Role of acoustic energy in reduction of background of PICASSO detector.

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Introduction

PICASSO (Project In Canada to Search for Supersymmetric Objects) at SNOLab, is one of the experiments which search for cold dark matter through the direct detection of WIMPs (Weakly Interacting Massive Particles) via spin-dependent interactions with ^{19}F nuclei [1]. It uses superheated droplet detector (SDD) consisting of a large number of droplets of superheated liquid, C_4F_{10} (b. p. -1.7°C at a pressure of 1.013 bar) suspended in an inactive polymerised gel matrix. The use of light target nucleus makes the PICASSO detector sensitive to low mass WIMPs (below 20 GeV/c^2). The energy deposition by energetic particle traversing through metastable superheated liquid drop causes a "heat spike" [2], leading to a phase transition if the energy deposition occurs within a certain critical length ($L_{\rm eff}$) and the deposited energy exceeds a certain critical energy (E_c). Acoustic pulse generated in this process constitutes the signal, which is recorded by piezoelectric transducers. These detectors are sensitive to neutrons, charged particles, gamma rays etc under different operating conditions of temperatures and pressures [3]. It is very crucial for WIMP search experiments, to adopt the methods for minimization of background events. Alpha particles are the most dominant intrinsic background for PICASSO detector of height 40 cm and diameter 14 cm. Though the shapes of the WIMP and α responses differ, it is comparatively difficult to discriminate by analysing event by events. As neutrons create nuclear-recoils similar to WIMPs, neutron calibration runs are used to study recoil induced events. In the present work, our aim is to reduce the α-background by increasing the resolution of alpha-recoil discrimination in the detector.

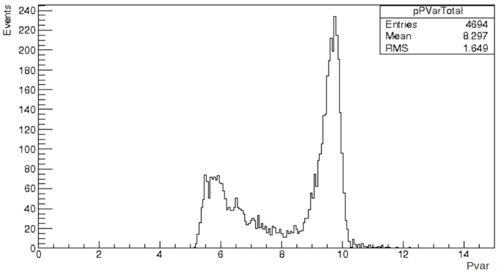

FIG. 1: Distribution of Pvar recorded in calibrations with an AmBe neutron source.

Variables for background reduction

In PICASSO experiment, the recorded transducer signals show that the intensity of the acoustic signals associated with bubble nucleation contains information about the nature of the different events —makes the acoustic energy an effective discrimination tool of non-particle and particle induced recoil events. The variable Pvar is a measure of the integrated sound intensity or acoustic energy. Fig. 1 shows that Pvar distribution contains two peaks —first peak from the left is related to non-particle induced background while the second peak is for particle-induced bubble nucleation. It is observed that alpha particle induced signals are significantly more intense than those of neutrons (and therefore of WIMP events). At present, 99.34% α rejection is possible at 80% WIMP acceptance. The aim is to achieve 100% WIMP accep-

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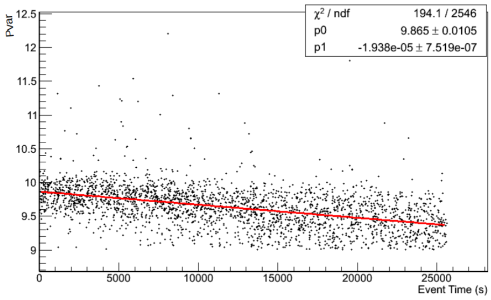
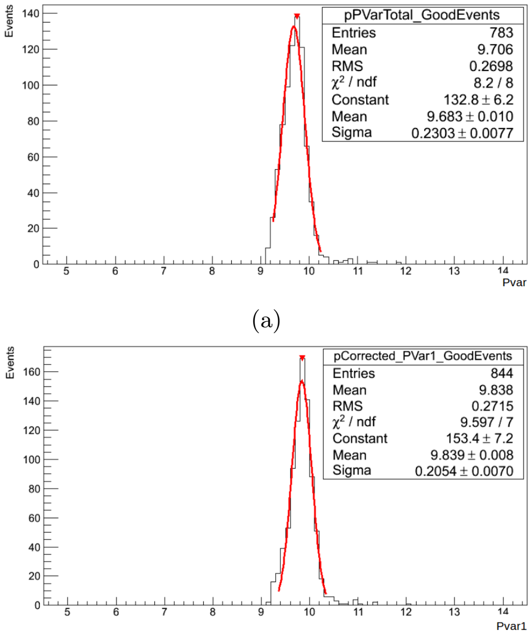


FIG. 2: Pvar as a function of Event Time for events with Pvar>9.0.

tance.

Present work

The Pvar variable for particle induced bubble nucleation decreases with time as shown in Fig. 2. With time the number of vapour bubble in the detector increases and the acoustic wave damps in vapour more than that in liquid—makes the value of Pvar lower. So a correction in Pvar is required. It is expected that the correction will improve the resolution of alpha-recoil discrimination by producing a narrower Pvar distribution. In the analysis, a fiducial volume of the detector is chosen to reject the events generated at the interfaces of two different media. The whole fiducial volume is divided into three equal cylindrical regions of diameter 8 cm and height 11 cm from top to bottom. The detector number 93 of PICASSO experiment at SNOLab and a calibration run with sampling rate 400 kHz at 40°C are used in present work. For the calibration run, the distribution of Pvar, calculated as the average over 9 piezoelectric sensors, is plotted separately for events of three regions. The second peak of each of the Pvar distributions is fitted by a Gaussian function and a cut value, PCut, is calculated in such a way that 97.5% of the neutron (or WIMP) induced recoils having Pvar>PCut are accepted. A correction factor is added to Pvar to make the slope of the Pvar vs Event Time plot flat. The correction factor depends on both the slope and Event Time and the corrected Pvar, denoted as Pvar1, are used in selection of the recoil induced events. Finally the Pvar distribution is plotted using the particle induced events of three regions and fitted by Gaussian function.



(a)

(b)

FIG. 3: Pvar distribution for particle induced events before correction (a) and after correction (b).

Results and discussions

The distribution of Pvar before and after correction is shown in Fig. 3 (a) and (b). It is observed that the FWHM after correction is improved by 10.70%, leading to better resolution of Pvar distribution. This study is carried out with several detectors and several runs also. This process is found to be effective in increasing the resolution of alpha-recoil discrimination.

References

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