Sun-like oscillators
(asteroseismology+interferometry)
and
Metal-poor stars

Orlagh Creevey

Thévenin, Bigot, Nardetto,
Provost, Berio et al.

VEGAS

Determination of stellar parameters and interior structure through stellar modelling using constraints from angular diameters

Radius

Effective temperature

Scientific drivers

Determining masses and ages of single stars and testing input physics in stellar models

-> stars

-> planets

-> Galaxy

structure, formation, evolution

VEGAS

1. More precision for brighter stars

2. Fainter magnitudes

VEGAS

1. More precision for brighter stars

   + Gaia distances!!

2. Fainter magnitudes

Outline

1. Metal-poor stars
2. Sun-like oscillators

Metal-poor stars

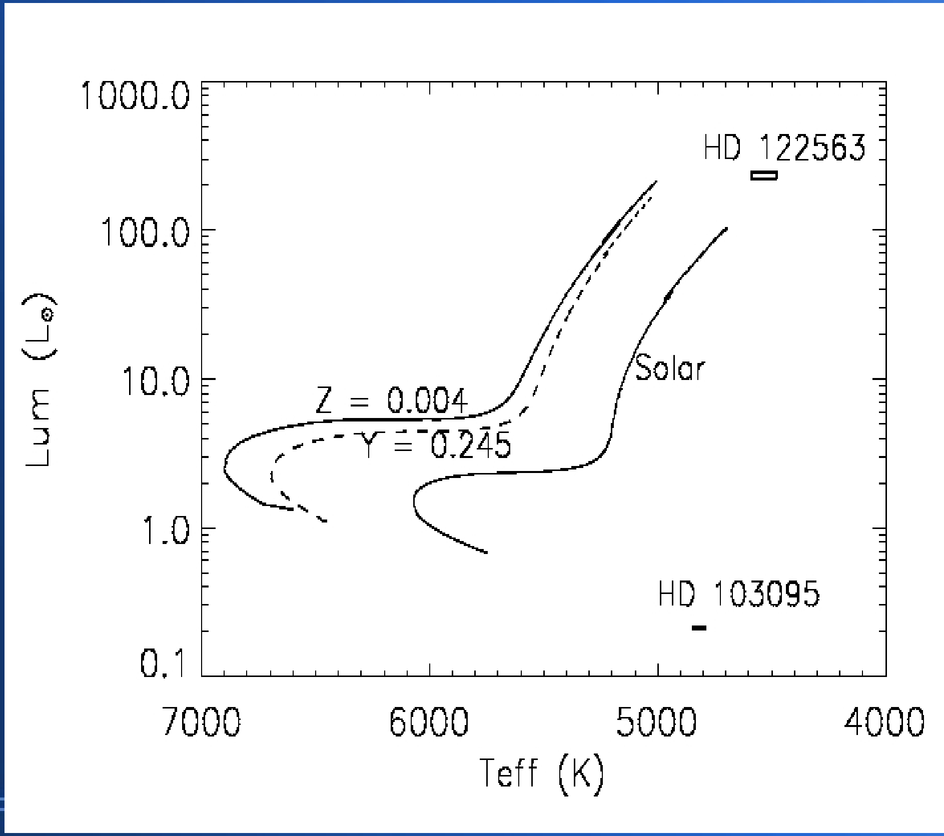
Oldest stars – carry information about early conditions of Galaxy/Universe

“Difficult” to model and

T_{eff} not well established

Interesting constraints

on models (age, Y_i, M)



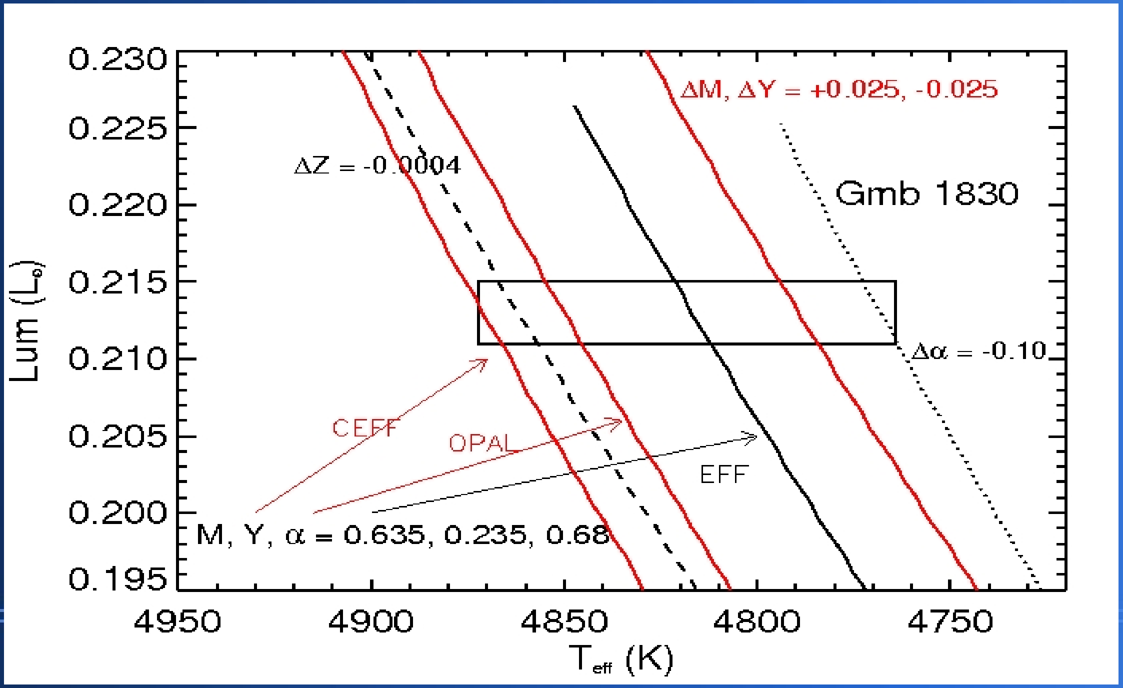
Gmb 1830

Angular diameter provides very precise T_{eff}:

1) Test input physics

2) Mixing-length parameter

Creevey et al. 2012: the 'small' error box in the HR diagram for Gmb1830, allows us nearly to distinguish between different equations of state, and a very precise determination of the mixing-length parameter.



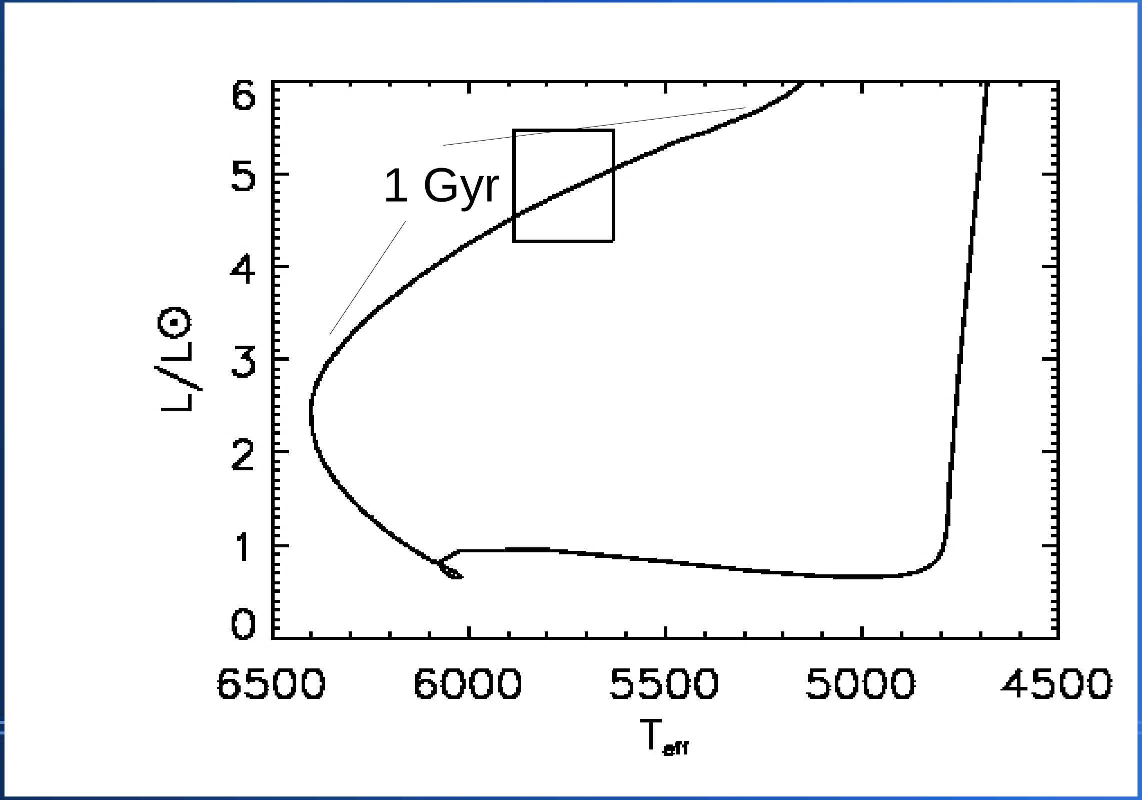
HD 140283 (V=7.2)

- Going to the limits of VEGA V~7.2 we determine T_{eff} but with $\sigma(T_{eff})$ = 127 K. This is similar to photometric/spectroscopic errors, although we know its accurate :)

- With VEGAS we can reduce this error bar

HD 140283 (V=7.2)

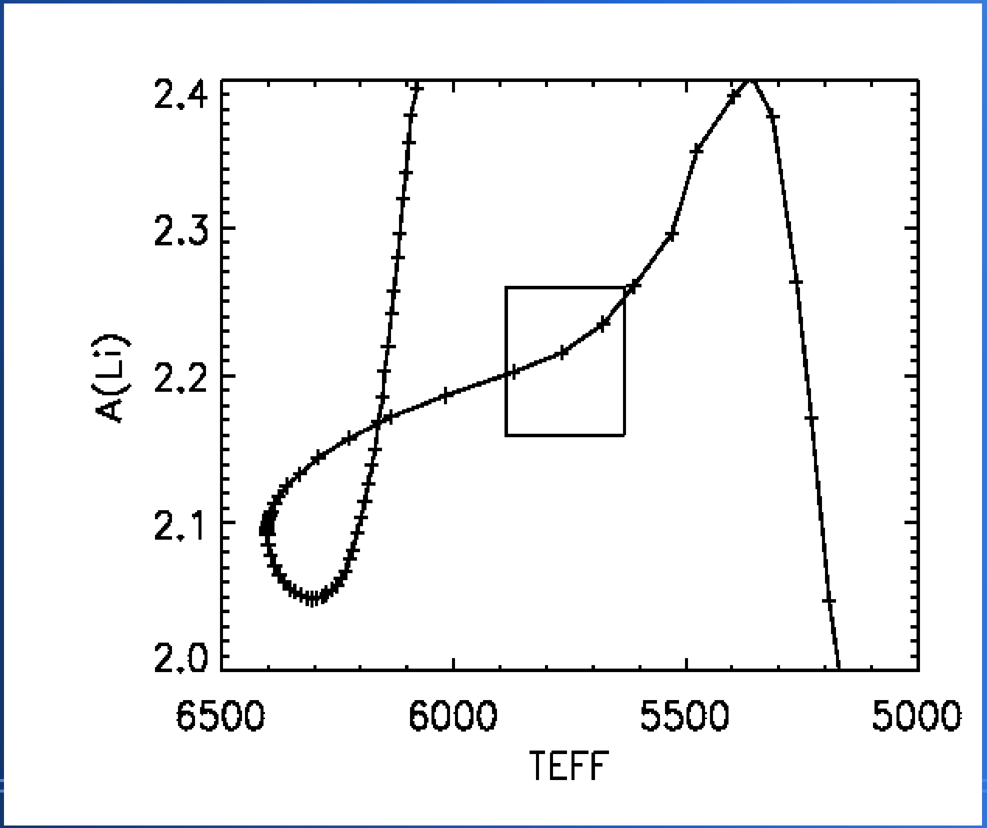
Creevey, Thévenin et al. in prep: Location of star in HR diagram, where the T_{eff} provides very tight constraints on its age and the mixing-length parameter. With VEGAS we could improve these.



HD 140283 (V=7.2)

Tighter constraints on T_{eff} provides critical input for spectroscopic analyses to determine high precision abundances.

Creevey et al in prep.: evolution track of the surface Li abundance, after modifying initial chemical mixture. We match the observed Li. With smaller errors we could refine this analysis and discard different 'diffusion scenarios'



Outline

1. Metal-poor stars
2. Sun-like oscillators

Sun-like oscillators

Radius from interferometry, $\langle \Delta\nu \rangle$ from asteroseismology => Mass

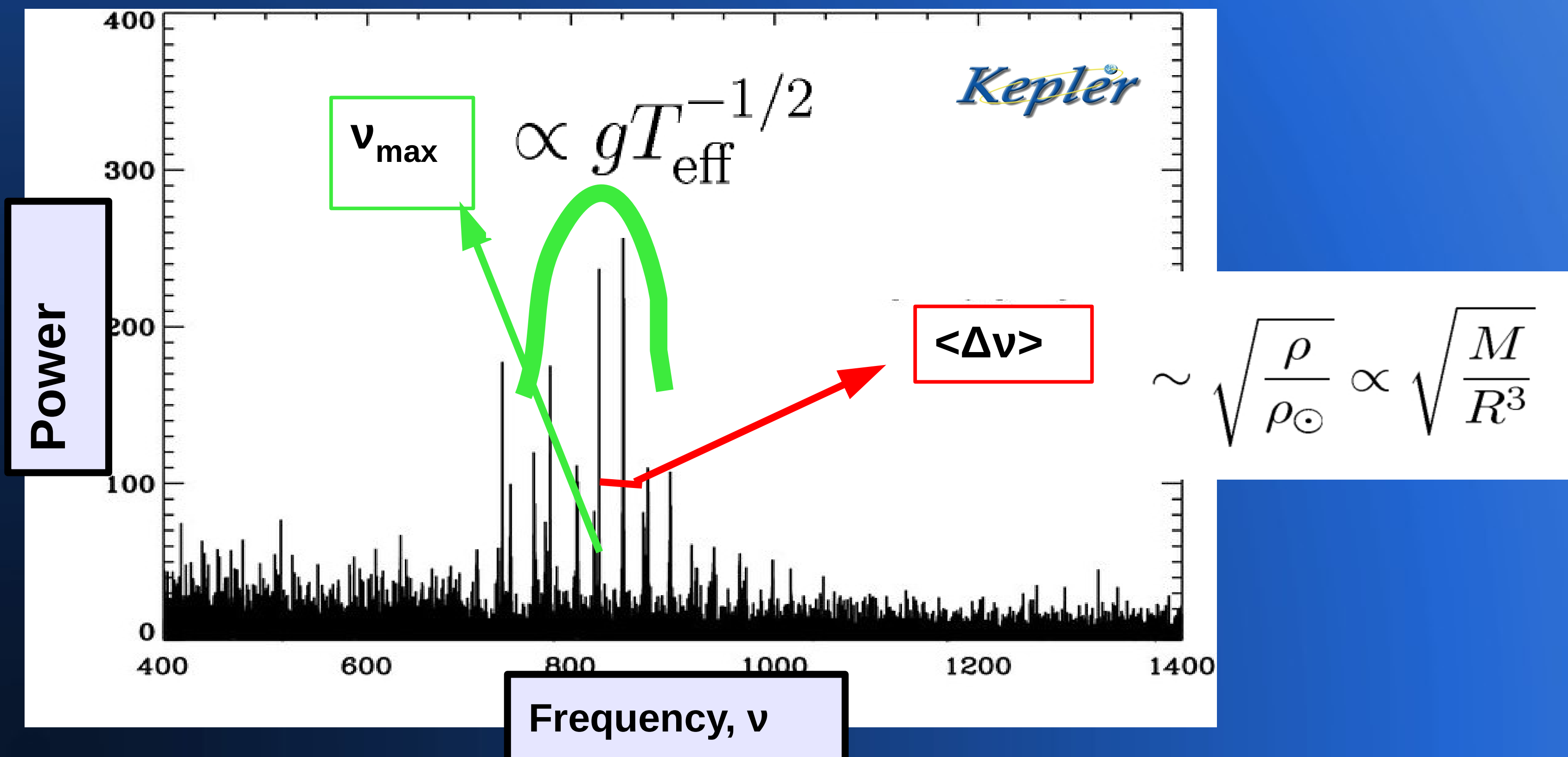
Seismic log g + Interferometric T_{eff}

-> mixing-length parameter

-> spectroscopic models (NLTE)

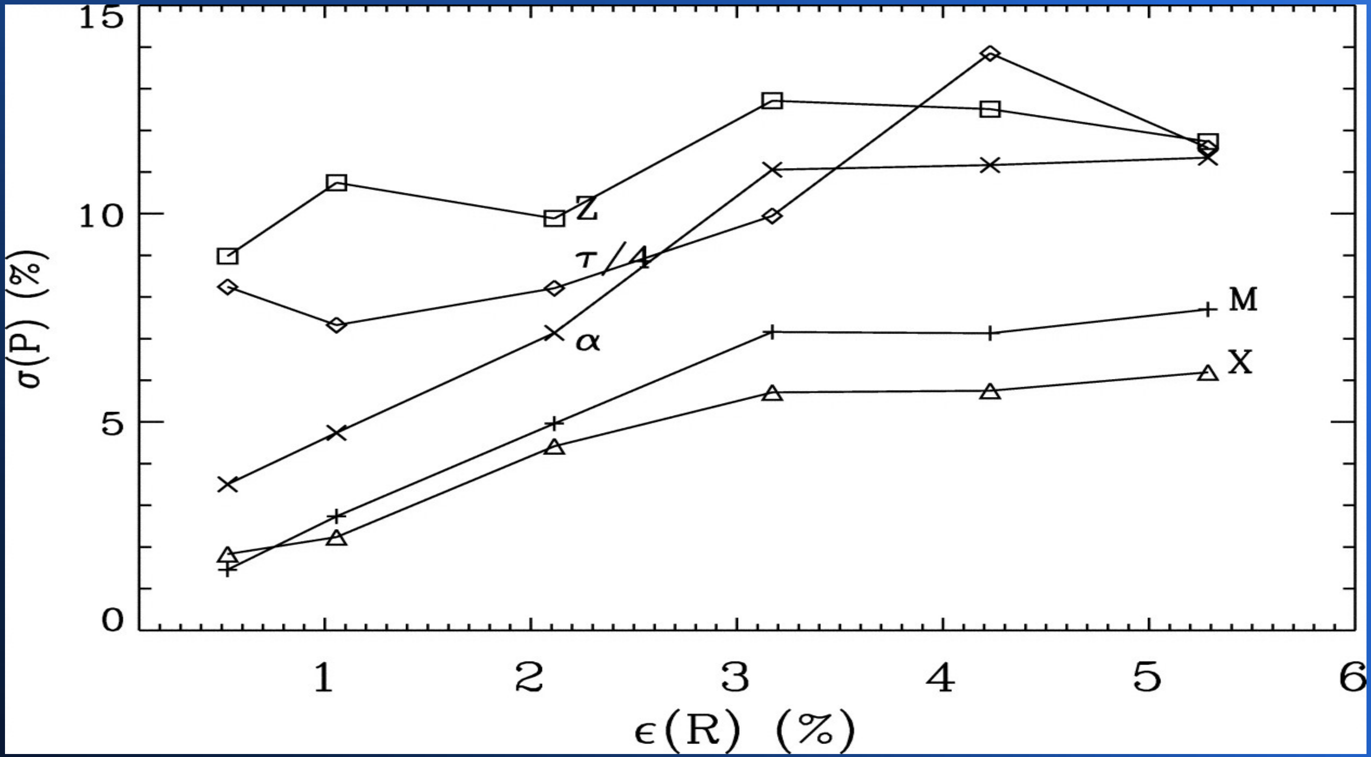
-> abundances

Sun-like oscillations



Mathur et al. 2011 (V=11)

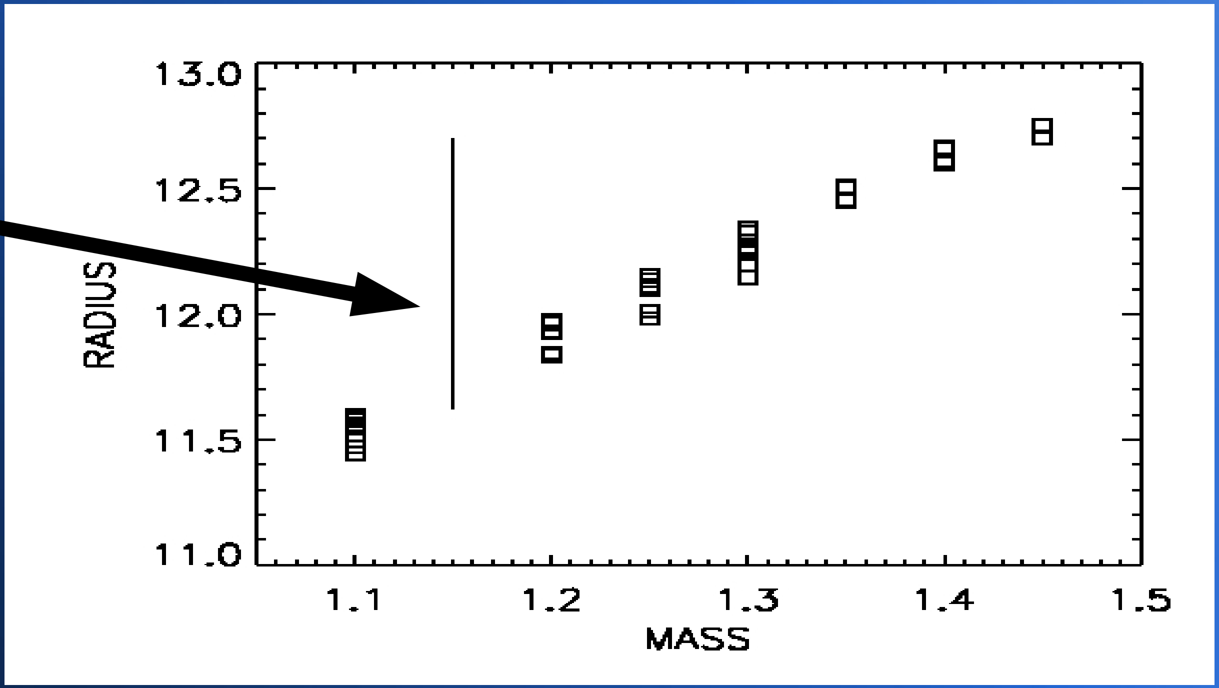
Determining mass



Creevey et al. 2007: the determination of stellar parameters (M = mass, X = hydrogen, τ = age, Z = metallicity, α = mixing-length parameter, when we use seismic data as constraints and a radius from interferometry with different precisions.

CoRoT red giant: HR 7349

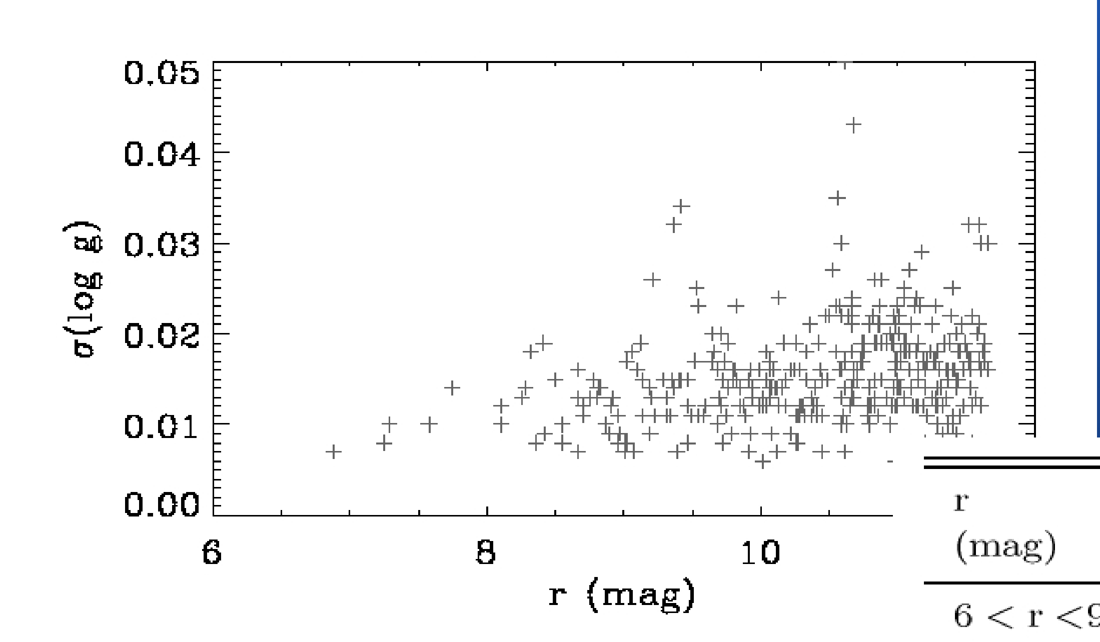
Interferometric Radius



Creevey, Bigot, Provost et al. in prep: Mass and radius of the best-fitting models from an asteroseismic analysis. A smaller error in the interferometric radius would allow us to narrow down the mass range. Note that the error bar on the radius includes a contribution from the error on the parallax, which will also reduce when both Gaia and VEGAS deliver!

Constraining log g

Creevey et al. 2013



r (mag)	$\langle\sigma\rangle$ (dex)	$\langle s_{\rm Teff}\rangle$ (dex)	$\langle s_{\rm [Fe/H]}\rangle$ (dex)	$\langle s_{\rm code}\rangle$ (dex)
$6 < r < 9$	0.012	0.004	0.014	0.005
$9 < r < 10$	0.014	0.004	0.009	0.004
$10 < r < 11$	0.016	0.009	...	0.006
$11 < r < 12$	0.017	0.009	...	0.006
$6 < r < 12$	0.015	0.01	0.02	0.01

Uncertainties and systematics in 'seismic log g' for 400+ Kepler stars

Int + Ast = Log g + T_{eff}

1. Spectroscopic analyses: better abundances
2. Improving atmosphere models
3. NLTE effects (esp. metal-poor stars)

Having access to fainter targets with VEGAS means increasing the sample size significantly. Many fainter stars have been measured seismically with CoRoT and Kepler.

Mixing-length parameter

Mixing-length parameter α in stellar models is an adjustable parameter, but many use the solar-calibrated value. Bonaca et al. (2012) studied a large sample of Kepler stars and derived the formula:

$$\alpha = a + b \log g + c \log T_{\mathrm{eff}} + d[\mathrm{M/H}].$$

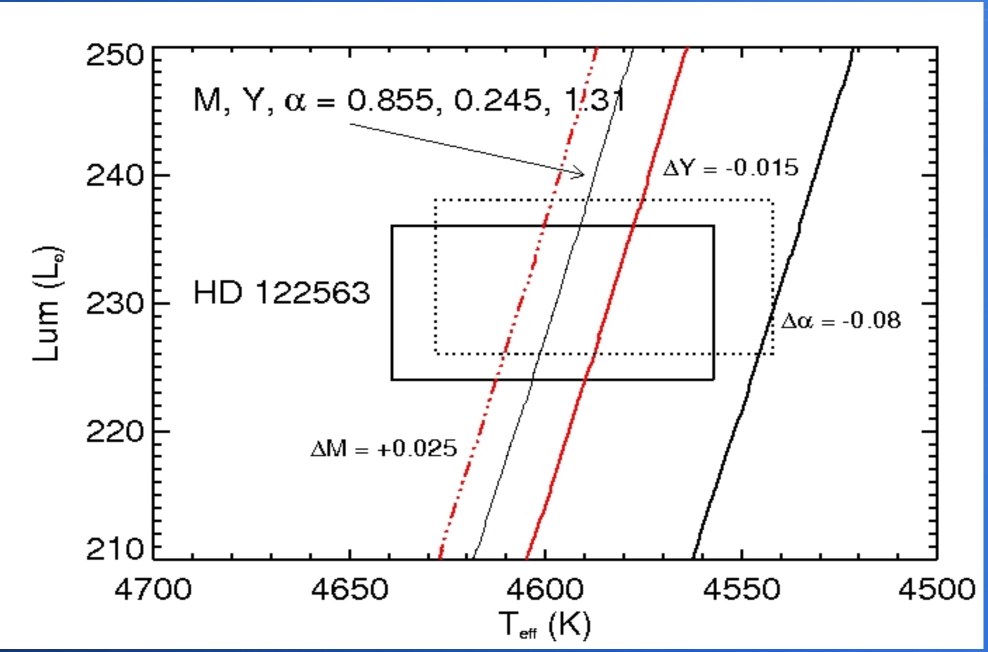
Trilinear Analysis

	All data		$\log g \geq 3.8$	
	fitted-value	p	fitted-value	p
a	7.97 ± 0.27	0.010	-12.77 ± 2.91	6.8×10^{-5}
b	-0.31 ± 0.09	0.002	0.54 ± 0.11	1.7×10^{-5}
c	-1.33 ± 0.80	0.102	3.18 ± 0.69	3.3×10^{-5}
d	0.48 ± 0.12	2×10^{-3}	0.52 ± 0.07	4.5×10^{-9}

Mixing-length parameter

Creevey et al. 2012b

- Interferometry of metal-poor stars using VEGA, Classic, FLUOR @ CHARA allowed us to well determine α.



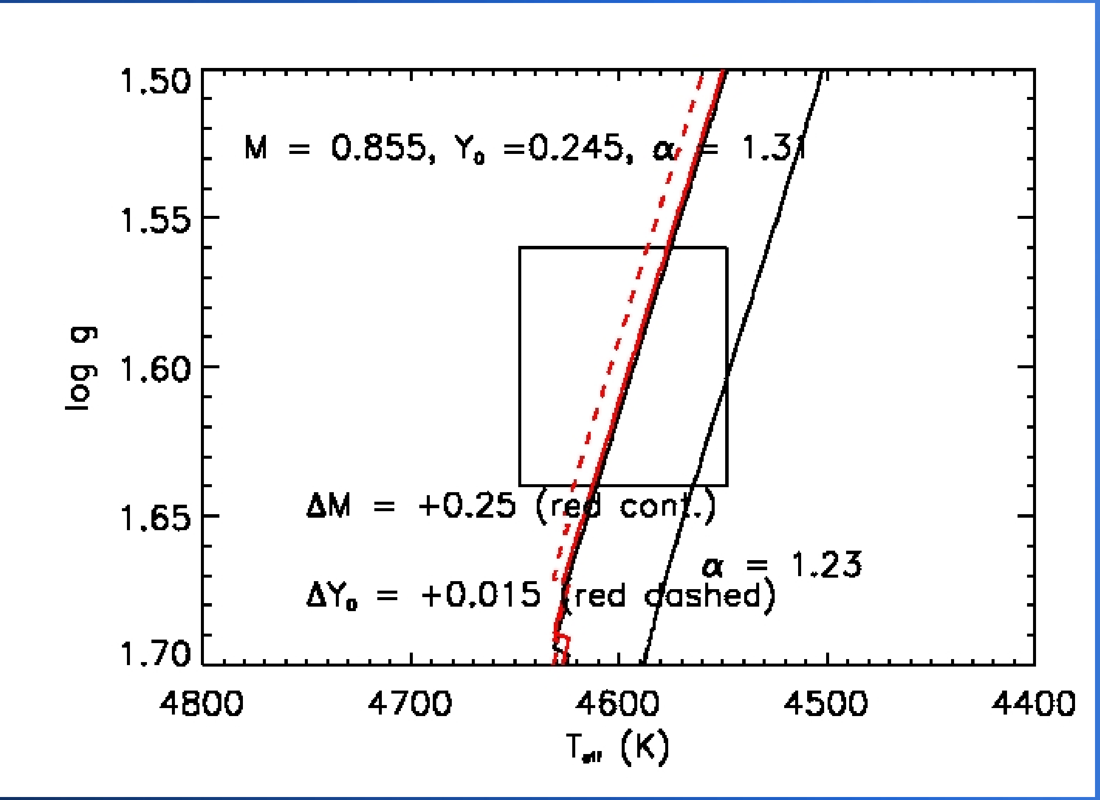
- We compare our detailed modelling results with Bonaca et al. formula.

Star	Estimated	Modelled
Gmb 1830 (MS)	0.75	0.65
HD 140283 (TO)	1.22	1.20 **
HD 122563 (G)	1.40	1.31

Mixing-length parameter

Log g versus Teff

HD122563 (G. Bono)



With VEGAS we could reliably determine α with high precision for a large number of targets.

Specific science cases

1. NGC 6633; observed by CoRoT

   Several red giants: θ_{pred} = 0.80, 0.38, 0.31

   V = 7.3 – 8.7

2. Kepler stars 6<V<12

Merci