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LHCb TFC Installation

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ABSTRACT

This document describes the installation of the LHCb Timing and Fast Control system, including all details on cabling and locations

Keywords: installation, TFC, TTC

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Contents

1 The TFC System

Figure 1 shows a logical view of the TFC system.

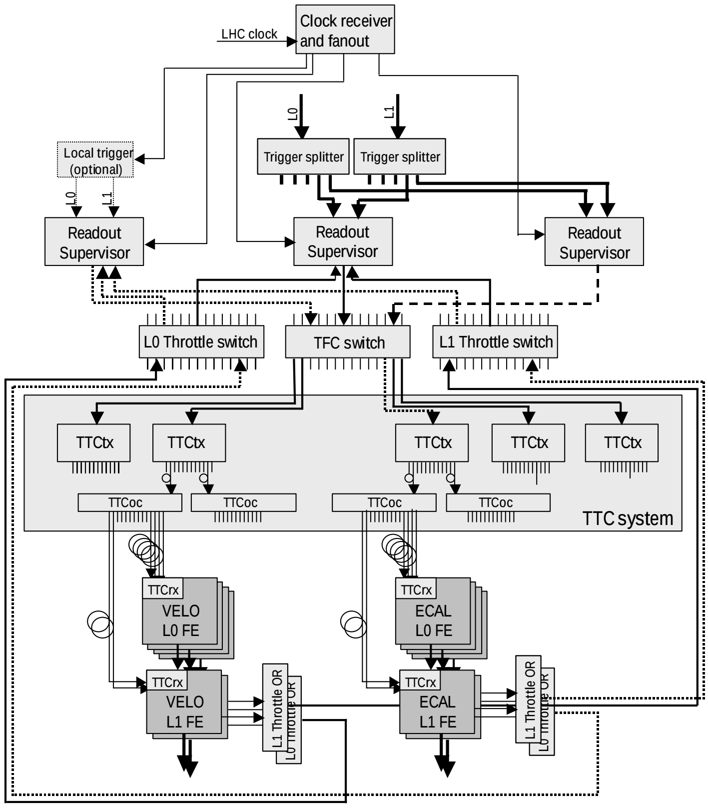

Figure 1: Overview of the TFC system architecture.

2 Connections with LHC

2.1 Timing, Trigger and Control (TTC) fibre

Fibres dedicated to the TTC system carry the LHC bunch clock and the LHC orbit signal from the LHC to the experiments. The orbit signal is transmitted in the form of a channel A pulse (25 ns). The TTC distribution starts out at the RF installation at SR4 and runs over a 9.5 km phase stabilized single-mode fibre to the CERN Control Centre (CCC, former PCR). Currently four high-power transmitters[1], one of which is used and three of which are spares, fan out the TTC signal to the different destinations around the LHC. The LHCb TTC fibre consist of a single-mode non-stabilized fibre of the type G.652.B 9µm/125µm and runs over a distance of 4.6km between the CCC and the SR8 building (bld. 2875) on the LHCb site where an 1-to-16 optical fan-out is installed. In order to have an immediate backup, there is a request for having two independent and active TTC fibres between the CCC and the SR8 building and thus two 1-to-16 optical fan-outs. The two fibres should be driven by separate transmitters at the CCC.

[1] There are ongoing discussion between the experiments and the ESS group about upgrading this equipment

From the fan-outs in SR8, via a patch-panel in building SG2870 and one in SX2885, there should be a minimum of two active single-mode fibres carrying the TTC signal via the PZ shaft to the patch panel in rack D2C09 in the D2 counting room [1]. The surface routing is shown in Figure 2 and the location of the rack is shown in Figure 4 in Appendix I. From the patch panel (E2000 connectors) there should be a single-mode (G.652B) 4-fibres patch cable E2000/ST-HQ (standard Physics Contact "PC") with individual protective sheath and common protective sheath up to a height of 45U on the right side of the TFC rack D3B07. Two fibres should be in use and the other two spares. ***Note that in all that follows the departure/arrival points of the fibres define the length of the bulk cable and should not include the ramified part which is used to attain the electronics.***

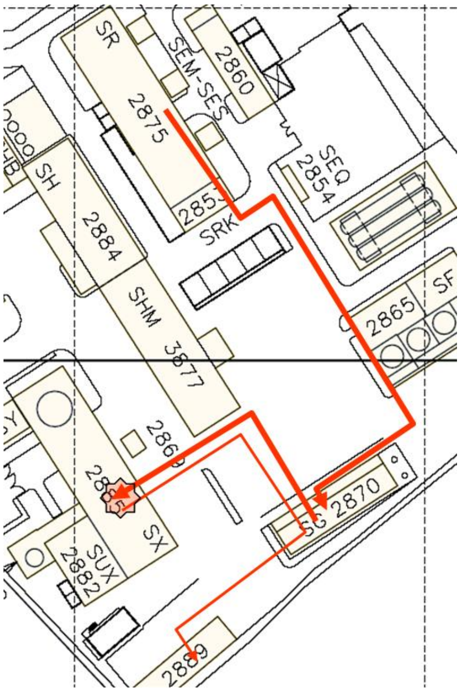

Figure 2: Routing of the fibres between SR8 and SX8.

2.2 Beam Instrumentation (BI) fibre

A set of data words are transmitted on the fibre dedicated to the BI system for every turn of the LHC beams, including GPS time, status of the accelerator, beam currents etc. The fibres start out at the CCC and arrive at an optical fan-out in the SR8 building on the LHCb site. There is one fibre per beam of the same type as the TTC fibre. Each BI fibre is fanned out by a 1-to-16 optical fanout.

From the fan-outs there should be a minimum of one fibre per beam going via the PZ shaft to the patch panel in the rack D2C09 in the D2 counting room [1]. From the patch panel (E2000 connectors) there should be a single-mode (G.652B) 4-fibres patch cable E2000/ST-HQ (standard Physical Contact "PC") with individual protective sheath and common protective sheath up to a height of 20U on the right side of the TFC rack D3B07. Two fibres should be in use and the other two spares. The BI fibres will be fanned out to the Readout Supervisors 'Odin' using two single-mode TTC optical splitters (TTCoc) located at the bottom of the rack D3B07 (Figure 3).

Table 1: Fibre connections between the patch panels in D2 and the TFC racks

Cable	Label 1	Label 2	Source-Destination	Dist.
4-fibre patch E2000/ST-HQ (G.652B)	LHC-TTC	TTC1,TTC2,TTC3,TTC4	D2C09 patch–D3B07 right	20m
4-fibre patch E2000/ST-HQ (G.652B)	LHC-BI	BI1, BI2, BI3, BI4	D2C09 patch–D3B07 right	20m

3 TFC racks

The two TFC racks (56U) are located in the D3 counting room (Figure 5 in Appendix I)[2], rack D3B07 and D3B08. Table 2 lists the TFC equipment which will be installed in the racks. Although in most cases below the functional name of the board is given together with its "proper" name, the correspondence is:

- Odin: Readout Supervisor
- Thor: TFC Switch
- Munin: Throttle Switch
- Hugin : Throttle OR
- Freja: TFC test board and TTC monitoring
- BPIM : Beam Phase and Intensity Monitor
-

Table 3 lists all the TFC modules and their power consumption. The TFC system will be kept on a UPS [3][4]. This means that a central clock is always available to the detector electronics, even if the LHC clock is not available. As a consequence, the power up sequence of the detector electronics will be smoother and more reliable since they directly come up in phase and in a stable state, which is not necessarily the case if the FE electronics are powered up before the clock is available.

Table 2: Equipment that will be installed in the TFC racks.

Equipment	Function	Size	Quantity
TTCmi crate	TTC machine interface	3U + 1U	2
9U VME crate	ODIN, THOR, MUNIN, FREJA, HUGIN	9U + 2U	3
6U VME crate	TTCtx, BPIM	6U + 2U	1
TTCoc (TTC Optical splitter)	Fan-out TTC BI signal + other	1U	2
Network patch panel	Patch panel for control and data links	1U	4
L0 trigger optical patch panel	*Patch panel for L0 trigger sources*	*2U*	*1*
Turbine	Cooling	4U	2
Heat exchanger	Cooling	2U	4
Fan tray	Cooling	2U	4
Deflector	Cooling	3U	2
	Total	85U / *87U**	

* Excluding/including L0DU equipment

Table 3: The TFC power consumption.

Module	Width	Voltage	Power	Quantity
TTCmi crate	-	5V	100W	2
ODIN (Readout Supervisor)	1 slot	5V	35W	16
THOR (TFC Switch)	2 slots	5V	55W	1
MUNIN (Throttle Switch)	2 slots	5V	15W	2
HUGIN (Throttle OR)	1 slot	5V	15W	1
FREJA (TTC monitoring)	2 slots	5V	25W	1
L0 Trigger fanout	1 slot	5V	Not available	1
TTCtx (TTC optical transmitters	1 slot	5V	10W	16
BPIM (Beam phase and intensity monitor)	1 slot	5V	Not available	1
9U fan tray	-	220	60W	3
6U fan tray	-	220	20W	1
TTCmi fan tray	-	220	30W	2
L0DU	*1 slot*	*48V/5V/-5V/5VA/3.3V*	*t.b.s.*	*1*
Trigger Receiver Module (TRM)	*1 slot*	*48V/5V/-5V/5VA/3.3V*	*t.b.s.*	*1*
		Total	1305W	

Figure 3 shows a schematic layout of the racks. The TELL1 type crates will be used for all boards. In order to have a common pool of spares of power supplies, the same supply as for the TELL1 crates will be used. The only disadvantage is that the TELL1 power supply only provides 100A at

5V, which means that it is not possible to place all the Readout Supervisors ‘Odin’ together in one crate. For this reason and for the reason of cabling, the safest solution which gives the best access is to have in total three crates and split the Readout Supervisors in the two upper crates.

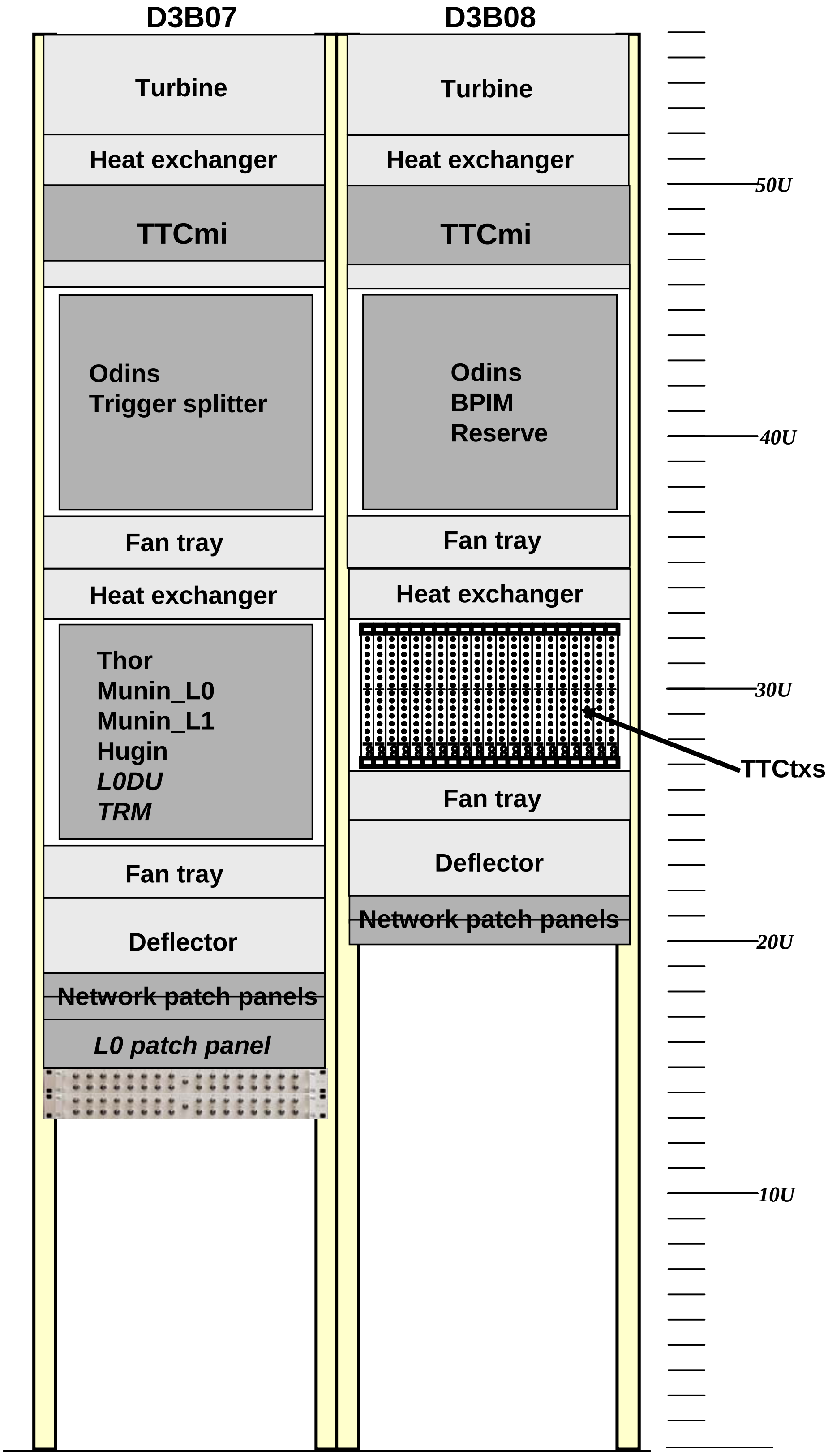

Figure 3: A schematic view of the TFC racks.

The L0 Decision Unit (L0DU) is currently planned to be located in rack D3B06. However, as it consists of only one board together with a 2U optical patch panel for the L0 trigger sources it is possible to locate it in the lower 9U crate in the TFC rack D3B07. This is also possible since the standard TELL1 power supply is used in all the TFC crates. This ensures a better and shorter connection with the Readout Supervisors ‘Odin’ and it frees the rack D3B06. Since space is available, it is also logical to install the Trigger Receiver Module in the same crate.

3.1 TFC cable labelling

The labelling of the TFC cables will be done according to the standard LHCb Part Identification system[5][6]. The standard identifier of all cables appears as both printed and as bar code. It consist of a mnemonic and 11 unique alphanumeric digits which for the TFC cables becomes 4OTnnnnnnnnnnn, where ”4” means the LHCb experiment, “O” the online system and “T” the TFC system. In addition there is a printed free field of 14 characters. In all what follows the suggested labelling corresponds to the free field.

3.2 TFC rack cabling

Table 4 lists the cabling of the ECL signals in the TFC racks. Since it is based on single-ended 50ohm coaxial LEMO cables the distances should be kept as short as possible to maintain good signal quality.

Table 4: Cabling of the ECL signals in the TFC racks using LEMO cables.

Signal	Label	Source-Destination	Distance	Qty
LHC clock	CLK	TTCmi/LHCrx/40.08 – TTCmi/C.GEN/IP	1ns/20cm	2
LHC clock	CLK	TTCmi/C.GEN/40.08 – TTCmi/VCXO-PLL/REF IP	1ns/20cm	2
LHC clock	CLK	TTCmi/VCXO-PLL/40.08 – TTCmi/TTCcf/IP1	1ns/20cm	2
LHC clock	CLK	TTCmi/TTCcf/OP – TTCmi/TTCcf/IP1	0.5ns/10cm	5
LHC clock	CLK	TTCmi/TTCcf/OP – ODIN/BCLK IN	3ns/60cm	16
LHC clock	CLK	TTCmi/TTCcf/OP – FREJA/BCLK IN	3ns/60cm	1
LHC clock	CLK	TTCmi/TTCcf/OP – BPIM/BCLK IN	3ns/60cm	1
LHC orbit	ORBIT	TTCmi/LHCrx/ORBIT – TTCmi/TTCcf/IP2	2ns/40cm	1
LHC orbit	ORBIT	TTCmi/TTCcf/OP – TTCmi/TTCcf/IP2	0.5ns/10cm	5
LHC orbit	ORBIT	TTCmi/TTCcf/OP – ODIN/ORBIT IN	3ns/60cm	16
LHC orbit	ORBIT	TTCmi/TTCcf/OP – FREJA/ORBIT IN	3ns/60cm	1
LHC orbit	ORBIT	TTCmi/TTCcf/OP – BPIM/ORBIT IN	3ns/60cm	1
TTC	TTC	ODIN/TTC OUT – THOR/TTC IN	5ns/100cm	16
TTC	TTC	THOR/TTC OUT – TTCtx/IP	5ns/100cm	16

Table 5 lists the cabling of differential signals and the cable types, and also the BI fibres. For the control network (ECS Ethernet), there is need for cabling to ~20 destinations + reserves in D3B07, and a minimum of 12 destinations in D3B08.

An Readout Supervisor ‘Odin’ board uses one data link (Gigabit Ethernet) out for the HLT data and one data link (Gigabit Ethernet) in for the L1 Trigger decisions. Since the data links are full duplex, it should in principle be sufficient with 16 data links in order for all the Odins to be fully functional. However, it might be safer to install a few more data links in order to allow using a separate link for receiving L1 triggers and transmitting HLT data. Therefore, a fully equipped patch panel with 24 Gigabit Ethernet links should be considered in D3B07. To allow for flexibility in the use of the racks it would also be useful to install a set of Gigabit Ethernet links in D3B08. The cabling of the Ethernet and the Gigabit Ethernet networks are described in Ref. [7].

The connectors for the control links and the data links are all located on the front of the TFC modules.

Table 5: Cabling of differential signals and the BI fibres in the TFC rack.

Signal	Cable	Label	Source-Destination	Distance	Qty
L0 Throttle	Dual twisted pair (MA4) RJ9/RJ9	THR_L0	MUNIN_L0/THR OUT – ODIN/THR IN1	150cm	16
L1 Throttle	Dual twisted pair (MA4) RJ9/RJ9	THR_L1	MUNIN_L1/THR OUT – ODIN/THR IN2	150cm	16
BI	Single-mode patch cord ST/ST(PC)	BI	TTCoc/OUT – ODIN/TTCrx/TTC IN	200cm	10
L0 Trigger	Twisted pair flat ribbon 34C	L0TRG	L0DU/TRG OUT – L0 trigger fan-out	150m	1
L0 Trigger	Twisted pair flat ribbon 34C	L0TRG	L0 trigger fan-out – ODIN/L0 TRG IN	50cm	4
BX INFO	Twisted pair flat ribbon 18C	BX_INFO	BPIM – ODIN/BX INFO IN	50cm	4
GbEthernet	GbEthernet/RJ45	GBE	ODIN/GbE – Network	200cm	24
Ethernet	Ethernet/RJ45	ETH	Network – ODIN/ETH	150cm	16
Ethernet	Ethernet/RJ45	ETH	Network – THOR/ETH	100cm	1
Ethernet	Ethernet/RJ45	ETH	Network – MUNIN/ETH	100cm	2
Ethernet	Ethernet/RJ45	ETH	Network – FREJA/ETH	100cm	1
Ethernet	Ethernet/RJ45	ETH	Network – BPIM/ETH	150cm	1
Ethernet	*Ethernet/RJ45*	*ETH*	*Network – L0DU*	*100cm*	*1*
Ethernet	*Ethernet RJ45*	*ETH*	*Network – TRM*	*100cm*	*1*

4 TFC partitioning

The organization of the TFC distribution via the TTC network should take into account the requirement of partitioning. A partition is a generic term defining a configurable ensemble of parts of the online system that can be run concurrently, independently, and with a different configuration than any other partition. Seen from the TFC system running a partition could be timing, triggering and controlling the Front-End electronics of a single sub-detector. The TFC Switch ‘Thor’ defines the TFC partition granularity as it allows distributing the TFC signals on independent paths between the Readout Supervisors ‘Odin’ and the detector electronics. The TFC Switch has been designed to have 16 inputs and 16 outputs meaning that the detector electronics can be subdivided into a maximum of 16 independent sub-systems. Table 6 suggests a possible subdivision.

Table 6: Suggested subdivision of the detector electronics. Note: An open issue concerns the association of the L0 muon and calorimeter trigger electronics that in this example have been associated with the L0DU and the TRM. It still has to be decided whether it is better to associate these to the detectors or even make independent partitions at the cost of for instance dropping the sub-division of the OT. The current suggestion has one spare connection.

Detector	Subdivision
VELO	2
PUS	1
RICH1	1
ST-TT	1
ST-IT	1
OT	2
RICH2	1
SPD/PS	1
ECAL	1
HCAL	1
MUON	2
L0 Decision Unit Muon trigger Calorimeter trigger Trigger Receiver Module (TRM)	1

The TTC distribution scheme below has been prepared to allow a maximum of flexibility which in turn allows the exact partitioning to be decided later. However, for this to be possible the sub-detector electronics must also be organized in a way that the connectivity is straight-forward between the electronic boards belonging to a sub-system and the neighbouring TTCoc modules.

5 TTC network

The TFC clock, trigger and synchronous control commands are distributed to the front-end electronics using the CERN RD12 TTC system. The TTC network is based on single-mode[2] G.652.B optical fibres operating at 1310nm. The TTC fibres will start out from 16 TTCtx (optical transmitter) modules located in the 6U VME crate in the rack D3B08. Each TTCtx has 14 high-power outputs on the front-panel to drive 1-to-32 single-mode optical splitters (TTCoc). The TTCoc modules are 1U x 19" and require no power. From a general point of view the fibres have two destinations: the L0 Front-End (L0FE) and the trigger electronics close to the detector and the L1 Front-End (L1FE) electronics (TELL1/UKL1 boards, etc) and L0 trigger processors in the D3 counting room. Although the fibres are identical and carry identical data, they are here referred to as L0 fibres and L1 fibres, respectively, for clarity.

All the TTC fibres between the TFC racks and the TTCoc modules will consist of single-mode 4-fibres patch cables ST/ST-HQ (standard Physical Contact "PC") G.652.B with individual protective sheath and common protective sheath. They should all start out at a height of 20U in the rack D3B08, the L0 fibres on the right side and the L1 fibres on the left side.

5.1 "L0 fibres"

Close to the detector, the single-mode TTC optical splitters 1-to-32 (TTCoc) are located in the racks of the sub-detectors. The sub-detector patch panel racks are grouped at four different locations (Figure 6 in Appendix I)[8]: on the balcony platform on the RB84 side, in the bunker, on the gantry on top of the tunnel entrance behind the muon detector and on the two platforms on each side of the tunnel entrance behind the muon detector. To reach the four locations, the fibre patch cables will be installed on both sides of the protection wall through the chicanes and in the cable duct in the groove in the cavern floor. This scheme has several advantages:

- It is easy to ensure that fibres for each sub-detector are of the same length.
- Only three different lengths for the fibres.
- The maximum difference in length for all detectors can be kept low in order to allow adjusting the L0 trigger latency with safe margins.
- The TTCoc modules function as patch panels, which isolates and protects the long-distance fibres between the counting houses and the detector racks and its connectors.

Table 7 lists the location of the sub-detector racks, the number of TTCrx chips, and the number of active L0 fibres (= TTCoc modules) which are needed per sub-detector. The scheme is flexible and contains enough TTCoc modules to allow the exact partitioning of the detector to be decided later. As mentioned above, all the L0 fibres should start out at a height of 20U on the right side of the rack D3B08. Table 8 suggests a labelling of the L0 fibres.

[2] It has been decided recently to make the entire TTC distribution network with single-mode fibres due to problems with the splitting of the single-mode signal transmitted by the TTCtx modules in the multi-mode TTCoc modules.

Between the TTCoc modules and the TTCrx receiver chips, single-mode fibre cords ST/ST (standard Physical Contact "PC") G.652.B are recommended. For the same reason as above, it is very important that the fibres are of equal length within a sub-detector and that the maximum variation in length between the sub-detectors is kept low. The sub-detector groups are responsible for this cabling.

Table 7: Number of active TTC "long-distance" fibres for the L0 front-end electronics and trigger electronics located close to the detector.

<table>
<tr><th>Rack location
(Dist. TFC-TTCoc)</th><th colspan="2">Detector (#patch panel racks)</th><th>L0 TTCrx</th><th>L0 fibres =L0 TTCoc</th><th>4-fibres patch cables</th><th>Approx. dist. TTCoc–TTCrx*</th></tr>
<tr><td rowspan="4">Balcony
(~50m)</td><td colspan="2">VELO (1 rack)</td><td>2*7</td><td>2</td><td>1</td><td>~15m</td></tr>
<tr><td colspan="2">PUS (1 rack)</td><td>3</td><td>1</td><td>1</td><td>~15m</td></tr>
<tr><td colspan="2">RICH1 (1 rack)</td><td>2*49</td><td>4</td><td>2</td><td>~15m</td></tr>
<tr><td colspan="2">ST-TT (1 rack)</td><td>2*8</td><td>2</td><td>1</td><td>~15m</td></tr>
<tr><td rowspan="4">Bunker
(~55m)</td><td colspan="2">ST-IT (2 racks)</td><td>2*12</td><td>2</td><td>2</td><td>~15m</td></tr>
<tr><td colspan="2">OT (2 racks)</td><td>4*6</td><td>2</td><td>2</td><td>~15m</td></tr>
<tr><td colspan="2">RICH2 (2 racks)</td><td>2*72</td><td>6</td><td>4</td><td>~15m</td></tr>
<tr><td colspan="2">MUON M1 (4 racks)</td><td>2*26</td><td>2</td><td>2</td><td>~15m</td></tr>
<tr><td rowspan="3">Calorimeter gantry
(~50m)</td><td>SPD/PS</td><td rowspan="3">(1 rack)</td><td>2*4</td><td>1</td><td rowspan="3">2</td><td>~20m</td></tr>
<tr><td>ECAL</td><td>2*7</td><td>1</td><td>~20m</td></tr>
<tr><td>HCAL</td><td>2*2</td><td>1</td><td>~20m</td></tr>
<tr><td>Muon gantry (~60m)</td><td colspan="2">MUON M2-M5 (2 racks)</td><td>2*49</td><td>4</td><td>2</td><td>~15m</td></tr>
<tr><td colspan="3">Total</td><td>499</td><td>28</td><td>19</td><td></td></tr>
</table>

* The cabling between the TTCoc and the TTCrx is made using patch cords and is handled by the sub-detector groups.

Table 8: Suggested labelling of the single-mode 4-fibres patch cables between the TFC rack and the sub-detector racks close to the detector.

<table>
<tr><th>Detector</th><th>Label</th></tr>
<tr><td>VELO</td><td>TTC0-VELO</td></tr>
<tr><td>PUS</td><td>TTC0-PUS</td></tr>
<tr><td rowspan="2">RICH1</td><td>TTC0-RICH1_0</td></tr>
<tr><td>TTC0-RICH1_1</td></tr>
<tr><td>ST-TT</td><td>TTC0-ST-TT</td></tr>
<tr><td rowspan="2">ST-IT</td><td>TTC0-ST-IT_0</td></tr>
<tr><td>TTC0-ST-IT_1</td></tr>
<tr><td rowspan="2">OT</td><td>TTC0-OT_0</td></tr>
<tr><td>TTC0-OT_1</td></tr>
<tr><td rowspan="4">RICH2</td><td>TTC0-RICH2_00</td></tr>
<tr><td>TTC0-RICH2_01</td></tr>
<tr><td>TTC0-RICH2-10</td></tr>
<tr><td>TTC0-RICH2-11</td></tr>
<tr><td rowspan="2">MUON M1</td><td>TTC0-MUON-S1_0</td></tr>
<tr><td>TTC0-MUON-S1_1</td></tr>
<tr><td>SPD/PS</td><td rowspan="3">TTC0-CALO_0
TTC0-CALO_1</td></tr>
<tr><td>ECAL</td></tr>
<tr><td>HCAL</td></tr>
<tr><td rowspan="4">MUON M2-M5</td><td>TTC0-MUON-S25_00</td></tr>
<tr><td>TTC0-MUON-S25_01</td></tr>
<tr><td>TTC0-MUON-S25-10</td></tr>
<tr><td>TTC0-MUON-S25-11</td></tr>
</table>

The number of 4-fibre patch cables is such that there are at two to three spare fibres per sub-detector rack.

5.2 "L1 fibres"

Figure 5 in Appendix I shows the locations of the detector front-end electronics in the D3 counting room which consist of the L1FE boards (TELL1 or UKL1) for the different detectors, and the L0 trigger processors. A single crate of L1FE electronics can house up to 20 boards and will be covered by one TTC optical splitter TTCoc. The TTCoc modules will all be located in the racks containing the detector electronics. A rack will fit up to two L1FE electronics crates and will therefore contain two TTCoc modules in most cases. Since the TTC input to the TELL1(and UKL1) boards are located at the back, the optical splitter must be fitted in a way that it allows easy cabling. The TTCoc modules must also be placed outside the cooling flow since they are closed box modules.

Table 9 lists the location of the detector electronics, the number of TTCrx chips and the number of active L1 fibres (=TTCoc) per sub-detector. In order to have at least two spare connections, there will be a 4-fibre patch cable installed between the TFC rack D3B08 and each detector rack. Table 10 lists the TTC patch cables and distances for all the sub-detectors. As mentioned above, all the L1 fibres should start out at a height of 20U on the left side of the rack D3B08.

Table 9: Number of active TTC counting room fibres for the L1 front-end electronics and the trigger electronics.

Detector	Rack	Crates	L1 TTCrx	L1 fibres ~ L1 TTCoc
VELO	D3E02	2	34	2
	D3E03	2	34	2
	D3E04	1	20	2**
PUS	D3E01	1	4	1
RICH1	D3C01	1	11	1
ST-TT	D3E07	2	28	2
	D3E08	1	20	1
ST-IT	D3D07	2	22	2
	D3D08	1	20	1
OT	D3D01	2	24	2
	D3D02	2	24	2
RICH2	D3C04	1	11	1
SPD/PS	D3B02	2	8	1
ECAL	D3B02		10	1
HCAL	D3B02		4	1
L0 calorimeter trigger	D3B01	1	9	1
	D3B02	-	1	*
MUON	D3A04	1	10?	2 **
L0 muon trigger	D3A01	2	2	1
	D3A03	2	2	1
	D3A04	-	5	***
L0 Decision Unit	*D3B07*	1	1	1
L1 Trigger Receiver Module (TRM)	*D3B07*		1	
		Total		28

***** The TELL1 board for the L0 calorimeter trigger is located in the same rack as the calorimeter readout TELL1 boards. However, the fibre for the TTCrx should be connected to the TTCoc in the L0 calorimeter trigger rack for partitioning reasons.

****** Although one TTCoc would be sufficient, an additional TTCoc is foreseen for the partition.

******* The TELL1 boards for the L0 muon trigger is located in the same crate as the muon readout TELL1 boards. However, the fibres for the TTCrx chips should be connected to the TTCoc in the L0 muon trigger racks for partitioning reasons.

Table 10: L1 TTC fibres between the TFC rack and the detector racks containing L1FE electronics. For the L0DU and the TRM, fibre patch cords will be used.

Detector	Label	Source-Destination	Distance[9]
VELO	TTC1-VELO_0	D3B08/TTCtx – D3E02/TTCoc	~17m
	TTC1-VELO_1	D3B08/TTCtx – D3E03/TTCoc	~17m
	TTC1-VELO_2	D3B08/TTCtx – D3E04/TTCoc	~18m
PUS	TTC1-PUS	D3B08/TTCtx – D3E01/TTCoc	~16m
RICH1	TTC1-RICH1	D3B08/TTCtx – D3C01/TTCoc	~13m
ST-TT	TTC1-ST-TT_0	D3B08/TTCtx – D3E07/TTCoc	~12m
	TTC1-ST-TT_1	D3B08/TTCtx – D3E08/TTCoc	~13m
ST-IT	TTC1-ST-IT_0	D3B08/TTCtx – D3D07/TTCoc	~11m
	TTC1-ST-IT_1	D3B08/TTCtx – D3D08/TTCoc	~12m
OT	TTC1-OT_0	D3B08/TTCtx – D3D01/TTCoc	~15m
	TTC1-OT_1	D3B08/TTCtx – D3D02/TTCoc	~14m
RICH2	TTC1-RICH2	D3B08/TTCtx – D3C04/TTCoc	~12m
SPD/PS ECAL HCAL	TTC1-CALO	D3B08/TTCtx – D3B02/TTCoc	~11m
L0 calorimeter trigger	TTC1-CALO-TRG	D3B08/TTCtx – D3B01/TTCoc	~12m
MUON	TTC1-MUON	D3B08/TTCtx – D3A04/TTCoc	~12m
L0 muon trigger	TTC1-MUON-TRG_0	D3B08/TTCtx – D3A01/TTCoc	~13m
	TTC1-MUON-TRG_1	D3B08/TTCtx – D3A03/TTCoc	~12m
L0 Decision Unit	TTC1-L0DU	D3B08/TTCtx – D3B07/TTCoc	-
Trigger Receiver Mod. (TRM)	TTC1-TRM	D3B08/TTCtx – D3B07/TTCoc	-

6 Throttle network

The throttle network consists of Throttle ORs ‘Hugin’, each concentrating the L0 and the L1 throttle signals separately for 20 L1FE boards (TELL1 or UKL1), and one or two central Throttle Switches ‘Munin’, which OR the signals from the different detectors and transmit them to the appropriate Readout Supervisor ‘Odin’ boards according to the way the TTC routing is configured in the TFC Switch ‘Thor’.

The Throttle ORs ‘Hugin’ will be located in the middle slot, or alternatively in the first or last slot, of each TELL1 crate. The L0 and L1 throttle connection between the L1FE boards and the Throttle ORs is based on LVDS using special dual twisted pair 100ohm cable (MA4) RJ9/RJ9. All the cabling is on the back of the boards. In the cases where there are several L1FE crates for a sub-system (e.g. ST-TT) an additional Throttle OR ‘Hugin’ is needed to produce a single L0 and a single L1 throttle signal per sub-system to be transmitted to the central Throttle Switches ‘Munin’. The connections in between the Throttle ORs are made using the dual twisted-pair cable RJ9/RJ9. The RJ9 throttle outputs are on the front of the board and the inputs are on the back. Thus this implies a cabling between front and back.

The Throttle Switches will be located in the central TFC rack (D3B07). The baseline solution for the L0 and the L1 throttle connection between the Throttle ORs ‘Hugin’ and the central Throttle Switches ‘Munin’ is based on a dual optical plastic fibre 1.0/2.2mm operating at 660nm. The fibres have no connectors as they are attached using a screw cap on the transmitter and the receiver components. Currently a fibre from FIBERDATA is used (EH4002).

Thus, a dual fibre (L0+L1) plus a spare will be installed between each rack containing L1FE electronics and the TFC rack D3B07. The optical transmitters on the Throttle ORs are located on the front of the board and the dual fibres should therefore start on the front of the rack at a height of

45U. The fibres should be installed with sufficient extra length. Since the fibres require no connectors, the exact length of the fibres can be easily “trimmed” at the moment of connection. Table 11 summarizes the number of Throttle ORs, throttle fibres and the distances. In practice it means having two dual plastic fibres laid together with a TTC patch cable for each L1FE rack. Note that, the exact rack from which the dual fibres go depends on in which crate the Throttle OR making the final OR is installed. The length of the fibres must also therefore contain a safe margin of about a metre.

The labelling of the fibres should be according to THR-*DET_PART*, where *DET* is VELO, PUS etc and *PART* is either 0 or 1 for those detectors which are divided into two sub-systems, eg THR-VELO_0.

Using optical fibres requires a separate L0 Throttle Switch and a L1 Throttle Switch due to limited front-panel space. Between the Throttle Switches and the Readout Supervisors, the L0 and L1 throttle connection is again based on LVDS using the special dual twisted pair cable RJ9/RJ9.

As an alternative to the optical plastic fibres, the Throttle ORs and the Throttle Switches have also been equipped with LVDS for the transmission between the detector racks and the TFC racks using the same cable and connector as the short distance transmission. This also allows using only one Throttle Switch ‘Munin’ for both the L0 and the L1 throttle signals.

Table 11: Throttle Ors and throttle fibres between the racks containing L1FE electronics and the TFC racks.

Detector	**Rack**	**Crates**	**Throttle ORs ‘Hugin’**	**Active dual throttle fibres****	**Distance**
VELO0/VELO1	D3E02	2	6 + 2*	2	19m
	D3E03	2			
	D3E04	1			
PUS	D3E01	1	1	1	18m
RICH1	D3C01	1	1	1	15m
ST-TT	D3E07	2	3 + 1	1	14m
	D3E08	1			
ST-IT	D3D07	2	3 + 1	1	14m
	D3D08	1			
OT0/OT1	D3D01	2	4 + 2*	2	17m
	D3D02	2			16m
RICH2	D3C04	1	1	1	14m
SPD/PS	D3B02	2	1	1	13m
ECAL	D3B02		1	1	13m
HCAL	D3B02		1	1	13m
L0 calorimeter trigger	D3B02		1	***	13m
MUON	D3A04	1	2*	2	14m
L0 muon trigger	D3A04	-	1	***	14m
L0 Decision Unit	*D3B07*	1	1	-	-
Trigger Receiver Module	*D3B07*				
		Total	33	14	

* Although one single Throttle OR would be sufficient to OR all the signal, two Throttle ORs are foreseen in order to split the sub-detector in two subsystems.

** The exact rack from which the dual fibres go depends on in which crate the Throttle OR making the final OR is installed. The length of the fibres must therefore contain a safe margin.

*** The Throttle OR ‘Hugin’ for the L0DU unit and the TRM is located in the crate in the TFC rack D3B07. If it is decided to associate the L0 calorimeter trigger and the L0 muon trigger to the L0DU partition, the cabling of the L0 and the L1 throttle signals from the calorimeter and the muon trigger must be based on LVDS using the dual twister-pair (MA4) RJ9/RJ9 cable.

7 Beam Phase and Intensity Monitor cabling

In order to monitor the stability of the LHC bunch clock and the arrival times of the bunches, and to monitor the intensity of each bunch a Button Electrode beam pick-up will be installed on each side of the experiment 180m from the interaction point behind QR4. An acquisition board BPIM is being developed which will measure and histogram the two quantities. In addition to the readout by the Experiment Control System, the BPIM will also be interfaced to the Readout Supervisor. The BPIM will be installed in one of the TFC racks. Therefore the signal cables from the two button electrodes must be cabled along the walls of the cavern, through the two chicanes and up to a height of 45U in between rack D3B07 and D3B08. The cable consists of a Sucofeed corrugated 50ohm coaxial ½” cable by Huber+Suhner. The actual installation of the cable is still being discussed with the group responsible for the cabling in the tunnel.

8 Planning

The installation of the TTC distribution network and the throttle network will take place during the summer 2005 and is planned to be ready by September. The installation and the commissioning of the TFC equipment will be ready by November 2005. The installation of the long distance “L0 fibres”will be done in the beginning of 2006.

9 Cost *(in preparation)*

The following is an estimate of the cost of the fibres, cables and the installation.

TFC crates

Two or possibly three TELL1 crates will be needed for the central TFC system. The crate including the TELL1 power backplane, short fan tray, and the standard TELL1 power supply costs 8900 CHF.

Total cost: 18 kCHF / 27 kCHF

ECL cabling

The ECL cabling is based on standard LEMO coaxial 50ohm cables available in the CERN store: SCEM 04.69.11.A. (e.g. 04.69.11.070.9).

Total cost: 1 kCHF

TTC fibres

All the TTC fibres up to the TTCoc modules are based on single-mode 4-fibres patch cables G.652.B ST/ST-HQ (standard Physical Contact “PC”) and in two cases E2000/ST-HQ(PC). For this cable there exist two options: a standard version or a more robust version with a pulling tube to protect the ends and allow easier installation. If not specified, the cables should have a 1m section of ramified fibres.

Throttle fibres

The throttle fibres are based on dual plastic optical fibres 1.0/2.2mm such as FIBERDATA EH4002.

Throttle cables

The throttle cables are based on dual twisted pair 100ohm(120ohm) cable (MA4) RJ9/RJ9. The cable is a custom-made cable which is now available in the CERN store #04.21.51.395.4. The price of the cable is 0.8CHF/m and 4 km have been ordered. The RJ9 connectors have been ordered separately and must be mounted.

Total cost: 3.5 kCHF (cable + connectors, no mounting)

Appendix I

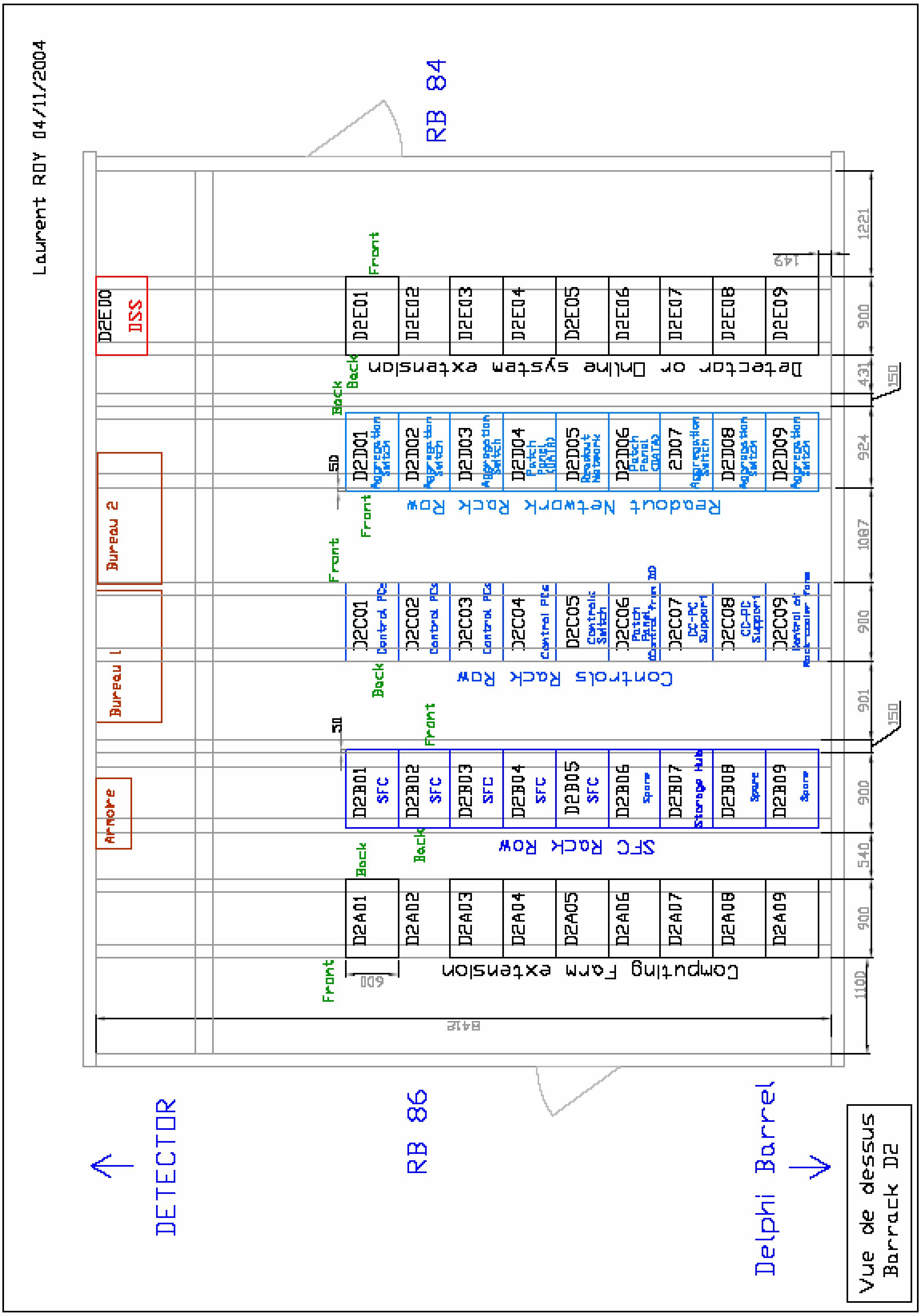

Figure 4: Layout of the D2 counting room.

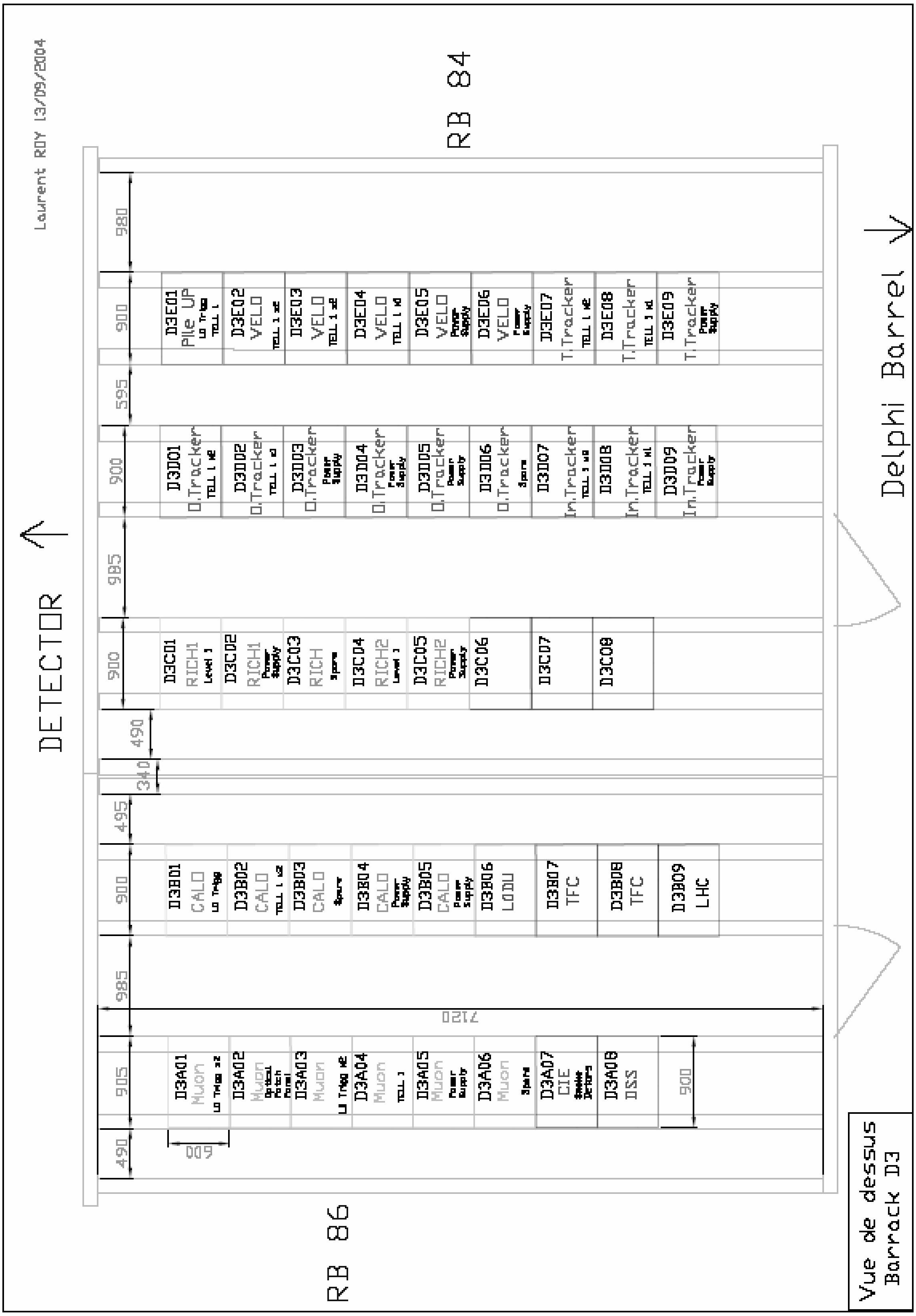

Figure 5: Layout of the D3 counting room.

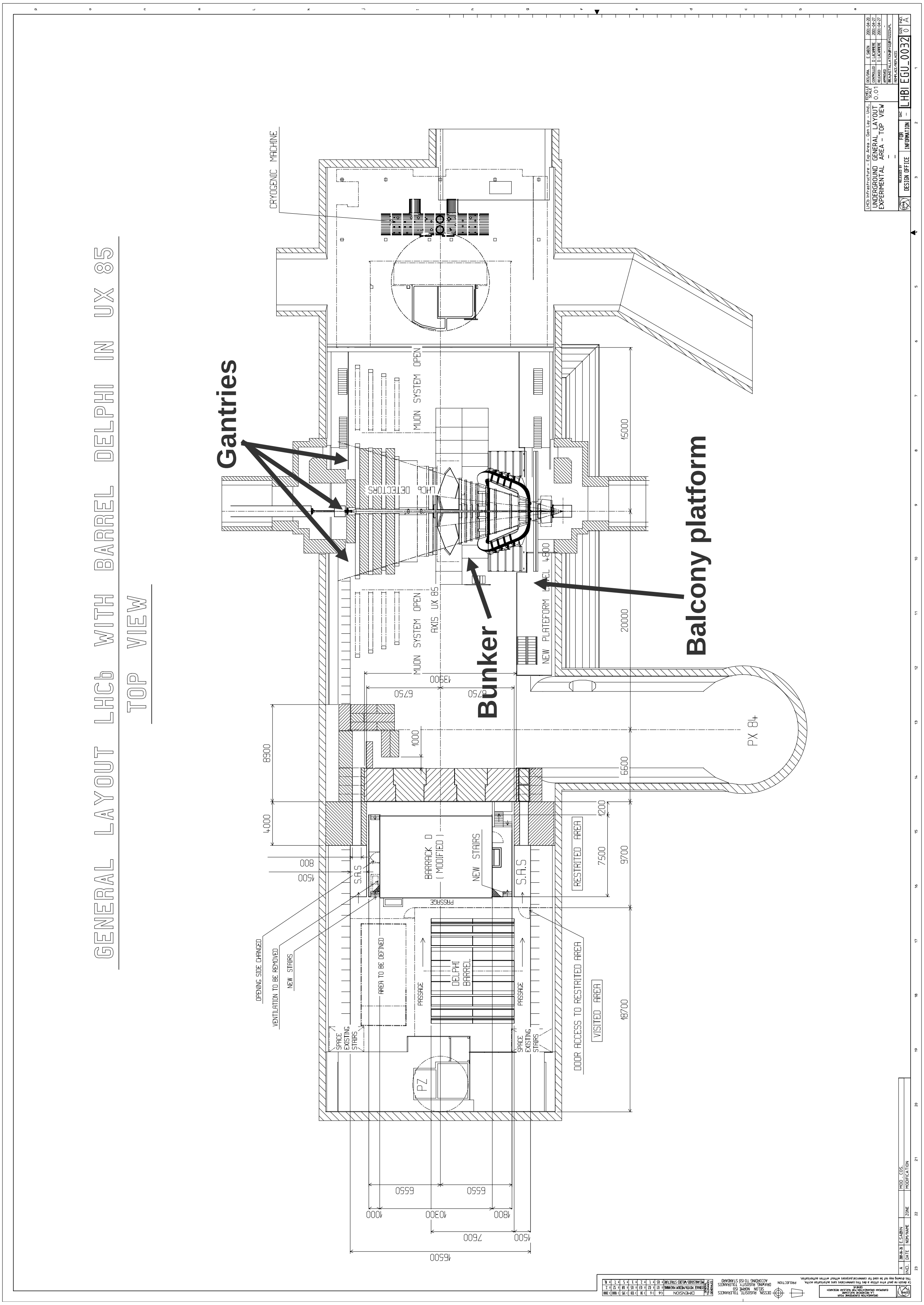

Figure 6: Layout of the experiment cavern with the location of the TTCoc modules for the detector electronics close to the detector.

References

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[6] LHCb Part Identification – Cables, R. Lindner, EDMS to be released.

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[9] Measurements by L. Roy and V. Bobillier