The Early eVolution Explorer (EVE)

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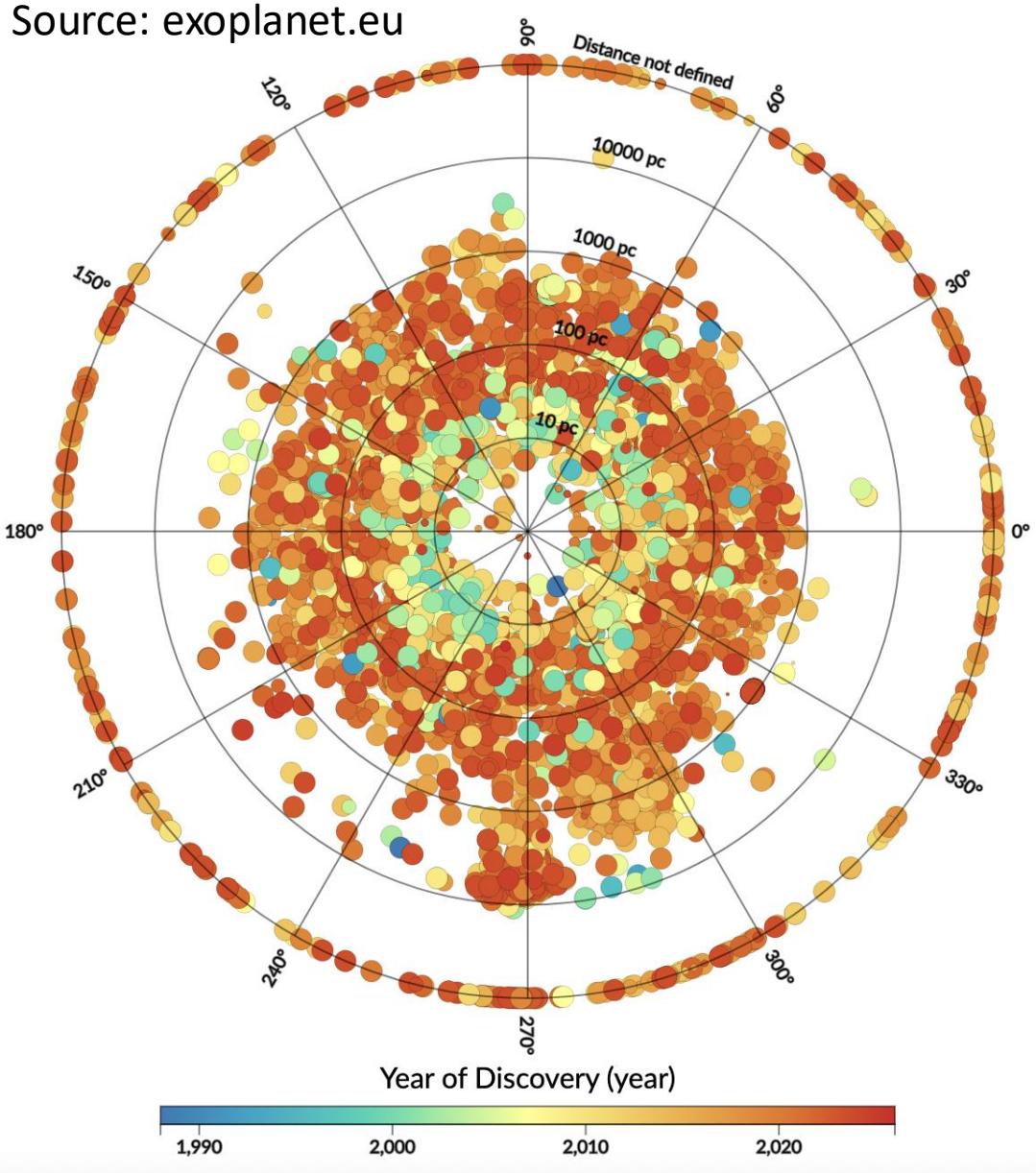
on behalf of the EVE science team

EVE
EARLY eVOLUTION EXPLORER

JPL
Jet Propulsion Laboratory
California Institute of Technology

Planet-hunting from space

Source: exoplanet.eu

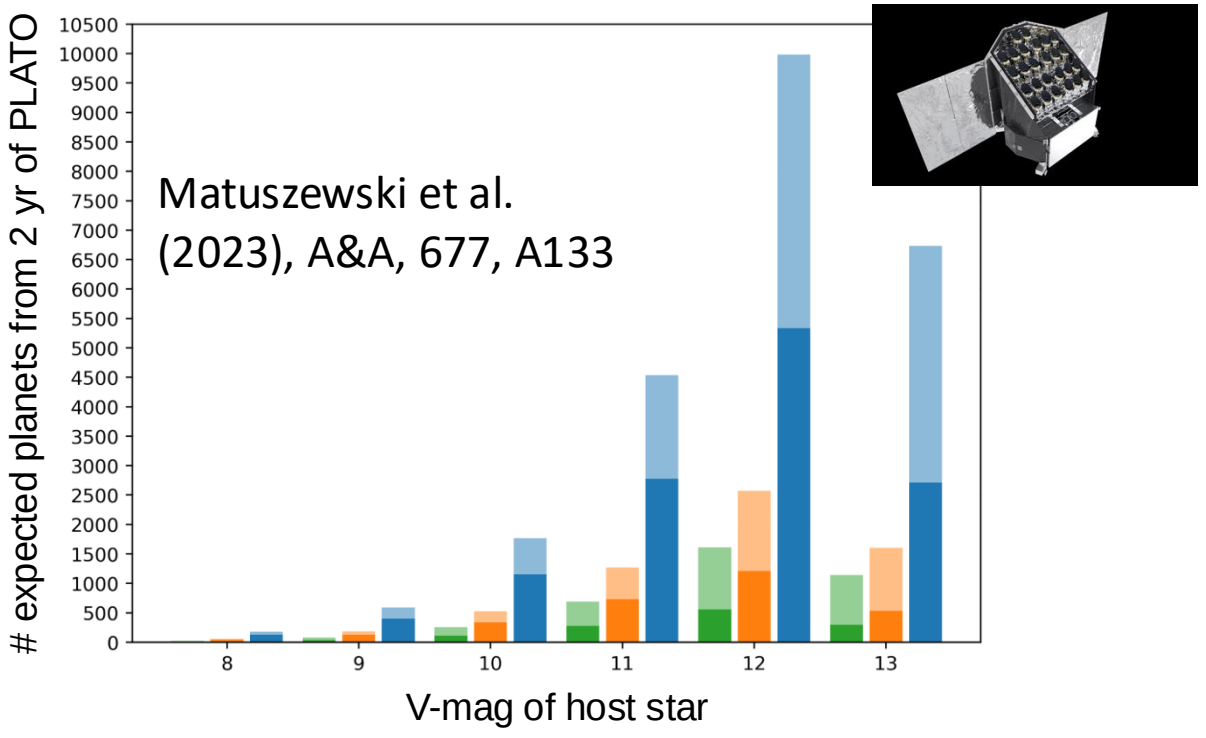


- > 5800 exoplanets to date (NASA Exoplanet Archive)

-> 2780 + 550 *(and 3000 candidates)*

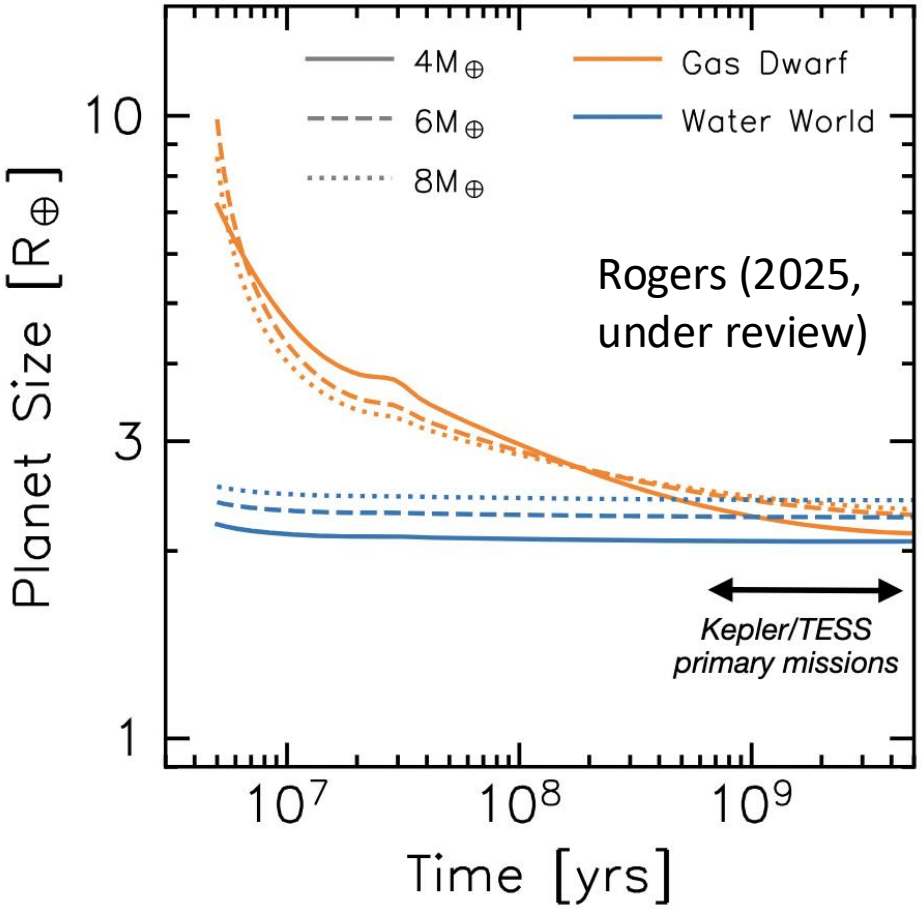
-> 600 *(and 4700 candidates)*

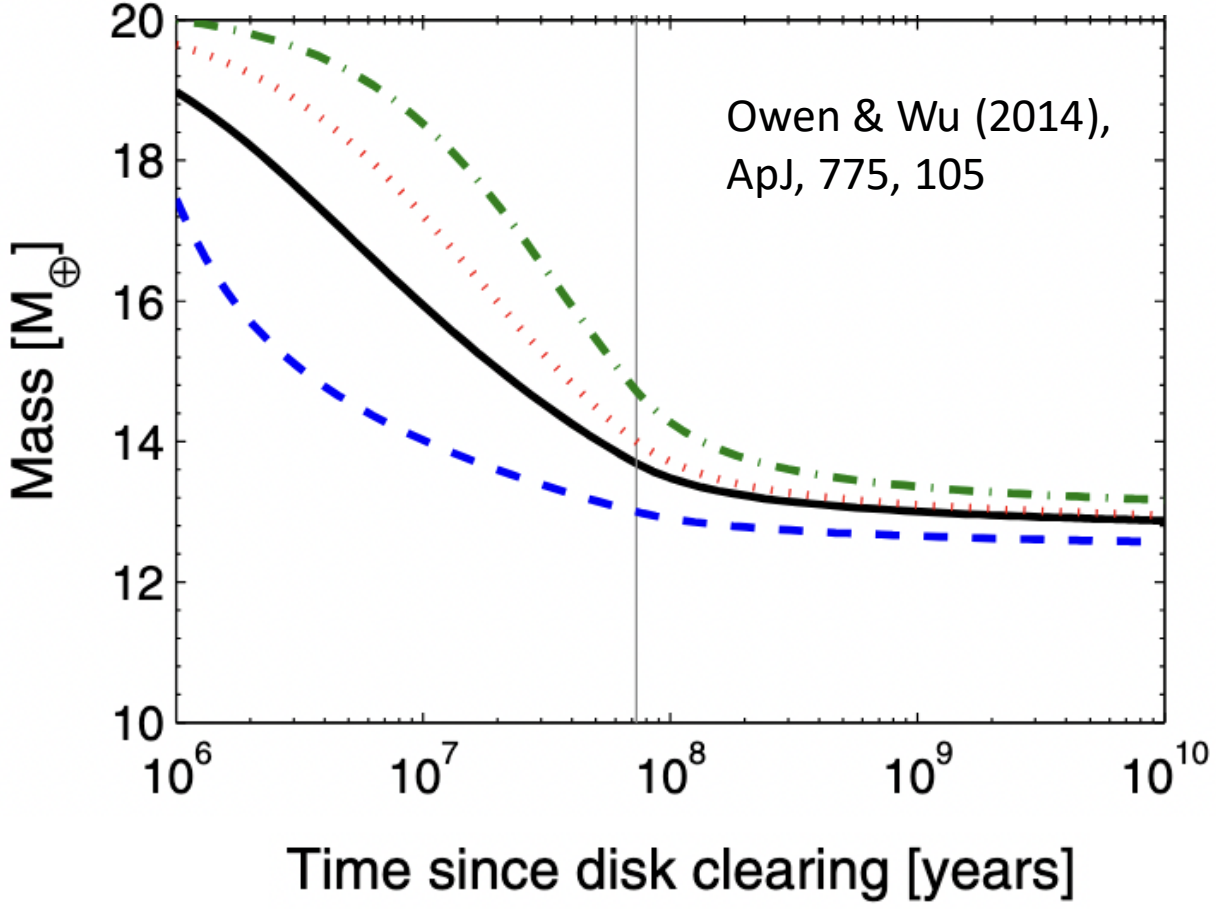
- Number to increase by factors with future missions



A key knowledge gap in the pre-main sequence

- Only ~15 planets currently known around $\lesssim$ 10-40 Myr-old stars
  [e.g., Barber et al. 2024, Nature 635, 574; Vach et al. 2025, under review]
- Young planets -> constrain thermal contraction, atmospheric evolution, orbital migration
- ***EVE: first mission to explore the processes that shape stars' and planets' early life stages***





How do stars shape the early evolution of planets and their atmospheres?

EVE will use multi-wavelength photometry to discover new young planets and determine how their host stars' activity and rotation shape their atmospheres and orbits.

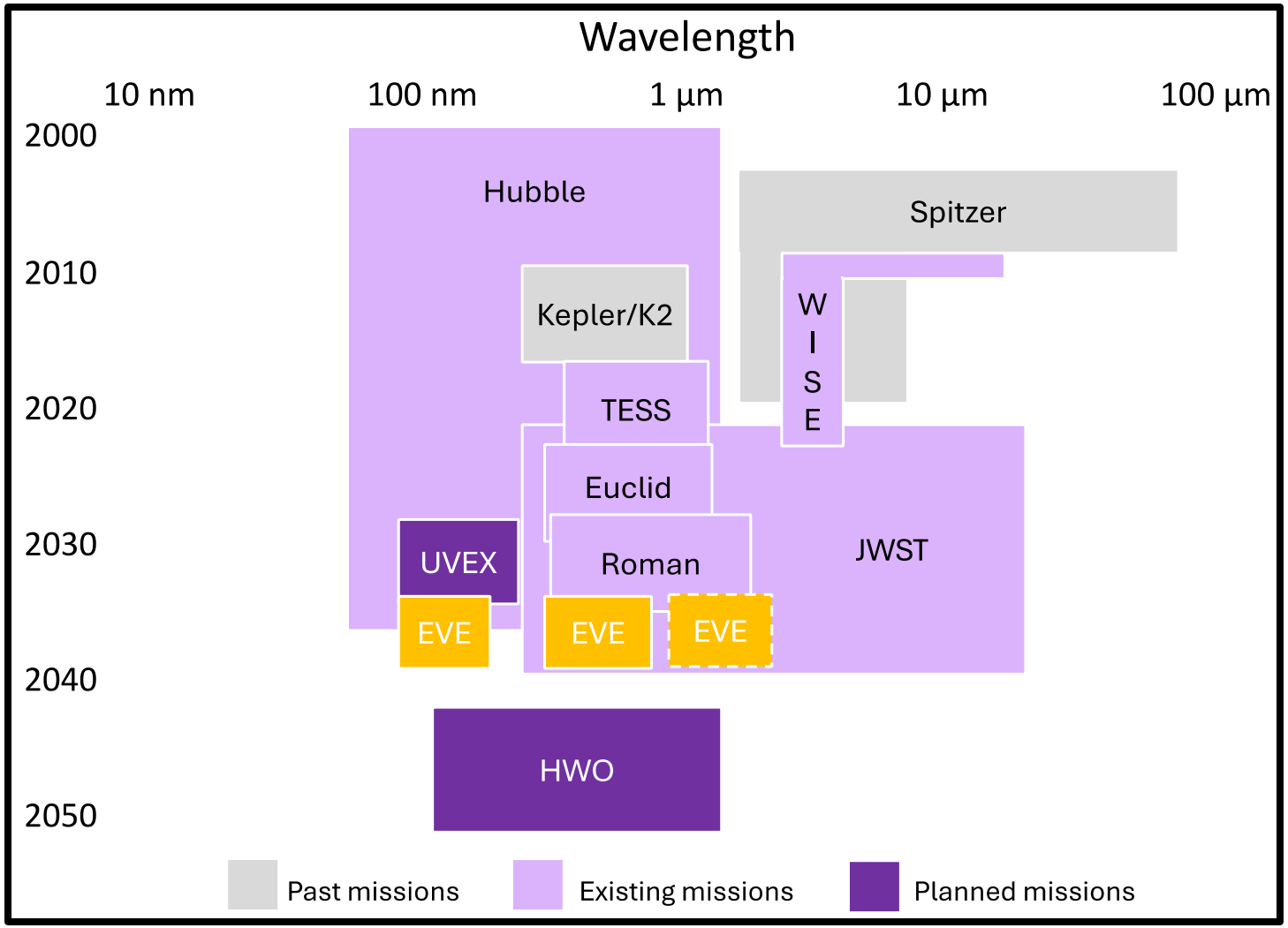
I. System Initial Conditions: Broadest NUV-to-NIR survey of young stars and their disks to determine how accretion sets stellar activity and planet architectures

II. Planet Primordial Atmosphere: First transit survey focused on discovering young, small planets and constraining their early atmospheric composition and water inventory

III. Star and Planet Coevolution: First large survey of optical and NUV flares to measure the photochemically active stellar flux received by young planets and the impact on their atmospheres

The EVE mission in a nutshell

EVE offers new observing capabilities not previously flown:



- Simultaneous photometry in NUV, optical, and near-IR bands
- Fast (30 sec) observing cadence
- Roughly 20-30 day stare duration for each pointing
- <20” resolution over 25 deg^2 field of view
- Targeting young (<100 Myr) clusters

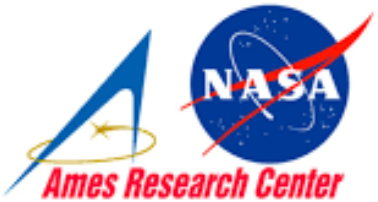
EVE Science and Instrument Team

PI: Meredith MacGregor
Deputy PI: Evgenya Shkolnik
Assistant Deputy PI: Ann Marie Cody
Project Scientist: Mark Swain

Capture Lead: Jaime Nastal

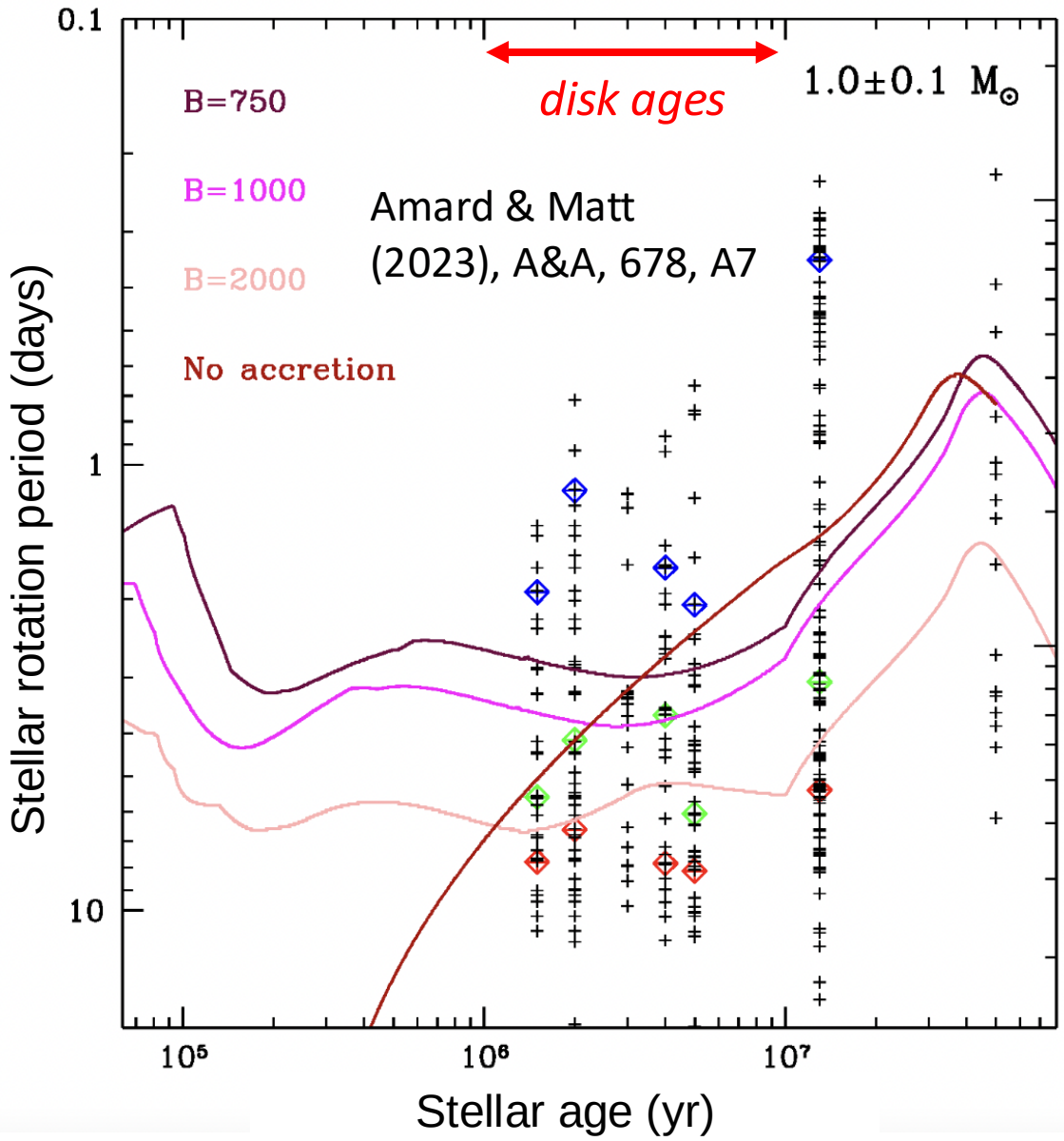
Systems Engineering: Alan Didion
Instrument Lead: Dave Makowski
Detectors: April Jewell
Optical Design: Christine Bradley

Accretion Lead: Laura Venuti
Exoplanet Lead: Jennifer Burt
Flares Lead: Ward Howard

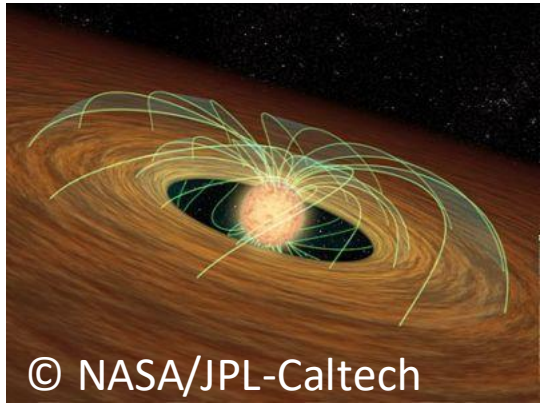


Science Team: Adina Feinstein, Eric Gaidos, Lukas Gehrig, Dan Huber, Andrew Mann, Rachel Osten, Connor Robinson, James Rogers, Neal Turner, Nick Wogan, George Zhou, Sydney Vach

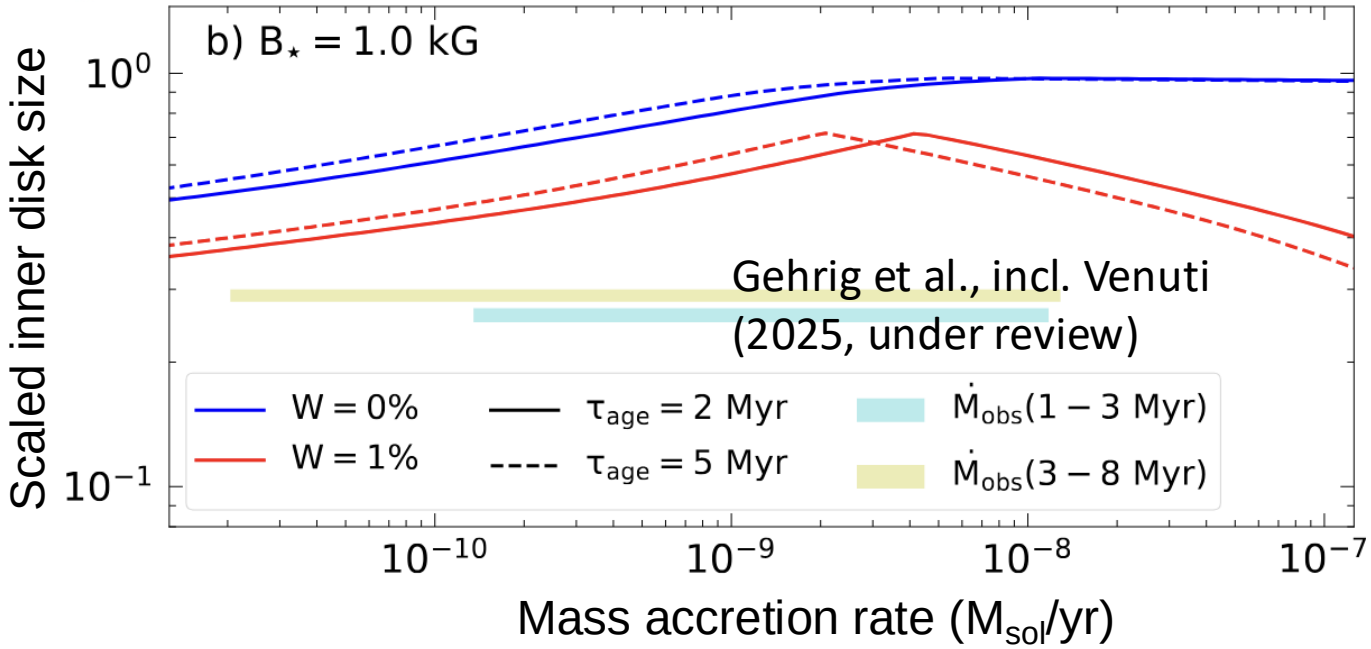
I. EVE tests what regulates rotation in young stars



- Constant rotation during protoplanetary disk stage
- Balance between star-disk interaction torques



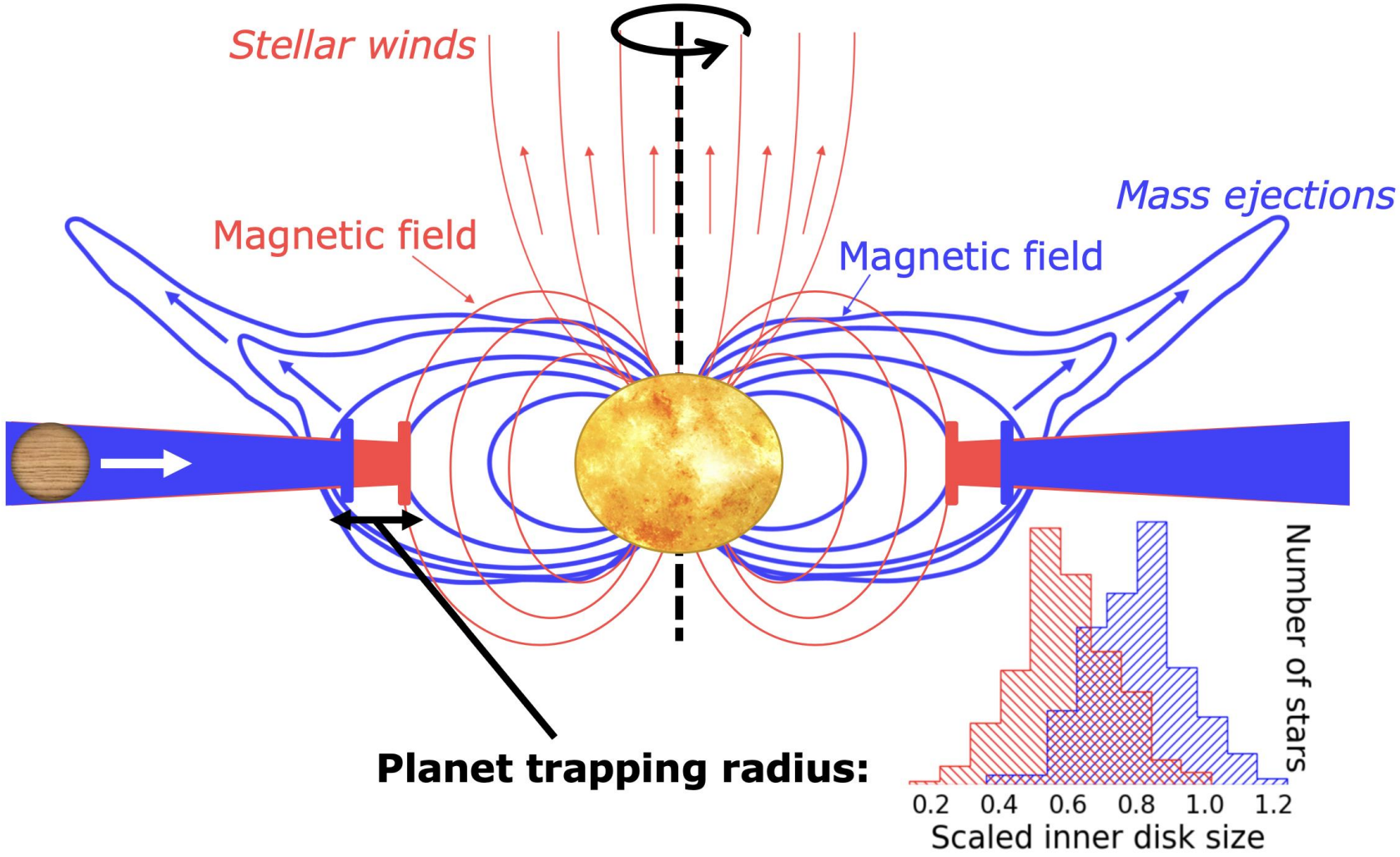
- *Equilibrium state affects location of inner disk truncation radius where close-in planets stop*



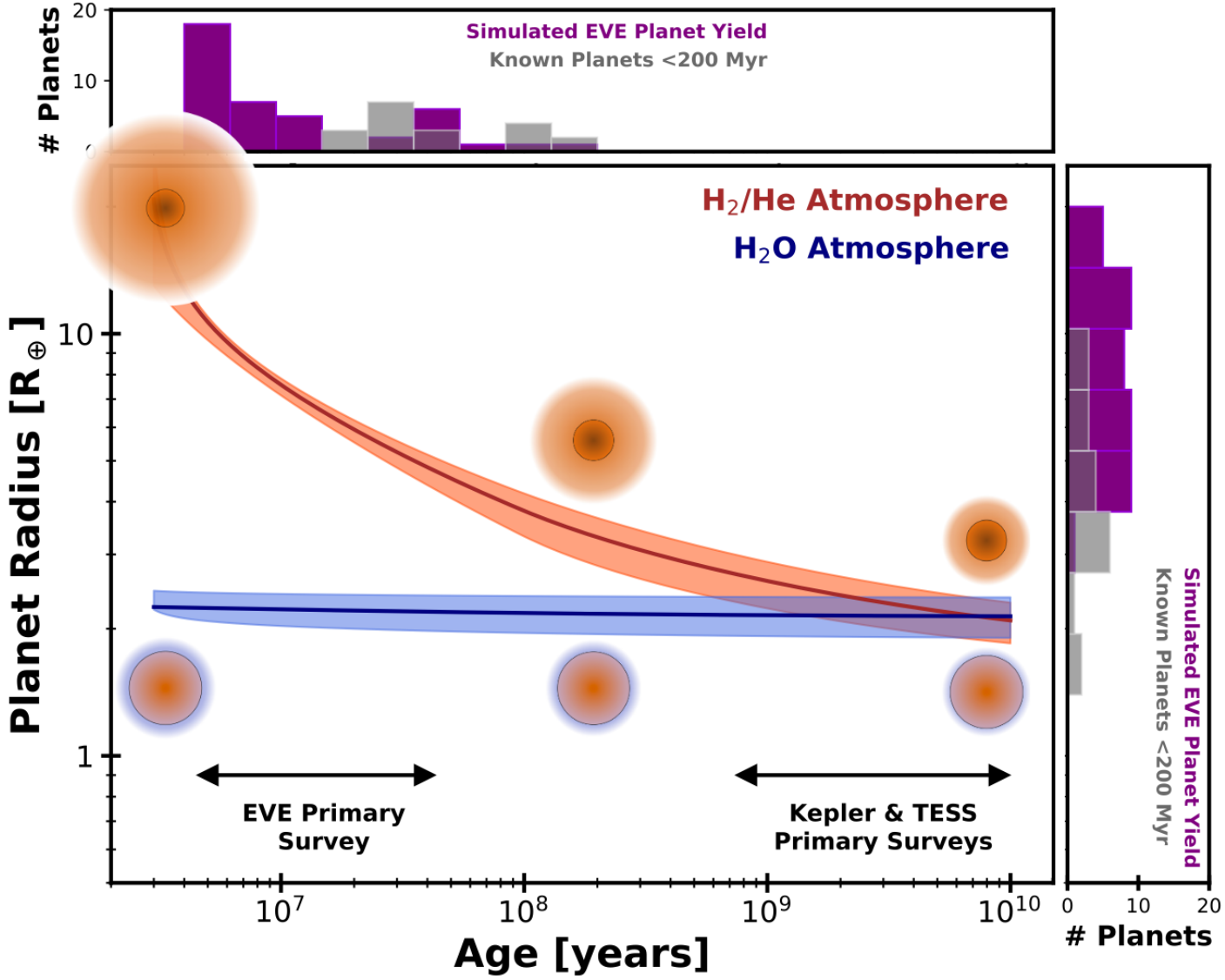
I. EVE tests what regulates rotation in young stars

EVE provides a ~15x increase in the sample of young stars with measured truncation radius, constraining where close-in planets are born and migrate.

This will give new insights into planets' initial conditions (i.e., orbit, stellar flux).

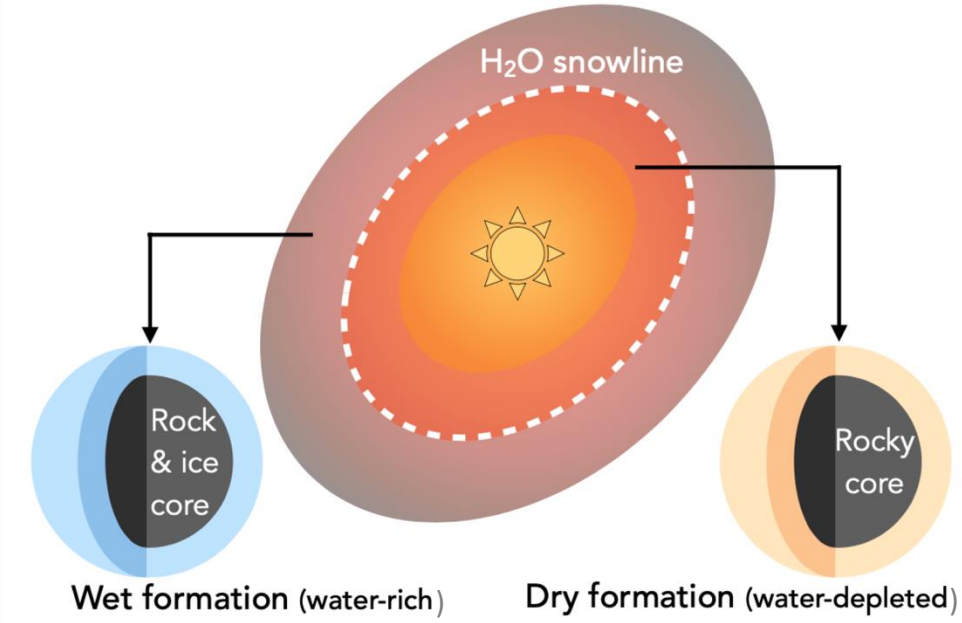


II. EVE probes the progenitors of small planets



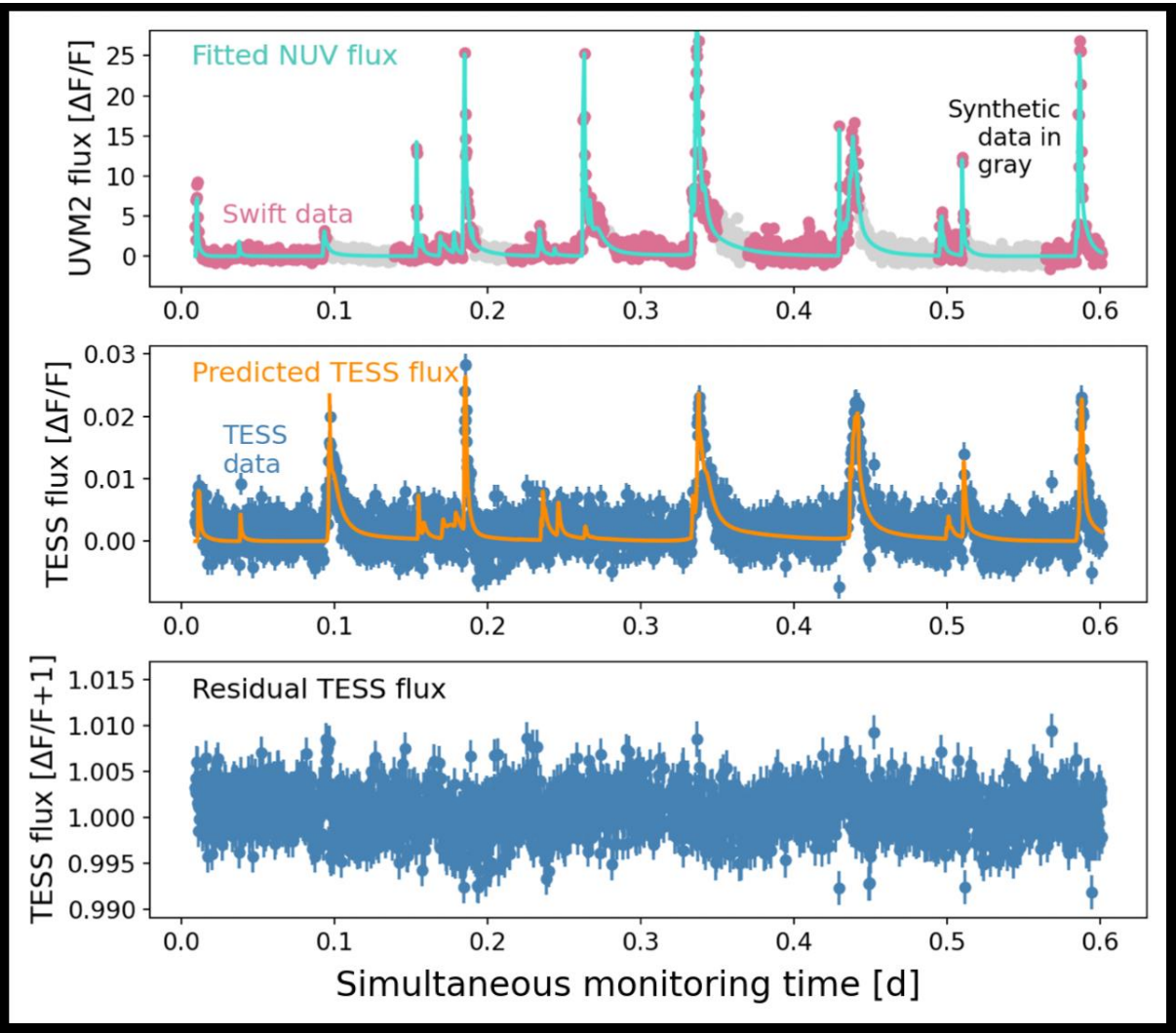
EVE increases the sample of planets younger than 30 Myr by 5x to determine whether the progenitors of small planets form close-in or far out.

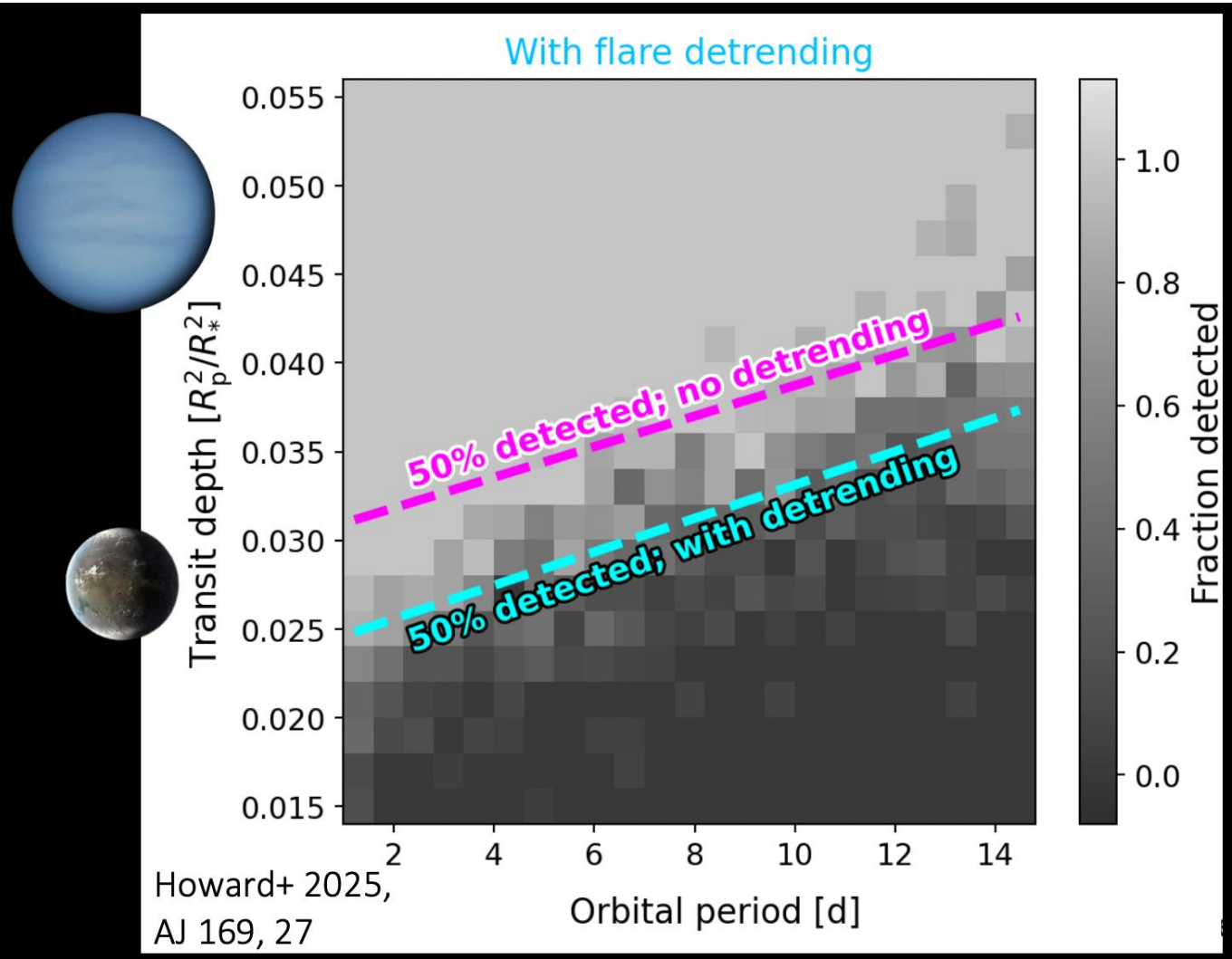
This will reveal the properties of planets' primordial atmospheres.



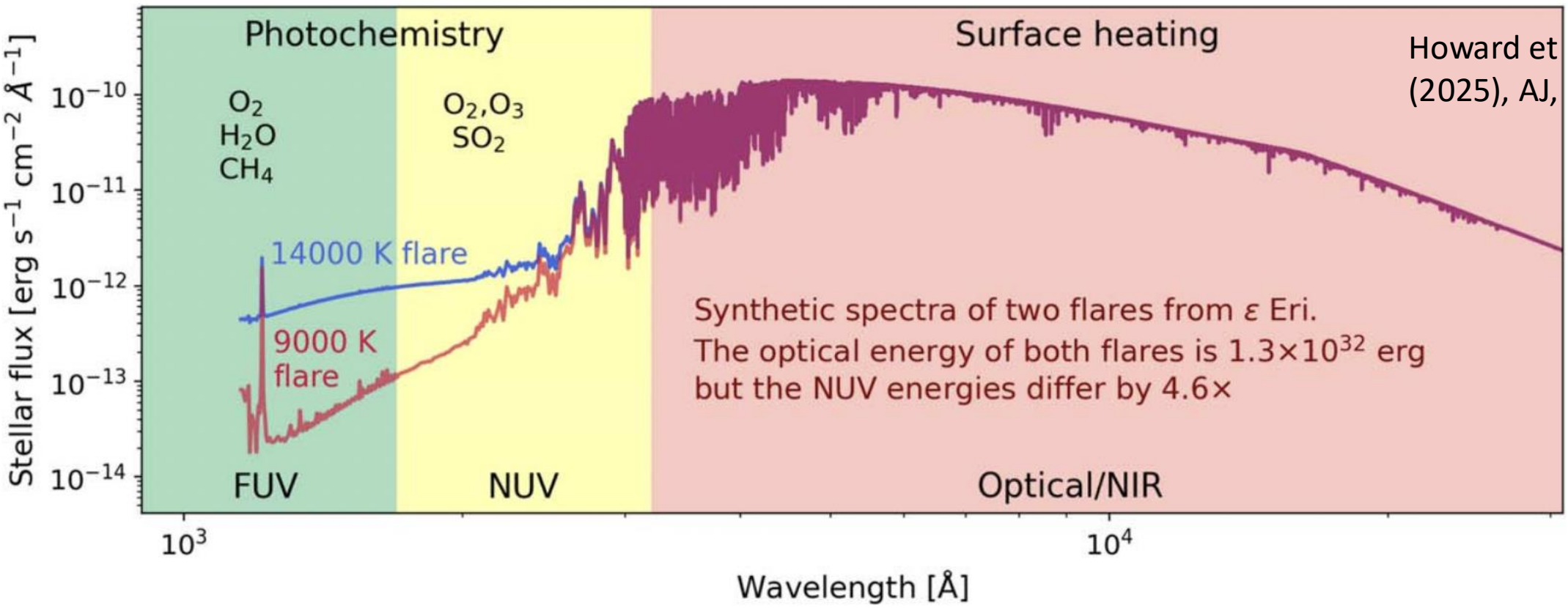
II. EVE probes the progenitors of small planets

- Simultaneous NUV + optical photometry enables flare removal, increasing sensitivity in transit depth by 20% and enabling detection of super-Earths around K7 dwarf stars





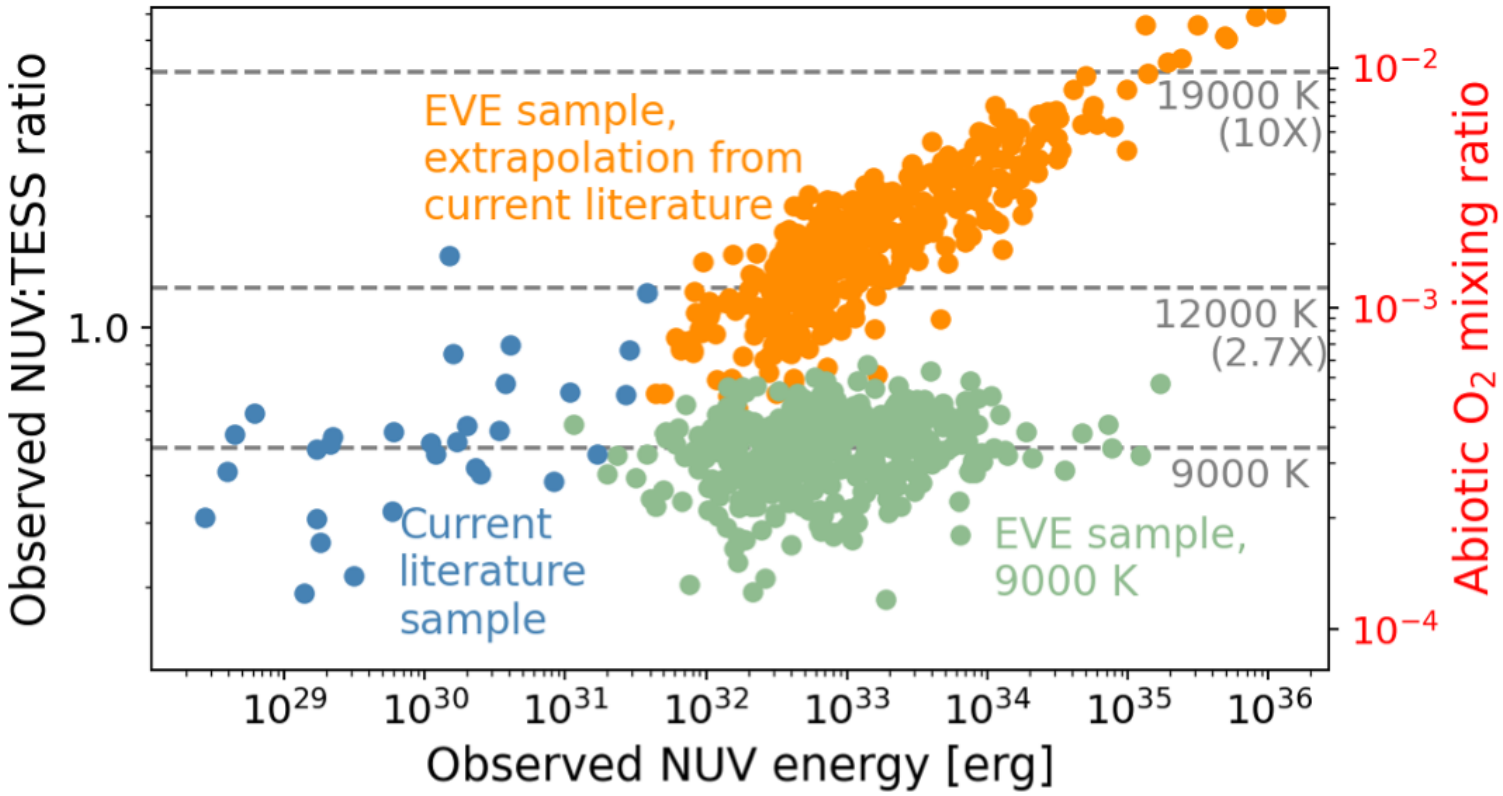
III. EVE determines flares' effect on photochemistry

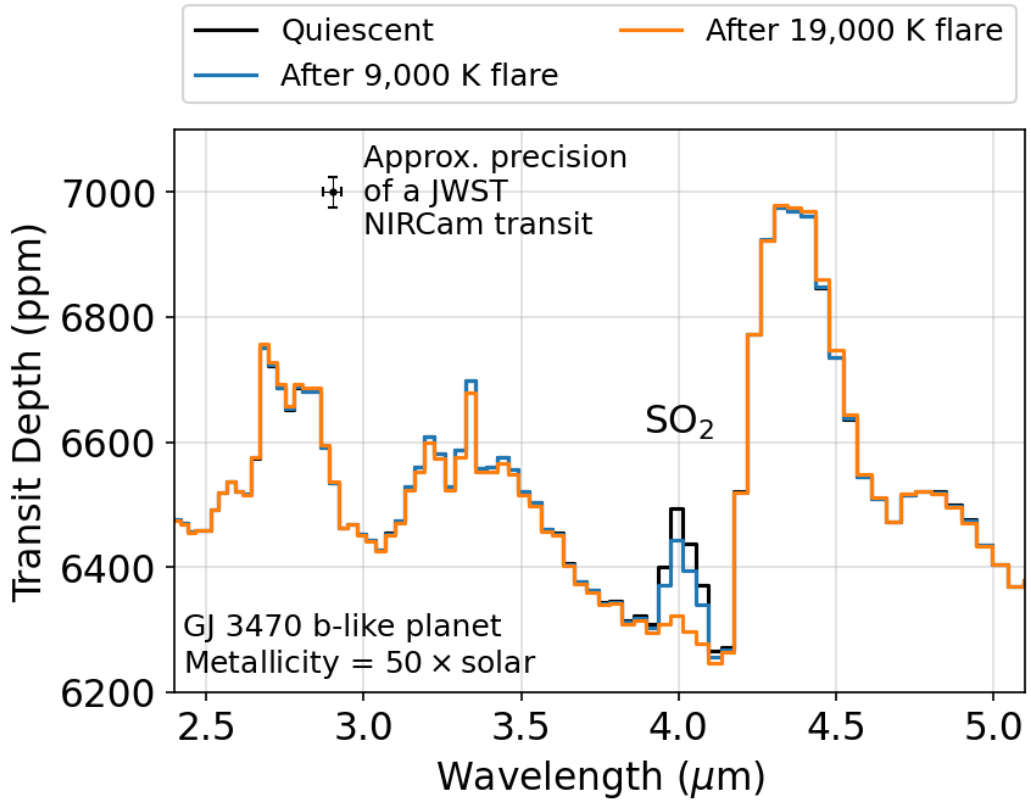


Howard et al., incl. Venuti (2025), AJ, 169, 27

- Unprecedented database of flare data (10^6 events) in the optical from TESS, but only a few dozen with simultaneous UV observations, often with coarse sampling
- FUV-NUV radiation drives photochemistry -> modeling of exoplanetary atmospheres

III. EVE determines flares' effect on photochemistry



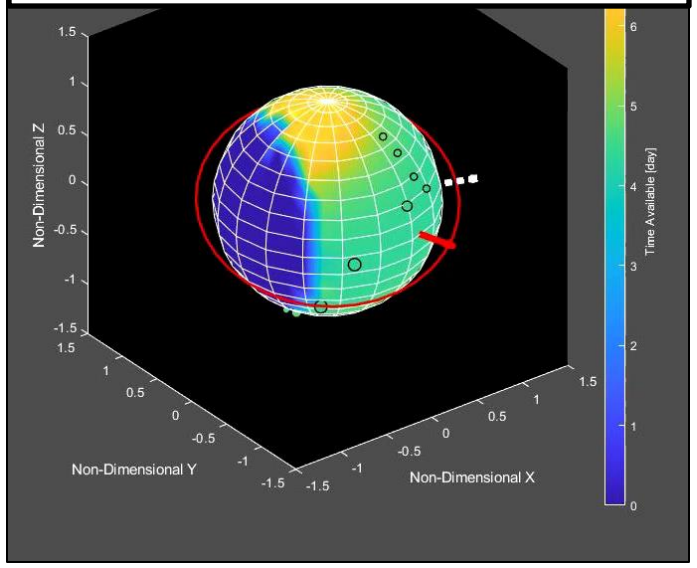


EVE expands the multi-wavelength superflare sample by 100x, determining the cumulative effect of NUV flare radiation on atmospheric photochemistry.

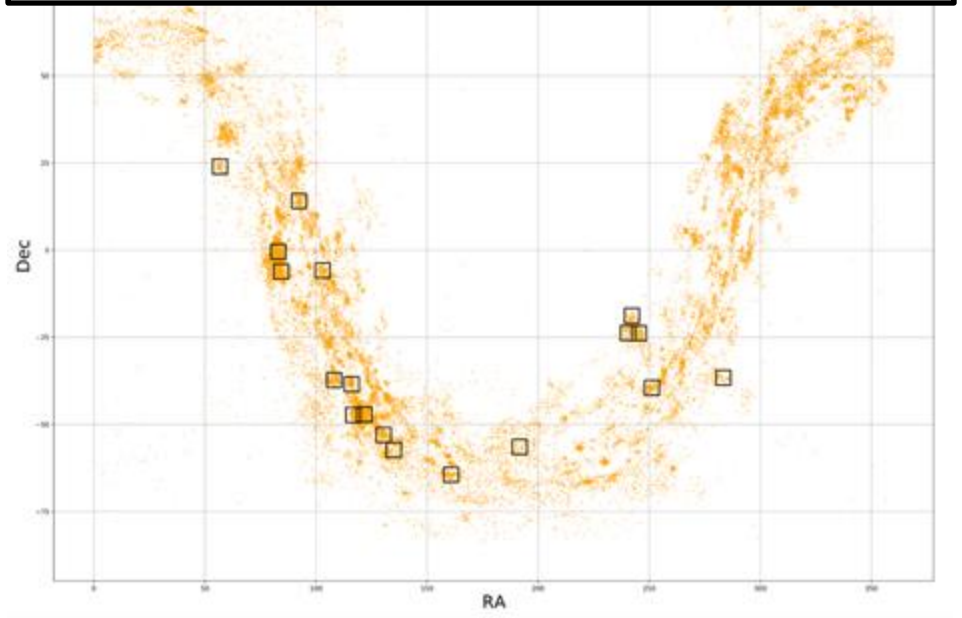
This will show how planetary atmospheres coevolve with their hosts' activity.

EVE mission design and implementation

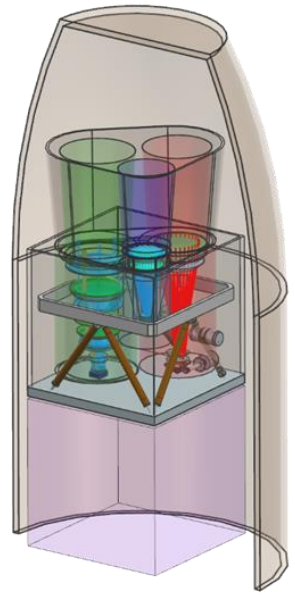
Orbit evolution relative to the celestial sphere



Example target distribution



Payload schematic



- One instrument with different sets of optics for the three bands
- Mid-inclination orbit at 1,000 km altitude that precesses to provide view of targets across the entire sky, while avoiding the sun, moon, and Earth limb

EVE: NASA's first NUV-optical-NIR photometry mission

Simultaneously observing young stellar clusters in three bands at fast cadence to understand how stars and their planets coevolve

System Initial Conditions: Broadest NUV-to-NIR survey of young stars and their disks to determine how accretion sets stellar activity and planet architectures

Planet Primordial Atmosphere: First transit survey focused on discovering young, small planets and constraining their early atmospheric composition and water inventory

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+ ancillary science goals, e.g. asteroseismology of low-mass stars