Backward ECAL geometry in DD4hep
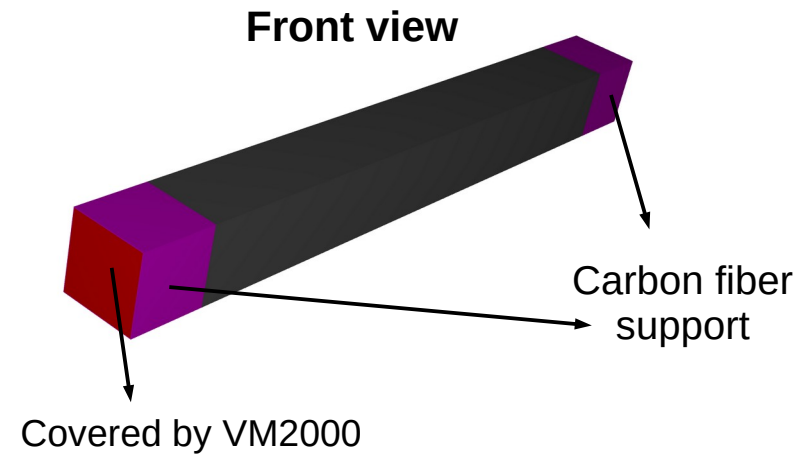
Carlos Muñoz Camacho, WANG Pu-Kai, ZHU Yuwei

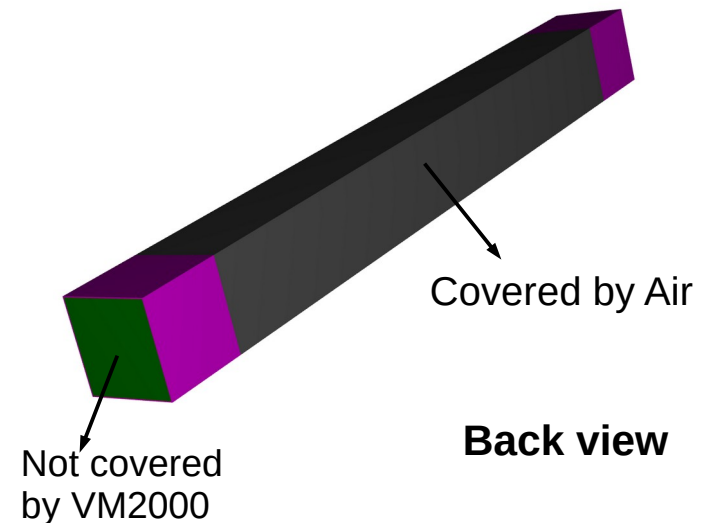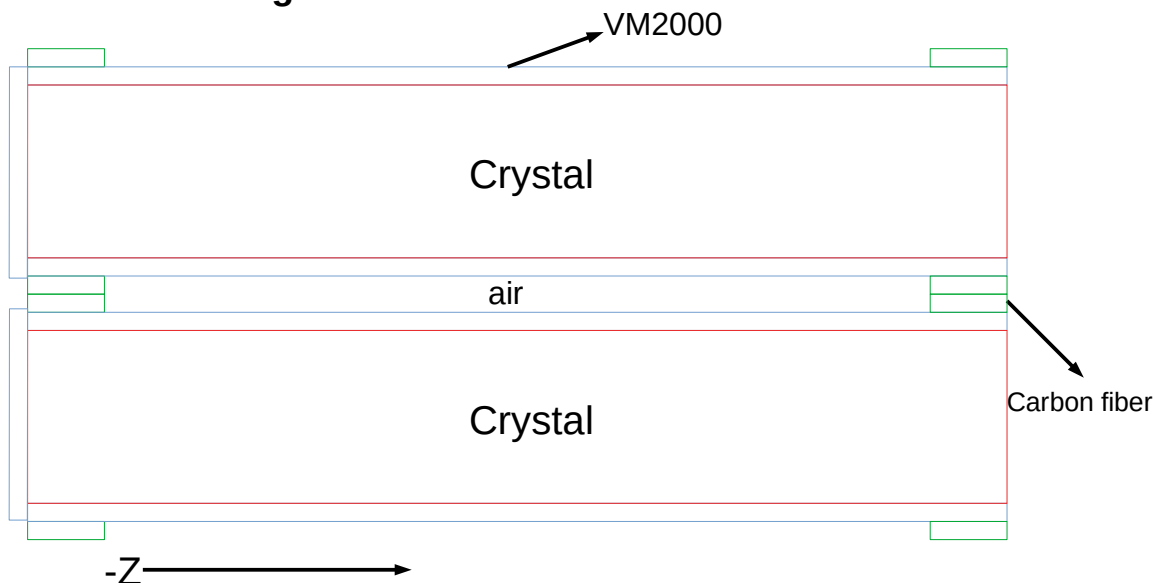IJClab

09/29/2022

Single module of backward end cap EM calorimeter

- Crystal[lead tungsten] size: 20x20x200 mm^3

- Reflector is VM2000 and the thickness is 0.1mm

- Supporting structure is Carbon fiber and the thickness is 0.4mm (0.2mm around each crystal module)

- Carbon fiber structure only along 20mm at the front and 20mm at the back of the crystals

- Optical property copied from fun4all

Front view

Carbon fiber support

Covered by VM2000

Schematic of single module

VM2000

Crystal

air

Crystal

Carbon fiber

-Z

Covered by Air

Not covered by VM2000

Back view

End cap calorimeter

- Crystal Front face @ -166cm

- Modules are placed from 8.5 to 64.1cm from the electron beam axis

- Inner and outer frame are made of steel

- Thickness of inner frame 0.5cm

- Thickness of outer frame 0.9cm

- 2932 modules are placed

- 26x2 modules along y axis

- The gap between modules and inner or outer ring is filled by steel [shown in next slide]

- Passed the overlap check

End cap calorimeter

Steel
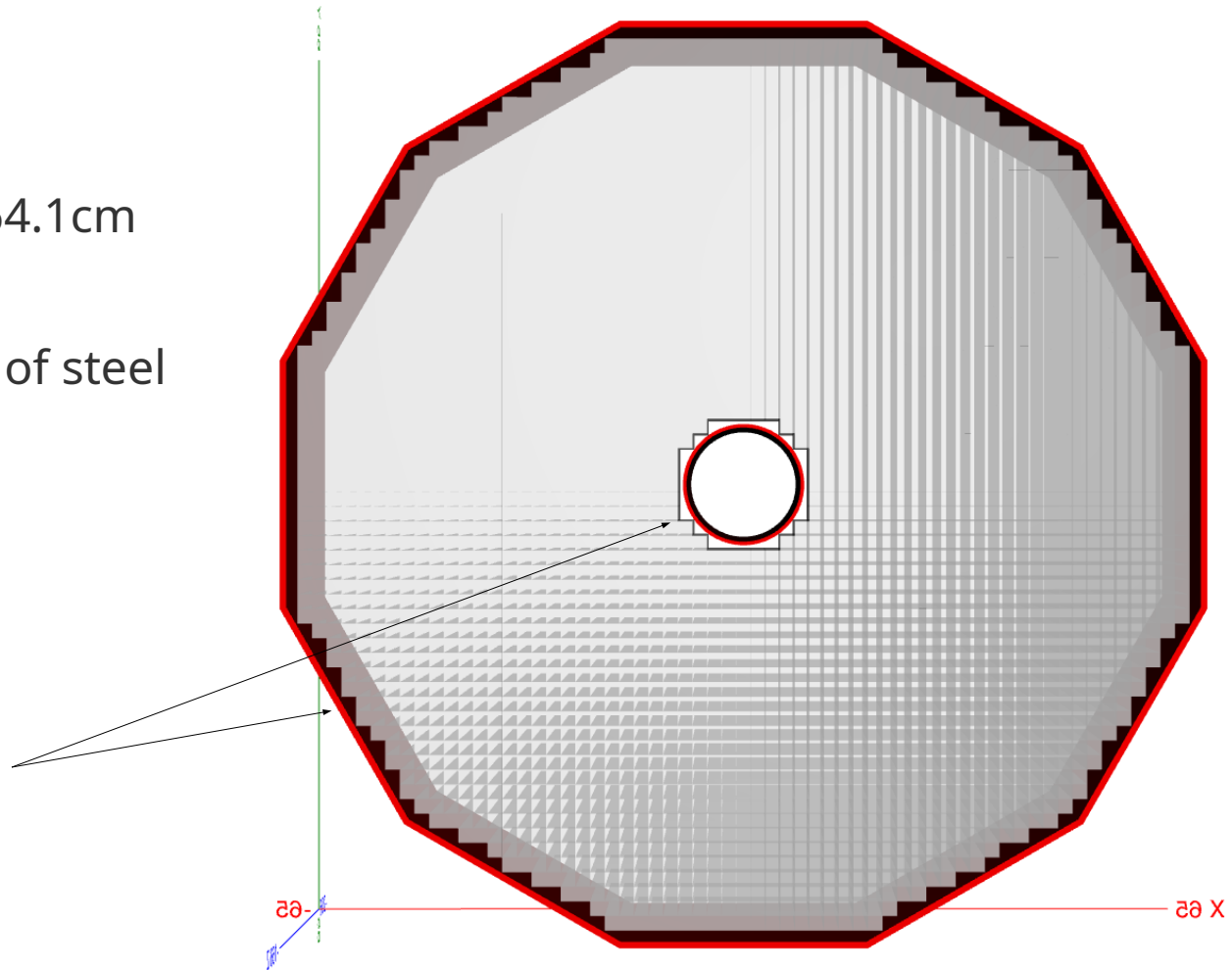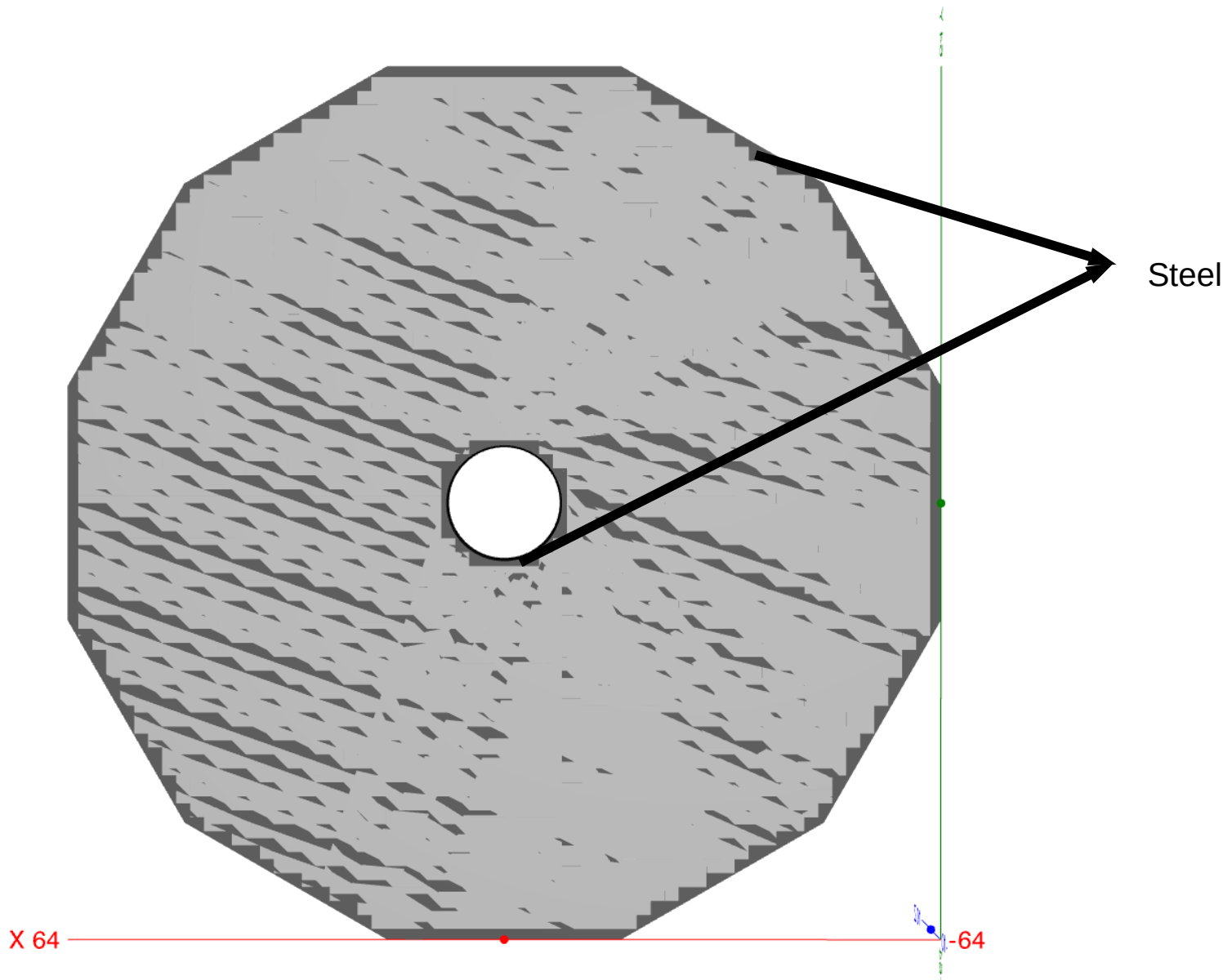
End cap calorimeter with DIRC and beam pipe
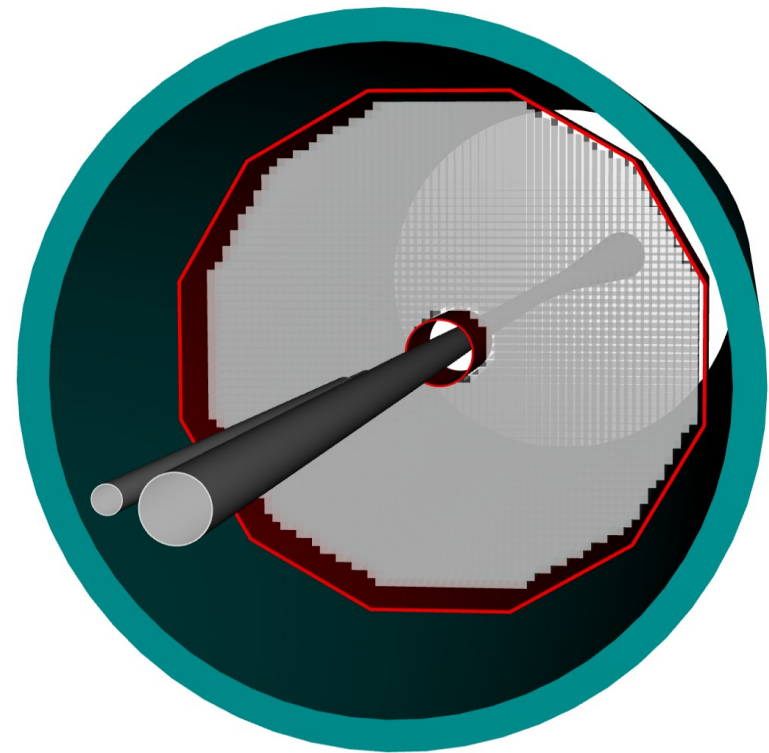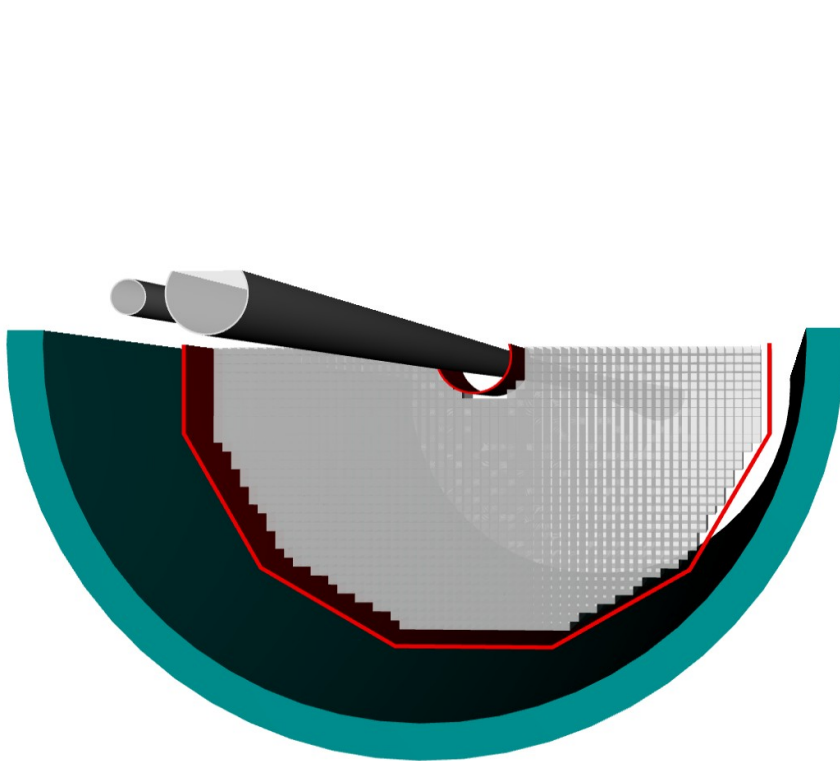
Material scan

Whole detector material scan (along the front of module)   Close to outer frame

```
+-------------------------------------------------------------------------------------------------------
+ Material scan between: x_0 = (   0.00,  66.00,-167.00) [cm] and x_1 = (   0.00, -66.00,-167.00) [cm] :
+-------------------------------------------------------------------------------------------------------
|    \   Material        Atomic                    Radiation   Interaction            Path  Integrated  Integrated  Material
| Num. \   Name        Number/Z   Mass/A  Density    Length      Length    Thickness Length     X0        Lambda    Endpoint
| Layer \             [g/mole] [g/cm3]   [cm]        [cm]        [cm]       [cm]     [cm]     [cm]     (      cm,       cm,      cm)
+-------------------------------------------------------------------------------------------------------
|    1 Air                  7   14.784   0.0012  30528.8407   71998.1725    1.000    1.00   0.000033   0.000014  (   0.00,  65.00,-167.00)
|    2 StainlessSteel      26   55.380   8.3000      1.6774      16.2392    0.900    1.90   0.536592   0.055435  (   0.00,  64.10,-167.00)
|    3 StainlessSteel      26   55.380   8.3000      1.6774      16.2392    1.575    3.48   1.475570   0.152423  (   0.00,  62.52,-167.00)
|    4 CarbonFiber          6   11.968   1.5000     28.0746      51.2277    0.020    3.50   1.476283   0.152813  (   0.00,  62.50,-167.00)
|    5 VM2000               8   15.811   1.4300     25.6110      59.7748    0.005    3.50   1.476478   0.152897  (   0.00,  62.50,-167.00)
|    6 PbWO4               68  170.881   8.3000      0.8903      20.9592    2.000    5.50   3.722903   0.248321  (   0.00,  60.50,-167.00)
|    7 VM2000               8   15.811   1.4300     25.6110      59.7748    0.005    5.51   3.723098   0.248404  (   0.00,  60.49,-167.00)
|    8 CarbonFiber          6   11.968   1.5000     28.0746      51.2277    0.020    5.53   3.723810   0.248795  (   0.00,  60.47,-167.00)
|    9 CarbonFiber          6   11.968   1.5000     28.0746      51.2277    0.020    5.55   3.724523   0.249185  (   0.00,  60.45,-167.00)
|   10 VM2000               8   15.811   1.4300     25.6110      59.7748    0.005    5.55   3.724718   0.249269  (   0.00,  60.45,-167.00)
|   11 PbWO4               68  170.881   8.3000      0.8903      20.9592    2.000    7.55   5.971143   0.344692  (   0.00,  58.45,-167.00)
|   12 VM2000               8   15.811   1.4300     25.6110      59.7748    0.005    7.56   5.971338   0.344776  (   0.00,  58.44,-167.00)
|   13 CarbonFiber          6   11.968   1.5000     28.0746      51.2277    0.020    7.58   5.972050   0.345166  (   0.00,  58.42,-167.00)
```

Whole detector material scan (along the front of module)   Close to inner frame

```
|  129 CarbonFiber          6   11.968   1.5000     28.0746      51.2277    0.020   54.74  57.682284   2.562104  (   0.00,  11.26,-167.00)
|  130 VM2000               8   15.811   1.4300     25.6110      59.7748    0.005   54.75  57.682479   2.562188  (   0.00,  11.25,-167.00)
|  131 PbWO4               68  170.881   8.3000      0.8903      20.9592    2.000   56.75  59.928904   2.657612  (   0.00,   9.25,-167.00)
|  132 VM2000               8   15.811   1.4300     25.6110      59.7748    0.005   56.75  59.929099   2.657695  (   0.00,   9.25,-167.00)
|  133 CarbonFiber          6   11.968   1.5000     28.0746      51.2277    0.020   56.77  59.929812   2.658086  (   0.00,   9.23,-167.00)
|  134 StainlessSteel      26   55.380   8.3000      1.6774      16.2392    0.725   57.50  60.362040   2.702731  (   0.00,   8.50,-167.00)
|  135 StainlessSteel      26   55.380   8.3000      1.6774      16.2392    0.500   58.00  60.660128   2.733520  (   0.00,   8.00,-167.00)
|  136 Air                  7   14.784   0.0012  30528.8407   71998.1725    4.316   62.32  60.660269   2.733580  (   0.00,   3.68,-167.00)
|  137 Aluminum            13   26.982   2.6990      8.8963      39.8672    0.200   62.52  60.682751   2.738597  (   0.00,   3.48,-167.00)
|  138 Vacuum               7   14.784   0.0000 3.66346e+11 8.63978e+11    6.969   69.48  60.682751   2.738597  (   0.00,  -3.48,-167.00)
|  139 Aluminum            13   26.982   2.6990      8.8963      39.8672    0.200   69.68  60.705232   2.743614  (   0.00,  -3.68,-167.00)
|  140 Air                  7   14.784   0.0012  30528.8407   71998.1725    4.316   74.00  60.705373   2.743674  (   0.00,  -8.00,-167.00)
|  141 StainlessSteel      26   55.380   8.3000      1.6774      16.2392    0.500   74.50  61.003462   2.774463  (   0.00,  -8.50,-167.00)
|  142 StainlessSteel      26   55.380   8.3000      1.6774      16.2392    0.725   75.23  61.435690   2.819108  (   0.00,  -9.23,-167.00)
|  143 CarbonFiber          6   11.968   1.5000     28.0746      51.2277    0.020   75.25  61.436402   2.819499  (   0.00,  -9.25,-167.00)
|  144 VM2000               8   15.811   1.4300     25.6110      59.7748    0.005   75.25  61.436597   2.819582  (   0.00,  -9.25,-167.00)
|  145 PbWO4               68  170.881   8.3000      0.8903      20.9592    2.000   77.25  63.683022   2.915006  (   0.00, -11.25,-167.00)
|  146 VM2000               8   15.811   1.4300     25.6110      59.7748    0.005   77.25  63.683217   2.915090  (   0.00, -11.25,-167.00)
|  147 CarbonFiber          6   11.968   1.5000     28.0746      51.2277    0.020   77.27  63.683930   2.915480  (   0.00, -11.27,-167.00)
```

Material scan

Whole detector material scan (along the center of module)   Close to outer frame

```
+----------------------------------------------------------------------------------------------------------------------------------------
+ Material scan between: x_0 = (   0.00,  66.00,-170.00) [cm] and x_1 = (   0.00, -66.00,-170.00) [cm] :
+----------------------------------------------------------------------------------------------------------------------------------------
|    \    Material          Atomic                    Radiation   Interaction             Path   Integrated  Integrated   Material
| Num. \   Name      Number/Z   Mass/A   Density       Length       Length     Thickness  Length     X0        Lambda     Endpoint
| Layer \            [g/mole]  [g/cm3]    [cm]         [cm]         [cm]        [cm]      [cm]       [cm]         (      cm,      cm,      cm)
+----------------------------------------------------------------------------------------------------------------------------------------
|     1 Air             7    14.784   0.0012   30528.8407   71998.1725     1.000    1.00   0.000033   0.000014   (   0.00,  65.00,-170.00)
|     2 StainlessSteel 26    55.380   8.3000       1.6774      16.2392     0.900    1.90   0.536592   0.055435   (   0.00,  64.10,-170.00)
|     3 StainlessSteel 26    55.380   8.3000       1.6774      16.2392     1.575    3.48   1.475570   0.152423   (   0.00,  62.52,-170.00)
|     4 Air             7    14.784   0.0012   30528.8407   71998.1725     0.020    3.50   1.475571   0.152423   (   0.00,  62.50,-170.00)
|     5 VM2000          8    15.811   1.4300      25.6110      59.7748     0.005    3.50   1.475766   0.152507   (   0.00,  62.50,-170.00)
|     6 PbWO4          68   170.881   8.3000       0.8903      20.9592     2.000    5.50   3.722191   0.247930   (   0.00,  60.50,-170.00)
|     7 VM2000          8    15.811   1.4300      25.6110      59.7748     0.005    5.51   3.722386   0.248014   (   0.00,  60.49,-170.00)
|     8 Air             7    14.784   0.0012   30528.8407   71998.1725     0.020    5.53   3.722387   0.248014   (   0.00,  60.47,-170.00)
|     9 Air             7    14.784   0.0012   30528.8407   71998.1725     0.020    5.55   3.722388   0.248015   (   0.00,  60.45,-170.00)
|    10 VM2000          8    15.811   1.4300      25.6110      59.7748     0.005    5.55   3.722583   0.248098   (   0.00,  60.45,-170.00)
|    11 PbWO4          68   170.881   8.3000       0.8903      20.9592     2.000    7.55   5.969008   0.343522   (   0.00,  58.45,-170.00)
|    12 VM2000          8    15.811   1.4300      25.6110      59.7748     0.005    7.56   5.969203   0.343605   (   0.00,  58.44,-170.00)
|    13 Air             7    14.784   0.0012   30528.8407   71998.1725     0.020    7.58   5.969203   0.343606   (   0.00,  58.42,-170.00)
```

Single module material scan (along the crystal axis)

```
+----------------------------------------------------------------------------------------------------------------------------------------
+ Material scan between: x_0 = (  10.00,  10.00,-160.00) [cm] and x_1 = (  10.00,  10.00,-200.00) [cm] :
+----------------------------------------------------------------------------------------------------------------------------------------
|    \    Material          Atomic                    Radiation   Interaction             Path   Integrated  Integrated   Material
| Num. \   Name      Number/Z   Mass/A   Density       Length       Length     Thickness  Length     X0        Lambda     Endpoint
| Layer \            [g/mole]  [g/cm3]    [cm]         [cm]         [cm]        [cm]      [cm]       [cm]         (      cm,      cm,      cm)
+----------------------------------------------------------------------------------------------------------------------------------------
|     1 Air             7    14.784   0.0012   30528.8407   71998.1725     6.000    6.00   0.000197   0.000083   (  10.00,  10.00,-166.00)
|     2 VM2000          8    15.811   1.4300      25.6110      59.7748     0.003    6.00   0.000294   0.000125   (  10.00,  10.00,-166.00)
|     3 PbWO4          68   170.881   8.3000       0.8903      20.9592    20.000   26.00  22.464542   0.954360   (  10.00,  10.00,-186.00)
|     4 Air             7    14.784   0.0012   30528.8407   71998.1725    13.998   40.00  22.465001   0.954555   (  10.00,  10.00,-200.00)
+----------------------------------------------------------------------------------------------------------------------------------------
|     0 Average Material 68  170.585   4.1507       1.7805      41.9044    40.000   40.00  22.465001   0.954555   (  10.00,  10.00,-200.00)
+----------------------------------------------------------------------------------------------------------------------------------------
```

Status and next step

- The geometry is ready and checked locally.

- The new geometry commit to branch:
140-the-build-of-electron-going-end-cap-emcalorimeter-geometry

- Next step:
- Improve the description of the calorimeter outer frame, including space for central detector cables, etc
- Increasing the coverage around the beam pipe based on the updated flange dimensions