

## SEP Events from STEREO A (Dec. 2006 - Nov. 2021) and B (Dec. 2006 - Sept. 2014) (Updated on 1/5/2022)

The list is compiled by Dr. Lan Jian (lan.jian@nasa.gov) using the criterion that the flux of 13-100 MeV protons from HET measurements > 10 pfu (1 pfu = 1 p cm<sup>-2</sup>sr<sup>-1</sup>s<sup>-1</sup>), to mimic the list of Solar Proton Events provided by NOAA Space Weather Prediction Center using the GOES spacecraft data (<http://www.swpc.noaa.gov/ftplib/indices/SPE.txt>). Checking with the data is highly recommended because there are data gaps sometimes.

Hourly data from Hight Energy Telescope (von Roseninge et al., Space Sci. Rev., 2008) are used. The events in 2006 are in the solar wind, outside the Earth's bow shock. There are no events reaching the criterion in 2007-2010 at either STEREO spacecraft.

There is a list of >25 MeV proton events and relevant solar events in a separate study by Richardson et al. (Solar Phys. 2014).

| # of STA | Start Time |       |     |      | End Time |       |     |      | Maximum Flux (pfu) | Fluence (cm <sup>-2</sup> sr <sup>-1</sup> ) | Comments   |
|----------|------------|-------|-----|------|----------|-------|-----|------|--------------------|--|--|
|          | Year       | Month | Day | Hour | Year     | Month | Day | Hour |                    |  |  |
| 1        | 2006       | 12    | 6   | 20.5 | 2006     | 12    | 11  | 22.5 | 1031.77            | 83391997                                     | CME and flare  |
| 2        | 2006       | 12    | 13  | 3.5  | 2006     | 12    | 14  | 17.5 | 449.22             | 21894825                                     | CME and flare  |
| 3        | 2011       | 3     | 9   | 8.5  | 2011     | 3     | 9   | 16.5 | 26.88              | 676257                                       | gradual rise, CME and flare                              |
| 4        | 2011       | 3     | 21  | 3.5  | 2011     | 3     | 22  | 21.5 | 685.06             | 25013660                                     | CME  |
| 5        | 2011       | 6     | 4   | 16.5 | 2011     | 6     | 7   | 23.5 | 2021.23            | 103897555                                    | CME and flare  |
| 6        | 2011       | 11    | 4   | 0.5  | 2011     | 11    | 5   | 0.5  | 124.00             | 4049773                                      | flare and CME  |
| 7        | 2012       | 1     | 24  | 8.5  | 2012     | 1     | 26  | 20.5 | 27.86              | 4183357                                      | CME  |
| 8        | 2012       | 1     | 28  | 5.5  | 2012     | 1     | 31  | 11.5 | 1311.82            | 23479615                                     | the 2nd rise is based on 1/24/2012 flux, no clear source |
| 9        | 2012       | 3     | 9   | 23.5 | 2012     | 3     | 12  | 22.5 | 15.92              | 3465837                                      | gradual rise, fast CMEs on 3/7 and 3/8                   |
| 10       | 2012       | 3     | 21  | 9.5  | 2012     | 3     | 21  | 20.5 | 37.48              | 920542                                       | 3/21 7:25 CME, no good flare                             |

|    |      |    |    |      |      |    |    |      |          |           |   |
|----|------|----|----|------|------|----|----|------|----------|-----------|---|
| 11 | 2012 | 3  | 24 | 1.5  | 2012 | 3  | 24 | 11.5 | 69.65    | 995532    | 3/24 00:10 CME, no good flare   |
| 12 | 2012 | 5  | 27 | 12.5 | 2012 | 5  | 28 | 7.5  | 546.73   | 8425291   | 5/26 20:57 CME, no good flare   |
| 13 | 2012 | 7  | 23 | 4.5  | 2012 | 7  | 27 | 19.5 | 27002.30 | 443080467 | 7/23 2:36 CME   |
| 14 | 2012 | 9  | 20 | 20.5 | 2012 | 9  | 22 | 16.5 | 175.77   | 10051864  | 9/19 12:25 CME  |
| 15 | 2012 | 9  | 27 | 13.5 | 2012 | 9  | 29 | 11.5 | 154.23   | 7638152   | 9/27 9:55 CME   |
| 16 | 2012 | 11 | 8  | 12.5 | 2012 | 11 | 9  | 5.5  | 19.36    | 841853    | 11/8 10:55 CME  |
| 17 | 2013 | 3  | 5  | 4.5  | 2013 | 3  | 7  | 17.5 | 1151.18  | 51289550  | 3/5 03:25 CME   |
| 18 | 2013 | 8  | 20 | 6.5  | 2013 | 8  | 22 | 12.5 | 260.53   | 21631482  | 8/19 23:24 CME  |
| 19 | 2013 | 10 | 5  | 14.5 | 2013 | 10 | 6  | 1.5  | 21.18    | 720568    | CME and flare?  |
| 20 | 2013 | 10 | 11 | 8.5  | 2013 | 10 | 12 | 4.5  | 152.47   | 4274389   | CME and flare   |
| 21 | 2013 | 11 | 2  | 5.5  | 2013 | 11 | 3  | 7.5  | 56.64    | 2612211   | CME and flare   |
| 22 | 2013 | 11 | 4  | 13.5 | 2013 | 11 | 6  | 1.5  | 98.69    | 4677715   | 2nd and gradual rise in a SEP event, CME, no flare at the right time                                |
| 23 | 2013 | 11 | 7  | 11.5 | 2013 | 11 | 8  | 5.5  | 47.71    | 1925607   | CME, no flare at the right time   |
| 24 | 2013 | 12 | 26 | 10.5 | 2013 | 12 | 27 | 9.5  | 28.10    | 1632087   | CME, no M or X class flare detected by GOES   |
| 25 | 2014 | 1  | 9  | 3.5  | 2014 | 1  | 10 | 2.5  | 24.71    | 1576536   | SEP onset on 1/6, gradual increase, CME, no M or X class flare detected by GOES                     |
| 26 | 2014 | 2  | 25 | 2.5  | 2014 | 2  | 26 | 9.5  | 108.28   | 5745902   | weaker SEP events ahead, CME, X4.9 flare detected by GOES   |
| 27 | 2014 | 3  | 12 | 16.5 | 2014 | 3  | 12 | 20.5 | 24.01    | 283356    | CME, M2.5 flare detected by GOES at N14W70  |
| 28 | 2014 | 8  | 28 | 20.5 | 2014 | 8  | 29 | 0.5  | 23.47    | 289856    | no STA images, STB observed halo CME on 8/28 when A & B were only 30° apart in longitude, data gaps |

|    |      |    |    |      |      |    |    |      |         |          |  |
|----|------|----|----|------|------|----|----|------|---------|----------|--|
| 29 | 2014 | 9  | 2  | 7.5  | 2014 | 9  | 4  | 15.5 | 579.95  | 7634659  | no STA images, STB observed a halo CME on 9/1 when A & B were only 30° apart in longitude  |
| 30 | 2014 | 9  | 25 | 19.5 | 2014 | 9  | 26 | 9.5  | 255.22  | 4290746  | no STA images, STB COR2 observed a halo CME at 21 UT on 9/24 at 21UT. Because there are large data gaps at STA, the fluence may be incorrect.                  |
| 31 | 2014 | 10 | 15 | 6.5  | 2014 | 10 | 16 | 21.5 | 176.26  | 3342622  | solar observation is too short to tell   |
| 32 | 2014 | 12 | 13 | 19.5 | 2014 | 12 | 17 | 21.5 | 2037.31 | 51565621 | flare from short EUVI movie, ICME on 12/16 with speed of about 600 km/s  |
| 33 | 2015 | 3  | 6  | 19.5 | 2015 | 3  | 6  | 23.5 | 56.15   | 786543   | solar observation is too short to tell   |
|    | 2017 | 7  | 23 | 10.5 | 2017 | 7  | 25 | 0.5  | 988.68  | 47761109 | CME and 2 B-class flares on 7/23   |
| 34 | 2017 | 7  | 25 | 4.5  | 2017 | 7  | 25 | 9.5  | 18.06   | 301259   | the same event with the previous one, separated by a dip in intensity profile  |
|    | 2017 | 9  | 13 | 8.5  | 2017 | 9  | 16 | 2.5  | 57.36   | 6073828  | CME and flares   |
| 35 | 2017 | 9  | 18 | 11.5 | 2017 | 9  | 19 | 8.5  | 257.78  | 5040994  | CME, gradual increase, following the pervious one  |
| 36 | 2020 | 11 | 30 | 16.5 | 2020 | 12 | 2  | 2.5  | 80.74   | 5769985  | an M4.4 flare on 11/29, CMEs on 11/26 and 11/29 (two bumps in SEP profile)   |
| 37 | 2021 | 10 | 9  | 8.5  | 2021 | 10 | 9  | 14.5 | 17.54   | 350419   | an M1.6 flare and a CME on 10/9, <a href="https://kauai.ccmc.gsfc.nasa.gov/DONKI/view/SEP/17919/1">https://kauai.ccmc.gsfc.nasa.gov/DONKI/view/SEP/17919/1</a> |

38    2021    10    28    16.5    2021    10    30    20.5    393.45    16888503    an X1.0 flare and a CME on 10/28,  
<https://kauai.ccmc.gsfc.nasa.gov/DONKI/view/SEP/18099/1>

| # of STB | Start Time |       |     |      | End Time |       |     |      | Maximum Flux (pfu) | Fluence (cm <sup>-2</sup> sr <sup>-1</sup> ) | Comments  |
|----------|------------|-------|-----|------|----------|-------|-----|------|--------------------|--|---|
|          | Year       | Month | Day | Hour | Year     | Month | Day | Hour |                    |  |   |
| 1        | 2006       | 12    | 6   | 19.5 | 2006     | 12    | 12  | 0.5  | 1142.04            | 39073  | CME and flare                                   |
| 2        | 2006       | 12    | 13  | 3.5  | 2006     | 12    | 14  | 18.5 | 413.87             | 51967  | the 2 are 1 event, flare and CME                |
|          | 2006       | 12    | 15  | 4.5  | 2006     | 12    | 15  | 8.5  | 16.08              | 38294  |   |
| 3        | 2011       | 3     | 8   | 1.5  | 2011     | 3     | 8   | 9.5  | 39.12              | 909795                                       | the 2 are 1 event, flare and CME                |
|          | 2011       | 3     | 8   | 14.5 | 2011     | 3     | 8   | 17.5 | 14.40              | 181029                                       |   |
| 4        | 2011       | 9     | 22  | 12.5 | 2011     | 9     | 26  | 3.5  | 1191.64            | 106348294                                    | flare and CME                                   |
| 5        | 2011       | 10    | 4   | 19.5 | 2011     | 10    | 5   | 1.5  | 12.10              | 290412                                       | 10/4 11:25 and 12:10 CME                        |
| 6        | 2012       | 1     | 23  | 9.5  | 2012     | 1     | 25  | 6.5  | 47.02              | 4352497                                      | 1/23 two fast CMEs                              |
|          | 2012       | 3     | 4   | 20.5 | 2012     | 3     | 5   | 21.5 | 74.18              | 2784298                                      | CME   |
| 7        | 2012       | 3     | 6   | 2.5  | 2012     | 3     | 6   | 8.5  | 12.41              | 295315                                       | it is the declining stage of the previous event |
| 8        | 2012       | 3     | 7   | 2.5  | 2012     | 3     | 10  | 20.5 | 1584.10            | 76224430                                     | 3/7 00:15 CME                                   |
| 9        | 2012       | 3     | 27  | 5.5  | 2012     | 3     | 29  | 4.5  | 43.68              | 3803015                                      | gradual, CME and flare                          |
| 10       | 2012       | 7     | 12  | 21.5 | 2012     | 7     | 13  | 0.5  | 11.59              | 159477                                       | 7/12 7:46 C3.1 S21E06, 15:37 X1.4 S13W03, CME   |
|          | 2012       | 7     | 25  | 2.5  | 2012     | 7     | 25  | 4.5  | 17.13              | 163708                                       | 7/23 2:25 halo CME,                             |

|    |      |    |    |      |      |    |    |      |         |          |  |
|----|------|----|----|------|------|----|----|------|---------|----------|--|
| 11 | 2012 | 7  | 25 | 15.5 | 2012 | 7  | 28 | 1.5  | 25.06   | 3761808  | it is the 2nd jump of the previous after a dip of flux, no good flare                          |
| 12 | 2012 | 8  | 31 | 21.5 | 2012 | 9  | 3  | 7.5  | 546.41  | 44217386 | 8/31 19:25 CME   |
| 13 | 2012 | 9  | 22 | 23.5 | 2012 | 9  | 23 | 10.5 | 23.86   | 763412   | CME  |
| 14 | 2012 | 9  | 28 | 5.5  | 2012 | 9  | 28 | 7.5  | 11.62   | 118808   | CME  |
| 15 | 2013 | 3  | 6  | 5.5  | 2013 | 3  | 7  | 14.5 | 30.47   | 2776362  | 3/5 3:45 NE halo CME   |
| 16 | 2013 | 4  | 11 | 8.5  | 2013 | 4  | 12 | 18.5 | 180.50  | 8075118  | 4/11 7:10 CME  |
| 17 | 2013 | 5  | 13 | 18.5 | 2013 | 5  | 15 | 8.5  | 301.16  | 11616014 | there is a second increase, CMEs   |
| 18 | 2013 | 6  | 21 | 6.5  | 2013 | 6  | 22 | 2.5  | 25.96   | 1415836  | CME  |
| 19 | 2013 | 8  | 21 | 3.5  | 2013 | 8  | 22 | 13.5 | 22.01   | 2242099  | CME  |
| 20 | 2013 | 10 | 11 | 13.5 | 2013 | 10 | 12 | 6.5  | 15.51   | 37452    | CME and flare  |
| 21 | 2013 | 10 | 25 | 14.5 | 2013 | 10 | 26 | 7.5  | 31.90   | 38233    | CME and flare  |
| 22 | 2013 | 11 | 7  | 13.5 | 2013 | 11 | 8  | 21.5 | 547.98  | 61693    | a second sharp rise after a gradual SEP event started on 11/2, CME, no flare at the right time |
| 23 | 2013 | 12 | 26 | 10.5 | 2013 | 12 | 27 | 1.5  | 26.93   | 46662    | CME, no M or X class flare detected by GOES  |
| 24 | 2014 | 2  | 25 | 2.5  | 2014 | 2  | 28 | 3.5  | 214.94  | 37144    | two weaker SEPs ahead, CME, X4.9 flare detected by GOES  |
| 25 | 2014 | 4  | 2  | 16.5 | 2014 | 4  | 3  | 7.5  | 104.50  | 38777    | 13:54 CME on 4/2 seen by STA COR2 when A & B were 42° apart in longitude                       |
| 26 | 2014 | 9  | 1  | 12.5 | 2014 | 9  | 4  | 21.5 | 2299.93 | 52242    | no STA images, STB observed a halo CME on 9/1 when A & B were only 30° apart in longitude      |

|    |      |   |    |     |      |   |    |      |        |       |   |
|----|------|---|----|-----|------|---|----|------|--------|-------|---|
| 27 | 2014 | 9 | 25 | 4.5 | 2014 | 9 | 27 | 14.5 | 238.91 | 36559 | no STA images, STB COR2 observed a halo CME at 21 UT on 9/24 at 21UT; data became unavailable after the event |
|----|------|---|----|-----|------|---|----|------|--------|-------|---|

Records:

1. 3/12/2004, add the SEP events in January 2011 - September 2013
2. 5/1/2014, remove the SEP events from LET observed by both STEREO A and B in 2007-2010, add the SEP events from HET in Dec 2006 - Dec 2010 and Oct 2013 - Mar 2014 using consistent criterion, add leading notes
3. 2/11/2015, add the SEP events during Apr 2014 - Jan 2015 for STA, Apr - Sept 2014 for STB
4. 6/9/2015, change the comments for 9/25/2014 event, and add some notes at the top
5. 11/8/2016, add the SEP events during Jan 2015 - Oct 2016 for STA
6. 7/15/2017, update the list to Dec 2016 for STA
7. 11/3/2017, update the list to Sept 2017 for STA
8. 2/13/2019, update the list to January 2019 for STA, merge the SEPs in the same event
9. 1/5/2022, update the list to Nov 2021 for STA