Simulation of SiWECAL and SDHCAL for combined beam test

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DD4hep based simulation

- The detector setting files locate at
  https://github.com/libo929/SiWECAL_SDHCAL_TB_2018
  which was updated from the version,
  https://svnsrv.desy.de/viewvc/calice/calice_dd_testbeams/2016_SiECAL_SDHCAL
  prepared for the combined beam test in 2016.

- ILCSoft: v02-00-01
- Driver: lcgeo/detector/CaloTB/CaloPrototype_v02.cpp,
  which is to build a box like calorimeter prototype

- Parameters:
  • https://twiki.cern.ch/twiki/bin/view/CALICE/SiWEcalBT201809Analysis
  • MainSetup.xml, ECAL.xml, HCAL.xml

- How to run
  • Visualise the geometry: geoDisplay MainSetup.xml
  • Simulate events: ddsim --steeringFile run_ddsim.py

```python
1   from DDSim.DD4hepSimulation import DD4hepSimulation
2   from SystemOfUnits import mm, GeV, MeV
3
4   SIM = DD4hepSimulation()
5
6   SIM.runType = "batch"
7   SIM.numberOfEvents = 2000
8
9   SIM.skipNEvents = 0
10  SIM.outputFile = "gun_test.slcio"
11
12  SIM.compactFile = "MainSetup.xml"
13  SIM.dumpSteeringFile = "dumpSteering.xml"
14
15  SIM.field.eps_min = 1*mm
16  SIM.part.minimalKineticEnergy = 1*MeV
17  SIM.physicsList = "QGSP_BERT"
18  SIM.enableDetailedShowerMode=True
19
20  SIM.enableGun = True
21  SIM.gun.energy = 80*GeV
22  SIM.gun.particle = "e-"
23  SIM.gun.position = "184., -32., -1." # center of ECAL
24  SIM.gun.direction = "0,0,1"
```

run_ddsim.py

Left panel:

```
xmlns:xs="http://www.w3.org/2001/XMLSchema"
xs:noNamespaceSchemaLocation="http://www.lcsim.org/schemas/compact/1.0/compact

<info name="SiW-SDHCAL-TB-2016_v02"
    title="SiW-SDHCAL-TB-2016_v02"
    author="Shaojun Lu/D. Jeans/T.Kurka"
    url="flc.desy.de"
    status="development"
    version="$Id$">
    <comment>The compact File for the SiECAL+SDHCAL TB Setup (2016) </comment>
</info>

<includes>
    <gdmlFile  ref="${DD4hepINSTALL}/DDDetectors/compact/elements.xml"/>
    <gdmlFile  ref="${DD4hepINSTALL}/DDDetectors/compact/materials.xml"/>
    <!-- gdmlFile  ref="/gridgroup/ilc/kurca/lcgeo1709/trunk/ILD/compact/ILD_o
    <gdmlFile  ref="/home/jeans/ilcsoft/v01-17-09/lcgeo/trunk/ILD/compact/ILD_
</includes>

<plugins>
  <plugin name="InstallSurfaceManager"/>
</plugins>

<define>
    <constant name="world_side" value="80000*mm"/>
    <constant name="world_x" value="world_side"/>
    <constant name="world_y" value="world_side"/>
    <constant name="world_z" value="world_side"/>

    <!-- to limit the amount of MCParticles stored -->
    <constant name="tracker_region_rmax" value="1*cm" />
    <constant name="tracker_region_zmax" value="1*cm" />

    <!-- relative positioning of ECAL & HCAL -->
    <constant name="Ecal_FrontFaceZ" value="0*cm" />
    <constant name="Ecal_Thickness" value="195*mm"/>
    <constant name="Ecal_HcalGap" value="20*mm"/>
    <constant name="Hcal_FrontFaceZ" value="Ecal_Thickness + Ecal_HcalGap" />
</define>


<limits>
    <limitset name="cal_limits">
        <limit name="step_length_max" particles="*" value="5.0" unit="mm" />
    </limitset>
```

Right panel:

```
<lccdd xmlns:compact="http://www.lcsim.org/schemas/compact/1.0"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
    xs:noNamespaceSchemaLocation="http://www.lcsim.org/schemas/compact/1.0/compact

<info name="SiW-SDHCAL-TB-2016_v02"
    title="SiW-SDHCAL-TB-2016_v02"
    author="Shaojun Lu/D. Jeans/T.Kurka"
    url="flc.desy.de"
    status="development"
    version="$Id$">
    <comment>The compact File for the SiECAL+SDHCAL TB Setup (2016) </comment>
</info>

<includes>
    <gdmlFile  ref="${DD4hepINSTALL}/DDDetectors/compact/elements.xml"/>
    <gdmlFile  ref="${DD4hepINSTALL}/DDDetectors/compact/materials.xml"/>
    <gdmlFile  ref="${lcgeo_DIR}/ILD/compact/ILD_o2_v01/materials.xml"/>
</includes>

<plugins>
  <plugin name="InstallSurfaceManager"/>
</plugins>

<define>
    <constant name="world_side" value="80000*mm"/>
    <constant name="world_x" value="world_side"/>
    <constant name="world_y" value="world_side"/>
    <constant name="world_z" value="world_side"/>

    <!-- to limit the amount of MCParticles stored -->
    <constant name="tracker_region_rmax" value="1*cm" />
    <constant name="tracker_region_zmax" value="1*cm" />

    <!-- relative positioning of ECAL & HCAL -->
    <constant name="Ecal_FrontFaceZ" value="0*cm" />
    <!--constant name="Ecal_Thickness" value="195*mm"/-->
    <constant name="Ecal_Thickness" value="150*mm + 0.001*mm"/> <!-- 10 * 15 m
    <constant name="Ecal_HcalGap" value="70*mm"/>
    <constant name="Hcal_FrontFaceZ" value="Ecal_Thickness + Ecal_HcalGap" />
</define>

<limits>
    <limitset name="cal_limits">
        <limit name="step_length_max" particles="*" value="5.0" unit="mm" />
```

Left panel:

```xml
<!--
    ECAL parameters for testbeam
-->


<lccdd>
  <define>
    <constant name="env_safety" value="0.001*mm"/>

    <constant name="Ecal_NcellsX" value="32" />
    <constant name="Ecal_NcellsY" value="32" />
    <constant name="Ecal_CellSizeX" value="5.5*mm" />
    <constant name="Ecal_CellSizeY" value="5.5*mm" />
    <constant name="Ecal_NLayers" value="11"/>
    <constant name="Ecal_NinstrumentedLayers" value="7"/>

    <constant name="Ecal_dim_x" value="Ecal_NcellsX*Ecal_CellSizeX"/>
    <constant name="Ecal_dim_y" value="Ecal_NcellsY*Ecal_CellSizeY"/>
    <constant name="Ecal_dim_z" value="Ecal_Thickness"/>

    <constant name="Ecal_LayerDistance" value="15.0*mm"/>
    <constant name="Ecal_WThickness" value="2.1*mm"/>
    <constant name="Ecal_AlThickness" value="0.1*mm+1.7*mm"/>
    <constant name="Ecal_GapThickness" value="0.1*mm"/>
    <constant name="Ecal_CuShieldThickness" value="0.5*mm"/>
    <constant name="Ecal_AsicThickness" value="1.1*mm"/>
    <constant name="Ecal_PcbThickness" value="1.61*mm"/>
    <constant name="Ecal_GlueThickness" value="0.08*mm"/>
    <constant name="Ecal_WaferThickness" value="0.5*mm"/>
    <constant name="Ecal_KaptonThickness" value="0.06*mm"/>
    <constant name="Ecal_CFThickness" value="0.9*mm"/>

  </define>

  <readouts>
    <readout name="SiEcalCollection">
      <segmentation type="TiledLayerGridXY"
                     grid_size_x="Ecal_CellSizeX" grid_size_y="Ecal_CellSizeX"
                     offset_x="-Ecal_dim_x/2.0" offset_y="-Ecal_dim_y/2.0"
                     identifier_x="I" identifier_y="J" identifier_layer="K"/>
      <id>system:8,K:8,I:8,J:8</id>
    </readout>
  </readouts>

    <envelope vis="EcalVis">
      <shape type="Box" dx="Ecal_dim_x/2.0 + env_safety" dy="Ecal_dim_y/2.0 + en
      <rotation x="0" y="0" z="0"/>
      <position x="0" y="0" z="Ecal_dim_z/2.0"/>
    </envelope>

    <slice material = "Air"        thickness = "10*mm"   vis="Invisible"/>

    <layer repeat="Ecal_NinstrumentedLayers" vis="EcalVis">

      <slice material = "TungstenDens1910" thickness = "3*Ecal_WThickness"  vis=
```

Right panel:

```xml
<!--
    ECAL parameters for testbeam
-->


<lccdd>
  <define>
    <constant name="env_safety" value="0.001*mm"/>

    <constant name="Ecal_NcellsX" value="32" />
    <constant name="Ecal_NcellsY" value="32" />
    <constant name="Ecal_CellSizeX" value="5.5*mm" />
    <constant name="Ecal_CellSizeY" value="5.5*mm" />
    <constant name="Ecal_NLayers" value="10"/>
    <constant name="Ecal_NinstrumentedLayers" value="7"/>

    <constant name="Ecal_dim_x" value="Ecal_NcellsX*Ecal_CellSizeX"/>
    <constant name="Ecal_dim_y" value="Ecal_NcellsY*Ecal_CellSizeY"/>
    <constant name="Ecal_dim_z" value="Ecal_Thickness"/>

    <constant name="Ecal_LayerDistance" value="15.0*mm"/>
    <constant name="Ecal_WThickness" value="2.1*mm"/>
    <constant name="Ecal_AlThickness" value="0.1*mm+1.7*mm"/>
    <constant name="Ecal_GapThickness" value="0.1*mm"/>
    <constant name="Ecal_CuShieldThickness" value="0.5*mm"/>
    <constant name="Ecal_AsicThickness" value="1.1*mm"/>
    <constant name="Ecal_PcbThickness" value="1.61*mm"/>
    <constant name="Ecal_GlueThickness" value="0.08*mm"/>
    <constant name="Ecal_WaferThickness" value="0.5*mm"/>
    <constant name="Ecal_KaptonThickness" value="0.06*mm"/>
    <constant name="Ecal_CFThickness" value="0.9*mm"/>

  </define>

  <readouts>
    <readout name="SiEcalCollection">
      <segmentation type="TiledLayerGridXY"
                     grid_size_x="Ecal_CellSizeX" grid_size_y="Ecal_CellSizeX"
                     offset_x="-Ecal_dim_x/2.0" offset_y="-Ecal_dim_y/2.0"
                     identifier_x="I" identifier_y="J" identifier_layer="K"/>
      <id>system:8,K:8,slice:4,I:8,J:8</id>
    </readout>
  </readouts>

    <envelope vis="EcalVis">
      <shape type="Box" dx="Ecal_dim_x/2.0 + env_safety" dy="Ecal_dim_y/2.0 + en
      <rotation x="0" y="0" z="0"/>
      <position x="184.75*mm" y="-32.75*mm" z="Ecal_dim_z/2.0"/>
    </envelope>

    <slice material = "Air"        thickness = "10*mm"   vis="Invisible"/>

    <layer repeat="Ecal_NLayers" vis="EcalVis">

      <slice material = "TungstenDens1910" thickness = "3*Ecal_WThickness"  vis=
```
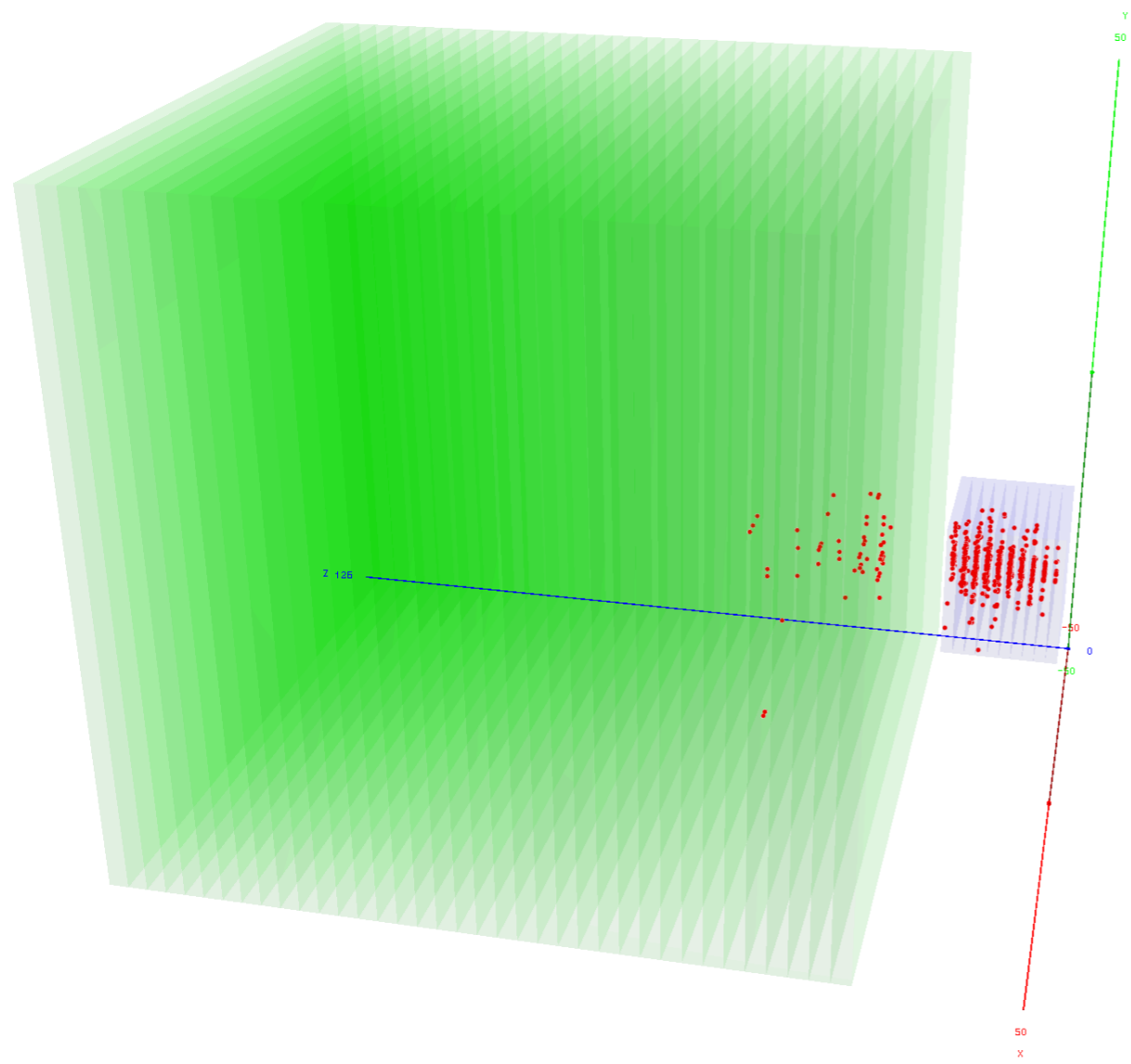
Left side:

```
<constant name="Hcal_NcellsX" value="96" />
<constant name="Hcal_NcellsY" value="96" />
<constant name="Hcal_CellSizeX" value="10.406*mm" />
<constant name="Hcal_CellSizeY" value="10.406*mm" />
<constant name="Hcal_NLayers" value="48"/>

<constant name="Hcal_radiator_thickness"         value="15.0*mm"/>
<constant name="Hcal_g10_thickness"              value="1.4*mm"/>
<constant name="Hcal_electronics_mask_thickness" value="1.6*mm"/>
<constant name="Hcal_PCB_thickness"              value="1.2*mm"/>
<constant name="Hcal_mylar_anode_thickness"      value="0.05*mm"/>
<constant name="Hcal_mylar_cathode_thickness"    value="0.175*mm"/>
<constant name="Hcal_graphite_cathode_thickness" value="0.05*mm"/>
<constant name="Hcal_graphite_anode_thickness"   value="0.05*mm"/>
<constant name="Hcal_glass_cathode_thickness"    value="1.1*mm"/>
<constant name="Hcal_glass_anode_thickness"      value="0.7*mm"/>
<constant name="Hcal_gas_gap"                    value="1.2*mm"/>
<constant name="Hcal_tb_airgap_thickness"        value="1.0*mm" />
<constant name="Hcal_steel_casette_thickness"    value="2.5*mm" />

<constant name="Hcal_LayerThickness"
          value="Hcal_radiator_thickness +
                 Hcal_tb_airgap_thickness +
                 Hcal_steel_casette_thickness +
                 Hcal_electronics_mask_thickness +
                 Hcal_PCB_thickness +
                 Hcal_mylar_anode_thickness +
                 Hcal_graphite_anode_thickness +
                 Hcal_glass_anode_thickness +
                 Hcal_gas_gap +
                 Hcal_glass_cathode_thickness +
                 Hcal_graphite_cathode_thickness +
                 Hcal_mylar_cathode_thickness +
                 Hcal_steel_casette_thickness +
                 Hcal_tb_airgap_thickness"/>

<constant name="Hcal_dim_x" value="Hcal_NcellsX*Hcal_CellSizeX"/>
<constant name="Hcal_dim_y" value="Hcal_NcellsY*Hcal_CellSizeY"/>
<constant name="Hcal_dim_z" value="Hcal_NLayers*Hcal_LayerThickness + Hcal_rad

</define>
</define>

<readouts>
  <readout name="SDHcalCollection">
    <segmentation type="TiledLayerGridXY"
               grid_size_x="Hcal_CellSizeX" grid_size_y="Hcal_CellSizeY"
               offset_x="-Hcal_dim_x/2.0" offset_y="-Hcal_dim_y/2.0"
               identifier_x="I" identifier_y="J" identifier_layer="K"/>

    <!-- identifier_dif="tower"/ -->
    <!-- id>system:8,I:8,J:8,layer:8,tower:2</id -->
    <!-- id>system:8,I:8,J:8,layer:8,tower:2</id -->

    <id>system:8,K:8,I:8,J:8</id>

  </readout>
</readouts>
```

Right side:

```
<constant name="Hcal_NcellsX" value="96" />
<constant name="Hcal_NcellsY" value="96" />
<constant name="Hcal_CellSizeX" value="10.406*mm" />
<constant name="Hcal_CellSizeY" value="10.406*mm" />
<constant name="Hcal_NLayers" value="37"/>

<constant name="Hcal_radiator_thickness"         value="15.0*mm"/>
<constant name="Hcal_g10_thickness"              value="1.4*mm"/>
<constant name="Hcal_electronics_mask_thickness" value="1.6*mm"/>
<constant name="Hcal_PCB_thickness"              value="1.2*mm"/>
<constant name="Hcal_mylar_anode_thickness"      value="0.05*mm"/>
<constant name="Hcal_mylar_cathode_thickness"    value="0.175*mm"/>
<constant name="Hcal_graphite_cathode_thickness" value="0.05*mm"/>
<constant name="Hcal_graphite_anode_thickness"   value="0.05*mm"/>
<constant name="Hcal_glass_cathode_thickness"    value="1.1*mm"/>
<constant name="Hcal_glass_anode_thickness"      value="0.7*mm"/>
<constant name="Hcal_gas_gap"                    value="1.2*mm"/>
<constant name="Hcal_tb_airgap_thickness"        value="1.0*mm" />
<constant name="Hcal_steel_casette_thickness"    value="2.5*mm" />

<constant name="Hcal_LayerThickness"
          value="Hcal_radiator_thickness +
                 Hcal_tb_airgap_thickness +
                 Hcal_steel_casette_thickness +
                 Hcal_electronics_mask_thickness +
                 Hcal_PCB_thickness +
                 Hcal_mylar_anode_thickness +
                 Hcal_graphite_anode_thickness +
                 Hcal_glass_anode_thickness +
                 Hcal_gas_gap +
                 Hcal_glass_cathode_thickness +
                 Hcal_graphite_cathode_thickness +
                 Hcal_mylar_cathode_thickness +
                 Hcal_steel_casette_thickness +
                 Hcal_tb_airgap_thickness"/>

<constant name="Hcal_dim_x" value="Hcal_NcellsX*Hcal_CellSizeX"/>
<constant name="Hcal_dim_y" value="Hcal_NcellsY*Hcal_CellSizeY"/>
<!--constant name="Hcal_dim_z" value="Hcal_NLayers*Hcal_LayerThickness + Hcal_
<constant name="Hcal_dim_z" value="Hcal_NLayers*Hcal_LayerThickness"/>

</define>

<readouts>
  <readout name="SDHcalCollection">
    <segmentation type="TiledLayerGridXY"
               grid_size_x="Hcal_CellSizeX" grid_size_y="Hcal_CellSizeY"
               offset_x="-Hcal_dim_x/2.0" offset_y="-Hcal_dim_y/2.0"
               identifier_x="I" identifier_y="J" identifier_layer="K"/>

    <!-- identifier_dif="tower"/ -->
    <!-- id>system:8,I:8,J:8,layer:8,tower:2</id -->
    <!-- id>system:8,I:8,J:8,layer:8,tower:2</id -->

    <id>system:8,K:8,slice:4,I:8,J:8</id>

  </readout>
</readouts>
```
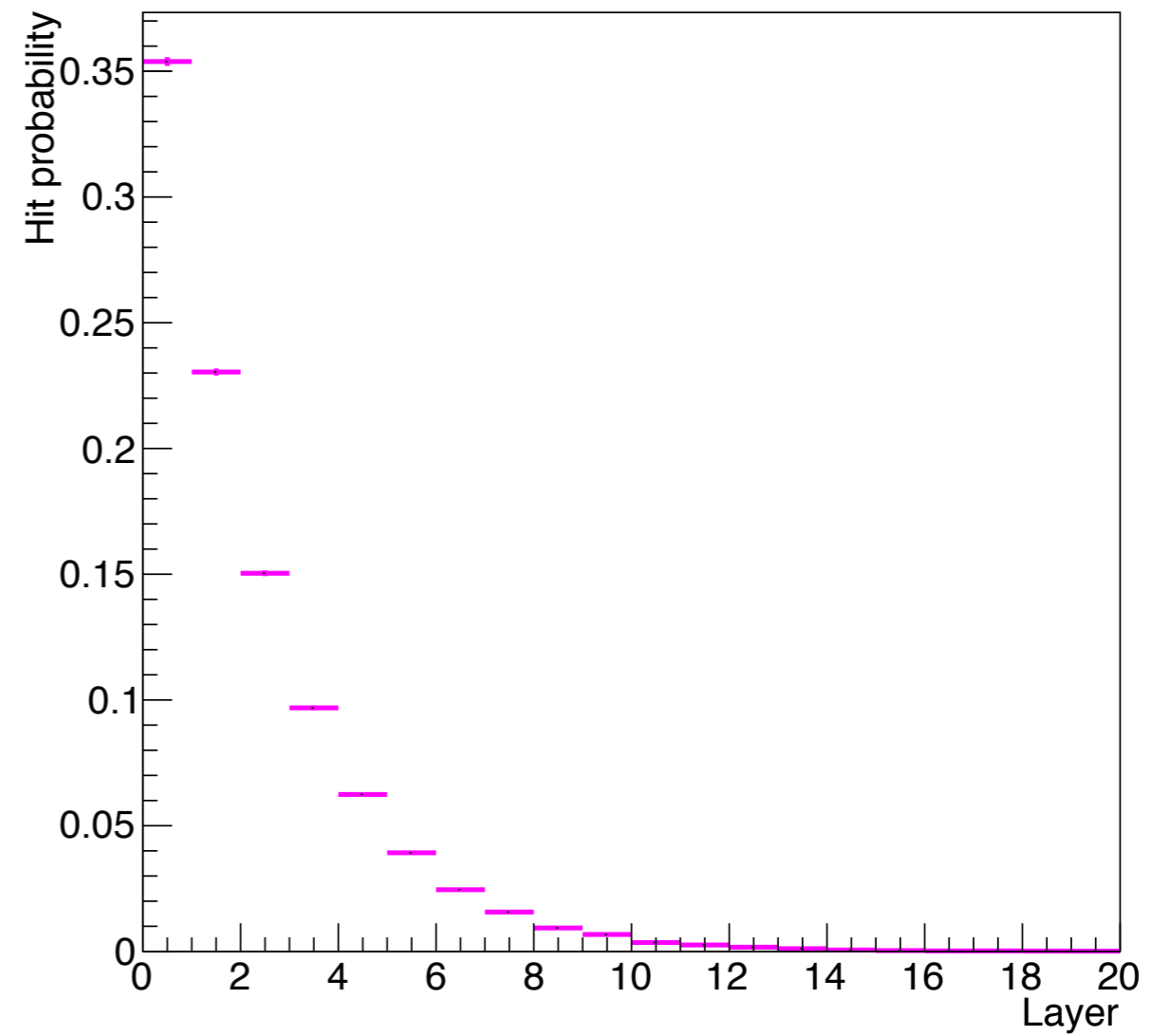
Example

80 GeV e⁻

Hit in SDHCAL