Geophysical Research Abstracts
Vol. 20, EGU2018-3264-1, 2018
EGU General Assembly 2018

Evaluation of Monte Carlo tools for high energy atmospheric physics II : relativistic runaway electron avalanches

Casper Rutjes (1), David Sarria (2), Gabriel Diniz (1,3), Alejandro Luque (4), Alexander Skeltved (2), Kevin Ihaddadene (5), Joseph Dwyer (5), Ivan Ferreira (3), Nikolai Ostgaard (2), Ute Ebert (1,6)

(1) Centrum Wiskunde Informatica (CWI), Amsterdam, The Netherlands, (2) Birkeland Centre for Space Science, Department of Physics and Technology, University of Bergen, Bergen, Norway, (3) Instituto de Fisica, Universidade de Brasilia, Brazil, (4) Instituto de Astrofisica de Andalucia (IAA-CSIC), P.O. Box 3004, Granada, Spain, (5) University of New Hampshire Main Campus, Department of Physics, Durham, NH, United States, (6) Eindhoven University of Technology, Eindhoven, The Netherlands

The emerging field of High Energy Atmospheric Physics (HEAP) studies events producing high energy particles and associated with thunderstorms, such as terrestrial gamma-ray flashes, electron–positron beams, thunderstorm ground enhancements and gamma-ray glows. Understanding these phenomena requires appropriate models, for the interaction of high energy electrons, positrons and photons with air. In our first study [1], we investigated the results and performance of several Monte Carlo codes, in the absence of electric fields. In this paper, we follow-up this study by investigating the results of several codes used in the HEAP community when the effects of the electric fields are included, more precisely when its magnitude is high enough to produce Relativistic Runaway Electron avalanches (RREA).

First, we provide two simple set-ups that could be used by the community for future benchmark of codes that are not included in this study. The first one checks the probability to create a RREA from a given seed electron inside a given electric field magnitude, and the second one checks the full properties of the RREA at different records in time and space and for several electric field magnitudes. Then we proceed to these two benchmark on three codes used in the HEAP community : Geant4 [2], GRRR [3], and REAM [4].

We found that the probability of a seed electron to trigger a RREA is mainly determined by the physical implementation of electron impact ionization above 10 keV and a proper integration of the electron energy and motion while it is undergoing friction from air and acceleration by the electric field. For Geant4, appropriate step-length limitations are mandatory to get accurate results. We show that accurate RREA simulations can be achieved with energy cutoff up to 10 keV, allowing for fast simulations.

Finally, we present the comparison of the outputs of the three codes in terms of average energies, multiplication factors, and size of the shower, and discuss some differences.

References :

[1] C. Rutjes et al, "Evaluation of Monte Carlo tools for high energy atmospheric physics.", Geoscientific Model Development, 9, 3961. 2016
[2] S.Agostinelli, et al. "Geant4-a simulation toolkit.", Nuclear Instruments and Methods in Physics Volume 506, Issue 3. 2003.
[3]A. Luque, "Relativistic Runaway Ionization Fronts.", Phys. Rev. Lett., 112, 045003. 2014.
[4] J. R. Dwyer, "A fundamental limit on electric fields in air", Geophys. Res. Lett., 30(20). 2007.