



# The 2013 MAVEN Mission To Mars



*Bruce Jakosky*  
*MAVEN Principal Investigator*  
*University of Colorado*

# Summary of MAVEN Status

- We've been developing MAVEN since 2003; now under 3 months to launch!
- All science instruments are complete and on the spacecraft
- Spacecraft assembly is complete, environmental testing is complete, observatory is at Cape Canaveral in final preparation for launch
- Launch period is 18 November – 7 December, 2013
- Arrival at Mars in September, 2014
- One-Earth-year primary science mission

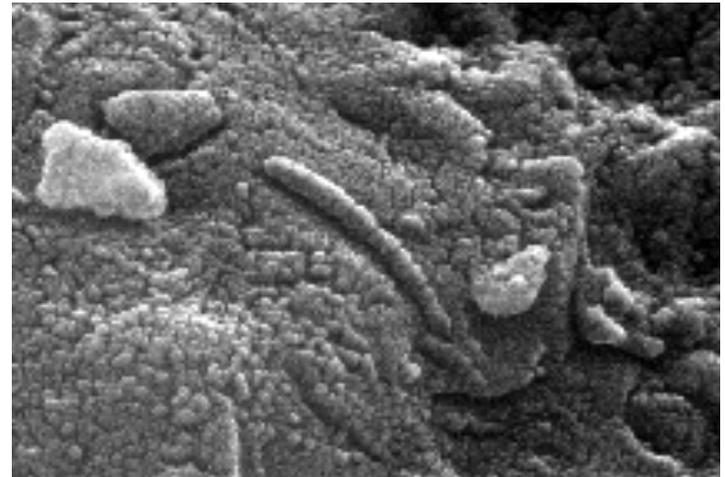
*Technical progress is on track, we are on schedule and on budget!*



# Overarching Question: Did Mars Ever Have Life?

Mars appears to meet or have met all of the environmental requirements for the occurrence of life:

- Liquid water
- Access to the biogenic elements
- Source of energy to drive metabolism



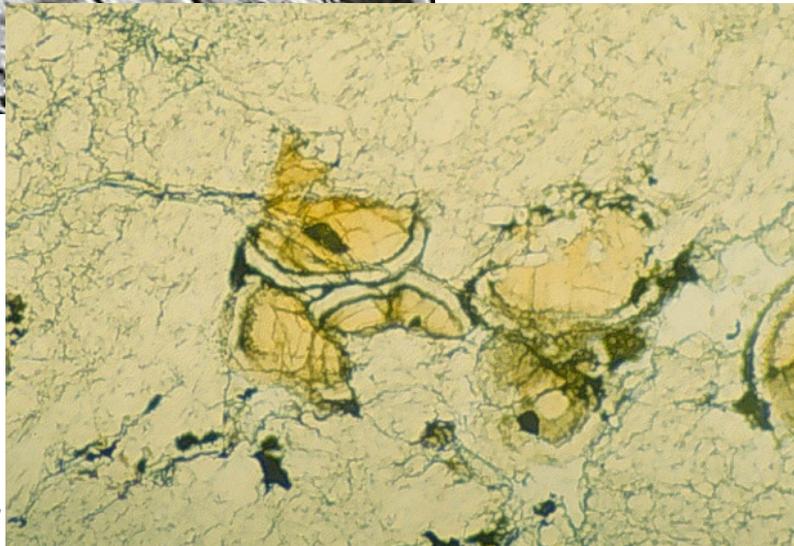
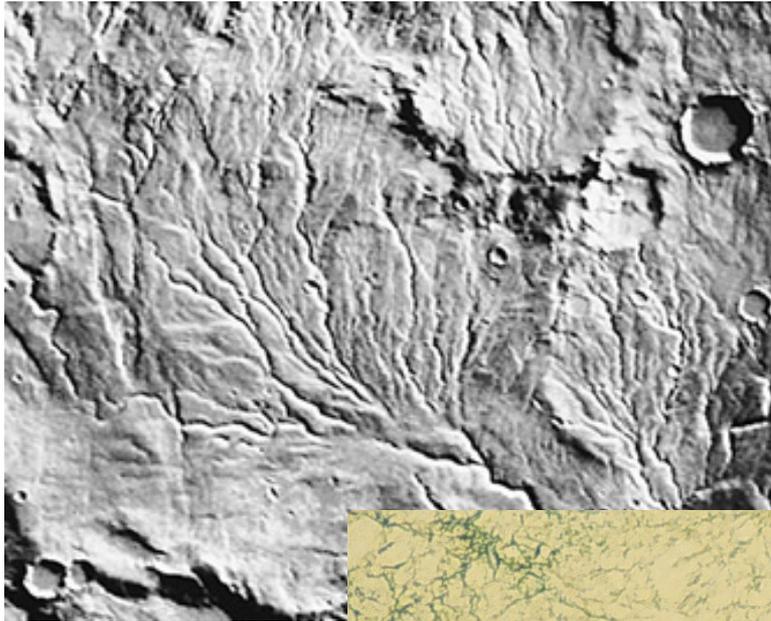
*Did Mars ever have life?*

*How did any life interact with its planetary environment?*

*How has the habitability of Mars changed over time?*

# Where Did The Water Go? Where Did The CO<sub>2</sub> Go?

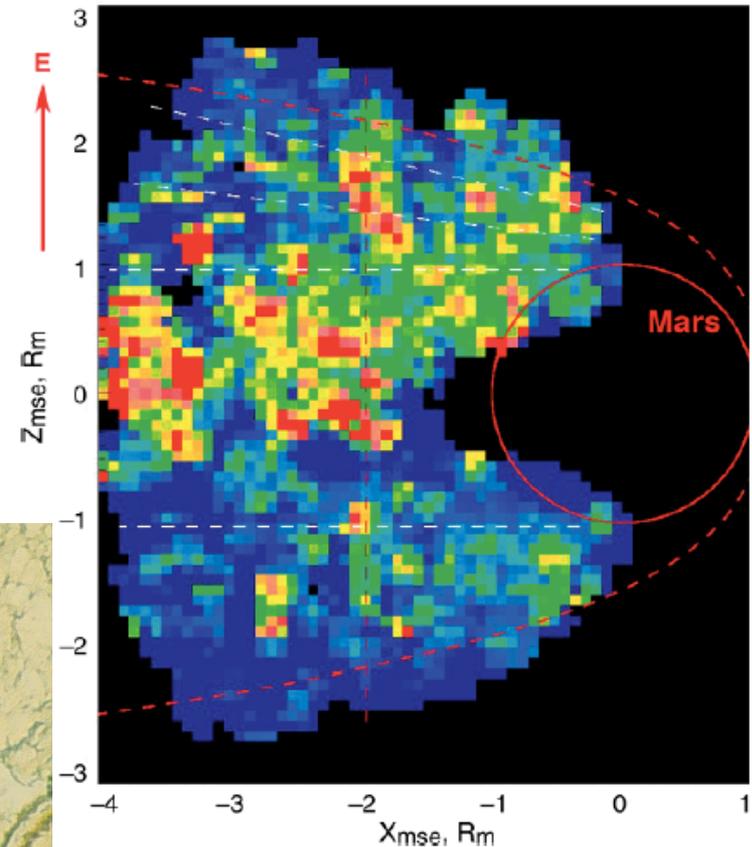
*Abundant evidence for ancient water*



*Carbonate deposits in a Martian meteorite*

*Volatiles can go into the crust*

*Volatiles can be lost to space*



*Escaping ions detected from Mars Express*

# Isotopic Evidence For Loss Of Atmosphere To Space

**Table 1 Martian isotope ratios and atmospheric loss\***

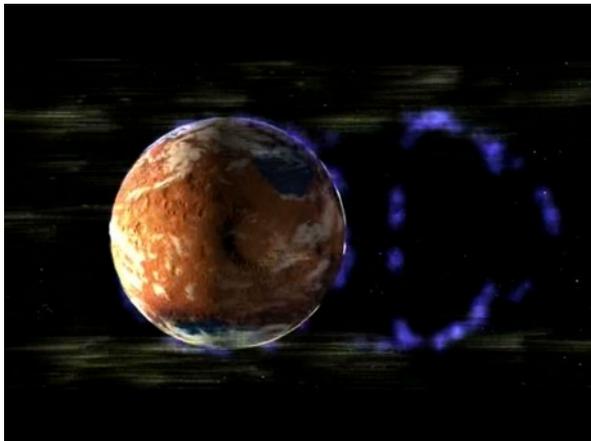
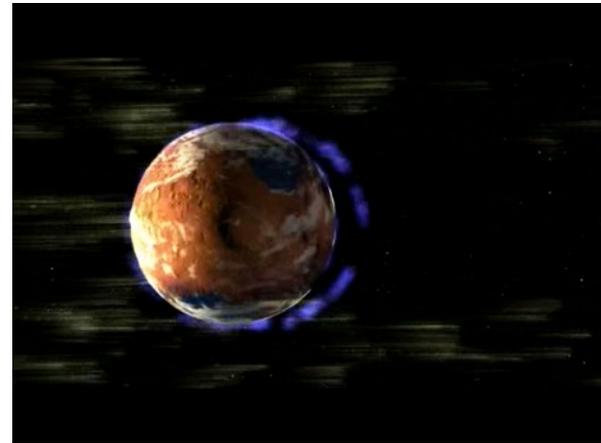
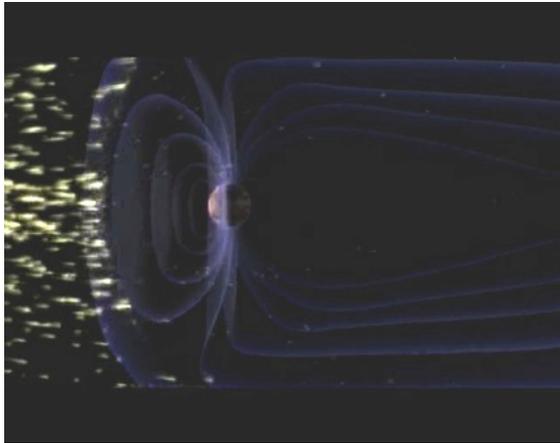
Isotope ratio	Measured value†	Amount lost to space (%)‡
D/H	5	~60–74
$^{38}\text{Ar}/^{36}\text{Ar}$	1.3	~50–90
$^{13}\text{C}/^{12}\text{C}$	1.05–1.07	~50–90
$^{15}\text{N}/^{14}\text{N}$	1.7	~90
$^{18}\text{O}/^{16}\text{O}$	1.025	~25–50

\*Values taken from refs 57–59, 62, 77 and 78, and references therein.

†Value estimated, observed or derived for martian atmosphere relative to terrestrial.

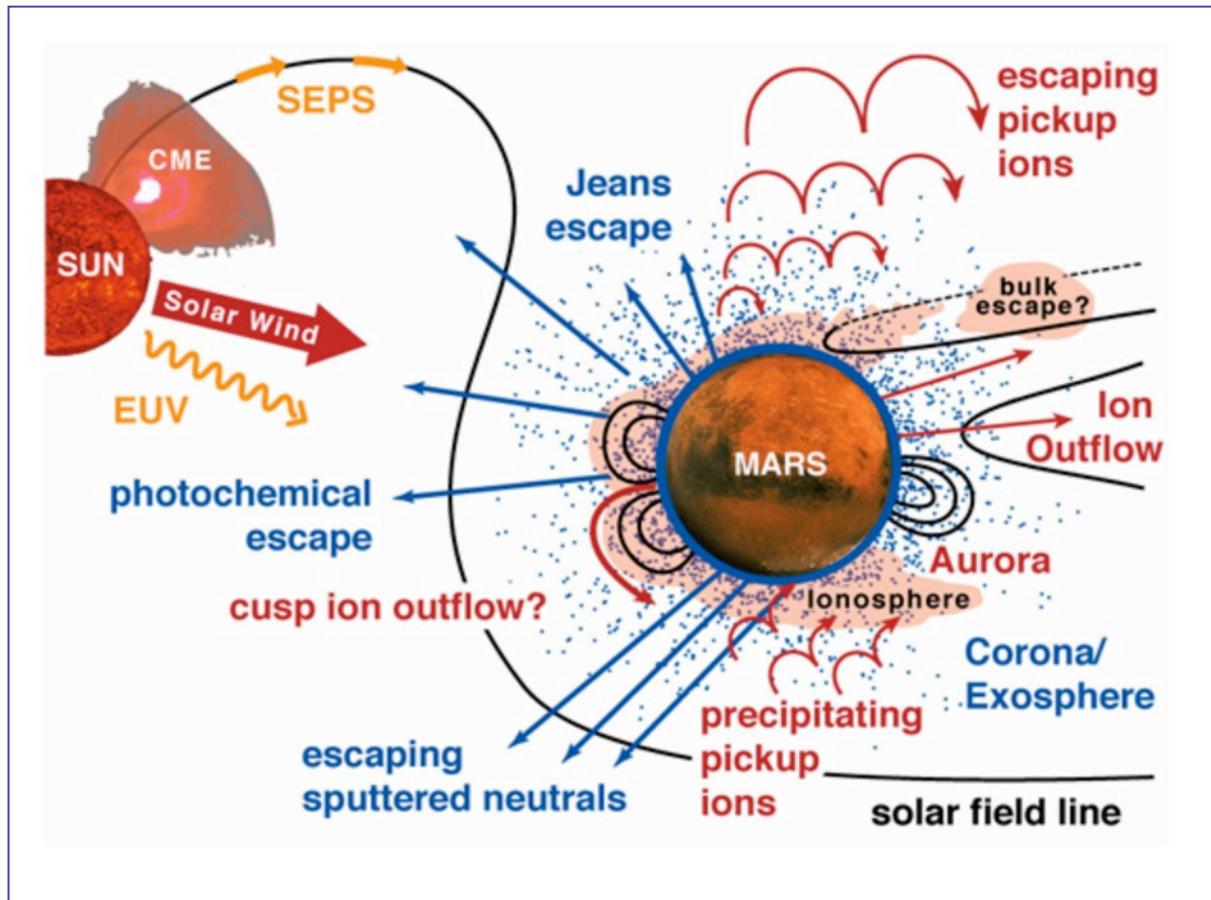
‡Calculated assuming Rayleigh fractionation. D/H range includes uncertainty in escape processes. Other ranges are based on uncertain timing of outgassing relative to escape.

# Working Scenario For Key Process In Evolution Of Martian Atmosphere



*Turn-off of the Martian magnetic field allowed turn-on of solar-EUV and solar-wind stripping of the atmosphere approximately 3.7 billion years ago, resulting in the present thin, cold atmosphere.*

# MAVEN Will Allow Us To Understand Escape Of Atmospheric Gases To Space

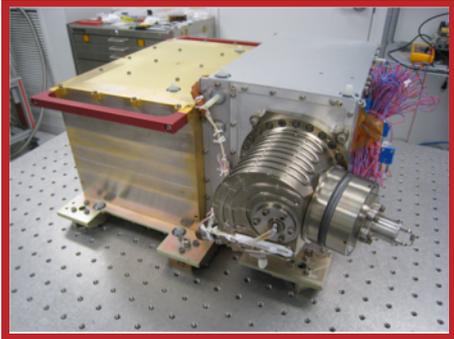


- MAVEN will determine the present state of the upper atmosphere and today's rates of loss to space.

- Measurements will allow determination of the net integrated loss to space through time.

# The MAVEN Science Instruments

## Mass Spectrometry Instrument

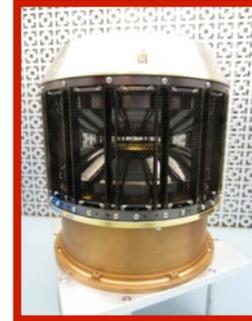


*Neutral Gas and Ion  
Mass Spectrometer;  
Paul Mahaffy, GSFC*

## Particles and Fields Package

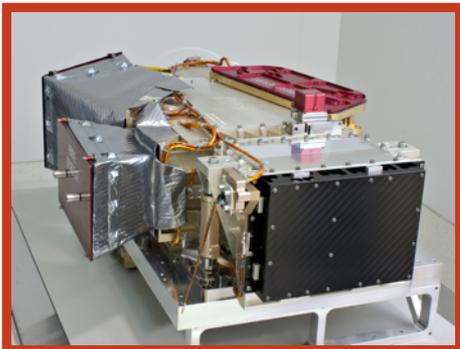


*Solar Energetic Particles;  
Davin Larson, SSL*

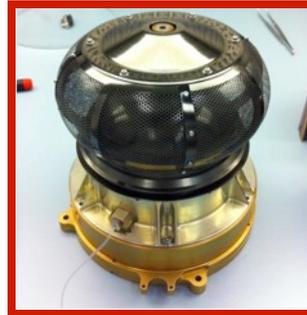


*SupraThermal and Thermal  
Ion Composition; Jim  
McFadden, SSL*

## Remote-Sensing Package



*Imaging Ultraviolet  
Spectrometer; Nick  
Schneider, LASP*



*Solar Wind Electron Analyzer;  
David Mitchell, SSL*



*Solar Wind Ion Analyzer;  
Jasper Halekas, SSL*



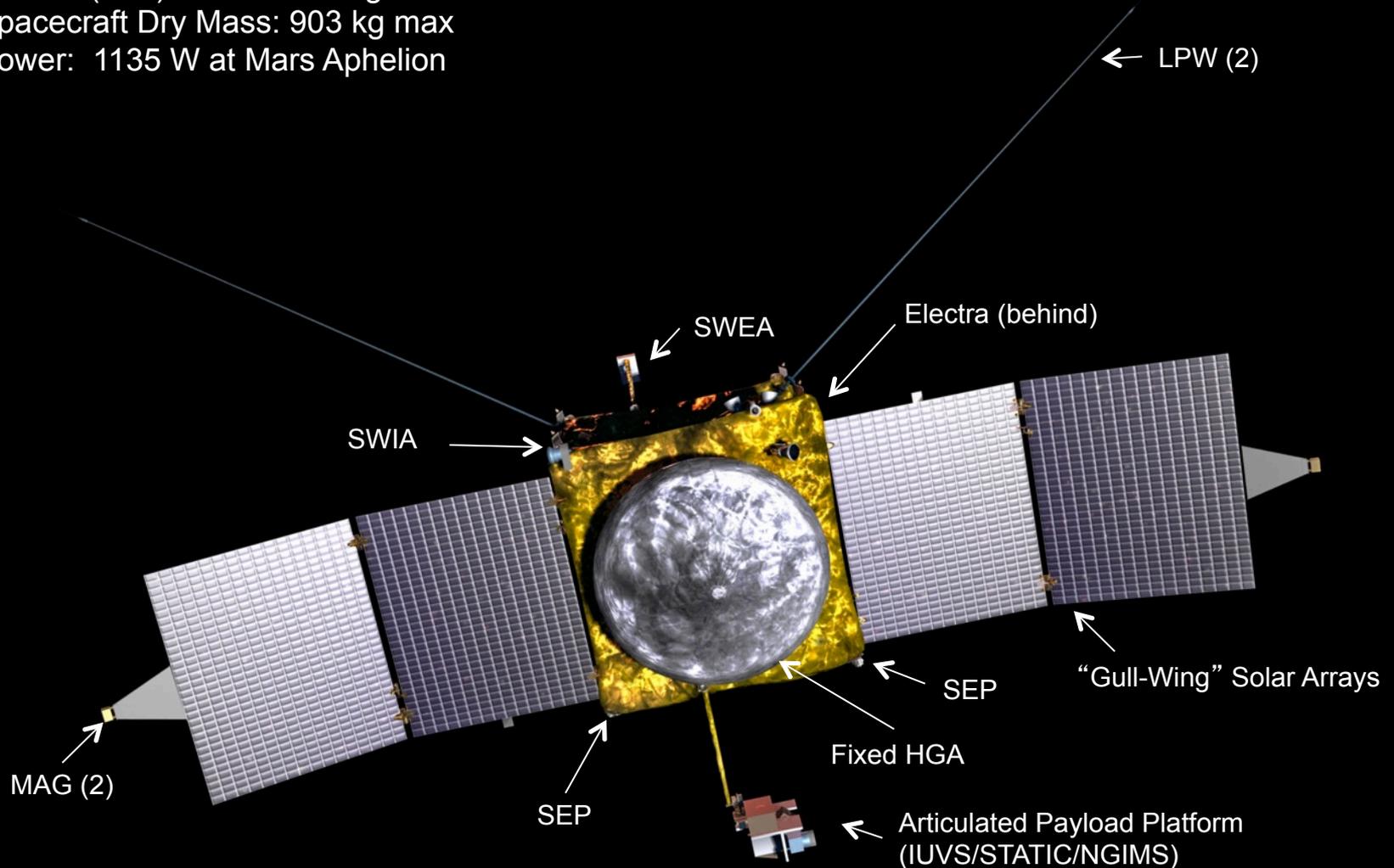
*Langmuir Probe and Waves;  
Bob Ergun, LASP*



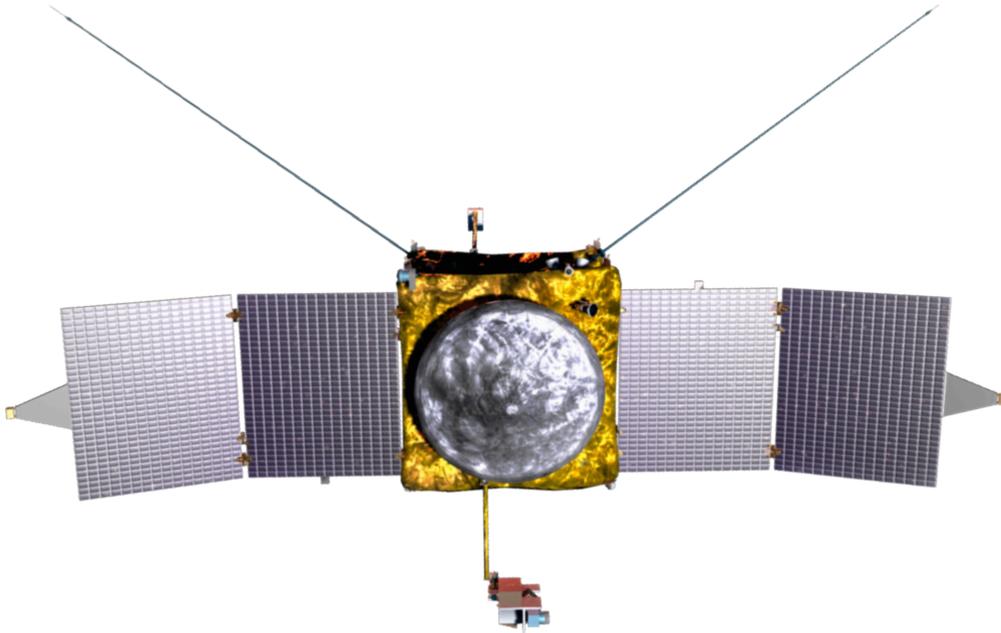
*Magnetometer;  
Jack Connerney, GSFC*

# The MAVEN Spacecraft

- Launch (Wet) Mass: 2550 kg max
- Spacecraft Dry Mass: 903 kg max
- Power: 1135 W at Mars Aphelion



# The MAVEN Spacecraft



Same weight fully loaded as a GMC Yukon – 2550 kg.



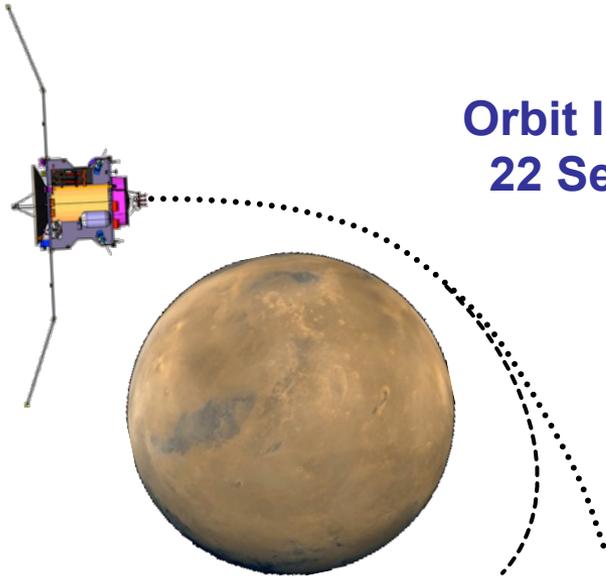
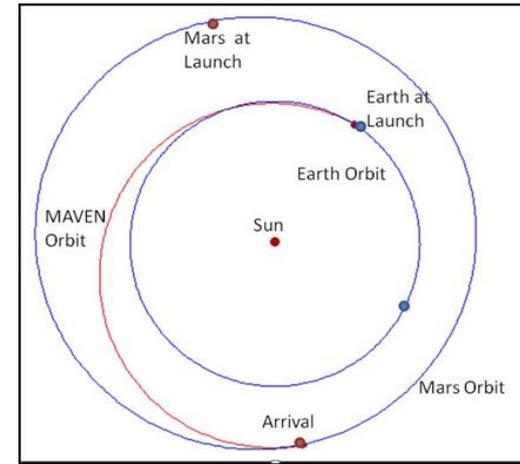
Same length as a school bus – wingtip-to-wingtip length of 37ft.

# MAVEN Mission Architecture



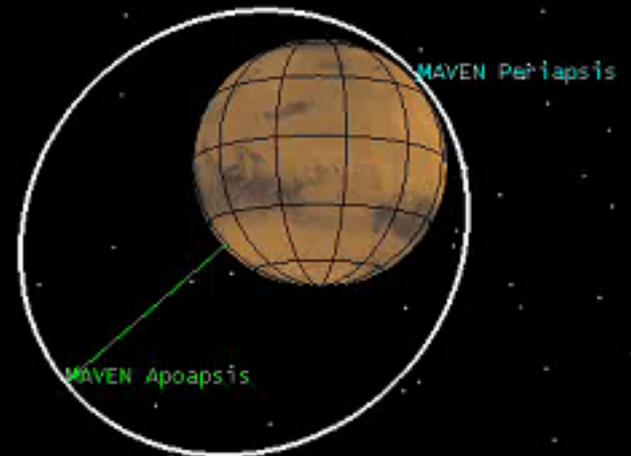
**20-Day Launch Period:  
November 18 –  
December 7, 2013**

## Ten-Month Ballistic Cruise to Mars

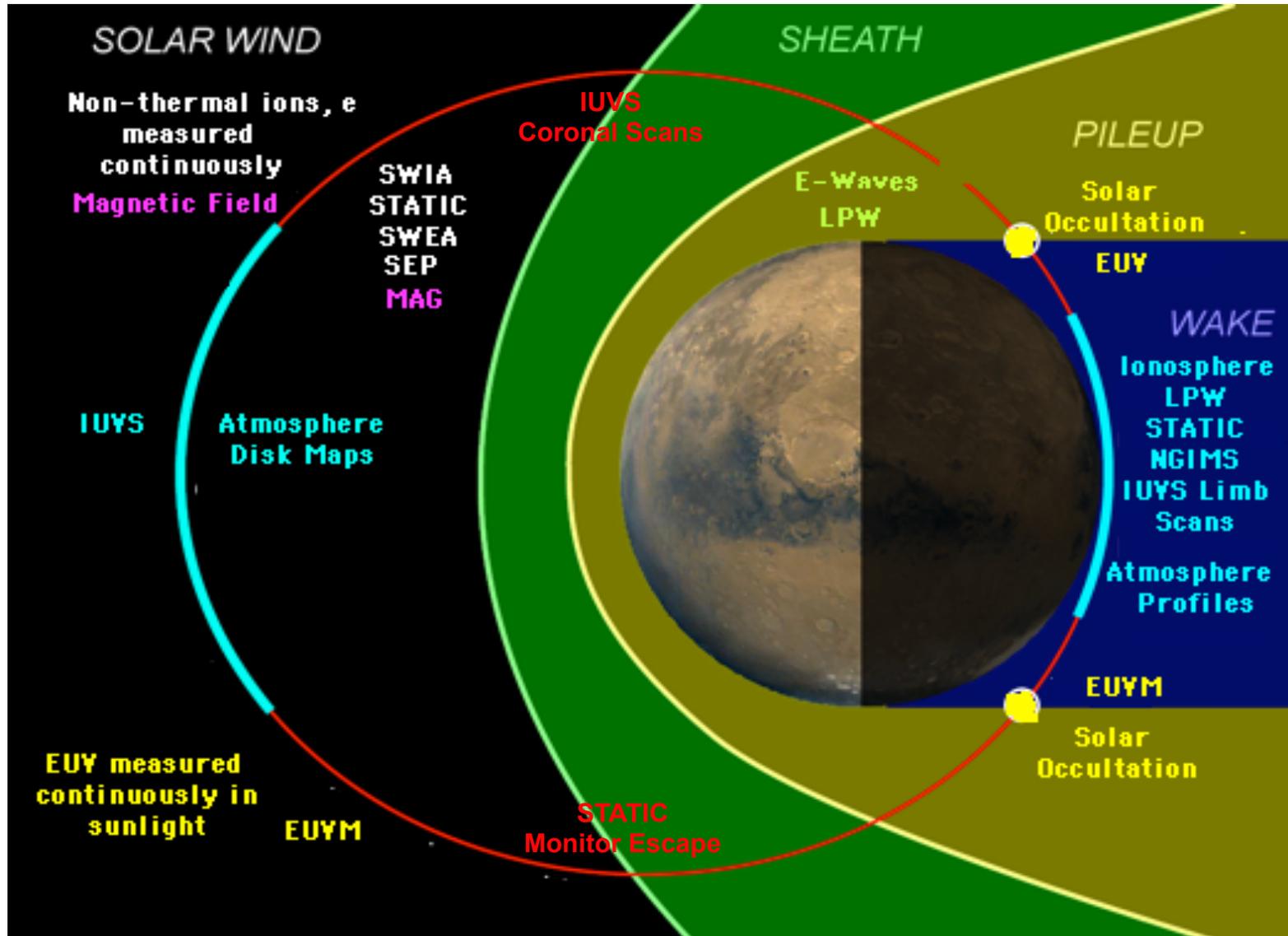


**Orbit Insertion:  
22 Sept 2014**

## One Year of Science Operations

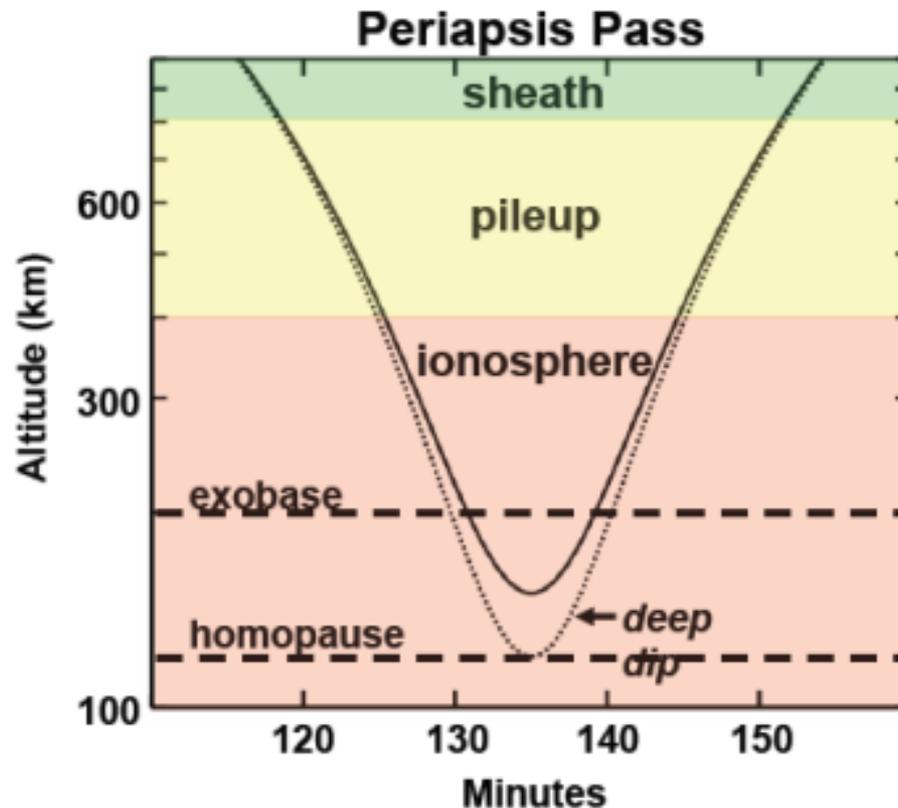


# MAVEN Makes Measurements Throughout The Orbit And Measures All Regions Of Near-Mars Space



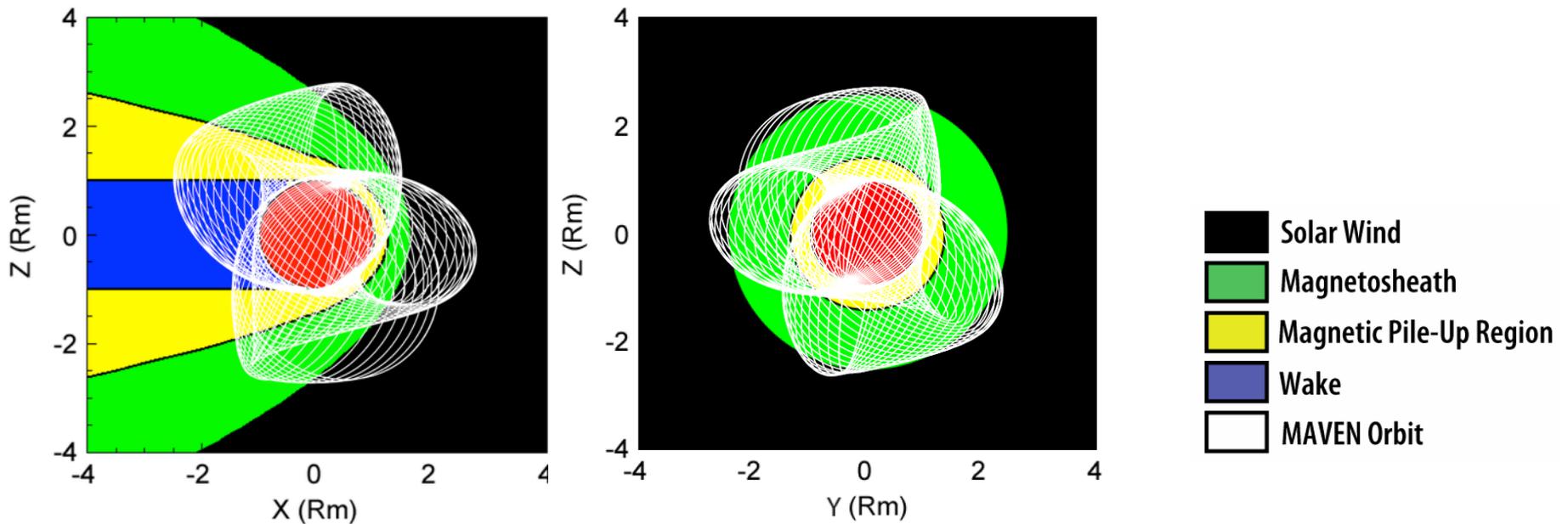
# Elliptical Orbit Allows Measurement of All Relevant Regions of Upper Atmosphere

- Nominal periapsis near 150 km.
- Five “deep-dip” campaigns with periapsis near 125 km.
- Provide complete coverage of entire upper atmosphere



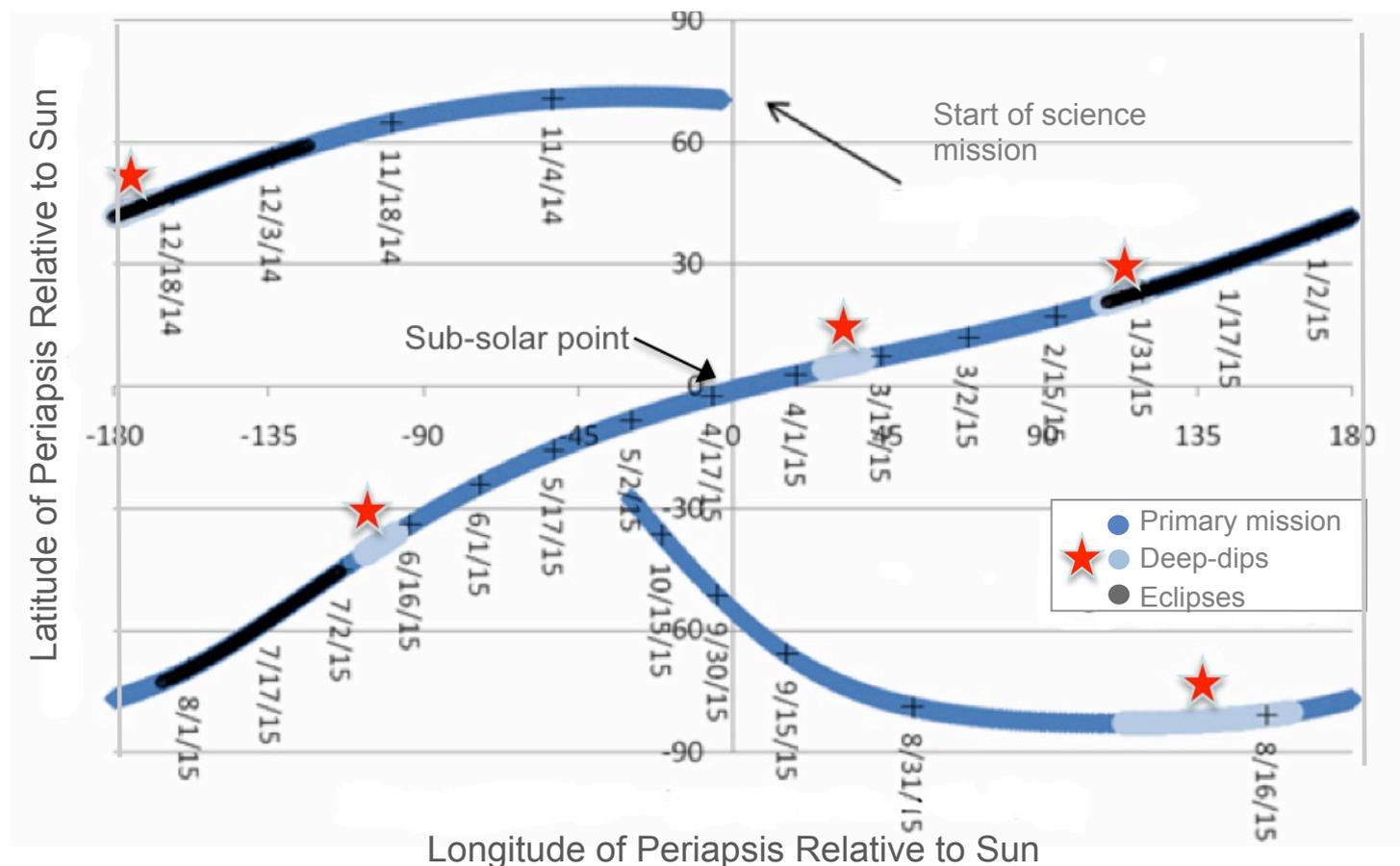
# MAVEN Orbit and Primary Science Mission

- Elliptical orbit to provide coverage of all altitudes
- The orbit precesses in both latitude and local solar time
- One-Earth-year mission allows thorough coverage of near-Mars space

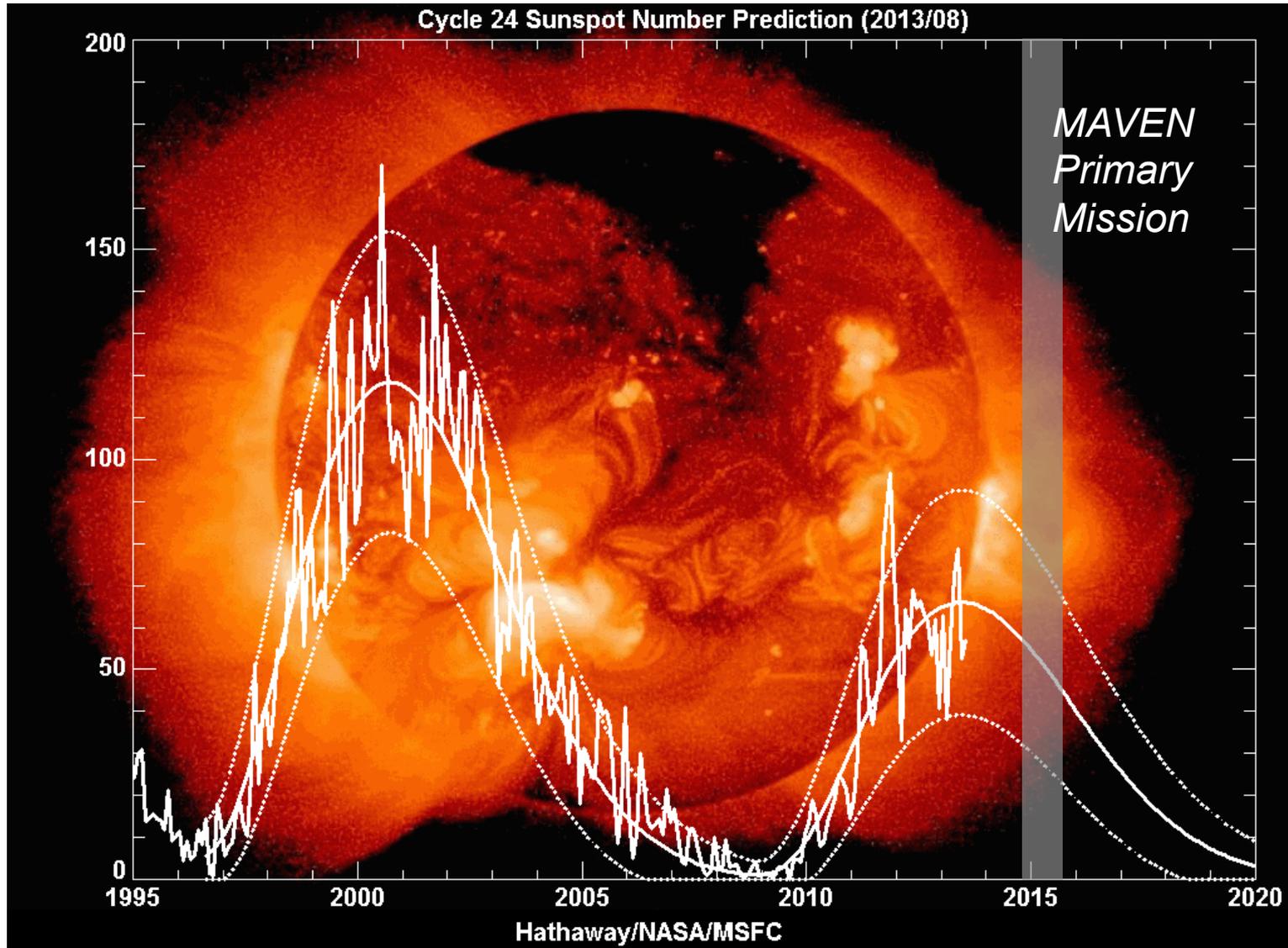


# Latitude and Local Time Coverage

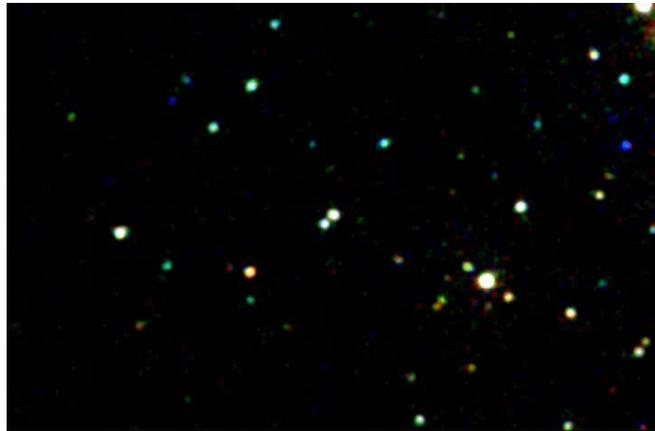
- One-Earth-year mission provides coverage of all local solar times and most latitudes.
- Figure shows periapsis location for each orbit.
- Deep dips near subsolar region, midnight, terminator, crustal B region, polar cap



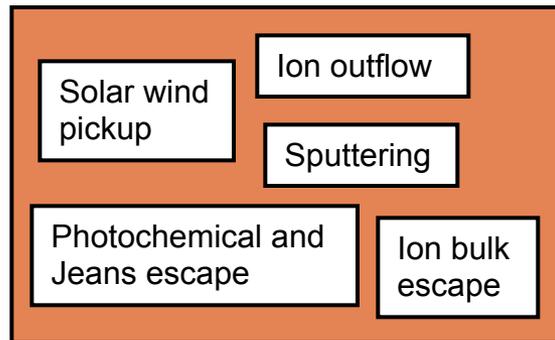
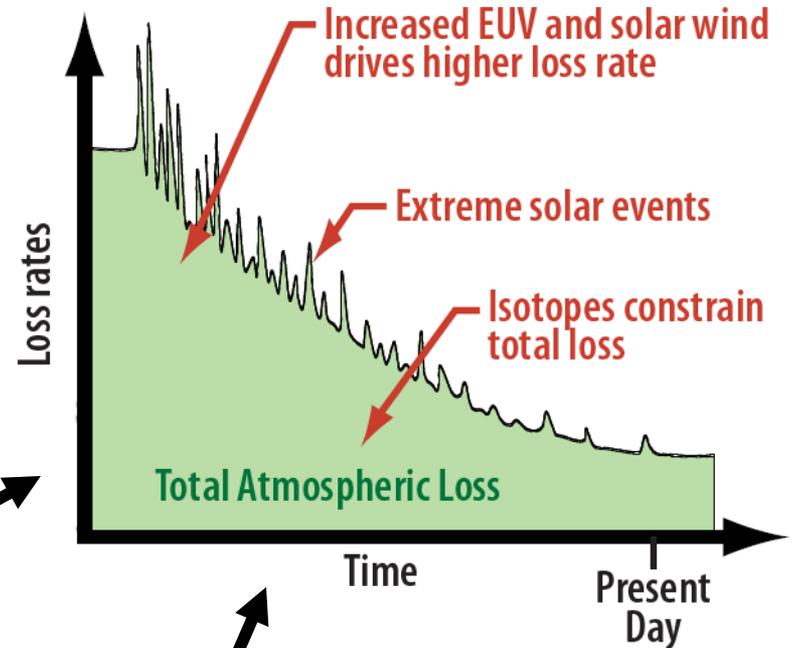
# MAVEN's Timing in the Solar Cycle



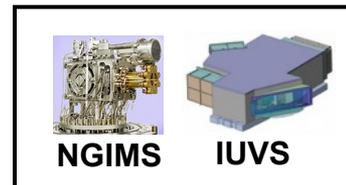
# Constraining the Total Atmospheric Loss Through Time



History of Solar Activity



Physical & Empirical Models



NGIMS

IUVS

Isotope Ratios

*We will use multiple, independent approaches to determining atmospheric loss.*

# Mission Operations at Lockheed Martin, Science Operations at CU/LASP



*Lockheed Martin Mission Support Area*



*LASP MAVEN Science Operations Center*

# Proposal, Site Visit, and Presentation at NASA HQ



# One Of ~220 Reviews Over The Life Cycle Of MAVEN



# MAVEN Spacecraft Early In Assembly

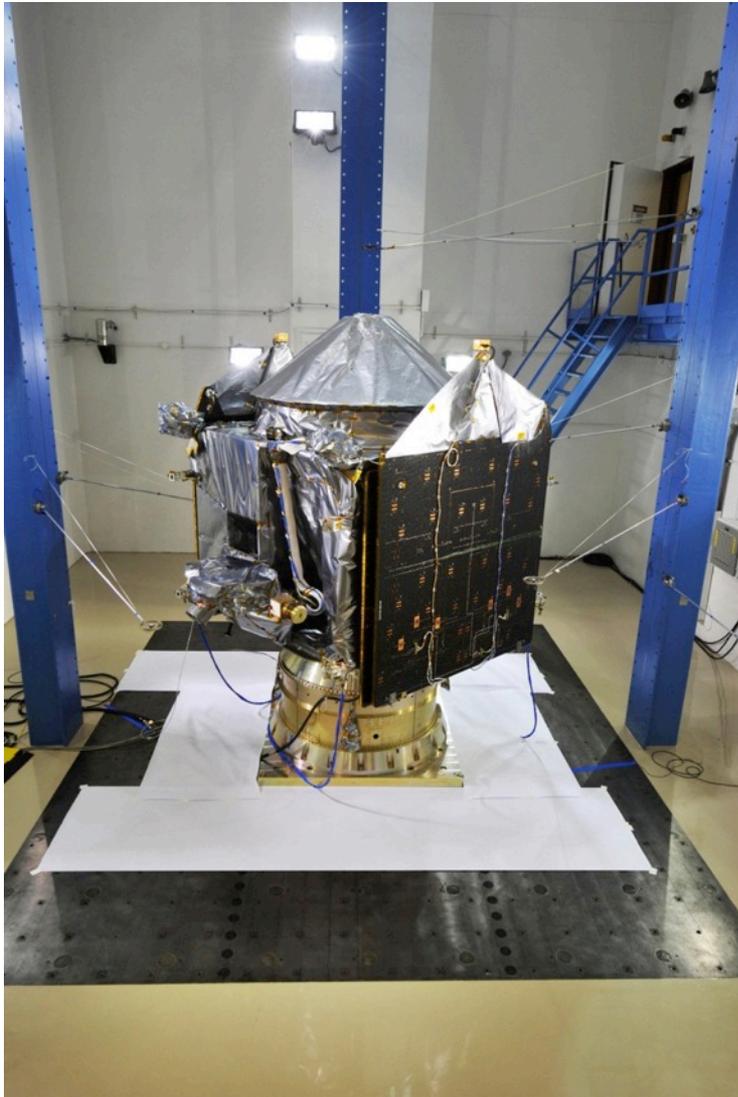


*Integration of core structure with fuel tank*

# Nearly Complete Spacecraft In Lockheed Martin High-Bay Cleanroom



# Observatory in Environmental Testing

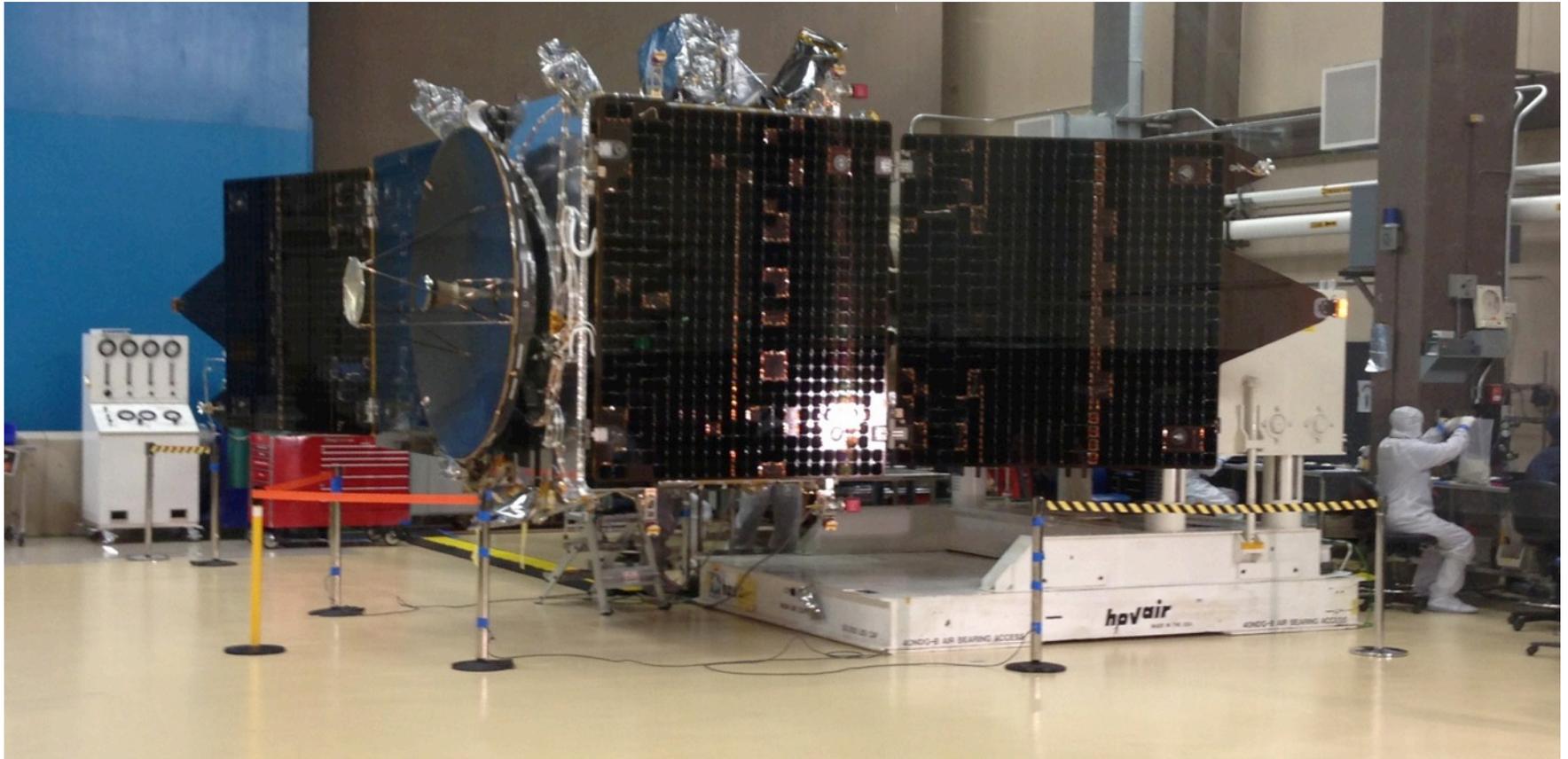


**MAVEN in Acoustics**



**MAVEN on Shaker – Sine Vibration**

# MAVEN Observatory Ready To Ship



# Starting Its Journey To Mars: From Lockheed Martin To Kennedy Space Center, 2 August 2013

*Lockheed Martin*



*Buckley AFB, Colorado*



*Shuttle Landing Strip, KSC*



*PHSF, KSC*



# MAVEN's Atlas V – 401



Atlas 1<sup>st</sup> Stage



En Route to the Cape

Atlas Centaur 2<sup>nd</sup> Stage



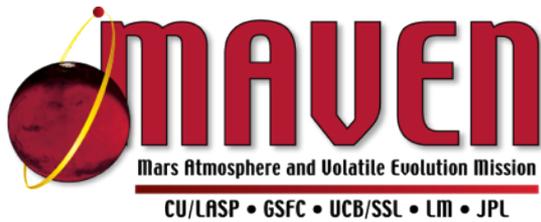
Atlas Payload Fairing



# From Arrival At Cape To Launch

- ✓ Inspect, clean, and prepare spacecraft after shipping
- ✓ Re-install equipment that had been removed for shipping
- ✓ Re-install components that had been removed for minor rework or calibration
- Conduct System Verification Tests to ensure that everything works properly
- Install pyro devices
- Final spin balance test
- Load fuel
- Mate spacecraft to payload support structure that will attach to upper stage
- Install spacecraft into payload fairing
- Transport to Vertical Integration Facility (VIF) and mate with Atlas booster and Centaur upper stage
- Roll out to launch pad (day before launch)
- Fuel booster and upper stage (on launch pad on day of launch)
- Final countdown and launch

***Note: Launch is a major milestone in the project, but remember that the goal is the science!***



***MAVEN is on track, on schedule, and on budget.***

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