Electronic tests of the barrel presampler mother boards

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ATLAS Note : ATL-LARG-98-103

EDMS # : ATL-AB-EN-0008

January 98

ELECTRONIC TESTS OF THE BARREL PRESAMPLER MOTHER BOARDS

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1 Introduction

The barrel e.m. presampler will be composed of 64 identical azimuthal sectors each of them consisting of 8 modules of different types. This requires 8 different mother boards (MBs) which are described in details in reference [1]. The functions of the mother boards are : 1) to collect the electronic signals from the presampler, 2) to distribute the calibration pulses, 3) to distribute the high voltage. They are 5-layered printed circuits (35 μm, class 4), with an overall thickness of $2.3^{+0}_{-0.2}$ mm, (each of the 5 FR4 layers being about 0.4 mm thick). The trace width (in the signal and injection layers) is 320 $\pm$ 30 μm in order to obtain an impedance close to 50 Ω. These signal and injection layers are separated by ground planes in order to reduce cross talks. In this report only the MB of type 3 (see figure 1) will be considered since this is the only one which was fully tested yet. It is 169 mm wide and 321 mm long. Except the geometrical aspects (sizes, length of the traces, etc...), the designs of all the MBs are essentially alike.

1.1 Calibration

A test pulse system is implemented on the MBs to be used as diagnostic and calibration means. For this purpose, accurate surface mounted resistors (0.1 %), with temperature coefficient 25 ppm/°C between -55°C and +125°C, are used. The value of some of these resistors has been measured at room temperature and at liquid nitrogen temperature (77 K) by means of a Hewlett Packard 4285A precision LCR meter working in that case at a frequency of 80 kHz. The results are reported in table 1.

Table 1: Resistor measurements at room temperature and at 77 K.

Nominal value of the resistors	# of tested resistors	Mean value at room temperature	$\frac{RMS}{\bar{R}}$ (%) at room temperature	Mean value at 77 K	$\frac{RMS}{\bar{R}}$ at 77 K in (%)	$\frac{\bar{R}_{77}-\bar{R}_{293}}{\bar{R}_{293}}$ in (%)
2 kΩ	100	1999.9 Ω	0.02	2006.1 Ω	0.08	0.31
51.1 Ω	99	51.11 Ω	0.016	51.27 Ω	0.06	0.32
44.2 Ω	98	44.26 Ω	0.11	44.87 Ω	0.54	1.38
41.2 Ω	101	41.27 Ω	0.11	42.17 Ω	0.66	2.18

The schematic diagram of the injection system on the mother boards is shown on figure 2. The 2 kΩ resistors are soldered as close as possible to the detection cell connection points in order to reduce parasitic capacitances.

2 Tests and results of the MB of type 3

The tests are achieved by injecting in the MB test pulses from a generator. The output signals are analysed with a numeric oscilloscope, (see figure 3). Capacitors of 377 pF were

soldered on the MB in order to simulate the detection cell capacitances of the presampler modules.

2.1 Response to a step pulse

The calibration signal is a step pulse with a leading edge rise time (10-90%) of 7.1 ns. The worst output signal directly observed with the oscilloscope at room temperature is shown in figure 4 (curve # 2). The exponential constant time of the signal response is τ=20 ns with an asymptotic value for the measured current of 92 μA. These two values can be compared to the predicted ones which are τ=19 ns for the exponential constant time and 93 μA for the current. In order to observe the cross talk effect (probably between the injection and the signal traces), the injection resistor of 2 kΩ of the corresponding channel was disconnected. One can check that the new signal (curve # 3) perfectly matches the small oscillation observed at the beginning of the previous response. Figure 5 shows the response for another channel among the 16 ones available on the MB. The cross talk effect is then quite small.

2.2 Response to an exponential pulse

The calibration signal is an exponential pulse with a leading edge rise time (10-90%) of 1.5 ns, and the exponential constant time is very close to 400 ns. The signal coming from the MB is amplified and then goes through a CR-RC^2 shaper with a shaping time of 15 ns. It is finally recorded by means of a digital oscilloscope. The worst output signal at room temperature, with and without the injection resistor of 2 kΩ, is shown in figure 6 (curves # 2 and 3). The maximun amplitude of the signal response is slightly reduced by the cross talk effect. Figure 7 shows the response for another channel (not the best one). One can check that the cross talk level is really quite small.

The maximum amplitude for each channel at room temperature and at liquid nitrogen temperature (77 K) is reported in figure 8. Figure 9 gives the dispersion of the maximum amplitude for both temperatures. This dispersion is of the order of 0.5 %.

3 Cross talk between AXON' cables

Calibration and signal pulses are carried out by means of small diameter (~1.1 mm) 50 Ω coaxial AXON' cables[1] soldered on the mother boards. One can notice (see figure 2) that the injected current in each detection cell is small compared to the one circulating in the calibration cable, ($i_{injected} \simeq i_{calibration\ cable}/659$). The experimental setup used to measure the cross talk between these cables is shown in figure 10. This setup is close to what will be used in the ATLAS detector, (i.e. amplification + CR-RC^2 filter with a shaping time of 25 ns). The MB is connected to the Faraday cage by a large ground bus in order to simulate the existence of all the electrical connections between MBs and the ATLAS cryostat, (shielding ot the AXON' cables). Our results are reported in figure 11 : an exponential pulse with an amplitude of 238 mV, a leading edge rise time (10-90%) of 1.6 ns and a constant

[1] AXON' CABLE S.A., Route de Chalons-en-Champagne, 51210 Montmirail FRANCE

time equal to 370 ns, is injected in the MB (curve # 1). The output signal (curve # 2) has an amplitude of 664 mV and a rise time (10-90%) of 37 ns. Then, in order to measure the cross talk between the calibration cable and the output cables, the exponential pulse is injected in a cable loaded with a 50 Ω resistor soldered on the MB. This new cable and the output signal cable are parallel to each other over a length of 2.2 m, their separation being 0 cm (curve # 3) and 5 cm (curves # 4 and 5, in this latter case the MB was not connected to the Faraday cage with the ground wire). Curve #6 shows the response when no pulse is injected. Curves # 3, 4, 5 and 6 are drawn with the same scale (5 mV/div). Table 2 gives the resulting cross talks for each curve. The calibration cross talk is obtained by dividing the maximum amplitude when a test pulse is injected in the cable loaded by the 50 Ω resistor (see figure 10) by the maximum amplitude when the same test pulse is sent through the mother board injection system. This measurement corresponds to the calibration signal distortion which will be really observed in the ATLAS detector. The cable-to-cable cross talk takes into account the fact that only a part of the initial current (16 channel/mother board to provide ; $R_{adaptation}/R_{injection}$ = 51 Ω/2 kΩ) is sent in the detection cell. The more realistic case, (curve # 4), leads to a calibration cross talk of about 0.2%, and a cable-to-cable cross talk of 3.10^{-6}. Table 3 shows the cross talks measured as a function of the separation between both cables when they are parallel to each other over a length of 1.8 m, and when the injected pulse has a leading edge rise time (10-90%) of 3 ns. The effect is of the order of one or several thousandths of the output signal, corresponding to a cable-to-cable cross talk of about a few ppm.

Table 2: Cross talk in different cases, see text.

Curve #	3	4	5	6
Calibration cross talk (%)	0.9	0.2	0.4	0.04
Cable-to-cable cross talk	$1.3\ 10^{-5}$	$3\ 10^{-6}$	$6\ 10^{-6}$	$6\ 10^{-7}$

Table 3: Cross talk for different space separations between cables, see text.

Distances (cm)	1.	2.	5.	10.
Calibration cross talk (%)	0.22	0.19	0.18	0.16
Cable-to-cable cross talk	$3.3\ 10^{-6}$	$2.9\ 10^{-6}$	$2.7\ 10^{-6}$	$2.4\ 10^{-6}$

4 Tests at CERN

A presampler module of type 3 and its corresponding MB have been tested at CERN at room temperature. Figure 12 shows the average output signal when exponential pulses, provided

by the standard calibration board with an amplitude of 381 mV, are injected in the MB, (the shaping time of the CR-RC^2 filter was equal to 13 ns). No significant pre-pulse (> 0.3 %) due to the cross talk between cables was observed. The standard deviation of the noise was equal to 3 mV, leading to an equivalent current input of 62 nA, in good agreement with what was expected.

References

[1] **Specification book for the mother boards and the cabling of the barrel e.m. presampler**
J.Y. Hostachy, J. Collot, D. Dzahini, P. Imbert, P. Perrodo
ATLAS Engineering Specification Note, ATL-AL-ISN-ES-8.0, June 97

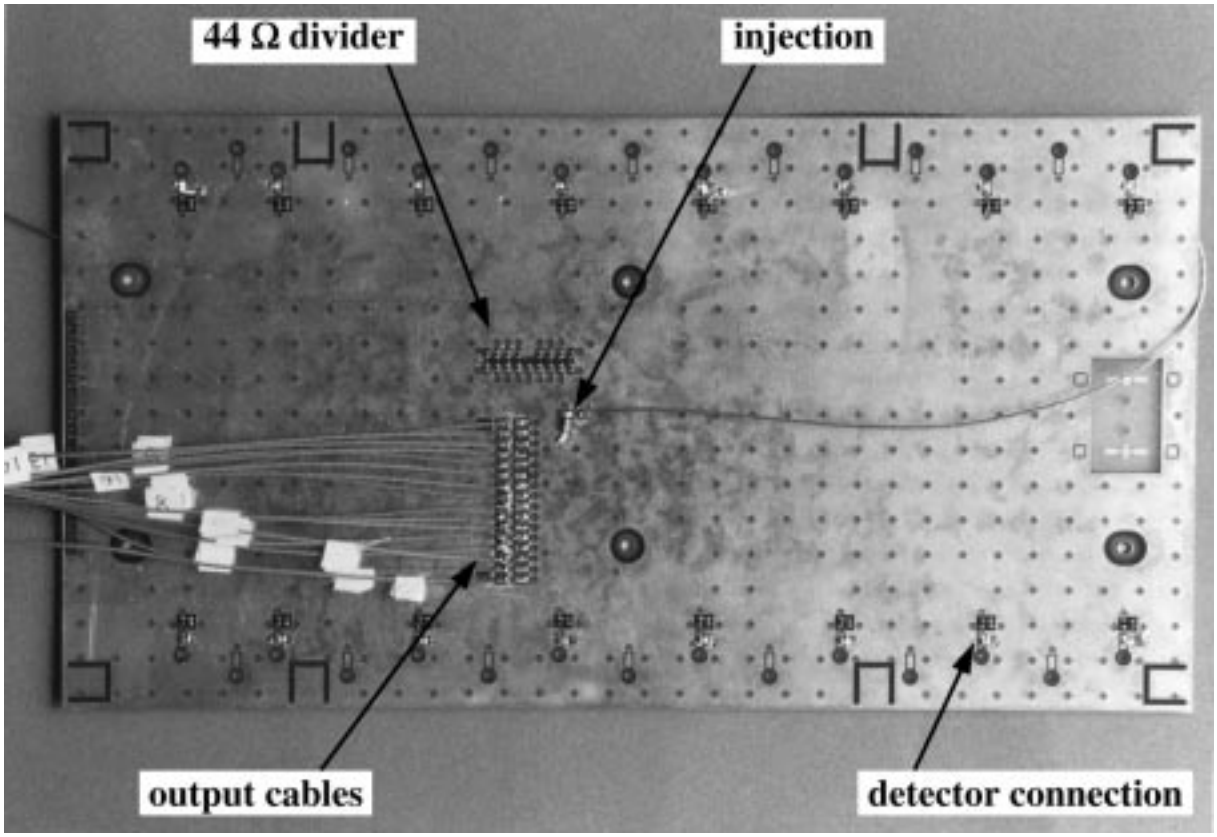

Figure 1: Mother board of type 3 with its cabling.

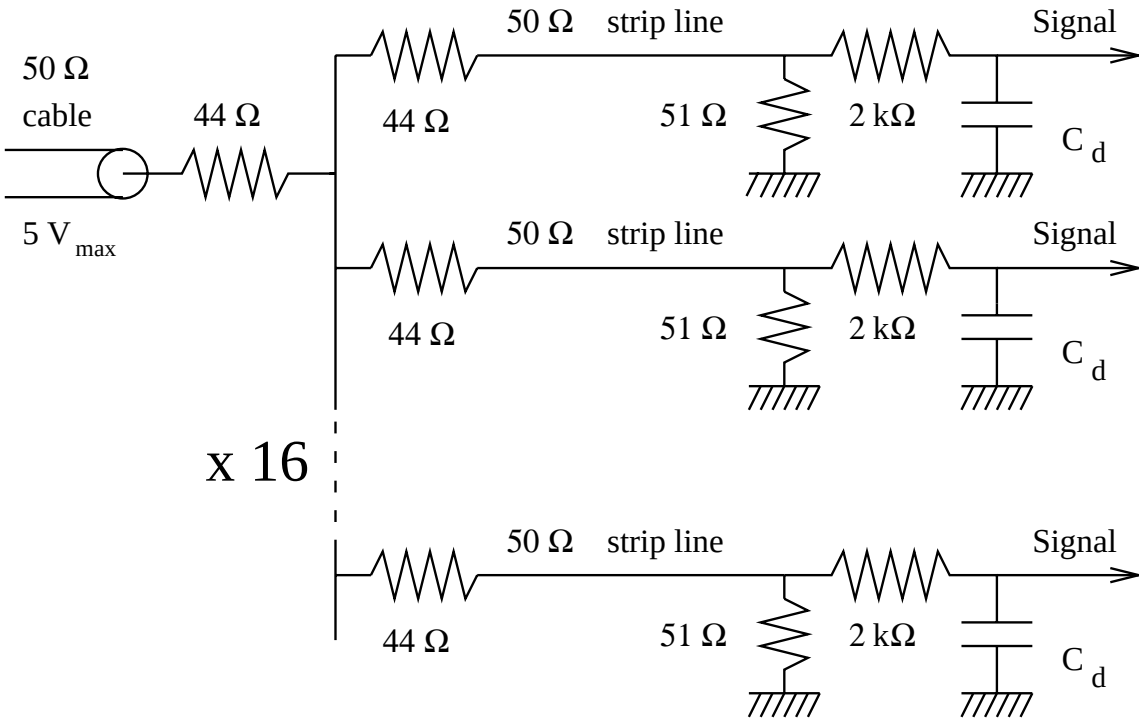

Figure 2: Schematic diagram of the test pulse injection system. (C_d represents the cell detection capacitance and therefore does not belong to the MB). As the total number of channels for MB of type 8 is only 10 (instead of 16), the 44 Ω resistors are replaced by 41 Ω resistors.

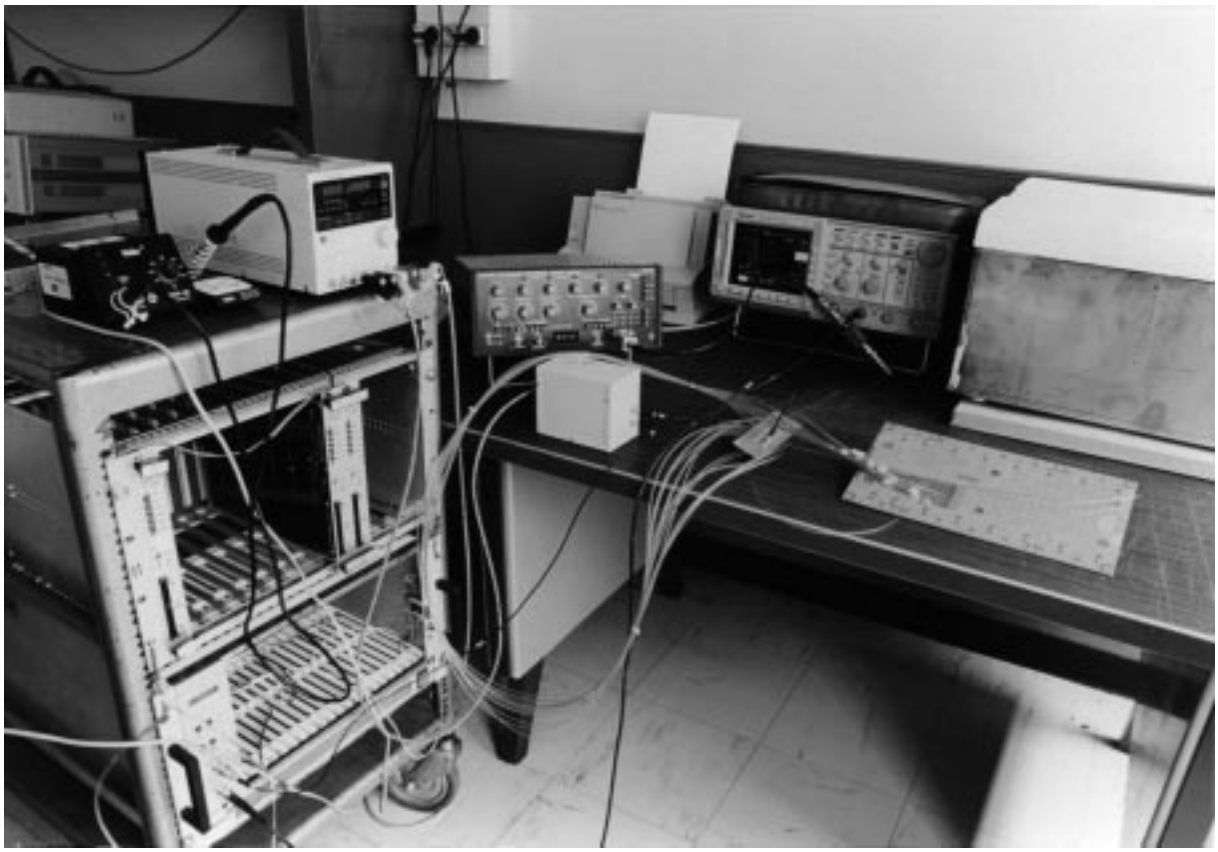

Figure 3: Photograph of the test bench. (The oscilloscope and the liquid nitrogen cryostat are beside the mother board).

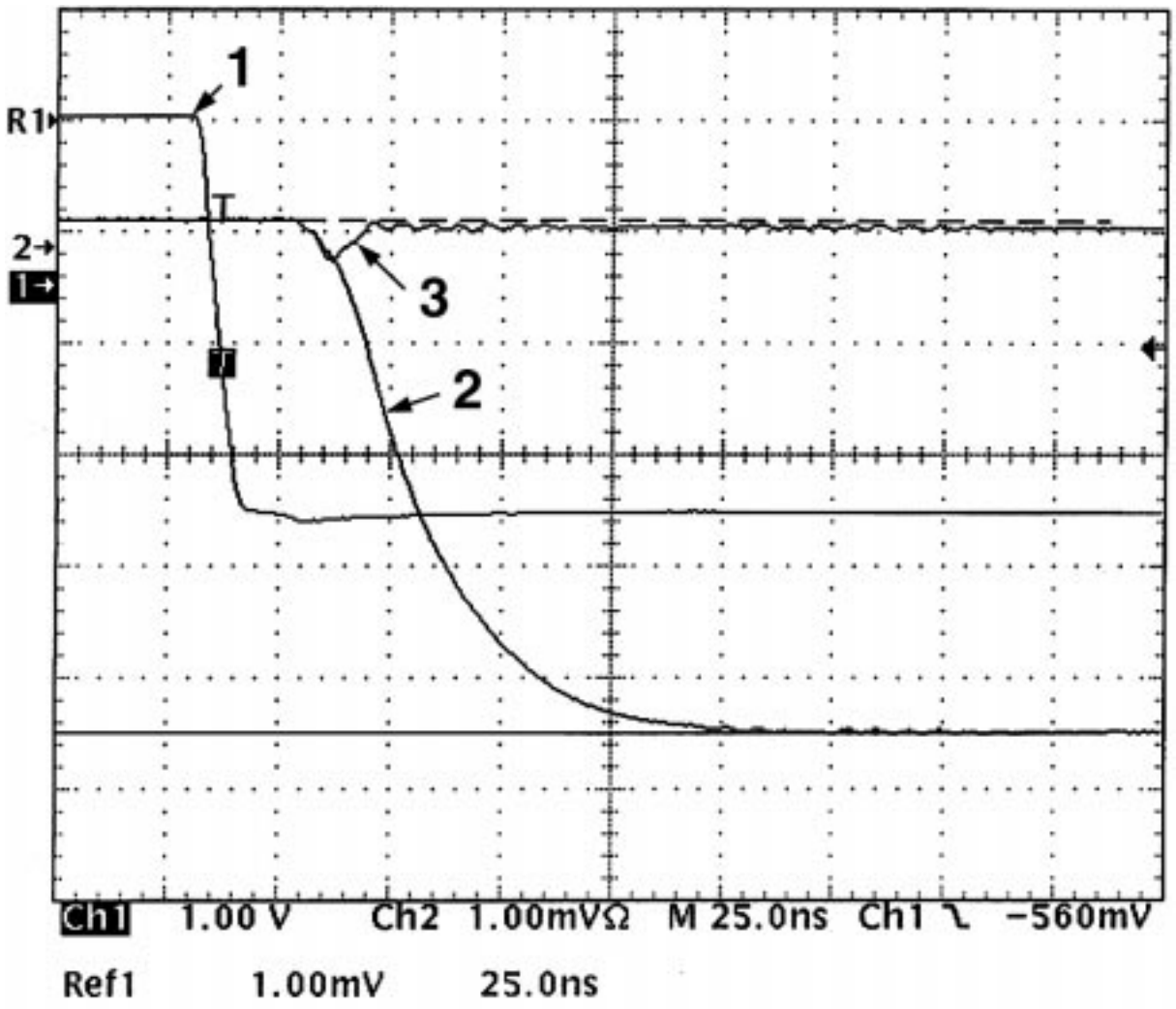

Figure 4: Response to a step pulse : worst signal. (Curve # 1 : injected pulse. Curve # 2 : signal. Curve # 3 : cross talk signal)

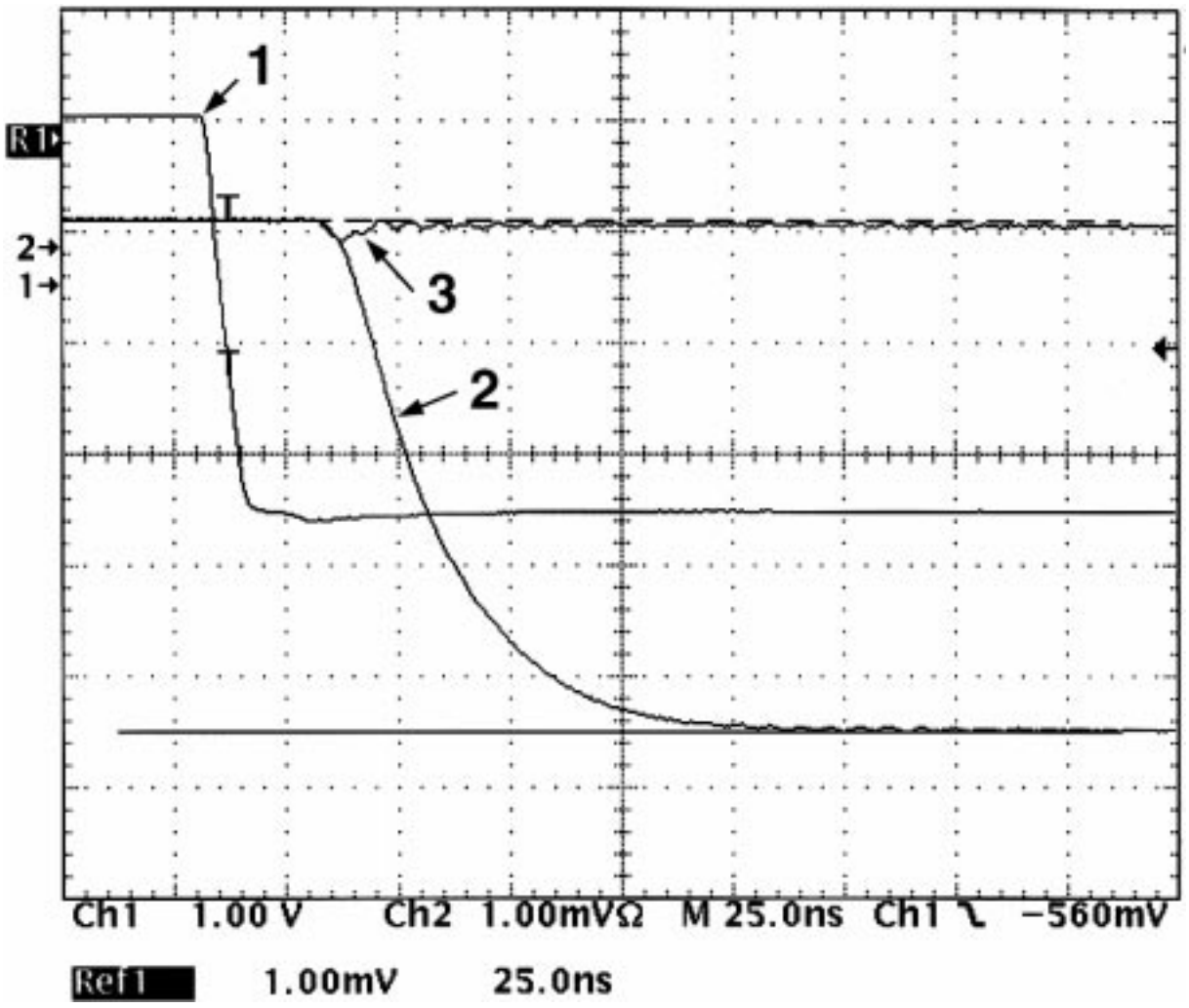

Figure 5: Response to a step pulse : another channel. (Curve # 1 : injected pulse. Curve # 2 : signal. Curve # 3 : cross talk signal)

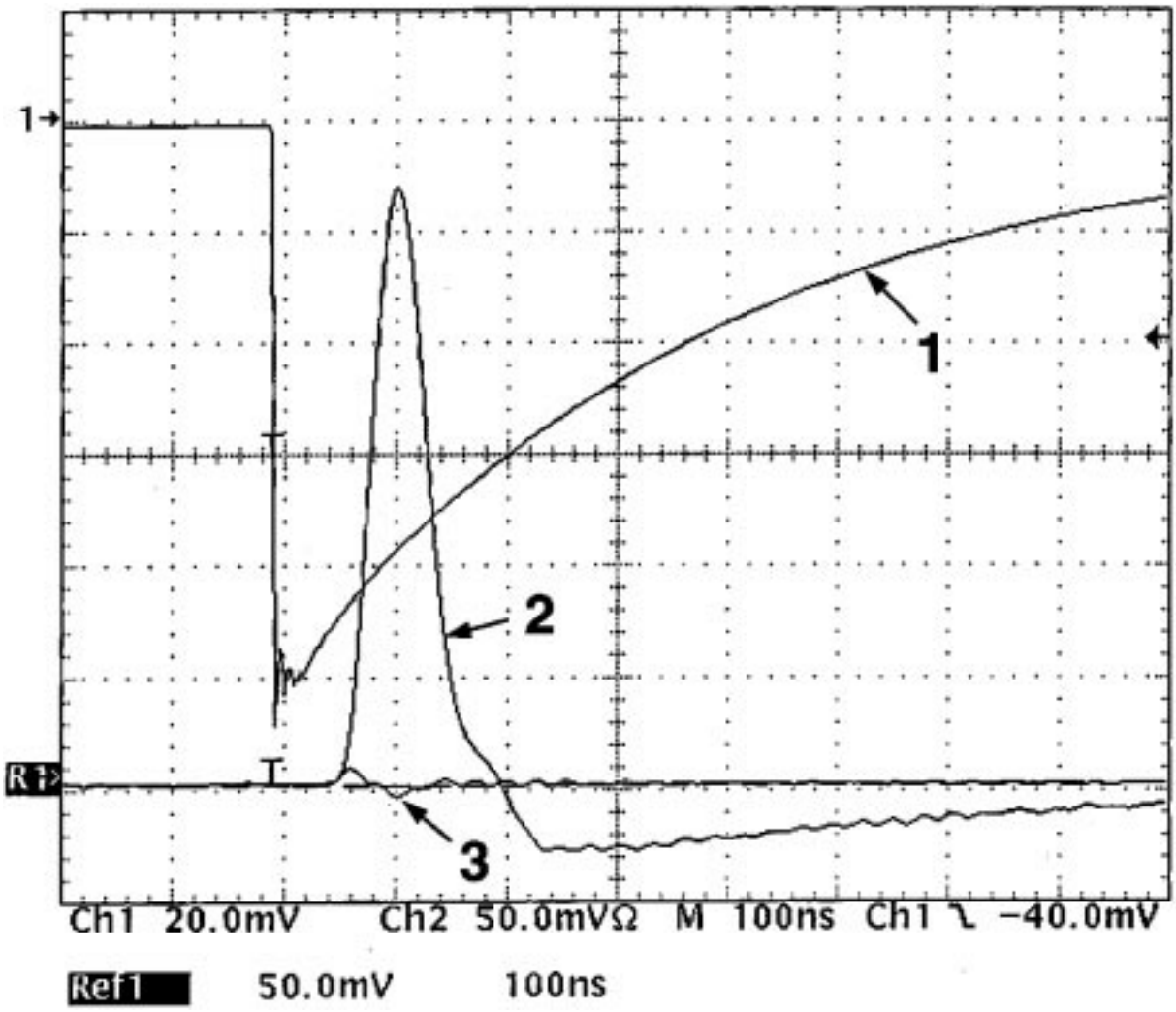

Figure 6: Response to an exponential pulse : worst signal. (Curve # 1 : injected pulse. Curve # 2 : signal. Curve # 3 : cross talk signal)

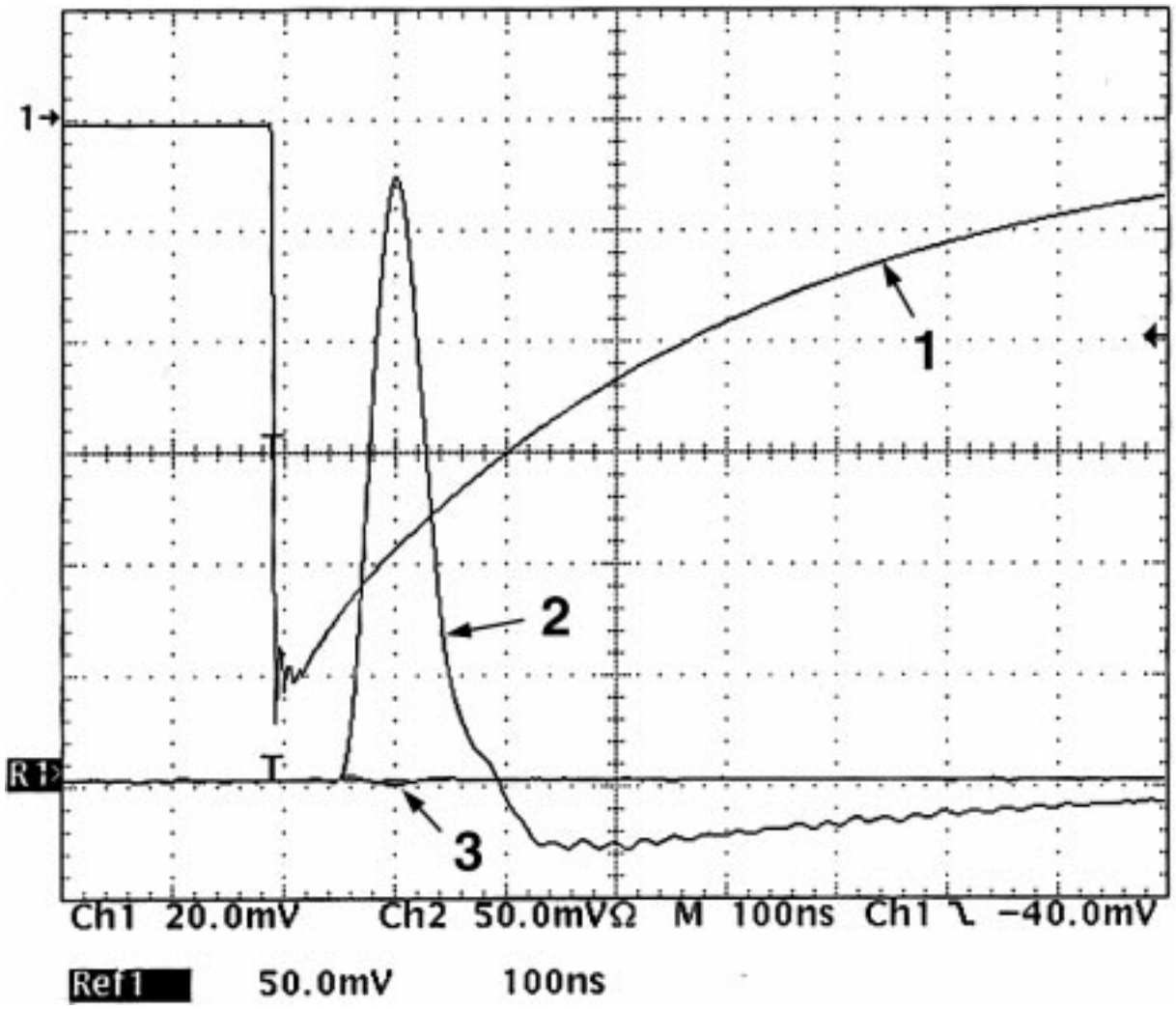

Figure 7: Response to an exponential pulse : another channel. (Curve # 1 : injected pulse. Curve # 2 : signal. Curve # 3 : cross talk signal)

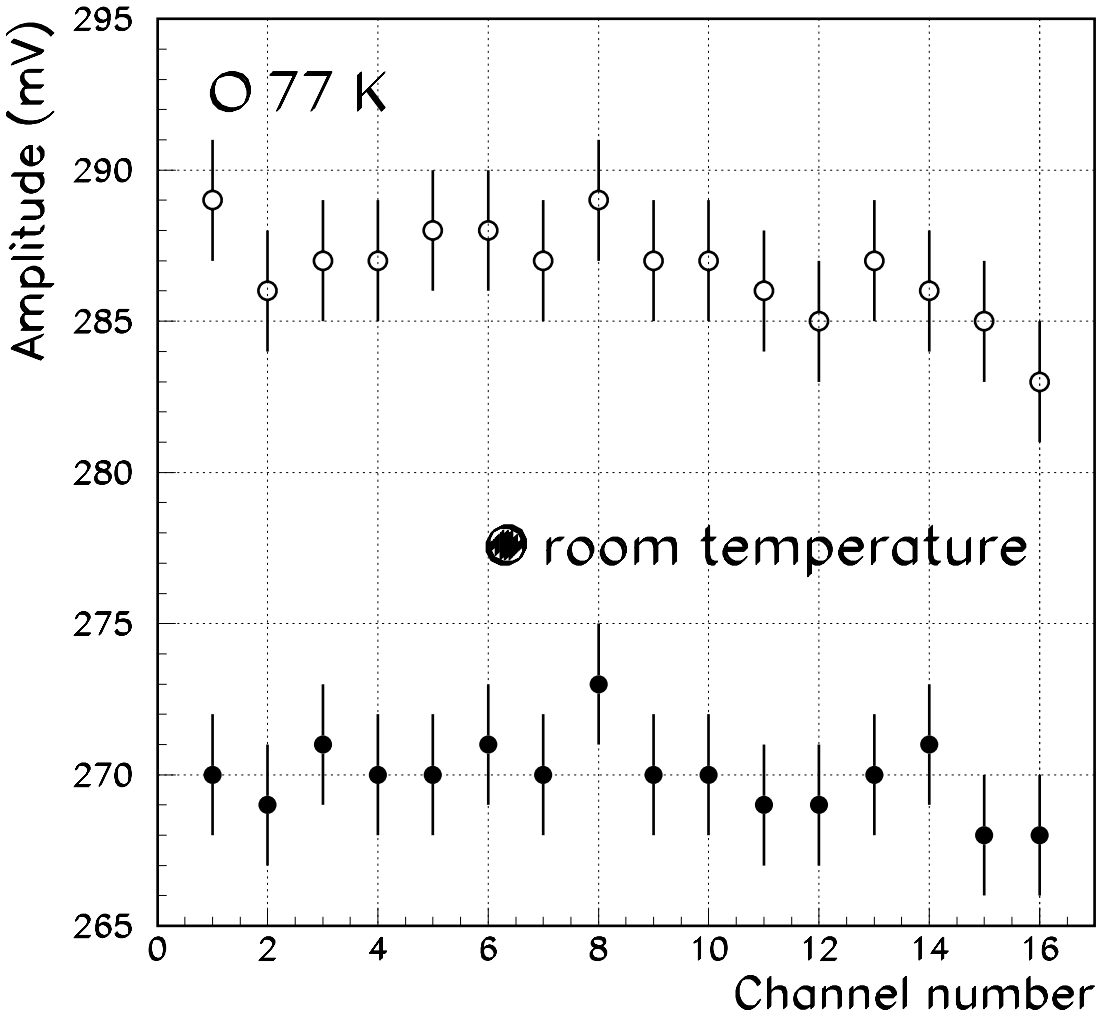

Figure 8: Maximum amplitude of each channel for the mother boards of type 3 at room temperature and at 77 K.

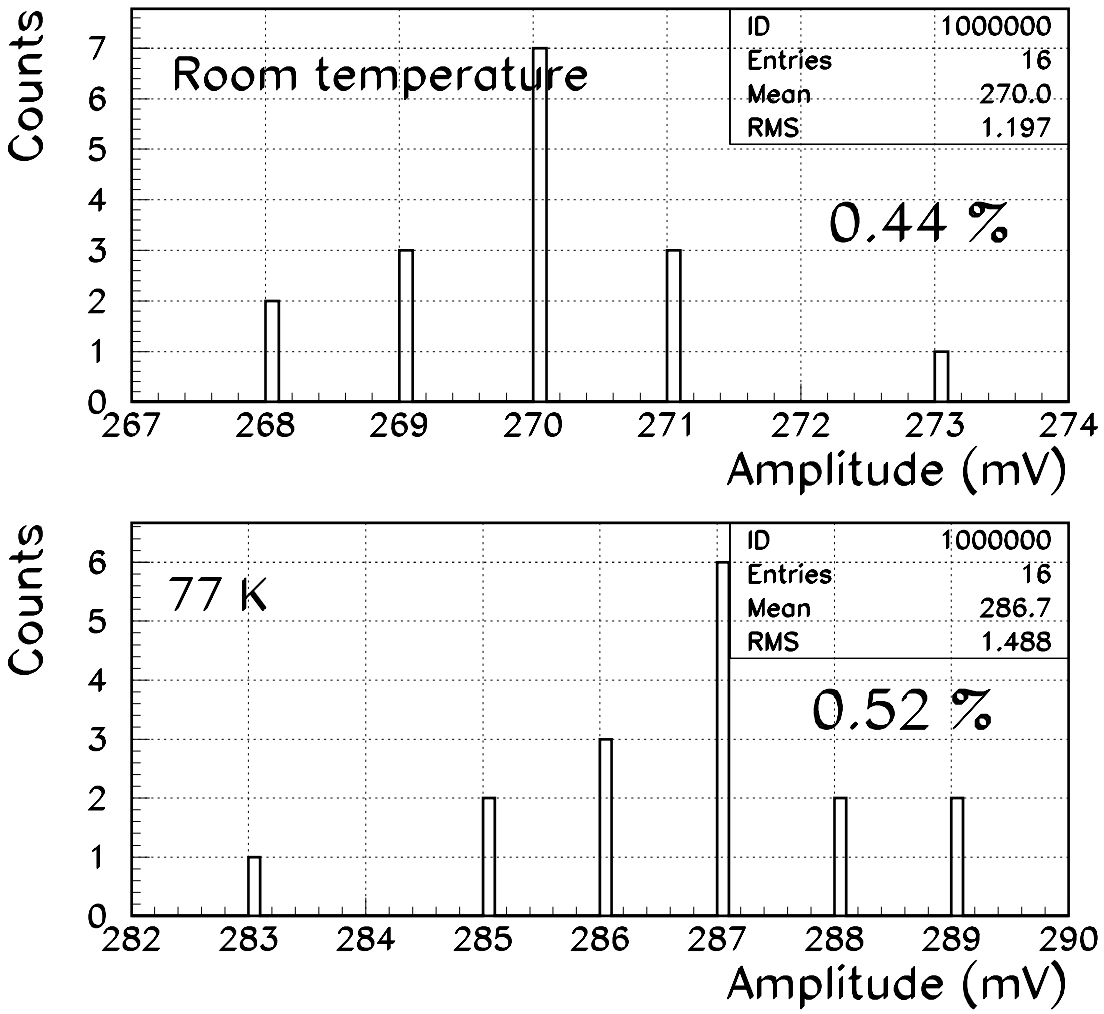

Figure 9: Dispersion of the response of each channel for the mother boards of type 3 at room temperature and at 77 K.

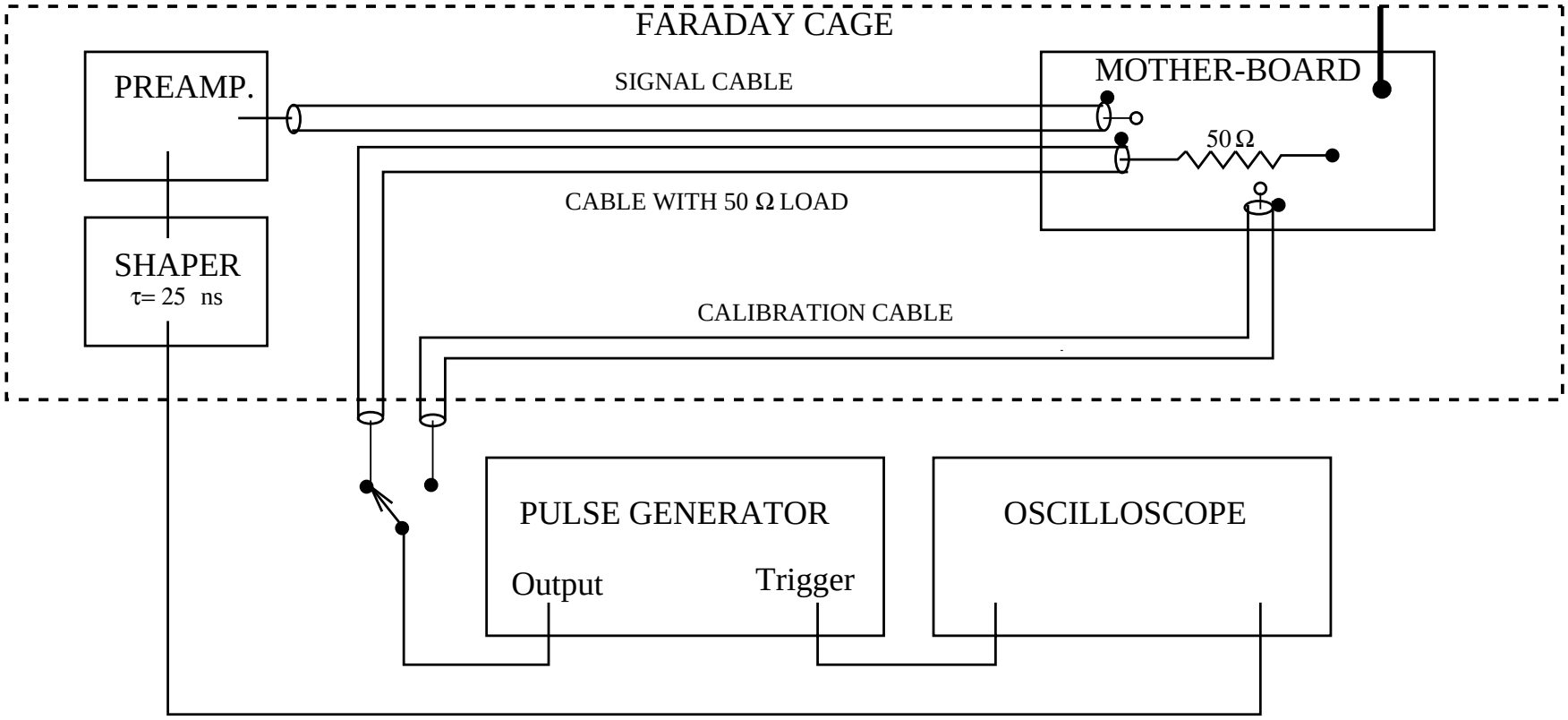

Figure 10: Experimental setup to measure the cross talk between cables.

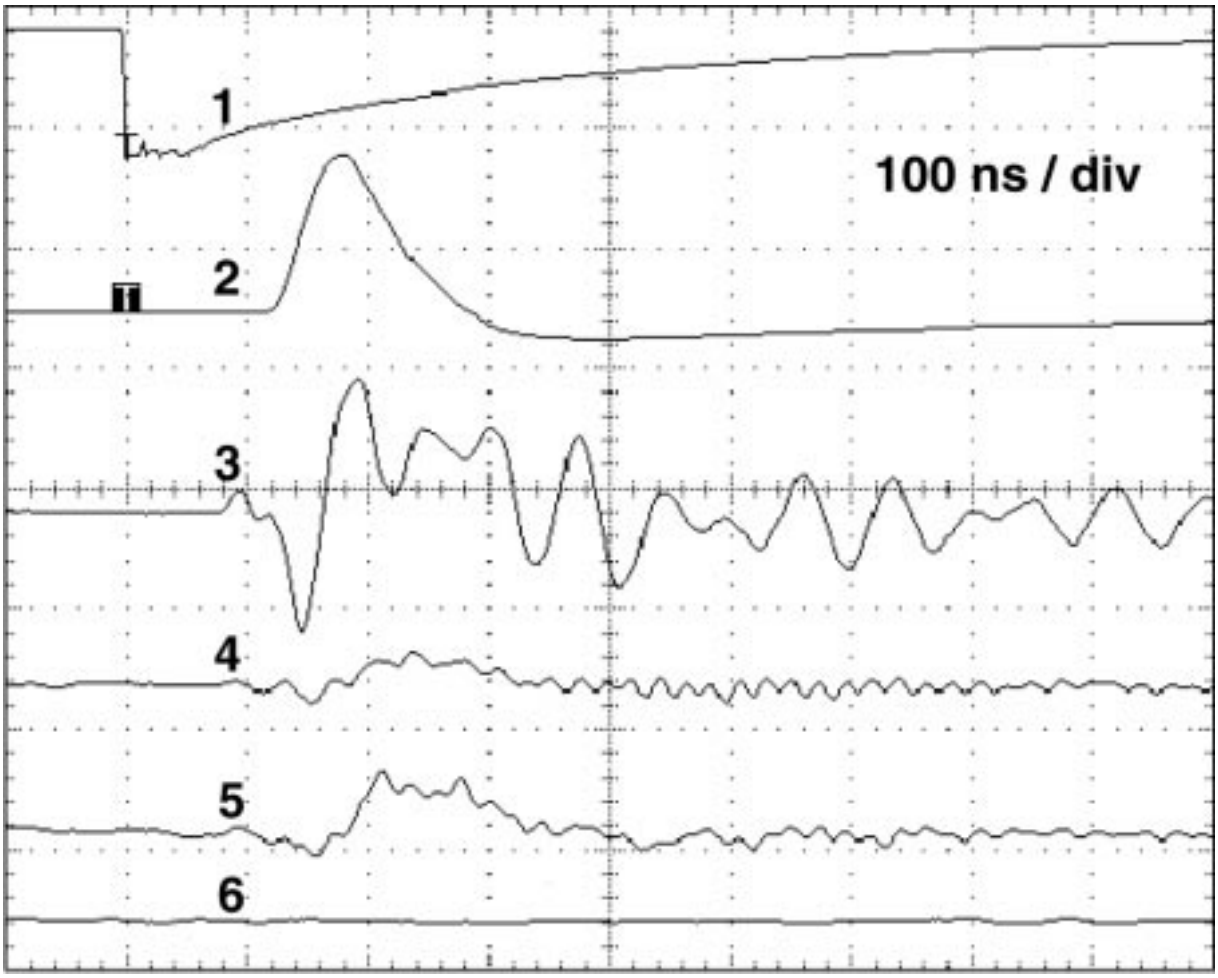

Figure 11: Cross talk between cables, see text.

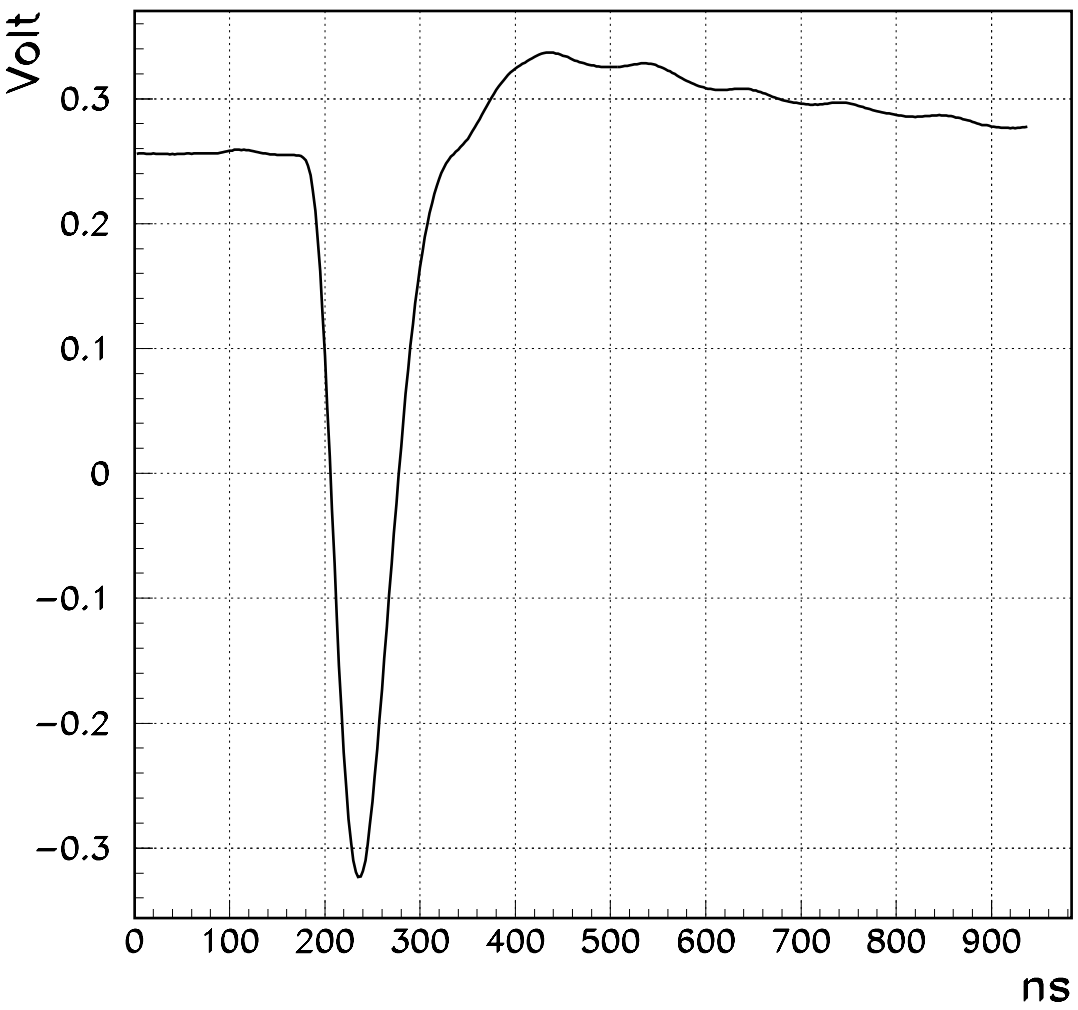

Figure 12: Output signal observed at CERN with the high gain amplification.