SLINK Misalignment & Single Plane Rate Analysis at Pixel Luminosity Telescope

Summer Student:
André Donadón Servelle
Workplace:
Pixel Luminosity Telescope - CMS - CERN
Supervisors:
Andres Delannoy & Andreas Kornmayer

Summer Student Program

CERN

August 2018

1 Abstract

This report shows the two analysis that has been done to understand in the Pixel Luminosity (PLT) data. The first one consisted in a misalignment observed between the PLT luminosity data and the CMS wbm reported luminosity. Meanwhile, the second analysis was about issues in the online data of the PLT.

Both project were attacked in the same. Create or modify python, C++ scripts to get more data to analyze and find hints to solve the issues. Regarding to the first project, an important discovery in the data was crucial to understand that the misalignment was because of an conflict in the triggers, and it was finally solved. Meanwhile, the other analysis advanced greatly, after a python script to find the issues in the data was created.

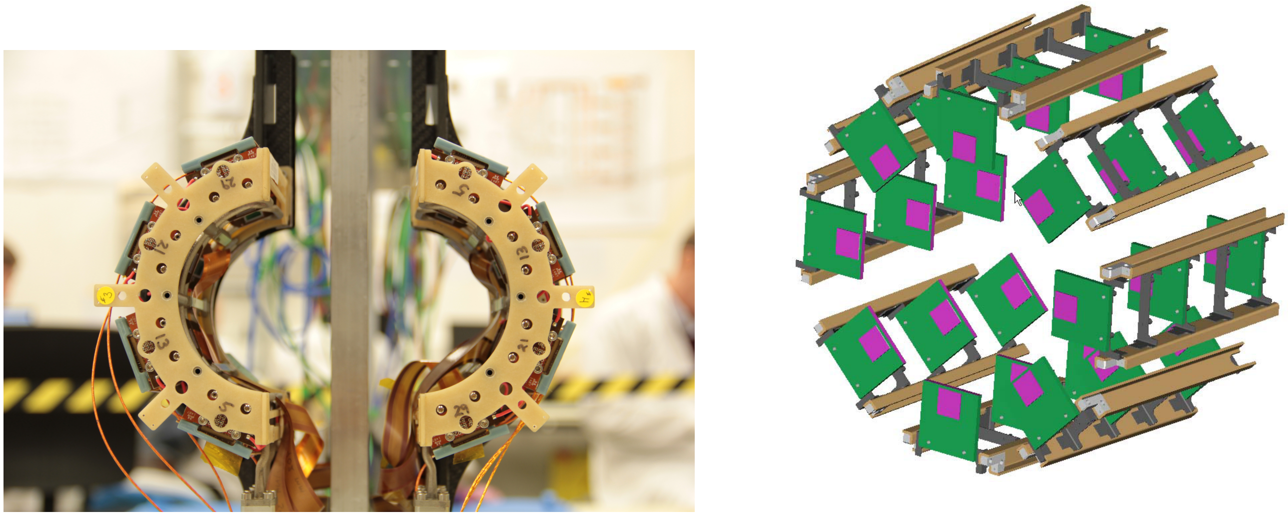

Figura 1: Pictures of two quarters of the PLT. The first one shows one of the real detector, meanwhile, the other is the design done for the construction, in which is possible to see the 8 telescopes that make up the quarter and the three silicon detectors in every channel.

2 Introduction

2.1 PLT

The PLT is the only sub-detector in CMS, whose sole purpose it is to measure the delivered instantaneous luminosity to the CMS detector at the LHC. The PLT is built using the same sensor and readout technology already used in the current CMS Pixel detector. The detector is separated in quarters (Fig. 1). Each quarter is a separate structure that houses four telescopes, placed in a half circle around the beam pipe. On each side of CMS two quarters are placed at a distance of 1.75m from the interaction point (η= 4; 1.55°).

Every telescope consists of three hybrid boards, each equipped with a single pixelated silicon sensor that is read out by a PSI46v2 readout chip (ROC). This chip is able to provide two diferent kind of data:

1. Pixel data: If one pixel of the sensor is hit and a charge higher than a previously programmed threshold is read out by the ROC, a pixel hit is created. The pulse height is saved together with a time stamp in a buffer and read out by an external trigger signal. The maximum trigger rate for pixel data is 100hHz. The pixel data is used to reconstruct tracks and allows to differentiate particles coming from the IP from beam halo particles

2. Fast-OR data: Whenever a pixel hit above threshold is being detected, the ROC will send out a fast-OR signal. The fast-OR signal height is proportional to the number of double columns hit in a specific bunch crossing (25ns window). In the Front END Driver (FED) dedicated to the fast-OR signals the triple coincidences between the three planes of a telescope are counted and can be translated into a luminosity value for each bunch crossing (40Mhz readout rate). This readout mode of the ROC is not used in the current CMS Pixel detector and finds its first application in the PLT.

3 1° Project: SLINK Bunch Crossing(BX) Misalignment

3.1 Motivation/Objective

The figure 2 shows perfectly the reason for this project. In the plot is possible to see the Pixel data (SLINK is the structure of the Pixel data) of the PLT and the luminosity published by CMS. In the case that the PLT data is correct, the plot should show an overlap between both data, but there is a kind of bias.

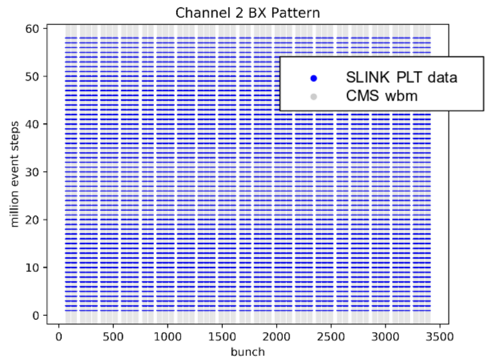

Figura 2: Plot showing the misalignment in the fill 6776.

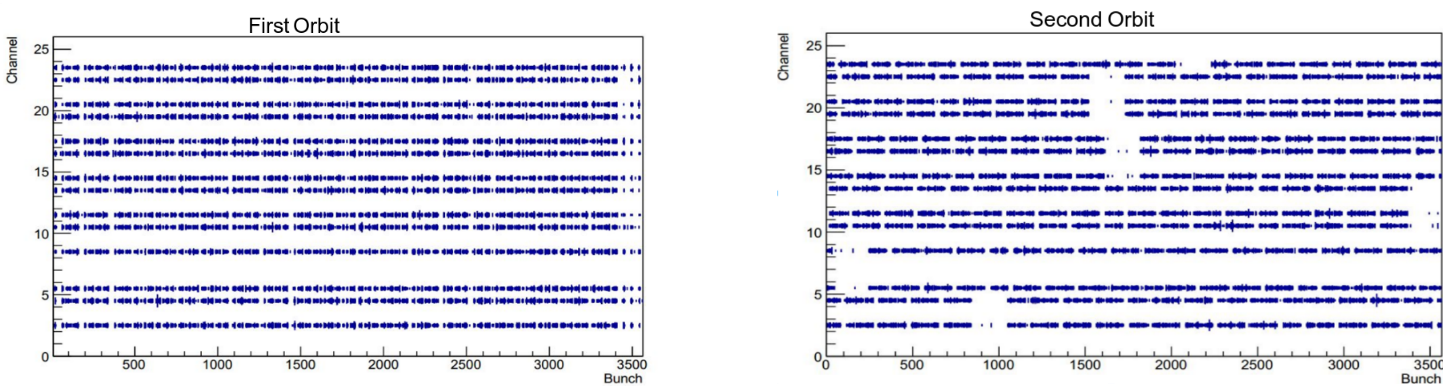

Figura 3: Plots created using the new script. The data is only aligned during the first orbit of the LHC. This was the crutial hint that helped to solve the SLINK misalignment

The tool available at the beginning of the project was a C++ script that could process the data and output a txt file reporting the number of hits per event in every bunch crossing. The objective is to modify this script to get more information to analyze the data in more detail. The output in the new script are root files.

3.2 Results

The figure 3 shows two important plot done using the new script. This plots show the information of each channel (telescopes) splitted for the fill 6776. It's interesting to see in a different way the misalignment, because now, to see that the misalignment is between the channels is a new information. The important conclusion is the fact that the misalignment happens at the beginning of the fill; in this particular fill, after the first orbit of the LHC.

All of this helped to realized that the problem was a conflict between the way in which the SLINK machine, and the workloop enabled and disabled the triggers. To make it simple, the main problem was that the workloop was enabling the triggers before the triggers in the PLT before the SLINK was ready to make measurements. So, after making this change, i.e., avoid the workloop enables the triggers, the figure 4 shows the new data, in which the SLINK data and CMS data is completely aligned.

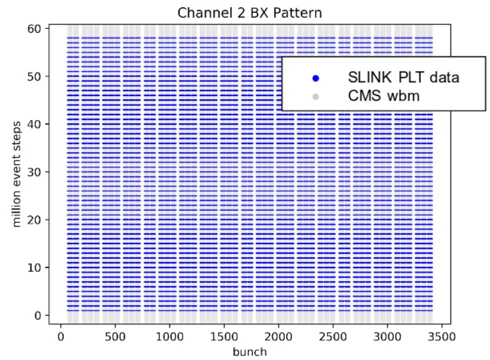

Figura 4: Data after the changes in the workloop. Now the PLT and the CMS wbm data are aligned.

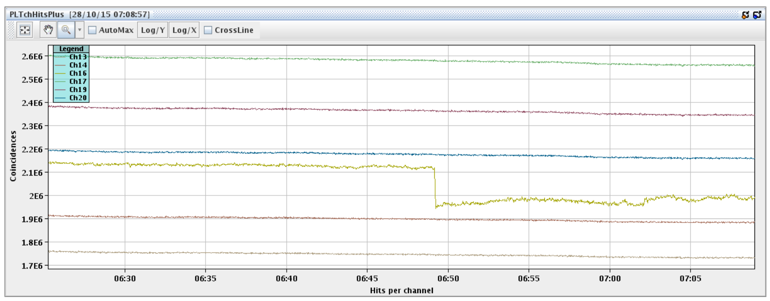

Figura 5: During a measurement a channel shows a drop in the instantaneous luminosity measured.

4 2° Project - Single Plane Rates

4.1 Motivation/objective

The figure 5 shows the instantaneous luminosity measured by the PLT for a few channels. An drop in the measurements of a channel can be observed. The issue is that in the moment when this changes happen an algorithm should try to fix it. Currently, a ROC Recovery algorithm is implemented to the online measurements in the PLT. The manner in which this algorithm works is calculating the ratio between a ROC and his neighbors, and use that value to identify an issue if this ratio achieves certain percent. But, as the plot shows, sometime this method does not "see" the issues.

The objective is to create a new script to find the issues exposed above analyzing the data of every readout chip(ROC) of every channel.

4.2 Results

Many ideas has been thought, but the one that was analyzed more is use the derivative of the luminosity to find the erratic behaviour in the measurements. The idea is that, when the data has a erratic behaviour, the value change a lot between two points in a "bad" ROC. Then, making an analysis of the fill 6909 (fig. 6), the figure 7 shows the histograms of the derivative of the luminosity(or rate). It is interesting to see that the ROC 2 has a long "tails", associated to the erratic behaviour. So, the goal is to use this information in the following way to find the moment in which the ROC 2 is jumping:

1. Fit Gaussian to get the Sigma

2. Select the number of sigmas to apply the following criteria:

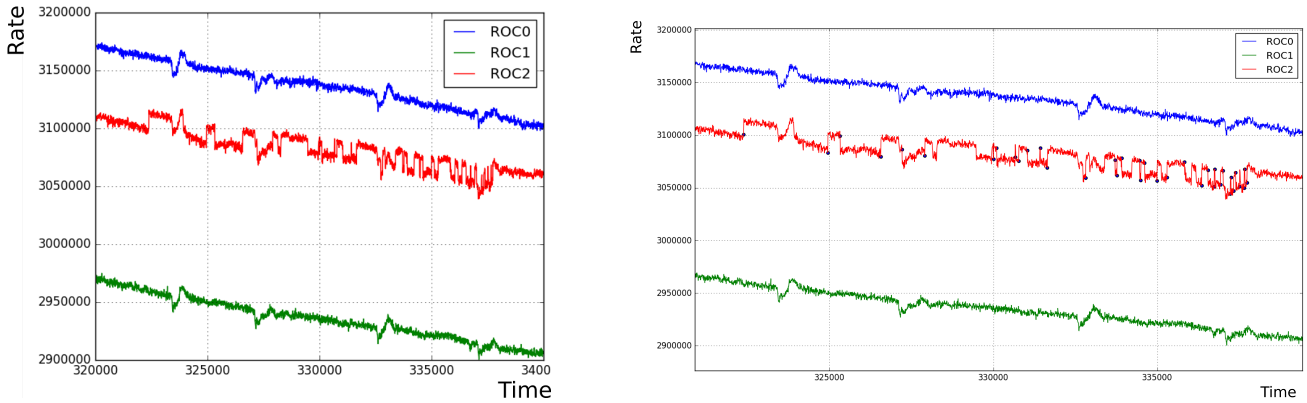

Figura 6: Single plane rate of channel 10. The new algorithm found several values with jumps, but not all of them.

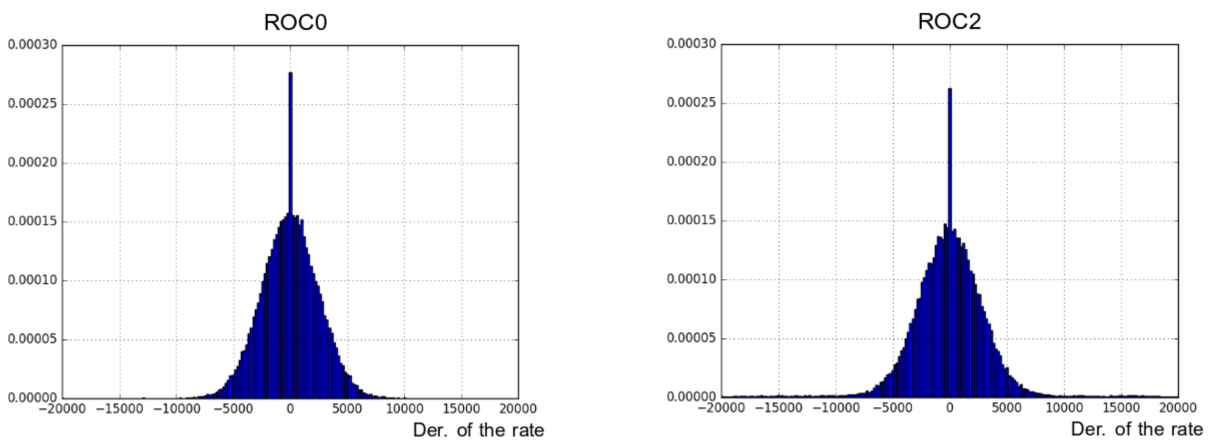

Figura 7: Histograms of the derivative of the rate. The ROC2 has long tails asociated to the jumps in the data.

- It is an erratic behaviour if :
  - ROCa value > # Sigmas
  - ROCb value < # Sigmas
  - ROCc value < # Sigmas

Then, doing this, the figure [ref] shows the results of the method. It's possible to see that the majority of the jumps and drops have been found, but not all of them. This plot express the fact that the script needs to be improved yet.

5 Conclusions

Two data analysis projects has been done. One, understanding a misalignment between the SLINK PLT data and the CMS wmb. A C++ script to analyze the luminosity in each telescope was done, and it had a crucial contribution to find the hint that helped to solved this issue.

Then, the second analysis based on the PLT online measurement had an important advanced to the erratic behaviours in the data measured by the ROCs using the derivative of the rate in each ROC to find them. This method must be improved yet, and the objective is to implement it in the online data taking.