IDM2010

Instrumentation, Acquisition and Analysis of the SIMPLE Dark Matter Search Signals

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Abstract: **Description of the new instrumentation for the SIMPLE experiment, and its use in identifying, validating and rejecting non-WIMP backgrounds in the project measurements. Besides acoustic intrinsic discrimination, evidence is provided for a possible discrimination between alpha and neutron events via analysis of the signal parameters.**

INSTRUMENTATION

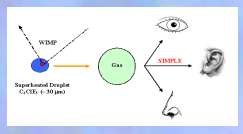

Fig. 1 SIMPLE sense detection

Fig. 2 The MCE-200 microphone

The new instrumentation chosen is based on a PANASONIC (omni directional) for PCB mounting, high quality electret microphone cartridge (MCE-200) with a frequency range of 20 Hz – 16 kHz (3 dB), signal-to-noise ratio (SNR) of 58 dB and a sensitivity of 7.9 mV/Pa at 1 kHz.

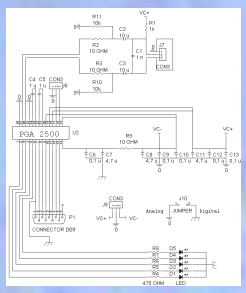

Fig. 3 Final electronic circuit for the microphone

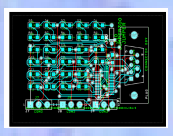

Fig. 4 Blueprint of the new SMD electronic board

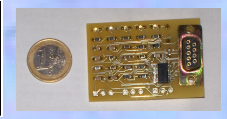

Fig. 5 One of the pre-amplification circuits

The new instrumentation's microphone was designed with a new microphone preamplifier (PGA 2500). The PGA 2500 is a digitally controlled, analog preamplifier designed for use as a front end for high performance audio analog-to-digital converters (ADCs). The PGA 2500 features include low noise, a differential signal path, and wide dynamic range.

ACQUISITION

Fig. 6 Left to right: SDD with instrumented cap; SDDs in 9ºC water pool; "Scorpios" box for the pre-amplification circuits and DAQ station at 1500 mwe

The detectors are capped using a new mechanical construction designed to eliminate previous problems with pressure microleaks. Each cap contains feedthroughs for signal and pressure monitoring, and the microphone encased in a latex sheath, which is immersed in a 2 cm thick glycerin layer covering the gel at the top of the detector.. The use of telecommunications-grade cabling eliminates electromagnetic noise signals. The SDDs are centrally installed inside a 700 liter water pool at a bath temperature of 9.0±0.1 ºC at the 1500 mwe level of the LSBB, and pressurized to 2 bar to reduce background sensitivity.

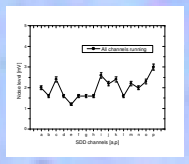

Fig. 7 Noise levels of each channel [alpha-papa]

The data was acquired in sequential Matlab files of ~ 6 MB each at constant rate of 8 kSps for a period of 8 minutes. The 14 kgd measurement with 15 superheated droplet detectors of total active mass 0.209 kg, produced 4056 events to be analysed above the 2 mV threshold linked to its corresponding noise level for each detector. 61 events were found to be particle induced (n, α, and WIMPS?), the remaining are acoustic noise and intrinsic SDD backgrounds

SIGNAL ANALYSIS

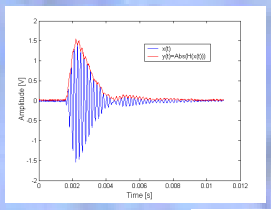

Fig. 8 Temporal evolution (pulse shape) of a typical bubble nucleation

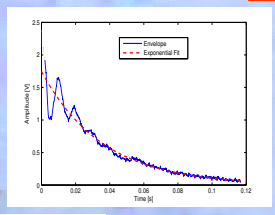

Fig. 9 Best fit of the exponential to the amplitude envelope of the pulse shown in Fig. 8

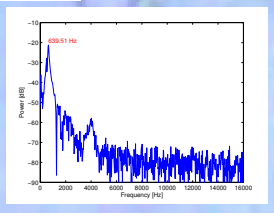

Fig. 10 PSD for the true nucleation event shown in Fig. 8

The SDD discrimination filter analysis consists on:

1. establishing a threshold for each detector (~2 mV above noise level);
2. rejecting events that occur with the Freon less detector (p);
3. rejecting all events with less than 5 pulse shape spikes;
4. rejections of acoustic duplicates on several detectors.;
5. rejection of events out of the stable bandpass filter constructed digitally with the window of known nucleations (450- 750 Hz);
6. rejection of events with different time constants from a true nucleation event that vary from 5- 40 ms;
7. validating the surviving events though parameters such as power spectral density, amplitude and time constants.

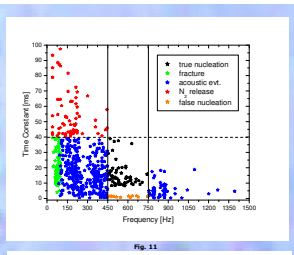

Fig. 11

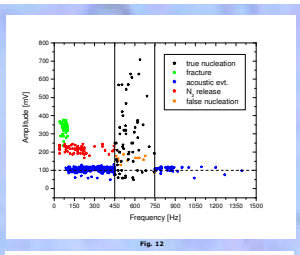

Fig. 12

The event counting and validation routine executes the following steps:

- Sets an amplitude threshold;
- Identifies the beginning and ending of each spike, based on the previous threshold;
- Amplitude-demodulates the time evolution of the spike;
- Measures the decay time constant (α) of the pulse;
- Suppresses the pulses which exhibit an α below a given threshold.

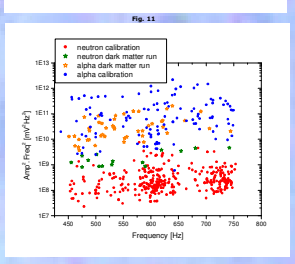

Fig. 13

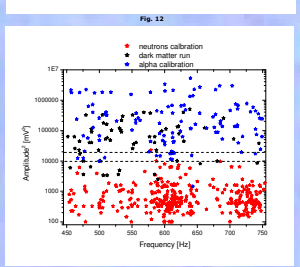

Fig. 14

Table I: Comparison of true event characteristics from a SDD with those of several common acoustic backgrounds

Event type	Time constant (ms)	frequency (Hz)	Power (dB)
True nucleation	5 - 40	450 - 750	- 20±6
Microleak	10 -40	2800 – 3500	- 25±10
Fracture	5 - 40	50 - 100	- 25±8
Trapped N_2	40 - 100	50 - 450	- 55±3