The Detector Control System for the ARGO-YBJ experiment

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Abstract

Monitoring and controlling the operational stability of the RPCs for ARGO-YBJ is a crucial task to achieve the reliability required for a long-term experiment of 6500 m^2 sensitive area, performed in an unusual environment at 4300 m a.s.l. on the Tibet plateau. An adequate Detector Control System (DCS) to accomplish this task is therefore required. We present here the architecture and control algorithms of the DCS purposely developed. Due to the large number of parameters to be monitored (4317), a cost-effective multiplexer board has been developed: 154 such boards and one central VME system will perform the control tasks for the whole experiment. The DCS also implements emergency and recovery procedures in case of anomalous system behaviour.

1. Introduction

The ARGO-YBJ experiment [1] is a system developed for the detection of small-size air showers generated by primary cosmic rays with energy ranging from 100 GeV to 10 TeV. The detector will have to operate for many years in order to map the galactic sources of high-energy cosmic rays which are visible at the experiment site. The operational reliability and stability of the detector is therefore a mandatory goal. A suitable system for monitoring and controlling the detector operation has been developed for this purpose.

2. The detector operational parameters and DCS algorithms

The ARGO-YBJ detector consists of Resistive Plate Chambers [2] fully covering a central area of about 74×78 m^2. One RPC is logically subdivided into 10 pads with 56×62 cm^2 area each. The 1560 chambers covering this region are grouped in 130 clusters containing 12 chambers each: the signals from the chambers belonging to a cluster are sent to line receivers in a Local Station [3]. The detector also includes 24 isolated clusters around the central region in order to sample the air showers not fully contained within the full-coverage area. So,

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the whole setup is composed of 1848 RPCs grouped in 154 clusters.

The RPC is a gas-ionization detector, which can be operated in either avalanche or streamer mode. For the ARGO-YBJ experiment, which requires a detector with modest rate capability, about 1 kHz/m^2 at the YangBaJing laboratory altitude, the streamer mode was chosen. This has the advantage of producing saturated signals of much larger amplitude than those expected in avalanche mode [4].

The gas mixture used in the experiment, $C_2H_2F_4$/i-C_4H_{10}/Ar/SF_6=54.7/30/15/0.3, requires an operating voltage of 7.7-7.8 kV in the YBJ laboratory working conditions. With the purpose of keeping the detector operating point stable, the applied voltage has to be corrected for temperature and pressure changes according to the formula

$$V\frac{T}{p} = V_0\frac{T_0}{p_0} \tag{1}$$

where V is the voltage to be set at temperature T and pressure p to obtain the same gas gain observed at "standard" temperature-pressure conditions, (T_0, p_0), with the applied voltage V_0. The chosen reference values, $T_0 = 283.15$ K and $p_0 = 603$ mbar, are very close to the average values recorded in the laboratory.

The main parameters to be monitored by the DCS are:

- *global parameters*, namely the parameters concerning the operation of the whole detector: atmospheric pressure and gas flux for each component of the gas mixture;
- *cluster parameters*: total HV circuit current for 4 clusters fed in parallel, environment temperature, relative humidity, outgoing gas flux, front-end electronics supply voltage (V_{EE}) and threshold reference voltage (V_{TH});
- *chamber parameters*: RPC currents and counting rates.

For economy reasons, however, temperature and relative humidity are measured for groups of 4 contiguous clusters.

The RPC current is given by the voltage drop across a 100 kΩ resistor placed on the HV return line.

3. DCS architecture

The RPC current measurement in ARGO-YBJ requires a suitable and modular slow-control system. As mentioned previously, the ARGO-YBJ detector is divided into clusters of 12 RPCs each, so the DCS channels can be logically and physically grouped on a cluster basis.

Table 1. lists the 4317 parameters to be monitored. The monitored parameters are measured according to the following scheme:

Table 1. Summary of the ARGO-YBJ parameters to be monitored.

	Number of parameters to be monitored
RPC currents	1848
RPC counting rates	1848
Environment temperature and relative humidity	154
Front-end electronics voltages	308
Outgoing gas flux	154
Atmospheric pressure	1
Input gas flux (from each bottle)	4

1. the parameters in one cluster are acquired sequentially using a software-controlled 16-channel switch board placed inside the cluster Local Station; this board (ARGO-MUX), which multiplexes the cluster parameters on a single acquisition channel, has been developed at the INFN labs of Roma 2;

2. up to 16 switch boards are interconnected in a double daisy chain, so that one single address line is used to select a given control parameter within a specific board, and one single ADC channel records up to 256 different parameters in a sequence.

The RPC counting rates will be measured separately: the Fast-OR signals of each chamber will be acquired with special boards mounted on the Local Station back-panels and sent to VME scalers.

4. DCS safety tasks

The DCS performs a periodic measurement (once every 10 minutes) of all the slow-control parameters, that are recorded on computer files on a daily basis. The RPC counting rates, instead, will be monitored at a much faster rate with the dedicated system mentioned earlier. The time information, available to all the users in the experimental area, is provided by a GPS clock.

The DCS requires a constant monitoring and control of the RPC high voltage supplies. These are located inside CAEN SY127 mainframes, and are computer-controlled through a dedicated interface (CAEN A1303 PCI board or V288 VME board) on the CAENET High Speed control bus.

A crucial point is the handling of safety tasks, strictly related to the occurrence of anomalous and unforeseen events. The main reasons for warnings are the following:

- high current values from one or more RPCs;

- gas exhaustion;
- wrong values of the front-end electronics voltages.

Each of these occurrences will be promptly signalled by the DCS so that the operator will be able to perform the required interventions to bring the situation back to normal. In the first occurrence, the high voltage channels feeding the RPCs affected by high-current problems will be switched off: if necessary, the HV cables will have to be physically disconnected from the RPCs with high current. In the second occurrence, if no quick gas refilling occurs, the high voltage will be switched off until the bottles have been replaced. Finally, warnings concerning the front-end electronics will be issued when anomalous values either of the chamber counting rates or of the supply or threshold reference voltages are recorded.

5. Conclusions

The DCS is a crucial tool for the ARGO-YBJ experiment management. The RPC working point equalization and the warnings in case of anomalous behaviour are crucial to guarantee the reliability of the acquired data and to avoid the risk of detector damages.

If necessary, future extensions of the setup will be possible at low cost and with little effort. The RPC counting rate monitoring (after the installation of the slow-control sub-system) will increase the DCS redundancy and robustness, providing invaluable support to the experiment data acquisition.

6. References

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