are around the linear slope = 1 (refer as region 1) and the one concentrated between y-real = ± 0.2 cm (refer as region 2). Inside region 1, the events can't be referred as proper noise, since it is only a consequence of the resolution of the y-silicon "measurement". Figure 39 shows the resolution of the silicon detector in the MC: histogram of y-real minus y-silicon. We observe that the silicon detector in the MC simulation has a resolution of 1.4%.

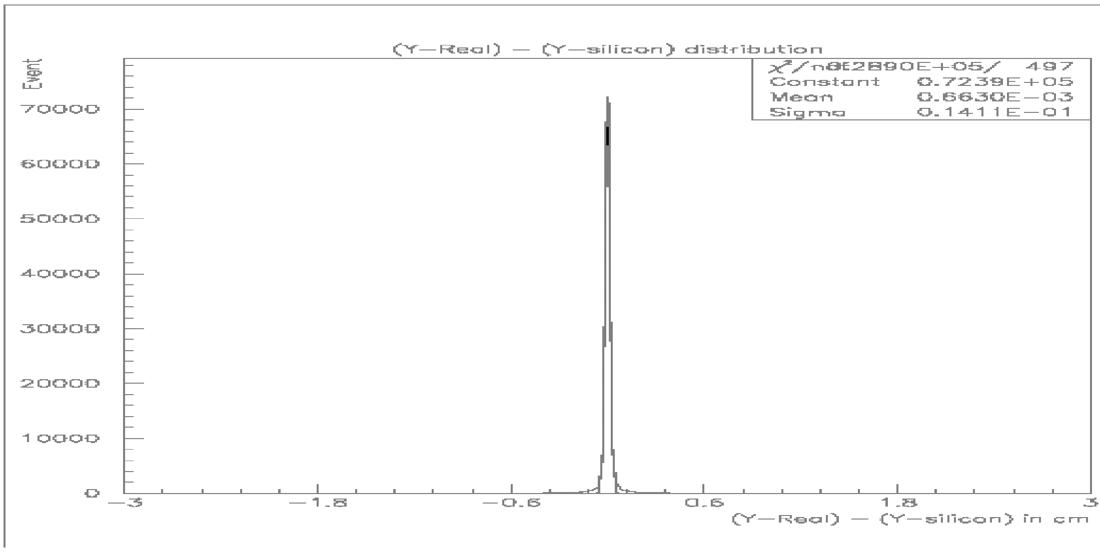

Figure 39: The distribution of (y-real) - (y-silicon). This histogram can be interpreted as the resolution of the silicon detector in the MC simulation. We get a sigma of 0.014 which correspond to a resolution of 1.4%.

The noise concentrated in the region 2 is more complicated to explain, since there is no apparent reason to be there... especially since we refer to a computer simulation. Whatever the reason of this noise, it seems to be responsible for the slope of (0.903 ± 0.001) of the y-real vs y-silicon correlation. Indeed, we can observe on the left graph of figure 38 that the proportion of noise below the slope = 1 increases and the proportion of noise over the slope decreases as y-silicon increases. That lead the average of each bin in the profile histogram to get lower than what it should be as y-silicon increases[26]. If we look now at the figure 40, we see that there also noise in the scatter plot of the η-y curve which is most probably also responsible for the divergence of the silicon η-y curve from the "real" η-y curve at large $|y|$.

26 For the region y-silicon < 0, we observe more noise over the slope = 1 than below which lead to an higher average for each bin of the profile histogram.

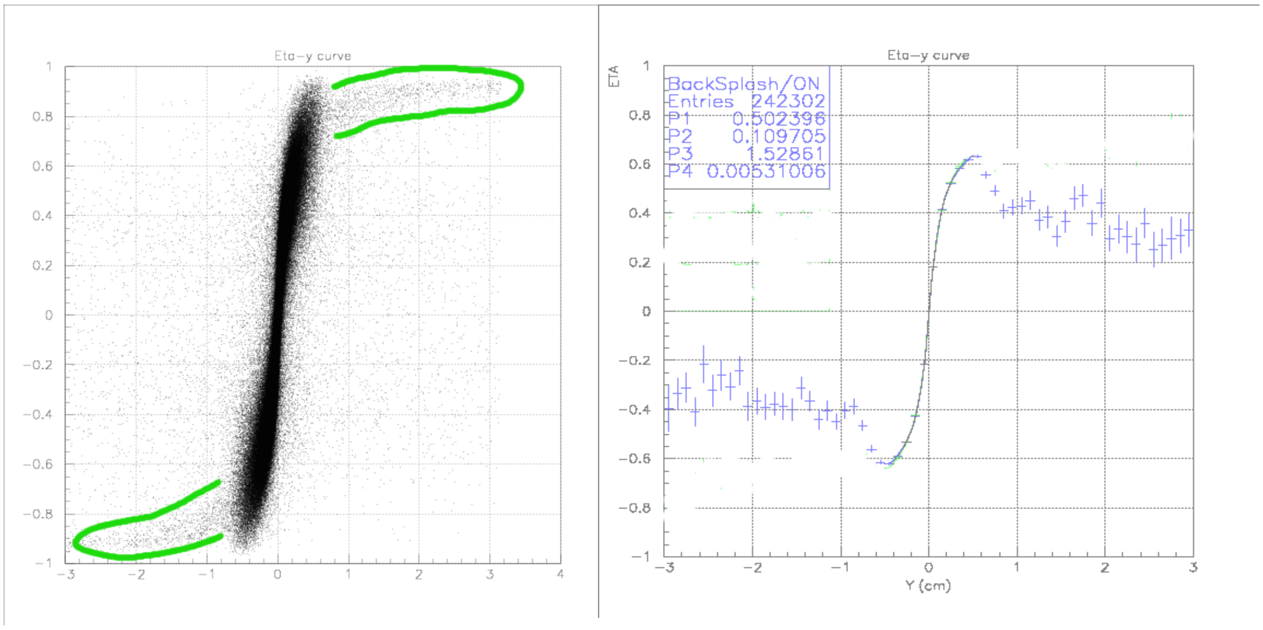

Figure 40: This figure shows the silicon η-y curve (scatter-plot on the left and profile histogram on the right). The y-axis is η and the x-axis is the y-silicon. Notice that the range of the y is [-3, 3] cm instead of [-0.8, 0.8] cm like for figures 36 and 37. In green are traced what seems to be "good" events.

This last graphs seems to confirm that the η-y curve start to go downward for large values of y[27] only because the ratio noise/good data increase as y increase. The method of the profile histogram is thus not relevant for large value of y. We also observe that there seems to be "good" events at $|y| > 0.8$cm, but there is no y-real events at $|y| > 0.8$ cm (figure 35). We conclude that the photon/shower[28] is sometime detected at the same position by the silicon detector and calorimeter, but this position is not the "real" one extrapolated from the Compton scattering with the electron. That is, something must changed the trajectory of the backscattered photon in the MC simulation.

8.2-Models and solutions

It worth spending some time to think of some models that could explain the difference between y-real and y-silicon and thus the divergence in the η-y curves. The

27 Similarly start go upward for large negative value of y.

28 We refer to "photon/shower" since the photon could be deviated before it convert into shower, but the shower could also be deviated.

effect of the backsplash as already been tested and we found that this is not the cause of the divergence in the eta-y curves. Another possibility would be that something deviate the trajectory of some photons/showers before they reach the silicon detector. The only candidate for this model are the converter and the fiber (figure 41).

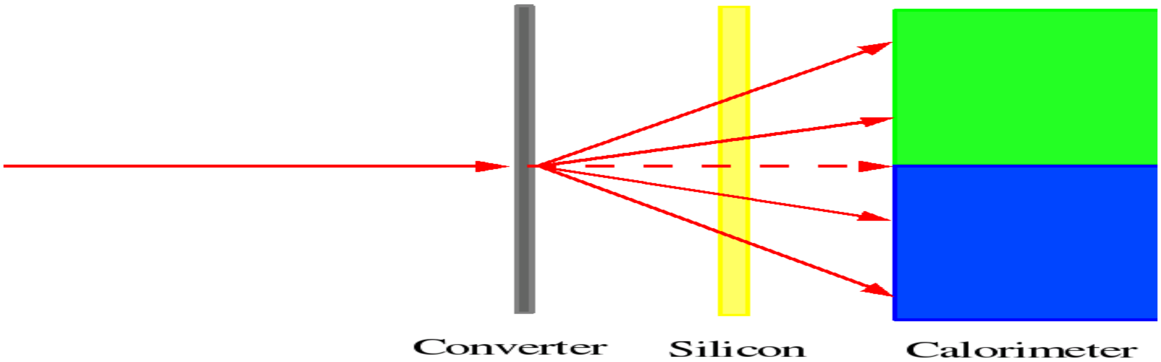

Figure 41: This figure shows a model in which the photon/shower could be deviated in the converter. The red dash line correspond to the trajectory that the photon/shower should follow from the extrapolation of the Compton scattering (y-real) and the plain lines correspond to the trajectory that the photon/shower could really take (y-silicon). The fiber don't appear on this scheme for clarity, but a similar deviation in the fiber could also happen.

We would like to point out that some events has been recorded with a difference of more than 2 cm between y-real and y-silicon. Since the distance between the converter and the silicon detector is of 2 cm, this implies a deviation of 45° which is considerable.

If really this model explain the noise discussed earlier, bringing the converter closer to the silicon detector should remove it. Figure 42 compares the y-real vs y-silicon correlation between a normal simulation and a simulation for which the distance between the converter and the silicon detector has been reduced to 0.1mm instead of 2cm[29].

29 Notice also that the fiber has been removed for this simulation.

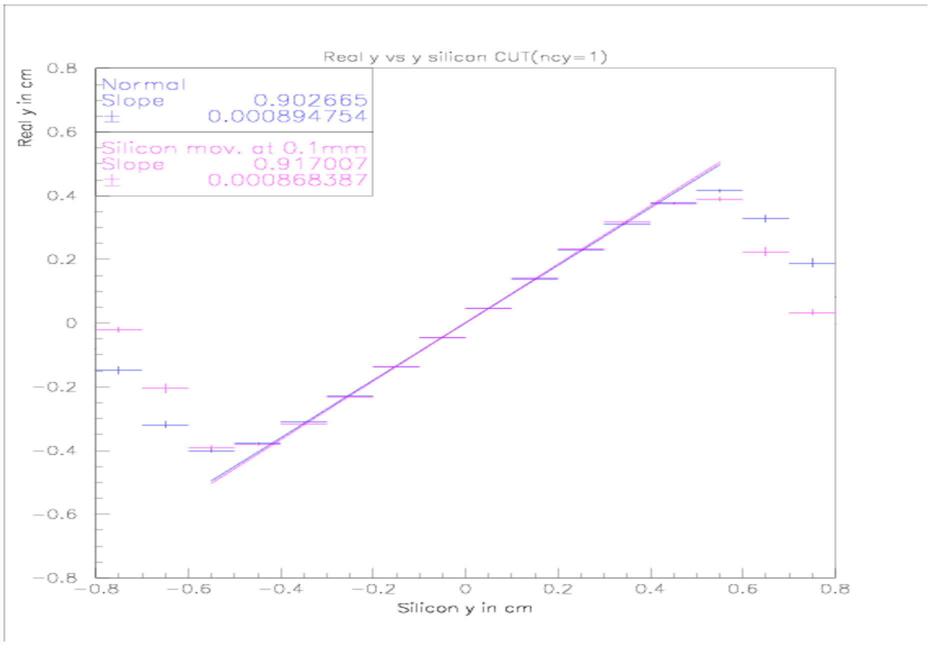

Figure 42: This figure shows the difference between the y-real vs y-silicon correlation of a normal simulation (blue) and a simulation for which the silicon detector has been brought at a distance of 0.1mm from the converter (purple). The slope of the normal simulation is (0.903 ± 0.001) and the "silicon moved" simulation has a slope of (0.917 ± 0.001).

We observe that the "silicon moved" simulation has a slope slightly closer to one than the normal run: (0.917 ± 0.001) instead of (0.903 ± 0.001). We can thus conclude that some of the noise on the figure 38 (region 2) was created by a deviation in the converter or in the fiber. However, there must be other noise sources, since we still don't get a slope = 1. These other sources has not been identify yet.

We want to clarify something that might be confusing. In the preceding discussion we often refer to the noise. We want to point out that we always referred the noise which respect to a graph and not to some particulars events. For figure 38, noise was define to be events with y-real ≠ y-silicon, but for figure 40, noise was defined to be events that don't follow the expected behavior of the η-curve. We assumed that most of the noise events from figure 38 should also be noise events for figure 40 and hoped that removing one would remove the other, but it doesn't have to be. That is, an event can be noise for one graph and good event for the other. Photon/shower deviated in the converter is certainly noise for the y-real vs y-silicon correlation, but not necessarily for the η-y curves.

Lot of investigations has been done to explain the sources of noise in the MC with hope that we could find solutions to remove it, and thus make agree the y-real η-y curve and the silicon η-y curve[30]. We unfortunately got no success doing that and we had to find another solution.

8.3-Table Scan

It seems to be hard to find a way to removed the noise that cause the “bad” η-y curve. However, we saw that this noise doesn't affect the η-y curve at small |y| since the ratio noise/good events is really low. Thus, a solution would be to increase our number of statistic with good events at large |y| such that the ratio noise/good events is also really low at large |y|. A method that has been suggested and tried once with the real TPOL polarimeter is to move the table that support all the detectors (calorimeter, silicon, converter and fiber) at different y position such that the beam isn't always center between both calorimeter[31]. That should have for effect to increase our number of good statistic at large |y|. We used the MC simulation to see if this method is indeed a good way to improve the quality of our η-y curve.

30 The y-real η-y curve could, at this stage, be wrong because of some deviations in the converter or others sources. However, the y-real η-y curve followed the expected behavior ($|\eta|$ always increases as |y| increases) which is not the case for the silicon η-y curve. We thus trust the y-real η-y curve to be the “good” one.

31 Of course, when we are doing that, we can't measure the polarization. The idea is to get a lot of statistic using this method and then use the resulting η-curve for all the further measurements of the polarization.

In order to simulate a table scan, we moved the table from -3cm to 3cm and we simulated 100 000 events run at each step of 0.5cm. We then merge all the statistic. Let's first observe if we really get what we expect for the y-distribution (figure 43):

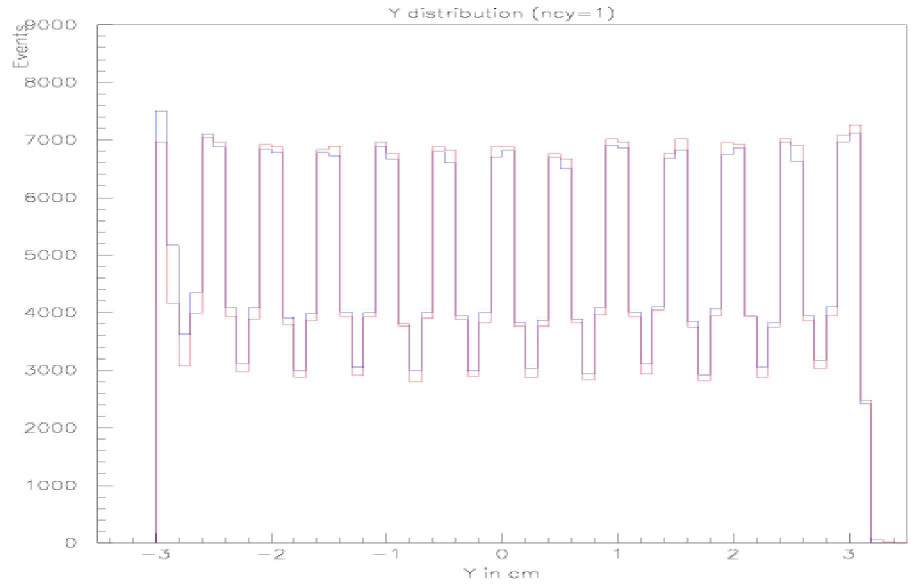

Figure 43: This figure shows the histogram of the y distribution for a table scan run. In red are the y-real and in blue are the y-silicon. Note that when it appears in purple both line, red and blue, are superposed

We see that with a table scan run, we get approximately the same quantity of events for each value of y. This is in opposition with a normal run in which we only get a central peak around y = 0 (figure 34). Moreover, we observe that the y-real and y-silicon y distribution agree very well.

Figure 44 shows the correlation y-real vs y-silicon for a table scan simulation.

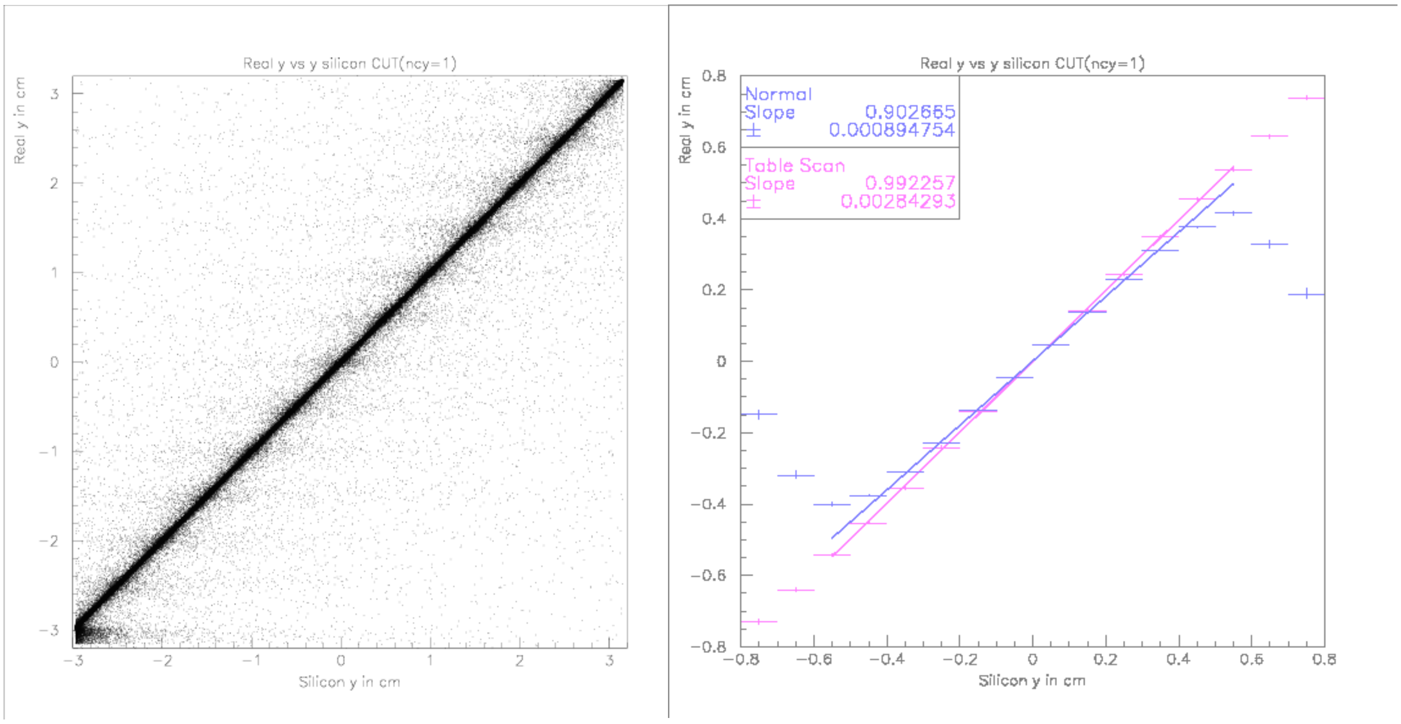

Figure 44: The left graph shows the scatter-plot of the correlation y-real vs y-silicon for a table scan run. The right graph shows the profile histograms of this correlation for a normal run (blue) and for a table scan run (purple). The slope for the normal run is (0.903 ± 0.001) and for the table scan run is (0.992 ± 0.003).

It is interesting to compare the left graph of figure 44 with the left graph of figure 38. The big difference between both is that the table scan give a nice dark line from y = -3 cm to 3 cm while the slope of a normal run begin the faint pass approximately ±0.5 cm. This confirm again that the ratio noise/good events is constant over y when we do a table scan simulation. This lead the slope of the y-real vs y-silicon correlation to be much closer to 1: (0.992 ± 0.003) for a table scan run instead of (0.903 ± 0.001) for a normal run.

Let's now see if this lead also to an amelioration in the η-y curve. Figure 45 compare different η-y curves {y-real (red), y-silicon with a normal run (blue), and y-silicon with a table scan run (purple)} for small range of y, while figure 46 does it for large range of y.

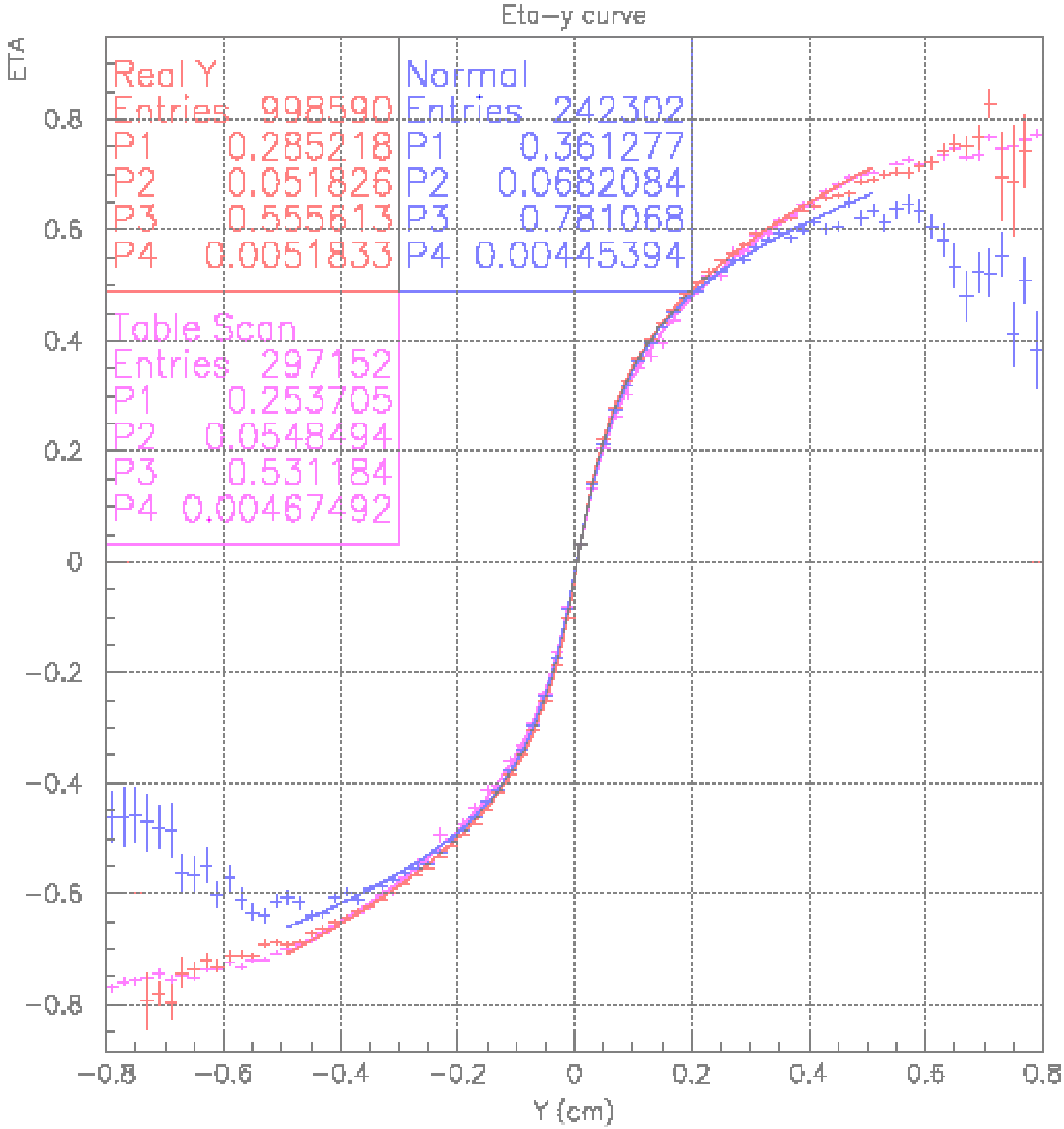

Figure 45: The η-y curve for the y-real (red), for the y-silicon taken from a normal run (blue), and for the y-silicon taken from a table scan run (purple). Notice that the data for the y-real η-y curve are taken from a normal run. The table scan η-y curve agrees almost perfectly with the y-real η-y curve. Each curves are fitted with the equation 10 over the range y=[-0.5, 0.5].

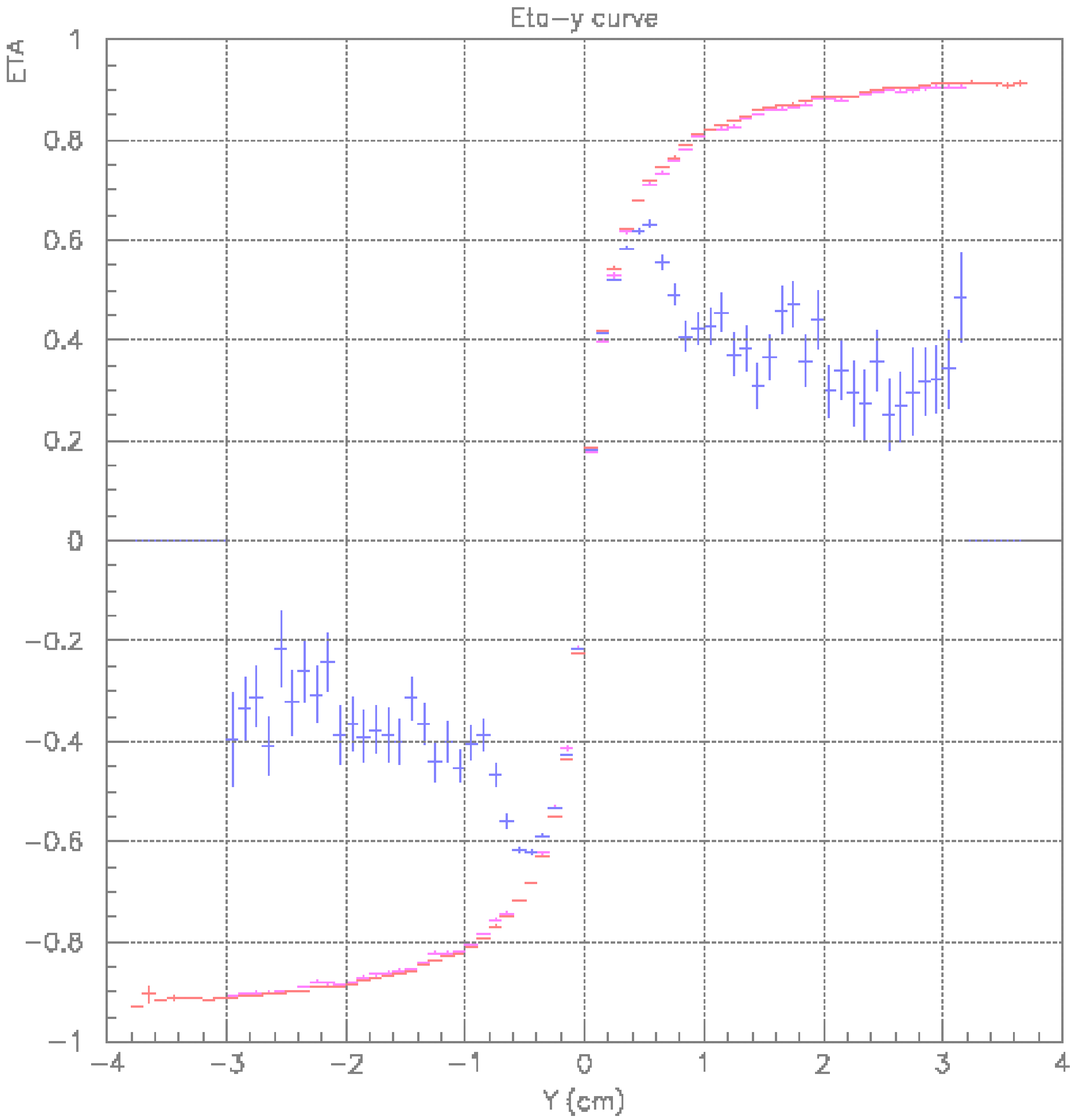

Figure 46: The η-y curve for the y-real (red), for the y-silicon taken from a normal run (blue), and for the y-silicon taken from a table scan run (purple). Notice that this time the data for the y-real η-y curve are taken from a table scan run. Even for large range of y, the table scan η-y curve curve agree almost perfectly with the y-real η-y curve.

We see that, even at really large |y|, the table scan η-y curve agree very well with the y-real η-y curve. We conclude that the method of the table scan is indeed efficient to obtain an accurate η-y curve and that normal η-y curve should not be used in the analysis.

9-Conclusion

The parameters Difu, Dilu and Phot had been identified to have a strong influence on the AP and the focus. However, a deeper analysis showed that only Dilu really affects η and thus the AP and the focus. The Difu and Phot parameters affect only eud. Their influence on η, and thus the AP and the focus, is then only a consequence of using fixed energy cuts. This analysis informed us that the energy cuts taken have an influence considerable on the AP and the focus. Our analysis also showed that it is possible to affirm with certitude that Dilu should be set around 5%. However, there is a lot of possible combinations for the parameters Difu and Phot. We concluded that our defaults parameters were reasonably well set to reproduce accurately the real TPOL data with the combination Difu = 60%, Dilu =4% and Phot = 15 000 photons/GeV. Nevertheless, we would like to point out, that even if this set reproduce well the real TPOL data, it doesn't mean that this model is optimal, neither realistic. It seems to be impossible to do an absolute calibration that we can fully thrust and thus claim to have the good F_0. There is place for amelioration in the TPOL MC simulation by adding new features.

The backsplash has been reveled to be quite significant in the TPOL MC simulation. However, we observed that most of the unwanted effect of the backsplash could be removed by requiring that the events create a single cluster in the y-silicon detector (ncy = 1). Unfortunately, using this method, we lose close to 50% of our statistic.

We also observed a divergence between the “real” η-y curve and the silicon η-y curve for large values of |y|. We concluded that this divergence was caused by our too high ratio of the noise/good events for the y-silicon at large values of |y|. The table scan simulation has been reveled to be an efficient way to increase our statistic at large |y| and thus getting a better η-y curve. The TPOL group plan to do a better table scan soon. Hopefully, this will contribute to reduce the systematic error of the TPOL polarimeter.

Finally, we point out that we haven't succeed to find all the reasons of the “noise” that we see in the MC simulation. Some seems to come from a deviation of the photons in the converter or in the fiber, but there is certainly other sources. More investigations about this noise could be done, but this is not really a big issues since we found that we can neglect this noise when we use the η-y curve from a table scan.

10-Acknowledgments

We would first like to thank professor Corriveau for making this project possible and is occasional advices. We need to mention as essential persons those who built and ameliorate the TPOL MC simulation before: Mathieu Plamondon, James Sully and Stefan Schmitt. We have a special thought for Mathieu who accept to work out is old code to make working the interactive version of the TPOL MC simulation. We finally thank Ties Behnke and the whole TPOL group for their really useful advice, ideas of MC investigation and for taking seriously the MC simulation in there analysis and projects.

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* These document are available at: http://www-eus.desy.de/~francois/ZEUS_ONLY/tpol/

12-Annex

12.1- tpolmc.cards

```
LIST

TIME 1. -10. 1.
DEBU 1 1 20

TRIG 300000

* name of ntuple file
NTUP 'test.rz'

* gap between scintillator plates [cm]
SGAP  0.002

* rotation of scintillator plates (August 2001) [deg]
SROT -0.0191 -0.0239 -0.0239 -0.0143  0.0143 -0.0239
      0.0334  0.0048  0.0334  0.0286 -0.0048 -0.0239
* rotation of scintillator plates (January 2001) [deg]
*SROT  0.000  -0.0191 -0.0239  0.0143  0.0191 -0.0048
*      0.0048  0.0143  0.0286  0.0334 -0.0286 -0.0382

* offset of scintillator plates (August 2001) [cm]
SOFF 0.001   -0.0005  0.0055  0.0105 0.0095  0.0015
     0.0015  -0.0055 -0.0085 -0.010  0.0015 -0.0025

* offset of scintillator plates (January 2001) [cm]
*SOFF -0.002  -0.003   0.0005  0.0125 0.      0.0005
*      0.0015 -0.0035 -0.0070 -0.0085 0.0060 -0.0010

* calorimeter offset relative to the beam in x,y
COXY 0.0 0.005

* distance of silicon front to calorimeter front [cm]
SILZ 2.2

* detector rotation [deg], using three Euler angles
*
* azimuth (first angle)
*  calo seems to have 1 mrad mis-alignment in phi from mirror scans.
*  what about the sign?
*  silicon could be rotated by 1-3 degrees,
*  judging from eta-x and eta-y correlation (which sign?)
*
* polar (second angle)
*  polar angles not known. calorimeter polar angle could be responsible for
*  altered eta-y transformation/resolution
*
* fiber rotation???
*
```

```
* rotation angles vs beam axis:
*    ------- phi -----------------theta --------------- psi ----------
*     calo silicon  fiber    calo silicon  fiber   calo silicon  fiber
DROT  0.06   1.0     0.0      0.0   0.0     0.0     0.0   0.0     0.0

* silicon X detector position of rightmost [cm]
SIX0 -2.75
* silicon Y detector position of lowest strip [cm]
SIY0 -2.98

* vertical fiber position [cm]
FIBY 0.0

* distance of preshower back to silicon front [cm]
PREZ 2.0

* distance of preshower back to fiber center [cm]
FIBZ 1.5

* table offset (all three detectors)
TBXY 0.0 0.0

* nominal position of interaction point [cm] and position offset [cm]
*
* change the IP position to move the calorimeter further away or
*  closer   -> beam parameters are not affected
*
* change the offset to simulate a mirror-misalignment
*    -> HERA beam parameters are calculated for the new offset
*       NOTE: HERA Magnets are not included!!!
*
*    nominal  offset
IPZ0 -6500.    0.0

* HERA beam parameters (horizontal) at nominal IP (offset=0)
*    alpha  beta [cm]  epsilon [cm*rad]
BEAX -0.41    848.0      5.4E-6

* HERA beam parameters (vertical) at nominal IP (offset=0)
*    alpha  beta [cm]  epsilon [cm*rad]
BEAY 1.45      5621.0    2.4E-7

* LASER beam radius [cm]
LASR 0.07

* LASER crossing angle
LASA 3.1E-3

* HERA beam energy [GeV]
BEAE 27.6

* laser beam energy [GeV]
LASE 2.41E-9
```

```
* LASER beam polarisation
* NOTE: left/right handed events are generated one after the other
*   event number 1 has circular-left polarized laser
*   event number 2 has circular-right polarized laser
*   event number 3 has circular-left polarized laser
* ...
*    S1(L)  S3(L)   S1(R)  S3(R)
S1S3   0.1    0.995   0.05   -0.998

* HERA BEAM polarisation
*      PY   PZ
PYPZ  1.0  0.0

* calorimeter light collection
*  fraction of light which diffuses to U,D,L,R independent of its origin
*  in the plate
* If this parameter is zero, the (L-R)/(L+R) asymmetry has maximal sensitivity
* to the horizontal position.
DIFU    0.6

* calorimeter photon statistics [photons/GeV]
*  the number of photons leaving the plates on one of the four sides per GeV
*  Increasing the number of photons causes the (U+D)/(L+R) distribution
*  for a fixed horizontal position to be smaller
*  A small number of photons will degrade the energy resolution
PHOT 15000.

* calorimeter photon dilution of U, D channel
*  the fraction of light which penetrates into the opposite plate.
*  NB: dilution of the L,R channels is not simulated
*  If this parameter is zero, the (U-D)/(U+D) asymmetry has maximum sensitivity
*  to the vertical position.
DILU 0.04

* calibrated calorimeter photomultiplier gains [GeV/photon]
*    up       down     left     right
GAIN  3.477E-3 3.477E-3 4.428E-3 4.428E-3

* silicon gain factor [GeV/ADC count]
*      x       y
SIGA  3.5E+5  1.3E+5

* silicon noise RMS per channel [ADC counts]
*      x     y
SRMS  3.0   2.5
```