# NuTeV Scintillator Restoration Overview 2005


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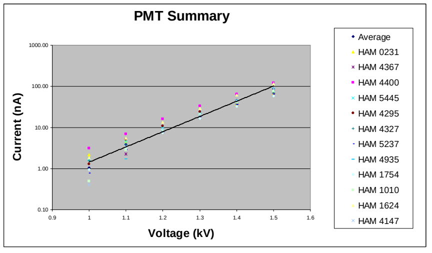
## ABSTRACT

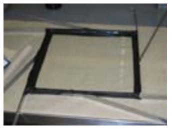
Our goal this year was to restore four scintillators we received from the Fermilab NuTeV experiment. We tested PMTs to check to make sure they functioned properly and to pair them to be placed on the scintillators. Once we paired them we did light leak testing on the panels, then testing with a Cs-137 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 quadrilateral.


## 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 picoammeter, 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 fluxuations 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.




## SILICONE COOKIES

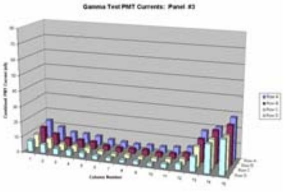



A transparent silicone elastomer was used as a mechanical shock absorber and optical pathway from the scintillator to the PMT.
We built a successful mold, used Dow Corning SYLGARD 184 and a vacuum chamber (to remove bubbles), and created a sheet of silicone we could punch into 1¾ inch diameter cookies. Cookies were tested in both a spectrograph test and in our black box prior to placement in all PMT connections.

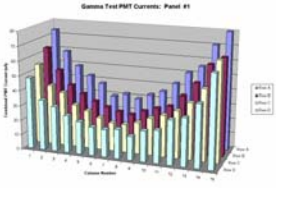

## GAMMA TESTING

To ensure that all of the scintillators function properly and that there are no dead spots on the scintillators, we tested each 20 by 20 centimeter area of the scintillators. Using Cesium-137 as the gamma source, we moved it across the grid, taking measurements of the current at each location, and we also took a background current at regulated intervals to check to see that the dark currents were not drifting. After completing the testing we found that each of the four scintillators were functioning properly. This testing also allows us to find the optimal voltage at which to run the PMTs. Symmetry also played a part in this testing because if one of the PMTs had a much higher reading that its partner, then the voltage must be changed accordingly to ensure that the readings were as accurate as possible. This process created some problems after the efficiency testing, because although at certain voltages there was symmetry in the system, the efficiency at those voltages were very low, thus creating the problem of whether to sacrifice efficiency for symmetry, or vice versa.

Low Response




High Response




## 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.

| PANEL # | 4 |
|---|---|

| | | |
|---|---|---|
| LEFT TUBE # | 4327 |
| VOLTAGE | 1550v |

| | |
|---|---|
| RIGHT TUBE # | 5327 |
| VOLTAGE | 1600v |

efficiencies

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | | | | | | | | | | | | | 98% | |
| B | | | 95% | | | | | 85% | | | | | | | |
| C | | | | | 82% | | | | | | 86% | | | | 97% |
| D | 96% | | | | | | | | | | | | | | |

DATA

| position | 1,2 | 1,2,3 |
|---|---|---|
| D 1 | 25 | 605 |
| A/B 3 | 33 | 595 |
| C 5 | 105 | 475 |
| B 8 | 96 | 561 |
| C 11 | 88 | 549 |
| A/B 14 | 14 | 616 |
| C 14/15 | 18 | 636 |

## 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 rectangle and three 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).

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