Draft
Lvl1 Calorimeter Trigger Analog Cabling and Channel Mapping for the H8 Combined Testbeam

The ATLAS Group at the KIP Heidelberg
University of Heidelberg
Frederik Ruehr

August 30, 2004

Abstract

This document shortly summarizes the results of the Pilot Installation week of the Lvl1 Calorimeter Trigger at the H8 Combined test beam area at CERN, regarding analog cabling and channel mapping. The work presented here was done mostly, but not exclusively, by Florian Foehlisch, Pavel Meshkov and Frederik Ruehr from the ATLAS Group at the KIP Heidelberg.

The general layout of the test beam setup regarding analog channels and cables is shown and trigger tower mapping is given from the η-ϕ space of the calorimeters to the input channels of the PreProcessor, for two options of Remapping Boards on the Receivers. Furthermore a definite cabling scheme for the test beam period in September/October 2004 is proposed.

Contents

List of Figures

1 Introduction

The ATLAS Lvl1 Calorimeter Trigger is going to take part in the test beam run at the ATLAS H8 Combined Test Beam in September/October 2004. The Lvl1 Calo PreProcessor will have to be connected in a sensible and practical way to the calorimeters, through the Receiver Boards and TileCal Patch Panels, taking the modules, layout and goals of the test beam into account.

This document heavily draws from other sources describing cabling and channel mapping for the final experiment [1, 2], where information is also often given in more detail. Furthermore the TileCal and LAr people present at the test beam were an invaluable help. The purpose of this document is to bring the information together in one place and apply it to the test beam situation. It is to be considered more a work document to inform and help in cabling the system, than a documentation of the work done.

2 Overview of the Setup

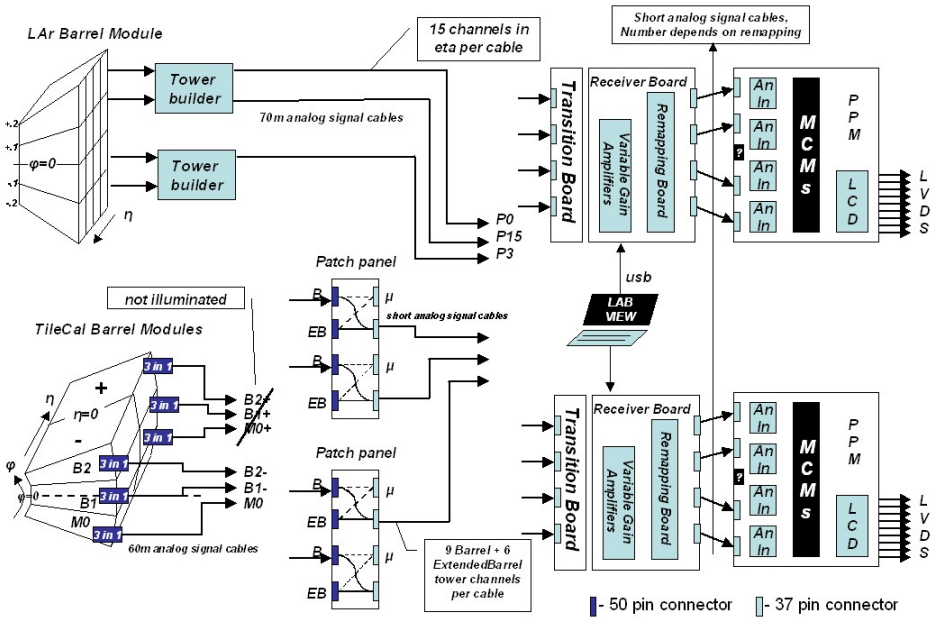


Figure 1: Sketch of the setup at the test beam, including maximum amount of cabling

2.1 Calorimeters and Frontend Electronics

There are two calorimeter types at the H8 Test beam, one LAr Barrel Module and three TileCal Barrel Modules. The LAr Barrel Module geometrically spans a range of -0.2-0.2 in ϕ and 0-1.5 in η. The Tower Builders sum calorimeter cells into the Trigger Towers, each having a size of 0.1x0.1 in η/ϕ. The signals are ordered in cables with a fixed ϕ and all 15 different η-values each.

The TileCal at the H8 test beam consists of three modules, each having a size of 0.1 in ϕ, resulting in a total ϕ coverage of -0.15-0.15, and -1 to 1 in η. The readout of the modules splits each module into two halves, positive and negative η. Thus the 3-in-1 cards sum the calorimeter cells into six cables, each holding signals with a fixed ϕ and either the negative or positive η values. All resulting Trigger Towers on the cables have a size of 0.1x0.1 in η/ϕ, except for the outermost ones which are 0.1 in ϕ and represent 0.8-1.0 in η.

In respect to the LAr calorimeter, the TileCal modules are flipped in η, but both modules share the η=0 plane. Thus the TileCal Trigger Towers have the same absolute η value as the LAr ones in front of them (seen from the beam), but a negative sign.

Regarding ϕ, all modules are shifted in respect to ATLAS, the LAr downward by 0.2, the TileCal downward by 0.15. The difference of these two shifts, half a trigger tower height, results in the LAr and TileCal trigger towers overlapping in ϕ.

2.2 Electronics in the Lvl1 Trigger counting room

The use of two PreProcessorModules is planned for the test beam, one being installed in the pilot installation, another one during the run. Analog Input Boards 1.0 will be used for these PreProcessors, and MultiChipModules with PPrAsic 1.0 chips. Two prototypes of the LVDSCableDriver boards will handle the digital realtime output of the boards.

To supply these PPMs with analog signals, two receiver boards are going to be installed at the test beam, each coming with a Transition Board to decouple the grounds of the front-end and processor systems. Four VariableGainAmplifier daughter boards for gain adjustments, in the test beam mainly to account for attenuation of signals in the cables, are fitted onto each of the receiver modules. One Remapping Board for each receiver sorts the analog channels for the output to the PPr, more information on the ones used in the test beam can be found in section 3.2 on page 7.

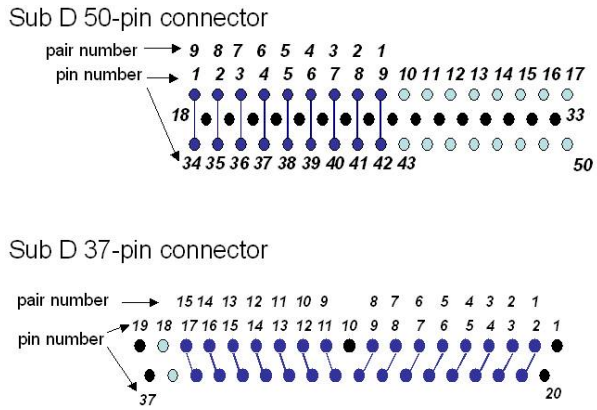
The Receiver Boards and their input and daughter boards are all prototypes predating the Receiver Board PRR, though the shaping constant of the boards has been changed to 5ns to comply to final specifications.

The cables coming from the TileCal 3-in-1 boards carry 9 trigger tower signals and 6 muon signals each. Two passive boards, the TileCal Patch Panels are used to separate the Trigger Tower and muon signals into two different cables.

2.3 Cabling

Most cables used for the analog signals in the setup are twisted pair cables with a 37-pin connector, carrying up to 16 differential signals, the rest of the pins connect to the cable shields. Three of these with a length of 70m connect the LAr calorimeter Tower Builder Boards with the Receiver Boards. Up to eight short ones are needed to connect the Receivers to the PreProcessors. Further three short ones connect the TileCal Patch Panels and the Receivers. Currently two 10m cables and nine 21m ones are available for the test beam in addition to the three 70m cables laid from the LAr module to the trigger counting room, being sufficient to cable the system.

The cables coming from the TileCal 3-in-1 boards have 50 pin connectors, and carry 15 individually shielded differential signal pairs. Nine of these 15 are Trigger Tower signals, the other six are muon signals. Only one half of the TileCal, the one also covered by the LAr calorimeter, is envisioned to be illuminated during the test beam run, resulting in three used cables, which are already installed and 60m in length. In the TileCal Patch Panels the trigger tower and muon signals are separated into



TileCal

η bin	0-0.1	0.1-.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-1.0
50 pin +	9	8	7	6	5	4	3	2	1
50 pin -	34	35	36	37	38	39	40	41	42
37 pin +	2	3	4	5	6	7	8	9	11
37 pin -	21	22	23	24	25	26	27	28	29

LAr

η bin	0-0.1	0.1-.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-9.0	0.9-1.0	1.0-1.1	1.1-1.2	1.2-1.3	1.3-1.4
37 pin +	2	3	4	5	6	7	8	9	11	12	13	14	15	16
37 pin -	21	22	23	24	25	26	27	28	29	30	31	32	33	34

Figure 2: Diagram showing position of trigger channels on the connectors(before the Receiver)

two cables. The Trigger Tower cables leaving the Patch Panels are the 37-pin ones described above, and carry 9 signals from the TileCal barrel. It would be possible to connect the other three 60m cables from positive η side of the TileCal, which are installed, to the Extended Barrel inputs of the Patch Panels. This would result in another 6 signal pairs in the Trigger Tower cables being occupied, although only by calibration signals and noise.

3 Channel Mapping

3.1 Calorimeters and TileCal Patch Panels

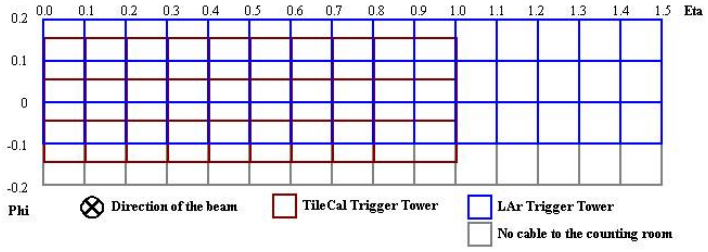


Figure 3: Orientation of LAr and TileCal trigger towers

The biggest difference of the calorimeter setups in the test beam and in ATLAS is the shift of modules in ϕ(from ϕ=0 downwards). As the TileCal Modules are shifted half a Trigger Tower height less than the LAr one, as sketched on figure 3, the TileCal and LAr Trigger Towers overlap in ϕ.

Furthermore the TileCal modules are flipped in η when compared to the LAr. But as the TileCal modules are symmetric in η i will only speak about the absolute value of η from now on, disregarding the negative sign in the TileCal case.

As shown on figure 3, the lowest ϕ row of the LAr module has currently no cable installed from the Tower Builder Boards to the trigger counting room. The cables can be moved on the Tower Builders, though, but the maximum number of usable cables is three.

The Trigger Towers, for both calorimeters, are sorted into cables by ϕ, one cable carrying signals from Trigger Towers with a fixed ϕ and all possible η values. On the cables from the LAr Tower Builders, the channels are ordered by η, the lowest η Trigger Tower occupying the lowest pair number. The signals on the 60m cables from the TileCal 3-in-1 boards are ordered differently, but after the TileCal Patch Panels the ordering in the cables going to the receivers is the same as for the LAr cables. This is also shown on figure 2 on page 6.

3.2 Remapping Boards

Two types of Remapping Boards for the Receivers are being considered for the test beam, and are being made available. The first type, probably used for simple tests, is Type 14, which will be used for the HECA in ATLAS. These Remapping Boards

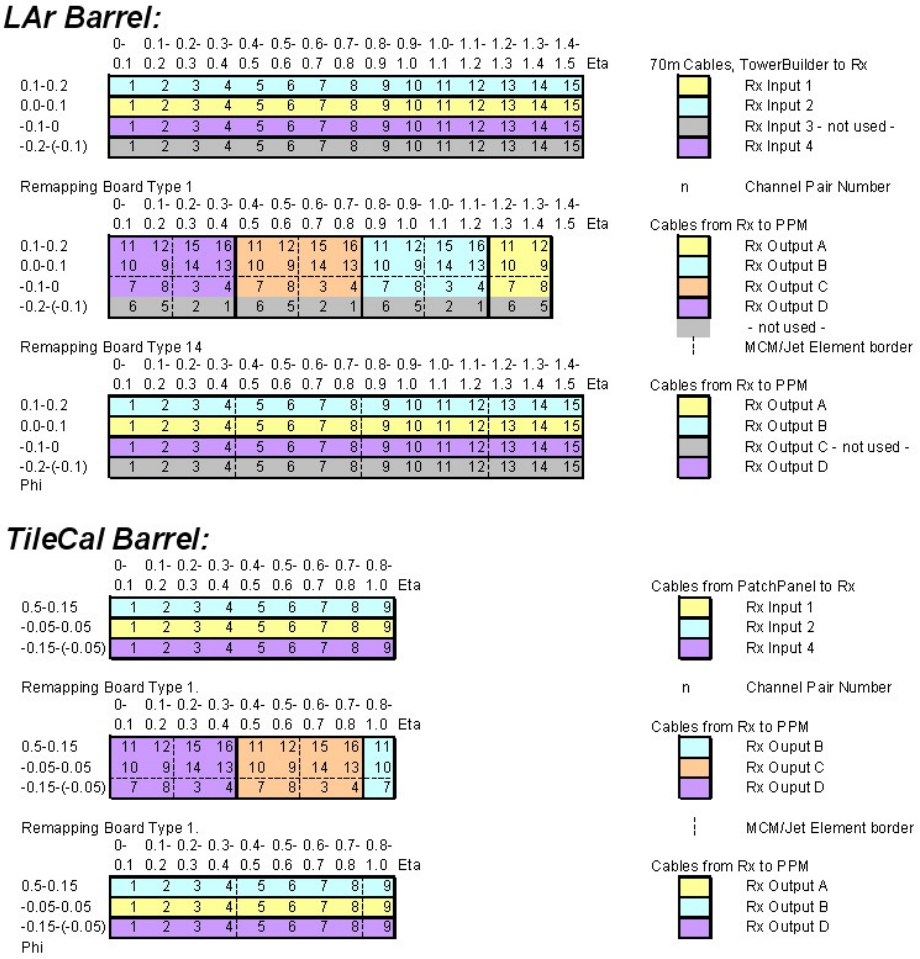


Figure 4: Mapping of cable channels to η-ϕ

function as a straight through module, directly mapping all receiver inputs onto the outputs without changing the order.

The other option are Type 1 Remapping Boards, designed for the LAr ElectroMagnetic Barrel (negative η). As it is sufficient to only consider the absolute values of η in the test beam setup, this module is fitting the LAr Barrel module. Furthermore, as the η to cable pair mapping is the same in the TileCal cables arriving at the receiver(for η of 0 to 0.8) as in the LAr cables, the Type 1 Remapping Boards can also be used for the TileCal barrel modules. These boards basically mix different ϕ values into one cable, grouping a 4x4 field of Trigger Towers, normally 0.4x0.4 in η/ϕ. Additionally the channels inside one cable are sorted in a way to allow the summing of sensible Jet Elements of 2x2 Trigger Towers in the PPr.

Considering the above, Type 14 Remapping Boards can be used to have the easiest possible mapping of η/ϕ to PPr inputs, while type 1 boards resemble ATLAS the closest, also allowing to use ATLAS cabling schemes to connect the PPr to the processors. The figure 4 shows the actual mapping of η/ϕ to Receiver Outputs/PPr Inputs for both calorimeters, using both Remapping Boards. Connectors are named 1-4 from top to bottom for receiver inputs, and A-D from top to bottom for outputs.

More information on Remapping Boards is given in [2].

4 Specific cabling plan

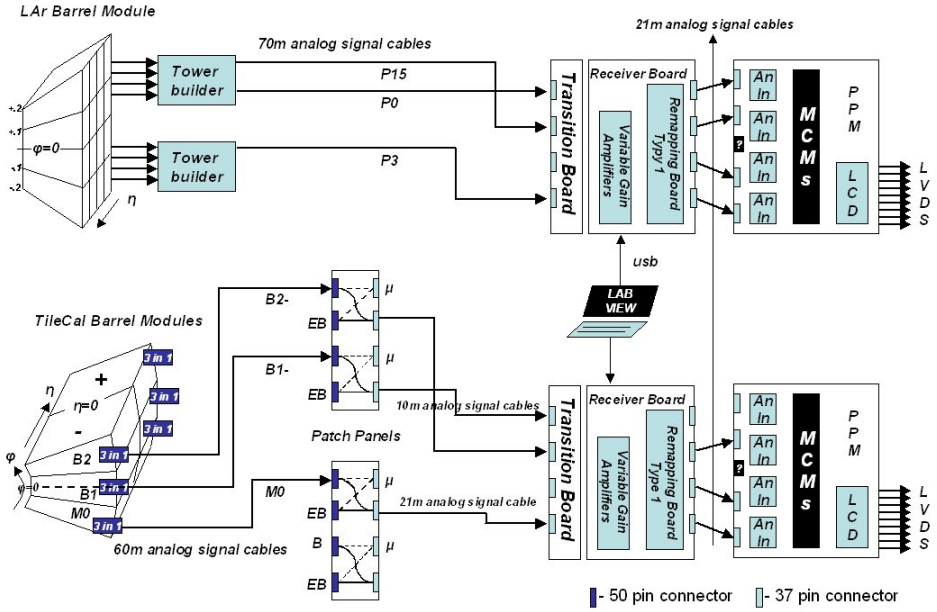


Figure 5: Sketch of a possible cabling scenario using type 1 Remapping Boards

An option for a specific cabling plan for the analog cabling of the Lvl1 Calo Trigger at the H8 test beam is presented in the following. The main emphasize of this cabling scheme was twofold, first having one setup closely resembling ATLAS, and secondly but more importantly allowing for the use of both types of remapping boards with a minimum amount of recabling needed.

Resembling the ATLAS setup as much as it is possible was thought as a goal to be able to stay close to the ATLAS setup for the digital cabling from the PPr to the processors. Having a sensible analog setup can simplify the digital cabling part significantly.

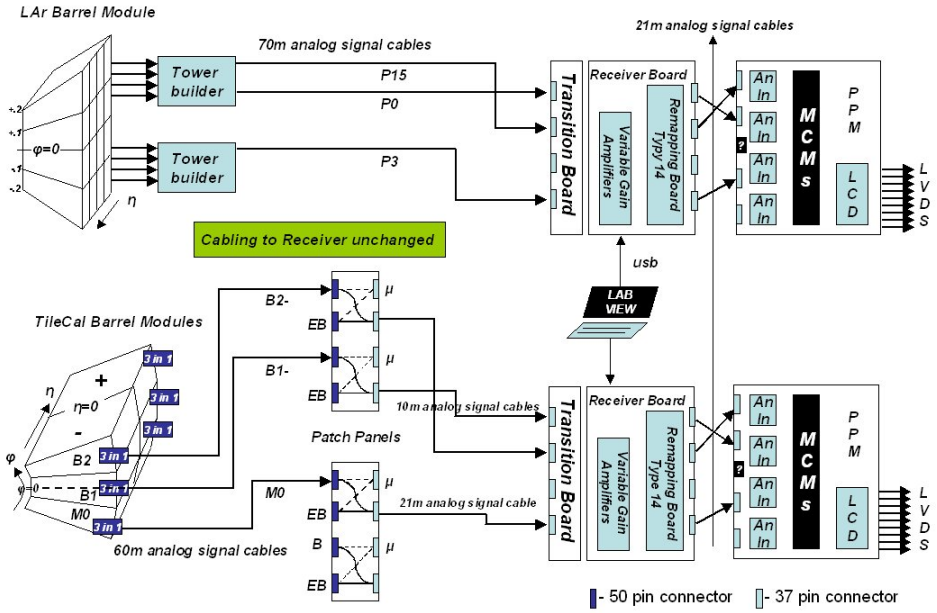


Figure 6: Cabling plan to use type 14 Remapping Boards with minimal recabling

Both the analog and digital cabling depend heavily on the processors test program, though, and using the simple straight-through type 14 remapping boards could be more practical for certain approaches. To minimize possible error sources recabling should be kept to a minimum when changing the remapping boards. The presented scheme does not require any of the cables upstream from the Receiver Board to be changed. All needed changes are implemented with the Receiver to PPr cables only, which have to be partly removed anyway to be able to remove the Receiver Board from the crate. Furthermore changing the cables to the receiver could require changes in the Receiver gain settings, which is to be avoided.

4.1 Scheme using Type 1 Remapping Boards

For Type 1 Remapping Boards a flip regarding receiver connector and ϕ sequence of cables is needed (see [2]). Naming input connectors 1-4 from top to bottom the cable carrying Trigger Towers with the highest ϕ value has to be connected to connector 2. Going from high to low ϕ they have to be connected in the following order: 2 1 4 3

On the receiver output side, as the Remapping boards orders the signals in groups of neighboring Trigger Towers in ϕ and η, all four cables are needed for the LAr. As the TileCal only covers η up to 1.0, the topmost output connector of the receiver can be left empty, see figure 4 on page 8.

It can also be seen on this figure that the amount of analog signal cables can be significantly reduced if one restricts cabling to the η-region of 0.0-0.8. As each cable coming from the receiver carries signals of a 4x4 trigger tower square in η/ϕ, this reduces the necessary receiver output cables to two each, the topmost two connectors empty on both receiver boards. The system can be set up using only one PreProcessor in this case. It is very probable that the beam will hit the calorimeters at an η of about 0.4 during most of the testbeam run.

4.2 Scheme using Type 14 Remapping Boards

The cabling scheme using type 14 remapping boards is principally quite straightforward, signals should arrive at the PPr ordered in cables with a fixed ϕ the same way they arrive from the detectors. But as the goal was to not change the cabling up to the receiver the flip of connector number and ϕ bin done there has to be undone again after the Receiver. This is possible as the remapping board does not mix any channels between cables and simply maps input connectors directly onto output ones.

5 Conclusion and Outlook

During the pilot installation stay at CERN the purposed mapping of calorimeter Trigger Towers, with certain ϕ and η values, to channels in the cables and arriving at the PreProcessor was determined. The connectivity of all cables was tested, the actual mapping was only verified for a few channels carrying beam signals, though. For the TileCal, as it consists of three modules with a fixed ϕ each, the possibility for errors in the front-end electronics cabling, resulting in differences from the above presented mapping, is small. For the LAr module and Tower Builder Boards, the channel mapping may have to be verified more thoroughly, though no indication for any errors have been found in the tested sample.

Furthermore the maximum amount of analog cables needed during the test beam run was determined, and all analog cables brought to the trigger counting room (except for one 10m cable still in Heidelberg for tests, which will arrive with the PPM). The required TileCal Patch Panels are already at the test beam, as well as one Receiver Board. The second one and the rest of the Remapping Boards will be kindly made available at the test beam by Pittsburgh before the start of the Lvl1 Calo test beam run.

The amount of LVDS cables from the PreProcessor to the processors was also determined, and the number of available cables found sufficient for full cabling of the system. These cables have still to be brought to the test beam, though, after determining who supplies how many.

Concluding, the Pilot Installation week at CERN can be considered a full success,

and, including module installation and software setup being done during the week, should allow for an uncomplicated installation of the full system in September 2004.

A Scope pictures taken at the test beam

A few pictures of TileCal signals were taken at the test beam, measured with a scope behind 10m of cables coming from the Receiver Board(unity gain). As the LAr trigger tower cables were not connected during the week and also our focus was on other work, we did not manage to get any decent sized usable pictures of LAr pulses. All pictures were taken with an internal scope trigger.

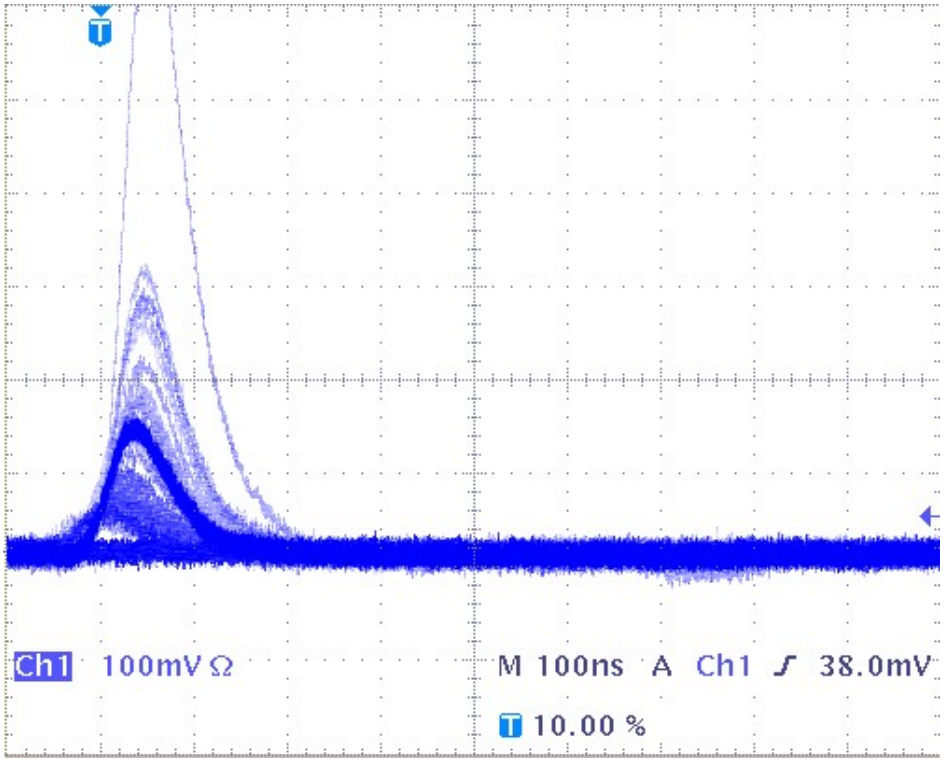


Figure 7: Beam spill during a pion run in the TileCal, taken with long persist time

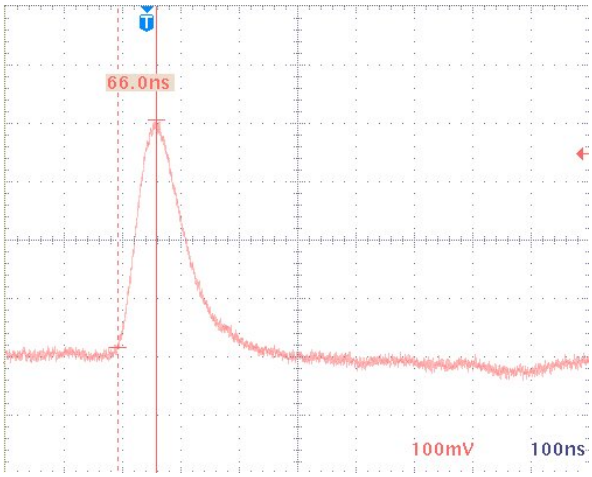


Figure 8: Single pion signal from the TileCal

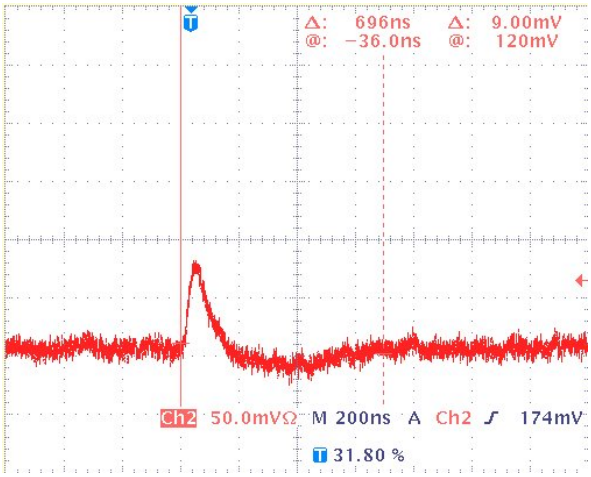


Figure 9: Low energy electron in the LAr Calorimeter

References

[1] L1 Calo Group: *Cabling Mappings and Crate Layouts from Analogue Inputs to Processors*, ATL-DA-ES-0036 (https://edms.cern.ch/document/399348)

[2] V. Paolone: *Remapping Boards for the ATLAS Liquid Argon Receiver System*, ATL-AL-EN0046, November 2003