NEW PARTICLE POSITION DETERMINATION MODULES FOR DOUBLE SIDED SILICON STRIP DETECTOR AT DGFRS

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New particle position determination modules for double-sided silicon strip detector (DSSD) were designed that allow to simplify existing multi-channel measurement system in search for the rare events of super heavy elements formation at DGFRS. The main principle is to search position correlated sequences of implanted SHE and followed by alpha-particles/or SF events above predefined threshold energy level in real-time for all 128 back strips. The resulting information is about providing the address of active strip and the coincidence sign. The newly developed system trigger passed the prototyping stage and is about to use in next experiment. This system will reduce the overall system dead time. This article is about describe in deep of the CD32-5M coder units and the PKK-05 preregister which are together the main part of the developed position determination subsystem.

Keywords: DGFRS, DSSD, SHE, Triggering, Data Acquisition, Nuclear electronics

1. Introduction

The pioneering research of the predicted domain of enhanced stability of the super heavy nuclei around Z ~114 and N=184 was performed in the FLNR JINR (Dubna, Russia) during last 15 years [1]. Six new super heavy elements with Z = 113-118 and more than 50 new isotopes with Z = 104-118 were observed for the first time at the Dubna Gas-Filled Recoil Separator (DGFRS) in irradiations of the targets of ^{233,238}U, ^{237}Np, ^{242,244}Pu, ^{243}Am, ^{245,248}Cm, ^{249}Bk and ^{249}Cf with accelerated ^{48}Ca ions beam delivered by U-400 cyclotron.

These new nuclei were detected using arrays of position-sensitive Si strip detectors (manufactured by Canberra NV, Belgium) in the focal plane of the DGFRS of two kinds, with 12 strips and 32 ones. Appropriate registering systems were designed and applied for the measurement of energy, position and time information from reaction products implanted into the detector and from their subsequent alpha-decay or spontaneous fission [2, 3]. Recently the array of detectors at the DGFRS has been modified to improve the position resolution of recorded signals and to reduce accordingly the probability of observing sequences of random events that imitate decay chains of implanted nuclei (fig. 1).

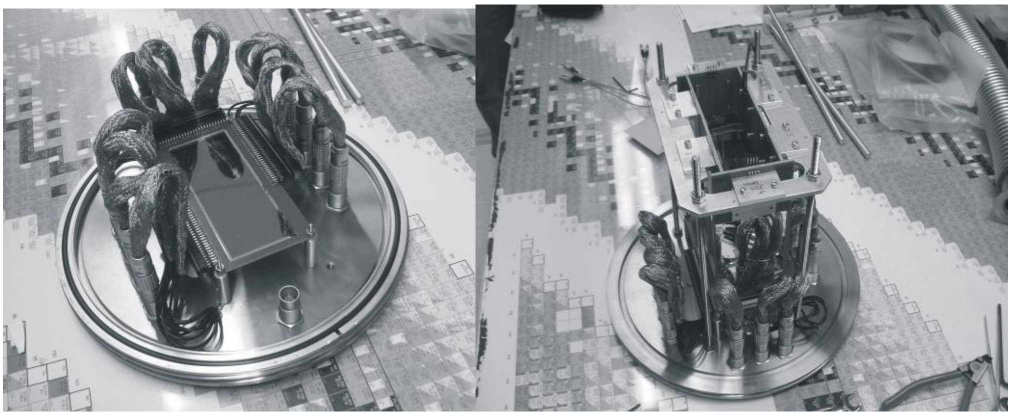

Figure 1. The assemblage of the new DSSD (48×128 strips of 1 mm width) with 48×128 mm^2 active area in focal plane and of six side SSSD

New detection system includes 0.3mm thick double-sided silicon strip detector (DSSD) manufactured by Micron Semiconductor Ltd. This large DSSD has 1-mm wide strips, 48 at the front side and 128 at the back side, equal to 6144 pixels of 1 mm^2 in one Silicon wafer (to compare with 240 and 960 individual cells of formerly used 12-strip and 32-strip detectors, respectively). Such a high pixilation enables to achieve superior position resolution for registering recoil-correlated decay sequences and thus reducing number of potential random events. This detector of implanted recoils was surrounded by six side Si-detectors (MICRON), each 500 microns thick with an active area of 65 mm by 120 mm without position sensitivity. This new Si-detector array has been designed, assembled, commissioned off-line and provided by the Oak Ridge National Laboratory.

Signals from all the detectors are processed using MESYTEC linear preamplifiers [4]. Further, analog signals from preamplifiers were split into two independent measurement branches. Special analog splitter-amplifier PA32-64 was designed by DGFRS group as 4M CAMAC module to provide sharing of every spectroscopic channel between two measuring branches. Transfer factor from input to output is 1.1. For better precision and stability, precision resistors with tolerance of 0.1% and low temperature coefficient of 25 ppm/°C were used in gain circuits. Every module splits 32 input signals into two separate output 32-channel streams. First 32 outputs go to analog registering system of the DGFRS, like what was used in previous experiments [5]; the other 32 outputs go to 50Ω digitizer inputs based on XIA PIXIE-16 modules provided by ORNL [6]. To split the all spectroscopic signals from 183 individual measuring cells of the focal plane detectors (48 plus 128 from DSSD, plus 6 from side SSSD and one from backplane detector used in "VETO-mode") six modules of the splitters PA32-64 were produced. Thus, all the spectroscopic signals together with signals from "START" and "STOP" multi-wire proportional chambers were processed by two different ("analog" CAMAC based and "digital" PIXIE-16 based) registering systems simultaneously, providing additional confidence in validity of performed data analysis.

2. Development of coordinate determination units

Another development of the operating "analog" registering system is associated with attempts to reduce the total system dead-time of data recording and to optimize the method (active-correlation method) of the on-line search for "recoil – alpha-particle" or "recoil – SF" correlations when detecting nuclei of the SHE and their decays.

Application of this method developed in DGFRS research group [7] allows to stop the ^{48}Ca ion beam from the cyclotron after detecting of candidate correlation sequence within energy and time intervals corresponding to decays of parent and/or daughter nuclei in the same position on detector. Thus, the background event rate in the separator's focal plane associated with ions beam, target-like nuclei and transfer-reactions products is strongly reduced. As an example, total energy spectra of beam-on α-like signals and beam-off α particles and total fission-fragment energy spectra, both beam-on and beam-off are shown in fig. 2, a) and b) correspondently. The arrows point the energies of events observed in the correlated decay chains.

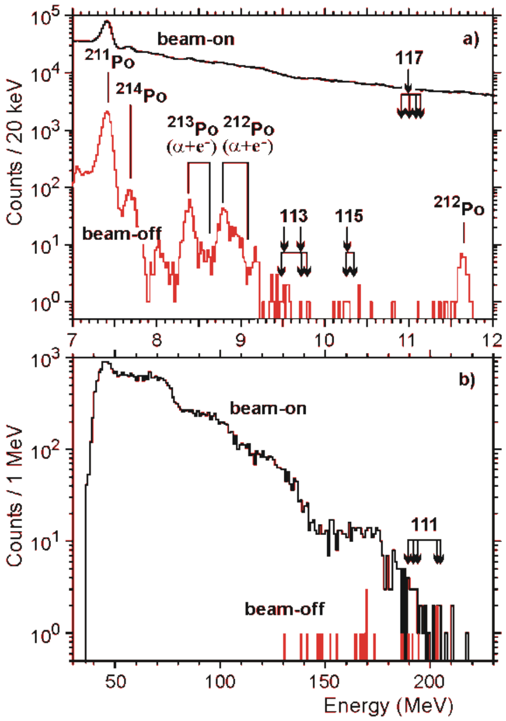

Figure 2. Energy spectra recorded during the 252MeV ^{48}Ca+ ^{249}Bk run [8]

Amplitude of the signals of the detected events in the "analog" CAMAC-based registering system are recorded after spectroscopic signals from 48 front strips and 128 rear strips of the DSSD are processed by measuring SAR ADCs. Every ADC works in combination with a 16-channel analog multiplexer (MUX) that reduces the total number of the measuring channels and gives the code number of the working strip [2]. Thus, we can measure the particle energy and its position in focal plane detector's area using three couples of MUX-ADC for serving the 48 front strips of DSSD and eight MUX-ADC couples for serving the 128 rear strips. In fact, we measure the energy of the detected particle in the DSSD twice (using separate ADCs for signals from front and rear detectors simultaneously). In CAMAC-based registering system the total "dead-time" can be reduced if the conversion time of each ADC is short enough and the number of ADCs to be read in CAMAC is minimum with this aim in view, a new fast analog multiplexer and a new 12-bit SAR ADC were designed (0.8 μs conversion time, compare with 40 μs in [9]).

On the other hand, new system for determining coordinate of detected particles from 128 rear strips was proposed and constructed. It consists of four individual modules CD32-5 that produce - binary code "1 strip of 32" each and primary register PKK-05 producing final code "1 of 128 strips". Every coder CD32-5 has 32 spectroscopic inputs with adjustable amplitude threshold from 5 mV to 300 mV with its viewing in front panel display (fig. 3).

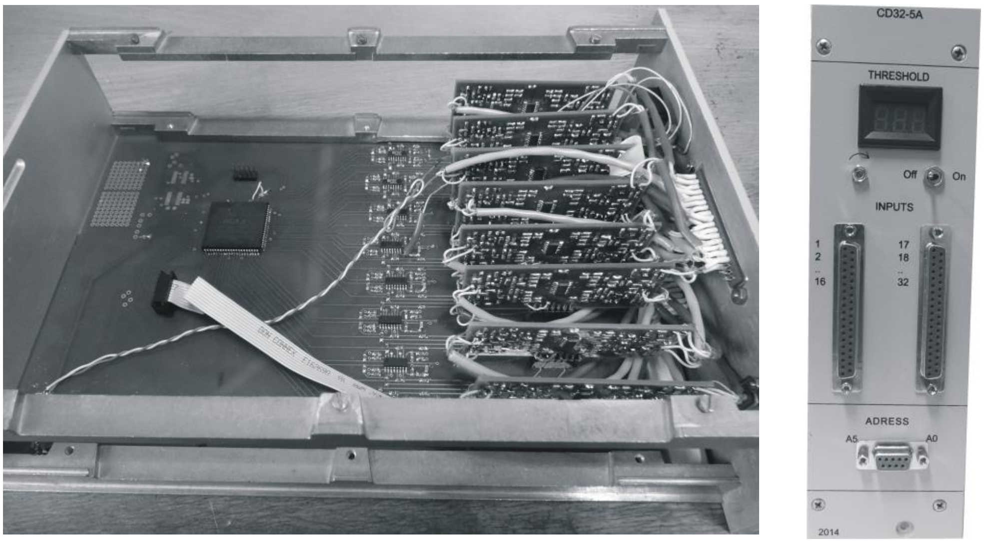

Figure 3. Lay-out of analog and digital parts in CD32-5 prototype and front panel view are shown

The common threshold level can be adjusted for all 32 channels in the module. The AD8564 quad 7 ns comparator [10] works as fast trigger with signals after additional amplification by factor 8 (eight vertical PCBs in fig. 3) and produce logical signal to priority coder if amplitude of input signal exceeds the preset threshold level of the comparator. At the output, each module gives the logical TTL-compatible 5-bit binary code corresponding to the channel. CD32-5 produces also additional output bit for "majority marker" if there were any two neighboring channels worked at the same time. The logical scheme for output code formation based on EPM7128SLC-15N chip application for 32 input channels is shown in fig. 4.

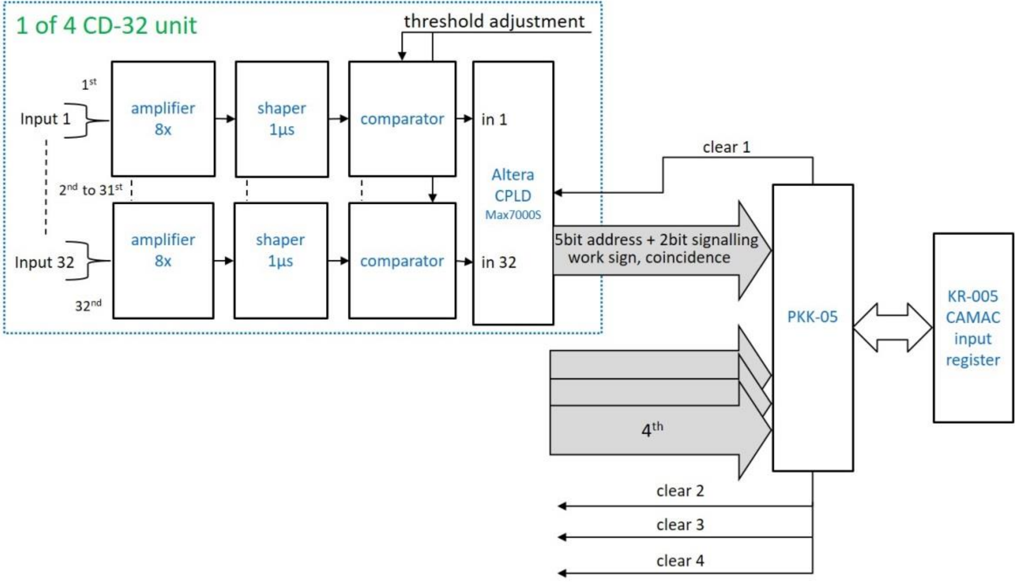

Figure 4. The logical scheme of binary position encoder for 32 channels in CD32-5

Specially designed module – "pre-register" PKK-05 – takes these 5-bit binary codes from four modules CD32-5 and combines these four codes into output 7-bit code (fig. 5 and fig. 6). This binary 7-bit code is transmitted to CAMAC input register KP-005 [11] to be read by crate-controller. The block function of PKK-05 is shown in fig. 6. The output signal levels are TTL compatible. Both CD32-5 and PKK-05 performed as CAMAC 4M and 1M wide modules, they apply only the advantage of CAMAC-crate power supply. So, instead of reading data words of 4 coders, one should read just one data word from KP-005 to obtain data about the strip number among 128 rear strips of focal plane detector. Reading just two data words from one MUX-ADC couple and from register KP-005 one can obtain full info about energy and two-dimensional position of registered charged particle in DSSSD. It helps to minimize the number of modules to be read in CAMAC cycle from eight to one and to get the digital address of the strip with the detected event when serving the rear 128 strips of the DSSSD.

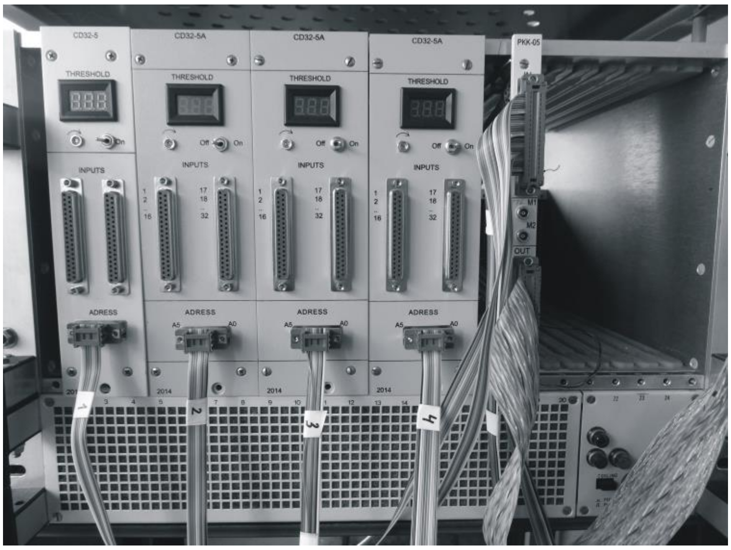

Figure 5. Encoding system "1 from 128" for rear DSSD strips in the individual CAMAC bin

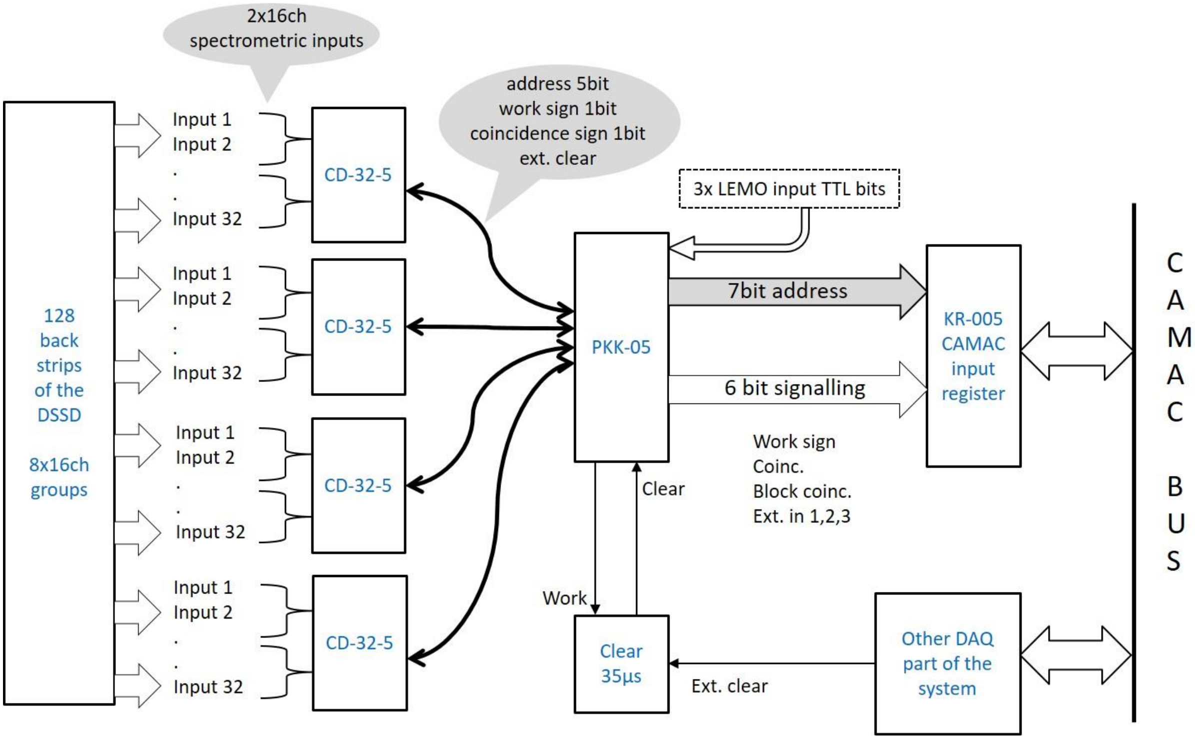

Figure 6. The functional block-diagram the encoder of "1 of 128 strips" into 7-bit code plus signaling

3. Conclusion

- ✓ The subsystem prototype consisting of four 32-inputs modules for coding the strip number for 128 rear strips of DSSD is manufactured. Maximum event rate is 100KHz.
- ✓ Just one CAMAC 1M station is needed to be read for launched rear strip determination in "analog" registering system. Now the coordinate determination system is under testing in real experiment conditions with usage of DSSD array.
- ✓ Subsystem provides also event sign, coincidence sign based on 25ns time window plus inter-block coincidence.
- ✓ Using this created subsystem prototype will improve the total system "dead-time" by ~15 μs.
- ✓ System is software configurable in digital logic sections thanks to Altera MAX7000s series PLDs. So, the new features can be added by new chip software based on request.
- ✓ The convenient code debug testing tool was designed during development for easy tuning the individual coders CD32-5 and the system in general.

4. Acknowledgments

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