Parameters for detector

Donatella Lucchesi, Laura Buonincontri

- The major part of the work was done by Laura, I copied form her thesis, I may have done mistakes… checks on the numbers in progress
- Based on MuColl_v1, version frozen for SnowMass studies
- First version of the document
  - Is the level of details good enough?
  - No figures so far, some will be added
  - No references, they will be added
- Link: Overleaf Authors25

1 Detectors

E. Métral[a], *D. Schulte*[a]
[a]CERN, Geneva, Switzerland

Here, we should write the summary of Chapter 25 and in particular the parameters to be used by the other chapters.

Table 1.1: Parameters to be used by the other chapters for their studies.

	Case1		Case2		Case3	
	Case11	**Case12**	**Case21**	**Case22**	**Case31**	**Case32**
Parameter1	Value11	Value12	Value13	Value14	Value15	Value16
Parameter2	Value21	Value22	Value23	Value24	Value25	Value26
Parameter3	Value31	Value32	Value33	Value34	Value35	Value36
Parameter4	Value41	Value42	Value43	Value44	Value45	Value46
Parameter5	Value51	Value52	Value53	Value54	Value55	Value56
Parameter6	Value61	Value62	Value63	Value64	Value65	Value66
Parameter7	Value71	Value72	Value73	Value74	Value75	Value76
Parameter8	Value81	Value82	Value83	Value84	Value85	Value86
Parameter9	Value91	Value92	Value93	Value94	Value95	Value96
Parameter10	Value101	Value102	Value103	Value104	Value105	Value106

The detector used for the studies at $\sqrt{s} = 3$ TeV starts from the CLIC proposal at the same center of mass energy and it is modified to include the beam-induced background absorbers, nozzles, with the consequently removal of the two small electromagnetic calorimeters in the forward region. The detector has a cilindrical shape and it has a $11, 4$ m long and has a diameter of $12, 8$ m. By going from the inside to the outside it is composed by:

– Tracking system
– Electromagnetic calorimeter (ECAL)
– Hadronic calorimeter (HCAL)
– A superconducting solenoid
– An iron joke instrumented with a resistive plate chamber for the muons detection

The origin of the space coordinates is the beam interaction point. The z-axis has direction parallel to the beam pipe, the y-axis is parallel to gravity acceleration and the x-axis is defined as perpendicular to the y and z axes.

1.1 Tracking System

Tracking detector is composed by the vertex and tracker sub-detectors, both of them structured in barrels and end-caps.Barrels are cylindrical surface with variable length and radius, whose axis coincides with the beam pipe and cover the central part of the detector. The endcaps are annulus centered on the z axis, with variable distance from the interaction point and radius which cover the forward part of the detector.

1.1.1 Vertex detector

The vertex detector is close to the interaction point in order to allow a good resolution on track impact parameter.

The building blocks of the barrel detection layers are rectangular staves of sensors, arranged to form a cilinder, while the endcaps are constituted by trapezoidal modules of sensor, arranged as "petal" to form the disk. They are all composed by double-sensor layers, two sensitive layers fixed on one support structure, in both barrel and forward region, with 2 mm gap. The barrel layers have silicon pixel of size 25×25 μm^2, and thickness 50 μm whose radius and geometrical characteristics are in Table 1.2 The eight endcaps layers, four for each side of the interaction point are composed by silicon pixel of size

Table 1.2: Vertex barrel layers geometrical characteristics.

R_1	3.1	16
R_2	5.1	15
R_3	7.4	21
R_4	10.2	29

25×25 μm^2 and thickness 50 μm and 16 modules. Their positions along the z axis and the geometrical characteristics are in Table 1.3.

Table 1.3: Vertex endcap disks characteristics.

Endcap	$\|\Delta z\|(cm)$	R_{min} (cm)	R_{max} (cm)
$\|\Delta z_1\|$	8.0	2.5	11.2
$\|\Delta z_2\|$	12.0	3.1	11.2
$\|\Delta z_3\|$	20.0	3.8	11.2
$\|\Delta z_4\|$	28.0	5.3	11.2

1.1.2 Tracker Detector

Both the inner and outer detectors have a single layer of silicon sensors of 100μ m thickness.

The inner tracker has three barrel layers with radius and geometric characteristics summarized in Table 1.4. Strips on the barrels have size 50 μm $\times$ 1 mm and thickness 100 μ m are oriented with the long side parallel to the beam axis. The fourteen end-caps, seven for each side of the interaction point, are

Table 1.4: Inner tracker barrels layers geometrical characteristics.

Barrel	Radius (cm)	Half length	N. staves
R_1	12.7	48.2	28
R_2	34.0	48.2	76
R_3	55.4	69.2	124

composed by 26 modules each. Their positions along the z direction and characteristics are in Table 1.5.

The first end-cap is composed by pixel sensors of size 25×25 μm^2, while all other end-caps by strips of size 50 μm $\times 1$ mm. Strips are oriented along the radius of the disk. All sensors have thickness 100 μm. The inner tracker and outer tracker end-caps are composed by radial modules composed by rectangular pads. The barrel outer tracker has three barrel layers with radius and characteristics in Table 1.6. They

Table 1.5: Inner tracker endcap disks geometrical characteristics.

$\|\Delta z_1\|$	52.4	9.5	42.7
$\|\Delta z_2\|$	80.8	14.7	55.8
$\|\Delta z_3\|$	109.3	19.0	55.6
$\|\Delta z_4\|$	137.7	21.2	56.1
$\|\Delta z_5\|$	166.1	23.7	55.7
$\|\Delta z_6\|$	194.6	26.4	55.4
$\|\Delta z_7\|$	219.0	28.4	55.8

are composed by strips of size 50 μm $\times 10$ mm and thickness 100 μm. As in the inner tracker, the strips are oriented with the long side parallel to the beam axis.

Table 1.6: Outer tracker barrels layers geometrical characteristics.

Barrel	Radius cm	N staves
R_1	81.9	184
R_2	115.3	256
R_3	148.6	328

The end-caps outer tracker has four disk on each side, positions and characteristics in table 1.7. They are composed by 48 modules with sensor strips of size 50 μm $\times 10$ mm and thickness 50 μm. As in the inner tracker, strips oriented along the radius of the disk.

Table 1.7: Inner tracker endcap disks geometrical characteristics.

Endcap	$\|\Delta z\|$ cm	R_{min} cm	R_{max} cm
$\|\Delta z_1\|$	131	61.7	143
$\|\Delta z_2\|$	161.7	61.7	143
$\|\Delta z_3\|$	188.3	61.7	143
$\|\Delta z_4\|$	219	61.7	143

1.2 Calorimeter System

The calorimeter system is composed by the electromagnetic (ECAL) and hadronic (HCAL) sub-detectors,

1.2.1 ECAL

The default ECAL configuration is inherited by CLIC and it is the one described here. An other configuration is being proposed, it is part of the simulation framework but not used for physics studies up to now. This detector consists of a dodecagonal barrel and two endcaps systems. It is composed by 40 interlaced layer of Tungsten as absorber material 1.9 mm thick and Si sensor as active material with 5×5 mm^2 silicon detector cells. Tungsten is a dense material with a large ratio of interaction length to radiation length. A small radiation length will promote the start of the electromagnetic shower earlier in the calorimeter, while a large interaction length will reduce the fraction of hadronic showers starting in ECAL. The choice of thin silicon layers offers an optimal spatial resolution. The total thickness of the ECAL corresponds to about 22 X_0. The characteristics ECAL are summarised in Table 1.8.

Table 1.8: ECAL characteristics.

ECAL absorber	W
ECAL X_0	22
ECAL barrel r_{min} [cm]	150.0
ECAL barrel r_{max} [cm]	170.2
ECAL barrel δr [cm]	20.2
ECAL barrel z_{max} [cm]	221.0
ECAL endcap z_{min} [cm]	230.7
ECAL endcap z_{max} [cm]	250.9
ECAL endcap δz [cm]	20.2
ECAL endcap r_{min} [cm]	41.0
ECAL endcap r_{max} [cm]	170.0

1.2.2 HCAL

The hadronic calorimeter allows the hadronic jets reconstruction and helps in particle idetifications, to separate hadrons from leptons. It consists of a dodecagonal barrel and two endcaps systems, structured in 60 interlaced layers of steel absorber 19 mm thick and plastic scintillating tiles with cell size 30×30 mm^2. Both, the endcap and the barrel HCAL, are around 7.5 λ_I deep, which brings the combined thickness of ECAL and HCAL to 8.5 λ_I. Table 1.9 describes the HCAL characteristics.

1.3 Magnet

A large superconducting solenoid is located outside the hadronic calorimeters. It contains a coil of radius 382 cm and produces a 3.57 T magnetic field. The iron yoke returns the magnetic flux, and has a magnetic field of 1.34 T pointing in the opposite direction with respect to the inner field. The magnet characteristics are summarised in table 1.10 .

1.4 Muon System

The iron yoke is instrumented with Resisitive Plate Chamber (RCP) sensor layers to reconstruct muon stubs. There are seven RCP layers in the barrel and six layers in the endcaps, with 30×30 mm^2 cell size. The free space between yoke steel layers is 40 mm.

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Table 1.9: HCAL characteristics.

HCAL absorber	Fe
HCAL λ_I	7.5
HCAL barrel r_{min} [cm]	174.0
HCAL barrel r_{max} [cm]	333.0
HCAL barrel δr [cm]	159.0
HCAL barrel z_{max} [cm]	221.0
HCAL endcap z_{min} [cm]	253.9
HCAL endcap z_{max} [cm]	412.9
HCAL endcap δz [cm]	159.0
HCAL endcap r_{min} [cm]	25.0
HCAL endcap r_{max} [cm]	324.6
HCAL ring z_{min} [cm]	236.0
HCAL ring z_{max} [cm]	253.9
HCAL ring r_{min} [cm]	173.0
HCAL ring r_{max} [cm]	324.6

Table 1.10: Magnet characteristics.

Solenoid R_{min}	348.3 cm
Solenoid R_{max}	429.0 cm
Solenoid half length	412.9 cm
Solenoid coil R	382.1 cm
Solenoid coil half length	390.0 cm
Yoke Barrel R_{min}	446.1 cm
Yoke Barrel R_{max}	645.0 cm
Yoke Barrel half length	390.0 cm
Yoke Endcap R_{min}	44.6 cm
Yoke Endcap R_{max}	645.0 cm
Yoke Barrel z_{min}	417.9 cm
Yoke Barrel z_{max}	563.8 cm

References