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Online Monitoring of the Pierre Auger Observatory

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Abstract: The data taking of the different components of the Pierre Auger Observatory, i.e. the surface detectors (SD) and the fluorescence telescopes (FD) has to be supervised by a shift crew on site to guarantee a smooth operation. A monitoring tool has been developed to support the shifter in judging and supervising the status of the detector components, the electronics and the data-acquisition (DAQ). Data are collected online for this purpose in the regular measuring time as well as in dedicated modes e.g., for calibration or atmospheric surveys. While for some components like SD this information is directly transmitted to the DAQ on the central campus, for others it is stored in a database locally, e.g for FD within the four remote housings of the telescopes. These databases are replicated to the central server on the campus via a wireless long distance link. A web-interface implemented on a dedicated server can dynamically generate graphs and particular developed visualisations to be accessible not only for the shifter, but also for experts remotely from anywhere in the world. In addition, in case of special occurrences an alarm is triggered automatically. This tool does also offer a unique opportunity to monitor the long term stability of some key quantities and the data quality. The concept and its implementation will be presented.

Introduction

The southern Pierre Auger Observatory is measuring cosmic rays at the highest energies in the Pampa Amarilla, Argentina, while awaiting the finish of its construction this year. The instrument [1] has been designed to measure extensive air showers with energies ranging from 10^{18} – 10^{20} eV and beyond. It combines two complementary observational techniques, the detection of particles on the ground using an array of 1600 water Cherenkov detectors distributed on an area of 3000 km^2 and the observation of fluorescence light generated in the atmosphere above the ground by 24 wide-angle Schmidt telescopes positioned in four buildings on the border around the ground array.

Requirements for an online-monitoring

Routine operation of the detectors has started in 2002 and first measurements have been presented [2]. The data taking, for the fluorescence telescopes only possible in moon-less nights, is organised in shifts. Telescope performance must be monitored constantly to assure the quality of the recorded data as well as guaranteeing the safe operation of all detector components, in particular of the light sensitive fluorescence cameras. The aim of the presented work is to help the shifter as well as the expert to judge the status of the detectors and the quality of the data. The data collected online are valuable not only for shifters but also for the analysis of the data offline. This is required for an accurate estimate of the measuring time in the given temporary configuration. The different detector sub-systems have different requirements. SD-tanks operate constantly in an semi-automated mode. Data acquisition must be monitored and failures of tanks or of their communication must be detected. The FD data-taking can only take place under specific environmental conditions. The sensitive cameras can only be operated in dark nights with not too strong wind and without rain. This makes the operation a full task for the shifters that have to judge the operation-mode on the bases of the information given.

Implementation of the monitoring system

The implementation splits up into a technical description of the implementation, separately for the central server-services and the sub-components. The sub-components show the different ways the data-flow to the central database is organised.

Server techniques

The basis of the monitoring system is a database. We have chosen the widespread and publically available MySql database system. Version 5 includes all necessary features e.g., replication, stored functions/procedures. The front-end is based on an web-server running Apache. The web-site is using mainly PHP, CSS and Java. For the generating of visualisations an interface has been developed. Currently only the usage of Gnuplot (Version 4.2) is implemented via an internal system-call. The second option used for the generation of visualisations is the JPGraph package which is implemented for direct php-calls on an object-oriented bases with the interface defined in the inherited classes.

Alarms, occurrences of states that require immediate action, are first filled into a specified table of the database. The web-front-end checks this table for new entries and indicates them on the web-page. The shifter is supposed to notice and acknowledge the alarm. After solving the problem he can declare this alarm as resolved.

In addition to the monitoring of the detector performance and the data-quality the functionality of the monitoring server itself has to be guaranteed. Therefore, the central services of the computer have to be monitored to assure that an alarm will definitely be noticed by the shifter.

Surface detector

With large ambient temperature variations, high salinity, dusty air, high humidity inside the tank, and remoteness of access, monitoring the performance and reliability of the surface detector is a challenge.

To monitor the whole array accurately various sensors are installed in each tank. Temperature is measured on each PMT base, on the electronics board, and on each battery. PMT voltage and current are also monitored, as well as solar panel voltages, individual battery voltage, and charge current. The calibration is operated online every minute. A num-

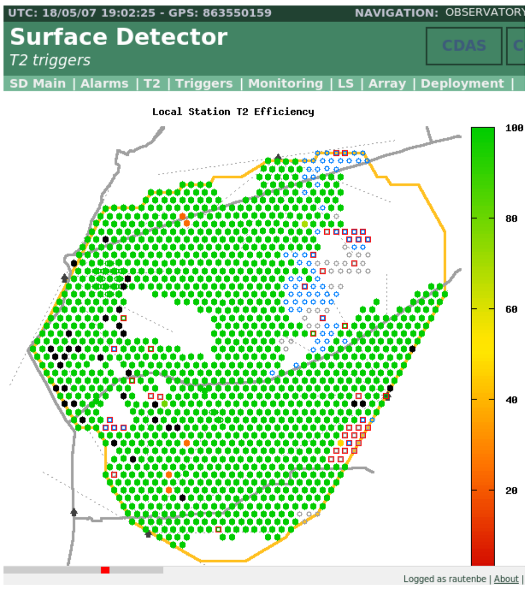

Figure 1: Screen-shot of the web-interface showing the graphical representation of the T2 trigger information for the array of the SD-tanks.

ber of quantities are computed to check the behaviour of the tank: baseline values, single muon peak signal, single muon average charge, dynode/anode ratio, and PMT stability. The monitoring and calibration data are sent to the Central Data Aquisition Server (CDAS) every six minutes.

Independently of this data flux, each tank sends every second to the CDAS its second level trigger (T2) informations, shown in Figure 1. This allows to know precisely the dead time of the surface detector as well to detect tank disappearance.

Dedicated software parses constantly the informations sent to the CDAS, independently of the acquisition processes and export the data to the MySQL server.

Alarms for the surface detectors are set at two levels:

High severity: if a short term problem is detected at the CDAS level requiring immediate interaction e.g., disappearance of a tank from the T2 flux, the alarm is triggered directly and the shifter sees the alarm displayed within few seconds.

Low severity: to detect long term problems e.g., PMT instabilities or discharging batteries, some analysis software is running only once per day since no urgent intervention by the shifter is required.

Fluorescence detector

The data-acquisition for the FD-telescopes is organised building-wise to insure against disruption of data collection due to possible communication losses between the CDAS and the remote detectors. For the FD-monitoring the data-transport is organised via database internal replication mechanism. This mechanism recognises communication-problems and tries to catch up with the submitted database changes when the connection is reestablished, thus guaranteeing completeness of the data-set on the central server, even if the information are not available online immediately in case of network failures. Figure 2 shows the schematic layout of the databases.

The information collected for the supervision of the FD-operation is organised in four parts:

Calibration: the information from the different levels of calibration are transferred to the monitoring database. The daily relative calibration using an LED in the mirror surface is important for the operation of the telescopes, while the less frequent calibration modes using a xenon-flasher with filters onto the mirrors and the absolute calibration using a gauged lightsource in front of the filter are valuable for long-term stability and data-quality studies. An example for the representation of calibration-data is given in Figure 3.

Background-data: with a frequency of every 30 seconds the complete camera is read out for background informations. This information is valuable as non biased observation of background. It can be used to verify the uptime as typical non-measuring states such as closed shutter lead to well identifiable pattern of low variances.

DAQ and trigger: the frequency of fired triggers indicate the status of the telescopes at an advanced stage. This signals not only low-level telescope failures but also errors in the data-acquisition.

LIDAR: the LIDAR [3] monitors the atmosphere especially close to the telescopes.

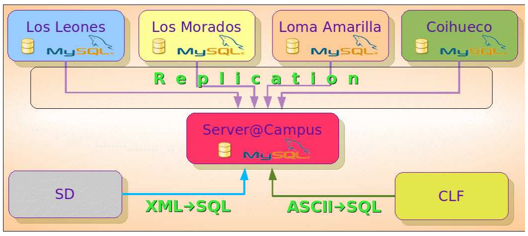

Figure 2: Organisation of the databases: The single databases at each FD-building are replicated to the database server at the central campus, while other sources like SD fill directly into the database.

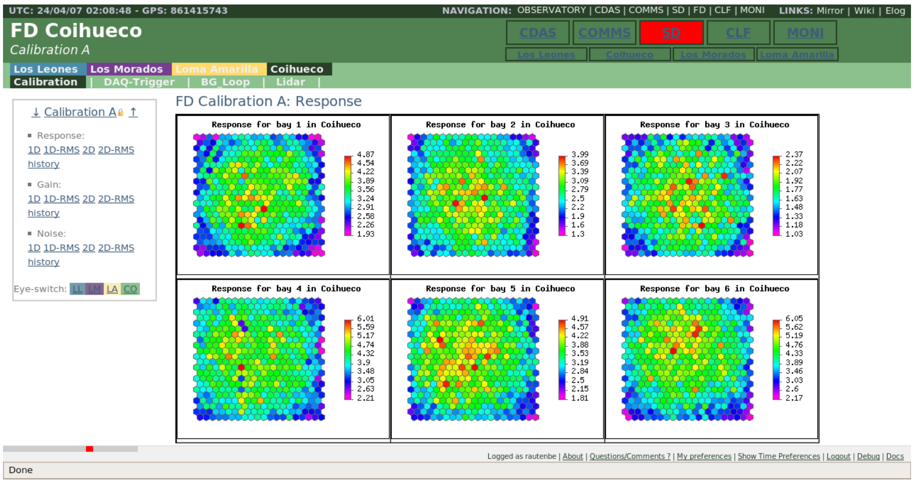

Figure 3: Screen-shot of the web-interface showing a selection of FD-calibration data for the six cameras in FD-building Coihueco in a specialised view representing the PMT geometry.

Their information helps judging the atmospherical conditions at the site which is vital for the operation of the telescopes. The LIDAR is not strictly a part of the FD, but since they are organised in combination with the telescope-buildings it was considered natural to include them in the site-wise FD-structure.

Additional components: CLF

The implementation of the Central Laser Facility [4] (CLF) in the monitoring is a good example for the integration of an additional subcomponent. The operation of the CLF produces a plain text log-file. On the central database server a perl-script is parsing this log-file and filling the database. This rather simple mechanism has proven to be robust and reliable.

Summary

The presented monitoring tool has been developed to support the shifter in judging and supervising the status of the detector components, the electronics and the data-acquisition. Data are collected online for this purpose and are directly transmitted or transferred via replication to the database hosted by a central server on the campus. A web-interface dynamically generates graphs and particular developed visualisations to be accessible not only for the shifter, but also remotely for experts. Alarms are triggered automatically in case of special occurrences. The presented tool helps the shifter to monitor constantly the performance of the detector to assure the quality of the recorded data as well as guaranteeing the safe operation of all detector components. In addition it offers a unique opportunity to monitor the long term stability of some key quantities and the data quality.

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