# Eye Shielding of Electron Beams with U.S. Based Currency

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## INTRODUCTION

Eye shields are used clinically to limit dose to the lens and eye when treating superficial lesions on the face using 6 or 9 MeV electrons. Eye shields are typically made of tungsten for a small form factor with an Al shield to attenuate backscatter to the eye lid. Eye shields may not be available in all clinics, require sterilization, may interfere with a mask and/or bolus and are uncomfortable for the patient. We investigated the use of U.S. currency as a widely available alternative to an eye shield or lead sheets, which reduces the need for sterilization, not as toxic as lead, and matches the dimensions necessary for blocking the eye.

## AIMS

Electron Eye Shields are ideal for protecting the eye from low energy electrons. This work investigated the attenuation properties of U.S. currency as a widely available alternative to using the electron eye shields or lead, as coins are primarily made of copper with consistent construction, and how it compares to what is currently being used in the clinic. Additionally, we are also investigated higher energies than those typically used with clinical eye shields.

## METHODS

Stacks of U.S. Currency of different types (penny, nickel, quarter and dollar) were placed on the Sun Nuclear IC PROFILER in an “L” arrangement such that each stack of coin attenuates the beam along a different profile. The profiler was irradiated with each available electron energy and the same number of monitor units at 100 cm SSD with a 15x15 electron cone. The number of coins in the stack were increased to determine the optimal thickness (number of coins) needed to sufficiently attenuate the beam. Additionally, lead cut into 25 mm diameter circles with a 1 mm thickness were also measured, along with three different sizes of the actual clinical tungsten eye shields (small, medium and large) (Radiation Products Design, Albertville, MN).

Measurements of the coins were repeated using drilled solid water and a PTW Advanced Markus Parallel Plate Ionization chamber (active diameter 5 mm) for each available electron energy at 100 cm SSD with the same 15x15 electron cone for comparison. The ionization chamber was covered only by its plastic protection cap, which has a water equivalent window thickness of 1.06 mm.

## RESULTS

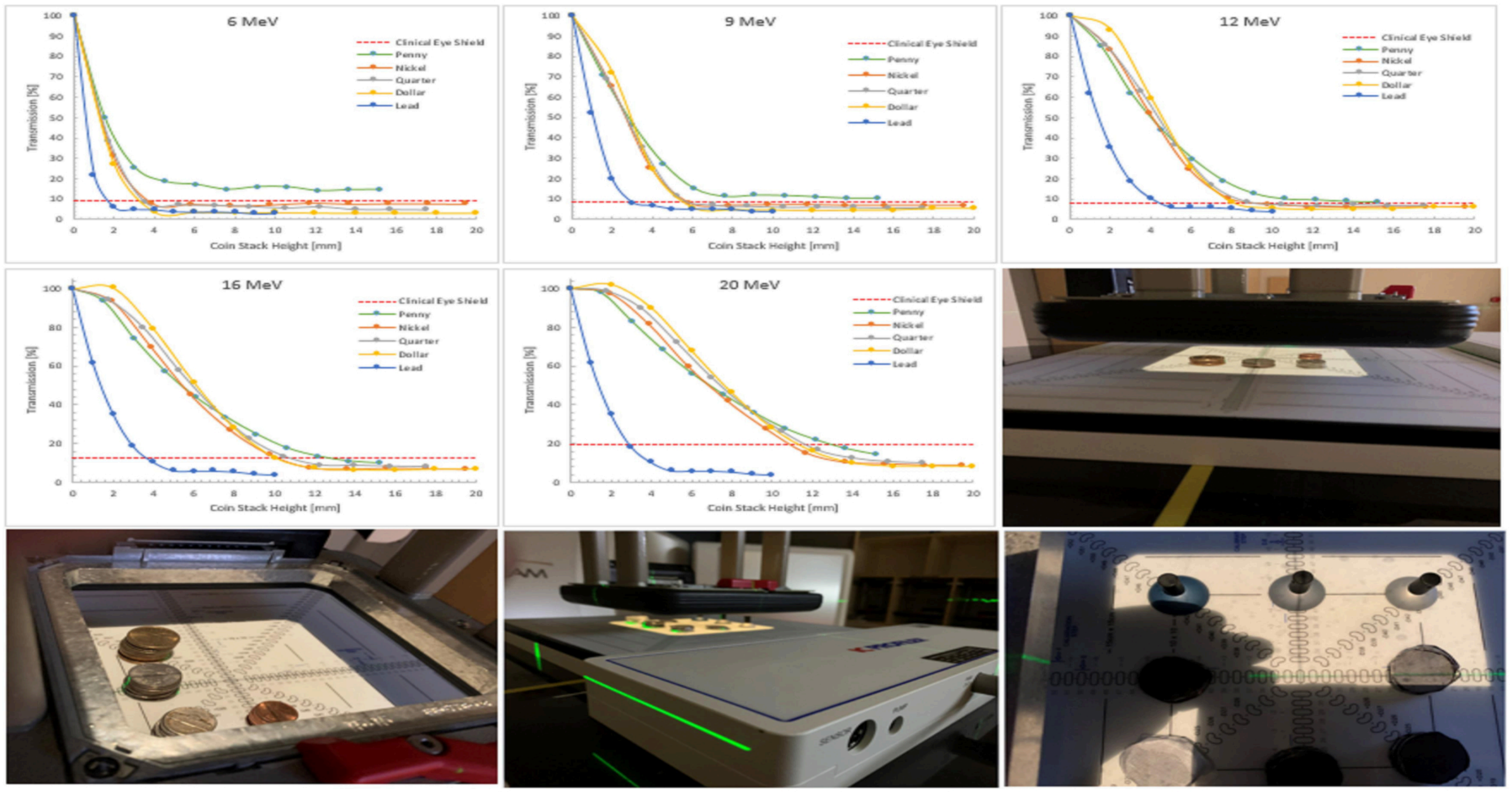


Figure 1: Transmission percentage vs Coin Stack Height for each specific coin and Lead with electron Energy Measured with IC PROFILER. The markers on each plot signify the actual thickness of the attenuating material taking into account the varying thicknesses of objects. Dashed Line through each plot indicates the average of the three eye different sized eye shields.

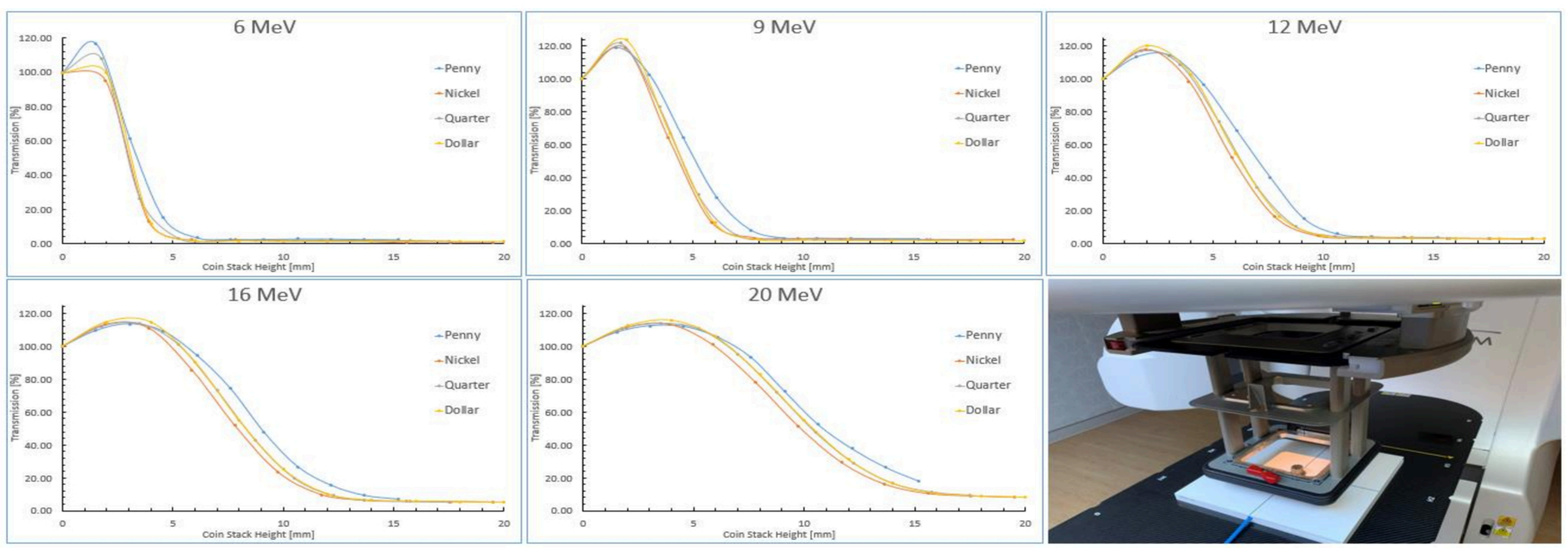


Figure 2: Transmission percentage vs Coin Stack Height for each specific coin with electron energy Measured with Parallel Plate Ionization Chamber

| Denomination | Cent | Nickel | Dime | Quarter Dollar | Half Dollar | Dollar |
|---|---|---|---|---|---|---|
| Composition | Copper Plated Zinc<br>2.5% Cu<br>Balance Zn | Cupro-Nickel<br>25% Ni<br>Balance Cu | Cupro-Nickel<br>8.33% Ni<br>Balance Cu | Cupro-Nickel<br>8.33% Ni<br>Balance Cu | Cupro-Nickel<br>8.33% Ni<br>Balance Cu | Manganese-Brass<br>88.5% Cu<br>6% Zn<br>3.5% Mn<br>2% Ni |
| Weight | 2.500 g | 5.000 g | 2.268 g | 5.670 g | 11.340 g | 8.1 g |
| Diameter | 0.750 in.<br>19.05 mm | 0.835 in.<br>21.21 mm | 0.705 in.<br>17.91 mm | 0.955 in.<br>24.26 mm | 1.205 in.<br>30.61 mm | 1.043 in.<br>26.49 mm |
| Thickness | 1.52 mm | 1.95 mm | 1.35 mm | 1.75 mm | 2.15 mm | 2.00 mm |
| Edge | Plain | Plain | Reeded | Reeded | Reeded | Edge-Lettering |
| No. of Reeds | N/A | N/A | 118 | 119 | 150 | N/A |

FIGURE 3: SPECIFICATIONS FOR U.S. BASED CURRENCY, TAKEN FROM WWW.USMINT.GOV

## EXPANDED RESULTS

The one dollar coin, which has a diameter of 26.5 mm, a thickness of 2 mm and has a composition of 88.5% Copper had the quickest fall off of dose with the increased number of coins, followed by the quarter, nickel and then penny. For energies <= 12E, anything greater than four coins seems to not make a significant impact in the drop off of dose. Figure 1 shows the transmission through each specific coin with respect to beam energy. As expected, the nickel, quarter and dollar coins, which are mostly copper by composition (Figure 3) all attenuate the beam better than the penny, and all drop the transmission to under 10% at roughly the same thickness. As expected, the number of stacked coins needed to decrease the transmission to below 10% increases with electron energy. Measurements with the stacks of coins placed directly on top of the plastic window of the parallel plate chamber yielded similar results (Figure 2), except that with a stack of one or two coins, we observed an increase in dose due to backscattering from the coin, which we did not observed previously because of the inherent buildup of 9 mm embedded in the IC PROFILER. This made the IC PROFILER an ideal detector, as it combines the inherent buildup similar to a moldable bolus, which is necessary to cover superficial areas and simultaneously acts as a holder and positioning device for the stacked coins. For all energies, the lead performed better than all of the coins, but data suggests it does not follow the E/2 + 1 mm rule, likely due to the buildup in the IC PROFILER. The average transmission of the three sizes of clinical eye shields as measured on the IC PROFILER were 9.14% and 8.50% respectively for 6 and 9 MeV, greater than manufacturer specification of 3.0% and 4.8% for the same energies. From our parallel plate measurements, it would take 3 and 4 one dollar coins and 3 and 5 quarters to obtain comparable transmission rates to those found on the eye shield product specifications.

## CONCLUSIONS

Using U.S. Currency as an alternative to an eye shield is feasible as long as the stack of coins were placed on top of an approximately 5-10 mm bolus, so that the backscattering from coins is absorbed into the bolus, rather than increasing the dose to the eye.

## CONTACT INFORMATION

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