A 4-layer Silicon Microstrip Telescope for High Precision Beam Definition

A.Bischoff, G.Bohm, K.Deiters, A.Donat, R.Heller, W.Lange, R.Leiste, W.-D.Nowak, U.Röser, F.Tonisch, K.Trützschler

Institut für Hochenergiephysik der AdW der DDR
1615 Berlin-Zeuthen, Platanenallee 6, GDR

Abstract: Design, construction and operation of a two-pair silicon microstrip detector telescope are briefly presented. Results on detector performance are given, as well.

1. Introduction

Test and calibration of the L3 central detector, in particular the Time Expansion Chamber aiming at about 40 micron intrinsic resolution, require an even more accurate beam definition telescope. Silicon microstrip detectors with 50 micron pitch were chosen to satisfy these requirements. A 4-layer telescope was designed, built and used at CERN in spring 1989. It consists of one upstream and one downstream pair, each pair measuring both horizontal and vertical beam position. Whereas chapter 2 describes briefly the detector hardware, the by-product results on detector performance are summarised in chapter 3. More detailed information can be found in /1/.

2. Detector Hardware

Wafers of 3 inch diameter and 350 micron thickness were produced /2/ from n-type high resistivity (2.5 kΩ cm) float zone silicon and processed /3/ to obtain single-sided dc-coupled microstrip sensors with 50 micron pitch and 50 mm strip length. The characteristic leakage current for intact strips is less than 10 nA at 200 V depletion voltage.

A complete telescope plane is schematically shown in fig.1. The printed circuit board carries the silicon wafer and a thick film hybrid, the latter serving as mechanical support as well as two-layer bus structure. It contains the control and readout

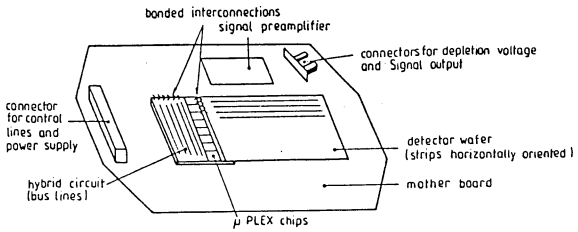

Fig. 1

bus and carries eight NMOS Micropl—ex chips /4/ which are interconnected to the 1024 sensor channels by a special bonding technique /5/. Due to insufficient wafer testing capabilities certain strip regions were found to be bad after bonding, only. The detectors were "saved" by removing a few groups of bond wires leaving some dead zones.

3. Detector Performance

To facilitate test and calibration of the L3 central detector an off-line package was developed to preprocess data from the microstrip telescope. Besides standard pedestal treatment it includes an extra pass to get rid off the common mode noise. Peak finder tuning led to the following criteria. The threshold for any individual channel was set to five times the corresponding pedestal r.m.s. value. Since genuine pedestal peaks were found to generally consist of only one channel, all positive neighbours were added to any signal peak found above threshold. This way we were left with mainly 3-strip clusters what seems the optimum situation for a center-of-gravity analysis. The resulting charge distributions split up according to different cluster widths is shown in fig. 2.

From 11000 events processed for this analysis only 40 % have exactly one hit in each telescope plane, mainly due to the above mentioned dead zones. With only two detectors per measuring plane the single detector resolution could not be measured. However, basing on mainly 3-strip clusters data would allow in principle to apply the center-of-gravity method to decrease the purely geometrical resolution being pitch/$\sqrt{12} \simeq 15$ micron by about a factor of three. Thus we can expect for our detectors a resolution well below 10 micron. The single detector efficiency was found to be better than 99 %. More details on efficiency calculation can be found in /1/. The signal-to-noise ratio was determined basing on the maximum of the Landau-like charge distribution. The four detectors yield S:N = 18:1, 14:1, 23:1, 14:1, respectively, thus we observe a typical value of 15:1.

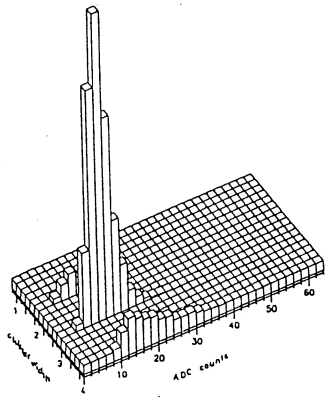

Fig. 2

Footnotes and References

/1/ A.Bischoff et al., Berlin-Zeuthen preprint PHE 89-16
/2/ Production by "VEB Spurenmetalle", Freiberg
/3/ Processing by "VEB Werk für Fernsehelektronik", Berlin
/4/ J.T.Walker et al., Nucl.Instr. and Methods A226 (1984), 200
/5/ Hybrid production and bonding was performed by "Zentrum für Forschung und Technologie des VEB Funkwerk Köpenick", Berlin