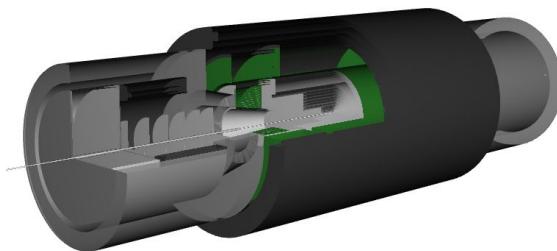


FCC Detector Palette

FCCSW Workshop October 2019

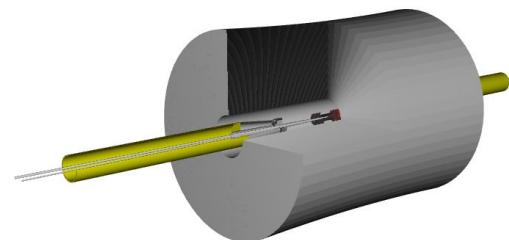
Oct 02, 2019
Valentin Volkl for the FCC Software and
Detector Groups
Univ. Innsbruck / CERN

- FCC-hh Baseline



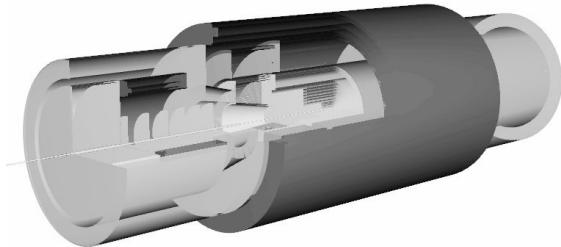
- Barrel, Endcap, Forward
- Beampipe
- Magnet Solenoid
- Shielding
- Silicon Tracker
- LAr-ECal
- Tile H-Cal
- Muon System

- FCC-ee IDEA



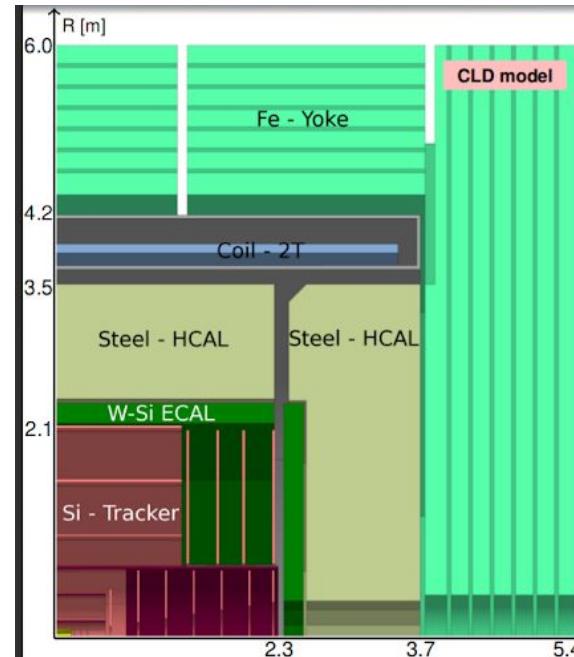
- Beampipe
- Beam Instrumentation
- LumiCal
- HOMAbsorber
- Vertex Detector
- Driftchamber
- Dual Readout Calorimeter
- Muon System

- FCC-hh Alternatives to Baseline



- Triplet Tracker
- Digital Calorimeter

- FCC-ee CLD



- Not in FCCSW!
<https://github.com/iLCSoft/lcgeo>

Note:

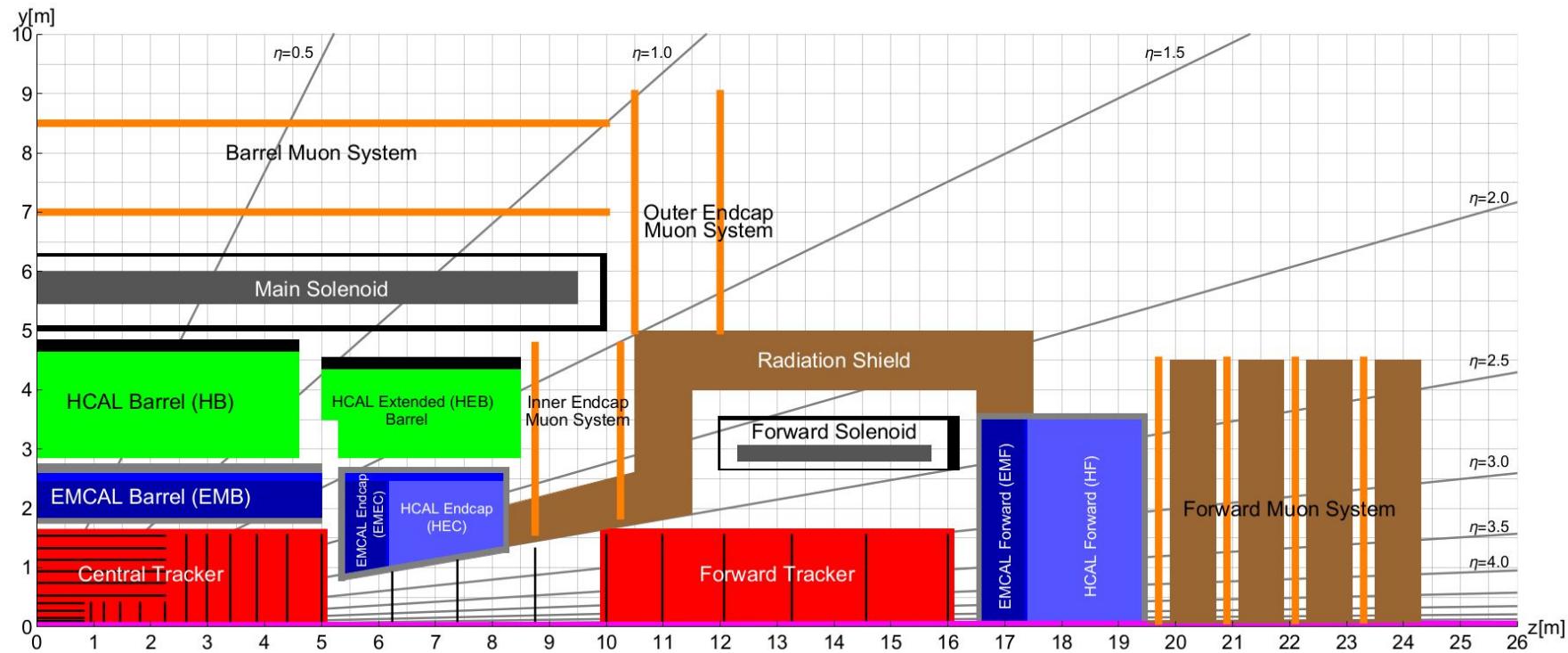
- Only Detectors in FCCSW are presented here
 - More DD4hep implementations exist in <https://github.com/iLCSoft/lcgeo>
- More detector concepts studied with fast simulation tools (tkLayout, Fast Tracking by F. Bedeschi https://www.pi.infn.it/~bedeschi/RD_FA/Software/)

Disclaimers

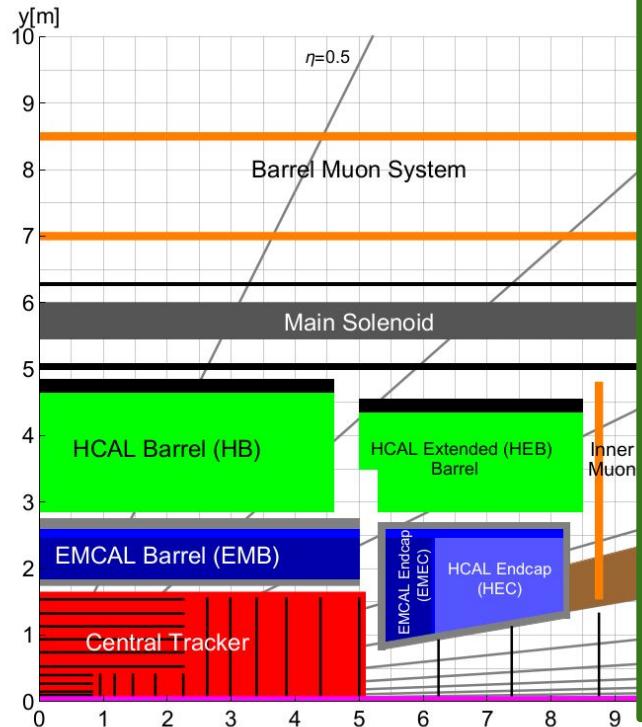
- Works in Progress (to a varying degree)!
- I am not an Expert for all of these (and it should not be necessary to be one to use these detector models!)
- Be aware of the level of approximations

FCC-hh Baseline

FCC-hh



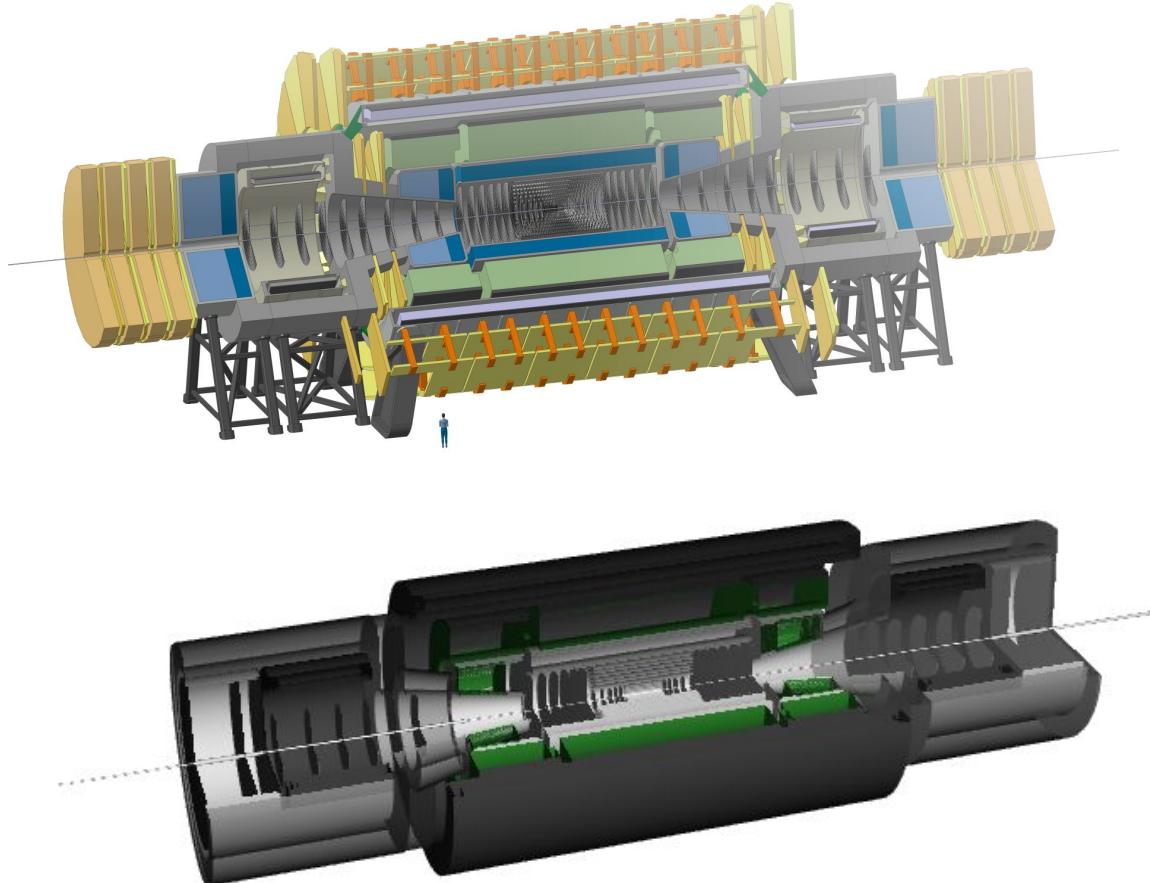
FCC-hh



A reference Delphes card can be found on the fccsw website: cern.ch/fccsw

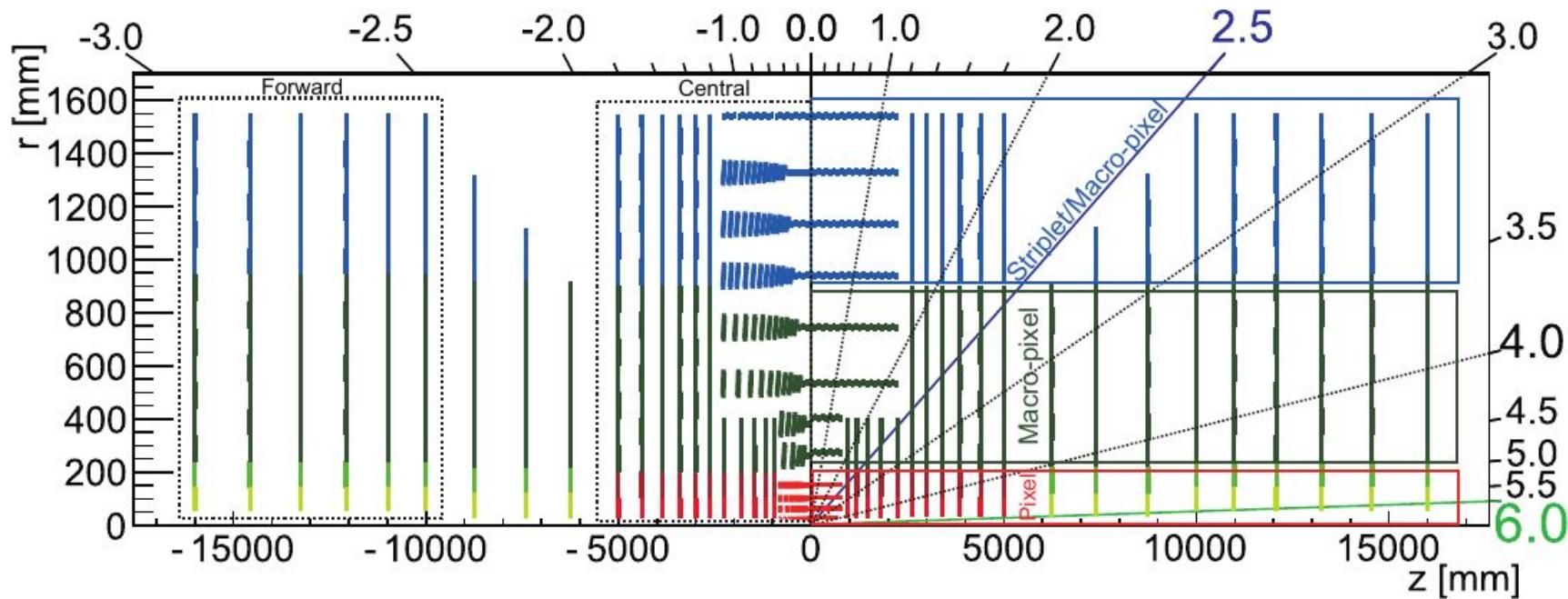
The FCC-hh CDR used this card extensively and it was partly validated in Full Simulation. It is integrated in the software framework also (see tutorials).

FCC-hh



FCC-hh Silicon Tracker

- Layout designed with TkLayout: fcc-tklayout.web.cern.ch



FCC-hh Beampipe



- Detector/DetCommon/compact/materials.xml
- Detector/DetFCChhBaseline1/compact/FCChh_DectDimensions.xml
- Detector/DetFCChhBaseline1/compact/FCChh_BeamTube.xml
- Detector/DetCommon/src/SimpleCone_geo.cpp

```
22 <!-- BEAM PIPE -->
23 <constant name="CentralBeamTube_dz" value="800.0*cm"/>
24 <constant name="CentralBeamTube_rmax" value="2.08*cm"/>
25 <constant name="CentralBeamTube_rmin" value="2.*cm"/>
26
27 <constant name="ForwardBeamTube_rmin1" value="2.*cm"/>
28 <constant name="ForwardBeamTube_rmax1" value="2.08*cm"/>
29 <constant name="ForwardBeamTube_rmin2" value="6.15*cm"/>
30 <constant name="ForwardBeamTube_rmax2" value="6.23*cm"/>
31 <constant name="ForwardBeamTube_dz" value="850*cm"/>
32 <constant name="ForwardBeamTube_zOffset" value="CentralBeamTube_dz +
ForwardBeamTube_dz"/>
```

FCC-hh - Magnets



- In [FCCSW](#)
- Field map on eos

</eos/experiment/fcc/hh/simulation/MagneticField>

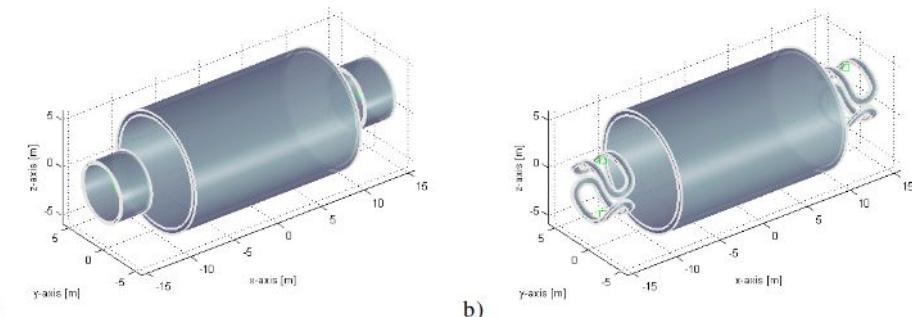
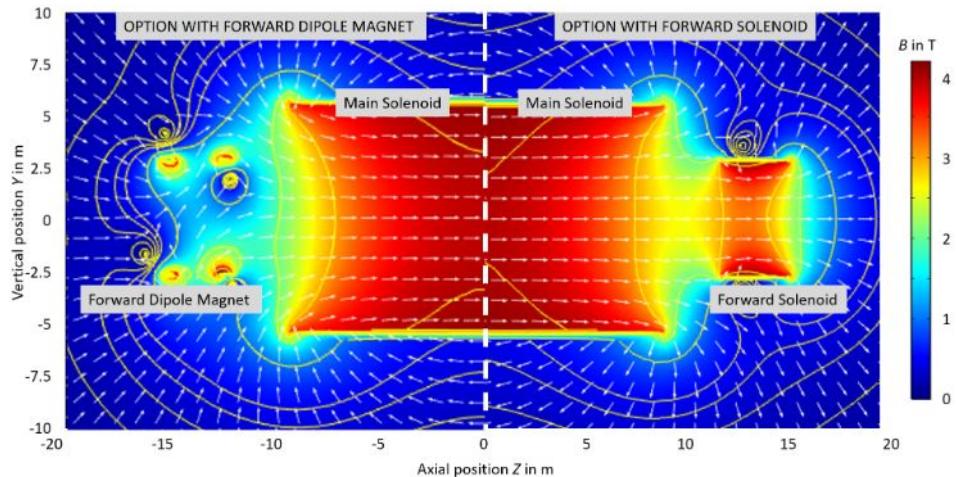


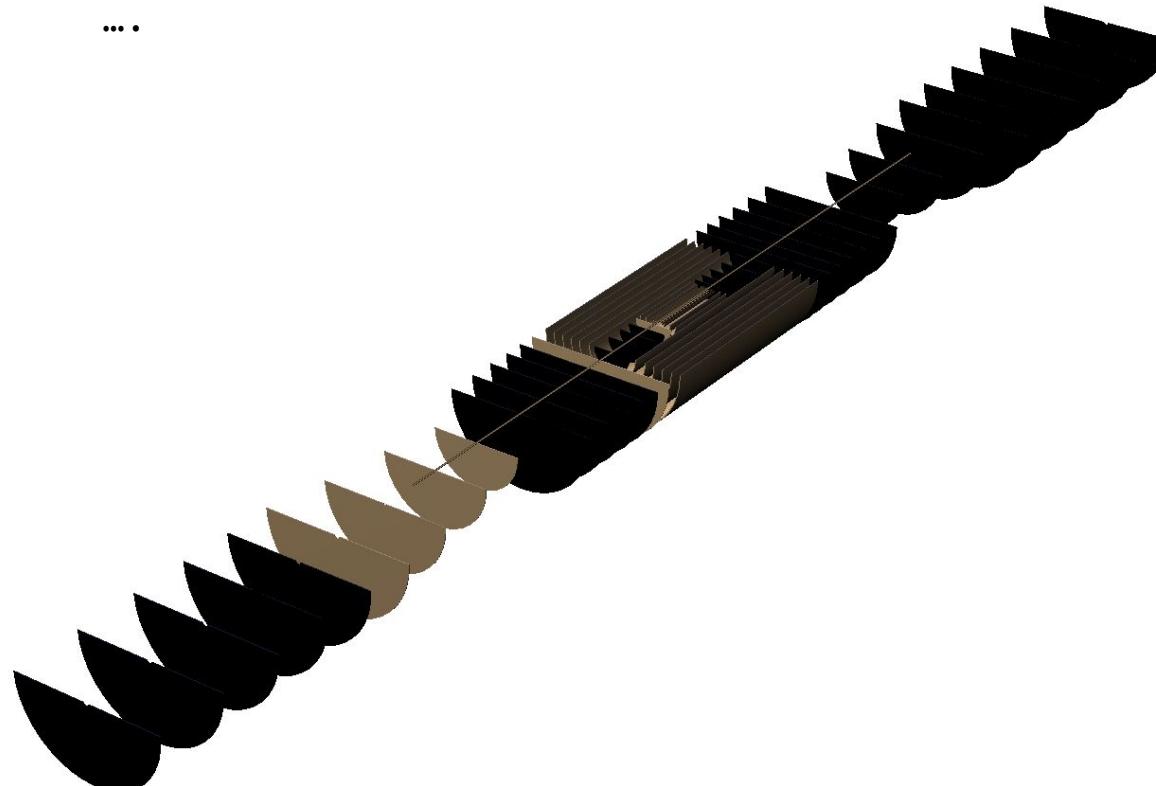
Figure 7.6: a) Cold mass for a central solenoid of 4 T with two forward solenoids and b) a central solenoid of 4 T and two forward dipole magnets with field integral of 4 Tm.

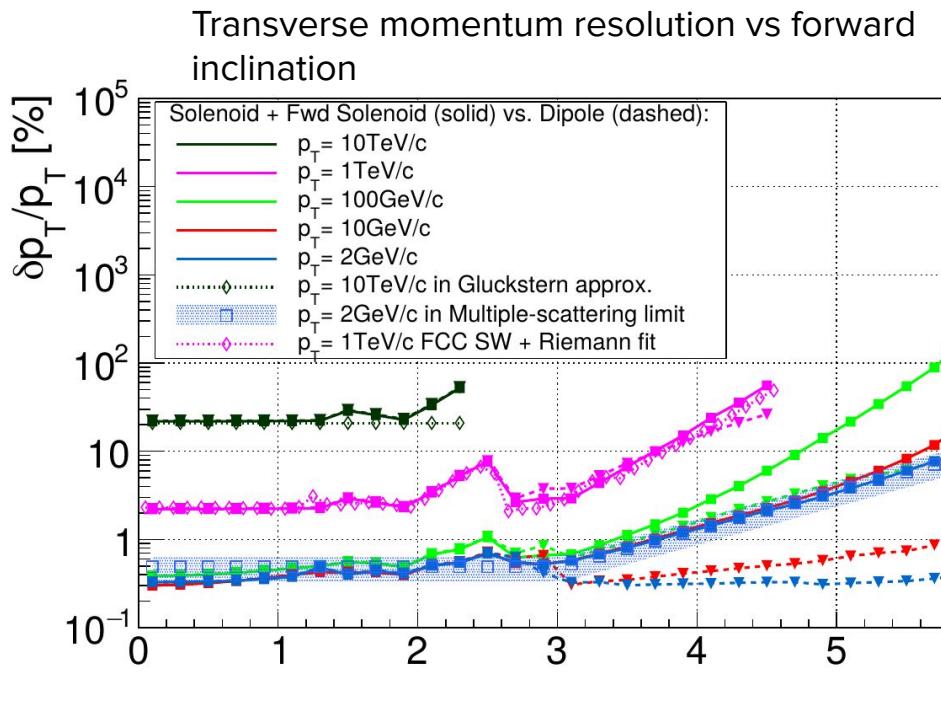
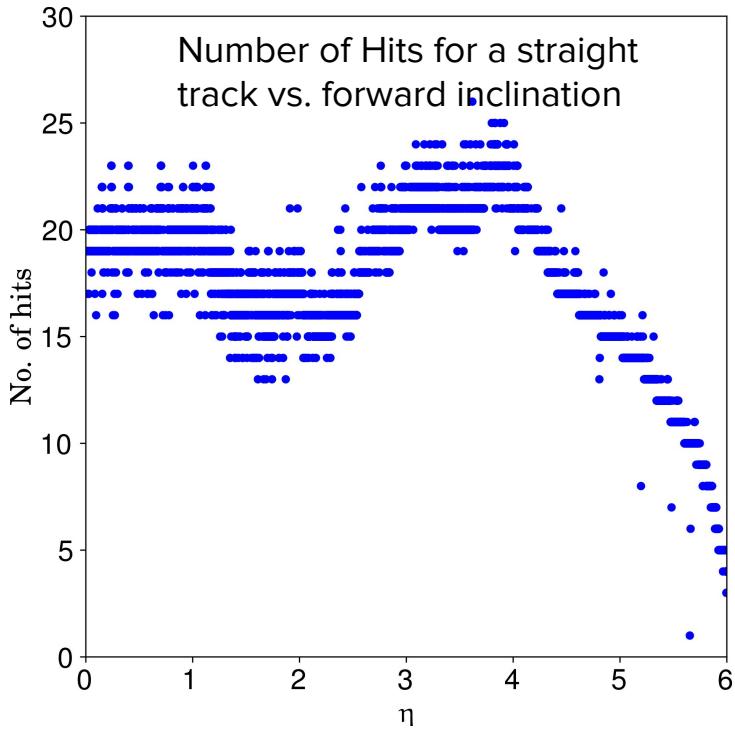


FCC-hh Tracker

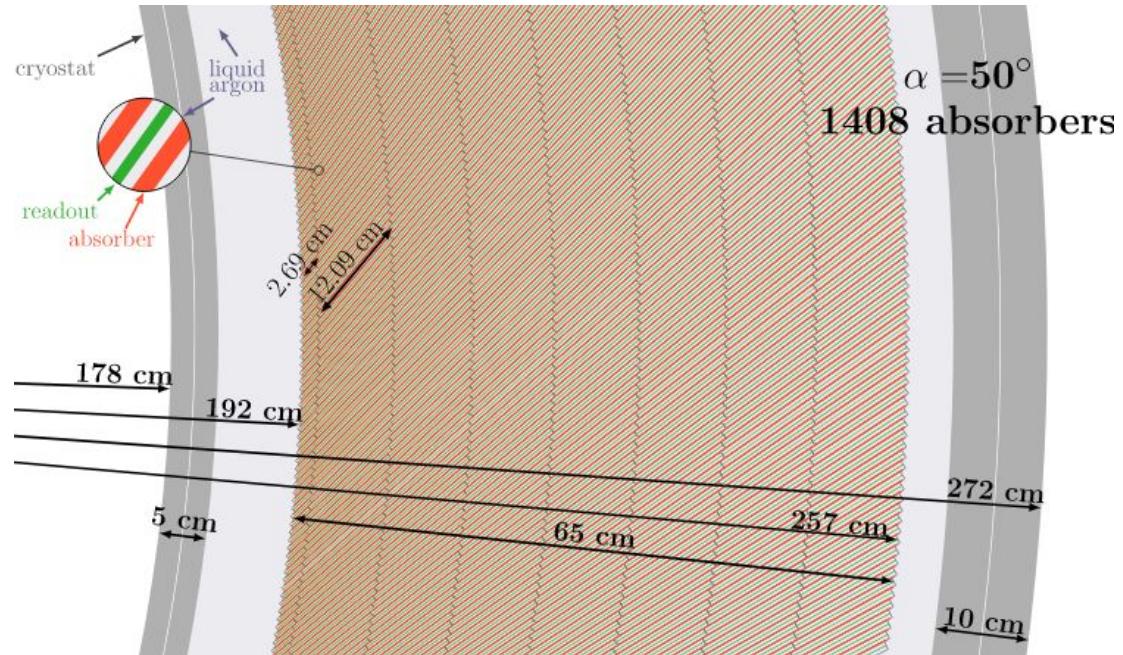
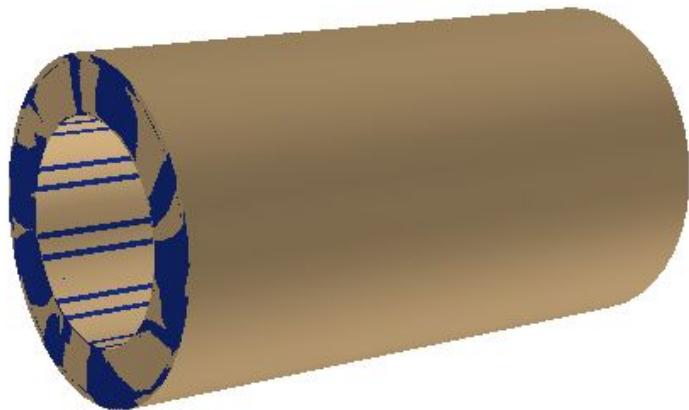
```
<readouts>
  <!-- readout for the simulation -->
  grid_size_x="0.005*mm" grid_size_z="0.010*mm"/>
  system:4,layer:5,module:18,x:-15,z:-15
  ...
  ....
```

- Layout designed with TkLayout:
fcc-tklayout.web.cern.ch
- Compact files
“machine-readable”
- Change tkLayout configuration to generate new model

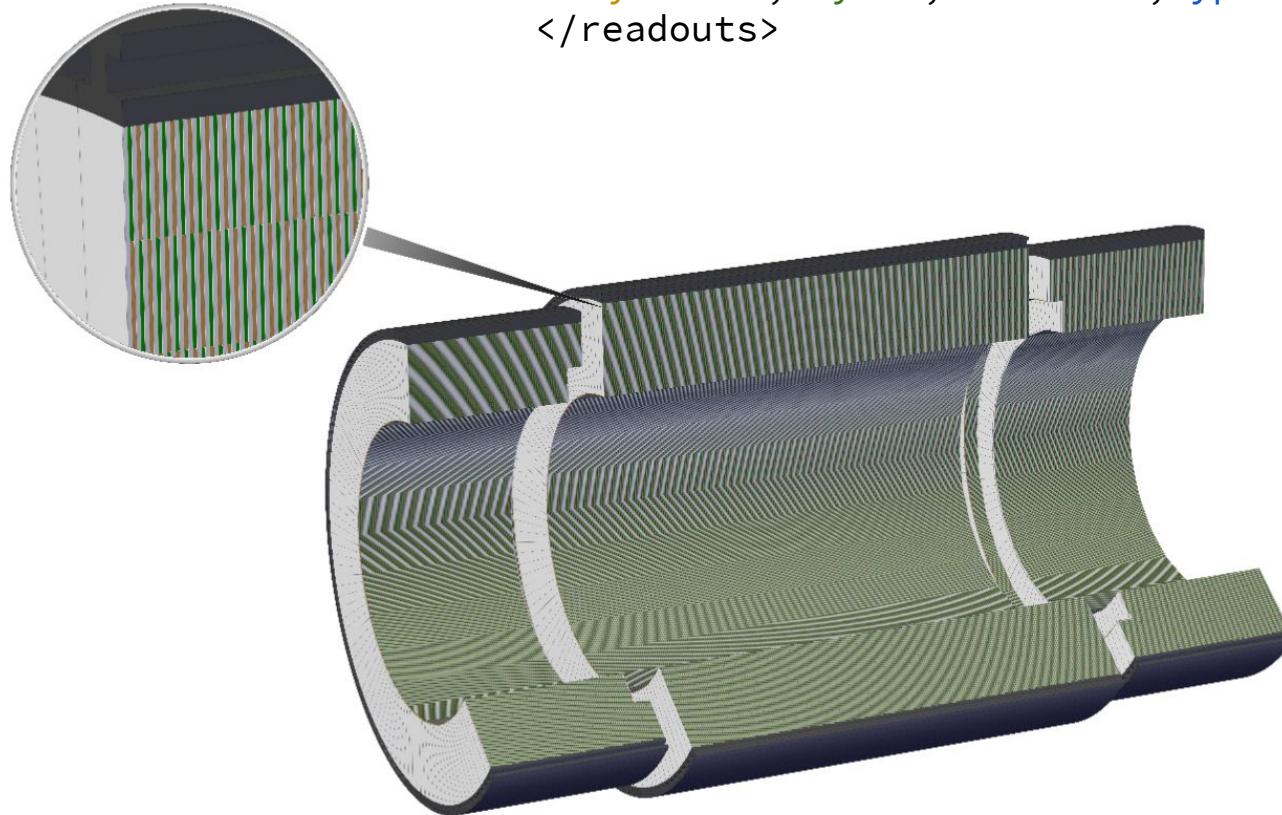




FCC-hh ECal



FCC-hh ECal



```
<readouts>
  <!-- readout for the simulation -->
  system:4,cryo:1,module:11,type:3,subtype:3,layer:8,eta:9
</readouts>
```

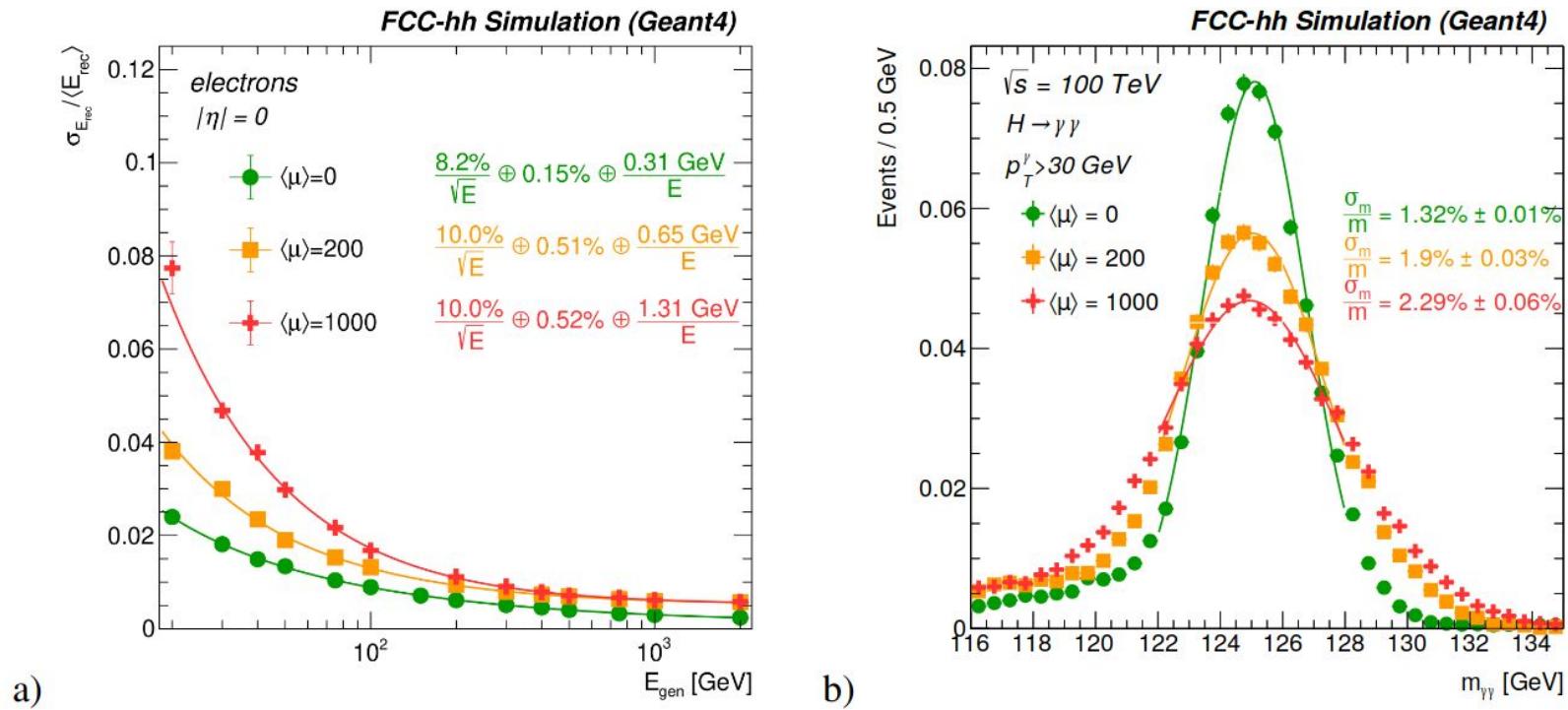
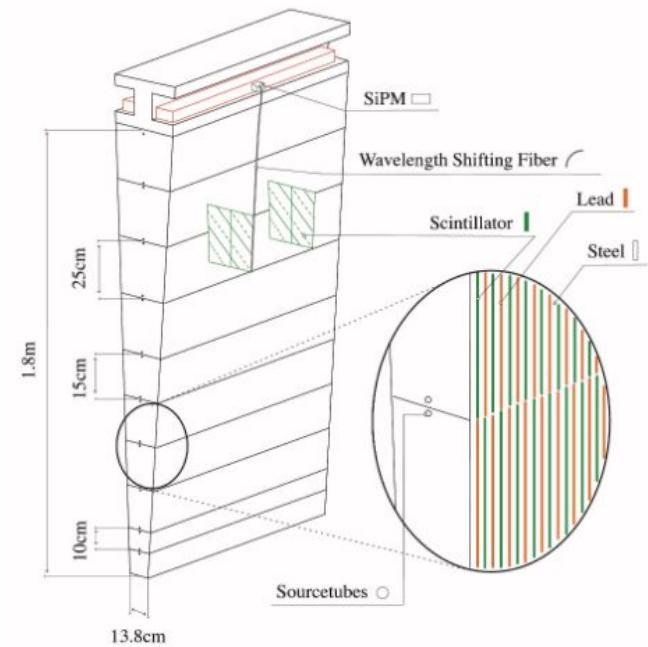
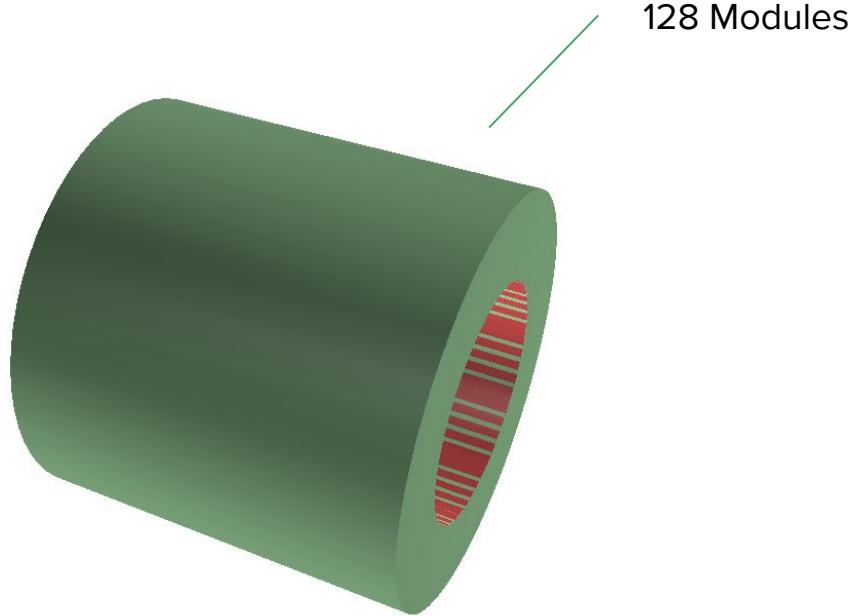
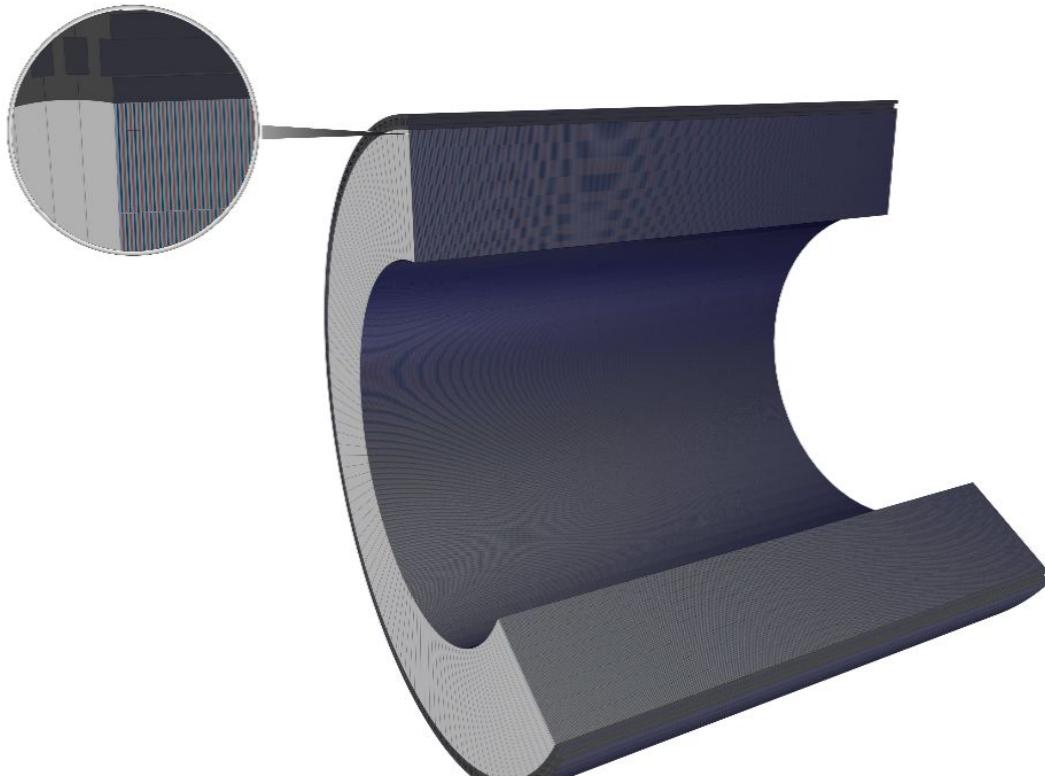


Figure 7.17: a) ECAL energy resolution for different levels of pile-up at $|\eta| = 0$. The no pile-up configuration uses a cluster size of $\Delta\eta \times \Delta\phi = 0.07 \times 0.17$ while with pile-up the optimised cluster size is $\Delta\eta \times \Delta\phi = 0.03 \times 0.08$. b) Effect of pile-up on the Higgs invariant mass distribution by selecting two photons with $p_T^\gamma > 30 \text{ GeV}$.

FCC-hh Hadronic Calorimeter



FCC-hh Hadronic Calorimeter



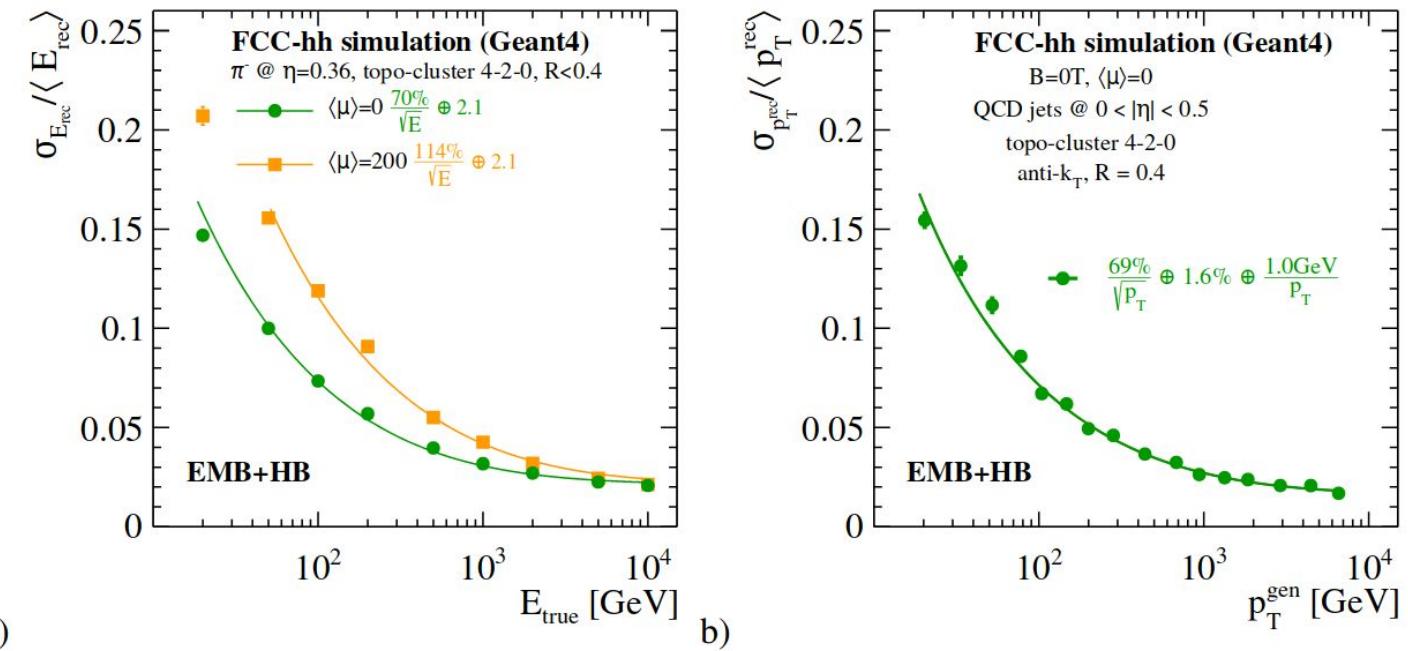
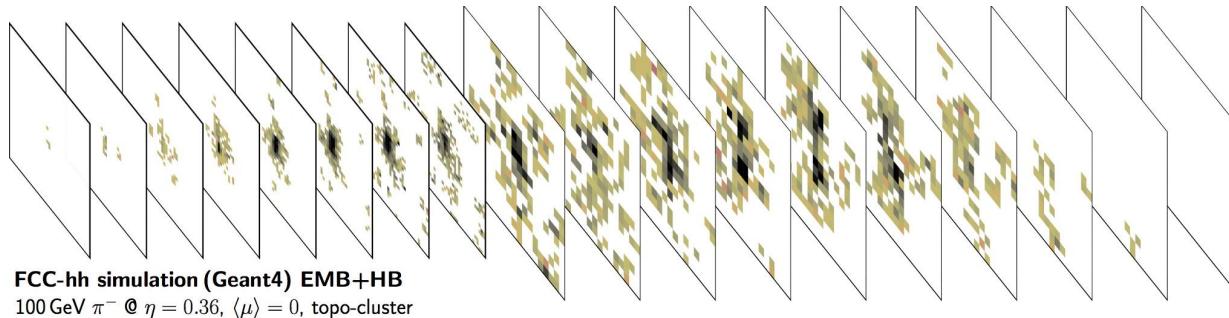
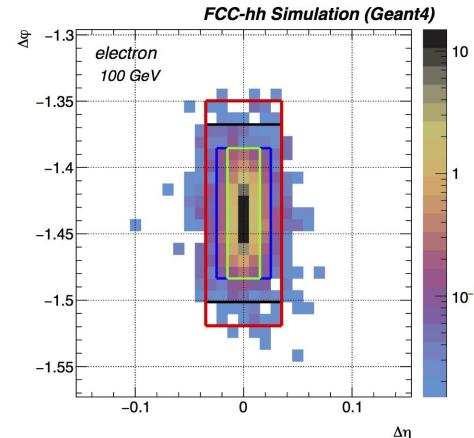


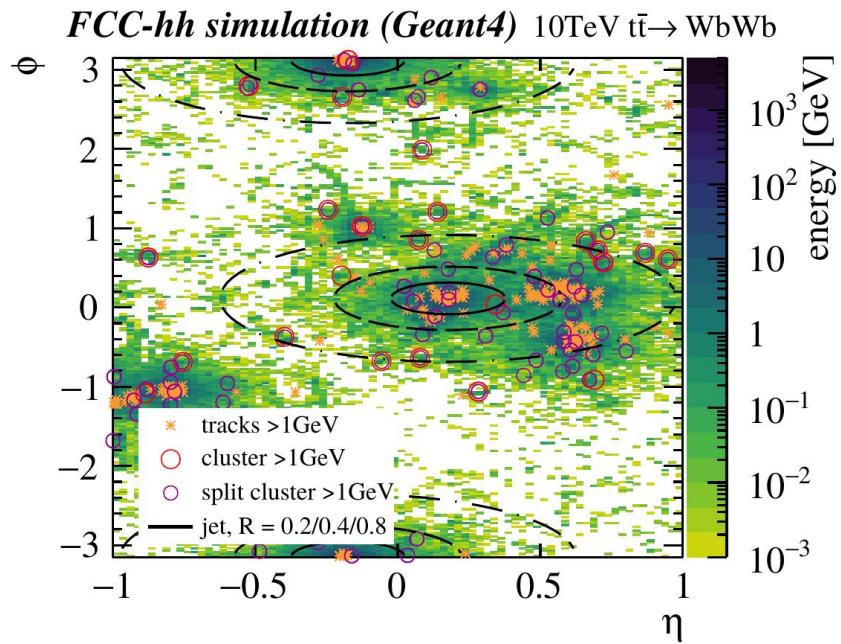
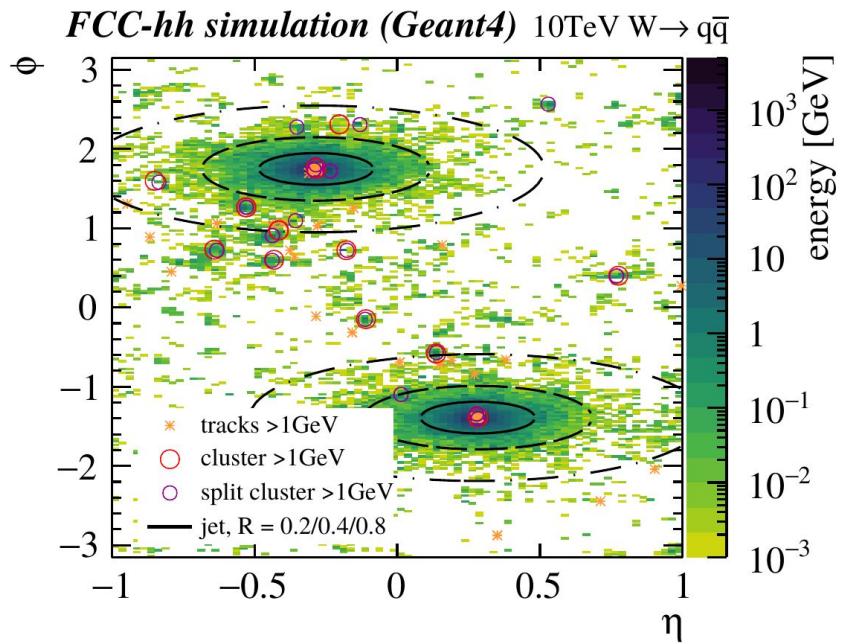
Figure 7.19: a) Single pion resolution using for barrel EMB + HB at $\eta=0.36$ and $B = 4$ T with electronics noise only (green circles) and for a pile-up of $\langle \mu \rangle = 200$ (orange squares). Only clusters with $\Delta R < 0.4$ from the generated particle direction are included. b) Momentum resolution for jets in the barrel EMB + HB at $B = 0$ T and without pile-up using the anti- k_T jet cone algorithm on top of the cluster reconstruction.

Calo Reconstruction Example

- Single 100 GeV e- reconstructed by sliding window
- Single 100 GeV pion in 8+10 layers of the E+HCal reconstructed by topo-cluster

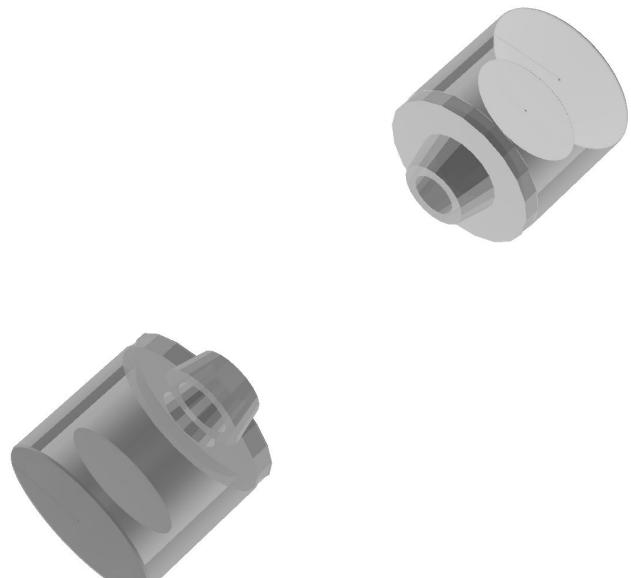
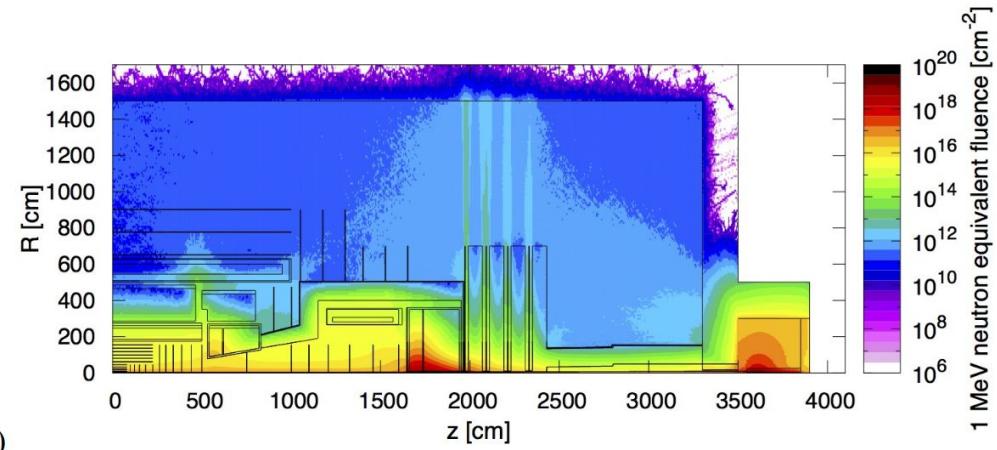


Calorimeter Reconstruction - boosted Objects



C. Neubuser, C. Helsens

FCC-hh Shielding



Organization in FCCSW/Detector

```
DetCommon
└── compact
    ├── Box.xml
    ├── EcalAir.xml
    ├── elements.xml
    ├── HcalAir.xml
    ├── materials.xml
    ├── MuonSystemAir.xml
    └── TrackerAir.xml
```

```
DetFCChhBaseline1/
└── CMakeLists.txt
└── compact
    ├── FCChh_BeamTube.xml
    ├── FCChh_DectDimensions.xml
    ├── FCChh_DectEmptyMaster.xml
    └── FCChh_DectMasterMaterial.xml
        ├── FCChh_DectMaster.xml
        ├── FCChh_ECalAir.xml
        ├── FCChh_MuonAir.xml
        ├── FCChh_Shielding.xml
        ├── FCChh_Solenoids.xml
        ├── FCChh_TrackerAir.xml
        └── FCChh_Visualisation.xml
```

FCC-ee IDEA

FCC-ee Beampipe & Beam Instrumentation



BeamPipe



HOMAbsorber



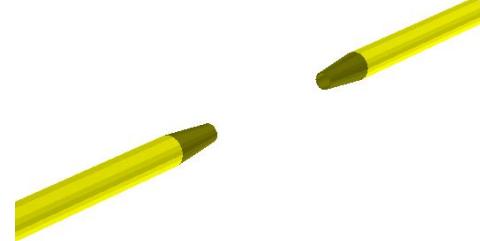
FCC-ee Beampipe & Beam Instrumentation



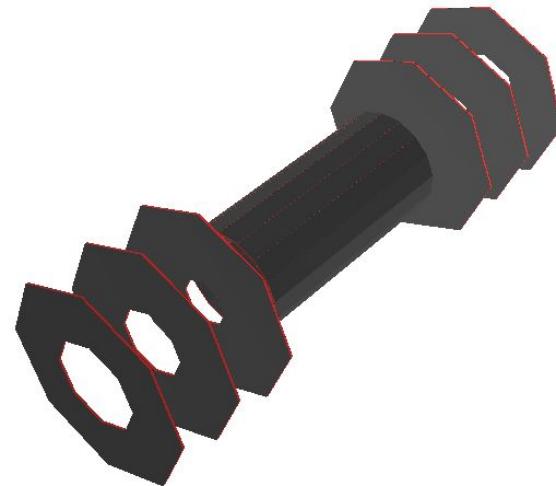
LumiCal



BeamInstrumentation

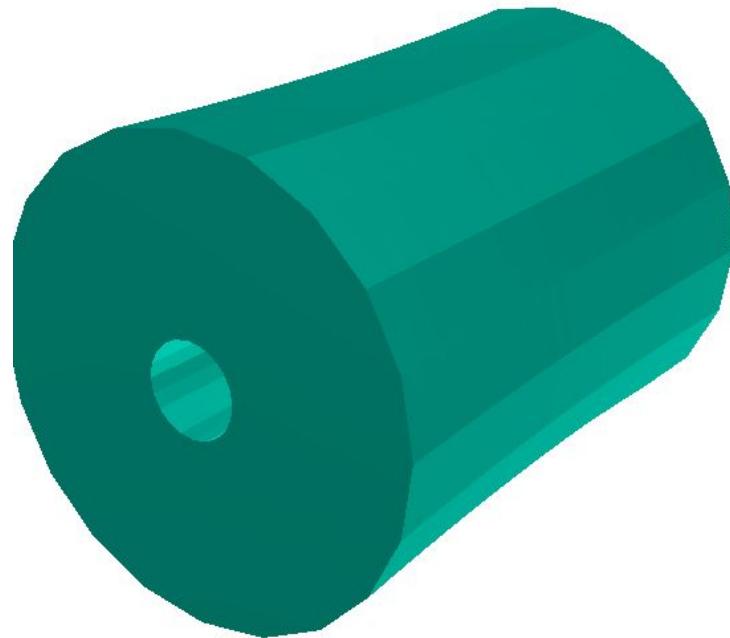
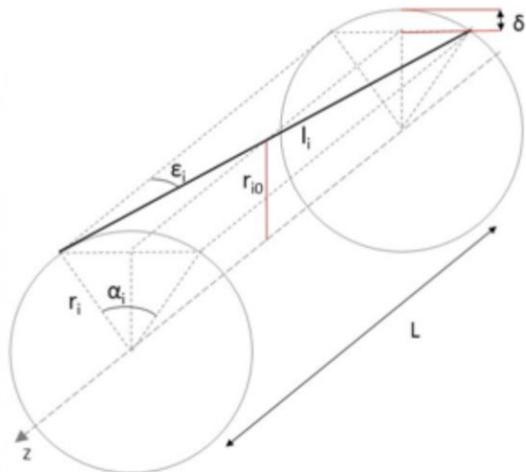


FCC-ee Vertex Tracker



FCC-ee DriftChamber

Wires implemented as a Segmentation in
Digitization, Chamber modeled as a material
mixture.

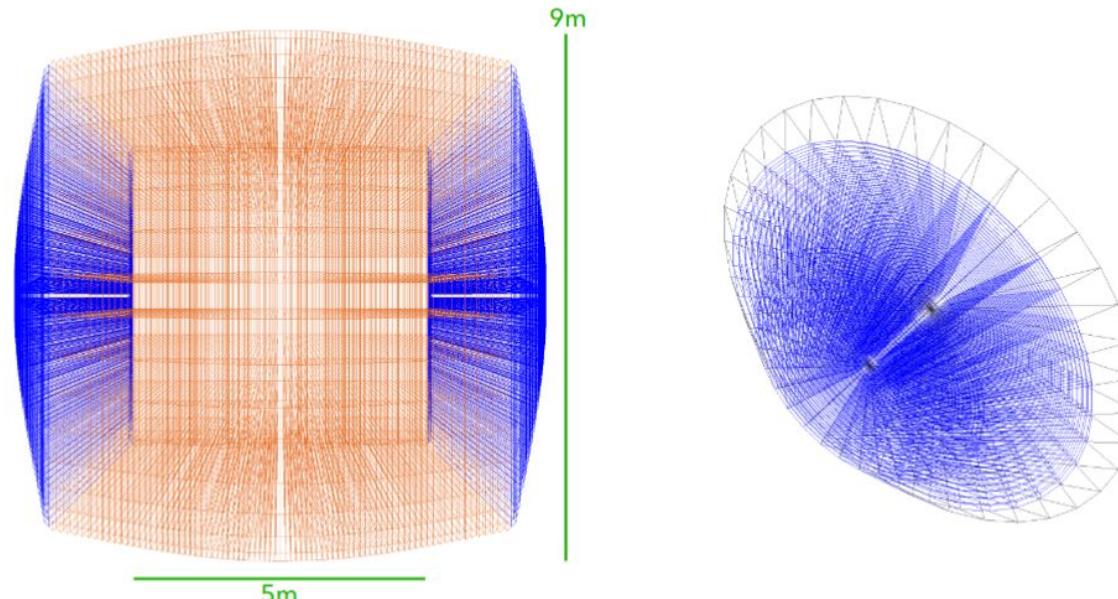


FCCee IDEA - DREAM Dual Readout Calorimeter

Barrel: Inner length: 5m - Outer diameter: 9 m @ 90°

2 m long copper based towers: $\sim 8.2 \lambda$

36 rotation around z axis



Implemented in Geant4 simulation

Not in FCCSW (yet!)

FCCee IDEA - LAr

Liquid Argon Calorimeter as developed for FCC-hh, adapted for FCC-ee

