IDEA concept Simulation and reconstruction status

21/10/2020 CEPC Meeting

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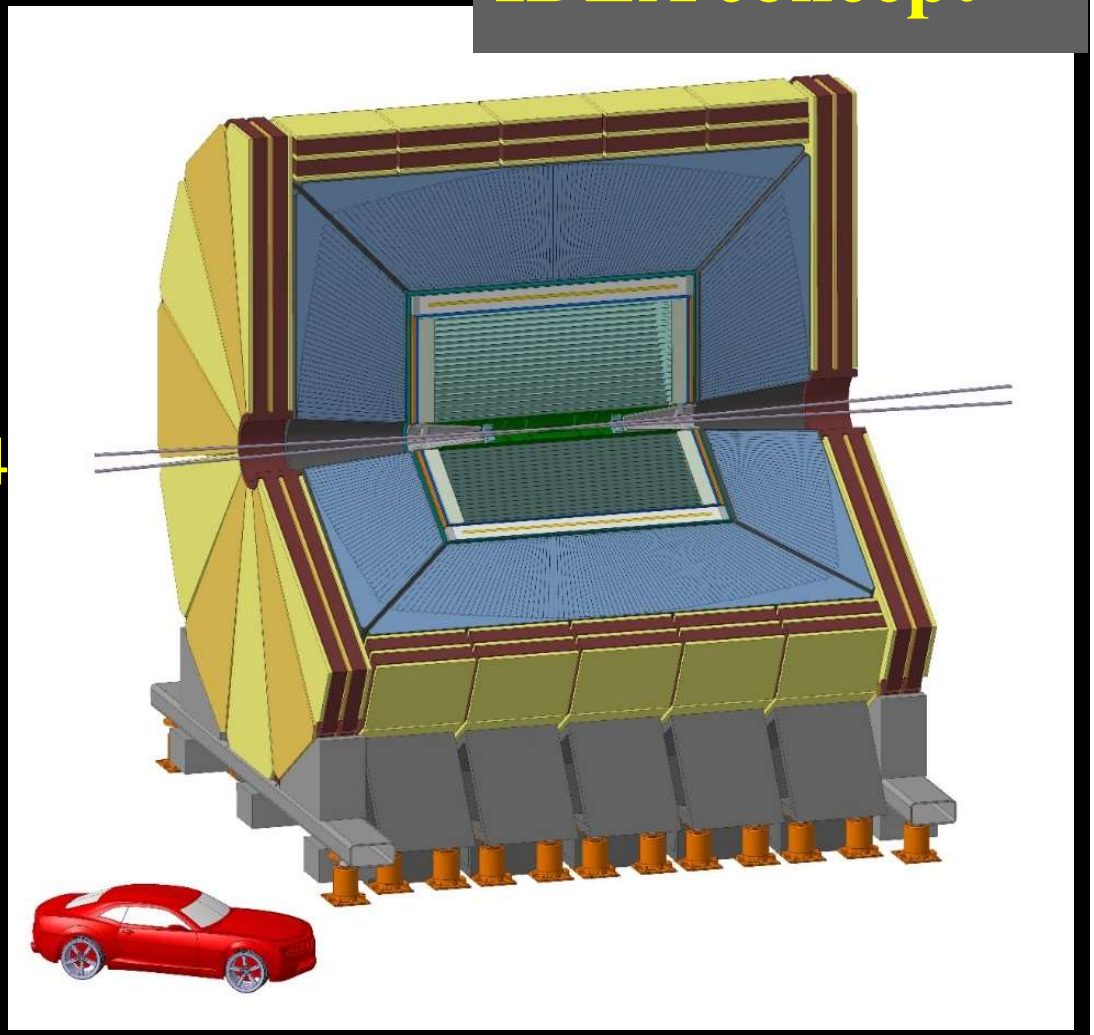
IDEA Detector concept

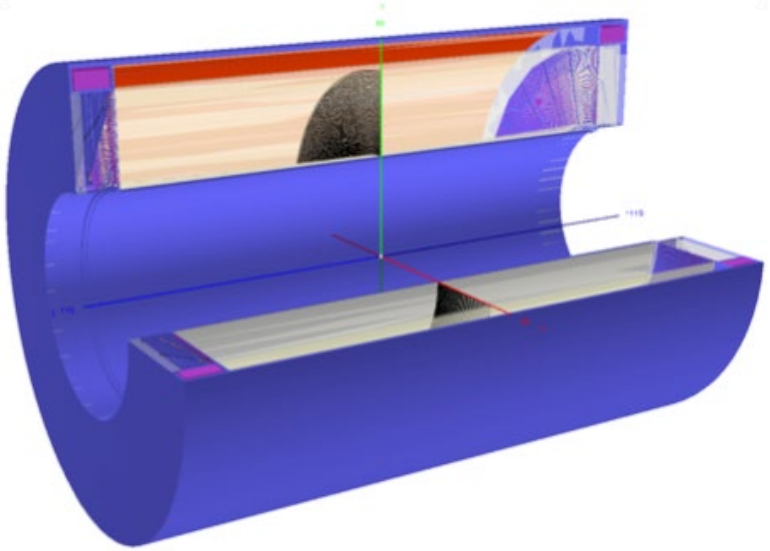
- Si pixel vertex detector
  - 5 MAPS layers
    - R = 1.7 – 34 cm
- Drift chamber (112 layers)
  - 4m long, r = 35 – 200 cm
- Si wrapper: strips
- Solenoid: 2 T - 5 m, r = 2.1-2.4
  - 0.74 X_0, 0.16 λ @ 90º
- Pre-shower: μRwell
- Dual Readout calorimetry
  - 2m deep/8 λ
- Muon chambers
  - μRwell

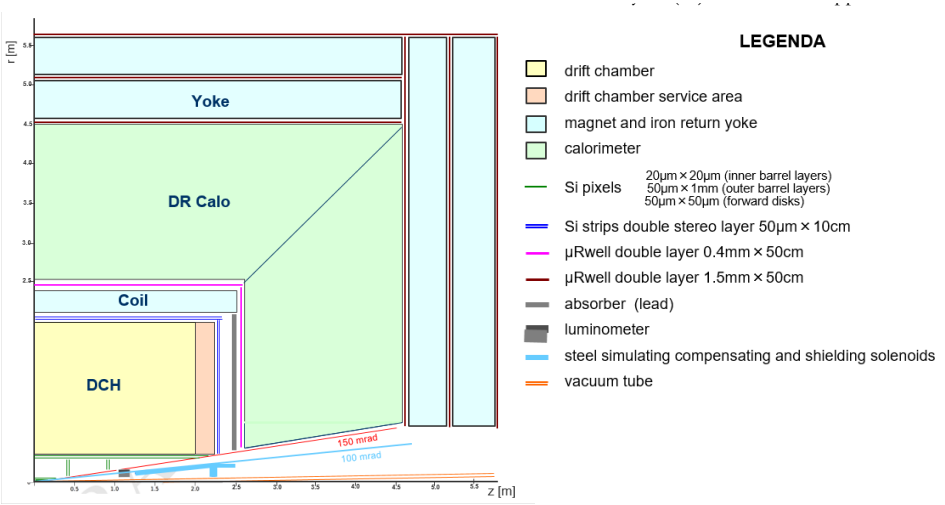
IDEA concept



IDEA Tracking System Layout

- Drift Chamber detailed Full Simulation with Geant4, hit creation and track reconstruction code available
- New: To investigate the potential of Cluster Counting technique (for the He based DC) on physics events needs to validate the simulation from Garfield/Geant.
  - Results based on Garfield simulations in a 1 cm cell of the IDEA drift chamber and for 1 m track lengths. Longer tracks under simulation.
  - Comparison with Geant4 simulation in progress



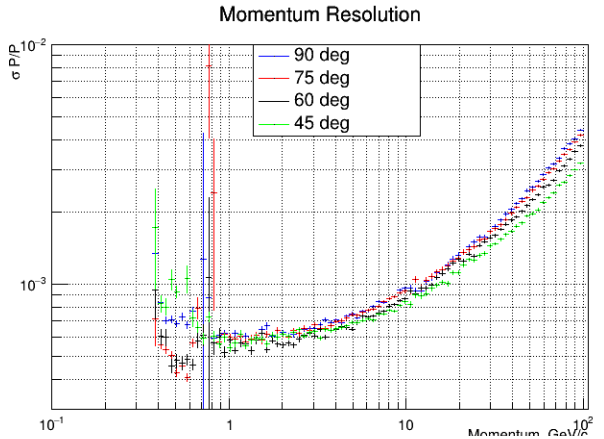


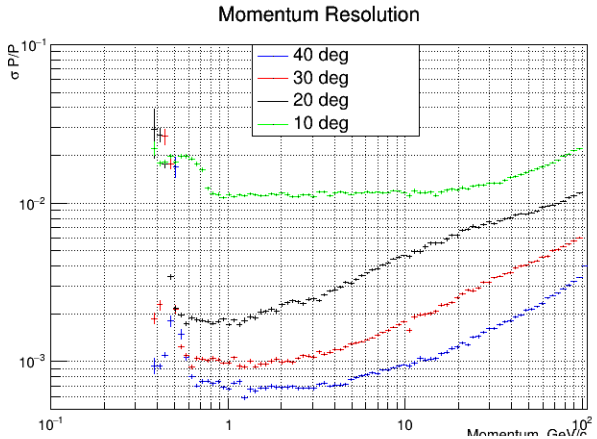
Expected Tracking Performance

BARREL:

FORWARD:

p

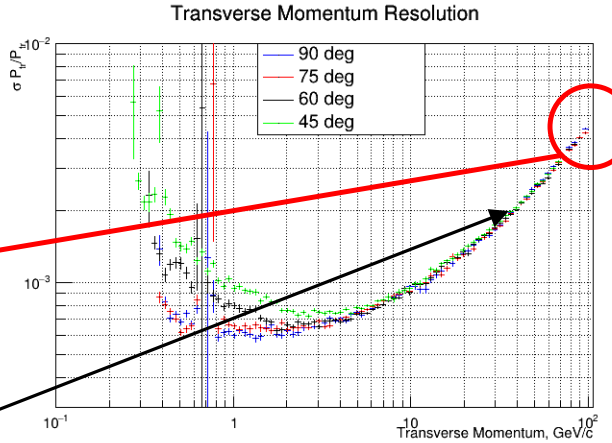


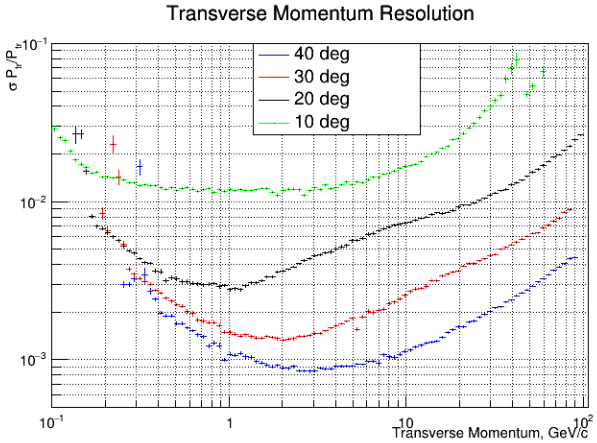


p_t

$$\frac{\sigma_{p_t}}{p_t^2} = 4 \bullet 10^{-5}$$

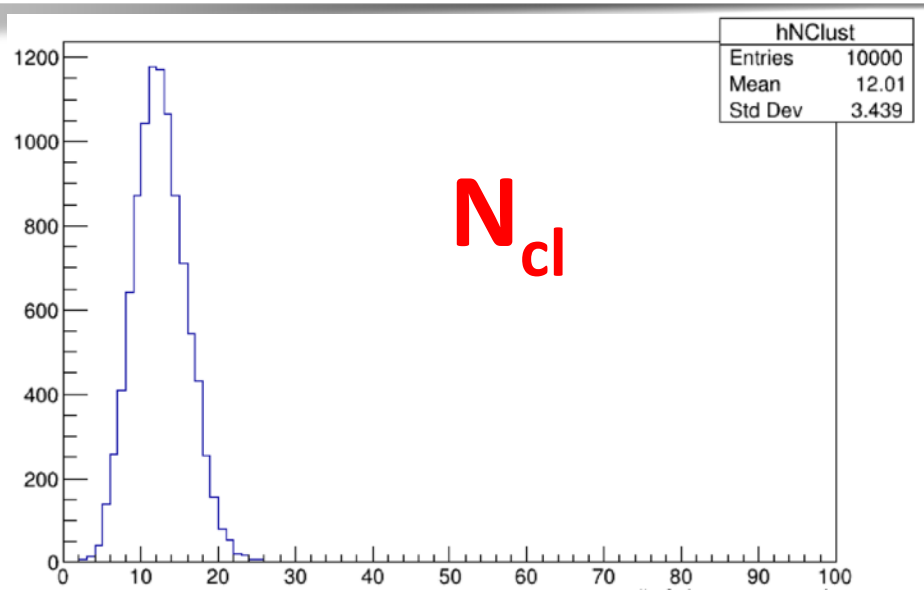
$$\frac{\sigma_{p_t}}{p_t^2} = 5 \bullet 10^{-5}$$





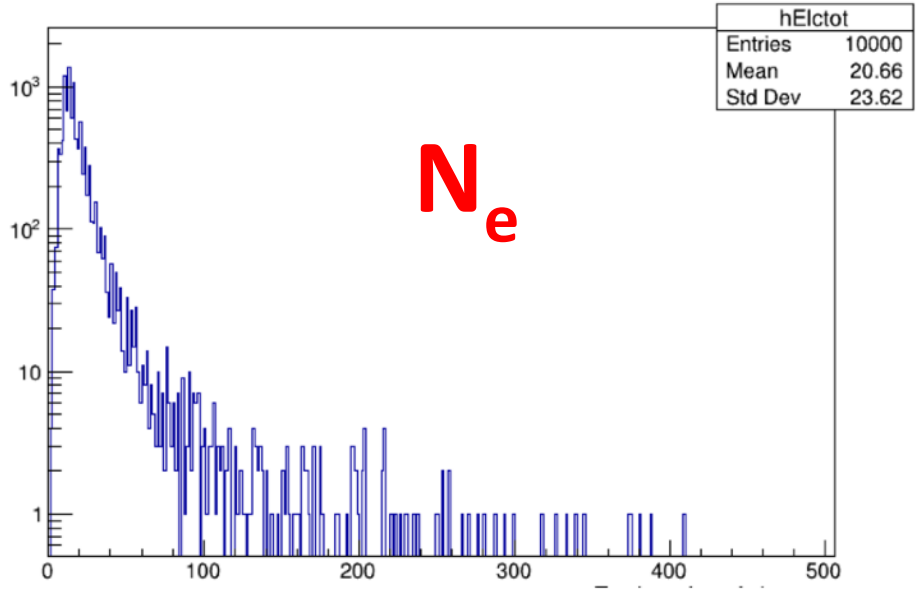
NOTE: the tracking resolution is with a pessimistic silicon resolution. If you use what has been used by both CLD and the CEPC baseline the resolution asymptotic is 3x10^-5 rather than 4x10^-5

Clustering Studies With Garfield



Number of ionization **clusters** in 1 cm of He/iC_4H_{10} for a 300 MeV/c muon

Notice the Poisson nature of the distribution: Std Dev = sqrt(Mean)

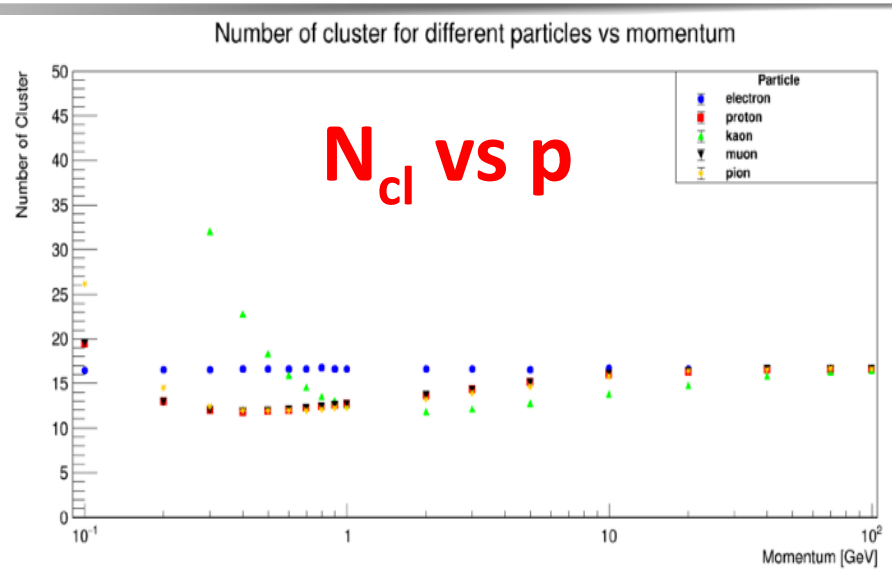


Number of ionization **electrons** in 1 cm of He/iC_4H_{10} for a 300 MeV/c muon

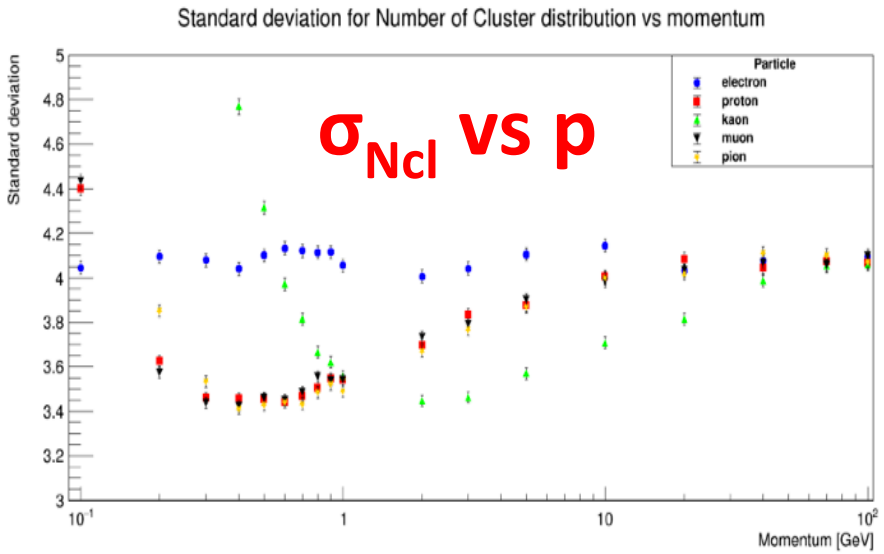
Notice the typical Landau fluctuations of the distribution.

Average number of electrons per cluster = 1.7

Particle separation in 1cm of gas



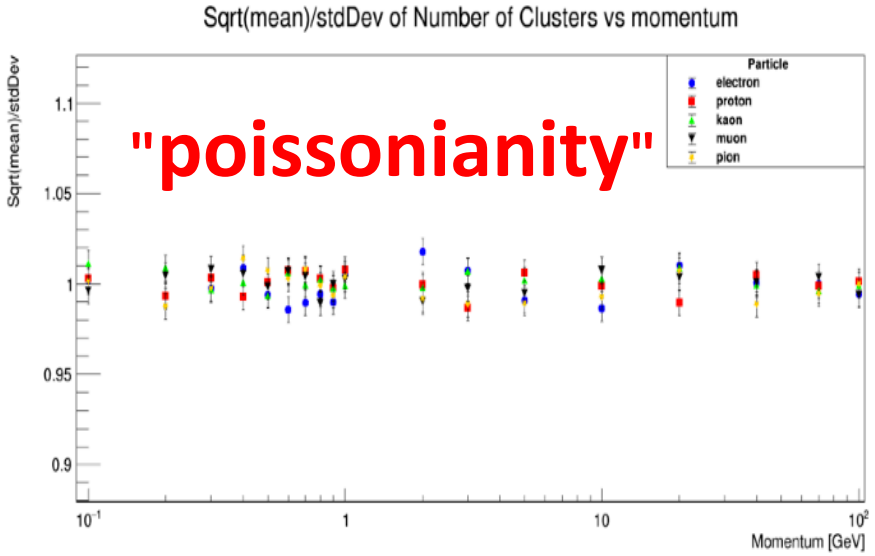
N_{cl} vs p



σ_{Ncl} vs p

Preliminary

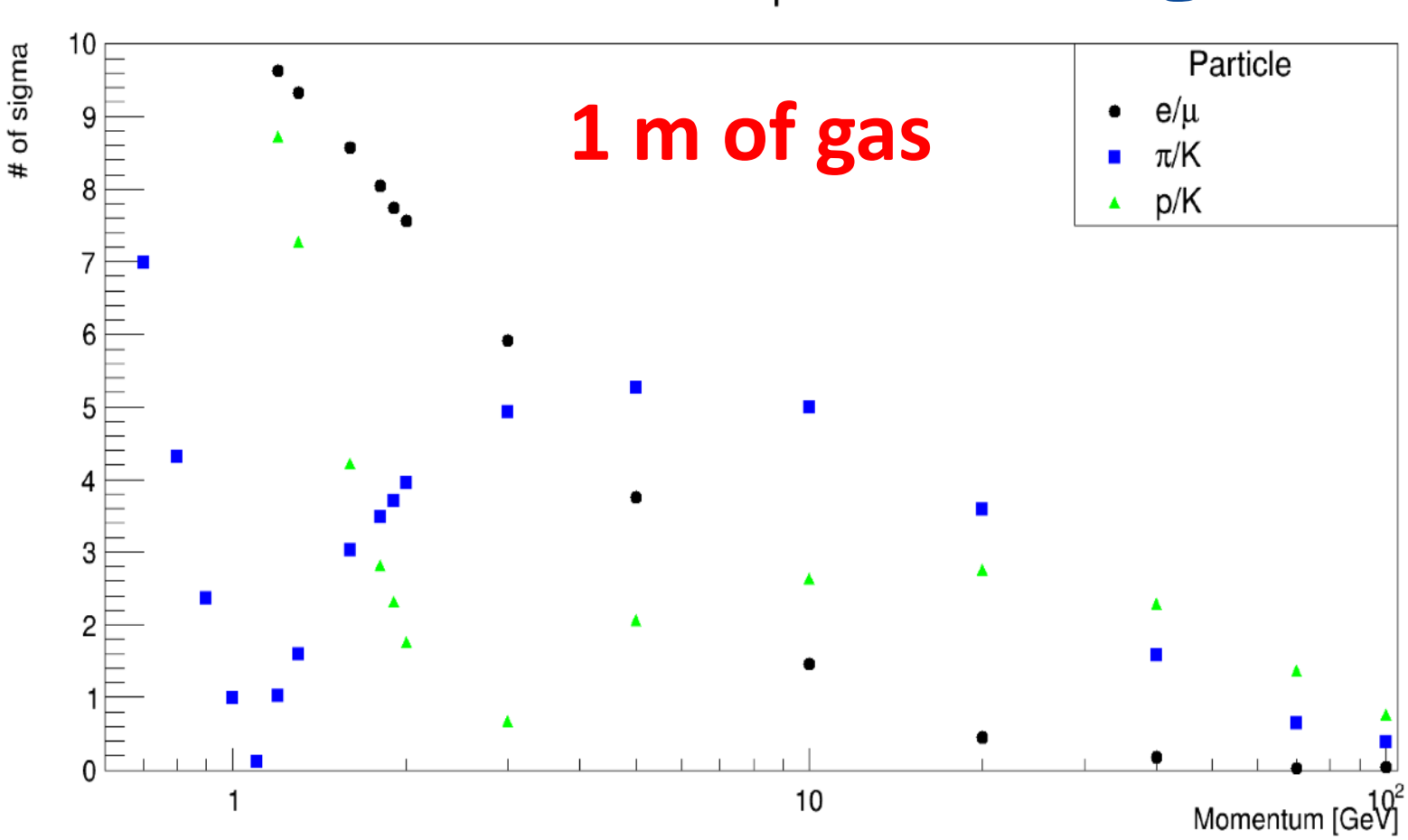
1 cm of gas



"poissonianity"

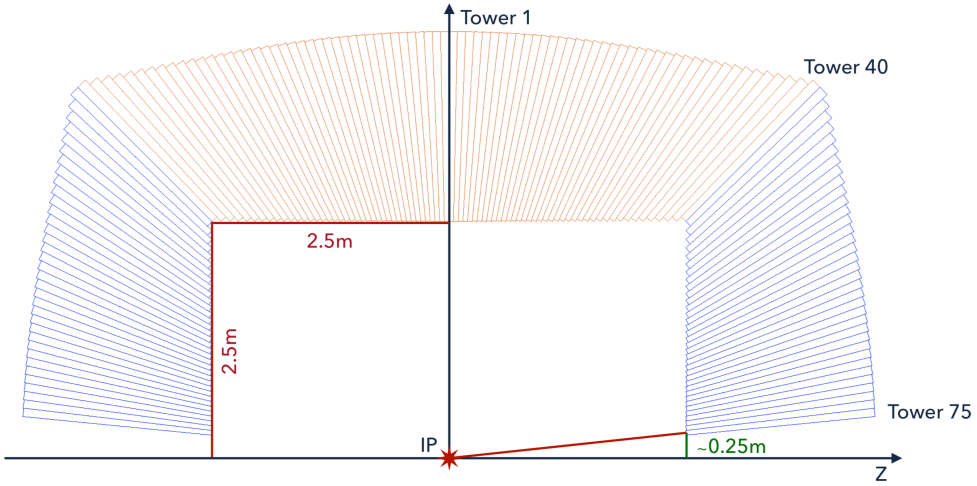
Particle Separation

Preliminary

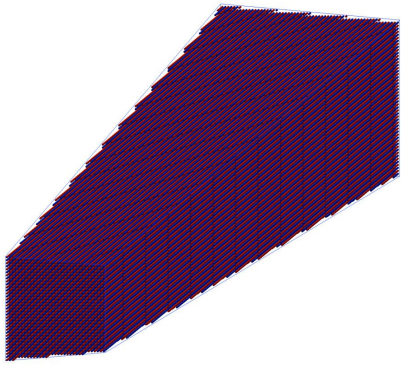


Dual Readout Calorimeter Status

- Geant4 fully projective fiber calorimeter description available in GitHub/lxplus
  - Projective towers, fibers are 1mm diameters, and 0.5mm absorber (copper) between two fibers
  - 130million fibers in the whole IDEA detector
- Performance studies with single particles, jets and physics events
- **Reconstruction code developed to reconstruct 2 jets final states. Exclusive jet clustering with N=2. Now moving on to 4 and 6.**



Geometry adapted to the IDEA drift chamber volume.



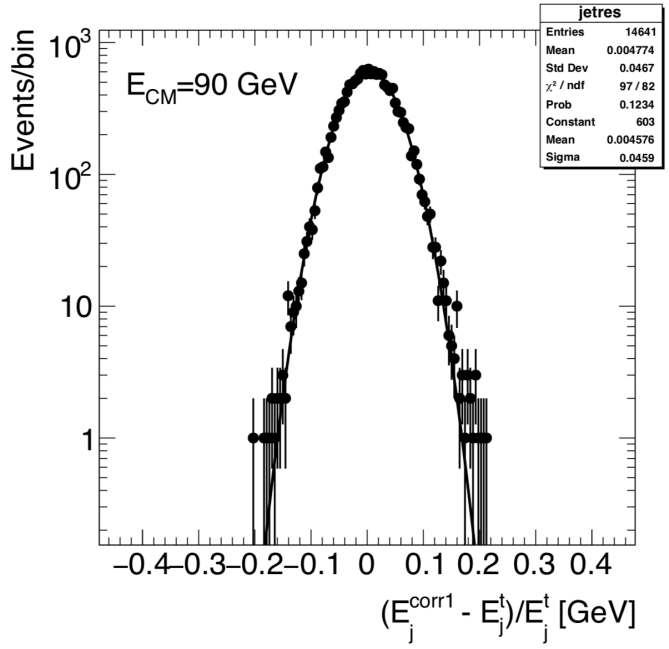
Event Reconstruction

A reconstruction code has been developed and is currently used to reconstruct 2-jet final states. Now targeting 4 and 6-jet final states.

- Studies based on 6 samples of e^+e^- -> $q\overline{q}$ produced with different E_{cm}: 30, 50, 70, 90, 150 and 250 GeV generated with PYTHIA8 and passed to the Geant4 Simulation.

- Scintillation and Cherenkov signals from each tower are fed into a single input vector of FastJet and a generalized Kt algorithm is used with a value of 2pi for the R parameter to cluster 2 exclusive jet. All energy deposits are used for jets.

- Separated Cherenkov and Scintillator jets are later extracted from the corresponding components of the FastJet output.

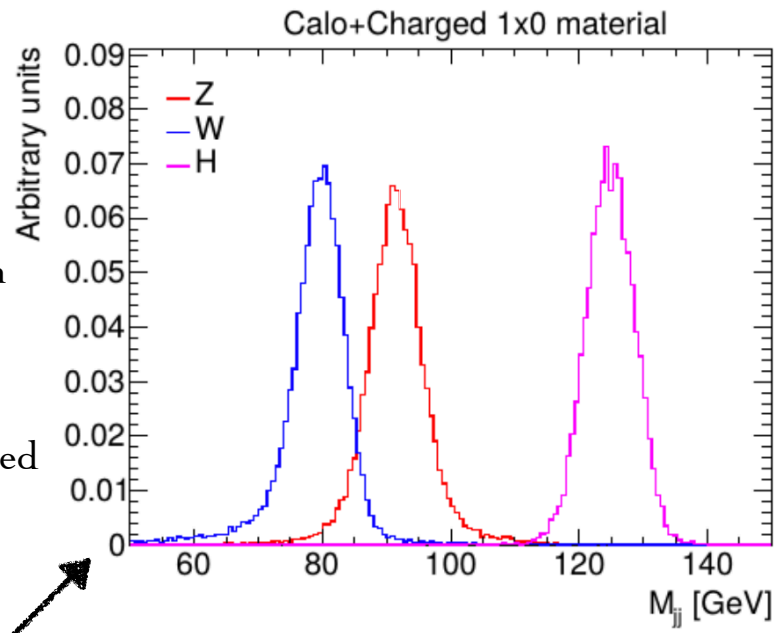


Physics benchmarks - 2 jets final state

$e^+e^- \to HZ \to \tilde{\chi}^0\tilde{\chi}^0 jj$ → Only decays to u,d,s,c
c semileptonic decays
excluded

$e^+e^- \to WW \to \nu_\mu \mu jj$ → Contribution of tagged muon
from Monte Carlo truth
subtracted from the
calorimeter signal
c semileptonic decays excluded

$e^+e^- \to HZ \to bb\nu\nu$ → b semi-leptonic
decays excluded



Still very well separated peaks when solenoid is included!

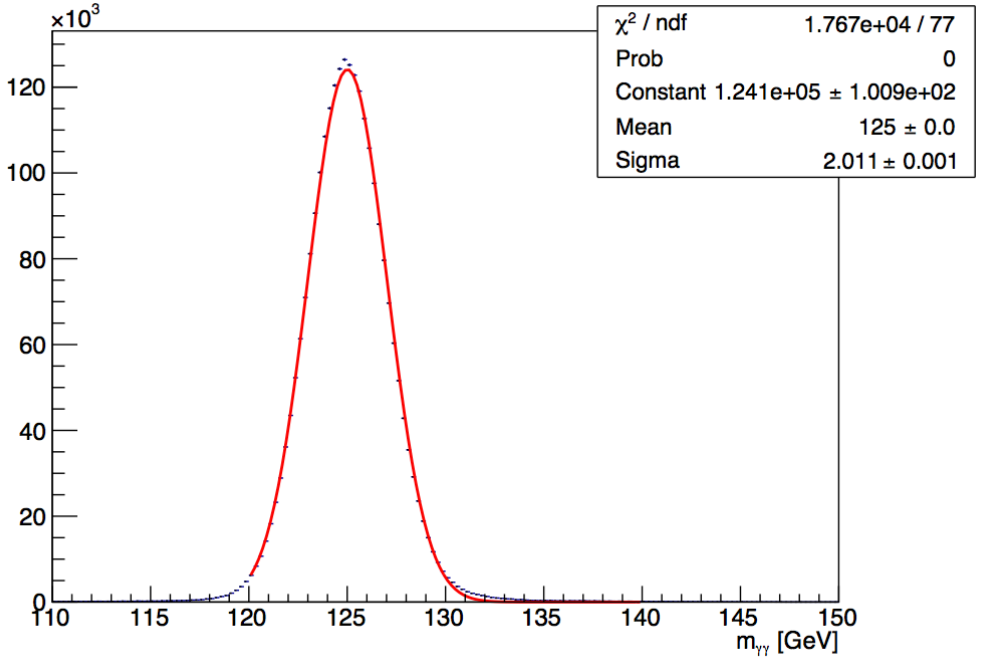
From INFN group

Physics benchmarks - 2 photons final states

$e^+e^- \rightarrow HZ \rightarrow \gamma\gamma\nu\nu$

5 million events fully simulated at Sussex University.

Starting from calibration constants estimated with particle gun, after few energy corrections, the resolution on the mass term is consistent with the single photon energy resolution.



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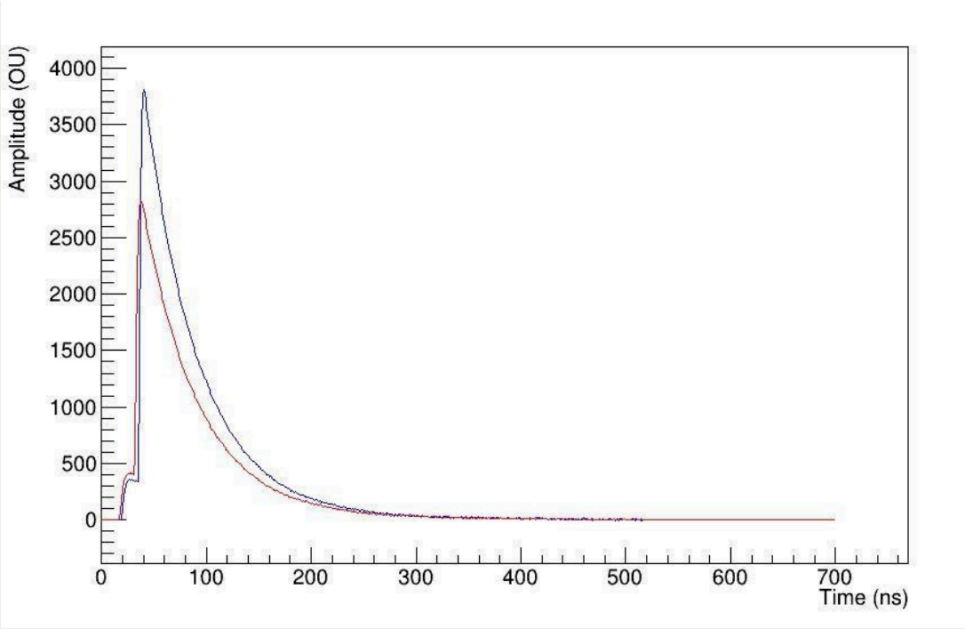
New Code development - SiPM Digitization

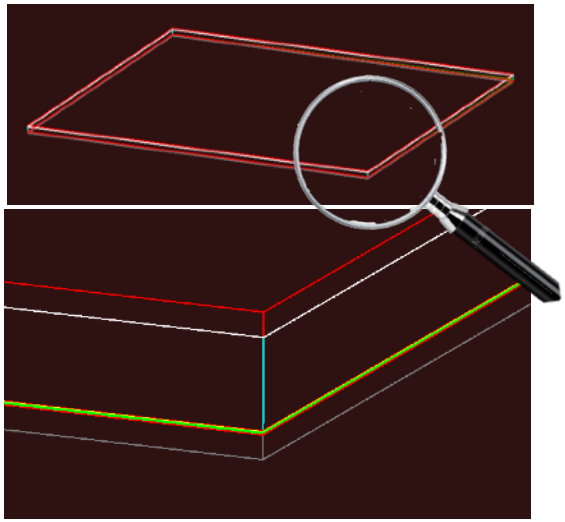
- A python based SiPM digitazion code has been developed to be used for timing studies
- Digitization includes several effects (noise, xtalk, etc) and it makes possible to extract timing information

- Example: analog sum of Cherenkov signals from 40geV electrons and pions showering in the calorimeter

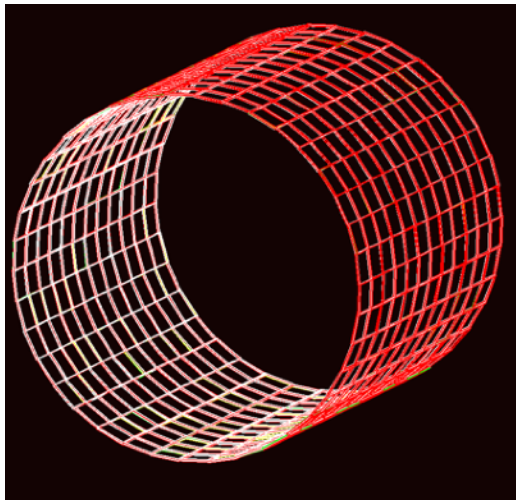


Preshower Full Simulation Status

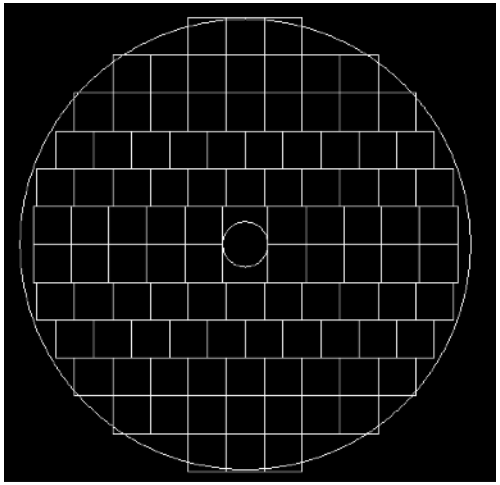
- **Implementation of a μ-RWELL detector in Geant4**
- All the materials and dimensions of a HR μ-RWELL HR-SG2++ have been considered



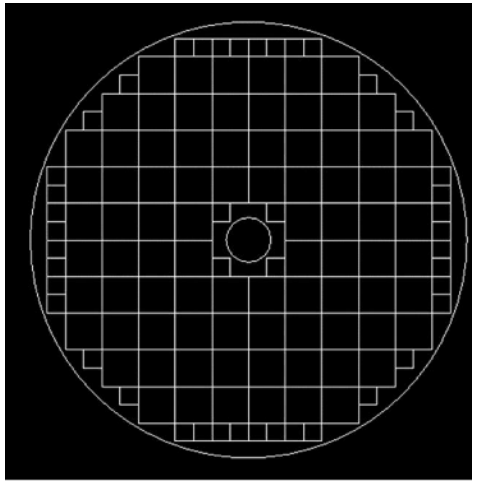
Barrel



Endcap option 1



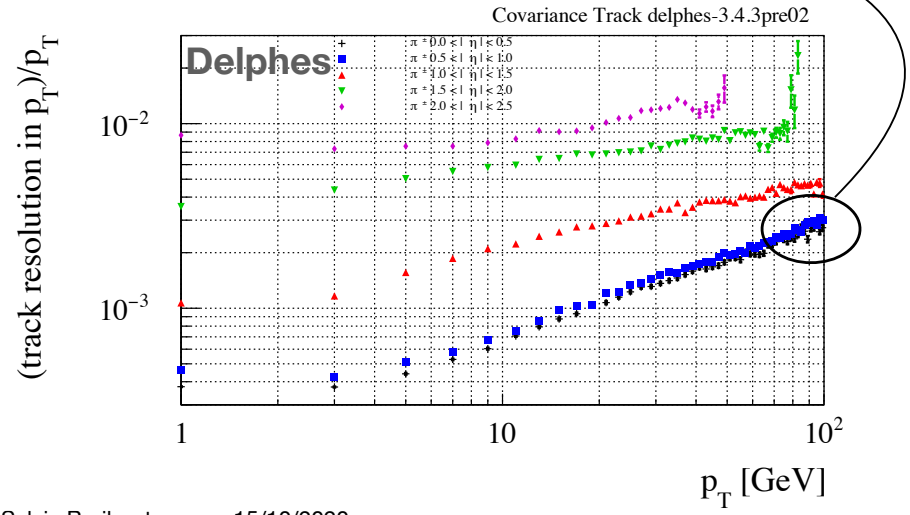
Endcap option 2



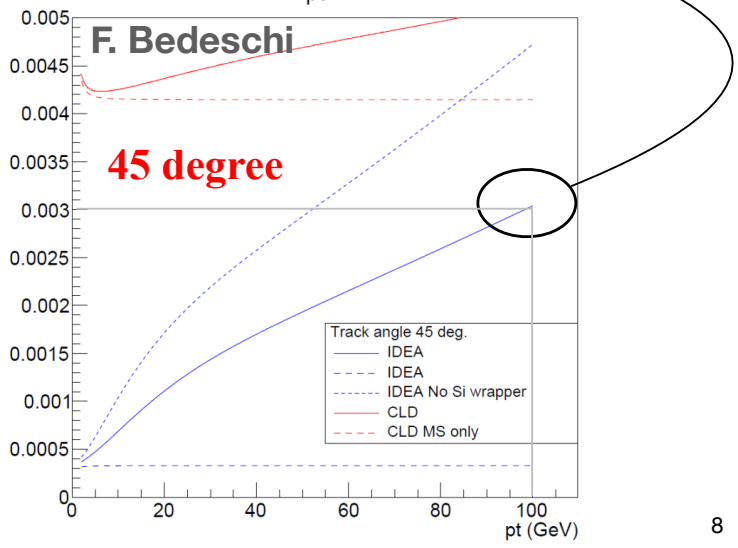
Delphes Fast Simulation of IDEA Detector

- Delphes provides the response of a multipurpose detector in a parameterised way
- **Addition to the official IDEA Delphes card (containing already the DR calo) of the covariance matrix description for tracks.**
- **Crucial feature for improving development of b- and c-tagging algorithm in a more realistic way**

Delphes [40° - 90°]@100 GeV: $\frac{\sigma_{p_T}}{p_T} \simeq 3 \cdot 10^{-3}$

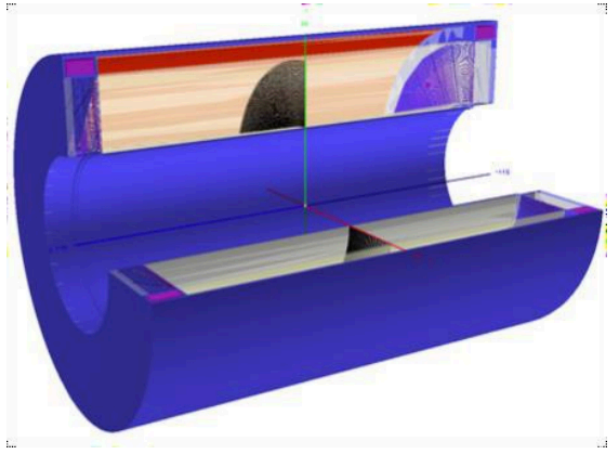


Standalone [45°]@100 GeV: $\frac{\sigma_{p_T}}{p_T} \simeq 3 \cdot 10^{-3}$

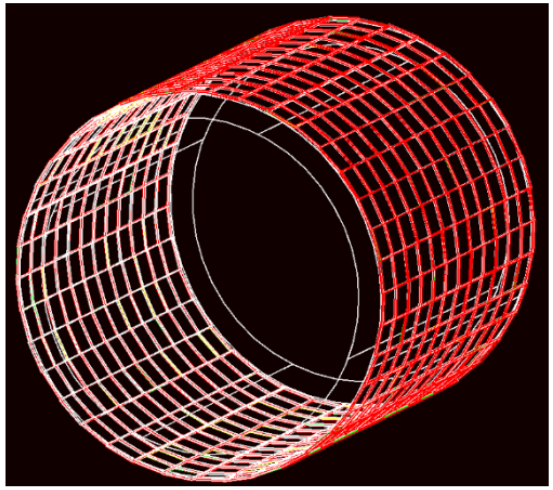


Complete IDEA Detector Concept Full Simulation Status

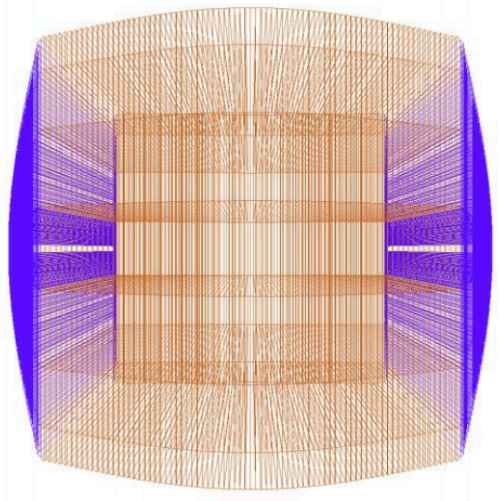
- **Standalone GEANT implementation of various IDEA components: Silicon Vertex, DriftChamber and DR Calorimeter (and Muon) in a standalone Geant framework in progress**
- **Conversion of the ROOT output into EDM4HEP format (starting) to facilitate further reconstruction development for key4HEP with this FullSimulation**



TRACKER



PRESHOWER



DR CALO

Summary

- Full Simulation in Geant of the components of the IDEA concept available. Work in progress to have a description of the complete detector for full reconstruction studies (high priority)
  - To be in sync with the overall software framework advancement will develop a code to convert the output to a EDM4HEP data model
- Refined studies in progress both for DC and DR Calo.
- An improved IDEA Delphes card is being validated for physics studies.