An improvement to the ZID algorithm from Tof Wall

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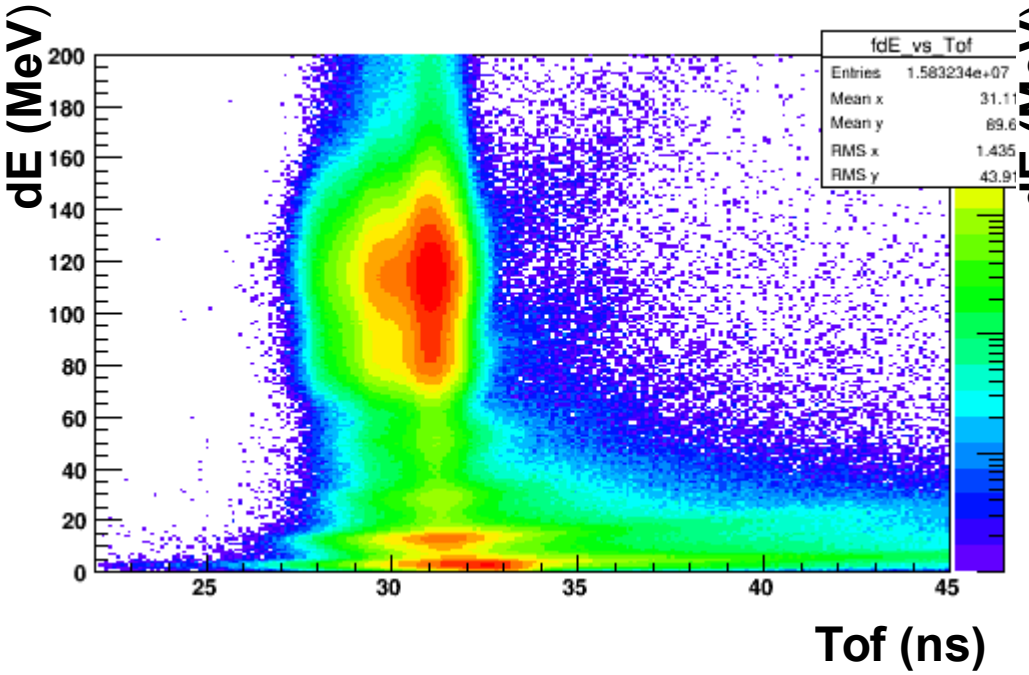
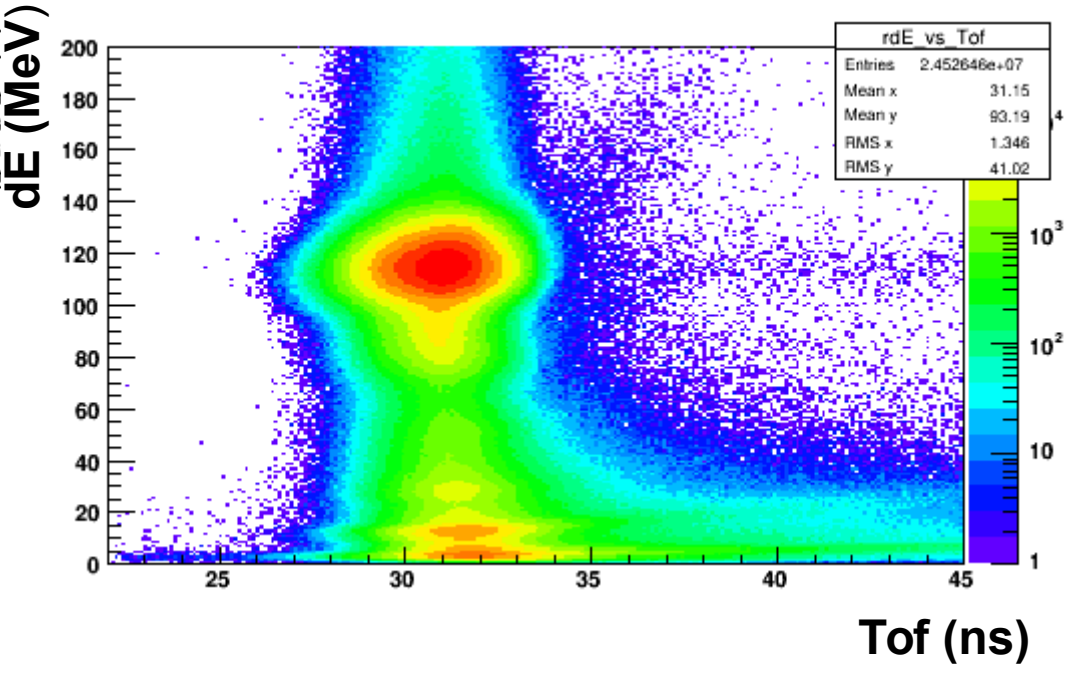
FIRST analysis meeting - 06 February, 2014

The starting point

Front TW



Rear TW



- This is the energy dE released in the Tof Wall front and rear vs Tof (Log scale) for data. All the statistics is used.
- The ZID algorithm in FIRST is based on fitting the six blobs in this plot corresponding to the fragments and carbon charges with the six Bethe-Bloch curves (one for each Z)

The Bethe-Bloch formula used

(Slide from S.Salvator talk in FIRST meeting, May 2013)

The formula used is based on Bethe-Bloch with low energy part and no corrections :

The energy released dE is thought like a function of the Tof

$$\Delta E = a_1(Z) \cdot \frac{Z^2}{\beta^2}\left[\ln\left(\frac{b\beta^2}{1-\beta^2}\right) - \beta^2\right]\Delta x.$$

with

$$\beta = \frac{d}{c \cdot ToF}$$

$$a_1(Z) = \text{“quenching factors”},$$

$$b = \frac{2m_e c^2}{I} = 6645.,$$

$$\Delta x = \text{thickness of the slat=15. mm}$$

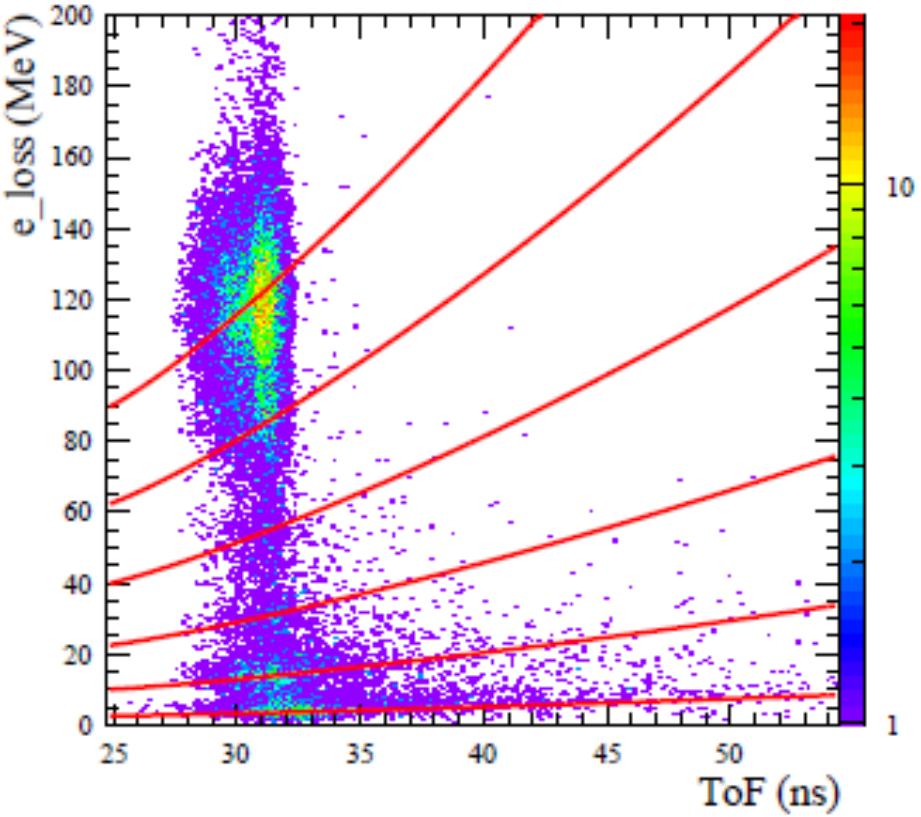
d = 6.64 m is the path distance for carbons that goes straight. So the constrain 0<β<1 implies ToF > 22 ns

Basically, only $a_1(Z)$ are left as free parameters, the others should be known.

Front and rear ToF Wall are studied separately both for data and MC so the fits return different parameters.

The minimization algorithm

1. For each data point characterized by the energy dE released in Tof Wall and a measured Tof, the minimum distance between it and the 6 Bethe-Bloch curves is calculated
2. The Z assigned to that particle is the one corresponding to the Bethe-Bloch curve closest to the data point



Plot from S.Salvator talk in FIRST meeting, May 2013

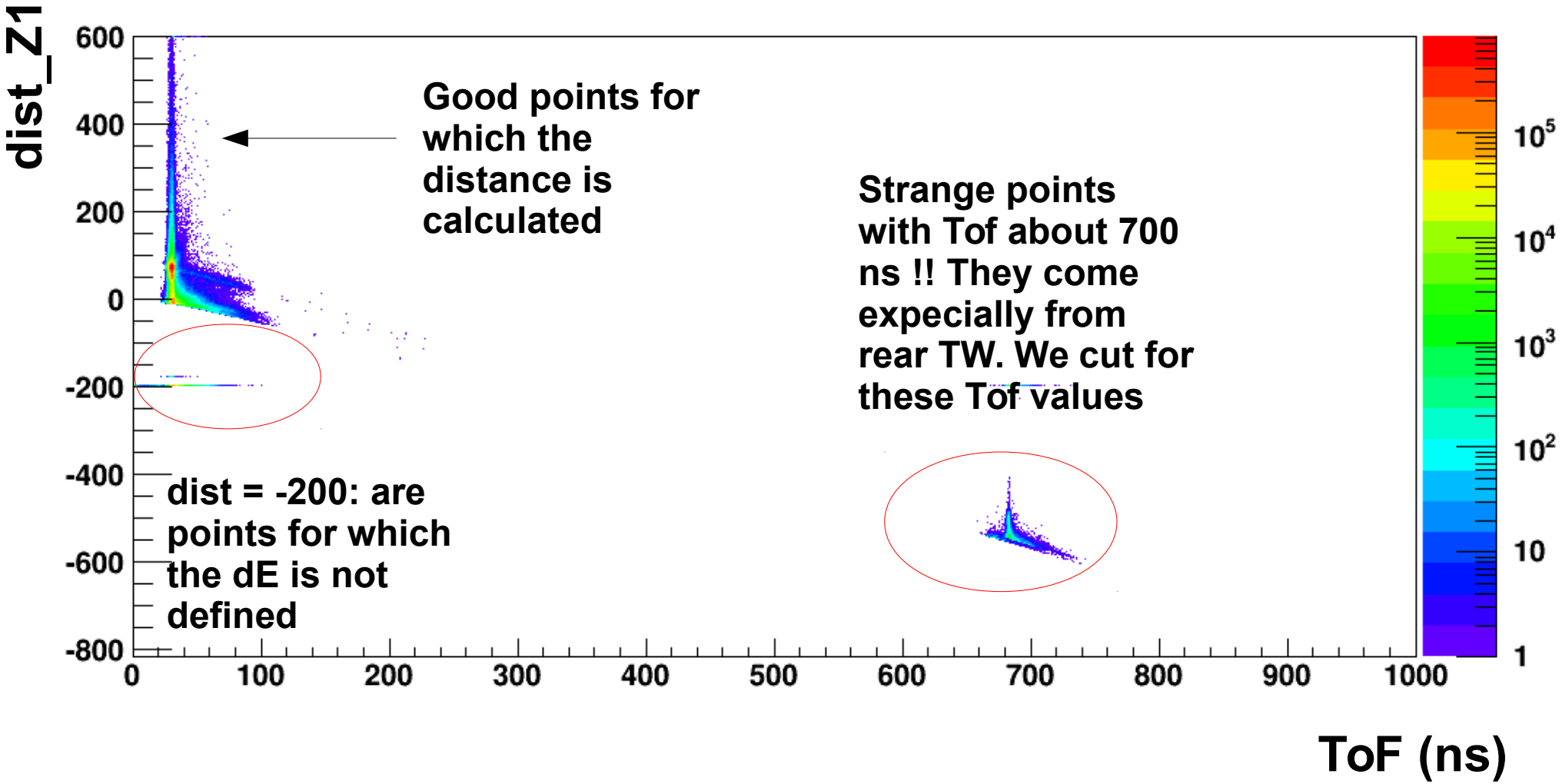
- Until now the Newton-Ralphson algorithm has been used to minimize the distance function respect to Tof. This algorithm is a root-finding method used here to find an approximation of the zero of the derivative of the distance function (the minimum).

New minimization algorithm

- Studing the correlation btw charge from Vtx detector and charge from Tof Wall a check of the ZID algorithm has been done. Two bugs were found and fixed, but after the fix the NR algorithm was not usable anymore
- We implemented the bisection method for finding the minimum distance that is known to have the advantage to always converge in the Tof intervall where the method is applied
- We decided for this method in sostitution of the NR algorithm because is more “safe”: different conditions have to be satisfied to be sure NR algorithm always converges
- The only disvantage of the bisection method is that its rate of convergence is slower respect to the one of NR. However this difference in timing is completely negligible in our case

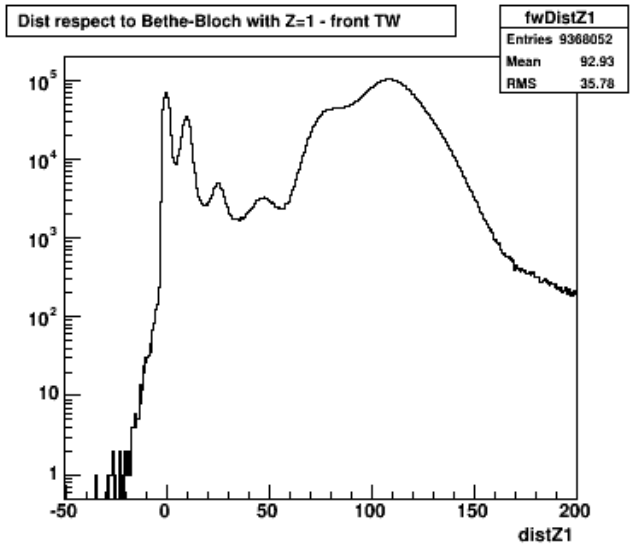
Where the bisection method fails

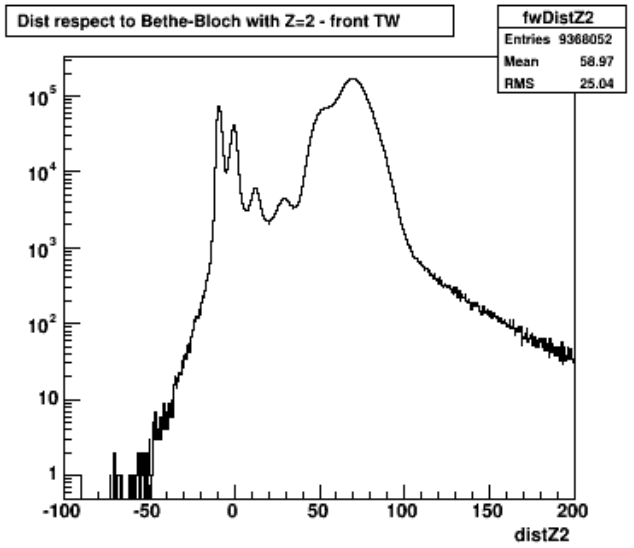
For less than 0.01% of the cases the conditions for applying the bisection method are not respected. So for these data points the algorithm doesn't return any charge

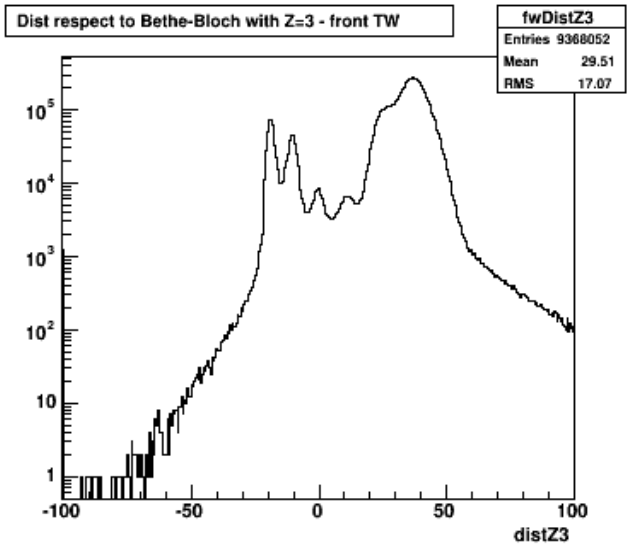


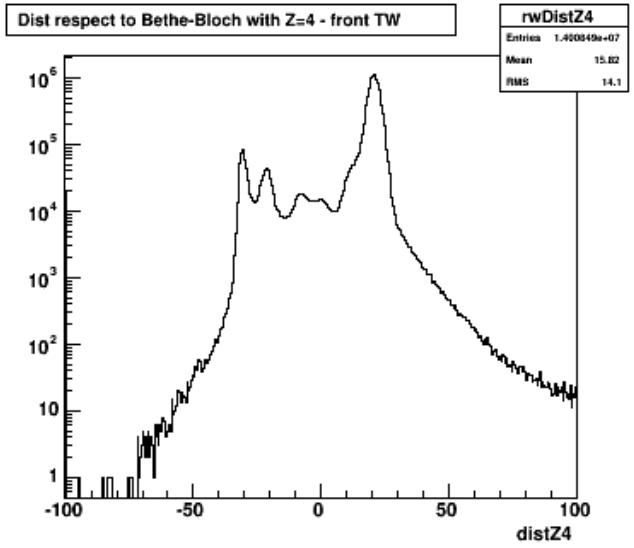
So the algorithm seems to be very robust!

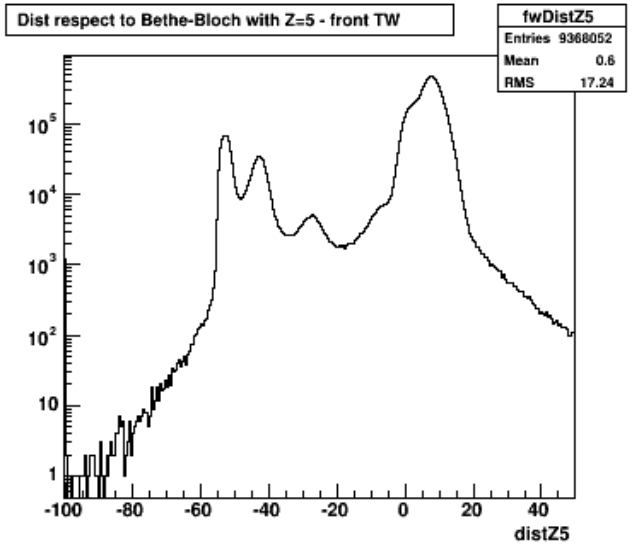
Distances from the six Bethe-Bloch curves for all the global tracks (with Nvertex = 1)

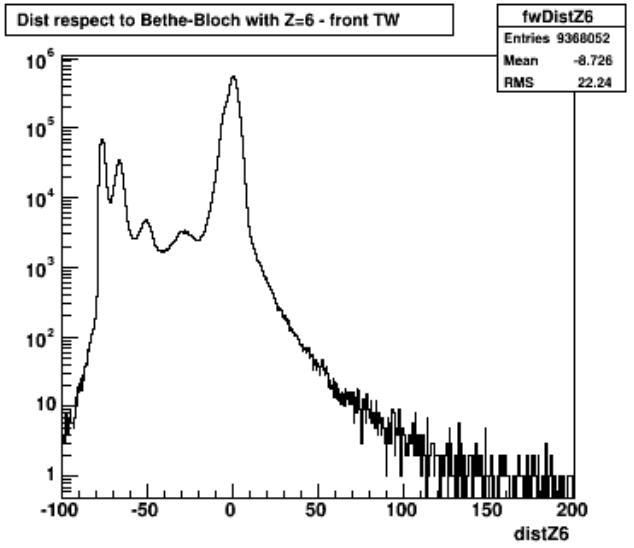






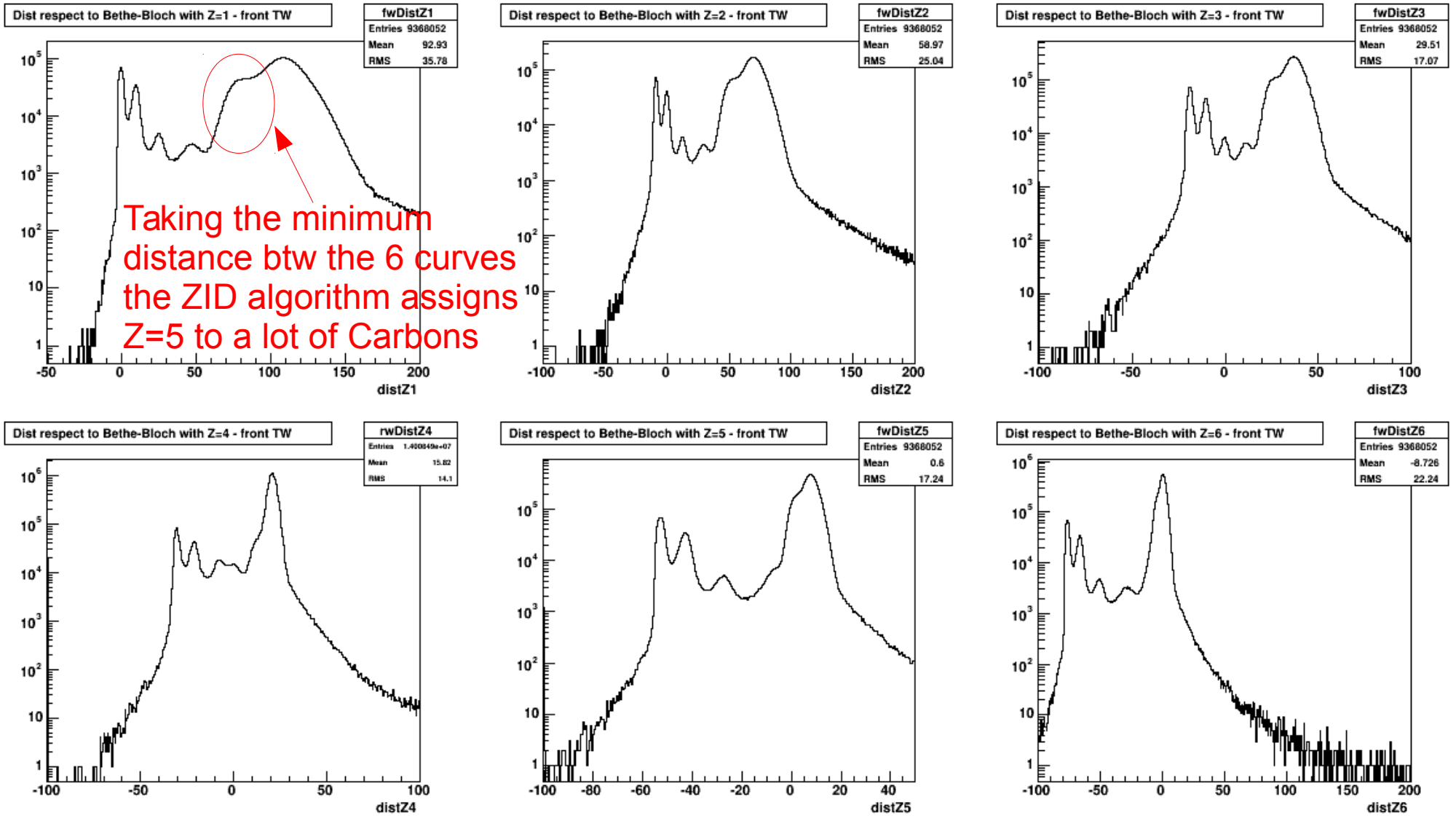






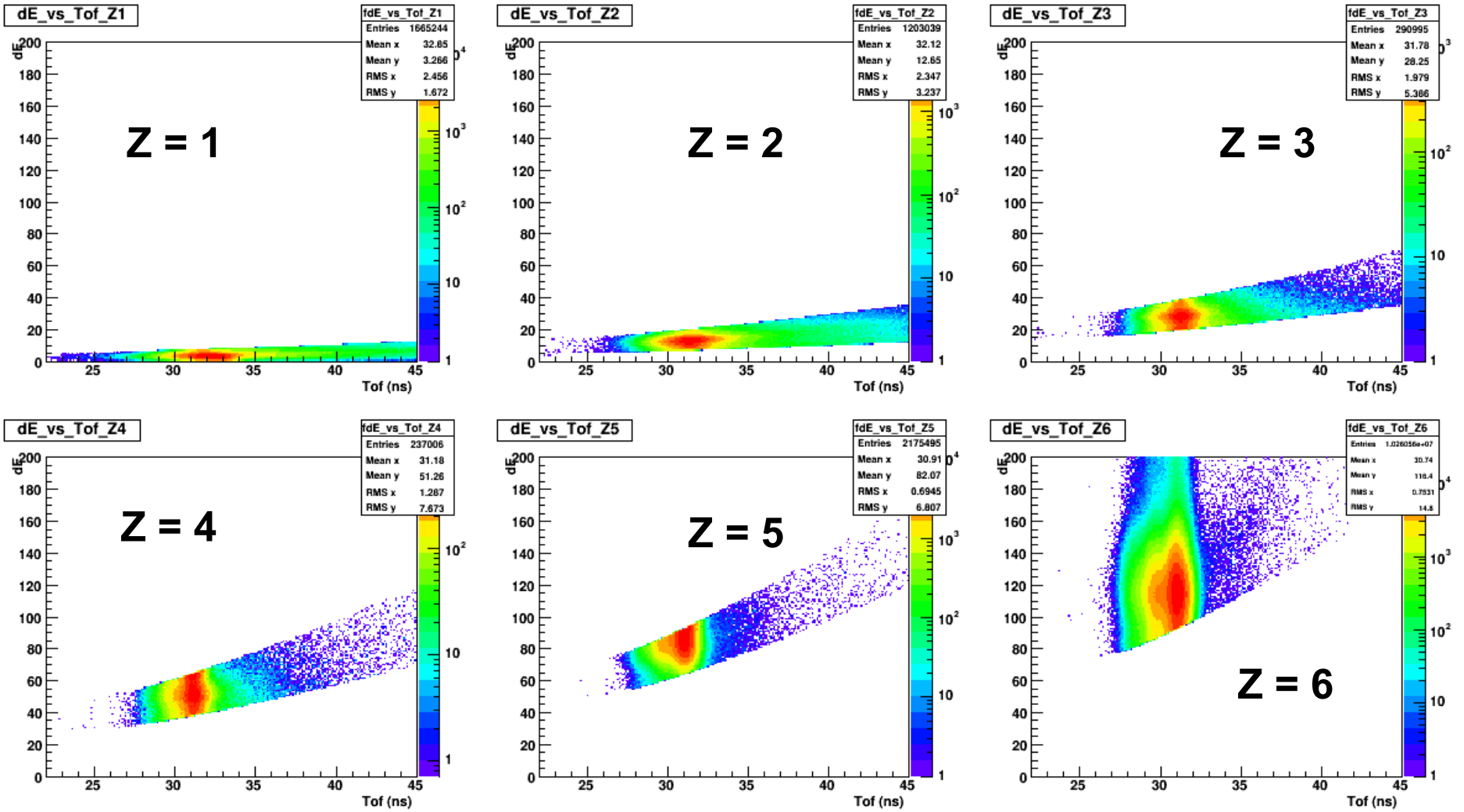
In each plot the peak centered in zero is the one corresponding to the data points near the Bethe-Bloch curve with the Z respect to which the distance is calculated

Distances from the six Bethe-Bloch curves for all the global tracks (with Nvertex = 1)



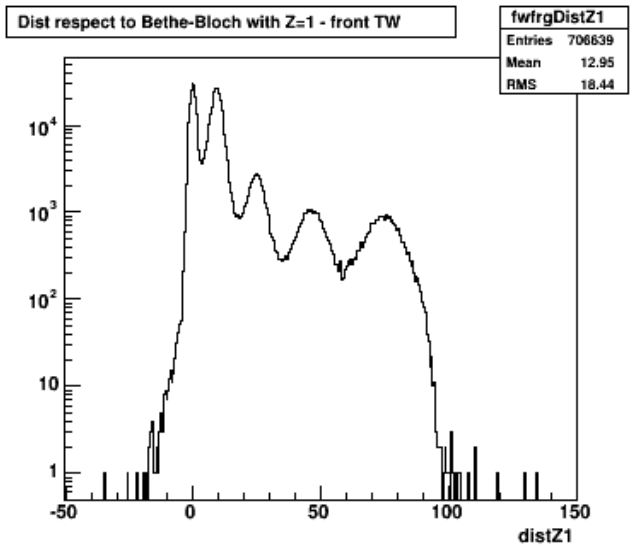
In each plot the peak centered in zero is the one corresponding to the data points near the Bethe-Bloch curve with the Z respect to which the distance is calculated

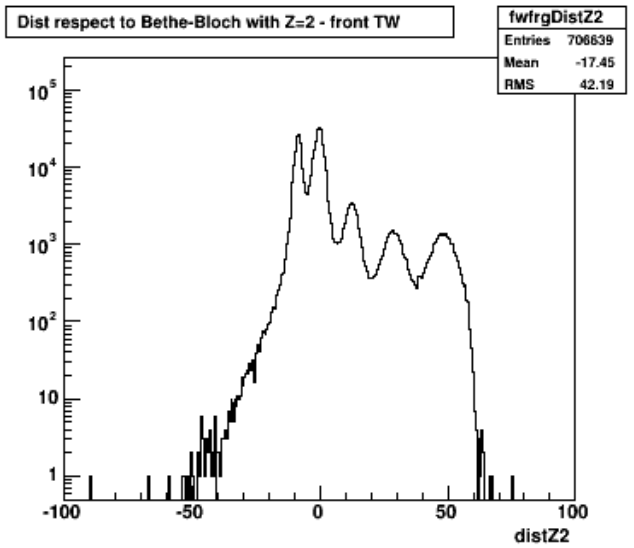
dE vs Tof for front TW with new algorithm for different Z

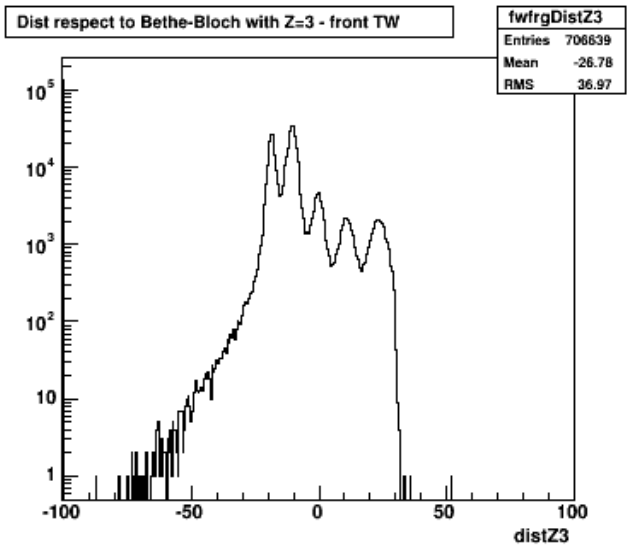


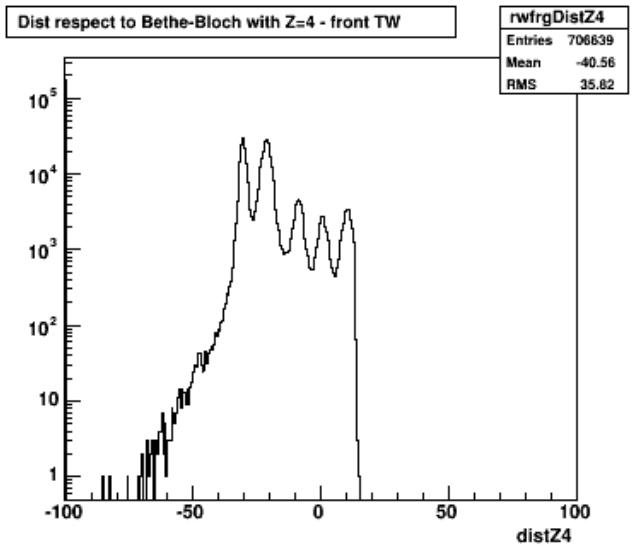
The blobs appear truncated as with the NR algorithm. Indeed this doesn't depend on the minimization algorithm but It depends on the method chosen to assign the charge that now is to take the minimum distance btw the 6 curves

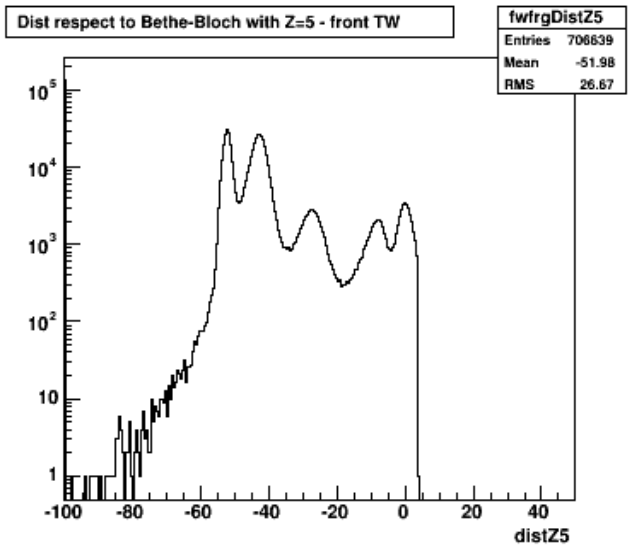
Distances from the six Bethe-Bloch curves for all the global tracks with charge != 6, Ntracks > 1 (fragmentation condition) and BM matching

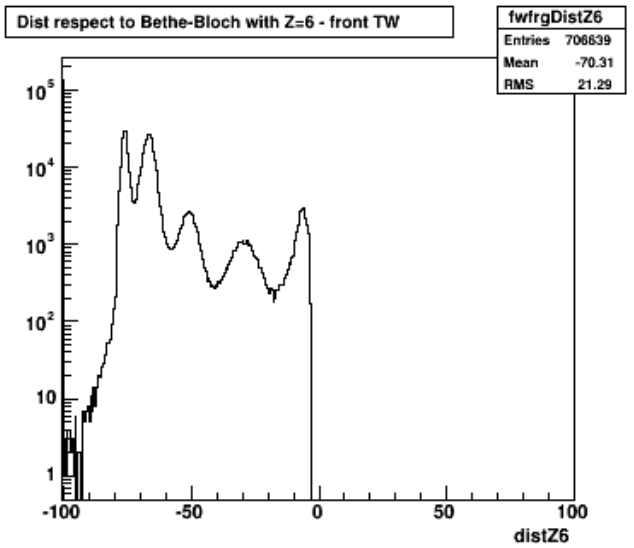




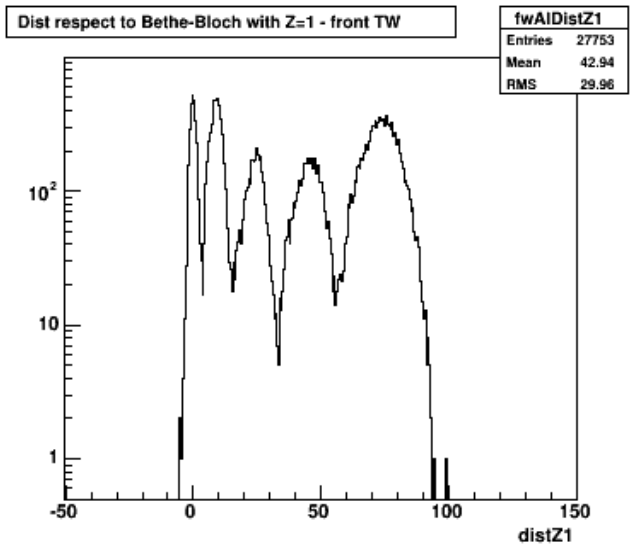


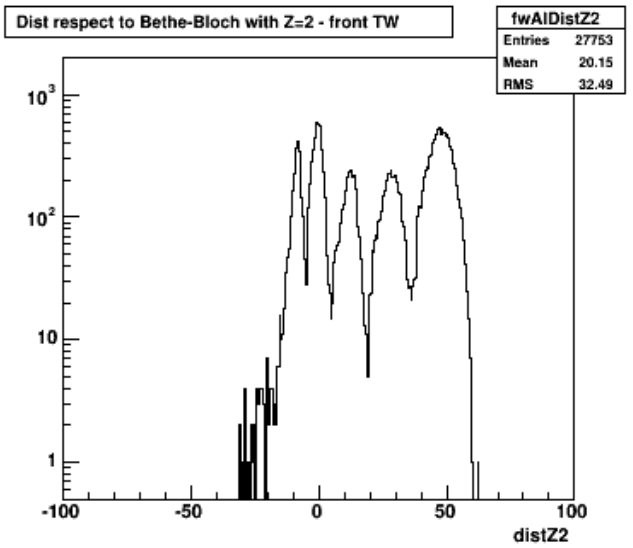


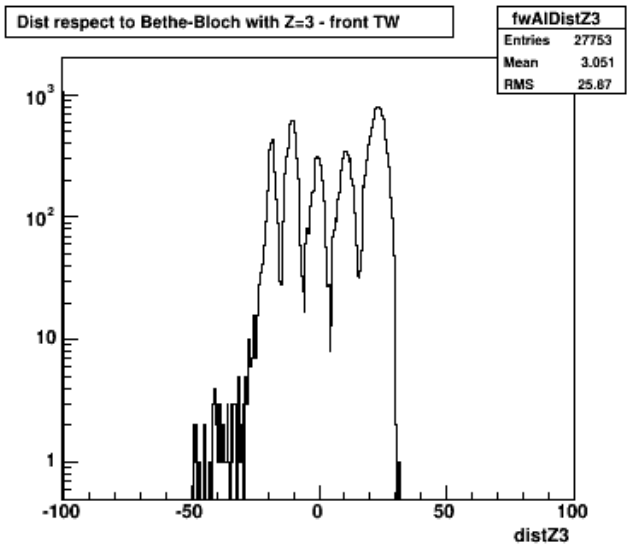


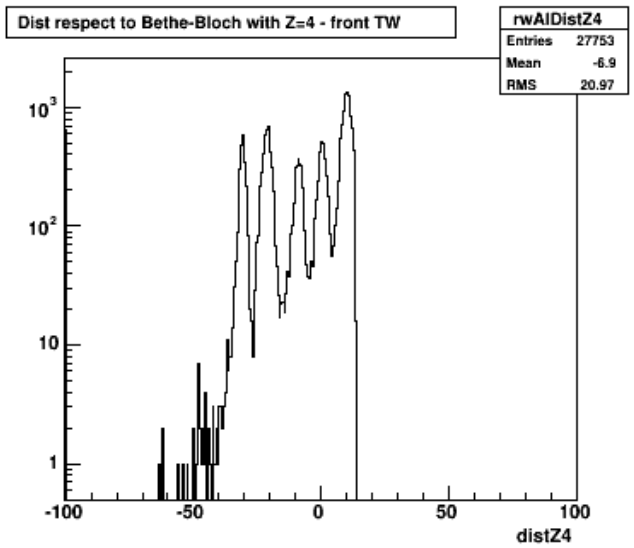


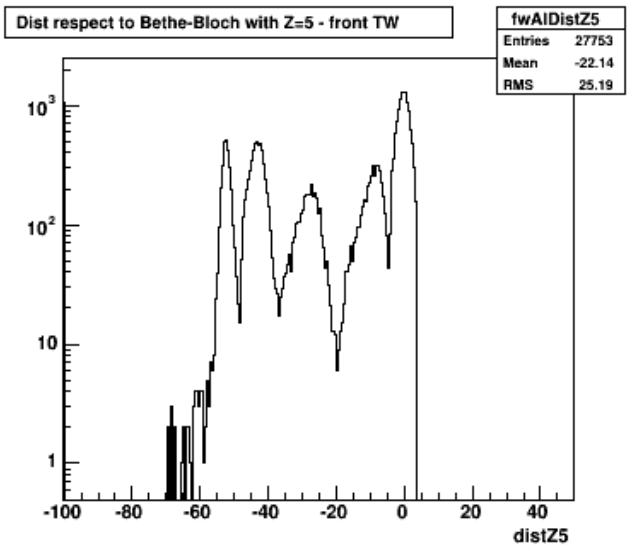
Distances from the six Bethe-Bloch curves for all the global tracks in the Aladin acceptance with Ntracks > 1 (fragmentation condition), BM matching and just one hit in the front and in the rear TW

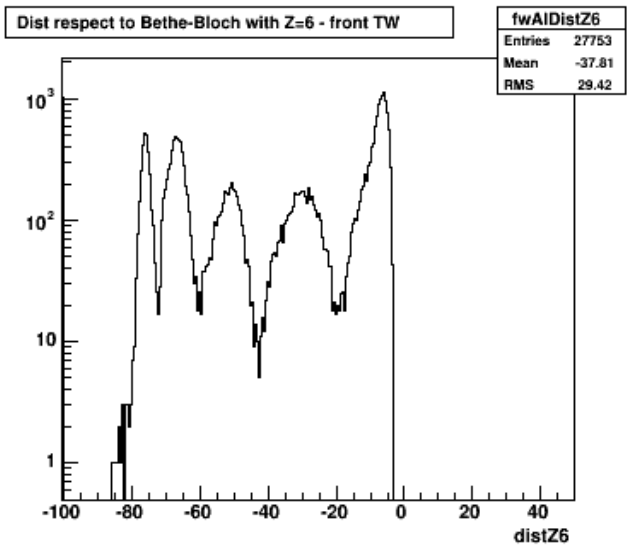




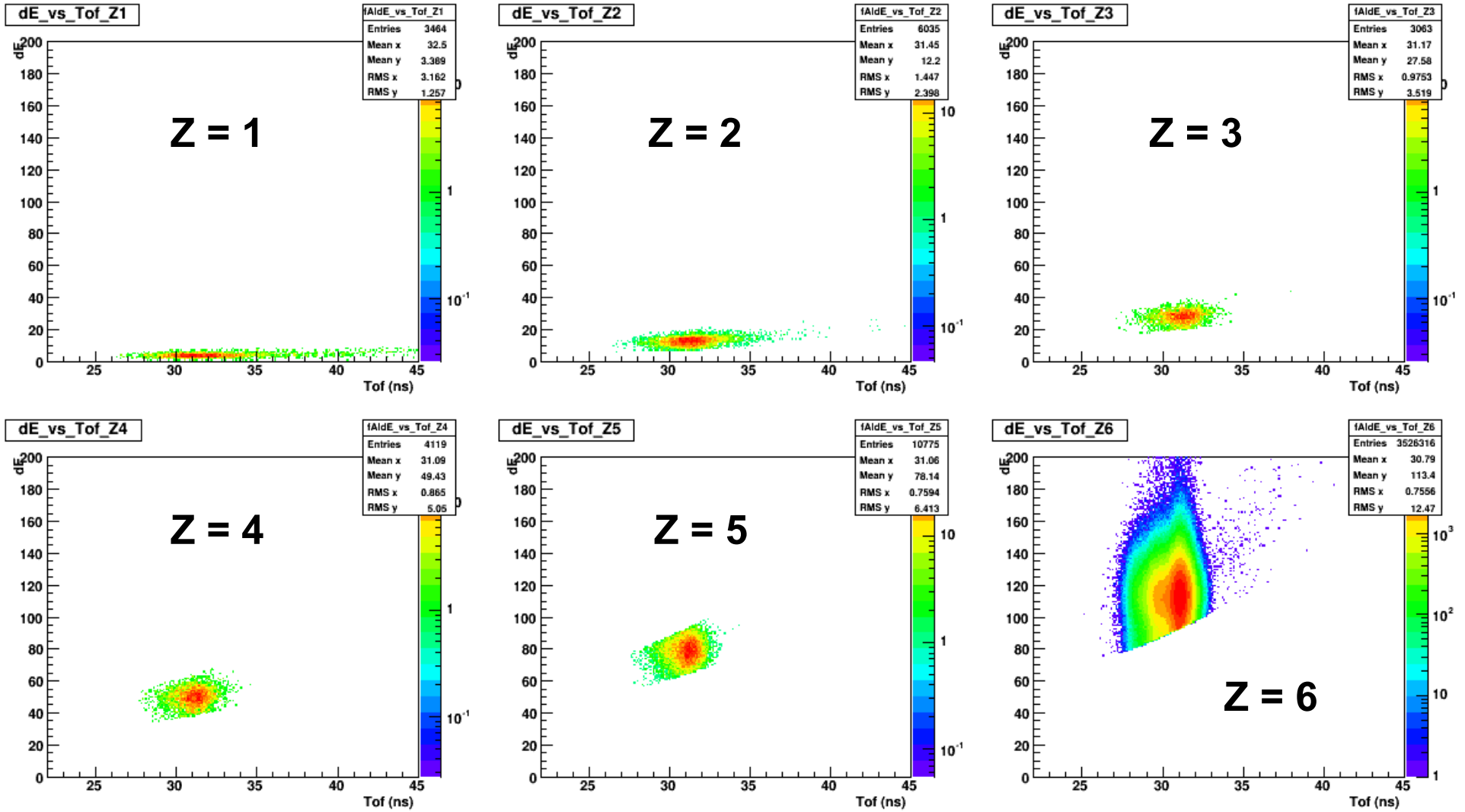








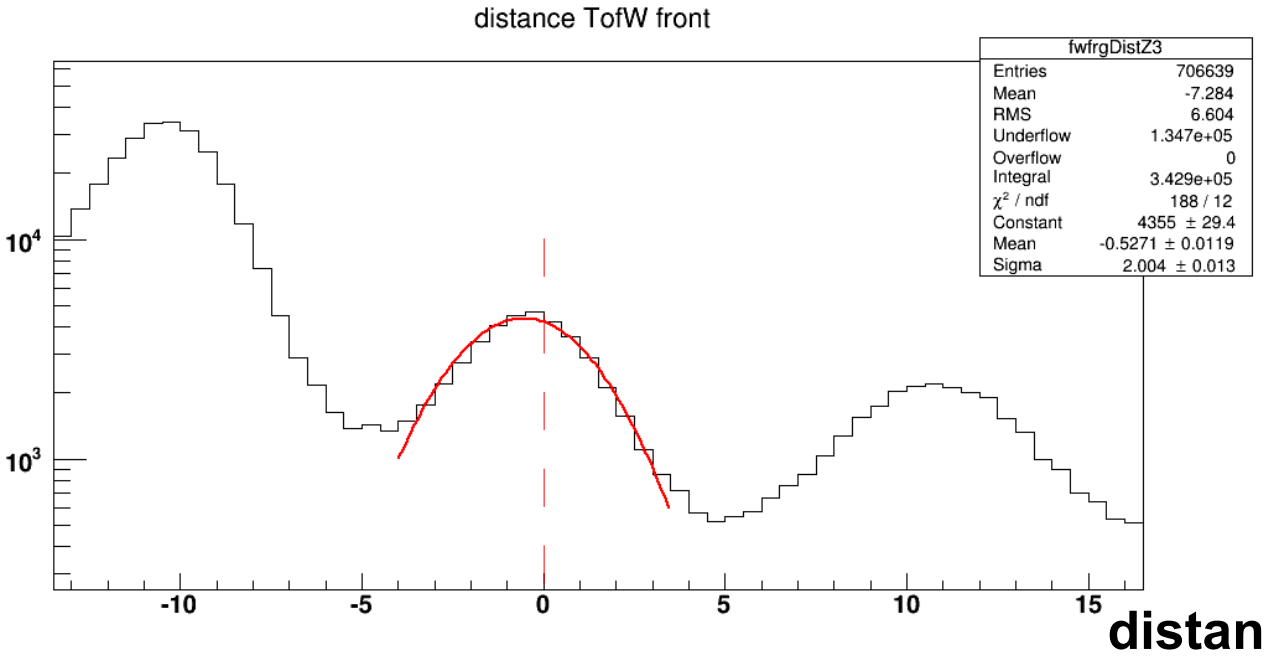
dE vs Tof for front TW with new algorithm for different Z



These conditions can be applied only after the track reconstruction!!

Future improvements of the algorithm

- We're testing an improvement of the algorithm using also the spread of the distributions of the data point in dE and Tof instead of the only distance from the Bethe-Bloch curves
- We extract the sigma from a gaussian fit for each distance distribution peaked in zero



It's evident that the distribution is not exactly centered in zero.
This is probably due to the fit of the Bethe-Bloch curve.
So an update of the fit is necessary to have distance distribution peaked in zero.

For the moment we can try to take the minimum value of the quantity:

(distance – mean)/sigma

from the 6 Bethe-Bloch curves to assign the charge to each track

Conclusions

- The minimization algorithm from Tof Wall has been carefully re-checked, bugs were fixed [found that they where nearly harmless], a slower but more stable minimization algorithm has been deployed
- We still need to redo the study on MC events, check if the parametrization works as on data
- We are about to deploy the mean/sigma_dist observable to improve the B/C separation and then benchmark it against the Vtx charge algorithms.