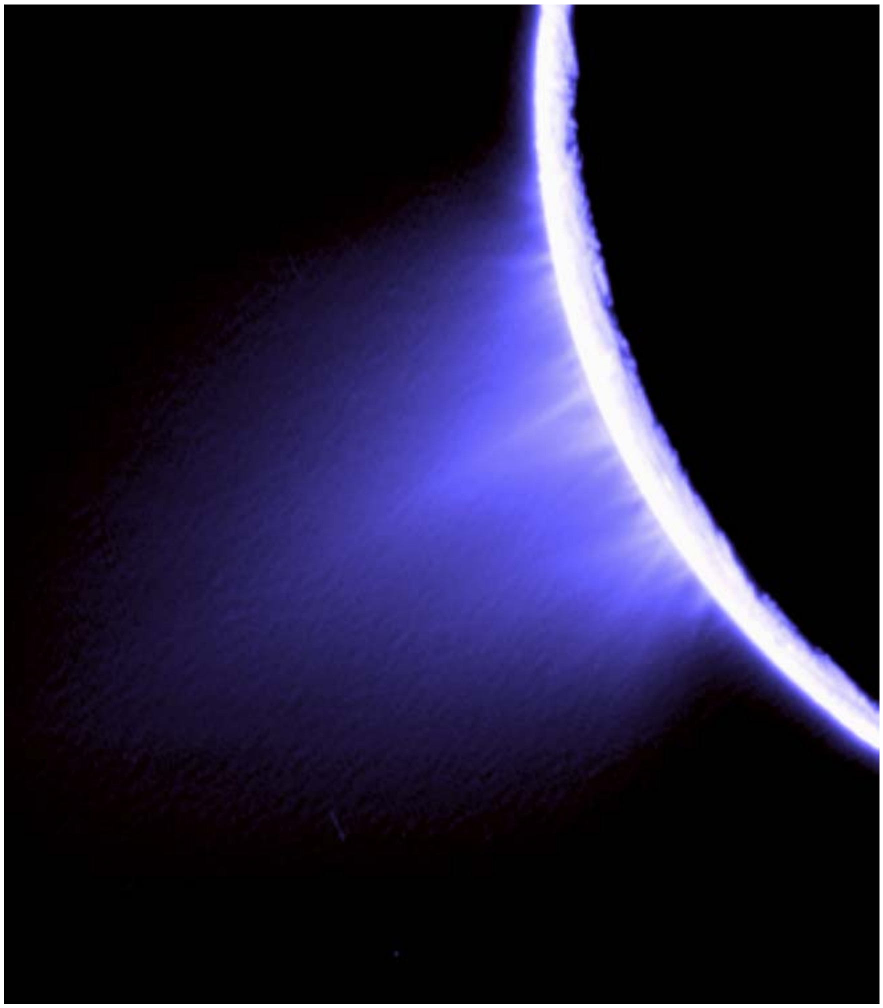
C A S S I N I



E N C E L A D U S 0 6 1 E N
MISSION DESCRIPTION

March 2008

Jet Propulsion Laboratory
California Institute of Technology

Cover image: Enceladus' south polar jets (November 27, 2005). Backlit by the sun, this image shows the fountain-like sources of the fine spray of material that towers over the south polar region of Enceladus. The image was taken looking more or less broadside at the "tiger stripe" fractures observed in earlier Enceladus images. It shows discrete plumes of a variety of apparent sizes above the limb of the moon. Credits: NASA/JPL/Space Science Institute

1.0 OVERVIEW

On March 12, 2008, Cassini will visit Enceladus for the first time since the discovery of active geysers on this icy moon, two-and-a-half years ago. The closest approach at 2008-072T19:06:12 spacecraft time at an altitude of just 52 kilometers (32.3 miles) above the surface and at a speed of 14.4 kilometers per second (32,234 mph). The latitude at closest approach is 20 degrees S, the longitude is 135 degrees W.

Cassini will approach Enceladus on a fast, inclined trajectory over the northern hemisphere and will depart over the southern hemisphere. Approximately 58 seconds after closest approach, Cassini will cross the center of the plume, at an altitude of approximately 641 km. Enceladus will be in eclipse (Saturn shadow) for ~2 hours starting near closest-approach.

This encounter will set up with three maneuvers, on March 1, March 7 and March 10. The Enceladus flyby occurs two days after the Titan T61 flyby, on the day of orbit number 61 periapse.

ABOUT ENCELADUS

Discovered by William Herschel in 1789, Enceladus orbits close (~4R_s) to Saturn, and thus it is exceedingly difficult to observe from Earth amidst the bright scattered light of the planet and its rings. Telescopic infrared spectra indicated a surface composed of almost pure water ice. The *Voyager 2* encounter with the satellite in 1982 established that its geometric albedo is startlingly high, at about 1.0, a number that is consistent with fresh snow or ice. Recent results from the Hubble Space Telescope yield a value of 1.4 for the geometric albedo. *Voyager 2* imaged sizable regions of crater-free areas thought to have been resurfaced within the last 1Gy, but other parts of the satellite were older (~3.9 Gy) and heavily cratered. Moreover, all regions of the satellite, whether young or old, exhibited uniformly high albedos, implying that the entire satellite is coated with a ubiquitous fresh material. Dynamic models have proposed that Enceladus is the source of the E-ring, which is most dense at the satellite's orbit and extends out to the distance of Titan. The mechanism for the injection of material from the satellite into the E-ring has been debated: volcanism, geysers, large impacts, and collisions between Enceladus and E-ring particles themselves have all been proposed. Regardless of the means of transport, one thing is certain: the micron-sized particles that comprise the ring must be constantly replenished, as dissipative processes would destroy them on time scales much shorter than the age of the solar system.

The first close *Cassini* flyby of Enceladus, which occurred on February 17, 2005 with a minimum approach distance of 1175 km, focused on the equatorial region of the sub-Saturn/trailing hemispheres. The Imaging Science Subsystem (ISS) revealed a world scarred by extensive tectonic activity with both extensional and compressional features. Magnetometer data showed a draping of Saturn's magnetic field lines around the moon, which suggested the presence of an atmosphere. However, a stellar occultation observed by the Ultraviolet Imaging Spectrometer (UVIS) showed no sign of an atmosphere. Infrared spectra from the Visual Infrared Mapping Spectrometer (VIMS) detected no surface components other than water ice. During the second flyby, on March 9, 2005, *Cassini* came within 500 km of Enceladus and observations concentrated on the equatorial region of the anti-Saturn/trailing hemisphere. This encounter revealed the diverse regions on Enceladus in striking detail: large complex networks of ridges and troughs coexisted with ancient cratered plains. The magnetometer measured a signature in addition to the one seen in February, one that possibly indicated an induced or intrinsic magnetic field. Based on these results – which could imply a liquid core – the Cassini Project moved the closest approach distance of the July 14 encounter from 1000 km down to 175 km.

The July 2005 observations of the south polar region by the remote sensing instruments, the stellar occultation by UVIS, and the close flyby distance over the south pole allowing in-situ measurements by particles and fields instruments (CDA, INMS) all amounted to a suite of observations providing multi-instrument evidence of geologic activity on Enceladus. ISS imaged the "tiger stripes," tectonic features evidently bounded by a compressional feature encompassing the south polar region; CIRS detected regions of elevated temperatures (up to

140K) associated with the "tiger stripes" and the south pole in general; VIMS detected the presence of crystalline, freshly deposited water ice; UVIS identified water vapor above the limb; INMS detected water vapor at higher altitudes; and CDA measured a stream of water ice particles emanating from the south polar region of Enceladus. The startling picture that emerged from these observations is that heat and gases are escaping from the interior of the satellite preferentially along the south polar region's "tiger stripes".

The major question that has emerged is why geologic activity exists at all on this small world. Other active satellites – Io (R= 1810 km) and Triton (R=1350 km) - are far larger. Even with a bulk density of 1.6 gm/cm^2, heat produced in Enceladus's core from radioactive decay would have long since peaked and dissipated. One mechanism that works marginally is tidal heating from eccentricities excited by the orbital resonance between Enceladus and Dione. Even if a sufficient heat source can be found, the question still remains: why is the activity concentrated at the south pole? These Cassini results have strong implications for models of planetary interiors and the role of tidal heating and dissipation.

1.1 ENCELADUS-61 SCIENCE HIGHLIGHTS

- **MAPS** instruments will examine of the particle environment at 50 km from the surface to determine the nature of the material coming form the surface and its relationship to the E-ring, and to distinguish between two potential populations of particles: plume particles and sputtered particles from elsewhere on the surface. CAPS will make measurements to understand Enceladus as a plasma source. Because Cassini will fly deeper into the plume than in July 2005, *in situ* instruments will measure a larger signal. The predicted increase in count rates suggests that INMS can provide new results on plume composition. One of the main science goals of INMS will be to try and determine the compositional differences in the plume gas versus the gas produced from E-ring bombardment at other latitudes. The close flyby distance will allow the magnetometer to determine whether Enceladus generates an induced magnetic field from a subsurface ocean. The magnetometer will also determine the composition of plume material from measurement of ion cyclotron waves in the magnetic field measurements.
- **VIMS** will perform compositional mapping to determine the identity of volatiles, organics, and minerals, and place them within a geologic context

- **ISS** will image the surface of the cratered north polar terrain at up to 200 meter-scale resolution to determine the geologic history of Enceladus, including possible remnant tiger stripes; first good view of north polar regions (is all of it heavily cratered?)

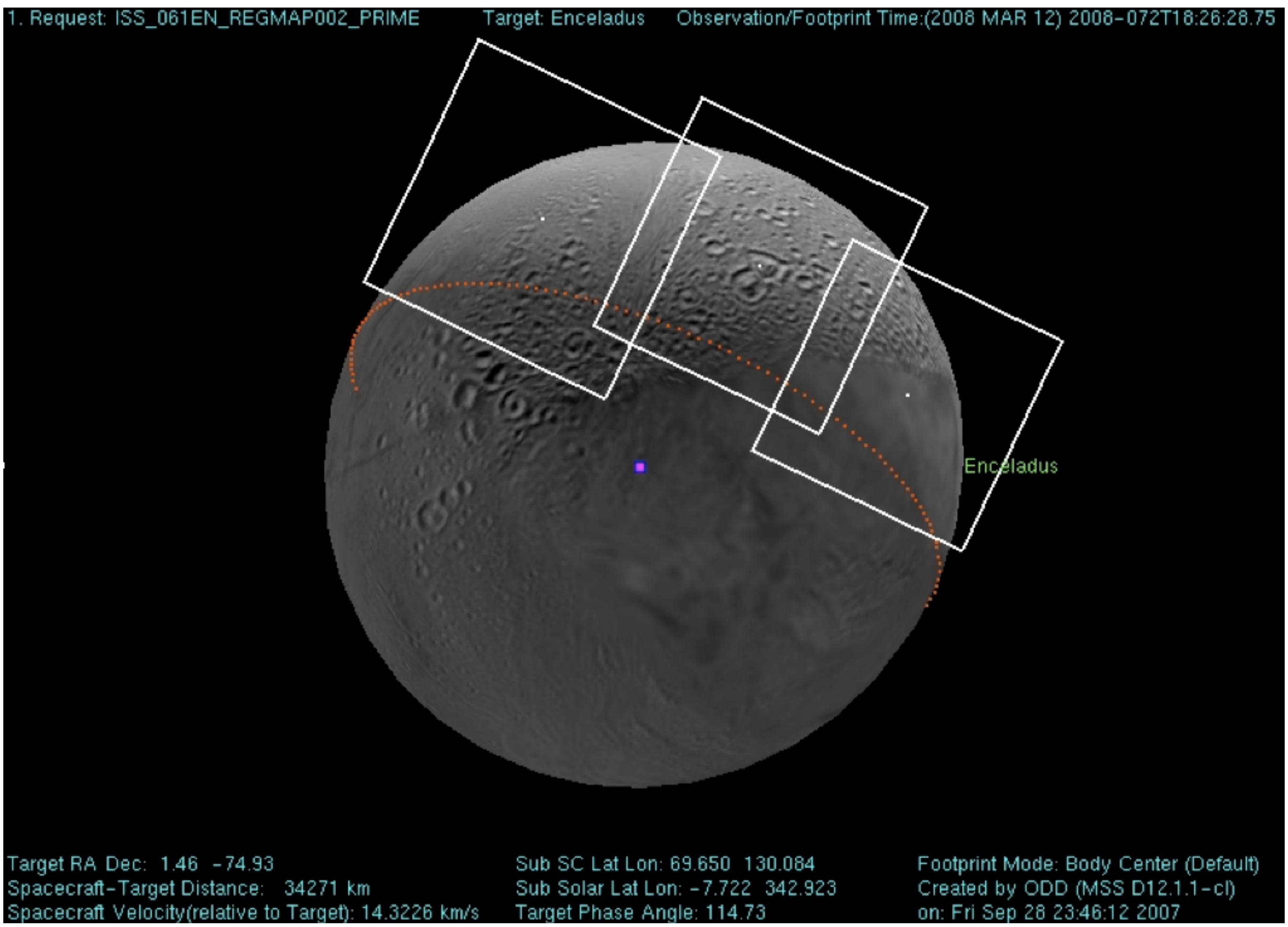
- **CIRS** will make observations of the warm-up after solar eclipse to determine the heat capacity and textural properties of the regolith; observations of hot spots and determination of any changes from the previous flyby

- **UVIS:** The team will obtain spectral images of Enceladus in the EUV (500-1100 Å) and FUV (1100-1900 Å) to map the surface composition, including water ice abundances and grain sizes, and will search for volatiles off the limb.

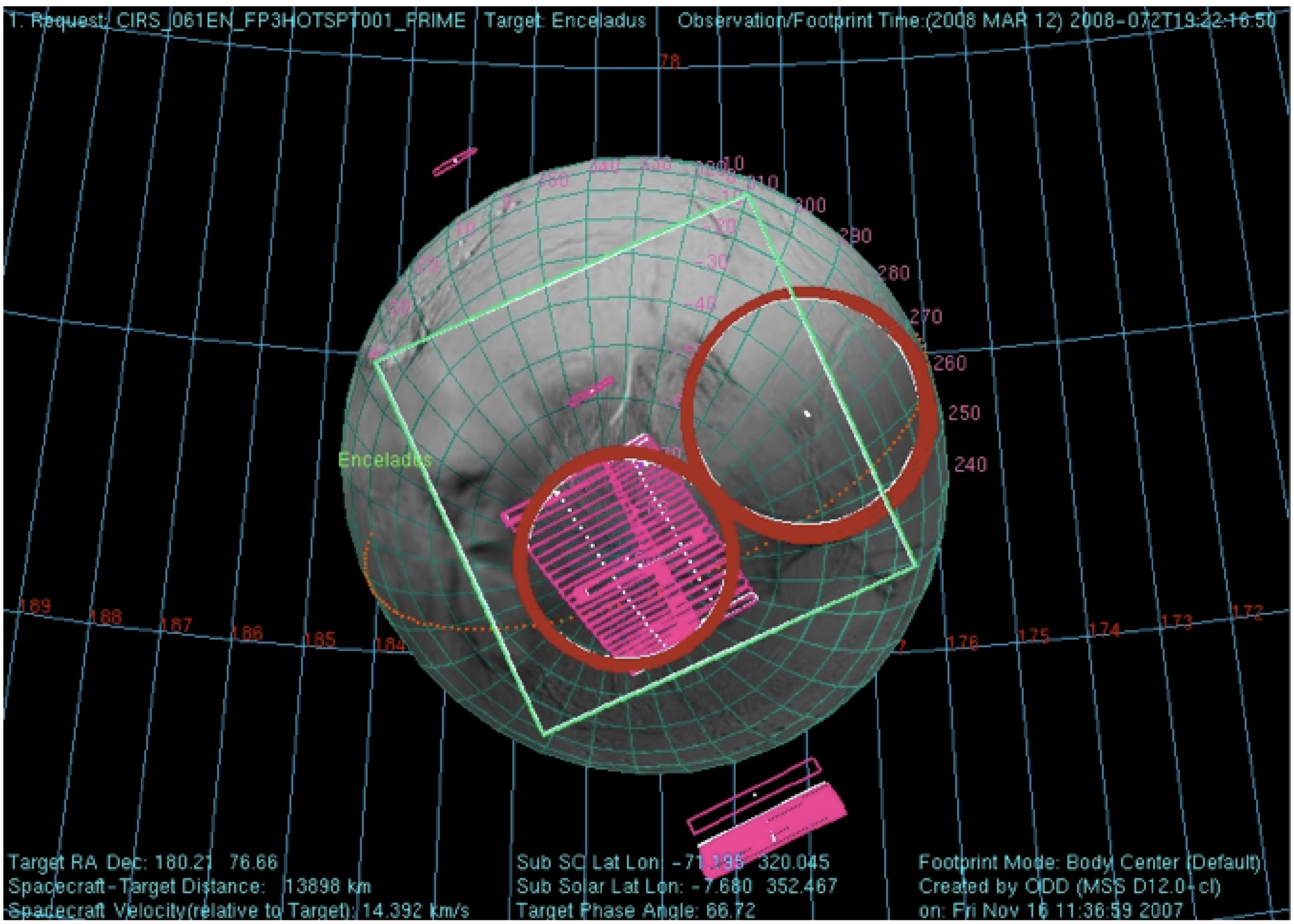
- **RADAR** will perform scatterometry of both hemispheres to determine cm-scale roughness and radiometry to understand the energy balance

1.2 SAMPLE SNAPSHOTS

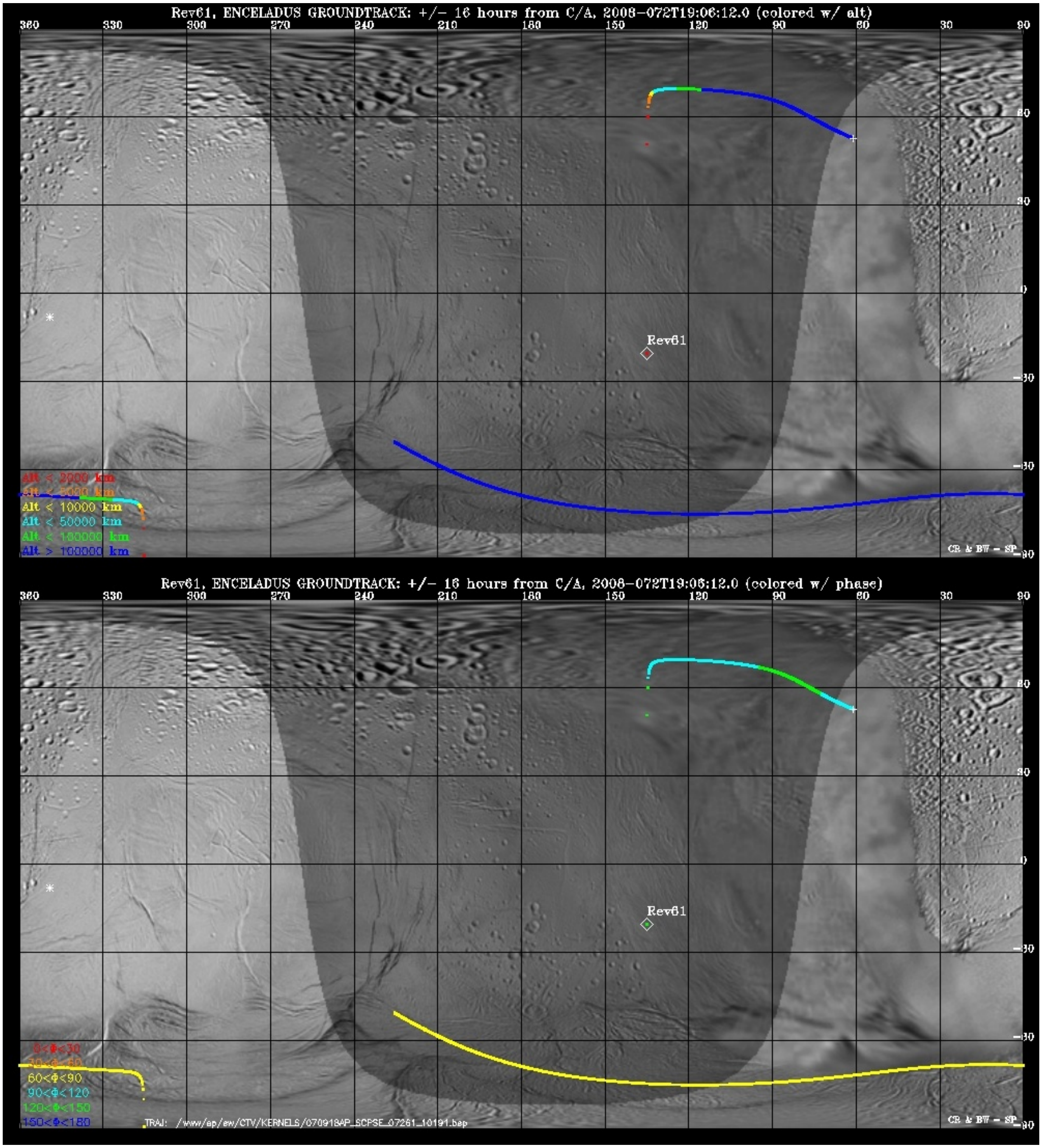
View of Enceladus from Cassini appox. 40 min before closest approach; ISS NAC fields-of-view are shown

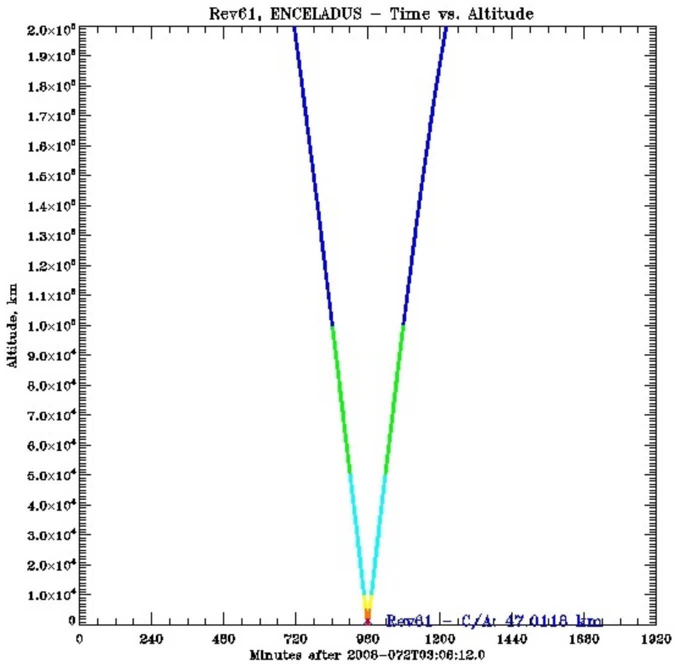


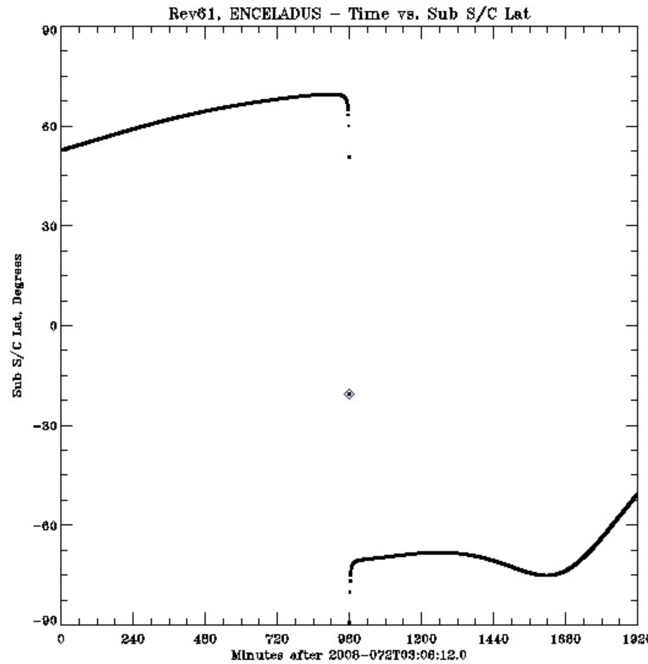
View of Enceladus from Cassini approx. 15 min after closest approach. The red circles are the CIRS FP1 fields-of-view, and the pink rectangles are the CIRS FP3 fields-of-view. The green box is the ISS NAC field-of-view. The geometry is changing rapidly during the observation sequence, as Cassini moves quickly away from Enceladus. The phase angle is ~67°, but Enceladus is in eclipse and is thus not illuminated by the Sun.

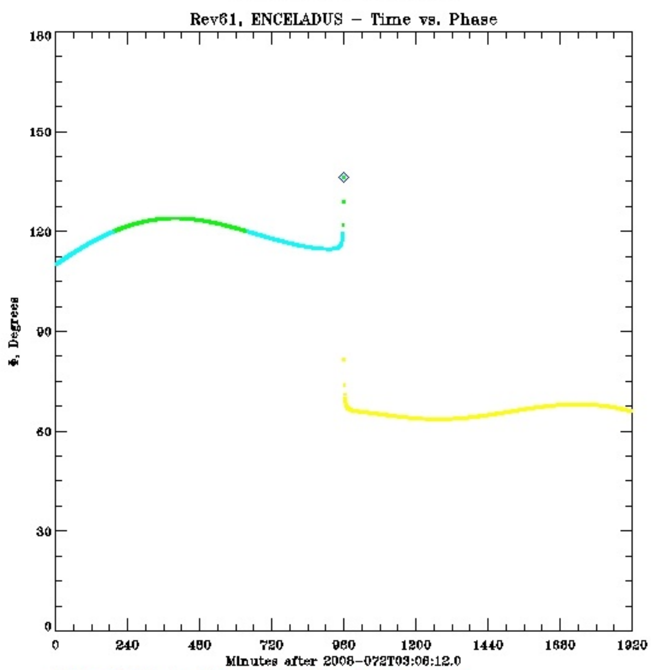


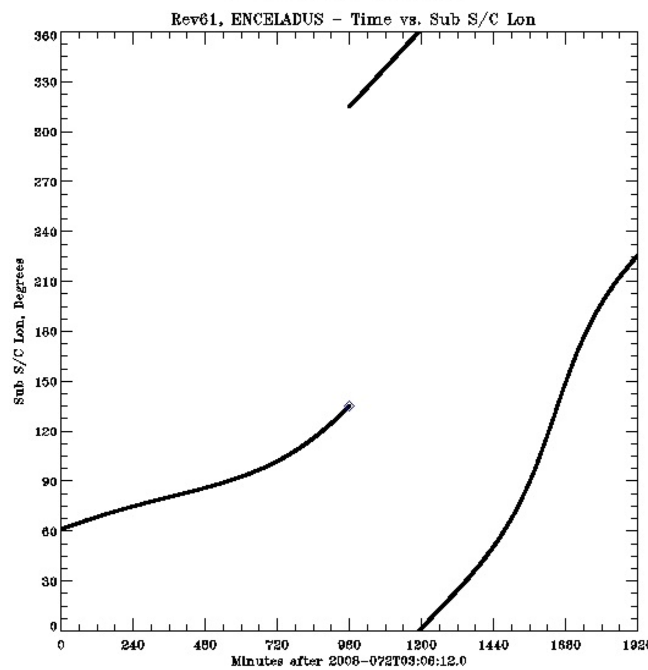
Titan Groundtracks for T41: Global Plot




Rev61, ENCELADUS - Time vs. Altitude
Altitude, km
Minutes after 2008-072T03:06:12.0
Rev61 - C/A: 47.0118 km


Rev61, ENCELADUS - Time vs. Sub S/C Lat
Sub S/C Lat, Degrees
Minutes after 2008-072T03:06:12.0


Rev61, ENCELADUS - Time vs. Phase
Φ, Degrees
Minutes after 2008-072T03:06:12.0


Rev61, ENCELADUS - Time vs. Sub S/C Lon
Sub S/C Lon, Degrees
Minutes after 2008-072T03:06:12.0

The Enceladus-61 events timeline is as follows:

Cassini Enceladus-61 Timeline - March 2008

Colors: yellow = maneuvers; blue = geometry; pink = 061EN-ORS-related; orange=RADAR; green = data playbacks; light green = 061EN-MAPS related

Orbiter UTC	Ground UTC	Pacific Time	Time wrt 061EN	Activity	Description
047T11:51:00	Feb 16 13:00	Sat Feb 16 06:00 AM	EN-25d07h	Start of Sequence S38	Start of Sequence which contains Enceladus-61.
070T01:06:00	Mar 10 02:15	Sun Mar 09 07:15 PM	EN-02d18h	OTM #148 Prime	Enceladus-61 approach targeting maneuver
071T01:06:00	Mar 11 02:15	Mon Mar 10 07:15 PM	EN-01d18h	OTM #148 Backup	
072T02:36:00	Mar 12 03:45	Tue Mar 11 08:45 PM	EN-16h30m	Start of the SOST Segment	
072T03:31:12	Mar 12 04:40	Tue Mar 11 09:40 PM	EN-15h35m	Inbound Enceladus ORS observations (distant)	Images, compositional and temperature maps;
072T14:36:12	Mar 12 15:45	Wed Mar 12 08:45 AM	EN-04h30m	Inbound Enceladus RADAR	
072T16:36:12	Mar 12 17:45	Wed Mar 12 10:45 AM	EN-02h30m	Inbound ORS observations	Images and compositional maps
072T17:13:12	Mar 12 18:22	Wed Mar 12 11:22 AM	EN-01h53m	Inbound ORS observations	Images and compositional maps
072T17:40:12	Mar 12 18:49	Wed Mar 12 11:49 AM	EN-01h26m	ORS observations	Images, compositional maps
072T18:07:12	Mar 12 19:16	Wed Mar 12 12:16 PM	EN-00h59m	ORS observations	Images, compositional and temperature maps
072T18:25:12	Mar 12 19:34	Wed Mar 12 12:34 PM	EN-00h41m	ORS observations	Images and compositional maps of North Pole region
072T18:44:42	Mar 12 19:53	Wed Mar 12 12:53 PM	EN-00h22m	MAPS prime observations	in-situ INMS and CDA measurements
072T19:06:12	**Mar 12 20:15**	**Wed Mar 12 01:15 PM**	**EN+00h00m**	**Enceladus-61 Flyby Closest Approach Time**	**Altitude =52 km (32.3 miles), speed = 14.41 km/s (32,234 mph); high phase inbound, 136.5 deg phase at closest approach, mid phase outbound**
072T19:11:12	Mar 12 20:20	Wed Mar 12 01:20 PM	EN+00h05m	CIRS observations during eclipse	Enceladus is in Saturn eclipse 19:05:16-21:18:08
072T20:10:12	Mar 12 21:19	Wed Mar 12 02:19 PM	EN+01h04m	Outbound Enceladus RADAR	
072T20:54:12	Mar 12 22:03	Wed Mar 12 03:03 PM	EN+01h48m	CIRS observations	
072T22:01:12	Mar 12 23:10	Wed Mar 12 04:10 PM	EN+02h55m	ORS observations (low-resolution); UVIS prime	
073T00:14:12	Mar 13 01:23	Wed Mar 12 06:23 PM	EN+05h08m	Deadtime	5 minutes long; used to accommodate changes in flyby time
073T00:20:00	Mar 13 01:29	Wed Mar 12 06:29 PM	EN+05h14m	turn to Earth	
073T00:51:00	Mar 13 02:00	Wed Mar 12 07:00 PM	EN+05h45m	Downlink	9 hr downlink - Goldstone 70M