1983; Vallianatos et al. 2004; Herraiz et al. 2000; Frid et al. 2003; Uyeda et al. 2009). The progressive accumulation of mechanical energy in the fracture site, also promotes a progressive variation in the electric and magnetic properties of the rock (Parrot 1990; Hadjicontis& Mavromatou 1994; Stravrakas et al. 2008), therefore, before the seismic event, which represents the rock fracture, one should observe a significant variation in the "leakage" of the geomagnetic field, affecting the vertical flow of high-energy charged particles near the event sites (Aleksandrin et al. 2003).

Among the factors that influence the cosmic flux variation in the atmosphere, the climatological variables and solar activity are the most important (Lockner et al. 1983; Usoskin et al. 2008), hence the need to eliminate these spurious contributions. Using the LAGO electronic we can easily isolate from a charge histogram the muon vertical contribution (see Figure 2). We improve the isolation by means of a lateral filter, consisting of a 22-meters-deep and 40-cm-thick reinforced concrete, from a structure already present in the building of the Science Faculty of Universidad de los Andes, Mérida-Venezuela (see Figure 3). A charge histogram at 0 and 22 mt is shown in Figure 3. Figure 4 shows the flux's vertical component, monitored every 5 minutes from Jun 2009 to January 2011, along with local seismicity at 50 km from detector. Of particular interest is the muon flux behavior before, during and after the seismic event (4.2 M) occurred on February 6, 2009, 30 km from the detector. This event was the principal in a seismic storm belong to the same seismic focus and registered it in the time interval between January 15 to February 8, 2009. Other case was observed one month before the seismic events (4.0 M) occurred on 28 November 2010. The muon flux decrease showing an anomalous behavior, that disappears after the event (see Figure 4). It is clear that more data has to be taken, but no other important seismic events ($>$ 4.0 M) have occurred during the period studied. A similar experimental setup has been recently installed by LAGO-Colombia in Bucaramanga, a region of prominent seismic activity, and is currently taking data.

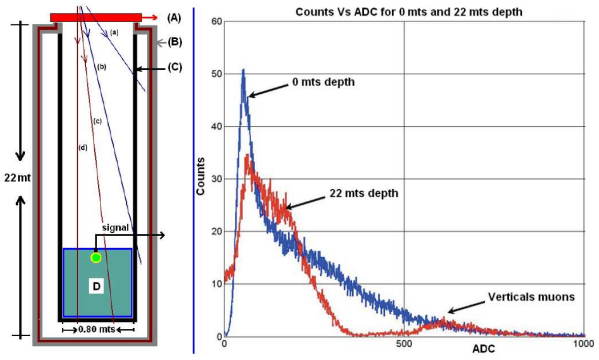

Fig. 3. In order to isolate the vertical muon flux, a WCD (D) has been installed at 22 mt depth within a reinforced (B and C) column of concrete (left). Low energy direct vertical particle has been removed with an iron filter 10 cm thick (A). A charge histogram at 0 and 22 mt depth illustrates the muon component (right).

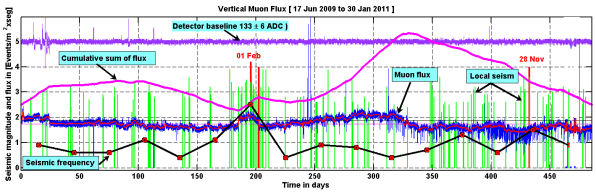

Fig. 4. Vertical muon flux from 17 jun 2009 to 30 January 2011. Cumulative sum of vertical muon flux events and seismic frequency are shown. Local seisms are selected at distances $<$ 50 km from detector.

4. REMARKS AND CONCLUSION

WCD used in Geiger mode are efficient detectors sensitive to the high energy photon flux of GRB, due to their ability to count secondary photons converting to an electron-positron pair in their water volume. When located in high altitude mountain sites, they can be a complementary method of observation of GRB, as their efficiency starts at high energies, where the flux of primaries is too low for satellite to perform observation.

The LAGO project is an international effort of many groups in different countries to operate a network of WCD in high altitude sites in Latin America. Data taking has started in 2007, and no GRB has been observed to date. Limits on 40 GRBs were set, with the most stringent one being 1.6×10^{-6}erg cm^{-2} for `GRB 080904` in the 0.5–100 GeV energy range.

LAGO data can also be used to monitor the solar activity through its modulation effect on galactic cosmic rays. A monitoring program has started in order to provide a network of observation during the current solar cycle, in particular during next maximum of activity in 2013.

The use of high energy vertical muons flux, from cosmic radiation may represent a possibility to measure the global geomagnetic field variations on large terrestrial areas. This methodology can be an indirect way to measure changes in the mechanical stress on rocks, before, during and after a seismic events,