Study of the effect of seismically-induced geoelectric and geomagnetic fields on secondary particle detection at a LAGO site

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Description

In this study, we looked at the relation between seismic activity and detection of secondary particles from cosmic rays at ground level, by taking results from studies on the changes in geoelectric and geomagnetic fields with respect to relevant seismic activity.
We performed simulations of extensive air showers initiated both by a single $10^4\,GeV$ proton and by a one hour flux of primary particles.
In both cases, we changed only the parameters for geoelectric and geomagnetic fields and studied how the models for electromagnetic and particle interaction present within the CORSIKA code changed the distribution of secondaries at particle level for detection in a WCD.

Simulation Parameters

The simulations were generated using the ARTI package used within the LAGO collaboration. Which includes the CORSIKA code.
Simulations are performed taking as a LAGO site, LEOPARD Laboratory at USFQ, located at 2200 m.a.s.l. in a tropical atmosphere.
For the one hour flux simulation, we take all possible zenith (-90°,90°) and azimuth angles of entry (-180°,180°). As well as energies between 5 and 10^6 GeV
We take baseline magnetic field parameters above Quito from November 13, 2020: $Bx = 11.031\,\mu\text{T}, Bz = 4.081\,\mu\text{T}$. Electric field parameters are taken from what would be expected for fair-weather days ($E_x = 0\,\text{V/cm}, E_z = 0\,\text{V/cm}$).
The change in magnetic field parameter is taken as $\Delta B_z = 0.25\,\mu\text{T}$. While the change in electric field parameter is taken as $\Delta E_z = 10\,\text{V/cm}$.
Simulations for One Hour of particle flux were performed in the Google Cloud Platform using Kubernetes and Argo.

Results for a shower started by a single $10^4\,GeV$ proton

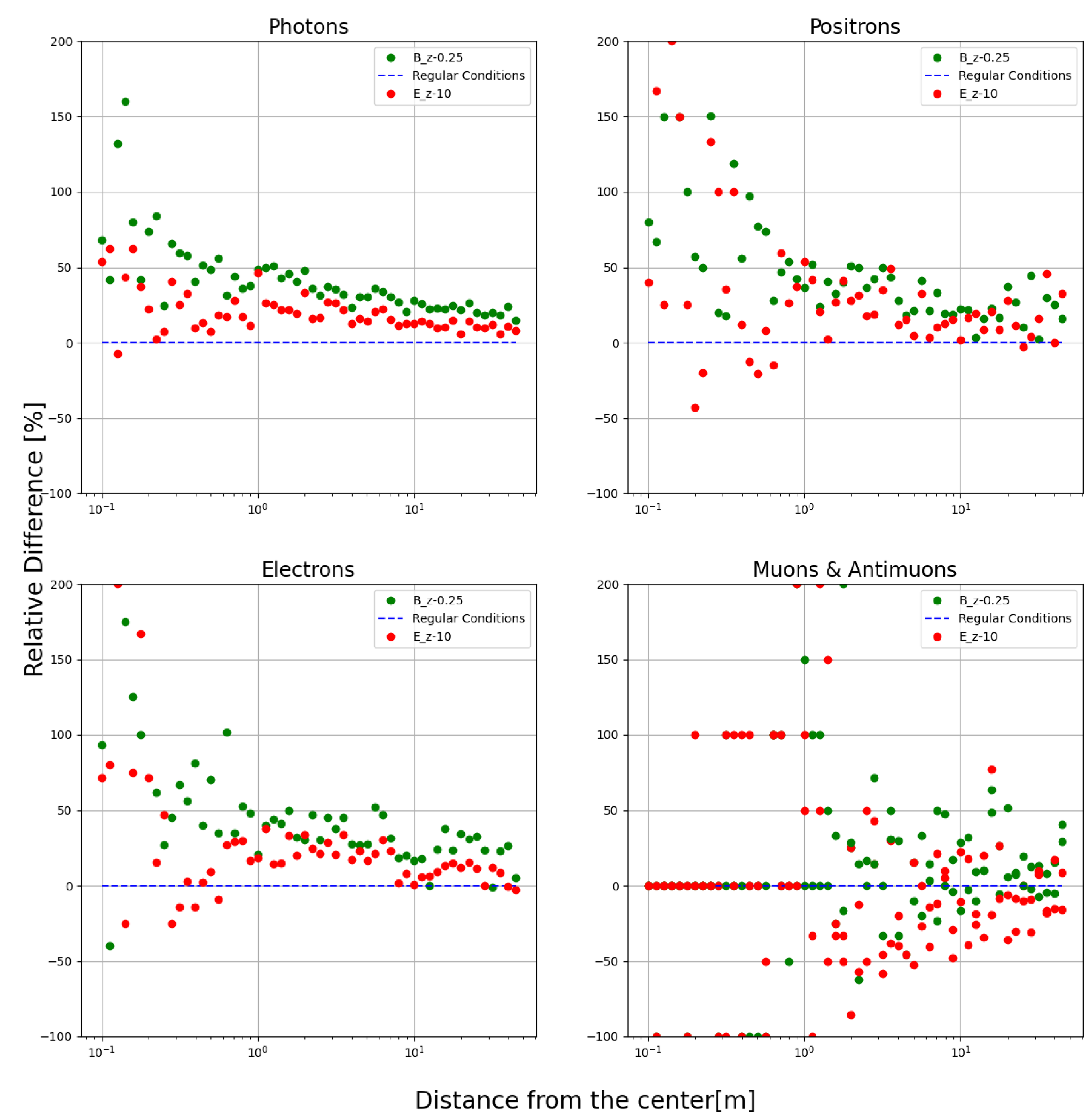

Figure: Relative difference of distributions of secondary particles at ground level from regular conditions for showers initiated by a single proton. Photons, Electrons and Positron all show high changes at distances closer to the detector Changes in the muonic component appear to lack this consistency and could be attributed to randomness

Results for one hour flux of primary particles

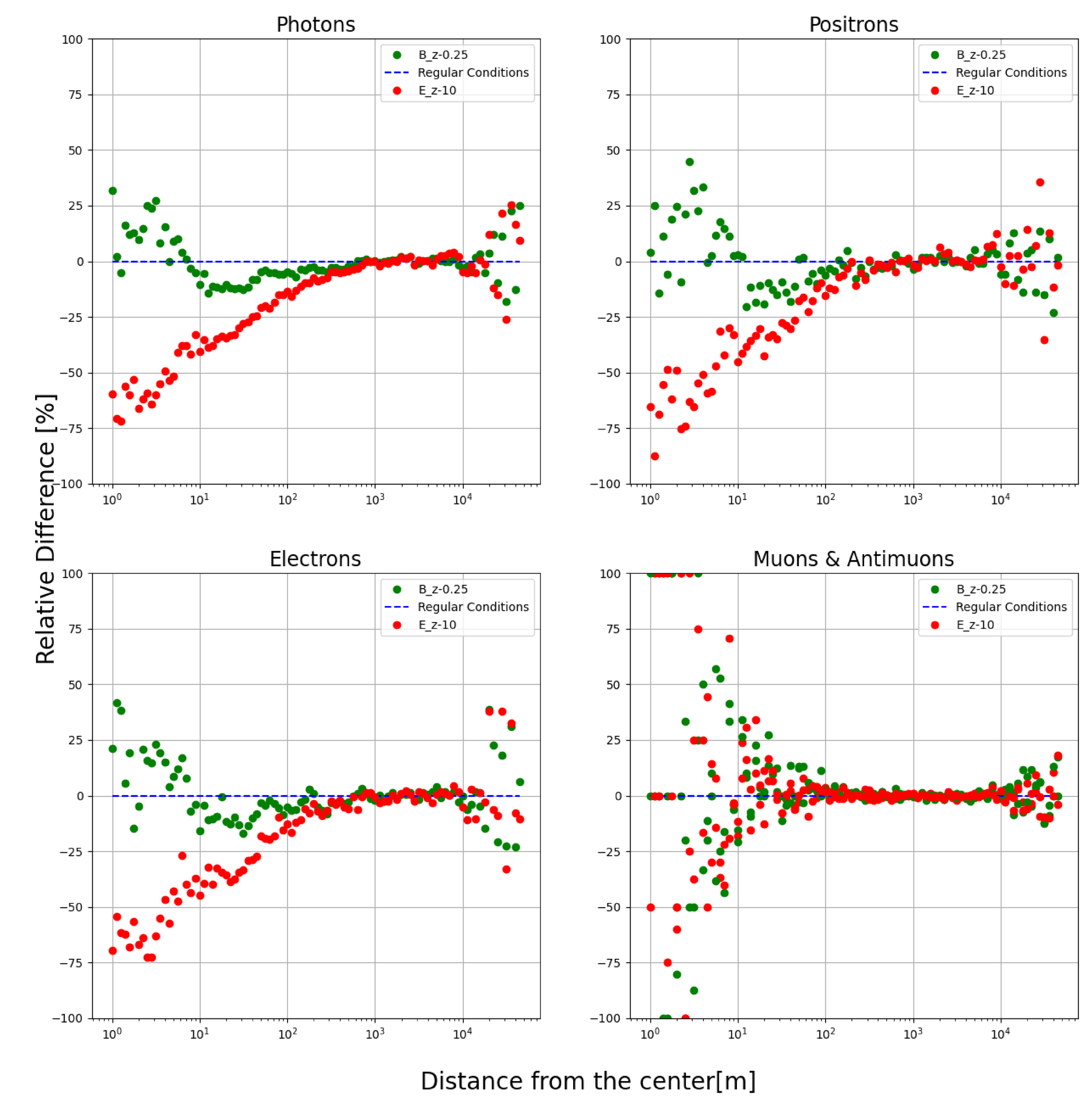

Figure: Relative difference of distributions of secondary particles at ground level from regular conditions for one-hour flux of particles. The magnetic and electric field change distributions reproduce different but consistent form of change for photons, positrons and electrons. Changes in the muonic component appear to lack this consistency.

Conclusion

The results show a shift in the distribution of simulated particle arrival at ground level when altering the geoelectric and geomagnetic parameters in EAS simulations.

Changes in the distribution can be observed for the photons, electrons and positrons in the shower. This is to be expected for the changes in electromagnetic forces affecting the interaction and trajectory of charged particles. However, this is not observed for the muonic component of the shower. This is also consistent with the higher energy of muons in the shower.

The results for changes in magnetic field imply change in the form of the distribution which is consistent for a change in the trajectory of charged particles. On the other hand, the change in electric field shows the arrival of less particles at ground level, which implies that in the simulation, the incidence of electric field reduces the energy of particles so they are deposited and do not reach the ground.

These results show that the electromagnetic component might be the most susceptible to changes in these fields, as well as a possible dependence on distance from the core.The results presented here are expected to be of continuous help in understanding the relationship between disturbance in geomagnetic/geoelectric fields and the background of cosmic rays at the ground.

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