

Final project report

Project ID: 2003/7.1
Title: CREAM

Principal investigator: Pier Simone Marrocchesi (for the Italian part)
(PI of the international experiment is Prof. Eun-Suk Seo, Maryland University)

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Duration: 2 years
Assigned funding: € 30000

Activities and results

The [Cosmic Ray Energetics and Mass \(CREAM\)](#) experiment was designed and constructed to measure [cosmic ray](#) elemental spectra using a series of [ultra long duration balloon \(ULDB\)](#) flights. The goal is to extend direct measurement of cosmic-ray composition to the energies capable of generating gigantic air showers in the atmosphere which have been mainly observed on the ground, thereby providing calibration for indirect measurements. The [instrument](#) has redundant and complementary charge identification and energy measurement systems capable of precise measurements of elemental spectra for $Z = 1 - 26$ nuclei over the energy range $\sim 10^{11}$ to 10^{15} eV. Precise measurements of the energy dependence of elemental spectra at the highest of these energies, where the rigidity-dependant supernova acceleration limit could be reflected in a composition change, provide a key to understanding cosmic ray acceleration and propagation. The instrument includes a [Timing Charge Detector \(TCD\)](#), a [Cherenkov Detector \(CD\)](#), a [Transition Radiation Detector \(TRD\)](#), a [Cherenkov Camera \(CherCam\)](#), a [Silicon Charge Detector \(SCD\)](#), scintillating fiber [hodoscopes](#), and a tungsten-scintillating fiber [calorimeter](#).

CREAM has been launched three times utilizing [zero-pressure balloons](#) (40M - L) in Antarctica, [first in December 2004](#), [second in December 2005](#), and [third in December 2007](#). It circumnavigated the south pole three times during the first flight, which set a flight duration record of 42 days, and twice during the second flight in 28 days. A cumulative duration of almost 100 days within ~ 3 years was achieved when the third flight was completed in 29 days.

The Italian group participated in the first two flights from McMurdo with the support of the PNRA. The S2 hodoscope (for the first flight) and the tungsten/SciFi calorimeter (for the second flight) were built in Italy under the support of INFN. The analysis of the data from the first two flights resulted in a number of publications, conference talks and scientific papers. In particular, the Italian group contributed in the analysis and energy calibrations of the calorimeter and in the measurement of the absolute fluxes of heavy nuclei.

Products

A – papers in scientific magazines

2004

1. E. S. Seo et al., "Cosmic Ray Energetics and Mass Balloon Project" *Advances in Space Research*, Vol.33, Issue 10, 1777-1785 (2004)
2. P. S. Marrocchesi et al., "Construction and test of a Tungsten/Sci-Fi imaging calorimeter for the CREAM experiment" *Nucl. Instrum.Meth. A* 535, 143-146 (2004)

2006

3. O. Ganel et al., "CREAM - Pushing the High Energy Frontier of Directly Measured Cosmic Rays," *Czech. J. Phys.* 56, A301-A312 (2006)

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4. N. H. Park et al., The First Flight of the CREAM Silicon Charge Detector, J. of Korean Physical Society. 49, No. 2, 815-818 (2006)
- 2007
5. H. Park et al., Silicon charge detector for the CREAM experiment© Nucl. Instrum. Methods A, 570, 286-291 (2007)
 6. S. Coutu et al., Design and performance in the first flight of the transition radiation detector and charge detector of the CREAM balloon instrument©, Nucl. Inst. Meth. A, 572, 485-487 (2007)
 7. H. S. Ahn et al., The Cosmic Ray Energetics And Mass (CREAM) instrumentNucl. Instrum. Methods A, 579, 1034-1053 (2007)
 8. S.W. Nam et al., Performance of a Dual Layer Silicon Charge Detector during CREAM Balloon Flights©, IEEE TRANSACTIONS ON NUCLEAR SCIENCE, 54, 1743 (2007)
- 2008
9. P. S. Marrocchesi et al., Preliminary result from the second flight of CREAM Advances in Space Research, Vol.41, Issue 12, 2002-2009 (refereed in 2007 and published at the beginning of 2008).
 10. S. WAKELY et al. First measurements of cosmic-ray nuclei at high energy with CREAM, Advances in Space Research, Vol.42, Issue 3, 403-408 (refereed in 2007 and published at the beginning of 2008).
 11. E. S. Seo et al., CREAM: 70 days of flight from 2 launches in Antarctica© Advances in Space Research, 42, 1656-1663 (refereed in 2007 and published at the beginning of 2008).
 12. H.S. Ahn et al., Measurements of cosmic-ray secondary nuclei at high energies with the first flight of the CREAM balloon-borne experiment, Astroparticle Physics, 30, 133-141, 2008

B – book chapters

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C - proceedings of international conferences

2007

Proceedings 30th International Cosmic Ray Conference, Merida (Mexico) 3-11 July, 2007

[Cosmic Ray Energetics And Mass\(CREAM\) Overview](#)

E. S. Seo et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 47-50, 2007

[Elemental Spectra from the CREAM-I Flight](#)

H. S. Ahn et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 63-66, 2007

[The CREAM-III calorimeter](#)

M. H. Lee et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 409-412, 2007

[Next Generation TRD for CREAM Using Gas Straw Tubes and Foam Radiators](#)

A. Malinin et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 345-348, 2007

[Construction and Performance of the Silicon Beam Tracker](#)

J. H. Han et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 389-392, 2007

[H and He spectra from the 2004/05 CREAM-I flight](#)

Y. S. Yoon et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 55-58, 2007

[Calibration of the CREAM-I calorimeter](#)

Y. S. Yoon et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 421-424, 2007

[Improved Data Acquisition System for CREAM-III](#)

J. H. Yoo et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 401-404, 2007

[Charge Identification in the CREAM Experiment](#)

T. J. Brandt et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 377-380, 2007

[Relative abundances of heavy ions measured by the CREAM Silicon Charge Detector](#)

N. H. Park et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 39-42, 2007

[Effect of albedo particles on charge measurement](#)

N. H. Park et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 381-384, 2007

[CHERCAM: the Cherenkov imager of the CREAM experiment results in Z=1 test beams](#)

L. Derome et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 453-456, 2007

[GEANT4 Based Model of the CREAM Timing Charge Scintillation Detector](#)

S. I. Mognet et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 385-388, 2007

[Timing charge and position analysis from the first CREAM flight](#)

J. T. Childers et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 373-376, 2007

[Preliminary measurements of carbon and oxygen energy spectra from the second flight of CREAM](#)

R. Zei et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 23-26, 2007

[Energy cross-calibration from the first CREAM flight: transition radiation detector versus calorimeter](#)

P. Maestro et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 333-336, 2007

[Measurements of High-Energy Heavy Nuclei with the CREAM-I TRD](#)

S. P. Wakely et al., Proc. 30th Int. Cosmic Ray Conf., Merida, 2, 187-190, 2007

2006

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CREAM: 70 days of flight from 2 launches in Antarctica

E. S. Seo et al., invited talk at COSPAR, 2006

[Preliminary results from the second flight of CREAM](#)

P.S. Marrocchesi et al., invited talk at COSPAR, 2006

First measurements of secondary nuclei at high energy with CREAM

S. Wakely et al., invited talk at COSPAR, 2006

[CREAM - Pushing the High Energy Frontier of Directly Measured Cosmic Rays](#)

O. Ganel et al., Czech. J. Phys. 56, A301-A312, 2006

CHERCAM: a Cherenkov imager for the CREAM experiment

A. Barrau et al., 10th Pisa Meeting on Advanced Detectors, Elba, Italy, May, 2006

A Cherenkov imager for the CREAM experiment

M. Buenerd et al., ECRS, Lisbon, 2006

[Design and Performance in the First Flight of the Transition Radiation Detector and Charge Detector of the CREAM Balloon Instrument](#)

S. Coutu et al., 10th Pisa Meeting on Advanced Detectors, Elba, Italy, May, 2006

2005

Proceedings 29th International Cosmic Ray Conference, Pune (India) 3-10 August, 2005

[New Observations with CREAM](#)

E. S. Seo et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 10, 185-198, 2005

[The Record Breaking 42-day Balloon Flight of CREAM](#)

E. S. Seo et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 101-104, 2005

[Flight Operations during the First CREAM Balloon Flight](#)

Y. S. Yoon et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 429-432, 2005

[Design and Tests of the Scintillating Fiber Hodoscopes in the CREAM Instrument](#)

Y. S. Yoon et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 433-436, 2005

[Performance of the CREAM calorimeter in accelerator beam test](#)

Y. S. Yoon et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 8, 371-374, 2005

[Performance of the CREAM calorimeter module during its first flight of 42 days](#)

M. H. Lee et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 417-420, 2005

[Electronics for the CREAM calorimeter and hodoscopes](#)

M. H. Lee et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 409-412, 2005

[Design and tests of the CREAM calorimeter](#)

M. H. Lee et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 413-416, 2005

[The data acquisition software system of the 2004/2005 CREAM Experiment](#)

S. Y. Zinn et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 437-440, 2005

[Beam test calibration of the balloon-borne imaging calorimeter for the CREAM experiment](#)

P. S. Marrocchesi et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 309-312, 2005

[Reconstruction of showers in the calorimeter during the first flight of the CREAM balloon experiment](#)

P. S. Marrocchesi et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 8, 109-112, 2005

[Performance of the CREAM Silicon Charge Detector during its First Flight](#)

J. Yang et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 345-348, 2005

[The First Flight Measurement with the CREAM Silicon Charge Detector](#)

I. H. Park et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 341-344, 2005

[Performance of the transition radiation detector and the timing charge detector in the first flight of the CREAM instrument](#)

S. Coutu et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 393-396, 2005

[CREAM Flight Data Processing](#)

H. S. Ahn et al., Proc. 29th Int. Cosmic Ray Conf., Pune, 3, 389-392, 2005

[A Cherenkov imager for the charge measurement of Nuclear Cosmic Rays in the CREAM II instrument](#)

2004

[Design, Implementation and Performance of CREAM Data Acquisition Software](#)

presented by S. Y. Zinn, 9th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD04) - Siena (23-26 May 2004)

[Performance of the Silicon Charge Detector for the CREAM Cosmic Ray Experiment](#)

presented by P. S. Marrocchesi (on behalf of J. Yang), 9th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD04) - Siena (23-26 May 2004)

[Performance of the CREAM calorimeter : Results of Beam Tests](#)

presented by P. Maestro (on behalf of M.H.Lee), 9th Topical Seminar on Innovative Particle and Radiation Detectors (IPRD04) - Siena (23-26 May 2004)

[Beam test calibration of the balloon-borne imaging calorimeter for the cream experiment](#)

presented by P. Maestro, 11th International Conference on Calorimetry in High energy Physics (CALOR04), Perugia March 29 - April 2, 2004

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[Construction and test of a Tungsten/SciFi imaging calorimeter for the CREAM experiment](#)

poster contribution by P. S. Marrocchesi, 10th Vienna Conference on Instrumentation - Vienna, Feb 16-2, 2004

2003

[Construction and test of a scintillator hodoscope for the CREAM experiment](#)

poster contribution by P. S. Marrocchesi (poster contribution), 2nd International Conference on Particle and Fundamental Physics in Space (SPACEPART03) - Washington DC 10-12 Dec 03 (in press)

[CREAM for High Energy Composition Measurements](#)

presented by E. S. Seo, 28th Int. Cosmic Ray Conf., (Tsukuba), 4, 2101, 2003

[Design and Construction of the Silicon Charge Detector for the CREAM Mission](#)

presented by I.H. Park et al., 28th Int. Cosmic Ray Conf., (Tsukuba), 4, 2105, 2003

[The Cosmic Ray Energetics and Mass \(CREAM\) Experiment Timing Charge Detector](#)

presented by J. J. Beatty, Proceedings of SPIE Vol. 4858: Particle Astrophysics Instrumentation, 4858, 248, 2003

D – proceedings of national meetings and conferences

1. CASTELLINA, M.G. BAGLIESI, G. BIGONGIARI, MARROCCHESI P., P. MAESTRO, R. ZEI. (2006). The CREAM balloon experiment. MEMORIE DELLA SOCIETÀ ASTRONOMICA ITALIANA SUPPLEMENTI (on line). vol. 9, pp. 385-388 ISSN: 1824-0178.

E – thematic maps

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F – patents, prototypes and data bases

1. Scintillation Hodoscope prototype (for 1st flight): <http://www.unisi.it/fisica/cream/S2-Flight-Model.html>
2. Tungsten/Scintillating-Fibers calorimeter prototype (for 2nd flight): <http://www.unisi.it/fisica/cream/Cream2-calorimeter.html>

G – exhibits, organization of conferences, editing and similar

1. P.S.MARROCCHESI, F.L.NAVARRIA, M.PAGANONI, P.G.PELFER. Innovative particle and radiation detectors (IPRD06): PROCEEDINGS OF THE TENTH TOPICAL SEMINAR ON INNOVATIVE PARTICLE AND RADIATION DETECTORS, SIENA, ITALY – OCTOBER 2006 (vol. 172, pp. 1-340). ISBN: 0920-5632
2. C.BOSIO, P.S. MARROCCHESI, F.L. NAVARRIA, M.PAGANONI AND P.G.PELFER. Innovative particle and radiation detectors (IPRD04): PROCEEDINGS OF THE 9TH TOPICAL SEMINAR ON INNOVATIVE PARTICLE AND RADIATION DETECTORS, SIENA, ITALY - MAY 2004 (vol. 150, pp. 1-439). ISBN: 0920-5632.

H - formation (PhD thesis, research fellowships, etc.)

1. M.G.Bagliesi (PhD. Ciclo XVI) *Calorimetric energy measurements in the CREAM experiment*
2. G.Bigongiari (PhD. Ciclo XVIII) *Energy measurements in the CREAM balloon experiment*
3. R.Zei (PhD. Ciclo XIX) *Preliminary measurements of cosmic-ray Carbon and Oxygen spectra with CREAM-II*

Research units

Italy: Università di Siena, Università di Pisa, Scuola Normale Superiore, INFN sez. di Pisa, INFN Gruppo Collegato di Siena, IFSI – Torino.

The CREAM international collaboration includes the following institutions:

USA - University of Maryland; University of Chicago; Pennsylvania State University; University of Minnesota; Northern Kentucky University; Ohio State University
South Korea - Department of Physics, Korea Advanced Institute of Science and Technology; Kyungpook National University; Ewha University
France - LPSC Grenoble, CESR Toulouse
Mexico - UNAM

The CREAM experiment is directed by Prof. Eun-Suk Seo of the University of Maryland (Principal Investigator). The Italian participation (Pisa, Siena, Torino), coordinated by Prof. Pier Simone Marrocchesi of the University

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Notes