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LIST OF ACRONYMS AND ABBREVIATIONS

SIRIUS	Spectroscopy and Identification of Rare Ions Using S3
IRFU	Institut de recherche sur les lois fondamentales de l'Univers
S^3	Super Separator Spectrometer
DSSD	double-sided silicon strip detectors
FPCSA	Floating point Charge sensitive amplifier

Optimization of the Sirius silicon detector (WP15 – TecHIBA)

Executive Summary

Introduction

During the last decades, continuous progresses have been made toward the mass frontier of the nuclear chart. Today, all heaviest elements up to 118 protons have been synthesized, through fusion-evaporation reactions, with production cross-sections diving below the picobarn. Nevertheless, due to these low production levels, the superheavy elements are still barely known. The high-intensity stable beams of the superconducting linear accelerator of the SPIRAL2 facility at GANIL coupled with the Super Separator Spectrometer (S3) and a high-performance focal-plane spectrometer will open new horizons for the research in the domains of rare nuclei and low cross-section phenomena at the limit of nuclear stability. In order to study them, we need to perform the measurement of their decays (emission of proton, alpha, electron, and gamma). The objective of the SIRIUS (Spectroscopy and Identification of Rare Isotopes Using S3) project is to develop, commission and exploit a state-of-art focal plane detector system for decay spectroscopy at the S3 separator. In this activity, we focus on the use of silicon detectors to detect and measure the decay particles. This task aims at the test and development of the data acquisition system of SIRIUS detector.

Section 1 SIRIUS

SIRIUS is a state of the art detector system for nuclear decay spectroscopy that will be mounted at the focal plane of S3 (Super Separator Spectrometer), which is part of the new SPIRAL2 facility at GANIL, Caen in France. Such a system requires high performance as it is dedicated to the study of very exotic nuclei. It is composed of a set of detectors (Trackers, Si DSSD and Tunnel plus an array of five clover Ge detectors). This set-up is mounted in a compact geometry using new advanced technologies. A sketch of SIRIUS detector is shown here below together with the electronics cards and the turbo pump systems.

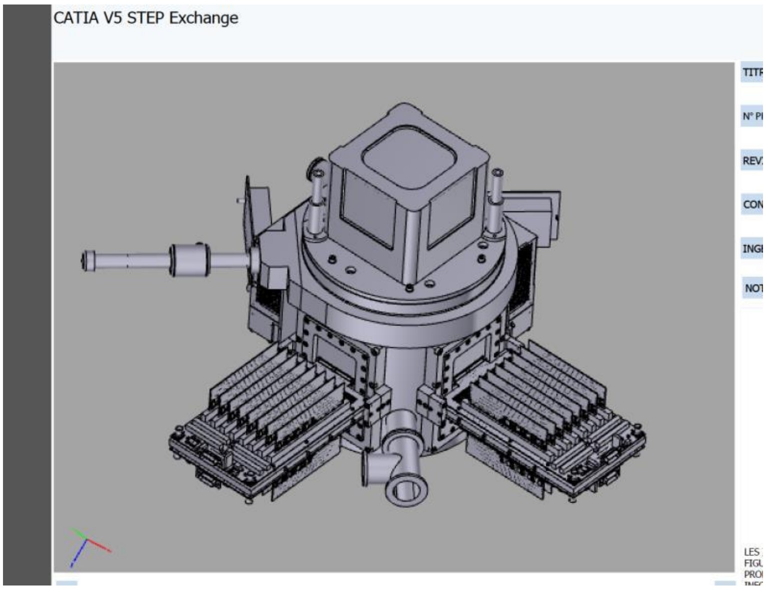

Figure 1 Catia sketch of SIRIUS chambers

SECTION 2 CHARACTERIZATION OF THE ELECTRONIC CHAIN

The complete detection and electronic chain has been built and integrated at IRFU for the DSSD and is now currently under test for full characterization and performance evaluation, using only two strips.

The new front end electronics developed at IRFU allows energy range measurement from 50 keV to over 500 MeV with high precision (2 x 10-3) on low energies and 1 % for the heavy ions. A major challenge has been the development of new electronics with a very large dynamic range maintaining an adequate resolution for the measured particles (with energies from a few hundred keV up to 500 MeV). The dual channel Floating point Charge sensitive amplifier (FPCSA), has been designed and built for the DSSD detector to meet these combined requirements, implements an automatic gain-switching feature based on output its voltage. Gain switching from high to low occurs when output voltage rises above a configured threshold. The FPCSA returns to high gain after 2.5 microseconds insuring system readiness for secondary detections in the same Si strip. A sketch of the electronic chain is shown in Fig1.

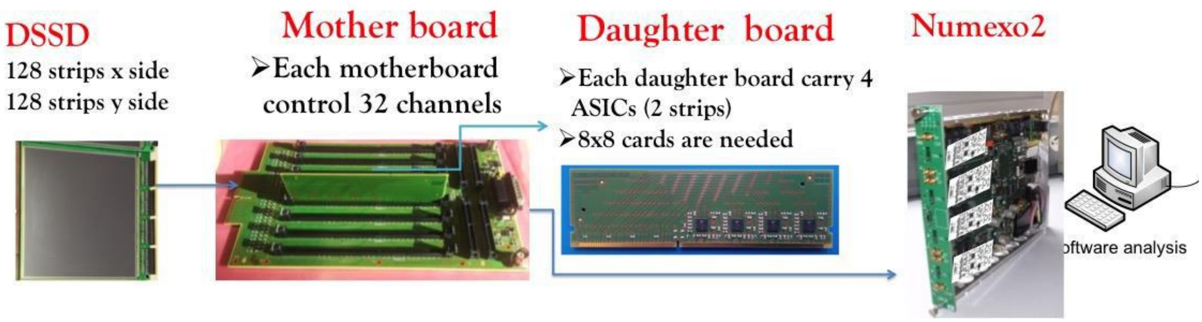

Figure 2 The full electronics chain is shown, where all the components from the motherboard to the daughter board hosting the Asics is shown.

An example of the resulting DSSD energy resolution with the complete electronic chain is shown in the plot below.

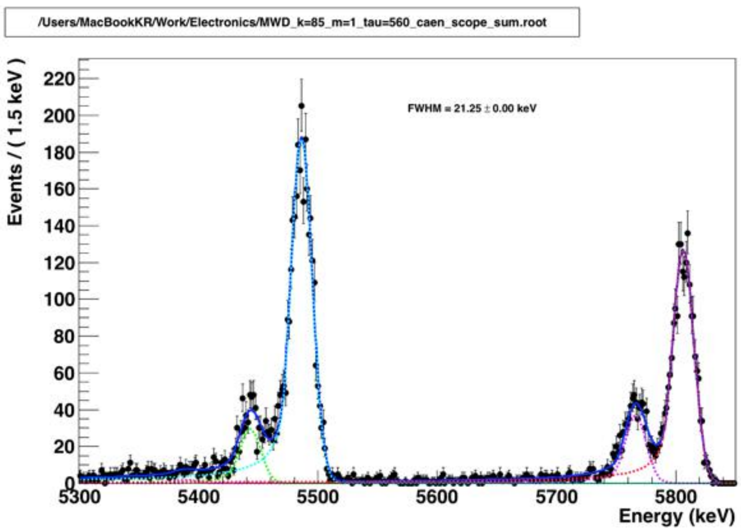

Figure 3 Energy spectrum of triple alpha source Am, Cm , Pu.

SECTION 3 IMPLEMENTATION OF PULSE SHAPE ANALYSIS

The 16 Numexo2 boards carry 16 ADC channels to digitize the input signals over 14bits at 200MHz. Each Numexo2 provides access to two Xilinx FPGAs (Virtex5 and Virtex6). A dedicated self-triggering and data concentration firmware is now under implementation in the Virtex 6 to manage the incoming data flow.

Specific interfaces for slow control and data transfer has been developed during this task. Finally, the DAQ software implement online data processing algorithms to extract physically meaningful information from the acquired data pulses accounting for the specific shaping induced by the FPCSA.

An example of pulse shape analysis algorithm, developed during this task, to extract the energy is shown in the figure below, using the well known trapezoidal filter method. This data comes from an experiment performed at university of Juvaskyla where a digital electronics have been used.

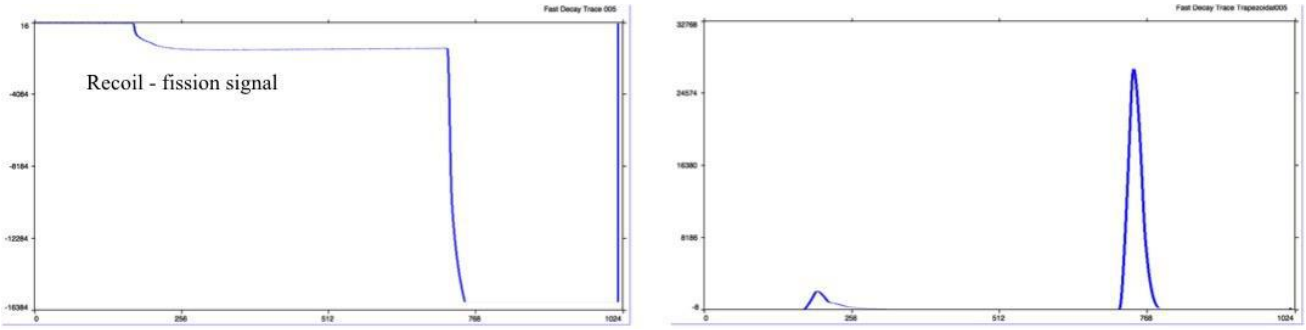

Figure 4 (Left side) Digital signals of recoil followed by a spontaneous fission signals. (Right side) Filtered data in order to extract energy and time of particles hitting the detector.

SECTION 4 WHAT REMAIN TO DO

- Perform characterization of the whole electronics chains (256 strips) with external source triple alpha source and electron source of ^{133}Ba at CEA/SACLAY

- Test the off-line and on-line data acquisition system with all the cards (256 strips) at the test bench

- External triple alpha source test at GANIL

-In-beam test at LISE 2000 at GANIL