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The short-lived (<2 minutes) acceleration of protons to >13 GeV in association with solar flares.

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There have been 72 occasions in the past 75 years when solar cosmic rays have been accelerated to >1 GeV in association with large solar flares. The largest such so called "ground level enhancement" (GLE) occurred on 23 February, 1956. We have recently gained access to the original real-time photographic record for that GLE obtained by the recording ionization meter located at Huancayo, Peru. The geomagnetic field excludes all cosmic rays <13GeV from this location, and consequently this record provides a record of the arrival at earth of the highly relativistic 13-20 GeV particles accelerated at the sun. While all previous studies have used 6 minute average data, examination shows that the original record is capable of providing 1 minute time resolution of the cosmic ray intensity during the GLE . The resulting dependence of intensity upon time shows considerable detail that was obscured by the coarser time resolution used in the past. Thus (1) The GLE commenced only 3 minutes after the peak flare intensity in Hα , this being consistent with the 4 minute delay associated with propagation along the "Parker" heliospheric field; (2) the cosmic ray intensity rose to within 10% of its peak in 2 minutes; (3) Peak intensity persisted for only 1 minute; and (4) the intensity had decreased to 50% of the peak value 5 minutes after the commencement of the GLE. There being no velocity dispersion at these energies, and little pitch angle scattering, we take the view that the intensity profile at earth is a close representation of the intensity-time profile of these newly accelerated cosmic rays at the sun. If so, these data impose strict tests on any putative acceleration model, and provide information on the physical properties in the vicinity of the source. In particular, the data show that the model must predict (a) that ambient protons can be accelerated to >13GeV in < 2 minutes; (b) that the protons have easy access to open solar fields; and (c) that the acceleration (or release) mechanism must then decrease greatly in efficiency abruptly $\sim$3 minutes after it started. We note that this is not a unique example; the >10GeV particle pulse in the GLE of 20 January 2005 persisted for only 3 minutes; and a >4.5 GeV pulse at the commencement of the GLE of 7 December, 1982, only lasted one minute. We conclude with a comparison between these observations and the predictions of several proposed acceleration models. We conclude that these short-lived bursts of highly relativistic cosmic rays have been accelerated in the reconnection regions associated with large solar flares. In the greater majority of cases, the short-lived, high energy cosmic ray pulse at the commencement of a GLE is followed by a slowly rising component accelerated in the CME generated shock.