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The 1997 GLE as seen by the Antarctic Laboratory for Cosmic Rays

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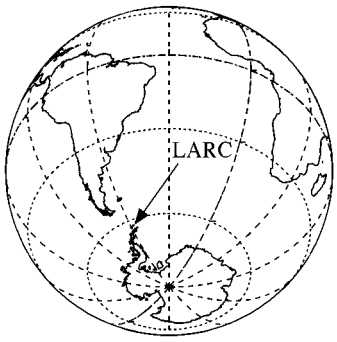
Abstract

The first relativistic solar cosmic-ray event of the on-going solar activity cycle (n. 23) occurred on November 6, 1997. Data, obtained with the standard neutron monitor (6-NM-64) of LARC (Antarctic Laboratory for Cosmic Rays – South Shetlands – King George Island – Ardley Cove: 62°12'09" S, 58°57'42" W; geomagnetic rigidity cut-off about 3 GV), are reported to show the ground level enhancement (GLE) registered by the Chile/Italy collaboration in the frame of the International Decade for Scientific Cooperation in Antarctica (1991-2000).

1 Introduction:

LARC (Antarctic Laboratory for Cosmic Rays) records the nucleonic component of the galactic cosmic rays in the high-latitude Latin-American sector, being this area not covered by the world wide network of detectors in the past (see the map for LARC site). The characteristics of LARC (Antarctica - King George Island) station are shown in the following table. The 1991-96 data (corrected for pressure variations to the 980 hPa level and using an attenuation coefficient of 0.74 %/hPa) are available on hourly basis (Cordaro et al. 1997). The analysis of the 1997-98 data is in progress, but a preliminary check of November 1997 file was made to evaluate the ground level enhancement (GLE) of November 6. Results for this GLE are here reported.



	LARC – initial phase	**LARC – improvement**	**References**
Location	Ardley Cove – Fildes Bay		*Cordaro & Storini*
Antarctic Base	E. Frei (F.A.Ch.)	+ Prof. J. Escudero (I.N.A.Ch.)	(1992)
Geogr. Lat.	62° 11' 08" S (estimated)	62° 12' 09" S (determined)	
Geogr. Long.	58° 55' 00" W (estimated)	58° 57' 42" W (determined)	*Storini et al. (1998)*
Altitude	40 m a.s.l.		
Type: 6-NM-64	three sections of $2BF_3$ each (left, central and right sections)		
Effective Rc	~ 3 GV	3.35 (1980) – 3.07 (1990) GV	*Storini et al. (1995)*
		3.06 (1990) – 2.97 (1995) GV	*Storini et al. (1999)*
Data resolution	5 minutes		
Scaling factor	100	1	
Barometers	Monolithic pressure transducer (B&H)	+ aneroid sensor (SIAP-1996) + vibrating cylinder pressure transducer (DMA-1997)	
Temperature		Sensor range: -30°C to +50°C	*Storini & Cordaro (1997)*
R.Humidity		Sensor range: 10% to 100%	
HV supply	2 units	3 units (1995-Bertan 230-03R)	

2..The November 6, 1997 cosmic ray records:

A large series of ground-level enhancements has been registered by the world-wide network of cosmic ray detectors during the 22nd solar activity cycle. They were fifteen events occurred between July 1989 and November 1992 (e.g. Shea et al., 1995), and all of them but one (October 19, 1989) were associated with solar flares in the Western heliographic longitudes. Smoothed sunspot numbers suggested June 1996 as the start of the 23rd cycle. Seventeen months later (November 6, 1997) several cosmic ray detectors recorded the first GLE of the new cycle, as shown in Figure 1 (left panel for cosmic ray stations in the Southern hemisphere and right panel for the Northern one). We observe that cosmic ray stations with low effective rigidity cutoff (Rc ≤ 5÷6 GV) show the GLE distinctly, while solar protons with energies above ~ 6 GeV seems to be absent in the Earth environment. The associated optical flare (S18º, W63º) was of class 2B (according with NOAA/Boulder Web pages) and the solar soft X-ray flux had its maximum intensity at 1155 UT (X9.4 event). Hence, the registered GLE was not very energetic but certainly it affected LARC counting rates.

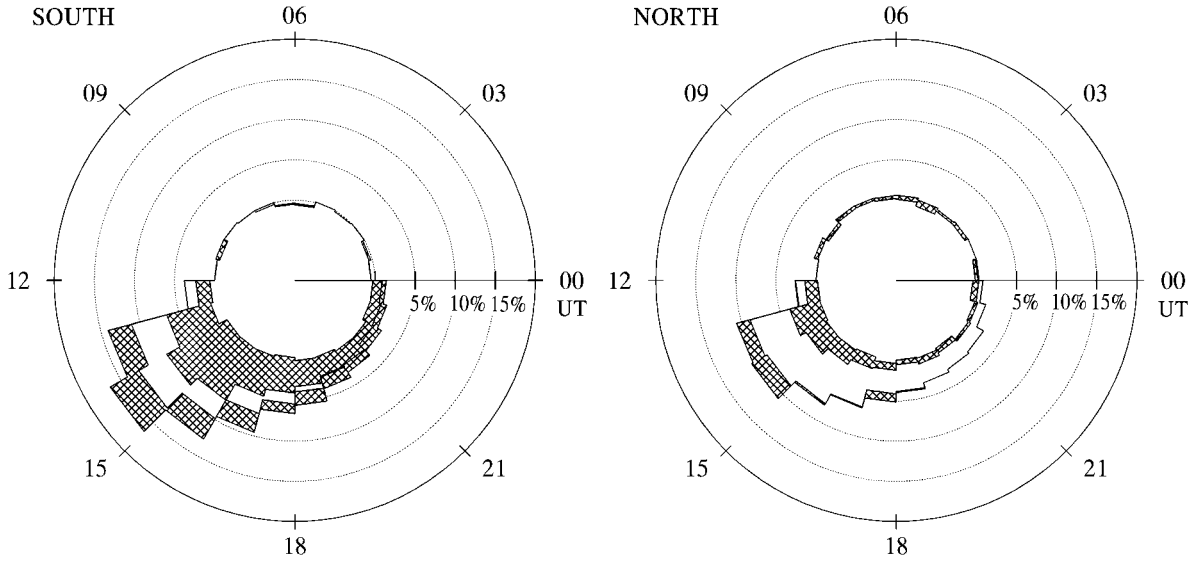


Figure 1: Percentage increase in cosmic ray hourly data from several detectors showing the GLE occurred during November 6, 1997. Left panel (southern hemisphere detectors), from outside to the centre: South Pole (effective rigidity cutoff Rc ~ 0.0 GV, altitude a.s.l. = 2820 m), Sanae (Rc ~ 1.1 GV, 53 m), Mc Murdo (Rc ~ 0.0 GV, 48 m) and Hermanus (Rc ~ 4.9 GV, 26 m). Right panel (northern hemisphere detectors), from outside to centre: Calgary (Rc ~ 1.1 GV, 1128 m), Cape Schmidt (Rc ~ 0.6 GV, 0 m), Moscow (Rc ~ 2.4 GV, 200 m) and Rome (Rc ~ 6.3 GV, 60 m).

Cosmic ray intensities recorded by LARC detector has been checked and Figure 2 reports the data for the whole November 6, 1997. Data are uncorrected for atmospheric pressure variations (left panel), which are also shown in the same figure (right panel). The interval 11:00-22:00 UT is reported with a 5-min resolution, while the other intervals (00:00-11:00 UT and 22:00-24:00 UT) are on a hourly basis. GLE signature was evident. Hence, data were processed to obtain pressure corrected intensities using as reference pressure P_0 = 980 hPa and as attenuation coefficient α = -0.74 %/ hPa (Figure 3). The attenuation coefficient chosen is only a preliminary one since it is affected by the presence of a 11-year trend, connected to solar activity cycle; a study on this topic for the LARC and others neutron monitors is in progress (see Massetti et al., 1998a and 1998b). The average nucleonic intensity measured over the interval

11:00-12:00 UT was selected as a reference level (77.07 counts/s). The maximum phase of the event occurred between 13:15 UT and 14:05 UT with several 5-min records over 4.5% of the reference level.

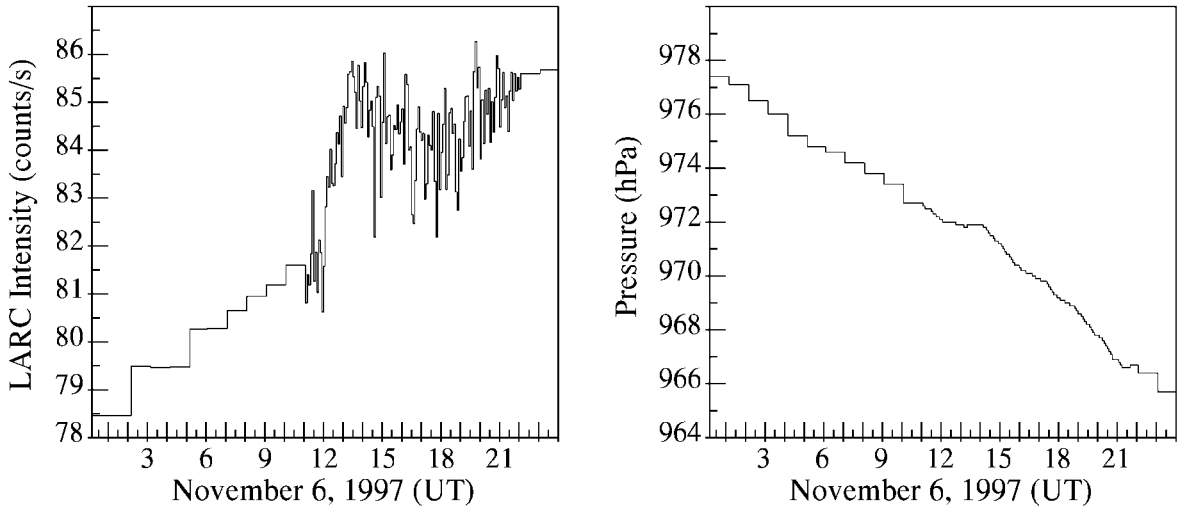


Figure 2: Counting rates (left) and atmospheric pressure (right) measured at the Antarctic Laboratory for Cosmic Ray during the November 6, 1997. Data plotted for the period 11:00 UT to 22:00 UT are on a 5-min base, while hourly means are used in the remaining parts of the day.

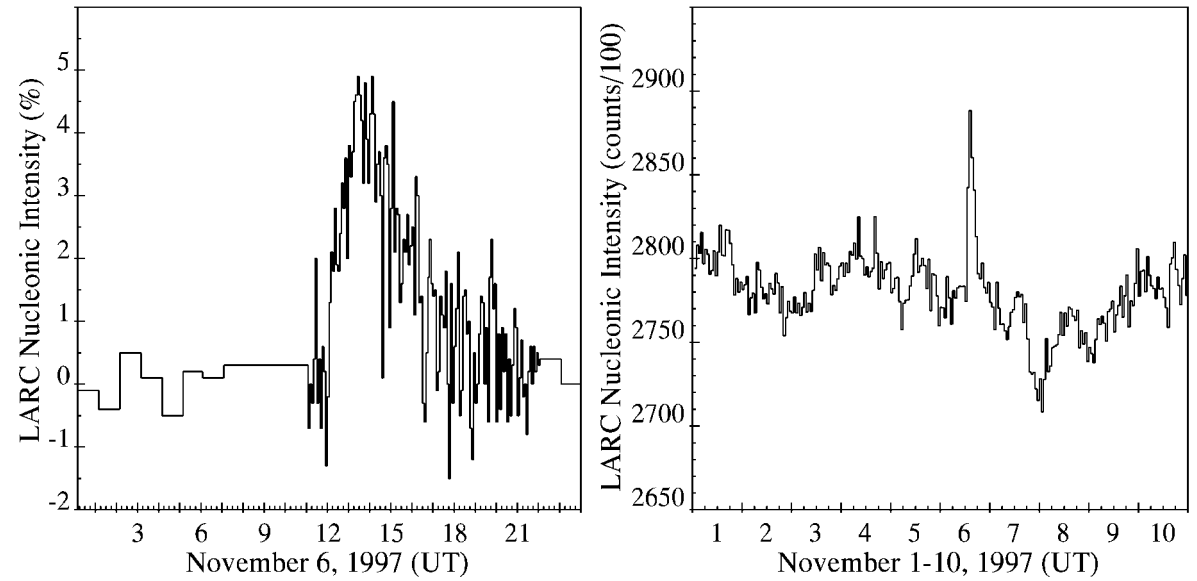


Figure 3: LARC pressure corrected data (P_0 = 980 hPa, α = -0.74 %/hPa) for November 6, 1997 (left panel, plotted as in figure 2) and for the first decade of the month (right panel, hourly means).

Efforts for archival GLE data have been started in U.S.A. several years ago (e.g. Shea et al., 1985; Shea et al., 1987; Gentile, Shea & Smart, 1990; Gentile, 1991). We believe that the distribution of GLE database to the cosmic ray community will facilitate not only studies on single events but also research work on long-term features in solar particle emission and associated effects in the earth environment. Hence, the data for

the November 6, 1997 were prepared in the standard GLE format (Massetti et al., 1999) and sent to the international database at the Geophysics Directorate of the Phillips Laboratory at Hanscom AFB.

3 Conclusion:

The preliminary analysis of cosmic ray particles reaching the LARC location (South Shetlands – King George Island - Fildes Bay - Ardley Cove) showed a ground-level enhancement of about 4.9% in the 5-min recorded intensities. LARC counting rates will be useful for additional studies using the international GLE database to determine: (i) the GLE temporal evolution, (ii) if there exists an anisotropy behaviour in the data recorded by the world-wide network of cosmic ray detectors, and (iii) the energy spectra of the relativistic solar particles.

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