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SOME FIBER-TILE OPTICAL STUDIES FOR SDC ELECTROMAGNETIC CALORIMETER

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ABSTRACT

A number of different issues have been studied at Argonne for development of the fiber-tile optical system for SDC EM. Results on uniformity, masking and wrapping, beveled tiles, timing, fiber damage, and pressure on the scintillator are presented. The instrumentation and techniques are also briefly discussed.

1. Tile Test Facility

The measurements of light output and uniformity of response have been done with a 3 MeV electron beam. This beam is derived from a Ru 106 source and a beamline of dipoles and quadrupoles. The electrons are momentum selected and focussed while flux is captured from a larger area and larger solid angle than could be obtained with a collimator. The gamma flux is attenuated by many cm of Pb, and there is no straight line path to the scintillator. With a 2 mCi source, the momentum selected flux is several hundred per second contained largely within a 1.5 mm by 6 mm spot. The combination of optics design and the particular design of the optical elements with permanent magnets is being patented.

A trigger is formed by using two scintillators in coincidence behind the tile to be tested. This trigger is used to gate an ADC and interrupt the computer for data acquisition. A 286 PC type computer is able to read in about 100 events/second through CAMAC and either do averaging or accumulate a histogram.

The tile and phototube are positioned in two dimensions in the vertical plane by a motor driven frame. The tile is restrained by thin sheets of mylar which interfere minimally with the electrons and allow placement of two tiles adjacent to each other. A mapping of 10^4 positions with 3×10^3 beam tracks at each point can be done automatically overnight. Generally maps with 50 to 100 positions on each of two or three lines are adaquate to answer basic questions of edge effects, light output, etc.

The calibration of ADC counts per photo-electron at the phototube can be easily checked by means of an LED system. If we assume that the output of each LED pulse is the same then the RMS of the pulse height distribution comes from photostatistics. The number of photoelectrons is then easily computed. This has been checked by attenuating the LED with neutral density filters and also by using a Quanticon to see individual photoelectron peaks.

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2. Measurements

Most of the tile-fiber assemblies used in recent tests are constructed in the same way as those we used in the prototype EM calorimeter as described by J. Proudfoot at this conference. This design evolved on the basis of tests of many different configurations, both at Argonne and at other institutions. We use a u shaped groove in the surface of the tile which is one fiber diameter deep, typically 1 mm. The fiber is not glued in but is held by two small pieces of tape during insertion and by the tile wrapping. In the prototype calorimeter and in many studies, both ends of the waveshifter fiber exited the tile at a wide area of the groove and were routed on the surface of the tile outside the wrapping. Splices to clear fiber were positioned over the surface of the tile also.

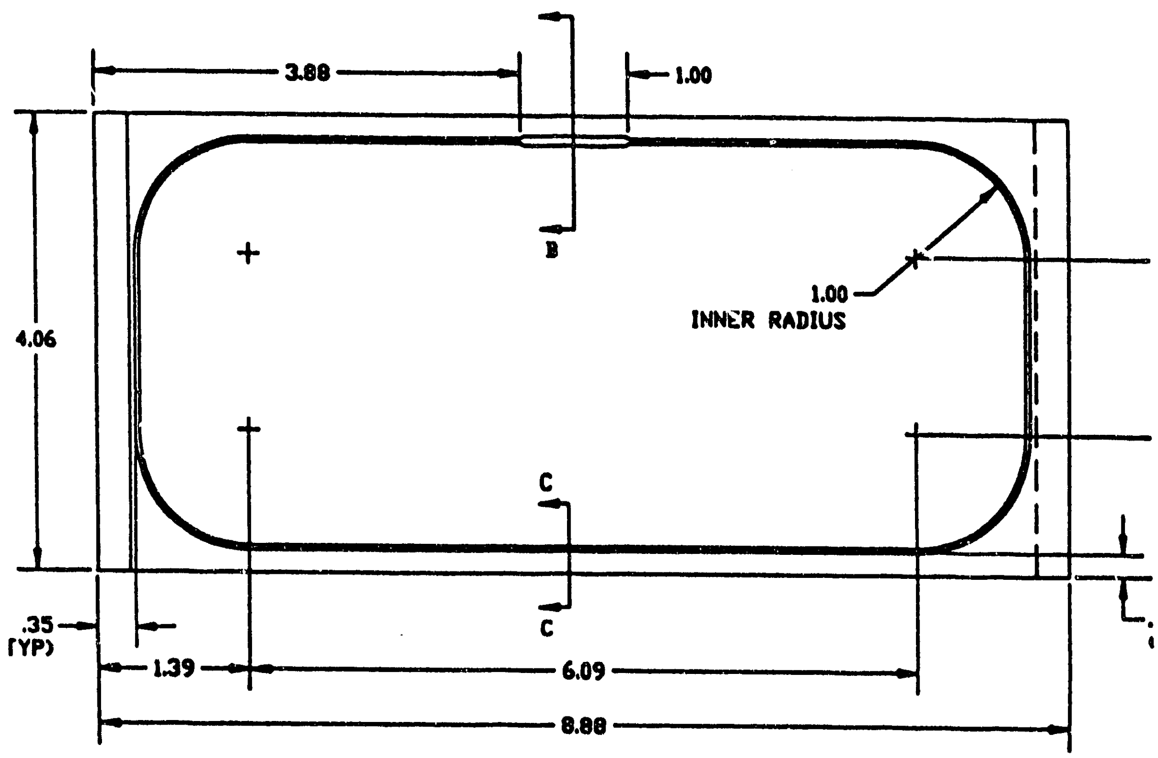

Figure 1: Configuration of a prototype high-η tile. The tile is 22.5 cm long, 10.3 cm wide and 4 mm thick. Two edges are beveled at 28 degrees to the surface. Both ends of the 1 mm diameter waveshifter come up out of the groove at the wide area of the groove, and are spliced to 1.5 m clear fibers. The tile material is a co-polymer from Bicron which has more light output than polystyrene.

The scintillator tiles at $\eta = 1.4$ in the cast lead EM calorimeter have edges which are beveled at 28 degrees to the plane of the tile in order to match tower boundaries, Fig 1. There was some interest in the influence of this sharply beveled edge on light collection near the edge of the tile and also on overall light collection. With the waveshifter fiber in a loop near the edge of the tile, no loss in overall light output was observed compared to an unbeveled tile. The light from the beveled part is roughly proportional to thickness of scintillator. This is resolved well since the bevel is 7.5 mm for a 4 mm thick tile and the beam rms is about 1 mm with multiple scattering Fig. 2. A map with two tiles with overlapping bevels is shown in Fig. 3. Several features are observed. The light output in the region of the bevel is about 15% higher than from the unbeveled region. This may be a light collection effect, due to either the angle or the surface treatment of the edge with a diamond fly cutter. It is known that in waveshifter bars there is a "hot spot" near acute angles and a "cold spot" near obtuse angles which can be simulated in Monte-Carlo. In this map one can also see increased output where the beam crossed one fiber diagonally and two fibers simultaneously.

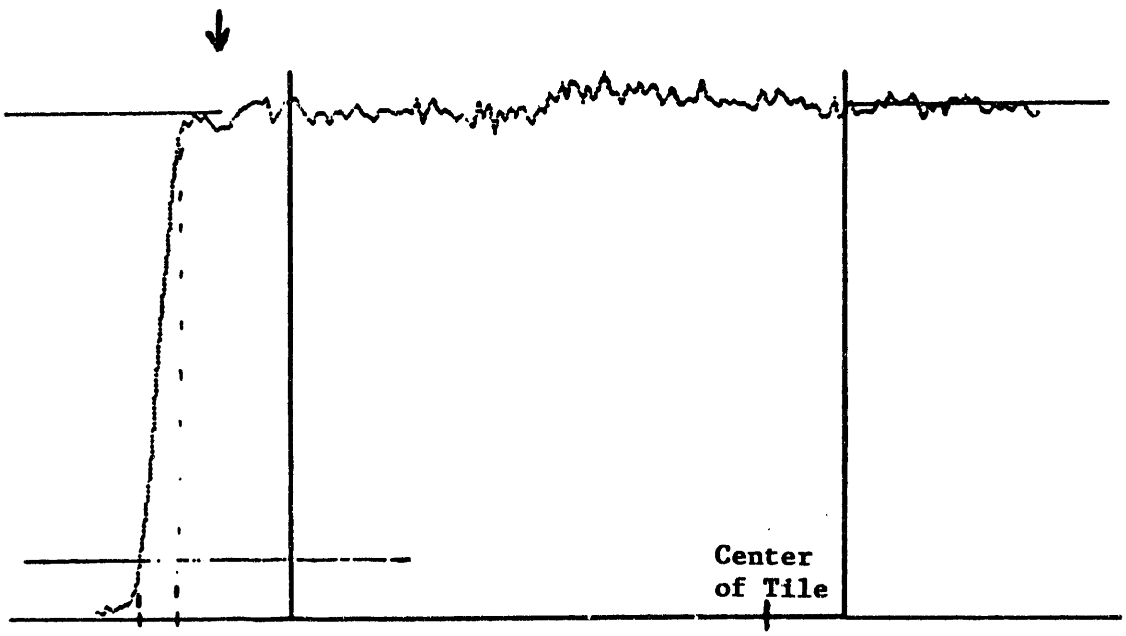

Figure 2: Response map of the prototype tile along a line 13 mm from a long edge. Aluminized mylar wrap was used with no masking. The ramp-up at the edge is approximately consistent with the light output being proportional to scintillator thickness. A 2% slow variation could be from variations in tile thickness. A 2% rapid variation is due to beam statistics with the resolution from four photoelectrons/mip.

When a prototype calorimeter was in the test beam, some gating studies were done which showed that as much as 40 ns might be required to collect all the signal. Some of the possible factors in that environment were dispersion in cables, dispersion in fibers, waveshifter decay time, and light collection time in the tile. To try to isolate some of the factors, we compared two cases that differed only in the scintillator configuration. For one case, a small scintillator, about 1.5 cm square, was drilled so that the waveshifter fiber could pass through it and the scintillator was wrapped in black. The oscilliscope trace from this case has a 1/e decay time of less than 10 ns, consistent with the waveshifter decay time. The trace from a 10 cm tile with highly reflective wrapping and two ends of the fiber to the phototube has a decay time of almost 20 ns. As shown by others, the signal can be shortened by clipping.

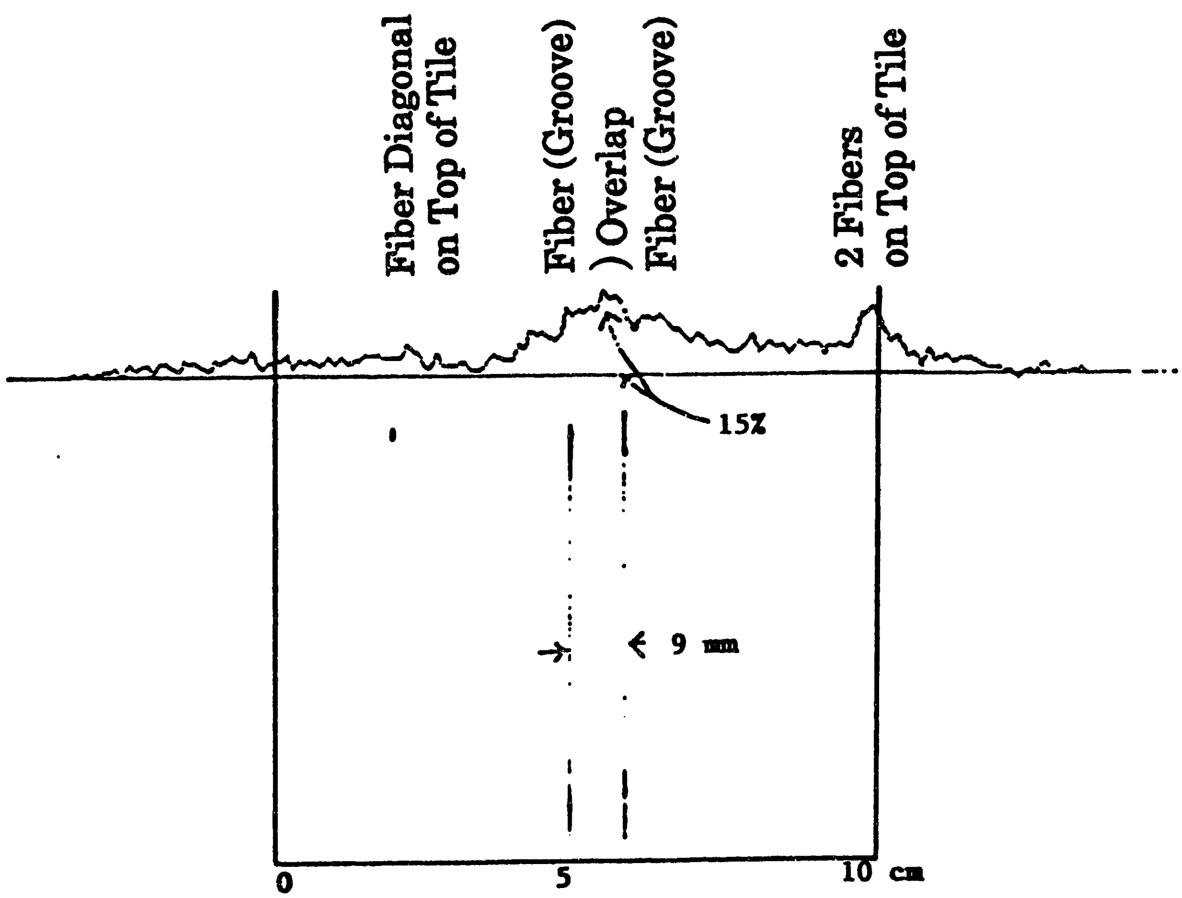

Figure 3: Response map of the overlap area of two beveled tiles. The tiles are individually wrapped in 25 micron aluminized mylar. One can see 15% increase in light output in the beveled area. The shifter fibers in the two tiles are about 9 mm apart. Increases can also be seen where the beam went through one or two waveshifter fibers which were routed on top of the tile.

We have done some studies of the light output of scintillator under pressure and the survival of scintillator under pressure. Two stacks of alternative metal plates and scintillator were constructed. The scintillator is read out by two waveshifter plates on each stack, each with its own phototube. Either one of the two stacks can be compressed hydraulically and held at a known pressure for long periods of time. A pulsed nitrogen laser is used to generate UV light which is injected into the scintillator layers. The light is injected about 1 cm in from the edge by means of quartz fiber optics which pass through the metal plates at an angle. In a typical measurement cycle we compressed the plates to 100 psi (8 kg/cm^2) for a few days and then released the pressure for one hour to look for permanent changes in light output. With 6 mm thick polystyrene scintillator the loss under pressure while compressed went as $(1.05-.0081)\,e^{PSI/50}$. This is about 5%

loss at 100 psi. A 3 mm co-polymer scintillator showed about twice the loss. These effects disappeared when the pressure was released. There was no measurable long-term degradation over two months during which we had a laser. There was no observable crazing over six months. It is suspected that the effecs are due to optical "wetting" of the surface by the wrapping, which was high fiber content white tying paper. A simple model did not reproduce the exponential loss of light.

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3. Reference

D. Underwood, D. Morgan and J. Proudfoot, *Fiber-Tile Optical Studies at Argonne*, SDC-91-00052 (1991).

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