Proposal for a Solid State Luminosity Monitor for ALEPH.


I. Need for higher low angle acceptance of the ALEPH luminosity monitor.

The ALEPH luminosity monitor consists of a tracking device placed in front of a calorimeter. The calorimeter is of the same basic construction as the ALEPH electromagnetic calorimeter. The system detects Bhabha events. The distance from the interaction point to the detectors on each side is ~270 cm, and the minimum radius for proper shower detection is ~15 cm. The outer effective radius is about 46 cm. As best as we know, the system is capable of the required systematic accuracy but limited in statistics. At the Z° the expected luminosity event numbers are slightly less than the total event numbers; we would like them to be several times greater so that luminosity will not add too much to the statistical error.

The statistics can be improved by extending the present monitor inwards to smaller radii. This possibility is made more attractive by the expectation that a beam pipe of 6 cm inner radius will be installed in the near future. The extension proposed here would reduce the effective inner radius from 15 cm to 7.5 cm, and so achieve a gain in luminosity statistics of a factor 4. The systematic accuracy would be maintained, and perhaps even improved.
II. Design

The design proposed here is only a sketch. Technical solutions are not presented, but we believe it can be realized. It is preliminary in that improvements may be suggested by the prototype studies.

**Basic concept.** - We propose a tungsten-silicon sandwich of twelve layers replacing the present tracking chambers. This calorimeter, due to its compactness, has adequate spatial resolution so that tracking is no longer required. It will no longer be possible to distinguish photons from electrons, but this presents no problem in the luminosity determination, since the cross-sections of photon containing processes are as well known as the Bhabha cross-sections.

**Dimensions.** - I.D. of sensitive volume ~6.7 cm, O.D. of sensitive volume ~16 cm. These should permit clearing the beam-pipe and an adequate overlap with the present luminosity calorimeter. It should have 22 radiation lengths, for an overall thickness of 12 cm if the silicon wafer containing gaps can be kept to 3 mm.

**Thickness of the tungsten layers.** - For optimum resolution of energy, $\theta$ and $\phi$, the thicknesses are not uniform, but could be, e.g., as follows: 2.8, 1.8, 1.34, 1.34, 1.34, 1.34, 1.34, 1.34, 1.34, 1.34, 2, 2.5 and 3.5 $X_0$. An overall layout is shown in Fig. 1.

**Pad layout.** - The radial interval is divided into 18 5mm wide intervals, and $\phi$ is divided into 32 11 1/4° intervals. All wafers are alike; each covers a $\phi$ sector of 11 1/4°. It should be possible to cut two such sectors from one 4" wafer. There are 32 * 12 * 2 = 768 sectors. To permit precise $\phi$ measurement, successive layers are rotated by one third of the $\phi$ interval, or 3 3/4°. The pad layout is shown in Fig. 2.

**Readout.** - All 768 * 18 = 13,824 sectors are read out independently. A dynamic range of ~200/1 is required (see ALEPH 89-15, H. Burkhardt). Circuits developed by P. Jarron of CERN for UA2 as well as circuits now under development at RAL seem good candidates but require modification.
III. Resolution.

H. Burkhardt (ALEPH 1989-15), using EGS, has obtained the following resolutions:

\[ \Delta E/E = 19.5\% / \sqrt{E} \text{ or } 2.9\% \text{ at } 46 \text{ GeV.} \]
\[ \Delta \phi = .3^\circ - .22^\circ, \quad \rho \Delta \phi = .42 - .56 \text{ mm (the values given are at the inner and outer radii)} \]
\[ \Delta \theta = .0085^\circ, \quad z \Delta \theta = .4 \text{ mm.} \]

These resolutions are more than sufficient to be able to achieve the best possible rejection of the background due to accidentals of wrong energy electrons from beam gas scattering.

IV. Estimated cost.

The bulk of the cost will be that of the silicon wafers, and this has varied a great deal in the past. At SF 40/cm² the cost of these would be \(~.64\) MSF, and the entire detector \(~0.8\) MSF.

V. Concluding remarks.

The proposed device will make a substantial contribution to the precision of ALEPH results on the \(Z^\circ\) peak. It should be ready, together with the smaller diameter beam pipe, for the shutdown 1990-91.

Figure Captions

Fig. 1 Side view of detector.
Fig. 2 End view, pad layout.
Fig. 1
12 x 18 x 32 x 2 = 13,824
Layers = R * 0 sides = channels

Fig. 2