**ABSTRACT**

Our goal this year was to restore four scintillators we received from the Fermilab NuTeV experiment. We tested PMTs to check to make sure they functioned properly and to pair them to be placed on the scintillators. Once we paired them we did light leak testing on the panels, then testing with a Cs-137 source to determine what voltage would be optimal to run each PMT at. After we tested the scintillators to determine if they were detecting muons efficiently. Once all the testing concluded we could finally run experiments with our restored scintillators! We ran two different experiments to detect muon showers: one with three paddles set up in a semi straight line, the other with all four paddles set up in a quardilateral.

---

**PMT TESTING**

To ensure the reliability of the Hamamatsu PMTs, we tested them to see how sensitive they are to light, and how much noise they produce with no light source, known as dark current. Placing the PMT in a darkbox and placing an LED in front of it, we tested to see how much current was produced both when the light was turned on and when it was turned off at different voltages ranging form 1 kV to 1.5 kV. To measure the extremely low currents we used a picoamperimeter, which read the currents and gave the average of 100 sample currents on a computer using the ExcelLinx program. By taking the ratio of these two numbers, we can create a signal/noise ratio which tells us the efficiency of the PMT. The higher the ratio, the better. We also tested the PMTs with a special encasing called Mu Metal. The Mu Metal is a protective shield that blocks out most of the outside magnetic fields that may cause fluctuations that would otherwise be unaccounted for. After placing the PMTs on the scintillators, and encasing it in the Mu Metal shield, we had to ground the Mu Metal. To do this, we soldered a copper wire to the base of the PMT and then connected it to the shield using a screw. Using all of the collecting data, we paired 4 sets of PMTs to use to put on the scintillators.

---

**EFFICIENCY TESTING**

We tested the efficiency of the large scintillators by placing two small paddles on a large panel in different places and ran a coincidence run to see how many muons each was detecting. We compared how many muons the large panel (P) was detecting to the amount of muons the two small paddles (p) were detecting together using this formula: Efficiency = P/(p+p) x 100%. We had to adjust the voltage on that was going into some of the PMTs to increase the efficiency of the large panels. We also did this, like the Gamma Testing to verify that the PMTs were well matched and the panels were scintillating correctly.

---

**SILICONE COOKIES**

A transparent silicone elastomer was used as a mechanical shock absorber and optical pathway from the scintillator to the PMT. We built a successful mold, used Dow Corning SYLGARD 184 and a vacuum chamber (to remove bubbles), and created a sheet of silicone we could punch into 1½ inch diameter cookies. Cookies were tested in both a spectograph test and in our black box prior to placement in all PMT connections.

---

**WHY DID WE DO ALL THIS??**

Our main purpose for analyzing these panels was to create a profile for each panel and how it performs. This is because these panels will be used at Fermilab in 2007 and it is necessary to know if the panels are functioning properly. Another reason we did this was to run coincidence testing of our own. We set up four panels in a straight line and ran coincidence runs. If a muon goes through all three/four panels within 1000ns we can assume it was a muon “shower” and came from the same primary particle (Cosmic Ray).