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CTC tracking study for the plug electron

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This note describes our CTC tracking performance study in the plug region. We focus on the tracking efficiency and the charge misassignment probability, and their charge dependence. In this analysis, the new CTC tracking code (CTC000) [1] was tested. Direct application of this study will be found in the W asymmetry measurement study in the plug [1].

The tracking code was tested on the no-jet plug W sample described in a previous note [2]. CTC tracking information was not used in the plug W preselection. Therefore this sample is unbiased with respect to the reconstruction of CTC tracks. W preselection parameters are shown in table 1. A background estimation for this sample yields:

$$\%BG(QCD) \leq 2.4 \pm 1.3\% \tag{1}$$

The momentum resolution of tracks hitting super layer 0 (SL0) only is not sufficient to make a good momentum measurement:

	σ_{P_T}/P_T		
	$P_T = 20$	$P_T = 40$	$P_T = 60$
SL0($\sigma_{P_T}/P_T = .04P_T$)	0.8	1.6	2.4
SL2($\sigma_{P_T}/P_T = .005P_T$)	0.1	0.2	0.3

For the charge measurement, CTC tracks should pass through SL2. We define R_{exit} to be the distance from a track to the beam axis, as measured at the CTC end plate. A cut is applied on R_{exit} to ensure tracks hit SL2 before reaching the end plate:

$$R_{exit} > 62.2cm$$

CTC track quality parameters are plotted in figures 1-6. The dashed lines show the Monte Carlo simulation (ISAJET + CDFSIM), which agree well. Following the above study, we decide to make the CTC track quality cuts described in table 2.

We observed 340 candidates in the region $R_{exit} > 62.2cm$, which corresponds to $\sim 35\%$ of the no-jet plug W candidates. The CTC tracking code has gone through some modification.

[1] This version was implemented by Peter Berge and Aseet Mukherjee. It was originally released on April 3, 1990 and has undergone some modification since then.

The original version (*old version*) and the current version (*new version*) were both applied to the no-jet plug W sample. Both versions reconstruct 239 tracks (events) accompanied with an EM cluster.

$$\epsilon = \frac{239}{340} = 70.3 \pm 2.5\%$$

The tracks can be split into four components: East/West and $+/-$.

old version

	+	−
West	48	55
East	91	45

new version

	+	−
West	48	54
East	90	47

A disagreement of 23 events was found between those versions. 18 out of the 23 tracks in the old tracking were also reconstructed by the new tracking. They gave relatively worse E/P values than the old version, but none of them flipped their charge. We combined the tracks found by both tracking versions into one sample:

Automatically found tracks

	+	−
West	50	60
East	101	51

Total 262 candidates

$$\epsilon = \frac{262}{340} = 77.1 \pm 2.3\%$$

On the remaining 78 candidates, manual tracking [2] was applied. This work was done on a graphic terminal by hand. For a given electron cluster position, the expected hits on the axial and stereo super layers were indicated on the display. The tracks for the plug electrons were mostly found as two dimensional (2D) tracks. In this case, the possible stereo hits were picked up with the mouse. The track was then fully reconstructed with the additional hit information. The following qualities of tracks were found through this procedure.

1. Silver: Good quality tracks
   - 3D track was found automatically but the position matching with the cluster was bad.
   - Track was found as 2D track and manually reconstructed as 3D.
   - Full manually reconstructed with clear axial and stereo hits.

	+	−
West	6	7
East	11	7

31 events

[2] Thanks to P. Berge for his great help.

2. Bronze: Low quality tracks

   - 2D track was found but the stereo hits were slightly ambiguous.
   - Full manually reconstructed, but a part of the hits are obscured.
   - Bad radius matching caused by a bad stereo information.

	+	−
West	3	3
East	3	3

12 events

3. Track reconstruction error

   - Row of hits pointing the cluster was visible but the track reconstruction failed.

24 events

4. Complex (Background?)

   - Very dense CTC hits.
   - Hits seemed to be wiped out by nearby tracks.

6 events

5. Background candidates

   - No visible hit points the cluster.

4 events

6. No CTCE bank

1 event

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78 events

From this, the total (automatic and manual) tracking efficiency was estimated:

$$\epsilon = \frac{239 + 23 + 43}{340 - 11} = \frac{305}{329} = 92.7 \pm 1.4\%$$

The background level can also be estimated from this scan.

$$\%BG = \frac{10}{340 - 1} = 3.0 \pm 1.4\%$$

This value is consistent with the independent estimation (1). We have to note that group 1 shows the same charge distribution as the automatic tracks. There is no evidence the tracking has charge dependence.

The charge identification reliability was checked with the Central-Plug Z sample. Z events were selected by the cuts shown in table 3. 27 plug electrons associated with a CTC

track were found in this sample in the region $Rexit > 62.2\,cm$ and $1.32 > \eta > 2.22$. All of them were found to have a charge of opposite sign to that of the central electron. We observed the following numbers of plug electrons.

	West	East	Total
e^+	6/9	6/13	12/22
e^-	3/5	12/16	15/21
Total	9/14	18/29	27/43

(Candidates with a CTC track)/(Total candidates)

From 27 events, we can estimate the charge misidentification probability (p^{+-}):

$$p^{+-} < 0.085(90\%\text{C.L.}) \tag{2}$$

In order to estimate p^{+-}, a Monte Carlo simulation was used. W^+s and W^-s were generated by the ISAJET Monte Carlo V6.25 generator, simulated with CDFSIM, and reconstructed with the new tracking code. Internal bremsstrahlung effect was not included in the simulation, which makes the electron momentum measurement lower. Slight disagreement of E/P distribution was observed due to the absence of Bremsstrahlung effect. But we don't think it changes the following numbers a lot because the efficiency is high enough and the high momentum tail almost agrees with the data.

	Candidates	Wrong sign	Correct sign
e^+	287	3	284
e^-	319	7	312

$$p^+ = 0.010 \pm 0.006 \tag{3}$$
$$p^- = 0.022 \pm 0.008 \tag{4}$$

p^+ : probability of charge misassignment ($+ \rightarrow -$)
p^- : probability of charge misassignment ($- \rightarrow +$)

The track reconstruction efficiency of the current code is 70%. Track quality parameters show good agreement with the CDF simulation. We don't find any significant difference between positive and negative tracks. Manual tracking was applied on the unreconstructed track sample, which increased the tracking efficiency to 93%. We didn't see any evidence that tracking has charge dependence. 262 candidates will be used in the W asymmetry measurement. Charge misassignment probabilities are also used in the systematics study.

References

[1] S. Ogawa, *W boson decay asymmetry measurement in the plug* , CDF 1334.

[2] S. Ogawa, *W measurement in the plug* , CDF 1345.

Table 1: W **cuts**

	Variables	Cut values	
·Event topology cuts	Transverse mass	>	60
	$\not\!\!E_{\mathrm{T}}$	>	25.0
	$\sigma^2_{\not\!\!E_{\mathrm{T}}} / \sum E_{\mathrm{T}}$	>	2.4^2
	no jet: E_{T}^{Jet}	>	10
·Electron cuts	E_{T}	>	25.0
	Pad3*3 χ^2	<	15.0
	Isolation($R = 0.4$)	<	0.1
	Had/EM	<	0.05
	VTPC hit occupancy	>	0.5
·Event quality cuts	Z vertex	<	60.0
	Fiducial volume cut		
	BADRUN		

Table 2: **CTC track selection**

variables		cut value
P_{T}	>	1.0 GeV/c
R_{exit}	>	62.2 cm
$\Delta\phi$	<	0.04 rad.
ΔR	<	10.0 cm
$\lvert E/P \rvert$	<	2.5

Table 3: **Central-Plug Z sample**

	Variables	Cut values	
Event cut	two ELES segments		
	$80 < M_{ee} < 100\,GeV$		
Central electron cut	E_T	$>$	15
	HAD/EM	$<$	$0.055 + 0.045E/100$
	E/P	$<$	1.7
	$LSHR$	$<$	0.2
	$R*(\Delta\phi)$	$<$	1.5(cm)
	ΔZ	$<$	3.0(cm)
	χ^2 *strip*	$<$	15
Plug electron cut	E_T	$>$	15
	see table 1		
	see table 2		
Fiducial cut	Z *vertex*	$<$	60 (cm)
	Bad runs		
	FIDELE		

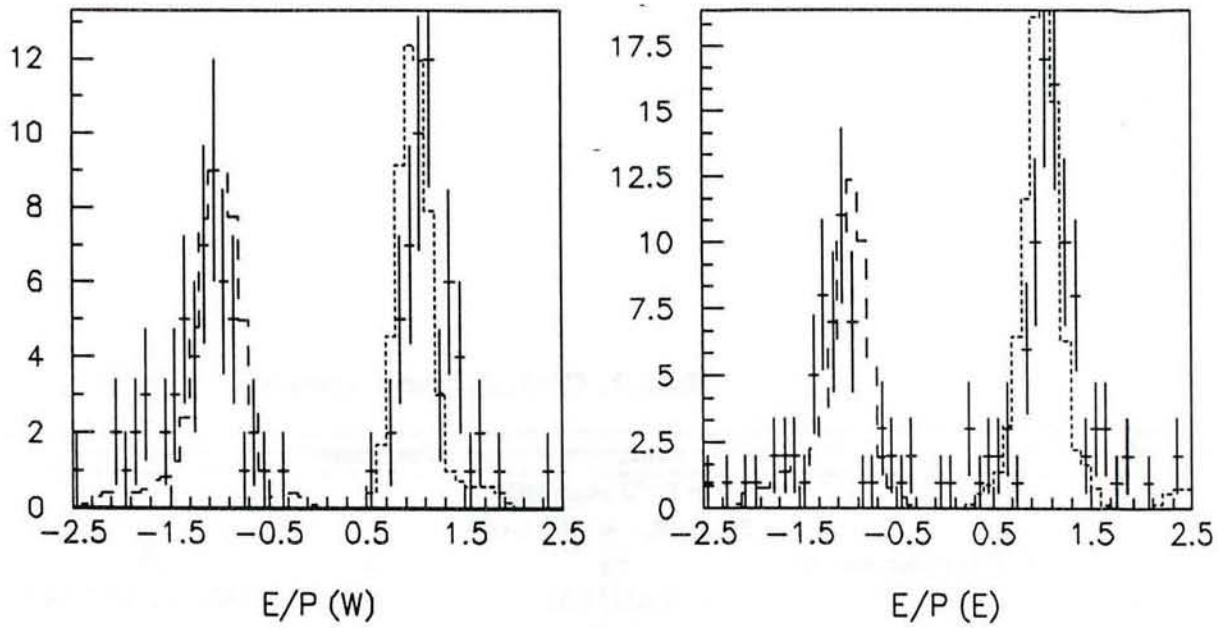

Figure 1: The energy and momentum matching of the plug electrons

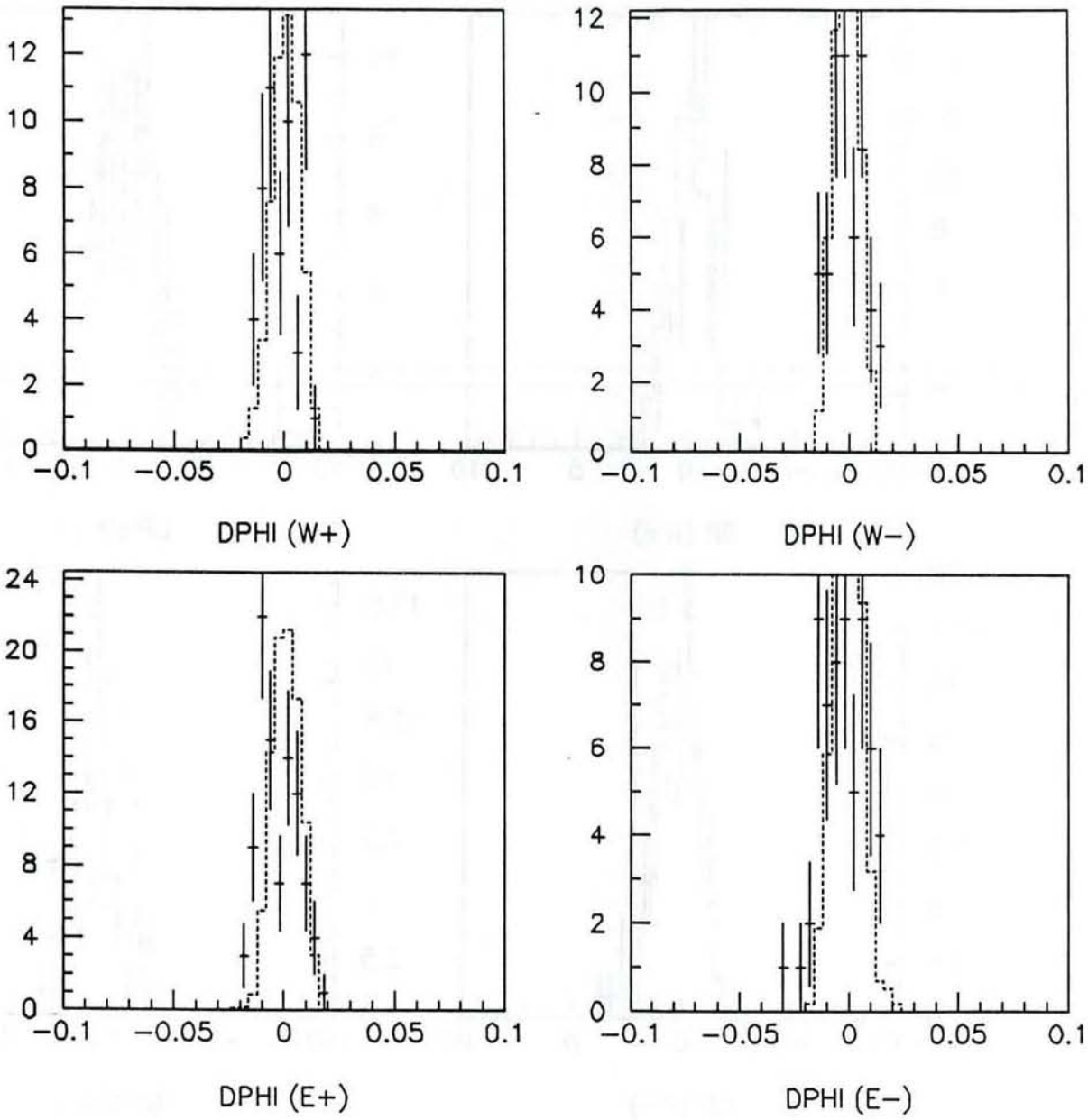

Figure 2: The azimuth angle matching between CTC track and the cluster.

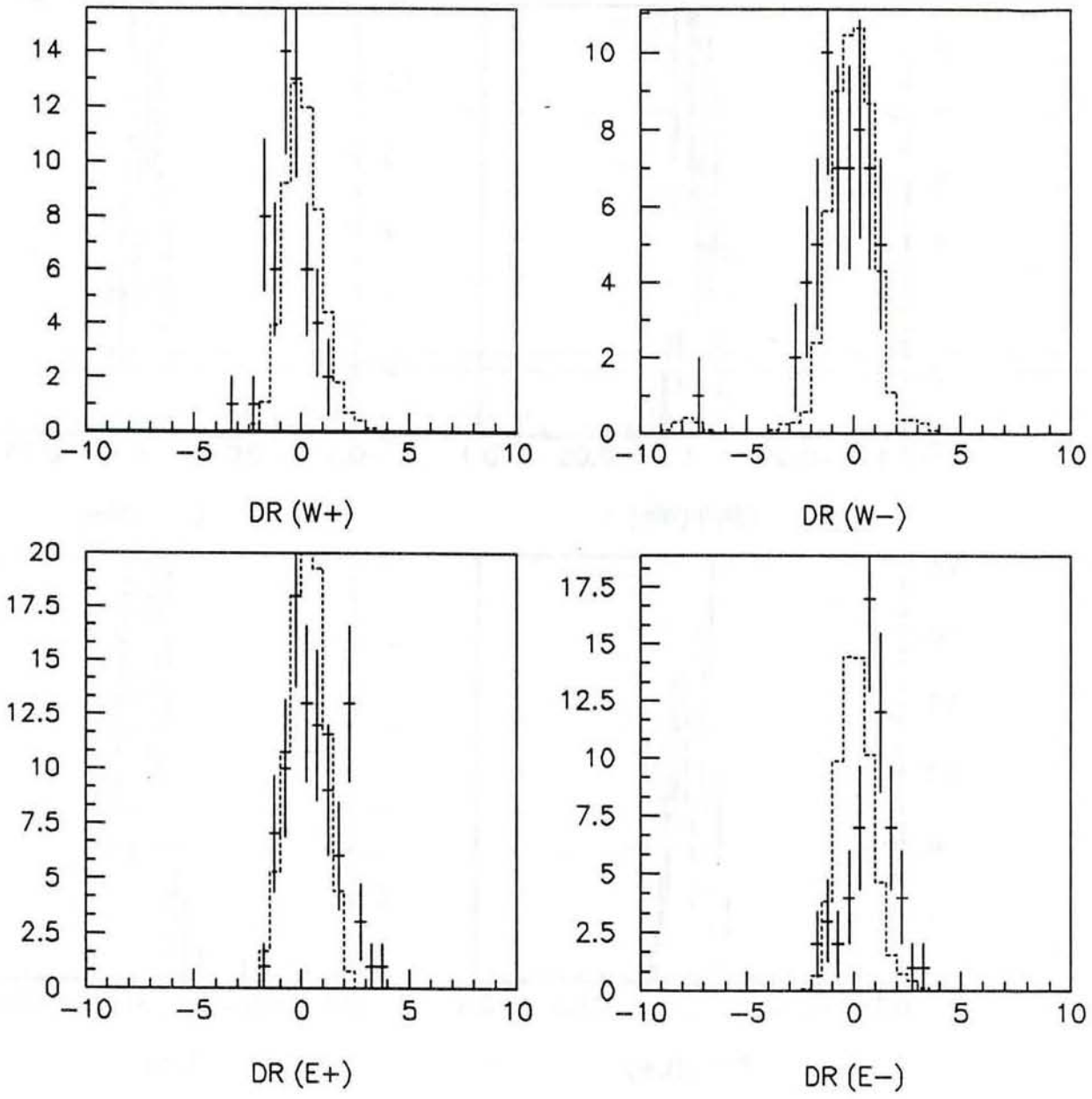

Figure 3: Radius matching between CTC track and the cluster.

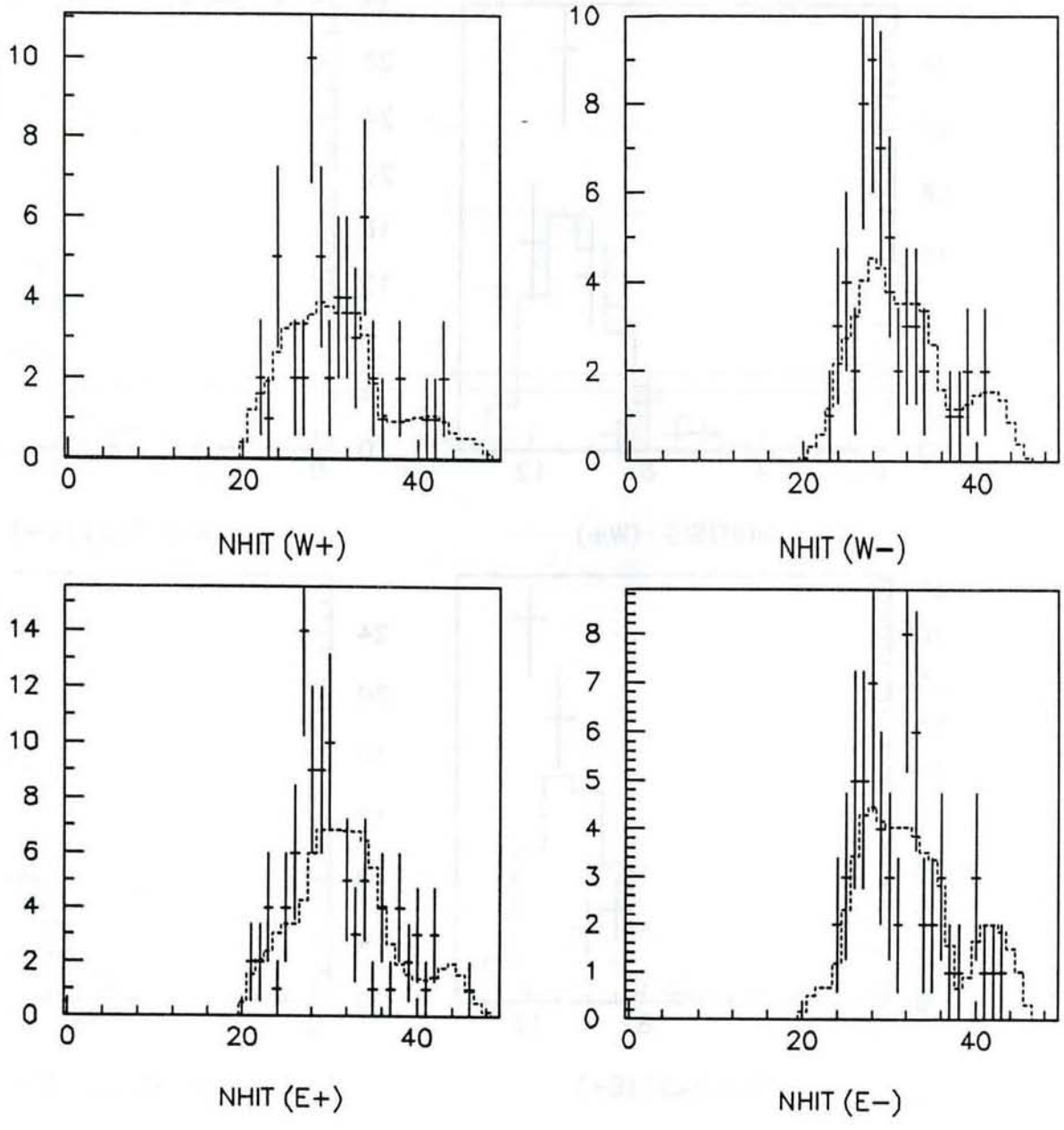

Figure 4: Number of CTC hits used for the fitting

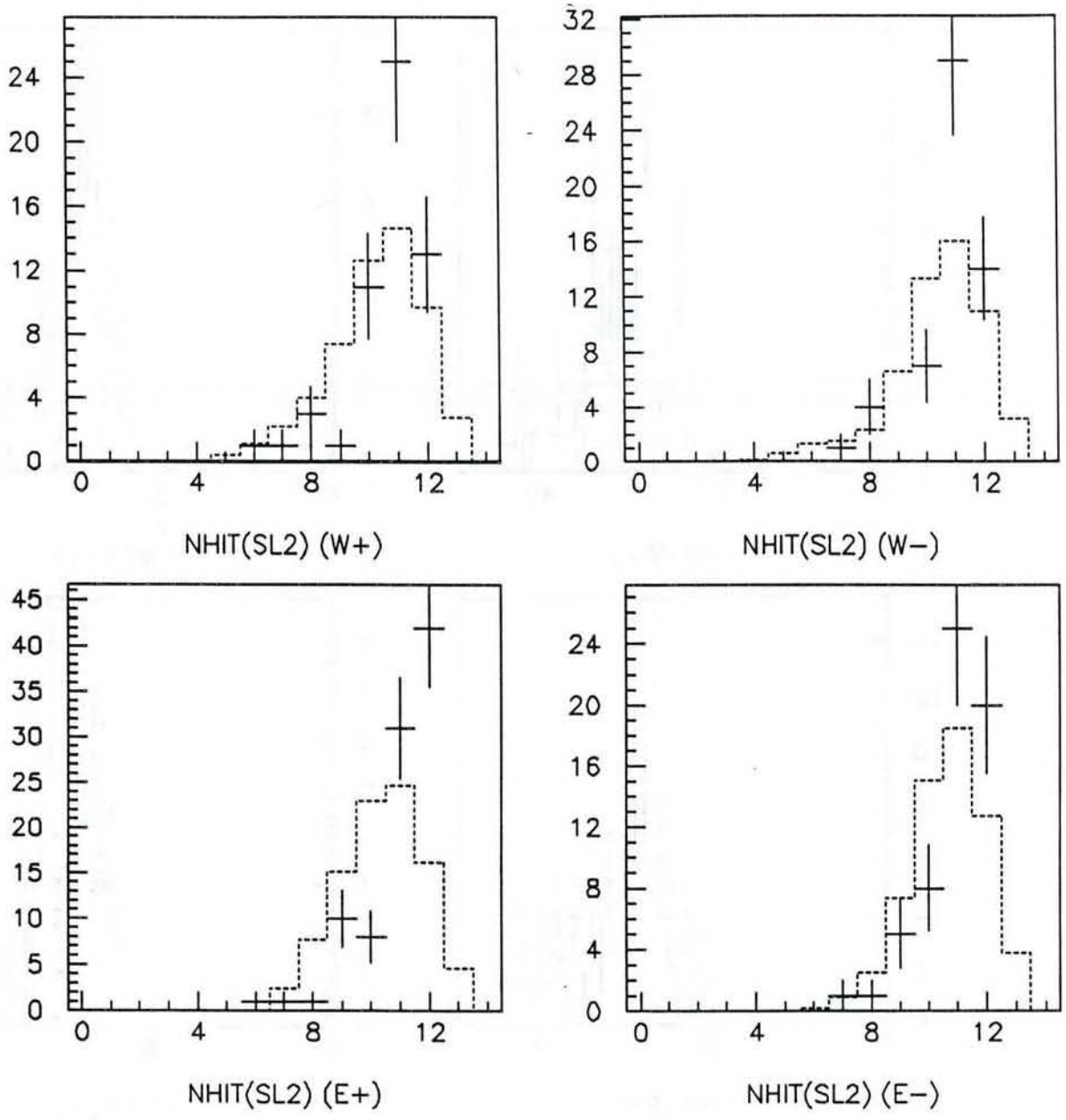

Figure 5: Number of CTC hits in the super layer 2 used for the fitting

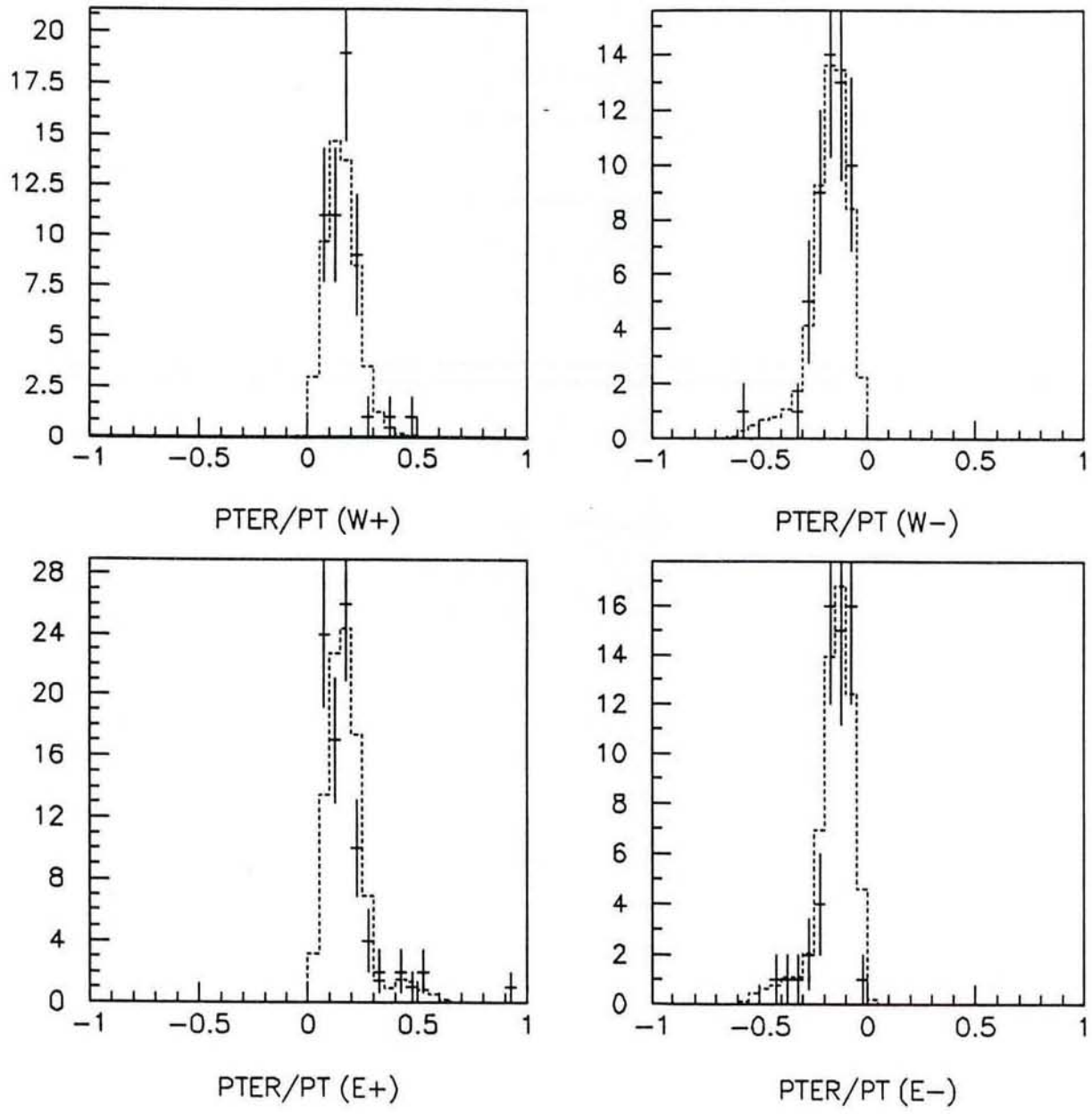

Figure 6: Relative curvature error