Design of a drift chamber tracking system for the IDEA experiment at FCC-ee

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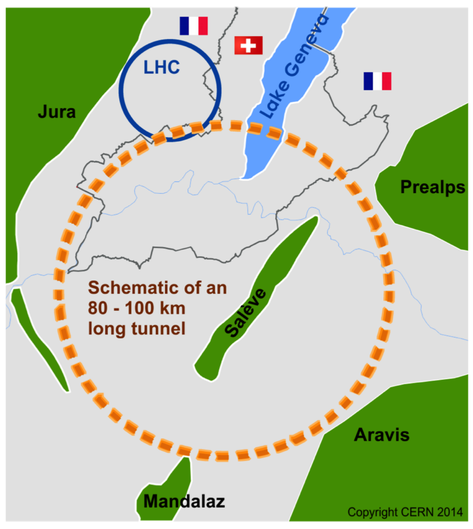
The Future Circular Collider Experiment (FCC)

- A future possibility for the post-LHC era
- 3 options of circular colliders
  - FCC-ee: electron - positron collisions
  - FCC-hh: proton - proton collisions
  - FCC-eh: electron - proton collisions
- ∼100 km tunnel in Geneva area
- FCC-ee collider parameters:

Stages	Z	WW	H (ZH)	$t\bar{t}$
Beam energy [GeV]	45.6	80	120	182.5
Average bunch spacing [ns]	19.6	163	994	3396



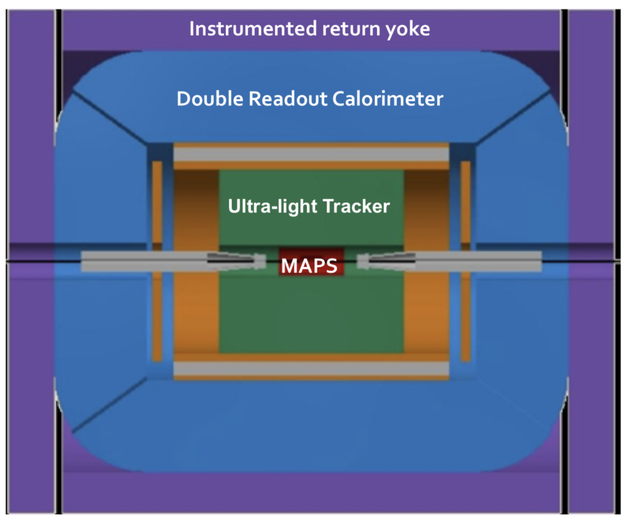
FCCSW: Physics and Detector simulations with FCCSW

- Common software for all FCC experiments (ee, hh & eh) [3]
- 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 [1]
  - DD4hep [2] from CLIC & LHCb
  - New solutions where needed
- The simulation pipeline

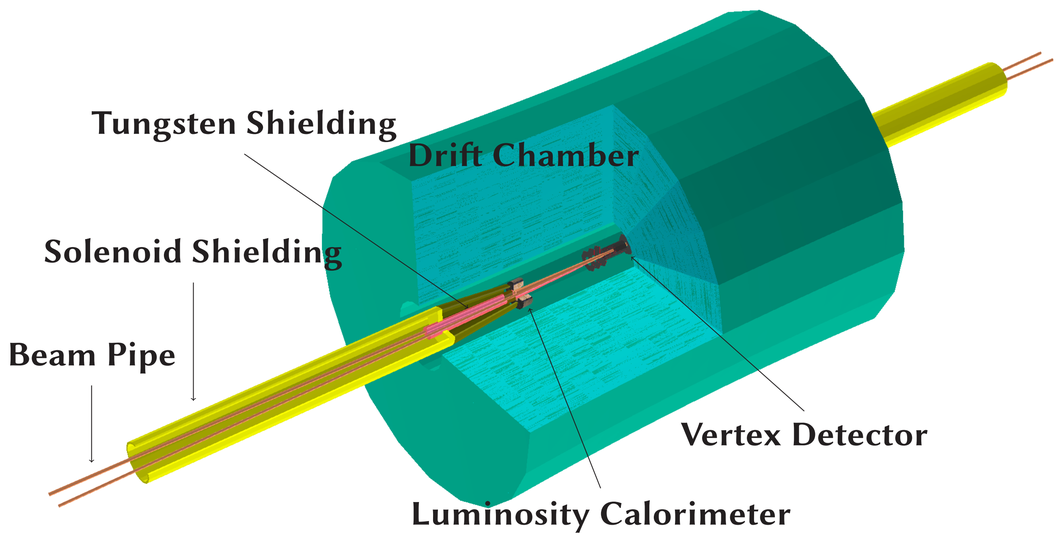
Geometry DDhep → Segmen-tation → Geant4 simulation → Digiti-zation

The IDEA detector concept for FCC-ee

- The IDEA detector is one of the two detector concepts for the FCC-ee
- Ultimate goal for the IDEA detector concept
  - Vertex detector: MAPS
  - Ultra-light drift chamber with particle identification
  - Double readout calorimetry
  - Aditional silicon disk layers placed in the space between the drift chamber and the dual readout calorimeter to increase the forward coverage
  - 2 T solenoidal magnetic field
  - Instrumented return yoke
  - Large tracking volume (R ∼ 8 m) for very weakly coupled (long-lived) particles



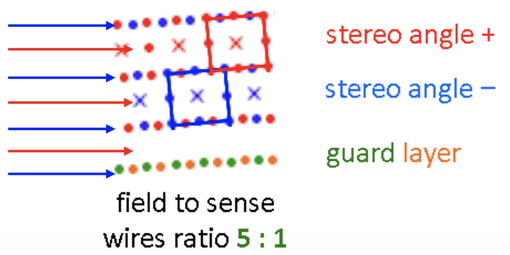
- The IDEA detector as simulated with FCCSW



The drift chamber

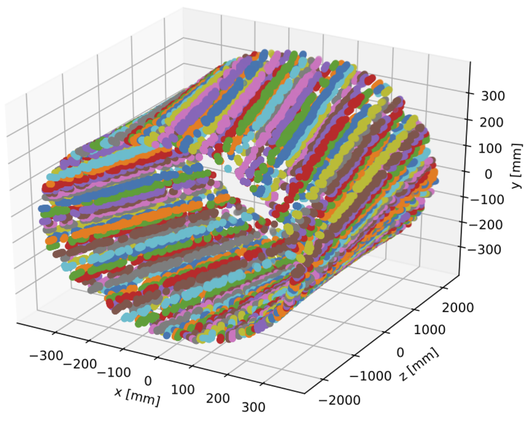
- The gas volume is divided into a set of hyperboloid layers.
- Each layer contains one sensitive wire for signal acquisition.
- Field wires surround the sensitive wires to provide homogeneous electric field for each cell.
- The wires are rotated with a stereo angle of 0.1 radians to improve the longitudinal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

Gas	90 % Helium & 10 % isobutane (C_4H_{10})
Length	4500 mm
Inner radius	345 mm
Outer radius	2000 mm
Nb. layer	112
Cell size	12 mm - 14.7 mm
Number of sensitive wires	56448
Single cell resolution	0.1 mm
Longitudinal resolution	1 mm

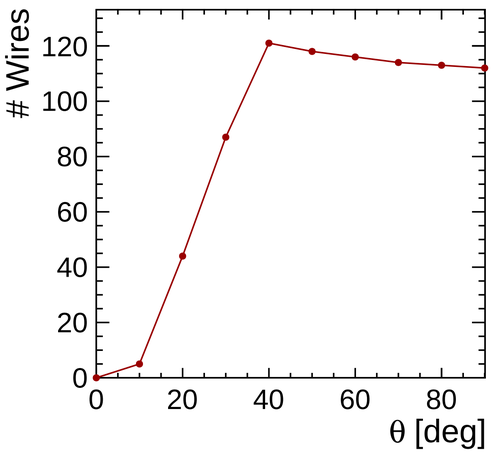


The simulation of the drift chamber with FCCSW

- The first layer of the drift chamber with wires rotated with a certain stereo angle.
- The DD4hep segmentation (DDSegmentation) is responsible to associate a hit to the wire it drifts to.
- Wires are illustrated using different colors.

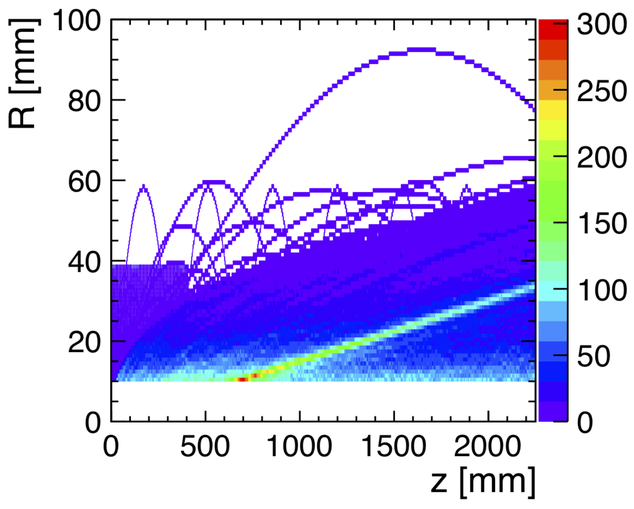


- The coverage of the drift chamber as a function of the polar angle θ is investigated using FCCSW.
- High coverage in the barrel region by ∼ 112 wires in average.
- In the forward region, silicon disks are foresean to increase the number of layers measuring the tracks.

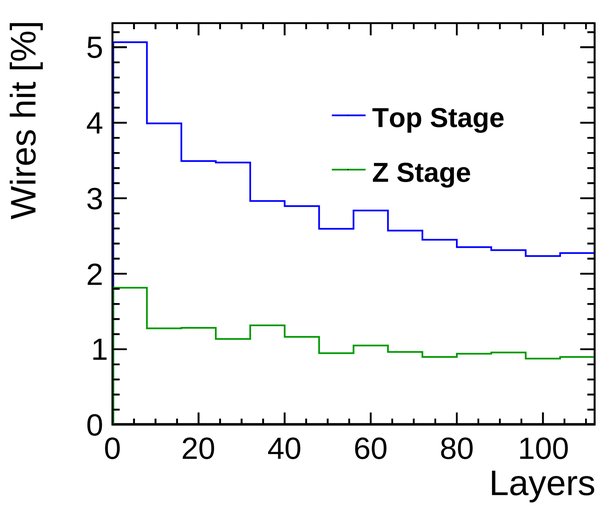


Beam-induced backgrounds and the impact on the drift chamber

- Three main sources of beam-induced backgrounds at FCC-ee [4]
  - **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 Tungesten)
    - 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

- The overall impact remains low and the results are promising for the track reconstruction with this detector.
- Summary of the occupancy of the drift chamber due to the beam-induced backgrounds

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

References

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M. Frank, F. Gaede, and P. Mato. “DD4hep: A Detector Description Toolkit for High Energy Physics Experiments”. In: J. Phys.: Conf. Ser. 513.AIDA-CONF-2014-004 (2013), p. 022010. URL: http://cds.cern.ch/record/1670270.