Laboratoire d'Annecy-le-Vieux de Physique des Particules

Implementation of the Micromegas detector for SiD and CLIC simulations

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Aim

To have a look at existing geometries and implement the Micromegas detector for SiD and CLIC simulations

SiD detectors:

- sid02 → sid02_mMegas
- sid01_polyhedra → sid01_polyhedra_mMegas

CLIC detectors:

- clic01_sid → clic01_sid_mMegas
- clic01_sid_p01 → clic01_sid_p01_mMegas

SiD geometry - barrel

LoI geometry

SiD BARREL	Technology	Inner radius	Outer radius	Z max
Vertex detector	Pixel	1.4	6.0	$\pm$ 6.25
Tracker	Silicon strips	21.7	122.1	$\pm$ 152.2
EM calorimeter	Silicon-W	126.5	140.9	$\pm$ 176.5
Hadron calorimeter	RPCs	141.7	249.3	$\pm$ 301.8
Solenoid	5 Tesla	259.1	339.2	$\pm$ 298.3
Flux return	RPCs	340.2	604.2	$\pm$ 303.3

Table 1.1: Key parameters of the baseline SiD design. (All dimension are given in cm.)

sid02 geometry

SiD Barrel	Technology	Inner radius	Outer radius	Z max
Vertex detector	Pixel	1.46	6.04	± 6.25
Tracker	Silicon strips	20.6	126.5	± 162.4
EM calorimeter	Silicon-W	127	140.1	± 182
Hadron calorimeter	RPCs	141	253	± 294
Solenoid	5 Tesla	255	337.8	± 288
Muon system	RPCs	338.8	591.9	± 294

SiD geometry - endcaps

LoI geometry

SiD FORWARD	Technology	Inner Z	Outer Z	Outer radius
Vertex detector	Pixel	7.3	83.4	16.6
Tracker	Silicon strips	77.0	164.3	125.5
EM calorimeter	Silicon-W	165.7	180.0	125.0
Hadron calorimeter	RPCs	180.5	302.8	140.2
Flux return	RPCs	303.3	567.3	604.2
LumCal	Silicon-W	158.0	173.0	19.0
BeamCal	Silicon-W	295.0	320.0	14.5

Table 1.1: Key parameters of the baseline SiD design. (All dimension are given in cm.)

sid02 geometry

SiD FORWARD	Technology	Inner Z	Outer Z	Outer radius
Vertex detector	Pixel	7.18	89.48	16.87
Tracker	Silicon strips	84.5	162.6	126
EM calorimeter	Silicon-W	168	181.1	126.5
Hadron calorimeter	RPCs	182	294	140.75
Flux return	RPCs	303.3	557.4	608.2
LumCal	Silicon-W	168	176.43	19.5
BeamCal	Silicon-W	295	313.55	12.96

Sid HCAL - barrel

1. LoI geometry:

   Barrel: ri = 141.7 cm

   ro = 249.3 cm it is not ro, but it is ECAL or + HCAL depth

   z = 603.6 cm

   If 1 layer = 2.69 cm then

   ro = (ri + 40 x 1 layer)/cos(15º) = 258.1 cm

2. Nicolas numbers:

   Barrel: ri = 141.9 cm

   ro = 258.3 cm

   z = 603.6 cm

   40 layers = (ro x cos(15º) – ri) = 107.6 cm

   → 1 layer = 2.69 cm

3. sid02 geometry:

   Barrel: ri = 141 cm

   ro = 253.3 cm

   z = 588 cm

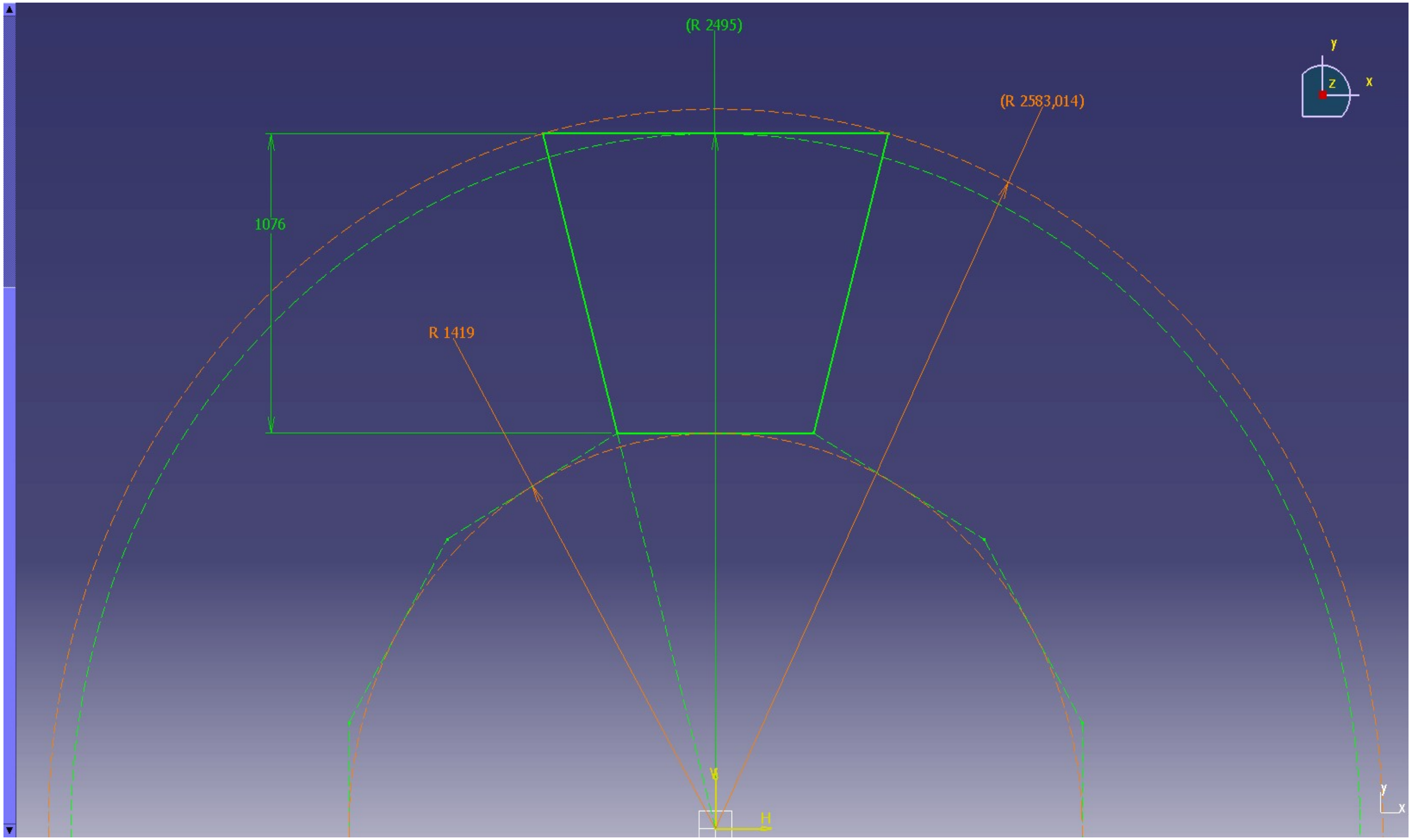
   ro – ri = 112 cm

   → 1 layer = 2.8 cm

N.B. Old concept: 2 mm steel absorber + 8 mm detector = 2.8 cm

New concept: 1.89 mm steel absorber + 8 mm detector = 2.69 cm

Sid HCAL - barrel



Sid HCAL - endcaps

1. LoI geometry:

   Endcap: z_i = 180.5 cm
   z_o = 302.8 cm
   r_o = 140.2 cm

   $z_o - z_i$ = 122.3 cm ?

2. Nicolas numbers:

   Endcap: z_i = 180.6 cm
   z_o = 302.8 cm
   r_o = 140.9 cm
   r_i = 20.6 cm

   $z_o - z_i$ = 122.2 cm ?

If 40 layers (4 λ) (107.6 cm HCAL depth) are used in endcaps then there is 14.7 cm air gap. Or, are there 45 layers (4.5 λ)?

3. sid02 geometry:

   Endcap: z_i = 182 cm
   z_o = 294 cm
   r_o = 140.75 cm

   $z_o - z_i$ = 112 cm

   → 1 layer = 112/40 = 2.8 cm

SiD Micromegas implementation

1. sid02 → sid02_mMegas

   Barrel: 40 layers with RPC → 40 layers with Micromegas
   1 layer = 1.49 cm steel absorber + 1.2 cm Micromegas detector including two 2 mm thick steels covers (1.89 cm of the absorber in total)

   Endcap: 40 layers with RPC → 40 layers with Micromegas
   Same as in case of barrel

   N.B 4.4 cm additional air gap is ue to a difference of 0.2 mm in absorber thickness.

2. sid01_polyhedra → sid01_polyhedra_mMegas

   Barrel: 34 layers with RPC → 35 layers with Micromegas
   Layers are same as in sid02_mMegas

   Endcap: 34 layers with RPC → 35 layers with Micromegas
   Layers are same as in sid02_mMegas

Micromegas geometry for SiD 1/3

Materials, region and limits:

```
<materials>
 <material name="IsoButane">
    <D type="density" value="0.00251" unit="g/cm3"/>
    <composite n="4" ref="C" />
    <composite n="10" ref="H" />
  </material>

  <material name="mMegasGas">
    <D type="density" value="0.00184" unit="g/cm3"/>
    <fraction n="0.95" ref="Ar" />
    <fraction n="0.05" ref="IsoButane" />
  </material>
</materials>

<regions>
 <region name="mMegasGasRegion" store_secondaries="true"
        cut="0.1" lunit="mm" threshold="0.0" eunit="MeV" />
</regions>

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

Micromegas geometry for SiD 2/3

Barrel:

```
<detector id="3" name="HADBarrel" type="CylindricalBarrelCalorimeter"
         readout="HcalBarrHits">
        <dimensions inner_r = "141.0*cm" outer_z = "294*cm" />
        <layer repeat="40">
             <slice material = "Steel235" thickness="1.49*cm" />
             <slice material = "Air" thickness="0.07365*cm" />
             <slice material = "Steel235" thickness="0.2*cm" />
             <slice material = "Kapton" thickness="0.01*cm" />
             <slice material = "Copper"  thickness="0.0005*cm" />
             <slice material = "mMegasGas" thickness="0.3064*cm"
                    sensitive = "yes" limits="cal_limits"
                    region="mMegasGasRegion" />
             <slice material = "mMegasGas" thickness="0.0158*cm" />
             <slice material = "Copper" thickness="0.0035*cm" />
             <slice material = "G10"  thickness="0.1165*cm" />
             <slice material = "Epoxy" thickness="0.2*cm" />
             <slice material = "Steel235" thickness="0.2*cm" />
             <slice material = "Air" thickness="0.07365*cm" />
        </layer>
 </detector>
```

N.B. The barrel inner radius and outer z value are kept to be same
→ 4.4 cm additional air gap between calorimeter and solenoid

Micromegas geometry for SiD 3/3

End-caps:

```
<detector id="7" name="HADEndcap" reflect="true"
        type="CylindricalEndcapCalorimeter" readout="HcalEndcapHits">
       <dimensions inner_r = "20.0*cm" inner_z = "182.0*cm" outer_r =
        "140.75*cm" />
       <layer repeat="40" >
            <slice material = "Steel235" thickness="1.49*cm" />
            <slice material = "Air" thickness="0.07365*cm" />
            <slice material = "Steel235" thickness="0.2*cm" />
            <slice material = "Kapton" thickness="0.01*cm" />
            <slice material = "Copper"  thickness="0.0005*cm" />
            <slice material = "mMegasGas" thickness="0.3064*cm"
                   sensitive = "yes" limits="cal_limits"
                   region="mMegasGasRegion" />
            <slice material = "mMegasGas" thickness="0.0158*cm" />
            <slice material = "Copper" thickness="0.0035*cm" />
            <slice material = "G10"  thickness="0.1165*cm" />
            <slice material = "Epoxy" thickness="0.2*cm" />
            <slice material = "Steel235" thickness="0.2*cm" />
            <slice material = "Air" thickness="0.07365*cm" />
        </layer>
</detector>
```

N.B. The endcap dimensions are kept to be same → 4.4 cm additional air gap between calorimeter and muon system

Clic Micromegas implementation

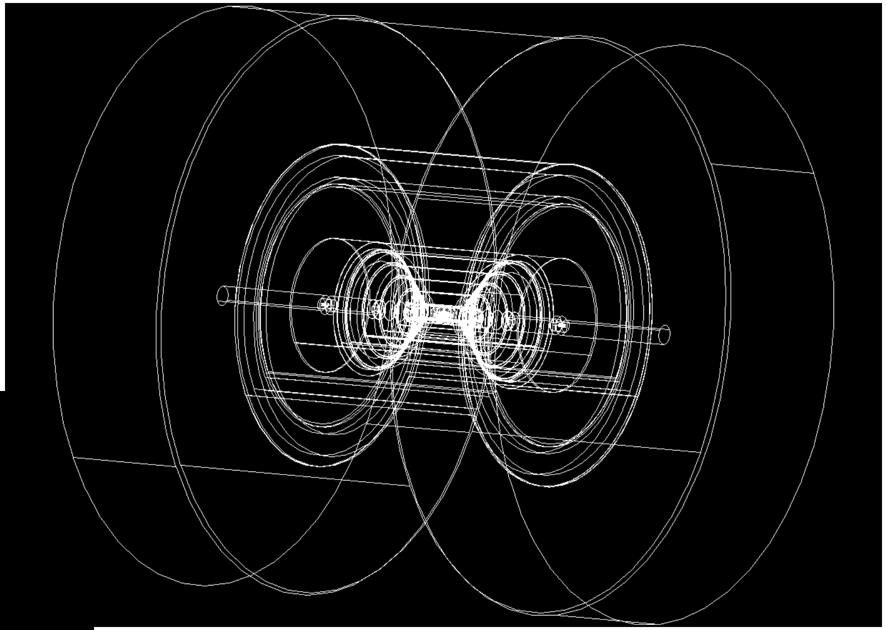
1. clic01_sid → clic01_sid_mMegas
   Barrel: 77 layers with scintillators → 77 layers with Micromegas
   Old: 1 layer = 1 cm tungsten absorber + 0.75 cm scintillator detector
   New: 1 layer = 1 cm tungsten absorber + 0.9 cm Micromegas detector
   Including 2 mm thick steels covers

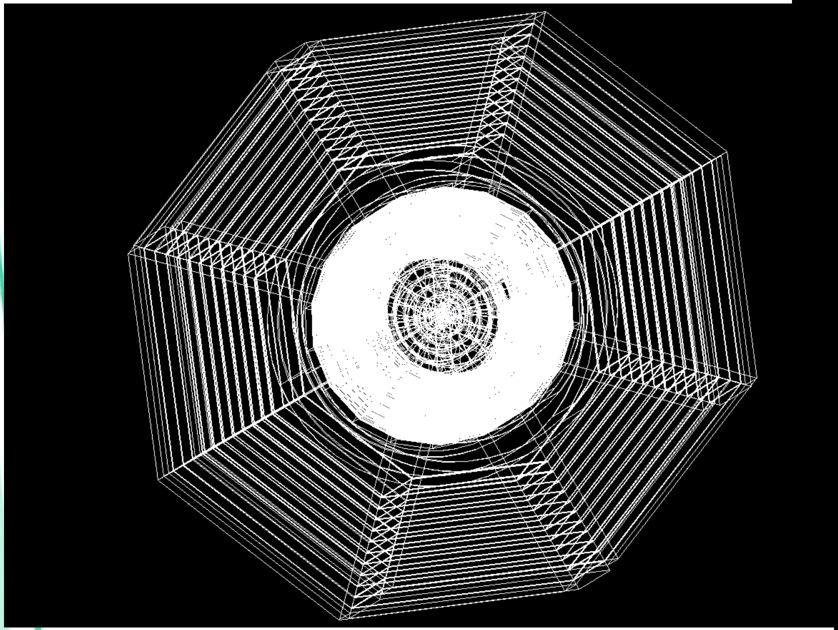
   Endcap: 70 layers with scintillators → 71 layers with Micromegas
   Old: 1 layer = 2 cm steel absorber + 0.75 cm scintilator detector
   New: 1 layer = 1.8 cm steel absorber + 0.9 cm Micromegas detector
   Including 2 mm thick steels covers

2. clic01_sid_p01 → clic01_sid_p01_mMegas
   Barrel: 74 layers with scintillators → 77 layers with Micromegas
   Old: 1 layer = 1 cm tungsten absorber + 0.85 cm scintillator detector
   New: 1 layer = 1 cm tungsten absorber + 0.9 cm Micromegas detector
   Including 2 mm thick steels covers

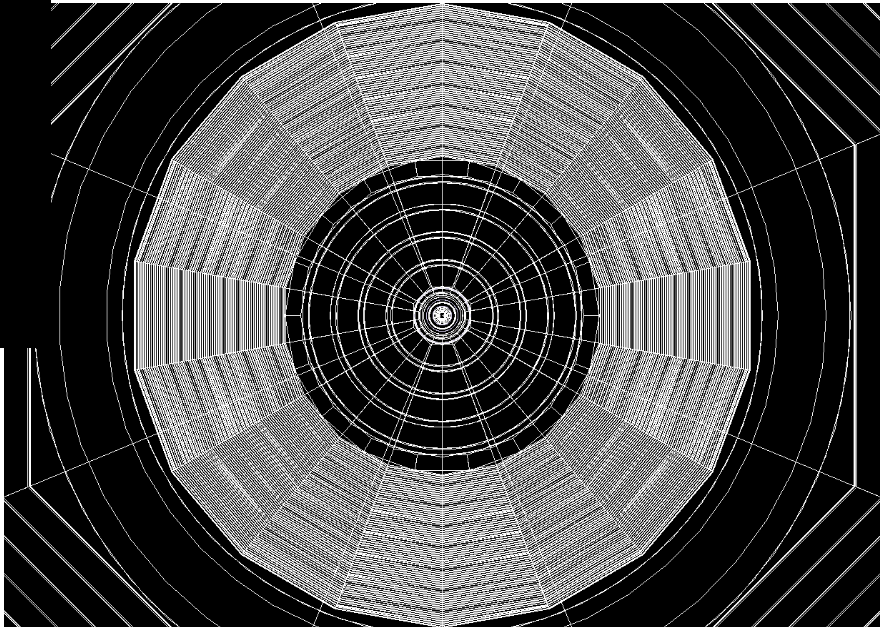
   Endcap: 70 layers with scintillators → 74 layers with Micromegas
   Old: 1 layer = 2 cm steel absorber + 0.85 cm scintilator detector
   New: 1 layer = 1.8 cm steel absorber + 0.9 cm Micromegas detector
   Including 2 mm thick steels covers

sid02_mMegas

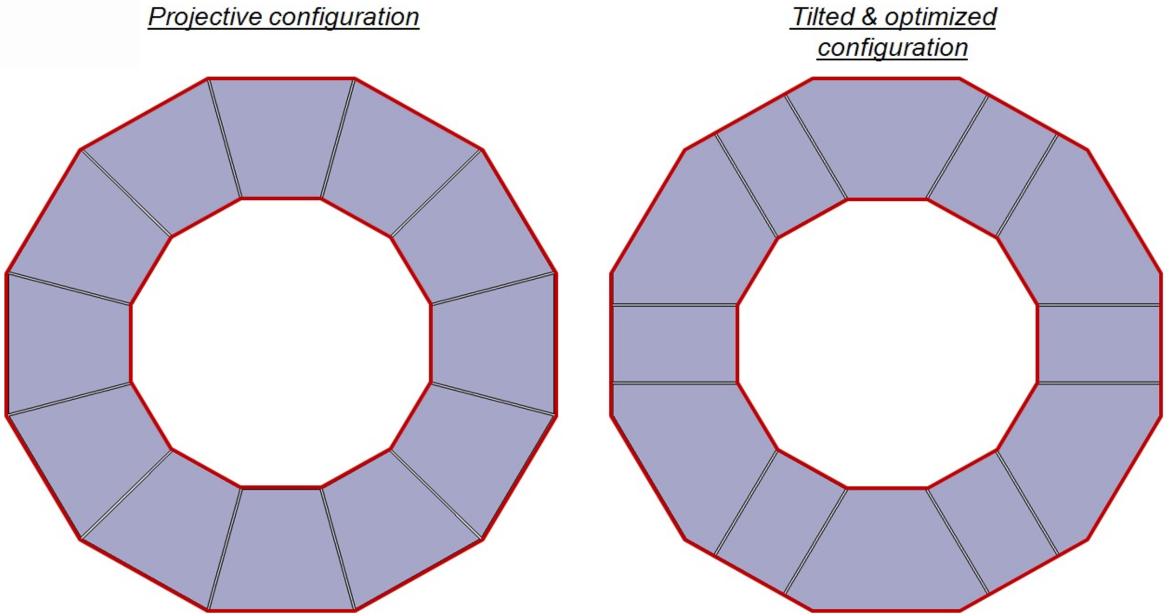




clic01_sid_p01_mMegas



Optimized geometry for HCAL?



Projective configuration already implemented as sid01_polyhedra and clic01_sid_p01.

Tilted configuration is not implemented so far. I will ask Jereme if is possible to do so.

It will be nice to compare physics performance of the projective, tilted and simple cylindrical configurations.

Conclusions

New geometry with compact.xml files for SiD and CLIC detectors have been created and after recalculation of the calibration constants can be used in simulations

The created geometries will be sent to SiD and CLIC groups for posting them as new official detector geometries

Recommendation: in order to be coherent with proposed mechanical design, the update of the official geometries is advisable.