IL NUOVO CIMENTO VOL. 20 C, N. 6 Novembre-Dicembre 1997

Italia/Chile Collaboration for LARC(*)

M. STORINI([1]) and E. G. CORDARO([2])

([1]) *Reparto Raggi Cosmici - IFSI/CNR, c/o Dipartimento di Fisica Università di Roma I "La Sapienza" - P.le A. Moro 2, I-00185, Roma, Italy*

([2]) *Laboratorio Radiación Cósmica - Departamento de Física Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile Casilla 487-3, Santiago, Chile*

(ricevuto il 5 Dicembre 1996; approvato il 18 Marzo 1997)

Summary. — An Antarctic Laboratory for Cosmic Rays (LARC) has been opened on the King George Island (Fildes Bay - Ardley Cove) during January 1991. The cosmic-ray detector is a standard 6-NM-64 type. The present status of the LARC project and relevant scientific goals for Solar-Terrestrial Physics are briefly outlined.

PACS 93.30.Ca – Antarctica.
PACS 96.40 – Cosmic rays.
PACS 13.85.Tp – Cosmic-ray interactions.
PACS 01.30.Cc – Conference proceedings.

1. – Introduction

LARC is an acronym which stands for Laboratorio Antártico de Radiación Cósmica (Laboratorio Antartico per la Radiazione Cosmica / Antarctic Laboratory for Cosmic Rays). LARC project started about eight years ago as a uniquely Chilean project [1], but approximately five years ago the cosmic-ray section of IFSI/CNR was called to collaborate with the Chilean researchers both for experimental and theoretical works [2,3]. A detailed proposal entitled *Cosmic Rays in Antarctica* was submitted to the Italian Antarctic Research Program (PNRA/MURST, 1992-96) and it was approved [4]. The Italian counterpart joined the project in November 1993 through the signature of a formal agreement (convention) between the Chilean *Laboratory for Cosmic Rays* (University of Chile - Santiago) and the Italian Project *Cosmic Rays in the Heliosphere* (IFSI/CNR - Rome). Immediately, the agreement was submitted to the INACH (Instituto Nacional Antártico Chileno) and to the PNRA. The Italia/Chile collaboration is made in the frame of the *International Decade for Scientific Cooperation in Antarctica* (1991-2000).

(*) Paper presented at the VII Cosmic Physics National Conference, Rimini, October 26-28, 1994.

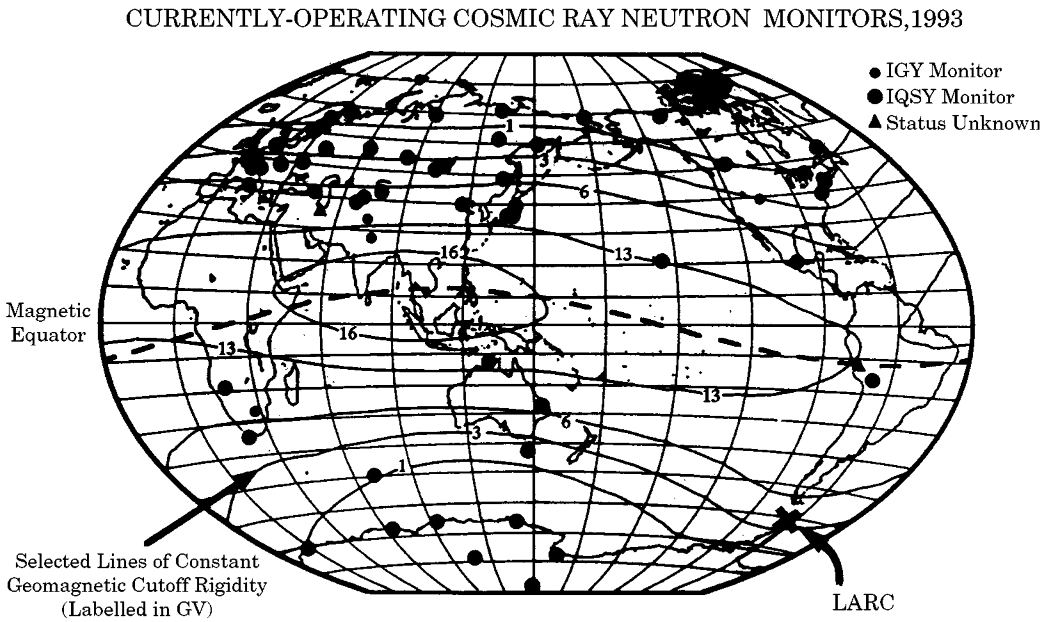

Fig. 1. – World map of neutron monitor (IGY: International Geophysical Year; IQSY: International Quiet Sun Year) locations for the 1993 year (adapted from SIMPSON [5]). LARC position is indicated by a cross.

2. – Cosmic-ray data from LARC

The main objective for the LARC project is the study of the cosmic-ray radiation in the high-latitude southern Latin-American sector, which is not covered by the world-wide network of cosmic-ray detectors (see fig. 1, adapted from [5]). A standard super neutron monitor (6-NM-64 type - IQSY detector [6]) is operating on King George Island (South Shetland Island - Fildes Bay - Ardley Cove) since January 19, 1991 (Geographic position: 62° 11′ 08″ S–58° 55′ 00″ W, 40 m a.s.l.). The place is the seat of the E. Frei Base and the T.te Marsh airport with *Las Estrellas* Village and a Meteorological Center. This Center kindly supplied us with the meteorological parameters for Ardley Cove (3 hourly readings of atmospheric pressure, air temperature, relative humidity, wind speed and direction).

The primary experimental equipment for LARC was furnished by the Cosmic-Ray Research Laboratory of the University of Chile. LARC data for the 1991 year have been recorded on paper tapes. During three successive summer campaigns (1991/92, 1992/93 and 1993/94) the data acquisition system has been changed. Present original data-base is on easily readable ASCII text files on DOS-formatted floppy disks. Data are collected and processed at Santiago. They are stored in a database to be delivered to Rome for parallel analyses. Data strings for the 1991-1994 epoch contain: date, universal time (U.T.), atmospheric pressure readings (mmHg), and the counting rates registered every 5 minutes by the three units (each with two BP28 Chalk River counters) of the monitor. Presently, the Italian team is analyzing the 1993-94 datasets. Data treatment includes:

- data-string decoding;
- data-format check;
- data recovery, if possible, when failure is present;

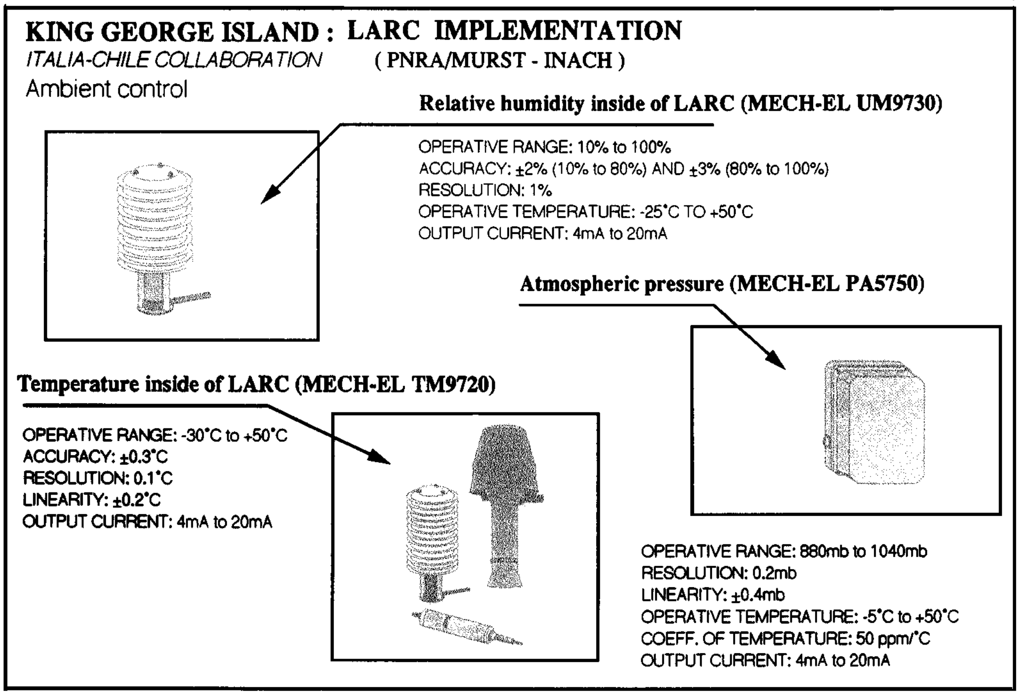

Fig. 2. – Some instruments for LARC implementation (ambient control).

– LARC pressure check with the pressure data supplied by the Meteorological Center E. Frei;

– Frei file set-up;

– hourly averages of the registered cosmic-ray intensity and of the atmospheric pressure;

– yearly LARC file set-up.

Moreover, a preliminary data analysis has been done on the original data for the 1991-1993 epoch to evaluate atmospheric pressure-induced effects. An attenuation coefficient of about 0.74%/mb seems to be the appropriate one to eliminate barometric induced variations on the recorded data to investigate time variations in the primary cosmic-ray flux [7]. The LARC implementation is carried out via the Italia/Chile collaboration. During the year 1994 several instruments for the ambient control of the laboratory (see fig. 2) have been tested operationally in Rome (Cosmic-Ray Section of IFSI/CNR) and delivered to INACH for their inclusion in LARC [8]. Moreover, three devices for high-voltage power supply (Bertan 230-03R) were also sent (see fig. 3 for their characteristics). During the 1994/95 summer campaign all the instruments were successfully added to the current data acquisition system.

We expect to be able to detect the cosmic-ray radiation in the austral ground at least for a complete solar activity cycle (sunspot cycle No. 23).

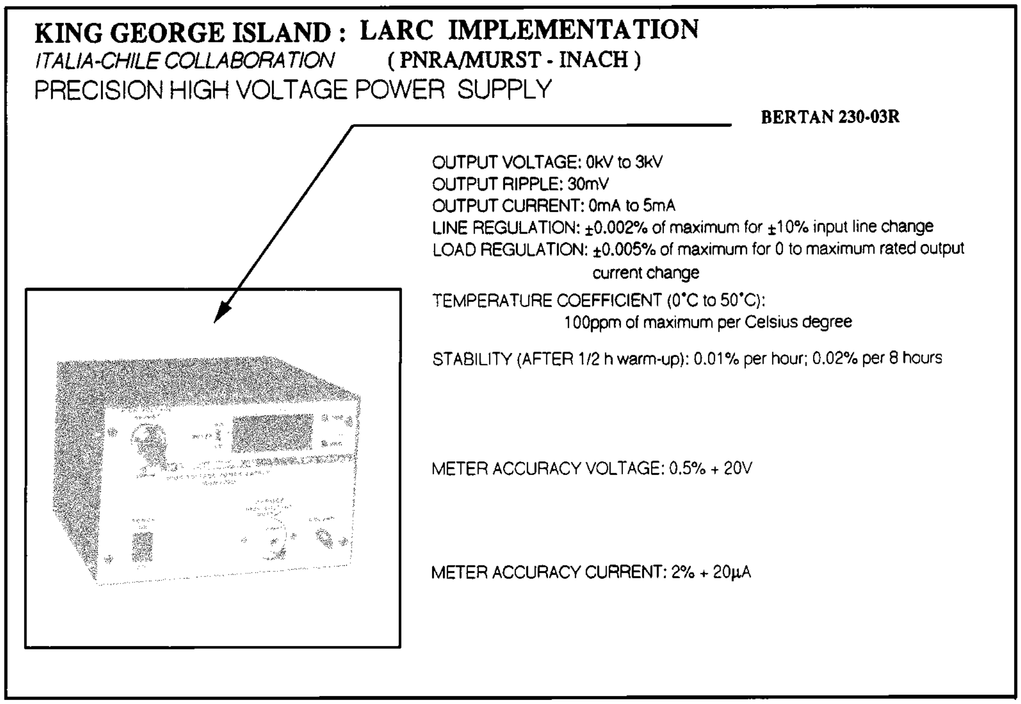

Fig. 3. – Relevant features for the high-voltage power supply at LARC.

3. – LARC **for Solar-Terrestrial Physics**

The combined use of cosmic-ray data from the world-wide ground-based network to improve Cosmic-Ray Physics has been already described in several works (see, for instance, [9-14]). Hence, we have no ambition to summarize present knowledge on the matter. We only notice that the systematic study of the nucleonic component intensity provides us with a powerful tool also to increase our knowledge on Solar-Terrestrial Physics. The interlacement of Cosmic-Ray Physics with other physical branches is summarized in fig. 4. Possible cosmic-ray data uses for the understanding of the Earth environment variability are also reported.

Nowadays the concept of *space weather forecast* (*i.e.* the forecast of disturbances in the radiation and plasma environment in the near-Earth space) is largely acquired with a high weight in Solar-Terrestrial Physics. Among the different issues involved the energetic cosmic-ray particles deserve attention.

Starting with solar cosmic rays, we notice that their flux is highly variable in time (*e.g.* [15, 16]), as it is the energy range of the involved particles. The evaluation of their contribution to the counting rate of ground-based detectors for galactic cosmic rays is relevant in assessing a spectral index on solar-proton events (SPEs). We recall that solar-proton spectra are generally much steeper (*i.e.* softer) than the galactic-cosmic-ray spectrum at 1 AU. Present results, based on ground-level enhancements (the so-called GLEs), suggest that solar cosmic rays can be accelerated at least up to 30 GeV during intense solar events (the September 29, 1989 GLE is an example). Moreover, unusual time variations were observed during several SPEs and often they show an anisotropic flux in the Earth environment. A world-wide network of cosmic-ray detectors distributed avoiding gaps in

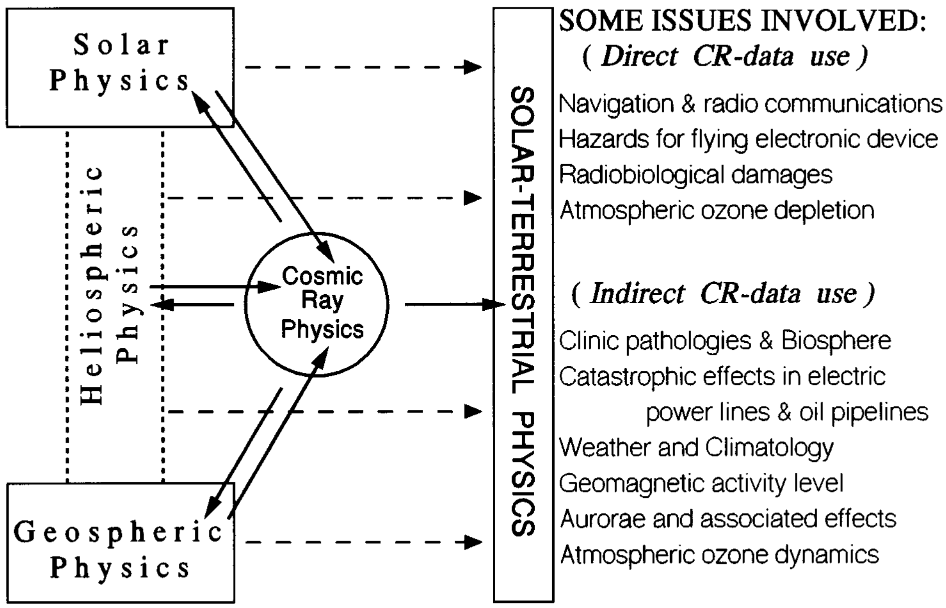

Fig. 4. – The interlacement of Cosmic-Ray Physics with other physical branches (left side) and issues for cosmic-ray data uses in Geospheric Physics (right side).

the key geographical areas is needed, and LARC is filling one of them.

The understanding of the basic physics of SPEs is a prerequisite to forecasts and/or to evaluate, among others:

– loss of telecommunication system on space vehicles,

– degradation of photo-sensitive satellite components (*e.g.* solar-power panels),

– deep dielectric charging of satellite parts,

– surface charging on satellites,

– hazards for astronauts (*e.g.* "flashes" in eyes),

– radiobiological damages on polar and subpolar high-altitude aircrafts,

– "miniholes" in the atmospheric ozone layer.

Until the end of the eighties it was believed that energetic solar cosmic rays were linked with solar flares occurring during magnetic reconnections in active regions and causing coronal mass ejections (CMEs) into the interplanetary space. Hence solar-particle forecasts was essentially based on Solar-Flare Physics. However, during the nineties, coronagraph data studies suggested that CMEs are initiated by the destabilization of large-scale magnetic structures in a wide solar region, which often but not always contains a flare source. Moreover, CME release can anticipate solar flare or PROMINENCE eruption phenomena. Gosling [17, 18], after a summary of present knowledge on the matter, arrives at a conclusion that *removes solar flares from their central position in the chain of events leading from the Sun to near-Earth space* (quotation). In this way a "flare/CME controversy" arose in Solar Terrestrial Physics. In fact, Gosling has stressed the relevance of CMEs not only for particle acceleration and shocks in the heliosphere but also for outstanding geomagnetic storms, being the latter the magnetospheric response to solar-wind macroperturbations. Also the medium-term modulation of galactic cosmic rays is caused by these interplanetary disturbances. Hence, data from the continuous monitoring of the nucleonic component can be used to investigate on the "flare/CME controversy".

We believe that Cosmic Rays inside the Solar-Terrestrial Physics is an open research field for the next years. In particular, we expect to learn more on:

– periodicities of solar-activity cycles,

– the interplay between poloidal and toroidal field systems during solar-activity phases,

– the space-time distribution of solar sources for outstanding activity phenomena,

– the solar output variability and the cyclic solar-activity manifestations from the Sun to the Earth environment,

– the use of solar activity parameters to describe dynamic processes in the interplanetary medium,

– geomagnetic perturbation forecasts.

Notes added in proofs. – i) LARC data are now available on hourly basis for the 1991-1996 period. ii) A general Chile / Italy Agreement for Scientific Cooperation in Antarctica was signed on october 31, 1997.

* * *

This work was supported by the Italian Antarctic Research Program (PNRA, MURST). The Chilean and Italian teams are acknowledged together with their institutions. Thanks are also due to the E. Frei Center for the use of their meteorological data and to the Chilean Air Force for supports during the summer work of each year.

REFERENCES

[1] CORDARO E. G., *Proc. XXII ICRC, Dublin*, **3** (1991) 800.
[2] CORDARO E. G. and STORINI M., *Nuovo Cimento C*, **15** (1992) 539.
[3] CORDARO E. G., JOHNSON E. R. and STORINI M., *Geofís. Intern.*, **31** (1992) 79.
[4] STORINI M. and CORDARO E. G., *SIF Conf. Proc.*, **35** (1992) 233.
[5] SIMPSON J. A., *J. Geophys. Res.*, **99** (1994) 19159.
[6] CARMICHAEL H., IQSY Instruction Manual, Vol. **7** (Deep River) 1964.
[7] CORDARO E. G. and STORINI M., Report CNR/IFSI-94-16 (Frascati) 1994.
[8] CORDARO E. G., LARENAS M., OLIVARES E., OPAZO M., JOHNSON E., BAVASSANO B., FELICI A., RE F., SIGNORETTI F., SIGNORINI C., STORINI M., VILLORESI G., ZANGRILLI N., IUCCI N. and PARISI M., Report CNR/IFSI-94-17 (Frascati) 1994.
[9] VENKATESAN D. and BADRUDDIN, *Space Sci. Rev.*, **52** (1990) 121.
[10] STORINI M., *Nuovo Cimento C*, **13** (1990) 103; *Nuovo Cimento C*, **14** (1991) 211 (E).
[11] DORMAN L. I. and VENKATESAN D., *Space Sci. Rev.*, **64** (1993) 183.
[12] POTGIETER M. S., *Proc. XXIII ICRC, Calgary - Invited, Rapporteur & Highlight papers* (Calgary) 1994, p. 213.
[13] STORINI M., STEP GBRSC News, **5** - Special Issue (1995) p.267.
[14] STORINI M., This issue, p. 871.
[15] SHEA M. A. and SMART D. F., *Solar Phys.*, **127** (1990) 297.
[16] SHEA M. A. and SMART D. F., *Nucl. Phys. B, Proc. Suppl.*, **39A** (1995) 16.
[17] GOSLING J. T., *J. Geophys. Res.*, **98** (1993) 18937.
[18] GOSLING J. T., *J. Geophys. Res.*, **99** (1994) 4259.