

RESULTS OF LOW ENERGY BACKGROUND MEASUREMENTS WITH THE
LIQUID SCINTILLATION DETECTOR (LSD) OF THE MONT BLANC LABORATORY

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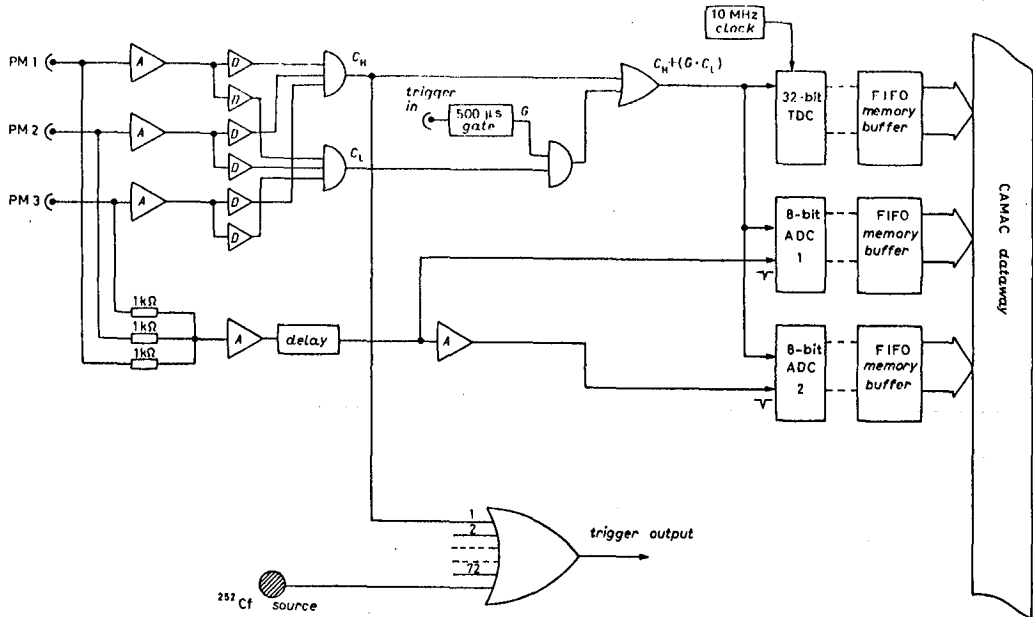
ABSTRACT

The 90 tons Liquid Scintillation Detector (LSD) is fully running since October 1984 in the Mont Blanc Laboratory, at a depth of 5,200 hg/cm² of standard rock underground. Even if the detector is a multi-purposes experiment, the main goal is to search for neutrino burst from collapsing stars. The experiment is very sensitive to detect low energy particles (at a threshold of 0.8 MeV), and thus has a very good signature to gamma-rays from (n,p) reaction which follows the $\bar{\nu}_e + p \rightarrow n + e^+$ neutrino capture. We present here the analysis of data, and discuss the preliminary results on low energy measurements.

1.Introduction. The analysis of low energy pulses in a massive detector deep underground is of primary importance to understand the background in experimental neutrino astronomy at low energies, when the signal is to be extracted from the background. Hence, a well defined analysis on the energy distribution of background pulses can be used as a calibration method for the existing underground stations of low energy neutrino astronomy. In addition, it provides an experimental basis to evaluate the feasibility to detect low energy neutrinos, for example from solar origin, in future and more massive detectors. The low energy background in a detector located very deep underground, is mainly due to gamma-rays from Compton scattering, either from the rock surrounding the laboratory or from small contaminating impurities in the material which the detector itself has been constructed with. Since it is necessary to reduce such a background to the lowest level, we have carried out a systematic study of the background spectrum in the energy region $\gg 0.8$ MeV, in our 90 tons Liquid Scintillation Detector, located inside the Mont Blanc tunnel and fully running since

October 1984. The results of such an analysis are here reported and discussed.

2. The LSD experiment. The aims and performances of our apparatus are described elsewhere (ref.1 and these proceedings, HE 5.3-6). Briefly, it consists of 72 scintillation counters, 1.5 m³ each shielded with Fe slabs 4 cm thick (see fig.1 of HE 5.3-6).



- Electronic block diagram for one counter channel.

Fig.1

Our recording system is triggered whenever one, out of the 72 counters, gives a pulse with energy threshold 7 MeV. The electronic method allows us to record the following parameters which could follow the main trigger: a) pulse height (at the energy threshold 0.8 MeV) in any of the 72 scintillation counters, during a 500 μ s gate duration, b) time delays among pulses in the gate with an accuracy of 100 ns, up to the gate duration, c) multiplicity of pulses for each counter and each event, up to 16 pulses. Fig.1 shows our electronic system for one scintillation counter.

3. The calibration method. To calibrate our counters, we used, as a neutron source, neutrons from the spontaneous fission of ²⁵²Cf; the source, enclosed in a semiconductor silicon surface barrier counter (SBC) in a stainless steel box, was placed inside a scintillation counter (ref.1). During several calibration runs, we used two different triggers following the spontaneous fission of the ²⁵²Cf source, namely: either pulses given by the SBC, or direct detection of pulses from high energy prompt gamma rays ($E > 7$ MeV) in the counter; the rate of the former is 0.12 s⁻¹, and that of the latter is 0.017 s⁻¹.

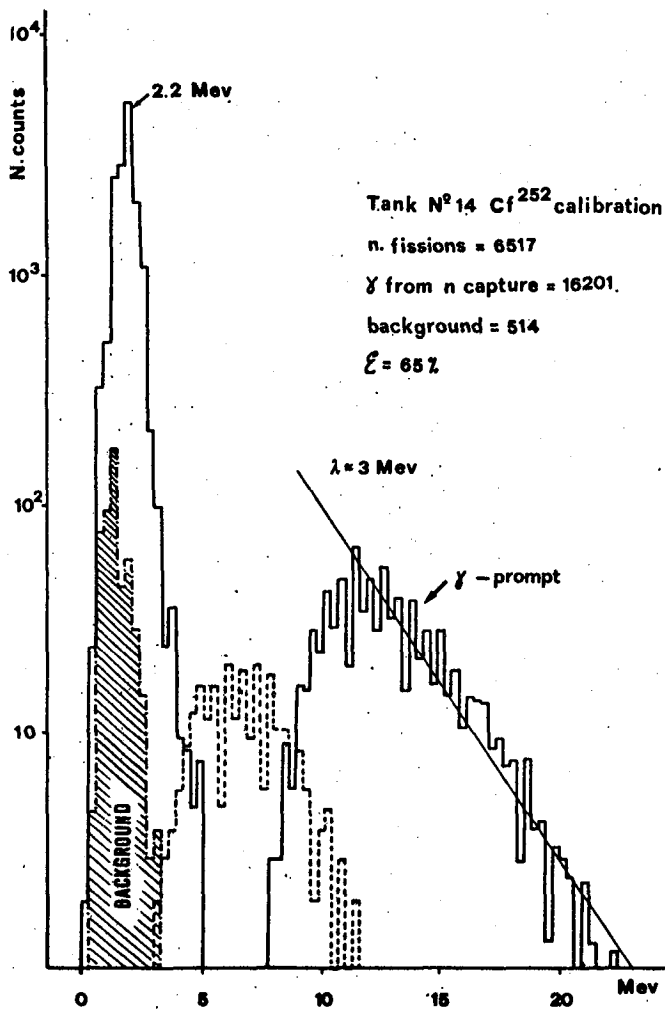


Fig.2

Fig.2 shows the results of our measurements on the inner counter n.14. The measured gamma spectrum (peaked at 2.2 MeV) is compared with the background distribution (shaded area) and with the spectrum of prompt high energy gamma rays, which extends up to 20 MeV. By subtracting the distributions of prompt and 2.2 MeV gamma events, one obtains a spectrum peaked at ~ 6 MeV (dashed line, fig.1). The high sensitivity of our apparatus is shown by the ratio of the resulting counting rate to that of the 2.2 MeV gammas from (n,p) capture, which is only 0.015. The origin of these pulses is now under an accurate analysis.

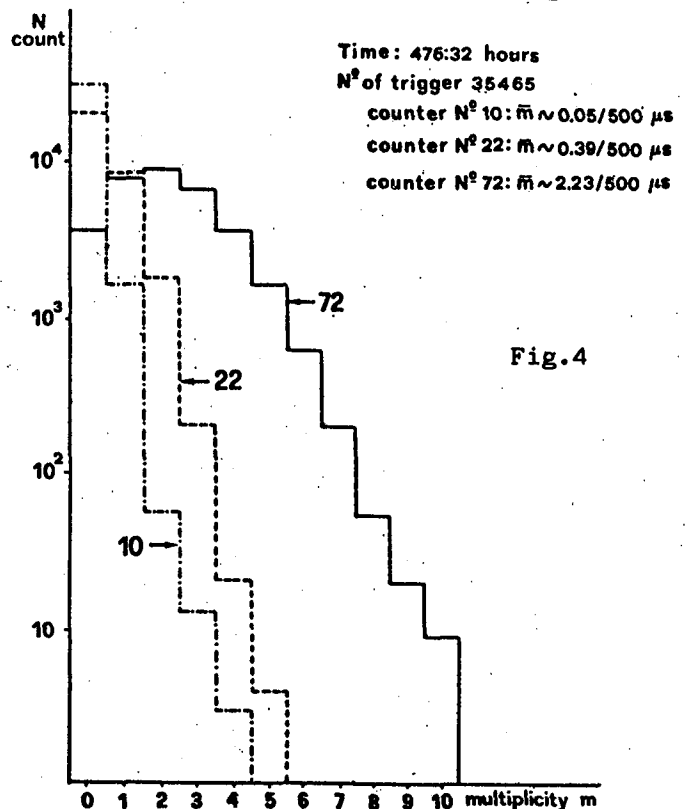
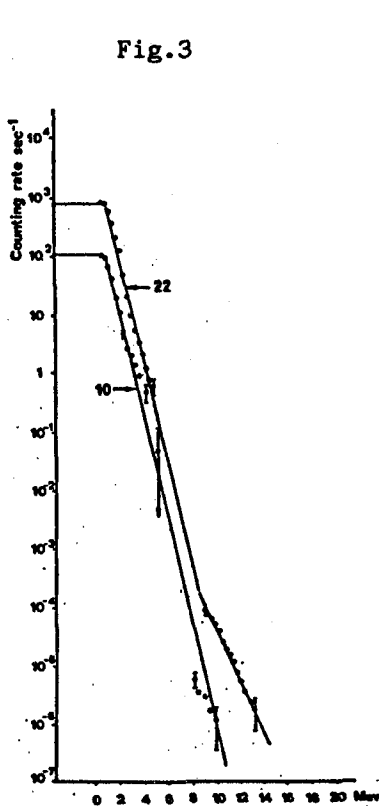
Moreover, our data show that the efficiency of neutron detection is of order or better than 0.65. This efficiency is nearly the same for all the other counters tested so far with this calibration method.

4. Analysis of background pulses. Since all the 216 photomultipliers of our detector have been chosen with a very low noise, with a single counting rate in the range 10^3 to $5 \cdot 10^3$ per s, the 3-fold coincidences in one counter are less than $3 \cdot 10^{-7}$ during the gate duration ($500 \mu\text{s}$), when our detector is sensitive at the low level discrimination (≥ 0.8 MeV). The background in this energy range is mainly due to the local radioactivity of the rock in the laboratory. For the high level discrimination at $E \geq 7$ MeV, besides this source of background, one should also take into account the soft component of muons crossing the rock near the apparatus; this effect is much more evident in the counters at the edge of the detector.

For background analysis we exclude all the muon-like events, and only

single events on any out of the 72 counters are considered. In this way, the background analysis has been made, within the 500 μ s gate duration, for the remaining 71 scintillation counters.

5. Conclusions. An example of the measured energy distribution of the events analysed according to the previous criteria is given in fig.3 for the scintillation counters n.10 (inner one) and n.22 (at the edge).



During 476 hours lifetime, out of 35465 triggers, the average value is 0.052 and 0.39 pulses/trigger for counters n.10 and n.22 respectively. In addition, the measured multiplicity of events in the same counters during the gate duration is shown in fig.4 together with that of the top layer counter n.72, for which an average value of 2.2 pulses/trigger has been obtained.

Similar distributions were also obtained for the other counters, thus showing a rather good uniformity in the counting rates. Finally, the ratio of background counting rates between inner counters to the top ones is on the average better than 0.05, and between the inner counters to those at the edge of the detector is of order of 0.1. This result clearly confirms the feasibility of our detector in performing neutrino astronomy with a very high sensitivity.

References

- 1) G.Badino et al., Nuovo Cimento C, 7, 573, 1984