A Scintillating-Fiber and Tungsten Calorimeter for E-774

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One aspect of Fermilab's efforts to develop state-of-the-art detectors is the Particle Detector Group (PDG) within the Research Division. The PDG is working in a number of R&D areas including the development of dopants for polystyrene fibers which may produce very radiation-hard scintillators that have good light output and short decay times. But this research work has present applications and has been used to develop a scintillating-fiber and tungsten calorimeter that will soon be part of the apparatus for experiment 774 which is located in the new Wide Band Photon Beamline.

Pictured is the calorimeter (left) and the actual fiber ribbon (right).

(Fermilab photograph 87-790-1)

The new scintillating-fiber and tungsten calorimeter were developed by PDG member Alan Bross. The calorimeter is very dense and uses newly developed doped polystyrene fiber ribbons as an active medium. The calorimeter is a 10 cm cubed stack of 3 mm-thick tungsten plates interspersed with 200-micron-sq scintillator fibers formed into ribbons. The sampling fraction of active medium
to absorber is very low (about 5/10 of 1%) in this device in order to keep the calorimeter as short as possible and thus yield the highest sensitivity to short-lived particles. This is possible because the light fibers provide a high-quality light piping capability. Also, the use of "ribbon fibers" has a distinct advantage over other scintillating structures, namely scintillator "sheets." If one used a 200-micron scintillator sheet rather than ribbons composed of 200-micron-sq fibers, the sheet would cause tremendous losses in transmitting light from one end of the sheet to the other. The fiber ribbons are quite uniform, yielding a more uniform response.

Experiment 774 uses the new scintillating-fiber tungsten calorimeter as an active beam-dump calorimeter. The experiment places the calorimeter in a 400-GeV electron beam with the beam entering the calorimeter perpendicular to the plates from the left. As the beam interacts in the tungsten calorimeter plates, the scintillator fibers are excited by the secondaries of the electron shower and the resultant light is emitted up in the fiber direction and detected by an array of 3/4-in. phototubes.

The goal of E-774 is to search for light, neutral, short-lived particles that couple to the electron. Interest in the existence of such objects has recently been stimulated by the anomalous electron-positron pair production seen in heavy ion collisions at the GSI. These coincident electron-positron pairs occur with approximately equal lab energies, consistent with the production and subsequent decay of a neutral particle of mass 1.8 MeV/c. While the simplest models for this particle seem to be excluded by recent experiments, its existence has not yet been conclusively ruled out, and the debate over the 1.8-MeV particle has focused attention on a region of mass/lifetime where similar objects may exist and yet would not have been seen.

Although the main purpose of the Particle Detector Group is to develop state-of-the-art detector designs in anticipation of the next generation of multi-TeV colliders and fixed-target experiments, it is important to note that these technologies have applications in currently running experiments.