

Final project report

<i>Project ID</i>	2004/7.06
<i>Title</i>	<i>Cosmic Rays in Polar Areas and Associated Terrestrial Phenomena</i>
<i>Principal investigator</i>	STORINI Marisa
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<i>Duration</i>	3 years
<i>Assigned funding</i>	130 000,00 Euro

Activities and results

The aim of the project was (i) to continue the detection of the nucleonic component of cosmic rays in the Latin-American sector by using the neutron monitors located in Antarctica (King George Island; **LARC subproject**) and Los Cerrillos (Santiago of Chile; **OLC subproject**); (ii) to develop new neutron detectors for polar areas.

The Antarctic Laboratory for Cosmic Rays (LARC subproject; location: $\sim 62^{\circ}\text{S} - 58^{\circ}\text{W}$; 40 m a.s.l.) is based on a Chile/Italy collaboration started in November 1993 to run a 6NM-64- $^{10}\text{BF}_3$ detector. Nowadays, also an Italian 3NM-64- ^3He detector (assembled and checked for its performance in Rome) is at work since January 2007. The obtained data [(URL: http://www.dfi.uchile.cl/ec_web/htm/datos.htm)] are used to investigate solar extreme events, such as energetic solar particles in the terrestrial environment and induced effects.

The Los Cerrillos Observatory (OLC subproject; location: $\sim 33^{\circ}\text{S} - 289^{\circ}\text{E}$; 570 m a.s.l.) is the result of a Chile/Italia collaboration via a PNRA/INACH agreement. Instruments sent to Santiago of Chile during the 2000 year allowed the build up of a 6NM-64- $^{10}\text{BF}_3$ at Los Cerrillos Observatory [(URL: http://www.dfi.uchile.cl/ec_web/htm/datosssl.htm)].

The combined data of both observatories allows to check on hourly basis the incoming radiation in the energy range of 3-10 GeV. Moreover, the identification of Ground Level Enhancements (known as GLEs; generally detected on 5-min basis) permits to estimate the ionization produced by the associated solar protons, particularly in polar areas where the variability of several minor atmospheric components is closely related (see references reported in the next sections).

The design of a new modular detector has been performed by using a helium counter (LND 25373 type). The detector configuration has reached the length of 216 cm with a mass of ~ 800 Kg. It is realized with 23 modules and it is closed by a plate at the both ends. The frontal plate has a hole for the tube and a bay for the electronics box fixed on the head of the counter, whereas the rear one is plane. Each module is composed by a polyethylene round shaped frame (outer reflector) with a tongue and groove joint to lock into one another. The central hole of the frame encloses a lead ring (producer) housing an interlocking polyethylene allow cylinder (inner moderator) which is the modular slot of the proportional counter. Four tie-rods block in the whole frame preventing any movement of the single elements which are boxed up with a strict mechanical accuracy.

Despite the overall weight, only one operator is required to assemble the whole modular detector, as the modular design made each loose component reasonably light, since the weight of the heaviest element (lead ring) is about 23 Kg. If PNRA will continue to support this kind of research, the build-up of the detector and test of its performance will be the next step for the use in polar areas.

Products

A – papers in scientific magazines

1. Damiani, A., Benedetti, E., Storini, M., Rafanelli C., *Italian polar data center for capacity building associated with the IHY*, **J. Adv. Space Res.** (ScienceDirect on line: 31 January 2007, doi:10.1016/j.asr.2007.01.046), **41**, 223-226, 2008.
2. Storini, M., Metteo P., Moreno G., *Effects of geomagnetic secular variations on cosmic ray access to the terrestrial environment*, **J. Adv. Space Res.** (ScienceDirect on line: 13 May 2007, doi:10.1016/j.asr.2007.04.091), **41**, 70-75. 2008.

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3. Damiani, A., Storini, M., Laurenza, M., Rafanelli, C., *Solar particle effects on minor components of the Polar atmosphere*, **Ann. Geophys.**, **26**, 361-370, 2008.
4. Damiani, A., Diego P., Laurenza, M., Storini, M., Rafanelli, C., *Ozone variability related to several SEP events occurring during solar cycle no. 23*, **J. Adv. Space Res.** (ScienceDirect on line: 24 June 2008, doi:10.1016/j.asr.2008.06.006), **43**, 28-40, 2009.
5. Usoskin, I. G., Desorgher, L., Velinov, P., Storini, M., Flückiger, E.O., Bütikofer, R., Kovaltsov, G.A., *Ionization of the earth's atmosphere by solar and galactic cosmic rays*, **Acta Geophysica** (SpringerLink on line: 30 September 2008, doi:10.2478/s11600-008-0019-9), **57 (n° 1)**, 88-101, 2009.
6. Storini, M., Signoretti, F., Diego, P., Re, F., Laurenza, M., *A 3NM-64 ³He added to LARC for Solar Extreme Event studies during solar cycle 24*, **J. Adv. Space Res.** (Science Direct on line: 17 October 2008, doi: 10.1016/j.asr.2008.10.004), **43**, 721-727, 2009.
7. Desorgher, L., Kudela, K., Flückiger, E. O., Bütikofer, R., Storini, M., Kalegaev, V., *Comparison of Earth's magnetospheric magnetic field models in the context of cosmic ray physics*, **Acta Geophysica** (SpringerLink online: 29 October 2008, doi:10.2478/s11600-008-0065-3), **57 (n°1)**, 75-87, 2009.
8. Storini, M., Signoretti, F., *SVIRCO contribution to the world-wide network of cosmic ray detectors*, Paper ICRCW-20, **J. Adv. Space Res.** (ScienceDirect on line: July, 2009, doi:10.1016/j.asr.2009.02.019), **44**, 121-1231, 2009.
9. Vecchio, A., Laurenza, M., Carbone, V., Storini, M., *Quasi-biennial modulation of solar neutrino flux and solar and galactic cosmic rays by solar cyclic activity*, **Astrophys. J. Letters** (IOP Science on line: 29 December, 2009: doi:10.1088/2041-8205/709/1/L1), **709**, L1-L5, 2010.
10. Damiani, A., Rafanelli, C., Benedetti, E., Storini, M., *Activities and issues of a developed information system for the Italian polar research*, **Data Science J.**, (Accepted: 30 December 2009, on line: 10 February 2010), **8**, IGY44-IGY54, 2010.
11. Diego, P., Storini, M., Laurenza, M., *Persistence in recurrent geomagnetic activity and its connection with Space Climate*, **J. Geophys. Res.**, doi:10.1029/2009JA014716, **in press** (Accepted 15 January 2010).

B – book chapters

1. Desorgher, L., Kudela, K., Flückiger, E.O., Bütikofer, R., Storini, M., Kalegaev, V., *Comparison of Earth's magnetospheric magnetic field models in the context of cosmic ray physics*, in Liliensten J. et al. (Eds.), COST 724 final report, Developing the scientific basis for monitoring, modelling and predicting Space Weather, **EC-EUR 23348, ISBN 978-92-898-0044-0**, pp. 119-126, 2008.
2. Usoskin, I., Desorgher, L., Velinov, P., Storini, M., Flückiger, E.O., Bütikofer, R., Kovaltsov, G.A., *Solar and galactic cosmic rays in the Earth's atmosphere*, in Liliensten J. et al. (Eds.), COST 724 final report, Developing the scientific basis for monitoring, modelling and predicting Space Weather, **EC-EUR 23348, ISBN 978-92-898-0044-0**, pp. 127-135, 2008.

C - proceedings of international conferences

1. Laurenza, M., Hewit, J., Cliver, E.W., Storini, M., Ling, A., *Solar Energetic Proton Events and Soft X-ray Flares*, Proc. 20th European Cosmic Ray Symposium, Lisbon, September 5-8, 2006, paper on line (and **CD, 2007**) at: <http://www.lip.pt/events/2006/ecrs/proc/ecrs06-s1-34.pdf>
2. Storini, M., Cordaro E.G., Parisi, M., *The December 2006 GLE Event as seen from LARC, SVIRCO and OLC*, Proc. 30th Int. Cosmic Ray Conference, Mérida (México), 3-11 July, 2007, edited by R. Caballero et al., Universidad Nacional Autonoma de México, Vol. 1, 273-276, 2008.
3. Storini, M., Damiani, A., *Effects of the January 2005 GLE/SEP events on minor atmospheric components*, Proc. 30th Int. Cosmic Ray Conference, Mérida (México), 3-11 July, 2007, edited by R. Caballero et al., Universidad Nacional Autonoma de México, Vol. 1, 277-280, 2008.
4. Storini, M., Giangravè, S., Diego, P., Laurenza, M., *More on the Gnevyshev Gap During the 11-year Solar Activity Cycle*, Proc. 30th Int. Cosmic Ray Conference, Mérida (México), 3-11 July, 2007, edited by R. Caballero et al., Universidad Nacional Autonoma de México, Vol. 1, 533-536, 2008.
5. Storini, M., Signoretti, F., Diego, P., Laurenza, M., Cordaro, E.G., Olivares, E.F., *A new detector added to the Antarctic Laboratory for Cosmic Rays*, in Proc. of the International Symposium on Solar Extreme Events of 2007: Fundamental Science and Applied Aspects, National and Kapodistrian University of Athens – Greece, pp. 350-355, distributed 2009.
6. Storini, M., Signoretti, F., Re, F., Parisi, M., *Cosmic rays during IHY/CIP 57 campaigns*, in Proc. 21st European Cosmic Ray Symposium (Kosice – Slovakia, 9-12 September 2008), edited by P. Király et al., Institute of Experimental Physics, SAS, ISBN 978-80-968060-5-8, pp. 620-625, distributed 2009.
7. Gardini, Angela, Damiani, Alessandro, Storini, Marisa, *Use of AURA Microwave Limb Sounder data for Dome C and Dome A site-testing*. EAS Publications Series, 40, 111-114, (2010); on line December 24, 2009.
8. Signoretti, Fabrizio, Storini, Marisa, *A Modular Neutron Detector*, in Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland, 7– 15 July, 2009), paper ID: 0039bw; available on CD (2009).
9. Signoretti, Fabrizio, Storini, Marisa, *A New Detector Operating at the Antarctic Laboratory for Cosmic Rays*, in Proceedings of the 31st International Cosmic Ray Conference (Lodz, Poland, 7–15 July, 2009), paper ID: 0040bw, available on CD (2009).

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10. Damiani, A., Gardini, A., Laurenza, M., Storini, M., *Investigation of Minor Components of the Terrestrial Atmosphere related to presence/absence of Solar Energetic Particles*, in Proceedings of 31th International Cosmic Ray Conference, (Lodz, Poland, 7-15 July 2009), paper ID: 481bw, available on CD (2009).

D – proceedings of national meetings and conferences

1. Damiani, A., Storini, M., Rafanelli, C., *Effects of SEP events on the atmospheric chemistry: An overview*, in XI Workshop Italian Research on Antarctic Atmosphere, edited by M. Colacino and C. Rafanelli, Conference Proceedings, Bologna, Vol. 97, pp. 199-210, 2009.
2. Storini, M., Signoretti, F., Diego, P., Re, F., Cordaro, E.G., Olivares, E.F., *LARC upgrade for solar activity cycle N° 24*, in XI Workshop Italian Research on Antarctic Atmosphere, edited by M. Colacino and C. Rafanelli, Conference Proceedings, Bologna, Vol. 97, pp. 211-221, 2009.

E – thematic maps

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F – patents, prototypes and data bases

1. *Database updated to December 2007: 3* (LARC_6NM-64_¹⁰BF₃ ; LARC_3NM-64_³He ; OLC_6NM-64_¹⁰BF₃) + **2** (LARC_GLEs; OLC_GLEs).
2. Storini, M., Signoretti, F., Diego, P., *Testing a new Italian cosmic-ray detector based on ³He counters*. Report IFSI-2009-6, February 2009.
3. Storini, M., Re, F., Signoretti, F., *LARC NORMALIZED DATA 1991-2007*. Report IFSI-2009-8, March 2009.

G – exhibits, organization of conferences, editing and similar

1. 37th COSPAR Scientific Assembly – D23 Energetic Solar Particle Events – Past, Present, Future/ Joint with E33, July 2008. Member of the Organizing Committee: M. Storini (IFSI-Roma/INAF).
2. M. Storini – 2008/2009 Guest editor for Adv. Space Res. (Vol. 44 - Elsevier Journal).

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

1. *UNISiena, Scuola di Dottorato di Ricerca in Scienze Polari – Piero Diego, Ricorsività nel mezzo interplanetario e climatologia dedotta da misure terrestri*, XIX Ciclo, IFSI-Roma/INAF: M. Storini (tutor of PhD thesis).
2. *UNISiena, Scuola di Dottorato di Ricerca in Scienze Polari – Alessandro Damiani, Effects of energetic solar particles on ozone and minor atmospheric components inside the polar regions*, XX Ciclo, IFSI-Roma/INAF: M. Storini (tutor of PhD thesis).
3. Research Contract (Assegno di ricerca) - Dr. Piero Diego: *Rivelatori terrestri per la radiazione cosmica – uso in aree polari/subpolari*.
4. Research Contract (Assegno di ricerca) – Dr. Alessandro Damiani: *SEP (Particelle Energetiche Solari) in ambito polare*.

Research units

CAN-STO.1: *Head:* Marisa STORINI (check of the experimental work and obtained data from neutron monitors; research for Solar-Terrestrial Relations/Space Weather)

Nome/Name	Qualifica/Role	Istituto/Institution
Marisa STORINI	Coordinator /Senior Scientist	IFSI_INAF
Piero DIEGO	Research Contract/PNRA	IFSI_INAF
Francesco RE	Technician	IFSI_INAF
Fabrizio SIGNORETTI	CTER	IFSI_INAF
Maria Paola ALLEMANDI	CTER	IFSI_INAF
Mario PARISI	Associated Professor	UNIRoma3

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CAN-STO.2: *Head:* Fabrizio SIGNORETTI (design and experimental test for a new compact detector)

Nome/Name	Qualifica/Role	Istituto/Institution
Fabrizio SIGNORETTI	Head /CTER	IFSI_INAF
Piero DIEGO	Research Contract/ PNRA	IFSI_INAF
Francesco RE	Technician	IFSI_INAF
Marisa STORINI	Senior Scientist	IFSI_INAF
Stefano MASSETTI	Collaborator	IFSI_INAF

CAN-STO.3: *Head:* Monica LAURENZA (database for Sun-Earth-Heliosphere System)

Nome/Name	Qualifica/Role	Istituto/Institution
Monica LAURENZA	Head /Researcher	IFSI_INAF
Maria Paola ALLEMANDI	CTER	IFSI_INAF
Marisa STORINI	Senior Scientist	IFSI_INAF
Alessandro DAMIANI	Research Contract/ PNRA	CNR_IDAC
Giovanni MORENO	Associated Professor	UNIRoma1
Angela GARDINI	Research Contract	IFSI_INAF
Karel KUDELA	Associated Professor.	SAV-Kosice
Julius SYKORA	Senior Scientist	SAV-T.Lomnica

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Notes