D2O Analysis with MCNP

Jasen Swanson

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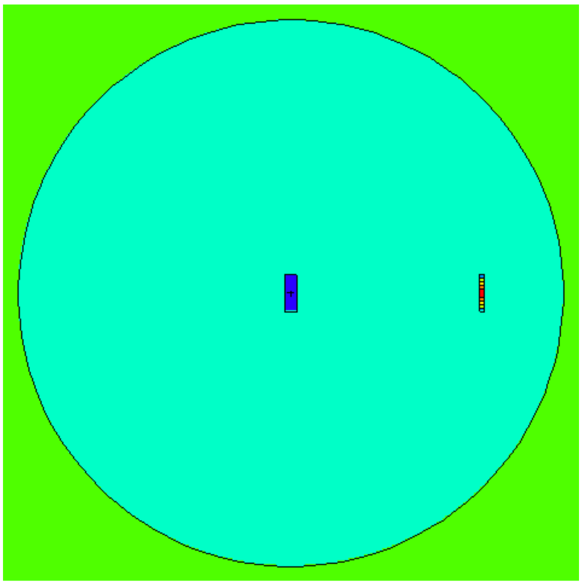
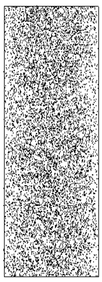
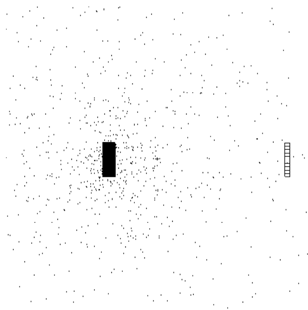
A MCNP simulation was done to see the effects a neutron may encounter while traveling one meter through air. The source of the neutrons was from a cylindrical bottle of heavy water (D2O) setup as to be distributed evenly from the center of the cylinder out to the edge for the full length of the cylinder. A segmented cylindrical detector was placed 1 meter from the source. The radius of the detector is equal to half the length of the source, as to make the detector the same size as the source. A drawing of the setup is shown in Figure 1.



(a) Source and detector setup



(b) Close-up of source showing uniform distribution

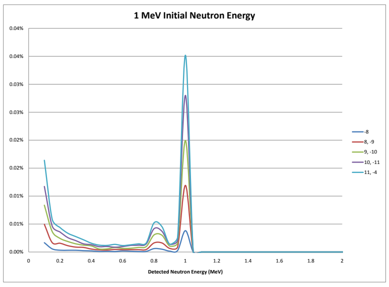


(c) Particle tracking display

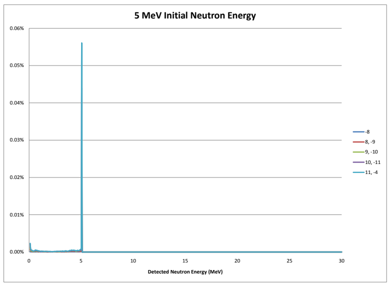
Figure 1: MCNP D2O simulation setup.

The area between the source and detector was first setup as air (Nitrogen, Oxygen, and all the other goodies). The simulation was then run with neutrons. The neutrons were generated throughout the heavy water, so a neutron could interact with the D2O and anything in the air. The neutrons are emitted from the source in all directions, so very few will actually hit the detector.

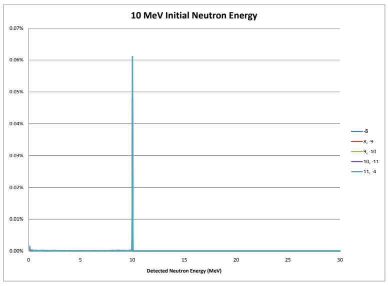
The simulation was run generating 1e7 neutrons. Five runs were done using a different initial neutron energy for each. The segments of the detector were then analyzed to see the energy distribution on each part. The results are shown in Figure 2.



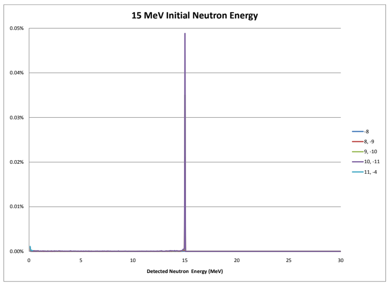
(a) 1 MeV Neutrons



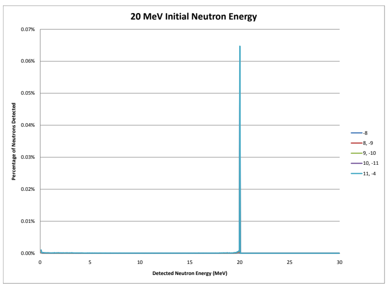
(b) 5 meV Neutrons



(c) 10 MeV Neutrons



(d) 15 MeV Neutrons



(e) 20 MeV Neutrons

Figure 2: Segmented energy distributions for neutrons traveling through D2O and then through air until the neutron reaches the detector.

As can be seen from the plots above, each segment has a peak at the same spot which corresponds to the initial neutron energy. Furthermore, there is not much interaction between the neutrons and the D2O or the air.

The next plot shows the energy distribution across the whole surface of the detector for various initial neutron energies.

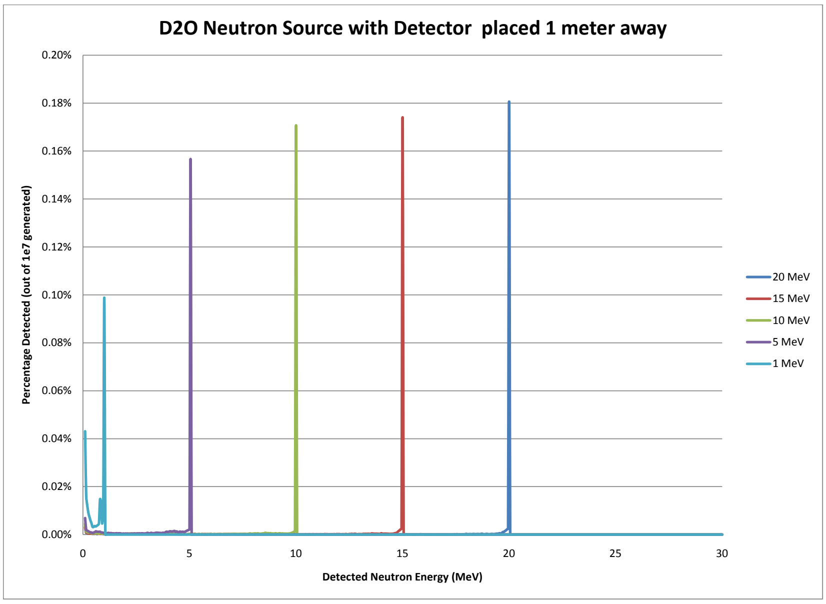
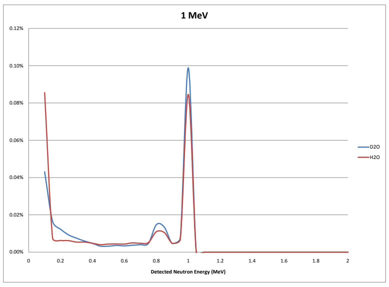


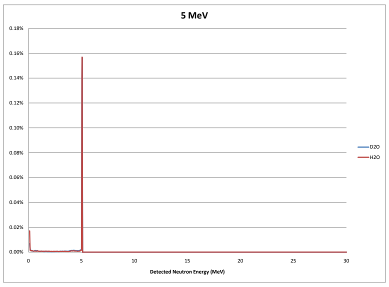
Figure 3: Energy Distributions for D2O in Air.

Once again, the peaks correspond to the initial neutron energy.

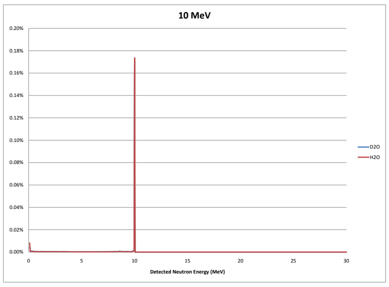
The next test done was replacing the D2O with H2O and comparing the energy distribution with the results of the D2O to see if there is any change. The results are shown in Figure 4.



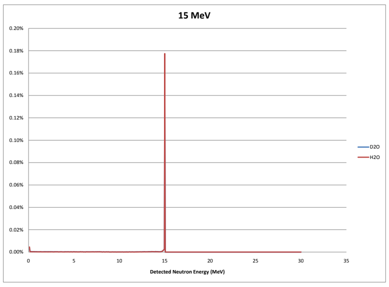
(a) 1 MeV Neutrons



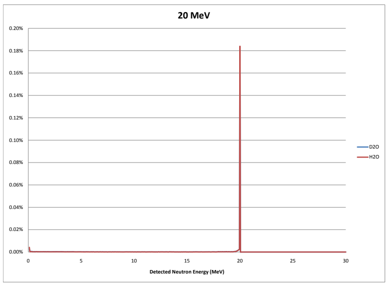
(b) 5 meV Neutrons



(c) 10 MeV Neutrons



(d) 15 MeV Neutrons



(e) 20 MeV Neutrons

Figure 4: Energy Distribution Comparison for D2O and H2O.

As can be seen above, the neutron detection percentages are about the same for each case.

The next test was to see if any noticable change would occur if the air was replaced by vacuum. Again using the cylinder of D2O, the simulation was run under the same conditions as before except the air was changed to vacuum. The results comparing the two are shown below in Figure 5.

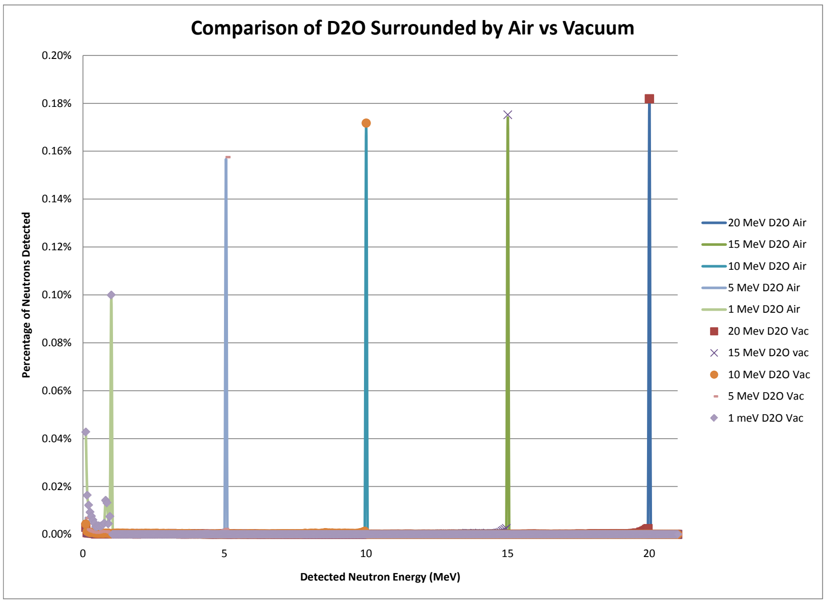


Figure 5: Energy Distribution Comparison for D2O in Air and Vacuum.

Again, no significant difference was noticed.