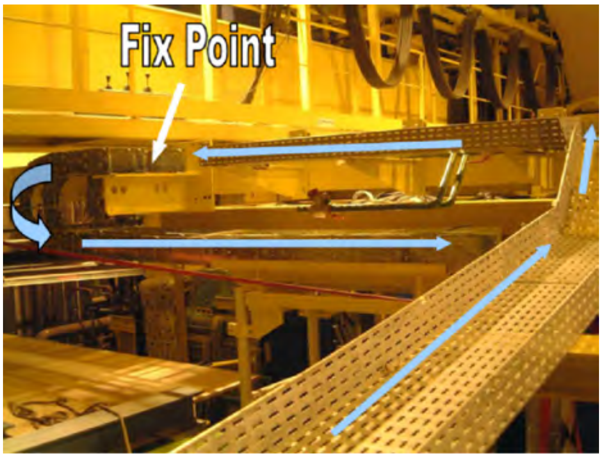
- LV cables (MARATON),
- DSS (CAN bus turbines).



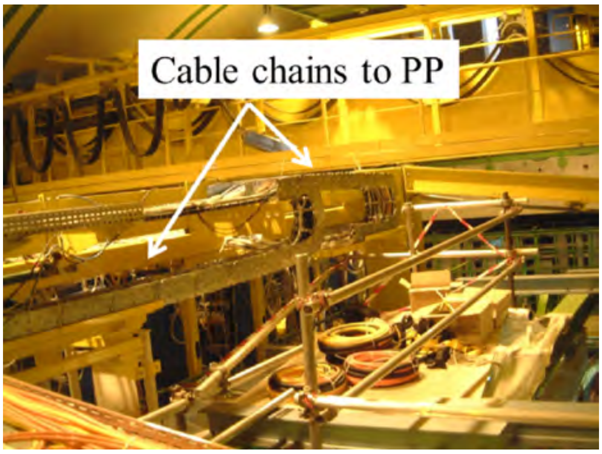


Figure 26: View of the cable path between the patch panel and the cable chain.

Some cables are going in a cable tray between the ECAL and HCAL platforms. The amount of work is estimated as two persons for two months for the dismantling of this part as the cables have to be sorted out in order to identify whose cables have to be kept for upgrade usage or can be recycled (MARATON).

Good access is needed and this activity will require the nacelle and an adequate positioning of the calorimeter sides, and of the muon filters. However, this work can be done in parallel with the installation of the front-end electronics.

6.6.2 SPD/Lead/PS dismantling

The SPD/PS detector consists of a lead converter that is sandwiched between two almost identical planes of rectangular scintillator pads and is described in Ref. [52]. The cells are packed in $\sim 48 \times 48\,\text{cm}^2$ boxes (modules) that are joined into supermodules. Each supermodule has a width of $\sim 96\,\text{cm}$, a height of $\sim 7.7\,\text{m}$ and consists of modules that form 13 rows and two columns mounted on a long aluminium strip which supports a service box (VFE box) in steel at each end which contains multianode photomultipliers (MAPMT), VFE electronics, regulator boards and pipes for the electronics water cooling system. A view of a typical box is given in Fig. 32. The modules are connected to the MAPMT by optical cables that consist of bundles of clear fibres, enclosed in a light-tight plastic tube. Depending on the position of the detector units inside the supermodule, the length of fibre bundles varies from 1.3 to 3.5 m. The detector planes are divided into two parts, each of them consists of four supermodules, a lateral and longitudinal cable tray, assembled altogether with screws and can slide independently on horizontal rails to the left and right thanks to a moving system (vis à billes, motor, etc.). Similarly the lead converter is divided into two parts, each of them consists of two independent strips 16 mm thick, 2 m wide and 8 m long screwed altogether, that can slide independently on horizontal rails. The main parameters of the mechanical structure are given in Table 33.

The PS/SPD electronics is split in two parts:

Table 33: Main parameters of the mechanical structure.

Structure	Material	z-x Cross-section	y length	Weight, kg
Supermodule		7 cm $\times$ 7.7 m	96 cm	330
Support Strip	Al	4 mm $\times$ 7.7 m	96 cm	46
Central piece	Al	4 mm $\times$ 48 cm	26 cm	7
VFE box	Steel	11 cm $\times$ 70 cm	96 cm	63
Modules	Sci	6 mm $\times$ 48 cm	48 cm	26 $\times$ 5
Fibre bundles		1.3 to 3.5 m		0.4 to 0.9
Detector + Support				21,130
Main Support Beams	Steel	200 cm^2	19 m	2,900
Base Beam	Steel	90 cm^2	19 m	1,300
Lead wall	Lead	16 mm $\times$ 7.9 m	7.7 m	10,000
4 $\times$ 1/2 detector		2 $\times$ 7 cm $\times$ 7.7 m	7.6 m	5,280
Lateral cable tray (PS) $\times$ 2		5.4 $\times$ 60 cm	8m	100
Bottom cable tray (PS) $\times$ 2		5.4 $\times$ 425 cm	44 cm	100
Top cable tray (PS) $\times$ 2		5.4 $\times$ 425 cm	460 cm	200
Lateral cable tray (SPD) $\times$ 2		5.4 $\times$ 60 cm	8m	100
Bottom cable tray (SPD) $\times$ 2		5.6 $\times$ 425 cm	30 cm	100
Top cable tray (SPD) $\times$ 2		5.6 $\times$ 425 cm	460 cm	200
Lower support beam	Steel	124 cm^2	9 m	850

- the Very Front-End (VFE) electronics housed in VFE boxes (Fig. 32) mounted on top and bottom of the supermodules [59],
- the Front-End (FE) electronics which is located in crates and racks over ECAL (see Fig. 27), on the ECAL platform [60, 61].

  At this place some services are also housed (high voltage system of the MAPMT, low voltage system of the VFE boards, LED monitoring system, etc.).

The whole SPD, lead and PS detectors have to be dismantled with their electronics and services. The dismantling will have to be done in a specific order. It will be possible to dismantle SPD and PS supermodules only once their cable trays and so all cables and part of the Very Front-End (VFE) water cooling system will have been dismantled.

Front-end electronics This is most certainly the easiest part to dismount. The eight SPD/PS crates (Fig. 28), one per rack (see Fig. 27) [56, 60, 61], have to be emptied from their FEB and removed (actually the crates and the backplanes can be used as spares of the XCAL and could be stored in the current racks). This corresponds to 100 SPD/PS FEB and 1800 (PS) + 116 (SPD) signal cables. The SPD control boards (16, two per crate) and CROC (eight boards, one per crate) should be removed with their cables (144 for the SPD CB and SPECS and optical fibres for the CROC). The present trigger cables (between racks) at the back of the crates have to be removed as well.

Each SPD/PS crate is equipped with a MARATON power supply (0M05.0002 type) which has to be removed. The 380 V primary power supplies are located in the UXB area, in the B1B01 rack.

Figure 27: The PS/SPD crates in their racks on the ECAL platform for C-side (left) and A-side (right) [60].

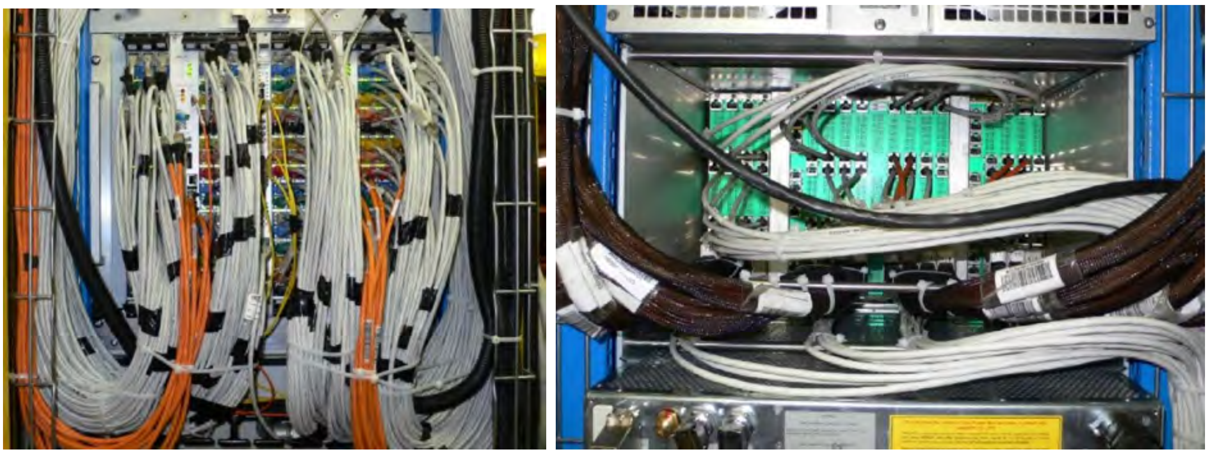


Figure 28: Front and back view of the SPD/PS front-end electronics. On the left the gray cables are PS signal and clock cables going to PS VFE boxes, the orange cables are clock and monitoring cables going to SPD VFE boxes. On the right black cables are SPD signal cables going to SPD VFE boxes and grey cables are L0 trigger cables connected to ECAL backplanes in the same rack.

The rectifiers and control system are no longer needed. They can be removed and used as spares of the XCAL. All power cables from UXA area to the detector in UXB are going through patch panels located in the rack Q2A01 on the third level behind the muon filter. The same rack host the ECS patch panel and some SPECS links used for PS/SPD.

Low voltage system A dedicated MARATON (0M22.0003 type) located in the upper part of rack L3B03 C-side and L3B13 A-side (Fig. 27) is used to provide low voltage to PS and SPD regulator boards which are housed in PS and SPD VFE boxes allowing to power the VFE boards. Outlets of the MARATON channels are connected to patch panels used to split low voltage power into cables. The PS patch panel (Fig. 29 left) is located on the rear of the MARATON on the top of the rack and serves 50 cables connected at the other end to 50 PS regulator boards with one additional spare cable. The SPD patch panel (Fig. 29 right) is near by, on the roof of the ECAL platform. Each SPD patch panel serves 16 cables connected at the other end to SPD regulator boards with two spare cables. Actually these two MARATON units and their spares can be used to power part of the SciFi electronics. Once the cables will have been disconnected from the patch panels, it could be easier to dismount these patch panels only when all the cables will have been removed. The access between the MARATON power bin and the patch panels to remove these intermediate cables is from the roof top of the ECAL platform and quite difficult due to the current amount of cables on it (Fig. 30).

The 380 V primary power supplies of these MARATON power bins are located in UXB in the B1B01 rack. The rectifiers and control system are no longer needed. They can be removed and used for the SciFi.

Figure 29: LV cable patch panels for PS VFE in rack L3B03 (left) and for SPD VFE (right).

High voltage and monitoring system Eleven dedicated Cockcroft-Walton boards per detector side are used for providing high voltage to the SPD and PS MaPMT which are in VFE boxes on the supermodules with specific cables. These boards are hosted in a 6U VME crate (Fig. 31) located on the ECAL platform in rack L3B03 (C-side) and L3B13 (A-side). SPECS cables are used to provide remote control and monitoring of the system. They are connected to a patch panel located in the rack Q2A01 (third level behind the muon filter). The Cockcroft-Walton units are powered with one output of a ECAL low voltage power supply located at the top of L3B01 (C-side) and L3B11 (A-side). In addition the medium voltage (150 V) is delivered from an AGILENT power supply located in UXB in D3B05. Cables are going through a patch panel host in Q2A01.

The same crate (Fig. 31) hosts the PS/SPD LED monitoring system composed of six boards per side. They are powered by sharing one output of the MARATON used to power ECAL LED monitoring system. DC voltages and trigger signals are sent with cables to the PS and SPD LED and drivers which are located on the supermodules [62, 63].

Just above this 6U crate is located a 3U crate (Fig. 31) which hosts four ELBM boards. These boards are used to monitor temperatures of the PS VFE electronics and regulator boards located in the VFE boxes on the PS supermodules thanks to cables connected on the rear of the crate. A

Figure 30: Part of PS cable chain and top roof of ECAL platform C-side with PS/SPD cables on it.

powered CAN bus connection is used for ECS and to supply the ELMB boards. Cables are going via a patch panel in Q2A01 to D2 in UXB. All these cables and the CAN bus chain are no longer needed and have to be dismantled. The “flat” cables are used for reading the temperatures and are going to the VFE boxes on the supermodules.

Figure 31: 6U crate in rack L3B03 C-side (L3B13 A-side) with the PS/SPD HV and LED monitoring system. On top of it, the 3U crate with ELBM boards for the VFE PS temperature monitoring system.

VFE Boxes PS VFE boxes (Fig. 32 right) and SPD VFE boxes (Fig. 32 left) [59] host MAPMT block and regulator boards with their cooling system and cables. They are attached at the top and bottom of each supermodule. A MAPMT block is composed of a MAPMT surrounded by a μ-metal cylinder, a high voltage board, a VFE board and is connected to an optical fibre bundle and to cables. An aluminium plate is mounted on the top of a VFE board in contact via thermal pads with the chips. MAPMT blocks and regulator boards are maintained with a special fixation in aluminium hosting a stainless pipe with circulating demineralized water to ensure the cooling of the electronics. This fixation is divided into two bars and can accommodate up to eleven MAPMT and some regulator boards. The number of MAPMT blocks and regulator boards inside a VFE box depends on the granularity of the detector and so on its location. VFE and regulator boards for PS and SPD are slightly different, but the principle is the same. Each VFE box is also equipped with a thermoswitch connected with a cable to the DSS system.

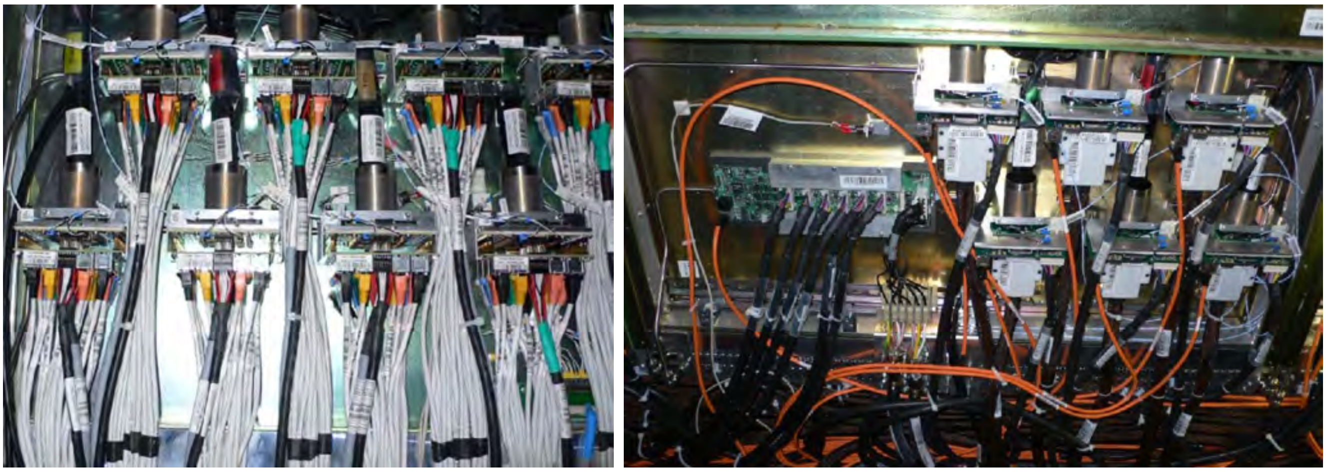


Figure 32: A PS VFE box with the electronics on the left and a SPD one on the right.

We can distinguish three kinds of connections/cables for a VFE box [56, 59]:

- Connections inside a box. These are mainly VFE LV power supply cables between a VFE board and the regulator board used to power it when they are in the same VFE box. In the PS VFE box, there are also some thin cables between temperature probes located on VFE and regulator boards and a patch panel inside the box. These cables could stay in place.
- Connections between two boxes. In most of the cases a VFE board and the regulator board used to power it are not located in the same VFE boxes and there are cables running on the top or bottom cable tray between them. These cables will have to be dismounted.
- Connections between boxes and ECAL platform. These are signal and clock/ECS cables, HV cables, LV cables, cables for PS temperature monitoring and DSS cables. In addition they are the cables uses for the LED monitoring system. All these cables have to be dismantled and are discussed further in the next paragraph.

The MAPMT blocks and the regulator boards could remain into the VFE boxes and dismantled later while all the cables, except the one used for internal connections inside a box, have to be dismantled.

The usual access to the VFE boxes will be needed for these operations and constraints are given in Table 34.

Table 34: Detector position to access PS/SPD VFE boxes.

Detector		Position	Constraints	Access
PS	top	closed	ECAL/HCAL open	“yellow” nacelle or PS passerelle
	bottom	closed	ECAL open	nacelle or scaffolding
		open	ECAL closed	nacelle or scaffolding
SPD	top/bottom	open	M1 closed	RICH tower

LED monitoring system The PS/SPD monitoring system consists of LEDs glued in each scintillator cells [62, 63]. They are driven thanks to a driver board for 16 cells and one splitter board for eight driver boards. These boards are fixed directly on the modules of the detector and the number of driver and splitter boards for each type of supermodule varies according to the granularity of the detector.

Splitter boards are connected to a monitoring control board (power supply and trigger signal) put in a 6U VME crate in rack L3B03 and L3B13 as previously described. This is done in two parts. First they are connected to a patch panel inside each upper supermodule VFE box. From there, cables are going to the ECAL platform with the other cables from the electronics systems. Two cables for each splitter board are used:

- Lemo type cables for trigger signal;
- RJ11 type cables for power supply.

After having unplugged the cables from the patch panels, they can be dismantled while the other parts of the system could stay mounted on the supermodules and be dismantled later.

Cables between PS/SPD supermodules and PS/SPD crates on the ECAL platform In addition to the cables used for the LED monitoring system described in the previous paragraph, we can distinguish five different type of cables for PS and SPD [64, 65].

- HV cables: one cable is made of four cable pairs; each cable pair is connected to one MAPMT to power it in a VFE box and on the other side to a HV board in the L3B03 rack for C-side and L3B13 rack for A-side. These cables are identical for PS and SPD.
- Signal cables: they are used to exchange clock, reset and signals between a PS or SPD VFE board inside a box and a PS FE board inside a crate in the ECAL platform. For PS, there are 17 RJ45 cables between a VFE and a FE board. To help for cabling, these cables are grouped by six to form a bundle. So three bundles of six cables are used to connect a VFE to a FE board. The extra 18^{th} cable is not connected and used for spare. For SPD there are four signal cables, equipped with a specific connector, for a VFE board and they are grouped to form a bundle and one RJ45 cable for the clock and reset plus one RJ45 cable connected to a regulator board for control/monitoring.
- LV power supply cables: they are used to power the regulator boards inside the boxes with the Wiener power supply in the L3B03/L3B13 rack. PS and SPD regulator boards are different. For PS there is one cable per regulator board and one regulator board for one VFE board while for SPD there are two cables per regulator board and one regulator board for seven VFE board. Consequently PS and SPD power supply cables are very different.

- PS temperature probe cables: from a patch panel inside each PS VFE box two 16-pair "flat" cables are used to connect the ELBM boards located in the L3B03/L3B13 rack.

A summary of the cables, with their main characteristics, used for the PS and SPD VFE electronics is given in Ref. [66]. All PS signal cables have a length of 27 m and others have a length varying from 18 m to 30 m depending on cable types and locations. Their total weight is about 2 t for PS and 1 t for SPD. All cables and bundles of cables have a printed label with a bar-code according to the convention given in Ref. [67] with some location information. These cables are running along the top or bottom of the supermodules on cable trays, then on a lateral cable tray for bottom cables up to the ECAL platform thanks to cable chains (Fig. 33). Each half of detector is equipped with a double cable chain with six compartments each, to allow independent moving of the detectors. The filling of the chain compartment depends on cable types and on the location where the VFE box cable end and the ECAL platform cable end are connected. The routing of the cables to go to the PS/SPD crates is quite complex and the extra cable length is stores on the top of the ECAL platform roof (Fig. 30). The weights of the empty cable chains are given in Table 35. A few smoke sniffers which are used for the fire detection system are also present.

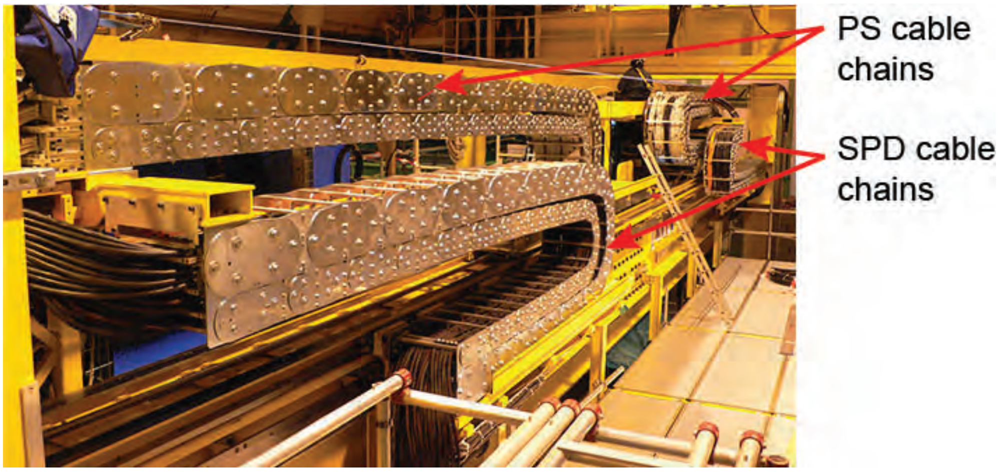


Figure 33: PS and SPD cable chains after their installation (view from the platform installed on the RICH).

Table 35: Weights of empty PS and SPD cable chains.

Cable chain	PS	SPD
Outer part	375 kg	300 kg
Inner part	260 kg	195 kg
Total	1270 kg	990 kg

All these cables have to be dismantled with the cable chains. A good access is very important to perform all these operations and will require different elements. A floor will have to be installed over the RICH to access cables and cable chains and a small scaffolding installed on it close to the ECAL beam. This could require partial dismantling of the upper elements of the RICH towers. The use of the PS passerelle, fixed on the two ECAL halves, will also be needed to dismantle PS cables fixed on the top cable tray. For safety when there are people working on the PS passerelle, HCAL has to be closed behind it. PS, SPD and ECAL detectors will have to be moved in different positions to allow a good access to the cable chains. A nacelle will be also needed to remove cables fixed on the lateral cable trays. Last but not least, M1 was not installed when SPD cables were put in place. It has to be checked that SPD cables can be dismantled with M1 closed, or if it has to be dismantled first. Part of the work will be at height, people will have to be equipped with a safety harness and the installation of a "ligne de vie" will be required, specially for the work on the top roof of the ECAL platforms. At least three persons will be needed for this dismantling under the supervision of a coordinator.

PS/SPD cables between ECAL platform and barracks Some PS/SPD cables used on the ECAL platform are going to the barracks via a patch panel located in the rack Q2A01, third level behind the muon filter. These cables are no longer needed and have to be removed. From the ECAL platform they are going to the cable chains between ECAL/HCAL and the fixed point and to cable trays to the patch panels (Fig. 26) as the one used for ECAL and HCAL [56]. There are two kinds of cables:

- Optical links and Ethernet cables (RJ45 connectors) connected to CROC, SPD multiplicity boards in PS/SPD crates and HV system which are used for data, ECS and clock transfer.

  Similar to those used for ECAL and HCAL, they are using the same path to go to the patch panel and can be removed at the same time than the ones for ECAL and HCAL which have to be removed too.

- LV and control cables used for PS/SPD Maraton, LV cables used for PS/SPD HV system, CAN bus cables used for PS monitoring system and PS/SPD DSS (thermoswitches, water leak detection).

  Either these cables can be removed or remain in place and used as additional spares for ECAL.

A good access will be needed to remove these cables. It will require the installation of a floor above the muon filters to have access to the cable trays and ECAL and HCAL detectors will have to be in some specific positions for a better access to the cable chains. The use of a nacelle will also be needed to access some parts. At least two persons will be needed for this operation. Part of the work will be at height, people will have to be equipped with a safety harness and the installation of a "ligne de vie" will be required.

It will have to be defined what to do with cables between the patch panel Q2A01 and the barracks.

PS/SPD water cooling system The PS/SPD VFE water cooling system is made of many parts on the detector:

- Pipes inside the VFE boxes as described in a previous paragraph;
- Distribution circuit along boxes protected by a small grid shaft from the cables and pipes along lateral cable trays (Fig. 34 left);
- Flexible pipes from end of pipes to manifolds on the lateral pillar of ECAL structure, going into plastic cable chains to allow detector movements(Fig. 34 middle);
- Manifolds on the lateral pillar of ECAL structure and pipes going to the primary manifolds under the magnet(Fig. 34 right).

In addition there is a water leak detection system made of water detection cables running close to the distribution circuits along the VFE boxes and connected to the detector safety system.

Once all the cables will have been dismantled and the water cooling system purged, it will be possible to access to the circuit and to dismount it. The pipes inside the VFE boxes have to be unscrewed from the distribution circuit and could remain in place while the other parts have to be dismounted up to the manifolds.

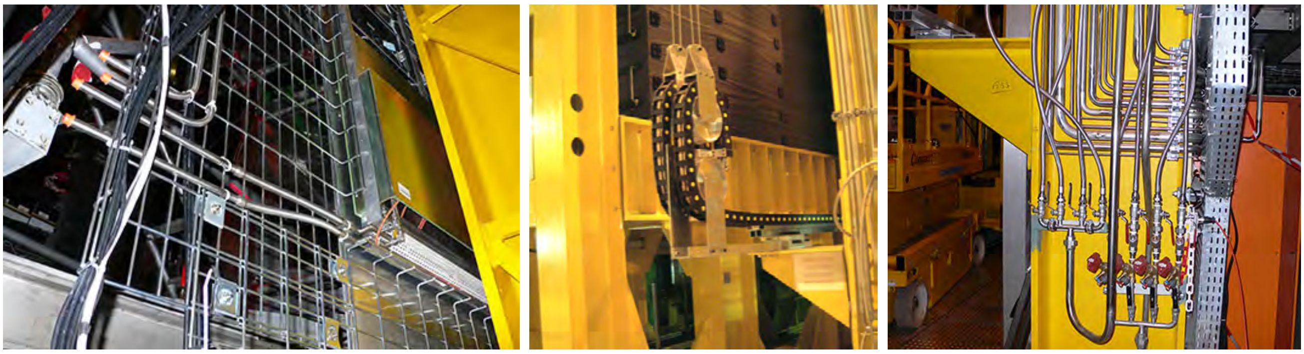


Figure 34: PS/SPD water cooling system elements. Left: distribution circuits and pipes along cable trays (before cable installation). Middle: Cable chains for the flexible pipes. Right: manifold on the ECAL pilar A-side.

Lead absorber The lead absorber is made of four panels, two on each detector side. The dimensions of one panel are $\sim 8.2\,\mathrm{m}\times 2\,\mathrm{m}\times 16\,\mathrm{mm}$, with a weight of about 2.5 tons. Two panels are screwed together to form a wall. As the supermodules, they are hanged by the top on a rail and guided at the bottom by a rail (Fig. 37). Its moving system is rather simple (a belt with a crank). The panels have been installed one by one on the top rail (Fig. 35), from A-side, by using a transport cradle and assembled in position. The reverse procedure will have to be used to dismount them. Panels will have to be unscrewed and removed one by one with the crane and put on the transport cradles. A nacelle will be needed to attach the panels to the crane and ECAL/HCAL A-side should be closed. C-side can be removed only after dismantling of the beam pipe. Two transport cradles were built and are stored at the P8 surface (Fig. 38 right) . Manipulation of the lead panels without their transport cradle is difficult and a storage will have to be found or two additional cradles will have to be built.

Super modules Each detector half is composed of four supermodules [62, 63] screwed altogether. The dimension of one supermodule is about 7.7 m $\times$ 0.96 m with a weight of about 330 kg with its VFE box at each end. The supermodules are hanged on a rail on the top and guided with another rail at the bottom. On the supermodules are screwed top, bottom and lateral cable trays to maintain cables between the VFE boxes and the ECAL platform. Each half of detector, four supermodules with the cable trays, can move as a whole on the rails thanks to a moving system (vis à billes, motor, etc.). After removal of all the cables and cable chains, the cable trays will have to be dismounted with a nacelle. The best should be to do that with the detector open on A-side and with ECAL and HCAL A-side closed. Then the supermodules can be unscrewed from a nacelle and it will be possible to remove supermodules, one per one, from A-side with a crane. A specific hanging tool, to fix on the crane, has been designed for the installation of the supermodules on

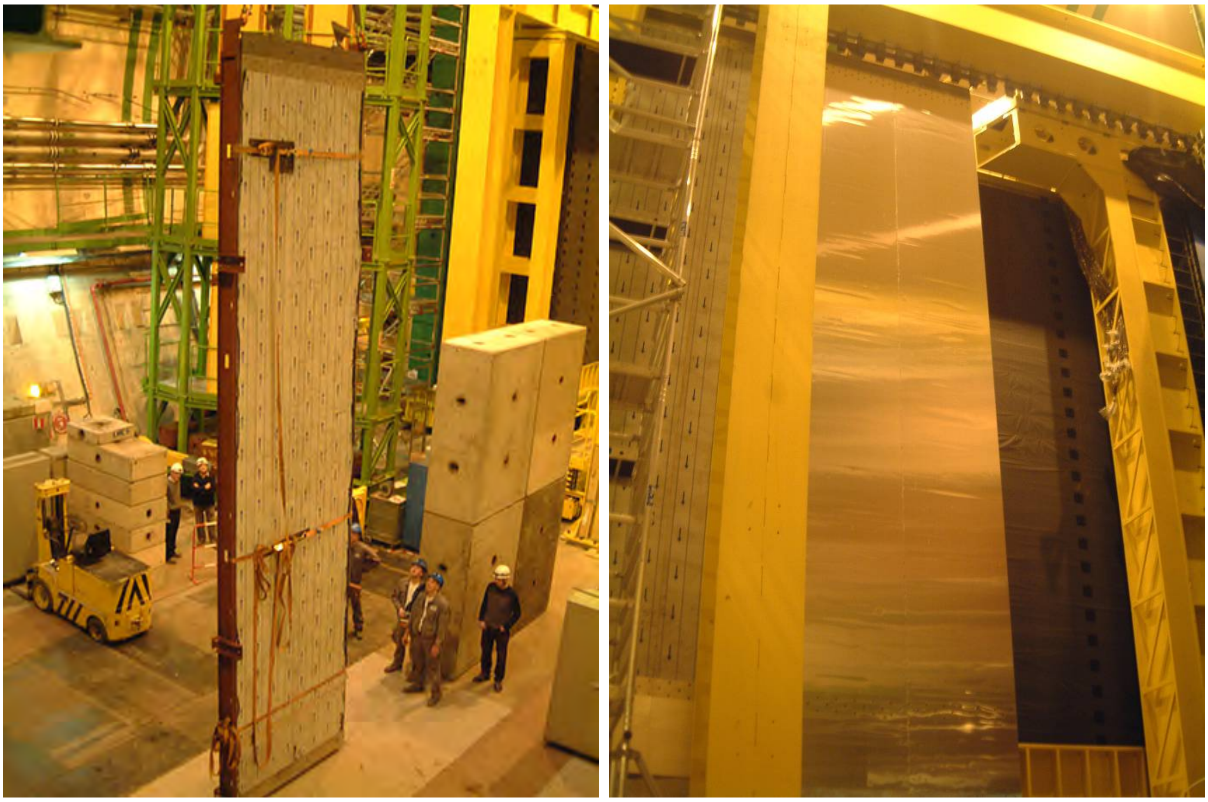


Figure 35: A lead panel on its transport cradle before its installation (left), and on its support after installation (right) beginning of 2006.

the upper rail as well as a transport cradle which can house four supermodules (Fig. 36). They are stored at the surface of P8 (Fig. 38) and can be re-used to take them away. A nacelle will be needed to attach the supermodules to the hanging tool and ECAL/HCAL A-side should be closed during this operation. A single transport cradle is available, either some storage cradles or three additional transport cradles will have to be built. Later and outside the cavern it will be possible, if needed, to dismantle the supermodules (VFE boxes, electronics, optical fibre bundles, cables, LED monitoring system made of splitter and driver boards, cell boxes, frames, covers, etc.). An assembly cradle was used to build the supermodules. It would be nice to use it for these operations.

Last but not least the hanging system, top and bottom rails (Fig. 37), will have to be dismantled. For the top part, the PS passerelle and a nacelle will be needed.

PS/SPD moving system Once the PS/SPD supermodules will have been removed, their moving system can be dismantled.

PS motors and vis à billes are located below PS cable chains. An access from the ECAL platform and from the RICH side will be needed to dismantle them. SPD motors and vis à billes are located on the rear of the ECAL beam (RICH side) and will have to be removed from the RICH side with the floor and scaffolding used to removed PS/SPD cables.

In addition there are few cables which are used for the PS and SPD moving system (control, command, end-switches) and which are not needed any more. These cables are going from the PS/SPD motors to the bunker in the center of ECAL bottom where the PS/SPD cabinet is

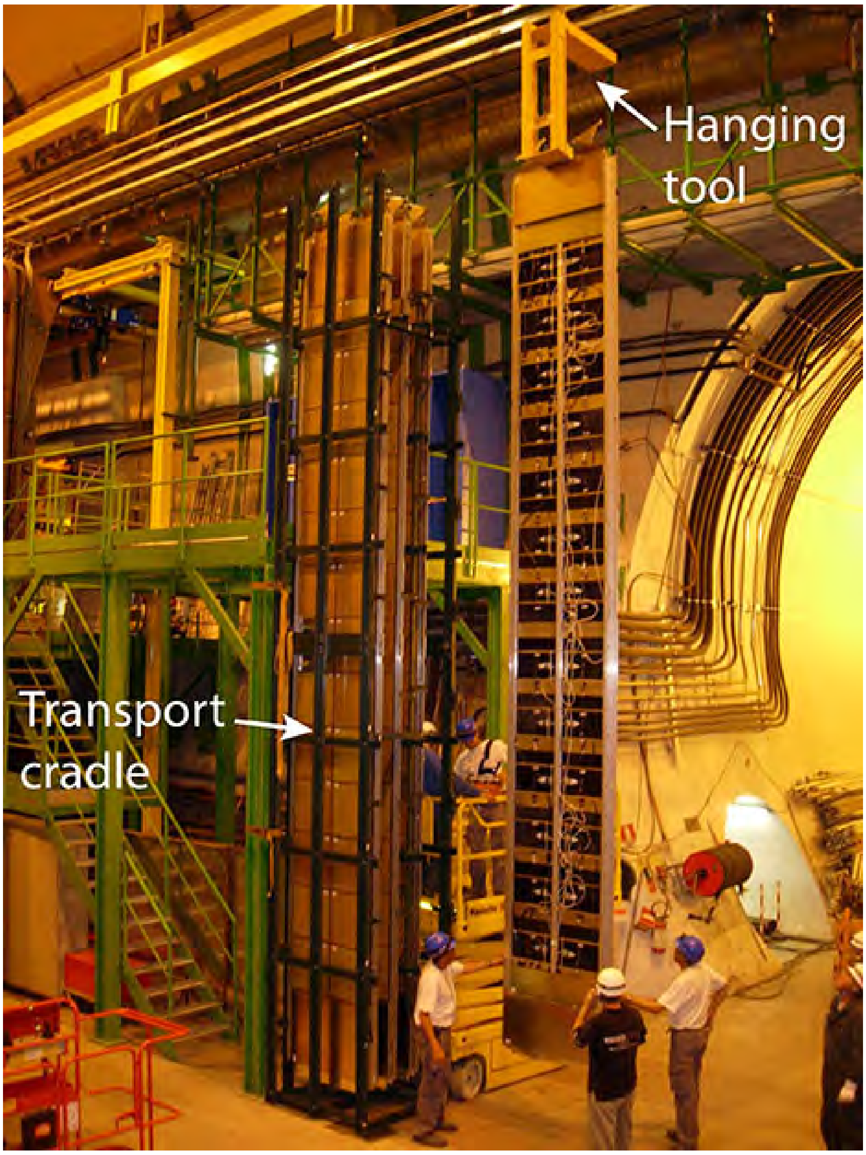


Figure 36: A PS supermodule taken out from the supermodule transport cradle during the installation in June 2006.

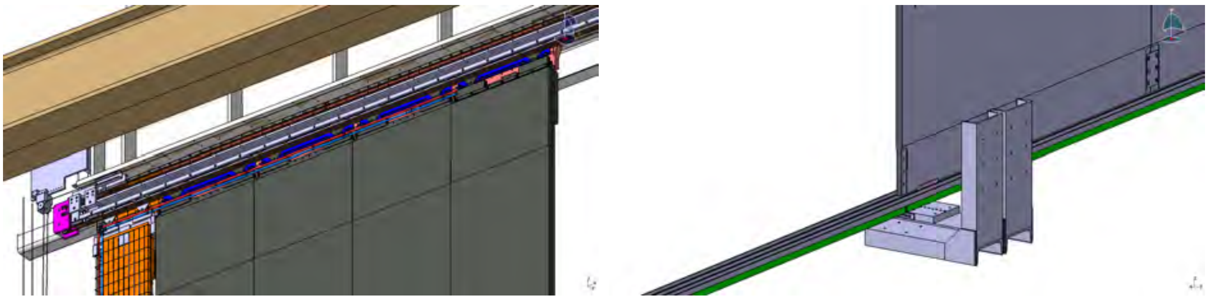


Figure 37: Top (left) and bottom (right) supports of SPD/Lead/PS detectors.

connected to move the detectors. Some of these cables are going first to the ECAL platform where a plug is installed on each side for the command of the moving. These cables are running along the ECAL pillars (A and C side) and inside some cable trays used for other services. They could

Figure 38: PS/SPD supermodule hanging tool on the left and transport cradle on the right on top of the lead panel transport cradles stored at P8.

stay in place or be removed with a nacelle for A-side. For C-side some specific scaffolding was used for the installation and it has to be checked if the access needed to remove the cables and a nacelle allows to dismantle them.

6.6.3 Installation

The installation concerns:

- the optical links and the related components (patch panels, . . .),
- the front-end boards 3CU boards in the ECAL and HCAL crates,
- the replacement of the mezzanines for the high voltage, calibration and monitoring systems and the installation of the new fanout boards.

The installation of the front-end electronics requires first the removal of the current electronics of the ECAL/HCAL/SPD/PS and a partial removal of the cables of the SPD/PS.

6.7 Safety and environment

The ECAL and HCAL sub-detectors comply with the safety policy at CERN (see Ref. [52]) and we will follow the safety rules and codes that are relevant for their modifications and operation. This concerns essentially the safety instructions

- for the "use of plastics and other non-metallic materials at CERN with respect to fire safety and radiation resistance" (use of polystyrene scintillator material in the modules),
- the dynamic behaviour under seismic excitation,
- the high voltage to power the photo-multipliers,