ENVIRONMENTAL DOSIMETRY WITH THE PILLE TL SPACE DOSIMETRY SYSTEM DURING THE BEXUS-12 STRATOSPHERIC BALLOON FLIGHT

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Introduction

A Hungarian student team were selected first time to take part in the Balloon Experiments for University Students (BEXUS) project of the European Space Agency Educational Office. The experiment used silicon detector telescope for active monitoring and several Pille thermoluminescent dosimeters to find out more about the possible usability of the Pille Hungarian passive dosimeter system during stratospheric balloon flights. Since the Pille was never used for balloon experiments the main topic of this paper to study this question in the following sections.

The CoCoRAD experiment box (right) and the BEXUS-12 gondola (left) right before the balloon flight

Objectives

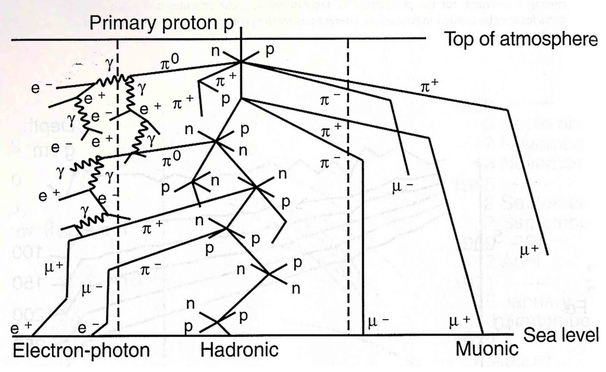
- to perform a successful radiation measurement by students on-board the BEXUS-12 stratospheric balloon
——————COMPLETED

- to study the usability of the Pille TL space dosimeter system during stratospheric balloon environmental monitoring missions
——————COMPLETED

- to measure the excess absorbed dose of a typical BEXUS stratospheric balloon flight with the Pille TL system
——————COMPLETED

The cosmic radiation environment in the stratosphere

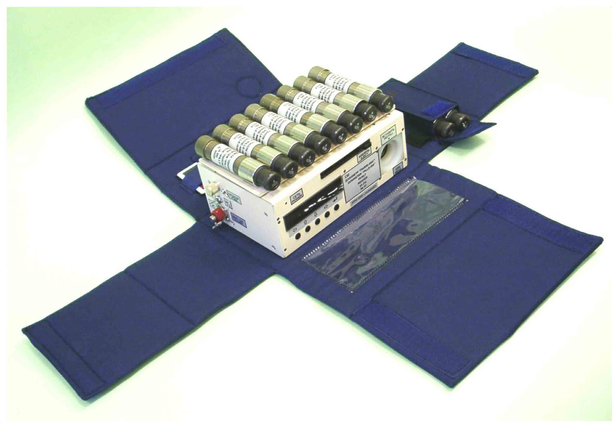
Since the typical altitude range for stratospheric research balloons is between 20 and 40 km it is important to give a short introduction to the cosmic particles of this region. The particle intensities change with the magnetic and geographic latitude and with the solar activity too. The galactic cosmic rays determine the components of the radiation field in the atmosphere. It consists of about 85% protons, 12% helium ions, 1% heavier ions and 2% electrons. The main interaction of a charged particles coming from space with the atmosphere is the ionisation of atoms and molecules. Protons are most likely responsible for the production of secondary particles. The Figure right shows an example for secondary particles production.



Schematic representation of the particle production in the atmosphere

The Pille TL space dosimetry system

The development of the Pille Thermoluminescent Dosimeter System started in the KFKI AEKI in the 1970s. The aim of the development was to invent a small, compact, space qualified TL reader device suitable for on-board evaluation of TL dosimeters. The Pille TL dosimeter contains $CaSO_4$:Dy TL material. The TL material is laminated to the surface of a resistive, electrically heated metal plate inside a vacuum bulb made of glass. The Pille TL Reader (Figure right) is designed for spacecraft: it is a small, light-weight device with a low energy consumption. The reader is capable of heating the dosimeters, measuring the emitted light during the read-out, performing preliminary data evaluation, storing and displaying the results.



The Pille TL dosimeter system

The expected doses during a typical BEXUS stratospheric flight

Ascent and landing phase		
	expected time	2.5 hours
	expected dose rate	3-10 μGy/h
	expected measured dose	7.5-25 μGy
Float phase (27.6 km altitude)		
	expected time	2 hours
	expected dose rate	9-16 μGy/h
	expected measured dose	9-32 μGy
Together		
	expected mission time	4.5 hours
	expected average dose rate	10 μGy/h
	expected measured excess dose	10-35 μGy

In the last row we took into consideration that the $CaSO_4$:Dy has a realtively poor sensitivity for the neutron component and at this altitude range 40% of the expected dose equivalent comes from neutrons.

The measured doses with the Pilles during the flight of the BEXUS-12

The CoCoRAD experiment flew on board BEXUS-12 on the 27th of September 2011 from ESRANGE Space Center located in Northern Sweden close to the city of Kiruna (latitude of N68°). The experiment contsisted of eight flight Pille bulbs and two reference bulbs. The reference dosimeters remained on ground at the ESRANGE base during the entire mission of the BEXUS-12.

The average background level of the choosen bulbs	1.4 ± 0.5 μGy
The mission time	4.3 ± 0.2 h
The time between the read-outs	70 ± 0.5 h
The measured average absorbed dose (flight bulbs)	20.8 ± 1.1 μGy
The measured average absorbed dose (reference bulbs)	5.4 ± 0.1 μGy
The measured average dose rate at the surface (in ESRANGE)	77.7 ± 1.5 nGy/h
The excess absorbed dose of the BEXUS-12 flight	13.1±1.5 μGy
The estimated error of the measurements	~ 7-10 %

Conclusions

The Pille TL dosimeters flew as a part of the CoCoRAD experiment on board the BEXUS-12 stratospheric balloon. The experiment included flight and reference TL dosimeters. The measured excess absorbed dose of the BEXUS-12 flight was 13.1±1.5 μGy which is in good agreement with the values estimated before the mission (10-35 μGy).

One of the main lessons learned from the CoCoRAD experiment is that the Pille TL system is capable of performing environmental monitoring measurements on board startospheric balloon flights. For the best measurement efficiency it is highly recommended to select dosimeters with the lowest noise level available. An important advantage of the Pille TL system is the possibility of the onsite data acquisition and data evaluation without the need of calculating the transport dose.

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