



Analysis of the trigger system of the ALFA detectors

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1 Introduction

During the CERN Summer Student Programme 2015 two different projects were carried out. Both related with the ALFA subdetector in ATLAS. The first, and main, project aimed to do an study of the trigger efficiency of the ALFA detector at $\sqrt{s} = 8$ TeV and $\beta^* = 90m$. The results can be found fully explained in the note [1]. A secondary task consisted on systematical tests of new chips for an update of the ALFA trigger system.

1.1 The ALFA detectors

The ALFA detectors aimed to measure the flux of scattered protons which leave the interaction point in the ATLAS detector with very small angles, $\sim \mu rad$. To reach sufficiently small angles the ALFA detectors are positioned about 240 m from the interaction point. In order to achieve this purpose, there are four ALFA stations, two stations in each side of the interaction point. Each station consists on two dedicated detectors, one upper and other one lower. A scheme of the location of the detectors is shown in figure 1.

The detectors are formed by a main detector and an overlap detector (figure 2a). The main detector is a tracking detector constructed mainly of scintillating fibers for

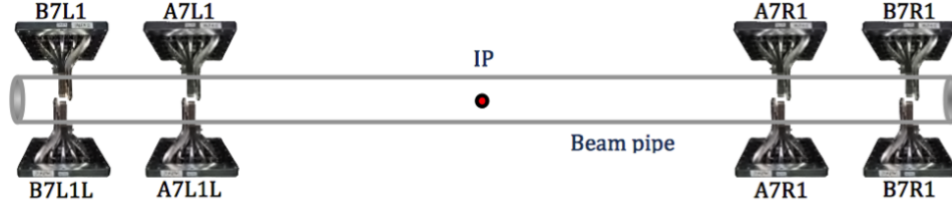


Figure 1: Scheme of the location of the ALFA detectors, in both sides of the ATLAS interaction points.

tracking of scattered protons and it contains two scintillating tiles for triggering. The overlap detector is used for the relative alignment of the two detectors of each station. In order to separate the detector from the ultra high vacuum in beam pipe a so-called Roman Pot is used, which allows a secondary vacuum in the detector (figure 2b).

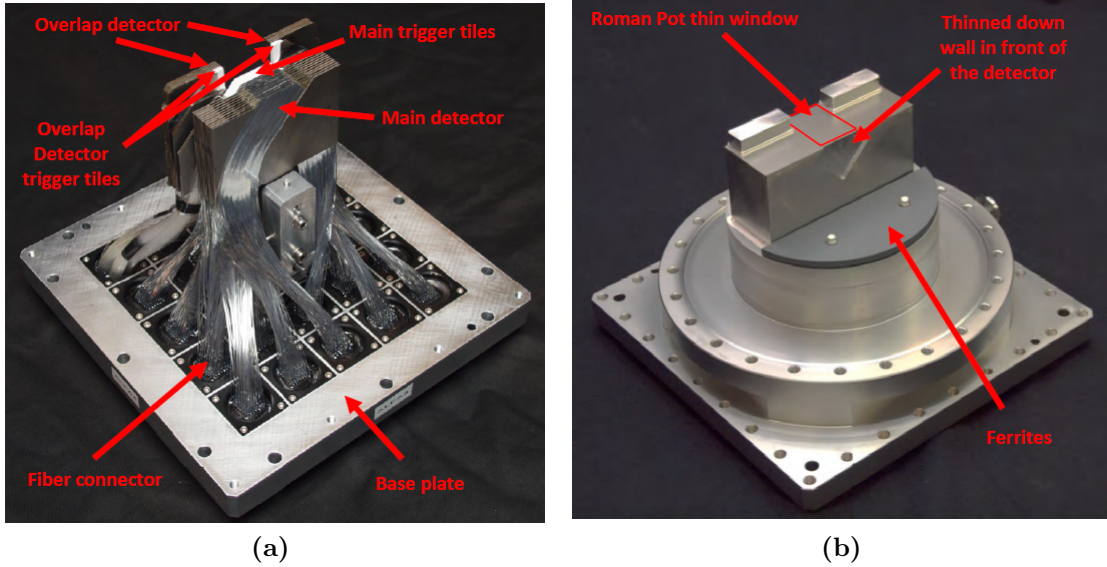


Figure 2: (a) Visualisation of all the parts of an ALFA detector, (b) ALFA detector covered by a Roman Pot.

2 Trigger efficiency for the ALFA detectors

This project started with the understanding of the ATLAS internal note [2] and the C++/ROOT code which was used to get those results. At this stage some pieces of the code were found which were not completely correct, so the code was improved. Some little bugs were fixed, some parts of the code were re-written in an easier way and some new analyses were included. In addition, the results presented in the note [2] were

reproduced to verify my correct understanding of the project and to check how relevant the new modifications were.



Figure 3: Trigger tiles of the ALFA detector, whose performance has been studied.

An adaptation of the code was necessary to use the new data (ATLAS run 206881), some types of variables were changed (i.e. from `float` to `double`) and the luminosity blocks and bunch crossing IDs in use were updated. After these changes, the trigger efficiency study was carried out. The study was done in three different ways: analysing the performance of the trigger tiles, through the CTP (Central Trigger Processor) trigger items for individual detectors and using a random trigger.

- A preliminary study about what are the reasons that may make the trigger tile fail. The triggering can be wrong because one tile (or both) is not firing or it does in a wrong BC due to an offset of the signals in time.
- Trigger efficiency through the performance of the trigger tiles. At this stage the study focuses on figuring out how often the trigger tiles produce wrong triggering¹.

$$\varepsilon = \frac{\text{\#elastic events with correct triggering}}{\text{\#elastic events}} \quad (1)$$

Also, the differences between both trigger tiles in each detector were investigated and the possible existence of geometrical effects which can generate a bigger number of wrong triggering in a certain part of the tiles. When the trigger is correct a signal is sent to the CTP, so it has also been studied which is the fraction of signals which should go to the CTP and actually arrives.

- Trigger efficiency through the CTP items for individual detectors. The CTP trigger item for a detector will be true only in the case that the trigger is correct, so the state (true/false) of the item can be used to study the trigger efficiency. As in the

¹An event with wrong triggering is one in which, at least, one of the trigger tiles does not fire or it does in a wrong moment.

previous analysis, it has been checked that there are no geometrical effects in the detector.

$$\varepsilon = \frac{\text{\#elastic events with true CTP trigger item}}{\text{\#elastic events}} \quad (2)$$

- Trigger efficiency through the CTP items for individual detectors and a random trigger. In this case, the elastic events and the elastic events with true CTP trigger item are counted only those cases in which a random trigger fires. An study of the geometrical effects is also done in this case.

$$\varepsilon = \frac{\text{\#elastic events with true CTP trigger item and fire by the random trigger}}{\text{\#elastic events in which the random trigger fires}} \quad (3)$$

- At high level trigger, ALFA has a calibration stream and a physics stream. During all the study the ALFA calibration stream has been studied, it has a larger amount of unbiased data, while the physics stream has a larger ratio of interesting events. The normalisation factor between both streams is calculated in order to know how many events are in the calibration stream, but not in the physics stream. Also, it has been calculated the fraction of events which may be missing in the calibration stream, one event is missing when the trigger of all four detectors in the arm fail.
- There are some CTP trigger items which are commonly used for physics analysis, its efficiencies have been calculated.

All the results for the mentioned study in this report are included and discussed in the note [1]. Also, the results were shown in the presentation “Trigger efficiency for the ALFA detector in run 206881” for the ALFA collaboration.

This study was done by using elastic and diffractive like events, but only the results for elastic like events were fully analysed.

3 Electronic test

New chips for the PMT (PhotoMultiplier Tube) read out in the trigger mezzanine were tested (see figure 4). The PMTs aimed to measured the light generated by the scintillating trigger tiles when a proton passes through them. So, it can be considered that the new chips are a part of the read out system of the trigger tiles.

Two chips will be used for each test, one per PMT, and they will be connected to the trigger mezzanine and to an analog board from which the input signal will be received. No PMT and no trigger tiles are available for these tests, so the signal they would generate is created by a pulse generator. That signal has an amplitude of 0.3V and width of 10ns.

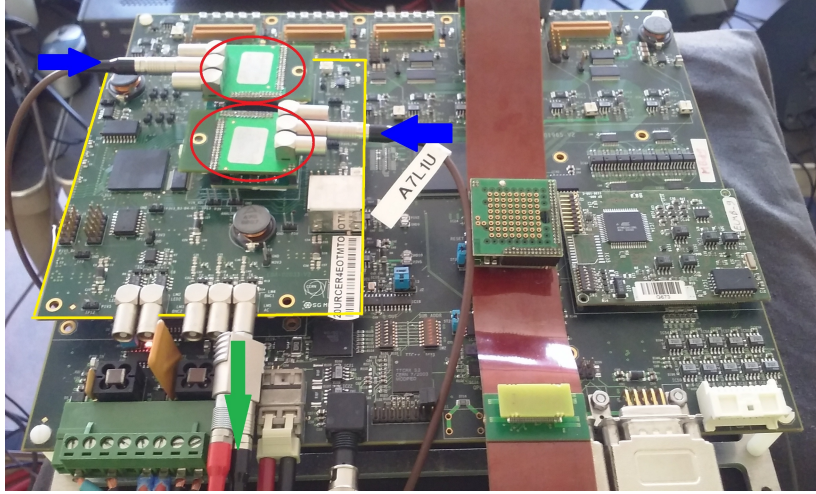


Figure 4: Motherboard of an ALFA detector, with the trigger mezzanine mounted on it. **Yellow:** trigger mezzanine, **Red:** analog board connected to the new chips, **Blue:** input signal, **Green:** output signal.

The output signal is observed with an oscilloscope and the test consist on observing (or not, in the case the chip does not work) an output signal when using different logics in the trigger tiles. Some logics can be established in the system, an ‘And’ logic means that in order to have an output signal both chips should be working, an ‘Or’ logic will produce an output signal when, at least, one chip works. Also, there are some combinations which allow to test both chips individually. In this way it is possible to check whether a chip is working correctly or not. This systematic study was done for 27 pieces and errors were found on 3 pieces, which then were rejected from later installation on an ALFA detector at LHC.

References

- [1] A. Guerrero Llorente, S. Jakobsen and S. S. Mortensen. *Trigger efficiency for the ALFA detector at $\sqrt{s} = 8$ TeV and $\beta^* = 90m$* . CERN, Geneva, in progress
- [2] M. A. Medici and S. Jakobsen. *Trigger efficiency for the ALFA detector in 2011*. CERN, Geneva, November 2013
- [3] S. Jakobsen. *Commissioning of the Absolute Luminosity For ATLAS detector at the LHC*. Phd thesis, University of Copenhagen, December 2013.
- [4] M. A. Medici. *Diffraction with ALFA and ATLAS at $\sqrt{s} = 8$ TeV*. Master thesis, University of Copenhagen, August 2013
- [5] ALFA Group. *Measurement of the total cross section from elastic scattering in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector*. CERN, Geneva, in progress