Time-zero Fitting

Date: July 30, 2001

1 Introduction

The purpose of this document is to describe the present state of the time_zero module and to try to clarify a few issues that were discussed concerning the time_zero module at the software meeting on July 24, 2001. Presently two complete and working time_zero modules exists; an older version implementing a complementary error function (ERFC) as the fitting function and a new version implementing a half-Gaussian. The newer version is presently in CVS. The older version of the time_zero module was successful in fitting to all wires in the large dense stack run, however failed fitting 112 wires out of 1328 of the half stack data. The new version successfully fits to all the wires using the half stack data, and has yet to be tested on large data sets. The newer version is inherently more stable in fitting to the time_zero region and should yield sufficient results for future runs.

2 Summary of time_zero fitting module

In order to fit the rise-time region of the TDC spectrum, the time_zero module rebooks and fills this region into new histograms. These histograms, with solely the rise-time region, are then fit using the HBOOK command HFITH using either a fitting function of a half-Gaussian or a complementary error function as will be described in section 2.1. To increase robustness, for each wire time_zero fitting, the module loops over several initial guess parameters to find the ones which minimize the χ^2 value. In principle, a true "time_zero" value will be found by using some functional relationship between the fit parameters.

2.1 ERFC fitting function

In the old version of the time_zero module the following three parameter complementary error function was used as the fitting function:

$$\frac{Param(1)}{2} * erfc\left(\frac{(x - Param(2))}{Param(3) * \sqrt{2}}\right)$$

Where, Param(2) is the 'raw' time_zero and Param(3) is the standard deviation.

The initial guess for Param(1) is set to the maximum height value of the spectrum. Param(2) is varied from the channel corresponding to the max height to the first channel with a zero value in six even steps. For each of these Param(2) values, Param(3) is varied from 1.5*(width of the spectrum) to (width of the spectrum)/7.5. *Only the fits with the lowest χ^2 value and Param(1) value within 25% of the max is stored.* If this criterion is not met the fit is rejected and the plane average values are used.

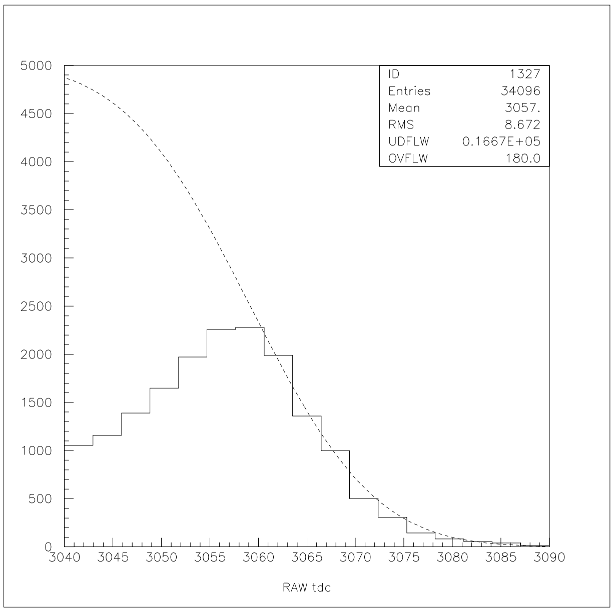

Figure 1: Half stack data time_zero fitting of plane 3 wire 27 using a Complementary Error Function with no cuts.

2.1.1 "Failed" fits discussion at July 24 2001 software meeting

At the software meeting confusion arose when discussing the "failure" of the fits. As was stated at the meeting, the module "failed" on 112 out of 1328 fits. The "failed" fits were rejected on the basis of cuts I had enforced. These cuts were to eliminate a fitting result with a high scaling factor (Param(1)). Accepting such fits, which do result in the lowest possible χ^2 using a complementary error function, would yield a deceptive left-shifted time_zero value as displayed in figure 1 (i.e. the fit to the height of the peak is so poor that the time_zero value is shifted too far to the left in the TDC spectrum.) The time_zero module, implementing a ERFC fitting function, had a very low "failure rate" when previously used on the dense stack data which contained more than a million events. This would imply that these "failures" are primarily due to low statistics and the nature of the fitting function.

2.2 Time-zero module implementing a half-Gaussian

Upon discussion of the "failed" fits with Dave Gill and Don Koetke, a suggestion was made to attempt fitting with the use of a half-Gaussian. Previously, on the dense stack data, the use of a half-Gaussian to fit the data was attempted and resulted in poor results. The fitting function was not pursued further since, with more statistics, fitting with the ERFC resulted in no "failures" of fits and was then decided to be the fitting function of choice.

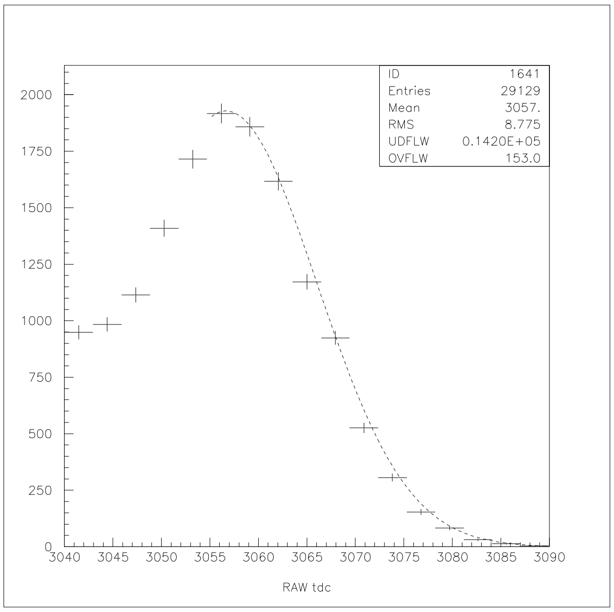

Figure 2: Half stack data time_zero fitting of plane 6 wire 41 using a half-Gaussian.

The time_zero module was thus again modified to implement a fitting function of a half-Gaussian:

$$Param(1) * exp\left[-\left(\frac{(x - Param(2))}{Param(3) * \sqrt{2}}\right)^2\right]$$

Where, Param(2) is the 'raw' time_zero and Param(3) is the standard deviation.

The initial guess for Param(1) is set again to the maximum height value of the spectrum. Param(2) is the time which corresponds to the maximum height. Its values are looped over the following range: from the channel corresponding to the maximum ±2ns in 1/10ns intervals. For each of these Param(2) values, Param(3) is again varied from 1.5*(width of the spectrum) to (width of the spectrum)/7.5. *Again, only the fits with the lowest* χ^2 *value and Param(1) value within 25% of the max is stored.* If this criterion is not met the fit is rejected and the plane average values are again used.

Upon fitting the half stack data no "failure" of fits resulted and the fit results had relatively lower χ^2 values then previously obtained using an ERFC fitting function. The summary of the fit plane averages are listed in Appendix A for both the ERFC fitting module and the half-Gaussian fitting module. This turn of events for fitting with a half-Gaussian is most likely due to:

- Less statistics which seems to discourage fitting with a complementary error function causing poor over-shoot fits.
- The algorithm of time_zero module has been improved from before when fitting with a half-Gaussian was first attempted.

A sample fit using a half-Gaussian can be seen in figure 2 and Appendix B.

3 Recommendations

My present recommendation is that the time_zero module that fits with a half-Gaussian should be used to determine a time_zero value. It is inherently more stable than fitting with a complementary error function to determine a time_zero value, i.e. there is no risk of grossly misleading fits. When a large statistical data set is used, the time_zero fits using a half-Gaussian should be checked. If poor fits result, the time_zero module that fits with a complementary error function should then be tried.

Please email me with any requests, recommendations, suggestions, or questions (hynes@triumf.ca).

A Plane Average Summary

Plane average time_zero and χ^2 summaries for the half stack data using both a Complementary Error Function and a Half-Gaussian fitting function.

ERFC Fitting Function

Plane	time_zero	χ^2
1	3065.36	6.75413
2	3065.78	8.93485
3	3065.56	9.57611
4	3065.70	8.28645
5	3066.06	8.64475
6	3065.87	8.69886
7	3066.30	6.84308
8	3065.96	6.74808
9	3066.45	6.15503
10	3065.90	7.38235
11	3066.89	5.74342
12	3066.13	6.89826
13	0.000000	0.000000
14	0.000000	0.000000
15	3066.86	6.62456
16	3066.56	6.46832
17	3067.28	5.94262
18	3066.84	8.38224
19	3066.70	8.23002
20	3066.39	7.89158
21	3066.45	5.95679

Number of rejected fits: 112 out of a possible 1328

Half-Gaussian Fitting Function

Plane	time_zero	χ^2
1	3056.32	4.35512
2	3056.76	4.38651
3	3056.47	4.97982
4	3056.72	4.71441
5	3057.11	4.90364
6	3056.51	4.47721
7	3056.80	4.26245
8	3056.84	4.16775
9	3057.25	4.41442
10	3056.80	4.65081
11	3057.27	4.66315
12	3056.74	4.42611
13	0.000000	0.000000
14	0.000000	0.000000
15	3057.13	4.54981
16	3056.86	4.77166
17	3057.08	4.83910
18	3056.90	5.84998
19	3056.43	5.31138
20	3056.21	5.09098
21	3056.28	3.98035

Number of rejected fits: 0 out of a possible 1328

B Sample fits for the half stack run: lowest and highest χ^2 per plane

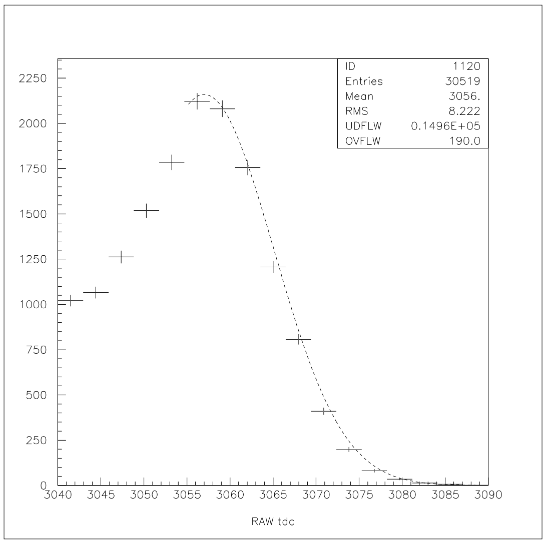

Figure 3: Lowest χ^2 time_zero fitting for plane 1, wire 20, using a half-Gaussian. χ^2=1.03346

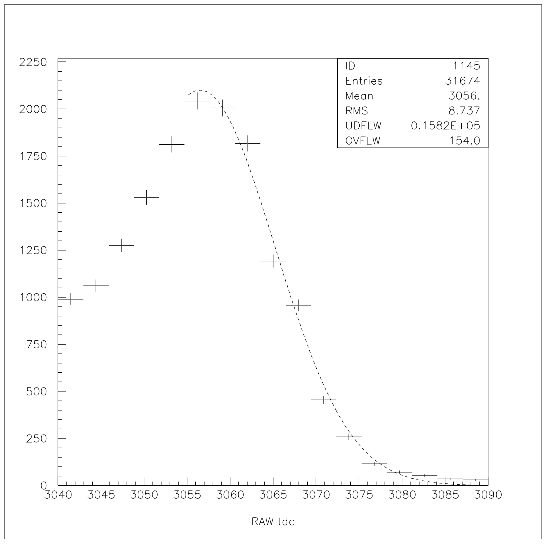

Figure 4: Highest χ^2 time_zero fitting for plane 1, wire 45, using a half-Gaussian. χ^2=10.7926

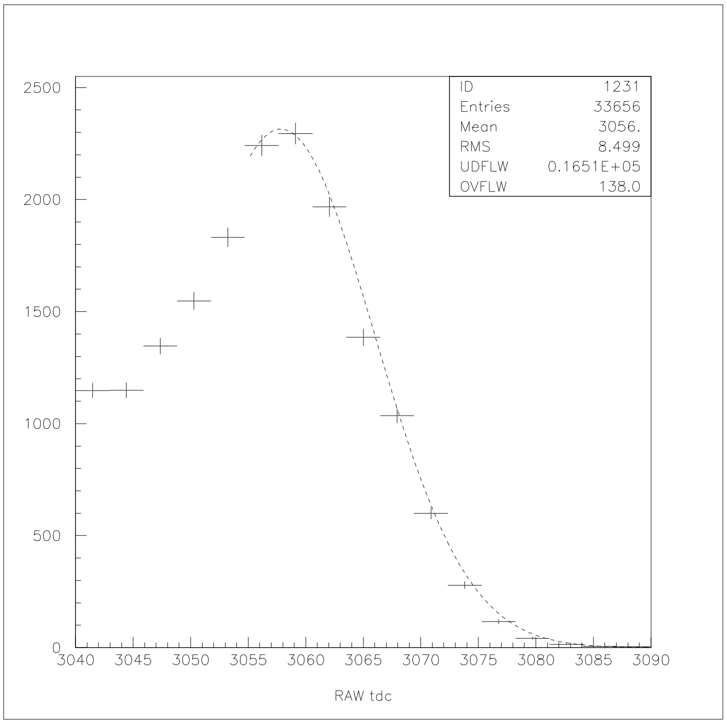

Figure 5: Lowest χ^2 time_zero fitting for plane 2, wire 31, using a half-Gaussian. χ^2=1.76546

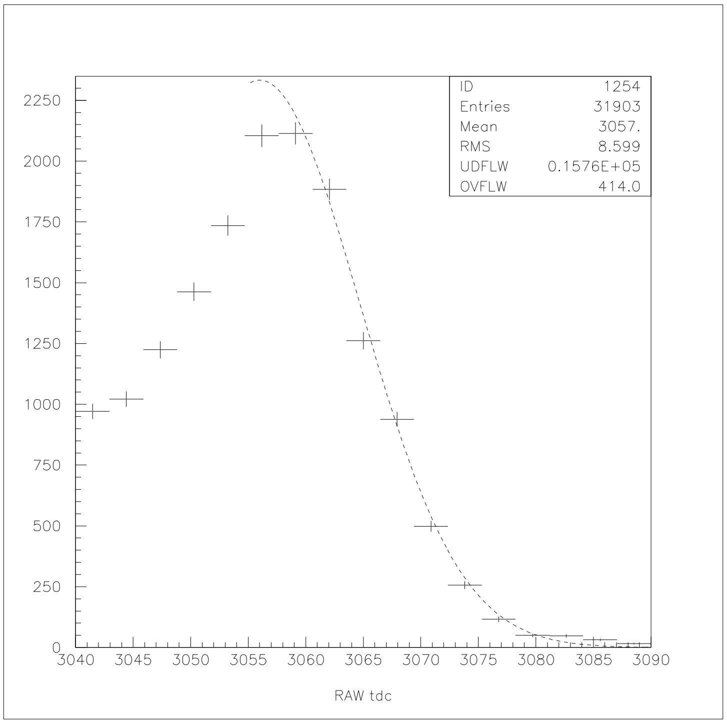

Figure 6: Highest χ^2 time_zero fitting for plane 2, wire 54, using a half-Gaussian. χ^2=7.1351

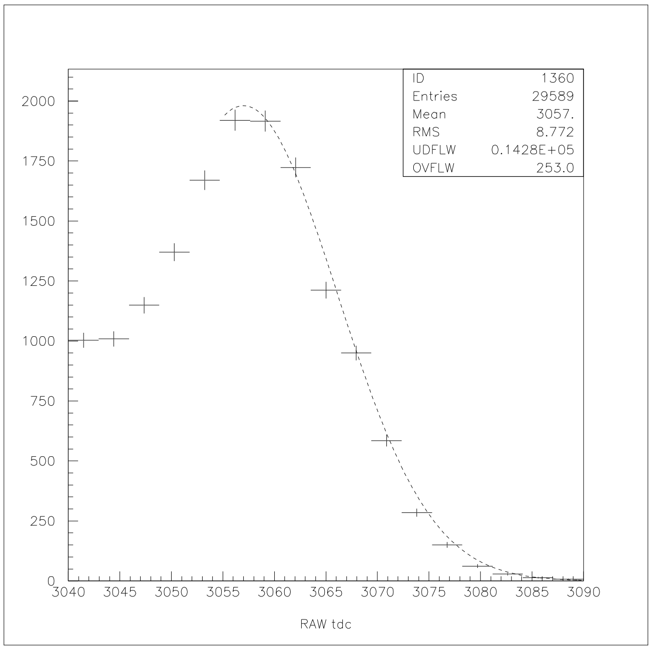

Figure 7: Lowest χ^2 time_zero fitting for plane 3, wire 60, using a half-Gaussian. χ^2=2.0086

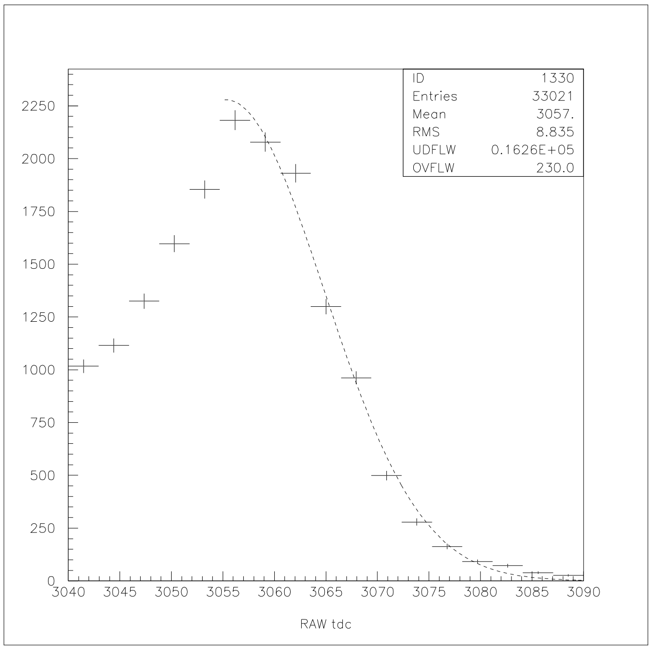

Figure 8: Highest χ^2 time_zero fitting for plane 3, wire 30, using a half-Gaussian. χ^2=9.978

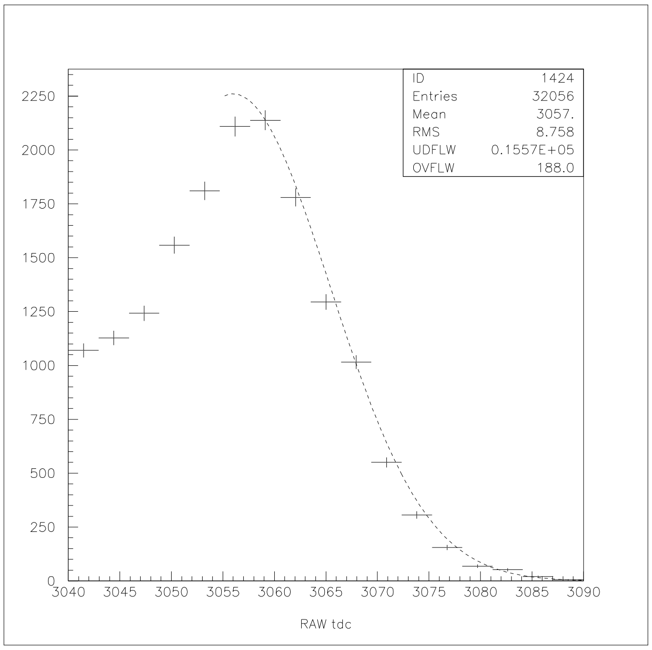

Figure 9: Lowest χ^2 time_zero fitting for plane 4, wire 24, using a half-Gaussian. χ^2=2.9636

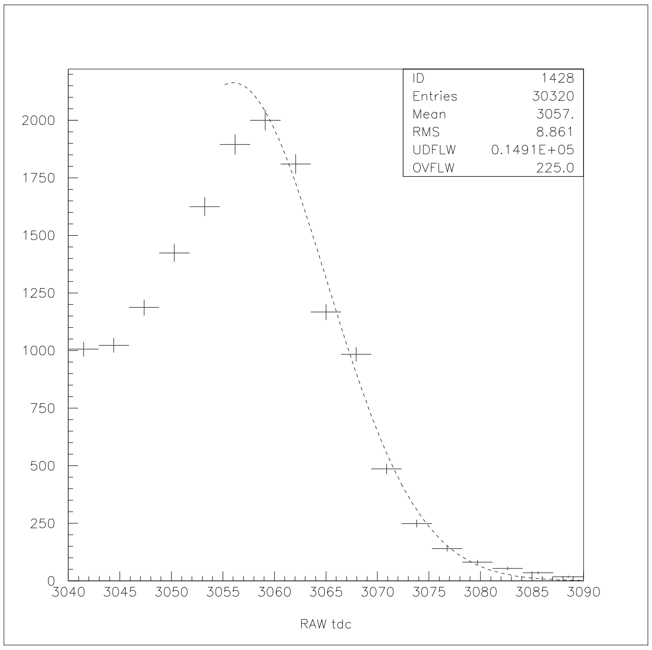

Figure 10: Highest χ^2 time_zero fitting for plane 4, wire 28, using a half-Gaussian. χ^2=10.253

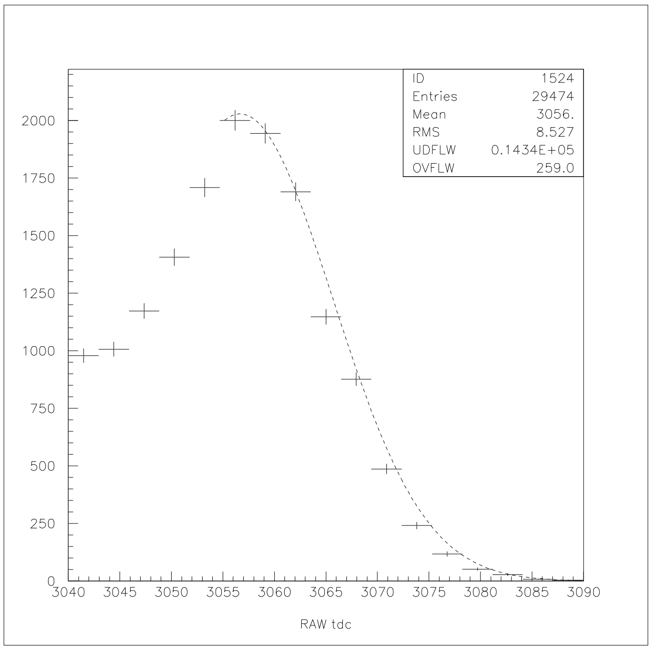

Figure 11: Lowest χ^2 time_zero fitting for plane 5, wire 24, using a half-Gaussian. χ^2=1.814

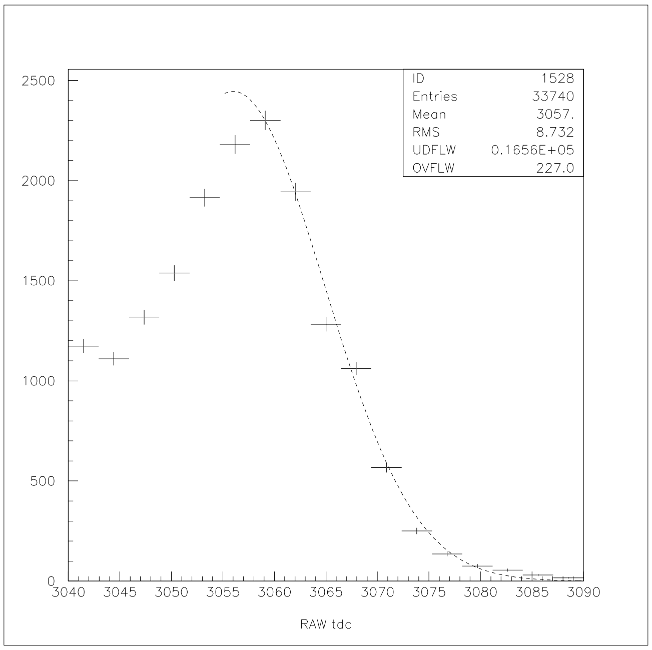

Figure 12: Highest χ^2 time_zero fitting for plane 5, wire 28, using a half-Gaussian. χ^2=9.45258

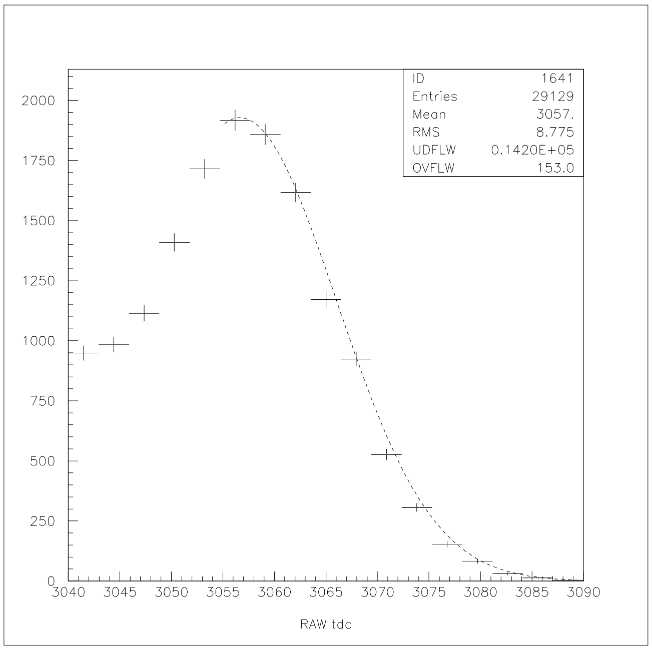

Figure 13: Lowest χ^2 time_zero fitting for plane 6, wire 41, using a half-Gaussian. χ^2=1.0226

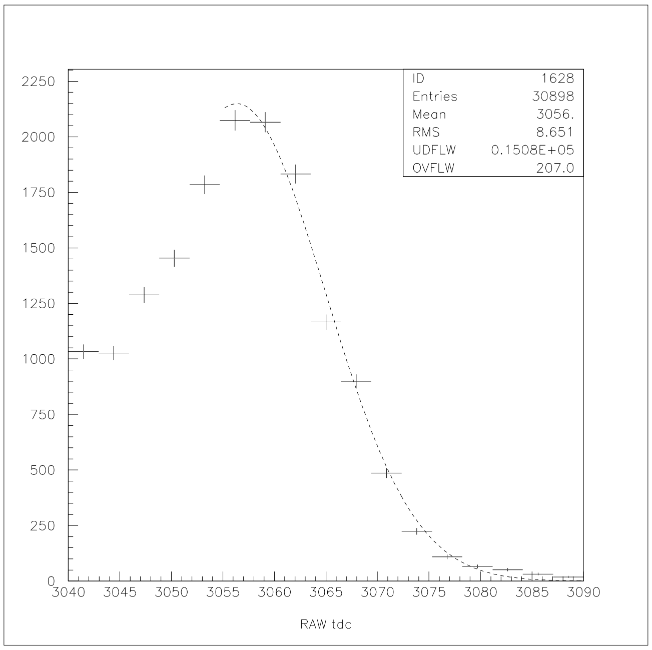

Figure 14: Highest χ^2 time_zero fitting for plane 6, wire 28, using a half-Gaussian. χ^2=9.4029

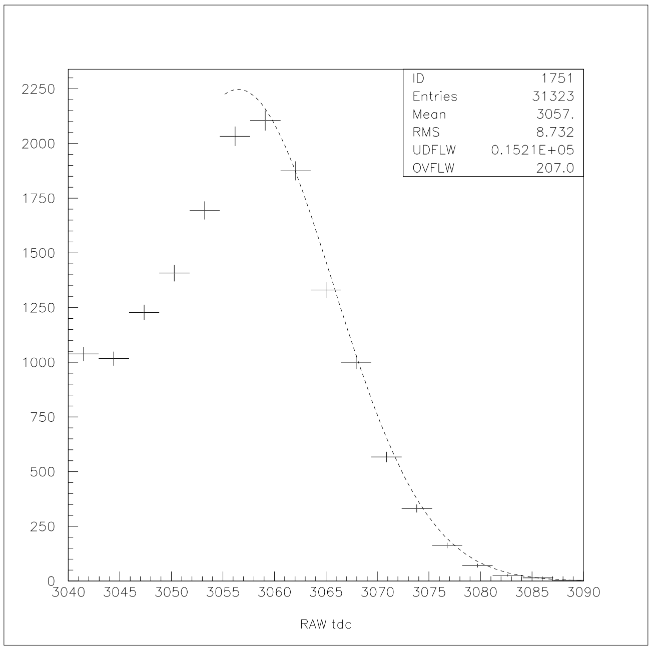

Figure 15: Lowest χ^2 time_zero fitting for plane 7, wire 51, using a half-Gaussian. χ^2=1.07608

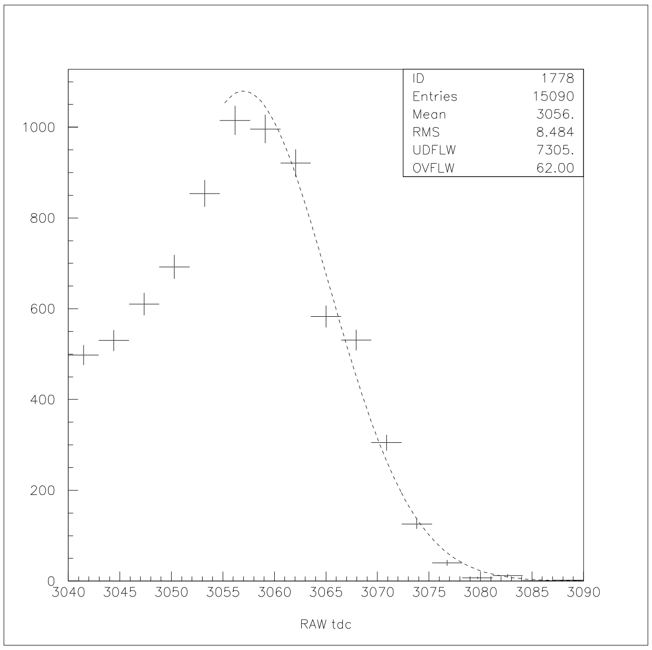

Figure 16: Highest χ^2 time_zero fitting for plane 7, wire 78, using a half-Gaussian. χ^2=9.5211

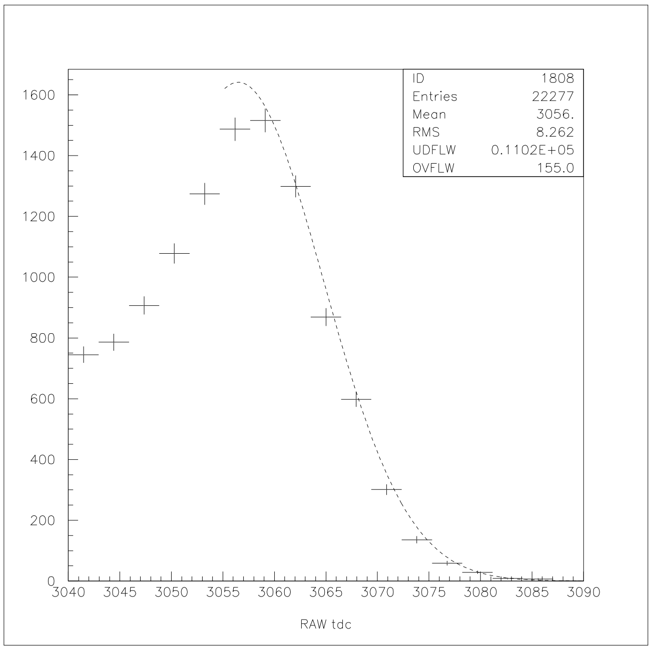

Figure 17: Lowest χ^2 time_zero fitting for plane 8, wire 8, using a half-Gaussian. χ^2=1.40794

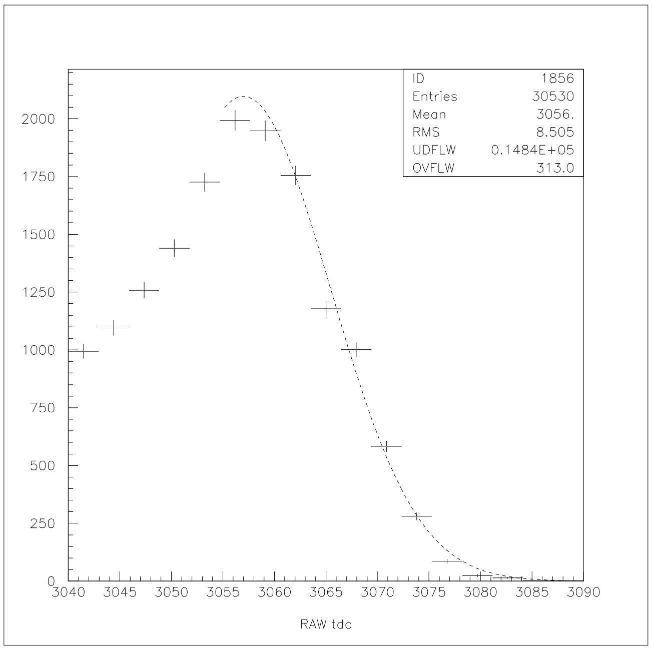

Figure 18: Highest χ^2 time_zero fitting for plane 8, wire 256, using a half-Gaussian. χ^2=11.4533

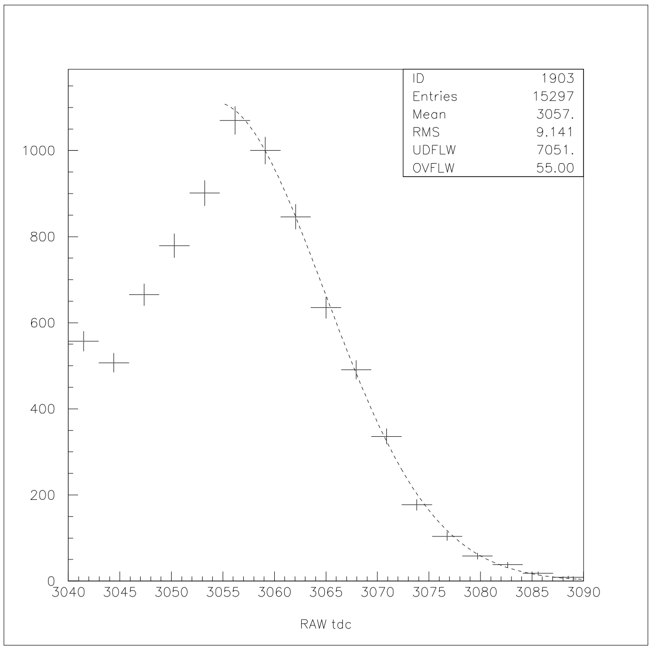

Figure 19: Lowest χ^2 time_zero fitting for plane 9, wire 3, using a half-Gaussian. χ^2=0.981527

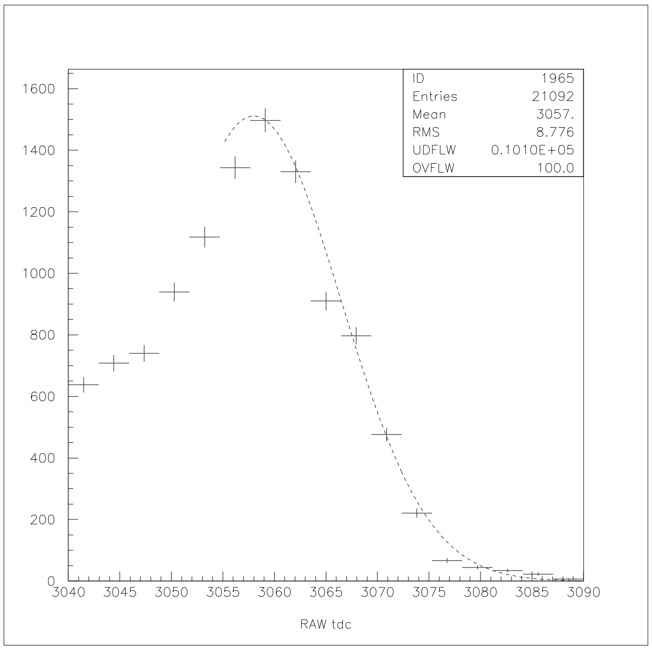

Figure 20: Highest χ^2 time_zero fitting for plane 9, wire 65, using a half-Gaussian. χ^2=9.087

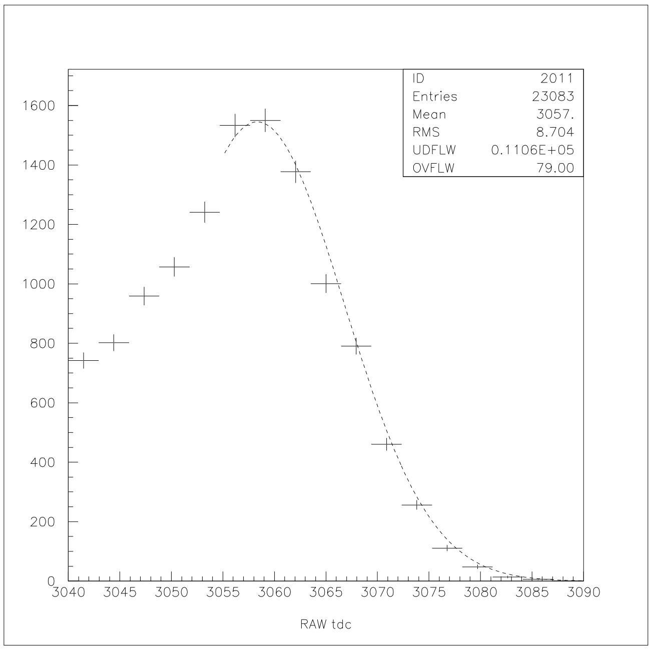

Figure 21: Lowest χ^2 time_zero fitting for plane 10, wire 11, using a half-Gaussian. χ^2=1.27263

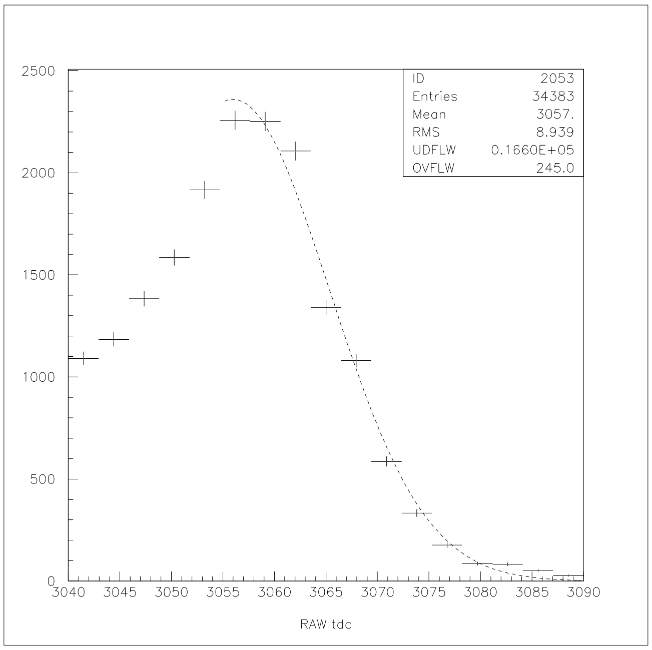

Figure 22: Highest χ^2 time_zero fitting for plane 10, wire 53, using a half-Gaussian. χ^2=12.0021

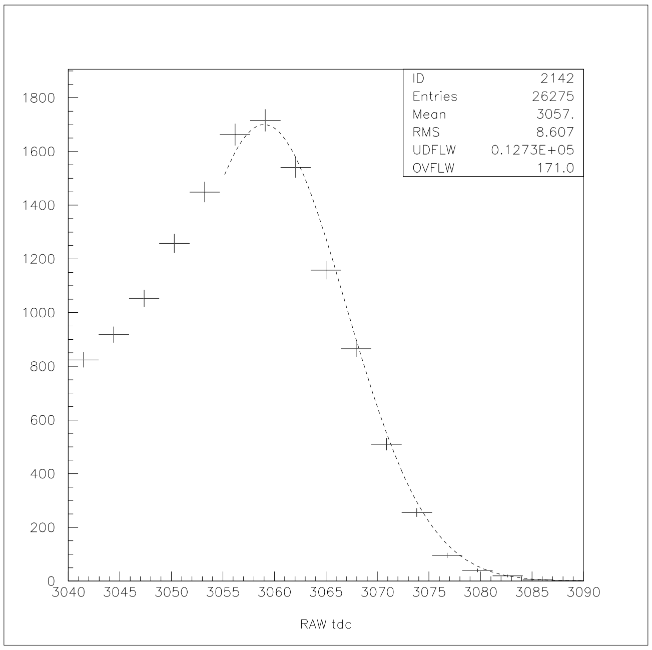

Figure 23: Lowest χ^2 time_zero fitting for plane 11, wire 42, using a half-Gaussian. χ^2=1.1683

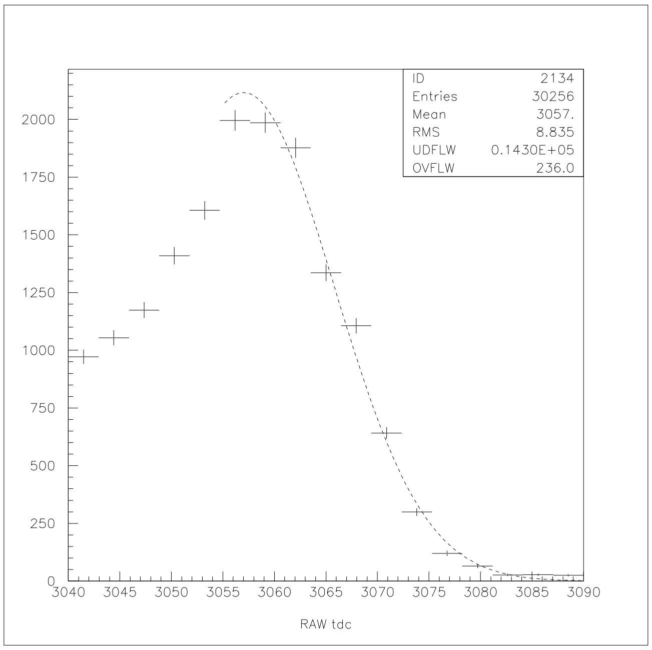

Figure 24: Highest χ^2 time_zero fitting for plane 11, wire 34, using a half-Gaussian. χ^2=9.15737

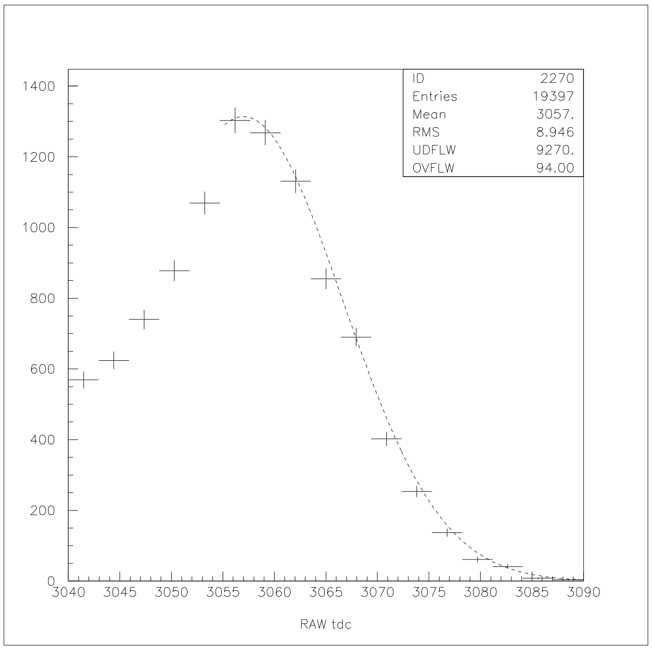

Figure 25: Lowest χ^2 time_zero fitting for plane 12, wire 70, using a half-Gaussian. χ^2=1.1446

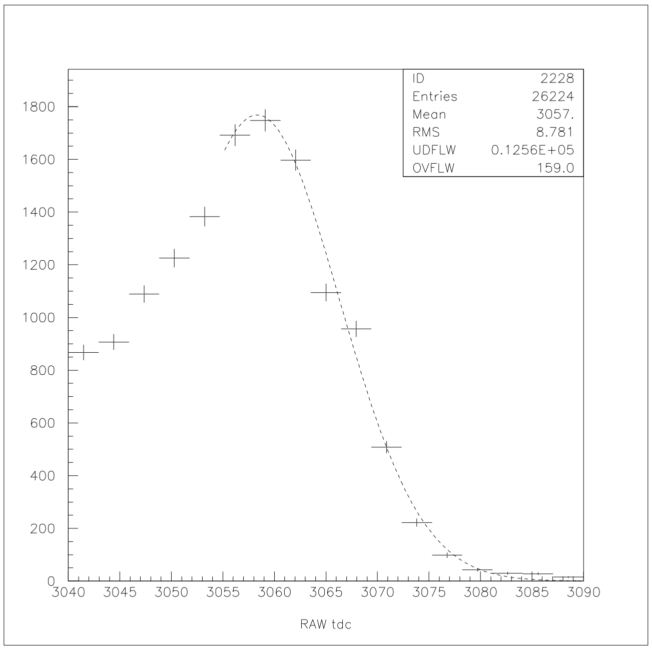

Figure 26: Highest χ^2 time_zero fitting for plane 12, wire 28, using a half-Gaussian. χ^2=8.770

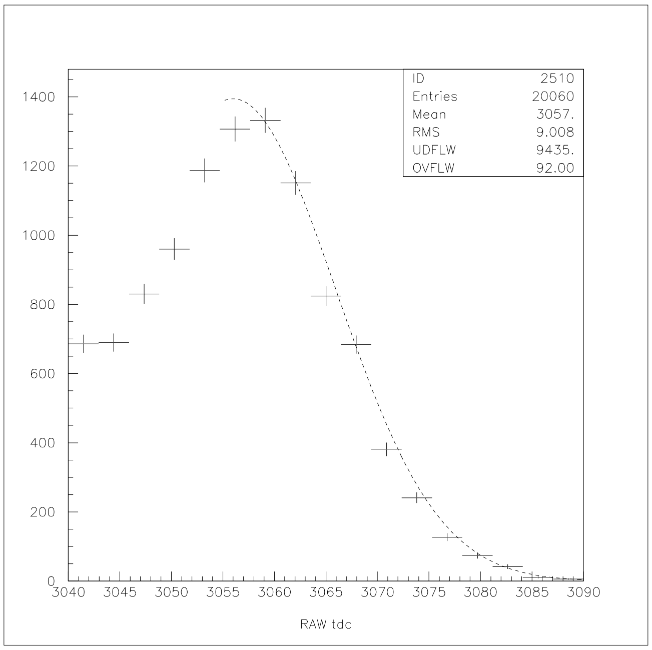

Figure 27: Lowest χ^2 time_zero fitting for plane 15, wire 10, using a half-Gaussian. χ^2=1.8599

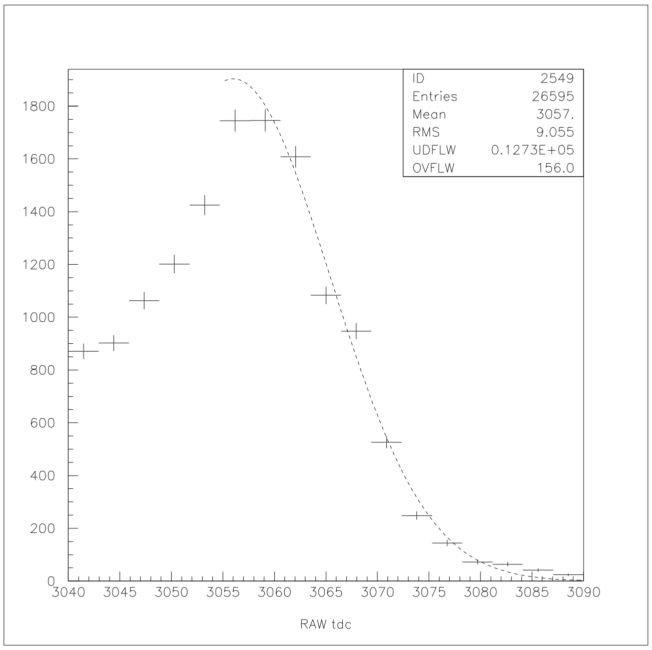

Figure 28: Highest χ^2 time_zero fitting for plane 15, wire 49, using a half-Gaussian. χ^2=10.491

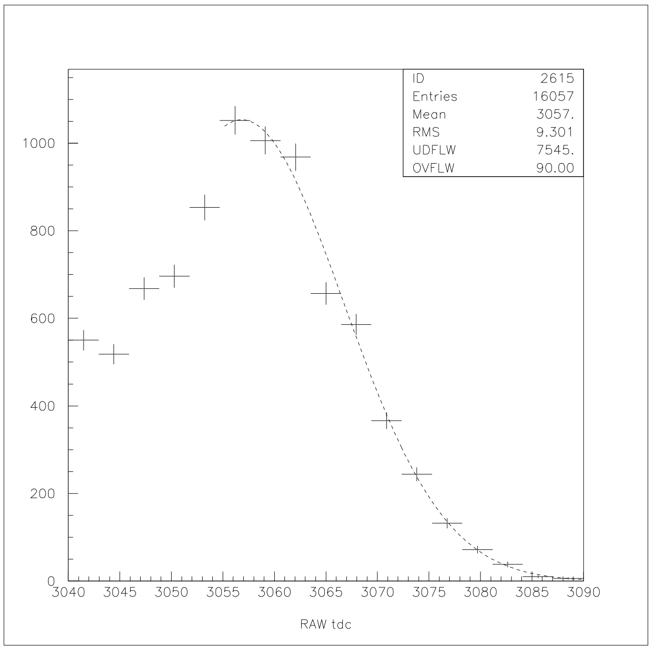

Figure 29: Lowest χ^2 time_zero fitting for plane 16, wire 15, using a half-Gaussian. χ^2=1.96817

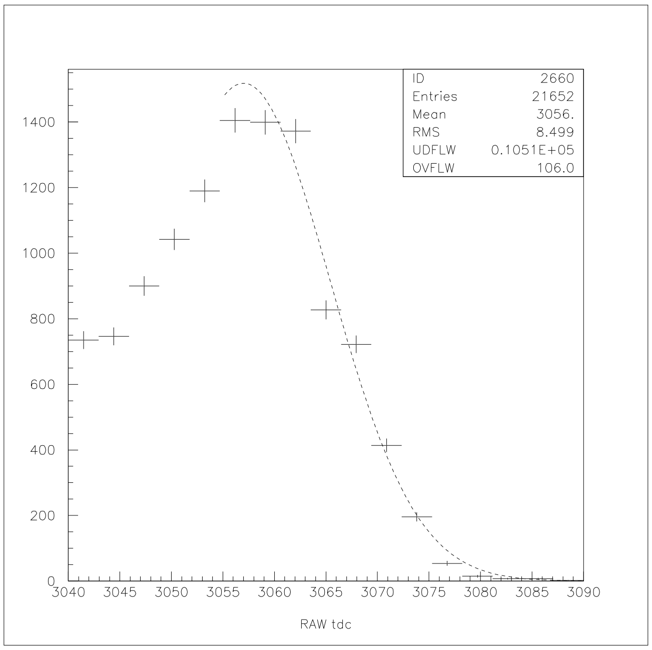

Figure 30: Highest χ^2 time_zero fitting for plane 16, wire 60, using a half-Gaussian. χ^2=12.4194

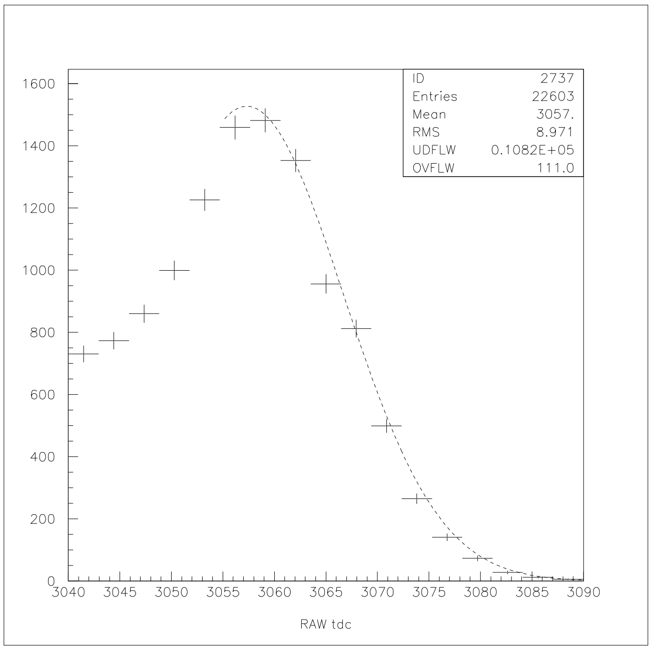

Figure 31: Lowest χ^2 time_zero fitting for plane 17, wire 37, using a half-Gaussian. χ^2=1.89847

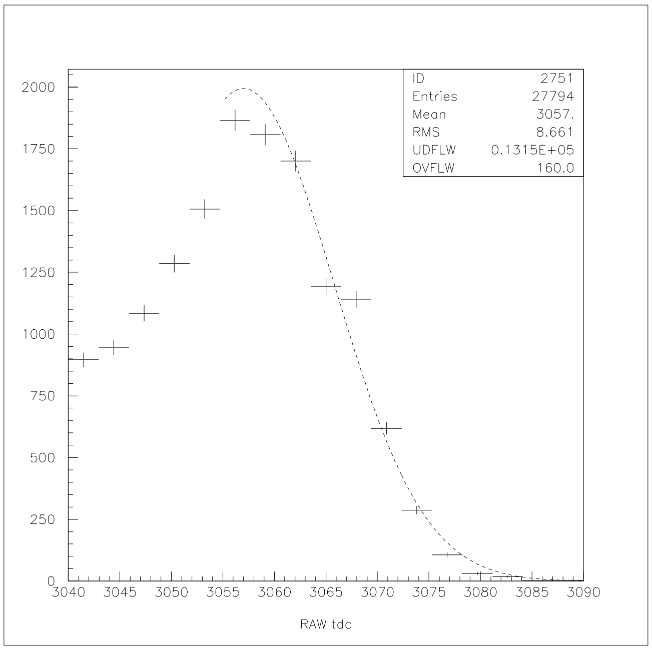

Figure 32: Highest χ^2 time_zero fitting for plane 17, wire 51, using a half-Gaussian. χ^2=17.0772

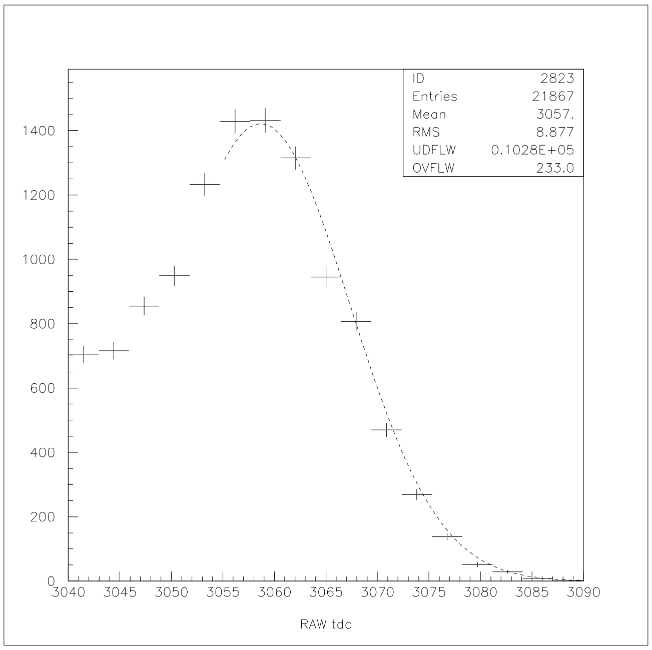

Figure 33: Lowest χ^2 time_zero fitting for plane 18, wire 23, using a half-Gaussian. χ^2=2.215

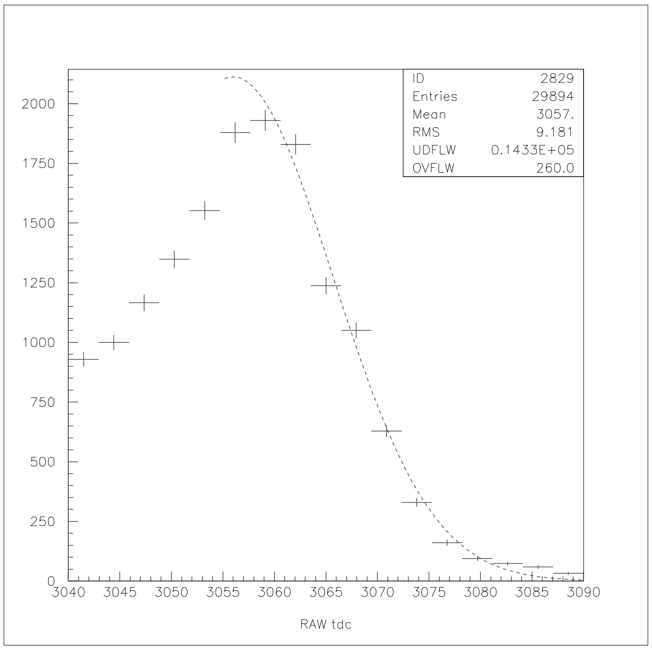

Figure 34: Highest χ^2 time_zero fitting for plane 18, wire 29, using a half-Gaussian. χ^2=11.2394

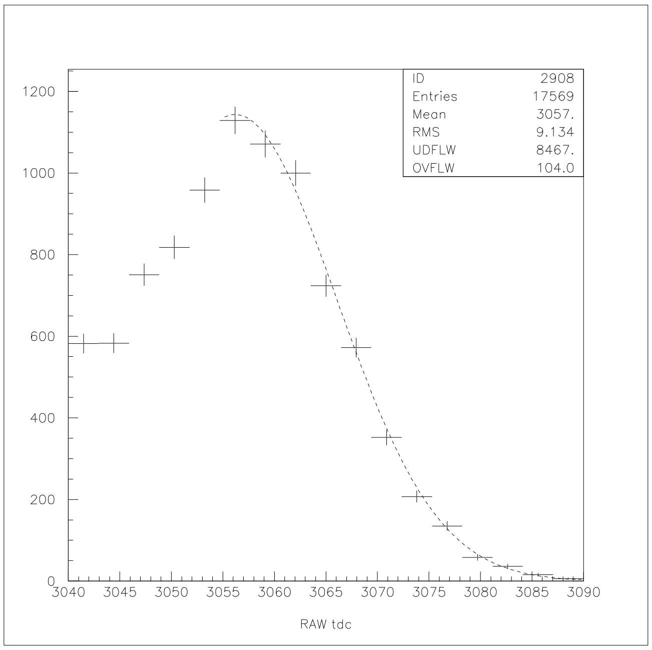

Figure 35: Lowest χ^2 time_zero fitting for plane 19, wire 8, using a half-Gaussian. χ^2=1.051

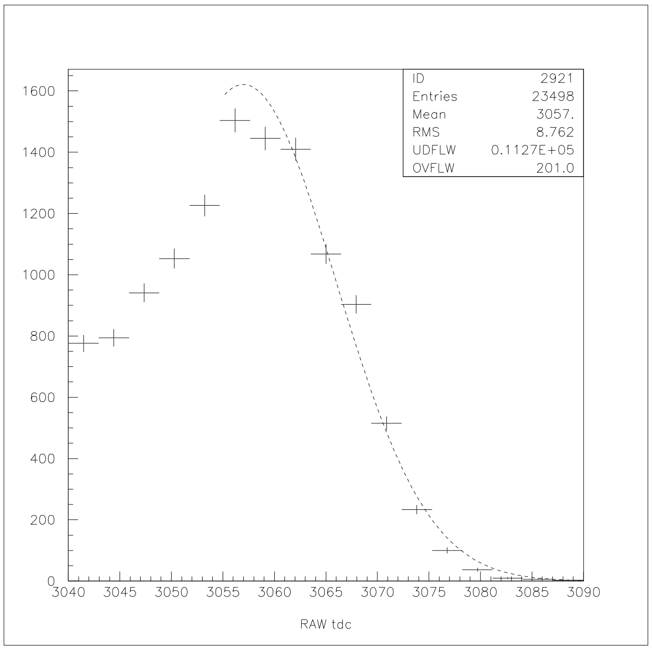

Figure 36: Highest χ^2 time_zero fitting for plane 19, wire 21, using a half-Gaussian. χ^2=10.5715

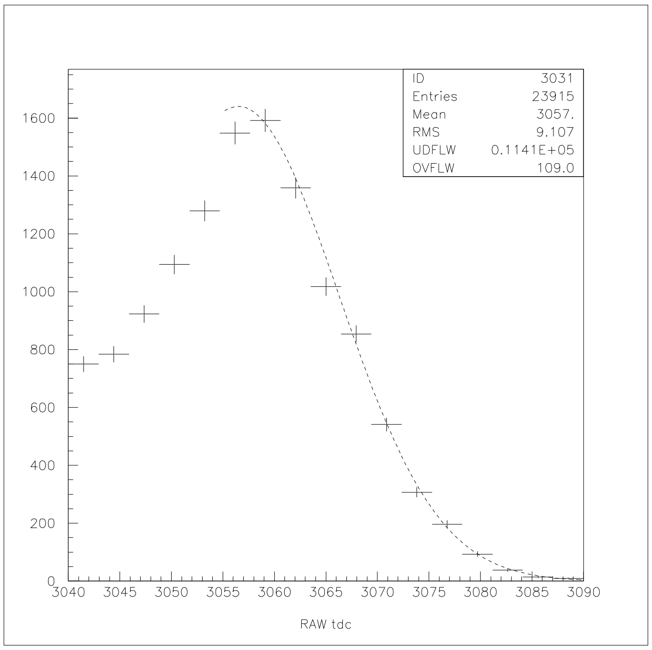

Figure 37: Lowest χ^2 time_zero fitting for plane 20, wire 31, using a half-Gaussian. χ^2=1.5853

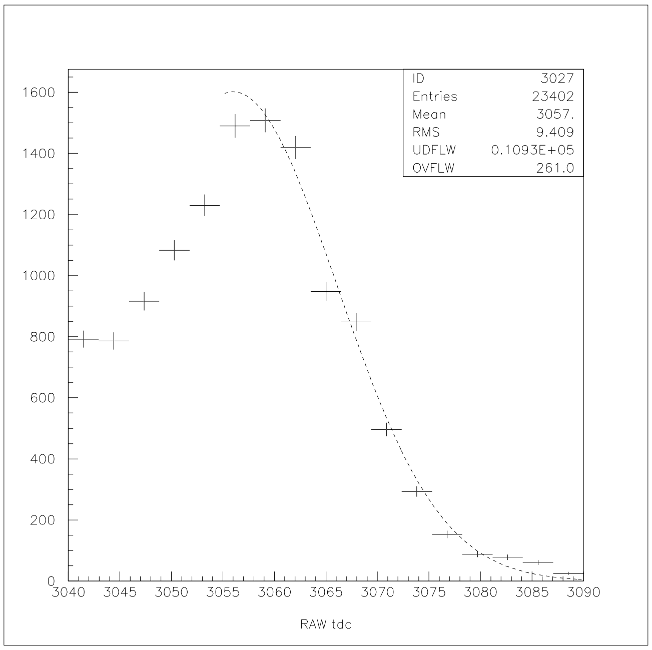

Figure 38: Highest χ^2 time_zero fitting for plane 20, wire 27, using a half-Gaussian. χ^2=9.68392

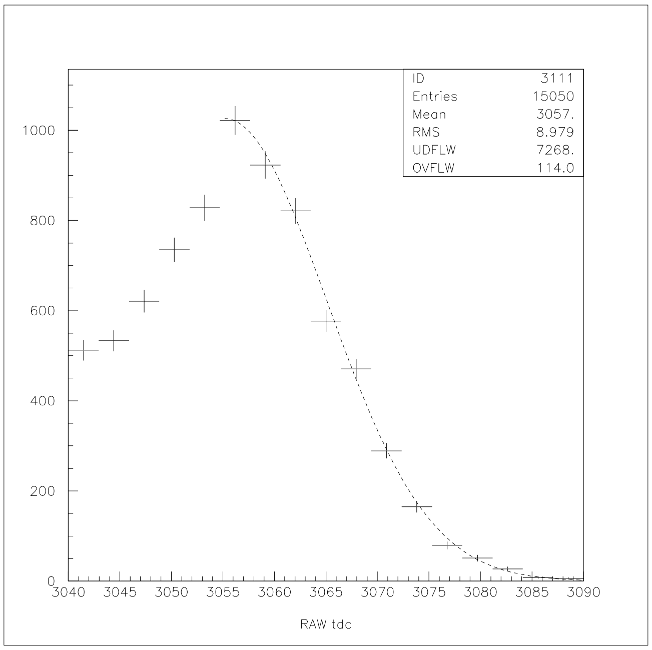

Figure 39: Lowest χ^2 time_zero fitting for plane 21, wire 11, using a half-Gaussian. χ^2=1.15348

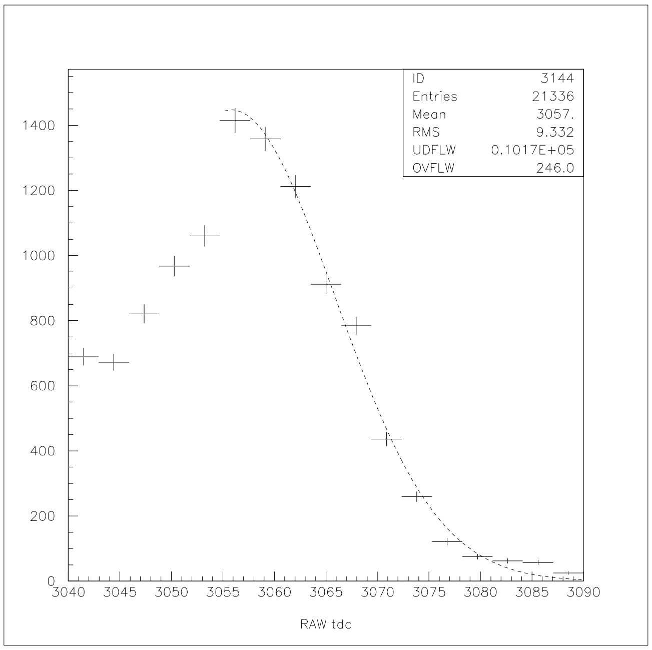

Figure 40: Highest χ^2 time_zero fitting for plane 21, wire 44, using a half-Gaussian. χ^2=8.01688

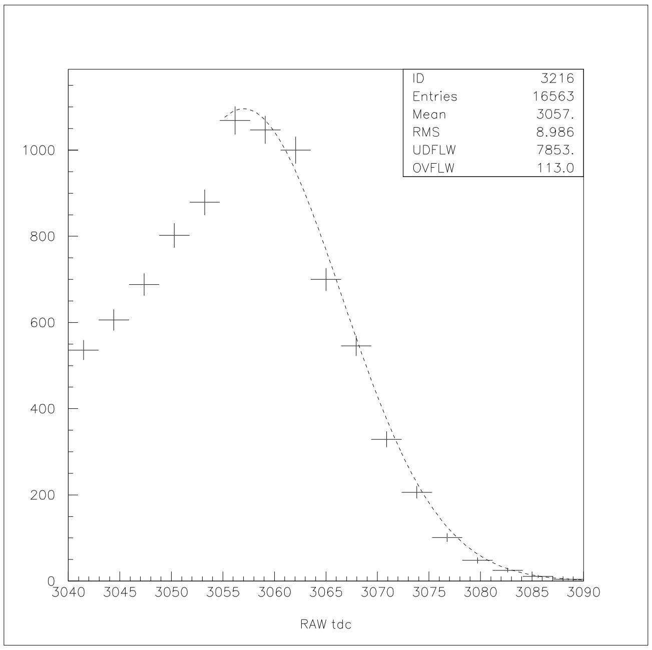

Figure 41: Lowest χ^2 time_zero fitting for plane 22, wire 16, using a half-Gaussian. χ^2=1.05516

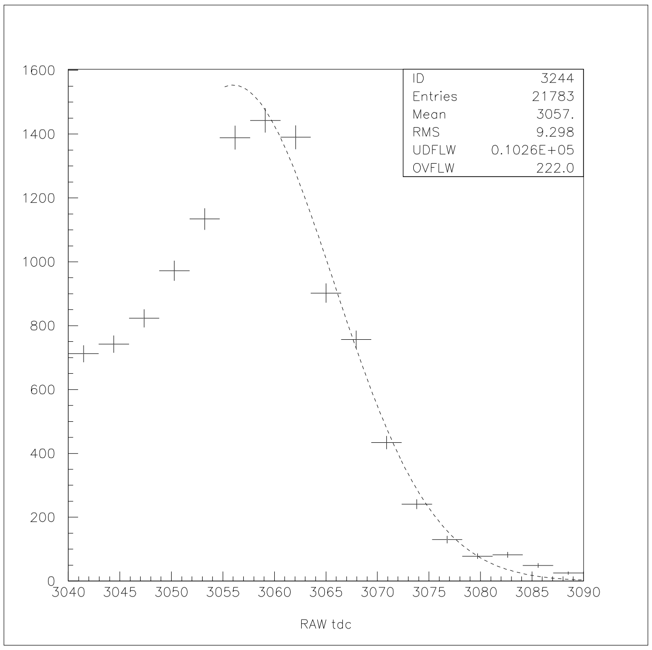

Figure 42: Highest χ^2 time_zero fitting for plane 22, wire 44, using a half-Gaussian. χ^2=11.3569