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375th Birthday of
Christiaan Huygens

Titan

From Discovery to Encounter

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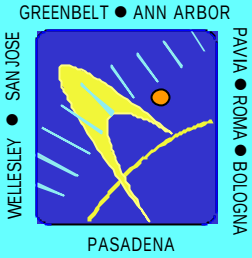
13 – 17 April, 2004



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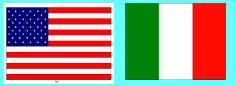

Cassini Radio Science at Titan

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Titan Radio Science

Fundamental Science Objectives

- **Atmosphere and Ionosphere (4 Occultations)**
  - **Atmospheric Circulation (Zonal Winds)**
  - **Ammonia Abundance**
  - **Ionospheric Structure at Various Latitudes Relative to Ram Direction**
- **Gravity - Internal Structure (4 Gravity Flybys)**
  - **Titan's Rigidity Over Long and Short Time Scales (Internal Ocean ?)**
- **Titan Bistatic Scattering**
  - **Surface Scattering Properties at two or three Wavelengths at Incidence Angles Other than Vertical**

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Titan Atmospheric and Ionospheric Occultations

● OBJECTIVES

1. Determine the global fields of temperature and pressure and derive the zonal wind field in the troposphere and stratosphere from about the 0.1 mb level to the surface
2. Constrain the vertical distribution of methane and determine the surface relative humidity
3. Measure the small-scale structure in temperature and density in the stratosphere associated with eddies and waves
4. Measure the electron density profile in Titan's near
   - terminator ionosphere and its behavior with the magnetospheric ram direction and latitude

● IMPLEMENTATION

Non-coherent open-loop Doppler tracking at X-, S-, and/or Ka-Band referenced to the USO during Titan occultations

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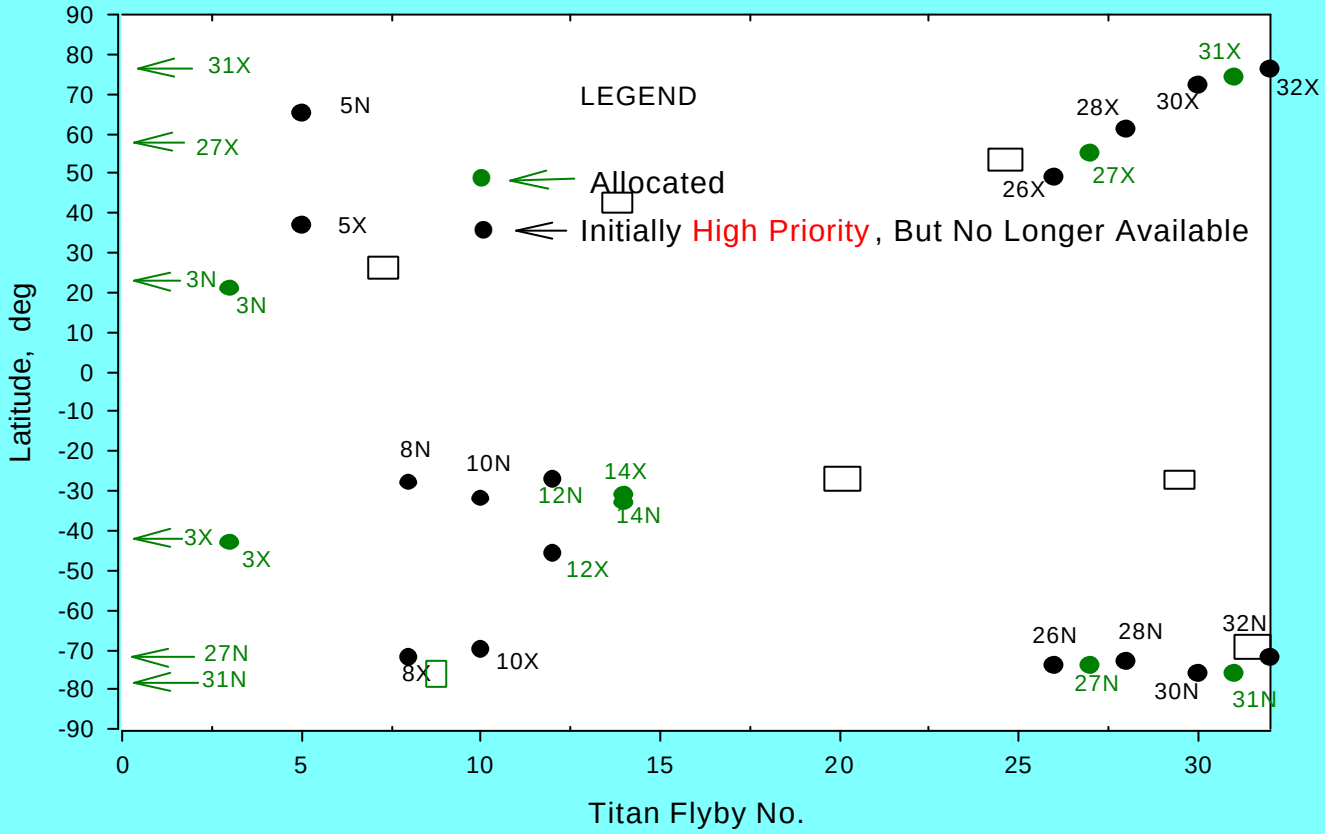
Titan Radio Occultations - Status 12/07/03



Allocated 3N, 3X , 12N, 12X, 14N, 14X, 31N, 31X

AJK 12/07/03

Unavailable 5N, 5X, 8N, 8X, 10N,10X, 15N, 15X, 26N, 26X, 28N, 28X, 30N, 30X, 32N, 32X

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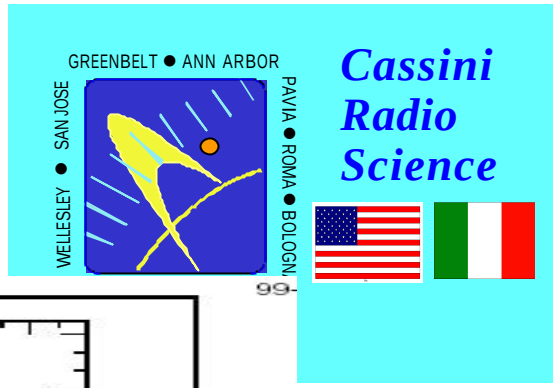

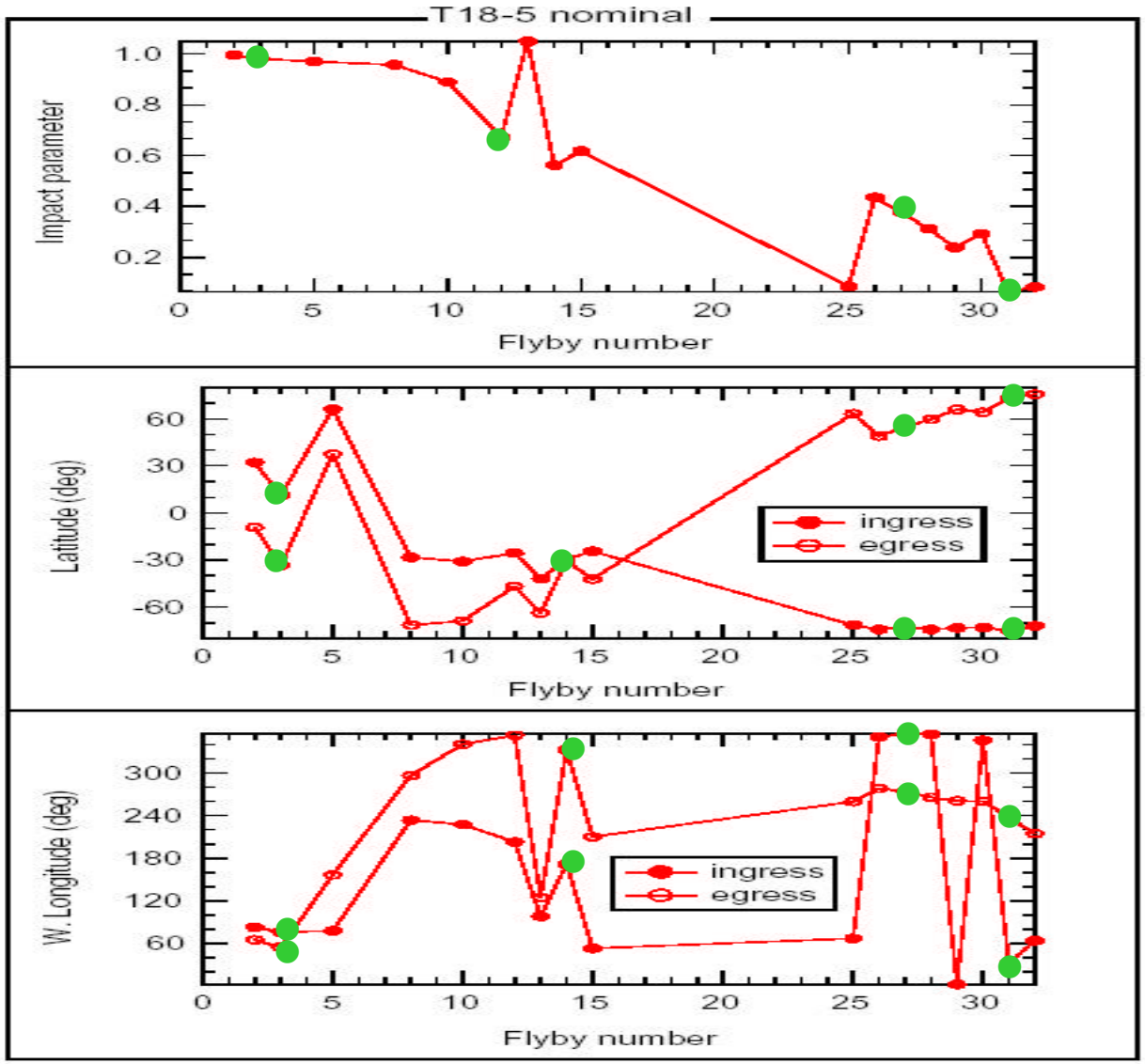

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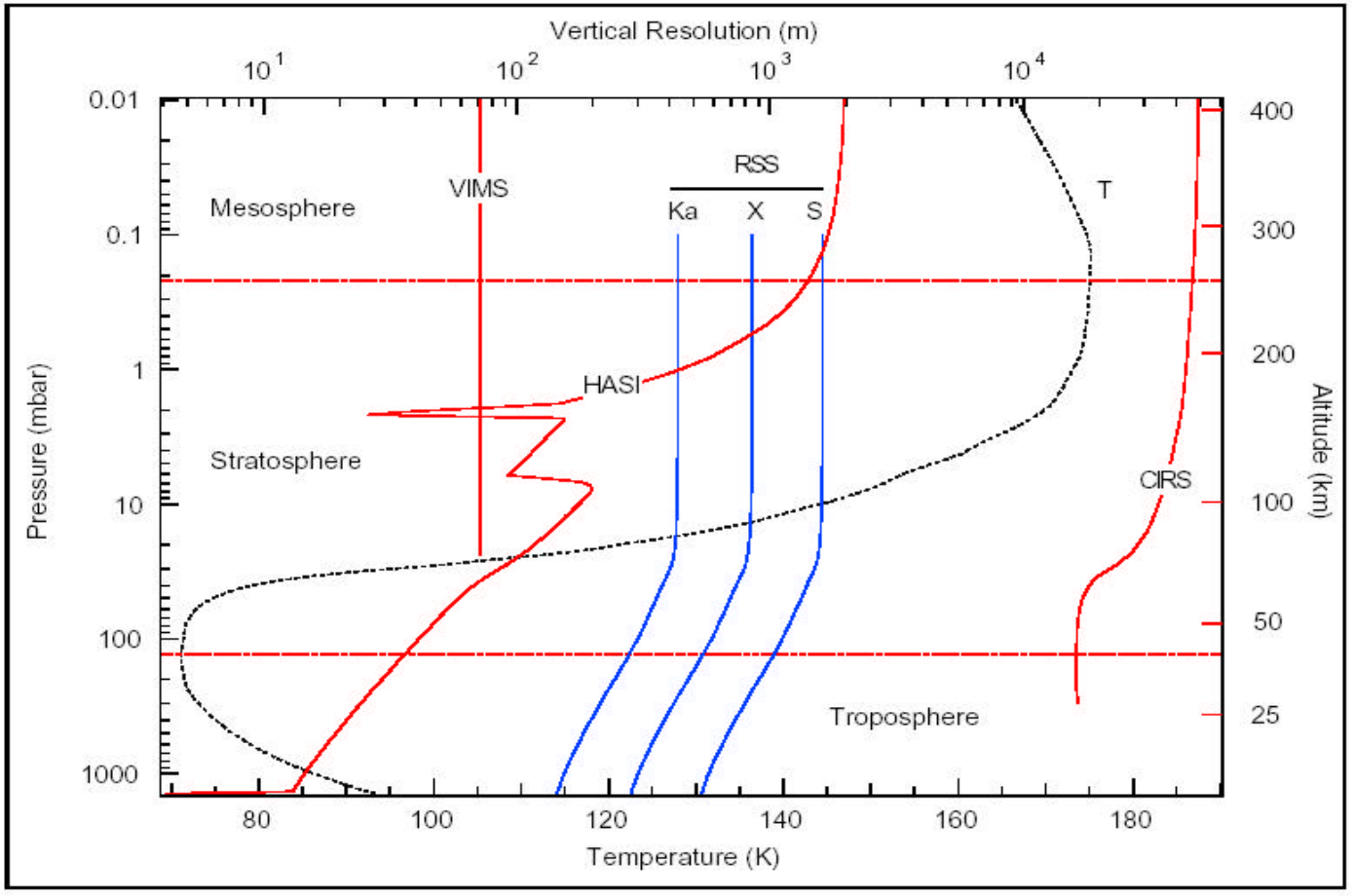
Temperature Sounding—Titan Lower Atmosphere



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Titan Gravity Field and Celestial Mechanics

Objectives:

- Determine the gravity field and measure the tidal deformation of Titan. This will provide information on its internal structure and evolution
- Improve the ephemerides of Saturn and Titan

Method:

- Coherent Doppler and range measurements during close Titan gravity flybys.

Requirements:

- Three-link coherent configuration
- Titan gravity flybys at periapse and apoapse
- Knowledge and calibration of non-gravitational forces
- Uninterrupted tracking during close flybys

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Titan Gravity Objectives

- **DETERMINATION OF TITAN'S GRAVITY FIELD**

DETERMINATION OF k_2 WITH 0.1 ABSOLUTE ACCURACY

- **Love Numbers k_s (secular) and k_2 (dynamic)**
- **Detection of a deep ocean**

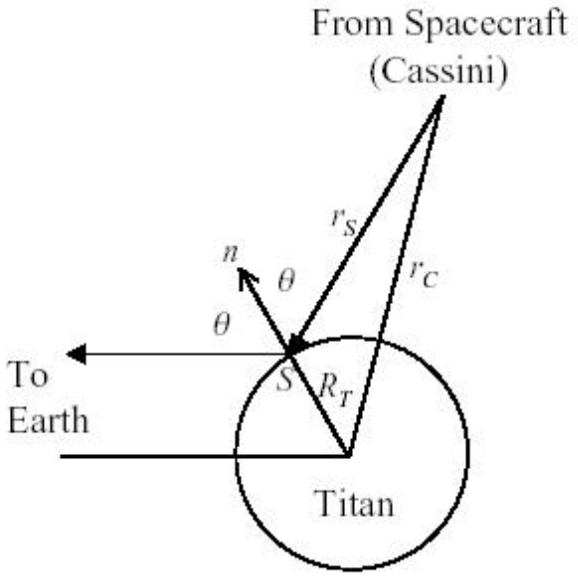
DETERMINATION OF k_2 WITH 0.01 ABSOLUTE ACCURACY

- **Nature of the core**
- **Crustal thickness**

Bistatic Observables and Relation to Surface Properties

- Right circularly polarized (RCP) radio signals transmitted from Cassini illuminate the specular region S on Titan's surface
- Signals scattered towards the Earth are primarily due to reflections from surface "facets" oriented for mirror-like reflections
- Same- & opposite-circular (SC, OC) scattered signals are measured at the DSN
- The echo strength is primarily controlled by the Fresnel power reflection coefficients R_{OC} and R_{SC}.
- The reflectivity $R_P = R_{OC} + R_{SC}$ and polarization ratio R_{OC}/R_P vs scattering angle θ provide unique information on the surface dielectric constant ε (composition), independent of roughness
- The measured power spectra provide additional independent information on surface roughness

Bistatic Geometry



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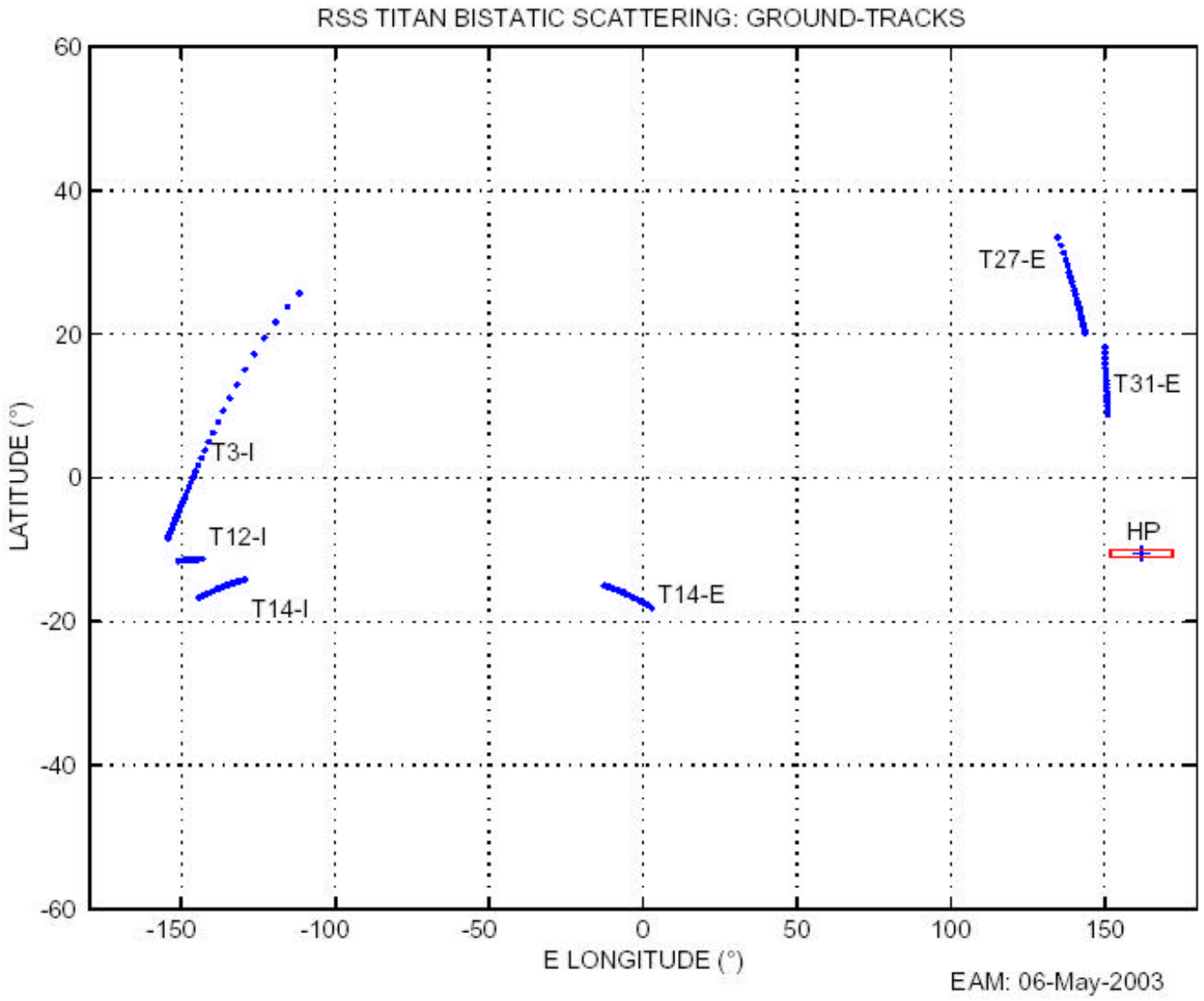

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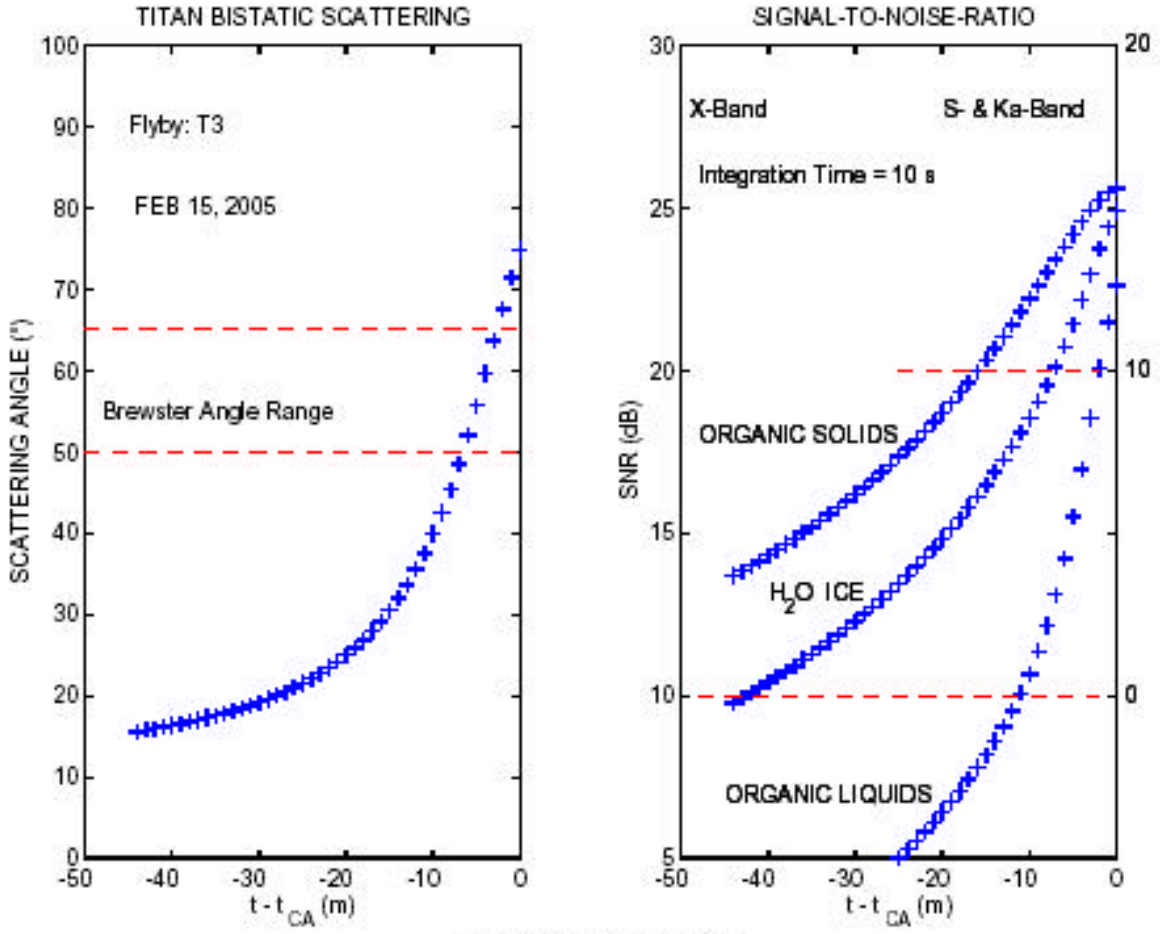

T3: 950 km Flyby

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Radio Science Data

Data				
I. Doppler or Open-loop	Uplink	Downlink		
		S-Band	X-Band	Ka-Band
A. Coherent (2- or 3-way)	X-Band	❁	❁	❁ ☸
	Ka-Band			❁
B. Non-Coherent (1-way)	none (U S O)	❁	❁	❁
II. Ranging	X-Band		❁	
III. VLBI	X-Band		❁	

☸ can be operated simultaneously

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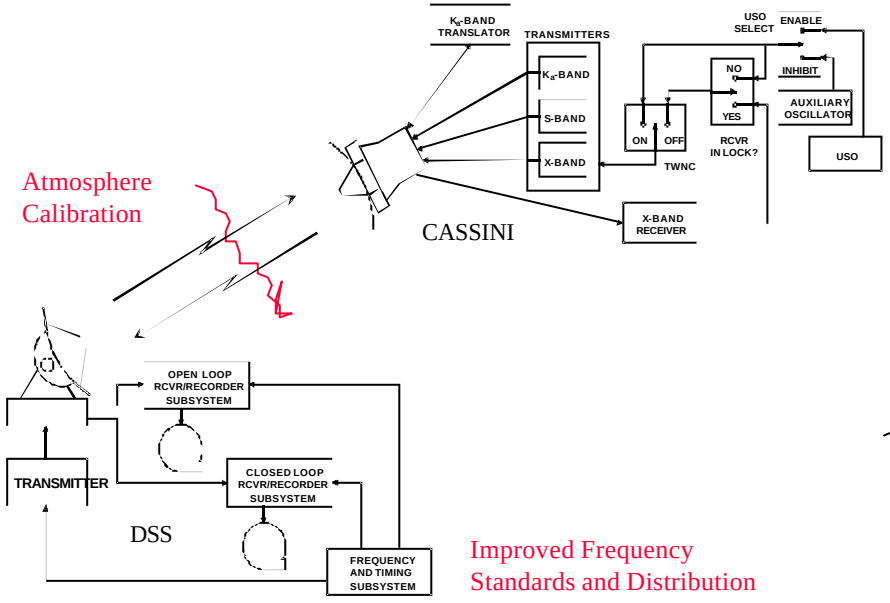
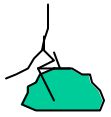
The Whole Instrument





Italian
IRA-CNR SRT
(Sardinia Radio Telescope)