Basics of Space Flight

Instruments and Experiments

Not science results *per se.* Instead, this is how to categorize the many varied kinds of observations made by interplanetary spacecraft.

Dave Doody

Basics of Space Flight

The four basic categories:

	Remote-sensing	Direct-Sensing (in-situ)
Passive	Camera	
Active		

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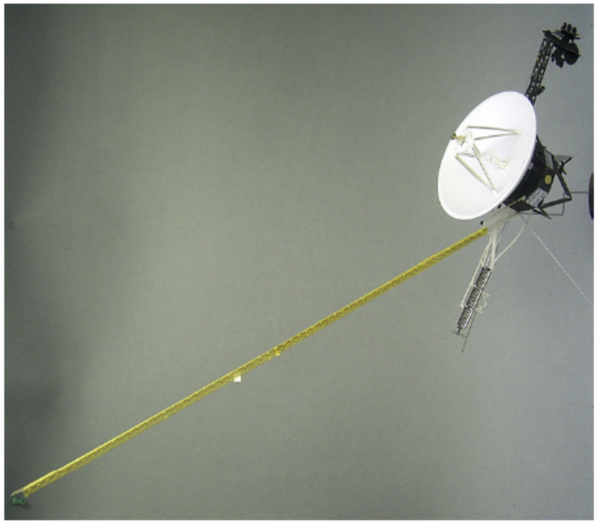

The four basic categories:

	Remote-sensing	Direct-Sensing (in-situ)
Passive		Magnetometer
Active		

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The four basic categories:

	Remote-sensing	Direct-Sensing (in-situ)
Passive		
Active	Radar	

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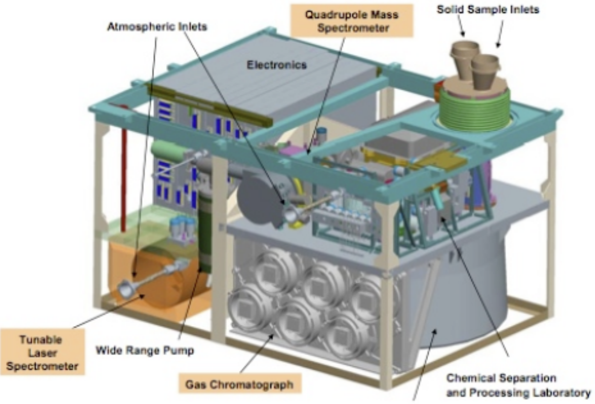

The four basic categories:

	Remote-sensing	Direct-Sensing (in-situ)
Passive		
Active		SAM (MSL Curiosity's Science Analysis at Mars instrument)

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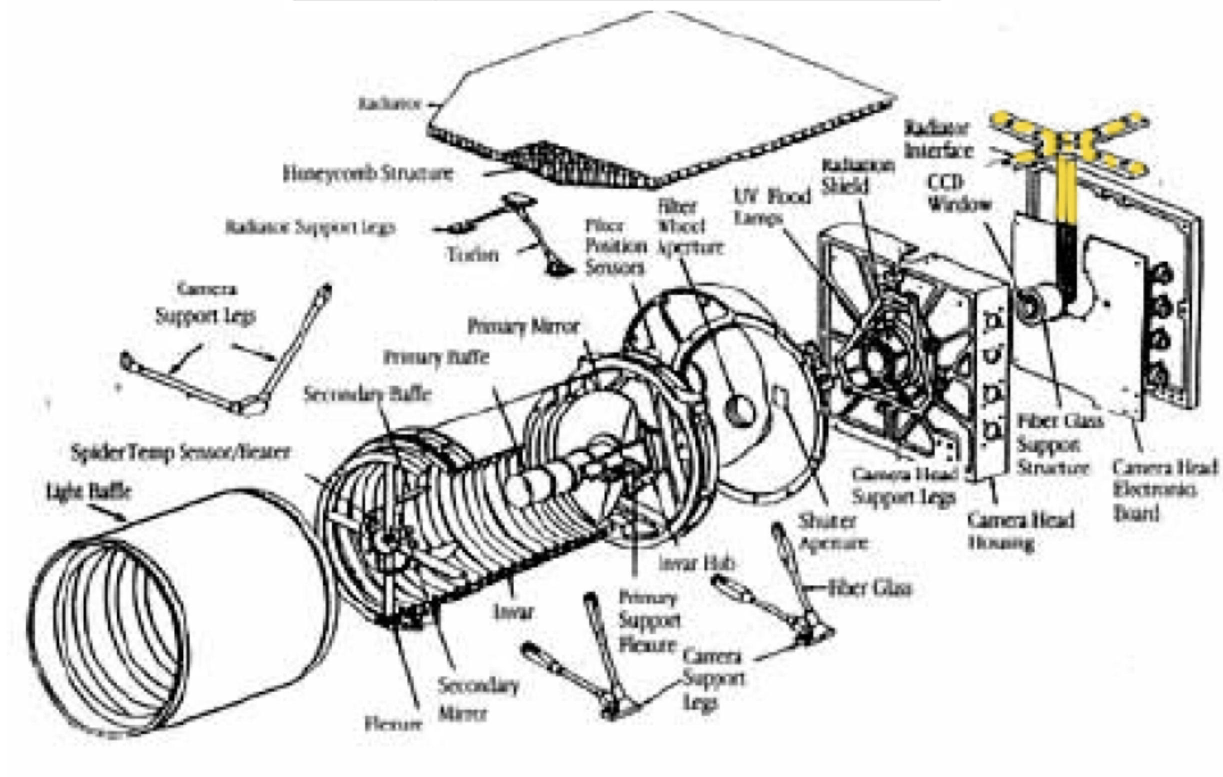
	Remote-sensing	Direct-Sensing (in-situ)
Passive		
Active		

Cameras



Spectrometers

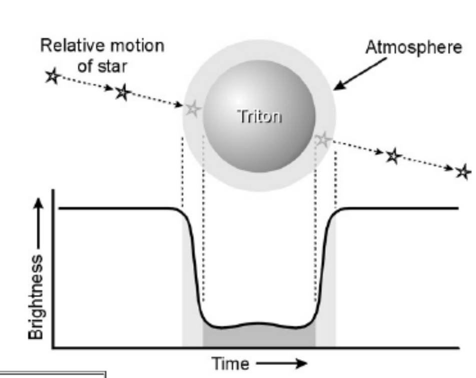
CCD

	Remote-sensing	Direct-Sensing (in-situ)
Passive		
Active		

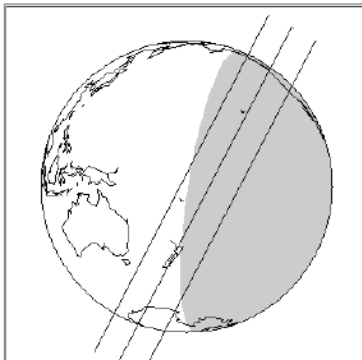
Occultation Experiments

- **Earth-based** telescopes watching a body pass in front of a star
- **Spacecraft instruments**
  - Solar port
  - Stellar
- **Radio Science**
  - Spacecraft goes behind while transmitting radio tones

Occultation of a Star by Triton



STSCI-PR98-23 • June 24, 1998 • J. Elliot (MIT) and NASA



P131.1 Current Prediction

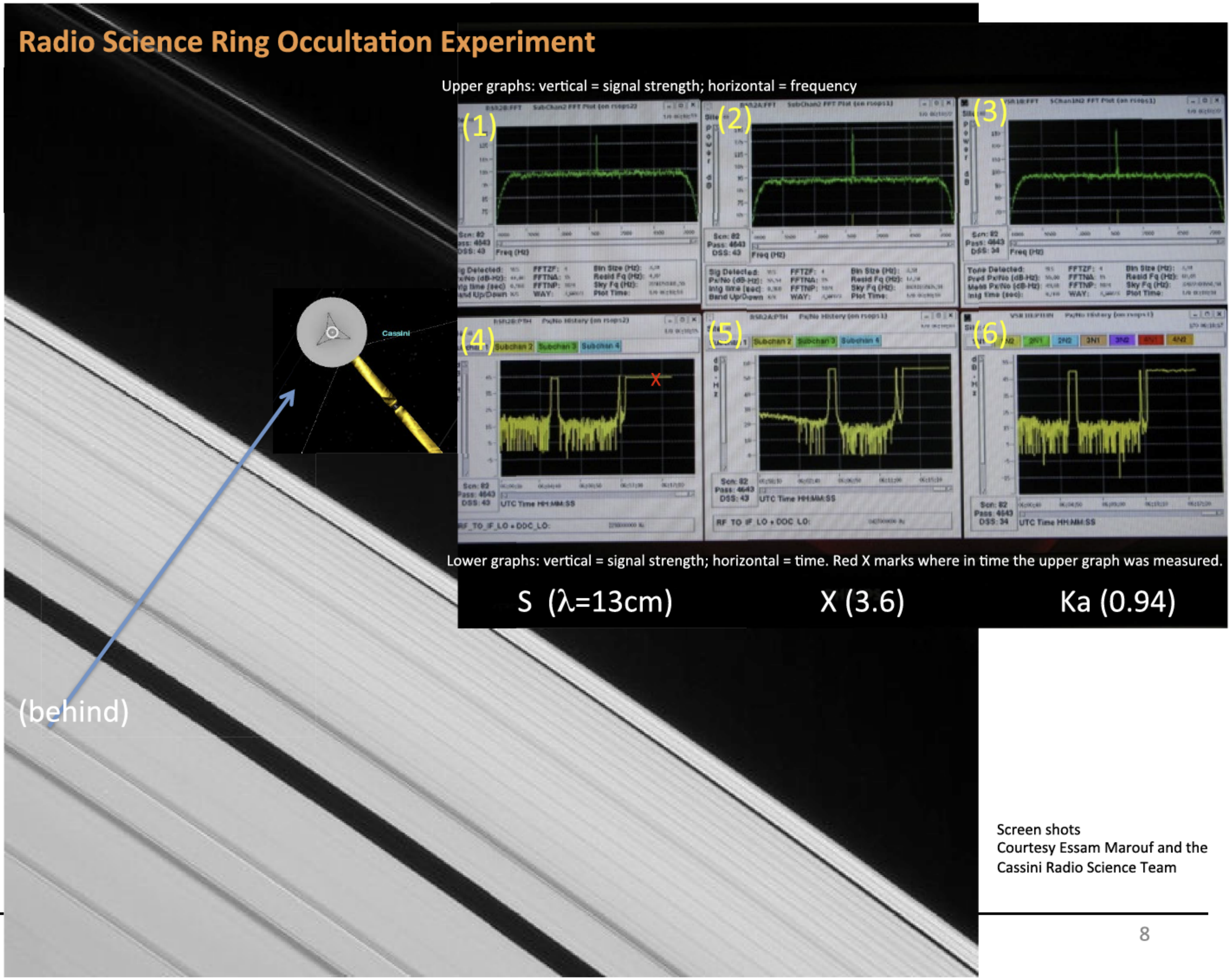
(as of 2002 08 16 05:12 AM EDT)

Date and Time (yyyy mm dd hh:mm:ss)	2002 08 21 06:59:41 UT
Minimum Geocentric Separation (arcsec)	**0.04 +/- 0.01**
Position Angle (degrees)	117
Geocentric Shadow Velocity (km s^{-1})	6.6
Star Magnitude	15.7 (V)
Solar Angle (deg)	107
East Longitude (deg)	-179
Distance (AU)	30.24
Prediction Version	*p131.1-2.8*

F

Keeler

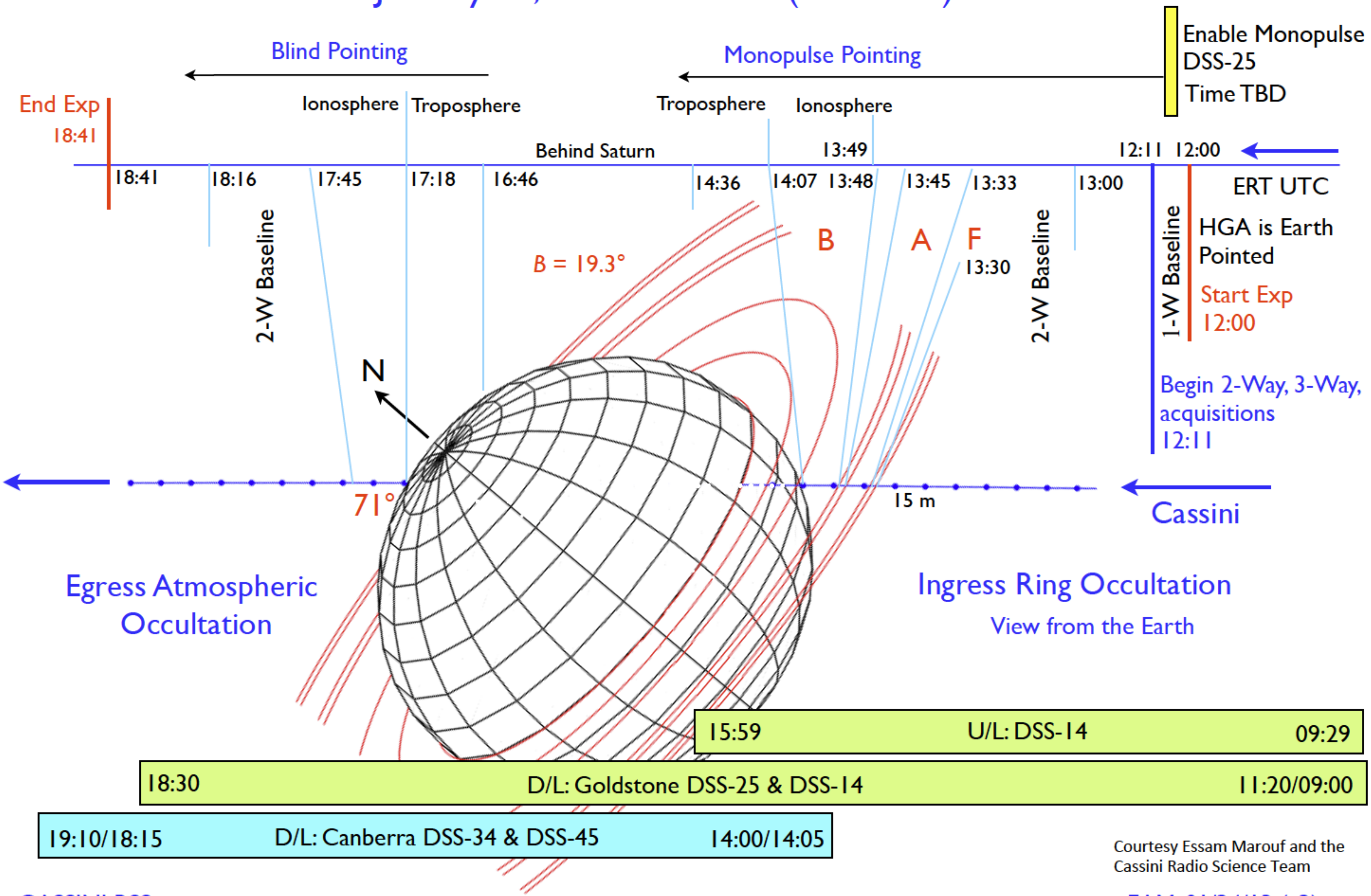
Enke



Screen shots
Courtesy Essam Marouf and the Cassini Radio Science Team

Cassini Rev180: 2-Way RSS Ring & Atmospheric Occultations

January 31, 2013 ERT UTC (DOY 031)



Courtesy Essam Marouf and the Cassini Radio Science Team

CASSINI RSS

EAM: 01/24/13 (v2)

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	Remote-sensing	Direct-Sensing (in-situ)
Passive		
Active		

Some interesting RS Ring Occultation Experiment results:

http://saturn.jpl.nasa.gov/photos/imagedetails/index.cfm?imageId=2937

Here's a description of Radio science investigations by the Venus Express Radio Science Experiment VeRa onboard the Venus Express spacecraft (B. Häusler et al.):

http://dx.doi.org/10.1016/j.pss.2006.04.032

	Remote-sensing	Direct-Sensing (in-situ)
Passive		
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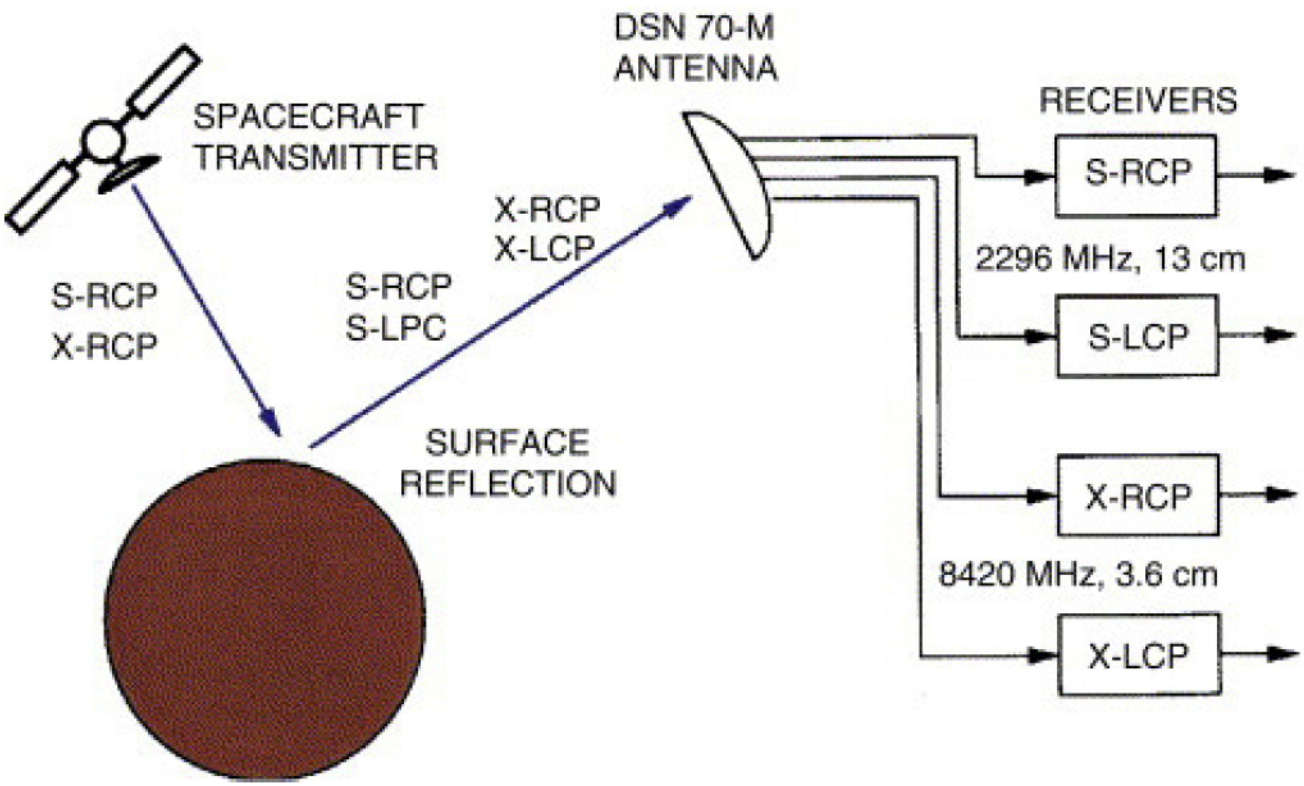
Radio Science Bistatic Experiment



Radio science investigations by VeRa onboard the Venus Express spacecraft, B. Häusler et al. http://dx.doi.org/10.1016/j.pss.2006.04.032

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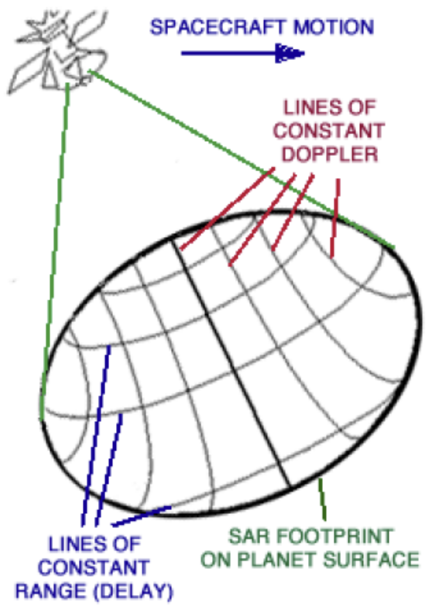
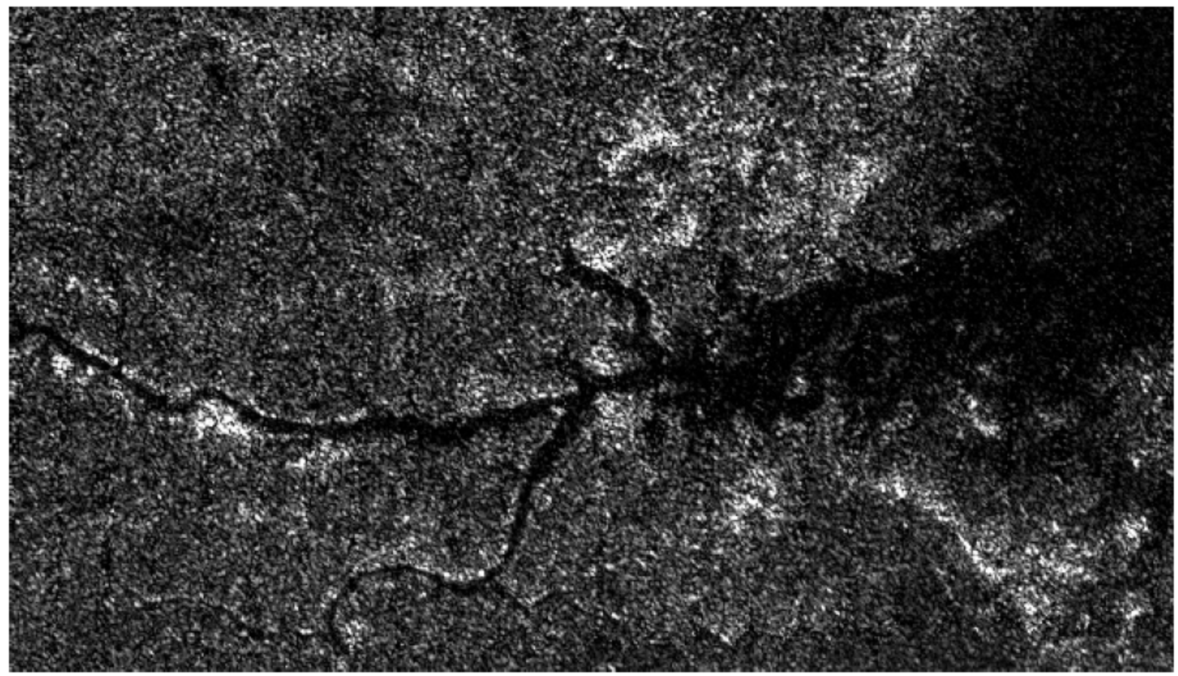
Synthetic Aperture Radar (SAR) Imaging





	Remote-sensing	Direct-Sensing (in-situ)
Passive		
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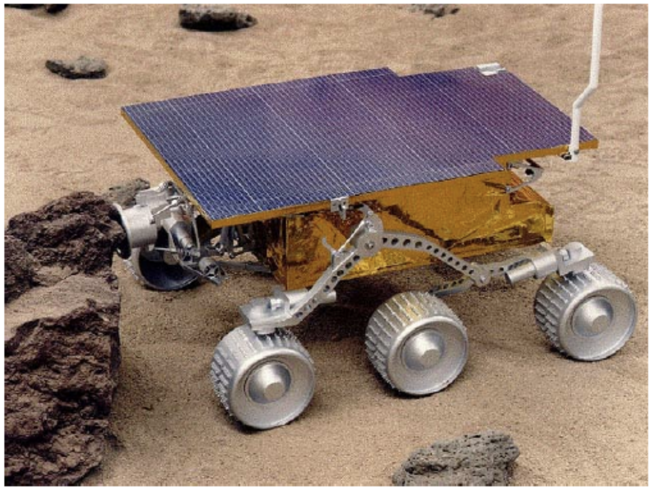
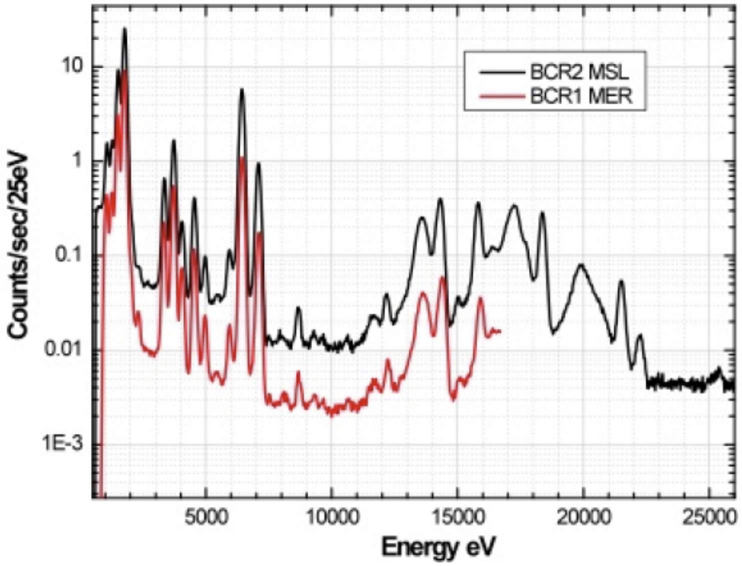
The Good Old APXS

Alpha-Particle X-ray Spectrometer



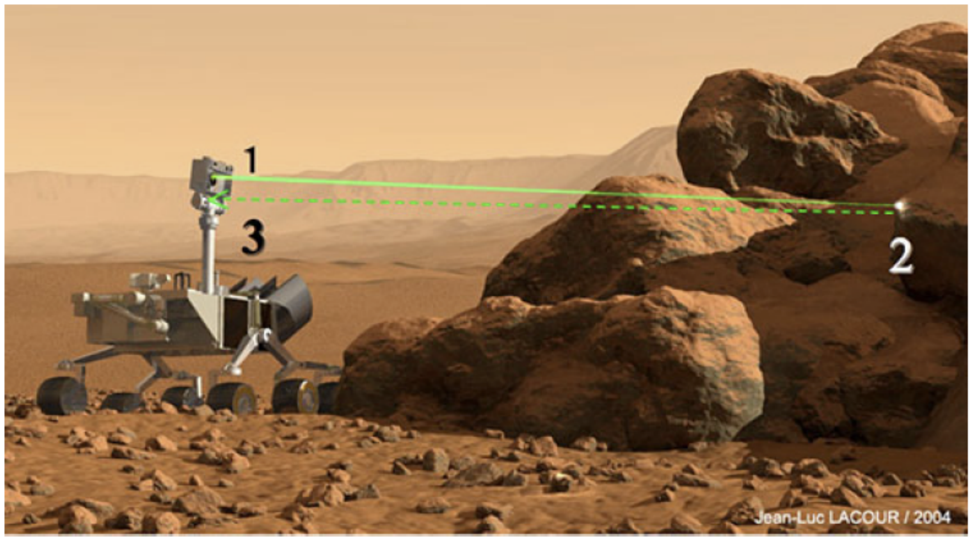


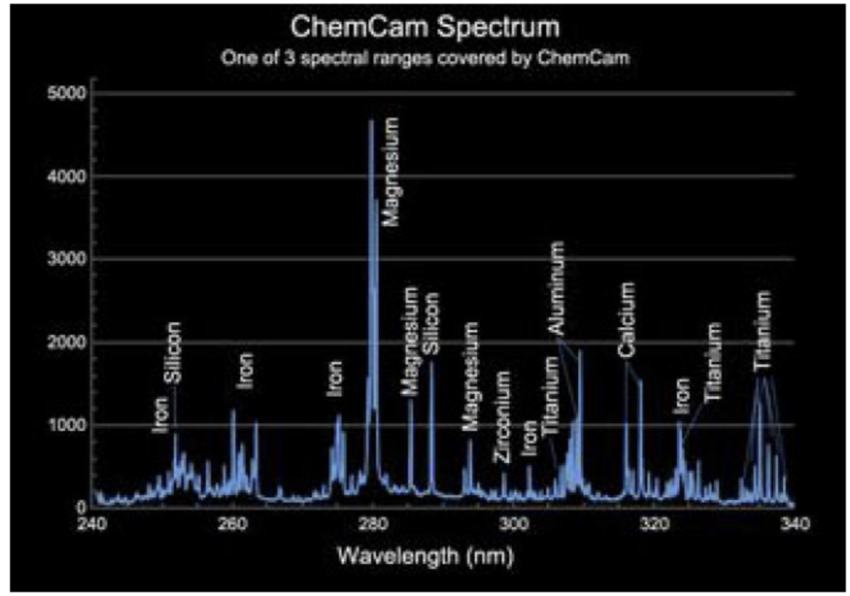
The APXS for MSL is an improved version of the one on Pathfinder and Mars Exploration Rovers Spirit and Opportunity. The MSL APXS takes advantage of a combination of the terrestrial standard methods Particle-Induced X-ray Emission (PIXE) and X-ray Fluorescence (XRF) to determine elemental chemistry. It uses curium-244 sources for X-ray spectroscopy to determine the abundance of major elements down to trace elements from sodium to bromine and beyond.

http://msl-scicorner.jpl.nasa.gov/Instruments/APXS/

MSL Chem Cam

	Remote-sensing	Direct-Sensing (in-situ)
Passive		
Active		





Previous spacecraft missions to Mars, like the Spirit and Opportunity rovers, had to undertake a rather laborious, and time-consuming, task of approaching a rock, brushing away dust, and, sometimes, grinding away outer layers of rock to take a measurement of a rock's true composition. To do all this, the rovers had to come into contact with the rock. When conducting a Mars mission, time is precious and efficiency is a necessity. It was not unheard of for Spirit and Opportunity to require two to three days to determine the composition of a rock. ChemCam's laser removes the need to touch the rock. It allows ChemCam to determine a rock's composition from a distance of up to 7 meters (~25 feet)! On average, the ChemCam team expects to take approximately one dozen compositional measurements of rocks per day.

http://mars.jpl.nasa.gov/msl/mission/instruments/spectrometers/chemcam/

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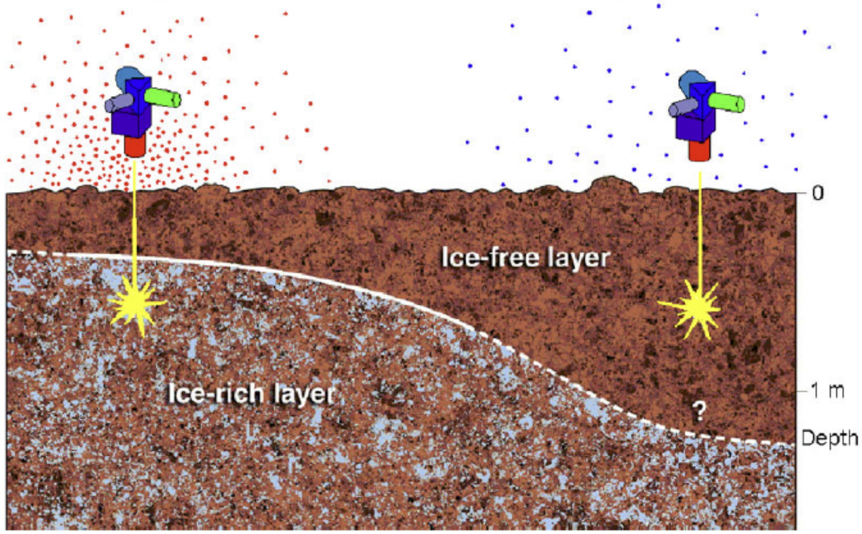
MSL's DAN

Dynamic Albedo of Neutrons instrument



DAN can work in a passive mode relying on cosmic rays, but it also has its own pulsing neutron generator for an active mode of shooting high-energy neutrons into the ground. In active mode, it is sensitive enough to detect water content as low as one-tenth of one percent in the ground beneath the rover.

http://mars.jpl.nasa.gov/msl/mission/instruments/radiationdetectors/dan/

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LPM’s Neutron Spectrometer

The NS looks for what scientists call "cool" neutrons -- neutrons that have bounced off a hydrogen atom somewhere on the lunar surface. When cosmic rays collide with atoms in the crust, they violently dislodge neutrons and other subatomic particles. Some of the neutrons escape directly to space, as hot or "fast" neutrons. Other neutrons shoot off into the crust, where they **collide with atoms**, bouncing around like billiard balls. If they only run into heavy atoms, they do not lose very much energy in the collisions, and are still traveling at close to their original speed when they finally bounce off into outer space. (Picture a billiard ball encountering a brick wall.) They will still be warm (or "epithermal") when they reach the NS.

The only effective way to slow down a speeding neutron is to have it collide with something close to its own mass. (The same is true with a billiard ball: if it runs head on into a stationary ball, it will come to a dead stop.) There's only one atom the same mass as a neutron: hydrogen. If the Moon's crust contains a lot of hydrogen at a certain location -- say, a crater with water in it -- any neutron that bounces around in the crust before heading out to space will cool off rapidly; the NS detects a surge in the number of cool ("thermal") neutrons, and a dropoff in the number of warm ("epithermal") neutrons.

http://lunar.arc.nasa.gov/results/neutron.htm

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www.jpl.nasa.gov/basics

Etc.