(S3 = 1 and S3 = -1), compute the mean of each and determine AP using equation (5)[8]. Figure 8 shows the η distributions for a simulation of 1 000 000 events (half have left helicity and the other half have right helicity) with the default parameters:

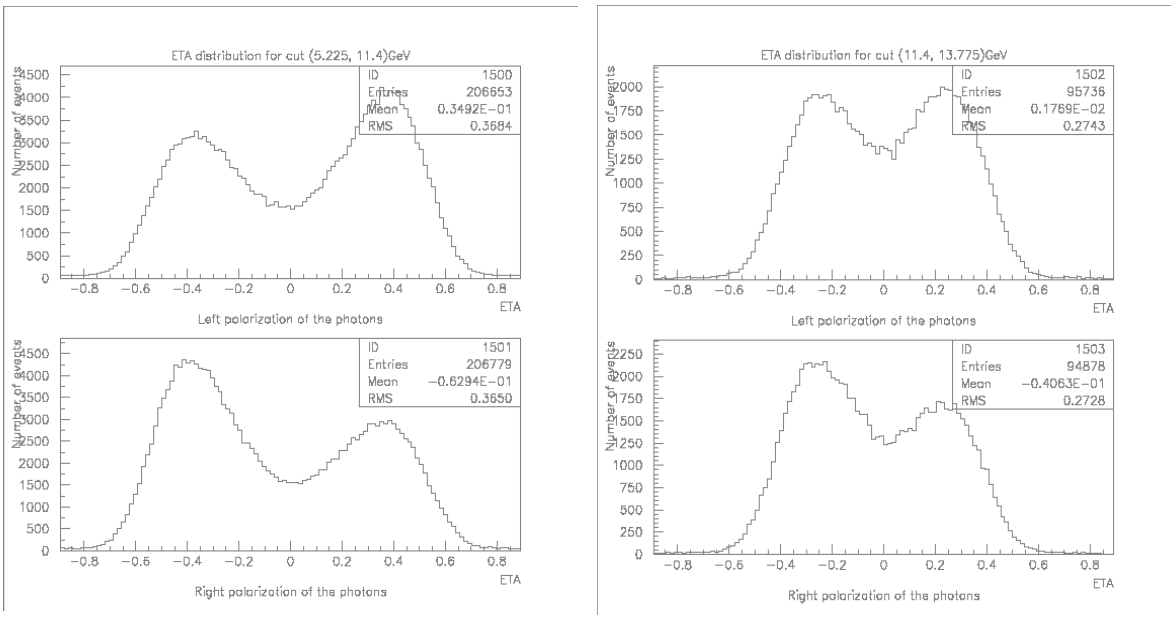


Figure 8: The η (ETA) distributions with two different energy cuts {the lefts one are for the calculation of the AP with equation (5) and the rights one are for the calculation of the focus with equation (6)}. The two upper distribution are from photons with left helicity and the two bottom distributions are from photons with right helicity.

We can deduce from these graphs that the photons with left helicity deposit generally more energy in the upper calorimeter than the bottom one, since there is more $\eta > 0$ events than $\eta < 0$ events. That means, from equation 3, that they hit more often the calorimeter at $y > 0$. On the other hand, the photons with right helicity have more often $\eta < 0$ events than $\eta > 0$ events. That means that they hit the calorimeter more often at $y < 0$. This is in perfect agreement with the theory. Now, if we use the mean of both left graphs and put in equation (5), we get an Analysing Power of (0.0979 ± 0.0008)[9]. The Analysing Power that had been calculated before using the rising time method was:

8 This is the inverse process that is done when the polarimeter measure the polarization. That is, usually we assume to know AP and we determine the polarization.

9 The error on the Analysing Power is define using $\pm\sigma$. It is easy to calculate, since sigma is the square root of the variance and the variance is RMS^2/n, where n is the number of event. The RMS and the total number of events are output on the graph.

(0.09608 ± 0.0011). Both result agree within their error. We can also use the right graphs to find that the focus should be (0.5806 ± 0.0019)[10]mm. This focus is about the same order of magnitude that we observe in the real polarimeter TPOL. We can thus say that the MC simulation reproduce well the reality for the determination of the AP and the focus.

6.2-Parameters with influence on the AP and focus

6.2.1-Polarization dependence

Let's first verify if the polarization itself has an influence on the AP and the focus. If the constant AP depends on the polarization, this would mean that this is not a constant anymore. In other word, let's verify that we can indeed use equation (5) to determine the polarization. Figure 9 shows the plot of the AP versus the polarization, and the focus versus the polarization:

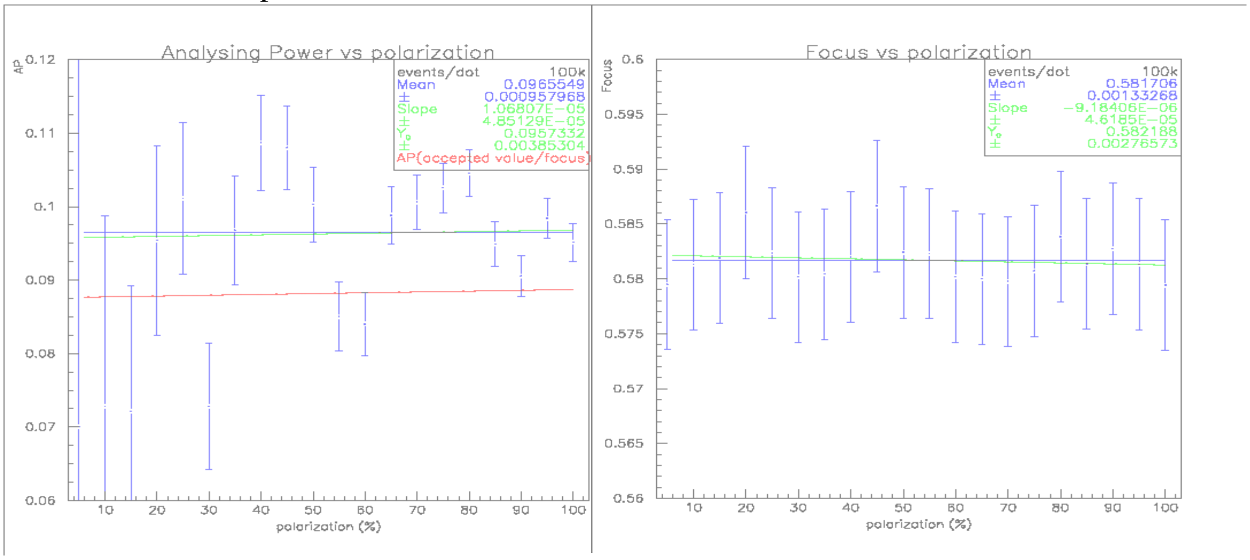


Figure 9: Plots of the of the Analysing Power vs the polarization (left graph) and the focus (mm) vs the polarization (right graph). Each data (dot) are from a simulation of 100 000 events. The blue line show the mean, the green line is a linear fit of the data and the red line is a linear fit of what should be the AP in function of the focus using equation (7).

10 Since it is a lot harder to find σ for the focus, we define the error on the focus as $focus \cdot \sqrt{1/n}$.

We first observe that, as the theory predict, there seem to be no polarization dependence on AP and the focus. The uncertainty on the slope of both graph agreed with 0: (1 ± 5)E-5 for the AP graph and (-9 ± 46)E-5 mm for the focus graph. However, the error on each data is considerable for simulation of 100 000 events; too much to be able to get accurate conclusions. It must be point out that we are left with only about 40% of the data when we use the energy cut for the calculation of the AP, and with 20% of the data when we calculate the focus (see the number of entries on the graphs of figure 8). That could explain these large error bars. The main thing that figure 9 tell us is that we need to simulate more events to get accurate data. Unfortunately, the computer has his limitations. It must be understood that a simulation of 100 000 events take about 2 hours to run and take about 20 megabytes of memory space. After some tests, we decided that simulation of 1 000 000 events was acceptable both for the error and the computer. Let's see what kind of graph we get for the polarization dependence now (figure 10):

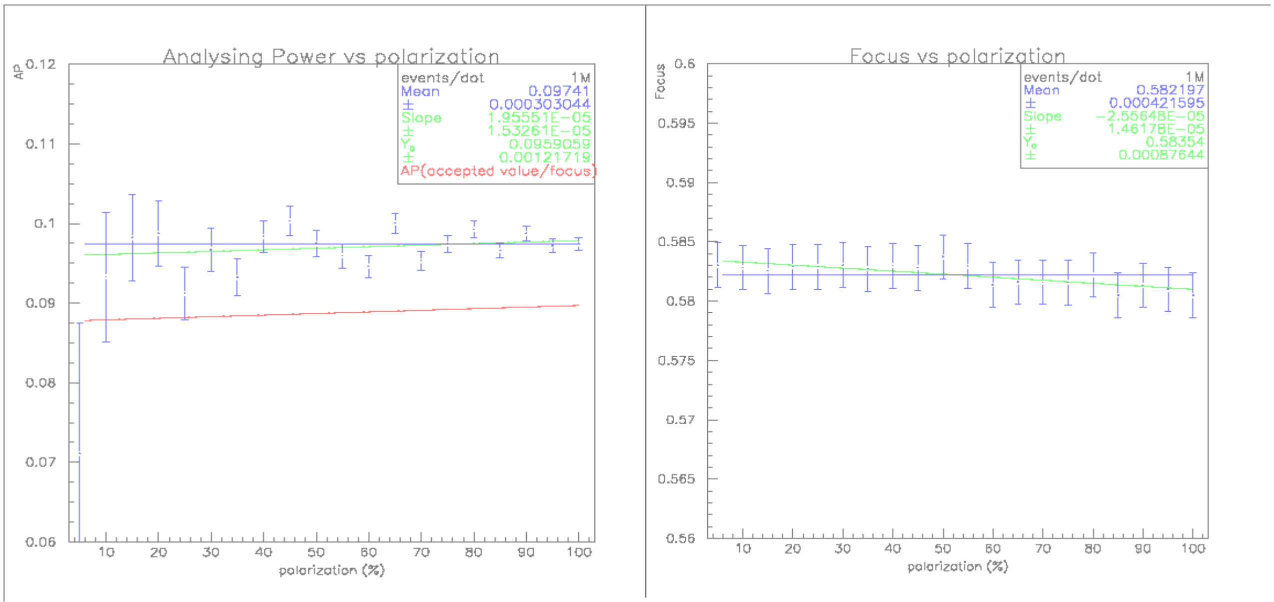


Figure 10: Plots of the of the Analysing Power vs the polarization (left graph) and the focus vs the polarization (right graph). Each data (dot) are from a simulation of 1 000 000 events. The blue line shows the mean, the green line is a linear fit of the data and the red line is a linear fit of what should be the AP in function of the focus using equation (7).

This time, the slope for the AP graph is (2.0 ± 1.5)E-5, which means that the slope = 0 is not include in the uncertainty. We can thus conclude that the value of the polarization has an effect on the AP. However, this effect is too small to stop using equation (5). Moreover, we see that the slope of the expected value of AP in function of the focus (red slope) is approximatively the same than the AP vs polarization slope (green slope). That mean that if the polarization change, the focus will change in such a way that the equation (7) will permit us to correct to get the good AP[11].

Finally, we can see that the error on AP is reduce has the polarization increases. This can be understood by looking at equation (5). When we try to determine AP, we have to divide by the polarization, which mean that a polarization of 5% (0.05) should have an error about 20 time bigger than for a polarization of 100% (1.00). For this reason, and the fact the polarization has not a big effect on AP, we will use a default polarization of 100%.

6.2.2-Emittance of the Hera's leptons beam dependence

Here are the plots of AP and the focus versus the emittance of the beam in x (figure 11):

11 This comparison is only qualitative for now. A deepest analysis about the AP we should get from the focus using equation 7 will be done later, including the reason why there is an offset between both linear fits.

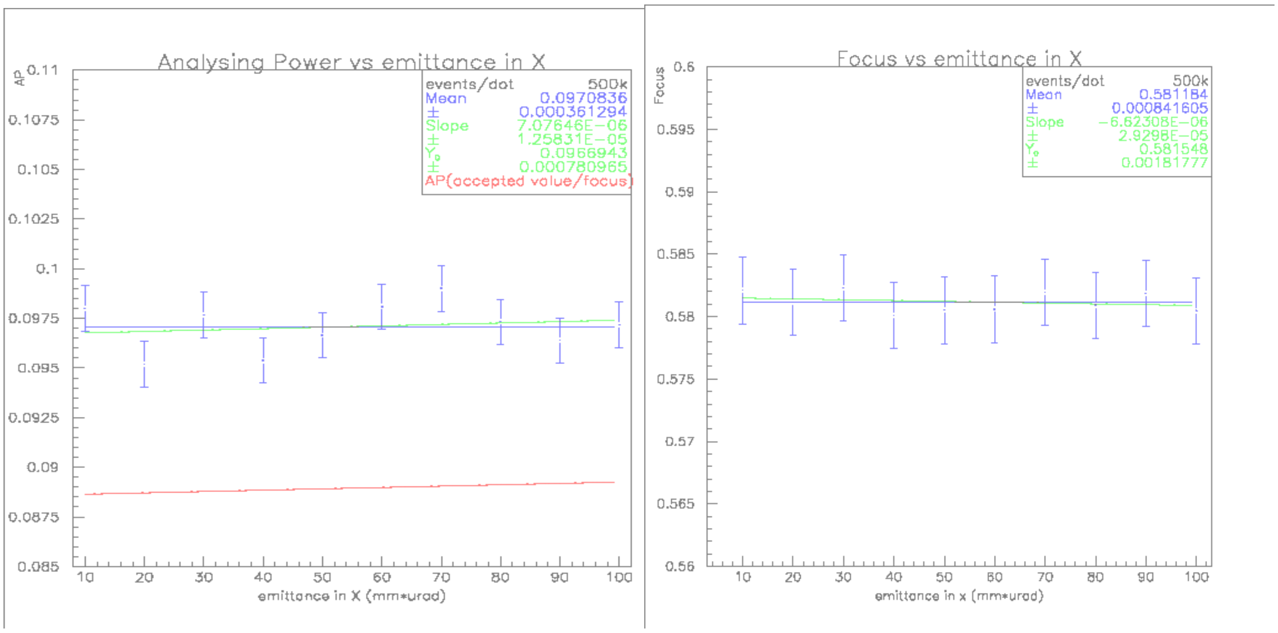


Figure 11: The graphs of AP and the focus (in mm) versus the emittance in x of the Hera's leptons beam. Again, the blue line shows the mean, the green line is a linear fit of the data and the red line a linear fit of what should be the AP in function of the focus using equation (7).

As one should have expected, the emittance in x has no influence on the Analysing Power, slope = (0.7 ± 2) E-5 $(\text{mm*urad})^{-1,}$ or the focus, slope = (-0.7 ± 3) E-5 urad^{-1}. Indeed, the tendency of the beam to enlarge in the x-direction obviously doesn't change anything to the behavior of the Compton collisions in the y-direction.

On the other hand, we should expect a strong correlation between the emittance of the Hera's leptons beam in y and the focus, since the focus describe the sprayed of the backscaterred photons in the y-direction. This should lead to a correlation between the AP and the emittance in y. This is confirmed by figure 12:

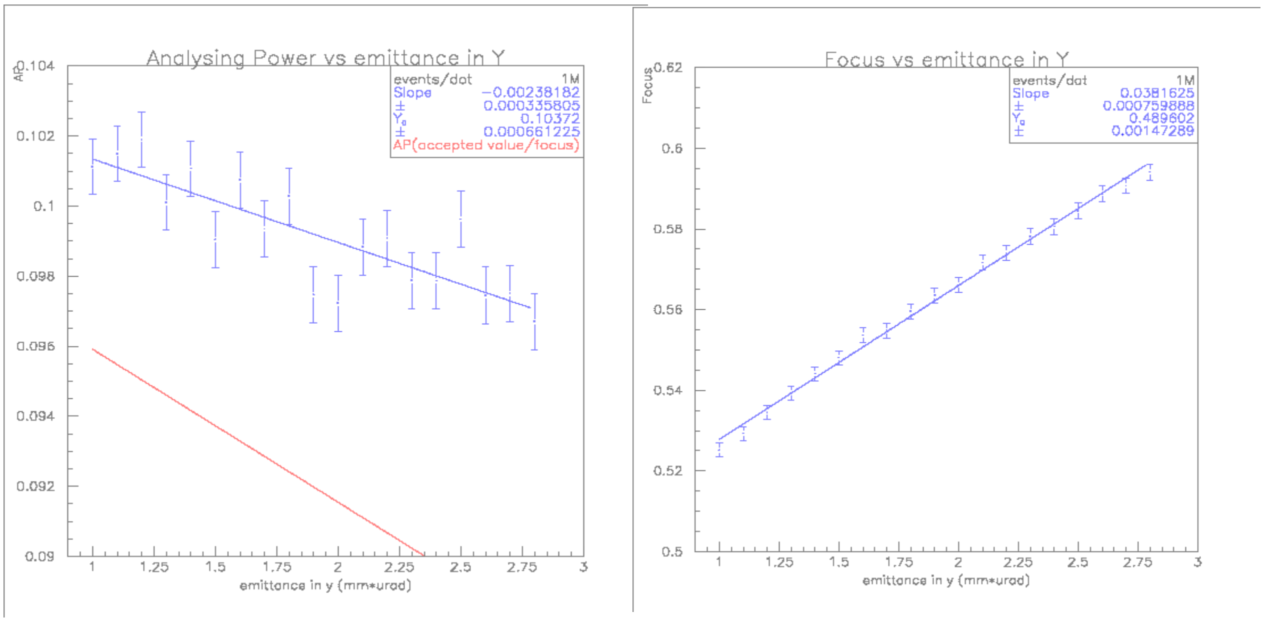


Figure 12 : The graphs of AP and the focus (in mm) versus the emittance in y of the Hera's leptons beam. The blue line is a linear fit of the data and the red line is a linear fit of what should be the AP in function of the focus using equation (7).

The linear correlation between the focus and the emittance of the beam in y is almost perfect, slope = (0.038 ± 0.001) urad^{-1}. We also observe that AP is indeed related to the emittance in y, slope = (-0.002 ± 0.001) $(\text{mm*urad})^{-1}$, but not exactly the way it should according to the equation 7 (the red and blue slope don't agree)[12]. In order to find why, let's, from these previous data, plot the following graph (figure 13):

12 Official numbers will be given later.

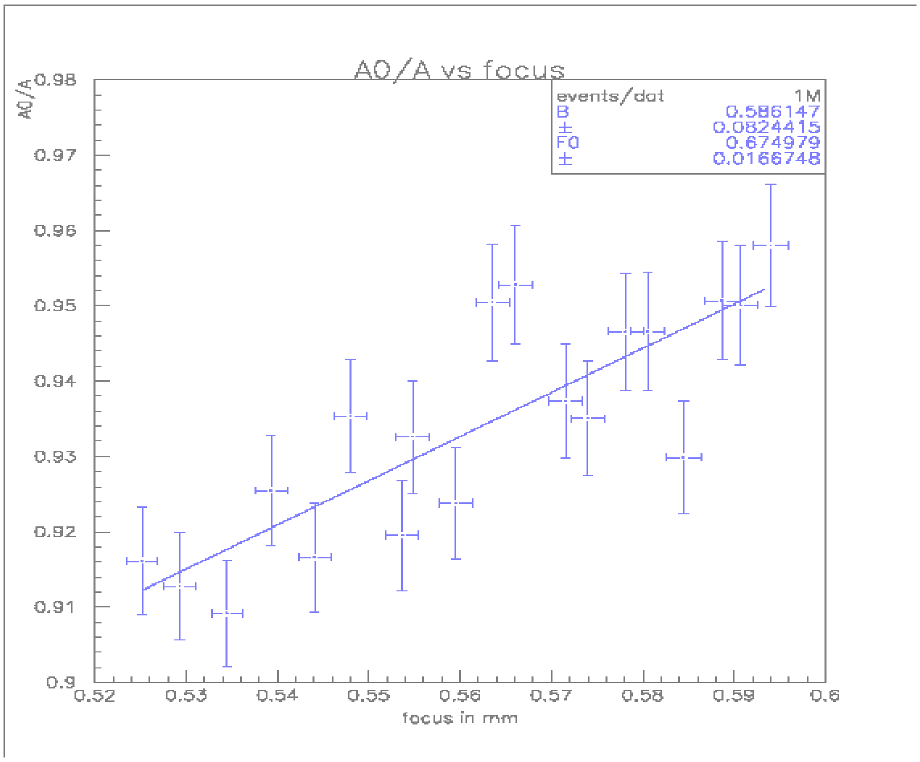


Figure 13: Plot of the A_0/A (Analysing Power measure in 1997 / Analysing Power)[13]vs the focus in mm. We can determine the values of equation (7) from this plot. In this case we have: B = (0.587 ± 0.082)mm^{-1} and F_0 = (0.675 ± 0.017)mm.

We see that the values we obtain, B = (0.587 ± 0.082)mm^{-1} and F_0 = (0.675 ± 0.017)mm, from this plot are quite different than the one obtained from the MC simulation done previously: B = (0.665 ± 0.010)mm^{-1} and F_0 = (0.444 ± 0.010)mm. The reason is that the MC simulation used are not the same, and the defaults parameters are also not the same. The good new is that both slopes B agree within their error. On the other hand, the F_0 are really different and they don't agree within their error. That means that there is other parameters that have a strong effect on the AP. Once these parameters will be identified, we will be able to do the absolute calibration of the MC simulation: find the defaults parameters that give the best fit of the real data of the TPOL polarimeter. We will then use them to find the “good” F_0.

13 We plot A_0/A vs focus instead of A vs focus only because it is what have been done before and we want to be able to compare the results.

6.2.3- Linear polarization of the photons dependence

Let's see what kind of influence the linear polarization of the photons (S1) with left helicity have on the AP and the focus (figure 14):

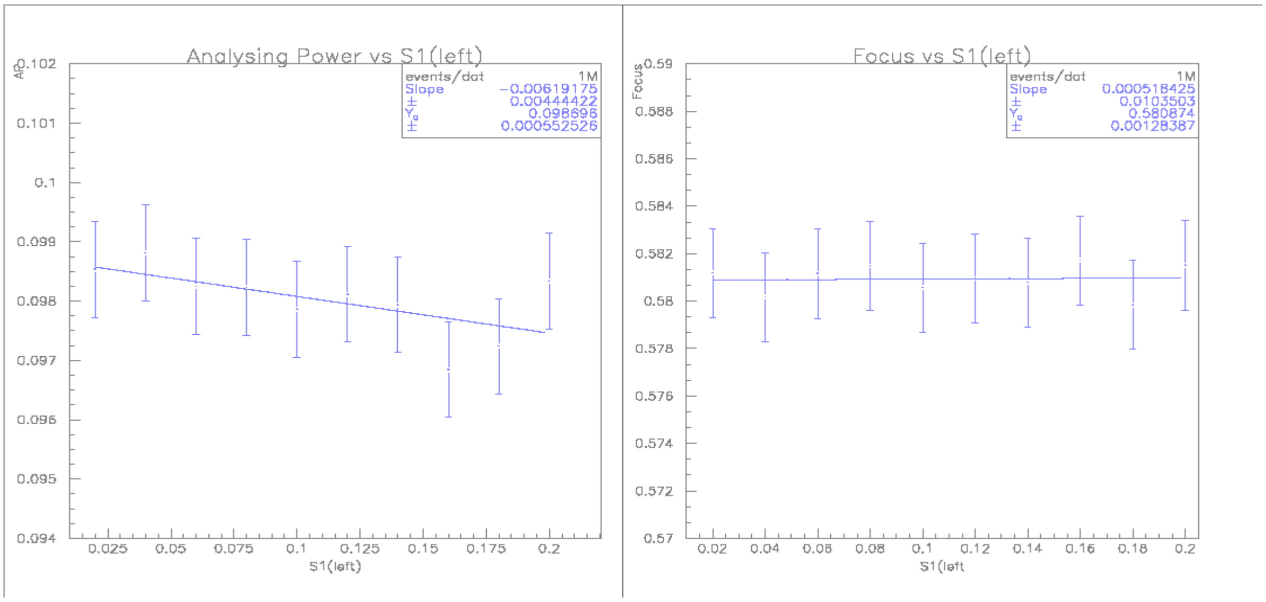


Figure 14: Linear fits of the AP and the focus (in mm) versus the linear polarization of the photons with left helicity (S1left).

We observe that the linear polarization of the photons with left helicity has a really small influence on the AP, slope = (-0.006 ± 0.005), and no influence on the focus, slope = (0.00 ± 0.01) mm. We assume that the linear polarization of the photons with right helicity should have the same kind of behavior. We know that S1 vary only between 0.04 and 0.06 at the TPOL polarimeter. This range doesn't really have an significant effect on AP or the focus, which mean that we don't have to worries that much about this parameter.

6.2.4-Dilu parameter dependence

Here is the influence of the parameter Dilu on the AP and the focus (figure 15):

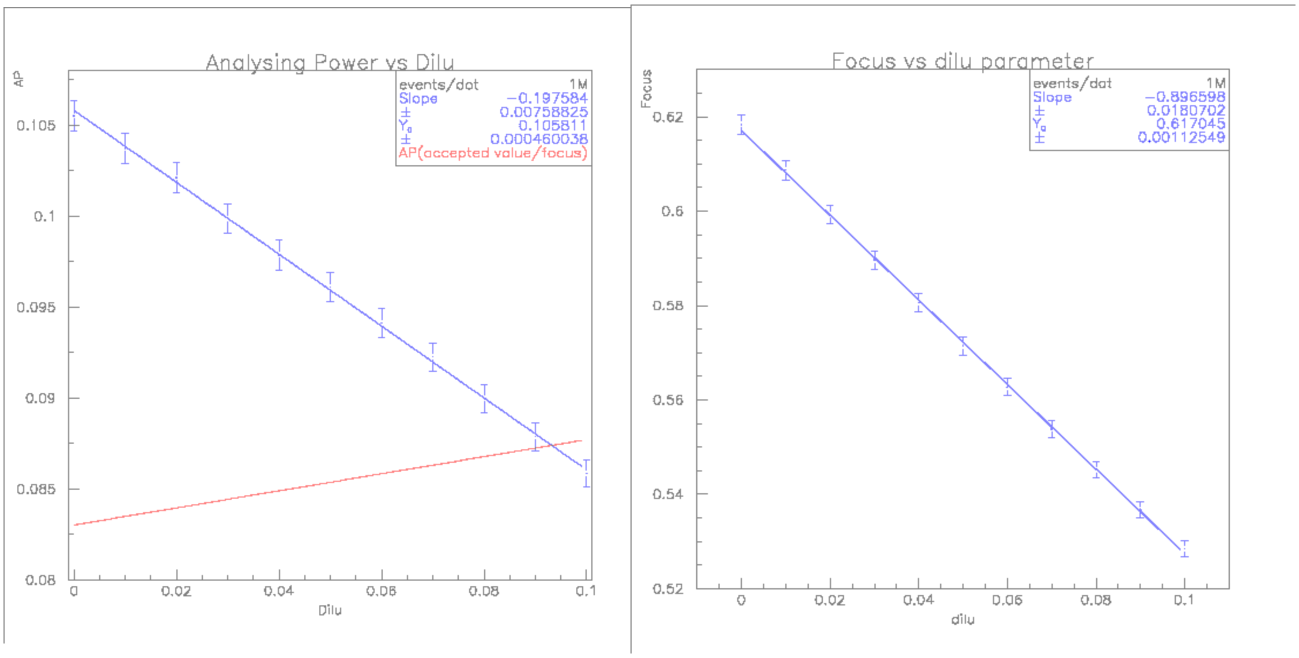


Figure 15: Linear fits of the AP and the focus (in mm) versus the Dilu parameter. The red line is a linear fit of what should be the AP in function of the focus using equation (7).

The AP seems to depend strongly on the Dilu parameter, slope = (-0.198 ± 0.008), as does the focus, slope = (-0.90 ± 0.02) mm. However, the AP seems not to be related to the focus as usual (the red line). Since the focus decreases as Dilu increases, we would expect to see the AP increase as Dilu increases, but this is not the case.

We conclude that the Dilu parameter affects AP independently of the focus. A deeper analysis of this parameter will be discuss later and the behavior of the graphs of figure 15 will then be explained.

6.2.5-Difu parameter dependence

Figure 16 shows our usual plots for the dependence of the AP and the focus on the parameter Difu:

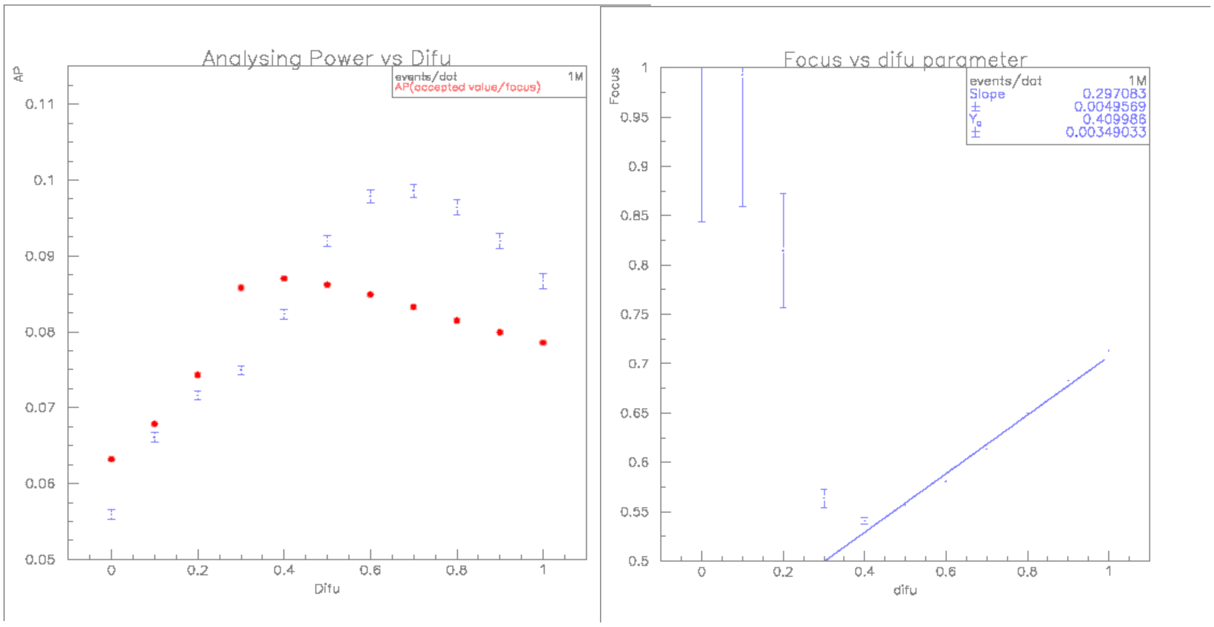


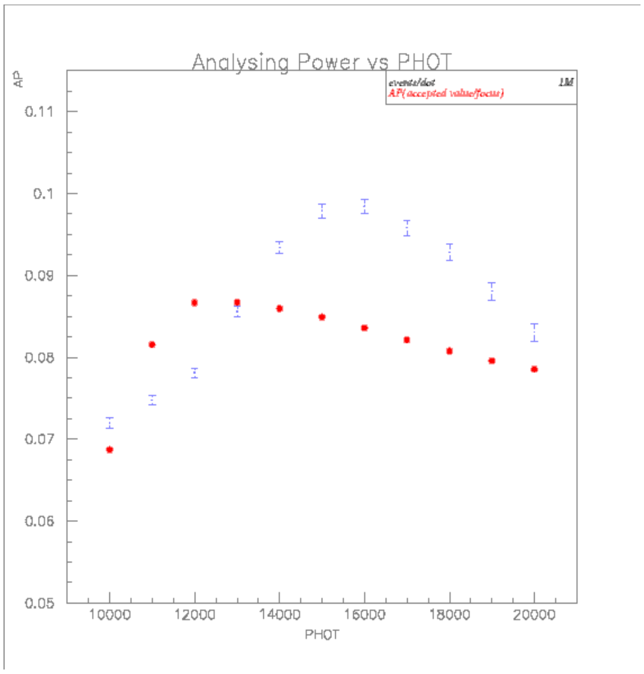
Figure 16: Plots of the AP and the focus (in mm) in function of the Difu parameter (in blue). The red dot are what should be the AP in function of the focus using equation (7); a linear fit would not have been relevant this time. Moreover, a linear fit is done from Difu=0.4 to Difu=1.0 on the focus graph principally to show that there is maybe a linear correlation for high Difu.

The parameter Difu has the strongest influence on the AP and the focus studied up to now: range of [0.055; 0.098] for AP and [0.54; 1.14]mm for the focus. Moreover, the effect of Difu on AP and the focus is not linear. The behavior of the accepted value of AP for the given focus (red dot) doesn't really agree with the simulated data for AP (blue). Thus the Difu parameter, as is Dilu, seems to be a parameter that have a “independent”[14] effect on AP. We will later elaborate in more details about the parameter Difu.

14 By independent, we mean that the correlation on AP is not a direct consequence of the correlation on the focus.

6.2.6-Phot parameter dependence

Figure 17 shows the relation between the AP and the parameter Phot, and the relation between the focus and the parameter Phot:



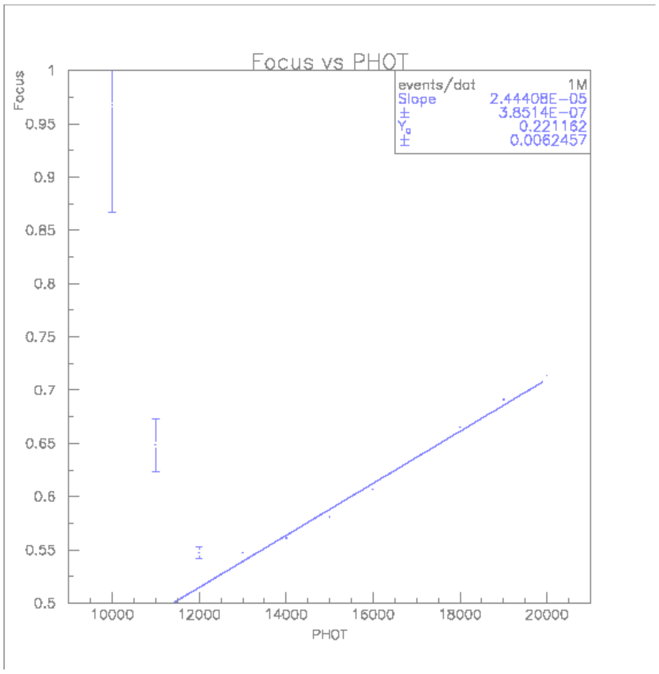


Figure 17: Plots of the AP and the focus (in mm) in function of the Phot parameter (in blue). The red dot are what should be the AP in function of the focus using equation (7). A linear fit is done from Phot=13000 to Phot=20000 on the focus graph principally to show that there is maybe a linear correlation for high Phot.

We observe that the parameter Phot is another parameter with a strong independent influence over the AP. Moreover, the behavior of these plots is really similar to the one of the Difu parameter. Some explanations will be given in the next section.

6.3-Influence of some parameters over the energy and η distributions

In order to understand the effect of the parameter Difu, Dilu and Phot on the Analysing Power and the focus; we must first understand their effect over the total energy (eud) distribution and especially over the energy asymmetry (η) distribution.

6.3.1-Dilu parameter

The figure 18 shows the energy distribution (eud = $E_{up} + E_{down}$) for different values of Dilu [0, 0.1] and fixed Difu and Phot. The real data of TPOL for the period of June (average polarization = 31%) also appear in blue to make a comparison[15]. We observe that the value of eud increases as Dilu increases (the graph in black is shifted to the right). In order to understand why, we refer to equation 9. As Dilu increases, the proportion of photons that cross the aluminum plate instead of being consider lost, increases. That is, the overall number of kept photons increases which implies that the overall energy (eud) increases. However, by looking at the graphs of figure 18, we see that this effect is not that significant over the range of Dilu = 0% to Dilu = 10%.

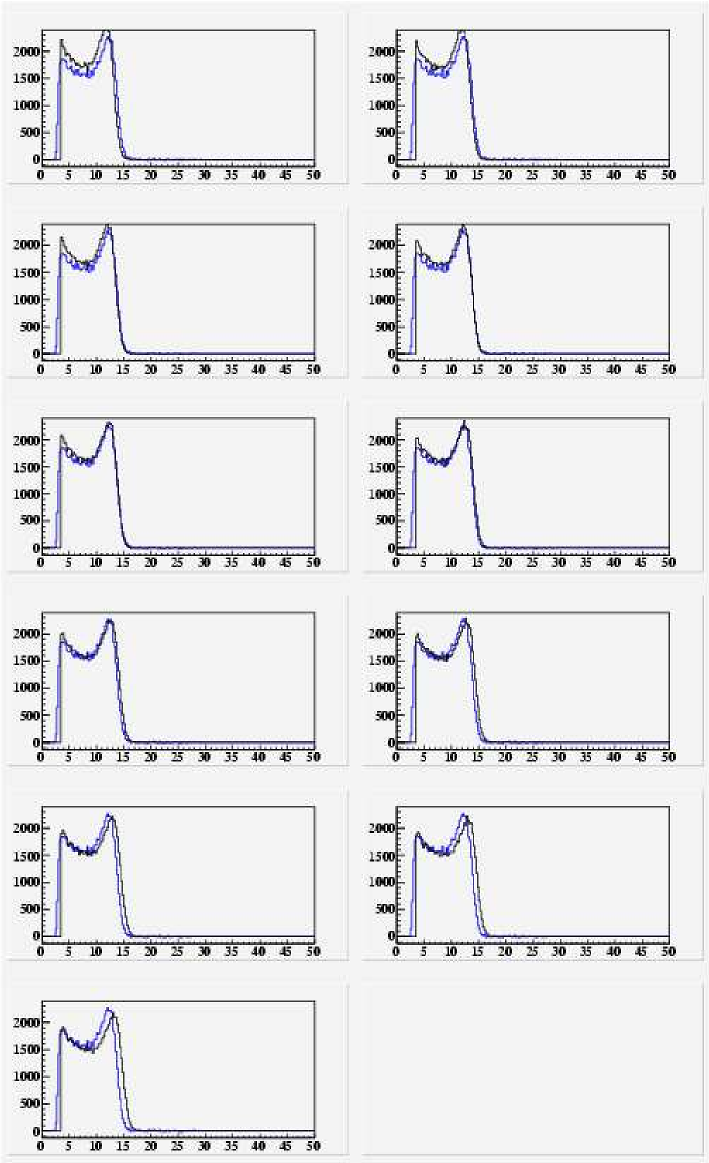


Figure 18: Plots of the energy distribution (# of events vs eud) for different values of Dilu. In black are the MC data and in blue are the data taken from the real TPOL polarimeter. The upper-left graph shows MC data for Dilu = 0. From left to right the value of Dilu increases of 0.01. For all the plot Difu = 0.6 and Phot = 15000 photons/GeV. Notice also that the MC histogram are normalized to have the same amount of events than the real distribution (blue).

15 This comparison will be treat in more details in the section 6.4. Obviously, we had to change the values of the polarization to 31% in the MC simulation. Notice also that for both, eud and eta, distributions, we use the cut eud > 3.5 GeV and $|\eta| < 0.890625$. These cut are necessary if we want compare to the real TPOL distribution, since after the background subtraction[12], the TPOL data have no events with eud < 3.5 GeV. Unit don't appear on the graphs, but eud is in GeV.