Ray-tracing simulation of light propagation in MoNA neutron slats

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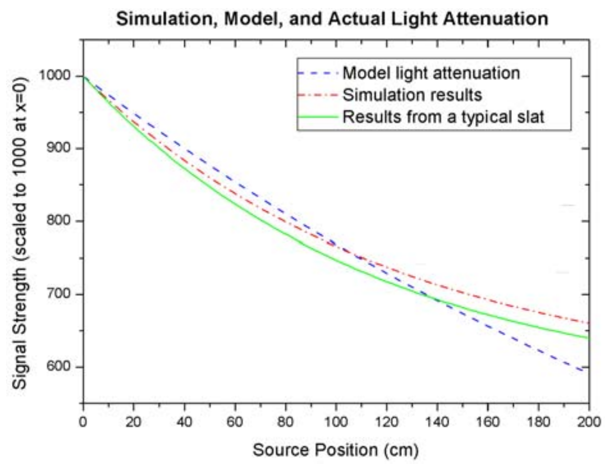
After testing attenuation on Hope College's sixteen MoNA neutron slats, it was noticed that the data did not fit the exponential decay model of light attenuation. For all sixteen slats, the testing produced data that was too curved to fit the model. In an attempt to understand these results, a ray-tracing simulation of the slats was created using simple light propagation models. The results of this simulation do reproduce this unexpected behavior quite well. Thus it can be reasonably concluded that the unexpected results are attributed to simple optical effects occurring within the slats.



Upon starting the simulation it asks for a few parameters. One of these is the x-position of source photons. This specifies where the photons start on the length of the bar. The y-position and z-position on the two 10cm sides are generated randomly for each photon. After finding initial position, the photons are given an initial velocity vector chosen randomly in 4π. The photon path is traced until it hits one of the surfaces of the slat or light pipes. If the photon is incident at an angle greater than the critical angle, total internal reflection occurs, and the photon continues traveling in a new direction (angle of incidence = angle of reflection). Even if the photon does not undergo total internal reflection, it may be reflected by the white coating on the slats. One of the parameters of the simulation is the "reflection fraction." This tells us what percent of these photons are reflected. If, by chance, it is reflected, it goes back into the bar having a new velocity vector chosen in the 2π of 4π which is into the bar rather than out (assuming a diffuse reflection surface). Finally, when a photon happens to hit one of the simulated photomultiplier windows, the ray trace for this photon is done. Also important is that the path length through the slat is recorded as the photon travels, and when it "gets" to the photomultiplier there is a chance that it actually didn't make it there because it was attenuated somewhere along its path. The chance that it is still good is given by $e^{-(\text{path length})/(\text{attenuation length})}$. A random number is generated to decide if the photon is good or if it has already been attenuated. If it is good, the event is counted. This loop is repeated for a specified number of photons, and the total number of good events is summed and displayed.

To reproduce the data observed in the slats, the program had to be run a number of times, varying parameters. The final parameters were an attenuation length of 380cm, and a reflection fraction of 0.7 or 70%. The attenuation length for BC-408 on Bicron's website was 210cm, but other references gave it at 380cm, and the simulation only worked well with the 380cm. The data on Bicron's website may well be wrong. The reflection fraction of 0.7 specifies what percent of photons are reflected when they exit the slat and hit the white reflective coating. Overall, the simulation explains the phenomena and helps us understand the slats in general.