Space Rider CdTe Monitor Experiments

R. M. Curado da Silva ,J. M. Maia, M. Moita, J. Mingacho
LIP—Physics Department, University of Coimbra
Physics Department, University of Beira Interior

Space Rider

The Space Rider experiment is an excellent opportunity to consolidate and extend our space science road map and objectives, providing new scientific and technological horizons. This experiment is addressed to two different domains of applications of CdTe detectors [1].

Figure 1: Space Rider

Tasks to be performed

- The CdTe semiconductor detector performances will be measured before, during and after the flight allowing to analyze the effects of the orbital environment. The spectroscopic and charge transport properties deterioration will be analyzed.

- Operating the CdTe detector as TGF Monitor will allow the measurement of this atmospheric transient strong gamma-ray emission, observed by space observatories. We propose to measure the TGF polarization for the first time, contributing to elucidate TGF emission mechanisms still pending questions [2].

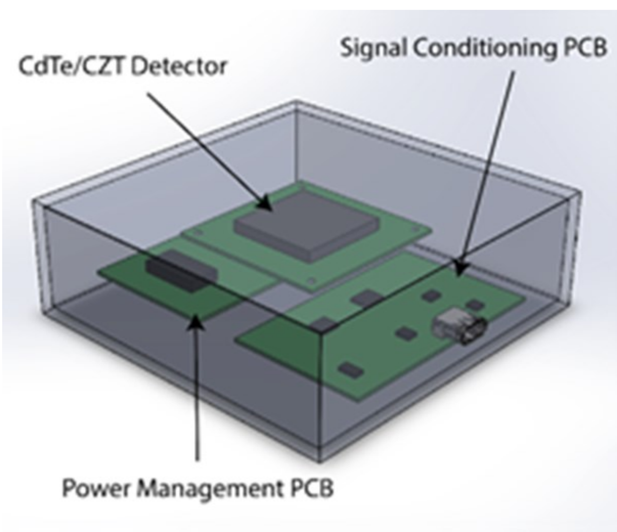


Figure 2: TGF Monitor prototype (5 mm thickness, 8x8 pixels, total 2.56 cm^2 area).

TGFs observed from space

The Terrestrial Gamma-ray Flashes also nominated TGFs, are gamma-ray emissions that occur in the Earth's atmosphere [3]. They were first discovered in 1994 by BATSE, and they were also detected by other operational space instruments. TGFs are generated on top of cumulonimbus clouds, they are produced at a low altitude, less than 20 km high, and are also associated with individual lightning strikes [4].

We simulated a possible scenario of a commercial aircraft being irradiated by a TGF emission from below, when flying nearby a cumulonimbus cloud, as seen in figure 3. For the geometric shape and size of this model, the dimensions of the Airbus A380 were considered, with 72 m long and 24 m high, with a 22 cm thick aluminum cabin fuselage.

The irradiation source is represented by the cone shaped emission, which is isotropic. The parameter that will vary is the distance h between the source and the aircraft model. The aircraft is positioned at an altitude of 12.5 km, above the cone center. So h take the values of 5, 2.5, and 0.5 km. Then, a human model was placed inside the aircraft model.

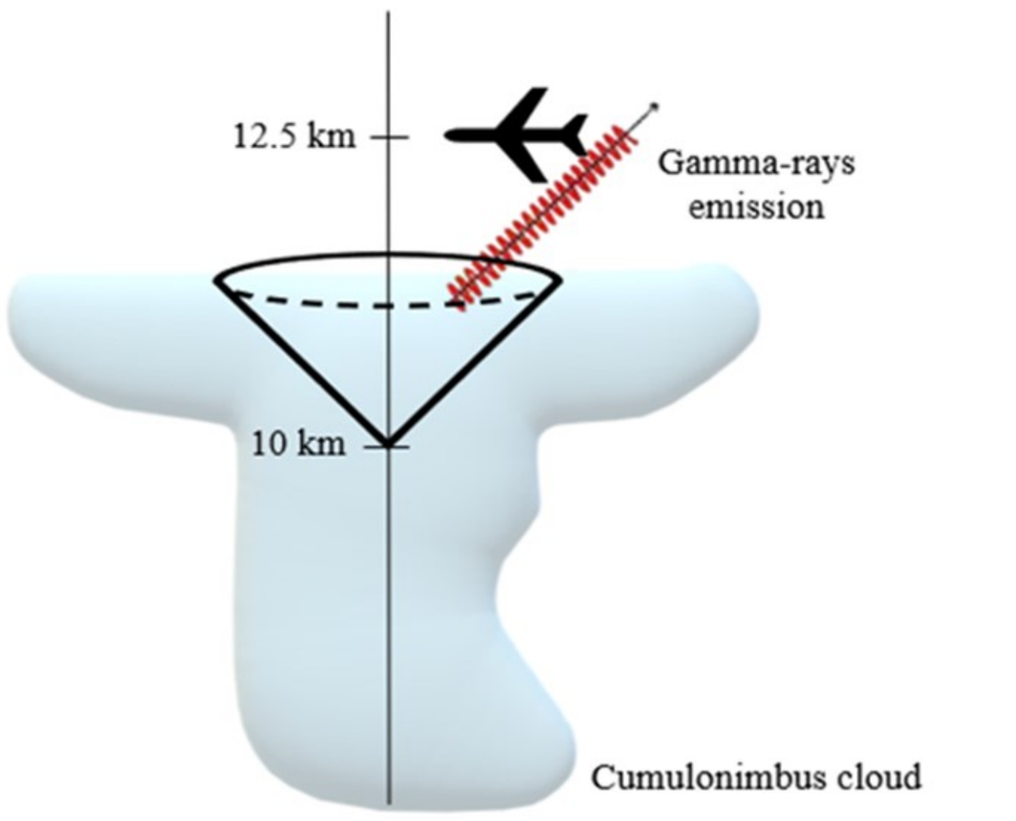


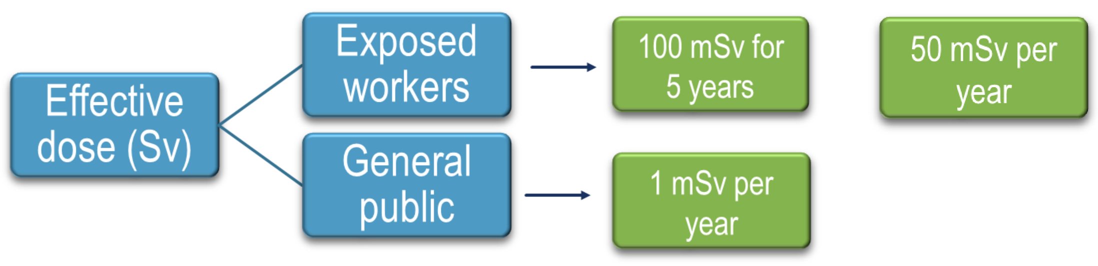
Figure 3: Schematics of the simulation geometry to estimate the radiation effective dose in a human model inside a commercial aircraft.

DISTANCE (km)	EFFECTIVE DOSE (mSv)	
	AVERAGE TGF	STRONG TGF
5.0	**1.4×10^{-4}**	**5.9×10^{-1}**
2.5	**5.6×10^{-3}**	**2.0×10^{1}**
0.5	**3.8×10^{-1}**	**2.1×10^{2}**

Table 1: Effective doses for the human model inside the aircraft advanced model.

Final Results

When an individual is exposed to radiation, its effect is determined by considering the following factors: dose intensity, exposure time, organ, or tissue that was exposed. According to the International Commission on Radiological Protection (ICRP), the effective dose is defined as the sum of the equivalent weighted doses in all tissues and organs of the body, and there are effective dose limits.



The effective dose limit, for the general public is 1 mSv per year, and the maximum effective dose for pilots/crew members is 50 mSv each year. The established limits for the effective dose per year will be clearly exceeded in the case of a strong TGF for a passenger at 2.5 km distance, and for a crew member at 0.5 km away from the emission center. For a medium intensity TGF, we can conclude that at least the aircraft passengers should be informed of a TGF irradiation with its emission site at 0.5 km, since a substantial part of the allowed dose limit per year (1 mSv) will be attained.

Future work

The main conclusions will be employed in future high energy astrophysics space telescopes' design such as Advanced Surveyor of Transient Events and Nuclear Astrophysics (ASTENA) and All-sky Medium Energy Gamma-ray Observatory (AMEGO).

The TGF monitor potential as a commercial aircraft safety product will be also analysed.

References

[1] M. Zanarini, et al., "Radiation damage induced by 2 MeV protons in CdTe and CdZnTe semiconductor detectors", Nucl. Instr. and Meth. in Phys. Res. B, 213, p. 315, 2004.
[2] M. Tavani, A. Argan et al, Possible effects on avionics induced by terrestrial gamma-ray flashes, 2013
[3] Fitzpatrick, G. and Foley, S. (2015). Pulse Properties of Terrestrial Gamma-ray Flashes detected by the Fermi Gamma-ray Burst Monitor. Journal of Geophysical research.
[4] Gjesteland, T. (2012). Properties of Terrestrial Gamma ray Flashes. Department of Physics and Technology. University of Bergen.

LIP
LABORATÓRIO DE INSTRUMENTAÇÃO E FÍSICA EXPERIMENTAL DE PARTÍCULAS
1290 UNIVERSIDADE D COIMBRA
FACULDADE CIÊNCIAS Departamento de Física