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Long-term environmental effects on the ARGO-YBJ RPC array studied with the Detector Control System

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Abstract: After a 1-year-long running time, much information has been collected on the performance of the ARGO-YBJ detector. In particular, increased expertise on the detector behavior in the peculiar environmental conditions of the experimental site (4300 meters a.s.l.) has been achieved. Here we show and discuss the correlation between the detector operating parameters and the environmental factors, exploiting the statistical significance provided by a long-term monitoring of the full-coverage central array of 1560 Resistive Plate Chambers.

Introduction

The ARGO-YBJ detector [1] is a full-coverage array of Resistive Plate Chambers (RPCs) [2] operated in streamer mode with a gas mixture $C_2H_2F_4$/Ar/iC_4H_{10} $= 75/15/10$. The data taking started in July 2006, after the central carpet was completed. The detector operation is monitored a Detector Control System (DCS) which was already described in ref. [3]. More details about the deployment of the DCS and results about the monitoring during the installation of the detector were reported in ref. [4]. The DCS provides control of the high-voltage power supplies for the RPCs, and monitoring of the main parameters related to the environment and the detector operation. Checking the detector stability and reliability is crucial for the data analysis as well.

Environmental conditions

The outer temperature is measured outside the ARGO-YBJ building, on the North side, using a sensor screened against direct sunlight. Inside the building the temperature is measured in about 30 different places on the carpet with a sensor array. A sensor measuring the barometric pressure is located close to the center of the building, where the air relative humidity is monitored as well. More information is also obtained by measuring the gas temperature and relative humidity in cluster 105, close to the carpet center, both for the input and the output line.

Constant monitoring of the environmental-parameter behaviour is crucial, since the effective operating voltage of RPCs depends on the changes of the temperature and the barometric pressure, which is equal to the gas-mixture pressure inside the RPCs. If the RPC operating voltage is V_0 at absolute temperature T_0 and barometric pressure P_0, the voltage V to be applied at temperature T and pressure P in order to keep the effective voltage unchanged is given by [5]:

$$V\frac{T}{P} = V_0\frac{T_0}{P_0} \quad (1)$$

In Fig. 1 and Fig. 2 the behaviors of the outer temperature and the temperature measured close to the center of the carpet are shown. The typical daily thermal excursion outdoors can exceed values as high as 25 degrees. It is easy to see that the temperature changes inside the experimental hall are correlated to the outer temperature. The data used for this analysis were collected during 8 days in February-March 2007, and 5 days in May 2007.

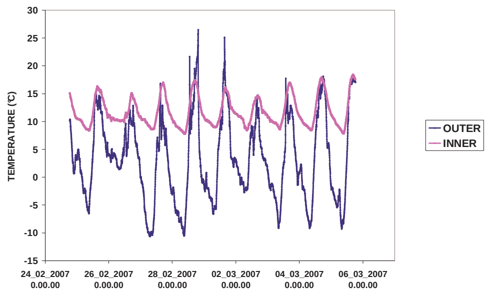

Figure 1: 8-day-long behaviors for the outer temperature and the inner temperature close to the RPC-carpet center, in February-March 2007.

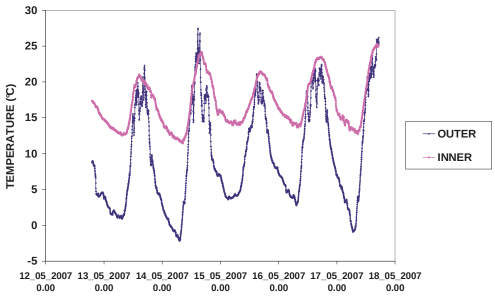

Figure 2: 5-day-long behaviors for the outer temperature and the inner temperature close to the RPC-carpet center, in May 2007.

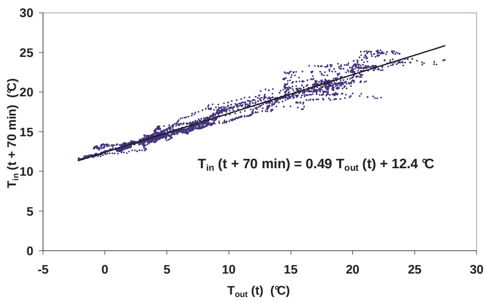

Figure 3: 70-minute time-delayed inner temperature near the carpet center versus the outer temperature, related to the May 2007 monitoring data. The result of the linear fit is also shown.

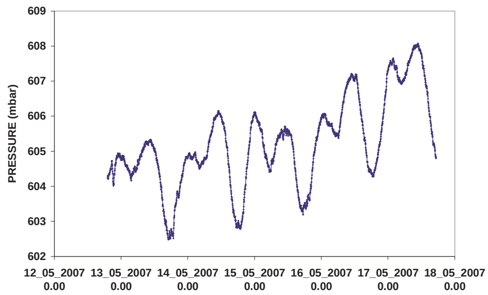

Figure 4: 5-day-long behavior for the barometric pressure at the ARGO-YBJ experimental site.

A detailed analysis of the data displayed in Fig. 1 shows that, as far as this specific data sample is considered (February-March 2007), the inner temperature was following the outer temperature with a delay of about 30 minutes. The same analysis performed on the May 2007 monitoring data (Fig. 2) gave a 70-minute delay as a result. A careful and constant monitoring will allow understanding the modified behaviours in the different seasons of the year.

In Fig. 3 the correlation plot (corresponding to the data in Fig. 2) of the time-delayed inner temperature near the carpet center versus the outer temperature is shown. The linear correlation obtained by accounting for the delay is evident.

In Fig. 4 the behavior for the barometric pressure is shown over a 5-day time interval. The average barometric pressure at the experimental site (Yang Ba Jing, China, 4300 m a.s.l.) is about 600 mbar, and the measured behavior shows that the typical daily excursion is not greater than 3 mbar.

To complete the description of the environmental features at the Yang Ba Jing site, the behavior for the air relative humidity at the experiment site is displayed in Fig. 5, which shows that the ARGO-YBJ experimental site experiences a rather dry weather (the typical range for the relative humidity is 15%-35%).

RPC absorption current

The current absorbed by the RPCs is a crucial parameter for the detector stability. High gap currents can accelerate the aging of a gaseous detec-

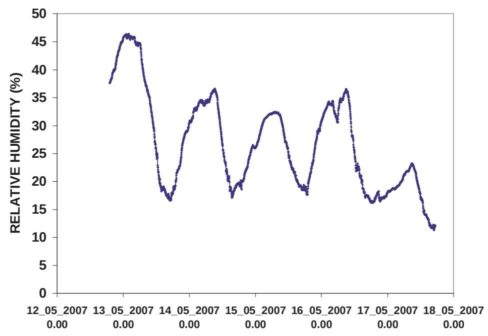

Figure 5: 5-day-long behavior for the air relative humidity at the ARGO-YBJ experimental site.

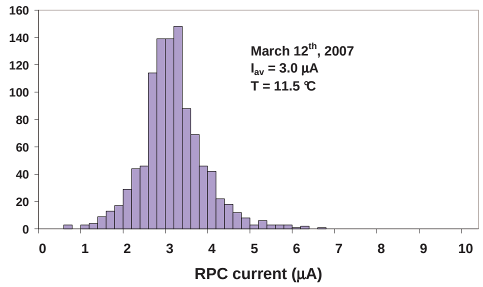

Figure 6: Single-chamber current distribution for 1400 RPCs of the ARGO-YBJ carpet.

tor, so that its efficiency would decrease with time if the gap current is not kept at a reasonably low value. High temperature changes greatly affect the gap current, so it is mandatory to correlate the RPC current with the local temperature. The data collected after the completion of the ARGO carpet allow performing a detailed study in this respect.

In Fig. 6 a typical RPC current distribution for 1400 chambers of ARGO-YBJ is shown. The average value of this distribution is 3 μA. A constant check of this distribution is a tool to see that the detector is operating in a stable and reliable way, and it also gives quick information about anomalous chambers, if any.

In Fig. 7 the correlation plot of the average RPC current of Cluster 91 (close to the center of the ARGO-YBJ carpet) and the local temperature is shown (May 2007 data). The correlation between

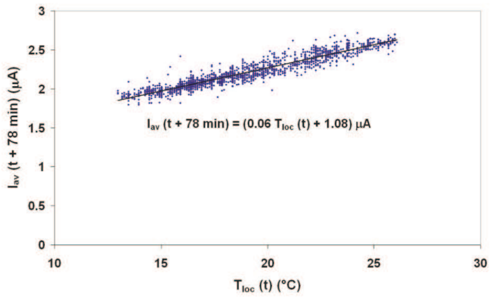

Figure 7: Correlation plot of the 78-minute delayed average RPC current and the local temperature for one ARGO-YBJ cluster near the carpet center (Cluster 91). The result of the linear fit is also shown.

the local temperature and the average RPC current in this cluster is maximum for a 78-minute delay of the average current with respect to the temperature. This delay was accounted for in the correlation plot. The distribution of the residuals of the RPC current with respect to the linear best fit is shown in Fig. 8, where the resulting behaviour is gaussian with RMS of about 0.06 μA.

Conclusion

The ARGO-YBJ Detector Control System is providing a huge deal of information for a better understanding of the ARGO-YBJ detector operating in a difficult environment with extremely peculiar features. The continuous long-term operation of the experiment allows collecting a huge amount of monitoring data, and significant correlation studies are made possible by the growing statistics. The increased expertise coming from this will be exploited to keep the ARGO-YBJ detector in a stable operating condition for the years to come.

References

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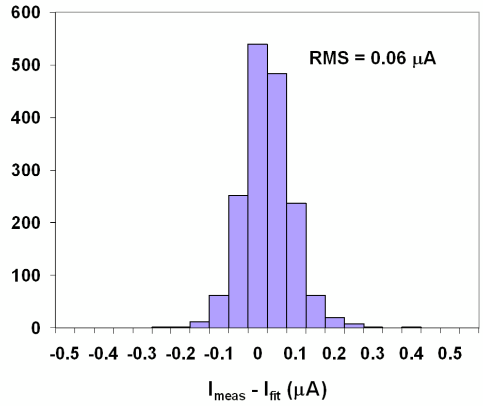

Figure 8: Distribution of the residuals of the RPC average current in cluster 91 with respect to the linear fit, based on the correlation plot in Fig. 7. The RMS is about 0.06 μA.

Collaboration, in the Proceedings of this conference.

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