# Spin-Orbit Alignment of Planetary Systems (SOAPS): The case of 64 *Kepler* planets and planet candidates

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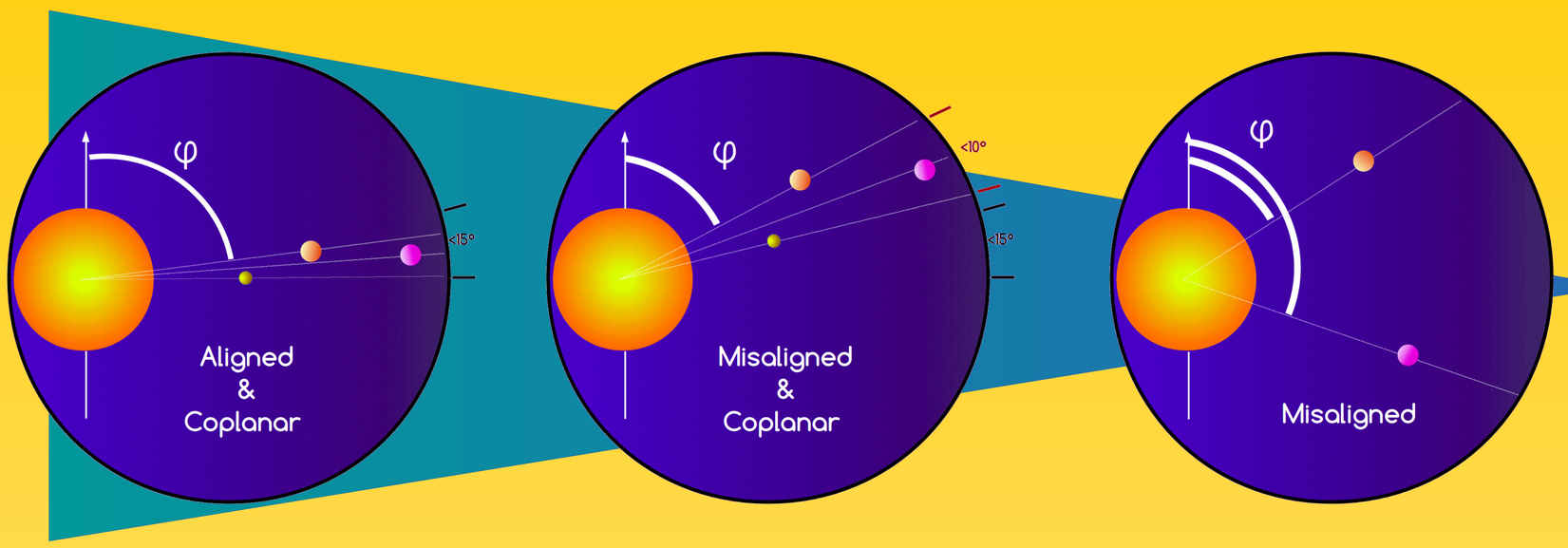
The **obliquity of a planet** is the physical property that may probe the history of formation and evolution of planetary systems describing their current orbital configuration.

**SOAPS** measured the obliquity in the line of sight (φ) for 34 *Kepler* planetary systems.



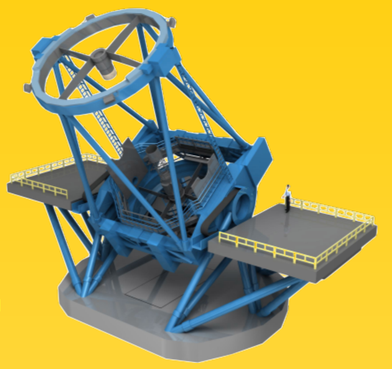

Expected outcome of classical planet formation [1]

Different mechanisms may change the planetary orbital architecture throughout a system's lifetime, for example: strong accretion [2], magnetic [3,4] and gravitational torques [5], planet-planet scattering [6,7], Lidov-Kozai cycles [8,9].

$$\varphi = |i_* - i_p|$$

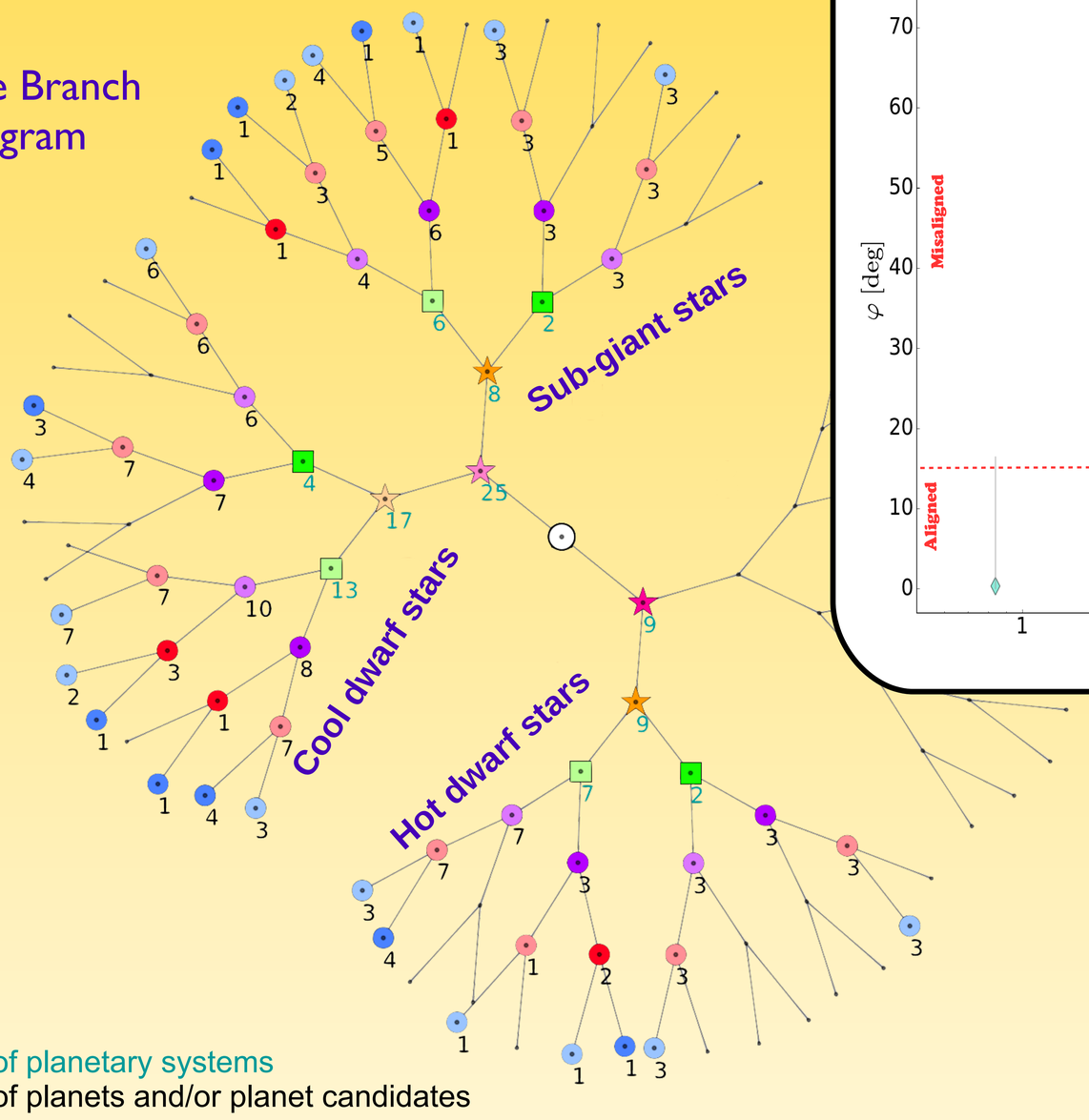
$$\sin i_* = \frac{vsini_* \cdot P_{rot}}{2\pi R_*}$$

Line of sight



The SOAPS measurements are based on ultra-high resolution échelle spectra acquired with Subaru+HDS (R~160,000) for precise $vsini_*$ measurements, combined with robust stellar rotational periods ($P_{rot}$) and stellar radii ($R_*$) from the literature [10].

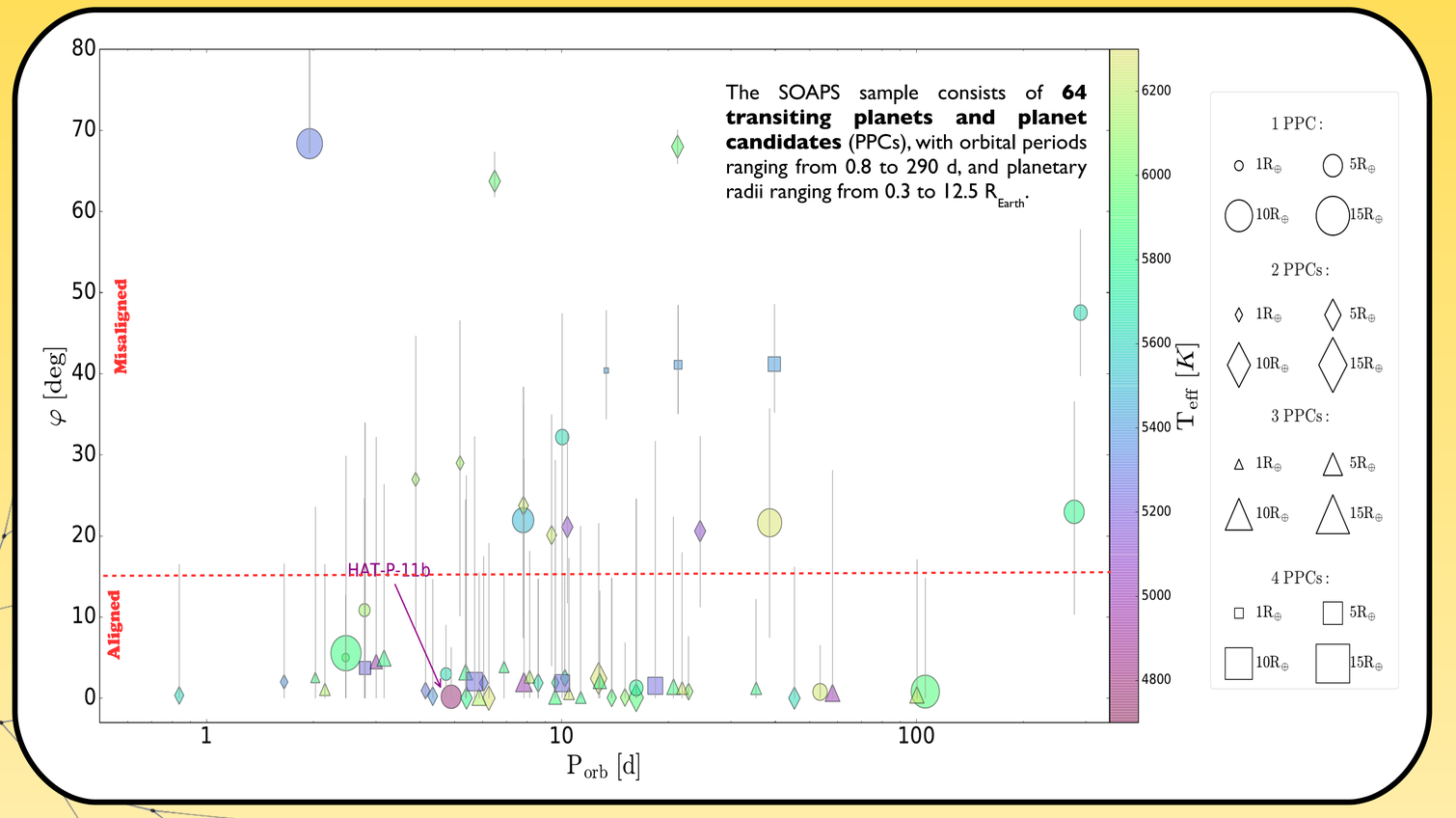
## The Branch Diagram




Number of planetary systems

Number of planets and/or planet candidates

$T_{eff}$ (6100.0 K) $R_*$ (1.2 $R_\odot$) Np (≥3) $P_{orb}$(10.0 days) $R_p$ (4.0 $R_\oplus$) φ (15.0 deg)




## Conclusions from SOAPS

**Planet Multiplicity**

- Multi-planet systems are coplanar.
- Systems with one (○) or two (◊) planets exhibit a large range of obliquities.
- Systems with three (Δ) or four (□) planets tend to be in aligned orbits.

**Host Temperature**

- Our results do not support that alignment occurs preferably for systems around relative cool stars over hotter stars.

**Star's Evolution**

- Hot and cool dwarf hosts: ~70% aligned
- Sub-giant hosts: 80% aligned

**Stellar Companions**

- We found no correlation with obliquity for stars with detected potential stellar companions and those without.

References:

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[10] Canul et al. submitted to an AAS journal.

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