The Status of the Large Volume Detector at Gran Sasso Laboratory

(Presented by B. Alpat)

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ABSTRACT

The Large Volume Detector (LVD) at Gran Sasso underground laboratories is described and the status of the detector with some results relative to the first one fifth of the apparatus are presented.

1. Introduction

The LVD[1] is a multipurpose detector located at the Gran Sasso Laboratory in Italy and it is designed primarly to study the neutrinos from supernovae, the neutrino oscillations with atmospheric neutrinos, the chemical composition and the energy spectrum of the high energy primary cosmic rays with cosmic ray induced muons. It is possible also to detect neutrinos from point like sources, dark matter, monopoles, proton decay, WIMPS, WIFS etc. In this report we shortly discuss some of these topics and describe the present status of the LVD.

2. Detector Characteristics

The Gran Sasso underground laboratory is located in Italy about 120 km east of Rome at a depth of 3,000 meters water equivalent below the peak of the Gran Sasso mountain. The LVD is a uniform detector of dimensions (w)13.8 m×(l)42 m×(h)12 m and it has a modular design. A total of 190 modules are divided into 5 towers and each module contains 9,6 tons of liquid scintillator filled into 8 counters. These counters are placed into a steel container and all is surrounded by tracking chambers at the bottom and at one vertical side. The overall geometrical acceptance of the LVD is 7710 m^2.sr. The L-shaped tracking system contains double layer of limited streamer tube (LST) chambers which are sense strip(X)-LST-sense strip(Y) sandwiches with 3.9 cm strip width. The 2 cm of stagger between the two LST layers yields to an angular resolution of 4 mrad.

The basic element of the scintillation system is a stainless steel tank of dimensions $1\times1\times1.5m^3$ filled with the liquid scintillator C_nH_{2n}, ($\langle n\rangle$=9.6). Each counter seen by three 15 cm PMTs yielding very good energy resolution ($\sigma(E)/E$=15% at 10 MeV).

3. Physics with LVD

3.1. Neutrinos From Supernovae

The neutrino bursts emitted by the collapse of a star in our galaxy or in Magellanic Cloud will be detected in LVD with very high precision. In Table 1 is given the supernova neutrino reactions detectable in LVD from a supernova (SN type-II) at the galactic center.

Table 1 The number of ν reactions detectable in LVD from a SN at the galactic center (8.5 kpc).

Reaction	E_{thr} (MeV)	Detectable particle	N. of exp. int. 1840 $tons$	368 $tons$
$\bar{\nu}_e p \rightarrow n e^+$	1.8	$e^+, \gamma^{(a)}$	500-1000	100-200
$\nu^{12}C \rightarrow \nu^{12}C^*$	15.1	γ	28-32	6-17
$\nu e^- \rightarrow \nu e^-$		e^-	16-27	3-5
$\bar{\nu}_e\,^{12}C \rightarrow \,^{12}B e^+$	14.4	$e^+, e^-\,^{(b)}$	5-15	1-3
$\nu_e\,^{12}C \rightarrow \,^{12}N e^-$	17.3	$e^+, e^-\,^{(c)}$	2-15	0-3

$^{(a)}$From the n capture by free protons;
$^{(b)}$From the subsequent β-decay of ^{12}B;
$^{(c)}$From the subsequent β^+-decay of ^{12}N;

In observing the SN neutrinos the LVD has two important features; the fast event recognition through an Supernova Online Monitoring (S.O.M.) system on statistical basis and the precise absolute timing of the burst given by the Gran Sasso ribidium atomic clock.

The candidate selection has been made by S.O.M. comparing the clusters of m events within $\Delta t \leq 100$ sec with the corresponding Poisson probability calculated from the current trigger rate. The check for the candidate consistency and fine-tuning has been made by off-line on the basis of the topological distribution of the pulses inside the entire detector, and in particular, by searching for the presence of a delayed low energy pulse from the neutron capture reaction (see the first reaction in Table 1).

3.2. Atmospheric Neutrinos (Neutrino Oscillations)

If the deficit of the atmospheric ν_μ flux as compared to the phenomenological model expectations measured by the Kamiokande-II experiment[2] is confirmed it will be a strong evidence for the presence of the neutrino oscillations.

The detection technique of the atmospheric neutrinos in LVD bases on the observation of the contained events where the neutrinos interact inside LVD and of the crossing muons induced by the ν_μ reactions in the surrounding rock. In LVD with 1 kton we expect to observe about 100 ν_μ and 60 ν_e contained events and with the full LVD, 78 horizontal and 155 upward going ν_μ induced muon ($E_\mu \geq 2$ GeV) events in a year.

3.3. High Energy Cosmic Ray Physics

The study of the multi muons at LVD will give valuable information about the elemental composition of the primary cosmic rays and their energy spectrum for the primaries with energies $\geq$100 TeV above which the primary cosmic ray flux falls steeply.

The method is to compare the measured muon multiplicity distribution with that calculated from an accurate Monte Carlo (MC) for a given trial primary composition model and energy spectrum. Our MC calculations indicate[3] that with one LVD tower at the muon multiplicity N_μ=11 the 3σ separation between two extreme models will be achieved in a year of data taking.

The correlations with the surface detector (EAS-TOP in LVD case) give also the possibility to couple the primary energy information from the shower size (N_e) measurements at the surface with that of the muon multiplicty distribution at LVD for the coincident events[4].

4. First Tower Results and the Present Status of the LVD

The current operating high energy threshold (HET) is 5 MeV and it is lowered to 0.8 MeV for about 1ms whenever a HET trigger occurs. The single muon rate for the whole tower is measured to be 0.03 Hz corresponding to 1.1 muons $m^{-2} \cdot sr^{-1} \cdot h^{-1}$ at the detector site while the event rate due to gammas and neutrons is 0.11 Hz.

Since 11 June 1992 until the end of August 1993 about 2.5 10^6 triggers have been observed with an average operational efficiency of $\langle\epsilon_{op}\rangle \geq 80\%$.

5. Summary

The first tower of LVD is fully operational since June of 1992 and it is the most sensitive liquid scintillator detector currently in operation. The data analyses related to the various physics topics are under way. The second tower is under construction and will be completed by the end of 1993.

6. References

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