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Level-1 Calorimeter Trigger: Receiver to PPM Patch Panel Specifications

L1Calo Group [1]

1 Introduction

The purpose of this note is to detail the Receiver to PPM patch panel connectivity in a more palatable format than that found in the overall Level-1 Calorimeter Trigger cabling document [1]. Much text and many figures from that document have been re-used here, but all material not of direct relevance has been omitted. If more details of the cable usage, and reasoning behind the connections is needed, that document should be consulted.

The Patch Panels are needed to re-package some of the signals coming from the receiver system [2],[3] and going to the PPM modules [4]. Typically, under-populated cables from the receivers are combined onto fully packed cables to go the the PPMs, or vice versa. They are needed at points where the detector geometry is complex, and the remapping of signals needed could not be performed in the receivers alone. They are intended to be PCBs similar in design to the already prototyped TileCal Patch Panels [5].

2 Receiver to Preprocessor cabling

The analogue receivers can output up to 64 differential signals on 4 cables each containing 16 signal twisted pairs. In a similar way, the PPMs process 64 input signals coming from 4 input cables and, in general, one receiver output cable carries 16 signals to one PPM input. For the majority of the trigger space (360 out of 496 PPM inputs), a simple 1:1 mapping of receiver output to PPM input is sufficient. However there are four regions where special arrangements are required either combining or splitting cables. These are at the inputs of PPM_4, PPM_7 and hadronic PPM_9s, where the PPM numbering is taken from the PPM specification [4]. The repackaging of signals is achieved via the Receiver to PPM

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patch panels. Note that there are similar, but generally not identical, patch panels dealing with the situations at each end of the detector.

In a little more detail, the four regions are:

- PPM_4 (EM): the EM barrel/endcap transition requires that two receiver outputs (of 8 signals) are combined to a single PPM input. There are 8 EM instances of PPM_4 (2 ends * 4 quadrants) making 32 special PPM input cables from 64 receiver outputs, dealt with by 32 identical patch panels.

- PPM_4 (had): the TileCal/HEC transition is more complicated. Here one HEC output cable must be split into four sets of 4 signals and combined with four TileCal receiver outputs (each providing 12 signals) making four PPM inputs. There are 8 hadronic PPM_4s (2 ends * 4 quadrants), making 32 PPM inputs coming from 40 receiver outputs, via 8 similar patch panels.

- PPM_7 (both): here one receiver output of 12 signals is split into two PPM inputs of 6 signals in both EM and hadronic layers, ie 64 special PPM input cables from 32 receiver outputs, using 32 similar patch panels.

- PPM_9 (had): each hadronic FCAL PPM input comes from combining two receiver outputs providing 8 signals each. There are two hadronic PPM_9s in the system, so this represents 8 PPM input cables from 16 receiver outputs, needing 8 identical patch panels.

The situation is sufficiently different at positive and negative eta in the case of PPM_4 hadronic, and PPM_7 that different patch panel designs are required at each end. That means there are a total of 6 patch panel designs needed. The total number of patch panels and cables needed is summarized in table 1, and broken down as a function of patch panel type, which is numbered 1–6.

Type Number	Region	Layer	Side	Patch Panels	Number of Input Cables	Number of Output Cables
1	PPM_4	EM	both	32	64	32
2	PPM_7	both	-ve	16	16	32
3	PPM_7	both	+ve	16	16	32
4	PPM_4	Hadronic	-ve	4	20	16
5	PPM_4	Hadronic	+ve	4	20	16
6	PPM_9	Hadronic	both	8	16	8
Total				80	152	136

Table 1: Receiver to PPM cabling: Numbers of patch panels and connections

3 Analogue Cable Connectors

In order to understand the connectivity of the analogue data at the individual signal level, rather than just cable level, one has to define the connector pin usage for the analogue cables. Standardised cables will be used throughout the receiver to PPM cabling, and these are described below.

There are 16 signals carried on twisted pairs in the standard analogue cables. The connectors at both ends are SUB D 37c connectors (male), which have 37 available pins. The 5 spare pins are used for grounds. For the purposes of this document, the 16 signal pairs are labelled 1–16. This is consistent with the most frequent uses of this label in all the reference documentation. However, in some documents the convention 0–15 is used, so care is needed when comparing with information using this convention. The assignment of pair wires to connector pins is shown in figure 3.

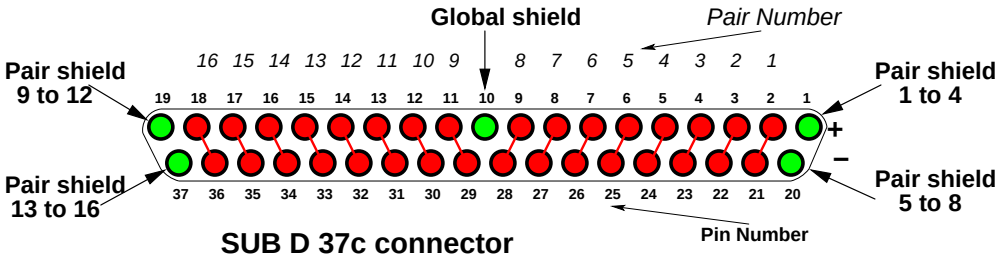

Figure 3: Connector pin usage on standard analogue cable

4 Patch Panels

The six types of patch panels needed have been described previously in the main cabling document [1]. For ease of reference, the specifications given there have been repeated here in Appendix A. However, it requires some effort to use these in conjuction with the cable specifications in figure 3 to determine the correct configuration of the patch panels. Therefore the details are also presented in hopefully more user friendly tables below.

4.1 Type 1: EM barrel/endcap merging

These are simple 2:1 merging patch panels, where each of the two input cables contains 8 signals to be combined onto a single fully packed output cable. They are the same for positive and negative eta, and so are the most common type of patch panel, with 32 needed for the full system. The PCB will consist of a single board with two input connectors at the top, and one output below. These are referred to in table 2 below, from top down, as Input 1, Input 2 and Output A. As detailed in the appendix, the assignment of input cables is:

- at negative eta, Input 1 is endcap, Input 2 is barrel
- at positive eta, Input 1 is barrel, Input 2 is endcap

Input Location			Output Location		
Cable	Signal Number	Pair Number	Cable	Signal Number	Pair Number
Input 1	1	2/21	Output A	1	2/21
Input 1	2	3/22	Output A	2	3/22
Input 1	3	4/23	Output A	3	4/23
Input 1	4	5/24	Output A	4	5/24
Input 2	5	6/25	Output A	5	6/25
Input 2	6	7/26	Output A	6	7/26
Input 2	7	8/27	Output A	7	8/27
Input 2	8	9/28	Output A	8	9/28
Input 2	9	11/29	Output A	9	11/29
Input 2	10	12/30	Output A	10	12/30
Input 2	11	13/31	Output A	11	13/31
Input 2	12	14/32	Output A	12	14/32
Input 1	13	15/33	Output A	13	15/33
Input 1	14	16/34	Output A	14	16/34
Input 1	15	17/35	Output A	15	17/35
Input 1	16	18/36	Output A	16	18/36

Table 2: Patch panel for EM barrel/endcap merging

The wiring splits neatly into four logical bundles of 4 signals, each contained within one grounding group on the input and output cables, so perhaps it might make sense for the populated 4-pair grounds to be wired straight through. However some care should be taken, particularly with the overall cable ground, as the input signals come from distinct barrel and endcap receiver crates, whereas all the

outputs go to PPM barrel modules. The barrel PPM crates will already have many direct cable connections, but the endcap receiver is isolated other than these patch patch connections.

4.2 Type 2: Negative high eta splitting

These are simple 1:2 splitting patch panels, where each of the two output cables contains 8 signals derived from the one fully packed single input cable. This type of patch panel only deals with signals at negative eta, but there are still 16 needed for the full system. The PCB will consist of a single board with one input connector at the top, and two outputs below. These are referred to in table 3 below, from top down, as Input 1, Output A and Output B. Output A corresponds to the low phi output, and Output B is high phi.

Input Location			Output Location		
Cable	Signal Number	Pair Number	Cable	Signal Number	Pair Number
Input 1	1	2/21	Output B	4	5/24
Input 1	2	3/22	Output B	6	7/26
Input 1	3	4/23	Output B	7	8/27
Input 1	4	5/24	Output B	8	9/28
Input 1	5	6/25	Output A	4	5/24
Input 1	6	7/26	Output A	6	7/26
Input 1	7	8/27	Output A	7	8/27
Input 1	8	9/28	Output A	8	9/28
Input 1	9	11/29	Output A	16	18/36
Input 1	10	12/30	Output A	10	12/30
Input 1	11	13/31	Output A	11	13/31
Input 1	12	14/32	Output A	12	14/32
Input 1	13	15/33	Output B	16	18/36
Input 1	14	16/34	Output B	10	12/30
Input 1	15	17/35	Output B	11	13/31
Input 1	16	18/36	Output B	12	14/32

Table 3: Patch panel for negative high eta splitting

Each input grounding bundle of four pairs goes mostly to one output bundle (3 out of 4 pairs) so it might be a good idea to wire these cases straight through. There are no crate to crate issues here, as each patch panel connects an endcap receiver crate to it's equivalent PPM crate, and these are already connected via many other direct cables.

4.3 Type 3: Positive high eta splitting

These are simple 1:2 splitting patch panels, where each of the two output cables contains 8 signals derived from the one fully packed single input cable. This type of patch panel only deals with signals at positive eta, but there are still 16 needed for the full system. The PCB will consist of a single board with one input connector at the top, and two outputs below. These are referred to in table 4 below, from top down, as Input 1, Output A and Output B.

Input Location			Output Location		
Cable	Signal Number	Pair Number	Cable	Signal Number	Pair Number
Input 1	1	2/21	Output A	1	2/21
Input 1	2	3/22	Output A	8	9/28
Input 1	3	4/23	Output A	3	4/23
Input 1	4	5/24	Output A	4	5/24
Input 1	5	6/25	Output B	1	2/21
Input 1	6	7/26	Output B	8	9/28
Input 1	7	8/27	Output B	3	4/23
Input 1	8	9/28	Output B	4	5/24
Input 1	9	11/29	Output B	13	15/33
Input 1	10	12/30	Output B	12	14/32
Input 1	11	13/31	Output B	15	17/35
Input 1	12	14/32	Output B	16	18/36
Input 1	13	15/33	Output A	13	15/33
Input 1	14	16/34	Output A	12	14/32
Input 1	15	17/35	Output A	15	17/35
Input 1	16	18/36	Output A	16	18/36

Table 4: Patch panel for positive high eta splitting

Each input grounding bundle of four pairs goes mostly to one output bundle (3 out of 4 pairs) so it might be a good idea to wire these cases straight through. There are no crate to crate issues here, as each patch panel connects an endcap receiver crate to it's equivalent PPM crate, and these are already connected via many other direct cables.

4.4 Type 4: Hadronic negative eta barrel/endcap merging

These, along with Type 5, are the most complex patch panels in the system, with a requirement to merge signals from 5 input cables onto 4 output cables. This type of patch panel only deals with signals at negative eta, and only 4 are needed in the full system.

Four of the input cables come from the barrel region, and have 12 populated signals, which are packed in the order required for the output cables, the only difference being the lack of 4 necessary signals. The final input cable comes from the endcap region and contains 16 signals which are split up onto the 4 output cables to fill in the empty signals. A possible design for these patch panels can be seen in figure 4.4, where the top horizontal cable inputs correspond to those from the endcap (referred to as Input Cable 5 in the following tables), and the top row of four connectors in each unit are Input Cables 1–4, reading left to right, and the bottom row are Output Cables A–D (again left to right).

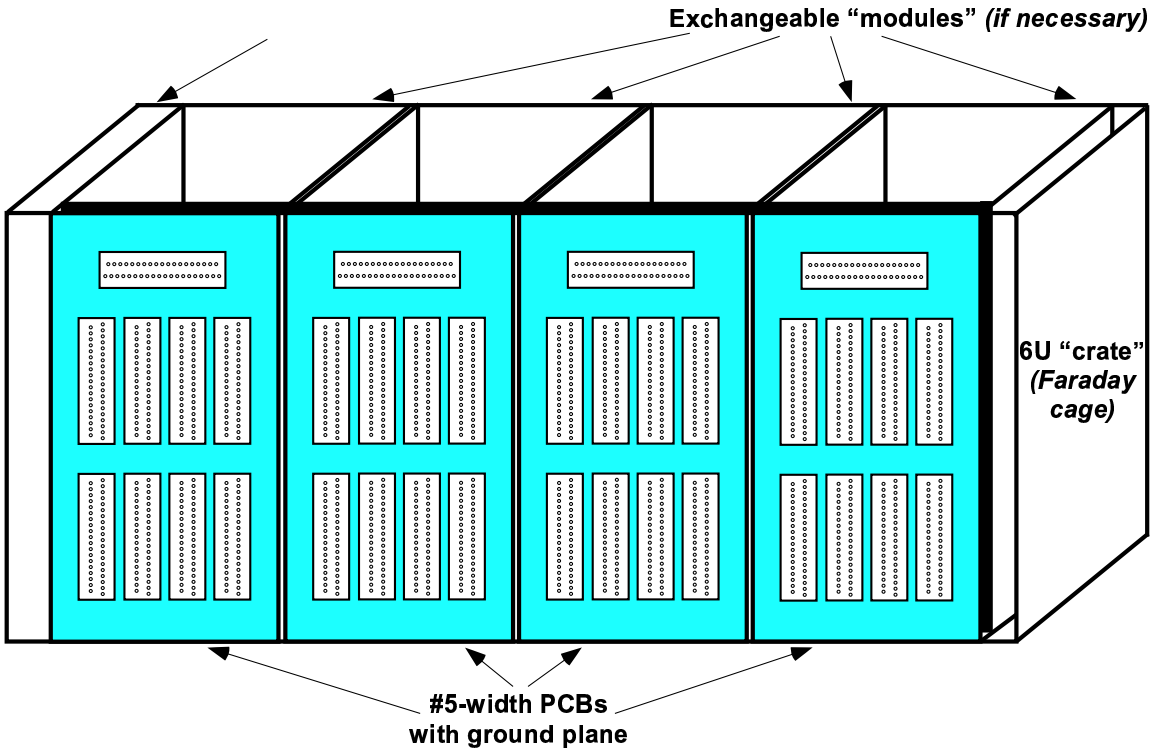

Figure 4.4: Layout of the four 5:4 patch panels required at each end

The connectivity is specified in the two following tables 5 and 6, where each table concentrates on the signal routing needed for two of the four output cables.

Input Location			Output Location		
Cable	Signal Number	Pair Number	Cable	Signal Number	Pair Number
Input 5	4	5/24	Output A	1	2/21
Input 1	2	3/22	Output A	2	3/22
Input 1	3	4/23	Output A	3	4/23
Input 5	3	4/23	Output A	4	5/24
Input 1	5	6/25	Output A	5	6/25
Input 1	6	7/26	Output A	6	7/26
Input 1	7	8/27	Output A	7	8/27
Input 1	8	9/28	Output A	8	9/28
Input 1	9	11/29	Output A	9	11/29
Input 1	10	12/30	Output A	10	12/30
Input 1	11	13/31	Output A	11	13/31
Input 1	12	14/32	Output A	12	14/32
Input 5	2	3/22	Output A	13	15/33
Input 1	14	16/34	Output A	14	16/34
Input 1	15	17/35	Output A	15	17/35
Input 5	1	2/21	Output A	16	18/36
Input 5	8	9/28	Output B	1	2/21
Input 2	2	3/22	Output B	2	3/22
Input 2	3	4/23	Output B	3	4/23
Input 5	7	8/27	Output B	4	5/24
Input 2	5	6/25	Output B	5	6/25
Input 2	6	7/26	Output B	6	7/26
Input 2	7	8/27	Output B	7	8/27
Input 2	8	9/28	Output B	8	9/28
Input 2	9	11/29	Output B	9	11/29
Input 2	10	12/30	Output B	10	12/30
Input 2	11	13/31	Output B	11	13/31
Input 2	12	14/32	Output B	12	14/32
Input 5	6	7/26	Output B	13	15/33
Input 2	14	16/34	Output B	14	16/34
Input 2	15	17/35	Output B	15	17/35
Input 5	5	6/25	Output B	16	18/36

Table 5: Patch panel for hadronic negative eta barrel/endcap merging (A and B)

Input Location			Output Location		
Cable	Signal Number	Pair Number	Cable	Signal Number	Pair Number
Input 5	12	14/32	Output C	1	2/21
Input 3	2	3/22	Output C	2	3/22
Input 3	3	4/23	Output C	3	4/23
Input 5	11	13/31	Output C	4	5/24
Input 3	5	6/25	Output C	5	6/25
Input 3	6	7/26	Output C	6	7/26
Input 3	7	8/27	Output C	7	8/27
Input 3	8	9/28	Output C	8	9/28
Input 3	9	11/29	Output C	9	11/29
Input 3	10	12/30	Output C	10	12/30
Input 3	11	13/31	Output C	11	13/31
Input 3	12	14/32	Output C	12	14/32
Input 5	10	12/30	Output C	13	15/33
Input 3	14	16/34	Output C	14	16/34
Input 3	15	17/35	Output C	15	17/35
Input 5	9	11/29	Output C	16	18/36
Input 5	16	18/36	Output D	1	2/21
Input 4	2	3/22	Output D	2	3/22
Input 4	3	4/23	Output D	3	4/23
Input 5	15	17/35	Output D	4	5/24
Input 4	5	6/25	Output D	5	6/25
Input 4	6	7/26	Output D	6	7/26
Input 4	7	8/27	Output D	7	8/27
Input 4	8	9/28	Output D	8	9/28
Input 4	9	11/29	Output D	9	11/29
Input 4	10	12/30	Output D	10	12/30
Input 4	11	13/31	Output D	11	13/31
Input 4	12	14/32	Output D	12	14/32
Input 5	14	16/34	Output D	13	15/33
Input 4	14	16/34	Output D	14	16/34
Input 4	15	17/35	Output D	15	17/35
Input 5	13	15/33	Output D	16	18/36

Table 6: Patch panel for hadronic negative eta barrel/endcap merging (C and D)

Given the straightforward mapping between input cables 1–4 and output cables A–D, it might be a good idea to take the grounds from these cables straight

through, and just terminate the grounds from input cable 5 in a suitable fashion. This would also make sense from a crate point of view, as these grounds would be connecting each tile receiver crate to its equivalent PPM hadronic barrel crate, which are already connected by direct cables.

4.5 Type 5: Hadronic positive eta barrel/endcap merging

These, along with Type 4, are the most complex patch panels in the system, with a requirement to merge signals from 5 input cables onto 4 output cables. This type of patch panel only deals with signals at positive eta, and only 4 are needed in the full system.

Four of the input cables come from the barrel region, and have 12 populated signals, which are packed in the order required for the output cables, the only difference being the lack of 4 necessary signals. The final input cable comes from the endcap region and contains 16 signals which are split up onto the 4 output cables to fill in the empty signals. The design of these patch panels should be similar to Type 4 described in the previous section.

The connectivity is specified in the two following tables 7 and 8, where each table concentrates on the signal routing needed for two of the four output cables. As in the previous section, cables are referred to as Input 1–5 and Output A–D.

Given the straightforward mapping between input cables 1–4 and output cables A–D, it might be a good idea to take the grounds from these cables straight through, and just terminate the grounds from input cable 5 in a suitable fashion. This would also make sense from a crate point of view, as these grounds would be connecting each tile receiver crate to its equivalent PPM hadronic barrel crate, which are already connected by direct cables.

Input Location			Output Location		
Cable	Signal Number	Pair Number	Cable	Signal Number	Pair Number
Input 1	1	2/21	Output A	1	2/21
Input 1	2	3/22	Output A	2	3/22
Input 1	3	4/23	Output A	3	4/23
Input 1	4	5/24	Output A	4	5/24
Input 1	5	6/25	Output A	5	6/25
Input 5	4	5/24	Output A	6	7/26
Input 5	3	4/23	Output A	7	8/27
Input 1	8	9/28	Output A	8	9/28
Input 1	9	11/29	Output A	9	11/29
Input 5	2	3/22	Output A	10	12/30
Input 5	1	2/21	Output A	11	13/31
Input 1	12	14/32	Output A	12	14/32
Input 1	13	15/33	Output A	13	15/33
Input 1	14	16/34	Output A	14	16/34
Input 1	15	17/35	Output A	15	17/35
Input 1	16	18/36	Output A	16	18/36
Input 2	1	2/21	Output B	1	2/21
Input 2	2	3/22	Output B	2	3/22
Input 2	3	4/23	Output B	3	4/23
Input 2	4	5/24	Output B	4	5/24
Input 2	5	6/25	Output B	5	6/25
Input 5	8	9/28	Output B	6	7/26
Input 5	7	8/27	Output B	7	8/27
Input 2	8	9/28	Output B	8	9/28
Input 2	9	11/29	Output B	9	11/29
Input 5	6	7/26	Output B	10	12/30
Input 5	5	6/25	Output B	11	13/31
Input 2	12	14/32	Output B	12	14/32
Input 2	13	15/33	Output B	13	15/33
Input 2	14	16/34	Output B	14	16/34
Input 2	15	17/35	Output B	15	17/35
Input 2	16	18/36	Output B	16	18/36

Table 7: Patch panel for hadronic positive eta barrel/endcap merging (A and B)

Input Location			Output Location		
Cable	Signal Number	Pair Number	Cable	Signal Number	Pair Number
Input 3	1	2/21	Output C	1	2/21
Input 3	2	3/22	Output C	2	3/22
Input 3	3	4/23	Output C	3	4/23
Input 3	4	5/24	Output C	4	5/24
Input 3	5	6/25	Output C	5	6/25
Input 5	12	14/32	Output C	6	7/26
Input 5	11	13/31	Output C	7	8/27
Input 3	8	9/28	Output C	8	9/28
Input 3	9	11/29	Output C	9	11/29
Input 5	10	12/30	Output C	10	12/30
Input 5	9	11/29	Output C	11	13/31
Input 3	12	14/32	Output C	12	14/32
Input 3	13	15/33	Output C	13	15/33
Input 3	14	16/34	Output C	14	16/34
Input 3	15	17/35	Output C	15	17/35
Input 3	16	18/36	Output C	16	18/36
Input 4	1	2/21	Output D	1	2/21
Input 4	2	3/22	Output D	2	3/22
Input 4	3	4/23	Output D	3	4/23
Input 4	4	5/24	Output D	4	5/24
Input 4	5	6/25	Output D	5	6/25
Input 5	16	18/36	Output D	6	7/26
Input 5	15	17/35	Output D	7	8/27
Input 4	8	9/28	Output D	8	9/28
Input 4	9	11/29	Output D	9	11/29
Input 5	14	16/34	Output D	10	12/30
Input 5	13	15/33	Output D	11	13/31
Input 4	12	14/32	Output D	12	14/32
Input 4	13	15/33	Output D	13	15/33
Input 4	14	16/34	Output D	14	16/34
Input 4	15	17/35	Output D	15	17/35
Input 4	16	18/36	Output D	16	18/36

Table 8: Patch panel for hadronic positive eta barrel/endcap merging (C and D)

4.6 Type 6: FCAL hadronic merging

These are simple 2:1 merging patch panels, where each of the two input cables contains 8 signals to be combined onto a single fully packed output cable. They are the same for positive and negative eta, but only deal with a small amount of FCAL signals, so only 8 are needed for the full system. The PCB will consist of a single board with two input connectors at the top, and one output below. These are referred to in table 9 below, from top down, as Input 1, Input 2 and Output A.

Input Location			Output Location		
Cable	Signal Number	Pair Number	Cable	Signal Number	Pair Number
Input 2	2	3/22	Output A	1	2/21
Input 1	2	3/22	Output A	2	3/22
Input 2	4	5/24	Output A	3	4/23
Input 1	4	5/24	Output A	4	5/24
Input 2	6	7/26	Output A	5	6/25
Input 1	6	7/26	Output A	6	7/26
Input 2	8	9/28	Output A	7	8/27
Input 1	8	9/28	Output A	8	9/28
Input 2	10	12/30	Output A	9	11/29
Input 1	10	12/30	Output A	10	12/30
Input 2	12	14/32	Output A	11	13/31
Input 1	12	14/32	Output A	12	14/32
Input 2	14	16/34	Output A	13	15/33
Input 1	14	16/34	Output A	14	16/34
Input 2	16	18/36	Output A	15	17/35
Input 1	16	18/36	Output A	16	18/36

Table 9: Patch panel for hadronic FCAL merging

The interleaving nature of the signal mapping makes it awkward to suggest a good straight through ground scheme — there's no obvious best choice of direct connection. Perhaps it would be OK in this case just to combine grounds, since the input cables come from adjacent slots in a receiver crate anyway, and that receiver crate is well grounded to the PPM destination by many other direct cable connections.

A Patch Panel specifications

This appendix contains the full specifications for the connectivity of all the patch panels required as documented in the full cabling document [1]. The main feature of each figure is a table showing the mapping from input cable/pin numbers to output cable/pin numbers. All the patch panels are passive and simply provide a repackaging of the signals. In all cases the input and output cables consist of 16 twisted pair signals, which are labelled as running from 1 to 16. The input pin numbers form the x–axis, and the cable number the y–axis, and the contents show the output pin number in the format Xnn (X can be A–D for the output connector). Output cables are also indicated by shading with the convention illustrated in figure A.

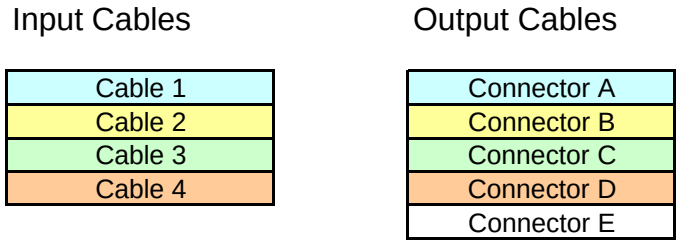

Figure A: Colouring key for patch-panel tables.

The number of input and output cables varies between patch panels. The majority are of a relatively simple 2:1 merging or 1:2 sparsification topology. The most complex region is the Tile to HEC merging, which has 5 input cables merged to produce 4 outputs.

After the table comes a summary of the names of the actual input and output cables involved in each type of patch panel, and some information about their multiplicity. To understand these labels, see [1]. Note that the designs in figures A.1 and A.2 are actually identical, and so only one type of patch panel is needed. The two specifications are separated for historical reasons.

EM negative eta barrel/endcap merging

Input Cables	Signal Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Cable 1	A01	A02	A03	A04									A13	A14	A15	A16
	Cable 2					A05	A06	A07	A08	A09	A10	A11	A12				

Input Cable 1: Ex4e
Input Cable 2: Ex4b

Output Cable A: Ex4 x = 0-F (ie four needed per quadrant)

Figure A.1: Patch panel type 1 for receiver outputs for PPM_4 electromagnetic at negative eta

EM positive eta barrel/endcap merging

Input Cables	Signal Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Cable 1	A01	A02	A03	A04									A13	A14	A15	A16
	Cable 2					A05	A06	A07	A08	A09	A10	A11	A12				

Input Cable 1: ExBb
Input Cable 2: ExBe

Output Cable A: ExB x = 0-F (ie four needed per quadrant)

Figure A.2: Patch panel type 1 for receiver outputs for PPM_4 electromagnetic at positive eta

EM/Hadronic negative eta endcap sparsification

Input	Signal Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Cable 1	B04	B06	B07	B08	A04	A06	A07	A08	A16	A10	A11	A12	B16	B10	B11	B12

Electromagnetic -Z rack

Input Cable 1: Ex1o

Output Cable A: Ex1
Output Cable B: E(x+1)1 x = 0, 2, 4, 6, 8, A, C, E (ie two needed per quadrant)

Hadronic -Z rack

Input Cable 1: Hx1o

Output Cable A: Hx1
Output Cable B: H(x+1)1 x = 0, 2, 4, 6, 8, A, C, E (ie two needed per quadrant)

Figure A.3: Patch panel type 2 for receiver outputs for PPM_7 at negative eta

EM/Hadronic positive eta endcap sparsification

Input	Signal Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Cable 1	A01	A08	A03	A04	B01	B08	B03	B04	B13	B12	B15	B16	A13	A12	A15	A16

Electromagnetic +Z rack

Input Cable 1: ExEo

Output Cable A: ExE
Output Cable B: E(x+1)E x = 0, 2, 4, 6, 8, A, C, E (ie two needed per quadrant)

Hadronic +Z rack

Input Cable 1: HxEo

Output Cable A: HxE
Output Cable B: H(x+1)E x = 0, 2, 4, 6, 8, A, C, E (ie two needed per quadrant)

Figure A.4: Patch panel type 3 for receiver outputs for PPM_7 at positive eta

Hadronic negative eta tile/endcap merging

Input Cables	Signal Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Cable 1		A02	A03		A05	A06	A07	A08	A09	A10	A11	A12		A14	A15	
	Cable 2		B02	B03		B05	B06	B07	B08	B09	B10	B11	B12		B14	B15	
	Cable 3		C02	C03		C05	C06	C07	C08	C09	C10	C11	C12		C14	C15	
	Cable 4		D02	D03		D05	D06	D07	D08	D09	D10	D11	D12		D14	D15	
	Cable 5	A16	A13	A04	A01	B16	B13	B04	B01	C16	C13	C04	C01	D16	D13	D04	D01

Input Cable 1:	H04b	or	H44b	or	H84b	or	HC4b
Input Cable 2:	H14b	or	H54b	or	H94b	or	HD4b
Input Cable 3:	H24b	or	H64b	or	HA4b	or	HE4b
Input Cable 4:	H34b	or	H74b	or	HB4b	or	HF4b
Input Cable 5:	H04e	or	H44e	or	H84e	or	HC4e
Output Cable A:	H04	or	H44	or	H84	or	HC4
Output Cable B:	H14	or	H54	or	H94	or	HD4
Output Cable C:	H24	or	H64	or	HA4	or	HE4
Output Cable D:	H34	or	H74	or	HB4	or	HF4

Figure A.5: Patch panel type 4 for receiver outputs for PPM_4 hadronic at negative eta

Hadronic positive eta tile/endcap merging

Input Cables	Signal Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Cable 1	A01	A02	A03	A04	A05			A08	A09			A12	A13	A14	A15	A16
	Cable 2	B01	B02	B03	B04	B05			B08	B09			B12	B13	B14	B15	B16
	Cable 3	C01	C02	C03	C04	C05			C08	C09			C12	C13	C14	C15	C16
	Cable 4	D01	D02	D03	D04	D05			D08	D09			D12	D13	D14	D15	D16
	Cable 5	A11	A10	A07	A06	B11	B10	B07	B06	C11	C10	C07	C06	D11	D10	D07	D06

Input Cable 1:	H0Bb	or	H4Bb	or	H8Bb	or	HCBb	
Input Cable 2:	H1Bb	or	H5Bb	or	H9Bb	or	HDBb	
Input Cable 3:	H2Bb	or	H6Bb	or	HABb	or	HEBb	
Input Cable 4:	H3Bb	or	H7Bb	or	HBBb	or	HFBb	
Input Cable 5:	H0Be	or	H4Be	or	H8Be	or	HCBe	
Output Cable A:	H0B	or	H4B	or	H8B	or	HCB	
Output Cable B:	H1B	or	H5B	or	H9B	or	HDB	
Output Cable C:	H2B	or	H6B	or	HAB	or	HEB	
Output Cable D:	H3B	or	H7B	or	HBB	or	HFB	

Figure A.6: Patch panel type 5 for receiver outputs for PPM_4 hadronic at positive eta

FCAL hadronic merging (both ends)

Input Cables	Signal Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Cable 1		A02		A04		A06		A08		A10		A12		A14		A16
	Cable 2		A01		A03		A05		A07		A09		A11		A13		A15

Input Cable 1:	HnGx	or	HnZx	
Input Cable 2:	HnGy	or	HnZy	
Output Cable A:	HnG	or	HnZ	n = 0, 4, 8, C

Figure A.7: Patch panel type 6 for receiver outputs for PPM_9 hadronic at both ends

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