OBELIX Note OX-TO / 87 - 01

TEST OF T.O.F. SYSTEM (EXTERNAL BARREL)

TURIN December 1986 - June 1987
CERN August 31st - September 13th, 1987

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1. INTRODUCTION

Some tests were done of the scintillators, photomultipliers and eletronics, which we intend to use for the external barrel for time of flight measurement in the OBELIX experiment.

These tests may be divided in two phases:

- a first series of tests were carried on at the INFN Turin Section Laboratories from December 1986 to June 1987;
- the second ones took place at CERN from August 31st to the September 14th 1987.

The aim of this work was to compare the perfomances of two types of scintillators, two types of photomultipliers and some Constant Fraction Discriminators (CFD) and Meantimer circuits (MT). Amoung the latest we had some prototypes developed by the Electronic Laboratory of the INFN Turin Section.

2. TESTS AT TURIN

2.1 Setup description

We first tested a Nuclear Enterprises NE 110 scintillator slab of $300 \times 3 \times 10\ cm^3$, which has the fitting size for the elements of the scintillator external barrel of the OBELIX spectrometer.
At the slab ends we mounted two "fish tail" light guides, coupled at the extremities to two PHILIPS XP 2020 photomultipliers (called PMA and PMB). The experimental lay-out is shown by Fig.2.1.

We used cosmic rays as our particle source and this fact made the tests much longer. Just during the photomultiplier gain factor adjustment, we also used a ^{90}Sr calibration source.

In order to localize the cosmic ray impact point on the NE 110 slab, we made use of two small scintillators ($8 \times 1 \times 1\ cm^3$), which were placed over and under the scintillator slab (indicated in Fig. 2.1 as PMJ_1 and PMJ_2) and mounted on a trolley, so that we could move them along the whole slab.

For the treatment of the analogic pulses coming from photomultipliers, powered by a CAEN high voltage system mod. SY 127, we used the ORTEC

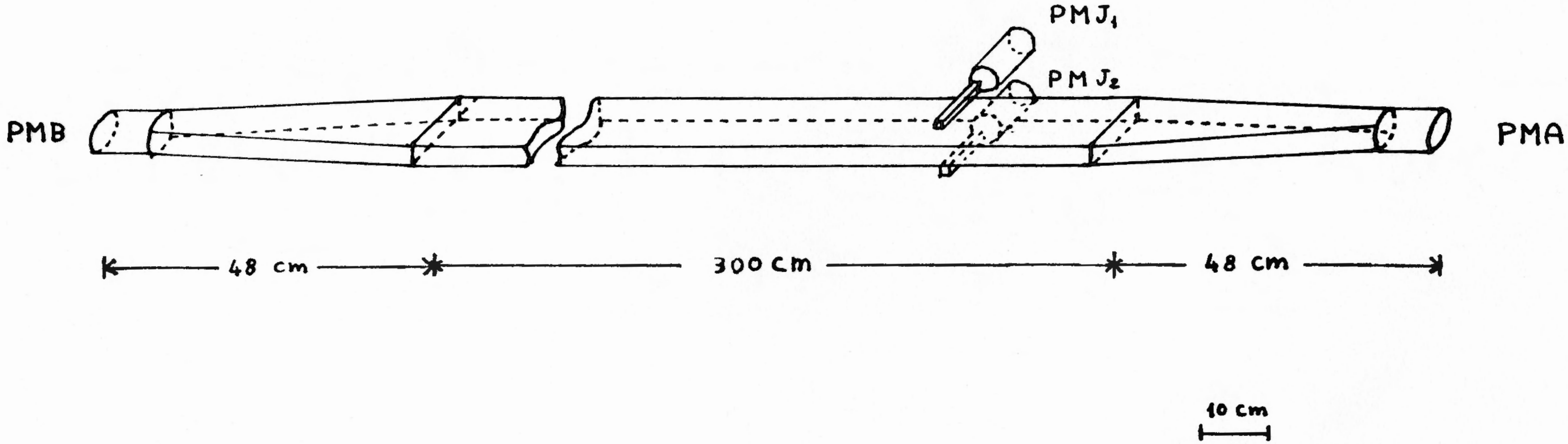

Fig.2.1. Experimental lay-out for Turin laboratory tests.

CFD mod. 934.

Our goal was to obtain the best possible time resolution and some useful informations about the behaviour of the various system components.

We have then realized the circuit we show in Fig. 2.2. As shown by the scheme, the trigger signal was given by the coincidence of four pulses coming from the photomultipliers (PMJ_1, PMJ_2, PMA, PMB). The same signal, properly delayed, gave the start to the time conversion (START TDC) and the gate for the pulse amplitude measurement (GATE ADC).

Time values were calculated as a difference between time intevals, we measured between the START pulse and the STOP pulses given by the two photomultipliers mounted on the scintillator slab (TDC values).

The data acquisition and processing were realized by means of a Digital MicroVAX II computer, interfaced with CAMAC modules. The necessary software was implemented on the base of the data acquisition system DAQ developed by CERN (monitored with PILOT).

2.2. Test results

At the end of a careful setting-up of the different components, we could obtain a distribution of measured times, that showed a FWHM of 550 ps (see Fig.2.3). This good result, though to be improved, was obtained by placing the two small scintillators at the slab centre and in the following conditions:

PMs	HV	Background	Signal (^{90}Sr)	CFD thr.	CFD ext. delay
PMA	2280 V	200-250 mV	600 mV	250 mV	6 ns
PMB	2300 V	200-250 mV	600 mV	250 mV	6 ns
PMJ_1	2090 V	30-50 mV	1200 mV	70 mV	5 ns
PMJ_2	2090 V	30-50 mV	1200 mV	70 mV	5 ns

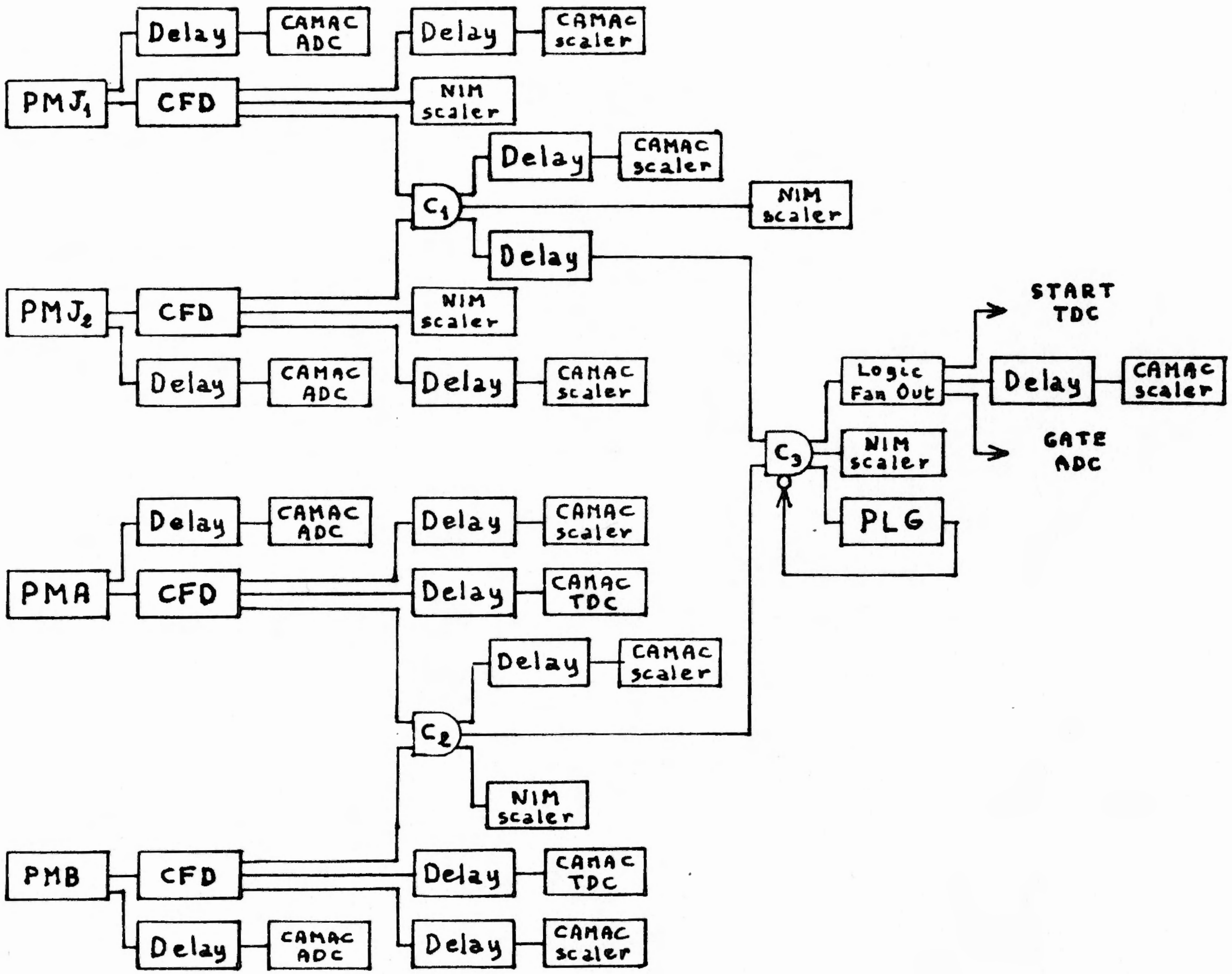

Fig.2.2. Eletronic circuit for Turin laboratory tests.

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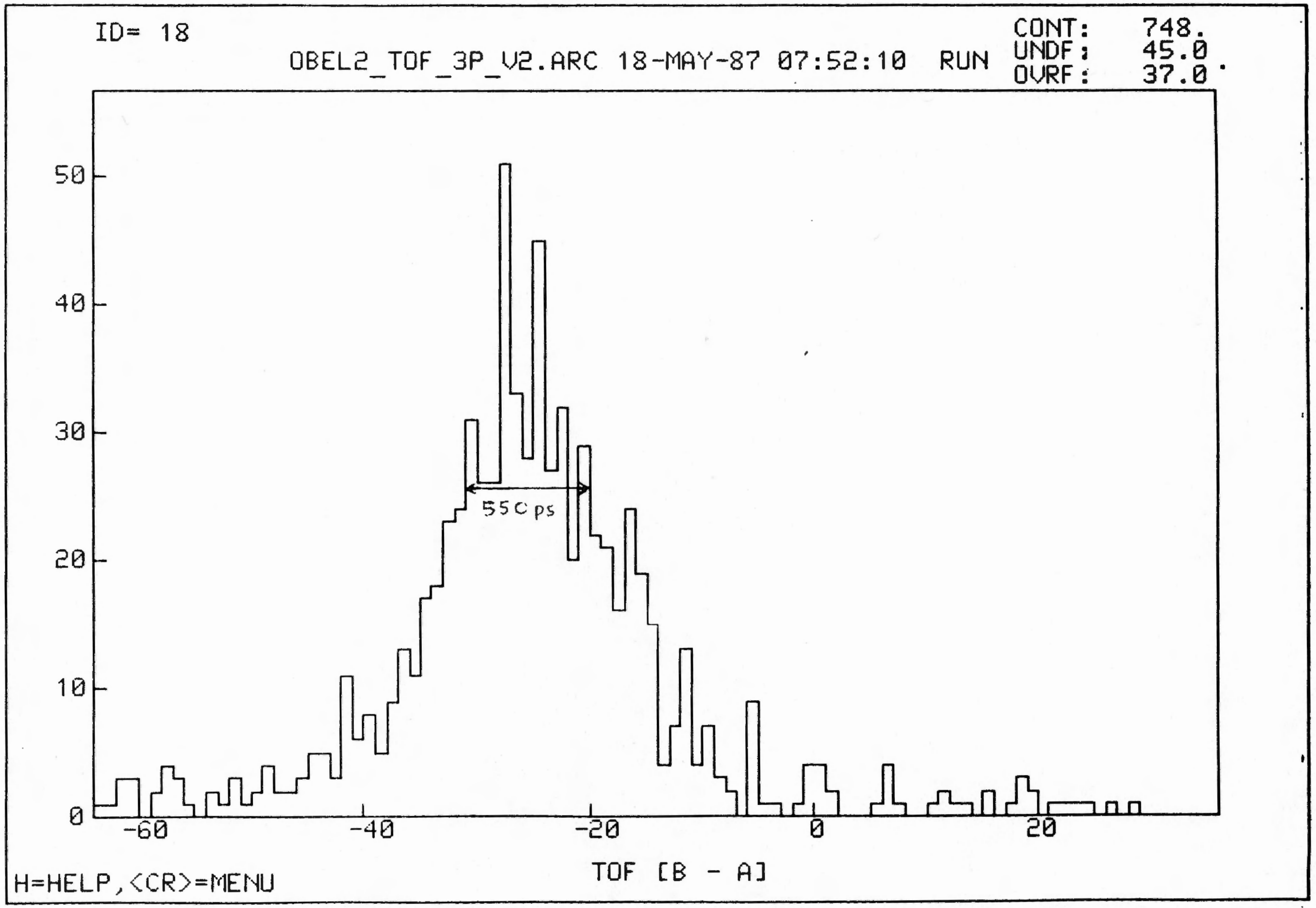

Fig.2.3. Time value distribution obtained in Turin Laboratory tests.

3. TESTS AT CERN

3.1 Setup description

The tests had been performed at CERN in the T11 beam, located in the experimental east area of PS. We used a 3.5 GeV π^+ beam: every burst had a lenght of 500 ms and the interval between the bursts was 8 s.

The Fig.3.1 shows the upper wiew of the experimental lay-out. Besides the Nuclear Enterprises NE 110 scintillator slab (the same we used for laboratory tests at Turin) we also mounted two thin NE 110 scintillator slabs (120 x 0.5 x 3 cm^3) and a BICRON scintillator slab BC 412 (176 x 3 x 10 cm^3). The setup was completed with three small scintillators for geometrical alignement with respect to the beam: upstream we placed two small scintillators (8 x 1 x 1 cm^3) orthogonally to the beam axis and forming a 90° angle (PMJ_1 and PMJ_2); downstream we mounted a rectangular scintillator (20 x 40 x 1 cm^3) called PMJ_3.

Each scintillator was coupled to a PHILIPS XP 2020 photomultiplier. All photomultipliers were powered by a Le Croy high voltage system mod. HV 4032A.

As far as the NE 110 scintillator slab is concerned, the object of our test was to check the highest possible resolution in time measurements, which could be reached through the setup we assumed as a reference one, that is using PHILIPS XP 2020 photomultipliers (PMD_4 and PMS_5), CFD ORTEC mod. 934 and the Le Croy meantimer circuit mod. 624.

The program of the tests, summarized in Tab. 3.1, included a series of comparating experiments between CFD ORTEC and other CFDs. More precisely, we realized some measurements by using alternatively a CFD with a built in MT circuit realized at Phisics Departement of Geneva University (DPNC 953), a CFD developed at Saclay Laboratories (coupled with Le Croy MT) and then prototypes of CFD and MT which were built at the Electronic Laboratoy of INFN Turin Section (respectively LE 243 and LE 244 identified). As far as the photomultipliers is concerned, there was a comparating tests too: in fact, we replaced XP 2020 photomultipliers by XP 2262 ones and compared the results obtained by using CFD ORTEC and Le Croy MT mod. 624.
In Fig. 3.2 we reproduce the scheme of the electronic circuit part we used

Setup	Photomultiplier	Scintillator	Constant Fraction Discriminator	Mean Timer
1	Philips XP 2020	NE 110	ORTEC mod. 934	Le Croy mod. 624
2	Philips XP 2020	NE 110	GENEVA DPNC 953	GENEVA DPNC 953
3	Philips XP 2020	NE 110	TURIN LE 243	TURIN LE 244
4	Philips XP 2020	NE 110	SACLAY	SACLAY
5	Philips XP 2262	NE 110	ORTEC mod. 934	Le Croy mod. 624

Tab.3.1. CERN tests program.

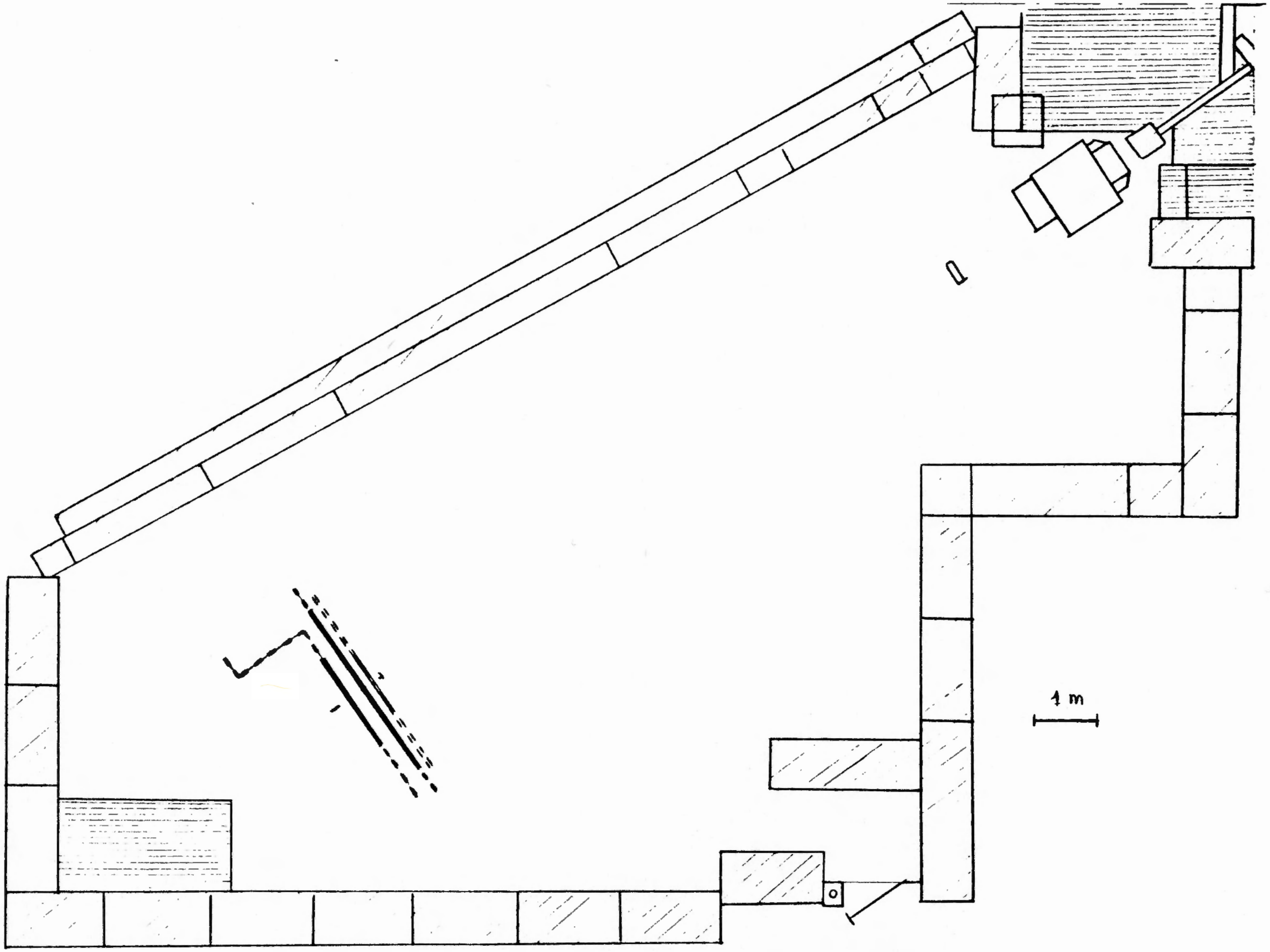

Fig.3.1. Top wiew of the experimental lay-out for CERN tests.

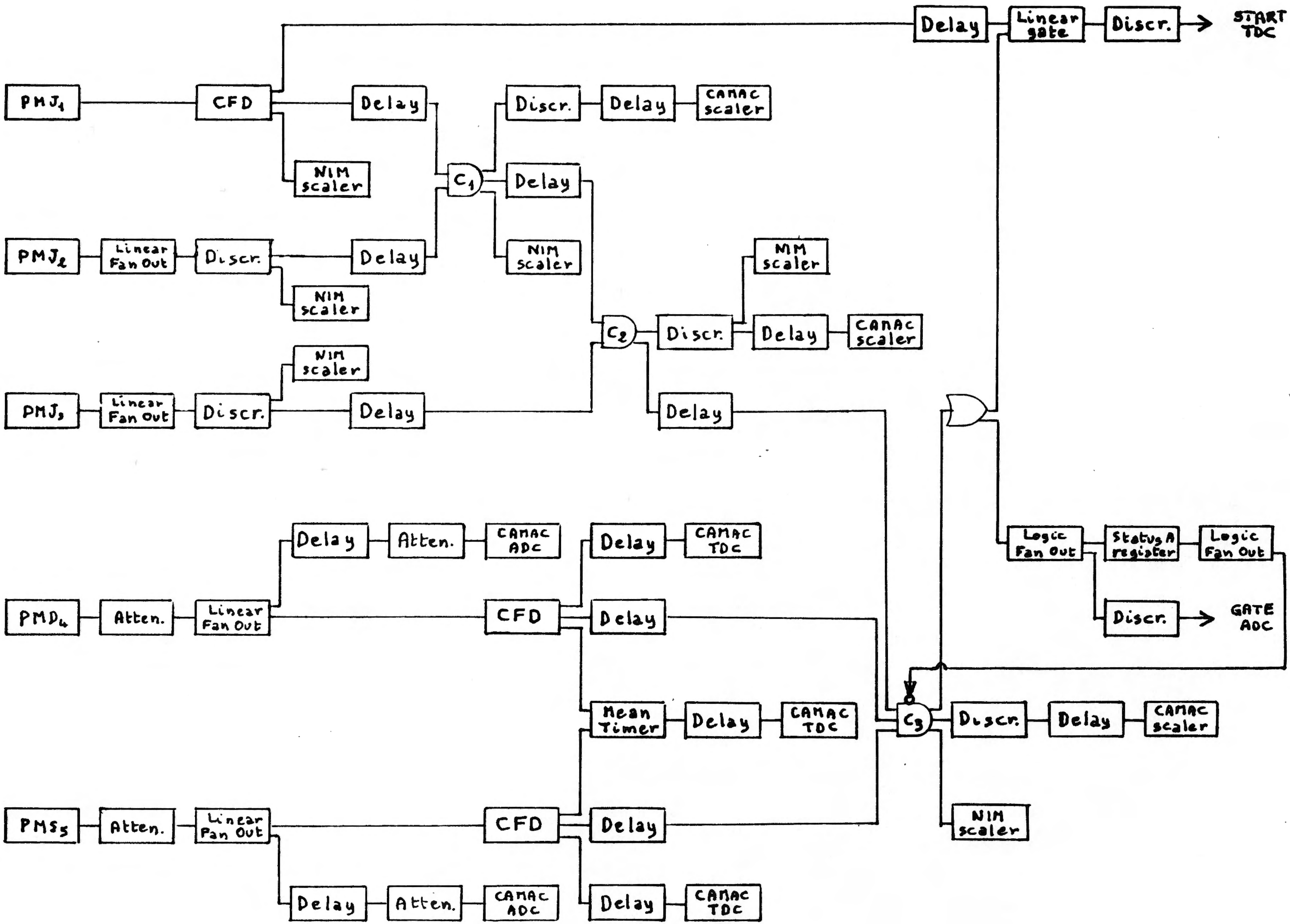

Fig.3.2. Electronic circuit for CERN tests.

in tests with the NE 110 slab.

Even in this case, the time value was calculated as the difference between the intervals we measured from the START pulse given to TDC modules (defined by PMJ_1 and activated by the coincidence of signals coming from PMJ_1, PMJ_2, PMJ_3, PMD_4 and PMD_5 photomultipliers) and STOP pulses coming from each photomultipliers we set on the NE 110 scintillator slab.

In order to estimate the behaviour of the different MT circuits we also calculated via software the mean value of the two measured time intervals, so that we would be able to compare meantimer values obtaneid via hardware.

For data acquisition and processing we used a Le Croy 3500N data acquisition system, interfaced with CAMAC modules. The necessary software was developed by the INFN Section of Cagliari.

3.2. Tests results

The results obtained at the centre and at one extemity of NE110 scintillator slab are presented in the following pages (beginning from Fig.3.3), according to the program shown in Tab.3.1. Tab.3.2 allows us compare them.

The tipical high voltage values by which we powered photomultipliers during the tests, were 2200 V for the XP 2020 ones and 2000 for the XP 2262 ones. The external CFD delay ranges from 4 ns to 6 ns and the CFD threshold level was 100 mV.

Unfortunately we are not to able to present Saclay Laboratory CFD test results (setup n° 4), becouse our module didn't work perfectly. Moreover we don't present graphics related to XP 2262 photomultipliers test, becouse off-line data analisys is still going on.

Setup	Time resolution		H/W MT resolution		S/W MT resolution	
	L	C	L	C	L	C
1	900 ps	900 ps	500 ps	500 ps	600 ps	<500 ps
2	1.05 ns	1.00 ns	750 ps	600 ps	600 ps	550 ps
3	1.15 ns	1.00 ns	900 ps	950 ps	650 ps	650 ps
4	/	/	/	/	/	/
5	1.00 ns	900 ps	600 ps	500 ps	650 ps	500 ps

Tab.3.2. CERN tests results.

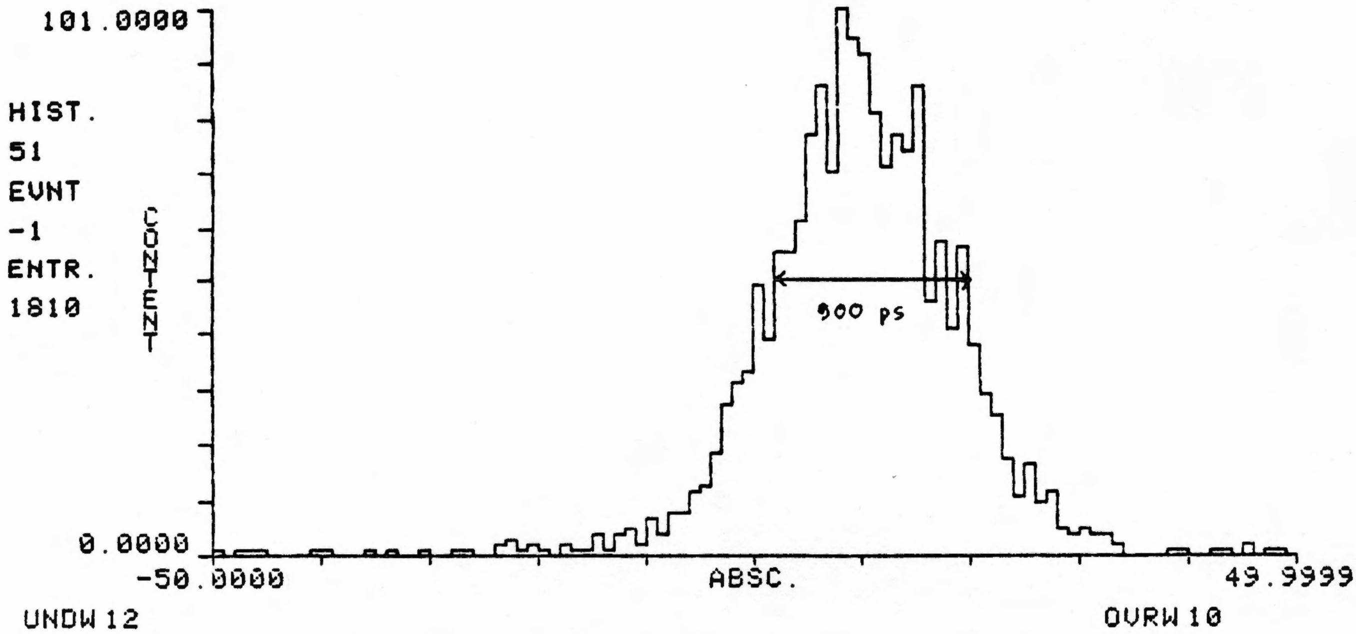

Fig.3.3. Time value distribution obtaneid with setup n° 1 (central position).

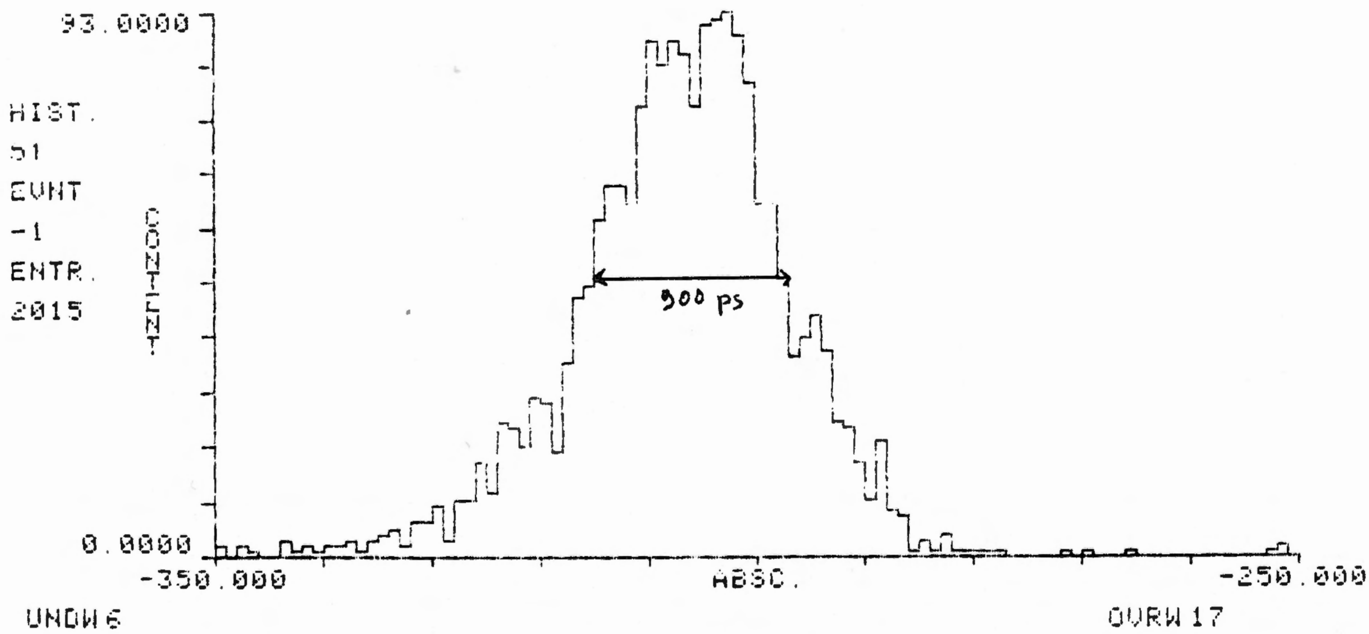

Fig.3.4. Time value distribution obtaneid with setup n°1 (lateral position).

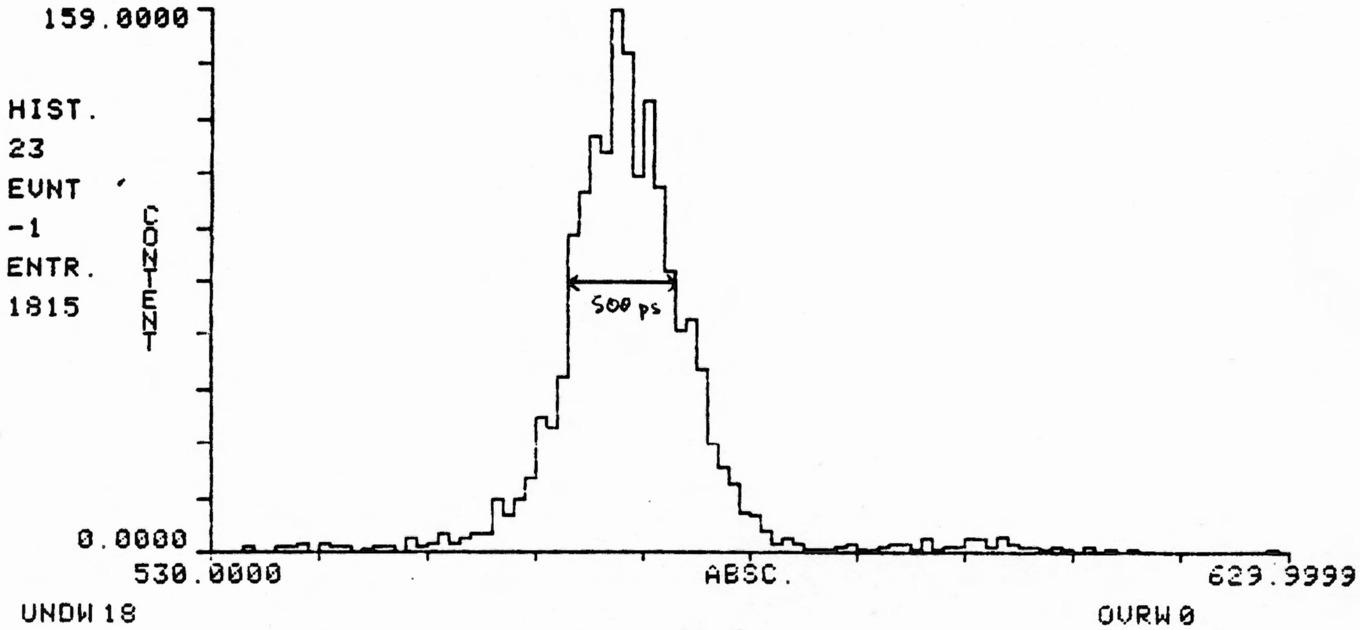

Fig.3.5. Meantimer value distribution obtained via hardware, with setup n° 1 (central position).

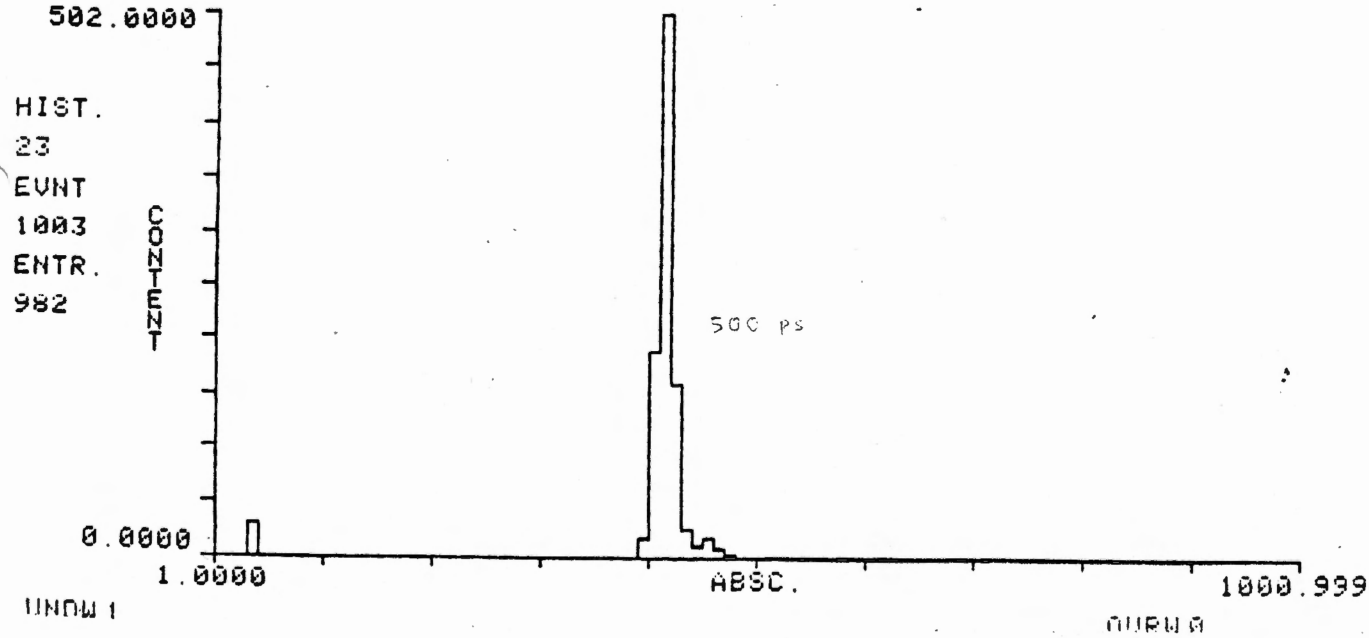

Fig.3.6. Meantimer value distribution obtained via hardware, with setup n° 1 (lateral position).

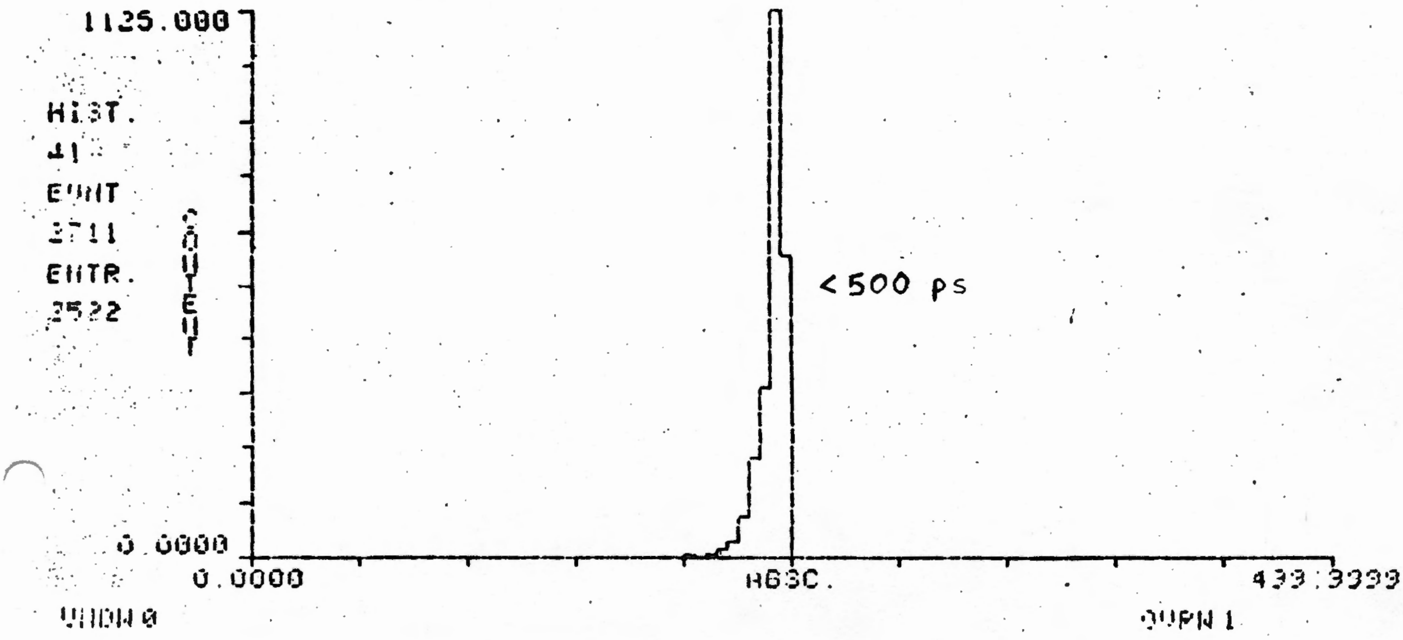

Fig.3.7. Meantimer value distribution obtained via software, with setup n° 1 (central position).

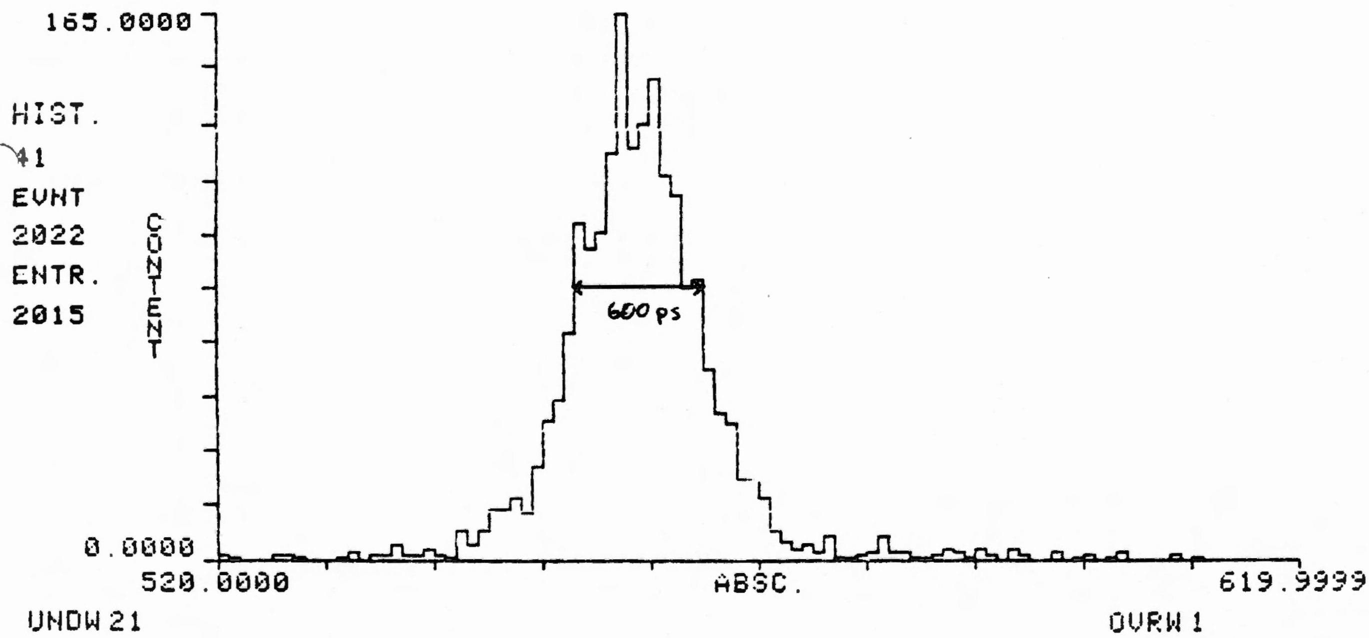

Fig.3.8. Meantimer value distribution obtained via software, with setup n°1 (lateral position).

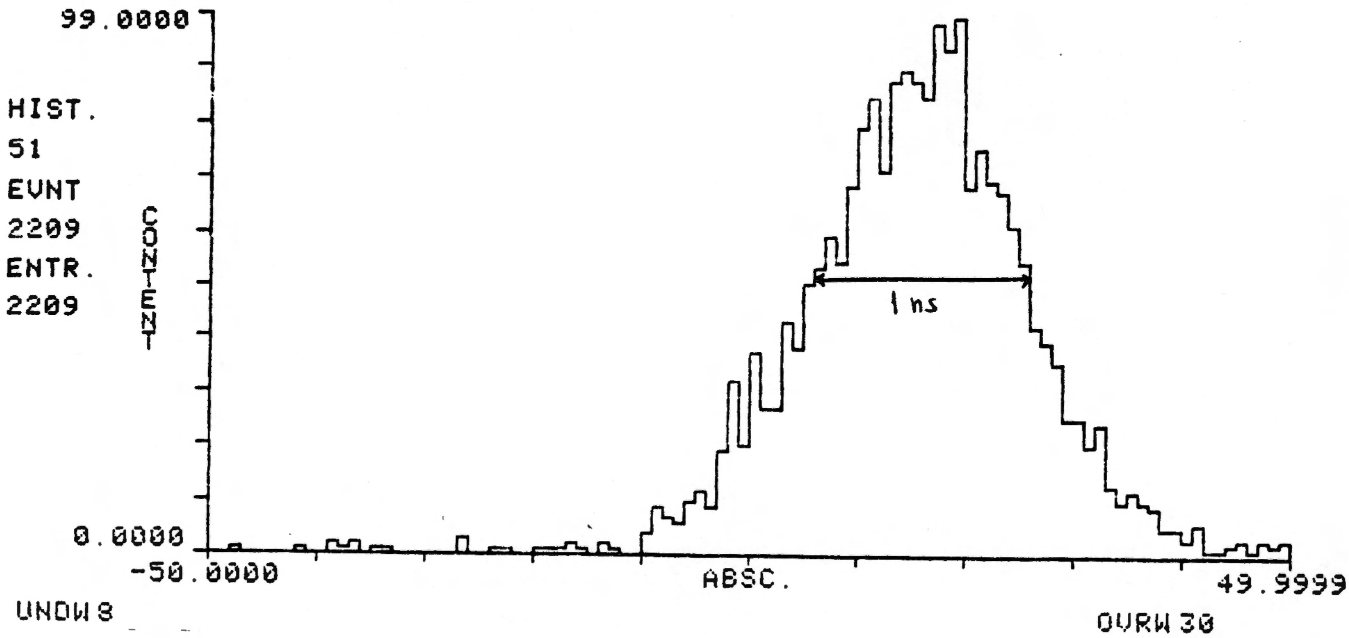

Fig.3.9.Time value distribution obtained with setup n° 2 (central position).

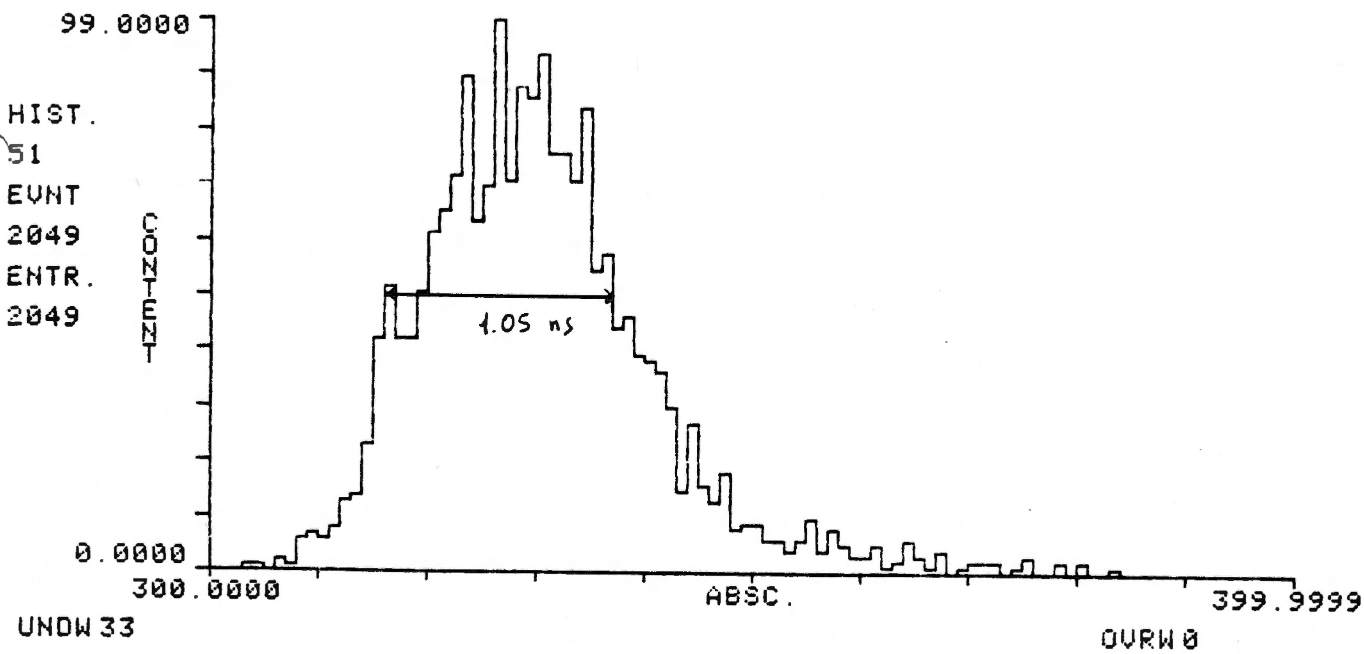

Fig.3.10. Time value distibution obtaneid with set up n° 2 (lateral position).

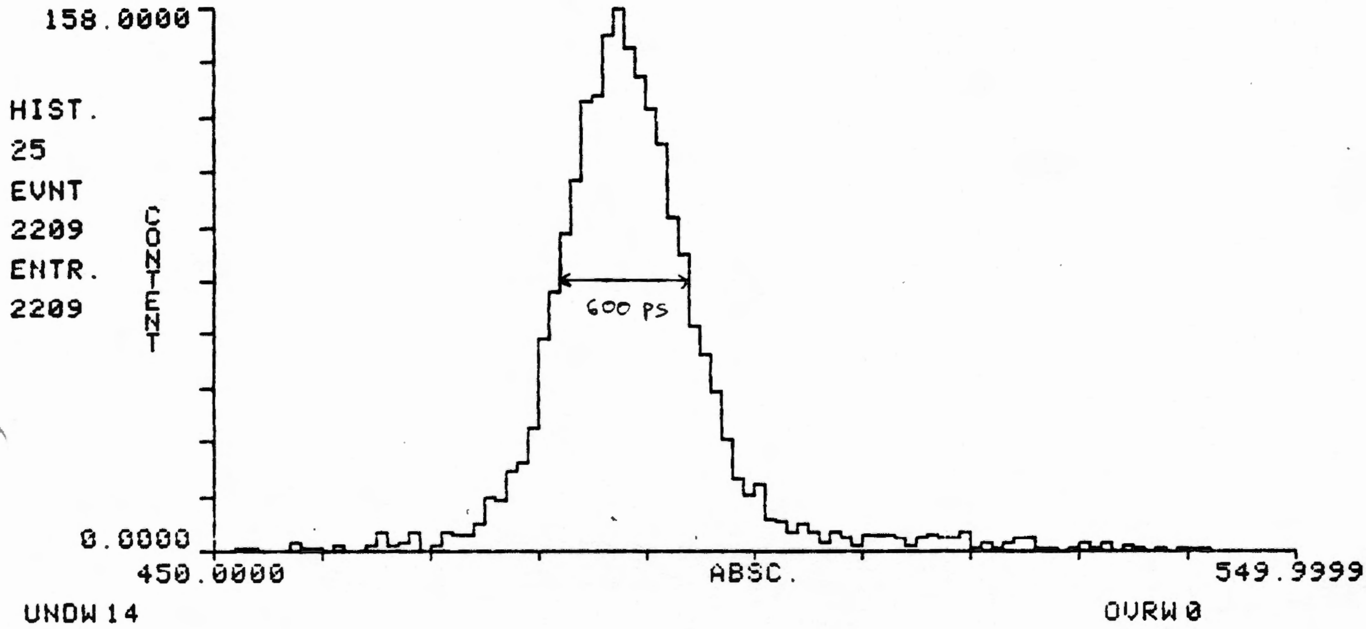

Fig.3.11. Meantimer value distribution obtaneid via hardware, with setup n° 2 (central position)

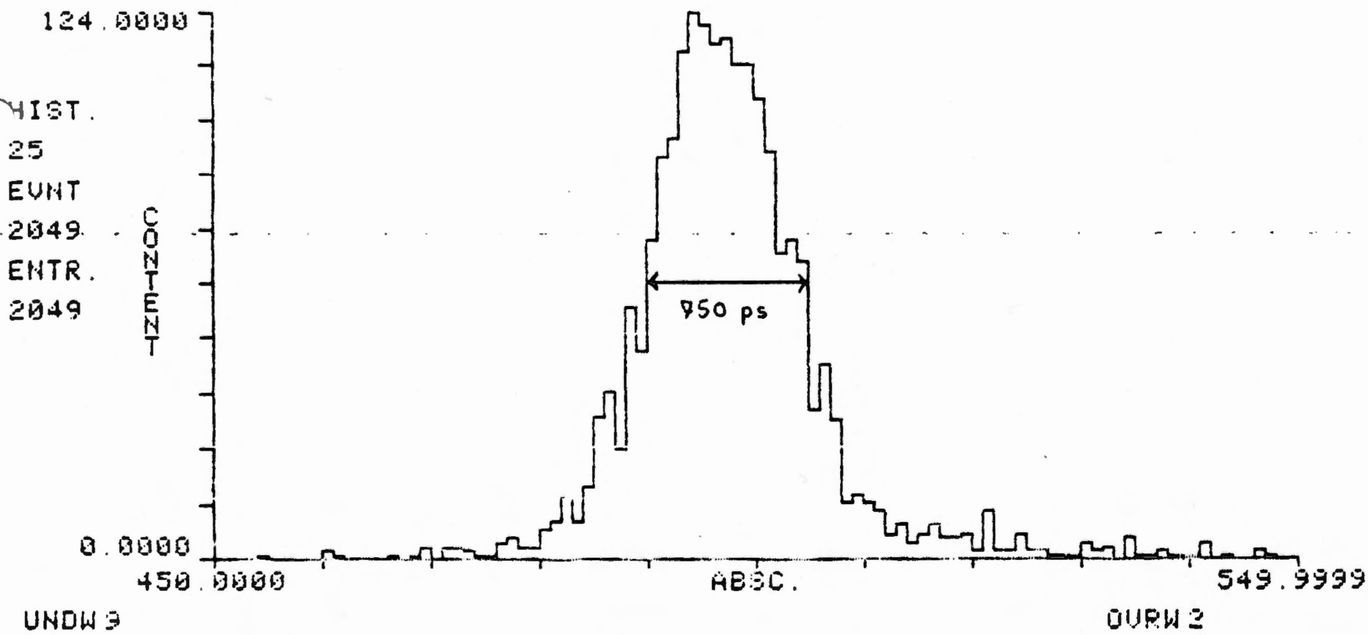

Fig.3.12. Meantimer value distribution obtained via hardware, with setup n° 2 (lateral position).

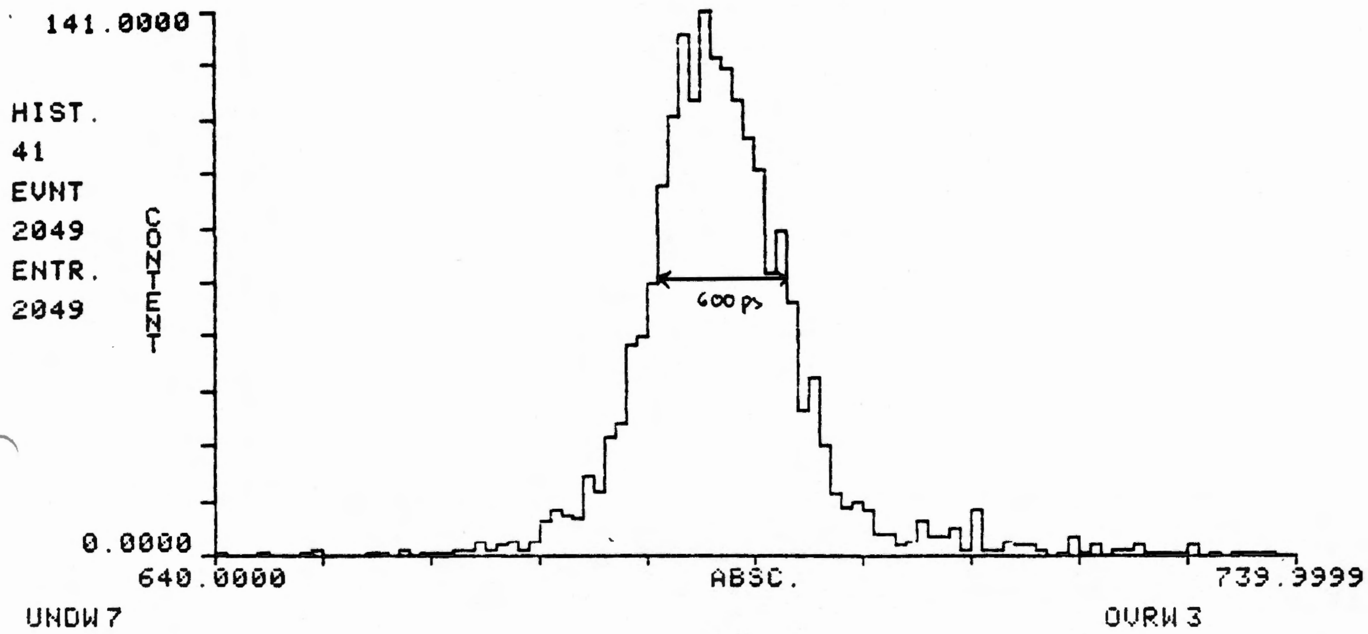

Fig.3.13 Meantimer value distribution obtained via software, with setup n° 2 (central position).

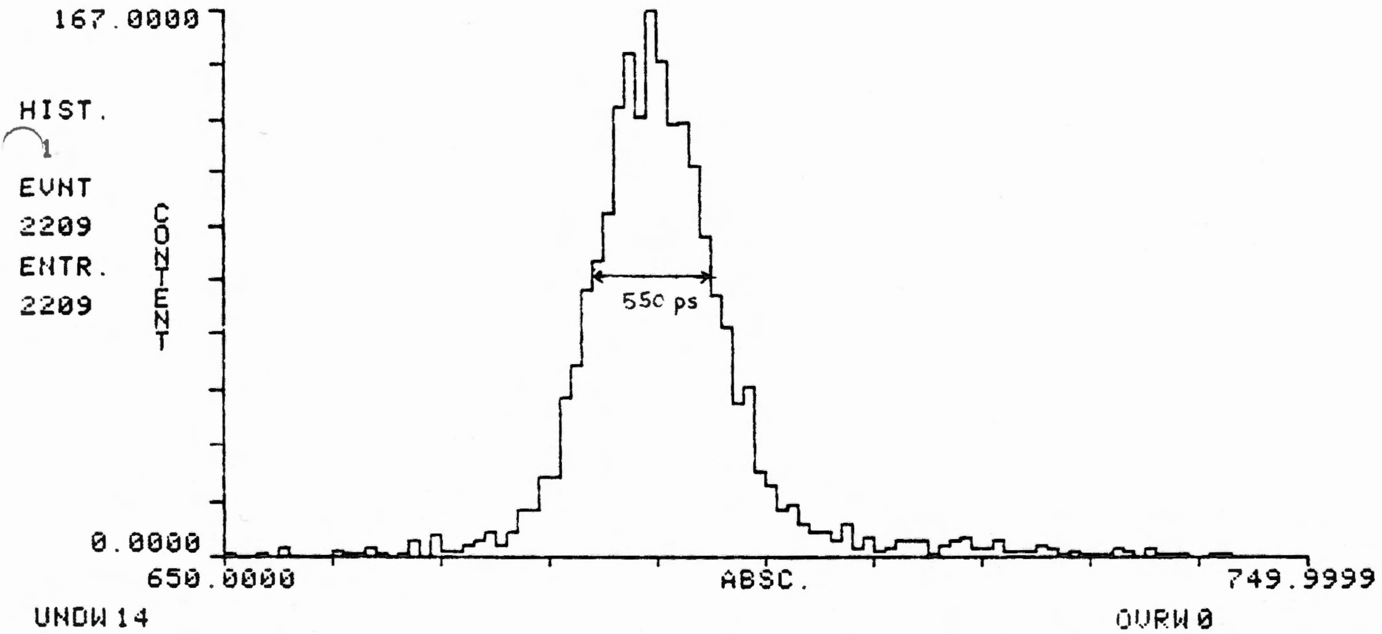

Fig.3.14. Meantimer value distribution obtained via software, with setup n° 2 (lateral position).

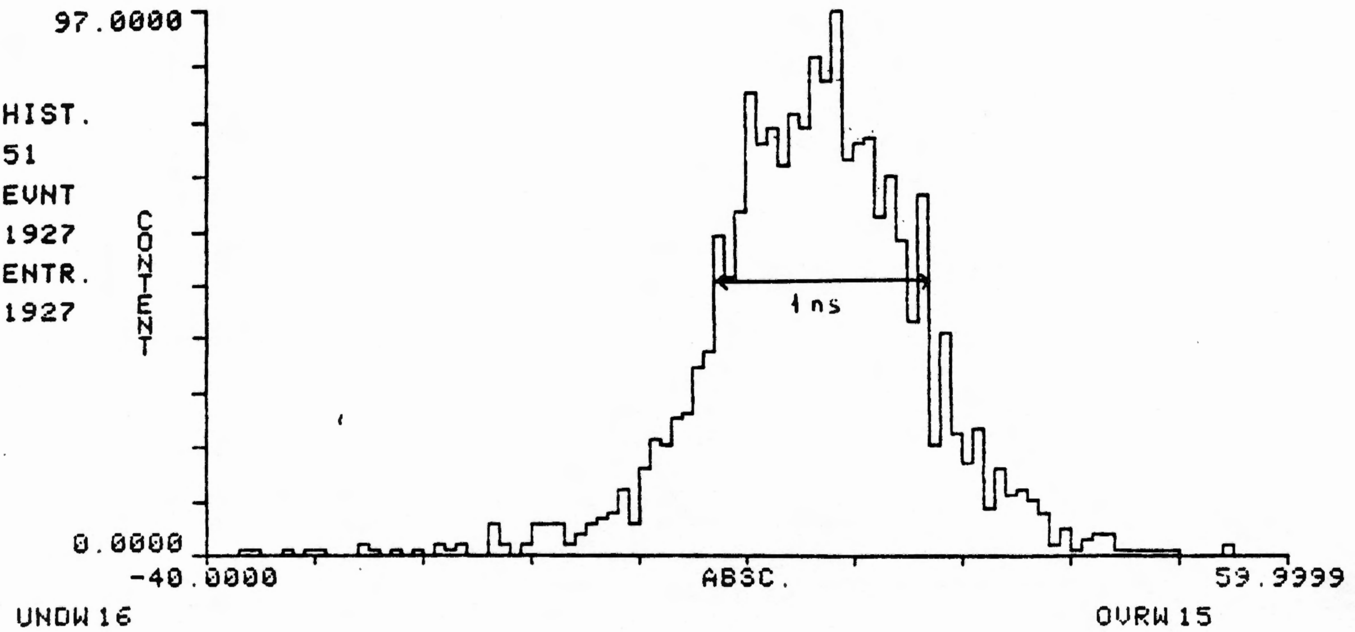

Fig.3.15. Time value distribution obtained with setup n° 3 (central position).

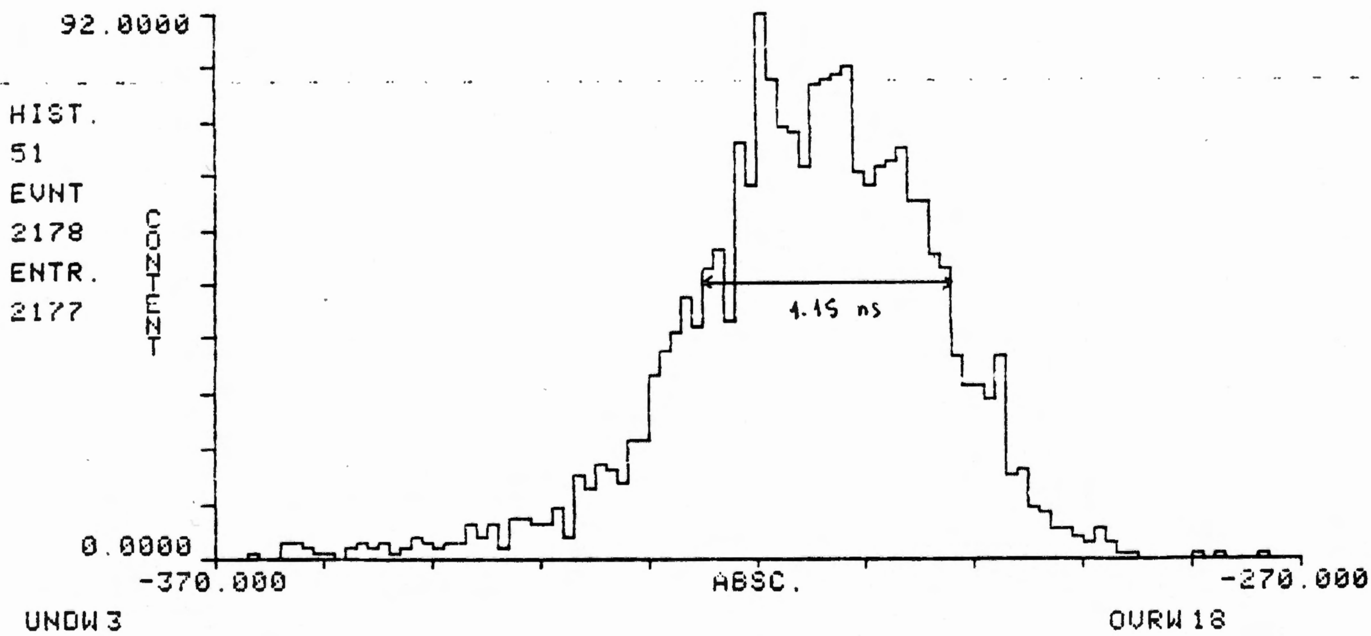

Fig.3.16. Time value distribution obtained with setup n° 3 (lateral position).

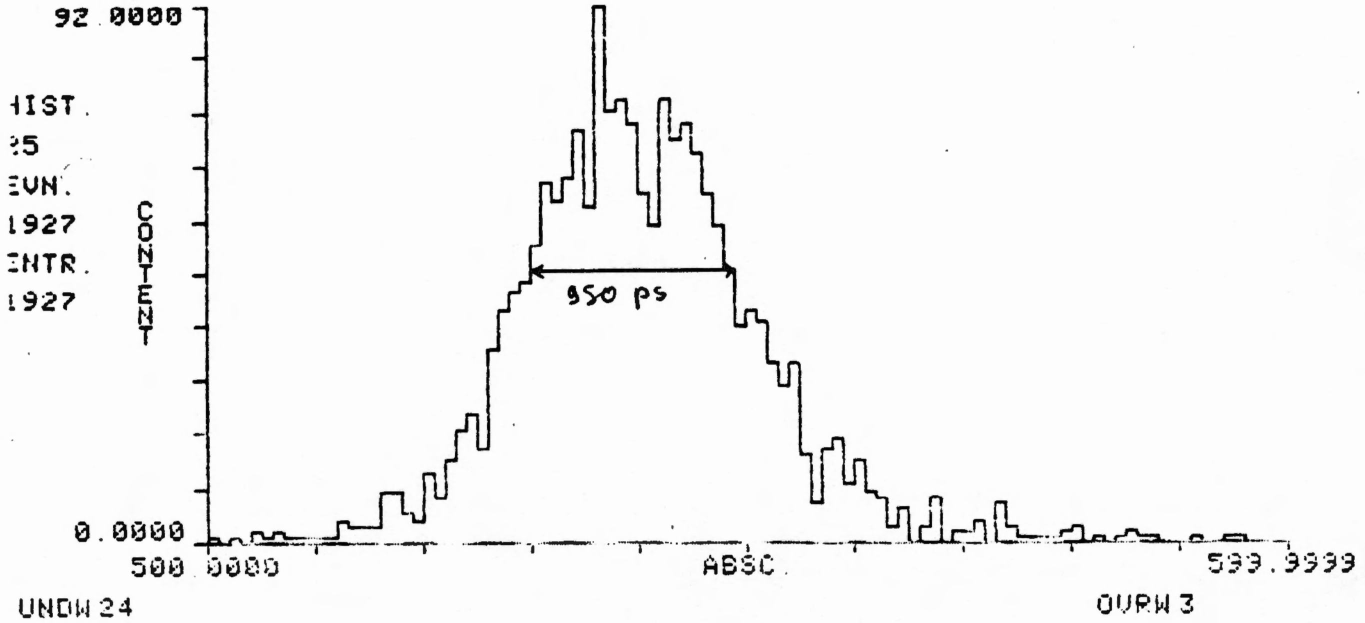

Fig.3.17. Meantimer value distribution obtaneid via hardware, with setup n° 3 (central position).

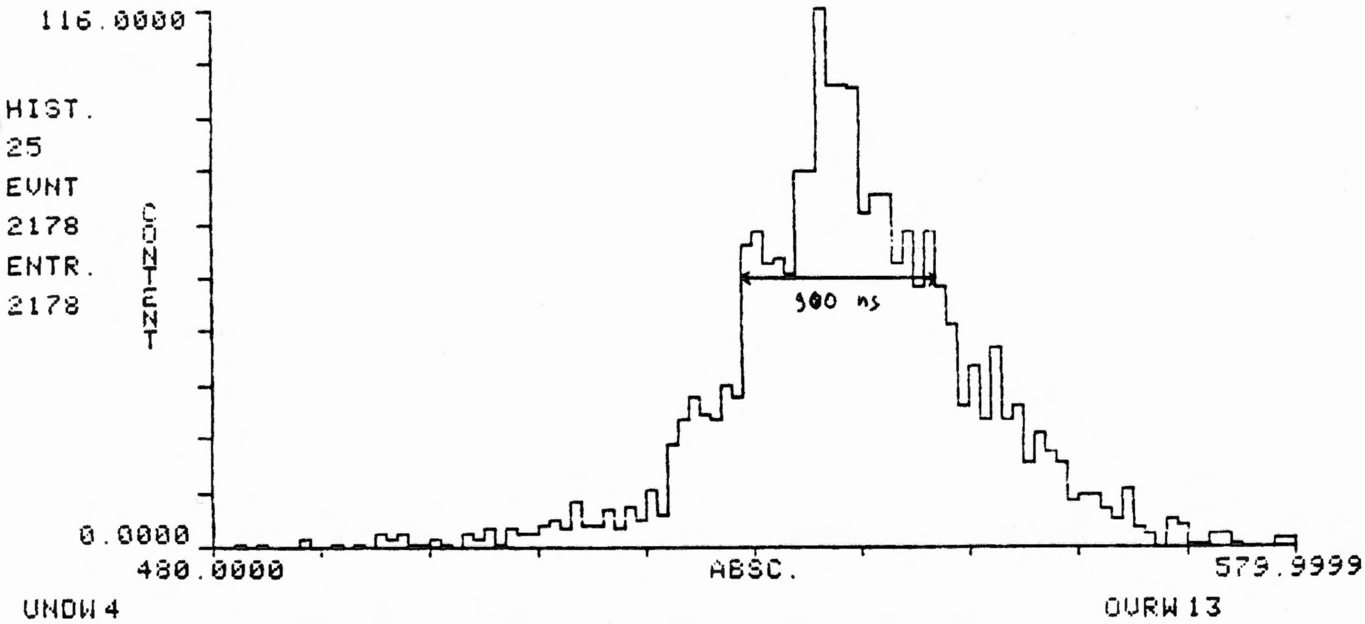

Fig.3.18. Meantimer value distribution obtained via hardware, with setup n° 3 (lateral position).

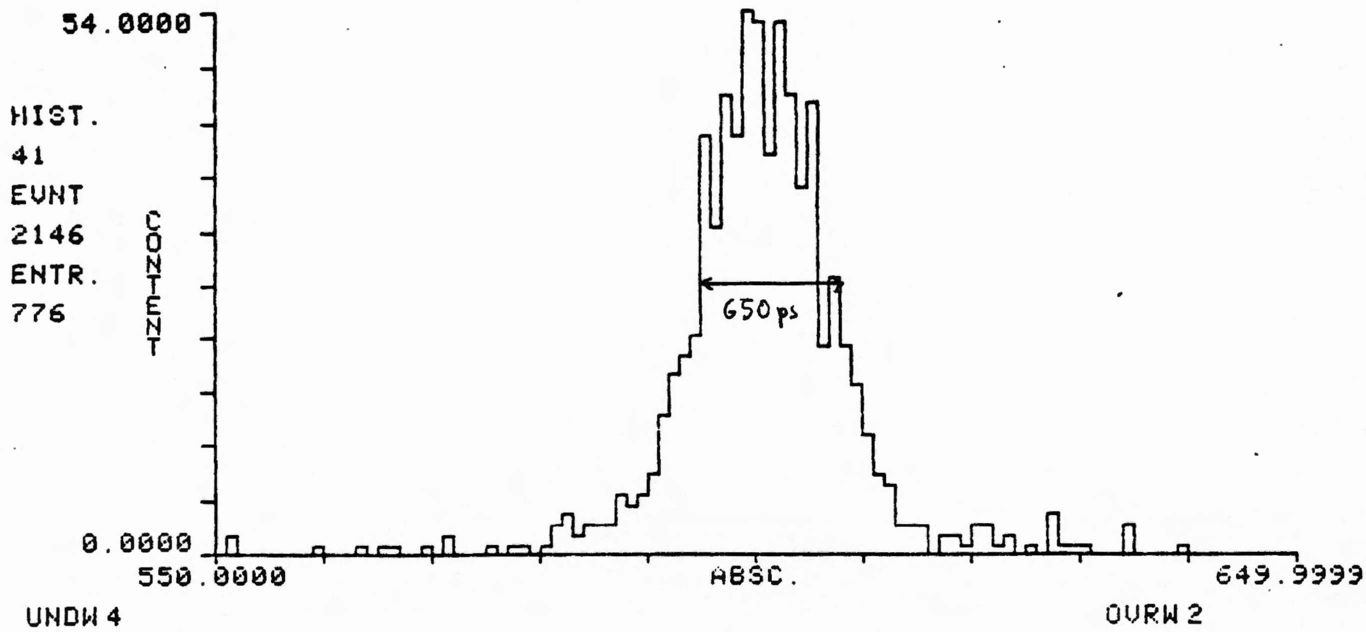

Fig.3.19. Meantimer value distribution obtained via software, with setup n° 3 (central position)

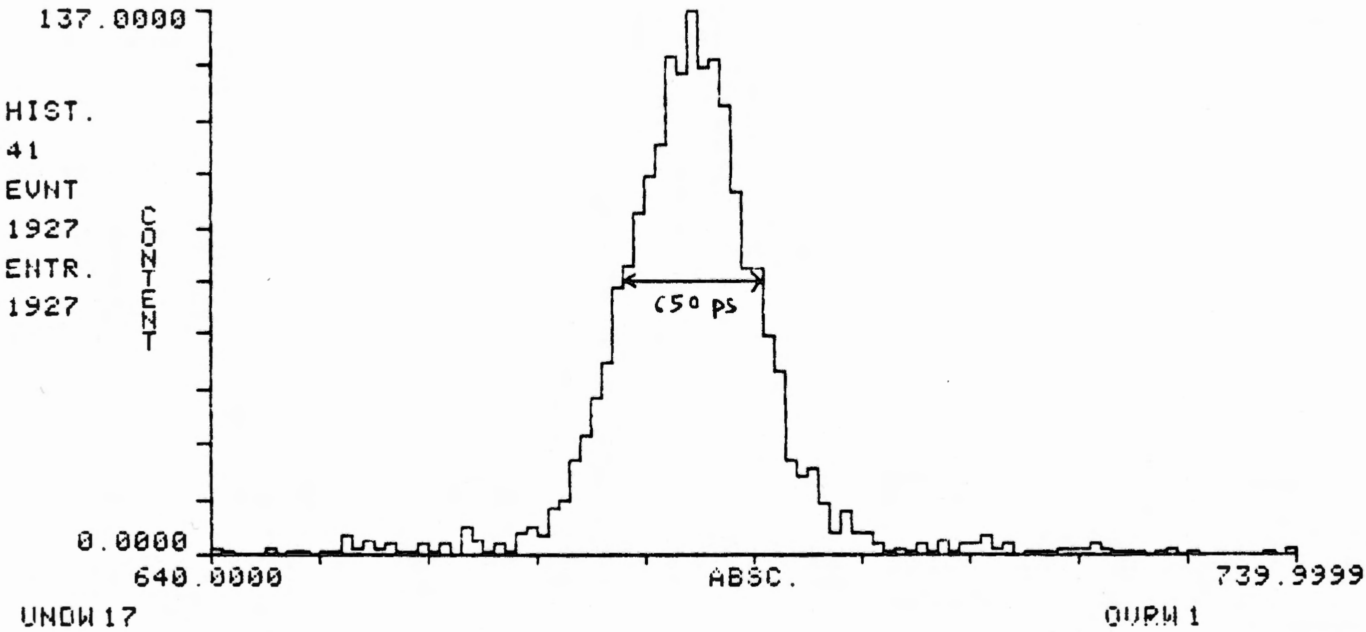

Fig.3.20. Meantimer value distribution obtained via software, with setup n°3 (lateral position)

4. CONCLUSIONS

On the base of the obtaneid results, we decided to use for external barrel of the OBELIX spectrometer odoscope the Nuclear Enterprises NE110 scintillator. Slab will measure 300 x 9 x 3 cm^3. The choise is due to the fact we don't know whether BICRON scintillators become yellow with age.

We also decided to use PHILIPS XP 2020 photomultipliers becouse the of their better performances.

As far as the electronics is concerned, we intend to keep on testing in order to check further on the CFD and MT improved module version developed by the Electronic Laboratory of INFN Turin Section.

ACKNOWLEDGEMENT

We would like to thank Miss S. Corsini for the collaboration given in the realization of this note.