Journal of Physics: Conference Series **203** (2010) 012139 doi:10.1088/1742-6596/203/1/012139

Detection of fast neutrons with LiF and Al_2O_3 scintillating bolometers

N Coron[1], C Cuesta[2], J Domange[2], E García[2], J Gironnet[1], J Leblanc[1], P de Marcillac[1], M Martínez[2], Y Ortigoza[2], A Ortiz de Solórzano[2], C Pobes[2], J Puimedón[2], T Redon[1], T Rolón[2], M L Sarsa[2], L Torres[1] and J A Villar[2]

[1] Institut d'Astrophysique Spatiale, Bât 121, 91405 Orsay, Paris, France
[2] Laboratorio de Física Nuclear y Astropartículas, Universidad de Zaragoza, 50009 Zaragoza, Spain

E-mail: puimedon@unizar.es

Abstract. Scintillating bolometers of LiF and Al_2O_3 can monitor the fast neutrons flux in WIMPs searches. With both materials we merge the traditional fast neutron detection methods of induced reactions and scattering. The ROSEBUD collaboration devoted an underground run in the old Canfranc laboratory to study the response of LiF and Al_2O_3 to fast neutrons from ^{252}Cf. Both bolometers were used simultaneously in a common experimental set-up resembling those of current WIMPs searches, which could give valuable insights into future WIMPs searches with cryogenic detectors as EURECA.

The ROSEBUD collaboration [1] can test several absorbers simultaneously [2] running as a small size multi-target experiment. A time fraction of the last run in the old Laboratorio Subterráneo de Canfranc [3,4] was used to study the nuclear recoil band of LiF, Al_2O_3 and BGO scintillating bolometers as well as the viability of monitoring fast neutrons inside the Pb shielding using the combined data of LiF and Al_2O_3. The irradiation with neutrons from a source of ^{252}Cf located outside the shielding shows their particle discrimination power: nuclear recoils, captures in ^{6}Li and β/γ events are clearly separated (figures 1 and 2). The Al_2O_3 heat channel was calibrated with a ^{57}Co gamma source, although the irradiation time was not enough to produce high statistics full absorption peaks.

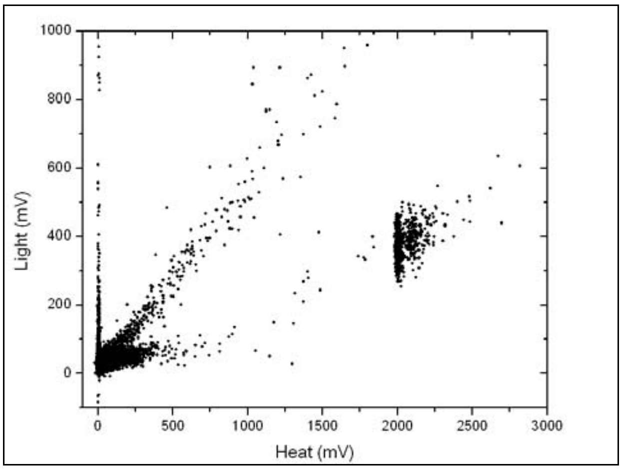

Figure 1. Heat-light plot of LiF. ^{6}Li(n,α)t captures are located around (2000,400) mV.

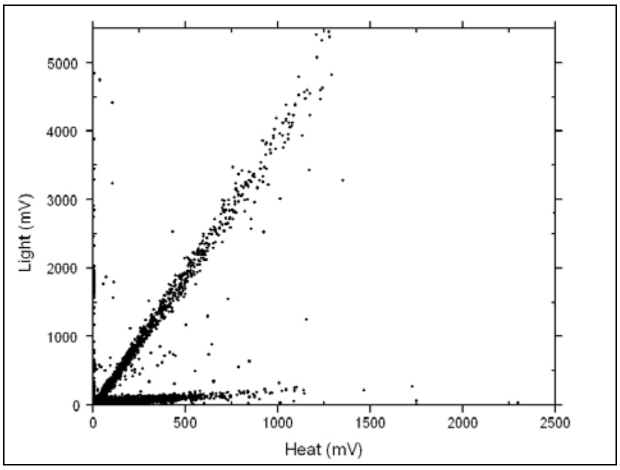

Figure 2. Heat-light plot of Al_2O_3. Nuclear recoil events give lower light output than β/γ ones.

We assumed an isotropic neutron flux around the bolometers and a three-parameter model for the neutron spectrum: $\Phi(E)dE=(\Phi_0/\Gamma(\alpha+1))(E/T)^{\alpha}\exp(-E/T)dE/T$. The isotropy can be justified because 25 cm of Pb flat the anisotropy of the neutrons from the outside point source; the energy dependence corresponds to the shape of the ^{252}Cf neutron spectrum (α=0.5, T=1.29 MeV) and it contains as special cases a translation in lethargy (α=0.5, T<1.29 MeV) and, asymptotically, the equilibrium spectrum (α→-1, E<<T). It seems valid that Pb produces an intermediate shape with other (α, T) pair.

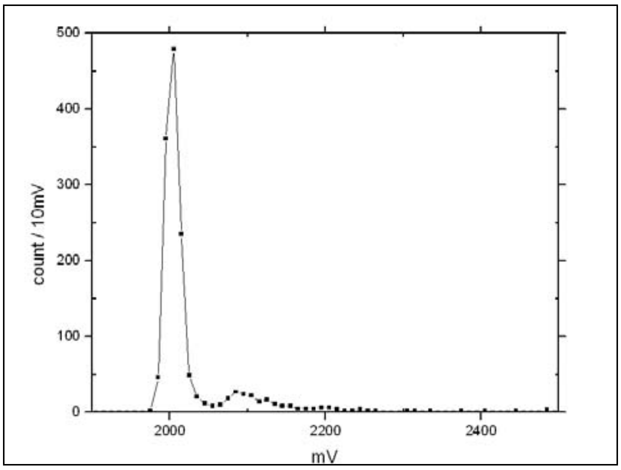

Figure 3. Heat spectrum of the (n,α) events in LiF

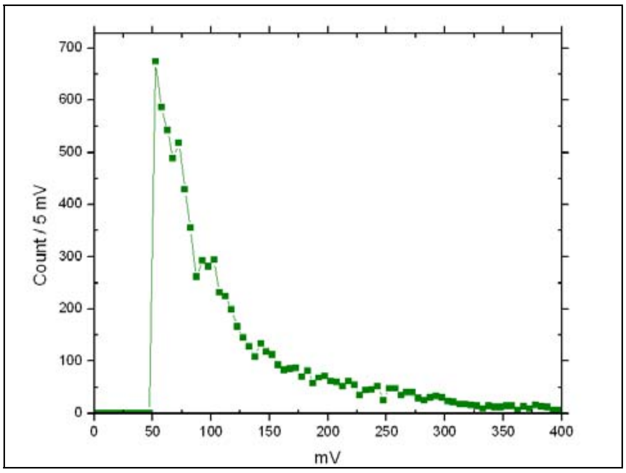

Figure 4. Heat spectrum of recoil events in Al_2O_3

Appropriate cuts on the heat-light plots provided the differential spectra of the heat channel for the ^{6}Li(n,α)t capture (figure 3) and for the elastic scattering in Al_2O_3 (figure 4). The capture by ^{6}Li of thermal neutrons and at the 0.24 MeV resonance can be seen in figure 3 as two peaks at 2000 mV and 2100 mV, respectively. The number (C) of neutron captures at the resonance, the number (A_1) of nuclear recoil events in Al_2O_3 in the interval [50, 100] mV and in the region above 100 mV (A_2) were used to estimate the free parameters α, T and Φ_0. The ^{57}Co calibration gave 37±9 keV at the 50 mV discrimination threshold and 85±4 keV at 100 mV. The choice of 100 mV gave similar values for A_1 and A_2, minimizing their joint contribution to the uncertainties of the three parameters. The efficiencies for each type of event were calculated as a function of the neutron energy with MCNP version 4C [5] and, finally, we obtained a solution with a neutron mean energy of 0.148 MeV, well below the mean energy of the original ^{252}Cf neutrons (1.9 MeV), showing that our model was not incompatible with the integral data C, A_1 and A_2. The parameters α and T were obtained with big uncertainties (-1<α<1 and 0.3 MeV<T<2.5 MeV) which came from the non accurate calibration of Al_2O_3 recoil spectrum and from the statistical uncertainty of the captures at the ^{6}Li resonance. We concluded that the experimental data gave information for neutron energies between 0.1 and 2 MeV and a fast (E > 0.1 MeV) neutron flux of 0.20±0.02 n s^{-1} cm^{-2}. We foresee further improvements exploiting the shape of the differential heat spectrum of recoil events in Al_2O_3.

Acknowledgements

This work has been supported by the Spanish Ministerio de Ciencia e Innovación (FPA2008-03228), the French CNRS/INSU (MANOLIA and BOLERO projects) and the EU project ILIAS (RII3-CT-2004-506222). Y Ortigoza and T Rolón thank the support of UZ/BSCH/Fundación Carolina.

References

[1] Cebrián S, Coron N, Dambier G, García E *et al* 1999 *Astroparticle Physics* **10** 361-8
[2] Cebrián S, Coron N, Dambier G, de Marcillac P *et al* 2004 *Astroparticle Physics* **21** 23-34
[3] Calleja A, Coron N, García E, Gironnet J, Leblanc J *et al* 2008 *J. Low Temp. Phys.* **151** 848-53
[4] Coron N, Gironnet J, Leblanc J *et al* 2008 *Proceedings of Science* PoS(idm2008)007
[5] Briesmeister J F (ed) 2000 MCNP - *A general Monte Carlo N-Particle transport code, version 4C*, LA-13709-M