A Front-End electronics board for single photo-electron timing and charge measurement from MaPMT

G. De Robertis[1], P. Fusco[1,2], F. Gargano[1], F. Giordano[1,2], R. Liuzzi[1], F. Loddo[1], F. Loparco[1,2], M.N. Mazziotta[1], V. Rizzi[1]

[1]INFN Sez. Bari, [2]Università degli Studi di Bari "A. Moro"

A Front End (FE) electronics board has been designed and implemented to test the H8500 PMTs at the INFN Bari Laboratory, with a CAEN VME based DAQ. These sensors have been selected for the SuperB PID detector [1]. Fig. 1 shows the CAD drawings of the mechanics being used at INFN-Bari for H8500 tests.

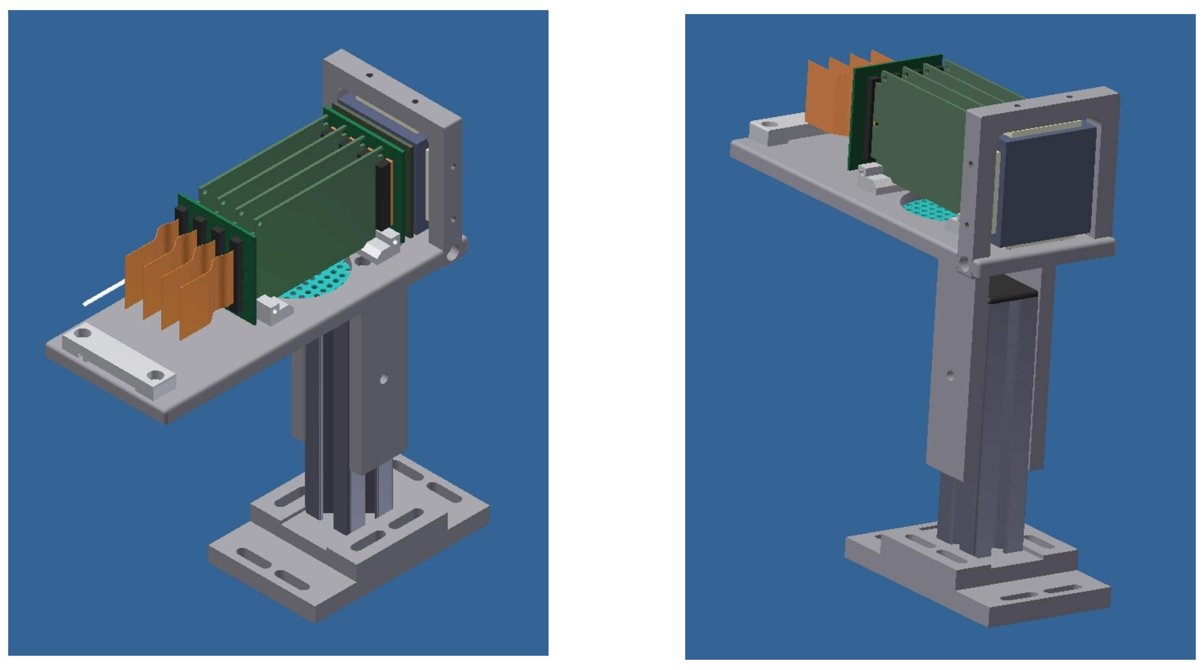


Fig.1 Mechanics of the FE for PMT tests

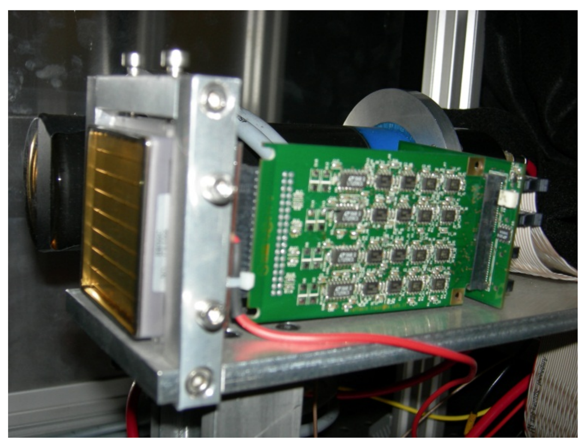


Fig.2 Picture of the FE mounted on the H8500 PMT

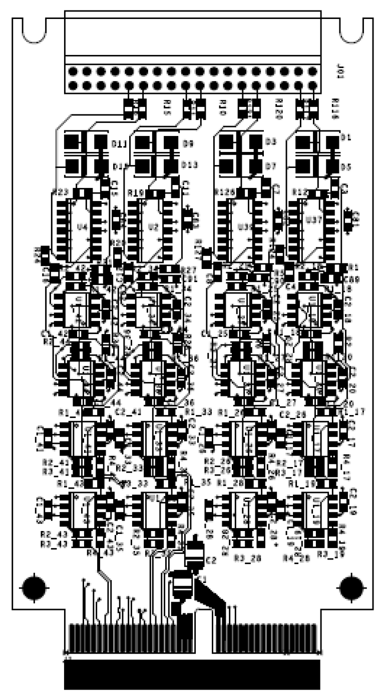


Fig.3 Footprint of one of the boards

Fig. 2 and fig.3 show one of the four 16-channel boards to be plugged into the H8500 PMT.

The basic design consists of a current sensitive preamplifier, whose output is fed both into a differential output driver to send the amplified analog signal to the CAEN charge ADC module and into a fast ECL discriminator for precise time tagging. The power supply has been chosen to provide ±5V, for a total power consumption of 300 mW/ch.

Fig.4 shows the schematic of the preamplifier: it consists of a 130MHz LT1260 operational amplifier in current feedback configuration and with a power consumption < 20 mW/ch.

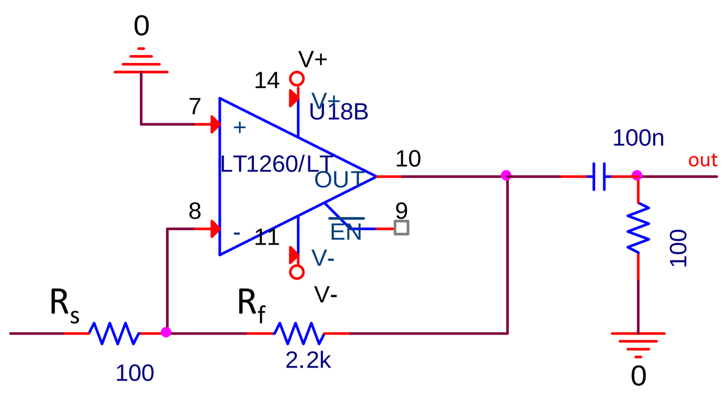


Fig.4 Preamplifier schematic

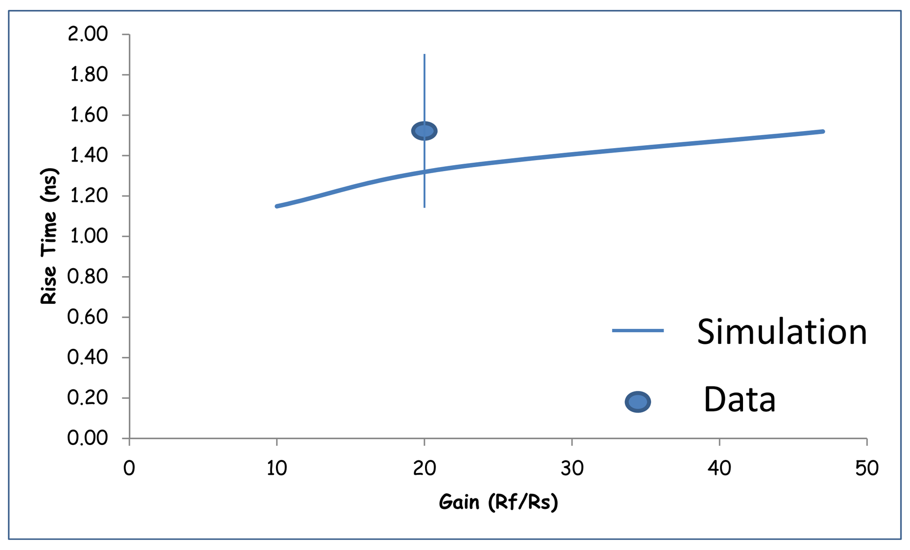


Fig.5 Rise Time vs Rf/Rs Voltage gain

The Gain-Bandwidth product has been studied in detail, in order to have enough gain while keeping a rise time less than 2ns. Injecting a current test pulse provided by a step voltage differentiated by an input series capacitance of 1pF, we have optimized the values of Rs and Rf resistors to have a current sensitivity of 2200 mV/mA and a rise time around 1.5 ns.

Fig. 5 shows the rise time simulated with "Orcad Cadence 16.5" of the output signal of the preamplifier for different Rf/Rs gain values, keeping fixed Rs = 100 Ω. The data point in the plot superimposed on the simulation was measured with Rf/Rs=22, which yields a rise time of 1.5±0.4ns.

The chosen fast ECL discriminator is the MAXIM 9691. The threshold is derived by a stable 1.2V provided by the voltage reference ADR280 and can be adjusted by means of a variable resistor buffered by a LT1490 in voltage follower configuration, as shown in Fig. 6. The threshold has been set at a value of 20 mV, corresponding to 0.2p.e. Fig. 8 shows the output from the driver and from the discriminator.

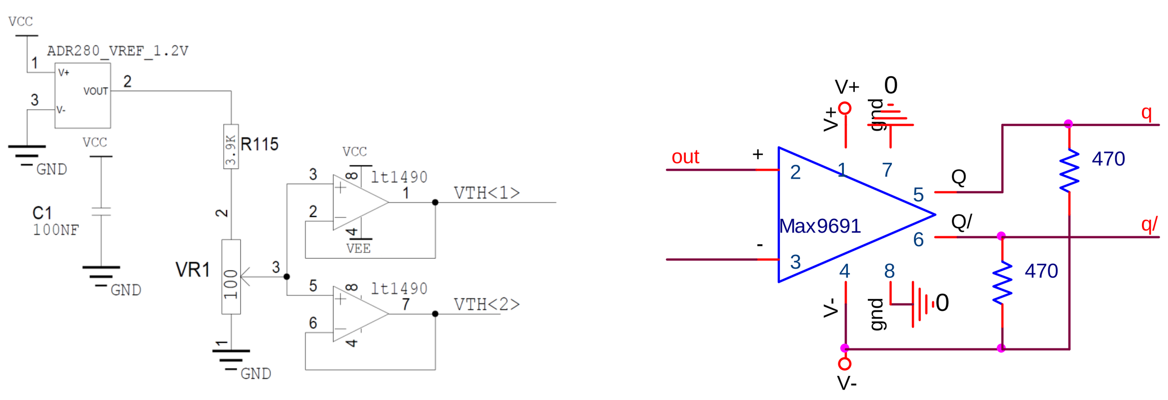


Fig.6 Fast ECL Discriminator Schematic. a) Details of the threshold stabilization system; b) Schematic of the Max 9691 configuration

The preamp output is fed into a AD8132 (Fig. 7) low power high speed operational amplifier, providing a voltage gain ~ 4 and differential output signal.

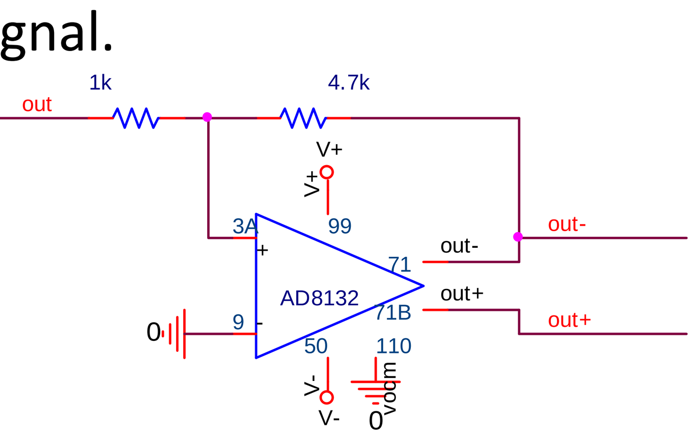


Fig.7 Schematic of the differential driver for charge measurements.

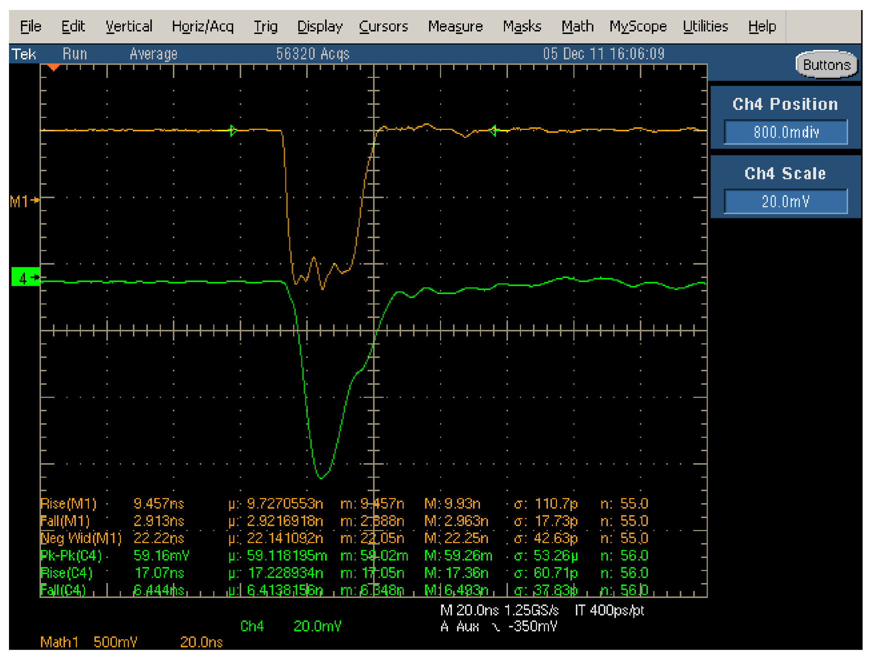
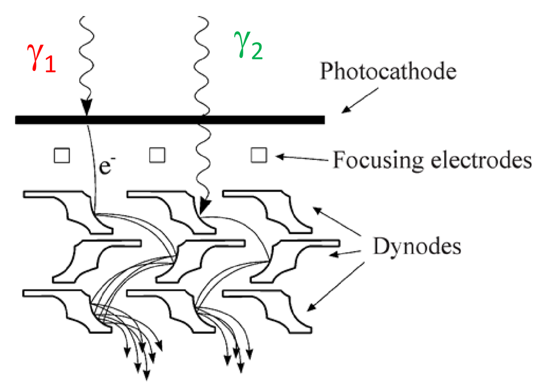


Fig.8 output signal from the AD8132 (green) and the MAX9691(red). The screenshot has been captured on Lecroy Wave Runner 610Zi



The performance of the FE have been tested also using a ps laser [1]. Fig. 9 and 10 show the charge distribution and the time of data collected on the H8500 for single p.e. events. In both distributions the two families of events corresponding to a photo conversion at the photo-cathode γ_1 and at the first dynode γ_2 (lower charge and earlier time of arrival) are visible.

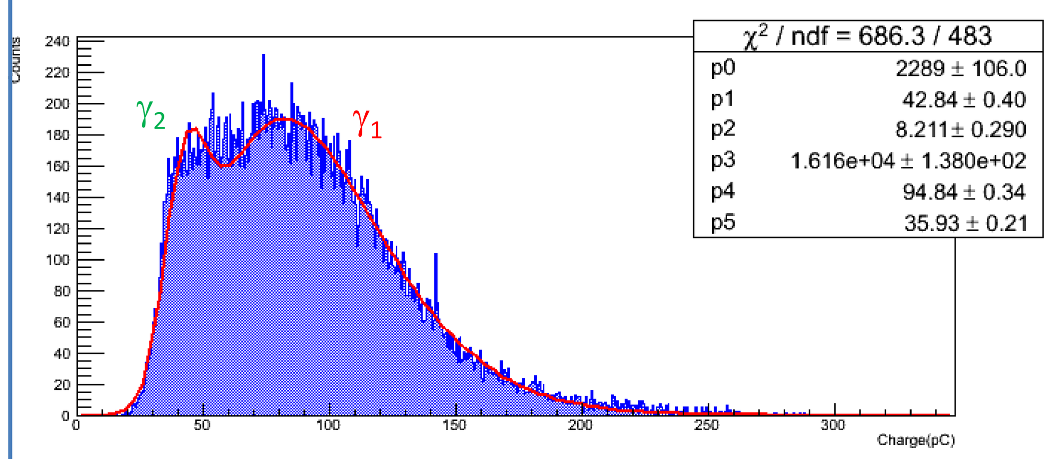


Fig.10 Charge distribution for single p.e. events on H500

The charge distribution has been fitted with two Polya functions; the two families of events are also well separated in the time distribution, once the correction for time-to-charge has been applied.

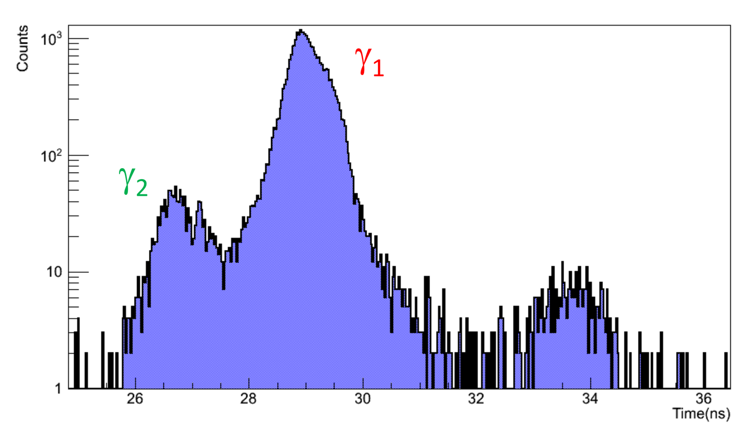


Fig.11) Transit Time distribution corrected for the time-to-charge calibration

Pulsing the FE with step voltage, the performance of the electronics as a function of the input charge in terms of timing resolution has been studied. The overall gain is 500 (Fig.9 a).

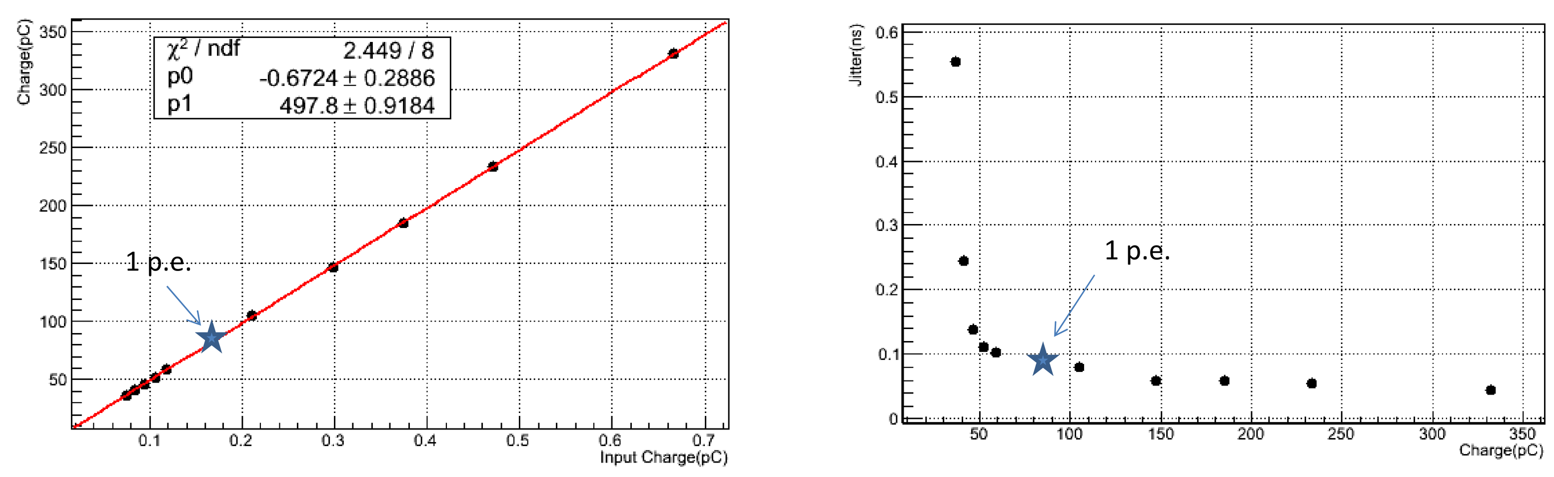


Fig.9 a) Charge calibration with voltage steps differentiated over 1pF capacitance; b) Time jitter versus the charge injected

Concerning the timing, the threshold crossing effect for low signal worsens the resolution. An off-line Charge-Time calibration has been then applied, showing that, setting the threshold at 0.2 p.e., the designed FE allows to obtain a minimum resolution of 60 ps for > 3-4 p.e. injected, and of about 90 ps for the single p.e. (Fig. 9 b).

[1] F. Gargano et al. P4- "H8500 Test for the SuperB PID detector"
[2] Hamamatsu Photonis K. K. "Photomomultipliers Tubes: basics and applications"

The authors thank Mr. M. Mongelli and V. Valentini for the mechanical structure design. And Mr. M. Franco, N. Lacalamita and A. Masciullo for the help in the construction of the set-up.