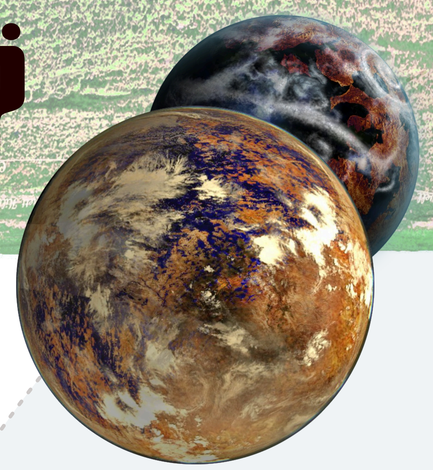
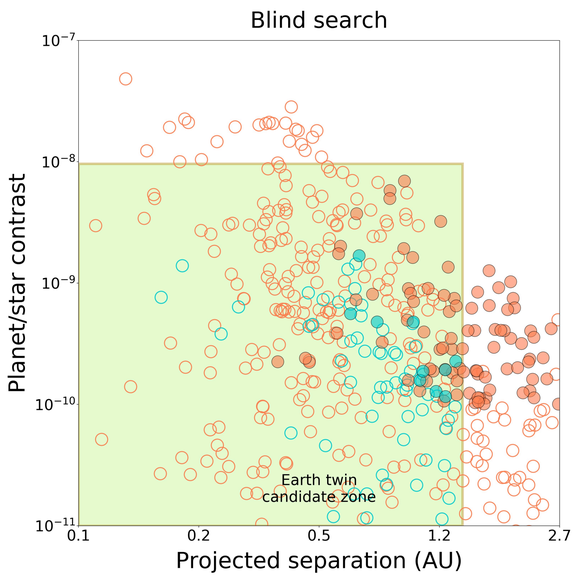
the direct imaging search for EARTH 2.0: blue dot or red herring?

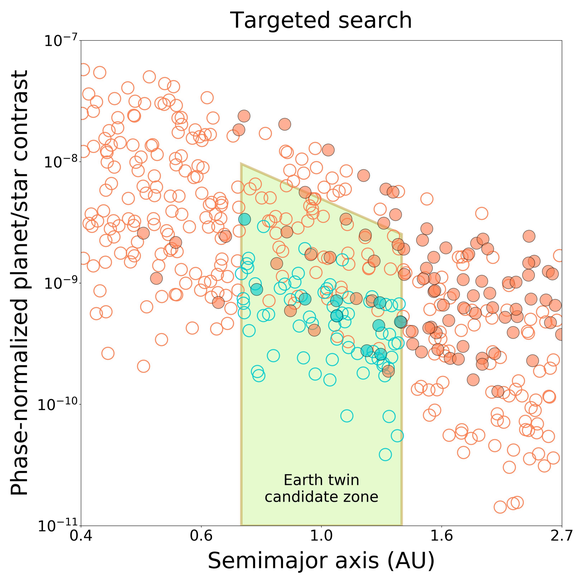


☛ Direct imaging mission concepts (LUVOIR, HabEx) plan to detect and characterize Earth twins: Earth-size planets in the habitable zones of Sun-like stars...

METHOD. We synthesized planets with random radius, semi-major axis, albedo, and inclination. We compared a blind search, where each planet is imaged once, versus a targeted search, where planetary orbits are constrained a priori.

Plotting planets in terms of direct imaging observables looks like this. The mint region is where an Earth twin could fall in this parameter space. Any un-Earth here is a false positive for an Earth twin:

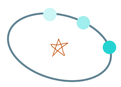




but direct imaging does not measure a planet's size...

RADIUS-ALBEDO DEGENERACY

...neither does direct imaging tell you a planet's orbit, unless you revisit it enough times...

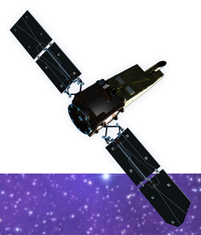


To calculate the false positive rate, just  count the dots in the Earth twin candidate zone:

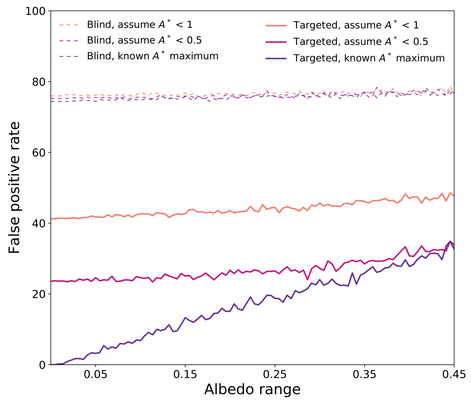
4 in 5 targets are false positives after one visit

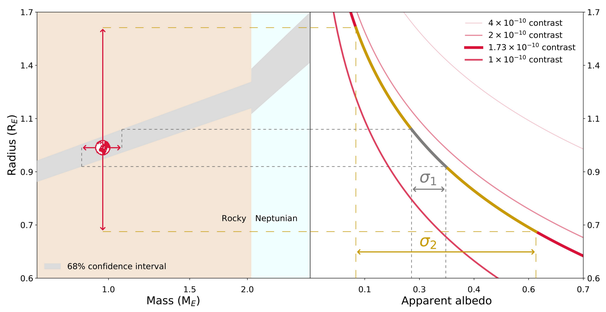
1 in 2 targets are false positives after many visits

...so a fraction of the yield will be **planetary false positives** for Earth twins: appearing Earth-like in planet-star contrast and projected separation, but outside the habitable zone, or with massive H/He envelopes.



BREAKING DEGENERACIES





(Left:) Prior knowledge of the albedo distribution sets our ability to identify Earth twins. The x-axis is the range of albedos in the model. The false positive rate is insensitive to this distribution, except in the limit of highly-informed a priori knowledge (solid purple line).

(Top:) We might constrain the apparent albedo, assuming a Lambertian phase curve, via a mass-radius relation (silver σ; Chen & Kipping 2017), or Rayleigh scattering spectra (gold σ; Feng+ 2018).

RELEVANCE

☛ Many planets at the correct relative brightness and separation to be Earth twins will actually be sub-Neptunes.

☛ Knowing where and when to look reduces false positives, though the best observation cadence is unknown.

☛ Further identification of Earth twins needed to help select characterization targets.

OUTER WORKING ANGLE = $10\lambda/D$ = 206 mas

INNER WORKING ANGLE = $3\lambda/D$ = 62 mas

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CRAQ Comprendre l'Univers Understanding the Universe

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