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Software for control and measuring instrumentation of the GAMMA-400 gamma-telescope fast scintillator detector system

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Abstract

Currently, the final stage of the ground tests for the technological detector of the high-energy gamma-ray telescope (GRT) GAMMA-400 are finished. The new space GRT will accept the gamma-rays with energy more than 400 MeV and is aimed to open our eyes for so-called “dark matter” problem in the Universe. The high-speed scintillation detectors system (SDS) is used one of the main GRT particle detectors and the good ground test measurements will let the future space mission to get the reliable data. This paper describes the software and hardware of the laboratory control and calibration systems for physical measurements of GRT STDS properties.

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Keywords: GAMMA-400, VME standard, GSE, gamma rays, scintillator; software and hardware

1. Introduction

The fast SDS includes fast anti-coincidence detector (AC), fast time-of-flight (TOF) detector system and fast scintillation detector system (S3,S4) of calorimeter detectors (CC1, CC2) [1] and generates trigger signals for gamma-ray event recording process (see Fig. 1.). The AC system allows to identify the gamma rays converted to the charged electron-positron pairs in converter detector (C). The TOF system allows to define the direction of the falling particles. The space GRT has the angular resolutions about 0.01° at the 100 GeV gamma-ray energy that allows to define direction to the sources of cosmic gamma rays.

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Characteristics of the GRT allow to explore the gamma lines from "dark matter" particles. These characteristics are the best to complain with other experiments (FERMI, AMS etc).

2. Hardware description

The AC, TOF and SDC detector systems are the fast plastic scintillation detectors with large active area, divided into separate modules in the form of strips. Light signals from the charged particles passed along scintillators are accepted by solid silicon photomultipliers (SiPM), mounted at the opposite ends of detectors.

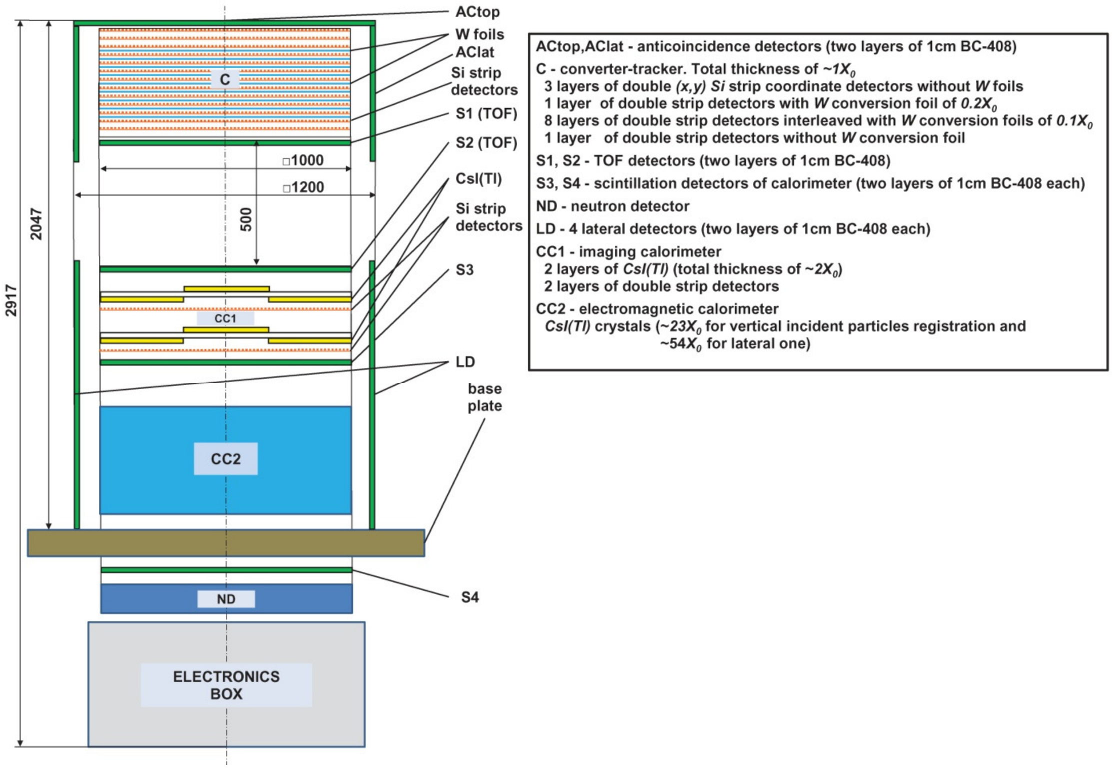

Fig. 1 Scheme of GRT

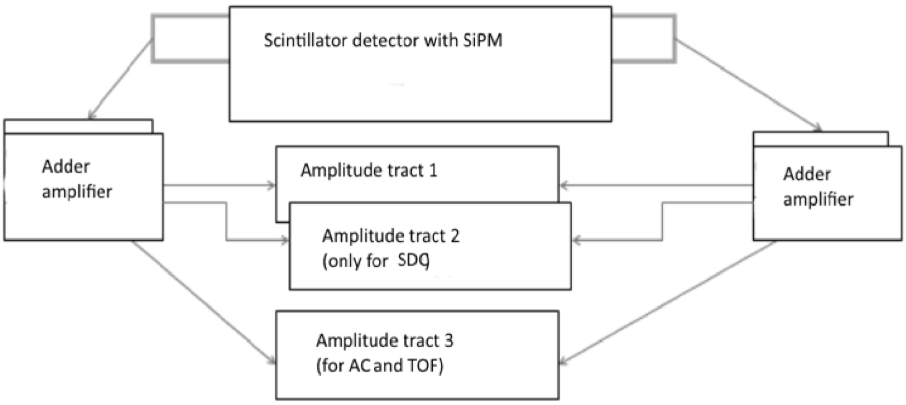

Fig.2 Simplified scheme of front-end electronics

The signal is processed in accordance to the following simplified block diagram (Fig. 2), and is amplified on the adder-amplifier for the TOF and AC. There are two electronic channels - amplitude and time ones.

The S3 and S4 systems has two amplitude electronic channels
(to increase a registration dynamic range).

We use the so-called "fast" scintillators made by Bicron Corp. (Bicron-408) for production of the light signals from charged particles. Scintillators dimensions are (100x10x1) cm. All the walls of each scintillator are polished, special coatings are not used.

Block diagram of the test ground support equipment (GSE) for quick measurement of main detectors characteristics in the laboratory is shown in Fig. 3.

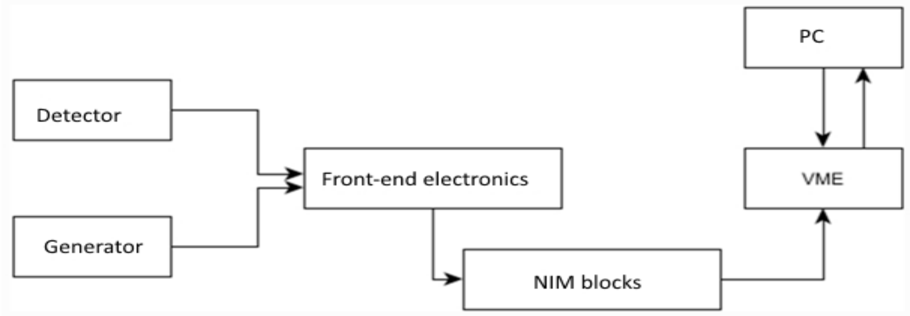

Fig.3 Block diagram of the ground test equipment

The main elements of the test equipment are the auxiliary signal generator that simulates the energy deposition of the particles, the system for the collection and pre-treatment on the basis of modular electronics of NIM and VME standards, as well as personal computer of the GSE (PC) with the specialized software (ACT).

In measuring complex the following hardware and interface VME modules are used:

- Crate CAEN VME 8011 - VME64 7U Low Cost crate, 21 Slot;
- Controller Rack CAEN V2718KIT - VME-PCI Bridge (V2718) + PCI OpticalLink (A2818) + Optical Fibre 5m duplex (AY27);
- CAEN 16 Channel dual range QDC MOD. V965 [2]:
- CAEN 8 Channel dual range pick ADC MOD. V1785 [3].

3. Software

3.1 Structure of the ACT imaging

ACT goals are the following:

- to provide an opportunity to recognize and initialize the ADC and QDC hardware devices in the rack;
- to provide an opportunity to set different parameters of the detection system, namely: a pedestal, thresholds, the survey blocks;
- to ensure the visualization of information coming from the detection system in real time;
- to ensure the preservation of the information received in a variety of formats and the possibility of its subsequent processing;
- to provide backup information in the case of equipment failure;
- to perform pre-processing: finding peak maximum, FWHM, and also calculation of the recommended width of QDC Gate to maximize the dynamic range.
- The result of the above tasks realization was the program with the opportunities which will be described in more detail below.
- ACT is a program consisted of the following major sub-programs:
- the functional testing of connected modules;

- the acquisition of experimental data from the detectors and their buffering in GSE and recording to the file;
- the online and offline data visualization modules, designed to collect the data from the fast scintillation detectors.

3.2 Description of the software package

The sub-program of functional testing allows us to define the types of connected modules (ADC or QDC), to prepare modules for use, collect and control the generation of data formats.

Preliminary, all the VME blocks, according to the instruction, were checked for serviceability by VME Firmware CAEN (*caenvmedemo* program) [4]. All blocks must correctly identify and display the correct version of their firmware. “Read” and “Write” commands must also run correctly.

We developed the algorithm and data collection program. This program includes sub-program for functional testing. This allows the user first to check the availability of the selected blocks to hold the trial read-write cycles, and positive results to start collecting data. The program collects the data from the selected blocks and writes them to a file on GSE PC.

The program of data collection has got the new opportunities:

- The ability to select the name of the file that will store the collected data;
- The ability to add new data to the end of the file, if the file is not empty;
- The ability to decide which units will carry out data collection;
- The ability to specify block addresses and name of the block manually;
- The ability to check the trigger signal automatically and the ability to collect data only when there is an active trigger signal from the trigger unit;
- The ability to collect the data without checking the trigger signal.

To test the models of detectors the visualization program for the information collection through the VME interface has been developed. The program is written for Linux development environment using *Qt Creator*, having a flexible graphical interface builder, compile and debug programs.

Visualization of the amplitude spectrum is produced in the form of a histogram "the channel number - the number of events in the channel" with the ability to change the scale if needed.

The program allows to visualize collected data in on-line mode and save the file on a physical device connected to a computer for further offline visualization.

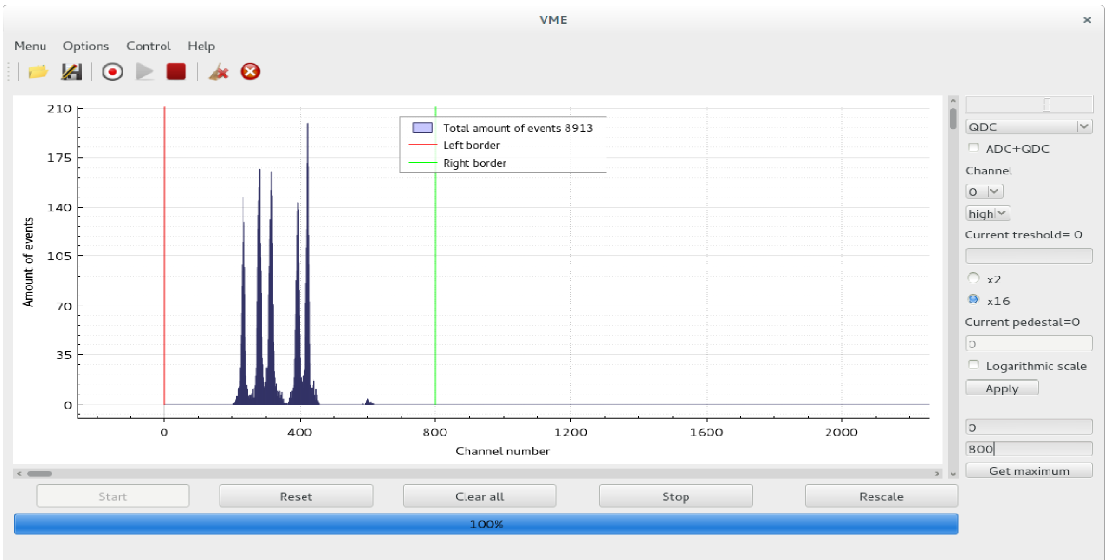

Fig.4 Main window of the visualization program

Data visualization is performed in two modes:

- Expectations of the situation when the buffer is full, i.e., after the prior accumulation (buffering) of registered events data, is used at low rate events;
- Expectations for a current event are used at high rate events.

The program also lets you to save addresses and configuration modules to access the modules without the necessity to enter manually an address and settings at the beginning of the next session of the experiment.

The main program window of data visualization is shown in Figure 4. This figure shows the field of data visualization in the form of the spectrum. The right-hand side menu allows to configure the functional blocks.

The program provides the identification, initialization and connection to all ADC and QDC units, founded in the track. This option gives some time to check the correct block unit connections to the crate and simplify the procedure for connecting the main PC to the block units.

The program allows to store data in different modes (formats) also, namely:

- CAEN format: data block (34 words for 32 bits each). Header format is always the “Header word”, the last word is the “End of block” word. Base block of words allows to take the data for each channel and range of collected data.
- Histogram format, i.e. files includes two columns (channel and amount of event of this channel);
- Image format (*.png).

The online visualization mode occurs during the data collection process, and the experimental data are displayed on the screen and saved to a file for temporary storage. These operations ensure a data integrity, even if a malfunction of the software part is existed.

4. Conclusion

As a result, we developed the base software system for data collection from the fast SDS based on the VME standard modular equipment, including the software functional testing, data collection software and open source visualization software also. The testing of the developed software provided the experimental data confirming the correctness of the choice of technological components for the gamma-telescope fast scintillator detectors system based on Bicron-408 plastics made by Bicron Corporation..

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