8. Electromagnetic Calorimeter

The purpose of the electromagnetic calorimeter (EMCAL) is to aid in the identification of electromagnetic energy coming from ν_e interactions or from electrons produced in τ decays. The energy measured in the calorimeter is also used in determining the total energy of a neutrino interaction.

The EMCAL is a wall comprising 400 elements of lead glass and scintillating glass instrumented with photomultiplier tubes. Its dimensions, as seen from the beam view, are 375 cm × 195 cm. The central region is made of SCG-1 scintillating glass blocks, while the outer regions are made of SF5 lead glass blocks. The parameters of the blocks are given in Table 1.

Glass	# Blocks	Dimensions (cm)	Location	Depth (em)	Depth (nucl)	Phototube
SCG1-C	100	7.5 × 7.5 × 89	Center	20.9	2.0	RCA 6342A
SCG1-C	74	15 × 15 × 89	Intermediate	20.9	2.0	EMI 9791KB
SF5	224	15 × 15 × 41.5	Outer	16.8	1.0	EMI 9791KB

Table 1 Parameters of the glass blocks used in construction of the EMCAL. The columns Depth columns list the depth of the blocks along the beam direction in radiation lengths (em) and nuclear absorption lengths (nucl).

The smallest blocks, which are of scintillating glass, are placed in the central region of the wall. They are surrounded by larger scintillating glass blocks and finally by lead glass.

A schematic diagram of the EMCAL system is shown in Figure 1. A pair of Lecroy 1440 high voltage power supplies provided power for the photomultiplier tubes. The voltage on each tube was adjustable through a pentium PC computer connected to the system through a serial RS-232 line. The anode signals from the PMTs were connected via RG8U cables to a passive splitter, where a fraction of each signal was used as an input to a calorimter trigger system. Most of the signal (80%) was delayed by 450 ns and read by LeCroy 2280 ADCs. The RG8U served to minimize signal loss, dispersion and noise due to the long cable runs. The integrating gate widths were 260 ns for the lead glass blocks and 350 ns for the scintillating glass blocks, the difference being due to the longer decay time of the latter.

An LED system continuously monitored the performance of the EMCAL to track and correct for gain variations of the PMTs. Optical fibers of 0.3 mm diameter distributed the LED light to the surface of the blocks. The LED measurements and the pedestals were read out between spills of the proton beam. The LED system, combined with muon measurements taken during the experiment, was crucial in the calibration of the EMCAL. Studies found the stability of the pedestals to be better than 1%. The stability of the LED system was approximately 2%.

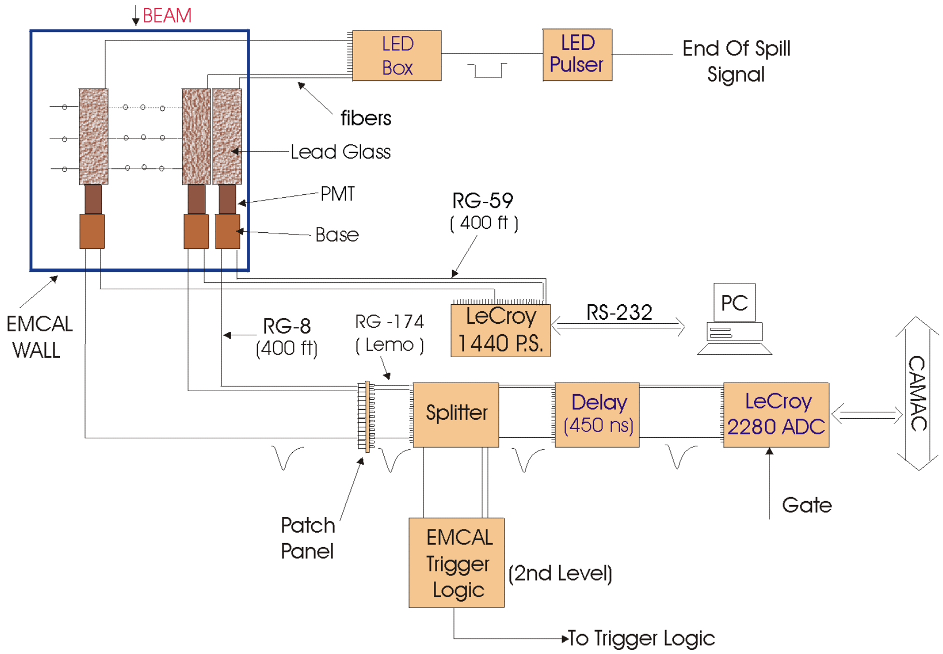
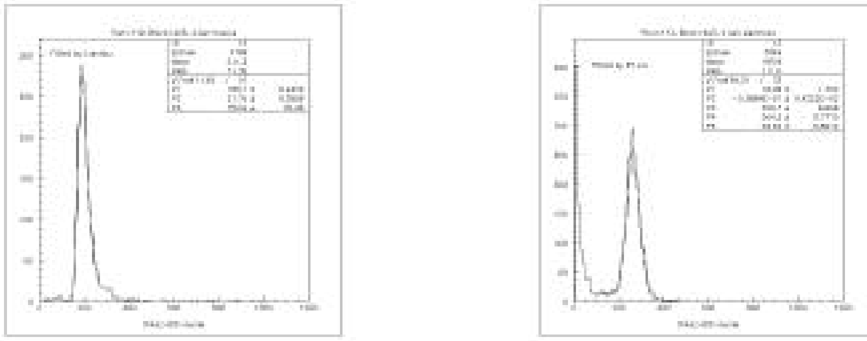


Figure 1. A schematic overview of the electromagnetic calorimeter system.

A representative sample of blocks, including all three types, was tested in a beam at Brookhaven National Laboratory before the experimental run at Fermilab. The blocks were exposed to electrons, pions and muons. The EMCAL calibration used the electron/muon response measured in the test beam. The energy resolution of the individual blocks at 1 GeV was about 6.5% for the lead glass, 7.5% for the large scintillating glass, and 12.5% for the small scintillating glass. Due to the lack of a calibration beam during the run, we expect a somewhat poorer overall energy resolution, but not worse than 20% at 1 GeV. Typical muon and electron energy distributions are shown in Figure 2 a and b.



a) b)

Figure 2. ADC response of a xxx block to minimum-ionizing particles a) and 2 GeV electrons b) in the Brookhaven test beam.