Coatings for the Antineutrino Detectors

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We plan to coat the inside of the antineutrino detectors with a black "paint" such that the PMTs only detect light directly from the antineutrino interaction in the liquid scintillator. This improves the position resolution of the positron interaction and of the neutron capture, at some expense in energy resolution. Here, we draw attention to a high quality black coating, Avian S. We also consider an ultrawhite coating, Avian D, from the same manufacturer, that would be suitable for coating the exterior of the antineutrino detectors to improve the performance of the muon water-Čerenkov system.

1 Black Coating of the Interior of the $\overline{\nu}$ Detector

The Avian S black coating[1] is perhaps the blackest black available in the form of a paint.[2] Its reflectivity is less than 3.5% over the entire near-UV and visible spectrum.

The Avian S coating costs about \$300/gallon, or about \$50/m^2 of coated surface. Each $\overline{\nu}$ detector has a surface area of about 120 m^2, so the cost of an Avian S black coating would be about \$6k per detector.

2 White Coating of the Exterior of the $\overline{\nu}$ Detector

The present baseline design is for no coating on the exterior of the stainless steel $\overline{\nu}$ detectors.

The reflectivity of (stainless) steel is about 60%, if its surface is not special prepared for good optical performance, as shown in the figure on the top of the next page.

We estimate the effect of this relatively low reflectivity on the performance of the muon water-Čerenkov system as follows. The surface area of a 2-detector pool is about 720 m^2. The total surface area of the pool plus 2 $\overline{\nu}$ detectors is about 940 m^2. The 40% absorption of light on the exterior surface of the antineutrino detectors corresponds to an effective loss of $0.4 \times 240 = 96$ m^2 or about 10% of the light that could reflect off the surfaces of the water-Čerenkov system.

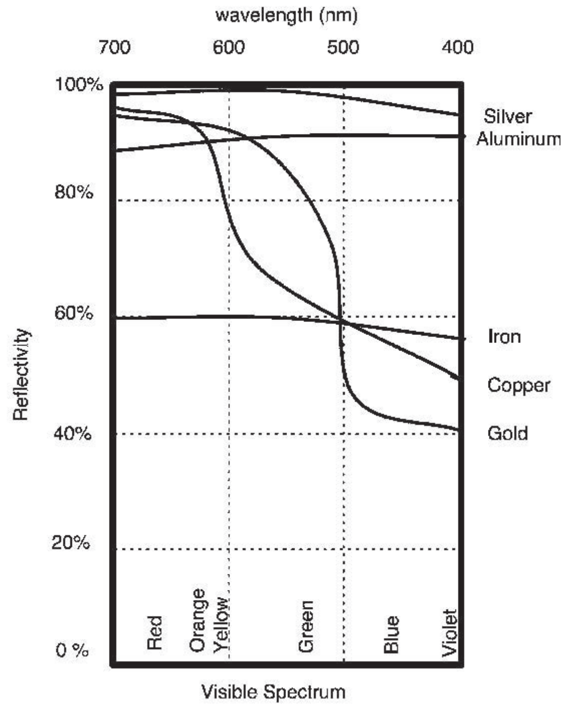
This lost light could be recovered by painting the exterior of the $\overline{\nu}$ detectors with a water-compatible white paint with high reflectivity in the near UV. The best candidate paint of which I am aware is the Avian D paint,[3] whose reflectivity is shown in the lower figure on the next page. It would also cost about \$6k per detector to coat it surface with this paint.

[1] http://www.aviantechnologies.com/products/coatings/diffuse_black.html

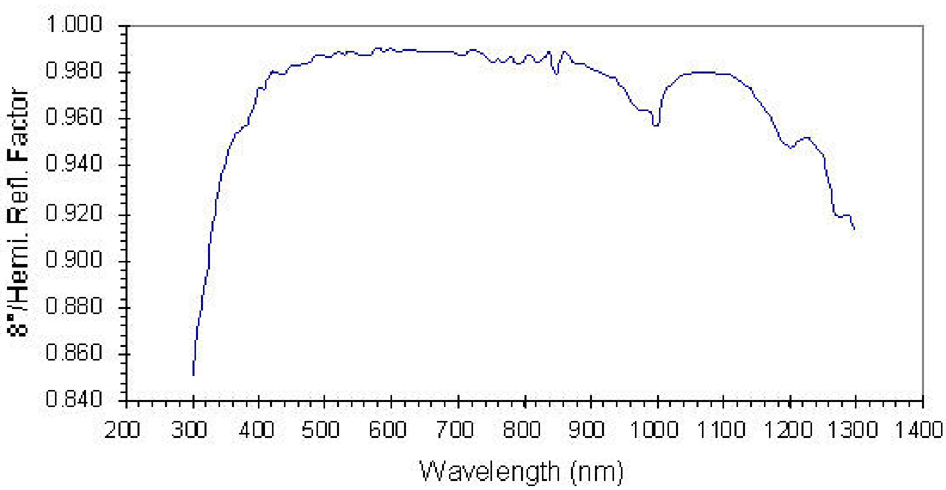
[2] Lower-reflectivity non-paint options include inexpensive black flocked paper from Edmund Scientifics, http://scientificsonline.com/product.asp_Q_pn_E_3060068
and Vel-Black G100C-M2 sheets from ESLI, http://www.esli.com/downloads/VelBlack_G100C_M2.pdf
For a review, see, K. Snail *et al.*, *Optical Characterization of Black Appliques*, SPIE **2864**, 465 (1996), http://kirkmcd.princeton.edu/examples/optics/snail_spie_2864_465_96.pdf

[3] http://www.aviantechnologies.com/products/coatings/highreflectance.html#d

Hence, for about \$12k per water pool, we could increase the useful light be about 10%. In exchange, we could reduce the number of PMTs by 10% keeping the performance of the water-Čerenkov system the same. If the pool needed, say, 200 PMTs in the absence of coating the $\overline{\nu}$ detectors, we could reduce the number of PMTs by 20 when using a coating. Each PMT, base and electronics costs about \$1.5k, so the savings would be about \$18k per pair of $\overline{\nu}$ detectors.



This is only a modest savings, so we might prefer to keep the number of PMTs the same, and improve the system performance at the relatively minor expense of coating the exterior of the $\overline{\nu}$ detectors.



A greater cost benefit to the use of a white coating on the exterior of the $\overline{\nu}$ detectors would obtain if we were to build them out of lower-cost, low-carbon steel rather than stainless steel. I estimate the cost savings of this option to be \$200-300k per $\overline{\nu}$ detector. But in this case, the exterior of the $\overline{\nu}$ detectors would need to be coated to suppress rust. A high-reflectivity coating would then become extremely cost effective.