Strategies to detect Earth-like planets around nearby stars

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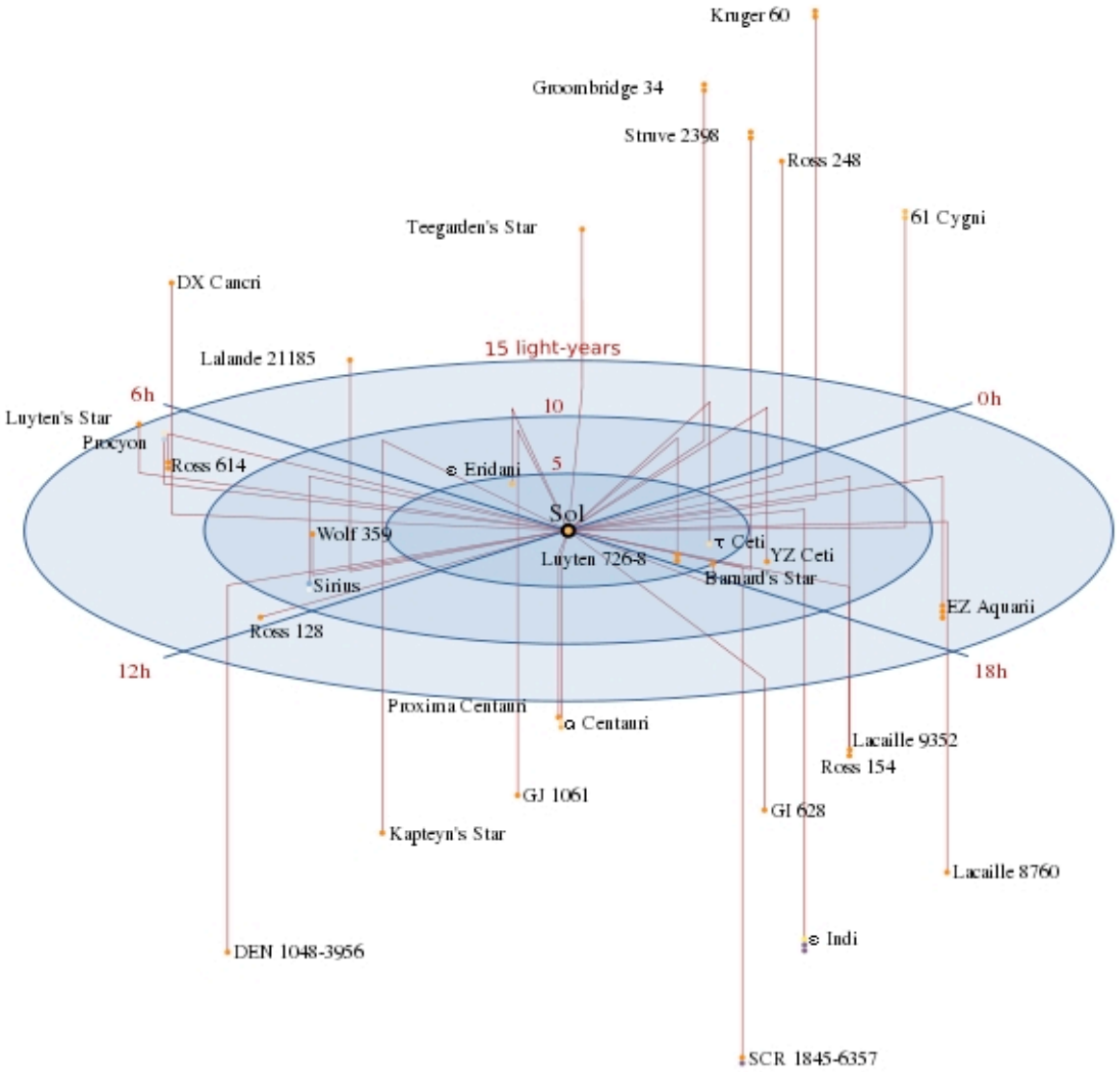

The solar neighborhood

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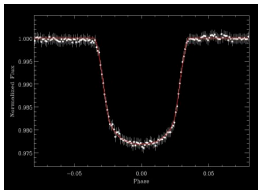
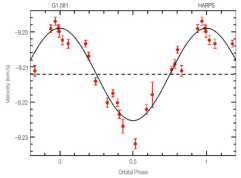
Transit method:



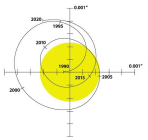
advantage: planetary radius & Doppler velocities => mean density
disadvantage: requires space telescope (CoRoT, Kepler), large sample

Doppler method:



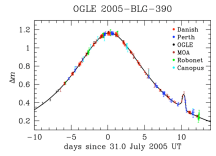
advantage: “cheap”, ground-based, well-established
disadvantage: only minimum mass, large data quantities needed

Astrometry:



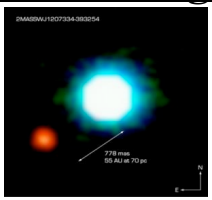
advantage: true masses (with Doppler), good for nearby stars!
disadvantage: extreme precision (SIM)

Micro-Lensing:



advantage: sensitive to habitable zone planets
disadvantage: requires star to move between us and background star

Direct Imaging:



advantage: it's a picture! (brightness, colors...)
disadvantage: it's only a picture (mass? orbit?,...), new telescopes (TPF)

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Doppler (or radial) velocity method:

measurement of the tiny velocity variations of the star due to the presence of an unseen planetary companion. This is done by determining the small Doppler shift of stellar lines over many years.

Systematic errors have to be under control!

Current highest precision: ~ 1 m/s
Earth imparts on the sun a velocity change of ± 10 cm/s over 1 year!
Completely new challenge!

Stellar variability:

- p-mode oscillations: few minutes, can be averaged out
- rotational modulation: cool spots, Prot ~ 30 days
- magnetic activity cycles: t ~ 11 years

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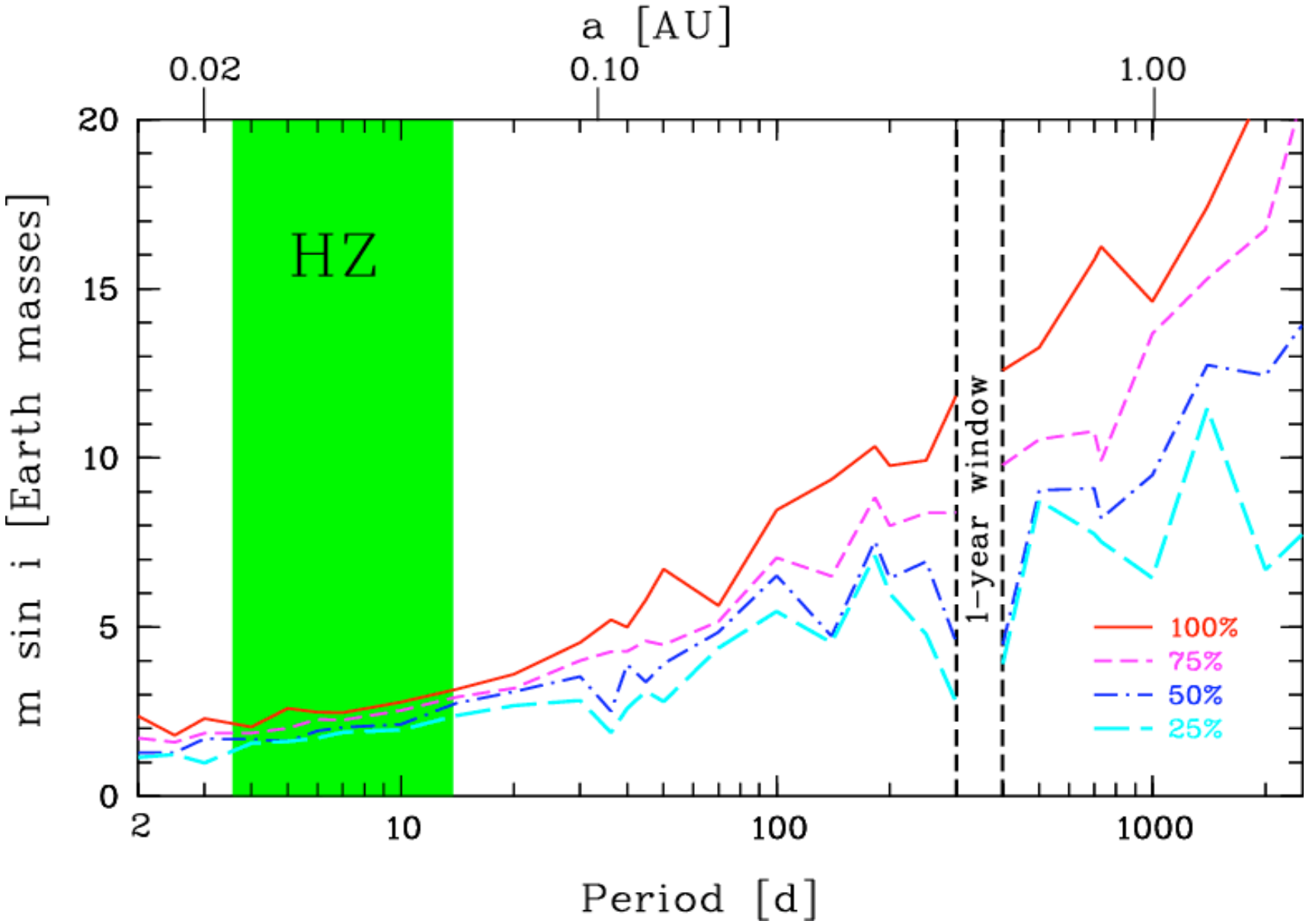

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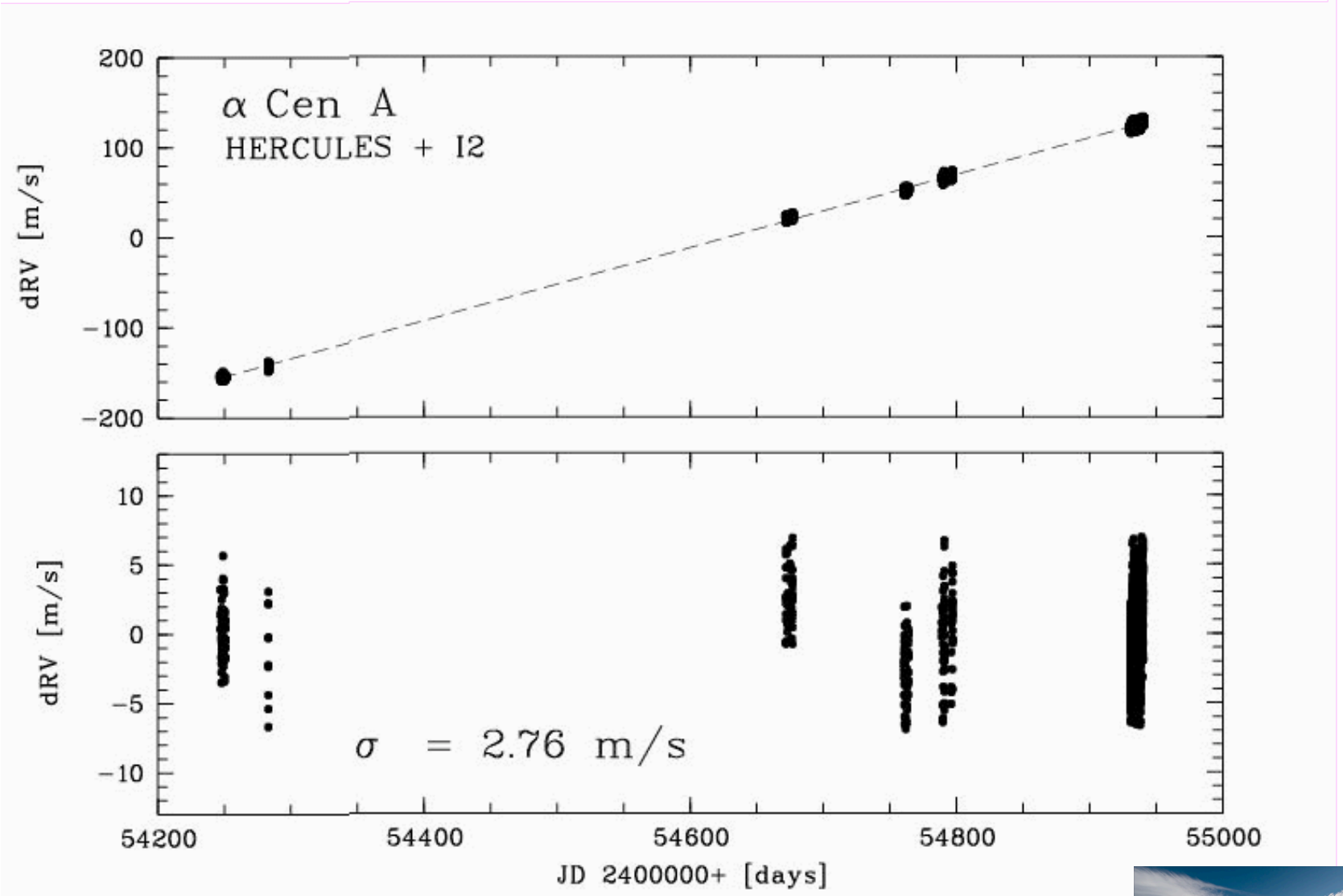

Alpha Centauri campaign at the McLellan 1 m telescope at Mt. John Observatory (NZ) with Stuart Barnes & John Hearnshaw

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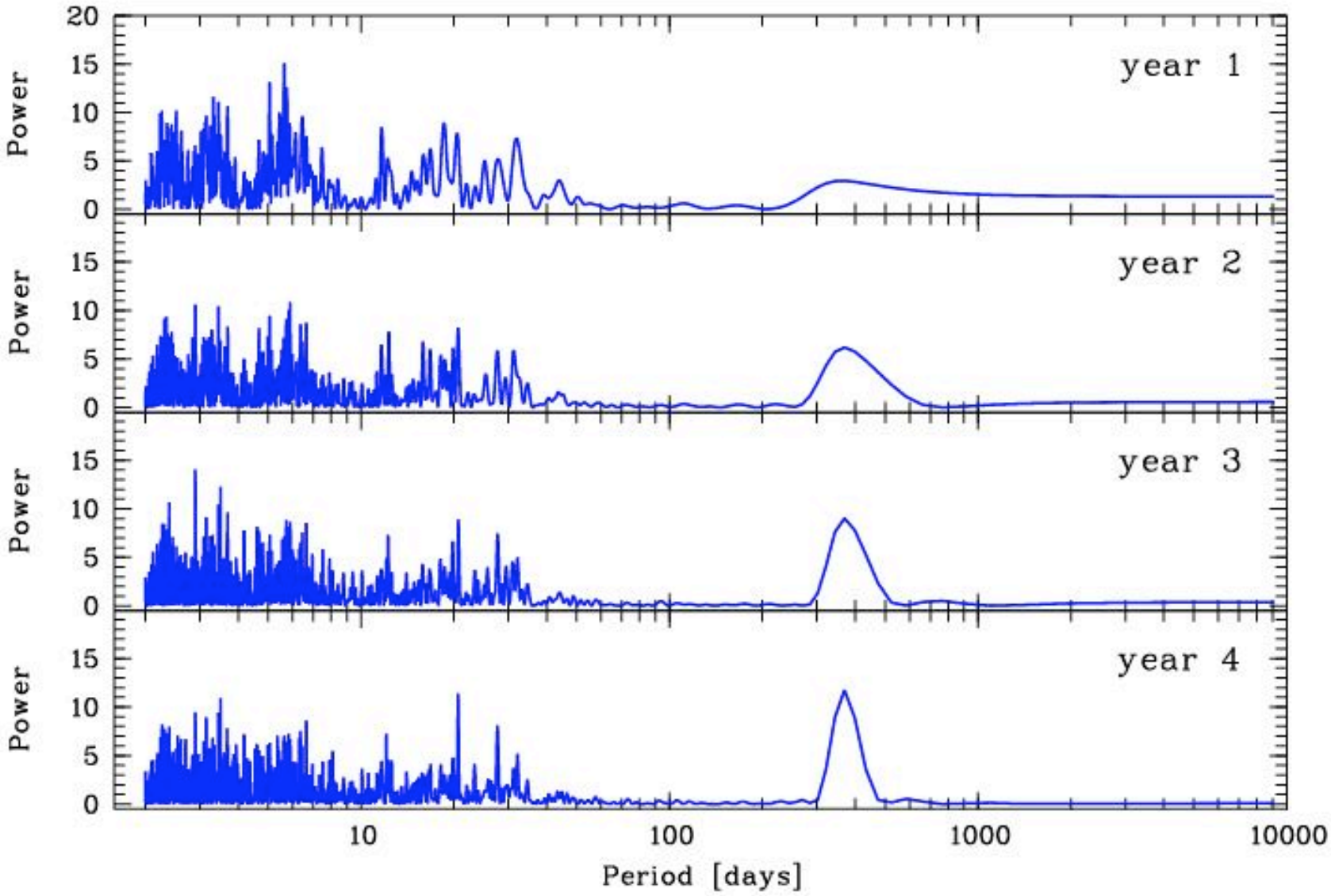

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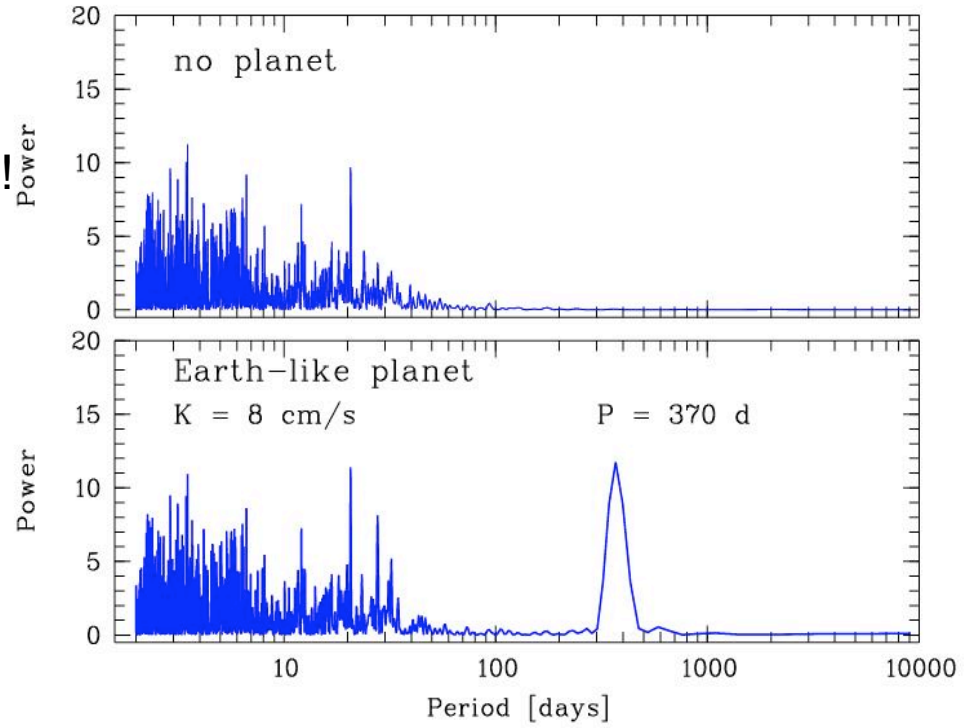
Doppler detection of Earth analogs
is possible with a precision of 2-3 m/s
and ~50,000 measurements over 4 -5 yrs!
IF error budget is dominated by white noise!



Pilot Study:
semi-dedicated telescope/spectrograph for intensive multi-year campaign on Alpha Cen.

Future:
Network of dedicated 2-4 m class telescopes with precision velocity spectrographs
=> monitor all 10-20 nearby solar-type stars over ~5 years
=> after a decade we would have an “Input Catalog” of candidates for space missions like the *Terrestrial Planet Finder* (TPF), allowing detailed follow-up observations