Comparison of CZT semiconductor and YAP scintillator as photon detectors for epithermal neutron spectroscopy

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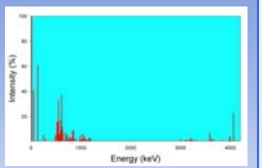
Deep Inelastic Neutron Scattering (DINS) measurements with **epithermal neutrons** are performed with the VESUVIO spectrometer at the ISIS spallation neutron source (UK).

New detectors are being developed within the eVERDI project to extend the measurements to the 10-100 eV neutron energy region.

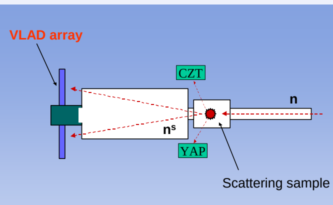
The new neutron detection method employs the Resonance Detector (RD) where a photon counter detects the γ and X-ray emission following resonant neutron absorption in a converter foil.

^{238}U resonances

E_0 (eV)	TOF (μs)
6.671	310
20.87	175
36.68	131
66.02	98.3
80.73	88.
102.5	78.
116.9	73.9
189.7	58.0
208.5	55.22



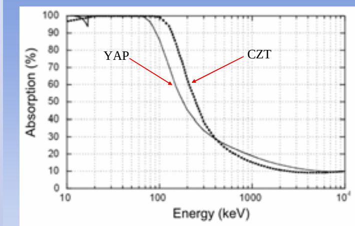
Expected relative intensities of the γ ray emission following thermal neutron capture on ^{238}U.



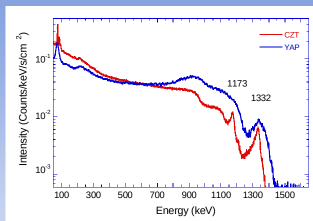
Schematics of the VESUVIO spectrometer showing the incoming neutron beam (n), the scattering sample, the scattered neutrons (n^s), the CZT, YAP and VLAD array positions.

Measurements performed on VESUVIO with a Cadmium-Zinc-Telluride (CZT) solid-state detector and a Yttrium-Aluminium-Perovskite (YAP) scintillator demonstrate the potential of these devices when combined with suitable converter elements such as ^{238}U.

A new Very Low Angle Detector (VLAD) array is being designed within the eVERDI project to extend the measurement to *very low scattering angles (<5°)* and to *10-100 eV neutron energy region.*

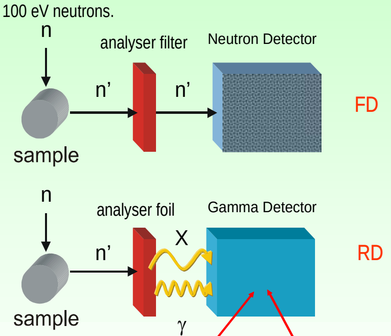


Photon interaction probability for a CZT (5.0 mm thick) and YAP (6.4 mm thick) crystal.

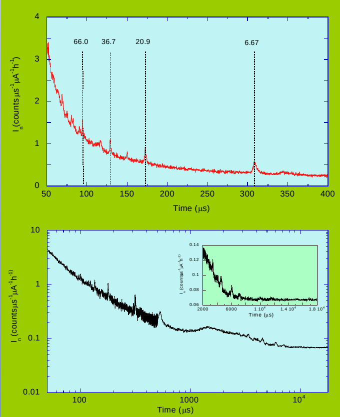


Pulse height spectrum recorded from a ^{60}Co shows that the two crystals have similar γ detection efficiencies.

Principles of the Filter Difference (FD) and Resonance Detector (RD). The FD is the standard method for detection of neutrons of energies below 10-20 eV. The RD is being developed for 10-100 eV neutrons.

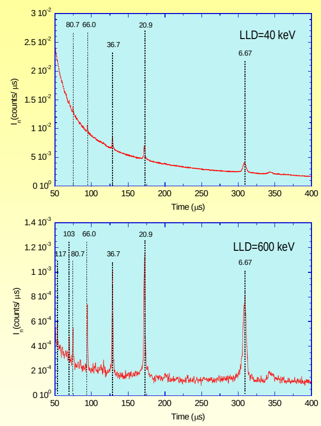


CZT



Time of flight scattering spectrum recorded with CZT, shown in lin (top) and log (bottom) scale. The region at t<1ms is characterised by ^{238}U neutron capture. For t>1ms direct detection of thermal neutrons from cadmium is dominant; the insert (bottom) is a blow-up of the cadmium region showing the Bragg peaks.

YAP



Time of flight scattering spectra recorded with a YAP scintillator. The top and bottom spectra were recorded with a LLD threshold of 40 keV (top) and 600 keV (bottom), respectively.


Photograph of the CZT (left) and YAP (right) γ detectors tested on VESUVIO. The CZT crystal is 5x5x5 (from eV product); two YAP crystals (6.4 mm thick from Crytur) of trapezoidal shapes are connected via an Aluminium case to the PM-tube.

CZT and YAP are very good candidates for Resonant Detection of epithermal neutrons !

CZT measures thermal neutrons (Cd absorbtion), too. Broader application potential.

YAP is insensitive to resonant neutron absorption in the detector itself, while CZT has initrinsic neutron resonances (such as Te or ^{197}Au present in the gold contacts).

YAP has an intrinsic higher efficiency above about 500 keV. Substantial improvement in Signal to Background has been obtained using a LLD of 600 keV.