Overview of Phobos/Deimos Regolith Ion Sample Mission (PRISM): Determining Origins

Planetary Science Deep Space SmallSat Study (PSDS3):
Sampling the surface from above the surface without landing...

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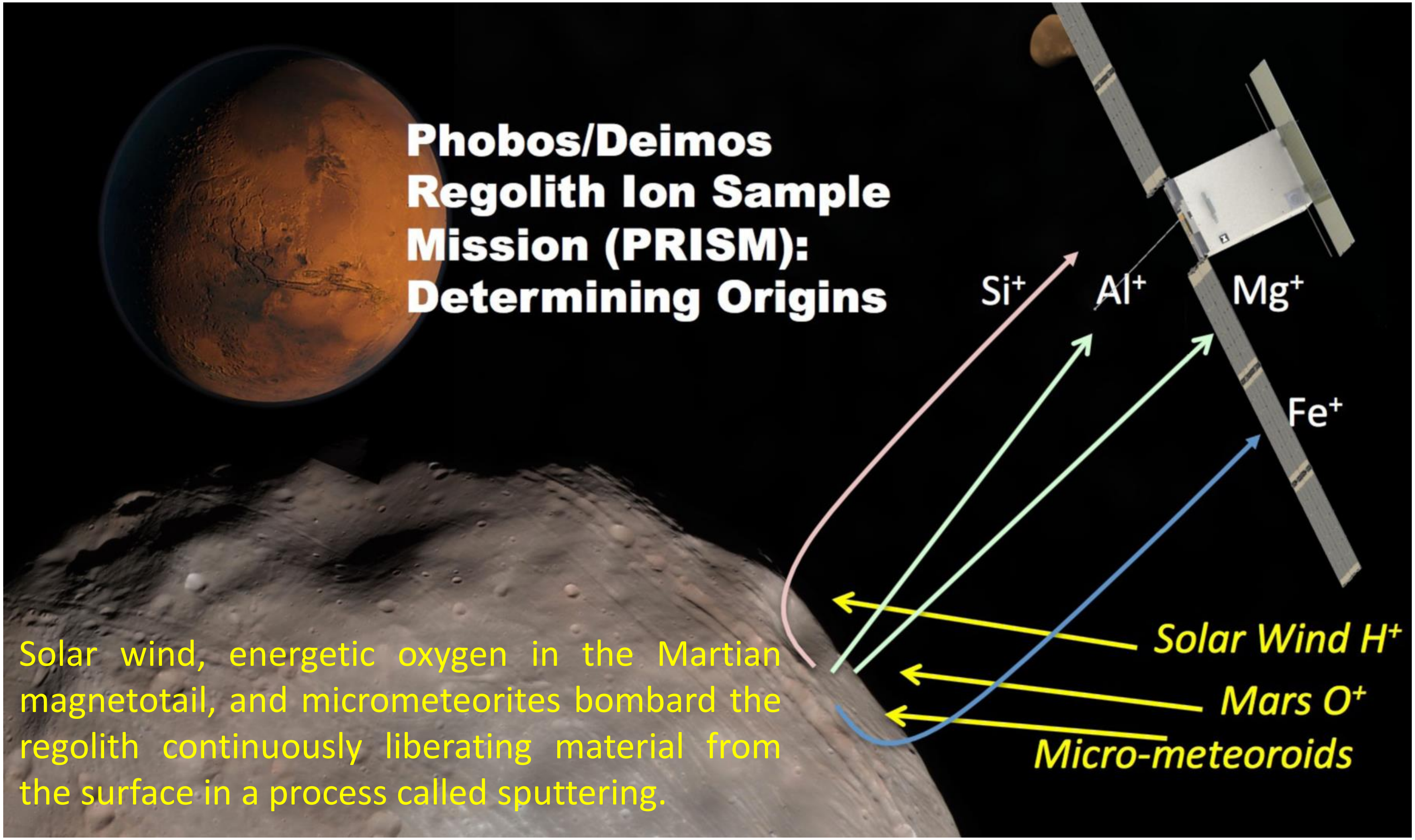
Sampling the surface from above the surface without landing...



What is the Origin of Phobos/Deimos?

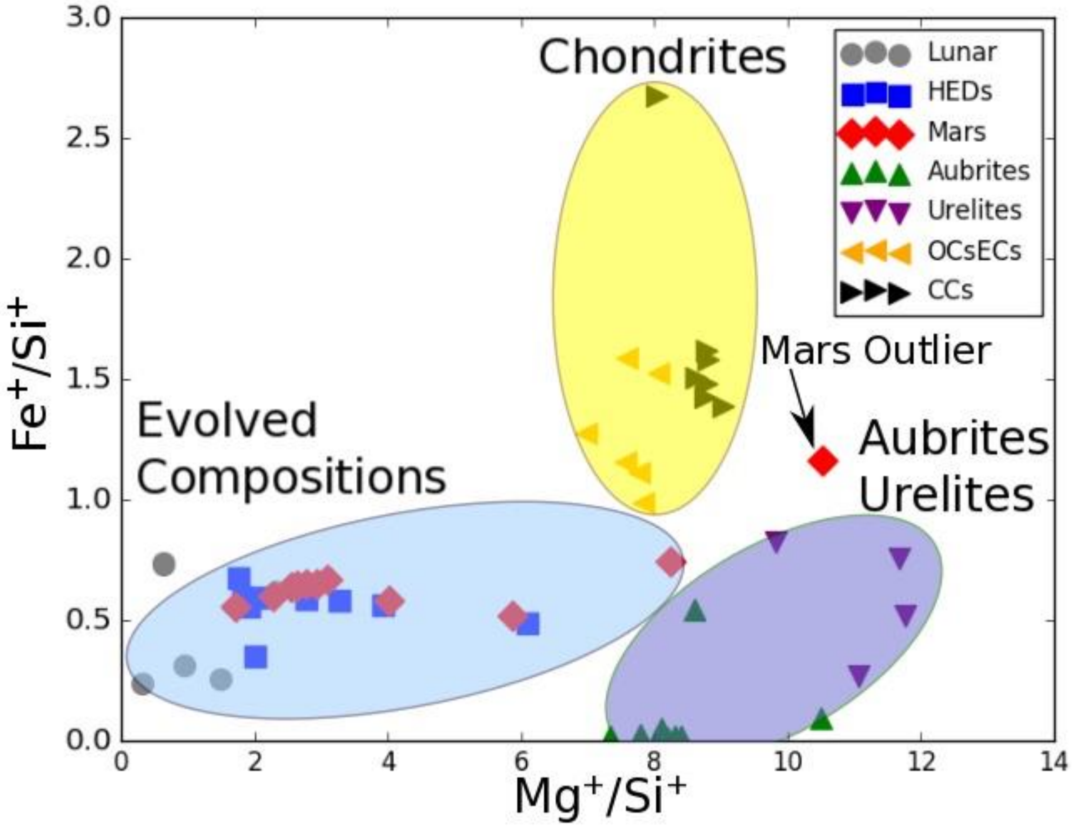
Composition provides the key to determining their origins

Phobos Origin Hypothesis	Predicted Composition	Elemental Abundance
Capture of organic and water-rich outer main belt or outer solar system body	Ultra-primitive or primitive like CI (Ivuna-like) or CM (Mighei-like) chondrites	Medium to high C and S, possibly unique composition
Capture of organic and water-poor outer solar system body	Anhydrous silicates plus elemental C [Emery and Brown, 2004]	High C, Mg/Fe ratio of 2-8 (*e.g.,* Fig. 1(a) - chondrites)
Capture of inner solar system body	Composition similar to common meteorites [Brearley and Jones, 1998]	Mg/Si ratio of <6, Al/Si ratio of 0.05-0.10, low C (*e.g.*, Fig. 1(c) - HED)
Co-accretion with Mars	Bulk Mars and ordinary chondrites [Wanke and Dreibus, 1988]	Mg/Si, Al/Si, Fe/Si typical of bulk Mars (*e.g.*, Fig. 1 - Mars), low C
Giant impact on Mars	Evolved martian crust/mantle, Mars rocks and soil [McSween *et al.*, 2009] plus contribution from impactor	High Al/Si, Ca/Si, lower Fe/Si (<1) and Mg/Si (<4) (*e.g.*, Fig. 1(b)(c) - Mars)

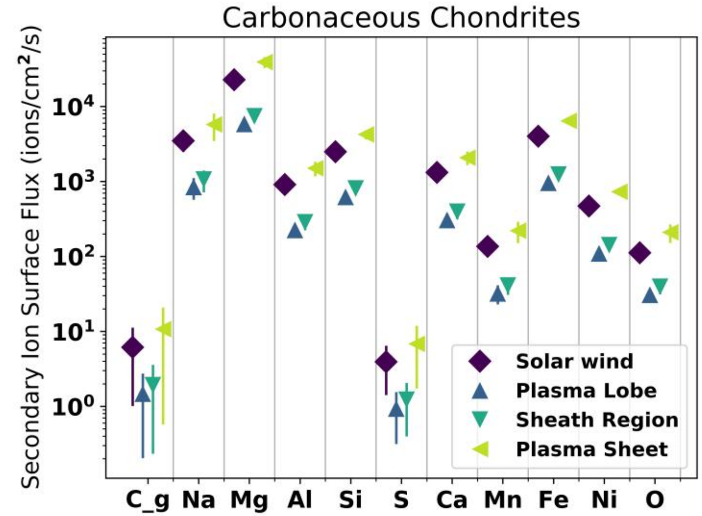
adapted from the Rivkin SSERVI Phobos talk

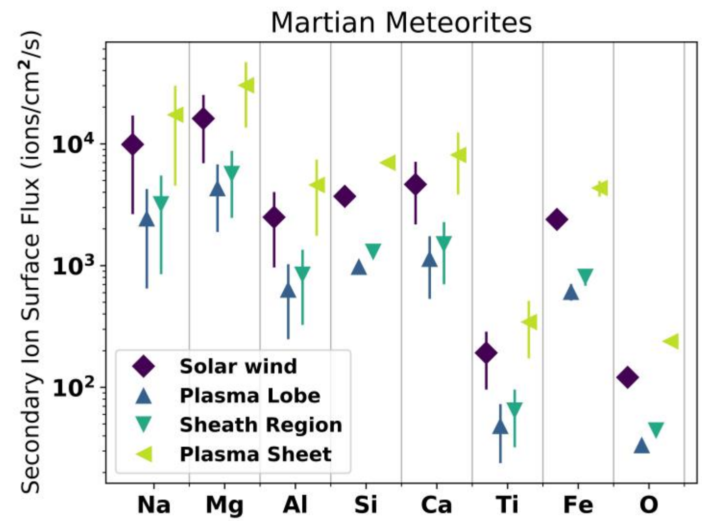
Composition Measurements Using SIMS

SIMS is a standard laboratory technique…

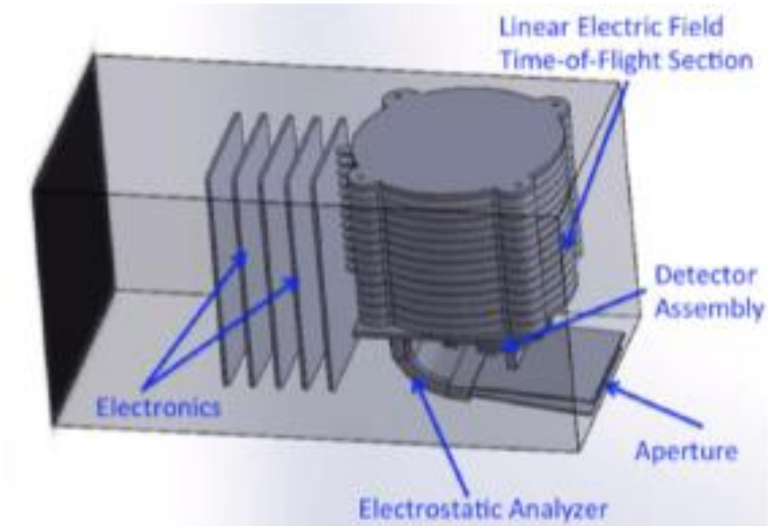


Schaible et al. (2017), JGR-Planets, 122, doi:10.1002/2017JE005359

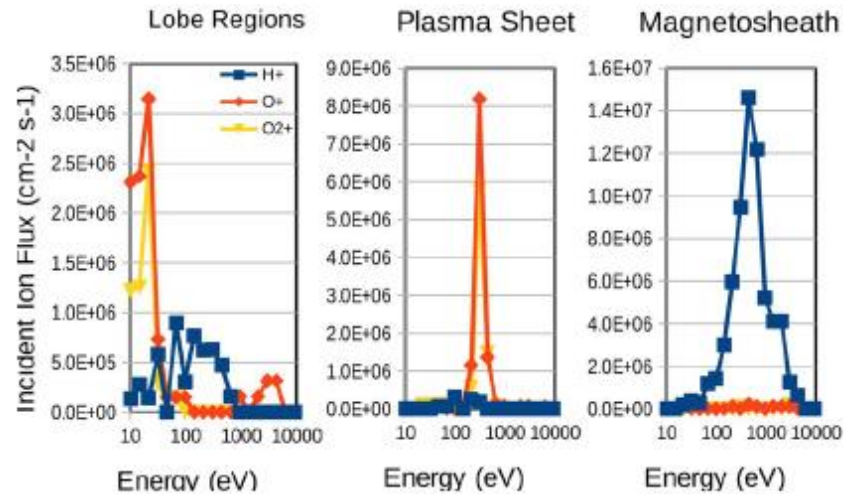




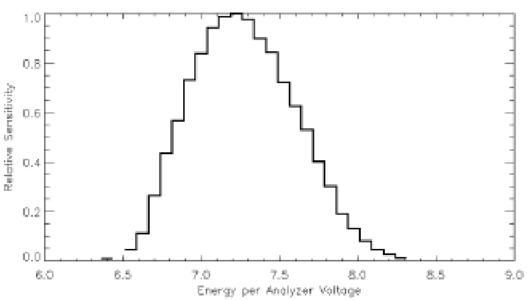
- The space environment continually liberates material from the regoliths of airless bodies throughout the solar system.



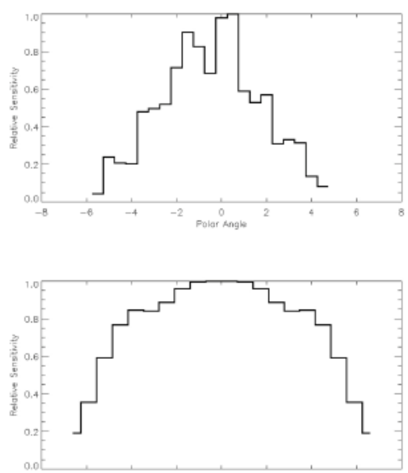
IMS: Ion Mass Spectrometer: Identity and direction secondary ions (e.g., solar wind generated 'pickup ions')



Energy distribution of magnospheric O^+, O_2^+, and H^+ ions at various locations in Phobos as measured by MAVEN mission.



IMS electrostatic analyzer Energy response with 7.2 (energy/voltage) analyzer constant



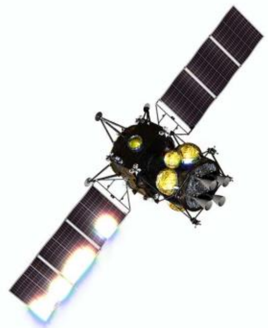
IMS polar (top) and azimuthal (bottom) angular response

Mini-Mag Magnetometer: Direction of Magnetic Field and thus confirmation of pickup ions direction

PRISM and MMX Synergy

Resolving the Origin of the Martian Moon System

JAXA Mars Moons eXploration mission (MMX, 2024-2029)

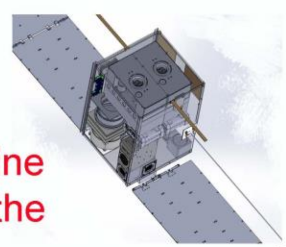


-Flyby of Deimos
-No sample
-Insufficient time for nuclear spectroscopy

-Neutron and Gamma Ray Spectrometer
-Sample return (2029)

Phobos/Deimos Regolith Ion Sample Mission (PRISM, TBD 2020s)

To resolve the origin of Deimos and thus the origin of the Martian Moon System

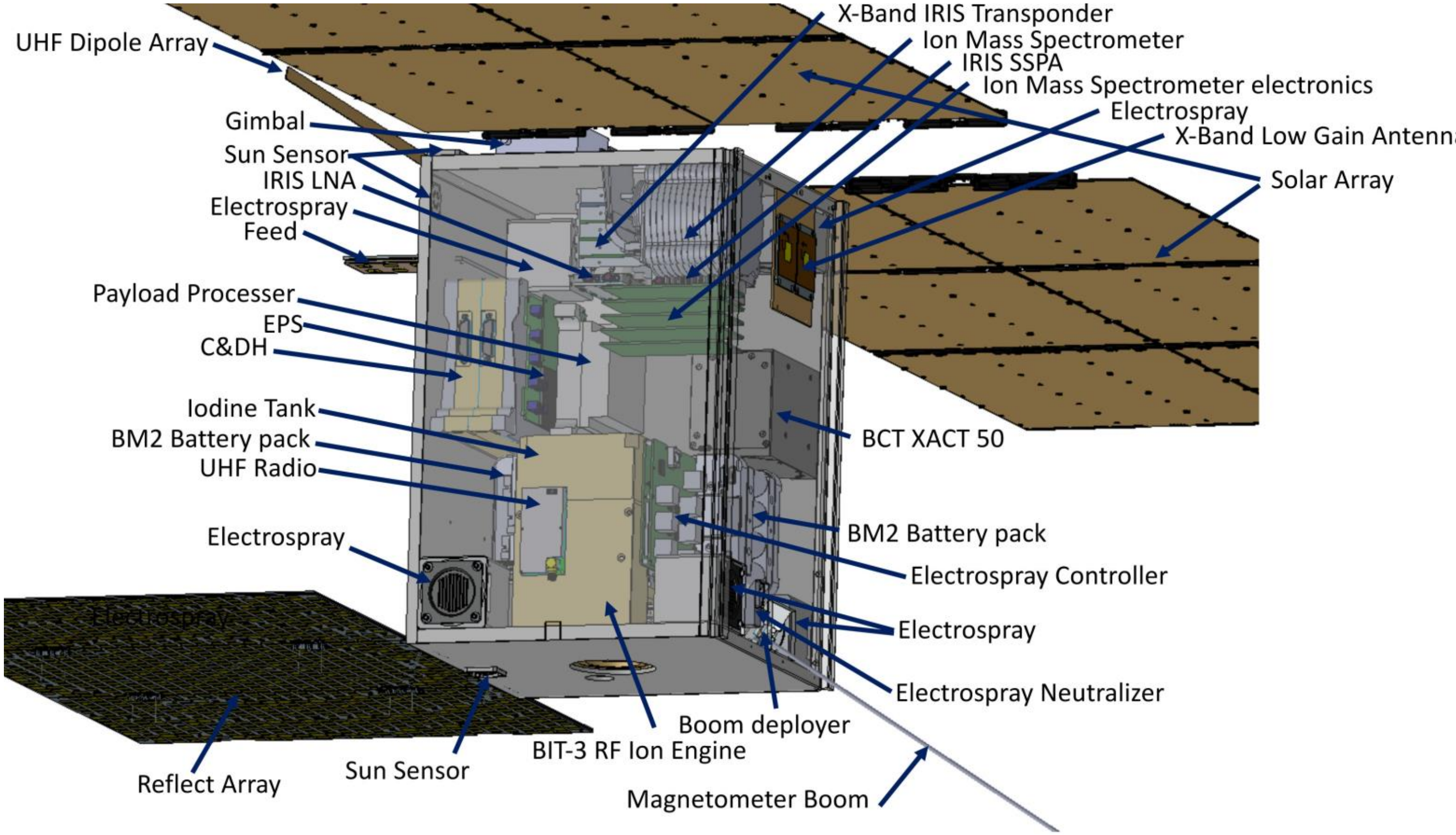


-Co-orbit of Deimos
-SIMS measurements
-Using MMX results, determine Deimos' origin and origin of the Martian Moons System

-Co-orbit of Phobos
-SIMS measurements
-Calibration with MMX results

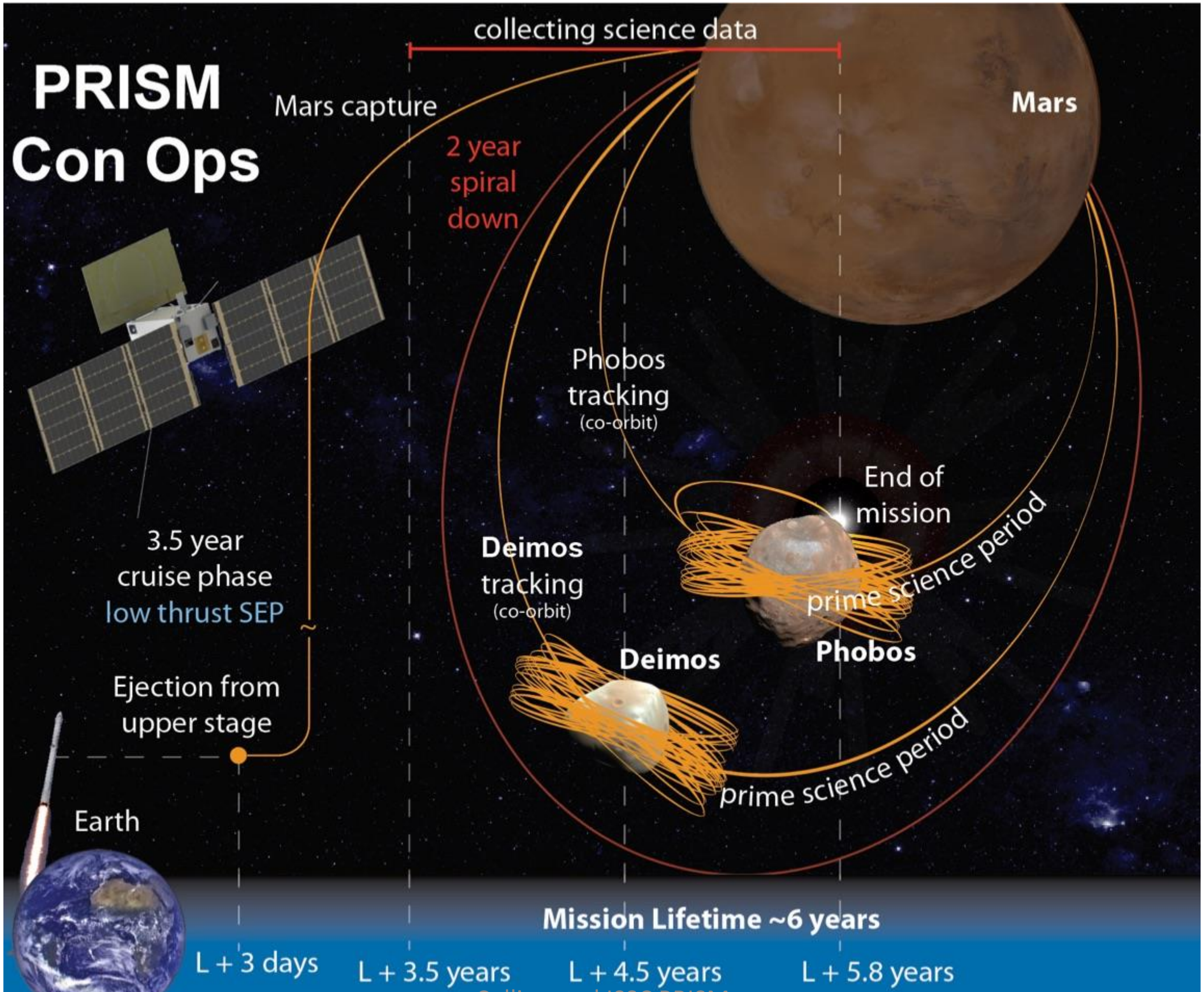
Even without MMX data, the elemental ratios measured by PRISM will establish the nature of the origins (capture versus accretion/cataclysmic) for Phobos and Deimos.

PRISM CubeSat Layout



- The fluxes of sputtered ions from Phobos at an altitude of around 27 km are about 10-1000/cm^2/s. Based on scaling published effective areas down to CubeSat form factors, these fluxes imply that between 0.01 and 1 counts per second per element will be observed. Even at a count rate as low as 0.01 Hz, this requires 10^6 s or a bit over ten days to accumulate sufficient counts in all species shown in the figure, easily achievable over the mission lifetime. Some species will achieve the necessary statistics in hours allowing compositional mapping of the surface and the red and blue units.

CONOPS Overview



Some Current Status Comments:

Instruments: Ion Mass Spectrometer compact version of MAVEN/SWIA operated at Mars; magnetometer, Polar Orbiting Geomagnetics Survey, 1990), high heritage, high TRL robust, experienced team.

Propulsion: Busek BIT-3, being used for Lunar Ice Cube. Useful to expand Busek BIT-3 power from 80 to 90 W to decrease flight time while remaining within same physical envelope

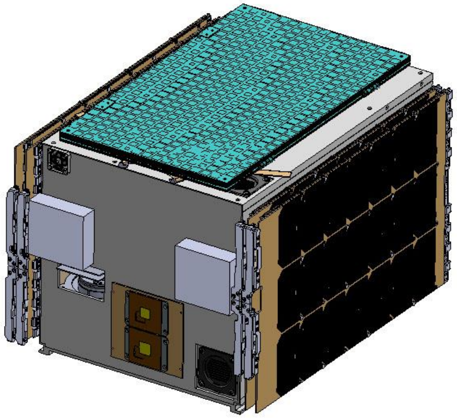
ACS: Further development to push Busek BET-3000-P electrospray ACS thrusters beyond current TRL 5 still needed. Should perform trade study re: adding larger reaction wheel with BCT XACT-50 or utilize XB1 to minimize and shorten desaturation periods.

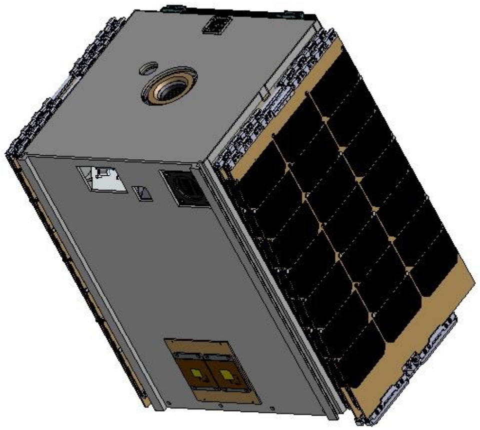
Comm: deployable X-band reflectarray (MarCO) combined with low data rates make this doable even though at Mars.

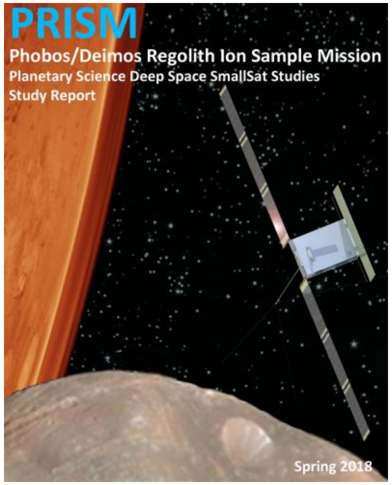
Thermal: 12 U for multiple Deimos/Phobos encounters around Mars seems like a picnic after dealing with 6U lunar ice cube in LUNAR orbit

Conclusion

- space environment to obtain In Situ samples of Phobos' and Deimos' composition to determine the origin of these satellites
- secondary ion mass spectrometry alone can accomplish
- within a CubeSat form factor, on a relatively small budget, and with current technology,
- a CubeSat SIMS mission to Phobos and Deimos will provide the tremendous science return for very little investment.







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