SCIONIX

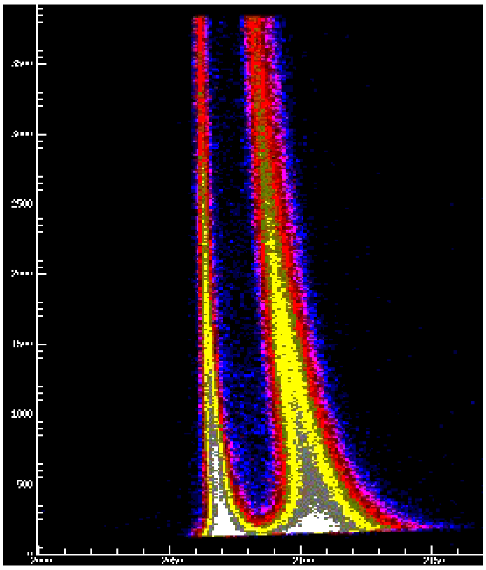
Application Note

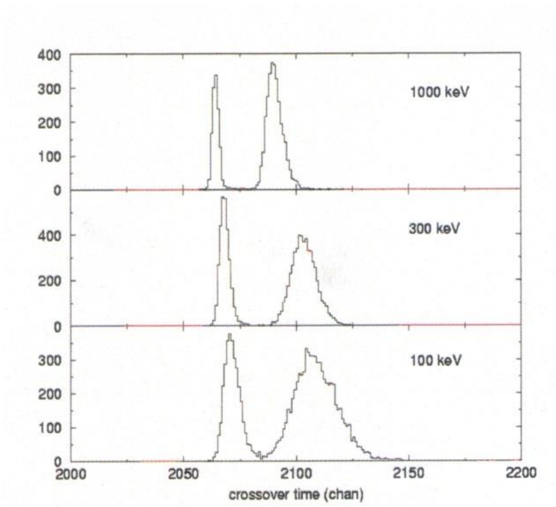
Neutron detection with scintillators

In general neutrons are more difficult to detect than gamma rays, because of their weak interaction with matter and their large dynamic range in energy.

Fast neutrons can interact with materials that contain a large concentration of hydrogen atoms (protons), for example organic materials, by means of elastic scattering in which case the energy of the neutron is (partially) transferred to the protons which on their turn can produce scintillation light. Using the above principle, fast neutrons can be detected in any organic (plastic or liquid) scintillator.

The efficiency of neutron absorption in a liquid scintillator can be increased by adding 0,5% by weight of Gadolinium to the liquid. In some liquid sinctillators fast neutrons produce scintillations with different decay times for neutrons and gammas. Using ***Pulse Shape Discrimination (PSD)*** techniques, it is therefore possible to separate fast neutrons from gammas. Specific details are to be considered in designing liquid cells for this application.



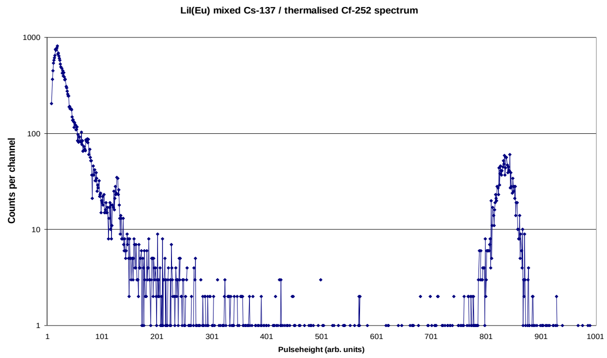


Thermal neutrons produce a continuous spectrum in organic scintillators and can be detected by means of a nuclear reaction with ^{6}Li atoms in Li containing scintillation materials. In this reaction, a triton and an alpha particle are produced. An example of such material is LiI(Eu) or Ce-doped ^{6}Li glass. It is possible to have enrichment up to 96% of ^{6}Li in these scintillation materials.

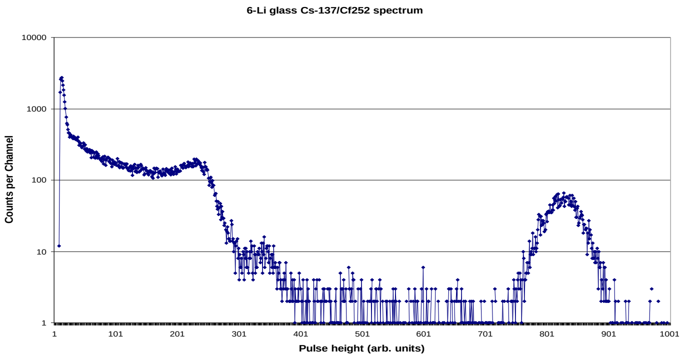
In order to detect fast neutrons with a ^{6}Li containing scintillation material, the neutrons must be first moderated with a suitable (hydrogen rich) material, for example a plastic.

Thermal neutrons produce a peak in Ce-doped Li glass scintillators at a gamma equivalent energy of approx. 1.9 MeV. In LiI(Eu), the thermal neutron peak likes above 3.6 MeV which provide a significantly better separation from natural gamma rays (< 2.6 MeV). Below some typical thermal neutron spectra are shown for Li-glass and LiI(Eu). The advantage of Li glass scintillators however is their shorter decay time.

Another technique to measure the energy of fast neutrons uses “time of flight measurements” which consists of an accurate determination of the moment of interaction between the neutron and a fast plastic scintillator.



Pulse height spectrum produced by thermal neutrons and Cs-137 in LiI(Eu)



The same for a ^{6}Li glass scintillator

Summary

Fast neutrons:

- Detected in hydrogen rich organic scintillators
- Continuous spectrum
- Neutron / gamma separation by PSD
- Significant absorption volume required

Thermal neutrons:

- Detected in ^{6}Li containing scintillation materials
- Produce “thermal neutron peak” in energy spectrum
- 3 mm thick, 96% enriched ^{6}Li glass or LiI(Eu) will stop 90% of thermal neutrons

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