SuperNEMO Demonstrator
Calorimeter Signal Readout System (CaloSignal)
Cabling scheme and cable labels
version 0.1

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Abstract

This document presents the cable labelling convention used for the SuperNEMO Demonstrator's Calorimeter Signal Readout System (CaloSignal). We reuse here some informations available from a couple of documents prepared by Cedric and Mathieu, SNDER, with some adaptations, fixes and addons.

This document and all associated tools are hosted at:

`https://gitlab.in2p3.fr/SuperNEMO-DBD/SNCabling`.

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1 Principle

The SuperNEMO Demonstrator's Calorimeter Signal Readout System (CaloSignal) uses three crates which host a total of 52 front-end boards to collect signals from 712 PMTs.

Each front end board manages up to 16 channels and is connected to a specific set of PMTs through a pair of harnesses. A first harness, called *external harness*, groups a set of signal cables linked to the Wavecatcher front-end board through MCX male connectors and to the patch panel (external side) also through MCX male connectors. From the internal side of patch panel, a new harness, namely the *internal harness*, routes internal signal cables to the PMTs. Both ends of the *internal harness* are designed in such a way internal signal cables can be connected individually from the patch panel to their associated PMTs. On the patch panel side, an internal signal cable is equipped with a MCX female connector. On the PMT side, an internal signal cable is equipped with a Souriau pin. A given harness handles a set of PMTs that are geographically close to each other, in order to optimize the length of the cables.

In the present scheme, it has been decided to identify individual signal cables within a harness using a unique cable identifier. This identifier is propagated through the patch panel to the end of the cable linked to the PMT. This scheme implies to use a dedicated cabling table.

Figure 1 shows the basic diagram of the CaloSignal system. A dedicated labelling system is used to ease the cabling operations (see next sections).

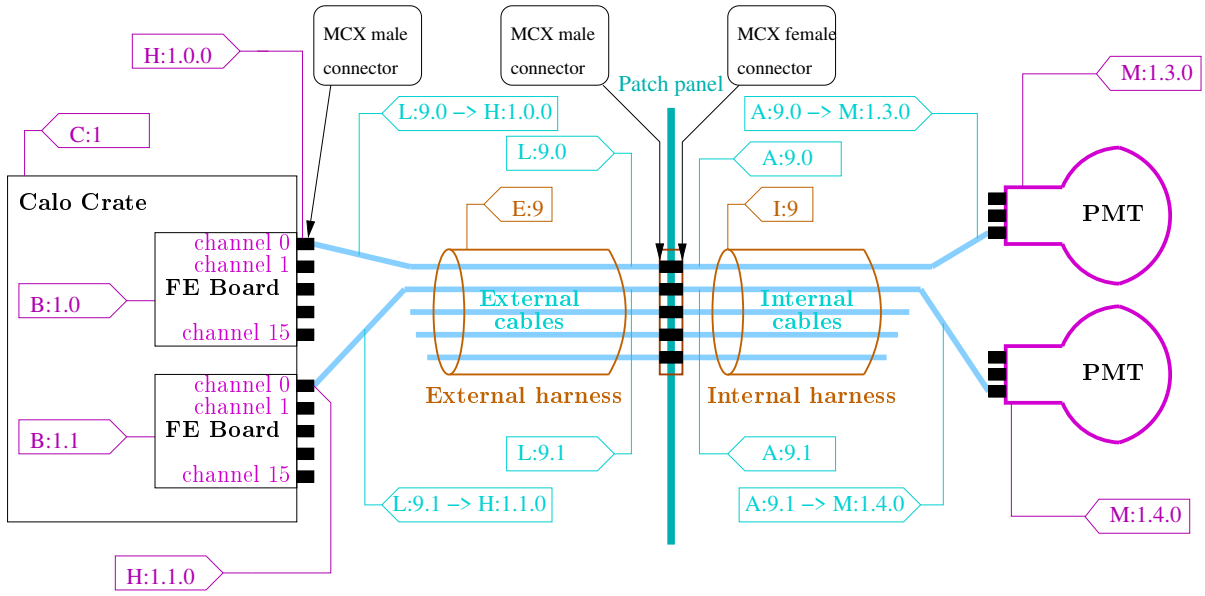

Figure 1: Principle of the signal distribution from the PMTs to the Wavecatcher CaloFEB boards and labelling of cables and harnesses.

2 Addressing objects

2.1 Format of a CaloSignal label

Each label used for calorimeter signal cabling uses the following format:

$$\boxed{\texttt{X:}id_1.id_2\ldots id_n}$$

where `X` is a single letter which describes the category of the labelled object, and the $id_1.id_2\ldots id_n$ sequence is the unique address of the object within its category. The id_x tokens are positive integers (possibly zero). The *colon* character is used to separate the category letter from the address. The sequence of identifiers in the address use the *dot* character as a separator.

2.2 Front-end crates, boards and channels

Front-end crates belonging to the CaloSignal system are installed in racks number 2 and 3 on the electronics platform. A crate is identified with an unique ID, namely a number ranging from `0` to `2`. A given crate is identified by its label with the following scheme:

$$\boxed{\texttt{C:}crate}$$

where *crate* is the number of the crate (positive integer).

Examples: `C:0`, `C:1`, `C:2`.

Conventionally, crate `0` manages PMTs from the main wall on the *Italy* side, crate `1` manages PMTs from the main wall on the *France* side and crate `2` manages PMTs from X-walls and gamma veto.

A crate contains up to twenty 16-channel boards. A board inherits the number of the crate it is plugged into and is located through its slot number. A given board is identified by its label with the following scheme:

$$\boxed{\texttt{B:}crate.board}$$

where *crate* is the number of the crate and *board* is the number of the board (slot) ranging from `0` to `20` except number `10` which is reserved for the control board slot number.

Examples: `B:0.0`, ... `B:1.11`.

Up to 16 channels are addressed within a board. A given channel is identified by its label with the following scheme:

$$\boxed{\texttt{H:}crate.board.channel}$$

where *crate* is the number of the crate, *board* is the number of the board in the crate and *channel* is the number of the channel in the board ranging from `0` to `15`.
Examples: `H:0.0.0`, ... `H:1.19.12`

A channel is automatically associated to a specific cable number in a given harness. The association between each readout channel and the cable it is connected to within a harness is described by a dedicated cabling table.

2.3 Harnesses and cables

One uses 2×22 harnesses to group individual channels from the front-end boards to the PMTs.

An external signal harness contains a set of individual external signal cables that connect to the patch panel and to individual channels divided up into several frontend boards. An external signal harness has an unique ID ranging from `0` to `21`. An external signal harness is identified by a label with the following scheme:

`E:`*harness*

where *harness* is the number of the external harness.
Examples: `E:0`, ... `E:21`

An internal signal harness contains a set of individual internal signal cables that connect to the patch panel and a given set of PMTs. An internal signal harness has an unique ID ranging from `0` to `21`. An internal signal harness is identified by a label with the following scheme:

`I:`*harness*

where *harness* is the number of the internal harness.
Examples: `I:0`, ... `I:21`

An internal harness with a given number is associated to a external harness with the same number.

Each external or internal harness groups up to 40 signal cables identified through a cable ID from `0` to `39`. An external signal cable is identified by a label with the following scheme:

`L:`*harness*`.`*cable*

where *harness* is the number of the external harness and *cable* is the number of the external cable.
Examples: `L:0.0`, ... `L:21.15`.

Internal signal cables use a similar scheme:

A:*harness*.*cable*

Examples: A:0.0, ... A:21.15.

Internal and external signal cables connected through the patch panel (MCX male/female connectors) share the same harness and cable numbers. Thus, the internal cable A:7.12 is connected to the external cable L:7.12:

L:7.12 -> A:7.12.

2.4 Optical modules

The identification scheme of the optical modules and their PMTs is based on the addressing scheme defined in the geometry model and implemented in the simulation and data analysis software[1]. There are 4 categories of optical modules and thus of scintillator blocks, depending on their location in the experimental setup:

- Main wall block (Falaise: geometry category `"calorimeter_block"` and type `1302`):

  OMs are addressed through their *side* number from 0 (Italy) to 1 (France), *column* number from 0 (Edelweiss) to 19 (Tunnel) and *row* number from 0 (bottom) to 12 (top).

  We propose to label such a block with the following scheme:

  M:*side*.*column*.*row*

  Examples: M:0.0.0, M:0.19.12, M:1.0.0, M:1.19.12.

- X-wall block (Falaise: geometry category `"xcalo_block"` and type `1232`):

  OMs are addressed through their *side* number from 0 (Italy) to 1 (France), *wall* number from 0 (Edelweiss) to 1 (tunnel), *column* number from 0 (source) to 1 (calorimeter) and *row* number from 0 (bottom) to 15 (top).

  We propose to label such a block with the following scheme:

  X:*side*.*wall*.*column*.*row*

  Examples: X:0.1.1.15, X:1.0.0.8

- Gamma veto block (Falaise: geometry category `"gveto_block"` and type `1252`):

  OMs are addressed through their *side* number from 0 (Italy) to 1 (France), *wall* number from 0 (bottom) to 1 (top) and *column* number from 0 (Edelweiss) to 15 (tunnel).

  We propose to label such a block with the following scheme:

[1] Falaise: `https://gitub.com/SuperNEMO-DBD/Falaise`

$\boxed{\texttt{G:}side\,.\,wall\,.\,column}$

Examples: $\boxed{\texttt{G:0.1.0}}$, $\boxed{\texttt{G:1.0.8}}$

- Block for reference optical module:

  OMs are addressed through their *ref* number.

  We propose to label such a block with the following scheme:

  $\boxed{\texttt{R:}ref}$

3 The Calorimeter crates

Figures 2, 3 and 4 show the association of the external harnesses with the Wavecatcher front-end board channels within the calorimeter front-end crates 0 (Italy), 1 (France) and 2 (X-wall and gamma veto).

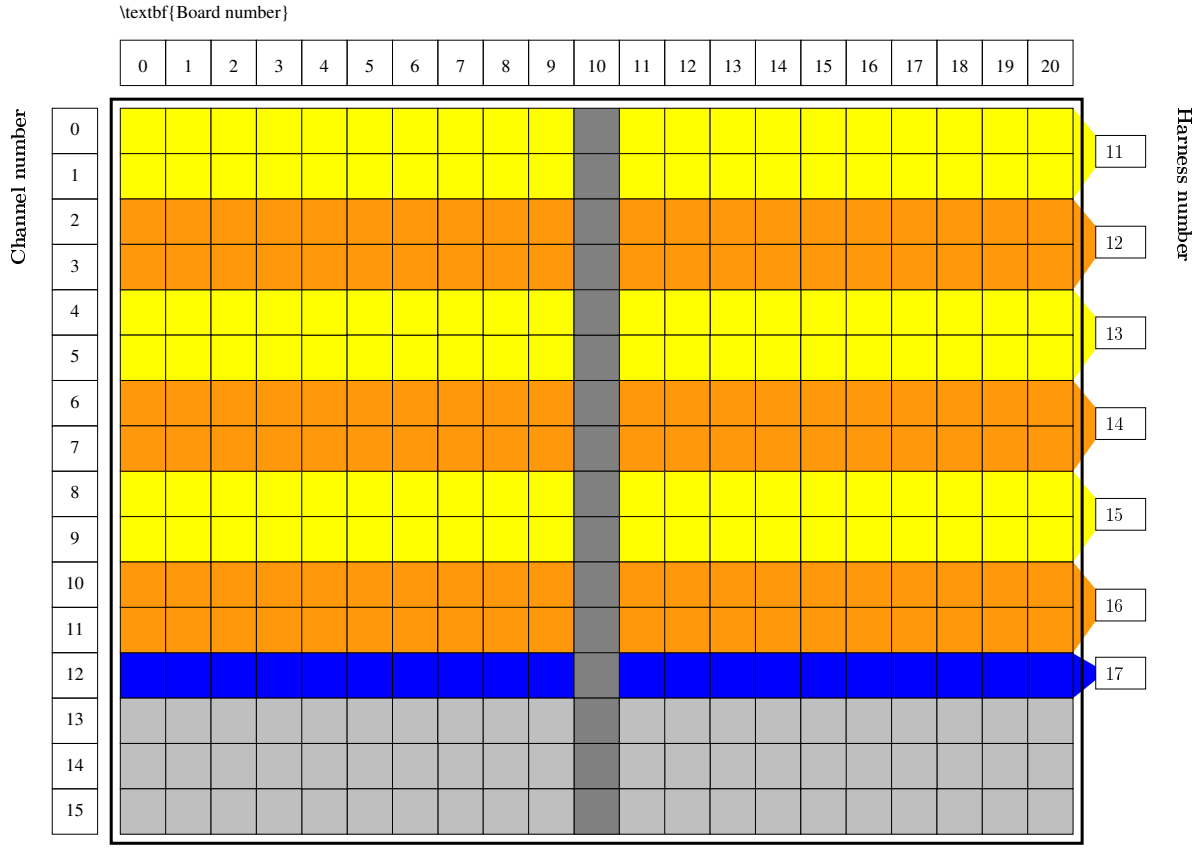

Figure 2: Calorimeter front-end crate 0 (main wall Italy).

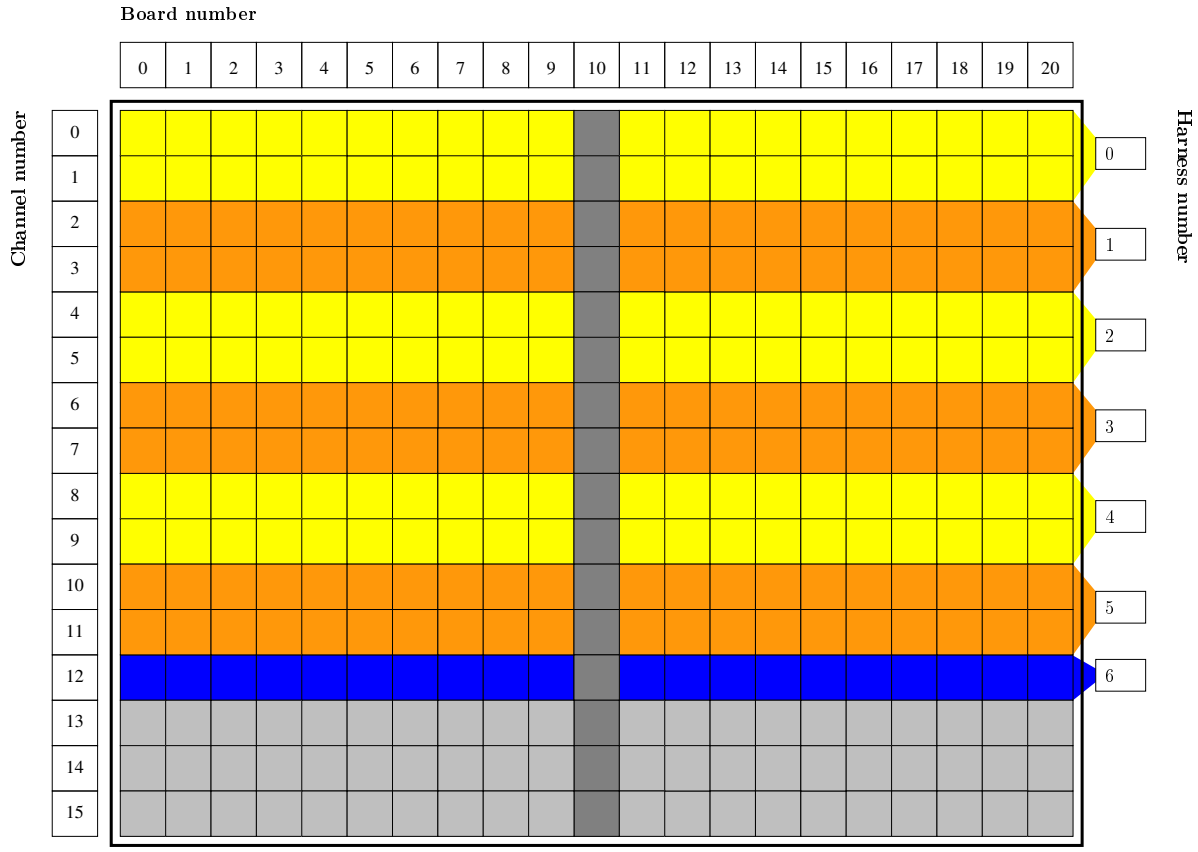

Figure 3: Calorimeter front-end crate 1 (main wall France).

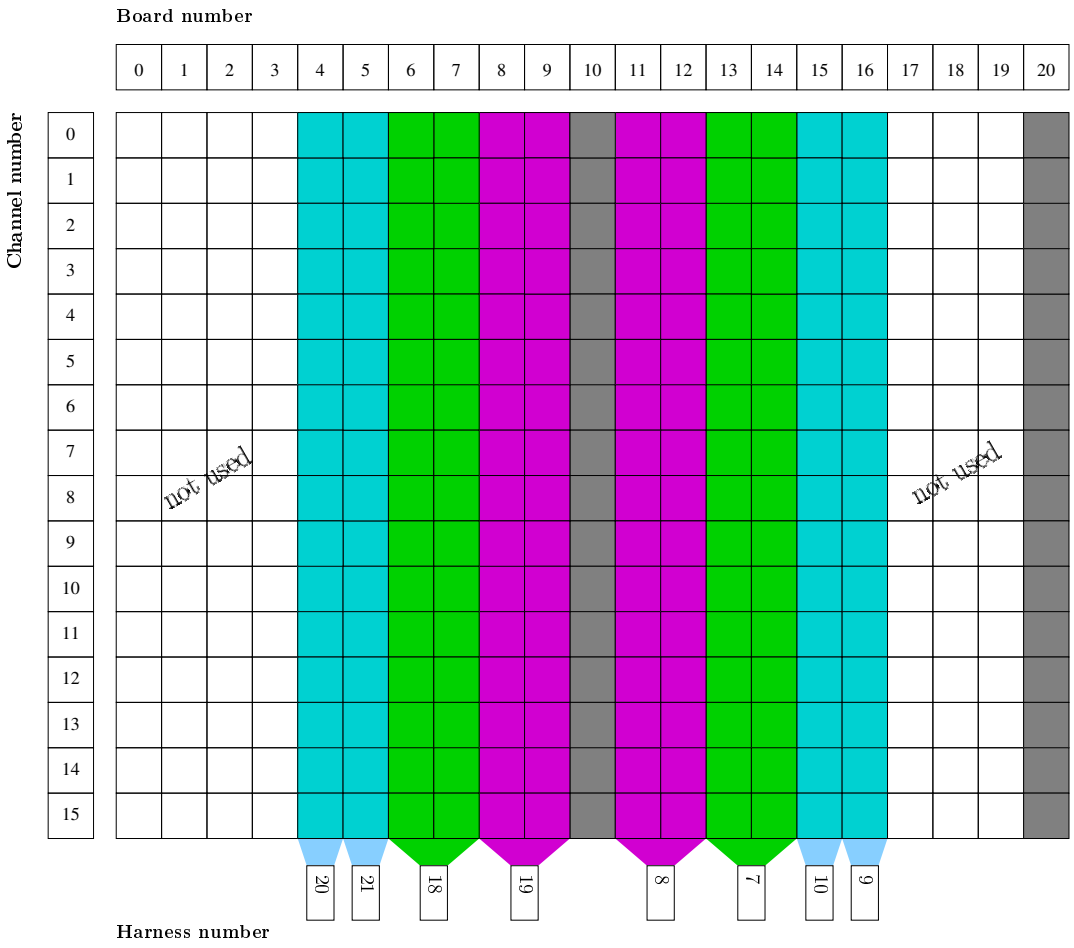

Figure 4: Calorimeter front-end crate 2 (X-wall and gamma veto).

4 The Calorimeter signal cabling table and its usage

4.1 Source table

Cabling the calorimeter readout system consists in the association of each PMT to a Wavecatcher channel. An unique cabling table is provided to give an unambiguous description of the signal cable paths from the calorimeter front-end boards to the detector. The table consists in an associative map like the one shown on table 1.

Readout Channel	External signal cable	Internal signal cable	Optical Module
H:0.0.0	L:11.0	A:11.0	M:0.0.0
H:0.0.1	L:11.20	A:11.20	M:0.0.1
H:0.0.2	L:12.0	A:12.0	M:0.0.2
⋮	⋮	⋮	⋮

Table 1: Example of CaloSignal cabling table

The table is provided in the form of a CSV[2] file. The file uses the following format:

- The file contains only ASCII characters.
- Blank lines are ignored.
- Lines starting with the hashtag character `#` are ignored, enabling to write some comments.
- There is only one Wavecatcher front-end board channel/PMT association per line.
- Each line has four columns separated by the *semi-colon* character `;`.
- The first column contains the label of the Wavecatcher front-end board readout channel.
- The second column contains the label of the external signal cable.
- The third column contains the label of the internal signal cable.
- The fourth column contains the label of the PMT (optical module).

The CaloSignal cabling map file is used as the unique source of information for different purposes:

- generation of labels to be stuck on external and internal cables or harnesses;

[2]CSV: coma separated value

- generation of printable tables for people in charge of the calorimeter readout cabling at LSM,
- input for dedicated software modeling tools used by the Control and Monitoring System (CMS), the simulation...

4.2 CaloSignal cabling sheets

The SNCabling package provides a Python script to automatically generate, from the CaloSignal cabling table, a printable PDF document with cabling tables corresponding to each part of the detector and each front-end crate.

4.3 Labels

The SNCabling package provides a Python script to automatically generate, from the CaloSignal cabling table, the lists of all labels for all signal harnesses and cables. The labels must be stuck on the terminations of all harnesses and cables to help the cabling team to identifiy the proper connections between front-end board channels/external cables/patch panel/internal cables/PMT. Figure 1 shows where various kinds of labels are supposed to be stuck on signal harnesses and cables.

- Each label stuck on the end of an internal signal cable on the PMT side identifies not only the signal cable itself but also the optical module/PMT it is connected to. Example:

```
A:9:1 -> M:1.4.0
```

- Each label stuck on the end of an external signal cable on the front-end crate side identifies not only the signal cable itself but also the Wavecatcher readout channel it is connected to.Example:

```
L:9:1 -> H:1.1.0
```