ATLAS Thin Gap Chamber

Cable connection between ASD and PS-Pack

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1. Introduction

This is a draft design of the connection between Amplifier-Shaper-Discriminator (ASD) Boards, Patch-Panel (PP) and Slave Boards (SLB) for the front-end electronics of the Thin Gap Chamber (TGC) trigger system. We will discuss cable route, mount, its length and weight as well as time delay.

The ATLAS experiment in the LHC uses TGC as its forward muon trigger detector. The TGCs are mounted in six big wheels, M1, M2 and M3 in each side(A and C) which support mechanically. M1 has three TGC layers, called as triplet. M2 and M3 both have two TGC layers called as doublet. The inner wheel is a doublet of TGC. The total number of TGCs is about 3600. The total number of TGC signals for wires and strips is nearly 321k channels.

A PS-Pack serves $1/24^{th}$ of triplet (M1) or two doublets (M2 and M3). A sub-PS-Pack consists of 1 mother Patch-Panel (PP) board, 2 daughter PP boards and 2 Slave Boards (SLB), which is called a standard sub-PS-Pack unit. A sub-PS-Pack unit is shown in Fig.1 schematicaly. The signals from the Amplifier-Shaper-Discriminator (ASD) Board are sent though a 20-pair twisted-pair cable to the PS-Pack. Each ASD Board consists of 4 ASD chips which corresponds to 16 wires/strips channels. Each unit of sub PS-Pack serves 16 ASD Boards which equals to 256 channels in the maximum (one exception exists in doublet which serves 18 ASD Boards corresponding to 258 channels) for doublet.

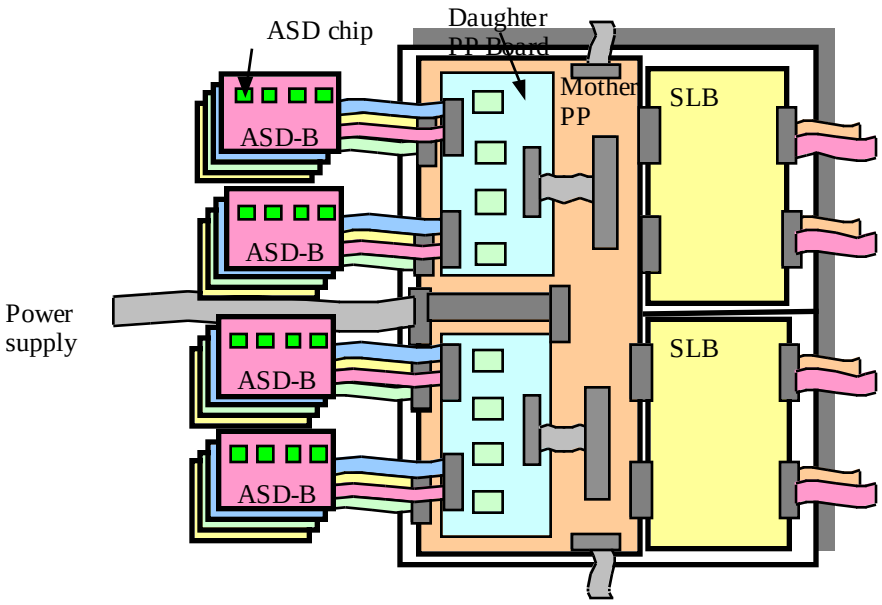


Fig.1 A sub PS-Pack unit of TGC and ASD boards

The wheels M1, M2 and M3 are divided into 24 identical elements, called sets. Three sets make an octant. Each set is divided radially into two regions, named Forward and End-cap.

The ASD Board is physically attached to the edge of a TGC and enclosed inside the TGC electrical shielding (Faraday cadge). Signals from the ASD Boards are sent to a Patch-Panel (PP) board, which houses receivers for the ASD outputs, TTC receivers and DCS, Bunch-Crossing Identification circuits, logic to take care of physical overlap in the TGCs and fan-outs. Outputs from the PP board are sent to corresponding Slave Board (SLB) where the coincidence and read-out circuits are placed. For M1 wheel, three groups of two ASD Boards are served by a SLB, which allows a 2-out-of-3 coincidence to be formed. For M2/M3 wheels, four groups of two ASD Boards are served by each SLB and a 3-out-of-4 coincidence is made.

The PS-Pack, which consists of PP and SLB, are placed on the accessible surfaces of the TGC wheels. Thus, PS-Pack for the M2 and M3 are mounted on the outer surface of the M3 wheel and those for the M1 are mounted on the inner surface of the M1 wheel.

The powers of PS-Packs are about 185W/set for doublet and 80W/set for triplet. Total power of PS-Pack is 13kW which will most transfer into heat. A cooling system is needed for removing heat. The double U-shape coolant pipe system has designed for cooling the PS-Pack. The cooling pipes made of Al is used not only as cooping pipes and but also as support bars for the PS-Pack. Low voltage is supplied by LV bus which consists of 4 wires (3.3V, ±3V and common ground) as shown in Fig.2.

The total number of electronic channels in the TGC system is 321k. The details of the channel distribution over the four sub-wheels are given in Table 1. Table 2 gives the total number of channels, ASD Boards and SLBs for a set (1/24), octant, one side and both sides.

There are 35 SLBs per set for the doublet, 23 SLBs for the triplet and 2 SLBs for the inner wheel. In order to reduce physical size of a PS-Pack, a high-density connector (KEL, 8830E-080-170L) is used at the PP board. With this connector, the length of a sub-PS-Pack can be designed to be 510 mm. Because the avairable radial length on the outer surface of M3 wheel is only 6000 mm, we arrange the PS-Pack in two layers construction. It occupies 5000 mm in length including Service PP board. We arrange all sub-PS-Packs in one-line configuration so that other service systems such as LV supply and cooling system can be simply in construction.

For the PS-Pack of triplet, it is a bit more complex than that of doublets because the support bar of TGC limits the avairable length on the inner surface of M1 wheel. The total usable radial length is 2500 mm, however, we need 3200 mm to arrange all sub-PS-Packs for M1 in one-line. We still designed all sub-PS-Pack units in one line which is based on the assumption that the support bar can be moved to the center of two TGCs by about 100 mm which can increase the available length to 3200 mm.

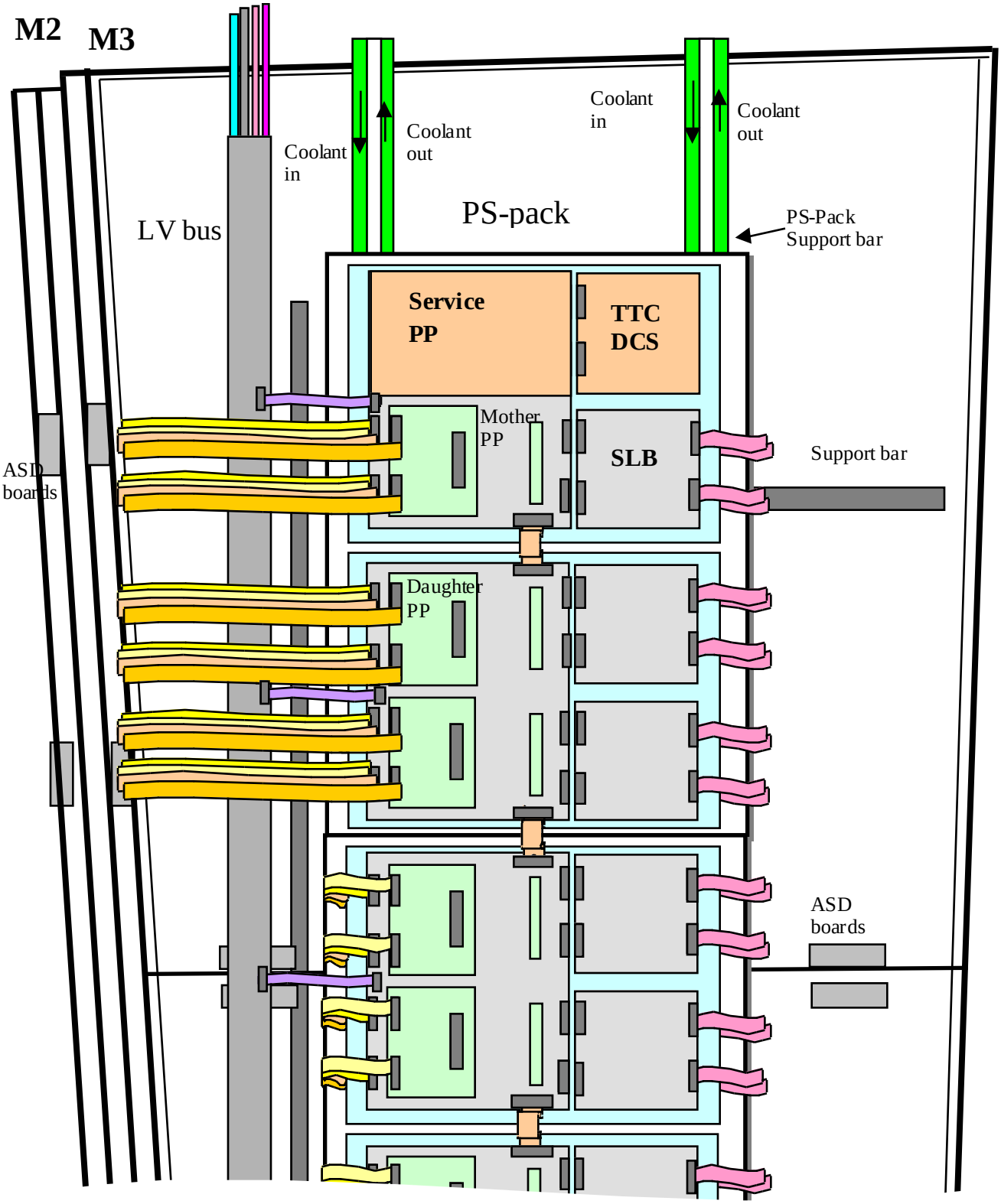


Fig.2 PS-Pack system

Table 1 The number of Channels, ASD chip, ASD Board, PP and SLB

M2+M3			(1/48)			one set(1/24)				
	Channel	ASD chip	ASD Board	PP	SLB	Channel	ASD chip	ASD Board	PP	SLB
EW	1214	306	78	5	10	2428	612	156	10	20
FW	506	128	32	2	4	506	128	32	2	4
ES	640	160	40	3	5	1280	320	80	6	10
FS	128	32	8	1	1	128	32	8	1	1
Total	2488	626	158	11	20	4342	1092	276	19	35
M1										
EW	606	153	42	4	7	1212	306	84	8	14
FW	335	84	21	2	4	335	84	21	2	4
ES	256	64	16	1	2	512	128	32	2	4
FS	64	16	4	1	1	64	16	4	1	1
Total	1261	317	83	8	14	2123	534	141	13	23
Inner										
	One set					Octant				
	Channel	ASD chip	ASD Board	PP	SLB*	Channel	ASD chip	ASD Board	PP	SLB
EW	32	8	2	1	1/2	96	24	6	2	3/2
FW	64	16	4	1	1/2	192	48	12	2	3/2
ES	64	16	4	1	1/2	192	48	12	1	3/2
FS	64	16	4	1	1/2	192	48	12	1	3/2
Total	224	56	14	4	2	672	168	42	6	6

* For Inner wheel, each TGC has a slave board, that is, it combines wires and strips in one SLB.

Table 2 The number of channels, ASD Board and SLB

	One set			Octant			One side			Two side		
	Channel	ASD Board	SLB	Channel	ASD Board	SLB	Channel	ASD Board	SLB	Channel	ASD Board	SLB
M1	2123	141	23	6369	423	69	50952	3384	552	101904	6768	1104
M2+M3	4342	276	35	13026	828	105	104208	6624	840	208416	13248	1680
Inner	224	14	2	672	42	6	5376	336	48	10752	672	96
Total	6689	431	60	20067	1293	180	160536	10344	1440	321072	20688	2880

2 Connection between ASD and PS-Pack

2.1 ASD connector name

As have given above, each PS-Pack set which is a 1/24 of a wheel, contains 141 ASD boards for triplet and 276 ASD boards for doublet. For triplet, middle layer (TGC1) has 35 connectors and two sides (TGC0 and TGC2) both have 53 connectors because there is not strip output in the middle layer. For doublet, there are 70 connectors per layer for M2 and 68 connectors per layer for M3. In order to make a distinction for different ASD boards, we name each connector of ASD boards as shown in Table 3.

TGCs were installed on both sides of ATLAS with a mirror structure as shown in Fig.3. We use "A" to present the TGCs which located in positive Z region and "C" present the TGCs located in negative Z region. We use M1, M2 and M3 to present the three wheels. M1 is a triplet consisting of A, B and C layers. M2 and M3 are doublet consisting of A and B layers. Each name of ASD connector for 1/24 wheel is shown in Fig.4 and Fig.5 for triplet and doublet, respectively.

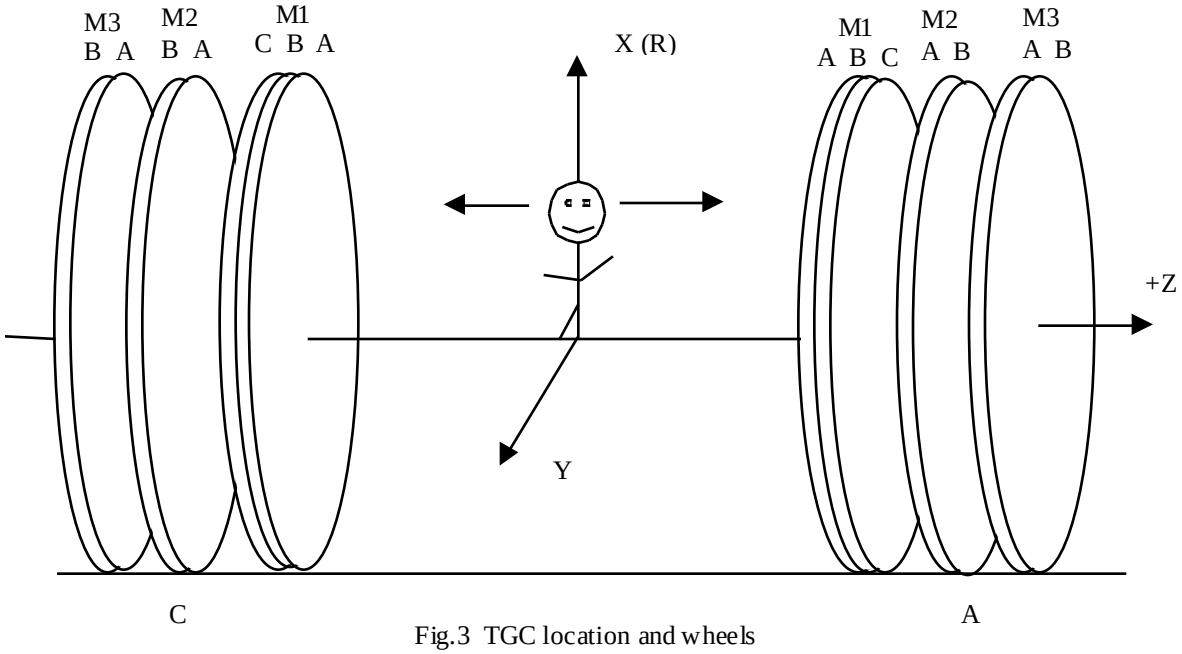


Fig.3 TGC location and wheels

Table 3 ASD connector naming

ASD	A/C	Wheel	E/F	ϕ	Layer	W/S	number
	Side	1=M1	E=End-cape	division	A,B for	W=wires	From 00 to
	A=+z	2=M2	F=Forward	0-23 for F	doublet	S=Strip	maximum with
	C=-z	3=M3		0-47 for E	A,B,C for		R decreased
		4=I			triplet		

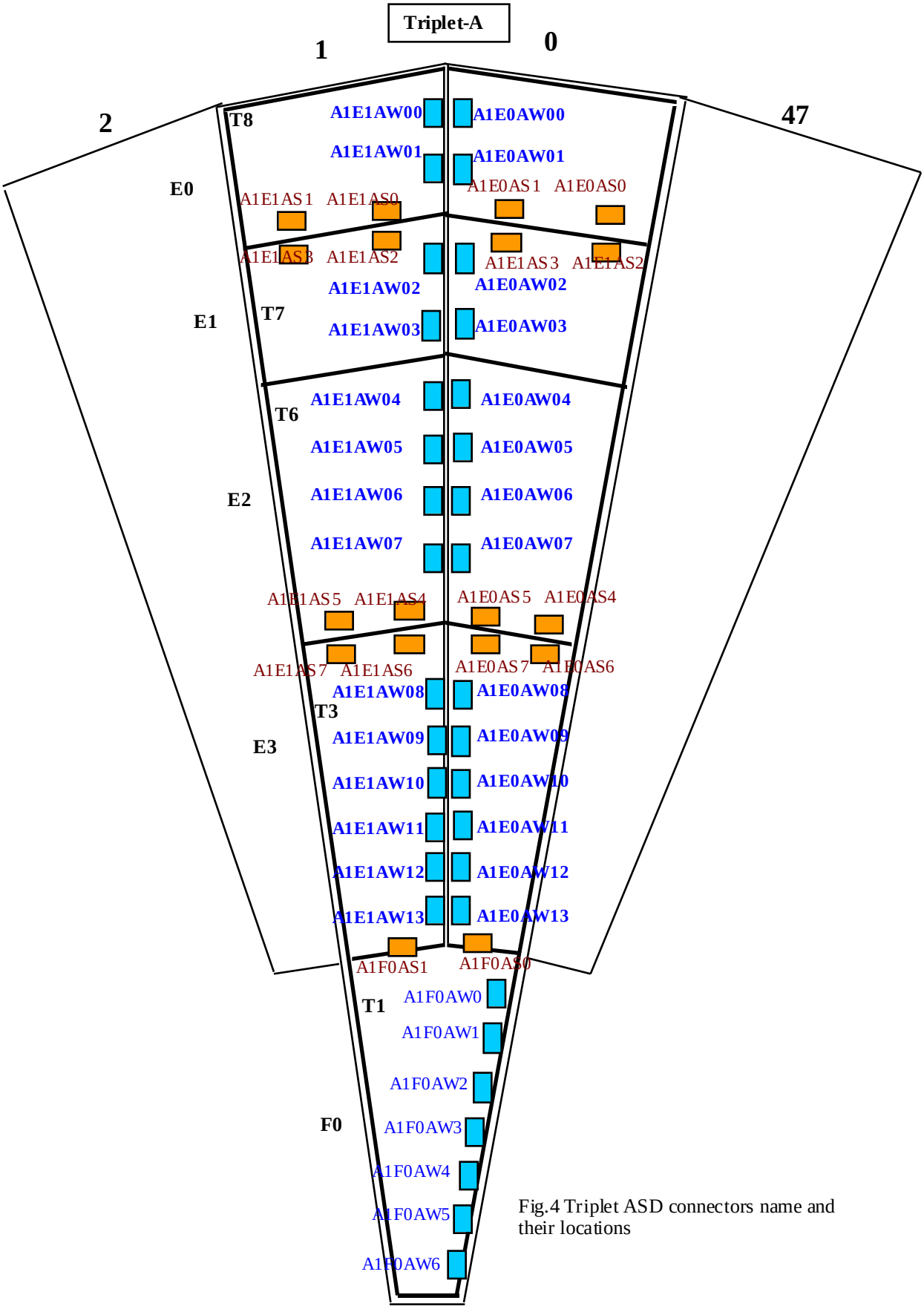


Fig.4 Triplet ASD connectors name and their locations

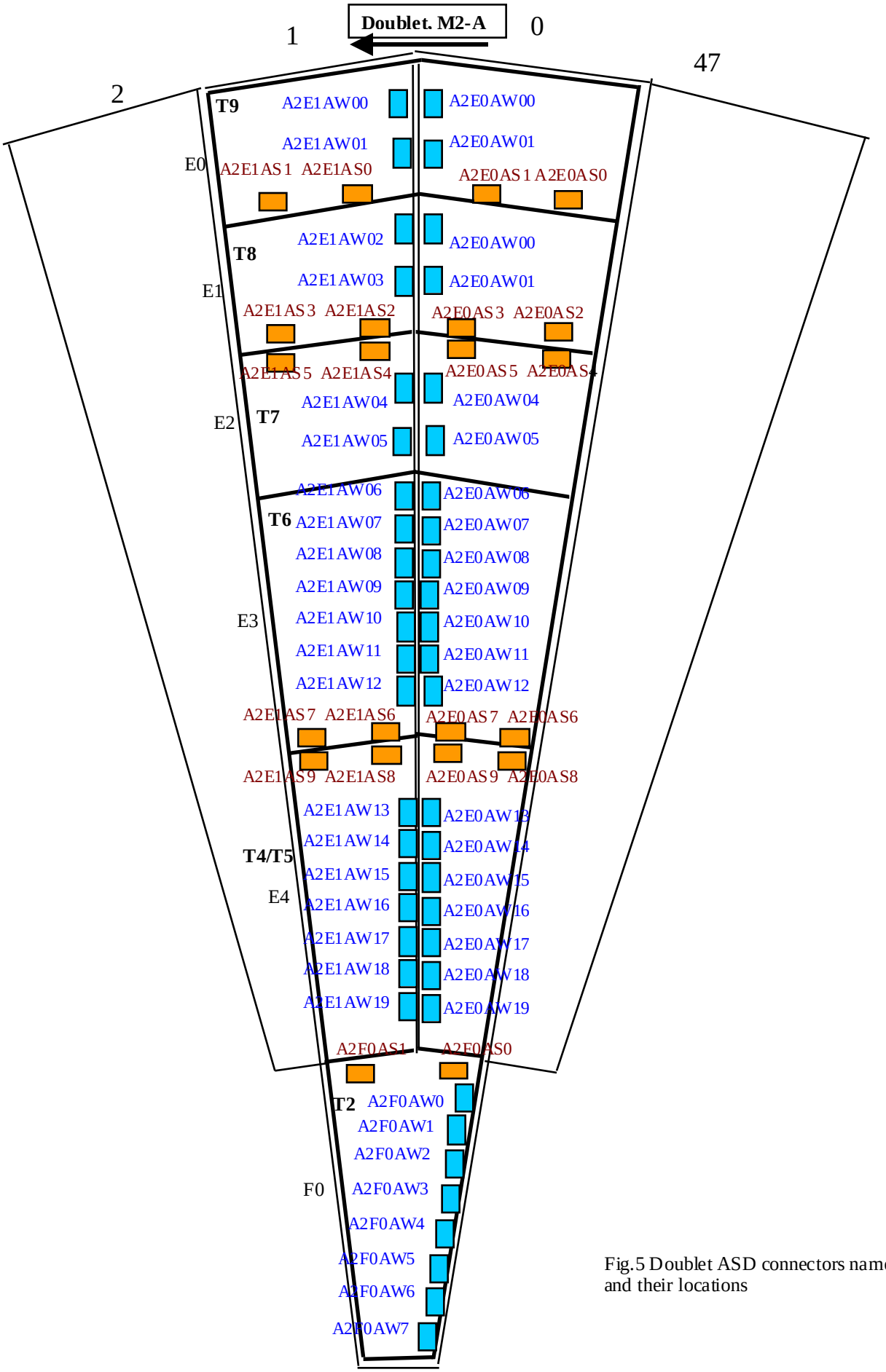


Fig.5 Doublet ASD connectors name and their locations

2.2 Sub-PS-Pack names and arrangement

Patch Panels and Slave Boards are assembled into PS-Pack. There are two kinds of PS-Pack: one is for the triplet (mounted on the surface of M1 wheel) and another is for the doublet(M2 and M3, mounted on the surface of M3 wheel). All sub-PS-Packs for 1/24 unit were arranged as two layers (upper and bottom layers). In order to predigest the support scheme and cooling system, all sub-PS-Packs are arranged in one-line structure. Total length of a PS-Pack is 3.2m for triplet and is 5.0m for doublet, respectively. Total numbers of PS-Packs are 24,24 and 8 for triplet, doublet and inner wheel. Their names are given in Table 4.

Table 4 PS-Pack naming

PS-Pack	A/C	D/T/I	set
	Side	D=Doublet	For D and T, set number is 0 to 23
	A:+z	T=Triplet	
	C: -z	I=Inner	For I, octant number is 0-7

Patch Panel names are shown in Table 5 according the E/F, ϕ, W/S, D/T/I and number orderly. Slave Boards names are almost same as PP names except for the number as shown in Table 6. At most situations, one PP board corresponds to two SLBs. An exceptions exist for a PP only with a SLB. Fig.6 and Fig.7 show all Patch Panels and Slave Boards names for AT0 and AD0 sets PS-Packs.

Table 5 Patch Panel naming

Patch Panel	E/F	ϕ	W/S	D/T/I	number
	E=End-cape	Set	W=Wires	D=Doublet	Running from 0 to
	F=Forward	0-23 for F	S=Strips	T=Triplet	maximum
		0-47 for E		I=Inner	

Table 6 Slave Boards naming

Slave Boards	E/F	ϕ	W/S	D/T/I	number
	E=End-cape	Set	W=Wires	D=Doublet	Running from 0 to
	F=Forward	0-23 for F	S=Strips	T=Triplet	maximum
		0-47 for E		I=Inner	

Triplet example

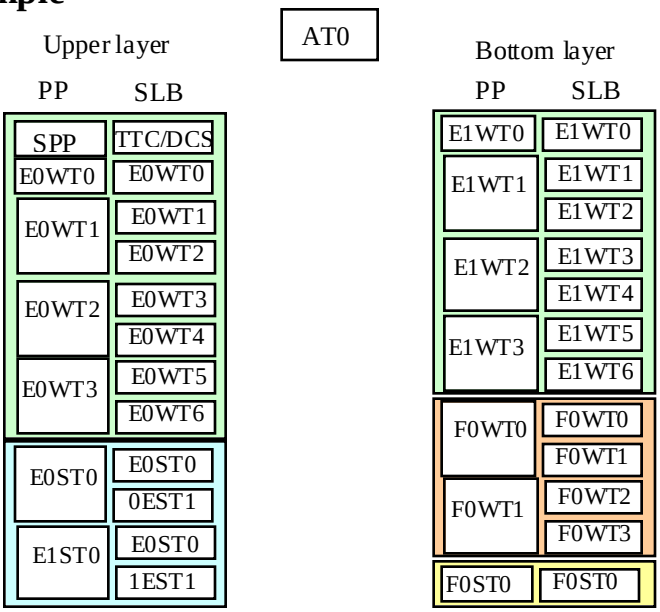


Fig.6 Sub-PS-Pack location name for PP and SLB for Triplet

Doublet example

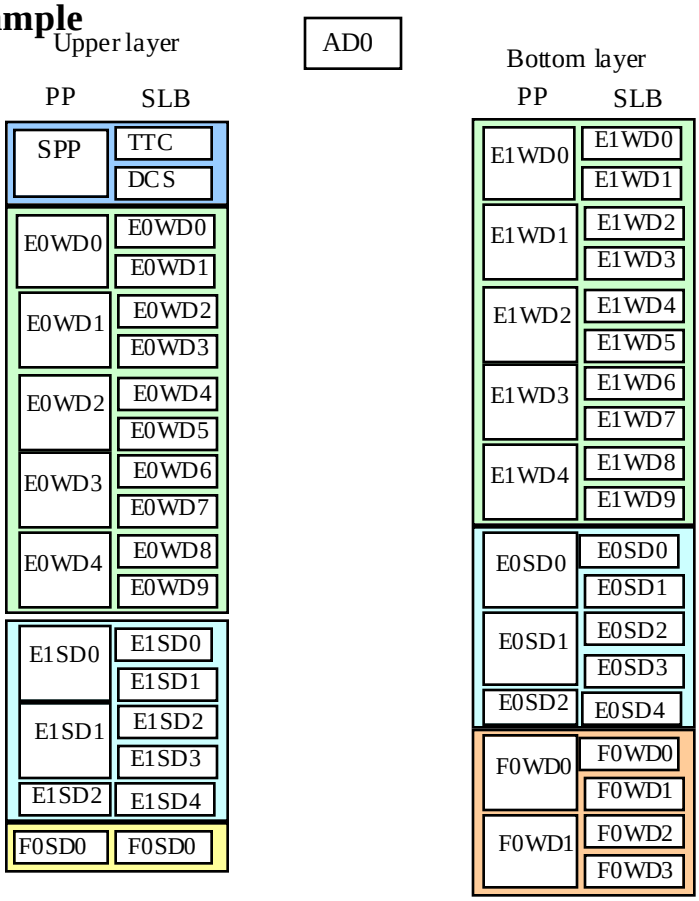


Fig. 7 Sub-PS-Pack location name for PP and SLB for Doublet

2.3 PP Connectors names

As mentioned before, each PP has two layers: one mother PP and two daughter PPs. Each mother PP has 4 high density connectors (one exception exists in doublet mother PP with 5 connectors) and each daughter has 2 high density connectors. In order to distinguish each connector in the same PP board, we give names to the connectors as shown in Fig.8.

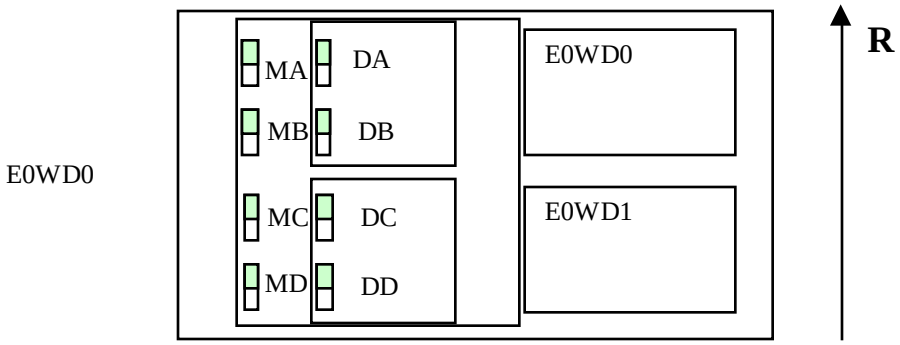


Fig.8 PP connector's names

The connector named to be E0WD0-MA, for example, is the first connector (R is larger than others connectors in same PP) on the mother PP for the Patch Panel E0WD0 and also E0WD0-DC is the third connector on the daughter PP for the same PP. Since each PP connector connects to 2 ASD-board connectors, we have to distinguish the different part of in one connector. Upper part (R is larger, the green part in Fig.8) can be signed as 1 and bottom part as 2. Therefore, connector DA1 means the upper part of connector DA.

2.4 Connection between ASD boards and PP

The 16-ch ASD Board has designed and built for both wire signals and strip signals from TGCs. Each board contains 4 ASD ICs with protection circuits. The ASD borad is directory attached to the TGC chamber. The ASD Board design is common for all TGC chambers. 16 LVDS logic signal outputs from the ASD Board are transmitted through a 20-pair twisted-pair cable from an ASD board. An amplified analog output through a LEMO type connector is equiped for each ASD. DC power, ground, threshold voltage and test pulse are supplied to the ASD Board by the same twisted-pair cable.

Each PP board consists of one mother PP and two daughters PPs (in some case one PP board consists of one mother PP and one daughter PP in order to save space). High density connectors are used as the connectors which receive signal from ASD Board in both mother and daughter PP. Each PP connector responds to two ASD boards by the twisted-pair cable. The connection between ASD

Board and PP Board has two kinds of scheme: one is common connection and another is special connection scheme which is a exception of common connection. Fig.9 and Fig.11 are the common connection scheme for doublet and triplet, respectively. Fig.10 and Fig. 12 are two special connection for doublet and triplet, respectively. All ASD connector connected to PP connector is one by one as shown in Tables 8-11 for doublet and triplet.

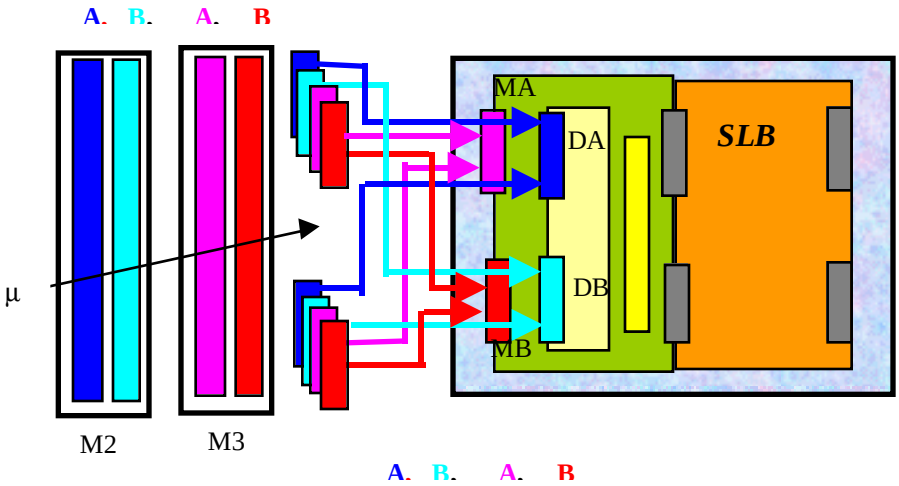


Fig.9 Normal connection between TGC connectors and PP connectors for doublet

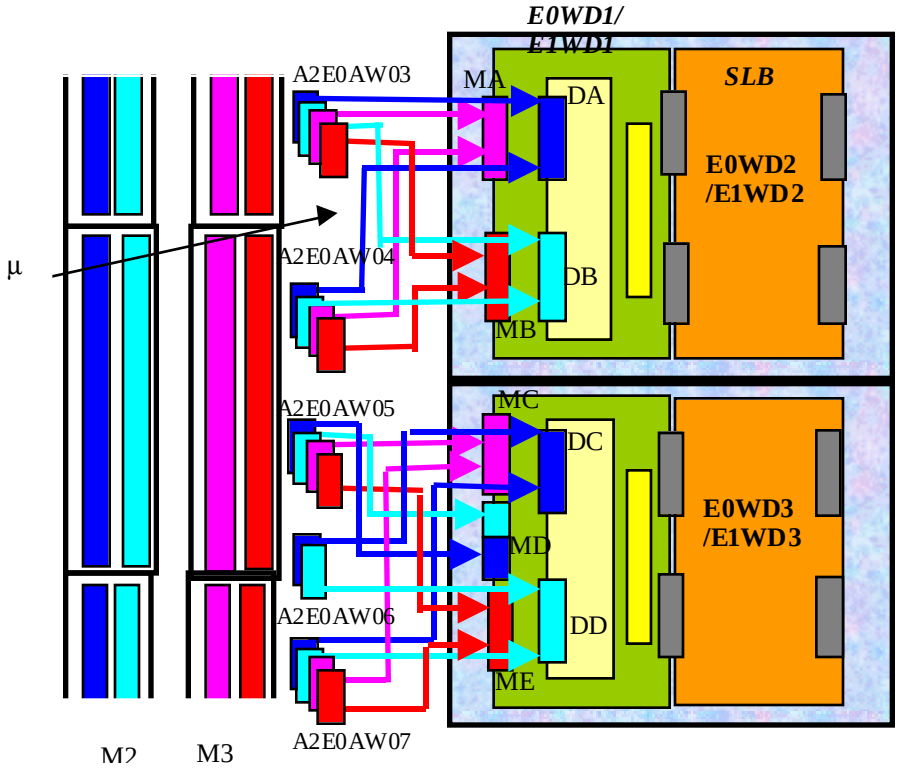


Fig.10 An exception for the doublet PP board with three connectors

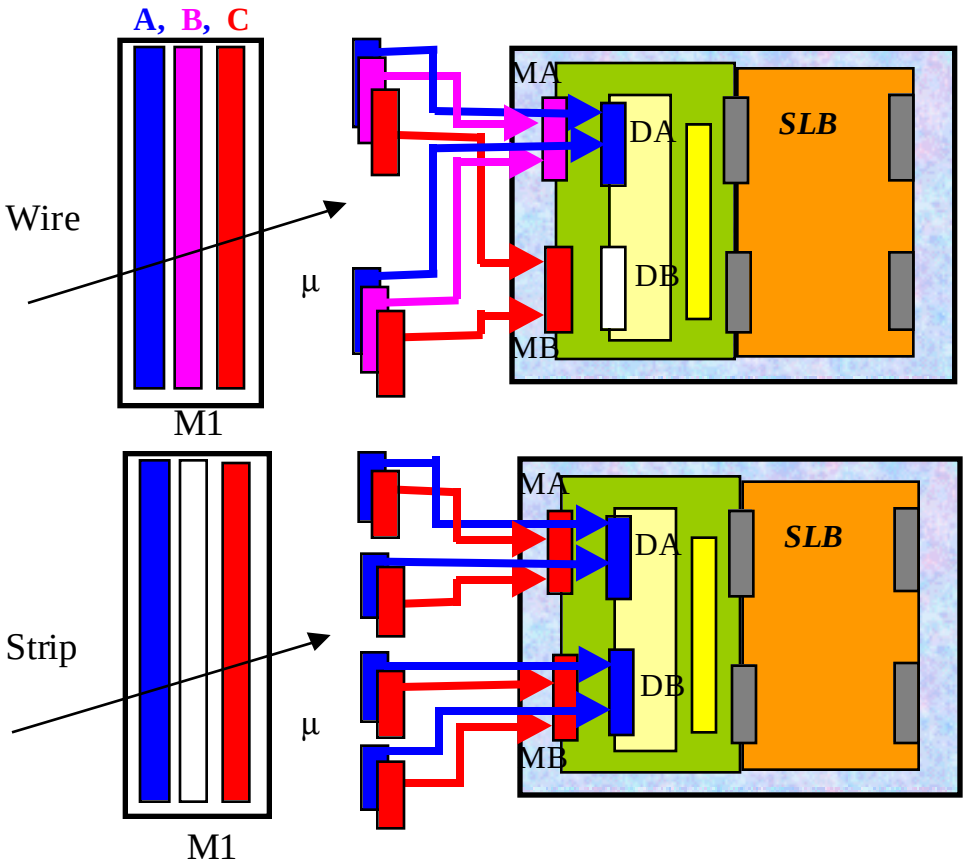


Fig.11 Normal connection between theASD connectors and PP connectors for the triplet

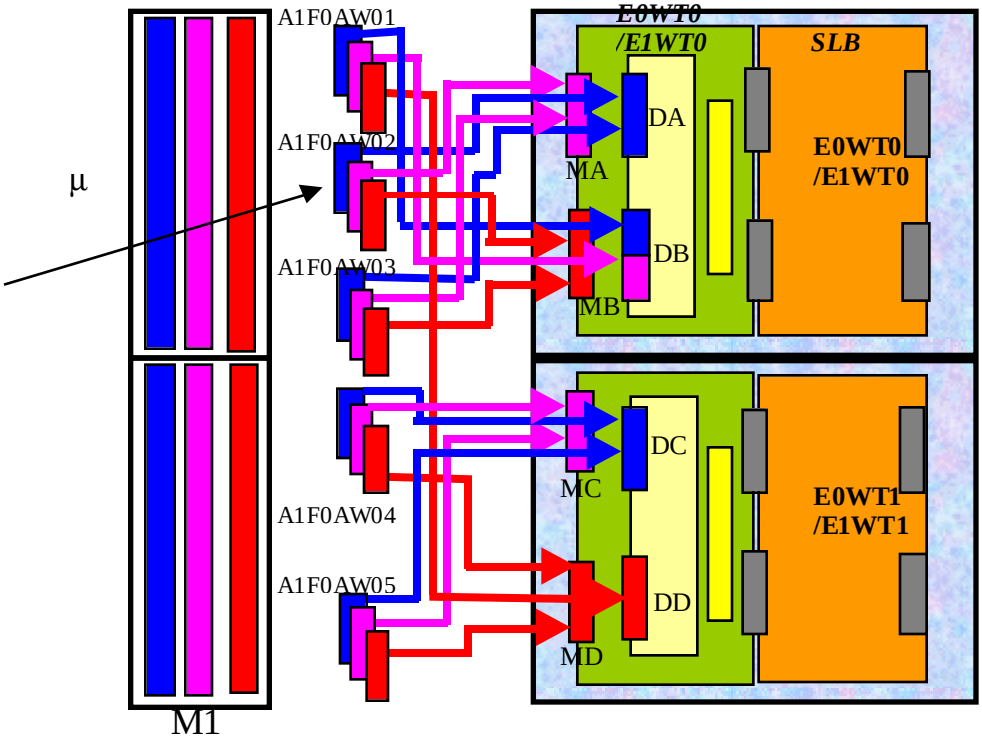


Fig.12 An exception for triplet PP board

Table 8 Connection between ASD connectors and PP connectors for Doublet Endcap wires

PP name			ASD name		PP name			ASD name
E0WD0	Daughter PP	DA1	A2E0AW00		E0WD3	Daughter PP	DA1	A2E0AW12
		DA2	-				DA2	A2E0AW13
		DB1	A2E0BW00				DB1	A2E0BW12
		DB2	-				DB2	A2E0BW13
		DC1	A2E0AW01				DC1	A2E0AW14
		DC2	A2E0AW02				DC2	A2E0AW15
		DD1	A2E0BW01				DD1	A2E0BW14
		DD2	A2E0BW02				DD2	A2E0BW15
	Mother PP	MA1	A3E0AW00			Mother PP	MA1	A3E0AW12
		MA2	-				MA2	A3E0AW13
		MB1	A3E0BW00				MB1	A3E0BW12
		MB2	-				MB2	A3E0BW13
		MC1	A3E0AW01				MC1	A3E0AW14
		MC2	A3E0AW02				MC2	A3E0AW15
		MD1	A3E0BW01				MD1	A3E0BW14
		MD2	A3E0BW02				MD2	A3E0BW15
E0WD1	Daughter PP	DA1	A2E0AW03		E0WD4	Daughter PP	DA1	A2E0AW16
		DA2	A2E0AW04				DA2	A2E0AW17
		DB1	A2E0BW03				DB1	A2E0BW16
		DB2	A2E0BW04				DB2	A2E0BW17
		DC1	A2E0AW06				DC1	A2E0AW18
		DC2	A2E0AW07				DC2	A2E0AW19
		DD1	A2E0BW06				DD1	A2E0BW18
		DD2	A2E0BW07				DD2	A2E0BW19
	Mother PP	MA1	A3E0AW03			Mother PP	MA1	A3E0AW16
		MA2	A3E0AW04				MA2	A3E0AW17
		MB1	A3E0BW03				MB1	A3E0BW16
		MB2	A3E0BW04				MB2	A3E0BW17
		MC1	A3E0AW05				MC1	A3E0AW18
		MC2	A3E0AW07				MC2	A3E0AW19
		MD1	A2E0AW05				MD1	A3E0BW18
		MD2	A2E0BW05				MD2	A3E0BW19
		ME1	A3E0BW05					
		ME2	A3E0BW07					
E0WD2	Daughter PP	DA1	A2E0AW08					
		DA2	A2E0AW09					
		DB1	A2E0BW08					
		DB2	A2E0BW09					
		DC1	A2E0AW10					
		DC2	A2E0AW11					
		DD1	A2E0BW10					
		DD2	A2E0BW11					
	Mother PP	MA1	A3E0AW08					
		MA2	A3E0AW09					
		MB1	A3E0BW08					
		MB2	A3E0BW09					
		MC1	A3E0AW10					
		MC2	A3E0AW11					
		MD1	A3E0BW10					
		MD2	A3E0BW11					

* There is no A3E0A(B)W06 connectors

Table 9 Connection between ASD and PP for doublet for Forward Strip/Wire and Endcap Strip

PP name			ASD name		PP name			ASD name
F0WD0	Daughter PP	DA1	A2F0AW0		E0SD0	Daughter PP	DA1	A2E0AS0
		DA2	A2F0AW1				DA2	A2E0AS1
		DB1	A2F0BW0				DB1	A2E0BS0
		DB2	A2F0BW1				DB2	A2E0BS1
		DC1	A2F0AW2				DC1	A2E0AS2
		DC2	A2F0AW3				DC2	A2E0AS3
		DD1	A2F0BW2				DD1	A2E0BS2
		DD2	A2F0BW3				DD2	A2E0BS3
	Mother PP	MA1	A3F0AW0			Mother PP	MA1	A3E0AS0
		MA2	A3F0AW1				MA2	A3E0AS1
		MB1	A3F0BW0				MB1	A3E0BS0
		MB2	A3F0BW1				MB2	A3E0BS1
		MC1	A3F0AW2				MC1	A3E0AS2
		MC2	A3F0AW3				MC2	A3E0AS3
		MD1	A3F0BW2				MD1	A3E0BS2
		MD2	A3F0BW3				MD2	A3E0BS3
F0WD1	Daughter PP	DA1	A2F0AW4		E0SD1	Daughter PP	DA1	A2E0AS4
		DA2	A2F0AW5				DA2	A2E0AS5
		DB1	A2F0BW4				DB1	A2E0BS4
		DB2	A2F0BW5				DB2	A2E0BS5
		DC1	A2F0AW6				DC1	A2E0AS6
		DC2	A2F0AW7				DC2	A2E0AS7
		DD1	A2F0BW6				DD1	A2E0BS6
		DD2	A2F0BW7				DD2	A2E0BS7
	Mother PP	MA1	A3F0AW4			Mother PP	MA1	A3E0AS4
		MA2	A3F0AW5				MA2	A3E0AS5
		MB1	A3F0BW4				MB1	A3E0BS4
		MB2	A3F0BW5				MB2	A3E0BS5
		MC1	A3F0AW6				MC1	A3E0AS6
		MC2	A3F0AW7				MC2	A3E0AS7
		MD1	A3F0BW6				MD1	A3E0BS6
		MD2	A3F0BW7				MD2	A3E0BS7
F0SD0	Daughter PP	DA1	A2F0AS0		F0SD0	Daughter PP	DA1	A2E0AS8
		DA2	A2F0AS1				DA2	A2E0AS9
		DB1	A2F0BS0				DB1	A2E0BS8
		DB2	A2F0BS1				DB2	A2E0BS9
	Mother PP	MA1	A3F0AS0			Mother PP	MA1	A3E0AS8
		MA2	A3F0AS1				MA2	A3E0AS9
		MB1	A3F0BS0				MB1	A3E0BS8
		MB2	A3F0BS1				MB2	A3E0BS9

Table 10 Connection between ASD connectors and PP connectors for Triplet

PP name			ASD name		PP name			ASD name
E0WT0	Daughter PP	DA1	A1E0AW00		F0ST0	Daughter PP	DA1	-
		DA2	-				DA2	-
		DB1					DB1	-
		DB2	-				DB2	-
	Mother PP	MA1	A1E0BW00			Mother PP	MA1	A1F0AS0
		MA2	-				MA2	A1F0AS1
		MB1	A1E0CW00				MB1	A1F0CS0
		MB2	-				MB2	A1F0CS1
E0WT1	Daughter PP	DA1	A1E0AW02		E0ST0	Daughter PP	DA1	A1E0AS0
		DA2	A1E0AW03				DA2	A1E0AS1
		DB1	A1E0AW01				DB1	A1E0CS0
		DB2	A1E0BW01				DB2	A1E0CS1
		DC1	A1E0AW04				DC1	A1E0AS4
		DC2	A1E0AW05				DC2	A1E0AS5
		DD1	A1E0CW01				DD1	A1E0CS4
		DD2	-				DD2	A1E0CS5
	Mother PP	MA1	A1E0BW02			Mother PP	MA1	A1E0AS2
		MA2	A1E0BW03				MA2	A1E0AS3
		MB1	A1E0CW02				MB1	A1E0CS2
		MB2	A1E0CW03				MB2	A1E0CS3
		MC1	A1E0BW04				MC1	A1E0AS6
		MC2	A1E0BW05				MC2	A1E0AS7
		MD1	A1E0CW04				MD1	A1E0CS6
		MD2	A1E0CW05				MD2	A1E0CS7
E0WT2	Daughter PP	DA1	A1E0AW06		F0WT0	Daughter PP	DA1	A1F0AW0
		DA2	A1E0AW07				DA2	A1F0AW1
		DB1	-				DB1	-
		DB2	-				DB2	-
		DC1	A1E0AW08				DC1	A1F0AW2
		DC2	A1E0AW09				DC2	A1F0AW3
		DD1	-				DD1	-
		DD2	-				DD2	-
	Mother PP	MA1	A1E0BW06			Mother PP	MA1	A1F0BW0
		MA2	A1E0BW07				MA2	A1F0BW1
		MB1	A1E0CW06				MB1	A1F0CW0
		MB2	A1E0CW07				MB2	A1F0CW1
		MC1	A1E0BW08				MC1	A1F0BW2
		MC2	A1E0BW09				MC2	A1F0BW3
		MD1	A1E0CW08				MD1	A1F0CW2
		MD2	A1E0CW09				MD2	A1F0CW3
E0WT3	Daughter PP	DA1	A1E0AW10		F0WT1	Daughter PP	DA1	A1F0AW4
		DA2	A1E0AW11				DA2	A1F0AW5
		DB1	-				DB1	-
		DB2	-				DB2	-
		DC1	A1E0AW12				DC1	A1F0AW6
		DC2	A1E0AW13				DC2	-
		DD1	-				DD1	-
		DD2	-				DD2	-
	Mother PP	MA1	A1E0BW10			Mother PP	MA1	A1F0BW4
		MA2	A1E0BW11				MA2	A1F0BW5
		MB1	A1E0CW10				MB1	A1F0CW4
		MB2	A1E0CW11				MB2	A1F0CW5
		MC1	A1E0BW12				MC1	A1F0BW6
		MC2	A1E0BW13				MC2	-
		MD1	A1E0CW12				MD1	A1F0CW6
		MD2	A1E0CW13				MD2	-

2.4 Mount scheme and cable route

The TGC system consists of two sides, A and C, which are mirror images of each other. The ASD Boards in TGC's edges are also different location as shown in Fig.13. We have considered this difference in the design of PS-Pack in order to decrease the cable length. Two kinds of PS-Pack were designed to meet the requirement for A and C sides: normal PS-Pack and upside-down PS-Pack as shown in Fig.14. In this case, about 1 ton flat cable can be reduced.

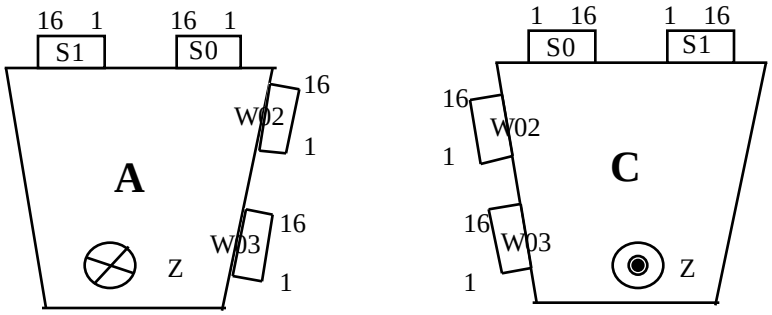


Fig.13 The location of ASD boards in TGC edge for A and C sides, looking at the TGC from the interaction.

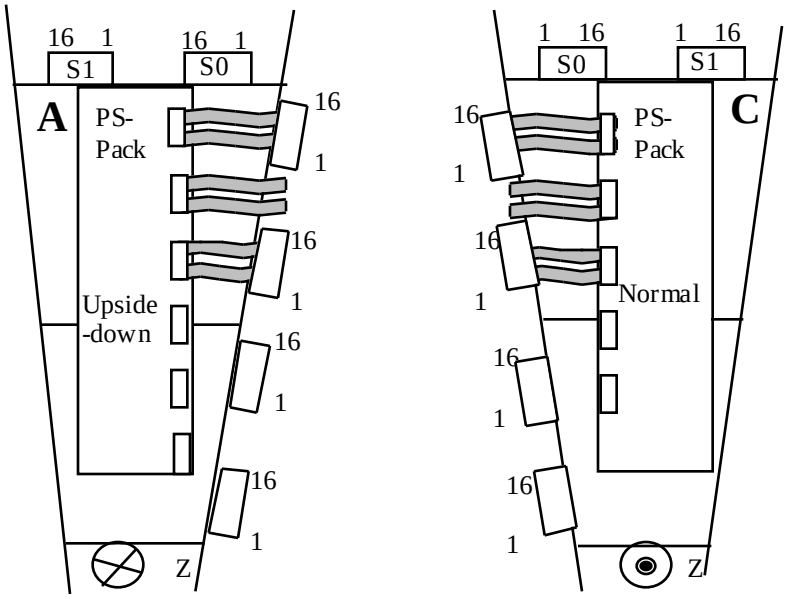


Fig. 14 Two kinds of PS-Pack schemes for both A and C sides, looking at the TGC from the interaction.

PS-pack located in the surface of M1 and M3. Total length is 5m and 3.2m for doublet and triplet as shown in Fig.15. The cooling pipe which has two parallel holes inside for coolant as shown in Fig.16 is also used as support bar of the PS-Pack. Additional 4 bars for support PS-Pack on the surface of TGC are needed for doublet and 3 bars for triplet. These additional bars are fixed with TGC support frames.

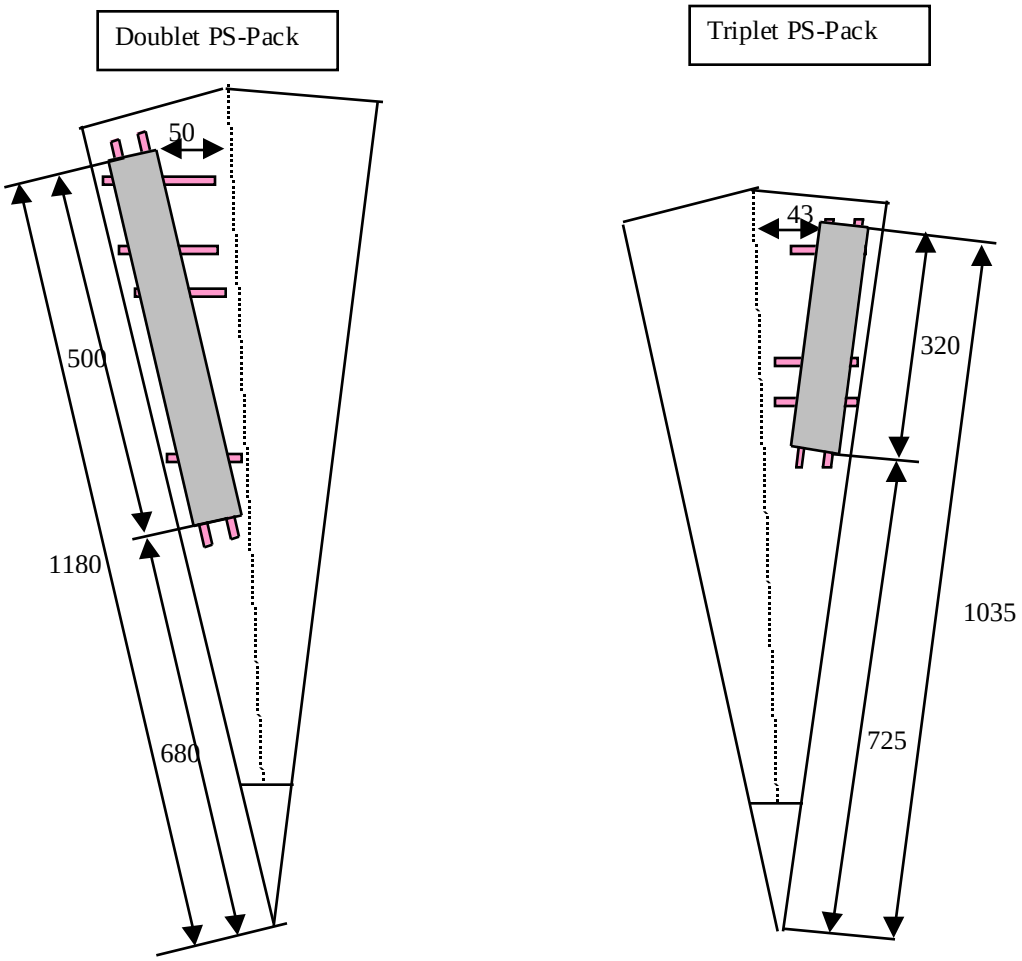


Fig.15 The location of PS-Pack in the 1/24 set

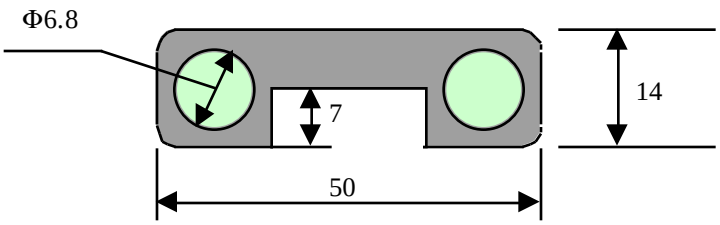


Fig.16 Cross section of the cooling pipe made of Al.

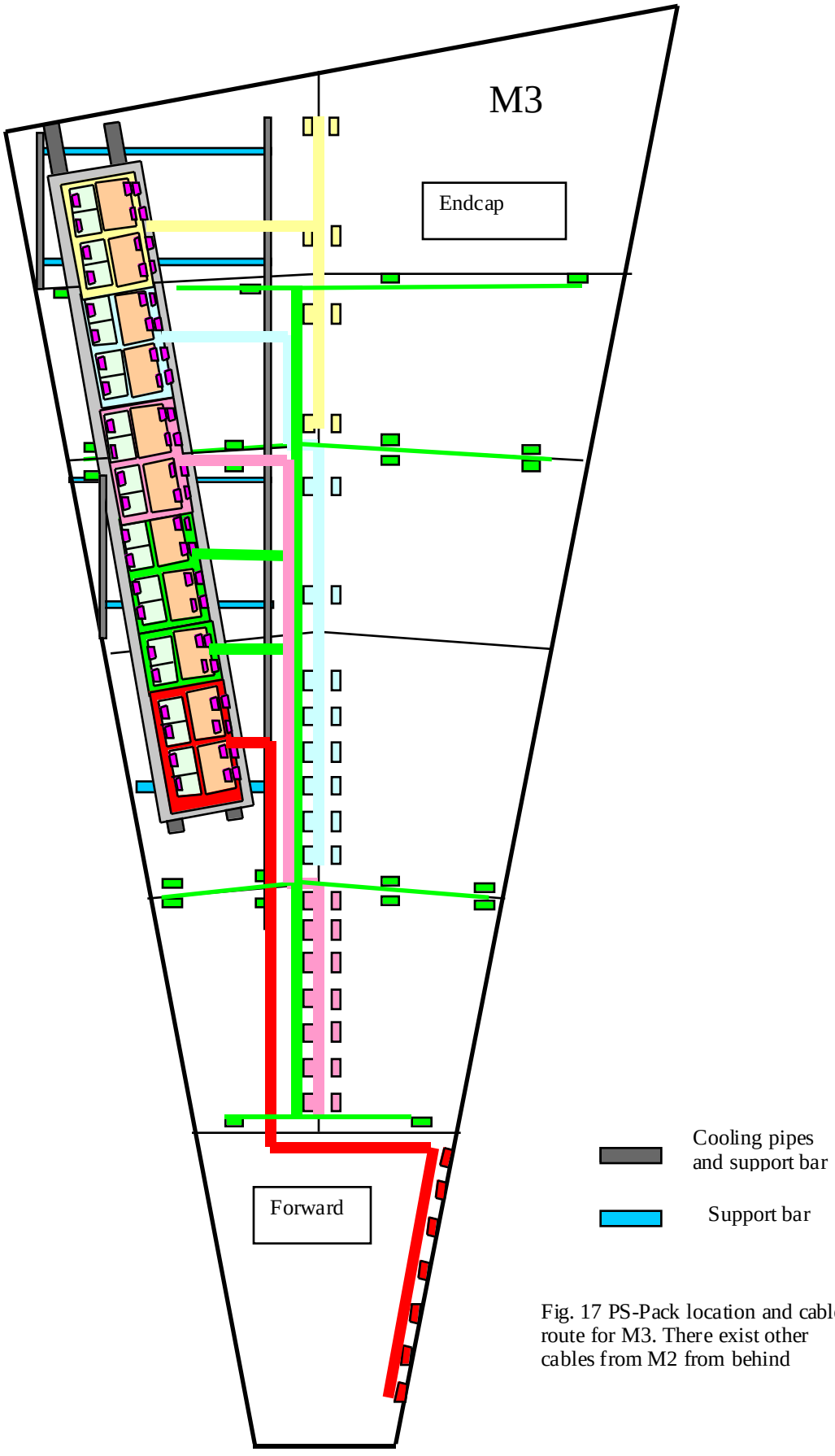


Fig. 17 PS-Pack location and cable route for M3. There exist other cables from M2 from behind

Each PP connector receives wire and strip signals which come from different ASD Board by flat cables. The connection relation between PP connector and ASD board is shown in tables 8-10. The length of each flat cable has been estimated according to both locations of PP connector and ASD Board as shown in Appendix. Fig.17 shows the cable route for 1/24 of M3 wheel and Fig18 shows a cable connection between M2 and M3 wheels. The cables from M2 wheel are grouped in a few groups. Some cable support bars are needed for fixing the cable as shown in Fig.18 between M2 and M3.

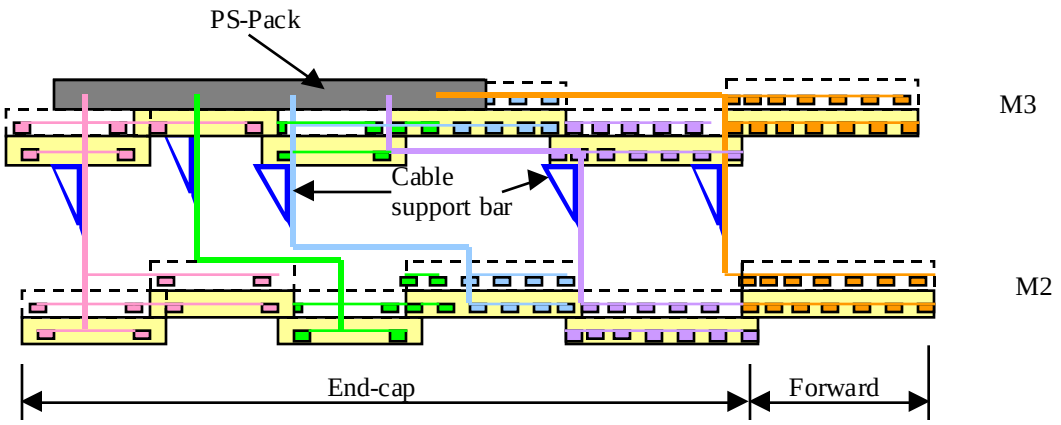


Fig.18 Cable route between M2 and M3

3. Cable length, weight and time delay

3.1 Cable length and weight

Cable weight is a very important factor for the design of the big wheel. We suppose that it uses flat cable without shielding. The weight of flat cable with 40-wires is 0.2kg per meter. According to the positions of the ASD connector and the PP connector, we can estimate each length of the cable and also the total length though. Table11 shows the length of cables for one PS-Pack set, one side and total. If we consider that about 10% additional cable is required for installing in turning the corner. The total length of flat cable is about 70 km and 14 tons. The length of the cable for each ASD connector link to PP connector is given in Appendix.

Table 11 Length and weight of cable

	one set		one side		In total	
	Length[m]	Weight[kg]	Length[m]	Weight[kg]	Length[m]	Weight[kg]
Doublet	900	180	21598	4320	43195	8639
Triplet	420	84	10072	2014	20145	4029
Total	1320	264	31670	6334	63340	12668

3.2 Time delay

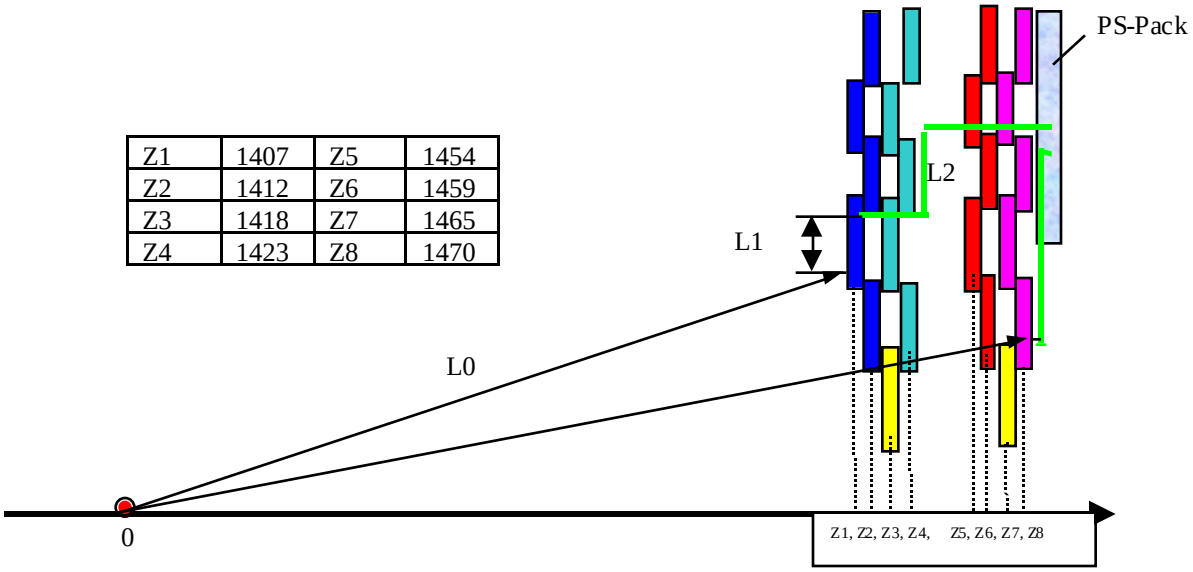
In ATLAS, TGC is chosen for the trigger chamber in the end-cap. It covers the pseudo-rapidity rang $1<\eta<2.4$. TGC has excellent timing resolution providing safe bunch-cross identification, owing to their narrow gap. The trigger system is based on a coincidence between a hit in the last station(M3) and a corresponding hits in the second (M2) or/and first station (M1). The low-p_T trigger formed by a 3 out of 4 coincidence in TGC2 and TGC3. For the high-p_T trigger an additional 2 out of 3 coincidence in the triplet of TGC1 is required.

The arrival timing of a signal at the input of the PP consists of three parts: time of flight (TOF) of particles from colliding point to TGC, signal transfer time from hit point inside of TGC to the edge of TGC along the wire or strip and the signal transfers time in the cable from ASD board to PP. Time delay depends on the position of the hit point, size of TGC and length of cable. Two type of TGCs, doublet and triplet, are located at about 14 m from the interaction point in the beam direction (z). Nine kinds of different TGCs are taken into account for the time calculation. The length of cable from ASD to PP depends on the locations of ASD Board and PP. The arrived time of signal in PP is then expressed as:

$$T=TOF+L_1/v_1+L_2/v_2$$

where $TOF=L_0/v_0$, L_0 is the flight distance from the interaction point to the TGC as shown in Fig.19 and v_0 is particle velocity which is nearly equal to the light velocity , L_1 is wire/strip length from the hit point inside of TGC to ASD Board, v_1 is the propagation velocity of wire signal (27cm/ns) or of strip signal (15 cm/ns), L_2 is the cable length from ASD Board to PP, v_2 is the signal transfer velocity along the cable. In the calculation, a half length of wire/strip for each TGC was assumed. The results are shown in Fig.20 for doublet and Fig.21 for triplet. The arrived time of signal to PP are from 66 ns to 80 ns for doublet and from 65 ns to 82 ns for triplet. The relative delay are shown in Fig.22 for doublet and Fig.23 for triplet.

The timing setup in a PP is very important because the asynchronous TGC signals are bunched by bunch-crossing identification (BCID). The time delay will be adjusted by an adjustable delay with 25 ns in a step 780ps in PP. The cable delay time is also tested by test pulses which generated in PPs, that is, the ASD Boards accepting the test pulses soon return them back to the PPs.



Z1	1407	Z5	1454
Z2	1412	Z6	1459
Z3	1418	Z7	1465
Z4	1423	Z8	1470

Fig.19 Timing calculation scheme in the end-cap.

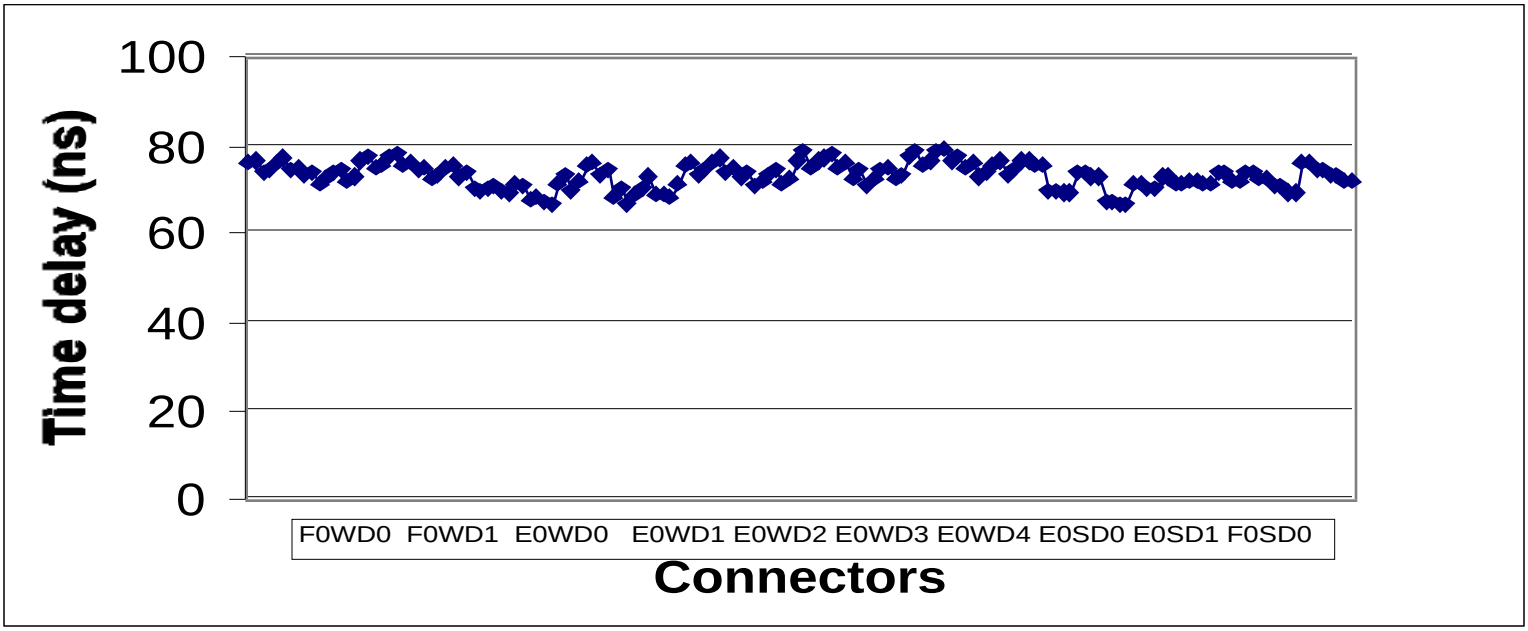


Fig.20 Time delays for each connector for the doublet

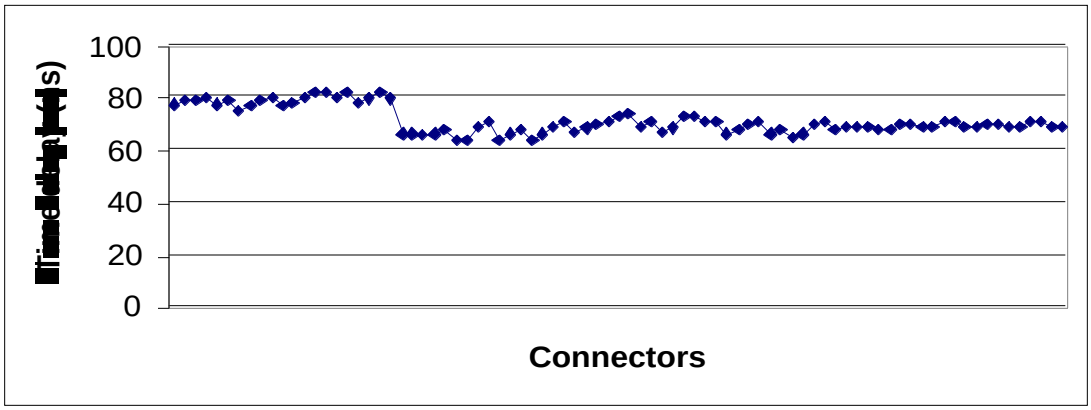


Fig.21 Time delays for each connector for the triplet

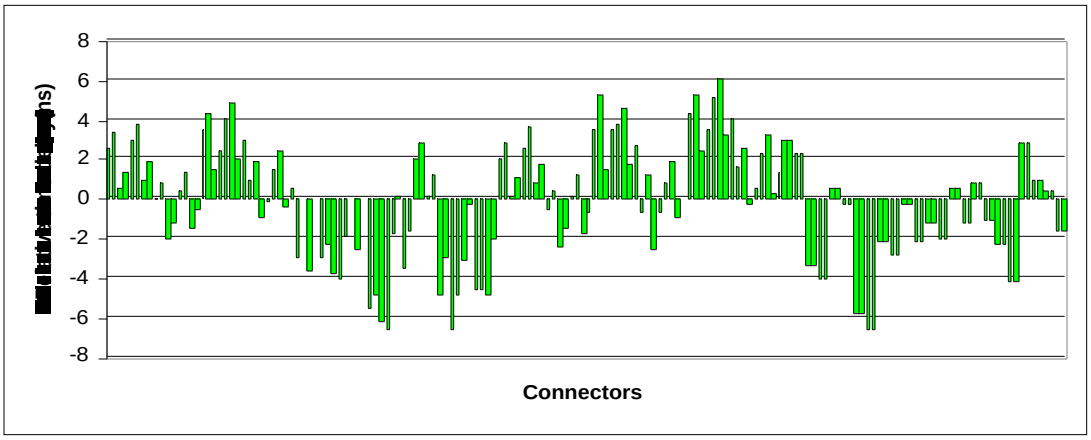


Fig.22 Relative time delays for the doublet

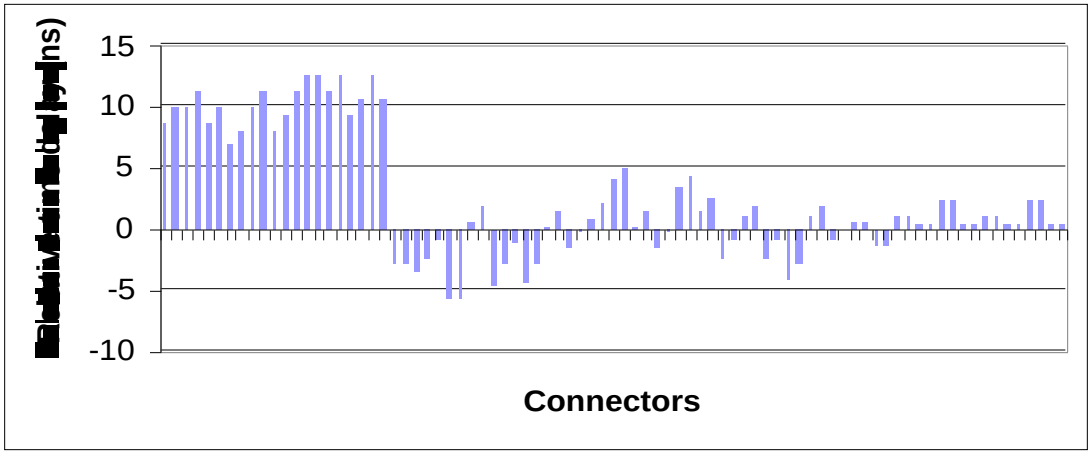


Fig.23 Relative time delays for the triplet

Appendix Minimum length of cable and time delay for triplet

PP name		Position	Conn.	Position	TGC	ASD name	Position	L_2	L_0	L_1	$\Delta T1$ (ns)	$\Delta T2$ (ns)
FoWT0	daughter	843	DA1	848	T1	A1FoAW0	377	524.7	1500	53.7	78.229	8.8142
	PP		DA2	848		A1FoAW1	347	554.7	1493		79.487	10.072
			DB1	838		-	-	-	-		-	-
			DB2	838		-	-	-	-		-	-
		817	DC1	822		A1FoAW2	317	558.7	1486		79.464	10.049
			DC2	822		A1FoAW3	287	588.7	1480		80.76	11.346
			DD1	812		-	-	-	-		-	-
			DD2	812		-	-	-	-		-	-
	Mother	830	MA1	848		A1FoBW0	377	524.7	1500		78.229	8.8142
	PP		MA2	848		A1FoBW1	347	554.7	1493		79.487	10.072
			MB1	838		A1FoCW0	377	514.7	1457		76.278	6.8638
			MB2	838		A1FoCW1	347	544.7	1449		77.529	8.1147
			MC1	822		A1FoBW2	317	558.7	1486		79.464	10.049
			MC2	822		A1FoBW3	287	588.7	1480		80.76	11.346
			MD1	812		A1FoCW2	317	548.7	1442		77.5	8.085
			MD2	812		A1FoCW3	287	578.7	1436		78.79	9.3752
FoWT1	daughter	791	DA1	796	T1	A1FoAW4	257	592.5	1475	53.5	80.759	11.344
	PP		DA2	796		A1FoAW5	228	621.5	1470		82.05	12.635
			DB1	786		-	-	-	-		-	-
			DB2	786		-	-	-	-		-	-
		766	DC1	771		A1FoAW6	200	624.5	1466		82.063	12.649
			DC2	771		-	-	-	-		-	-
			DD1	761		-	-	-	-		-	-
			DD2	761		-	-	-	-		-	-
	Mother	778	MA1	796		A1FoBW4	257	592.5	1475		80.759	11.344
	PP		MA2	796		A1FoBW5	228	621.5	1470		82.05	12.635
			MB1	786		A1FoCW4	257	582.5	1430		78.782	9.368
			MB2	786		A1FoCW5	228	611.5	1425		80.068	10.654
			MC1	771		A1FoBW6	200	624.5	1466		82.063	12.649
			MC2	771		-	-	-	-		-	-
			MD1	761		A1FoCW6	200	614.5	1421		80.078	10.663
			MD2	761		-	-	-	-		-	-
EoWT0	daughter	1000	DA1	1005	T8	A1EoAW00	1038	86.5	1785	74.3	66.572	-2.842
	PP		DA2	1005		-	-	-	-		-	-
			DB1	995		-	-	-	-		-	-
			DB2	995		-	-	-	-		-	-
	Mother	1000	MA1	1005		A1EoBW00	1038	86.5	1785		66.572	-2.842
	PP		MA2	1005		-	-	-	-		-	-
			MB1	995		A1EoCW00	1038	96.5	1748		65.859	-3.556
			MB2	995		-	-	-	-		-	-
EoWT1	daughter	975	DA1	980	T8	A1EoAW02	913	141.3	1715	74.3	66.99	-2.425
	PP		DA2	980		A1EoAW03	863	191.3	1689		68.62	-0.794
			DB1	970		A1EoAW01	975	79.3	1712		63.777	-5.637
			DB2	970		A1EoBW01	975	79.3	1712		63.777	-5.637
		949	DC1	954	T7	A1EoAW04	775	253.3	1646	66.9	70.006	0.5911
			DC2	954		A1EoAW05	738	290.3	1629		71.286	1.8712
			DD1	944		A1EoCW01	975	105.3	1712		64.803	-4.612
			DD2	944		-	-	-	-		-	-
	Mother	962	MA1	980	T7	A1EoBW02	913	141.3	1715	66.9	66.716	-2.699
	PP		MA2	980		A1EoBW03	863	191.3	1689		68.346	-1.068
			MB1	970		A1EoCW02	913	131.3	1677		64.952	-4.463
			MB2	970		A1EoCW03	863	181.3	1651		66.562	-2.852
			MC1	954	T6	A1EoBW04	775	253.3	1646	58.8	69.706	0.2911
			MC2	954		A1EoBW05	738	290.3	1629		70.986	1.5712
			MD1	944		A1EoCW04	775	243.3	1606		67.887	-1.528
			MD2	944		A1EoCW05	738	280.3	1589		69.153	-0.262

EoWT2	doughter	923	DA1	928	T6	A1EoAW0E	700	286.8	1612	58.8	70.249	0.8342
	PP		DA2	928		A1EoAW07	663	323.8	1596		71.575	2.1602
			DB1	918		-	-	-	-		-	-
			DB2	918		-	-	-	-		-	-
		897	DC1	902		A1EoAW0E	575	385.8	1562		73.525	4.1102
			DC2	902		A1EoAW0S	550	410.8	1553		74.474	5.0592
			DD1	892		-	-	-	-		-	-
			DD2	892		-	-	-	-		-	-
	Mother	910	MA1	928	T3	A1EoBW0E	700	286.8	1612	43.7	69.689	0.2749
	PP		MA2	928		A1EoBW07	663	323.8	1596		71.015	1.6009
			MB1	918		A1EoCW0E	700	276.8	1572		67.842	-1.572
			MB2	918		A1EoCW07	663	313.8	1555		69.155	-0.26
			MC1	902		A1EoBW0E	575	385.8	1562		72.965	3.551
			MC2	902		A1EoBW0S	550	410.8	1553		73.914	4.4999
			MD1	892		A1EoCW0E	575	375.8	1520		71.074	1.6593
			MD2	892		A1EoCW0S	550	400.8	1511		72.014	2.6
EoWT3	doughter	871	DA1	876	T3	A1EoAW10	700	234.8	1612	43.7	67.089	-2.325
	PP		DA2	876		A1EoAW11	663	271.8	1596		68.415	-0.999
			DB1	866		-	-	-	-		-	-
			DB2	866		-	-	-	-		-	-
		845	DC1	850		A1EoAW12	575	333.8	1562		70.365	0.951
			DC2	850		A1EoAW13	550	358.8	1553		71.314	1.8999
			DD1	840		-	-	-	-		-	-
			DD2	840		-	-	-	-		-	-
	Mother	858	MA1	876		A1EoBW10	700	234.8	1612		67.089	-2.325
	PP		MA2	876		A1EoBW11	663	271.8	1596		68.415	-0.999
			MB1	866		A1EoCW10	700	224.8	1572		65.242	-4.172
			MB2	866		A1EoCW11	663	261.8	1555		66.555	-2.86
			MC1	850		A1EoBW12	575	333.8	1562		70.365	0.951
			MC2	850		A1EoBW13	550	358.8	1553		71.314	1.8999
			MD1	840		A1EoCW12	575	323.8	1520		68.474	-0.941
			MD2	840		A1EoCW13	550	348.8	1511		69.414	0
FoST0	Mother	740	DC1	745		A1FoAS0	400	395	1506		69.953	0.5385
	PP		DC2	745		A1FoAS1	400	395	1506		69.953	0.5385
			DD1	735		A1FoCS0	400	385	1463		68.008	-1.406
			DD2	735		A1FoCS1	400	385	1463		68.008	-1.406
EoST0	doughter	817	DA1	822	T8	A1EoAS0	946	174	1733	60.8	70.519	1.1049
	PP		DA2	822		A1EoAS1	946	174	1733		70.519	1.1049
			DB1	812		A1EoCS0	946	184	1695		69.768	0.354
			DB2	812		A1EoCS1	946	184	1695		69.768	0.354
		791	DC1	796	T6	A1EoAS4	610	236	1575	111	71.718	2.3032
			DC2	796		A1EoAS5	610	236	1575		71.718	2.3032
			DD1	786		A1EoCS4	610	226	1534		69.838	0.4236
			DD2	786		A1EoCS5	610	226	1534		69.838	0.4236
	Mother	804	MA1	822	T7	A1EoAS2	946	174	1733	60.8	70.519	1.1049
	PP		MA2	822		A1EoAS3	946	174	1733		70.519	1.1049
			MB1	812		A1EoCS2	946	184	1695		69.768	0.354
			MB2	812		A1EoCS3	946	184	1695		69.768	0.354
			MC1	796	T3	A1EoAS6	610	236	1575	112	71.731	2.3165
			MC2	796		A1EoAS7	610	236	1575		71.731	2.3165
			MD1	786		A1EoCS6	610	226	1534		69.851	0.4369
			MD2	786		A1EoCS7	610	226	1534		69.851	0.4369
						Length			Weight			
						1/24 unit	[m]	419.7	1/24 unit		[kg]	83.937
						One side	[m]	10072	One side		[kg]	2014.5
						Two sides	[m]	20145	Two sides		[kg]	4029

Appendix Mininum length of cable and time delay for double

PP name		Position	Conn.	Position	TGC	ASD name	Position	L_2	L_0	L_1	ΔT1(ns)	ΔT2(ns)
F0WD0	doughter	768	DA1	773	T2	A2F0AW0	414	468.5	1510	59.5	75.958	2.5471
	PP		DA2	773		A2F0AW1	394	488.5	1505		76.779	3.3684
			DB1	763		A2F0BW0	414	458.5	1467		74.017	0.6063
			DB2	763		A2F0BW1	394	478.5	1461		74.833	1.4223
		743	DC1	748		A2F0AW2	373	484.5	1499		76.4	2.9896
			DC2	748		A2F0AW3	352	505.5	1494		77.281	3.8701
			DD1	738		A2F0BW2	373	474.5	1456		74.449	1.0382
			DD2	738		A2F0BW3	352	495.5	1450		75.324	1.9136
	Mother	755	MA1	773		A3F0AW0	414	418.5	1510		73.458	0.0471
	PP		MA2	773		A3F0AW1	394	438.5	1505		74.279	0.8684
			MB1	763		A3F0BW0	414	408.5	1467		71.517	-1.8937
			MB2	763		A3F0BW1	394	428.5	1461		72.333	-1.0777
			MC1	748		A3F0AW2	373	434.5	1499		73.9	0.4896
			MC2	748		A3F0AW3	352	455.5	1494		74.781	1.3701
			MD1	738		A3F0BW2	373	424.5	1456		71.949	-1.4618
			MD2	738		A3F0BW3	352	445.5	1450		72.824	-0.5864
F0WD1	doughter	718	DA1	723		A2F0AW4	331	501.5	1489	59.5	76.92	3.5098
	PP		DA2	723		A2F0AW5	310	522.5	1485		77.819	4.4089
			DB1	713		A2F0BW4	331	491.5	1445		74.959	1.5485
			DB2	713		A2F0BW5	310	512.5	1441		75.854	2.443
		693	DC1	698		A2F0AW6	289	518.5	1480		77.478	4.0675
			DC2	698		A2F0AW7	268	539.5	1477		78.396	4.9857
			DD1	688		A2F0BW6	289	508.5	1436		75.508	2.0973
			DD2	688		A2F0BW7	268	529.5	1432		76.422	3.0114
	Mother	705	MA1	723		A3F0AW4	331	451.5	1489		74.42	1.0098
	PP		MA2	723		A3F0AW5	310	472.5	1485		75.319	1.9089
			MB1	713		A3F0BW4	331	441.5	1445		72.459	-0.9515
			MB2	713		A3F0BW5	310	462.5	1441		73.354	-0.057
			MC1	698		A3F0AW6	289	468.5	1480		74.978	1.5675
			MC2	698		A3F0AW7	268	489.5	1477		75.896	2.4857
			MD1	688		A3F0BW6	289	458.5	1436		73.008	-0.4027
			MD2	688		A3F0BW7	268	479.5	1432		73.922	0.5114
E0WD0	doughter	1113	DA1	1118	T9	A2E0AW00	1166	107.5	1862	82	70.486	-2.9245
	PP		DA2	1118		-	-	-	-		-	-
			DB1	1108		A2E0BW00	1166	117.5	1827		69.824	-3.5869
			DB2	1108		-	-	-	-		-	-
		1088	DC1	1093	T8	A2E0AW01	1106	137.3	1825	74.3	70.459	-2.952
			DC2	1093		A2E0AW02	1041	176.3	1787		71.121	-2.2899
			DD1	1083		A2E0BW01	1106	147.3	1790		69.772	-3.6383
			DD2	1083		A2E0BW02	1041	166.3	1750		69.408	-4.0025
	Mother	1100	MA1	1118	T9	A3E0AW00	1166	130	1862	82	71.611	-1.7995
	PP		MA2	1118		-	-	-	-		-	-

			MB1	1108		A3E0BW00	1166	140	1827		70.949	-2.4619
			MB2	1108		-	-	0	-		-	-
			MC1	1093	T8	A3E0AW01	1106	87.3	1825	74.3	67.959	-5.452
			MC2	1093		A3E0AW02	1041	126.3	1787		68.621	-4.7899
			MD1	1083		A3E0BW01	1106	97.3	1790		67.272	-6.1383
			MD2	1083		A3E0BW02	1041	116.3	1750		66.908	-6.5025
E0WD1	doughter	1063	DA1	1068	T8	A2E0AW03	981	211.3	1752	74.3	71.728	-1.6826
	PP		DA2	1068		A2E0AW04	923	269.3	1721		73.568	0.1574
			DB1	1058		A2E0BW03	981	201.3	1715		69.991	-3.4194
			DB2	1058		A2E0BW04	923	259.3	1683		71.808	-1.6027
		1038	DC1	1043	T7	A2E0AW06	809	350.9	1662	66.9	75.428	2.0177
			DC2	1043		A2E0AW07	781	378.9	1649		76.38	2.9694
			DD1	1033		A2E0BW06	809	340.9	1623		73.623	0.2122
			DD2	1033		A2E0BW07	781	368.9	1609		74.564	1.1531
	Mother	1050	MA1	1068	T7	A3E0AW03	981	153.9	1752	66.9	68.584	-4.8267
	PP		MA2	1068		A3E0AW04	923	211.9	1721		70.424	-2.9867
			MB1	1058		A3E0BW03	981	143.9	1715		66.847	-6.5635
			MB2	1058		A3E0BW04	923	201.9	1683		68.664	-4.7468
			MC1	1043	T6	A3E0AW05	866	235.8	1691	58.8	70.322	-3.0881
			MC2	1043		A3E0AW07	781	320.8	1649		73.175	-0.2356
			MD1	1038		A2E0BW05	866	230.8	1652		68.789	-4.621
			MD2	1038		A2E0BW05	866	230.8	1652		68.789	-4.621
			ME2	1033		A3E0BW05	866	225.8	1652		68.539	-4.871
			ME2	1033		A3E0BW07	781	310.8	1609		71.359	-2.0519
E0WD2	doughter	1013	DA1	1018	T6	A2E0AW08	753	373.8	1636	58.8	75.389	1.9785
	PP		DA2	1018		A2E0AW09	725	401.8	1623		76.366	2.9552
			DB1	1008		A2E0BW08	753	363.8	1596		73.562	0.1514
			DB2	1008		A2E0BW09	725	391.8	1583		74.528	1.1174
		988	DC1	993		A2E0AW10	697	404.8	1611		76.105	2.6947
			DC2	993		A2E0AW11	669	432.8	1599		77.108	3.6975
			DD1	983		A2E0BW10	697	394.8	1570		74.257	0.8465
			DD2	983		A2E0BW11	669	422.8	1558		75.249	1.8389
	Mother	1000	MA1	1018		A3E0AW08	753	323.8	1636		72.889	-0.5215
	PP		MA2	1018		A3E0AW09	725	351.8	1623		73.866	0.4552
			MB1	1008		A3E0BW08	753	313.8	1596		71.062	-2.3486
			MB2	1008		A3E0BW09	725	341.8	1583		72.028	-1.3826
			MC1	993		A3E0AW10	697	354.8	1611		73.605	0.1947
			MC2	993		A3E0AW11	669	382.8	1599		74.608	1.1975
			MD1	983		A3E0BW10	697	344.8	1570		71.757	-1.6535
			MD2	983		A3E0BW11	669	372.8	1558		72.749	-0.6611
E0WD3	doughter	963	DA1	968	T6	A2E0AW12	641	435.8	1587	58.8	76.874	3.4637
	PP		DA2	968		A2E0AW13	590	486.8	1567		78.761	5.3503
			DB1	958		A2E0BW12	641	425.8	1546		75.006	1.595
			DB2	958		A2E0BW13	590	476.8	1526		76.874	3.4638
		938	DC1	943	T4	A2E0AW14	565	471.7	1558	43.7	77.139	3.7281
			DC2	943		A2E0AW15	540	496.7	1549		78.092	4.6817
			DD1	933		A2E0BW14	565	461.7	1516		75.244	1.8331
			DD2	933		A2E0BW15	540	486.7	1507		76.189	2.7785
	Mother	950	MA1	968	T5	A3E0AW12	641	367.5	1587	40.5	72.781	-0.6291

	PP		MA2	968		A3E0AW13	590	418.5	1567		74.668	1.2575
			MB1	958		A3E0BW12	641	357.5	1546		70.913	-2.4977
			MB2	958		A3E0BW13	590	408.5	1526		72.782	-0.629
			MC1	943		A3E0AW14	565	418.5	1558		74.36	0.9496
			MC2	943		A3E0AW15	540	443.5	1549		75.314	1.9032
			MD1	933		A3E0BW14	565	408.5	1516		72.465	-0.9454
			MD2	933		A3E0BW15	540	433.5	1507		73.411	0
E0WD4	doughter	913	DA1	918	T4	A2E0AW16	515	496.7	1541	43.7	77.808	4.3972
	PP		DA2	918		A2E0AW17	490	521.7	1532		78.785	5.3747
			DB1	908		A2E0BW16	515	486.7	1498		75.897	2.486
			DB2	908		A2E0BW17	490	511.7	1490		76.866	3.4557
		888	DC1	893		A2E0AW18	465	521.7	1525		78.525	5.1143
			DC2	893		A2E0AW19	440	546.7	1517		79.527	6.1164
			DD1	883		A2E0BW18	465	511.7	1482		76.598	3.1879
			DD2	883		A2E0BW19	440	536.7	1474		77.593	4.1828
	Mother	900	MA1	918	T5	A3E0AW16	515	443.5	1541	40.5	75.029	1.6187
	PP		MA2	918		A3E0AW17	490	468.5	1532		76.007	2.5961
			MB1	908		A3E0BW16	515	433.5	1498		73.118	-0.2925
			MB2	908		A3E0BW17	490	458.5	1490		74.088	0.6772
			MC1	893		A3E0AW18	465	468.5	1525		75.746	2.3358
			MC2	893		A3E0AW19	440	493.5	1517		76.748	3.3379
			MD1	883		A3E0BW18	465	458.5	1482		73.82	0.4094
			MD2	883		A3E0BW19	440	483.5	1474		74.815	1.4043
E0SD0	doughter	913	DA1	918	T9	A2E0AS0	1065	247	1801	60.8	76.427	3.0162
	PP		DA2	918		A2E0AS1	1065	247	1801		76.427	3.0162
			DB1	908		A2E0BS0	1065	257	1765		75.724	2.3134
			DB2	908		A2E0BS1	1065	257	1765		75.724	2.3134
		888	DC1	893		A2E0AS2	955	162	1738		70.084	-3.3269
			DC2	893		A2E0AS3	955	162	1738		70.084	-3.3269
			DD1	883		A2E0BS2	955	172	1700		69.336	-4.0741
			DD2	883		A2E0BS3	955	172	1700		69.336	-4.0741
	Mother	900	MA1	918	T8	A3E0AS0	1065	197	1801	60.8	73.927	0.5162
	PP		MA2	918		A3E0AS1	1065	197	1801		73.927	0.5162
			MB1	908		A3E0BS0	1065	207	1765		73.224	-0.1866
			MB2	908		A3E0BS1	1065	207	1765		73.224	-0.1866
			MC1	893		A3E0AS2	955	112	1738		67.584	-5.8269
			MC2	893		A3E0AS3	955	112	1738		67.584	-5.8269
			MD1	883		A3E0BS2	955	122	1700		66.836	-6.5741
			MD2	883		A3E0BS3	955	122	1700		66.836	-6.5741
E0SD1	doughter	863	DA1	868	T7	A2E0AS4	955	187	1738	60.8	71.334	-2.0769
	PP		DA2	868		A2E0AS5	955	187	1738		71.334	-2.0769
			DB1	858		A2E0BS4	955	197	1700		70.586	-2.8241
			DB2	858		A2E0BS5	955	197	1700		70.586	-2.8241
		838	DC1	843		A2E0AS6	610	333	1575		73.201	-0.2096
			DC2	843		A2E0AS7	610	333	1575		73.201	-0.2096
			DD1	833		A2E0BS6	610	323	1534		71.321	-2.0892
			DD2	833		A2E0BS7	610	323	1534		71.321	-2.0892
	Mother	850	MA1	868	T6	A3E0AS4	955	137	1738	111	72.2	-1.2102
	PP		MA2	868		A3E0AS5	955	137	1738		72.2	-1.2102

			MB1	858		A3E0BS4	955	147	1700		71.453	-1.9575
			MB2	858		A3E0BS5	955	147	1700		71.453	-1.9575
			MC1	843		A3E0AS6	610	283	1575		74.068	0.6571
			MC2	843		A3E0AS7	610	283	1575		74.068	0.6571
			MD1	833		A3E0BS6	610	273	1534		72.188	-1.2225
			MD2	833		A3E0BS7	610	273	1534		72.188	-1.2225
E0SD2	doughter	813	DA1	818	T4	A2E0AS8	610	308	1575	96.1	74.304	0.8938
	PP		DA2	818		A2E0AS9	610	308	1575		74.304	0.8938
			DB1	808		A2E0BS8	610	298	1534		72.425	-0.9858
			DB2	808		A2E0BS9	610	298	1534		72.425	-0.9858
	Mother	813	MA1	818	T5	A3E0AS8	610	258	1575	86.7	71.178	-2.2329
	PP		MA2	818		A3E0AS9	610	258	1575		71.178	-2.2329
			MB1	808		A3E0BS8	610	248	1534		69.298	-4.1125
			MB2	808		A3E0BS9	610	248	1534		69.298	-4.1125
F0SD0	doughter	723	DA1	728	T2	A2F0AS0	430	398	1514	89.2	76.324	2.9139
	PP		DA2	728		A2F0AS1	430	398	1514		76.324	2.9139
			DB1	718		A2F0BS0	430	388	1471		74.388	0.9775
			DB2	718		A2F0BS1	430	388	1471		74.388	0.9775
	Mother	723	MA1	728		A3F0AS0	430	348	1514		73.824	0.4139
	PP		MA2	728		A3F0AS1	430	348	1514		73.824	0.4139
			MB1	718		A3F0BS0	430	338	1471		71.888	-1.5225
			MB2	718		A3F0BS1	430	338	1471		71.888	-1.5225
						Length			Weight			
						1/24 unit	[m]	899.9	1/24 unit		[kg]	179.98
						One side	[m]	21598	One side		[kg]	4319.5
						Two sides	[m]	43195	Two sides		[kg]	8639

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