



The ion environment of Phobos, as observed by MAVEN

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Phobos is bombarded by two populations of ions:

Solar wind ions (H^+ and He^{++})



H^+ , O^+ , O_2^+ and CO_2^+
ions coming from the
ionosphere and
exosphere of Mars



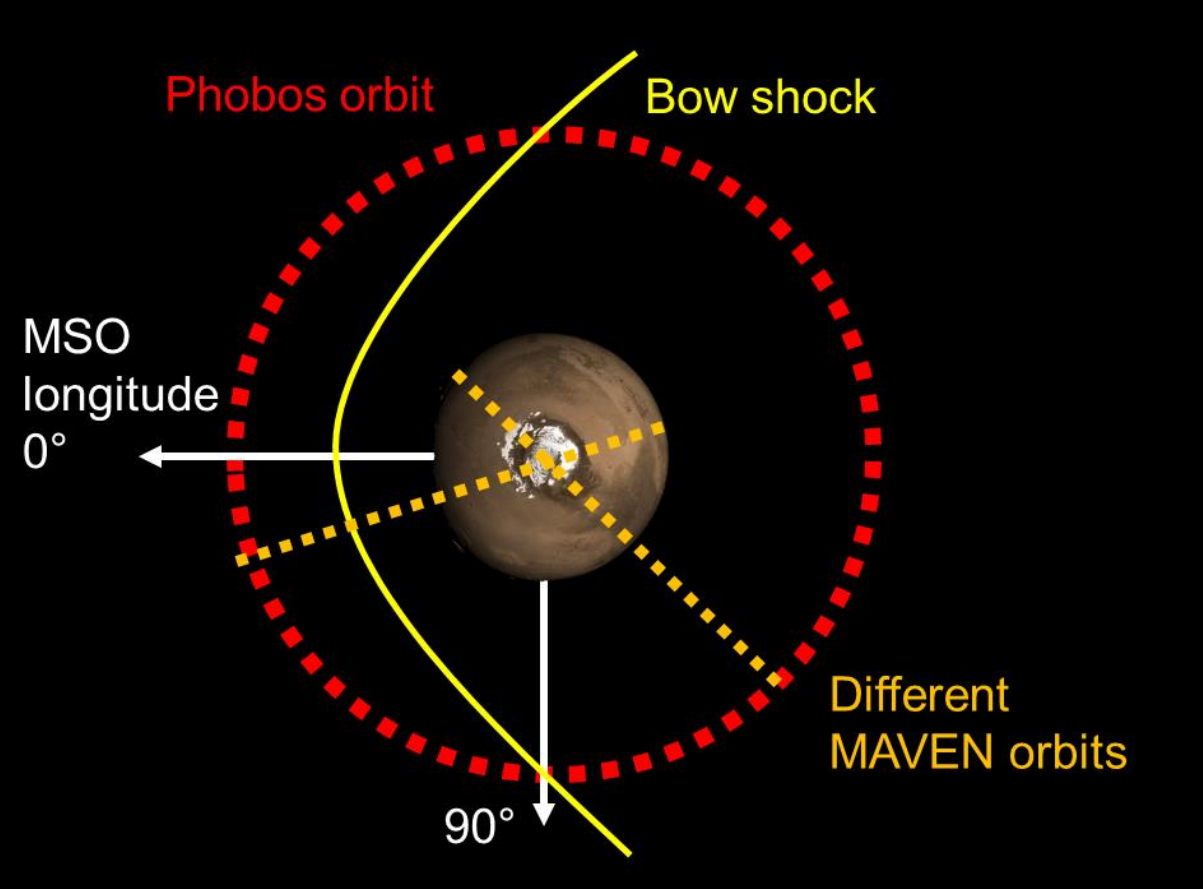


Figure 1

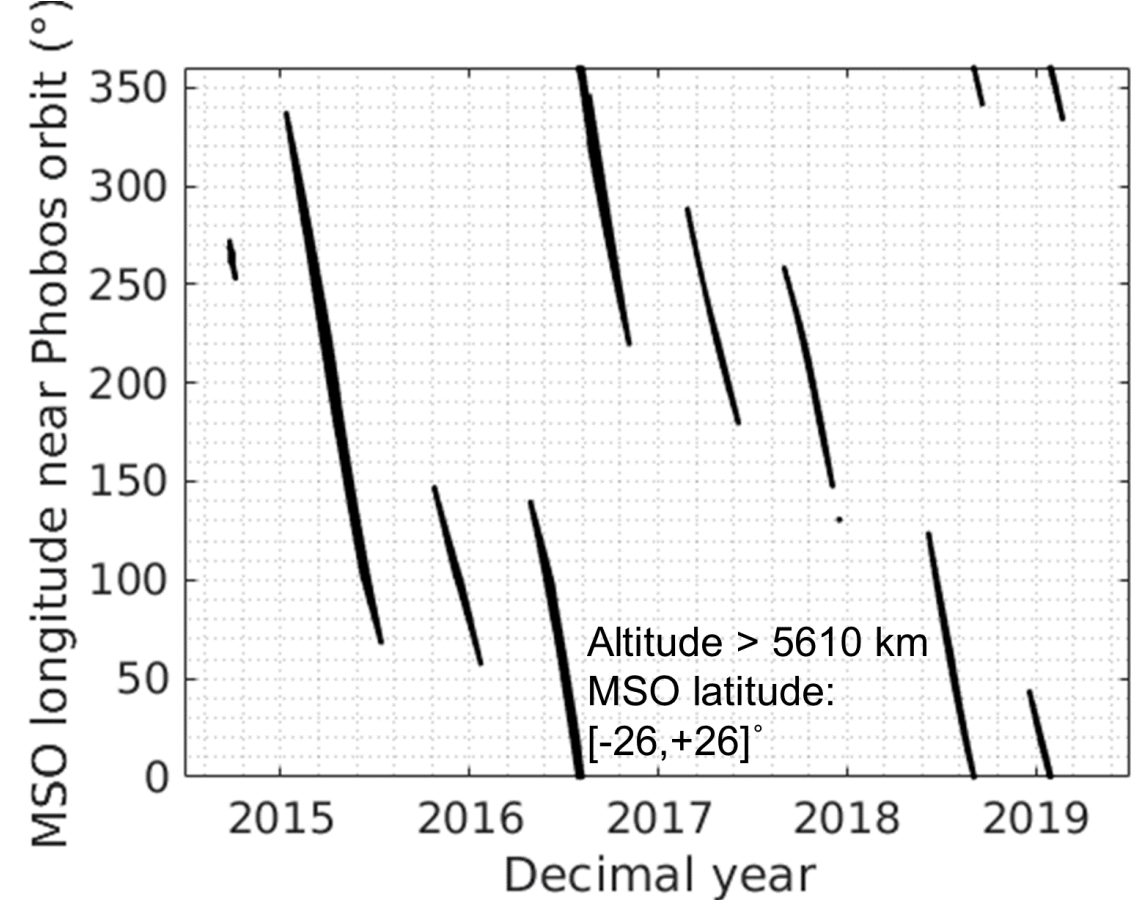
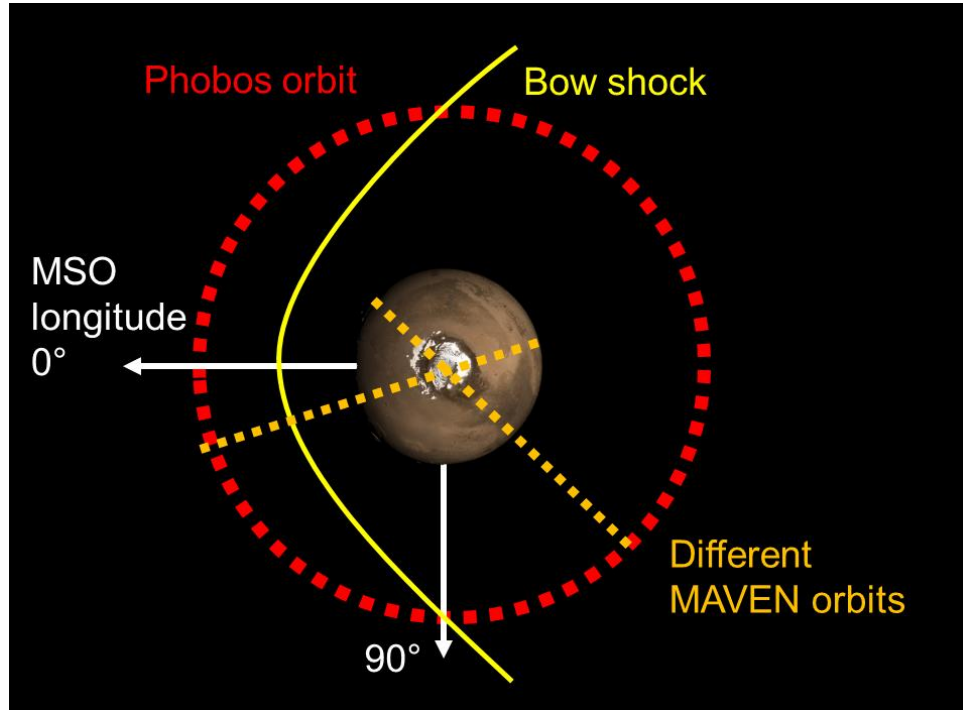


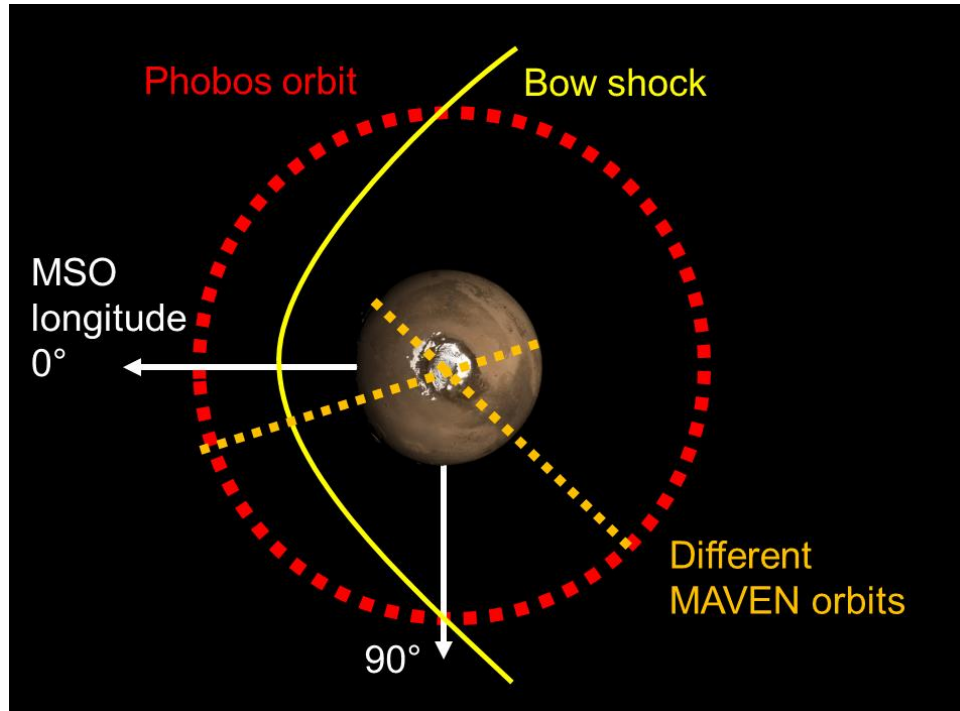
Figure 2

- The NASA MAVEN spacecraft is in orbit around Mars since September 2014
- **Figure 1:** MAVEN repeatedly crossed the orbit of Phobos up to February 2019
- **Figure 2:** It observed only a narrow range of Mars-Solar Orbital (MSO) longitudes at a time, but all longitudes several times over the entire mission period

MAVEN repeatedly crossed the orbit of Phobos



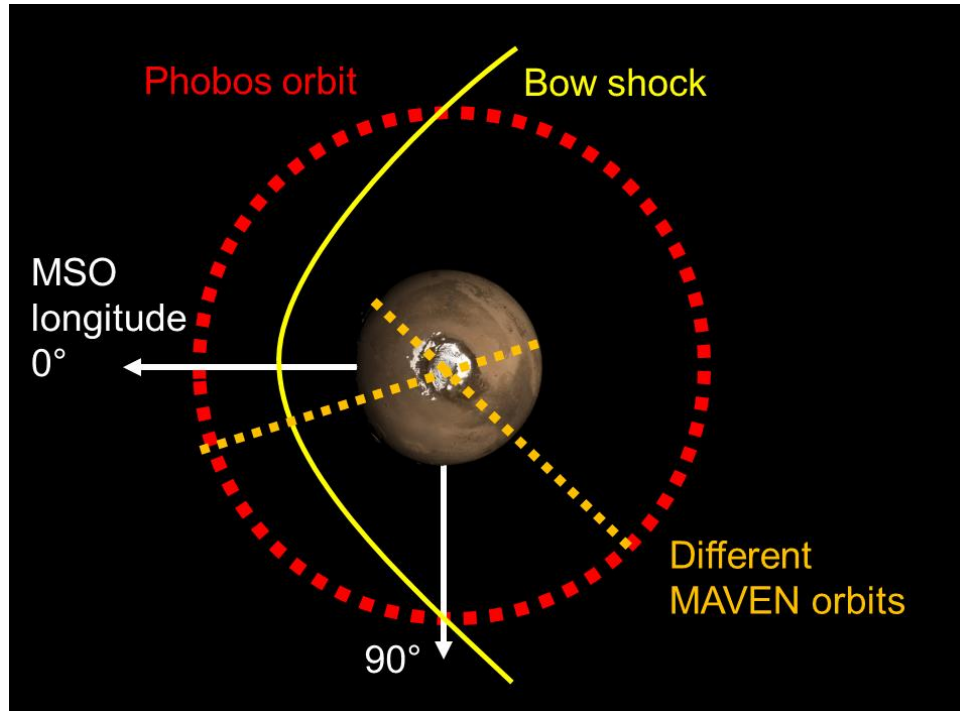
MAVEN repeatedly crossed the orbit of Phobos



MAVEN is fully equipped to observe ions

- The Solar Energetic Particle (**SEP**) experiment, 20 keV to more than 6 MeV ions, does not distinguish ion species
- The Solar Wind Ion Analyzer (**SWIA**): 30 eV to 30 keV ions, does not distinguish ion species
- The Suprathermal and Thermal Ion Composition instrument (**STATIC**): 0.1 eV to 30 keV ions, **was designed to separate ion species !**

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MAVEN unprecendently constrains our understanding of the ion environment at Phobos

The two questions addressed today:

- 1) What are the characteristics of the ion environment encountered by Phobos along its orbit: species, fluxes, long-term average and time variability?
- 2) Surface sputtering by precipitating ions is a universal process that alters the surface composition of airless bodies, and sources exospheres and extended neutral tori.

Are heavy ions coming from Mars important for the sputtering of Phobos' surface against ions of the solar wind?

Figure 3: Omnidirectional, long-term averaged and longitude averaged flux of ions bombarding Phobos

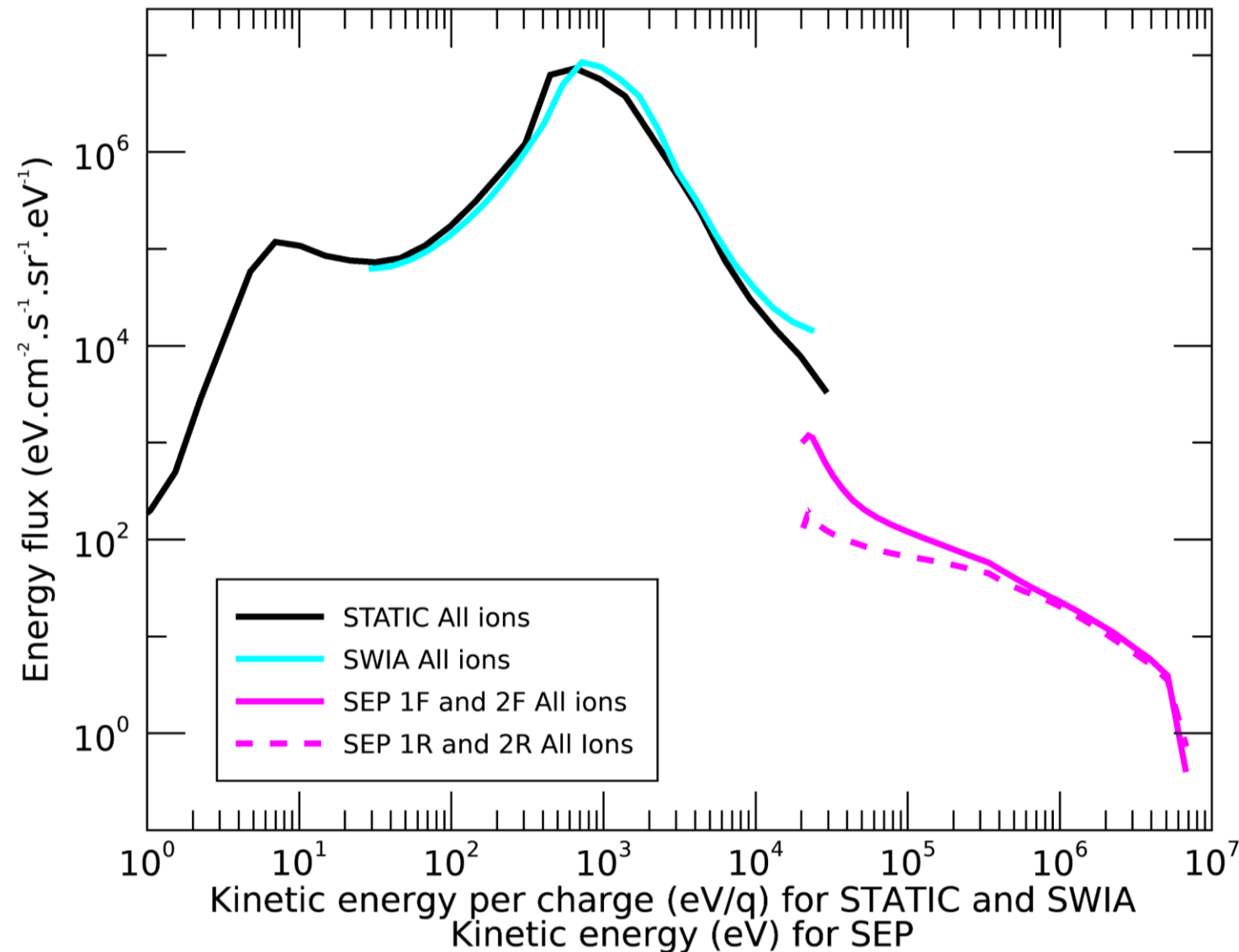
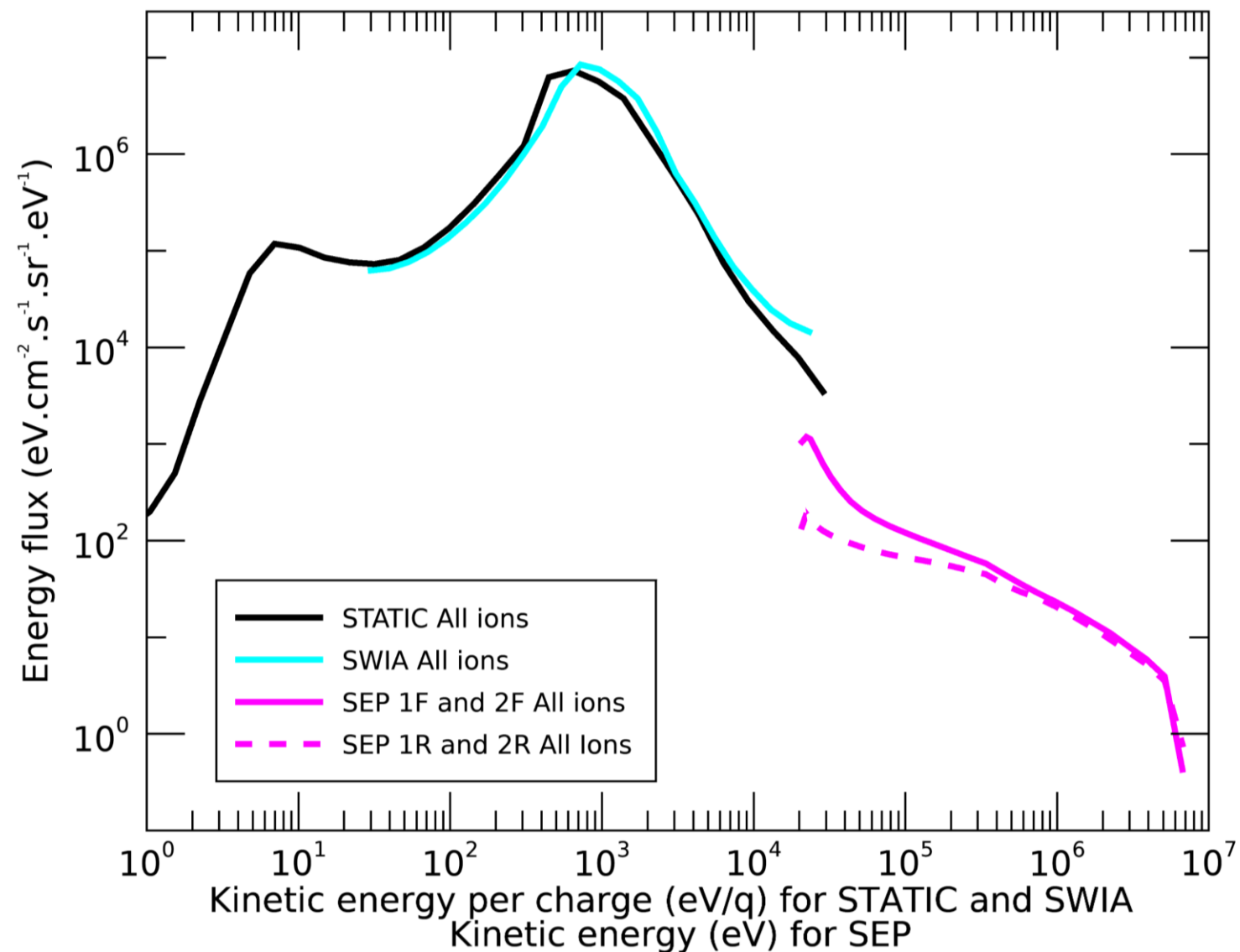


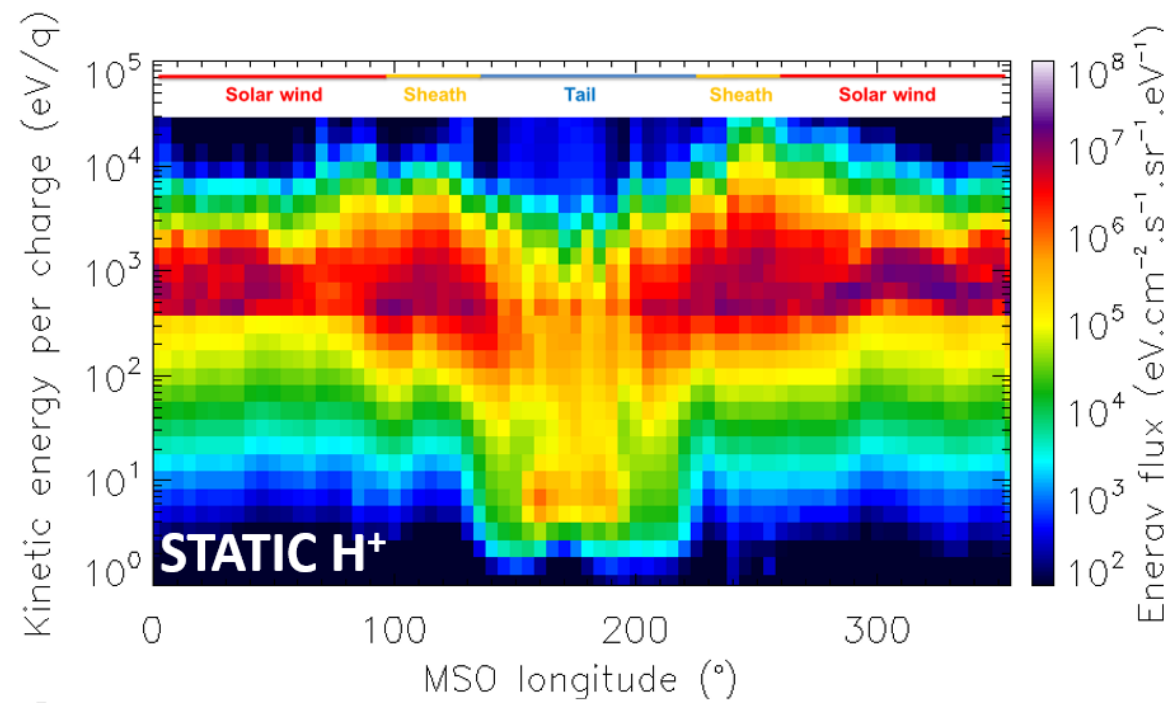
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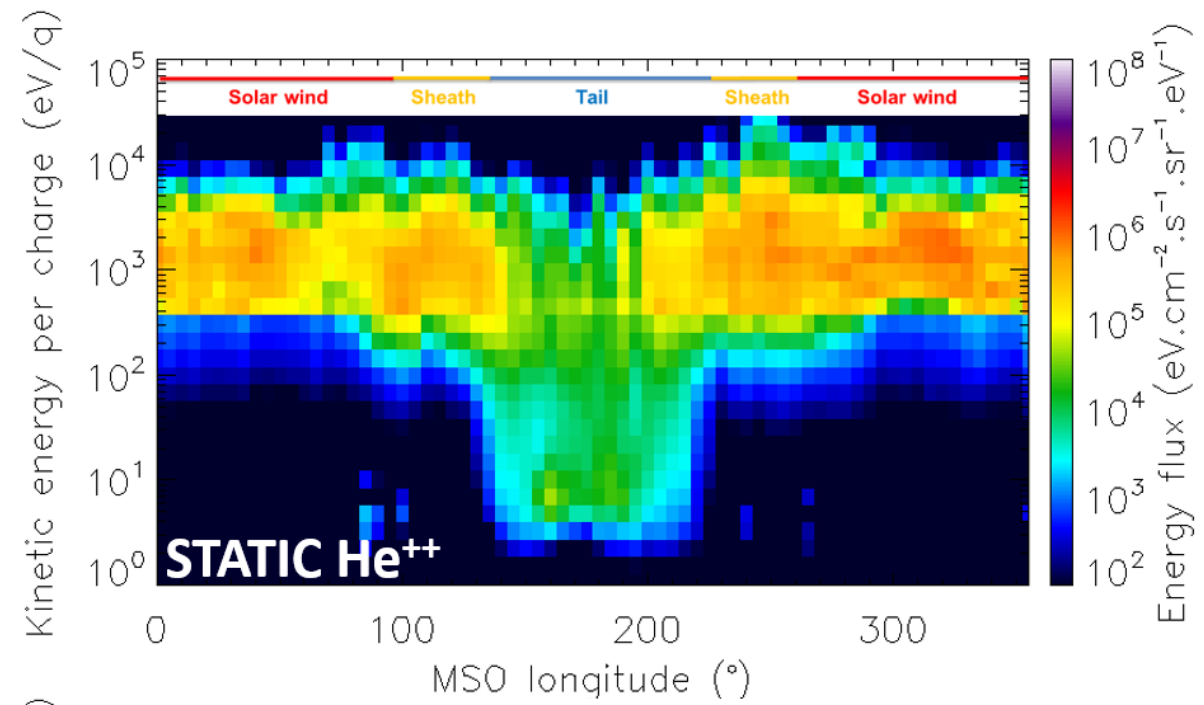
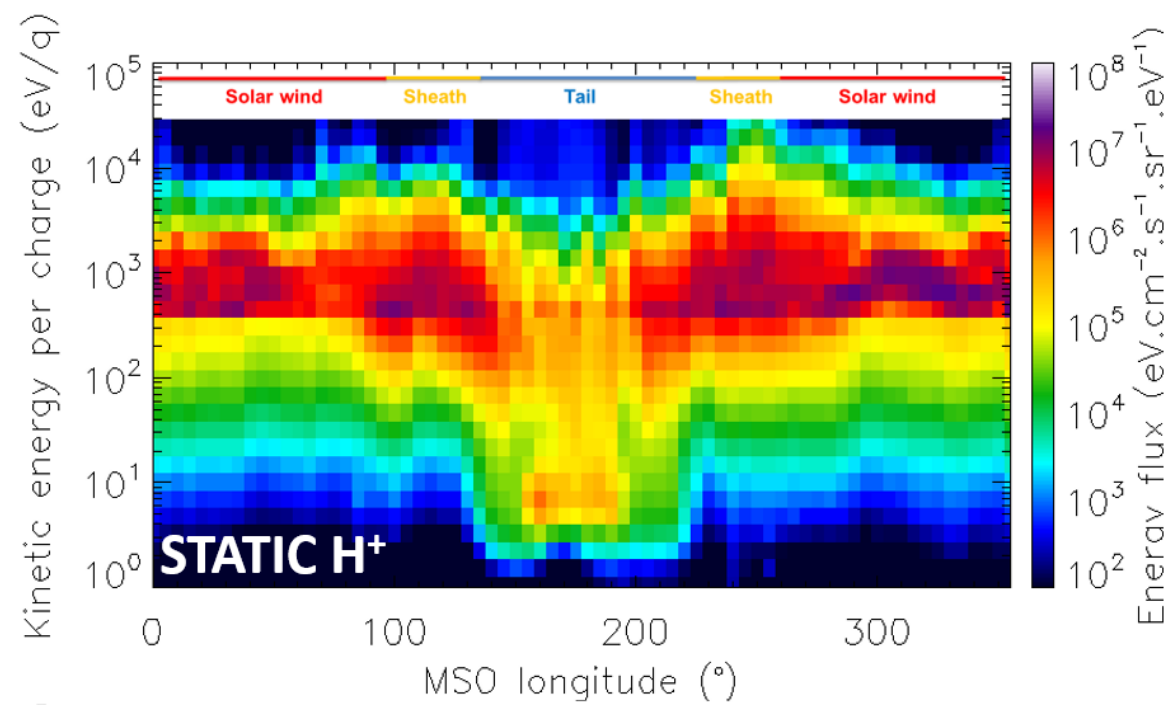
It is however crucial to identify the specie of these ions

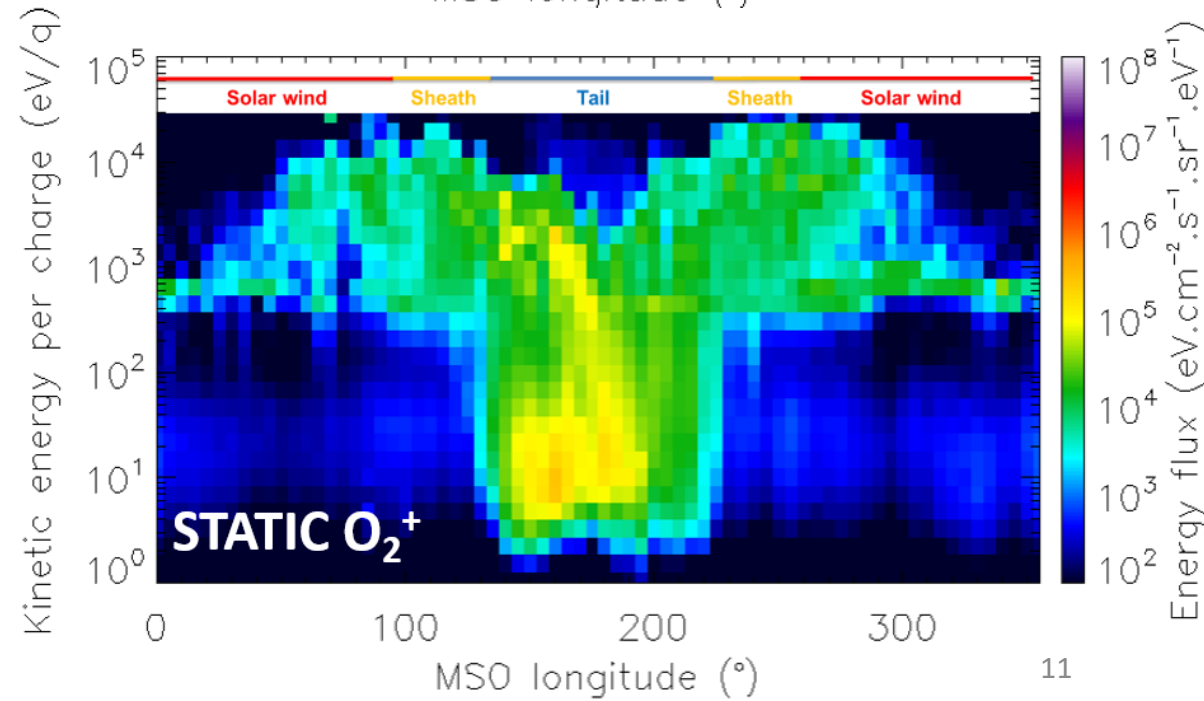
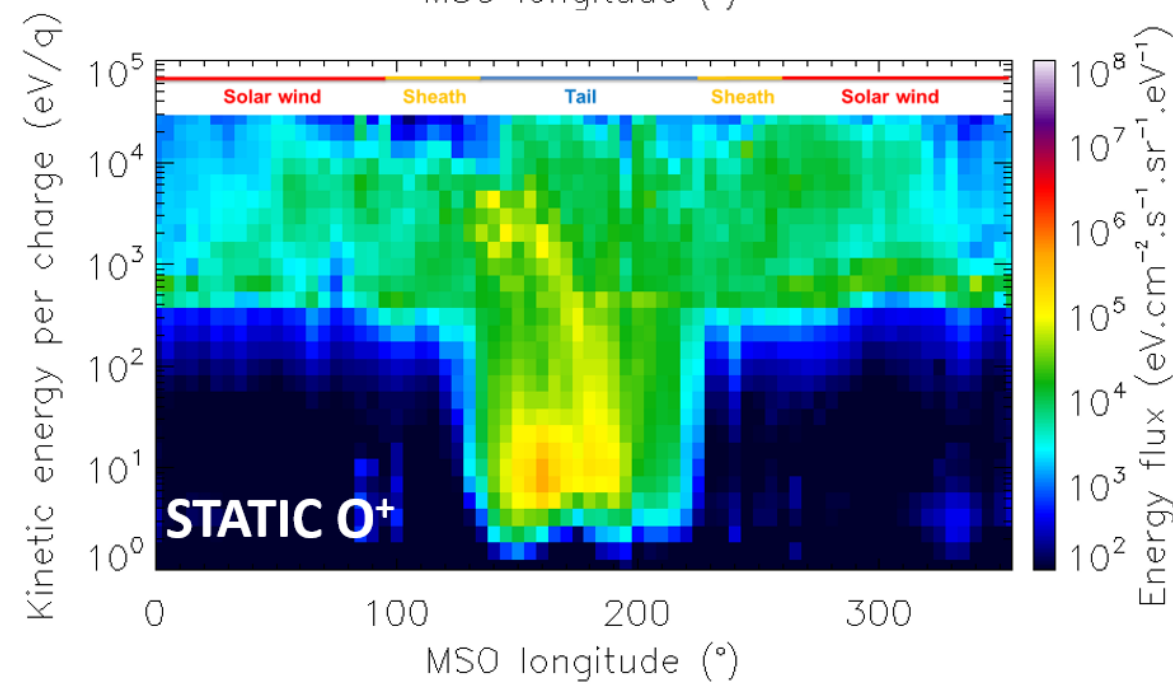
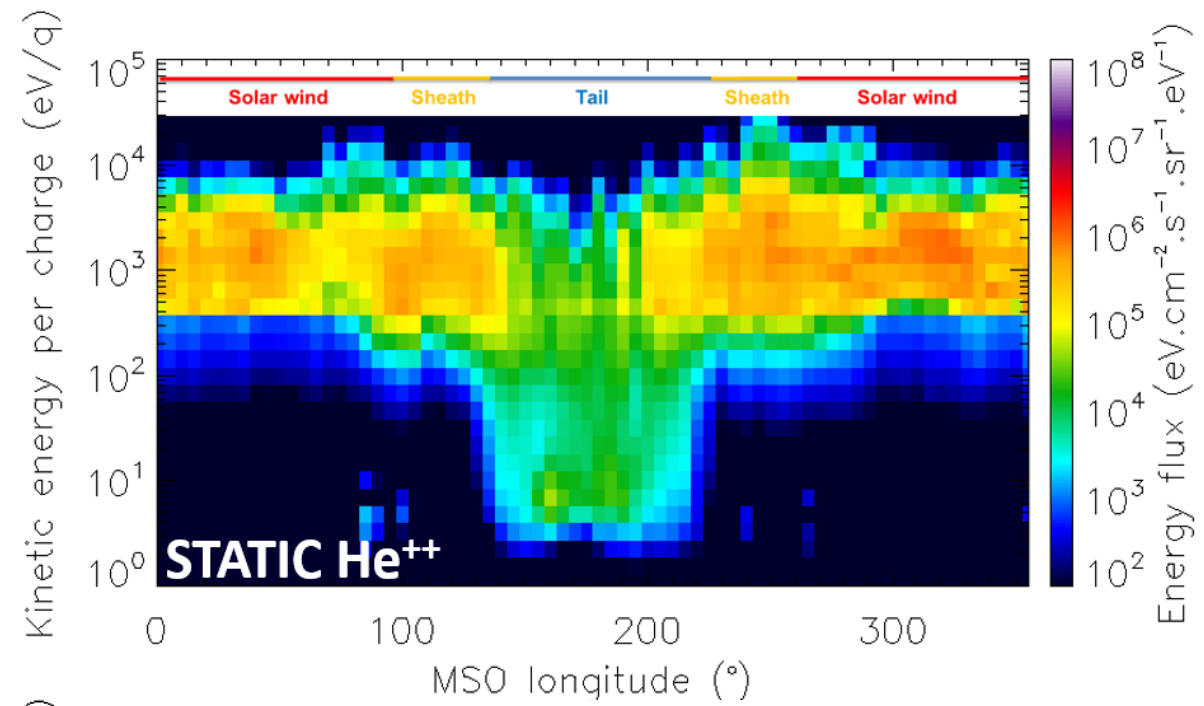
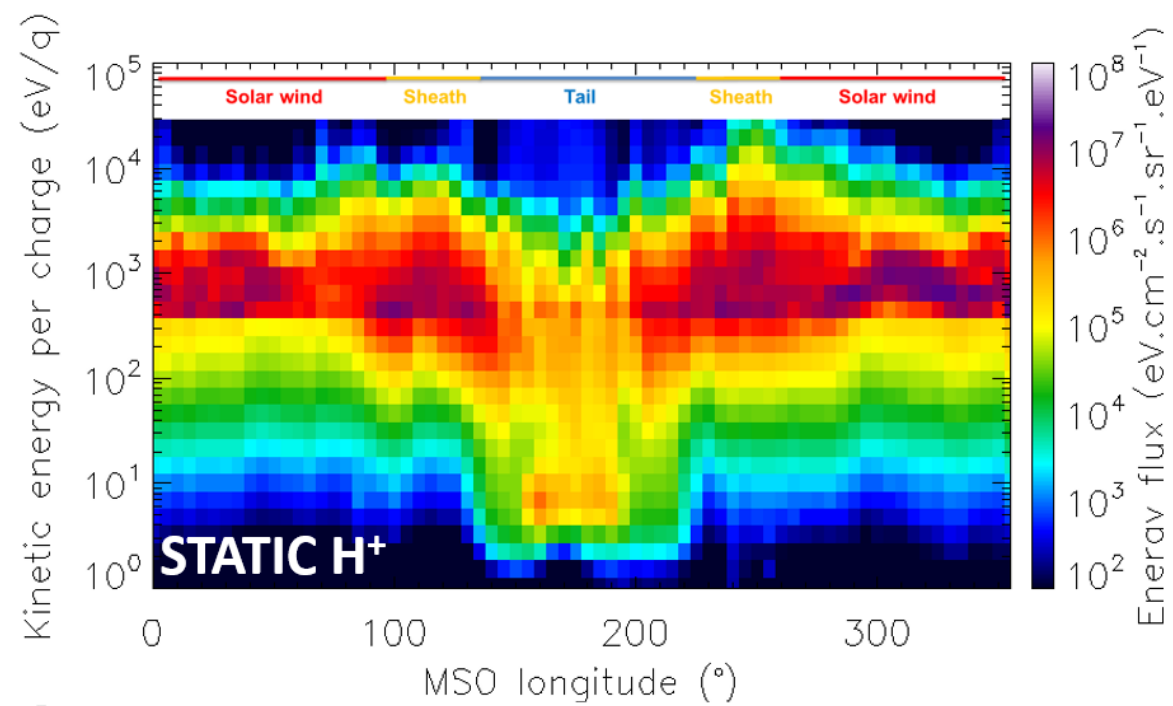
e. g.: sputtering yields of O^+ ions can be 100 times higher than the ones of protons

➤ **The STATIC instrument!**



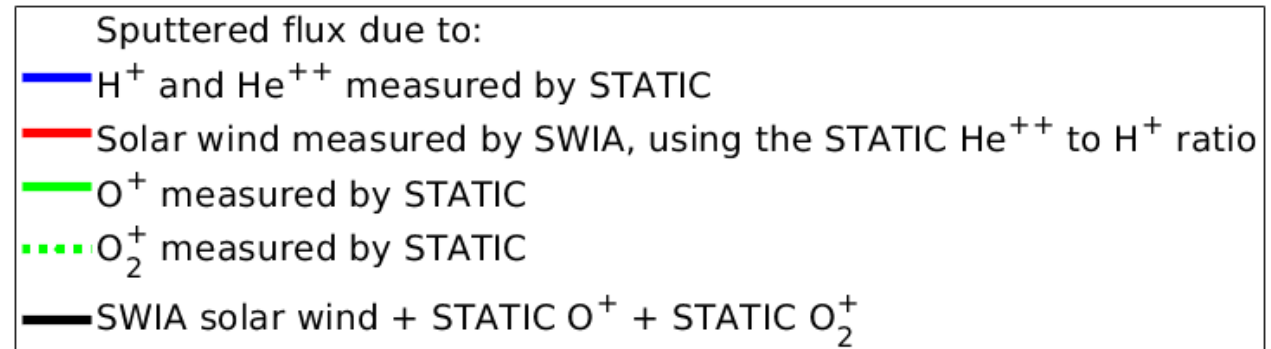
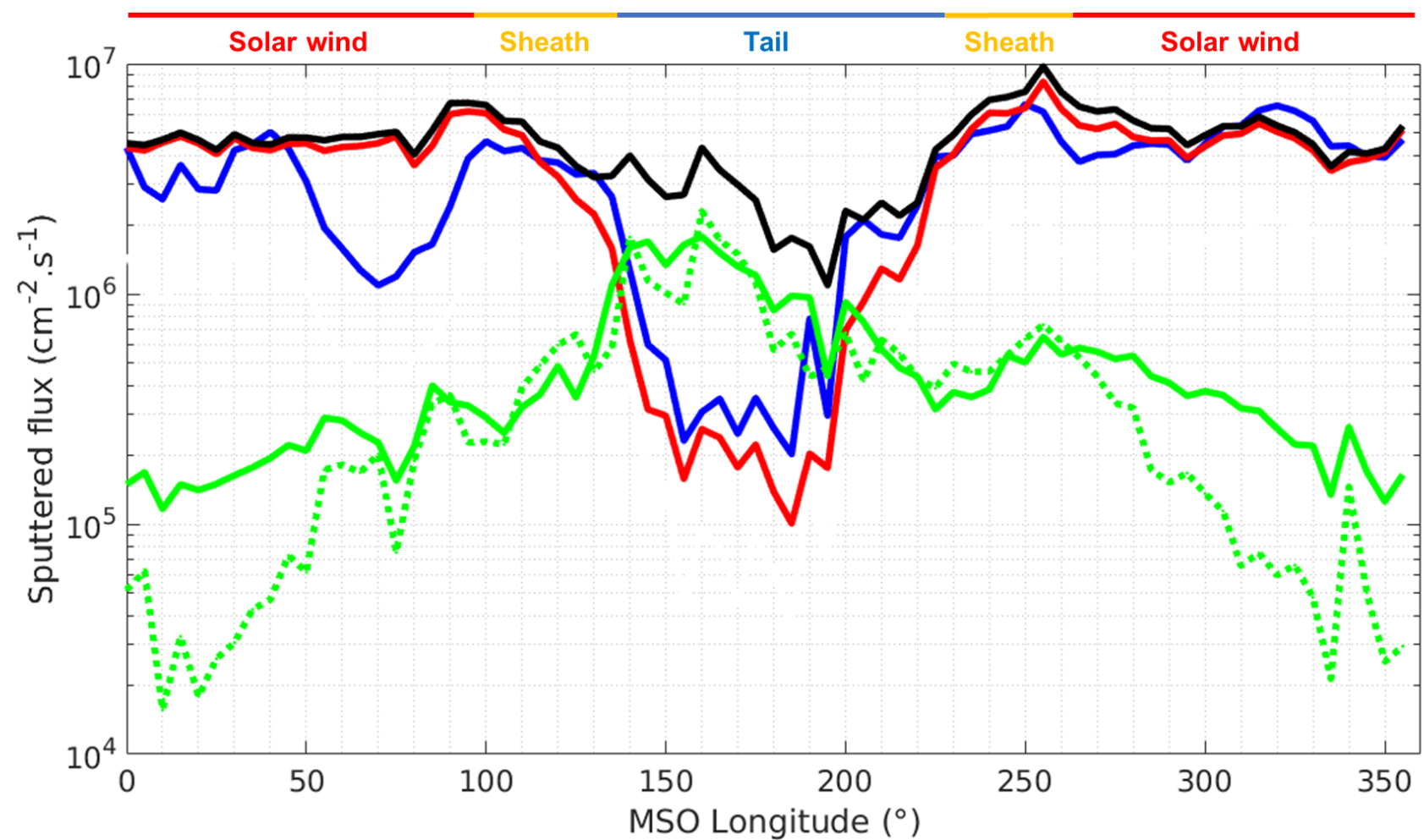






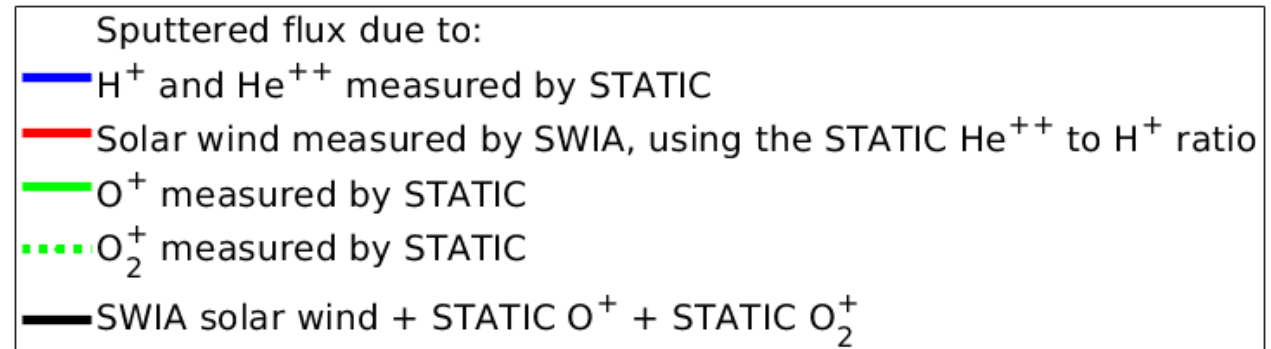
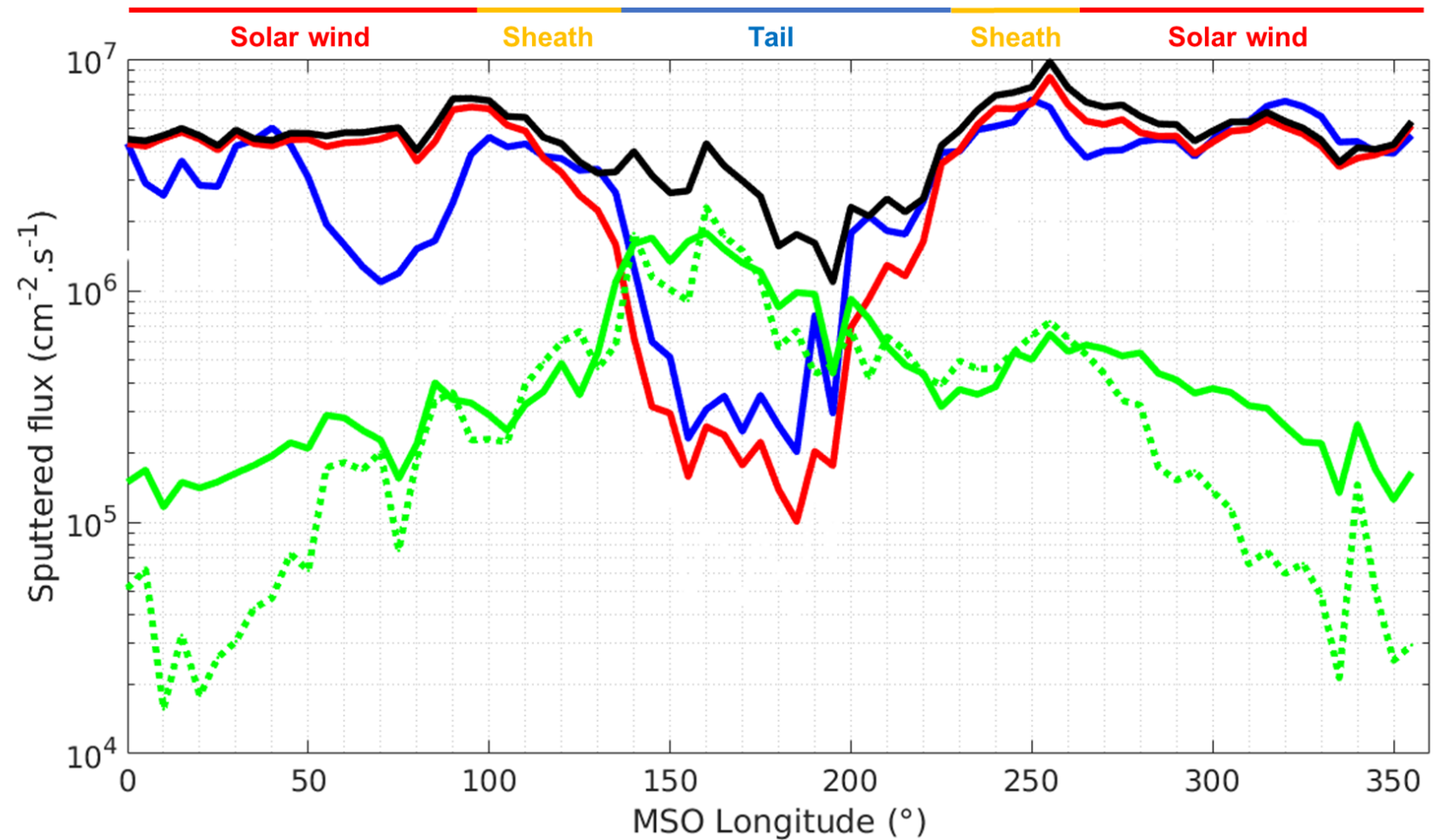
Using sputtering yields given by Poppe and Curry [GRL, 2014], we compute the long-term flux of material **sputtered** from Phobos surface

- Martian O^+ and O_2^+ ions dominate sputtering when Phobos is downstream of Mars



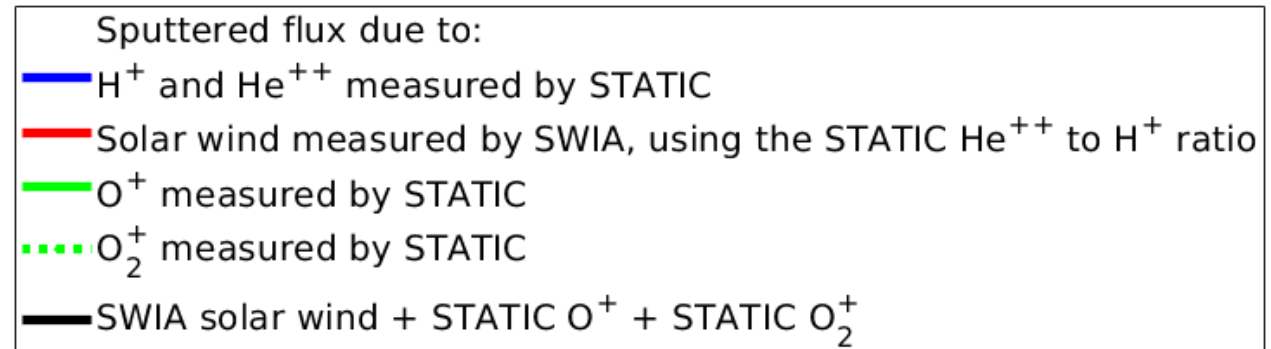
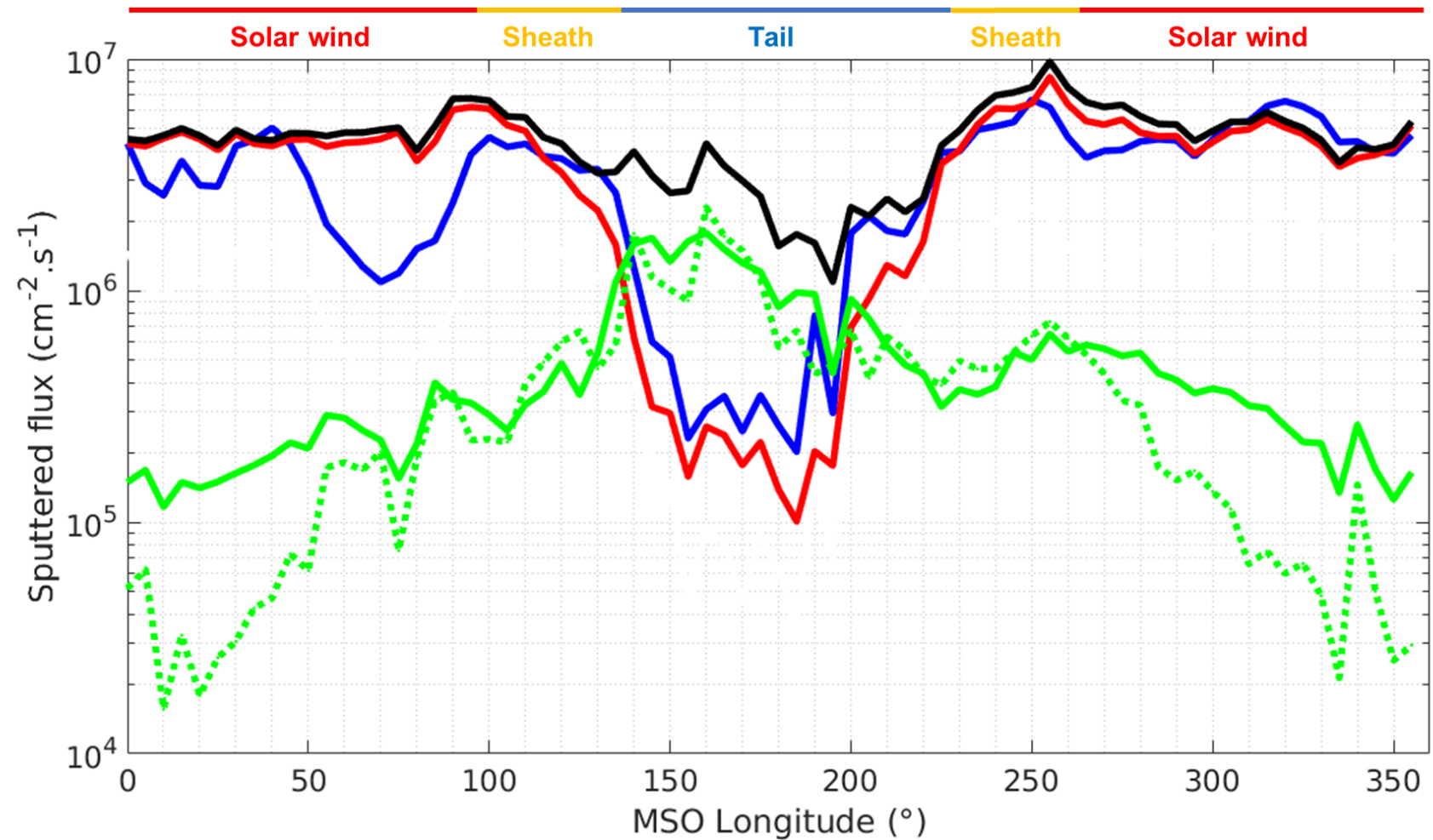
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- They contribute to $\sim 30\%$ of the longitude averaged sputtered flux
- O_2^+ ions sputter as much as or more than O^+ ions (were considered negligible before MAVEN, Poppe and Curry 2014)



Conclusion: the atmospheric escape of Mars, which supplies significant fluxes of O^+ and O_2^+ ions, is a fundamental process to understand ion weathering of Phobos' surface. This situation is unique in the Solar System.

Backup slide

How much does the flux of material sputtered from Phobos' surface vary over time?

