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Development of ATLAS New Small Wheel Performance Monitoring Web Based Tool

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1 Abstract

The ATLAS detector is one of two multi-purpose detectors positioned in the Large Hadron Collider (LHC). The relevant subdetector system for this project within ATLAS is the Muon Spectrometer. This system consists of several gaseous detectors. The New Small Wheel (NSW) was introduced during the second long shutdown to reduce the fake muon trigger rate and maintain tracking precision at high rates in the forward region. The NSW consists of two endcap wheels, one on either side of the ATLAS detector. These wheels in turn consist of layers of small Thin Gap Chambers (sTGC) which are multi-proportional wire chambers, and Micro Mesh Gaseous Structure (MM) for increased redundancy.

The performance of these devices is constantly monitored using a variety of techniques. This monitoring is crucial for data quality, for experts on call during the LHC runs, and for informing future upgrades. As such, a need for a central community-wide tool for performance monitoring was identified. In this project a web page was developed to complete an automatic workflow in which performance plots are created from posted datasets, processed, sorted, and then published on a webserver available to the ATLAS community.

This webtool was subsequently used to examine the development of resistive chambers in the sTGCs. Several chambers were identified as candidates for continuous sparking. These had a low efficiency and high effective resistance, meaning they were drawing a large amount of current while not functioning as expected. One explanation for this could be sparking from the wires to some grounded surface. Occupancy plots of the sTGC pads suggested sparking, so a standalone run on the NSW was performed to gather more data. Finally, this technique was introduced as a method to monitor sTGC chamber performance.

Contents

2 Introduction

The ATLAS detector is one of two multi-puropose detectors within the Large Hadron Collider (LHC). ATLAS consists of multiple subsystems designed to detect different types particles. The relevant subsystem for this project is the muon spectrometer. This muon system consists of several gaseous detectors. In preparation for the high luminosity LHC (HL-LHC), the small wheel was replaced during the long shutdown 2 of LHC with the New Small Wheel (NSW). The NSW enchances both the tracking and the triggering of the muon system, allowing for high-precision high-rate measurements. This project focused on the study of the performance of the NSW.

The NSW consists of two devices, the small Thin Gap Chambers (sTGC) and the Micro Mesh Gaseous Structure (MM). The sTGCs are primarily used for triggering, while the MM are used for more precision measurements, however the whole system is highly redundant. The performance of the NSW is of interest, and performance monitoring is crucial for data quality, on-call experts, and for informing future upgrades.

3 NSWPlotWeb Performance Monitoring Tool

3.1 Motivation

After the implementation of the NSW, a common plotter program was created by Patrick Scholer in order to streamline the performance monitoring process. This is a tool that checks for incoming data from the ATLAS detector, and processes the files into ROOT files containing performance plots of interest. The next logical step in this project is to make these plots easily available to a wider audience. The project proposal was to create a webpage within the CERN IT infrastructure where relevant performance plots will be posted automatically.

3.2 Implementation

An Apache server hosted on the CERN Electronic Open Storage (EOS) system was created hosting a web server of php pages. The website is dynamic, meaning the pages are automatically updated. To accomplish this, a main page was created linked to a JSON database which contains information for each run such as the name, number, start of run (SOR), end of run (EOR), webpage location etc. The main page, along with javascript code, dynamically creates a table containing each of the runs along with relevant information first with a link to the Express stream (a lighter data stream) data, and after processing, for the Physics Main data stream as well (a bulkier but larger data stream often used for physics analyses).

In order to update the webpages dynamically, an intermediary program was created which takes the output from the common plotter and updates the website accordingly. This was accomplished with a FileTrimmer program, which takes the ROOT file and creates a trimmed ROOT file containing only the relevant formatted plots. This ROOT file are then moved to the server host. Next, php generator code extracts different image formats from the ROOT file, create a new php page on the server, and populates it with relevant plots sorted by location and cuts. Cuts can be specified in a configuration file and dictate which plots from the original ROOT file make it to the website.

By this method, the programs run automatically through a cron job. The workflow is as follows: the common plotter cron job checks for new runs from the detector. Once the new data is processed, it is passed to the FileTrimmer tool, which in turn calls the php generator. In this way the website is kept up to date automatically with the runs, streamlining the performance monitoring process and making the plots easily available to the wider community. Figure (1) below shows the PlotWeb main page.

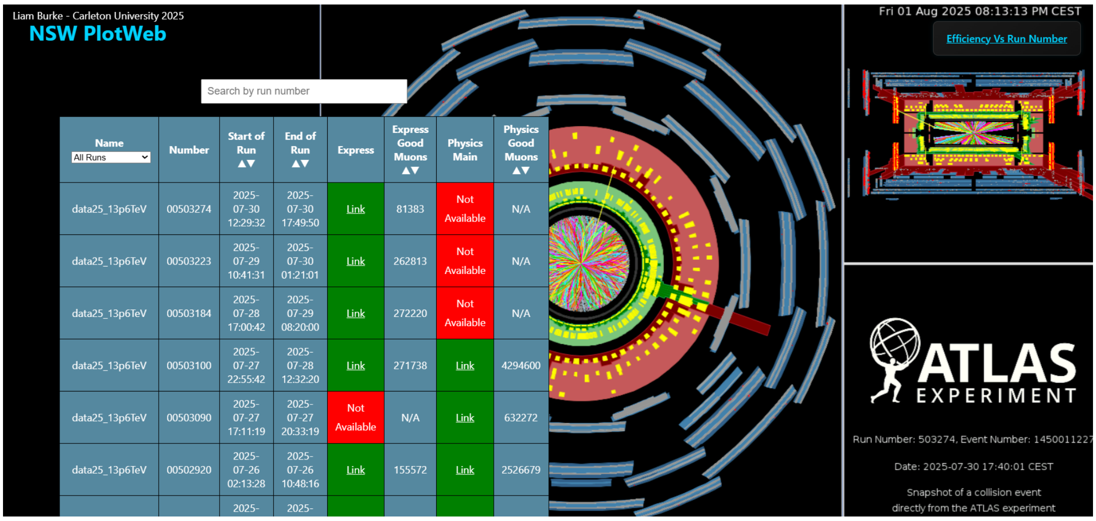


Figure 1: NSW PlotWeb main page.

There are several types of plots included in the initial version of the website. The plot shown in Figure (2) is the Track 4 Over 8 Plot. These are created by requiring that at least 4 layers out of 8 for sTGCs or MMs on the NSW record a hit when a muon passes through the ATLAS detector. The left most plot in Figure (2) shows this concept for the sTGCs, while the middle plot shows it for the MM. Overlaying these two plots yields the right most plot in Figure (2) and demonstrates the redundancy in the system. These plots are useful for physics analysis since the 4/8 coincidence is a cut applied on muons used for analysis.

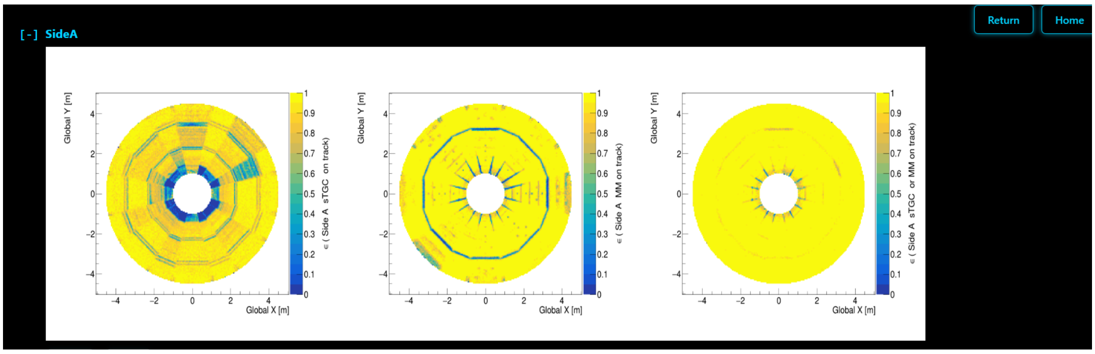


Figure 2: Track 4 over 8 performance plots on the PlotWeb website.

Other performance plots include single layer strip efficiencies, as shown in Figure (3) below. The single layer strip efficiencies are created using a 5 mm window. If a certain layer contains a hit within 5 mm of the expected track, it is calculated as efficient and added to the histogram. This plot gives a detailed view of the detector performance layer by layer.

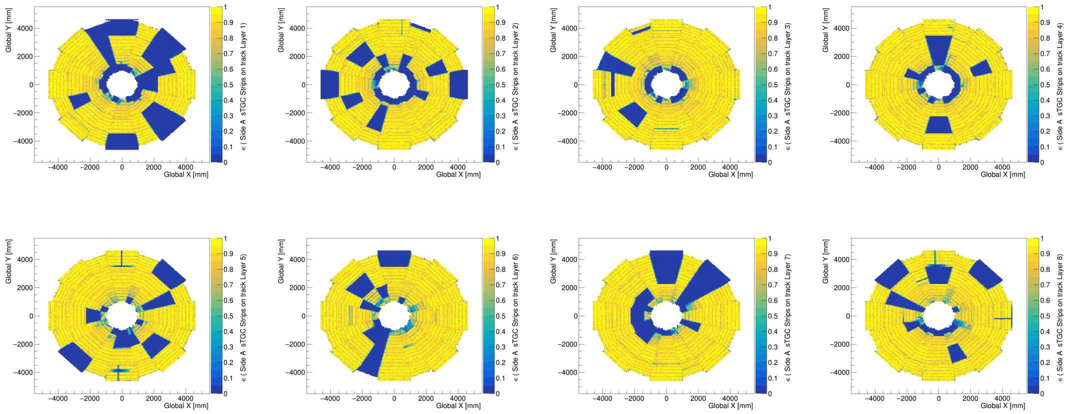


Figure 3: Single layer strip efficiencies on the PlotWeb website.

PlotWeb also includes efficiency over time plots, as shown in Figure (4) below. This plot shows averaged efficiency per run, across runs, and demonstrates the stability of the NSW over time.

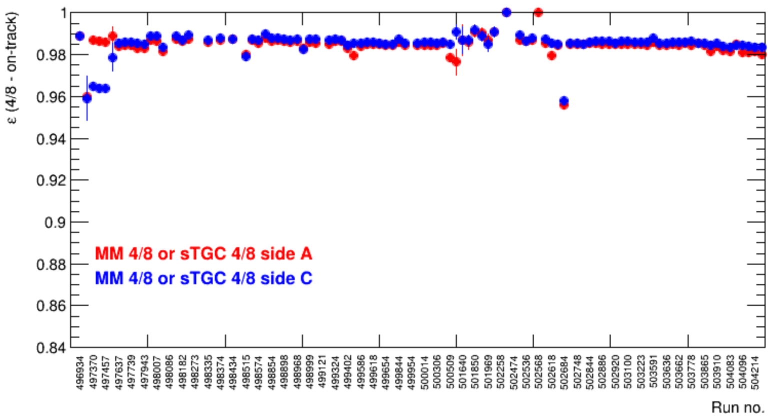


Figure 4: Efficiency vs run number plots on the PlotWeb website.

3.3 Performance Studies

Several performance studies were carried out with the help of and alongside this tool. To reduce the strain on some of the sectors, it was decided to run them at a lower voltage setpoint. Verification that lowering the voltage setpoint would not adversely affect the efficiency of the NSW was required. Previously the strip efficiencies across voltage setpoints was examined, but this needed to be compared with the pad efficiencies across voltage setpoints. Figure (5) below shows that indeed there is not an appreciable difference in the efficiencies between pads and strips for a HV setpoint of 2750 V (compared to the initial value of 2800 V).

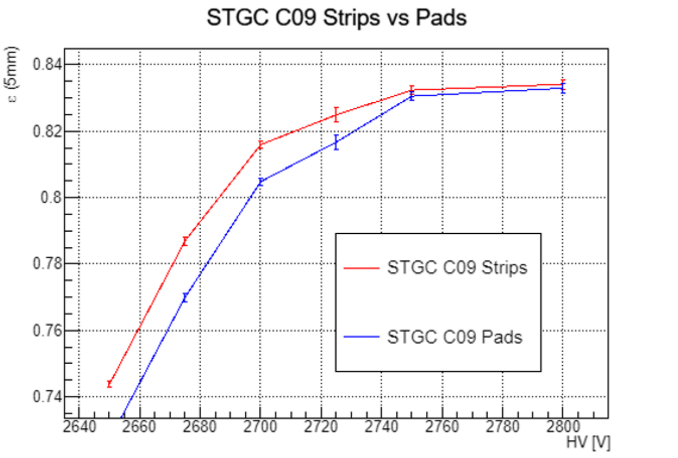


Figure 5: Efficiency vs HV Comparing Strips and Pads

There are resistive sTGC chambers within the NSW. One possibility to explain this resistivity is sparking. The effect of this on the efficiency can be visualized in the PlotWeb tool as shown in Figure (6) below. In this particular case, this informed that the inefficiencies were local and not sector wide. These results supported switching back on the chambers to maintain trigger and efficiency.

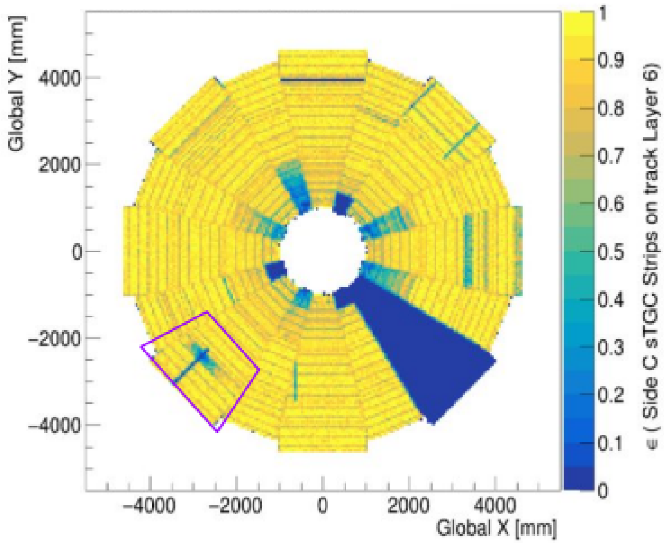
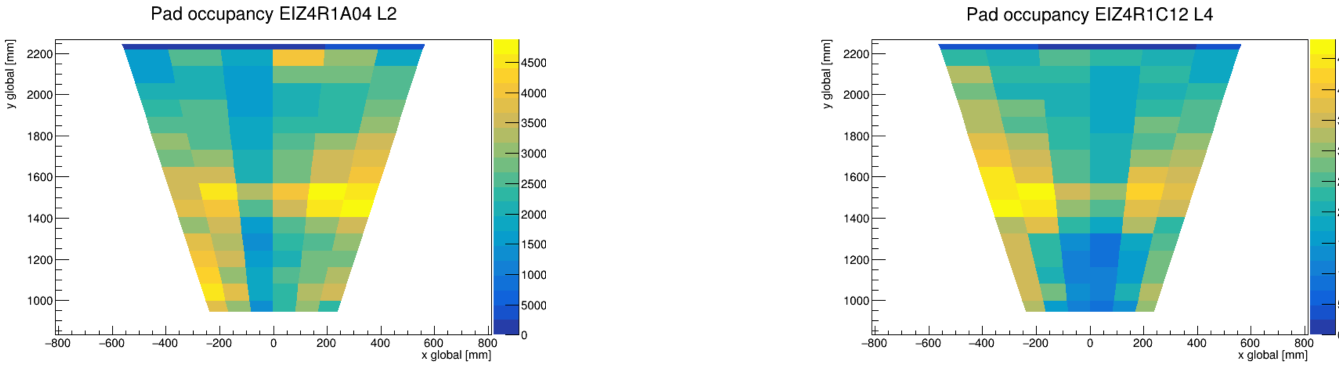


Figure 6: Pad Sparking Strip Efficiency Plots.

The motivation behind the study was to better understand why such a high current is being drawn in these sectors using a pad occupancy plot. Initially, certain highly resistive sectors which had been switched off were identified and ramped up to a lower voltage setpoint of 2000 V. This setpoint meant that there would be no amplification, and so all that would be visible is electronic noise and potentially sparking. The results for a few sections are shown in Figures (7a) and (7b) below.

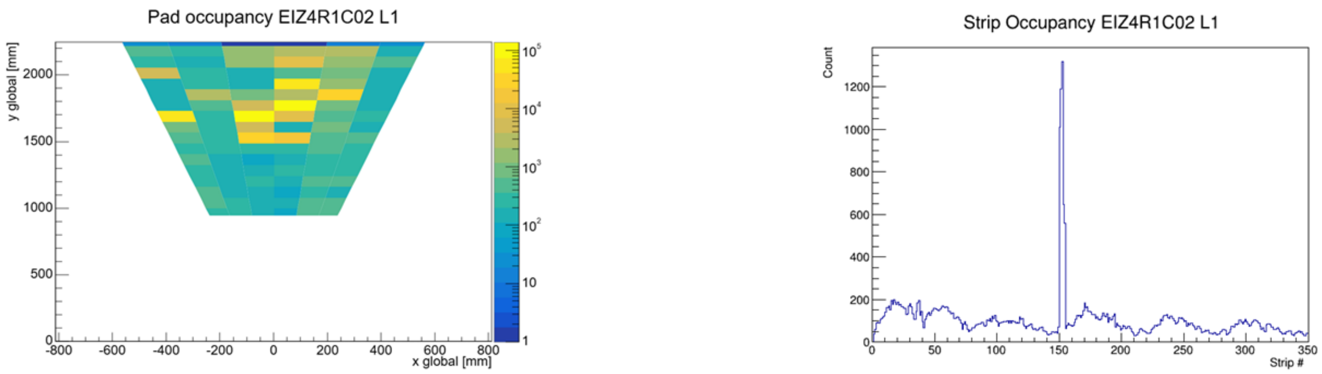


(a) sTGC sector EIZ4R1A04 layer 2.

(b) sTGC sector EIZ4R1C12 layer 4.

Figure 7: Pad occupancy plots for inner sTGC sectors.

There are several chambers which are higly resistive yet still active, since the power supply can still function at these currents. Since these chambers were still active, a standalone run was performed during LHC downtime, and these sectors were ramped up to the lower HV setpoint of 2200 V from the ATLAS control room. After data was taken, the same pad occupancy plots were produced. An example plot is shown in Figure (8a) below with a log scale to better show the occupancy. Figure (8b) below shows the strip occupancy for the same chamber, emphasizing the high occupancy in the inner region. These plots were presented as a proof of concept for the performance monitoring technique of resistive sectors that was followed.



(a) Pad occupancy plot.

(b) Strip occupancy plot.

Figure 8: Occupancy plots for inner sTGC sector EIZ4R1C02 layer 1.

4 Summary

The PlotWeb tool has been used broadly by the New Small Wheel community, thus fulfulling this project's goal. In addition, several insights have been gained regarding ongoing issues with the small Thin Gap Chamber (sTGC) high voltage performance. It was seen that there is likely sparking in highly resistive chambers which draw high currents. Insight gained guides the future work to try and both recover and maintain the sTGCs, as well as provides lessons learned from the implementation in order to avoid this in the future.