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#10-271 High-time and energy resolution detection system for Radioactive Ion Beam Tagging and Diagnostics based on SiC detectors

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Radioactive Ion Beams (RIBs) are a unique tool to study the properties of nuclear structure, exploring also regions of the nuclei chart, located far from the stability valley. Moreover Radioactive Ion Beams (especially β+ emitters) have the potential to provide a large improvement in image quality and signal-to-noise ratio in image-guided particle therapy. The main hindrance toward a clinical use of radioactive ions is their challenging production and the low intensities of the beams. However, several nuclear physics laboratories worldwide have recently undergone or are undergoing relevant upgrades to develop powerful facilities able to deliver intense Radioactive Ion Beams (RIBs), therefore potentially overcoming the aforementioned limitations. At the Laboratori Nazionali del Sud of INFN in Catania (Italy), the construction of a novel high intensity Radioactive Ion Beams (RIBs) facility named FRAISE, called for novel detection systems for the diagnostics and the tagging of RIBs along the transport line and in the measurement chamber. To this aim and for the need of many other particle accelerators around the world, we are developing a novel detection system, based on an array of Silicon Carbide (SiC) diodes, readout by an optimized fast frontend electronics. The full detection system is based on a matrix of sensors that have to withstand a particle rate ranging from 102 pps (very exotic isotopes, extremely far from the stability valley) up to 107 pps, as typical for exotic isotopes near to the stability valley and be able to measure the spatial distribution of the beam intensity and trajectory with sufficient spatial resolution (of the order of 1-2 mm). The choice of SiC is dictated by its superior performance in terms of radiation hardness. In fact, the full detection system is designed to be housed in a DN160 spherical cross to be inserted along the beam path. 100 μm - 180 μm thick monolithic detector tiles, duly segmented in pads of the order of 3 mm x 5 mm, will be arranged to cover a detection active area of about 30 mm × 60 mm as required to reconstruct typical RIBs profiles in the high dispersion point of the fragment separator. The joint measurement of the energy loss (ΔE) of the ions passing through the sensors and the time of flight between two sensors or with respect to a given reference signal such as the Radio-Frequency signal of a Cyclotron provides the Radioactive Ion Beam composition (tagging). Therefore, one of the critical requirements of the developed system is to provide high time resolution in the 100ps range and adequate energy resolution, below 100 keV. The proper identification of "close"nuclei in fact requires time resolutions of the order of 100 ps – 200 ps rms. The core of the system is the custom fast frontend electronics, able to perform full shaping in less tan 60 ns. It is critical to experimentally study the detector response matrix and in particular the mapping of the timing response. To this aim, we carefully developed different small format demonstrators to mimic the different situations we will have to face in the final system and performed several tests with radioactive alpha sources and stable beams. The measured energy resolution is below 60 keV FWHM with the fast frontend electronics and goes down to 30 keV FWHM with a custom ASIC, with slower response. The measured time resolution is below 200 ps rms at 2.5MeV deposited energy and drops below 50 ps rms at 10 MeV deposited energy and below 20 ps rms at 40 MeV deposited energy.

This contribution deals with the study and the experimental qualification of the energy and timing response of the proposed detection system, through a detailed qualification of the timing properties of the developed frontend electronics and the map of the detector response at different beams in the small format demonstrators. The contribution will also show the steps towards the final detection system, with an active area of 30 mm x 60 mm, presently under design.

Primary author: GUAZZONI, Chiara (Politecnico di Milano & INFN, Sezione di Milano)

Co-authors: ACOSTA, Luis (Instituto de Estructura de la Materia, CSIC, Spain); ALTANA, C. (LNS-INFN - Catania, Italy); BARBON, Alice (Dipartimento di Fisica e Astronomia "Ettore Maiorana", Universita'degli Studi di Catania - Catania, Italy and INFN, Sezione di Catania - Catania, Italy); CARDELLA, Giuseppe (INFN, Sezione di Catania - Catania, Italy); CASTOLDI, Andrea (Politecnico di Milano, Dip. Elettronica, Informazione e Bioingegneria and with INFN, Sezione di Milano - Milano, Italy); D'AGATA, Giuseppe (Dipartimento di Fisica e Astronomia "Ettore Maiorana", Universita'degli Studi di Catania - Catania, Italy and INFN, Sezione di Catania - Catania, Italy); DE FILIPPO, Enrico (INFN, Sezione di Catania - Catania, Italy); DE LUCA, Saverio (INFN - LNS, Catania, Italy); GERACI, Elena (Dipartimento di Fisica e Astronomia "Ettore Maiorana", Universita'degli Studi di Catania - Catania, Italy and INFN, Sezione di Catania - Catania, Italy and CSFNSM, Catania, Italy.); GNOFFO, Brunilde (Dipartimento di Fisica e Astronomia "Ettore Maiorana", Universita'degli Studi di Catania - Catania, Italy and INFN, Sezione di Catania - Catania, Italy.); MAIOLINO, C. (INFN-LNS , Catania, Italy); PAGANO, Emanuele V. (INFN-LNS, Catania, Italy); PIRRONE, Sara (INFN, Sez. di Catania, Catania, Italy); POLITI, Giuseppe (Dipartimento di Fisica e Astronomia "Ettore Maiorana", Universita'degli Studi di Catania - Catania, Italy and INFN, Sezione di Catania - Catania, Italy.); QUATTROCCHI, Lucia (Dip. di Scienze MIFT Universita'di Messina - Messina, Italy and INFN, Sezione di Catania - Catania, Italy); POZZI, Mattia (Politecnico di Milano and INFN Sez. di Milano, Milano, Italy); RISITANO, Fabio (Dip. di Scienze MIFT Universita'di Messina - Messina, Italy and INFN, Sezione di Catania - Catania, Italy); RIZZO, Francesca (Dipartimento di Fisica e Astronomia, Universita'di Catania - Catania, Italy, LNS-INFN - Catania, Italy and CSFNSM, Catania, Italy); RUSSOTTO, Paolo (INFN-LNS, Catania, Italy); STUCCHI, Carlo (Politecnico di Milano and INFN, Sez. di Milano, Milano, Italy); TRIMARCHI, Marina (Dip. di Scienze MIFT Universita'di Messina - Messina, Italy and INFN, Sezione di Catania - Catania, Italy); TUDISCO, S, (INFN-LNS, Catania, Italy); ZAGAMI, Cristina (Dip. di Scienze MIFT Universita'di Messina - Messina, Italy and INFN, Sezione di Catania - Catania, Italy)

Presenter: GUAZZONI, Chiara (Politecnico di Milano & INFN, Sezione di Milano)

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