Status of the R&D for surface events rejection in the EDELWEISS experiment

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Abstract. The first data taking of EDELWEISS-II the Dark Matter search with bolometers, measuring simultaneously ionization and heat, indicate the presence of incomplete charge collection events underneath the electrodes. These events, interpreted as surface interactions limit strongly the sensibility to WIMPs. In this paper, we are describing the status of the different techniques that are under development in our collaboration to identify and reject this type of events.

1. Surface events: the limiting factor
The first data taking of EDELWEISS-II (EDW2) indicates that the WIMPS search with ionization-heat detectors might be affected by the presence of so-called surface events as expected by the last analysis of EDELWEISS-I (EDW1) [1] [2] [3]. These events are due to the energy deposition mainly induced by the interaction of beta particles and X-rays in the first 20 to 100 microns underneath the electrodes for which the collection of free charge carriers is not complete. This is due to efficient trapping and recombination of charges that occurs in the electrodes during the screening of the electric field just after the free charge carrier production. For these events the ionization measurement is lowered in such a way that some electron recoils can mimic the nuclear recoils.

In this paper, we present briefly the status of the investigation of different techniques of reduction, identification and rejection of surface events under development for very low radioactive detectors to improve the physics results of the experiment EDW2.

2. Passive rejection of surface events
2.1. Detectors with amorphous layers
The deposition of a silicon or germanium amorphous layer just underneath the aluminum electrodes strongly reduces the number of surface events [4]. The free carriers can not access to the electrode anymore during the diffusion phase due to the barrier created in the band profile by the amorphous layer. Nevertheless, the surface events are not completely suppressed.

2.2. Ionization-heat detectors with thick electrodes
For electrode thicker than the range of 210Pb betas in aluminum (main source of beta background), no ionization occurs for surface events. Because of the good discriminations between non-ionizing events and low ionization events such as nuclear recoils even at the threshold level (15-20keV), this approach
should reduce significantly the number of problematic events. The difficulty to apply this technique is to control the deposition parameters of very thick aluminum electrodes as stability and homogeneity. Moreover, the energetic photons that will interact underneath the electrodes will suffer of incomplete charge collection as the surface events did.

The power of reduction of surface events of both techniques is limited. This is why the more promising techniques based on an active rejection of surface events have been developed.

3. Active rejection of surface events

3.1. Identification of surface events with interleaved-electrode-detectors

The replacement of the standard full electrodes by interleaved electrodes [5] creates two main orientations for the electric fields. The field’s lines are perpendicular to the face in the bulk, while they are mainly parallel to the electrodes surface plane near the surfaces. Thus the electrodes involved in the charge carrier collection are different for bulk events and surface events (respectively A and B in Figure 1). This electric field configuration creates some low field areas (event C in the same figure) which might constitute the limiting factor of this technique. A first 200g prototype has been developed in a program called INTERDIGIT.

![Figure 1. Carrier trajectories and event populations in detectors fitted with interleaved collection electrodes. Picture of the first 200g prototype.](image)

For illustration of present status of test and performance, Figure 2 presents the results of a recent calibration of a 200g prototype with $^{241}$Am and $^{252}$Cf sources ($\gamma$ rays and neutrons respectively) before and after the rejection of the surface events. A sizeable fraction of the low penetration 60 keV gamma events at high Q are rejected, most of low Q region ones disappear, while most of the neutron induced interactions in the bulk are kept. Its performances in a low radioactive background will be evaluated before the end of 2007.

3.2. Measurement of the event depth with Pulse shape analysis of the ionization signal

A good resolution in time of the ionization channel (in the 10ns range) allows the extraction of the depth of the energy deposition from the rise of the pulse [6]. A first application of this technique took place in the late run of Edelweiss-1. It showed that the surface event rejection by pulse-shape analysis can only be applied to high energies only (>50keV) due to electronic noise, and that the precision of the event localization is in the order of 1mm. Therefore this technique has a limited interest for low energy surface events rejection which is strongly required for WIMP research. Nevertheless it can be used to characterize the production of a space charge in the volume of the detectors with time. [7][8]
3.3. Athermal phonons measurement with NbSi thin films
This latter technique is based on a transient enhancement of the heat channel signal produced by the direct absorption of athermal phonons in the thermal sensor [9]. When two NbSi films are evaporated on both sides of the detector the enhancement will be larger in the closer film. This allows the determination of the depth of the interaction with a precision better of order of 1mm. Fig 3 shows results of recent beta and neutron calibration performed on a 200g detector. Beta rays from 109Cd source and energy lower than 100 keV are clearly separated from bulk events on the scatter plot of the athermal amplitude asymmetry parameter as a function of ionisation energy (97 % have asymmetry higher than 0.3). Right figure shows that neutron recoils, identified as low ionisation yield events as black dots, have indeed low asymmetry, the cut 0.3 keeps most of them. Accurate determination of efficiency and fiducial volumes are under way.

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