RevMexAA (Serie de Conferencias), **49**, 57–57 (2017)

XV Latin American Regional IAU Meeting (Cartagena de Indias, Colombia, 3-7 October 2016)
Editors: Mario Armando Higuera Garzón & Santiago Vargas Domínguez

ASTROPARTICLE TECHNIQUES: SIMULATING COSMIC RAYS INDUCED BACKGROUND RADIATION ON AIRCRAFTS

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Incident cosmic ray fluxes over flying aircrafts are compared with those in Bucaramanga, Colombia and very significant differences are observed for proton and neutron fluxes. We also obtained that major contributions in the deposited energy by Cherenkov photons on blood plasma is in the UV-C band.

Cosmic Rays (particles and nuclei with energies from 10^5 eV to 10^{20} eV) enter into the atmosphere generating a cascade of particles impinging on aircrafts flying between 10 km to 12 km. It has been found that at these altitude airplanes are exposed to cosmic ray radiation levels up to two order of magnitude higher than at sea level (Pinilla et al. 2015).

Integrated particle flux and its modulation are carefully calculated and corrected by considering local atmospheric profiles and dynamic geomagnetic conditions at a constant altitude of 11 km (Asorey et al. 2015). Subsequently, these results are piped into a GEANT4/GATE simulation platform (OpenGate Collaboration 2011) to model the interaction of high energy particles with a spherical blood plasma phantom of 0.1 m^3.

Hight energy secondary particle flux at flight level directly (for charged particles) and indirectly (trough, e.g., pair creation) generate Cherenkov photons in the medium. The Cherenkov energy spectra and the corresponding deposited energy in blood plasma are estimated for five flight trajectories: BOG-BUE, BUE-MAD, JNB-SYD, JFK-HND and SAO-JNB. These flights were selected due different geomagnetic features they cross, such as the Arctic oval or the South Atlantic Anomaly.

Every 30 minutes the flux is calculated with the corresponding local atmospheric profile and secular geomagnetic conditions and this flux value is assumed constant during the next 30 minutes track.

When compared with a reference point (Bucaramanga, Colombia, 965 m.a.s.l.), very significant differences on the relative flux ($\Delta N = (N_{\rm Route} - N_{\rm BGA})/N_{\rm BGA}$) for photons, protons and neutrons are observed (see Table 1). Our calculations show that the major deposited energy contribution in blood comes from Cherenkov photons in the UV-C 100 nm−280 nm band. With these calculated values for UV exposure, it seems that it is possible to induce some damage at cellular level (Prada-Medina et al. 2016).

TABLE 1

NUMBER OF SECONDARIES AT FLIGHT LEVEL RELATIVE TO BUCARAMANGA

Route	γ	e_+	e_-	μ_+	μ_-	n_0	p_+	Others	Total
BOG-BUE	55.5	56.0	56.2	3.5	3.9	84.6	165.8	122.6	46.1
BUE-MAD	56.6	57.0	57.3	3.6	4.0	90.7	175.9	124.6	47.1
JNB-SYD	93.3	89.3	90.3	6.2	6.5	388.7	638.0	195.6	82.2
NYC-TYO	91.0	87.2	88.1	6.1	6.3	380.6	621.9	190.4	80.2
SAO-JNB	71.3	70.5	70.8	4.9	5.3	162.7	296.6	151.7	60.3

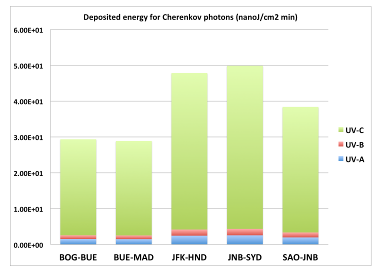

Fig. 1. Deposited energies in plasma by Cherenkov photons in the standard ultraviolet (UV) bands: UVA (315 nm−400 nm), UVB (280 nm−315 nm) and UVC (100 nm−280 nm).

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