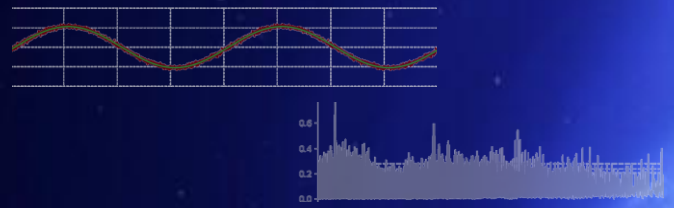
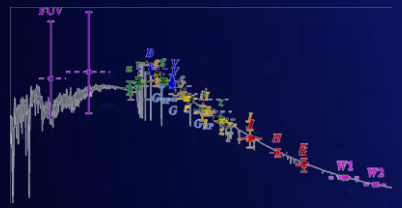
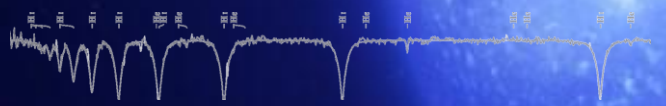
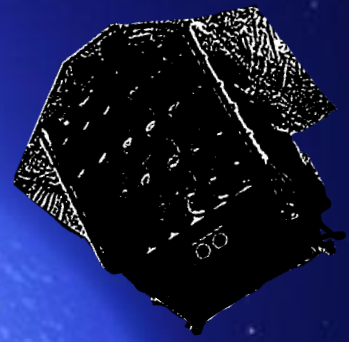
Probing common-envelope evolution with hot subluminous stars in the PLATO era

Anna Gebhardt









(ESO/L. Calçada, INAF-Padua/S. Zaggia)

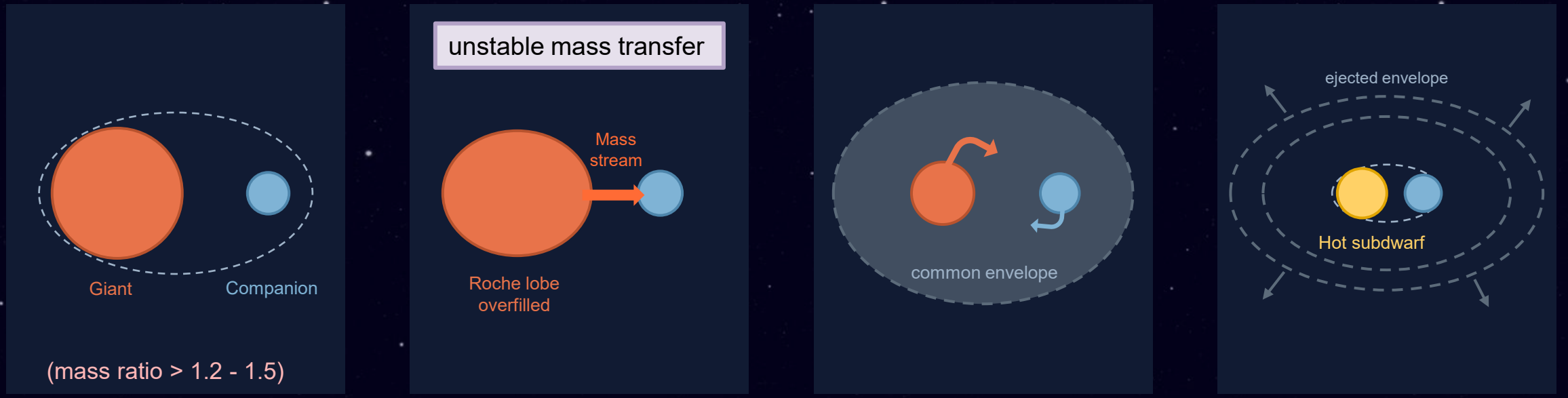
Collaborators:

Ulrich Heber, Stephan Geier, Matti Dorsch, and Murat Uzundag

September 8th, 2026

Dr. Karl Remeis-Observatory Bamberg

Common envelope evolution (CEE)



The *PLATO* mission - Complementary Science and Guest Observers

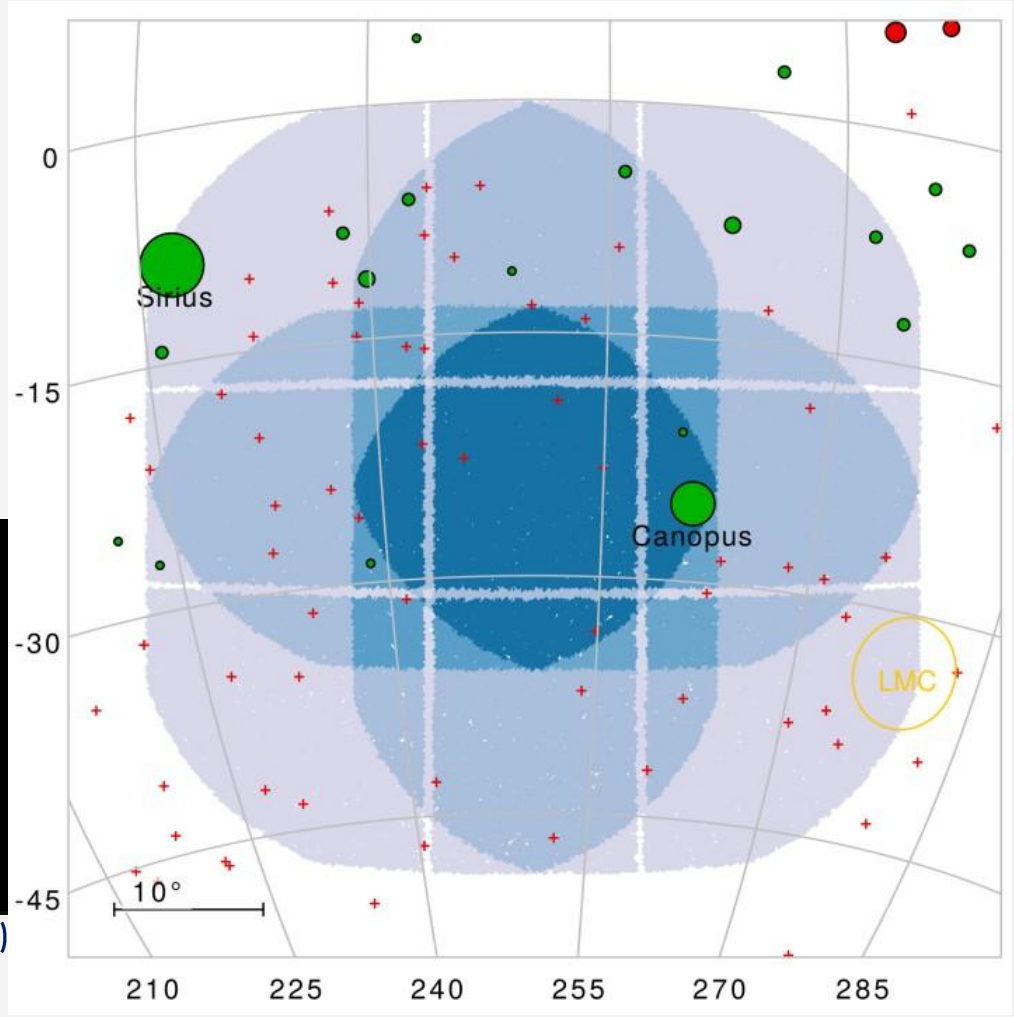
PLAnetary **T**ransits and **O**scillations of stars in LOPS2

- Launch planned by 01.01.2027
- topics not covered by the core program
- 8% of the total mission telemetry budget (~35 Gbit/day)

- High-precision, long-baseline photometry (up to 2 years)
- Sensitive to low-amplitude variability

↔ TESS

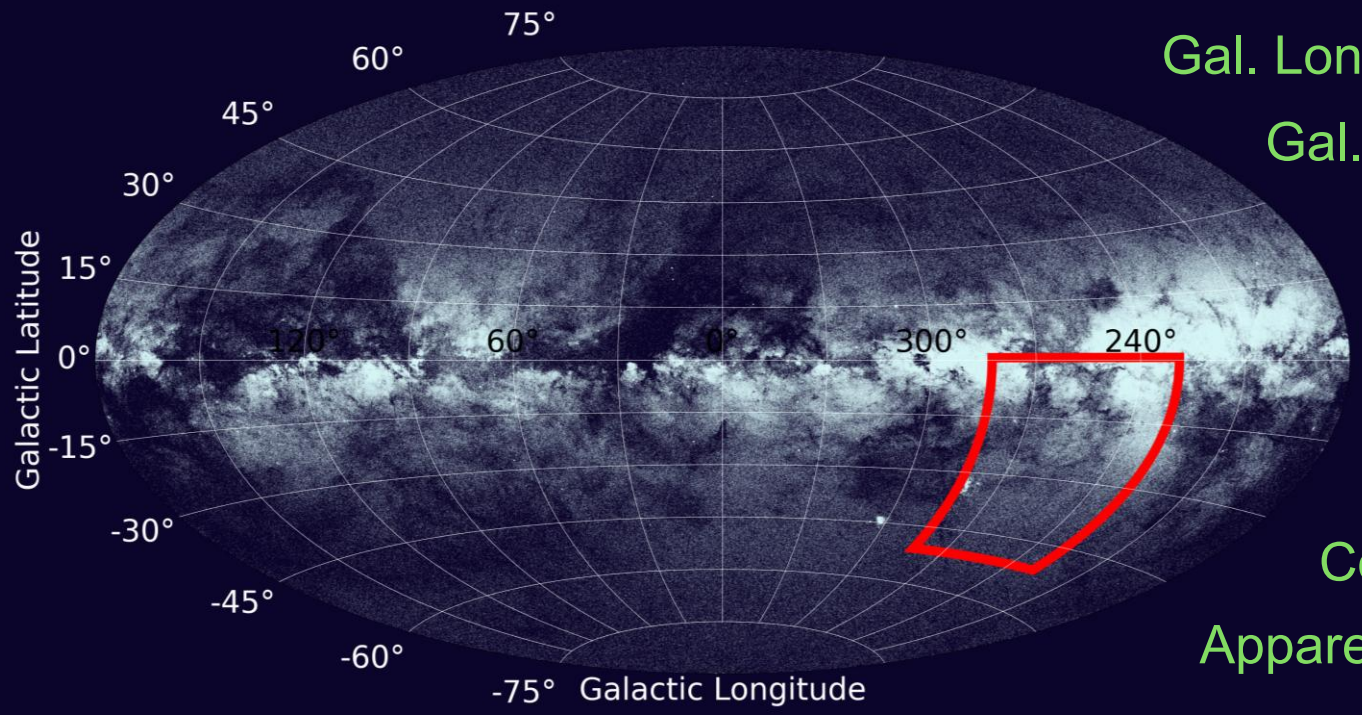
(Credit: OHB System AG)



(Nascimbeni et al., 2021)

Information about hot subdwarf population required!

Sample selection



Gal. Longitude 230.9° ~ 280.9°

Gal. Latitude - 49.6° ~ 0.4°

Parallax > 0 mas

Parallax error < 20 %

Colour - 0.7 ~ 0.7 mag

Apparent magnitude < 17 mag

+

- Known hot subdwarfs (Geier, 2020 + Culpan, 2023)
- Candidate hot subdwarfs (Geier, 2019 + Culpan, 2023)

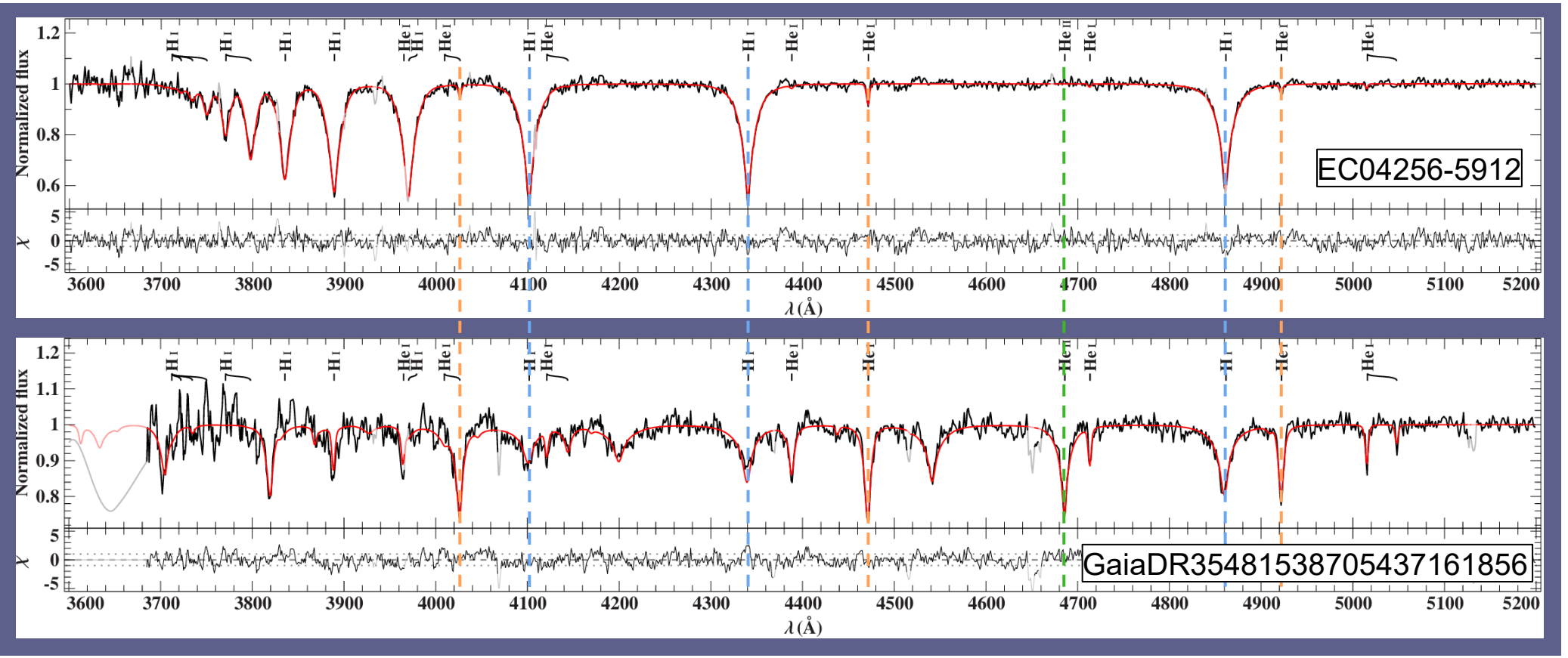
+

SED parameter limit for the T_{eff}, L, and R errors

→ 352 objects

Optical and NIR spectroscopy

(Credit: Sloan Digital Sky Survey, 2022)



sdB

$T_{\rm eff} = 25960^{+50}_{-40}$ K

He-sdO

$T_{\rm eff} = 44030^{+90}_{-60}$ K

107 non-composite spectra

→ Atmospheric parameters $T_{\rm eff}$, $\log g$, $\log \mathrm{He/H}$ from spectra or estimated from evolutionary predictions

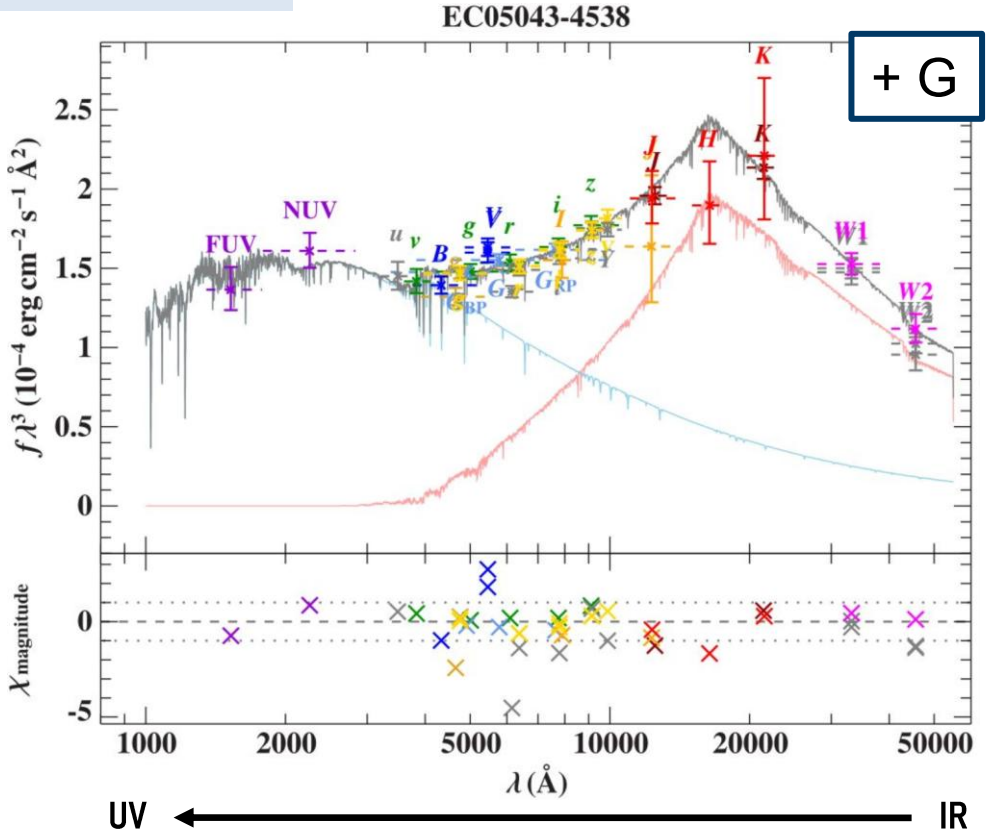
SED fits + *Gaia* DR3 : stellar parameters

Input: $T_{\rm eff}$, $\log g$, $\log \mathrm{He/H}$

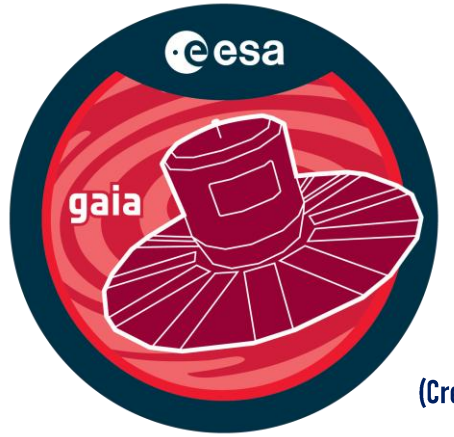
→ Angular diameter Θ

→ Colour excess $E(\mathrm{B}-\mathrm{V})$

→ Composites



+



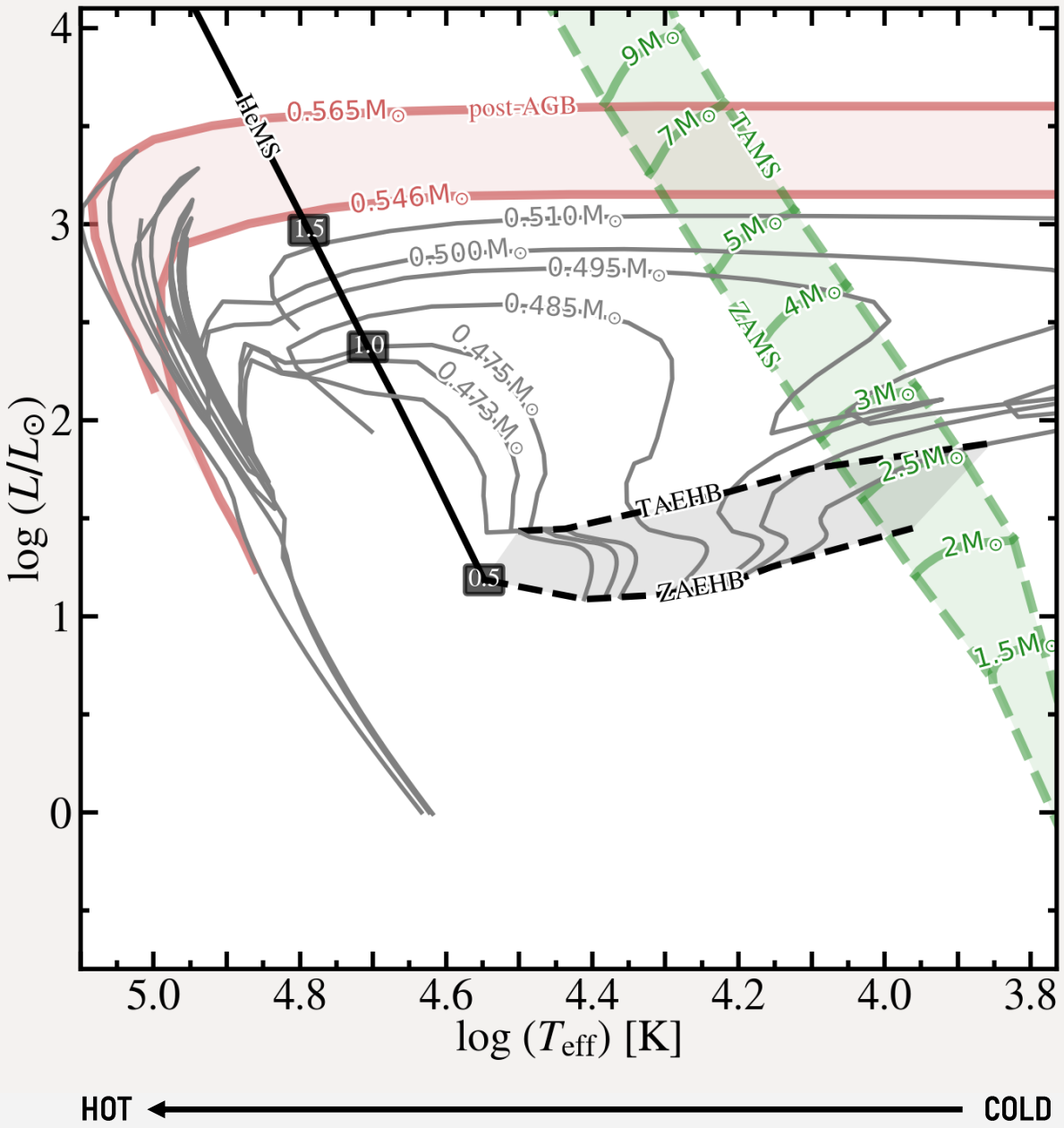
(Credit: Gaia/ESA)

parallax ϖ

$$L = 4\pi\sigma \left(\frac{\Theta}{2\varpi}\right)^2 T_{\rm eff}^{\ 4}$$

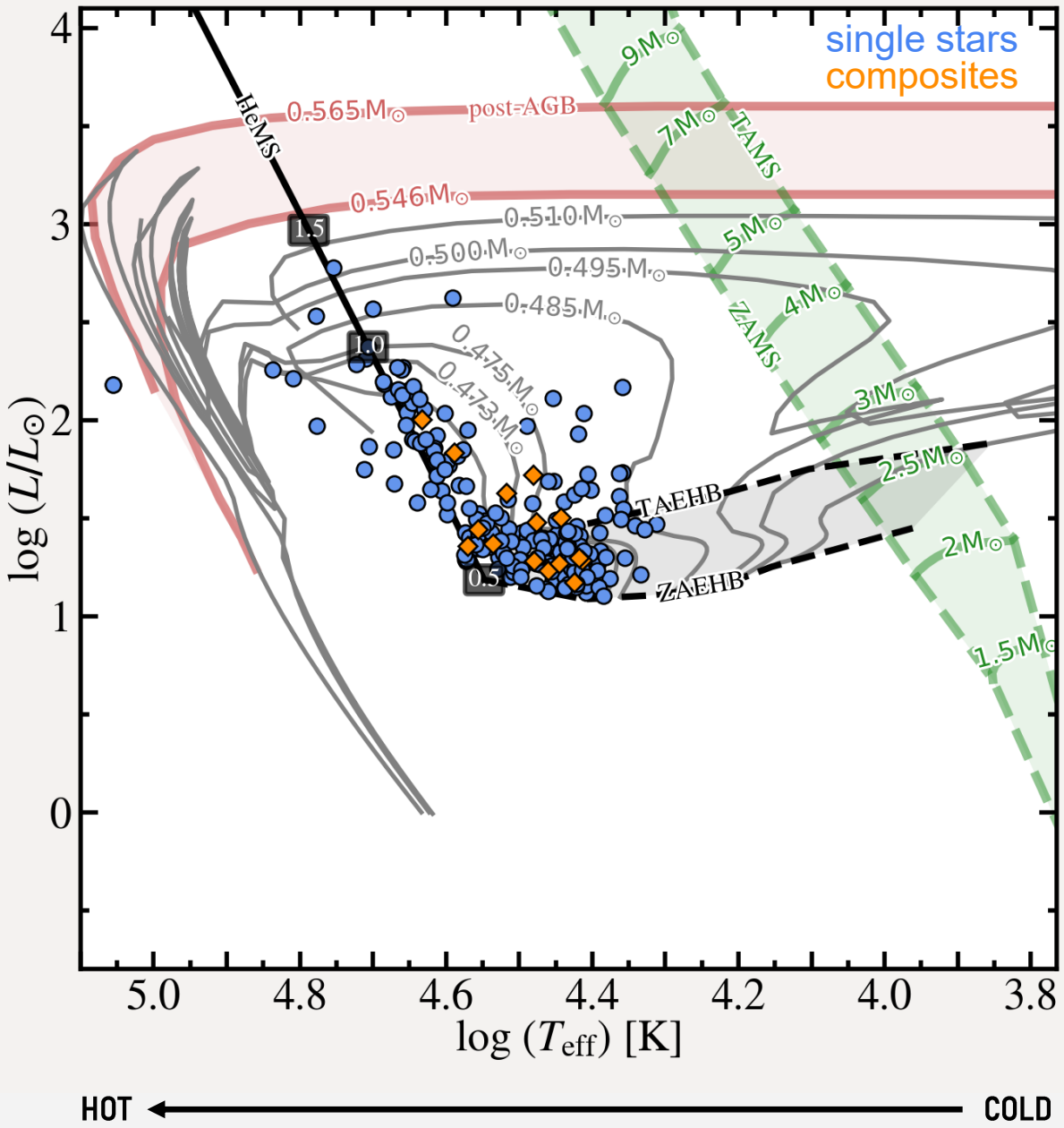
$$\mathrm{M} = \left(\frac{\Theta}{2\varpi}\right)^2 \frac{\mathrm{g}}{\mathrm{G}}$$

Luminosity



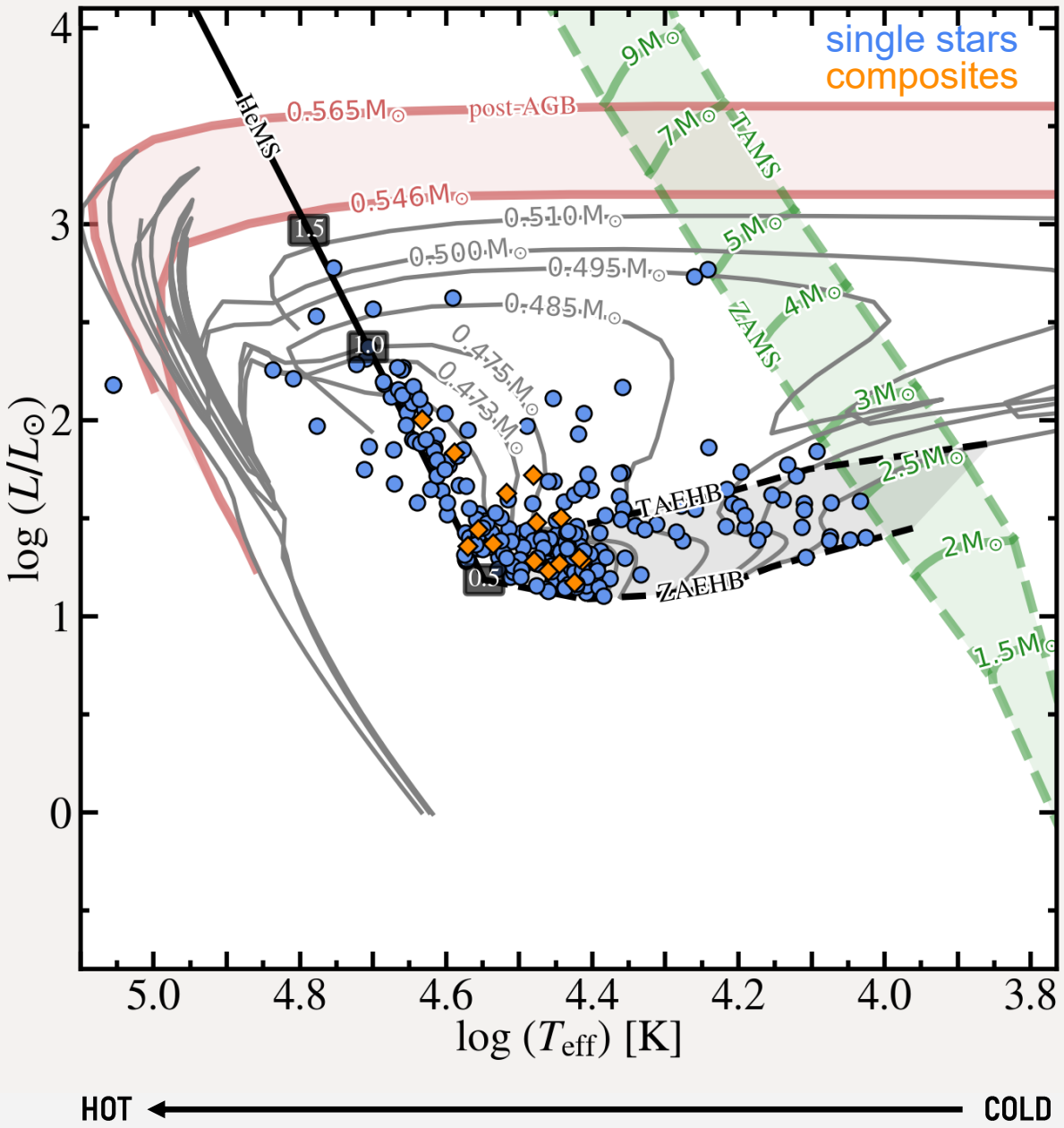
(Tracks: Dorman et al., 1993; Schaller et al., 1992; Miller Bertolami, 2016; Paczyński, 1971)

Luminosity



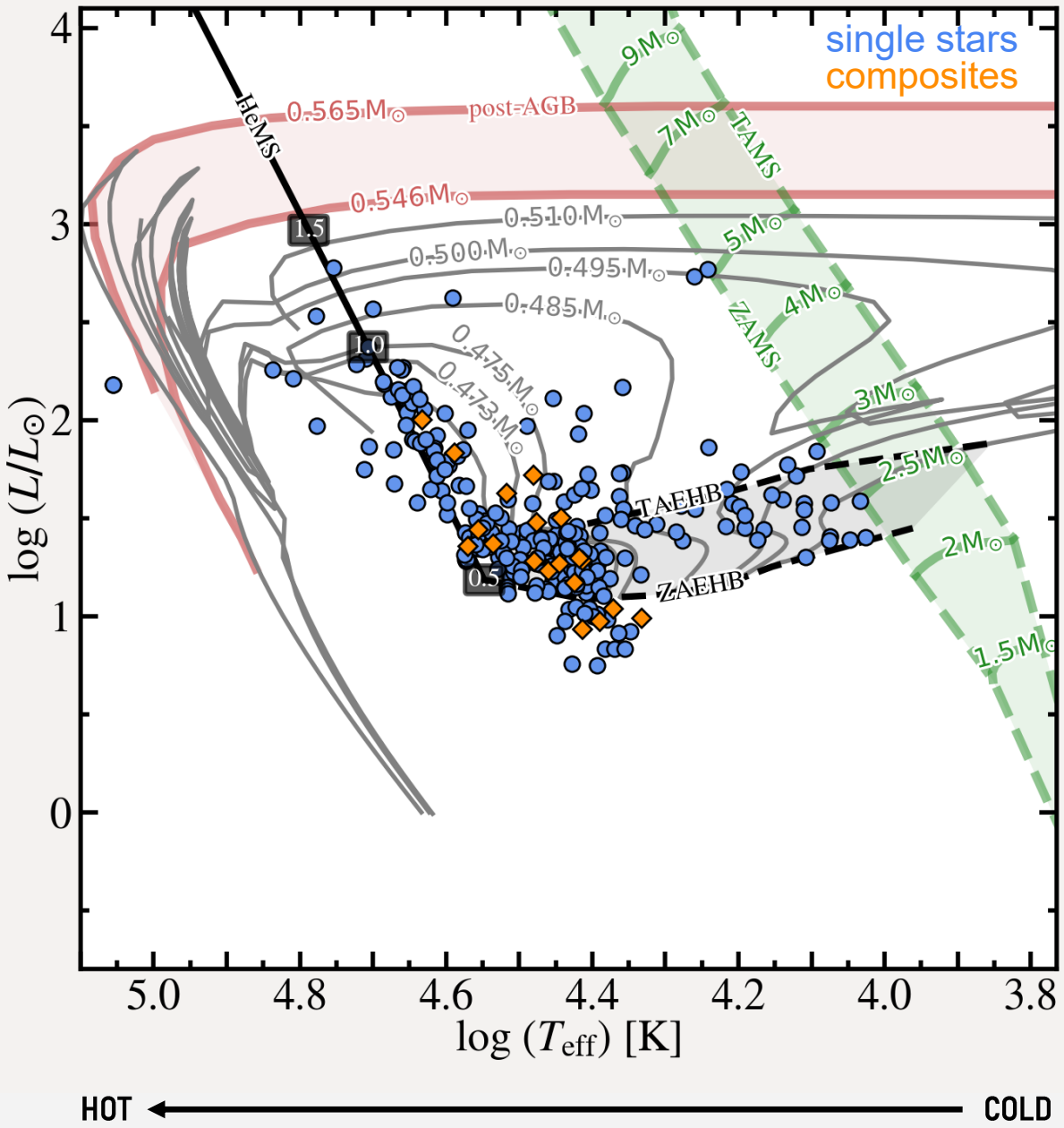
(Tracks: Dorman et al., 1993; Schaller et al., 1992; Miller Bertolami, 2016; Paczyński, 1971)

Luminosity



(Tracks: Dorman et al., 1993; Schaller et al., 1992; Miller Bertolami, 2016; Paczyński, 1971)

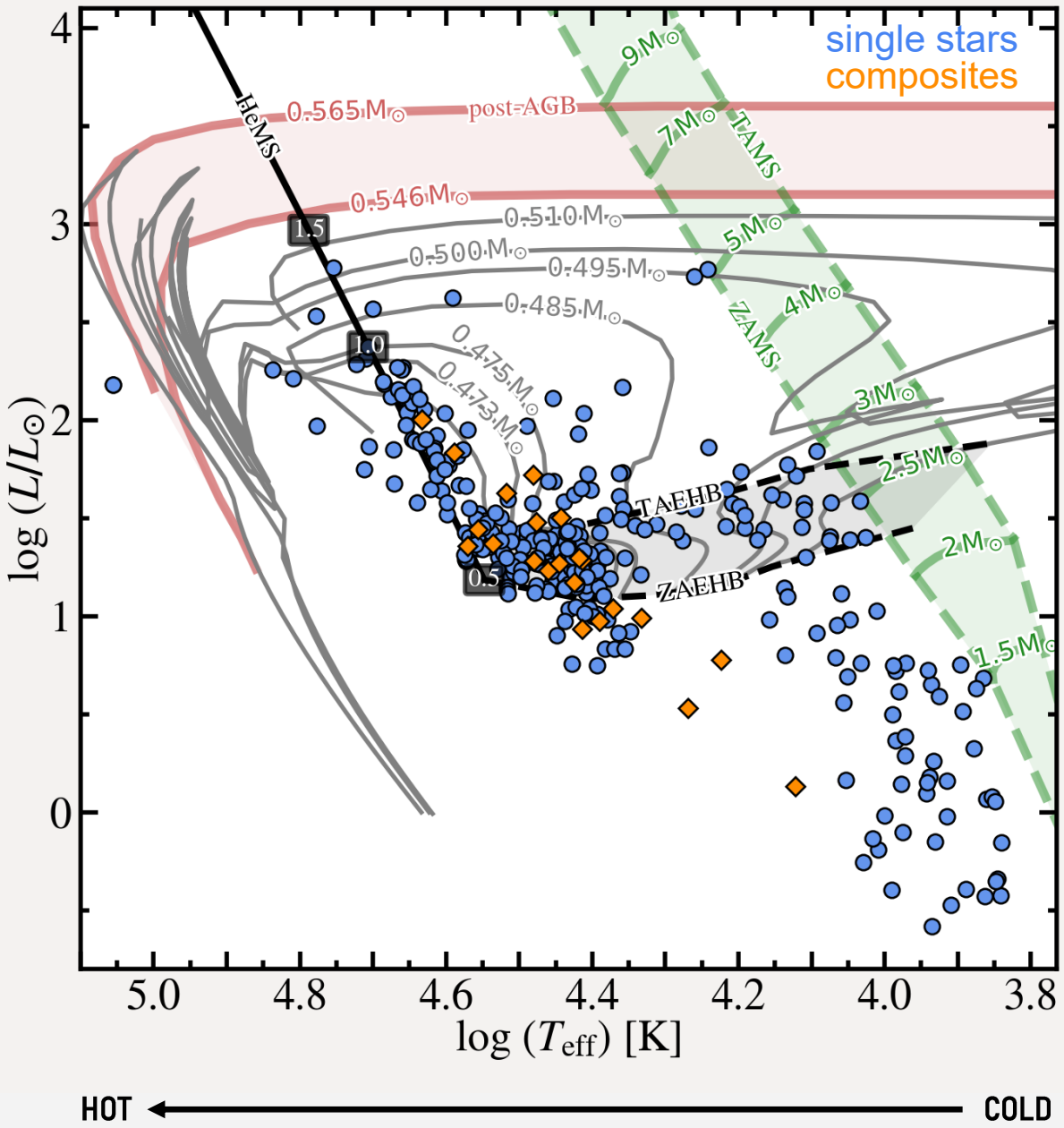
Luminosity



below the EHB evolved from intermediate mass stars

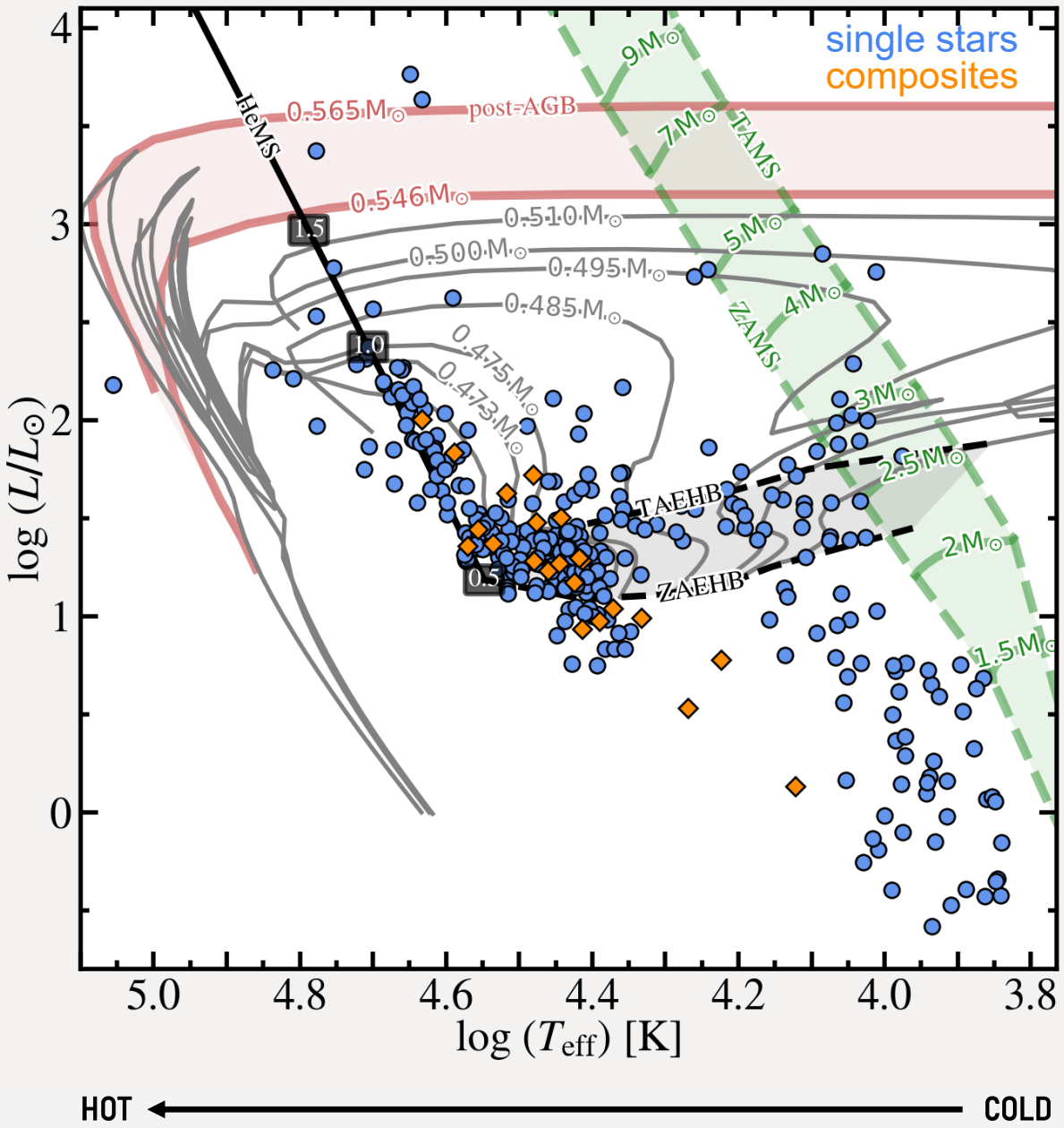
(Tracks: Dorman et al., 1993; Schaller et al., 1992; Miller Bertolami, 2016; Paczyński, 1971)

Luminosity



(Tracks: Dorman et al., 1993; Schaller et al., 1992; Miller Bertolami, 2016; Paczyński, 1971)

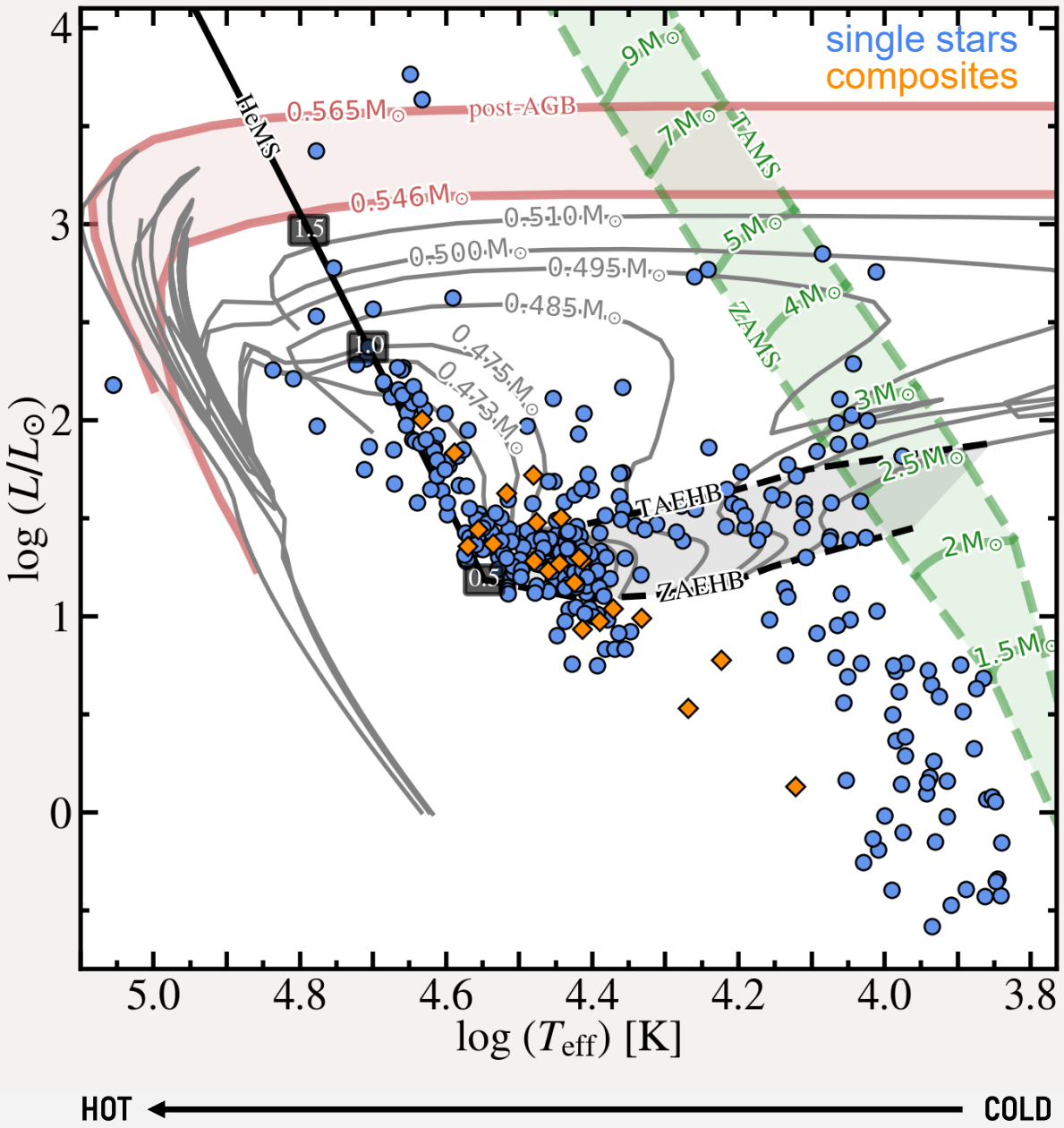
Luminosity

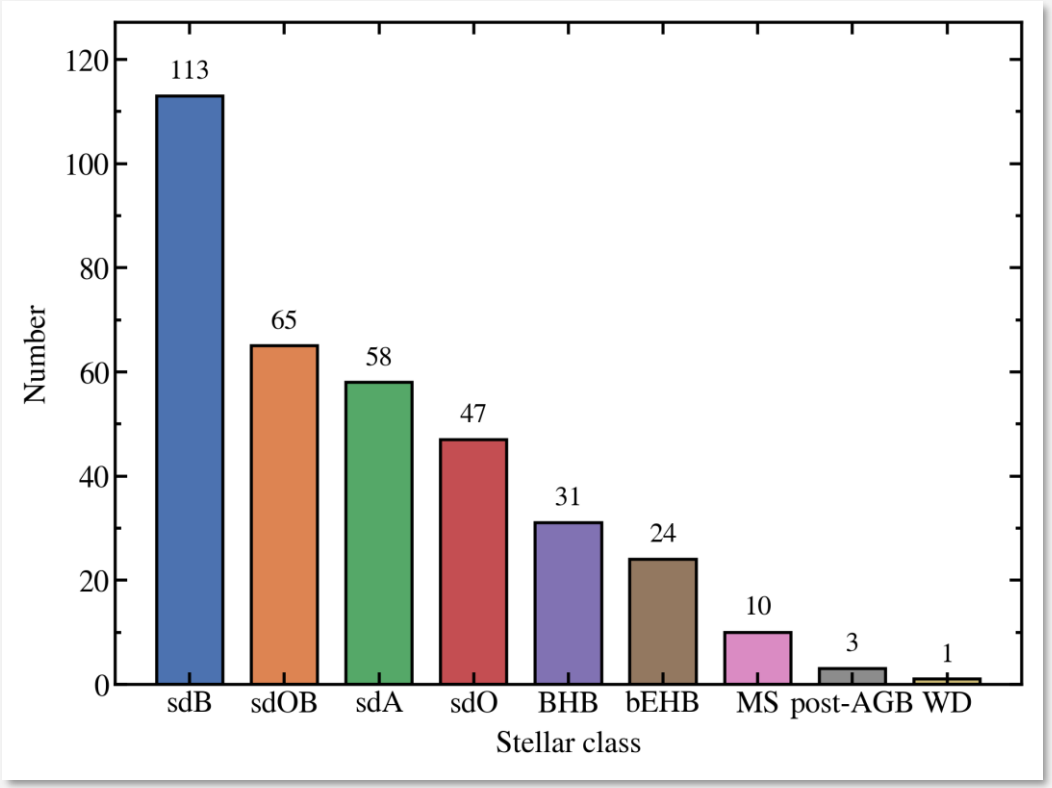


(Tracks: Dorman et al., 1993; Schaller et al., 1992; Miller Bertolami, 2016; Paczyński, 1971)

Luminosity

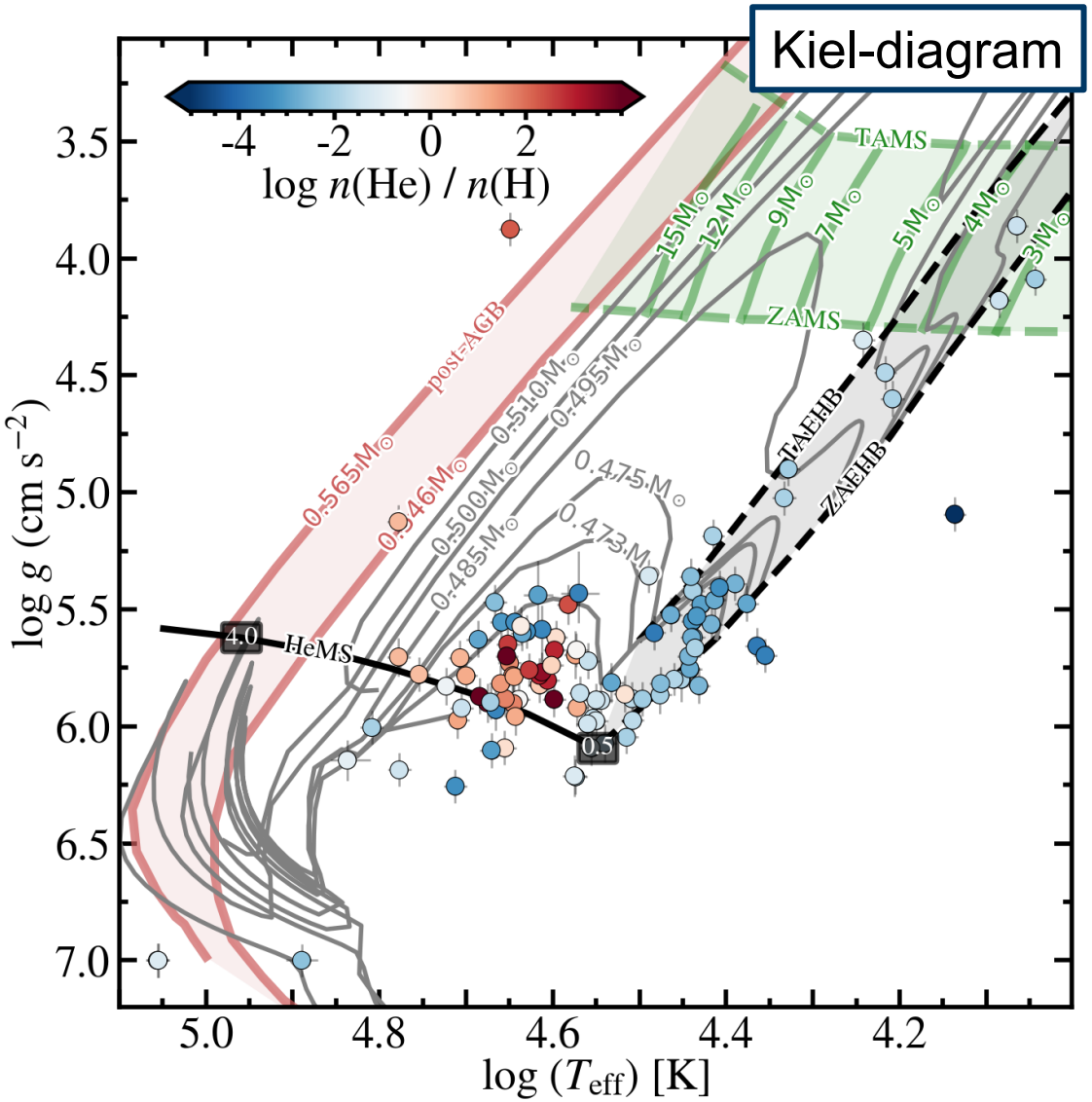
- Total of 352 objects (SED-confirmed hot subdwarfs ~240, ~8% composite spectrum)





(Tracks: Dorman et al., 1993; Schaller et al., 1992; Miller Bertolami, 2016; Paczyński, 1971)

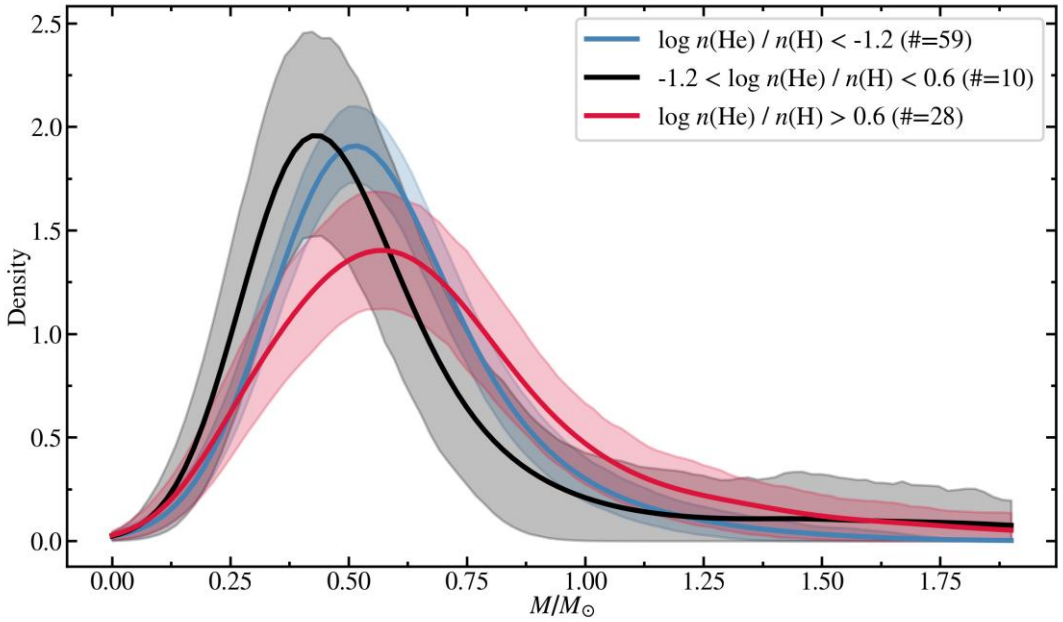
Spectroscopic log *g* and mass distribution



He-poor

intermediate-He

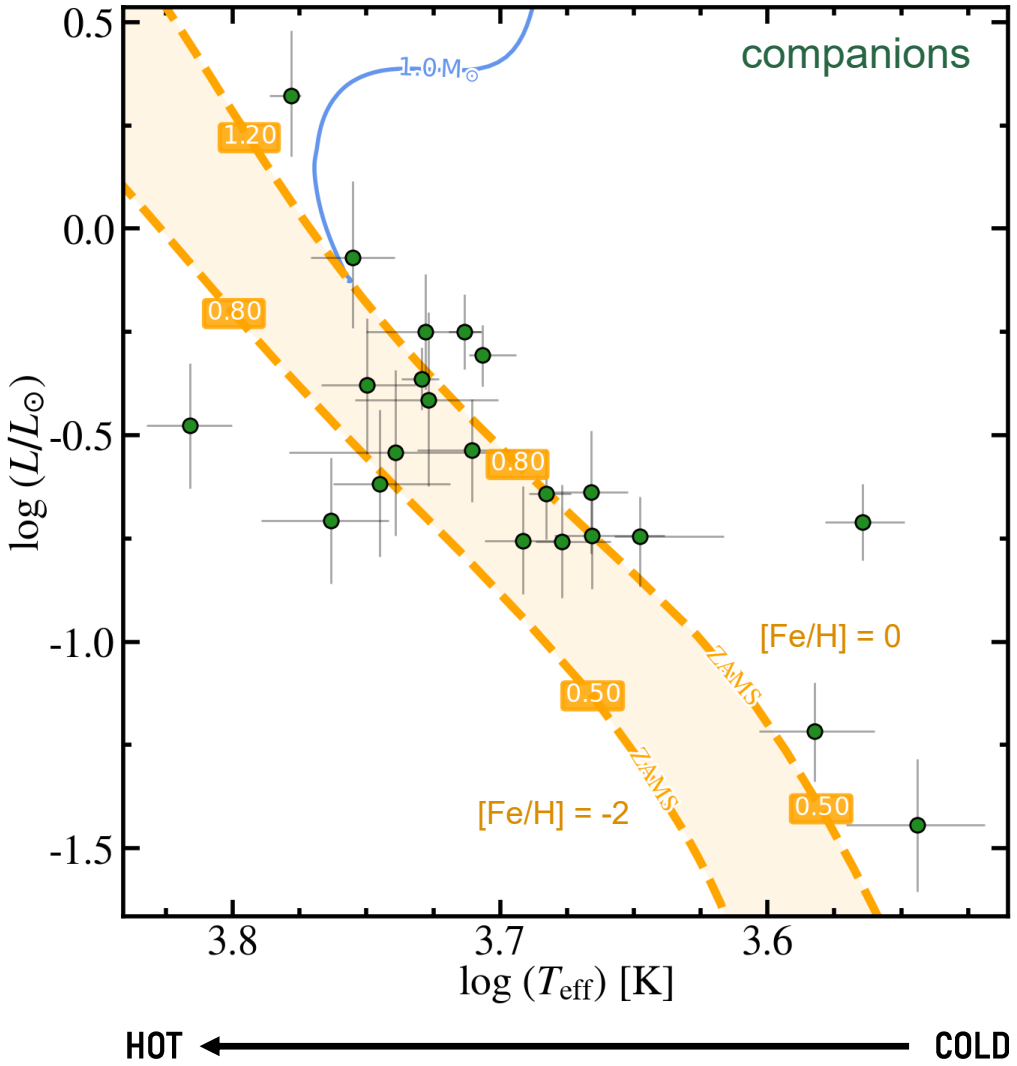
He-rich



(Tracks: Dorman et al., 1993; Schaller et al., 1992; Miller Bertolami, 2016; Paczyński, 1971)

Luminosity

- The main-sequence companion



→ only normal (F/G/K-type) main sequence stars

need lightcurves → *PLATO* science case

(Tracks: Dotter, 2016)

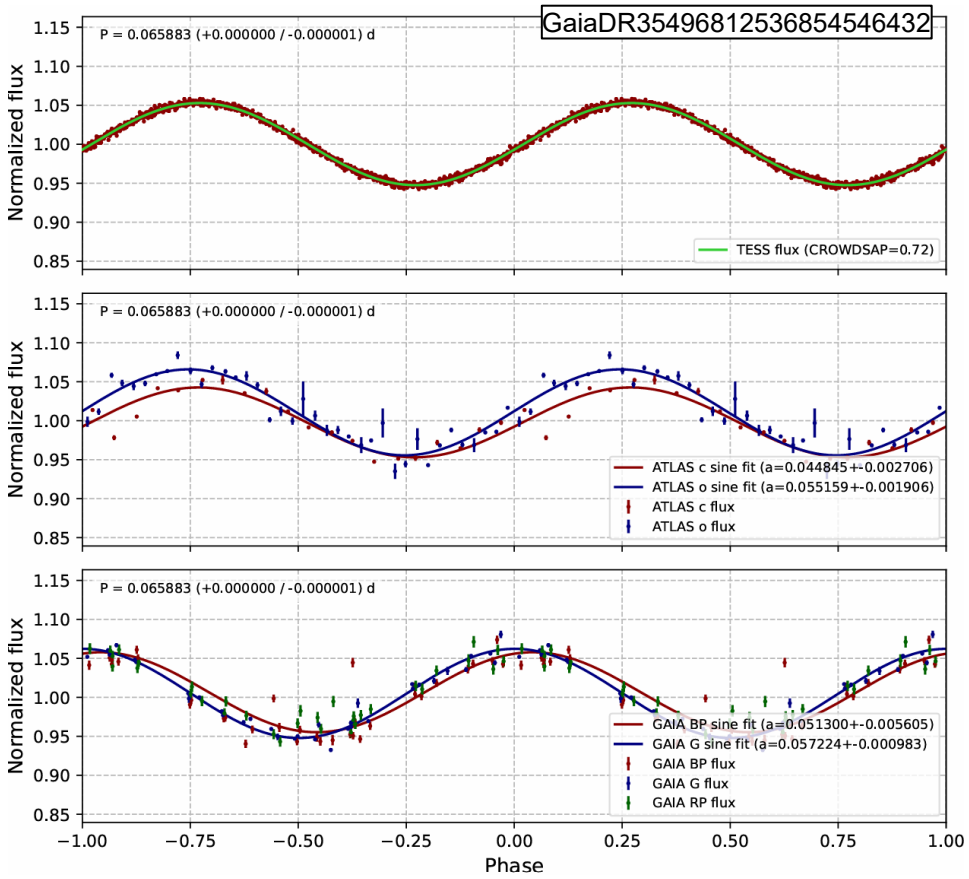
Thank you for joining!

key result →

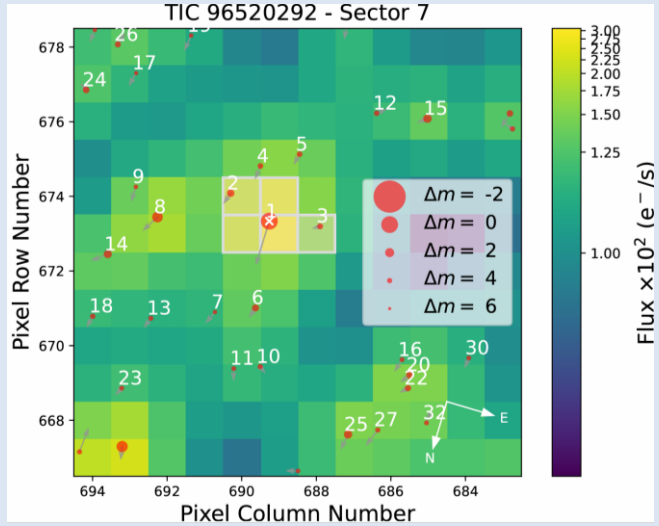
one of the most comprehensive samples of hot subdwarf stars in a single field

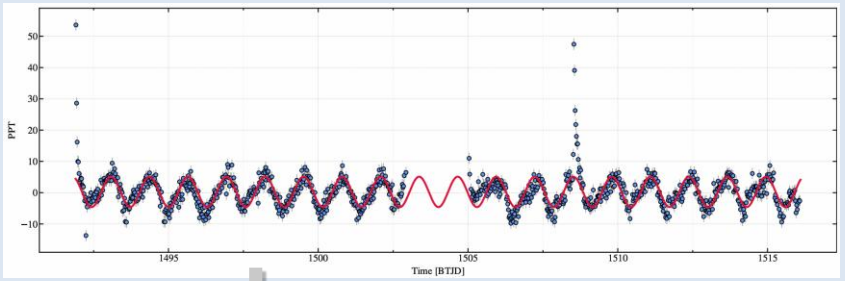
- ~ 300 PLATO targets
- homogeneous stellar parameters
- first-order classification of the likely binary configuration (SED + lightcurves)
- PLATO will deliver the missing precision
- together, this enables statistical constraints on CE evolution

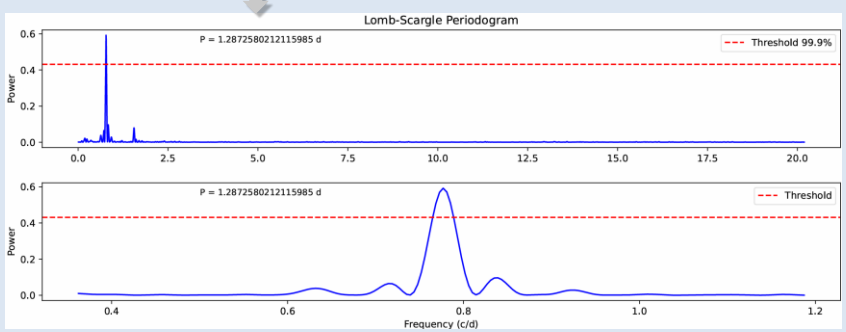
Lightcurves from TESS, ZTF, Gaia, ATLAS

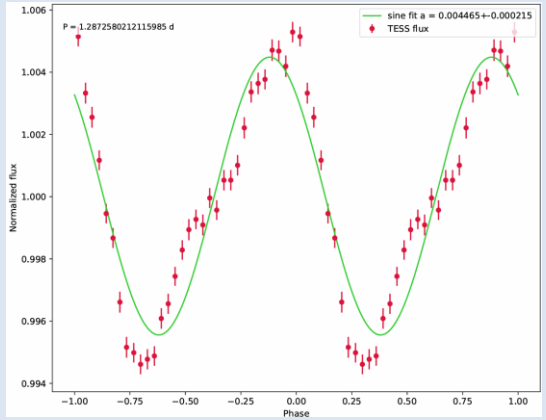


New routine for TESS full-frame lightcurve extraction





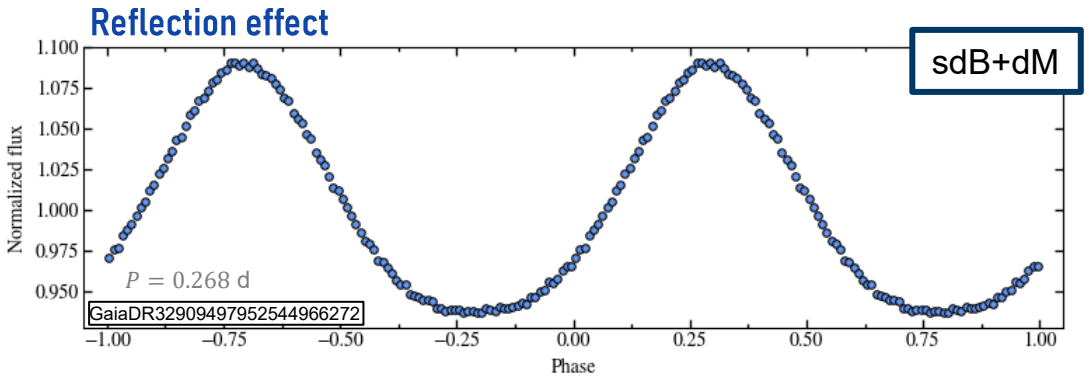


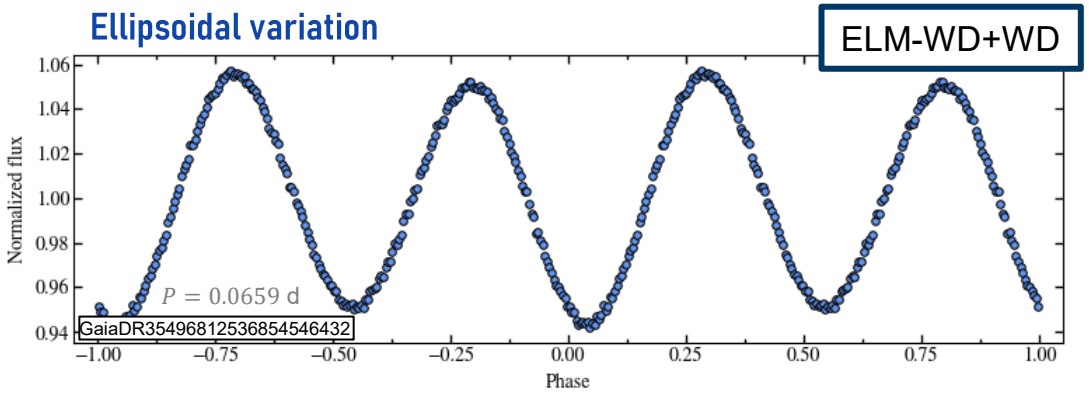


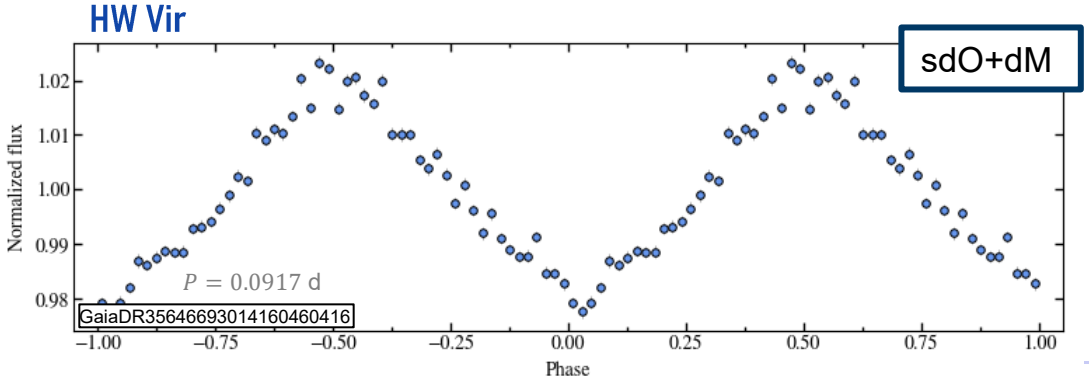
Lightcurves (program by F. Mattig) and FFIs (with the Eleanor-package and support from M. Uzundag)

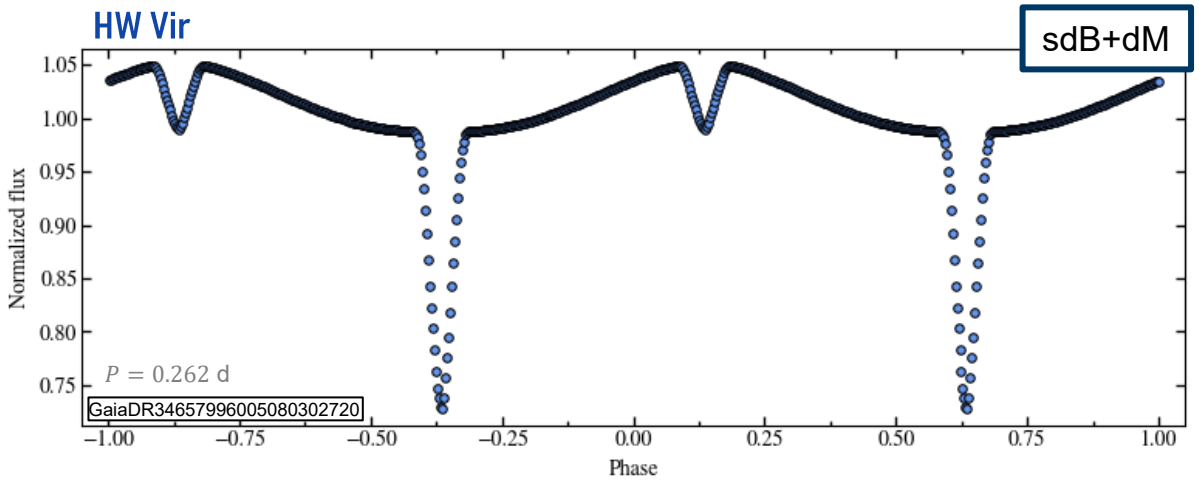
Lightcurves from TESS

candidate post-CE binaries





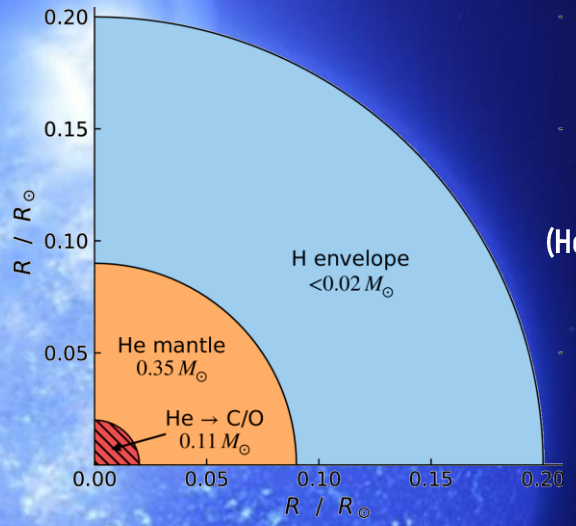




no variability and flat lightcurves
→ *PLATO* discovery potential

Hot subdwarf stars

sdB/O



(Heber, 2024)

0.1 ~ 0.3 $R_\odot$

10 ~ 100 $L_\odot$

0.5 $M_\odot$

log(🍎) 4.5 ~ 6.5 cm s^{-2}

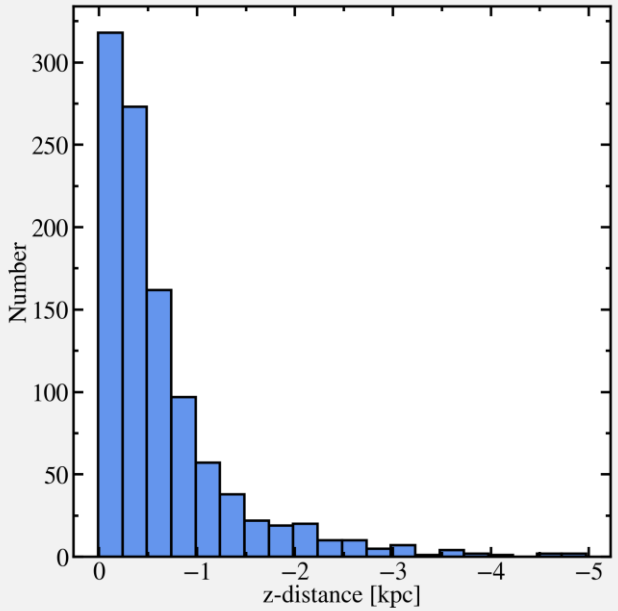
log($🍎_\odot$) ~ 4.44 cm s^{-2}

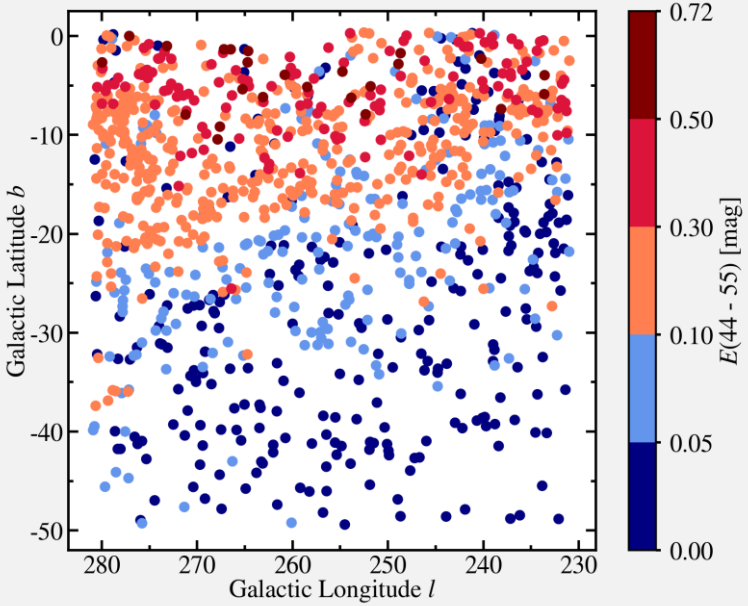
20.000 ~ 100.000 K

Hot subdwarfs can **not** be explained by normal single stellar evolution.

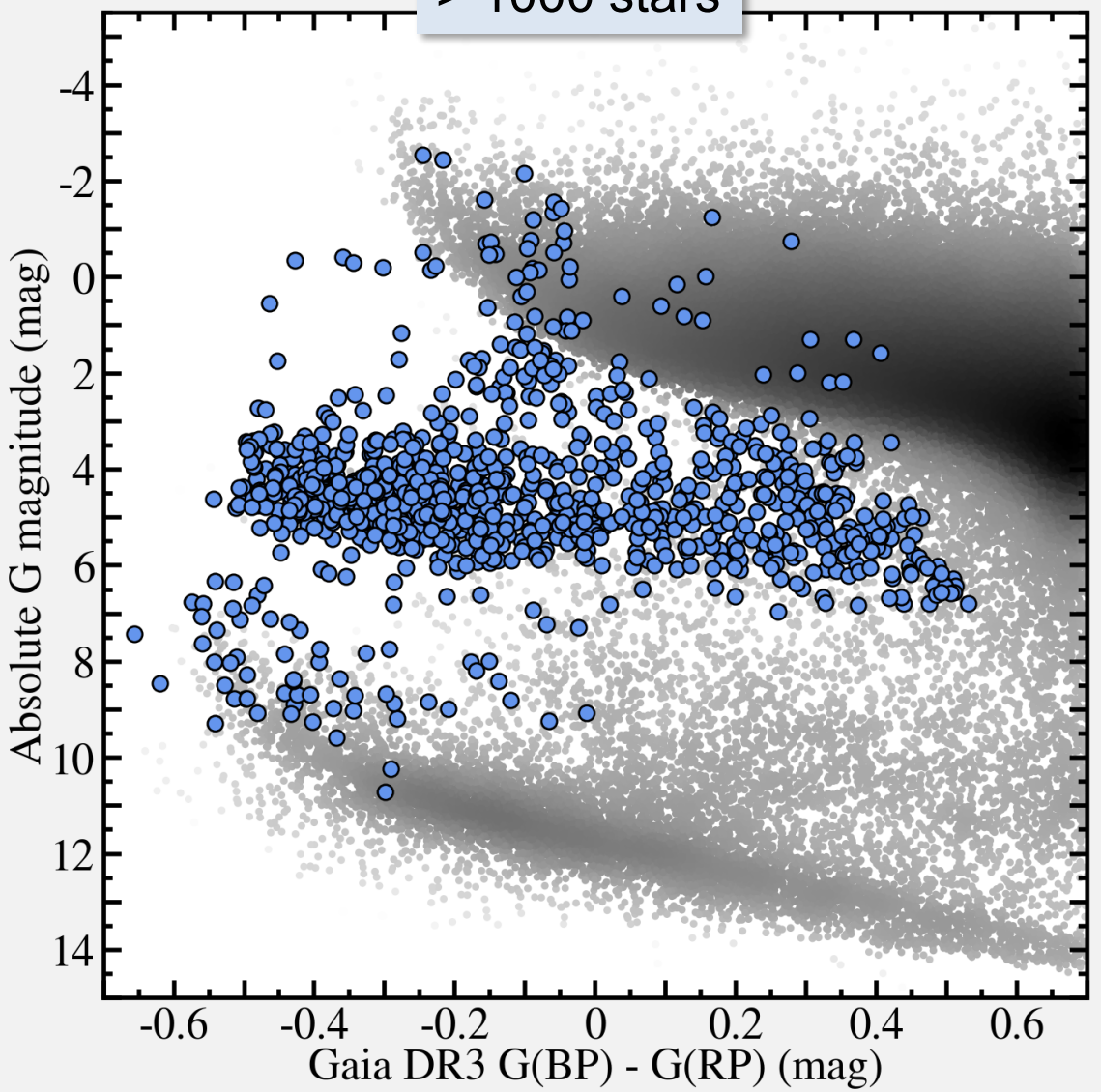
(ESO/L. Calçada, INAF-Padua/S. Zaggia)

Sample selection



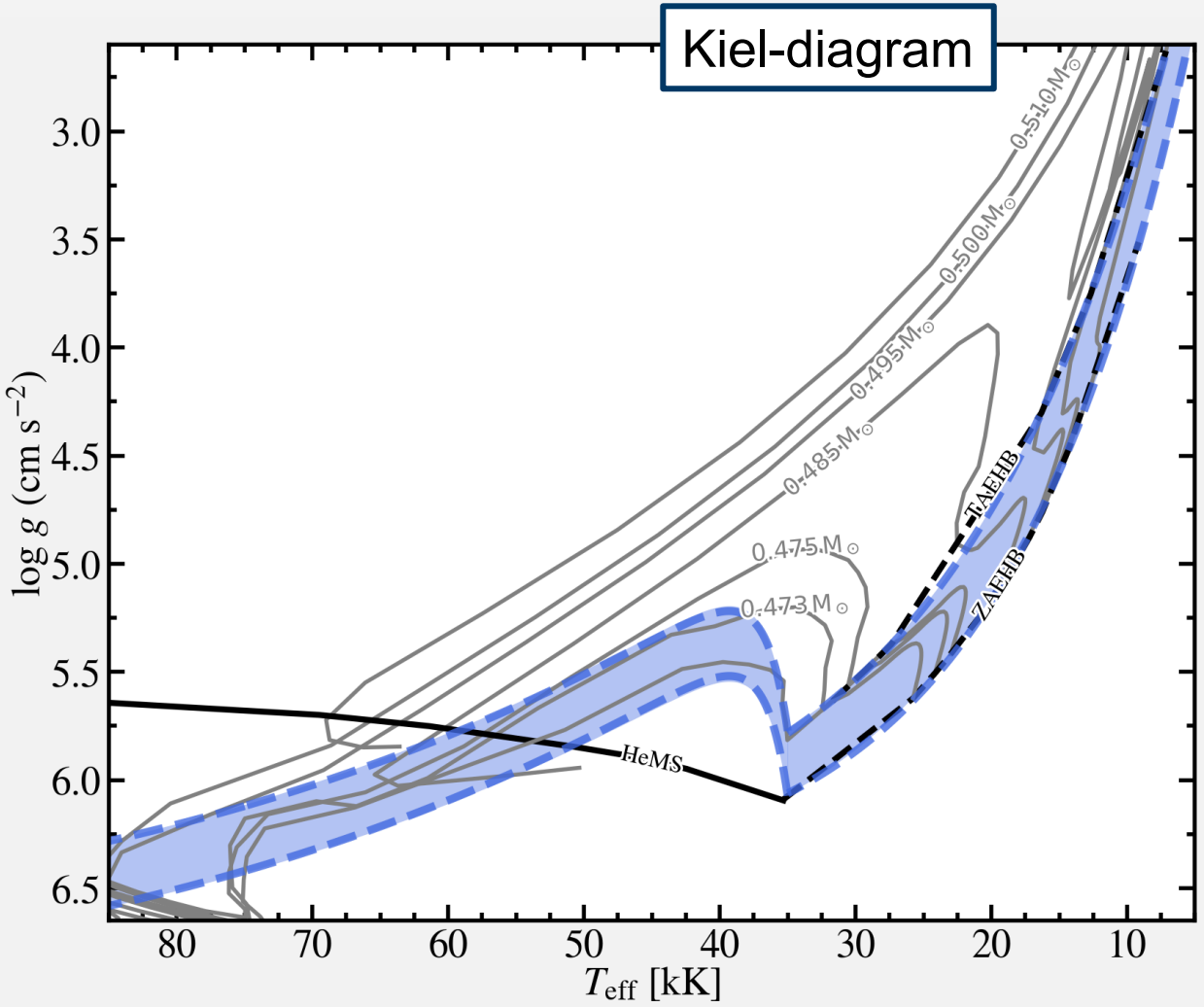


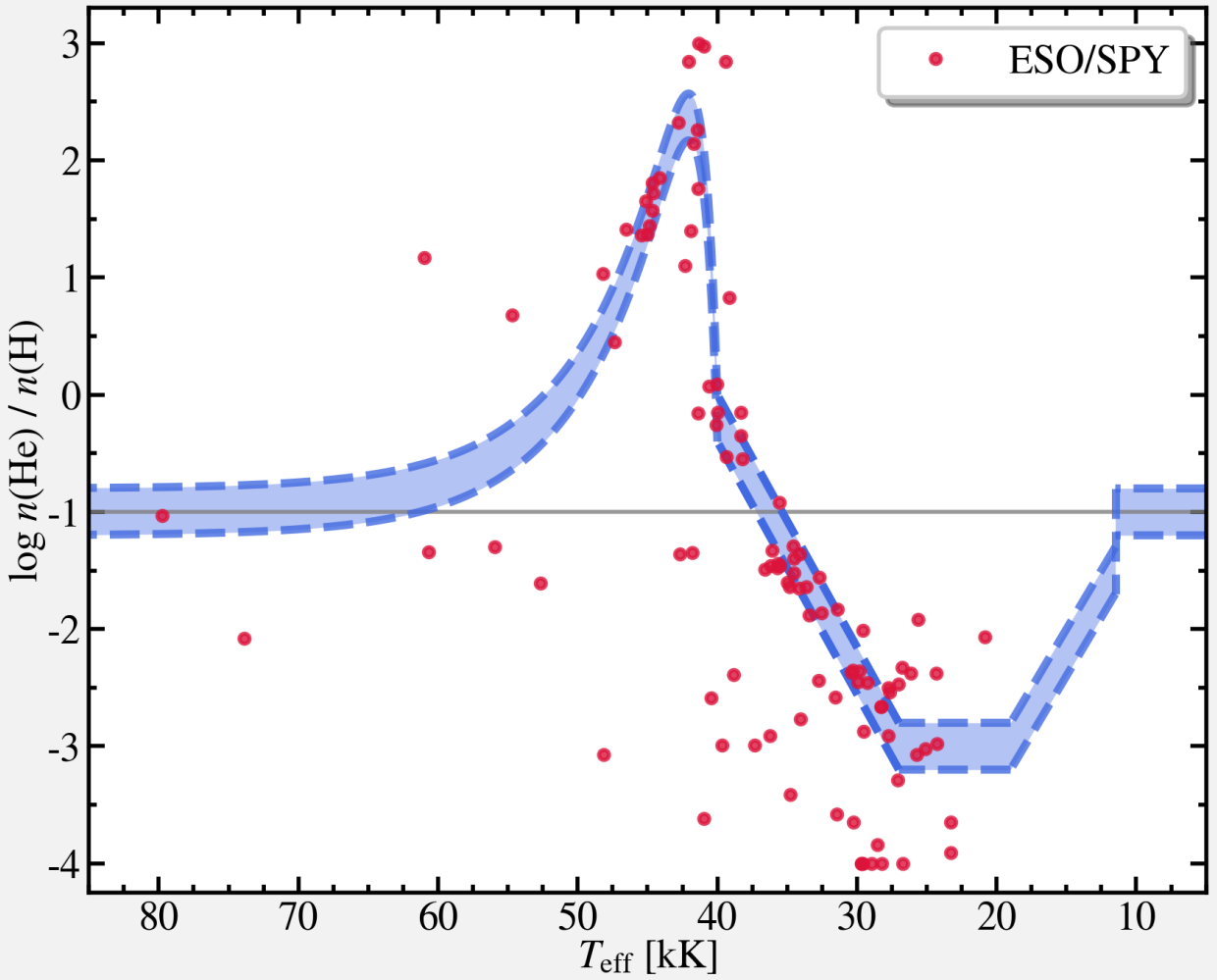
> 1000 stars



$M_G = m_G + 5 + 5 \cdot \log_{10}(\varpi/1000)$

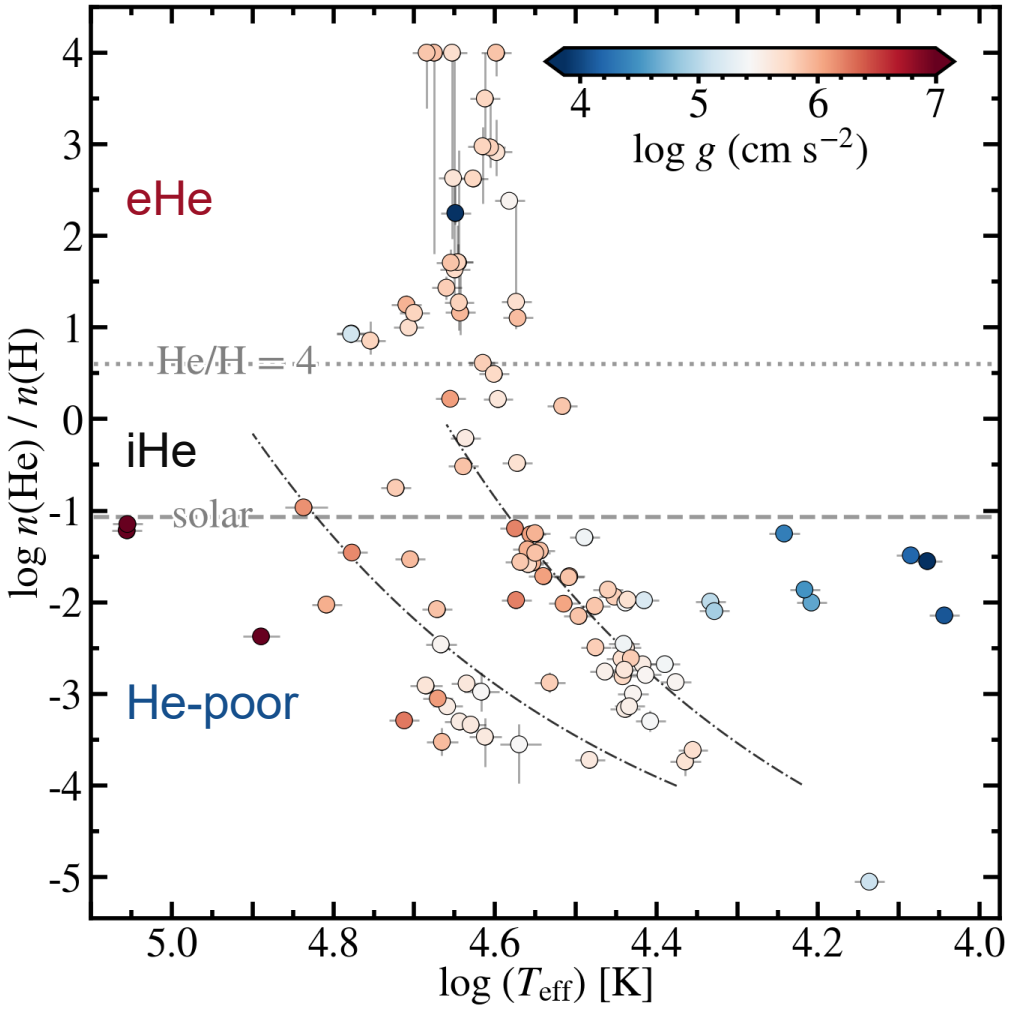
Methodology for stars in the *PLATO* field



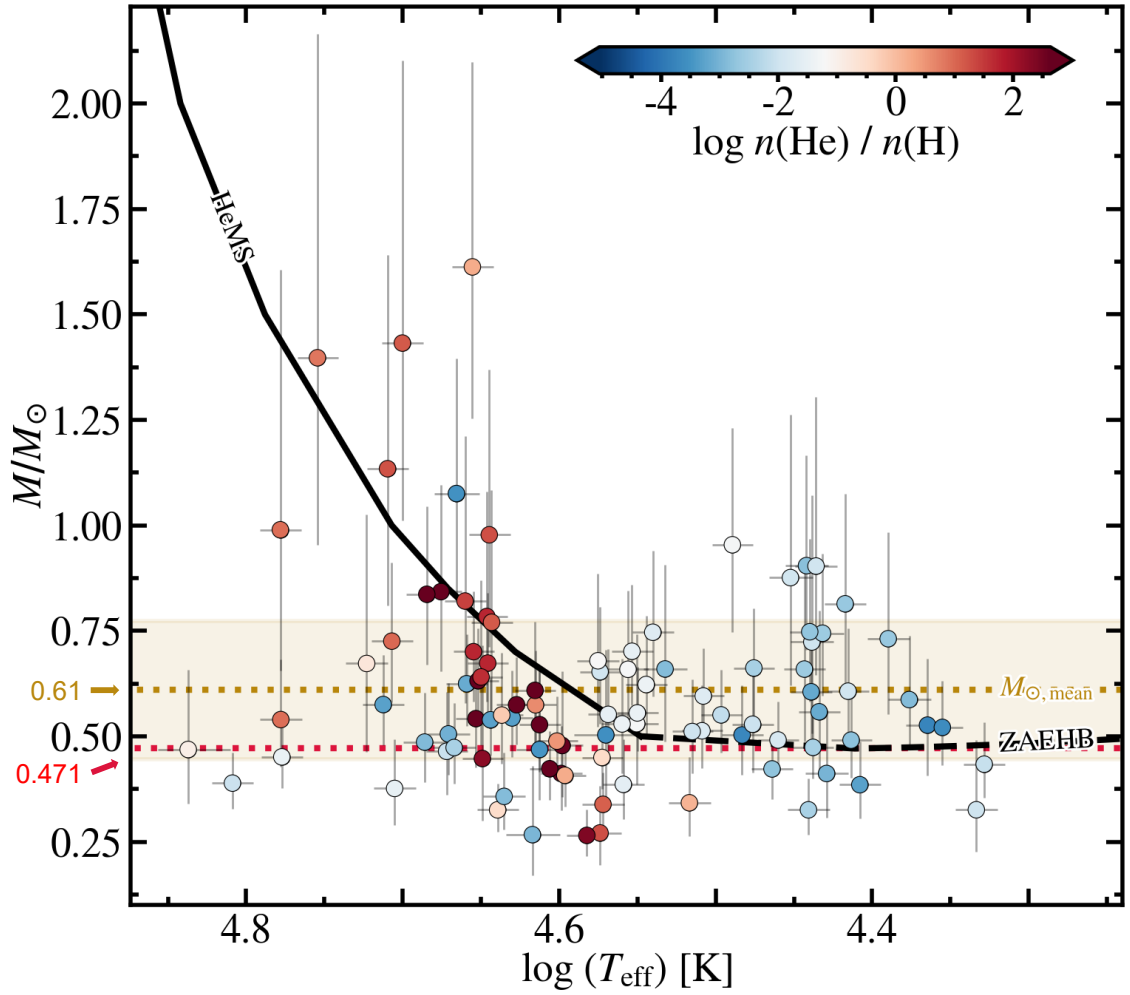


T_{eff} → Literature or *Gaia* DR3

Helium abundance and mass



(Tracks: Edelmann et al., 2003; Németh et al., 2012)



(Tracks: Dorman et al., 1993; Paczyński, 1971)