Neutron detectors

Neutron sources

Neutrons are particles with zero net charge. They appear in laboratories from …, airplane highs due to …, nuclear reactors, nuclear weapons and more. The last years there has been a growth of fields dealing with neutrons: storage of nuclear waste, search for illicit trafficking and hidden nuclear materials, and increased awareness in aviator hights(?).

The He-3 gas counter widely used, but there is a shortage of He-3. Motivation for developing alternative neutron detection methods. Gd- up and coming? Increased focus on Gd?

Neutrions are ahdronic particles contituing three quarks whos charge sum equals zero. In other words the neutron has no charge and does not interact through electromagnetic forces. IT does, owever interact with the hadronic force, which is strong, but has a very short range (10^-15m). Because it doesn’t interact with matter through electromagnetic force it does not ionize matter. It does however ionize indirectly. Neutrons may interact through hadorinc processes, which produce otherparticles (of charge) such as electrons and protons, and these are directly ionizing particles. Neutrons must therefor first be converted into otherparticles to be detected. This is done using a convertermaterial. The converte material may be gad, liwuid or solid.

The most common neutron detector is the gas proportional counter (?). A widely used convertermaterial is He-3 which brings many good qualities such as high count rate, fast countrate(?), A gas chamber is only a counter and does not give information about energy deposition.

Information about neutron energy is difficult to track and is still being developed?? (find any ref?)

The most common use of neutron detectors are counters. Active counters are gas, solid-state and scintillators.

Gas detectors (1/4) (particles of interest?, pros and cons? Set up? Most popular design? Cost? Efficiency?)

Scintillation (1/4)

Solid state (2/4)

There are many diffrent types of neutron detectors and the requirements for each is depedent on their field of use. For instance, in dosimetry a high persistion energy resolution and spatial resolution is required to give an accurate treatmentplan. On the other hand, energy deposition is not of interest in fields where only the activity of neutron flux is of intterest, such as in nuclear reactor monitoring to reulate neutrons bombarding fissile material.

The use of detect

Gas

Solid state

Scintillators

Requirements

Speed

Efficiency

Energy deposition

Spatial resolution

Convertermaterial

He-3

Gd

B-10

Li-6

??

Active

Passive

Examples

Nuclear Weapsons

Illicit trafficking and hidden nuclear materials

Radiation safety

Nuclear reactors

Nuclear storage

Neutron sources

Neutrons

Zero net charge

Indirecyly ionizing

Strongly penetrating radiation

Nuclear reaction

Reaction products

Q-value

Thermal energy

Neutron energy

Reaction cross section

What are neutrons?

**NEUTRONS**

* Have Zero charge, zero net charge,
* Are penetrating particles (penetrating radiation)
* Interact with hadronic force
* Has short interaction range (10^-15m)
* Do not interact electromagnetically
* Indirectly ionizing
* Non-destructing

**WHY DETECT NEUTRONS?**

* Many fields(?) in physics dealing with neutrons and the monitoring of neutrons is essential(?). (3 examples why. There are plenty more, but no need to list them all)
* Reactors?
  + Neutron induced reactions, U-235.
  + Produce two/three neutrons
  + Cascade of reactions, exponential growth of neutrons(?)
  + If incident neutron flux too high, cascade escalates out of hand and it can have lethal consequences(?) .
  + E.g. Hiroshima?
  + Monitoring neutron flux allows us to keep reactor in stable conditions and calibrate neutron flux as needed.
* Nuclear weapons
  + Often contains Plutonium (?)
  + Plutonium is unstable and decays by ??. neutron??
  + Many nuclear materials produces alpha, beta, gamma and neutrons. The first three are easy to shield, but neutrons less so.
  + Neutron detection methods are therefore beneficial in the search of illicit trafficking of nuclear and other radiative materials.
  + neutron detection is an essential part of a comprehensive nuclear security program to prevent nuclear proliferation and possible construction of nuclear devices.
* Neutron detection has become increasingly important du to the development of new fields dealing with neutrons, for instance neutron spallation sources.
  + ESS??
  + What do they do
  + Why do they want to track neutrons.

**HOW TO DETECT NEUTRONS?**

* Most (all?) particle detectors are based on ionization to produce a signal. An incoming particle strikes the detectors sensitive volume resulting in signal generating charge carriers (electrons).
* Neutrons have zero net charge and does not interact electromagnetically with material, they cannot not ionize material directly.
* Neutrons can, however, be converted to charged particles which in turn (?) activate a signal in the detector.
* Particles from neutron conversion function as neutron indicators.

**TYPES OF NEUTRON DETECTORS?**

* There are many different methods for detecting neutrons. They can be grouped into two categories: active and passive.
* Passive methods yield information after irradiation is complete.
* In contrast, active methods monitor neutron presence in real time.
* Examples of **passive detectors** are: thermoluminescent, etched-track, and nuclear-emulsion detectors
* Passive detectors do not need a power supply, do not experience any electromagnetic interference and respond well to high-energy radiations. For these reasons, passive detectors are commonly used in areas involving in high-energy dosimetry.
* Nuclear track emulsion is the oldest method of neutron personal dosimetry. ([\*](https://watermark.silverchair.com/nch129.pdf?token=AQECAHi208BE49Ooan9kkhW_Ercy7Dm3ZL_9Cf3qfKAc485ysgAAApIwggKOBgkqhkiG9w0BBwagggJ_MIICewIBADCCAnQGCSqGSIb3DQEHATAeBglghkgBZQMEAS4wEQQMmjOgYv5S7D7kdhETAgEQgIICRbTB5j39f9ufWccHJM0DDGB1k7UuRgKZQRlBdKhbpBgB8Xs9hz6Y0uw4iV7-IMFBvsYbM_yM5OcllScoEIHVDsmN8J51lBXAGE3hjX_E8OAHq-7S79rnPndj3jD2uuw56FLqEGbYby2tA0x1Te1bjRftELelKcUKYrRQobCoLaJLwGWrcOfZgyMQ-hWO_wKAlxvL7cKuV7MygjcPjbWVUVwHNRjWPkx9xMGrVc_RPKR48__vi1laCF5_4HHxXQgEraqOSw_3eaFGOWqTtUFeJKBagkqHCakGd9xYTcU5EZFjOW7fSEnT9Zs7LFD3-IZy5mhSU3wT2arZ4RR4VTwoyjFfa7rlXLBjAZ-EfNGah1h6WOwQYTm5POUge6SDun5aUSXiW07G3UOY2DTwcB9Z_4720Q6pWVuStJUQy-GjIhXUqNNZemXkOPGwaAy2O6fC4oyBtU4xR1Syviodw-LywtVqq2i2-UQ4Ph4zfz0c5ZskCBXmDCLNDJt5JioY7aoRoNQKWkYqYsh3HgM-C3-o7HJFDIUL4xKysyY78pfW9b3wQAjob8_uQrfO8IjC5G3225ULuHIrjph8xWCd8-7WSNxXqeQ2j3Sc6MMvIioISJBjNXA1n_MxHx4ZsgL1Po6Cy-ec5KHFh2nPyxRyQKyNECKf-vDxgf0W9WuRI4WrHuIvVtuLqq4F8J0kSC5ZPvV3qaso07tofTcMF4GoA8BOSmVT2xmHghlalLnAqiVAyn45ce6sCxQB6SuA5s6UhN6THOJa6Jfx))
* The most important **active methods** are those using gaseous detectors, scintillators and semiconductor detectors.
* Active neutron detection methods have a wide range of applications like tracking movement of water in plants, providing compositional information on metallic cultural artifacts, and determining the structure of crystalline solids (Kilde: Advances in neutron radiography and tomography). A relatively new development is active personal dosimeters (APD). Even though they compete with passive methods, there is still progress to be made with respect to energy-dependency.

FORTSETT HER

* Types of active detection methods