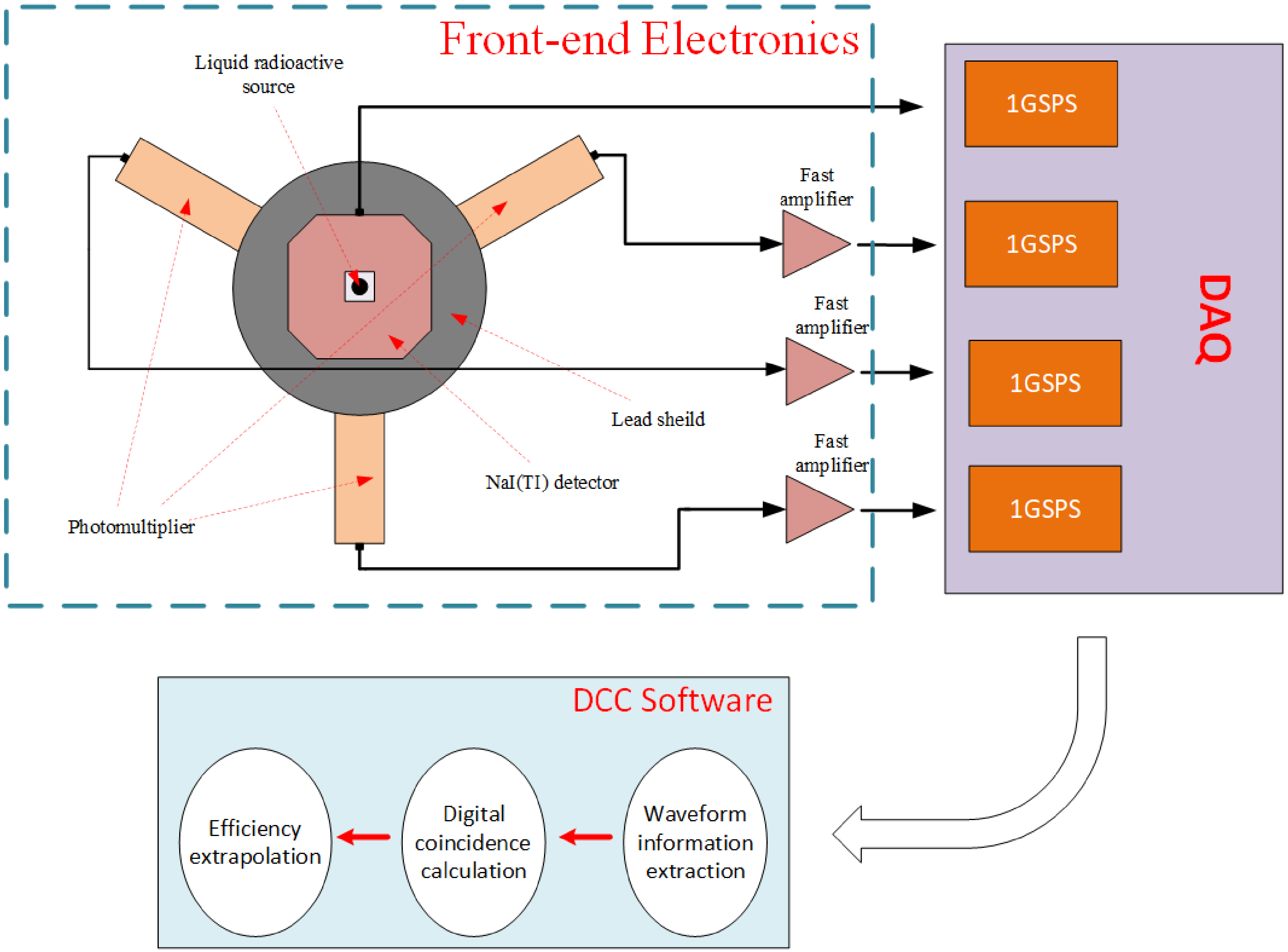
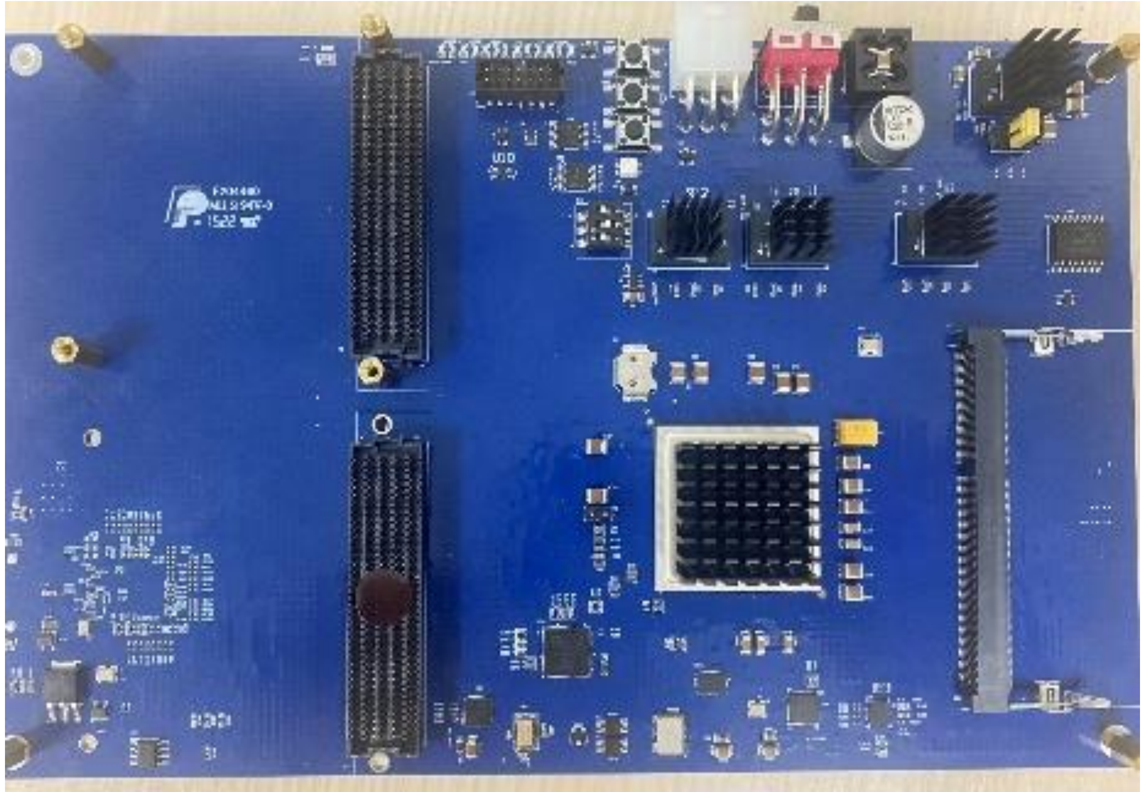
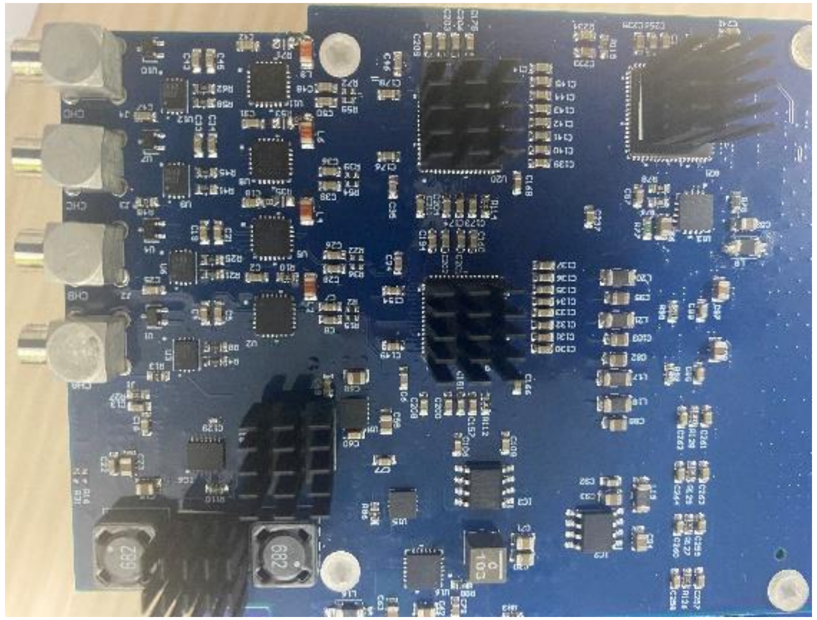
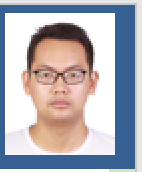

Front-end Electronics
Liquid radioactive source
Fast amplifier
Fast amplifier
Fast amplifier
Lead sheild
NaI(TI) detector
Photomultiplier
1GSPS
1GSPS
1GSPS
1GSPS
DAQ
DCC Software
Efficiency extrapolation
Digital coincidence calculation
Waveform information extraction





Developments of counting rates correction method and its use in the self-developed high speed digitalizer



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Abstract

With the further development of the electronics and software, the digital nuclear instrument will hold a bright prospect. This study develops a self-developed 4πβ-γ coincidence counting system employed for the absolute radionuclide activity determination. The new self-developed 4πβ-γ coincidence counting system consists of the 4 channel 1GSPS sample rate DAQ submodule, the all-in-one kit digital nuclear digital signal processing submodule and the DCC (digital coincidence calculation) calculation software equipped with the new counting rate correction method. The experiments on 60Co indicates that this software can work well in the absolute radioactive measurement.

Introduction

The coincidence counting system consists of the FEE (front-end electronics) subsystem , DAQ subsystem and SCC software subsystem, as fig.1 shown. The FEE subsystem is made up of the detectors(including beta detectors and gamma detectors), pre-amplifiers and fast amplifiers, with which the unclear signals can be transferred into electronic signals. The DAQ subsystem is acted as by the self-designed digitalizer, which is able to run online advanced algorithms for digital pulse process or transmit the waveform to the PC via USB3.0 . The DAQ subsystem generates a file including the energy information and trigger time information of the nuclear signals and this file is used for SCC subsystem to calculate the absolute radioactivity determinations.

the USB3.0 control subsystem is to generate transmit the cmd from PC or receive the data from the DAQ.

the SCC subsystem is coded by C# and constitutes "Spectrum-generation module", "Coincidence-calculation module " and "correlation and extrapolation module". The "Spectrum-generation module " is aimed to obtain the energy spectrums and delay-time spectrum from the recording information. The "Coincidence-calculation module" is employed to calculating the particle count rate and coincidence counting rate. Finally, all of these results are entered into the "correlation and extrapolation module". In the "Efficiency-extrapolation module" , the counting rates are corrected for dead-time loss and accidental-coincidence and then extrapolated to obtaining absolute radioactivity determinations.

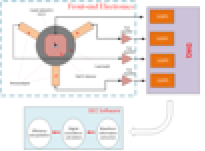


Figure 1. the diagram of the coincidence counting system

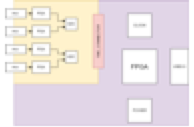


Figure 2. the diagram of self-designed digitalizer

Critical Algorithm

The software can work out the absolute radioactivity determination relays on following aspects:

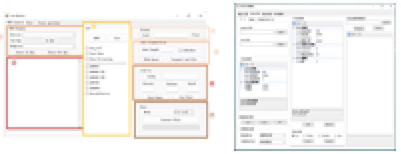
On the one hand , the developed Campion method is applied in our software to correct the dead time loss. In the digital coincidence counting routine, the pulse sequences are inputted into dead-time process to to eliminating the impact of the front end dead time and the after-pulse and this process can cause dead time counting loss. Different from the Smith and Muller formula correction, our developed Campion method can handle both the fixed dead-time mode and the extendable dead-time mode and it is easily to be implemented in software or programmable devices.

On the other hand, accidental coincidence correction is carefully studied in our software. A viable solution is to rearranging the developed Campion method and separated it into dead-time correction section and accidental correction:

[illegible]

where λ represents the accidental coincidence counting rate.

Figure 3. Self developed USB control and DCC software interface



Results

In the experiment, 60Co is used to verify the DCC software equipped the new generalized counting correction method. Five LS sources, four solid sources and five point sources made from the same mother solution were measured by the 4πβ(LS)-γ, 4πβ(PC)-γ and a calibrated high purity germanium (HPGe) γ-ray spectrometer respectively. The uncertainty of the γ-ray spectrometer is about 0.5%. The new method can be verified by comparing the results calculated by the DCC software and the results obtained by the γ-ray spectrometer.

The En value in figure 4 is less than 1, indicating that the results are consistent within their uncertainties.

Figure 4. COMPARATIVE OBSERVATION ON THE RESULTS OF THE TWO METHODS

Method				$\Delta\%$	E_n
The $4\pi\beta(PC)-\gamma$ coincidence counting method		The γ-ray Spectrometry			
A_{ref} (kBq/g)	μ_A (kBq/g)	A_{ref} (kBq/g)	μ_A (kBq/g)		
196.65	0.37	196.7	1.0	0.00	0.2

Method				$\Delta\%$	E_n
The $4\pi\beta(LS)-\gamma$ coincidence counting method		The γ-ray Spectrometry			
A_{ref} (kBq/g)	μ_A (kBq/g)	A_{ref} (kBq/g)	μ_A (kBq/g)		
196.89	0.21	196.7	1.0	0.00	0.04

Discussions and Conclusions

In this study, a new digital coincidence counting system consisting of the self-design DAQ and the generalized counting correction method is developed. The method can work well in both 4πβ(LS)-γ and 4πβ(PC)-γ coincidence counting system regardless of which dead-time mode is set. The results show that the self-developed digitizer is work well and the generalized method can completely take place of the Smith formula and the Muller formula when first-order approximation is used

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