Test of a CMOS front-end electronics for high integration detectors

G. Prete, R. Ponchia, G. Bassato

INFN, Laboratori Nazionali di Legnaro

I. INTRODUCTION

The study of exotic nuclei is at the forefront of today nuclear Physics research; coordinated efforts among the European nuclear physics community are on the way, both to develop more intense unstable beams and to study new detection techniques, detectors and related electronics.

To take full advantage of the radioactive beams, high efficiency detectors are needed, able to cover the full solid angle with a high granularity.

To sketch the main requirements of an up to date detection system one can analyse the needs for the study of direct reactions, a basic tool for nuclear structure study based on the interaction of nuclei with light particles like protons and deuterons.

Elastic scattering and inelastic nucleon scattering are the main probes to study the interaction potentials and the density distribution of halo nuclei such as $^{11}$Be, $^{11}$Li discovered in the last decade [1, 2]. Due to the presence of the neutron halo, new low-energy resonances named “soft modes” are predicted [3] which could be studied by inelastic nucleon scattering.

Transfer and break-up reactions give access to the nuclear structure and could be used to study the shell modifications: with the increasing number of neutrons, nuclei are expected to modify the shell structure [4] and the disappearance of magic numbers for nuclei approaching the neutron drip line is predicted.

While the traditional direct reactions were performed using a target of nuclei under study and a beam of protons or deuterons, to study unstable nuclei we have to produce a beam of nuclei of interest (exotic beam) and an inverse kinematic reaction is performed on a proton or deuteron target. Analysing the kinematic of such reaction we observe that the heavy ions are focused in a small cone in the forward direction and the light particles are scattered at large angles, backward also.

A convenient way to study the excited states of these exotic nuclei is to develop a light particle hodoscope with an energy resolution on the order of 100KeV, covering a solid angle of $4\pi$ and with an angular resolution on the order of $1^\circ$ or less, which correspond to a position resolution of few mm if the detector is placed at 15-20 cm from the target.

An alternative way is to detect the heavy ions in the forward direction with the help of a spectrometer and a well segmented focal plane detector.

These design parameters ask for a large number of independent detectors reaching several thousand of electronic channels. To instrument such hodoscopes ASICs (Application Specific Integrated Circuits) are the most convenient approach; they can offer high performances in a compact and detector-integrated solution.

II. MEASUREMENTS

With the aim to study the possible application of such devices, preliminary tests were performed on the VA32_HDR11 produced by IDEAs [5].

It is a CMOS chip integrating 32 channels of low power (2.3 mV/channel) charge sensitive preamplifiers followed by CR-RC shapers and sample and hold circuitry, input and output multiplexing and one analog output buffer in which the amplitude of each channel is serialized for subsequent digital conversion. To allow the connection with trigger electronics each preamplifier output is also available.

Two chips are connected together for a total of 64 input channels and one analog serial output. For trigger purpose the two VA32_HDR11 are connected to two TA32 which generate the trigger for the sample and hold circuitry and

---

**FIG. 1 Operating principle of VA and TA modules.**

the clock for the output multiplexer. The physical size of each ASIC is $\sim 4\times4$ mm$^2$. A stand-alone data acquisition

---
system (VATA_DAQ) connected to the parallel port of a PC has been used to acquire the data. It is equipped with a 14bit ADC (AD7871) with ±3Volt range and a pulse generator, splitting a test pulse to each input channel by the input multiplexer.

The principle of operation of the VA and TA chips is shown in fig.1.

The dynamic range for the VA32_HDR11 is 25pC corresponding to an energy loss of 400MeV in a silicon detector. Due to the high dynamic range this device is suitable for the detection of heavy ions.

Preliminary tests were performed to check the integral linearity and the noise response as a function of the input capacitance.

Results are reported in fig. 2 and fig. 3. The injected charge has been converted in energy loss in Silicon detector for convenience.

Good linearity is evident up to an energy of 350 MeV. An Equivalent Noise Charge following the relation:

$$\text{ENC (e^\text{rms})} = 2132.7 \times C \text{[pF]} + 57552$$

has been measured.

As the capacitance for a 300µm Silicon detector with an area of 1 cm² is on the order of 100 pF, a noise of 271000 e^rms is expected, resulting in a FWHM resolution of ~2 MeV_Si.

An in beam test of the system coupled to a silicon detector array is planned.

The test of other ASICs with the same architecture but with a dynamic range suitable for light particles detection will be performed in the next future.

---

[5] IDEAs : http://www.ideas.no

---

**FIG. 2**  a) Linearity performance for channel 18, a saturation is evident for energies higher than 400MeV. b) linearity evaluation up to 350 MeV. The response is typical of all channels.

**FIG. 3** Noise characteristic as a function of the input capacitance