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THE ALEPH DOUBLE SIDED SILICON STRIP VERTEX DETECTOR

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ABSTRACT

The ALEPH silicon vertex detector at the LEP e^+e^- collider at Cern is described. Two concentric barrels of double sided Si strip detectors have been installed in February 1991 around the new 12 cm diameter Be beam pipe. 96, 5x5 cm^2 double sided Si strip detectors have been precisely positioned in 48 modules; the total number of readout channels is 73728 in the $r - \phi$ and z projections. The performance of these Si detectors and the preliminary results obtained during 1991 LEP run are presented.

Introduction

The study of the production and the decay properties of short lived particles containing heavy flavours motivated the ALEPH Si vertex detector. This detector, with high spatial resolution ($\approx$10 μm), provides a high precision measurement of charged tracks close to the interaction point, complementing the momentum measurement in the main tracking system. It also allows for the measurement of multiple vertices.

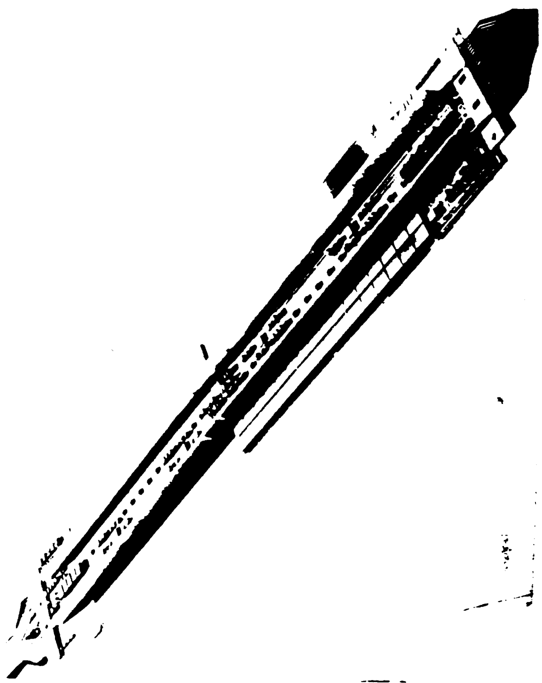

Fig. 1. z view of one *face*

*representing the ALEPH collaboration.

The detector

The ALEPH Si vertex detector(VDET) has as elementary unit a *face*, fig.1. Twenty-four of these *faces* are placed in two concentric barrels around the beam pipe. The *inner* layer has 9 *faces* at an average radius of 6.4 cm and the *outer* layer has 15 *faces* at a radius of 11.5 cm. The high precision carbon fiber mechanical support frame has been divided in two sectors to allow the installation inside ALEPH with the 12 cm diameter Be beam pipe already mounted. Four *faces* of the inner layer and seven *faces* of the outer one are mounted in the smaller sector, the remaining *faces* are mounted in the bigger one; the complete structure is held by the inner wall of the inner tracking chamber (ITC). The *faces*, with a 5% overlap between each other, have been staggered in azimuth between the inner and outer layers to ensure full angular coverage. The solid angle coverage is 87% for the inner layer and 70% for both layers. Each *face* is electrically divided in two *modules* [1]. Each of the 48 *modules* consists of two Si strip detectors 51.2x51.2 mm^2, 300 μm thick with orthogonal strips on the two sides. The strip pitch is 25 μm on the junction side ($r - \phi$ projection) and 50 μm on the ohmic side (z projection) ; the readout strip pitch is 100 μm on both sides, with 497 strips per side [2]. AC coupling between the Si detectors and the preamplifiers has been used; a custom made VLSI chip has been built for this purpose. The detectors are mounted onto a system of two ceramics, both 250 μm thick, used as a mechanical support for the Si detectors and as substrate for thick film hybrid circuitry to accomodate the front-end electronics for the readout. The analog readout of the detector strips is performed with the custom designed CAMEX64A chip [3]. One chip has 64 channels, each one providing signal amplification, noise filtering, parallel storage and serial readout for the analog signals. Switched capacitor filters are used to reduce the noise by multi-correlated double sampling. To reduce the number of output signals a multiplexing of 256 : 1 has been used. The main change to the readout scheme of [1] has been the replacement of the TPD digitizer with a Sirocco IV module [4]. This unit has a 10-bit FADC with DSP and allows more sophisticated pedestal calibration, zero suppression, subtraction of 'common mode' noise and cluster finding. After mounting, the position of each wafer has been measured with a microscope to an accuracy of 1-2 μm in the wafer plane and 10 μm orthogonally.

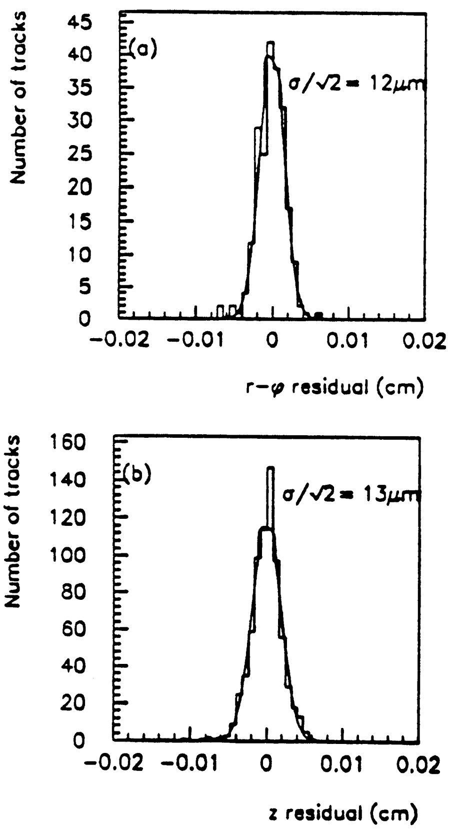

Fig. 2. Residuals measured in the overlap region in the a) $r - \phi$ and b) z projections.

Preliminary results

Since April 1991 VDET has been taking data in ALEPH. The detector shows an average of 15 hits on both the ϕ and z sides in random events. The probability that a VDET hit gets assigned to a track is 95% per layer averaged over the entire detector, where the inefficiency includes contributions from online thresholds, vetoed strips and dead areas. The optical measurements have been used as a starting point for the in-situ alignment, performed by using tracks from Z^0 decays measured in the central tracking system(ITC+TPC) and minimizing the distance between the tracks and the hits in the VDET. To avoid systematic errors, four independent techniques have been developed which use the information from the VDET itself. The combined information of these techniques can determine all 6 parameters describing each wafer position [5]. Fig.2 shows the residuals in the $r - \phi$ (a)) and z (b)) projections for tracks constrained to one of the two VDET hits in the wafer azimuthal overlap region. This gives a single hit resolution of 12 μm in $r - \phi$, 13 μm in z.

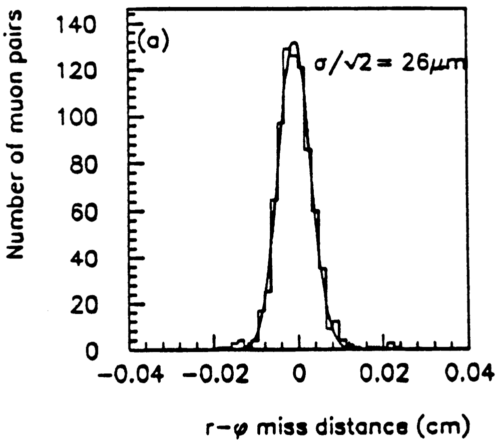

Fig. 3a). Muons 'miss distance' in the $r - \phi$ projection.

From $Z^0 \to \mu^+\mu^-$ events the 'miss distance' is shown in fig.3a), 3b) where both tracks have at least one VDET hit. The impact parameter resolution extracted from a gaussian fit is 26μm in $r - \phi$ and 34μm in the z projection.

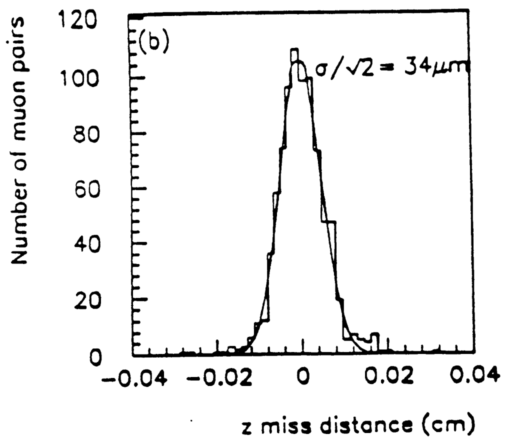

Fig. 3b). Muons 'miss distance' in the z projection.

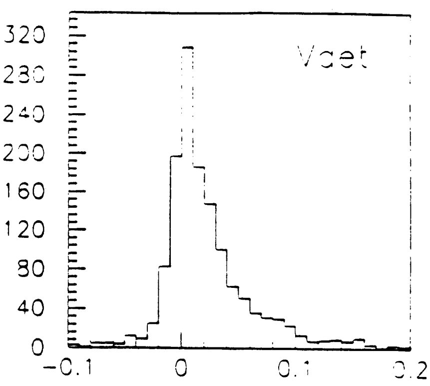

Fig. 4b). High p_t lepton impact parameter distribution with VDET information.

A sizeable improvement is also seen in the quality of the lepton impact parameter distribution which is used to extract the B lifetime information; fig.4a), 4b) show this impact parameter distribution without and with the vertex information. In fig.4a the lepton impact parameter is measured with respect to the centroid of the beam spot while in fig 4b the tracks have been refitted with hits given by VDET and the production vertex position has been reconstructed on an event-by-event basis.

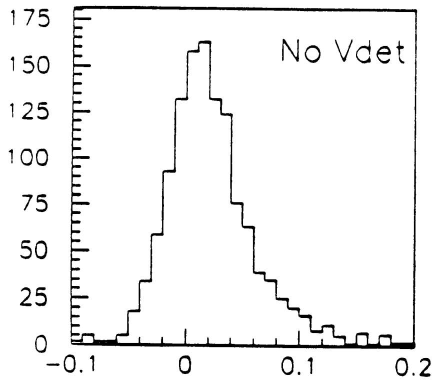

Fig. 4a). High p_t lepton impact parameter distribution without VDET information.

Conclusion

A complete detector with two concentric layers of double sided Si strip wafers has been taking data at Cern e^+e^- LEP collider since April 1991. Preliminary results show the qualitative improvement in the data analysis by using the vertex information. Single hit and impact parameter resolutions measured are close to the expected values.

References

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