

# The Huygens Mission to Titan: Overview and status

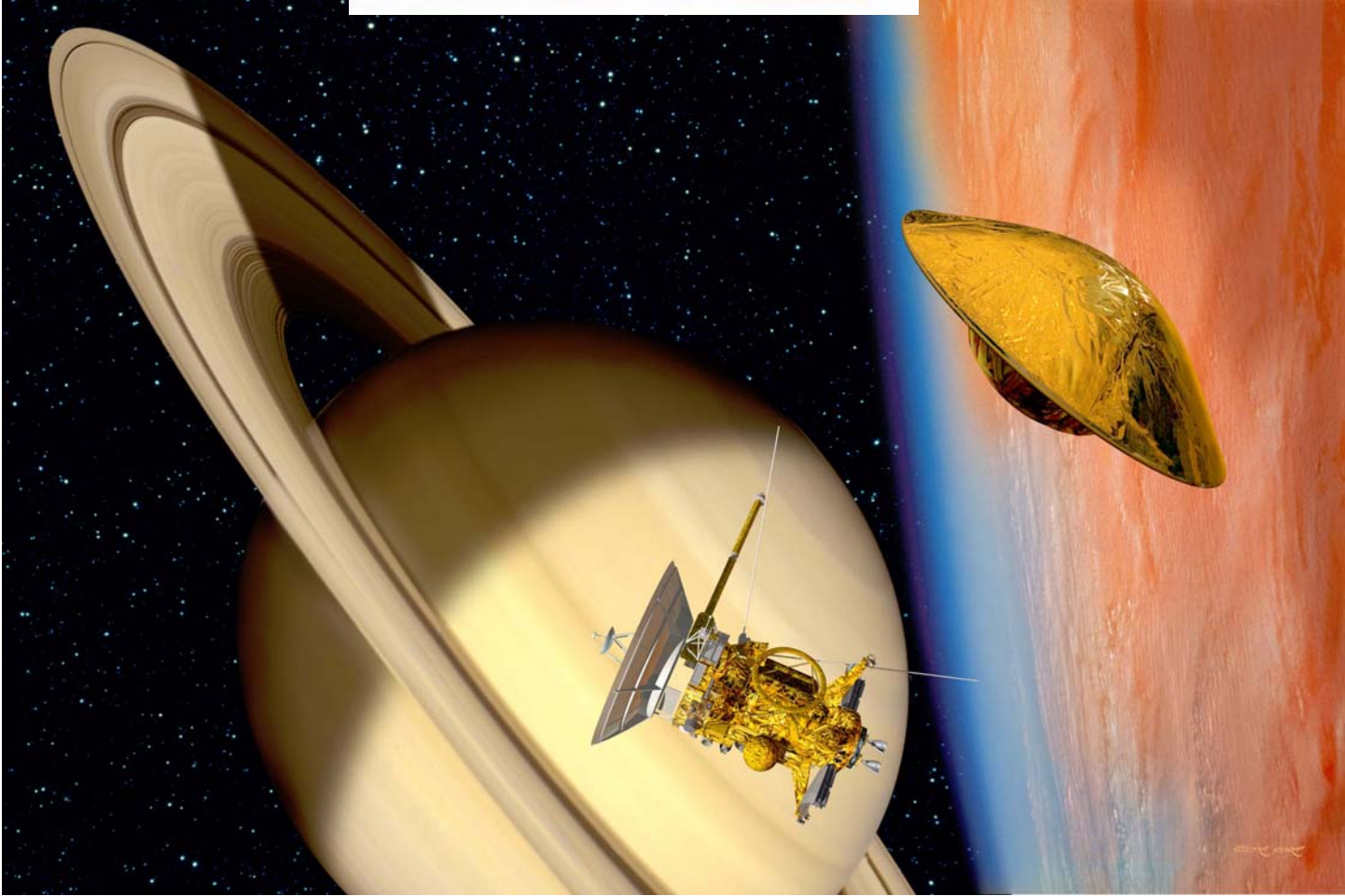
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24-08-2004

2nd International Planetary Probe  
Workshop

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Cassini-Huygens  
A 3-agency International Mission  
NASA, ESA, ASI  
19 countries involved



*Christiaan Huygens*



*Giovanni Domenico Cassini*

# CASSINI SCIENCE OBJECTIVES

## MAGNETOSPHERE

1. CONFIGURATION AND CURRENT SYSTEMS
2. PARTICLE COMPOSITION, SOURCES AND SINKS
3. DYNAMICS OF THE MAGNETOSPHERE
4. INTERACTION WITH SOLAR WIND, SATELLITES AND RINGS
5. TITAN'S INTERACTION WITH SOLAR WIND AND MAGNETOSPHERE

SOLAR

WIND

## SATURN

1. CLOUD PROPERTIES/ATMOSPHERIC COMPOSITION
2. WINDS AND TEMPERATURES
3. INTERNAL STRUCTURE AND ROTATION
4. SATURN'S IONOSPHERE
5. ORIGIN AND EVOLUTION OF SATURN

RINGS

1. STRUCTURE AND COMPOSITION
2. DYNAMICAL PROCESSES
3. INTERRELATION OF RINGS AND SATELLITES
4. DUST/MICROMETEOROID ENVIRONMENT

## TITAN

1. ATMOSPHERIC CONSTITUENT ABUNDANCES
2. DISTRIBUTIONS OF TRACE GASES AND AEROSOLS
3. WINDS AND TEMPERATURES
4. SURFACE STATE AND COMPOSITION
5. UPPER ATMOSPHERE

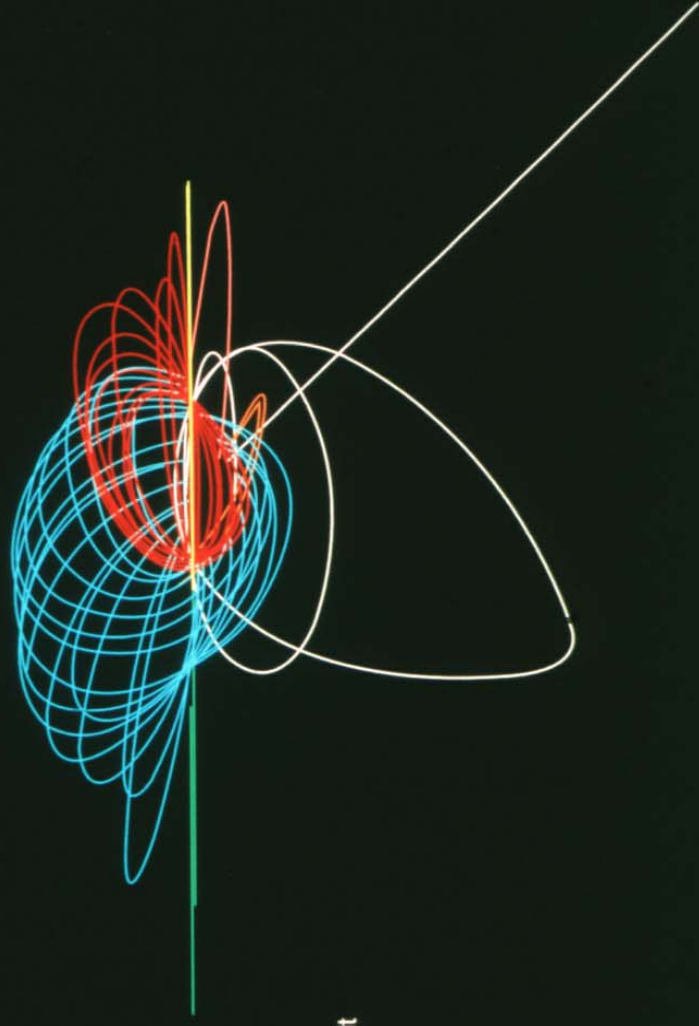
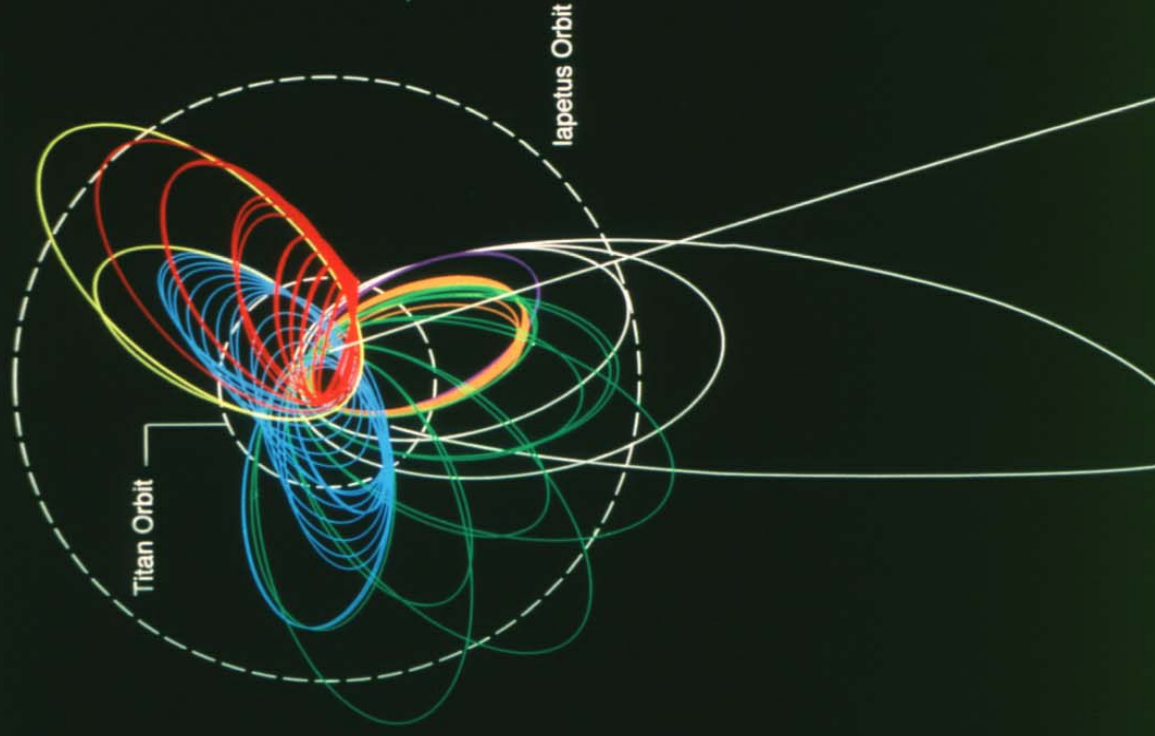
## ICY SATELLITES

1. CHARACTERISTICS AND GEOLOGICAL HISTORIES
2. MECHANISMS OF SURFACE MODIFICATION
3. SURFACE COMPOSITION AND DISTRIBUTION
4. BULK COMPOSITION AND INTERNAL STRUCTURE
5. INTERACTION WITH MAGNETOSPHERE



# Polar View

# Equatorial View





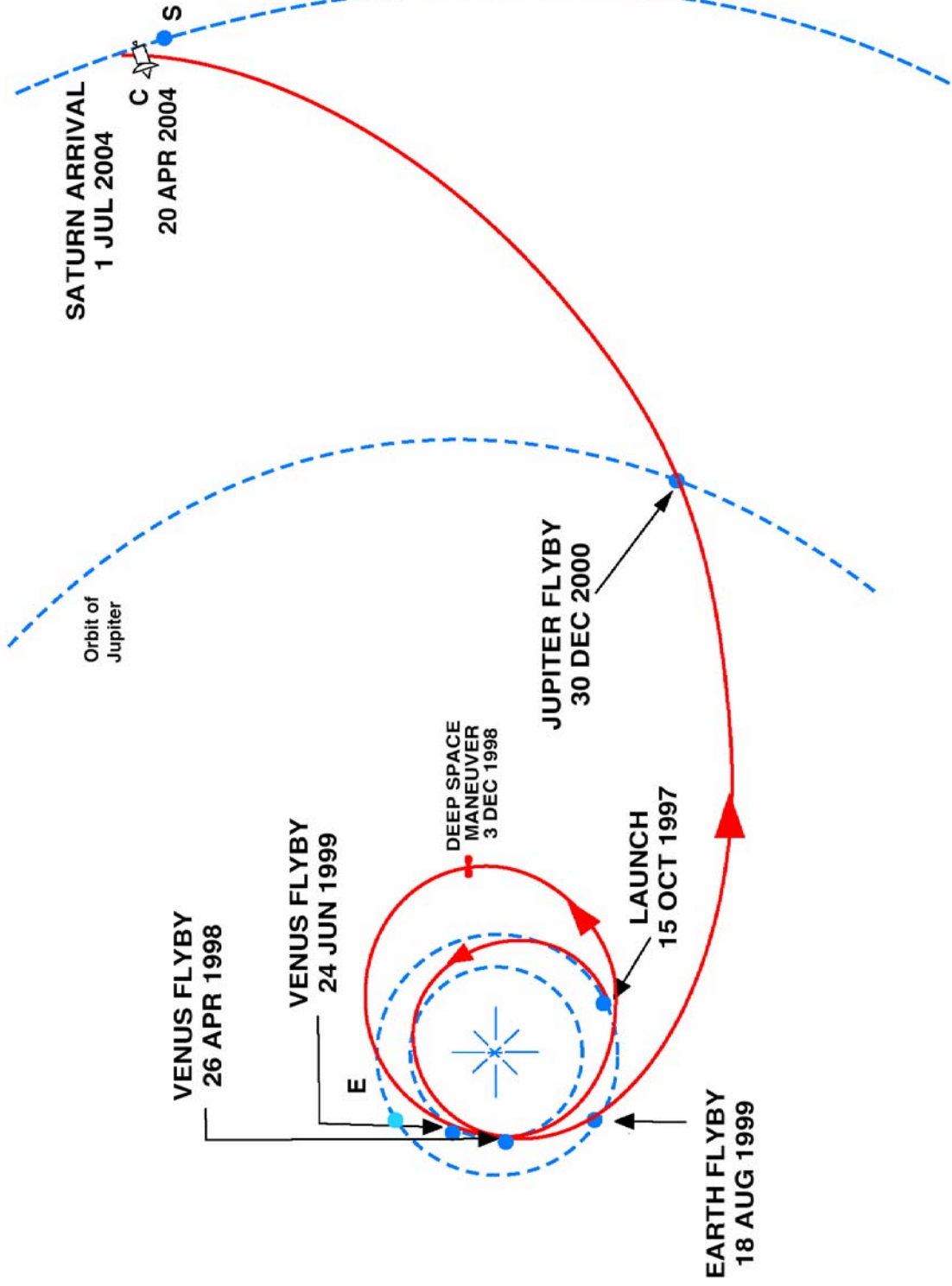




October 15, 1997

Launched from K.S.C.

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



Saturn  
North Pole

Spacecraft turns away from Earth  
for SOI activities  
June 30 6:11pm PDT

Ascending ring-plane crossing  
7:11pm PDT

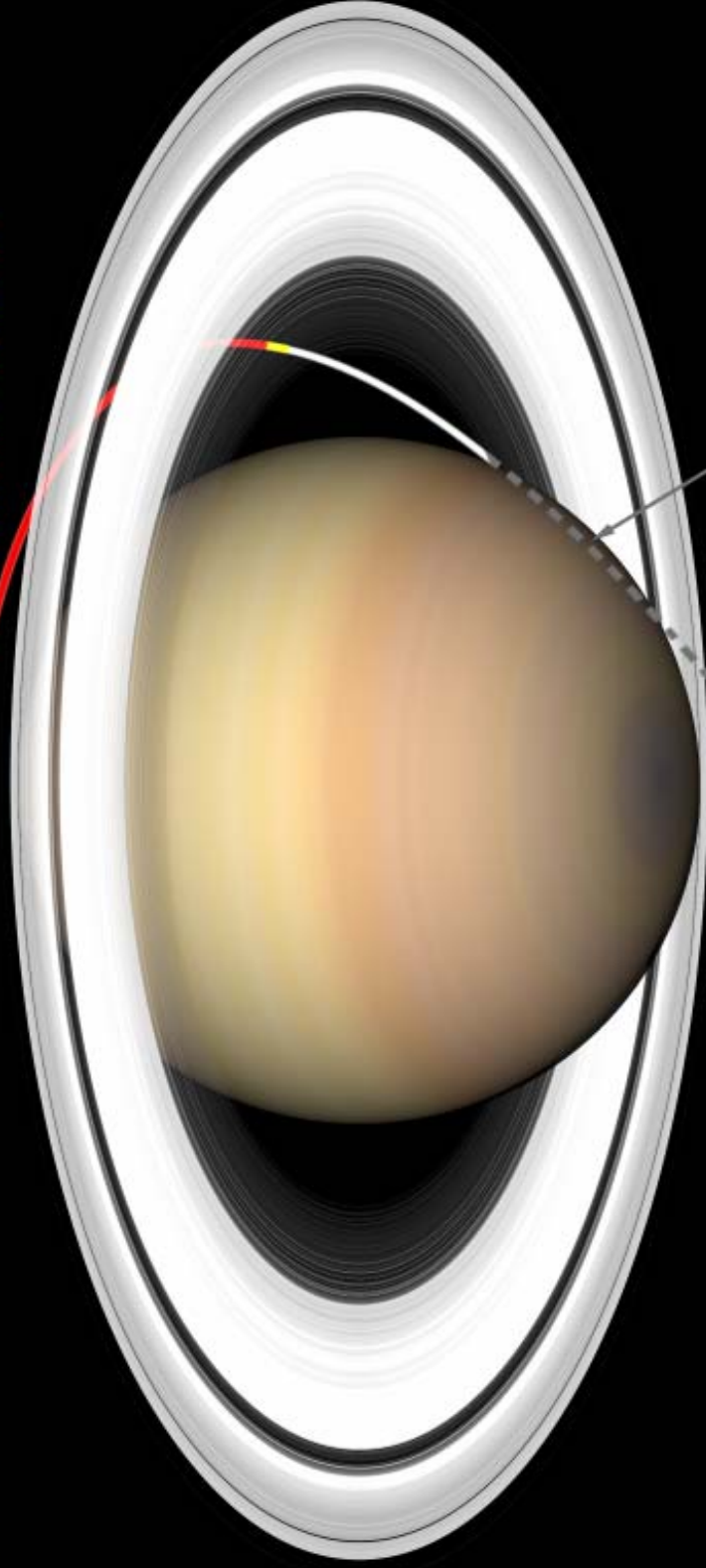
SOI burn 7:36 - 9:12pm PDT

Spacecraft passes behind rings, planet  
9:54 - 10:44pm PDT

Descending ring-plane crossing  
10:58pm PDT

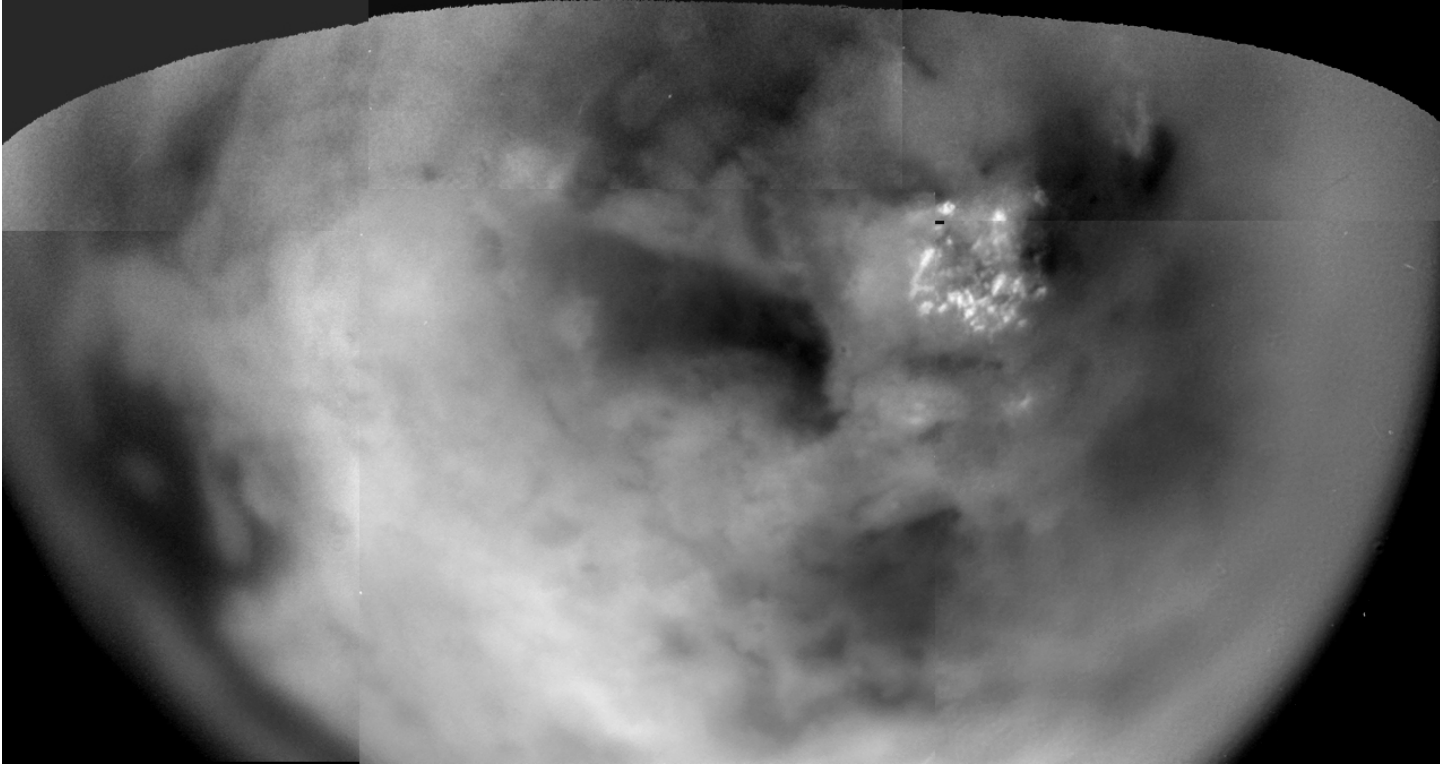
Spacecraft returns to Earth-point  
Playback of SOI data begins  
July 1 12:00am PDT

Cassini Saturn Orbit Insertion  
View from Earth

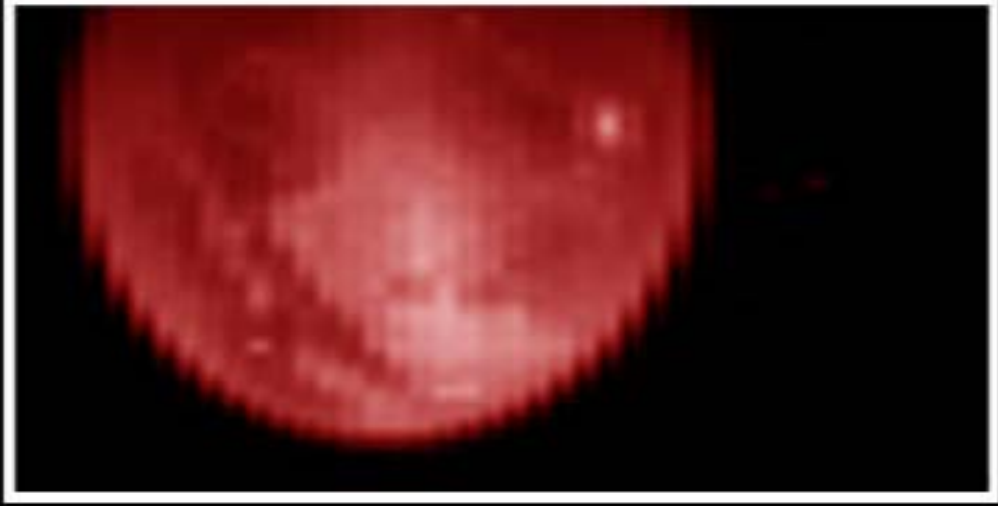




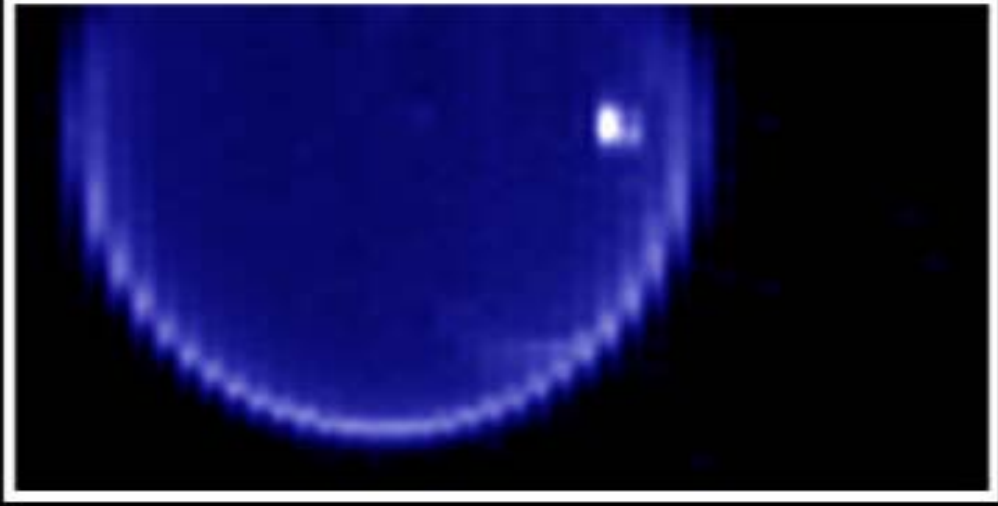
# Cassini ISS



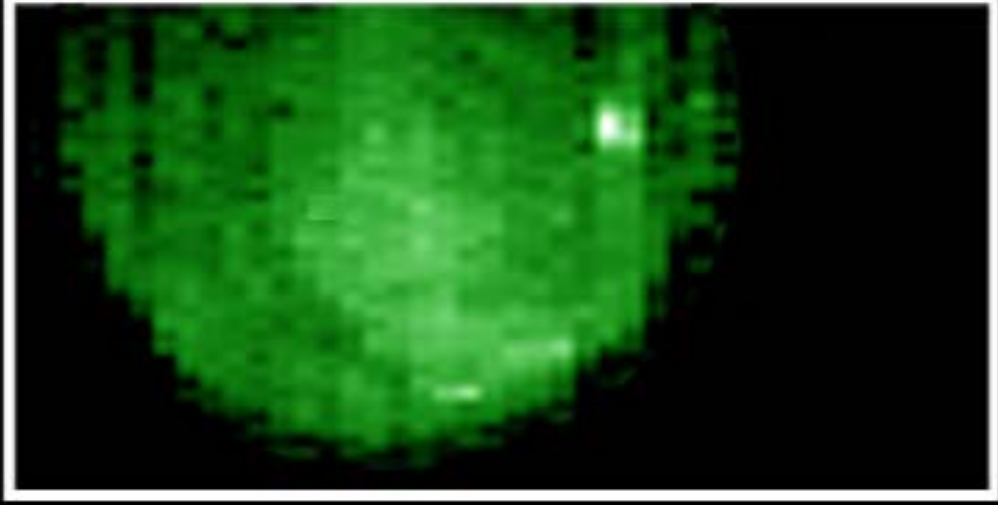
24-08-2004



Surface



Ice

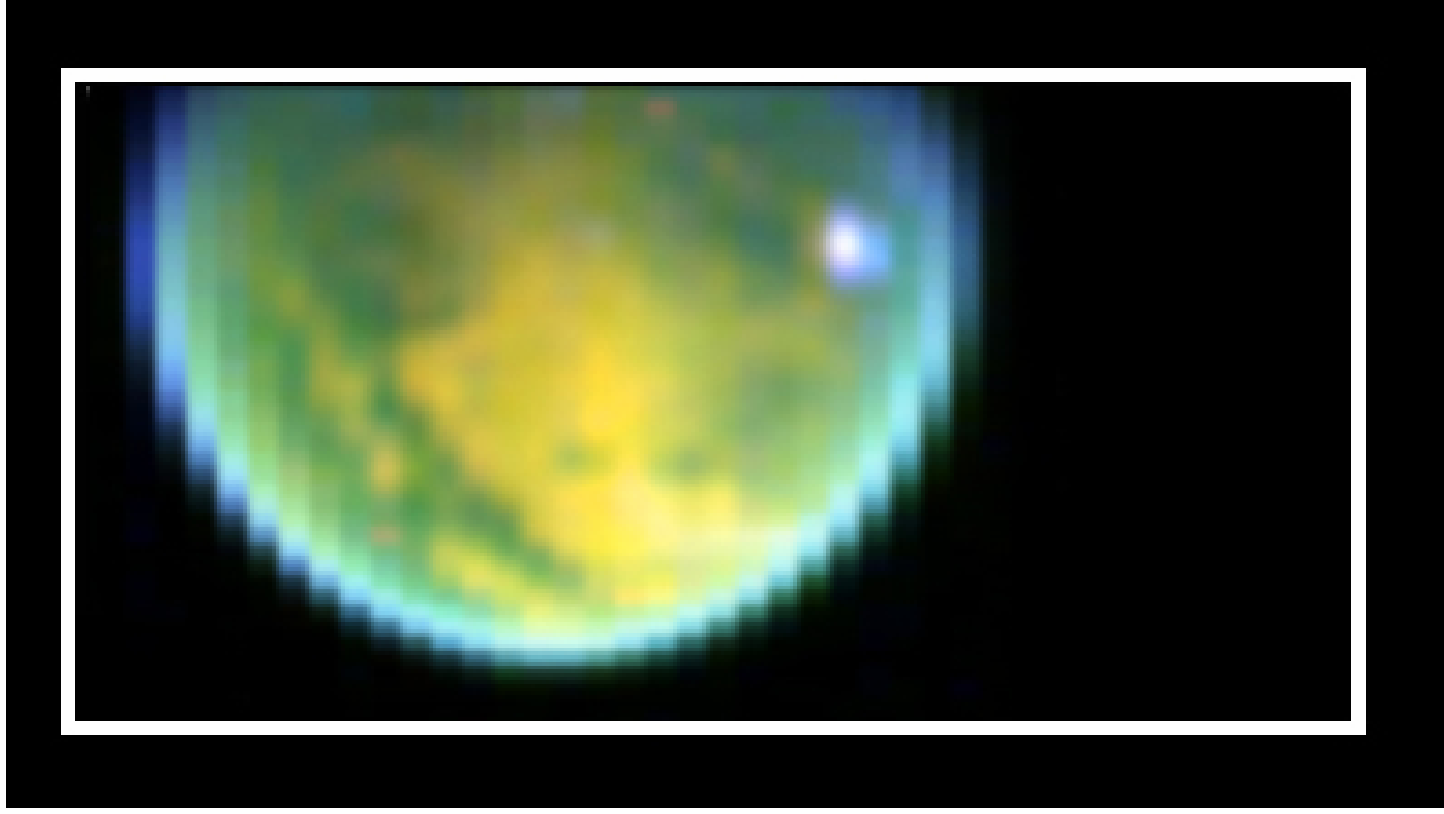


Organics ?

Cassini VIMS

# Cassini VIMS

24-08-2004

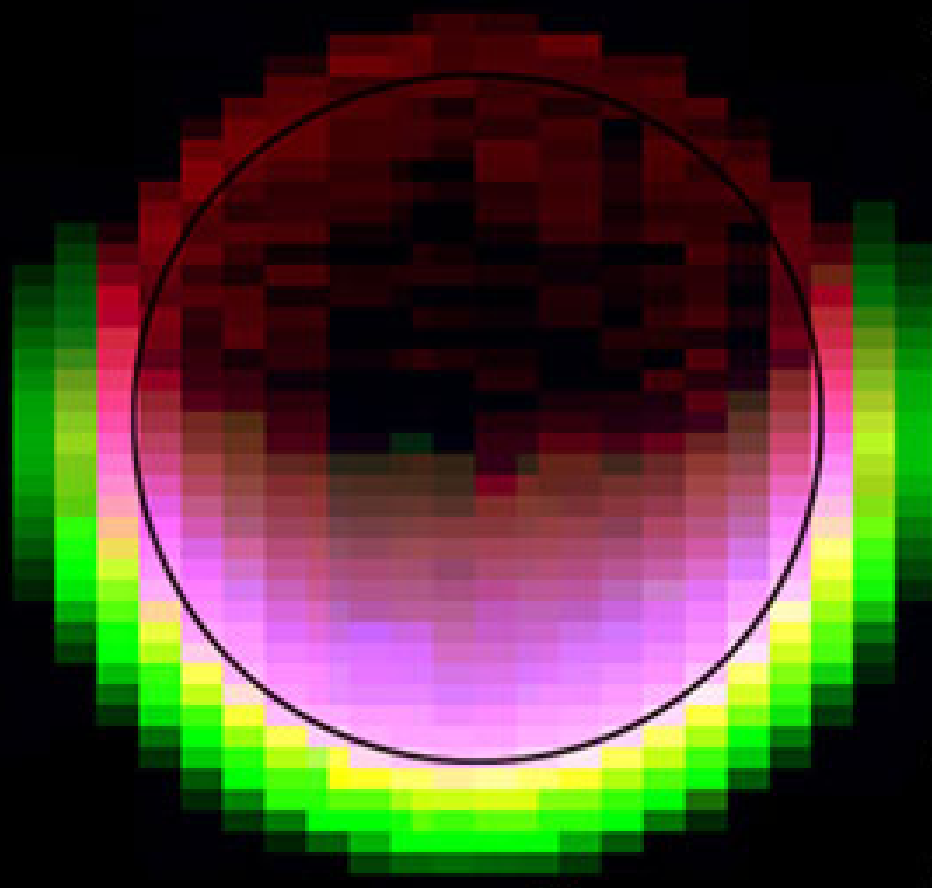




# Glowing Titan

Dayside  
Methane  
Fluorescence

Nightside  
Stratospheric  
Emission

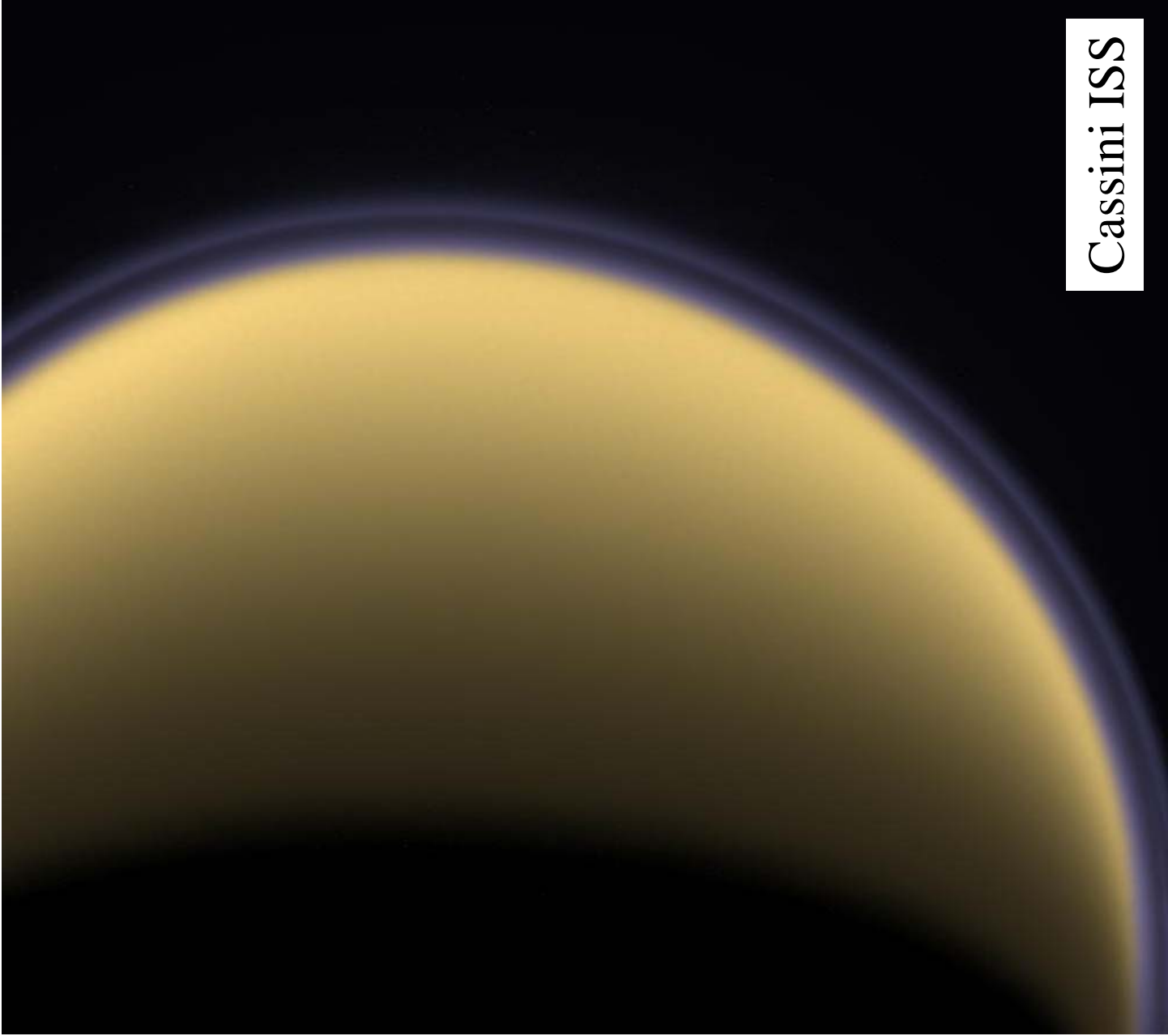


730 km



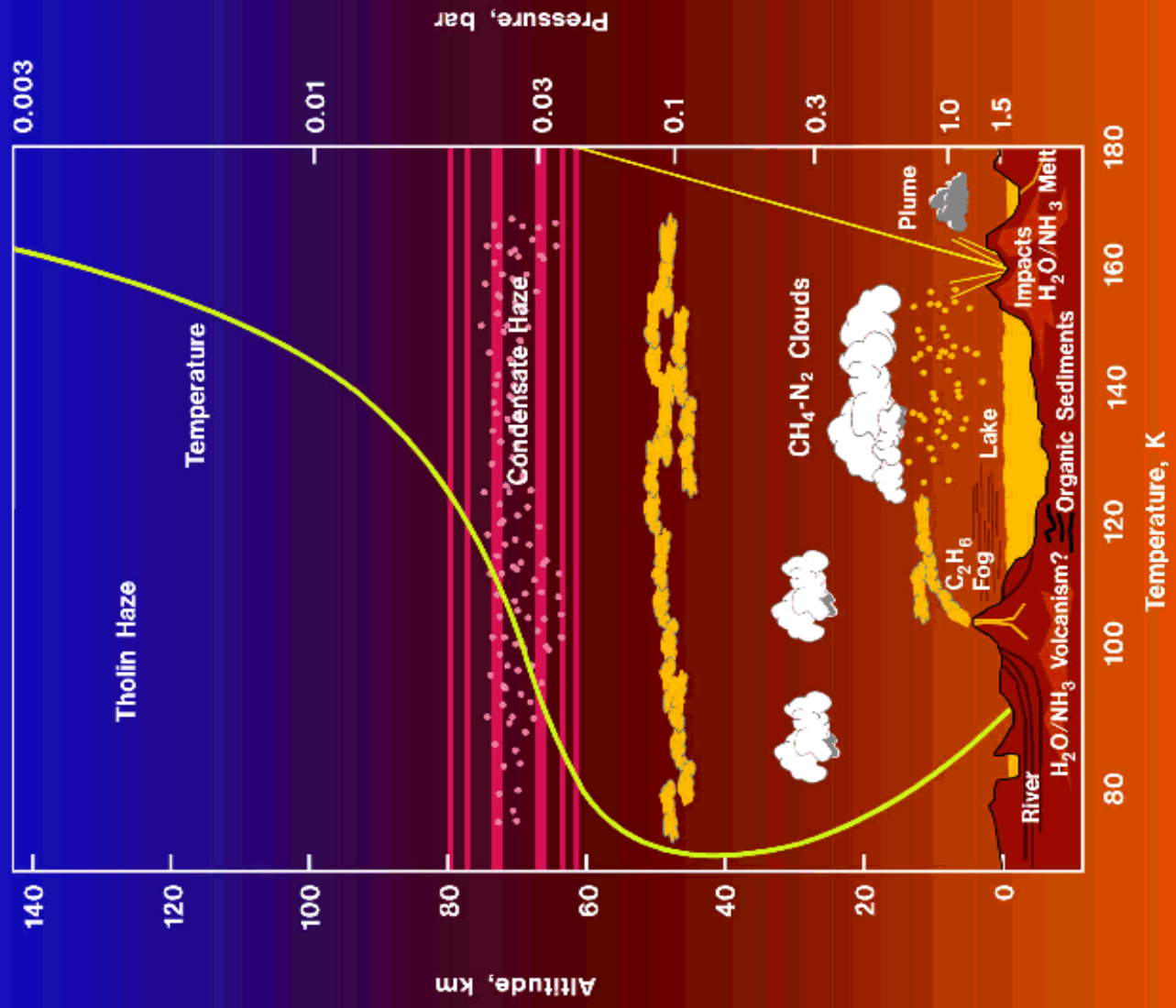
390 km

Cassini VIMS



24-08-2004

Cassini ISS



Tholin Haze

Temperature

Altitude, km

Pressure, bar

Condensate Haze

CH<sub>4</sub>-N<sub>2</sub> Clouds

C<sub>2</sub>H<sub>6</sub> Fog

Plume

Lake

Organic Sediments

Impacts H<sub>2</sub>O/NH<sub>3</sub> Melt

H<sub>2</sub>O/NH<sub>3</sub> Volcanism?

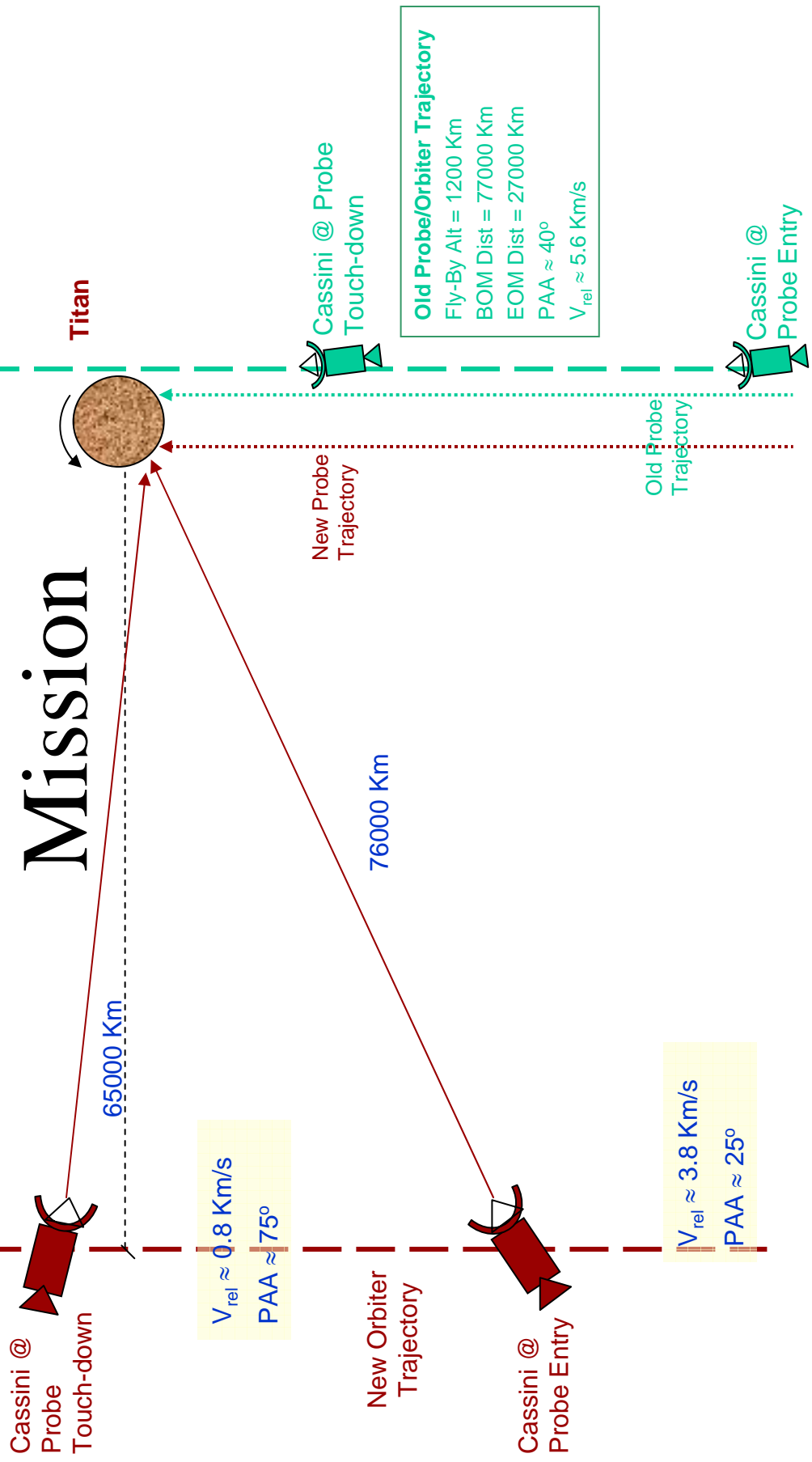
Temperature, K







# The New (and Old) Huygens





## Baseline scenario: Pre-heating

Probe wake-up by programmed timer  
4 hr 28 min before arrival  
at predicted interface altitude

CDMU's pre-heating

GCMS pre-heat  
HASI ON, Stby

GCMS pre-heat  
HASI Meas.

Interface  
Alltitude  
1270 km

Time

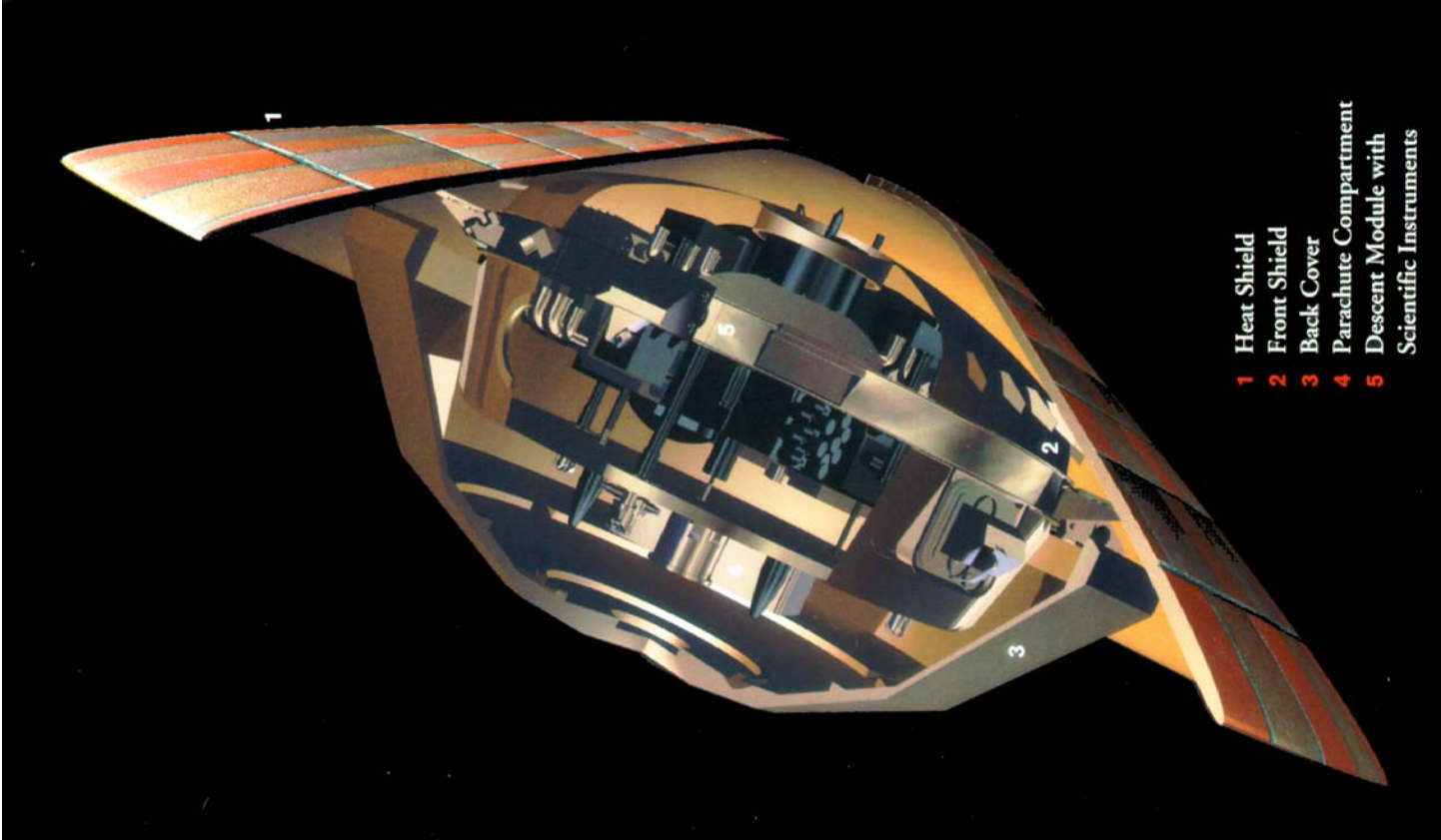
## Back-up scenario: No pre-heating

Probe wake-up by programmed timer  
28 min before arrival  
at predicted interface altitude

GCMS pre-heat  
HASI ON, Meas

Interface  
Alltitude  
1270 km

Time



- 1 Heat Shield
- 2 Front Shield
- 3 Back Cover
- 4 Parachute Compartment
- 5 Descent Module with Scientific Instruments

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1270 km  
above surface

Mach 20  
300-250 km

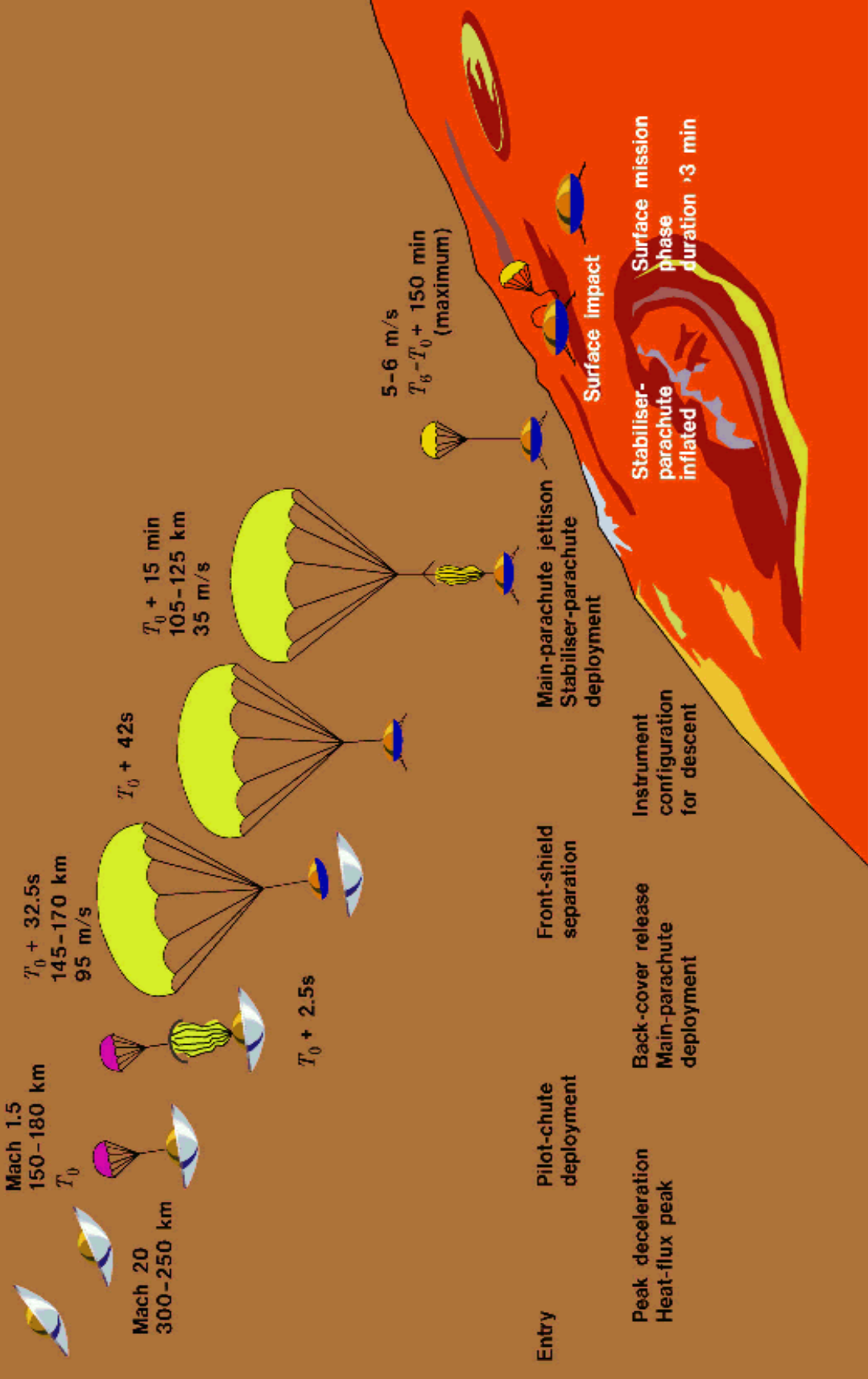
Mach 1.5  
150-180 km  
 $T_0$

$T_0 + 32.5s$   
145-170 km  
95 m/s

$T_0 + 42s$

$T_0 + 15 min$   
105-125 km  
35 m/s

5-6 m/s  
 $T_6 - T_0 + 150 min$   
(maximum)



Entry

Peak deceleration  
Heat-flux peak

Pilot-chute  
deployment

Back-cover release  
Main-parachute  
deployment

Front-shield  
separation

Instrument  
configuration  
for descent

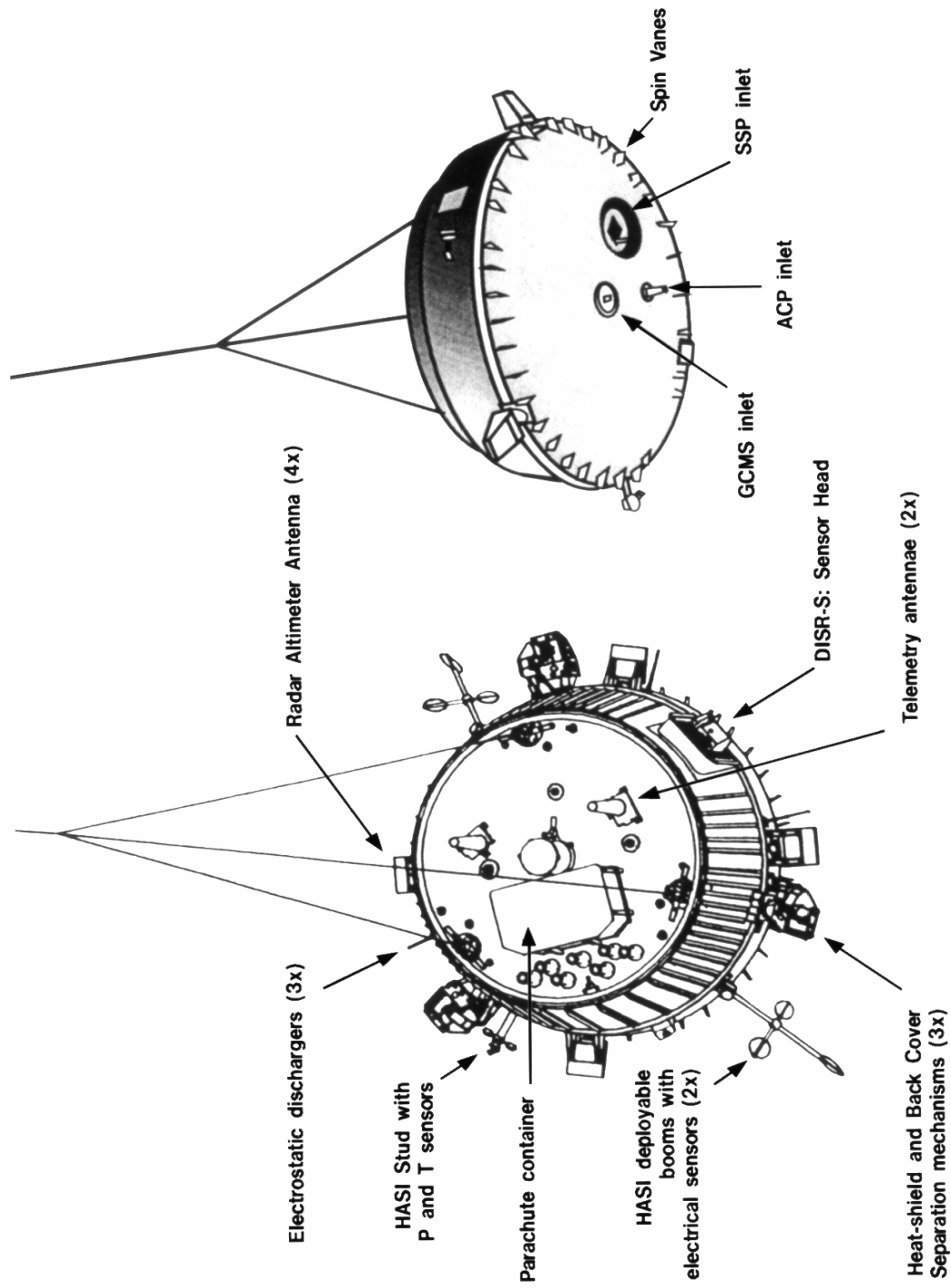
Main-parachute jettison  
Stabiliser-parachute  
deployment

Stabiliser-  
parachute  
inflated

Surface impact

Surface mission  
phase  
duration ~3 min

# The Huygens Science Payload



## Huygens Payload

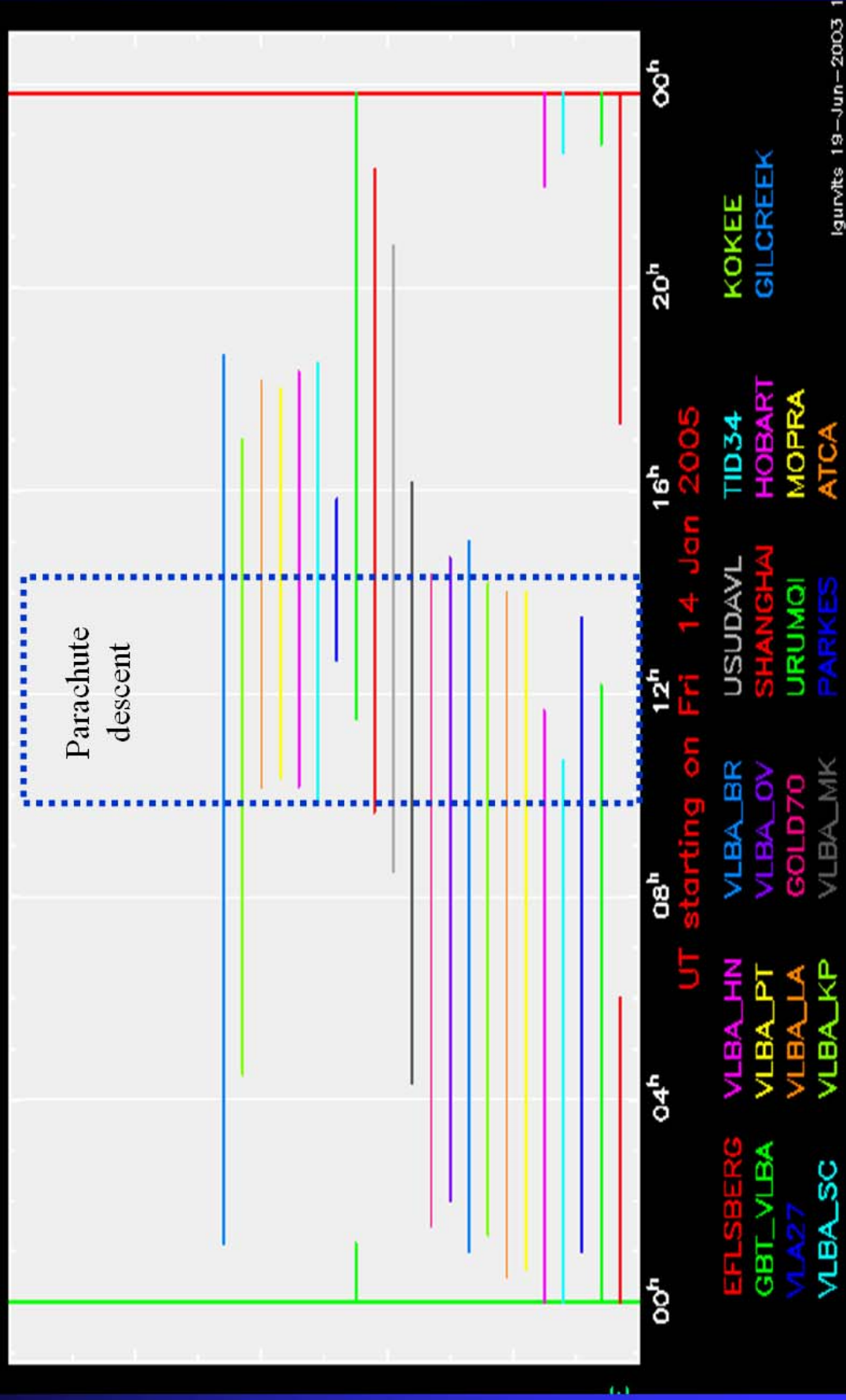
<p>Huygens Atmospheric Structure Instrument (HASI). M. Fulchignoni (Paris 7/Obs Meudon)</p>	<p>T, P, <math>\gamma</math>, Winds, Turbulence, Conductivity; lightning; surface permittivity &amp; radar reflectivity</p>
<p>Gas Chromatograph/Mass Spectrometer (GCMS), H. Niemann (NASA/GSFC)</p>	<p>Atmosphere composition; trace constituents; isotopic ratios; aerosol analysis</p>
<p>Aerosol Collector and Pyrolyzer (ACP) G. Israel (CNRS/SA Verrieres)</p>	<p>Aerosol sampling in two layers. Stepped pyrolysis (0 C, 200 C, 650 C); injection to GCMS</p>
<p>Descent Imager/Spectral Radiometer (DISR) M. Tomasko (U of Arizona)</p>	<p>Heat flux, energy budget, clouds, aerosols properties, surface imaging &amp; composition</p>
<p>Doppler Wind Experiment (DWE) M. Bird (U of Bonn)</p>	<p>Zonal wind profile, turbulence</p>
<p>Surface Science package (SSP) J. Zarnecki (Open Univ.)</p>	<p>Surface state and composition at landing site. Atmospheric measurements</p>
<p>24-08-2004</p>	<p>2nd International Planetary Probe Workshop</p> <p style="text-align: right;">22</p>



## Huygens Payload & Ground-based Radio Signal Detection

Huygens Atmospheric Structure Instrument (HASI). M. Fulchignoni (Paris 7/Obs Meudon)	T, P, $\gamma$ , Winds, Turbulence, Conductivity; lightning; surface permittivity & radar reflectivity
Gas Chromatograph/Mass Spectrometer (GCMS), H. Niemann (NASA/GSFC)	Atmosphere composition; trace constituents; isotopic ratios; aerosol analysis
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<b>VLBI Probe signal carrier detection Ground-based DWE</b>	<b>Probe localisation to ~ km acc. in x-y plane; 2D wind measurements</b>

# Visibility of the H-Probe from radio telescopes





# Engineering Status; On-going activities

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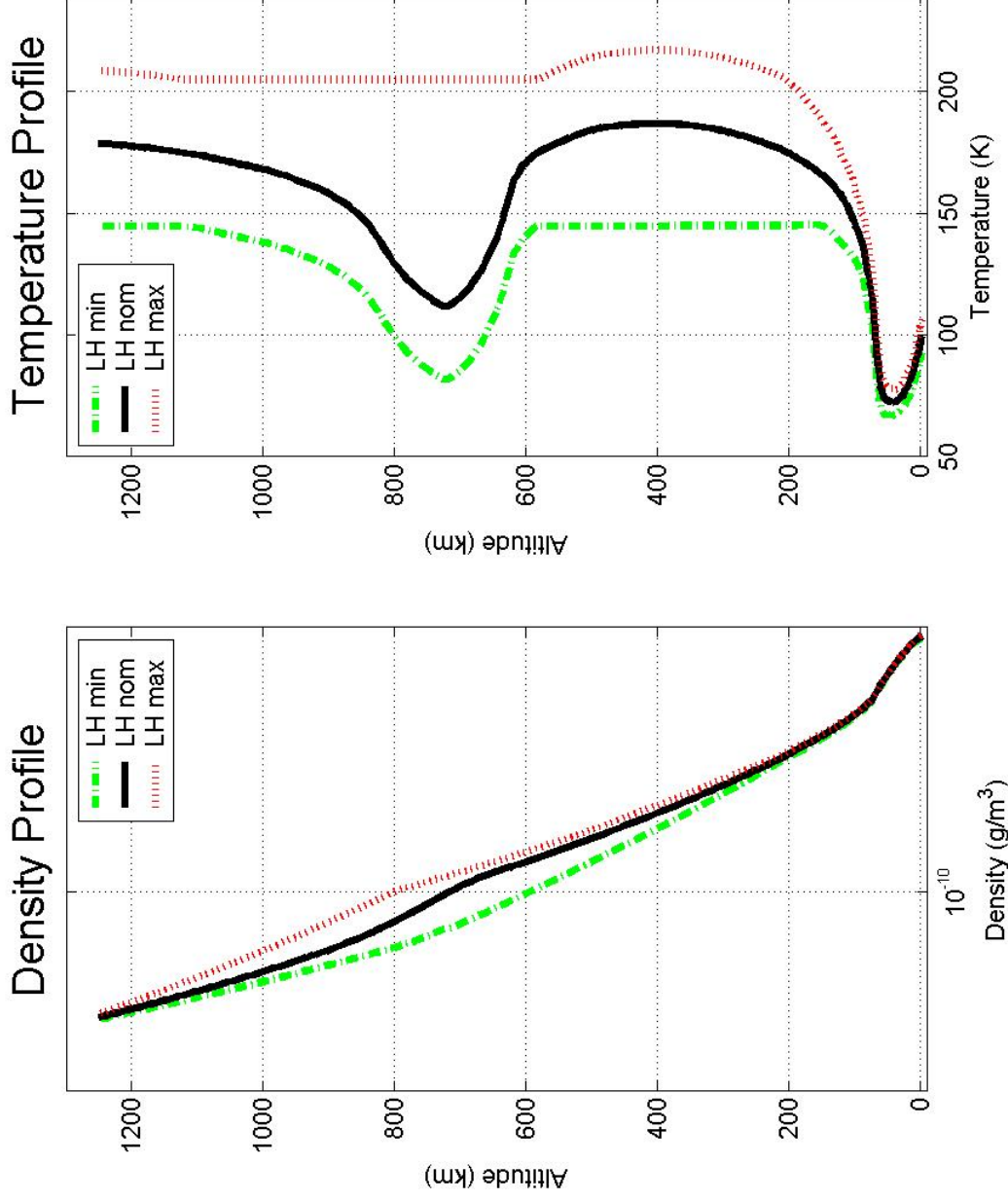
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# TITAN Atmosphere environment

- Atmosphere Density, Pressure and Temperature models available:
  - Design model: Lellouch-Hunten (rec, min, max, 1986)
  - Updated model: Yelle (rec, min, max, 1994)
- Gravity Waves:
  - D. Strobel Model (single phase large amplitude profiles, 1994)
  - Analytical Model (J.P. Lebreton, 2004)
- Wind Model: so-called HRTF (Flasar model)
- Titan GRAM (disturbances on Yelle profiles - developed for aerocapture studies and used as is)

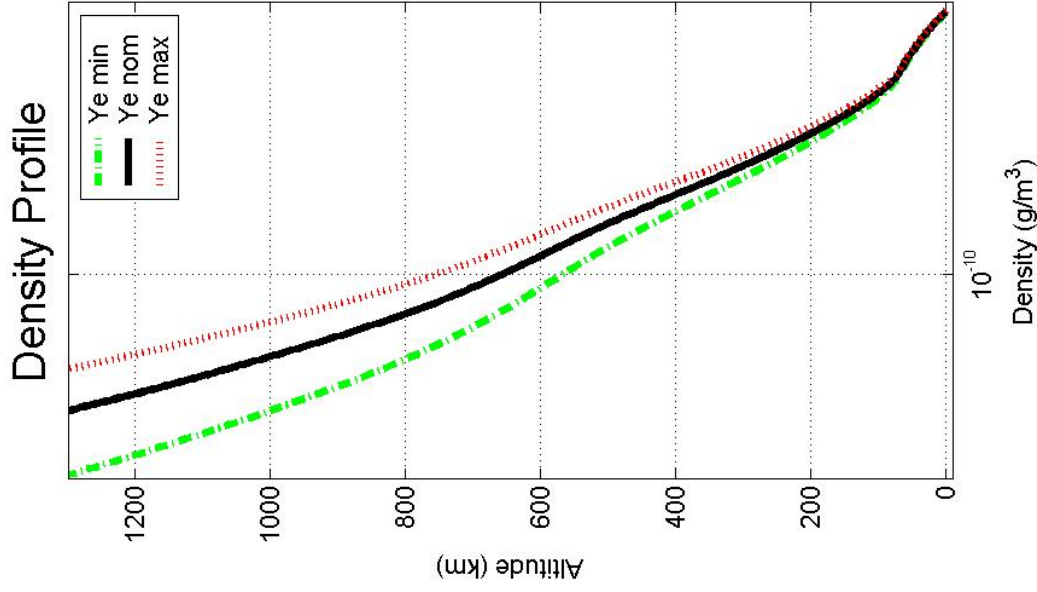
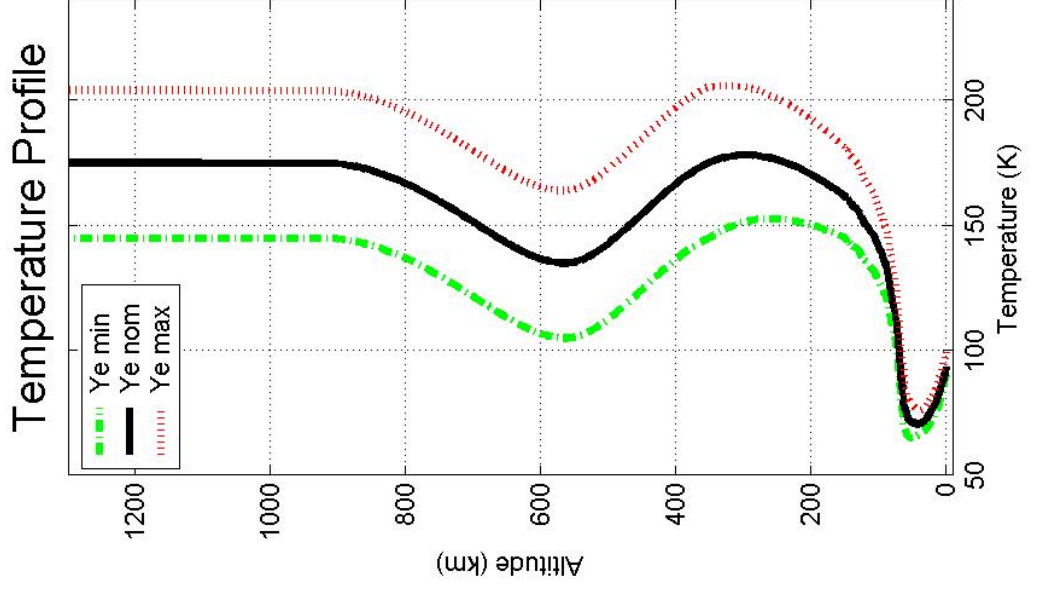


# Lellouch-Hunten Model

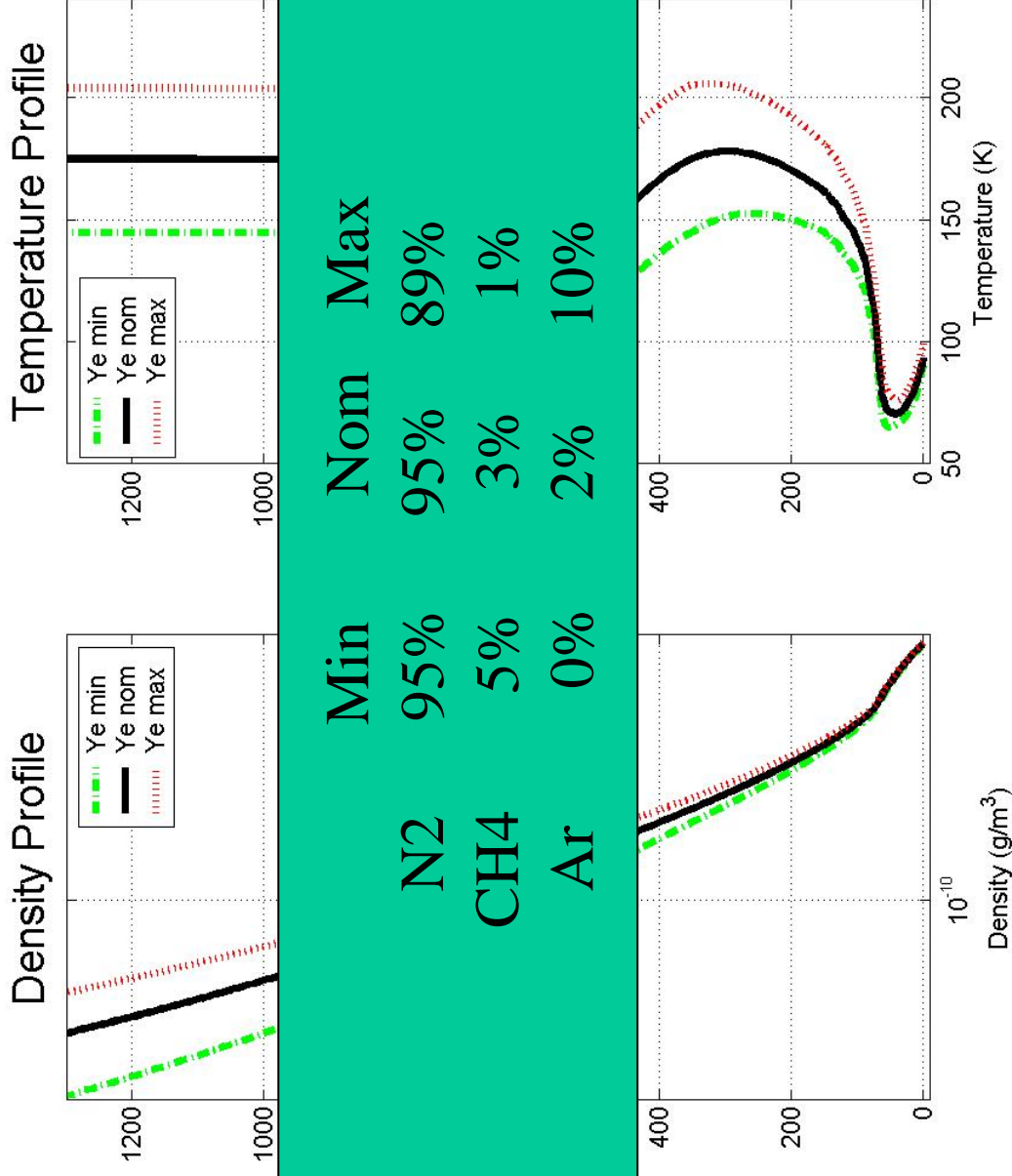


Three main components are Nitrogen (N<sub>2</sub>), Methane (CH<sub>4</sub>), and Argon (Ar).  
0.5% < X<sub>CH<sub>4</sub></sub>/X<sub>N<sub>2</sub></sub> < 3.5 %; Relative molar abundance of Argon : 0 < X<sub>Ar</sub>/X<sub>N<sub>2</sub></sub> < 27%.

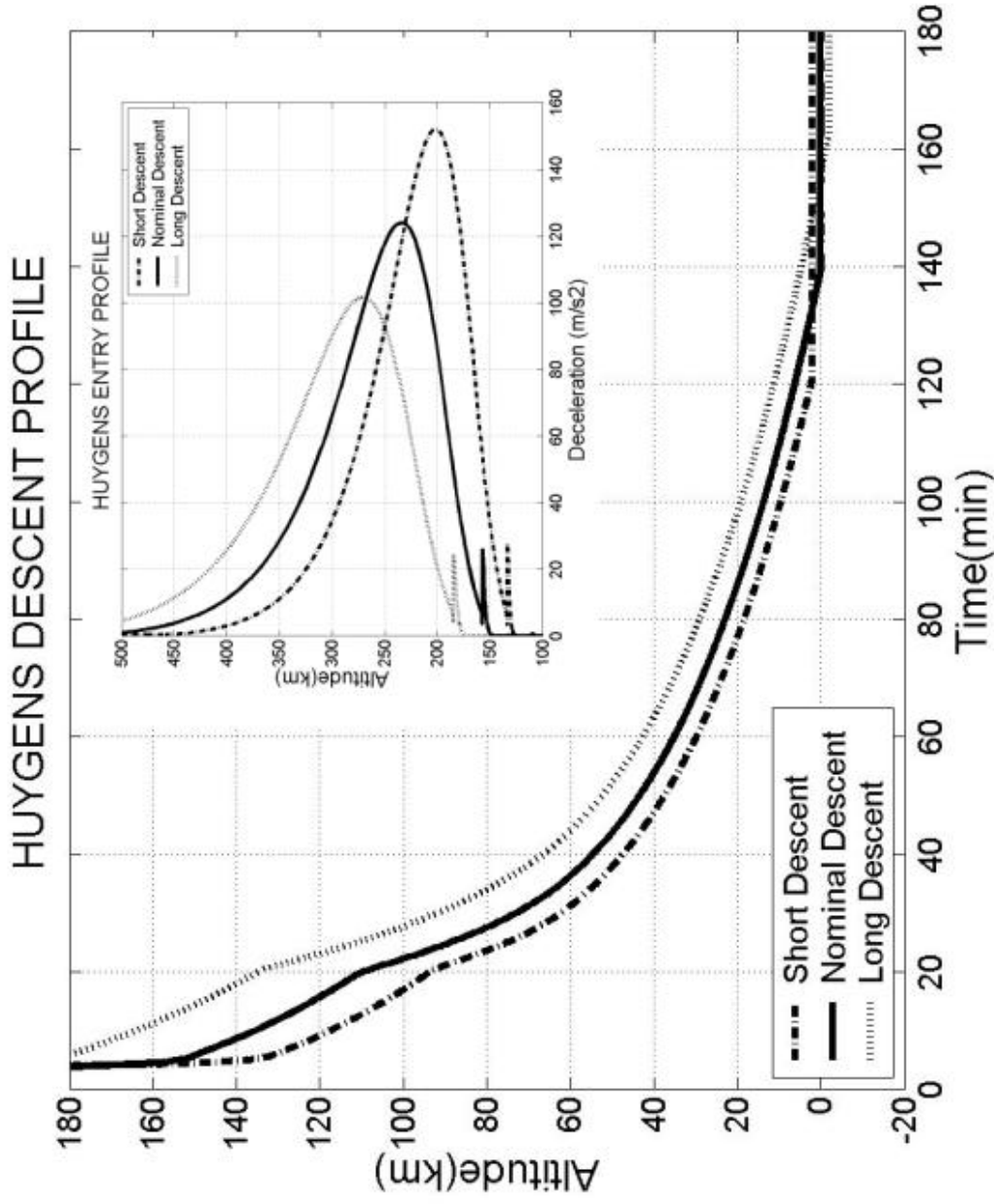
# Yelle Model

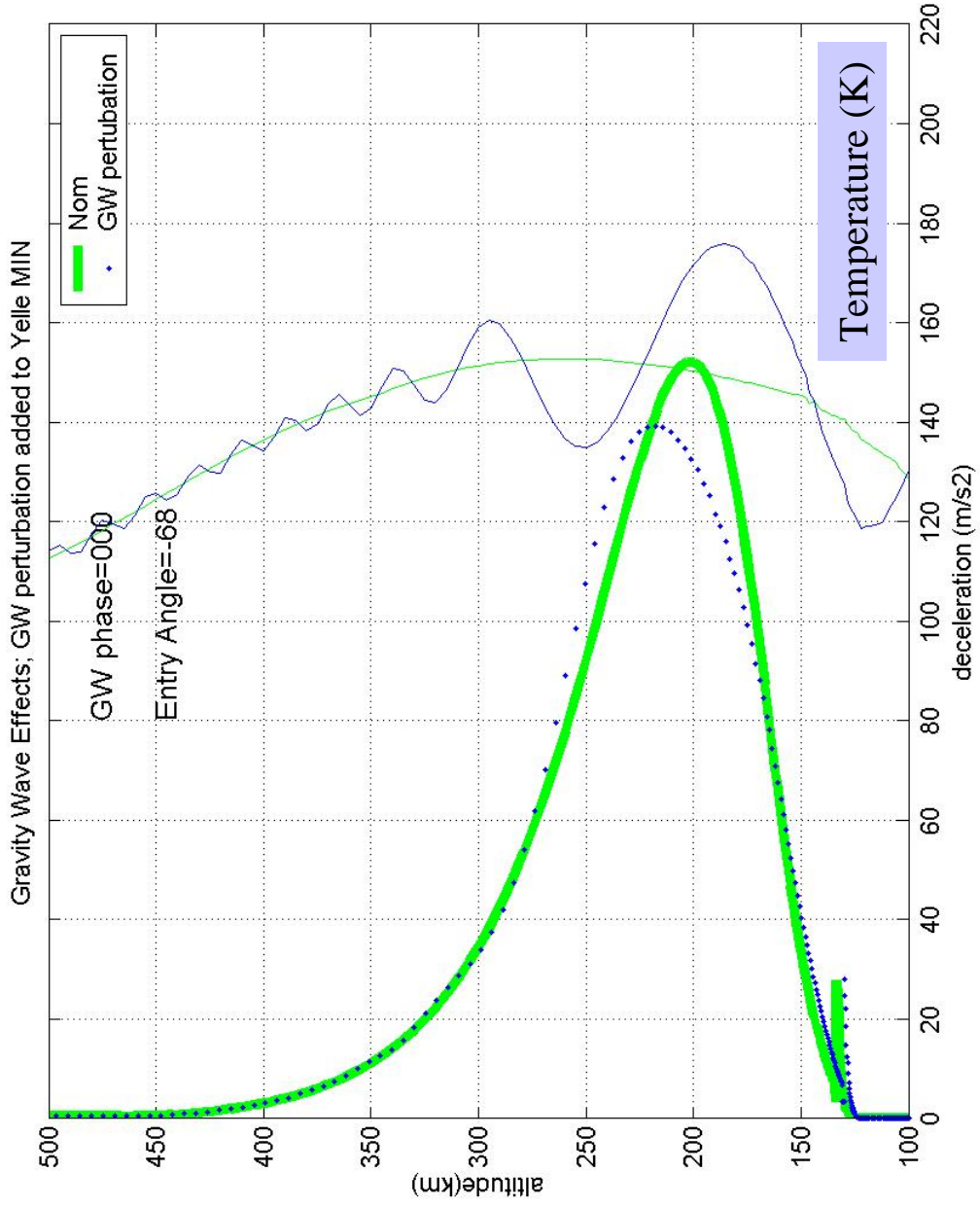


# Yelle Model



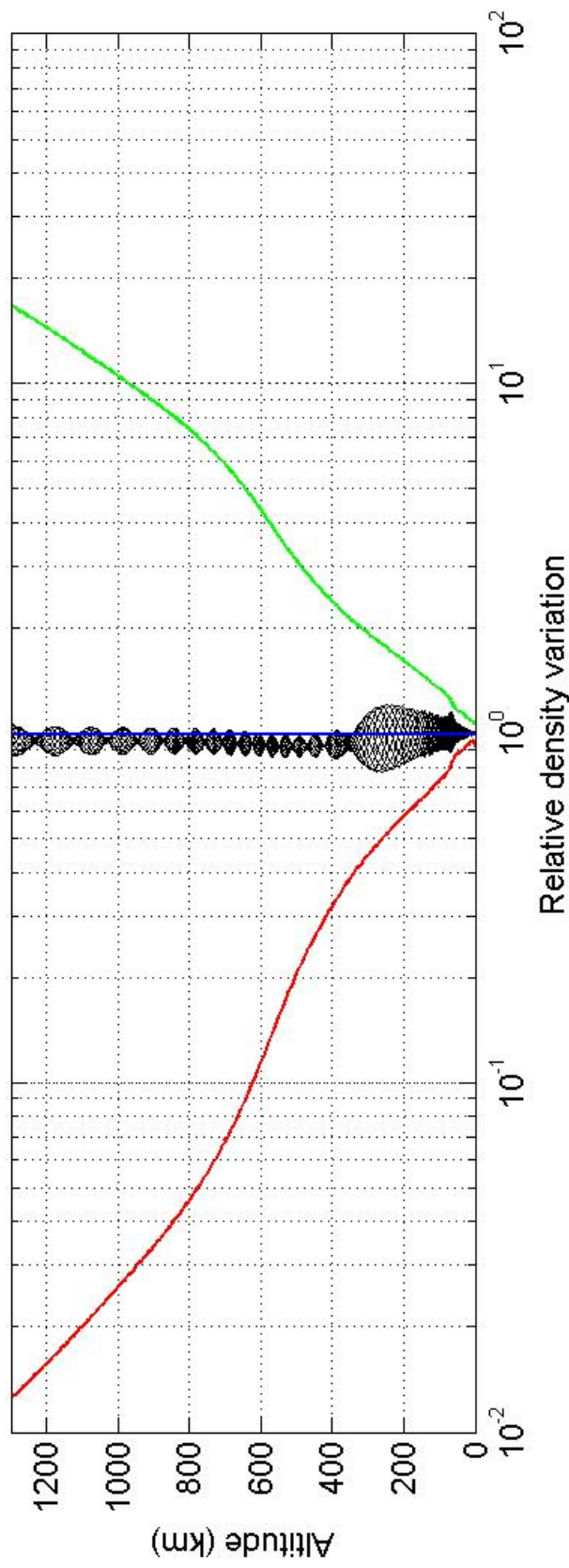
# Entry Altitude Range



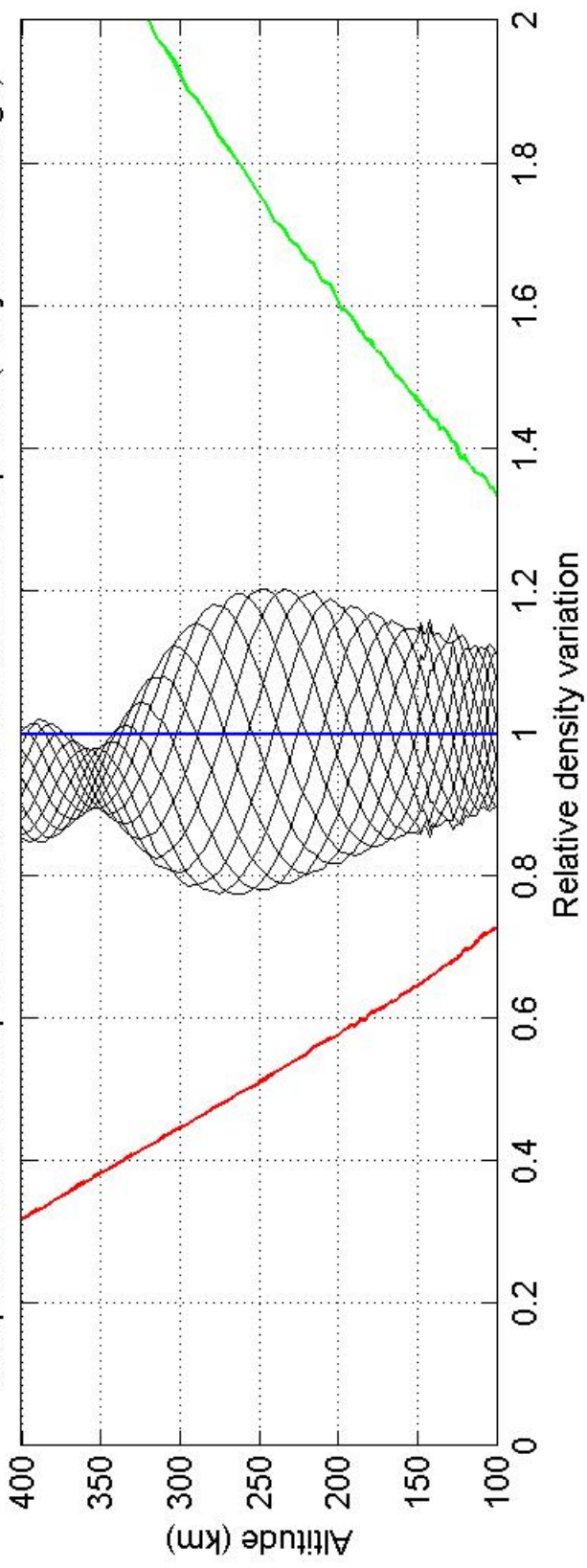




Comparison of all Atmosphere models to Yelle recommended profile (whole altitude range)



Comparison of all Atmosphere models to Yelle recommended profile (Entry altitude range)



## ΔFAR Outcome (Overall)

The Board concluded that the objectives of the review have been met. No show-stopper has been identified. The implementation of the mission should proceed as planned.

However, it is urgently needed to set-up a special activity to finalise the re-validation of the entry corridor and to assess whether the residual risks are equally balanced as the nominal value was shifted from the FAR baseline of  $-64 (\pm 4)^\circ$  to  $-65 (\pm 3)^\circ$ .

The following major short-term actions have been agreed:

- Re-assess worst case atmosphere engineering models: by end of March
- Independent assessment of the EADS and NASA/Ames heat flux calculations: by end of March
- Perform heat-shield material (AQ60) UV transparency tests (at ESTEC and at NASA/Ames): by end of April
- Perform parachute model validation with MER data (pending MER data availability from NASA/JPL to ESA): Mid-April

# On-going activities

- Re-validation of entry and descent performance
  - Heat flux recently re-assessed: 1400 → 2000 kW/m<sup>2</sup>
  - TPS and overall System performance under ~ 2000 kW/m<sup>2</sup>
  - Heat-flux re-evaluation (ESTEC, EM2C, NASA/AMES, EADS, Alcatel)
  - Heat shield tile transparency tests to CN violet radiation
  - Parachute deployment loads
  - Entry angle confirmation (baseline -65 ° ± 3° )
- Validation of atmosphere model
  - T0 (3<sup>rd</sup> July) Cassini orbiter observation
  - Relevant ground based observations (e. g. occultation of Nov. 2003)
  - Planned Ta Cassini Orbiter observations (26 October 2004)
  - Planned Tb Cassini Orbiter observation (13 Dec. 2004)

# On-going activities (2)

- Huygens designed for (cumulated) worst case conditions
  - Atmosphere Model Composition
  - Gravity waves
  - Failure cases
- Monte-Carlo study based on TitanGRAM
- Mission baseline re-validation and margins to be clarified by early October
- NASA/ESA Review in planning (Sept/Oct ?-Nov)

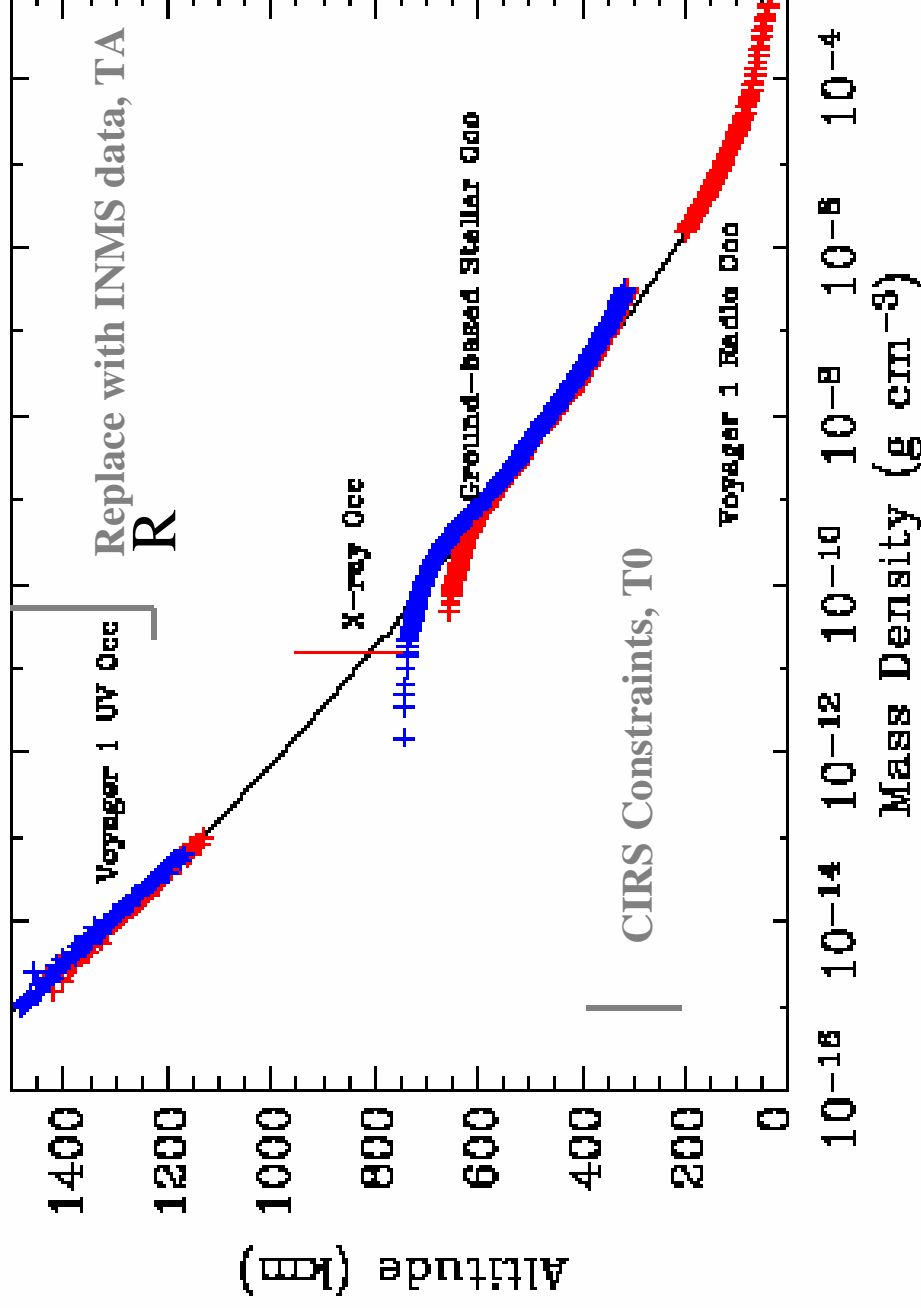
# Huygens key operational milestones

- T0: 3 July; T0 workshop: 8/9 Sept. at NASA/GSFC
- Titan atmosphere models validation/update#1: 30 Sept.
- PCO#15: 14<sup>th</sup> September; battery depassivation#1
- Ta: 26 October; Ta Workshop: 15 Nov at JPL
- Titan atmosphere models validation/update#2: 25 Nov.
- PCO#16: 23 November; battery depassivation#2
- GO/NOGO for primary mission: 2 Dec.
- Tb: 13 Dec; Titan atmosphere report: 15 Dec.
- PTM: Approval: 15 Dec; Execution 17 Dec.
- Probe pre-separation configuration: 21 Dec
- GO/NOGO for Probe separation: 23 Dec.
- Probe Release: 25 Dec.
- Probe Entry: 14 January 09:07 UTC



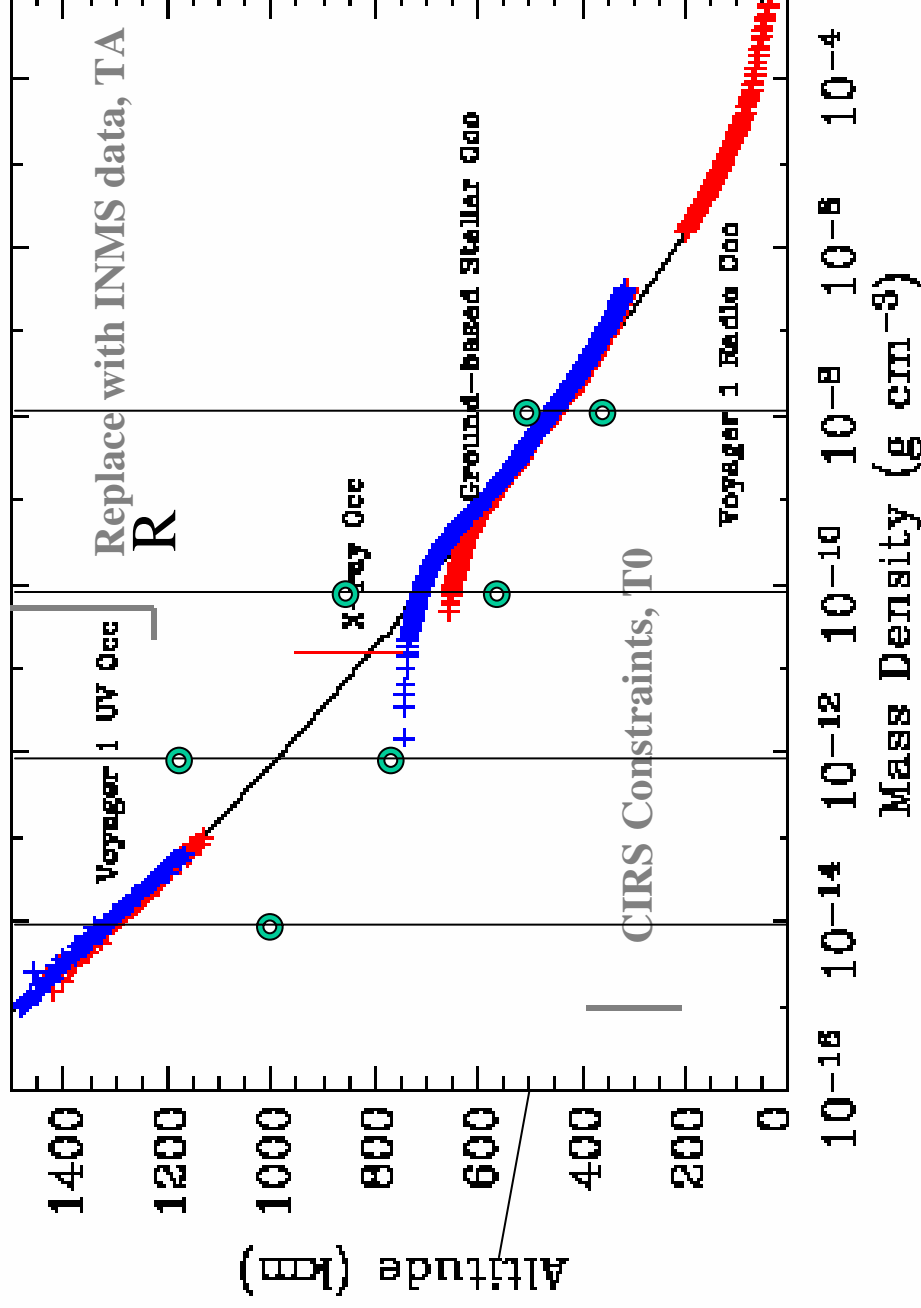
# What Happens Next

## re. atmosphere validation ?



# What Happens Next

## re. atmosphere validation ?

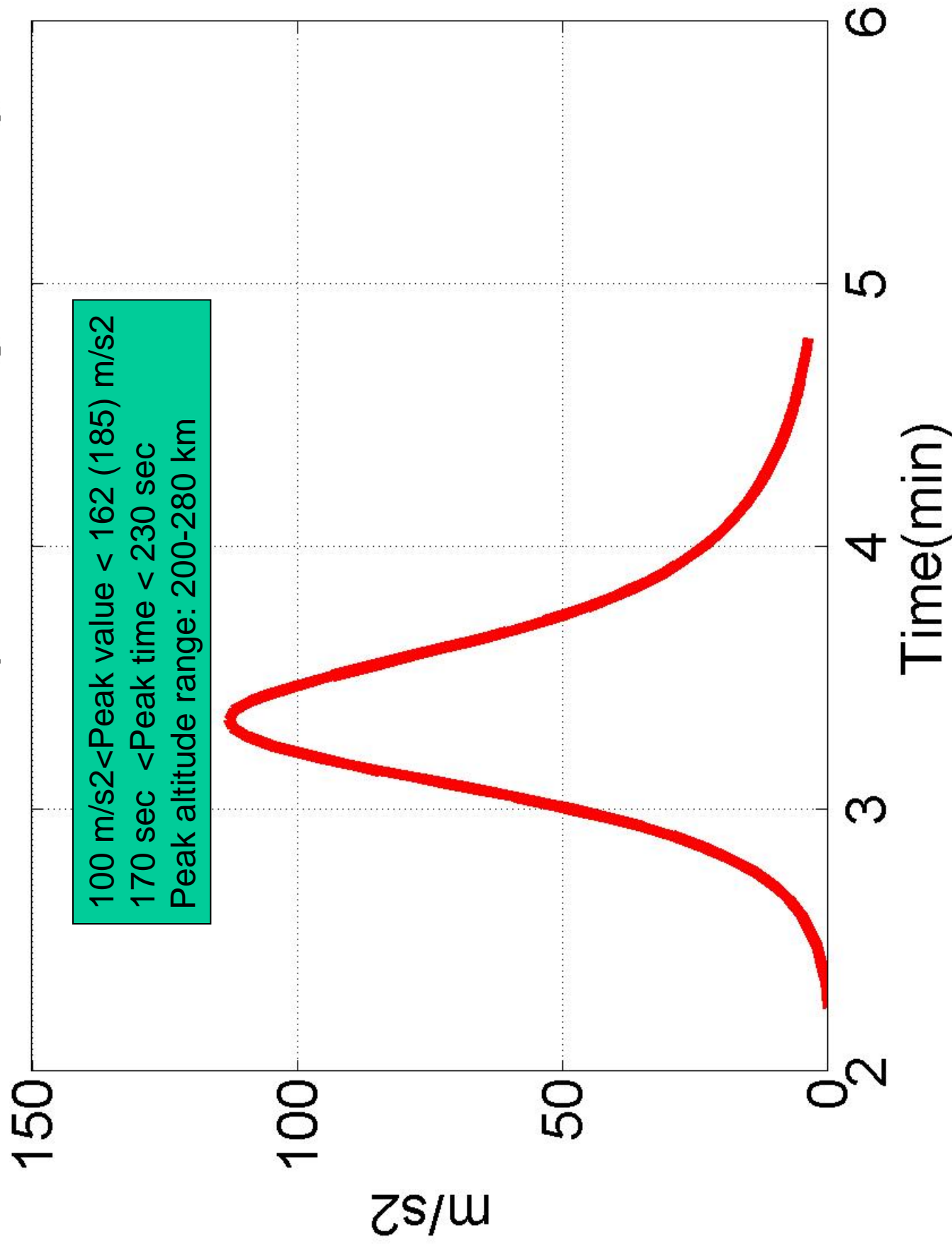


# Conclusions

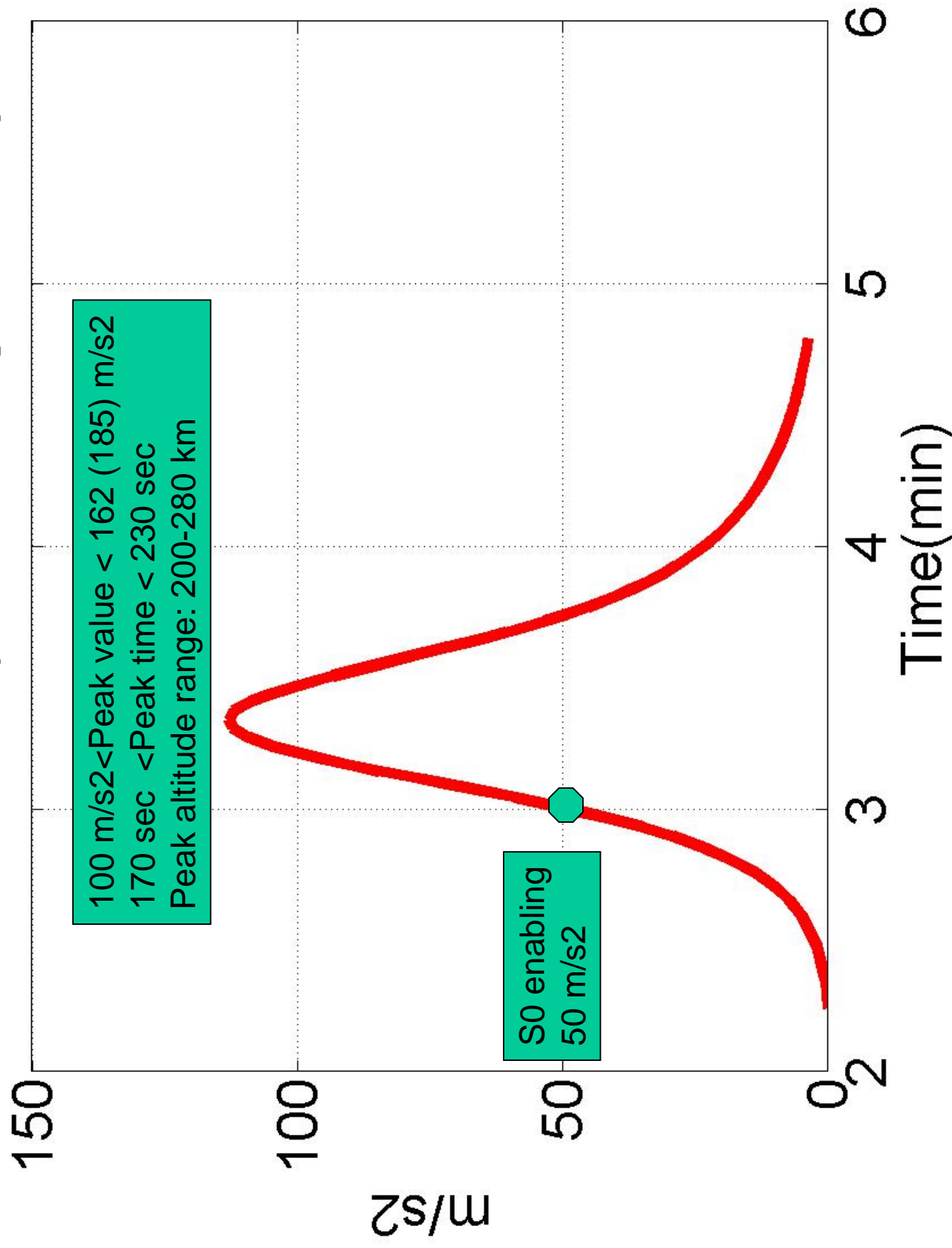
- Probe/Orbiter synergy approach to explore Titan
- Titan atmosphere seems to be well within Yelle envelope
- Some Huygens open issues in work; closure expected by early October. Possible outcome:
  - Baseline mission confirmed; target for entry at  $-65^\circ \pm 3^\circ$
  - Adjust entry angle ( $-64^\circ \pm 3^\circ$ ) or ( $-66^\circ \pm 3^\circ$ )
  - Delayed release on Tc (by up to 10 days ?) allows to reduce entry corridor but risks ; benefits not quantified
- Two contingency scenarios identified with probe release on later orbit: Overall mission impacts are high
- Look forward to PWS#3 !!

# •Back-up material

# Acceleration profile during the entry

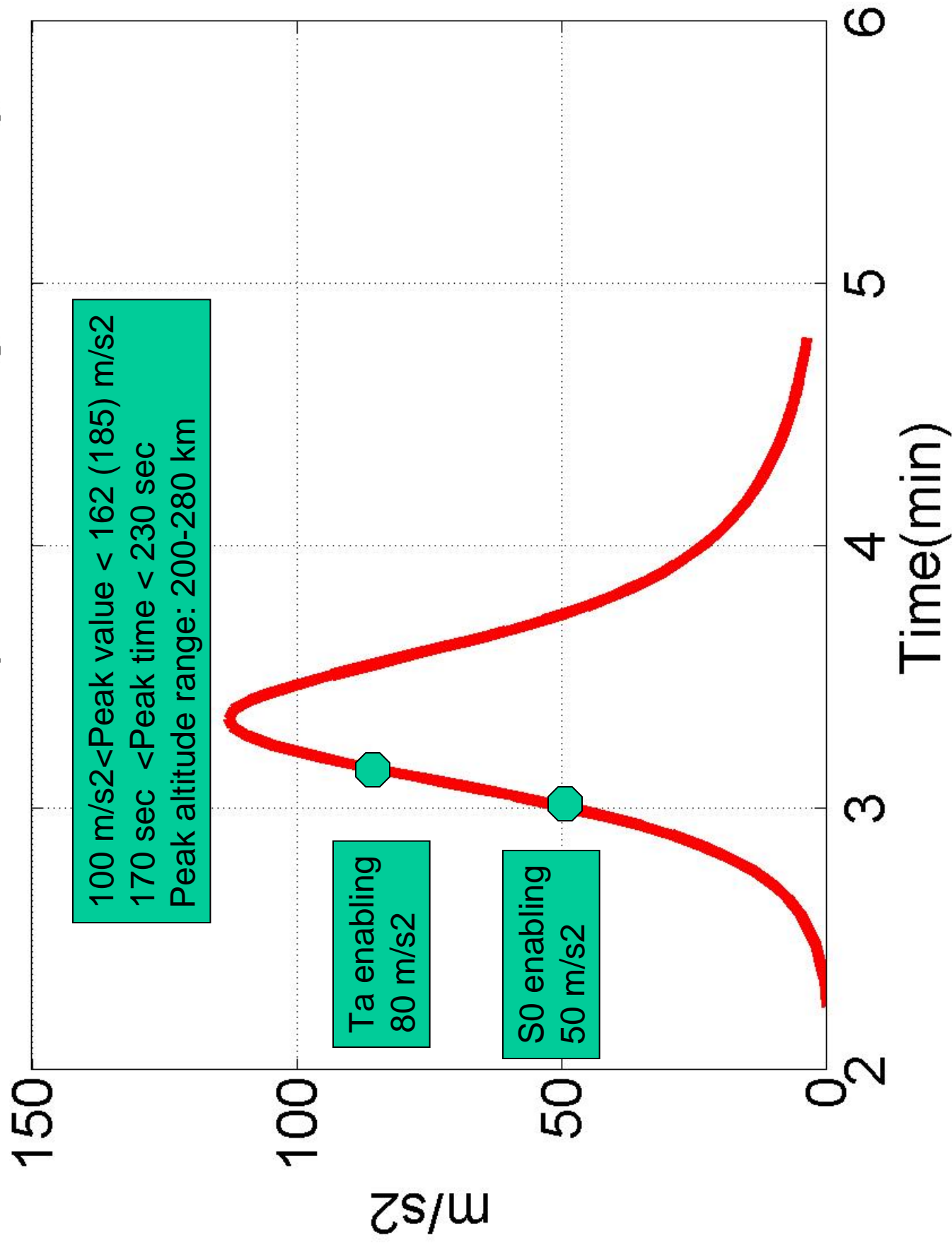


# Acceleration profile during the entry

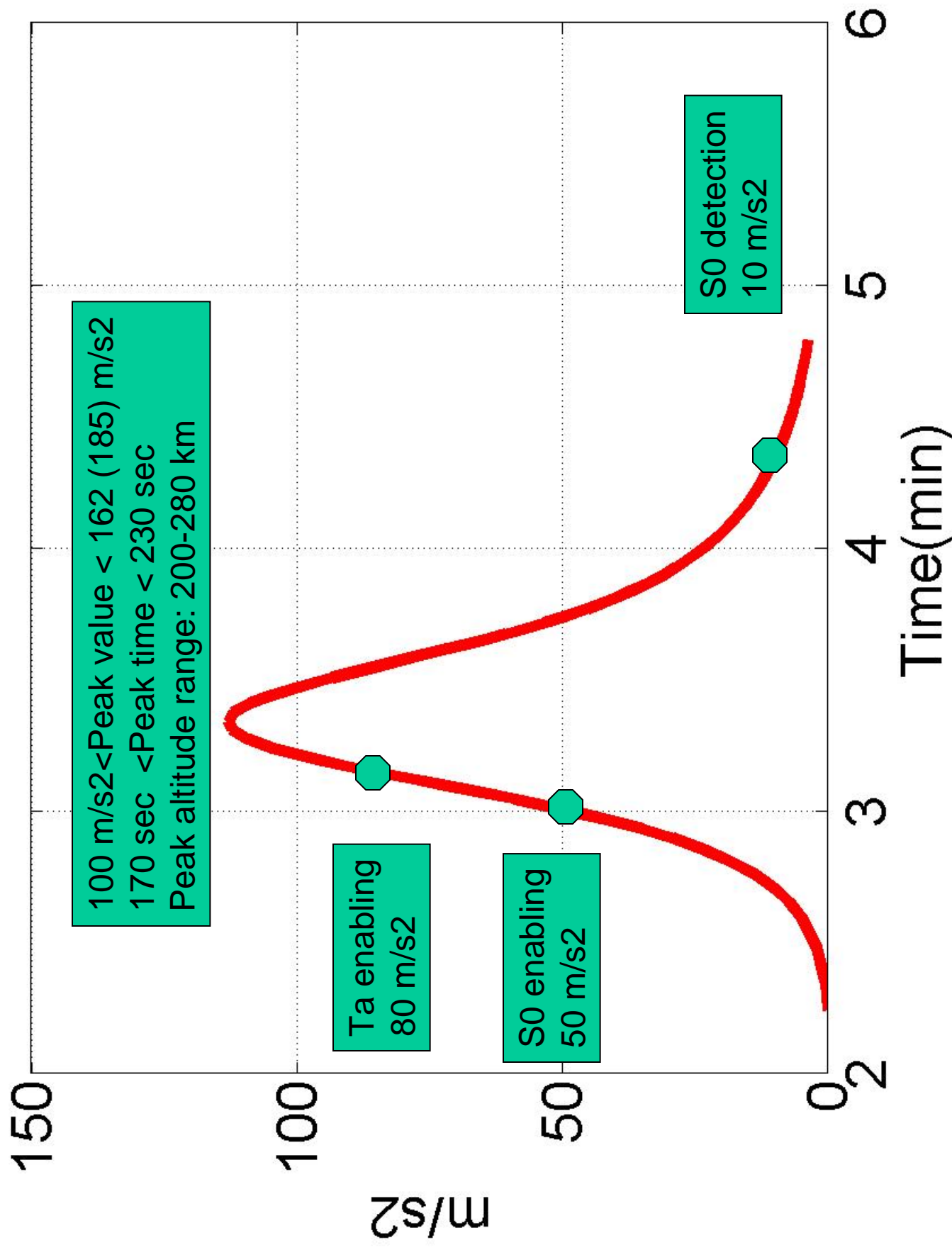




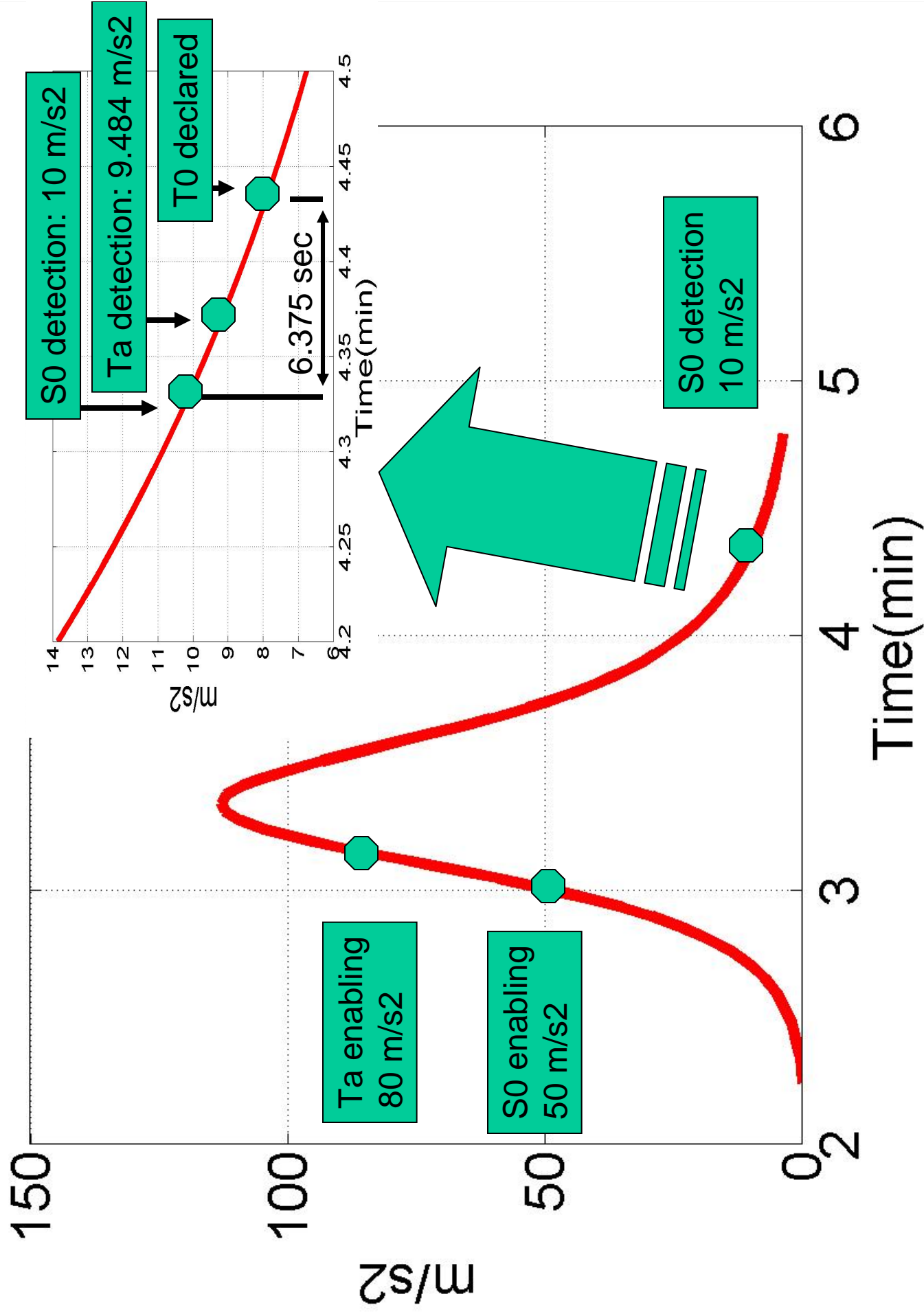
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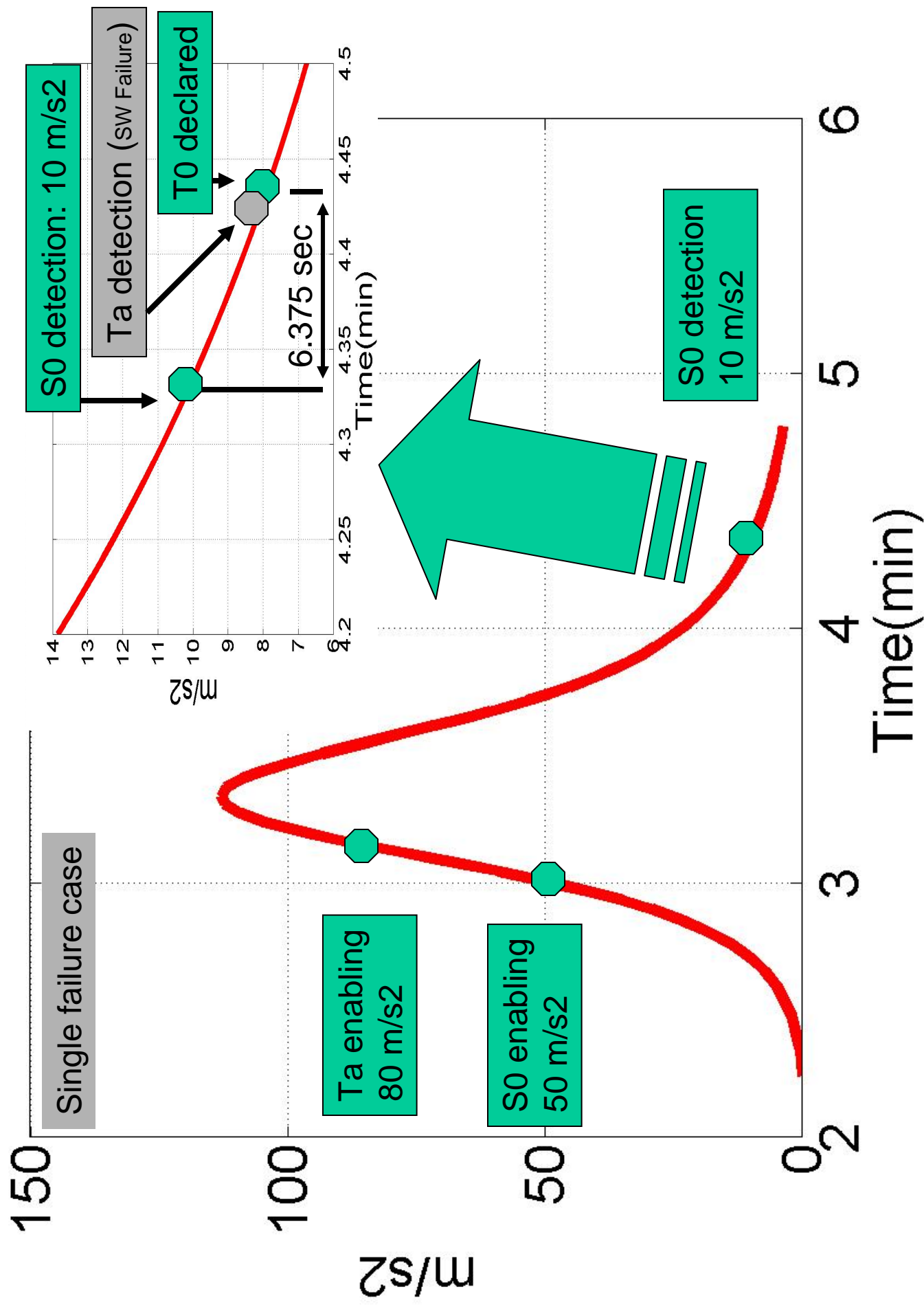
# Acceleration profile during the entry



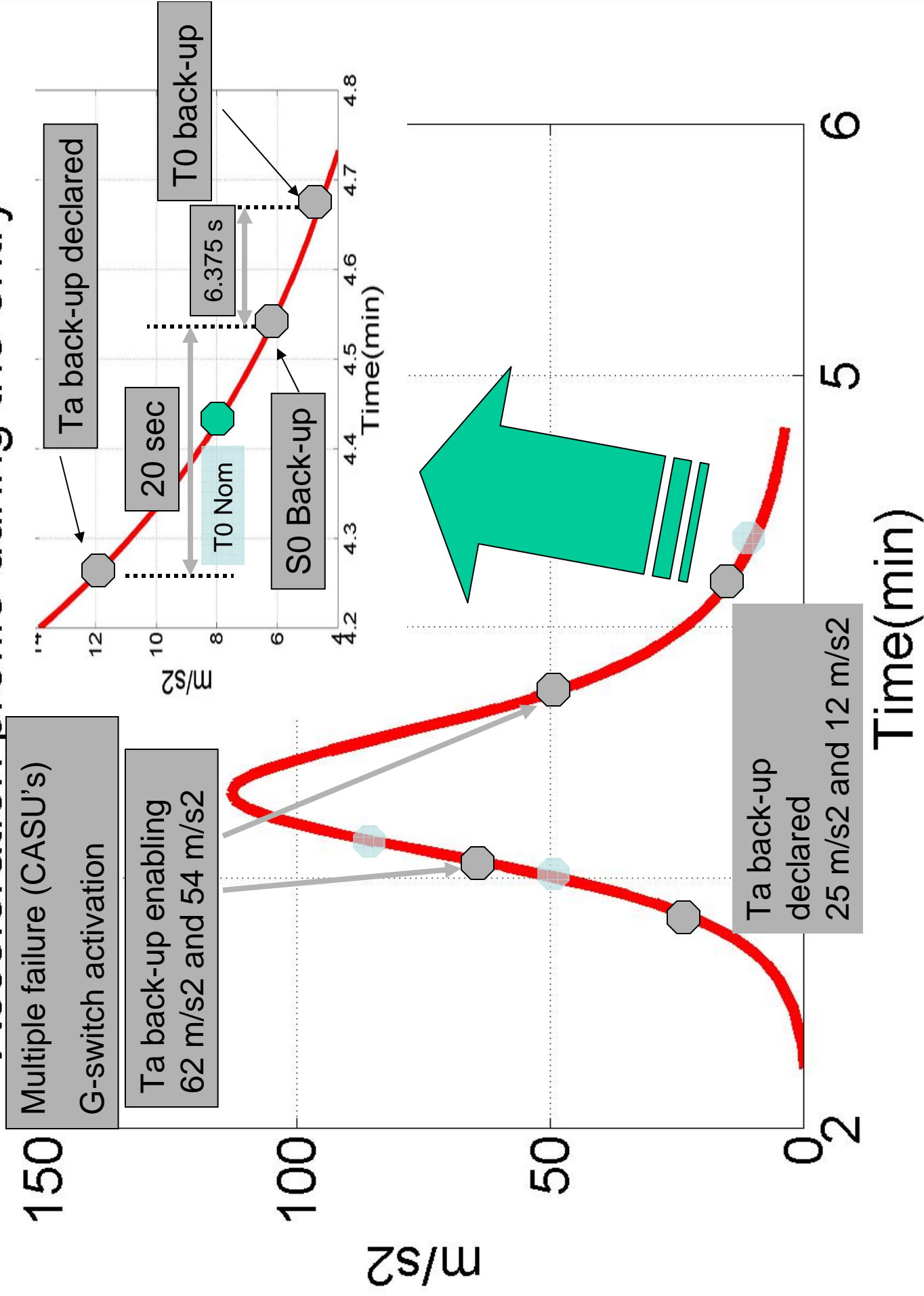
# Acceleration profile during the entry



# Acceleration profile during the entry



# Acceleration profile during the entry



# Zonal wind effects

