ExoEarth Target Lists
How Many Stars Need to be Searched?
How Large a Telescope is Needed?

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Background

- Want the mission to have a positive result.
  - Find an Earth with >95% probability
  - On average find 3 Earths
- What is an Earth clone?
  - 0.5~10 Mearth?   (but > 5Me the planet can have a hydrogen atmos)
  - 0.7~1.8 AU*sqrt(Lum)? Colder than Mars,
- How many Earths are there? (Catanzarite, Shao) ~3% of solar like stars have Earths.

- Should we include wide doubles? (double stars are now known to have planets) Include doubles unless there is a Jupiter between 0.2~5yr period?
  - Astrometry (unlike coronagraph) has no problem with wide doubles. In fact the search time is halved.

Background 2

- How a question is asked changes what the correct answer is.
  - If we assume that every star either has 1 Earth or 0 Earths in the HZ and **no other planets**, that assumption provides a strong constraint on what search techniques can work.
  - External occulters (starshades) are very limited in the number of targets they can look at. But with the above assumption a single detection of a dot, is proof that an Earth has been found. If one assumes every planet is Earth mass(or size) and every planet is in the habitable zone, then any detection of a planet is a detection of an Earth.
  - Brightness of a planet (in reflected light) can change by a factor of 10 depending on phase angle. Angular separation can also change 10X depending on orbit inclination and orbit phase. A Neptune @ 4 AU can have the same brightness and apparent angular separation as Earth at 1AU.

Scaling Laws for Photon Limited Astromeric Detection of Exoplanets

- If the field of view (FOV) is held constant (eg ~0.5deg dia)
  - Accuracy goes as Dia^{-2}
  - Integration time to reach XX uas precision goes as Dia^{-4}
  - # stars increases as $Dist^3$
  - Astrometric signal goes as $Dist^{-1}$
  - Integration time as $Dist^2$
- If our final accuracy is limited (by Dia^{-1}) but not obs time
  - # targets grows Diameter^3
- If we totally photon and mission time limited and accuracy goes as Dia-2
  - 2X increase in distance => 8X as many targets
  - But each target has ½ the astrometric signature => 4X integ time per target => total 32X increase in mission time.
  - Compensate with Dia that is 2.3X larger.
  - #targets ~ $Dia^{2.4}$, 1.34m NEAT => 2X as many Earths (~200)
- If Eta_Earth is **30%, a 37cm dia NEAT** would have a 95% chance of finding 1 Earth. If Eta_Earth is **3%, Dia ~ 1m**

Narrow Angle Astrometry is not Necessarily 1 mission

- Astrometry at <10uas has to be done from space
- From 40cm telescope to 2.0m telescope (with 0.6deg Dia FOV) represents a wide range of accuracy & # of targets as well as cost
  - 40cm ~ search 10 stars to 1 Me, (or ~40 stars to 2 Me) (10% of cost of $ NEAT assuming $$ = ~ $D^{2.5}$)
  - 1m (default NEAT) ~100 stars at a cost of ESA M mission
  - 2m version ~ 500 stars to 1 Me, $$~ 5.5X Neat cost

- A version that can "drain the lake" at 100pc, would be **very** expensive.
  - ~10,000 stars down 1 Me, (in a 5yr mission) ~ 5 m telescope. But even if eta_Earth is 3%, this would produce ~300 Earths.