P.Gorbunov Draft 2. 22-Nov-2003

Calibration run types in FCal beam tests

1. Generalities

The data files are /raid/data/calib/calXXXXX.dat, where XXXXX is the run number. Most of the calibration runs were taken in a stand-alone mode, using the program `calib_run.` They are distinguished by the run number of >10000. The runs with the numbers of <10000 were taken with a standard DAQ program. Both programs were using the same online readout codes and differed only by the source of the calibration triggers.

The standard DAQ is fully driven by external triggers detected by the trigger/busy module CIRQ. The calibration triggers were coming from a ~1 kHz pulser. The actual trigger frequency was defined by the DAQ readiness to accept the next trigger. The calibration signals (**TTC Calib**) were initiated by the CIRQ BUSY output connected to the PDC **Trig1** input, and propagated to the Calibration Board only when a) the DAQ was ready for the readout and b) the corresponding CIRQ input was enabled[1]. In this mode, the calibration "stamps" (see below) were read-out from the Calibration Board in advance, before getting ready for the next trigger.

In the stand-alone mode, the loop over the calibration triggers is organized by the software and the **TTC Calib** signals are generated by writing to a corresponding VME register of the PDC module. In this mode, there is no correlation with the beam.

With one exception (runs 2805-2812), all calibration runs were taken during periods with no beam from the SPS. Runs 2805-2812 were taken between the spills, when the beam was on.

The exact run conditions (settings) can be extracted from the run-headers or, for individual pulser events, from the Calibration Board "tamps" stored as sub-blocks ID=0xFFFF (the format is described in [Ref. 1]).

The "stamp" contains the pattern of the pulsed channels, the DAC value (pulse amplitude) and the pulse delay offset (in steps of 0.996 ns) with respect to the "nominal" pulse phase. The latter, defined by the run-header [Ref. 1] key "TtcCalDly", had been tuned to have the pulse peak roughly at the sample 3; it stayed unchanged during the tests. On the contrary, the delay offset was actively used for pulse-shape scans. The offset value of 15 steps makes the pulse peak positioned within ±1.5 ns from the sample 3, in all the FEBs.

The pulser board hardware permits to execute a pre-programmed sequence of pulses (a *calibration cycle*) in three embedded loops:

```
loop over "patterns/delays" (up to 64)
   loop over DAC values (up to 256)
      loop over triggers with the given DAC and pattern
      end of loop over triggers
   end of loop over DAC
end of loop over "patterns"
```

[1] The CIRQ enable/disable logic is controlled by the "trigger grading" mechanism. In calibration runs, the calibration triggers are enabled only outside of spills and not downscaled..

The board is first initialized and loaded with the parameters defining the cycle. At each subsequent occurrence of the TTC **Calib** signal on the Calibration Board it delivers one calibration pulse with the parameters (pattern/delay and DAC) defined for the current iteration. See [Ref. 2] for further details on the calibration board logic.

A "pattern" defines the combination of FEB channels to be pulsed and the corresponding delay offsets. There is one-to-one correspondence between the pulser channels and the base-plane lines connected to the FEB input channels (see Table 1). The delays, theoretically, can be different for different channels in a given pattern[2], but I never used this option and specified the same delay for all pulsed channels.

The relevant run-header keys defining the calibration cycle are:

```
CalNtrig  - number of triggers per setting
CalNpatt  - number of patterns
CalDelays - list of delay offsets per pattern
CalDac    - list of DAC values per pattern
CalPatt_X - channel pattern X (0<= X <= [CalNpatt] )
```

For convenience their description is reproduced from [Ref.1] in Appendix A.

The FCal DAQ has an additional option to execute "super-cycles" of the form:

```
loop over delays (by software)

  loop over "patterns"
     loop over DAC values (up to 128)
        loop over triggers with the given DAC and pattern
        end of loop over triggers
     end of loop over DAC
  end of loop over "patterns"

end of loop over delays
```

where all the channel pattern are pulsed with the same delay defined by the external loop.

This mode is enabled by replacing the `CalDelays` key with a `CalSDelays` key containing the list of delay offset values in super-cycles.

2. Some details of FCalTB DAQ implementation

In FCalTB DAQ P.Perrodo's low-level primitives are used for FEB and calibration board loading and communications (Ref. [2]). The whole high level layer is re-written. The modifications related to the calibration procedure are as follows:

- The super-cycles. One physical run can contain *any* number of hardware calibration cycles, each performed with a constant delay value. On a completion of the current cycle, the calibration board is automatically re-initialized and reloaded with the same settings except the delay value, which is modified according to the configuration file (see below).
  The traditional mode, with a single calibration cycle per physical run and correlated delay/pattern pairs is retained as an option.

- The calibration *stamp* are written to each individual pulser event, as a sub-block. The stamp contains a copy of all calibration board registers read-out before the corresponding calibration trigger. Two calibration modes are implemented: with external and software-

[2] Up to 8 groups of channels can be pulsed with different delay offsets in the same trigger ([Ref. 2]).

generated calibration triggers. At each event, the hardware stamp is compared with the expected one, computed by the DAQ. In case of a discrepancy the error flag is written to the event, the board is re-initialized and the ongoing calibration cycle is repeated. The advantage of having calibration stamps in each event is that each event can be analyzed individually and is garanteed to have a consistent data. The drawback is the overhead caused by check-reading of the board registers.

- Like for all other configuration (condition, settings etc) parameters in FCalTB DAQ, the calibration board settings are specified in a small configuration file containing *name-value* records in a compact and flexible format (Ref. [1]). This configuration file is copied to the run header an stored with the data.

3. Calibration run types in FCal beam tests

We had three regular types of calibrations runs described below: “standard”, “long” and “Xtalk”. The list of runs is given in Appendix B.

- **Standard (daily) calibration runs.** Fixed delay (with the peak at about sample 3), fine amplitude ramp, 3 gains (low, medium, high), 7 samples, *all* channels pulsed.

One set of "Standard Calibration" consists of 8 runs:

```
run type "A" DAC= 0-2000     in steps of 25, 50 triggers per setting
run type "B" DAC= 2000-4000  -"-
run type "C" DAC= 4000-6000  -"-
run type "D" DAC= 6000-8000  -"-
run type "E" DAC= 8000-10000  in steps of 25, 25 triggers per setting
run type "F" DAC= 10000-12000 -"-
run type "G" DAC= 12000-14000 -"-
run type "H" DAC= 14000-16000 -"-
```

In each run of types A-D there are 50*81=4050 pulser events, in runs of type E_H ─ 25*81= 2025 pulser events. At the end of each run, 100 pedestal events are recorded (the PDC is pulsed but the **Calib** signals are blocked at the Fan-out level).

The event order in these runs is as follows:

```
loop over DAC values
   loop over triggers (50 or 25)
   end of loop over triggers
end of loop over DAC

100 pedestal events
```

Several sets of runs were usually taken during beam interrupts.

Configuration files: `StdCalibrationA.v0 … StdCalibrationH.v0`

Run-header records:

```
CalNpatt 1      // one "pattern"
CalPatt_0 0:127 // all channels pulsed
CalDelays 15    // peak at around sample 3
CalNtrig 50     // runs A-D
   CalNtrig 25  // runs E-H
CalDac 0:2000;25  // A-run
CalDac 2000:4000;25    // B-run
   CalDac 4000:6000;25    // C-run
   CalDac 6000:8000;25    // D-run
   CalDac 8000:10000;25   // E-run
   CalDac 10000:12000;25  // F-run
   CalDac 12000:14000;25  // G-run
CalDac 14000:16000;25  // H-run
FebSamples 7
FebGains 1 2 3    // low med high
```

- **"Long" calibration runs,** usually taken during MDs. The features are:

— a coarse delay offset scan, with 8 different delays:

0, 3, 6, 9, 12, 15 18 and 21 steps;

— 12 different amplitudes in the 0-4000 DAC range, chosen to have no overflows in medium gain:

0 50 100 250 500 750 1000 1500 2000 2500 3000 4000,

— 2 gains (high and medium) and 24 samples. In each event only *one* channel is pulsed.

One "Long Calibration" set consists of 2 runs:

1 run of type "A": channels 0-63 are pulsed, one-by-one
1 run of type "B": channels 64-127 are pulsed, one-by-one

In one run, there are 8*12*64=6144 pulser events, followed by 100 pure pedestal events:[3]

```
loop over delays (0, 3, 6, 9, 12, 15 18 and 21 ns)
  loop over channels (0-63 or 64-127)
    loop over DAC values (0, ...., 4000)
       -- one pulser trigger
    end of loop over DAC
  end of loop over channels
end of loop over delays

100 pedestal events
```

Only one trigger per setting is taken in each run, so to obtain about 100 measurements per setting we took the corresponding number of long sets[4]The whole series took 1-1.5 days.

Configuragtion files: LongCalibrationA.v0 and LongCalibrationB.v0

[3] The pedestal events at end of calibration runs: since run 10084.
[4] In practice, we often took "Long Calib" runs in A+A+B+B groups.

Run-header records:

```
CalSdelays 0 3 6 9 12 15 18 21  // 8 super-cycles per run
CalNPatt 64
CalPatt_0    0
CalPatt_1    1   // A-run
. . .
CalPatt_63   63  // A-run
CalDac 0 50 100 250 500 750 1000 1500 2000 2500 3000 4000
CalNtrig 1  // only one trigger per setting

FebSamples 24
FebGains 2 3 // med, high
```

Alternative settings for B- runs:

```
CalPatt_0    64   // B-run
CalPatt_1    65   // B-run
. . .
CalPatt_63   127  // B-run
```

- **"Cross-talk" and auto-gain study**.

This type of runs is somewhat similar to Long Calibration runs, but features an automatic gain selection and fewer (one or three) and greater DAC values.

Like in LongCalib runs, only one channel is pulsed at a time, therefore, the X-talk runs are split in A-type (channels 0-63) and B-runs (channels 64-127). 24 samples are recorded. The 8 delay offsets are the same as in LongCalib runs:

```
0, 3, 6, 9, 12, 15 18 and 21 steps,
```

The concept of this run-type was developing "dynamically", so we had three versions of X-talk runs:

v0: CalDac 64000. Very large pulse amplitude. This version as abandoned because an anomalously strong (non-linear?) cross-talk was observed in some channels (particularly, inchannel 126)

v1: CalDac 18000. The pulse amplitude had been reduced to get rid of the anomalous cross-talk and have all signals digitized in medium and high gain only (avoid low gain). Both in v0 and v1 runs the upper auto-gain threshold which governs switching between medium and low gain was the same as in all our physics runs, namely 3500:

```
FebAutoGainThr  1150 3500
```

In physics runs we never had signals with amplitudes >2000 in medium gain, so the issue of the upper threshold was not addressed before X-talk runs.
It turned out, however, that with CalDac=18000, even though there were no overflows in medium gain, we were hitting the floor with the negative pulse lobe. This problem was fixed in

v2: Modified upper auto-gain threshold:

```
FebAutoGainThr  1150 2500
```

and three different CalDac settings in each run:

```
CalDac  11000 22000 33000
```

With DAC=11000, the signals in all the FEBs is digitized in medium or high gains (for direct and induced signals, respectively). With 22000 and 33000, the direct signals are digitized in low gain.

The run structure is like this:

```
loop over delays
  loop over DAC (one or three values)
     loop over triggers (10)
     end of loop over triggers
  end of loop over DAC
end of loop over delays

100 pedestal events
```

Configuration files: `XtalkA.v2, XtalkB.v2`

Run-header records:

```
CalSdelays 0 3 6 9 12 15 18 21  // 8 super-cycles per run
CalNPatt 64
CalPatt_0    0
CalPatt_1    1   // A-run
. . .
CalPatt_63   63  // A-run

CalDac 11000 22000 33000
   CalDac  64000   // v0
   CalDac 18000    // v1

CalNtrig 3  // (10 in v0 and v1)

FebSamples 24
FebGains 0 // automatic gain selection
FebAutoGainThr 1150 2500  // auto-gain thresholds
   FebAutoGainThr 1150 3500  // auto-gain thresholds

FebFirstSample 3 // the sample to be used for auto-gain selection
```

Alternative settings for B- runs:

```
CalPatt_0    64   // B-run
CalPatt_1    65   // B-run
. . .
CalPatt_63   127  // B-run
```

4. Other types of calibration runs

During preparations for the tests (mainly in May), a number of special calibration runs were recorded. They are described in Appendix C.

References:

1. P. Gorbunov, “FCal Test Beam DAQ: description of raw data file format”, Part 2 (Run Configuration and Control Keys),
http://cern.ch/atlas-fcaltb/Memos/Daq/DataFormatGeneral.doc

2. J.Colas et al, “The ATLAS Calorimeter calibration board: a test of a first set of boards”, CERN-OPEN-2000-058”
http://documents.cern.ch/cgi-bin/setlink?base=preprint&categ=cern&id=cern-open-2000-058

2. P. Perrodo, “Software for the ATLAS LAR Electromagnetic test beam setups H6 and H8”, ATLAS Note ATC-TT-EN-0002,
https://edms.cern.ch/file/324407/1/testbeam-SA-software.ps.
In the FCalTB DAQ, an old version (~1998) of the STCHC package, obtained from Francesco Lanni, is used.

Table 1 Correspondence between the cal. board and FEB channels

```
//----------------------------------------
  inline int calib_ch_map(int feb_ch) {
//----------------------------------------
// The topology of the 2003 base-plane:
// for FEB channels 0-31 and 64-95 odd and even channels must be
// swapped to obtain the corresponding cali. Board channels
//
if(ch/32)%2) return feb_ch;
else return (feb_ch%2)? feb_ch-1:feb_ch+1;
}
```

Appendix A. The configuration parameters for the FCal calibration pulser board

key	*# of values*	*Default value(s)*	*Value type, description and range*
CalSDelays	any	0	int, list of calibration pulse delay(s) in the corresponding calibration super-cycles, in [ns]. The CalSDelays key makes a CalDelays key void (ie, the latter will not be taken into account) *e.g. CalSDelays 0:17 // 18 super-sycles with constant delays 0,...,17*
CalNpatt	1	1	int, number of palibration patterns in one super-cycle.
CalPatt_x	1..128	0:127	int, list of FEB pins to be pulsed in the corresponding pattern "x" (x=0..127) (ie, CalPatt_0 - for pattern #0, CalPatt_1 - for pattern #2 etc) *e.g. CalPatt_14 0 7 15 21:47;8 90:127 // a weird pattern*
CalDelays	=CalNpatt	0	int, list of calibration pulse delays in [ns], for each of the requested patterns. This key is ignored if a CalSDelays key appears in the same configuration file. The number of values should be equal to the number of patters requested by CalNpatt key. *e.g. CalNpatt 20* *CalPatt_0 ...* *...* *CalPatt_20 ...* *CalDelays 0:10 9*11 // 0,1...10 ns, followed by 9 delays of 11 ns*
CalDac	1..256	0	int, list of DAC values for each pattern *e.g. CalDac 1000:10000;500* *CalDac 0x12345*
CalNtrig	1	0	int, number of consequtive cal. pulses with the same parameters. *e.g. CalNtrig 1000*

Appendix B. The "production" calibration runs

Filenames: `/raid/data/calib/calXXXXX.dat`

runs	Calibration Type	Date	# of sets
10000-10083	Long Calibration runs, no pedestals at the end of run,	1-Jul-2003	42
10084-10088	Long Calibration, with pedestal events	1-Jul-2003	2
10090-10214	Long Calibration	2-3-Jul-2003	62.5
10215-10230	Standard Calibration	3-Jul-2003	2
2805-2812	Standard Calibration (taken between the spills)	7-Jul-2003	1
10231-10246	Standard Calibration	8-Jul-2003	2
10247-10251	Long Calibration (2 series only)	9-Jul-2003	2
10252-10331	Long Calibration	12-Jul-2003	40
10332-10411	Long Calibration	13-Jul-2003	40
10412-10443	Standard Calibation	14-Jul-2003	4
10500-10519	X-talk.v0 Modules are connected	14-Jul-2003	10
10520-10539	X-talk.v1	14-Jul-2003	10
10540-10559	X-talk.v1, FEC is re-assembled	15-Jul-2003	~10
10560-10625	X-talk.v2	15-Jul-2003	33
10626-10657	Standard Calibration, pedestal cables are disconnected	15-Jul-2003	4
10658-10725	X-talk.v2, pedestal cables are disconnected	15-Jul-2003	34
10726-10813	Long Calibration	16-Jul-2003	44
10828-10835	Standard Calibration, HV cables are disconnected	1-Sep-2003	1 (A-H)
10836-10837	Long Calibration, HV disconnected	1-Sep-2003	1 (AB)
10836-10921	Long Calibration, HV disconnected	9-Sep-2003	42 (AB)
10923-10946	Standard Calibration, HV on	17-Sep-2003	3 (A-H)
10947-11128	Long Calibration, HV on (run 11128 incomplete)	17-18-Sep-2003	91 (AB)
runs taken during the failure of the Pulser Board (delay unit)			
10814-10815	Long Calibration: wrong calib. pulse delay in FEB2	16-Jul-2003	1
10816-10825	Long Calibration: delay step=3*0.38 ns	16-Jul-2003	6

Filenames: `/raid/data/calib/July22/calXXXXX.dat`

The "Long" series taken right after the Calibration board had been fixed. The data was recorded on the local hard disk on pcfcal02 and copied to the /raid only much later(in November 2003).
This caused a clash with run numbers taken on September 9, 2003.

runs	Calibration Type	Date	# of sets
10828-10901	Long Calibration runs, ped. cables connected, HV off	22-Jul-2003	74

Appendix C. The "special" calibration runs

Filenames: `/raid/data/calib/calXXXXX.dat`

cal501.dat: 64 events

7 samples, 4 FEBs, Gain=1, in each event only one ch. is pulsed

```
 CalSDelays 0
 CalNtrig    1
 CalDac       10000
 CalDac       0x1000
 CalNpatt  64
 CalPatt_0  0
 ...
 CalPatt_63 63
```

cal502.dat: 180 events, 6.5 MB

32 samples, 4 FEBs, Gain=2, amplitude scan

18 Groups of 10 events, in each event all 128 ch. are pulsed with the amplitude = group*500 (i.e., 500, 1000, ..., 9000)

```
 CalSDelays 0
 CalNtrig    10
 CalDac      500:9000;500
 CalNpatt  1
 CalPatt_0  0:127
```

cal503.dat: 10000 events, 358 MB

32 samples, 4 FEBs, Gain=2, pedestals

for all events, no pulsing, the same DAC offset=0xc00 (ped ~ 1000)

```
 CalSDelays 0
 CalNtrig    1000
 CalDac      10*0
 CalNpatt  1
 CalPatt_0  0:127
```

cal504.dat: 25 events, 1 MB

32 samples, 4 FEBs, Gain=2, calib delay scan

For the pulse shape study: each event is taken with a different calib. pulse delay: delay=(event#-1) ns

```
 CalSDelays 0
 CalNtrig    1
 CalDac      9000
 CalNpatt  25
 CalPatt_0  0:127  // all missing keys are copied from CalPatt_0
 CalDelays  0:24
```

25 May 2003 As of that date: all 8 FEBs, except that the FEB#6 (out of 0...7) sits in the wrong slot and does not "see" the calib pulse

---

cal508.dat - cal524.dat

Pulser runs: Gain=2, all 128 channels pulsed

For each of the following DAC settings: 7000, 6000, 5000, 4000, 3000, 2000, 1000 and 500, a pair of runs was taken:

- "regular" : 1000 events, with a constant Calib Pulse delay=0 and FEB#0 only

- "signal shape": 25 events, with consequtive h 1 ns increments of the Calib Pulse delay: 0, 1, ..., 24 ns; all 8 FEBs

DAC	regular_runs	signal_shape_runs
7000	cal524.dat	cal508.dat and 509
6000	523	510
5000	522	511
4000	521	512
3000	520	513
2000	519	514
1000	518	515
500	517	516

Runs cal508.dat and cal509.dat were taken with the same conditions, but with a time gap of 3 days. During this period modifications were done to the VME crate configuration and the DAQ software. In addition, cal509.dat was taken after a mechanical intervention to the FE crate (it was lifted by 2 cm over the feed-through flange).

Runs for the gain intercalibration: two different gains are taken simultaneously, with different CalDac amplitudes. Number of samples: 15, channels: 0:127

Gains 2 and 3:

run	CalDac	Events
Cal525.dat	500	2000
526	750	-"-
527	1000	-"- (overflow is possible at Gain 3)
528	1250	-"- -"-
529	1500	-"- -"-

Gains 1 and 2:

run	CalDac	Events
Cal530.dat	2000	2000
531	3000	2000
532	4000	~1920 (no run trailer)
533	5000	2000
534	6000	2000
535	7000	2000
536	8000	2000

cal551-557. Runs for V.Epstein. Feb#0 only, Gain 3, CalDelay=0, # ev 1000/run.

31 May 2003, after installation of the termination boards and a complete re-assembly of the FEC. All 8 FEBs are fully functional and react to the calib pulses.

CalRun0.conf series: pulser runs with 1 ns delay scan and 100 events per setting:

```
FebSamples 25
FebDacOffset 0xc00 (pedestals @ ~1000)
FebGains 2 3
CalDelays 0:24
CalPatt_0  0    // only ch. 0 is pulsed
```

```
run           CalDac Events
---           ------  ------
Cal560.dat    100    2500
   561           200 -"-
   562           300 -"-
   563           400 -"-
   564           500 -"-
   565           600 -"-
   566           700 -"-
   567           1000-"-
   568           1500-"-   // overflow is likely at Gain 3
   569           1250-"-   -"-
```

2-3 June 2003 PG: Old Calibration Board (tau=300 ns)

Composite pulser runs, with the new event format (long block length).
On request by A.Hincks, the CalDac scan is done within the same run.
The idea is to do a complete calibration in one go.
Note that one of the DAC values is zero (to see what the "residual"
pulse looks like).

Configuration set: CalRun0.conf

```
FebSamples      8    // to reduce the file size
FebGains        2 3
*
FebAddr         0x28 0x26 0x3F 0x22 0x30 0x3a 0x12 0x21 // FEB addr
miniROD         1   2    3    4       5    6    7     8
FebTimeout      1000   // ns
FebDacOffset    0xc00

CalNtrig    100                //  (1) inner loop (trig)
CalDac      0 50 100:1000;100  //  (2) middle loop (DAC)
CalNpatt  25               //  (3) outer loop  (patt)
CalDelays 0:24
```

Several similar runs were taken:

```
570 and 571: one with new and the other with the old event format,
             otherwise identical; pin 0 is pulsed
572-575    : new event format; different patterns of pulsed pins

cal570.dat     BLK_HDR_LEN=3   30000 events , new event format
cal571.dat     BLK_HDR_LEN=2   30000 events , old event format
CalPatt_0 0   // pin 0 is pulsed

cal572.dat     BLK_HDR_LEN=3   30000 events , new event format
CalPatt_0 31  // pin 31 is pulsed

cal573.dat     BLK_HDR_LEN=3   30000 events , new event format
CalPatt_0 0:127;4  // every 4-thpin is pulsed

cal574.dat     BLK_HDR_LEN=3   30000 events , new event format
CalPatt_0 0:127;2  // every other pin is pulsed

cal575.dat     BLK_HDR_LEN=3   30000 events , new event format
CalPatt_0 0:127  // all pins are pulsed
```

---

8 June 2003 New calibration board, BLK_HDR_LEN=3

```
cal576.dat    CalPatt_0 0    // pin 0 is pulsed
cal577.dat    CalPatt_0 31   // pin 31 is pulsed
cal578.dat    CalPatt_0 0:127;4    // every 4-th pin is pulsed
cal579.dat    CalPatt_0 0:127;2    // every other pin is pulsed
cal580.dat    CalPatt_0 0:127    // all pins are pulsed
```

The calibration runs to be discarded

Filenames: `/raid/data/calib/calXXXXX.dat`

cal1890: ??? 824 MB

cal2028-2053 : short runs, DAQ development (to include "monitor" triggers)

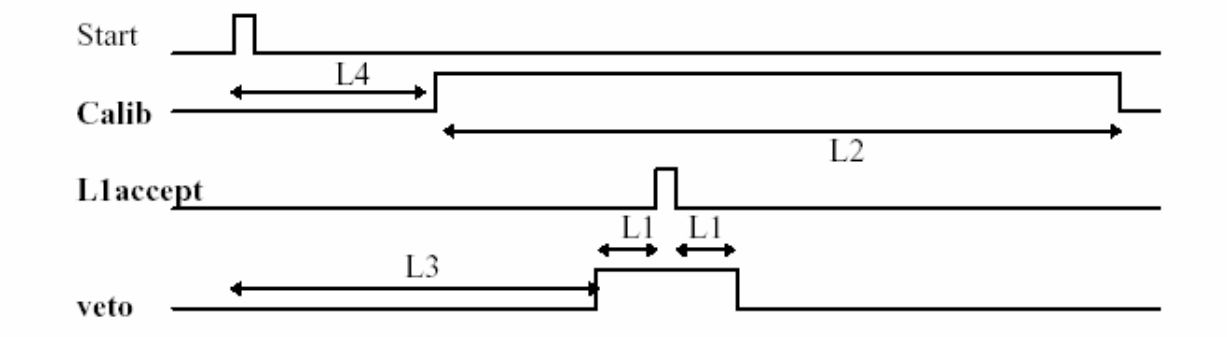
cal2400: a preliminary version of a "Long" run

cal3419-3421: investigation of the pulser failure

cal10814...10827: "Long" runs, the pulser failure (actual selay step= 0.38 ns); pedestal cables are disconnected

Appendix D: Calibration pulse timing

(from R.Bernard, J.F.Renardy, "Fast signals distribution for Module 0", ATL-AL-CEA-ES-4.0, available from
atlas-fcaltb.web.cern.ch /Memos/Hardware/FEB0/TTC_ATL_AL_CEA_ES-4.0.pdf



Description:

L1	width of the veto for external L1accept	default=8×25 ns
L2	width of the Calibration pulse	default=4×400 ns=**1600 ns**
L3	Delay before veto	default=33×25 ns
L4	Delay before Calib	default=13×25 ns