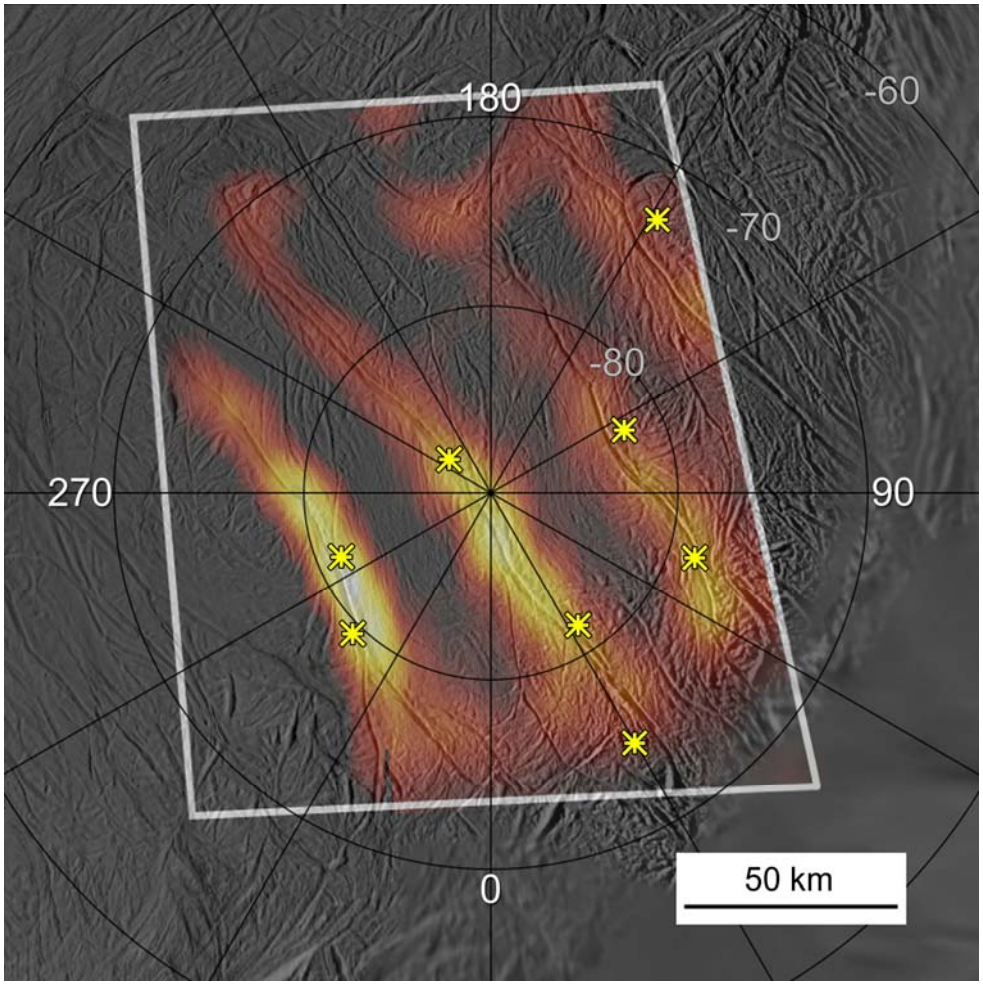
C A S S I N I



E N C E L A D U S **0 8 0 E N** M I S S I O N D E S C R I P T I O N

August 2008

Jet Propulsion Laboratory
California Institute of Technology

Cover image: Enceladus' hot south polar "tiger stripes" (March 12, 2008). This view of Enceladus shows that the cracks at the south pole of Enceladus exhibit hotter temperatures than the surrounding region. Previous measurements by the Cassini spacecraft had shown that geysers emanate from the tiger stripes. The locations of some of the geyser jets are indicated with yellow asterisks. Credits: NASA/JPL/GSFC/SwRI/Space Science Institute

1.0 OVERVIEW

On August 11, 2008, Cassini will visit Enceladus to obtain the highest resolution images of the enigmatic south polar region in the mission. The closest approach is at 2008-224T21:06:19 spacecraft time at an altitude of just 54 kilometers (33.5 miles) above the surface and at a speed of 17.7 kilometers per second (39,594 mph). The latitude at closest approach is 28 degrees S, the longitude is 98 degrees W.

Cassini will approach Enceladus on a fast, inclined trajectory over the northern hemisphere and will depart over the southern hemisphere. The Imaging Subsystem camera will execute a sophisticated series of images at and, just after closest-approach, obtain images of the south polar "tiger stripes" at resolutions as high as 7 m/pix. Enceladus will be in eclipse (Saturn shadow) for ~2.5 hours starting ~36 minutes after closest-approach.

This encounter will be set up with a maneuver on August 8. The Enceladus flyby occurs on the day of orbit number 80 periapse, on the inbound leg of the orbit.

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.

Cassini has executed four close passes by Enceladus. The first close *Cassini* flyby of Enceladus, which occurred on February 17, 2005 with a minimum approach distance of 1175 kilometers, 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 kilometers 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 kilometers down to 175 kilometers.

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 fourth close Enceladus flyby, on March 12, 2008, focused on plume measurements by fields-and-particles instruments. By flying deeper into the plume than on previous flybys, the Ion and Neutral Mass Spectrometer (INMS) was able to obtain more sensitive measurements of the composition of the plume. In addition, the Composite Infrared Mapping Spectrometer (CIRS) mapped the temperatures at the south pole while Enceladus was in eclipse – and found that the highest temperatures are found along the tiger stripes, where most of the jets are also seen by ISS.

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' 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-80 SCIENCE HIGHLIGHTS

- **ISS** will image the south polar terrain at up to 7 meter-scale resolution. ISS will execute a "skeet shoot" series of images to carefully balance light and smear during the closest approach of this fast flyby. The result will be the highest-ever resolution images of the tiger stripes, and clues to what drives the jets that feed the plume.

- **CIRS** will make observations of the south polar temperatures during solar eclipse to determine the heat capacity and textural properties of the regolith; these maps will complement data obtained in the previous flyby.

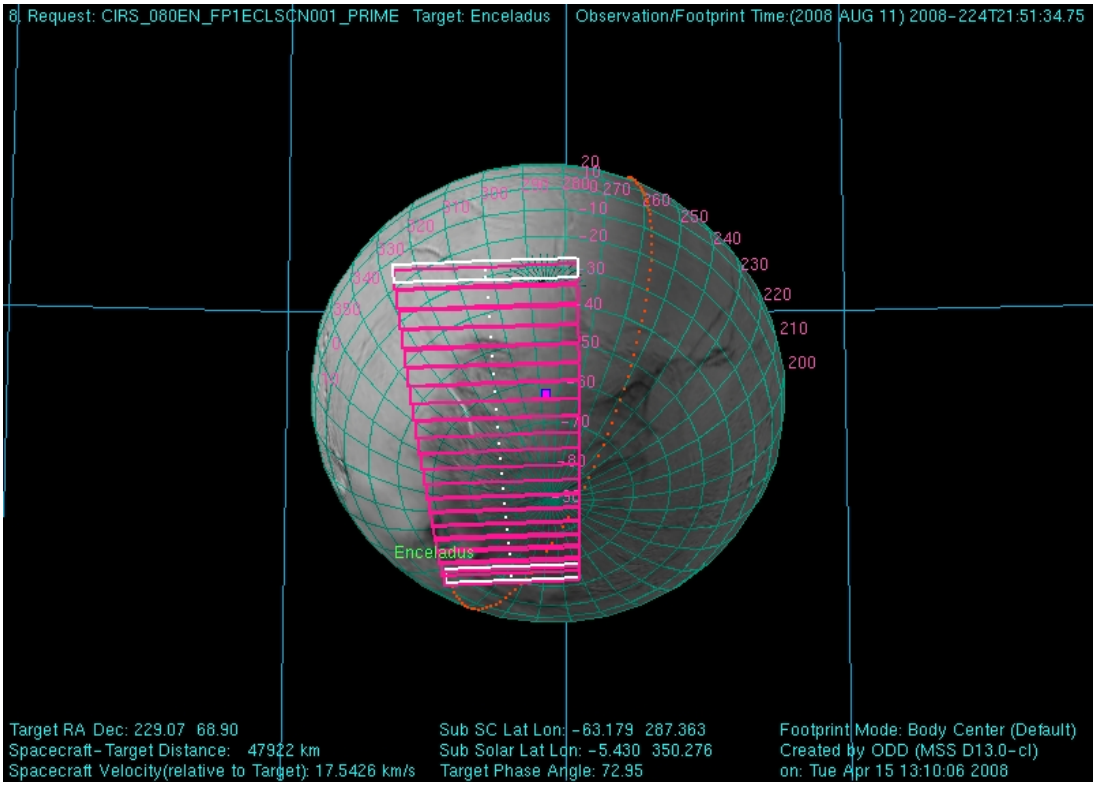
- **VIMS** will perform compositional mapping to determine the identity of volatiles, organics, and minerals, and place them within a geologic context.

- **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.

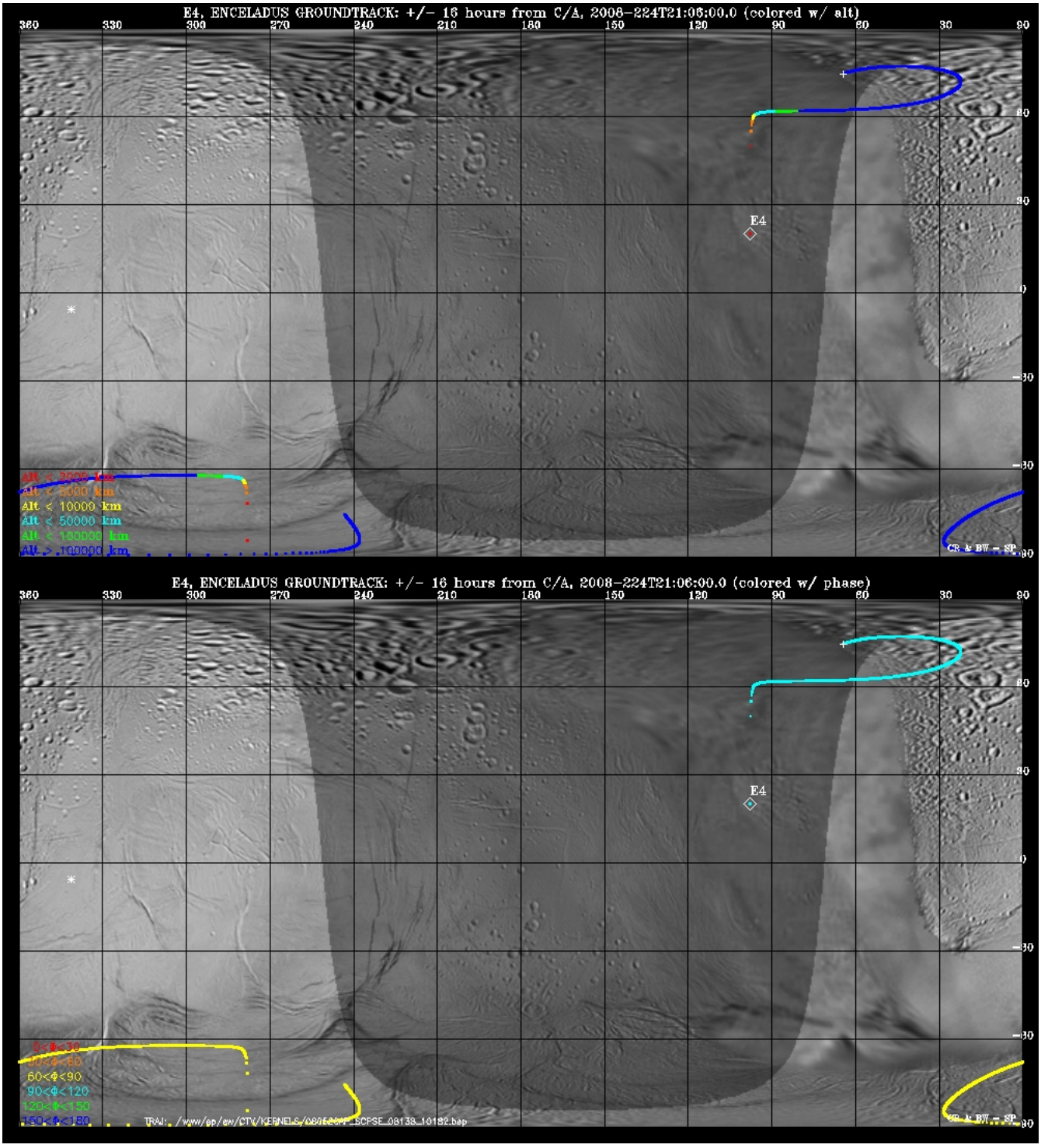
- **MAPS** instruments will examine of the particle environment at 54 kilometers from the surface. The spacecraft will be oriented to optimize remote sensing measurements, but MAPS instruments may obtain interesting data nevertheless. The fields-and-particles instruments will eventually determine the nature of the material coming form the surface and its relationship to the E-ring, and distinguish between two potential populations of particles: plume particles and sputtered particles from elsewhere on the surface. 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.

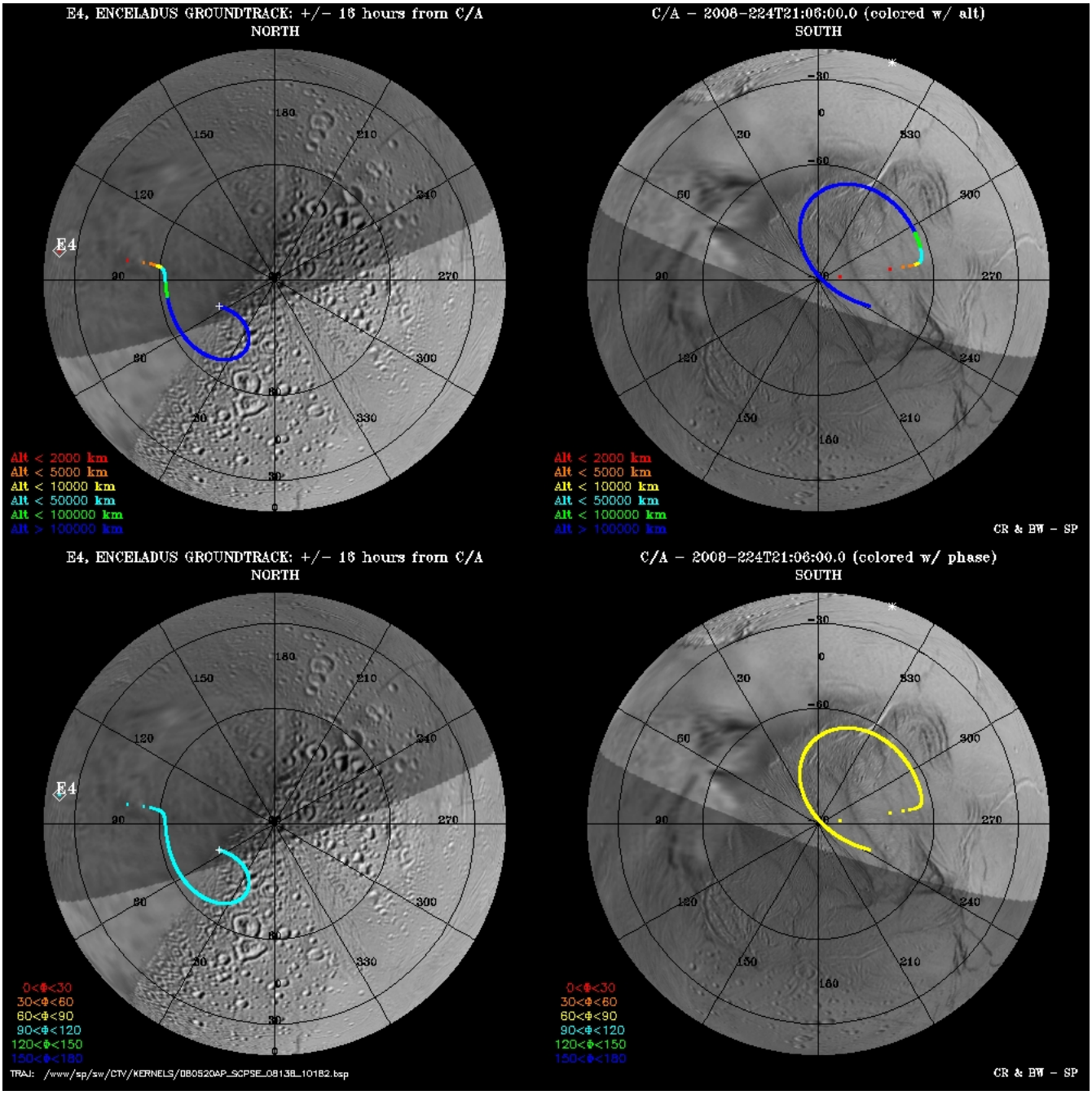
1.2 SAMPLE SNAPSHOTS

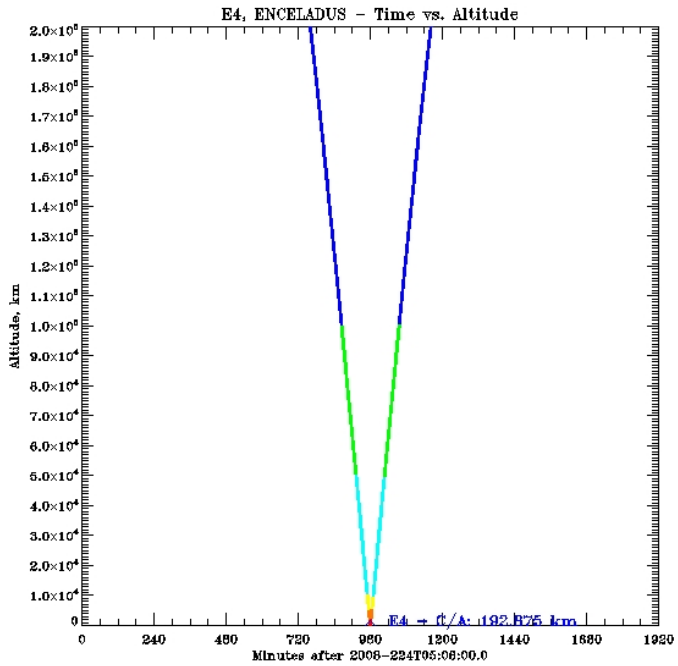


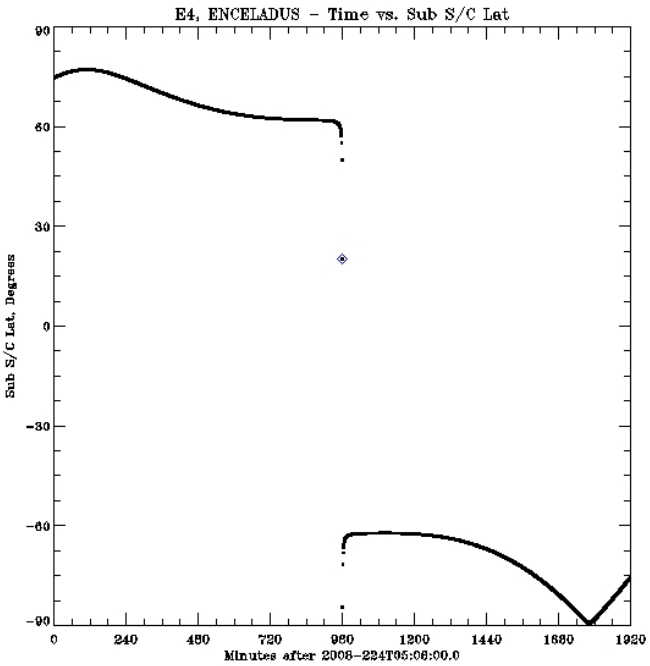
View of Enceladus from Cassini approx. 45 min after closest approach. The pink rectangles are the CIRS FP3 fields-of-view. The geometry is changing rapidly during the observation sequence, as Cassini moves quickly away from Enceladus. The phase angle is 73°, but Enceladus is in eclipse and is thus not illuminated by the Sun.

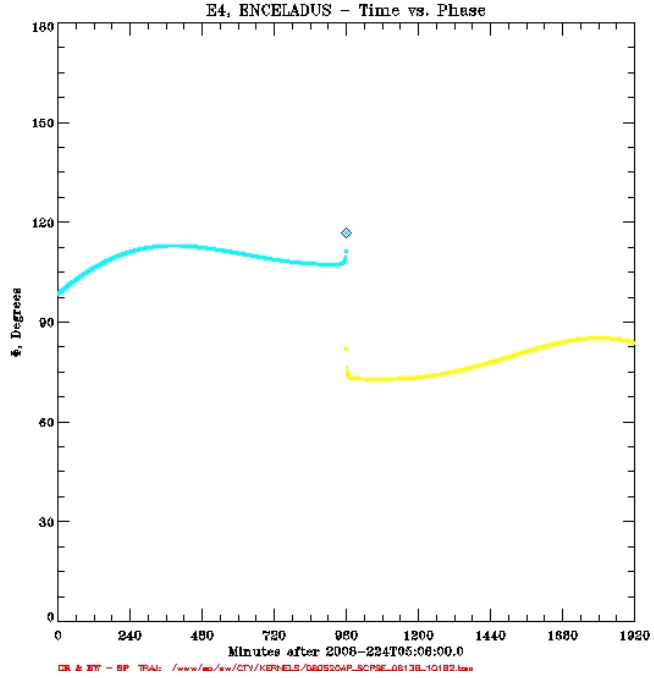
Enceladus Groundtracks and Body Information for 080EN

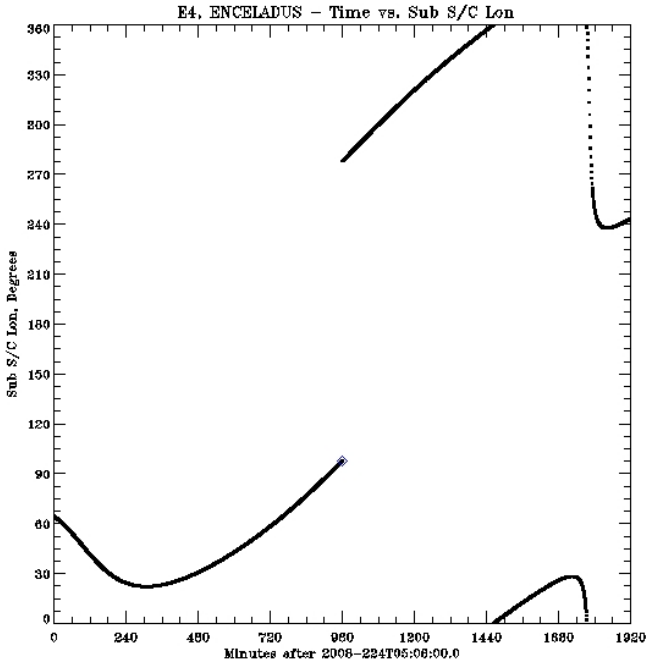



E4, ENCELADUS GROUNDTRACK: +/- 16 hours from C/A
NORTH
E4
Alt < 2000 km
Alt < 5000 km
Alt < 10000 km
Alt < 50000 km
Alt < 100000 km
Alt > 100000 km
C/A - 2008-224T21:06:00.0 (colored w/ alt)
SOUTH
Alt < 2000 km
Alt < 5000 km
Alt < 10000 km
Alt < 50000 km
Alt < 100000 km
Alt > 100000 km
CR & BW - SP
E4, ENCELADUS GROUNDTRACK: +/- 16 hours from C/A
NORTH
E4
0<Φ<30
30<Φ<60
60<Φ<90
90<Φ<120
120<Φ<150
150<Φ<180
TRAJ: /www/sp/sw/CTV/KERNELS/080520AP_SCPSE_08138_10182.bsp
C/A - 2008-224T21:06:00.0 (colored w/ phase)
SOUTH
0<Φ<30
30<Φ<60
60<Φ<90
90<Φ<120
120<Φ<150
150<Φ<180
CR & BW - SP


E4, ENCELADUS - Time vs. Altitude
Altitude, km
Minutes after 2008-224T05:06:00.0


E4, ENCELADUS - Time vs. Sub S/C Lat
Sub S/C Lat, Degrees
Minutes after 2008-224T05:06:00.0


E4, ENCELADUS - Time vs. Phase
Φ, Degrees
Minutes after 2008-224T05:06:00.0


E4, ENCELADUS - Time vs. Sub S/C Lon
Sub S/C Lon, Degrees
Minutes after 2008-224T05:06:00.0

The Enceladus-80 events timeline is as follows:

Cassini Enceladus-80 Timeline - August 11 2008

Colors: yellow = maneuvers; blue = geometry; pink = 080EN-ORS-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time	Time wrt 061EN	Activity	Description
221T15:20:00	Aug 08 16:45	Fri Aug 08 09:45 AM	EN-03d06h	OTM #163 Prime	Enceladus-80 approach targeting maneuver
222T15:20:00	Aug 09 16:45	Sat Aug 09 09:45 AM	EN-02d06h	OTM #163 Backup	
224T00:20:00	Aug 11 01:45	Sun Aug 10 06:45 PM	EN-20h46m	Start of Sequence S43	Start of Sequence which contains Enceladus-80.
224T00:20:00	Aug 11 01:45	Sun Aug 10 06:45 PM	EN-20h46m	Start of the SOST Segment	
224T01:05:00	Aug 11 02:30	Sun Aug 10 07:30 PM	EN-20h01m	Deadtime	15 minutes long; used to accommodate changes in flyby time
224T05:40:19	Aug 11 07:05	Mon Aug 11 12:05 AM	EN-15h26m	Inbound Enceladus plume observation (distant)	6.5 hour medium-phase angle observation of Enceladus plumes (inbound over northern hemisphere)
224T12:06:19	**Aug 11 13:31**	**Mon Aug 11 06:31 AM**	**EN-09h00m**	**Downlink**	**3-hour downlink to empty SSRs for Enceladus flyby (Madrid)**
224T16:06:19	Aug 11 17:31	Mon Aug 11 10:31 AM	EN-05h00m	Inbound ORS observations	VIMS prime - sit 'n stare; Enceladus is 1.82-5.6 mrad across; northern hemisphere; phase angle~100 deg
224T18:36:19	Aug 11 21:01	Mon Aug 11 02:01 PM	EN-01h30m	Inbound ORS observations	JVIS prime - long slow scan starting off disk and ending on disk of Enceladus; search for neutral gases
224T20:26:19	Aug 11 21:51	Mon Aug 11 02:51 PM	EN-00h40m	Closest-approach ORS observations	ISS prime - images of south polar terrain at resolutions up to 7 m/px
224T21:06:19	**Aug 11 22:31**	**Mon Aug 11 03:31 PM**	**EN+00h00m**	**Enceladus-80 Flyby Closest Approach Time**	**Altitude =54 km (33.5 miles), speed = 17.7 km/s (39,594 mph); mid phase inbound, 110.4 deg phase at closest approach, mid phase outbound**
224T21:34:49	Aug 11 22:59	Mon Aug 11 03:59 PM	EN+00h28m	Outbound ORS observations	CIRS prime - temperature maps of tiger stripes at south pole. Enceladus goes into eclipse at ~21:41 SCET
225T01:06:19	Aug 12 02:31	Mon Aug 11 07:31 PM	EN+04h00m	Outbound ORS observations	VIMS prime - sit 'n stare; Enceladus is 2.2-1.83 mrad across; southern hemisphere; phase angle~80 deg
225T02:06:19	**Aug 12 03:31**	**Mon Aug 11 08:31 PM**	**EN+05h00m**	**Downlink**	**5 hr downlink - Canberra + Madrid**
225T08:06:19	Aug 12 09:31	Tue Aug 12 02:31 AM	EN+11h00m	Outbound ORS observations	JVIS prime - final long distant observation to map out the neutral oxygen around Enceladus
225T13:33:19	Aug 12 14:58	Tue Aug 12 07:58 AM	EN+16h27m	Deadtime	15 minutes long; used to accommodate changes in flyby time
225T15:04:00	**Aug 12 16:29**	**Tue Aug 12 09:29 AM**	**EN+17h58m**	**Downlink**	**9 hr downlink - Goldstone 70M**