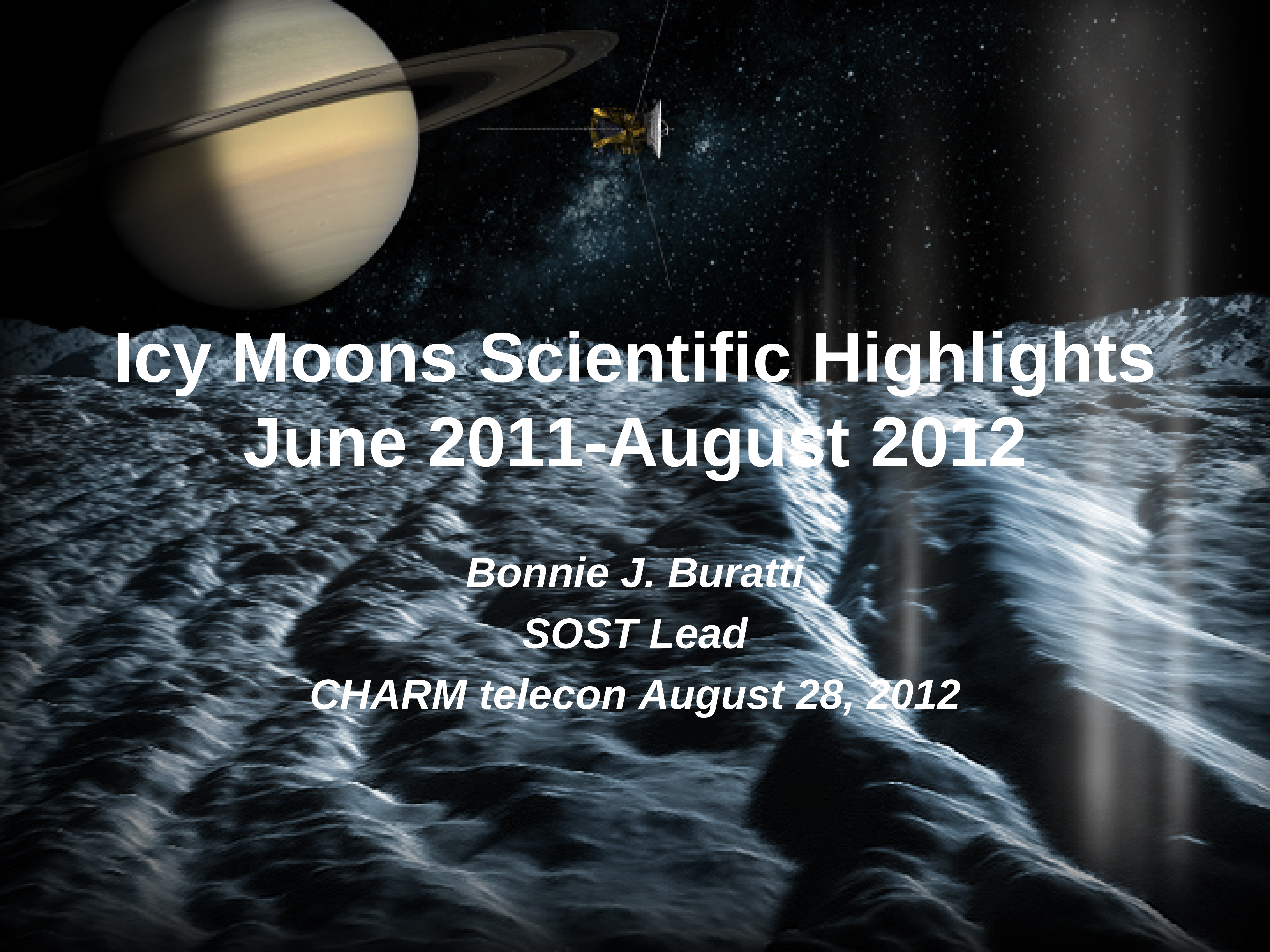

# Icy Moons Scientific Highlights June 2011-August 2012

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*SOST Lead*

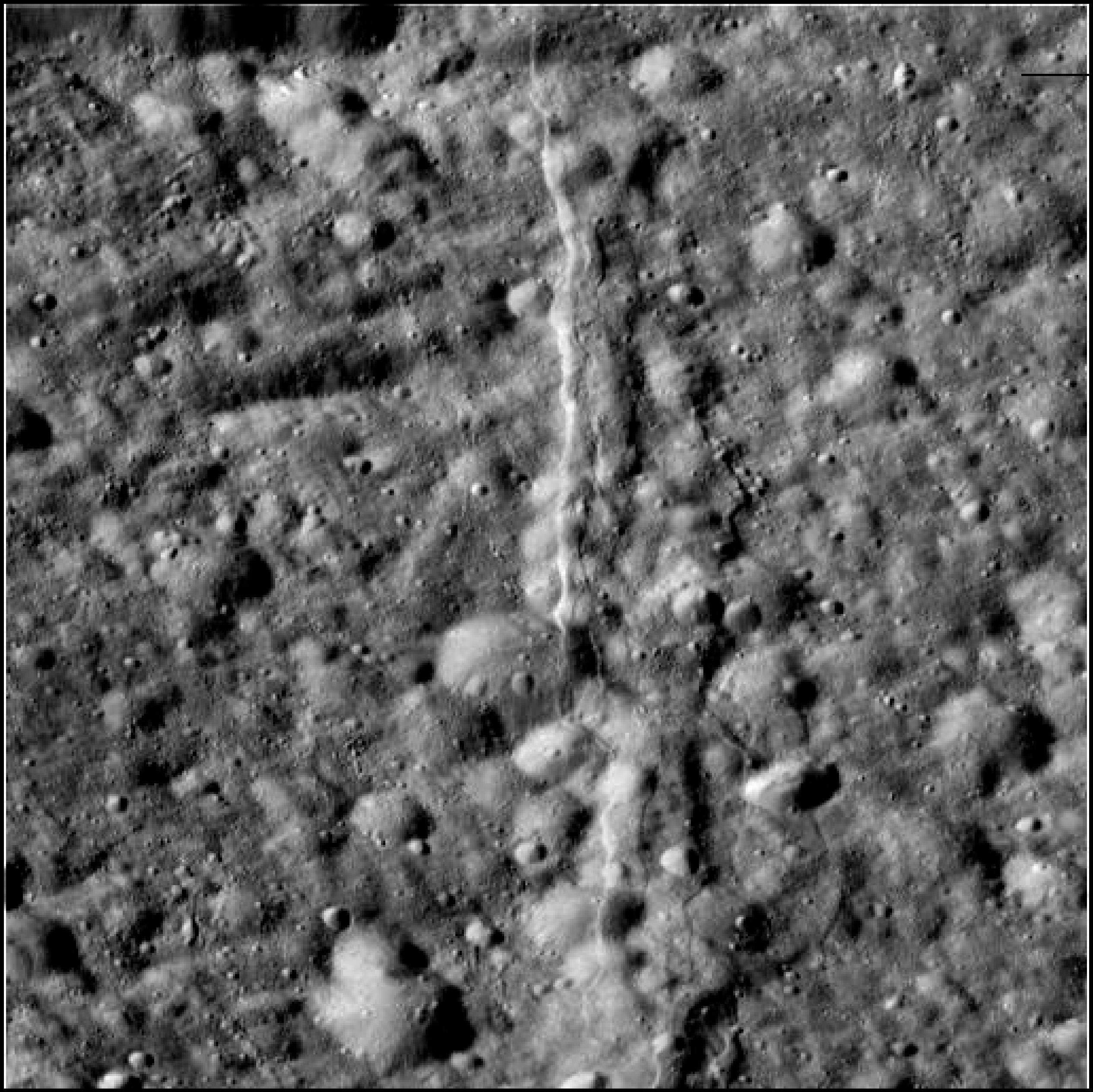
*CHARM telecon August 28, 2012*

# Summary of targeted flybys

| Flyby | Date | C/A(km) | Flavor | Comments |
| --- | --- | --- | --- | --- |
| E14 | Oct. 1, 2011 | 103 | MAPS (INMS) | |
| E15 | Oct. 19, 2011 | 1235 | UVIS double occ | Successful |
| E16 | Nov. 6, 2011 | 500 | RADAR | On thrusters; successful |
| E17 | March 27, 2012 | 78 | MAPS (INMS) | |
| E18 | April 14, 2012 | 78 | MAPS | ORS drag – VIMS data |
| E19 | May 2, 2012 | 77 | RSS gravity | One of a pair |
| D3 | Dec. 12, 2011 | 100 | RSS (gravity) MAPS ridealong | $CO_2$, $O_2$ atm detected by INMS D1-D3; ($O_2$+ by CAPS previously) |

# Scientific Highlights

- **Activity on Dione?**
- **Double occultation of Enceladus plumes**
- **First high resolution RADAR images of an icy satellite (Enceladus)**
- **Heat detected by VIMS on Enceladus**
- **Small satellite observations**
- **Pacmen**
- **Theory on colors of the satellites**
- **Small satellite observations; Hyperion and Iapetus campaigns**
- **Plumes galore**
- **MAPS: Auroral hiss and electron beams on Enceladus; "Van Allen" belts and moon cavities**



Dione 8461 km ISS image on May 3, 2012

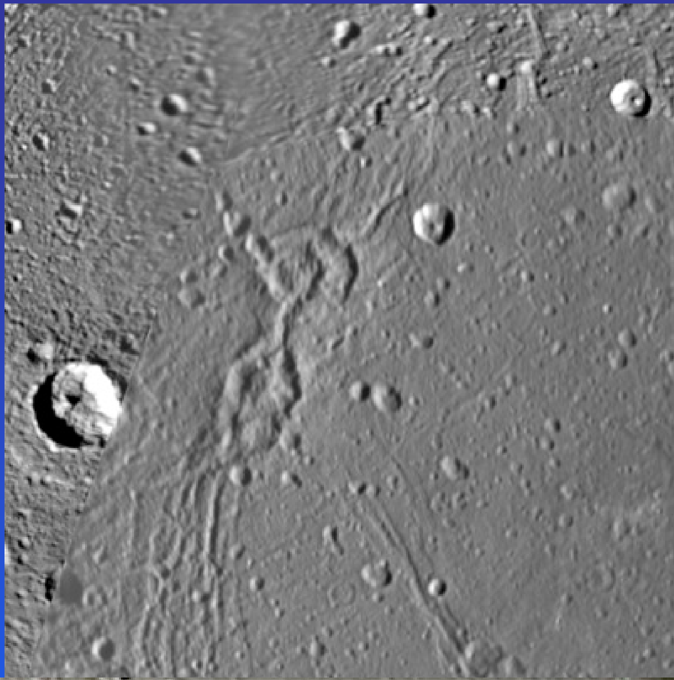
# Activity on Dione?

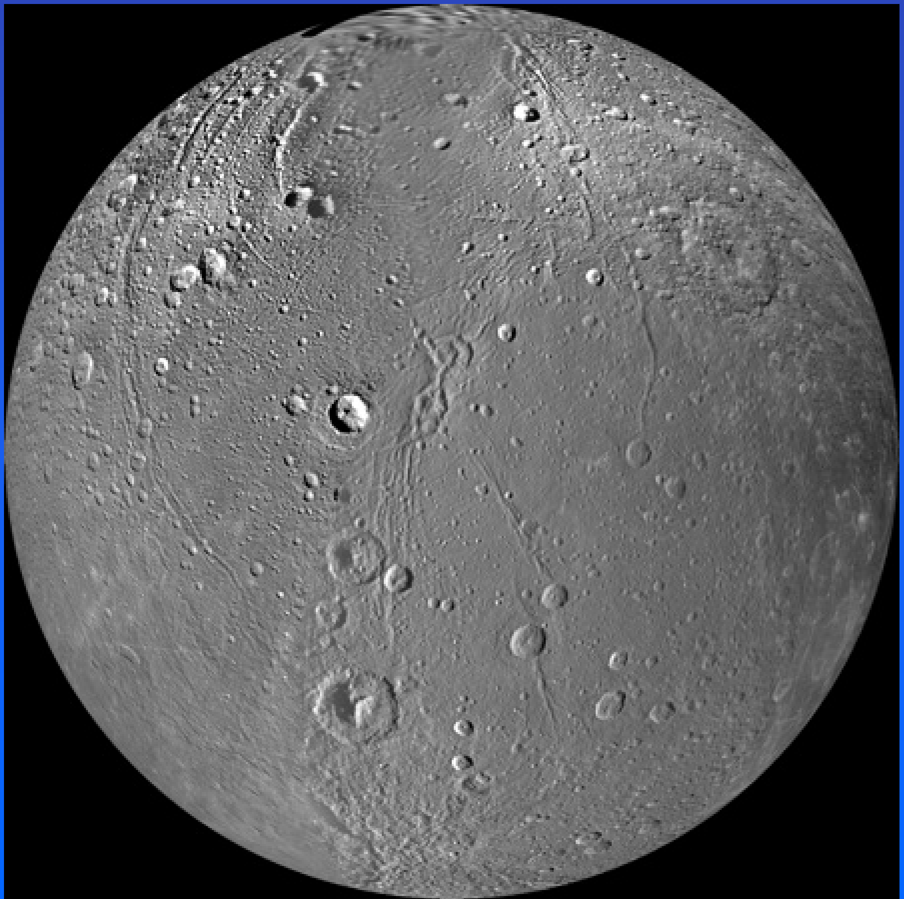
- There are multiple lines of evidence for some sort of recent and/or ongoing activity on Dione.
- These include detection of a tenuous atmosphere  by multiple instruments; MAPS observations that indicate an atmosphere or “plume” is altering the fields and particles environment; “paleo” tiger stripes; possible cryovolcanoes; and highly crystalline ice.

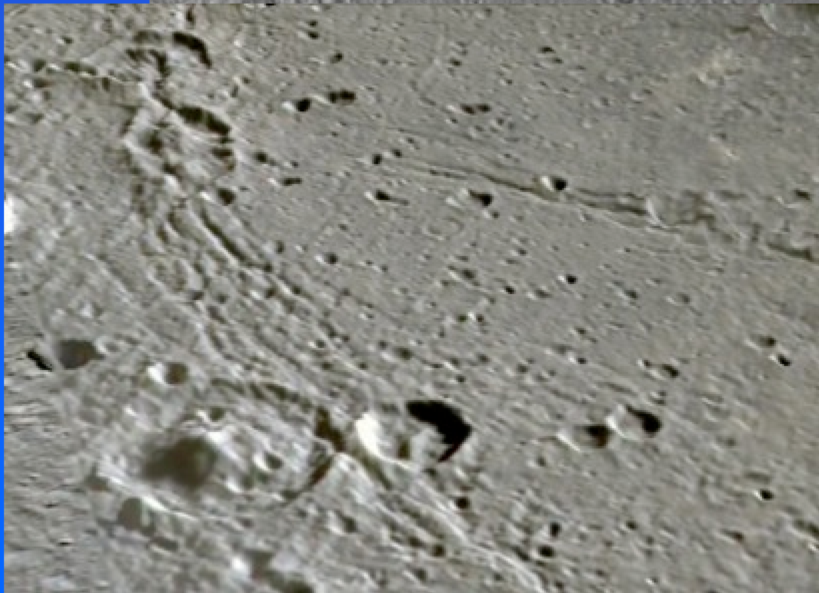
# Paul Schenk: Volcanism

## Smooth plains on Dione

- Lower crater density
- Linear grooves and scarps
- Rampart craters
- Anomalous crater pair: Possible volcanic vent!







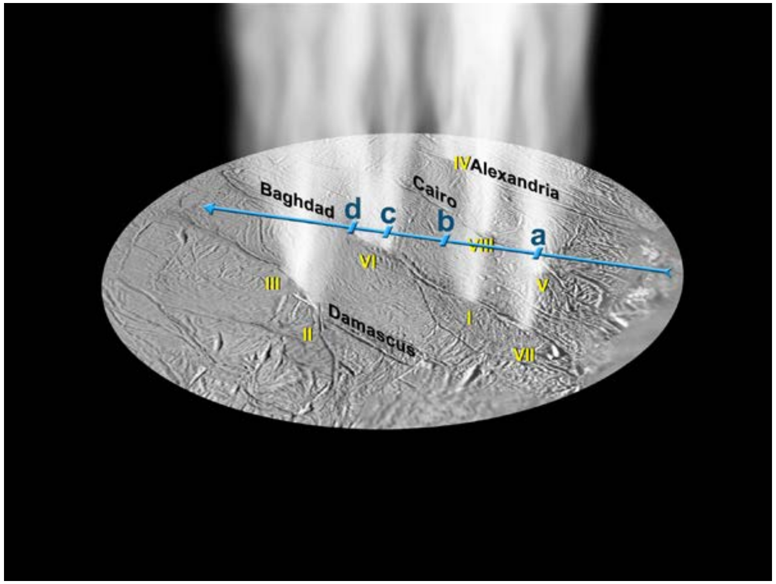
# E15: UVIS Double Occultation

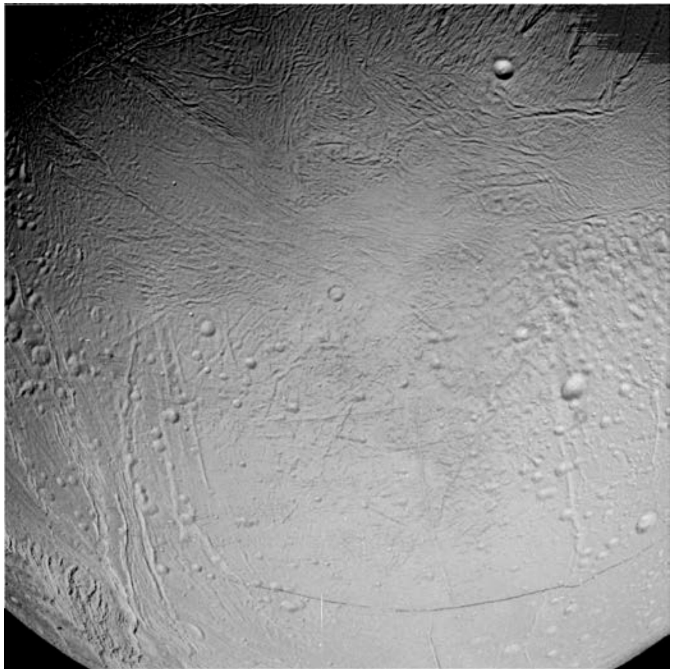
**2011-292T09:22:11.57**
**(19 Oct 2011) 1234.8 km**

**The main goal of this flyby was to obtain a double UVIS occultation by Enceladus of two stars in Orion's Belt, epsilon Ori and zeta Ori, as they pass behind the plume of Enceladus. This observation is being analyzed to yield vertical structure in the plume, to measure variability, and to pin down collimation of gas in the jets.**

**During the lit approach, ISS obtained images observing with ORS ridealong**

**During the exit, during which Enceladus was in eclipse, CIRS observed to map thermal emissions and their variability.**



**(Top) Schematic drawing of occ**
**(Right) An ISS image during the flyby**

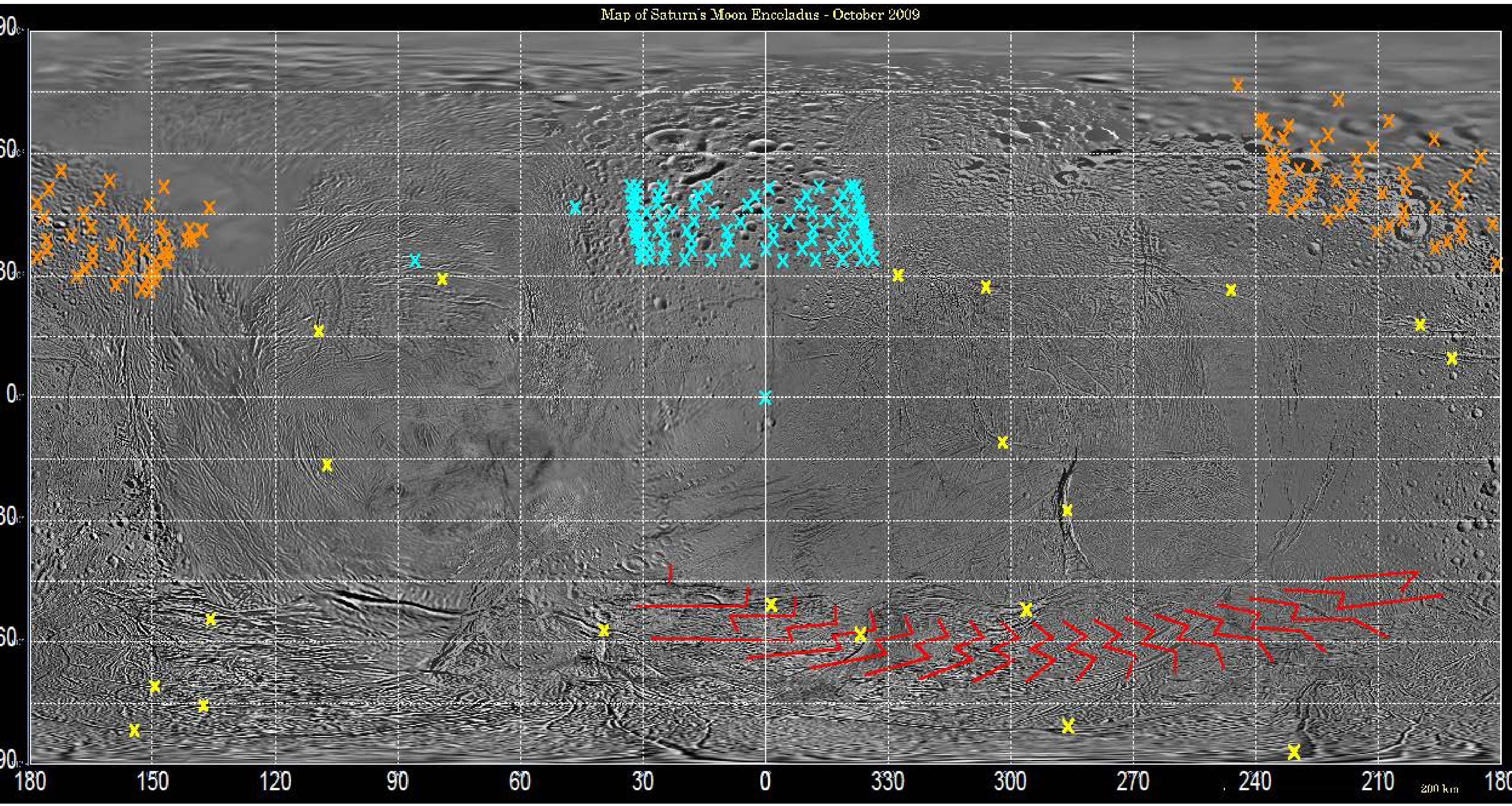
# E16: Rev 154

2011-310T04:58:53.21
(6 Nov 2011)
499.5 km (on thrusters)

A unique Radar SAR flyby with two goals: to compare an object with known composition to Titan SAR data, and to provide the first close SAR passage of an icy satellite.

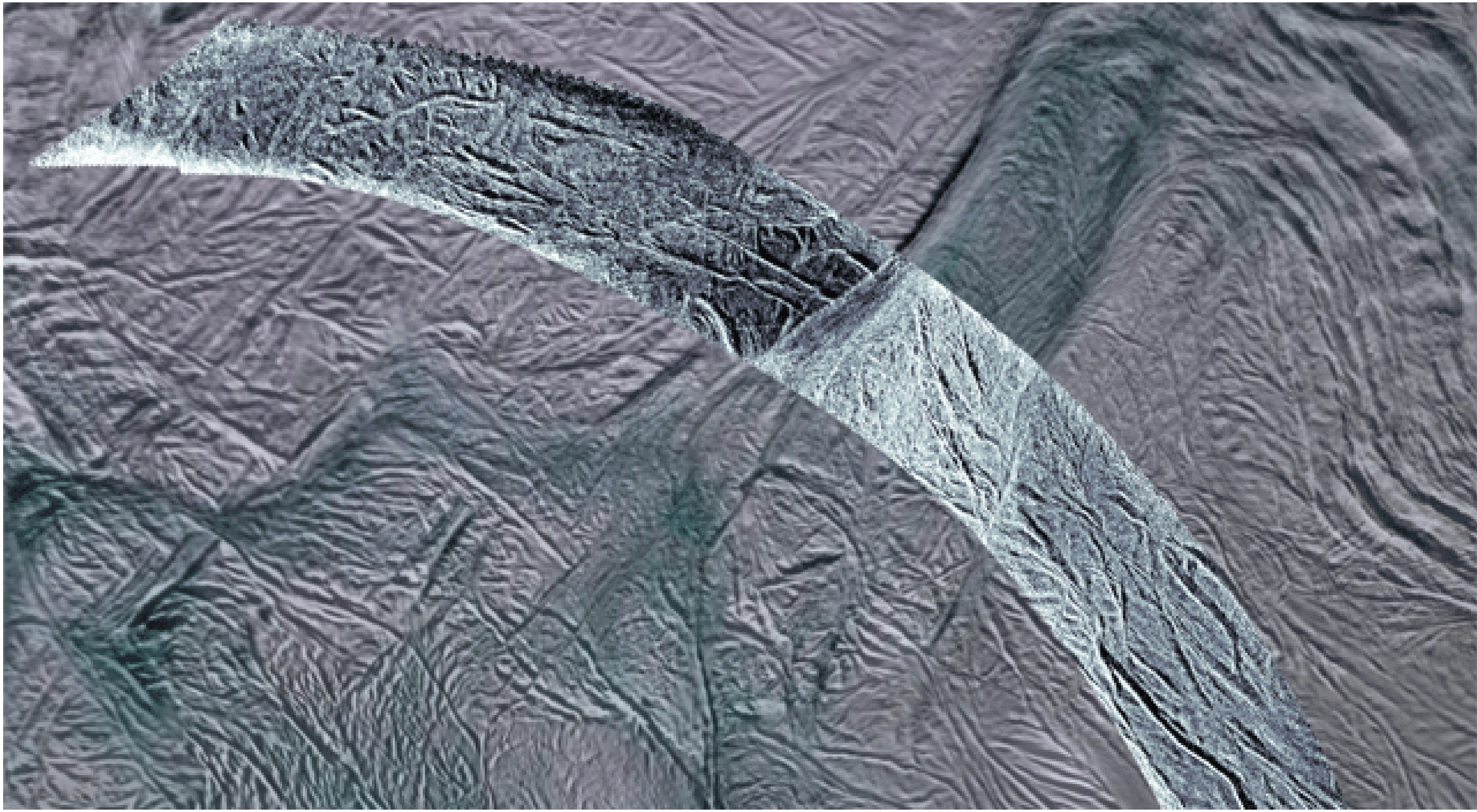
Other highlights: Plume observation on approach and CIRS scan to monitor variability of plumes and heat on Enceladus; ISS observations on exit. UVIS was prime on a Dione stare observation after closest approach (exosphere search). Finally, there was an ISS Lagrangian satellite search at Enceladus and Rhea (none found)

Titan SAR image



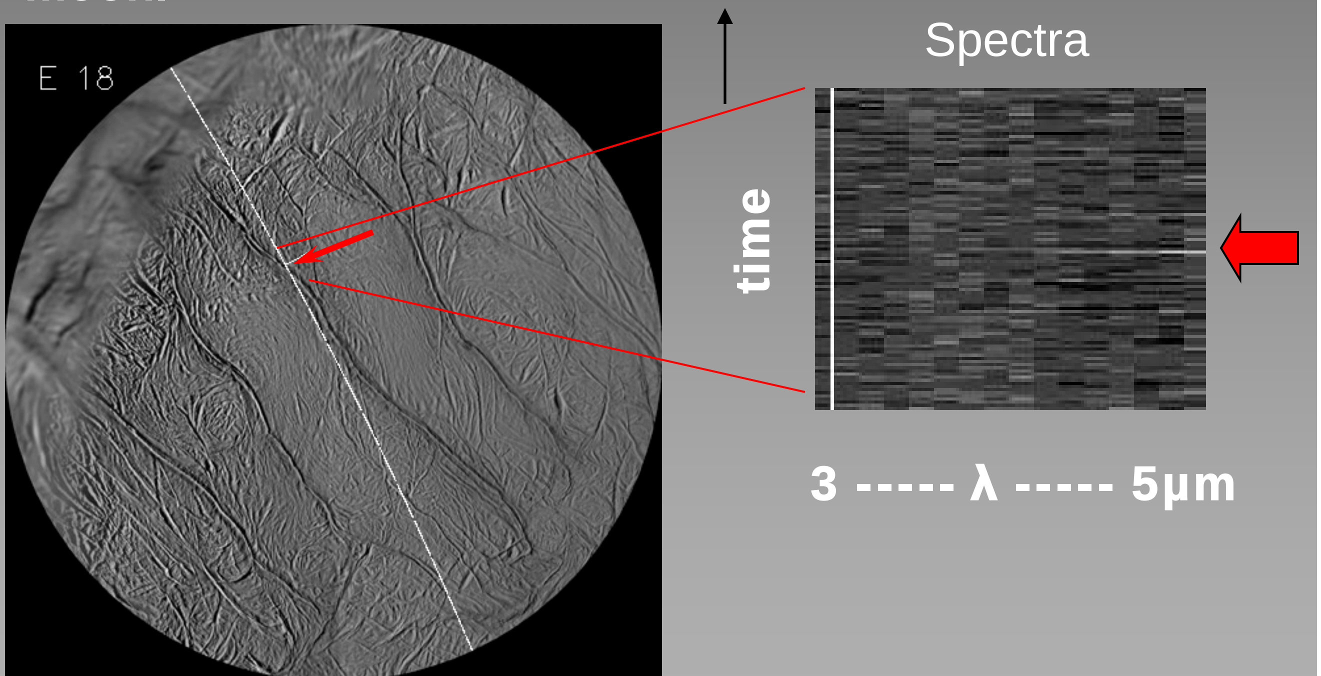

**Footprints for 3 SAR observational periods proposed by Radar for E16. Limits on hydrazine usage precluded doing the orange scans**

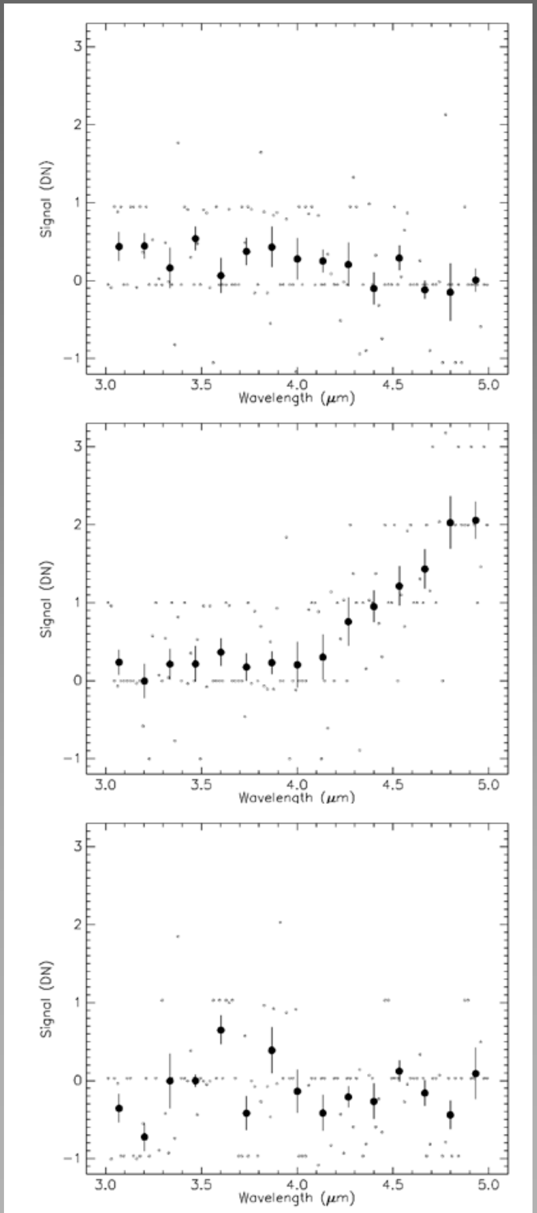
# Analysis of Radar Data



# Detection of a hot spot on Enceladus by VIMS (E18)

**VIMS detected a thermal signature from a hot spot on Enceladus during a 74 km flyby. Preliminary analysis shows that the size of the emitting region is less than 90 km and emits at 200 K or more. This measurement is the best determination of the size of hot spots on the moon.**



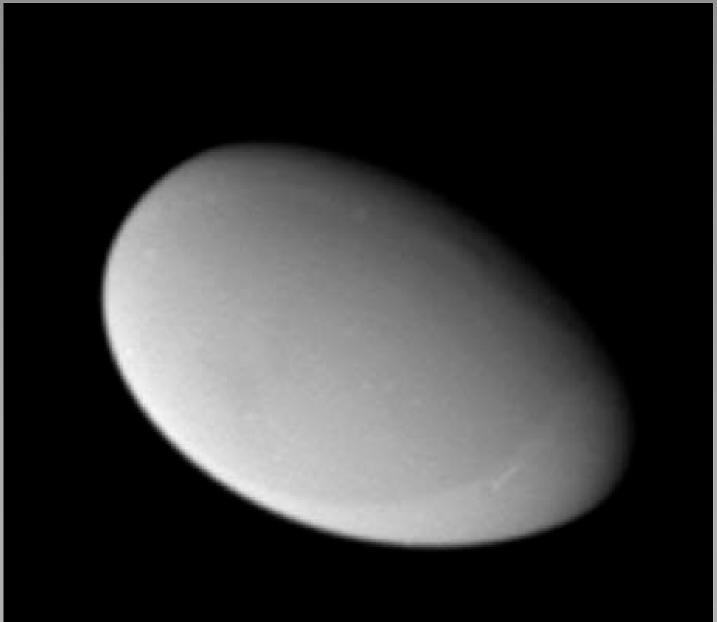

**The ground track of Cassini during E18. The red arrows show the location and spectrum of the hot spot. Measurements before and after show no thermal emission.**

# Observations of small satellites

Two major "best-ever" observations of the small moons of Saturn were obtained. Janus, one of the two coorbitals of Saturn, was observed on March 27 and found to be heavily cratered and covered with ring particles. Methone, which was discovered by Cassini in 2004 between the orbits of Mimas and Enceladus, is remarkably smooth. Is this unusual surface texture caused by accretion of ice particles from the E-ring?

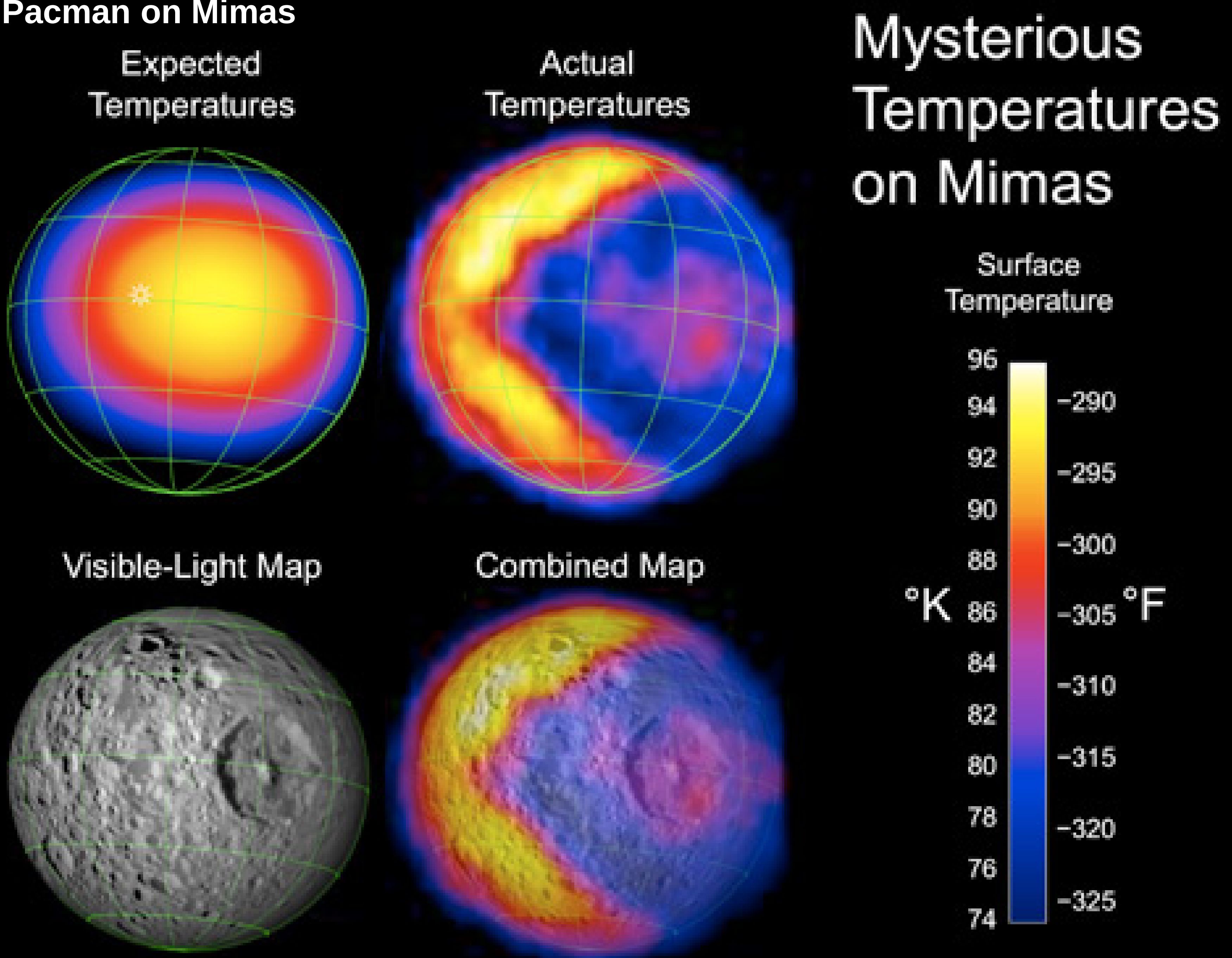
The completely different morphology of these two inner small satellites of Saturn speaks to the diversity of processes occurring on small moons in the system.

Janus at 28,000 km on March 27, 2012

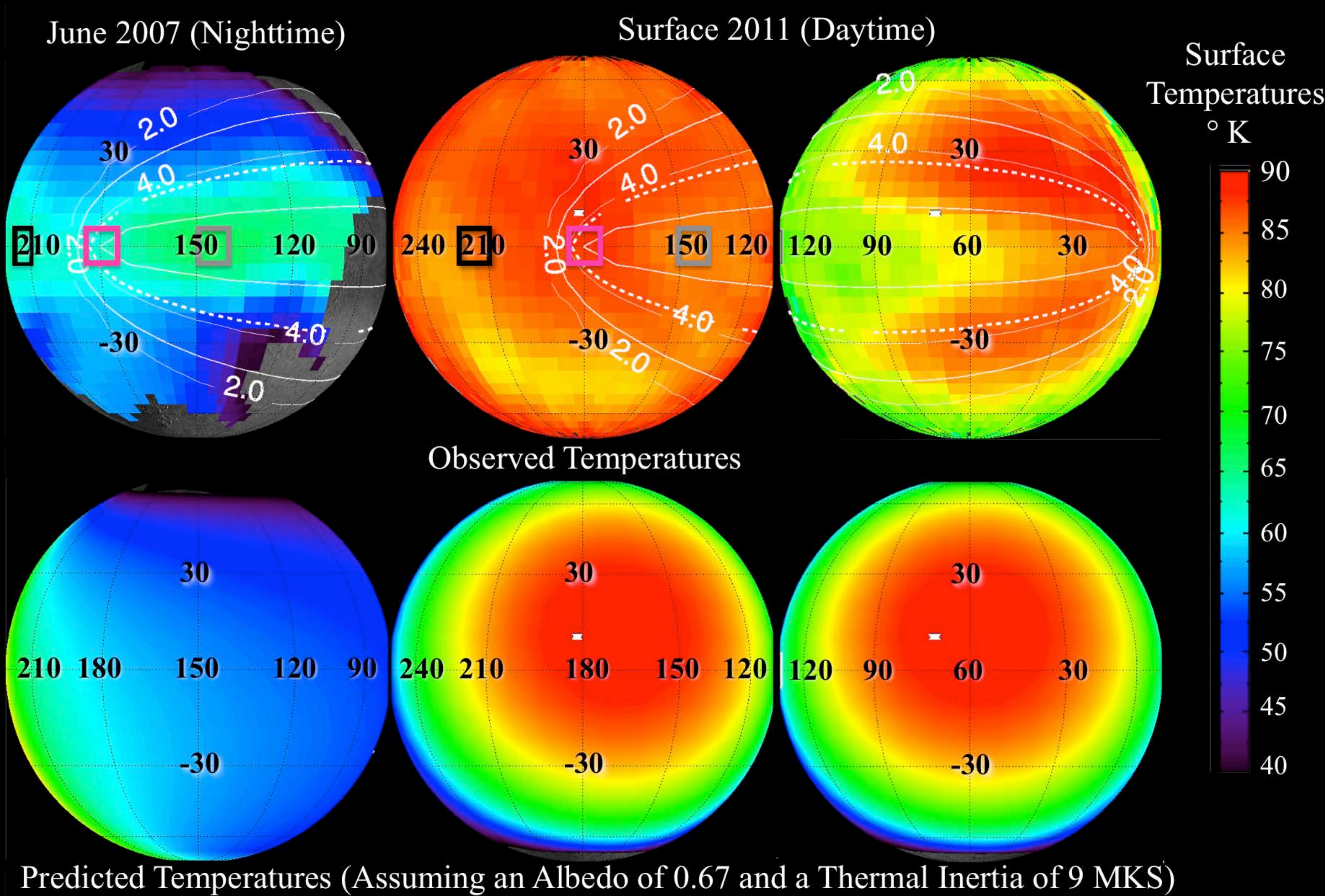


Methone at 4500 km on May 20, 2012

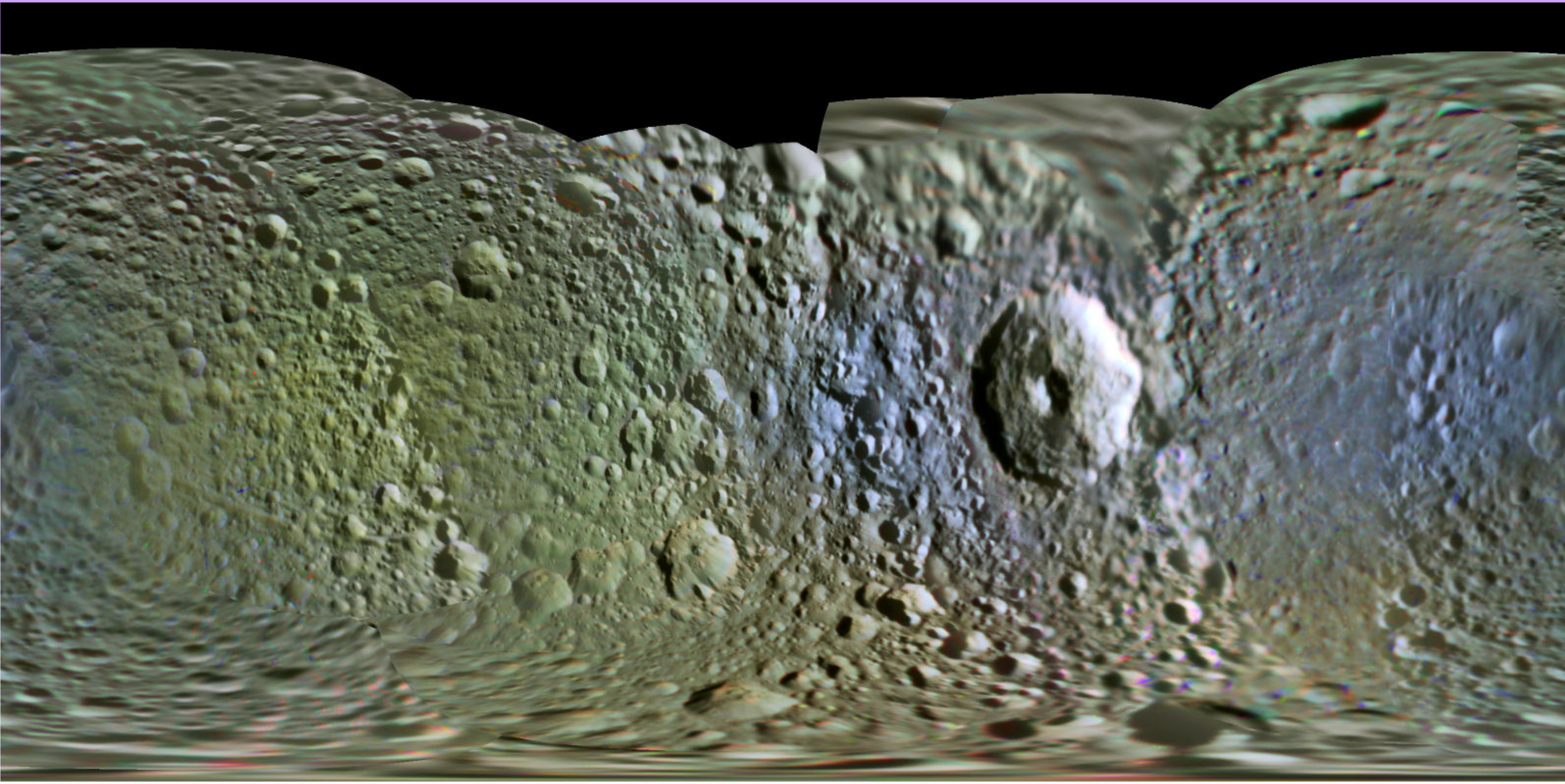
# Pacman on Mimas



## Pacman on Tethys (Howett et al, 2012) : In both cases the cause may be the alteration of the surface by high-energy electrons.



Mimas: Schenk et al. 2011, based on ISS images



Hendrix et al. (2012) also show that E-ring deposition important (UVIS and VIMS data)

# The rotational states of the outer irregular satellites

**Saturn has a large family of outer irregular satellites that are believed to be captured objects that are highly collisionally evolved (Phoebe is the largest one). The Cassini mission offers a unique opportunity to observe these objects for hours to derive rotation curves and thus rotational periods,which give clues to their collisional evolution, particularly when the periods are known for many objects.**

**An ISS team led by T. Denk has been designing and reducing photometric measurements to derive rotation periods of Ymir: 11.93 hr; Mundilfari 6.74 h; Kari 7.70 h; Albiorix 13.32 h; Kiviuq 21.82 h. More uncertain values are: Skathi ~12 h; Bebhionn ~16 h; Thrymr ~27 h; Erriapus ~28 h.**

***Phoebe***

# The Iapetus and Hyperion campaigns

**Although no targeted flybys of Hyperion and Iapetus were in the XXM, 2011 saw untargeted flybys that provided new views. The shape and rotational state of Hyperion could be better determined.**

**Iapetus S. pole, July 25, 2011, 863,000 km**
**Hyperion, Sept. 16, 2011, 88,000 km**

# Many Plume Observations

*Why so many plume observations?*

To obtain different viewing geometries which better characterize plume morphology, particle size, and the relationship between plumes and surface features and thermal anomalies. Specific jets are mapped to specific locations. In addition, large distances are required for context and to understand the relationship of the plumes to E-ring (tendril observations useful here). Observations of both jets and plumes required.

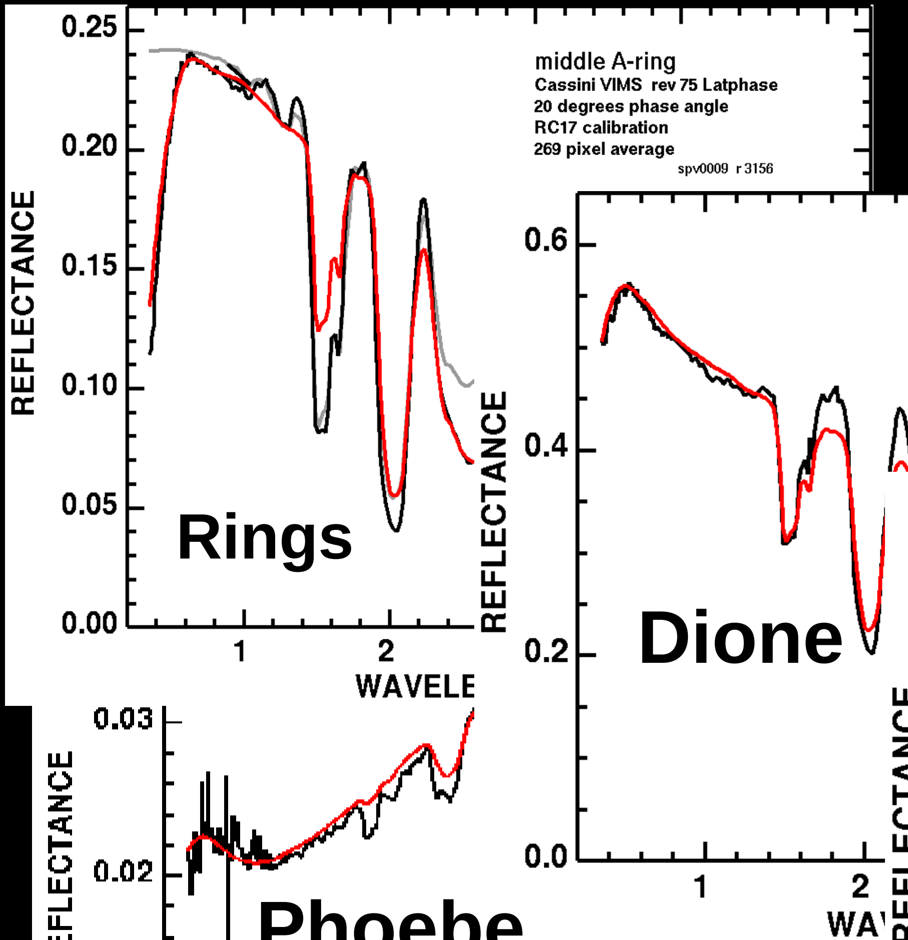
To understand the variability of geologic activity on Enceladus.

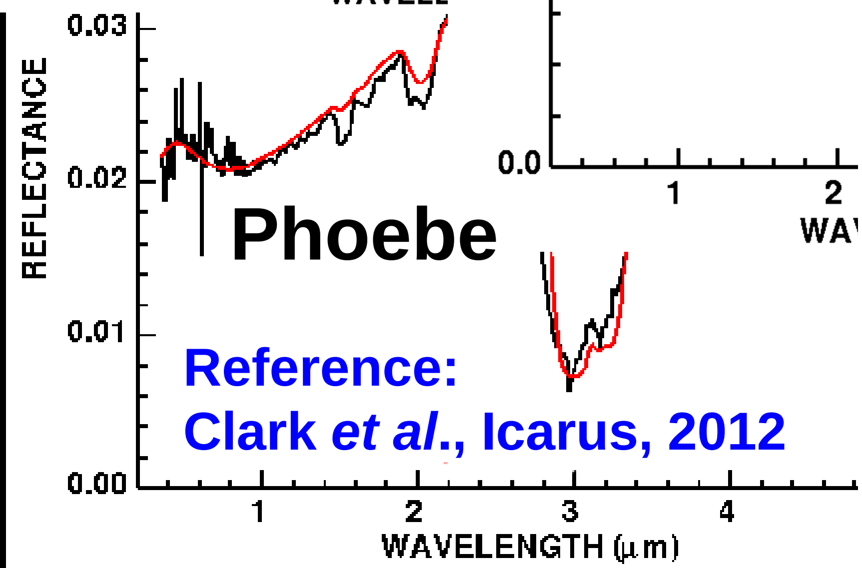
There are now two competing plume models: Tidal heating (Hurford et al., 2012) and shear heating Porco et al. 2011)

ISS Enceladus image of the surface and the plume

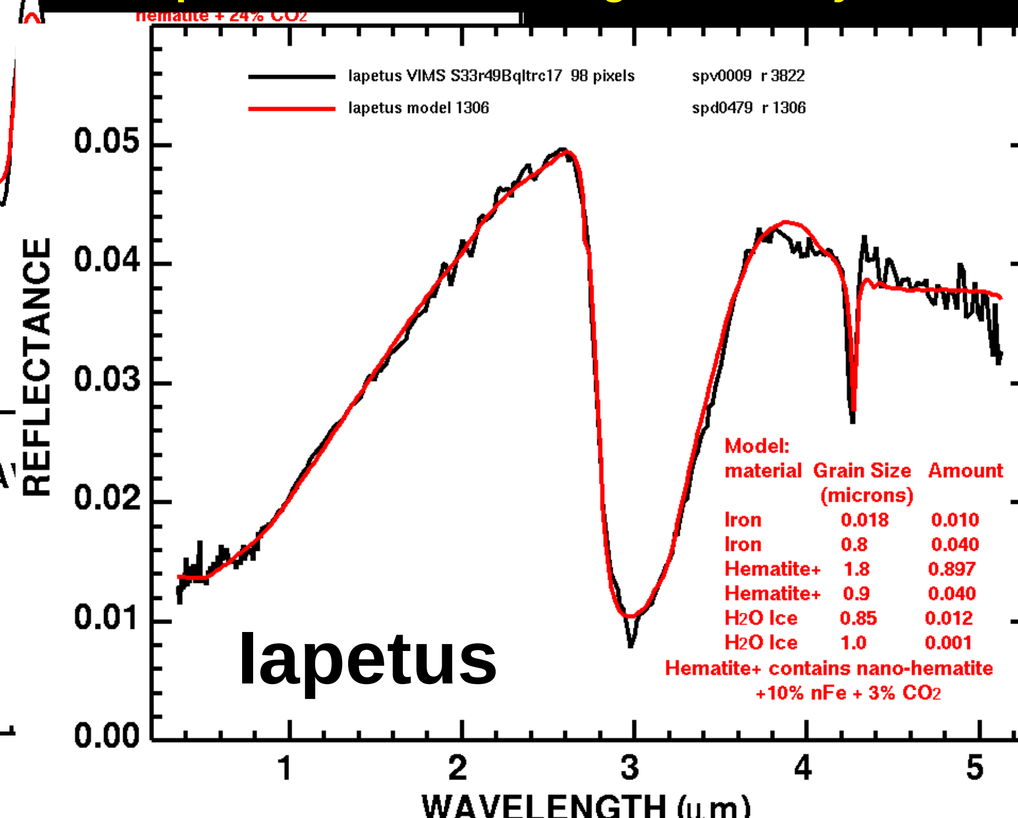
# Nano-Iron + Nano-Hematite and sub-micron Ice may be the best explanation for the icy spectral shapes in the Saturn system

**A simple explanation from Cassini is that fine-grained metallic iron dust contaminates the ice, from Phoebe to the rings. Some of the iron may be oxidized and hydrated giving the 3-micron water absorption in the dark material. The competition of sub-micron ice, iron and hematite creates the varying blue peaks and UV absorption observed throughout the system.**



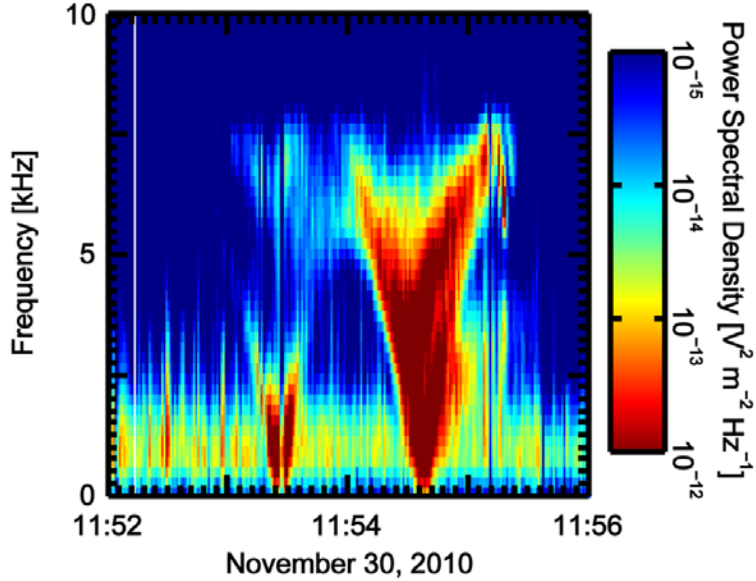



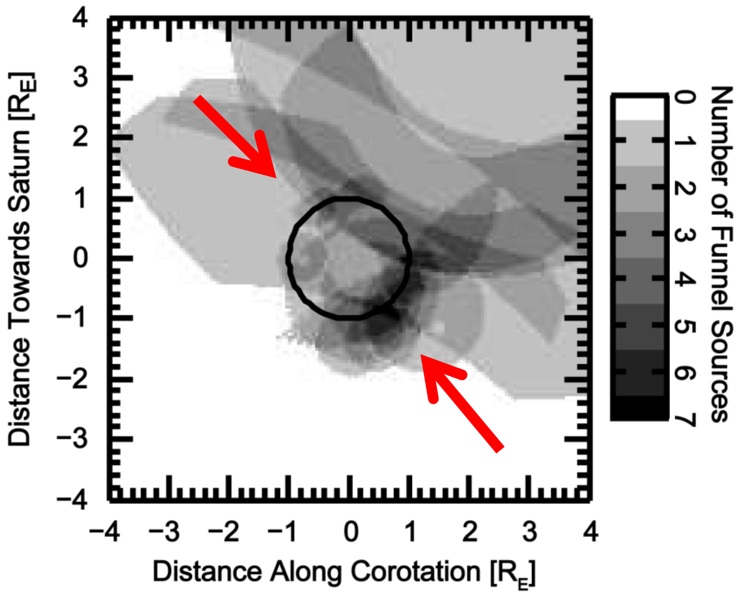

**Reference:**
**Clark *et al*., Icarus, 2012**



# Auroral Hiss and Electron Beams (Leisner et al., 2012)

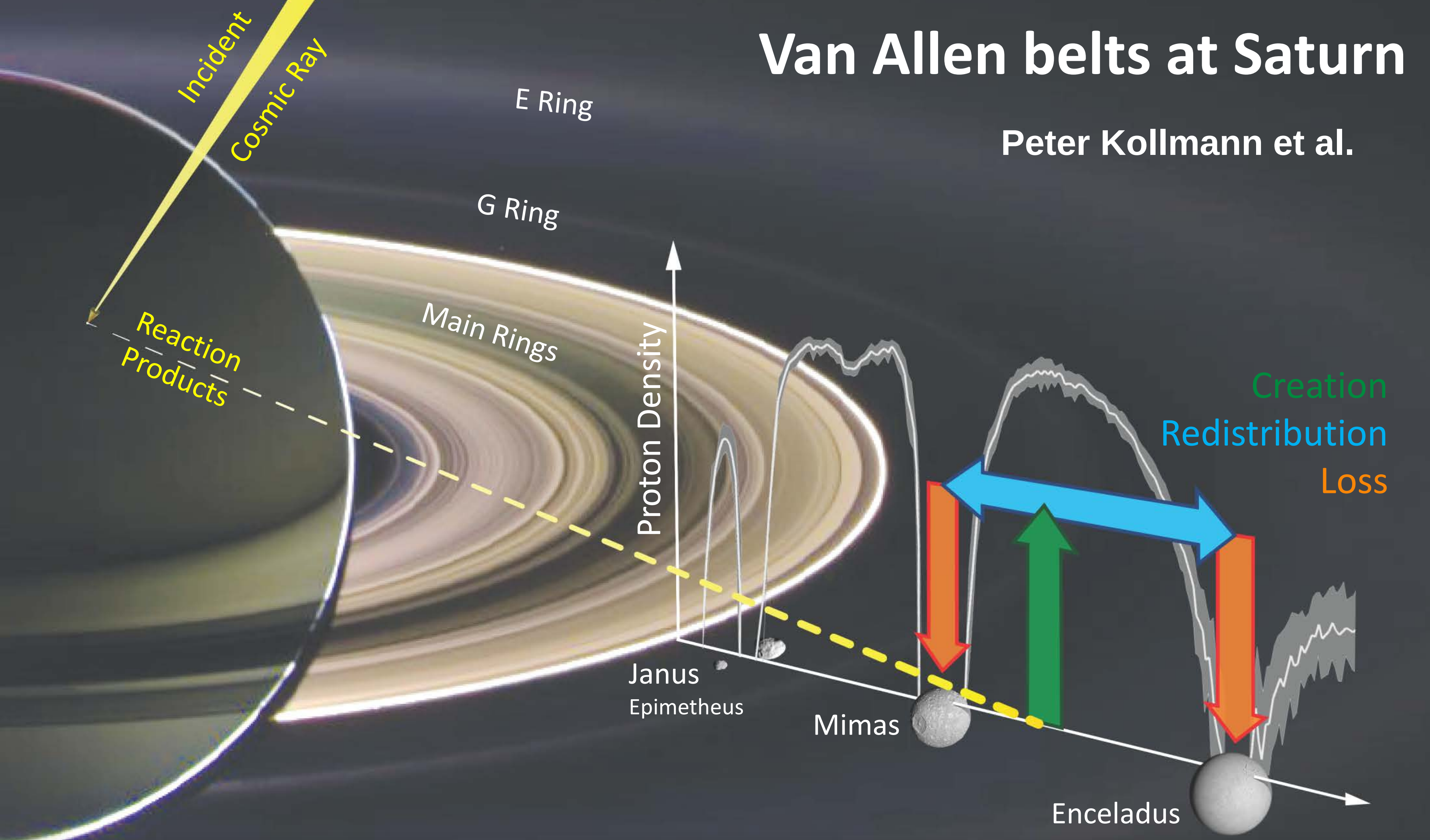
- Auroral hiss is a plasma wave generated by a low-energy electron beam moving along the magnetic field (spectrogram to the right)
- This emission has been observed on nearly all flybys over Enceladus' poles
- When we trace these waves backwards, we find that potential sources are clustered in two regions around the moon (red arrows)
- These imply that electron beam generation is a consistent feature of the Enceladus-plasma interaction that the Cassini plasma wave instrument is capable of remotely monitoring during flybys



# Van Allen belts at Saturn

**Peter Kollmann et al.**




- Saturn and its icy moons are embedded in a region of **proton radiation**, similar to Earth's Van Allen belts.
- The protons are **produced from cosmic rays** hitting Saturn's atmosphere.
- These **moons sweep their orbits** free of protons and therefore affect the environment of Saturn.