Summer Student Program 2017

ALFA detector, Background removal and analysis for elastic events

Report by: Nazim Belaloui

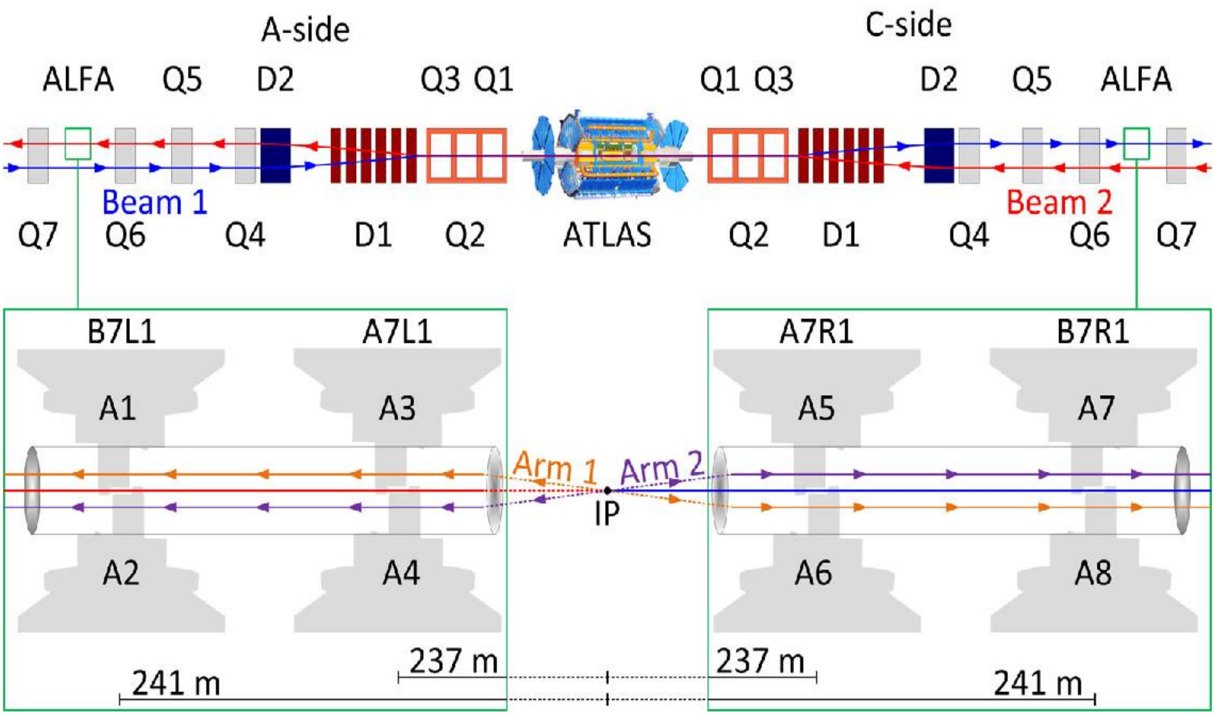
Supervisor: Simon Stark Mortensen

CERN Summer Student Report 2017

I worked on the ALFA project which has the aim to measure the total cross section in PP collisions as a function of t, the momentum transfer by measuring the scattering angle of the protons. This measurement is done for all available energies; so far 7, 8 and 13 TeV.

ALFA (Absolute Luminosity for ATLAS)

ALFA is a high-precision scintillating fibre detector which has been designed to determine the LHC absolute luminosity at the ATLAS interaction point. In addition it is dedicated to the measurement of elastic scattering at very small angles for the total cross section determination and diffractive studies.



This detector consists of 8 Roman Pots arranged in 4 pairs of detector modules on each side of ATLAS at a distance of 240 m.

detector module:

Main Detector: is made of 20 staggered layers of square-shaped 0.5 mm thick scintillating fibres, with 64 fibres arranged in UV geometry under an angle of $\pm 45^0$ relative to the vertical axis. Its ultimate spatial resolution, ignoring any geometrical imperfection, is about 14.4µm thanks to staggering of the layers.

Overlap Detector: Since the exact position of the LHC beam spot at the location of the ALFA tracking station may vary from fill to fill by a couple of mm, it is necessary to position the upper and lower ALFA detectors adequately. OD is consist of fibres arranged horizontally measuring the vertical coordinate only with a precision of 100 µm used for alignment of an upper detector to a lower detector.

The readout system is composed by Multi-Anode Photo-Multiplier Tubes, which convert light to electric signal that can be readout.

Triggers: 3 mm thick plastic scintillator trigger tiles have the shapes of the corresponding sensitive areas of MD and OD

The Roman Pot: have been designed to move the detectors as close as 1 mm to the beam, but only from above and below, due to the mechanical constraints imposed by the two horizontal beam-pipes of the LHC that's why the side walls are 500µm, bottom window is 200µm thick. The design of the RPs obeys strict requirements to ensure the positioning precision and the operating conditions of the LHC accelerator. Such requirements are the use of secondary vacuum inside the RP for safe separation from the ultra-high vacuum of LHC. Also stainless steel cylindrical pot with a cavern for the detector and two flanges to allow the movement of RP.

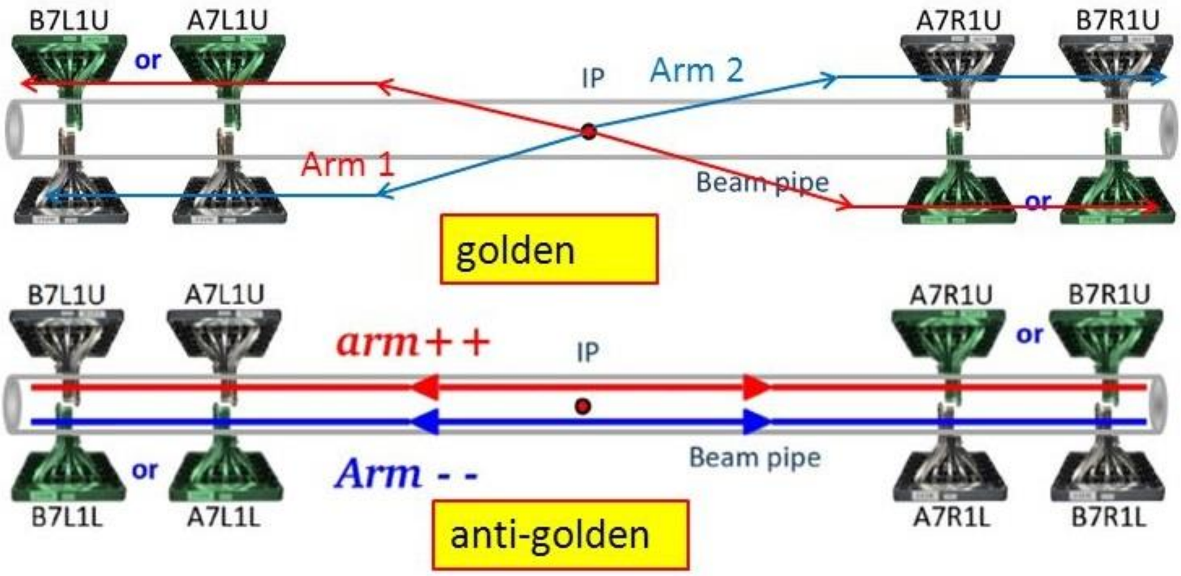
After the collision happens at the IP, the outgoing particles will be detected by the station so we can record the position in the detector coordinate system and then calculate the scattering angle at the IP.

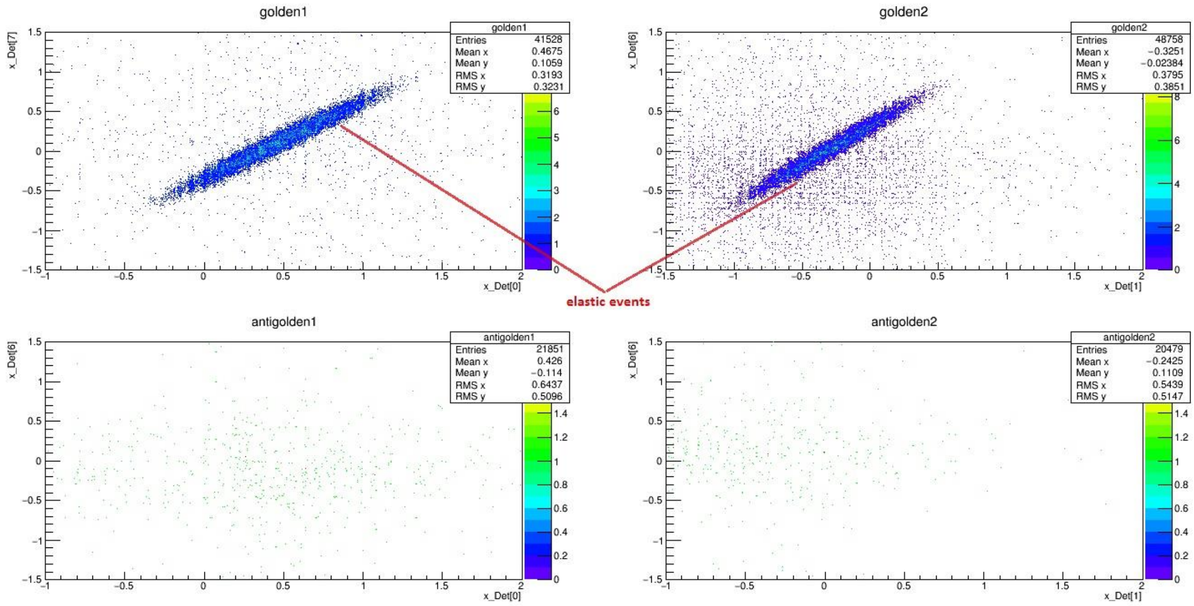
There are many analysis steps and we have focused on enhancing the signal-to-noise ratio. First of all I tried to be more familiar with ROOT, worked on understanding the code used to access to the data, plotting histograms, then cutting-off background.

Elastic events plots:

The momuntum in conserve in the elastic events, so there is a coleration between the protons in A-side and C-side that's why we can see the elastic events in the golden plots, but it's uncolerate in the anti-golden so we use the plots to identifie background.

The background is determined from anti-golden events by flipping the coordinates of one of the tracks.



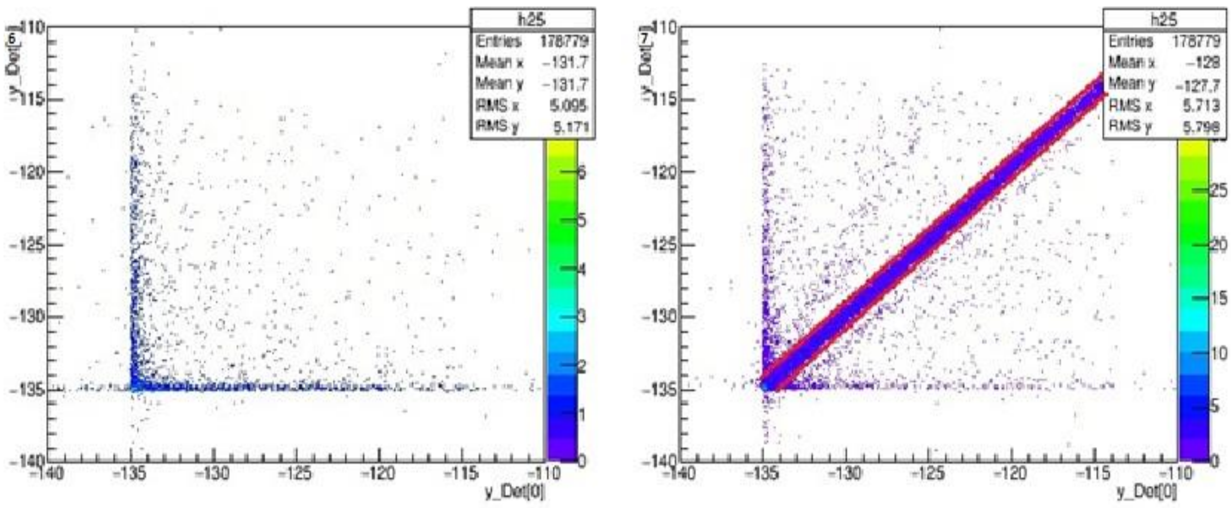


From the anti-golden plots we can deduce that the ellipse in the golden plots is an elastic events and the rest is the background.

In the next plots I tried to cut-out the background with several methods.

<u>First:</u>

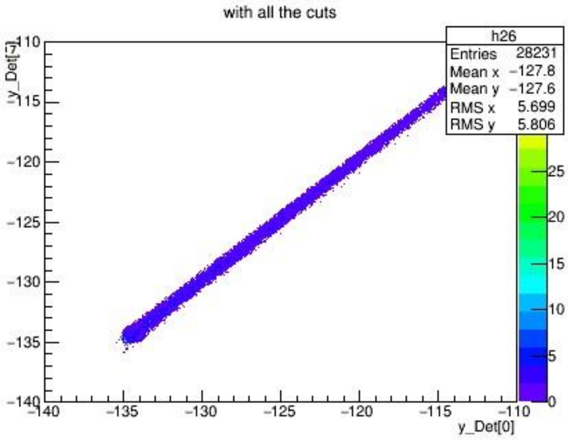
We used to draw this plots the y coordinate of the [0] detector and [7] detector (golden) and [0] detector and [6] detector (anti-golden)

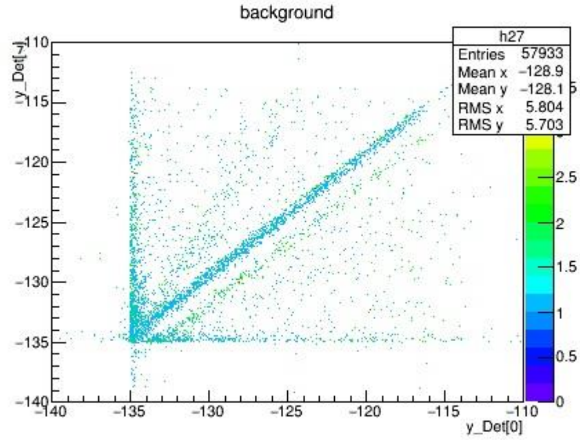


Anti golden

Golden

From the anti-golden plots we can see the background, and to cut it out we used 2 lines parallel to the elastic events with slope equal to 1, and we removed all the events above the upper line and bellow the lower line.

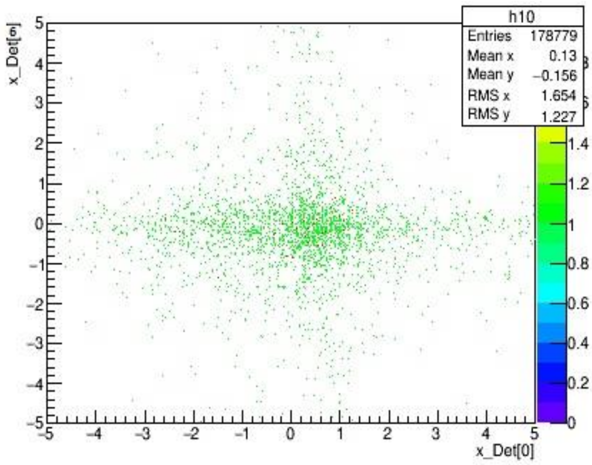




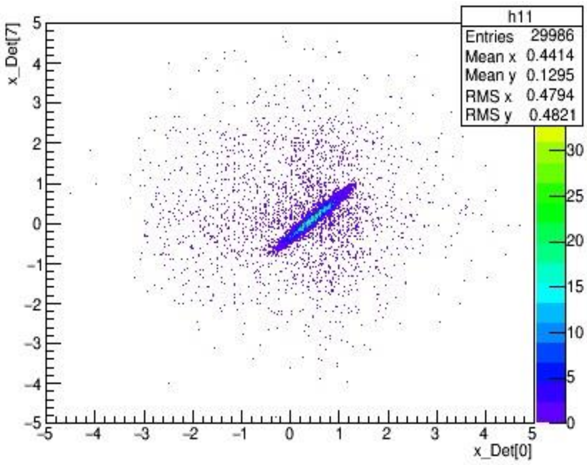
So now in the 1st plot we can see the elastic events and in the 2nd one we see the extracted background.

Second:

We used to draw this plots the x coordinate of the [0] detector and [7] detector (golden), and [0] detector and [6] detector (anti-golden)

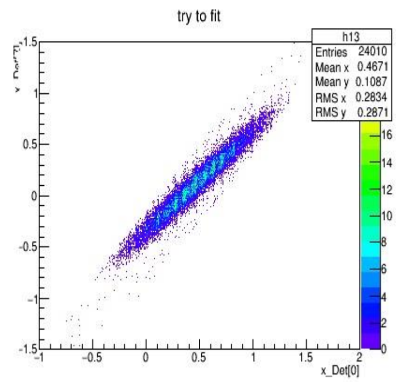


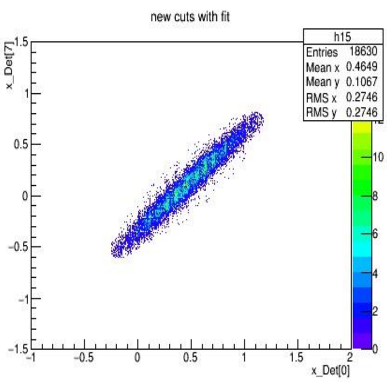
Anti-golden

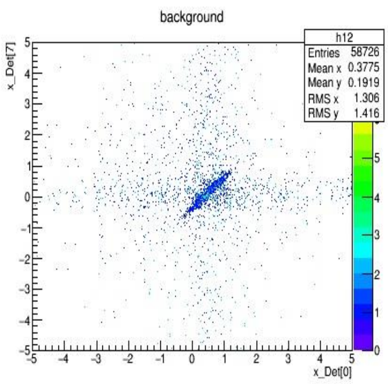


Golden

First we used the same code as in the first plots to take some background but in this case we still have a lot of unremoved background which is why we decided to use an additional method







To cut away the background we tried first to fit the elastic events in an ellipse. But we still have some background so we had to fill the ellipse to the data then the result of this fit used to cut away the background .

<u>Conclusion:</u>

- Anti-golden plots show us the background and gives us an idea where the elastics events are.
- We can cut the background with correlation plots.
- From the plots we can see that we had so many events and after cutting away the background we had less events