Improved resolution with z-chamber hits

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ABSTRACT. The very precise information from the z-chamber improves considerabely the resolution in the $s - z$ fit parameters, especially in ϑ, both for the DL8- (starting with run $\approx$18250 in 1984) and for the FADC data.

Following Beate's suggestion, I've investigated what improvement if any results if one includes the z-chamber hits into the $s - z$ fits. The following results have been obtained:

There is a relatively large z-dependent mismatch between the z-chamber hits and the tracks extrapolated from the jet-chamber. I have fitted (or rather roughly described) the mismatch as function of z separately for the years 84, 85 and 86, for the inner and outer wires and for $x < 0$ and $x > 0$ corresponding to the two separate halves of the z-chamber (see JN 138). The results are indicated in Fig.1. The difference in the mismatch for the inner and outer wires is negligible relative to their common (averaged) mismatch. Errors in the z-chamber wire T_0's have effects within 300 μm. These are small compared to the mismatch and to the track extrapolation error (12-18 mm) and are in the range of the statistical and systematic uncertainties in the determination of the mismatch. Since no further improvement in the resolution expected, I did not try to correct the T_0's.

It is not clear whether the jet-chamber- or the z-chamber calibration is (rather) in error. An overall shift might be understandable but the mismatch is significantly z-dependent. The jet-chamber was calibrated to the lead glass whereas the z-chamber by using cosmics which, besides having an angular distribution different from that for tracks from interactions, are partially "out of time" and fly from outside to inside. On the other hand, the mismatch can not be accounted for by errors in the T_0's and drift velocities in the z-chamber, one would need errors in the relative wire positions in the order of several mm's within the z-chamber (and varying in time). In any case, the correction for the mismatch is, of course, applied to the z-chamber hits rather than moving all the other components of the detector.

When two z-chamber hits are assigned to the track, from the difference of their residuals one can extract the single hit resolution of the z-chamber: 600 μm, in agreement with Susan's findings. Since this is much better than the resolution of the jet chamber (20-40 mm) and the extraploation error, the z-chamber hits must help!

The corrected z-chamber hits were then supplied to the fitting program ZSRFTV. It was found by trial that the optimum weight for the z-chamber hits relative to that for the jet-chamber is in the order of 50 for FADC- and 30 for the DL8-data. (One would expect it to be much bigger.) The resolutions in the fit parameters for μ-pairs with and without the z-chamber hits are summarized in Table 1. Note that the sample on which the DL8 numbers were based in Table 1. of JCN 95, was dominated by μ-pairs in '81 with the best z-resolution

	80	81	82	83	84	85	86
$\sigma\left(\frac{z_{01}-z_{02}}{\sqrt{2}}\right)(mm)$	14.3	12.7	13.0	16.6	18.4	17.2	25.4
with z-chamber:					13.5		20.0
$\sigma\left(\frac{\cot\vartheta_1+\cot\vartheta_2}{\sqrt{2}}\right)/10^{-3}$	34	28	31	35	37	37	48
with z-chamber:					25		30

Table 1. Resolutions for μ-pairs with and without z-chamber.

and hence the comparison with the FADC was not quite fair. The values given here in Table 1. separately for the years correspond to fits without constraints. While the width of the $(z_{01}-z_{02})/\sqrt{2}$ distribution directly represents the measurement error, the width of $(\cot\vartheta_1+\cot\vartheta_2)/\sqrt{2}$ includes the effect of initial state radiation as explained in JCN 95.

The results with the z-chamber are not shown separately for '84 because of the smallness of the statistics. Table 1. represents the net improvement, no selection was made for tracks with z-chamber hits. The fraction of tracks with two associated z-chamber hits is 78%, with one hit 4% in the DL8 sample, 63% and 11%, resp. in the FADC sample. (The hits are allowed to be discarded in the course of hit cleaning in ZSRFT1. This might be one of the reasons why the optimum weight is smaller than expected and why supplying both hits gives slightly better result than just giving one hit with averaged coordinates although, in case of two hits, even relatively small calibration errors might disturbe the fit due to the large weight.) Subtracting the effect of the initial state radiation, one obtains for the improvement in the intrinsic angular resolution 19/33 for the DL8 and 25/45 for the FADC which are close to factor half even without correcting for the fact that not all tracks have z-chamber hits. (One would roughly expect an improvement of 0.3 in the angle and a smaller improvement, factor 0.6 in z_0 when fixing the track completely at the z-chamber.)

The performance of the z-chamber in multihadronic events is not known in detail. For long isolated tracks, it should be just as useful as for μ-pairs or Bhabha's. The only check I've made was to look at the distribution of χ^2_{z0} (introduced in JCN 95) which measures the spread of the track intersections at $r = 0$ within events. A definite improvement can be observed in Fig.2*d* although the fraction of tracks with two z-chamber hits is only 45% and with one, 10%. These figures can slightly be increased by loosening the acceptance cut for the hit association from 75 to 100 *mm*. Since no further improvement was seen, I left the value set by Susan (probably optimized for the DL8).

Since the z-chamber seems to provide a fair improvement, I've tried to understand why Susan failed to demonstrate it in the K^0 mass resolution. According to the current state of the code, she provided just one hit (the one on the outer wire in case of two associated hits) to the fitting routine ZRVOPT. The weight was chosen to be 800 (divided by $\sqrt{2}$ in case there was

only one hit association) which is a little too high but, according to my experience, this setup still should work reasonably well. (The two hits are very close to each other anyway. When I use a single hit for fitting with coordinates averaged for those of the two, the result is only slightly worse, even for large weights, than the fit with two hits.) Susan did correct for an overall shift between the chambers. The remaining z-dependent mismatch may have only a small effect on the resolution. I have found two errors in the χ^2-minimization code in ZRVOPT, which apparently do not cause any disaster. In fact, one of them had already been noticed by Susan but when correcting it the peak was not as nice as before, she reinstalled the wrong statement!

Without having done any serious investigation, I can only make the following guess. The comparison was made on top of a common-z constraint. As mentioned in JCN 95, due to correlations, the statistical error of the difference in the angles may be small compared to the single track angular measurement error so that the mass resolution is then dominated by other errors. This may or may not be provable on the real data by releasing the constraint in ZRVOPT (or simply not calling it) but should be testable on Monte Carlo where the other sources of errors can be set to zero.

The request for including the z-chamber hits in the fits by ZSRFTV can be made by setting appropriately the weight for them in ZCHWW of /CCMZCT/ which has been extended again:

COMMON/CCMZCT/ DIMPCT, ZCUTV, ZCUTVV, IZVCST(5), ZCHWW.

If the value of ZCHWW is between 0.1 and 2000.0, JFETCH or JFTNEW, when called with INDEX=4, will fetch the z-chamber hits as well, otherwise not. (Only ZSRFTV makes such a call.) The new routine ZCFTNW supplies the hit coordinates corrected for the mismatch. At the first hit request for an event, it calls Susan's ZCDATA which calculates the coordinates for each z-chamber hit and performs the track-hit association. I have made only a few minor corrections to some of Susan's routines but one of them is a removal of a divide check so please don't use the original versions in F22CAR.ZS. The recommended value for the weight is 50 which will apply to FADC and scaled automatically down by a factor of 3/5 for the DL8. The current default is ZCHWW=0.0 (no z-chamber hits).

To summarize, Susan did a pretty good job on the z-chamber calibration. The hits are almost immediately usable for the z-fits (correcting the mismatch in a z-dependent way has only a minor importance concerning the resolution). The association algorithm she established can hardly be improved. The z-chamber can be considered as a success rather than a failure providing us for '85 with the best angular resolution ever and even for the FADC data almost as good as the best DL8 resolution.