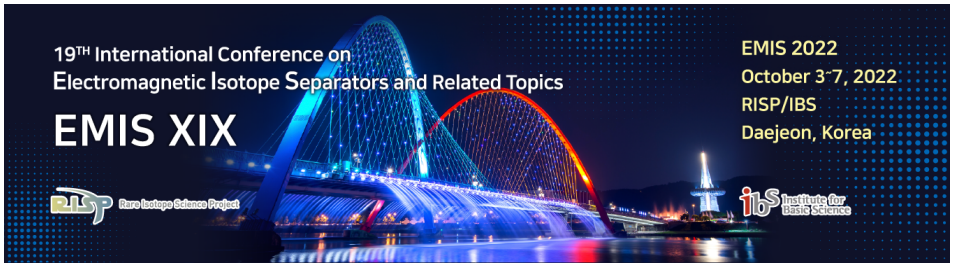

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Development and optimization of the digital electronic for the search of new super heavy element at RIKEN on GARIS-III

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With the extension of the nuclear chart to more extreme regions, the precise and accurate measurement of the decay properties also become more and more challenging. Part of the solution to tackle down some of these challenges is to improve the detection setup of the nuclear experimental setup. One of these solutions is the transition to a fully digital electronic acquisition system.
The Super Heavy Element (SHE) program at RIKEN is currently undergoing such transition to digital electronics for the GARIS II/III detection system [1]. The GARIS II/III implementation of digital electronics uses Pixie-16 revF modules designed and manufactured by XIA LLC (16 bits resolution, 250 MHz sampling [2]). This transition opened the door to a triggerless overall system, the drastic reduction of the dead time in comparison to the analog electronic currently in-use. Moreover, the direct access to the waveform of detected events also triggered the development and investigation of the pulse shape analysis and its performance in the SHE mass region. These electronics modules allow for the online detection of pile up event channel by channel. Combined with the recent upgrade to fast charge sensitive preamplifiers (CREMAT Inc. CR-110 and CR-111 [2]), it led to a reduction of the dead time of the overall system down to 64 ns after implantation. This is a drastic reduction compared to the counterpart analog electronic currently in-used, which only allow 2 events detection within a 70 µs windows (with a 5 µs dead time after the first event).
In addition, the optimization of the energy parameters is crucial to insure the best performance of such system. The onboard energy measurement is performed using some implementation of the Jordanov algorithm [4] which transform the standard exponentially decaying signal of a preamplifier into a trapezoidal shape. This shape is defined by two main parameters (integration time and flat top duration). The optimization of the parameters led to a reduction of the Full Width at Half Maximum (FWHM) of the alpha spectrum of 5 keV, compared to the analog electronic (from 31 to 26 keV), at 7.133 MeV using the production of the 207Ra. Moreover, with the direct access to the waveform of individually recorded events, we developed the Pulse Shape Analysis (PSA) of these data. Indeed, thanks to the very fast response-time of the CR-111 preamplifier the rising edge of waveform are in the vicinity/faster than the typical collection time in the Silicon detector given the optimized condition of operation (-5 C, 80 V). The main component of background in the alpha spectrum comes from the passing through particle (H-like and He-like) in the implantation detector. Most of them can be removed using the veto detector placed directly behind the implantation detector. However, based on this PSA analysis, we determined that we could reduce this background by additional 50 to 60% compared to the veto-detector suppression only.
The detail of the optimization of the digital electronic and the analysis of the data produce will be presented.

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[2] https://xia.com/dgf_pixie-16.html
[3] https://www.cremat.com/home/charge-sensitive- preamplifiers/
[4] Valentin T. Jordanov and Glenn F. Knoll. Digital synthesis of pulse shapes in real time for high-resolution radiation spectroscopy. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 345(2):337–345, 1994.

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