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Assembly and Housing of the MAPMT and VFE Boards of the PS/SPD System

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Abstract

This note describes the assembly of the clear fibres from the cells to the MAPMT and the housing of the MAPMT and of the VFE boards for the PS and SPD system in the upper and lower part of the detector.

1 Introduction

The LHCb preshower detector (PS) provides the longitudinal segmentation of the electromagnetic shower detection. It is located immediately upstream from the electromagnetic calorimeter (ECAL), with one-to-one correspondence between ECAL towers and preshower cells. It is made of a 15 mm thick lead ($2.5\,\mathrm{X}_0$) followed by a detection plane of 15 mm thick scintillator pads. The PS/SPD detector is part of the LHCb Level-0 trigger system. It is used in conjunction with the ECAL/HCAL to search for clusters of 2×2 cells and to identify e, γ, π^0, hadron of highest E_T. The design of PS/SPD detector is described in [1]. The total number of cells in each detector is 5984. The cells are about 4×4 cm^2 in the central region, 6×6 cm^2 in the middle region and 12×12 cm^2 in the outer region. The unit part of the detector is a 40×40 cm^2 module, that contains 16, 64 or 144 scintillator pads depending on the module position with respect to the beam axis. 13×2 modules are arranged in a supermodule. Each plane of SPD/PS is assembled into 8 supermodules [2] (Fig. 1).

The scintillation light is collected with helicoidal wavelength shifting fluorescent fiber held in a groove in the scintillator. Both fiber ends are connected to long clear fibers which send the light to multianode photomultiplier tubes (MAPMT) that are located on the top or on the bottom of the detector. The realization of the clear optical fibre bundles and their assembly on the MAPMT is described in section 2.

The deposited energy in the preshower is measured. First, the comparison to a threshold allows to produce, every 25 ns, a Yes/No signal for the L0 calorimeter trigger system. Second, this energy is used to correct the energy measurements in ECAL. For that PS signals require digitisation over 10 bits. The phototube chosen to detect the light from the PS is a multi anode photomultiplier tube with 64 channels. So PS front-end electronic boards handle 64 channels corresponding to one photomultiplier. It covers two ECAL front-end boards. In some areas, the front-end boards are partialy used, only 32 channels.

The HV of a MAPMT is common to all 64 channels and there is a non-adjustable gain dispersion among these channels of about a factor 4. It has therefore been decided to sub-divide the front-end electronics in two parts. The "very front-end" (VFE), part described in reference [3], is placed the closest possible to the MAPMT, on its back, and it compensates the gain variation by serial resistors at the entrance of the amplifier which will be adjusted. It comprises amplification, integration and holding operation of the signal. In the new design an ASIC handles 4 channels. The housing of the MAPMT and of the VFE boards, located on the top and on the bottom of the detector is described in section 3.

The analog signal is then sent with twisted-pair cables, between 10 and 20 meter length according to their location, to the front-end board located in racks put on a platform on the top of the detector [5, 6]. In this board, the signal is

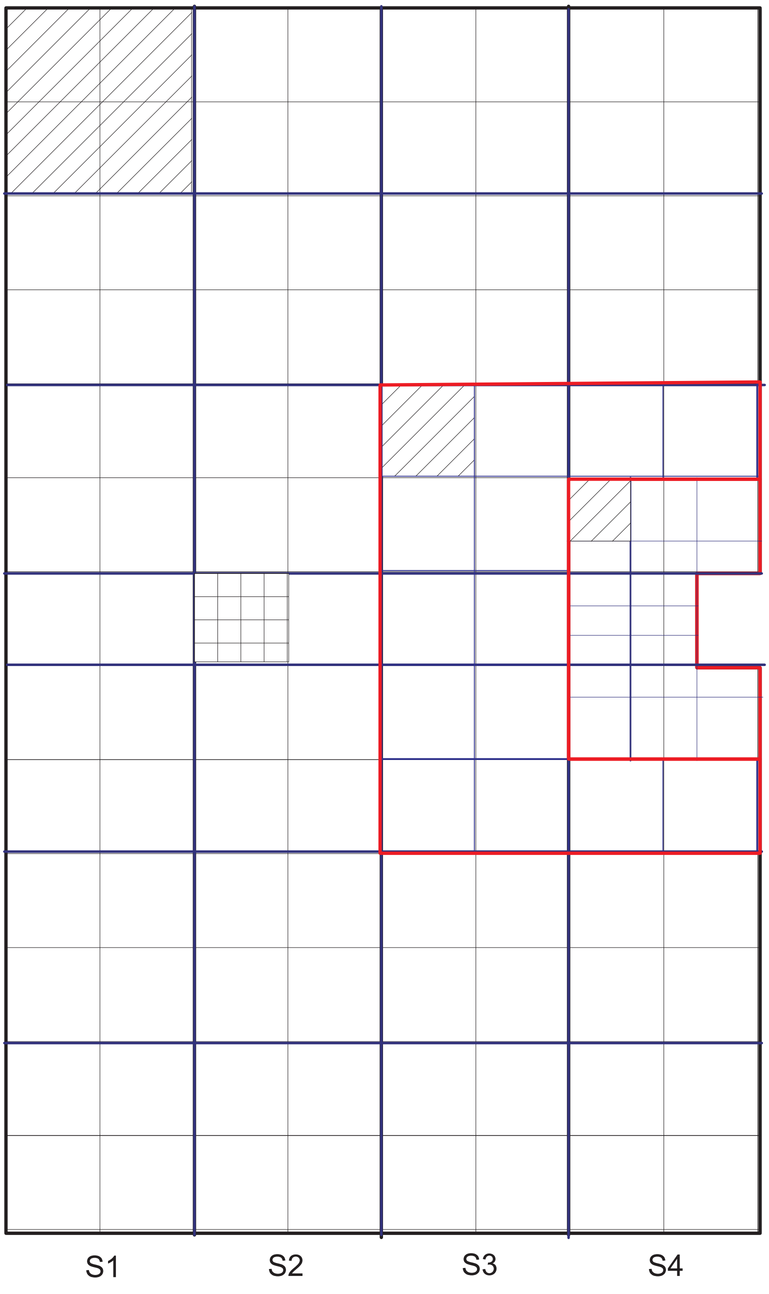

Figure 1: Shematic view of the PS layout for half of the detector. It is made of 4 supermodules. The segmentation in modules is shown. A supermodule contains 13×2 modules. Its width is 96 cm. The cell size is about 12×12 cm^2 in the outer region, 6×6 cm^2 in the middle region and 4×4 cm^2 in the central region. A module contains 16 cells in the outer region, 64 in the middle region and 144 in the central region. Grouping of 64 cells (hashed squares) separated by blue lines are read-out with 1 MAPMT. In some places, near to the middle, MAPMT read-out 32 cells only.

digitized with a 10 bits ADC and stored in a FIFO pipeline until Level-0 (L0) and Level-1 trigger decision.

The PS front-end board handles 64 channels [4]. It receives the analog signals coming from the PS very-front-end board and 64 bits, one per channel, coming from the scintillator pad detector (SPD). SPD is made of a detection plane of scintillator pads placed just before the PS lead. It has the same granularity and structure than PS and allows to identify charged particles for L0 calorimeter trigger. It provides one bit per cell, coming from a sample discriminator telling whether a cell has been hit.

The connectivity between the different parts is very important; it has been defined in note [7] with the numbering convention and the optical and electrical cabling of the PS/SPD system.

This note describes the realization of the clear fibre bundles and their assembly on the MAPMT. For this purpose a dedicated MAPMT connector has been designed.

2 Fiber bundles and MAPMT block

Inside a PS/SPD module, a bundle of 32 WLS optical fibers from 4×4 cells is made and coupled to an optical connector. This unit of 4×4 cells is called a *PS element* hereafter. A fiber strand, coming from 4 PS elements, is coupled to a MAPMT thanks to a MAPMT connector which is read-out with a Very-Front-End board. This is a multistage board, made of 3 boards [7]; the MAPMT is connected on the first board that contains its base. For magnetic shielding, a μ metal cylinder is put around the MAPMT. The MAPMT with is connector, the μ metal cylinder and the VFE board is an unit called a MAPMT block.

2.1 Fiber strands

A strand is made of 64 pairs of clear fibers divided into 4 bundles of 16 pairs. The diameter of the fibers is 1 mm. Each bundle of 32 fibres is equiped at one end of a WLS fiber-clear fiber connector (so called WLS connector). The four bundles are assembled into a single strand with a 64 pair connector (so called MAPMT mask) to position it in front of the MAPMT window and of its 64 pixels. The fibres are protected inside a flexible sheath as shown on Fig. 2.

It has still to define some strands packs according to their length by trying to group at maximum the strands in order to decrease the number of different kind of strand packs and so the spares.

Figure 2: Picture of a fiber strand with the connectors (the MAPMT mask is an old design).

2.2 MAPMT connectors

The MAPMT connector is made of 2 parts: the MAPMT mask and the MAPMT support. These two pieces are indexed to allow assembly without possible mistake on the pairing of the lecture channels (1 to 1, 2 to 2, ...) and a better precision and reproductability of the positioning. The adopted matter is POM (polyoxymethen) because it has a good compromise between cost, milling, gluing, radiation hardness, ...

2.2.1 MAPMT mask

The MAPMT mask (Fig. 3) is the piece which is fixed at the fiber end and which position the fiber pairs into a square lattice of 8×8 pairs corresponding to the MAPMT anodes. The fiber pairs (insert into a groove) are centred on the diagonal of a 2×2 mm^2 square (area of one anode).

The number of masks to manufacture is 270: 220 MAPMT + 20 spares + 30 scraps strands.

2.2.2 MAPMT support

The MAPMT support (Fig. 4) is the piece which allow to ensure a rigid connection with the MAPMT case and to transfer outside the indexing position of the anode

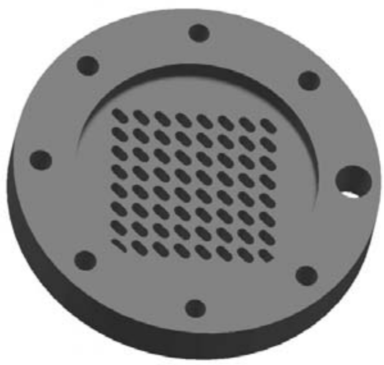

Figure 3: Shematic view of a MAPMT mask.

lattice. The number of pieces to manufacture is 240 (220 MAPMT + 20 spares).

Figure 4: Shematic view of a MAPMT support.

A setting tool allows to position the MAPMT with respect to its support (Fig. 5). This is done by aligning the guide marks of the MAPMT window with a reference transparent plate (Fig. 6), under a binocular. The obtained precision will be the one of the tool plus the one of the optical positioning. The potential flaw will be identical for all the pieces assembled by a same operator.

After to have adjusted the pieces in position, the space between the MAPMT case and support is filled up with silicon injection in order to have a rigid connection but dismentled without breaking the MAPMT or its support. This work will be done in a cleaning room, with restricted access because the parts have to stay in place a minimum of 12 hours in the setting tool to allow silicon to attain its maximal rigidity.

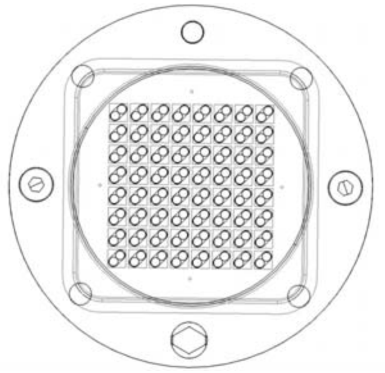

Figure 5: MAPMT anodes position in front the fibre mask inside its support.

2.3 Fibres

The clear fibres will be cut according to the length repartition table which has to be finalized, then polished in order to pass a first check of the integrity of the fiber cladding and core.

Two working hypothesis have to be considered: gluing of the MAPMT connector at first or at last.

2.3.1 MAPMT connector gluing at first

Under this hypothesis, LPC Clermont-Ferrand will do the fibre cutting and the first polishing for the check before gluing. Then the MAPMT connector gluing is done, followed by its final polishing and the control of the fibre quality. A special devise has been made to allow to easily place and maintain the 128 fibres into a MAPMT mask (Fig. 7).

The WLS connector gluing by LPC or INR (to be defined) needs to put marks on the 64 fiber pairs and a flexible sheath into 4 bundles of 16 pairs on the "free" half length and into one bundle on the remaining part before the gluing process. Every flaw on a WLS connector, not solved by polyshing, will imply the remove of all the four WLS connectors to preseve the same length of the fibres glued to a same MAPMT connector.

A final optical control, after polishing, will be performed to make certain the uniformity and the good light transmission. Then the connectors will be protected. The strands which have pass the quality control will be packed up according to their length, either lay flat, either wrap on a big radius of 0.75 m or more according to the sheath flexibility, with immobilization.

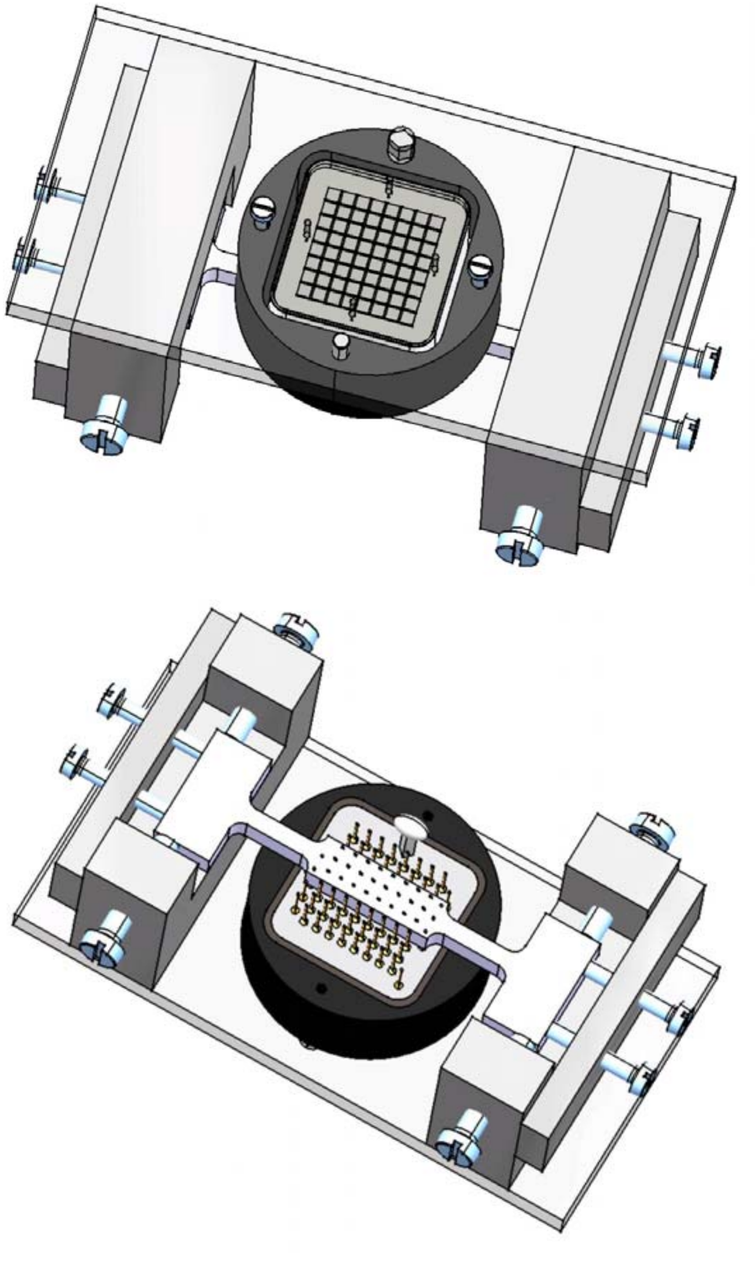

Figure 6: Drawings of the setting tool to position the MAPMT in its support; top and bottom view.

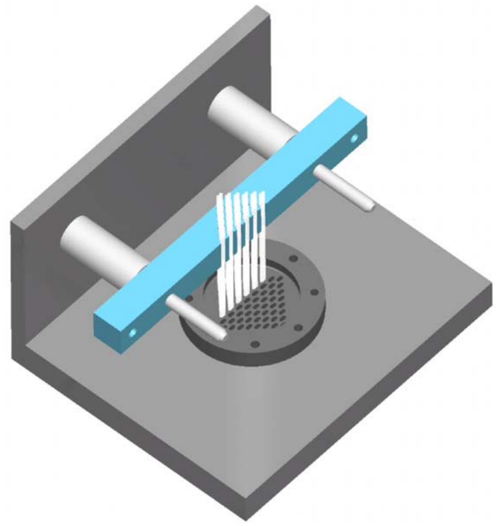

Figure 7: Drawing of the tool to position and maintain the 128 fibres into a MAPMT mask.

2.3.2 MAPMT connector gluing at last

Under this second hypothesis, INR would do the fiber cutting with its first polishing for the control, the WLS connector gluing and their polishing, then the optical control and the flat package of these stands.

The MAPMT connector gluing by LPC requires the setting of a flexible sheath on each bundle of 16 pair fibres on the half length, on the WLS connector side, and another sheath on the remaining single strand before the gluing process. For the gluing, identification of 16 pairs bundle as well as of each fibre pair has to be easy to set up fibers. A tool allowing to light up sequentially the pair fibres from the WLS connectors, will be made.

A final optical control, after polishing, will be performed in order to assure the uniformity and the good light transmission, after that the connectors will be protected.

The strands which have pass the quality control will be packed up according to their length, either lay flat, either wrap on a big radius of 0.75 m or more according to the case flexibility, with immobilization.

2.4 μ metal

A maximal magnetic field of around 100 G is expected in the region where are stood the MAPMT. The magnetic shielding will be obtained with a μ metal cylinder of 40 mm inside diameter, 50 or 60 mm long and 1 mm thickness (Fig. 8).

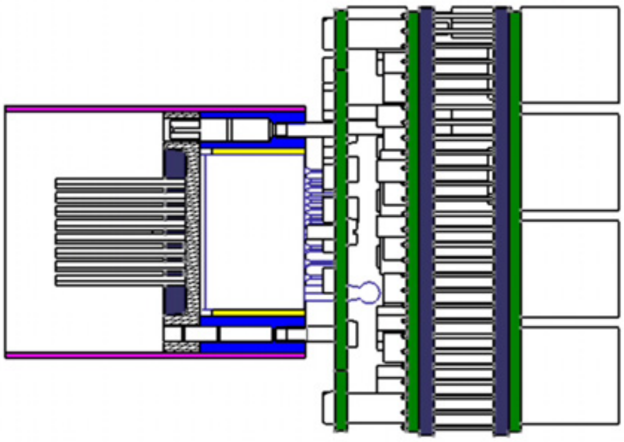

Figure 8: Shematic view of the magnetic shielding in μ metal (section view).

2.5 MAPMT block

The MAPMT block (Fig. 9) is made of a 64 clear optical fibre pair strand, a MAPMT put inside its MAPMT support, its active base, its VFE board and a magnetic shielding in μ metal. Each MAPMT has its own dedicated VFE board. These two pieces made up a whole which cannot be separated. A flaw in one of them imply the change of the unit.

2.6 Extracting tools

It will be necessary to develop two specific tools to help for MAPMT and associated boards manipulations; one to easily unplug the MAPMT/active base unit from the VFE board and to secure the integrety of the active base 64 pins, and the other to disentangle the active base from its MAPMT.

3 MAPMT box

The MAPMT box is the part which contains the MAPMT blocks, their supports, the LV regulators, the cables and the cooling (Fig. 10). They are attached at the top and at the bottom of each supermodule.

The MAPMT block repartition in an half of the detector is given in Table 1. It varies according to the granularity of the detector. The remaining free place can therefore be used to locate the LV regulators used to supply the VFE boards. 200 positif and negatif radiation hard voltage regulators from CERN (L4913 and L7913) will be used. Around 25 of each type will be placed in the MAPMT boxes located in the upper and lower side of supermodules 1, 2, 7 and 8 (Fig. 11).

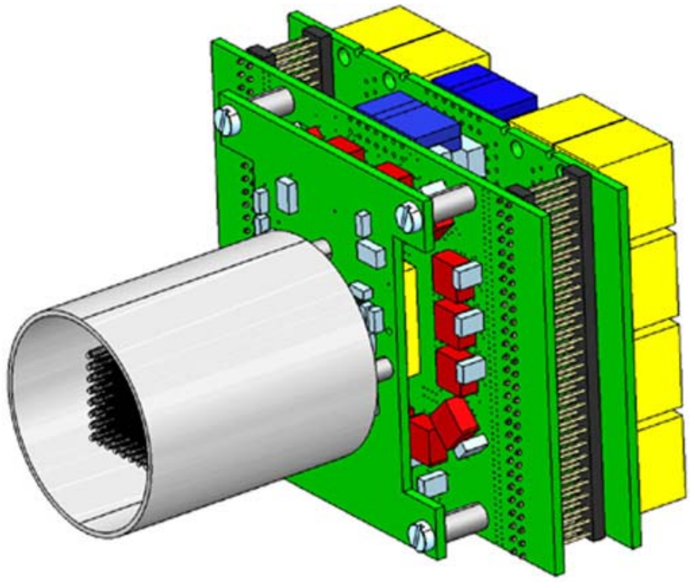

Figure 9: Shematic view of a MAPMT block. The dimension of the PS VFE board is 72×110 mm^2.

Super Module	1	2	3	4
Upper Side	4 (1)	4 (1)	8	11 (2)
Lower Side	3	3	6	11 (2)

Table 1: Number of MAPMT blocks per Supermodule for the upper and lower side of the PS/SPD (half of the detector), from the outer part of the detector (Super Module 1) to its inner part (Super Module 4). In bracket is given the number of boards (MAPMT) with only 32 channels.

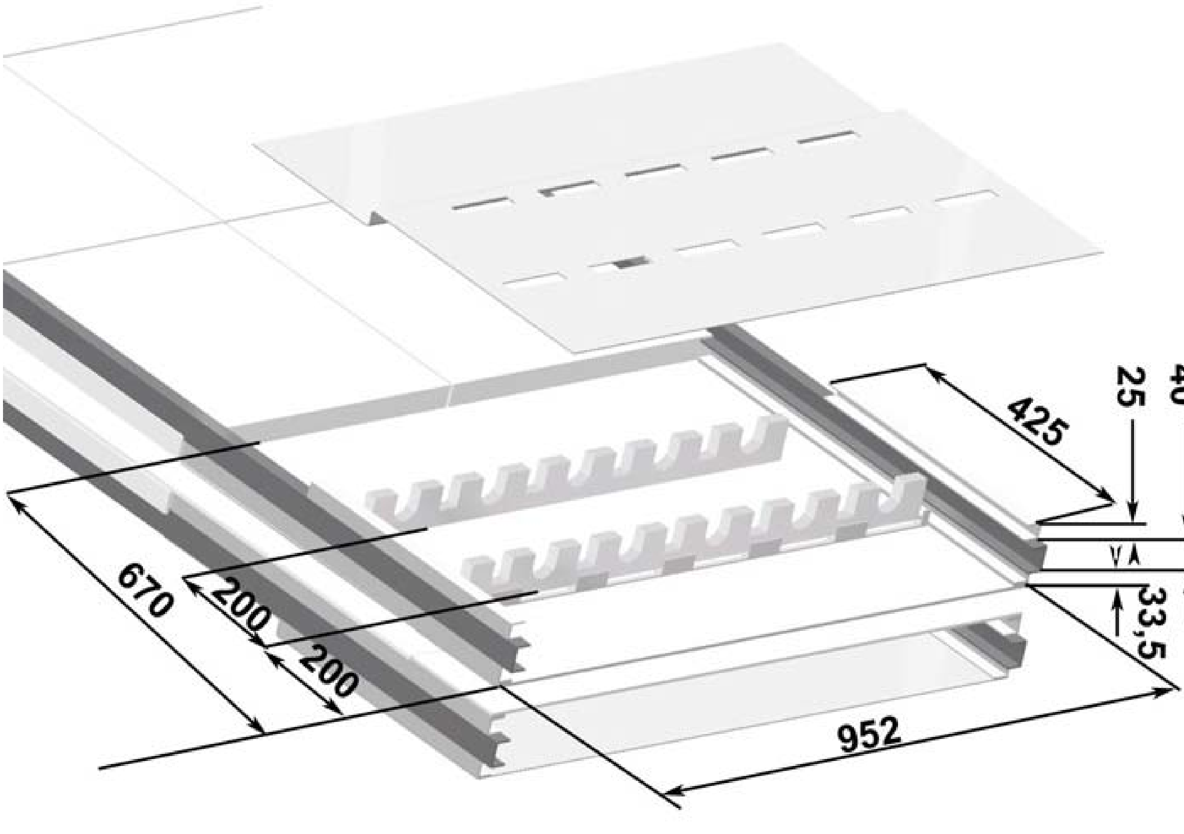

Figure 10: Shematic view of a MAPMT box, with MAPMT supports and its cover, attached to a supermodule (dimensions are in mm).

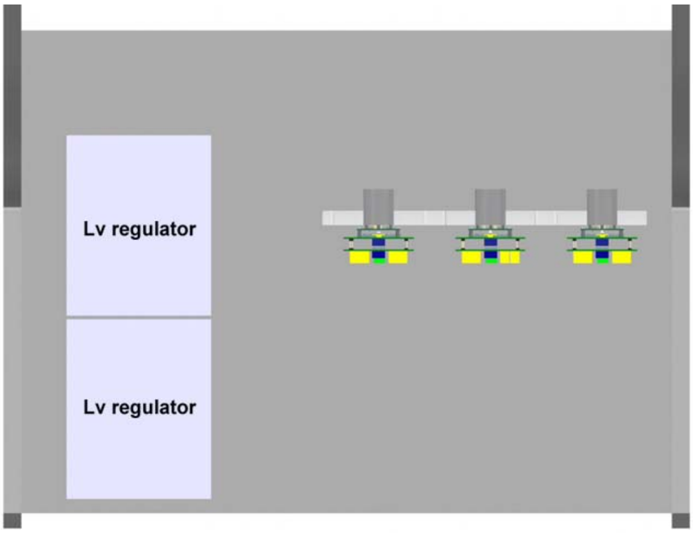

Figure 11: Shematic view of the regulators location inside a MAPMT box.

The number of cables per board and their functionalities is summarized in Table 2. A cable with RJ45 connector (cat. 7), compliant with the CERN norms, is under test. Its external diameter is 5.8 mm with a mass of 34 kg/km. Some boards, 12 in the current mapping, are used with 32 outputs only. As regulators are located near the VFE boards, the maximal length is 3 m for this kind of cables. The LV power supplies for the regulators (+5 V and -5 V) could be located on the ECAL platform. The power supply cables will use the same tray that the one for the signal cables between the VFE and FE boards, the distance between the LV power supplies and the regulators being around 15 m for the regulators located on the top of the PS, and 25 m for the one located on its bottom.

Functionnality	Number	Type	Unit Section
64 signal output	16	RJ45	28 mm^2
Clock and reset	1	RJ45	28 mm^2
VFE LV power supply	4	cable	5 mm^2
HV power supply	1	cable	10 mm^2
Total per board with an expansion of 0.9			630 mm^2
Regulators LV power supply	4	cable	5 mm^2

Table 2: Cables per board

3.1 PS/SPD envelope

The envelope of the PS/SPD system is given in Fig. 12.

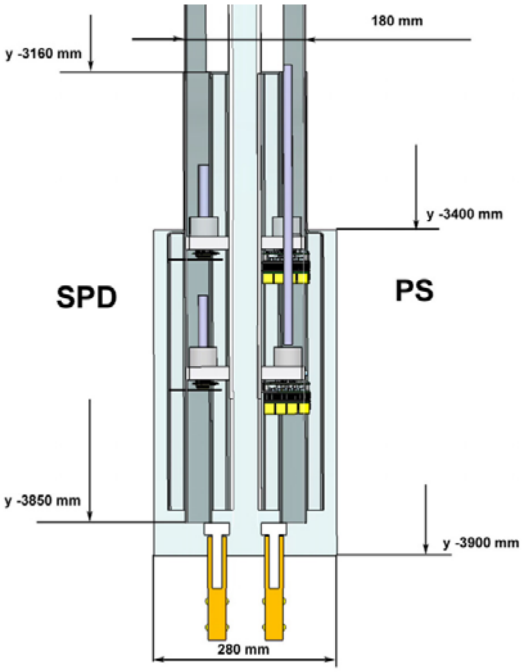

Figure 12: Shematic view of the PS/SPD envelop.

3.2 Supports

The MAPMT block support is the piece which maintains in place the MAPMT block. There are two kind of supports (Fig. 13): one for 2 MAPMT and one for 3 MAPMT in order to fit with the number of MAPMT in each box (Table 1). Two support stages are necessary.

The MAPMT block support is made of aluminium, it will go with a plastic piece, the VFE support, and an aluminium flange.

The VFE support allow an axial positioning of the MAPMT block unit and will be used for effort recovery during cable manipulation.

3.3 Cooling

The power dissipated by the electronic components is around 0.5 W per chip and 2 W per regulators. This corresponds to a total of 1.6 kW for the PS or SPD, approximatively equally reparted among the MAPMT boxes with a maximum

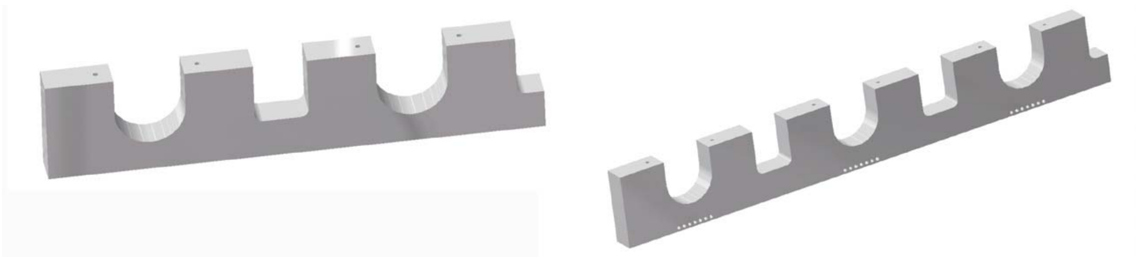

Figure 13: Shematic view of the MAPMT block supports.

of 130 W per MAPMT box. This means a forced convection to evacuate the dissipated heat. This hard convection will be obtained by a dry air circulation forced and canalized.

The air distributor will be on the back, the circulation will be directed towards the cap in which vents will be done to allow the fast evacuation of the air flow (Fig. 14).

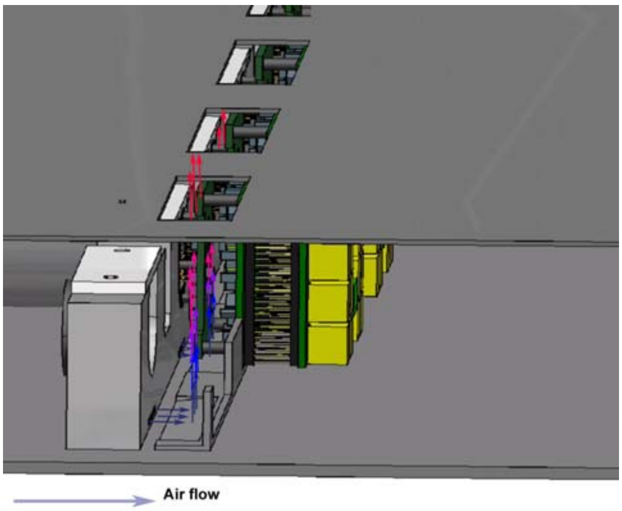

Figure 14: Shematic view of the cooling inside a box.

3.4 Assembly

The supports, the bonding pieces with the supermodule, the pieces for the cooling, and the regulators are assembled on the backplane plate. This unit is then slipped under the fiber strands which were first put in place in the supermodules (Fig. 15) and fixed to the supermodule frame.

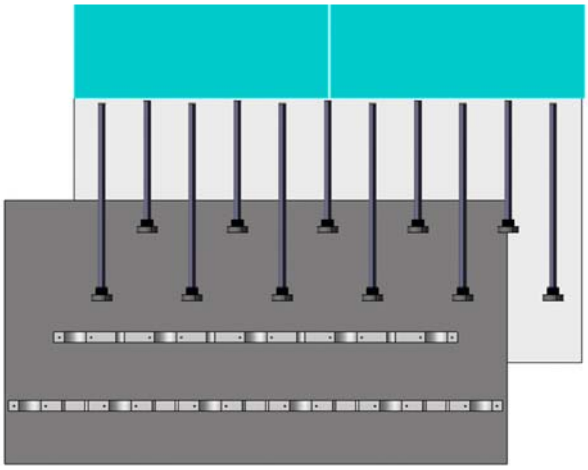

Figure 15: Shematic view of the MAPMT box assembly.

For each MAPMT, the μ metal cylinder is slipped on the fibers strand, then the MAPMT mask and the MAPMT, enclosed in its support, and with its VFE board are assembled. After the μ metal cylinder is put in position around the MAPMT connector (Fig. 16) and the VFE board is cabled. This block is positioned and after that clamped on the MAPMT block support. This process is repeated for each MAPMT.

A closing plate covers the whole to protect MAPMT and electronics (Fig. 17).

3.5 Cable routing

Cables will be set into groups of two.

- A group, made up of the cables for the VFE board power supplies, will be distributed among supermodules of a same quarter of detector. These cables will go from the regulator boards to the VFE boards.
- All the other cables will go through the cable trays to the ECAL platform and the PS FE racks or power supplies.

All these cables will go out the MAPMT boxes in 2 plans parallel to the detector plan (x,y) (Fig. 18). They will be mechanically held in position at the MAPMT box exit level so as to not transmit stress to the VFE boards and connectors at which they are linked.

Furthermore, for each MAPMT box, there will be one or two dry air admission for the cooling.

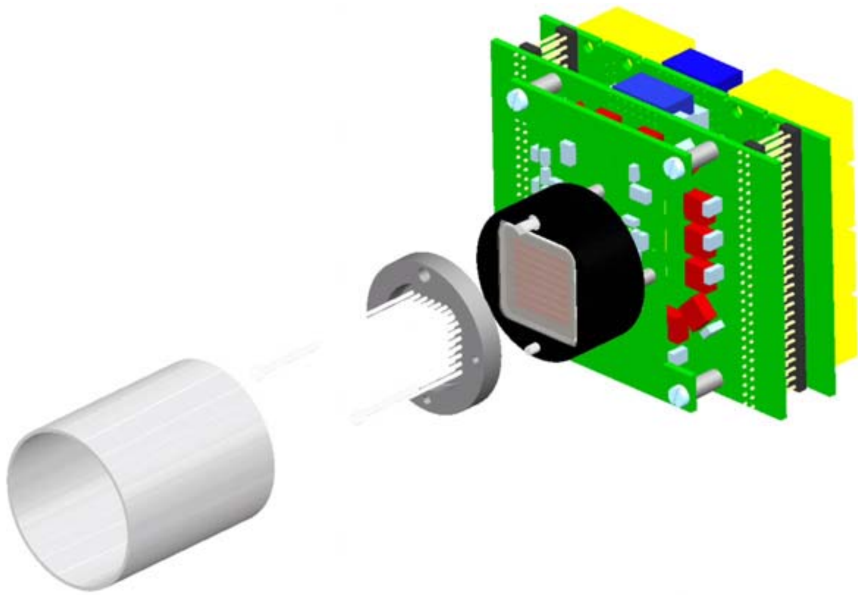

Figure 16: Shematic view of the MAPMT block assembly.

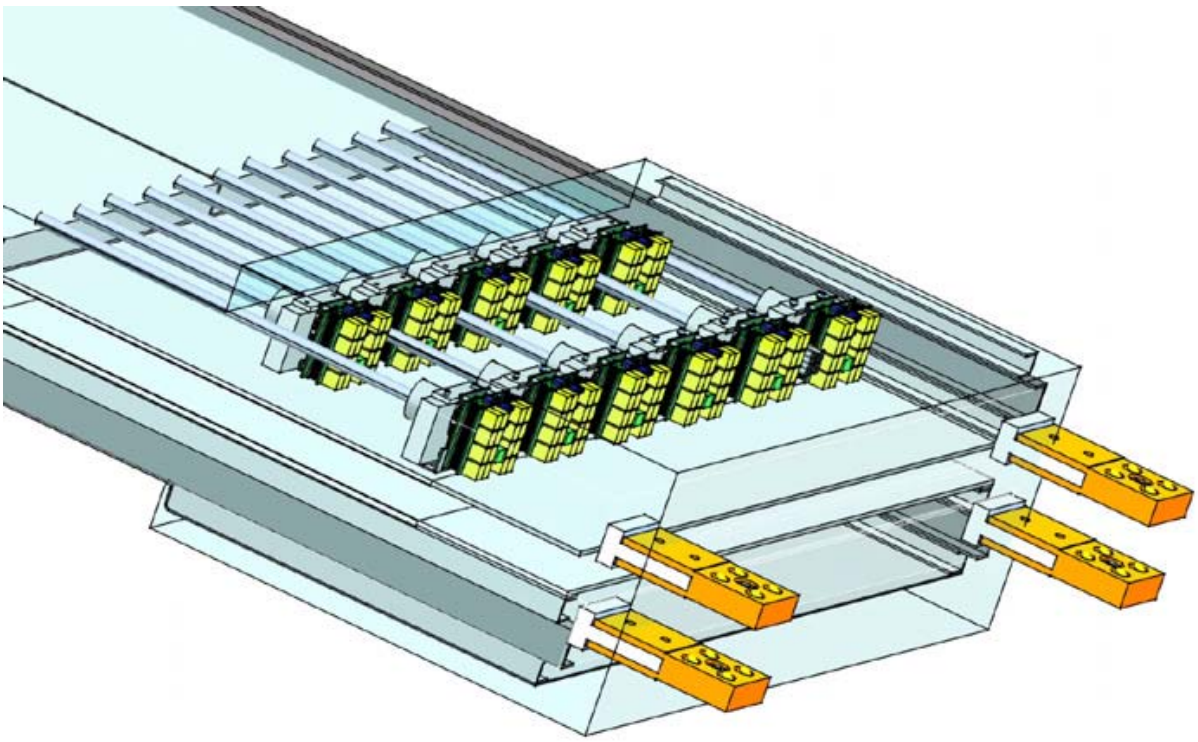

Figure 17: Shematic view of a MAPMT box.

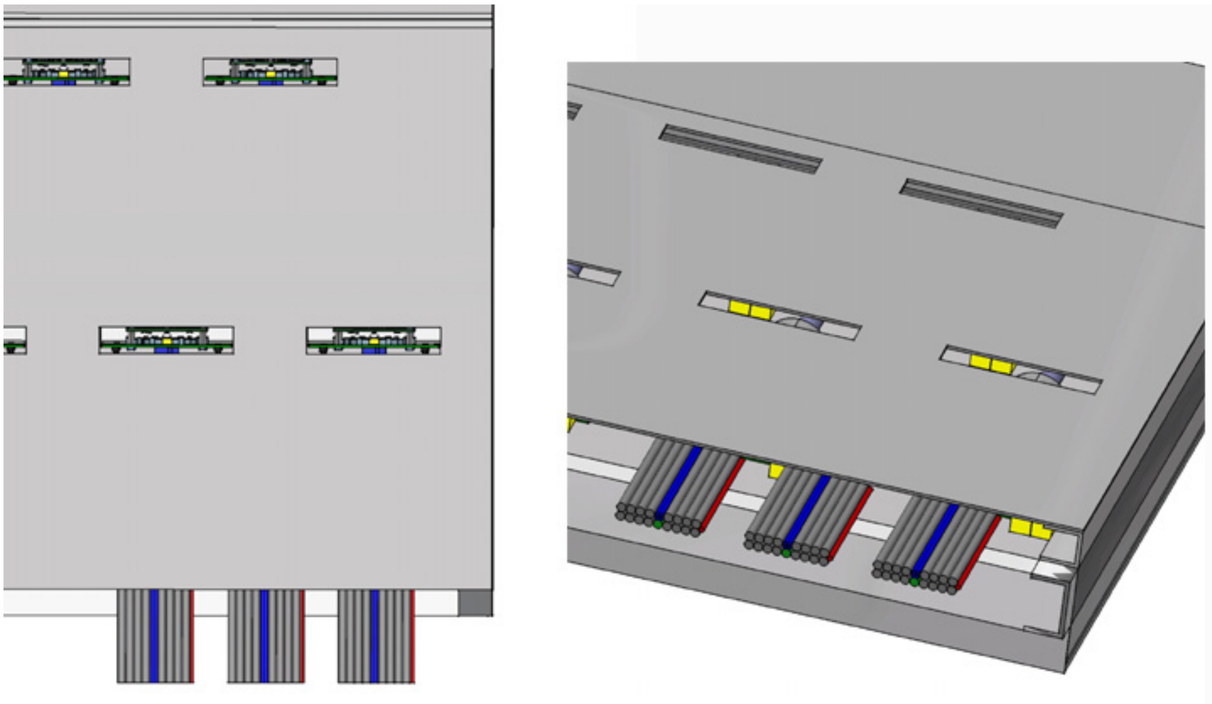

Figure 18: Shematic view of the cable disposition to go out the MAPMT box.

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