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# Estimation of AdV rack needs and locations

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# 1 Introduction

A preliminary estimation of the needs of racks in Advanced Virgo had been done for the Technical Design Report [1] beginning of 2012. The latest estimation of the needs of racks in the different AdV locations are given in this note. It is based on discussions with the different AdV sub-system managers and on the presentation [2] from March 2013.

The needs are not summarized for each sub-system, but for each location. The latest building maps were provided by the EGO Infrastructure group.

The AdV sub-systems that need electronics to be installed are given here, with an idea of their main goals:

- PSL: electronics for the main laser generation and pre-stabilization,
- INJ: electronics for the main laser modulation and injection to the ITF,
- DET: electronics to control the OMC, the longitudinal and quadrant photodiodes, the phase cameras and mirror mount picomotors. Most of the DET electronics will be put in the air-tank below the benches suspended inside the mini-towers (thus not in external racks).
- TCS: electronics for the 2 TCS (around NI and WI mirrors) and the 5 Hartmann beams.
- SAT: electronics for the control of the 10 long suspensions (accelerometers, LVDT, coil drivers, ...).
- SBE: electronics for the control of the 5 multiSAS suspensions and of the EIB-SAS suspension (LVDT actuator conditioners, stepper motor controllers, LVDT/actuator drivers for local controls, DC power supplies:  $\pm 18$  V and +48 V).
- ISC: electronics for the 2 auxiliary lasers (CALVA).
- SLC: electronics to control some suspended baffles (LVDT/actuator drivers for controls).
- VAC: electronics for the vacuum control.
- DAQ: digital electronics to synchronize all the AdV electronics, DACs and ADCs channels to collect the data and provide digital loops, control and acquisition of the digital cameras, It also includes the front-end electronics for the environmental monitoring.
- EGO Computing group: electronics for the Ethernet network: space for Ethernet switches and optical fibers patch panels is needed in each location.

The goal of the electronics architecture is to limit the copper connections between different locations of the detector. It implies to have the front-end electronics close to the sensors and actuators, as well as the front-end digital electronics (ADCs and DACs). The timing data,

Ethernet data and digital detector data are then collected through networks of optical fibers between the different systems.

No general DC power distribution is planned in AdV. However, a local DC power distribution is planned for the injection labs.

The room naming convention and building plans have been extracted from the notes [3].

## 2 Preliminary remarks

### 2.1 Racks

#### 2.1.1 Type of racks for AdV

The racks that has been used in Virgo are 220 cm high, 60 cm wide, 80 cm deep cabinet dedicated to hosting 19" wide equipment. The number of U<sup>1</sup> that can fit in such rack is 42.

A selection of racks have been done (see note [4]). The new racks are expected to be  $220 \times 80 \times 80 \text{ cm}^3$ , still with 42 U height available for equipments.

As a consequence, two sizes of racks are possible: (60 cm  $\times$  80 cm  $\times$  42 U) or (80 cm  $\times$  80 cm  $\times$  42 U).

#### 2.1.2 Virgo racks

About 36 long (60 cm  $\times$  80 cm) racks were used for the Virgo ITF electronics in the central building, the MC building and the end buildings, as well as 1 long (80 cm  $\times$  80 cm) rack in the DAQ-room and  $\sim$ 3 short racks:

- CEB-Injection laboratories: 2 long + 1 short
- CEB-EE-room: 2 long + 1 short
- CEB-Detection laboratory: 3 long
- CEB-TCS room: 1 short ?
- CEB-Platform: 7 long
- CEB-DAQ-room: 14 long and 1 long larger rack (80 cm $\times$ 80 cm) for network.
- MCB: 2 long
- NEB: 3 long
- WEB: 3 long

Most of them will be re-used for AdV. Additionnaly, 2 long racks that have been temporarily installed in the EGO Optic labs can be used for AdV.

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<sup>1</sup>U = 44.45 mm

## 2.2 Space needed for the DAQ digital electronics

The DAQ digital electronics concerns the TDBox for the timing distribution network, the DAQ-box with the ADC and DAC channels in particular (also the digital demodulation channels and the photodiode control electronics), the ADC7674 boards for ADC channels and the CameraBox to supply and trigger the digital cameras.

The heights of the different devices are the following:

- TDBox: 1 U.
- DAQ-Box: 2 U.
- ADC7674 board in its crate: 6 U. Two possibilities are available to install the ADC7674 boards: one crate of 6 U with a power supply and space for 3 boards ; one crate of 6 U with one or two power supplies, and a second crate of 6 U with space for 6 boards.
- CameraBox: 2 U.

A lot of cables are plugged onto the front panels of these devices. In order to ease the cabling and the possibility to remove/re-install the boxes or crates, it is necessary to keep some space below a device to pass the cables going to the device. In this note, we have estimated:

- TDBox: no space should be needed below: since there are not a lot of cables connected to it, they can go along the rack on the sides. Total: 1 U.
- DAQ-Box: 1 U below the DAQ-Box. Total: 3 U.
- crate with the ADC7674 boards: 1 U below the crate. Total: 7 U.
- CameraBox: 1 U below. Total: 3 U.

Moreover, such space will allow to evacuate the heat produced in the devices.

The number of each DAQ devices has been estimated for each sub-system and will be summarized in a future document. In this note, their number has been given for all labs.

## 3 Central Building (CEB)

Sketches of the central building, level 2 (ground) and level 3 (platform and DAQ-room), with the foreseen racks are given in figures 1 and 2.

### 3.1 Injection laboratories (CEB-L2-11,12,13,14)

Most of the electronics of the injection lab and injection electronics lab will be plugged on a DC distribution provided from DC power supplies in the DAQ-room. The PSL and INJ analog electronics will be located in the injection electronics lab (CEB-L2-11), in the atrium (CEB-L2-13) and in the laser lab (CEB-L2-14):

- **three racks** are needed in CEB-L2-11 for the RF generation and distribution and the PSL/INJ analog services and actuator drivers. The network will use 16 U inside the racks for Ethernet switches and optical fibers patch panels.
- **one rack** is needed in CEB-L2-13 for the "interface and distribution" between the benches and the rest of the world.
- **one half rack** is needed in CEB-L2-14, close to the PSL bench.

**Initial needs for the Virgo+ laser** – The new more powerful laser will not be available from the start of AdV. As a consequence, some electronics used for the Virgo+ laser will still be needed at the beginning of AdV. The corresponding PSL needs are summarized here:

- **one rack** fully occupied for the laser control. It will be installed in the EE-room.
- **one half-sized rack** for the pump diodes of the optical amplifier. It will be installed in the EE-room.
- **one rack** for the Virgo+ laser servos. To be installed in the atrium (CEB-L2-13).
- **one half-sized rack** for the master laser. To be installed in the laser lab (CEB-L2-14).

### 3.2 EE-room (CEB-L2-26)

The EE-room will contain the digital electronics of the systems installed in the INJ labs (PSL, INJ, EIB-SAS, Hartmann sensor, environmental monitoring). Racks for VAC will also be added in this room.

In the EE-room, the electronics will be installed in **four racks for electronics and three racks for VAC (and 1.5 racks for PSL at the start of AdV: for slave laser and pump diodes for the optical LZH amplifier):**

- One rack dedicated to the network that will use 25 U to 30 U.
- One rack dedicated to the control of the EIB-SAS.
- One rack dedicated to the DAQ
  - the DAQ environmental electronics: 12 U (4 U for 2 slow monitoring modules, 3 U for 2 Nexus amplifiers and 2 U for 1 custom board).

- the DAQ collection electronics of the INJ labs data: 22 U (15 U for 5 DAQ-boxes, 7 U for 1 crate with three ADC7674 and one DC supply, 1 U for 1 TDBox).
- there should be some space left in the previous racks for the electronics of the Hartmann sensor (10 U) (most probably in the EIB-SAS rack).
- ISC might need  $\sim 4$  U. Some space should be found in the previous racks.
- Three racks dedicated to the VAC sub-system: tower vacuum, IB cryotrap and link pumps. No additional rack should be needed for the vacuum of the SPRB minitower since it will be separated from the ITF by a viewport.
- a (possibly short) rack might be needed for the SPRB minitower<sup>2</sup>:
  - $\sim 20$  U for the phase camera of the bench EPRB and associated DAQ data collection (3 U for a DAQ-Box).
  - it must be possible to add the DAQ environmental electronics (1 slow monitoring module and 1 Nexus amplifier) to the other environmental electronics (possibly adding 2 U more, and maximum 6 U).

Additionally, 1.5 rack will be installed for PSL to use the Virgo+ laser at the start of AdV for laser control and pump diodes of the optical amplifier (see section 3.1).

This will make the EE-room very crowded, particularly at the start of AdV. The air conditioning has to be adapted accordingly.

### 3.3 Detection laboratories (CEB-L2-08,09)

No rack is planned in the DET lab itself (CEB-L2-09). Only front-end electronics and drivers might be installed below the external detection bench (EDB). Additionally, a patch panel for the optical fibers going into the SDB2 minitower is needed there.

The electronics will be installed in **five racks** in the Elec. DET lab (CEB-L2-08):

- One rack will be dedicated to the network that will use 20 U.
- One rack will be dedicated to the control of the SDB2 multiSAS.
- Two racks will be dedicated to the DET sub-system.
  - Linked to SDB1, the control of the OMCs implies piezo drivers and Peltier drivers, the control of different mirrors implies picomotor drivers, some electronics to control the two quadrant photodiodes used to align SDB1 on the ITF, and electronics is needed for SDB1 local controls.

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<sup>2</sup> If this short rack cannot be installed close to the EPRB bench

- The SDB2 electronics will be installed in the air-tank below the bench. All the SDB2 electronics will be powered in DC: the DC power supply will be installed in a rack of the Elec. DET lab.
- Some electronics will be needed to control and readout the phase camera and the scanning Fabry-Perot installed on EDB.
- A rack will be used for
  - the TCS electronics of the EDB Hartmann sensor: 10 U (it could be moved to the same rack as SDB2 multiSAS electronics),
  - the DAQ environmental electronics: 12 U (4 U for 2 slow monitoring modules, 3 U for 2 Nexus amplifiers and 2 U for 1 custom board).
  - the DAQ collection electronics: 17 U (9 U for 3 DAQ-boxes, 7 U for a crate with 3 ADC7674 and their DC supply, 1 U for 1 TDBox).
- It is not expected that VAC will need any rack in the DET labs. If necessary, one rack could be added later to improve the vacuum in the SDB2 minitower.

At longer term, another minitower could be installed to add the squeezing technique to AdV. It is estimated that two additional racks would then be needed.

### 3.4 TCS room (CEB-L2-07)

The TCS room will contain the electronics for the TCS. **Six racks** are needed:

- One rack will be dedicated to the network: at least 10 U.
- One rack will be dedicated to DAQ:
  - DAQ environmental electronics: 10 U (2 U for 1 slow monitoring modules, 3 U for 1 Nexus amplifier and 2 U for 1 custom board).
  - DAQ collection electronics: 18 U (3 U for 1 DAQ-boxes, 14 U for two crates with 4 ADC7674 and their DC supplies, 1 U for 1 TDBox).
- Four racks will be dedicated for the TCS electronics.

### 3.5 Central Building platform (CEB-L3-10)

The electronics to control the super-attenuators will be put close to each tower, along with the corresponding needs for Ethernet and DAQ. A sketch of the central building platform and racks is given in figure 2.



### 3.5.1 Need for one suspension

Two racks are needed for each tower:

- 6 U for the network
- 24 U for the SAT electronics (3 or 4 crates of 6 U).
- 3 U for the DAQ environmental electronics (2 U for 1 slow monitoring module).
- 8 U to 10 U for the DAQ collection electronics (BS tower: 3 U for 1 CameraBox, 6 U for 2 DAQ-boxes, 1 U for 1 TDBox ; other: 7 U for 1 ADC7674 and its DC supply, 1 U for 1 TDBox).

### 3.5.2 Need for INJ sub-system

One half rack might be needed close to the SIB1 tower on the platform:

- for the SIB in-vacuum piezzo drivers.

There might be some room in the two racks already installed around this tower for SAT and DAQ.

### 3.5.3 Racks on the platform

A total of **14 racks** are needed for the **7 suspensions** of the Central Building.

Additionally, **7 racks** are needed for the **vacuum** sub-system. The VAC racks will be attached to the walls in order to limit the seismic noise transmitted to the platform.

## 3.6 DAQ-room (CEB-L3-09)

Since the front-end electronics and front-end DAQ electronics will be moved close to the actuators and sensors, there will be less racks in the DAQ-room for AdV than for Virgo.

**8 racks** are needed in the DAQ-room:

- Two racks dedicated to the network.
- One rack for the DAQ/network common rack, with the common optical fiber patch panels (Ethernet, Timing and TOLM networks).
- Two racks dedicated to the DAQ:
  - DAQ environmental electronics: 4 U (3 U for 1 Nexus amplifier)
  - DAQ: GPS receiver, master TDBoxes and Mux/Demux

- Two racks dedicated to the control of SIB2 and SPRB multiSAS (including DAQ collection electronics) and their DC power supplies.
- Two racks dedicated to the DC power supply of the INJ labs (at least  $3 \times 11$  U).

The racks for the Ethernet network, the DAQ rack (GPS, TDBox, MuxDemux) and the rack with the optical fiber patch panels will be installed close to each other in order to ease the sharing of the optical fibers.

It is not planned to modify the installation of the 14 racks in the DAQ-room, even if some of them will not be used following the current plan. However, one larger rack will be needed for Ethernet network, which will induce some modifications.

### 3.7 Racks in the Central Area (CEB-L2-01)

One rack is needed for the environmental monitoring and the phase camera around the SPRB minitower. If this rack does not fit close to the bench EPRB, it can be installed in the EE-room.

- less than  $\sim 20$  U for the phase camera of the bench EPRB,
- 18 U for the DAQ:
  - DAQ environmental electronics: 7 U (2 U for 1 slow monitoring module and 3 U for 1 Nexus amplifier).
  - DAQ: 11 U (3 U for 1 DAQ-Box, 7 U for 1 ADC7674 and its power supply, 1 U for 1 TDBox).
- patch panel for the optical fibers going inside the SPRB minitower.

One other rack is needed in the central area for VAC. Additionally, 8 racks are planned by VAC in the arm galleries, close to the central building: 4 racks in the north gallery and 4 rack in the west gallery. Their positions in the area are shown in the figures 4 and 5.

## 4 Mode-Cleaner Building (MCB-L2)

**1 rack for vacuum and 3 racks for electronics** are needed in the MC building. They will be installed on the ground (no more on the platform as the SAT rack during Virgo):

- One rack dedicated to the network (10 U).
- One rack dedicated to the SAT electronics.
- One rack dedicated to INJ and DAQ:
  - INJ: few U for photodiode, camera.

- DAQ environmental electronics: 13 U (4 U for 2 slow monitoring modules, 3 U for 1 Nexus amplifier and 2 U for 1 custom board).
- DAQ collection electronics: 11 U (3 U for 1 DAQ-Box, 7 U for a crate with 3 ADC7674 and their DC supply, 1 U for 1 TDBox).
- VAC: 1 rack.

## 5 End Buildings (NEB-L1-01 and WEB-L1-01)

**2 racks for vacuum and 6 racks for electronics** are needed in each end building. They will be installed on the ground, all on the same side of the vacuum tubes if possible in order to ease the cabling and maintenance.

- One rack dedicated to the network.
- Two racks dedicated to the SAT electronics.
- One rack dedicated to control the SNEB/SWEB multiSAS.
- 40 U for DAQ electronics, possibly installed in two blocks:
  - DAQ environmental electronics: 13 U (4 U for 2 slow monitoring modules, 3 U for 2 Nexus amplifier and 2 U for 1 custom board).
  - DAQ collection electronics: 25 U (9 U for 3 DAQ-Box, 14 U for two crates with five ADC7674 and two DC supplies, 2 U for 2 TDBox).
- less than 20 U for DET electronics (SNEB/SWEB minitower DC power supply, SNEB/SWEB alignment control to follow the end mirror)
- 10 U for the Hartmann sensor (TCS)
- ISC might need  $\sim 4$  U for auxiliary laser electronics. Some space should be found in the previous racks.
- VAC: 2 racks.

The electronics of the auxiliary laser (ISC) will be installed below the bench ENEB/EWEB, so no specific rack is needed.

## 6 Summary

The number of racks needed for AdV and their repartition in the different locations are summarized in table 1. Racks needed for some AdV upgrades such as the squeezing are not included in this estimation, even if they have been discussed in the note.

Two sizes of racks are possible: (60 cm  $\times$  80 cm  $\times$  42 U) or (80 cm  $\times$  80 cm  $\times$  42 U). Larger racks have been asked for the racks in the Electronic Injection Laboratory and for the racks dedicated to the network. The other racks will have the same size as during Virgo, which allow to re-use the Virgo racks. The Virgo racks have to be used in some locations:

- in the DAQ-room: 12 old (60 cm  $\times$  80 cm racks and 1 old 80 cm  $\times$  80 cm rack. The installed Virgo racks will be kept, except two that will be removed in order to place a second 80 cm  $\times$  80 cm rack for the Ethernet. It will prevent to dismount most the present installation, even if five racks will not be used.
- for the SAT sub-system since there is no space for larger racks on the platforms: 14 old racks on the CEB platform, and 6 old racks in total for the MCB, NEB and WEB. In order to help integration with the scaffolding, the SAT racks on the CEB platform might be changed to have slightly smaller racks in height.
- in the Elec DET lab (4 old racks) and in the EE-room (4). The space in these labs is confined. It will be easier to install the Virgo racks.

The final estimation for AdV is 24 long racks for the vacuum sub-system, and 52 Virgo-like racks and 13 larger racks for the other sub-systems.

Additionally, 3 short racks used for Virgo+ will be re-used for AdV (laser lab, EE-room, platform around INJ tower).

As a consequence, the number of 42 U racks to be bought for AdV is estimated to 26 (without VAC). One large (80 cm  $\times$  80 cm  $\times$  42 U) rack for the DAQ-room will be provided by EGO Computing Service.

To conclude, the number of racks to be bought by the DAQ sub-system for AdV is:

- 12 large (80 cm  $\times$  80 cm  $\times$  42 U) racks,
- 14 Virgo-like (60 cm  $\times$  80 cm  $\times$  42 U) racks.

Three short racks used for Virgo+ will be re-used for AdV.

It should fit within the budget of 24 k€ planned in the WBS for the order of the new racks.

Buildings	Rooms	VAC racks	Non-VAC racks		
			80 cm x 80 cm	60 cm x 80 cm	half racks
CEB	Elec INJ lab		3		
	Atrium		1	1	
	Laser lab				1 (PSL)
	EE-room	3	1	4	1 (PSL)
	Elec DET lab	(1?)	1	4	
	TCS-room		1	5	
	Platform	7		14	1 (INJ)
	DAQ-room			3	12
	Hall	1			1 ? (tbc)
	North gallery	4			
	West gallery	4			
MCB	Hall	1	1	2	
NEB	Hall	2	1	5	
WEB	Hall	2	1	5	
Total		24 (+1?)	13	52	3 or 4
Available old racks		–	1	38	$\geq 3$
Provided by EGO		–	1	0	0
<b>Racks to be bought</b>		–	<b>11</b>	<b>14</b>	0

Table 1: Summary of the racks needed in AdV.

## 7 Figures: building plans with rack locations

The plans of the buildings are given in this section. The racks described in this note have been drawn at their expected location, with colored-filled squares. More precise location of the racks within each laboratories can still be improved.

The racks dedicated to vacuum are shown in yellow, with a "V" written inside. The other general racks are shown in green. Some optional or future racks have lighter color.

The size of the squares are approximatively at scale. In order to be conservative concerning the space needs, most of the racks have been drawn assuming a size of  $80\text{cm} \times 80\text{cm}$ . However, some are still shown assuming a size of  $60\text{cm} \times 80\text{cm}$ : in the DAQ-room (expect 2 larger racks) and on the CEB platform.

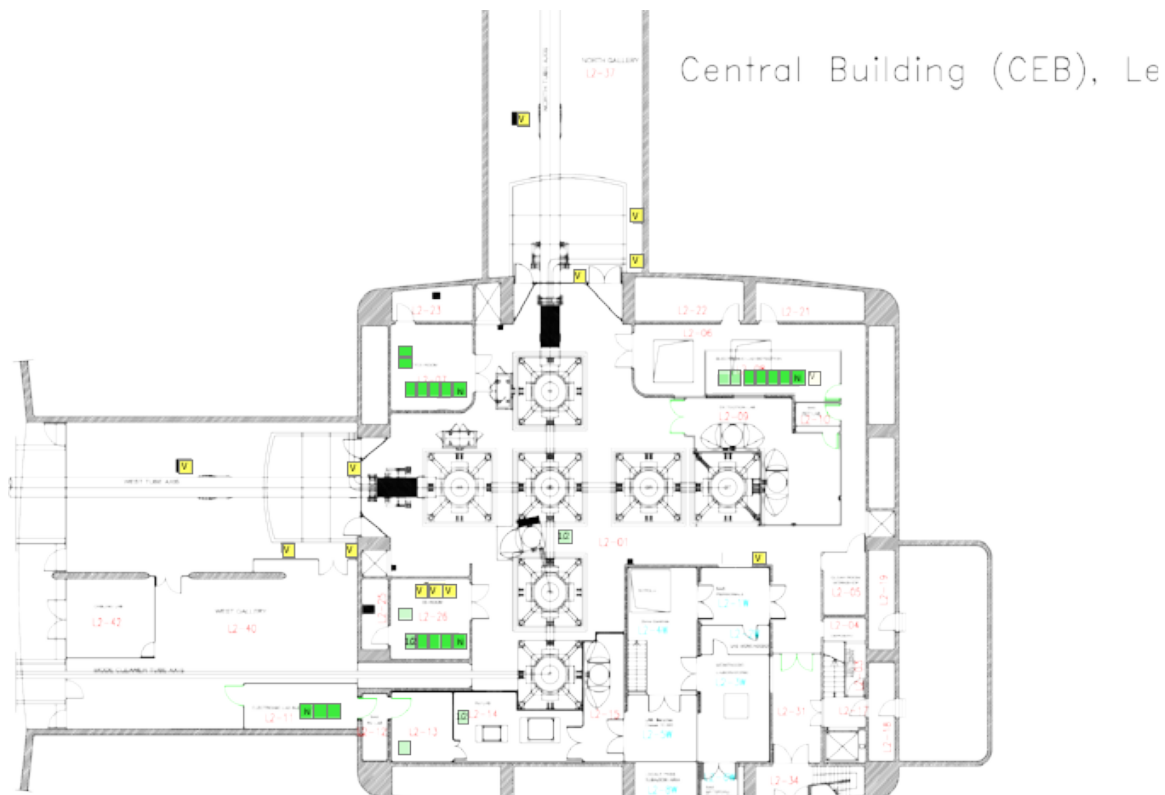


Figure 1: Central building, level 2 (ground).



## Mode Cleaner Building (MCB), Level 1

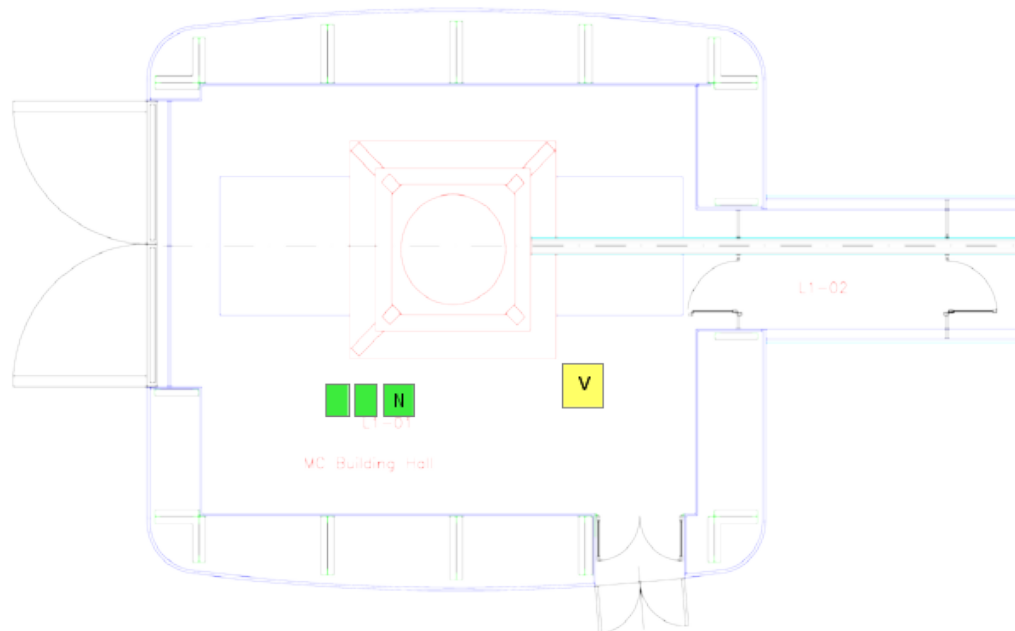


Figure 3: Mode-cleaner building, level 1 (ground).



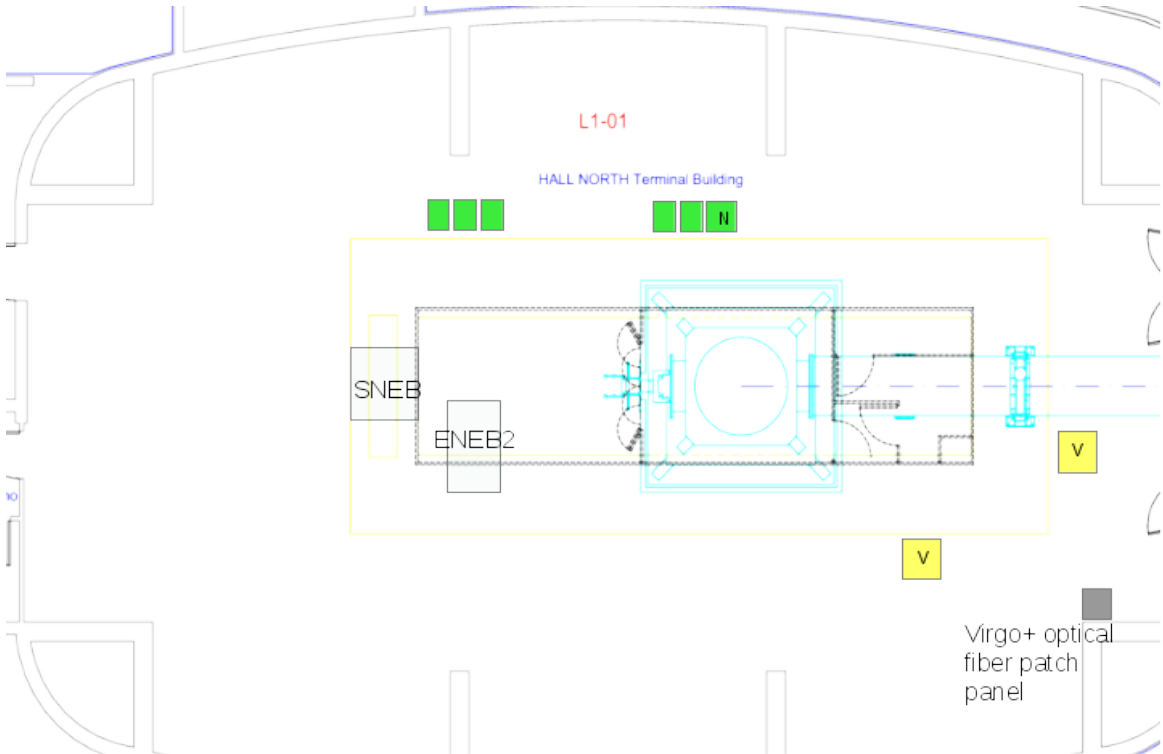


Figure 4: North end building, level 1 (ground).

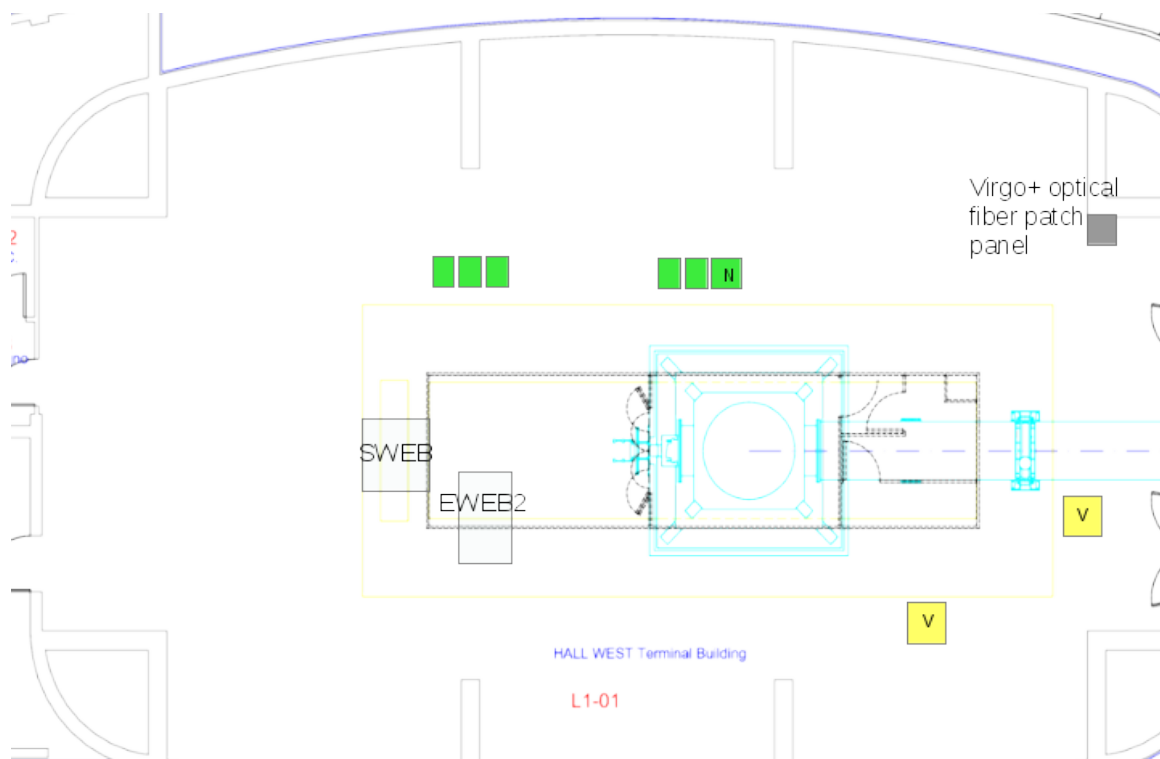


Figure 5: West end building, level 1 (ground).

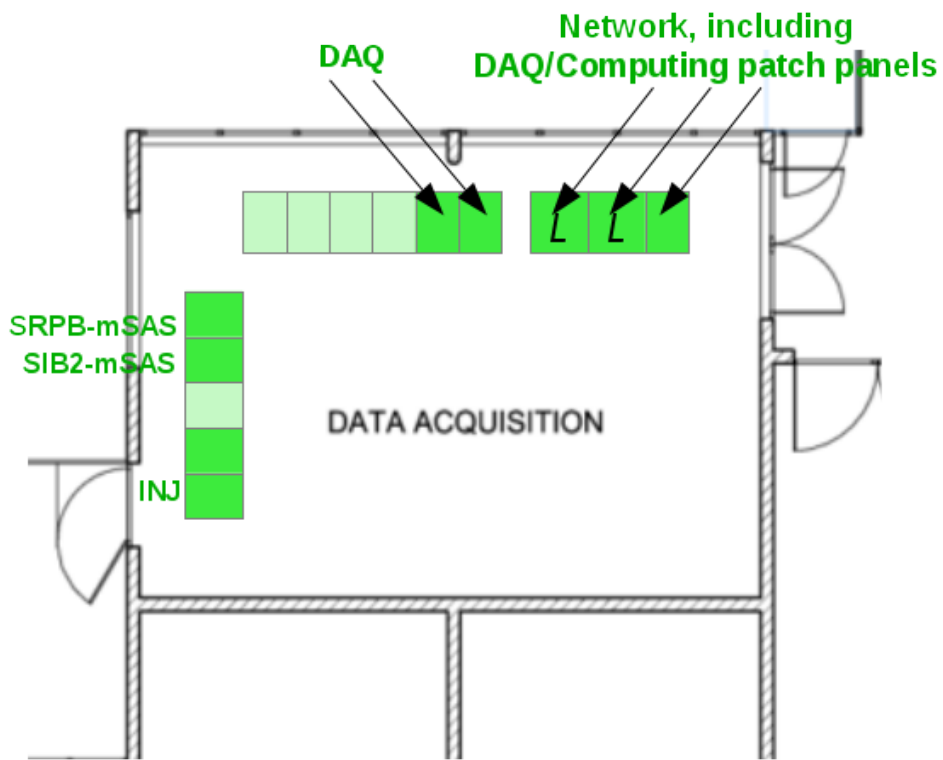


Figure 6: Central building, level 3, zoom on DAQ-room.

## References

- [1] The Virgo collaboration, *Advanced Virgo Technical Design Report* (2012) [VIR-0128A-12](#).
- [2] L. Rolland, *Estimation of AdV racks needs and location* (2013) [VIR-0071A-13](#).
- [3] F. Carbognani, *Rooms naming convention* (2013) [VIR-0186A-13](#) to [VIR-0197A-13](#)
- [4] F. Nocera, F. Paoletti, *Electronics for Advanced Virgo: Guidelines and Requirements for Electronics Installation* (2009) [VIR-0737B-09](#)