

Nuclear Lab 101- Manipulating Neutrons

Neutrons can be bent, reflected, moderated (slowed down) and absorbed

Most neutron detectors respond only to “thermal” or slowed neutrons. Most neutron reactions and therefore most neutron sources generate “fast” or highly energetic neutrons. Very few detection systems can pick up fast neutrons directly. The BTI Bubble Detector is one such fast neutron detector.

The He3 tube is currently the most sensitive and popular instrument to detect neutrons and available to the Home Rad Lab, it too requires Thermal Neutrons to perform.

So keep in mind when reading the following article describing experiments with neutrons, that they must first be generated in their native FAST condition, then slowed down to detect and/or measure them.

Materials used in these experiments are:

1 Standard lab neutron detector calibration source, a/Be > N

1 Lot of HDPE (High Density Poly Ethylene) sheets, 6” X 6” X ½” thick.

1 Lot of pure graphite (carbon) sheets 6” X 6” X ½” thick.

1 1 lb. Container of 100% Boric Acid

1 He3 detector tube with associated electronics (BNC SAM 935)

HDPE is used for its hydrogen atoms, well know to be key players in the slowing down of fast neutrons (moderator)

Graphite is used for its carbon atoms, also key players in neutron moderation, the first and all early “PILES” used graphite moderators.



Actual sample of graphite used in CP-1 courtesy of George Dowell Collection

100% Boric Acid is used for its boron atoms, well know to react with neutrons. About 20% of natural boron is the isotope B-10, the rest being B-11, both are stable (non radioactive) isotopes. B-10 has a particular affinity towards neutrons and is even used in some neutron detector tubes.

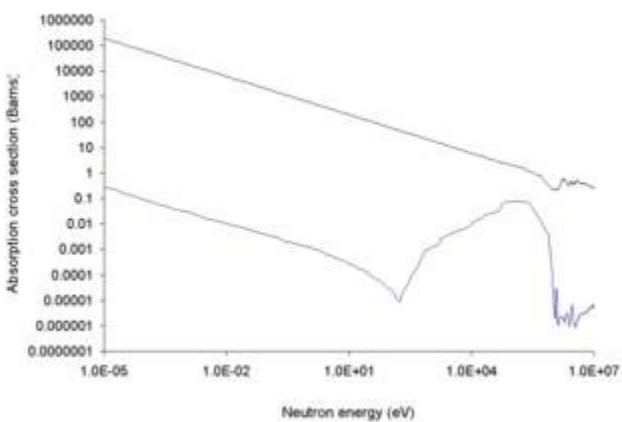
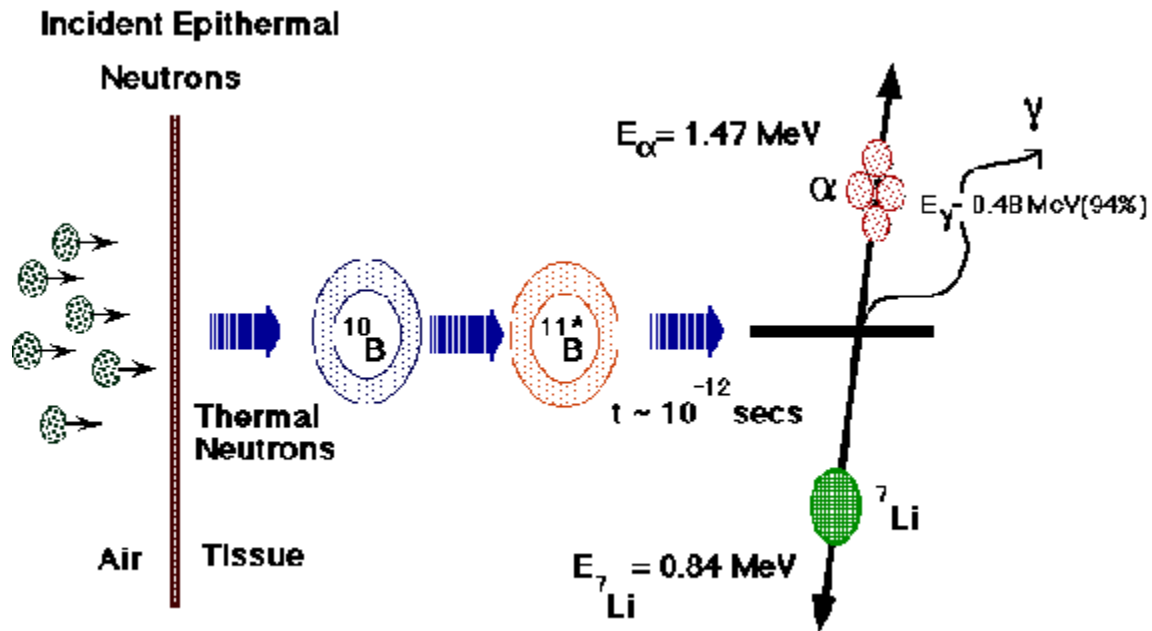


Photo credit: <http://en.wikipedia.org/wiki/Boron>

The boron $n + B-10$ reaction captures a neutron, emits an alpha particle and a recoil Li-7 ion.



Above photo credit: <http://web.mit.edu/nrl/www/bnct/info/description/description.html>

The instrument package used is a BNC SAM 935 with internal He3 tube in a lightweight HDPE moderator.





Shown below in detail is the internal He3 tube in its moderator. Our lab tests have shown that this moderator is insufficient to slow down many neutrons. This makes it ideal for our purposes since we want to test the affects of various moderators, reflectors and absorbers.



For the first step, we measure the bare neutron source with the SAM 935 with no additional apparatus. The distance chosen for ALL tests was 4" from source to He3 tube center.

The source:



Without any external apparatus, the SAM 935 reads the source as a steady 6 CPM:



Next we try adding reflectors **BEHIND** the source:

GN 1 Graphite, then the source



GGN 2 Graphite, then the source (this setup reduced the readings to near zero):

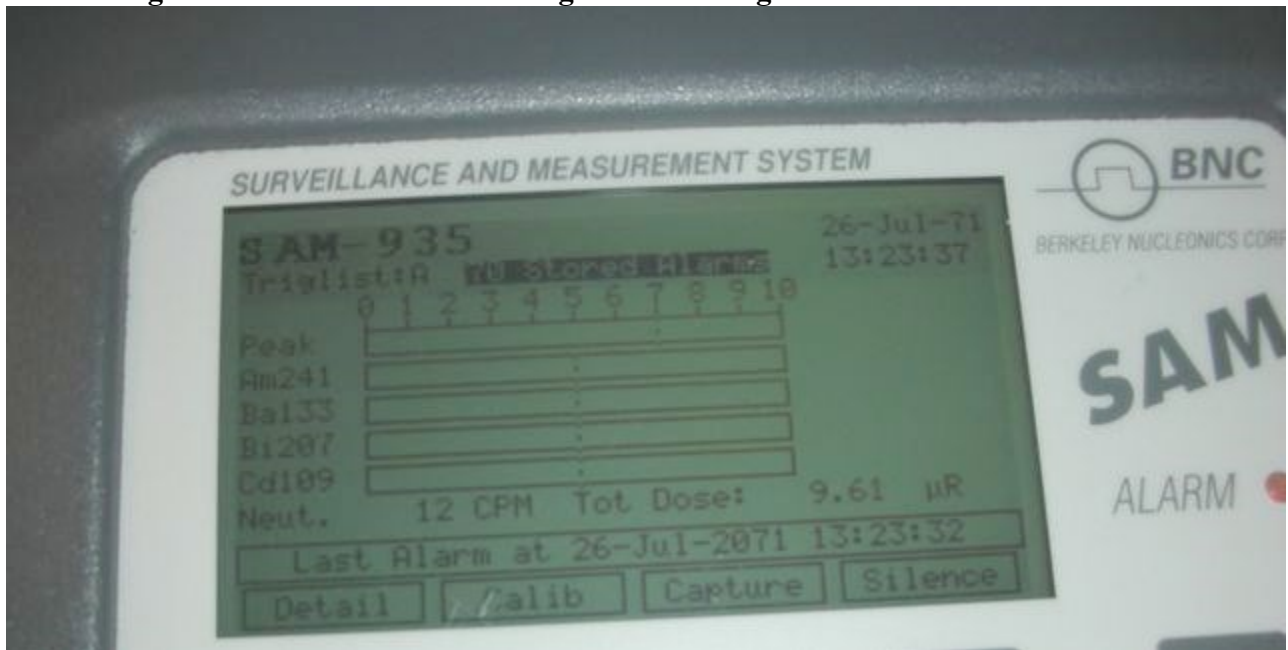


Trying next the HDPE as a reflector, we added one sheet at a time and carefully took readings. More HDPE was better but only up to a point. Fine tuning the reflector Resulted in 1 inch as being the most efficient for this neutron energy. Note> In all cases, the source is the same 4" from the He3 tube center. Apparatus is added behind and in front as needed.

PPN 2 HDPE, then the source.



Fine tuning reflector results in a doubling of the readings:



Next we tried many combinations of reflector and moderator:

GGGSGGG 3 graphite reflectors, 3 graphite moderators (very poor performer)



Next we tried various HDPE combinations:



Fine tuning an all HDPE arrangement, the very best combination for this energy neutron seems to be PPN_PP.

2 HDPE Neutron Source Space Space 2 HDPE.

Putting the moderator right next to the source was not as helpful as placing them right next to the detector:

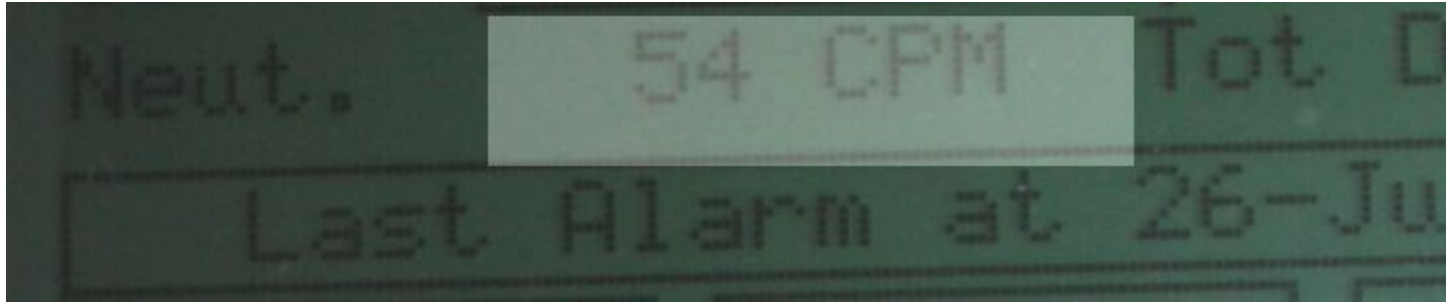


By fine tuning the distances we could increase the reading from the original 6 CPM to a steady 48 CPM.



Once in a while we would get readings of more than 50 to over 100 CPM.

Analyzing our methodology lead to the conclusion the extra hydrogen atoms IN MY HAND made that difference. I had decided that if anyone walked in to see me waving my hands and fingers around, I would tell them I was practicing my Theremin concert!!



Finally with the best reflector/moderator scheme in place, we tried applying the boron atoms. The results indicate that it does not matter much where the boron is placed, it will suck up the neutrons. Shown below is an arrangement of apparatus that gives a near zero reading. The boron does not seem to have to be in the direct path all.



Conclusions:

A) From observation, neutrons do not travel in a straight line when in the presence of light nuclei as in hydrogen.

B) Carbon atoms affect the travel of neutrons.

C) Boron atoms are an effective absorber of neutrons.

**Soon we will be in possession of some new BTI BND Neutron Bubble Detectors.
Then we can repeat and fine tune the sub-critical fission project using this new data.**

Have Fun

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