JPL

CASSINI PROGRAM

Mission to Saturn and Titan

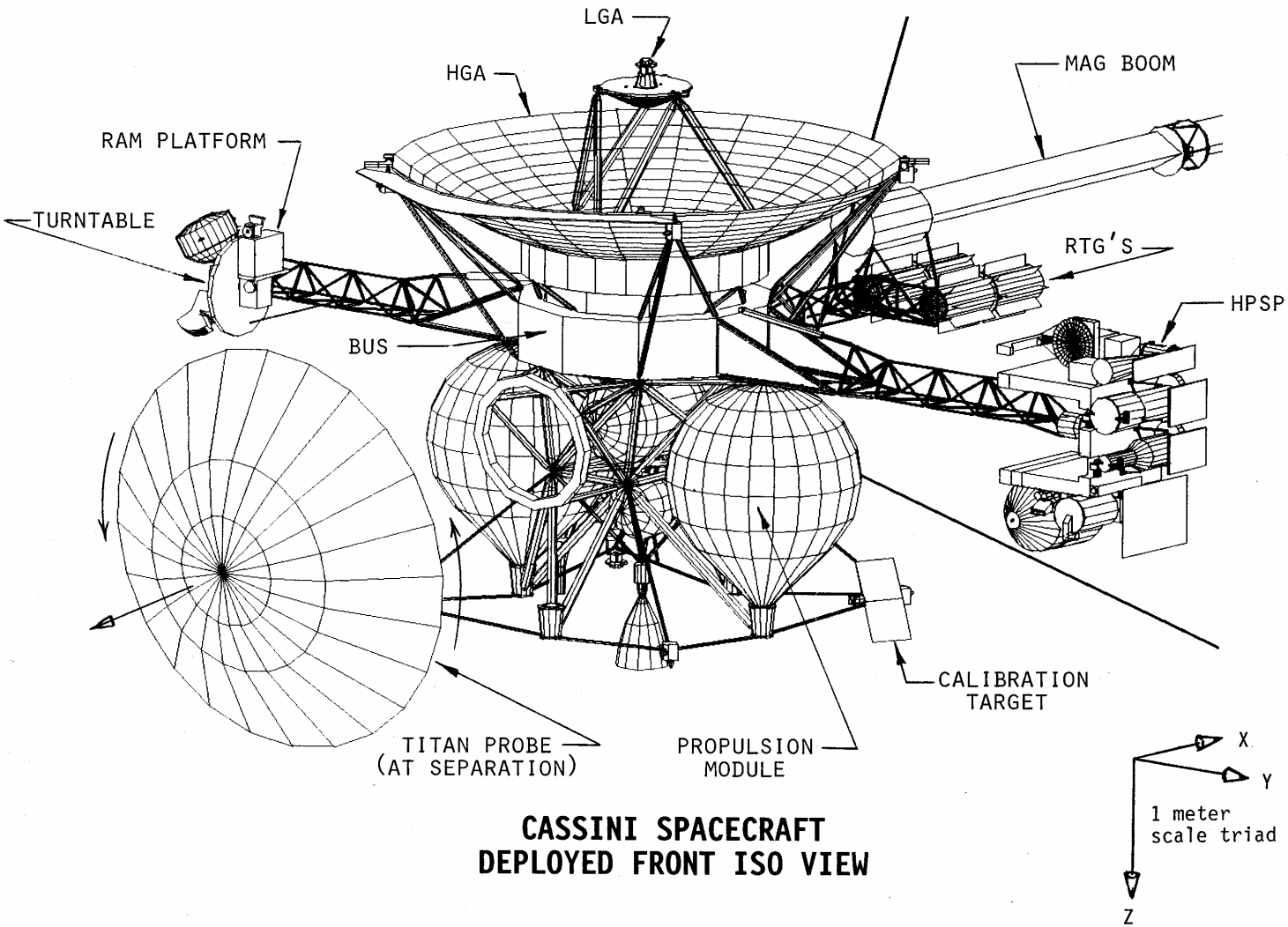
CASSINI SCIENCE OBJECTIVES

ELLIS D. MINER

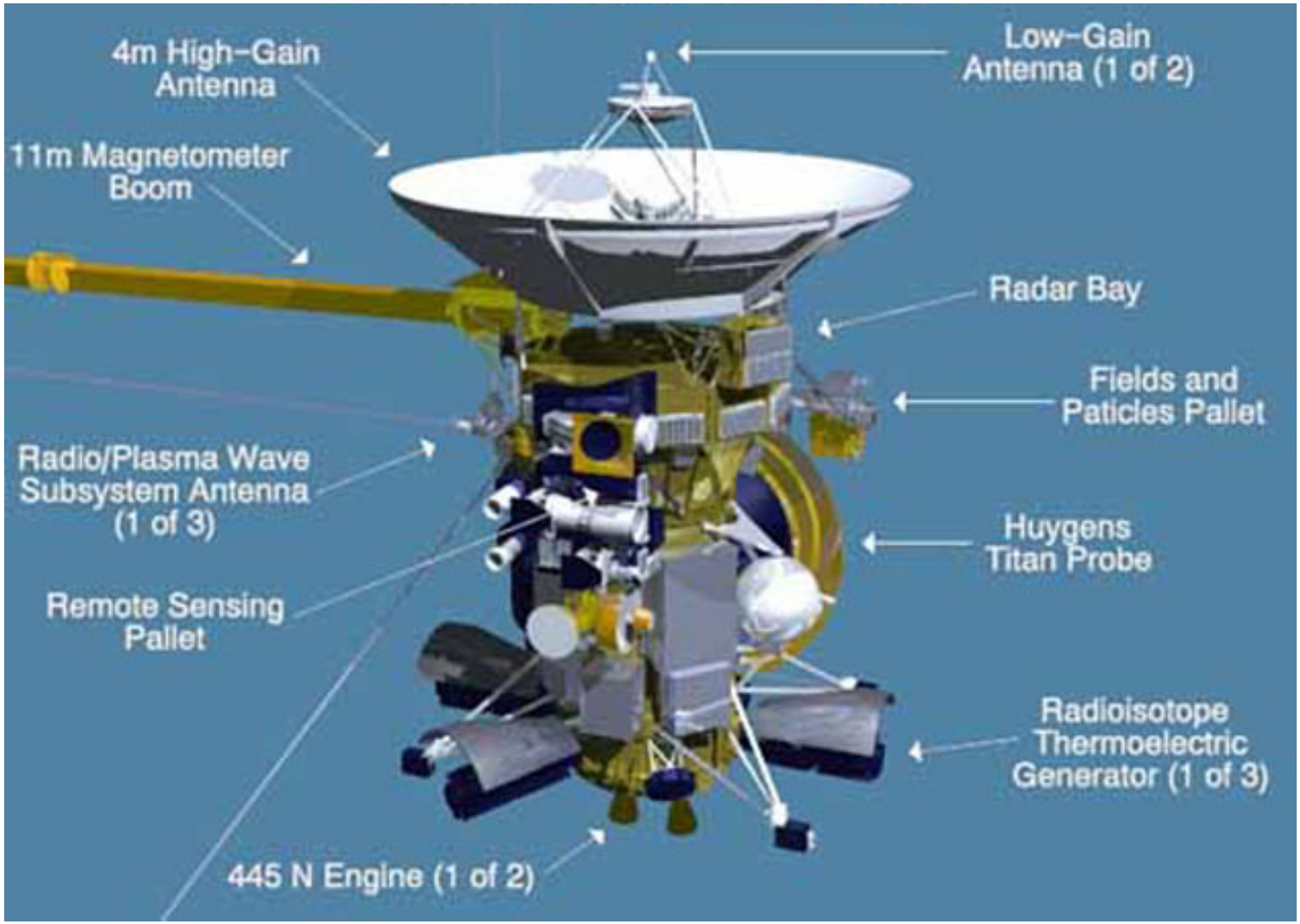
AUGUST 11, 2000

Cassini is an International Mission

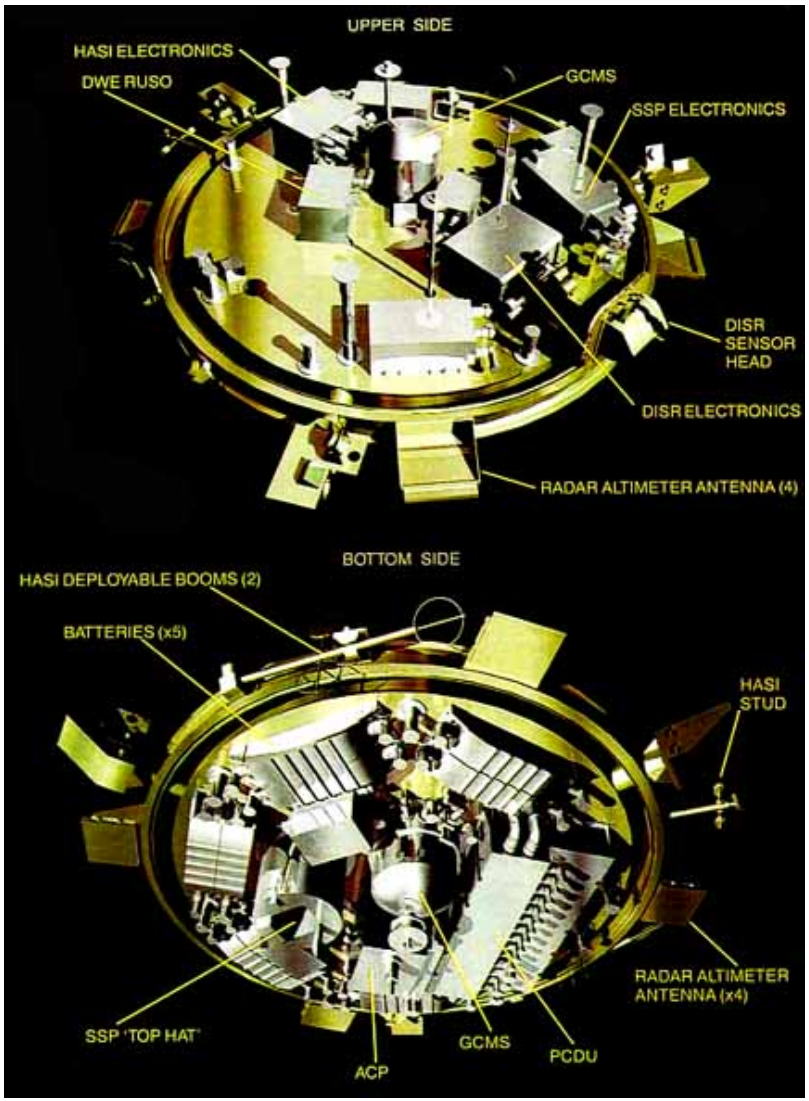
Original Spacecraft Design (Ideal for Science)



Cassini Spacecraft Diagram



Huygens Titan Probe



Aerosol Collector Pyrolyser (ACP) - In-situ study of clouds and aerosols in Titan atmosphere

Descent Imager and Spectral Radiometer (DISR) - Temperatures and images of Titan's atmospheric aerosols and surface

Doppler Wind Experiment (DWE) - Study of winds from their effect on the probe during descent

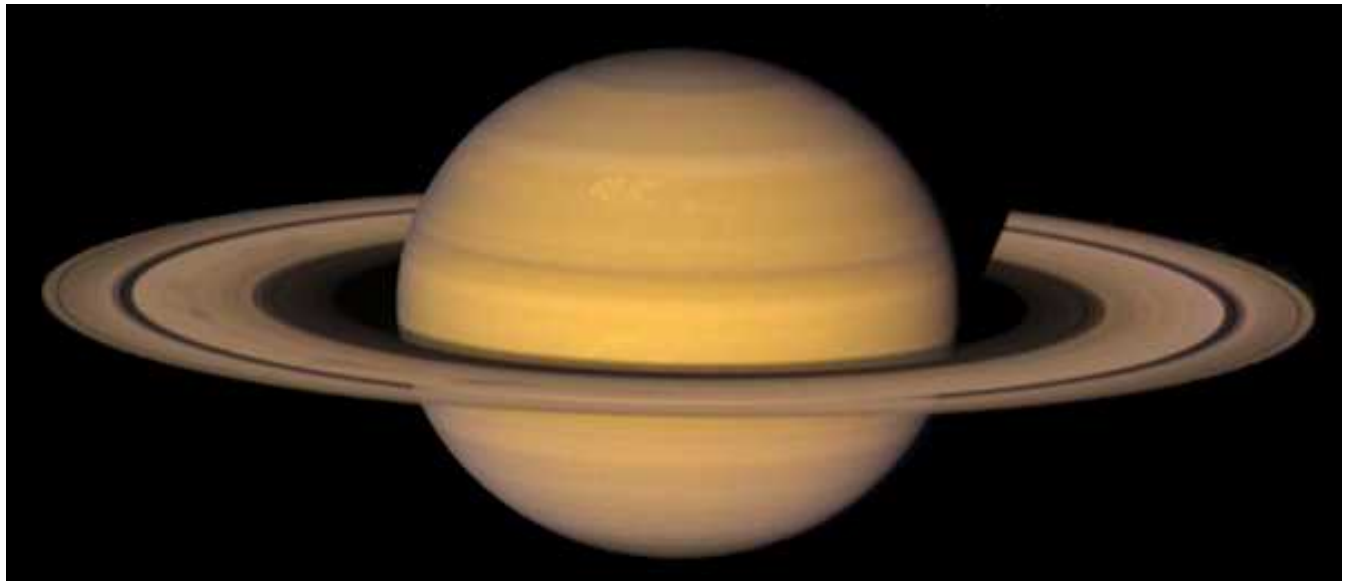
Gas Chromatograph and Mass Spectrometer (GCMS) - Measurement of chemical composition of gases and aerosols in Titan's atmosphere

Huygens Atmospheric Structure Instrument (HASI) - Study of Titan atmospheric physical and electrical properties

Surface Science Package (SSP) - Measurement of the physical properties of Titan's surface

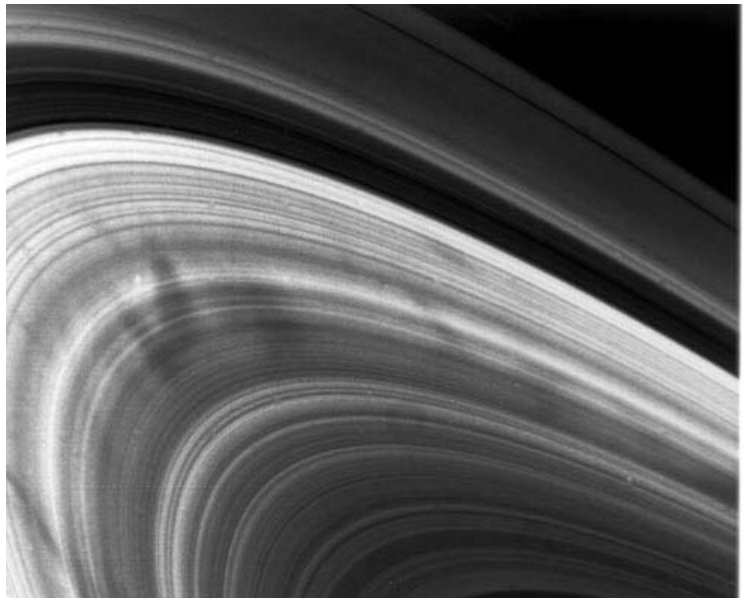
3 Interdisciplinary Scientists (IDSs) - Titan aeronomy, Titan atmosphere-surface interactions, Titan chemistry and exobiology

Cassini Saturn Objectives



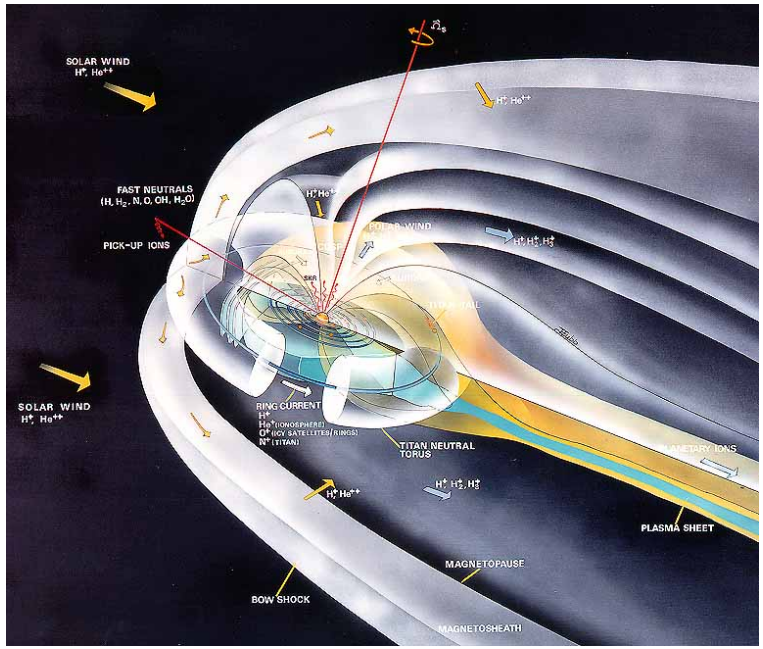
- Compositional abundances of gases.
- Wind speeds and directions.
- Internal structure and dynamics of the planet.
- Day-to-night variations of the ionosphere.
- Scenarios for formation and evolution.
- Sources and characteristics of lightning and radio emissions.

Cassini Ring Objectives



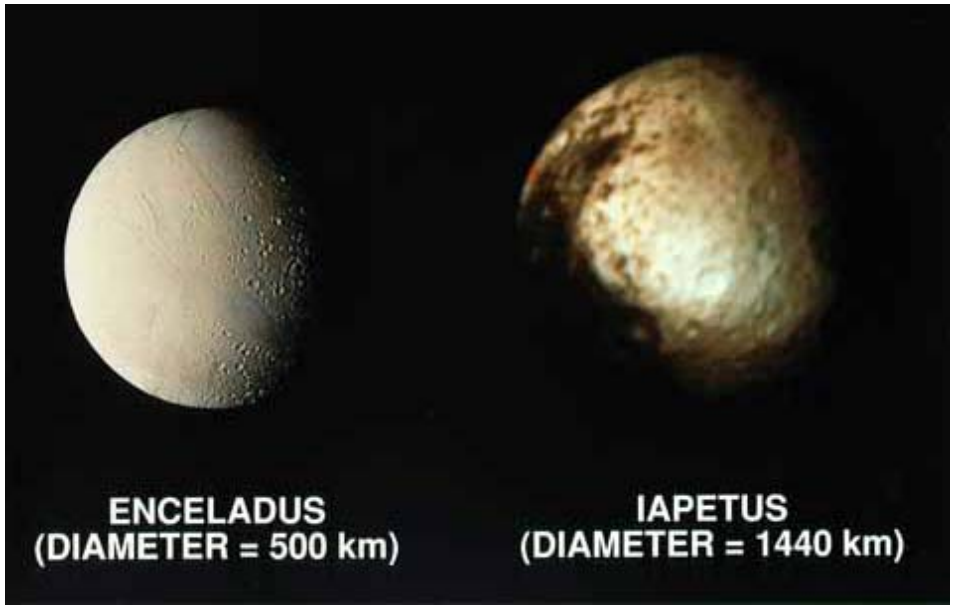
- Shape and structure of the rings and their formative processes.
- Composition and sizes of ring particles.
- Relationship between the rings and the moons.
- Distribution of dust and meteoroids.
- Interactions between the rings and Saturn's magnetosphere, ionosphere, and atmosphere.

Cassini Magnetospheric and Plasma Science Objectives



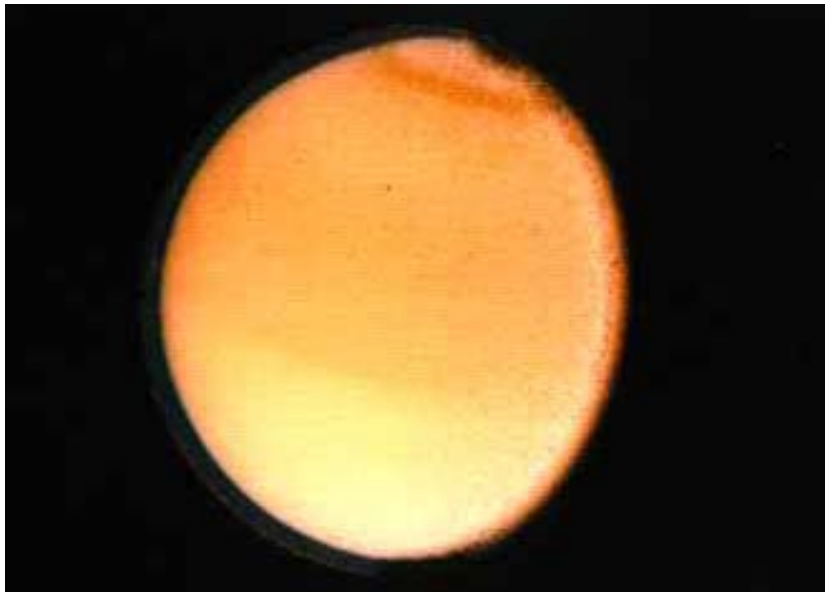
- Shape/orientation of the magnetic field; relationship to radiation.
- Current flow and composition/sources/sinks of charged particles.
- Interactions between the charged particles and radio waves.
- Titan's interaction with the plasma.
- Interactions between Titan's atmosphere and the magnetosphere.

Cassini Icy Satellite Objectives



- Characteristics and geological histories.
- Processes that change the surface.
- Surface materials and their spatial distribution (especially Iapetus).
- Constraints on internal structure and composition.
- Interactions with the magnetosphere and the ring system.

Cassini Titan Objectives



- Abundances of gases, learn how Titan formed and evolved.
- Trace gases, complex organic molecules, and “chemical” energy sources.
- Winds, global temperatures, cloud properties, search for lightning.
- Nature of surface (liquid or solid), internal structure.
- Upper atmosphere / ionosphere as sources of magneto-material.

254 Cassini Science Team Members

INMS (7:6us/1eu)
Waite, Hunter (TL)
Cravens, Thomas
Ip, Wing-Huen
Kasprzak, Wayne
Luhmann, Janet
McNutt, Ralph
Yelle, Roger

ISS (14:11us/3eu)
Porco, Carolyn (TL)
Brahic, Andre
Burns, Joseph
Del Genio, Anthony
Dones, Henry
Ingersoll, Andrew
Johnson, Torrence
McEwen, Alfred
Murray, Carl
Neukum, Gerhard
Squyres, Steven
Thomas, Peter
Veverka, Joseph
West, Robert

RADAR (13:7us/6eu)
Elachi, Charles (TL)
Encrenaz, Pierre
Janssen, Michael
Kirk, Randolph
Muhleman, Duane
Ostro, Steven
Picardi, Giovanni
Posa, Francesco
Rapley, Chris
Seu, Roberto
Vetrella, Sergio
Wood, Charles
Zebker, Howard

RSS (11:8us/3eu)
Kliore, Arvydas (TL)
Ambrosini, Roberto
Anderson, John
Armstrong, John
Bertotti, Bruno
Flasar, Michael
French, Richard
Iess, Luciano
Marouf, Essam
Nagy, Andrew
Rappaport, Nicole

VIMS (22:9us/13eu)
Brown, Robert (TL)
Baines, Kevin
Belluchi, Giancarlo
Bibring, Jean-Pierre
Buratti, Bonnie
Bussoletti, Ezio
Cappaccioni,Fabrizio
Cerroni, Priscilla
Clark, Roger
Combes, Michel
Coradini, Angioletta
Cruikshank, Dale
Drossart, Pierre
Formisano, Vittorio
Jaumann, Ralf
Langevin, Yves
Matson, Dennis
McCord, Thomas
Nelson, Robert
Nicholson, Philip
Sicardy, Bruno
Sotin, Christophe

Orbiter IDSs (6:5us/ 1Eu)
Blanc, Michel
Cuzzi, Jeffrey
Gombosi, Tamas
Owen, Tobias
Soderblom, Laurence
Strobel, Darrell

CAPS (15:7us/8eu)
Young, David (PI)
Berthelier, Jean-Jacques
*Blanc, Michel
Burch, James
Coates, Andrew
Goldstein, Raymond
Grande, Manual
Hill, Thomas
Johnson, Robert
Kelha, Vaino
McComas, David
Sittler, Edward
Svenes, Knut
Szegö, Karoly
Tanskanen, Pekka

CDA (20:5us/15eu)
Grün, Eberhard (PI)
Ahrens, Thomas
Auer, Siegfried
Cruise, Michael
Fechtig, Hugo
Havnes, Ove
Igenbergs, Eduard
Jessberger, Elmar
*Johnson, Torrence
Lamy, Philippe
Lura, Franz
McDonnell, Anthony
Möhlmann, Dietrich
Morfill, Gregor
Pernicka, Ernst
Schwehm, Gerhard
Svestka, Jiri
Tuzzolino, Anthony
Wäsch, Richard
Zook, Herbert

CIRS (31:15us/16eu)
Kunde, Virgil (PI)
Abbas, Mian
Ade, Peter
Barucci, Antonietta
Bezard, Bruno
Bjoraker, Gordon
Brasunas, John
Calcutt, Simon
Cesarsky, CatherineR
Conrath, Barney
*Coradini, Angioletta
Courtin, Regis
Coustenis, Athena
*Flasar, Michael
*Gautier, Daniel
Gierasch, Peter
Grossmann, Klaus
Jennings, Donald
Lellouch, Emmanuel
Marten, Andre
Meyer, Jean-Paul
Orton, Glenn
*Owen, Tobias
Pearl, John
Prange, Renee
*Raulin, Francois
Read, Peter
Romani, Paul
Samuelson, Robert
Spilker, Linda
Taylor, Fredric

MAG (12:4us/8eu)
Southwood, David (PI)
Balogh, Andre
Cowley, Stanley
Dougherty, Michelle
Erdös, Geza
Glassmeier, Karl-Heinz
Neubauer, Fritz
Russell, Christopher
Siscoe, George
Smith, Edward
*Szegö, Karoly
Tsurutani, Bruce

MIMI (22:13us/9eu)
Krimigis, Stamatios (PI)
Alcaydé, Denis
Armstrong, Thomas
Bosqued. Jean-Michel
Cheng, Andrew
Dandouras, Jannis
Gloeckler, George
Hamilton, Douglas
Hsieh, K. C. "Johnny"
*Ip, Wing-Huen
Keath, Edwin
Kirsch, Erhard
Lanzerotti, Louis
Livi, Stefano
Mauk, Barry
McEntire, Richard
Mitchell, Donald
Reme, Henri
Roelof, Edmond
Sauvaud, Jean-Andre
Wilkin, Berend
Williams, Donald

RPWS (21:7us/14eu)
Gurnett, Donald (PI)
Boström, Rolf
Canu, Patrick
Cornilleau-Wehrlin, Nicole
Desch, Michael
Farrell, William
Galopeau, Patrick
Goetz, Keith
Gustafsson, Georg
Harvey, Christopher
Kaiser, Michael
Kellogg, Paul
Kurth, William
Ladreiter, Hans
Lecacheux, Alain
Louarn, Philippe
Pedersen, Arne
Roux, Alain
Rucker, Helmut
Wahlund, Jan-Erik
Zarka, Philippe

UVIS (14:10us/4eu)
Esposito, Larry (PI)
Barth, Charles
Festou, Michel
Hansen, Candice
Keller, Uwe
Korth, Axel
Lane, Lonne
Lauche, Hans
Lawrence, George
McClintock, William
Shemansky, Donald
Stewart, Ian
*West, Robert
Yung, Yuk

HUYGENS PROBE

Huygens IDSs
(3:1us/2eu)
Gautier, Daniel
Lunine, Jonathan
Raulin, Francois

ACP (Huygens)
(14:4us/10Eu)
Israel, Guy (PI))
Atreya, Sushil
Bauer, Siegfried
Cabanne, Henri
Chassfiere, Eric
Hauchecorne, Alain
Muller, C.
*Niemann, Hasso
*Owen, Tobias
*Raulin, Francois
Riedler, Willi
Sable, Claude
*Samuelson, Robert
Torre, Jean-Pierre

DISR (Huygens)
(14:5us/9eu)
Tomasko, Martin (PI)
*Bezard, Bruno
*Combes, Michel
*Coustenis, Athena
DeBergh, Catherine
Doose, Lynn
Gliem, Fritz
*Keller, Uwe
*Lellouch, Emmanuel
Saint-Pé, Olivier
Smith, Peter
*Soderblom, Laurence
Thomas, Nicholas
*West, Robert

DWE (Huygens)
(7:4us/3eu)
Bird, Michael (PI)
Allison, Michael
Asmar, Sami
Atkinson, David
Edenhofer, Peter
*Iess, Luciano
Tyler, Leonard

GCMS (Huygens)
(13:9us/4eu)
Niemann, Hasso (PI)
*Atreya, Sushil
*Bauer, Siegfried
Biemann, Klaus
Carignan, George
Donahue, Thomas
*Gautier, Daniel
Hunten, Donald
*Israel, Guy
*Lunine, Jonathan
Mauersberger, Konrad
*Owen, Tobias
*Raulin, Francois

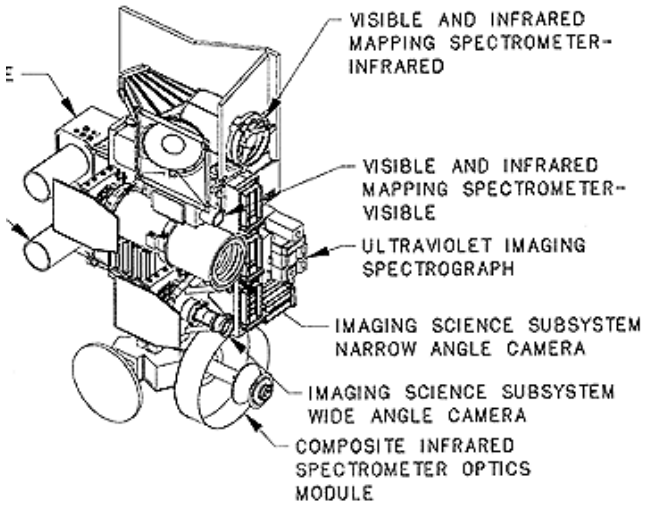
HASI (Huygens)
(21:2us/19eu)
Fulchignoni, Marcello (PI)
Angrilli, Francesco
Bianchini, Gianandrea
Blix, Thomas
Borouki, William
*Coustenis, Athena
Grard, Rejean
Hamelin, Michel
Harri, Ari-Matti
Lopez-Moreno, Jose
*McDonnell, Anthony
*Neubauer, Fritz
*Pedersen, Arne
Pellinen, Risto
Rodrigo, Rafael
Schwingenschuh, Konrad
Seiff, Alvin
Thrane, Eivind
Vanzani, Vittorio
Visconti, Guido
*Zarnecki, John

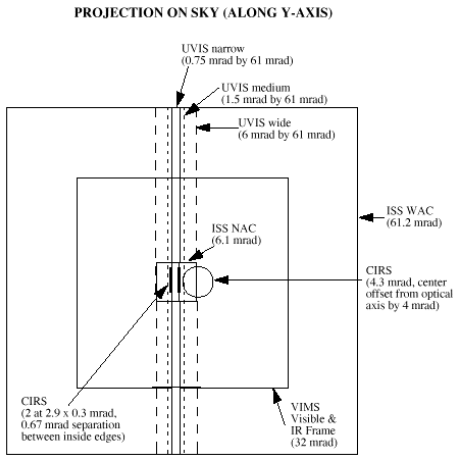
SSP (Huygens)
(12:3us/9eu)
Zarnecki, John (PI)
Boynton, William
Challenor, Peter
Clark, Benton
*Cruise, Michael
Delderfield, John
*Fulchignoni,Marcello
Geake, John
*Grard, Rejean
Green, Simon
Lorenz, Ralph
*McDonnell, Anthony

TOTAL Europe 132
TOTAL US 122

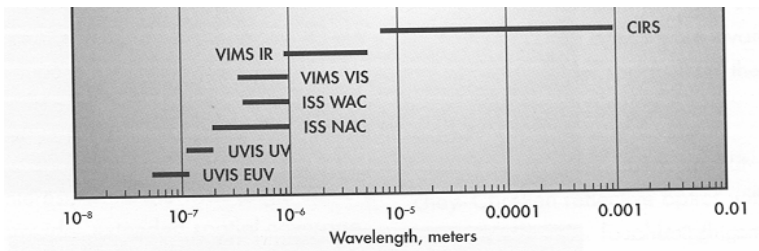
***2nd listing, not in totals**

Optical Remote Sensing Instruments

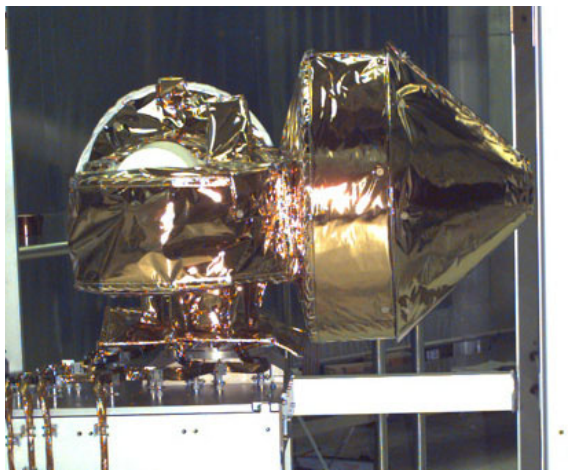


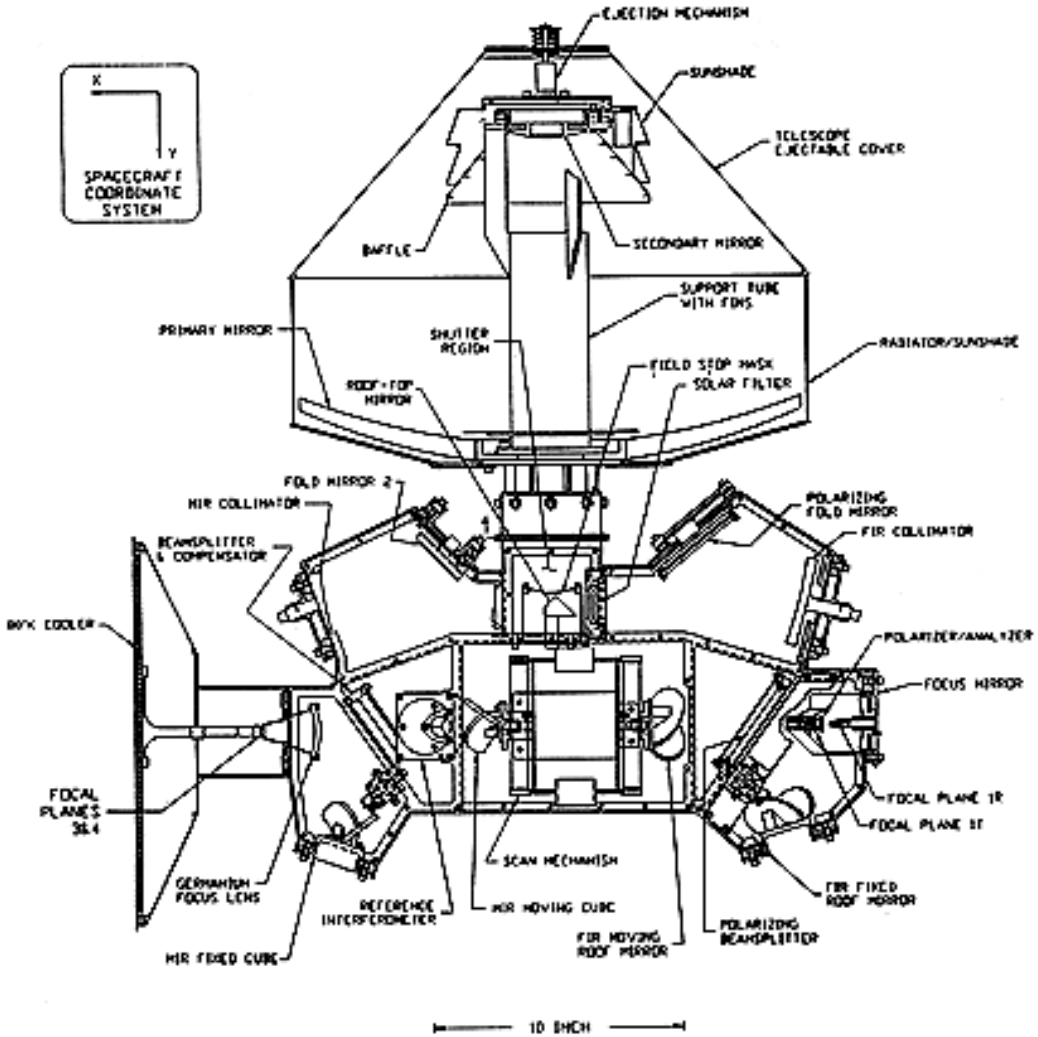


- **CIRS (Composite Infrared Spectrometer)** measures temperatures and compositions of surfaces, atmospheres, and rings.
- **ISS (Imaging Science)** does multispectral imaging of Saturn, Titan, rings, and icy satellites to observe their properties.
- **UVIS (Ultraviolet Imaging Spectrograph)** collects ultraviolet spectra / low-resolution images of atmospheres and rings.
- **VIMS (Visible and Infrared Mapping Spectrometer)** does spectral mapping of surfaces, atmospheres, and rings.

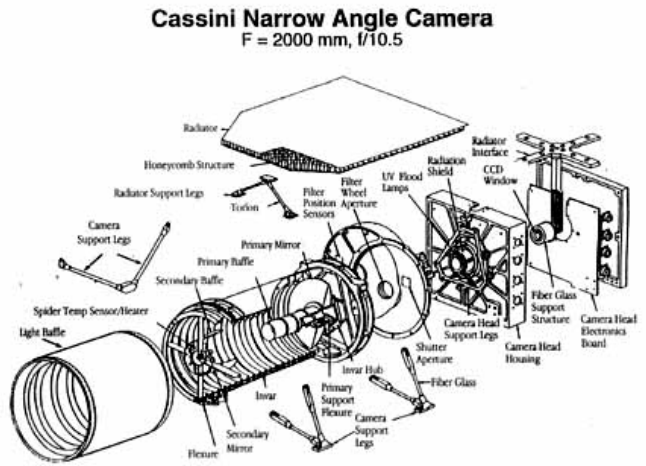


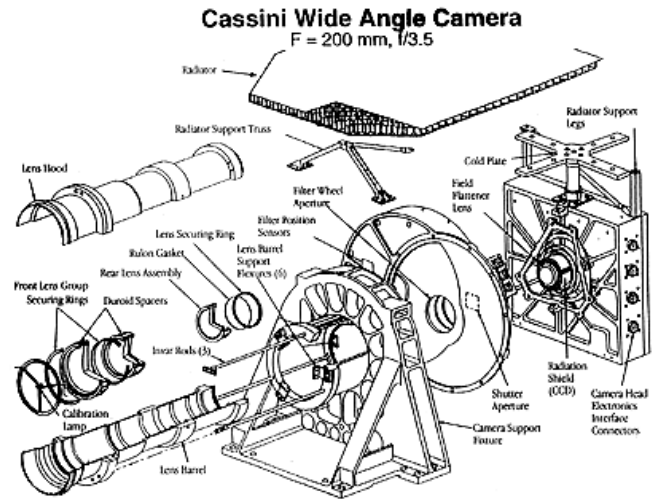
Composite Infrared Spectrometer (CIRS)



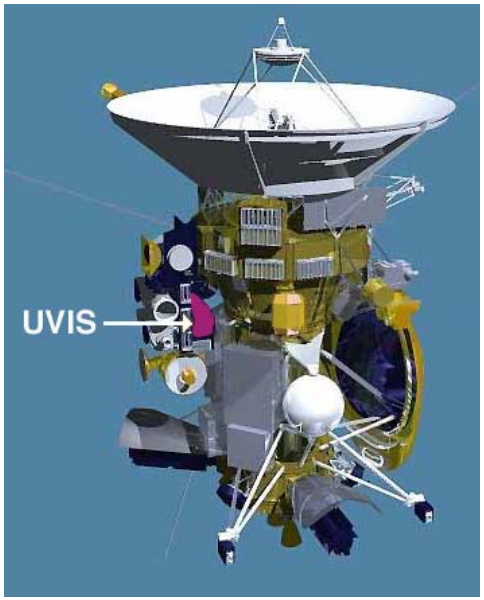


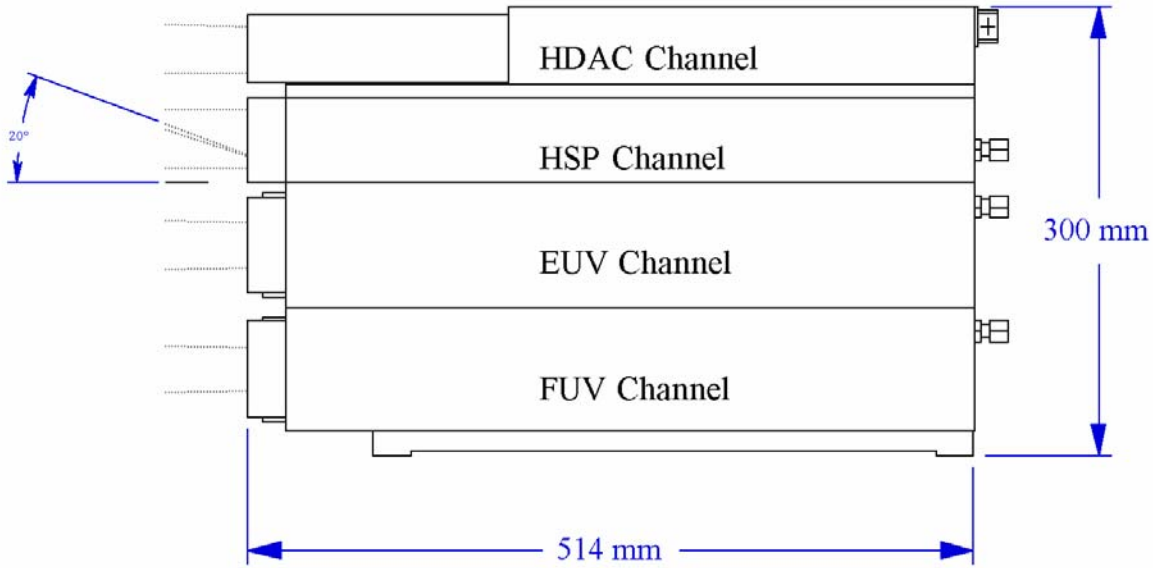
Imaging Science (ISS)

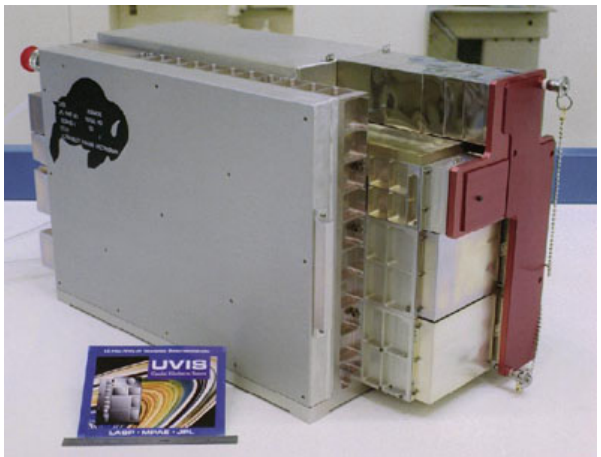




Ultraviolet Imaging Spectrograph (UVIS)







HDAC = Hydrogen-Deuterium Absorption Cell

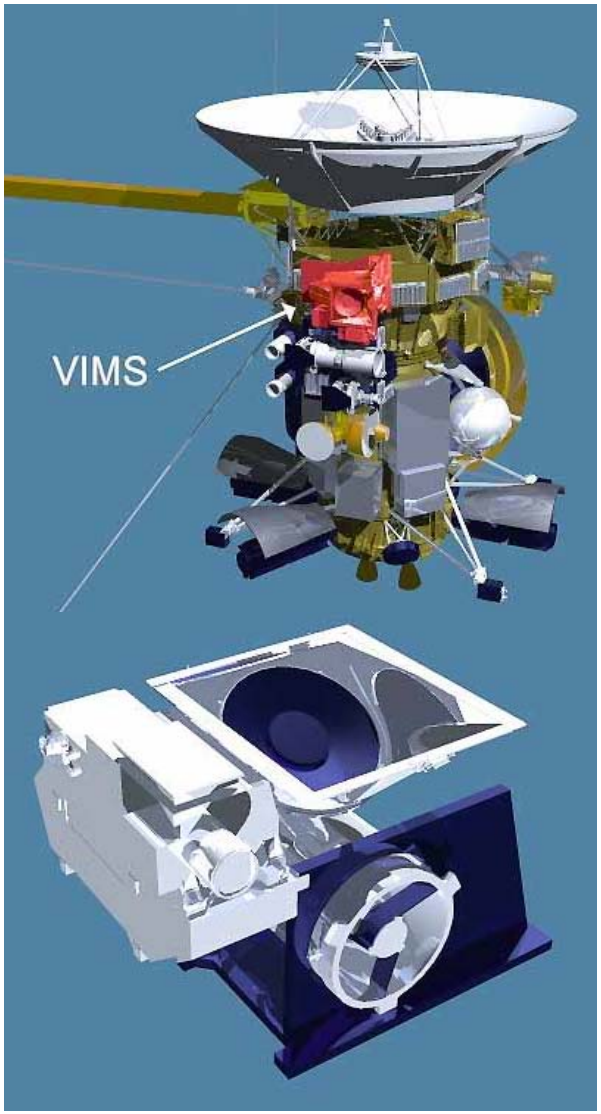
HSP = High Speed Photometer

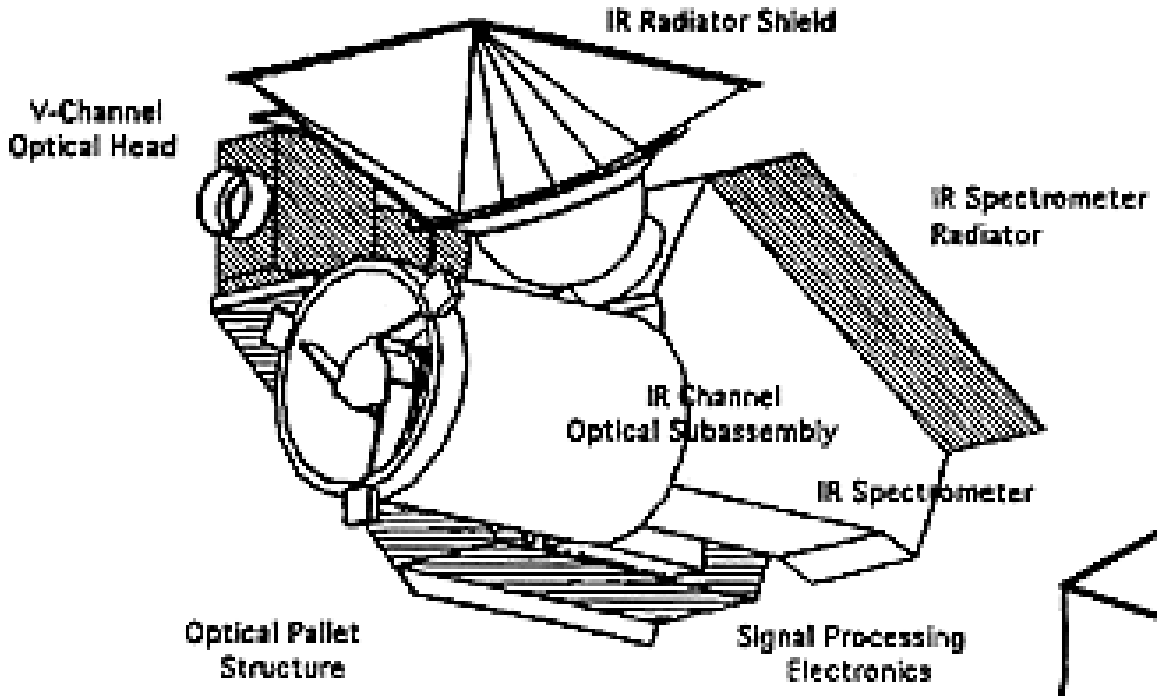
EUV = Extreme Ultraviolet

FUV = Far Ultraviolet

FOV = Field of View

Visible and Infrared Mapping Spectrometer (VIMS)





Microwave Remote Sensing Instruments

- **RADAR (Cassini Titan Radar) does imaging, altimetry, and passive radiometry of Titan's surface.**
- **RSS (Radio Science) performs studies of atmospheric and ring structure, gravity fields, and gravitational waves.**

Radio Frequencies

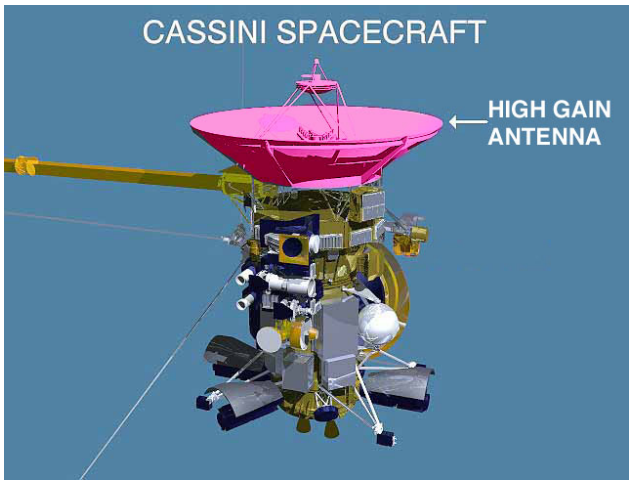
RADAR Ku-band: 13.8 GHz

RSS Ka-band: 32.0 - 34.3 GHz

RSS X-band: 7.2 - 8.4 GHz

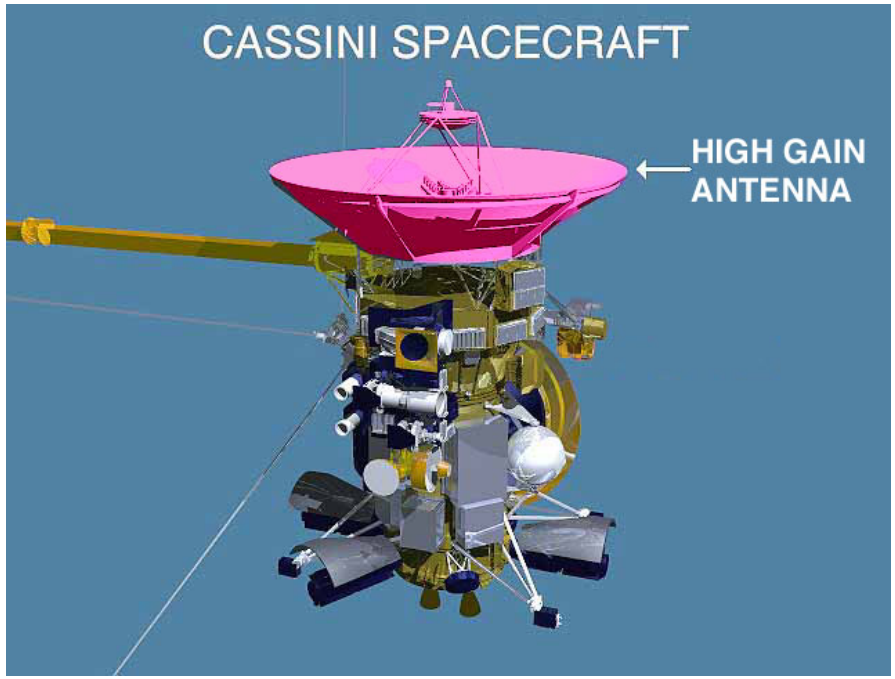
RSS S-band: 2.3 GHz

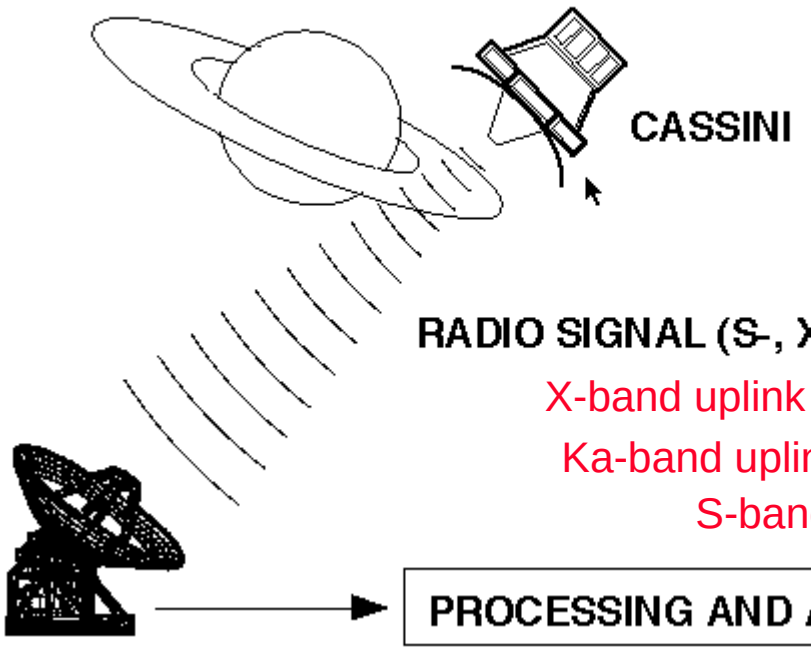
Cassini Titan Radar (RADAR)



Radio Science (RSS)

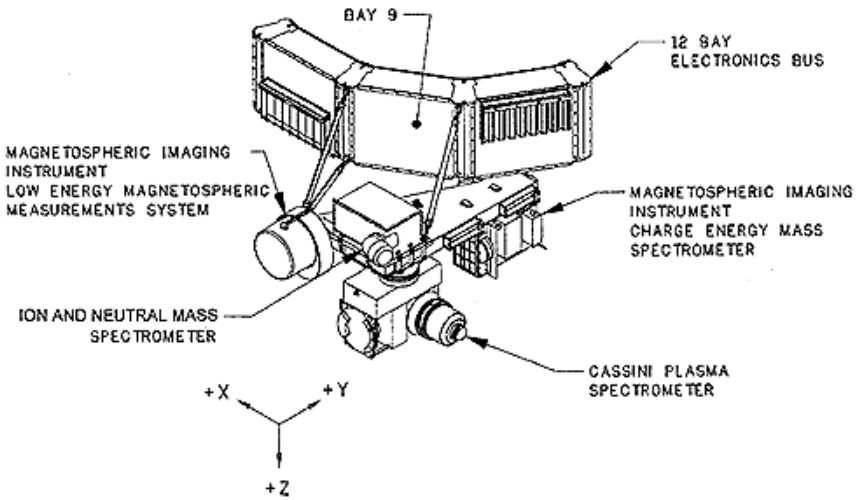
Gravitational Wave Experiments
Occultations of rings or atmospheres
Mass and gravity field harmonics
Solar corona and general relativity

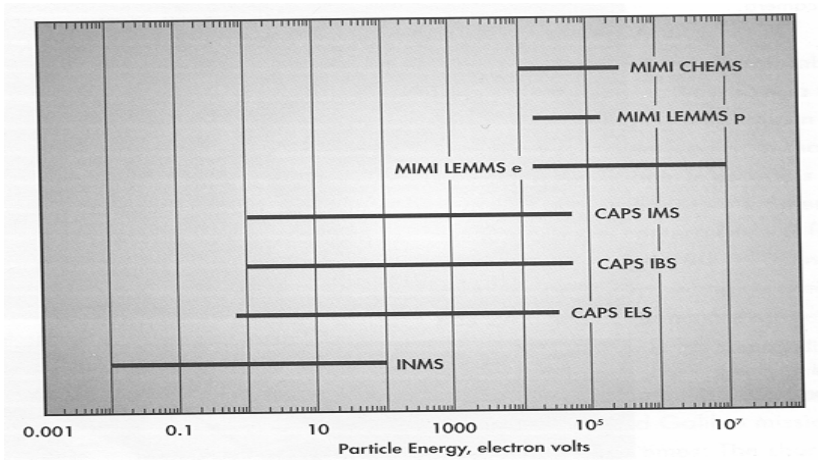




X-band uplink and downlink (part of communications system)
Ka-band uplink and downlink (coherent with X- or Ka-band)
S-band downlink only (coherent with X-band)

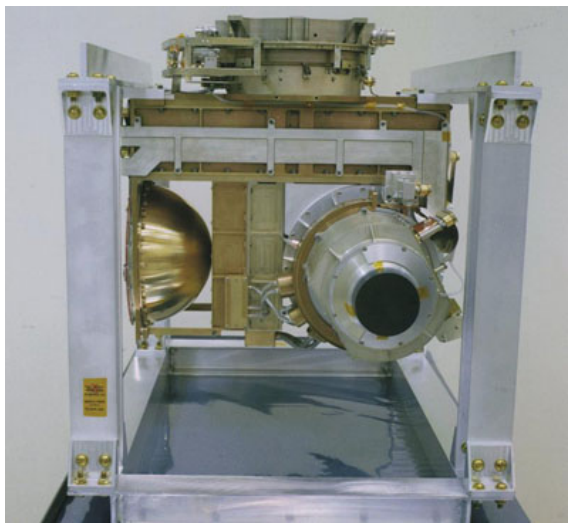
Magnetospheric and Plasma Science Instruments



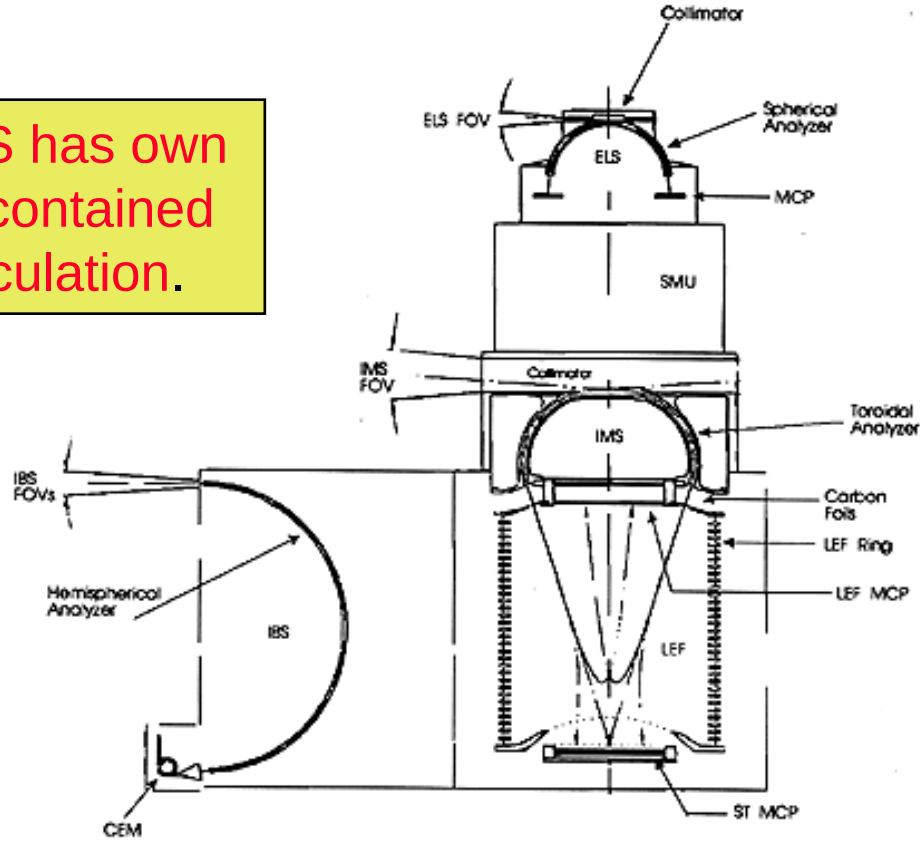


- **CAPS (Cassini Plasma Spectrometer)** measures within Saturn's magnetic field.
- **CDA (Cosmic Dust Analyzer)** studies ice and dust grains within the Saturn system
- **INMS (Ion and Neutral Mass Spectrometer)** studies particle composition near Titan.
- **MAG (Dual-Technique Magnetometer)** measures Saturn's magnetic field.
- **MIMI (Magnetospheric Imaging Instrument)** images magnetosphere and studies ions.
- **RPWS (Radio and Plasma Wave Science)** measures wave-particle interactions.

Cassini Plasma Spectrometer (CAPS)

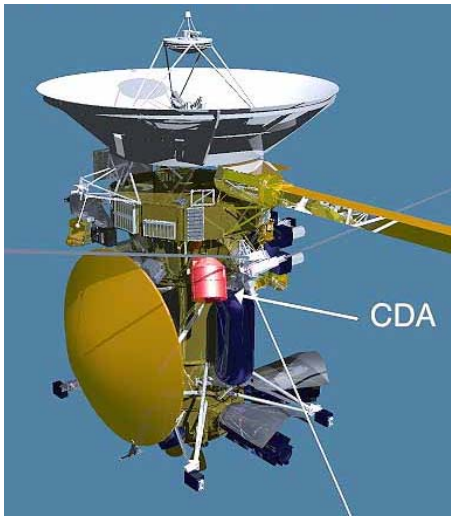


CAPS has own self-contained articulation.

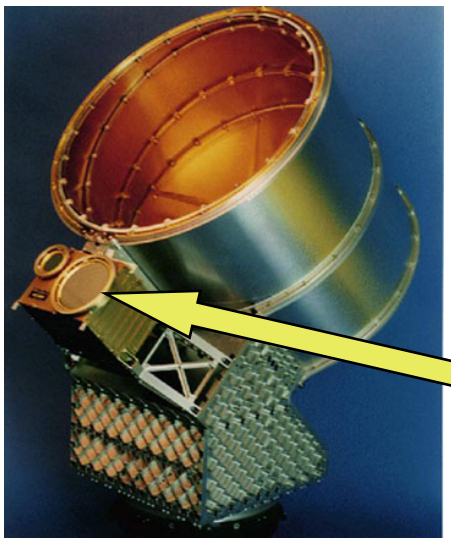


IMS = Ion Mass Spectrometer
IBS = Ion Beam Spectrometer
ELS = Electron Spectrometer

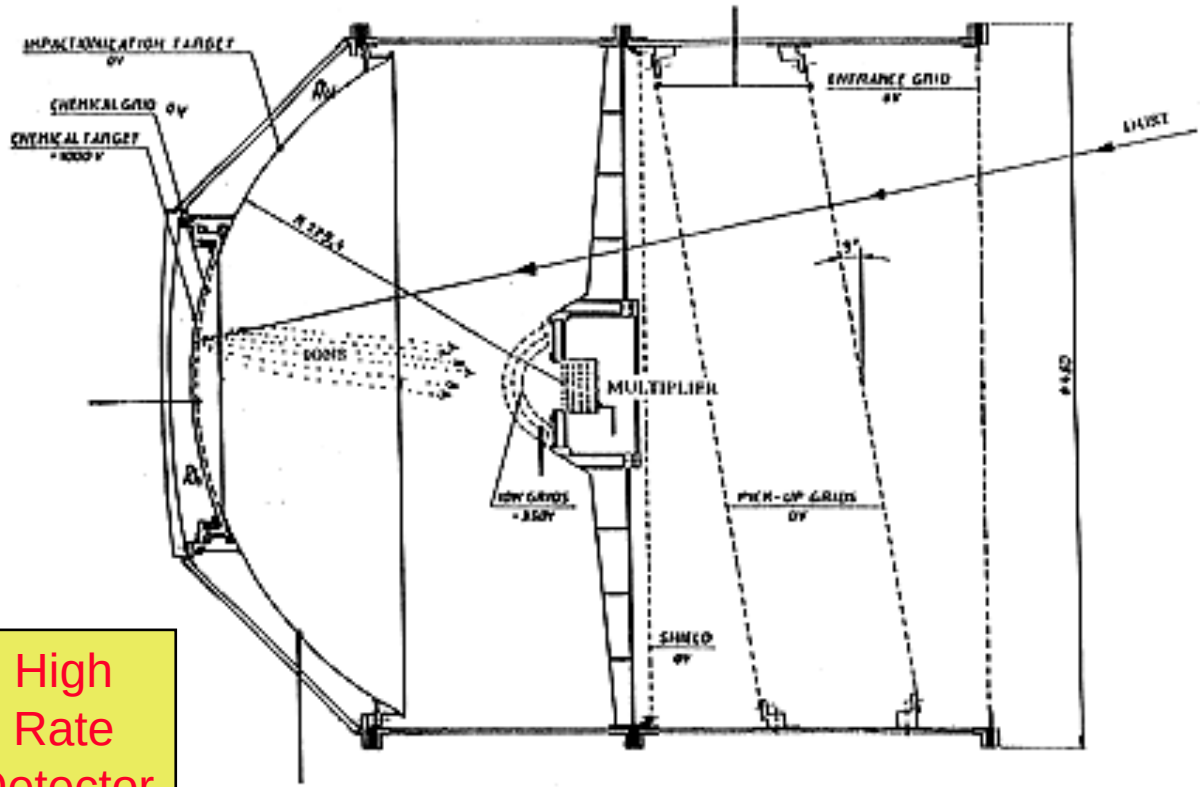
Cosmic Dust Analyzer (CDA)



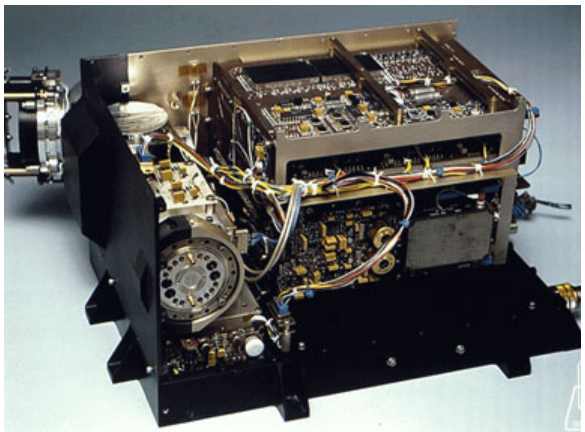
CDA has its own self-contained articulation.

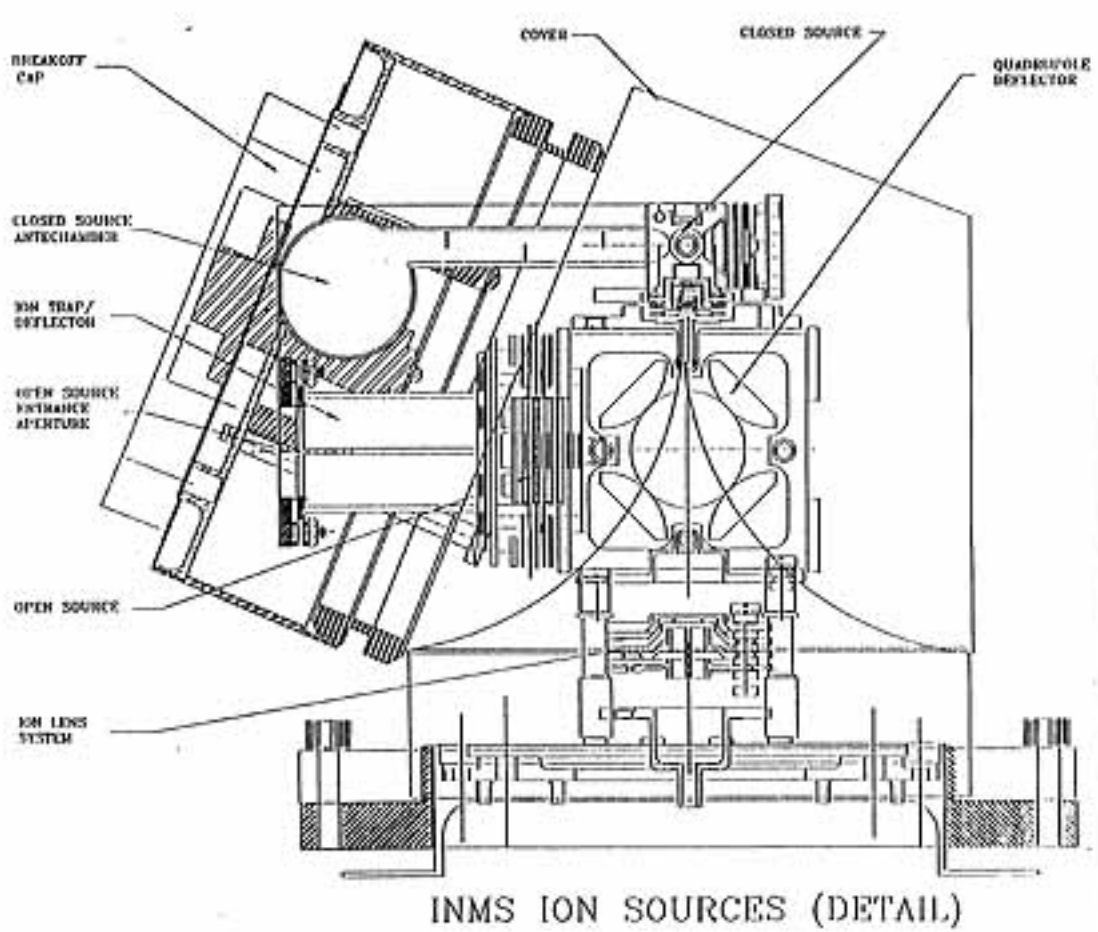


High Rate Detector



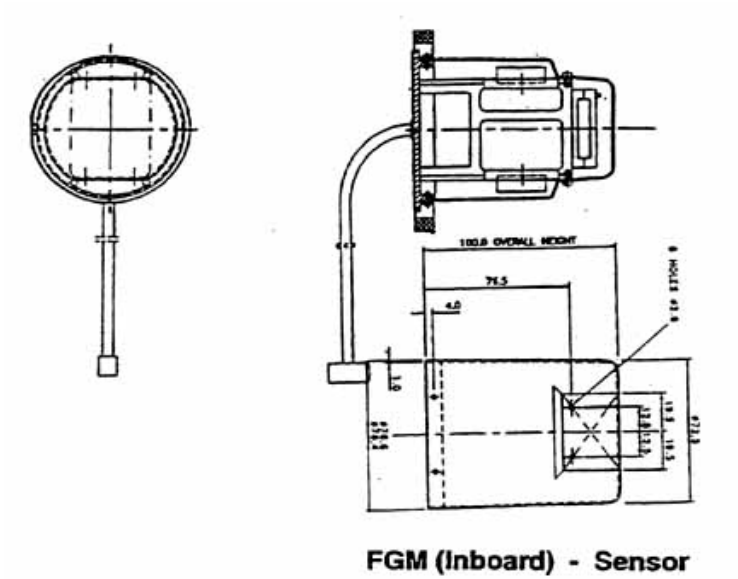
Ion and Neutral Mass Spectrometer (INMS)



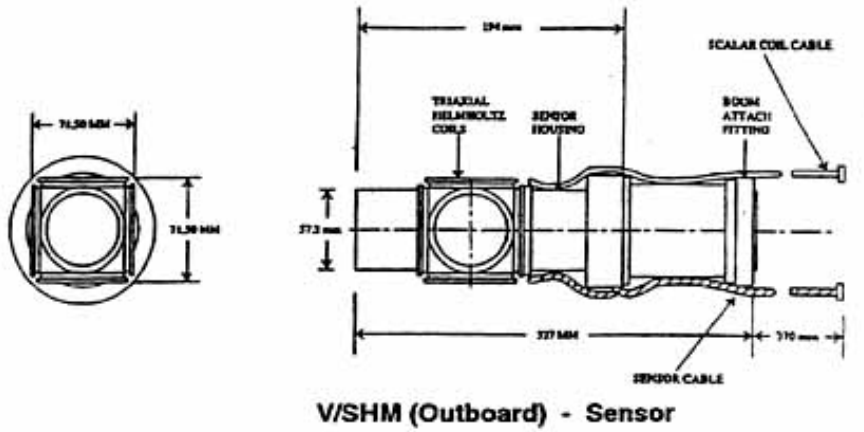


INMS ION SOURCES (DETAIL)

Dual Technique Magnetometer (MAG)



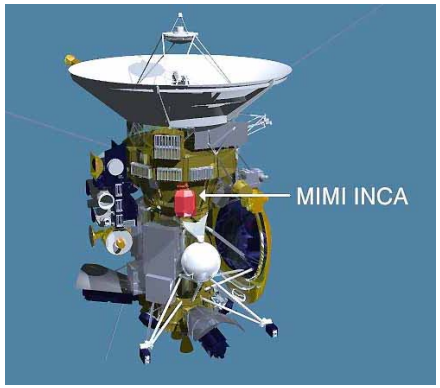
FGM (Inboard) - Sensor



V/SHM (Outboard) - Sensor

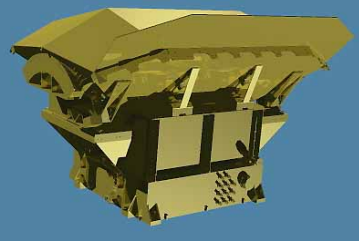
FGM = Flux Gate Magnetometer
V/SHM = Vector/Scalar Helium Magnetometer

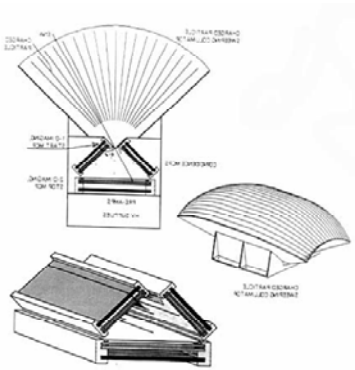
Magnetospheric Imaging Instrument (MIMI)



MIMI INCA

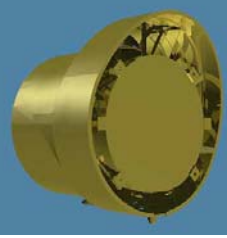
Magnetospheric Imaging Instrument
Ion and Neutral Camera

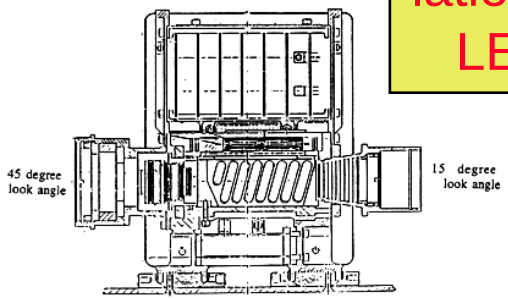




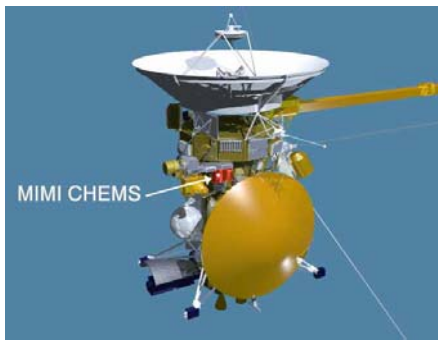
MIMI LEMMS

Magnetospheric Imaging Instrument
Low Energy Magnetospheric Measurement System



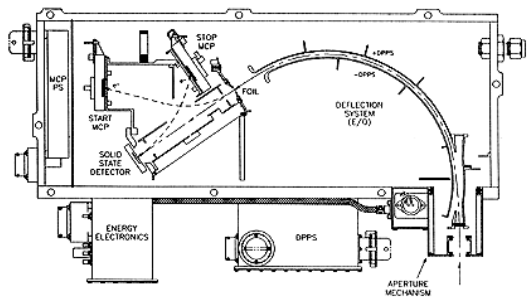


MIMI has its own articu-lation for the LEMMS.

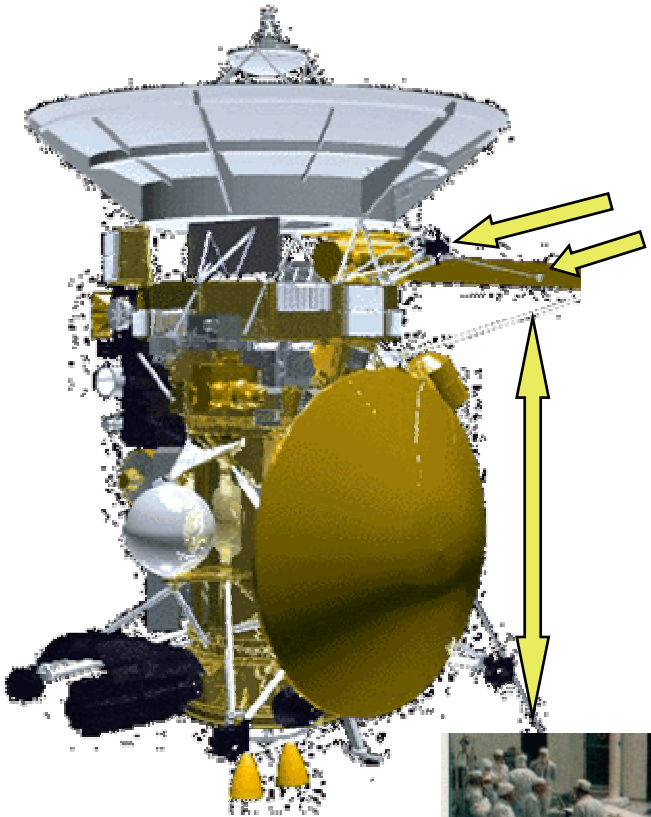


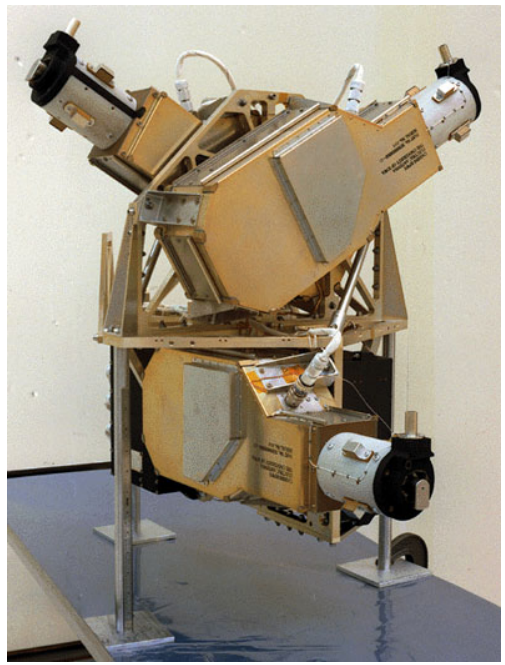
MIMI CHEMS

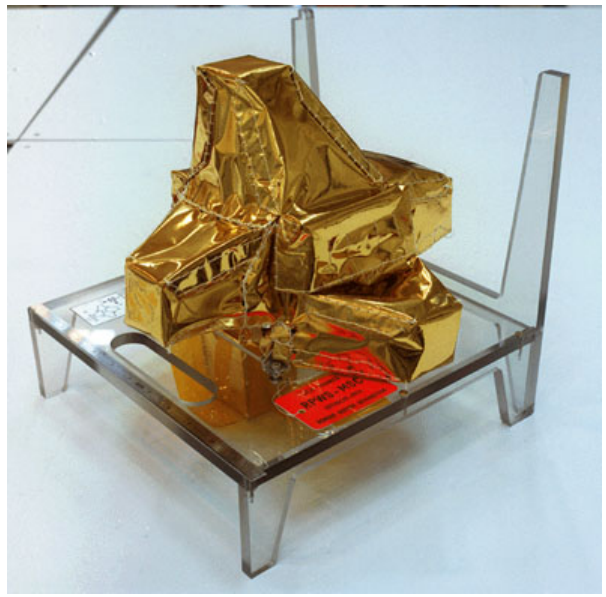
Magnetospheric Imaging Instrument
Charged Energy Mass Spectrometer

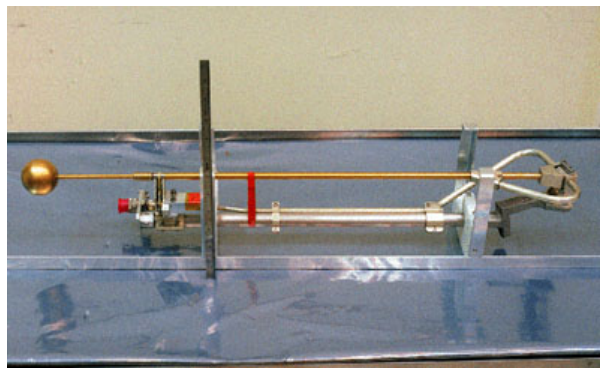


Radio and Plasma Wave Science (RPWS)

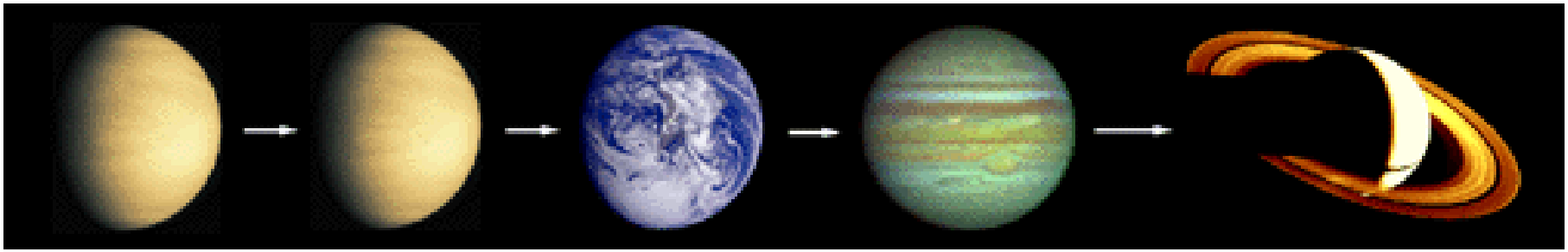








Getting to Saturn (Science along the Way)

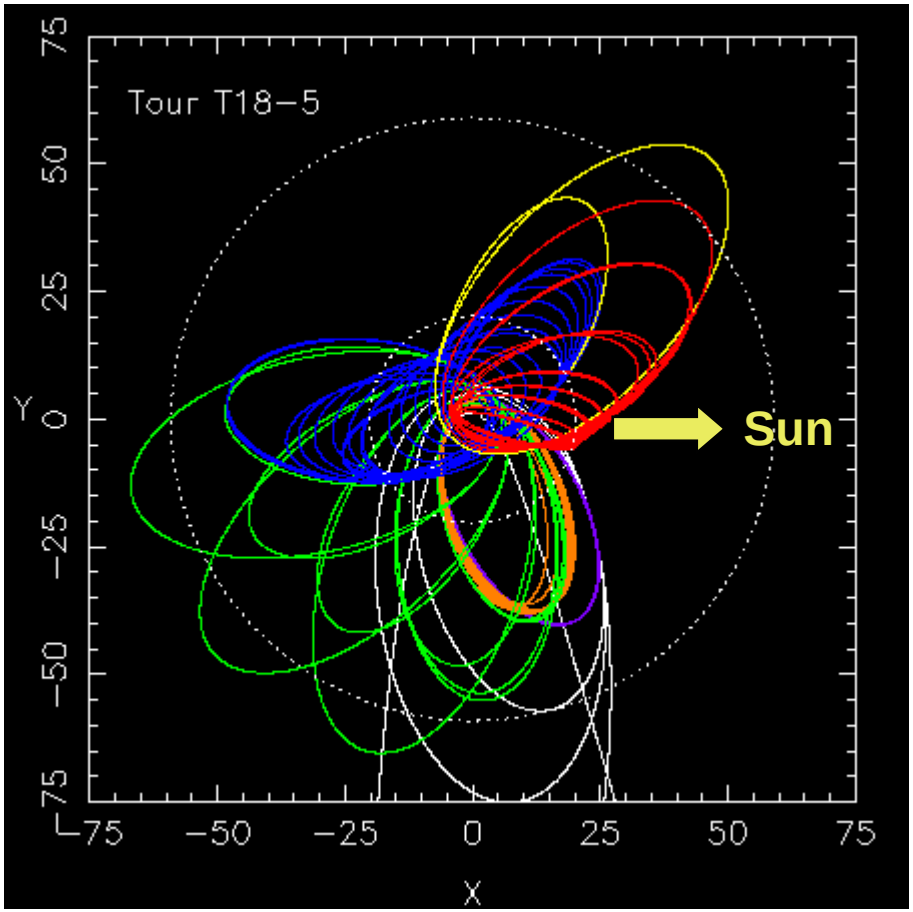


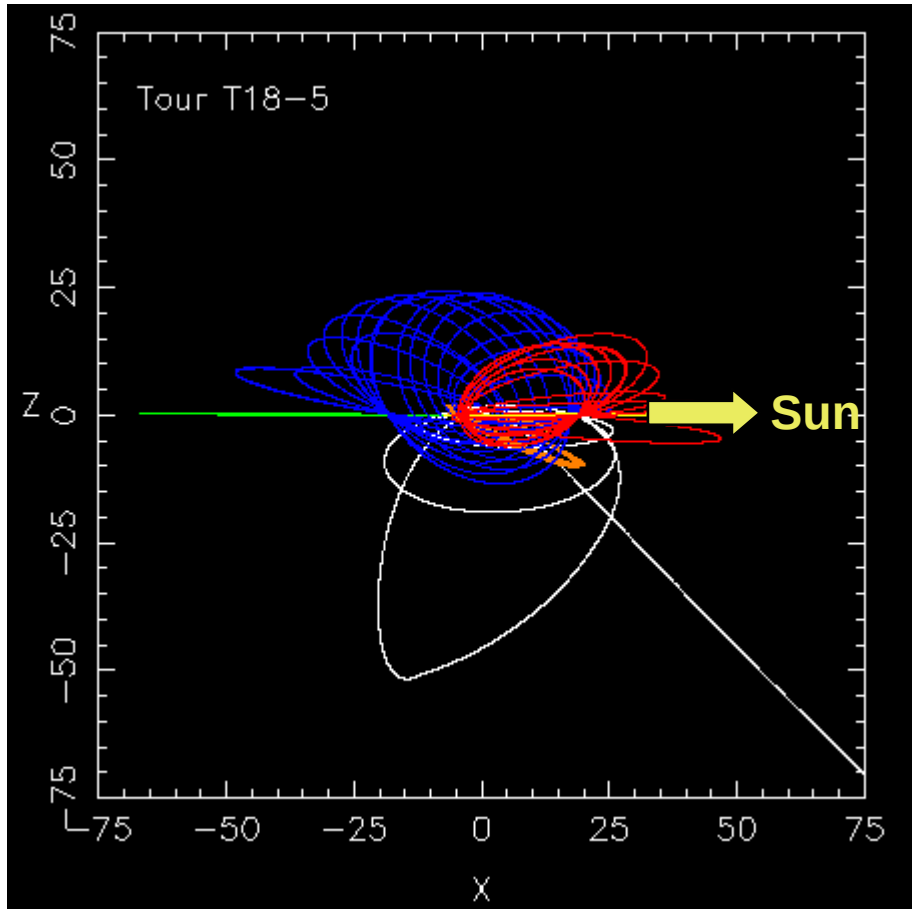
Venus 1	Venus 2	Earth/Moon	Jupiter	∧	Saturn
04/26/98	06/24/99	08/18/99	12/30/00	∧	07/01/04 - 07/01/08
RADAR RPWS RSS	CAPS ISS MIMI RPWS UVIS VIMS	CAPS CDA ISS MAG MIMI RADAR RPWS RSS UVIS VIMS	Test Ground System, Flight Software, and 11/12 instruments (no INMS).	∧ ∧ RSS Gravitational Wave Experiment	Approach SOI Probe Mission Tour

Overview of Saturn Tour

- Close flyby of Phoebe 19 days before Saturn Orbit Insertion (SOI)
- Ring and magnetic field observations immediately following SOI
- Titan-0 observations to scout Huygens Probe landing site
- Periapsis raise, probe separation, orbiter deflection maneuvers
- Titan-1 probe descent, supporting observations, data return
- Orbital Tour with changing geometry, multiple targets / ranges
  - 44 targeted Titan flybys (also used to shape tour)
  - 7 in-orbit targeted icy satellite flybys (3 Enc, Dio, Rhe, Hyp, Iap)
  - 75 Saturn periapsis passages, varied ring/magnetosphere geometries
  - hundreds of satellite flybys at better resolution than Voyager 1/2

Saturn Tour Geometry





Summary

- Large set of capable instruments - provides potential for useful synergism and better science return.
- Simplification of spacecraft design has led to less efficient use of available opportunities and more conflicts and complexity.
- Continuous downlink not possible. Remote sensing data is collected 15 hours per day, followed by 9 hours of data downlink.
- Sophisticated science payload needs a large contingent of science experts to plan sequences and analyze the data.
- Wide variety of targets and geometries requires 4-year tour to cover Saturn system sufficiently to satisfy science objectives.
- Body-fixed instruments and power limitations necessitate longer times and/or repeated geometries to collect high-value data.
- In spite of complexity, Cassini promises to return more significant science data per dollar than small planetary missions.