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Cabling of the HEC and FCAL Level 1 Trigger Sums

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1 Introduction

This note describes the composition of the trigger sums for the HEC and FCAL calorimeters. The corresponding information for the EM calorimeters (EM Barrel and EM End-Cap) are treated elsewhere[1].

The analog summing chain for HEC and FCAL is simpler than for the EM calorimeters. In the latter, it is necessary to perform sums betwen the different depth layers in a separate module, called the Tower Builder Board. This stage is unnecessary in the HEC and FCAL, so the outputs of the layer sum boards (LSBs) on these FEBS are sent to USA15 using the Tower Driver Board (TDB), which has 96 channels and drives six output cables. There is no difference between the TDB used for the HEC and the FCAL, and no other calorimeters use the TDB. Thus this note describes the cabling for all cases in which the TDB is employed.

2 Trigger Sum Nomenclature

The designation for the HEC trigger sums is the same for the EMEC calorimeter: $I_\eta L_\phi$ (a number folled by a letter), and a sum with the same name in the EMEC and HEC covers the same region of (η, ϕ) The number corresponds to the η coordinate, starting (the HEC trigger sums start at I_η=2) at the outer rim and increasing with $|\eta|$. The phi index corresponds to the phi coordinate within a quadrant. It runs from A through P for ($|\eta| < 2.5$), with each segment equal to $\pi/32$, and for ($|\eta| \geq 2.5$) it runs from A through H, with each segment equal to $\pi/16$.

For the FCAL, a similar designation is used, except that I_η runs from 1 to 4 in the direction of increasing $|\eta|$, and L_ϕ runs from A through P as ϕ runs from 0 to 2π (each phi segment is $\pi/8$).

The correspondence between the trigger sum indices and the angular variables for both HEC and FCAL is given in Table 1.

3 HEC Trigger Sums

For the HEC, the only stage of summing for the trigger which is carried out on the front end board (FEB) is in the shaper chip. The layer sum board (LSB), which performs a

Table 1: Correspondence between the indices used for the trigger sums and angular coordinates within a quadrant (for the HEC). For the FCAL the angular intervals are only approximate.

η Intervals for HEC

I_η	$\|\eta\|$
2	1.5-1.6
3	1.6-1.7
4	1.7-1.8
5	1.8-1.9
6	1.9-2.0
7	2.0-2.1
8	2.1-2.2
9	2.2-2.3
10	2.3-2.4
11	2.4-2.5
12	2.5-2.7
13	2.7-2.9
14	2.9-3.1
15	3.1-3.2

ϕ Intervals for HEC (within a quadrant)

L_ϕ	ϕ ($I_\eta < 12$)	ϕ ($I_\eta \geq 12$)
A	0.000-0.098	0.000-0.196
B	0.098-0.196	0.196-0.393
C	0.196-0.295	0.393-0.589
D	0.295-0.393	0.589-0.785
E	0.393-0.491	0.785-0.982
F	0.491-0.589	0.982-1.178
G	0.589-0.687	1.178-1.374
H	0.687-0.785	1.374-1.570
I	0.785-0.884	
J	0.884-0.982	
K	0.982-1.080	
L	1.080-1.178	
M	1.178-1.276	
N	1.276-1.374	
O	1.374-1.473	
P	1.473-1.570	

η Intervals for FCAL

I_η	$\|\eta\|$
1	3.2-3.6
2	3.6-4.0
3	4.0-4.4
4	4.4-4.9

ϕ Intervals for FCAL

L_ϕ	ϕ
A	0.000-0.393
B	0.393-0.785
C	0.785-1.178
D	1.178-1.570
E	1.570-1.963
F	1.963-2.356
G	2.356-2.748
H	2.748-3.140
I	3.140-3.533
J	3.533- 3.926
K	3.926-4.318
L	4.318-4.710
M	4.710-5.103
N	5.103-5.496
O	5.496-5.888
P	5.888-6.280

Table 2: Layer Sum Boards used in FEBs for HEC

Type	Gain
S1 × 16L	1
S1 × 16H	2
S1 × 16M	mixed: G=2 (ch 1-8), G=1 (ch 9-16)

second level of summing at each depth layer for the EM calorimters, serves only as an amplifier/driver. For this reason, the LSBs which are used for the HEC are one of the three models of the S1×16 board shown in Table 2, which differ only in the gain of the circuits.

The Front End Crate for the HEC contains 6 FEBs, each of which receives inputs from the four depth segments of the calorimeters. The sum of the four layers is formed in the shaper chip, so each shaper output is a fully formed trigger sum In Fig. 1 is shown a table giving the content of each FEB in terms of its trigger sums. The trigger sums are available on the middle connector (J2) of the baseplane of each FEB, and the pinouts of these connectors is also shown. The front end crate also contains two Tower Driver Boards, which are modules containing 96 unity gain amplifiers which drive six trigger sum cables containing 16 channels each. In Fig. 2 is shown the trigger sum contents by channel for each of the tower driver boards.

4 FCAL Trigger Sums

The LSBs which are used for the FCAL are S4 $\times$ 4 for FCAL1, S2 $\times$ 8 for FCAL2, and S1 $\times$ 16L for FCAL3. Because of significant variations in $\sin\theta$ within each of the trigger sums in FCAL, the relative weights in the S4 $\times$ 4 and S2 $\times$ 8 layer sum boards are tailored for each bin. The sums that are made on each FEB are over a single depth layer and are transmitted to the receivers in USA15 through the Tower Driver Board. The distribution of LSBs within the FCAL crate is shown in Fig. 3.

The Front End Crate for the FCAL contains 14 FEBs, each of which receives inputs from one of the three calorimeters. Within each FEB, a set of trigger sums are formed by the layer sum boards. The trigger sums are available on the middle connector (J2) of the baseplane of each FEB, and the pinouts of these connectors is also shown in Fig. 4 The front end crate also contains two Tower Driver Boards. In Fig.4 is shown the trigger sum contents by channel for each of these boards.

		HADRONIC ENDCAP A					
	FT		5	6	7	8	9	10
	SLOT		25	26	28	29	30	32
	LSB TYPE		1X16	1X16	1X16	1X16	1X16	1X16
	CONN.		J17	J18	J20	J21	J22	J24
		J2						
	SHAPER	OUT	FEB1	FEB2	FEB3	FEB4	FEB5	FEB6
	LOCATION							
	0	1	2A	2I	6A	6I	10A	10I
	1	3	2B	2J	6B	6J	10B	10J
	2	5	2C	2K	6C	6K	10C	10K
	3	7	2D	2L	6D	6L	10D	10L
	4	9	3A	3I	7A	7I	11A	11I
	5	11	3B	3J	7B	7J	11B	11J
	6	13	3C	3K	7C	7K	11C	11K
A	7	15	3D	3L	7D	7L	11D	11L
	8	66	4A	4I	8A	8I	12A	12E
	9	68	4B	4J	8B	8J	12B	12F
	10	70	4C	4K	8C	8K	13A	13E
	11	72	4D	4L	8D	8L	13B	13F
	12	74	5A	5I	9A	9I	14A	14E
	13	76	5B	5J	9B	9J	14B	14F
	14	78	5C	5K	9C	9K	15A	15E
	15	80	5D	5L	9D	9L	15B	15F
	16	17	2E	2M	6E	6M	10E	10M
	17	19	2F	2N	6F	6N	10F	10N
	18	21	2G	2O	6G	6O	10G	10O
	19	23	2H	2P	6H	6P	10H	10P
	20	25	3E	3M	7E	7M	11E	11M
	21	27	3F	3N	7F	7N	11F	11N
	22	29	3G	3O	7G	7O	11G	11O
B	23	31	3H	3P	7H	7P	11H	11P
	24	82	4E	4M	8E	8M	12C	12G
	25	84	4F	4N	8F	8N	12D	12H
	26	86	4G	4O	8G	8O	13C	13G
	27	88	4H	4P	8H	8P	13D	13H
	28	90	5E	5M	9E	9M	14C	14G
	29	92	5F	5N	9F	9N	14D	14H
	30	94	5G	5O	9G	9O	15C	15G
	31	96	5H	5P	9H	9P	15D	15H

		HADRONIC ENDCAP C					
FT		5	6	7	8	9	10
SLOT		25	26	28	29	30	32
LSB TYPE		1X16	1X16	1X16	1X16	1X16	1X16
CONN.		J17	J18	J20	J21	J22	J24
	J2						
SHAPER	OUT	FEB1	FEB2	FEB3	FEB4	FEB5	FEB6
LOCATION							
0	1	2P	2H	6P	6H	10P	10H
1	3	2O	2G	6O	6G	10O	10G
2	5	2N	2F	6N	6F	10N	10F
3	7	2M	2E	6M	6E	10M	10E
4	9	3P	3H	7P	7H	11P	11H
5	11	3O	3G	7O	7G	11O	11G
6	13	3N	3F	7N	7F	11N	11F
7	15	3M	3E	7M	7E	11M	11E
8	66	4P	4H	8P	8H	12H	12D
9	68	4O	4G	8O	8G	12G	12C
10	70	4N	4F	8N	8F	13H	13D
11	72	4M	4E	8M	8E	13G	13C
12	74	5P	5H	9P	9H	14H	14D
13	76	5O	5G	9O	9G	14G	14C
14	78	5N	5F	9N	9F	15H	15D
15	80	5M	5E	9M	9E	15G	15C
16	17	2L	2D	6L	6D	10L	10D
17	19	2K	2C	6K	6C	10K	10C
18	21	2J	2B	6J	6B	10J	10B
19	23	2I	2A	6I	6A	10I	10A
20	25	3L	3D	7L	7D	11L	11D
21	27	3K	3C	7K	7C	11K	11C
22	29	3J	3B	7J	7B	11J	11B
23	31	3I	3A	7I	7A	11I	11A
24	82	4L	4D	8L	8D	12F	12B
25	84	4K	4C	8K	8C	12E	12A
26	86	4J	4B	8J	8B	13F	13B
27	88	4I	4A	8I	8A	13E	13A
28	90	5L	5D	9L	9D	14F	14B
29	92	5K	5C	9K	9C	14E	14A
30	94	5J	5B	9J	9B	15F	15B
31	96	5I	5A	9I	9A	15E	15A

Figure 1: Content of the HEC front end crate in terms of the trigger sums.

TDB	ENDCAP A		ENDCAP C		Output Cable
Channel number	Trigger Sum	Trigger Sum	Trigger Sum	Trigger Sum	Channel number
0	6A	12A	6P	12H	J8 0
1	6B	12B	6O	12G	1
2	6C	12C	6M	12F	2
3	6D	12D	6N	12E	3
4	6E	12E	6L	12D	4
5	6F	12F	6K	12C	E 5
6	6G	12G	6J	12B	6
7	6H	12H	6I	12A	7
8	6I	13A	6H	13H	8
9	6J	13B	6G	13G	9
10	6K	13C	6F	13F	10
11	6L	13D	6E	13E	11
12	6M	13E	6D	13D	12
13	6N	13F	6C	13C	13
14	6O	13G	6B	13B	14
15	6P	13H	6A	13A	15
16	7A	14A	7P	14H	J9 0
17	7B	14B	7O	14G	1
18	7C	14C	7M	14F	F 2
19	7D	14D	7N	14E	3
20	7E	14E	7L	14D	4
21	7F	14F	7K	14C	5
22	7G	14G	7J	14B	6
23	7H	14H	7I	14A	7
24	7I	15A	7H	15H	8
25	7J	15B	7G	15G	9
26	7K	15C	7F	15F	10
27	7L	15D	7E	15E	11
28	7M	15E	7D	15D	12
29	7N	15F	7C	15C	13
30	7O	15G	7B	15B	14
31	7P	15H	7A	15A	15
32	4A	10A	4P	10P	J6 0
33	4B	10B	4O	10O	1
34	4C	10C	4M	10M	C 2
35	4D	10D	4N	10N	3
36	4E	10E	4L	10L	4
37	4F	10F	4K	10K	5
38	4G	10G	4J	10J	6
39	4H	10H	4I	10I	7
40	4I	10I	4H	10H	8
41	4J	10J	4G	10G	9
42	4K	10K	4F	10F	10
43	4L	10L	4E	10E	11
44	4M	10M	4D	10D	12
45	4N	10N	4C	10C	13
46	4O	10O	4B	10B	14
47	4P	10P	4A	10A	15

TDB	ENDCAP A		ENDCAP C		Output Cable
Channel number	Trigger Sum	Trigger Sum	Trigger Sum	Trigger Sum	Channel number
48	5A	11A	5P	11P	J7 0
49	5B	11B	5O	11O	1
50	5C	11C	5M	11M	D 2
51	5D	11D	5N	11N	3
52	5E	11E	5L	11L	4
53	5F	11F	5K	11K	5
54	5G	11G	5J	11J	6
55	5H	11H	5I	11I	7
56	5I	11I	5H	11H	8
57	5J	11J	5G	11G	9
58	5K	11K	5F	11F	10
59	5L	11L	5E	11E	11
60	5M	11M	5D	11D	12
61	5N	11N	5C	11C	13
62	5O	11O	5B	11B	14
63	5P	11P	5A	11A	15
64	2A	8A	2P	8P	J4 0
65	2B	8B	2O	8O	1
66	2C	8C	2M	8M	A 2
67	2D	8D	2N	8N	3
68	2E	8E	2L	8L	4
69	2F	8F	2K	8K	5
70	2G	8G	2J	8J	6
71	2H	8H	2I	8I	7
72	2I	8I	2H	8H	8
73	2J	8J	2G	8G	9
74	2K	8K	2F	8F	10
75	2L	8L	2E	8E	11
76	2M	8M	2D	8D	12
77	2N	8N	2C	8C	13
78	2O	8O	2B	8B	14
79	2P	8P	2A	8A	15
80	3A	9A	3P	9P	J5 0
81	3B	9B	3O	9O	1
82	3C	9C	3M	9M	B 2
83	3D	9D	3N	9N	3
84	3E	9E	3L	9L	4
85	3F	9F	3K	9K	5
86	3G	9G	3J	9J	6
87	3H	9H	3I	9I	7
88	3I	9I	3H	9H	8
89	3J	9J	3G	9G	9
90	3K	9K	3F	9F	10
91	3L	9L	3E	9E	11
92	3M	9M	3D	9D	12
93	3N	9N	3C	9C	13
94	3O	9O	3B	9B	14
95	3P	9P	3A	9A	15

Figure 2: Trigger sum assignment to channels in the Tower Driver Boards for the HEC for each of the endcaps. The six output cables are labelled A through F.

SLOT #					3	4	5	6	7	8	9	10	11	12		13	14	15	16	17		18	19	20	21
LAY SUM BOARD TYPE					4X4	4X4	4X4	4X4	TDB 0	4X4	4X4	4X4	4X4	CONTROL		2X8	2X8	2X8	2X8	TDB 1		1x16	1X16	MONITOR	S. CONT
CONNECTOR					J22	J23	J24	J25	J26	J27	J28	J29	J30	J31		J32	J33	J34	J35	J36		J37	JX 20	JX 21	JX 22
					FEB 01	FEB 02	FEB 03	FEB 04		FEB 05	FEB 06	FEB 07	FEB 08		J2	FEB 09	FEB 10	FEB 11	FEB 12		J2	FEB 13	FEB 14		
SHAPER	LAYER SUM BD PI		CON OUT	OUT	FCAL 1	F CAL 1	FCAL 1	FCAL 1		FCAL 1	FCAL 1	FCAL 1	FCAL 1		OUT	FCAL 2	FCAL 2	FCAL 2	FCAL 2		OUT	FCAL 3	FCAL 3		
OCATION	IN	OUT																							
0	2	49	1	1	1A_1	1C_1	1E_1	1G_1		1I_1	1K_1	1M_1	1O_1		1	1A_1	1E_1	1I_1	1M_1		1	1A	1I		
1	4	47	3		1A_2	1C_2	1E_2	1G_2		1I_2	1K_2	1M_2	1O_2			1A_2	1E_2	1I_2	1M_2		3	2A	2I		
2	5	46	5		1A_3	1C_3	1E_3	1G_3		1I_3	1K_3	1M_3	1O_3		5	2A_1	2E_1	2I_1	2M_1		5	3A	3I		
3	7	44	7		1A_4	1C_4	1E_4	1G_4		1I_4	1K_4	1M_4	1O_4			2A_2	2E_2	2I_2	2M_2		7	4A	4I		
4	8	43	9	9	2A_1	2C_1	2E_1	2G_1		2I_1	2K_1	2M_1	2O_1		9	3A_1	3E_1	3I_1	3M_1		9	1B	1J		
5	10	41	11		2A_2	2C_2	2E_2	2G_2		2I_2	2K_2	2M_2	2O_2			3A_2	3E_2	3I_2	3M_2		11	2B	2J		
6	11	40	13		2A_3	2C_3	2E_3	2G_3		2I_3	2K_3	2M_3	2O_3		13	4A_1	4E_1	4I_1	4M_1		13	3B	3J		
7	13	38	15		2A_4	2C_4	2E_4	2G_4		2I_4	2K_4	2M_4	2O_4			4A_2	4E_2	4I_2	4M_2		15	4B	4J		
8	14	37	66	66	3A_1	3C_1	3E_1	3G_1		3I_1	3K_1	3M_1	3O_1		66	1B_1	1F_1	1J_1	1N_1		66	1C	1K		
9	16	35	68		3A_2	3C_2	3E_2	3G_2		3I_2	3K_2	3M_2	3O_2			1B_2	1F_2	1J_2	1N_2		68	2C	2K		
10	17	34	70		3A_3	3C_3	3E_3	3G_3		3I_3	3K_3	3M_3	3O_3		70	2B_1	2F_1	2J_1	2N_1		70	3C	3K		
11	19	32	72		3A_4	3C_4	3E_4	3G_4		3I_4	3K_4	3M_4	3O_4			2B_2	2F_2	2J_2	2N_2		72	4C	4K		
12	20	31	74	74	4A_1	4C_1	4E_1	4G_1		4I_1	4K_1	4M_1	4O_1		74	3B_1	3F_1	3J_1	3N_1		74	1D	1L		
13	22	29	76		4A_2	4C_2	4E_2	4G_2		4I_2	4K_2	4M_2	4O_2			3B_2	3F_2	3J_2	3N_2		76	2D	2L		
14	23	28	78		4A_3	4C_3	4E_3	4G_3		4I_3	4K_3	4M_3	4O_3		78	4B_1	4F_1	4J_1	4N_1		78	3D	3L		
15	25	26	80		4A_4	4C_4	4E_4	4G_4		4I_4	4K_4	4M_4	4O_4			4B_2	4F_2	4J_2	4N_2		80	4D	4L		
16	2	49	17	17	1B_1	1D_1	1F_1	1H_1		1J_1	1L_1	1N_1	1P_1		17	1C_1	1G_1	1K_1	1O_1		17	1E	1M		
17	4	47	19		1B_2	1D_2	1F_2	1H_2		1J_2	1L_2	1N_2	1P_2			1C_2	1G_2	1K_2	1O_2		19	2E	2M		
18	5	46	21		1B_3	1D_3	1F_3	1H_3		1J_3	1L_3	1N_3	1P_3		21	2C_1	2G_1	2K_1	2O_1		21	3E	3M		
19	7	44	23		1B_4	1D_4	1F_4	1H_4		1J_4	1L_4	1N_4	1P_4			2C_2	2G_2	2K_2	2O_2		23	4E	4M		
20	8	43	25	25	2B_1	2D_1	2F_1	2H_1		2J_1	2L_1	2N_1	2P_1		25	3C_1	3G_1	3K_1	3O_1		25	1F	1N		
21	10	41	27		2B_2	2D_2	2F_2	2H_2		2J_2	2L_2	2N_2	2P_2			3C_2	3G_2	3K_2	3O_2		27	2F	2N		
22	11	40	29		2B_3	2D_3	2F_3	2H_3		2J_3	2L_3	2N_3	2P_3		29	4C_1	4G_1	4K_1	4O_1		29	3F	3N		
23	13	38	31		2B_4	2D_4	2F_4	2H_4		2J_4	2L_4	2N_4	2P_4			4C_2	4G_2	4K_2	4O_2		31	4F	4N		
24	14	37	82	82	3B_1	3D_1	3F_1	3H_1		3J_1	3L_1	3N_1	3P_1		82	1D_1	1H_1	1L_1	1P_1		82	1G	1O		
25	16	35	84		3B_2	3D_2	3F_2	3H_2		3J_2	3L_2	3N_2	3P_2			1D_2	1H_2	1L_2	1P_2		84	2G	2O		
26	17	34	86		3B_3	3D_3	3F_3	3H_3		3J_3	3L_3	3N_3	3P_3		86	2D_1	2H_1	2L_1	2P_1		86	3G	3O		
27	19	32	88		3B_4	3D_4	3F_4	3H_4		3J_4	3L_4	3N_4	3P_4			2D_2	2H_2	2L_2	2P_2		88	4G	4O		
28	20	31	90	90	4B_1	4D_1	4F_1	4H_1		4J_1	4L_1	4N_1	4P_1		90	3D_1	3H_1	3L_1	3P_1		90	1H	1P		
29	22	29	92		4B_2	4D_2	4F_2	4H_2		4J_2	4L_2	4N_2	4P_2			3D_2	3H_2	3L_2	3P_2		92	2H	2P		
30	23	28	94		4B_3	4D_3	4F_3	4H_3		4J_3	4L_3	4N_3	4P_3		94	4D_1	4H_1	4L_1	4P_1		94	3H	3P		
31	25	26	96		4B_4	4D_4	4F_4	4H_4		4J_4	4L_4	4N_4	4P_4			4D_2	4H_2	4L_2	4P_2		96	4H	4P		

SLOT #					3	4	5	6	7	8	9	10	11	12		13	14	15	16	17		18	19	20	21
LAY SUM BOARD TYPE					4X4	4X4	4X4	4X4	TDB 0	4X4	4X4	4X4	4X4	CONTROL		2X8	2X8	2X8	2X8	TDB 1		1x16	1X16	MONITOR	S. CONT
CONNECTOR					J22	J23	J24	J25	J26	J27	J28	J29	J30	J31		J32	J33	J34	J35	J36		J37	JX 20	JX 21	JX 22
					FEB 01	FEB 02	FEB 03	FEB 04		FEB 05	FEB 06	FEB 07	FEB 08		J2	FEB 09	FEB 10	FEB 11	FEB 12		J2	FEB 13	FEB 14		
SHAPER	LAYER SUM BD PI		CON OUT	OUT	FCAL 1	F CAL 1	FCAL 1	FCAL 1		FCAL 1	FCAL 1	FCAL 1	FCAL 1		OUT	FCAL 2	FCAL 2	FCAL 2	FCAL 2		OUT	FCAL 3	FCAL 3		
OCATION	IN	OUT																							
0	2	49	1	1	1H_1	1F_1	1D_1	1B_1		1P_1	1N_1	1L_1	1J_1		1	1H_1	1D_1	1P_1	1L_1		1	1H	1P		
1	4	47	3		1H_2	1F_2	1D_2	1B_2		1P_2	1N_2	1L_2	1J_2			1H_2	1D_2	1P_2	1L_2		3	2H	2P		
2	5	46	5		1H_3	1F_3	1D_3	1B_3		1P_3	1N_3	1L_3	1J_3		5	2H_1	2D_1	2P_1	2L_1		5	3H	3P		
3	7	44	7		1H_4	1F_4	1D_4	1B_4		1P_4	1N_4	1L_4	1J_4			2H_2	2D_2	2P_2	2L_2		7	4H	4P		
4	8	43	9	9	2H_1	2F_1	2D_1	2B_1		2P_1	2N_1	2L_1	2J_1		9	3H_1	3D_1	3P_1	3L_1		9	1G	1O		
5	10	41	11		2H_2	2F_2	2D_2	2B_2		2P_2	2N_2	2L_2	2J_2			3H_2	3D_2	3P_2	3L_2		11	2G	2O		
6	11	40	13		2H_3	2F_3	2D_3	2B_3		2P_3	2N_3	2L_3	2J_3		13	4H_1	4D_1	4P_1	4L_1		13	3G	3O		
7	13	38	15		2H_4	2F_4	2D_4	2B_4		2P_4	2N_4	2L_4	2J_4			4H_2	4D_2	4P_2	4L_2		15	4G	4O		
8	14	37	66	66	3H_1	3F_1	3D_1	3B_1		3P_1	3N_1	3L_1	3J_1		66	1G_1	1C_1	1O_1	1K_1		66	1F	1N		
9	16	35	68		3H_2	3F_2	3D_2	3B_2		3P_2	3N_2	3L_2	3J_2			1G_2	1C_2	1O_2	1K_2		68	2F	2N		
10	17	34	70		3H_3	3F_3	3D_3	3B_3		3P_3	3N_3	3L_3	3J_3		70	2G_1	2C_1	2O_1	2K_1		70	3F	3N		
11	19	32	72		3H_4	3F_4	3D_4	3B_4		3P_4	3N_4	3L_4	3J_4			2G_2	2C_2	2O_2	2K_2		72	4F	4N		
12	20	31	74	74	4H_1	4F_1	4D_1	4B_1		4P_1	4N_1	4L_1	4J_1		74	3G_1	3C_1	3O_1	3K_1		74	1E	1M		
13	22	29	76		4H_2	4F_2	4D_2	4B_2		4P_2	4N_2	4L_2	4J_2			3G_2	3C_2	3O_2	3K_2		76	2E	2M		
14	23	28	78		4H_3	4F_3	4D_3	4B_3		4P_3	4N_3	4L_3	4J_3		78	4G_1	4C_1	4O_1	4K_1		78	3E	3M		
15	25	26	80		4H_4	4F_4	4D_4	4B_4		4P_4	4N_4	4L_4	4J_4			4G_2	4C_2	4O_2	4K_2		80	4E	4M		
16	2	49	17	17	1G_1	1E_1	1C_1	1A_1		1O_1	1L_1	1K_1	1I_1		17	1F_1	1B_1	1N_1	1J_1		17	1D	1L		
17	4	47	19		1G_2	1E_2	1C_2	1A_2		1O_2	1M_2	1K_2	1I_2			1F_2	1B_2	1N_2	1J_2		19	2D	2L		
18	5	46	21		1G_3	1E_3	1C_3	1A_3		1O_3	1M_3	1K_3	1I_3		21	2F_1	2B_1	2N_1	2J_1		21	3D	3L		
19	7	44	23		1G_4	1E_4	1C_4	1A_4		1O_4	1M_4	1K_4	1I_4			2F_2	2B_2	2N_2	2J_2		23	4D	4L		
20	8	43	25	25	2G_1	2E_1	2C_1	2A_1		2O_1	2M_1	2K_1	2I_1		25	3F_1	3B_1	3N_1	3J_1		25	1C	1K		
21	10	41	27		2G_2	2E_2	2C_2	2A_2		2O_2	2M_2	2K_2	2I_2			3F_2	3B_2	3N_2	3J_2		27	2C	2K		
22	11	40	29		2G_3	2E_3	2C_3	2A_3		2O_3	2M_3	2K_3	2I_3		29	4F_1	4B_1	4N_1	4J_1		29	3C	3K		
23	13	38	31		2G_4	2E_4	2C_4	2A_4		2O_4	2M_4	2K_4	2I_4			4F_2	4B_2	4N_2	4J_2		31	4C	4K		
24	14	37	82	82	3G_1	3E_1	3C_1	3A_1		3O_1	3M_1	3K_1	3I_1		82	1E_1	1A_1	1M_1	1I_1		82	1B	1J		
25	16	35	84		3G_2	3E_2	3C_2	3A_2		3O_2	3M_2	3K_2	3I_2			1E_2	1A_2	1M_2	1I_2		84	2B	2J		
26	17	34	86		3G_3	3E_3	3C_3	3A_3		3O_3	3M_3	3K_3	3I_3		86	2E_1	2A_1	2M_1	2I_1		86	3B	3J		
27	19	32	88		3G_4	3E_4	3C_4	3A_4		3O_4	3M_4	3K_4	3I_4			2E_2	2A_2	2M_2	2I_2		88	4B	4J		
28	20	31	90	90	4G_1	4E_1	4C_1	4A_1		4O_1	4M_1	4K_1	4I_1		90	3E_1	3A_1	3M_1	3I_1		90	1A	1I		
29	22	29	92		4G_2	4E_2	4C_2	4A_2		4O_2	4M_2	4K_2	4I_2			3E_2	3A_2	3M_2	3I_2		92	2A	2I		
30	23	28	94		4G_3	4E_3	4C_3	4A_3		4O_3	4M_3	4K_3	4I_3		94	4E_1	4A_1	4M_1	4I_1		94	3A	3I		
31	25	26	96		4G_4	4E_4	4C_4	4A_4		4O_4	4M_4	4K_4	4I_4			4E_2	4A_2	4M_2	4I_2		96	4A	4I		

Figure 3: Utilization of the LSBs in the FCAL. At left is shown the Endcap A trigger sums and at right is shown the Endcap C trigger sums.

TDB	ENDCAP A		ENDCAP C		Output Cable
	139	140	137	138	
Channel number	Trigger Sum	Trigger Sum	Trigger Sum	Trigger Sum	Channel number
0	1A_F2	1I_F3	1H_F2	1P_F3	J8 0
1	2A_F2	2I_F3	2H_F2	2P_F3	1
2	1B_F2	1J_F3	1G_F2	1O_F3	2
3	2B_F2	2J_F3	2G_F2	2O_F3	3
4	3A_F2	3I_F3	3H_F2	3P_F3	4
5	4A_F2	4I_F3	4H_F2	4P_F3	E 5
6	3B_F2	3J_F3	3G_F2	3O_F3	6
7	4B_F2	4J_F3	4G_F2	4O_F3	7
8	1C_F2	1K_F3	1F_F2	1N_F3	8
9	2C_F2	2K_F3	2F_F2	2N_F3	9
10	1D_F2	1L_F3	1E_F2	1M_F3	10
11	2D_F2	2L_F3	2E_F2	2M_F3	11
12	3C_F2	3K_F3	3F_F2	3N_F3	12
13	4C_F2	4K_F3	4F_F2	4N_F3	13
14	3D_F2	3L_F3	3E_F2	3M_F3	14
15	4D_F2	4L_F3	4E_F2	4M_F3	15
16	1E_F2	1M_F3	1D_F2	1L_F3	J9 0
17	2E_F2	2M_F3	2D_F2	2L_F3	1
18	1F_F2	1N_F3	1C_F2	1K_F3	F 2
19	2F_F2	2N_F3	2C_F2	2K_F3	3
20	3E_F2	3M_F3	3D_F2	3L_F3	4
21	4E_F2	4M_F3	4D_F2	4L_F3	5
22	3F_F2	3N_F3	3C_F2	3K_F3	6
23	4F_F2	4N_F3	4C_F2	4K_F3	7
24	1G_F2	1O_F3	1B_F2	1J_F3	8
25	2G_F2	2O-F3	2B_F2	2J-F3	9
26	1H_F2	1P_F3	1A_F2	1I_F3	10
27	2H_F2	2P_F3	2A_F2	2I_F3	11
28	3G_F2	3O_F3	3B_F2	3J_F3	12
29	4G_F2	4O_F3	4B_F2	4J_F3	13
30	3H_F2	3P_F3	3A_F2	3I_F3	14
31	4H_F2	4P_F3	4A_F2	4I_F3	15
32	1E_F1	1A_F3	1D_F1	1H_F3	J6 0
33	2E_F1	2A_F3	2D_F1	2H_F3	1
34	1F_F1	1B_F3	1C_F1	1G_F3	C 2
35	2F_F1	2B_F3	2C_F1	2G_F3	3
36	3E_F1	3A_F3	3D_F1	3H_F3	4
37	4E_F1	4A_F3	4D_F1	4H_F3	5
38	3F_F1	3B_F3	3C_F1	3G_F3	6
39	4F_F1	4B_F3	4C_F1	4G_F3	7
40	1G_F1	1C_F3	1B_F1	1F_F3	8
41	2G_F1	2C_F3	2B_F1	2F_F3	9
42	1H_F1	1D_F3	1A_F1	1E_F3	10
43	2H_F1	2D_F3	2A_F1	2E_F3	11
44	3G_F1	3C_F3	3B_F1	3F_F3	12
45	4G_F1	4C_F3	4B_F1	4F_F3	13
46	3H_F1	3D_F3	3A_F1	3E_F3	14
47	4H_F1	4D_F3	4A_F1	4E_F3	15

TDB	ENDCAP A		ENDCAP C		Output Cable
	139	140	137	138	
Channel number	Trigger Sum	Trigger Sum	Trigger Sum	Trigger Sum	Channel number
48	1I_F1	1E_F3	1P_F1	1D_F3	J7 0
49	2I_F1	2E_F3	2P_F1	2D_F3	1
50	1J_F1	1F_F3	1O_F1	1C_F3	D 2
51	2J_F1	2F_F3	2O_F1	2C_F3	3
52	3I_F1	3E_F3	3P_F1	3D_F3	4
53	4I_F1	4E_F3	4P_F1	4D_F3	5
54	3J_F1	3F_F3	3O_F1	3C_F3	6
55	4J_F1	4F_F3	4O_F1	4C_F3	7
56	1K_F1	1G_F3	1N_F1	1B_F3	8
57	2K_F1	2G_F3	2N_F1	2B_F3	9
58	1L_F1	1H_F3	1M_F1	1A_F3	10
59	2L_F1	2H_F3	2M_F1	2A_F3	11
60	3K_F1	3G_F3	3N_F1	3B_F3	12
61	4K_F1	4G_F3	4N_F1	4B_F3	13
62	3L_F1	3H_F3	3M_F1	3A_F3	14
63	4L_F1	4H_F3	4M_F1	4A_F3	15
64	1A_F1	1I_F2	1H_F1	1P_F2	J4 0
65	2A_F1	2I_F2	2H_F1	2P_F2	1
66	1B_F1	1J_F2	1G_F1	1O_F2	A 2
67	2B_F1	2J_F2	2G_F1	2O_F2	3
68	3A_F1	3I_F2	3H_F1	3P_F2	4
69	4A_F1	4I_F2	4H_F1	4P_F2	5
70	3B_F1	3J_F2	3G_F1	3O_F2	6
71	4B_F1	4J_F2	4G_F1	4O_F2	7
72	1C_F1	1K_F2	1F_F1	1N_F2	8
73	2C_F1	2K_F2	2F_F1	2N_F2	9
74	1D_F1	1L_F2	1E_F1	1M_F2	10
75	2D_F1	2L_F2	2E_F1	2M_F2	11
76	3C_F1	3K_F2	3F_F1	3N_F2	12
77	4C_F1	4K_F2	4F_F1	4N_F2	13
78	3D_F1	3L_F2	3E_F1	3M_F2	14
79	4D_F1	4L_F2	4E_F1	4M_F2	15
80	1M_F1	1M_F2	1L_F1	1L_F2	J5 0
81	2M_F1	2M_F2	2L_F1	2L_F2	1
82	1N_F1	1N_F2	1K_F1	1K_F2	B 2
83	2N_F1	2N_F2	2K_F1	2K_F2	3
84	3M_F1	3M_F2	3L_F1	3L_F2	4
85	4M_F1	4M_F2	4L_F1	4L_F2	5
86	3N_F1	3N_F2	3K_F1	3K_F2	6
87	4N_F1	4N_F2	4K_F1	4K_F2	7
88	1O_F1	1O_F2	1J_F1	1J_F2	8
89	2O-F1	2O-F2	2J-F1	2J-F2	9
90	1P_F1	1P_F2	1I_F1	1I_F2	10
91	2P_F1	2P_F2	2I_F1	2I_F2	11
92	3O_F1	3O_F2	3J_F1	3J_F2	12
93	4O_F1	4O_F2	4J_F1	4J_F2	13
94	3P_F1	3P_F2	3I_F1	3I_F2	14
95	4P_F1	4P_F2	4I_F1	4I_F2	15

Figure 4: Trigger sum assignment to channels in the Tower Driver Boards for the FCAL for each of the endcaps. The six output cables are labelled A through F.

Table 3: Numbering of Tower Drivers for the HEC, specifying the trigger sums formed and the quadrant in the calorimeter. The quadrants are numbered Q1, Q2, Q3, and Q4, in order of increasing ϕ The symbols A and C refer to the endcaps at $+z$ and $-z$, respectively.

TDB Number	Quadrant No.	Trigger sums
121	Q1C	2A-2P, 3A-3P, 4A-4P, 5A-5P, 6A-6P, 7A-7P
122	Q1C	8A-8P, 9A-9P, 10A-10P, 11A-11P, 12A-13H, 14A-15H
123,124	Q2C	2A-15H (distributed as 121-122)
125,126	Q3C	2A-15H (distributed as 121-122)
127,128	Q4C	2A-15H (distributed as 121-122)
129,130	Q1A	2A-15H (distributed as 121-122)
131,132	Q2A	2A-15H (distributed as 121-122)
133,134	Q3A	2A-15H (distributed as 121-122)
135,136	Q4A	2A-15H (distributed as 121-122)

5 Trigger Sum Cables

There are six output cables connected to each TDB. The ordering of channels within the cables are given in Figures 2and 4. Here we describe the cable plant which transport these signals from the front end crates to the L1 Cavern.

Since the notation for the HEC trigger sums given in Section 2 are repeated within each quadrant, we introduce a label for each of the eight quadrants. We call the quadrants Q1, Q2, Q3, and Q4, in increasing ϕ, and the two ends are labelled A and C, according to the sign of the z coordinate in the standard coordinate system. Each TDB card in the experiment is assigned a number, and in Table 3 is given the correspondence between the TDB number, the trigger sums carried on the cable, and the quadrant of the calorimeter. We suggest that the cable numbering also follow this convention, using the TDB number followed by suffixes A through F.

For the FCAL, a similar procedure is followed, only the quadrant number is not used since all quadrants of the detector are contained in each front end crate. The Tower Driver Boards and output cables are numbered using the same convention as for the HEC.

Table 4: Numbering of Tower Drivers for the FCAL, specifying the trigger sums carried by each cable. The symbols A and C refer to the endcaps at $+z$ and $-z$, respectively.

TDr Cable	Calorimeter	Endcap	Trigger sums
139A	FCAL1	A	1A-4D
139B	FCAL1	A	1M-4P
139C	FCAL1	A	1E-4H
139D	FCAL1	A	1I-4L
139E	FCAL2	A	1A-4D
139F	FCAL2	A	1E-4H
140A	FCAL2	A	1I-4L
140B	FCAL2	A	1M-4P
140C	FCAL3	A	1A-4D
140D	FCAL3	A	1E-4H
140E	FCAL3	A	1I-4L
140F	FCAL3	A	1M-4P
137A	FCAL1	C	1H-4E
137B	FCAL1	C	1L-4I
137C	FCAL1	C	1D-4A
137D	FCAL1	C	1P-4M
137E	FCAL2	C	1H-4E
137F	FCAL2	C	1D-4A
138A	FCAL2	C	1P-4M
138B	FCAL2	C	1L-4I
138C	FCAL3	C	1H-4E
138D	FCAL3	C	1D-4A
138E	FCAL3	C	1P-4M
138F	FCAL3	C	1L-4I

References

[1] W. E. Cleland, Cabling of the Barrel and EMEC Level 1 Trigger Sums, ATL-AL-PITT-ES-9.0