SDC-91-00072

SDC
SOLENOIDAL DETECTOR NOTES

SIMULATION STUDIES FOR A SCINTILLATING FIBER TRACKER

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SIMULATION STUDIES FOR A SCINTILLATING FIBER TRACKER*

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Abstract

High p_t leptons will be used to trigger on candidate events for physics studies (e.g. Higgs decay) at the SSC. Rates for producing high p_t leptons are low, compared with the maximum 1000 MHz pp interaction rate. Unusual combinations of background processes can imitate features of the high p_t signal, requiring a considerable degree of event reconstruction at the trigger level. We are presently addressing the problem of recognizing high p_t tracks in the SciFi central tracker proposed for SDC. Minimum bias events generated by Pythia are superposed, and hit patterns are analyzed to find candidates for high p_t tracks from unassociated hits. The fiber tracker is compared with a straw tube tracker, showing selectivity for various choices of redundancy as a function of luminosity.

A. Introduction

A major challenge is to construct a tracking detector which is useful for triggering at luminosities up to 10^{34}/cm^2-sec. The fiber tracker solves a potential problem of occupancy by providing a large number of detector elements over which the hits are spread.

The layout of the SciFi tracker proposed for SDC is shown in Figure 1. The central tracker consists of 4 superlayers of 650 micron scintillating fibers, with two sublayers of axial fibers in each superlayer. The intermediate tracker is comprised of 3 superlayers of 1 mm diameter fibers.

B. Backgrounds from Pileup

Particles from 40 TeV pp interactions generated by Pythia [1] were swum through the 2T magnetic field, simulating the effects of gamma pair conversions, Coulomb scattering, and ionization losses. Hits due to particles which loop for more than 16 nsec, the time between bunch crossings, were superposed on events

*Work supported in part by the U.S. Dept. of Energy and the Texas National Research Laboratory Commission.

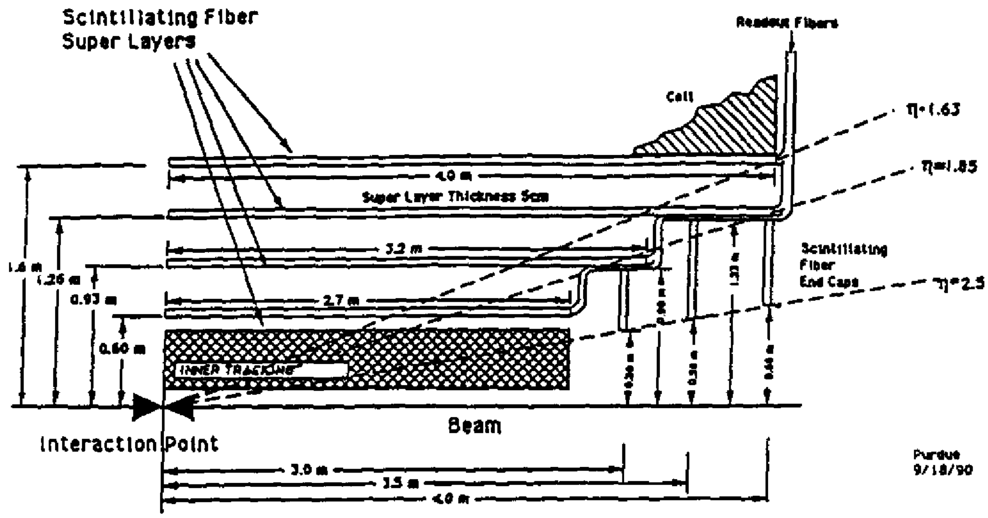

Figure 1 – Central and Intermediate Scintillating Fiber Tracker Layout.

occurring in up to 10 subsequent beam crossings. Table 1 shows the average multiplicity of hits/beam crossing in each of the superlayers, assuming one pp interaction/beam crossing.

Table 1 - Occupancies in SciFi Tracker.

Superlayer	Hits/event
(Central Tracker)	
1	63.6
2	42.2
3	31.5
4	19.0
(Intermediate Tracker)	
1	7.1
2	9.0
3	7.7

A trigger based on the central tracker uses two hits to define the azimuth and p_t of a high p_t track candidate, and the other 6 hits as a redundancy check. Figures 2 and 3 illustrate the effects of occupancy, showing the probability of finding a high p_t (> 10 GeV/c) track among non-associated hits. At a luminosity of 10^{33}/cm^2–sec or greater, hits in 8 layers of 4 mm straw tubes (Fig. 2), consistent with high p_t track, can be found at a rate of at least 0.3/bunch crossing. With the fiber tracker (Fig. 3), the fake high p_t rate of 10^{-6}/bunch crossing is well below the rate of

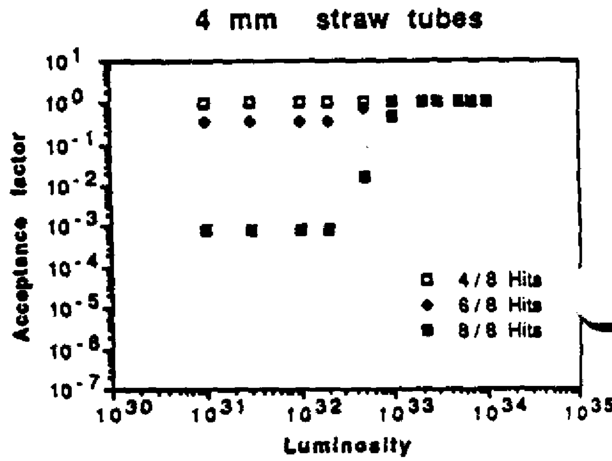

Figure 2 – Simulated acceptance for fake high p_t (> 1 GeV/c) tracks in a 4 mm straw tube tracker.

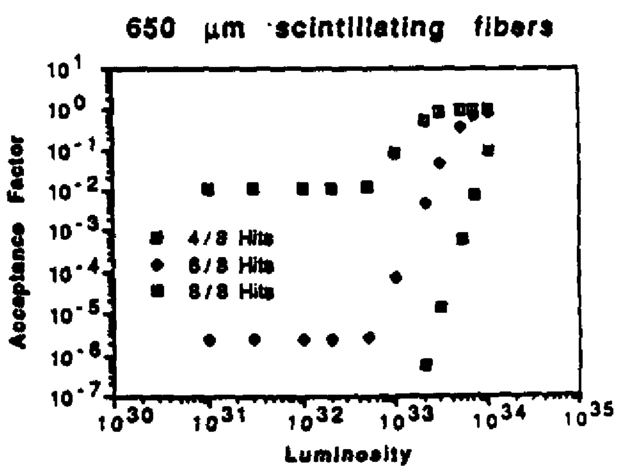

Figure 3 – Simulated acceptance for fake high p_t (> 1 GeV/c) tracks in a scintillating fiber tracker.

0.02/bunch crossing at which high p_t pions are created. By contrast, the straw tracker will yield a noise-to-signal of 15 at the same luminosity. At $10^{34}/cm^2$-sec, the fiber tracker provides a noise-to-signal of 0.5, still satisfactory as a first level trigger. At this luminosity, a straw tube tracker is clearly swamped with background.

A similar high p_t algorithm applied to the intermediate tracker results in a fake trigger rate of ~ 5/bunch crossing, at L = $10^{34}/cm^2$-sec. Smaller diameter fibers of 500 microns are desirable, if intermediate tracking information is to be used at an early stage of the trigger logic.

C. High p_t Resolution

The p_t resolution of the central tracker is important both at the trigger level, and in extracting physics at a later stage of analysis. The resolution is studied by simulating the effects of fiber granularity, efficiency, finite target size, delta rays, and pileup. At the trigger level, information about the vertex is ignored. The p_t resolution expected, assuming that the beam crossing is within a 1000 micron radius of the nominal beam centerline, is 60% r.m.s. at p_t = 1 TeV/c. However, the vertex can be defined more accurately at a later stage of the analysis by using more complete information. The p_t resolution versus p_t shown in Figure 4 is calculated assuming that the vertex is known within 20 microns. In this case, the p_t resolution is 25% r.m.s. at 1 TeV/c.

D. Neutrons in the Central Tracker

Neutrons from hadronic interactions in nearby calorimeters produce hits in the fiber tracker from np scattering. The neutrons have typically 1 MeV energies, whereas a 3 MeV proton will range out in a fiber radius of 250 microns. Thus neutrons produce hits in single fibers which can be rejected in the electronics.

At a luminosity of $10^{34}/cm^2$-sec, neutron hits are expected at a rate of about 76 per monolayer of 15,000 fibers, at a radius of 160 cm. Neutron hits within 1 fiber diameter in any two of the 4 layers of fibers will occur at a rate of 2.7/proton bunch crossing. This rate is small compared with about 200 hits from pions and electrons.

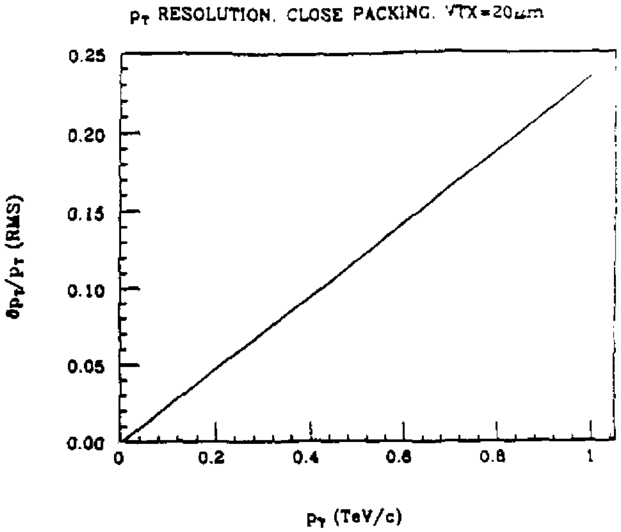

Figure 4 - Simulated momentum resolution versus p_t with a 20 μm vertex constraint imposed.

E. Conclusions

Background rates due to pileup faking a high p_t trigger are used as a criterion for evaluating the performance of a central tracker design. At a luminosity of $10^{33}/cm^2$-sec, background rates with 650 micron fibers are small compared with the production of pions with p_t > 10 GeV/c. At a luminosity of 10^{34}, the fiber tracker is still able to cope with all conceivable backgrounds. However, a 4 mm straw tube tracker starts to have serious difficulties (noise/signal = 15) with background at $10^{33}/cm^2$-sec, and at $10^{34}/cm^2$-sec is overwhelmed with backgrounds.

[1] H. Bengtsson and T. Sjöstrand, "The Lund Monte Carlo for Jet Fragmentation and e^+e^- Physics - JETSET Version 6.3 - An Update," Comp. Phys. Commun. 43, 367 (1987).