Cooking TGFs with GEANT4

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In this study we show a preliminary set of simulations carried on with Geant4 [4] [3]. The main goal of this study is to explore the Terrestrial Gamma-rays Flashes (TGFs) ignition mechanism using the Geant4 facility and starting with the quasi-electrostatic mechanism theory for producing a Relativistic Run-away Electron Avalanche (RREA) [9]. To do this simulation we have used some typical parameters of the discharge and lightning process in the atmosphere [1][5] and some high energy electrons as seeds that trigger the ignition of the Flash. Results of this study are expected to been useful for a better understanding of where and in which conditions TGFs are produced and how will be the signal that we expect to receive in the Atmosphere-Space Interactions Monitor (ASIM) when it starts to collecting data.

1. Motivation

In recent years, the detection of surprisingly energetic terrestrial gamma-rays (TGFs) from space (BATSE and RHESSI) [2][7] raised interest of the scientific community regarding their origins. Nowadays, intra-cloud (IC) lightning flashes seem to be the leading candidate to TGF production) [8]. Two main mechanisms have been proposed for TGF generation, the quasi-electrostatic mechanism and the electromagnetic pulse mechanism. In this work we will explore the first of those two mechanisms.

2. The simulation

We use the Geant4 toolkit [1] [2] a Monte Carlo simulation method. This toolkit is capable varying the material and the physics involved in a given phenomena. This is an open source modular toolkit and has been well tested in high energy physics.

2.1. Geometrical conditions

Our simulation has to ran in small computers in a reasonable time. That is why we try different configurations of electric field geometry and different sizes of boxes in order to optimize the detail/time simulation. A box with size 1x0.5x0.5 km of low density air and a small box with 40x40x40 m with an electric field inside seems to produce good detail/time results.

2.2. Electric field and seeds

For the TGF ignition we are testing several combinations of electric fields 0-1MV/m, kinetic energy of electrons seeds 1keV-500keV and densities of the air depending on the high of the process.

2.3. Some preliminarily results

A middle kinetic energy electron seed (50keV) in a high electric field (900kV/m) recreates the expected bremsstrahlung spectrum of a TGF.

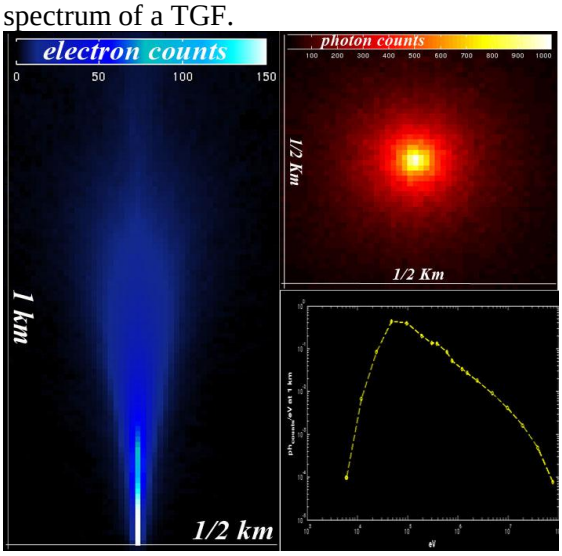

Figure 1 Electrons view; Photon production view; Photon spectral distribution; Results of one 1e5 electron avalanche with 100MeV kinetic energy in a Standard Atmosphere

3. References

[1] Cooray, 2004

[2] Fishman et al., 1994

[3] IEEE Transactions on Nuclear Science 53 No. 1 (2006) 270-278.

[4] Nuclear Instruments and Methods in Physics Research A 506 (2003) 250-303

[5] Rakov & Uman, 2003

[7] Smith et al., 2005

[8] Williams et al., 2006

[9] Wilson, 1924