Space Science Seminar
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Why is the 2012 July 23 Backside Solar Eruption an Extreme Event?

Dr. Nat Gopalswami / NASA/GSFC
Host: Dr. James Spann (Sponsored by ZP01)

Even though solar cycle 24 is the weakest in the space era, it did produce the 2012 July 23 backside eruption that can be counted among the historical extreme events. If there were no STEREO spacecraft to detect the SEP event and the underling CME, this event would have been considered as a small event, based on GOES measurements made along the Sun-Earth line. I give the following ten reasons that strongly support that the 2012 July 23 event was an extreme event (details in http://adsabs.harvard.edu/abs/2016ApJ...833..216G).

1. The shock transit time from the Sun to 1 au was ~18.5 hours, similar to the two 2003 Halloween events on October 28 and 29 and to 13 other fast-transit events since the Carrington event in 1859.
2. The CME speed and the strength of the magnetic field it contained at Earth orbit are high enough that the CME would have produced a Carrington-sized geomagnetic storm if it had occurred on the frontside of the Sun.
3. The >10 MeV SEP and ESP intensities of the 2012 July 23 event exceeded the corresponding values of all large SEP events detected by GOES since 1976.
4. The 10-100 MeV time of maximum spectrum of the 2012 July 23 SEP event is very small ($\gamma \sim 1.30$) consistent with GLE events.
5. The fluence spectral index of the 2012 July 23 event was 2.28, which is similar to index of known GLE events from cycles 23 and 24 ($\gamma \sim 2.68$). The spectral index of the other two groups is much larger: $\gamma \sim 4.89$ for SEP events associated with filament eruptions outside of active regions, and $\gamma \sim 3.83$ for regular SEP events.
6. The >30 MeV integral fluence of this event was similar to that in historical SEP events such as the 1972 August 4 and 1956 February 23 GLE events (Cliver and Dietrich, 2013, J. Space Weather Space Climate, 3, A31), strongly supporting the result that the July 23 event was indeed an extreme event from the standpoint of accelerating the highest energy particles.
7. Even though there are some discrepancies in the literature on the speed of the CME-driven shock near the Sun for the July 23 event, it was found that the CME speed certainly exceeded 2000 km s-1, which is the average speed of GLE-producing CMEs.

8. The initial acceleration of the 2012 July 23 CME was ~1.7 km s-2, also typical of GLE-producing CMEs in cycles 23 and 24.
9. The July 23 event was accompanied by a type II burst with emission components from metric to kilometric wavelengths. This is typical of all GLE events. Both flank and nose emissions were observed and the speeds derived from the radio dynamic spectra are consistent with the shock speeds at the nose and flanks.
10. The shock formation height was estimated to be at least 1.48 Rs from the starting frequency of the metric type II burst observations and the attainment of super-Alfvenic speeds early in the event. Such low shock formation heights is typical of GLE events.

https://solarscience.msfc.nasa.gov/colloquia/