CMS Internal Note

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CSC Strip, Wire, and Chamber Orientation

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Abstract

We present a labeling scheme for the endcap muon cathode strip chambers, including the strips, wire groups and layers within a chamber, chambers within a sector and sectors within a station. Care is taken to ensure consistent labeling between the two endcaps.

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Introduction

It took several years to come up with a consistent labeling scheme for the CSC muon stations (ME1/1, ME1/2, etc.). There needs also to be a generally-accepted finer-grain labeling scheme for strips, wires, and chambers positions in ϕ. This is largely for use by the trigger, where stubs are found from multi-layer coincidences, and true space coordinates and vector directions are used for track finding and for correlation with the calorimetry. (On the other hand, for the DAQ readout of the CSC system, the relative orientation and labeling of CSC strips, wires, and chambers does not much matter - they can always be re-oriented or re-labeled in software). These matters lead us to propose a scheme by which any strip or wire in the system can be uniquely identified and its position in various coordinate systems understood. There also seems to be a need to explain the various coordinates in one self-consistent place.

Single-Chamber, Standalone Layout – non-ME1/1 case

The CSC chambers are constructed as trapezoidal objects, and during assembly they lay on tables so that electronics can be mounted on top. In this configuration, the top plane of wires and strips (*i.e.* those closest to the electronics) is layer 1, and the bottom plane is layer 6. ME1/1 is a special case in this respect as described below. The wire group number increases from inner radius to outer radius (1:*n*). Strip number increases from left to right (1:*n*) when one looks from the small "inner" end toward the large "outer" end of the chamber, as shown in
Figure 1:

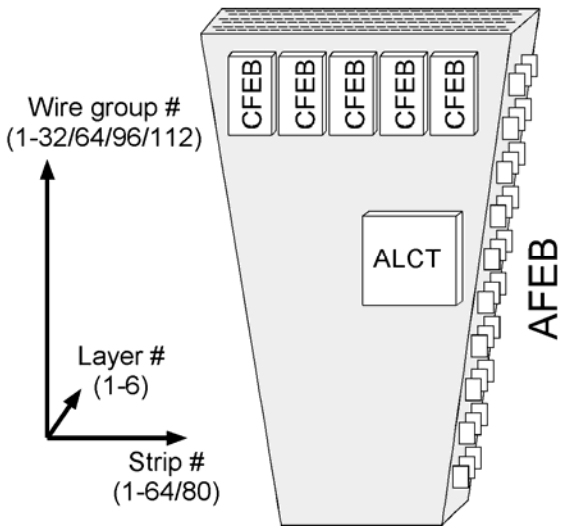


Figure 1. A view of a (non-ME1/1) CSC chamber with electronics on top and the corresponding definition of local CSC coordinates.

Single-Chamber, Standalone Layout - ME1/1 only

The ME1/1 chambers differ from all other chambers in that within a single station the electronics are mounted facing alternately toward and away from the interaction region. For the chambers centered at 0^o, 10^o, 20^o, etc.; the electronics face towards, away, towards etc. the interaction region, respectively.

ME1/1 is divided into two chambers in η, labeled ME1/1a inner part (by radius) and ME1/1b outer part. ME1/1b has 64 strips while ME1/1a 48 strips.

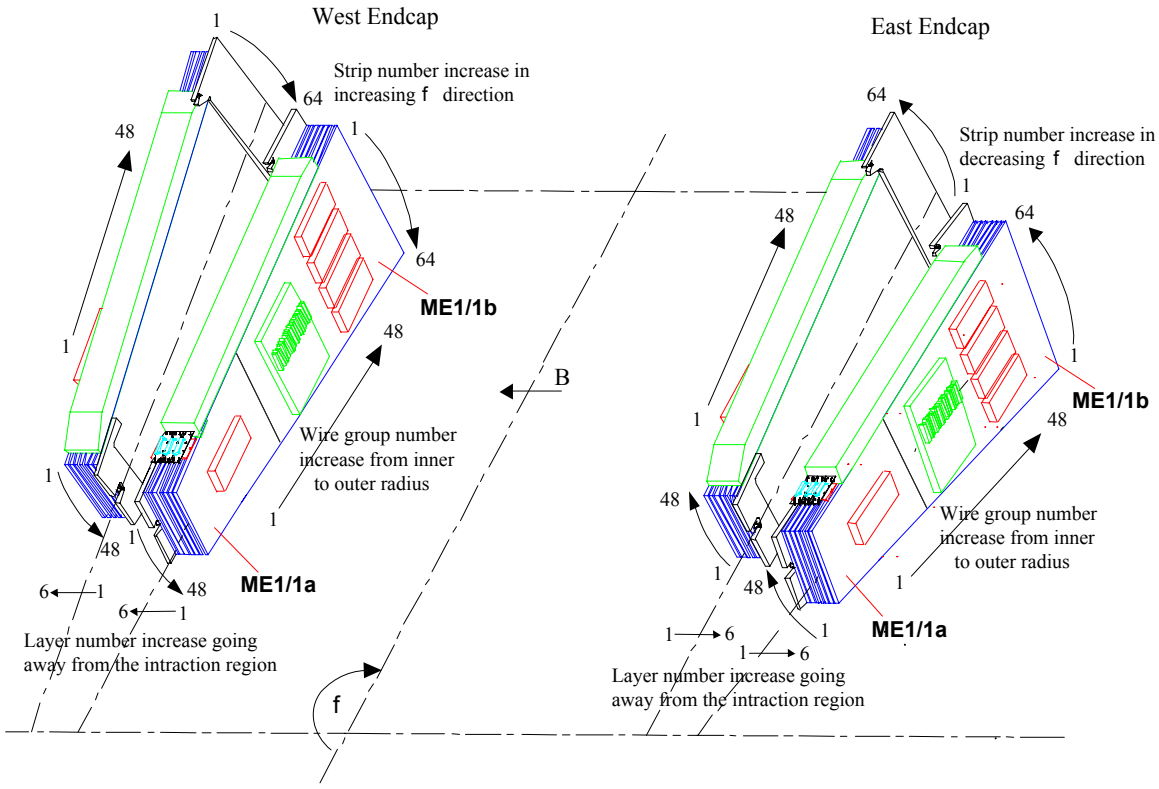


Figure 2. Orientation of layers and strips in the specific case of ME1/1 chambers.

Also, the cabling has been arranged so that the firmware in ALCT, CLCT, etc electronics does not depend on the ϕ position of the chamber.

To summarize, the local coordinate definition in the +z (West) endcap is as follows:

- Wire numbers increase from inner to outer radius (same as other chambers)
- Strip numbers increase from 1-64 in increasing ϕ direction for ME1/1b.
- Strip numbers increase from 1-48 in increasing ϕ direction for ME1/1a.
- Layer numbers increase going away from the interaction region.

In the –z (East) endcap:

- Wire numbers increase from inner to outer radius (same as other chambers)
- Strip numbers increase from 1-64 in *decreasing* ϕ direction for ME1/1b.
- Strip numbers increase from 1-48 in *decreasing* ϕ direction for ME1/1a.
- Layer numbers increase going away from the interaction region.

These points are illustrated in Figure 2.

Layout of CSC Chambers in CMS

The CMS detector lies on the North side of the LHC ring. The x-axis (ϕ=0°) points toward the center of the ring (South), while the y-axis is vertical and to complete the right-handed coordinate system, the z-axis points West. Therefore, the West (Jura direction) endcap is at +z and +η (rapidity), while the East (Saleve direction) endcap is at –z and –η, as shown in Figure 3.

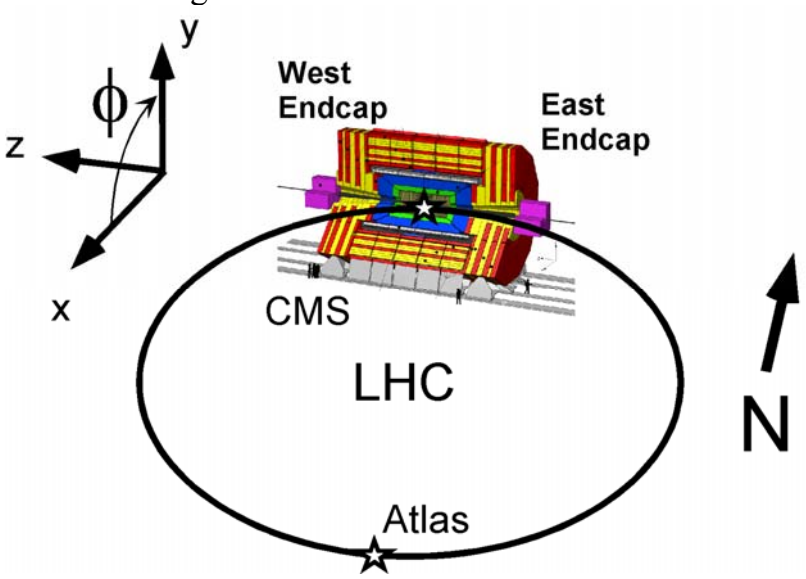


Figure 3. Overall CMS coordinate system

Stations 1 and 2 chambers are mounted on the endcap iron disks on the sides closest to the interaction point, as shown in the following figure. Conversely, in stations 3 and 4, chambers are mounted on the iron disks on the sides away from the interaction point. This is shown in Figure 4, which is similar to figure 4.6.3 in the CMS Muon TDR.

We can conclude that in the West (positive *z*, positive η) endcap, strip numbers in stations 1 and 2 are in increasing ϕ order, and strip numbers in stations 3 and 4 are in decreasing ϕ order. In the East (negative *z*, negative η) endcap, strip numbers in stations 1 and 2 are in decreasing ϕ order, while strip numbers in stations 3 and 4 are in increasing ϕ order. These statements are also true in ME1/1, although the precise reasoning is somewhat different.

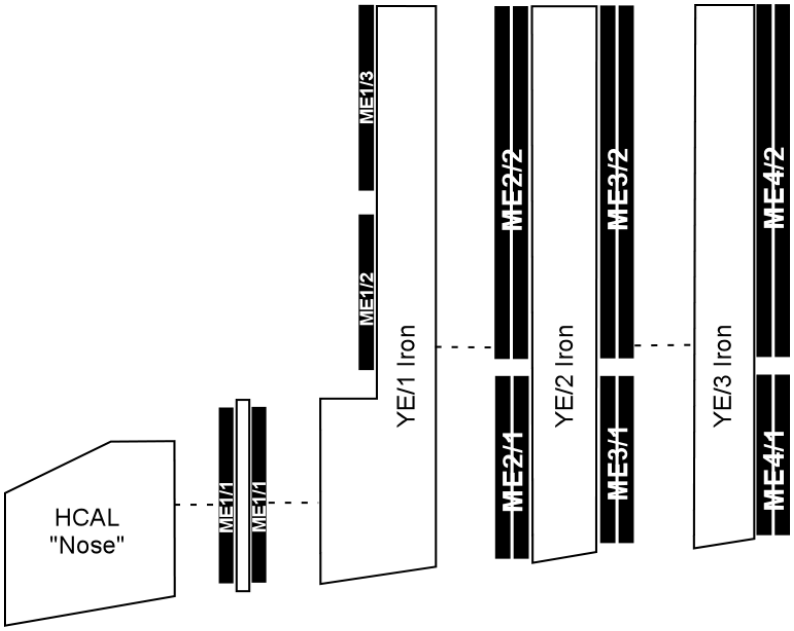


Figure 4. An r-z cross-section of the endcap muon system, showing the sides of the iron disks on which the CSC chambers are mounted.

We use the CMS convention of defining $\phi = 0°$ at the positive x-axis. In the endcap muon system, there are 10° and 20° chambers. Every ring of chambers starts in ϕ with a chamber that has an edge at approximately -5°. The first chamber in ϕ of 10° chamber types such as ME1/1 span approximately −5° to +5°, while the first chamber in ϕ of 20° chamber types such as ME2/1 span approximately −5° to +15°.

The chambers are numbered as ME<+->/<station>/<ring>/<phi index>. For example ME+2/1/1…ME+2/1/18 represent labels for all of the ME2/1 type chambers in the +z (Jura direction) endcap.

For purposes of triggering, the first chamber of the first 60^{o} muon sector starts at $\phi = 15°$. This location is determined by the first ϕ value at which chamber edges in the endcap line up with chamber edges in the barrel muon system.

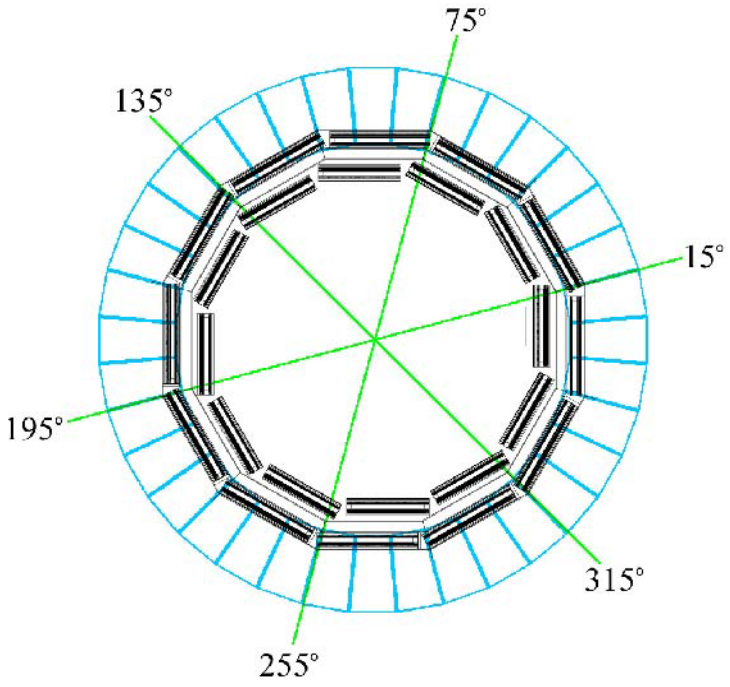


Figure 5. An r-ϕ cross-section of the endcap muon system, showing the edges of the 60° sectors and the position of the outer (large) chambers.

The Definition of Peripheral Electronics Crates

Since peripheral crates contain one trigger sector of electronics each, the peripheral crates are designated in ϕ the same as the trigger sectors in CSC stations 2, 3, and 4. In station 1, however, in order to match the RPC system, the first peripheral crate is defined as the one covering the ϕ range of -15° to 15°. Therefore, in ME1 the first 30° trigger sector corresponds to peripheral crate 2, and the last 30° trigger sector corresponds to peripheral crate 1. This is shown graphically in Figures 6 and 7 below.

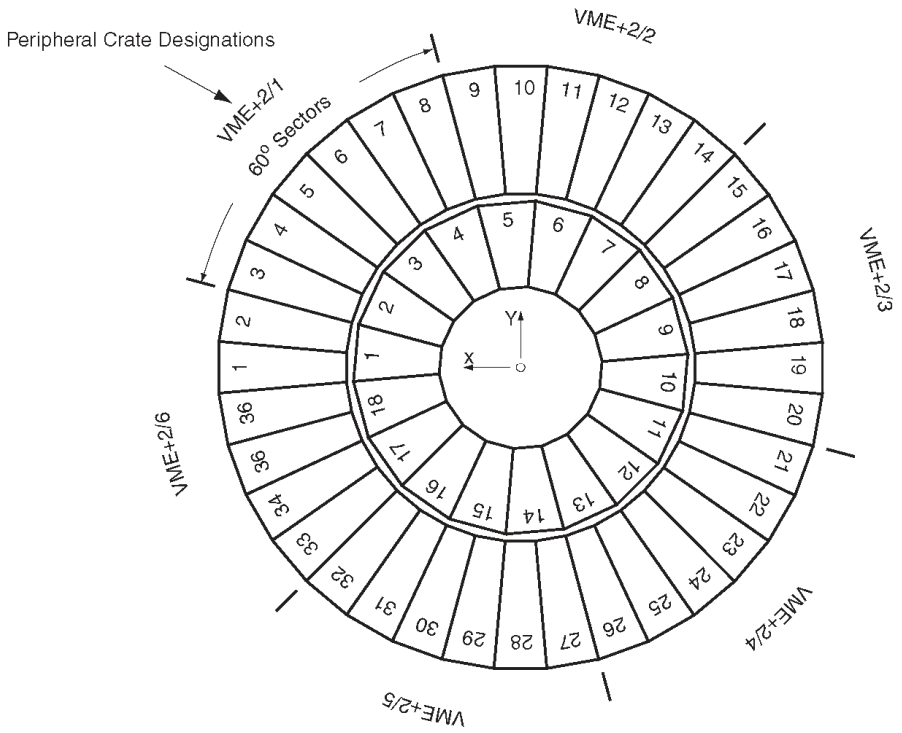


Figure 6. An r-ϕ cross-section of the ME2, ME3, and ME4 endcap muon station, showing the positions of chambers, trigger sectors, and peripheral crates.

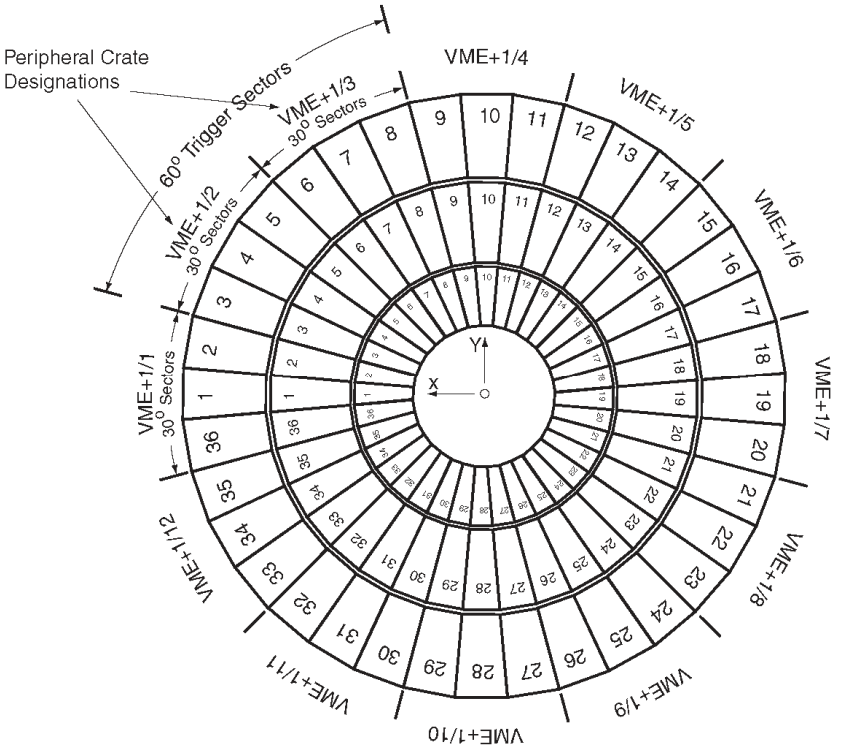


Figure 7. An r-ϕ cross-section of the ME2 endcap muon station, showing the positions of chambers, trigger sectors, and peripheral crates. ME3 and ME4 follow the same numbering scheme.

Within each peripheral crate, slot 1 is always used for the VME Crate Controller, Slot 12 is for the MPC (Muon Port Card), and Slot 13 for the CCB (Clock and Control Board). Other slots are used by TMB/DMB board pairs. There is one TMB/DMB board pair occupying two slots for each chamber. In ME2, ME3, and ME4, the TMB/DMB order corresponds to ϕ order of chambers, with all of TMB/DMB board pairs corresponding to inner-radius chambers (MEn/1) occupying the lower-numbered slots (2/3, 4/5, and 6/7), followed by the TMB/DMB pairs for outer-radius (MEn/2) chambers occupying higher-numbered slots (8/9, 10/11, 14/15, 16/17, 18/19, 20/21). An example is shown in Figure 8. In ME1, the same pattern is followed: ME1/1 chambers occupy lower-numbered slots (2/3, 4/5, 6/7), ME1/2 chamber occupy middle slots (8/9, 10/11, 14/15), and ME1/3 TMB/DMB board pairs occupy high-number slots (16/17, 18/19, 20/21) as shown for example in Figure 9.

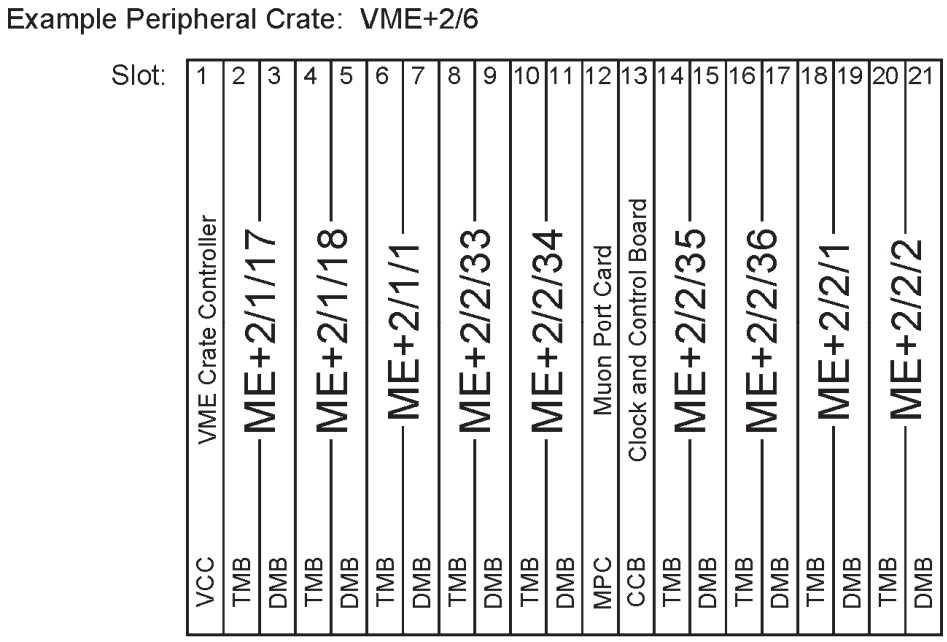


Figure 8. An example of the arrangement of slots in peripheral crates to TMB/DMB board pairs and other modules (CCB, MPC, Controller) in ME2, ME3, and ME4.

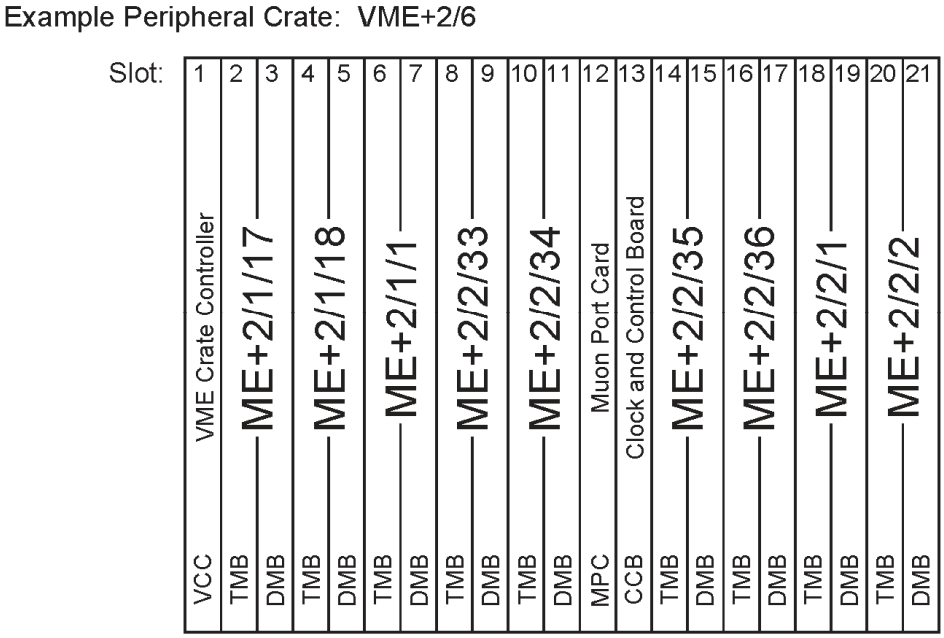


Figure 9. An example of the arrangement of slots in peripheral crates to TMB/DMB board pairs and other modules (CCB, MPC, Controller) in ME1.

The Direction of Muon Bending

The magnetic field points along the z-axis. The bending direction of endcap muons reverses along the muon trajectory: initially, the muon crosses the +z solenoidal field lines, but around station 1 the magnetic field lines diverge in the +r direction and the

muon crosses the field lines in the opposite direction. From looking at the picture above, one can tell that the positive muons travelling in either direction (East or West) will first bend in the -ϕ direction and then reverse at some point toward the +ϕ direction in travelling through the return flux of the muon system.

The Orientation of Strip Staggering

The CSC chambers contain strips milled on every anode and cathode panel. In all types of chambers except ME1/1, strip 1 is indented by 1/2-strip in layers 1 (top), 3, and 5; with respect to strip 1 in layers 2, 4, and 6 (bottom). In ME1/1, there is no strip staggering.

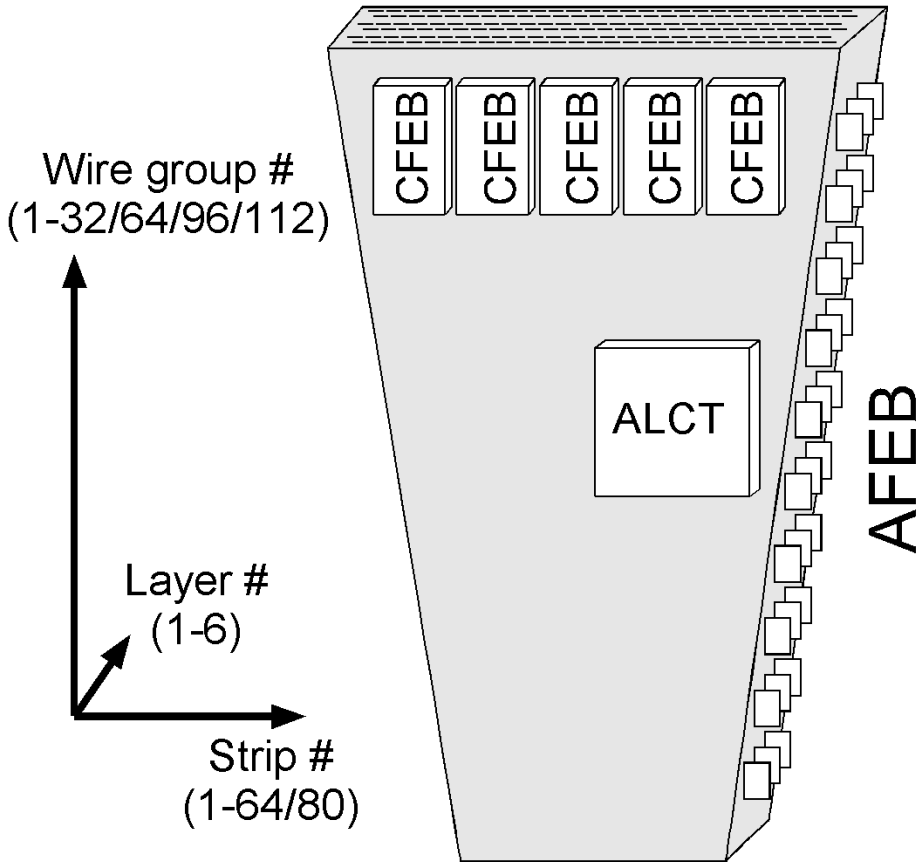


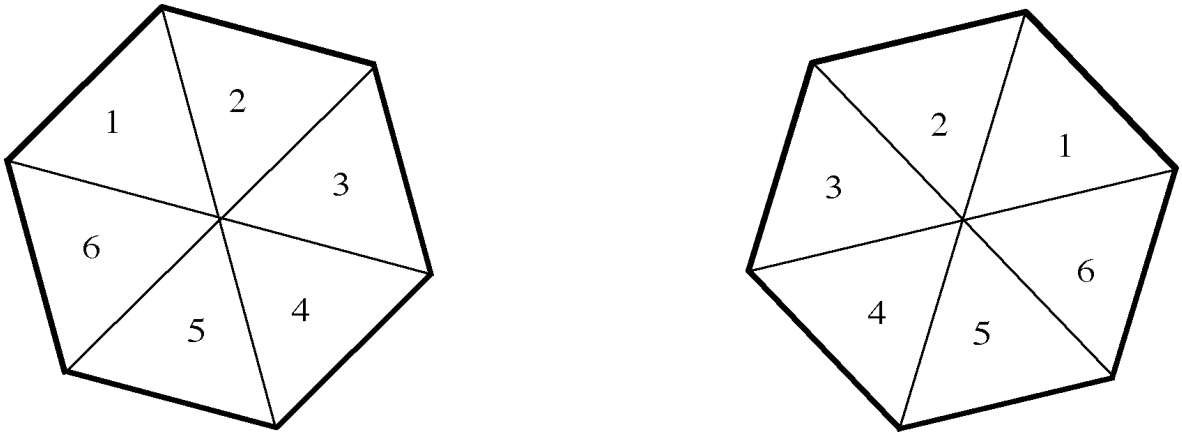
Figure 10. Staggering of strips in (non-ME1/1) CSC chambers. The first strip is indented in the top, third, and fifth layers with respect to the alternate layers.

Global labeling of chambers

Starting at ϕ = 15°, each chamber is numbered from 1 to 18 (for the 20° chambers) and 1 to 36 (for the 10° chambers). In the positive η endcap, the chamber number increases clockwise; in the negative η endcap the chamber number increases counterclockwise.

Numbering of endcap trigger sectors, and chambers within a sector

The first trigger sector in each endcap starts at +15°. Note that once a sector is defined, it has the same sense of ϕ in both endcaps. In the $+\eta$ endcap the sector number increases clockwise. In the $-\eta$ endcap the sector number increases counterclockwise. Likewise, the numbering of the chambers within a sector goes in the opposite direction (within a ring) in the $-\eta$ endcap.



Positive η endcap, viewed from the IP *Negative η endcap, viewed from the IP*

Figure 11. Endcap trigger Sector Numbering.

Each sector in stations 2, 3, 4 consist of three 20° chambers and six 10° chambers. They are numbered as shown below, as seen from the interaction point:

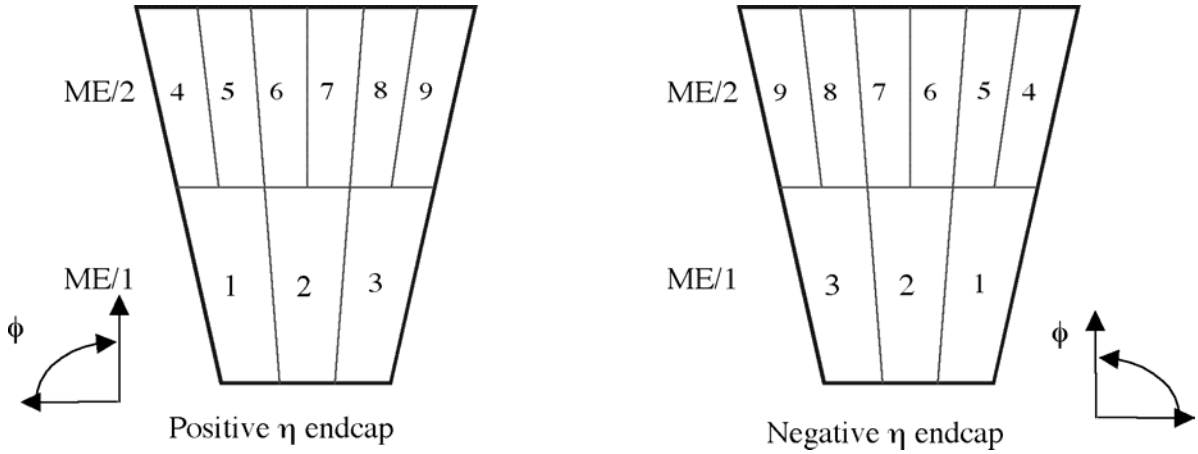


Figure 12. CSC numbering in ME2, ME3, and ME4 within a 60-degree trigger sector.

In station 1 we have two 30° subsectors in each 60° sector. Each 30° subsector consists of nine 10° chambers. Note that ME1/1 is divided into two chambers in η, labeled

ME1/1a and ME1/1b. We number them from 1 to 12 (again, viewing from the interaction point):

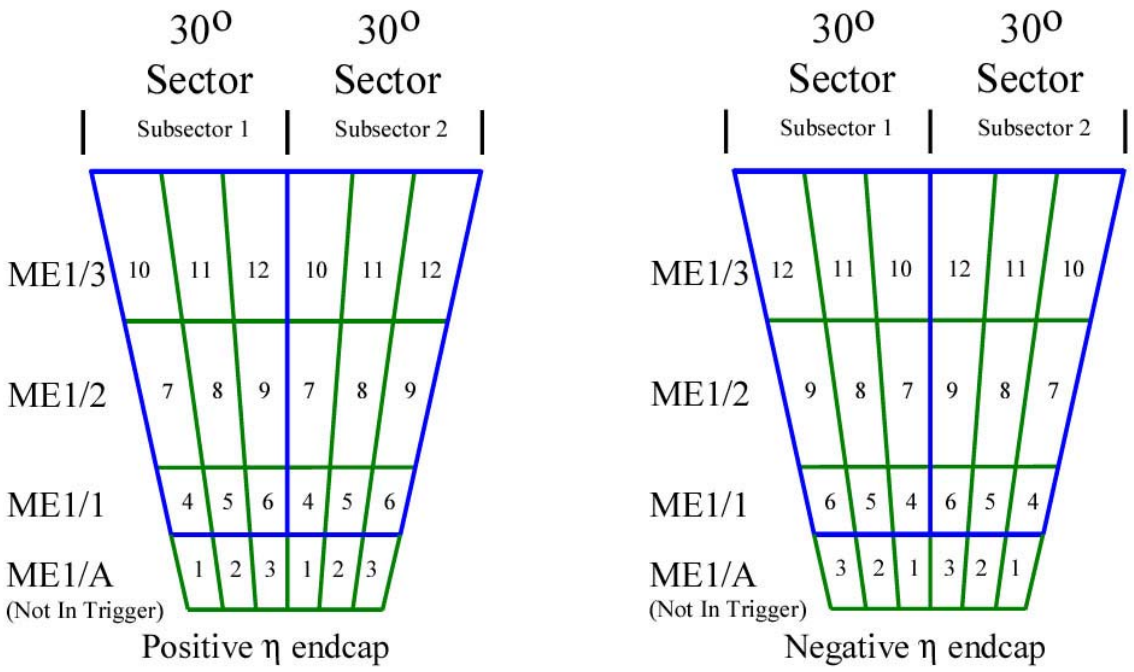


Figure 13. Numbering of CSC chambers within trigger sectors.

Summary

For non-ME1/1 chambers, if a chamber is lying on a table with cathode electronics on top, and the narrow end towards the viewer:

- Strip numbers increase from left to right
- Wire group numbers increase from small end to large end
- Layers run from top to bottom

The same points happen to be valid for ME1/1 except that the order of layers is defined in a more global way to increase starting with the side closest to the interaction point and going outward (larger |z|).

This then has the following implications:

- For ME1 and ME2 in the positive η endcap, the strip number increases with ϕ.
- For ME3 and ME4 in the positive η endcap, the strip number *decreases* with ϕ.
- In the negative η endcap, the opposite happens.
- In all stations the wire group number increases with decreasing |η| in both endcaps.

Viewing the positive η endcap from the interaction point:

- ϕ = 0° at the positive *x*-axis, increasing clockwise.
- 60° sectors begin at ϕ = 15°, increase clockwise, and are numbered from 1-6.

In the negative η endcap, all numbering (and ϕ) increase counterclockwise.

Within a sector in the positive η endcap:

- For station ME1 the numbering runs from 1-12, where chambers 1-3 are ME1/1a, chambers 4-6 are ME1/1b, chambers 7-9 are ME1/2 and chambers 10-12 are ME1/3. Only chambers 4-12 are in the trigger baseline. The numbering increases clockwise
- For all other stations, 1-3 are the inner ring, 20° chambers and 4-9 are the outer ring, 10° chambers. All are in the trigger and the numbering increase clockwise.

In the negative η endcap all numbering increases counterclockwise.

Document history:

18 February 1998. Originally written by Jay Hauser for distribution on the Web.
19 November 1999. Modified by Benn Tannenbaum for distribution as a CMS note and to include information about labeling within a sector.
July-Aug 2002. Modified by Jay Hauser, Vladimir Karjavin, and Serguei Khabarov to include ME1/1 orientation and improve quality of figures, add captions.
October 2005. Modified by Jay Hauser. Text for peripheral crate numbering and slots added, and figures from Ben Bylsma.