TOF beta resolution

A. Contin

TOF Group, September 2011

Goals

Measure:

- TOF beta
- TOF beta resolution

for different ions.

Principle of the measurement – present calibration procedure

Beta is measured by fitting the *track length vs. time* plot.

Track lengths between different layers are given by the track extrapolation into TOF planes.
Time is given by TOF as paddle time after calibration (see Tutorial - A. Contin talk at KSC, February 2011):

Slewing calibration constant (same for all counter sides in the present procedure)

$$-\frac{l_{ij}}{v} = \left(\frac{t_{m_1} + \frac{s}{\sqrt{A_1}} + t_{m_2} + \frac{s}{\sqrt{A_2}}}{2}\right)_i - \left(\frac{t_{m_1} + \frac{s}{\sqrt{A_1}} + t_{m_2} + \frac{s}{\sqrt{A_2}}}{2}\right)_j + C_i - C_j$$

Zero-time calibration constants (1 per counter)

l_{ij} = positive track length from plane i to plane $j = l_i$ - l_j
Time difference is negative because times are measured relative to FT time.
All constants are determined at the same time with a global minimization procedure.

Event selection and analysis

1. Trigger: all triggers

2. One and only one good track (Chi2<20, at most one central plane missing)
3. Only four TOF clusters (one per layer) made by only one counter
4. All TOF clusters used in the fit

Charge measured by TRACKER (function TrCharge::GetMean): $Z = \frac{\sqrt{\mathrm{TrCharge :: GetMean}}}{6.2}$

Charge measured by TOF (from reduced mean of Edep): $Z = \frac{\sqrt{\mathrm{ReducedMean}}}{1.289}$

5a. Charge selection: $|Z - i| < 0.3$; i=1,..,8
5b. Additional charge selection with TOF, for Z=1: $Z_{TOF}<1.4$; for Z=2: $Z_{TOF}<2.4$

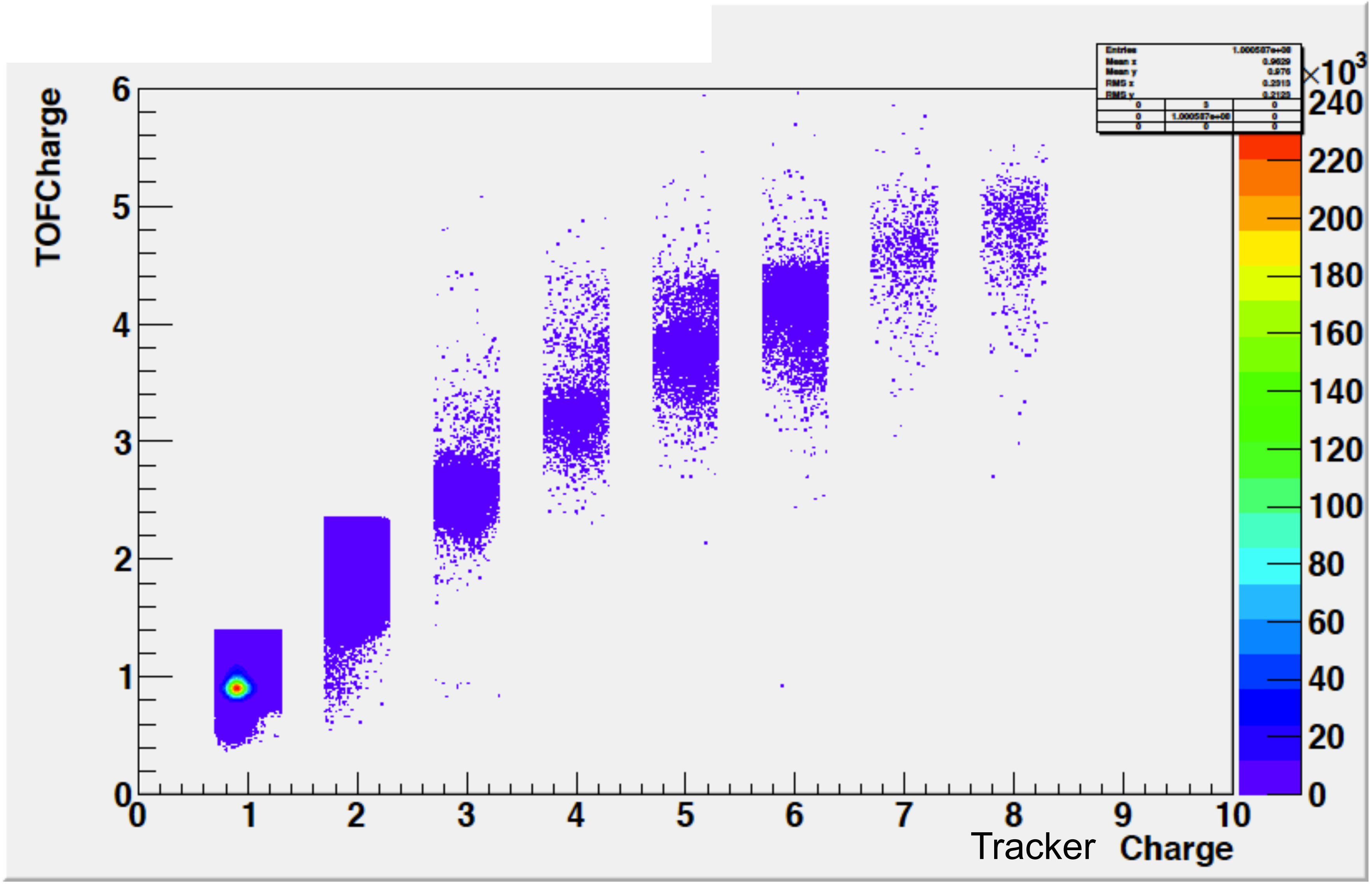
6. Relativistic particle selection (β > 0.994): $Z = 1 : \; R > 9\,\mathrm{GV}$

$Z > 1 : \; R > 20\,\mathrm{GV}$

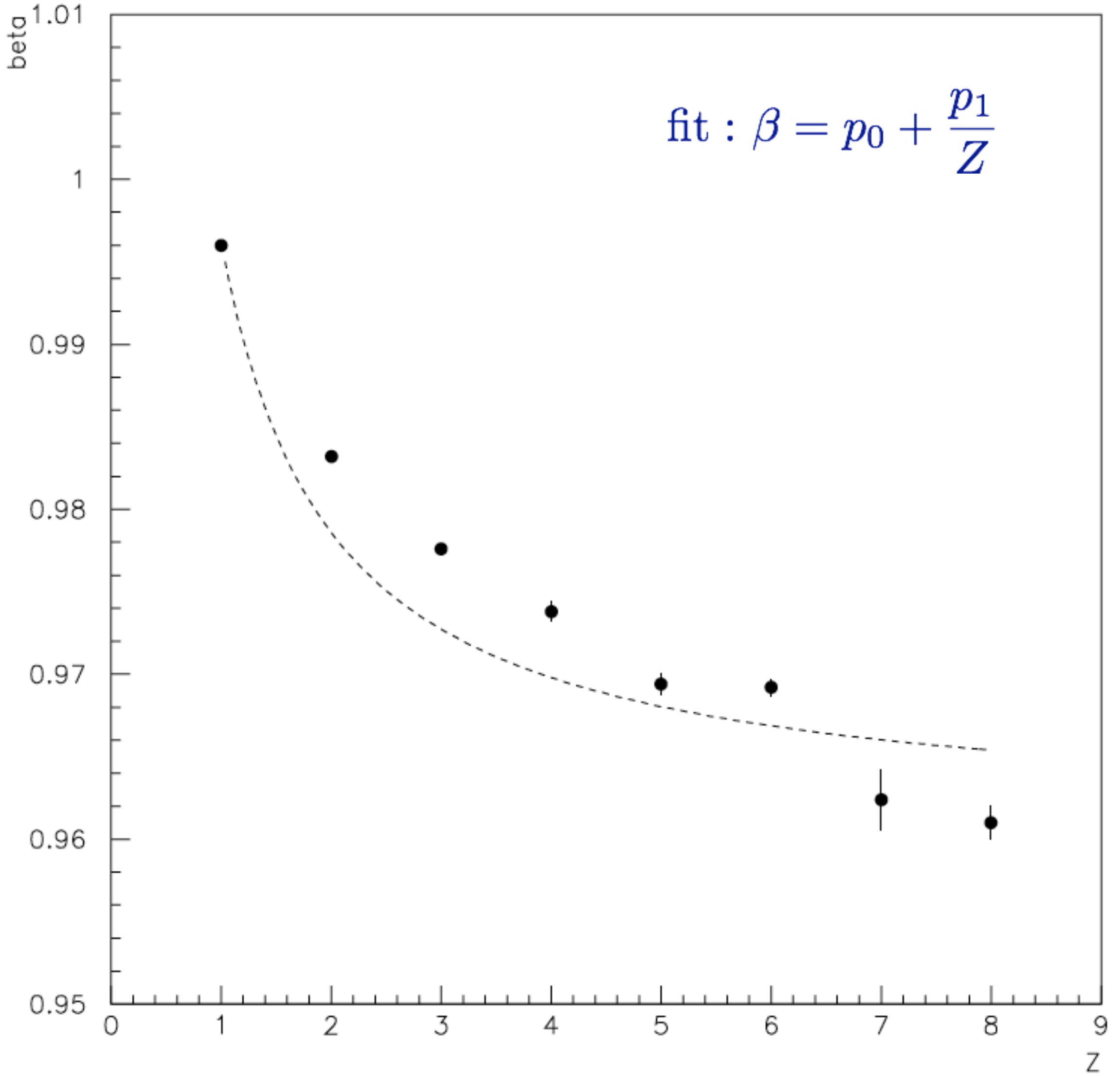
All runs reconstructed with pass2, B530 gbatch version

- 2,993,758,400 recostructed events
- 1,325,933,613 events satisfying selection criteria 2 and 3
- 100,058,304 events satisfying also selection criteria 4, 5 and 6

Charge selection

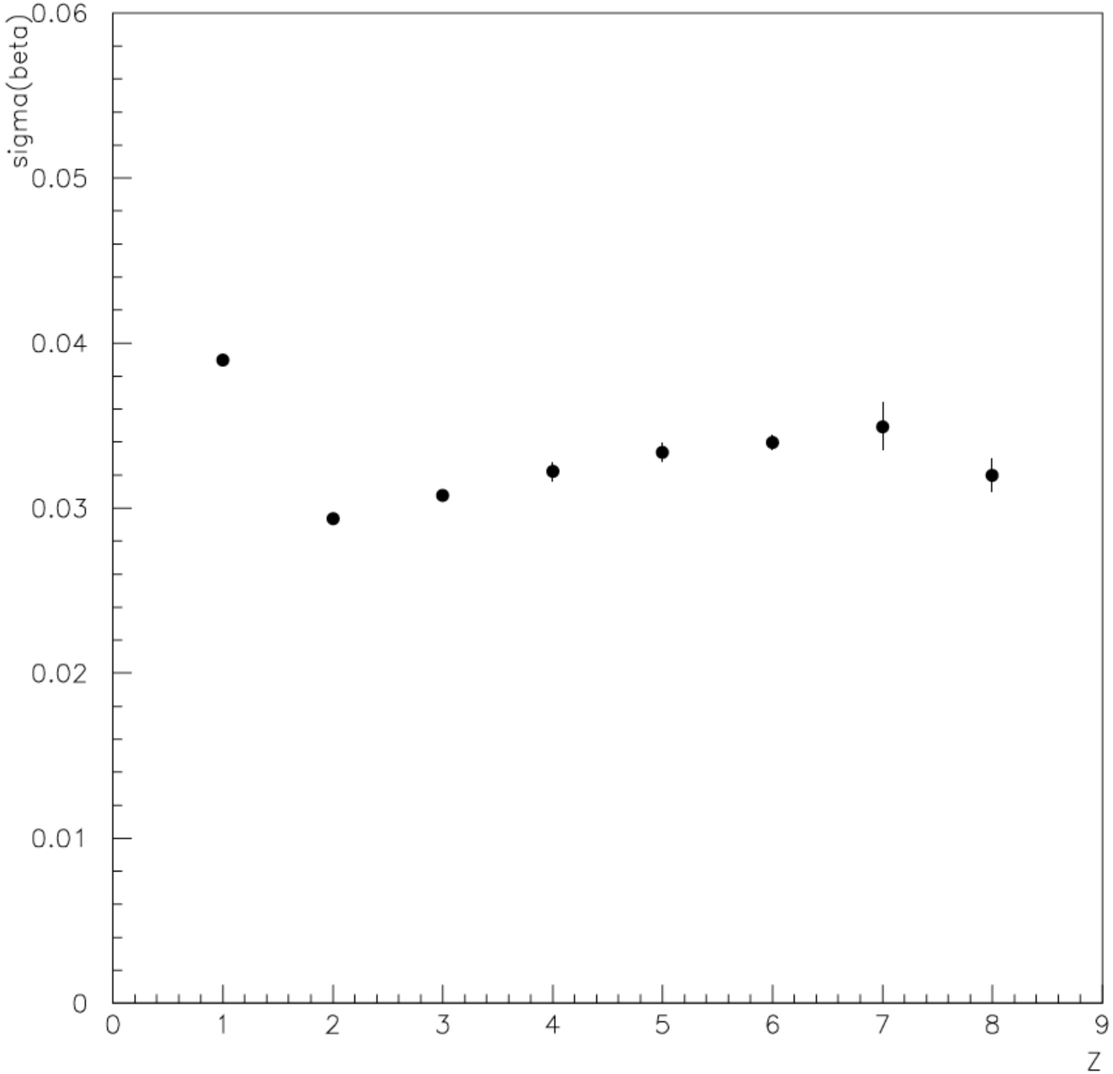


Results - Average Beta (from BetaR class) vs. Charge



The mean value of β decreases as the inverse of Z, i.e. as the inverse of the square root of the amplitude. This points to wrong slewing corrections applied to the counter time.

Results - Beta resolution (from BetaR class) vs. Charge



The beta resolution does not decrease as expected.

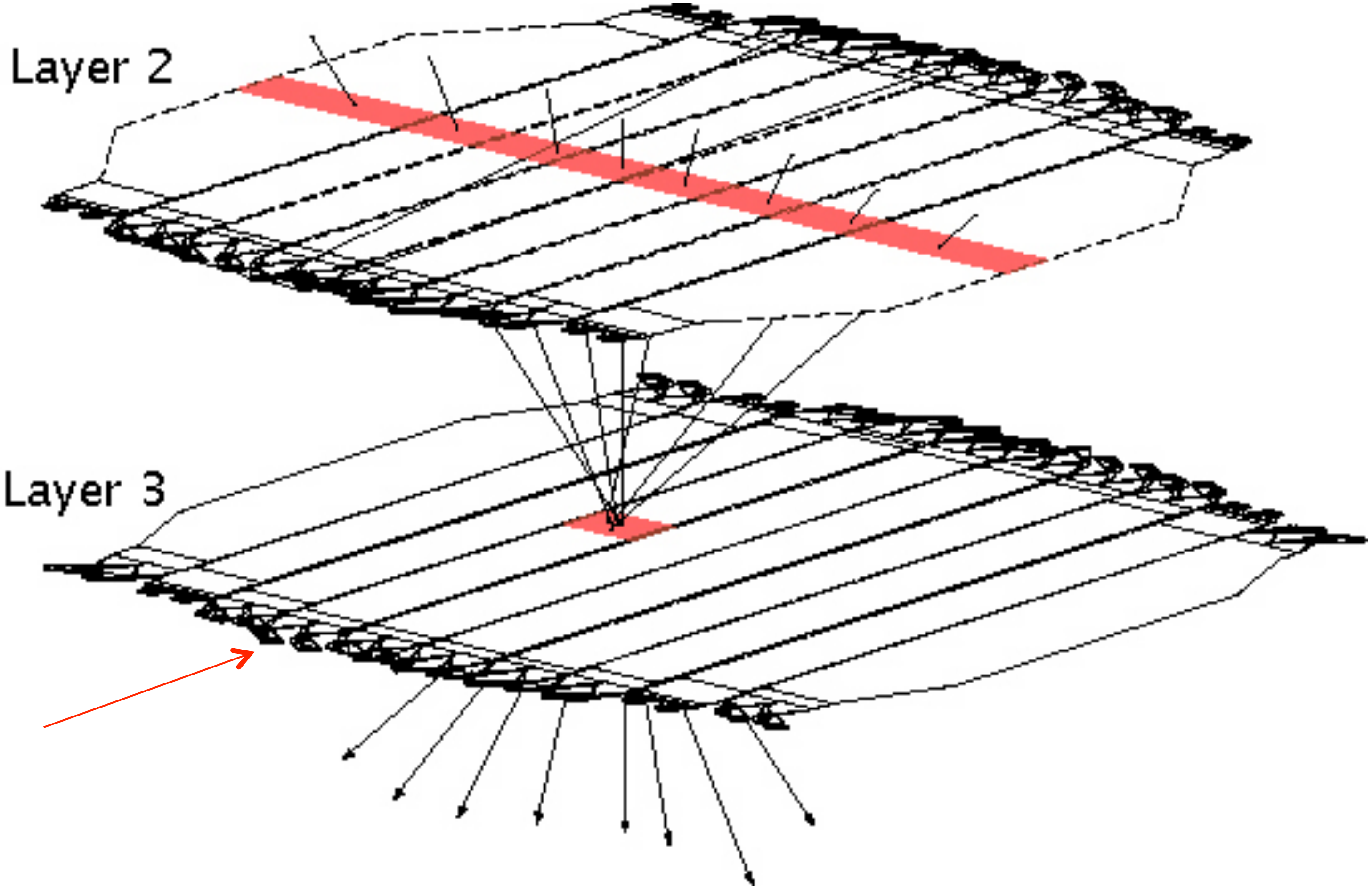
First conclusion

Slewing corrections have to be reviewed:

- Slewing corrections should be computed individually for each counter side
- Then zero-times (constants C) have to be computed for all counters

Slewing correction

Side time: each side of another layer



Reference time: mean time of one counter in one layer (e.g. counter 4)

Plot: $$\underbrace{[t_{m_s}]_{i,l1}}_{\text{Side time}} - \underbrace{\left[\left(\frac{t_{m_1}+t_{m_2}}{2}\right)\right]_{4,l2}}_{\text{Reference time}} \quad \text{vs.} \quad \frac{1}{\sqrt{A_{i,s}}}$$

Slewing corrections

Layer combinations: 1-4, 2-3

- Counter 4 in one of the two layers gives the reference time for the counters of the other layer
- Particles are selected which cross the counters within ±5 cm from the counter center in both layers
- Plot:

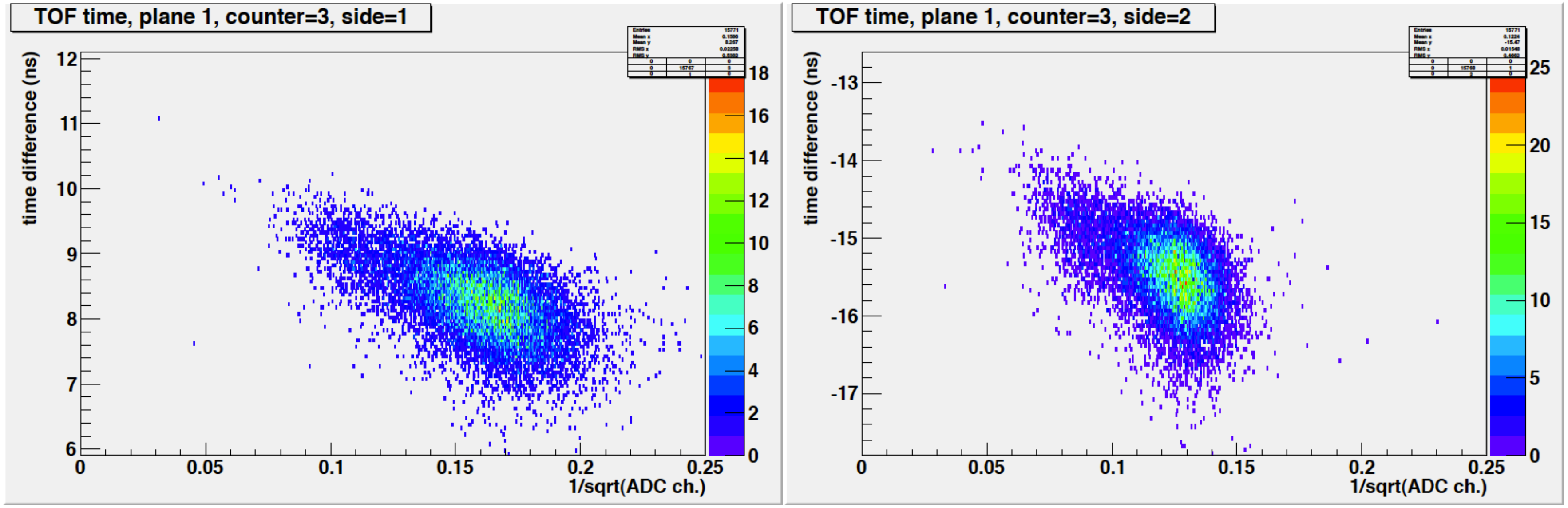
$$[t_{m_s}]_{i,l1} - \left[\left(\frac{t_{m_1} + t_{m_2}}{2}\right)\right]_{4,l2} \quad \text{vs.} \quad \frac{1}{\sqrt{A_{i,s}}}$$

where:

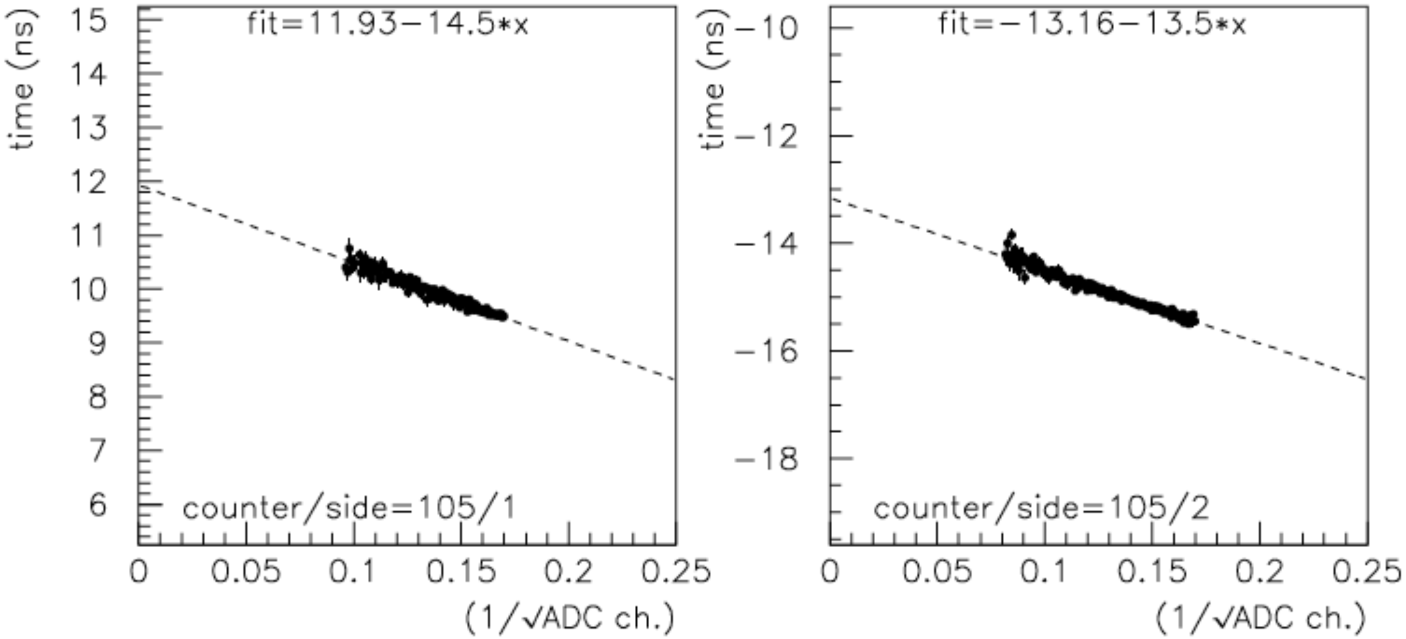
- i is the counter under measurement
- s is the side under measurement
- $l1$ is the layer under measurement,
- $l2$ is the reference layer (layer 1 for layer 4, layer 4 for layer 1, layer 2 for layer 3 and layer 3 for layer 2)
- $A_{i,s}$ is the amplitude of the signal on side s of counter i

t_m is variable sdtm in class TofRawCluster
A is variable adca in class TofRawCluster

Sample plots using only Z=1 particles



Fits:



Slewing constants with all particles

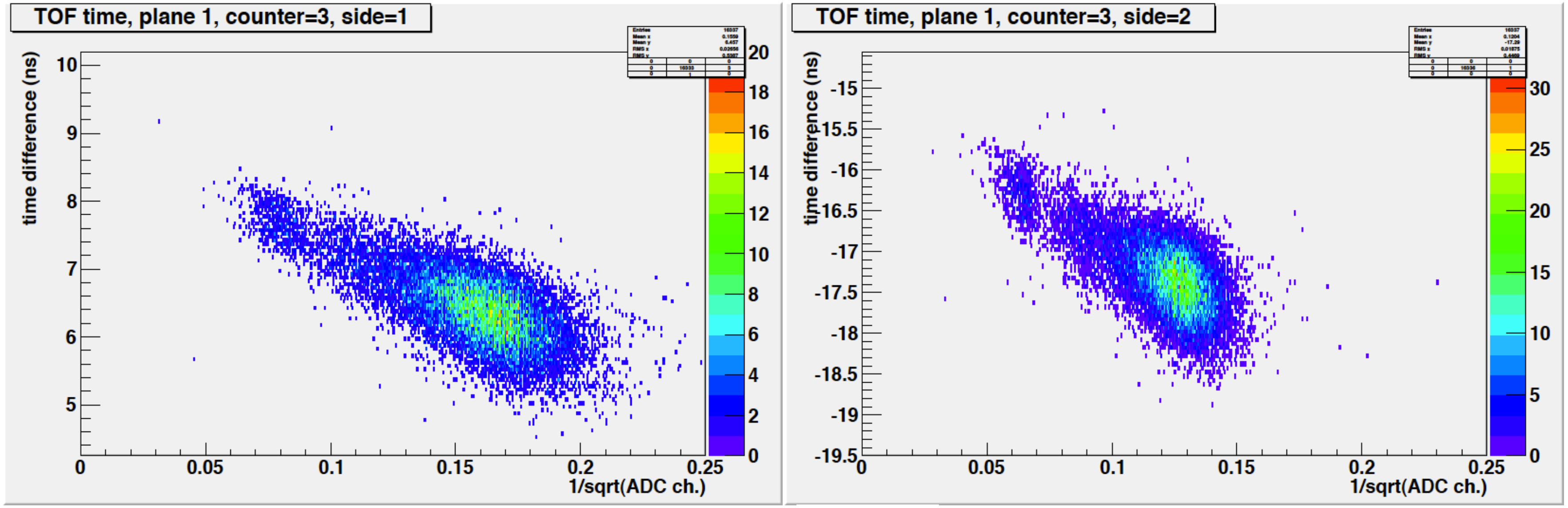
Z=1 particles give an uncorrelated signal in the two layers: the effect of the slewing in the reference time is simply to widen the time difference distribution.

In order to compute the slewing in the most accurate way, also higher charge particles (Z>1) must be used (which give lower values of $1/\sqrt{A}$).

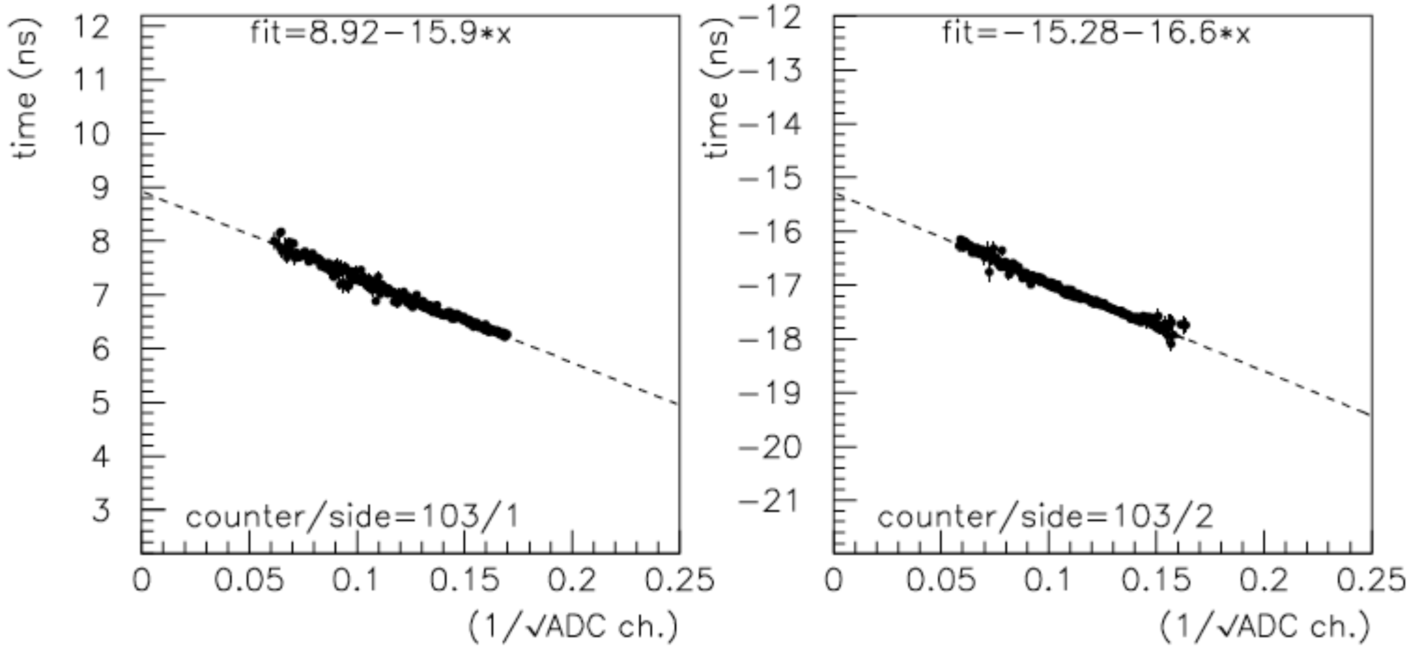
But higher charge particles have lower slewing corrections in the reference time and the amplitudes are correlated. This causes a different zero intercept in the plot w.r.t. Z=1 particles.

To avoid biases for Z>1 particles, a second pass is done, correcting the reference time for slewing using the slope computed with Z=1 particles.

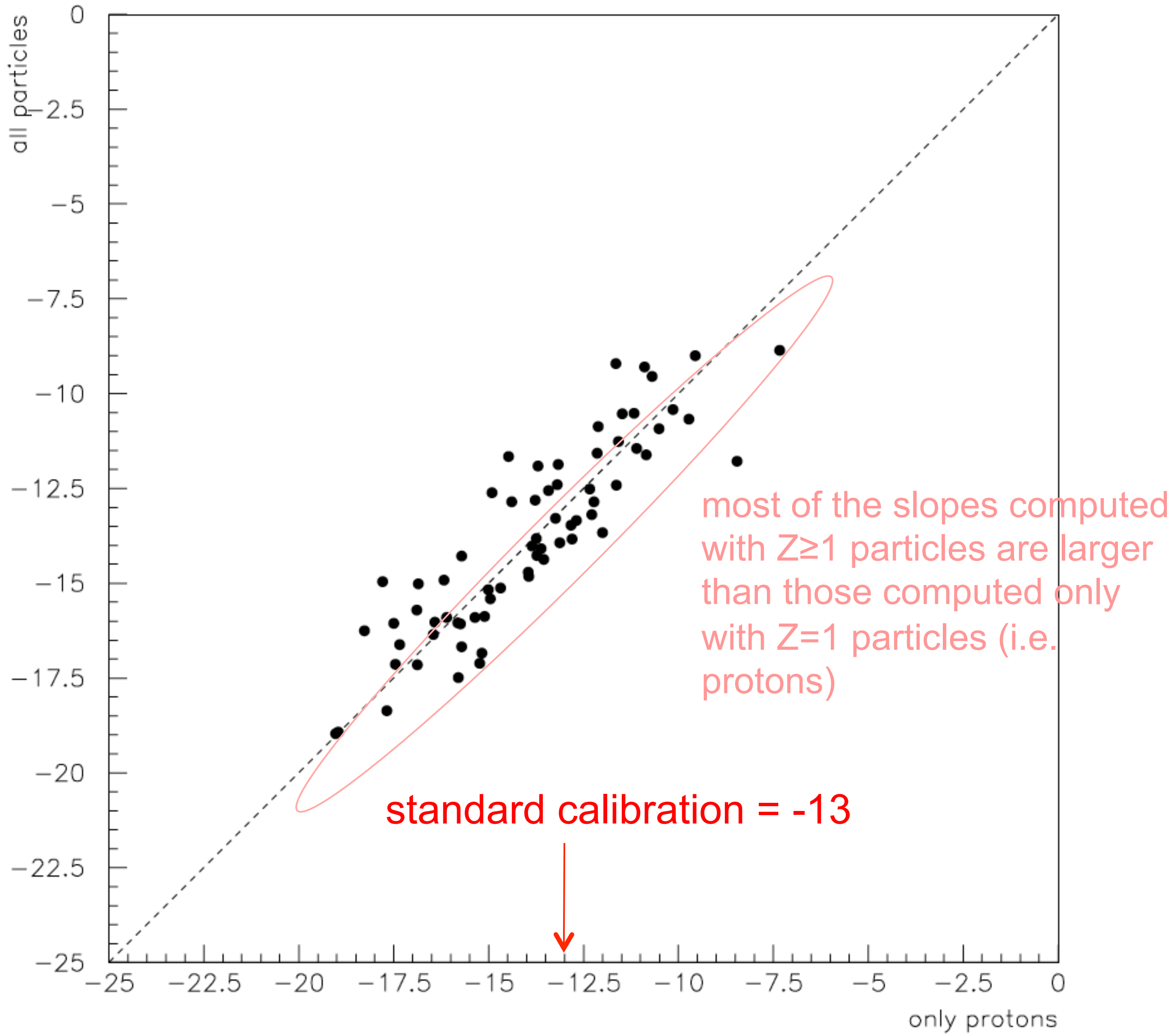
Sample plots using all partricles (including ions)



Fits:



Slewing constants distribution



Zero times

Layer combinations: 1-3, 2-3, 1-4, 2-4

Plot:

$$\left(\frac{t_{m_1} + \frac{s_{1i}}{\sqrt{A_1}} + t_{m_2} + \frac{s_{2i}}{\sqrt{A_2}}}{2}\right)_i - \left(\frac{t_{m_1} + \frac{s_{1j}}{\sqrt{A_1}} + t_{m_2} + \frac{s_{2j}}{\sqrt{A_2}}}{2}\right)_j + \frac{l_{ij}}{v}$$

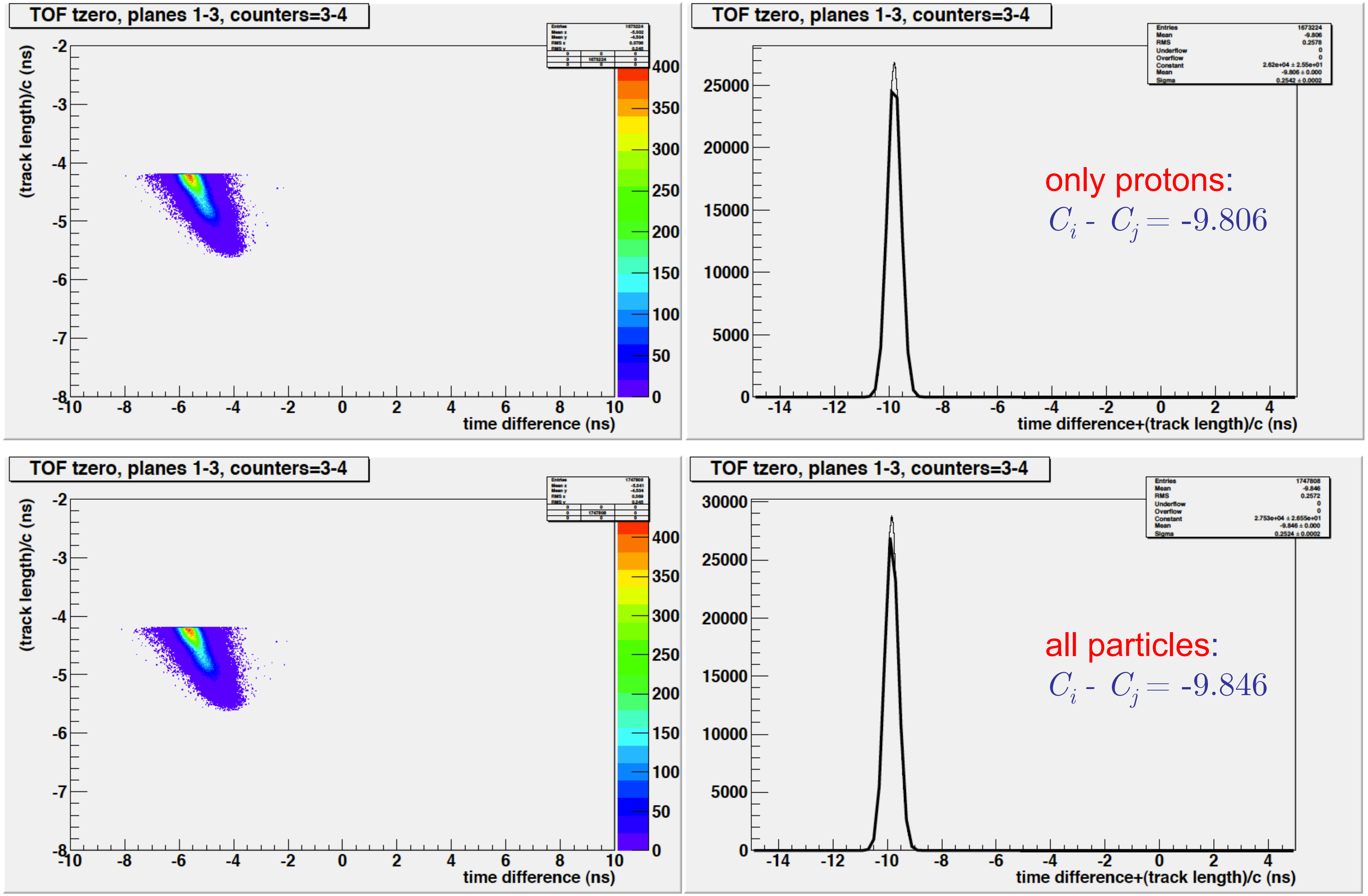
where:

- i and j are counters from different layers
- $A_{1,2}$ is the amplitude of the signal on side 1 or 2

The gaussian fit of the distribution gives the difference between the zero time constants of the two counters involved: C_i - C_j

t_m is variable sdtm in class TofRawCluster
A is variable adca in class TofRawCluster

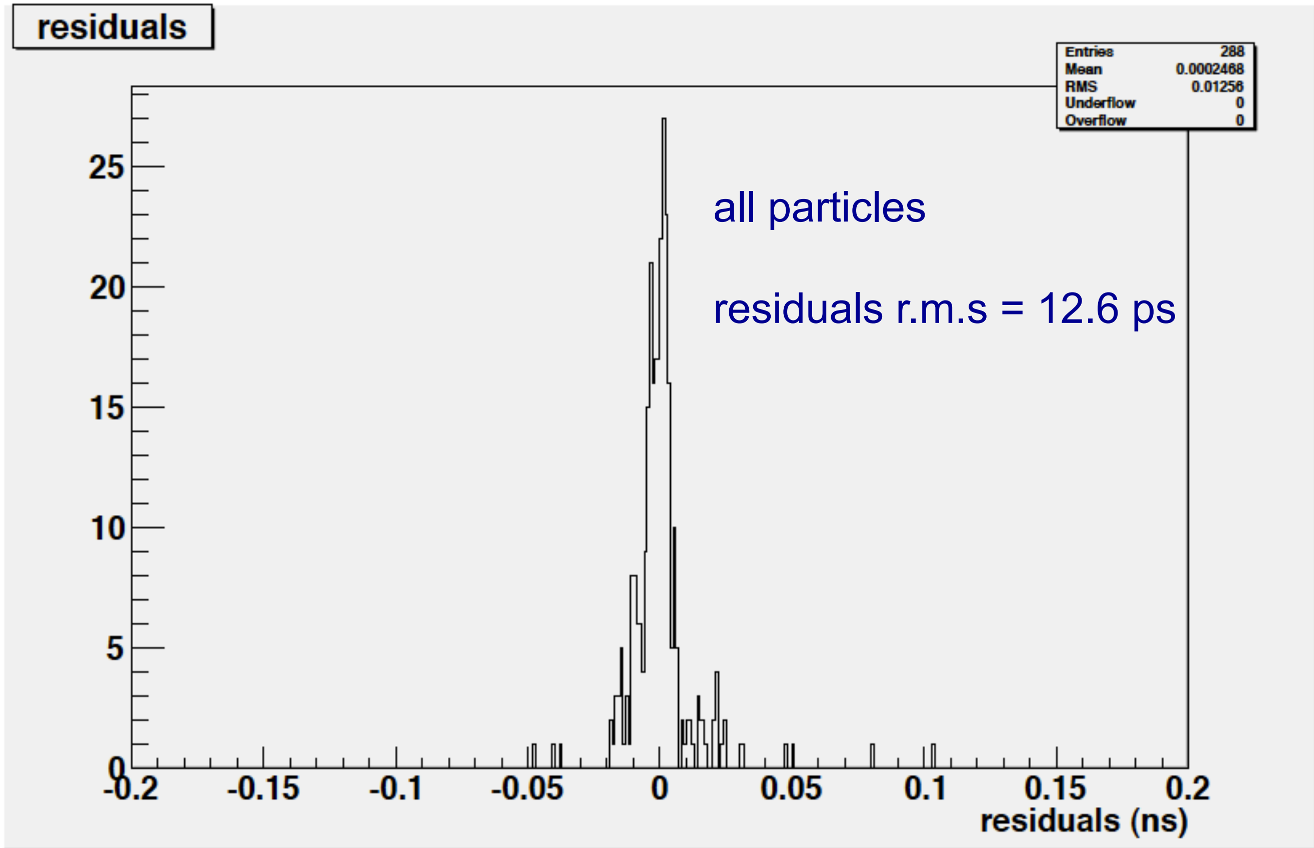
Sample plots



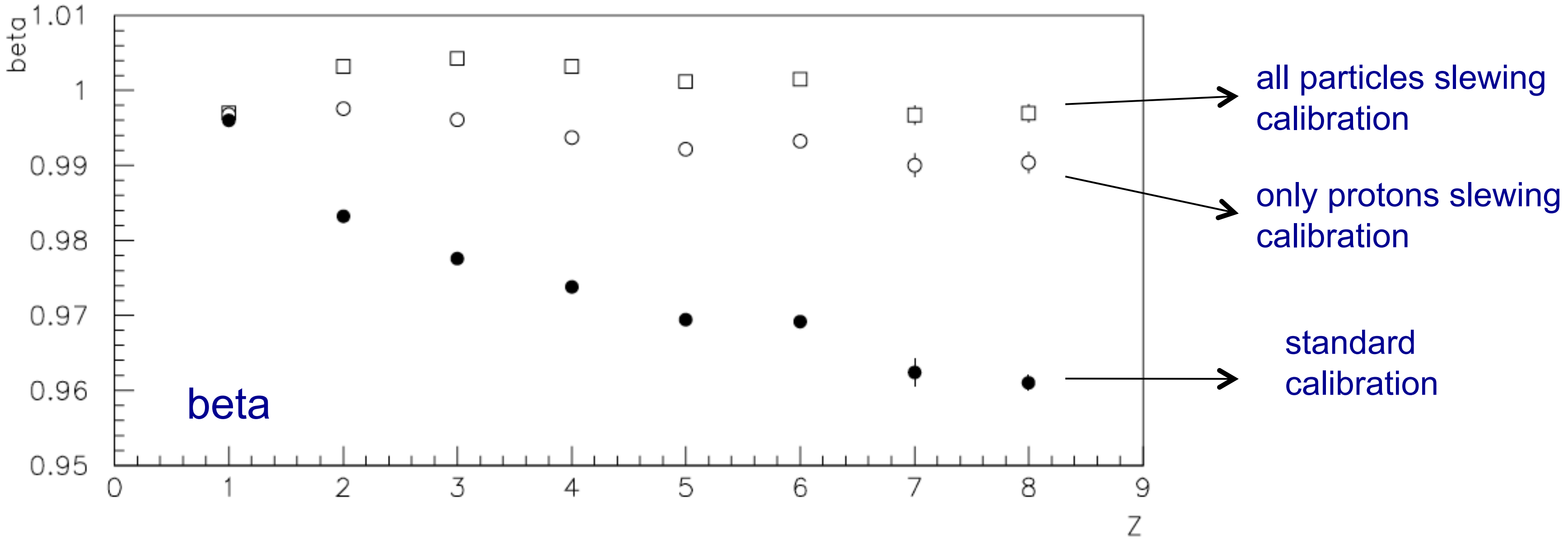
Note: 40 ps corresponds to about 1% in beta.

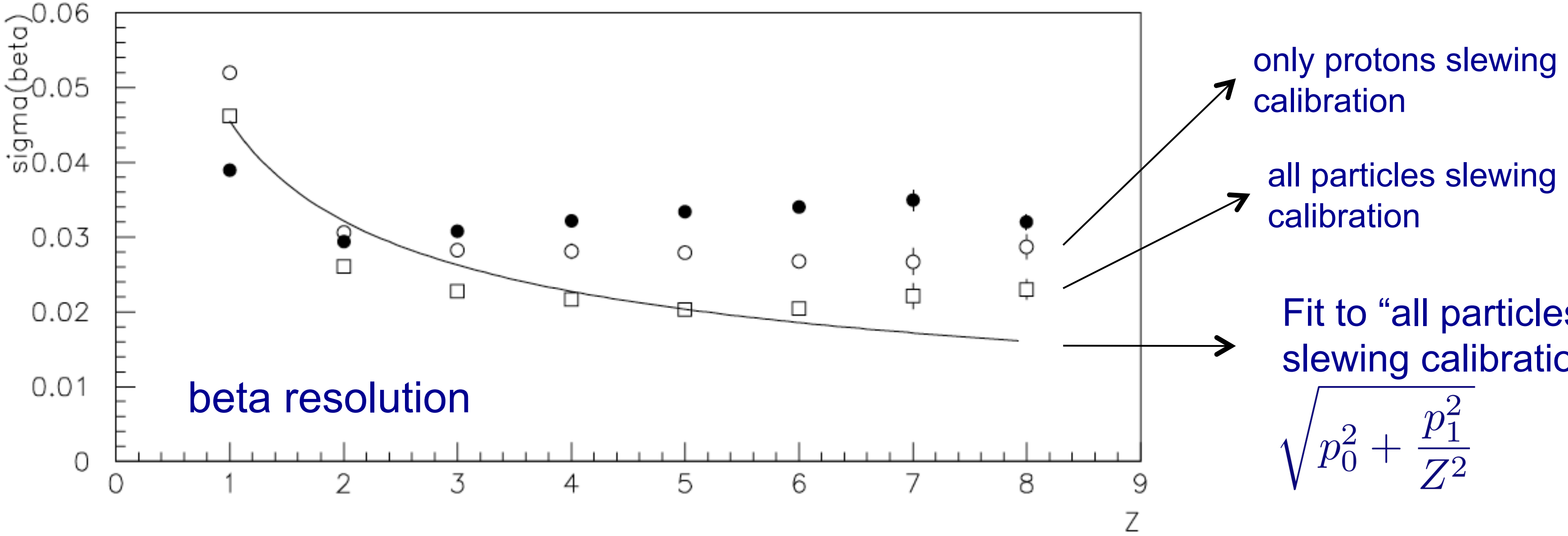
Single counter zero time

Global fit with 34 constants (one per counter) and 288 measurements (all counter pair combinations).



Beta measurement versus charge

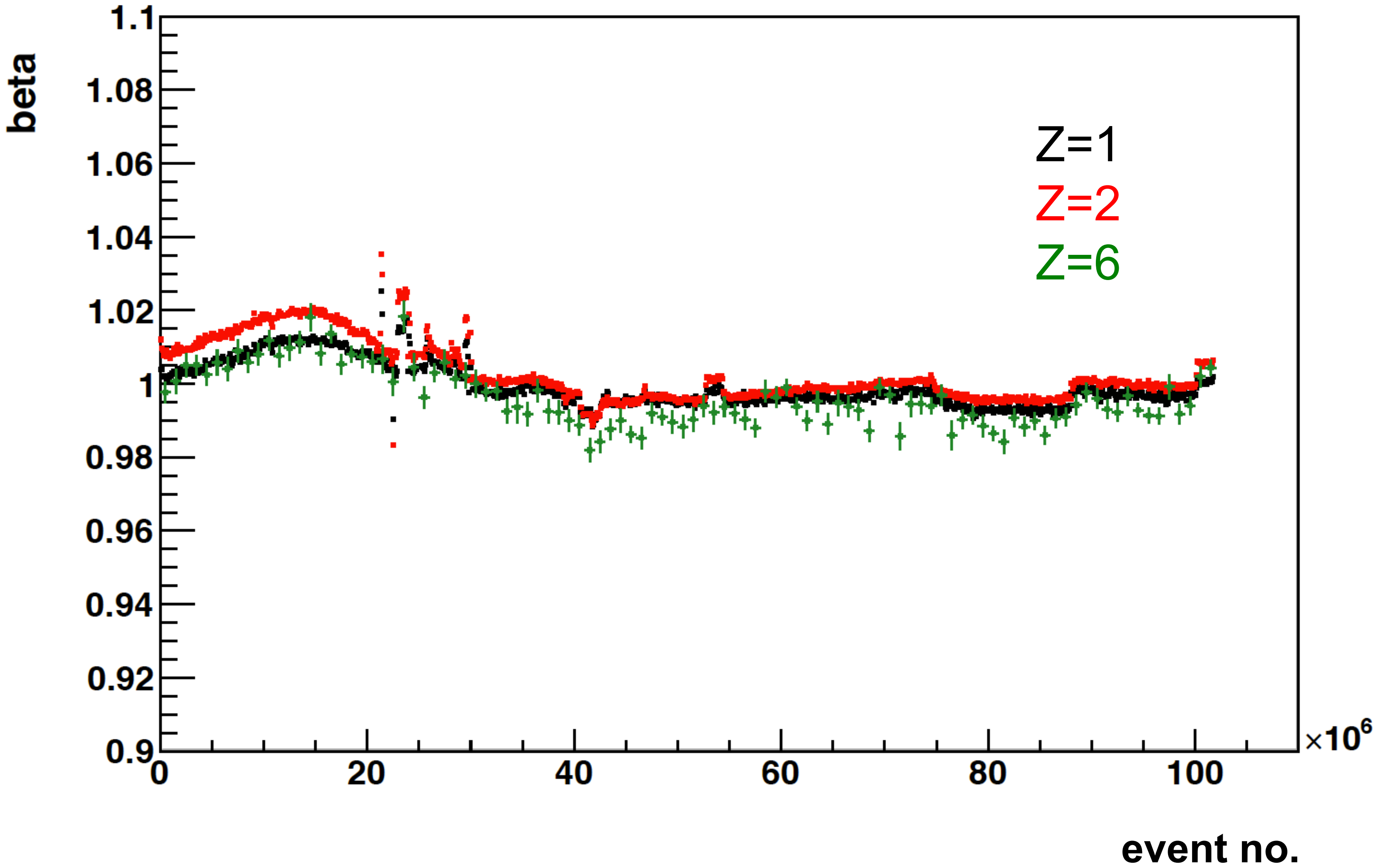




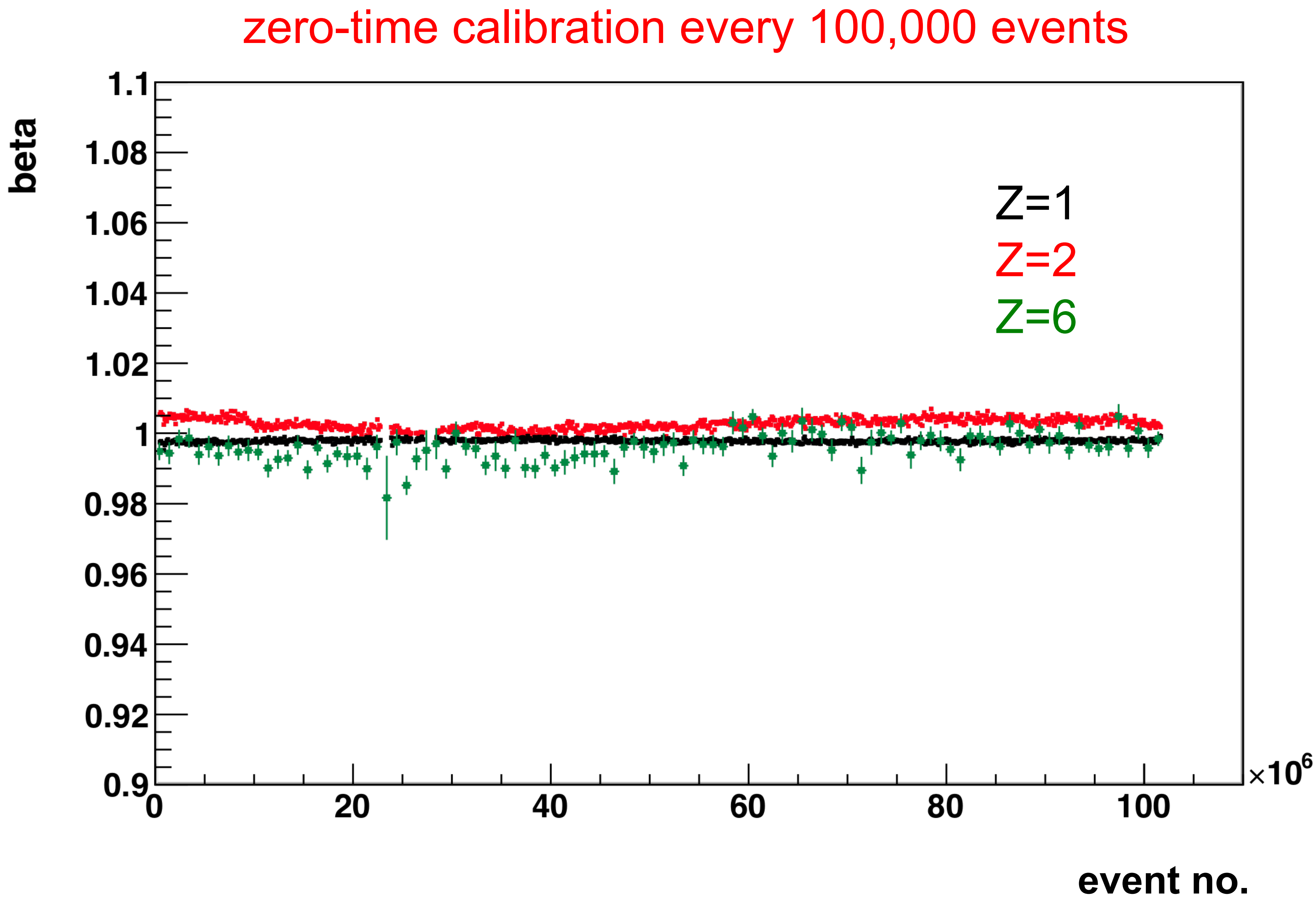
Fit to "all particles slewing calibration":

$$\sqrt{p_0^2 + \frac{p_1^2}{Z^2}}$$

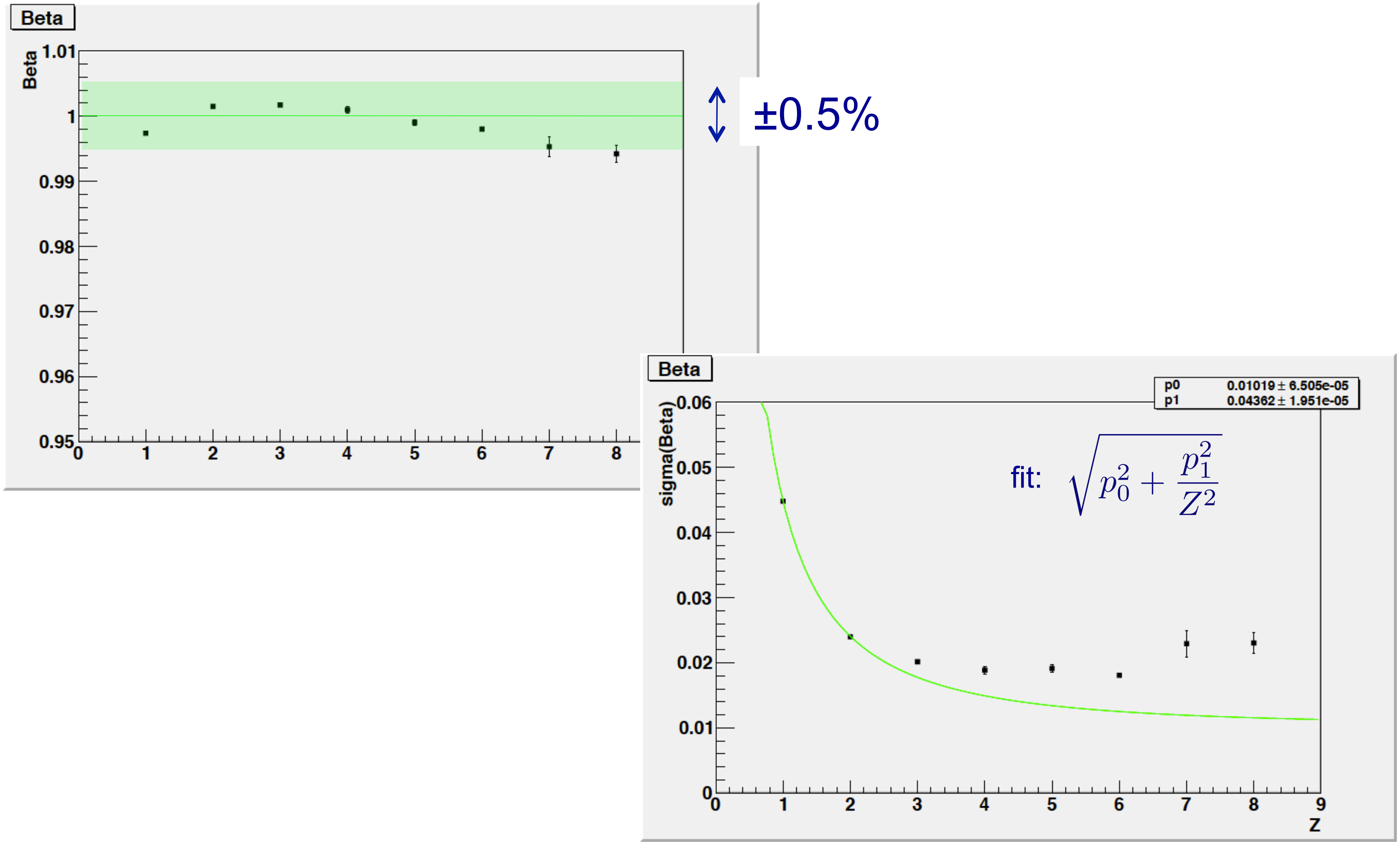
Beta versus time – single zero-time calibration



Beta versus time

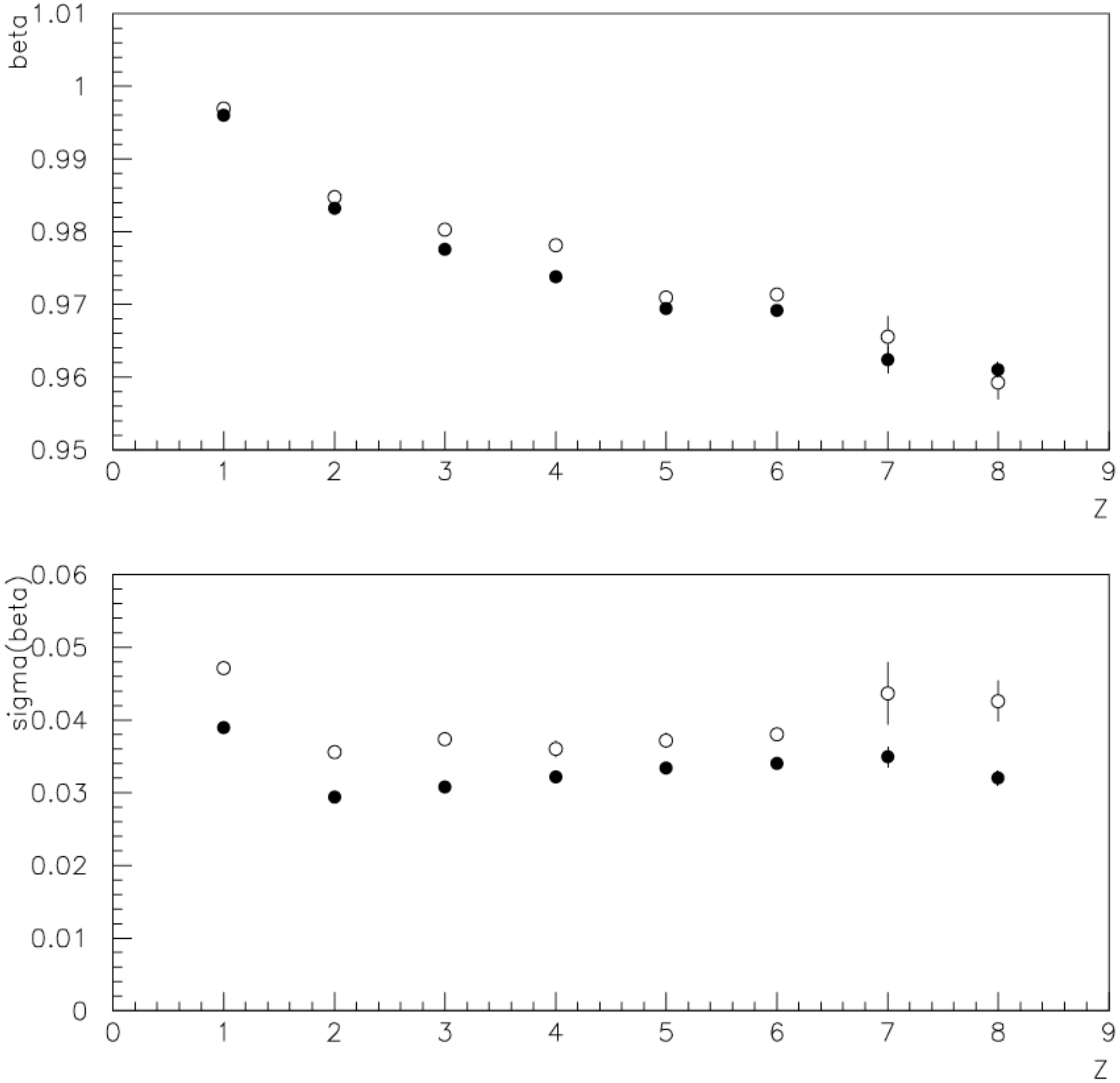


zero-time calibration every 100,000 events



Comparison with the standard calibration (consistency check)

The same analysis using a fixed parameter (=13) for the slewing correction of all counter sides has been done. The results compare well with the results from the standard calibration.



○ this analysis, with fixed slewing correction

● standard calibration (beta from BetaR class)

The difference in resolution is expected because this analysis uses a single zero-time calibration, while the standard calibration is repeated every day

Conclusion

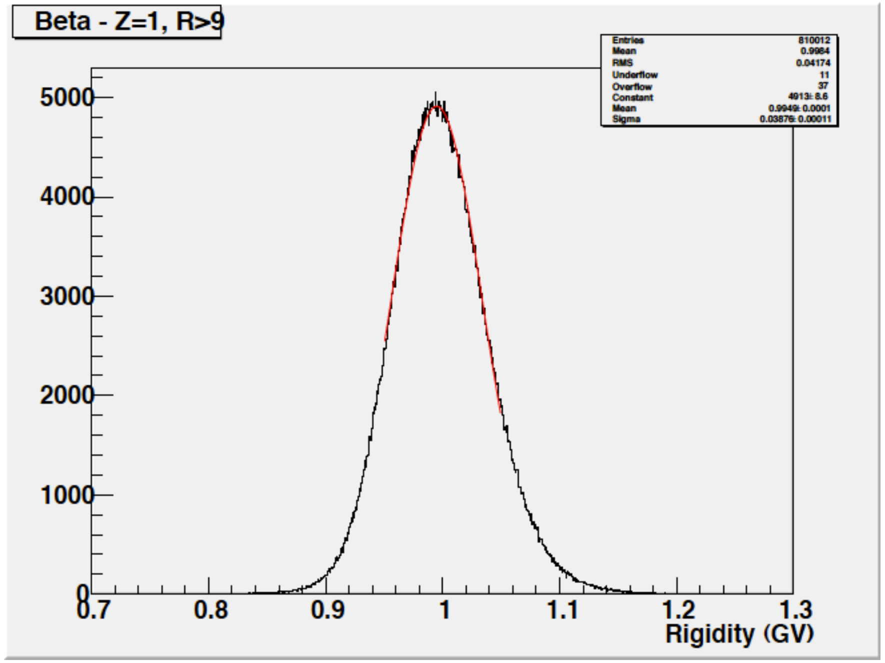
The slewing/zero-time calibration must be done in two steps:

1. Compute the slewing parameters for each counter side with strict definition of the hit point in the counters, using all particles and with adequate statistics.
2. Compute the zero-times using the slewing corrections computed in point 1.

A single slewing calibration needs a very long period of time (at least 2 months of data), but it is stable with time and running conditions.

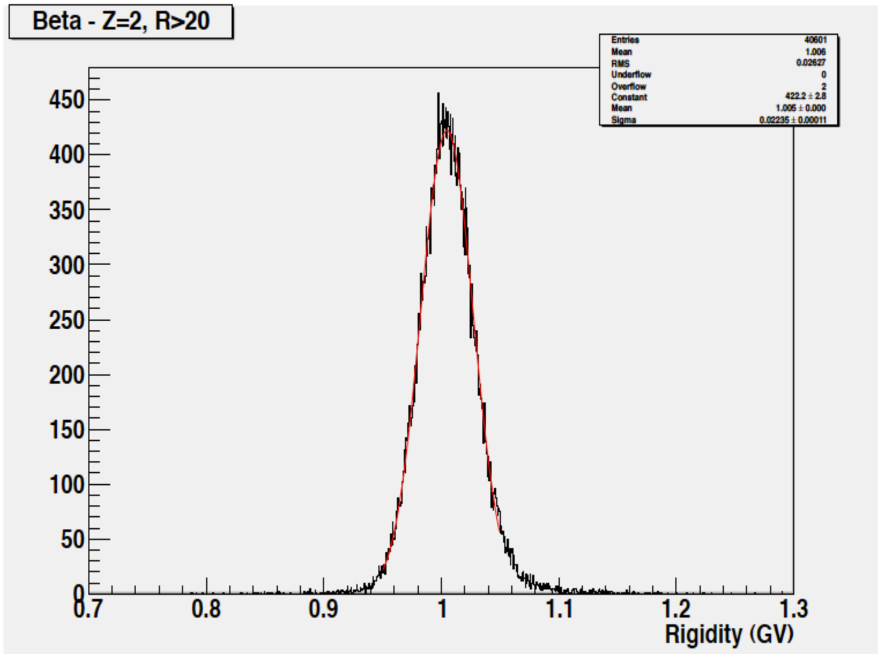
Zero time calibrations can be repeated every 2 million triggers (as it is done now).

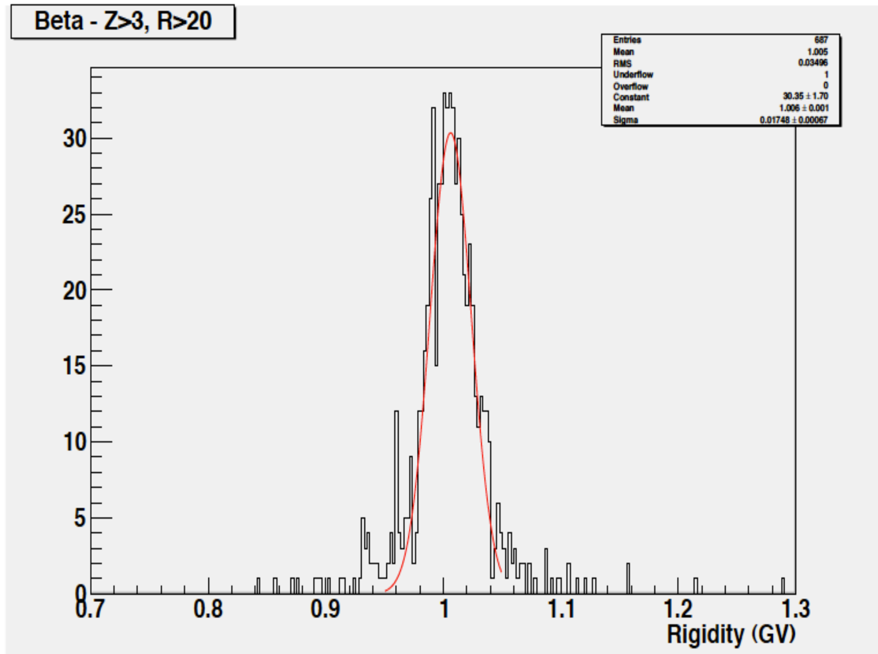
Application of the new procedure to the space data - beta



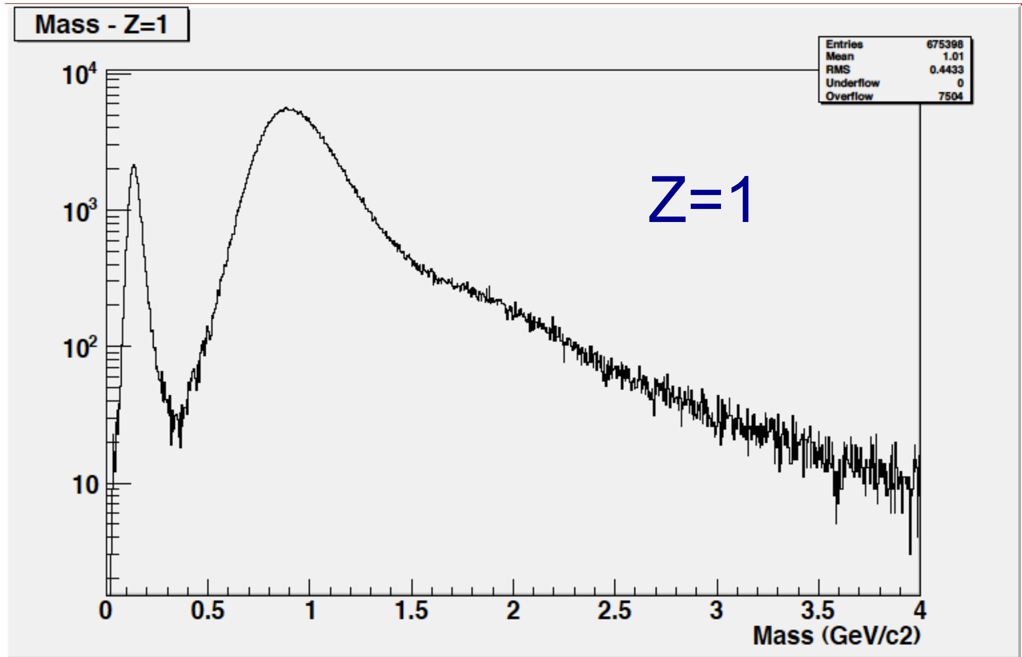
The new calibration procedure have been applied on runs: 1311786564, 1312431216, 1313410673, 1314161751, 1314806339, 1315366412 and 1316017744.

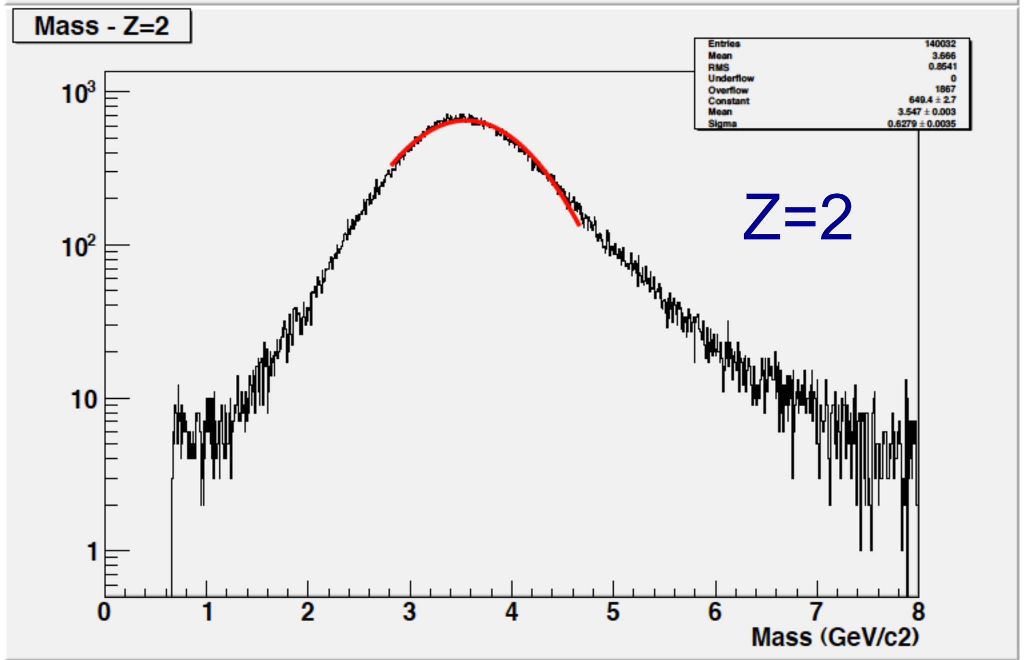
Runs 1311786564 to 1312432541 have been reconstructed up to now.
Beta is well centered at 1 for all charges.



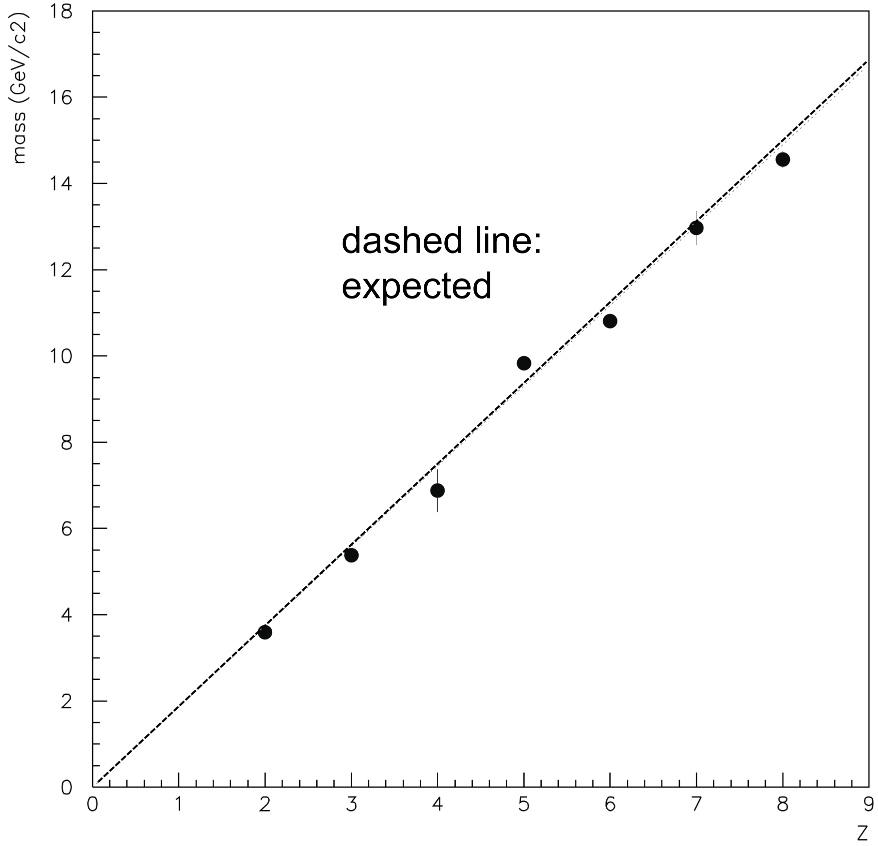


Application of the new procedure to the space data - mass

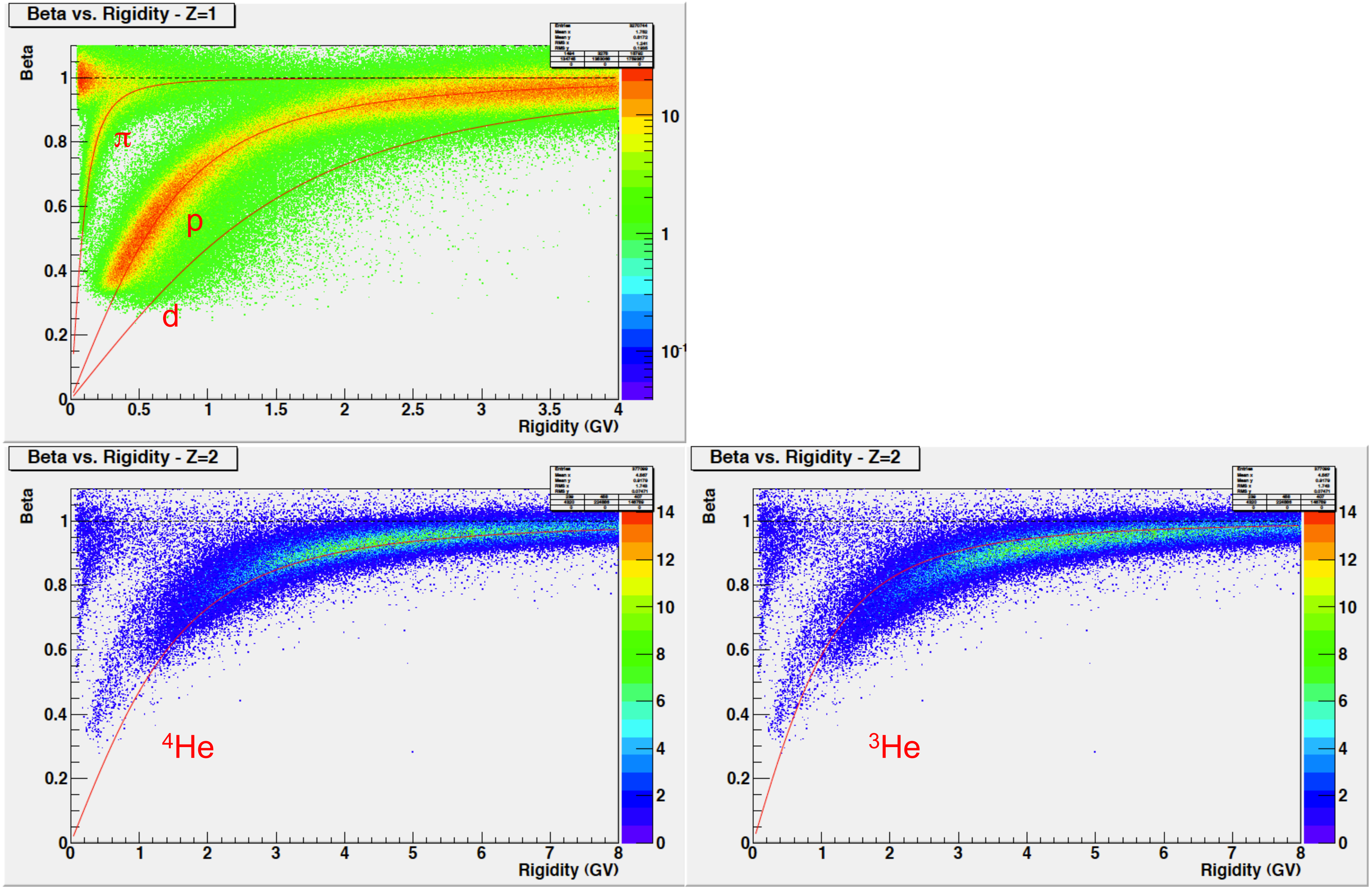




β>0.95



Application of the new procedure to the space data – β vs. R

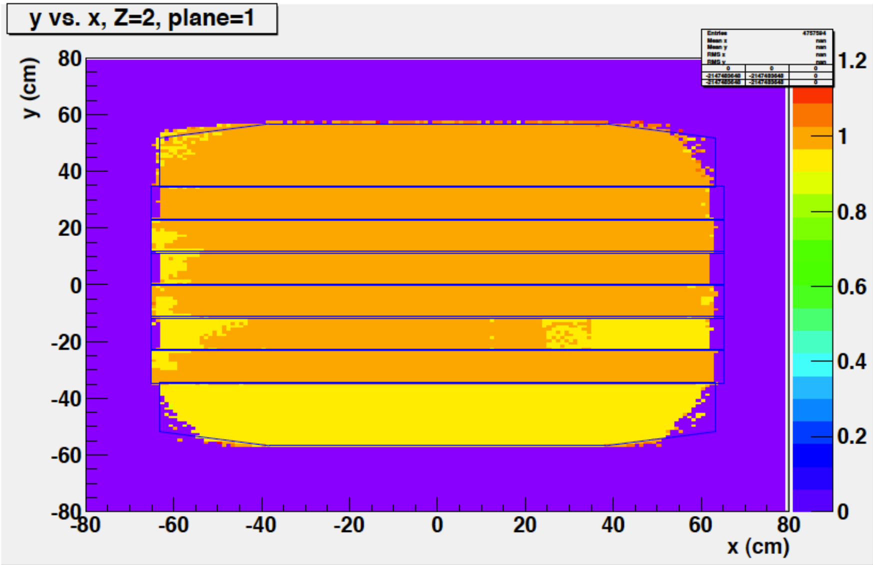


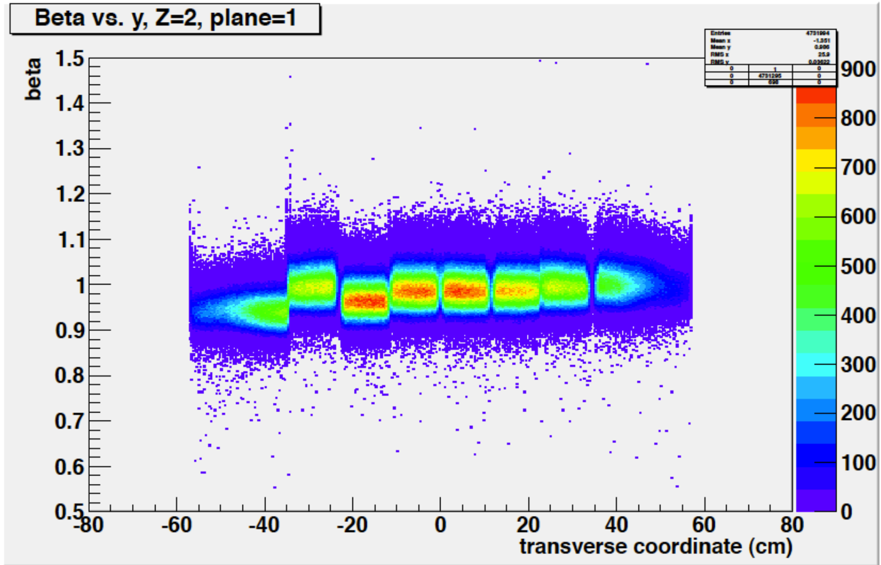
WHY?

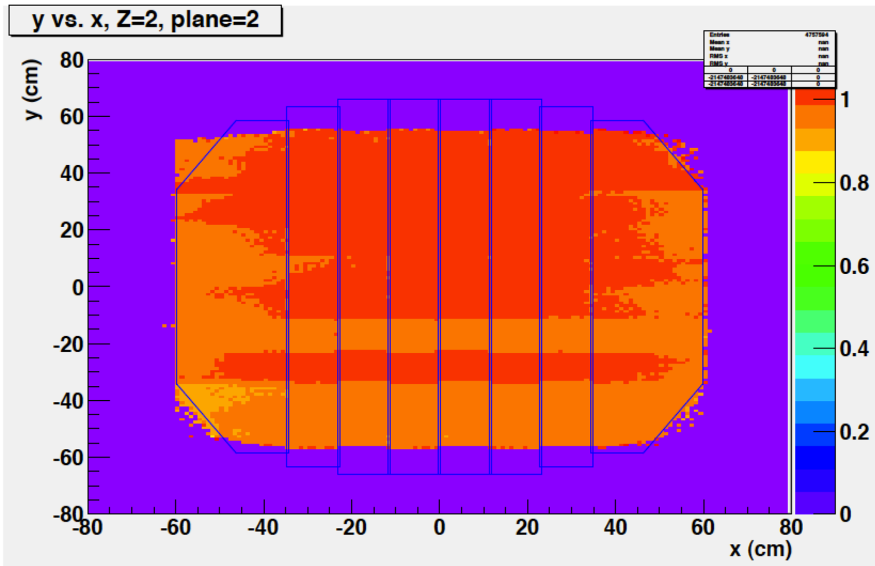
Analysis with constant slewing parameters, Z=2

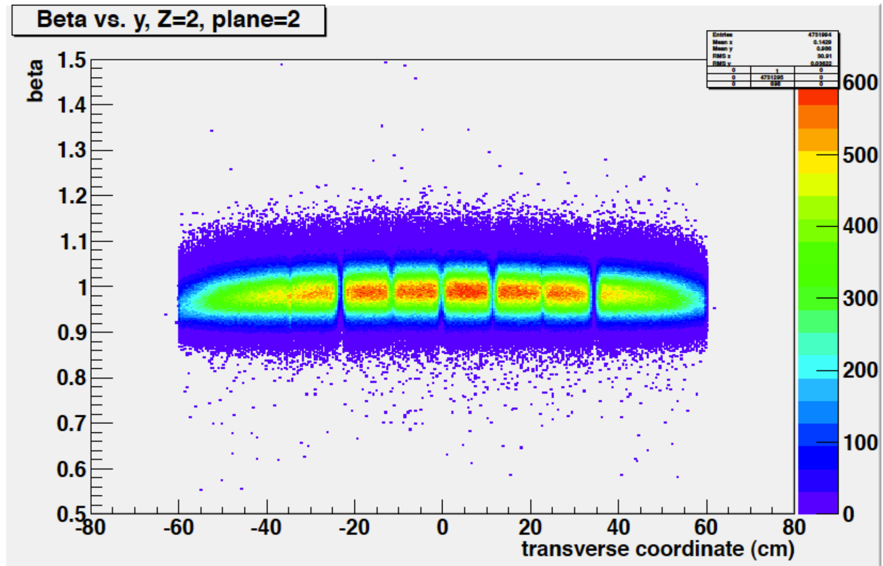
beta vs. position

beta vs. transverse position

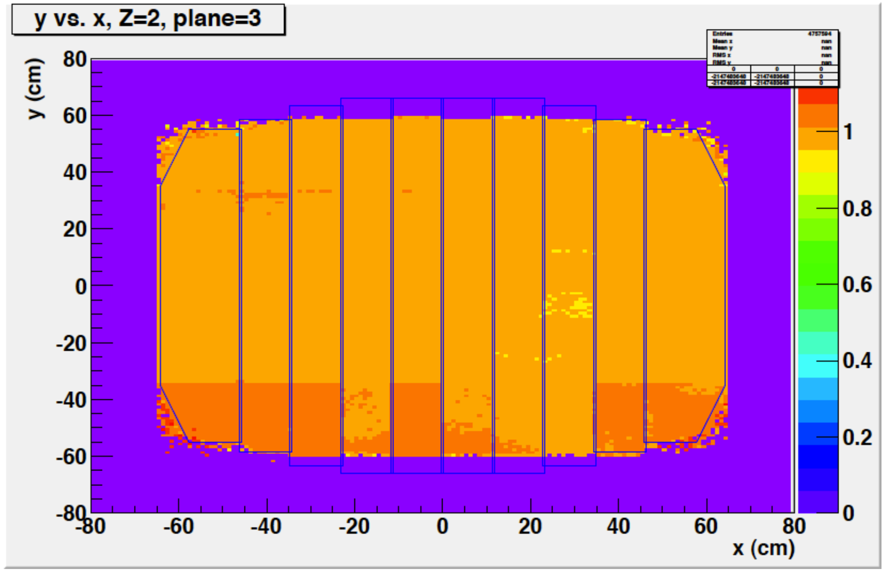


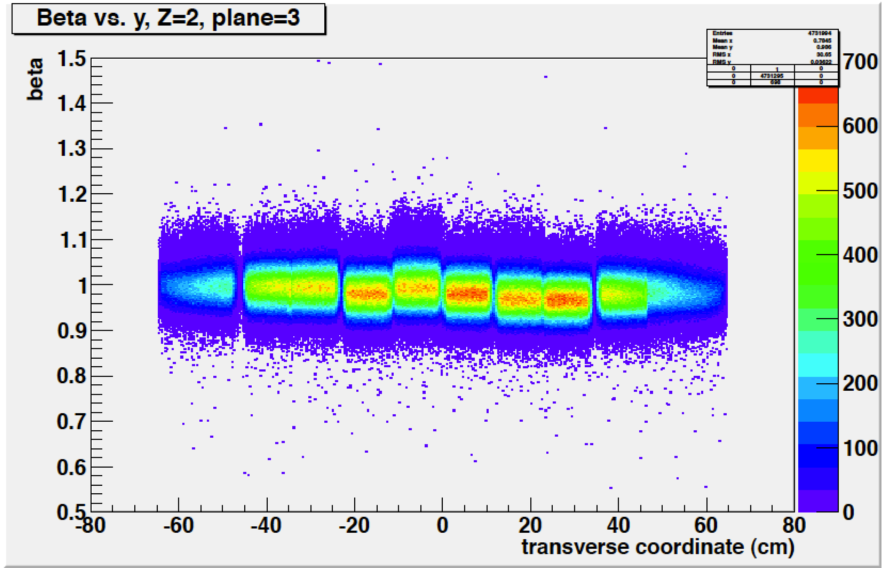


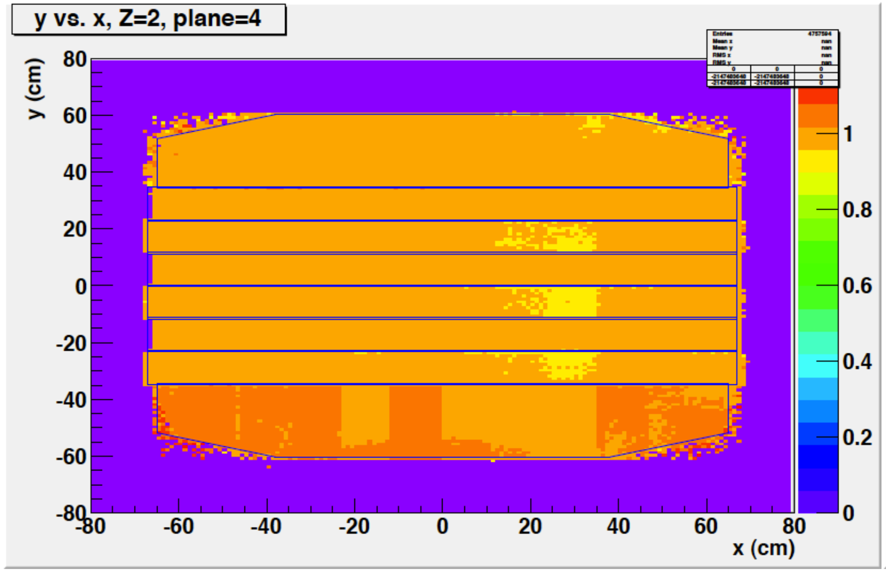


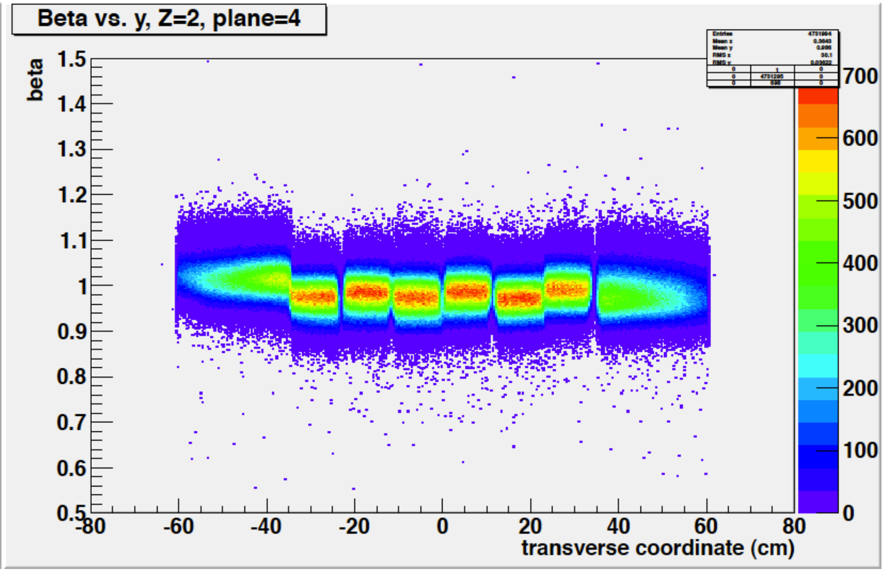


beta vs. position	beta vs. transverse position







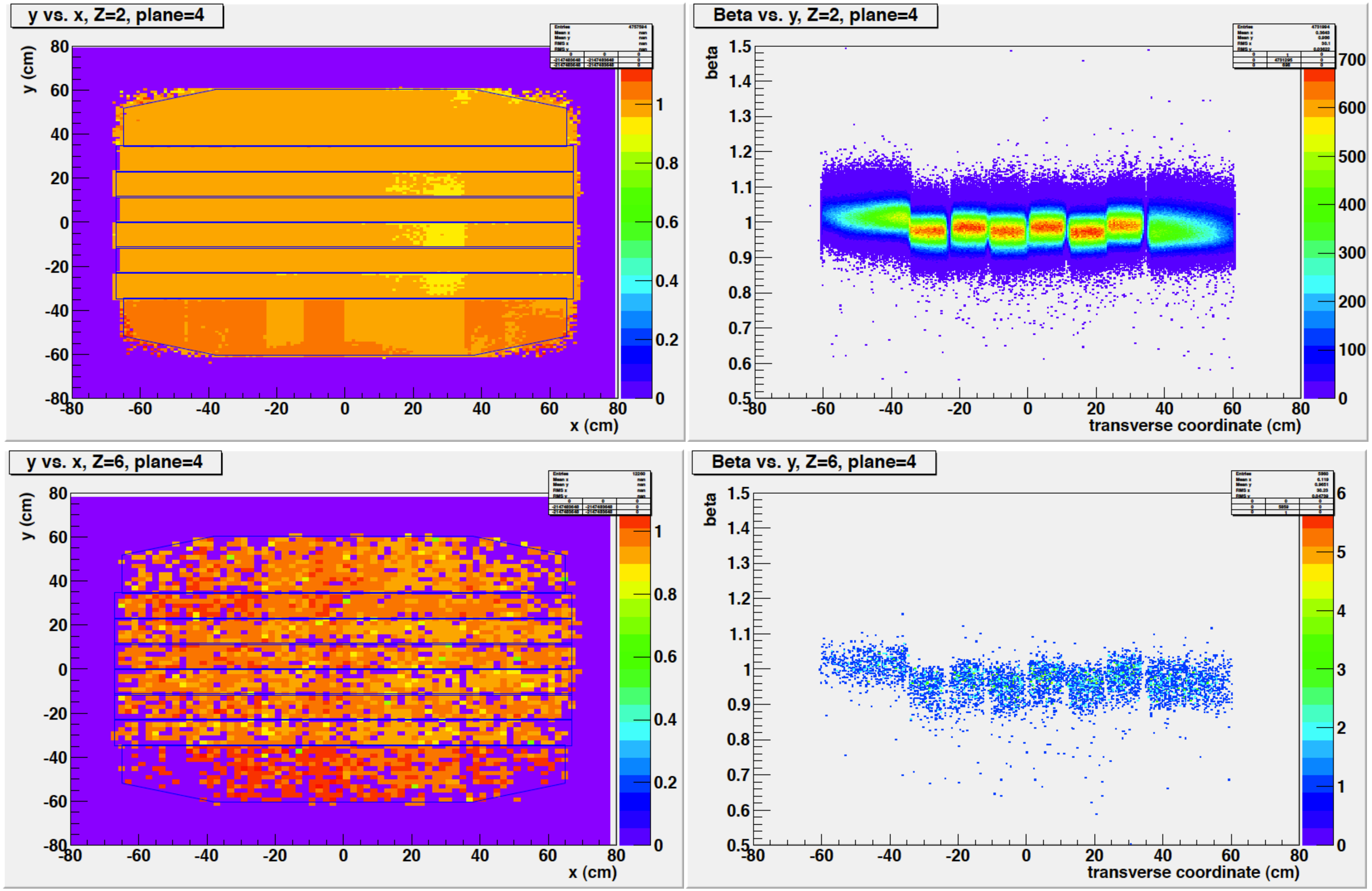


Wrong slewing corrections produce wrong zero-times and the effects are amplified for higher charges

beta vs. position — beta vs. transverse position

Z=2

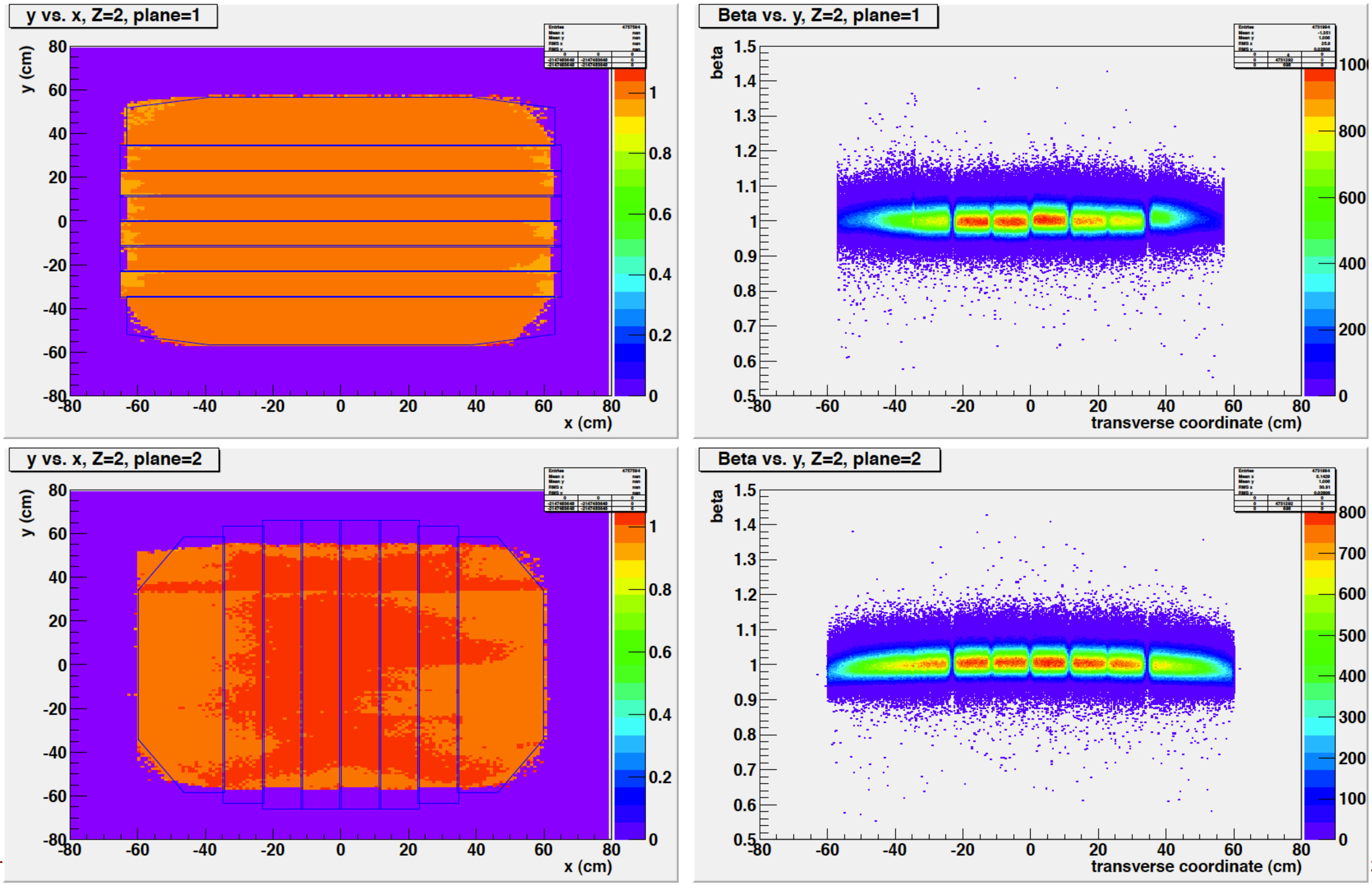
Z=6



Analysis with slewing parameters computed with all particles, Z=2 (to be compared with slides 27 and 28).

beta vs. position

beta vs. transverse position



beta vs. position

beta vs. transverse position