MEMORANDUM NFSt. Note 5

To: CPLEAR Collaboration October 25, 1993

From: Ronny Adler

Subject: **Spatial Resolution of the Calorimeter**

Abstract

In this note the spatial resolution of the electromagnetic calorimeter of the CPLEAR experiment has been studied. The resolution of showers belonging to a charged track was found to be 3.6 mm in $r\varphi$ and 7.1 mm in z (in the first conversion layer of the calorimeter). The main contributions to these values are an intrinsic resolution of the calorimeter (about 2.0 mm in $r\varphi$ and 3.3 mm in z), the multiple scattering in the PID's (about 2.2 mm) and the uncertainty from the track extrapolation (about 0.8 mm in $r\varphi$ and 6.1 mm in z). The overall impact point resolution for photon showers was found to be 4.5 mm.

1 Introduction

After the alignment of the 18-layer gas-sampling electromagnetic calorimeter (6.2 radiation lengths) of the CPLEAR experiment was completed at the end of 1992 [1], an accurate determination of the new spatial resolution of the detected showers in the calorimeter was needed. The previously reported resolution in the alignment memorandum was determined with the same special data sample, which was used for the alignment itself (e.g. at least five hits per shower and only one wire hit per calorimeter layer). Therefore a new determination of the spatial resolution with real data, using the existing alignment, was appropriate.

The evaluation of the K^0-decays into two neutral pions involves mainly constraint fits using the two charged tracks and the impact points of the four photons. The unknown decay vertex is determined with a 6c energy momentum constrained fit, assuming a decay of the neutral Kaon into two pions. Besides the impact points of the four photons, their errors also are needed for this fit. This explains why an accurate determination of the spatial resolution of the photon showers is important.

The desired precision for the measured CP-violating parameters requires a spatial resolution of the photon showers of the order of $\sigma \approx 5$ mm. In this report the spatial resolution of the shower impact points has been studied and found to be in agreement with the design specifications.

2 Resolution of Charged Showers

The charged track sample, used for the resolution studies, was obtained from minimum bias tapes, taken in the run period P19 in 1992. Due to the main annihilation channels, the sample contained mostly pionic tracks.

A shower in the calorimeter was defined to be a charged shower, if the shower was found to lie not more than 25 cm away from one extrapolated charged track (both in $r\varphi$ and z). Beside that, every shower had to pass the shower pattern recognition algorithm, where at least three hits in two different calorimeter layers were requested.

Some quality cuts on the tracks (enough $r\varphi$ and z information / only tracks from the center / track momentum bigger than 500 MeV/c) provided a good sample of charged tracks. In addition, only charged showers with their impact points lying in layer 1 were considered, in order to minimize the multiple scattering.

The resolution was found by comparing the φ- (or z-) coordinate of the extrapolated charged track with the calorimeter φ- (or z-) information of the impact point. With a double Gaussian fit of this $\Delta\varphi$- (or Δz-) distribution, a parametrization was made, where the resolution was defined to be the width of the smaller Gaussian. The values so obtained still include an error contribution from multiple scattering in the scintillators and the Cherenkov detector of the PID's (about 2.2 mm for Pions with a momentum of 500 MeV/c) and from the track extrapolation to the calorimeter (about 0.8 mm in $r\varphi$ and 6.1 mm in z, using for the error propagation the errors of the tracking devices).

The resolution of charged showers was found to be $\sigma_{r\varphi} \approx 3.6$ mm in the $r\varphi$-plane and $\sigma_z \approx 7.1$ mm in the z-direction, as shown in fig. 1.

3 Intrinsic Resolution of the Calorimeter

The shower sample used for the intrinsic resolution studies was also obtained from minimum bias tapes taken in the run period P19 in 1992. It contained mainly photon showers and showers originating from charged pions. Here again, every shower had to pass the shower pattern recognition algorithm where at least three hits in two different calorimeter layers were requested. A shower (or better its impact point) was taken for the intrinsic study, if all its three projections were available (i.e. if in addition to the wires, the U-strip and the V-strip planes also contained information).

The resolution was determined by comparing the φ of the wires with the φ using both pick-up strip informations and by the z-information obtained using on one hand the wires and the U-strips and on the other the wires and the V-strips. In the first case, a single Gaussian was fitted; in the second case, a double Gaussian. The resolution obtained in this way, should be free from multiple scattering uncertainty.

The intrinsic resolution was found to be $\sigma_{r\varphi} \approx 2.0$ mm in the first case and $\sigma_z \approx 6.6$ mm in the second case, as shown in fig. 2.

These two values depend on each other. If one looks how z is calculated:

$$z = const. + \frac{Radius \cdot \varphi}{\tan 30^\circ} = const. + \sqrt{3} \cdot Radius \cdot \varphi$$

one finds with the $\Delta\varphi$-resolution of 2.5 $mrad$:

$$\sigma_z = \sqrt{3} \cdot Radius \cdot \sigma_\varphi \approx 3.4 \ mm$$

For the z-information, both U-strip and V-strip values are combined. Because

$$\Delta z = z_{w,u} - z_{w,v} \quad \Longrightarrow \quad \sigma_{\Delta z} = \sqrt{\sigma^2_{z_{w,u}} + \sigma^2_{z_{w,v}}} \approx 6.6 \ mm$$

where the Δz-resolution of 6.6 mm was used, one finds:

$$z = 0.5 \cdot (z_{w,u} + z_{w,v}) \quad \Longrightarrow \quad \sigma'_z = 0.5 \cdot \sqrt{\sigma^2_{z_{w,u}} + \sigma^2_{z_{w,v}}} = 0.5 \cdot \sigma_{\Delta z} \approx 3.3\ mm$$

which is almost identical with the previously calculated σ_z!

4 Resolution of Photon Showers

To study the impact point resolution of the photon showers, a sample of events produced in the reaction: $\bar{\mathrm{p}}\mathrm{p} \rightarrow \phi\pi^0$ was used, taken in the run period P13 by the end of 1991 and selected by Andreas Schopper.

For a given momentum (i.e. a given velocity) of the neutral pion, the opening angle distribution of the two photons (the two decay particles of the neutral pion) has a well defined form with a known minimal value, as shown in fig. 3. In the case of the selected $\phi\pi^o$-events (two body system!) we therefore should see such an opening angle distribution smeared by the uncertainty of the impact points of the photon showers. Fitting the distribution with the known function folded with a Gaussian gives us the desired impact point resolution of the photon showers.

The overall opening angle resolution of the two photons was found to be of the order of $\sigma_\varphi \approx 7.9\ mrad \mathrel{\hat{=}} 6.3\ mm$ (see fig. 4). The overall impact point resolution for one photon shower is therefore $\sigma_{space} \approx 4.5\ mm$.

References

[1] *Alignment of the Calorimeter*
R. Adler
NFSt. Note II

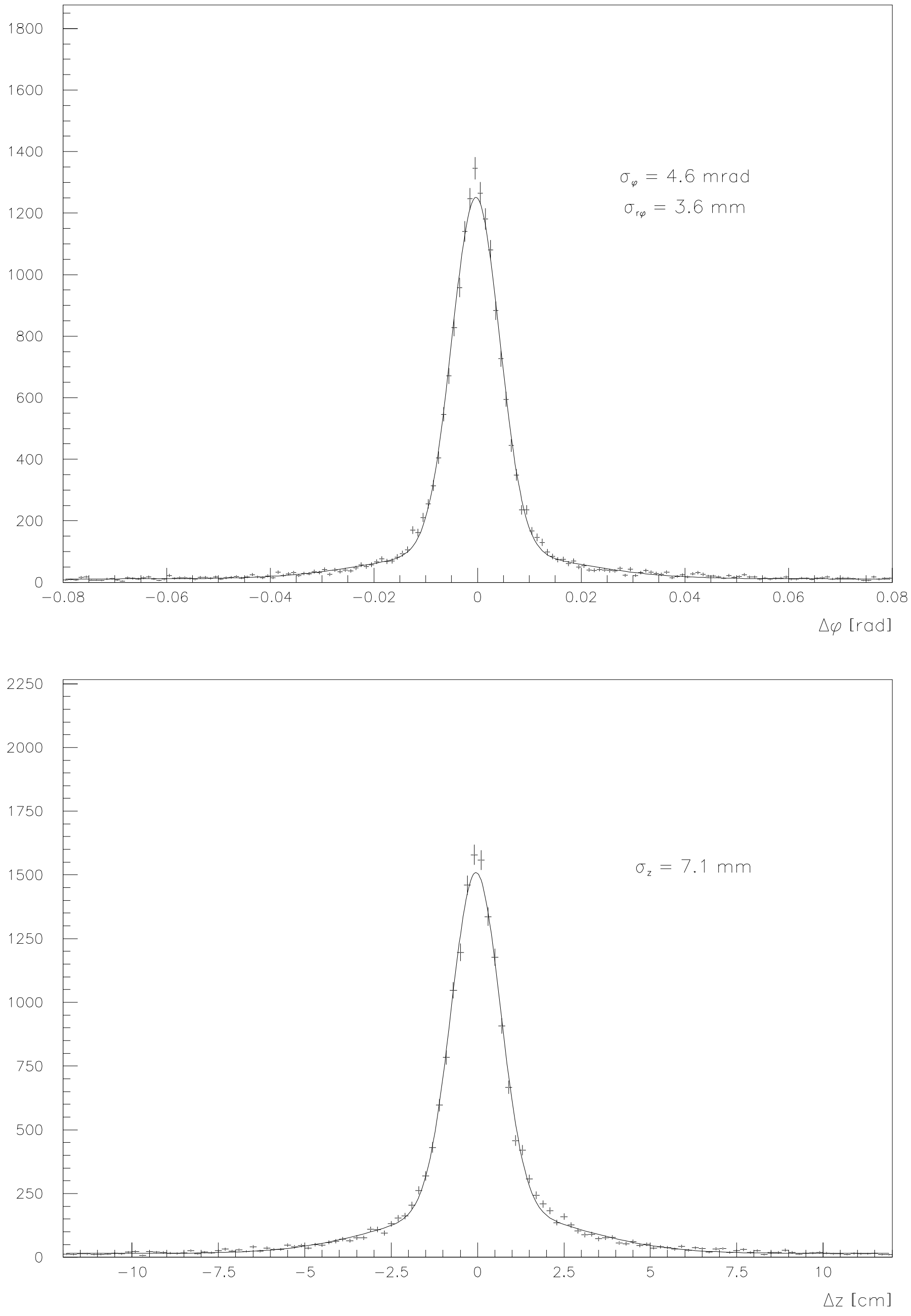

Figure 1: Final impact point resolution in the first conversion layer of the calorimeter for the selected charged showers.

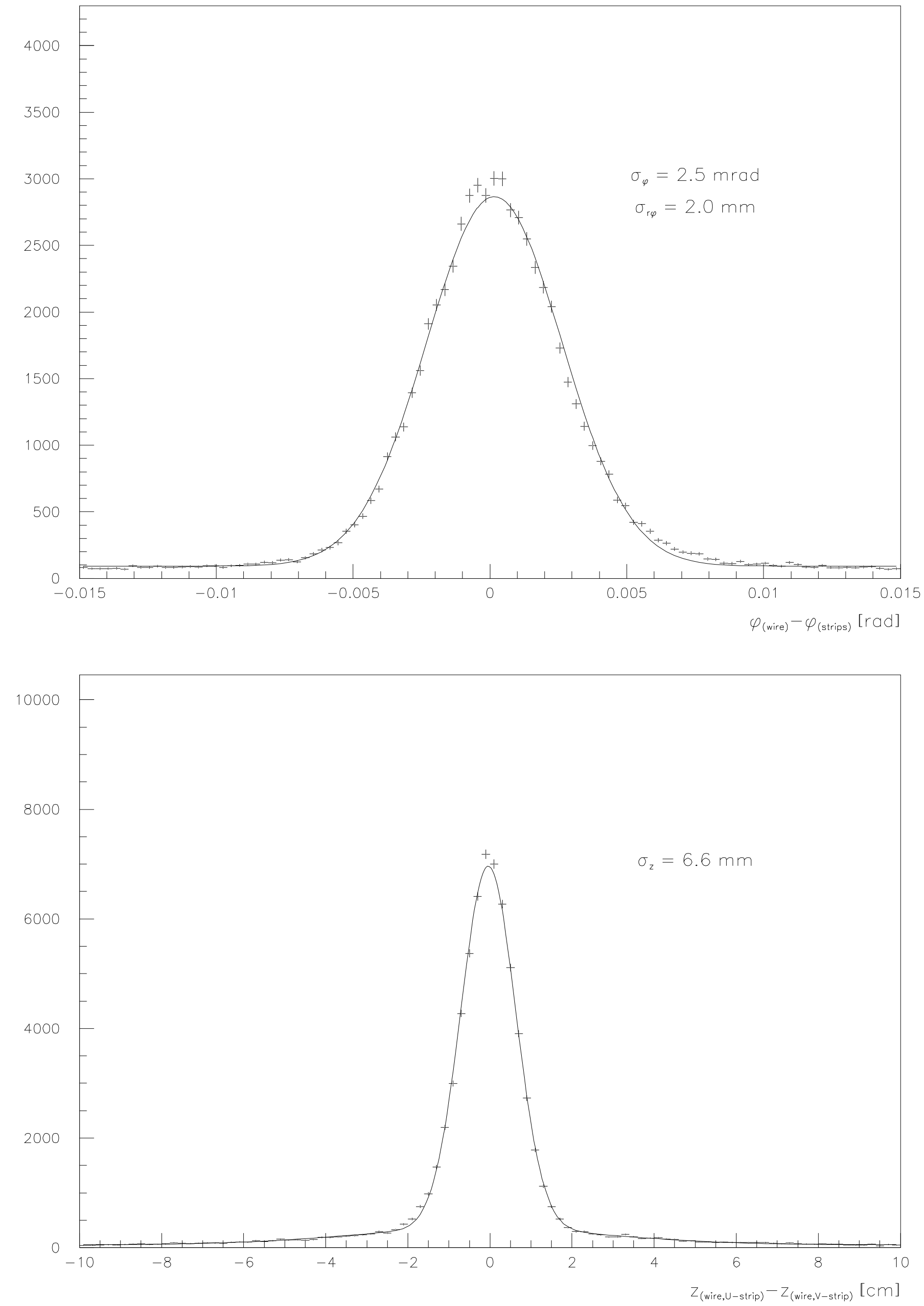

Figure 2: Intrinsic φ- and z-resolution of the calorimeter as described in the text.

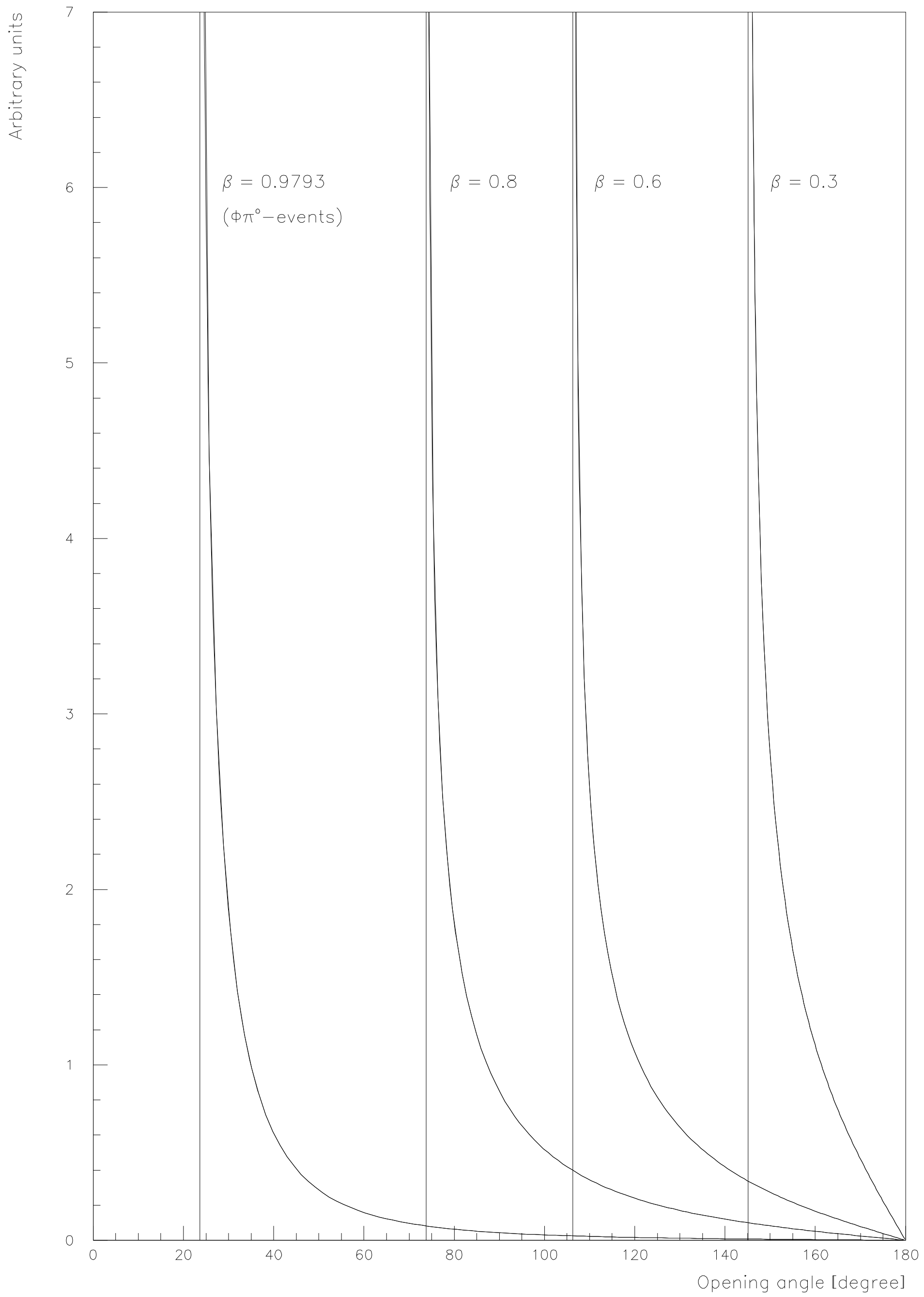

Figure 3: Opening angle distribution of the two photons for different velocities of the decaying neutral pion.

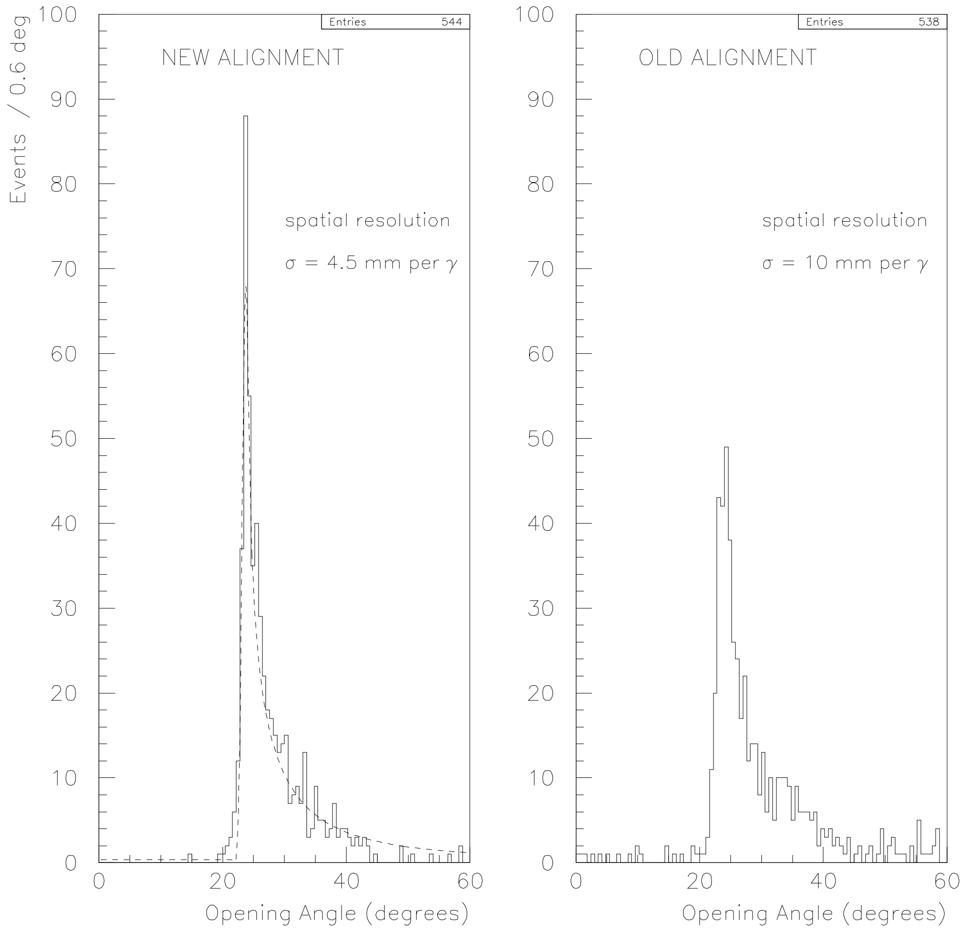

Figure 4: Opening angle distribution of the two photons from π^0's produced in the reaction $\overline{\text{p}}\text{p} \rightarrow \phi\pi^0$ before and after the alignment. The dashed curve is calculated by folding a Gaussian distribution with the appropriate function of fig. 3.