# D0 Upgrade Electronics

## Introduction

This note defines the positions of the data in the L3 readout, defines the cabling of the detectors from FE to VRB, and defines the meaning and position of the L1 and L2 information in the L3 readout for the CFT, CPS, and FPS detectors. It also covers the reserved places for the FPD.

## Overview for all Detectors

The L3 readouts for the four detectors are divided into 3 Geographical Sectors, GS, each with one VME Readout Buffer Crate, VRB crate. A summary of the GS for the systems is shown in Table B1, appendix B table 1. The CFT system is divided into 2 GS, with the axial fibers in one and the stereo fibers in the second. The FPS is completely included in the third. The CPS is split into two GS, the axial strips are combined with the CFT axial in the first and the stereo strips are combined with the FPS in the third. The FPD has space reserved in the second, which it shares with the CFT stereo. The L1 hardware located in Muon Trigger Manager crates are in two additional GS. One GS is for the L1 CFT and another for the L1 FPS.

The L3 readout hardware for these systems is the silicon readout system, which as the name implies is shared with the silicon detector. For this system the ADC is the 8 bit SVX2e chip, which has 128 channels. From 1 to 10 SVX chips are daisy chained into one High Density Interconnect, HDI, string. Eight HDI strings are connected to a single Sequencer board and each sequencer board is connected to a single VRB board. Each sequencer board has 4 optical link fibers, which transfer data up to the 4 inputs on each VRB board. While it is possible to connect the four fibers from a given sequencer board to more than one VRB board, for several reasons the following rule has been adopted. <u>Each Sequencer board is always connected to one and only one VRB board, and each VRB board is always connected to one and only one Sequencer board.</u> Therefore the Sequencer ID is defined as identical to the VRB ID.

The data from a GS of the CFT has the following structure.

GS
    VRB (14 word header )

```
        Sequencer ID                Sequencer Status
            HDI ID                      HDI status
                Chip ID                     00
                    Channel Number                      Data
                    Channel Number              Data
                                        ….      …..
    C0      C0  (EOR)
```

Each GS is one VRB crate, which contains up to 11 VRB boards.
Each VRB has 4 optical fiber inputs from one sequencer board.
Each sequencer reads out 8 HDI, SVX strings.
Each HDI contains 8 SVX chips plus 1 or more VSVX chips at the end of each string.

**Structure of the CFT Axial**

The CFT Axial and the CPS Axial are intermixed on the FE boards and in the L3 data at the SVX chip level. Each FE board contains one HDI. The chips on each FE board / HDI are numbered from 0 to 15, using 4 bits. The contents of each chip are as follows.

| Chip ID | | Contents | |
|---|---|---|---|
| 0 - 6 | | ADC values for fibers | |
| 7 | | ADC values for CPS Axial Stips | |
| 8 | | CFT L1 Data | |
| 9 | | CPS L1 Data | |

Chips 0 though 6 are SVX2e chips and contain the digitized analog signal values for each of the 480 fibers on a FE board. Chip 7 is a SVX2e chip, which contains the digitized values for the 32 CPS strips. Chips 8 and 9 are Virtual SVX chips. A Virtual SVX chip, VSVX, is a PLD plus buffer memory which appears to the sequencer as just another SVX chip in the HDI. The data it contains, however, is arbitrary, and can be inserted at each crossing for that crossing and pipelined until readout, or inserted just before the HDI is readout. In general a VSVX contains both types of data. The VSVX is used to transfer FE information to the L3 and offline systems on an event by event basis.

The contents of each SVX chip in the CFT FE board are shown in figure A1. There are two FE boards for each VLPC cassette. The fiber contents into each of the 40 cassettes is identical, but the two FE boards are asymmetric. Figure xx shows the division of the fibers from a single cassette into the two FE boards. This asymmetry is a result of requiring that the fibers be plugged into the top of each cassette in groups of 16. In figure A1 the left hand board, LHB, is shown of the left hand side of the figure and the RHB is shown on the right. On each side there are three rows of boxes. The center row, which are open boxes, represent the fibers from each doublet layer on the CFT. The boxes on the left represent the cassette modules. The boxes on the right represent the MCM's. Since each MCM contains only one SVX they also represent the SVX chips. Looking at the figure we see, for example, that the A layer fibers for the LHB are routed into MCM #1 in 32 of the 68 used channels. Note that each MCM has 72 channels. And we see that MCM #1 on the LHB has 32 inputs from the A layer, 32 from the B layer and 4 from the C layer. While MCM #1 on the RHB has 32 inputs from the A layer and 36 from the B layer. The 32 channels from the CPS axial are always input as 64 channels into MCM #8.

The CFT/CPS VSVX chips contain several types of data, which are as follows.

| VSVS | Channels | | Contents |
|---|---|---|---|
| 8 | 60 | | Discriminator Outputs for 480 fibers |
| | 12 | | Track counts sent to L1 |
| | 48 | | Track lists sent to L2 |
| | 8 | | FE board monitoring data |
| | 128 | | |
| | | | |
| 9 | 8 | | Discriminator Outputs for 64 PS strips |
| | 8 | | Cluster lists sent to L2 |
| | 16 | | |

The tables at the end of this section list the format of the data within the two VSVX chips. Table 1 shows the packing of the discriminator outputs. Table 2 the packing of the track counts, and table 3 the packing of the track lists. Tables 4 and 5 show the same for the CPS.

The CFT and CPS axial are in GS #80 and are located in the East cryostat. Appendix B contains a series of tables listing the locations of the FE boards in the Cassettes and the routing of the readout. The two charts labeled East Cryostat and West Cryostat list the FE boards sorted by cassette location and the three charts labeled Geographical Sector 1 through 3 list the FE boards sorted by Sector, VRB and HDI.

### Structure of the CFT Stereo

The CFT Stereo consists of 75 FE boards, each of which contains 512 CFT Stereo fiber channels. Each FE board contains one HDI. The chips on each FE board / HDI are numbered from 0 to 15, using 4 bits. The contents of each chip are as follows.

| Chip ID | | Contents |
|---|---|---|
| 0 - 7 | | ADC values from two ribbons |

Chips 0 though 7 are SVX2e chips and contain the digitized analog signal values for each of the 512 fibers on a FE board. The fiber tracker has 16 stereo doublet layers alternating between u and v layers laid down in ribbons 256 fibers wide. Each FE board receives the input from two ribbons.

The contents of each SVX chip in the CFT FE stereo board is shown in figure A2. There are two FE boards for each VLPC cassette. The analog aspects of the FE boards for the CFT Stereo are identical to those for the CFT axial.

The CFT stereo is in GS #81 and is located in the West cryostat in crates 1 through 5. Since there are only 75 FE boards, 37.5 cassettes are occupied and 2.5 in crate 5 are open or spares. The L3 readout from these FE boards constitutes the bulk of a single GS.

## Structure of the FPS

The FPS is on 32 FE boards in two crates. Each of the crates is at either end of the cryostat row in the platform. Each FE board contains two HDI's and the chips on each HDI are numbered from 0 to 15, using 4 bits. The contents of each chip are as follows.

| HDI ID | Chip ID | | Contents |
|---|---|---|---|
| 0 | 0 - 3 | | ADC values for forward strips - no charge division |
| 0 | 4 - 7 | | ADC values for backward stips - high gain |
| 1 | 0 - 3 | | ADC values for backward stips - low gain |
| 1 | 4 | | VSVX |

Chips 0 though 3on HDI 0 are SVX2e chips and contain the digitized analog signal values from the 101 forward strips in each of the u and v layers. Chips 4 though 7 on HDI 0 are SVX2e chips and contain the digitized analog signal values from the 135 back strips in each of the u and v layers for the high gain arm of the charge division. Chips 0 though 3 on HDI 1 are SVX2e chips and contain the digitized analog signal values from the 135 back strips in each of the u and v layers for the low gain arm of the charge division. Chip 4 on HDI 1 is a Virtual SVX chip.

The contents of each SVX chip in the CFT FE board is shown in figure A3.

The FPS VSVX chips contain several types of data, which are as follows.

| VSVS | Channels | | Contents |
|---|---|---|---|
| 8 | 13 | | Discriminator Outputs for u forward (101 strips) |
| | 13 | | Discriminator Outputs for v forward (101 strips) |
| | 17 | | Discriminator Outputs for v back - high gain (135 strips) |
| | 17 | | Discriminator Outputs for u back - high gain (135 strips) |
| | 17 | | Discriminator Outputs for v back - low gain (135 strips) |
| | 17 | | Discriminator Outputs for u back - low gain (135 strips) |
| | 8 | | FE Board Monitoring data |
| | **102** | | |
| | | | |
| 9 | 12 | | Cluster counts sent to L1 |
| | 96 | | Cluster lists sent to L2 |
| | **108** | | |

## Structure of the CPS Stereo

The CPS Stereo is on 10 FE boards in two 'small' crates. Each of the crates is at either end of the cryostat row in the platform just inboard of the FPS crates. The CPS Stereo is made up of two layers, u and v, at two ends, n and s, of the detector cylinder. The cylinder is broken up in phi into 5 groups of 256 strips. Two of these groups of 256 contiguous strips from overlapping u and v layer from a single end are routed to each FE board. Each FE board contains two HDI's and the chips on each HDI are numbered from 0 to 15, using 4 bits. The contents of each chip are as follows.

| HDI ID | Chip ID | | Contents |
|---|---|---|---|
| 0 | 0 - 3 | | ADC values for u layer - low gain |
| 0 | 4 - 7 | | ADC values for u layer - high gain |
| 1 | 0 - 3 | | ADC values for v layer - low gain |
| 1 | 4 - 7 | | ADC values for v layer - high gain |
| 1 | 8 & 9 | | VSVX |

The contents of each SVX chip in the CFT FE board is shown in figure A4.

The CPS Stereo VSVX chips contain several types of data, which are as follows.

| VSVX | Channels | | Contents |
|---|---|---|---|
| 8 | 32 | | Discriminator Outputs for u - low gain (256 strips) |
| | 32 | | Discriminator Outputs for u - high gain (256 strips) |
| | 32 | | Discriminator Outputs for v - low gain (256 strips) |
| | 32 | | Discriminator Outputs for v - high gain (256 strips) |
| | **128** | | |
| | | | |
| 9 | 96 | | Cluster lists sent to L2 |
| | 8 | | FE Board Monitoring data |
| | **104** | | |

## Tables

| Channel | msb | | | | | | | lsb |
|---|---|---|---|---|---|---|---|---|
| 0 | A I 7 | A I 6 | A I 5 | A I 4 | A I 3 | A I 2 | A I 1 | A I 0 |
| 1 | A I 15 | A I 14 | A I 13 | A I 12 | A I 11 | A I 10 | A I 9 | A I 8 |
| 2 | A O 7 | A O 6 | A O 5 | A O 4 | A O 3 | A O 2 | A O 1 | A O 0 |
| 3 | A O 15 | A O 14 | A O 13 | A O 12 | A O 11 | A O 10 | A O 9 | A O 8 |
| 4 | B I 7 | B I 6 | B I 5 | B I 4 | B I 3 | B I 2 | B I 1 | B I 0 |
| 5 | B I 15 | B I 14 | B I 13 | B I 12 | B I 11 | B I 10 | B I 9 | B I 8 |
| 6 | B O 3 | B O 2 | B O 1 | B O 0 | B I 19 | B I 18 | B I 17 | B I 16 |
| 7 | B O 11 | B O 10 | B O 9 | B O 8 | B O 7 | B O 6 | B O 5 | B O 4 |
| 8 | B O 19 | B O 18 | B O 17 | B O 16 | B O 15 | B O 14 | B O 13 | B O 12 |
| 9 | C I 7 | C I 6 | C I 5 | C I 4 | C I 3 | C I 2 | C I 1 | C I 0 |
| 10 | C I 15 | C I 14 | C I 13 | C I 12 | C I 11 | C I 10 | C I 9 | C I 8 |
| 11 | C I 23 | C I 22 | C I 21 | C I 20 | C I 19 | C I 18 | C I 17 | C I 16 |
| 12 | C O 7 | C O 6 | C O 5 | C O 4 | C O 3 | C O 2 | C O 1 | C O 0 |
| 13 | C O 15 | C O 14 | C O 13 | C O 12 | C O 11 | C O 10 | C O 9 | C O 8 |
| 14 | C O 23 | C O 22 | C O 21 | C O 20 | C O 19 | C O 18 | C O 17 | C O 16 |
| 15 | D I 7 | D I 6 | D I 5 | D I 4 | D I 3 | D I 2 | D I 1 | D I 0 |
| 16 | D I 15 | D I 14 | D I 13 | D I 12 | D I 11 | D I 10 | D I 9 | D I 8 |
| 17 | D I 23 | D I 22 | D I 21 | D I 20 | D I 19 | D I 18 | D I 17 | D I 16 |
| 18 | D O 3 | D O 2 | D O 1 | D O 0 | D I 27 | D I 26 | D I 25 | D I 24 |
| 19 | D O 11 | D O 10 | D O 9 | D O 8 | D O 7 | D O 6 | D O 5 | D O 4 |
| 20 | D O 19 | D O 18 | D O 17 | D O 16 | D O 15 | D O 14 | D O 13 | D O 12 |
| 21 | D O 27 | D O 26 | D O 25 | D O 24 | D O 23 | D O 22 | D O 21 | D O 20 |
| 22 | E I 7 | E I 6 | E I 5 | E I 4 | E I 3 | E I 2 | E I 1 | E I 0 |
| 23 | E I 15 | E I 14 | E I 13 | E I 12 | E I 11 | E I 10 | E I 9 | E I 8 |
| 24 | E I 23 | E I 22 | E I 21 | E I 20 | E I 19 | E I 18 | E I 17 | E I 16 |
| 25 | E I 31 | E I 30 | E I 29 | E I 28 | E I 27 | E I 26 | E I 25 | E I 24 |
| 26 | E O 7 | E O 6 | E O 5 | E O 4 | E O 3 | E O 2 | E O 1 | E O 0 |
| 27 | E O 15 | E O 14 | E O 13 | E O 12 | E O 11 | E O 10 | E O 9 | E O 8 |
| 28 | E O 23 | E O 22 | E O 21 | E O 20 | E O 19 | E O 18 | E O 17 | E O 16 |
| 29 | E O 31 | E O 30 | E O 29 | E O 28 | E O 27 | E O 26 | E O 25 | E O 24 |
| 30 | F I 7 | F I 6 | F I 5 | F I 4 | F I 3 | F I 2 | F I 1 | F I 0 |
| 31 | F I 15 | F I 14 | F I 13 | F I 12 | F I 11 | F I 10 | F I 9 | F I 8 |
| 32 | F I 23 | F I 22 | F I 21 | F I 20 | F I 19 | F I 18 | F I 17 | F I 16 |
| 33 | F I 31 | F I 30 | F I 29 | F I 28 | F I 27 | F I 26 | F I 25 | F I 24 |
| 34 | F O 3 | F O 2 | F O 1 | F O 0 | F I 35 | F I 34 | F I 33 | F I 32 |
| 35 | F O 11 | F O 10 | F O 9 | F O 8 | F O 7 | F O 6 | F O 5 | F O 4 |
| 36 | F O 19 | F O 18 | F O 17 | F O 16 | F O 15 | F O 14 | F O 13 | F O 12 |
| 37 | F O 27 | F O 26 | F O 25 | F O 24 | F O 23 | F O 22 | F O 21 | F O 20 |
| 38 | F O 35 | F O 34 | F O 33 | F O 32 | F O 31 | F O 30 | F O 29 | F O 28 |
| 39 | G I 7 | G I 6 | G I 5 | G I 4 | G I 3 | G I 2 | G I 1 | G I 0 |
| 40 | G I 15 | G I 14 | G I 13 | G I 12 | G I 11 | G I 10 | G I 9 | G I 8 |
| 41 | G I 23 | G I 22 | G I 21 | G I 20 | G I 19 | G I 18 | G I 17 | G I 16 |
| 42 | G I 31 | G I 30 | G I 29 | G I 28 | G I 27 | G I 26 | G I 25 | G I 24 |
| 43 | G I 39 | G I 38 | G I 37 | G I 36 | G I 35 | G I 34 | G I 33 | G I 32 |
| 44 | G O 7 | G O 6 | G O 5 | G O 4 | G O 3 | G O 2 | G O 1 | G O 0 |
| 45 | G O 15 | G O 14 | G O 13 | G O 12 | G O 11 | G O 10 | G O 9 | G O 8 |
| 46 | G O 23 | G O 22 | G O 21 | G O 20 | G O 19 | G O 18 | G O 17 | G O 16 |
| 47 | G O 31 | G O 30 | G O 29 | G O 28 | G O 27 | G O 26 | G O 25 | G O 24 |
| 48 | G O 39 | G O 38 | G O 37 | G O 36 | G O 35 | G O 34 | G O 33 | G O 32 |
| 49 | H I 7 | H I 6 | H I 5 | H I 4 | H I 3 | H I 2 | H I 1 | H I 0 |
| 50 | H I 15 | H I 14 | H I 13 | H I 12 | H I 11 | H I 10 | H I 9 | H I 8 |
| 51 | H I 23 | H I 22 | H I 21 | H I 20 | H I 19 | H I 18 | H I 17 | H I 16 |
| 52 | H I 31 | H I 30 | H I 29 | H I 28 | H I 27 | H I 26 | H I 25 | H I 24 |
| 53 | H I 39 | H I 38 | H I 37 | H I 36 | H I 35 | H I 34 | H I 33 | H I 32 |
| 54 | H O 3 | H O 2 | H O 1 | H O 0 | H I 43 | H I 42 | H I 41 | H I 40 |
| 55 | H O 11 | H O 10 | H O 9 | H O 8 | H O 7 | H O 6 | H O 5 | H O 4 |
| 56 | H O 19 | H O 18 | H O 17 | H O 16 | H O 15 | H O 14 | H O 13 | H O 12 |
| 57 | H O 27 | H O 26 | H O 25 | H O 24 | H O 23 | H O 22 | H O 21 | H O 20 |
| 58 | H O 35 | H O 34 | H O 33 | H O 32 | H O 31 | H O 30 | H O 29 | H O 28 |
| 59 | H O 43 | H O 42 | H O 41 | H O 40 | H O 39 | H O 38 | H O 37 | H O 36 |

Table 1 - The channel and bit number in the Virtual SVX for the discriminator outputs for the CFT fibers. The layers are doublets A through H with an Inner and Outer singlets.

| **Channel** | | **msb** | | | | | | | **lsb** |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | SAME as from FE to Concentrator | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | | | | | | | | |

Table 2 - Track counts.

| Channel | | msb | | | | | | | lsb |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | SAME as from FE to Concentrator | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | | | | | | | | |
| 12 | | | | | | | | | |
| 13 | | | | | | | | | |
| 14 | | | | | | | | | |
| 15 | | | | | | | | | |
| 16 | | | | | | | | | |
| 17 | | | | | | | | | |
| 18 | | | | | | | | | |
| 19 | | | | | | | | | |
| 20 | | | | | | | | | |
| 21 | | | | | | | | | |
| 22 | | | | | | | | | |
| 23 | | | | | | | | | |
| 24 | | | | | | | | | |
| 25 | | | | | | | | | |
| 26 | | | | | | | | | |
| 27 | | | | | | | | | |
| 28 | | | | | | | | | |
| 29 | | | | | | | | | |
| 30 | | | | | | | | | |
| 31 | | | | | | | | | |
| 32 | | | | | | | | | |
| 33 | | | | | | | | | |
| 34 | | | | | | | | | |
| 35 | | | | | | | | | |
| 36 | | | | | | | | | |
| 37 | | | | | | | | | |
| 38 | | | | | | | | | |
| 39 | | | | | | | | | |
| 40 | | | | | | | | | |
| 41 | | | | | | | | | |
| 42 | | | | | | | | | |
| 43 | | | | | | | | | |
| 44 | | | | | | | | | |
| 45 | | | | | | | | | |
| 46 | | | | | | | | | |
| 47 | | | | | | | | | |

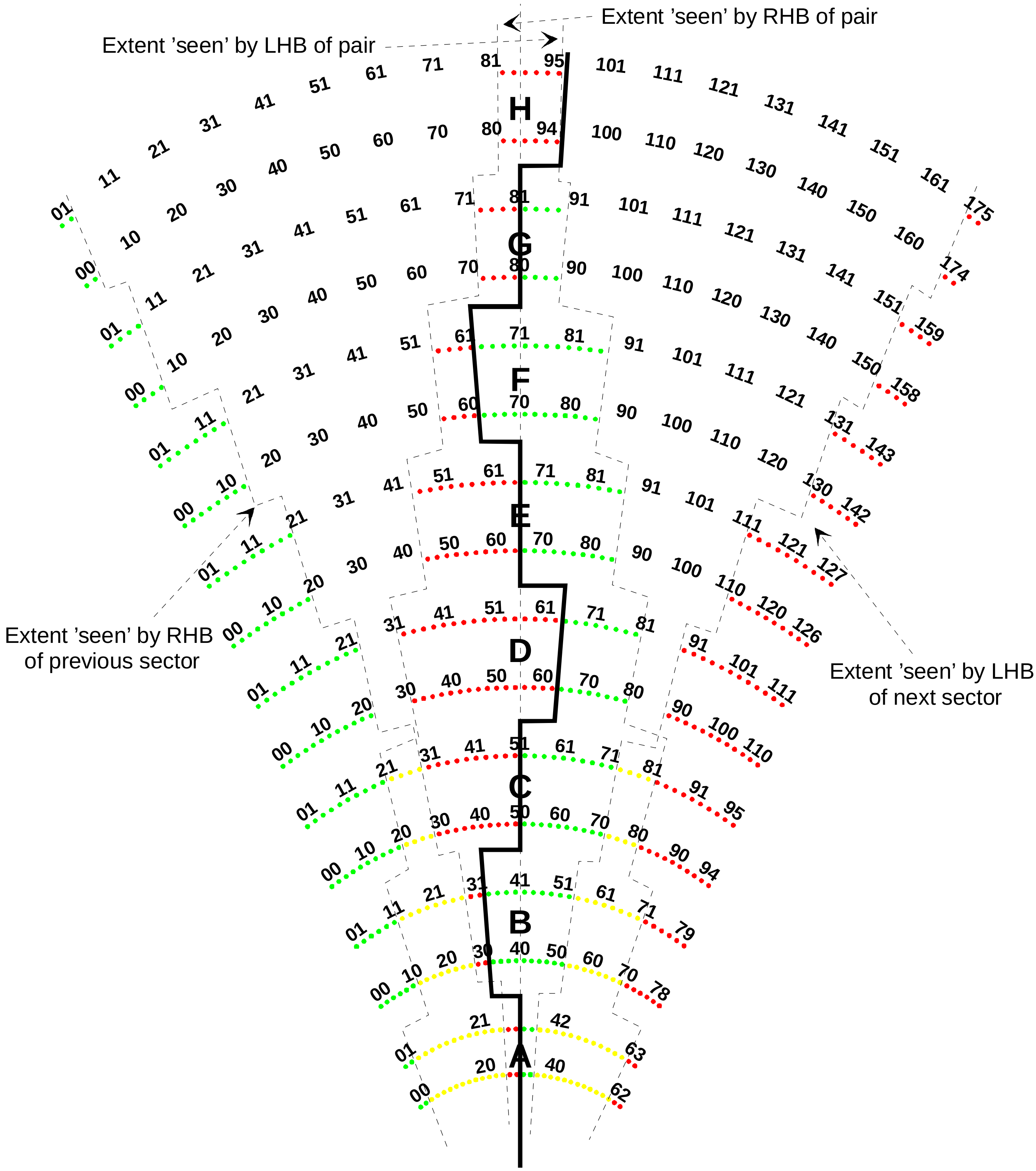
Table 3 - Track lists.

| Channel | msb | | | | | | lsb |
|---|---|---|---|---|---|---|---|
| 0 | NH 7 | NH 6 | NH 5 | NH 4 | NH 3 | NH 2 | NH 1 | NH 0 |
| 1 | NH 15 | NH 14 | NH 13 | NH 12 | NH 11 | NH 10 | NH 9 | NH 8 |
| 2 | SH 7 | SH 6 | SH 5 | SH 4 | SH 3 | SH 2 | SH 1 | SH 0 |
| 3 | SH 15 | SH 14 | SH 13 | SH 12 | SH 11 | SH 10 | SH 9 | SH 8 |
| 4 | NL 7 | NL 6 | NL 5 | NL 4 | NL 3 | NL 2 | NL 1 | NL 0 |
| 5 | NL 15 | NL 14 | NL 13 | NL 12 | NL 11 | NL 10 | NL 9 | NL 8 |
| 6 | SL 7 | SL 6 | SL 5 | SL 4 | SL 3 | SL 2 | SL 1 | SL 0 |
| 7 | SL 15 | SL 14 | SL 13 | SL 12 | SL 11 | SL 10 | SL 9 | SL 8 |

Table 4 - The channel and bit number in the Virtual SVX for the discriminator outputs for the CPS strips. The N/S signifies the N or north end and S or south end of each strip. The H/L signifies the H or high threshold channel discriminator output and the L or low channel output.

| Channel | | msb | | | | | | | lsb |
|---|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | | |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | SAME as from FE to Concentrator | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |

Table 5 - cluster lists.


Extent 'seen' by RHB of pair
Extent 'seen' by LHB of pair
Extent 'seen' by RHB of previous sector
Extent 'seen' by LHB of next sector
H
G
F
E
D
C
B
A