

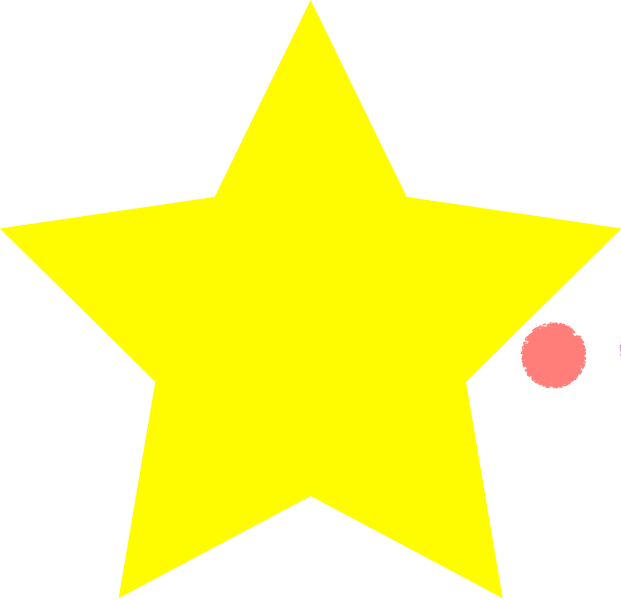
I can show you the worlds

The Science of Planetary Exploration

Anjali Tripathi
Kirit Karkare
Sukrit Ranjan

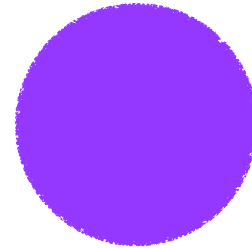
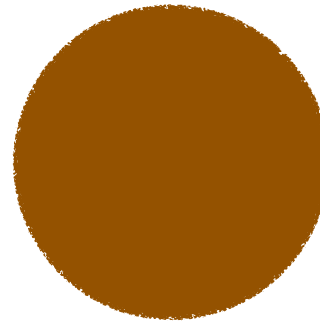
Solar System

Sun



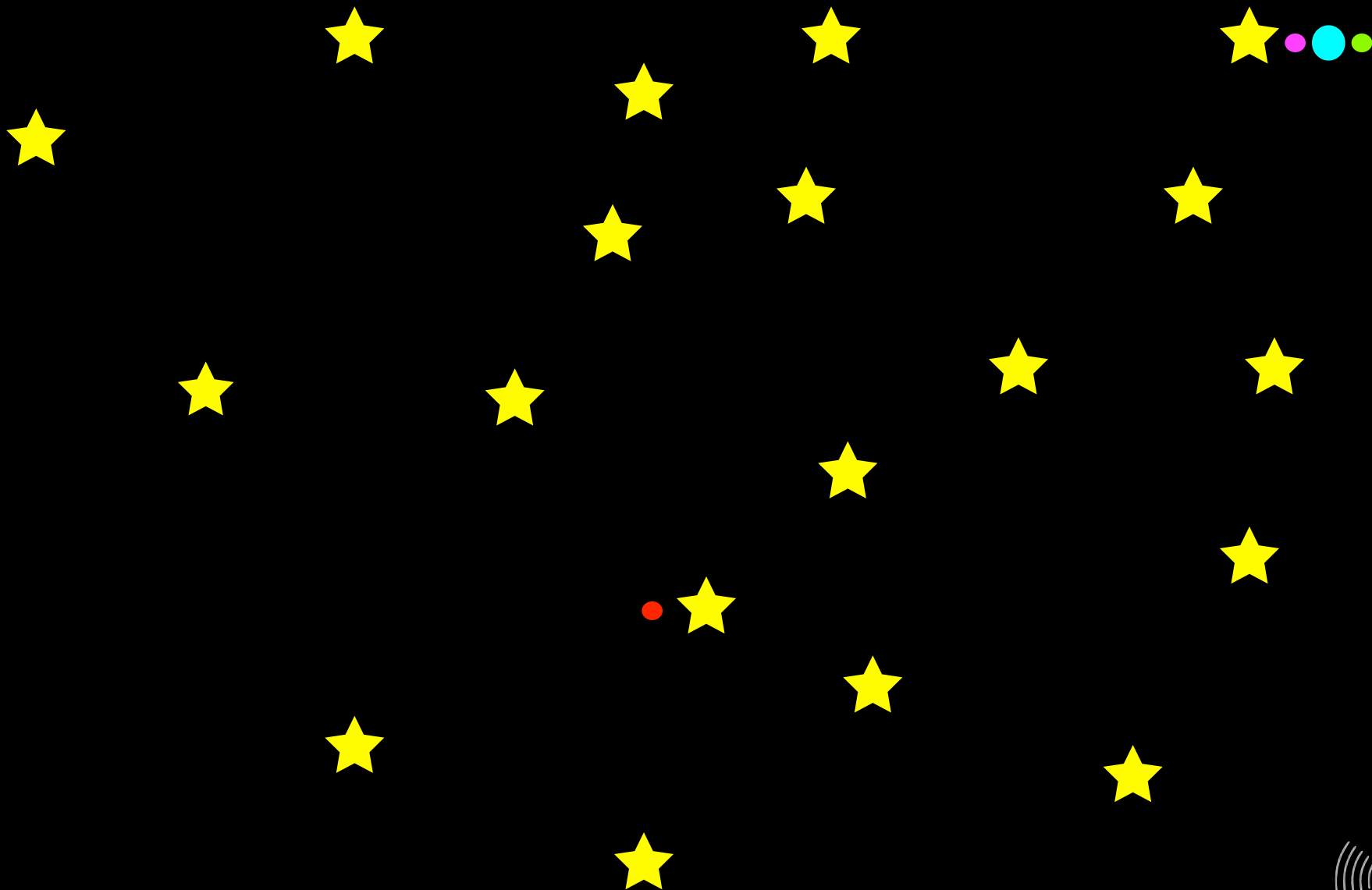
Star

Earth



Planets





Outline

- Anjali: Robotically Exploring the Solar System
- Kirit: Detecting Extrasolar Planets
- Sukrit: The Search for Life Beyond Earth

I can show you the worlds

How can we learn about the planets?

Anjali Tripathi

Kirit Karkare

Sukrit Ranjan

The Naked Eye



Telescopes



Wellcome Library

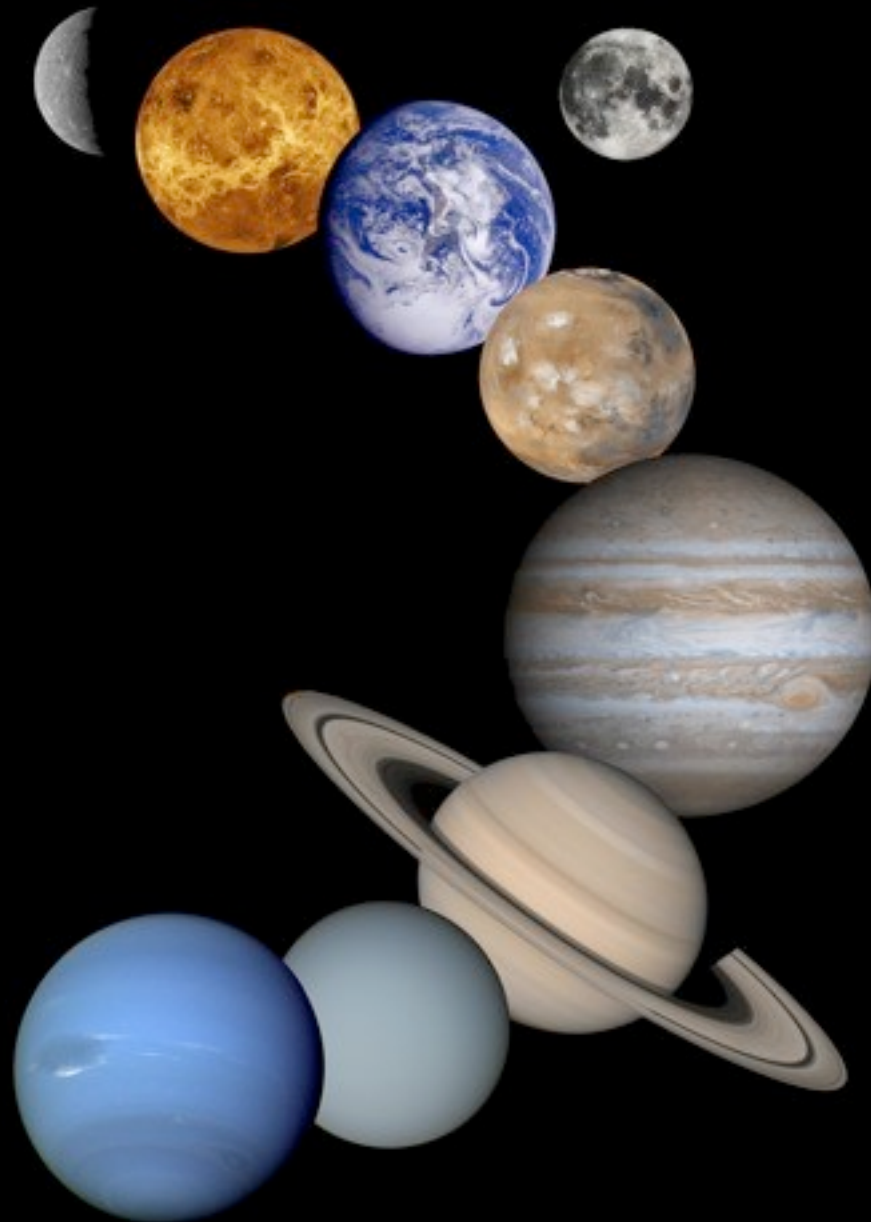
Telescopes



Wellcome Library

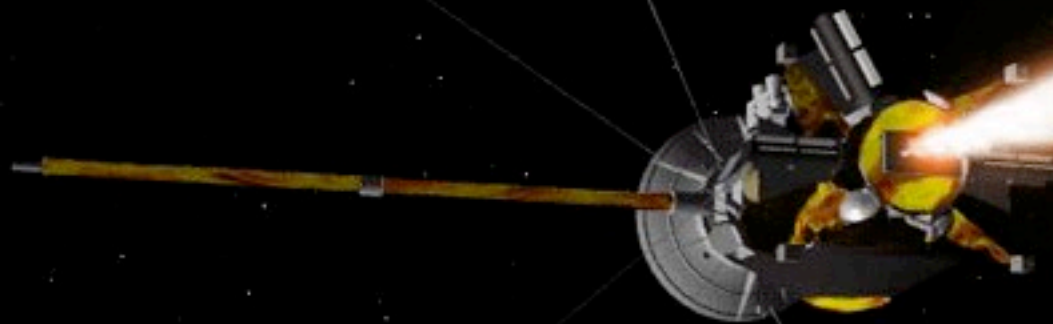


AIP



Spacecraft!

Unmanned, or robotic missions





Allow us to get a closer view

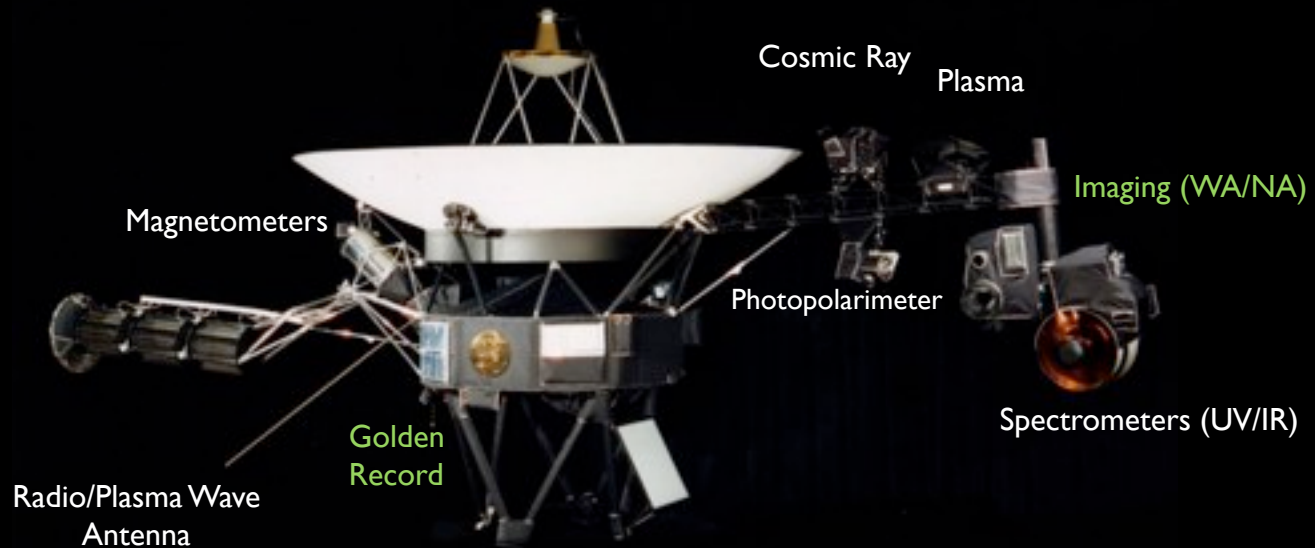


Get measurements in place

SENSES in space

Voyager I & II

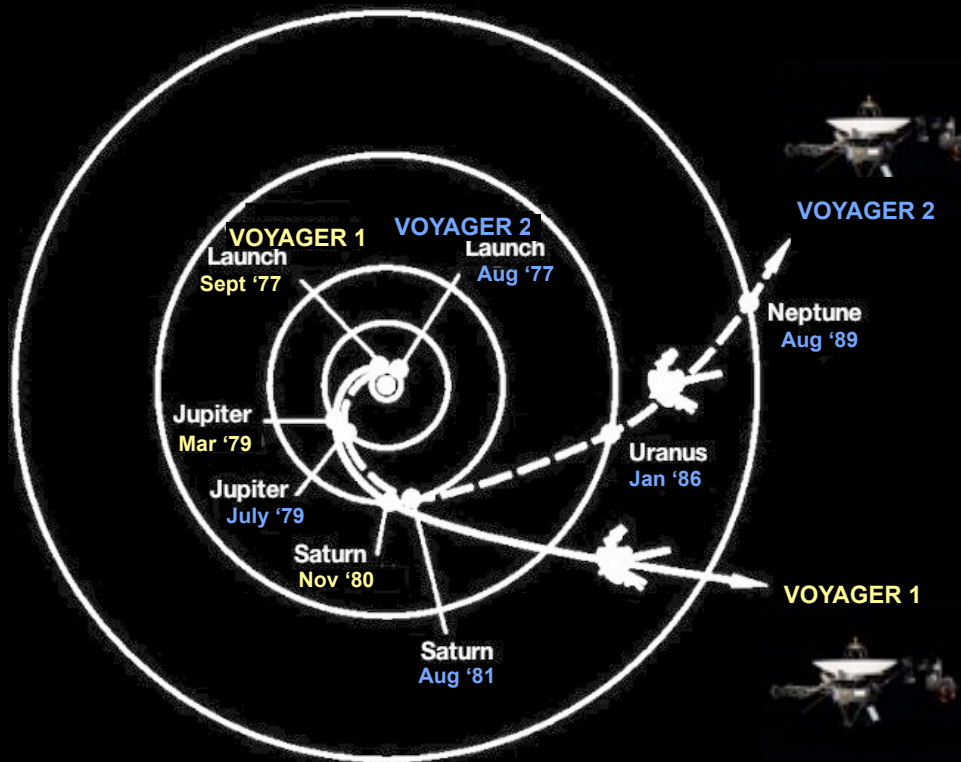
Flying by the Gas Giants



Science Instruments

Voyager I & II

Flying by the Gas Giants



NASA/JPL

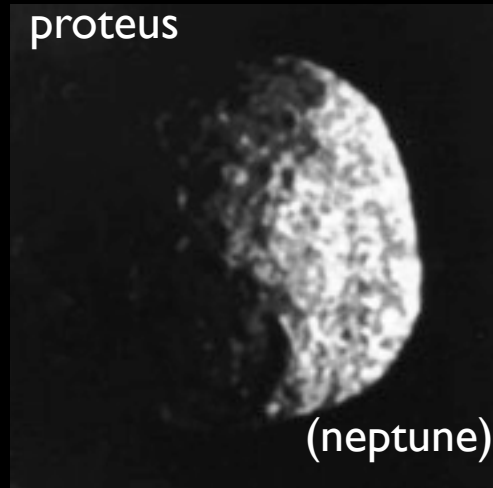


Visited Jupiter, Saturn, Uranus & Neptune

discoveries:

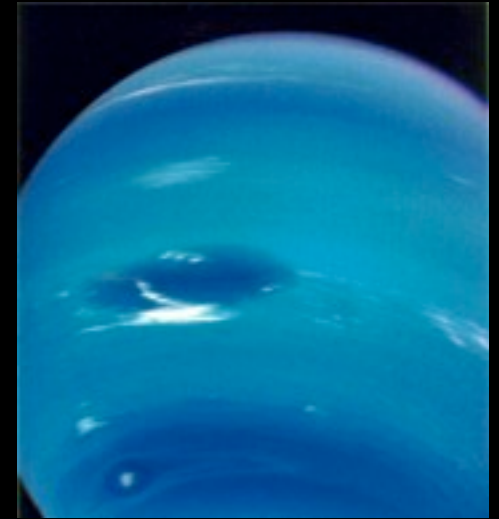


jupiter has **rings**



more **moons**

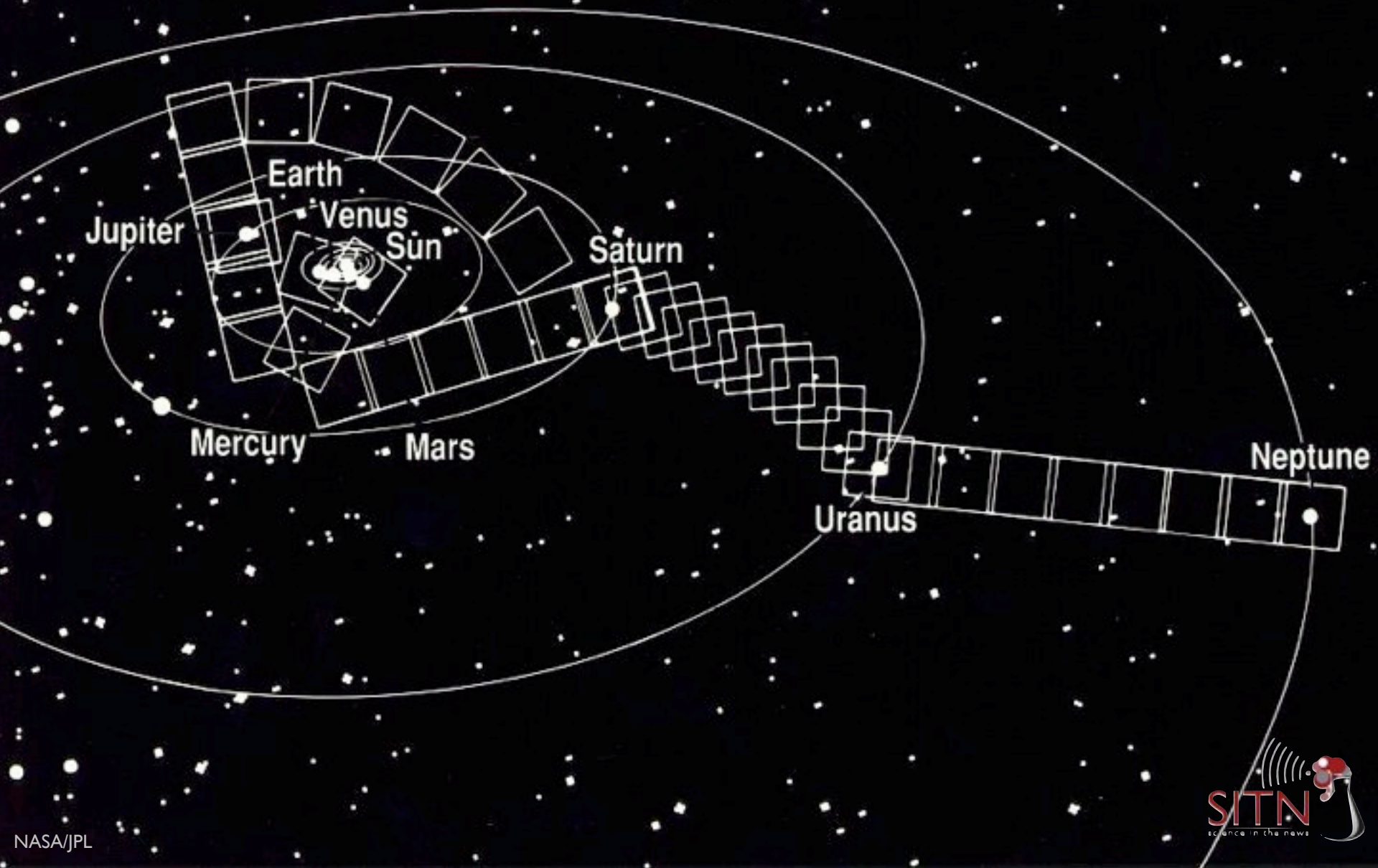
- 3 - jupiter
- 3 - saturn
- 10 - uranus
- 6 - neptune



storms on neptune

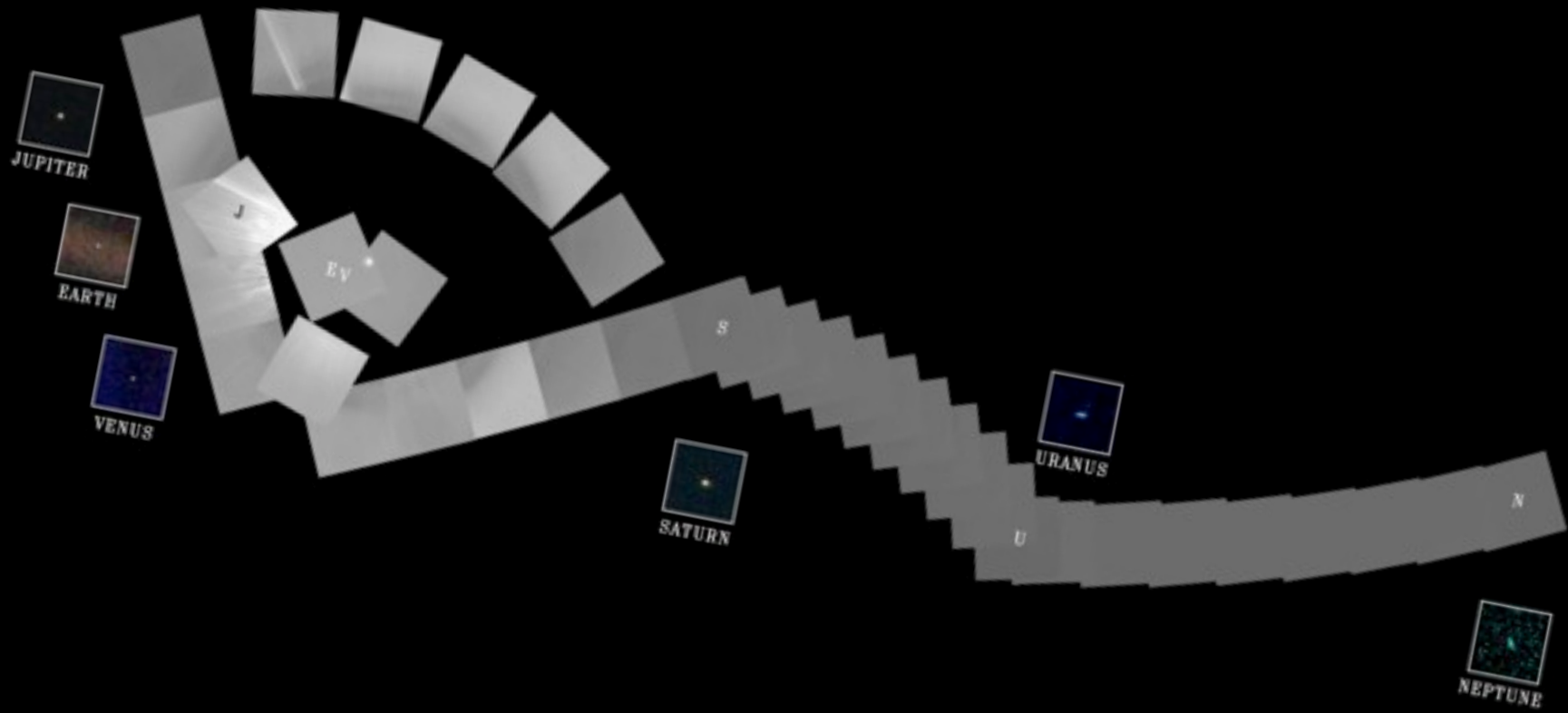
February 14, 1990

4,000,000,000 miles away



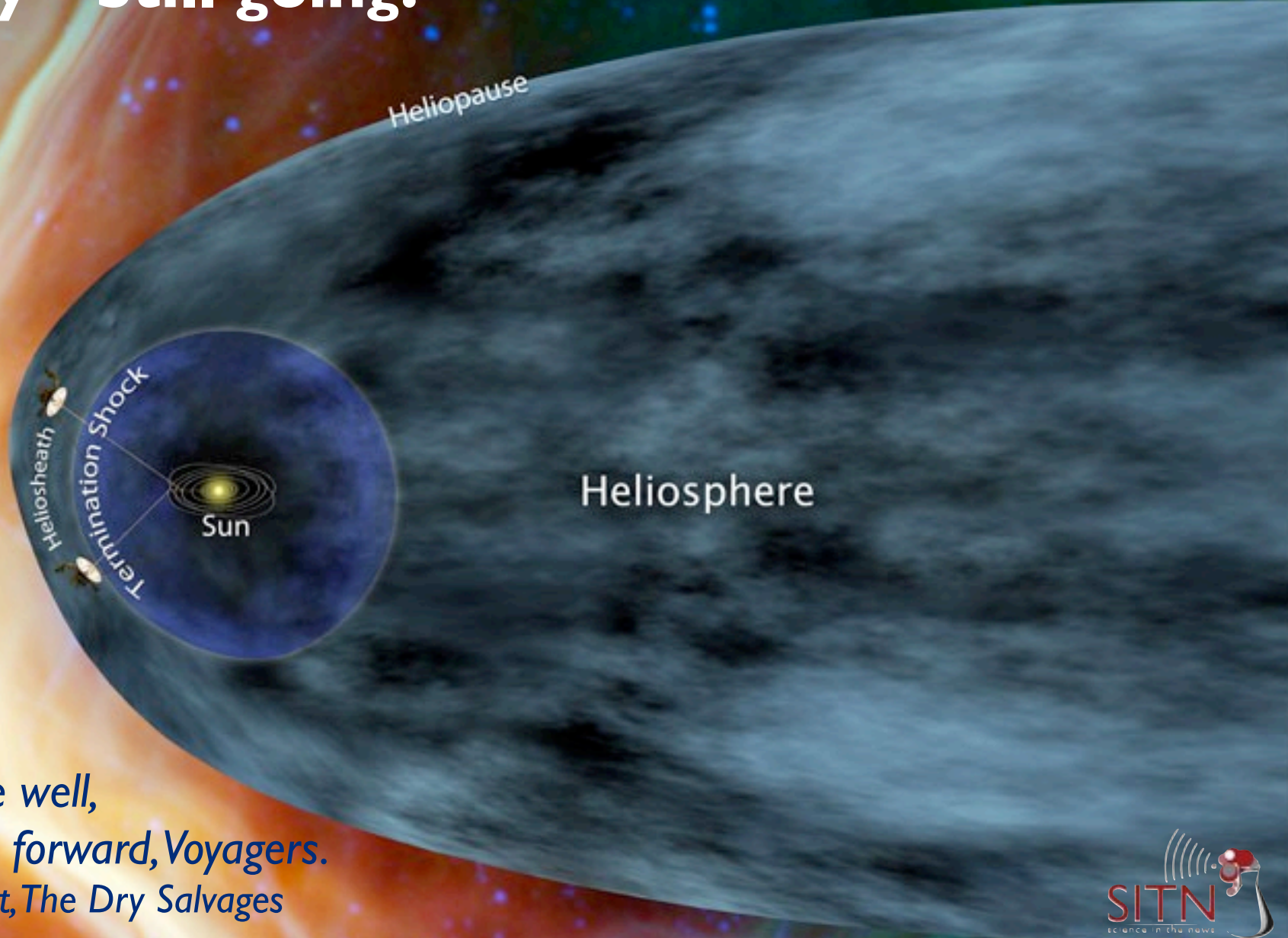
February 14, 1990

4,000,000,000 miles away



Today - Still going!

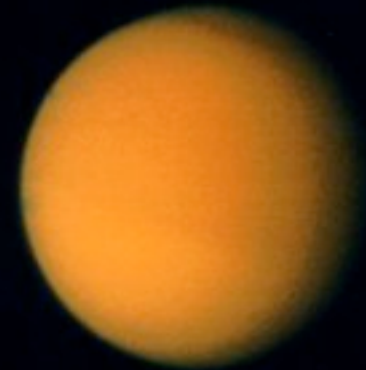
10,000,000,000 miles away



*Not fare well,
But fare forward, Voyagers.
– T. S. Eliot, The Dry Salvages*

Cassini-Huygens

Orbiting Saturn, Landing on Titan

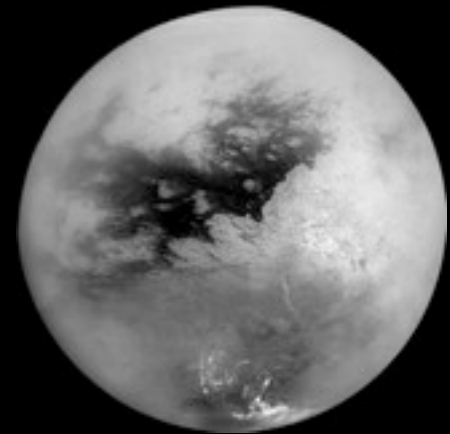


NASA/ESA/ASI



Cassini-Huygens

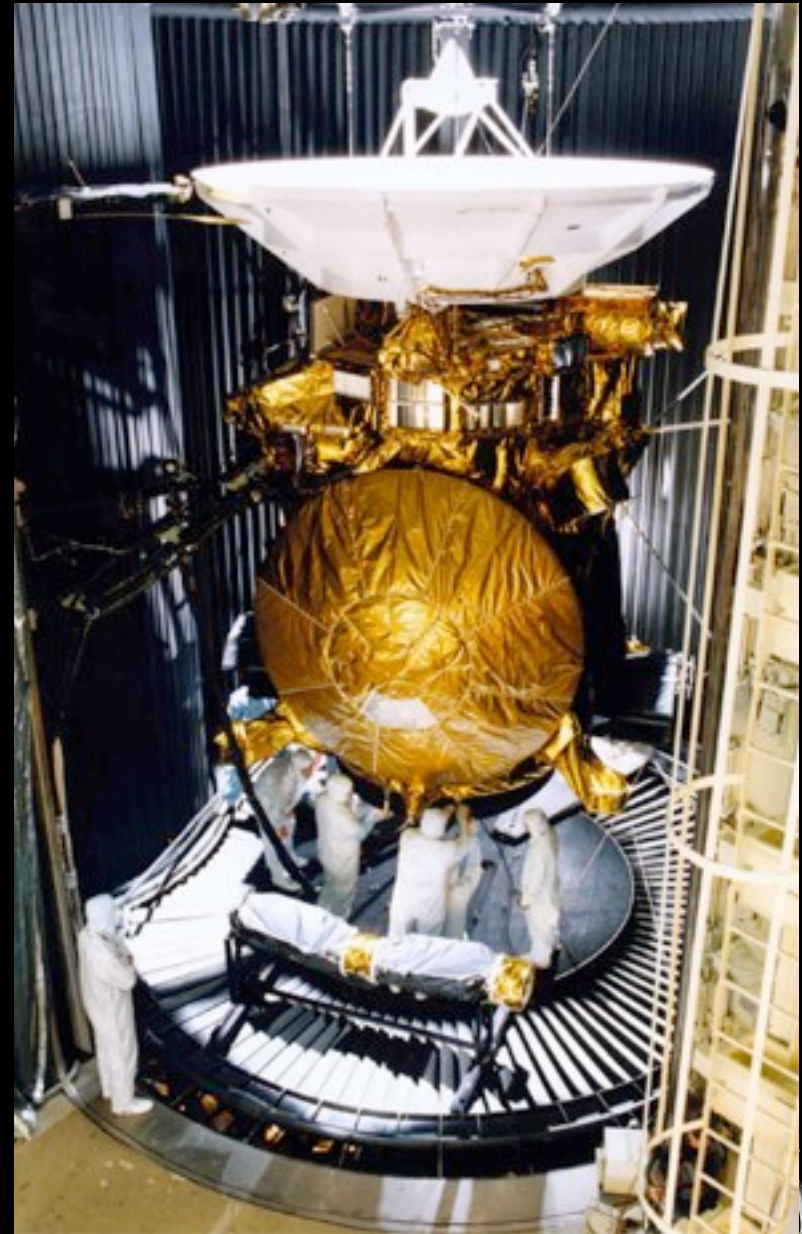
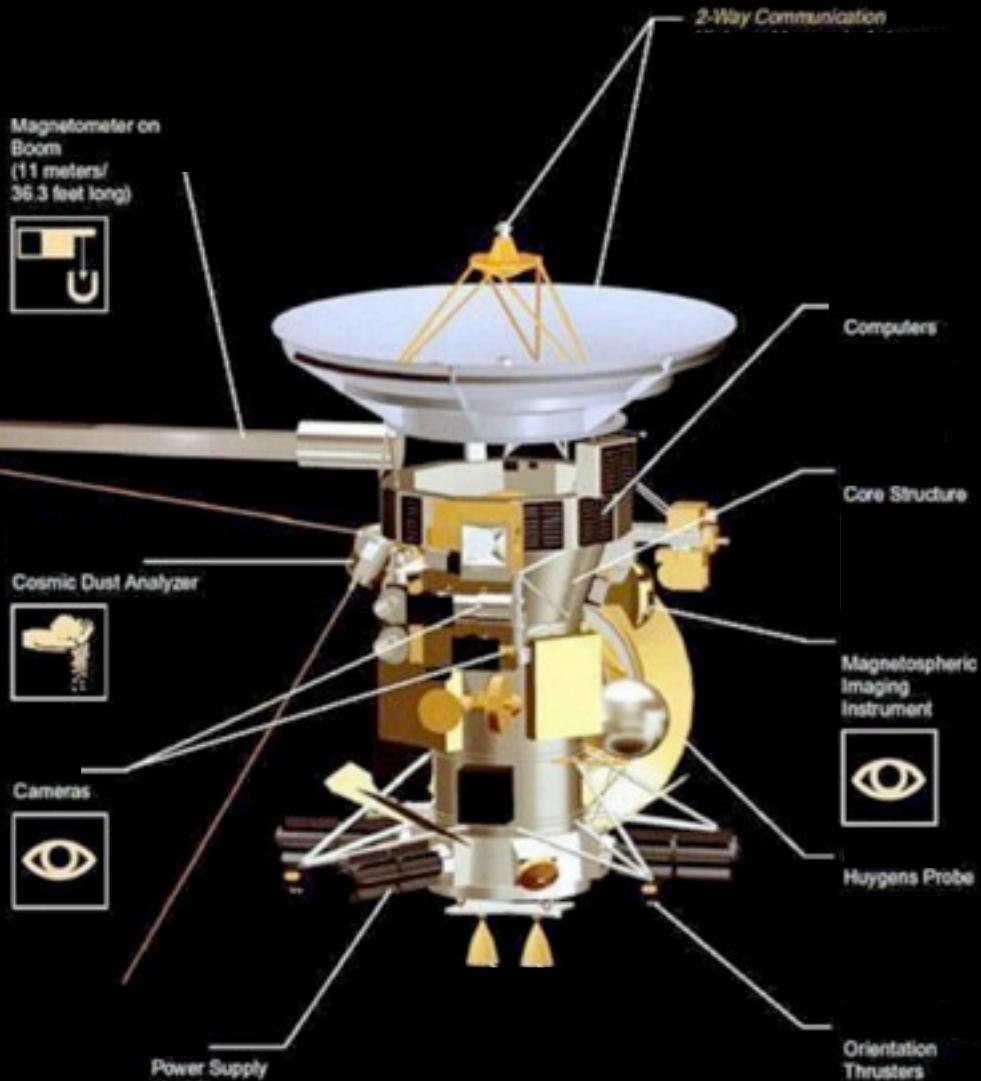
Orbiting Saturn, Landing on Titan

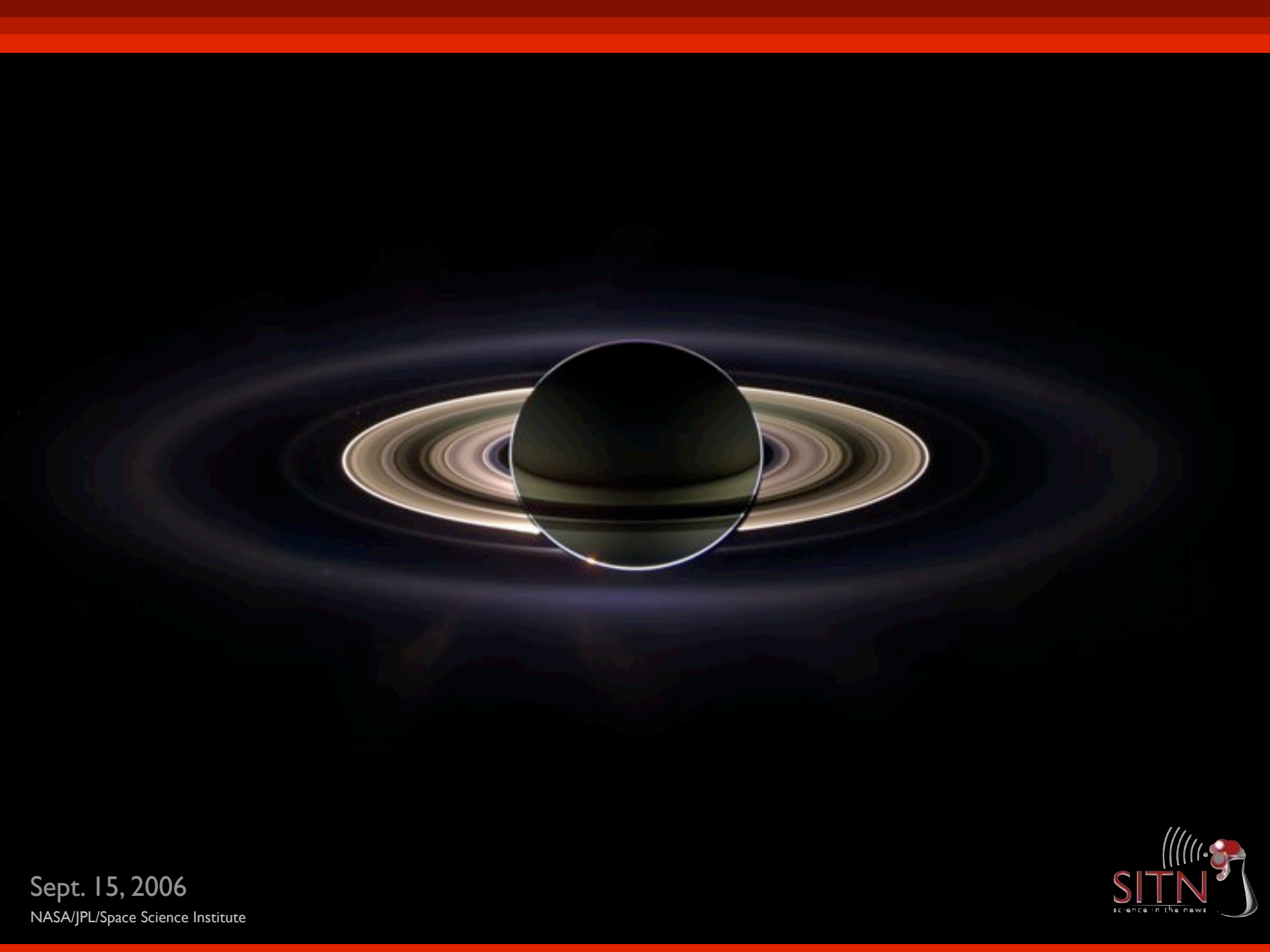


NASA/ESA/ASI

Cassini

Orbiting Saturn

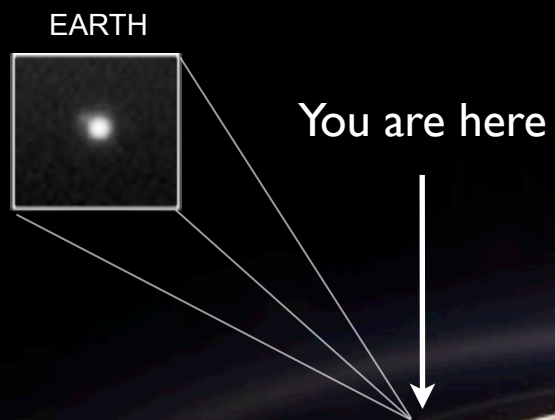




Sept. 15, 2006

NASA/JPL/Space Science Institute





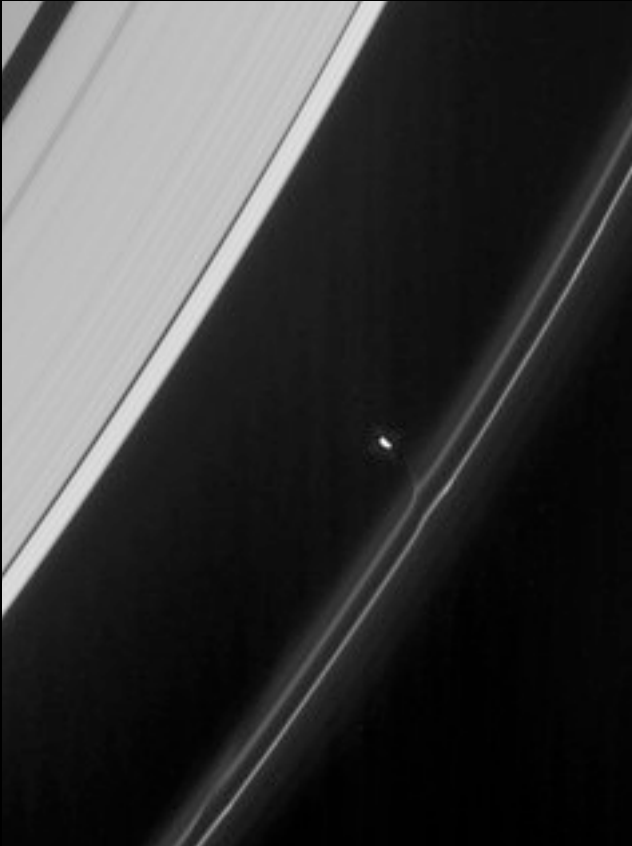
Sept. 15, 2006

NASA/JPL/Space Science Institute

discoveries

about Saturn's moons:

Prometheus



perturbs Saturn's rings

Enceladus



has **icy jets**

Phoebe

Voyager II

Sept. 4, 1981



1.3 million miles away



Cassini

June 11, 2004

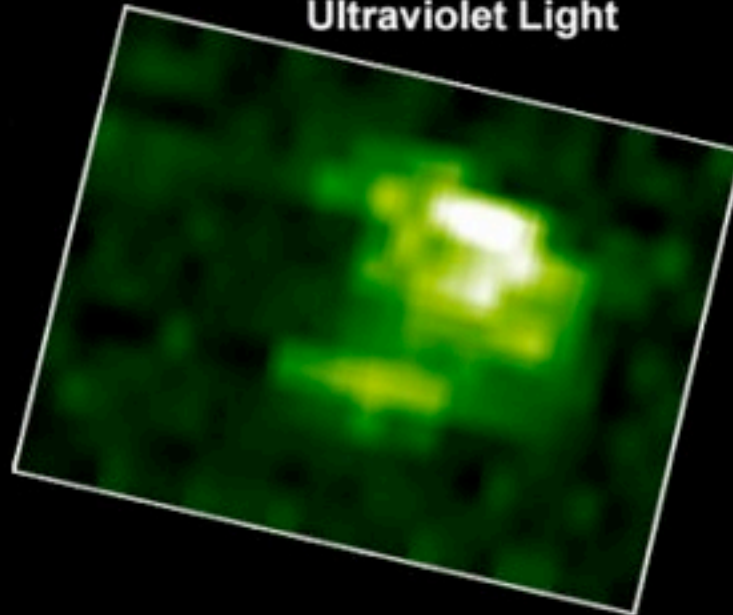
1200 miles away

a view from the ultraviolet

Visible Light



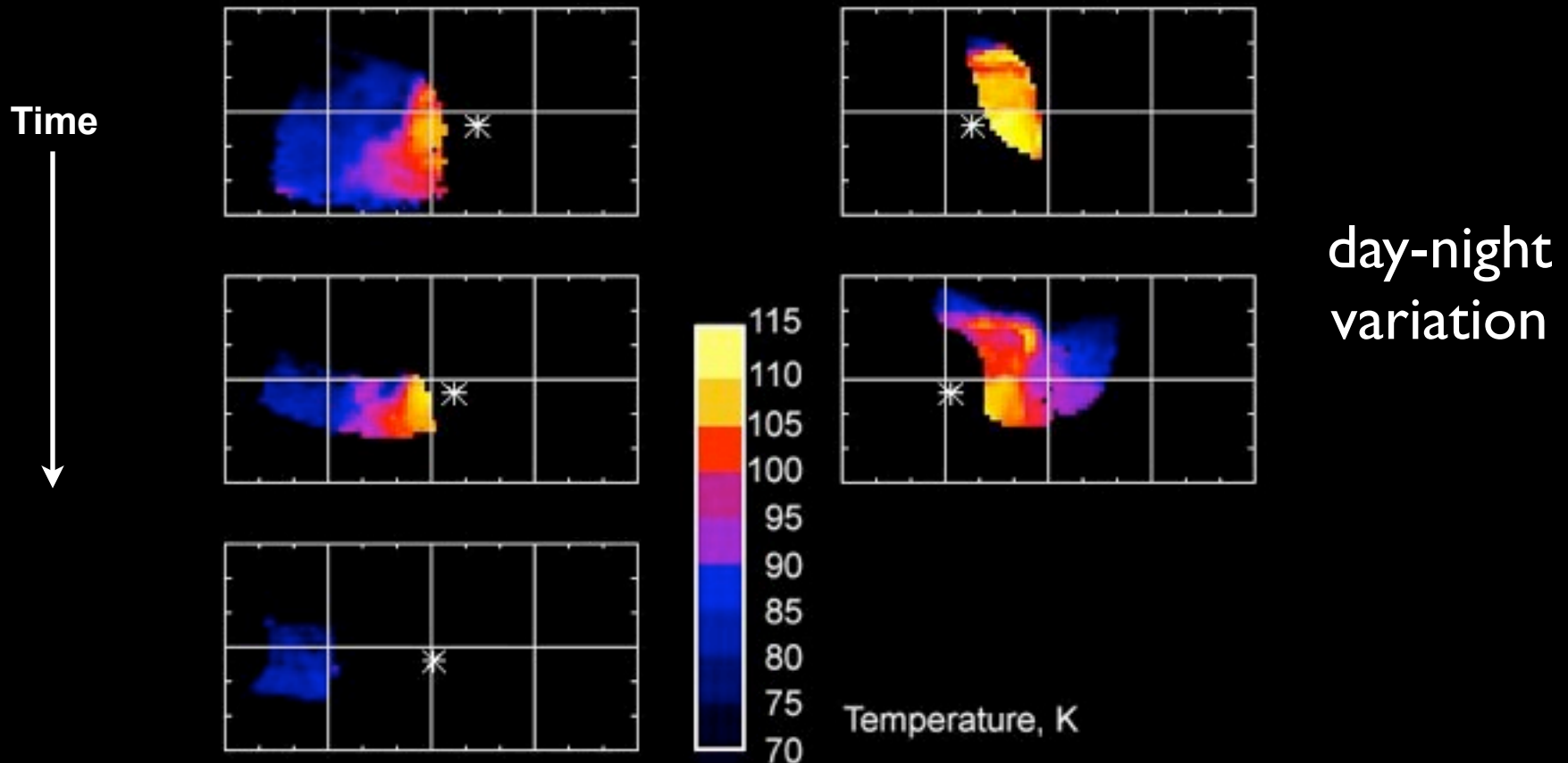
Ultraviolet Light



water frost

Ultraviolet (UV) image displays brightness variations.
UV spectra confirm presence of water frost on surface.

a view from the infrared - temperature



Phoebe
Saturn's Moon
NASA/ESA/ASI

made of loose dust and ice particles

a view from the infrared - mineral distribution



Phoebe
Imaging
Mosaic



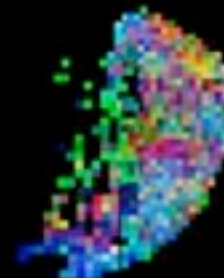
Infrared
Reflectance



Carbon Dioxide
Locations



Unidentified
Material



Ferrous Iron



Unidentified
Material



Water Ice



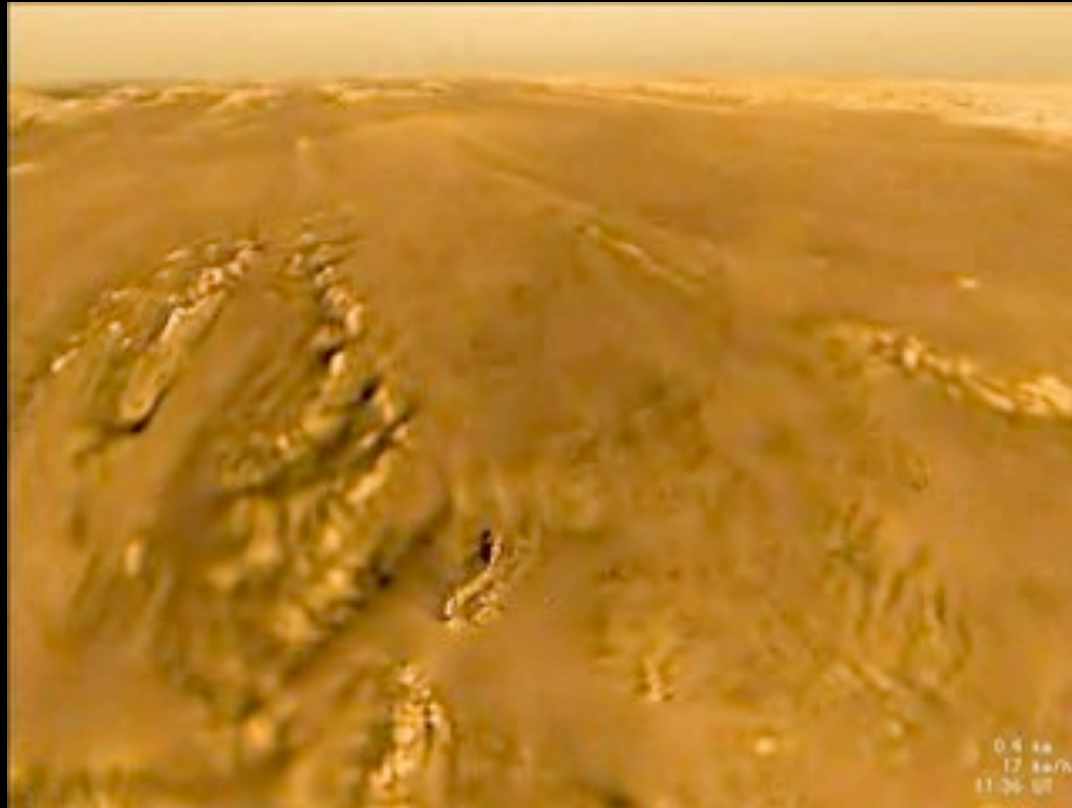
Cassini-Huygens

Landing on Titan

- Imager
- Measure winds using radio
- Analyze the atmosphere
- Measure Titan's surface

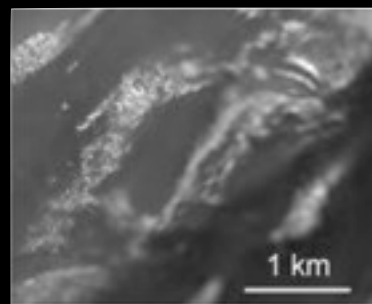
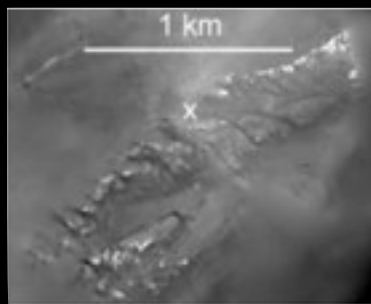
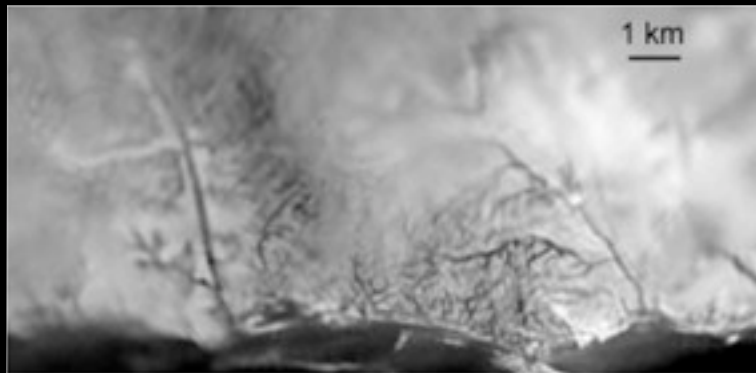
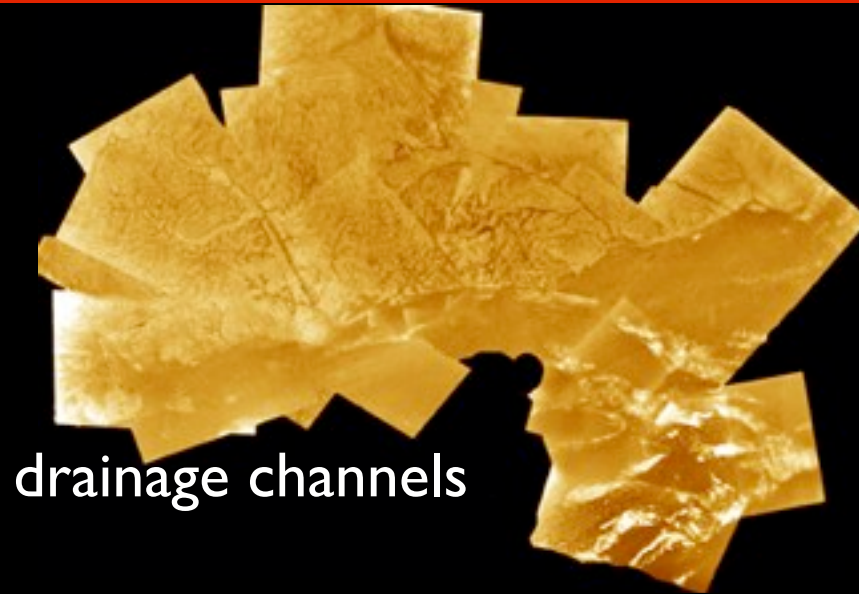


descent unto Titan



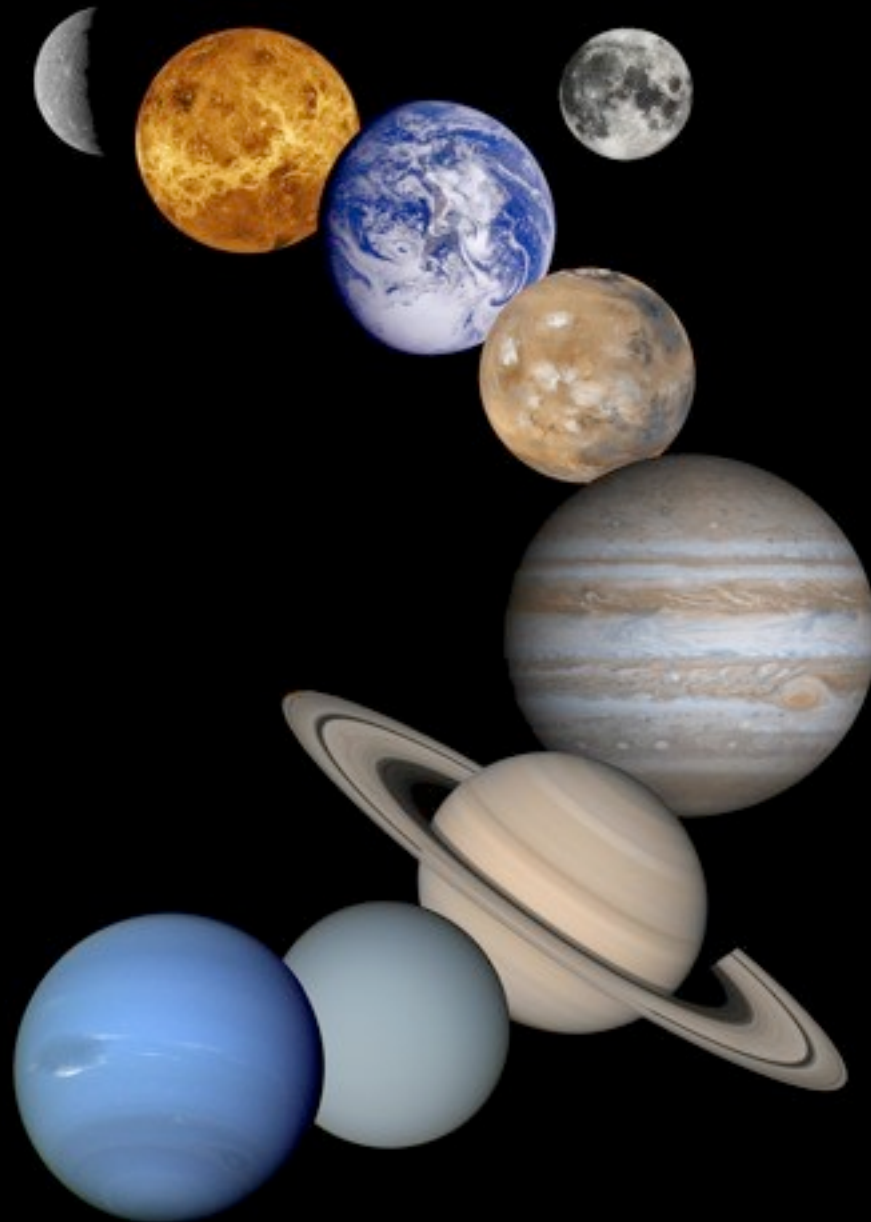
Titan's wind - the furthest sounds in the Solar System

Titan has rain & flows of liquid methane

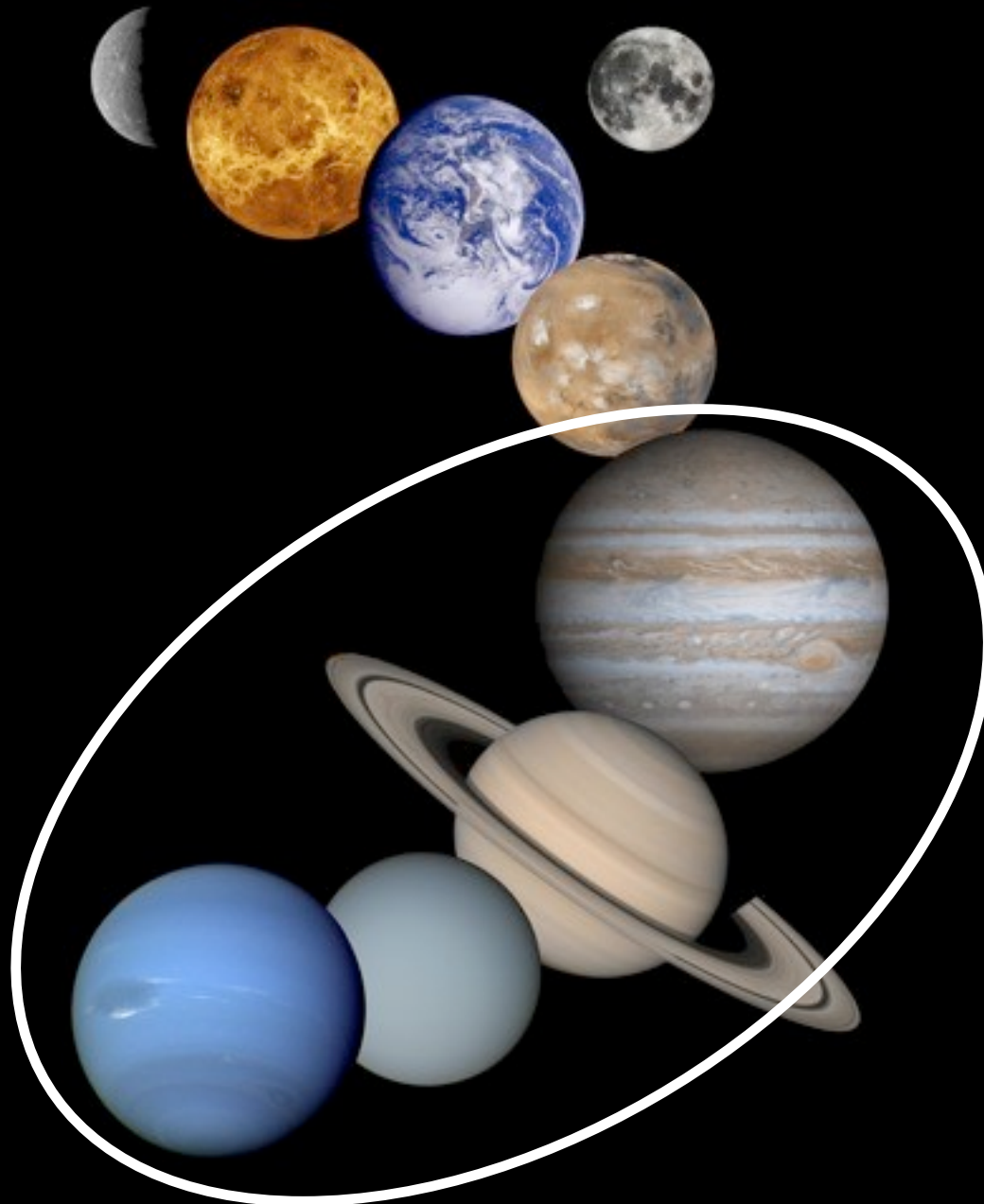


lakes

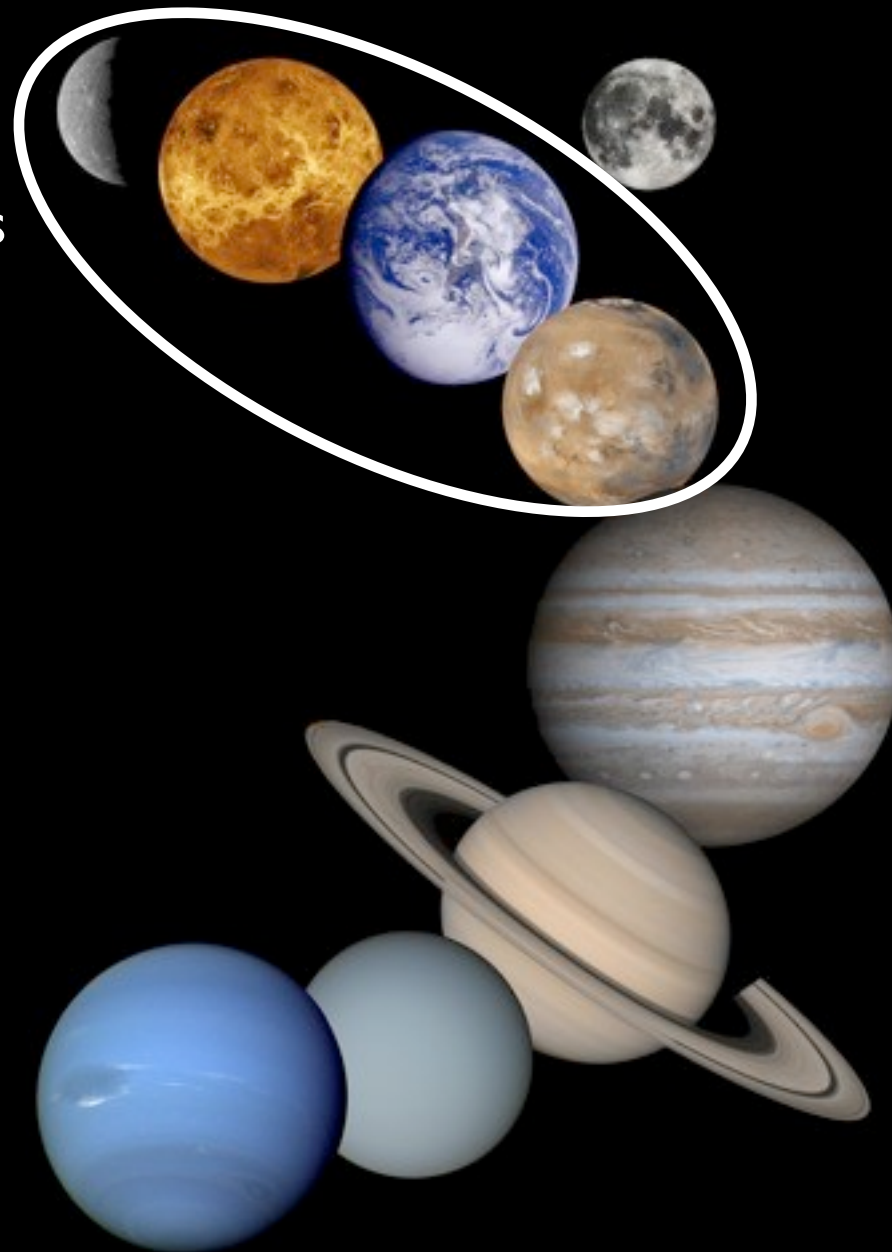




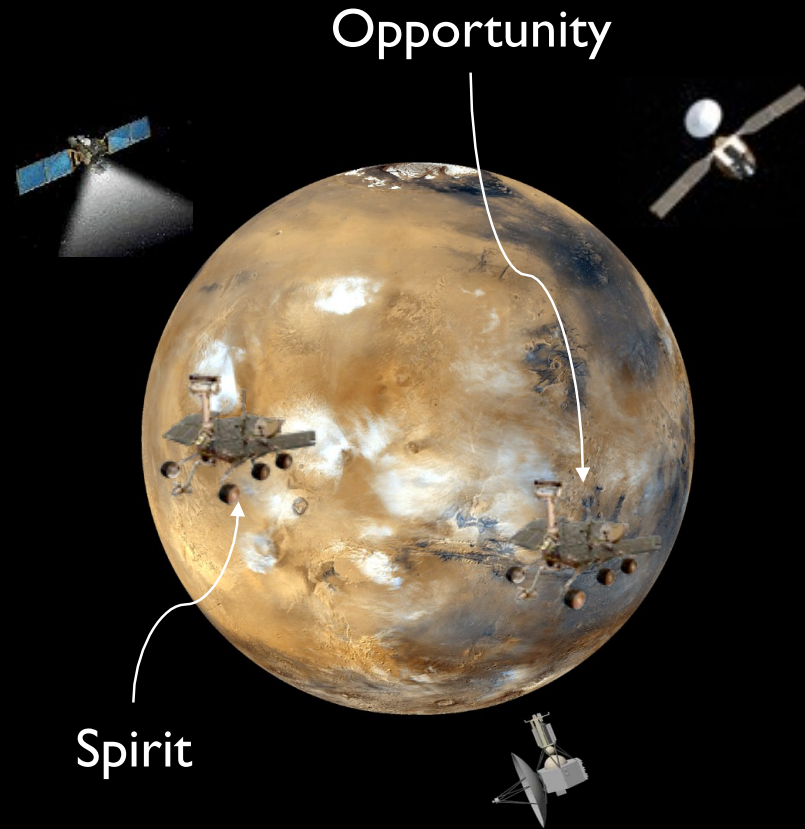
Gas giants



Rocky planets



Mars



Mars Exploration Rovers

Roving a Rocky World

Remote Sensing Package

Pancam

Mini-TES

In-Situ Package

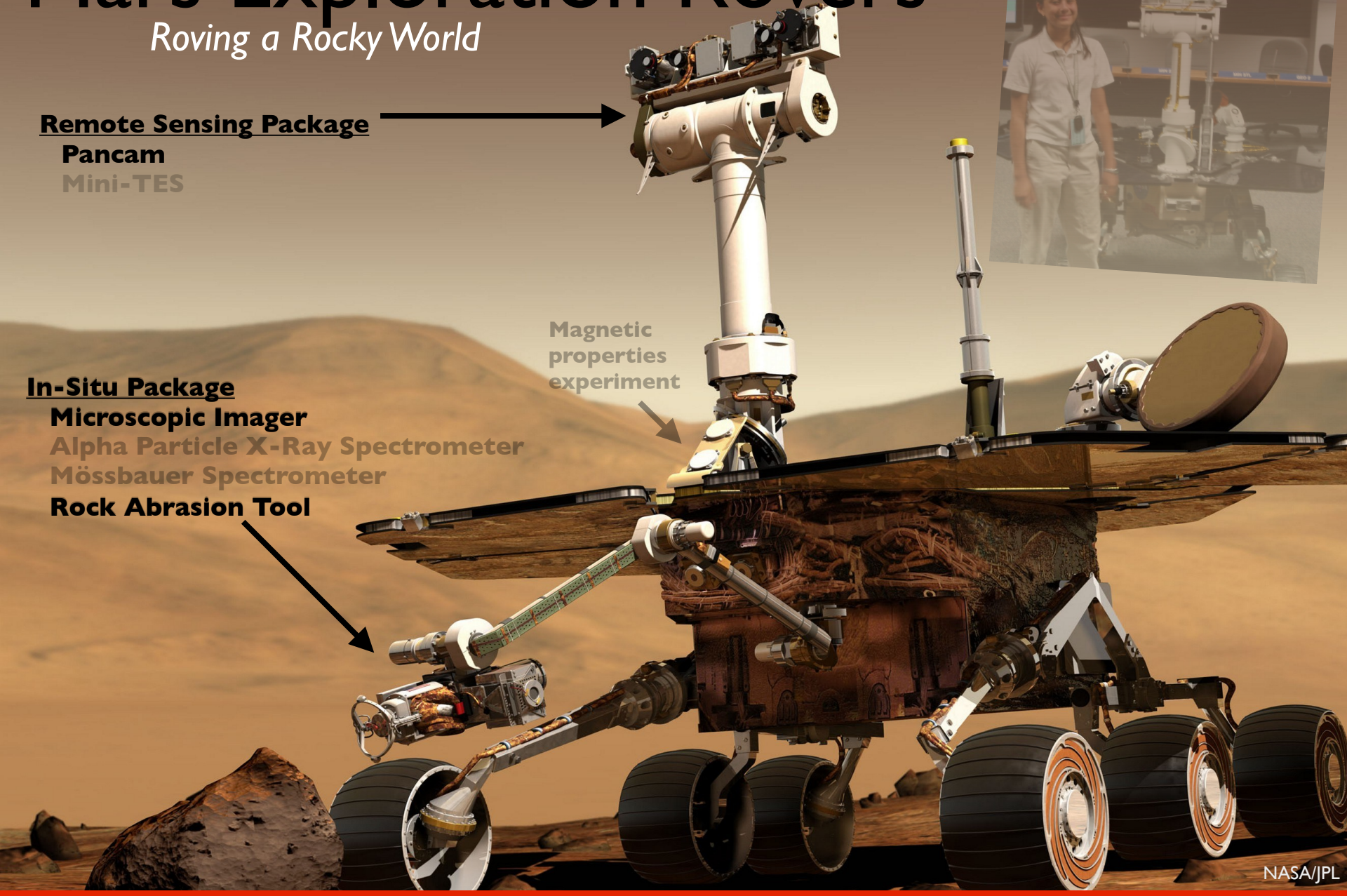
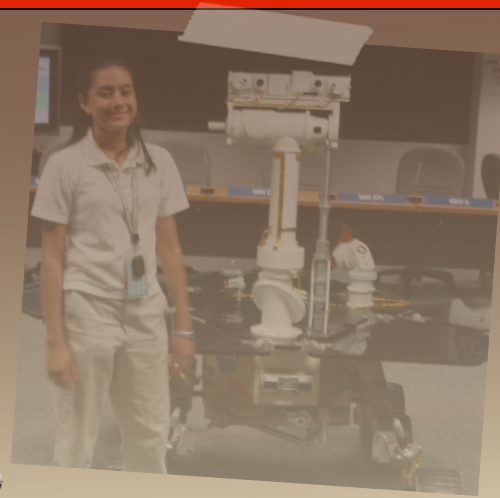
Microscopic Imager

Alpha Particle X-Ray Spectrometer

Mössbauer Spectrometer

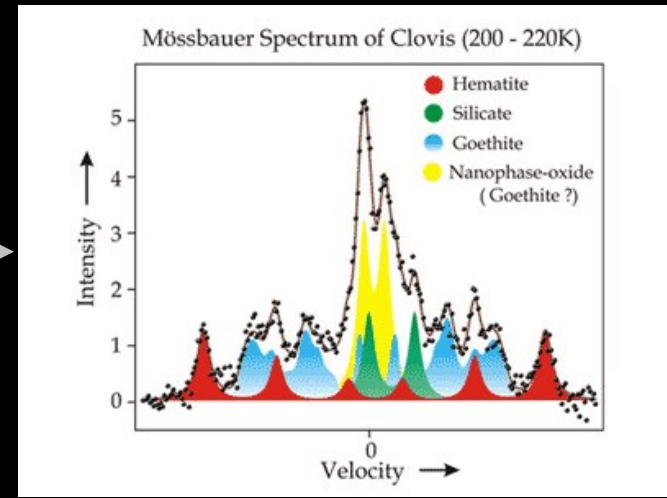
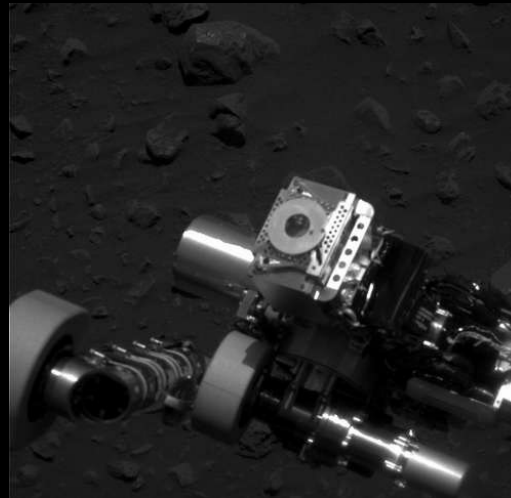
Rock Abrasion Tool

Magnetic
properties
experiment





RAT hole

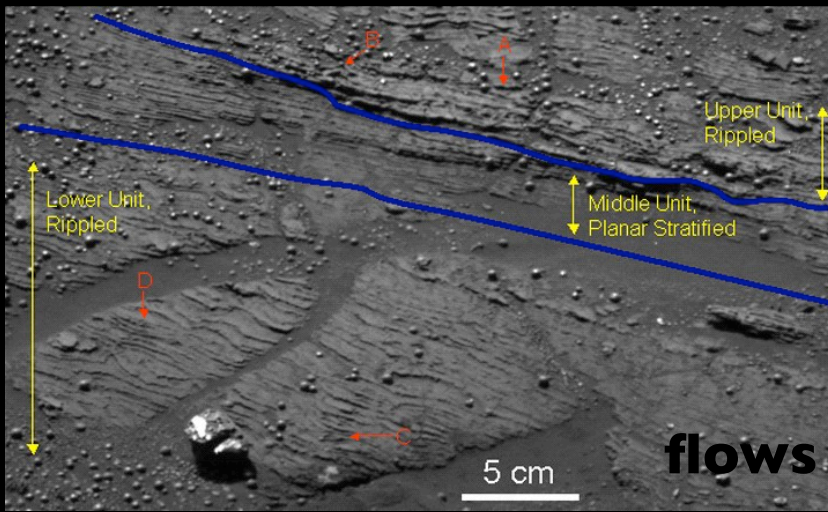
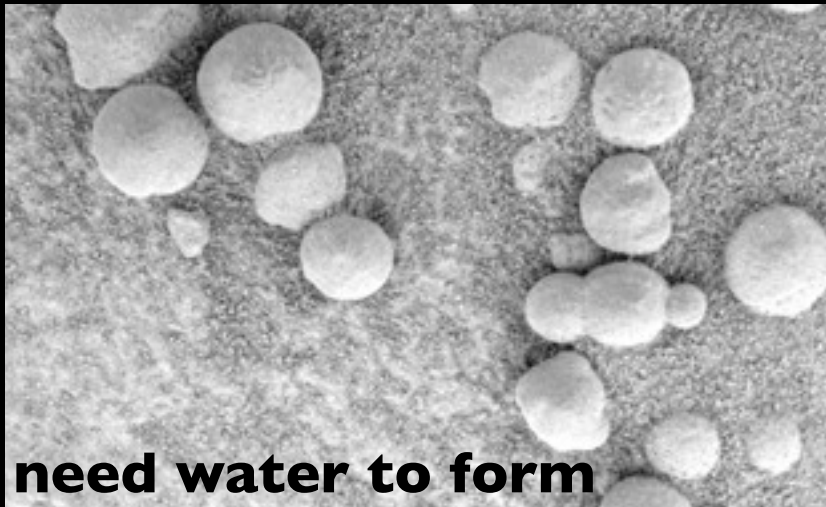


water?

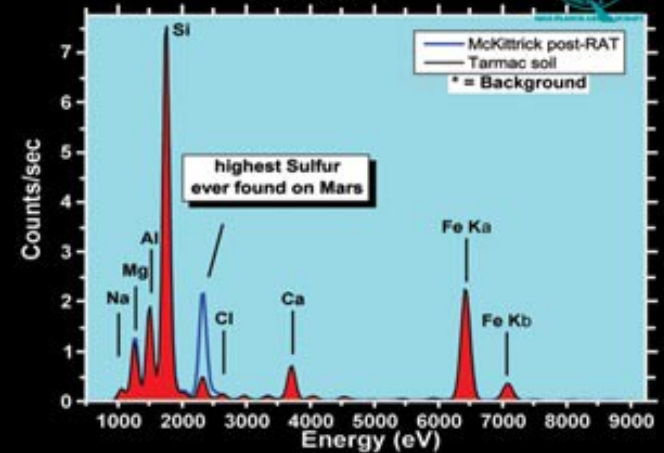


water?

blueberries

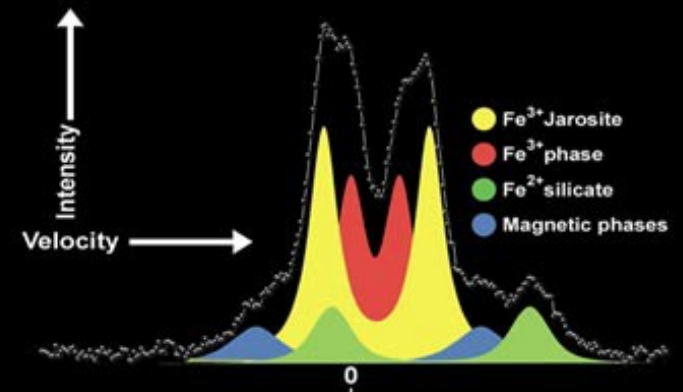


Meridiani Rock and Soil Sample



sulphates and standing water

Mössbauer Spectrum of El Capitan: Meridiani Planum
Jarosite: $(K, Na, X^{+1})Fe_3(SO_4)(OH)_6$



1996



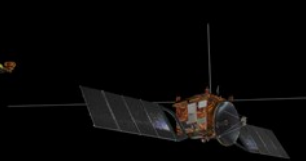
Mars Global
Surveyor

2001



Mars Odyssey

2003



European Mars Express

2005



Mars
Reconnaissance
Orbiter

2007

Mars Pathfinder



Mars
Exploration Rovers



Phoenix Scout



Mars
Science Laboratory



... Next Decade

Science pathways
responsive to discovery

Search for
Evidence of Past Life

Explore
Hydrothermal
Habitats

Search for
Present Life

Explore the
Evolution of Mars

coming soon...

sample return

Spacecraft help us sense

worlds like our own and wildly different worlds.



Sunset on Mars
Spirit Rover
May 19, 2005