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HCAL Partition Definitions

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Abstract

The readout system for the Hadron Calorimeter is organized into five separate and distinct groups of channels according to the natural physical and logical characteristics of the calorimeter subsections. These partitions and their operation in the data acquisition and TTC systems are described.

1 Introduction

Many changes have occurred in the design of the CMS Hadron Calorimeter readout since the original TDR[1]. Additionally, the design and structure of the DAQ and TTC systems were finalized with the Trigger and DAQ TDRs[2][3], but the implications for the HCAL have not been documented. This note documents the baseline structure for the HCAL readout and controls, based on the final electronics design. This document does not describe in detail the structure of the HCAL DCS tree.

2 Structure of the HCAL Readout

2.1 A Standard HCAL Readout Crate

The full HCAL system will contain sixteen 9U VME readout crates, each hosting two HCAL Data Concentrator Cards (HCAL DCC). The HCAL DCC performs the role of Front-End Driver (FED) in the HCAL, and there are a total of 32 FEDs in HCAL. Besides the two HCAL DCCs, each crate will house a VME controller, a TTC and timing distribution board, and a number of HCAL Trigger and Readout (HTR) cards.

The HTR receives the channel data from the HCAL front-ends continuously over 1.6 GBps optical links. The HTR board constructs the trigger primitives which are transmitted by Serial Link Boards (SLBs) to the Regional Calorimeter Trigger. The HTR board also contains the DAQ pipeline. When a Level-1 Accept is received over the TTC system, the HTR transmits the appropriate data to the HCAL Data Concentrator (DCC) over an LVDS Channel Link. The DCC fulfills the role of Front-End Driver (FED) in the HCAL, and hosts the SLINK64 which feeds the DAQ.

Each optical link into the HTR carries the data from three front-end channels. The HTR accepts sixteen fibers which are handled by two large Xilinx FPGAs. Each FPGA has its own output link to the HCAL DCC. Thus, each physical HTR board handles 48 front-end channels, but each input to the HCAL DCC carries the data from 24 channels. The data transmitted from the HTR to the DCC, or subfragment, has its own internal headers and trailers, including the L1A number and bunch number for monitoring usage.

The HCAL DCC will support up to fifteen inputs or *spigots*, but only twelve are expected to be used for reading out physical tower data, while an additional spigot will be used for calibration data. Thus, each HCAL FED link will represent ($3 \times 8 \times 12 = 24 \times 12 =$) 288 physical channels plus 24 calibration channels. Within the FED data, the useful electronics indexes will be the spigot number (0-14) within the DCC and the channel number (1-24) within a single subfragment.

2.2 Partitioning of HCAL

The HCAL consists of 11 separate physical pieces

- The positive and negative barrels : HB+ and HB-.
- The positive and negative endcaps : HE+ and HE-.
- The positive and negative forward calorimeters : HF+ and HF-.
- The five rings of the outer HCAL : HO2-, HO1-, HO0, HO1+, and HO2+.

The barrel and endcap sections of the calorimeter participate in the calorimeter trigger. One of the trigger towers (tower 16) is shared between HB and HE – calculation of the energy requires adding the energy in both detectors (Fig. 1). For this reason and to maximally utilize the readout electronics, the readout of HB and HE are combined at the HTR level of the readout (individual HTRs read out from both HB and HE) and thus share partitions. Thus, it is impossible for HCAL to use the original partitioning from the Trigger TDR. Instead, the central portion of HCAL is partitioned into three 120° sectors combining HE-, HB-, HB+, and HE+ which are dubbed *HBHEa*, *HBHEb*, *HBHEc*. Each partition contains three crates and six FEDs and corresponds to a single superfragment within the DAQ. The arrangement of the readout crates for each partition is shown in Figure 2.

The forward calorimeter (HF+/HF-) also participates in the calorimeter trigger, but there is no overlap calculation to perform for it. It forms its own partition in CMS consisting of three crates and six FEDs. Each of the eight front-end crates produces a single fiber (three channels) of calibration input. The data from the HF should be fed into one FEDbuilder and become a single superfragment in the DAQ.

The outer calorimeter (HO) covers towers 1-15 on the positive and negative sides of the calorimeter. The segmentation in phi is the same (5°) as in the rest of the system, although the local symmetry is 12-fold instead of 18-fold. The HO does not participate in the calorimeter trigger and has its own partition with four crates and eight FEDs. The HO crates are not 100% occupied, unlike the HBHE and HF crates. At maximum packing, the HO would require $3\frac{3}{4}$ standard crates. The data from HO should go into one FEDbuilder and become a single superfragment in the DAQ.

Partition	Crates	FEDs	Detector Channels	Calibration Channels
HBHEa	3	6	1728	108
HBHEb	3	6	1728	108
HBHEc	3	6	1728	108
HO	4	8	2160	108
HF	3	6	1728	24
Totals	16	32	9072	456

Table 1: Crate, FED, and Channel Counts for the HCAL partitions.

3 Conclusion

The final baseline partition and crate structure of the CMS HCAL has been described. This document represents the detector as-built and should be the basis for development of DAQ and reconstruction software.

References

[1] **CERN/LHCC 97-31**, CMS Collaboration, *"CMS HCAL Technical Design Report"*.

[2] **CERN/LHCC 2000-38**, CMS Collaboration *"CMS TriDAS Project Technical Design Report Volume 1: The Trigger Systems"*.

[3] **CERN/LHCC 2002-26**, CMS Collaboration *"CMS TriDAS Project Technical Design Report Volume 2: The Data Acquisition System"*.

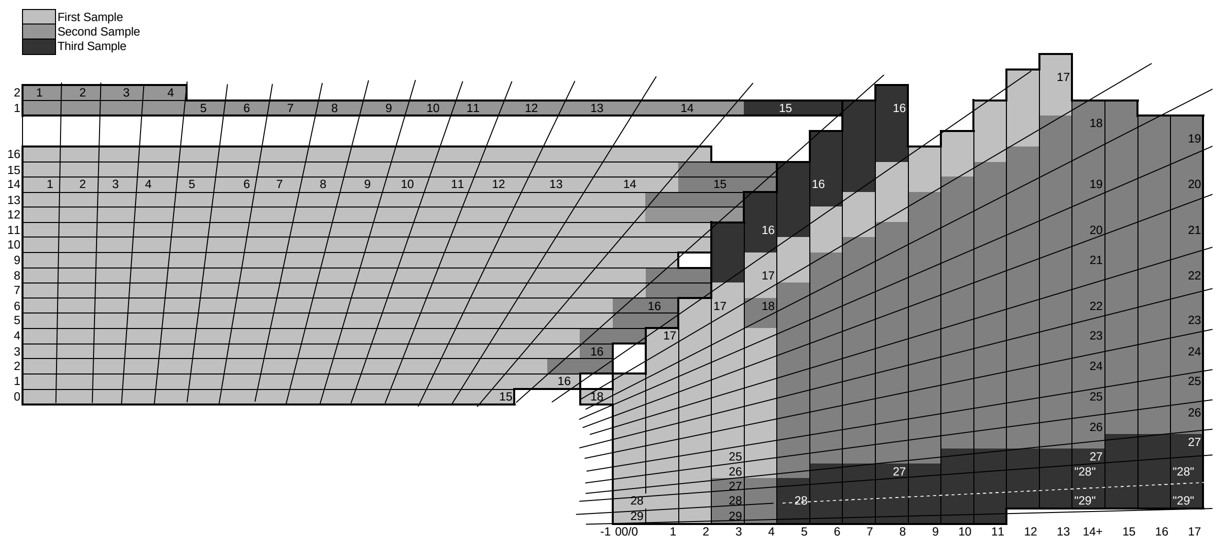

Figure 1: Segmentation and tower assignments for HB, HE, and HO as a function of detector eta (ieta). The number of layers in tower ieta=15 in the HB varies as a function of phi. The last three layers of tower ieta=15 are combined to form depth two of the readout, so the number of layers in depth one varies between 12 and 13. In the azimuthal direction, there are 72 towers in phi (5° width) for ieta between 1 and 20, and 36 towers in phi (10° width) for ieta 21 and above.

	Lower Crate	Upper Crate
1	***HB/HE a*** $\eta = (-3,+3)$ $\phi = (90,130)$	***HB/HE a*** $\eta = (-3,+3)$ $\phi = (50,90)$
2	***HO*** $\eta = (-1.3,+1.3)$ $\phi = (350,80)$	***HF*** $\eta = (+3,+5)$ $\phi = (50–170)$ $\eta = (-5,-3)$ $\phi = (10–130)$
3	***HB/HE b*** $\eta = (-3,+3)$ $\phi = (130,170)$	***HB/HE a*** $\eta = (-3,+3)$ $\phi = (10,50)$
4	***HO*** $\eta = (-1.3,+1.3)$ $\phi = (80,170)$	***HO*** $\eta = (-1.3,+1.3)$ $\phi = (170,260)$
5	***Luminosity***	***HF*** $\eta = (+3,+5)$ $\phi = (330–50)$ $\eta = (+3,+5)$ $\phi = (170–210)$ $\eta = (-5,-3)$ $\phi = (130–210)$ $\eta = (-5,-3)$ $\phi = (330–10)$
6	***HB/HE b*** $\eta = (-3,+3)$ $\phi = (170,210)$	***HB/HE c*** $\eta = (-3,+3)$ $\phi = (330,10)$
7	***HO*** $\eta = (-1.3,+1.3)$ $\phi = (260,350)$	***HB/HE b*** $\eta = (-3,+3)$ $\phi = (210,250)$
8	***HB/HE c*** $\eta = (-3,+3)$ $\phi = (290,330)$	***HF*** $\eta = (+3,+5)$ $\phi = (210–330)$ $\eta = (-5,-3)$ $\phi = (210–330)$
9	***HB/HE c*** $\eta = (-3,+3)$ $\phi = (250,290)$	***Calibration Crate***

Figure 2: Arrangement of the HCAL readout crates in rack row “F” of the counting house. There are two 9U crates in each rack (1-9). The partition and detector angular assignments for each crate are shown.