Design of Light Pipe for an Active Target in the Blowfish Detector Array

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1 Introduction

This report outlines the development of a light pipe for an active target in the Blowfish array at the High Energy Gamma Source at Duke University. The light pipe is designed to transport photons generated by a scintillating target to a photomultiplier tube located outside of the array for detection. No final results were obtained, but several prototype light pipes were constructed of varying lengths. The effectiveness of their design will be tested using LUCID software to determine the attenuation per unit length that these tubes possess.

2 Requirements

The light pipe's purpose is to transport light from a scintillating target to a photomultiplier tube located outside of the Blowfish array. The tube needs to be positioned around the path of the beamline, to preserve Blowfish's cylindrical symmetry about the beamline. A bend is then needed in the pipe after it is outside of the sphere of detectors, so that the photomultiplier tube is not in the path of the beamline. A thin mirror surface is needed at the joint of the pipe: the blue scintillation photons will be redirected to the photomultiplier tube while the high energy beamline photons will pass right through the mirror.

The diameter of the pipe was chosen to be approximately 2.5", which is larger than the beamline diameter while keeping the pipe as narrow as possible. Aluminized mylar was selected for the reflecting material due to its thinness, which will minimize its impact on any particles passing through the tube to reach a Blowfish detector. The support material used to form the tube was selected to be the thin black plastic used to cover paddle detectors, due to its thinness and flexibility.

3 Construction

The primary challenge in creating the light pipe was to attach the mylar to the supporting plastic while keeping the mylar as smooth as possible (i.e. no wrinkles). Several methods were attempted:

- Epoxy was used by spreading it out on the plastic and laying the mylar in place on top. This did not work well, as the epoxy was thick and caused the mylar to develop bubbles. As well, the epoxy did not appear to bond well to the mylar, and it was thought that this method would not prove durable enough for long term use.

- An aerosol spray glue was used for the actual prototype tube. It had the benifits of easy application, reasonably uniform coverage, and created an extremely thin layer. The strength of the bond was reasonable, and the mylar showed no signs of peeling even two weeks after application.

To attach the mylar to the plastic, the plastic was cleaned and laid flat, and a thin layer of spray glue was applied over an entire (21”x40”) sheet. The mylar came in a roll approximately four feet wide, and was heavy enough to act as a rolling pin to avoid wrinkles in the mylar. The mylar roll was unrolled over the plastic, with care taken to keep the mylar sheet taut and smooth. Once the mylar was applied, a soft rubber strip was wiped over the mylar to force air bubbles to the edges of the sheet. The glue was allowed to set overnight, and the excess mylar was then trimmed off.

Once the mylar was bonded to the sheet, the sheet was cut into strips about 10” wide and as long as was needed for each tube segment. The strips were flipped over so the mylar was down, and glue was applied to the first 3” or so of the strip along its entire length. The strip was then rolled so that no glue was showing on the outside of the roll. A wide strip of black electrical tape was run along the visible seam to hold the tube together, and the glue was allowed to set overnight.

Three tube segments were produced in this way, measuring 12”, 36”, and 48”.

4 Remaining Work

The prototype tubes have been constructed, but it still remains to test them using a scintillator and a photomultiplier tube to measure their effectiveness quantitatively. This could be done using the LUCID data acquisition software and the equipment in room 74.3 of the laboratory here in the physics building at the U of S. The software was prepared for this task already by Darren Chabot, but time constraints prevented any trials from being run before the end of the summer work term.

The software can measure the attenuation of the light pipes by observing how the channel numbers of a source’s features vary with tube length. As more photons are lost in transit along the light pipe, the pulse produced by the photomultiplier tube will shrink accordingly and the feature will move to smaller channel numbers. By taking ratios of channel numbers between different lengths of light pipe, it will be possible to quantify the amount of light lost and decide whether these light pipes are experimentally viable.

A recommended way to measure this relative attenuation is to choose a fixed voltage for the PMT, and attach it directly to the scintillator. A small air gap should be left between the two optical surfaces, to account for the losses that will always be present due to the air/glass boundaries. A trial should be performed with this setup using a source with a well-defined feature, such as a Compton edge. Next, one of the light pipes should be inserted between the scintillator and the PMT and the trial should be repeated, taking care not to change the PMT voltage. Further trials should alternate between direct connections and intermediate light pipes, so that each trial involving a light pipe is bracketed by two trials that do not.

Execution of these trials should not be time-intensive, as long as a sufficiently active source is used to provide a feature.