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BALLOON BORN PLATAFORM DEVELLOPMENT TO STUDY LOW EARTH ATMOSPHERIC EXPERIMENTS

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Abstract: Whenever it is intended to make measurements in space of any physical or chemical parameter, a platform is needed that allows hosting such experiments with all possibilities of support for carrying out the planned measurements. In addition, it stores the measurements on board and at each chosen time interval and sends them to a reception station on land. The same as the ground station send commands on board for possible changes in the on board electronics that you want to make. Also monitor the flight at least every instant of 10 seconds, having data from the balloon with GPS, data from the temperature outside the platform and inside it. Perform flight termination with order from the ground station for a balloon separation command and flight platform to parachute down. This development of this balloon flight platform will allow high school and university students to carry out technical and scientific experiments without worrying about this very important part of onboard and ground infrastructure. It is proposed in this work a simple low-cost proposal already with tests carried out on land showing good functioning.
Keyworlds: Balloon, platform development, lower earth atmosphere, ionizing radiation, dosimeters, scintillators.

INTRODUCTION

From the ground to an altitude of 40 km, the earth's lower atmosphere is concentrated. In this height range, meteorological and ionizing radiation phenomena are studied, which are extremely important for the survival of living beings on planet Earth. Close to the ground up to 12 km of altitude, aircraft can be used as platforms for carrying out various measures. The speed and the enormous amount of metallic mass of the plane make today the main types of desired measurements very difficult. Between 13 and 17 km of altitude there is the Pfotzer maximum, where the collisions of external ionizing radiation from the earth with the atmosphere occur, thus producing the maximum of secondary ionizing radiation that reach the soil (EAS phenomenon – Extensive Air Shower) (1). Above 17 km of altitude, the primary radiations coming from outer space and even from the Sun begin to appear. A very educative image about the place of production and propagation to the terrestrial surface is shown in the figure 1. The cosmic ray that can be particles or photons of very high energies collide with atoms of the terrestrial atmosphere (13 to 17) km and create the EAS that propagate to the Earth's soil. As of November 1, 2022, it has been possible to detect cosmic rays of up to 10^{21} eV of energy. The Pierre Auger observatory located in Córdoba, Argentina is the largest of its kind. Above this energy, have no particles or photons been observed on the surface of the Earth? Linear accelerators go up to a value of 10^{13} eV. The particles and photons sent to Earth by the Sun have energies lower than 100 GeV and those arriving with energies below 10 GeV are trapped by the Earth's magnetic field forming figure 2 below. All particles arriving from the Sun and outer space with energies below 10 GeV undergo a spin around the magnetic field line, a back and forth motion from pole to pole, and an azimuthal east-west or west-east motion creating the magnetosphere.

In addition to particles and photons coming from the Sun and outer space, gases in the lower atmosphere can also be measured, mainly for studies of terrestrial atmospheric pollution.

MATERIALS AND METHODS

Whenever an experiment is placed on board a balloon, different types of measurements have to be sent as a function

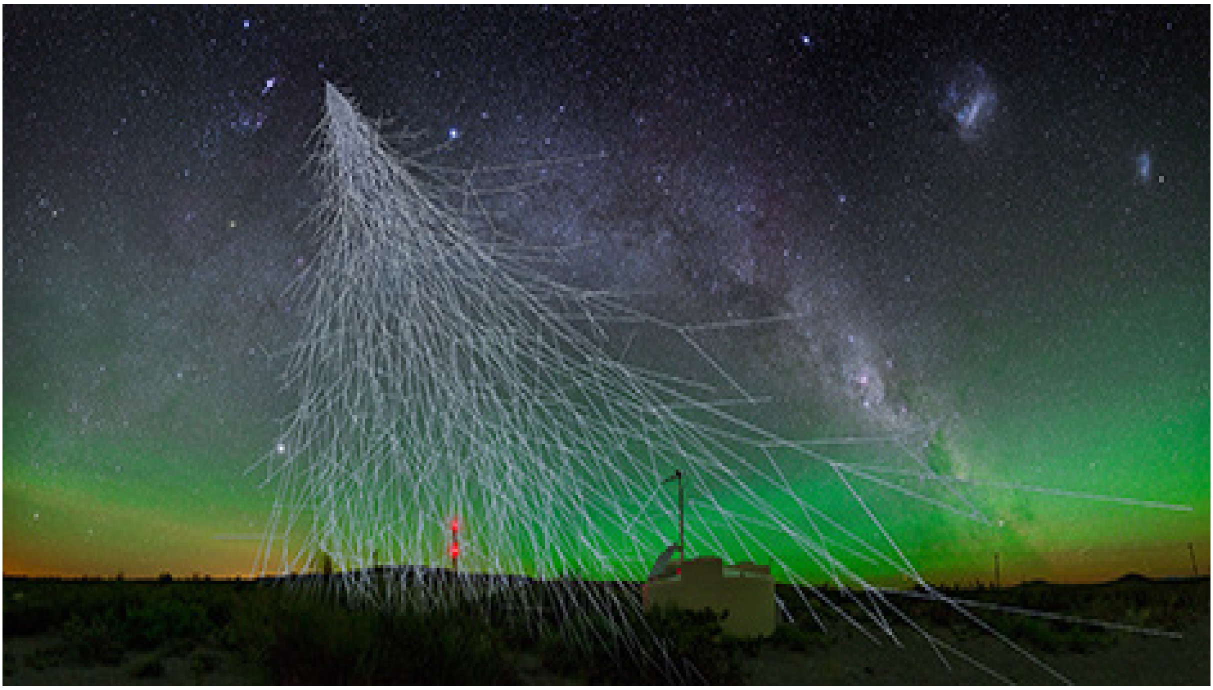

Fig. 1 - Extensive air shower (EAS) (1).

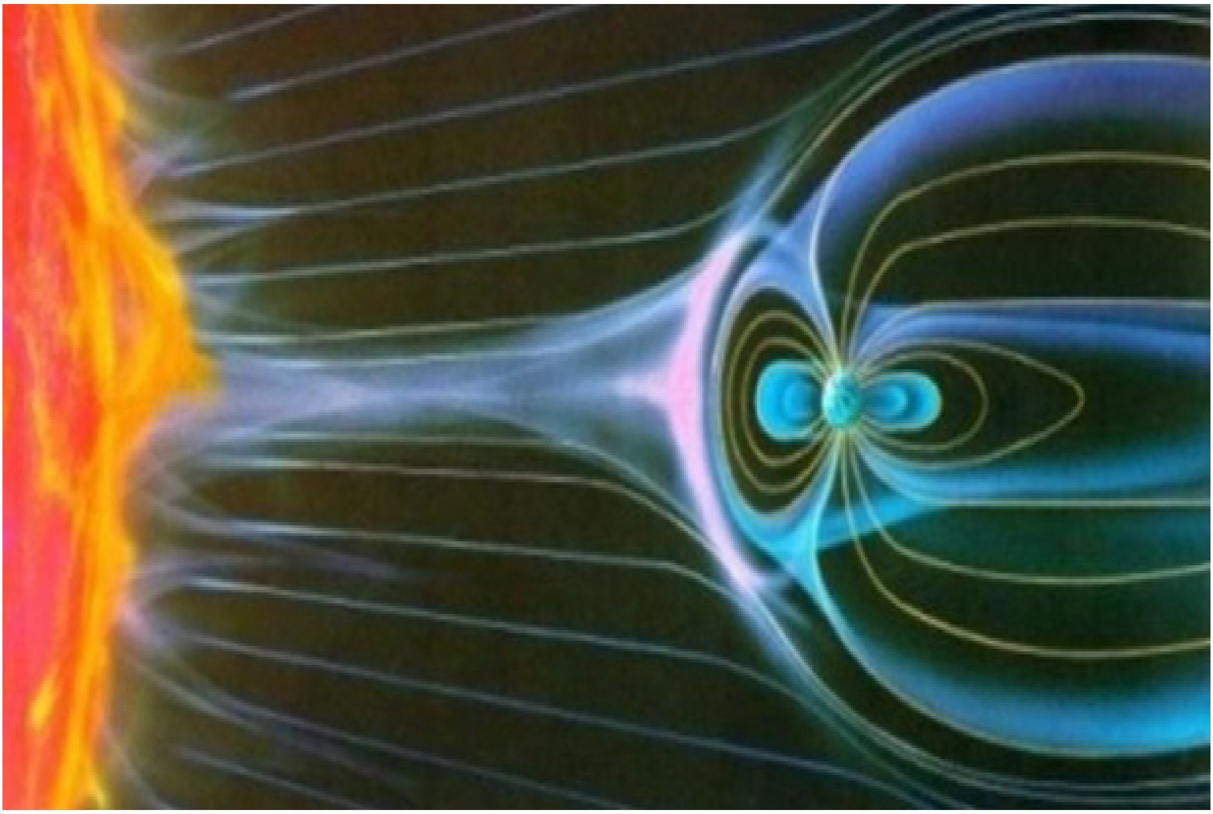

Fig. 2 Low energy solar and external particles trapped by the Earth's magnetic field, (2).

of time to a receiving station on Earth. You can also simplify and record all data on an SD card on board, but the experiment in this case needs to be rescued after the flight, which is not favorable in Brazil, even with the use of GPS on board. Soon it was necessary to develop here at ITA a simple telemetry system (onboard and land) to send the measurements that are carried out on board the balloon in flight to the land reception station. Therefore, this system would serve for several flights with different types of onboard experience for launching in a balloon.

1 – Onboard telemetry

Fig. 3 – Weather balloon carrying the platform (3,4).

RESULTS AND DISCUSSION

A first on-board experience was prepared for flying in a balloon with this telemetry system. This experiment consists of a dosimeter built with a Geiger tube built in Russia to measure ionizing radiation (gamma rays, electrons and protons) from the ground up to an altitude of 30 km. This dosimeter performs the integrated count of these radiations as a function of time. Figure 7 shows the on-board set (telemetry + dosimeter) making measurements in the Atmosrad laboratory at ITA and figure 8 shows the ground receiver with the measured and already digitalized data of ionizing radiation on a computer screen. The ground and on-board telemetry system in this test, as well as the dosimeter, proved to be very efficient and operational, ready to fly the whole set aboard a 1000-gram meteorological balloon (5,6).

The experiment itself consists of a Geiger tube built at the Atmospheric and Solar Physics Laboratory in Moscow (Dolgaproudny), Russia. The tube used, model CTC-6, 19 cm long and 2 cm in diameter, containing argon and other gases at low pressure, and subjected to a voltage of approximately 500 VDC through a plate dedicated to raising the base voltage from 5 V to the high voltage necessary for the ionization of the gas present in the tube. In addition, the counting board has an amplifier that acts on the signal generated in the ionization of the internal gas due to radiation. The board used is of Chinese origin and originally works with a smaller Geiger as shown in figure 7. An Arduino UNO counts the number of pulses emitted from the Geiger board and transmits this data to the telemetry system.

In this test condition of the dosimeter in a room at the ATMOSRAD laboratory at ITA, 5 hours of measurements were performed at the base of 1 minute for each measurement. In the case of flight, the time will be 10 seconds for each measurement. Figure 7 highlights the electronics on board with the dosimeter with acquisition of measurements of ionizing radiation, the Tx transmitter on board the GPS to measure altitude and location of the balloon. In figure 8 the test shows the

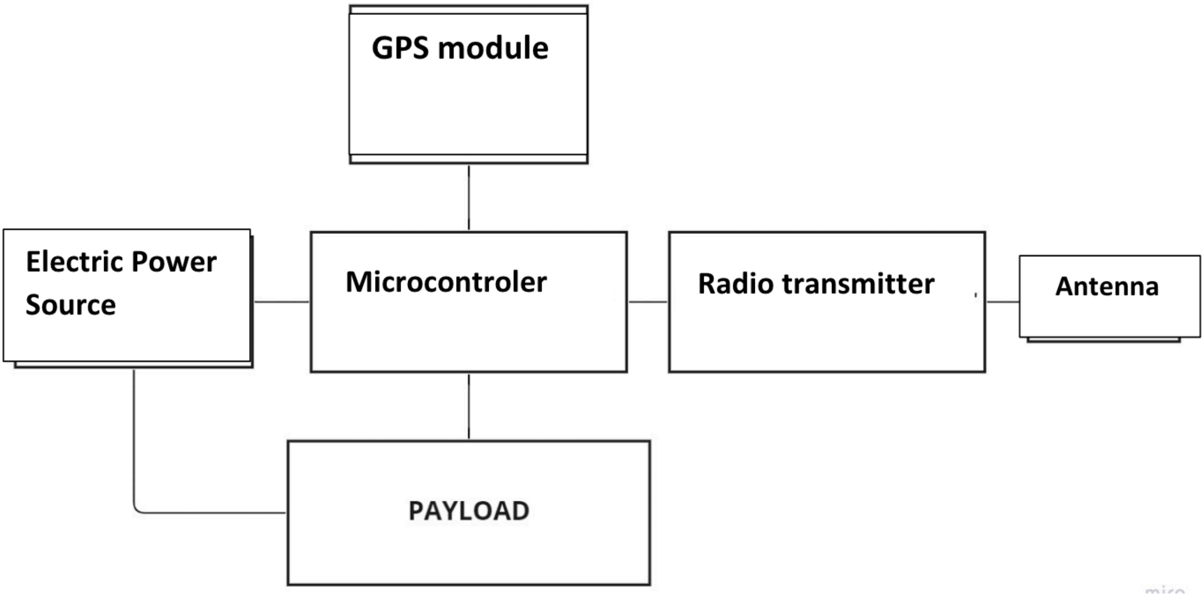

Fig. 4– Architecture of the working material on board (author).

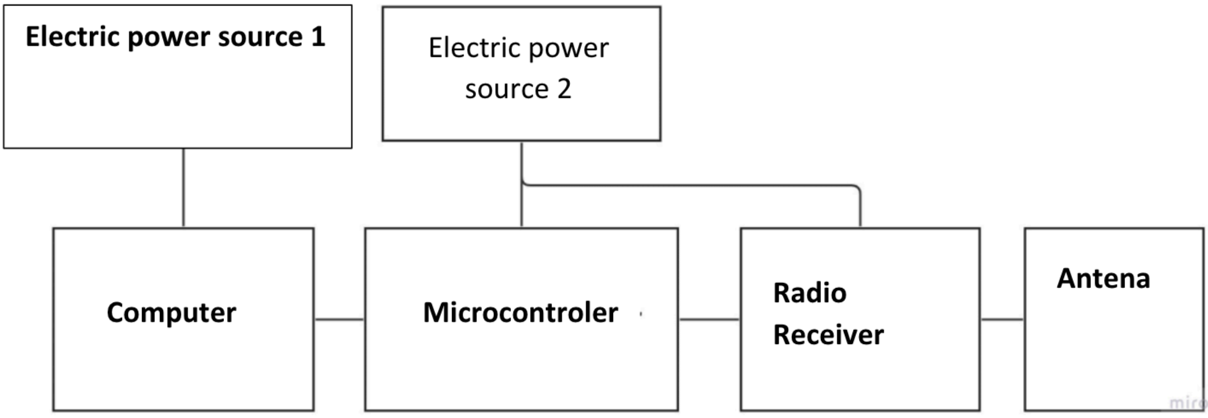

Fig. 5 – Architecture of earth working material (author).

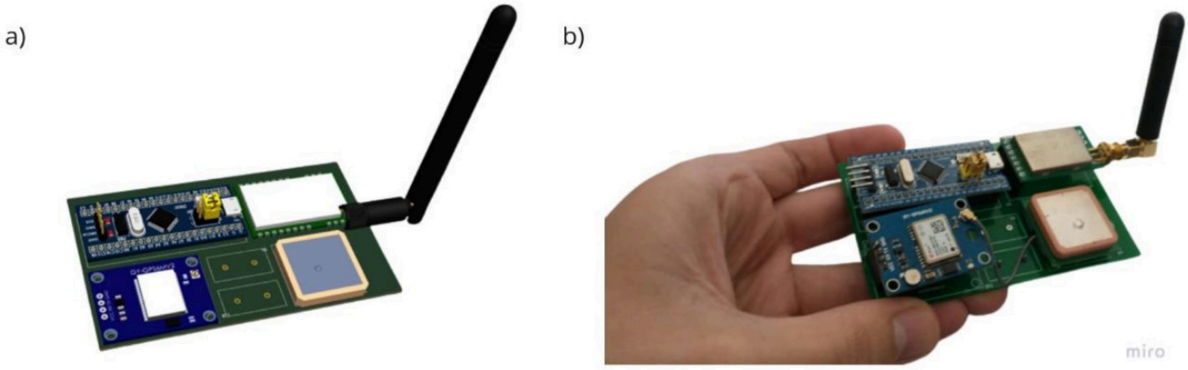

Fig. 6– Onboard telemetry system a) system design in CAD; b) Built prototype. (author).

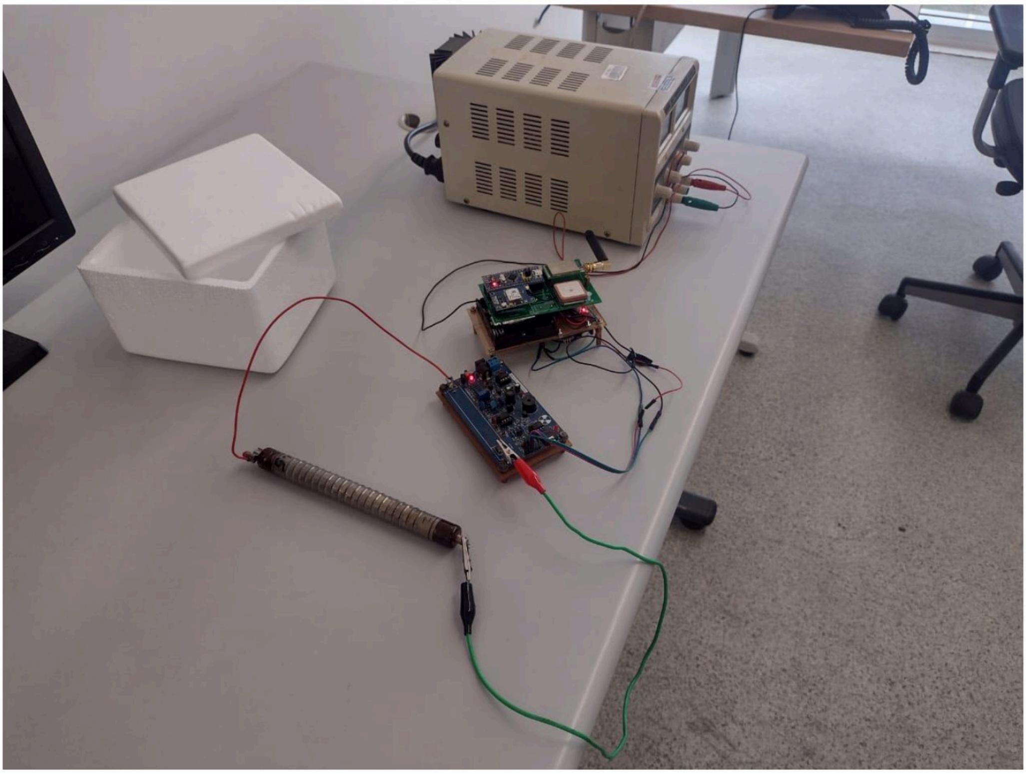

Fig. 7 – From right to left you can see a voltage source after electronics and Tx transmitter and on the left the dosimeter tube and flight styrofoam box (author).

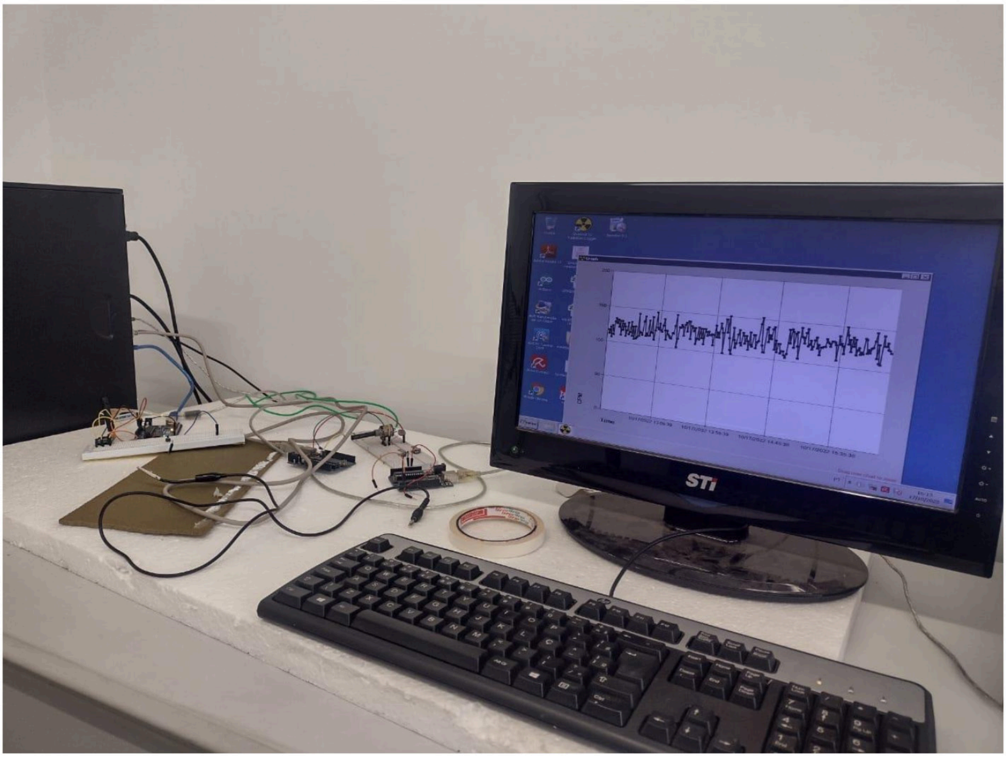

Fig. 8 – From left to right, the Rx receiver circuit and data acquisition interface with a graph of measurements performed by the dosimeter (author).

Fig. 9 – Russian Geiger tube for construction of the Dosimeter.

ground receiver receiving the measurements coming via RF from the transmitter. These measurements are digitalized and, through a PC, the graph of ionized radiation is executed as a function of time, as shown in the monitor in figure 8.

CONCLUSION

A basic and simple shipboard-to-balloon telemetry and land-based telemetry was developed and tested on land using a simple shipboard experiment to measure the counts-times rate of ionizing radiation. This dosimeter as it is called measures electrons, protons and gamma rays of energy less than 100 MeV (millions of electron volts). However for gamma rays it measures from 0.2 to 10.0 MeV. Every 10 seconds the dosimeter saves the previous measurement that is related to an altitude, longitude and latitude observed by the (GPS – Global Position System) existing on board the balloon. That is, it will be possible to determine the radiation dose profile as a function of altitude and the position of the balloon.

In this work, the design and prototyping of a telemetry system for weather balloons was carried out, as well as the integration with a functional payload, namely, a Geiger counter. A quarter-wave monopoly antenna was produced and tested with good results; manufactured a ground station to operate along with the embedded system.

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