Science with the Deep Space Network

Joseph Lazio

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Jet Propulsion Laboratory
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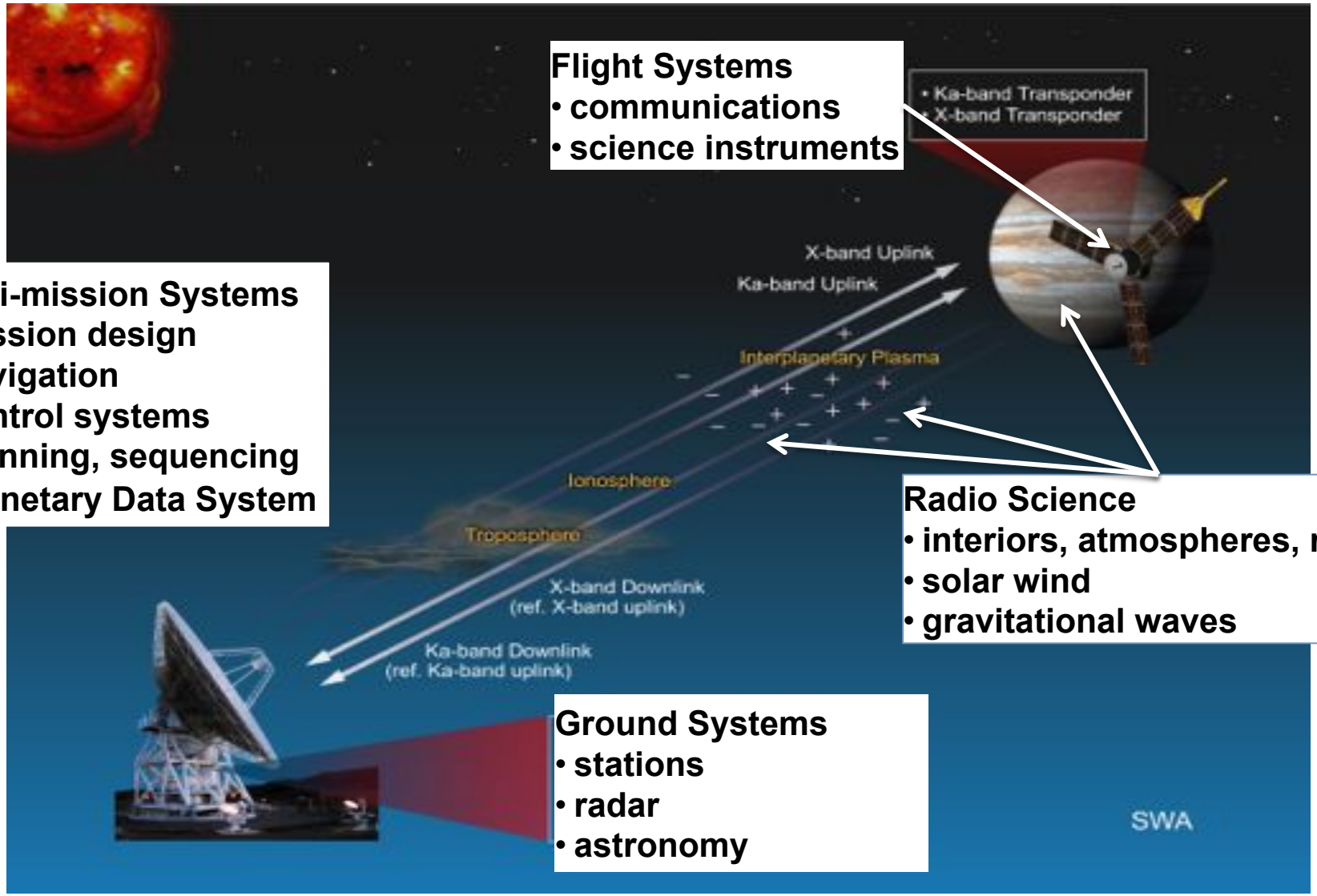
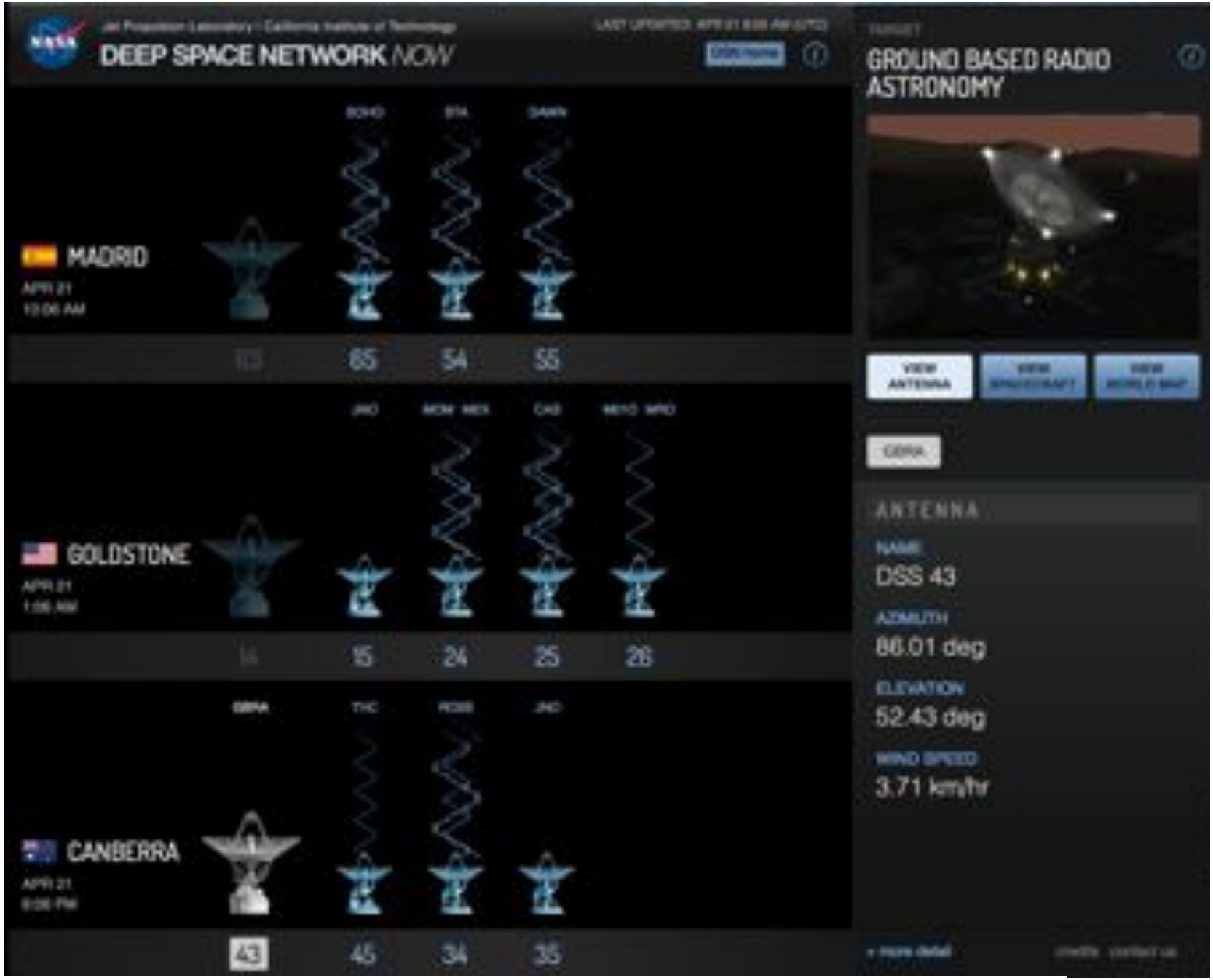
National Aeronautics and Space Administration
NASA
Juno

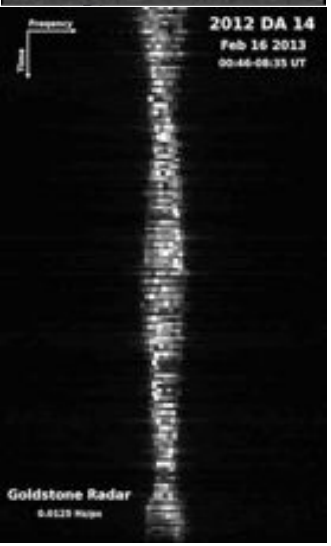
IND View


Flight Systems
• communications
• science instruments
• Ka-band Transponder
• X-band Transponder
X-band Uplink
Ka-band Uplink
Interplanetary Plasma
Ionosphere
Troposphere
X-band Downlink
(ref. X-band uplink)
Ka-band Downlink
(ref. Ka-band uplink)
Multi-mission Systems
• mission design
• navigation
• control systems
• planning, sequencing
• Planetary Data System
Radio Science
• interiors, atmospheres, rings
• solar wind
• gravitational waves
Ground Systems
• stations
• radar
• astronomy
SWA



http://eyes.nasa.gov/dsn/dsn.html

DSN as a Ground(-Space) Observatory



Solar System Radar

Unique solar system science; provides support to most planetary missions, Exploration, NEO Program

Radio Science

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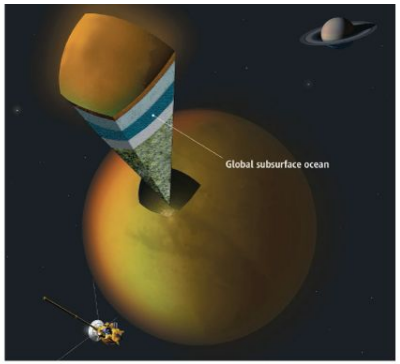
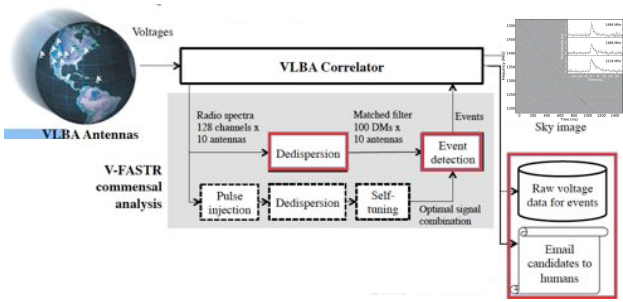
Astronomy

Radio telescopes for mission science enhancement and international peer-reviewed proposals



PLANETARY SCIENCE

Cassini Spies an Ocean Inside Saturn's Icy, Gassy Moon Titan

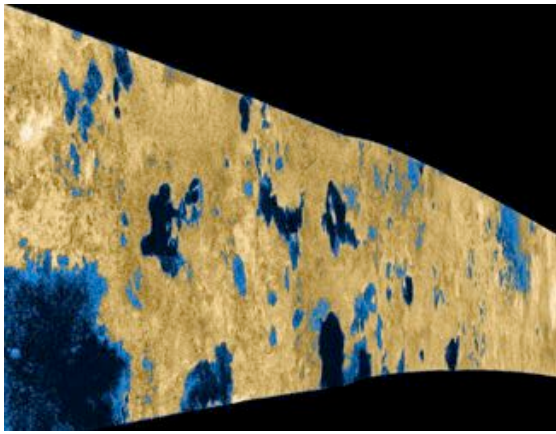


Radar with the DSN

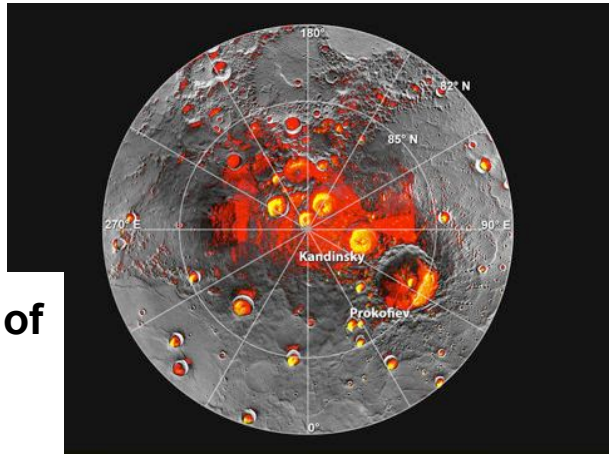
DSN Radar Accomplishments

- **Measurement of the astronomical unit (1962)**
- **First indications of Venus retrograde rotation (1962)**
- **Probing the surfaces of asteroids (1976)**
- **First radar returns from Titan (1989-1993), suggestive of icy surface but with potential liquids**
- **Anomalous reflections from Mercury (1991), indicative of polar ice**

***Magellan* radar image of Venus (NASA/Caltech/JPL)**



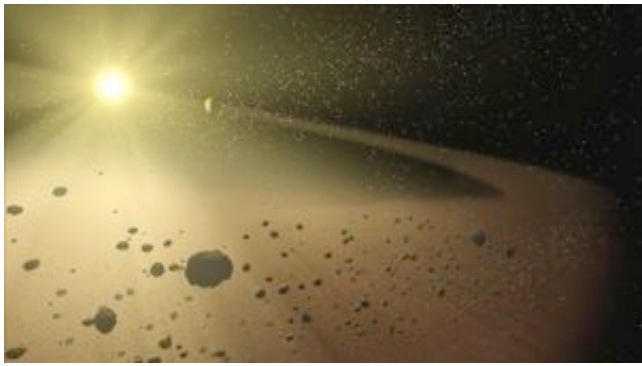
***Cassini* radar image of Titan (NASA/JPL/USGS)**



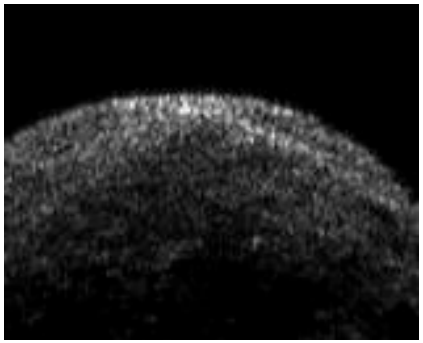
MESSENGER+radar image of Mercury (NASA/HU APL/CIW/NAIC)

Radar Observations of Asteroids

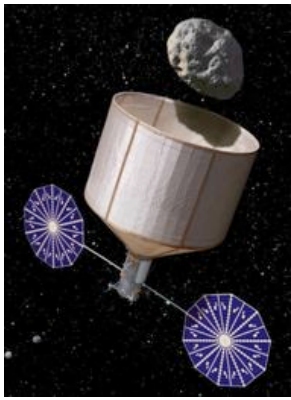
Radar delivers size, rotation, shape, density, surface features, precise orbit, non-gravitational forces, presence of satellites, mass, …



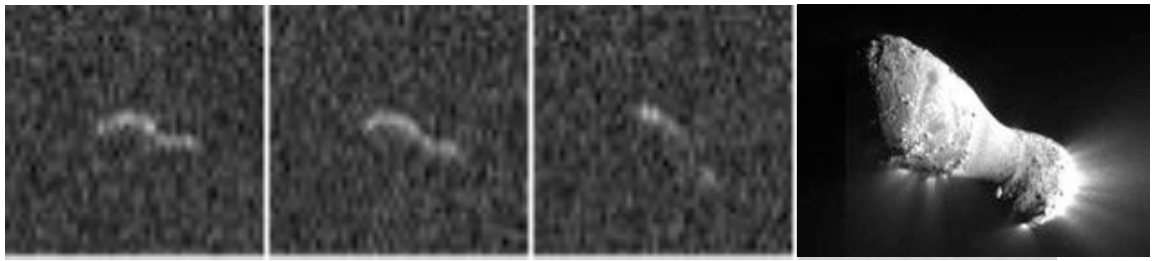
- **Science:** Decipher the record in primitive bodies of epochs and processes not obtainable elsewhere



- **Robotic or crewed missions**: Navigation, orbit planning, and observations

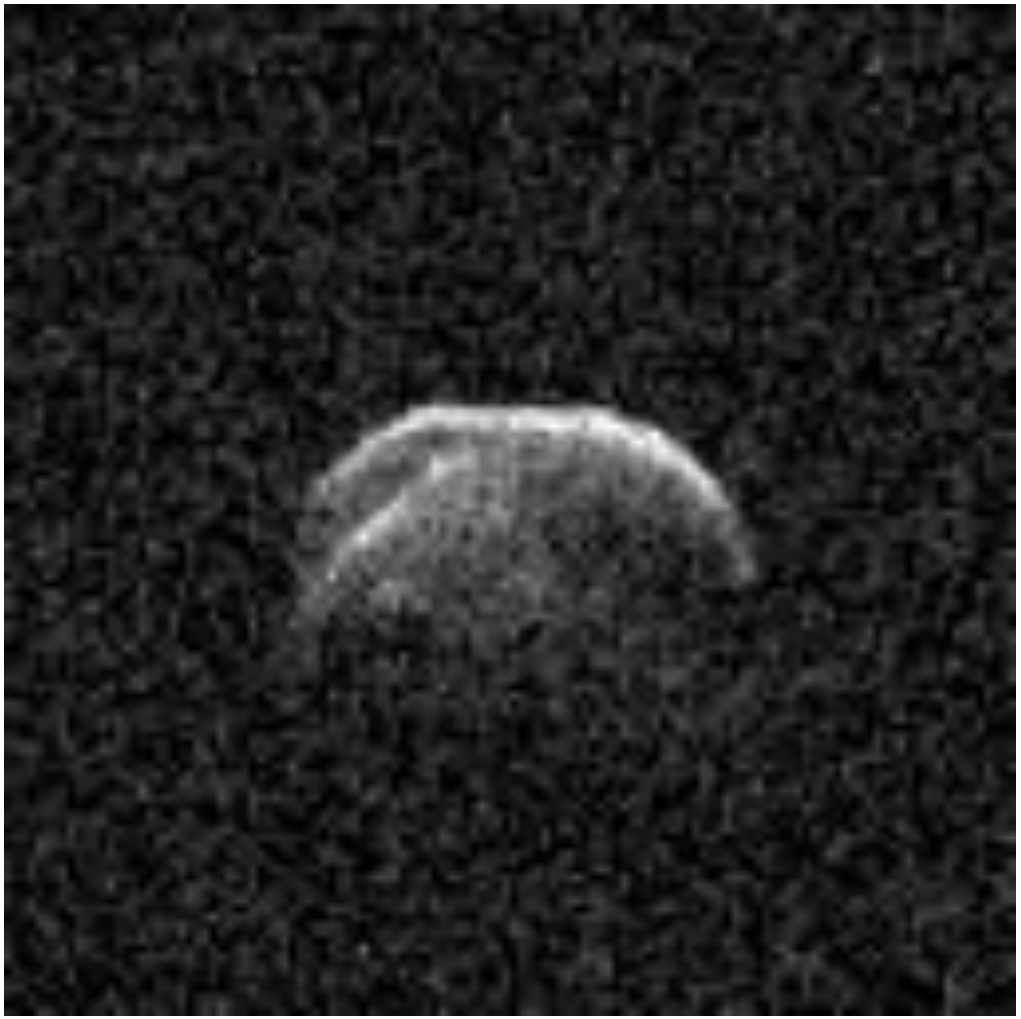


- **Planetary defense**: Orbit determination for hazard assessment



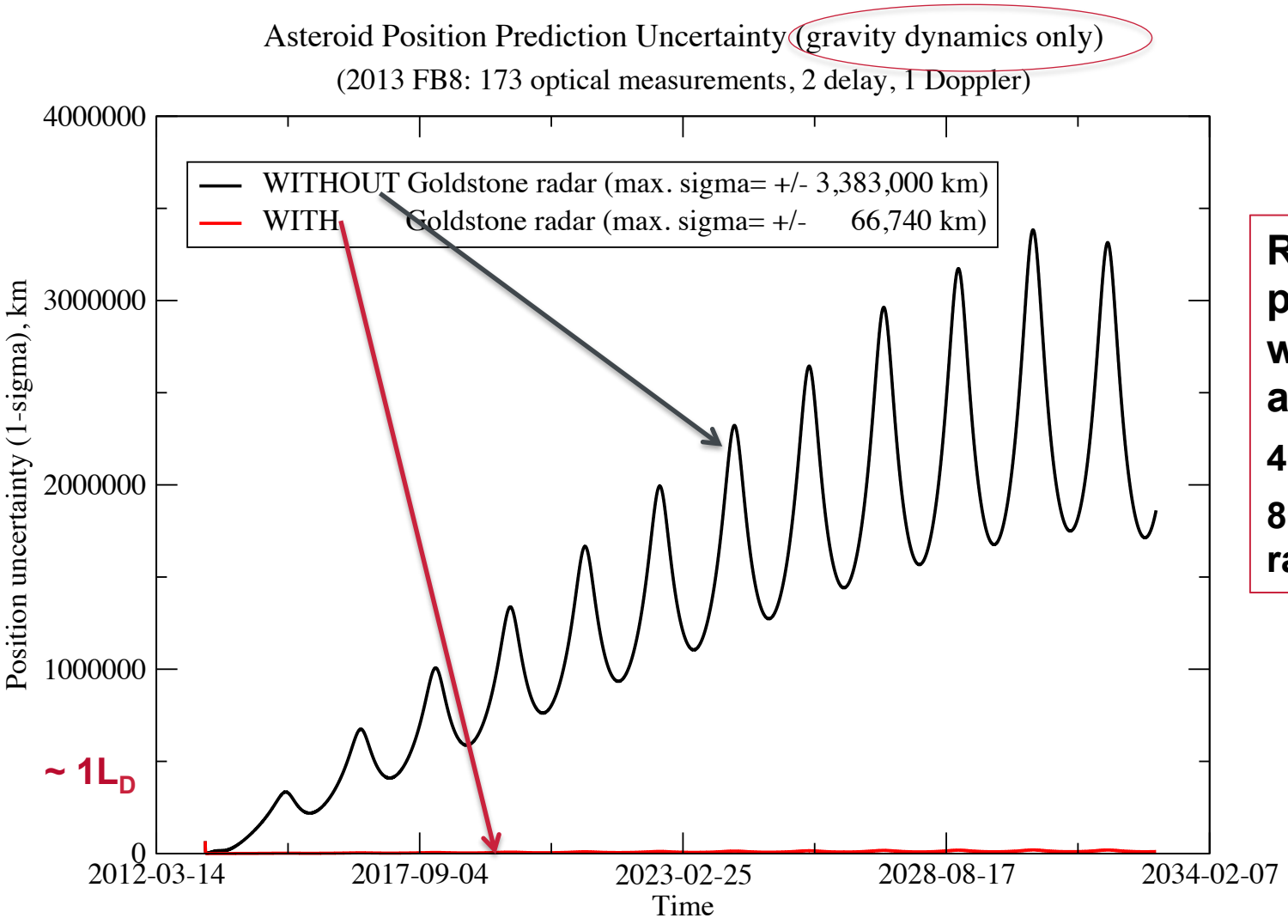
Radar Observations of Near-Earth Asteroids

1998 WT_{24}



Orbital Determination

Value of Radar



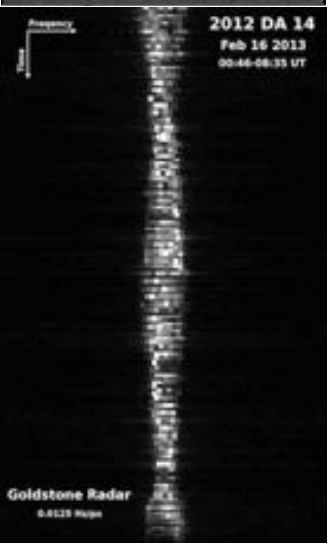
Radar extends prediction window ~ 5× on average

400 yr with radar

80 yr without radar

J. Giorgini

DSN as a Ground(-Space) Observatory



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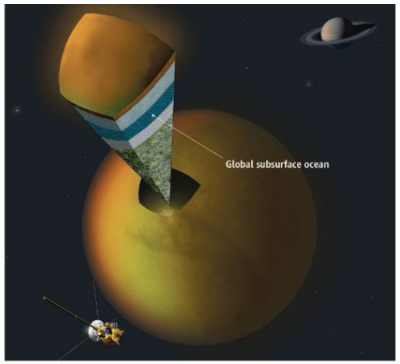

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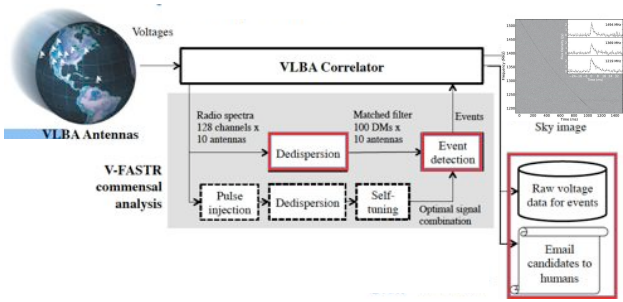
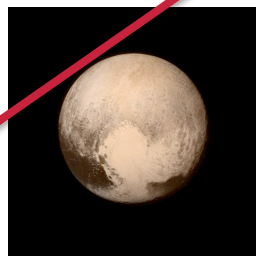
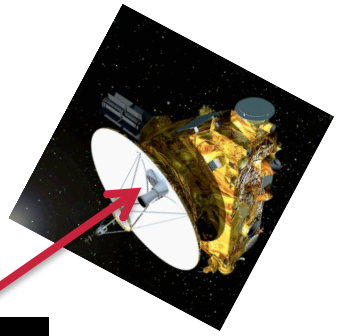


DSN-New Horizons Radio Science Experiment (REX)

One of Top Three Required Science Investigations





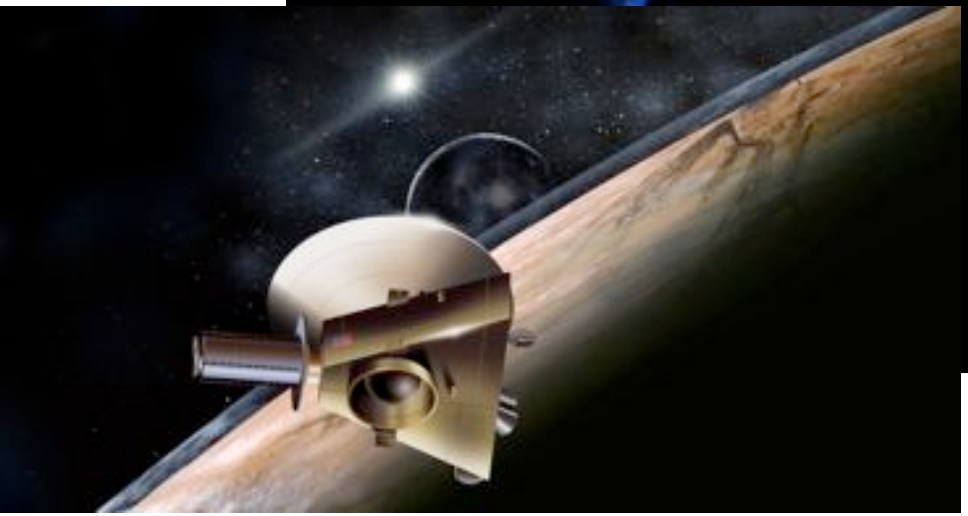
Transmit to New Horizons through Pluto's atmosphere … if it has one,

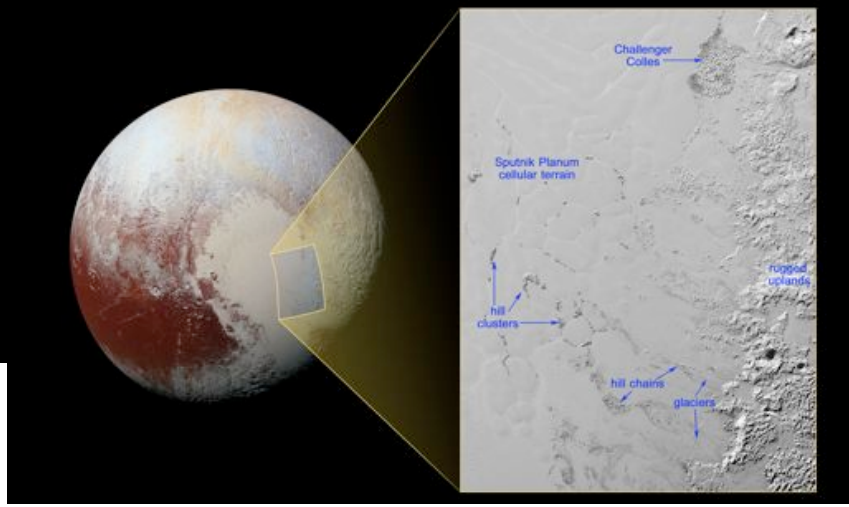
Also get Charon's atmosphere for free, if it has one ….

Not to scale!

DSN-REX

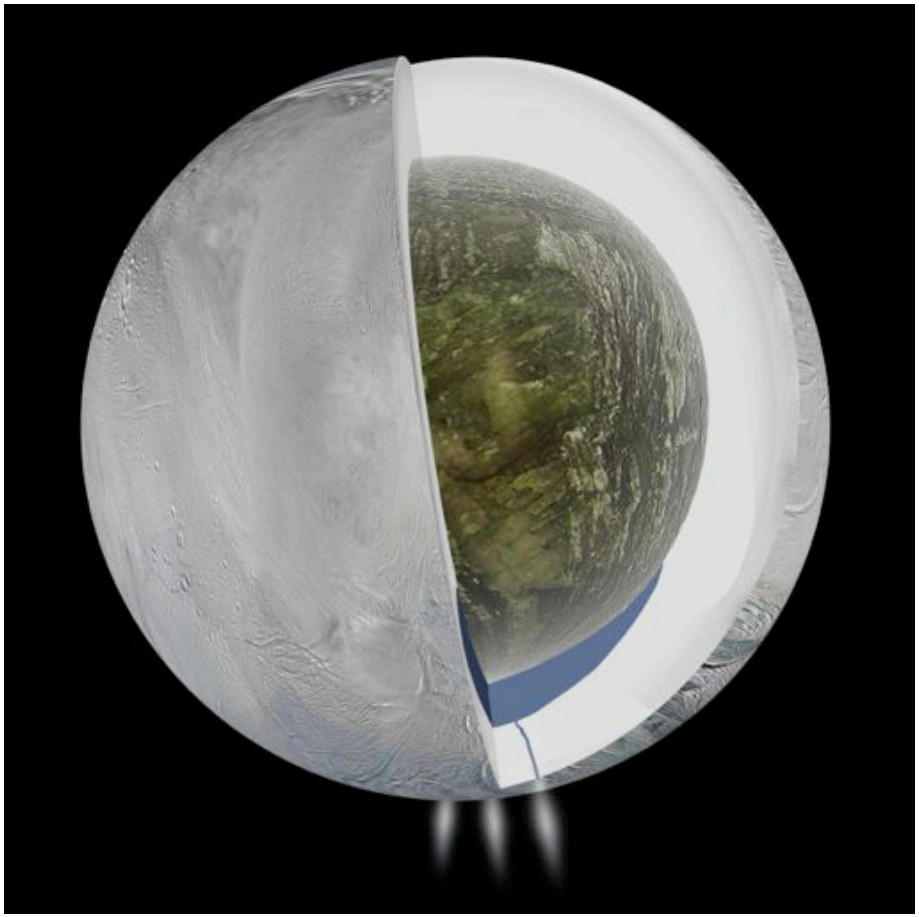
New Horizons





Radio Science

Interiors of Moons: Enceladus

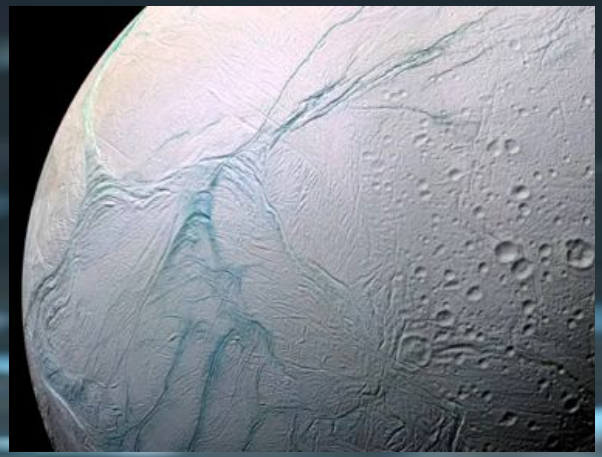


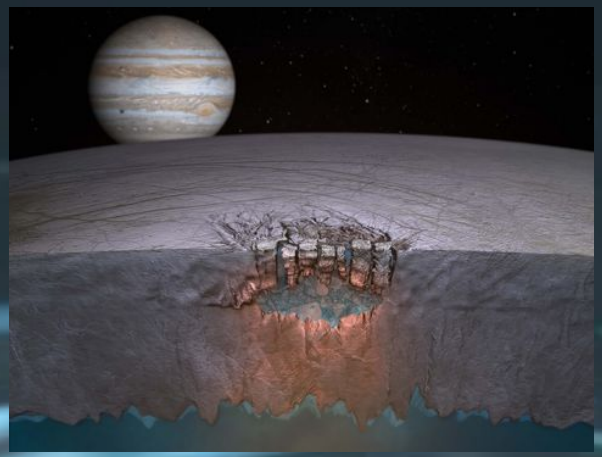
Another possible habitat in the solar system?

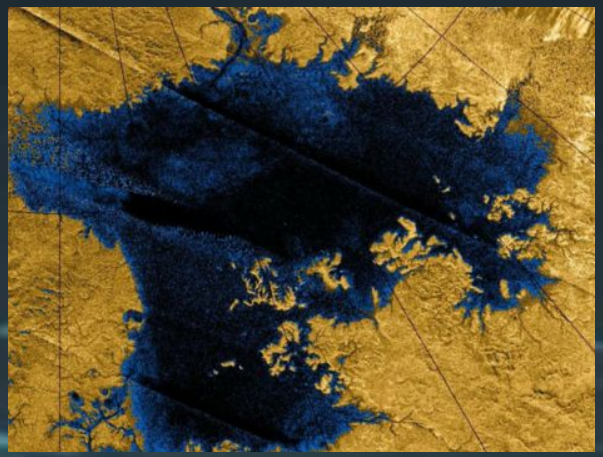
viz. Europa

Oceans of the Solar System

Europa, Enceladus, Titan, …



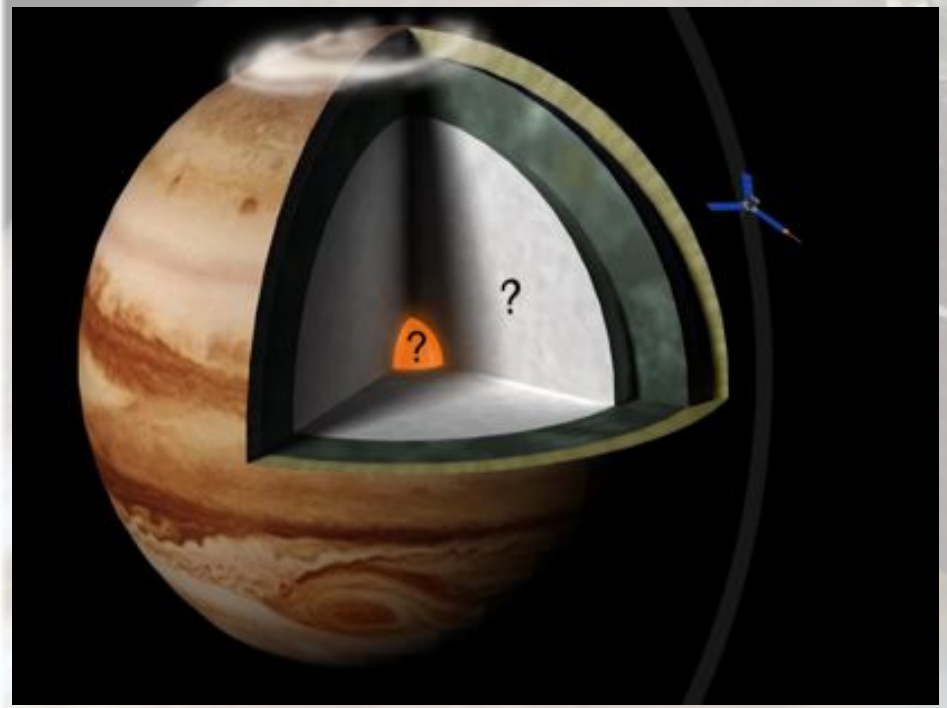




National Aeronautics and Space Administration

Radio Science

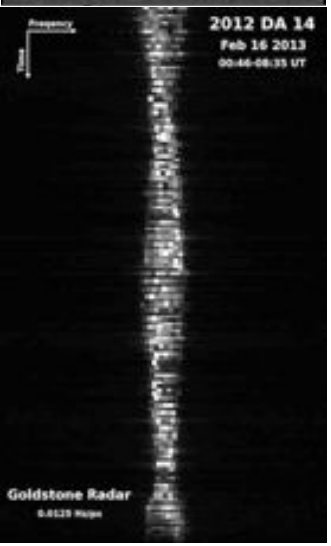
Giant Planet Interiors: Juno at Jupiter



Juno Gravity Science

- **Precise measurement of spacecraft motion (Doppler) measures gravity field**
- **Close-in Juno polar orbit maximizes sensitivity to gravity**
- **Distribution of mass reveals core and deep structure**
- **Higher degree harmonics reveal convective motion in deep atmosphere**

DSN as a Ground(-Space) Observatory



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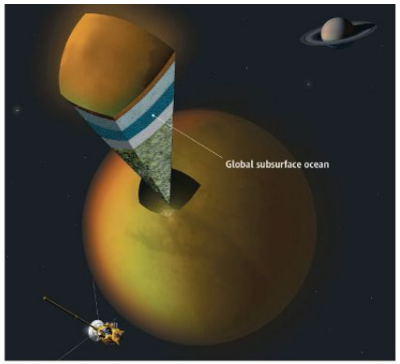

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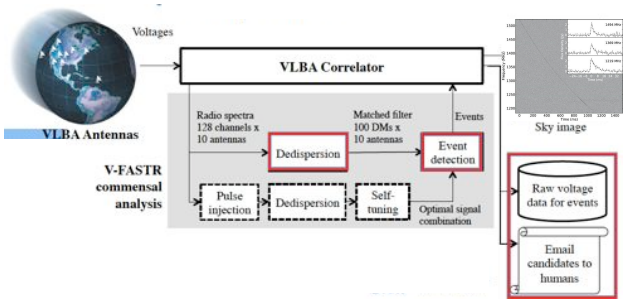
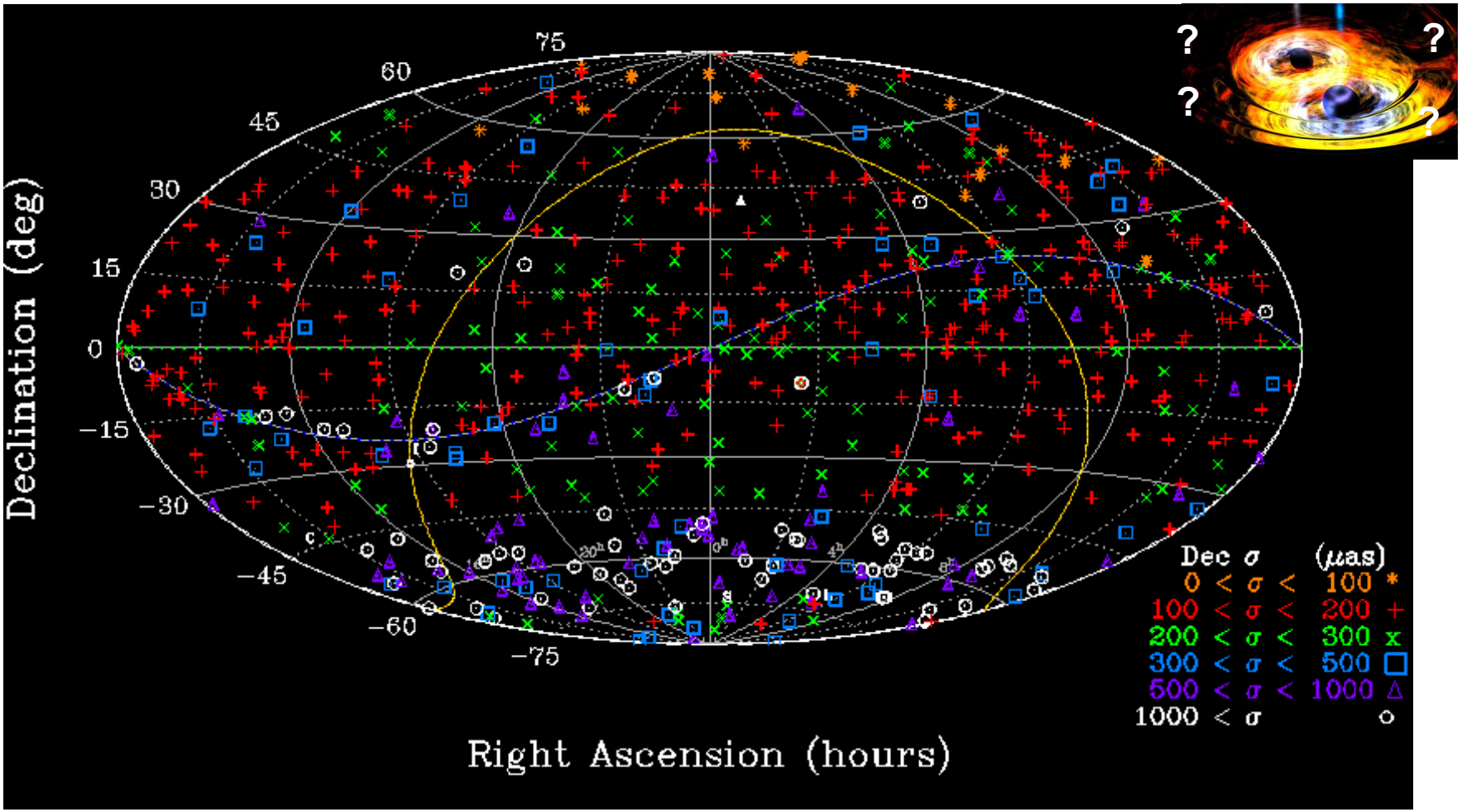
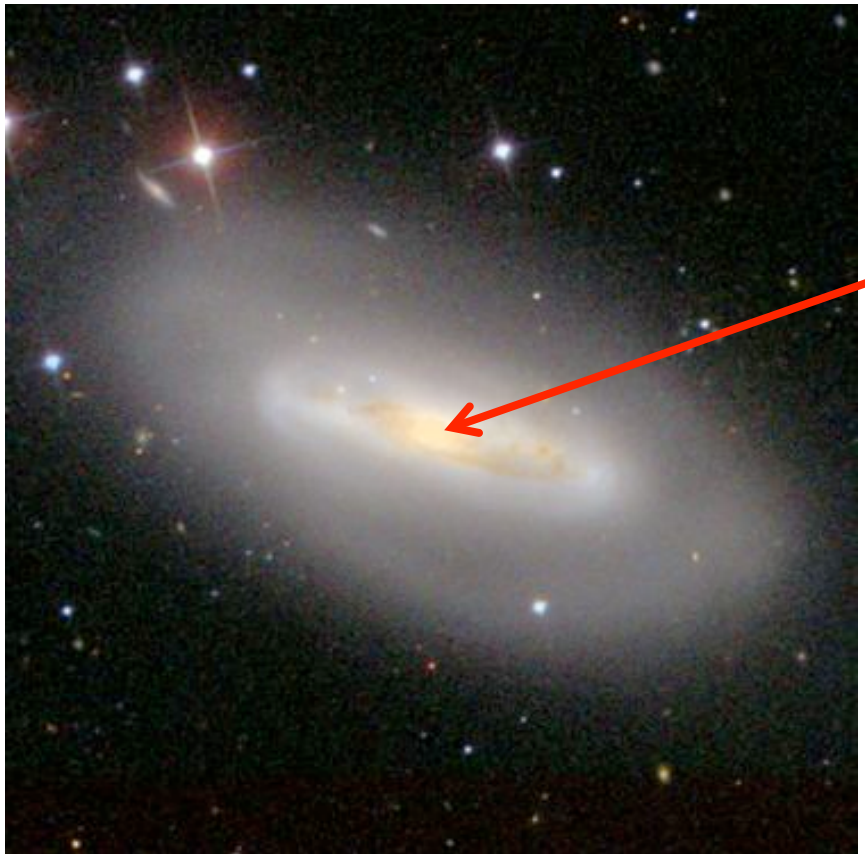


VLBI: Radio Reference Frame

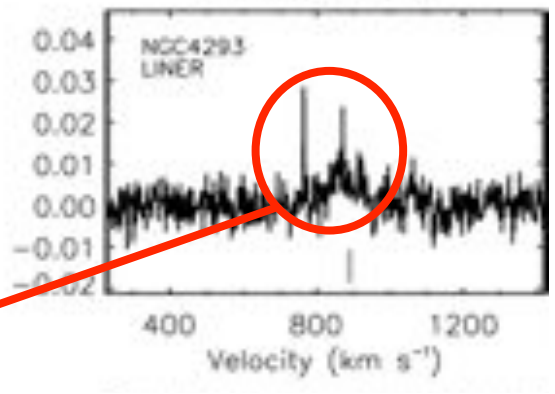
"And all I ask is a tall ship and a star to steer her by;"

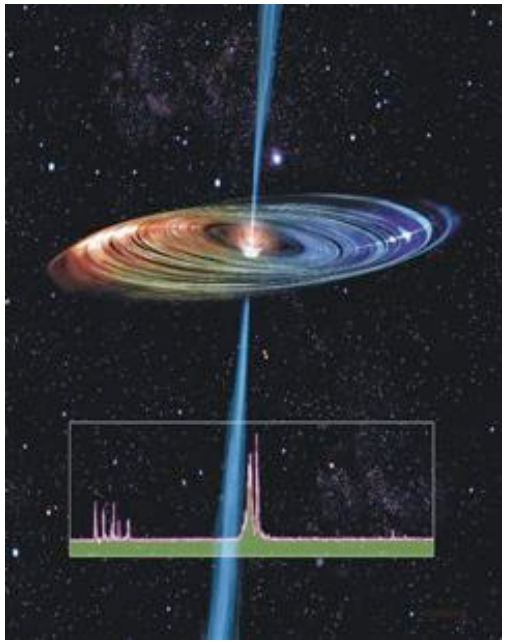


DSS-63 Hunts for Black Holes



NGC 4293





Kondratko, P. T., et al. 2006, "Discovery of Water Maser Emission in Eight AGNs with 70 m Antennas of NASA's Deep Space Network"

Next 50 Years?

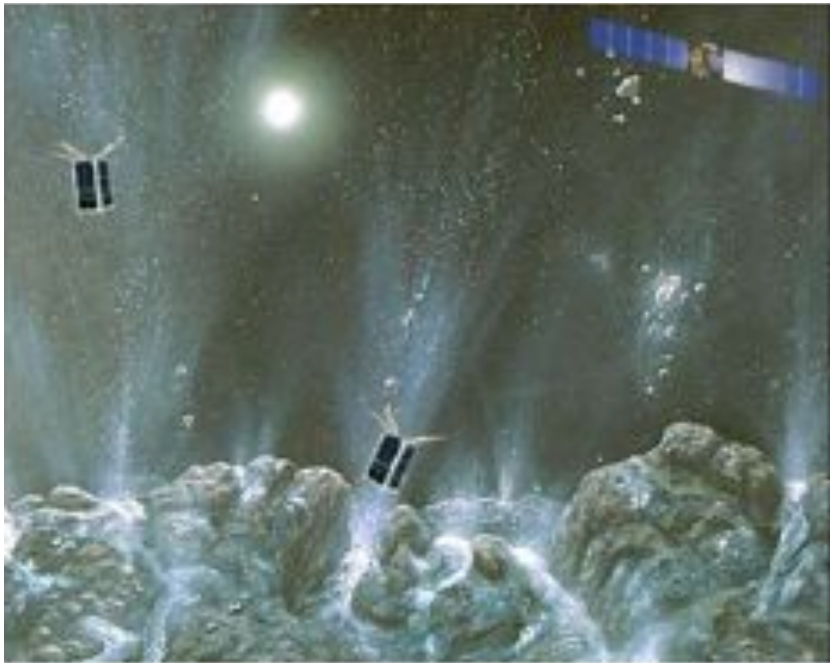
Deep Space SmallSat Constellations

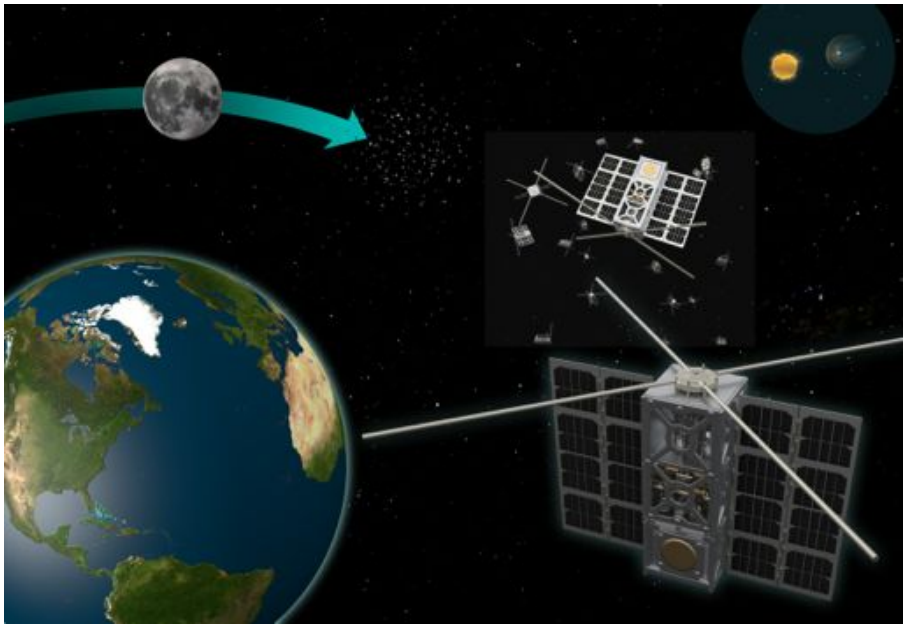
Imagine fleets of spacecraft at other bodies …

- **Possible with “smallsats”?!**
- **Lunar Flashlight, NEO Scout, Biosentinal attached to E-M 1**

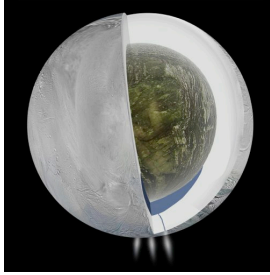
Planetary and Space Science Constellations

An Incomplete List …





Deep Space Network as a Ground-Space Observatory



Three major tracking sites around the globe, with 16 large antennas, provide continuous communication and navigation support for world's deep space missions

- **Spigot for science data from most spacecraft instruments exploring the solar system**

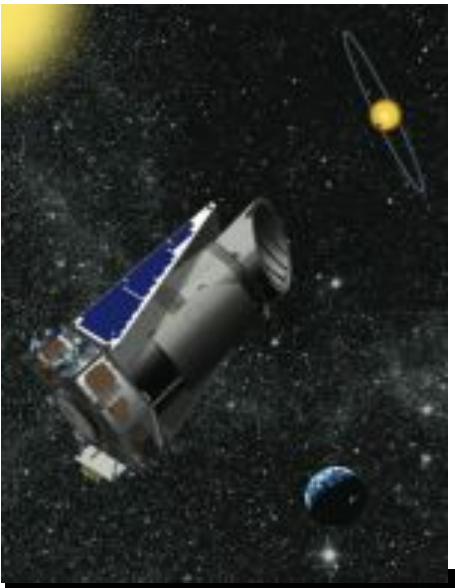
  Partners with ~ 35 spacecraft both for NASA and foreign agencies

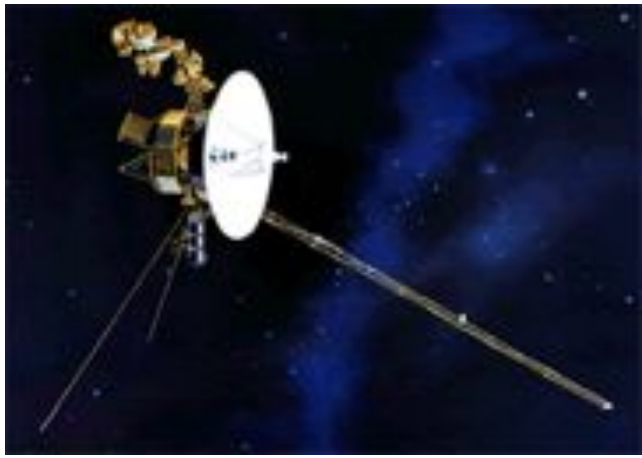
- **Science instrument in its own right**
  - **Radar astronomy of most solid system bodies with solid surfaces**
  - **Radio science probing interiors, atmospheres, and rings**
  - **Radio astronomy to address fundamental questions**

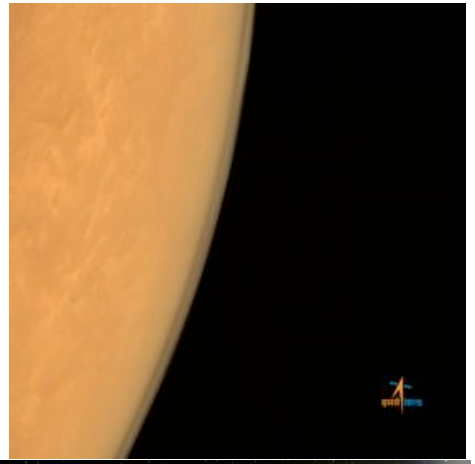

Backup

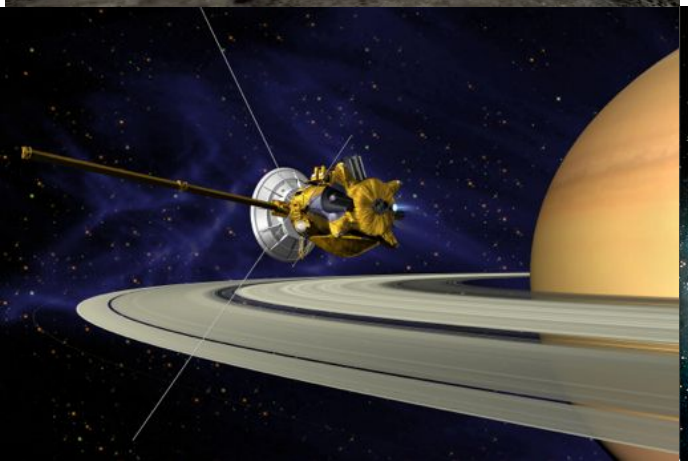
Missions

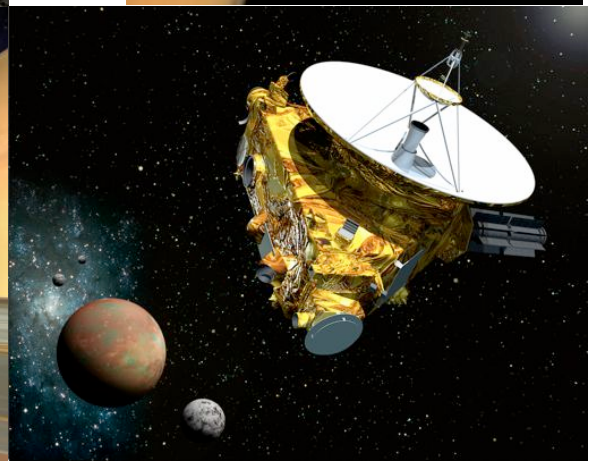
Integral partner for ~ 36 missions











Ultimate Long Distance Carrier

The power received by 70 m DSN antenna from Voyager is so small that if it were to be accumulated for 10 trillion years, it could power a refrigerator light bulb for one second!!!

Can you hear me now?

The Deep Space Network

Signals from Distant Spacecraft are Faint