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FY2021 PAIN Portable Neutron Radiography Project October 1-15, 2020 Effort

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October 1-October 15, 2020
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At the start of FY2021, the PAIN portable neutron radiography project had approximately \$26K of carryover funding from the FY2020 NA-22 DNN R&D PAIN budget that was used during the period October 1-15, 2020. During this period, the carryover funding was used to continue work on qualification of the Adelphi Technology DD108.2i neutron generator prior to returning for the DT upgrade, and further develop the neutron radiography modeling and simulation effort. This project is also being funded through NA-84 for FY2021.

Figure 1 below is a photograph of the setup used to measure the DD108 neutron generator spot size. In this case, a 1.9” thick block of tungsten is aligned with the center of the neutron generator target. The block is halfway between the DD source and the detector providing a magnification of 2 ($M=2$). Using this geometry, the transition between the attenuated and unattenuated region in the resulting image is approximately equal to the spot size. Figure 2 shows the resulting image and a lineout of the transition. The transition occurs over about 13 400 micron pixels which corresponds to 5-6 mm. This is larger than the 2 mm expected spot size and likely is due to the large ion source current observed during operation. Consultation with the vendor indicates that this will be corrected during the planned upgrade to DT110.

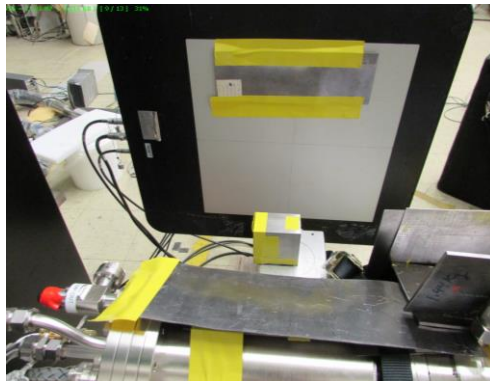


Figure 1 Photograph of the setup used to measure the neutron generator spot size using a 1.9” straight-edge block of tungsten

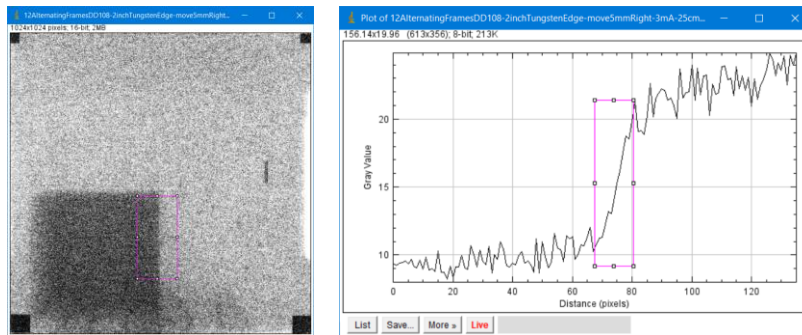


Figure 2 Neutron image (left) obtained with the DD108 neutron generator at 50 cm from the detector using a 1.9” block of tungsten at $M=2$ aligned with the target, and lineout (right) through the image to show the transition width.

The left side of Figure 3 shows the MCNP model of the imaging lab used in simulations to quantify the contribution of room scattered neutrons to the acquired neutron images. The right side of Figure 3 shows the resulting fractional increase in counts on the panel from various room features. These features include the concrete walls, drywall walls, polyethylene shielding, concrete ceiling, and steel staircase. With all features included in the model, the fractional increase in detected counts from scatter is about 2.3% as shown in the upper grey curve. This is about 1/2 to 1/3 of the 6% scatter contribution seen in the data obtained through matching the data with a scatter contribution in a separate model.

Potential additional contributions from the panel are currently being investigated to match the 6% observed scatter contribution. Figure 4 shows an estimate of the primary features in the XRD digital imaging panel that may be causing additional neutron scattering effects, as well as faint rectangular features observed in the flat field images. This model currently being incorporated into the MCNP model for study.

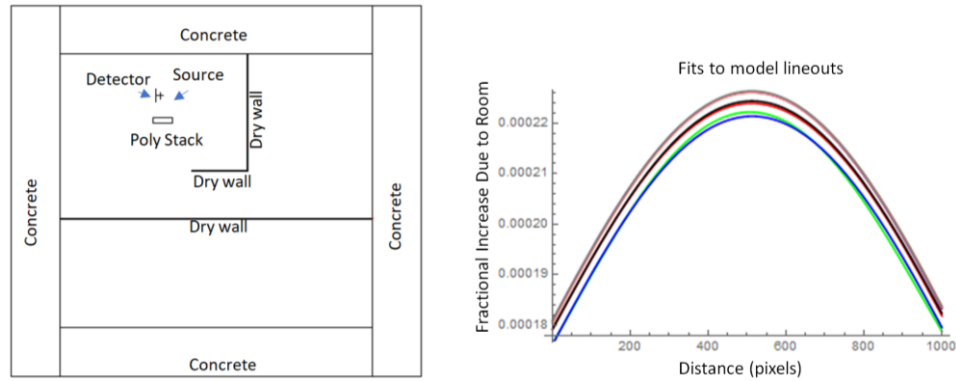


Figure 3 Model of imaging room using in MCNP simulations (left), and curves showing fractional increase in panel counts from scatter caused by various room features. The current scatter contribution from all room features sums to about 2.3%

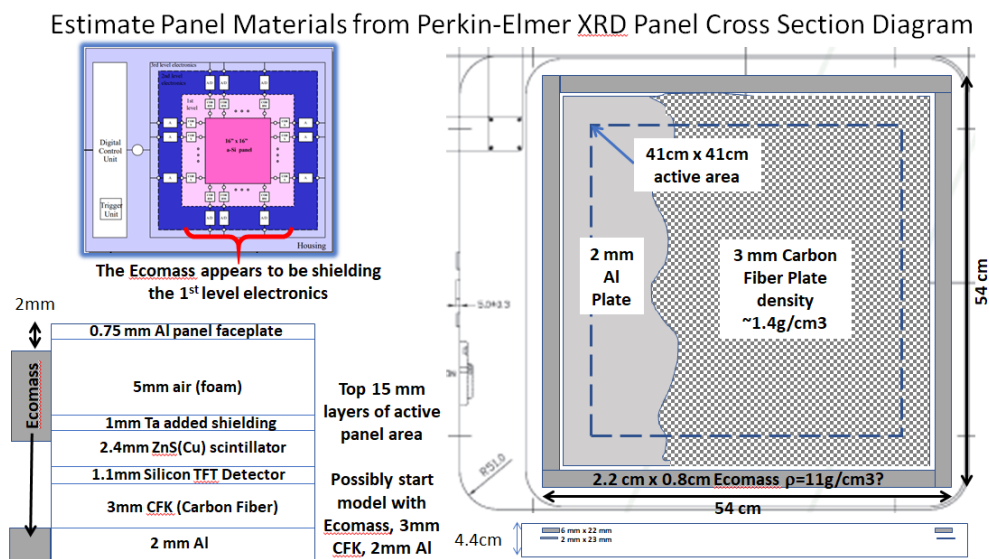


Figure 4 Model of XRD imaging panel including most likely sources of image scatter and other features in the flat field images

Figure 5 shows the modeling effort looking at the direct unscattered neutrons and scattered neutrons from the Thermo Scientific P 385 neutron generator at 90 degrees orientation. This modeling is able to demonstrate the fraction of neutron emission within various energy bands. This enables creation of look-up tables of “effective source particles” which represent what the source looks like to the detector in a given imaging scenario. This is planned to be used in the development of a rapid modeling tool that does not require full MCNP simulations. The figure on the left shows the MCNP model, the figure in the center shows the unscattered neutrons, and the figure on the right shows the neutrons that scattered from between 1 and 100 collisions. Also modeled was 0 degrees and 45 degrees tube orientation. Note that the target spot size at 90 degrees orientation (center figure) is very narrow in the Y direction due to collection of the image perpendicular to the neutron generator target face.

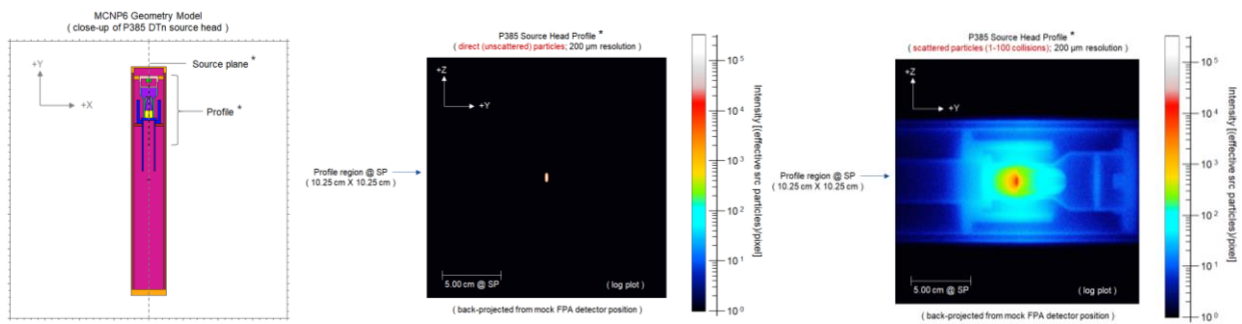


Figure 5 Modeling effort showing the unscattered and scattered neutron emission of the Thermo Scientific P 385 neutron generator at 90 degree orientation. The left figure shows the MCNP model; the center figure shows the unscattered neutrons; and the right figure shows the neutrons that scattered after between 1 and 100 collisions. Also modeled was 0 degrees and 45 degrees. Note that the target spot size at 90 degrees orientation (center figure) is very narrow in the Y direction due to collection of the image perpendicular to the target face.