# **SPRITE:** **S**aturn **PR**obe **I**nterior and a**T**mosphere **E**xplorer

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# Decadal Survey Saturn Probe

### *PSDS Highest Priority Science Objectives*

1. Determine the noble gas abundances and isotopic ratios of H, C, N, and O in Saturn's atmosphere.
2. Determine the atmospheric structure at the probe descent location.

### *PSDS Lower Priority Science Objectives*

1. Determine the vertical profile of zonal winds as a function of depth at the probe descent location(s).
2. Determine the location, density, and composition of clouds as a function of depth in the atmosphere.
3. Determine the variability of atmospheric structure and presence of clouds in two locations.
4. Determine the vertical water abundance profile at the probe descent location(s).
5. Determine precision isotope measurements for light elements such as S, N, and O found in simple atmospheric constituents.

SOURCE: NASA Mission Study (transmitted from Leonard Dudzinski, NASA SMD/Planetary Science Division

NASA GSFC, JPL/Caltech

# Science Overview

- The giant planets in our solar system contain clues to the origin of the planets and the conditions that set up terrestrial planet formation
  - Comparative study of Jovian and Saturnian composition and structure maps gradients in time and space in our protoplanetary disk
  - Jupiter will be well studied after Galileo/Juno, but which of its features (core size, circulation, etc.) are unique vs universal?
  - *Cassini* will leave knowledge gaps about Saturn that are critical pieces of the puzzle of solar system formation and can only be filled by *in situ* sampling
  - These will be key also for understanding exoplanet systems

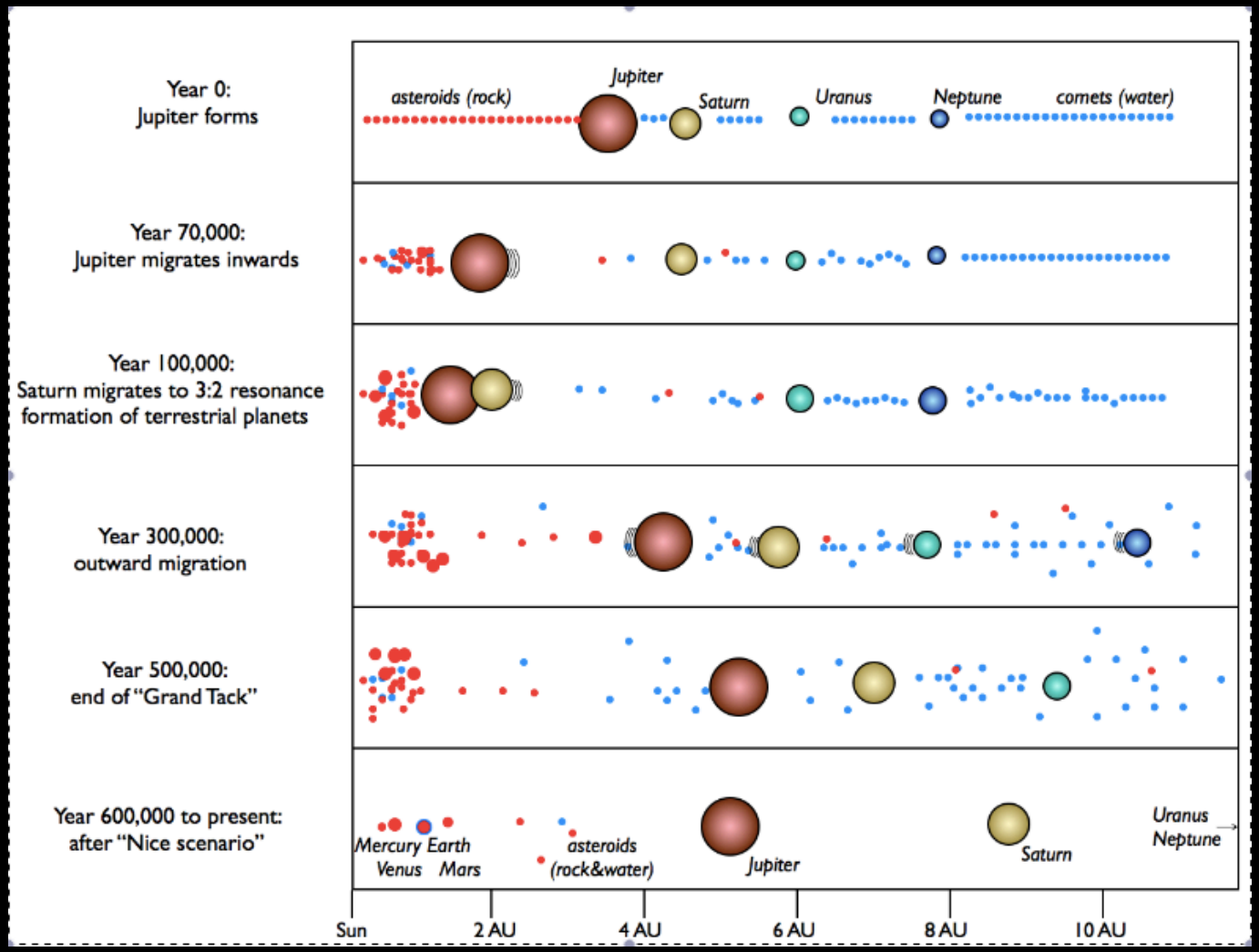
# SPRITE Mission Science Goals and Objectives

- Goal I. Understand Saturn's formation and early evolution
  - Obtain a chemical inventory of Saturn's troposphere to distinguish between competing models of planet formation and extent of migration in the early solar system.
  - Constrain Saturn's He depletion to reconcile observed temperatures with thermal evolution models.

- Goal II. Reveal the actual conditions beneath Saturn's clouds
  - Measure Saturn's atmospheric chemistry *in situ* to test condensation models and to interpret remote sensing observations.
  - Perform *in situ* characterization of Saturn's tropospheric clouds to understand their structure and provide ground truth for cloud retrieval models.
  - Measure *in situ* Saturn's 3-D atmospheric dynamics along the probe descent path to better understand global circulation and constrain analytical models of the time-variable cloud top motions

***Critical investigations into Saturn's formation and evolution require* in situ *measurements that also provide ground truth for remote sensing observations.***

# Goal 1: Saturn's Formation and Early Evolution

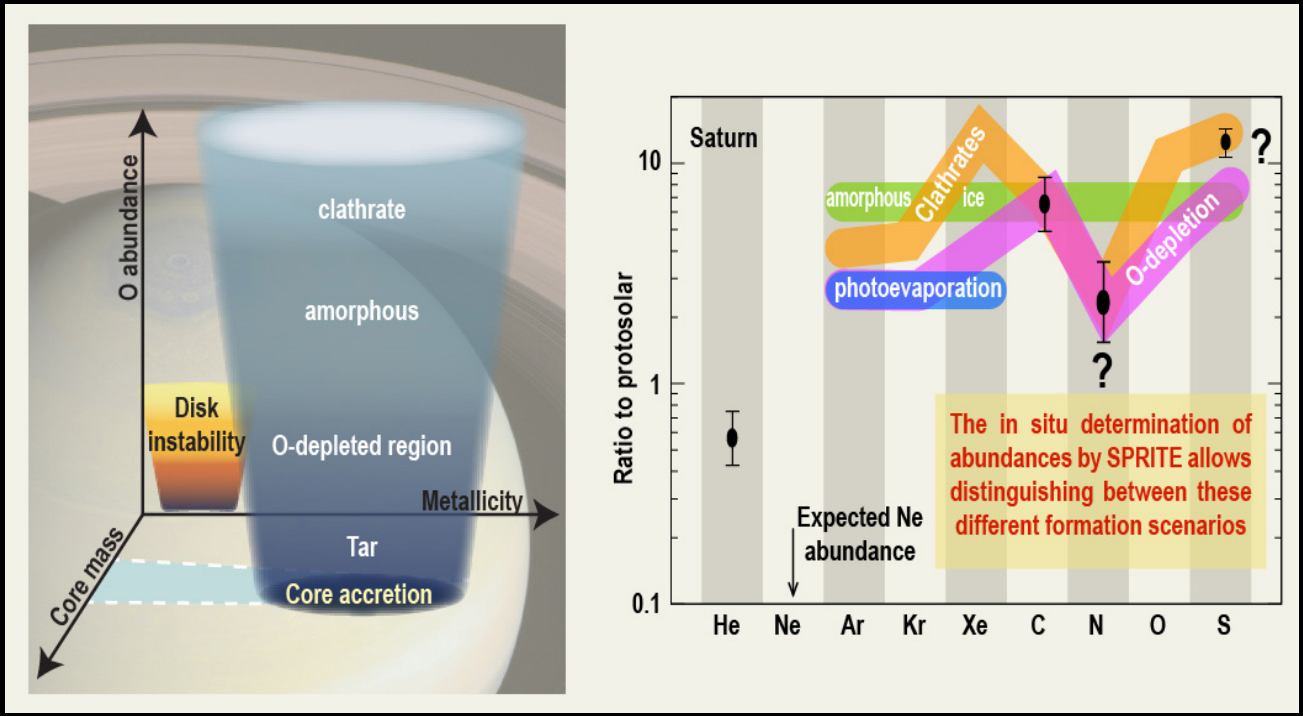



Did Saturn stop Jupiter's inward migration?

Need to know when and where it formed!

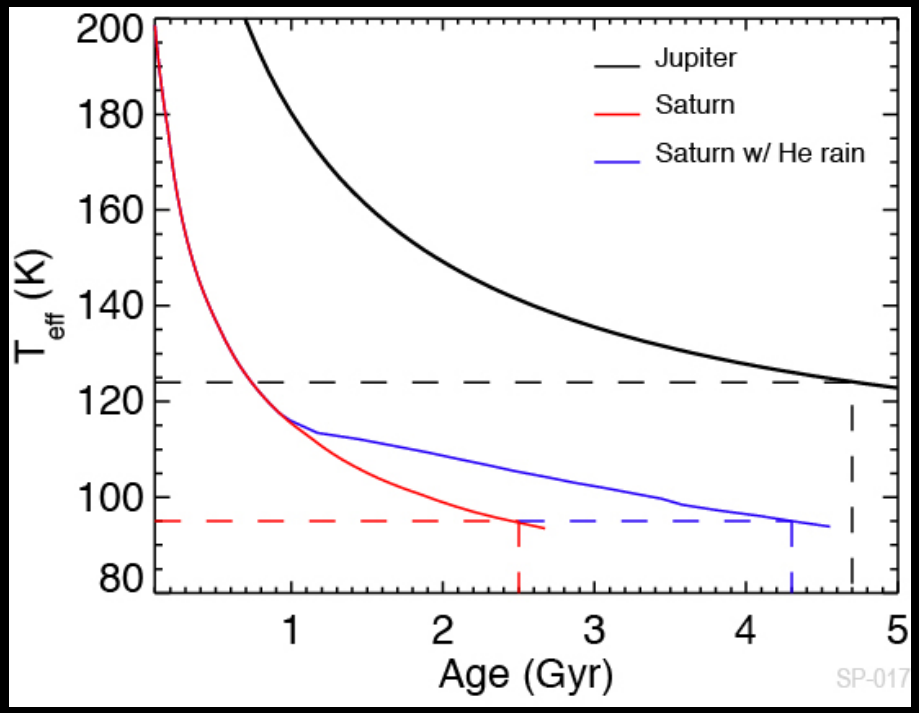
http://www.exoclimes.com/wp-content/uploads/2014/07/GrandTackIllustration1.png

# Objective 1: Composition




Light elemental and noble gas abundances will tell us when and where Saturn formed, as well as distinguish among protosolar nebula models

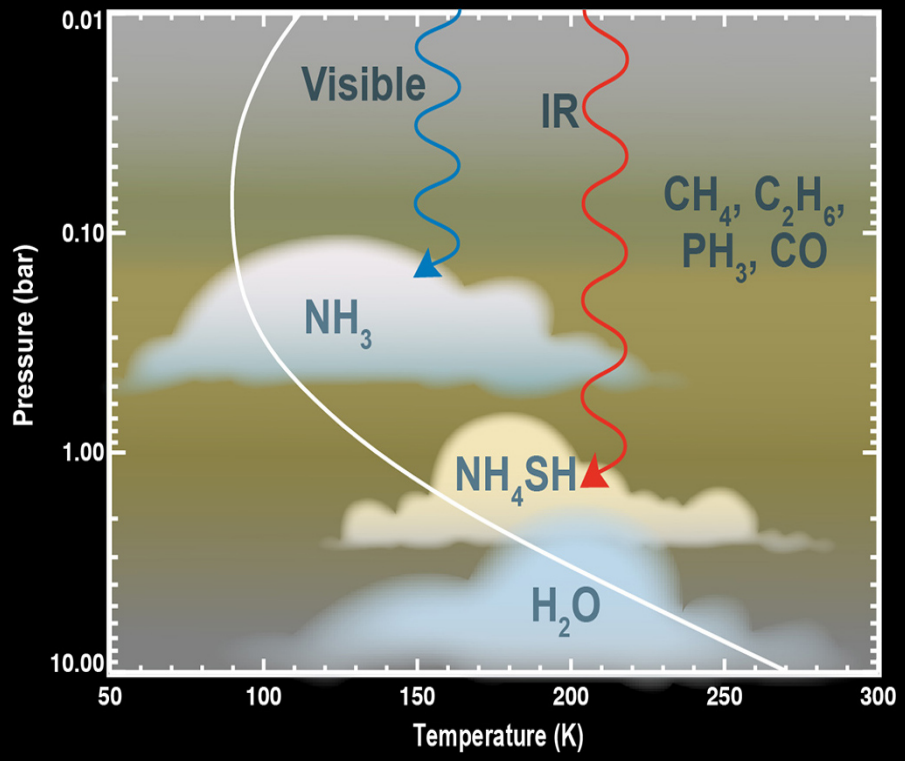
# Objective 2: Helium abundance and thermal evolution




Saturn's observed effective temperature is too warm if it formed 4.6 Gyr ago.

Helium rain or internal structure can prolong thermal evolution

# Goal 2. Actual Conditions Beneath Saturn's Clouds




Remote sensing limits us primarily to the upper cloud decks, hiding deeper composition and motions

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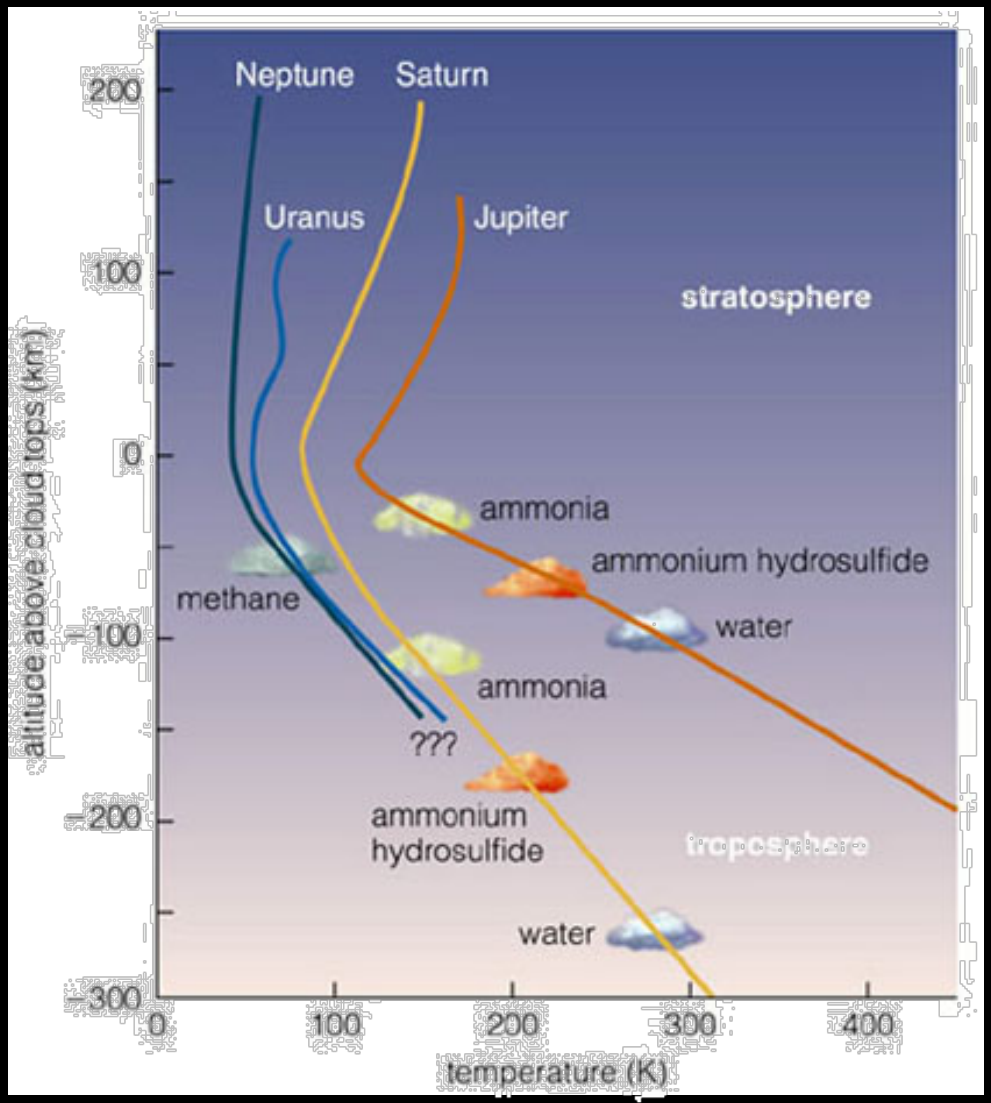
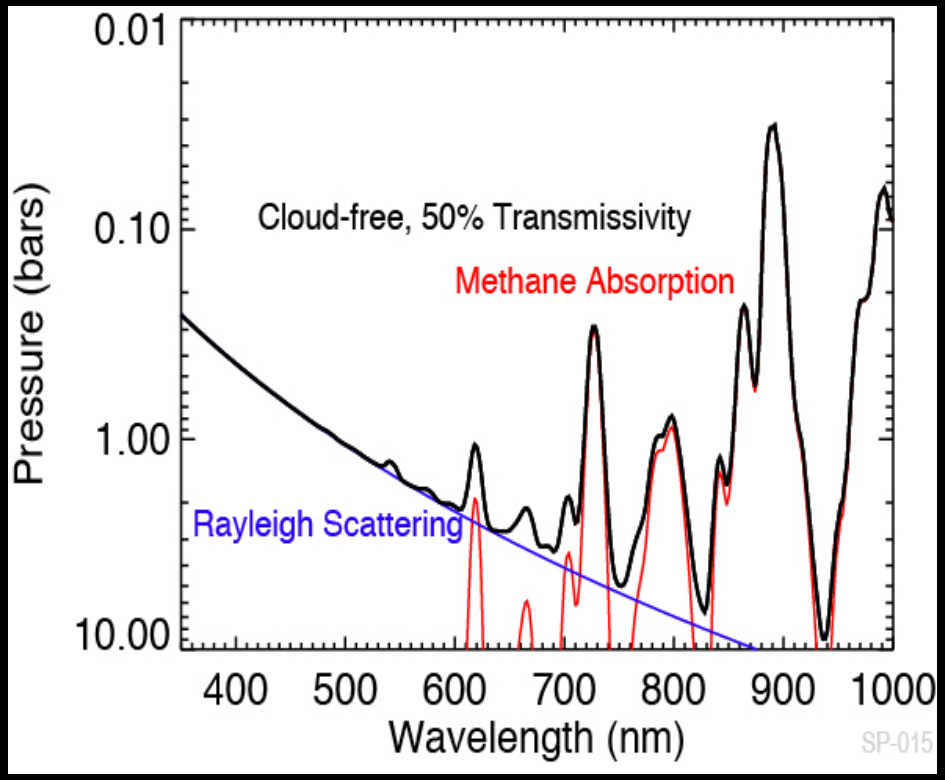
# Objective 3. Cloud chemistry




What are Saturn's cloud layers?

Direct measurement of condensable species, plus temperature profile to distinguish cloud forming regions

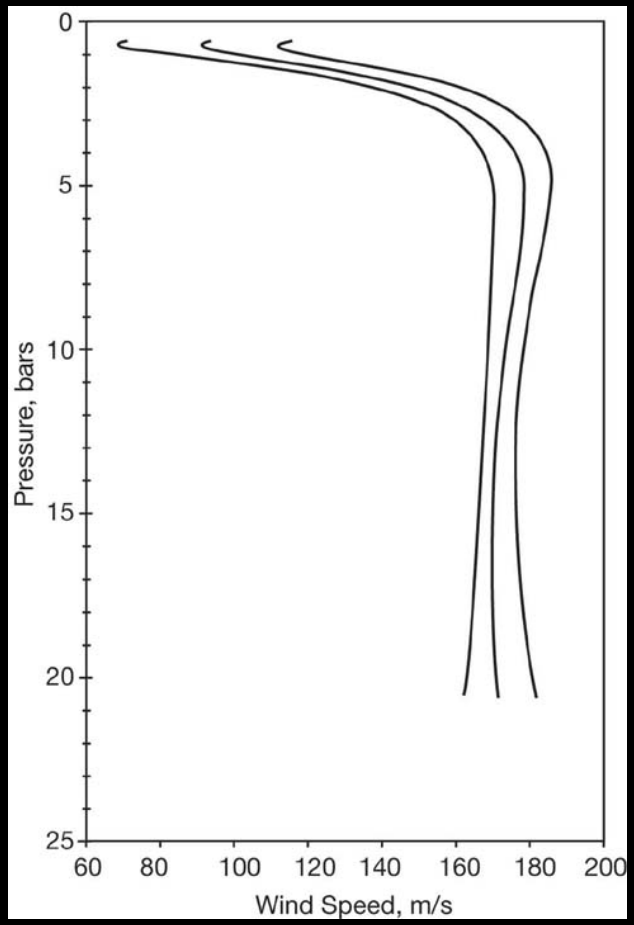
# Objective 4. Measurements of Cloud Structure




Hazes and cloud reflections vary with wavelength, allowing some constraint from remote sensing.

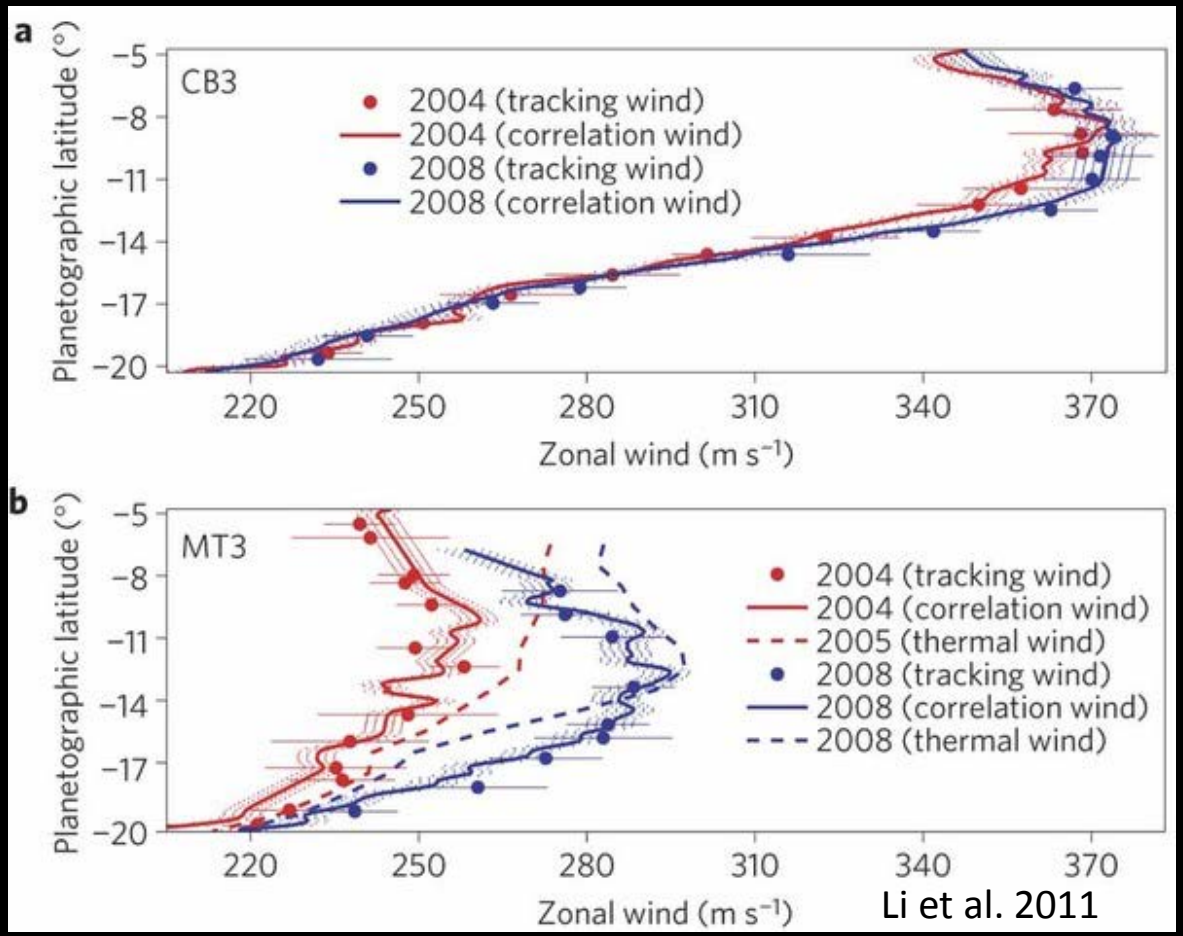
Direct measurement of cloud particles provides ground truth.

# Objective 5. 3-D Dynamics



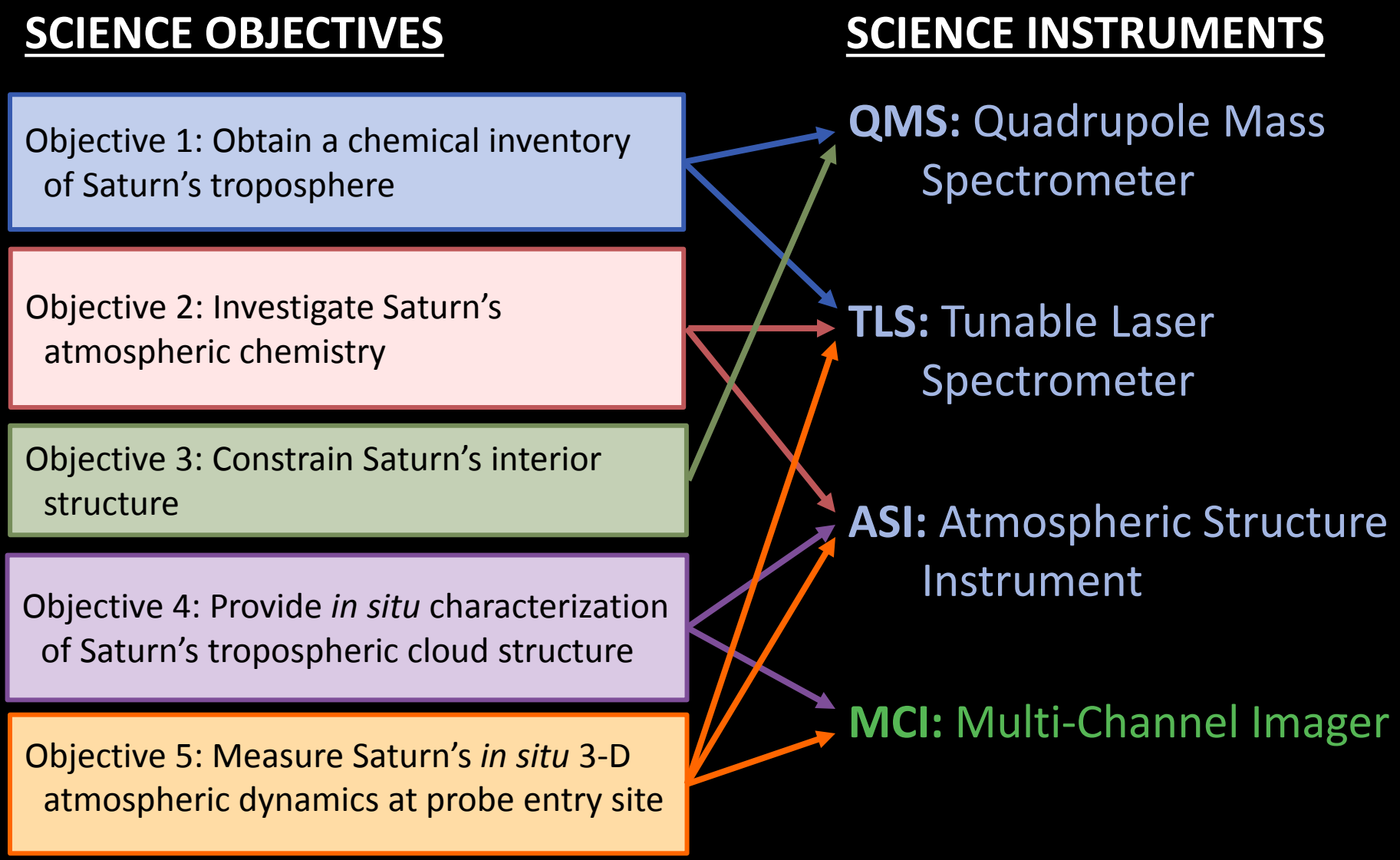

Galileo Probe showed high speed winds below Jupiter's clouds, and waves above. Does Saturn do the same?

Saturn's winds vary at low latitudes over time and altitude



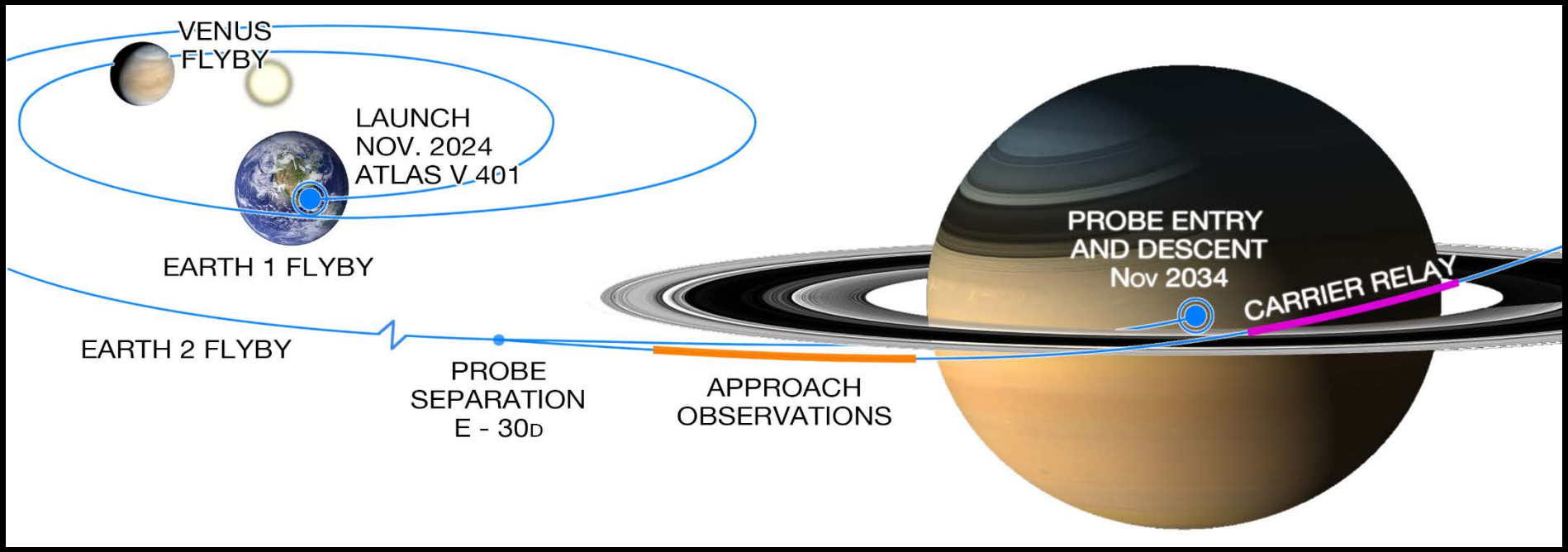

Li et al. 2011

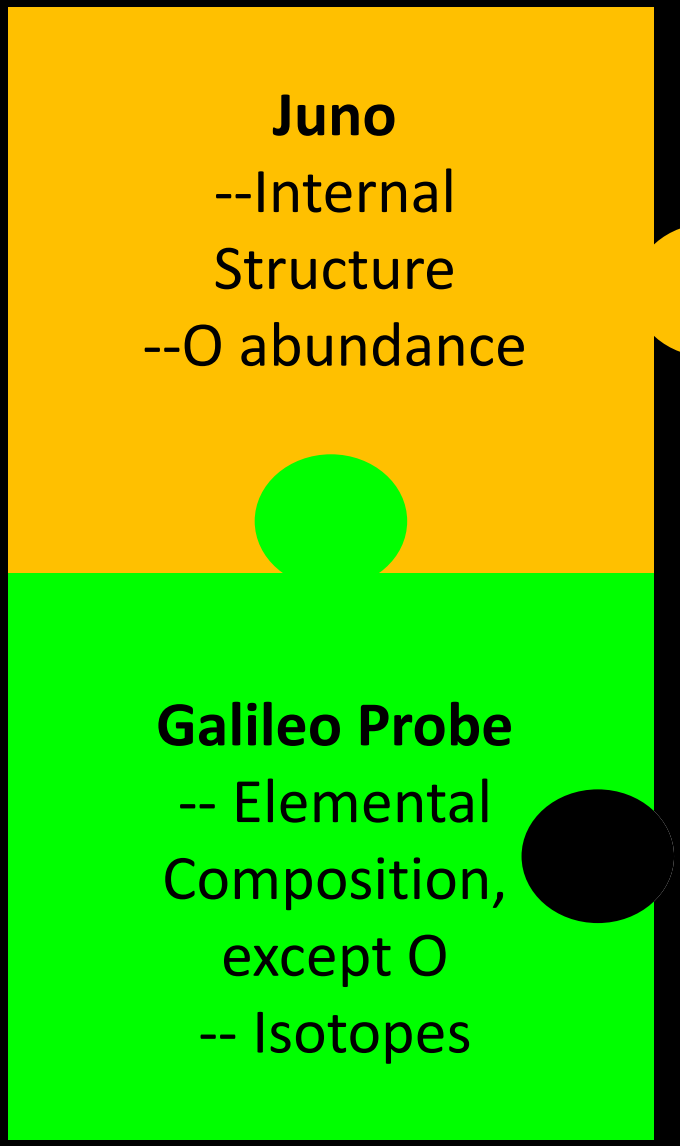
# Science Implementation: Payload



# Mission Architecture Overview

- Solar-powered Carrier-Relay Spacecraft (CRSC) carries atmospheric probe
  - Probe released at Entry T-30 days on battery power
  - CRSC performs a divert maneuver to relay trajectory
  - Relay: ~80 minute descent, 120 minute relay window
- CRSC tracks Probe, records data; relays back to Earth after flyby
- Multiple launch opportunities



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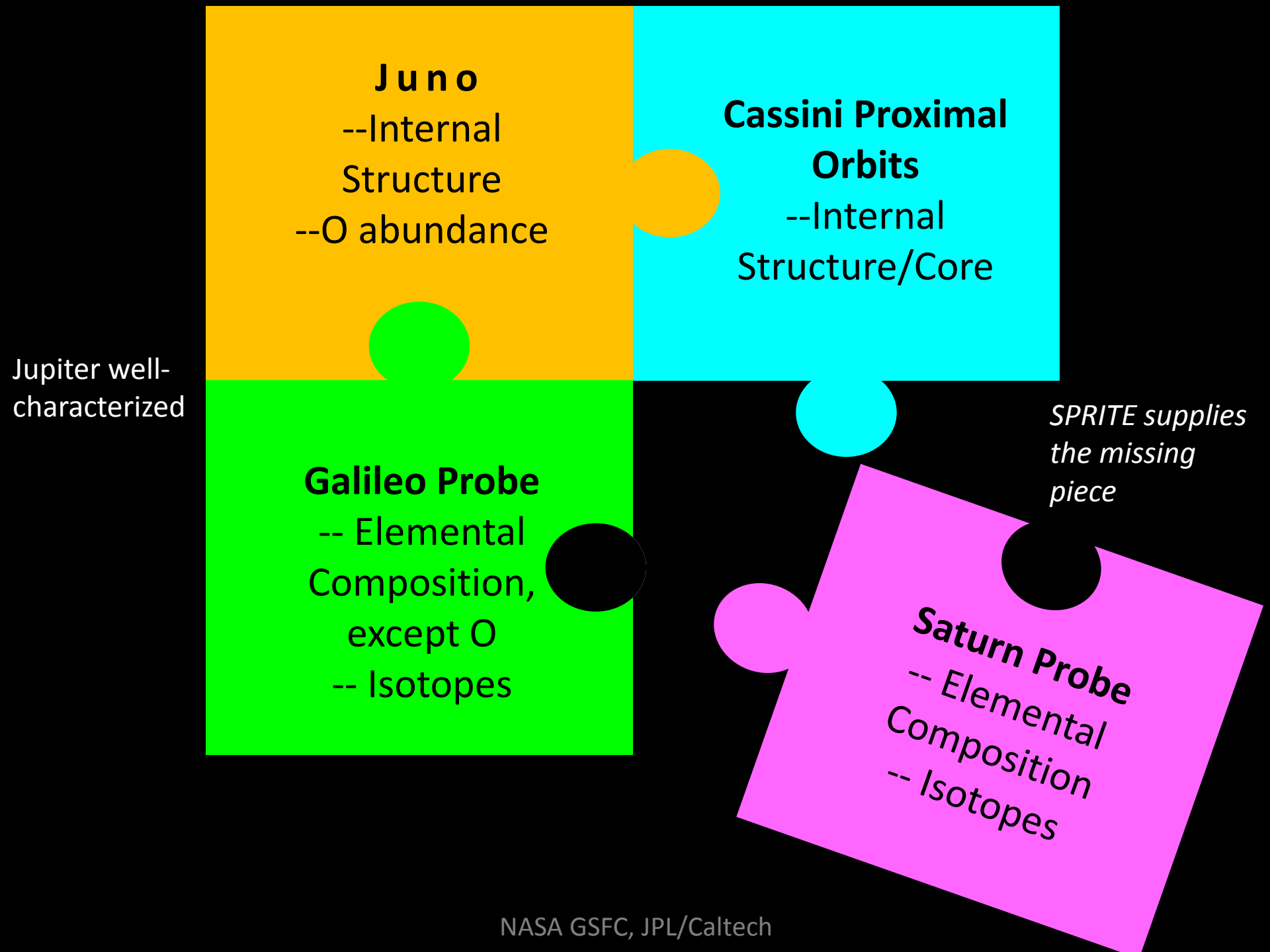
Juno
--Internal Structure
--O abundance
Cassini Proximal Orbits
--Internal Structure/Core
Jupiter well-characterized
Galileo Probe
-- Elemental Composition, except O
-- Isotopes
SPRITE supplies the missing piece
Saturn Probe
-- Elemental Composition
-- Isotopes
NASA GSFC, JPL/Caltech

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# *Questions?*