Simulation of the IDEA Drift Chamber at the FCC-ee

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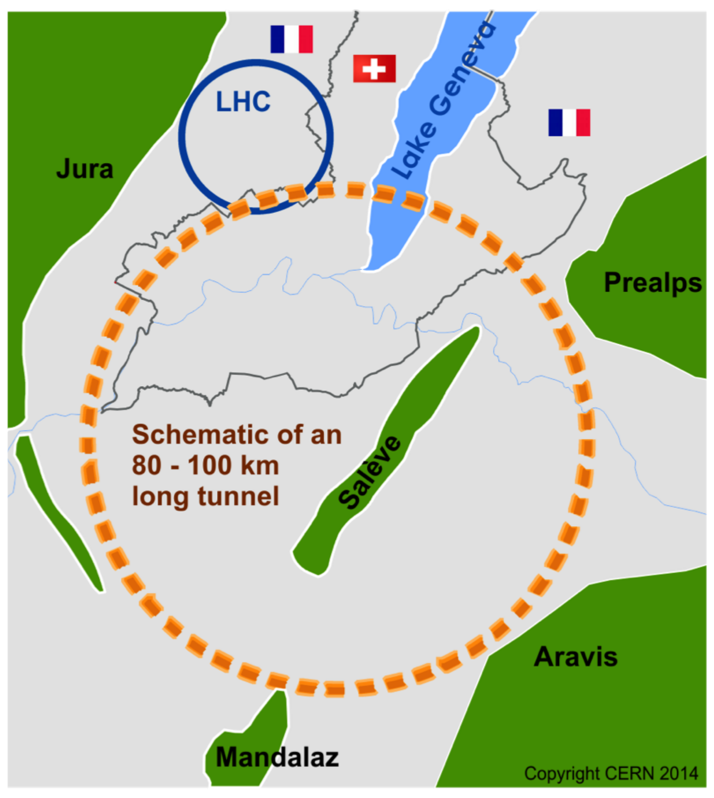
The Future Circular Collider Experiment (FCC)

- A possibility for the post-LHC era at CERN
  - First step: FCC-ee (electron - positron)
  - Ultimate goal: FCC-hh (proton - proton)
  - Optional: FCC-eh (electron - proton)
- ∼100 km tunnel in Geneva area
- FCC-ee collider parameters:

Stages	Z	WW	H (ZH)	$t\bar{t}$
Center of mass energy $\sqrt{s}$ [GeV]	91.2	160	240	365
Average bunch spacing [ns]	19.6	163	994	3396



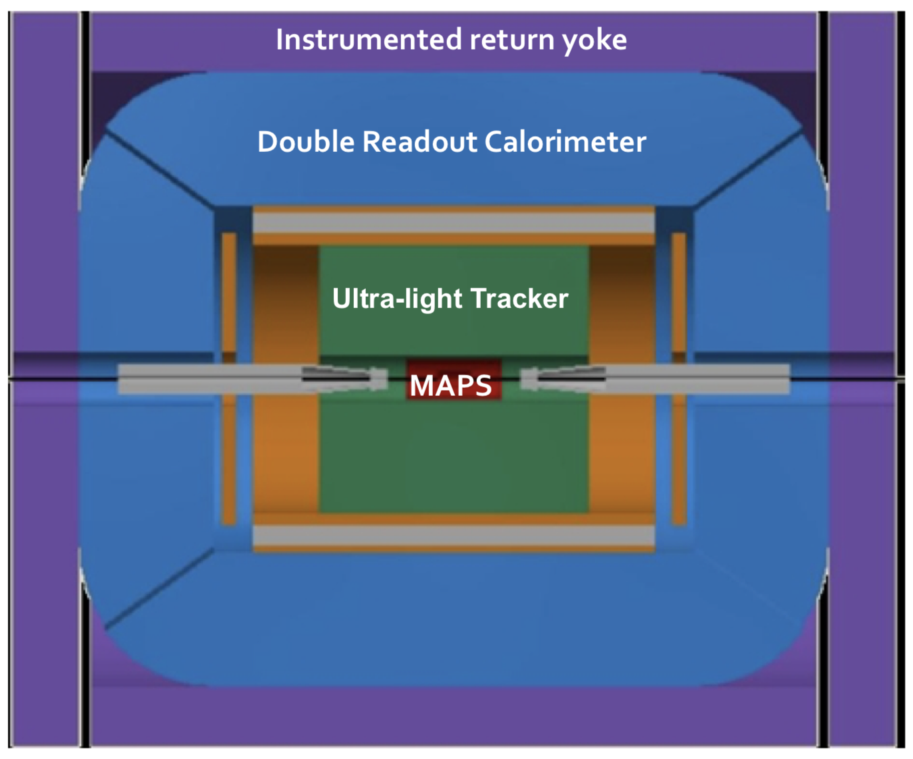
FCCSW: simulation software for FCC

- Common Geant4-based software for all FCC experiments (ee, hh & eh) [1]
- Detector and physics studies
  - Fast & full simulations
  - One software stack from event generation to physics analysis
- Collaborative approach with other CERN experiments
  - Gaudi from LHC [2] ⇒ software architecture
  - DD4hep [3] from CLIC & LHCb ⇒ detector description
  - New solutions where needed
- The simulation pipeline

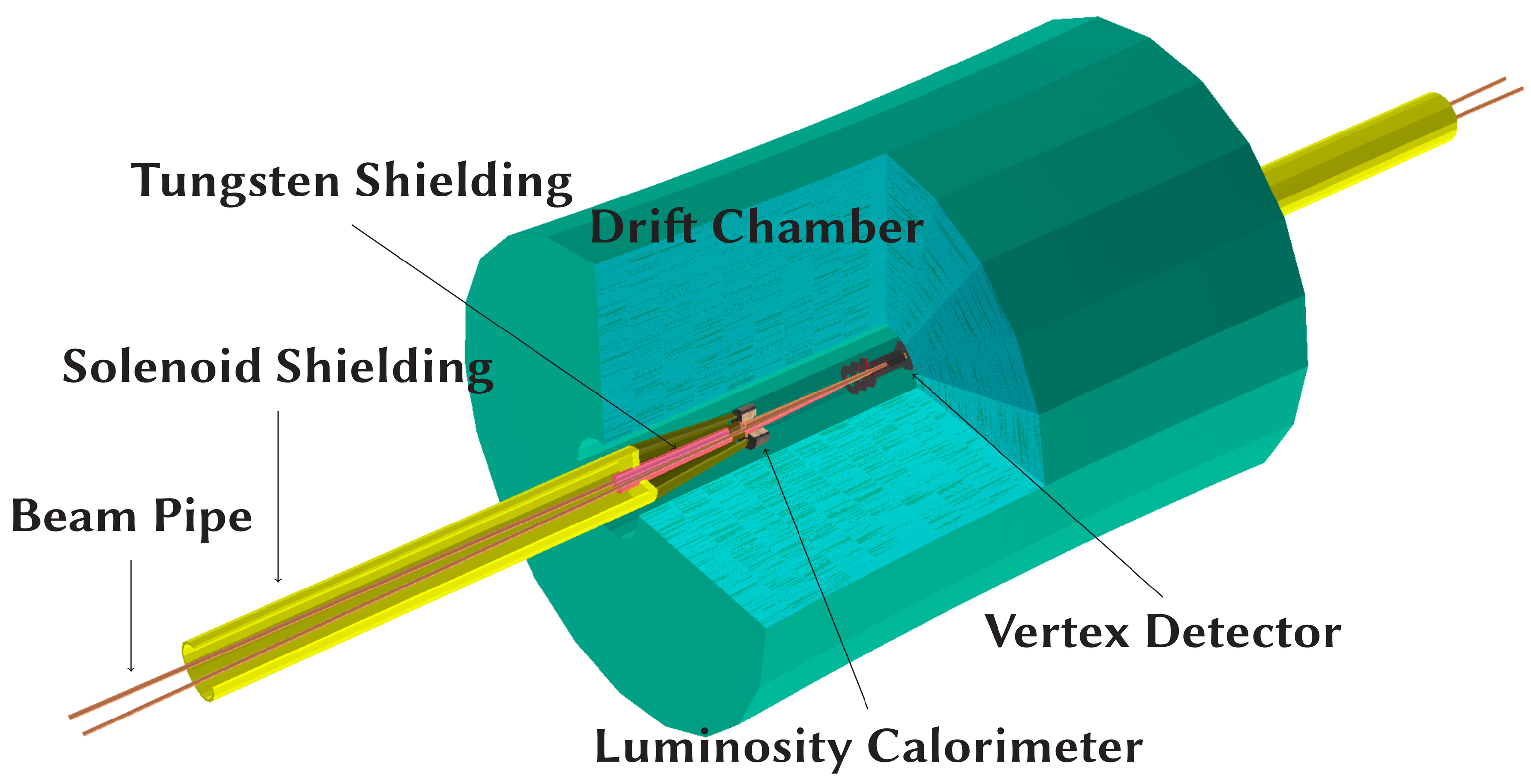
Geometry DDhep → Segmentation → Geant4 simulation → Digitization

The IDEA detector concept for FCC-ee

- The IDEA detector is one of the two detector concepts for the FCC-ee
- Main features of the IDEA concept
  - Vertex detector: MAPS
  - Ultra-light drift chamber with particle identification
  - Dual-readout calorimetry
  - Aditional silicon disk layers placed in the space between the drift chamber and the dual readout calorimeter to serve as a precise tracking layer and a pre showering device
  - 2 T axial magnetic field
  - Instrumented return yoke



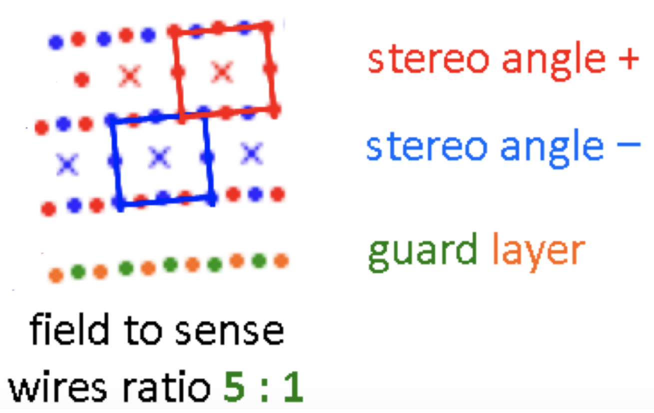
- The IDEA detector as currently simulated with FCCSW



The IDEA drift chamber

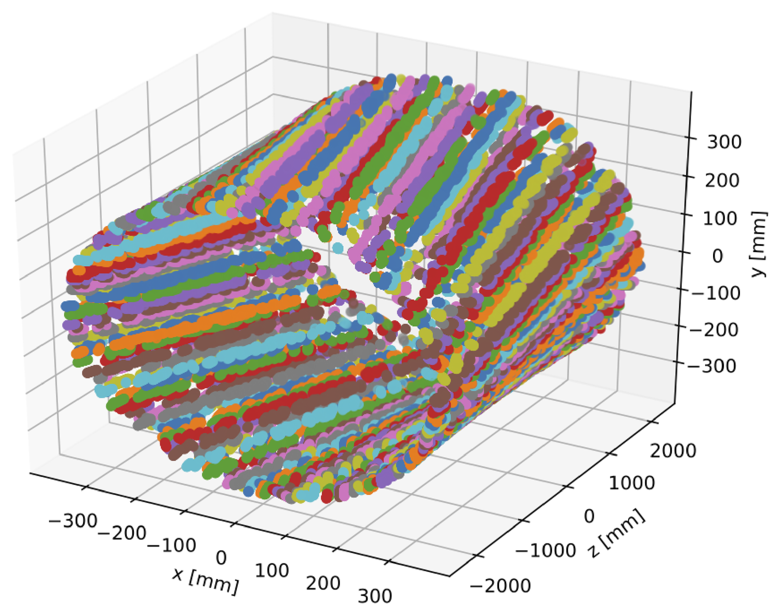
- The gas volume is divided into a set of hyperboloid layers.
- Each layer contains single sense wire cells.
- Field wires surround the sense wires to provide homogeneous electric field for each cell.
- The wires are rotated with an average stereo angle of 0.1 radians to improve the longitudinal resolution along them.
- The parameters of the drift chamber

Gas	90 % Helium & 10 % isobutane (C_4H_{10})
Length	4000 mm
Inner radius	345 mm
Outer radius	2000 mm
Nb. layer	112
Cell size	12 mm - 14.7 mm
Number of sensitive wires	56448
Transverse resolution	0.1 mm
Longitudinal resolution	1 mm

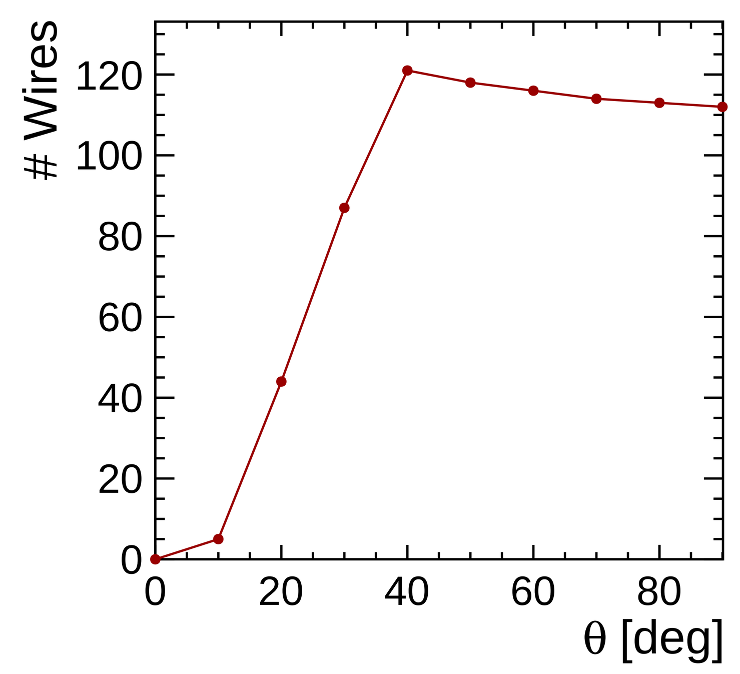


The simulation of the drift chamber with FCCSW

- The sensitive wires as simulated in the first layer of the drift chamber with FCCSW.
- The DD4hep segmentation (DDSegmentation) is responsible to associate a hit to the wire it drifts to
  - Reduces the running time by avoiding to place each wire individually

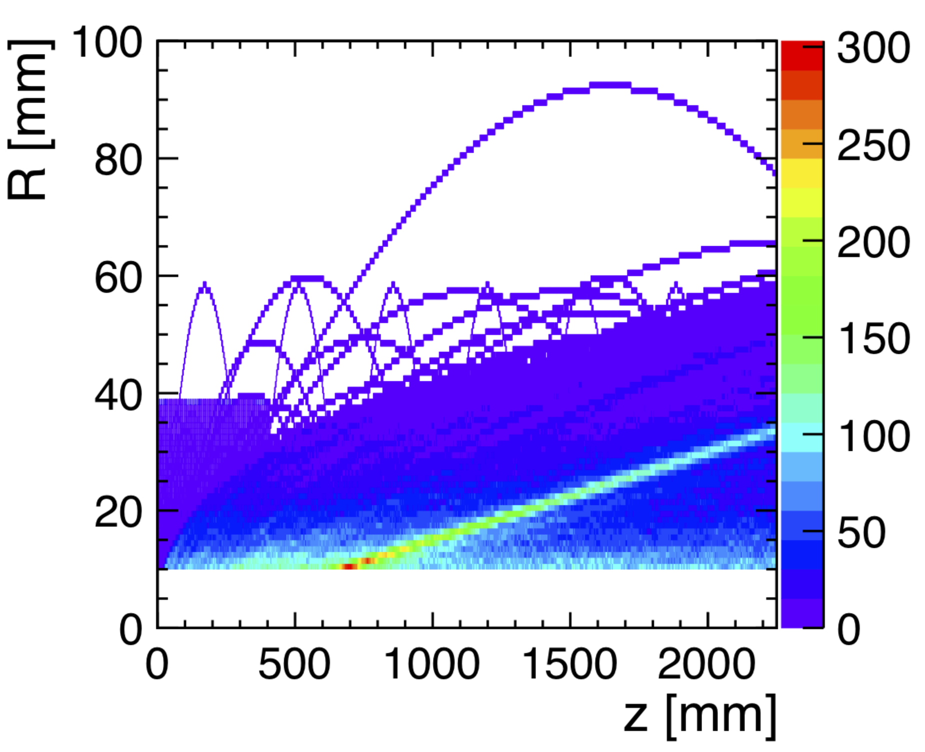


- The coverage of the drift chamber as a function of the polar angle θ is investigated using FCCSW.
- High coverage in the barrel region by ∼ 112 wires in average.
- In the forward region, silicon disks are foreseen to improve the track angle coverage.

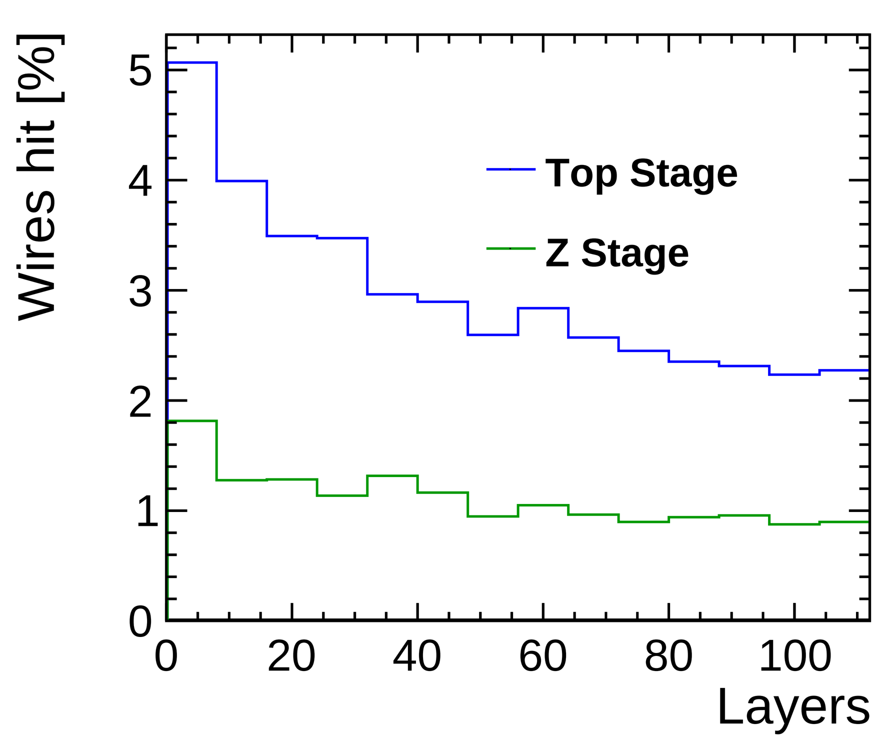


Beam-induced backgrounds and the impact on the drift chamber

- Three main sources of beam-induced backgrounds at FCC-ee
  - **Incoherent e^+e^- pairs** due to bremstrahlung photons ⇒ highest source of background
  - $\gamma\gamma \rightarrow$ **hadrons** ⇒ Expected to have a very low impact
  - **Synchrotron radiation (SR)** ⇒ Dictates the design of the interaction region (IR)
    - Defines the beampipe radius, the design of the shielding (in Tungsten)
    - Mostly stopped by the shielding, few SR photons can hit the detector
- The trajectory of the e^+e pairs in a 2 T magnetic field (using helix extrapolation).



- Simulation of the hits produced in the drift chamber due to incoherent e^+e^- pairs (using FCCSW)



Conclusions

- Summary of the occupancy of the drift chamber due to the beam-induced backgrounds

Background	Average occupancy	
	E_{cm} = 91.2 GeV	E_{cm} = 365 GeV
e^+e^- pair background	1.1%	2.9%
$\gamma\gamma \rightarrow$ hadrons	0.001%	0.035%
Synchrotron radiation	-	0.2%

- The overall impact remains low and the results are promising for the track reconstruction with this detector.

References

[1] URL: http://fccsw.web.cern.ch/fccsw.
[2] G. Barrand et al. “GAUDI - A software architecture and framework for building HEP data processing applications”. In: Comput. Phys. Commun. (2001).
[3] M. Frank et al. “DD4hep: A Detector Description Toolkit for High Energy Physics Experiments”. In: J. Phys.: Conf. Ser. (2013).