Sun-like oscillations in a metal-poor population II star :

Using an old nearby star to constrain our understanding of the Milky Way

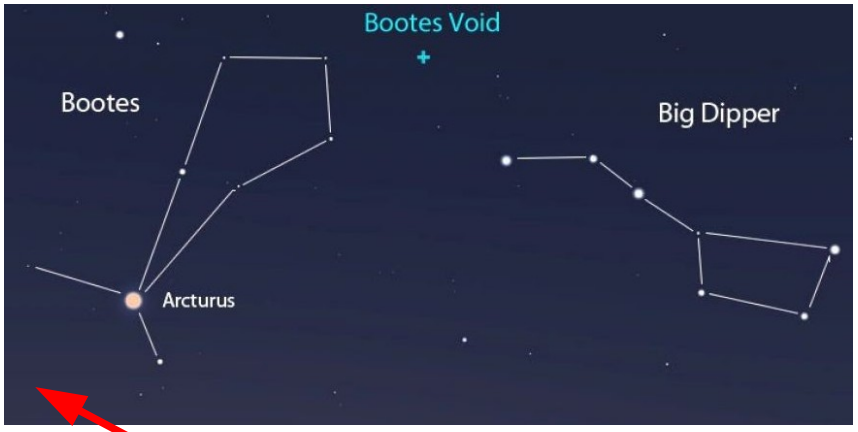
Orlagh Creevey

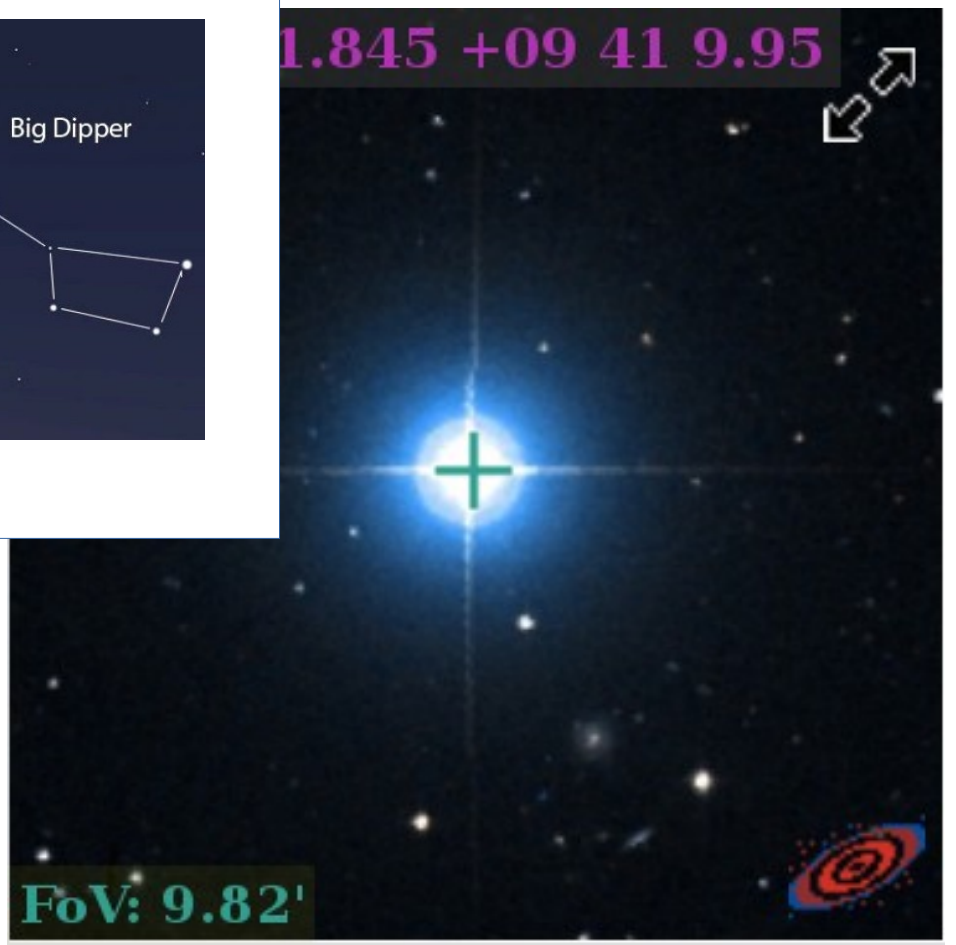
In collaboration with : Thevenin, Corsaro, Pichon, Bigot

And SONG collaborators

11 December 2018 : Nice

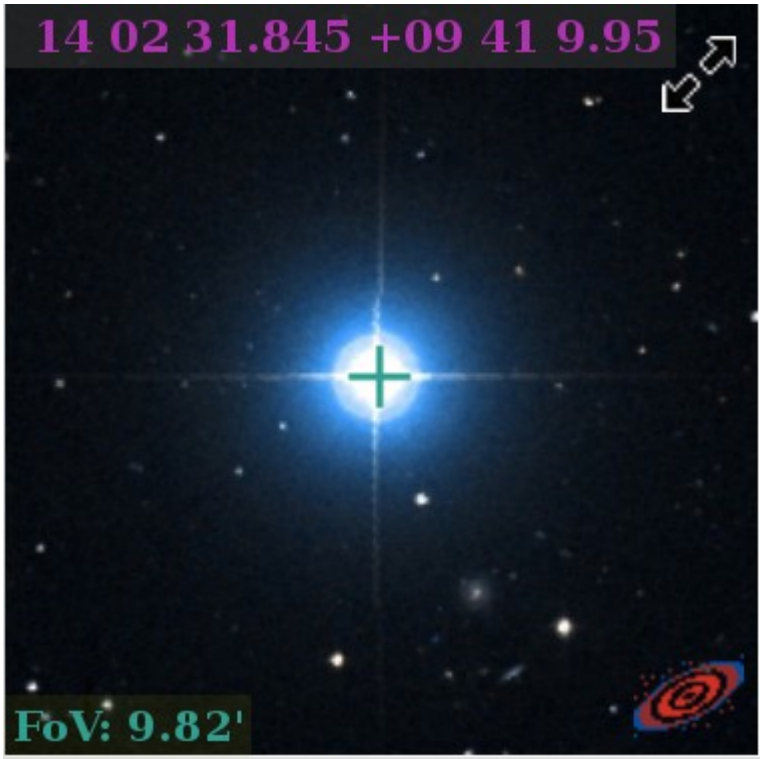
HD 122563 (M/H) = - 2.4 dex





Case of HD 122563

- (M/H) = - 2.4 dex
- Test (3D) Atmospheres



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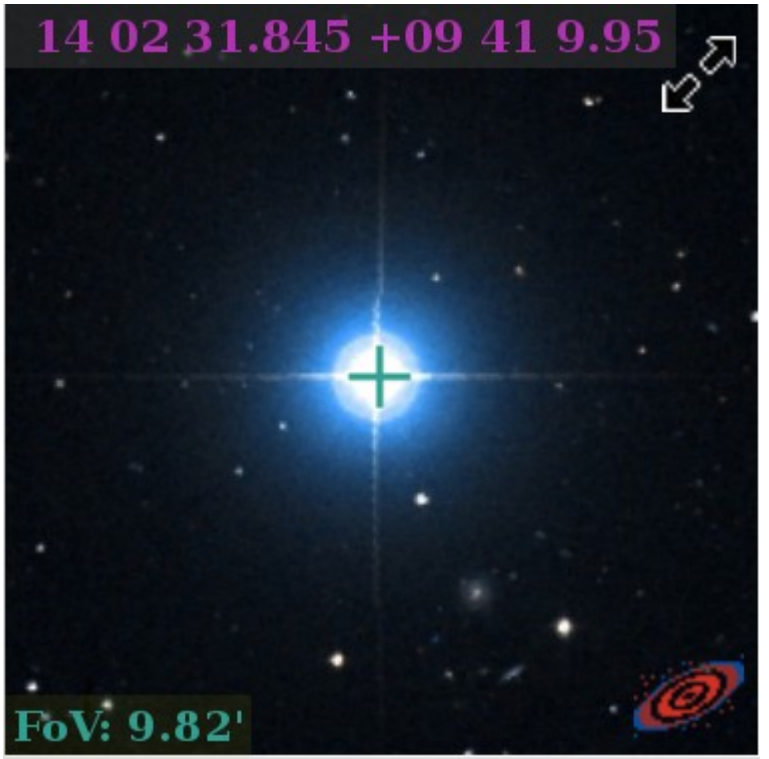

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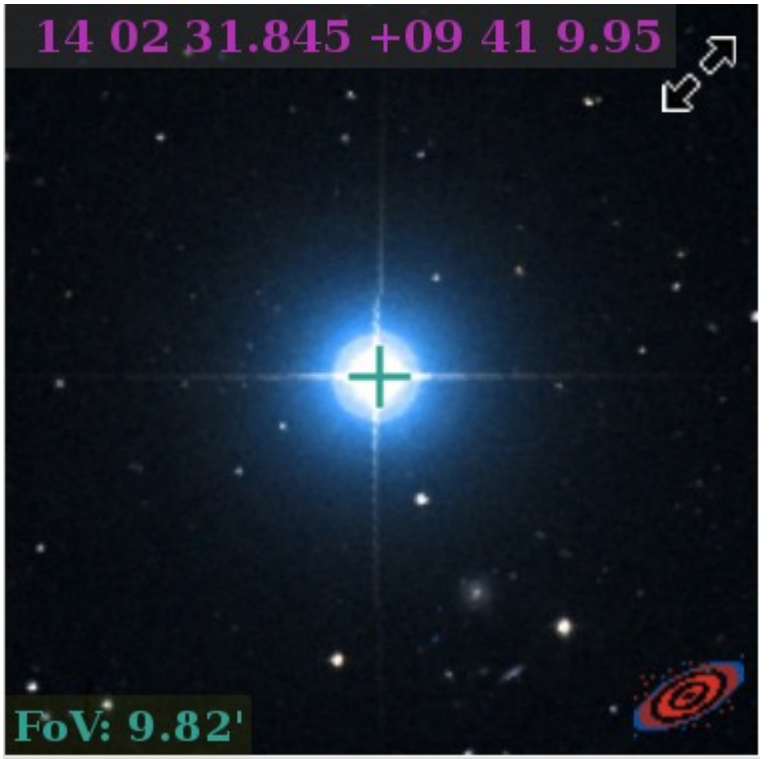

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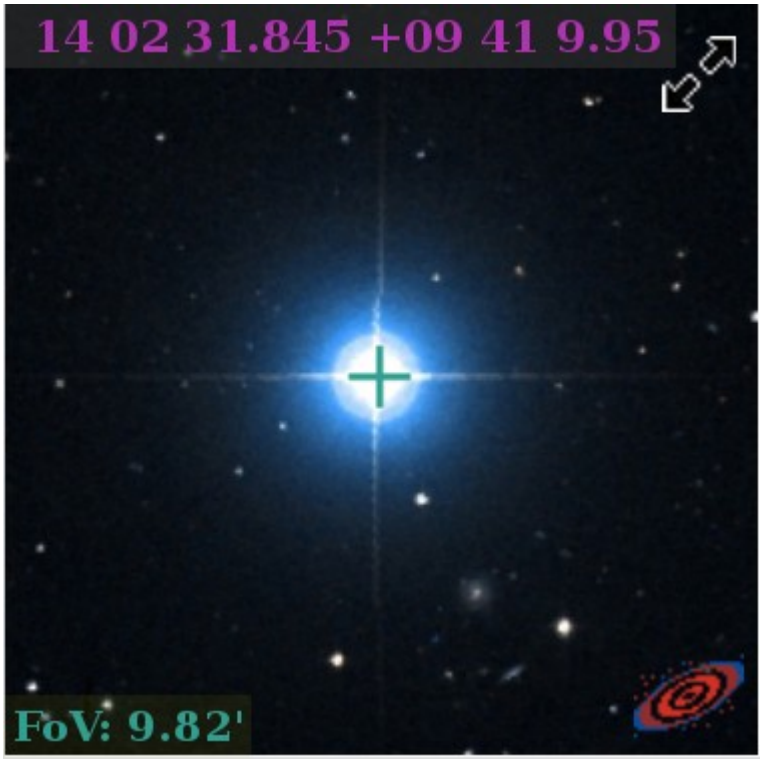

· Test (chemical) formation and evolution of Galaxy

The problem

Creevey et al. 2012

Θ	0.940 ± 0.011
Teff	4598 ± 41
Rad	23.9 ± 1.9
log g	1.60 ± 0.05

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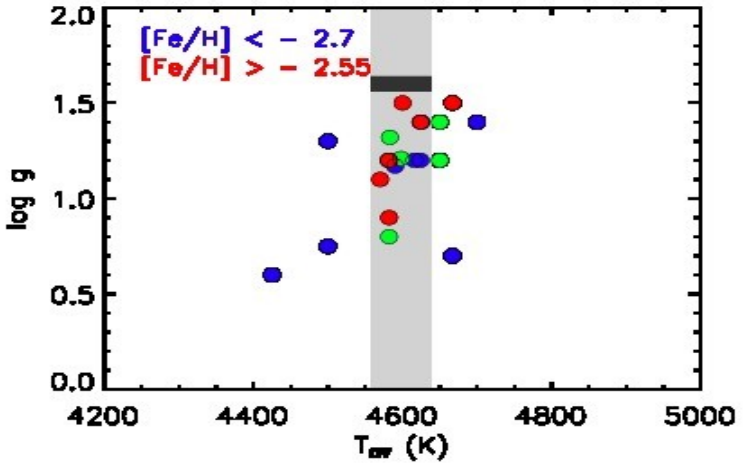

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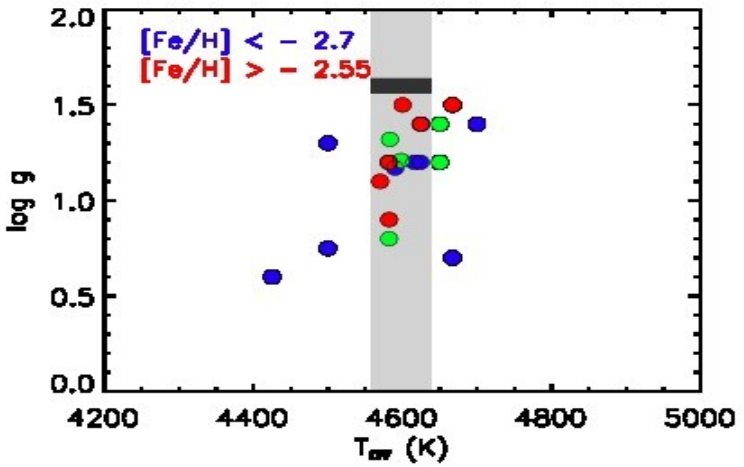

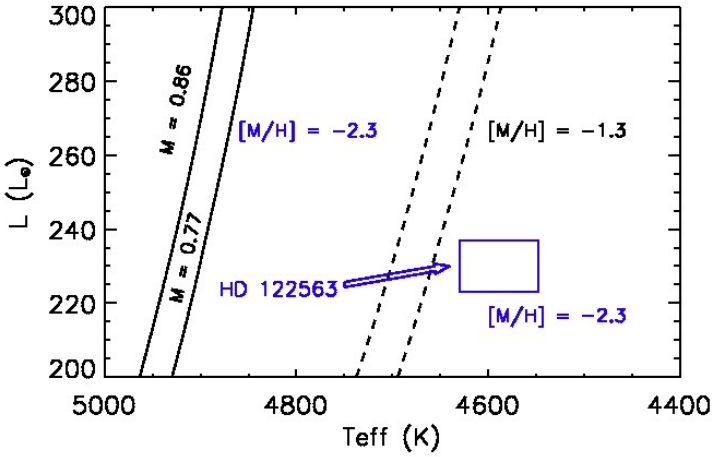

The problem

	Creevey et al. 2012		Casagrande et al. 2014
Θ	0.940 ± 0.011	vs	0.941 ± 0.019
Teff	4598 ± 41	vs	4600 ± 47
Rad	23.9 ± 1.9		
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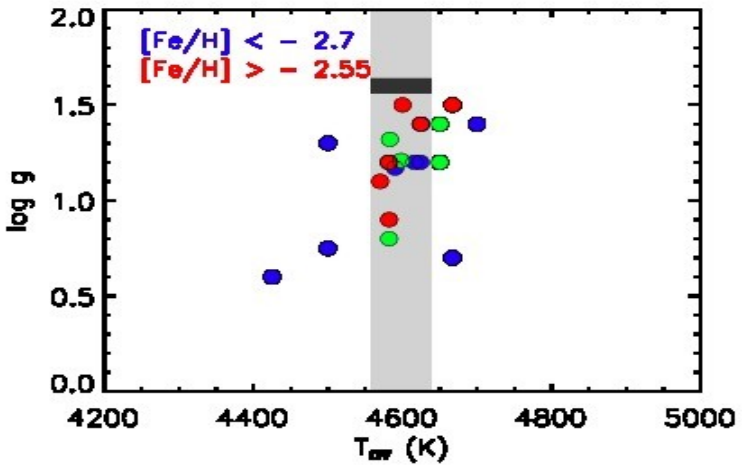
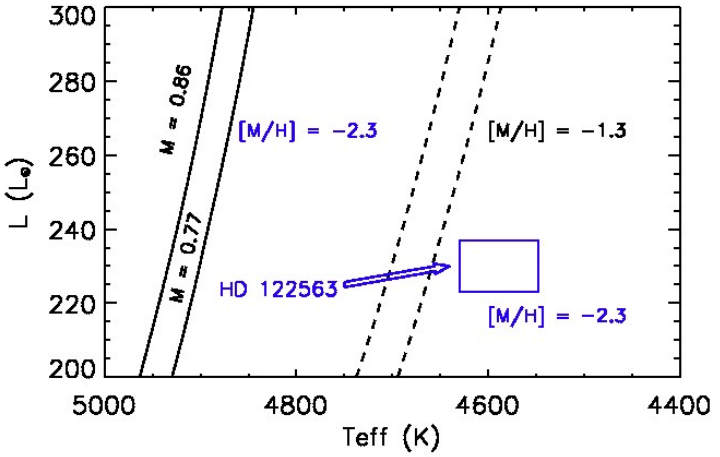
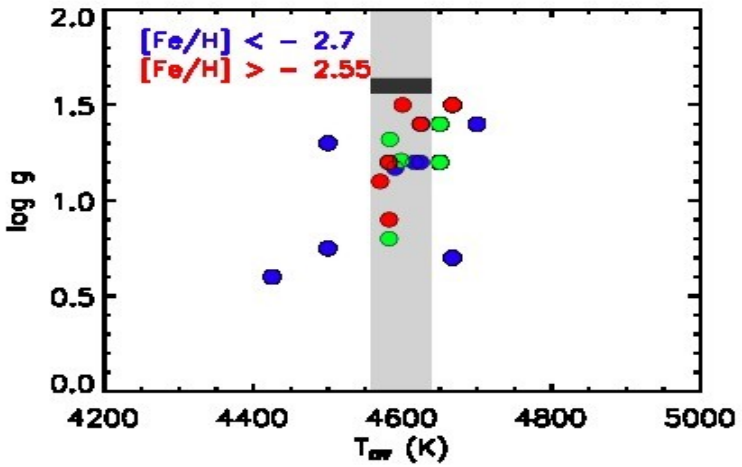
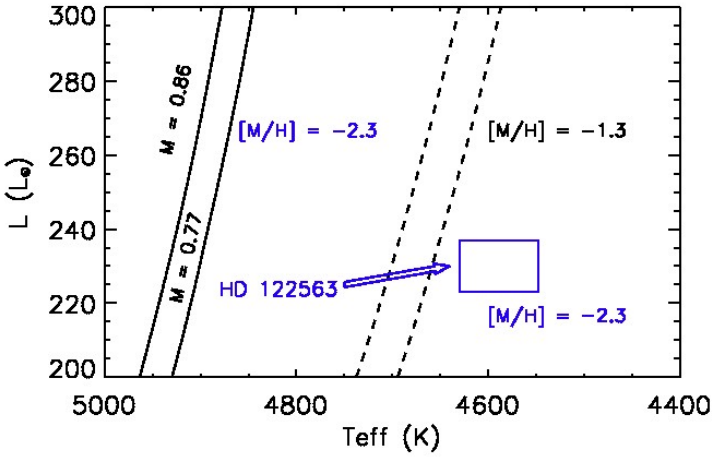




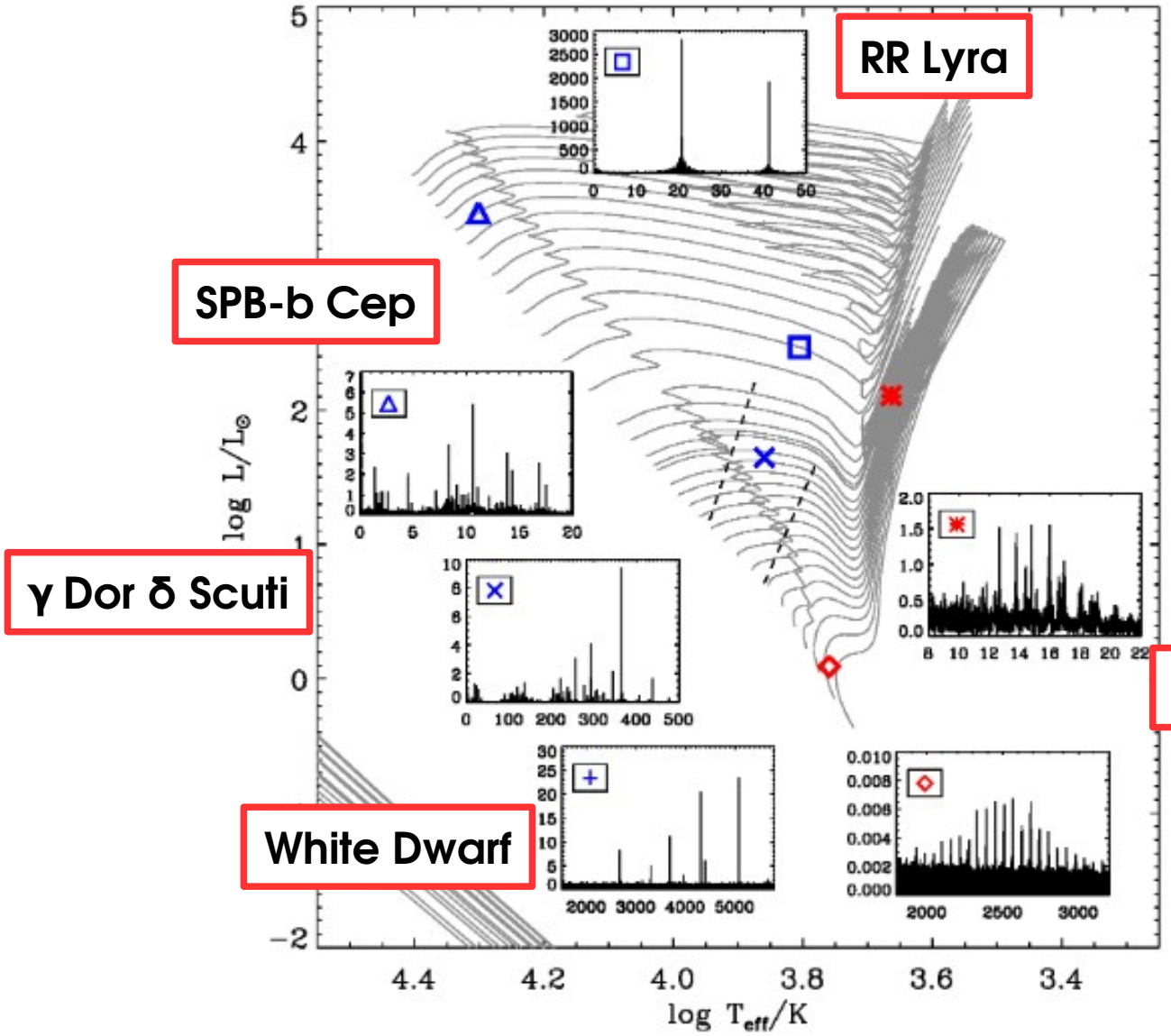
The problem

	Creevey et al. 2012		Casagrande et al. 2014		Karovicova et al. 2018
Θ	0.940 ± 0.011	vs	0.941 ± 0.019	vs	0.928 ± 0.011
Teff	4598 ± 41	vs	4600 ± 47	vs	4636 ± 36
Rad	23.9 ± 1.9				
log g	1.60 ± 0.05				



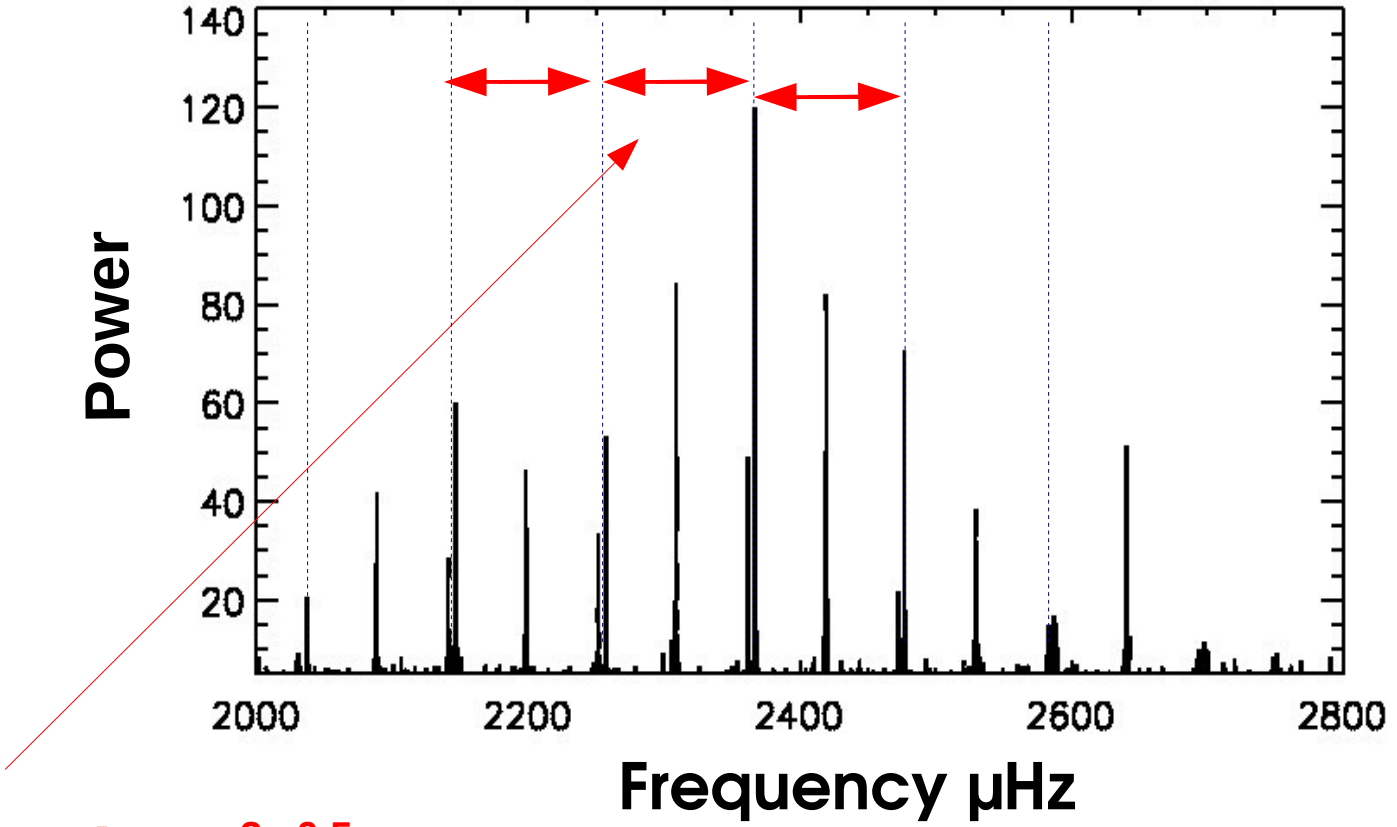


Pulsations: hint towards a solution



Huber et al. 2014

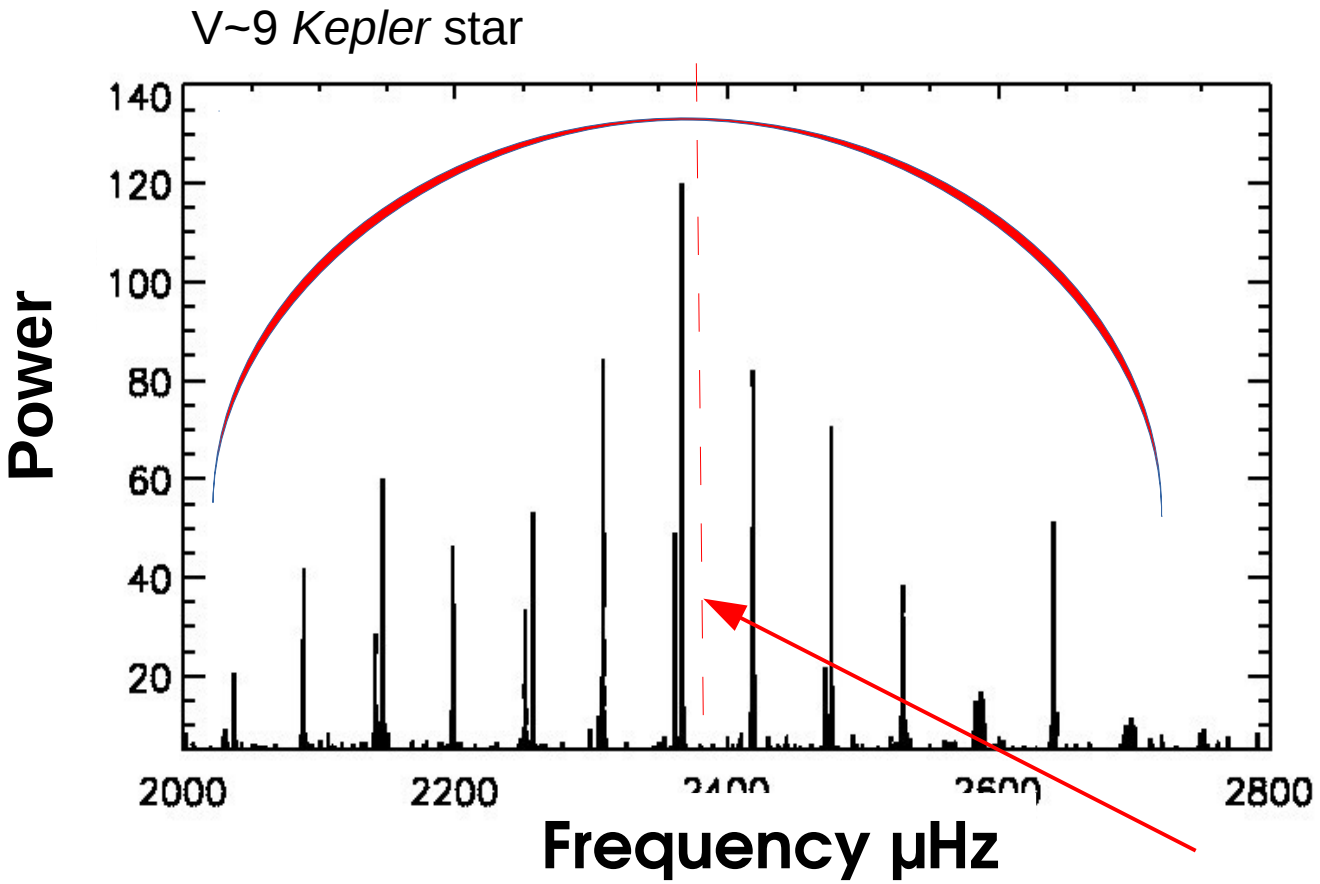
Sun-like oscillations



$\langle \Delta\nu \rangle = (M/R^3)^{0.5} =$

<Large frequency separations>

Sun-like oscillations



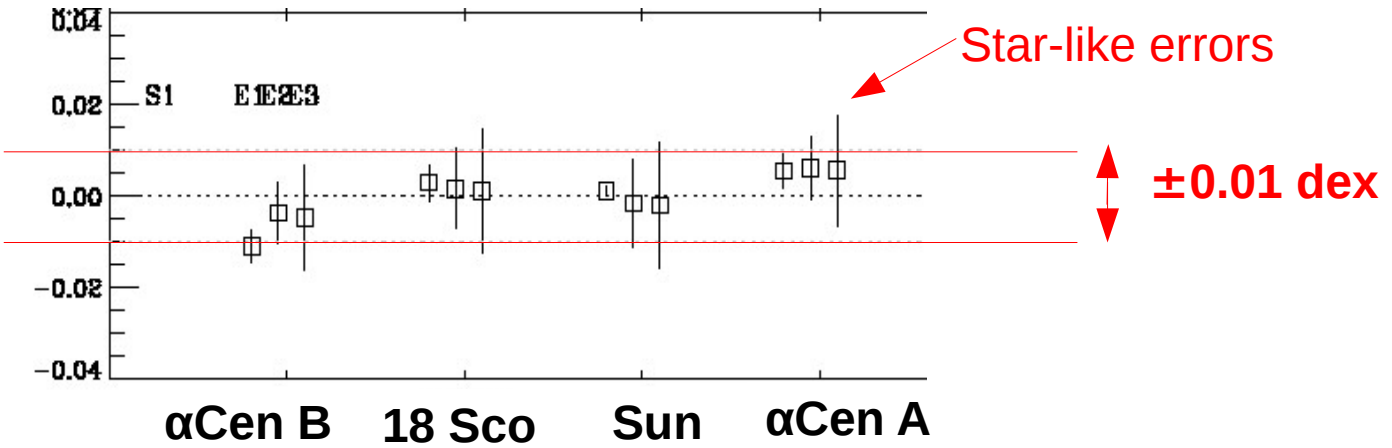
Frequency of maximum power

Sun-like oscillations

$$R = \frac{\nu_{max}}{\Delta\nu^2} T_{eff}^{0.5}$$

$$M = \frac{\nu_{max}^3}{\Delta\nu^4} T_{eff}^{1.5}$$

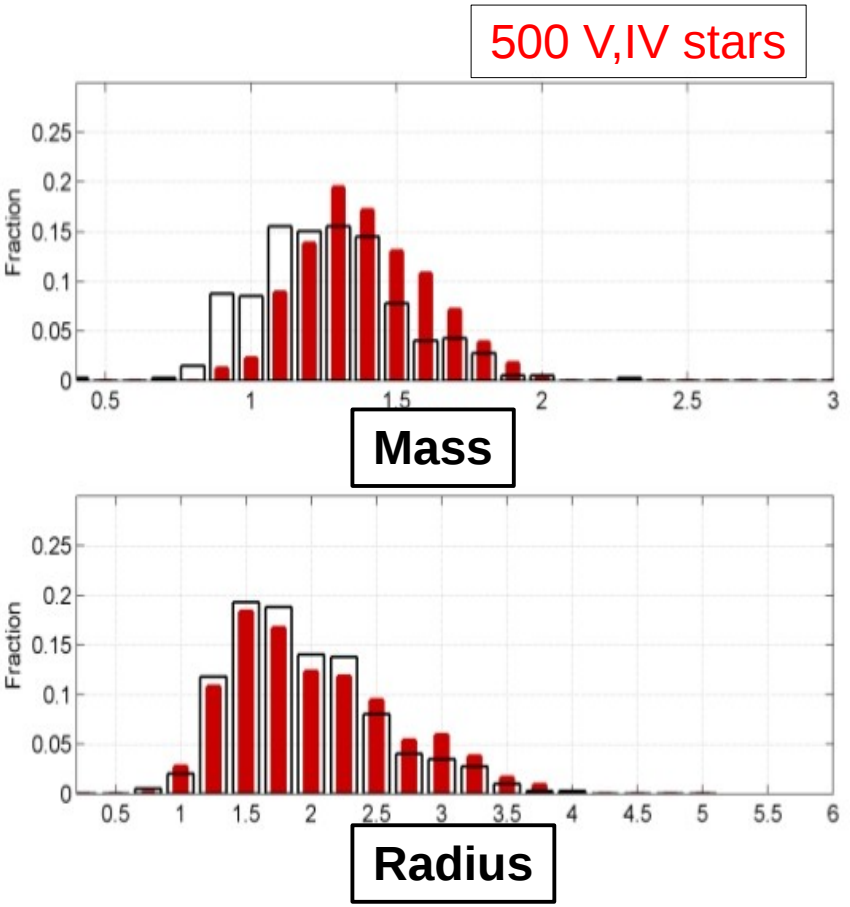
$$g = \nu_{max} T_{eff}^{-0.5}$$



Creevey et al. 2013

Seismic relations for Stellar populations

- Comparison of observed and predicted radii and mass
- Application to giants where ~20,000 giants are known
- Scaling relation not proven for giants NOT metal-poor
- HD122563 now benchmark for seismic studies



Chaplin et al. 2011

Asteroseismic observations

- SONG network RV measurements

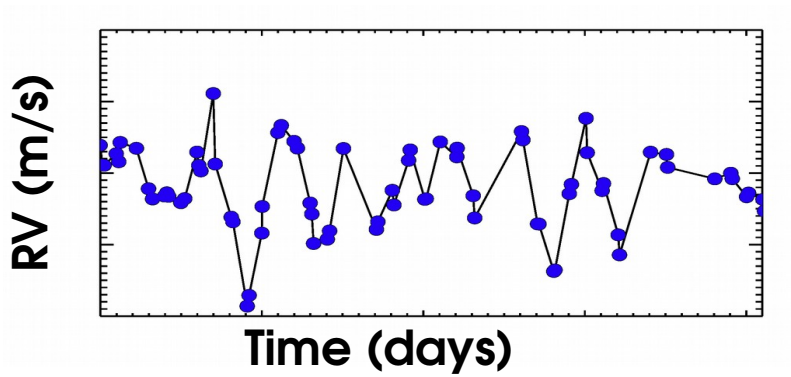
Creevey et al. 2011
Grundahl et al. 2011, …, 2017

Mads Fredslund Andersen

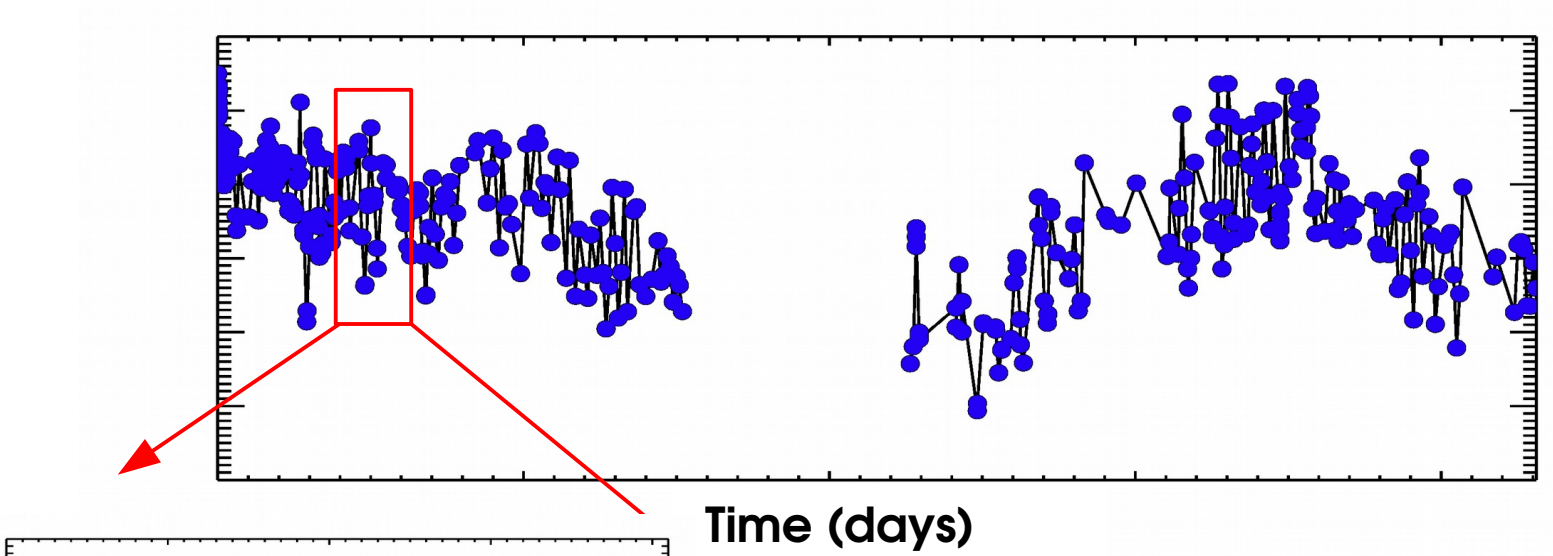
Asteroseismic observations

- SONG network RV measurements
- Observing HD122563 since May 2016 from Tenerife
- Time series allows seismic investigation

Mads Fredslund Andersen

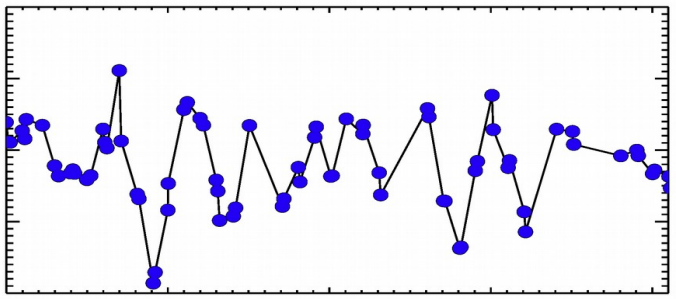


HD 122563: Radial velocity data

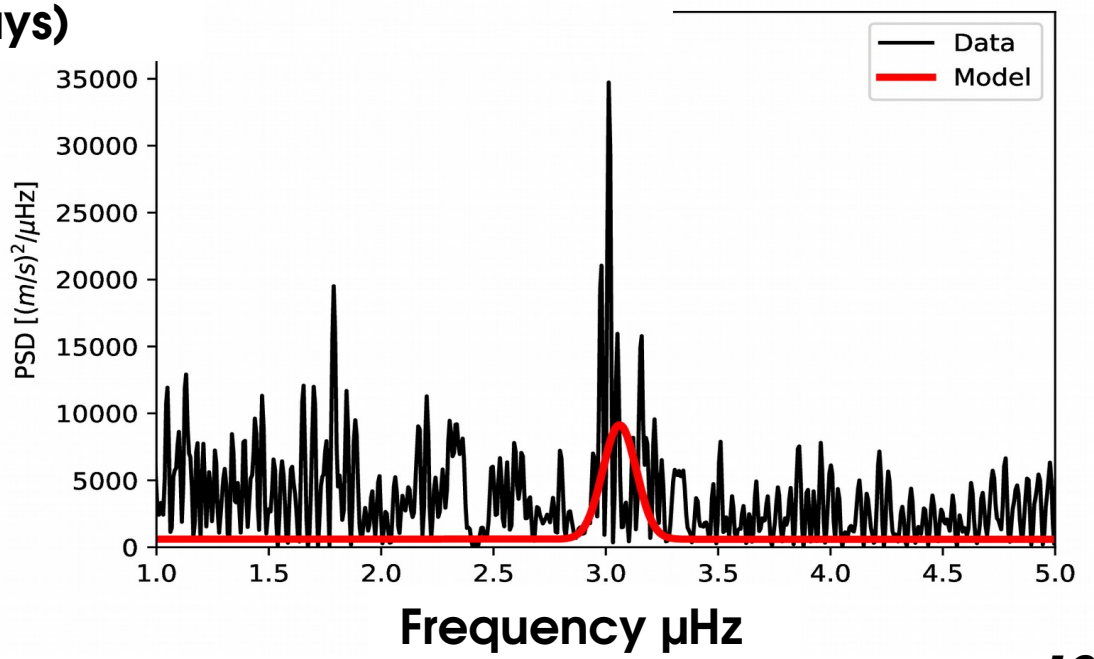


Time Series

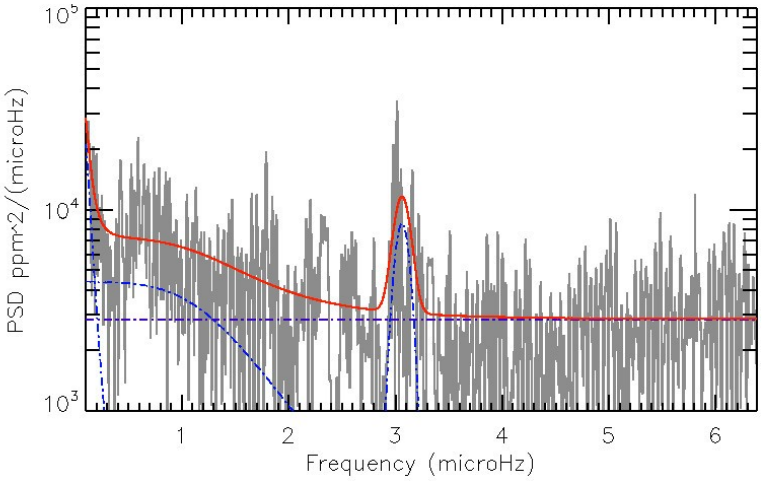
Time (days)

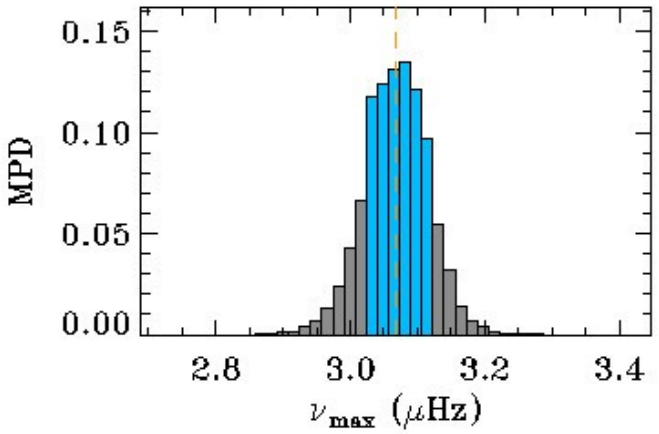


Power Spectrum



Analysis of Power Spectrum





- Bayesian analysis using nested sampling

  Corsaro & Ridder, 2014

- Analysis and evidence of background components
- Probability distribution of numax

https://github.com/EnricoCorsaro/DIAMONDS

DIAMONDS™ BAYESIAN SOFTWARE

Interpretation of data

- Seismology: log g reduces 0.20 dex
- Mass: Radius increases to 30 Rsol
- Interferometry: distance increases to 300 pc

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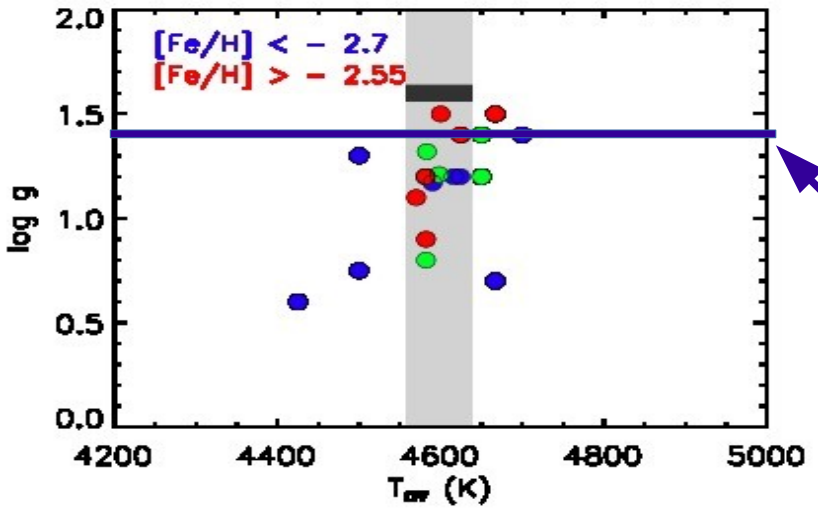

New Constraints :
log g=1.40 ± 0.01 dex

Gaia & HD 122563

- Parallax = 3.444 +- 0.063 mas
- Distance ~25 % further than Hipparcos (2007)

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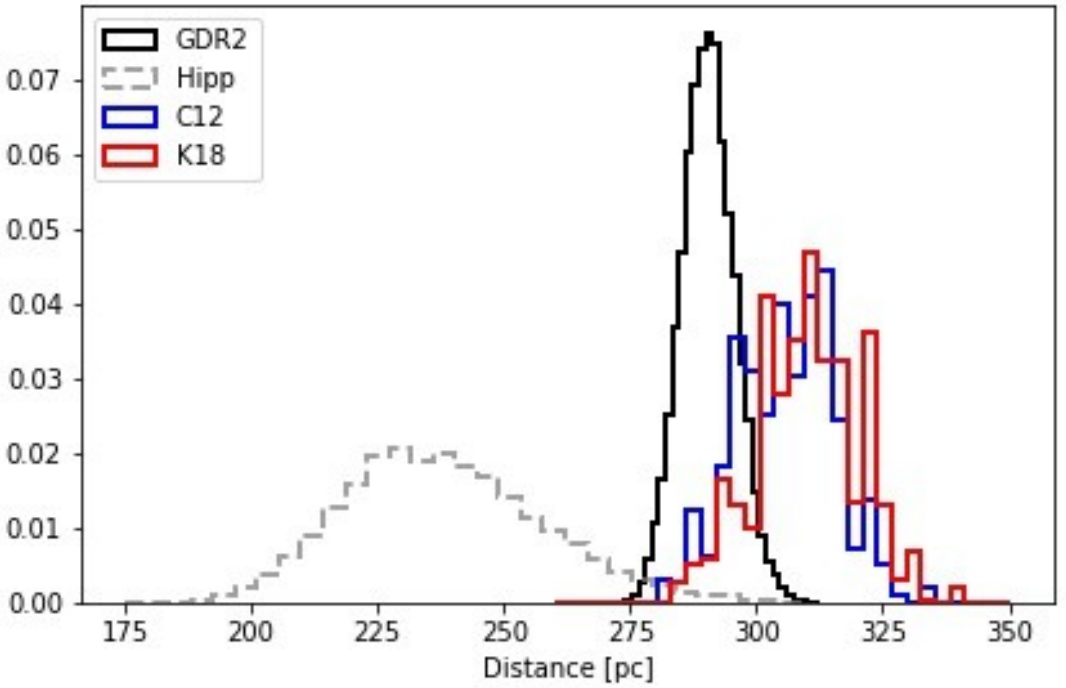
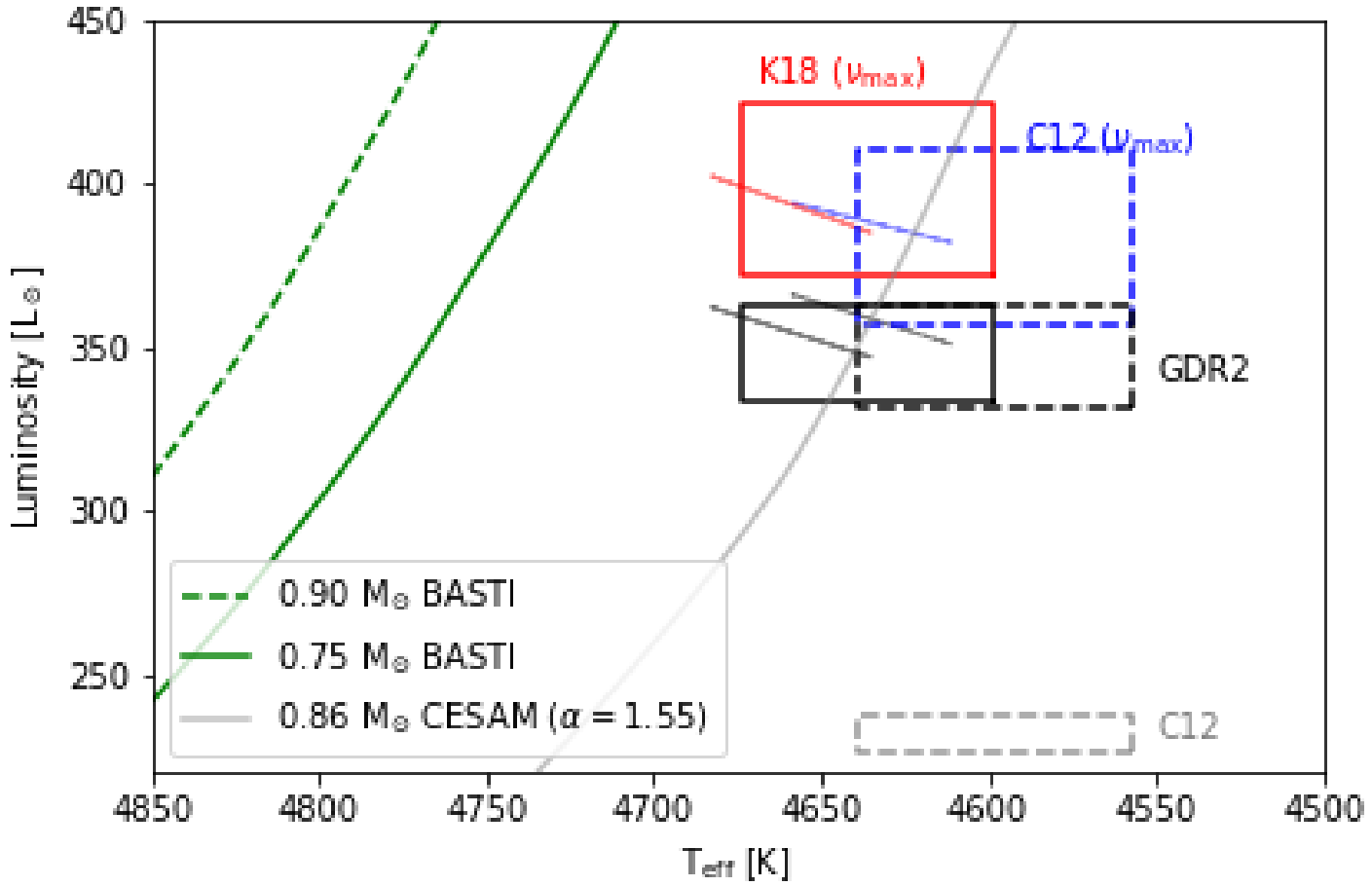


- Log g = 1.43 ± 0.03 dex

HD 122563 in the HR diagram



- Gaia corroborates our results **so scaling relations work** !
- Understand now the earlier discrepancies
- Refined mass 0.85-0.87 Msol
- Alpha value consisten ith 3D models

Today's conclusions...

- Importance of different types of measurements for benchmark stars in particular those different from the Sun (systematics) !
- SONG telescope in Tenerife
- Detection of oscillation signatures ! Log g, radius, distance
- **Gaia and new parallax : prove that scaling relations are valid to within 0.05 dex**: HD122563 benchmark for seismic scaling relations
- New constraints support predictions from 3D simulations
- Continuing SONG observations : Stellar evolution and atmosphere model tests
- Detection in other stars to calibrate the relations

Thank you for your attention