The Hera Entry Probe Mission to Saturn, an ESA M-class mission proposal

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Hera

- Daughter of Kronos, Father of the Olympians, and of Rheia (Rhea), daughter of Heaven and Earth.
- Granddaughter of Gaia (Earth).
- Hera was the wife and sister of Zeus, Father of Gods and Men.

Hera was swallowed by Kronos (Saturn) before being released by Zeus.

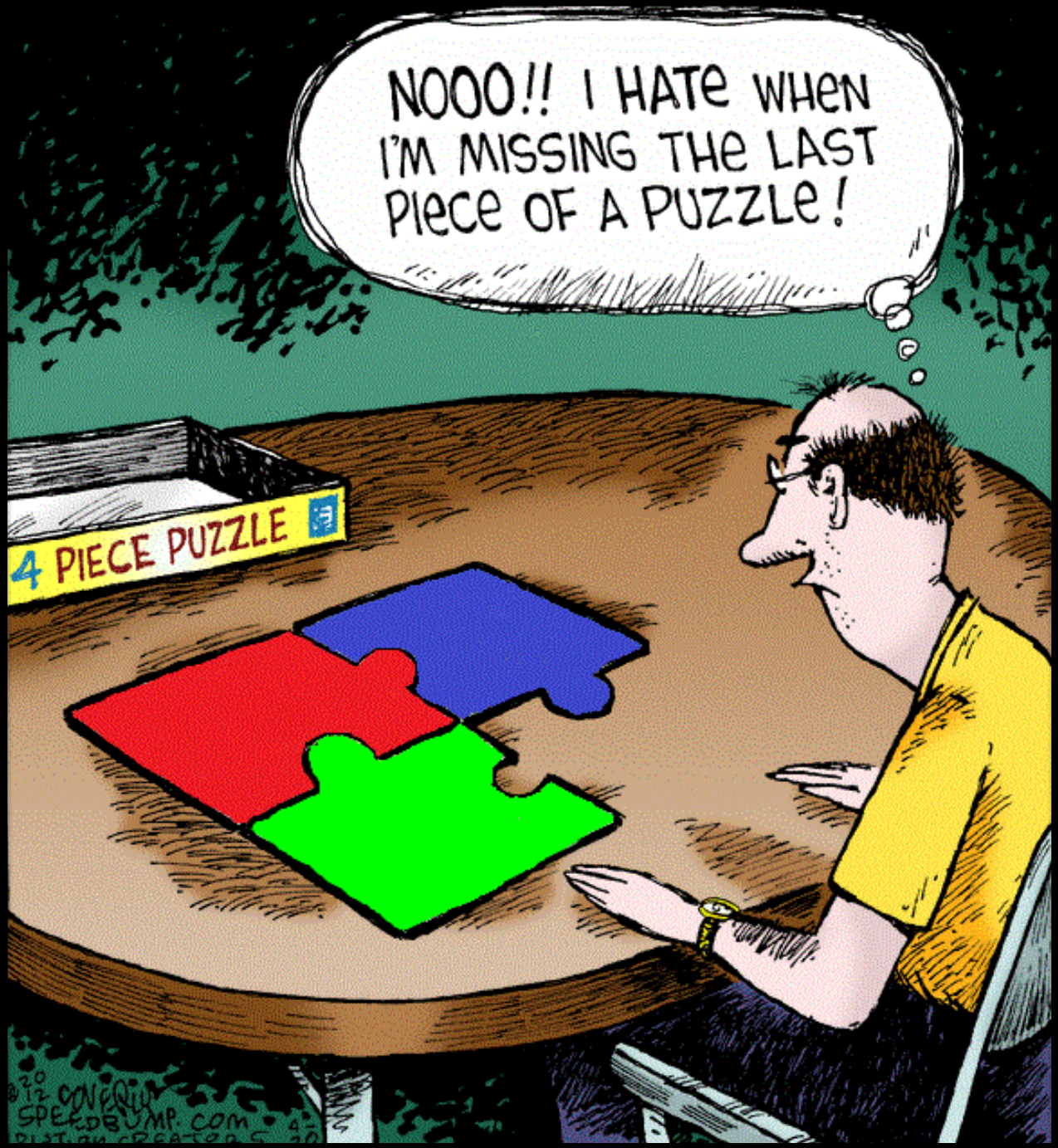
Science Justification for Exploring Giant Planets

Comparative planetology *of well-mixed atmospheres of the outer planets is key to the* ***origin and evolution of the Solar System****, and, by extension, Extrasolar Systems.*

Atreya, S. K. et al., "Multiprobe exploration of the giant planets – Shallow probes", Proceedings of the 3rd International Planetary Probes Workshop, Anavyssos, Greece, 2005.

There is only one Rosetta Stone in the solar system and it's in the British Museum. We cannot hope to understand the big problems of ***origin and evolution*** *by studying only one planet or one comet. Indeed, we must be able to make* ***comparative*** *studies even to understand a single planet. Thus our strong need to improve our knowledge of Jupiter is inextricably coupled to the necessity to achieve a comparable understanding of Saturn, Uranus and Neptune.*

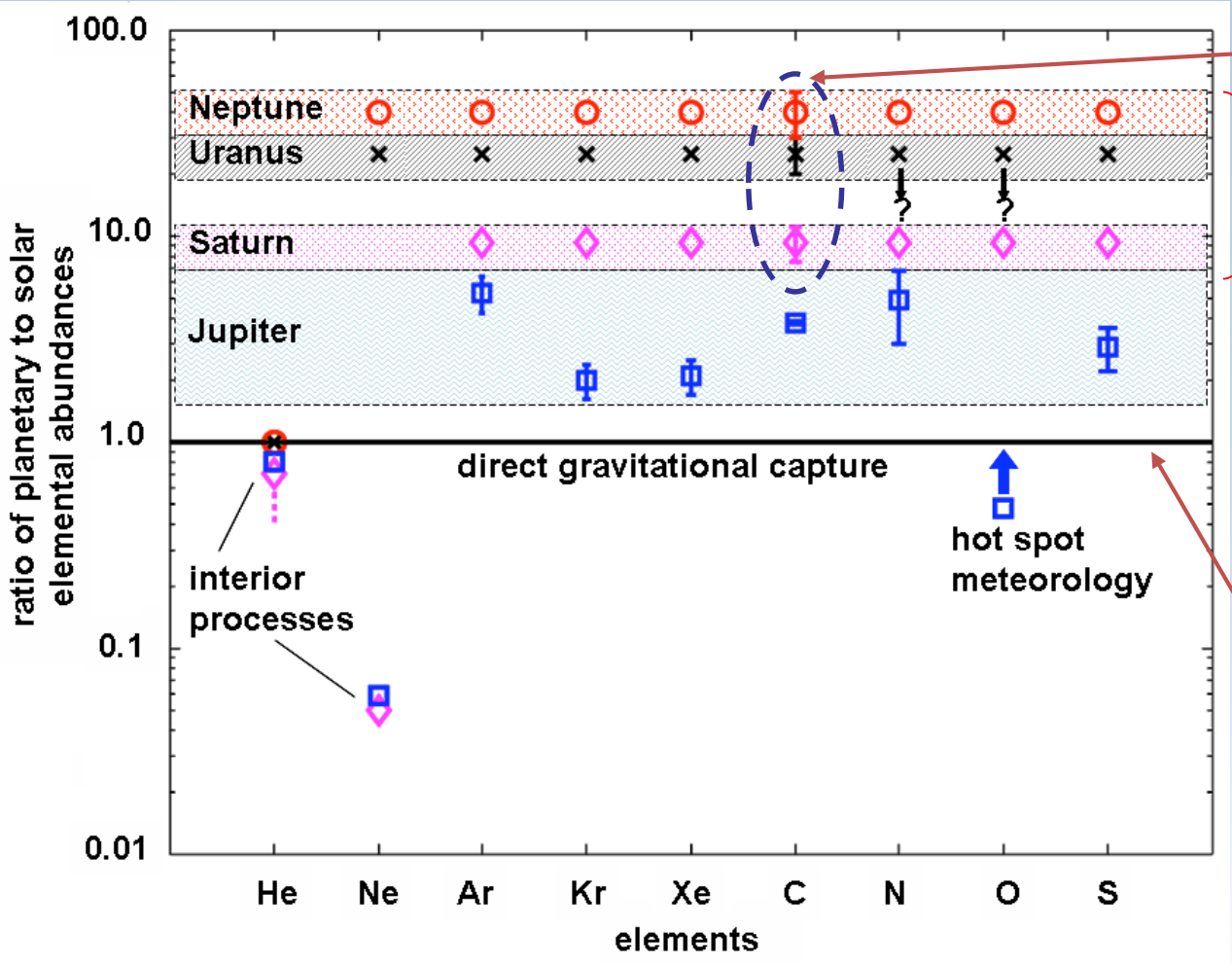
Owen, T., "Atmospheric Entry Probes: Needs and Prospects", Proceedings of the 1st International Planetary Probes Workshop, Lisbon, 2003.


NOOO!! I HATE WHEN I'M MISSING THE LAST PIECE OF A PUZZLE!
4 PIECE PUZZLE

Background

Heavy Elemental Abundances of the Giant Planets

(Relative to H in the atmospheres of the Giant Planets)



Saturn/Uranus/Neptune: only carbon is measured

Do not represent measured data; Based on predictions of icy planetesimal model assuming enhancement similar to carbon

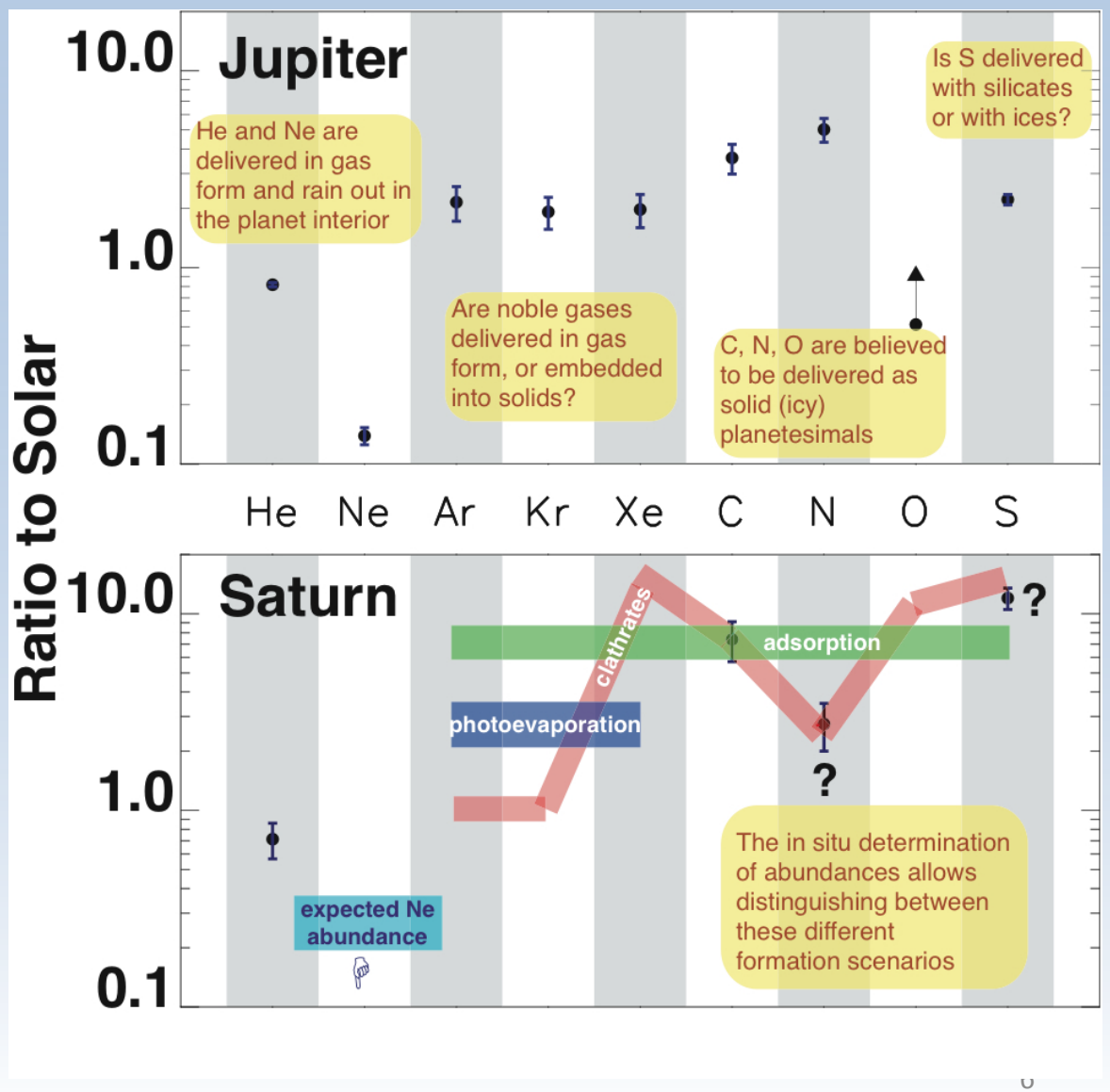
Jupiter data from Galileo Probe Mass Spectrometer

Represents elemental abundances (ratioed to hydrogen) being the same as in the Sun

Origin and Evolution of Solar System

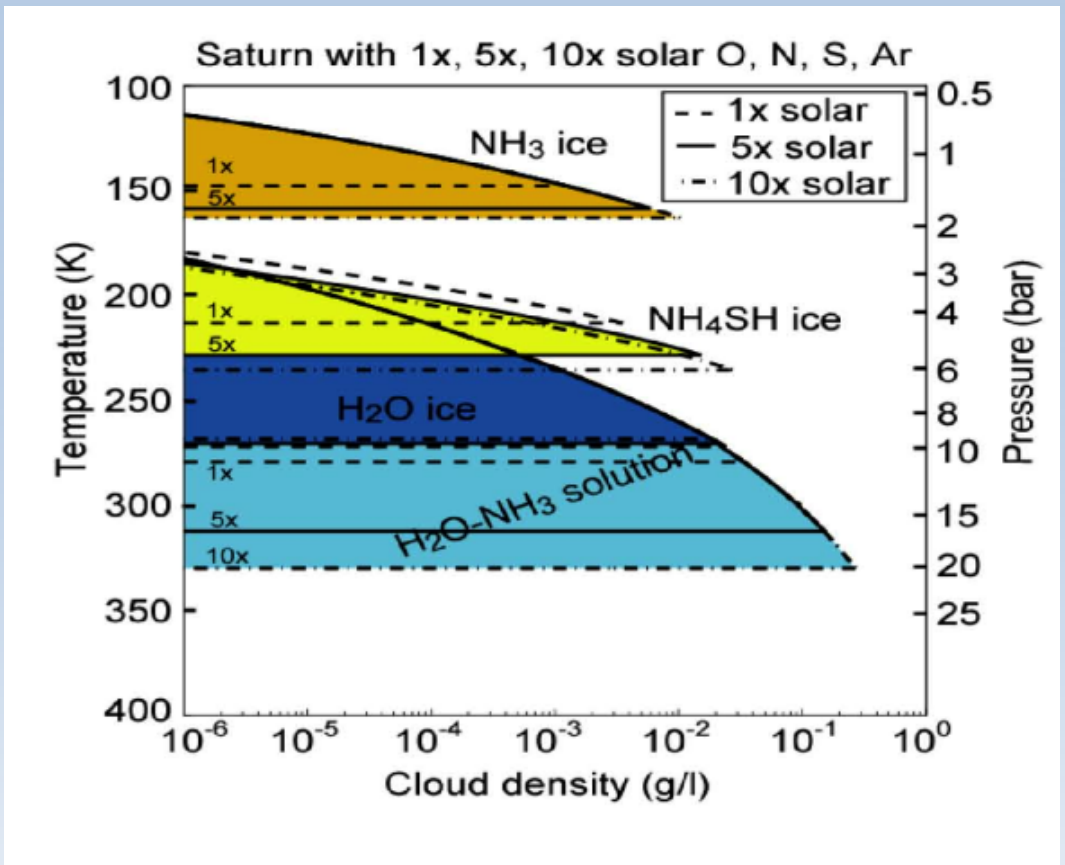
The Galileo probe found most noble gases to be enhanced relative to solar by a factor of 2 - 3 in Jupiter's atmosphere.

Different ?
Alternative theories of solar system formation and evolution predict different abundances of noble gases in Saturn's atmosphere.



Predicted Saturn Clouds

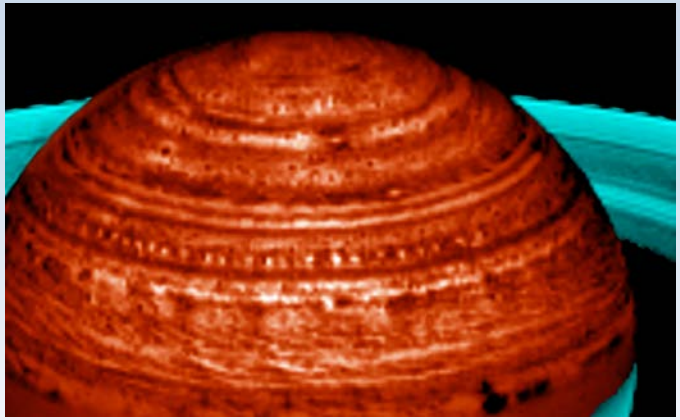
Liquid water clouds (or H_2O-NH_3 solution clouds) are the lowest altitude clouds in Saturn's atmosphere. Base of cloud is expected at 10-20 bars, but dynamical meteorology could push the base as deep as 45 bars.



Ref: Sushil Atreya, "SATURN PROBES: Why, Where, How?", International Planetary Probe Workshop, IPPW-4, Pasadena, California, June 2006

Science Goals

Origin and Evolution Saturn atmospheric elemental ratios relative to hydrogen (C, S, N, O, He, Ne, Ar, Kr, Xe) and key isotopic ratios (e.g., D/H, $^{15}N/^{14}N$, $^{3}He/^{4}He$ and other noble gas isotopes) relative to solar and Jupiter.



Planetary Processes Global circulation, dynamics, meteorology. Winds (Doppler and cloud track), interior processes (by measuring disequilibrium species, such as PH_3, CO, AsH_3, GeH_4, SiH_4).

Hera Saturn Entry Probe
Mission Concept

Heritage:

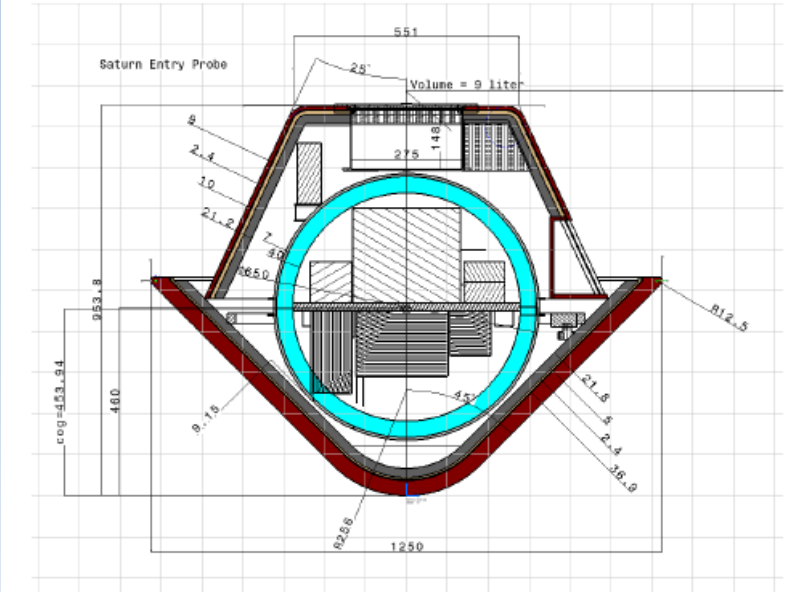
1) **Galileo** (NASA Flagship at Jupiter, 1996)

2) **KRONOS** (ESA L1-CV candidate, 2007)

3) **Planetary Entry Probe** Assessment Study (ESA, 2010)

4) **Cassini / Huygens** Original concept offered possibility of Saturn probe, but later proved not feasible.

KRONOS Saturn probe concept



Descent Science:

- ❑ Atmosphere composition from direct sampling (isotopic ratios, noble gases)
- ❑ Atmosphere dynamics
- ❑ Properties of cloud and haze layers
- ❑ Energy balance of atmosphere.

Approach and Flyby Science:

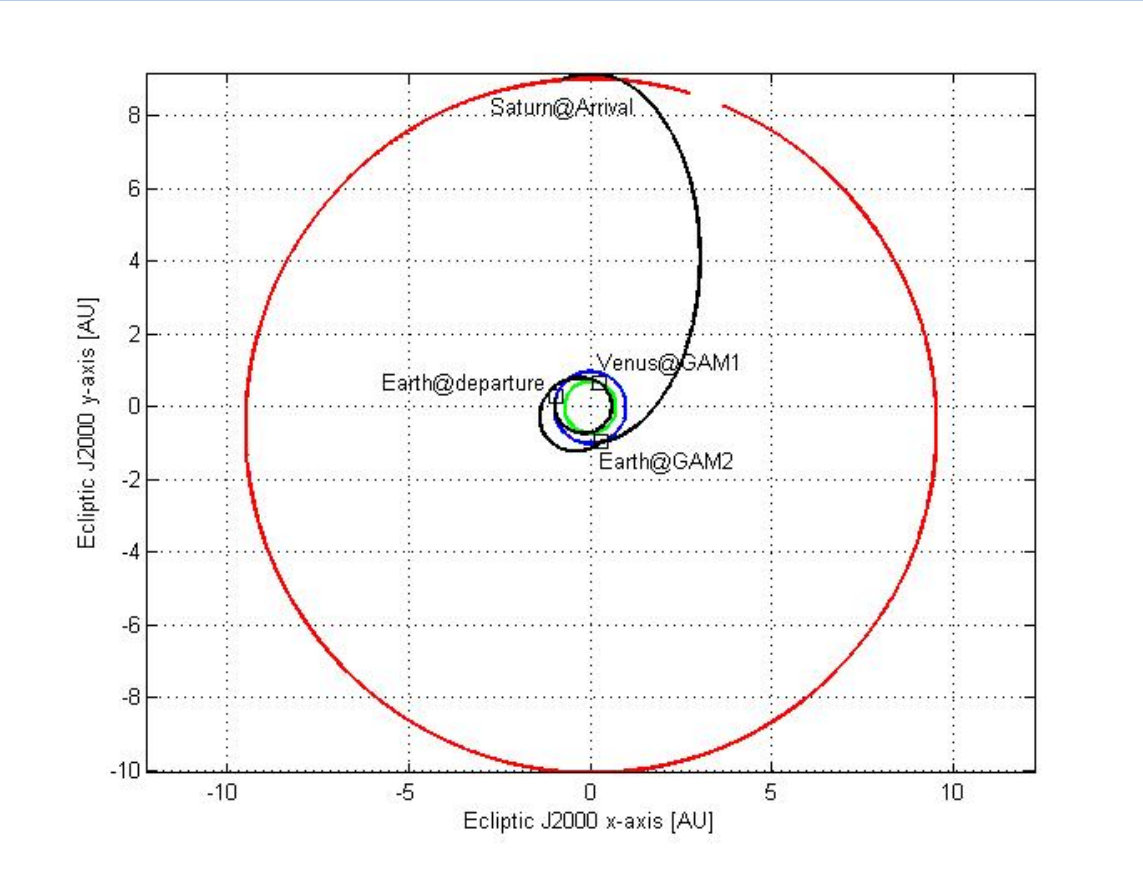
- ❑ Deep interior structure
- ❑ Saturn's atmosphere dynamics and clouds

Possible Saturn Probe Scientific Investigations

Instrument	Location	Measurement
Mass Spectrometer	Probe	Elemental, Chemical, and Istotopic Composition, Noble Gas Abundance
Atmospheric Structure Instrument	Probe	Pressure and Temperature
Radio Science Experiment	Probe	Atmospheric winds and waves
Nephelometer	Probe	Cloud structure, location, & density
Net-Flux Radiometer	Probe	Atmospheric Energy Balance
Camera	Carrier	Cloud structure, Winds, Probe Entry&Descent Location Context

Mission Architecture

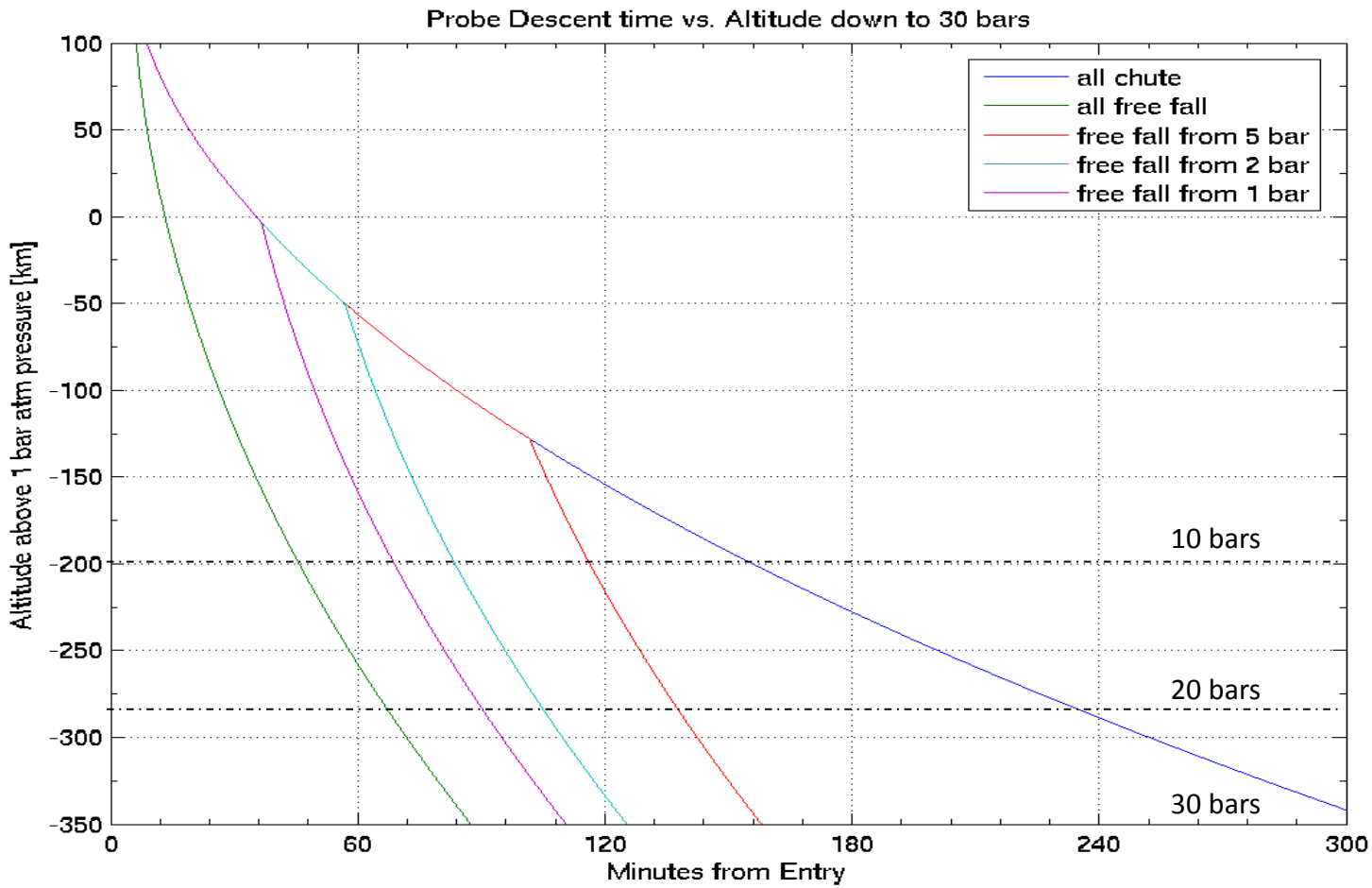
- Launch ~2025
- Inner solar system trajectory includes Venus and Earth flybys
- Arrival ~2033
- Solar Power (~300 W at Saturn)
- Flyby Carrier/Relay spacecraft
- Probe release from carrier ~several weeks before entry.
- Carrier science during Saturn approach and departure.
- Probe entry (< 30 km/s) much less difficult than Galileo at Jupiter (~48 km/s).
- Probe descent under parachute to 10 bars in ~75 minutes.



Architecture Options

Even with a focused payload, the problems of atmosphere attenuation and descent time are significant even for relatively shallow probes.

Parachute descent time can be up to 2.5 hours to reach 10 bars



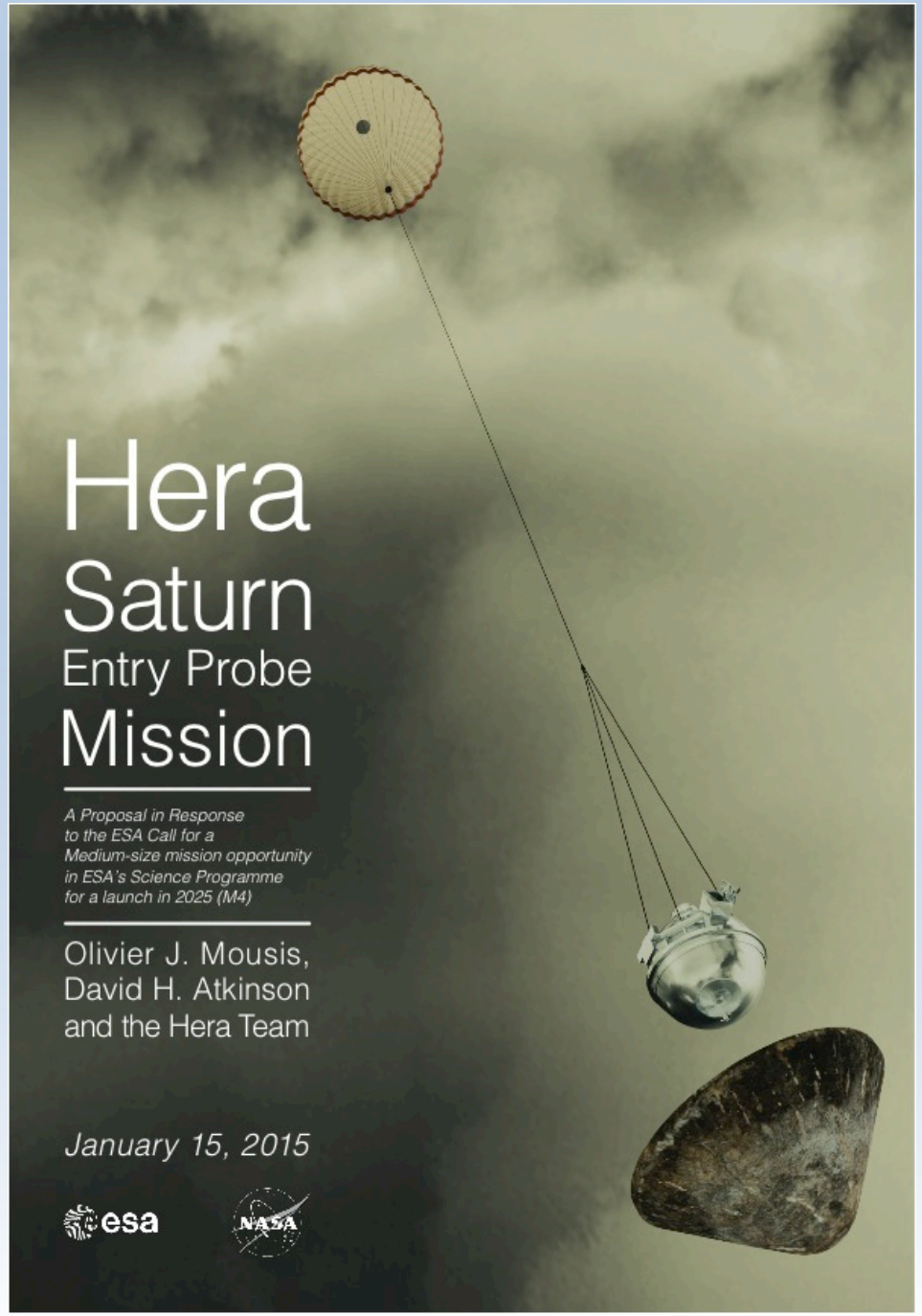
Saturn Probe
Proposal Opportunities

- **January, 2015** Submission to the 4th ESA Medium Class (M4) mission call including significant US contribution (probe TPS and aeroshell, solar panels, instruments).

  Not selected

- **September, 2015** ESA M5 ESA call. Plans underway to improve M4 proposal and submit.

- **September, 2016** NASA New Frontiers mission call expected.



Hera: Saturn Entry Probe Mission

Lead Proposer: Olivier J. Mousis
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Co-Proposer: David H. Atkinson
(University of Idaho, USA)

European *Hera* Team: 28 members from 8 EU countries
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G. Fischer (AUT), L. Fletcher (UK), D. Gautier (FR),
T. Guillot (FR), A. Holland (UK), R. Hueso (ES),
C. Keller (NL), E. Kessler (DE), J.-P. Lebreton (FR),
M. Leese (UK), P. Levacher (FR), B. Marty (FR),
A. Morse (UK), O. Munoz (ES), J. Poncy* (FR),
F.-X. Schmider (FR), J.-B. Renard (FR),
A. Sánchez-Lavega (ES), S. Sheridan (UK),
F. Snik (NL), D. Stam (NL), P. Wurz (CH)

US *Hera* Team: 14 members
M. Amato, S. Aslam, S. Atreya, D. Banfield, T. Colaprete,
J. Fortney, R. Frampton*, J. I. Lunine, C. Nixon, K. Reh,
G. S. Orton, T. Spilker, E. Venkatapathy, J. H. Waite

A list of international scientists who have indicated their support for this proposal is indicated on the website: http://mission.lam.fr/hera

*Industrial team members from Thales Alenia Space and Boeing who contributed to the development of the mission architecture in the proposal.

Image courtesy of T. Balint

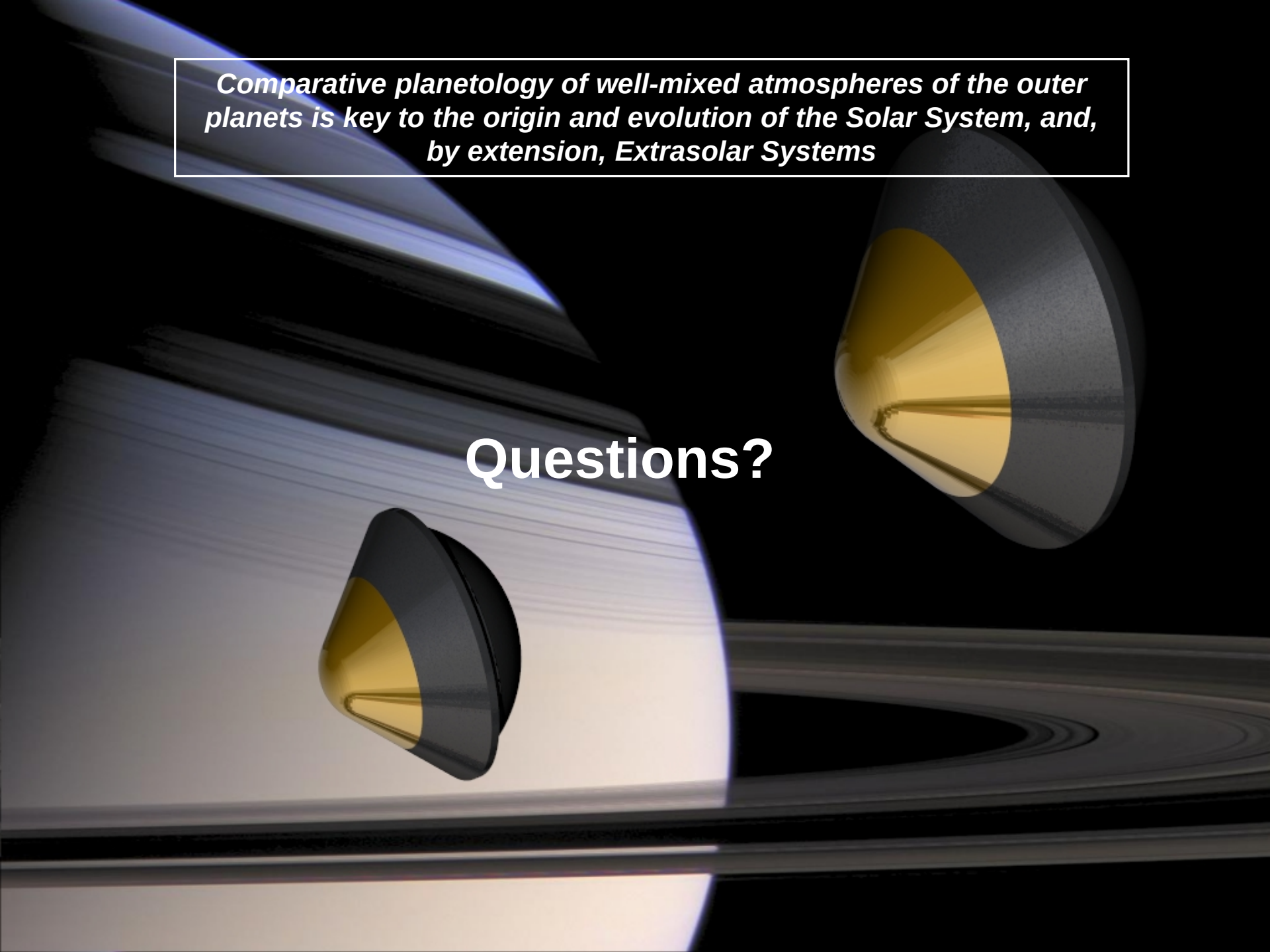
Conclusion

- Critical, high-priority science at Saturn can be accomplished with shallow probes. A **very focused** set of measurements should allow mission to be proposed under New Frontiers costcap.

- Maintaining a disciplined approach to minimizing the payload will ripple through the system, reducing required mass, power, data rates, and total data volume.

- These savings can result in a overall **reduction in probe size (by ~50% or more)**, which in turn enables consideration of possible orbiter and multiple-probe concepts.

Comparative planetology of well-mixed atmospheres of the outer planets is key to the origin and evolution of the Solar System, and, by extension, Extrasolar Systems



Questions?