TileDCS Web System

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Abstract. The web system described here provides features to monitor the ATLAS Detector Control System (DCS) acquired data. The DCS is responsible for overseeing the coherent and safe operation of the ATLAS experiment hardware. In the context of the Hadronic Tile Calorimeter Detector (TileCal), it controls the power supplies of the readout electronics acquiring voltages, currents, temperatures and coolant pressure measurements. The physics data taking requires the stable operation of the power sources. The TileDCS Web System retrieves automatically data and extracts the statistics for given periods of time. The mean and standard deviation outcomes are stored as XML files and are compared to preset thresholds.

Further, a graphical representation of the TileCal cylinders indicates the state of the supply system of each detector drawer. Colors are designated for each kind of state. In this way problems are easier to find and the collaboration members can focus on them. The user selects a module and the system presents detailed information. It is possible to verify the statistics and generate charts of the parameters over the time. The TileDCS Web System also presents information about the power supplies latest status. One wedge is colored green whenever the system is on. Otherwise it is colored red. Furthermore, it is possible to perform customized analysis. It provides search interfaces where the user can set the module, parameters, and the time period of interest. The system also produces the output of the retrieved data as charts, XML files, CSV and ROOT files according to the user's choice.

1. Introduction

The Hadronic Tile Calorimeter (TileCal) is one of the detectors of the ATLAS experiment [1]. It is designed to absorb the energy of the particles that cross the detector. It is a sampling calorimeter made of scintillating tiles using iron as absorber and photo-multipliers (PMT) as photo-detectors [2]. TileCal is composed of four sections divided in two Long Barrels (central section) and two Extended Barrels. Each barrel is divided azimuthally into 64 wedges, so-called modules.

The front-end and digitizing electronics are situated in the outer region of the modules, named drawers. These electronics are fed by eight low voltage lines provided by Low Voltage Power Supplies (LVPS). There are also up to 45 PMTs in a drawer. The sensors are powered by 800 V channels that are controlled by the High Voltage System (HV). The stable operation of these power sources is a requirement for the TileCal operation.

The Detector Control System (DCS) provides control over the LV and HV systems [3]. It also manages the cooling system. The DCS main task is to guarantee the coherence and safety of the experiment. Its architecture consists of a distributed back-end system running on computers and different front-end systems. The back-end software is developed under the PVSS framework. It acquires voltages, currents, temperatures and inner water pressure measurements from the front-end equipment. The acquired data is filtered before being stored into the on-line database. This process, called "smoothing", is based on testing each parameter every 10 seconds and recording it either if one hour has elapsed after its last record or if a relative change occurred since the previously recorded value. The described process reduces the amount of stored data. The on-line database is replicated after few seconds and the replica is made available for off-line analysis.

It is important to notice that the "smoothing" process makes the analysis procedure more laborious because the data need to be "unsmoothed". In other words, it is needed to build a virtual table where each parameter is accessed for common points that appears in this table. Then, weights are assigned to the parameters according to the elapsed period between two occurrences. This procedure will be detailed in Section 2.

DCS also offers supervisory control functions, such as data processing, analysis or display [4]. The access to these features is restricted though. The PVSS project runs under Windows machines, a single-user operating system. Thus, PVSS usage should be reserved for advanced users directly responsible for the detector operation.

To perform the off-line monitoring of the power sources operation the researchers should retrieve data directly from the Offline Oracle Archive. Therefore, users can customize their own analysis. However this approach has some disadvantages: there were no guidelines for it; the amount of data makes impossible to monitor all the existing parameters; the lack of a standard procedure facilitates misjudgment about the real state of the power supplies. Moreover, it requires advanced knowledge about computer languages like SQL (Sequence Query Language).

2. Proposal

The TileDCS Web System supports physicists and engineers to monitor the DCS data. Web based systems have the advantage of being accessible by any collaborator even outside CERN, requiring only a web browser. Therefore a web environment is the ideal one for a global collaboration like ATLAS.

The system provides a standard procedure by calculating the mean and the standard deviation of the measurements for the most important parameters. These parameters were defined after the observation of the power supplies behavior through the time:

- The *output voltage*, the *input voltage*, *output current*, the *inner temperature* and *sense line voltage* from the LVPS. The sense line voltage refers to the voltage measured in the detector electronics boards.
- The *output voltage* of the HV channels

The values are retrieved in a transparent way for the final user. After being retrieved, data is automatically "unsmoothed". Table 1 illustrates the "unsmoothing" procedure for hypothetical parameters A, B and C. The first column represents the acquisition time recorded in the database. A new row is added to the table every time a parameter changes its measurement, according to the following algorithm:

(i) Fill the time column with the acquisition time;
(ii) insert the new measurement in the correspondent column;
(iii) repeat all the unchanged values from the last row; and
(iv) calculate the weight by subtracting the current time and the previous one.

In the example, the point $1256182021\ s$ refers to the moment when *Parameter A* changes to *Value 2A*; $1256182039\ s$ to the moment when *Parameter B* changes to *Value 2B* and $1256182043\ s$ to the moment when *Parameter C* changes to *Value 2C*. Through this procedure it is possible to weight measurements according to the time between two consecutive records.

Time (s)	**Parameter A**	**Parameter B**	**Parameter C**	$\cdots$	**Weight**
1256182000	Value 1A	Value 1B	Value 1C	$\cdots$	15
1256182021	Value 2A	Value 1B	Value 1C	$\cdots$	21
1256182039	Value 2A	Value 2B	Value 1C	$\cdots$	18
1256182043	Value 2A	Value 2B	Value 2C	$\cdots$	04
		$\vdots$			

Table 1. Example of a virtual built table after the "unsmoothing" procedure.

After being "unsmoothed", the statistical parameters are calculated and compared to preset thresholds. The system highlights the power supplies that have any bad behaved channels through a graphical representation. In this way, the users glance at all the problems. The user can select a power supply for displaying all the calculated values in a table. At this point, the user can generate plots on the fly.

The described procedure is made for the period of one day or one month. Each one is available in different interfaces. A third interface displays the current state of the power sources based on the latest values stored in the off-line database.

3. Used Technologies

The TileDCS Web System is hosted under the CERN web server. This is an APACHE server and its operating system is the Linux distribution Scientific Linux CERN 4 (SLC4). All the interfaces are implemented using PHP. The web application is based on the AJAX [5] execution model. AJAX at providing a greater interactivity between the system and the users. It integrates several technologies for achieving this objective:

- standards-based presentation using CSS and XSLT;
- data interchange, storing and manipulation using XML;
- asynchronous data retrieval;
- SAX and DOM algorithms for accessing XML documents;
- and JavaScript binding everything together.

The data retrieval is performed through the Glance System [6]. Glance is developed in common collaboration between the ATLAS Technical Coordination and the Software Developing Group of the Signal Processing Laboratory from the Federal University of Rio de Janeiro (Brazil). It automatically recognizes the internal structure of the databases, thus allowing the creation of customized Search Interfaces (SI) without the need of previously knowing the data modeling of each data set [7]. For the DCS Data some SIs were created, one for each subsystem: LVPS, HV, cooling data and power sources statuses. Figure 1 presents the search interface for the LVPS data.

The SI displays the possible attributes that the user can use to retrieve data. The attributes for the LVPS SI are *system*, *module number*, *brick name*, *channel name*, *time stamp* and *value number*. Then the user selects the operators that depend on the kind of attribute that is being used for the query and the required values. Glance also displays options for a known attribute, i.e., the user can pick one of the four barrels (LBA, EBA, LBC, EBC) for the attribute *system* in a select box.

Glance also supports the usage of add-ons. In this way, the system is not just the data retrieval. It also offers the possibility of handling and processing data for providing outcomes according to the user requirements. It is possible to produce CSV files, ROOT trees and charts, to generate "unsmoothed" data, mean and standard deviation values recorded in XML files and to merge different data sets through this technology for the DCS search interfaces. All the available operations can be seen in the select box located at the bottom of the Glance main interface, as shown in Figure 1.

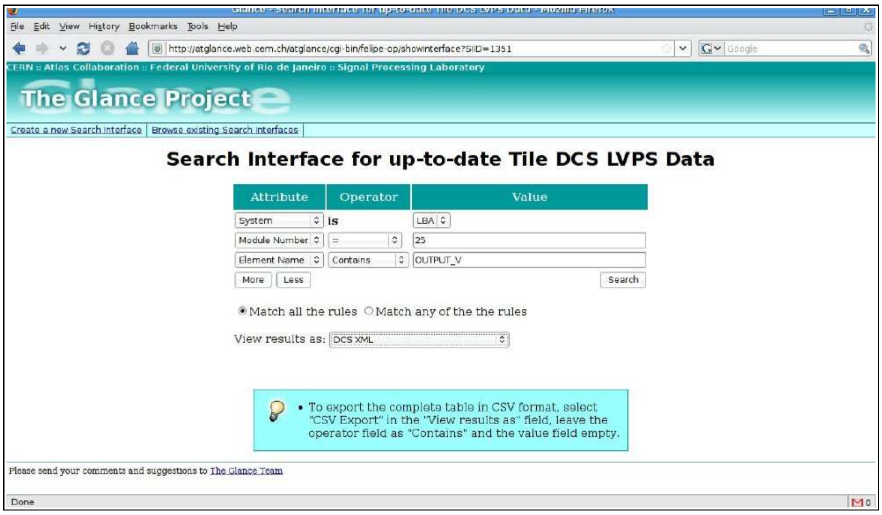

Figure 1. Glance search interface for LVPS data.

These add-ons were developed using C++ or Python languages. For the plotting features the python module *matplolib* was used. The creation of ntuple files and the mean and standard deviation calculation used ROOT libraries.

4. TileDCS Web System

As discussed in Section 2, the TileDCS Web System aims at establishing a standard procedure for monitoring the TileCal power supplies operation.

4.1. Real-Time Display

Different applications were developed for the different DCS subsystems. By accessing the TileDCS URL (`http://cern.ch/tcws/DCS`), the system displays the status of the power supplies as shown in Figure 2.

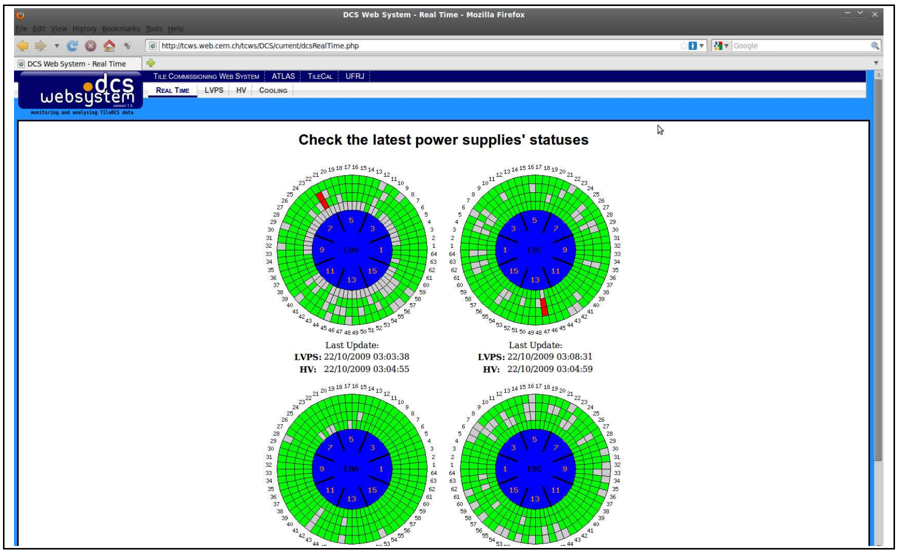

Figure 2. Interface to display the updated status of the power supplies

The main interface presents the graphical representation of the TileCal barrels. Each wedge represents one module. One module is divided into 4 parts, one for each DCS subsystem (from the outer side to the inner one): 200 V PS, LVPS MB (Mother board powering side), LVPS HV (high voltage system powering side), HV.

The subsystem statuses are retrieved from the database every 10 minutes. A XML file is generated after the data retrieval. This file is interpreted by the interface that assigns colors to the circles. Green signals the power supplies that are turned on. Otherwise the red color is used. The description of the power supplies representation is provided on mouse-over action. Figure 2 shows that all the power supplies were turned on for the LBA and LBC barrels. The power supplies of the EBC and EBA barrels are available after scrolling down the page. The page also presents the menu bar with the access to the other system's interfaces: LVPS Display, HV Display and Cooling Display.

4.2. LVPS Display

The LVPS data is monitored according to two different time periods: daily and monthly monitoring. Figure 3 presents the interface for the daily monitoring. This interface presents an overview of the LVPS operation. The mean and the standard values are compared to preset thresholds. Colors are designated according to the power supplies' performance. The module is colored green if the mean values for currents, voltages and temperatures are inside the limits. In the case of over-current the module is colored orange. When the difference between the output voltage and the sense line voltage (voltage drop) exceeds 0.5 V for one channel the yellow color is used. The module is highlighted with red if this problem occurs for more than one brick.

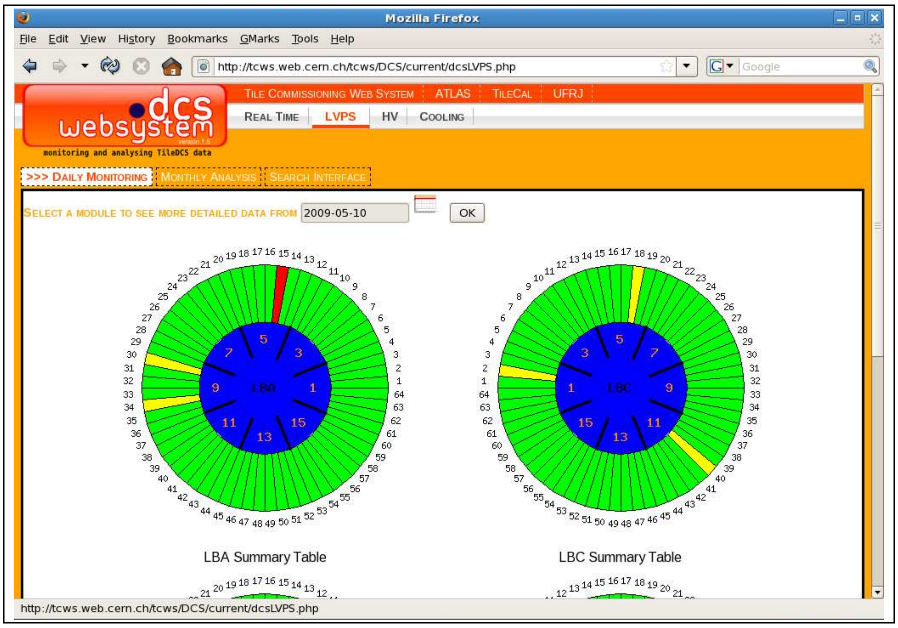

Figure 3. Main interface for the monitoring of LVPS data set.

Below the barrel graphical representation, the user can access a summary table. This table shows all the calculated values for all the power supplies for one barrel, as it is shown in Figure 4. It is possible to generate a CSV file. In this way, the retrieved information can be exported to spreadsheet software managers.

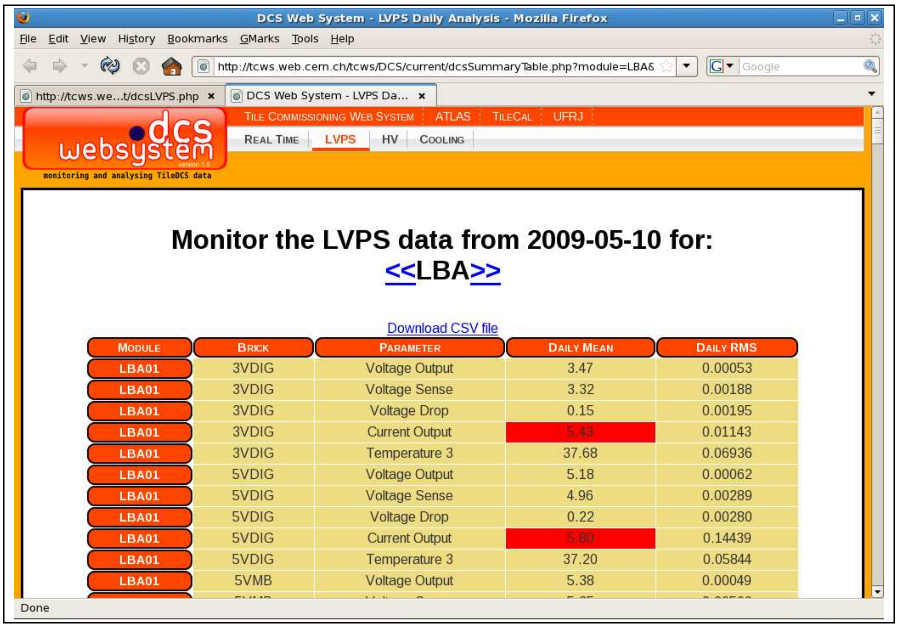

Figure 4. Summary table for all LVPS data set.

The user can select a module in the main interface to see detailed information. It is possible to check the statistics and generate charts of the parameters over the time by clicking the button "RUN". Several plots can be created at the same time.

Figure 5 presents the detailed information for the module LBA15 on May 10^{th}, 2009.

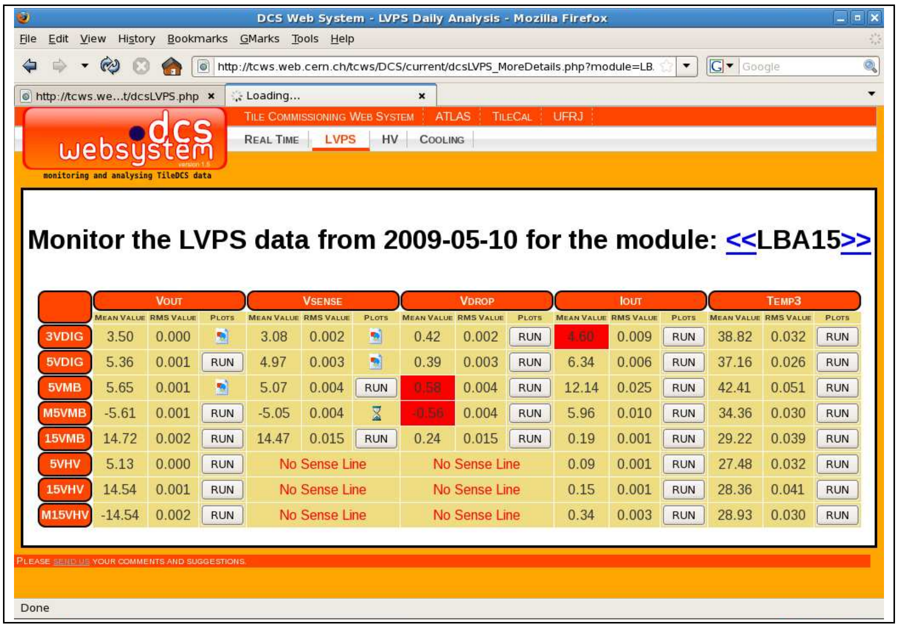

Figure 5. Table presenting the mean and the standard deviation values for the module LBA15 on May 10th, 2009

The problematic bricks are highlighted. This particular module presents over-current for the 3VDIG brick. The voltage drop is high for the channels that feed the mother board. An expressive difference between the output voltage and the sense line voltage indicates a high impedance inside the module. Sometimes this could mean a bad connector or a broken cable. The user can select a month and a module (Figure 6) in the Monthly Analysis display.

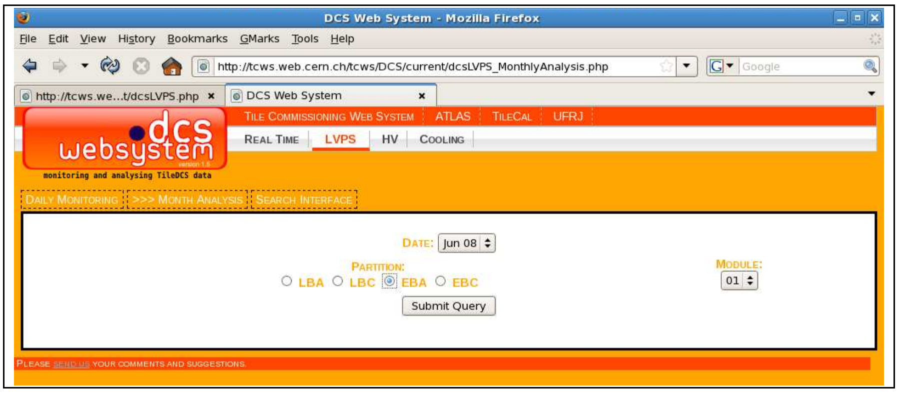

Figure 6. Main interface for the monthly analysis of the LVPS data set.

Like the Daily Monitoring interface, mean and standard deviation values are displayed. A graphic correlating the parameters is generated, as shown in Figure 7.

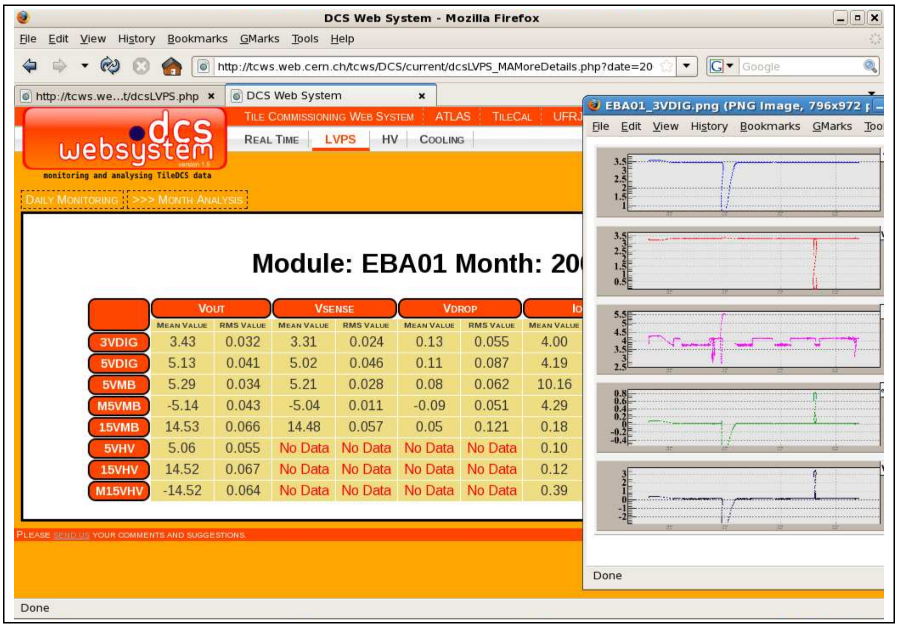

Figure 7. Table presenting the mean and the standard deviation values for the module EBA01 in June, 2008

The previous interfaces were provided in the way to make a standard procedure for monitoring the LVPS data. However, features for advanced analysis are also needed. For this reason, a search interface is provided. As it was described in Section 3, this interface presents all the parameters that the user can use and the data can be retrieved in several formats. The TileDCS Web System imports the Glance SI description and applies its own style.

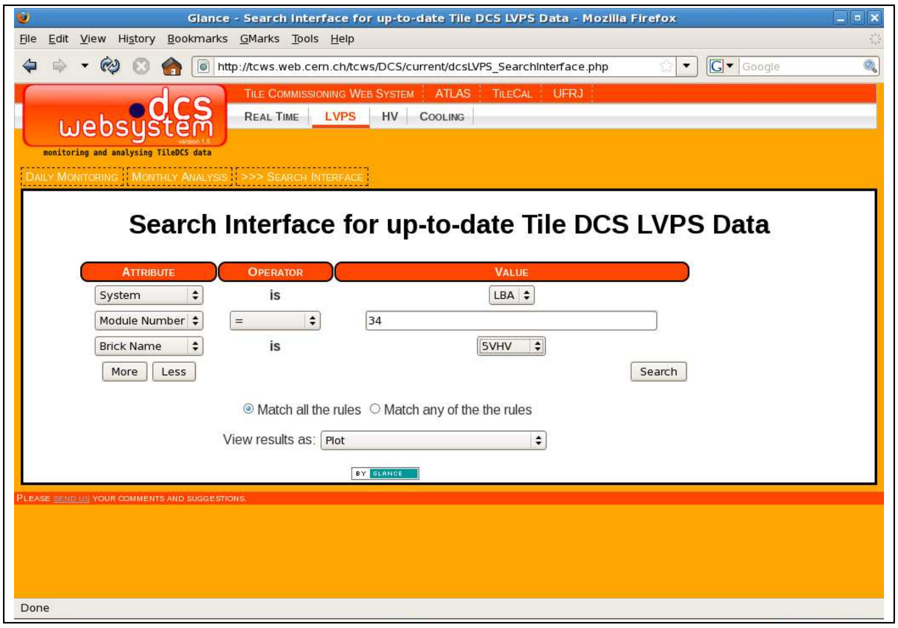

Figure 8. Search Interface for the LVPS data. It was designed for advanced analysis.

4.3. HV and Cooling Display

Search Interfaces (SI) are also available for HV and Cooling data. Figure 9 presents the SI for the HV data. The attributes for the HV SI are *system*, *module number*, *element name*, *time stamp* and *value number*. The element names are the output and input voltages.

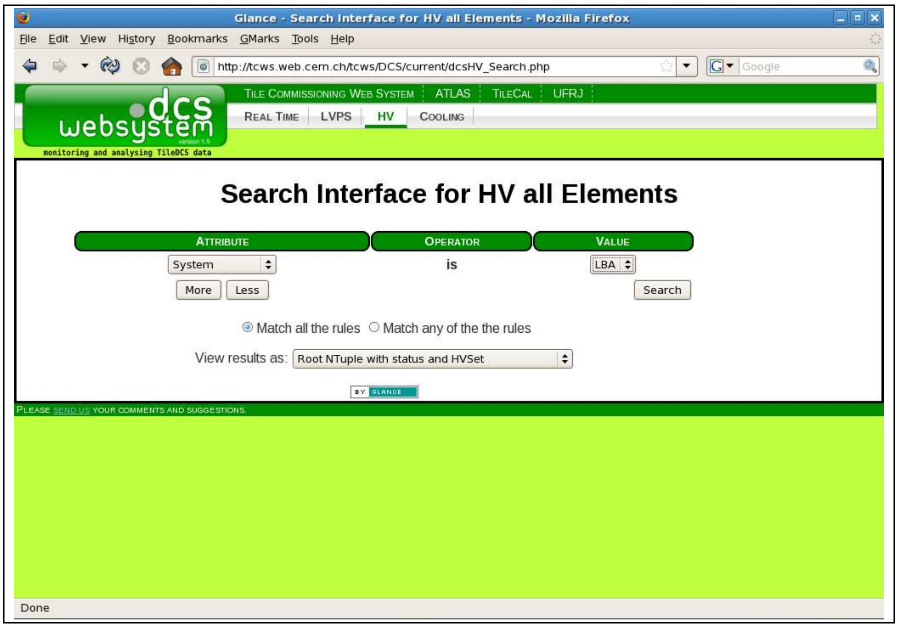

Figure 9. Search Interface for the HV data.

Figure 10 shows the SI for the cooling data. The attributes for this SI are the *Cooling Parameters* and the *Timestamp*.

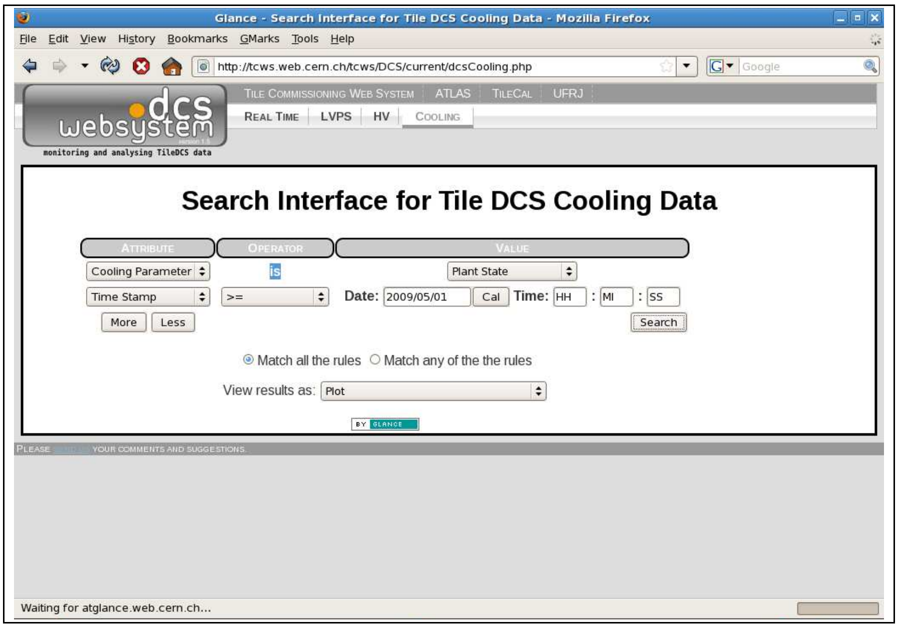

Figure 10. Search Interface for the Cooling data.

The possible Cooling Parameters are *Plant State*, *Pump Pressure*, *PPV cycle time*, *Tank Pressure* and a set of *Loop Pressure* nodes.

5. Conclusion

The TileDCS Web System established a standard procedure for TileCal DCS data Monitoring. It provides a graphical overview of the operation status of the low voltage and high voltage power supplies, using colors to highlight issues. The problems are detected by comparing the mean and standard deviation for voltage, current and temperature sensors with predefined values. If more details are needed, the system presents a detailed view of a particular power supply, and allows the generation of plots for the channel of interest.

The system is used by the TileCal collaborators since early 2007 and it is planned to be used during the operation stage.

Among the next steps are the implementation of the monthly analysis for the HV data, a timeline interface for display of the parameters history and the integration with the data quality systems.

6. Bibliography

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