HUYGENS MISSION OVERVIEW AND EARLY RESULTS HIGHLIGHTS

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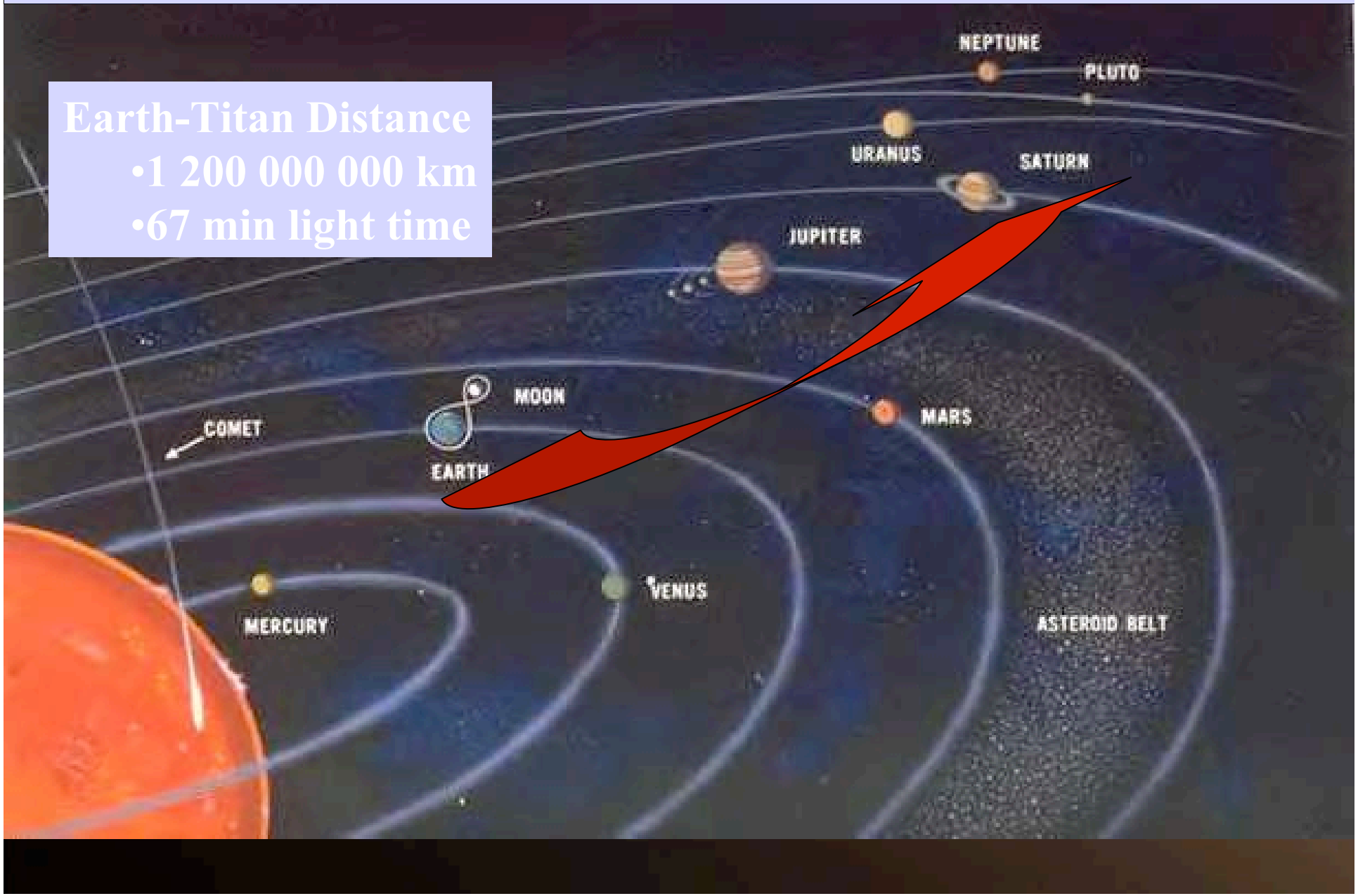
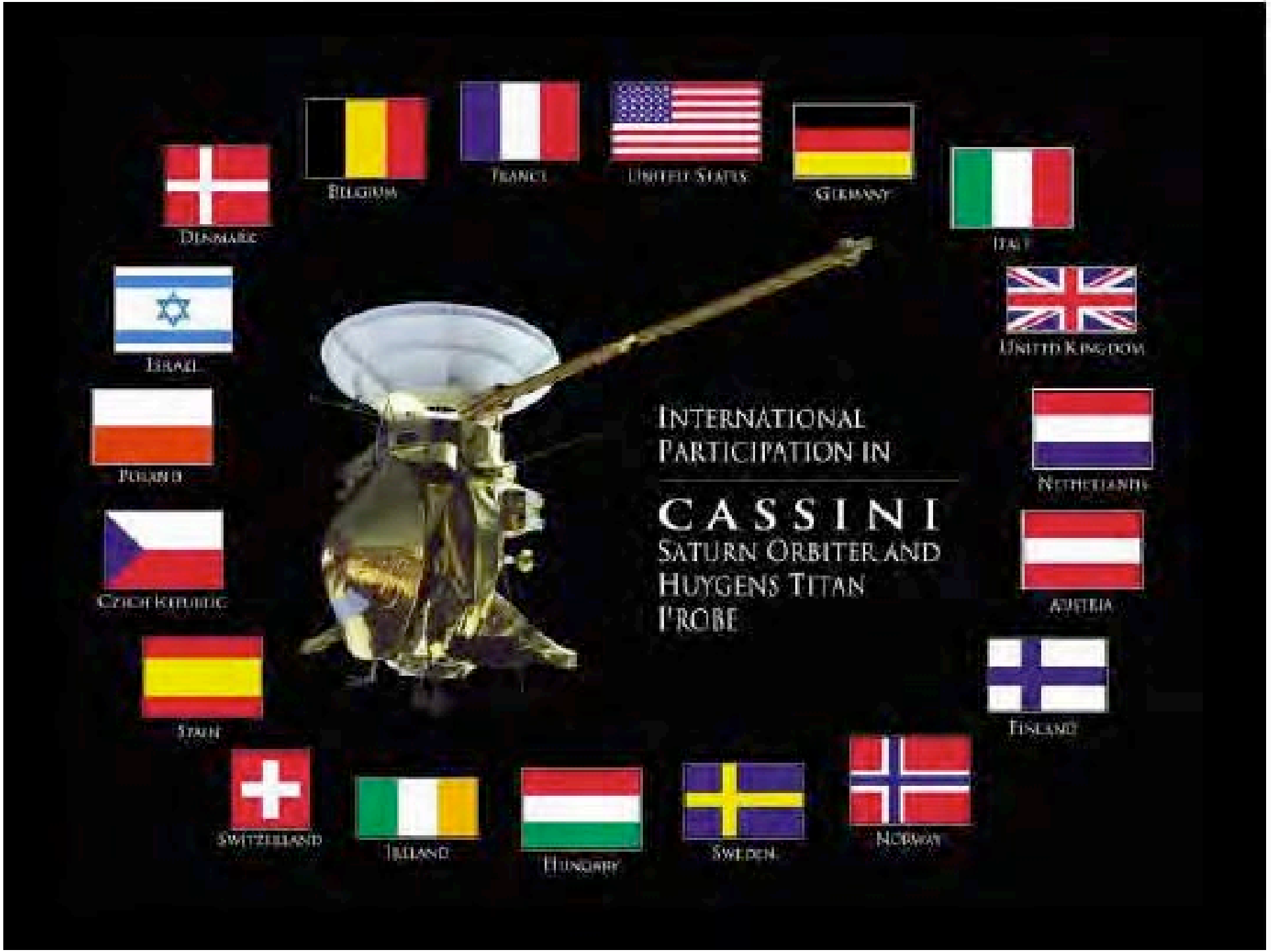
3rd International Planetary Probe Workshop
Eden Beach Hotel-Club. Anavyssos, Attiki, Greece
June 27-July 1, 2005

Cassini-Huygens: 7 years of preparation, 7 years of planning, 7-year trip to Saturn, 7-hour visit to Titan




DENMARK
BELGIUM
FRANCE
UNITED STATES
GERMANY
ITALY
ISRAEL
UNITED KINGDOM
POLAND
NETHERLANDS
CZECH REPUBLIC
AUSTRIA
SPAIN
FINLAND
SWITZERLAND
IRELAND
HUNGARY
SWEDEN
NORWAY
INTERNATIONAL
PARTICIPATION IN
CASSINI
SATURN ORBITER AND
HUYGENS TITAN
PROBE

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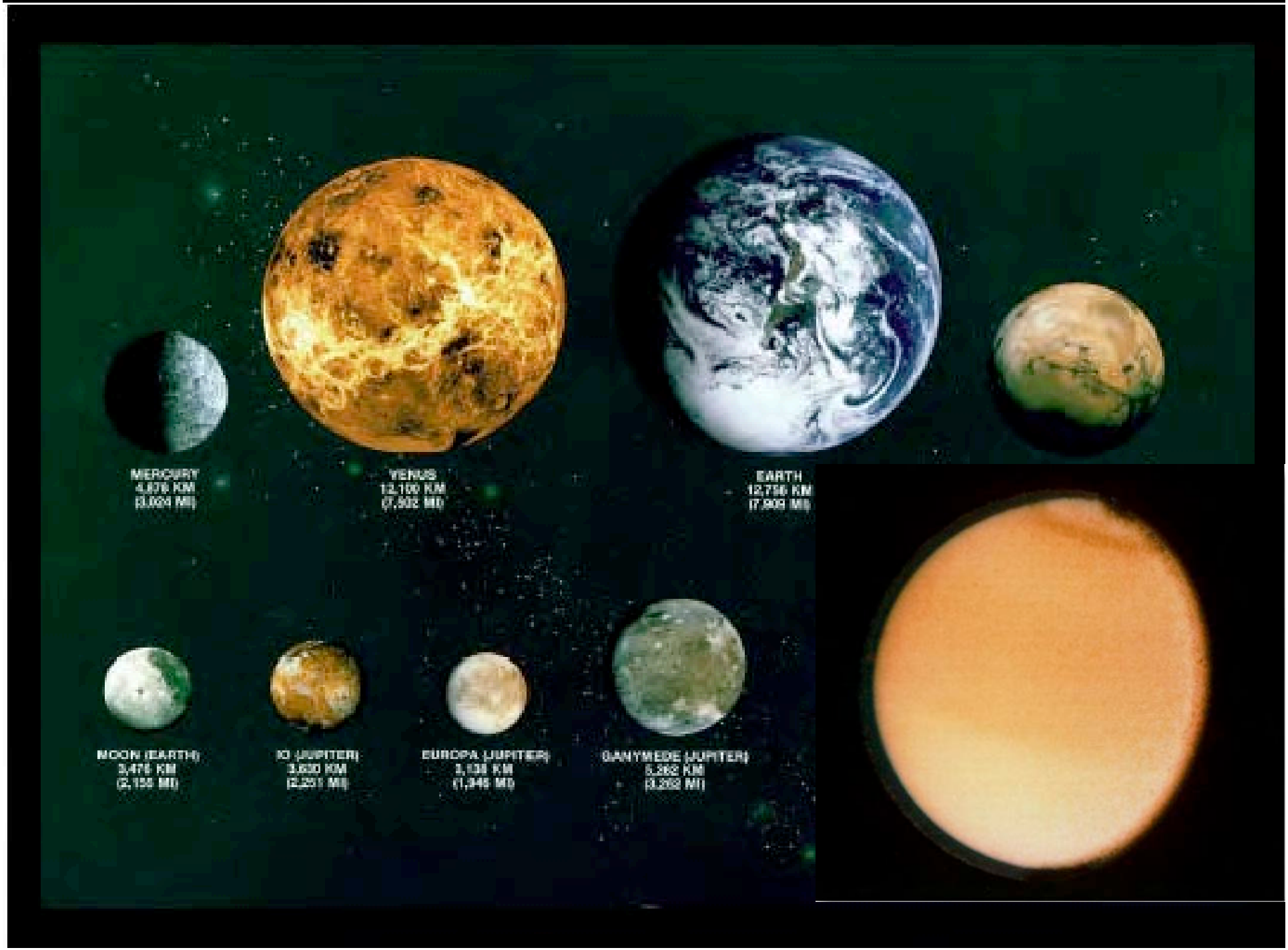
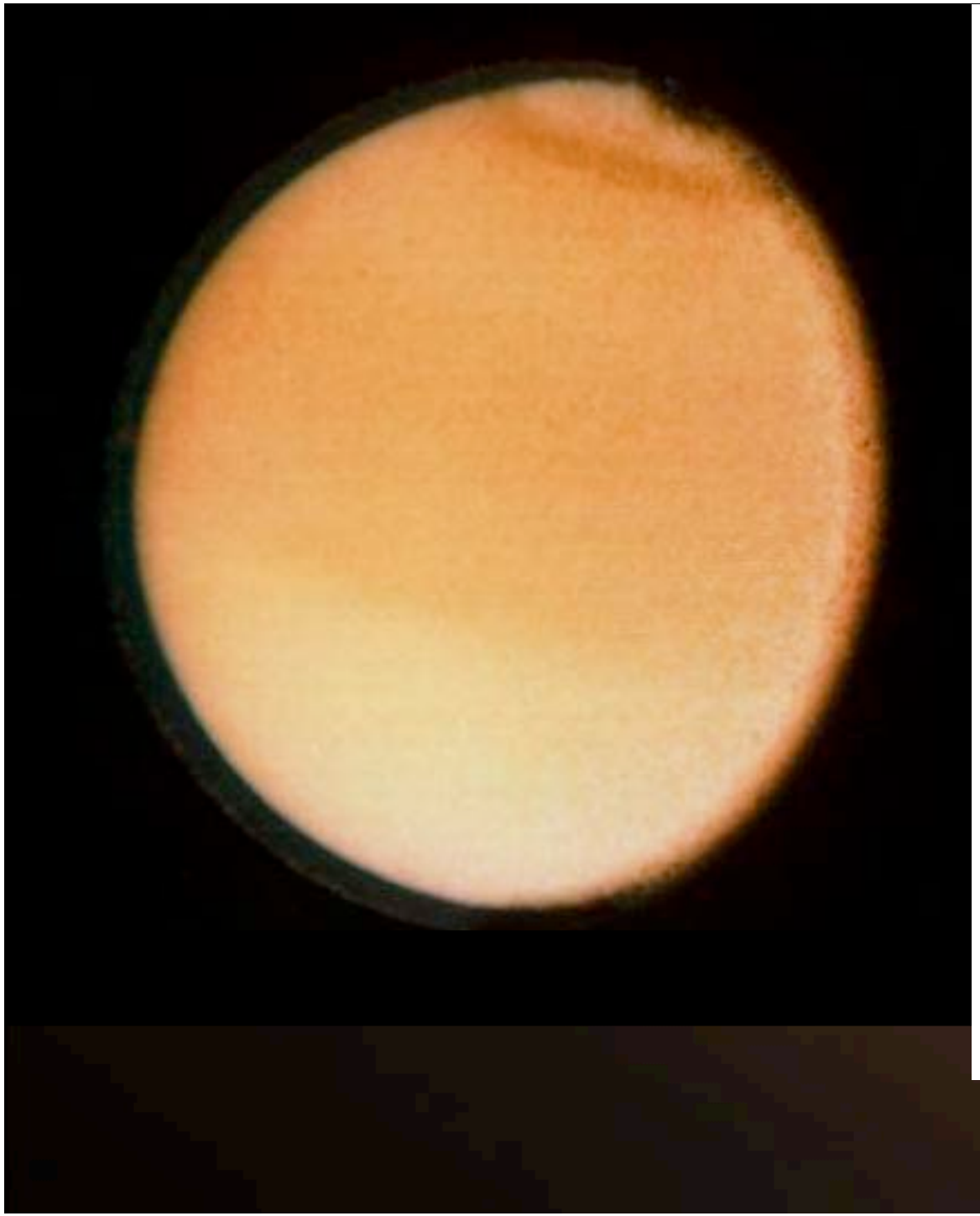
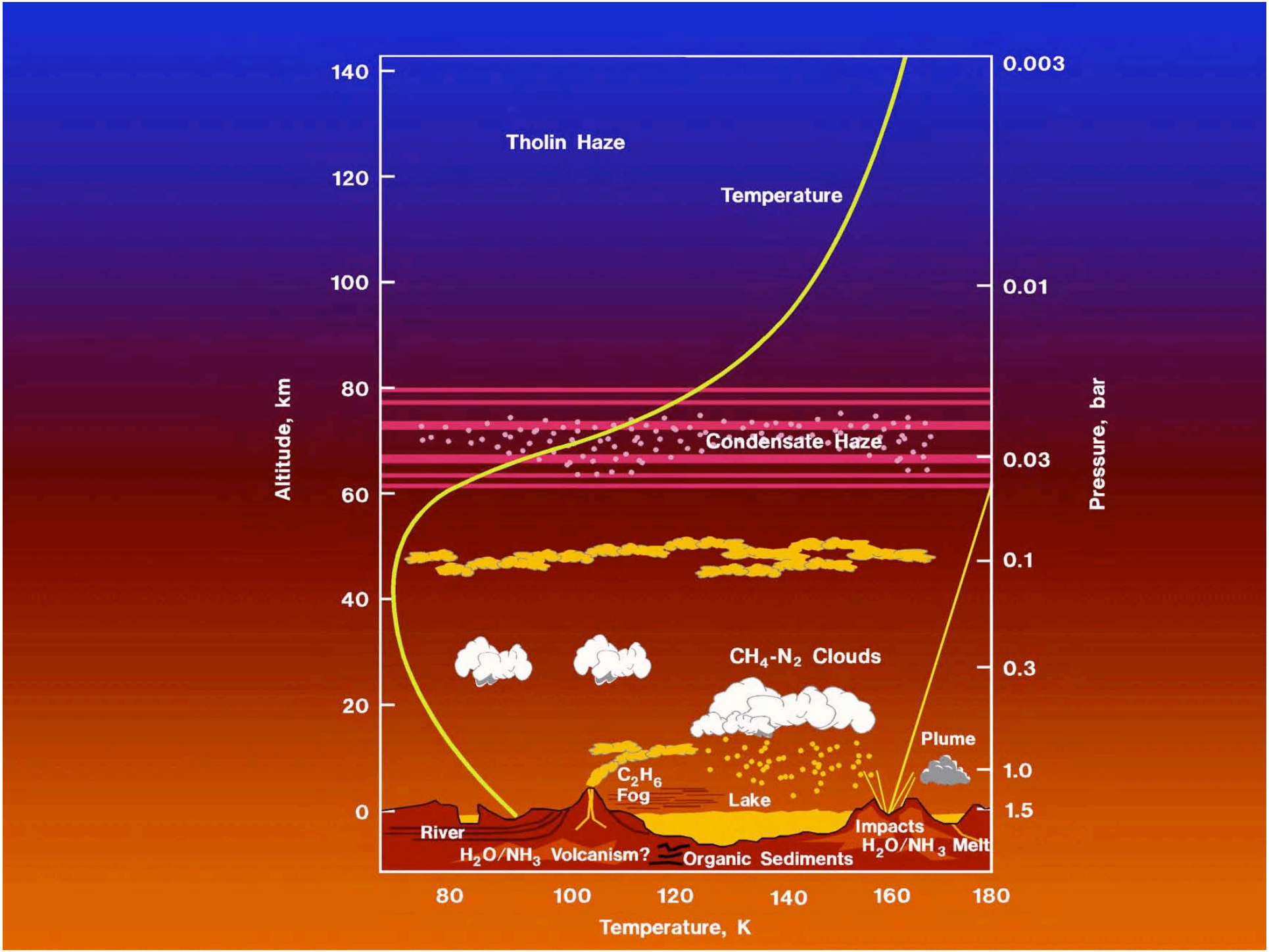
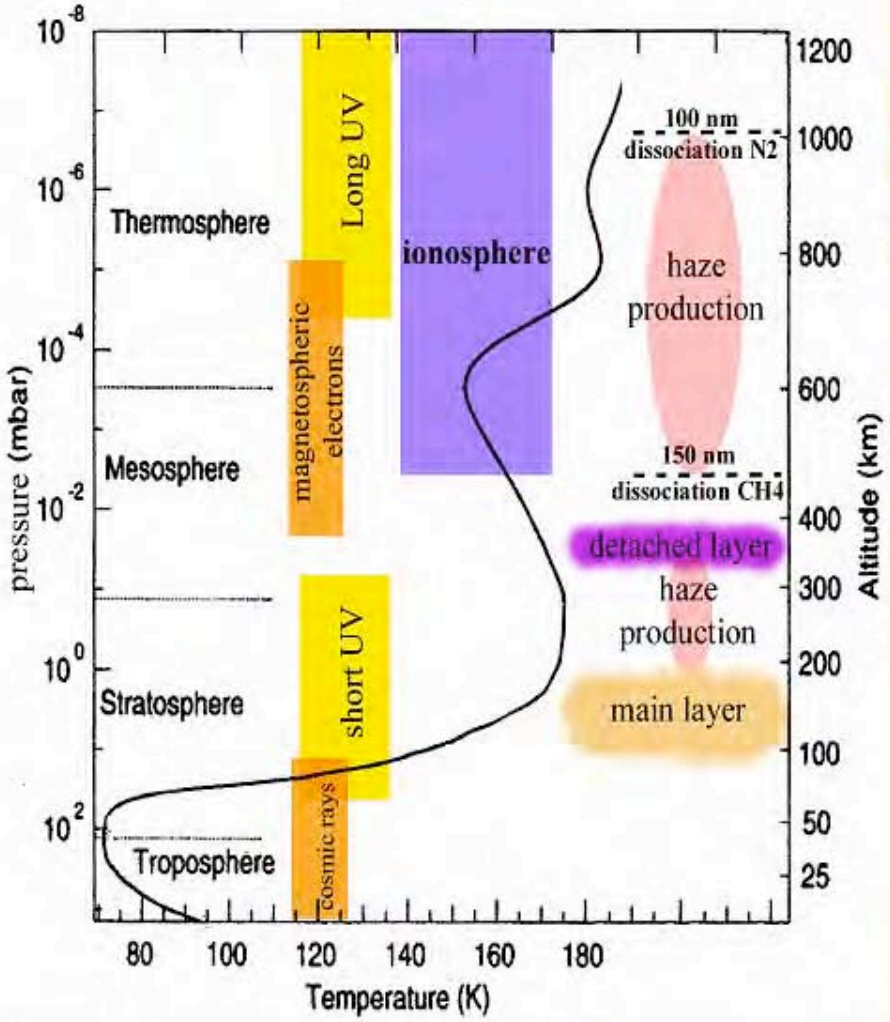

MERCURY
4,878 KM
(3,024 MI)
VENUS
12,100 KM
(7,502 MI)
EARTH
12,756 KM
(7,909 MI)
MOON (EARTH)
3,476 KM
(2,155 MI)
IO (JUPITER)
3,630 KM
(2,251 MI)
EUROPA (JUPITER)
3,138 KM
(1,946 MI)
GANYMEDE (JUPITER)
5,262 KM
(3,263 MI)



- Titan, largest moon of Saturn as photographed by NASA's Voyager (1980)
- N2-Atmosphere, rich in CH4
- Home of complex organic chemistry
- Surface:
  - Pressure: 1.5 bar
  - Temperature: -179 C


Tholin Haze
Temperature
Condensate Haze
CH_4-N_2 Clouds
C_2H_6
Fog
Lake
Plume
River
H_2O/NH_3 Volcanism?
Organic Sediments
Impacts
H_2O/NH_3 Melt
Altitude, km
Pressure, bar
Temperature, K
140
120
100
80
60
40
20
0
0.003
0.01
0.03
0.1
0.3
1.0
1.5
80
100
120
140
160
180

Titan Atmospheric chemistry



N_2

Electron impact dissociation

CH_4

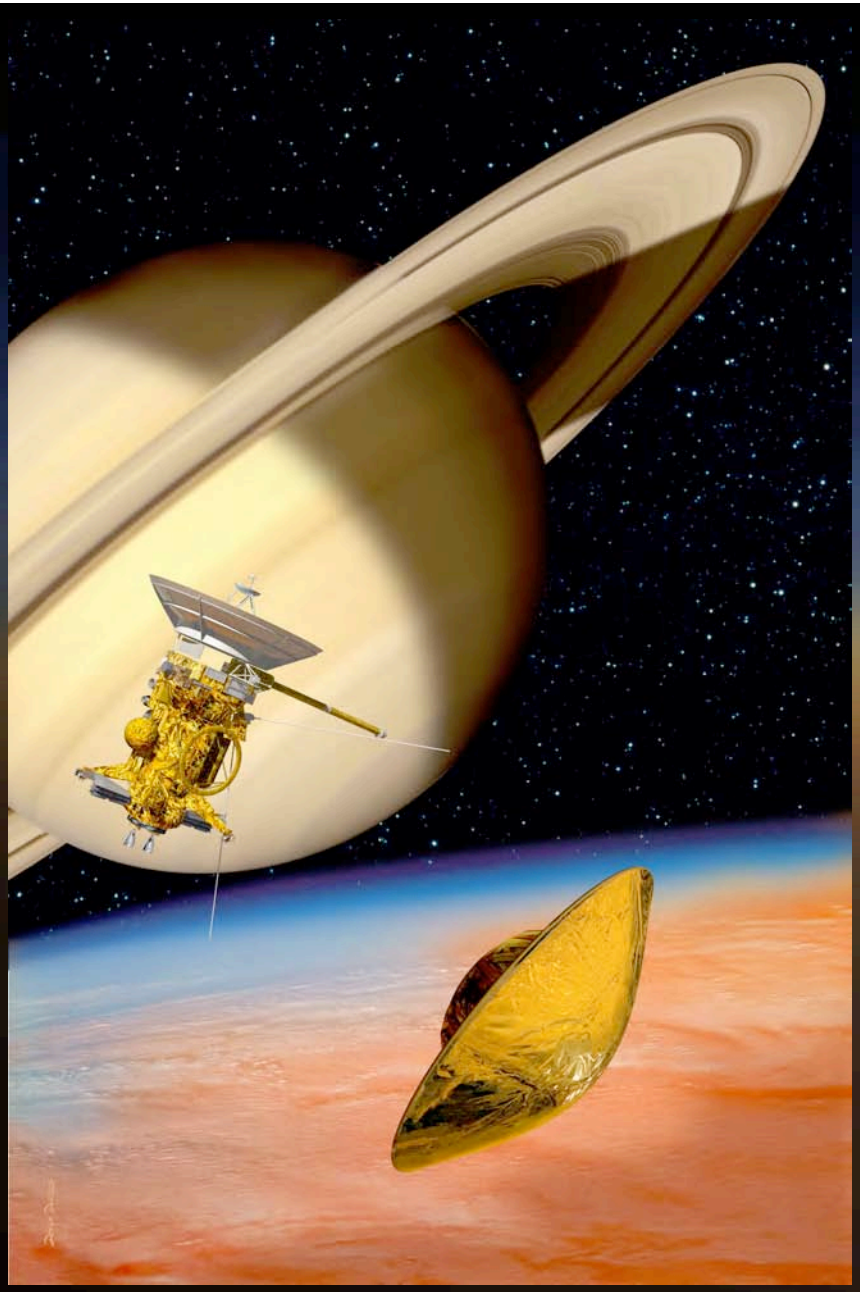
photolysis

C_2H_4 HCN C_2H_2 CH_3CN CH_3CCH HC_3N C_2H_6 C_4H_2 C_2N_2 C_3H_8

condensation

sedimentation

Courtesy: Marie-Claire Gazeau



Christiaan Huygens

Giovanni Domenico Cassini

Christiaan Huygens (1629-1695) scientifique hollandais a decouvert les anneaux de Saturne et, en 1655, sa plus grosse lune, Titan

Giovanni Domenico Cassini (1625-1712), astronome franco-italien a decouvert plusieurs satellites de Saturne: Japet, Rhea, Tethys et Dione. En 1675, il a decouvert ce que l'on appelle de nos jours la "Division de Cassini" l'espace entre les deux anneaux principaux de Saturne.

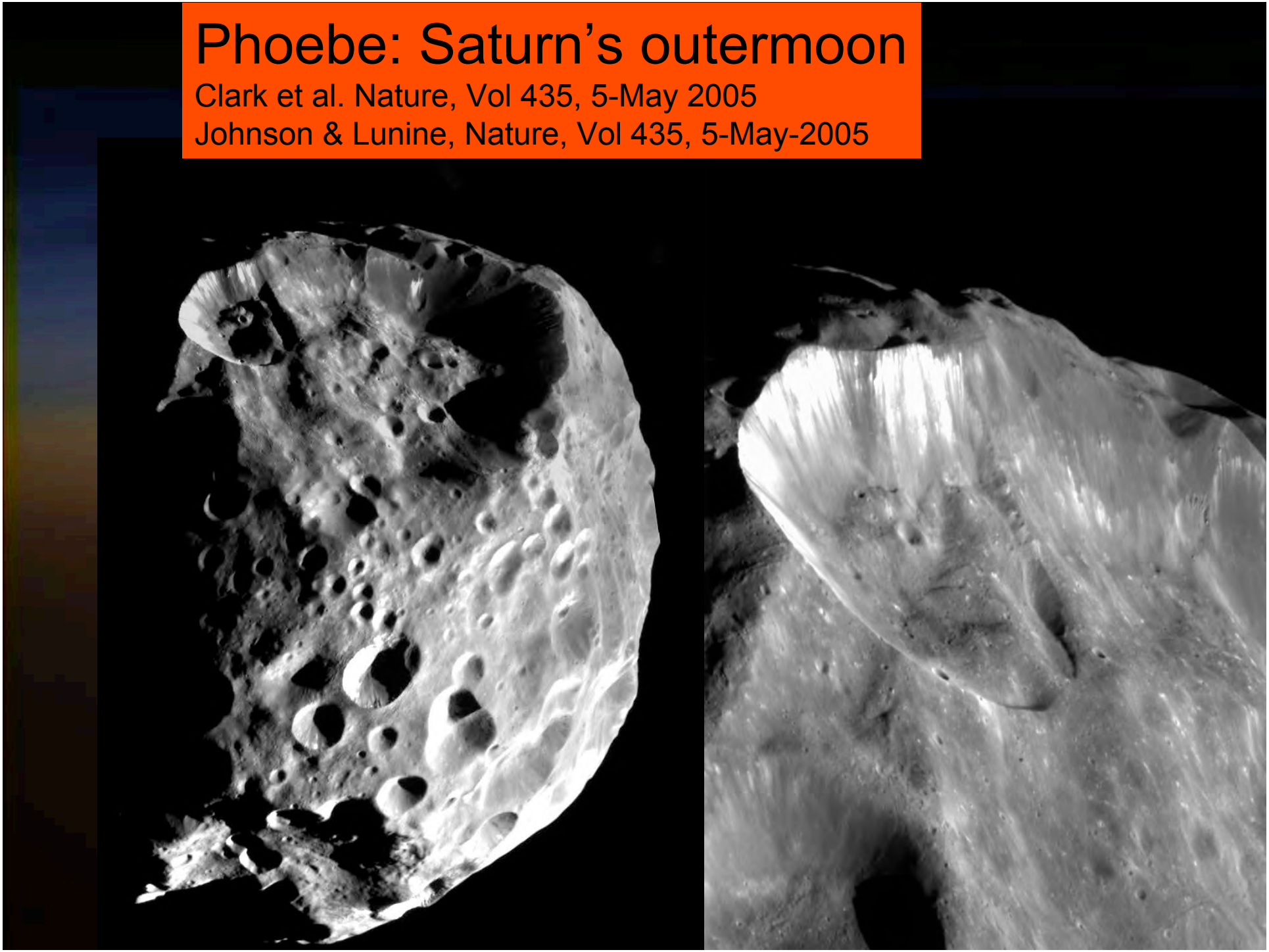
Cassini/Huygens Science

- Cassini/Huygens has already revised our view of the entire Saturn system
  - Saturn
  - Icy satellites
  - Rings
  - Magnetosphere
  - Titan

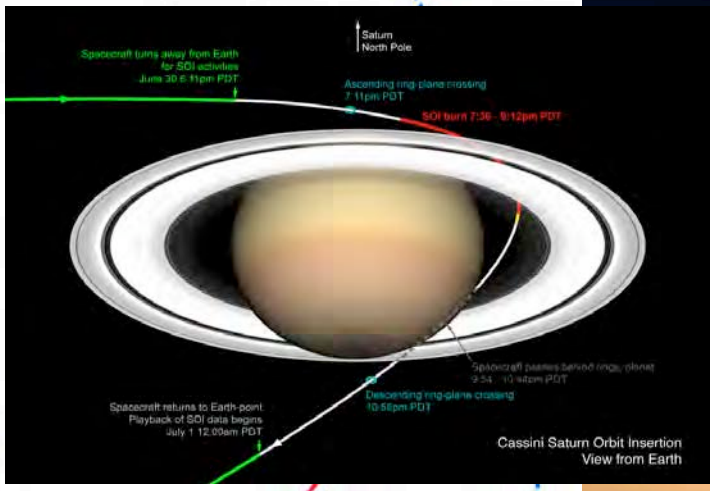
Phoebe: Saturn's outermoon

Clark et al. Nature, Vol 435, 5-May 2005

Johnson & Lunine, Nature, Vol 435, 5-May-2005



CASSINI MISSION CRUISE TRAJECTORY
Earth (E), Saturn (S), and Cassini (C) Locations on 20 April 2004



Orbit of
Jupiter

VENUS FLYBY
26 APR 1998

VENUS FLYBY
24 JUN 1999

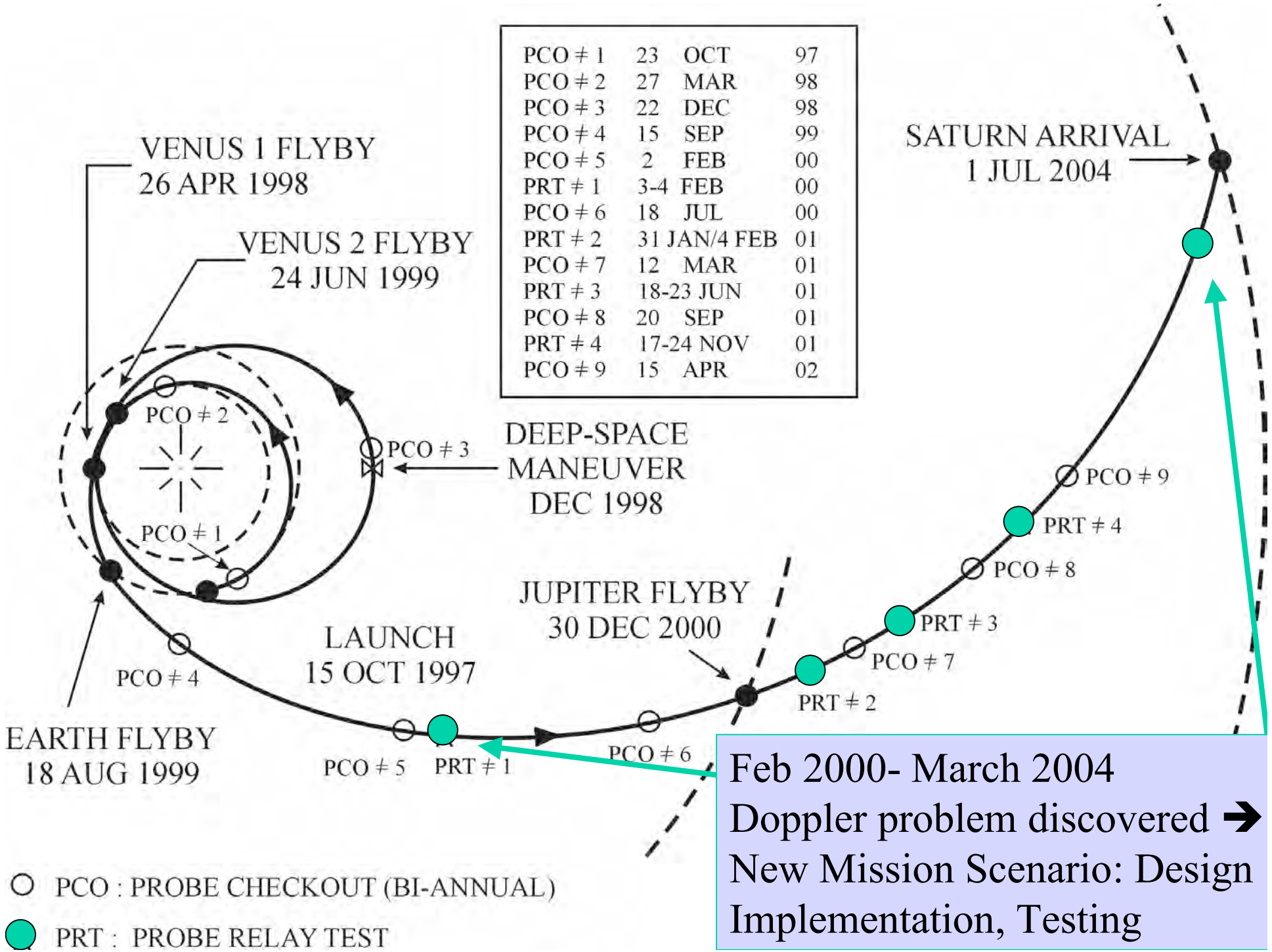
E

DEEP SPACE
MANEUVER
3 DEC 1998

JUPITER FLYBY
30 DEC 2000

LAUNCH
15 OCT 1997

EARTH FLYBY
18 AUG 1999

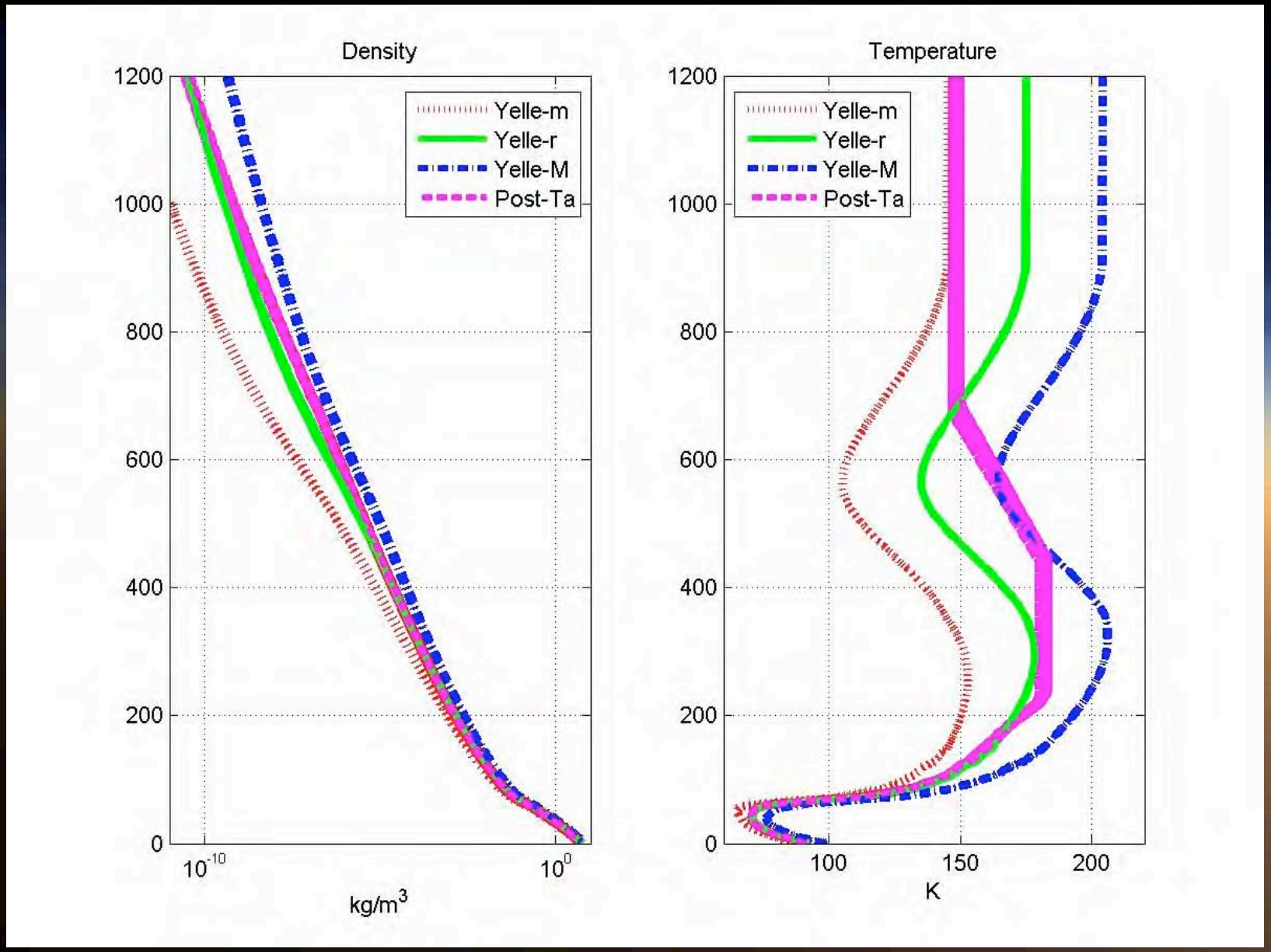


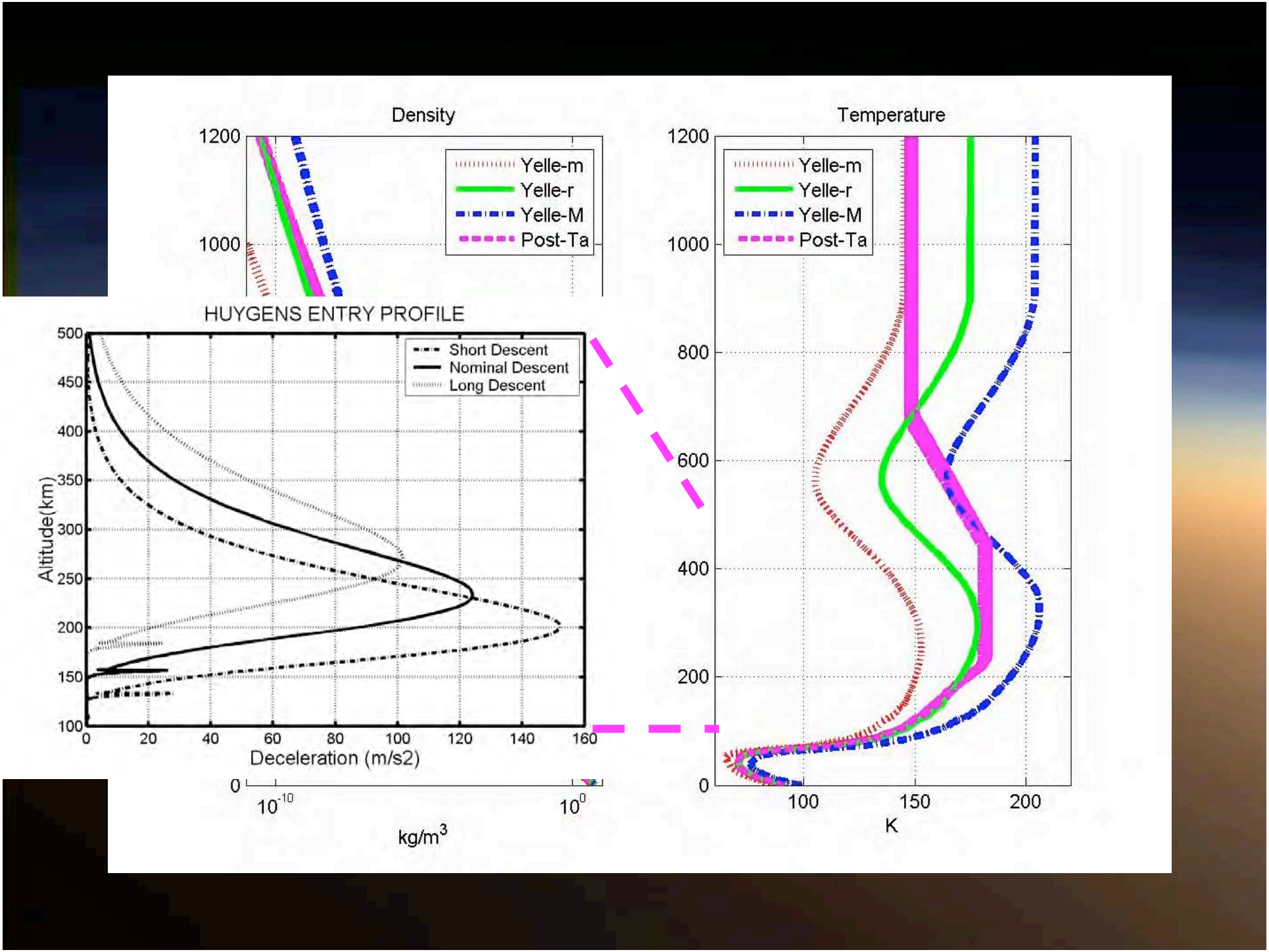
PCO ≠ 1	23	OCT	97
PCO ≠ 2	27	MAR	98
PCO ≠ 3	22	DEC	98
PCO ≠ 4	15	SEP	99
PCO ≠ 5	2	FEB	00
PRT ≠ 1	3-4	FEB	00
PCO ≠ 6	18	JUL	00
PRT ≠ 2	31 JAN/4	FEB	01
PCO ≠ 7	12	MAR	01
PRT ≠ 3	18-23	JUN	01
PCO ≠ 8	20	SEP	01
PRT ≠ 4	17-24	NOV	01
PCO ≠ 9	15	APR	02

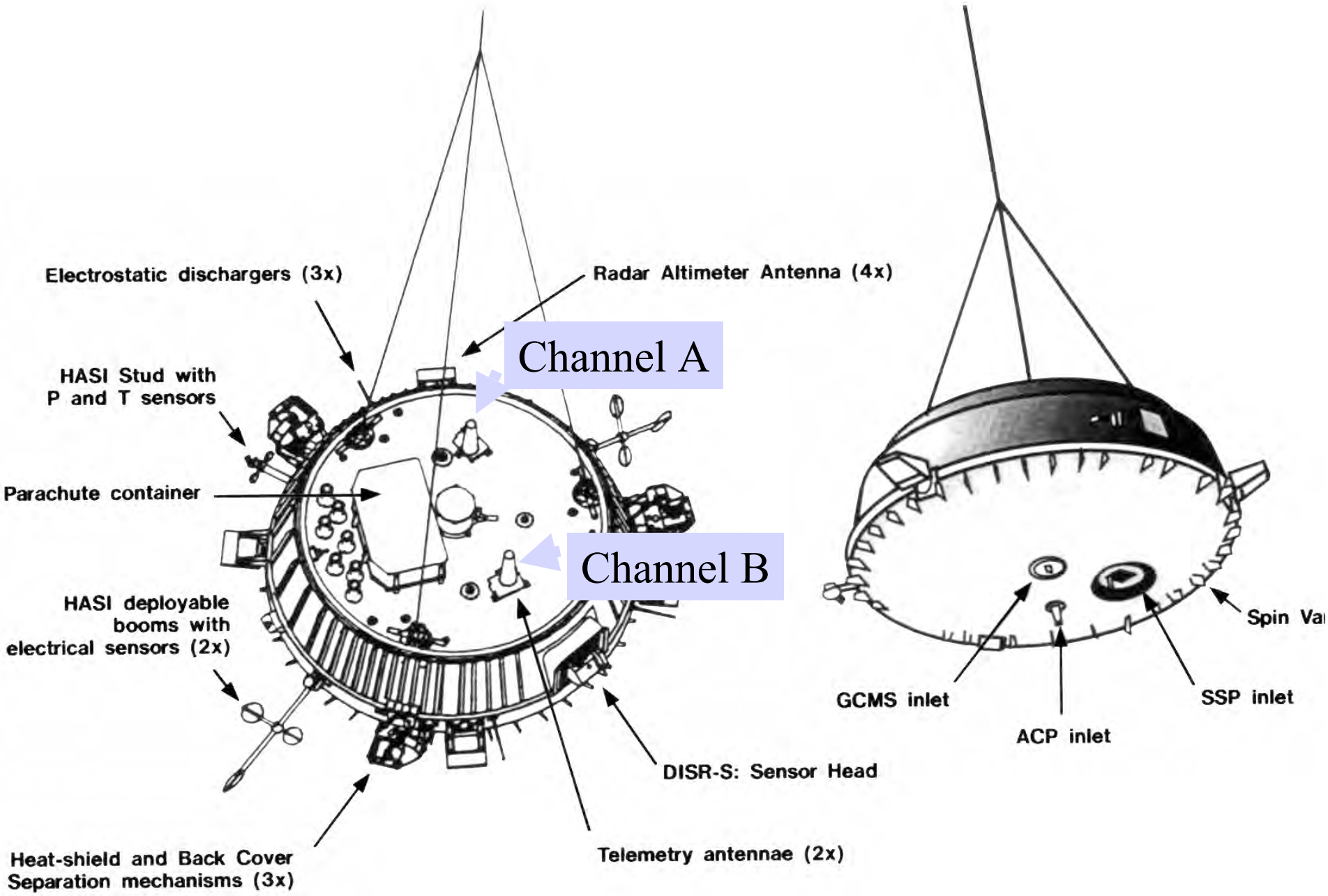
Feb 2000- March 2004
Doppler problem discovered ➔
New Mission Scenario: Design
Implementation, Testing

Year 2004: getting ready for release

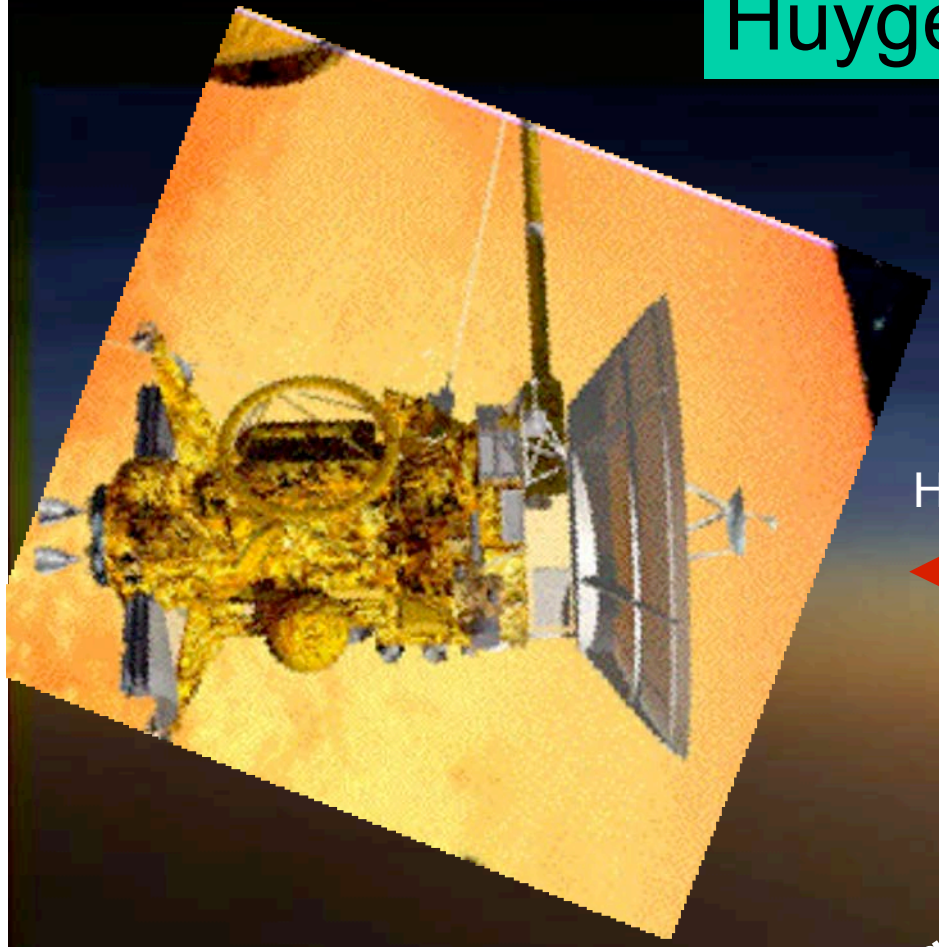
- Delta FAR (Flight Acceptance Review)
  - Nov 2003 - Feb 2004
  - Aeroheating predictions (QSS approach) challenged
- Aeroheating Convergence Working Group
  - March ’04- ??
- Back to basic: Boltzman approach for radiative heat flux re-assessment
- World-wide Collaboration: ESA, NASA, Alcatel, EADS, EM2C, Others,…
- Cassini Observations of Titan (2 July, 26 Oct; 13 Dec); Titan Atmosphere Model Working Group (Yelle et al.)
- ESA/NASA Mission Risk Review (Oct-Dec ’04)
- Green Light to release on 16 Dec ‘04


Density
Temperature
Yelle-m
Yelle-r
Yelle-M
Post-Ta
1200
1000
800
600
400
200
0
10^{-10}
10^{0}
kg/m^3
100
150
200
K


Density
1200
1000
Yelle-m
Yelle-r
Yelle-M
Post-Ta
HUYGENS ENTRY PROFILE
Short Descent
Nominal Descent
Long Descent
Altitude(km)
500
450
400
350
300
250
200
150
100
0
20
40
60
80
100
120
140
160
Deceleration (m/s2)
0
10^{-10}
10^{0}
kg/m^3
Temperature
1200
1000
800
600
400
200
0
Yelle-m
Yelle-r
Yelle-M
Post-Ta
100
150
200
K


Electrostatic dischargers (3x)
Radar Altimeter Antenna (4x)
Channel A
HASI Stud with
P and T sensors
Parachute container
Channel B
HASI deployable
booms with
electrical sensors (2x)
DISR-S: Sensor Head
Heat-shield and Back Cover
Separation mechanisms (3x)
Telemetry antennae (2x)
GCMS inlet
ACP inlet
SSP inlet
Spin Va

Huygens radio signal paths



Channel B

Huygens Carrier +Data

Channel A

TXB

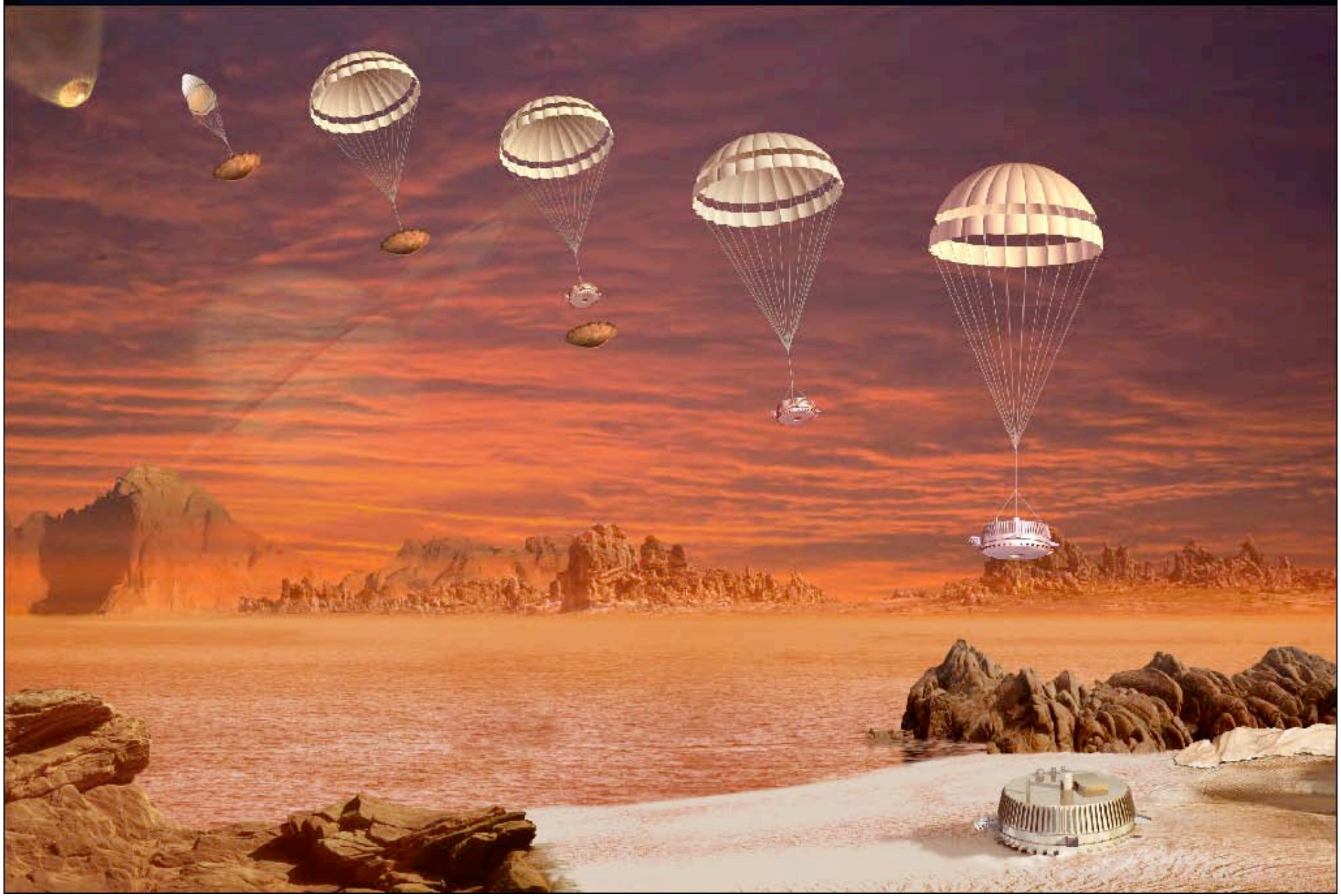
TXA

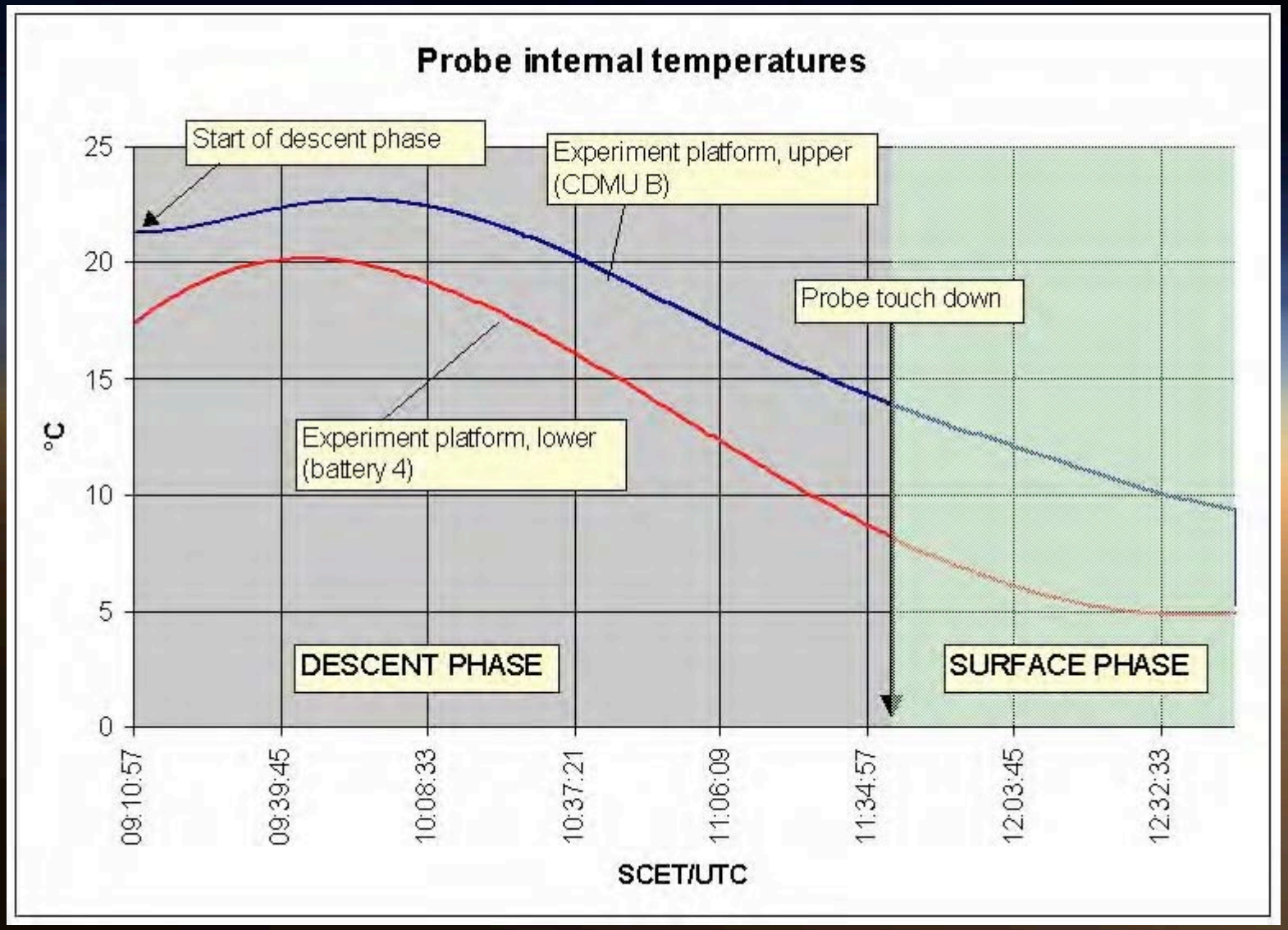
Huygens

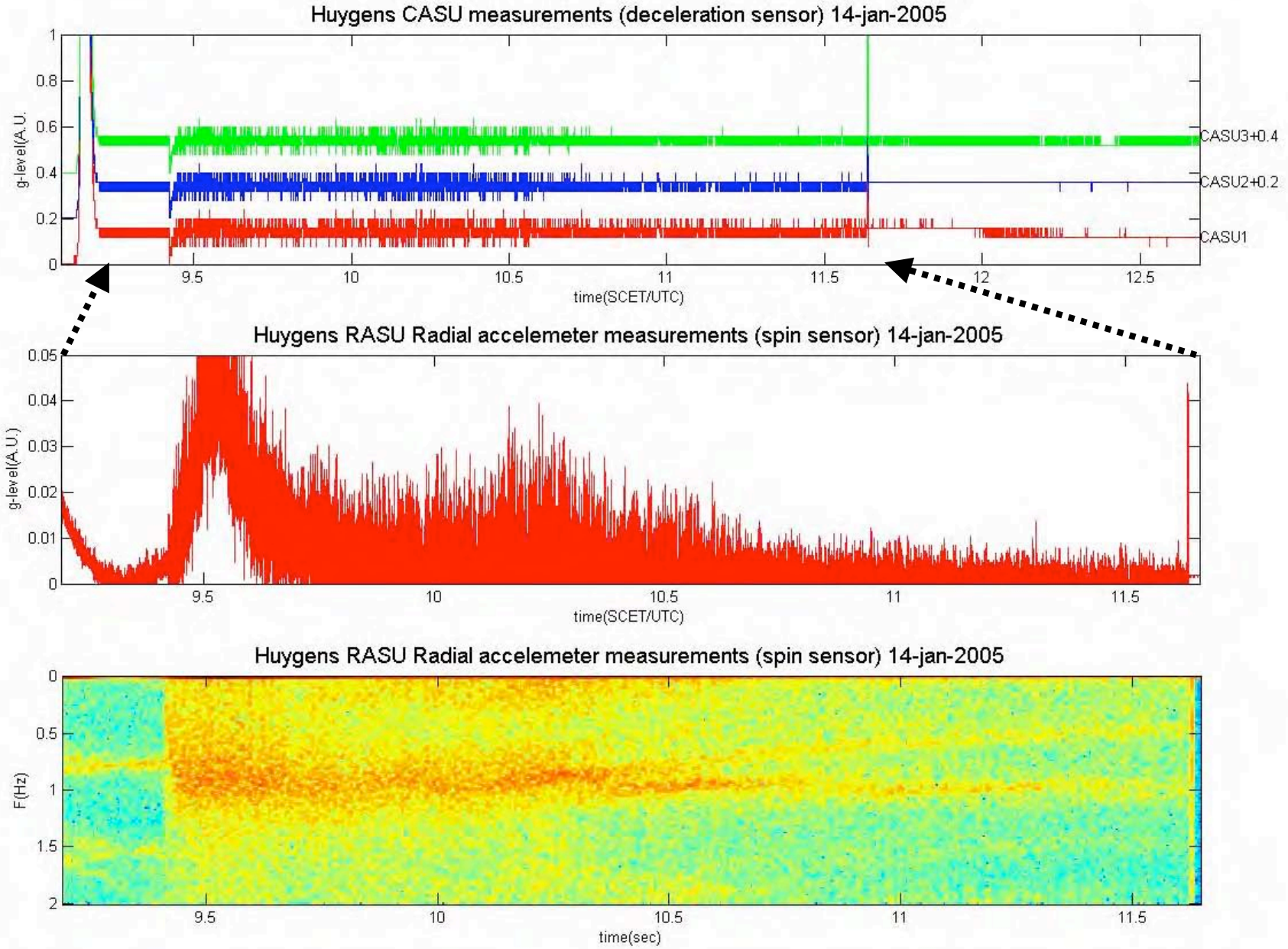
Huygens Carrier

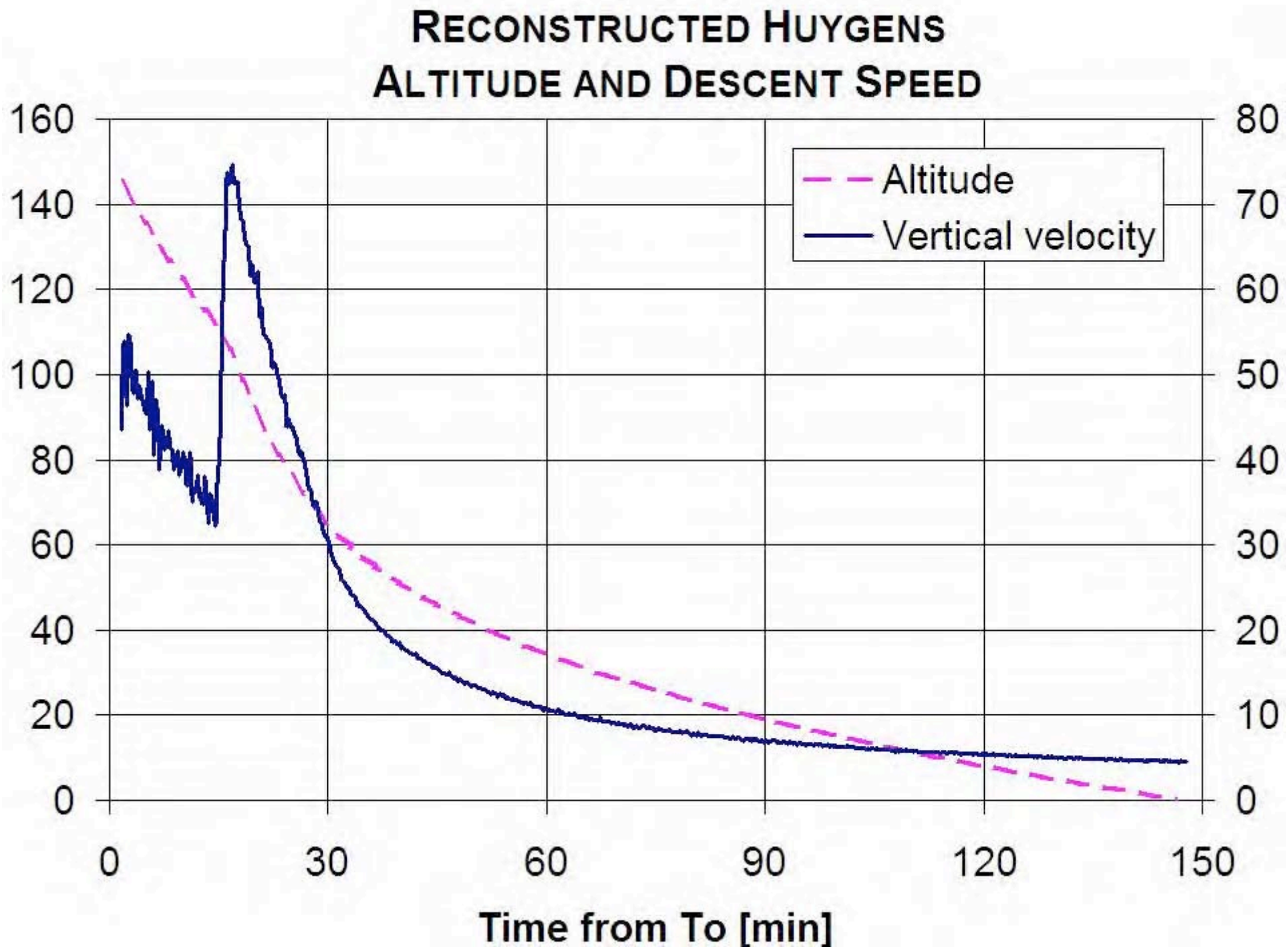
Channel C

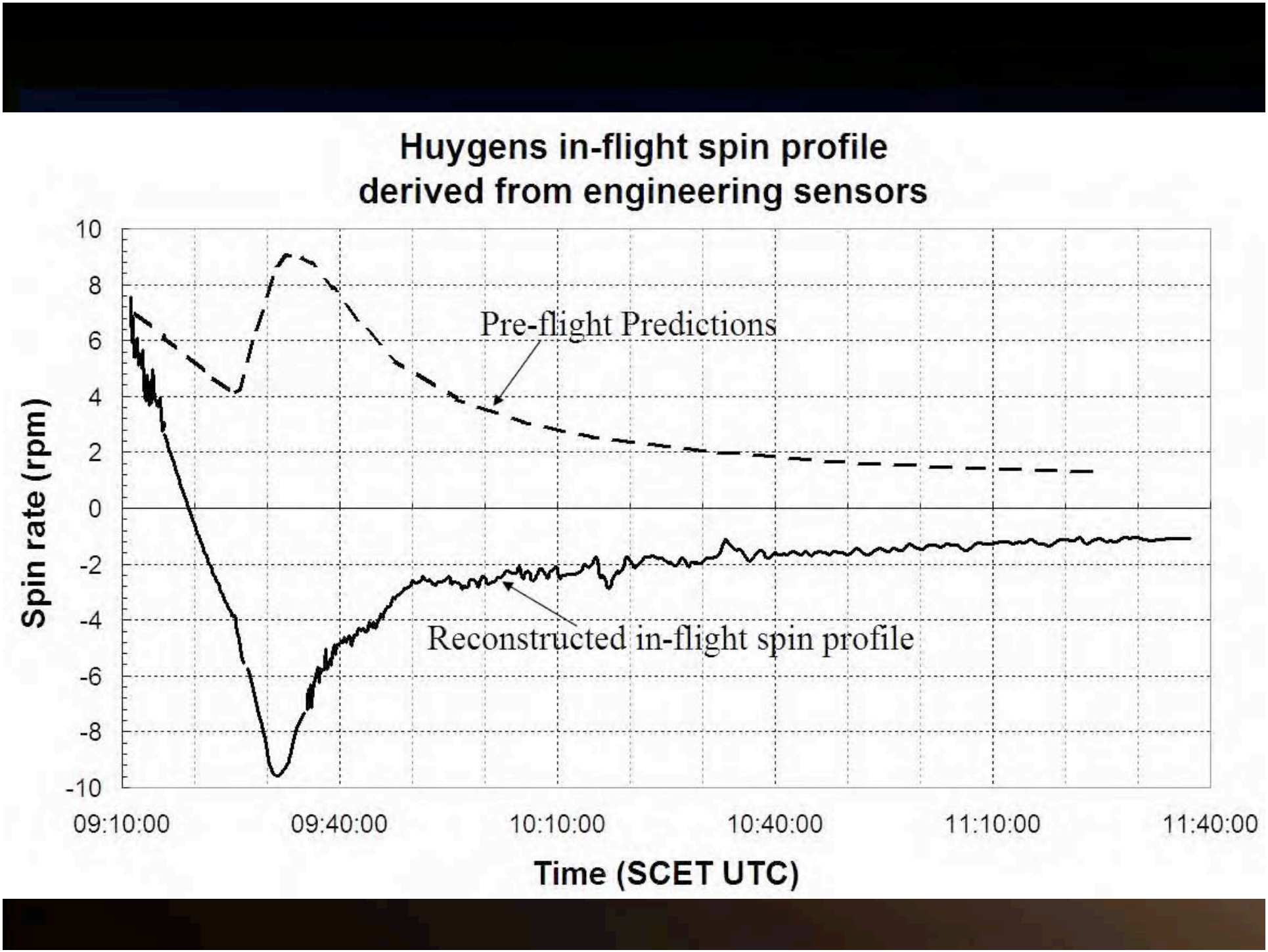
Huygens Entry, Descent and Landing




Probe internal temperatures
Start of descent phase
Experiment platform, upper (CDMU B)
Probe touch down
Experiment platform, lower (battery 4)
DESCENT PHASE
SURFACE PHASE
°C
25
20
15
10
5
0
09:10:57
09:39:45
10:08:33
10:37:21
11:06:09
11:34:57
12:03:45
12:32:33
SCET/UTC

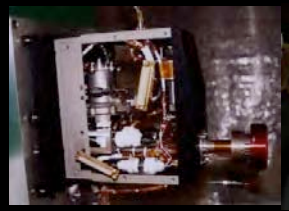

Huygens CASU measurements (deceleration sensor) 14-jan-2005
g-level(A.U.
time(SCET/UTC)
CASU3+0.4
CASU2+0.2
CASU1
Huygens RASU Radial accelemeter measurements (spin sensor) 14-jan-2005
g-level(A.U.)
time(SCET/UTC)
Huygens RASU Radial accelemeter measurements (spin sensor) 14-jan-2005
F(Hz)
time(sec)


RECONSTRUCTED HUYGENS
ALTITUDE AND DESCENT SPEED
160
140
120
100
80
60
40
20
0
80
70
60
50
40
30
20
10
0
0
30
60
90
120
150
Time from To [min]
Altitude
Vertical velocity


Huygens in-flight spin profile
derived from engineering sensors
Spin rate (rpm)
10
8
6
4
2
0
-2
-4
-6
-8
-10
Pre-flight Predictions
Reconstructed in-flight spin profile
09:10:00
09:40:00
10:10:00
10:40:00
11:10:00
11:40:00
Time (SCET UTC)

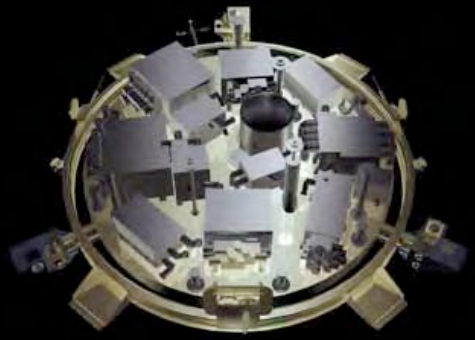
Huygens probe experiment(er)s

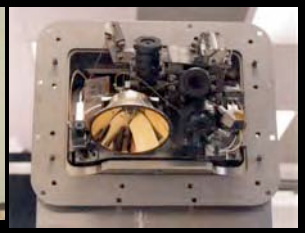
ACP



GCMS

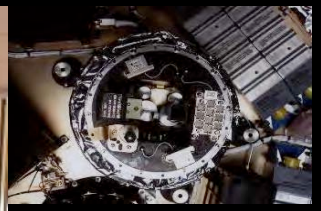
DWE



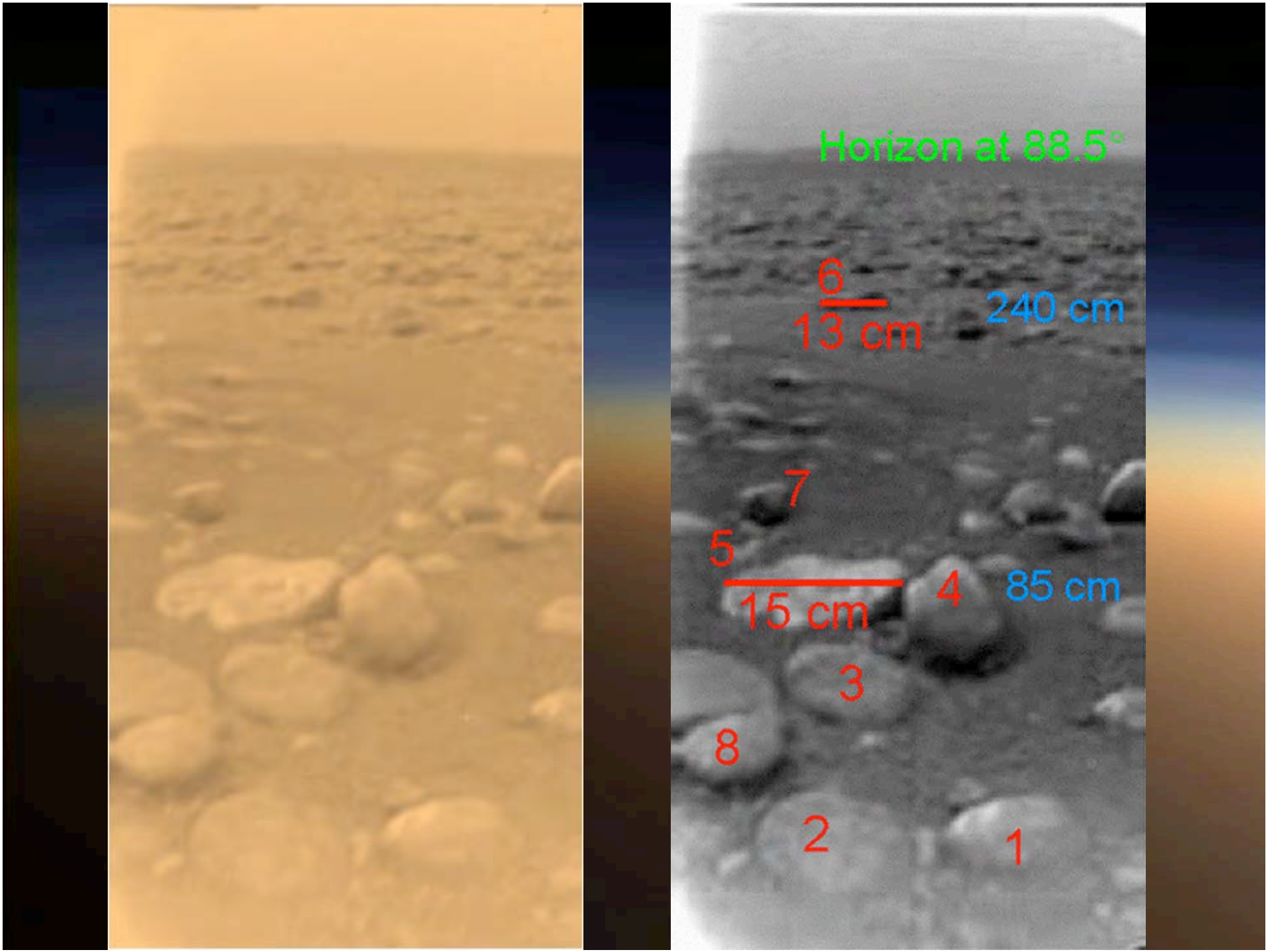


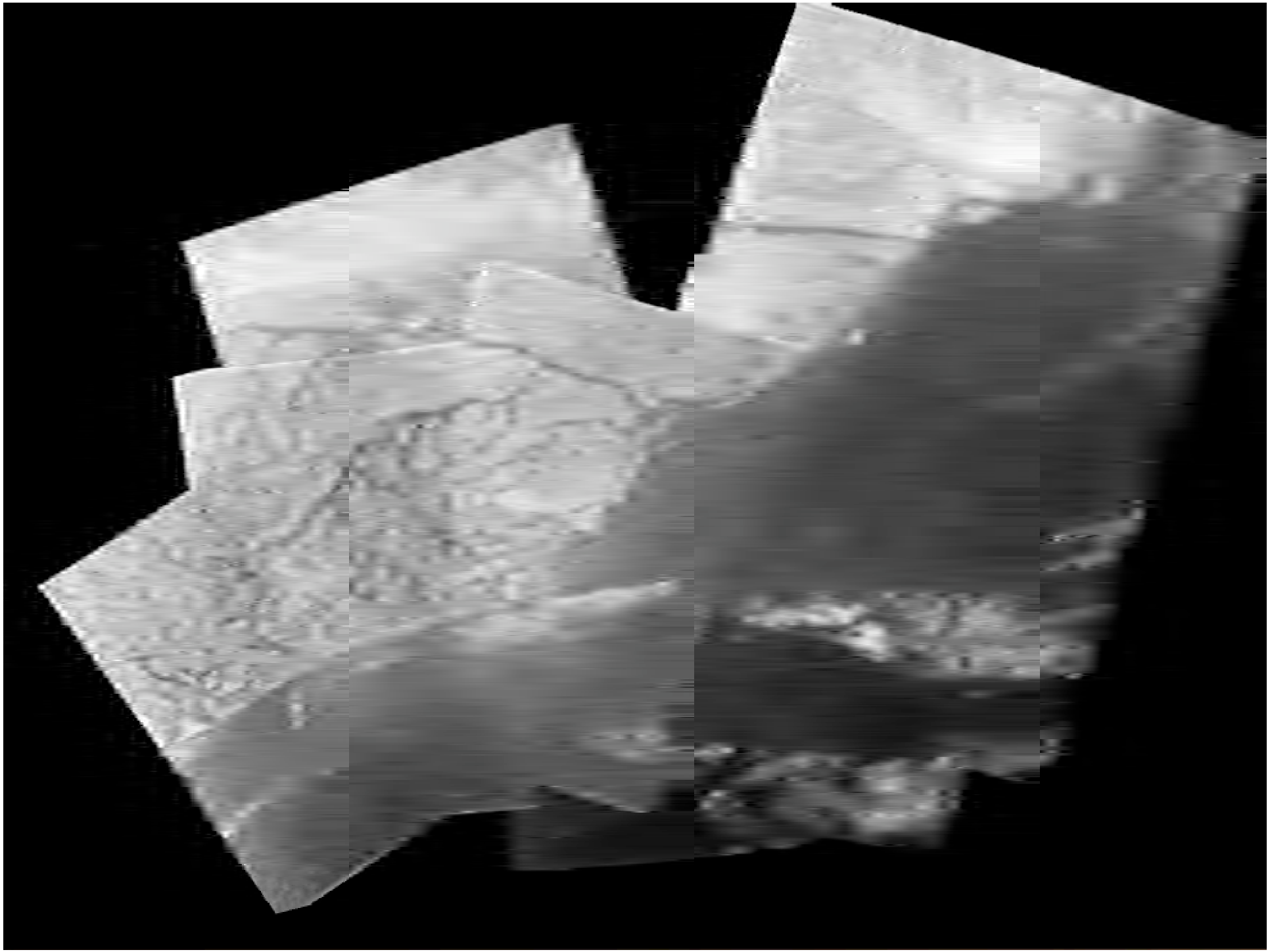
DISR

HASI

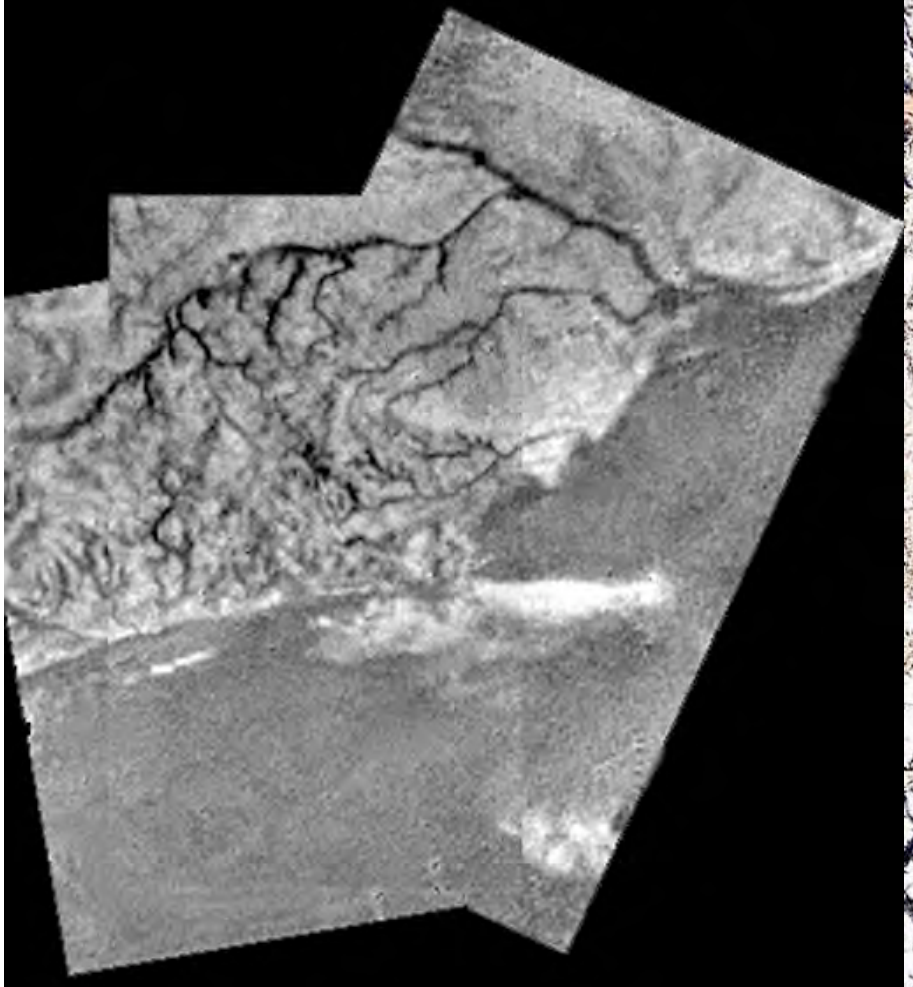


SSP


Horizon at 88.5°
6
13 cm
240 cm
7
5
15 cm
4
85 cm
3
8
2
1



Huygens/Titan

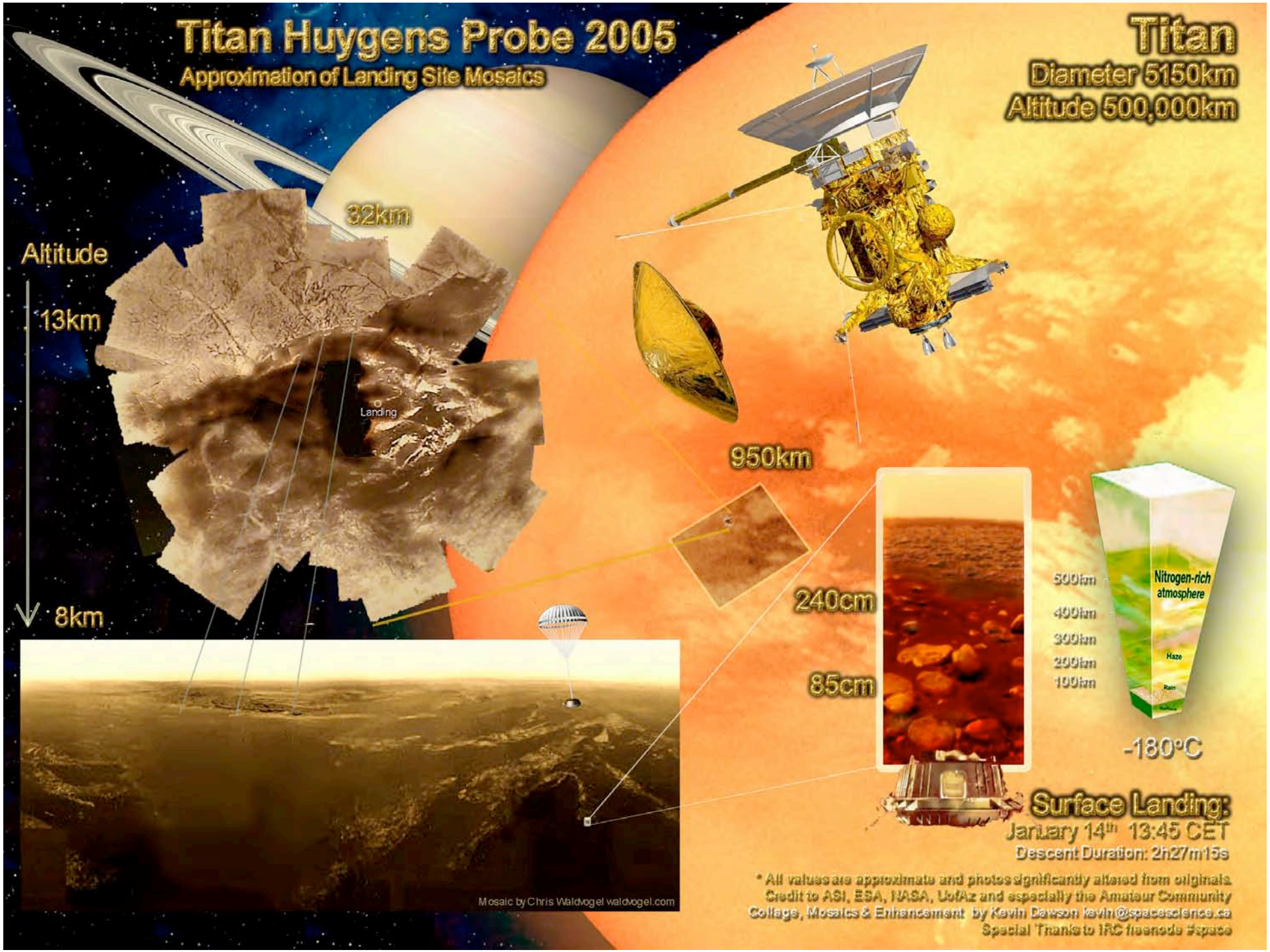


Envisat/Vancouver

CASSINI-HUYGENS

Concluding words

- Huygens tremendous success: most distant landing in the outer solar system; first landing on a moon other than Earth's
- Cassini-Huygens: Model for future international collaboration for space exploration ?
- Almost everything went right (97 things OK, 3 problems, but one corrected). Performance better than expected in several areas. Tremendous capability on surface not fully exploited
- Added-value of VLBI observation
- Lots of lessons to be learned


Titan Huygens Probe 2005
Approximation of Landing Site Mosaics
Titan
Diameter 5150km
Altitude 500,000km
32km
Altitude
13km
Landing
8km
950km
240cm
85cm
500km
400km
300km
200km
100km
Nitrogen-rich atmosphere
Haze
Rain
-180°C
Surface Landing:
January 14th 13:45 CET
Descent Duration: 2h27m15s
Mosaic by Chris Waldvogel waldvogel.com
* All values are approximate and photos significantly altered from originals.
Credit to ASI, ESA, NASA, UofAz and especially the Amateur Community
Collage, Mosaics & Enhancement by Kevin Dawson kevin@spacescience.ca
Special Thanks to IRC freenode #space