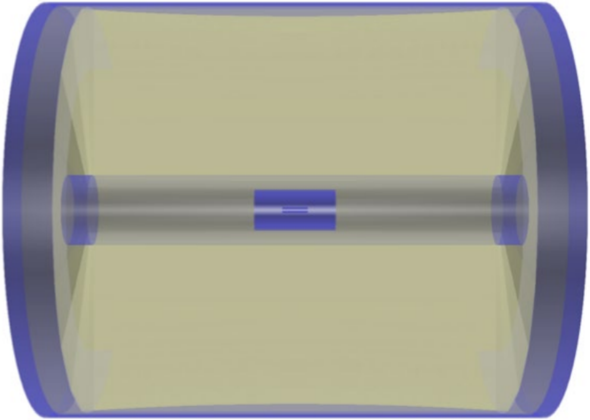
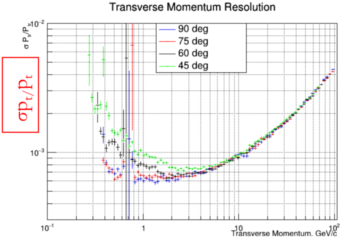
- Si vertex, Si wrapper and preshower are simulated as simple layers
- Drift chamber simulated good level of geometry details, including wires and detailed description of the endcaps
- 56448 cells ($\approx$1.2 cm) for a total of 343968 wires



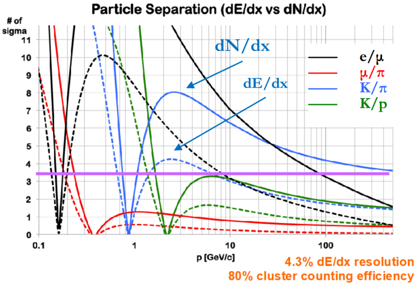
GEANT4: tracking system

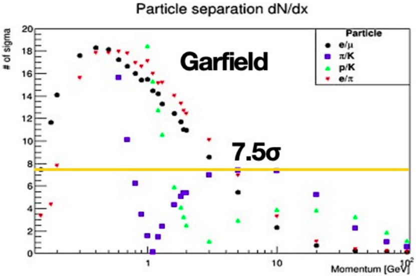
Expected performances:

- Good p_T resolution, from $\approx 0.1\%$ at low p_T up to 0.5% for $p_T = 100$ GeV
- $> 99.5\%$ of tracks are reconstructed with $> 60\%$ good hits

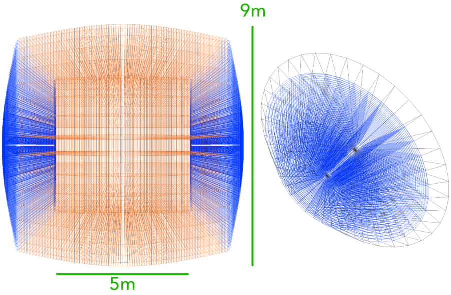


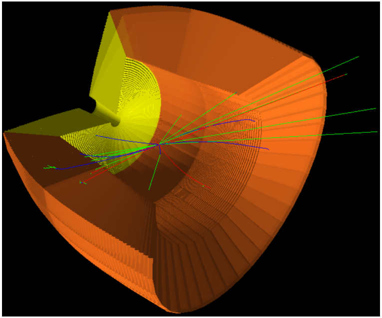
PID with a cluster counting technique is under study by using simulations and beam-test data, see [Nicola's talk] at ECFA workshop





GEANT4: dual-readout calorimeter



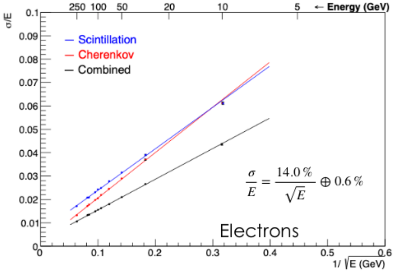


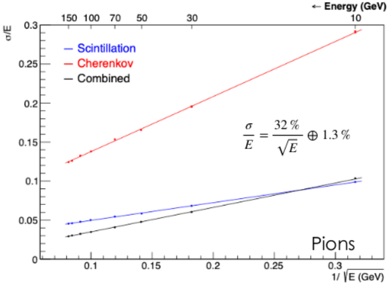
54000 Cu towers with high-granularity scintillating and Cherenkov fibers

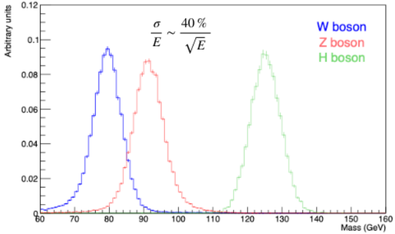
- $\frac{10\%-15\%}{\sqrt{E}}$ EM energy resolution
- $\frac{25\%-30\%}{\sqrt{E}}$ single-hadron energy resolution (also neutral)
- 5% jets energy resolution at 50 GeV
- $< 1\%$ linearity in FCCee energy ranges for e^-, γ, hadrons and jets

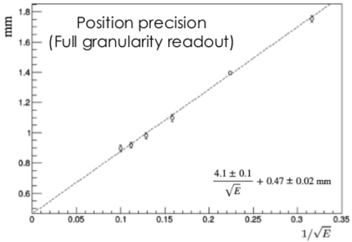
GEANT4: dual-readout calorimeter

Expected performances:

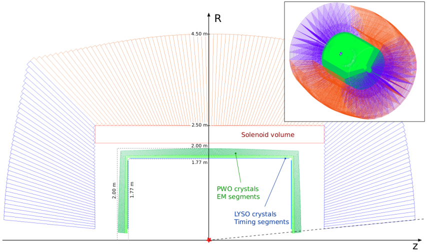






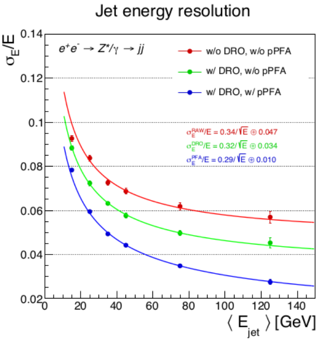


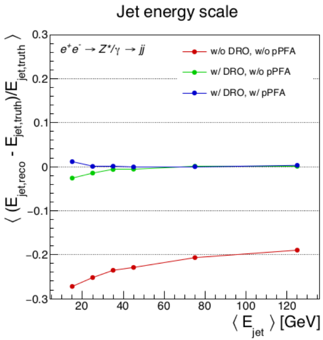
GEANT4: DR calorimeter and crystals



Integration of a crystal calorimeter option in the Geant4 IDEA simulation:

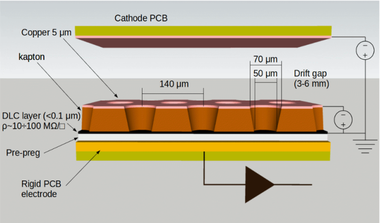
- Barrel crystal section inside solenoid
- 1x1 cm^2 PWO segmented crystals granularity
- Radial envelope $\approx 1.8 - 2.0$m

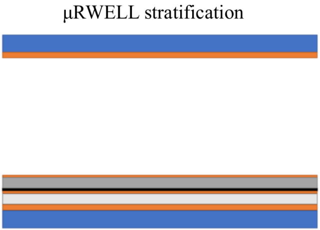




GEANT4: preshower and muon counters

Based on the μRWELL technology

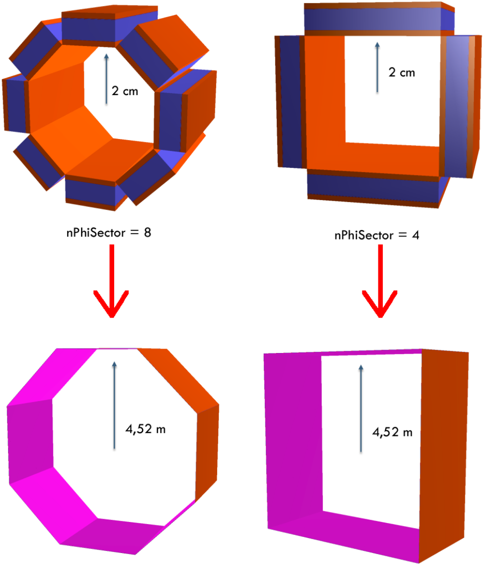




- Only barrell is present in the official framework
- Preshower is simulated as a uniform cylinder with smeared hits
- Holes and strips are taken into account by simulating an effective material density for the relevant layers

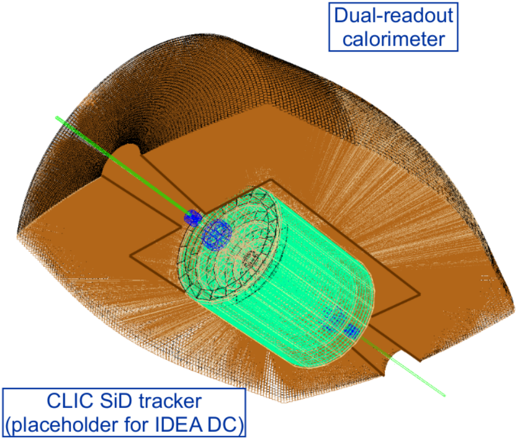
GEANT4: preshower and muon counters

Material stratification implemented



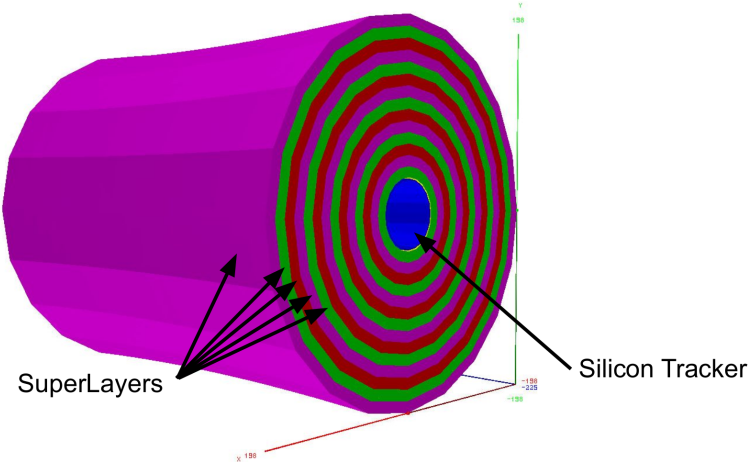
DD4HEP: dual-readout calorimeter

Geometry description already implemented, to be coupled with a DD4hep description of the IDEA Drift Chamber



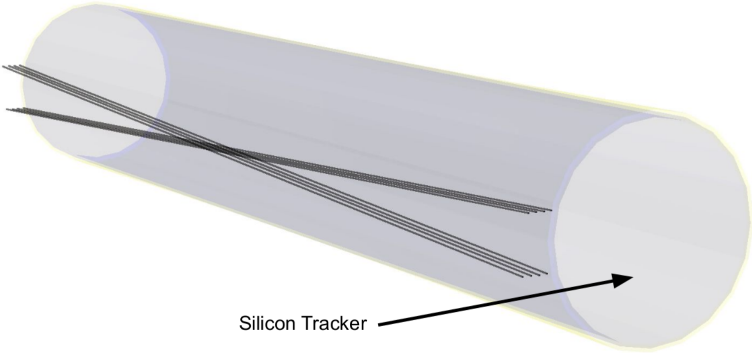
DD4HEP: drift chamber (SuperLayers)

Drift chamber geometry migrated from geant4, almost complete
Gas volume is divided into 14 hyperboloid "SuperLayers"



DD4HEP: drift chamber (Layers)

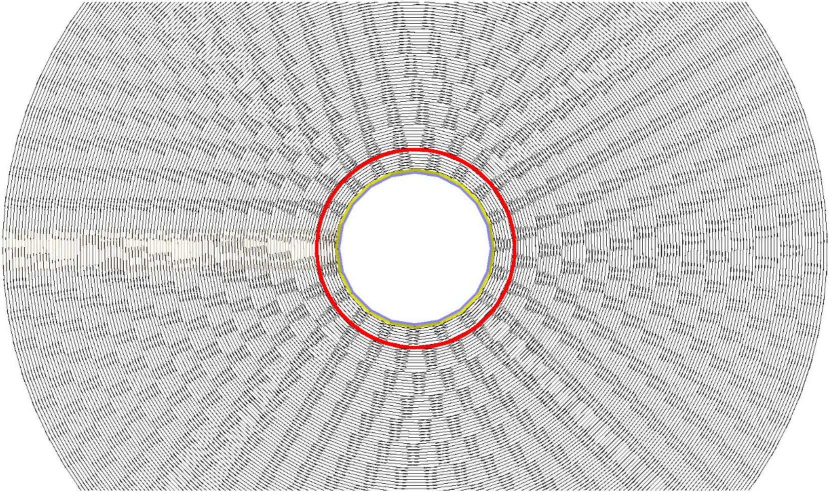
Each SuperLayer is divided into 8 Layers: 4 for wires with stereo angle +30° and 4 for wires with stereo angle -30°



Wire radius here is x100 the actual size

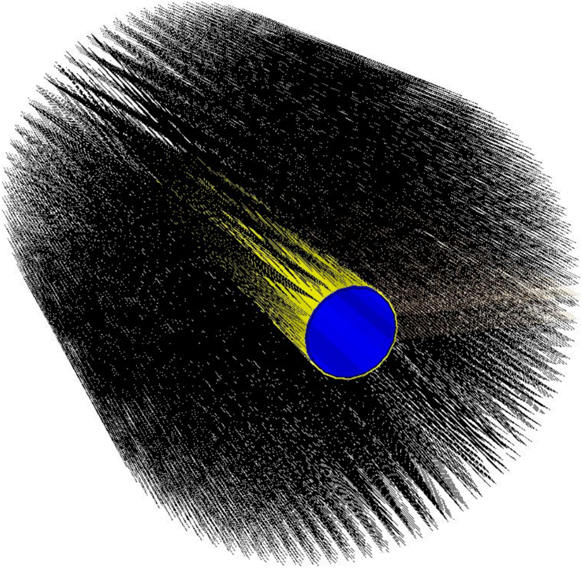
DD4HEP: drift chamber (ortographic view)

Ortographic view, the first SuperLayer is in red
The figure only shows about 2% of all wires.



DD4HEP: drift chamber (perspective view)

Perspective view from above. The figure only shows about 2% of all wires.



Conclusions

A fast simulation in DELPHES is fully operational

- Inlcudes track smearing, PID, jet clustering, flavour tagging...
- Versatile and extremely fast!

The Geant4 description is almost complete

- Only μRWELL missing (preshower, muon counters)
- Expected performances for calo and tracker are very good and in line with IDEA requirements

The DD4hep description is on its way

- For now we only have a description of the calo
- Drift chamber is almost ready; a first test of synchrotron radiation background for drift chamber to be expected very soon
- Si vertex also work in progress