Following solar activity with CaLMa after two years

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Abstract: The Castilla-La Mancha neutron monitor (CaLMa) is continuously operating since 26 October 2011. It is located at Guadalajara (40º 38'N, 3º 9'W) at 708 m above sea level and 55 km away from Madrid. It is covering a gap in the Neutron Monitor Data Base (NMDB), thanks to its geographical location, its height above sea level and its vertical cutoff rigidity (6.95 GV). CaLMa is providing counts of galactic cosmic rays (GCRs) with a temporal resolution of 1 min, being the mean count rate 5 c/s/counter. This high cadence allows the monitoring of solar activity by the means of the observed variation in count rate. Both in the sort term and in the long term activity, i.e., flare or coronal mass ejections and solar modulation. They can therefore be studied with CaLMa's measurements. During this last year, CaLMa has measured variations in the GCR count rate related to interplanetary coronal mass ejections, fast solar wind streams, shocks and stream interaction regions. In this work we analyze the solar wind conditions associated to variations in CaLMa's count rate and we compare them with other neutron monitors.

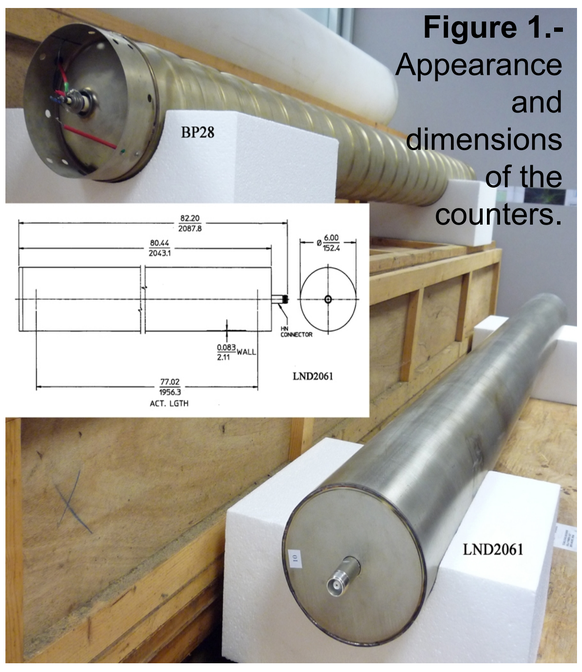
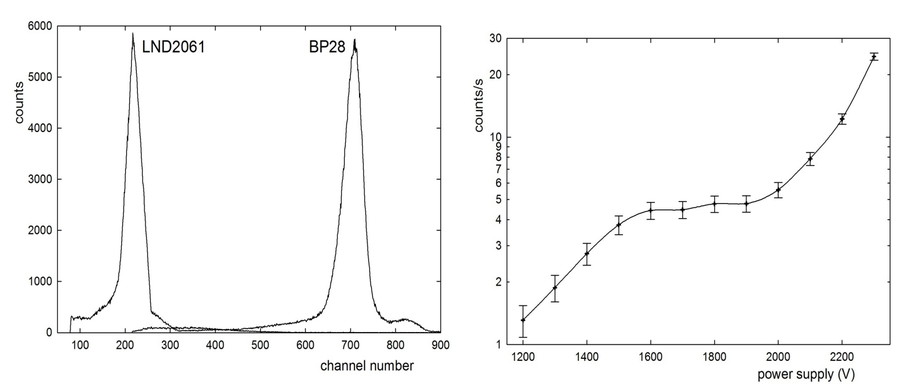


Figure 1.- Appearance and dimensions of the counters.

Counter type	BP28	LND2061
Effective diameter (cm)	14.85	14.91
Cathode material	stainless steel	stainless steel
Gas filling	BF_3 (96 % ^{10}B)	BF_3 (96 % ^{10}B)
Gas pressure (mm Hg)	200	200
Effective length (cm)	190.80	195.63
Effective volume (liters)	33	34.1
Operating voltage (V)	-2800	1870
External shape	wavy	smooth
Wall thickness of the tube (cm)	0.084	0.211
Outer tube	Aluminum	no

The LND2061 tests. The table shows the main characteristics of the two types of detectors. There are only slight differences in the constructive parameters, although the external appearance is different as it is shown in figure 1.



Figures 2-1 and 2-2.

To perform the tests, the counters have been connected to a Canberra ACHNA98 amplifier. The amplifier's analog output is connected to an AmpTek 8000A multichannel analyzer. Figures 2-1 shows PHA spectra for tubes LND2061 and BP28. Figure 2-2 shows the variation of the counter response with the operating voltage, From the observed plateau, we have concluded that 1870 V is the optimal operating tension.

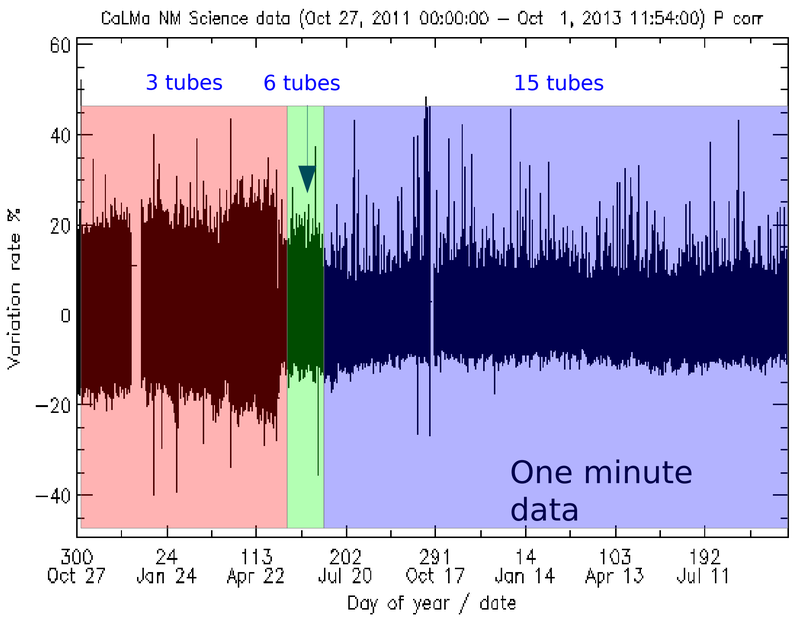


Figure 3.- CaLMa one minute data

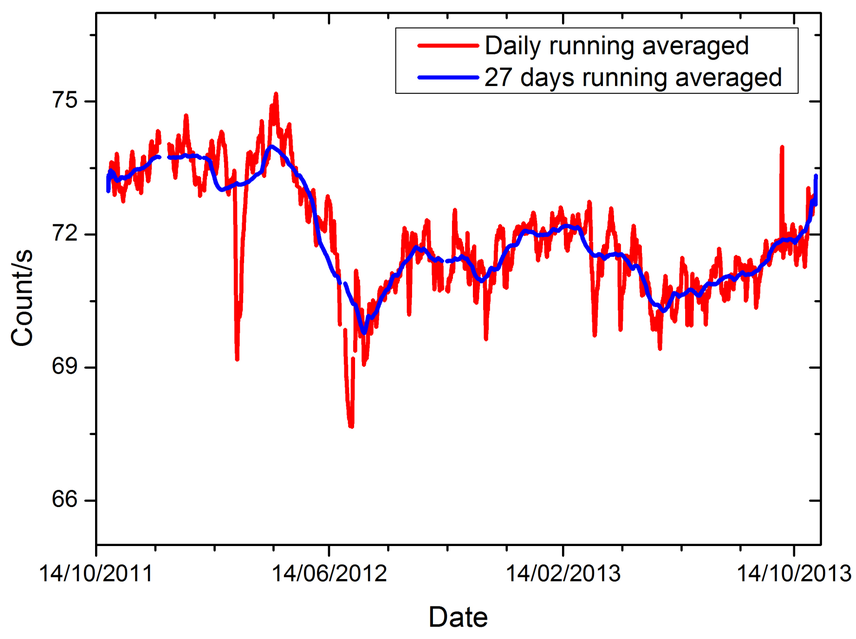


Figure 4.- CaLMa Two year birthday

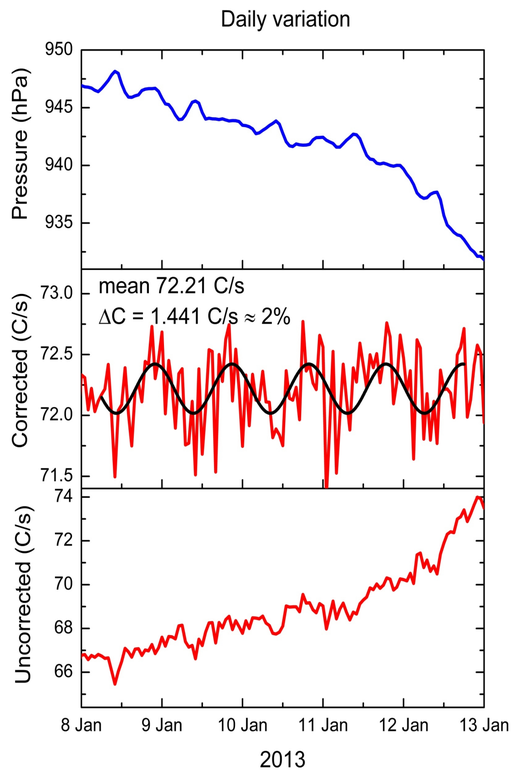


Figure 5.- CaLMa daily variation

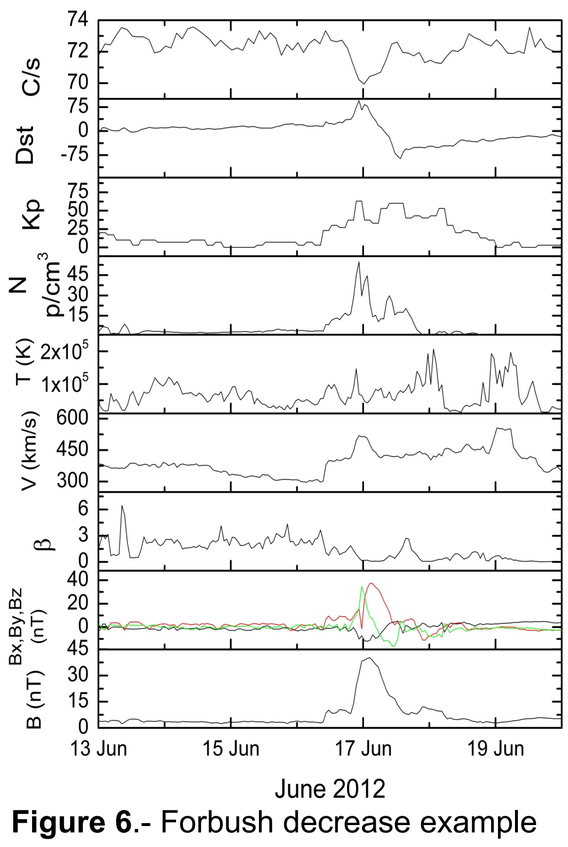


Figure 6.- Forbush decrease example

Event	Date	FD	gmtorm
sh+MC+SIR	24/01/2012 23:59	2.3	Yes
sh+MC+sh+MC	08/03/2012 22:38	8.9	Yes
sh+MC	13/03/2012 06:38	3.1	No
MC	06/04/2012 01:38	4.7	No
sh+SIR+MC	26/04/2012 13:38	1.9	Yes
sh+MC	17/06/2012 00:00	3.0	Yes
sh+MC	14/07/2012 16:00	3.0	Yes
sh+MC+MC	05/09/2012 03:00	2.9	Yes
sh+MC	13/11/2012 15:00	3.6	Yes
sh+MC + SIR	24/11/2012 23:00	3.3	No
MC	17/01/2013 13:00	1.9	No
sh+SIR+sh+MC	18/03/2013 20:00	5.1	Yes
sh+MC	14/04/2013 18:00	3.7	No
sh	24/06/2013 06:34	2.3	No
sh+MC	28/06/2013 08:20	2.1	Yes
sh+MC	13/07/2013 08:45	2.4	No

Table 1: FDs observed by CaLMa from November 2011 to November 2013. gmtorm = geomagnetic storm and sh = shock

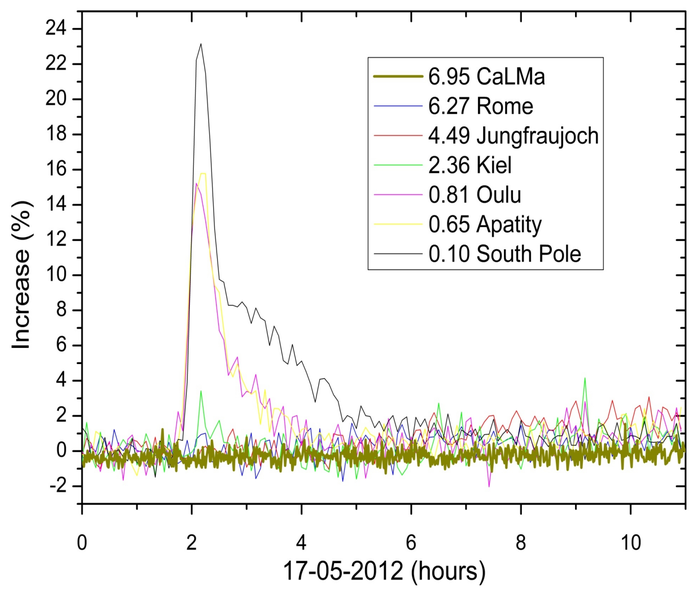


Figure 7.- GLE 71 is not observed by CaLMa indicating energies lower than 6 Ge

Conclusions

CaLMa is working since end of October 2011. It is providing one minute-averaged measurements of GCRs with energies higher than 6.07 GeV/amu arriving to the Earth. It is composed by 15 $^{10}BF_3$ counters following the NM64 standard and it is integrated into the Neutron Monitor Data Base. It is providing one minute real time data.

CaLMa has detected sixteen FD with decreases higher than 2% in clear association with solar wind structures arriving to the Earth orbit. This fact confirms the adequate response of CaLMa to changes in the GCR propagation conditions due to variation in solar activity.

CaLMa has not observed any enhancement in its count rate during the last ground level enhancement (GLE 71). It is expected that CaLMa will observe GLEs produced by solar energetic particles with rigidities higher than 6.95 GV.

CaLMa measurements are reflecting the rising phase of Solar Cycle 24.

References: J. Medina et al., Nuclear Instruments and Methods (2013) doi: 10.1016/j.nima.2013.06.028
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