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CERN, 16 February 1996

# ECAL end-cap geometry in CMS

In this note we propose a geometry for the CMS ECAL end-cap which fulfills the requirements indicated below. It tries to incorporate the principles used in the IHEP-Protvino design and to comply with the trigger needs. In figure 1 we show a sketch of one end-cap sector and in table 1 we give an estimation of the crystal parameters.

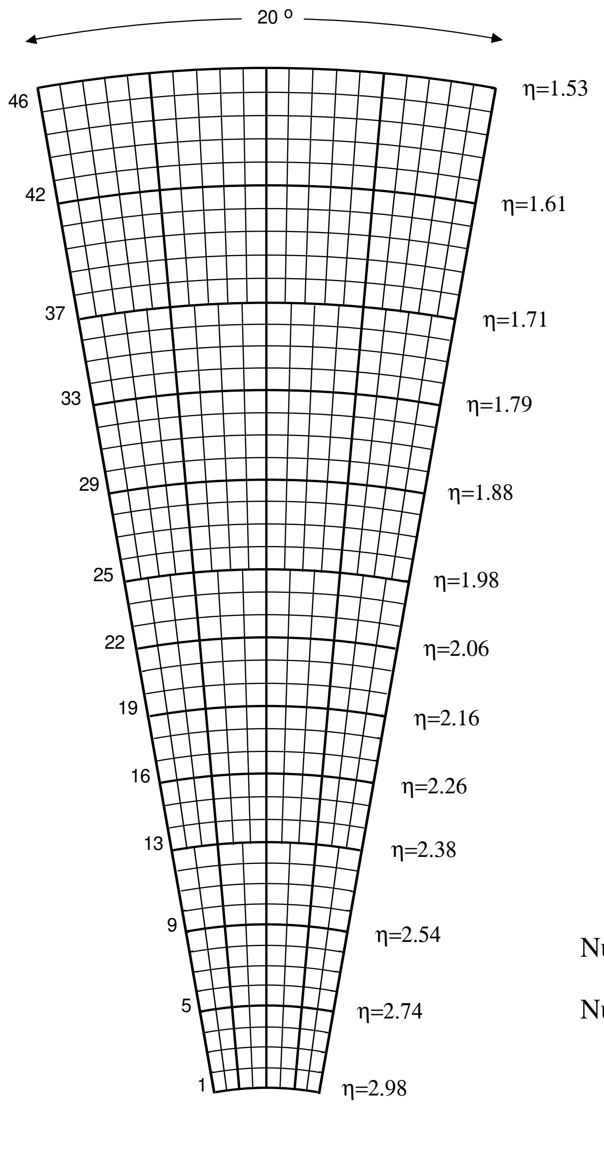
*Physics requirements:*
- The crystals have typical size 2 to 2.5 cm, for $\eta<2.54$, suitable for the reconstruction of e.m. clusters.
- The dimensions $\Delta\eta.\Delta\phi$ of the HCAL cells are of the order of 0.1x0.1 up to $\eta=2.38$, and of the order 0.2x0.1 up to $\eta=2.98$, suitable for jet reconstruction and for the implementation of isolation criteria to electrons and photons.

*Sector geometry:*
- Organization in 18 sectors of 20°, in order to match the barrel geometry.
- The ECAL end-cap covers the rapidity domain from 1.53 to 2.98.
- The start of the end-cap is located at z=317 cm.

*Trigger requirements:*
- The electron/photon trigger covers rapidities up to $\eta=2.98$.
- The number of crystals per row in a sector is divisible by 4, in order to form 72 trigger towers along $\phi$ for every $\eta$.
- The trigger towers have dimensions $\Delta\eta.\Delta\phi$ of the order 0.1x0.1 up to $\eta=2.38$, and of the order 0.2x0.1 up to $\eta=2.98$.
- The dimension of the ECAL trigger towers matches the HCAL towers.

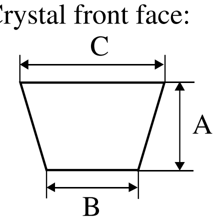
*Crystals requirements:*
- The crystal front face dimensions A, B or C (see figure 1) do not exceed 2.6 cm.
- The number of crystal per end-cap is of the order of 11000.

Figura 1 - ECAL End-cap Sector




Start of ECAL End-cap: z=317 cm

Crystal front face:




$\eta < 2.16$ :

A $\in$ [2.31, 2.48] cm
B $\in$ [1.95, 2.53] cm
C $\in$ [2.00, 2.59] cm

$\eta > 2.16$ :

A $\in$ [2.25, 2.51] cm
B $\in$ [1.41, 2.48] cm
C $\in$ [1.51, 2.58] cm

Number of crystals per sector: 632

Number of crystals per end-cap: 11376

Crystal boundary

Trigger tower boundary

Table 1 - Parameters of ECAL end-cap

| Row number | # crystals per row | R (cm) (low edge) | $\eta$ (low edge) | $\Delta\eta$ | A (cm) | B (cm) | C (cm) |
|---|---|---|---|---|---|---|---|
| 1 | 8 | 32.3 | 2.98 | 0.067 | 2.30 | 1.41 | 1.51 |
| 2 | 8 | 34.5 | 2.91 | 0.063 | 2.30 | 1.51 | 1.60 |
| 3 | 8 | 36.8 | 2.85 | 0.059 | 2.29 | 1.60 | 1.70 |
| 4 | 8 | 39.0 | 2.79 | 0.055 | 2.29 | 1.70 | 1.80 |
| 5 | 8 | 41.3 | 2.74 | 0.052 | 2.28 | 1.80 | 1.90 |
| 6 | 8 | 43.5 | 2.68 | 0.050 | 2.28 | 1.90 | 2.00 |
| 7 | 8 | 45.7 | 2.63 | 0.047 | 2.27 | 2.00 | 2.09 |
| 8 | 8 | 48.0 | 2.59 | 0.045 | 2.27 | 2.09 | 2.19 |
| 9 | 8 | 50.2 | 2.54 | 0.043 | 2.26 | 2.19 | 2.29 |
| 10 | 8 | 52.5 | 2.50 | 0.041 | 2.26 | 2.29 | 2.39 |
| 11 | 8 | 54.7 | 2.46 | 0.040 | 2.25 | 2.39 | 2.48 |
| 12 | 8 | 56.9 | 2.42 | 0.038 | 2.25 | 2.48 | 2.58 |
| 13 | 12 | 59.2 | 2.38 | 0.041 | 2.51 | 1.72 | 1.79 |
| 14 | 12 | 61.7 | 2.34 | 0.039 | 2.51 | 1.79 | 1.87 |
| 15 | 12 | 64.2 | 2.30 | 0.037 | 2.50 | 1.87 | 1.94 |
| 16 | 12 | 66.7 | 2.26 | 0.036 | 2.49 | 1.94 | 2.01 |
| 17 | 12 | 69.2 | 2.23 | 0.035 | 2.49 | 2.01 | 2.09 |
| 18 | 12 | 71.7 | 2.19 | 0.033 | 2.48 | 2.09 | 2.16 |
| 19 | 12 | 74.2 | 2.16 | 0.032 | 2.48 | 2.16 | 2.23 |
| 20 | 12 | 76.7 | 2.13 | 0.031 | 2.47 | 2.23 | 2.30 |
| 21 | 12 | 79.2 | 2.10 | 0.030 | 2.47 | 2.30 | 2.38 |
| 22 | 12 | 81.7 | 2.06 | 0.029 | 2.46 | 2.38 | 2.45 |
| 23 | 12 | 84.2 | 2.04 | 0.028 | 2.45 | 2.45 | 2.52 |
| 24 | 12 | 86.7 | 2.01 | 0.027 | 2.45 | 2.52 | 2.60 |
| 25 | 16 | 89.2 | 1.98 | 0.026 | 2.38 | 1.95 | 2.00 |
| 26 | 16 | 91.7 | 1.95 | 0.025 | 2.37 | 2.00 | 2.05 |
| 27 | 16 | 94.1 | 1.93 | 0.025 | 2.37 | 2.05 | 2.11 |
| 28 | 16 | 96.6 | 1.90 | 0.024 | 2.36 | 2.11 | 2.16 |
| 29 | 16 | 99.0 | 1.88 | 0.023 | 2.36 | 2.16 | 2.21 |
| 30 | 16 | 101.4 | 1.86 | 0.023 | 2.35 | 2.21 | 2.27 |
| 31 | 16 | 103.9 | 1.83 | 0.022 | 2.35 | 2.27 | 2.32 |
| 32 | 16 | 106.3 | 1.81 | 0.022 | 2.34 | 2.32 | 2.37 |
| 33 | 16 | 108.8 | 1.79 | 0.021 | 2.33 | 2.37 | 2.43 |
| 34 | 16 | 111.2 | 1.77 | 0.020 | 2.33 | 2.43 | 2.48 |
| 35 | 16 | 113.7 | 1.75 | 0.020 | 2.32 | 2.48 | 2.53 |
| 36 | 16 | 116.1 | 1.73 | 0.020 | 2.31 | 2.53 | 2.59 |
| 37 | 20 | 118.5 | 1.71 | 0.020 | 2.41 | 2.07 | 2.11 |
| 38 | 20 | 121.1 | 1.69 | 0.019 | 2.40 | 2.11 | 2.16 |
| 39 | 20 | 123.6 | 1.67 | 0.019 | 2.40 | 2.16 | 2.20 |
| 40 | 20 | 126.2 | 1.65 | 0.019 | 2.39 | 2.20 | 2.25 |
| 41 | 20 | 128.7 | 1.63 | 0.018 | 2.38 | 2.25 | 2.29 |
| 42 | 20 | 131.3 | 1.61 | 0.018 | 2.37 | 2.29 | 2.34 |
| 43 | 20 | 133.8 | 1.60 | 0.017 | 2.37 | 2.34 | 2.38 |
| 44 | 20 | 136.4 | 1.58 | 0.017 | 2.36 | 2.38 | 2.42 |
| 45 | 20 | 138.9 | 1.56 | 0.017 | 2.35 | 2.42 | 2.47 |
| 46 | 20 | 141.5 | 1.55 | 0.016 | 2.35 | 2.47 | 2.51 |