Name of research institute or organization:

Project SPAESRANE (Solutions for the Preservation of Aerospace Electronic Systems Reliability in the Atmospheric Neutron Environment)

Title of project:

SPAESRANE environmental experiments

Project leader and team:

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Project description:

A range of detectors to monitor cosmic-ray effects in electronics was deployed at the Jungfraujoch Sphinx between January 2006 and April 2007. These detectors were as follows:

1. An Imaging Single-Event Effects Monitor (ISEEM, University of Central Lancashire). This is a novel monitor based upon the use of a commercial charge-coupled device (CCD) sensor directly to image charge packets resulting from nuclear interactions in semiconductor devices. ISEEM was deployed between January 2006 and April 2007.

2. A Cosmic Radiation Effects and Activation Monitor (CREAM, QinetiQ). CREAM is a multichannel dosimeter providing time-resolved deposited energy measurements and calibrated against reference fields to provide radiobiological equivalent dose. CREAM has previously been deployed in a wide range of aircraft and spacecraft environments. CREAM was deployed at Jungfraujoch between January and August 2006.

3. An experiment comprising five Unibrain Fire-i scientific webcams (MBDA UK). This experiment was deployed at Jungfraujoch between January and May 2006.

4. A portable cosmic ray three-band neutron detector (Lancaster University). This spectrometer was deployed between November 2006 and April 2007.

The aims of the experiments were to

- Measure single-event effect (SEE)-inducing phenomena in the natural cosmic-ray field and compare with effects in accelerated test facilities.
- Gather data for validation of atmospheric radiation models.
- Reduce risk in the development of future advanced flight experiments for monitoring SEE-inducing phenomena in flight.

The experiments provided valuable data making significant progress towards these goals. For example, Figure 1 shows the differential charge-collection spectrum observed in ISEEM compared to that observed in the simulated cosmic-ray neutron test field at Los Alamos Neutron Science Center (LANSCE). The peak in the Jungfraujoch data is caused by α particles arising from radioactive contamination of the CCD packaging. This is not visible during accelerated testing, such as at LANSCE. Some discrimination between spurious events (due to contamination) and true events (due to cosmic rays) was achieved. Outside the region affected by spurious events the statistics of generated charge packets were consistent with those observed during accelerated testing. The mean true event rate in ISEEM was estimated to be 0.6 d^{-1}. This was somewhat greater than predicted from extrapolations from accelerated test data informed by atmospheric radiation simulations, but insufficient for it to be possible to detect the December 2006 disturbances in the cosmogenic neutron field. We believe that long term exposure of a larger device would provide valuable data to benchmark accelerated testing for neutron-induced single-event effects. We estimate that a large-area CCD or a group of similar devices with a total active area of 14 cm^2 would provide a useful dataset of about 10,000 events in about one year. We are working on developing such a system and on obviating the influence of radiactive contamination, and hope to deploy one or more monitors in suitable locations.

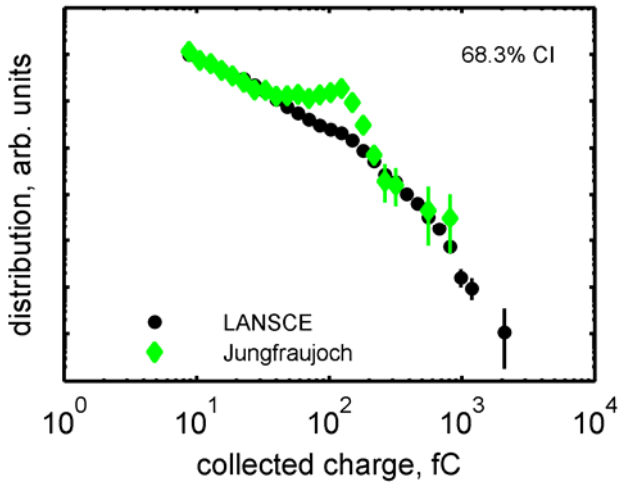

Figure 1: Differential charge collection spectra observed using ISEEM: Jungfraujoch and LANSCE compared

CREAM data gathered at Jungfraujoch are contributing to QinetiQ's characteristaion and simulation of atmospheric radiation fields (for example see http://geoshaft.space.qinetiq.com/qarm).

As a result of their successful observations of cosmic-ray events in webcams, MBDA UK have proposed a global cosmic-ray event network exploiting idle webcams.

The raw spectrometer data is awaiting unfolding at Lancaster.

These experiments contributed to a publication (in press) on the Lancaster spectrometer [1], and were the subject of two papers which were presented at the 9th European Conference on Radiation and its Effect on Components and Systems [2,3] and which are due to appear in the conference proceedings during 2008.

The experiments contributed to a PhD thesis from the University of Central Lancashire which was sucessfully defended during 2007 [4]. Data from the

experiments are contributing to continuing PhD projects at both UCLan and Lancaster.

Key words:

Cosmic rays, neutrons, electronic system reliability, single-event effects

Internet data bases:

http://www.spaesrane.com

Collaborating partners/networks:

University of Central Lancashire
University of Lancaster
MBDA UK
QinetiQ

Scientific publications and public outreach 2007:

Refereed journal articles

[1] Monk S. D., Joyce M. J., Jarrah, Z., King, D., and Oppenheim, M., A portable energy-sensitive cosmic neutron detection instrument, Review of Scientific Instruments, in press

Conference papers

[2] Török, Z., Platt, S. P., and Cai, X. X., SEE-inducing effects of cosmic rays at the High-Altitude Research Station Jungfraujoch compared to accelerated test data, 9th European Conference on Radiation and its Effect on Components and Systems, RADECS 2007, Deauville, France, September 10-14, 2007, paper D-1

[3] Burnell, A. J. and Chugg, A. M., Webcam Observations of SEE Events at the Jungfraujoch Research Station, 9th European Conference on Radiation and its Effect on Components and Systems, RADECS 2007, Deauville, France, September 10-14, 2007, paper PD-1

Theses

[4] Török, Z., Development of Image Processing Systems for Cosmic Ray Effect Analysis, PhD Thesis, University of Central Lancashire, 2007

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