CONSTRUCTION, OPERATION AND FIRST RESULTS FROM THE ALEPH DOUBLE SIDED SILICON STRIP VERTEX DETECTOR

presented by

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ABSTRACT

The ALEPH experiment at the e^+e^-–collider LEP at CERN is the first colliding beam experiment that uses a Micro Vertex Detector based on silicon strip detectors with VLSI readout on *both* sides of the silicon wafers thus providing a true three dimensional information on the position of a particle hit.

A large part of the detector has been installed in ALEPH in February 1990. The overall system design, the construction of the detector and results from a beamtest as well as first results from the running at center of mass energies corresponding to the mass of the Z^0 resonance will be described.

The Design of the ALEPH Minivertex Detector

The ALEPH Minivertex Detector [1] has been designed and built to study the production and decay properties of heavy shortlived particles containing the charmed quark or the bottom quark. Fig.1 shows a schematic overview of the detector.

The basic *mechanical* building unit is the "face". Twentyseven of these faces are arranged in two concentrical layers around the beampipe (12 in the inner layer at an average radius of 9.6 *cm* and 15 in the outer layer at an average radius of 11.3 *cm*). Four faces of the inner layer and 5 faces of the outer layer are mounted on one high precision mechanical mounting frame, the *sector frame.* The three sectors which are individually shielded are in turn mounted onto a carbon fibre tube that is connected mechanically to the ALEPH beampipe.

Each face consists of two identical units which are the basic *electrical* building blocks of the detector: the *modules* [2]. Each of the 54 modules consists of two identical silicon strip detectors (with a size of 51.2×51.2 mm^2 each) that are patterned on both sides with readout strips. The strips on the two sides are orthogonal to each other. The two detectors are daisychained on the side that provides the $r\phi$ coordinate. The detectors are mounted onto a system of two thick film hybrids (the z–side hybrid and the ϕ–side hybrid, so named after the side of the detector they read out). These hybrids house the readout electronics and provide a connection of the detectors and the electronics to the outside world. The ϕ–side detectors (the z–side detectors) are read out by 8 (16) VLSI chips with 64 channels each.

When completed, the system consists of 108 silicon strip detectors with double sided readout (≈ 0.25 m^2 of silicon) and has 82,944 analog readout channels. The weight is approximately 2 *kg* and a particle at 90 degrees incidence sees ~ 2.3 % of a radiation length. The total power dissipation is ~ 9 Watts per sector.

The analog readout of the detector strips is performed with the custom designed CAMEX64 chip [3]. The chip is 4.95×6.35 mm^2 large and provides 64 charge sensitive amplifier channels with a readout pitch of 100 μm. Noise filtering is performed by fourfold double correlated sampling and the equivalent noise charge under optimized running conditions is $ENC\ (e^-) = 335 + 30/pF\ C_{in}$, where C_{in} is the input capacitance for the amplifier.

For the design of the silicon strip detectors with double sided readout, historically two approaches have been pursued. Features common to both approaches are: overall area 51.2×51.2 mm^2, readout pitch on both sides 100 μm, thickness of the wafers

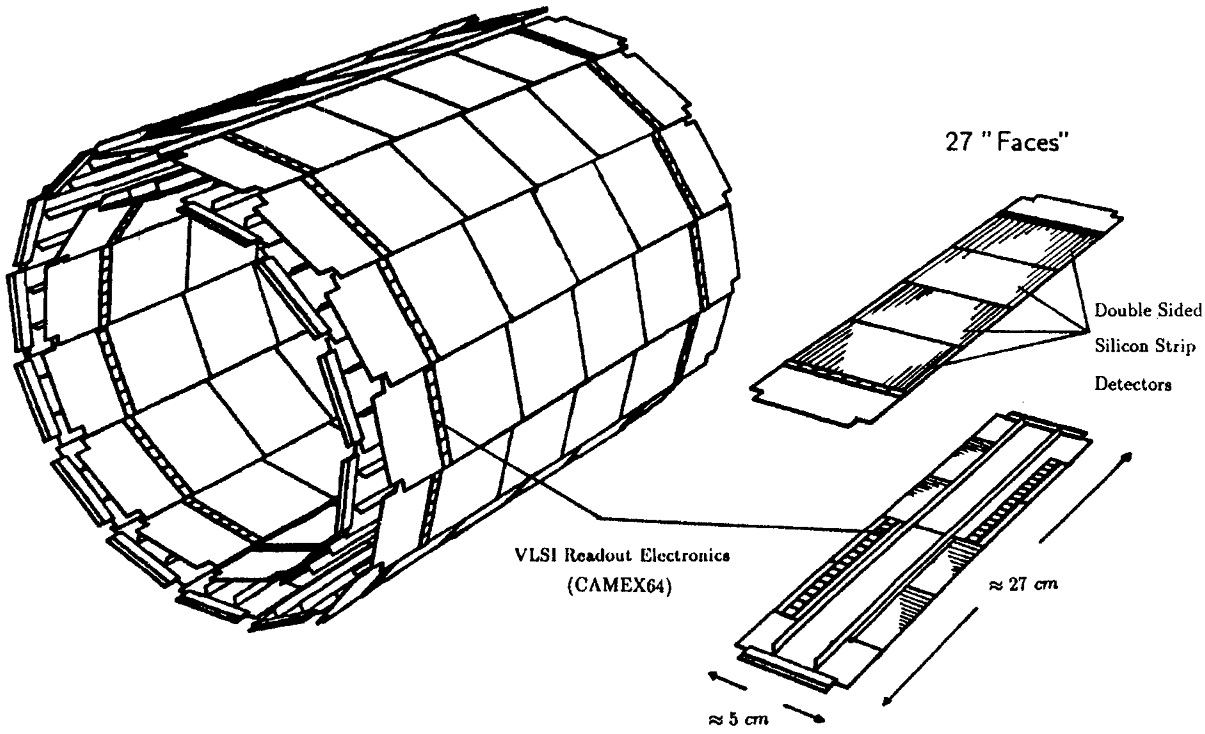

Fig. 1: A schematic overview of the ALEPH Minivertex Detector

$\approx 280 \mu m$ and the introduction of p^+ blocking strips on the ohmic ($n-$) side of the detector [4] to prevent a shorting of all the strips on the n–side due to the electron accumulation layer which is present at the interface between the silicon and the silicon dioxide.

For the first approach a new type of double sided silicon strip detector has been built that incorporates capacitive coupling to the readout electronics by *integrating* the capacitors into the detector design [5]. This has been made possible by the introduction of a new detector biasing concept. These detectors have been developed in collaboration between the Max Planck Institute, Munich, the Technische Universität Munich and the company Messerschmidt Bölkow Blohm (Munich).

The second approach, pursued by collaborators from the INFN Pisa converged with respect to the biasing scheme to the same design (see Ref.5) with one exception: the AC coupling of the strips to the readout electronics has to be performed with a *separate* AC coupler chip which has to be mounted between the CAMEX64 chips and the detector. These detectors are produced by the company CSEM in Neuchatel.

Results Obtained in a Beamtest

Several of the described silicon detector modules have been tested in a 50 GeV/c electron beam at CERN in November 1989. Fig.2 shows the residual distribution for projected hits from tracks on the ϕ–side and on the z–side respectively. The fit with a single gaussian gives a resolution of $\sigma_\phi \approx 12 \mu m$ and $\sigma_z \approx 17 \mu m$. The resolution on the ϕ–side is consistent with the observed signal–to–noise of $\approx 12:1$.

Results Obtained in ALEPH

In February 1990 the complete inner layer of the ALEPH Minivertex Detector and 7/15 of the outer layer were instrumented resulting in 58,368 analog channels. The system basically works and no principal flaws in the design could be found. The pulseheight distribution from particle hits and the signal–to–noise ratio compared well to the results of the beamtest.

During the running we observed the occurence of baseline shifts from event to event ("common mode noise"). In the present ADC system these shifts cannot be corrected for on an event by event basis thus resulting in an occasional increase in the number of fake hits (due to upward fluctuations) and occasional inefficiencies (due to downward fluctuations).

Several modules "died" in the course of the running due to problems with part of the peripheral electronics. Since the detector is unaccessible during running, these modules could not be repaired.

The alignment of the detector with tracks found with the rest of the tracking system of ALEPH (the Time Projection Chamber and the Inner Tracking Chamber) has been started. Since the sectors are fixed to the beampipe a coincidence of the coordinate system of ALEPH and the coordinate system of the Minivertex Detector cannot a priori be expected. In a first *global* alignment where the detector as a whole is treated as a rigid body it was indeed found that the Minivertex Detector center was displaced from the ALEPH center and that the whole detector was rotated by about 10 *mrad* from its nominal position.

In a first attempt of a *local* alignment of each individual wafer we reached the precision limit given by the other track defining detectors.

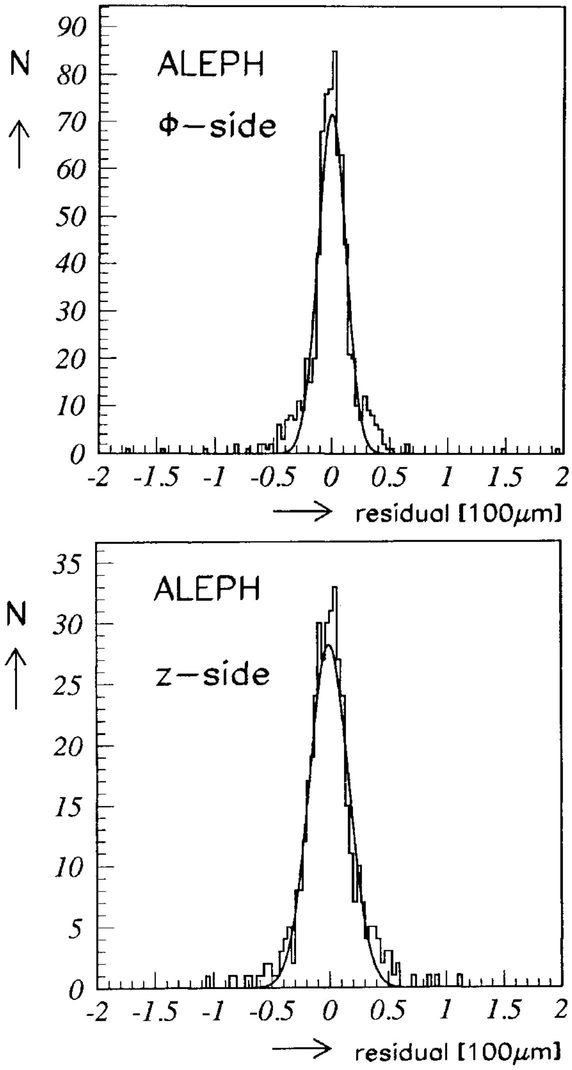

Fig. 2: Residual distributions for the ϕ-side and the z-side obtained in a testbeam

Conclusions

The ALEPH experiment is the first colliding beam experiment that has taken data with silicon strip detectors that can be read out on both sides. The detectors and the VLSI readout electronics (CAMEX64) work as expected and the results obtained in ALEPH compare well to previous beamtest results. Parts of the peripheral electronics have to be improved however.

The alignment has been started and reached the precision of the rest of the ALEPH tracking system.

In January 1991 a completed (and improved) detector for a new beampipe with a smaller radius ($r_i \approx 6$ cm) will be installed.

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