A Helium-Carbon correlation on the Extreme Horizontal Branch in ω Centauri

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RASPUTIN: Resolved And unresolved Stellar PopUlaTIoNs
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ESO Garching

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

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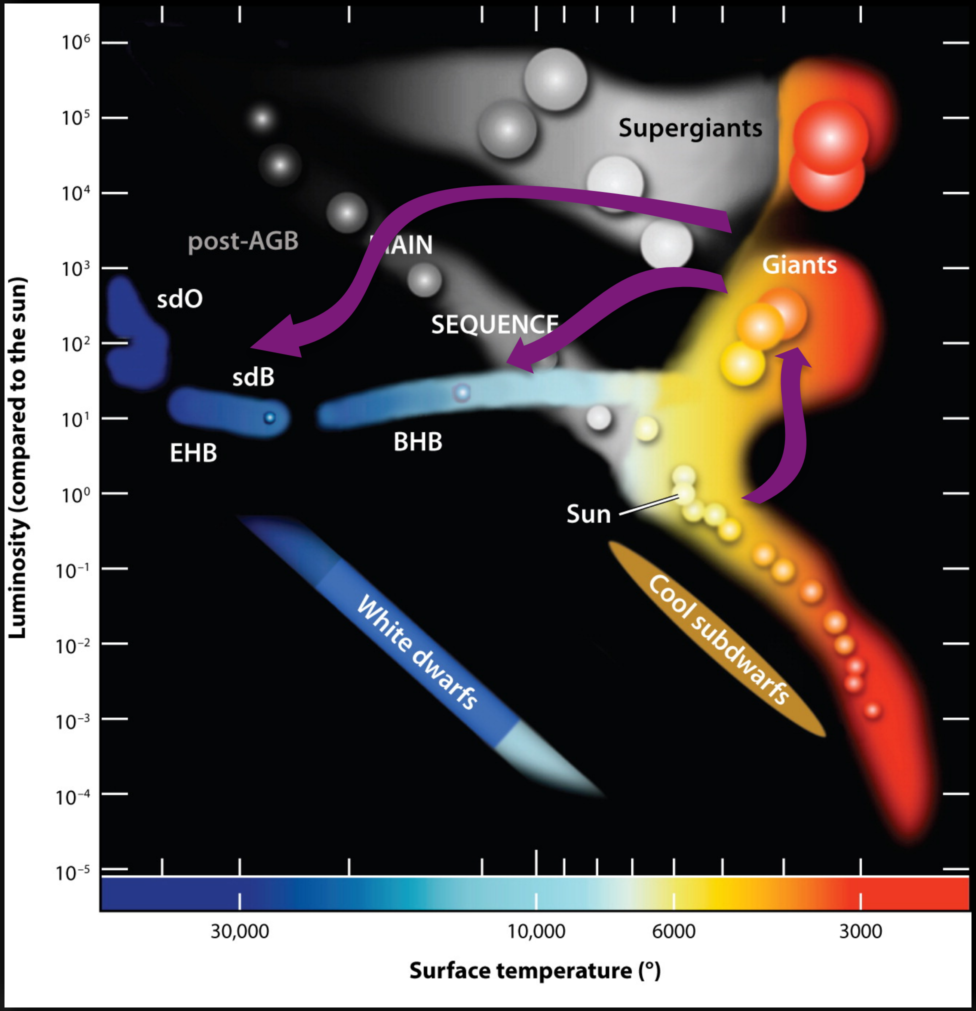
Outline

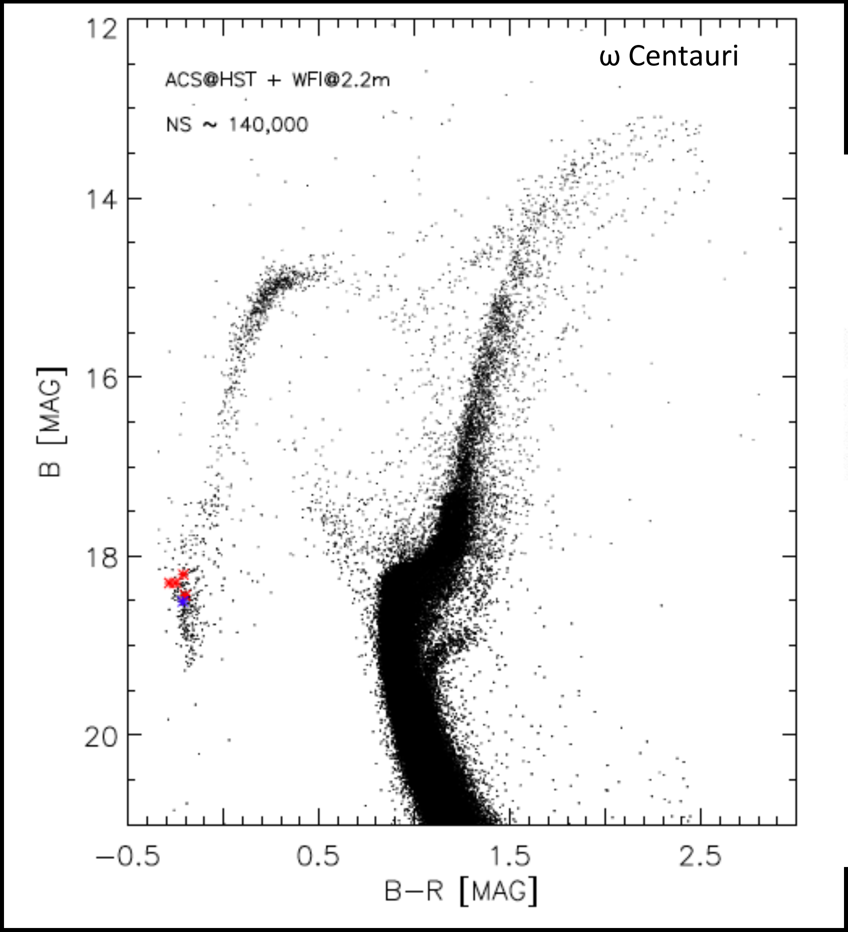
1. Introduction
2. Spectroscopic Analysis
3. Carbon abundances
4. Evolution
5. Conclusion

What are Extreme Horizontal Branch stars?

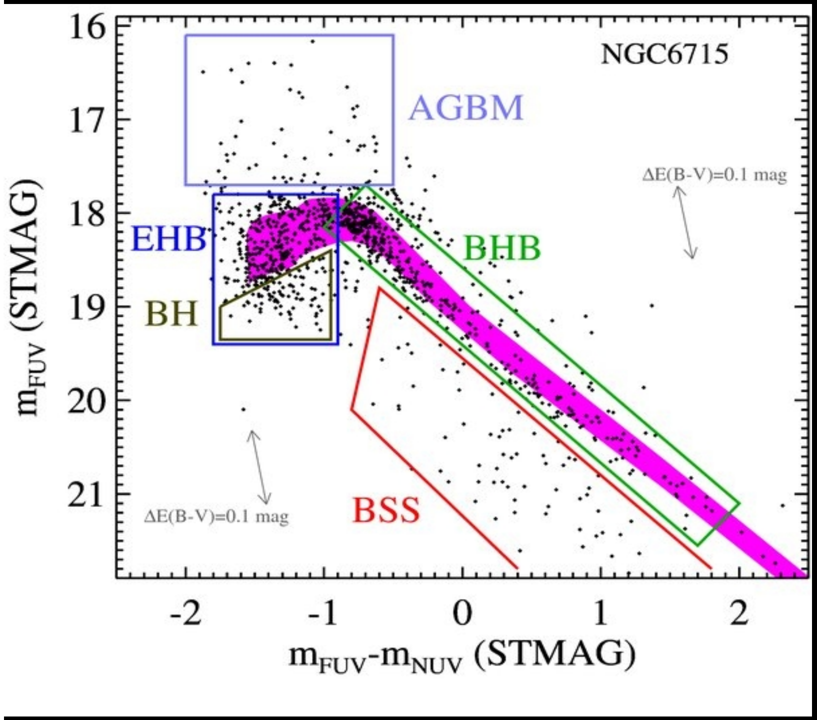


- Come from main sequence stars that lost a lot of mass on the RGB
- EHB stars = hot subdwarfs (sdB & sdO)
- Surface gravity between MS stars and white dwarfs (log *g* between 5.2 and 6.4)
- 2 classes sdB (22 000 – 35 000 K)
  sdO (35 000 – 90 000 K)

EHB in clusters



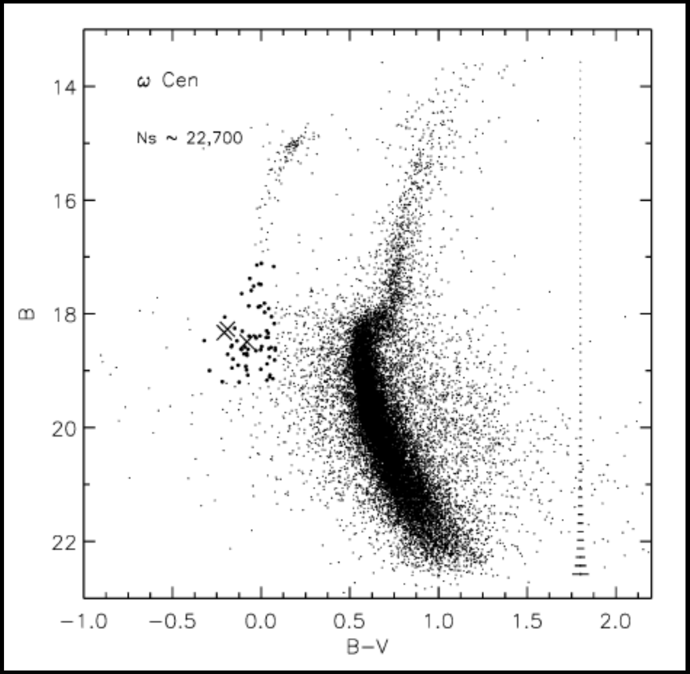
Randall et al. 2013



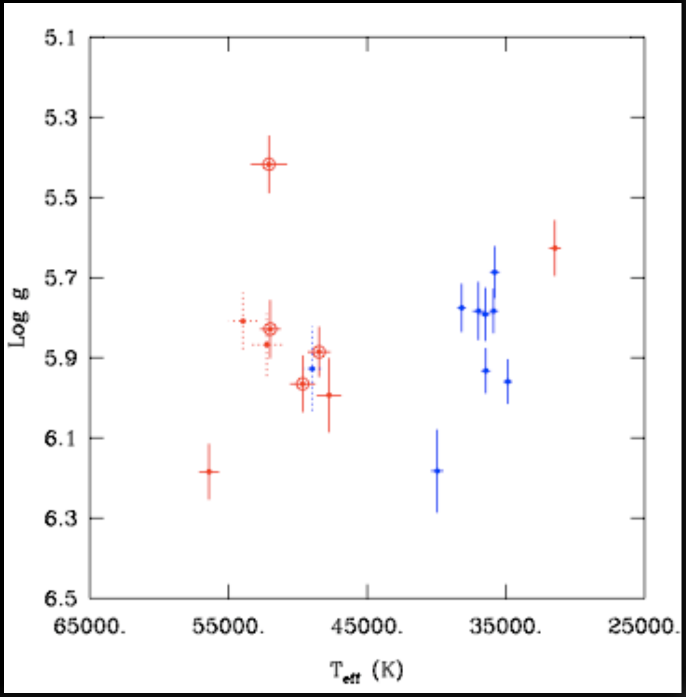
Brown et al. 2010

Context

- Search for pulsating hot subdwarf stars in ω Centauri (5 sdO found, Randall et al.)
- Follow-up FORS2 (VLT) spectroscopy carried out for several stars.
- Obtain atmospheric parameters to map the instability strip.



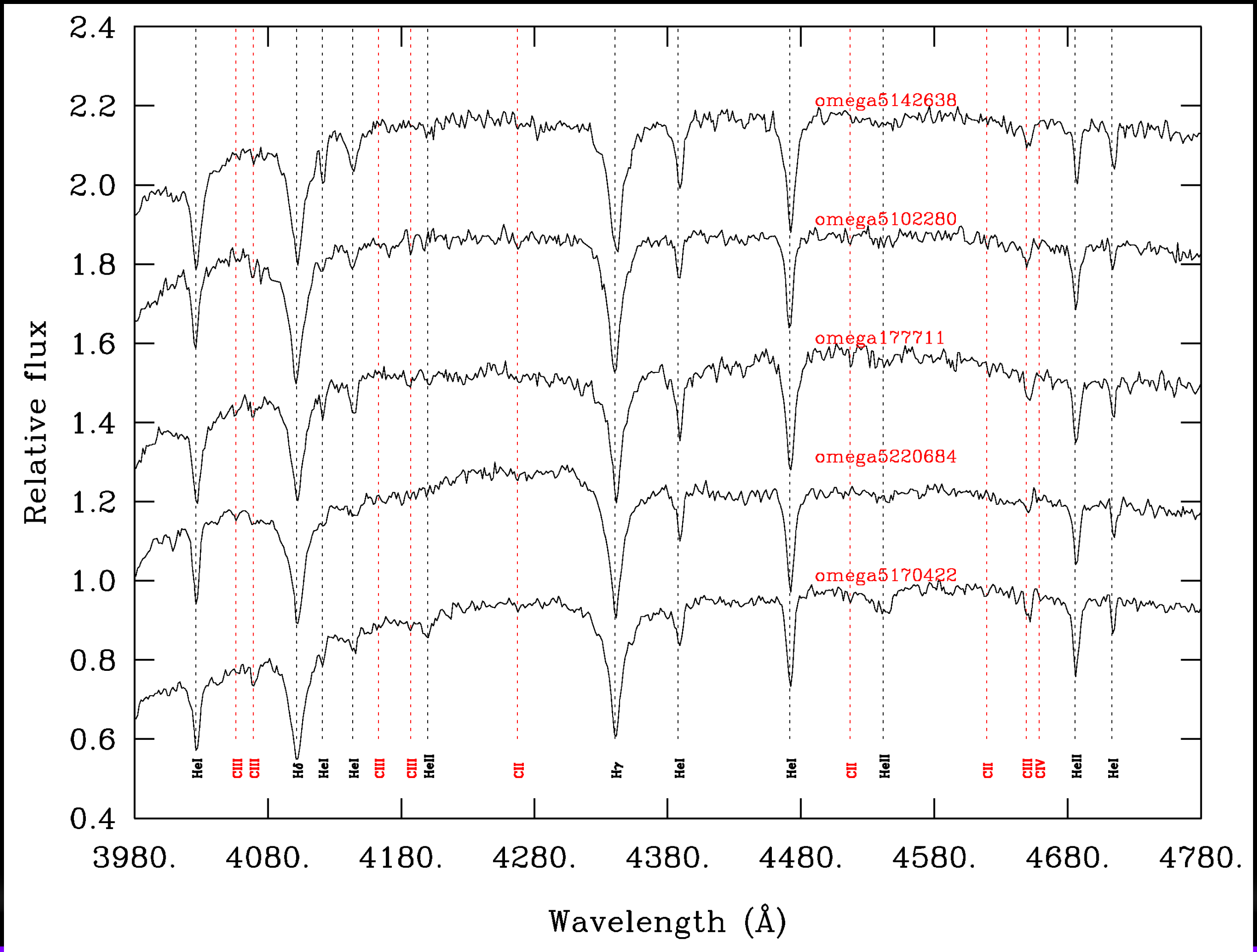
Randall et al. 2010



Randall et al. 2012

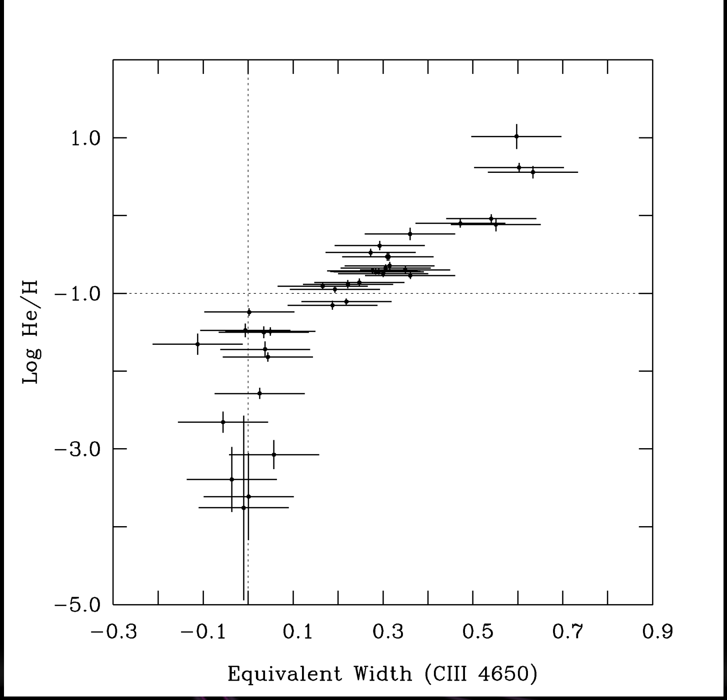
Intro - Observations

- Spectra for a sample of 38 EHB stars (FORS/VLT spectroscopy)



Intro - Observations

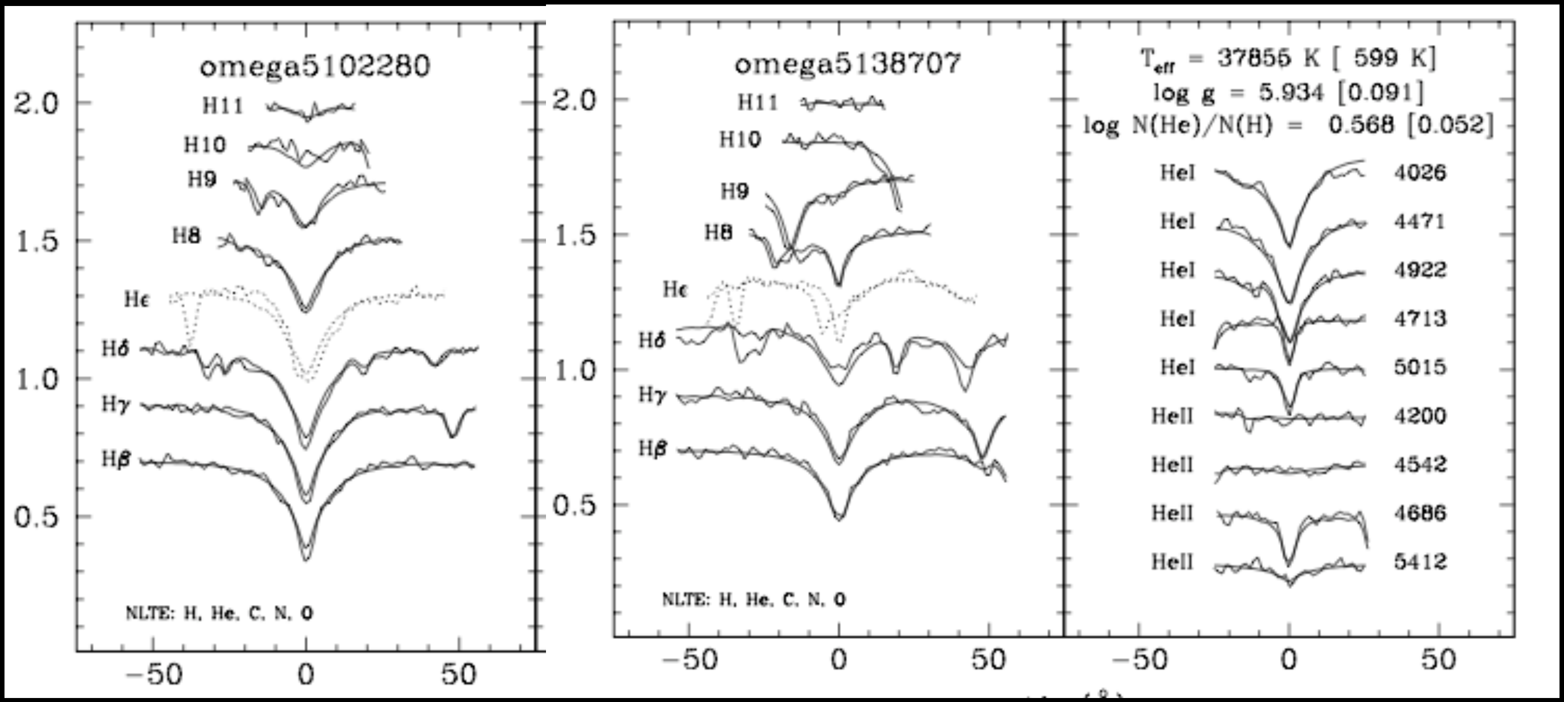
- Most of the stars showing helium lines also feature carbon ones
- Strength of carbon lines seems correlated with the helium abundance
- Noticed by Moehler et al. (ω Cen) and Ströer et al. 2007 (field sdO)



- Test with the E.W. of C III complex around 4650 Å

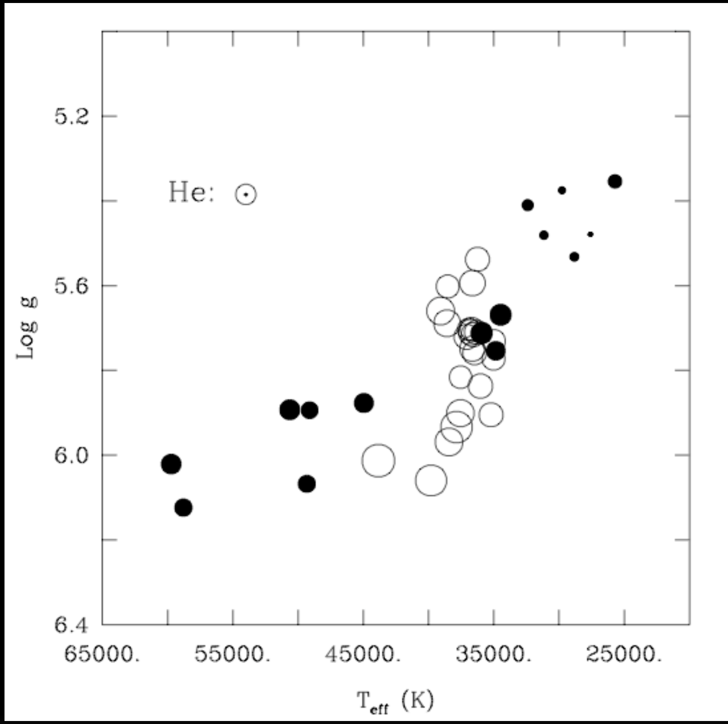
Spectro - Fundamental parameters

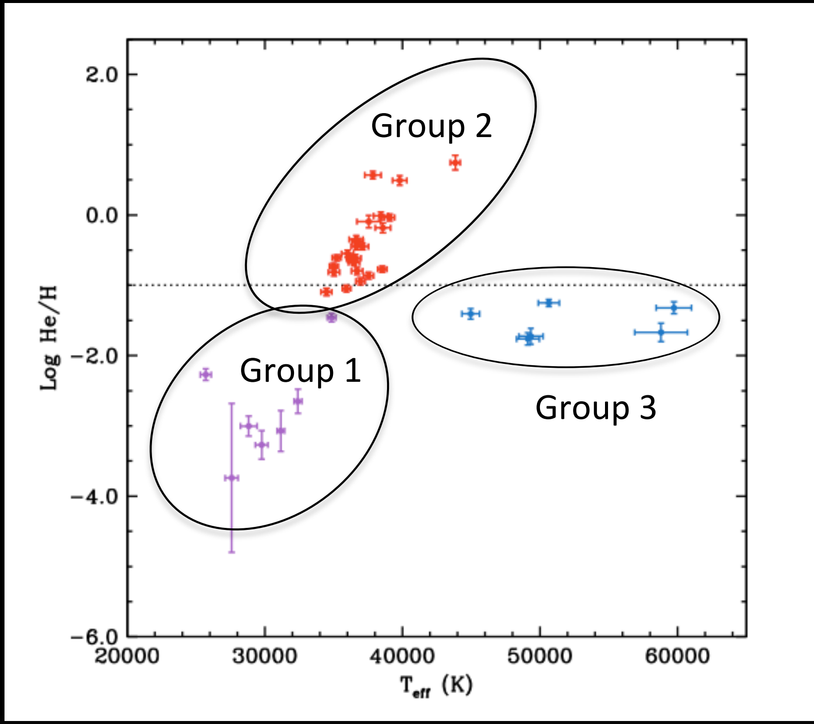
- Large grid of models : 1428 models
  26 – 58 kK, 5.2 – 6.4 dex (log g), -4.0 to 1,5 dex (log N(He)/N(H))
- NLTE, with TLUSTY/SYNSPEC, CNO blanketing



Spectro - Fundamental parameters

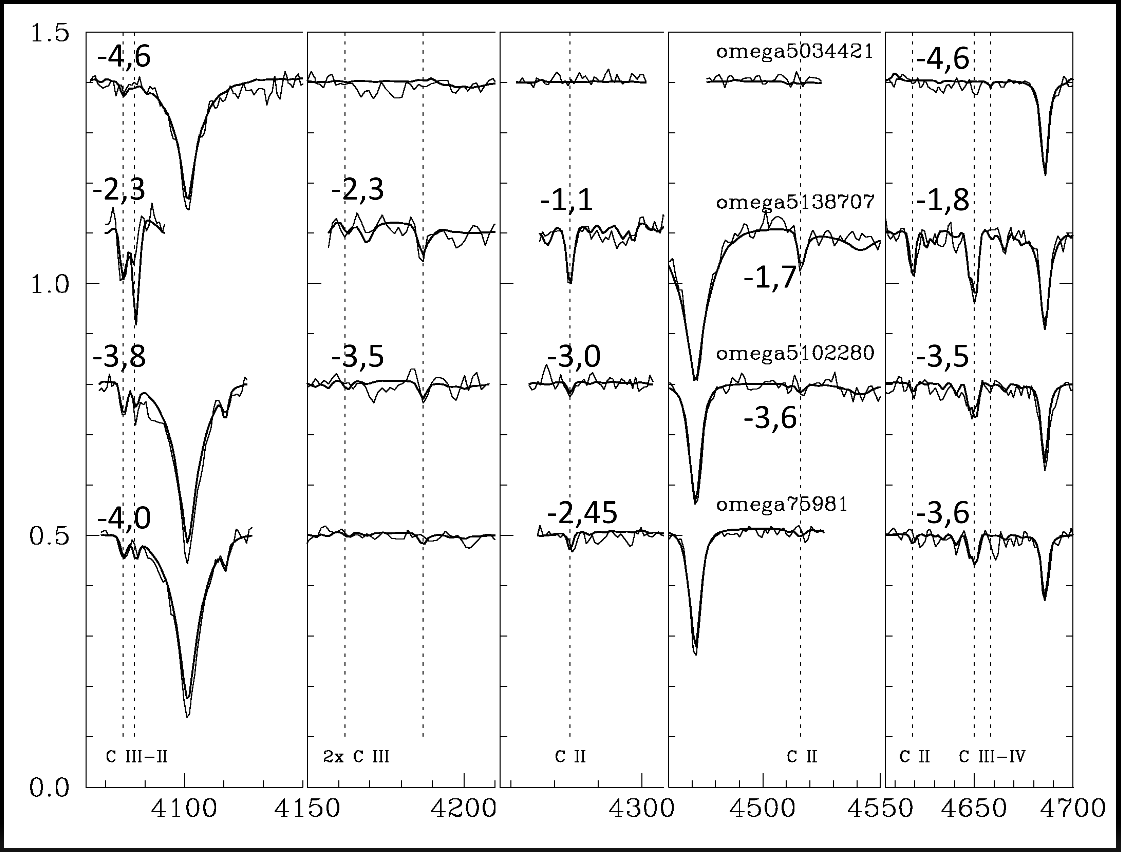
- Log g – Teff distribution for the 38 stars
- **open** circles **He-rich**, filled circles He-poor, dimension proportional to log N(He)/N(H).





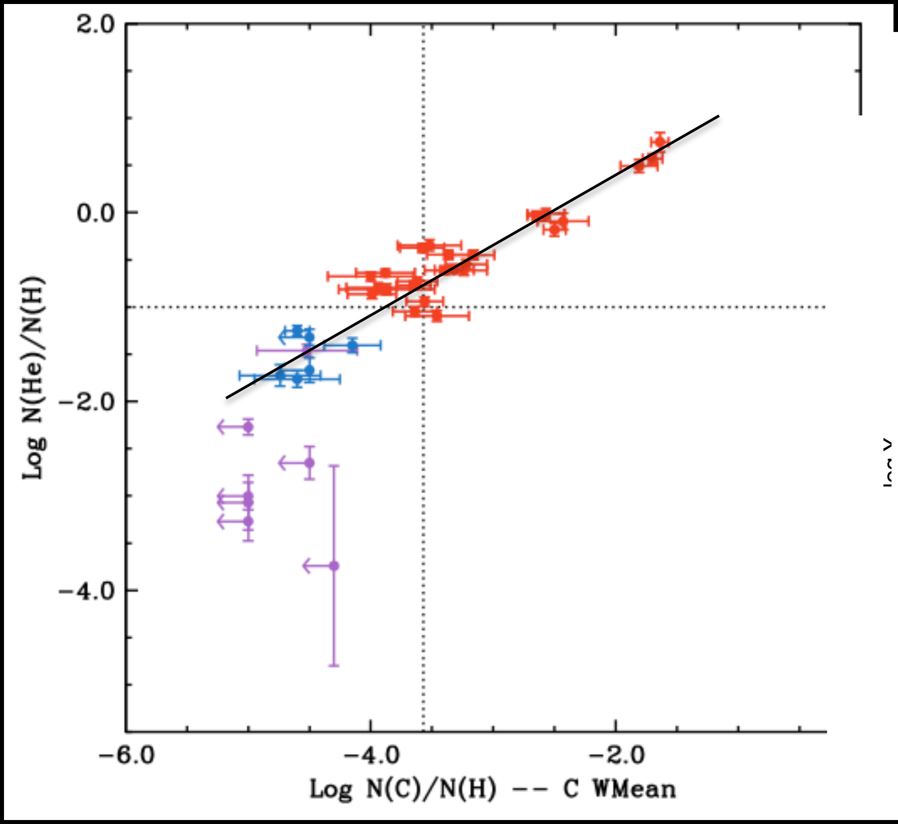
Carbon abundances

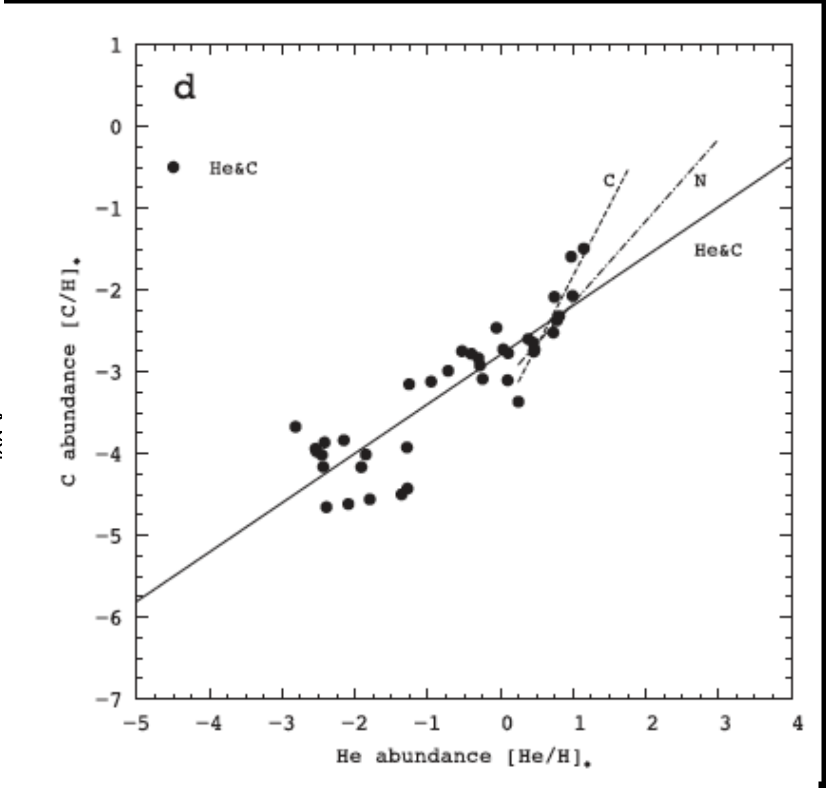
- Individually fitted 5 regions showing carbon lines.
- Weighted mean abundance for each star.



Carbon abundances

- Correlation between He and C abundances

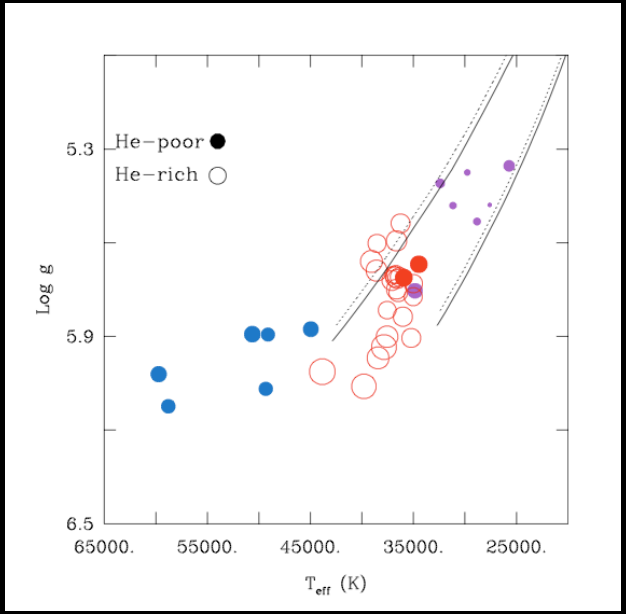




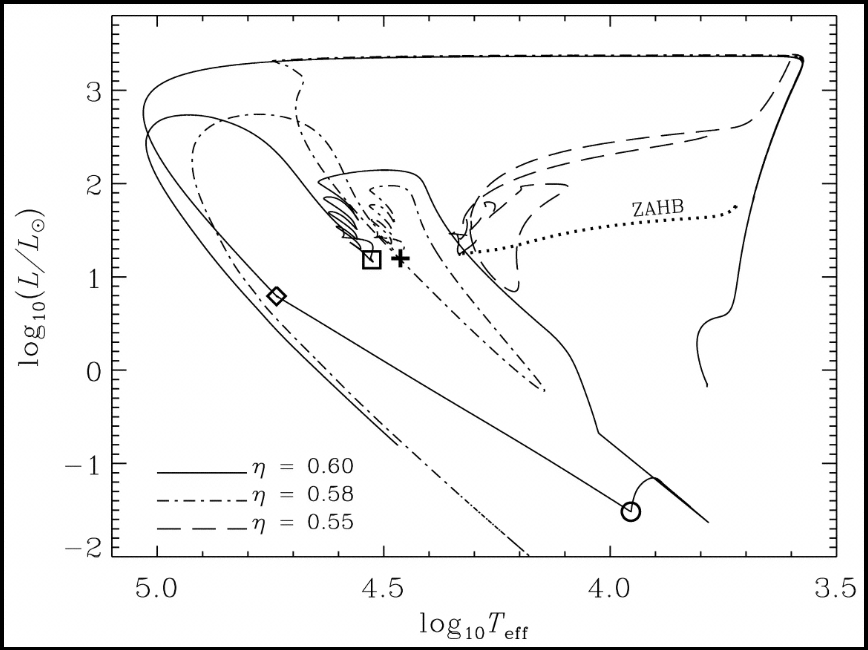
Németh et al. 2012

Evolutionary status

- The He-enriched stars origin:
  Late flasher vs He-enriched population (Y~0.4)
  (Brown et al. 20xx, D'Antona et al. 20xx)
- Both predict hot stars and helium enrichment, late-flasher also predicts carbon enhancement

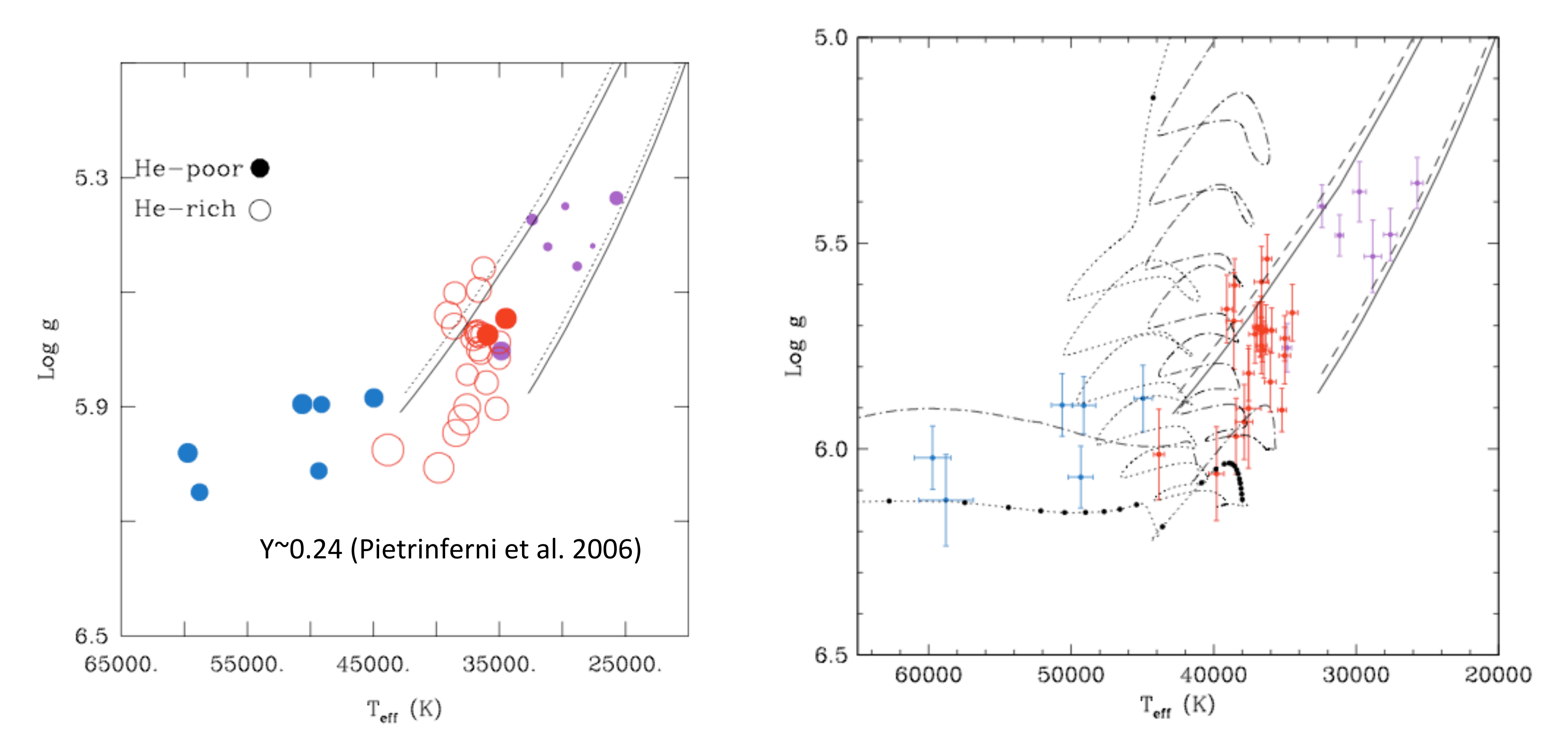


Cassisi et al. 2003



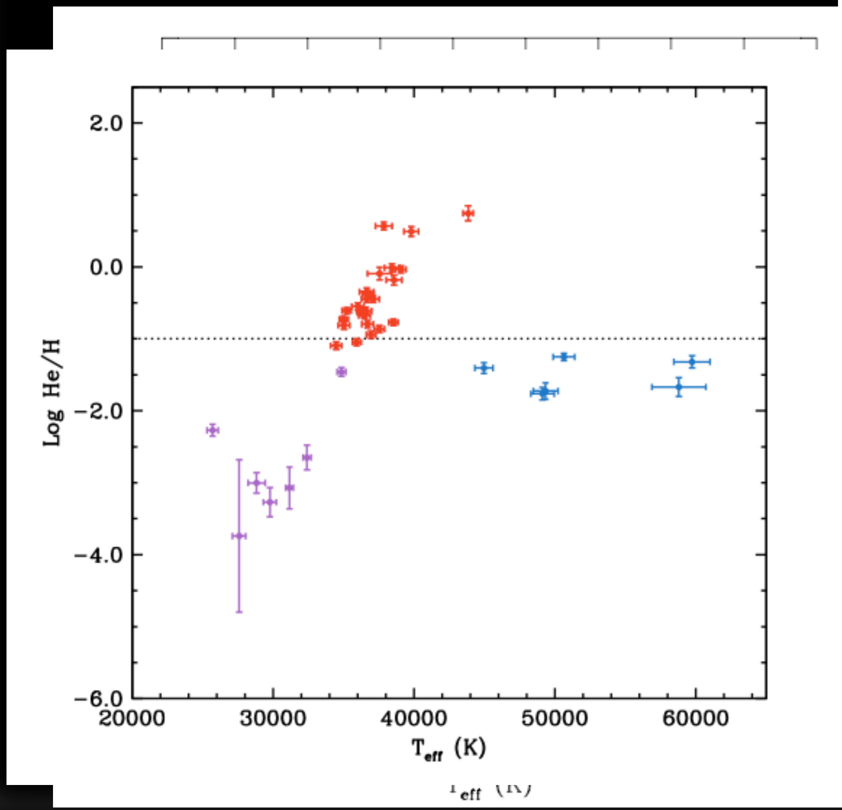
Evolutionary status

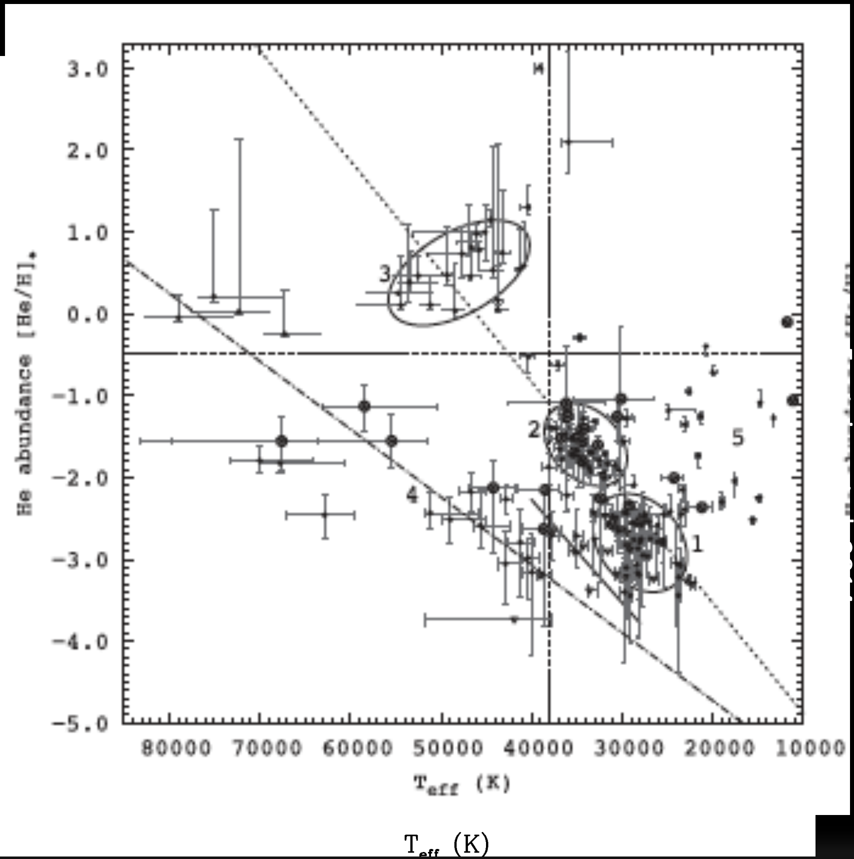
- EHB band for normal (Y~0.24) and helium-enriched (Y~0.40) models
- Late-flasher tracks (Miller Bertolami et al. 2008)



Evolution – Comparison with field hot subdwarfs

- ω Cen vs field sample of sdB and sdO

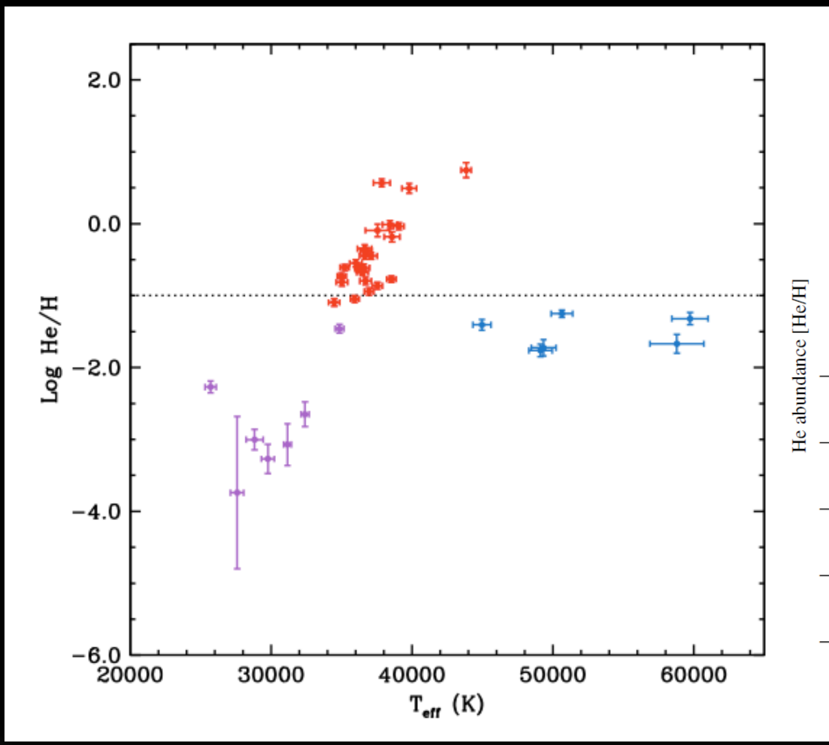


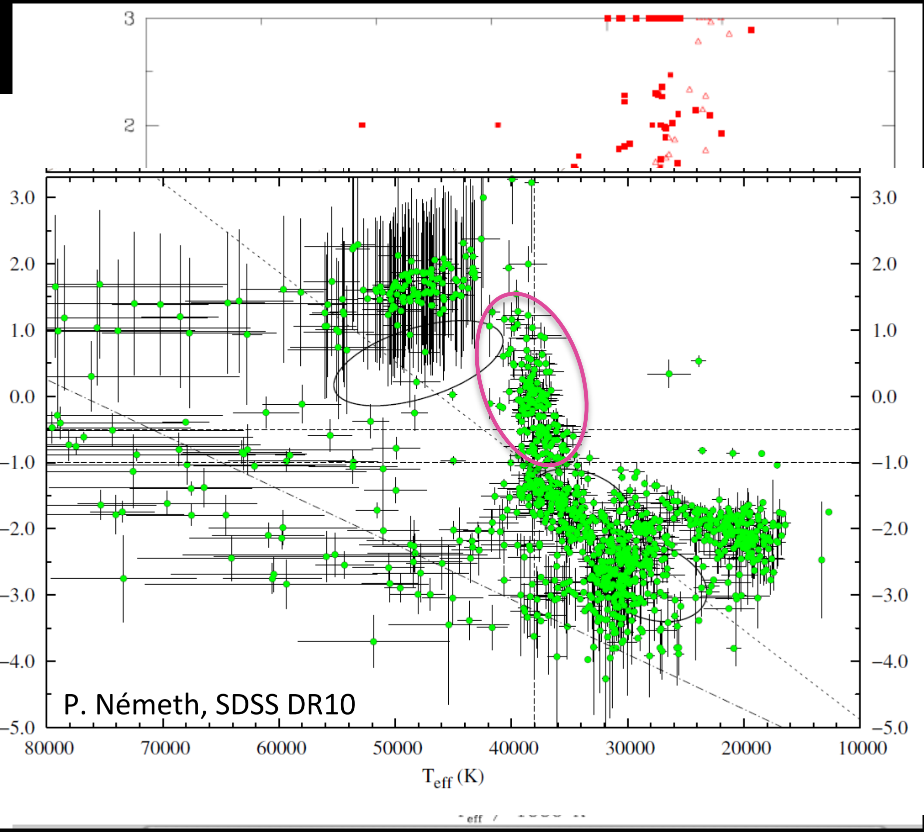


Németh et al. 2012

Evolution – Comparison with field hot subdwarfs

- Where is the field counterpart of ω Cen helium-enriched population ?
- In SDSS !!! Halo stars (?)





Conclusion

- Helium-Carbon correlation → Diffusion effect, gravitational settling + weak stellar wind
- High carbon and helium abundances → hot-flasher scenario
- ω Cen vs field : many differences
  → Where are the "typical" sdBs in ω Cen ?
  → High log g of the sdOs
  → He-enriched population similar to the halo one ?
- Much more ω Cen hot subdwarf spectra to analyze !

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A HELIUM–CARBON CORRELATION ON THE EXTREME HORIZONTAL BRANCH IN ω CENTAURI*

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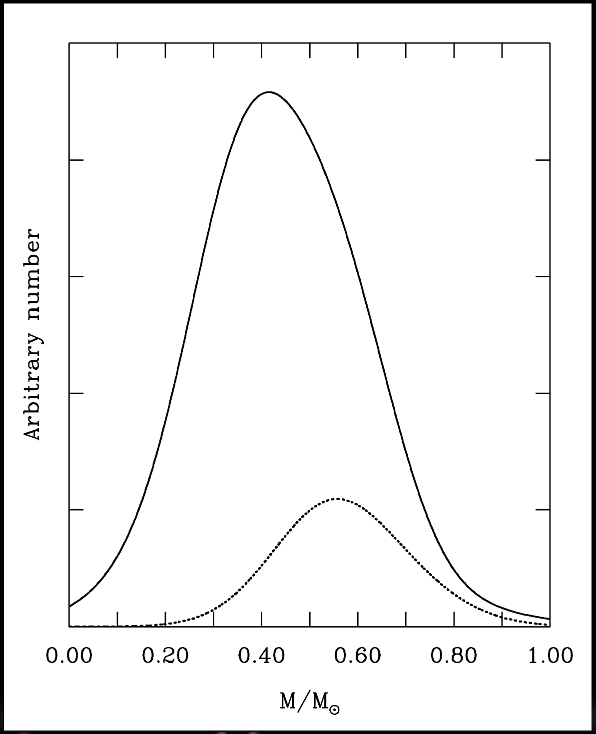
Mass Distribution

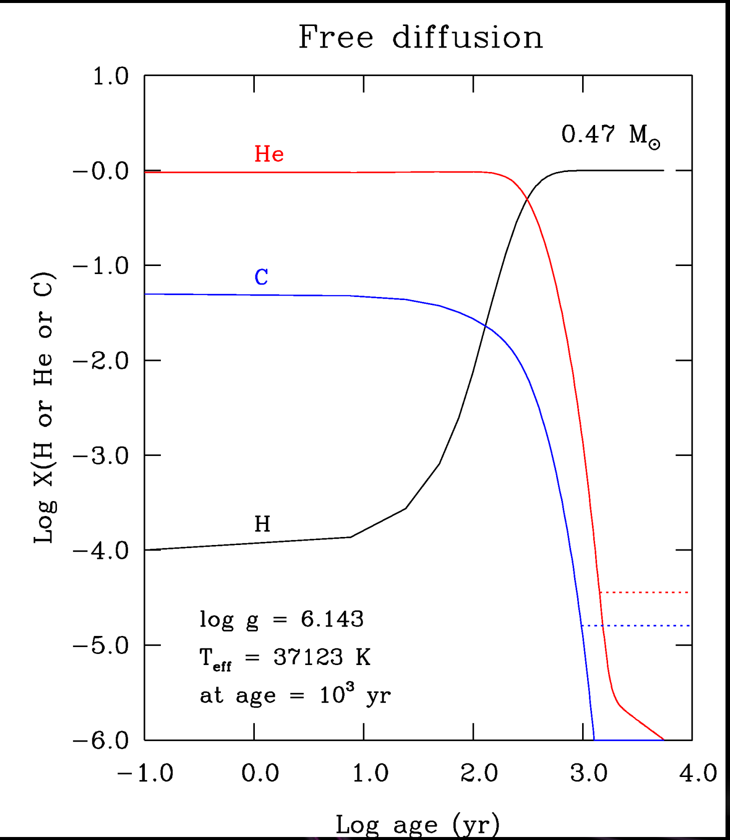
- **Distance modulus and reddening index from Calamida et al. 2005 and Bono et al. 2008.**
- **The mean masse of the sample 0.329 $M_{\odot}$, same problem discussed in Moni Bidin et al. 2011**
- **The six hottest stars (H-rich) mean mass of 0.456 $M_{\odot}$**



- Extreme values from Moni Bidin 2011 give more reasonable masses.
- High masses of the hottest stars, likely due to underestimation of their T_{eff}

Carbon abundances

- **Where does this relation comes from ? Where do carbon and helium come from ?**



- Gravitational settling turns a He and C enriched star into a H rich one in 1000 yr.
- Need stellar wind or internal turbulence to slow down the separation.

- black : this work
- red : Moehler et al (2011)

- black : Arizona-Montréal Green et al. 2008
- red : Németh et al (2012)
- blue : Ströer et al (2007)