CLIC DETECTOR SIMULATION MODEL

The 2015 International Workshop on Future Linear Colliders

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on behalf of the CLICdp Collaboration

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Status of Detector Model

- All sub-detectors implemented in DD4hep
- Two implementation branches:
  - More realistic, following the engineers
  - More flexible, to finish the reconstruction chain
- Rough parameters of the detector “frozen”
- Walkthrough over sub-detectors and review status and open questions

Detector Conventions

Convention: all sub-detectors must reside in an envelope volume described by high-level parameters ('engineering parameters')

- Cross-check between envelope and content, nothing is allowed to stick out of its envelope
- Simplified visualisation of envelope-only detectors

Convention: Sub-Detectors must depend only on envelope parameters

- Avoid hidden dependencies between sub-detectors

Envelopes

Arbitrarily complicated envelopes can be entirely defined in the XML

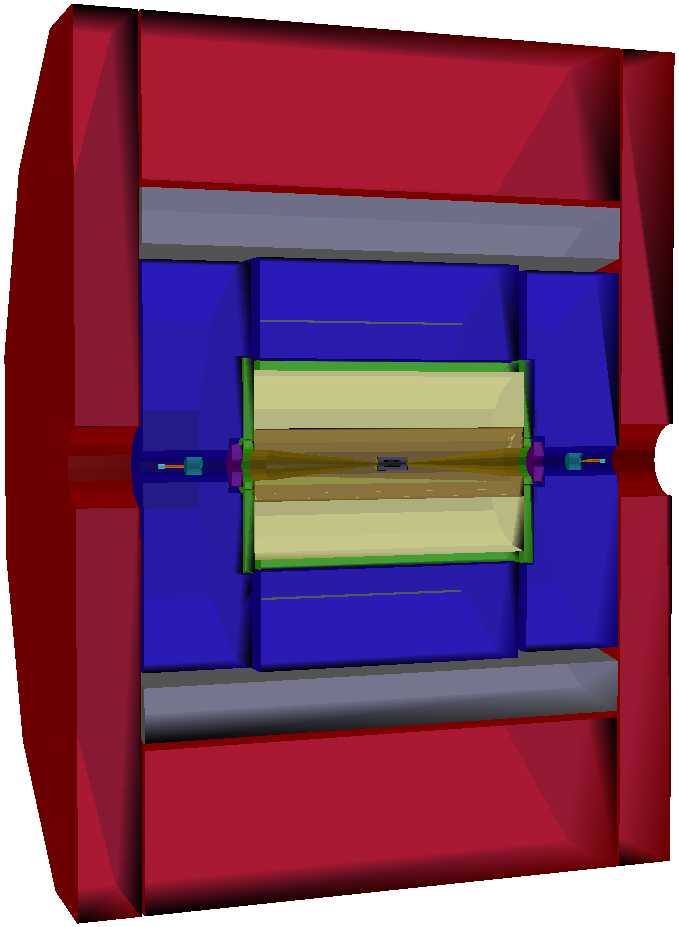
```
<envelope vis="ECALVis">
    <shape type="BooleanShape" operation="Subtraction" material="Air">
        <shape type="BooleanShape" operation="Subtraction">
            <shape type="PolyhedraRegular"  numsides="ECalEndcap_outer_symmetry"
                   rmin="0" rmax="ECalEndcap_outer_radius" dz="2.0*ECalEndcap_max_z"/>
            <shape type="PolyhedraRegular"  numsides="ECalEndcap_outer_symmetry"
                   rmin="0" rmax="ECalEndcap_outer_radius" dz="2.0*ECalEndcap_min_z"/>
        </shape>
        <shape type="Box" dx="ECalEndcap_inner_radius"
               dy="ECalEndcap_inner_radius" dz="ECalEndcap_max_z"/>
        <rotation x="0*deg" y="0*deg" z="180*deg/ECalEndcap_outer_symmetry"/>
    </shape>
    <rotation x="0*deg" y="0*deg" z="90*deg-180*deg/ECalEndcap_outer_symmetry"/>
</envelope>
```

And then make any given driver have an envelope:

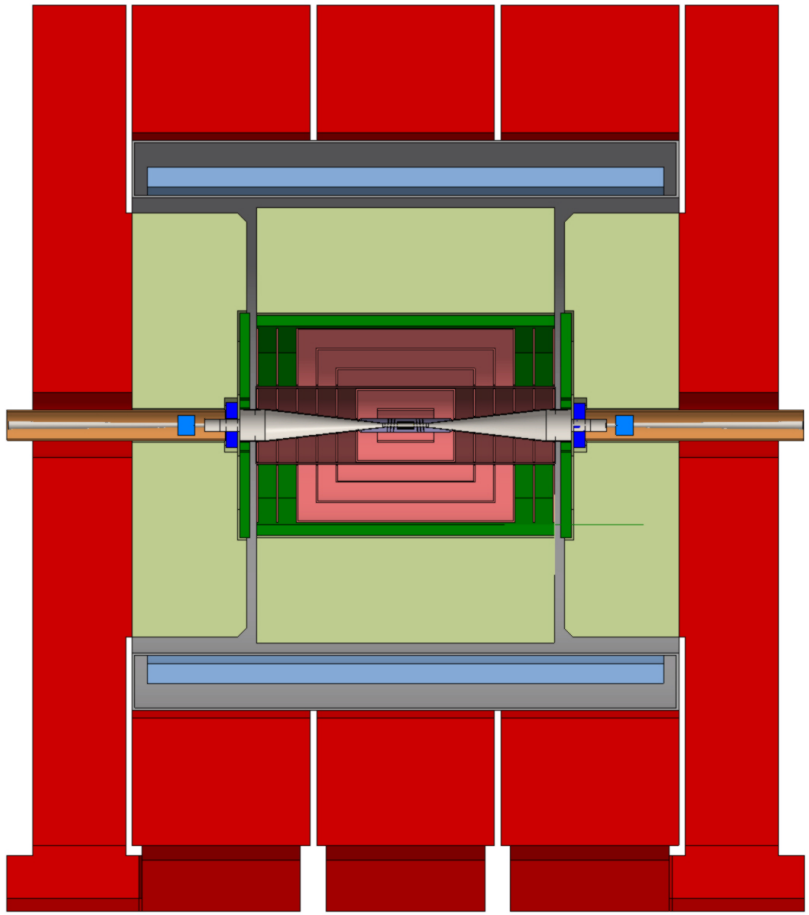
```
Volume envelope = XML::createPlacedEnvelope(lcdd, element, sdet);
if(lcdd.buildType() == BUILD_ENVELOPE) return sdet;
```

Envelopes for Full Detector

Combined envelopes for all sub-detectors



CLICdet_2015 envelopes



Regions defined by engineers

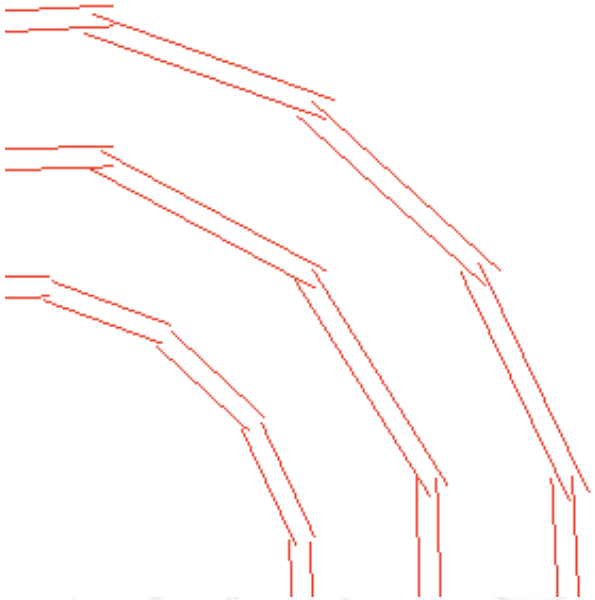
Vertex Barrel

Layer	r[cm]	#staves	width[mm]
1–2	3.1–3.3	16	13
3–4	4.4–4.6	12	26
5–6	5.8–6.0	16	26

Simplified composition Si and C = 0.4%X_0 per double layer

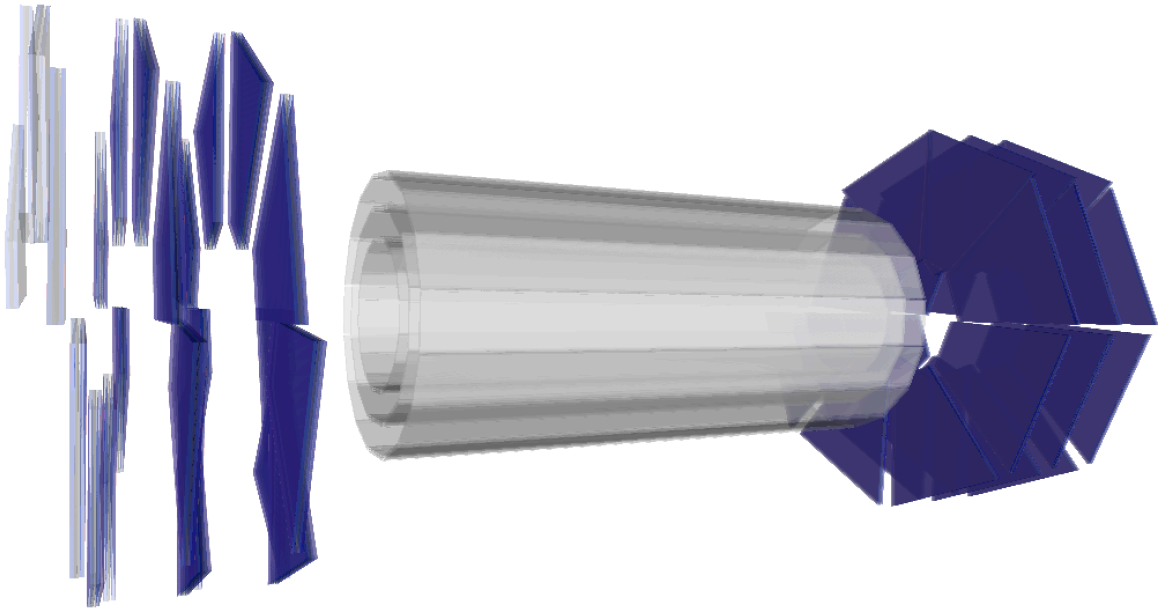
Option 1

Option 2

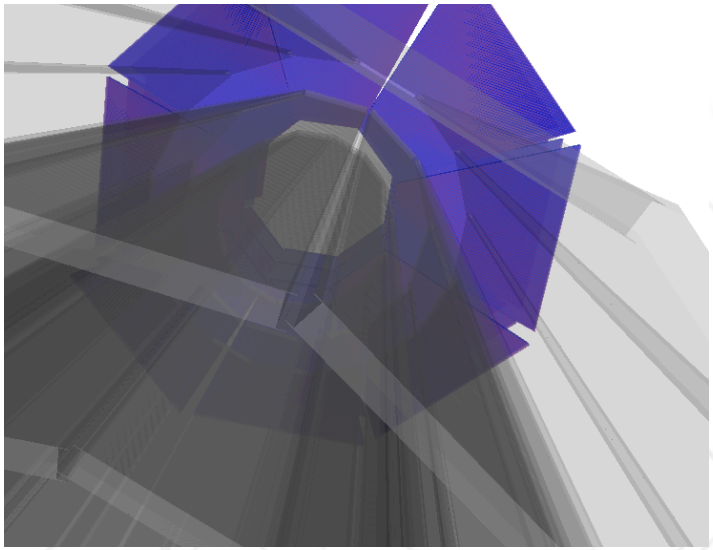


Working with Option 2 due to reconstruction software reasons.

Vertex Disks



- Petal structure same in both options
- $3.3\ \text{cm} < r < 10.2\ \text{cm}$
- $\Delta z = 5.9\ \text{mm}$
- No support structure or support shells yet



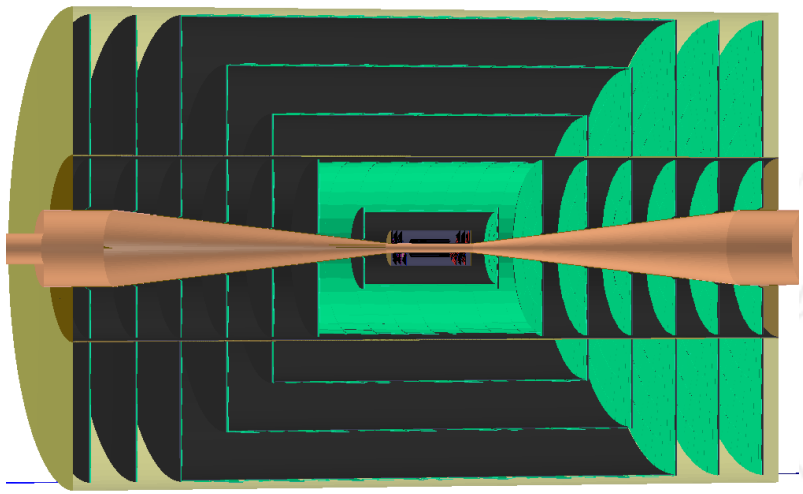
Tracker Layout

Barrel

layer	$r[mm]$
1	230
2	535
3	840
4	1145
5	1450

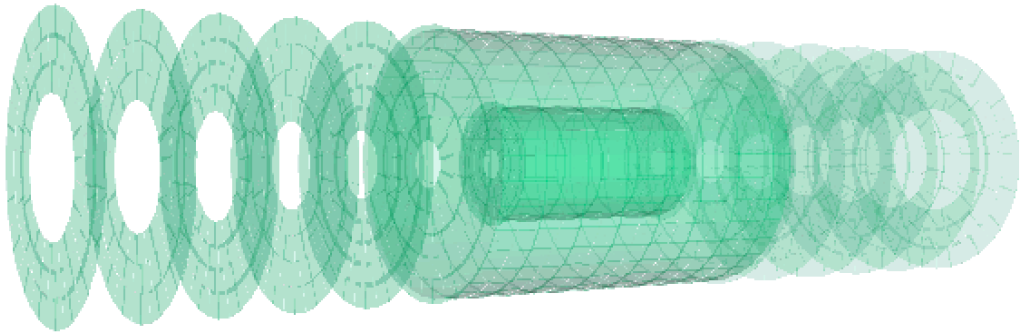
Disks

layer	$z[mm]$	$r_{inn}[mm]$	$r_{out}[mm]$
1	430	60	255
2	730	95	555
3	1030	130	840
4	1330	165	1145
5	1630	200	1450
6	1930	235	1450
7	2230	255	1450

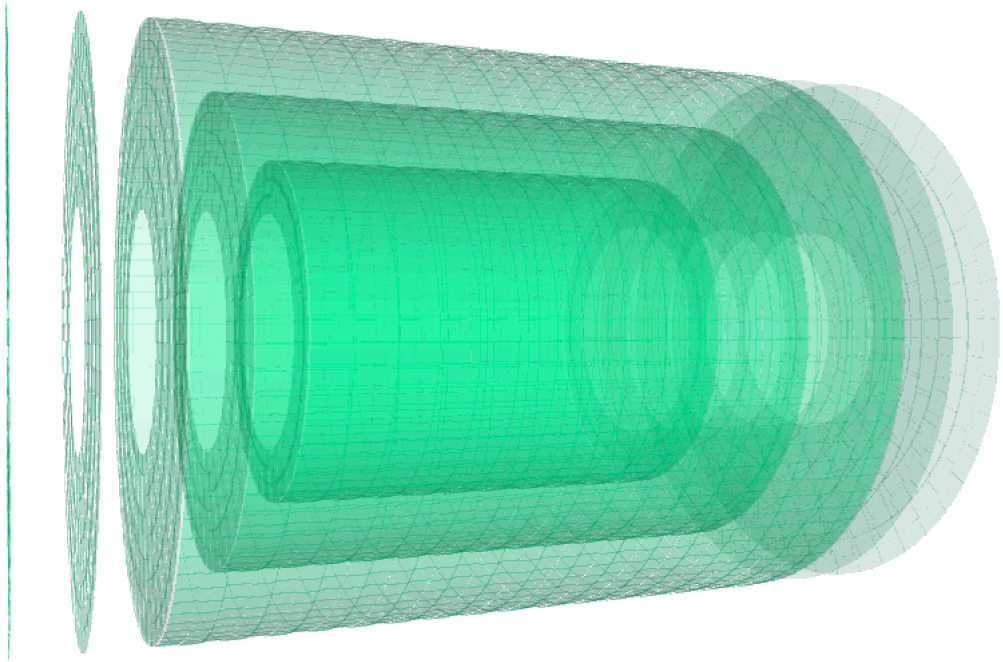


Tracker Layout

- Separated into:
  - Inner Tracker ($r < 58$ cm)



  - Outer Tracker ($r > 58$ cm)

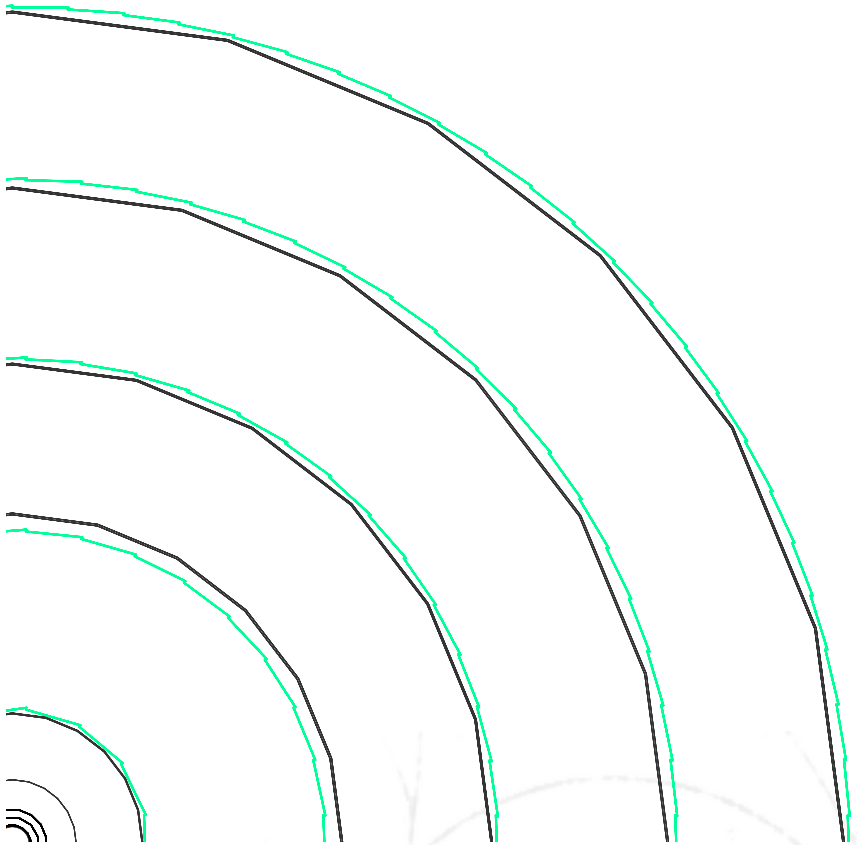


Barrel and Disk Tracker Module Cross-section

Section	Component	Material[Real]	d[μm]	Material[SW]	d[μm]
Modules	Metal Layer	Aluminum	50	Aluminium	70
	Insulating Layer	Polymide	100	Kapton	100
	Module Plate	Carbon	120	Carbon	120
	Chip	Silicon	300	Silicon	300
	Glue	Eccobond	100	Epoxy	100
X_0[%]		0.49		0.49	
Cables		Carbon fleece	40	Graphite	120
		Graphite Foil	30	Graphite	120
	Pipe	Polymide	64	Kapton	100
	Fluid	Water	0	Water	0
	Carbon Plate	Carbon	120	Carbon	120
	Glue	Eccobond	100	Epoxy	100
X_0[%]		0.32		0.32	
Cooling	Metal Layer	Aluminium	200	Aliminium	200
	Insulation	Polymide	200	Kapton	200
	Glue	Eccobond	100	Epoxy	100
X_0[%]		0.21		0.21	
Total X_0[%]		1.02		1.02	

Tracker Barrel Support

layer	X_0[%]	Total X_0[%]
1	0.54	1.57
2	1.15	2.15
3	1.04	2.06
4	1.11	2.13
5	1.11	2.13



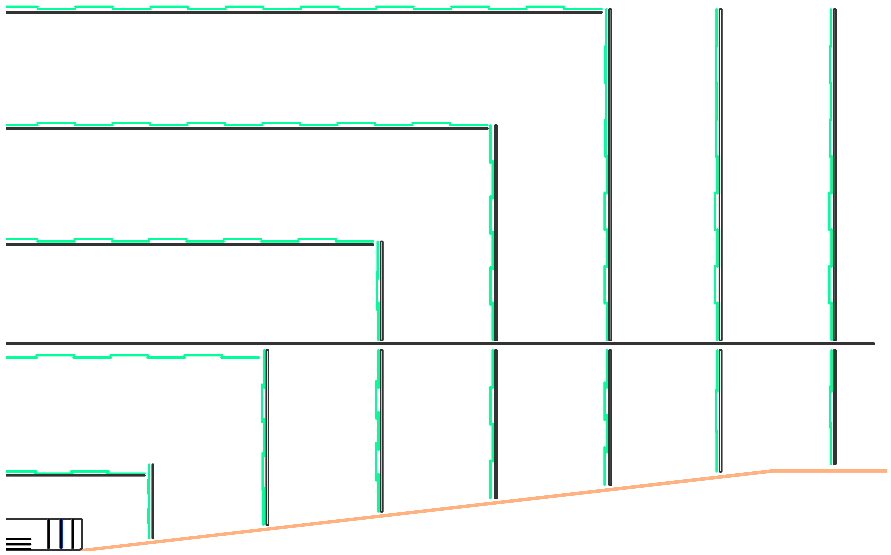
Modules

Support

- Positioned tightly below each layer
- Exception: Layer 2 where modules are suspended from tube

Tracker Disk Support

layer	X_0[%]	Total X_0[%]
1	0.54	1.57
2	1.04	2.06
3	1.04	2.06
4	1.11	2.13
5	1.11	2.13
6	1.11	2.13
7	1.11	2.13



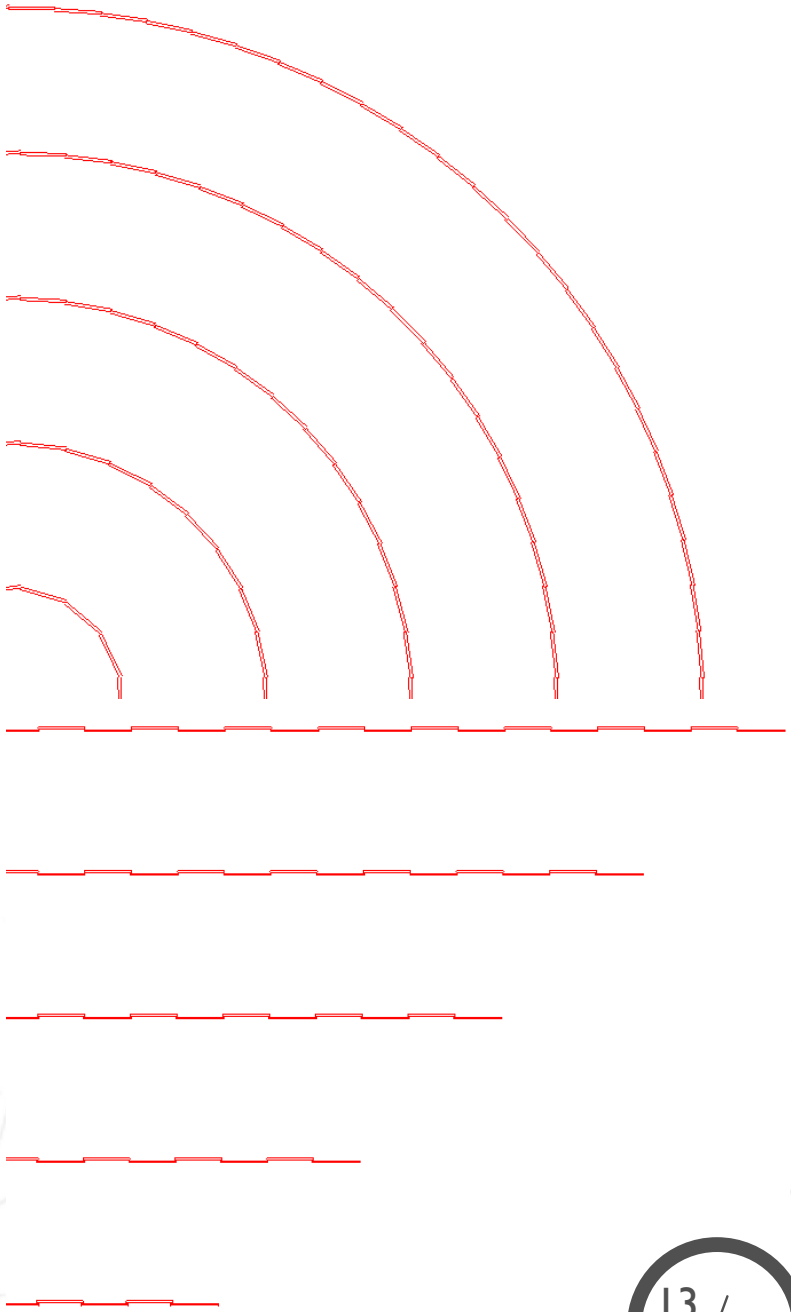
Modules

Support

- Positioned tightly behind each layer
- Different trapezoidal modules used to close gaps

Tracker Barrel Tiling

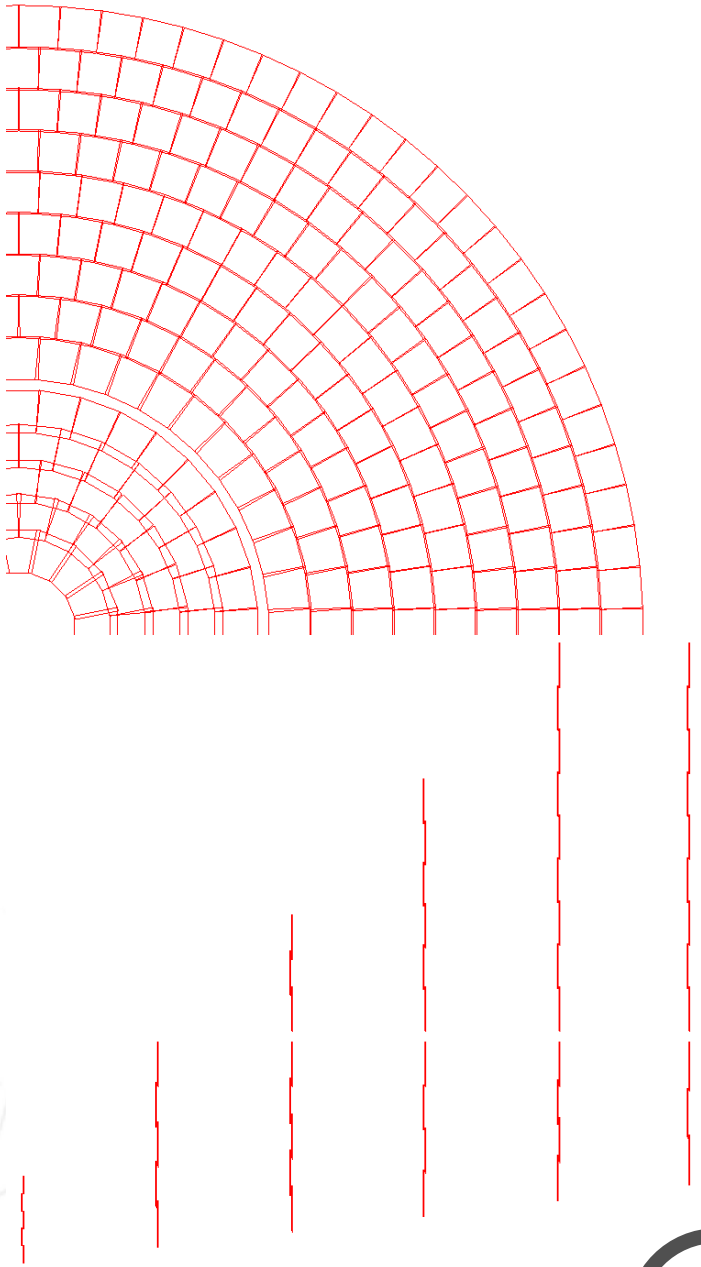
layer	N_r	N_z
1	15	9
2	35	15
3	55	21
4	75	27
5	94	33



- Module size 10×10 cm
- Modules tilted by $2\,\mathrm{deg}$
- $\Delta r = 6$mm in z direction
- Small overlap in r and z

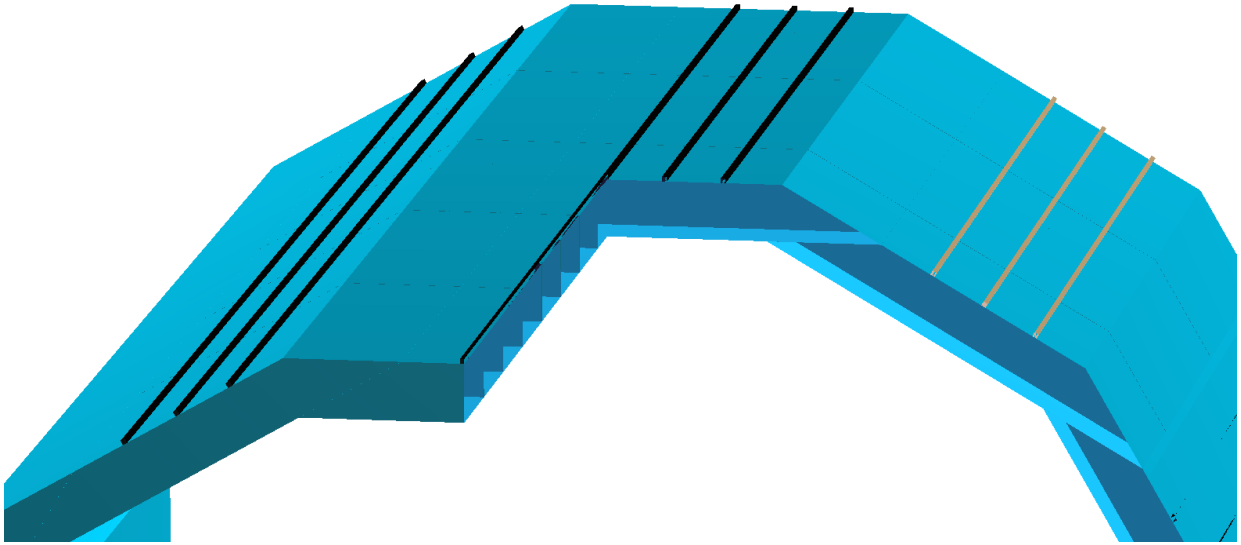
Tracker Disk Tiling

layer	N_r	N_ϕ
1	5	$14 - 38$
2	5	$14 - 36$
3	10	$16 - 54$
4	10	$18 - 74$
5	13	$22 - 94$
6	12	$22 - 94$
7	12	$22 - 94$



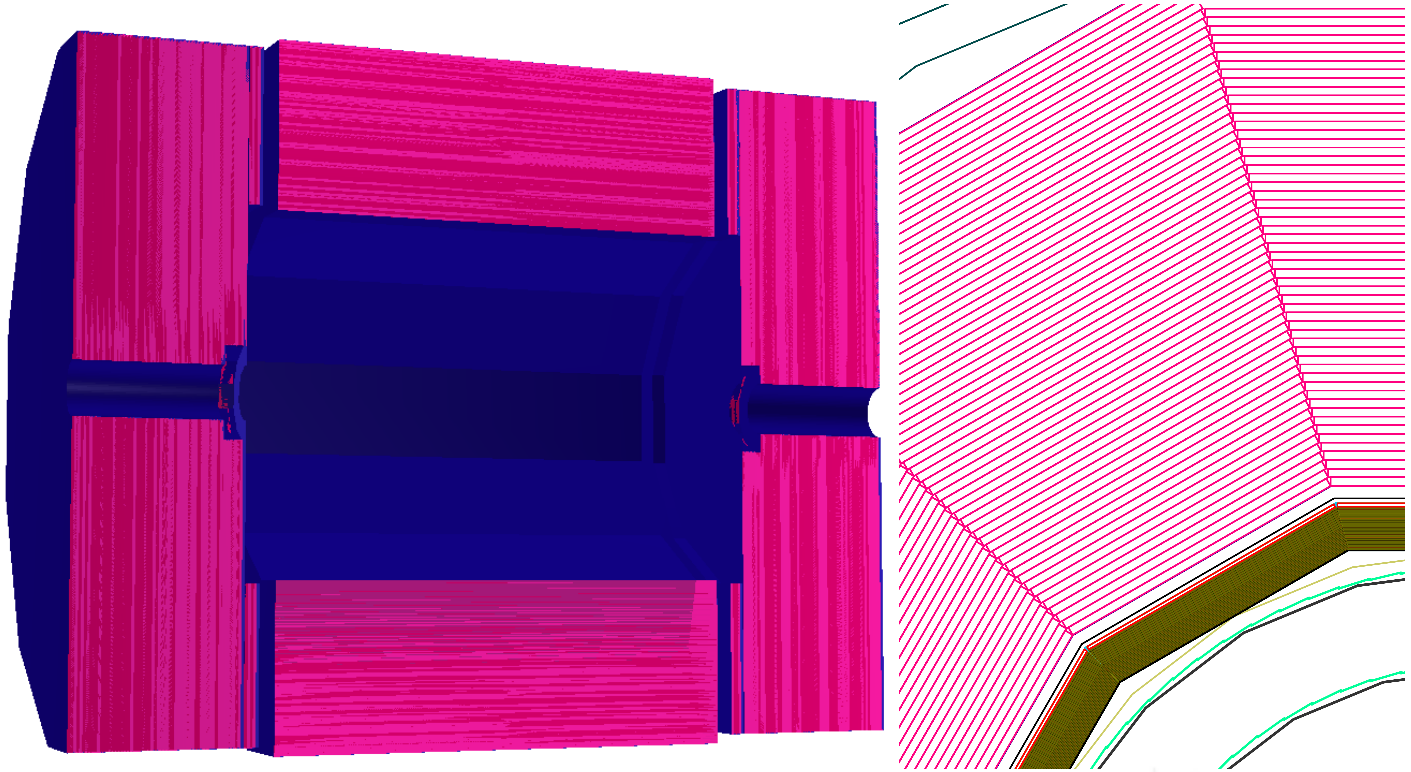
- 4 different trapezoidal modules
- $\Delta z = 2$mm in r direction
- Small overlap in r and z

ECal



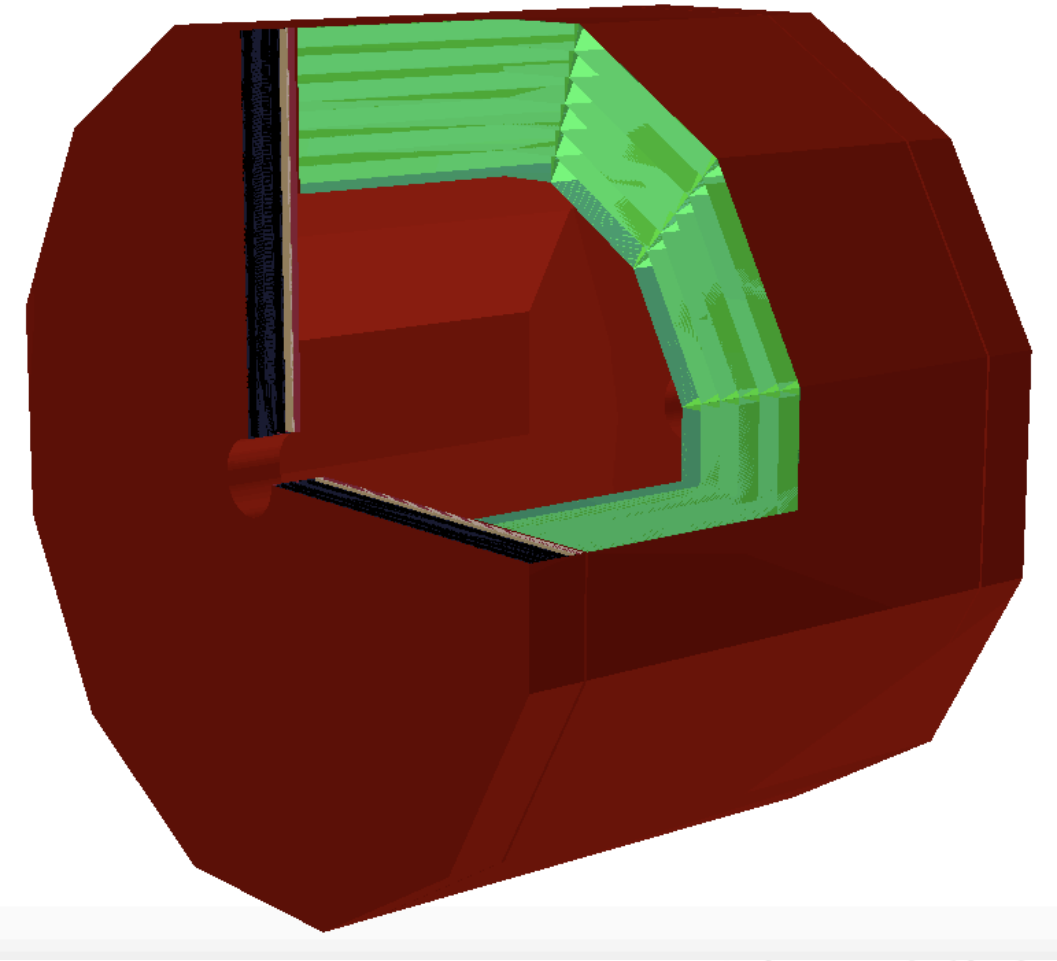
- Developing two versions
  - Barrel according to LLR design
  - Generic driver for calorimeters
- Barrel in good shape, advanced degree of details
- Endcap: basic implementation open discussion on technology
- Plug tight around beampipe – no specific design at present
- LLR has very detailed specifications for ECal

HCal and Solenoid



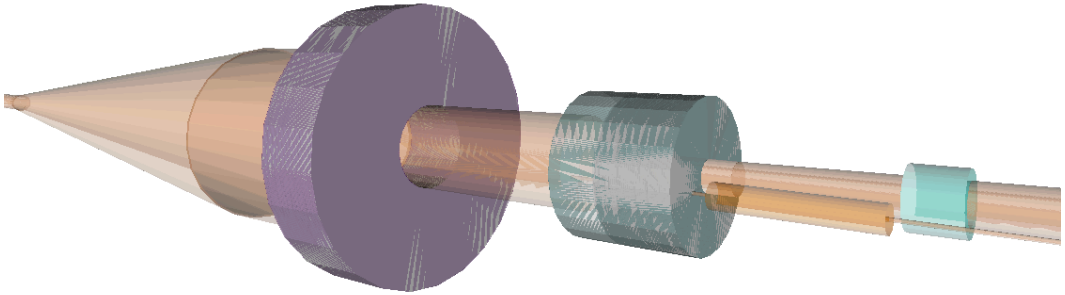
- Using generic calorimeter driver
  - Sufficiently finalising reconstruction chain to Pandora
- Some details like cassettes present
- Solenoid: Layers of steel, vacuum and Al
- Solenoid: Suffices for current simulation

Yoke and Muon System

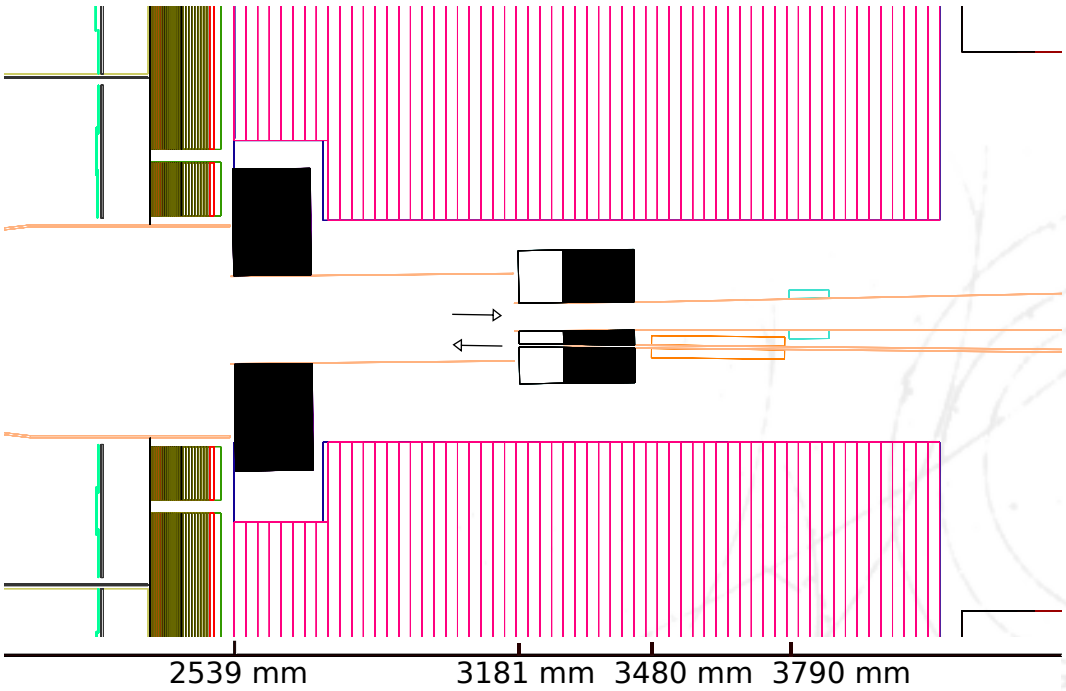


- A basic level of detail implemented
- Barrel composed of 6×39 cm Fe, Endcap of 6×12.5 cm Fe
- With RPC sensitive layers in between layers

FCal and Beampipe



- Both implemented as layered stack
- LumiCal has a development version with more details
- Kicker and BPM implemented as steel tubes



Summary

- All detector components working
- Detector model is in a good shape
- New tracking and calorimetry studies underway with new model
- Slowly adding details when software chain allows