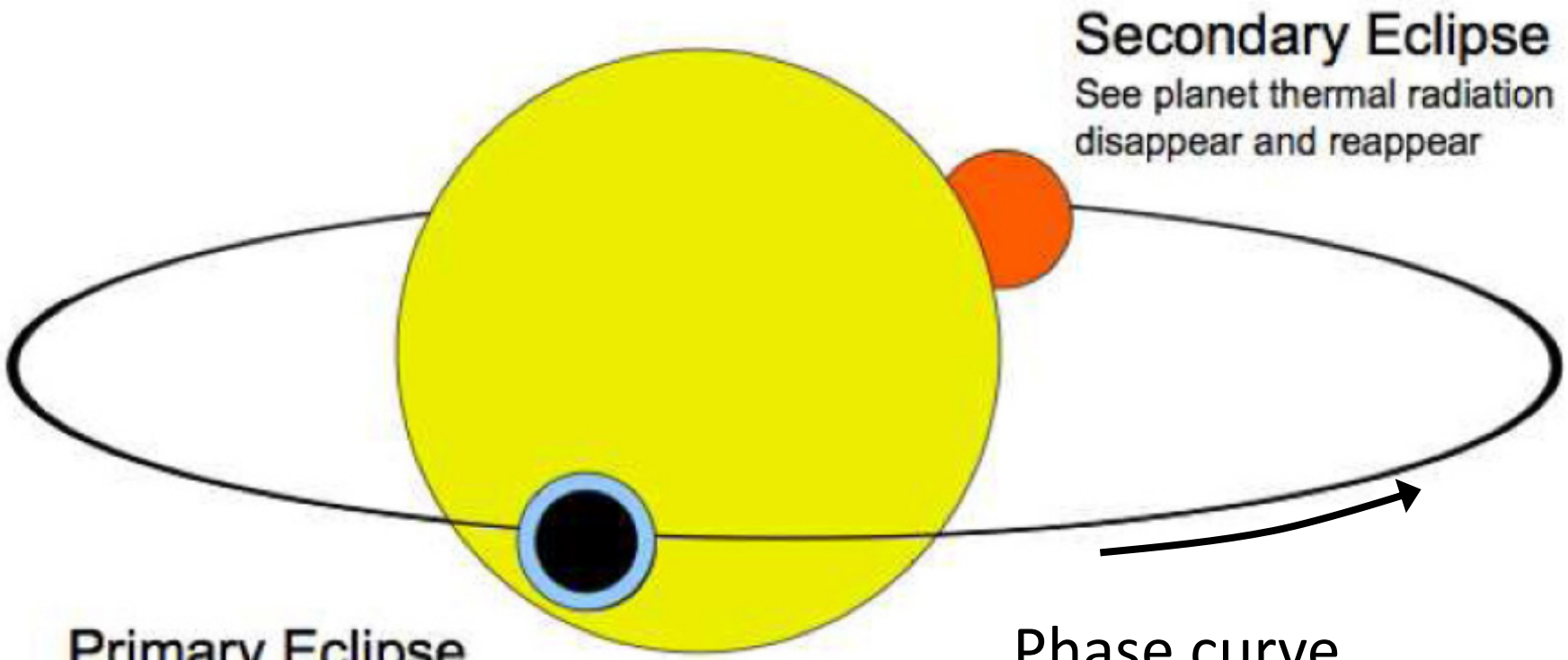
NEAT: NIRISS Exploration of the Atmospheric diversity of Transiting exoplanets – an update

2019 November, Science Team meeting, Montreal

An investigation of exoplanet atmospheres using transit, eclipse and phase spectroscopy



Main science goals

- Determine abundances of major atomic and molecular constituents, C/O ratio, overall metallicity, atmospheric scale height, mean molecular weight, and temperature-pressure profile
  - Formation & migration scenario
  - Out-of-equilibrium chemistry
  - Effects of stellar irradiation, photochemical processes, thermal inversion
- Investigate presence & properties of haze/clouds
  - Altitude, grain size, composition
  - Processes of grain formation
- Probe longitudinal temperature profile & atmosphere kinematics
  - Energy balance, heat circulation, global dynamics
- Detect reflected light and measure albedo
  - Composition, clouds, energy balance

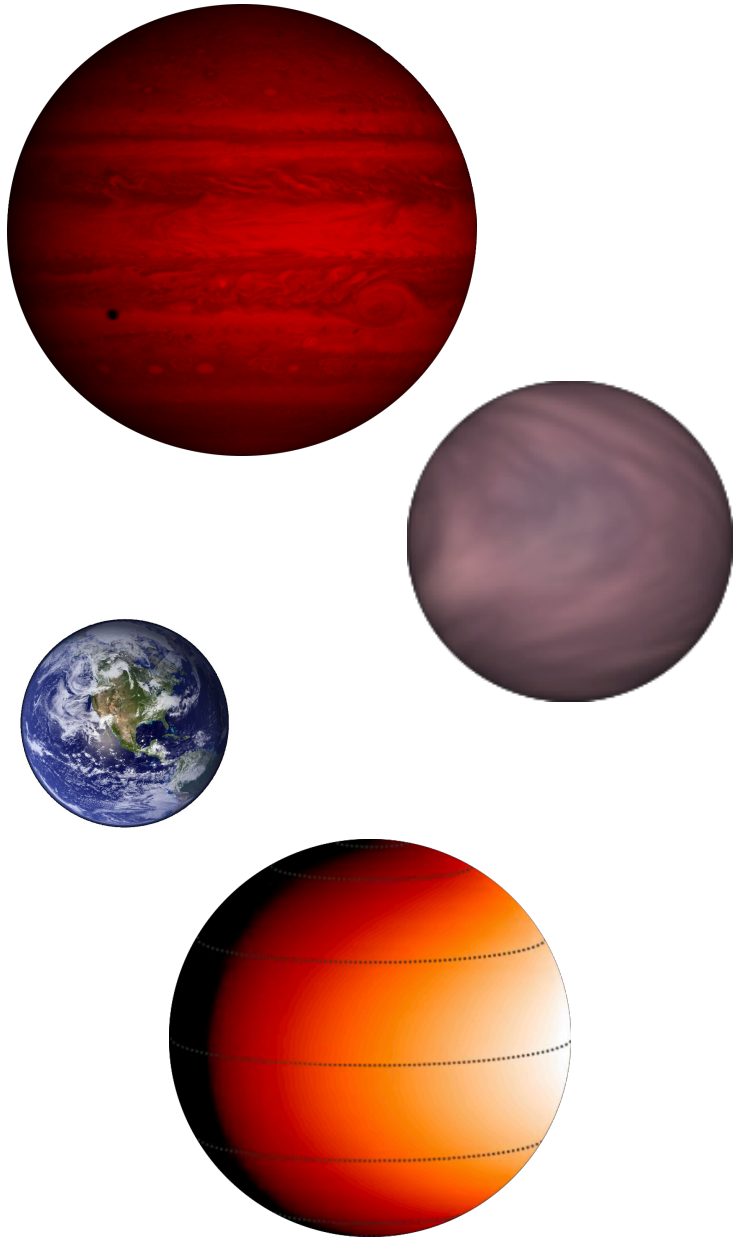
Main science goals

- Uncover trends and correlations in any of the above properties
  - Explore wide range of planet masses & temperatures, and a large sample

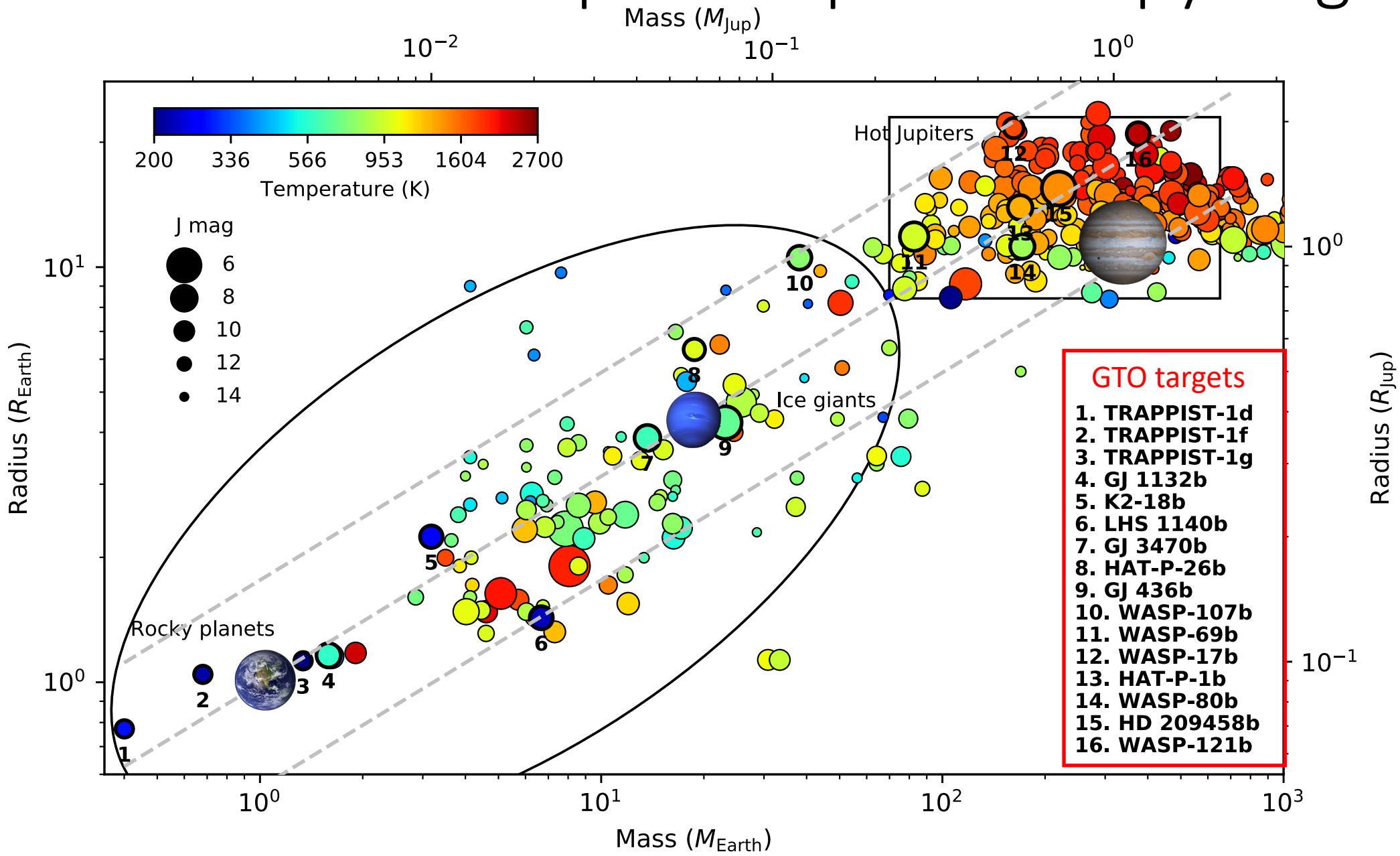
- For rocky planets, detect their atmosphere
  - Bulk composition
  - Formation & evolution scenario
  - Accretion, escape, and outgassing

NEAT Program components 200 h – 2017 version

- Ice & gas giants
  - 9 targets for which a single visit is sufficient to achieve a robust detection of atmospheric signature at the native resolving power of the SOSS mode
- Rocky planets
  - 6 planets for which a detection will require multiple visits and binning down the spectra to lower resolution
- Phase curve program
  - Full phase curve spectroscopy of one target



NIRISS team GTO exoplanet spectroscopy targets



Changes

We dropped

- HD209458b & GJ436b
  - Too bright. Recent update of the NIRISS saturation level suggests that these targets would saturate -> too risky for GTO.
- WASP-69b
  - Near bright limit, and need to gain time for other observations
- TRAPPIST-1g (but kept planets f & d)
- LHS 1140b, GJ 1132b and K2-18b
  - All Earths/super-Earths, swap for new more favourable TESS planets.

We added these two hot Jupiters

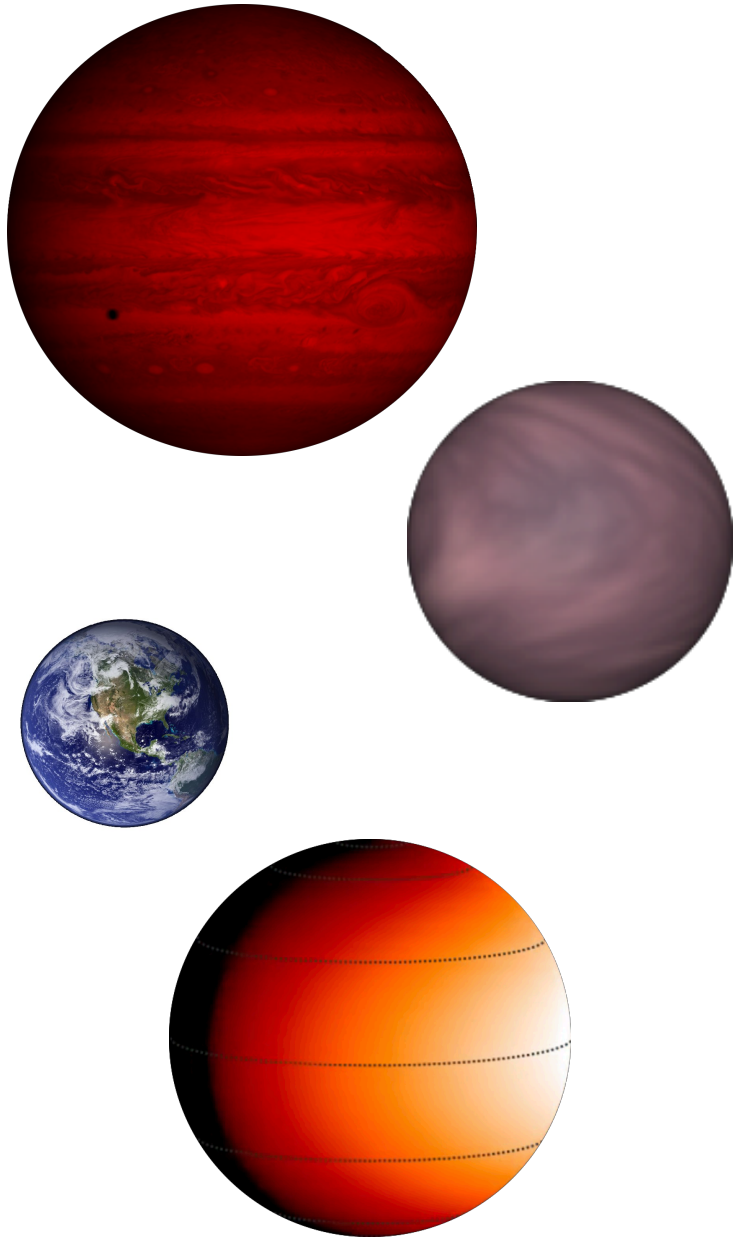
- WASP-52b, clear strong detection with HST, similar to HAT-P-1b
- WASP-127b, super puffy, extremely favourable for atm. detection

and the following TESS planets

- LP-791-18c (TOI736.02; Crossfield et al. 2019).
  - 2.4 R_E, T_{eq}=370 K, ~5d orbit, late-type host (M6-7, 0.13 R_{Sun}), favourable
- GJ 357b (Luque et al. 2019) A hot (T_{eq}~530 K) Earth-sized planet
  - 1.84 M_E in a 3.93 d orbit. Bright (J=7.3) M2.5V host.
- L98-59c,d (Cloutier et al. 2019) Bright M3 host. Planets likely rocky.
  - R_c=1.35 R_E, P=3.7d, Teq~500 K
  - R_d=1.57 R_E, P=7.5d, Teq~400 K
- TOI193.01, new Hot Neptune (very few known), T_{day}=2500K, T_{eq}=2000K.
  - Expected SNR highest among Neptunes, go for a full phase curve

NEAT Program components
186 h – 2019 version

- Ice & gas giants
  - 8 ~~9~~ targets for which a single visit is sufficient to achieve a robust detection of atmospheric signature at the native resolving power of the SOSS mode
- Rocky planets
  - 5 ~~6~~ planets for which a detection will require multiple visits and binning down the spectra to lower resolution, some single visits
- Phase curve program
  - Full phase curve spectroscopy of ~~one~~ two target

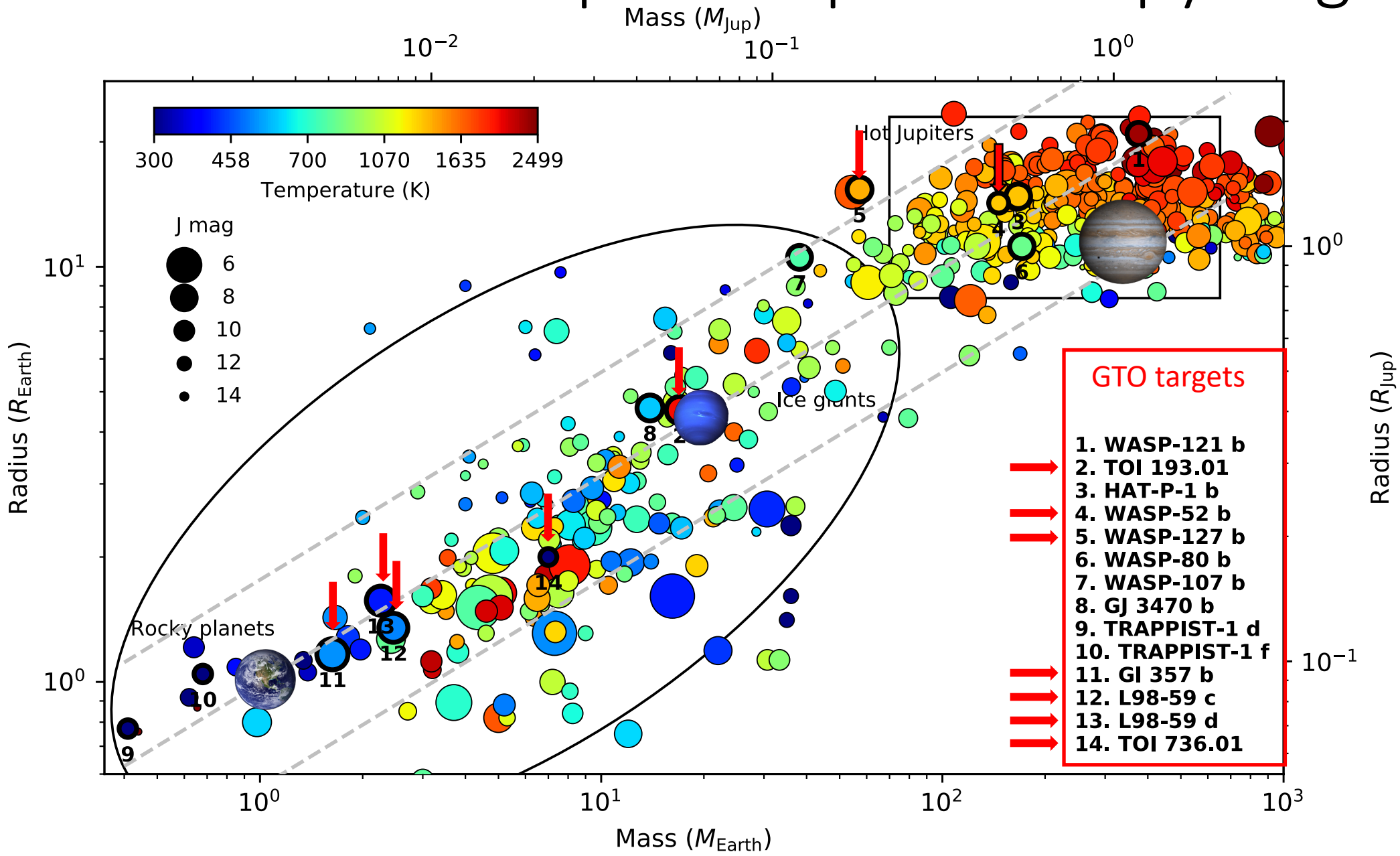


NEAT program summary

Total observing time: 186 hours, ~14 hours kept for Cycle 2

Target	Exoplanet type	Observations
WASP-121b	Hot Jupiter	Full phase curve
TOI 193.01	Hot Neptune	Full phase curve
HAT-P-1b	Hot Jupiter	Transit+eclipse
WASP-52b	Hot Jupiter	Transit
WASP-127b	Warm Jupiter	Transit
WASP-80b	Warm Jupiter	Eclipse
WASP-107b	Warm Neptune	transit with NIRISS, eclipse with NIRSPEC
GJ 3470b	Warm Neptune	Eclipse with NIRSPec
LP-791-18c	Sub-Neptune	1 visit with NIRSPec prism
L98-59c & d	Earth/Super-Earth	1 visit each with NIRISS
GJ 357b	Hot Earth	1 visit with NIRISS
TRAPPIST-1d	Temperate Earth	2 visits with NIRPec prism
TRAPPIST-1f	Temperate Earth	5 visits with NIRISS

NIRISS team GTO exoplanet spectroscopy targets



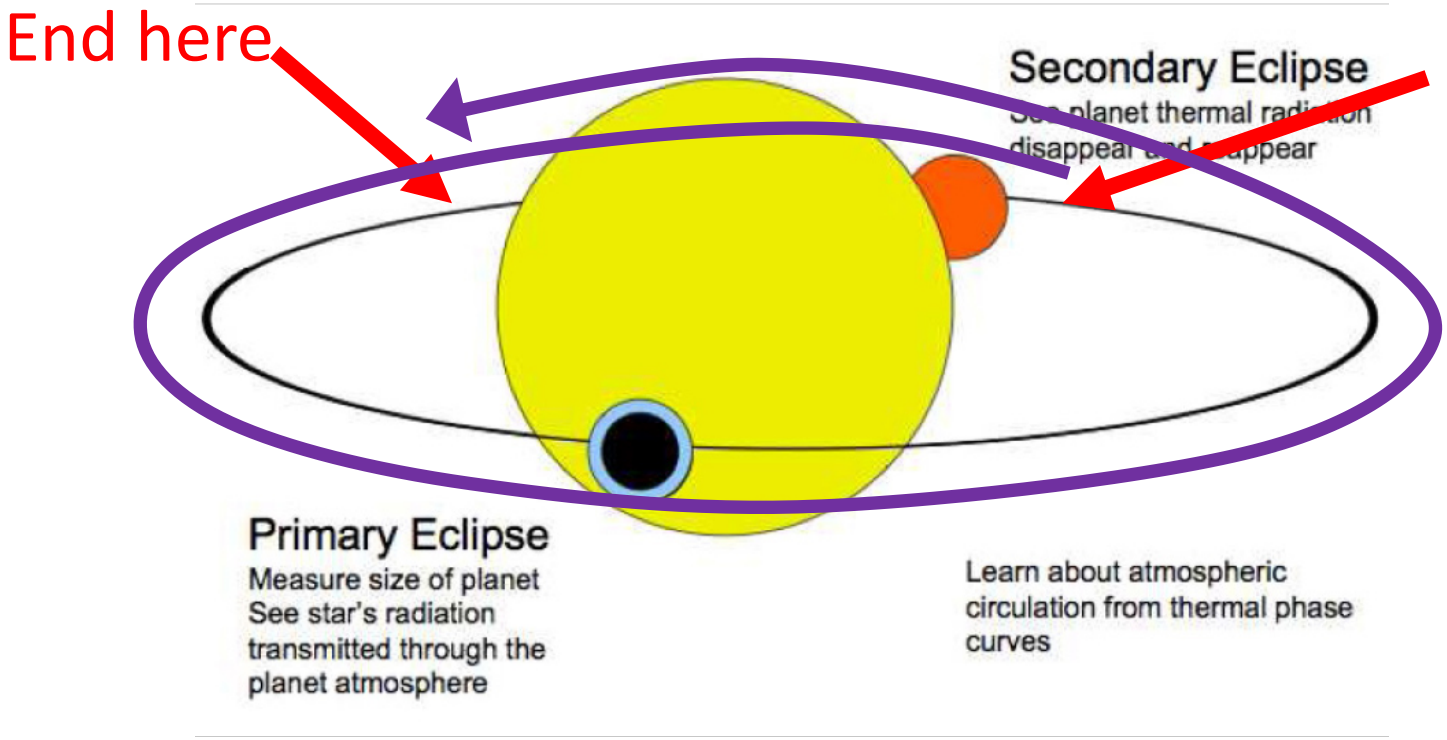
Transit/eclipse observing strategy

- Default: observe out-of-transit baseline at least as long as T14
  - For some targets with short transits (<2.5 h), add more baseline before transit

- Use 60-minute wide observation start window, to avoid the 1 h overhead for tight windows
  - Add 40 minutes to total integration time to ensure we get enough baseline after if we start early in the 60-min window.
  - This is less than the 60 min window but as much as we could fit within 200 h given our targets/program
  - Could modulate per target

Observation strategy: phase curve

- Stare continuously for entirety of orbit starting before its secondary eclipse, and ending with additional phase overlap extending slightly beyond its secondary eclipse



Capture 2 eclipses, 1 transit and full orbit

Targets in common with other GTOs

- NIRCam + US MIRI (T. Greene)
  - GJ 3470b, transit, NIRCam 2.4-5 um (we do eclipse 3-5 um w/ NIRSpec)
  - WASP-80b, transit+eclipse, NIRCam 2.4-5 um + MIRI 5-11 um (we do eclipse)
  - WASP-107b, transit, NIRCam 2.4-5 um + MIRI 5-11 um (we do transit w/ NIRISS, eclipse 3-5 um with NIRSpec)
- STScI (N. Lewis) – share data with us
  - WASP-17b, 0.6-11 um transit + eclipse (share NIRISS data)
  - TRAPPIST-1e, 0.6-11 um transit with NIRSpec prism
- NIRSpec (S. Birkman)
  - Eclipse 0.6-11 um of WASP-52b (we do the transit)