IMPACT OF COSMIC RAYS' MUONS ON PLANETARY ENVIRONMENTS. D. Galante[1], F. Marinho[2] and L. Paulucci[3], [1]Brazilian Synchrotron Ligth Laboratory, Av. Giuseppe Maximo Scolfaro, 10000, 13083-100, Campinas, SP, Brazil, e-mail: douglas.galante@lnls.br, [2]Universidade Federal do Rio de Janeiro, [3]Universidade Federal do ABC.

Introduction: The Earth is constantly struck by radiation coming from the interstellar medium, either electromagnetic or particulate. Cosmic rays, mainly composed by charged particles, are produced by different astrophysical events, going from local (our Sun) to cosmological (such as giant stellar explosions). The range of energy of these particles is also very broad, going from a few to 10^{18}eV, depending on the source and propagation. The very low energy end of the spectrum is shielded by the geomagnetic field but charged particles with energies higher than the geomagnetic cutoff will penetrate the atmosphere and are likely to interact, giving rise to secondary particles, on events known as cosmic-ray showers. Some astrophysical events, such as γ-ray bursts and supernovae, when happening at short distances, may affect the planet's biosphere, due to the temporary enhanced radiation flux produced.

Muons are abundantly produced by high-energy cosmic rays in the Earth's atmosphere. These particles, due to their low cross-section, are able to penetrate deep both underground and underwater, with the possibility of affecting biological niches normally considered shielded from radiation. We investigate the interaction of muons produced by high-energy cosmic rays on the Earth's atmosphere using the Geant4 toolkit, which uses a MonteCarlos approach for the analysis of the interaction of the primary and secondary particles, as they travel through different materials.

Results: We have analysed the penetration power of muons in water and on typical crustal rocks, and the interaction effects within bacteria-like material according to the particle type and energy [1].

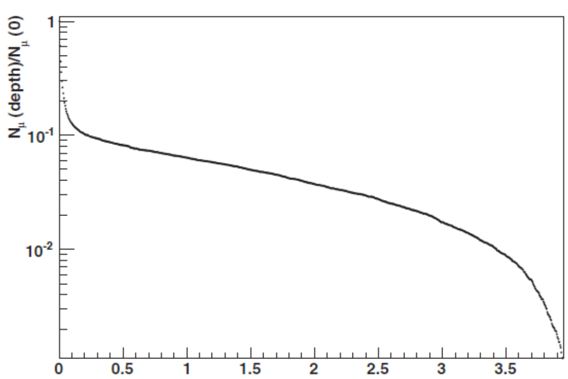

Fig. 1: Fraction of muons reaching a given depths of crustal materials.

As can be seen on Fig 1, a significant flux of muons is still expected even at depths of a few kilometers. However, the most efficient way of producing biological or chemical damage with these particles is through the production of secondary electrons. More dense and higher-Z materials will have a higher cross section of interaction with the muons, resulting in Bragg peaks at different depths. At these points, it is expected that most of the energy will be transferred to the material and a higher damage produced locally.

However, we have also analysed the production of secondary electrons by the muons throughout their trajectories, before reaching the Bragg peak depth.

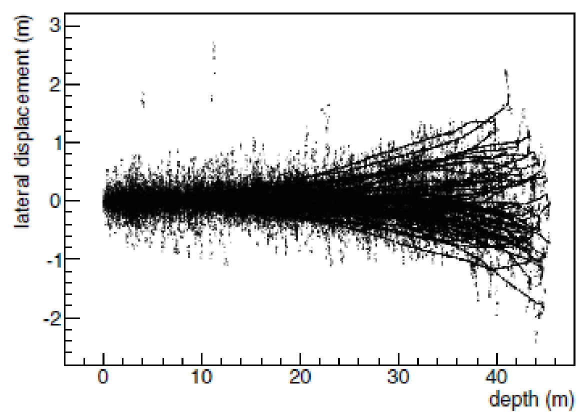

Fig. 2: Production of secondary electrons by a 10GeV muon on organic material.

By our model, as can be seen on Fig. 2, there is a significant production of electrons also on the trajectories of the particles, which can produce typical track-like damage.

The results show that muons, although having a low cross section of interaction, can produce secondary electrons which, in contrast, can produce biological damage very efficiently, and this effect should not be neglected when considering the impacts of high-enery events on planets and lige.

[1] Marinho F., Paulucci L and Galante D (2014) *Int. J. Astrobiology* 13(04), 319-323.