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PHYSICS OF ELEMENTARY PARTICLES AND ATOMIC NUCLEI. EXPERIMENT

Online Gas Gain Monitoring System

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Abstract—The paper presents methods and means of automated gas gain stability monitoring and registration for gaseous proportional counters. Experiments using straw-detectors require permanent monitoring of the gas gain, which depends on a set of variables. However, it is not always possible to control each parameter, so monitoring the resulting gas gain change is more optimal. To solve this problem, a monitoring system was developed that digitizes the complex influence of all factors and is designed to diagnose and debug the detector operation performance, as well as to prevent distortion of experimental data. The work of the system is based on acquiring ADC spectra of the detector response to a Fe^{55} source and on monitoring the peak position of this distribution. The peak position in the specified range of values is the main indicator of the correct operation of the detector. Using this system, useful information was obtained about the undesirable influence of some of external factors and a procedure of a complex troubleshooting was developed for the experimental stand.

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MINISPD TEST STAND

MiniSPD is a setup for testing of all types of detectors that will be used in the SPD [1]. It includes a trigger system, straw, silicon and GEM trackers, electromagnetic calorimeter modules, and a lead filter for rejecting the soft component of cosmic rays. The stand is designed to measure important parameters such as spatial and time resolution, efficiency, drift characteristics, gas gain, etc.

In addition, the installation is used for testing the data acquisition systems, slow-control, and online monitoring.

STRAW TRACKER

The straw tracker of the test stand consists of 2 chambers. Each one has 64 drift tubes in 2 layers with the straw diameter of 6 mm and the length of 20 cm. The setup has also an additional straw chamber with 4 tubes only especially for the gas gain monitoring purposes.

Gas mixture for the straw chambers consists of Ar and CO_2 in the proportions of 70 : 30. Mixing of the gases in the required proportions is performed using the gas mass flow regulators and special controller manufactured by "Eltochpribor". Maintaining the desired pressure in the system is provided by oil valves.

SLOW CONTROL SYSTEM

Experiments using straw detectors require continuous monitoring of the gas gain coefficient, which depends on a set of variables: the temperature of the gas mixture, absolute pressure, proportional gas composition, operational high voltage. A number of systems is responsible for keeping these parameters within acceptable range. It is possible and necessary to control and monitor each parameter separately, but it is also important to track the complex influence of all the factors.

Our system for monitoring selected parameters digitizes the complex influence of all factors and is designed to diagnose and debug detector parameters, as well as to prevent distortion of experimental data.

GAS GAIN MEASUREMENT

The operation of the slow control system for monitoring the working gas parameters of the detector is based on acquiring the charge spectra peak of a calibrated radioactive source as it is shown in Fig. 1. In our case, the source is Fe^{55}.

The peak position corresponds to a given gas gain, so it is a good indicator of the gas gain stability of the detector, which, in turn, depends on the gas mixture composition. If variation of the peak position exceeds a given threshold, it is an emergency situation. A specialized software was developed for gas parameters slow control. Both Windows and Linux versions of software were created.

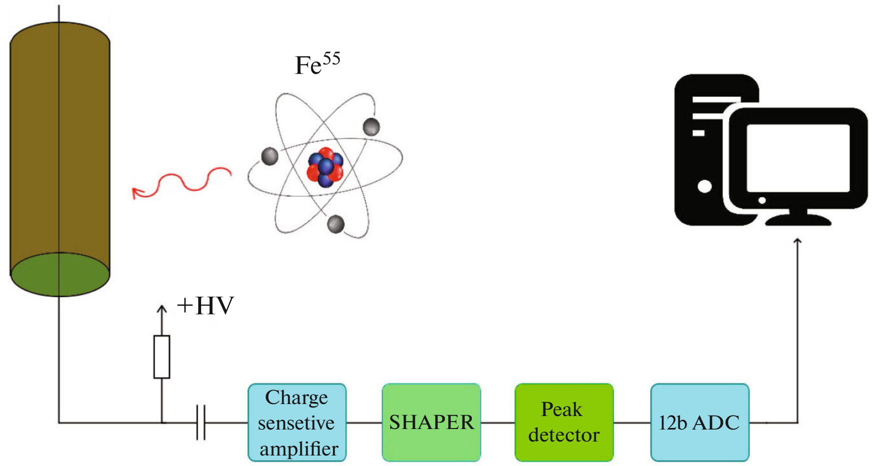

Fig. 1. Architecture of gas gain monitoring system.

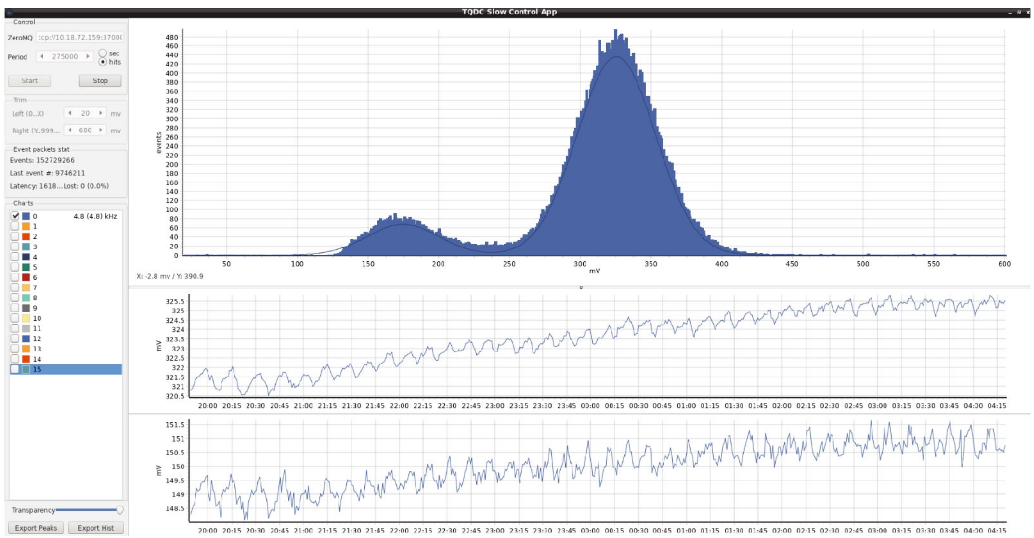

Fig. 2. Main screen of the gas gain monitor application with an acquired Fe^{55} spectrum (top) and the positions of the main (middle) and escape (bottom) peaks recorded during the monitoring periods of several hours.

The application receives data from an ADC over the network using the ZeroMQ [2] protocol. A charge spectrum is formed based on data from the ADC. The data are acquired periodically with a given interval to collect enough statistics to determine the spectrum peak position. Parameters of the peak are logged, and if they go beyond specified limits, an alarm is issued by the software.

An algorithm for finding the peak of the acquired spectrum is fully automatic and consists of the following steps:

(1) An approximate position of two peaks of the measured Fe^{55} spectrum is determined.

(2) Two peaks are preliminary fitted with two independent Gaussian distributions.

(3) More precisely the peak positions are determined by fitting the spectrum with a sum of two Gaussians using the least squares method.

SOFTWARE INTERFACE

The software interface is concise and intuitive as is shown in Fig. 2: controls and parameters are located on the left, and graphical output occupies the main area on the right. The graphs are interactive and allow to zoom easily the area of interest with the mouse.

The interface is the same on all platforms. Multiple instances of the application can be started simultaneously. It makes easy to access the application from multiple workstations as well as to make a visual comparison of the data taken at different time periods.

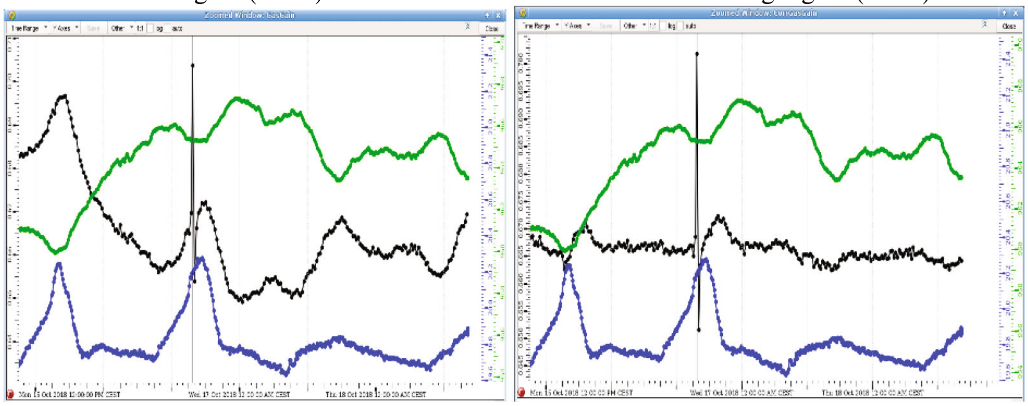

Fig. 3. Gas gain (black) correction at NA62 experiment data. Temperature (blue) and pressure (green) fluctuations.

During a trial operation of the monitoring system a number of problems of the gas supply system were identified:

• The proportion of the gas mixture was changing in time as a result of the electronic gas mixing unit failure. At the same time, the gas mixing controller reported normal operation.

• The gas gain variation caused by changes of the ambient temperature exceeded the detector specification.

TEMPERATURE AND PRESSURE CORRECTION

Since the gas gain depends on a number of variables, the reason for the controlled value going beyond the limits set by an operator is not always obvious and may require a lot of time to find the cause. In this regard, the priority task is to take into account the influence of possible drift of individual environmental parameters. The strongest dependence of the gas gain coefficient is observed on the composition, temperature, and pressure of the gas in the detectors.

It is planned to install temperature and pressure sensors in the gas system and receive information from the sensors via the ModbusRTU [3] network. A beta version of the software with the function of leveling the effect of changes in the gas gain coefficient caused by changes in temperature and pressure values has been prepared. The result of a similar algorithm applied to NA62 [4] straw tracker response is shown on Fig. 3.

CONCLUSIONS

• A system for monitoring the gas quality and the detector operation performance is created.

• A specialized software for the monitoring system is developed both for Windows and Linux operating systems.

• A change in the gas mixture composition due to an electronic gas mixing unit failure has been identified using the developed monitoring system.

• An algorithm of leveling the effect of changes in the gas gain coefficient caused by changes in temperature and pressure is now being developed.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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