Development of anticoincidence system for “Signal” experiment

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Abstract. An information about development of an anticoincidence system for charge particle rejection in “Signal” experiment on a board of “Interhelioprobe” spacecraft are presented. A construction of a detector and components of scientific equipment are described. Initial tests of the scintillation detector, silicon photomultipliers and future plans of developing are discussed.

1. “Interhelioprobe” mission and “Signal” experiment
The “Interhelioprobe” [1] mission aims at study of the inner heliosphere and the Sun at close distance and from out-of-ecliptic orbit. List of mission goals:

- Magnetic field in the solar polar area;
- Fine structure and dynamics of the solar atmosphere;
- Mechanisms of solar corona heating and acceleration of solar wind;
- Origin and global dynamics of solar flares and coronal mass ejections;
- Generation and transport of energetic particles at the Sun and in the heliosphere.

“Signal” experiment is developing by National Research Nuclear University MEPhI for the study of solar gamma-ray using the xenon gamma-ray spectrometer. The main scientific tasks of “Signal” experiment are:

- Research of X-ray and gamma emission in lines and continuum in energy range 30 keV - 5 MeV;
- Study of gamma-ray bursts of Galactic and Metagalactic origin;
- An analysis of gamma-ray lines near the Earth and Venus;
- Charged particle fluxes registration along the spacecraft trajectory.

2. Scientific equipment and anticoincidence detector system
The main part of “Signal” experiment scientific equipment is xenon gamma-ray detector (XeGD) [3]. It is a cylindrical ionization chamber with Frisch grid, filled with high-pressure xenon (density of ~ 0.3 g/cm³) and operating in pulse mode. Detector is surrounded by scintillator anticoincidence detector (ACD), which protect from charged cosmic-ray particles.
Electric signals produced by anticoincidence detector system will be used for formation of inhibit signal. During this timeframe Digital Electronics Unit will reject signals from XeGD.

2.1. Scintillator detectors, silicon photomultipliers, comparators
Anticoincidence detector is made of plastic scintillators BC-408 based on polyvinyltoluene manufactured by Bicron. Barrel part of ACD consists of plates shown in figure 2.

The size of each plate is 325x40x5 mm. For light detection Silicon Photomultipliers MicroSB-30035-X13 manufactured by Sensl (SiPM) of 3x3 mm size are used. Endcaps are disks of 140 mm diameter and 5 mm thin.

For counting application or inhibit signal generation a fast comparator is suitable. We have used AD8561 single supplied 7ns comparator. To control inhibit signal width a latch of comparator and additional resistor-capacitor were used. By adjusting of RC constant it possible to setup required time gate. Digital electronics unit is a device based on FPGA Cyclon III for signal processing and spectra acquisition.

3. Initials tests of scintillator detector components
For test of detectors we registered atmospheric muons. Scintillators was wrapped in white paper used as diffuse light reflector. For light transmission between Silicon Photomultipliers and scintillators, silicon
optical grease BC-630 was used. SiPMs were powered by laboratory power supply. Biasing voltage was 27.6 V. An example of an electric signal from SiPM is shown in figure 2.

![Figure 3. Example of single SiPM signal waveform.](image)

![Figure 4. Waveforms superposition of signals detected by SiPM.](image)

![Figure 5. Signal amplitude distribution.](image)

In figure 5 atmospheric muons signals amplitude distribution registered by SiPM coupled with scintillator is shown. Voltage amplitude of signals has average of 10 mV. Decay time of signals was several hundred nanoseconds. No additional signal preamplifiers were used.

3.1. Comparator tests

On first stage comparators were tested with rectangular pulse generator. Oscillograms of various width generator pulses and comparator response signals are shown in figure 6 and 7. Performance of AD8561 is enough to register 20 ns width signals.
After the generator, AD8561 were tested with scintillator detectors and silicon photomultipliers. Threshold voltage of comparator was 10 mV. Scintillator registered atmospheric muons. SiPM signals weren’t amplified. An example of comparator response on photomultipliers signal is shown in figure 8.

There is ringing on SiPM signal waveform caused by comparator switching at pulse edges due to a result of stray capacitance, improper ground impedance. To reduce negative effects optimization of electrical circuit for high speed performance is required.

4. Conclusion
On next steps muon telescope will be constructed to measure efficiency registration for each scintillator of anticoincidence detector. Due to low muon rate registered by scintillator it is planned to use a microcontroller as counting device. After efficiency registration measurements, anticoincidence detector will be tested with xenon gamma-ray detector.

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6. References
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