Extreme events of solar energetic particles

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1. Extended Abstract

The era of direct in-situ measurements of solar energetic particle (SEP) events by space-borne detectors covers 40-50 years, and by ground-based instruments (neutron monitors and ionization chambers) 70-80 years. During that time, about 70 events with hard SEP spectrum, that can cause a detectable enhancement at the ground level (called GLE, ground-level enhancement), have been recorded. The greatest GLE event is numbered as #5 and took place on 23-Feb-1956 with a 5000% increase of the count rate of Leeds neutron monitor. However, for many practical purposes it is important to know whether the Sun can produce stronger events, how much stronger and what the expected rate of their occurrence can be. Extreme SEP events, accompanied by radiation storms, pose a serious hazard for the modern technology, specifically space-based navigation and communication systems. A very important question faced by our technologies is – what is a realistic worst case scenario for a solar radiation storm we may experience in the near future? Because of the limited dataset we possess, these questions can be answered only using indirect methods. One method is to overview statistic of a large ensemble of sun-like stars [1], and it is only briefly mentioned here. The other method is to monitor extreme SEP events in the Sun's past using indirect proxy, which forms the main topic of this work.

Cosmogenic radionuclides (^{14}C, ^{10}Be, ^{36}Cl) measured in independently dateable natural archives, form a reliable proxy of cosmic ray variability, and thus solar activity, on the centennial-millennial time scale [2,3]. On the other hand, extreme SEP events may leave clear signatures in the records of cosmogenic isotopes. So far, two extreme SEP events have been identified during the last millennia: the event of 775 AD [4,5], which was a factor 40-50 stronger than the greatest GLE #5, and a slightly weaker event of 994 AD [6].

Here we overview the recent achievements in this field and argue that the event of 775 AD may serve as the worst case scenario, and why we don't expect the events stronger than that to occur on the millennial time scale.

2. References:

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