IL NUOVO CIMENTO **47 C** (2024) 63
DOI 10.1393/ncc/i2024-24063-6

Colloquia: COMEX7

Latest results on NArCoS: A new correlator for neutrons and charged particles with high angular and energy resolution (Neutron Array for Correlation Studies)

E. V. Pagano(1), C. Boiano(5), P. Russotto(1), E. De Filippo(3), G. Cardella(3), A. Castoldi(4)(5), E. Geraci(2)(3), B. Gnoffo(2)(3), C. Guazzoni(4)(5), G. Lanzalone(6)(1), C. Maiolino(1), N. S. Martorana(3), A. Pagano(3), S. Pirrone(3), G. Politi(2)(3), F. Risitano(7)(3), F. Rizzo(2)(1)(8), G. Santagati(3), M. Trimarchi(7)(3) and C. Zagami(2)(1)(8)

(1) *INFN, Laboratori Nazionali del Sud - Catania, Italy*
(2) *Dipartimento di Fisica e Astronomia "Ettore Majorana", Università di Catania - Catania, Italy*
(3) *INFN, Sezione di Catania - Catania, Italy*
(4) *Dip. di Elettronica, Informazione e Bioingegneria, Politecnico di Milano - Milano, Italy*
(5) *INFN, Sezione di Milano - Milano, Italy*
(6) *Facoltà di Ingegneria e Architettura, Università Kore - Enna, Italy*
(7) *Dipartimento di Scienze MIFT, Univ. di Messina - Messina, Italy*
(8) *CSFNSM-Centro Siciliano di Fisica Nucleare e Struttura della Materia - Catania, Italy*

received 31 October 2023

Summary. — An overview concerning the electronic frontend and readout system for the prototype of the neutron correlator NArCoS is reported. The proposed prototype of electronic is designed for the next source and beam commissioning experiments.

1. – Introduction

The NArCoS project [1] (Neutron Array for Correlation Studies) concerns the construction of a new detector devoted to detect neutrons (and light charged particles) performing high angular and energy resolutions. Conceptually the prototype is an array of 64 plastic scintillator detectors (EJ 276G) having the dimension of 3x3x3 cm^3 arranged in a cubic geometry and individually read by SiPM. Assuming a distance of 150 cm from the interaction target the neutrons angular resolution is estimated to be about 1° in the laboratory frame. The energy neutron measurement is entrusted to the time-of- flight (ToF) technique for which about 5% of energy resolution is estimated (Δt = 500 ps). The interest energy range of neutrons is the intermediate one (2 AMeV $\leq$ E/A $\leq$ 100 AMeV) and they will be detected through the proton recoil technique so a veto detector will be mandatory in order to disentangle a charged particle from a primary

neutron. The mission of this project is to have a second generation neutron correlator (but also light charged particles), designed to work in a stand alone mode or coupled to high granularity 4π multi-detector systems like CHIMERA [2] at INFN-LNS, suitable for the incoming facilities for radioactive ion beams (RIBs) [3]. Benefits to the large isospin asymmetry it will be possible to study the in-medium nuclear interaction, the equation of state of nuclear matter, the reaction mechanism just to quote few examples. Among some data-analysis techniques the particle-particle correlations involving neutrons is little explored in the literature and allows the Coulomb interaction to be "turned off". The project received a new impulse in terms of workforce and economical support thanks to the PRIN2021 ANCHISE (contract 2020H8YFRE), which will provide new studies for the next three years (2022–2024), focusing on a dedicated readout digital electronic and the best mechanical configuration. One of the most important issue for the next few years will be the cross-talk study performed both with simulations and with dedicated experiments and tests. In the following sections the prototypal electronic readout system will be briefly described.

2. – The electronic prototype

The circuit of the prototypal readout system performs the sum of all the signals of a matrix of 25 SiPM, AFBR-S4N66C013 manufactured by BROADCOM, in order to have a fast signal, with low noise and amplitude that matches with the energy range of interest with the dynamics of the DAC acquisition. Each of the SiPMs has an active area of 6x6 mm^2 - a thickness of 0.3 mm - and contains 39384 square micro cells of 30 μm of pitch, working in avalanche mode. The readout electronics has been implemented on the bottom side, of the same PCB housing in the front side (with respect to the plastic scintillator) the SiPM matrix that is covering an active area of 30x30 mm^2. The front side of the PCB has also some pins useful for the SiPMs power supply, for the signal, for a test input and for the temperature control. Acquired signals of a neutrons and gammas AmBe source for PSD tests have shown a very good separation between the two particles. This solution performs a very compact design that will allow to bring the detectors of the array closer together as maximum is possible. The circuit has a fast response time of less than 4 ns, while the intrinsic electronic noise of the readout circuit is lower by a factor of 4 than the noise due to the dark current. These characteristics are fundamental for the application of pulse shaping necessary for the discrimination of neutrons. In this electronics prototype good performances are achieved and in the next future a first prototype of the hodoscope will be ready to be tested with sources and beams.

The whole project, involving the INFN (LNS, CT and MI units), University of Catania and the Politecnico of Milano, recently received financial support thanks to funding of Italian Government PRIN2021 ANCHISE (contract 2020H8YFRE). A prototype as demonstrator will be ready at the end of 2024.

REFERENCES

[1] Pagano E. V. *et al.*, *Front. Phys.*, **10** (2023) 1051058 and references therein.
[2] De Filippo E. and Pagano A., *Eur. Phys. J. A*, **50** (2014) 32 and references therein.
[3] Martorana N. S. *et al.*, *Front. Phys.*, **10** (2022) 1058419 and references therein.