An Efficient Neutron Detector Probe Construction Project Using an He3 Tube

By George Dowell

As a form or radiation, neutrons come from nuclear fission in reactors, and from spontaneous fission from certain Uranium, Plutonium and Californium isotopes. Cf-252 is one such isotope that gives off a lot of neutrons, and is used as a neutron source in industry.

Another neutron source commonly used in industry utilizes an alpha emitter and the reaction between alpha particles and low atomic weight nuclei, such as Oxygen, Carbon, Lithium or Beryllium.
Sources made with Am-241/ Beryllium (Am/Be), Cm/Be, Ac/Be, Pu-238/Be, Pu-239/Beryllium (Pu/Be), Radium/Beryllium (Ra/Be) and Po-210/beryllium (Po/Be) are made, with Am/Be being the most widely deployed today.
Am/Be sources with 40 milliCuries of Am-241 are part of the so-called nuclear gauges made by Troxler, and used in road construction etc.
The reaction is:
$^{9}Be(a,n)^{12}C$.

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Various neutron generator tubes are out there in use, these are electronically driven devices that create neutrons in the reaction between Deuterium or Tritium atoms in a simple form of an electronic accelerator.
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Gamma Rays can create neutrons too, called PhotoNeutron sources.

Lastly neutrons come indirectly from Galactic Cosmic Rays. When a very powerful cosmic particle, mostly hyper energetic protons, enters the earth's atmosphere, it collides with atomic nuclei, shattering them into pieces with tremendous energy. Neutrons fly on and eventually collide with other nuclei, creating "neutron showers".
Some of the resulting neutrons are detectable here on the earth's surface.

Neutrons are neutral of course, and that makes them problematic to detect. In a gas filled detector, the neutron interaction with Boron or Helium-3 is capitalized to create a secondary charged particle, which is then detected by normal ionization techniques. Currently the most efficient of these methods uses He3, and the higher the pressure within the tube, the higher the chance of an interaction, therefore the higher the efficiency.

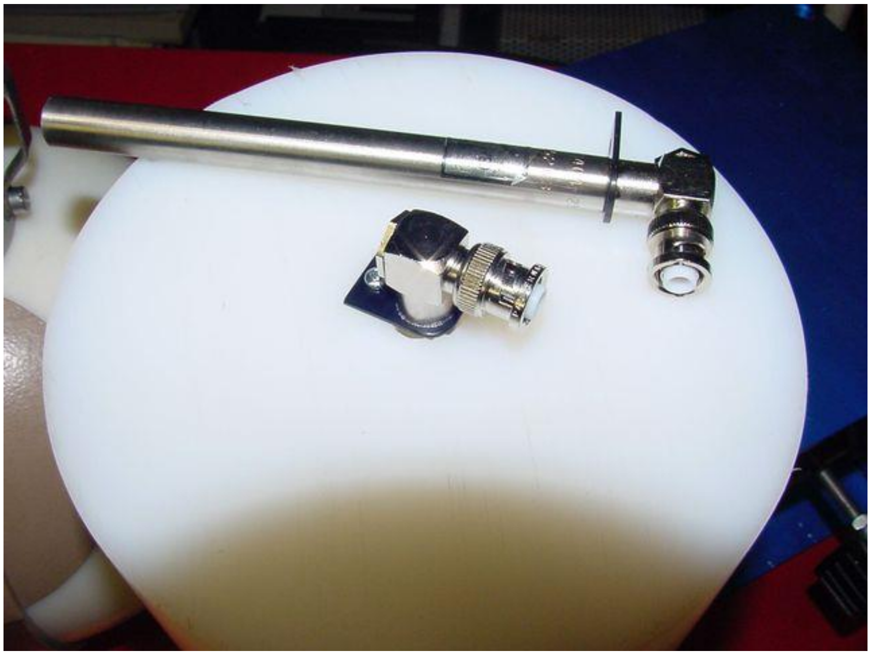
Solid detectors made up of material high in hydrogen atoms uses a reaction between neutrons and the proton in the hydrogen to induce a Proton Recoil, which can be easily detected by ZnS(Ag), converting the neutron into an optical light photon, in a manner similar to an Alpha Scintillator. The resulting light pulse is converted to an electrical pulse by a Photo Multiplier Tube in both instances.Some plastic scintillation material provides both the Hydrogen atoms and the Proton detection in a single material, making for a simple detector scheme, needing only a PMT and dynode string.

Among present state-of-the-art techniques, high pressure He-3 tubes are the most efficient available, being 50 times more sensitive than the previous king of the hill, BF3 tubes.

Almost all of the detection schemes mentions will only respond to very slow neutrons. At the point of generation, neutrons are very fast indeed and must be slowed down to very low speeds, referred to as "thermal", a reference to room temperature.

Think of bowling balls, marbles and billiard balls for a moment. There are all similar in rigidity and shape, but differ greatly in size, also called mass. A marble slammed into a bowling ball will not affect the bowling ball, nor would a billiard ball. Another bowling ball would of course have a great affect.This same principle is at work on the sub atomic scale as well. Nothing will affect a neutron more than something about its own size. For this reason, hydrogen atoms are used to interact with neutrons, slowing the neutron down by robbing some of its energy art each interaction.
Hydrogen in the form of water, wax of high-density-polyethylene (HDPE) is the material of choice to slow down or "moderate" neutrons so that they can be more easily detected by the tubes in the probe.

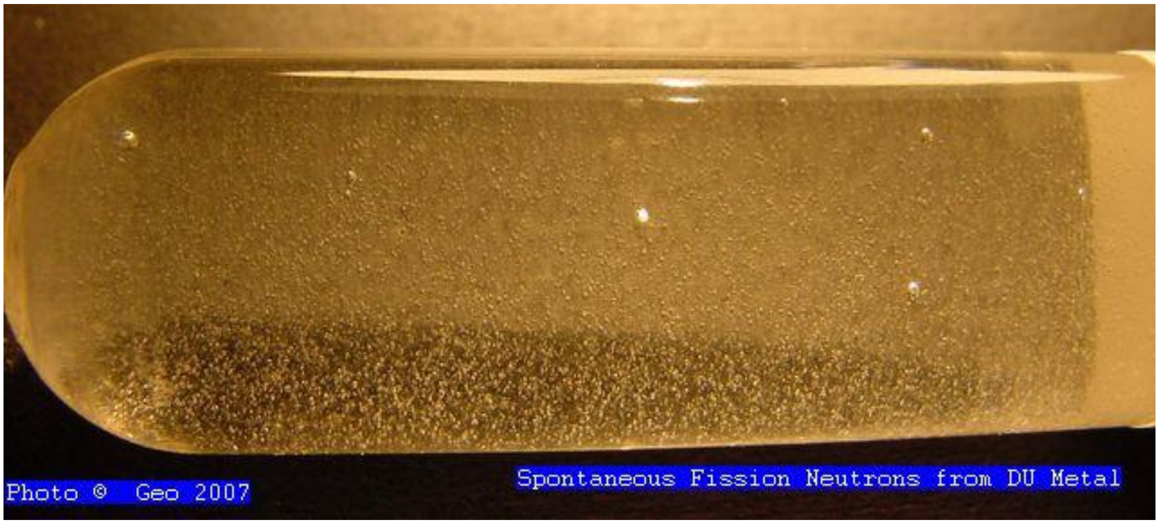
For mechanical reasons HDPE was chosen as the moderator for this project.



Pictures of home-made neutron detector using 20 atm He3 proportional neutron detector tube. Tube is 1/2" x 4 " active length, He3 is 300 PSI, moderator is 6.5" X 12.5" HDPE. Compare this to the N. Wood BF3 tube in the 9" Remball @ 1" active length. and .78 ATM or roughly equiv. to LND 20126.
A handle will be fitted when the final arrangement is decided.

Pickup tube is a GE/ Reuter-Stokes RS-94-0404-253 and is equiv. to LND 25143, with thermal neutron sensitivity of 12.7 cps/nv.
An N. Wood G-5-1 as used in the Remball is rated at .25 cps/nv making the home made probe some 50 times more sensitive as the Remball and 4 times the active length. .

Shown is a very small, temporary Ra/Be neutron source which was constructed for testing purposes then quickly dismantled.



Have Fun

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Comments, criticism and questions will be appreciated and may be directed to

the author by email to GEOelectronics@netscape.com

"Our progress as a nation can be no swifter than our progress in education" -- J. F. Kennedy

"You do not really understand something unless you can explain it to your grandmother." - Albert Einstein (1879-1955)