EXOMARS 2022: PLANNED MEASUREMENTS OF ELECTROMAGNETIC RADIATION ON THE SURFACE OF MARS

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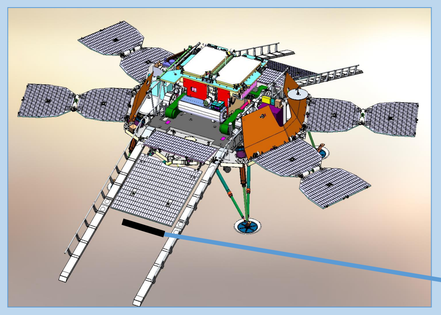
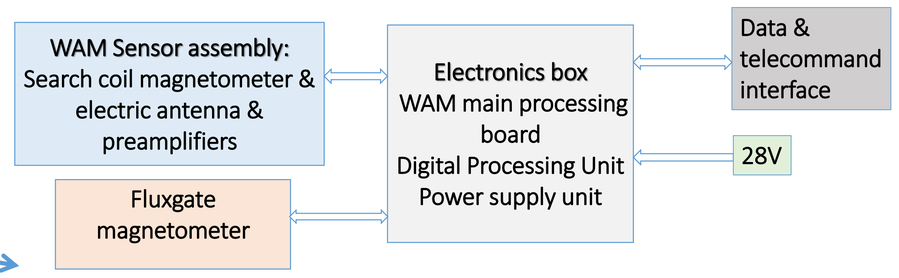
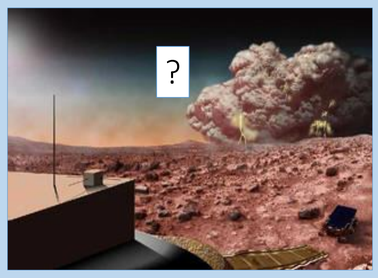
The main scientific targets of the MAIGRET (MArtian GRound Electromagnetic Tool) instrument

- Local magnetization of the Martian surface material
- Interactions of interplanetary plasma medium with Martian ionosphere and Martian magnetic anomalies at the surface
- Electromagnetic emissions of atmospheric origin: dust storms, possible wave activity originated in electrical discharges
- Ionosphere-atmosphere-lithosphere interactions on Mars related to space weather effects
- Internal structure of the planet, investigated using electromagnetic sounding methods based on the analysis of the response of deep conductive structures to excitation by time-varying external electromagnetic field of natural origin



Functional scheme of the MAIGRET instrument



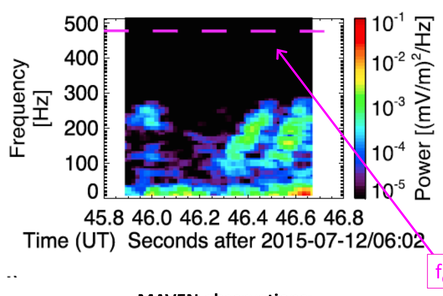


Wave analyser module (WAM)
Measurements of electromagnetic field fluctuations in the frequency band from **100 Hz to 20 kHz**, electric field up to **8 MHz**

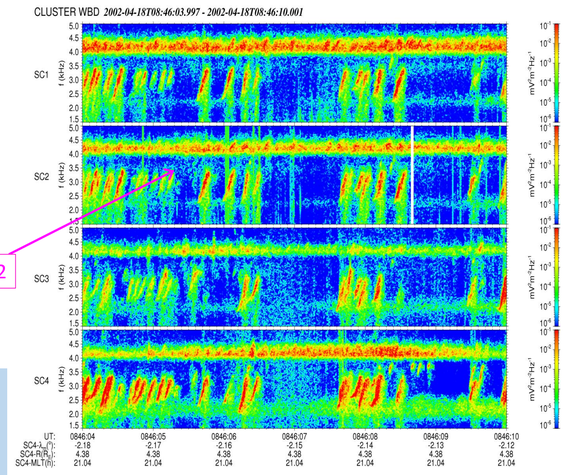
Scientific questions specific to the Wave analyzer module

A. Can we observe electromagnetic radiation propagating from the interplanetary space down to the surface of the planet?

- Which frequencies and plasma wave modes can penetrate down to the surface of Mars?
- What are the conditions under which we observe the penetration of electromagnetic radiation from interplanetary space down to the surface of Mars?
- What state of the Martian ionosphere is the most favorable for the penetration to happen?



MAVEN observations:
Harada, Y., et al. (2016), *JGR*

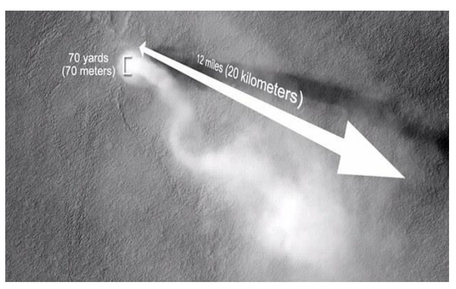


Simulations show that ELF-VLF waves below ~ 4 kHz can propagate to the surface, considering crustal magnetic field on the nightside and during low solar activity
Melnik and Parrot, 1999, *JGR*

Similar to chorus at Earth
CLUSTER observations

B. Can we observe electromagnetic radiation from electric discharges in the Martian dust storms?

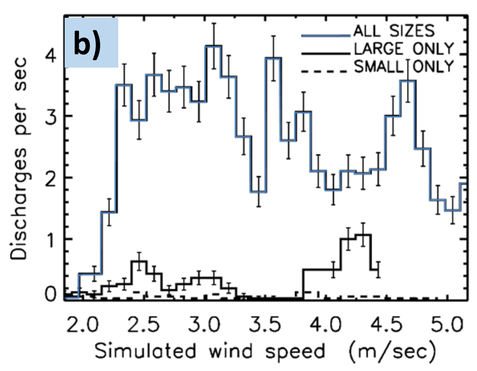
- Are the waveforms of the electromagnetic radiation from Martian discharges similar to the waveforms radiated from the terrestrial lightning?
- Which processes lead to initial breakdown of Martian discharges and how are these processes reflected in the detectable electromagnetic radiation?
- Which special meteorological conditions lead to initiation of Martian discharges?



HiRISE camera, Mars Reconnaissance orbiter, NASA

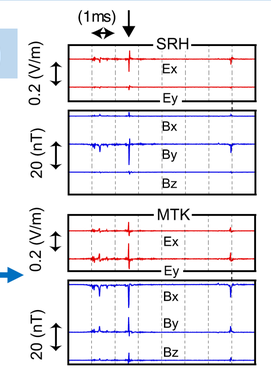
Impulsive radio signals originating in the Martian dust storm lightning discharges have never been detected from the orbit: Gurnett et al., 2010, *GRL* (using MARSIS instrument onboard Mars Express spacecraft); the search covered altitudes from 275 km to 1400 km, frequencies from 4.0 to 5.5 MHz.

a) **Numerical simulations: low pressure CO_2 atmosphere breakdown at 5-20 kV/m, triboelectric charging of dust** Melnik and Parrot, 1998, *JGR*
b) **Laboratory experiment** Kraus et al., 2003, *New Journal of Physics*
c) **Analogy with the terrestrial dust devils** Farell et al., 2004, *JGR*
d) **Analogy with volcanic lightning** Antel et al., 2014, GRL, Aizava et al, 2016, *EPSL*
e) **Emission of non-thermal radiation by Martian dust storm**, Ruf et al., 2009, *GRL*



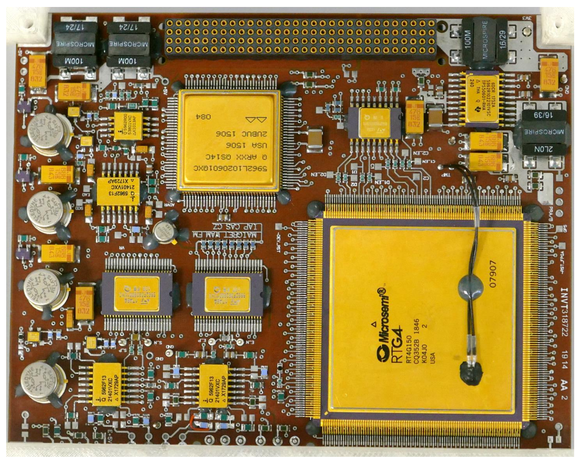
Mixture of particles of different sizes [51% 250-1000 μm; 24% 150-249 μm; 25% < 150 μm] and vertical or horizontal wind is needed to produce observable discharges

Electromagnetic measurements in a frequency band of 0.3 Hz – 32 kHz show observable signatures of volcanic discharges at a distance of 2.2 km (MTK) and 3.5 km (SHR) from the Sakurajima crater.

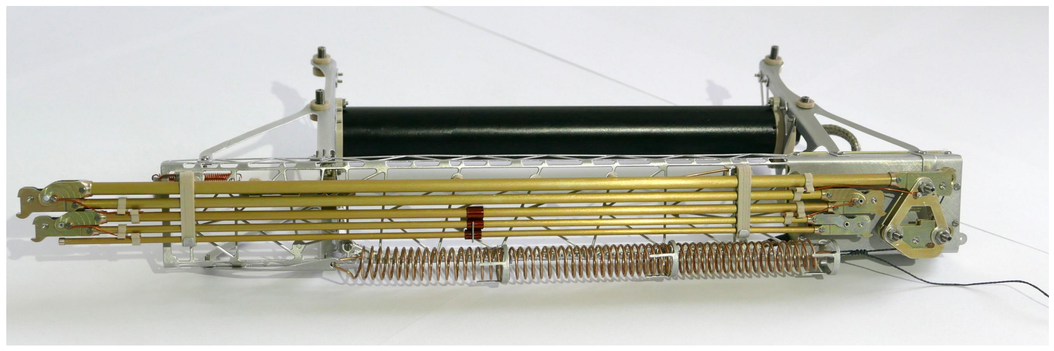


Implementation of the Wave analyzer module

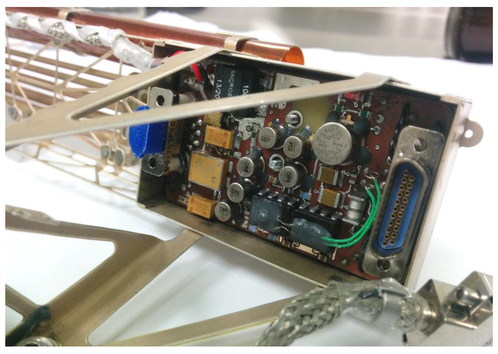
- **Sensor assembly** (300 g): search coil antenna **<20 kHz**
  2m vertical electric antenna **<8 MHz**
- **Data products:** time and frequency averaged survey mode spectra; high-resolution burst mode spectra; selected high-resolution waveform burst mode snapshots.
- Onboard storage in WAM non-volatile memory, selective download.
- **Nighttime operations, <3W**
- Triggering and selection algorithms adjustable by telecommand
- Efficient onboard processing and robust **science-based compression methods**



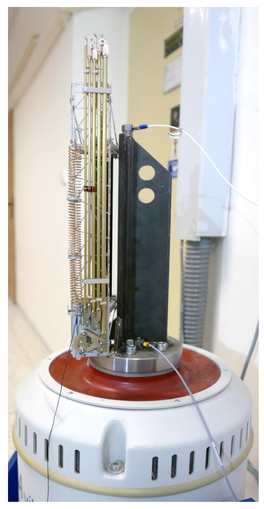
Flight model of the WAM



Flight model of the combined magnetic/electric field deployable sensor with integrated preamplifiers



Detail of the electric field preamplifier



Sensor during the vibration tests