2ES (2nd Earth project) target list

Project goal: Search for earth analogs, i.e., rocky planets in the habitable zone around nearby solar-type stars with the radial velocity method.

Goal of this WP: Establish a list of suitable and well-characterised target candidates.

Initial work (by Melissa Hobson and Lars Buchhave): Pre-select a target candidate list from Gaia DR3 via CMD G{BP}-G{RP} (blue ~550Å - red ~750Å)

Criteria: GAIA stars within 20 parsec
GAIA stars with Gmag<9
GAIA CMD G{BP}-G{RP}

2ES (2nd Earth project) target list

194 pre-selected target candidates of which **108** had time series of **Harps** spectra, and **86** had **no Harps** data in the archive.
Added **16** overlooked **HWO** target candidates and **49** F9-F5 (6000-6500 K) stars with d<25pc => in total **258** target candidates

To further down-select the list, I collected: 2MASS mags, luminosities, Teff, stellar radius, mass, [Fe/H], debris disk parameters (where applicable), and activity labelling from Simbad.

=> **21** stars had close **visual companions within 1"** => all **rejected**
=> **9** stars are known **SB** => **rejected**
=> **9** stars have **hot or warm Jupiters** => **rejected**, but might still be useable for special purposes
=> **22** stars are labelled "**BY Dra variable**" (exhibit variations in their luminosity due to rotation of the star coupled with starspots, and other chromospheric activity => all marked, but not yet rejected
=> **3** stars are labelled "**CVn variable**" (close binary stars having active chromospheres which can cause large stellar spots) => **rejected**
=> **4** stars are labelled "**eruptive variable**" (varying in brightness because of violent processes and flares occurring in their chromosphere and coronae => **rejected**
=> **2** stars are labelled "**rotationary variable**" => **rejected**
=> **2** stars turned out to be over luminous **giants** => **rejected**
=> **29** stars are PMS stars with **ages significantly <500Myr** (mostly moving group association) => rejected 23 of them (with MG confidence >90%, mostly 99%, one star had only 77% confidence)

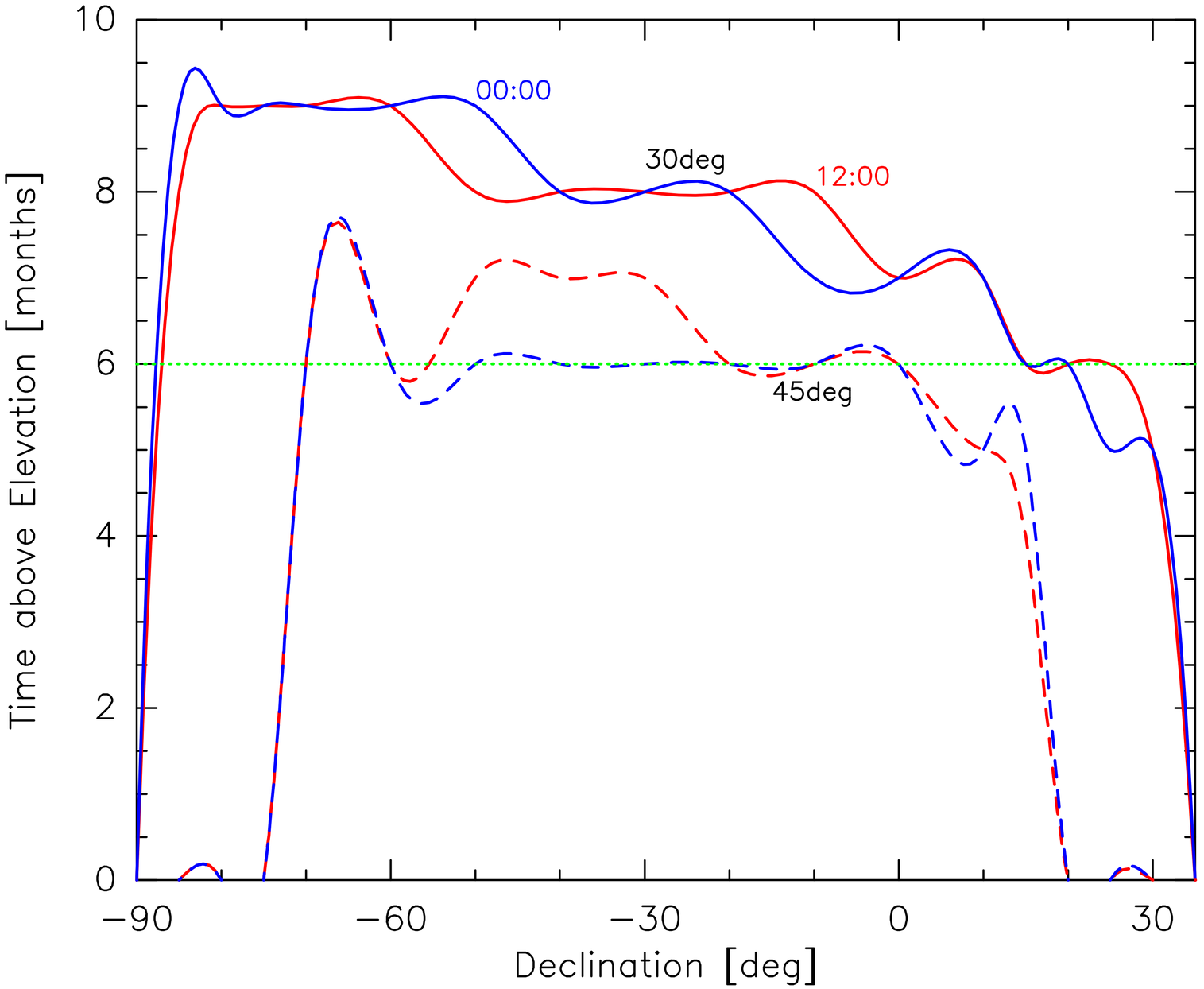
=> **71** stars **rejected**
=> **187** stars **potentially suitable** (i,e., not yet rejected), of which 80 have issues that need a closer look

=> **32** stars have known **RV planets** => must check individually if there is still space for a rocky planet in the HZ

=> **61** stars have significant **debris disk** excess

=> **128** stars are in **multiple** (mostly binary) systems, rejected only **21** of them with sep. <1" => must check at which physical sep. we make a cut, likely >1" (e.g., >30au)?

2ES (2nd Earth project) target list - Declination range



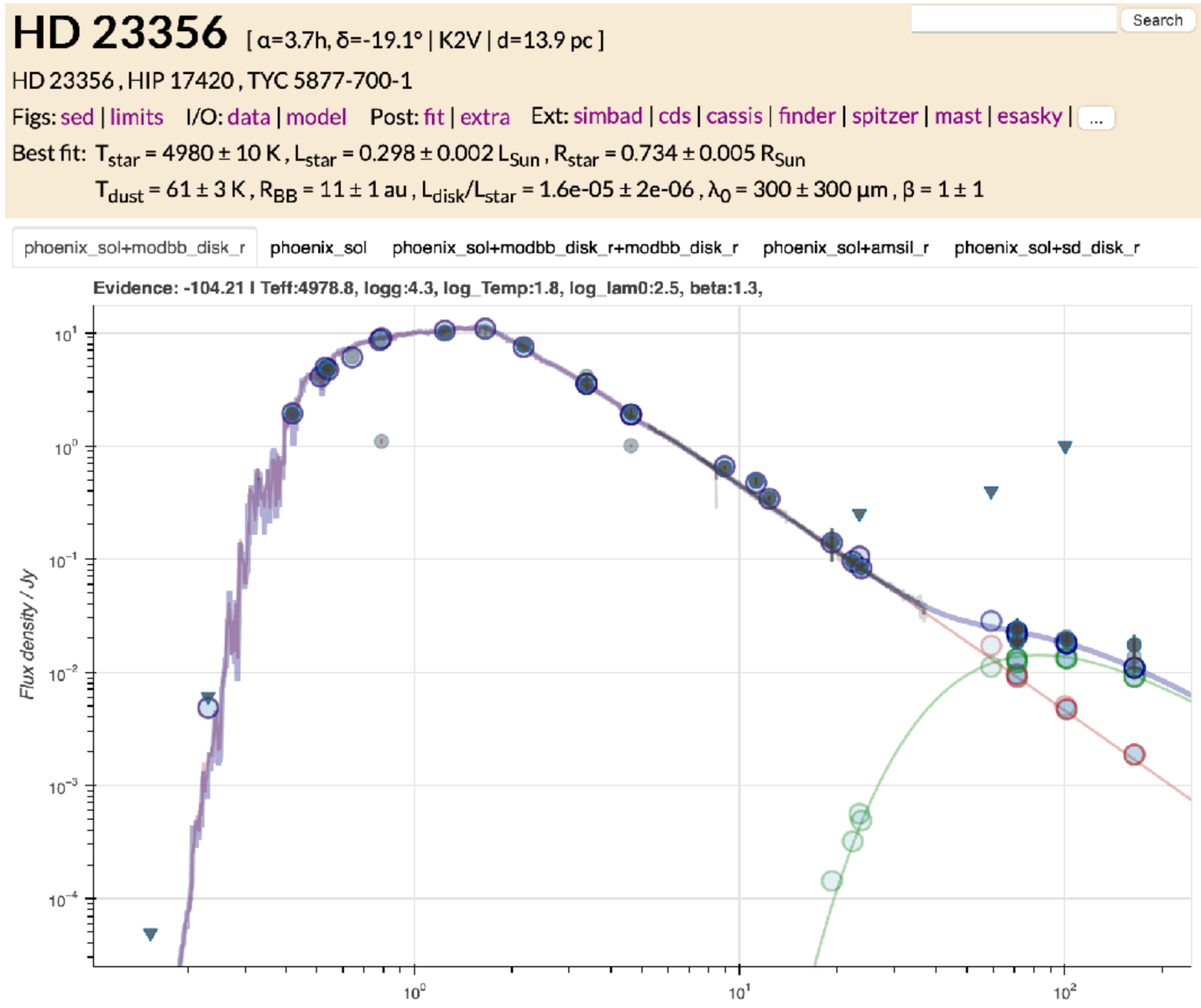
=> Targets with -85deg < dec < 30deg are for > 6 months for at least 1 hr above 30deg (AM 2)

=> If we find a really promising star between dec 25 and 30deg, we could still observe it.

=> Targets with -70deg < dec < 15deg are for > 5 months for at least 1 hr above 45deg (AM 1.4)

=> Use Declination range -85 deg - 30 deg for target candidate search!

2ES (2nd Earth project) target list - Derivation of stellar parameters



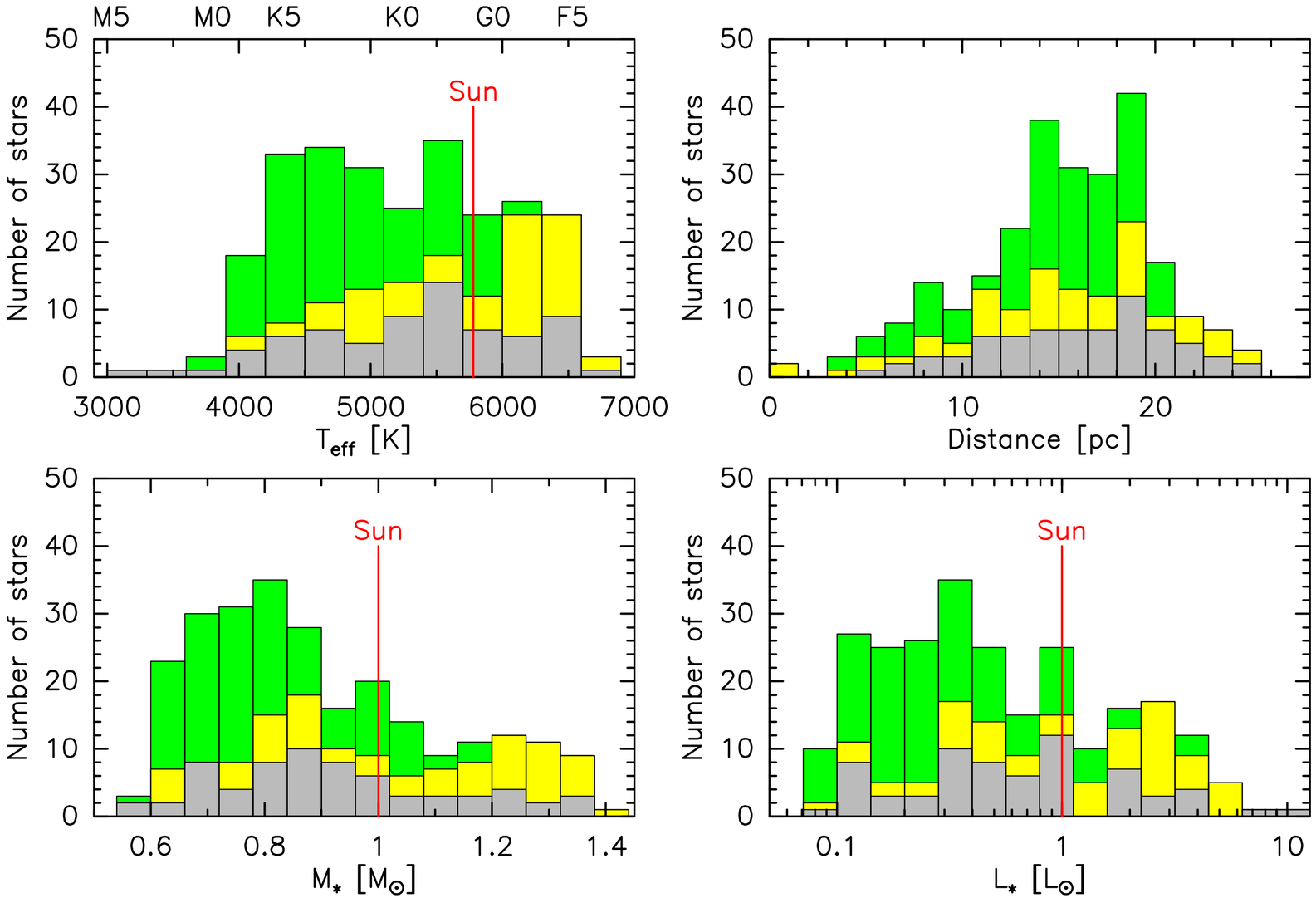
=> Phoenix model atmosphere fit to entire SED (incl. debris disk excess where applicable) gives much more accurate Teff etc. than Gaia only based values

2ES (2nd Earth project) target list - distribution plots 1

258 target candidates total

187 stars potentially suitable

71 stars rejected (hot and warm Jupiters, vis. Binaries with a<1”, eclipsing or other interacting binaries, …)

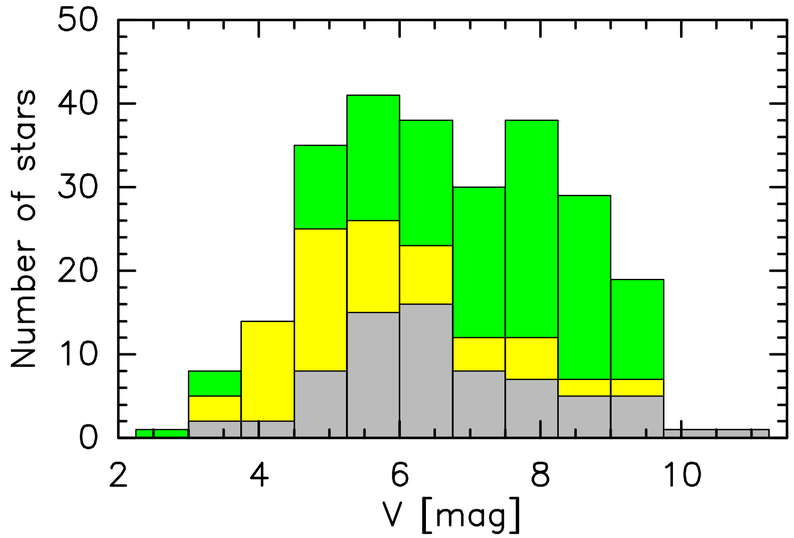


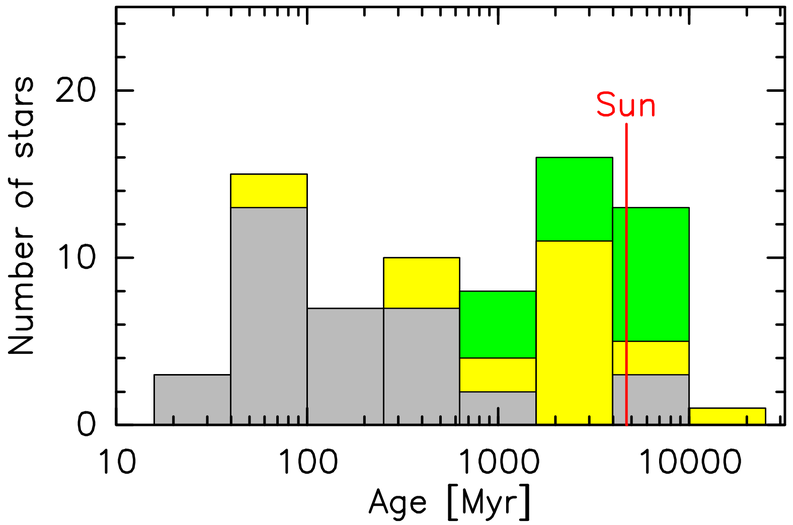
2ES (2nd Earth project) target list - distribution plots 2

258 target candidates total

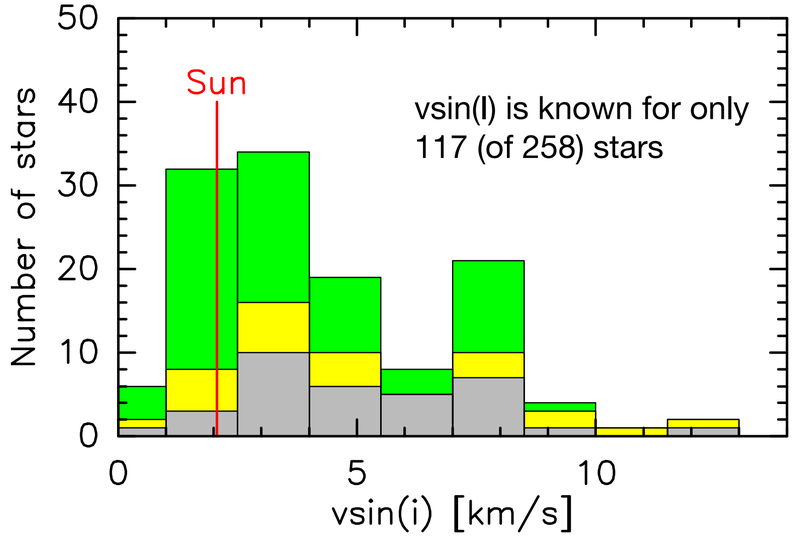
187 stars potentially suitable

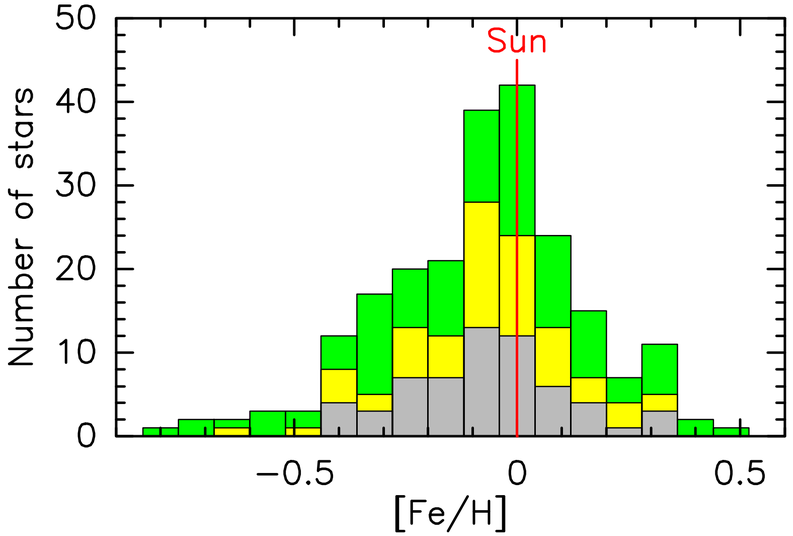
71 stars rejected (hot and warm Jupiters, vis. Binaries with a<1”, eclipsing or other interacting binaries, …)





Ages are know for only ~70 (of 258) stars, mostly for the young ones



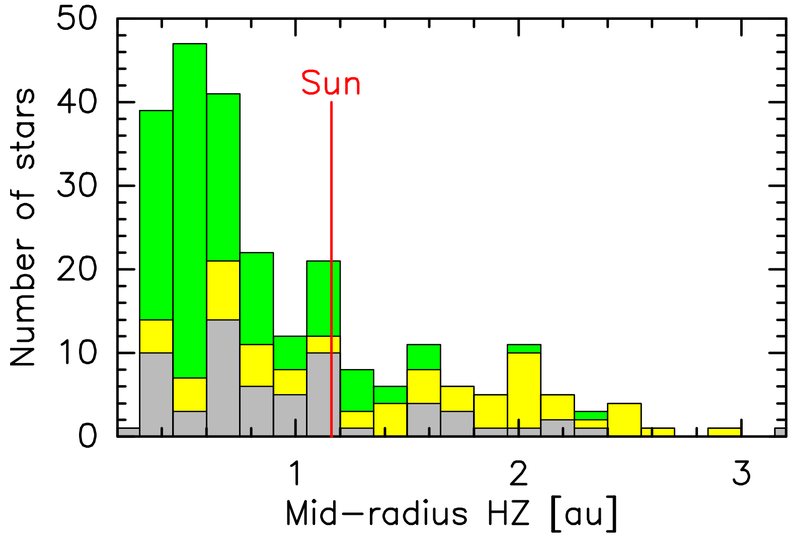


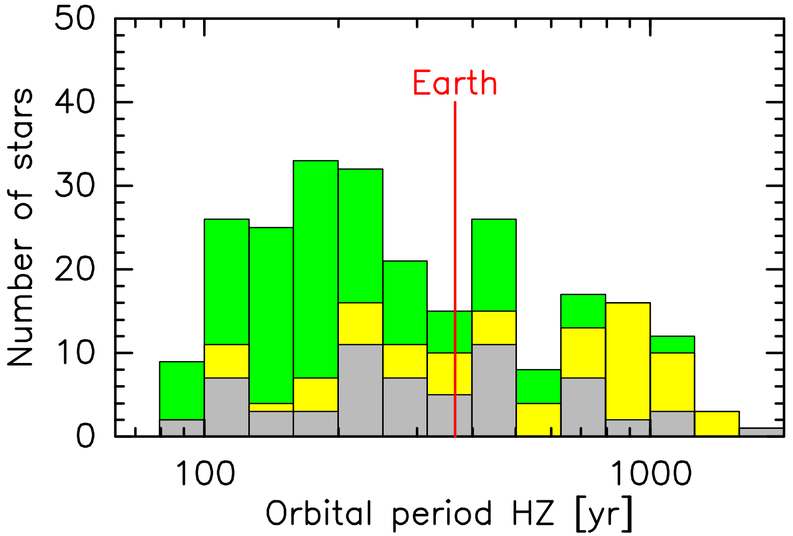
2ES (2nd Earth project) target list - distribution plots 3

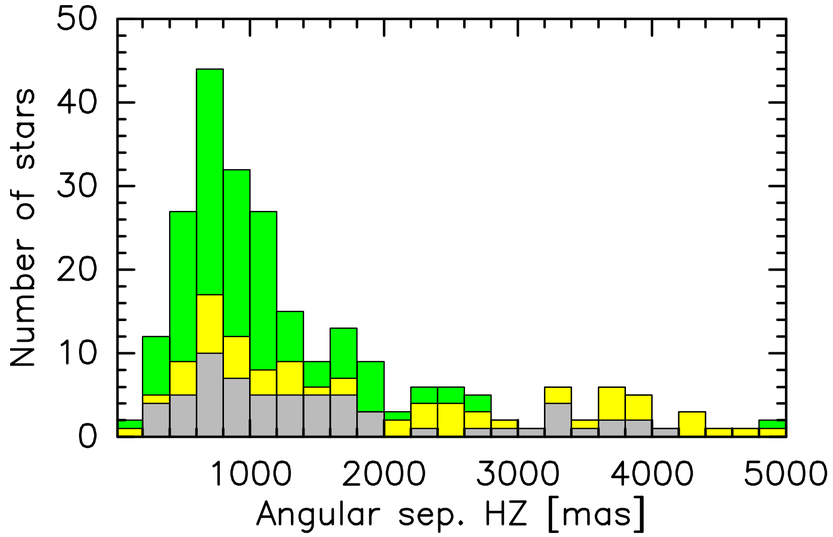
258 target candidates total

187 stars potentially suitable

71 stars rejected (hot and warm Jupiters, vis. Binaries with a<1”, eclipsing or other interacting binaries, …)

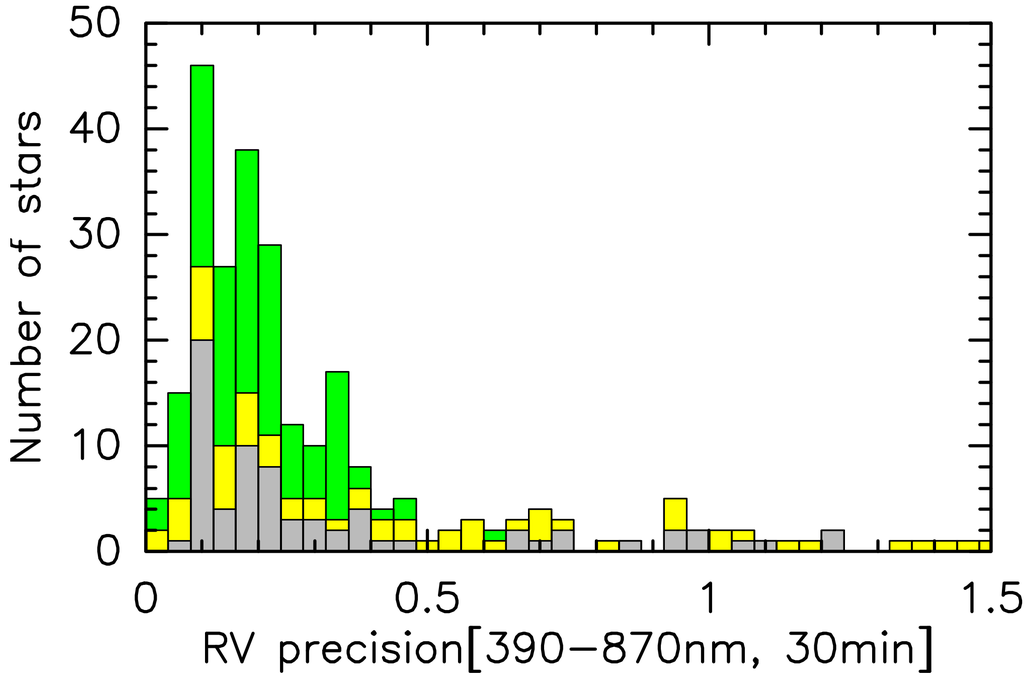


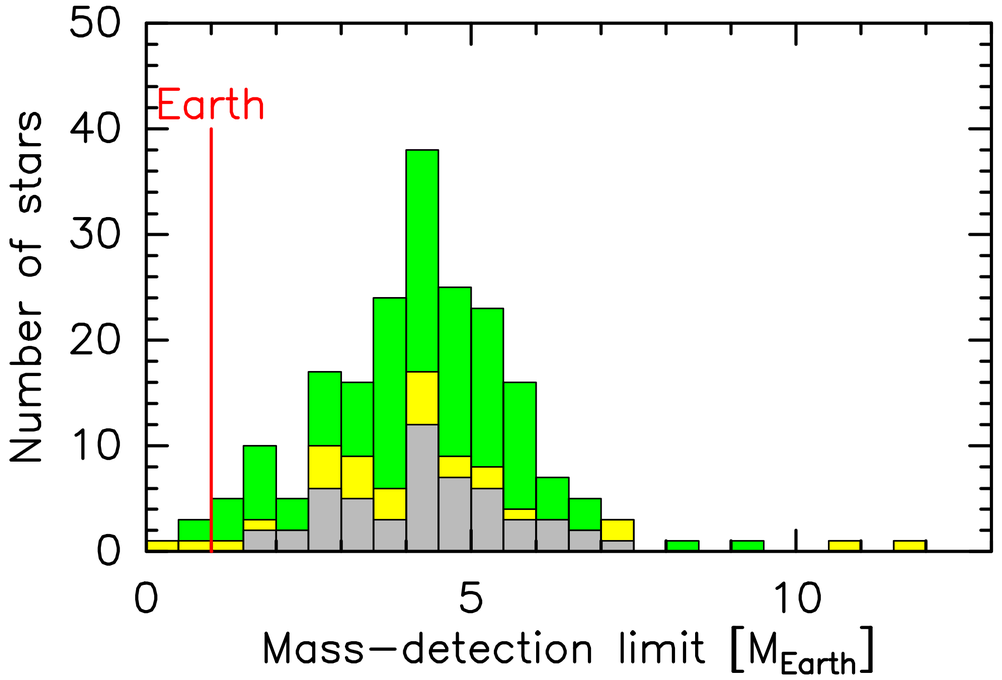




2ES (2nd Earth project) target list - distribution plots 3

258 target candidates total
187 stars potentially suitable
71 stars rejected (hot and warm Jupiters, vis. Binaries with a<1”, eclipsing or other interacting binaries, …)



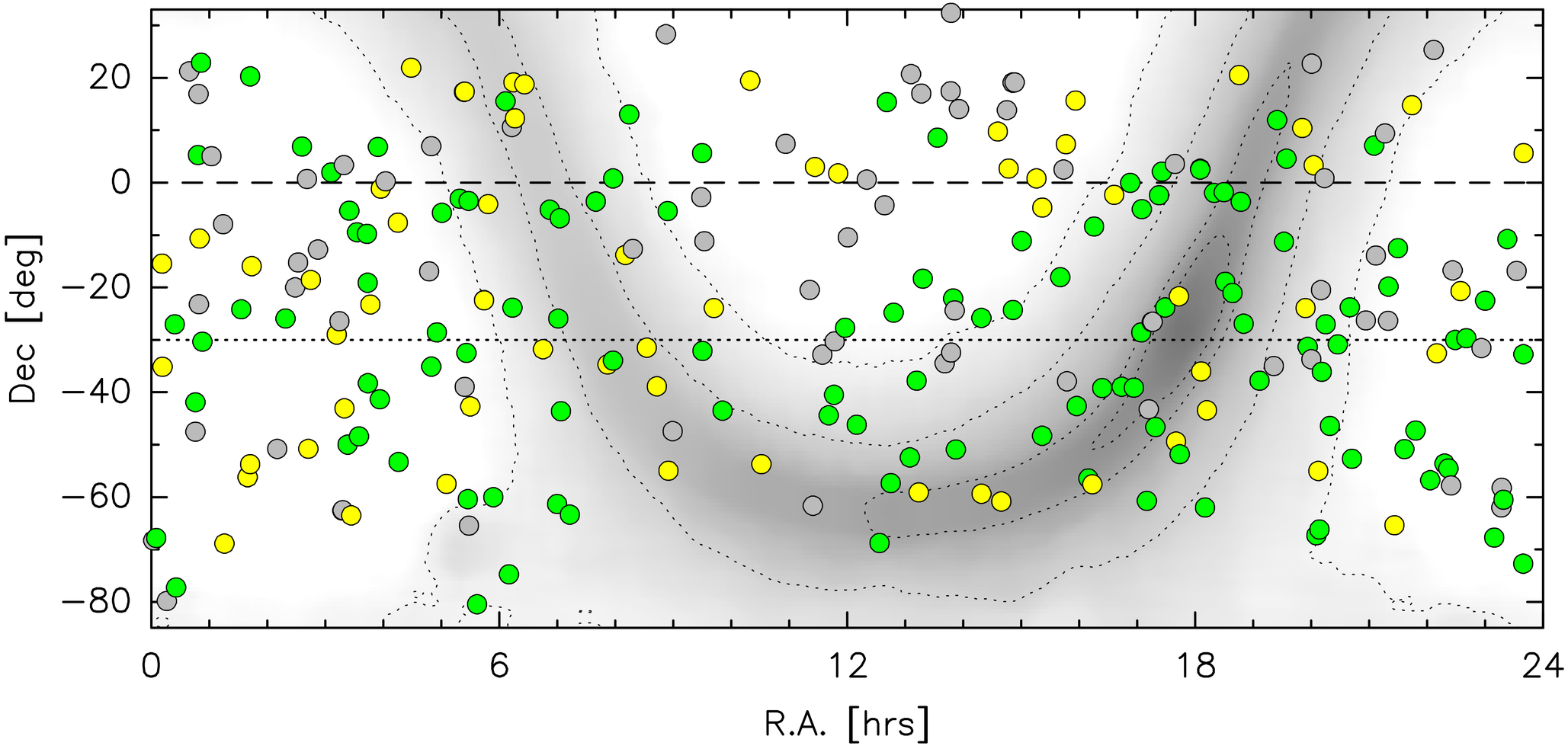


2ES (2nd Earth project) target list - distribution on sky

258 target candidates total

187 stars potentially suitable

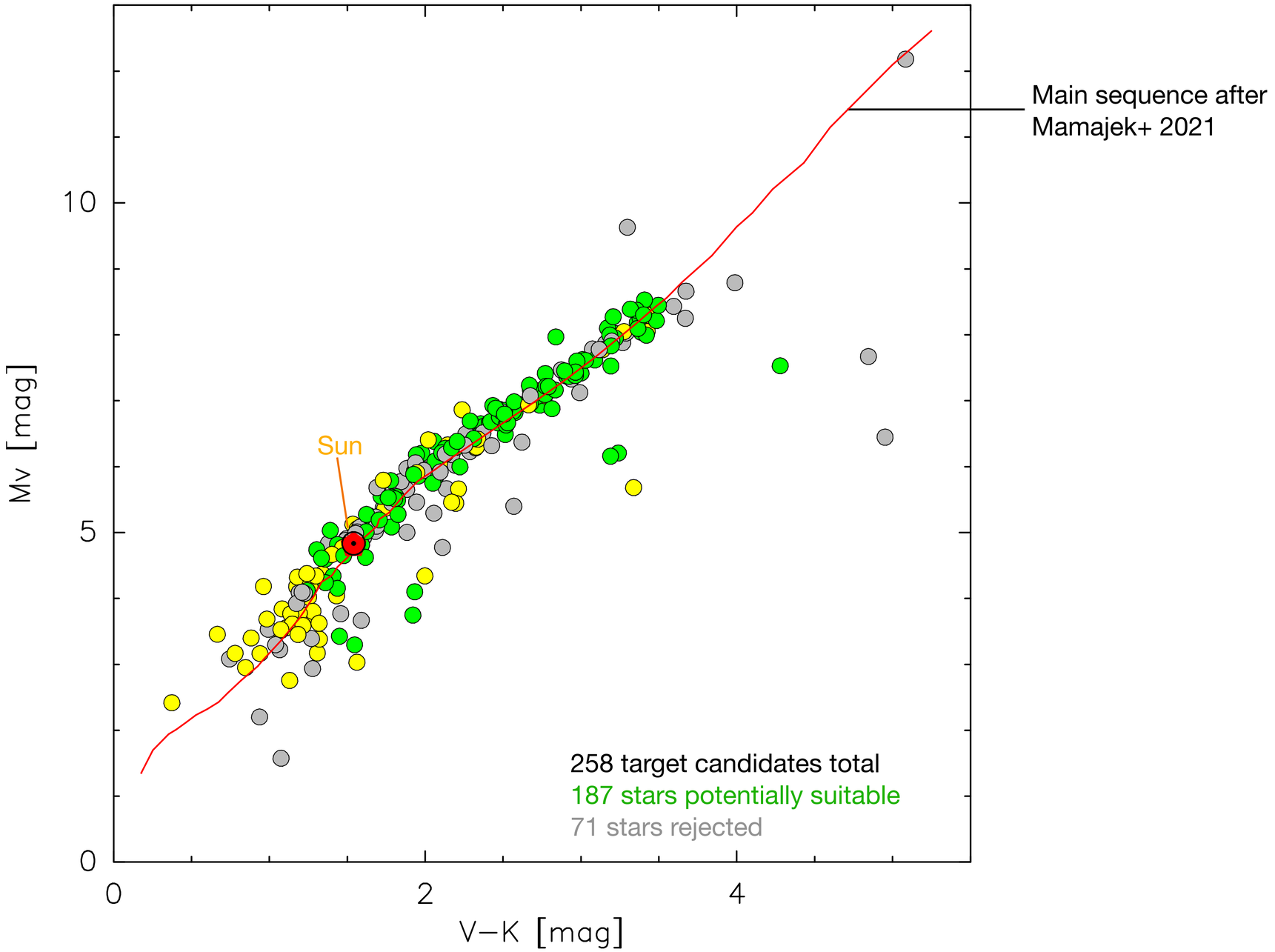
71 stars rejected (hot and warm Jupiters, vis. Binaries with a<1”, eclipsing or other interacting binaries, …)



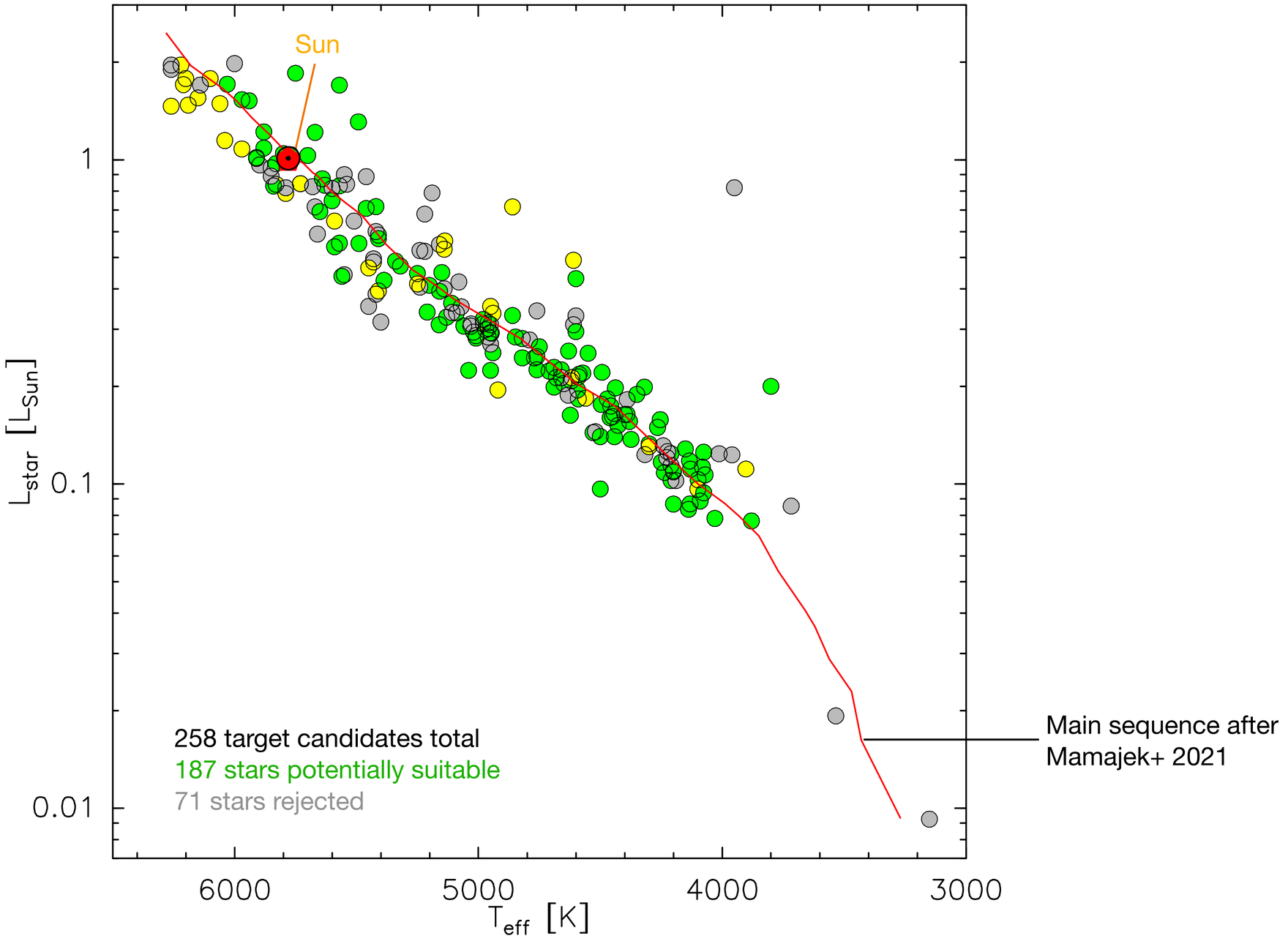
DEC limit for La Palma

Q: how much potential overlap do we want to have with the northern survey by DQ?

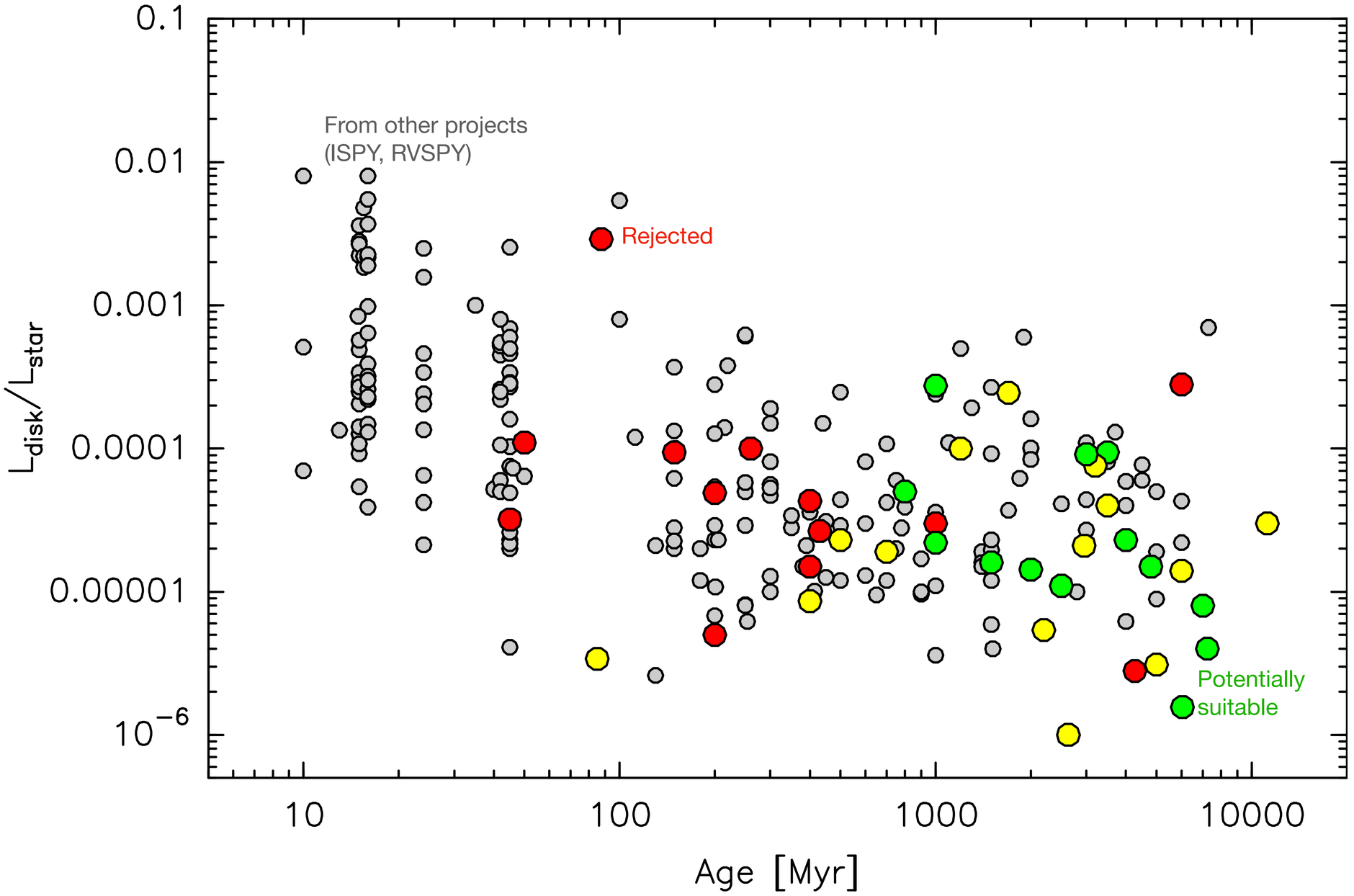
2ES (2nd Earth project) target list - CMD



2ES (2nd Earth project) target list - HRD

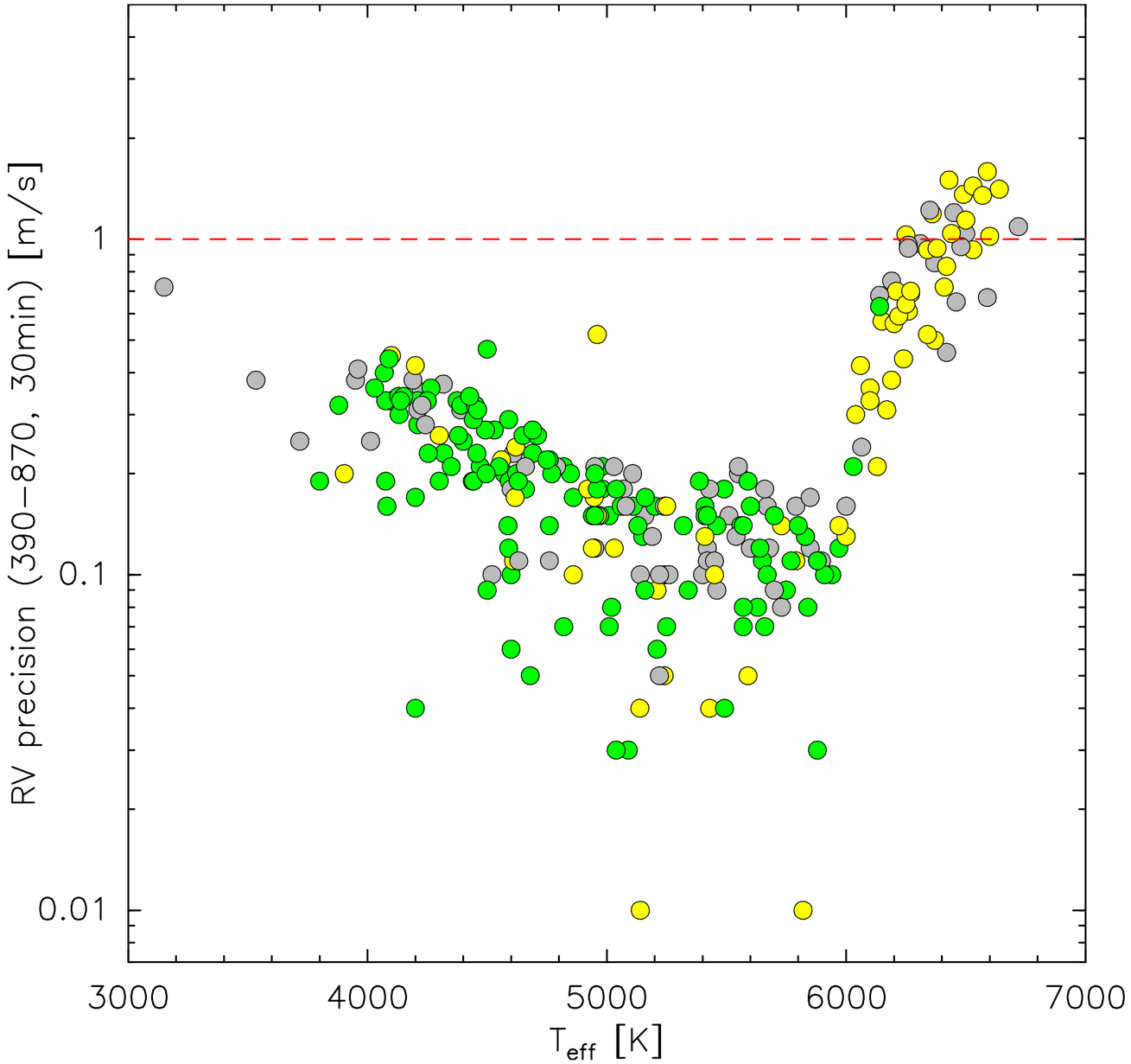


2ES (2nd Earth project) target list - debris disks



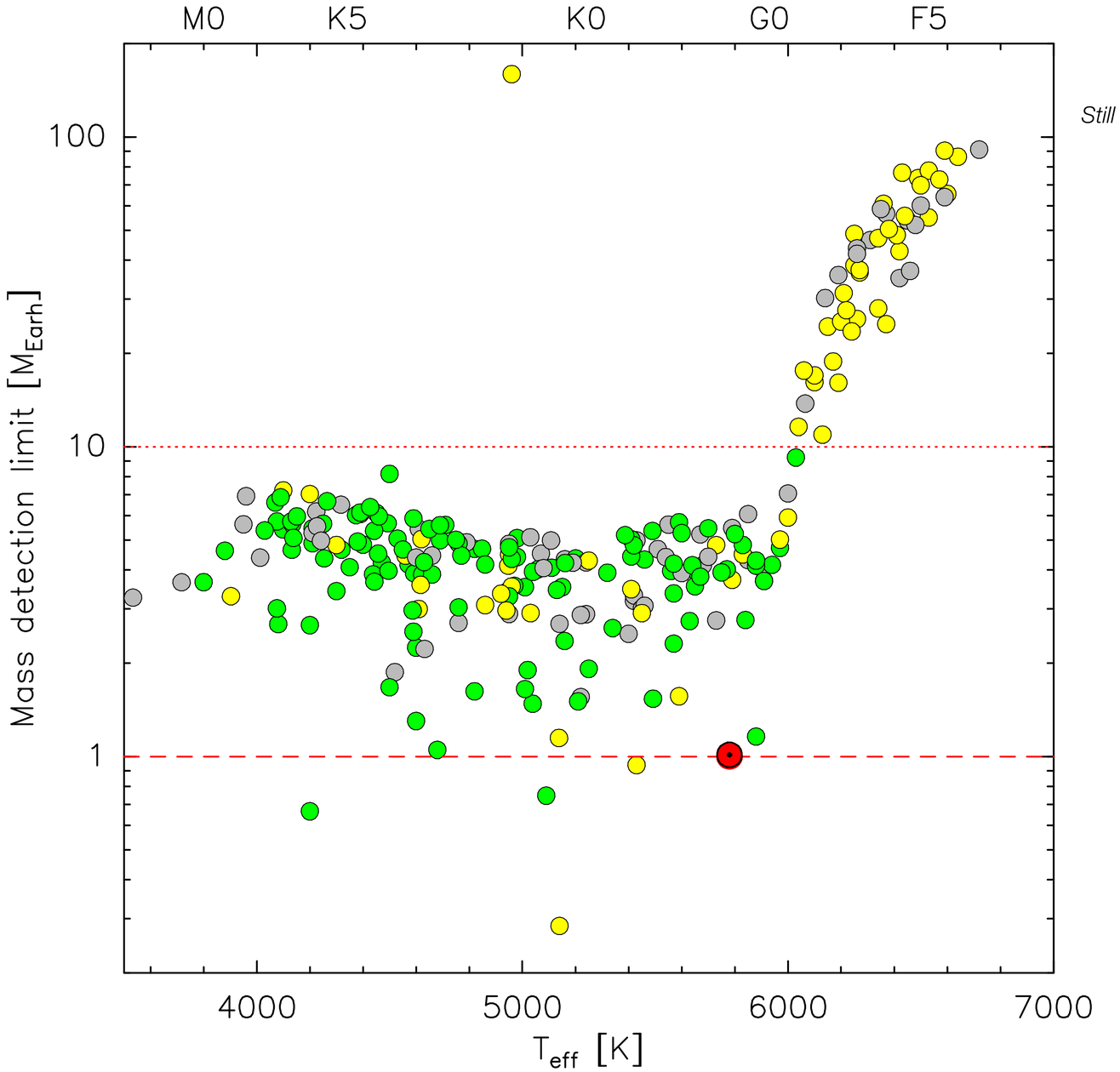
Only 37 out of 61 2ES target cand.
With DEB have ages assigned

2ES (2nd Earth project) target list - achievable RV precision



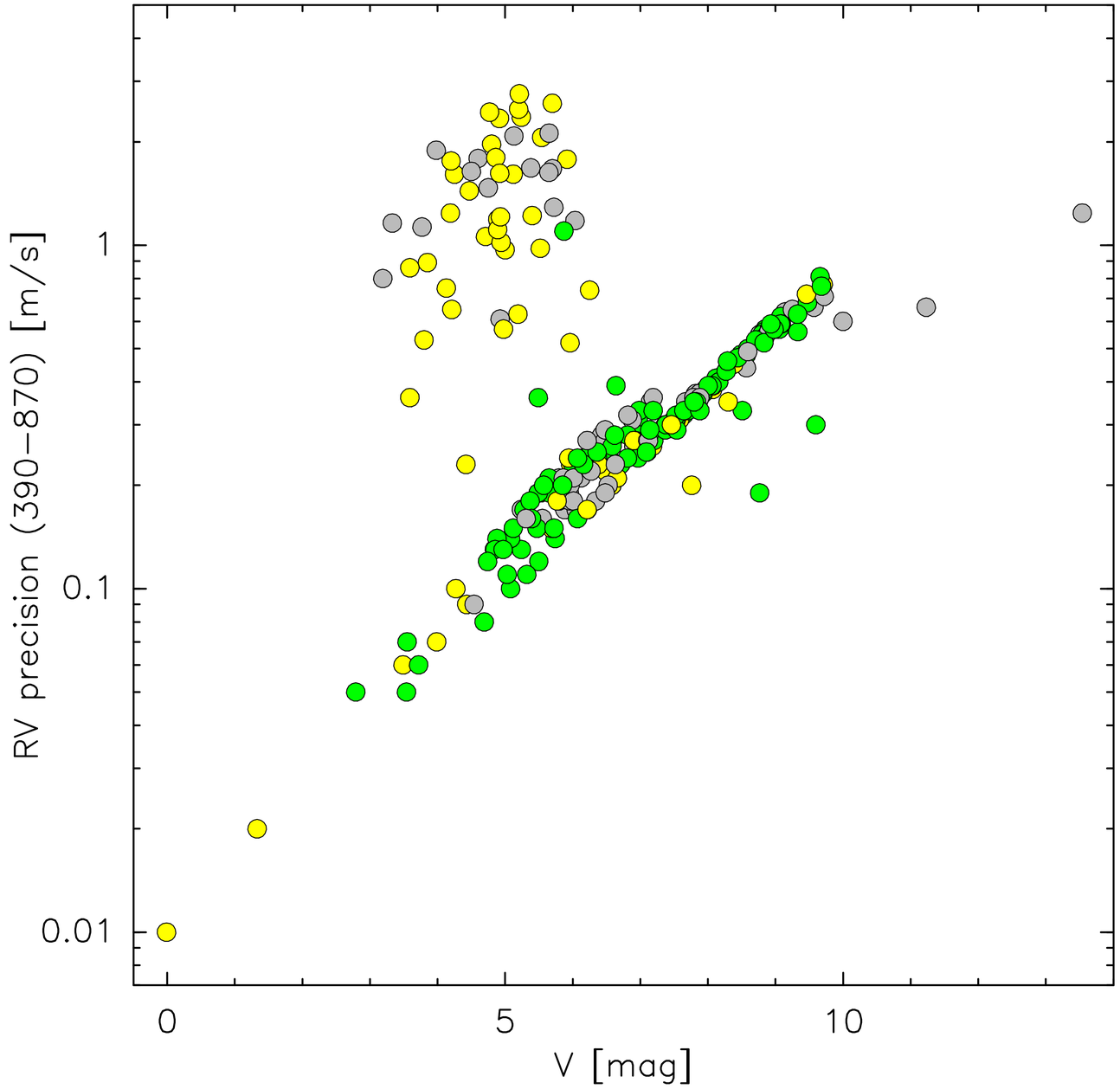
Still without taking vsin(i) into account

2ES (2nd Earth project) target list - mass-detection limits



Still without taking vsin(i) into account

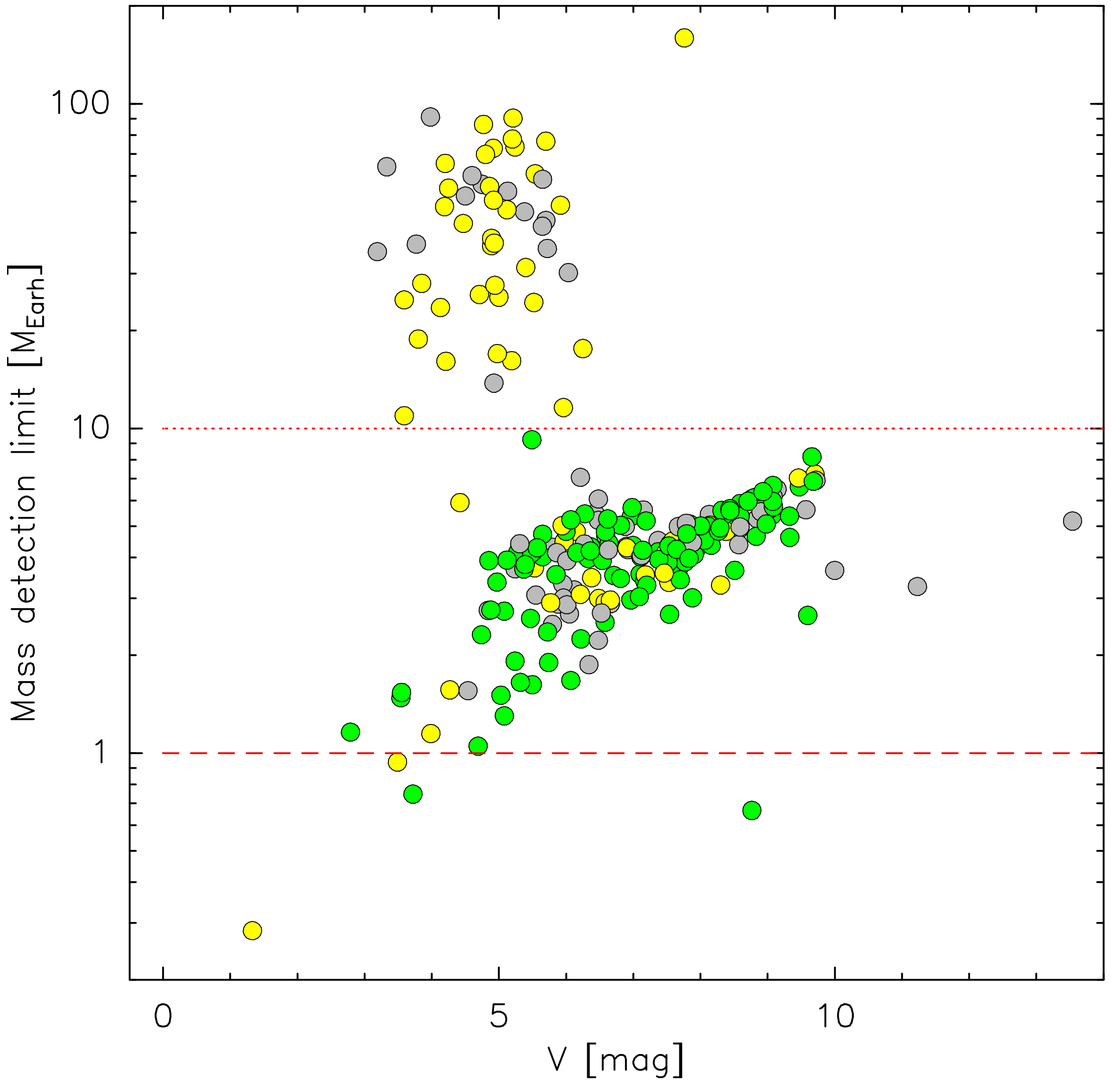
2ES (2nd Earth project) target list - RV precision vs. Vmag

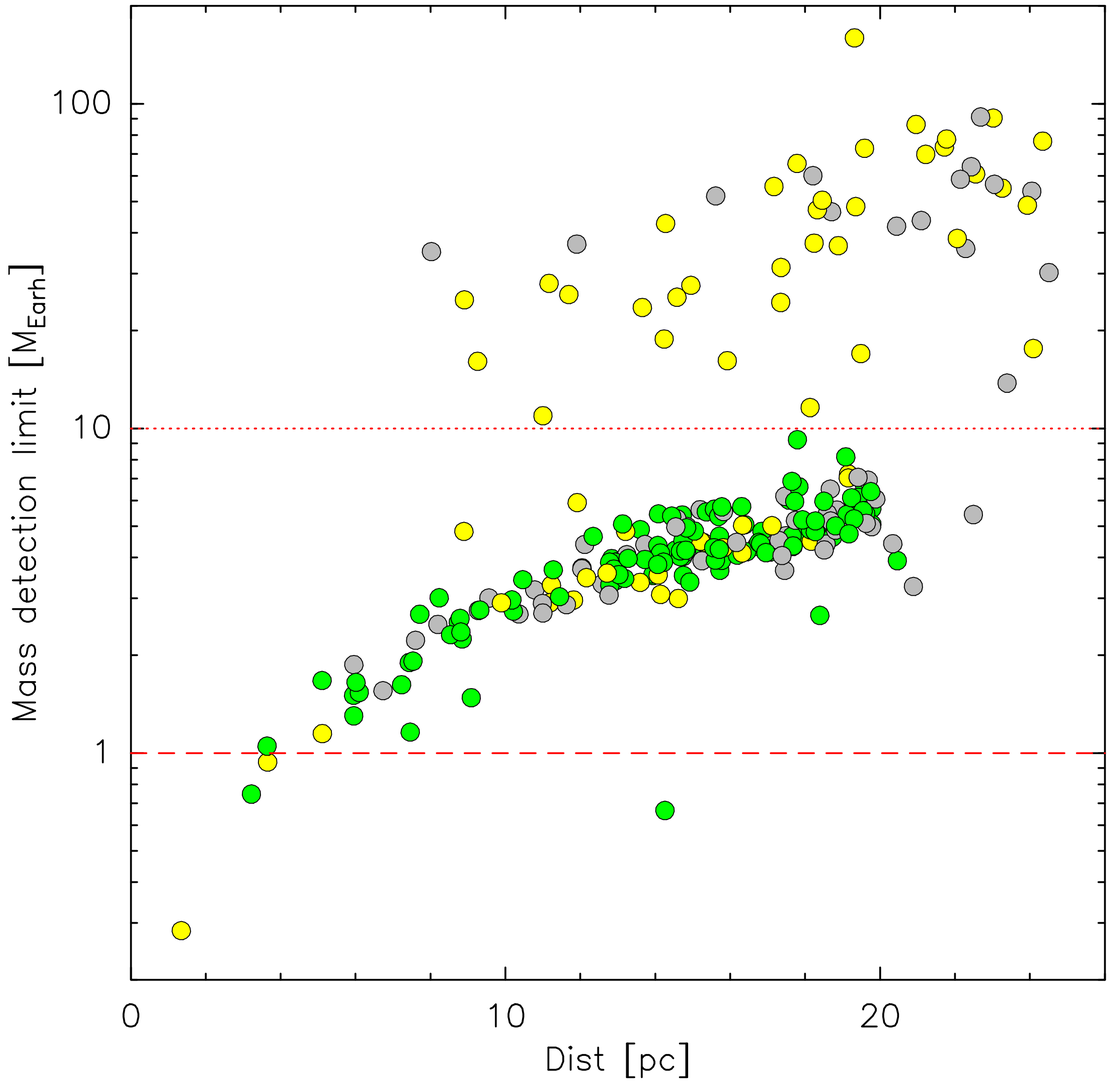


Still without taking vsin(i) into account

=> Photons matter!

2ES (2nd Earth project) target list - Mass det.lim. vs. Vmag and dist.





=> Going to larger distances or fainter, does not gain us more good targets!
=> Limit target candidate search to V/G ≦ 10 mag. Can drop distance limit or set to 50 pc.

Still without taking vsin(i) into account

2ES (2nd Earth project) target list - next tasks

=> Check **FEROS archive** for useable spectra to derive vsin(i) (and other pars.) for those stars that don't have them yet => Rafael Brahms *(I obtained already FEROS spectra for 27 stars)*

=> Schedule **FEROS observations** for those stars for which we don't find archive spectra *(can mostly do within my current project RVSPY, but coordinate with Rafa)*

=> Settle on a lower limit on **physical separation in binary stars** (e.g. 30au)

=> Go through **Melissas comments** on stars with Harps spectra

=> Do similar assessment of all potentially suitable stars w/o Harps spectra

=> Get **TESS** data to derive stellar rotation periods *(I have Prot thus far for only 10 stars, 2.1…13 days)*

=> Get HAT-pi data (lower precision, but longer time line)

=> Use Ansgar's RV precision tool and crossmatch target candidates, add scaling relation for RV precision as function of vsin(i)

=> Select and include stars with T_{eff}~6000-6500K (~F9-F5)? Thus far only T_{eff}~3000-6000K (M5-G0) => *Added 48 F9-F5 stars to list*