cc BY

# ATMOSUV-CanSat

## (Atmospheric Thunderstorms's Monitor Optical Signal & UV)

**David Calvo (1), Javier Navarro-González (2), Fernando Carrió (1), Pere Blay (2), Héctor Espinós (2), Paul Connell (2), Chris Eyles (2), and Víctor Reglero (2)**

**(1) IFIC, Valencia, Spain (david.calvo@ific.uv.es),**
**(2) IPL, University of Valencia, Valencia, Spain (nagonja@uv.es)**
**contact: nagonja@uv.es**

## Abstract

The **ATMOSUV-CanSat** is a small instrument aimed to study the **Optical** and **UV** signal in a **TGF (Terrestrial Gamma-ray Flash)** process, as a complementary ground monitor facility in the study of thunderstorms at high altitude in the atmosphere. The main goal is to take complementary data to that of the MXGS/ASIM (Modular X-ray and Gamma-ray Sensor in the Atmosphere-Space Interactions Monitor) mission, taken from the ISS (International Space Station). The detector is planed to be launch in a balloon during severe thunderstorms and take measurements of air conditions and to perform fast imaging with high temporal accuracy. We expect to measure UV emission, optical signal, temperature, pressure, and accurate 3D location, with FPGA controlled high velocity imaging devices and sensors

## Motivation

In recent years, the detection of surprisingly energetic terrestrial gamma-rays (TGFs) from space (BATSE and RHESSI) [2][5] raised interest of the scientific community regarding their origins. Nowadays, intra-cloud (IC) lightning flashes seem to be the leading candidate to TGF production) [6] by the thermal runaway electron production. In that case, these TGFs may be viewed as a by -product of lightning. However it is not already known what lightning processes are in association with these TGF and because of that, it is difficult to calculate the optical emissions involved in the process. Relativistic feedback discharges (RFDs) also involve relativistic runaway electrons avalanches (RREAs) and produce TGFs too. Unlike normal lightning process, RDFs do not produce bright incandescent light. The main mechanisms for producing light by RDFs are the fluorescence from the runaway electrons and the excitation of neutral molecules by low-energy electrons. The main fluorescence emission consist of two band systems $2PN_2$ $1NN_2{}_+$ between 300 and 400 nm [1]

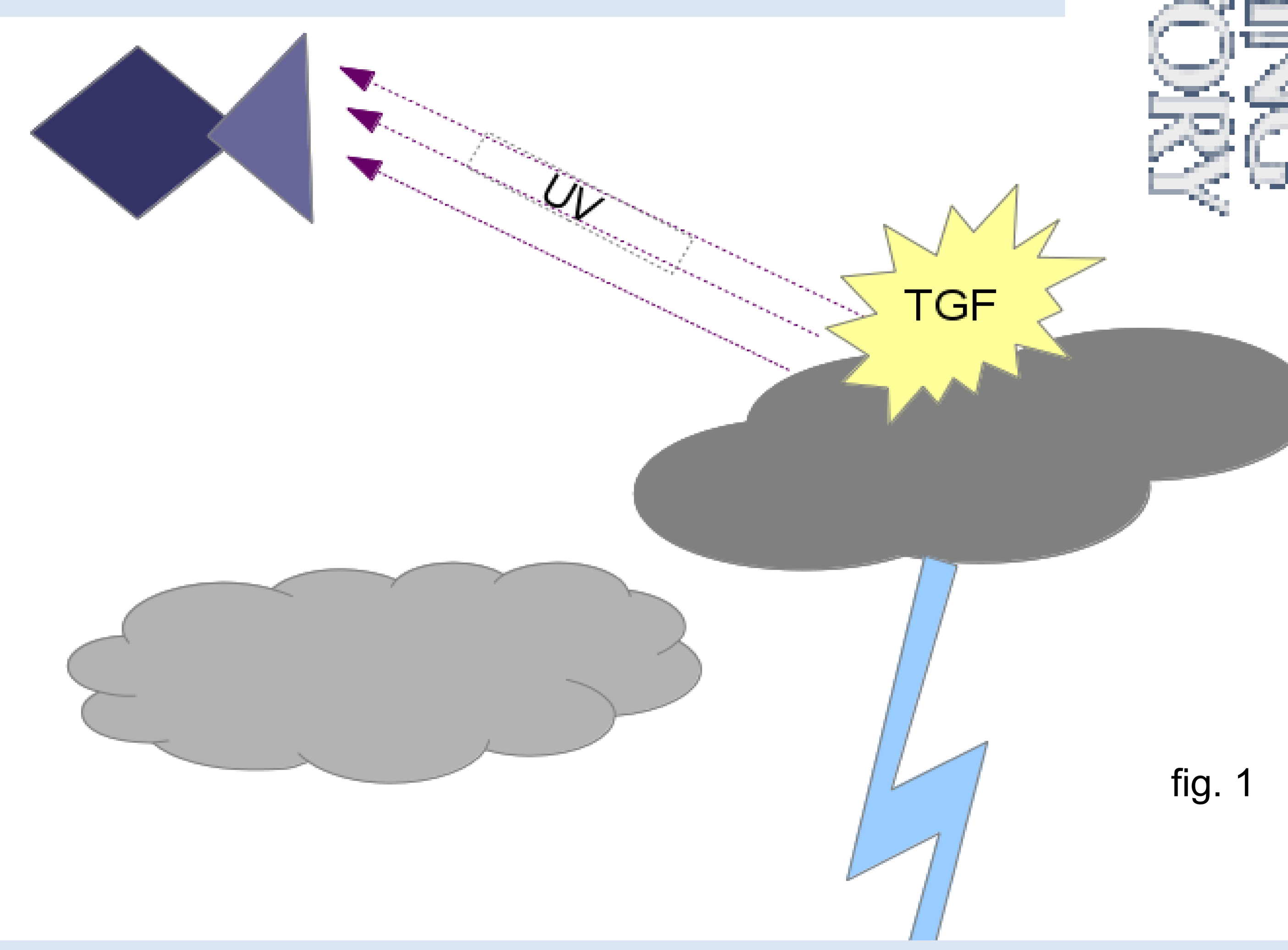



fig. 1

## The Instrument

**ATMOSUV-CanSat** is designed to study the Optical and UV signal in a TGF (Terrestrial Gamma-ray Flash) process. The detector is planed to be launch in a balloon during severe thunderstorms or be fixed in very high altitude observatories. The instrument can be separated into two main devices, the UV imaging detector and the control decoder unit (fig.2)

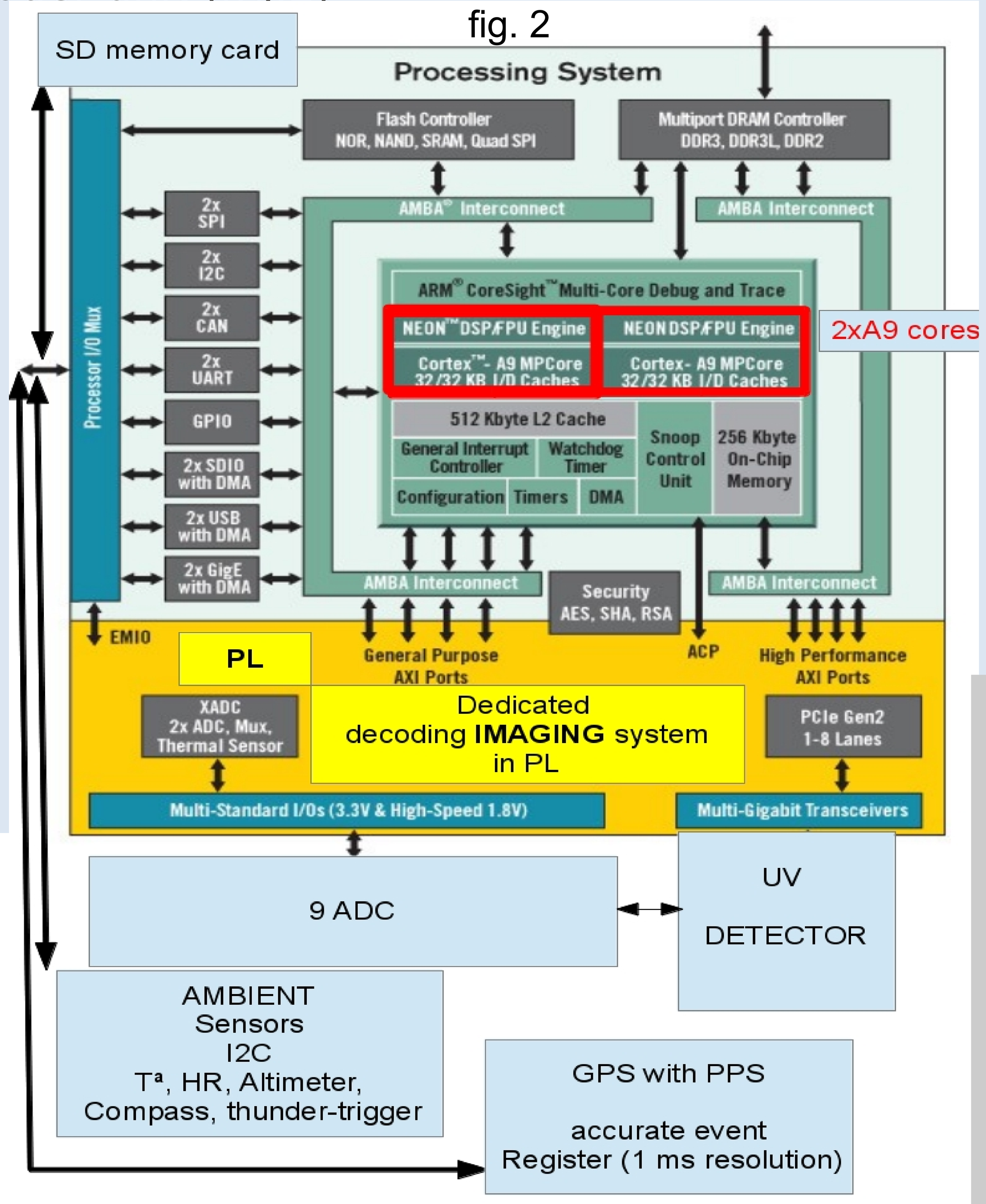
## The control decoder unit

For the prototype we use the ZedBoard, a complete development kit for designers with the Zynq® -7000 All Programmable SoC.

This unit decode the UV image and save it in the SD memory with all the environmental parameters with a real time clock with 1 ms of temporal resolution.

For doing the real time decoding we use the FPGA in the Zynq SoC. The Programmable logic (PL) of the SoC decodes in parallel the 9 lines of the detector plane, obtaining a real time image of the event.

fig. 2




## The UV detector

We use a 3x3 detector array with a 7x7 random coded mask (fig.3a)to detect and image the UV events.

The UV detector is designed with the following characteristics:

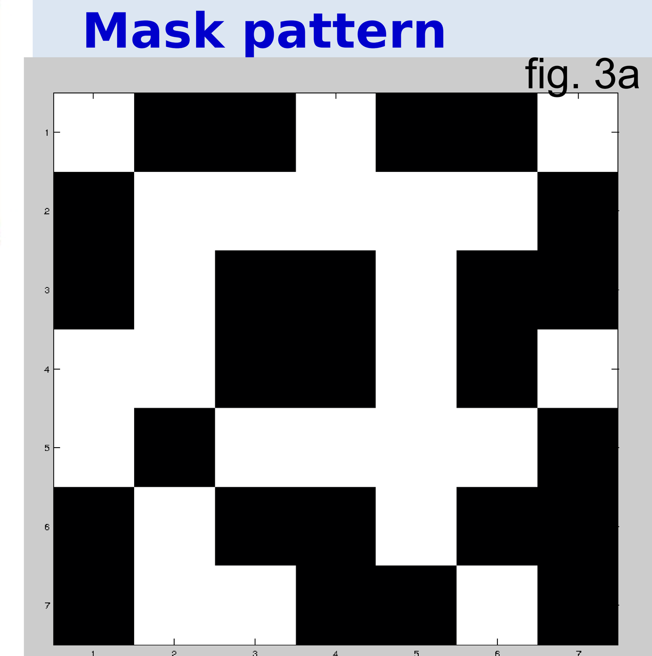
*Fully covered field of view (FCFOV): 36'8°

*Angular resolution: 9'5°

The detector is able to code the FCFOV in 5x5 pixels as we can see with some response simulations(fig.3b):

**Mask pattern & decoded images**

fig. 3a



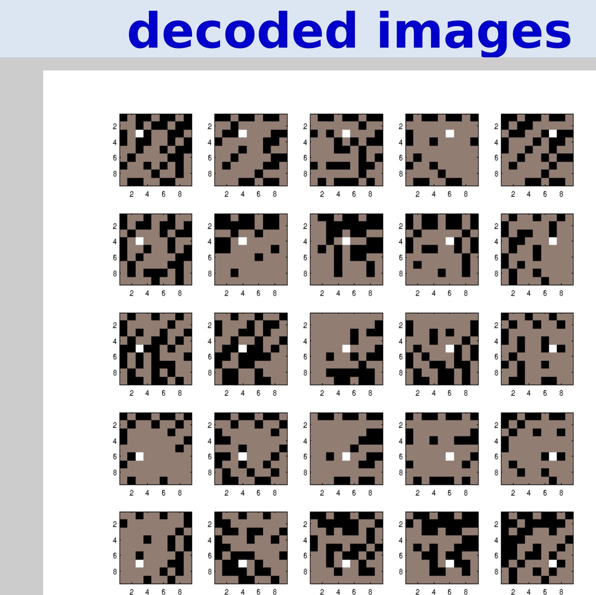


fig. 3b

## Simulation

* We use GEANT4 [3] [4] to simulate the dispersion of UV in the atmosphere and to know how UV light arrives to our detector. For the simulation we assume an atmosphere of "GEANT air" (NIST material [3]) with exponential density variation. In fig.4 you can see the simulated volume and in fig.5 the flux variation with the high and the distance.

fig. 4

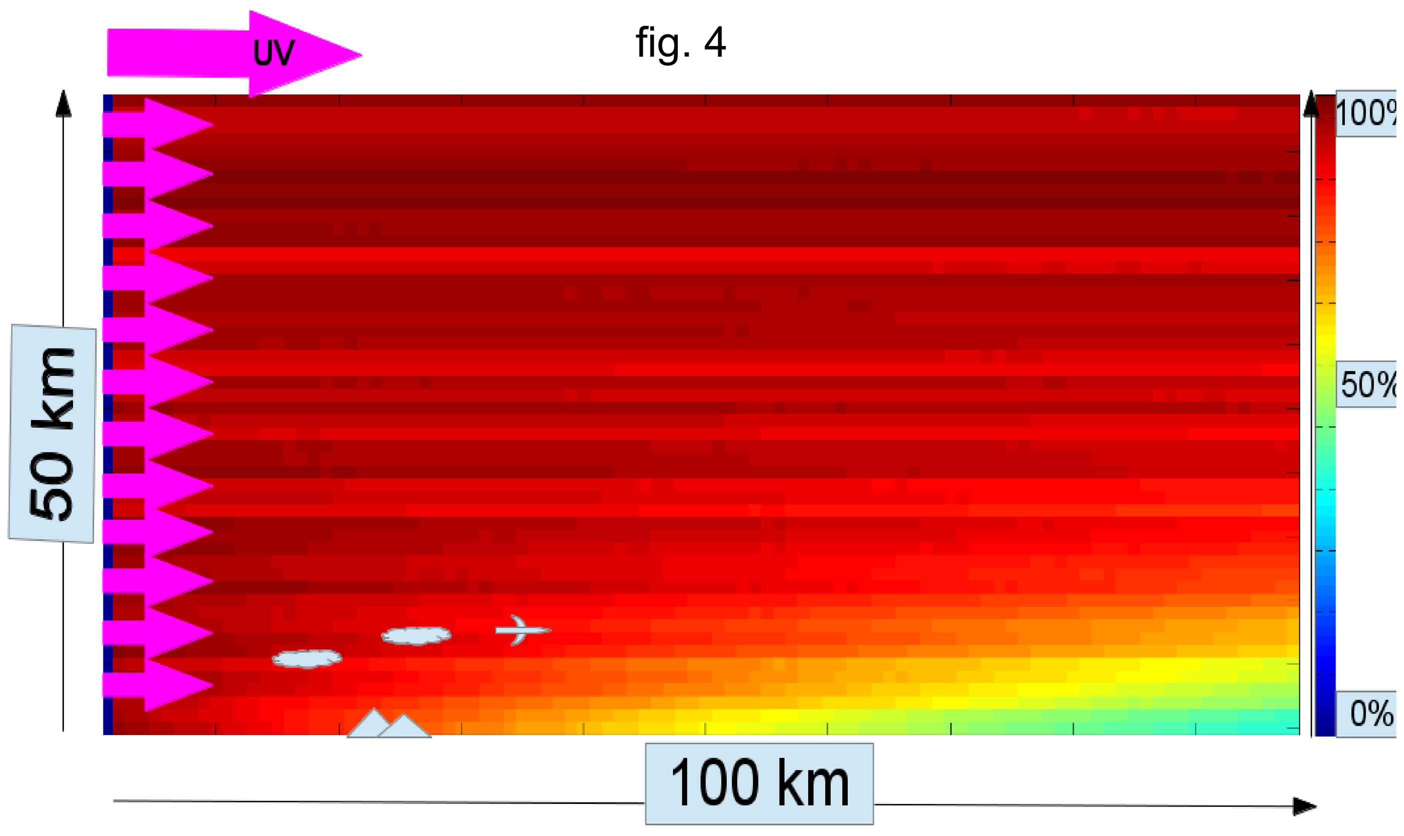
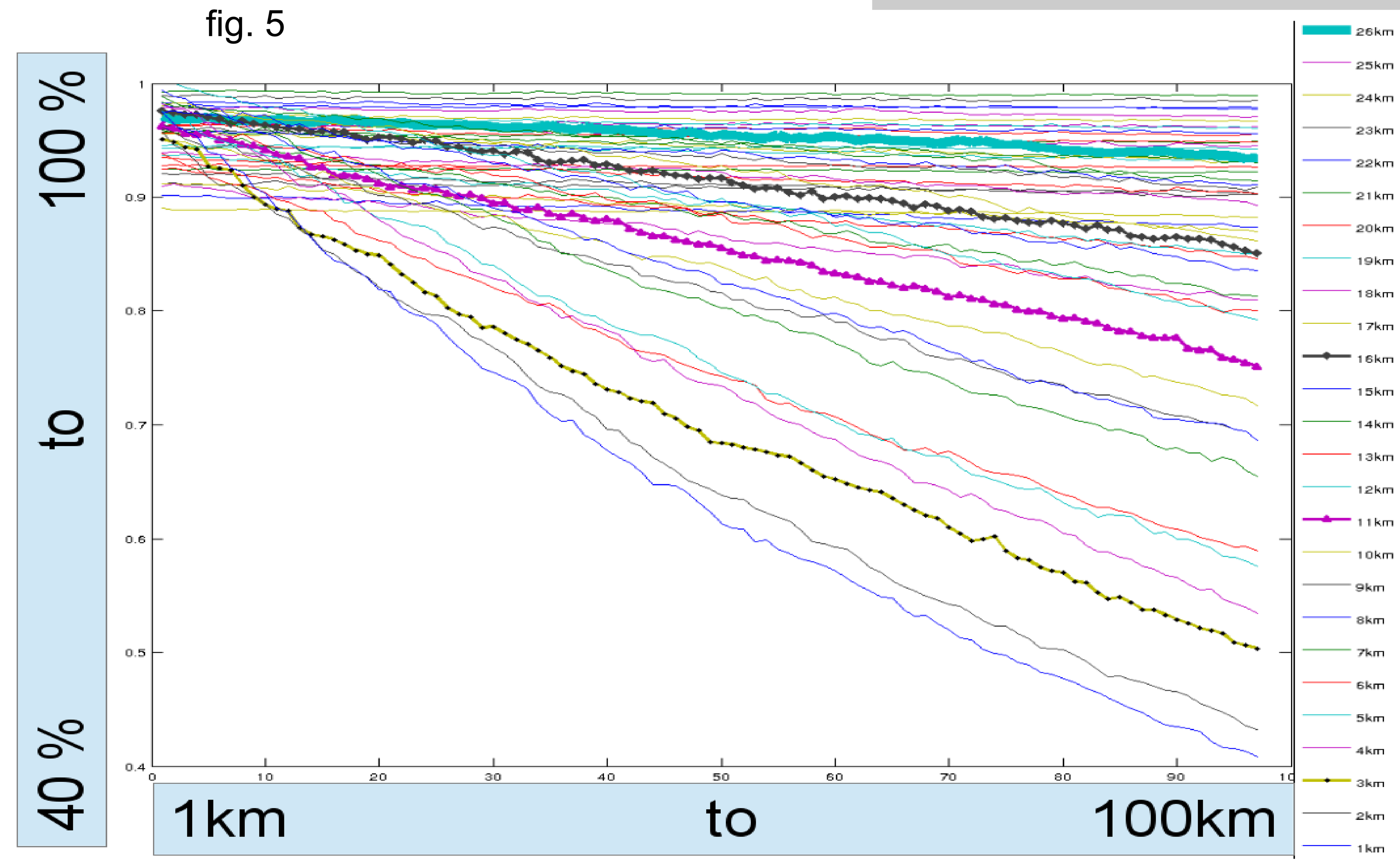



fig. 5




## References:

[1] Dwyer et al. 2013

[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] Smith et al., 2005

[6] Williams et al., 2006