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Connections in the L0 Calorimeter trigger

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Abstract

This note summarizes the specification of the interfaces and connections between various components of the L0 Calorimeter system.

1. Global description

The connection between cards is a very important ingredient of the L0 Calorimeter trigger. During the design phase, one of the main concerns has been to minimize the number of external connections, as every connection is a possible source of operational problems, bad contacts, wrong cabling and transmission errors.

In a first step, the information available on the FE cards is condensed, to select only the highest 2x2 sum. This requires access to the neighbouring cells. Most of the connections are via dedicated lines on the backplane, while the so called vertical connections are via dedicated RJ45 connectors and Cat6 cables. This applies both to the Calo FE card and to the PreShower FE card. Note that the "Calo FE" card is used both for ECAL readout and for HCAL readout. The results from the ECAL and HCAL front-end cards are sent to different location:

- to the Trigger Validation Board via the backplane, and to the PreShower card via Cat6 cables for ECAL.
- to the ECAL Trigger Validation Board via Cat6 cables for HCAL.

The results from the PreShower FE card are sent to the ECAL Trigger Validation Board via dedicated RJ45 cables. As we use the same backplane for ECAL, HCAL and PreShower crates, the function of the same output pins may be different. A detailed description is given in [1]. The list and type of connections are listed in Figure 1.

The Trigger Validation Board receives inputs from up to 8 ECAL FE cards via the backplane, from the same number of PreShower cards via Cat6 RJ45 cables[1], and from up to 4 HCAL cards via Cat6 RJ45 cables. Its output is via optical connections towards the Selection cards.

The SPD control board has also some trigger function, it receives input from 8 PreShower cards by the backplane, and sends its single output optically to a Selection card.

Finally, the Selection card receives up to 28 optical inputs, and produces one optical output to the L0DU, plus output to the TELL1 board for readout, and some interconnection for the HCAL dedicated cards.

In this note we will review the various connections, with as much technical details as possible.

1.1. Naming

The data processed by the trigger is the transverse energy, usually called E_T. The Calo front-end card produces a candidate, the one with the highest E_T of the card, as computed on the 2x2 sums. This is named **E_Highest**. The card produces also the sum of the transverse energies of the 32 cells, this is called **E_Sum**. After the Trigger Validation Board, the 8 bit information is named $\mathbf{E_T}$ as this is now one or the other, depending on the type of data, usually E_Highest but in fact E_Sum for local π^0.

[1] In fact the Trigger Validation Boards receives 8 informations, but they usually come from only 4 PreShower cards, as the PreShower cards are handling 64 channels per card, twice as much as ECAL cards.

	16 FE Preshower	16 FE Ecal	16 FE Hcal	2 Validation Ecal	2 SPD Multiplicity	1 CROC
1	8x2 Top neighbours Ser,Diff,EP2P : 8 1 RJ45	4x8 Bot neighbours Ser,Diff,Ep2P : 16 2 RJ45	4x8 Bot neighbours Ser,Diff,Ep2P : 16 2 RJ45			
2	8x2 Bot neighbours Ser,Diff,EP2P : 8 1 RJ45					
3	2x(8Bx+5Add+4Spd+4Ps) Ser,Diff,EP2P : 16 -> Valid Ecal 2 RJ45	4x8 Top neighbours Ser,Diff,Ep2P : 16 2 RJ45	4x8 Top neighbours Ser,Diff,Ep2P : 16 2 RJ45	8 x(8BXlD+5Add+4Spd+4Prs) Ser,Diff,EP2P: 64 <- FE PS 8 RJ45		
4	9x2b R.Side neighbours IP2P : 18	9x8 R.Side neighbours IP2P : 72	9x8 R.Side neighbours IP2P : 72			
5	9x2b L.Side neighbours IP2P : 18	9x8 L.Side neighbours IP2P : 72	9x8 L.Side neighbours IP2P : 72			
6	(1+10+10) Readout Ser,Diff,IP2P : 8 -> Croc	(1+8+12) Readout Ser,Diff,IP2P: 8 -> Croc	(1+8+12) Readout Ser,Diff,IP2P : 8 -> Croc			16x(21b) Readout Ser,Diff,IP2P: 128 <- FE
7	8Bx+6Fixed+7Mult Ser,Diff,IP2P : 8 -> SPD Mult.	8Esum+5Add+8Et Ser,Diff, IP2P : 8 ->Valid Ecal		8x (8Esum+5Add+8Et) Ser,Diff,IP2P 64 <- FE Ecal	8x(8Bx+6Fixed+7Mult) Ser,Diff,IP2P : 64 <- FE PS	
8	2[8Bx+5Add+8Et] Ser,Diff,EP2P : 16 <-Ecal 2 RJ45	8Bx+5Add+8Et Ser,Diff,EP2P : 8 -> FE PS 1RJ45	2(8Bx+5Add+8Et) Ser,Diff,Ep2p: 16 ->Valid Ecal 2 RJ45	4 (8BXlD+5Add+8Et) Ser,Diff,EP2P 32 <- FE Hcal 4RJ45		
9	64 SPD+Clk Diff EP2P <-SPD Z-PACK 2 mm Hard Metric 14 pairs					

Ser : Serial LVDS data
Diff : Differential LVDS signals
EP2P : External point to point links via cables
IP2P : Internal point to point links via backplane

: to xxxx
: from xxxx

Output
Input

name and number of bit
type of link
source/destination

xxxxx xxxx
xxxxx
xxx xxxx

number of pins
connector

Version 24/01/07

Figure 1 : List and type of the backplane connections

1.2. Numbering

The general Calorimeter numbering scheme has been already described [2]. Each cell is identified by its area (outer, middle and inner), its row and column. The column number increases with *x*, the row number with *y*. The natural order is to have the data ordered by cell number, which means sorted by area, by increasing row number in the area, and by increasing column number in each row.

1.3. LVDS multiplexed links

The L0 Calorimeter trigger uses LVDS multiplexed links in several locations. All these links are point-to-point links. A 21:3 multiplexer converts a 21 bit word into 3 pairs, and an extra pair transmits the multiplexing clock, so that 4 pairs at 280 MHz are used to transport 21 bits at 40 MHz. The serializer chip DS90CR215 and the de-serializer DS90CR216 are used, both qualified for use in a radiation area like the Calorimeter platform. A 100 Ohm resistor adapts the link in differential at the receiver end.

2. Calo Front-end card

The Calo FE card has connections to neighbouring cards and cards in other crates for neighbour access, to the PreShower FE card (ECAL cards) or, using the same connector, to the Trigger Validation Board for HCAL cards, to the Trigger Validation Board via the backplane for ECAL cards. It should be noted that, even if the connections are made via a cable, the connectors are all on the backplane. The front panel of the Calo FE card receives the analogue signals from the 32 PMT.

A global view of the connections is shown in Figure 2. The number of connection pins is indicated, together with the total number of used pins for each slot.

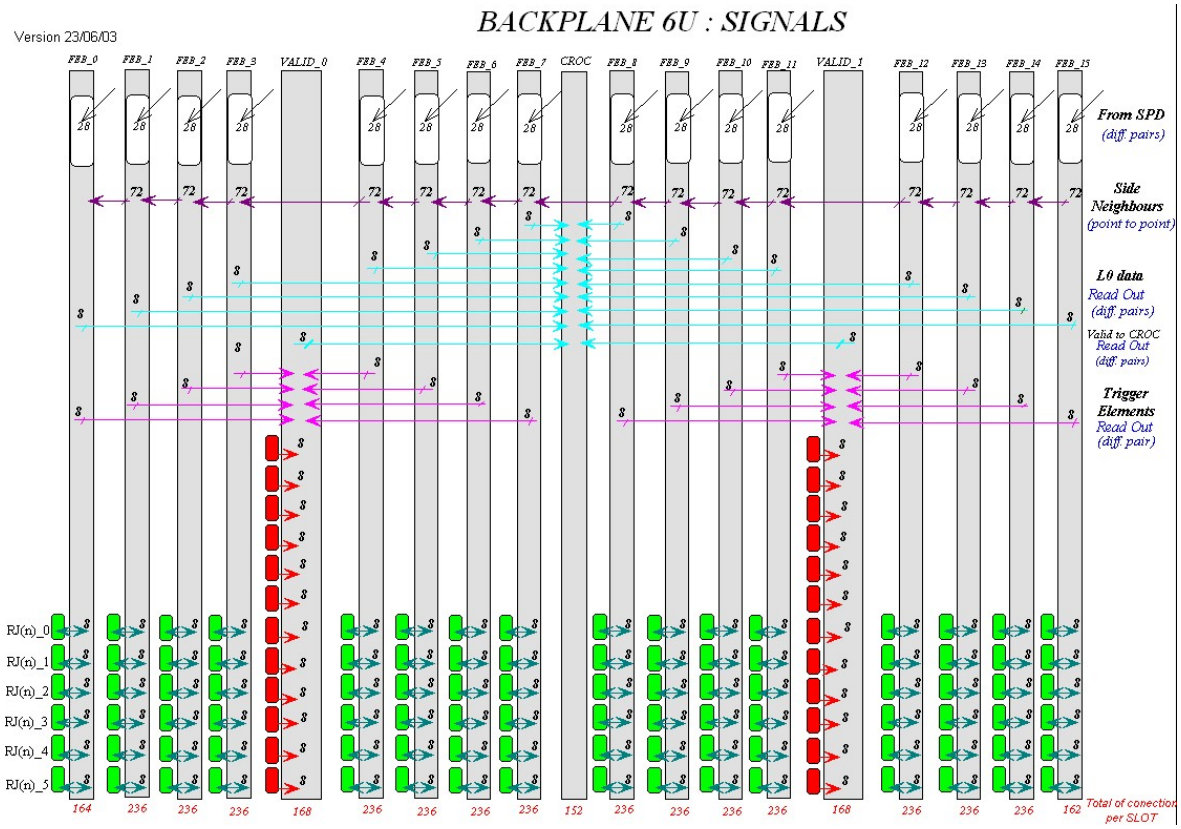

Figure 2 : Global view of the backplane connections

2.1. Service backplane

The Calorimeter crate, the same for ECAL, HCAL and PreShower, has two backplanes [1]. A 3U backplane distributes the power, the TTC signals (clock and Channel B broadcast) and the ECS, as the SPECS bus is distributed also on the 3U backplane. The Calorimeter and the PreShower front-end cards, the Trigger Validation Board and the SPD multiplicity cards are using this backplane. Power settings are however different between PRS crates and ECAL/HCAL crates. The 5V pins used by the CROC and the Front End boards in the ECAL/HCAL Crates are set to 3.3V in the PRS crate and spare pins are set to 5V in the PRS crate to be used by the CROC.

2.2. Neighbours in the same crate: “horizontal neighbours”

This connection uses backplane dedicated, point to point lines. There are 9 words of 8 bits = 72 pins used for this connection. In fact, one needs twice this number, as each slot has 72 incoming lines and 72 outgoing lines. Their location on the connectors is shown on Figure 3 and specified a bit more on Figure 4. The first cell uses lines 0-7, the second the lines 8-15 and so on. The lowest order bit is on line 0. The technology is LVTTL with a 15 Ohm resistance in series at the source. One should remark that the pin assignment is a pure internal convention, as the sender and the receiver cards are both Calorimeter front-end cards. The only important point is that the pin ‘n’ of the sending side is connected by the backplane to pin ‘n’ of the receiving side of the previous slot in the crate.

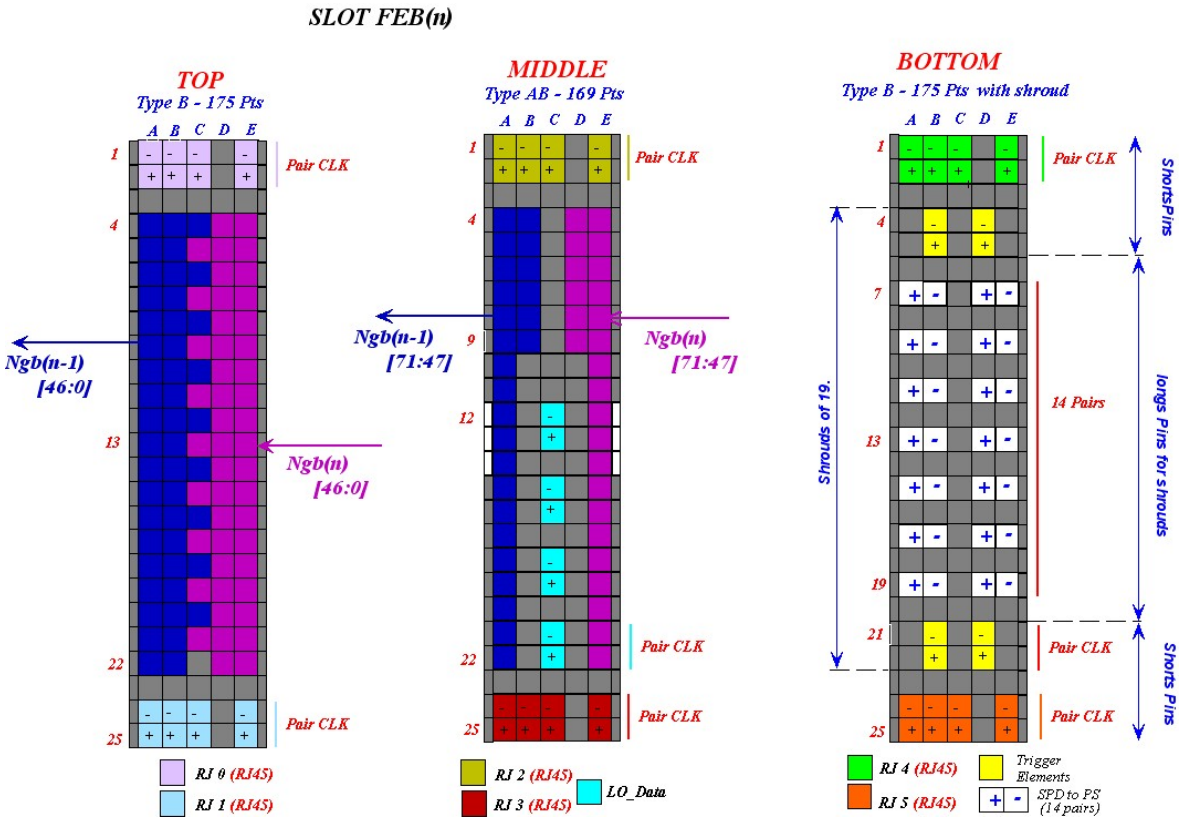

Figure 3 : Connection assignment on the 3 connectors, FE slot.

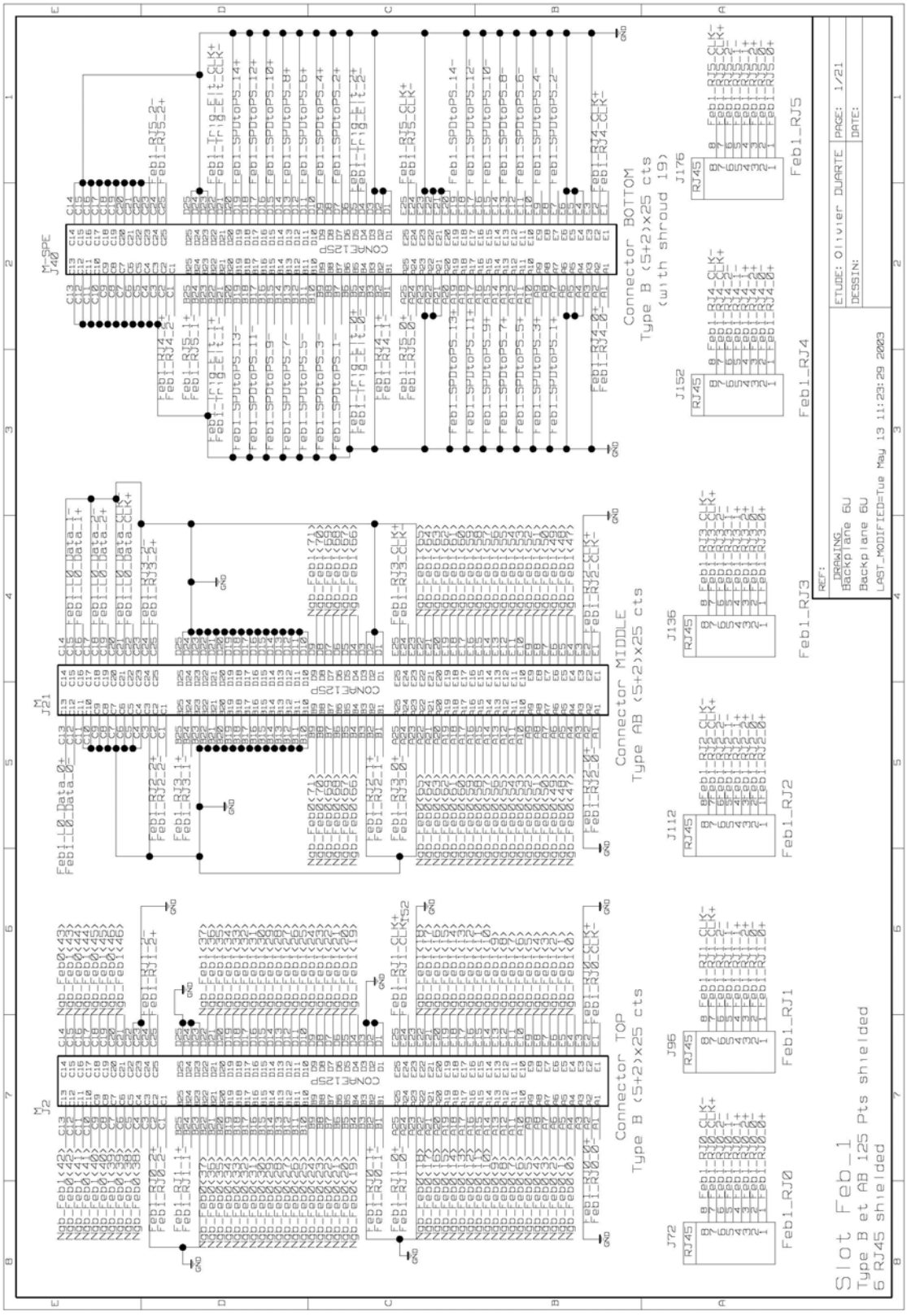

Figure 4 : Functional assignment of the connector for the Calorimeter FE board.

2.3. Neighbours in other crates: “vertical neighbours”

The connection between non-adjacent cards is performed using serialized links, with 4 pairs of differential signals (3 data and one clock) at 280 MHz as the ratio of serialisation is 7 to 1. Two RJ45 connectors are used for incoming signals, labelled RJ2 and RJ3 in Figure 3, and two other for outgoing signals, labelled RJ0 and RJ1 on the same figure. Each RJ45 connector transports 16 bits of data, twice 8 bits, and the connector assignment is given on Figure 5.

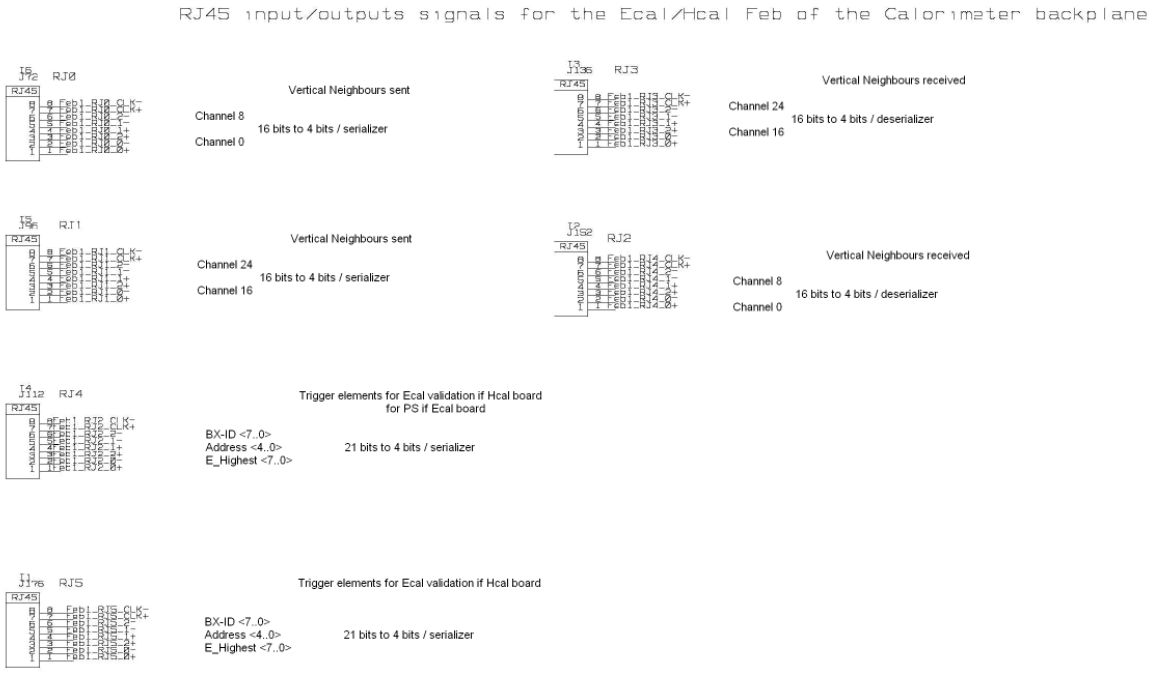

Figure 5 : RJ45 functional assignment for Calo FE board.

2.4. Connection to the Trigger Validation Board

The result of the Calo FE processing is 21 bits wide. This is 8 bits for E_Sum, 5 bits internal address of the highest cluster, and 8 bits for the E_Highest. The format is the following

[20:13] E_Sum (8b)	[12:8] Address (5b) X2 X1 X0 Y1 Y0	[7:0] E_Highest (8b)

The data is sent on the backplane via multiplexed LVDS links implemented on the backplane.

2.5. Connection to the PreShower (ECAL) or Validation (HCAL)

The same connectors RJ4 and RJ5 are used, in the case of ECAL cards to send the candidate to the PreShower front-end card (only RJ4 is used), in the case of HCAL to send the candidate to the Trigger Validation Board. The information is similar to the previous one, except that the E_Sum is replaced by a BX-ID on 8 bits, as the information needs to be re-synchronised when transported to a different crate with different internal timing. This is again LVDS multiplexed levels on an RJ45 connector. In fact, there are two identical RJ45 connectors, with exactly the same signal, as several HCAL cards send their result to two Trigger Validation Boards, as indicated on Figure 5.

[20:13] BX-ID (8b)	[12:8] Address (5b) X2 X1 X0 Y1 Y0	[7:0] E_Highest (8b)

The address identifies a cell inside the card. Each card has 32 channels, organized as 4 rows of 8 columns, numbered as indicated in section 1.2. The position in the calorimeter numbering system of the 32 channels is indicated below. The x coordinates increases along the X axis, from left to right as seen from the Muon looking towards the interaction point, the y coordinate increases along the Y axis, from bottom to top.

3	7	11	15	19	23	27	31
2	6	10	14	18	22	26	30
1	5	9	13	17	21	25	29
0	4	8	12	16	20	24	28

Input channel numbering scheme

24	25	26	27	28	29	30	31
16	17	18	19	20	21	22	23
8	9	10	11	12	13	14	15
0	1	2	3	4	5	6	7

Cell readout order

Due to these two numbering schemes, a mistake was made in programming the Trigger FPGA of the ECAL/HCAL calorimeter front-end cards, and the address sent is the ‘input channel’ and not the ‘cell readout order’ as it should. The address sent has the 5 bits as ‘X2 X1 X0 Y1 Y0’ and it is converted to the official cell number ‘Y1 Y0 X2 X1 X0’ at the entrance of the PreShower front-end card and at the entrance of the Trigger Validation Board.

During the certification procedure of the ECAL and HCAL front-end boards, the transmission of only 7 bits out of the 8 bits of the BX-ID counter sent by the board, could be tested, and only 7 bits are used in the boards receiving this information.

2.6. Output to the CROC

The card has also a LVDS multiplexed link to the CROC, using another point-to-point connection on the backplane. The content of the data transferred on this link is being reviewed. The information for each channel is fixed, only header and possible trailer are being re-discussed. For each of the 32 channels, one will get the 12 bit ADC value, and the 8 bit E_T value used for the trigger computation.

3. PreShower Front-End card

The card has very similar connection for what concerns the trigger. In fact it is placed in an identical crate, using the very same backplanes as described in sections 2 and 2.1. The main difference is that the neighbour information is smaller: From the 9 “horizontal” neighbours, only 2 bits are received (PreShower and SPD trigger bits) instead of 8 for ECAL. For the vertical neighbours, the change is smaller as there are 8 vertical neighbours, but only 16 bits are transported, using a single RJ45 connector with multiplexed LVDS levels. The connections of the card are listed in Table 1.

Name	Format	Physical interface	Remarks
Front panel			
PS VFE – analogue input	64 analogue channels	64 pairs on 16 Cat5+ RJ45 connectors	
PS VFE – clock output	2 analogue channels	2 pairs on one Cat5+ RJ45 connector	Same connector Pairs 2 and 4
PS VFE – reset output	1 analogue	1 pair on one Cat5+ RJ45 connector	
Backplane			
SPD – input data Figure 1 row 9	64 bits + 1 ?	Serial LVDS 21 :3	3x4 pairs + 2 pairs
ECAL – input 1 (Right part, not used for half boards) Figure 1 row 8/1	See section 2.5	Serial LVDS 21 :3 Cable on RJ4	Two independent inputs from two ECAL cards
ECAL – input 2 (Left part) Figure 1 row 8/2		Serial LVDS 21 :3 Cable on RJ5	
VALID – SPD multiplicity output Figure 1 row 7	See section 3.3	Serial LVDS 21 :3 On the backplane	Bus 4 pairs
CROC – DAQ output Figure 1 row 6	21 bits	Serial LVDS 21 :3 Bus on the backplane	Bus 4 pairs
PS – neighbour input top Figure 1 row 1	8b (ps) + 8b (spd)	Serial LVDS 21 :3 Cable on RJ0	5 unused bits
PS – neighbour output bottom Figure 1 row 2	8b (ps) + 8b (spd)	Serial LVDS 21 :3 Cable on RJ1	5 unused bits
PS – neighbour input right Figure 1 row 5	8+1b (ps) + 8+1b (spd)	CMOS + R series 18 wires	54 unused wires
PS – neighbour output left Figure 1 row 4	8+1b (ps) + 8+1b (spd)	CMOS + R series 18 wires	54 unused wires
VALID – Trigger output data 1 (Right part, not used for half boards) Figure 1 row 3/1	See section 3.2	Serial LVDS 21 :3 Cable on RJ2	2 independent outputs
VALID – Trigger output data 2 (Left part) Figure 1 row 3/2		Serial LVDS 21 :3 Cable on RJ3	

Table 1 : List of connections for the PreShower front-end card

3.1. Inputs from ECAL

Two RJ45 connectors are used to receive the ECAL candidates, as one PreShower card handles TWO ECAL cards. The format of the data is described in section 2.5.

3.2. Output to the Trigger Validation Board

Two other RJ45 connectors are used to send the result of the trigger processing to the ECAL Trigger Validation Board, again using multiplexed LVDS levels. The format of the 21 bits word is the following:

Field	BX	ADD Y1 Y0 X2 X1 X0	SPD T C R cell	PS T C R cell
#bit inside field	7…0	4 3 2 1 0	3 2 1 0	3 2 1 0
#bit inside word	[20:13]	[12:8]	[7:4]	[3:0]

Where T, C, R, Cell denote respectively the Top (x'+1,y'), corner (x'+1,y'+1), right (x',y'+1) neighbours of the considered "Cell" (x',y').

3.3. Output to the SPD Multiplicity card

Using the same backplane lines described in section 2.4, the total SPD multiplicity is send to the SPD multiplicity card. The data are multiplexed LVDS levels, and the content is only 7 bits, counting from 0 to 64, right adjusted.

Field	BX	Fixed pattern = 101010	MULT
#bit inside field	7…0	5 … 0	6…0
#bit inside word	[20:13]	[12:7]	[6:0]

3.4. Output to the CROC

The card has also a LVDS multiplexed link to the CROC, using another point-to-point connection on the backplane. The content of the data transferred on this link is being reviewed. The information for each channel is fixed, only header and possible trailer are being re-discussed. For each of the 64 channels, one will get the 10 bit ADC value compressed to 8 bits, and both trigger bits, the SPD and the PreShower ones. Two consecutive channels are packed into a 20 bits word, completed by a parity bit, and the data block has then the same size as the one of the Calorimeter front-end card.

4. Trigger Validation Board

The Trigger Validation Board receives input from ECAL front-end cards, from the corresponding PreShower cards and from HCAL. The link between the ECAL card and the Trigger Validation Board is implemented on the backplane, while the two other links use external Cat6 cables connected on the backplane. The connectors are described on Figure 6. ECS and TTC are available on the 3U backplane.

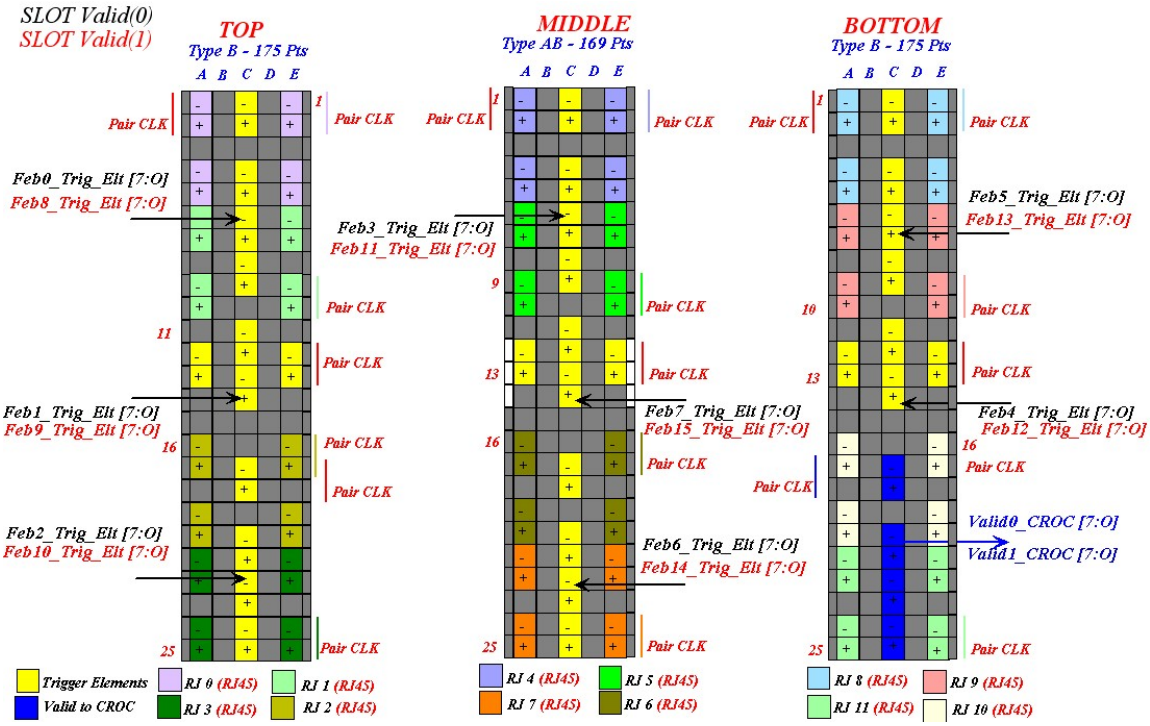

Figure 6 : Connectors on the Validation slot

There are 12 RJ45, 4 on each of the three connectors. They contain the 8 PreShower inputs, and the four HCAL inputs, as described in Table 2. The 8 FE boards from the same crate are connected, 3 on the top connector, 3 on the middle one and 2 on the bottom one, as indicated on the figure, leaving space for a connection to the CROC, in case we would like, in an upgrade, to readout an upgraded Trigger Validation Board on an event by event basis.

Table 2 : Correspondence between connector number and function

Top connector	
RJ0	PS_SPD7
RJ1	PS_SPD6
RJ2	PS_SPD5
RJ3	PS_SPD4

Middle connector	
RJ4	PS_SPD3
RJ5	PS_SPD2
RJ6	PS_SPD1
RJ7	PS_SPD0

Bottom connector	
RJ8	HCAL3
RJ9	HCAL2
RJ10	HCAL1
RJ11	HCAL0

Another view of these connectors is given in Figure 7 with the name of each signal.

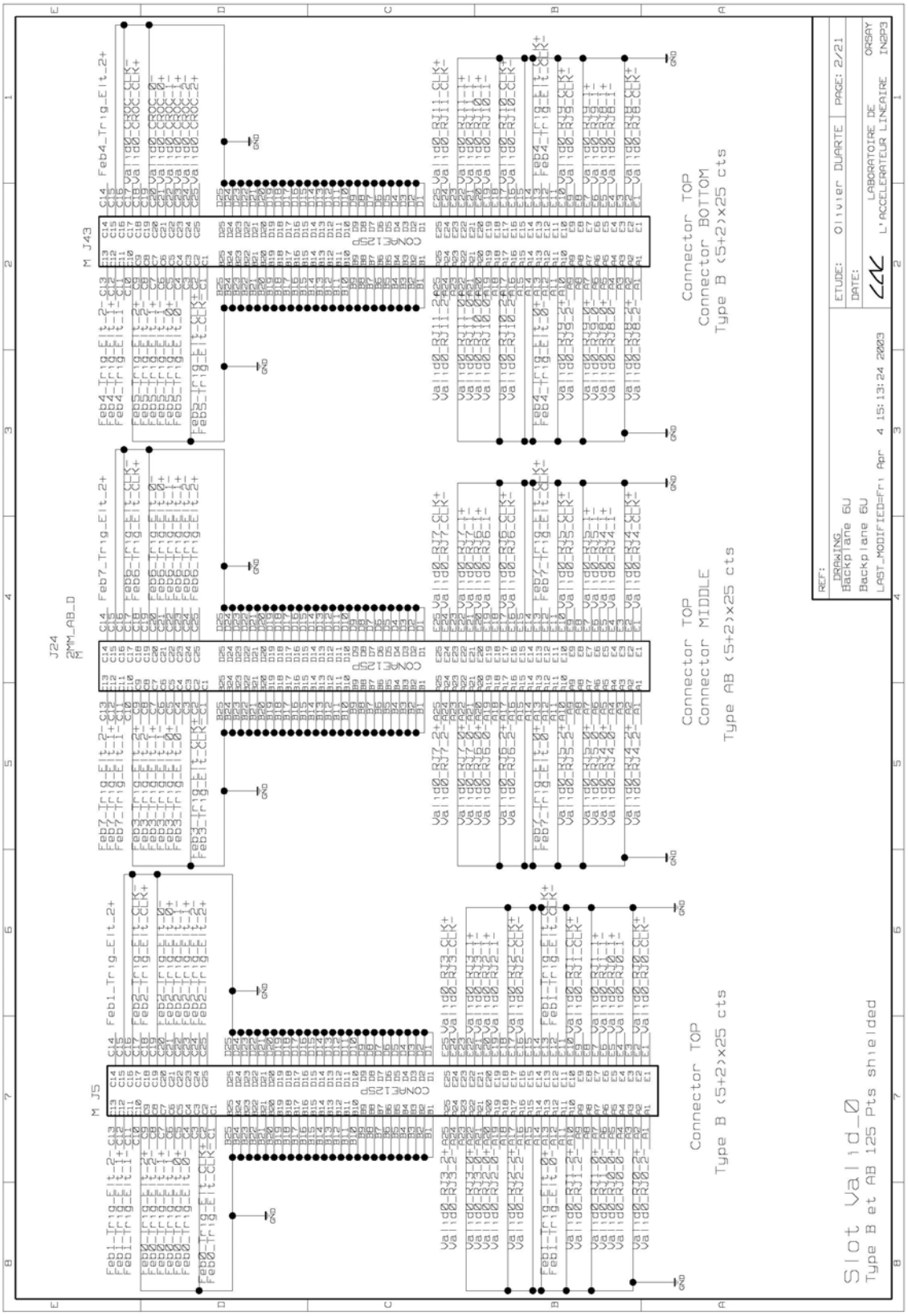

Figure 7 : Pin assignment on the Trigger Validation Board slot.

4.1. From ECAL cards

The link is a multiplexed LVDS link and is described in section 2.4.

4.2. From PreShower card

The link is a multiplexed LVDS link and is described in section 3.2.

4.3. From HCAL cards

The link is a multiplexed LVDS link and is described in section 2.5.

4.4. Output links

The Trigger Validation Board has 8 outputs, 4 for the various types of ECAL candidates, and 4 for the updated HCAL candidates. They are optical links, as the data is sent to the counting room. The words are now 32 bits wide, made of two 16-bit words and contain the following information:

First 16b word	[15:9] BX-ID (7b)		[8:1] E_T (8b)	[0:0] '0'
Second 16b word	[15:13] Type (3b)	[12:9] number (4b)	[8:1] Address (8b)	[0:0] '1'

The 'Type' field indicates the type of information: electron (0), photon (1), local pi0 (2) and global pi0 (3), hadron (4 to 7). The 'number' field specifies a partial serial number in the type. This can not be unambiguous, as we have only 4 bits to label 28 cards. The following scheme is proposed: The lower bit is the Trigger Validation Board number in the crate, 0 for the left slot (FE cards 0-7) and 1 for the right slot (FE boards 8-15). The upper 3 bits indicate the ECAL crate number, only on 3 bits this means starting at 0 for each calorimeter half. These crate numbers are taken from the calorimeter readout document [4]. For the C side the crate numbers are from 8 to 14, coded as 0 to 6. For the A side, the numbers are from 15 to 21, coded as 0 to 6.

The other fields are the usual ones. Note that the address is on 8 bits as ECAL candidates have to indicate from which of the 8 input boards the candidate was selected. The input board is put in the upper 3 bits of the address. For HCAL candidates, the 3 upper bits of the address field are zeroes.

5. SPD Multiplicity card

This card is mainly used to drive the SPD Very Front-End. But it contains a small trigger part, using the very same connections as the Trigger Validation Board. ECS and TTC are available on the 3U backplane. However, the inputs and outputs are quite simpler:

5.1. Inputs from PreShower Front-End card

The format is described in section 3.3.

5.2. Output to the Selection Board

This is an optical connection, single fibre. The format of the 32 bits word is the following:

First 16b word	[15:11] zeros (5b)	[10:1] Multiplicity (10 bits)		[0:0] ‘0’
Second 16b word	[15:13] Type (3b)	[12:9] number (4b)	[8:1] BX-ID (8 bits)	[0:0] ‘1’

The ‘Type’ and ‘number’ fields are similar to those defined in section 4.4, the type is ‘7’ and the number is the board’s number, as we have only 16 such boards, the 3 MSB of the field denoting the crate number where the board is located (from 0 to 7), and the least significant bit set to '0' for the board in the left slot of the crate, and to '1' for the board in the right slot.

The connector to the optical one channel mezzanine is specified in [3], of type SMA. The SPD Multiplicity card sends its output through one single fibre.

6. Cables and Patch panels

6.1. Trigger Validation Boards

The physical implementation of the link from the Trigger Validation Board to the Selection Boards is a 12-fibre ribbon, and the interface to it is a mezzanine as described in [3]. The connector type of 12-fibre ribbon connected to the Validation Board is MPO, female, with guiding holes. Four ribbons are grouped together to form a cable where all of the four end connectors are connected to the same ECAL crate (two on the two Validation Boards of the same crate and two on the CROC of the crate). On the other side of the cable, the four MPO connectors of the four 12-fibre ribbon are connected to the front side of two patch panels (in rack Q2A01, in the cavern). Figure 8 shows the connections of the L0 Calorimeter optical fibres in this patch panel, seen from the front. The patch panel contains 12 slots filled with MPO-MPO adapters. Each MPO-MPO adapter has 6 connectors, the 12-fiber ribbon coming from the Validation Board is connected to the front side of the connector. Then one adaptor's connector corresponds to one Validation Board, indicated in Figure 8 by the crate number of the Validation Board followed by 1 for the left Validation Board in the crate and 2 for the right board. On the back sides of the adapter's connectors are connected the long distance cables which go up to the barrack. The long distance cables group together 8 12-fiber ribbons with Male MPO (with guiding pins) connectors at each end. Figure 8 shows also the long distance cabling, each colour representing a different cable and the number between brackets indicating the 12-fiber ribbon number inside the optical cable.

There are 28 ribbons (plus 2 for the SPD candidates and 10 spare ribbons) in 5 multi-ribbon long distance cables, up to the D3 barrack. There, in the rack D3B01, a patch panel will give access to each individual fibre. In this rack, there are 3 patch panels with 12 slots each. 28 slots are filled with MPO-SC cassettes, with a MPO Female connector at the back where a 12-fiber ribbon from one Validation Board is plugged (contained in one multi-ribbon long distance cable). The top patch panel contains 12 cassettes, the middle patch panel 4 cassettes and the bottom patch panel, 12 cassettes. On the front side of the cassette, 12 SC connectors give access to each of the fibre contained in the 12-fiber ribbon and then to each of the 8 signals sent by each Validation Board. Figure 9 shows the position of the cassettes in these patch panels. The number of the Validation Board corresponding to the fibre arriving in the cassette is written inside the cassette's slot, together with the 12-fiber ribbon fibre number inside the multi-ribbon long distance cable between parentheses.

6.2. SPD Multiplicity Card

Two boxes located on the calorimeter platform (one for each side) group 8 single fibres from the SPD Multiplicity Cards into a single ribbon. The other end of the box is connected to the MPO Female end connector of a 12-fiber ribbon. The other end of this ribbon is plugged into the front side of one MPO-MPO adaptor of the patch panel in the cavern, as show in Figure 9. 8 fibres out of 12 inside the 12-fiber ribbon are used as indicated in Table 3.

Table 3: Fibre assignment for SPD Multiplicity Cards

Fiber	C Side	A Side
1	Crate 0, Left	Crate 4, Left

2	Crate 0, Right	Crate 4, Right
3	Crate 1, Left	Crate 5, Left
4	Crate 1, Right	Crate 5, Right
5	Crate 2, Left	Crate 6, Left
6	Crate 2, Right	Crate 6, Right
7	Crate 3, Left	Crate 7, Left
8	Crate 3, Right	Crate 7, Right
9	Spare	Spare
10	Spare	Spare
11	Spare	Spare
12	Spare	Spare

The other sides of the MPO-MPO adaptors corresponding to the SPD Multiplicity boards in the Q2A01 rack are connected to long distance cables which arrive in the D3B01 rack of the D3 barrack. The middle patch panel of the L0 Calorimeter Trigger Patch Panels contains 2 MPO-MPO adaptor plates where 2 slots receive at the back side the SPD Multiplicity 12-fiber ribbons.

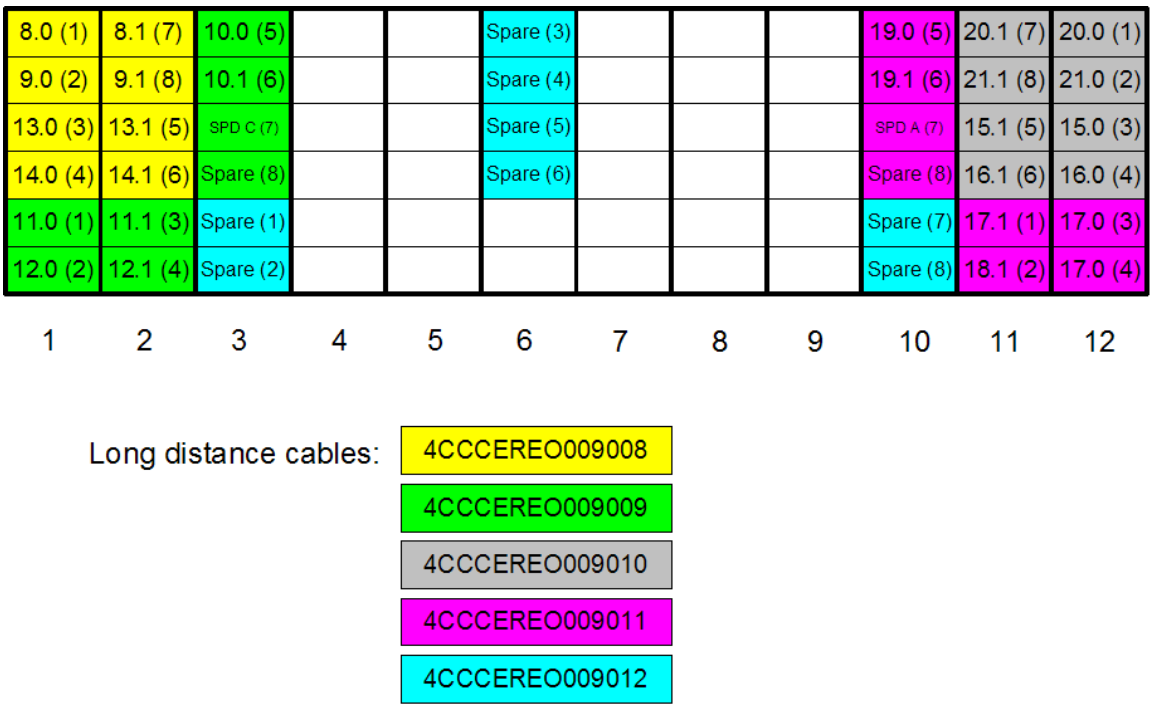

Figure 8: L0 Calorimeter Trigger Patch Panel cabling in Rack Q2A01 (Cavern)

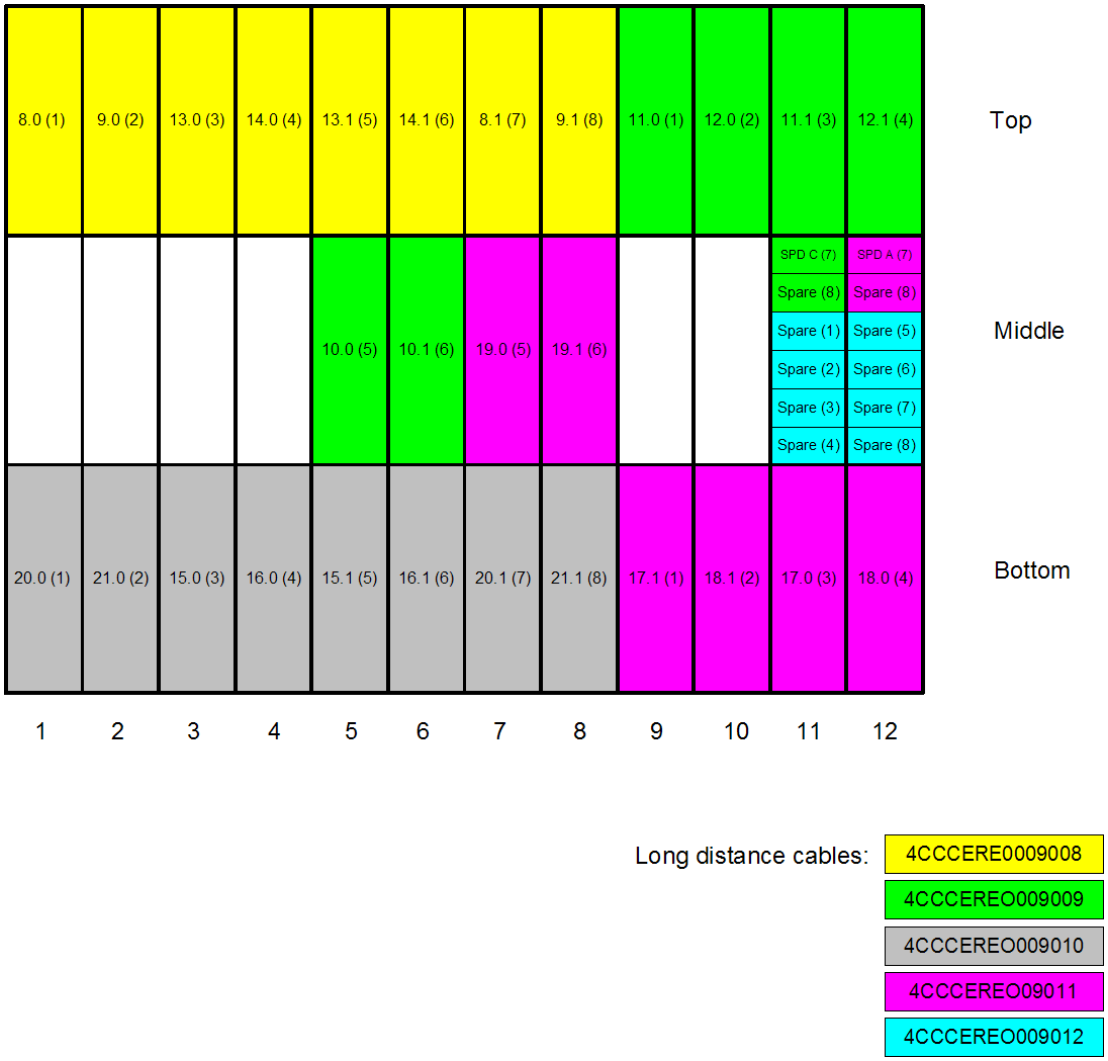

Figure 9: Front View of the L0 Calorimeter Trigger Patch Panels in the D3B01 rack of the D3 barrack

7. Selection Boards

The selection boards are identical, even if they have different processing code inside. The input is what is sent by the Trigger Validation Board and the SPD Multiplicity cards. The output is towards the L0 Decision Unit, plus towards the DAQ via a TELL1 board.

7.1. Inputs

Each Selection Board is equipped with 28 independent input channels, receiving a 32 bit data word at 40 MHz. Each channel is an optical link running at 1.6 GHz. They are grouped in 3 patch cords of 12 fibres, with one MPO Female connector at one side and 12 individual SC connectors at the other side. The bit pattern transferred is given in section 4.4 and 5.2.

The inputs are connected to the front side of the L0 Trigger Calorimeter patch panels of the D3B01 rack. Two of the three fibres carry 12 channels; the third fibre carries 4 channels.

Figure 10 shows the positions of each type of candidates on the front side of a cassette connected to a Validation Board, and where the Selection Boards take the input signals from.

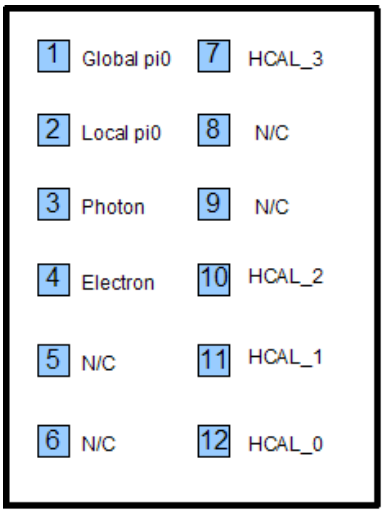

Figure 10: Front view of a MPO-SC Cassette receiving a fibre from a Validation Board

For each of the 4 Selection Boards handling electromagnetic candidates:

- One fibre will group all electromagnetic candidates of the type handled by the Selection Board from the top patch panel (channel 1 being connected to the first cassette on the left, channel 12 to the last cassette on the right), ie each individual fibre of the patch cord is connected to the same output of each cassette of the row.
- One fibre will group the 4 candidates from the middle patch panel,
- One fibre will group the 12 candidates from the bottom patch panel.

For the Selection Board receiving the SPD multiplicity information, two 12-fiber ribbons with MPO Female connectors at each end will connect the two MPO-MPO adaptors of the middle patch panel to 2 inputs of the Selection Board.

For the 3 Selection Boards handling hadron candidates, the repartition of HCAL candidates in each fibre is indicated in Table 4, with the number of the Validation Board and the number of the HCAL candidate for the board between parentheses. Duplicate candidates are grouped in the same cell of the table.

Table 4: Fibre assignments for hadron candidates

Channel	ribbon 1	ribbon 2	ribbon 3	ribbon 4	ribbon 5	ribbon 6	ribbon 7	ribbon 8	ribbon 9
1	8.0 (3)	13.0 (3)	8.1 (1)	14.0 (2)		10.0 (1)	20.0 (3)	17.0 (2)	17.1 (3)
2	9.0 (3)	14.0 (3)	9.1 (1)	13.1 (2)		10.1 (1)	21.0 (3)	18.0 (2)	18.1 (3)
3	8.0 (2)	13.1 (3)	11.0 (3)	11.1 (1)		19.0 (1)	20.0 (2)	17.0 (1)	17.1 (2)
4	9.0 (2)	14.1 (3)	12.0 (3)	12.1 (0)		19.1 (1)	21.0 (2)	18.0 (1)	18.1 (2)
5	8.0 (1)		11.0 (2)	10.0 (3)		10.0 (0)	20.0 (1)		17.1 (1)
6	9.0 (1)		12.0 (2)	10.1 (3)		10.1 (0)	21.0 (1)		18.1 (1)
7	8.0 (0)		11.0 (1)	19.0 (3)		19.0 (0)	20.0 (0)		15.0 (3)
8	9.0 (0)		12.0 (1)	19.1 (3)		19.1 (0)	21.0 (0)		16.0 (3)
9	8.1 (3)		11.1 (3)	10.0 (2)		17.0 (3)	20.1 (3)		15.1 (3)
10	9.1 (3)		12.1 (3)	10.1 (2)		18.0 (0)	21.1 (3)		16.1 (3)
11	8.1 (2)		11.1 (2)	19.0 (2)		20.1 (1)	20.1 (2)		16.0 (2)
12	9.1 (2)		12.1 (2)	19.1 (2)		21.0 (1)	21.1 (2)		15.1 (2)

Each board has also an optical input for the TTC, and an Ethernet input for ECS using a CC-PC.

7.2. Outputs to L0 Decision Unit

Each board produces one output, with the very same format for all of them. One minor difference is that two outputs, HCAL Total E_T and SPD Multiplicity, don't have an address by construction, but on the other hand they need more bits for the computation result.

These words are transmitted as TWO 16b half-words via optical links. The lowest bit identifies the current half-word ('0' for the first and '1' for the second). This is described in [5].

First 16b word	[15:9] BX-ID(6-0) (7 bits)	[8:1] E_T (8 bits)	[0:0] '0'
Second 16b word	[15:15] status	[14:1] Address (14 bits)	[0:0] '1'

First 16b word	[15:9] BX-ID (7 bits)	[8:1] zeros (8 bits)	[0:0] '0'
Second 16b word	[15:15] status	[14:1] Multiplicity / Total E_T (14 bits)	[0:0] '1'

The link from the Selection Boards to the L0DU Patch Panel in the D3B05 rack of the D3 barrack is a single fibre with SMA connector on the Selection Board side, and SC connector on the other side, which is plugged on the front side of the Patch Panel.

7.3. Output to the TELL1 board

They will conform to the TELL1 board specification. The block of data will be the 28 inputs received for the selected crossing and the resulting selected output.

Each board has an output optical connection for the TELL1. The optical cables are 12-fibre ribbons with a MPO Female connector on the TELL1 side and 12 individual fibres with SMA connectors on the other side.

8. References

[1] Ch. Beigbeder *et al.,* “The LHCb Calorimeter Front-End Crate”, Note **LHCb 2003-038**

[2] D.Gascon *et al.*, “Cards, Crates and Connections for the Calorimeters”, Note **LHCb 2003-121**

[3] LHCb Bologna group, “The Optical Transmitters for the LHCb Calorimeter”, Document **CERN-EDMS 528243**

[4] D.Boget *et al*, “The Readout of the LHCb Calorimeter”, **CERN-EDMS 527942**

[5] R.Cornat *et al*, “Specification of the L0DU trigger input and output”**, CERN-EDMS 528259**