Optical Fiber Experimentation for the Electromagnetic Calorimeter Design

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October 24, 2004

1 Overview

Current particle colliders cannot reach the high energy necessary to test theories of high energy Supersymmetry (SUSY). The Next Linear Collider (NLC) will be able to reach these energies and help test supersymmetric theories. Our group at the University of Colorado is working on the design of an electromagnetic calorimeter to measure the energies of photons and charged particles created in the high energy collisions of the NLC. To do this, we must carry out various simulations and eventually decide upon the best detector design.

2 Motivation

The calorimeter we are currently designing will have several million scintillator tiles of area 5x5 cm. Each tile will have an optical fiber embedded within it to absorb light emitted inside the scintillator by particles from the high energy collisions inside the collider (See Figure 1). The optical fiber will be laid in circles

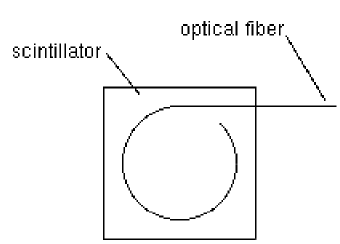

Figure 1: Diagram of scintillator tile and optical fiber

of 2 cm radius. We are trying to determine whether or not this will result in any light loss from photons escaping the light-guide because of the small radius of curvature. By comparing the amount of light transmitted through an optical fiber laid in circles of different radii, we will be able to determine if and how much light is lost in each case.

3 Optical fiber setup

Four circular grooves of different radii (2 cm, 4 cm, 6 cm, 8 cm) were cut about 0.3 cm into the surface of a plastic plate of dimensions 28x28x1 cm. An optical fiber 80 cm in length was placed into the 8 cm radius groove with one end facing a green LED and the other end directed into a phototube (Electron Tubes type 9814B). Light pulses emitted from the LED were coupled into the fiber and the amount of light transmitted through the fiber was measured by the phototube. Both the phototube and the diode were covered in black tape to ensure that light only entered the phototube from the end of the optical fiber and not from the diode directly. The diode was pulsed at a rate of 10 Hz for approximately one hour and was then turned off while the optical fiber was set into another radius. The experiment was repeated for the 6 cm, 4 cm, and 2 cm radii. This order was used to prevent possible cracks from affecting measurements taken at the smaller radii.

4 Electronics setup

The diode was driven at a rate of 10 Hz by a pulse generator (BNC Pulse Generator Model 8010); the pulse width was set to 1 ms, and the pulse height to 800 mV with a bias voltage of 300 mV. This was achieved by means of a variable attenuator (Radio Shack 15-678 RF Attenuator) and the 1.5 V output of the pulse generator.

The phototube was powered by a high voltage DC power source (Power Designs Inc., Model 1570B) at 1800 V. The signal from the phototube was split in half by a signal splitter (Mini-Circuits Splitter ZFRSC-2050). The two split signals were connected to two independent inputs of a National Instruments digitizer (National Instruments PXI-5122 Digitizer). The digitizer sampled each pulse every 10 ns. One of the signals was sent through a wire 5 ns longer than the other. By delaying one of the signals by 5 ns we were able to double the temporal resolution of the digitizer to 5 ns. The digitized signal from the phototube was then analyzed by the same LabView digital pulse height analyzer that was used for the Electromagnetic Calorimeter Studies[1]. Each pulse from the phototube was integrated over 80 data points (equivalent to 400 ns).

[1] hep-www.colorado.edu/SUSY/grpwk_meas.html

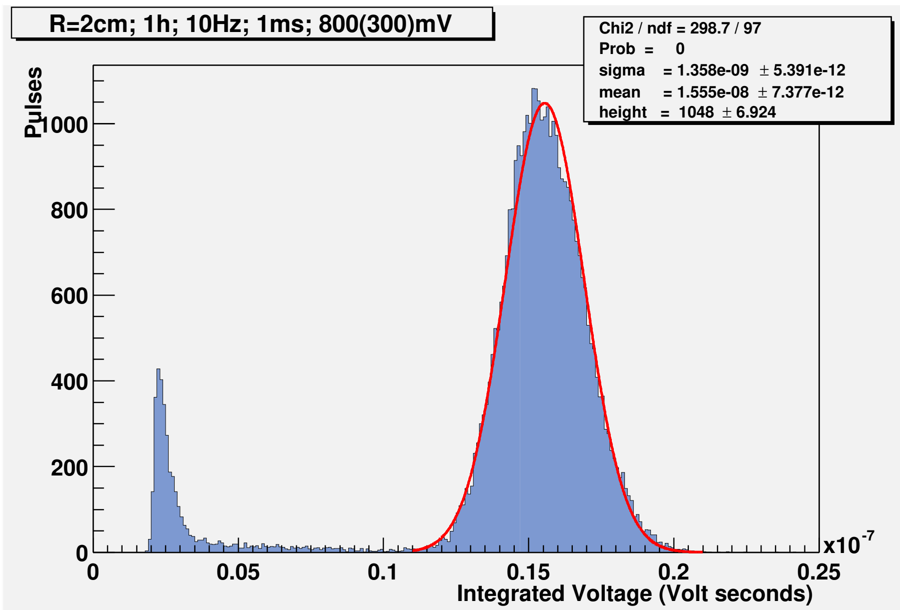

Figure 2: Histogram of integrated pulses at the 2 cm radius

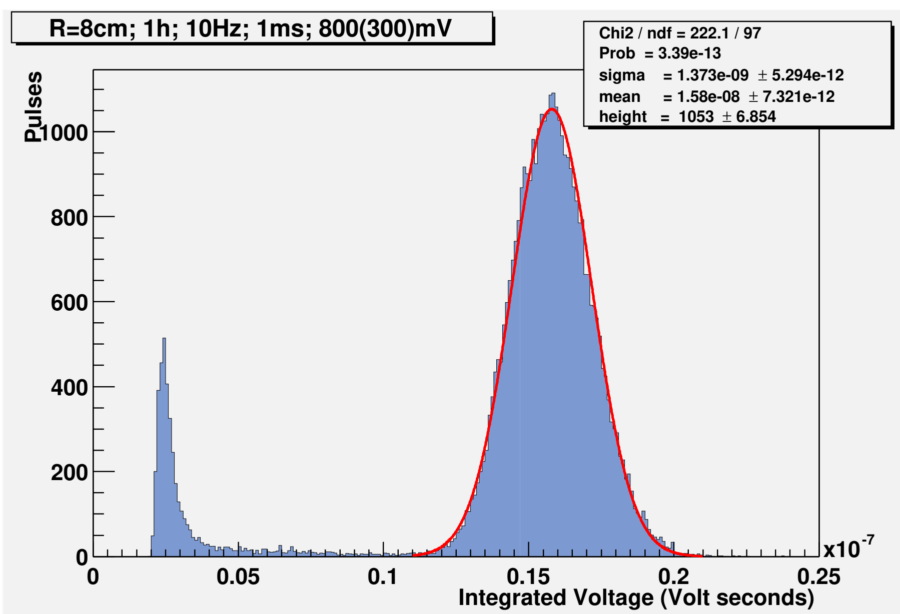

Figure 3: Histogram of integrated pulses at the 8 cm radius

Radius in cm	8	6	4	2
Mean integrated voltage in $10^{-8} Vs$	1.58	1.55	1.53	1.56

Table 1: Center of a Gaussian fit to the integrated voltage for different fiber radii

5 Analysis

The integrated pulse-heights of all of the pulses for a given radius were plotted on a histogram (number of pulses vs. integrated pulse-height). See Figures 2 and 3 for histograms of the 2 cm radius and 8 cm radius, respectively. A gaussian fit was used to find the mean integrated voltage for each radius. The mean values for each radius were constant (see Table 1), within the error margin of the experiment. The varying amount of light coupled into the fiber from the diode was considered the greatest source of error in this experiment. We therefore concluded that there was no significant light loss between a radius of 2 cm and a radius of 8 cm.