IL NUOVO CIMENTO **39 C** (2016) 411
DOI 10.1393/ncc/i2016-16411-x

COLLOQUIA: IWM-EC 2016

Test of GET Electronics for the CHIMERA and FARCOS multi-detectors

S. DE LUCA(1), L. ACOSTA(2)(3), L. AUDITORE(1), C. BOIANO(4), G. CARDELLA(3), A. CASTOLDI(4)(5), M. D'ANDREA(3), E. DE FILIPPO(3), D. DELL'AQUILA(6), F. FICHERA(3), B. GNOFFO(3)(7), C. GUAZZONI(4)(5), G. LANZALONE(8)(9), I. LOMBARDO(6), N. S. MARTORANA(8)(10), T. MINNITI(11), S. NORELLA(1), A. PAGANO(3), E. V. PAGANO(8)(10), M. PAPA(3), S. PIRRONE(3), G. POLITI(3)(10), L. QUATTROCCHI(3)(10), F. RIZZO(8)(10), P. RUSSOTTO(3), G. SACCÀ(3), A. TRIFIRÒ(1), M. TRIMARCHI(1), G. VERDE(3)(12) and M. VIGILANTE(6)

(1) *INFN, Gruppo Collegato di Messina and Dip. di Scienze Matematiche ed Informatiche, Scienze Fisiche e Scienze della Terra, Università di Messina - Messina, Italy*
(2) *Instituto de Física, Universidad Nacional Autonoma de Mexico - Mexico City, Mexico*
(3) *INFN, Sezione di Catania - Catania, Italy*
(4) *INFN, Sezione di Milano - Milano, Italy*
(5) *Dip. di Elettronica, Informazione e Bioingegneria, Politecnico di Milano - Milano, Italy*
(6) *INFN, Sezione di Napoli and Dip. Fisica, Università di Napoli - Napoli, Italy*
(7) *CSFNSM-Centro Siciliano Fisica Nucleare e Strutura della Materia - Catania, Italy*
(8) *INFN, Laboratori Nazionali del Sud - Catania, Italy*
(9) *Università Kore - Enna, Italy*
(10) *Dipartimento di Fisica e Astronomia, Università di Catania - Catania, Italy*
(11) *CNR-IPCF - Messina, Italy*
(12) *Institut de Physique Nucléaire, CNRS/IN2P3, Université Paris-Sud 11 - F-91406 Orsay Cedex, France*

received 10 January 2017

Summary. — In this paper we present the results of the tests on the new digital electronics GET (General Electronics for Tpc), which will be used for the readout of the CsI(Tl) detectors of CHIMERA (Charged Heavy Ion Mass and Energy Resolving Array) and for the new correlator FARCOS (Femtoscope ARray for COrrelations and Spectroscopy). The new electronics allows us to digitize the full waveform of the signals produced by the detector. Among its features it is worth noticing the compactness and low power consumption (5 W for 256 channels). Tests have been performed with pulsers, radioactive sources and ion beams. With such electronics very good results in energy resolution and isotope separation of the detected fragments were obtained, by using both hardware and software filters.

1. – Introduction

At the intermediated energies, *i.e.*, starting from Fermi ones ($\sim 30\,\text{MeV/nucleon}$) up to few GeV/nucleons, the studies of reaction dynamics and nuclear structure between Heavy Ions collisions (HI) are faced with the detection of a large number of particles (both charged and neutral) produced in the final states. Many efforts have been done in recent years to cover the complex problems arising in such studies [1]. In recent years, the equation of state (EoS) of the asymmetric nuclear matter and in-medium nuclear effective interactions have attracted much interest in the nuclear and the astrophysical community [2, 3]. Motivated by this physics background and experimental complexity, with the beginning of the new millennium at the LNS (Laboratori Nazionali del Sud) of INFN in Catania the construction of a second-generation device, the 4π multi-detector CHIMERA (Charged Heavy Ion Mass and Energy Resolving Array) was accomplished [4]. The CHIMERA detector is equipped with electronics in discrete components that allowed to identify fragments and light charged particles in charge and-or mass in a wide dynamic range [5]. Evidently, a wide number of investigations performed in heavy-ion collision researches the required multi-particle correlation measurements of high both angular and energy resolution. In fact, light particles and fragments are abundantly produced during the overall dynamical evolution of the reactions from the most peripheral to central collisions covering an impressive time scale from fast (few tens of fm/c) to sequential decay (hundreds of fm/c). The stringent requirements pencilled above triggered also the design of a new ancillary FARCOS detection array [6]. This work is devoted to study and characterization of the compact GET electronics; in fact the final FARCOS array constituted by 5 modules (20 telescopes, in the final project) needs to manage more than 2500 channels. Moreover the 4π CHIMERA CsI(Tl) front-end electronics (1192 detectors) is now obsolete. Our choice was to develop a first stage front-end circuit for FARCOS (including new ASIC pre-amplifiers) and new dual-gain modules coupled to a compact hardware architecture covering digitalization and signal readout, syncrhonization and trigger functions. These last aspects are covered by the GET project. By using the compact GET electronics we have several relevant advantages; for example few racks will be enough for all FARCOS and CHIMERA (CsI detectors) electronics and we will use only 5 W for 256 channels, so the total power consumption will be much lower than the present (for CHIMERA we need now about 60 kW of power on 10 racks).

2. – GET Electronics description

GET electronics is based on the AGET [7] (Asic for General Electronics for Tpc) circuit. Each ASAD (Asic Support and Analog-Digital conversion) card houses 4 AGET ASICs and 4 12-bit ADCs. Each AGET handles up to 64 channels and therefore each ASAD card accepts up to 256 channels. The digital outputs of the 4 ADCs are transmitted with a maximum speed of 1.2 Gbit/s to the CoBo board. The CoBo (Concentration Board) manages up to 4 ASAD, therefore 4 CoBo manage more than 4000 electronic channels. The CoBo is responsible of applying a time stamp, zero suppression and compression algorithms to measured data. It will also serve as a communication intermediary between the ASAD and the outside world with a maximum speed of 1 Gbit/s per CoBo. The MUTANT (MUltiplicity Trigger ANd Time) card manages the multiplicity conditions for the trigger and distribution of the clock on the whole system. The MUTANT capability of accepting external triggers or providing trigger outputs allows communication

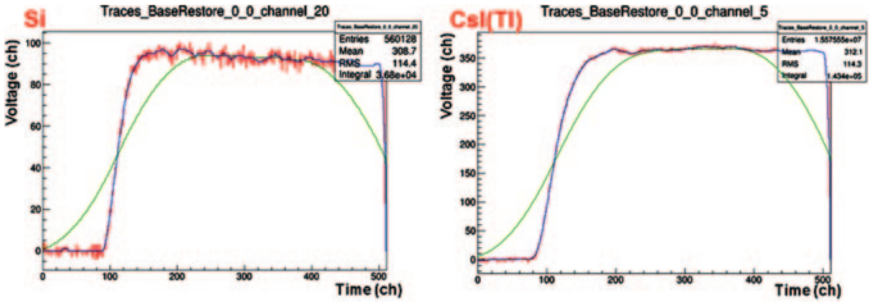

Fig. 1. – Digitized waveforms (red lines in both panels) of a Silicon detector (left panel) and of a CSI(Tl) scintillator (right panel), digitally filtered signals used to determine the signal amplitude (green lines in both panels) and filtered signals used to determinate the rise-time (blue lines in both panels).

with different acquisition systems. The global data are transmitted through the network switch to the computer farm with a maximum speed of 10 Gbit/s for the storage and online analysis. The AGET chip includes 64 channels handling each one detector unit. The architecture is based on the AFTER chip [8] with significant new features and modifications to match very different detector needs. The main characteristics are flexibility and programmability of the system. One can easily change the gain, adjust the required timing of single read out and adapt the trigger system to a given experiment not only using the information on channel multiplicity but also on the position of fired channel. A read-out channel integrates mainly: a charge sensitive preamplifier, an analogue filter (shaper), a discriminator for trigger building and a 512-sample analogue memory. An important feature of GET electronics is that you can choose, for each AGET, at which stage of the channel chain to apply the input signal, *i.e.* charge preamplifier input, analogue filter input, analogue memory input. To identify fragments in charge and in mass during our test we chose the hardware filter input (16 values in the range of 70 ns to 1 μs) and we used numerical triangular filters on the digitized signals to determine the signal amplitude and the rise-time of the signals (fig. 1).

3. – Experimental qualification

Preliminary tests with internal pulser and external pulser and radioactive sources have been performed in order to probe the integral nonlinearity of GET electronics and the reliability of the internal trigger even at low multiplicity values. We probed the performance of the GET electronics coupled with a single CHIMERA telescope (both Silicon detector and CsI(Tl) scintillator) with proton beam at 62 MeV on various targets. The elastic scattering peaks observed in the reactions were used for the particle energy calibration. As expected, energy calibration is practically linear in the investigated range of dynamics (~ 100); however a small quadratic term must be added to match calibration at low energy for the CsI channels. During the CLIR experiment [9], a fragmentation beam on hydrogenated plastic was used. Using the GET electronics we got the ΔE-E identification matrix reported in fig. 2. The comparison between this matrix and the one obtained with classical electronics during the UNSTABLE experiment highlights the better isotopic separation achievable with the GET electronics at least up to Carbon ions.

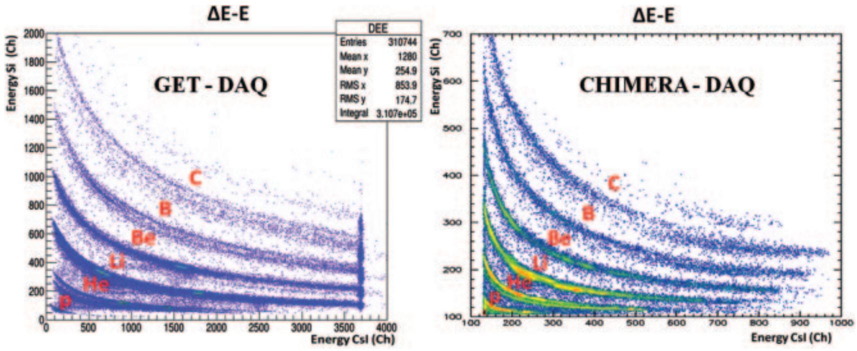

Fig. 2. – Two ΔE-E identification matrixes obtained from the same telescope with GET Electronics (left panel) and the standard CHIMERA acquisition (right panel). We used fragmentation beams at 50 AMeV on a plastic target in both experiments.

4. – Conclusions

We characterized the performance of the GET electronics and evaluated the feasibility of its use for the readout of the CHIMERA and FARCOS telescopes. The possibility of using adjustable numerical filters allows improvements on the CsI(Tl) resolution. Regarding the silicon channel we observe that a very good energy resolution can be attained allowing to satisfy isotopic identification also at very low released energy (the energy loss of 62 MeV proton in silicon is only 500 keV). The dynamic range is limited, therefore two GET readout channels per detector readout channel are needed. Moreover one of the advantages of digital acquisition is the fact that the pedestal is measured event by event (by measuring the baseline of the preamplifier signal) and, consequently, subtracted. Therefore the fit calibration line must intercept the zero and small nonlinearities characterizing CsI(Tl) can be easily measured. In addition, the signal is completely digitized and saved, allowing a more accurate offline analysis thus improving the resolution. The reduction of power dissipation and the decrease in size of the GET electronics (an ASAD card as large as a VME card) make the system transportability easier.

REFERENCES

[1] Cardella G. *et al.*, these Proceedings and references therein.

[2] Li B.-A., Ramos A. Verde G. and Vidana I. (Editors), *Nuclear Symmetry Energy, Topical Issue, Eur. Phys. J. A*, **50** (2014).

[3] De Filippo E. and Pagano A., *Eur. Phys. J. A*, **50** (2014) 32; Russotto P. *et al.*, *Phys. Rev. C*, **91** (2015) 014610; Russotto P. *et al.*, *Phys. Rev. C*, **94** (2016) 034608; De Filippo E. *et al.*, *Acta. Phys. Pol. B*, **40** (2009) 06011; Cardella G. *et al.*, *Phys. Rev. C*, **85** (2012) 064609.

[4] Pagano A. *et al.*, *Nucl. Phys. A*, **734** (2004) 504; Pagano A., *Nucl. Phys. News*, (2012) 22.

[5] Alderighi M. *et al.*, *Nucl. Instrum. Methods A*, **489** (2002) 257; Leneindre N. *et al.*, *Nucl. Instrum. Methods A*, **490** (2002) 251; Alderighi M. *et al.*, *IEEE Trans. Nucl. Sci.*, **52** (2005) 1624.

[6] Pagano E. V. *et al.*, *EPJ Web of Conferences*, **117** (2016) 10008; Verde G. *et al.*, *J. Phys. Conf. Ser.*, **420** (2013) 0112158; TDR FARCOS, `https://192.84.151.50/joomla/`; Acosta L. *et al.*, *J. Phys.: Conf. Ser.*, **730** (2016) 012001, p. 1.

[7] Pollacco E. *et al.*, *Phys. Procedia*, **37** (2012) 1799.

[8] Baron P. *et al.*, *IEEE Trans. Nucl. Sci.*, **55** (2008) 1744.

[9] Dell'Aquila D. *et al.*, *EPJ Web of Conferences*, **117** (2016) 06011.