Painting and Packaging Scintillator Tiles for the STAR Forward Upgrade

Madison Meador of Abilene Christian University for STAR Collaboration

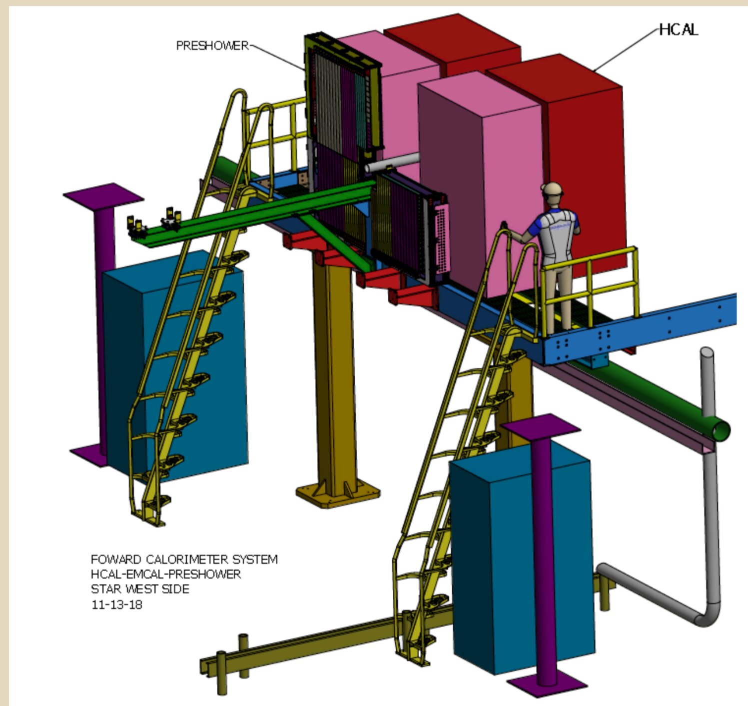
Abilene Christian University

www.acu.edu

The STAR experiment at the Relativistic Heavy Ion Collider, Brookhaven National Laboratory

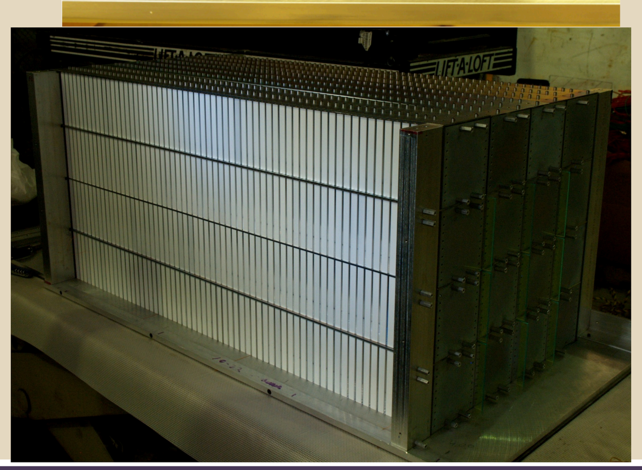
STAR Forward Upgrade

Since 2000, the Solenoidal Tracker at RHIC (STAR) at BNL has pioneered the investigation of the complex structure of nucleons through high energy collisions of polarized proton beams. STAR has begun constructing the Forward Upgrade, which will enable charged-particle tracking and calorimetry measurements at very close proximity to the beam line ($2.5<\eta<4$).



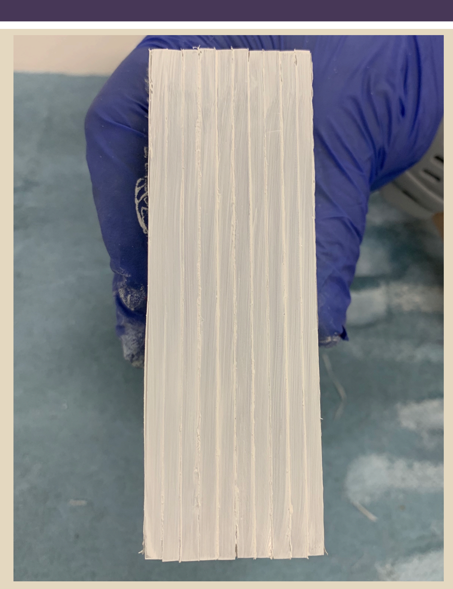
Hadron Calorimeter

Abilene Christian University's contribution to the Forward Upgrade includes machining, polishing, and painting 7,200 of the 18,000 scintillator tiles needed to construct the Hadron Calorimeter. A painting process was developed to accommodate the specific requirements of the calorimeter, and to validate the procedure, the wavelength of light absorbed by the scintillator tile was measured as a function of paint thickness.



Painting Scintillator Tiles

Improvements made to the scintillator painting process include trimming the tiles in stacks rather than as individual tiles, and using a separate room for Painting and packaging. These adjustments not only maximized tile production, but also optimized our facilities and equipment.

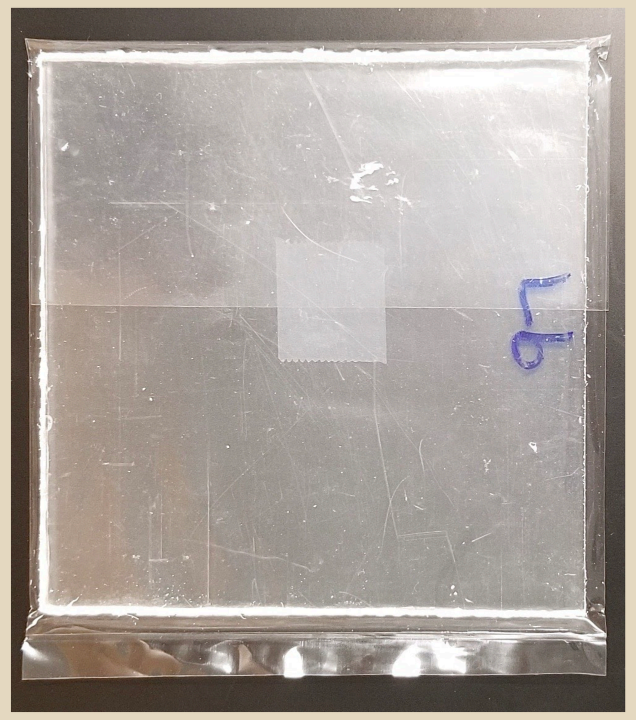


Thin two-coat layer

Thick two-coat layer

The most significant improvement involved adjusting the number of applied coats. We found that switching from three thin coats to two slightly thicker coats saves us at least eight hours in the tile manufacturing process. To ensure that reducing the number of coats does not decrease the effectiveness of the paint, this decision was supported by further experimentation explained in another section.

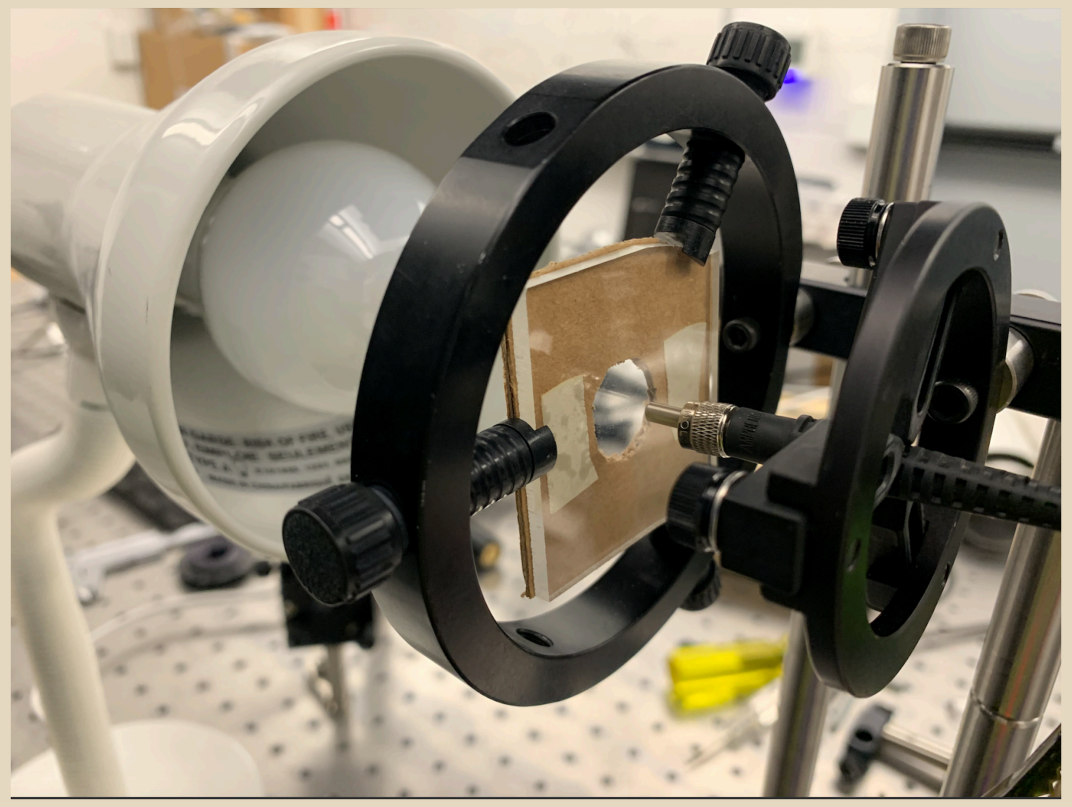
Packaging Scintillator Tiles



Adjustments were also made to the packaging method, such as wiping the polished edge before splitting the stacks, removing the plastic film before packaging, and using distilled water to neutralize the electrical charge created by peeling off the film. We found that a clearer, cleaner product was produced when these adjustments were set in place.

Spectrometer Testing

To validate the decision to move from three coats of paint to two, an experiment was set up to measure the wavelength of light absorbed by the scintillator in order to analyze and plot the data as a function of paint thickness. A lamp containing an incandescent bulb was placed on one side of the tile, with an HRS-BD1-025 Mightex spectrometer with a wavelength range of 300-1,070nm measuring the output of light on the other side.



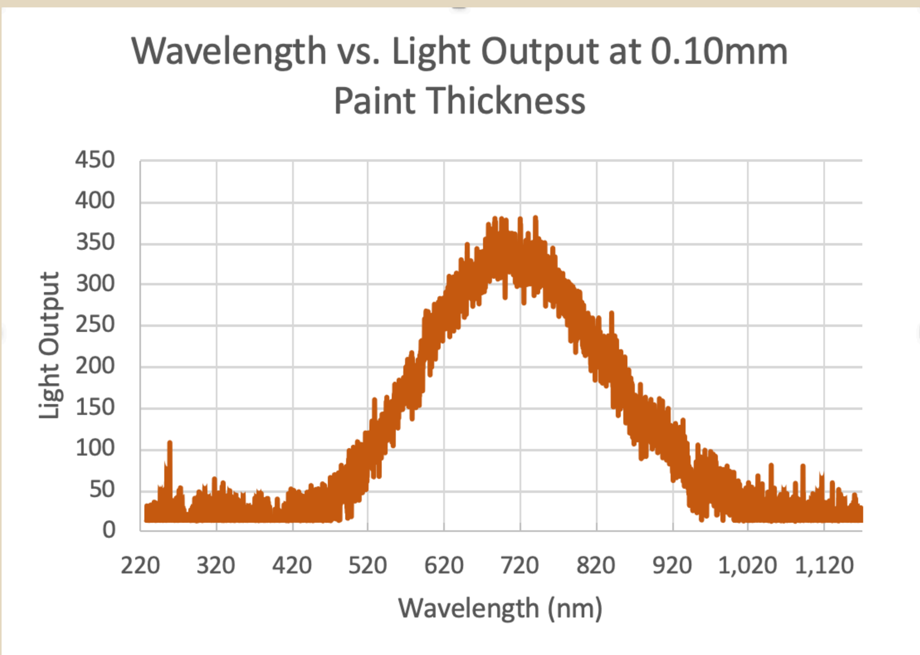
Optical lens mounts were used to hold the tile and optic fiber in place, and a cardboard cutout was attached to the tile to isolate the output of light to the center of the tile. All lights were turned off, and three runs of data were taken for each measured thickness of paint. Control data was also taken with no tile in place, giving the maximum light output possible.

Data Analysis

$$\frac{loss_{paint}}{control\ output} = 1 - \frac{output}{control\ output} - \frac{loss_{tile}}{control\ output}$$

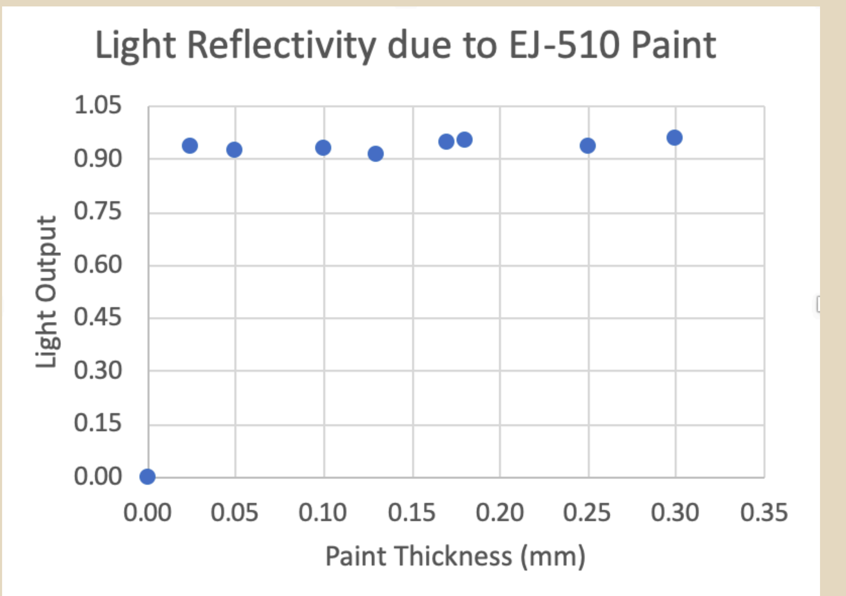
Equation for percentage of light output loss due to paint (graphed in results section)

- The measured light output at each wavelength was summed to obtain the total light output. This was done for all 3 runs taken for each thickness, such as this run shows.
- The sums for the three runs were averaged, giving a total light output for each paint thickness.
- Each average was then compared to the control output using the above equation to find a percent loss of light output due to the paint.



Results/Conclusion

The data show an increase in reflectivity of 94% from 0.00mm to 0.025mm thickness. Each applied coat in our optimized painting process measured approximately 0.10mm, which means that nearly all reflectivity is achieved within the first coat. Between two and three coats, there is only 1% increase in light reflectivity. The difference between painting two coats and three coats with the optimized painting procedure is therefore negligible.



Acknowledgements

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Brookhaven National Laboratory

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