

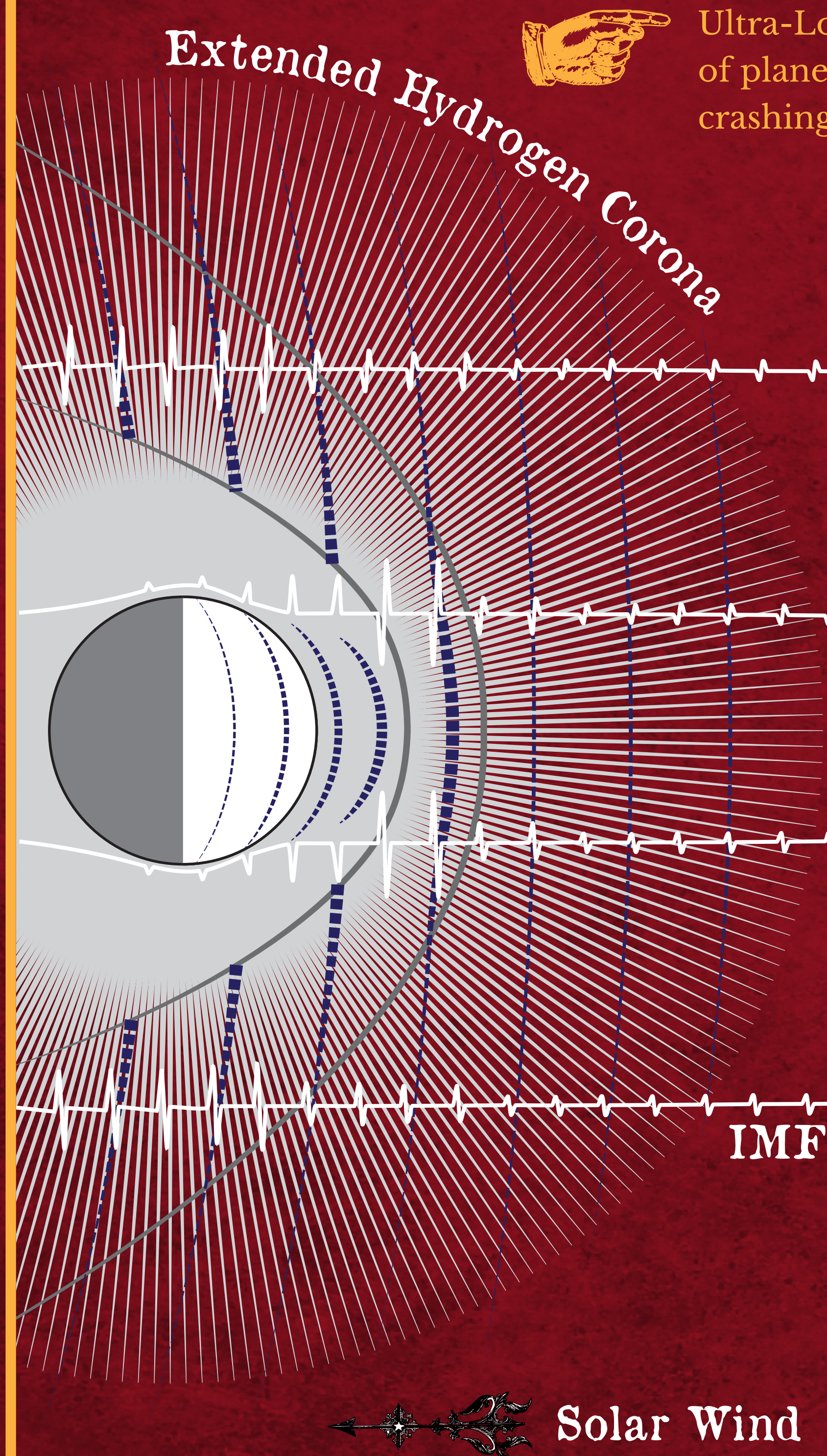
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SOLAR WIND INDUCED WAVES IN THE SKIES OF MARS

IONOSPHERIC COMPRESSION, ENERGIZATION, AND ESCAPE RESULTING FROM THE IMPACT OF ULTRA-LOW FREQUENCY MAGNETOSONIC WAVES GENERATED UPSTREAM OF THE MARTIAN BOW SHOCK



WAVES CRASHING ON A COSMIC SHORELINE



Ultra-Low Frequency waves are a common phenomena upstream of planetary bow shocks, and rain down upon a planet like waves crashing upon a cosmic shoreline



At Earth, they penetrate the Magnetosheath and can stream down open field lines at the poles, and are detectable by ground-based ionospheric radar



BUT WHAT HAPPENS IF A PLANET HAS NO MAGNETIC FIELD?



We report MAVEN observations of the penetration ULF waves in the solar wind into the ionosphere of Mars



Compressive magnetosonic ULF waves form upstream of Mars and steepen as they approach the Bow Shock



ULF waves steepen, pile up, and form the quasi-parallel bow shock and magnetosheath



Collision with the magnetopause drives compressive magnetosonic ULF waves in the ionosphere

Solar Wind

SHAKING THE SKIES OF MARS: IMPACT ON THE UNPROTECTED IONOSPHERE



The entire ionosphere is compressed and heated



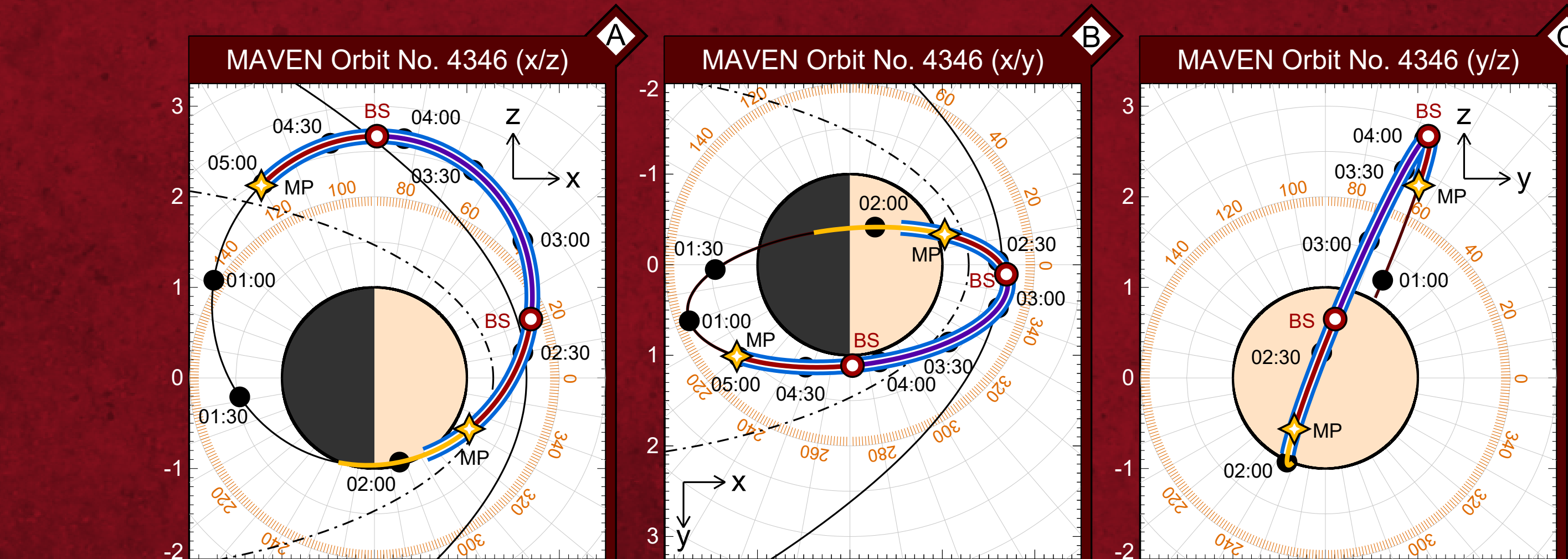
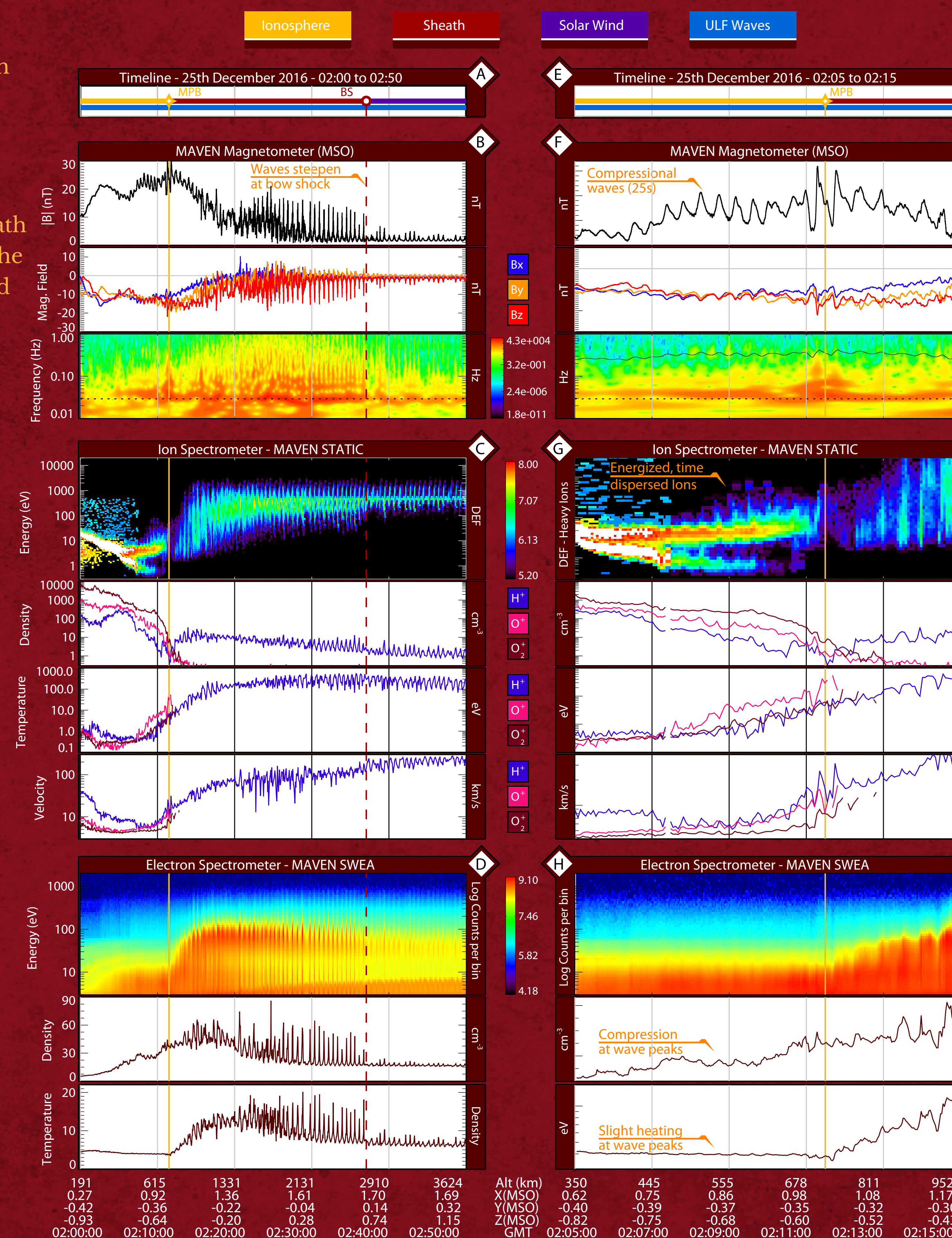
Bursts of time-dispersed ions are launched



The ionosphere “rings” like a bell, at the local cyclotron frequency



Ionospheric Escape is enhanced



ABSTRACT:

Using MAVEN and Mars Express, we show that transient phenomena in the foreshock and solar wind can directly inject energy into the ionosphere of Mars. We demonstrate that the impact of compressive Ultra-Low Frequency (ULF) waves in the solar wind on the induced magnetospheres drive compressional, linearly polarized, magnetosonic ULF waves in the ionosphere, and a localized electromagnetic “ringing” at the local proton gyrofrequency. The pulsations heat and energize ionospheric plasmas. A preliminary survey of events shows that no special upstream conditions are required in the interplanetary magnetic field or solar wind. Elevated ion densities and temperatures in the solar wind near to Mars are consistent with the presence of an additional population of Martian ions, leading to ion-ion instabilities, associated wave-particle interactions, and heating of the solar wind. The phenomenon was found to be seasonal, occurring when Mars is near perihelion. Finally, we present simultaneous multipoint observations of the phenomenon, with MEX observing the waves upstream, and MAVEN observing the ionosphere.

A QUEST FOR MORE EVENTS



We searched through 1747 other MAVEN orbits, finding 11 additional orbits where this penetration of solar wind ULF waves occurred. Waves were observed down to 186km



For one event, simultaneous multi-point observations were possible, with Mars Express recording the compressive ULF waves upstream in the solar wind, and MAVEN observing the waves in the ionosphere



Unambiguous evidence that at unmagnetized planets, waves in the solar wind can directly impart energy into the ionosphere, resulting in compression, heating, and escape



Found to be a seasonal effect, occurring when Mars is near Perihelion:



The brightening sun heats and expands the atmosphere beyond the bow shock



Pickup ions from the expanded Hydrogen corona result in enhanced upstream waves which rain down upon the ionosphere of Mars, and shake the skies



See our paper: Collinson et al., “Solar Wind induced waves in the skies of Mars”, *Journal of Geophysical Research: Space Physics*, vol 123, 2018

