

# Solar Energetic Particle Event occurrence prediction using Solar Flare Soft X-ray measurements and Machine Learning

## Supplementary Materials

Table 1. The 26 parameters derived from the heliolongitude and the SXR time-series of each flare used as input in the neural network model.

1	$\cos(\theta)$ = cosine of SF heliolongitude
2	$\sin(\theta)$ = sine of SF heliolongitude
3	PksL = Peak flux of SXR long band
4	PksS = Peak flux of SXR short band
5	FluL = Fluence (integrated over duration) of SXR long
6	FluS = Fluence (integrated over duration) of SXR short
7	stdL = standard deviation of SXR long time-series
8	stdS = standard deviation of SXR short time-series
9	$\log PksL$ = logarithm of Peak flux of SXR long band
10	$\log PksS$ = logarithm of Peak flux of SXR short band
11	$\log FluL$ = logarithm of Fluence of SXR long
12	$\log FluS$ = logarithm of Fluence of SXR short
13	FluPksL = Fluence over Peak ratio of SXR long
14	FluPksS = Fluence over Peak ratio of SXR short
15	$\log FluPksLratio$ = $\log FL$ over $\log PL$ ratio of SXR long
16	$\log FluPksSratio$ = $\log FS$ over $\log PS$ ratio of SXR short
17	PksLS = Peak long over Peak short ratio
18	FluLS = Fluence long over Fluence short ratio
19	$\log FluPksL$ = logarithm of FluPksL
20	$\log FluPksS$ = logarithm of FluPksS
21	FluPksslope = (FluL minus FluS) over (PksL minus PksS)
22	$\log Dur$ = logarithm of flare duration
23	$\log PksLS$ = logarithm of PksLS
24	$\log FluLS$ = logarithm of FluLS
25	invFPSLratio = PksLS over FluLS
26	$\log invFPSLratio$ = logarithm of PksLS over logarithm of FluLS

Figures S1 – S4 show four of the never-predicted (NP) Events from the validation process discussed in section 3.2 of the main text. Figures S1 and S2 show cases typical of the majority of the NP Events with low Peak fluxes at low proton energies and mostly background signal in

higher energies. Figure S3 shows a medium intensity Event with some enhancement even up to 166 MeV while the overall Peak Fluxes and Fluences remain low. Finally Figure S4 shows the NP Event with the highest intensities among all, appearing with a sharp rise at  $\sim 40$  hours in its duration.

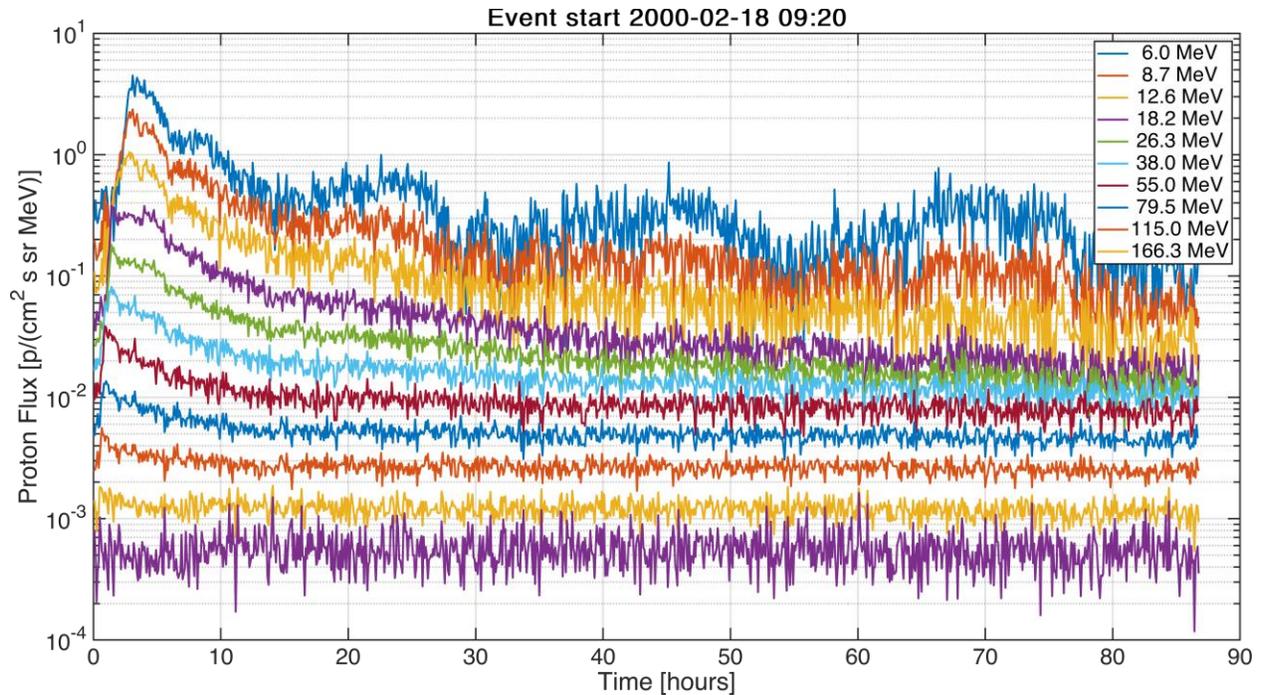


Figure S1. One of the more typical NP Events with a minor enhancement in lower proton energies and mainly background noise in higher energies.

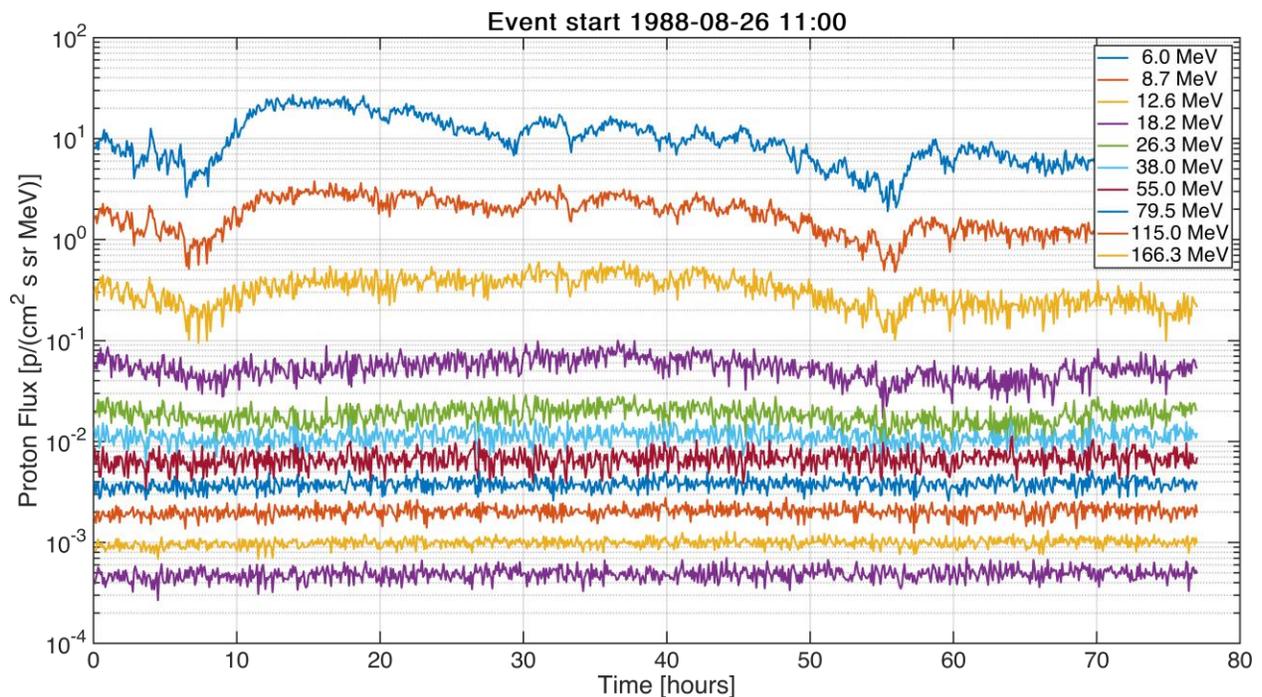


Figure S2. Similarly to S1, another typical NP Event with slightly higher intensities at low energies.

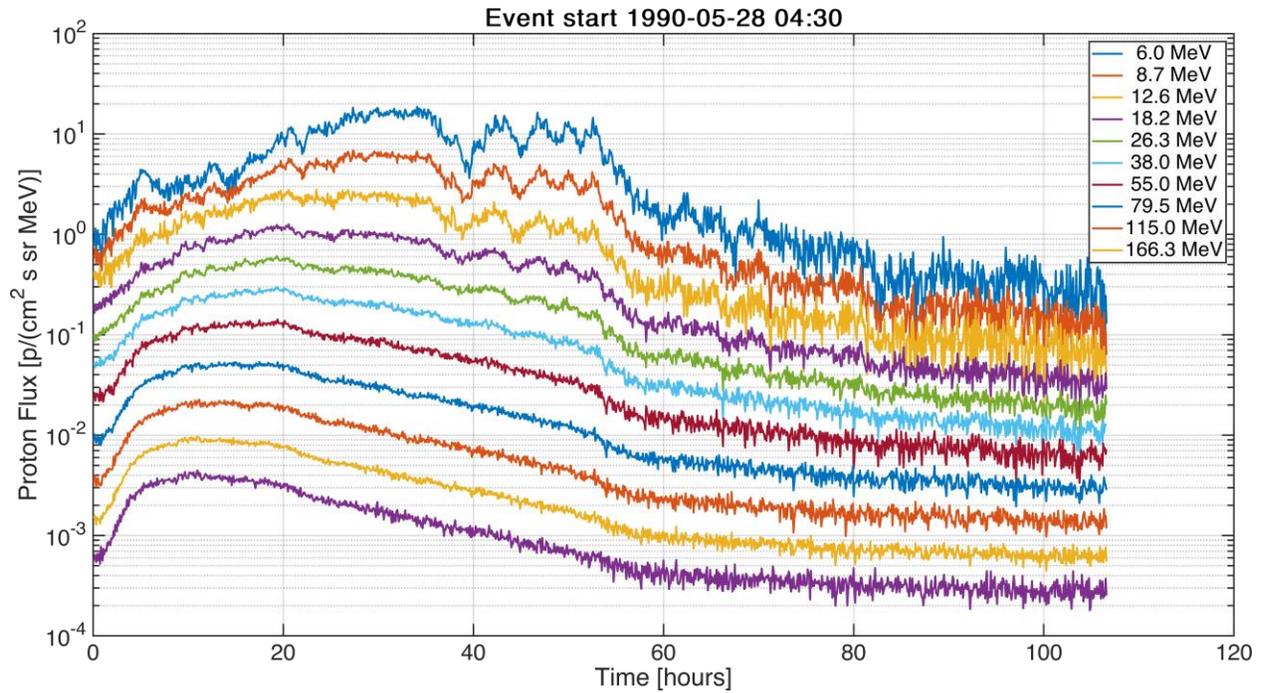


Figure S3. A medium intensity NP Event which exhibits enhancement up to the 166 MeV channel

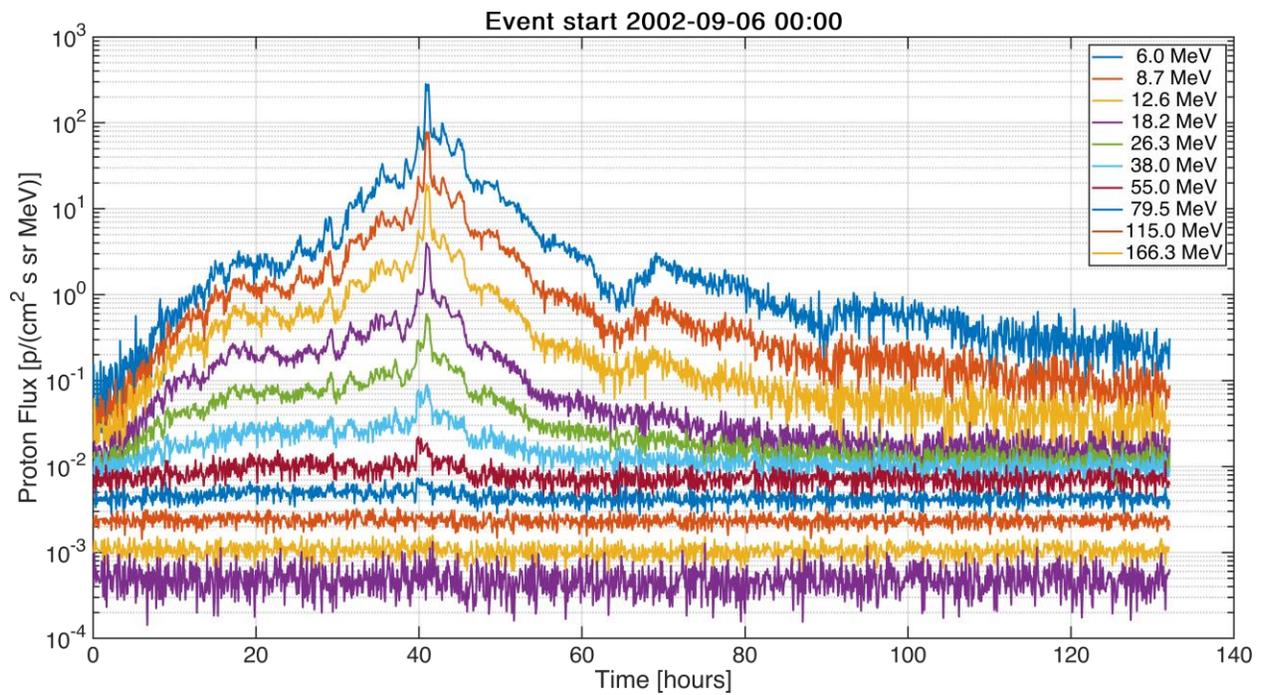


Figure S4. The most intense NP Event with the highest Peak Flux reaching  $\sim 300$  p/(cm<sup>2</sup>·s·sr·MeV) for the 6 MeV channel. However, higher energies are again mostly if not entirely background.