Detection of dust grains by MAVEN using electric field instruments

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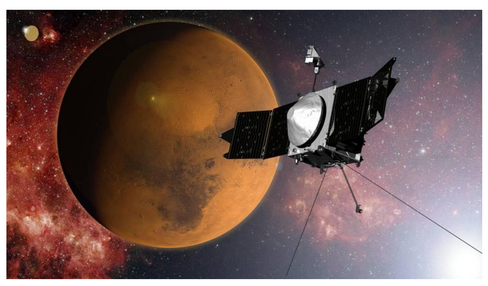
Abstract

Detection of dust grains in space is limited by a small number of dedicated dust detectors, however we aim to study dust detection by using electric field instruments usually placed on the majority of scientific spacecraft. The major advantage of this technique is that entire spacecraft surface acts as a detector. The main objective of this work is to study pulses generated by dust impacts on the Mars Atmosphere and Volatile Evolution (MAVEN) spacecraft. We show some preliminary results of pulses detected by MAVEN spacecraft.

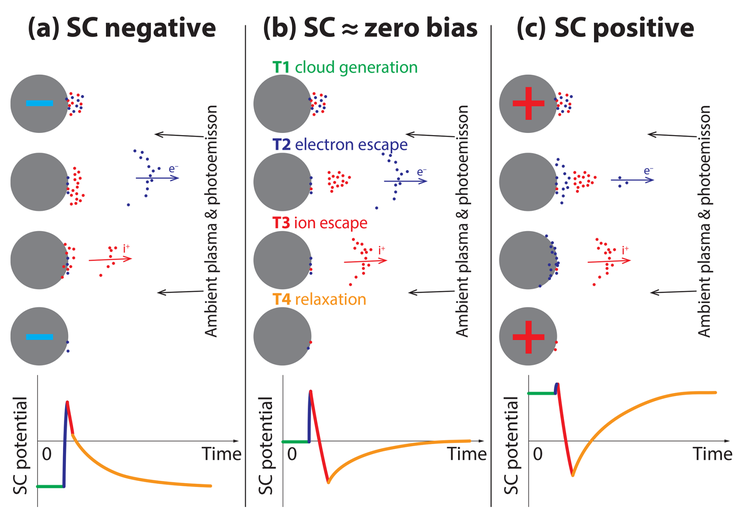
Introduction



Source:https://www.nasa.gov/mission_pages/maven/overview/index.html.

- MAVEN launched in November 2013 and entered the Martian atmosphere roughly a year later. Since that time, MAVEN has made fundamental contributions to understanding the history of the Martian atmosphere and climate.
- MAVEN will be working on collaborative data analysis with the current missions and with the missions about to arrive at Mars, it has enough fuel to operate until at least 2030.
- We use burst mode (16,384 samples/s) of Langmuir Probe and Waves (LPW) instrument in dipole configuration.

Impact Process



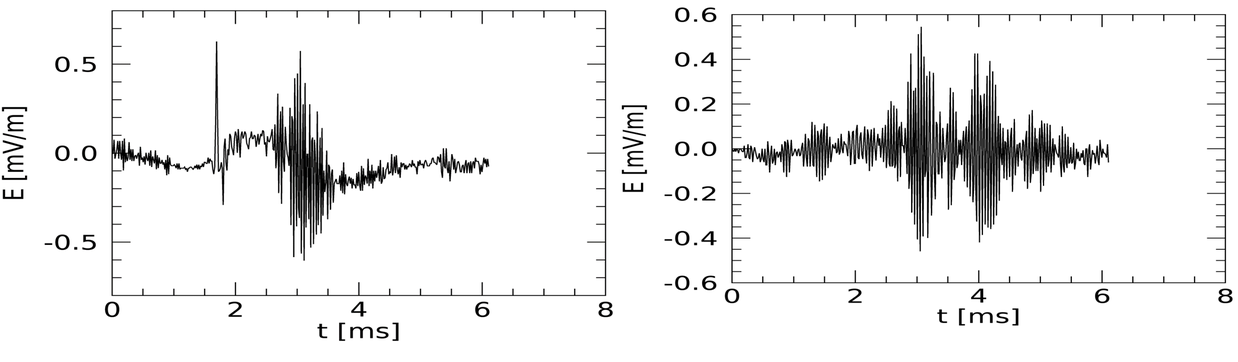
This figure introduced by Mann et al (2019) sketches the impact process for a spacecraft that is slightly negatively charged (a), zero biased (b) and slightly positively charged (c) .

- In the first phase (T1), at which the spacecraft is assumed to be in equilibrium potential, the impact occurs, and an impact cloud is generated (green). Some of the cloud particles may be re-collected.
- The second phase (T2) is characterised by electron escape and partial recollection depending on the target's potential, yielding an initial rise in signal strength(blue).
- The third phase (T3) is characterised by the ion escape, decreasing the spacecraft potential (red).
- The final phase (T4) is the relaxation phase when the spacecraft potential returns to the equilibrium value (orange) .

Details of Computation

We employ the following condition for event selection:

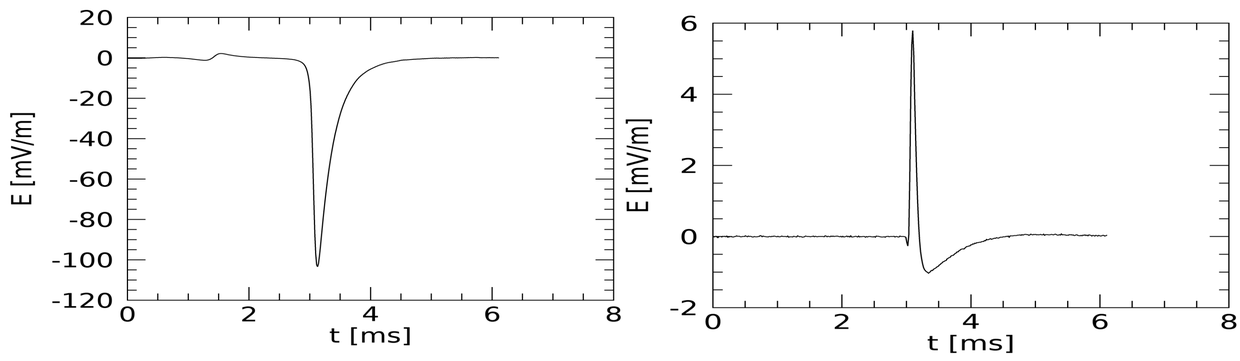
- Events are selected when the derivation exceeds a threshold value.
- The noise events (waves) are removed by comparing the amplitude of the pulse with the fluctuation of the signal before the event.



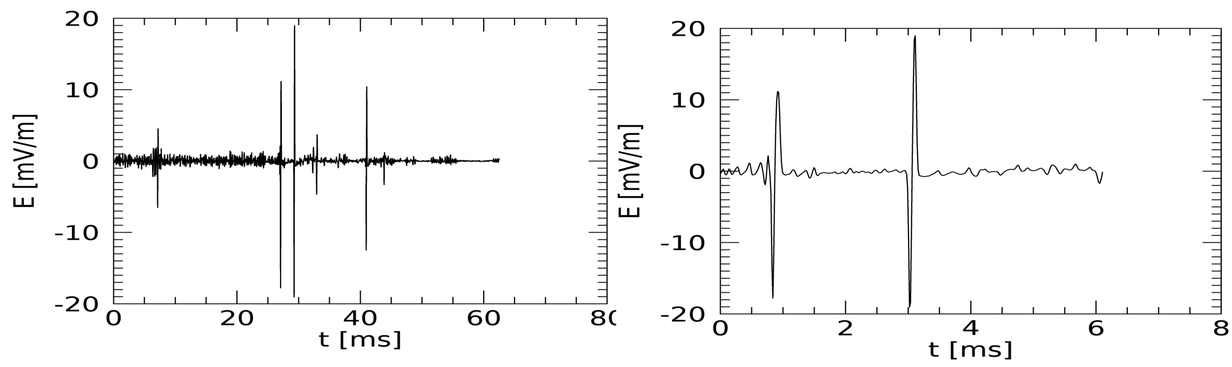
Analysis

Our goal is to identify the transient pulses in the measured data which correspond to dust impact onto spacecraft body. This will improve our understanding of the signal detection and presence of dust around Mars.

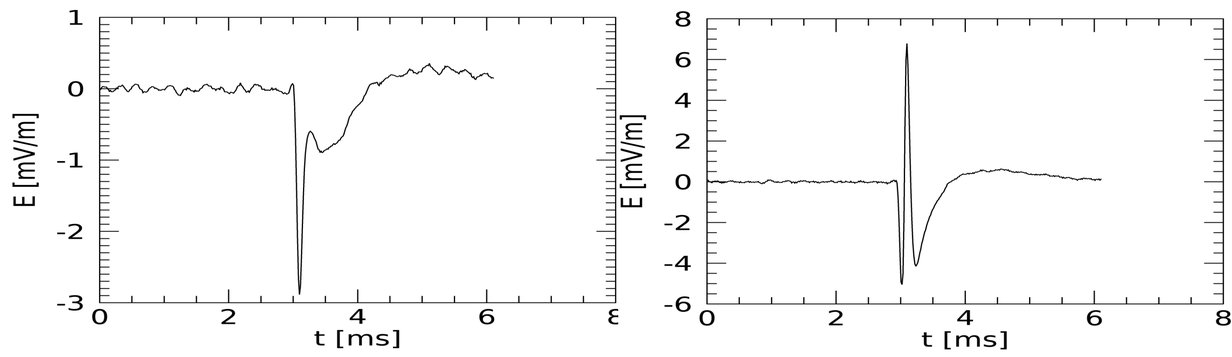
Examples of detected signals

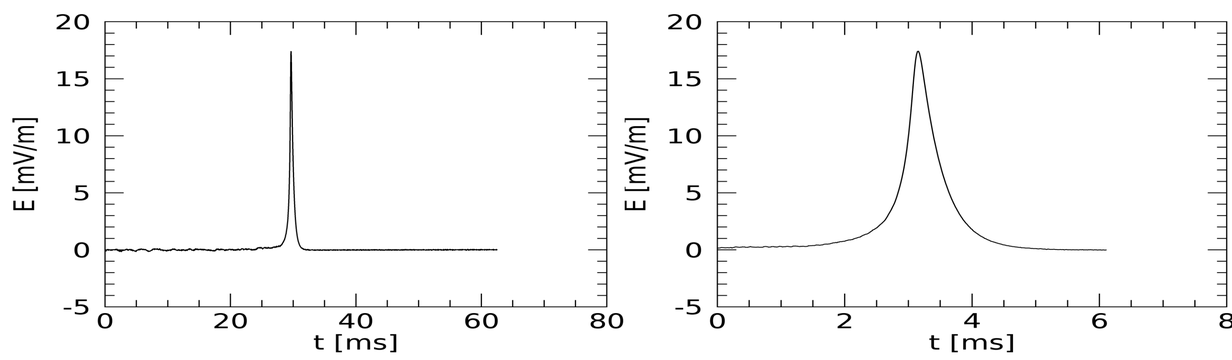


Examples of two different pulses - candidates for dust impacts.



Pulses identified as solitary waves.





The above four figures correspond to pulses with an unknown origin which is an important fact that dust impact detection by electric field instruments is a challenging issue.

Summary

- Obtained results indicate that there is a need for better understanding of signals generated by dust impacts , their detection and identification.
- Our next step is to develop a detail statistical analysis of the events detected by MAVEN spacecraft.
- The future goal is to identify the observed dust impact signals on the different spacecraft missions.

References

- Mann I, et al. (2019). Dust observations with antenna measurements and its prospects for observations with Parker Solar Probe and Solar Orbiter. *Annales Geophysicae*, *37*(6), 1121-1140. doi: 10.5194/angeo-37-1121-2019