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THE HARP TOF-WALL ELECTRONICS AND TRIGGER LOGIC

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Abstract

In this note the HARP TOF-WALL electronic system is described. The TOF-WALL system adopted as a time digitizer the TDC CAEN V775, which was expressly designed and tested in collaboration with INFN TOF HARP groups. The measurements of TDC linearity, crosstalk and thermal drift, show a very good performance. Details of the behavior of re-designed discriminators and new-designed line receivers are also given. Finally, the TOF-WALL trigger logic is described, in particular the implementation of the local triggers foreseen specifically for the needs of the TOF-WALL.

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1 Introduction

Particle identification (PID) , especially the capability to distinguish pions from protons over the full solid angle, plays a key role in HARP experiment, whose aim is to measure the production cross section of pions, kaons and protons by the interaction of protons or pions beams in several target nuclei. The PID is based on dE/dx measurement in the central gaseous argon TPC for large angle tracks, while for tracks in the forward direction the combined response of time-of-flight (TOF) detector for momentum below 3.5 GeV/c and a threshold Cherenkov detector for momentum above 3.5 GeV/c is employed.

The time-of-flight in HARP is measured by the TOF-WALL, a set of 39 scintillation counters, arranged in three vertical walls, each consisting of 13 counters, placed at about 10 meters from the target, covering an overall area of 657×243 cm^2 . In the Left/Right walls, the scintillators are 250 cm long and lie vertically, while in the central wall the scintillators are 180 cm long and lie horizontally [1]. The TOF technique, using plastic scintillation counters, is a conventional method very powerful for particle identification. For a 10 m flight path, a TOF system with 250 ps time resolution over a large area is effective for 4σ pion/proton separation for particle momentum below 3.5 GeV/c.

To achieve the 250 ps goal, special care was dedicated to the design and actual realization of the HARP TOF-WALL electronics.

This report describes the design , test and performance of the main HARP TOF-WALL electronic elements. The electronic chain described in the memo is then completed by a trigger logic (see section 8) and a system of scalers used to monitor the single count rate of each photomultiplier.

2 HARP TOF-WALL electronics design

To achieve the 250 ps design resolution, each counter was realized by using:

1) a fast scintillator (Bicron BC-408 with emission peak at 430 nm) of length of 250 cm (lateral counters) and 180 cm (central counters) with an attenuation length of about 400 cm in order to maximize the photon collection (Fig. 1).

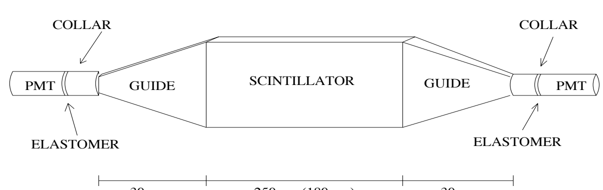

Figure 1: HARP TOF-WALL counter with readout at both ends.

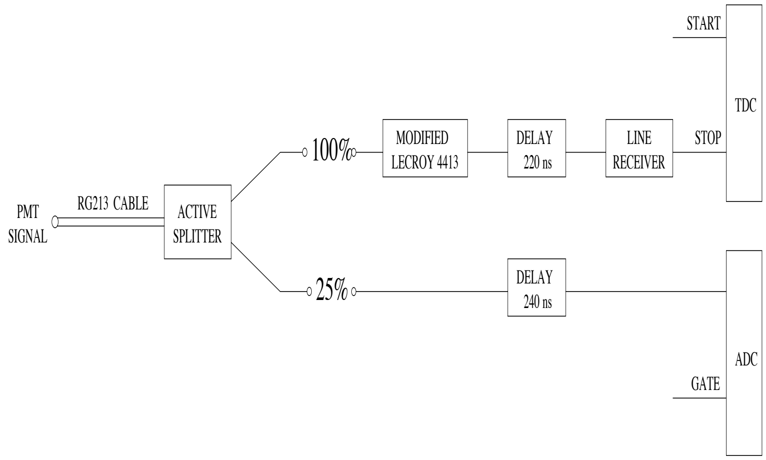

Figure 2: Block diagram showing the processing and conversion of PM signals.

2) a fast rise time ($\sim$ 2 ns) , low time jitter ($\sim$ 250 ps), large area photocatode phototube (2.55 inch Philips XP2020) with a quantum efficiency $\sim 26\%$ at 401 nm, that is well matched with the range of wavelengths emitted by BC-408 .

As far as the specific electronic system is concerned, with the above specifications, the following scheme (see the block diagram in Fig. 2) was adopted: the analog signal from PMs was fed, after a 40 m long RG-213 cable to an active splitter chain in the counting room, that divided the signal 25% to the ADC line and 100% to the TDC line, after a leading edge discriminator. The discriminator signal was first delayed by $\sim$ 220 ns using single high-quality cable, then regenerated by a fast discriminator and finally processed by the TDCs (model CAEN V775, 32 channels, $\sim$ 35 ps/ch). The second output of the splitter was sent to a charge-integrating ADC (model CAEN V792, 12 bit, 0.1 pC/ch) after being delayed by $\sim$ 240 ns.

The following strategies were adopted:

1) use of low time dispersion high quality cables (RG-213) to transmit the signal from the PM anode to the front end electronic system about 40 m far away.

2) use of an active splitter device in order to combine in an optimal way the leading edge time measurements (from TDC) with pulse-height informations for time-walk corrections (from ADC).

3) use of a modified version of leading-edge discriminator (LECROY 4413 , 16 input channels organized in 4 independent chips) in order to improve the slew of the discriminator output signal. Moreover appropriate cabling (Fig. 3) was adopted to reduce the crosstalk. (For details of crosstalk measurements see section 5.2 and 7.2)

. Each palisade of TOF-WALL was subdivided in 2 groups of 7 and 6 scintillator slabs (top panel in Fig. 3). Signal from PM coming from the same slab were fed to discriminator channels located in different chips (bottom panel in Fig. 3) in order to minimize the crosstalk. During data taking a pulser signal was injected in the test in input of each discriminator module to trace the time response of the electronic chain for all channels.

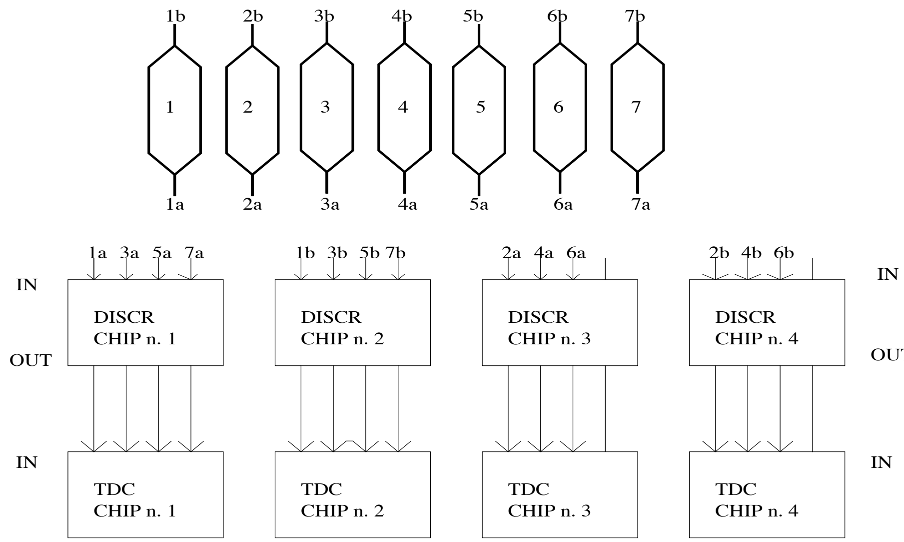

Figure 3: Cabling scheme. Each palisade is subdivided in 2 groups of 7 and 6 scintillator slabs (top panel). Signal from PM coming from the same slab are fed to discriminator channels located in different chips (bottom panel) to minimize the crosstalk. The 4 DISCR chips belong to the same discriminator LECROY 4413. The 4 TDC chips belong to the same TDC VME CAEN V775.

4) use of passive $\sim$ 220 ns delays with high quality cables, stored in thermostatic modules, in order to minimize the signal time variation due to thermal drift. (test measurements are presented in section 6). This delay is imposed by the delayed common start to the TDC coming from the trigger logic with respect to the individual stop signals coming from the phototubes.

5) use of a fast discriminator (Line Receiver) to regenerate $\sim$ 220 ns delayed signals before TDC time measurement (details are given in section 6.1).

6) use of TDC VME CAEN V775, with optimum performance as far as linearity, crosstalk and thermal drift is concerned (test measurements are presented in section 7).

In the following sections each item is analyzed in more detail. Guidelines for test measurements were taken from [2].

3 RG-213 cable choice

Fast timing of signals from the TOF-WALL system requires cables with low signal distortion in order to avoid the reduction of the slew rate of the signal entering the discriminator with consequent increase of the signal jitter. When the fastest possible rise time is required no compromise in quality has to be made and RG-213 cable rather than the usual RG-58 cable for fast NIM electronics was used in order to minimize skin effect and dielectric losses. RG-213 moreover offers a better stability of the propagation time as a function of the temperature with respect to RG-58. A time variation of 30 ppm/°C , due to thermal drift, has been measured on single channels for RG-213 cable while RG-58 cable gives ,for the same measurements , a time variation 95 ppm/°C . On the basis of these considerations RG-213 cables , 45 m long, were chosen to connect the PM anode in the experimental area to the active splitter, the first stage of front end electronics, located in the counting room.

4 Active splitter

In order to minimize the transit time spread in the photo-multipliers, H.V. values exceeding by 100-200 V the minimum required for the full efficiency of particle detection were chosen. As a result PM signals of few Volts amplitude were split by an asymmetric active splitter, 100 % of the amplitude going to the leading edge discriminator (LECROY 4413) and 25 % to the QDC line.

The input impedance of the active splitter was properly modified in order to match the impedance of the RG-213 cable , thus reducing signal reflections between the photomultiplier and the front end electronics (Fig. 4).

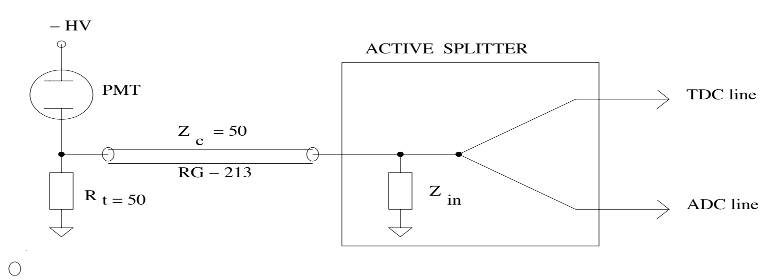

Figure 4: Active splitter impedance matching scheme.

5 Leading-edge Discriminator (LECROY 4413)

A leading-edge discriminator was chosen for the system. Off-line time walk corrections to leading-edge time were then applied.

5.1 Discriminator (LECROY 4413) modification

330 Ω pull-down resistors have been used instead of the factory installed 470 Ω. With this modification the slew of the discriminator output signal has been improved (Fig. 5).

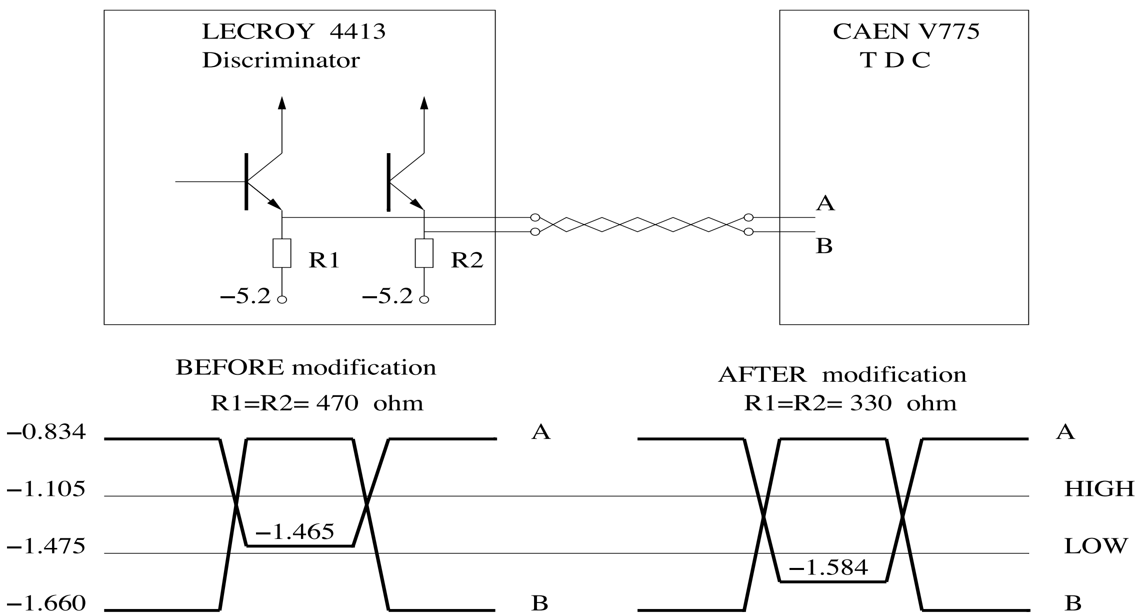

Figure 5: Discriminator signals before and after modification.

5.2 Discriminator (LECROY 4413) crosstalk

It is very important, designing an accurate TOF system with many channels, to avoid possible crosstalk between neighboring channels which could spoil the system resolution. Both the discriminator and the TDC were investigated as possible sources of such perturbations. The setup used to perform such a measurement is sketched in Fig. 6. It was

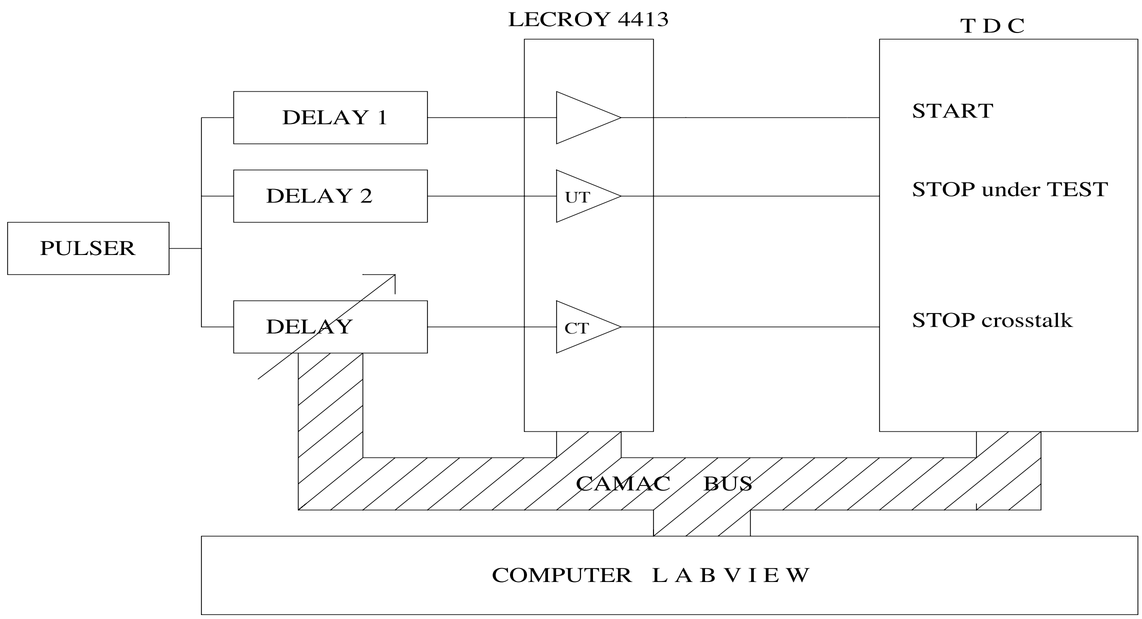

Figure 6: Setup scheme of crosstalk measurement.

conceptually similar for both discriminator and TDC tests. A pulser circuit provided, via the LECROY 4413 discriminator, the common start signal to the TDC (START). The same pulse simulated also two different input signals to the discriminator: the channel under test (UT) and the possible crosstalk generating channel (CT). Suitable delays shown in the picture allowed to fix the relative timing between UT and START: $\Delta T_{UT} = STOP_{UT} - START$. A variable programmable delay allowed also to change in 1 ns steps the relative timing of CT with respect to UT. With such a setup it was possible to study the perturbation of the firing time of UT channel induced by CT channel as a function of their relative timing. The range of the variable delay allowed to generate CT pulses starting from 10 ns before the START and 100 ns after it. Systematic measurements were taken over the full range of possible delays and for different combinations of the START, UT and CT channels on the discriminator. The conclusion was that the perturbation is strongly correlated to the internal structure of the discriminator. The LECROY 4413 holds 8 input channels processed by two equal integrated circuits (IC), one for channels 1 to 4 and the other for channels 5 to 8. A sizable interference effect could be measured only if the two channels were processed by the same IC. In this case perturbations of the order of 150 ps were observed on the channel under test and the effect was strongly dependent on the relative timing of UT and CT. The distortion was present when the leading edge of CT signal was within 5 ns of the leading edge either of UT (see Fig. 7 Right) or - with opposite sign - of the START signal [1] (see Fig. 7 Left). A typical example of the time shift of UT as a function of the delay of CT is shown in Fig. 8: the first distortion around 5 ns is due to START-CT overlap while the one around 55 ns is due to UT-CT overlap.

A temporal coincidence of the order of around 10 ns was expected between each pair of PM viewing the same counter and the crosstalk, were then processed by adjacent discriminator channels, could significantly worsen the time resolution. The simple scheme of cabling shown in Fig. 3 was exactly designed to minimize the crosstalk effect: the two PMs of the same counter and the PMs of adjacent counters - which due to geometrical overlap could be fired by the same particle - are branched to different chips. The residual crosstalk remains only in the case of PM signals arriving in the same discriminator chip within 5 ns and coming from different slabs located far away in the TOF-WALL. It is useful to stress that the scheme in Fig. 6 used to test the crosstalk due to the discrim-

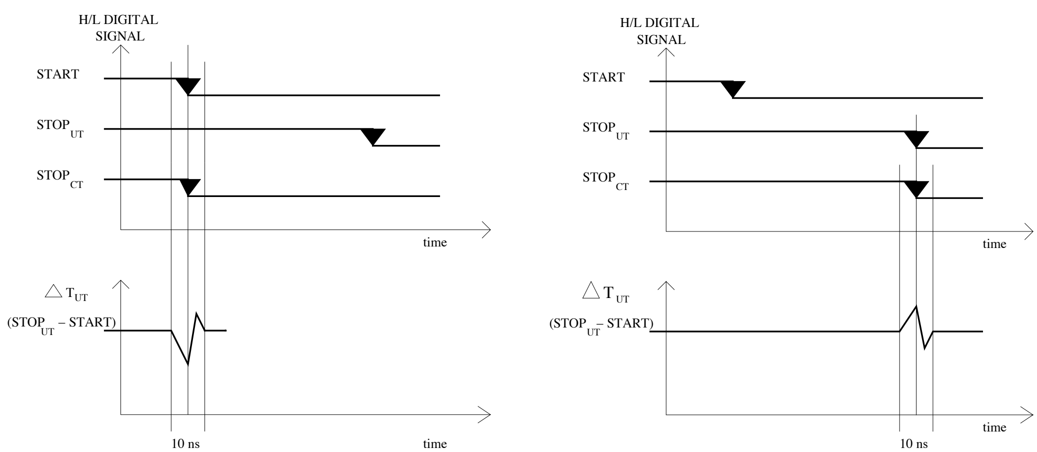

Figure 7: Left: a variation of $\Delta T_{UT} = STOP_{UT} - START$ is measured when a coincidence of the transitions $START \times STOP_{CT}$ is within 5 ns. Right: a variation of $\Delta T_{UT} = STOP_{UT} - START$ is measured when a coincidence of the transitions $STOP_{UT} \times STOP_{CT}$ is within 5 ns.

inator was also used (with appropriate cabling) to test the crosstalk due to the TDC itself

[1] Of course also the cross-talk with the START signal was observed only if it was in the same IC as the CT.

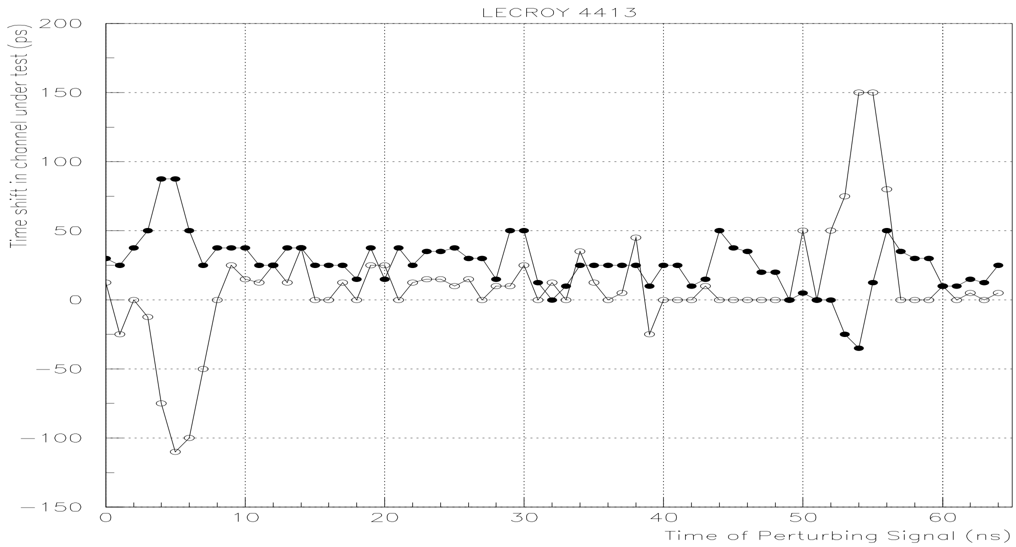

Figure 8: Discriminator LECROY 4413 crosstalk time measurement: the time shift in channel under test (UT) is plotted as a function of the time of two adjacent discriminator firing channels (CT) which generate the crosstalk and which belong to the same chip. Black dots refer to adjacent firing channel 1 and white dots to adjacent firing channel 2.

(see section 7.2). In the case of discriminator-crosstalk study , while the discriminator channels belong to the same chip , the TDC stop signals refer to remote TDC channels and therefore do not perturb the measurement.

6 Passive Delay choice

The signals to the TDCs and ADCs are delayed by approximately 220 ns to allow time for the trigger logic decision to be made. The requirements for the delay were:

- Crosstalk below 1 LSB[2] ($\leq 37\,ps$).
- Integral time variation on a single channel due to thermal drift below 1 LSB, that is 80 ppm.
- Max rate of $300\,kHz$.

Only passive cable delays could satisfy all these requirements. A couple of single twisted shielded cables were used for each channel, with propagation time of 5.1 ns/m and 90 Ω impedance. The cables were housed, in groups of 16, in thermally insulated boxes

[2]Least Significant Bit.

obtaining an integral time variation of 185 ppm/°C , on a single channel. Therefore a maximum temperature excursion of 1/2 °C was required to the electronics in order to have the desired time stability. With this control of the temperature, differential time variation due to thermal drift, i.e. the difference of time measurement between two delay channels, was measured to be below our sensitivity .

6.1 Passive Delay : line receiver

The presence of a passive delay with its intrinsic signal distortion forced to design and realize a second fast discriminator (VME Line Receiver) with the aim to reshape the pulse restoring a sharp leading edge of the signal at the input to the TDC CAEN V775. Schematically the Line Receiver is composed by two elements :

- the input network which has to match the impedance of the delay twisted cable ;
- the integrated circuit (comparator AD966685) which acts as fast discriminator .

The final scheme (Fig. 9) consisted of the following three parts:

1. Impedance match of the cable (90 Ω) and small impedance in common mode. This last characteristic decreased by a factor $\sim$ 26 the common mode signal, generated by the unavoidable couplings of the parasitic capacitors. Since the rejection of the following comparator AD966685 is small, it was imperative to limit the input common noise, for the crosstalk issues.
2. RC filter , to cut signals below 12 MHz of frequency.
3. Integrated circuit "Ultrafast Comparator AD96685 Analog Devices'. The discriminator threshold, one of the critical items in term of stability, have been locally generated trough stabilized reference voltages.

7 TDC CAEN V775

The TOF-WALL system adopted as a time digitizer the TDC CAEN V775, which was expressly designed and tested in collaboration with INFN TOF HARP groups. It is a VME module operating in common start mode, i.e. a common start signal arriving at least 14 ns (enable time) before the individual stops would yield a valid time measurement. Its measured resolution is 37 ps/channel.
The performances of the TDC CAEN V775 were extensively tested. The following sections will present the results of the measurement of its linearity, of the crosstalk behavior and of the temperature dependence.

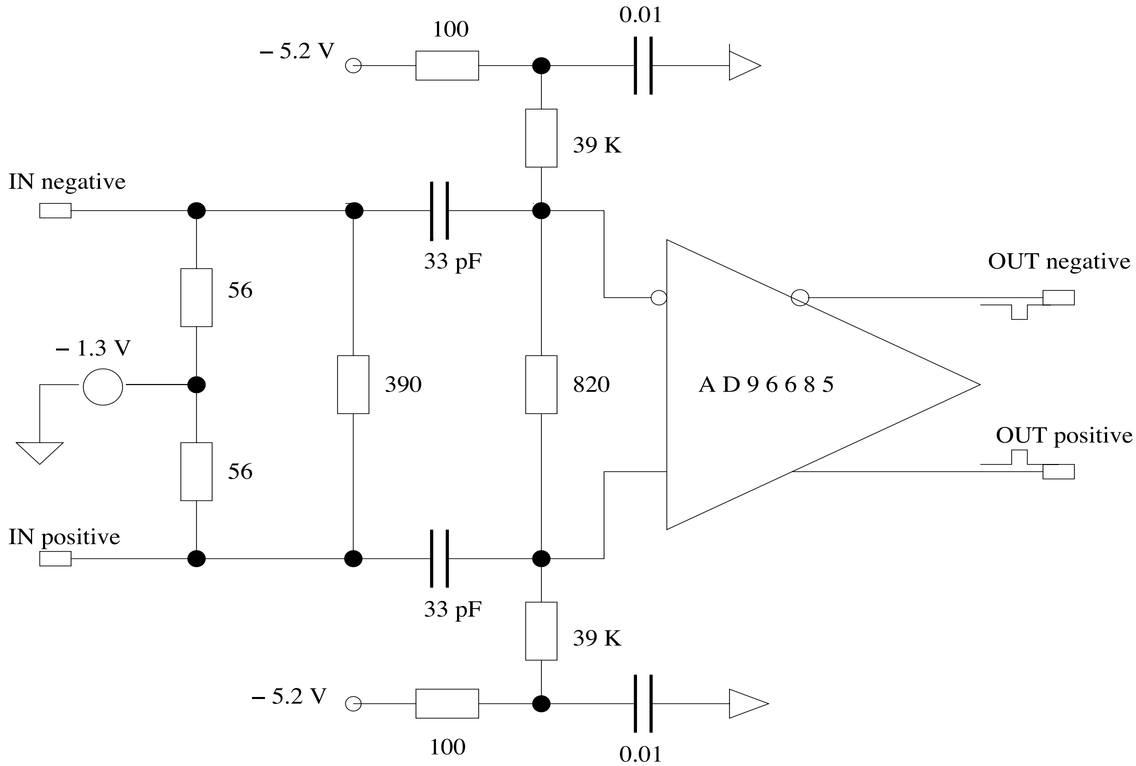

Figure 9: Line Receiver electronic circuit.

7.1 TDC Linearity

The linearity of the TDC has been measured using as a reference the time base system of the LECROY LT344 digital oscilloscope. The scope has a time accuracy of 10 ppm and a resolution in interpolation mode of 5 ps so that its global accuracy is about $4 \cdot 10^{-5}$ of the TDC range, much better than the TDC one (nominal LSB $\sim 35\,ps$). The setup used for this measurement is schematically shown in Fig. 10. A pulser circuit was used to trigger

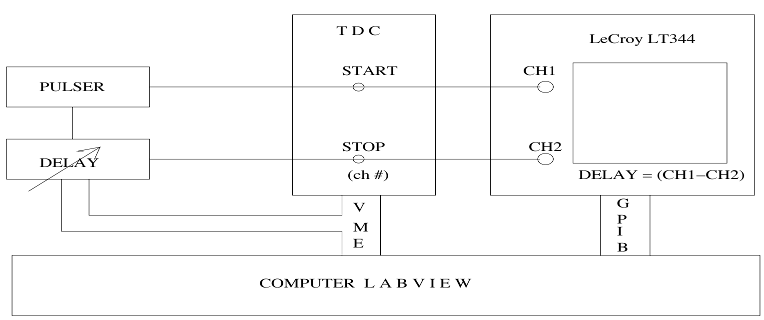

Figure 10: Setup scheme of TDC linearity measurement.

the system, to send a start signal to the TDC and, after a proper time delay Δt, a stop signal to a single TDC channel at a time. In each measurement we compare the "absolute time" , $\Delta t_{\mathrm{SCOPE}}$, as measured by a digital oscilloscope LECROY LT344, with the TDC time measurement Δt_{TDC}. The delay Δt was varied to cover - in 2 ns steps - the full dynamic range of the TDC and for each value of the delay the measurement was repeated 10 times. The linearity of the TDC could then measured by plotting the dependence of Δt_{TDC} from $\Delta t_{\mathrm{SCOPE}}$[3]. Δt_{TDC} was fitted as linear function of $\Delta t_{\mathrm{SCOPE}}$: Fig. 11 shows the deviations from a linear fit of the TDC output (average Δt_{TDC}) as a function of true input $\Delta t_{\mathrm{SCOPE}}$, for all the 32 channels of one TDC card.

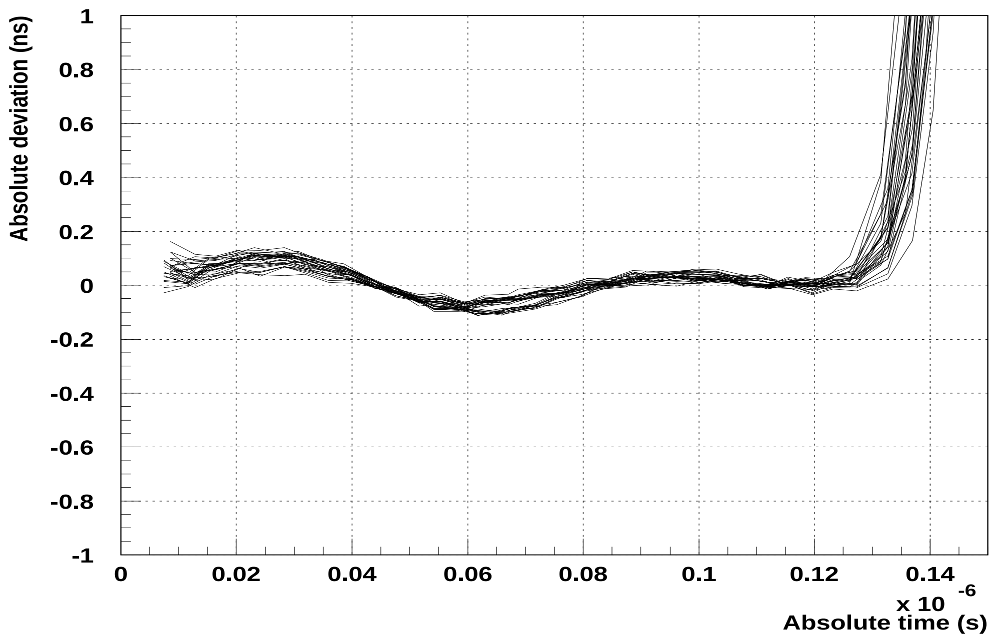

Figure 11: Absolute deviation (in ns) from a linear fit to the TDC measured delay (average Δt_{TDC}) as a function of $\Delta t_{\mathrm{SCOPE}}$, for all the 32 TDC CAEN V775 channels under test.

The measurement was repeated for all the three TDC used in the TOF-WALL. The calibration constants obtained for all the channels were compared to the ones measured with a different method [4] and found to agree to better than a few per mill.
The same measurements were repeated at the end of the experiment (1.5 years later) and found stable to better than a per mill [5].

[3]Of course Δt_{TDC} and $\Delta t_{\mathrm{SCOPE}}$ are the averages over the 10 measurements

[4]The measurement were done by C. Wiebush, as part of a campaign of calibration of all the TDC used in HARP.

[5]See D. Gibin presentation at the Harp General meeting on 9/12/2002

The integral non linearity (INL) is defined by the maximum absolute deviation between the true input $\Delta t_{\mathrm{SCOPE}}$ and the measured Δt_{TDC} referred to the Full Scale Range (FSR). The measured INL is within specifications ($\pm 0.1\%$ of FSR) for $10\,ns \leq \Delta t_{\mathrm{SCOPE}} \leq 135\,ns$.

7.2 TDC Crosstalk

The interchannel isolation of the time measurement, namely the dependence of any time measurement on the activity in other channels, was tested according to the setup scheme in Fig. 6. It was already noticed that the scheme used for the TDC-crosstalk study is the same (with appropriate cabling) employed for the discriminator-crosstalk study (see section 5.2). To separate the tdc contribution to crosstalk from the discriminator one, the signals were sent to distant channels of the discriminator and were not overlapped in time at the discriminator.

The measurement was in all respects similar to the one already described in section 5.2. Also in this case the distortion on the TDC conversion of the time $\Delta T_{UT} = STOP_{UT} - START$ was measured as a function of the delay of CT. A perturbation of ΔT_{UT} could be observed when the leading edge of $STOP_{CT}$ was within 5 ns of the $START$ or of the $STOP_{UT}$ signal as already shown in the similar case of Fig. 7.

The maximal deviation in the measurement of ΔT_{UT} represents the crosstalk of the TDC channel under test (UT) with respect to the CT input channel . A maximal crosstalk contained within 50 ps was observed for all the 32 channels (see a typical behavior in Fig. 12).

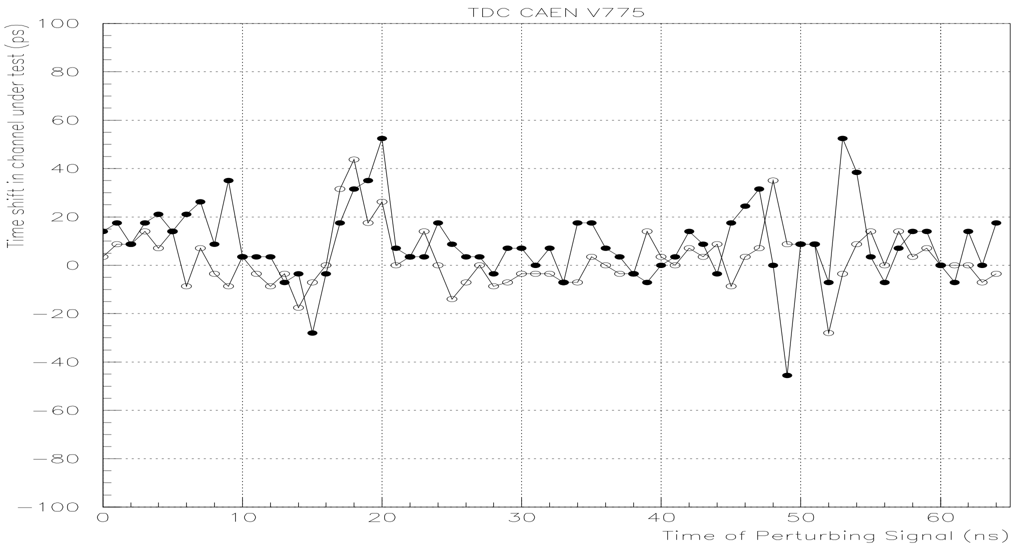

Figure 12: TDC CAEN V775 crosstalk time measurement: the time shift in channel under test (UT) is plotted as a function of the time of two adjacent TDC firing channels (CT) which generate the crosstalk and which belong to the same chip. Black dots refer to adjacent firing channel 1 and white dots to adjacent firing channel 2.

This crosstalk effect was always confined in groups of four TDC channels belonging to the same chip (1.2.3.4, 5.6.7.8, ..., 29.30.31.32) while is negligible for all the UT, CT combinations not confined within these groups. What we have measured is well within the module specifications (interchannel isolation = 57 db $\Rightarrow < 4$ counts). Moreover these shifts on the time measurement were minimized by appropriate cabling the TDC (Fig. 3), requiring that PM signals coming from the same slab are fed to TDC channels located in different chips. In such a way an unavoidable crosstalk remains only in the case of PM signals arriving in the same TDC chip within 5 ns and coming from different slabs located far away in the TOF-WALL.

7.3 Temperature Variation

The temperature variation of the time measurement, namely the dependence of any time measurement on the thermal drift of the electronics, was tested according to the setup scheme in Fig. 13.

A simple pulser circuit was employed to measure time variations in 2 adjacent TDC channels. If Δt_n is the time measurement by using TDC channel number n and $\Delta t_{(n+1)}$ that of adjacent TDC channel number $n+1$, it was possible to trace the response of these 2 channels while the electronics temperature was varied. The temperature was monitored

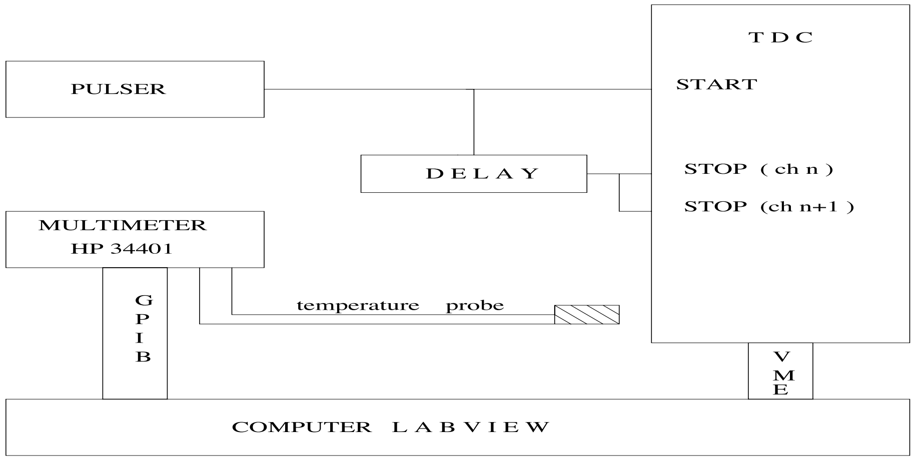

Figure 13: Setup scheme of TDC measurement allowing temperature variation.

by using a temperature probe, read by the multimeter HP 34401.
For a single channel, the slope of integral thermal drift of the TDC time was measured to be 1300 ppm/°C . For adjacent channels, the slope of the differential thermal drift $\delta \equiv \Delta t_n - \Delta t_{(n+1)}$ was measured to be 88 ppm/°C.
Therefore with a maximum temperature excursion of 1/2 °C, as required to the electronics in the experiment, the thermal drift for a single channel was expected to be of 13 ps, for a typical time delay of 20 ns. With this level of temperature control, the differential time variation due to thermal drift - i.e. the difference of time measurement between two channels - was expected to be below our sensitivity .

8 Implementation of the Trigger Logic

The TOF-WALL (TW) has been complemented with a trigger system permitting both global (i.e. driven by the central trigger of the Harp experiment [4]) and local triggers, to fulfill different tasks.
The implementation of the local logic was meant to permit:

- the collection of cosmic rays crossing the TW (to obtain a time alignment as described in [3]);
- the generation and collection of laser light shots into the counters (to monitor the time stability of the full system) [5];
- to pulse the discriminators (to test the full electronic chain downstream the discriminators and to monitor its time stability).

With the only exception of the local cosmic trigger, which was deliberately a standalone operation mode and by consequence mutually exclusive with respect to the global triggers [6], the architecture of the system allowed to arbitrarily mix in the same run any kind of trigger, keeping track of the source for offline analysis.
The following sections describe the different local trigger implementations.

8.1 Local cosmic trigger

The PM signals are used to produce a trigger based on pattern of hit counters to select cosmic ray crossing the TW.
Fig. 14 shows a cross section of the TOF-WALL together with the naming scheme of the

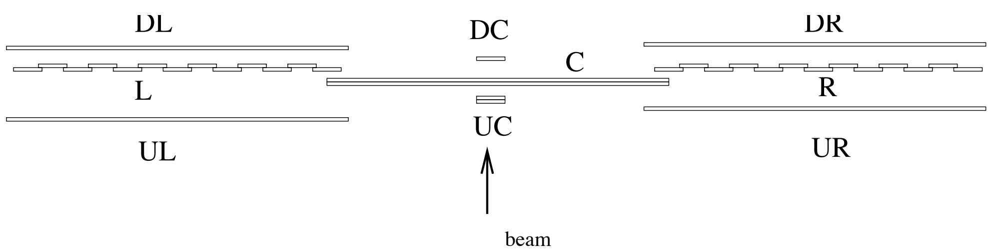

Figure 14: A cross section of the TOF-WALL showing also the adopted naming scheme. Also the ancillary upstream counters are shown.

different sections and counters.
Fig. 15 schematically shows the treatment of the PM signal of left and central TW sections for trigger purposes. The first step after the discriminators is the generation of the coincidence between the two PMs of each counter, to kill the random signals of each PM. This is accomplished by sending the discriminated PM signals [7] to a mean timer module [6] (MT) which generates at its output a coincidence between adjacent channels at their average time. Each MT card accepts 16 inputs and produces 8 individual mean time coincidences. The MT generates also the logical OR of its 8 outputs. In this way each palisade generated two MT OR signals (corresponding two 7 and 6 counters respectively). The input signals to the local cosmic trigger were produced by 6 MT cards - corresponding to the logical OR of groups of 7 or 6 counters of the Left, Center and Right palisades [8] - corresponding to the logical OR of groups of 7 or 6 counters of the Left, Center and Right palisades - plus an additional MT card making available the individual signals for

[6] This could be easily circumvented by disconnecting the so called standalone bit line - see below - but had no real interest since the physical configuration of the TW had to be changed with the addition of ancillary counters, possible only during prolonged shut down of the beam.

[7] Of course some reshuffling of the cables is needed to pair the corresponding signals.

[8] The 6 global OR from the these MTs were again put in OR to generate a signal of TW crossing which was used f.i. in the CAL sub-detector to build a cosmic trigger for calibration purposes.

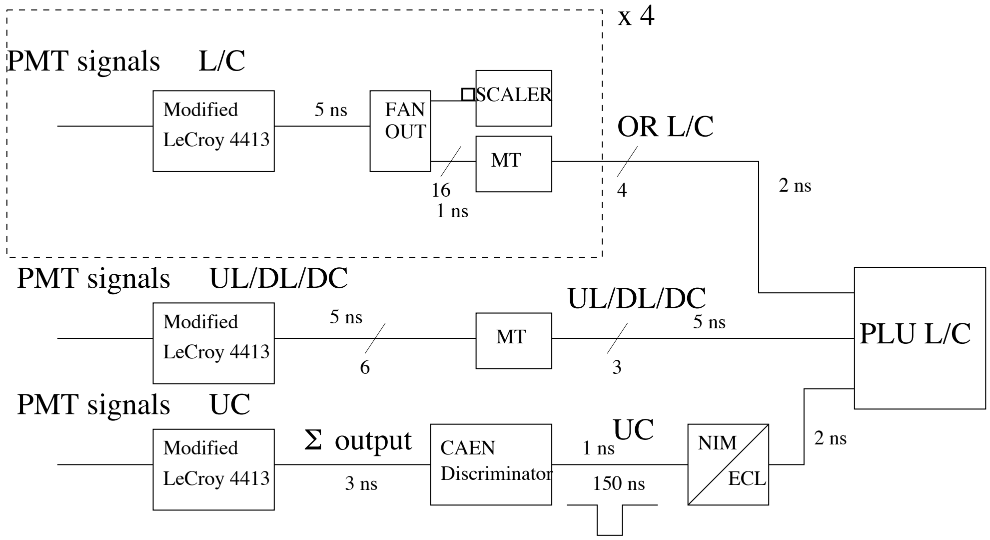

Figure 15: Sketch of the treatment of the PM signals in the Left and Central palisades to generate a local cosmic trigger.

the downstream (DL, DC, DR) and ancillary upstream (UL, UR) counters.
The upstream central signal UC was an array of 13 small scintillators seen by a single PM [3] so needed a special treatment, as sketched in Fig. 15. The OR of this array was obtained by discriminating at 1 single count the logical sum generated by the LECROY 4413 (see Fig. 15) [9].
For each section 4 signals are used for the trigger: the 2 OR of the palisade and the signals of the corresponding upstream and downstream counters. The coincidence of downstream and upstream counters was meant to define a good geometry [3], the palisade signals were foreseen to enforce the crossing condition and to allow a better rejection of showers.
The combination of the signals of the full wall was obtained by a cascade of three PLUs [10] (see Fig. 16): the Left/Center and the Right one are used as input to the Local Cosmic PLU. By appropriate reprogramming of the various PLUs it was possible to measure on the scaler the frequency of each individual signal contributing to this trigger.

The so formed local cosmic signal can be chosen as an alternative to the global cosmic signal to generate a trigger to the DAQ as shown in Fig. 17. The selection of which one of the signal has to trigger is done based on the standalone (SA) bit, set by DAQ at the beginning of the run.

[9] To identify off-line which counter of the UC array was firing the discriminator output was sent to the pattern unit input of the CIRQ module [7].

[10] CAEN CAMAC Programmable Logic Unit mod. B

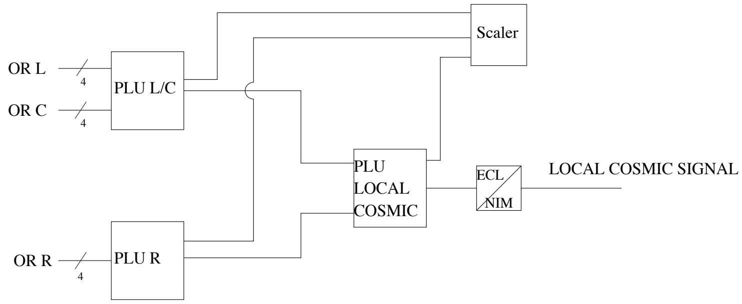

Figure 16: The cascade of the PLU generating the signal of a cosmic crossing the Up-stream Downstream counters and possibly also the TW.

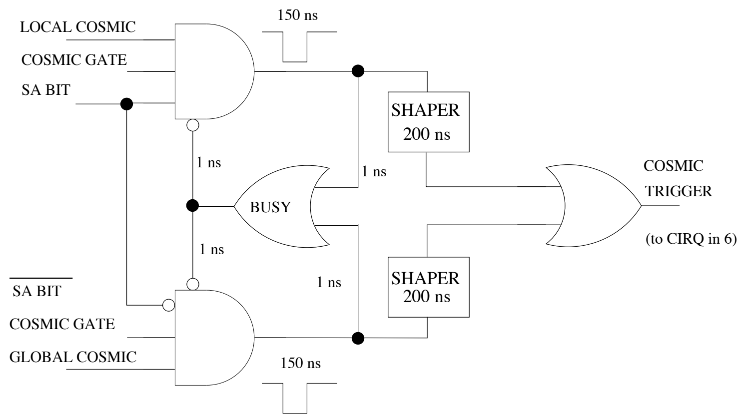

Figure 17: The logic implemented to generate the Cosmic Trigger and selection of local vs global cosmic signal.

8.2 Laser Trigger

The laser trigger was meant to produce a laser light shot to the counters and then to trigger the conversion of the signal and the DAQ. During the stable operation the laser worked in slave mode, i.e. it was triggered by an external signal. This was obtained by the system shown in Fig. 18 a).

The same signal pulsing the laser could not be used directly as a trigger due to shot to shot fluctuation in the time of response of the laser. The trigger was instead produced by the signal of a fast photo-diode (PHD) [5] detecting the light pulse and processed like shown in Fig. 18 b) [11].

[11] During the first phase of set-up the laser was taken with special standalone runs but after-wards the SA bit was deselected in the coincidence of Fig. 18 b) and the laser trigger was simply mixed with the physics triggers, without any waste of beam time

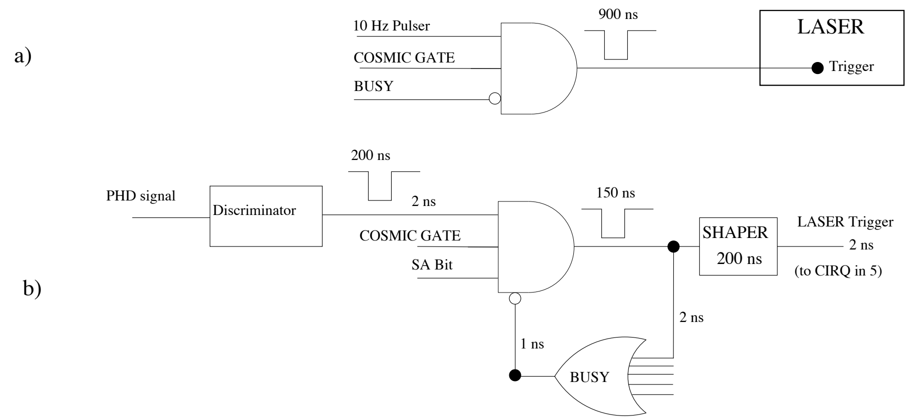

Figure 18: The generation of the laser pulse a) and the logic to produce a laser trigger b).

8.3 Pedestal Trigger

The pedestal trigger was used with a twofold purpose: to monitor the stability of the ADC pedestals and to monitor the time stability of the electronic downstream of the discriminator. Its logic is shown in Fig. 19. The request to be inside or not the cosmic gate could

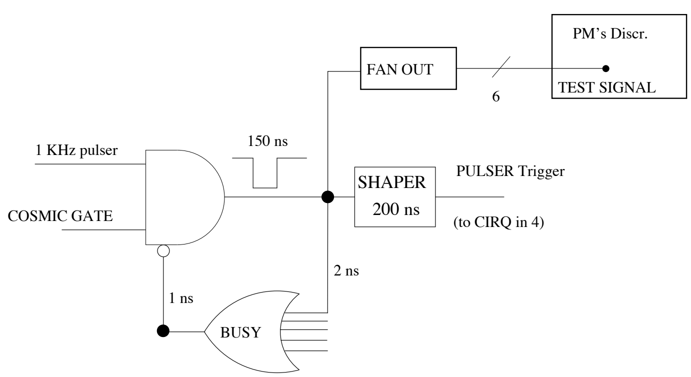

Figure 19: The generation of the pedestal trigger.

be hand (de)selected: no difference was observed for pulser in beam or in cosmic gate. The trigger to CIRQ was delayed so that the TDC were firing at about half their range. The modularity of the eventual time shifts could be used to trace the source of the shifts themselves: fan out and/or trigger logic shift (all the channels), TDC start signal shift (32 channels), single discriminator test pulse shift (16 channels), single channel.
By appropriately programming the CIRQ it was possible to accept or not this source of trigger: typically after the first 200 pedestals the trigger was masked away.

8.4 The Logic common to all triggers

The busy is built out of all the triggers (as they come up) and of the general busy of the CIRQ [7] as sketched in Fig. 20. All of the triggers go to their corresponding line in

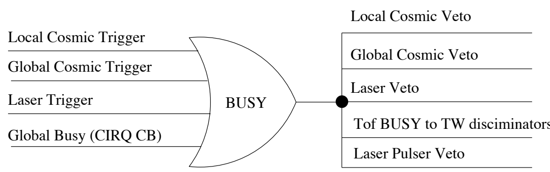

Figure 20: The generation of the busy signal.

CIRQ. The trigger OR as provided by the CIRQ is then used to generate the gate to ADC and the start to TDC as shown in Fig. 21.

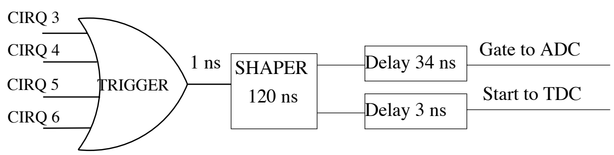

Figure 21: The generation of the gates to ADC and TDC.

References

[1] G. Barichello *et al.*, *”The HARP TOF-WALL counter construction and test”*, HARP note 02-001 , June 27, 2002 . INFN/AE-02-01 , 28 giugno 2002 .

[2] E. S. Smith *et al.*, Nucl. Instrum. Meth. A **432** (1999) 265.

[3] F. Bobisut *et al.*: *“The Harp Tof Wall performance and time calibration”*, INFN/BE-02/003 and HARP Note 02-007;

[4] See the J. Panman’s presentations in the trigger page http://harp.web.cern.ch/harp/Classified/Sub_detectors/Trigger/talks/talks.html ;

[5] M. Bonesini *et al.*: *“Construction of a Fast Laser-based Calibration System for the HARP Tof counters Wall ”*, INFN/AE-02/02 and HARP Note 02-004 ;

[6] A. Cavestro *et al.*: *“An analog mean-timer for long scintillation counters”*, Nucl. Instr. and Meth. A305, N. 2, 488 (1991);

[7] F. Bal, VME/VSB Interrupt Request Module, V-451 CIRQ, CERN-ECP/EDA (1992).