Multi-Anode Readout Chip for MaPMTs

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I. INTRODUCTION

MAROC is the 64 channel readout chip designed for the ATLAS luminometer made of Roman pots [1]. This ASIC is an evolution of the OPERA_ROC ASIC [2] developed and installed on the OPERA experiment to auto-trigger and readout 64 channels Hamamatsu multi anode PMTs [3].
Its main requirements are a 100% trigger rate for signal greater than 1/3 photoelectron, a charge measurement up to 30 photoelectrons with a linearity of 2% or better and a crosstalk less than 1%.
In order to check the functionalities of MAROC, laboratory tests have been performed and have shown a good global behaviour of the chip, which allows to use it for beam tests at CERN in summer 2006.
In this summary, section II describes the architecture of the ASIC. The section III is dedicated to laboratory test results.

II. DESCRIPTION OF THE ASIC

The MAROC chip [4] is a 64-channel input front end circuit developed to read out MAPMT outputs. Its main characteristics are the following:

- AMS SiGe 0.35µm technology
- 12mm^2 (3.5mm × 3.9mm) area
- 3.5V power supply
- 130mW power consumption
- Package: CQFP240

The block diagram of the ASIC is given in Fig. 1. For each one of the 64 channels, the PM signal is first amplified thanks to a variable gain preamplifier which has low noise and low input impedance (~50 Ω) to minimise crosstalk. It allows compensating for the PM gain dispersion up to a factor 4 to an accuracy of 6% with 6 bits.

The amplified current feeds then a slow shaper combined with a Sample and Hold buffer to store the charge in 2pF and provide a multiplexed charge output up to 30 pe-.
In parallel, trigger outputs are obtained via fast channels made of a fast (15 ns) shaper followed by a discriminator.
The discriminator threshold is set by an internal 10 bit DAC, made of a 4 bits thermometer DAC for coarse tuning and a 6 bits mirror for fine tuning.

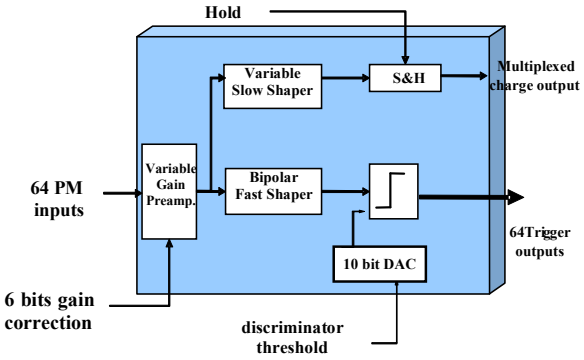

Fig. 1: Block diagram of the ASIC.

III. LABORATORY TESTS

Since October 2005, date of the chip delivery, extensive tests have been performed. The first ones have shown substrate coupling between mirror output and preamplifier ground return leading to oscillations for ground inductance higher than 20 nH when all channels were used at high gain. By mounting the chip on board these effects are reduced and this allows the use of MAROC during beam tests.

The results shown here have been obtained with a chip mounted on the test board developed at LAL.

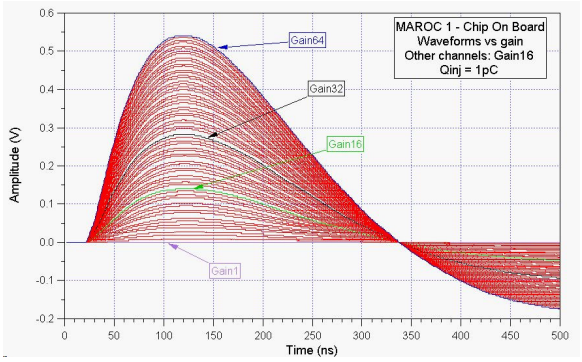

Fig. 2. Waveforms (slow shaper) taken at different gains and with a constant charge injected.

Fig.2 shows slow shaper waveforms obtained for preamplifier gain varying from 0 to 4 (6 bits)[1]. From the maximum of these waveforms a linearity of ± 1% is obtained, in agreement with the requirement.

[1] The gain amplification varies from 0 to 4. It is set via a 6 bits (G=0 to 4) gain correction level.

The trigger functionality also behaves as expected. The Fig. 3. shows the trigger efficiency as a function of the input charge for the 64 channels set at gain 1. In average the 50 % trigger efficiency is reached at 50 fC which corresponds to 1/3 pe- for a PMT functioning with a gain of 10^6. The noise is in the order of 1 fC.

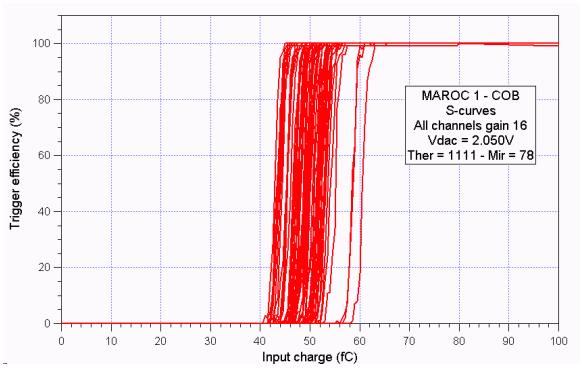

Fig. 3: Trigger efficiency (S-curves) for the 64 channels.

The Fig.4, which represents the evolution of the 50% trigger efficiency input charge as a function of the channel number, illustrates the reasonable spread (3.8 fC rms) between channels.

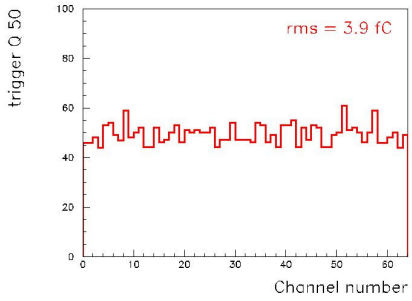

Fig. 4: 50% trigger efficiency input charge as a function of the channel number.

The linearity of the 50% trigger efficiency point with respect to the preamplifier gain has been found better than 5 ‰.

As can be seen in Fig. 5, which represents the S-curves for 3 neighboring channels, the central one is fed with signal up to 10pC, while the neighbors do not trigger up to 8 pC, showing a crosstalk smaller than 1% as required.

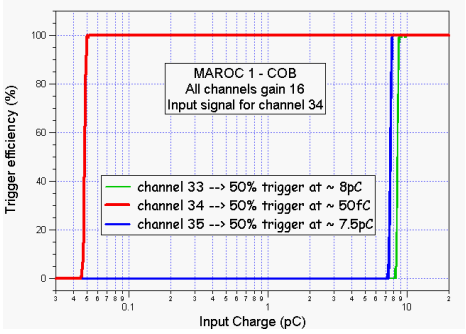

Fig. 5. S-curves for channel 34 and its two direct neighbours, up to an input charge of 10pC.

The pedestal for both fast and slow shapers has a spread of a few mV for the whole chip as illustrated in Fig. 6.

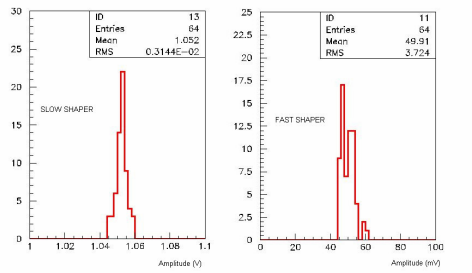

Fig. 6. Pedestal distribution for the 64 channels for the slow shaper (left) and fast shaper (right).

IV. Conclusion

All the tests performed have shown a satisfying global behavior of the chip. By using a chip on board, the substrate coupling problem is removed up to gain 2. This will allow the use of MAROC chip during summer and autumn 2006 beam tests, with a reasonably large choice of configurations.

Thanks to the results obtained from the tests of this first version of MAROC, a new version (Fig. 7) has been developed at LAL and has been submitted in March 2006. The substrate separation applied should solve the coupling problem. Three discriminators are now implemented to have a 2 bit trigger output per channel, which is encoded at 80 MHz. In addition to the functionalities mentioned in the second section a 12 bits Wilkinson ADC has been added per channel on the charge readout path after the track and hold, to deliver directly digitized data.

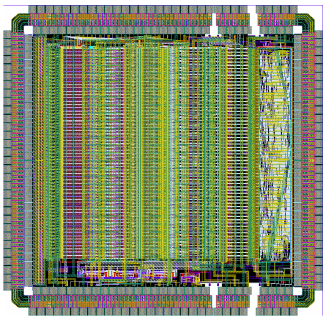

Fig. 7: MAROC 2 layout.

V. References

[1] ATLAS Luminometer Technical Design Report

[2] A. Lucotte et al., *A front-end read out chip for the OPERA scintillating tracker*. Nucl Instr. and Meth. **A521** (2004) 378-392.

[3] Hamamatsu web site, PM H7546B datasheet.

[4] P. Barrillon et al., *64-channel Front-End readout chip – MAROC datasheet*.