THE RESEARCH PROGRAM OF THE LIQUID SCINTILLATION DETECTOR (LSD) IN THE MONT BLANC LABORATORY

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ABSTRACT

A massive (90 tons) Liquid Scintillation Detector (LSD) is running since October 1984 in the Mont Blanc Laboratory at a depth of 5,200 hg/cm^2 of standard rock. The research program of the experiment covers a variety of topics in particle physics and astrophysics. We present here the performances of our detector, the main fields of research, and we discuss the preliminary results.

1.Introduction. Since October 1984 a massive (90 tons) Liquid Scintillation Detector (LSD), is fully running in the Mont Blanc Laboratory, in a cavity inside the road tunnel linking Italy and France, at a depth of 5,200 hg/cm^2 of standard rock. LSD has been designed as a multipurposes experiment, with a large mass of sensitive material deep underground, to perform researches in several fields of particle physics and astrophysics (ref.1). In particular: a) search for $\bar{\nu}_e$ bursts from collapsing stars, b) direct measurements of atmospheric ν_e and $\bar{\nu}_e$ spectrum at energies $\geq$10 MeV, c) possible detection of solar neutrinos at the energy threshold 5 MeV, d) search for nucleon instability, n-$\bar{n}$ oscillations and magnetic monopoles, e) researches in cosmic ray physics: muons, muon-bundles, μ-stop, electromagnetic and hadronic cascades, prompt muon production at high energies.

The experiment has been designed with the combination of four excellent conditions, namely: a) large depth underground of the Laboratory, b) good shielding against the local radioactivity background, c) high performances in the electronic system, and d) good quality and efficiency in the detection system (scintillator and streamer tubes).

2. The LSD experiment. The detector is made of 72 scintillation counters (1.0x1.5x1.0 m^3 each) on 3 layers as shown in fig.1. To reduce the low energy local radioactivity background from the rock, each counter

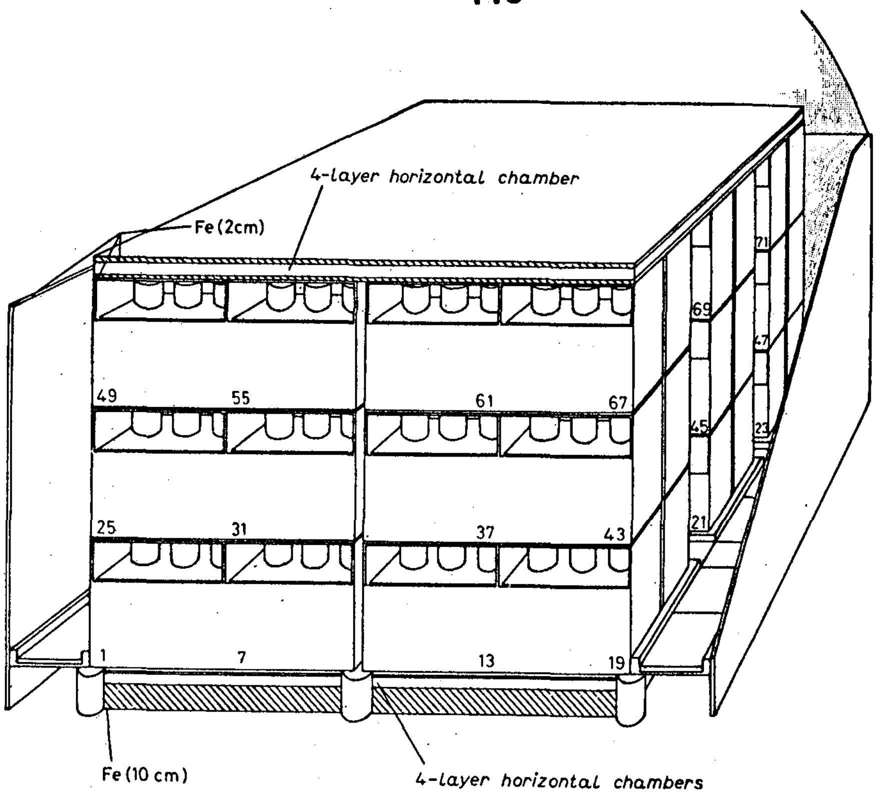

Fig. 1. – The 90 ton liquid scintillation detector in the Mont Blanc Laboratory (dimensions $(7\times8\times5)$ m^3).

and the whole detector (8x7 m^2 area, 5 m height) are shielded with Fe slabs. The total mass of Fe in the shield is 200 tons, and the 100 tons internal can be considered also as a target and active material. In the scintillator we have 8.5 10^{30} free protons, and 5.1 10^{31} bound protons and 6.0 10^{31} electrons in the scintillator and inner Fe.

A 4π anticoincidence system, made of limited streamer resistive tubes of the NUSEX type (ref.2), is now under construction. The system allows to reconstruct tracks of charged particles, mainly muons at our depth, with an accuracy of ~ 1 cm in spatial resolution and with an angular resolution better than 0.2° for particles crossing the apparatus.

The electronic system, monitored by a PDP 11/24 computer, consists of (ref.3) two level discriminators for each scintillation counter: a high level discriminator (for pulses with energy threshold 7 MeV), which is OR-ed for main trigger functions, and a low level discriminator (with an energy threshold 0.8 MeV) active only during a 500 μs gate, opened by the main trigger. Two ADC's measure the energy deposition of charged particles in the scintillation counters in two overlapping energy ranges: 0-70 MeV and 0-700 MeV respectively.

A 200 ns resolution time provided by a coincidence system for every pulse is recorded by a TDC, 32 bits of dynamic range. The absolute time of each event is recorded with an accuracy better than 1 ms, to

correlate our detector with the neutrino network. A FIFO memory buffer system is used for each channel to accumulate up to 16 events/channel before the read out.
Background measurements and results on the efficiency to detect low energy pulses are reported elsewhere (ref.3 and these proceedings HE 5.3-5). In particular we have measured the efficiency in detecting low energy neutrons, which give a very good signature to $\bar{\nu}_e$ from collapsing stars in a delayed coincidence with positron pulses.

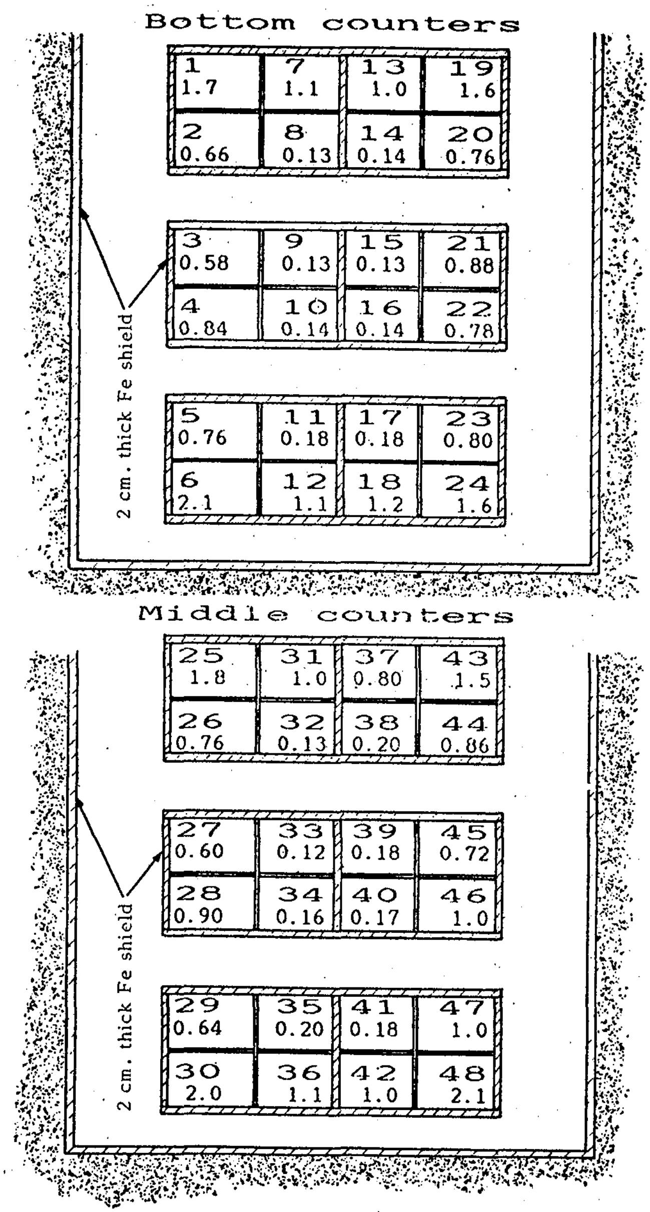

Fig.2 Counting rate 10³/sec (E ≥ 0.8 MeV)

3. Data analysis. We report here the results from a preliminary analysis made after 76 days lifetime. In order to estimate the counting rates in our apparatus, we performed a separate analysis of events in any of the 72 scintillation counters, both at the energy threshold 7 MeV and 0.8 MeV. Fig.2 shows the counting rates above the low level discrimination for bottom and middle counters; the top layer of counters is not desplayed because of the lack of the Fe shield, which will be set up in the near future. From fig.2 we conclude that the uniformity and homogeneity of the counting rates are within 90% for counters in similar positions; this represents a good check on the consistency of our apparatus.
In HE 5.3-5 we present the analysis of the low energy pulse distribution; here we discuss the data analysis above the 7 Mev energy threshold. At this discrimination level the counting rate (which represents the total trigger frequency in our apparatus) is 1.2 events min^{-1}.

For muons in single counters the pulse amplitude distribution has been cut at ∼ 20 MeV in software analysis. Fig.3 shows the events pulse-height distribution for vertical through going muons, crossing a vertical telescope of 3 scintillation counters. From this distribution, and from that of the pulse-height in single counters, the ADCs scale has been calibrated, giving a sensitivity of 3.0 MeV/channel, and covering an energy range up to 700 MeV for each scintillation counter.

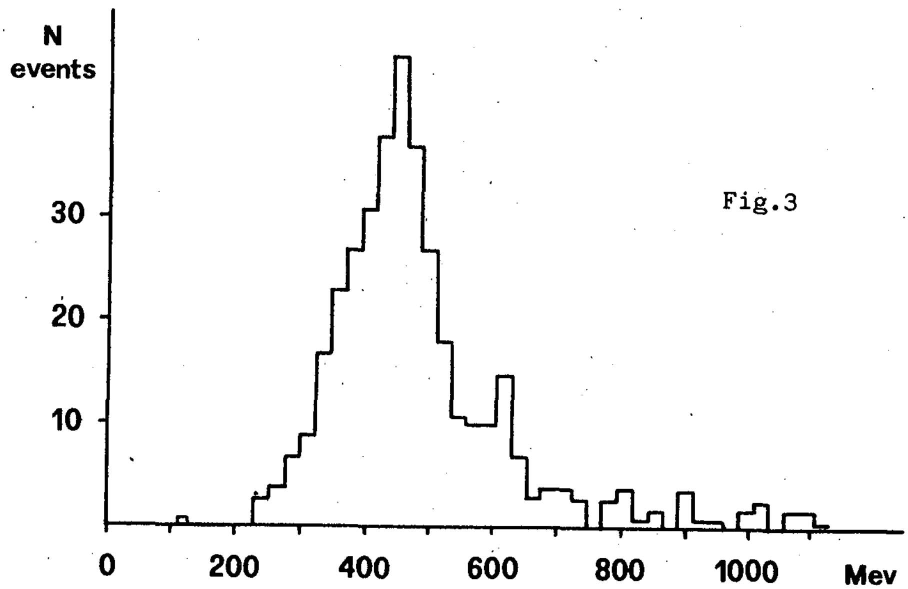

Fig.3

4. Conclusions. From the analysis of our data, we obtained the multiplicity m of counters fired per event (see table I). From the 5291 muons involving at least 2 counters, a rate of 2.9 muons/hour has been obtained for the whole our detector; this value agrees with the expected one at our depth, obtained with previous experiments in the Mont Blanc Laboratory.

The analysis on muon-bundles, muon-interactions, confined events, neutrinos from collapsing star, etc. is now in progress.

m	1	2	3	4	5	6	7	8	9	10	11	12	13
n. of events	11173	2399	2009	657	130	57	14	11	4	4	3	2	1

Table I

References

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2) G.Battistoni et al., Phys.Lett.B,133,454,1984
3) G.Badino et al., Nuovo Cimento C,7,573,1984