

**Cosmic Ray Energetics and Mass (CREAM)  
Penn State Final Report for NAG5-5248 and NAG5-5250  
August 2005  
Stephane Coutu, P.I.**

The CREAM instrument was flown on a Long Duration Balloon in Antarctica in December 2004 and January 2005, achieving a flight duration record of nearly 42 days. It detected and recorded cosmic ray primary particles ranging in type from hydrogen to iron nuclei and in energy from 1 TeV to several hundred TeV. With the data collected we will have the world's best measurement of the energy spectra and mass composition of nuclei in the primary cosmic ray flux at these energies, close to the astrophysical "knee". The instrument utilized a thin calorimeter, a transition radiation detector and a timing charge detector, which also provided time-of-flight information. The responsibilities of our group have been with the timing charge detector (TCD), and with the data acquisition electronics and ground station support equipment. The TCD utilized fast scintillators to measure the charge of the primary cosmic ray before any interactions could take place within the calorimeter. The data acquisition electronics handled the output of the various detectors, in a fashion fully integrated with the payload bus. A space-qualified flight computer controlled the acquisition, and was used for preliminary trigger information processing and decision making. Ground support equipment was used to monitor the health of the payload, acquire and archive the data transmitted to the ground, and to provide real-time control of the instrument in flight.

In the last year of the project grant, leading up to the record-breaking flight, we completed construction and evaluation of the TCD scintillator detectors. We studied the response of the scintillators and custom-made flight electronics to a variety of test signals, including UV laser flashes of varying intensity, and also high energy muon, electron and heavy ion signals recorded during a series of beam tests conducted at CERN in 2003. We completed the fine-tuning of the custom TCD electronics, in an iterative procedure involving the pulsed-laser facility. We worked to integrate the TCD and flight computer systems within the entire CREAM instrument at the University of Maryland. We participated in thermal-vacuum tests of the full CREAM instrument at the NASA Goddard Space Flight Center, when it became apparent that a high-voltage breakdown path existed in the TCD PMT electronics, which had not been identified previously in component-level vacuum testing. We worked to troubleshoot and remedy the problem by implementing an alternate high-voltage distribution scheme, which proved robust in flight. We conducted the final integration and testing of the TCD systems at the NASA Goddard Center and Wallops Island Flight Facility. We also took part in the very successful flight campaign in Antarctica and in in-flight data taking and instrument control and monitoring at the University of Maryland CREAM Science Center. All CREAM instrument components were successfully recovered in Antarctica and returned to the US for evaluation and refurbishment. The PSU personnel supported by this grant that have conducted these activities were Profs. S. Coutu and J. Beatty (who since departed PSU to take up a position at Ohio State University) and graduate students N. Conklin and S. I. Mognet. We also had the help of Prof. S. Nutter of Northern Kentucky University via subcontract.

We worked to implement the final commissioning and testing of the PC/104-based data acquisition systems and science flight computer for the CREAM instrument. We procured and implemented a last-minute on-board data storage solution when it became clear that the available TDRSS bandwidth would be insufficient to transmit all flight data to the ground station computers. We fabricated and tested a full duplicate science flight computer to bring to the Antarctic campaign as a spare. We conducted full compatibility tests of the CREAM data acquisition system with the NSBF systems. This work was done in collaboration with University of Minnesota personnel via subcontract, including Prof. M. DuVernois, and graduate student T. Childers.

The CREAM program was renewed for another funding cycle. We have constructed a duplicate TCD system for a second CREAM payload, which will permit staggered Antarctic operations and increased overall integrated exposure and energy reach. We are planning an Antarctic flight of this second CREAM payload in December 2005. Meanwhile we are engaged in the analysis of the data from the first CREAM flight. Preliminary results indicate that all systems behaved nominally in flight and achieved the target performance. First reports of the instrument performance in flight have been presented, in particular at the 29<sup>th</sup> International Cosmic Ray Conference in Pune, India in August 2005.