Measurement of signal delay and attenuation in clear fiber

B.Satyanarayana,
Department of High Energy Physics,
Tata Institute of Fundamental Research,
Mumbai, INDIA, 400005

March 9, 2001

Abstract

Signal delay and attenuation in Kuraray clear fiber of type PSMS-35J and 0.94mm in diameter were measured. A brief description of the measurement technique and results were presented.

1 Introduction

Outer Hadron detector modules of CMS experiment are made up of plastic scintillator tiles, wave length shifting(WLS) and clear fibers. The light produced by the scintillator tiles is trapped by the WLS fibers which are embedded into the tiles. The wave length shifted light is transported to the photo devices located far away by clear fibers which are spliced to the WLS fibers. While typically the WLS fibers used are smaller in lengths compared to clear fibers, variations in the lengths of latter on a given module are large.

In order to estimate the relative arrival times of the signals at the front-end electronics, from the detector modules located at different geographical locations in the detector, we need to the know the signal delay in the clear fiber. Similarly, attenuation length of the clear fiber is an useful parameter in estimating the quality of various fiber assemblies of the detector modules.

2 Measurement setup

Fabrication details of the detector module which is used in this measurement setup is shown in Fig. 1. A typical scintillator tile of Outer Hadron detector design and of dimensions 350mm X 310mm is used. This tile had four σ-shaped grooves. Four Kuraray clear fibers of the type PSMS-35J, 0.94mm in diameter and five meters in length were spliced to WLS fibers of appropriate lengths corresponding to the groove lengths on the tile. The non-spliced ends of the WLS fibers were mirrored with aluminium coating.

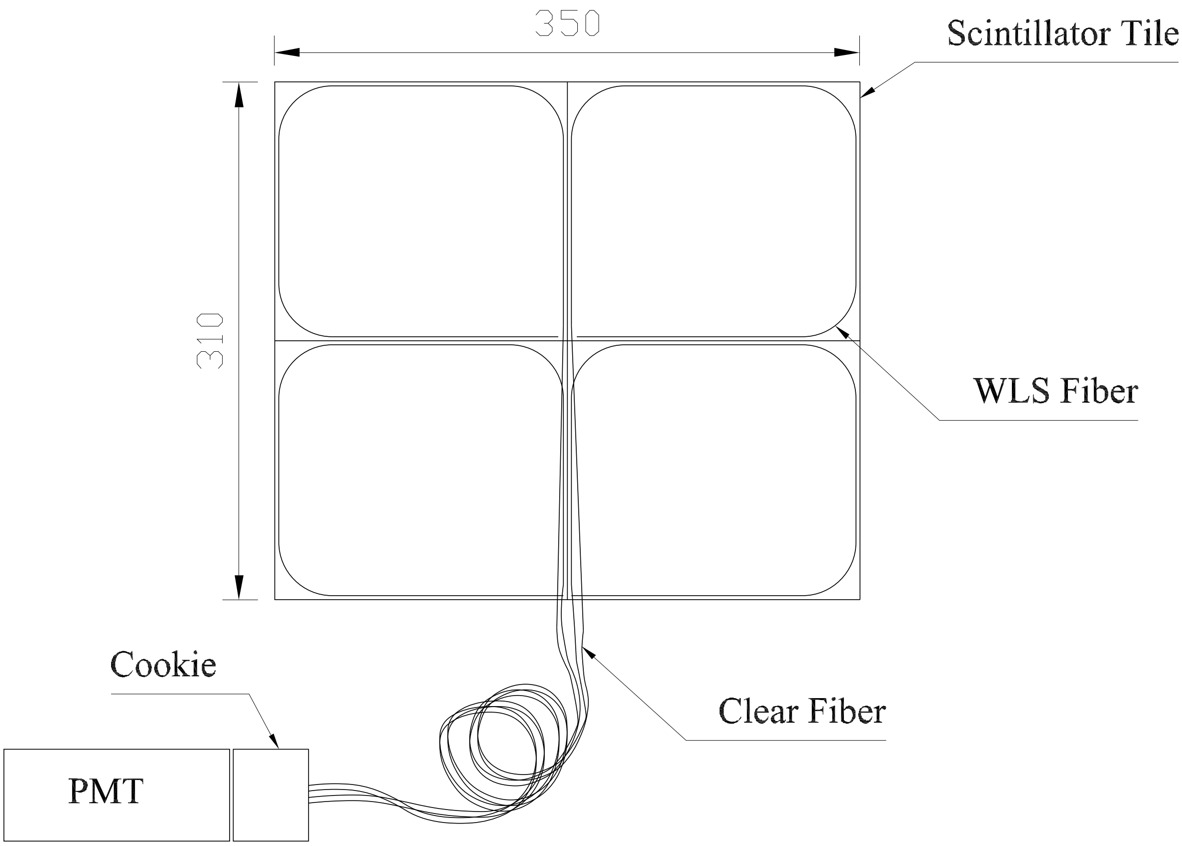

Figure 1: Schematic of light readout

While the WLS portions of the composite fibers were inserted into the grooves, the clear fiber ends were inserted into an acrylic cylinder(*cookie*) and glued to it. The outer face of the cookie was diamond polished along with the glued fibers inside it. The tile was wrapped with one layer of Tyvek and Tedler sheet each.

A calibrated EMI made photomultiplier was attached to the cookie and operated at its nominal high voltage of positive polarity.

3 Data acquisition

Three, well calibrated scintillator based paddles, geographically aligned with the measurement tile are used for generating a Cosmic Ray muon trigger. A trigger was generated on 3-fold coindence of signals from the paddles. Signal from the test tile was fed into a FIFO unit, two output copies of which were fed into a Lecroy CAMAC charge ADC module as well as into a discriminator. The discrimator NIM logic output signal is used as individual stop signal to a LeCroy CAMAC TDC module. The trigger signal after appropriate pulse shaping and fanout is used as the ADC gate as well as common start for the TDC modules. Charge and timing data is recorded on trigger. About 30,000 events were recorded in each run.

After each run, the clear fibers from the cookie end were cut by 100cm in length, glued, polished again. Five runs were taken with different lengths of the clear fibers.

4 Results and conclusions

Charge and timing distributions are similar in shape for all five runs. The distributions obtained from the run with clear fiber length of 400cm are shown in Fig. 2.

Fig. 3 shows the plot of the fit peak values of the timing distributions obtained with different clear fiber lengths, fitted with a straight line. We obtain from the above plot, a signal delay of 6.2$\pm$0.1 nSec per meter of clear fiber.

Fig. 4 shows the plot of the fit peak values of the charge distributions obtained with different clear fiber lengths, fitted with an exponential function. We obtain from the above plot, a signal attenuation length of 912$\pm$14 cm.

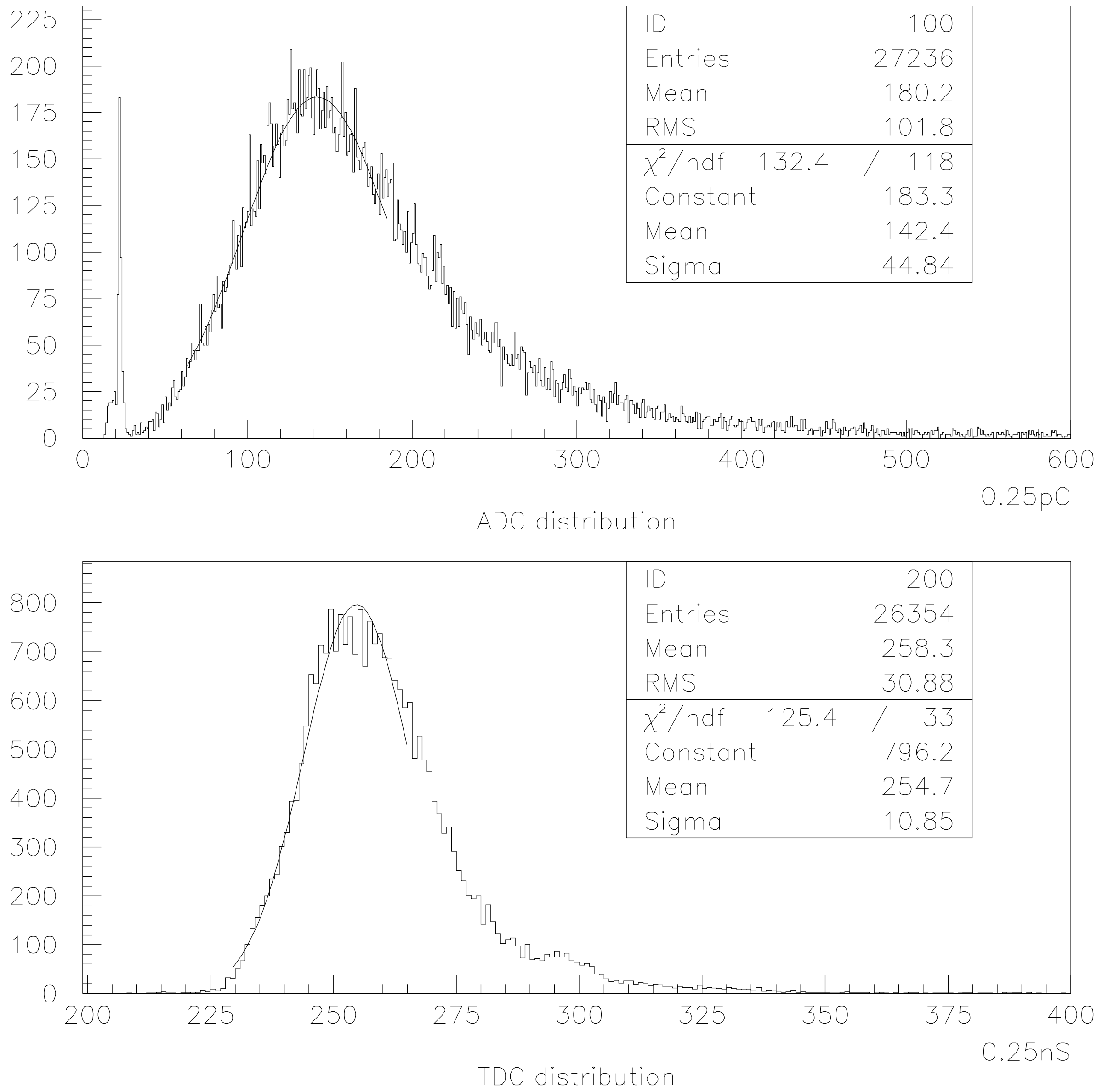

Figure 2: Typical charge and timing distributions

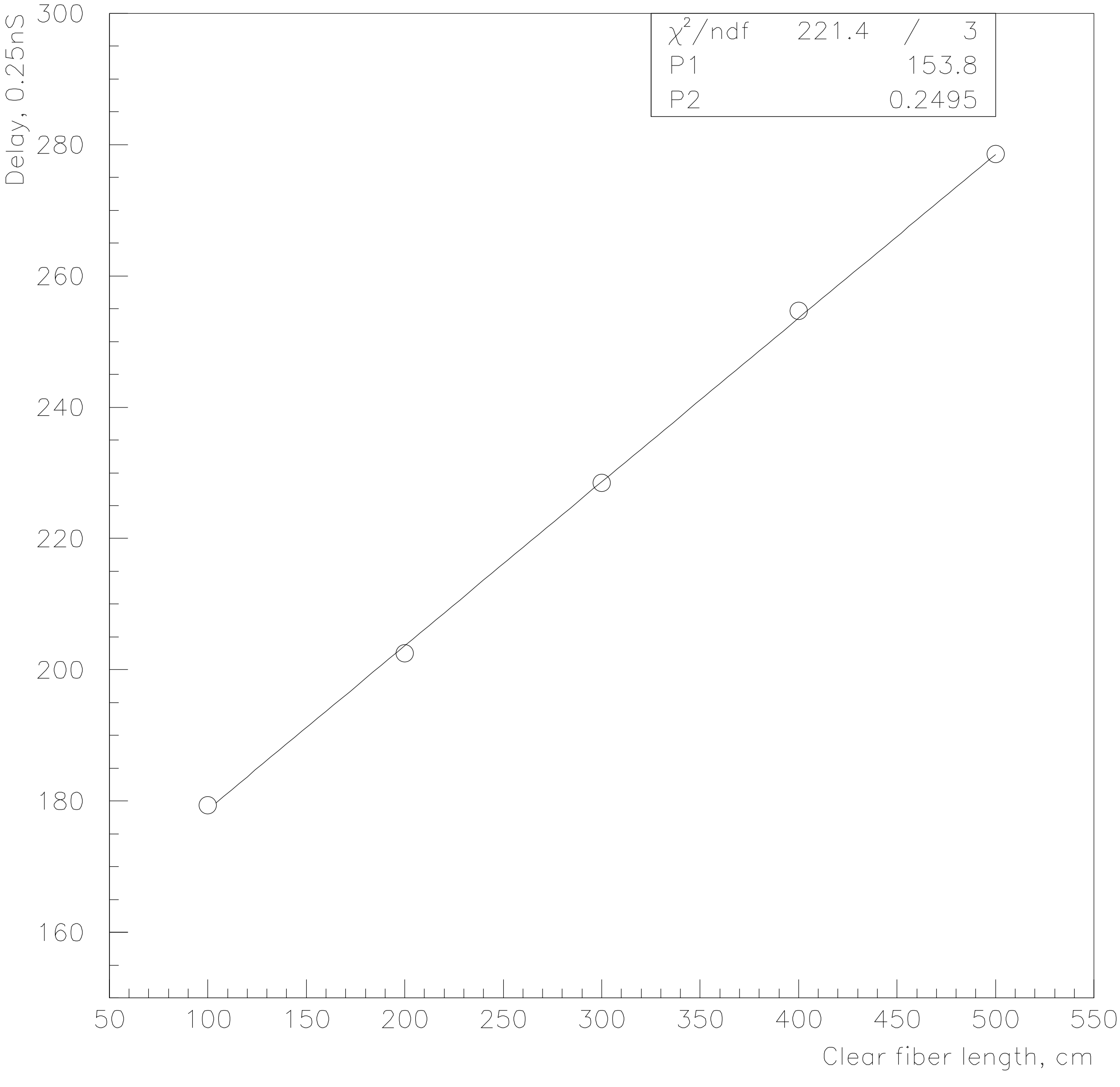

Figure 3: Relative delay of signal in clear fiber

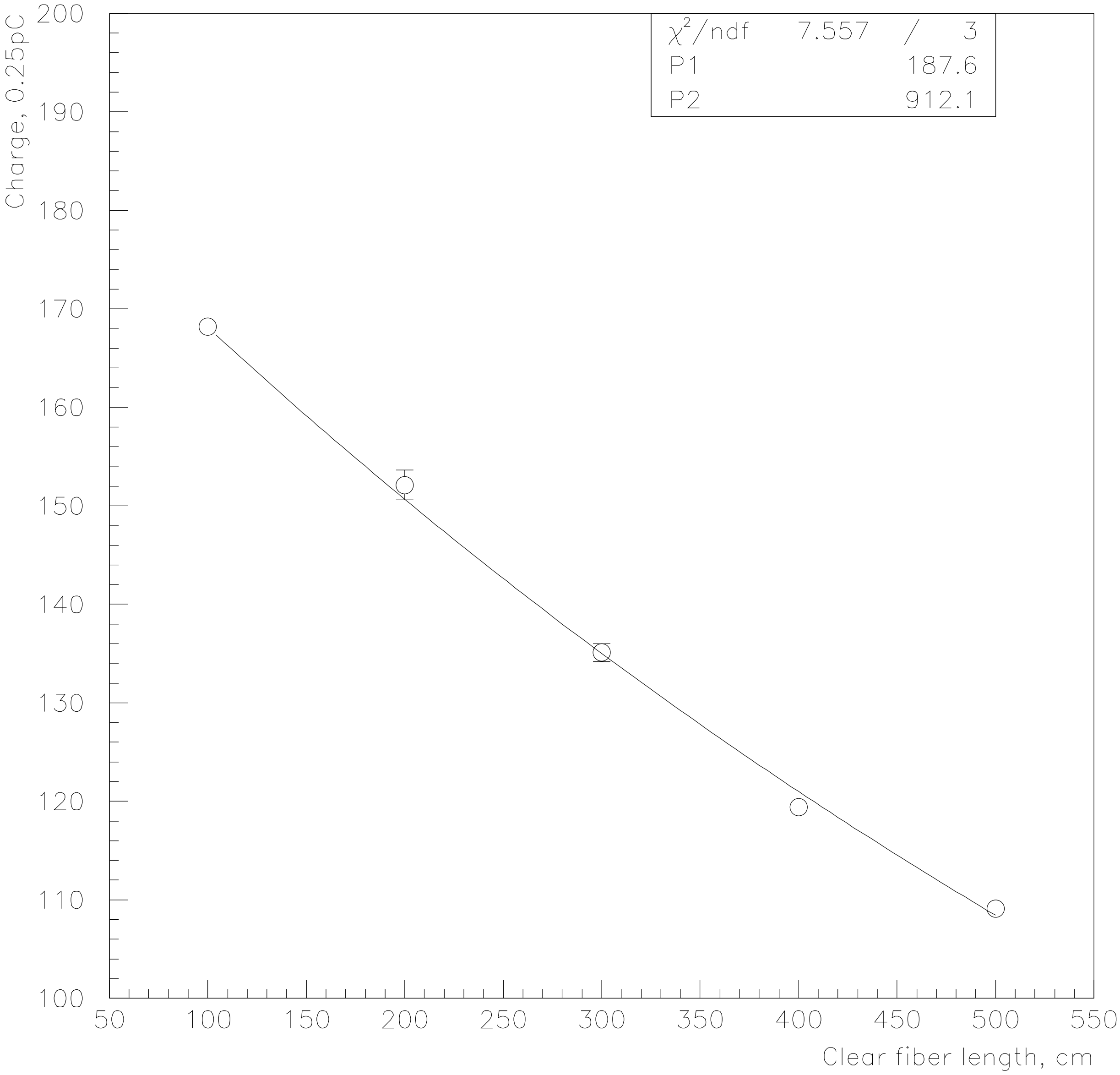

Figure 4: Attenuation of signal in clear fiber