Monitoring ATLAS L1 CTP data from P-BEAST

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Abstract

The ATLAS Level-1 Central Trigger Processor combines information from the calorimeters and the muon detectors and takes a decision to accept an event based on a list of selection criteria (trigger items). Busy signals from the detectors and generated dead time by the Central Trigger Processor prevents the buffers to become full. The visualisation of this data is useful to check the functionality of the system. My project during the CERN summer student programme was to develop an application, which produces plots of relevant Central Trigger Processor data and presents the results in an appropriate format for experts and users.

1 Introduction

During the CERN summer student programme I worked in the ATLAS Level-1 (L1) Central Trigger Processor (CTP) group. My task was to develop an application, which visualises relevant CTP data from P-BEAST [1] and publishes them in a suitable format for experts and users. A description of the ATLAS trigger system, especially the functionality of the Level-1 CTP, and the database P-BEAST is given in sections 1.1 and 1.2. The results of this project are presented in sections 2 and 3.

1.1 ATLAS Level-1 Trigger – CTP

The ATLAS trigger system, responsible for selecting interesting collision events for physics analyses, consists of two stages. The Level-1 trigger is a hardware based trigger reducing the 40 MHz bunch-crossing frequency to trigger rate of up to 100 kHz. The final trigger decision of the first stage is formed by the CTP [2] using information from the calorimeters and the muon detectors. The high level trigger (HLT), the second stage of the trigger system, is a software-based trigger reducing the trigger rate to an average rate of 1 kHz [3].
The CTP combines the information of the calorimeters and the muon detectors to construct

512 possible trigger items using logical tables [4]. This information consists, for example, of multiplicities for candidate electrons/photons, jets and muons. A possible item can be "1EM10", which means that at least one electron/photon candidate above a p_T-threshold of 10 GeV is required to select the event. Each trigger item has an associated prescaling factor to keep the total L1 rate below 100 kHz, the main triggers used for physics analyses being unprescaled. The L1 accept is the logical OR of all trigger items.
In order to prevent that buffers of the readout electronic becoming full the CTP generates two types of dead time. The "simple dead time" is the number of bunch-crossings vetoed after each L1 accept. "Complex dead time" is generated by the CTP using a leaky-bucket algorithm. This bucket leaks with a constant rate R and is increased by a given value X each time a L1 accept occurs. When the bucket is full, dead time is introduced. The parameters of this algorithm determine the maximal number of L1 accepts before dead time is generated. When dead time is applied, the events are vetoed and cannot be selected for a L1 accept. Events are also vetoed if a busy signal coming from any subdectector is received by the CTP. When the CTP accepts an event, it sends this information to the subdetectors to read out the data. Then the information is propagated to the HLT. The decision to accept an event in the L1-trigger has to be made within a time of 2.5 µs.

1.2 P-BEAST

ATLAS has two types of data: event and condition data. While the event data contain information about the collisions in the detector, the condition data store all the other information like trigger rates and dead times. These kind of data, which would be otherwise lost, are stored in a database called P-BEAST. P-BEAST is a long-term storage, which enables the possibility to investigate the behaviour of the systems during data taking at a later time.

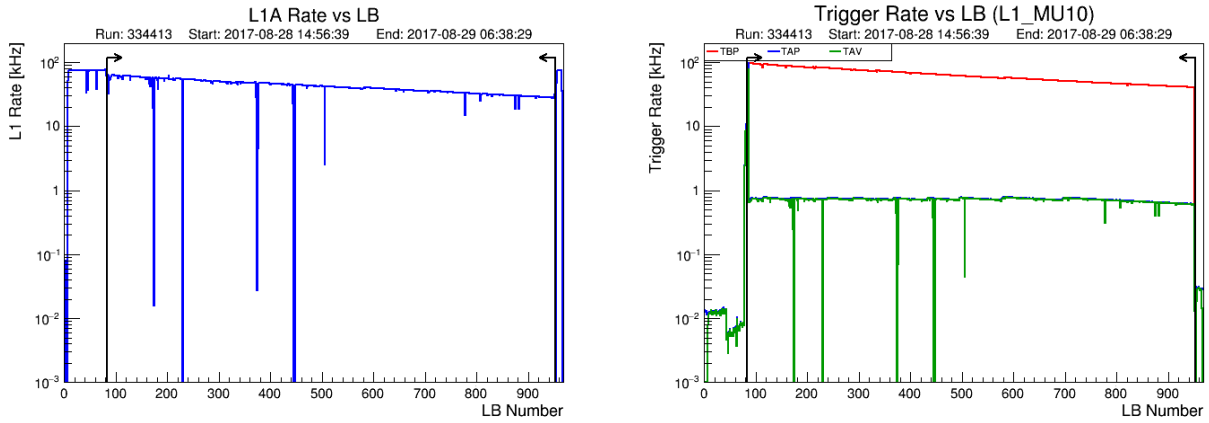
2 Visualising CTP data from P-BEAST

My first task was to develop a program which produces plots for the CTP group relevant data from P-BEAST. The data, which are stored in P-BEAST with a timestamp, are fetched from the database via an interface called "Beauty" [5]. Instantaneous data are stored every few seconds, while data per lumi block (LB) give information about the average value within a LB. A LB has usually a length of around 1 min, but the length can be changed. The written program utilises both types of data. For example, the relation between L1A rate and time is plotted for the instantaneous data, and the relation between rate and LB for the data per LB. The reason of producing plots for both types is that abrupt fast changes of values can only be seen in the instantaneous data, while the plot against the lumi block numbers provides information about the average values. The program produces all the plots given in the following list:

- L1A rate vs. time and LB

- Subdetector busy fractions vs. time and LB
- ATLAS dead times vs. time and LB
- Trigger item rates vs. LB
- Pile-up vs. time and LB
- Correlation between L1A rate and Pile-up

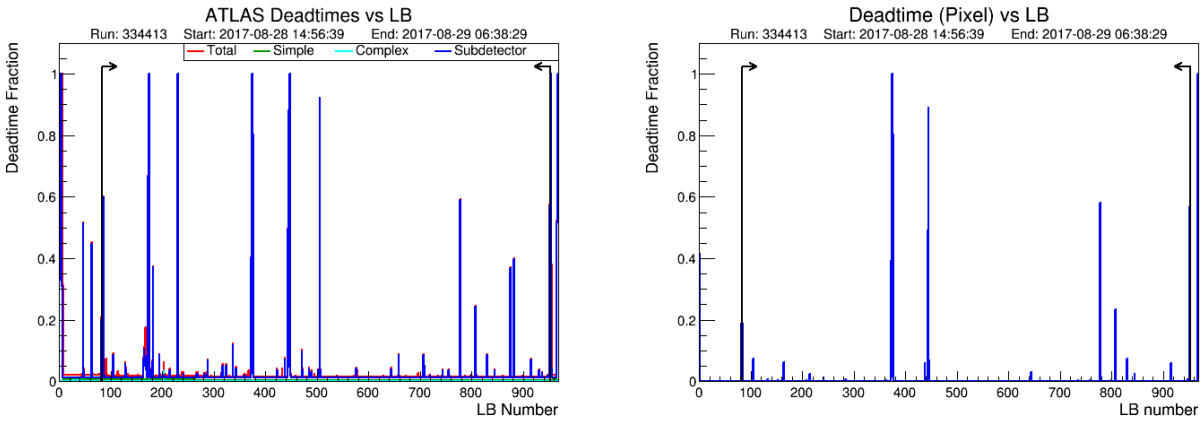
The Pile-up information is the only one which is presented without being produced by the CTP. However, the Pile-up plots and especially the correlation of the Pile-up with the L1A rate are helpful to check the behaviour of the system.
Examples of the produced plots are shown in figures 2.1 and 2.2. In figure 2.1b an example for the trigger item rate is given. The three lines in the plots indicate the item rate before prescale (TBP), after prescale (TAP) and after the veto due to the dead times generated by the CTP and the subdetectors (TAV). The program saves the graphs and histograms as png-files and in root-files. Using the root-files the user can plot the data again with different plotting options and ranges than the standard ones. Further information printed on the png images are the run number, if applicable, the start and end time either of the run or the selected time interval. Furthermore, in case of runs containing stable beams the start and end of the stable beams are visualised by black arrows.



(a) L1A Rate vs LB **(b)** Trigger Item Rate vs LB

Figure 2.1: Plots of the L1 acceptance rate vs LB (a) and of the trigger item rate (trigger item MU10) for a given run number (b). The three lines for the trigger item show the trigger rate at different stages: before prescale (TBP), after prescale (TAP) and after veto (TAV). Black arrows symbolise the start and end of stable beams.

The program can be used with different options. It can produce all the plots for a given run number or for an inserted start and end point of a time interval, but both have to be within the same run. An additional option is implemented to provide the plots for all runs with stable beams in a given time interval.



(a) Dead time vs LB

(b) Subdetector busy signal

Figure 2.2: Plot for the ATLAS dead times vs LB (a) and busy fraction of the Pixel-detector vs LB (b). The dead-time fraction is the fraction of BCIDs with dead time or busy signal. For the given run one recognises that the busy signal of the subdetectors is dominant in comparison to the dead time generated by the CTP.

3 Visualising the results on a webpage

Currently, there is a webpage publishing CTP data like the L1 rate per LB and an overview about the daily busy and dead-time fractions [6]. The motivation to publish the plots produced with data from P-BEAST for each run with stable beams is that the user is available to check all the interesting data for all runs very fast without the need to produce all the plots manually. Additionally, publishing the results on a webpage in an user-friendly way gives access to the data to interested parties outside the CTP group and the new webpage is a complement to the existing webpage.

The webpage consists of a main page presenting an overview table with all available runs. For each run there exists a separate page with the produced plots (s. fig. 3.1). To have a closer look at the data the root-files of the plots are provided. The users are able to download the root-file of each plot and have the possibility to modify the plots for their own purpose. This is especially useful for plots with several lines contained on the png images. The subdetector plots and the trigger item versus LB plots are hidden by default in order to keep the page clean and fast. All or only a special subset of plots can be shown by pressing the corresponding button on the webpage.

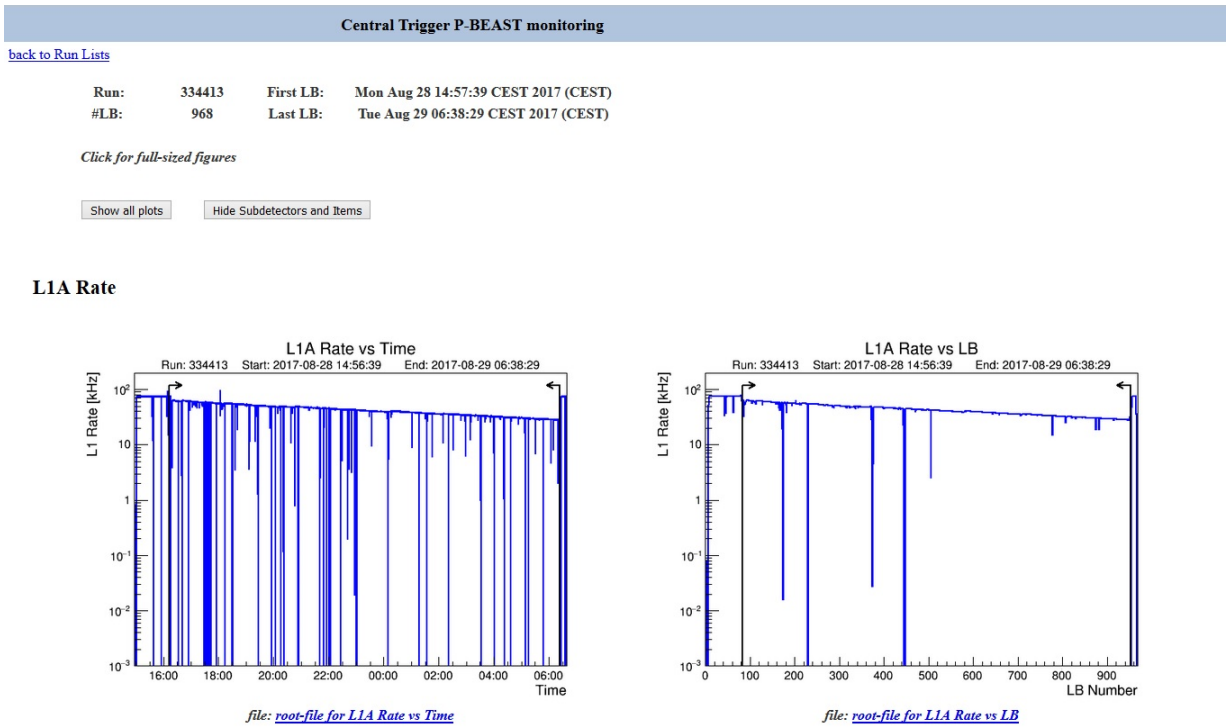


Figure 3.1: Screen shot of a run page part.

4 Conclusion

During the summer student programme I wrote a program which fetches data from P-BEAST in an efficient way and produces plots for data relevant for the CTP. The program allows the user to choose between creation of plots for a specific run or for a given time interval. The program can be easily adapted to produce more plots. The same script can be utilised to create plots for runs with stable beams, which can be published on a webpage. A program, which creates the webpage with the plots was implemented as well [7, 8]. The created webpage is an appropriate way to publish the results and allows experts and interested users outside the CTP group to check the status of the CTP during runs with stable beams at a later time.

References

[1] A. Sicoe et al., *A Persistent Back-End for the ATLAS TDAQ Online Information Service (P-BEAST)*, URL: https://cds.cern.ch/record/1402973/files/ATL-DAQ-PROC-2011-047.pdf.

[2] S. Ask et al., *The ATLAS central level-1 trigger logic and TTC system*, JINST 3 P08002 (2008).

[3] A. Ruiz-Martinez, *The Run-2 ATLAS Trigger System*, Journal of Physics: Conference Series 762 012003 (2016), URL: https://cds.cern.ch/record/2133909/files/pdf.pdf.

[4] H. Bertelsen et al., *Operation of the upgraded Central Trigger Processor during the LHC Run 2*, JINST 11 C02020 (2016).

[5] W. Vandelli, *Beauty project*, URL: https://gitlab.cern.ch/vandelli/beauty.

[6] *CTP Busy Webpage*, URL: https://atlas-l1ct.cern.ch/busy/.

[7] *CTP P-BEAST Webpage*, URL: https://atlas-l1ct.cern.ch/pbeast_plots/.

[8] *CTP Webpages Project*, URL: https://gitlab.cern.ch/atlas-l1ct/CtpWebSummary.