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PERFORMANCE OF A LARGE SCALE SCINTILLATING FIBER TRACKER USING VLPC READOUT.

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ABSTRACT

We report on results of a cosmic-ray test of a 3072 channel scintillating fiber tracker using VLPC readout. This system is a prototype for the D0 detector tracking upgrade, and represents a configuration that is similar to that planned for the final detector. A detailed description of the cosmic ray test, including trigger, fiber configuration, lightguides, VLPC cassettes and cryogenics, calibration system, and DAQ is given. Tracking results with a muon momentum cutoff of 2.5 GeV/c include R-ϕ and R-Z resolution studies, light yield/mip, and efficiency measurements. Preliminary analysis gives a most probable value of 19.2 photoelectrons/mip per fiber doublet, an R-ϕ resolution of 163 microns (before corrections for fiber position survey), and an efficiency of nearly 100% after accounting for known dead channels in the system.

1. Introduction

In order for the D0 experiment to fully exploit the physics opportunities at the Tevatron during the next decade, the collaboration has begun the process of a major detector upgrade.[1] In the upgraded detector, the central tracking will consist of a silicon vertex detector and an 80,000 channel scintillating-fiber tracker in a 2T magnetic field. The primary purpose of the work described in this report is to validate the performance capability of the proposed fiber tracking system by a cosmic-ray test of a 3072-channel prototype.

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*Representing the D0 Collaboration.

2. Apparatus

A schematic layout of the cosmic ray test stand is shown in Fig 1. The system consists of three layers of scintillating fiber ribbons mounted on a carbon fiber cylinder, four scintillation counters, four Iarocci-tube planes, and a steel absorber 2.1 m thick. The scintillation counters provide a cosmic-ray trigger. Two majority logic triggers can be used in the test; one requires a particle to penetrate the entire stack, the other requires penetration through only 1/3 of the stack. The two triggers correspond to momentum filters of approximately 2.5 GeV/c and 0.8 Gev/c and give trigger rates of 1.8 and 5.0 Hz, respectively. Four limited streamer Iarocci-tube planes are installed as an independent external tracker having a tracking resolution of about approximately 300 μm. They will be used during the commissioning phase of the fiber system.

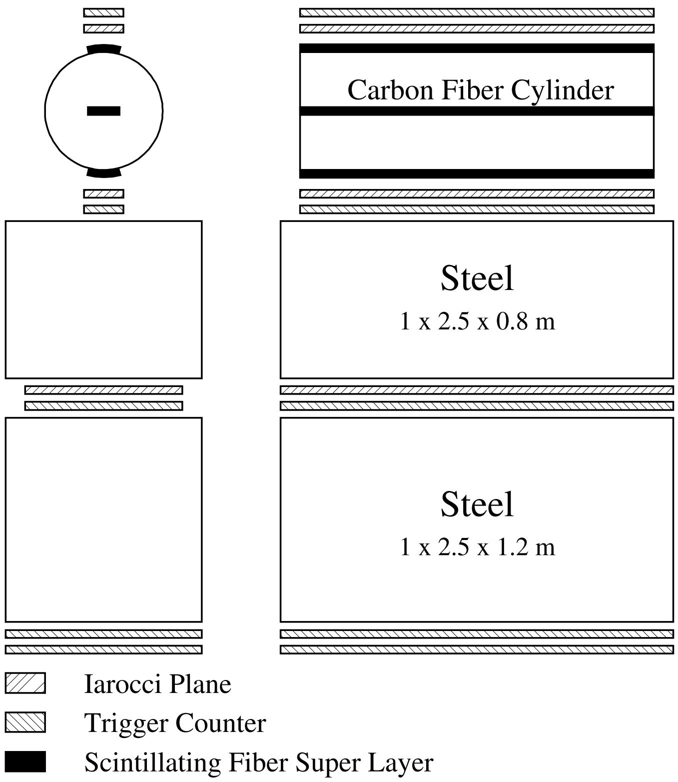

Fig. 1. Cosmic-ray test stand.

A scintillating fiber singlet ribbon consists of 128 835-μm-diameter scintillating fibers spaced on 870 μm centers. A doublet consists of two single-layer ribbons stacked on the top of each other and offset by a half fiber spacing. Four doublets are put together to form a superlayer in which the doublets are oriented as x (axial), u ($+2^\circ$ stereo), v (-2° stereo), and t (axial). Two superlayers are mounted on the top and bottom of the cylinder, and one superlayer is placed on a flat carbon fiber board that is mounted in the middle of the cylinder. Each layer of fibers is coupled via a 128 channel connector to an 8-m-long clear fiber bundle. The clear lightguide bundles couple to a connector on a VLPC cassette. Kuraray multiclad fiber doped with 1% p-terphenyl and 1500 PPM 3-hydroxyflavone SP(3HF) has been selected for the active (scintillating) fiber in the tracker because of its high light yield and excellent attenuation properties ($\lambda = 5$ m at the 3HF fluorescence of 525 nm)

The percentage of bad channels in the prototype was found to be 6%, of which 3% were dead (due to bad connections) and 3% were noisy and had to be disconnected. The number of dead channels in the fiber tracker to be installed in D0 is expected to be less than 1%.

3. Results

The results presented in this report were obtained by analysing data collected using the trigger which corresponds to a momentum filter of 2.5 GeV/c.

3.1. Resolution Studies

A preliminary measurement of the resolution of a fiber doublet has been obtained by reconstructing tracks using the fiber coordinates from all but one of the doublets. The deviation of the fiber coordinates in this doublet from a track is then measured. The resulting resolution was found to be 137.2 μm. Some improvement in the resolution is expected once the system is fully aligned.

3.2. Light Yield

The light yield of a fiber doublet has been measured by summing the light output of the fibers within a doublet that are contained within a good track. For high-momentum tracks, a light yield of 19.2 photoelectrons per doublet with a RMS of 6.4 is found. The light yield of the two singlet that make up the doublet are 10.8 photoelectrons with a RMS of 4.3 and 9.6 photoelectrons with a RMS of 4.5 respectively.

3.3. Efficiency Studies

The fiber-singlet and doublet efficiencies are determined by finding a good track in the detector and determining if there was a hit in the singlet or doublet plane. The efficiencies are then corrected to remove the effects of dead channels. The singlet and doublet efficiencies for one of the axial layers are shown in Fig 2, and the corrected doublet efficiency is shown in Table 1 as a function of the threshold. It is important to note that the contamination of the signal is minimal with a threshold as low as 1.3 photoelectrons.

4. Conclusion

Initial work has shown that the system performance of the D0 prototype fiber tracker is excellent. Data from the fully instrumented prototype system is being analysed, and studies are being made to fully realise the capabilities of this detector.

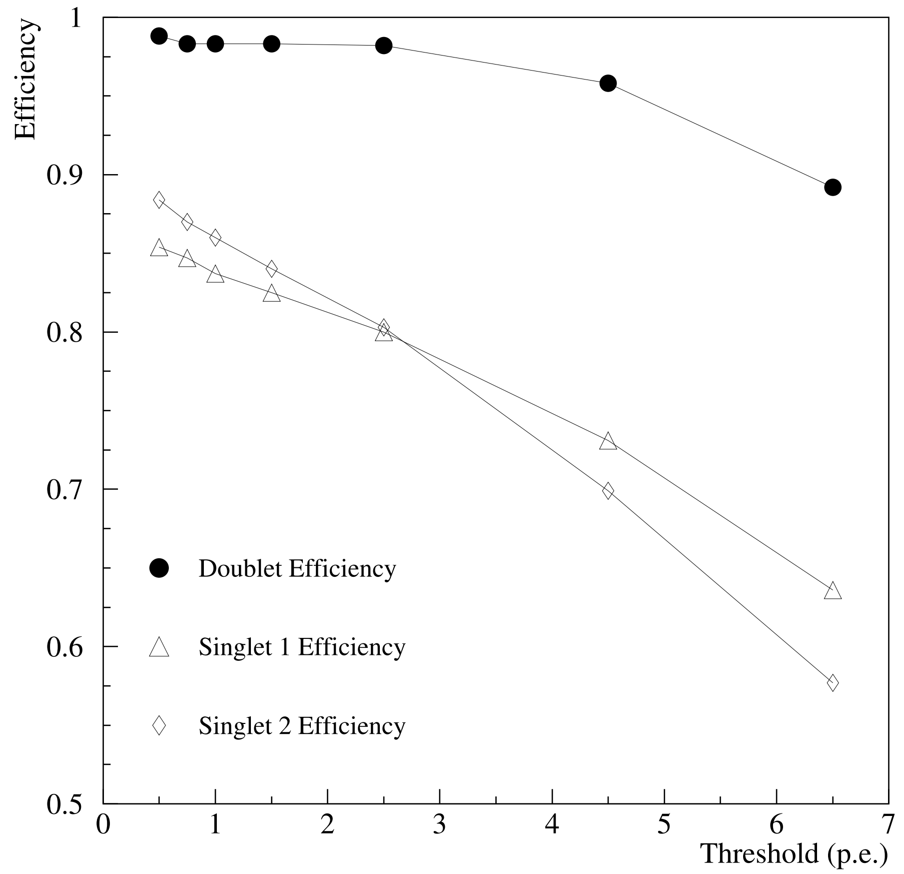

Fig. 2. Singlet and doublet efficiencies as a function of ADC threshold.

Cut (Photo Electrons)	Lost ($\times 10^{-3}$)	Contamination ($\times 10^{-3}$)	Efficiency (ϵ)
1.3	0.525	3	99.6
2.7	3.63	1	99.5
4.0	13.7	1	98.5
5.3	43.3	1	95.6

Table 1. Efficiencies of a fiber doublet after correction for known bad channels. The efficiency is given by $\epsilon = (1 - \text{lost}) \times (1 - \text{contamination})$.

References

1. E823 at Fermilab, *D0 note 1733.*