
The Search for Other Earths
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500 Earths

- During a ~2009 conversation with one of the *original* planetary scientists
- "Why were planetary atmospheres originally studied? *To orbit and land on other planets*
- Nice idea, TPF, but you need 500 Earths
- You can be as impactful as the original application of atmosphere studies"

What do you remember from the last 400 years? What will our descendants remember? It's not going to be sub Neptune spectra.

Why So Many Earths?

- Understand diversity of terrestrial planets
- Insurance against a low eta_Earth
  - Chance of finding and identifying Earth-like planets out of Earth-size planets
  - For an ultra-low eta_Earth provide a useful null result in terms of driving the steps that will be faced by the next generation of astronomers
- For an assessment of biosignature gases
  - Increase chances to find a single exoplanet with atmospheric gases readily identified as biosignature gases
  - In contrast, taking the view that we will not be 100% certain a planet has life we aim to find many planets with candidate biosignature gases to establish the concept that life exists beyond our solar system

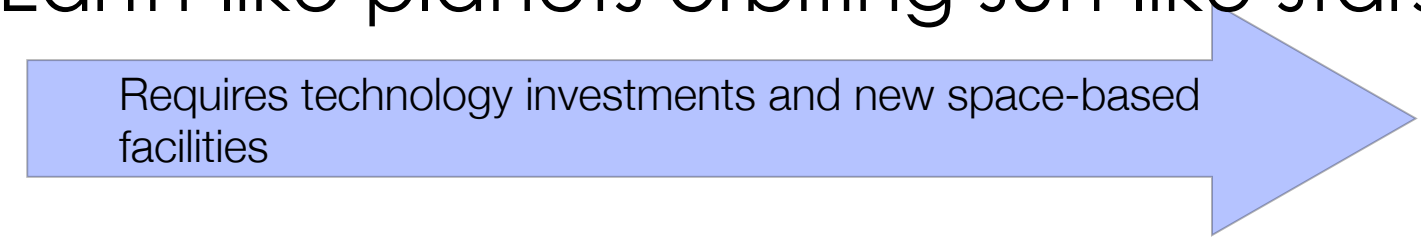
500 Earths or … ?

- We may not have the resources to find identify 500 exoEarths
- Scott asked me to share my opinion
- http://science.house.gov/hearing/full-committee-hearing-astrobiology-search-biosignatures-our-solar-system-and-beyond
- http://science.house.gov/sites/republicans.science.house.gov/files/documents/HHRG-113-SY-WState-SSeager-20131204.pdf

Two-Pronged Strategy

This decade: super Earths transiting small stars

Future: Earth-like planets orbiting sun-like stars



Credit 2007 NASA/NSF Exoplanet Task Force

Strategy Part I

- Existing assets, existing plans, focused on M stars
  - TESS and other transit surveys/JWST
  - GMT/TMT/ELT for high spectral-dispersion Doppler-shifted cross-correlation template matching
  - GMT/TMT/ELT for high contrast imaging for Earth-sized planets in HZ of nearby bright M stars

Strategy Part II

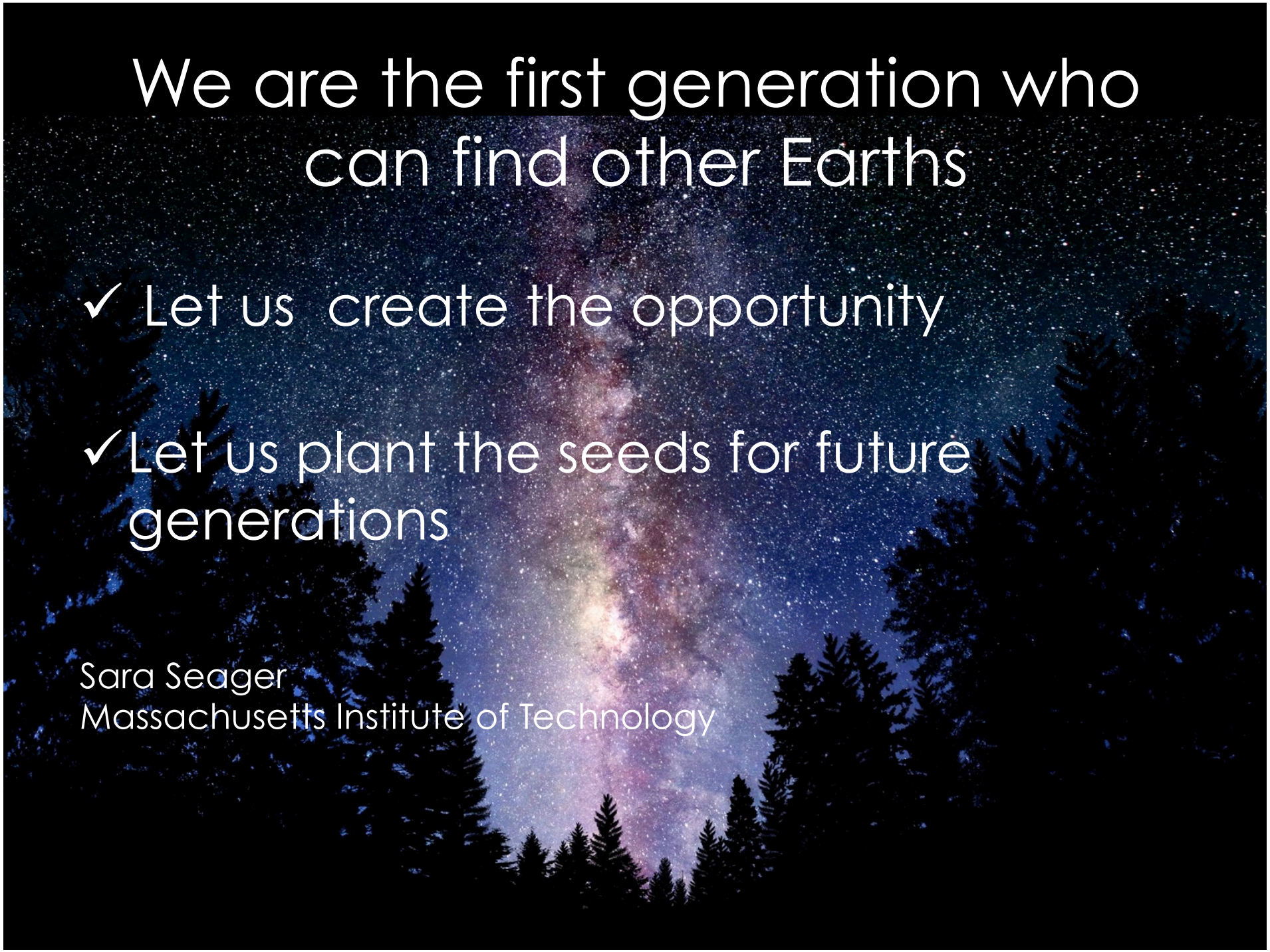
- Space-based direct imaging via a small space telescope
  - Prove the technology
  - Deliver breakthrough exoplanet science
  - Lay the ground-work for a much larger system
- Starshade and coronagraph should both be launched
  - Both should be carried forward until we are confident in their functionality
  - This may be a reality with WFIRST/AFTA
- Starshade reaches smaller planets for small aperture telescopes than the coronagraph
  - Starshade contrast and IWA is decoupled from the telescope size
  - Coronagraph aperture limits contrast partly via star magnitude for sensing for wavefront control
  - Starshade has the capability to find Earth-size planets in HZ around a couple of dozen favorable stars

Strategy Part III

- Part I and II have a shot at identifying an exoEarth
- But it's a small chance and shouldn't be over promised
- The community often argues over what's next
- Many of us argue, a mission with a large enough aperture to find enough exoEarths

Strategy Part III

- A large space-based telescope on the order of 12 m
- Starshade and coronagraph could both be launched
  - Corongraph efficiently surveys a large number of stars as compared to the starshade's limited number of retargets
  - Starshade (working with the large telescope, a stopped down version or a different smaller telescope) characterizes at broad band as well as further into the red than a coronagraph efficiently can
- But both have major challenges
  - Large starshades go beyond heritage
  - Picometer stability requirements for coronagraphs
- General astrophysics community supports > 12 m aperture for the Universe at High Definition, but not a 4 m
- Starshade vs coronagraph
  - A separate discussion is needed


We are the first generation who can find other Earths
✓ Let us create the opportunity
✓Let us plant the seeds for future generations
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