Nuclear Physics B (Proc. Suppl.) 35 (1994) 259–260
North-Holland

NUCLEAR PHYSICS B
PROCEEDINGS
SUPPLEMENTS

Multicomponent EAS observations from EAS-TOP and LVD at Gran Sasso

EAS-TOP and LVD collaborations[a]

Presented by G. Navarra (Istituto di Fisica Generale dell' Universita' di Torino, Italia)

EAS-TOP (at the surface) and LVD (deep underground) provide a telescope for a multicomponent study of Extensive Air Showers (EAS). Examples of different classes of events observed in coincidence and their physical significance are presented and discussed.

1. INTRODUCTION

Surface EAS arrays provide measurements of the e.m., hadronic, low energy muon, atmospheric Cerenkov light, radio components of Extensive Air Showers.

The simultaneous observations from suitable deep underground detectors provide the possibility of measuring the high energy muon component (through the detection of the muons themselves and of the products of their interactions), which is related to the energy/nucleon of the primary cosmic ray, and the possible neutral penetrating particles produced in the high energy interactions in the atmosphere.

High energy cosmic ray events are studied through such technique by EAS-TOP and LVD operating as a combined telescope at the Italian Gran Sasso Laboratory.

EAS-TOP [1] is a multicomponent surface EAS array operating at Campo Imperatore (2000 m a.s.l.), and including detectors of all the previously quoted EAS components: e.m. (enclosed area $\approx 10^5$ m^2), muon hadron (area 144 m^2) and atmospheric Cerenkov light (8 telescopes).

LVD [2] is a compact large volume apparatus (40x13x12 m^3), located in hall A of the underground Gran Sasso laboratories (at a depth of ≈3300 m.w.e. in the direction of EAS-TOP, $E_{\mu th} \approx 1.3$ TeV), including streamer tubes for muon tracking and thick scintillation counters for energy loss measurements with wide linearity.

The two apparata are separated by ≈1000 m in altitude, and ≈500 m on the horizontal projection, the relative zenith angle being on average 25 degrees. The combined geometric factor of LVD and of the e.m. detector of EAS-TOP is $\Gamma \approx 10^5$ cm^{2}sr, that allows to operate at primary energies around 10^{15} eV (corresponding to primary fluxes $\approx 10^{-9}$-10^{-10} cm^{-2} s^{-1} sr^{-1}) with a rate of ≈1 event day^{-1}.

2. COINCIDENT EVENTS

The combined measurements are in operation since June 1992 with the first tower of LVD (i.e.1/5 of full detector).[3]

i) the e.m. detector of EAS-TOP and LVD (coincidence event rate ≈2.23 h^{-1}; for EAS-TOP internal events the coincidence event rate is ≈0.18 h^{-1}).

In fig. 1a the coincidence event with the largest multiplicity muon bundle detected by LVD (N_μ=32) is shown. In fig. 1b the corresponding e.m. component as recorded by EAS-TOP is shown. The reconstructed shower size at the surface is Ne=5·10^7 particles corresponding to a primary energy $E_0 \approx 10^{17}$eV.

The analysis of such events is very important to study primary composition, and protons and nuclei interactions at the quoted primary energies.

ii) the e.m., GeV, and muon detector of EAS-TOP and LVD

Simultaneous measurements of the three components are necessary since, at the moment, the correlated data, obtained with two

SSDI 0920-5632(94)00468-B

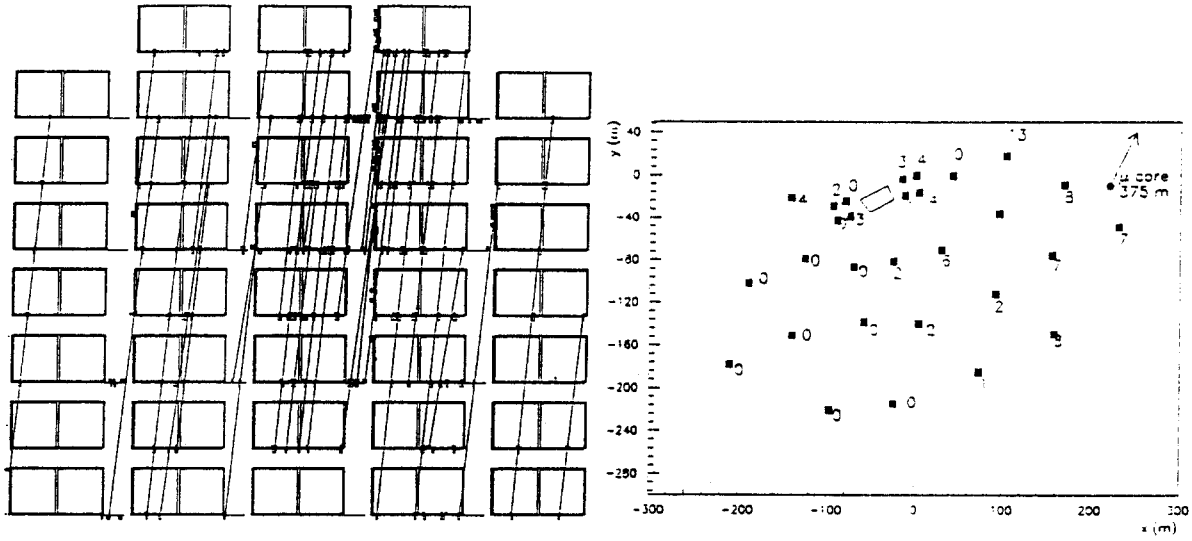

Fig. 1 - The correlated event with largest muon multiplicity (32) detected in LVD: (a) the LVD tracking data and (b) the EAS-TOP data: number of detected particles in each module (the harrow indicate direction and position of the core for the μ-bundle).

of them, lead to rather contradictory results on the c.r. primary composition

iii) the deep underground events and atmospheric Cerenkov light flashes.

Nine correlated events between two large angle C.I. detectors and the LVD scintillator trigger have been recorded in 24.25 hours of operation of one Cerenkov EAS-TOP telescope.

In five events no e.m. trigger was present. This is due to the fact that the Cerenkov Light detector has a lower threshold than the e.m. detector. The increase of about a factor two of the coincidence trigger rate with LVD, implies that the Cerenkov detection threshold level is about a factor of three lower than the e.m. one, i.e. E_{th}(Cerenkov)≈30 TeV. This is in agreement with photon content of the Cerenkov Light pulses: F≈500 ph/m^2, at an average core distance d≈100 m.

iv) the H.E. cascades deep underground and EAS at surface.

A few such events have been recorded; they provide a correlated measurement of the highest energy muons produced as a function of primary energy (again related to the composition, and to the production processes).

v) the anticoincidence experiment.

For this analysis the three upper layers, and two double walls of scintillators of LVD in the direction of EAS-TOP have been used in anticoincidence. The efficiency of such configuration of the scintillator detector, when combined with the information of the streamer chambers has thus been studied. No muon-like track originated inside the detector, in temporal coincidence with an EAS-TOP event, has been found in this first analysis, thus showing the feasibility of the experiment.

3. CONCLUSIONS

The EASTOP + LVD considered as a multicomponent array at Gran Sasso is in operation with good efficiency.

The experimental techniques, and the methods of analysis provide a new methodology for studying a large variety of open problems in cosmic ray and high energy physics.

REFERENCES

1) M. Aglietta et al. (EAS-TOP coll.), Il Nuovo Cimento, 9C, 262 (1986); Nuclear Instruments and Methods, A277, 23 (1989) and A336, 310-321 (1993); and these proceedings

2) C. Alberini et al. (LVD coll.), Il Nuovo Cimento, 9C, 237 (1986); Nuclear Instruments and Methods, A277, 11 (1989); and these proceedings

3) M. Aglietta et al. (EAS-TOP and LVD coll.), Il Nuovo Cimento, A, 105, (1992), pag. 1793

a) For the complete list of authors see references [1], [2] in these proceedings.