

Full simulation of the FCC-ee IDEA detector with FCCSW

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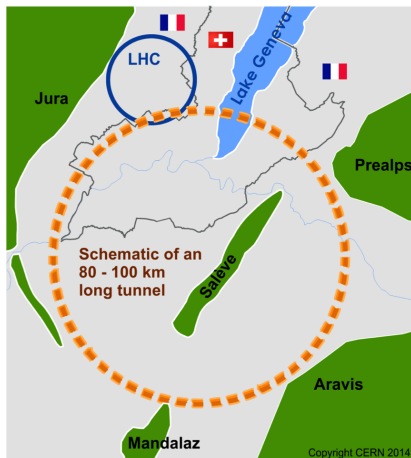
RD-FA Collaboration Meeting

CERN
6 July 2018



FCC Software: FCCSW

- ▶ Common software for all FCC experiments
 - ▶ ee, hh & eh
- ▶ Detector and physics studies
 - ▶ Fast & full simulations
 - ▶ One software stack from event generation to physics analysis
- ▶ Collaborative approach
 - ▶ LHC: Gaudi
 - ▶ CLIC: DD4hep
 - ▶ New solutions \Rightarrow where needed



- ▶ The IDEA concept is under development within FCCSW
 - ▶ Impact of beam-induced background is under study

FCCSW

- ▶ Webpage and tutorials: <http://fccsw.web.cern.ch/fccsw>
- ▶ GitHub link for the code:
<https://github.com/HEP-FCC/FCCSW>

The screenshot shows the GitHub repository page for HEP-FCC/FCCSW. At the top, there is a search bar and navigation links for Pull requests, Issues, Marketplace, and Explore. The repository name is HEP-FCC / FCCSW, with 21 Unwatch, 7 Stars, and 84 Forks. Below the repository name, there are tabs for Code, Issues (10), Pull requests (18), Projects (0), and Insights.

FCC software, common to FCC-hh, -ee, and -eh. <http://fccsw.web.cern.ch>

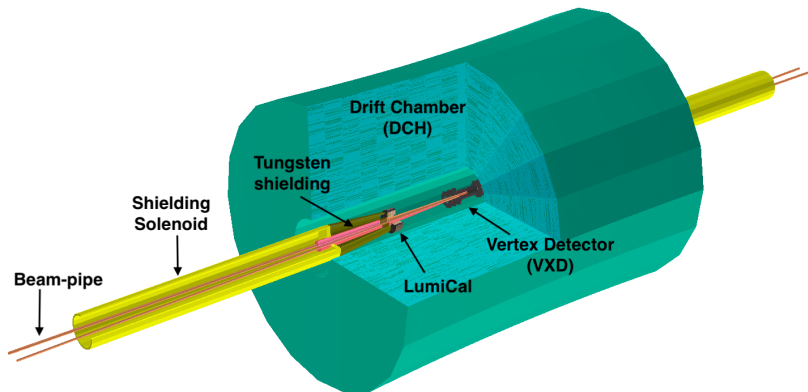
The screenshot shows the commit history of the repository. At the top, there are statistics: 2,426 commits, 3 branches, 8 releases, and 27 contributors. Below these statistics is a horizontal bar chart. The main content area shows a list of commits, with the most recent one selected. The selected commit is a merge pull request #303 from JavierCVilla/dd4hep-v01.05, with the latest commit ba07b2d on May 16. The commit list includes folders for .github, Detector, Examples, FWCore, Generation, Reconstruction, Sim, Test, Visualization, cmake, and doc, each with a description of the changes and the time since the commit.

Commit	Description	Time
vovkl Merge pull request #303 from JavierCVilla/dd4hep-v01.05	Latest commit ba07b2d on May 16	
.github	Fixing typos in contribution guide.	a year ago
Detector	Merge branch 'master' into dd4hep-v01.05	a month ago
Examples	Merge branch 'master' into dd4hep-v01.05	a month ago
FWCore	Add option to allow empty signal collection for the pileup overlay	4 months ago
Generation	Merge branch 'master' of https://github.com/HEP-FCC/FCCSW into test-c...	3 months ago
Reconstruction	Merge branch 'master' into dd4hep-v01.05	2 months ago
Sim	Merge branch 'master' of https://github.com/HEP-FCC/FCCSW into test-c...	3 months ago
Test	Merge branch 'master' into dd4hep-v01.05	a month ago
Visualization	Namespace changes and fixes for LCG_92 compatibility	5 months ago
cmake	Add run bash script to install	a year ago
doc	Merge branch 'master' into merge_collections	8 months ago

The IDEA interaction region in FCCSW

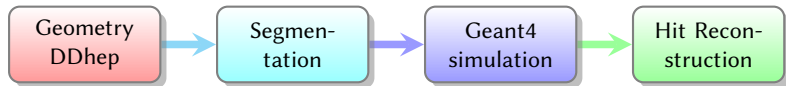
- ▶ Beam-pipe, beam instrumentations and the vertex detector are taken from the CLD concept
 - ▶ Temporary design of VXD for the IDEA detector \Rightarrow ultimate goal: MAPS
- ▶ The DCH implemented from scratch in FCCSW
- ▶ Missing elements
 - ▶ Alice-like ITS, solenoid magnet, dual-readout calorimeter, instrumented return yoke

Visualisation with FCCSW



FCCSW simulation chain

1. Detector geometry description with DD4hep
2. Segmentation of the sensitive areas:
 - ▶ Speed up the simulation
 - ▶ Example: information on the position of the sense wires instead of placing physical volumes
3. Geant4 simulation:
 - ▶ Calculate the E_{dep} in sensitive volumes
4. Hit reconstruction:
 - ▶ Combination of individual hit calculations from (3)
 - ▶ Calculation of the drift, diffusion and signal in the wire

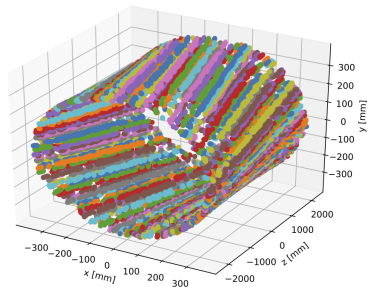


The drift chamber (DCH)

Parameters of the DCH

Length	4500 mm
Inner radius	345 mm
Outer radius	2000 mm
Number of sensitive wires	56448
Single cell resolution (transverse plane)	0.1 mm

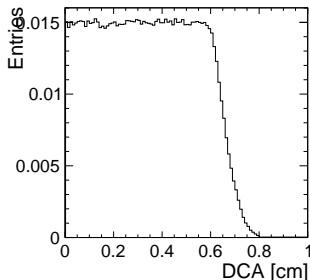
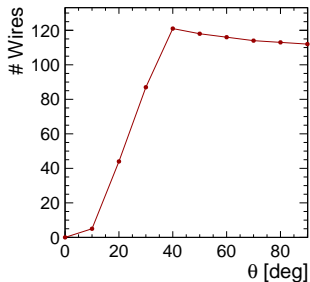
- ▶ The segmentation concept is used to access the information on the positions of the wire



Coverage of the drift chamber

- ▶ The number of wires as a function of θ
- ▶ The coverage in the forward region will be improved by the placement of disks

- ▶ The distance of the closest approach (DCA)
- ▶ Provides the information on the drift time
- ▶ Maximum drift time (corresponding to the corners): 400 ns

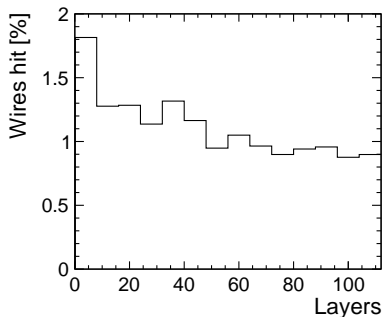


Beam-induced backgrounds at FCC-ee

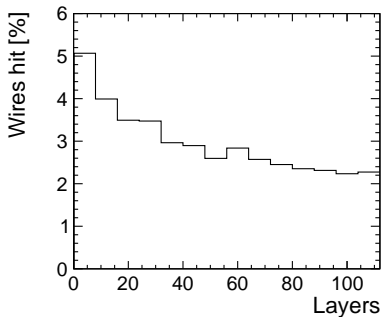
- ▶ Incoherent e^+e^- pairs
 - ▶ Produced in $\gamma\gamma$ interactions from beamstrahlung
 - ▶ Forward region
- ▶ $\gamma\gamma \rightarrow$ hadrons
 - ▶ Possibly results in jets in the detector
- ▶ Synchrotron radiation (SR)
 - ▶ Photons from the last bending magnet

Incoherent e^+e^- pairs

$E_{\text{cm}} = 91.2 \text{ GeV}$ (Z stage)



$E_{\text{cm}} = 365 \text{ GeV}$ (top stage)



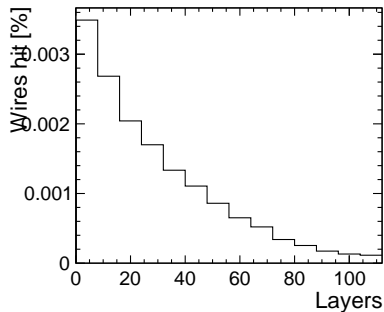
▶ Average occupancy: 1.1%

▶ Average occupancy: 2.9%

▶ The effect of this background does not pose problem for the track reconstruction.

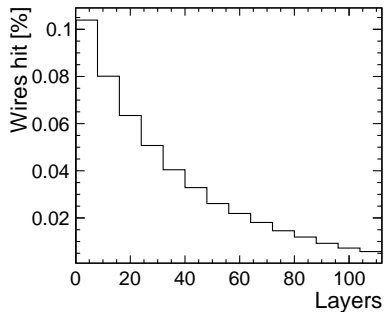
$\gamma\gamma \rightarrow \text{hadrons}$

$E_{\text{cm}} = 91.2 \text{ GeV}$ (Z stage)



- ▶ Average occupancy: 0.001%
- ▶ Negligible effect

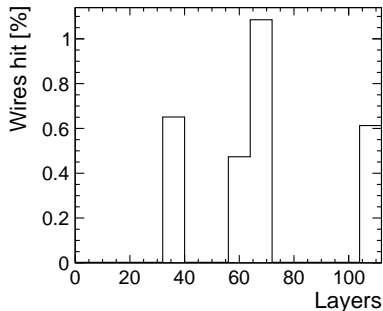
$E_{\text{cm}} = 365 \text{ GeV}$ (top stage)



- ▶ Average occupancy: 0.035%

Synchrotron radiation: $E_{\text{cm}} = 365 \text{ GeV}$

- ▶ The shielding stops most of the SR photons.
- ▶ Average occupancy: 0.2%
- ▶ Negligible effect



Summary: background occupancy in DCH

- ▶ The overall effect of the backgrounds on the DCH remains small
- ▶ e^+e^- pair background is the largest source of background

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

Conclusions

- ▶ The FCCSW is ready for the full simulation of the IDEA detector
- ▶ Background estimations in full simulations have been performed for the drift chamber
 - ▶ Low effect
- ▶ Contributions are more than welcome
 - ⇒ Input for tracking
 - ⇒ Dual-readout calorimeter, ...

Thank you for your attention!