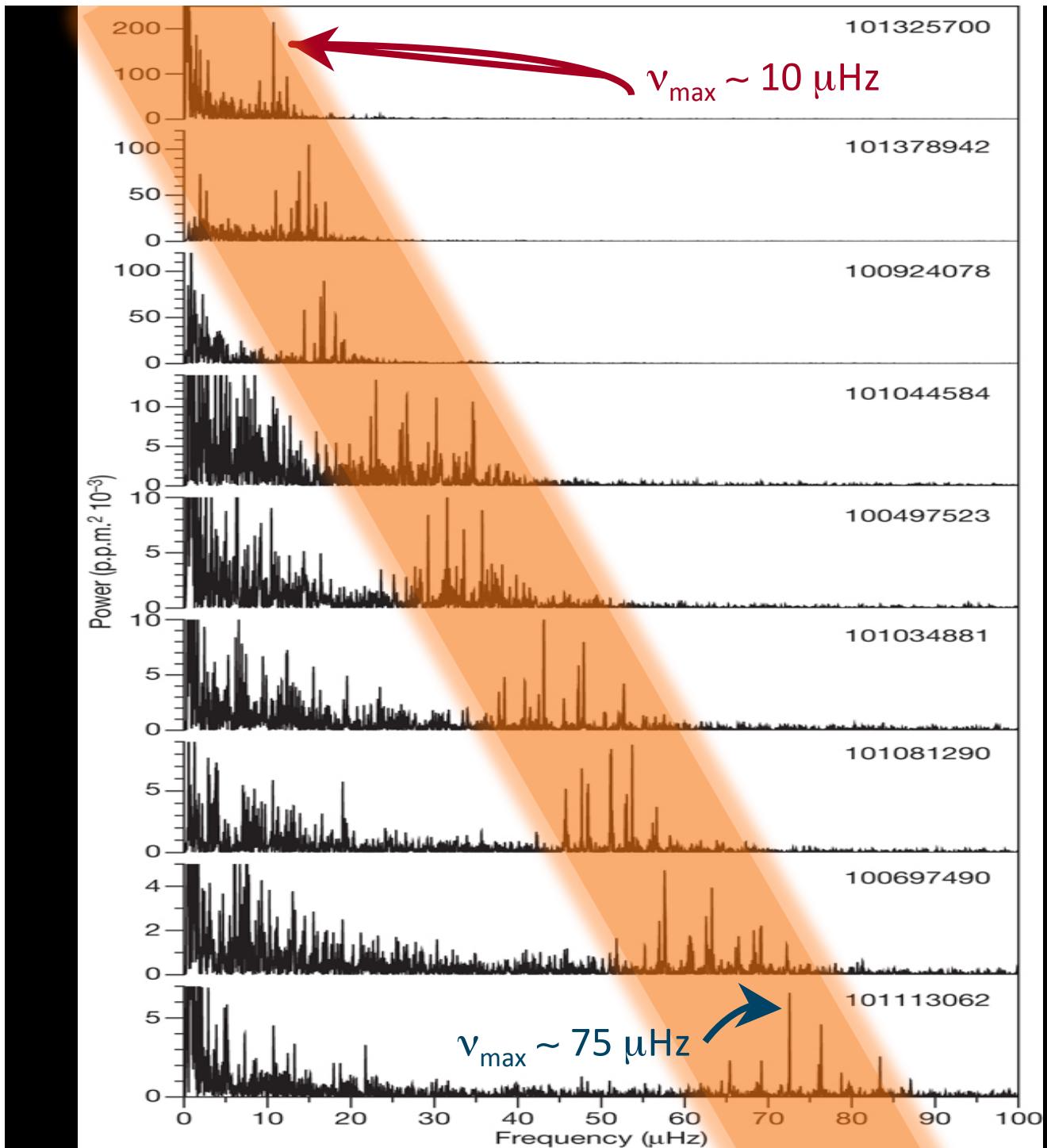


Red Giants

J. Montalban, C. Chiappini, A. Miglio & RG WG team

1. Red Giants in the exofield

Stellar populations and Galaxy history



De Ridder et al. 2009, *Nature*
459, 398

$$\nu_{\text{max}} = \frac{M/M_{\odot}}{(R/R_{\odot})^2 \sqrt{T_{\text{eff}}/5777K}} 3.05 \text{ mHz}$$

$$\Delta\nu = (M/M_{\odot})^{1/2} (R/R_{\odot})^{-3/2} 134.9 \mu\text{Hz}$$



Mass & Radius → *Luminosity*

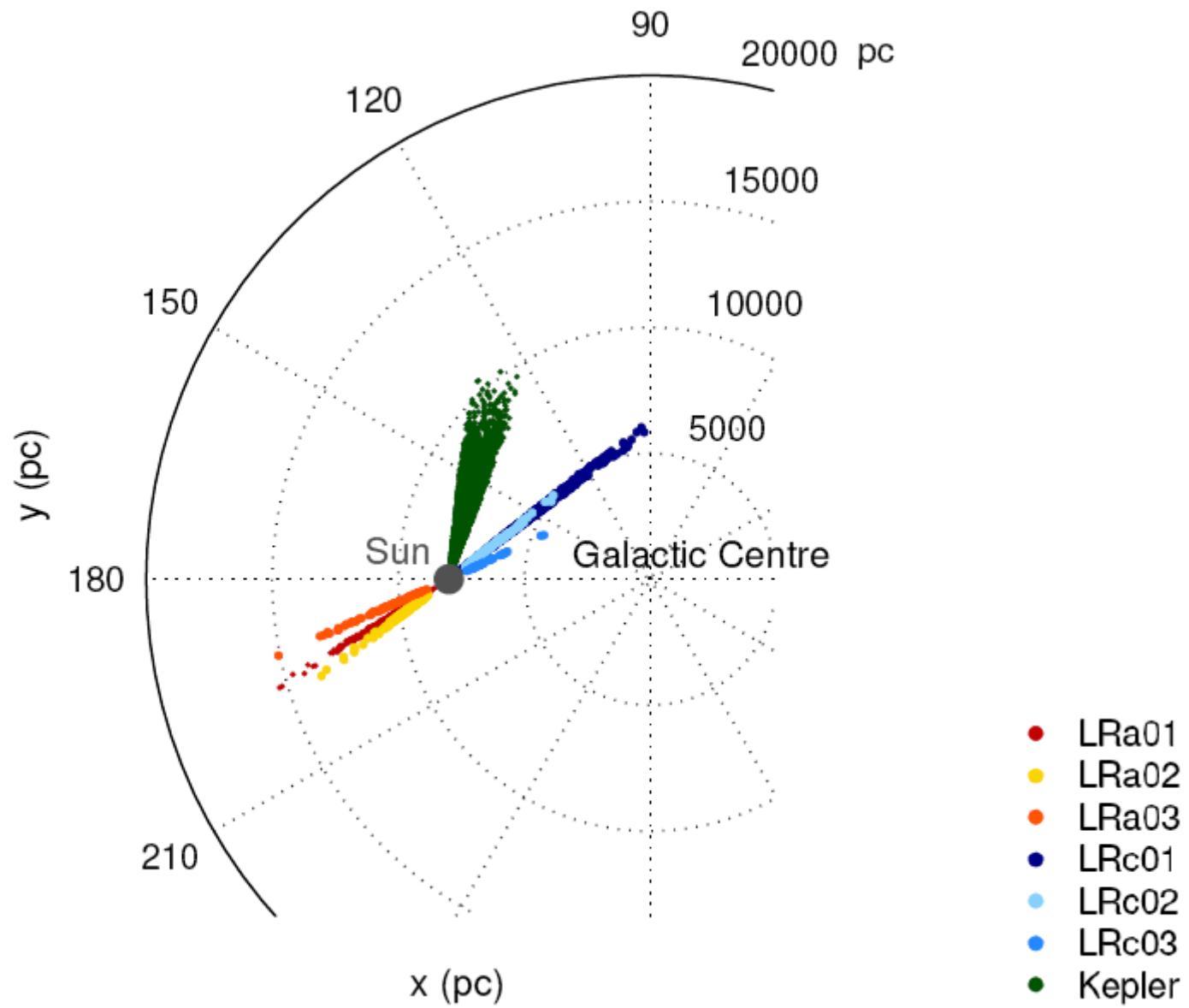


Distances *up to 10 kpc (Hipparcos 100 pc)*

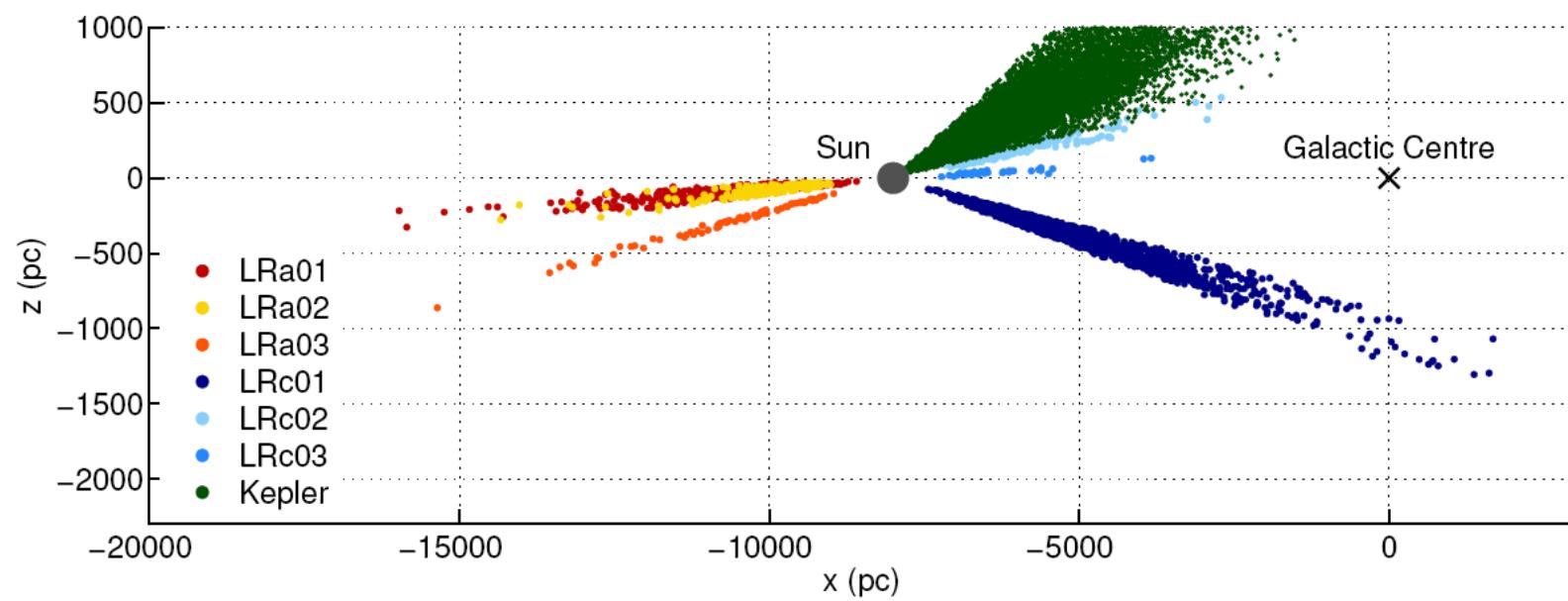


3D map of the Galaxy

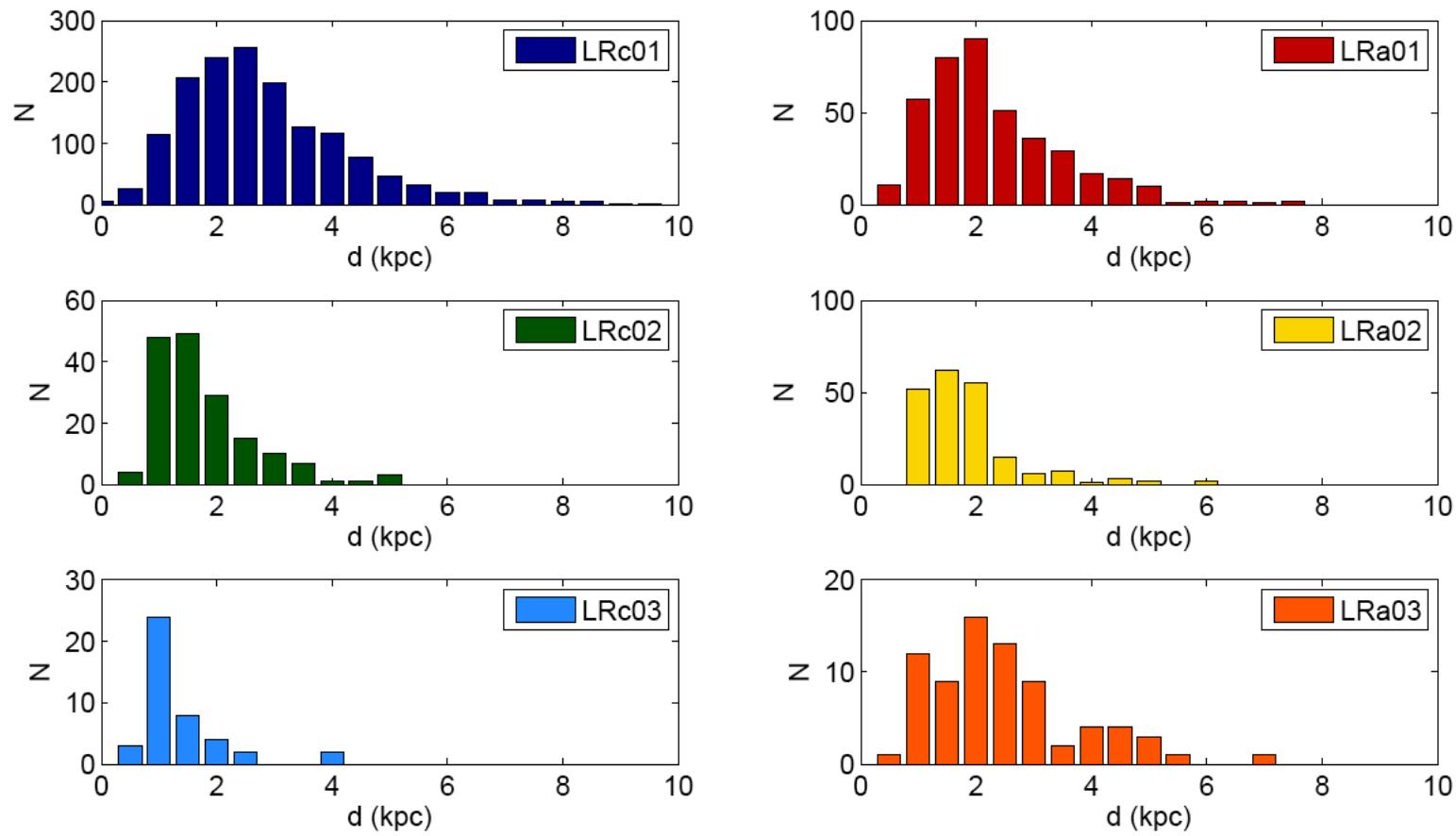
Hekker et al. 2009
Miglio et al. 2009
Mosser et al. 2010



Miglio et al. 2011



Miglio et al. 2011



Number of red giants as a function of the distance from the sun

Miglio et al. 2011

Mass (& chemical composition)

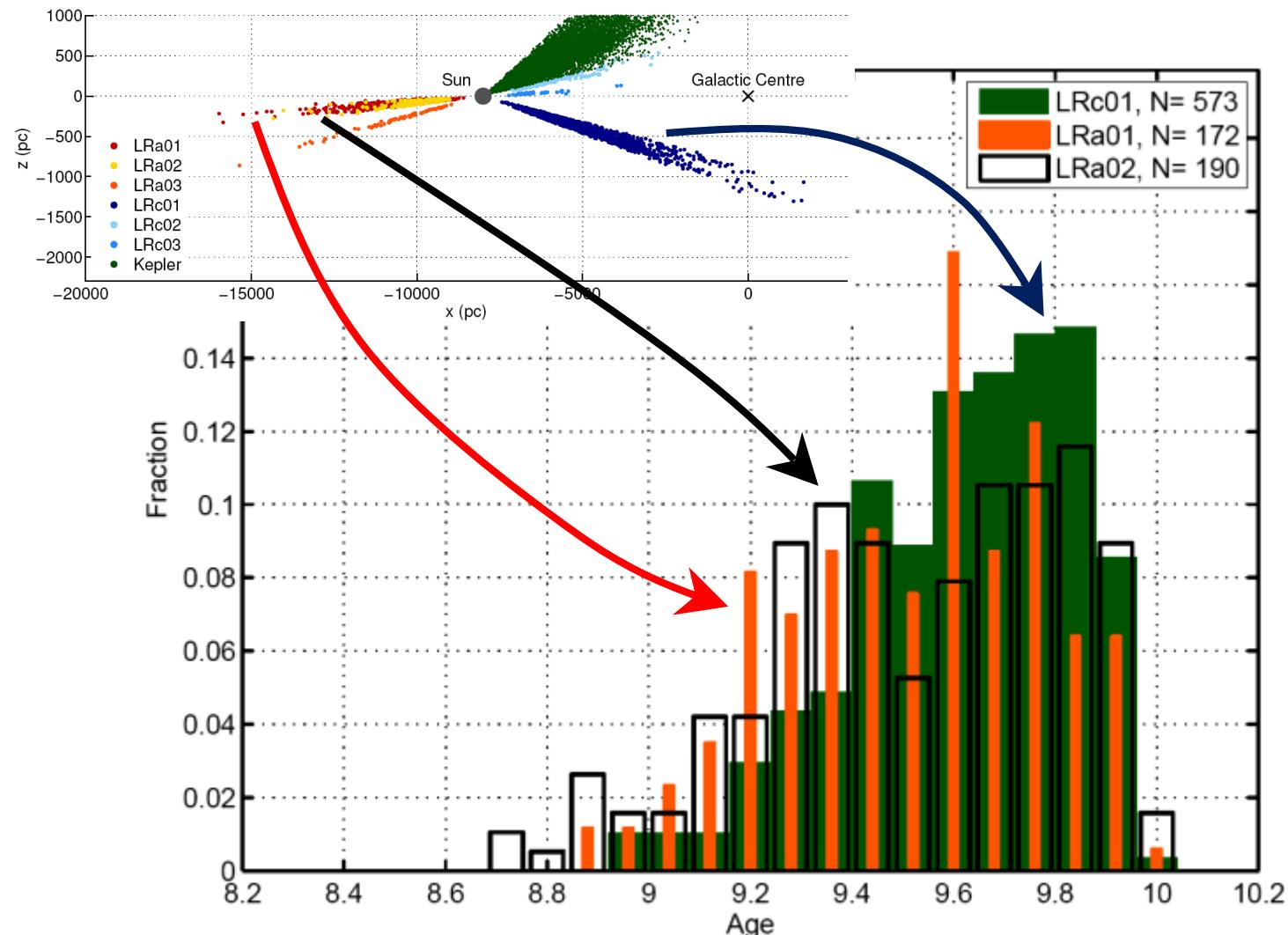


Age $\pm 15\%$

Isochrone fitting → $\pm 100\%$

Uncertainty related to overshooting

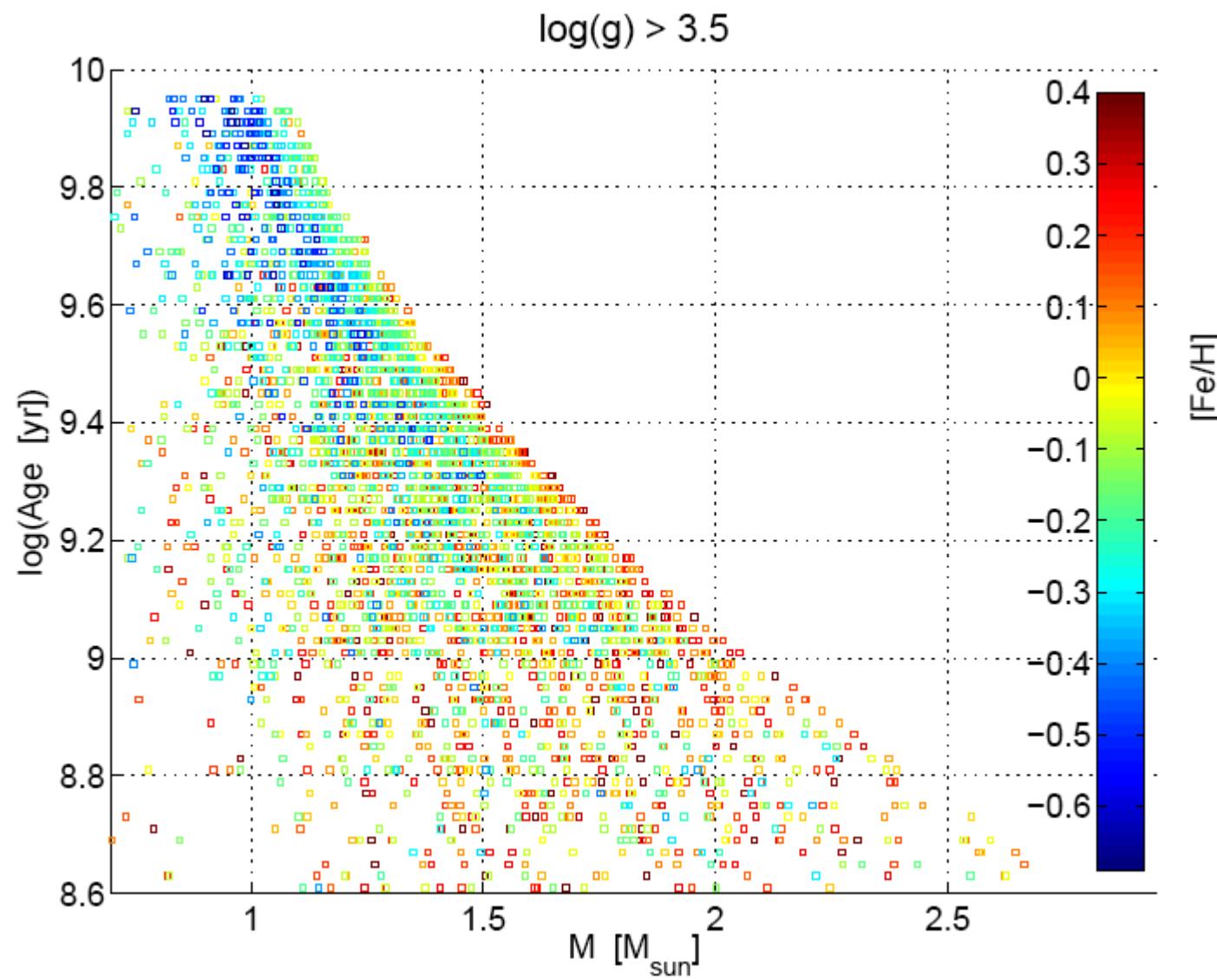
- 20 % in MS stars
- 5 % in RG



Age distribution

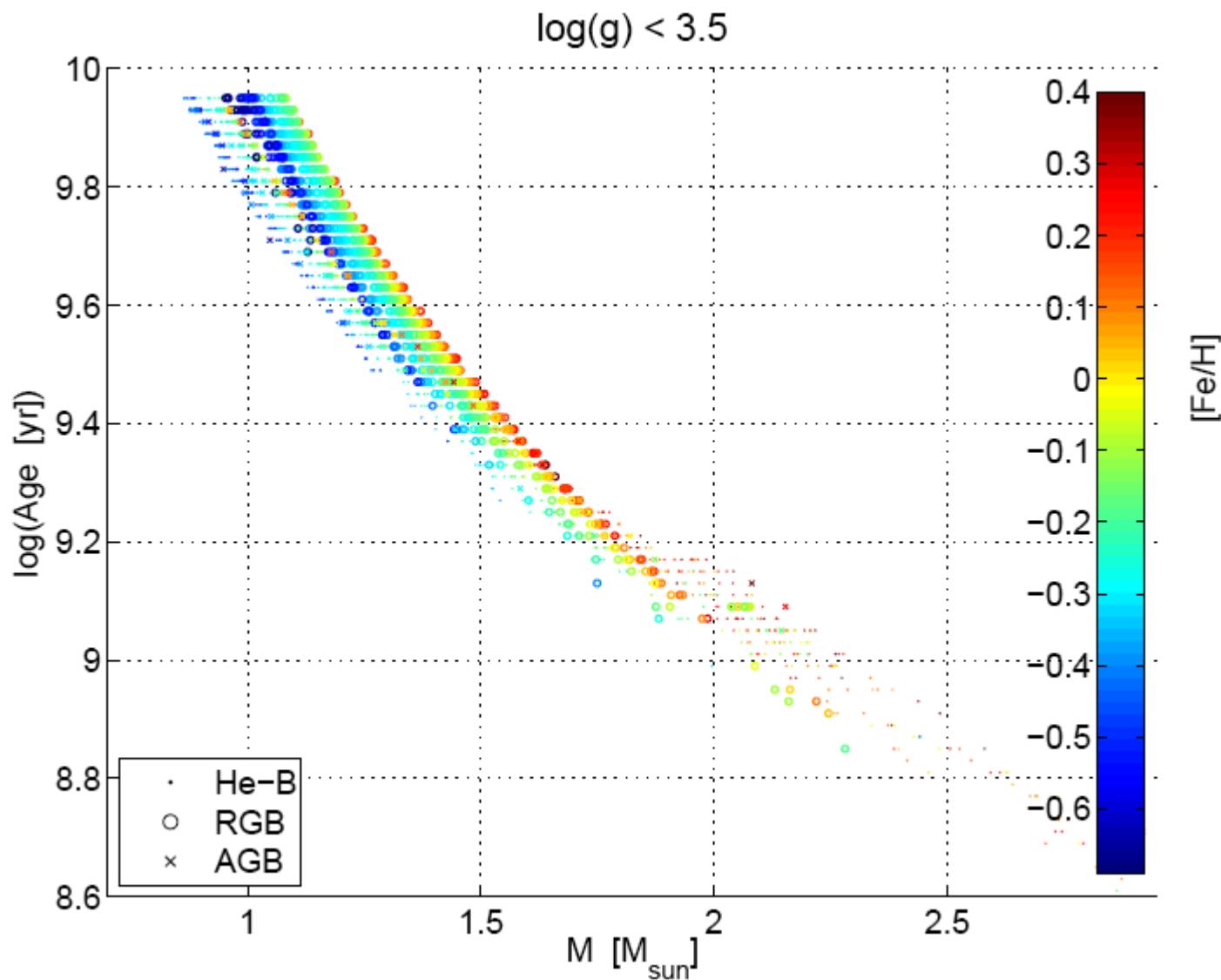
Asteroseismology and stellar population synthesis

Miglio et al. 2011



Age – Mass – Metallicity for MS stars

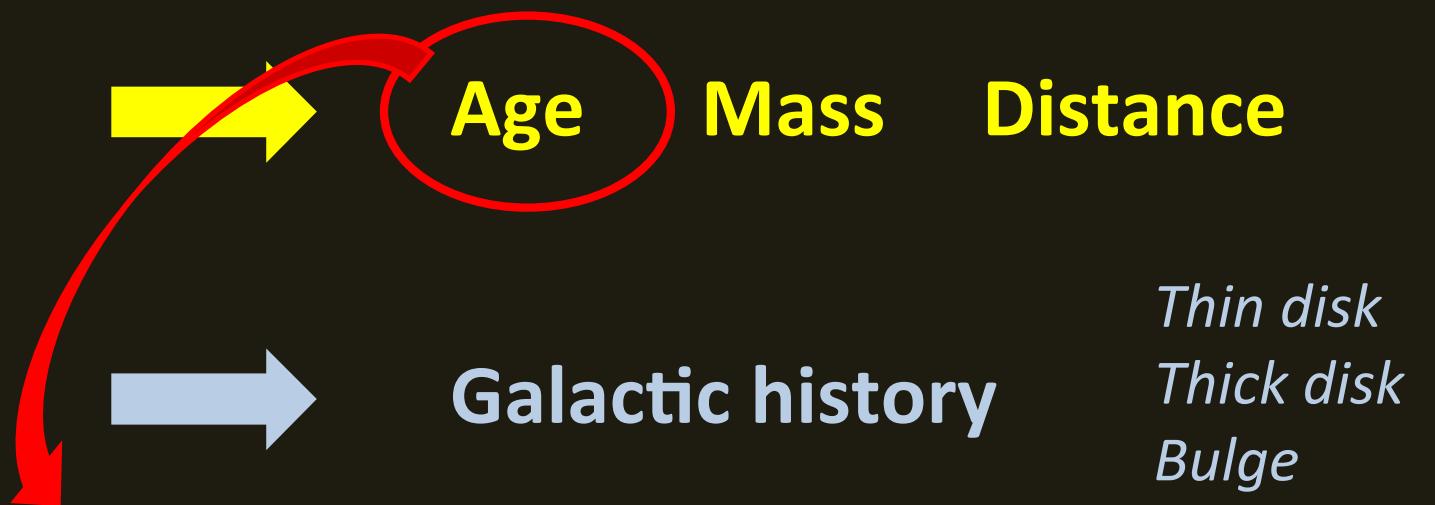
Miglio et al. 2011



Age – Mass – Metallicity for RG stars

Miglio et al. 2011

Asteroseismology



Gaia → 3D map of the Galaxy
SEGUE-2, APOGEE, Gaia-ESO spectroscopic surveys

Thin disk
Thick disk
Bulge
Halo

Asteroseismology is a major tool to complement Gaia with respect to age determinations. ESA should encourage the community to prepare for a next-generation mission, which would sample the different populations of the Galaxy.



CoRoT is needed more than ever

*ESO-ESA Working Groups Report #4, 2008
Galactic populations, Chemistry & Dynamics*



Kepler

- *a large number of targets are observed in the halo and partly in the galactic disk*



CoRoT Mission Extension

- *a large number of targets should be observed in a few selected directions of the disk and hopefully of the bulge*

Are the ages of the most metal-poor bulge stars (CoRoT) and those of the very metal-poor halo stars (Kepler) similar?

Chiappini et al. 2011

Red Giants in the exo field

Red Giants in clusters

A. Miglio, J. De Ridder, T. Morel, V. Ripepi,
A. Noels, J. Montalban & RG WG team

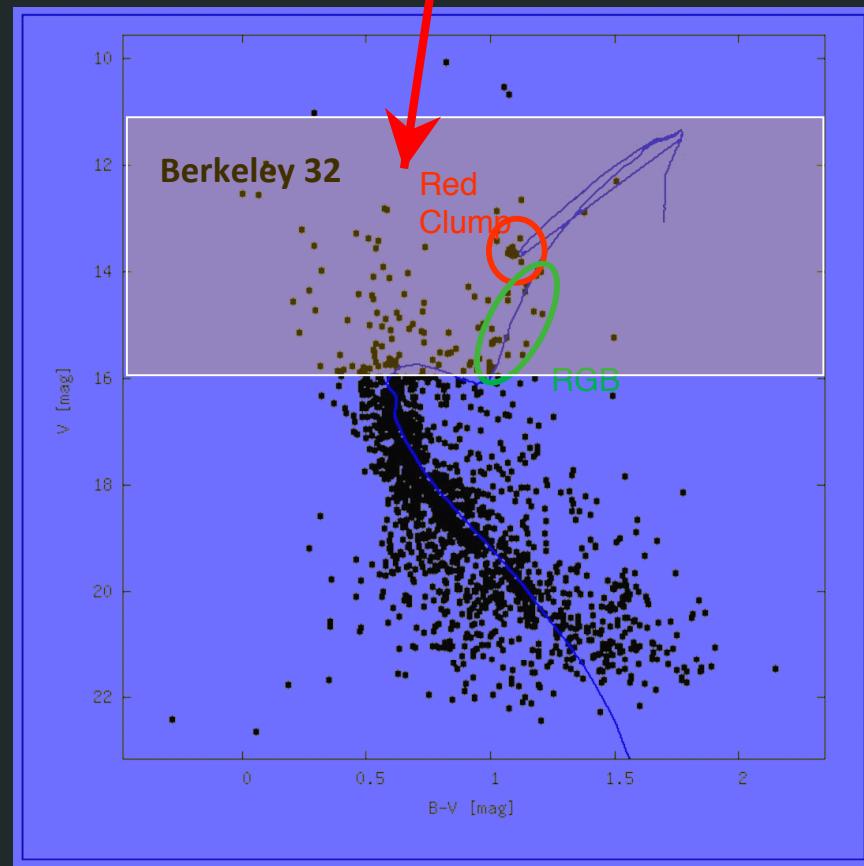
Advantages

1. Constraint on age and metallicity
2. Mass of the turn-off / RG mass
→ Mass loss (Miglio et al. 2011)
3. Seismic estimate of He abundance
4. Validation of scaling laws
5. Metallicity dependence of the amplitude

ID	Alpha	delta	dist (pc)	log(age)	Fe/H	Priority
Berkeley 32	06 58 06	06 26 00	3100	9.53	-0.5	1
Collinder 110	06 38 24	02 01 00.	1950	9.2	0.0	2
NGC 2236	06 29 39	06 49 48	2930	8.54	-0.30	2
NGC 6705	18 51 05	-06 16 12	1877	8.3	+0.13	2

Berkeley 32

CoRoT magnitude domain

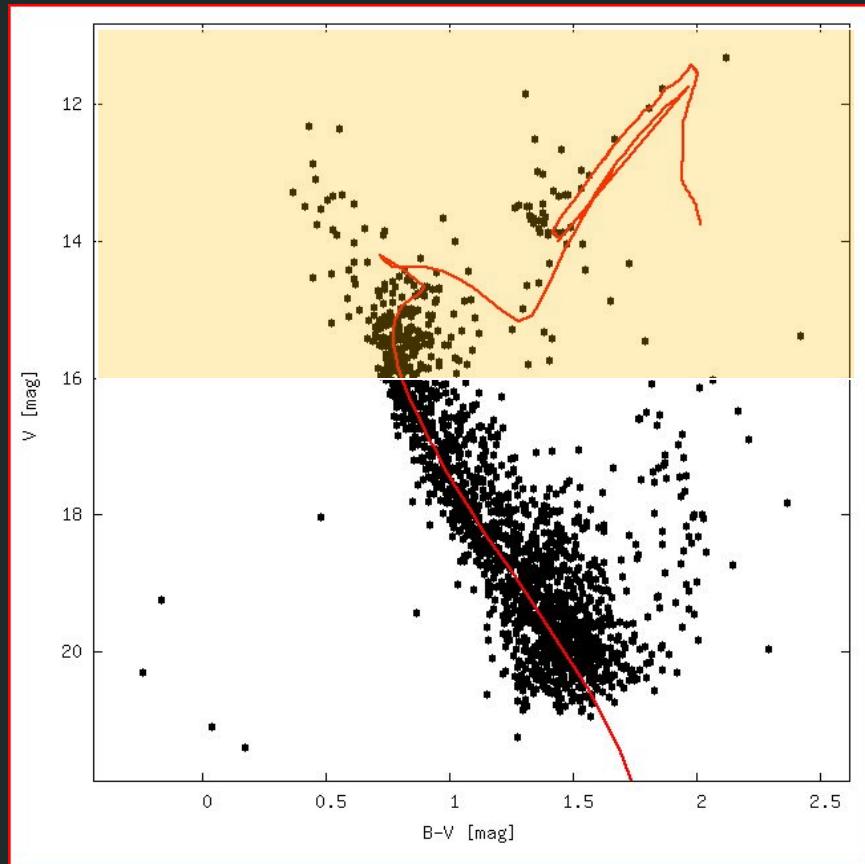


$\text{Fe}/\text{H} = -0.5$

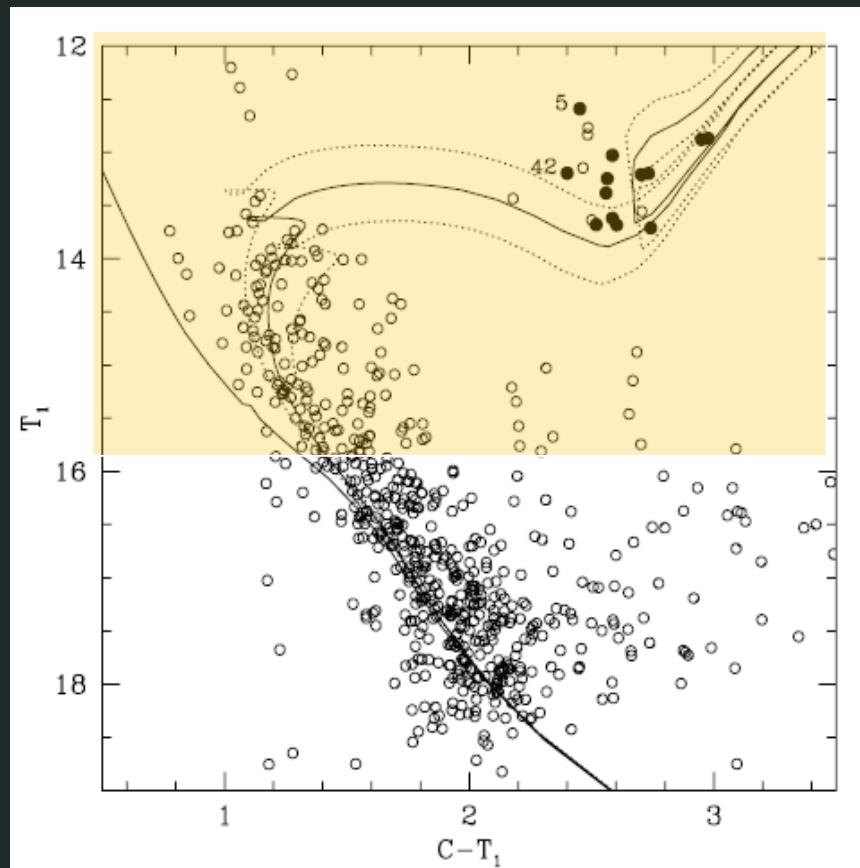
- Amplitude of solar-like oscillations
- Validity of scaling relations

at low metallicity

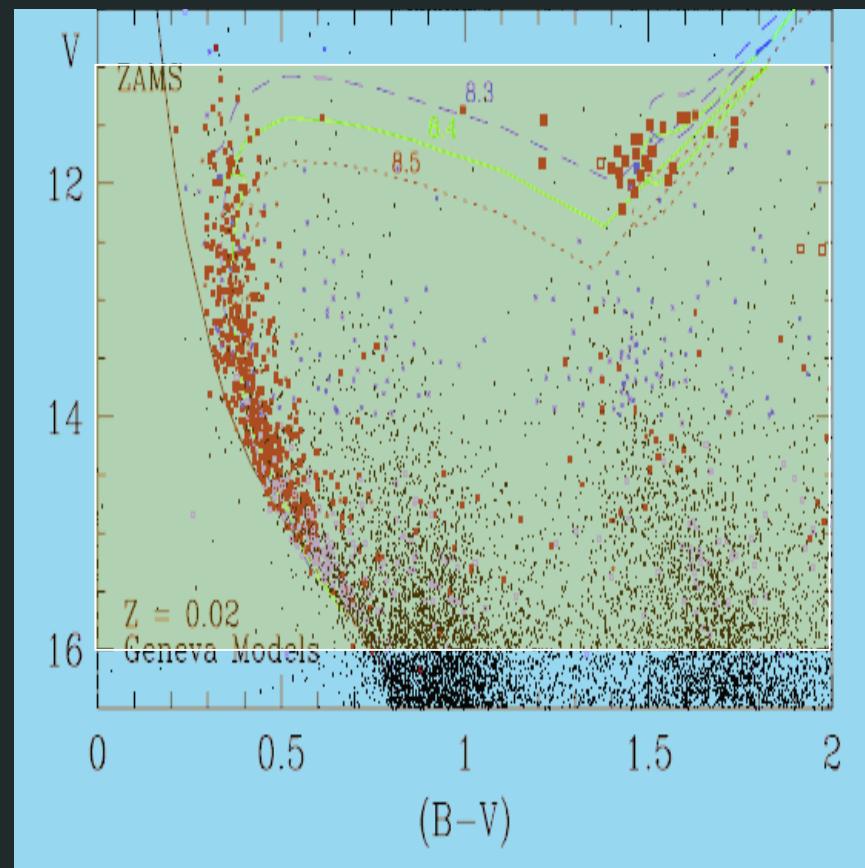
Collinder 110



NGC 2236



NGC 6705



2. Red Giants in the seismofield

Specificity CoRoT/Kepler

- Bright Red Giants *Mass, Radius*
 - Binary systems, clusters, parallax, interferometry
 - Ground-based spectroscopic follow-up
Chemical composition, rotation velocity, ...
 - Test of standard/non standard models
 - Detection of Hell signature
 - precision on frequencies
 - frequency spacings

Specificity CoRoT/Kepler

- Bright Red Giants

Mass, *R*

- Binary systems, clusters, mass, interferometry
- Ground-based spectroscopic follow-up
Chemical composition, rotation velocity, ...
- Test of standard/non standard models
- Detection of Hell signature

Long runs (continuous or not)

- precision on frequencies
- frequency spacings

Red Giants in the seismo field

Calibration of the scaling relations

A. Miglio, J. De Ridder, F. Carrier, T. Morel,
A. Noels, E. Poretti, J. Montalban & RG WG team

$$\nu_{\max} = \frac{M/M_{\odot}}{(R/R_{\odot})^2 \sqrt{T_{\text{eff}}/5777K}} 3.05 \text{ mHz}$$

$$\Delta\nu = (M/M_{\odot})^{1/2} (R/R_{\odot})^{-3/2} 134.9 \mu\text{Hz}$$

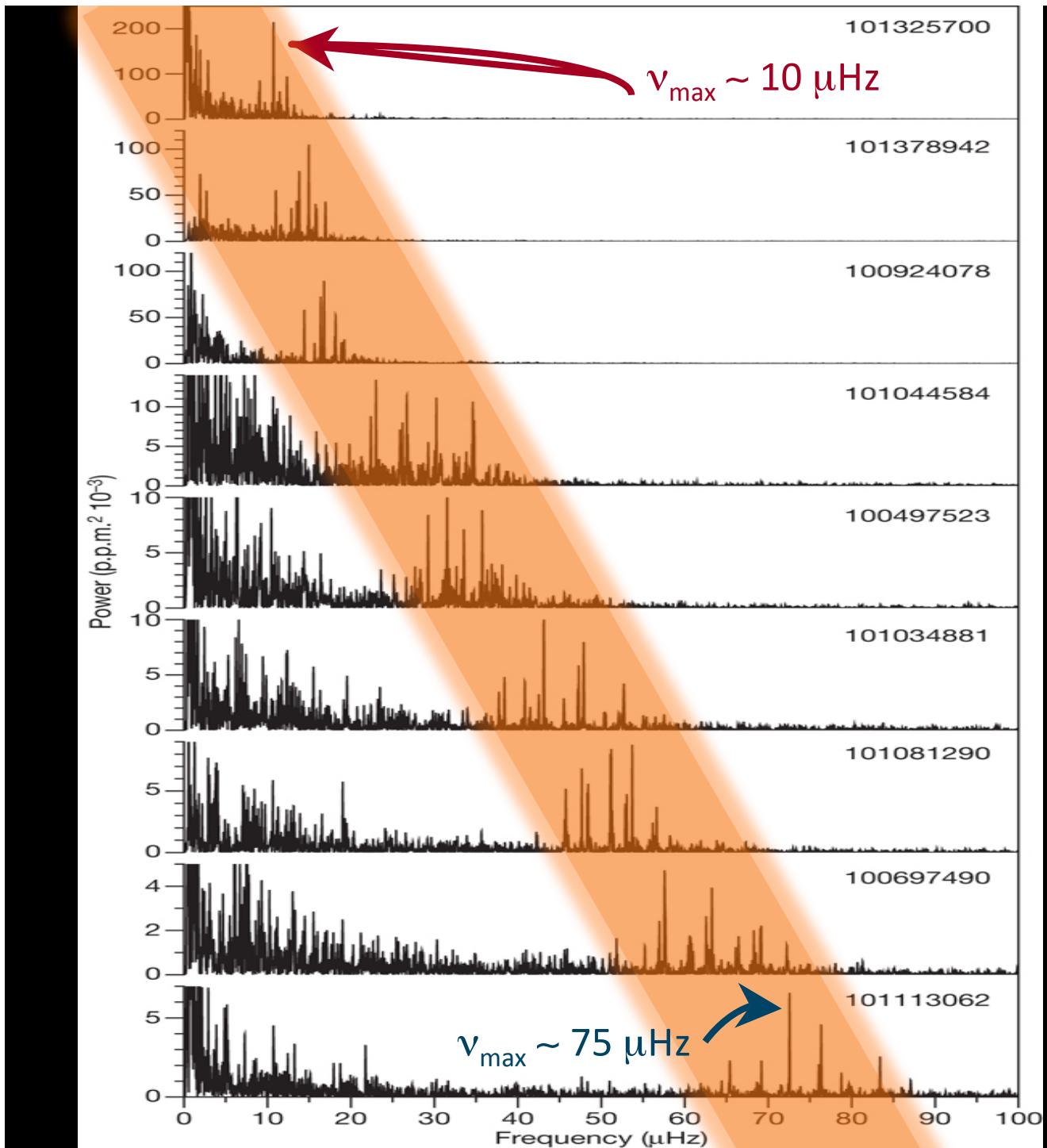


Mass & Radius *if Te is known*

10% 5%

Check ???

Stello et al. 2010
Basu et al. 2011
Miglio et al. 2011



De Ridder et al. 2009, *Nature*
459, 398

Best candidates

- Bright stars → high S/N
- Known parallax
- Interferometric measurement of Radius
- v_{\max} large → less interference with granulation
- $v \sin i$ large → detection of rotational splitting

Specificity CoRoT/Kepler

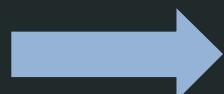
HIP	V	π (mas)	L/Lsun	Teff (K)	R/Rsun	M/MSun	nu_max (μ Hz)	vsini
28485	7	3.48	136.77	5048	15.32	3.14	44	?
29575	5.84	10.61	42.85	5018	8.68	2.31	100	3.85
31672	6.18	7.37	76.56	4672	13.38	2.36	45	<1.8
38306	6.38	6.14	108.64	4424	17.77	2.38	26	1.5
86391	6.26	8.85	46.13	4782	9.91	2.18	74	<1.2
87224	6.46	8.65	52	4425	12.29	1.95	45	<1.0
88986	7.41	5.11	61.94	4433	13.37	2.06	40	2.5
96071	6.78	6.76	78.7	4207	16.73	1.63	21	?
96187	7.61	3.97	75.86	4553	14.02	2.29	40	?

ESO Large Programme

2 runs of 10 and 5 nights separated by 10 days with HARPS

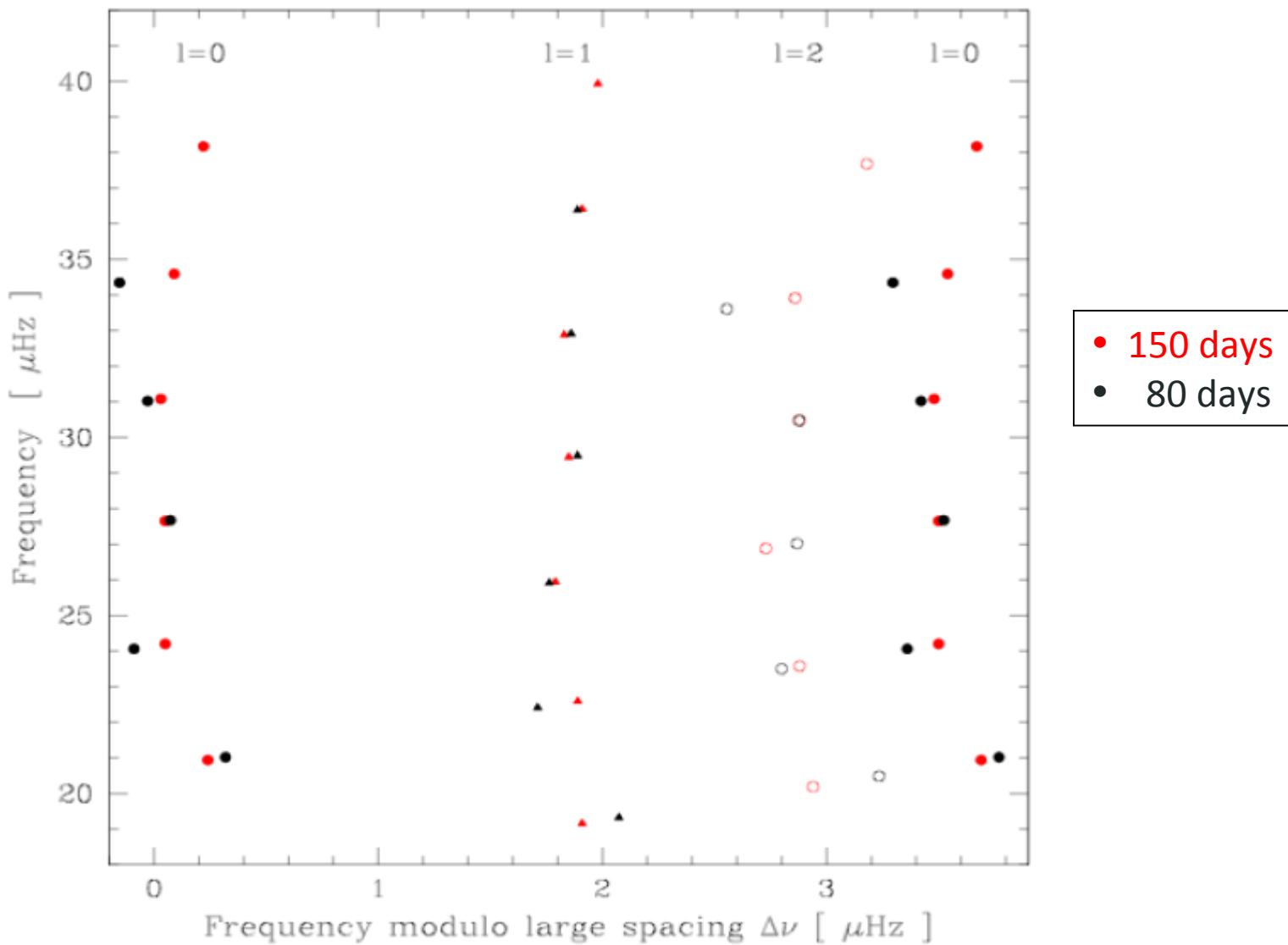


Observations in both photometry
and radial velocity



Relation between velocity and
mode amplitude

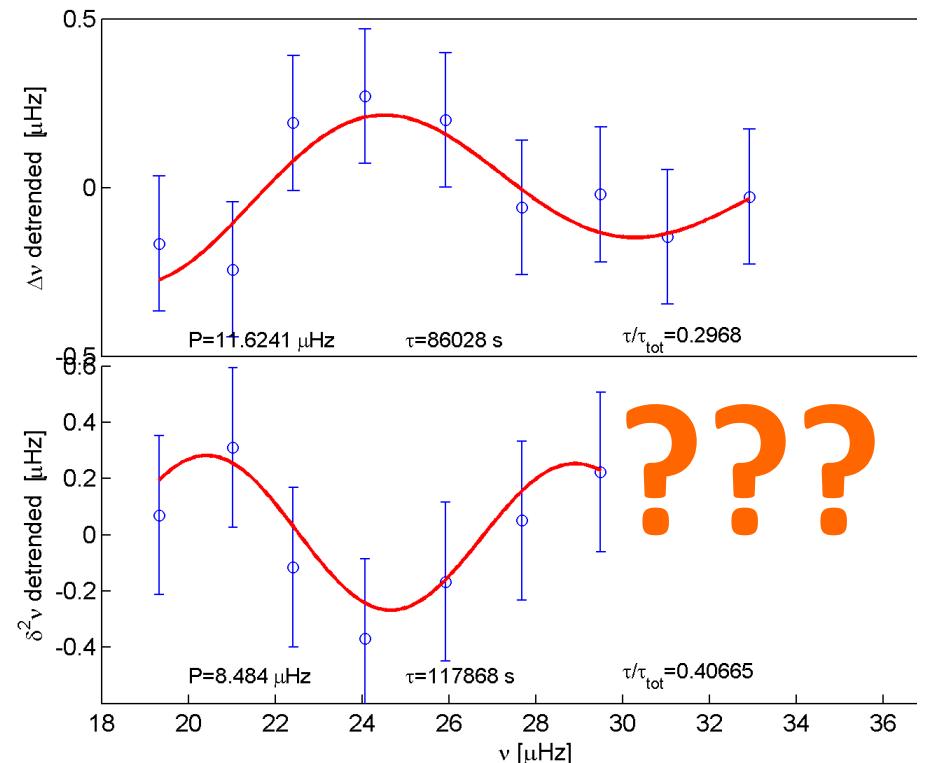
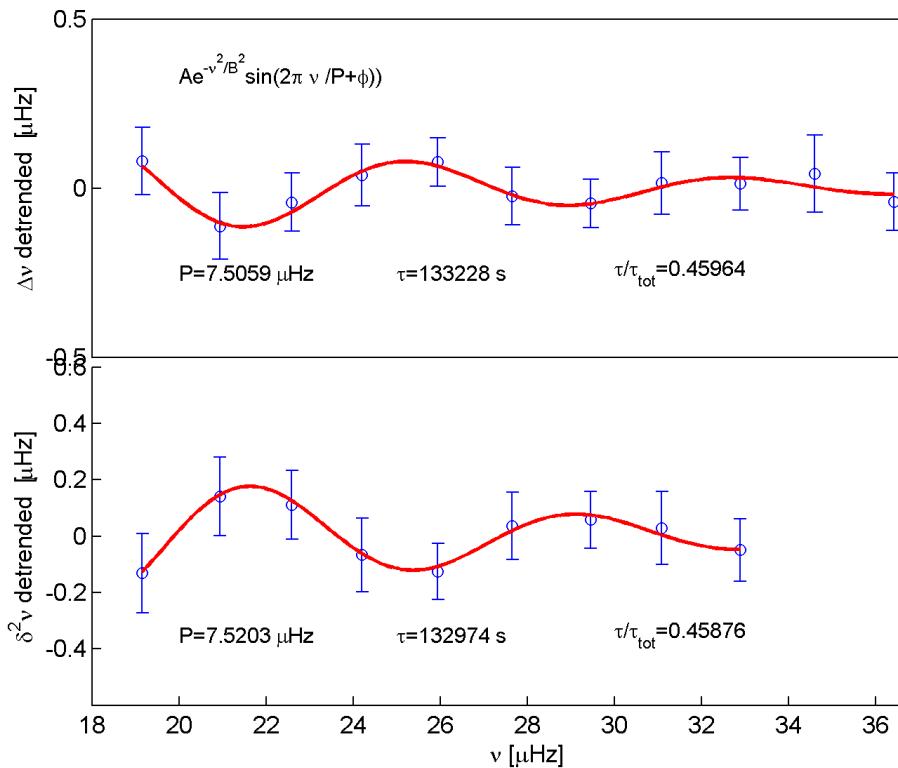
HR 7349 – echelle diagram



Location of Hell ionisation zone

150 days $\tau/\tau_{\text{tot}} = 0.46 \pm 0.05$

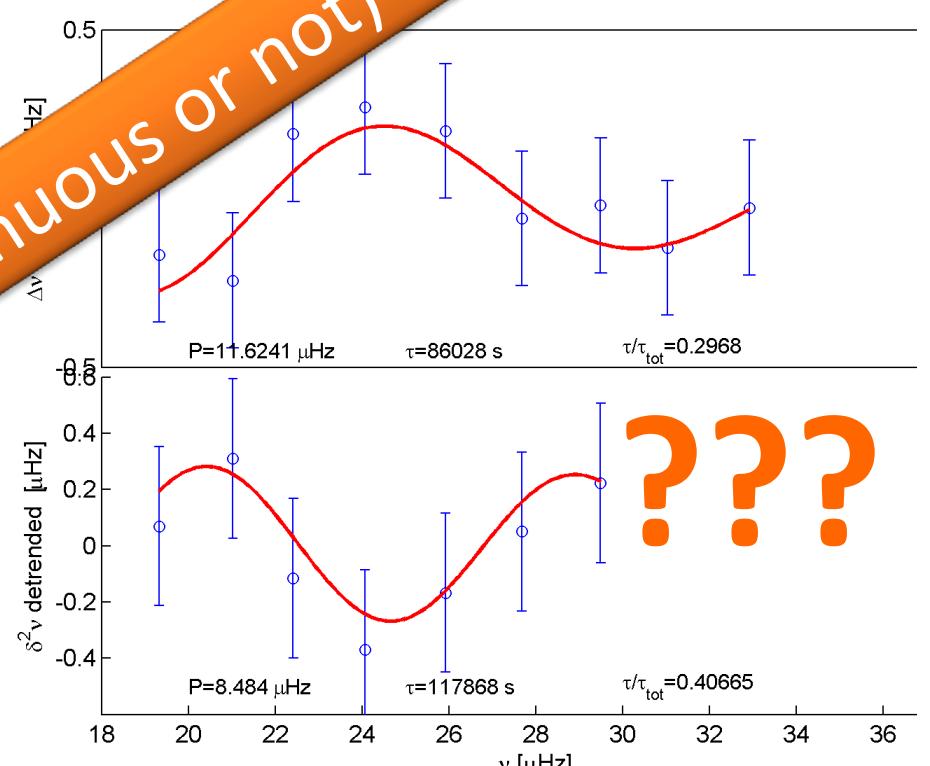
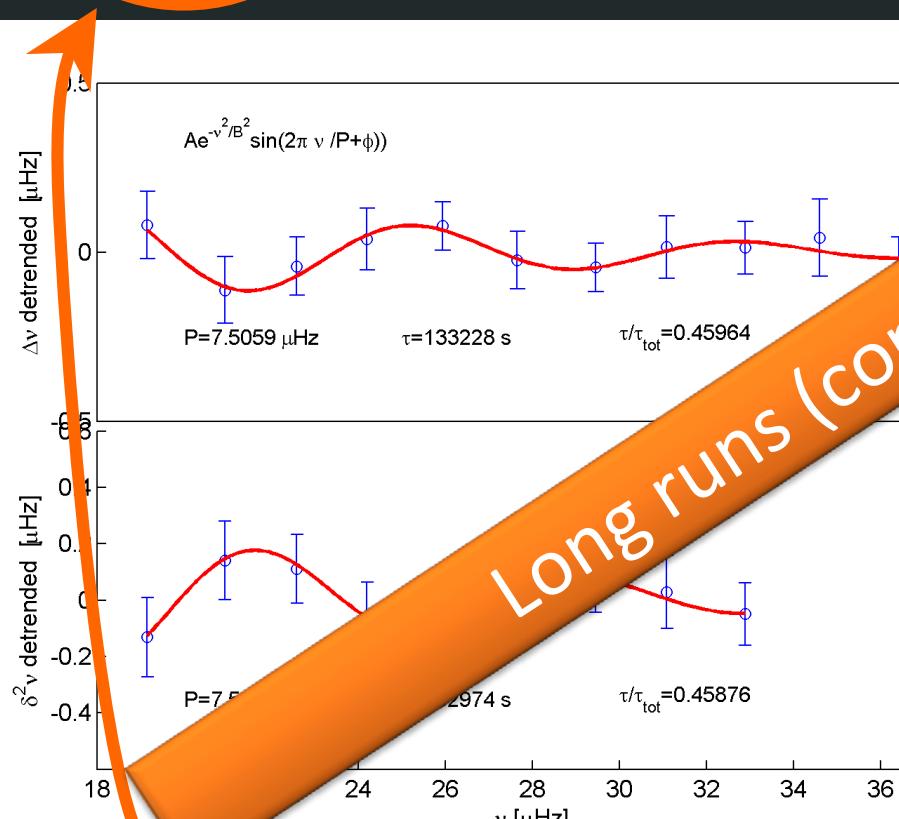
80 days $\tau/\tau_{\text{tot}} = 0.30 \pm 0.15$
 $= 0.41 \pm 0.15$



Location of Hell ionisation zone

150 days $\tau/\tau_{\text{tot}} = 0.46 \pm 0.05$

80 days $\tau/\tau_{\text{tot}} = 0.15$ $\tau=117868 \text{ s}$ $\tau/\tau_{\text{tot}} = 0.41 \pm 0.15$



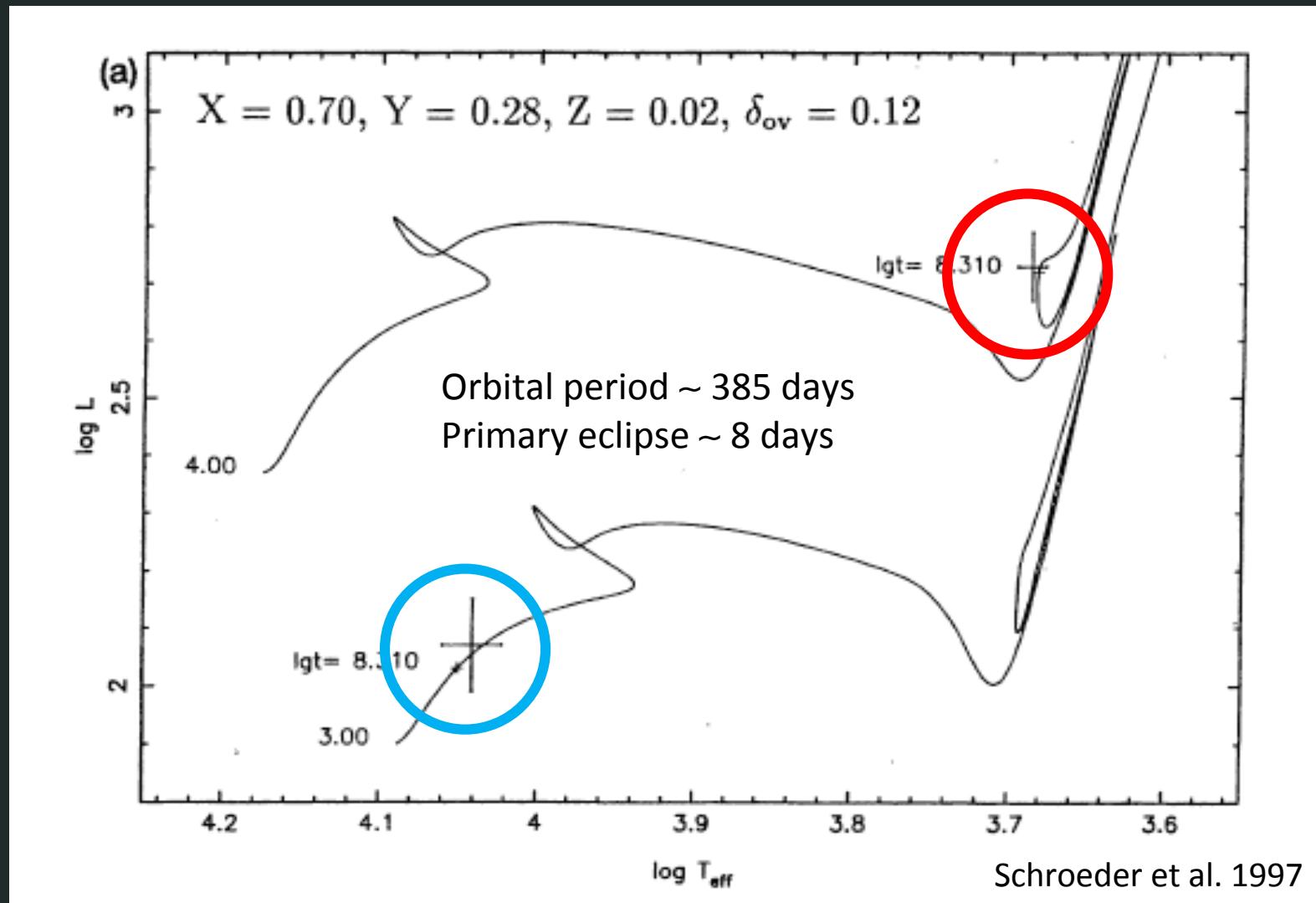
Small mode linewidths

Red Giants in the seismo field

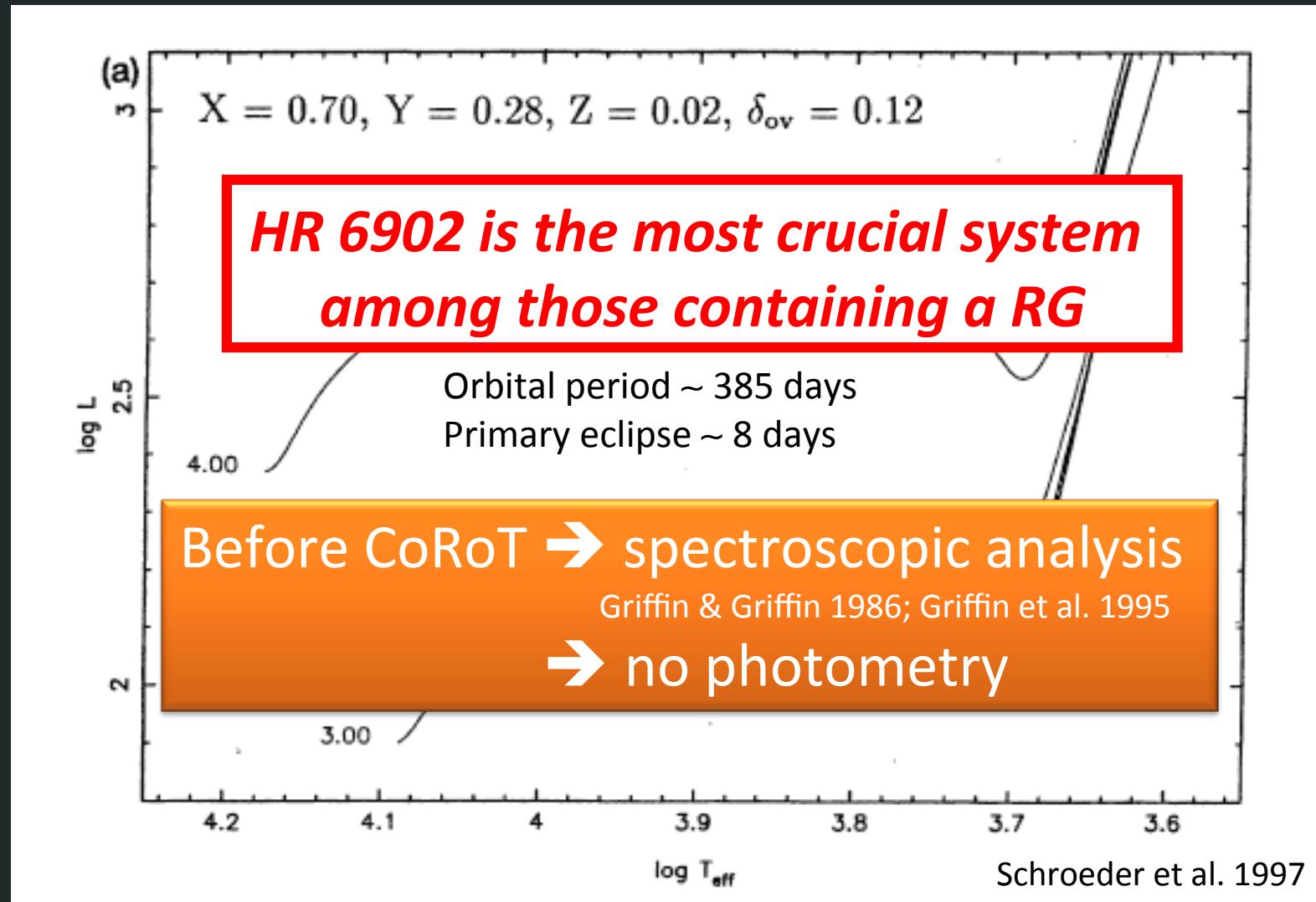
Red Giant in a binary system

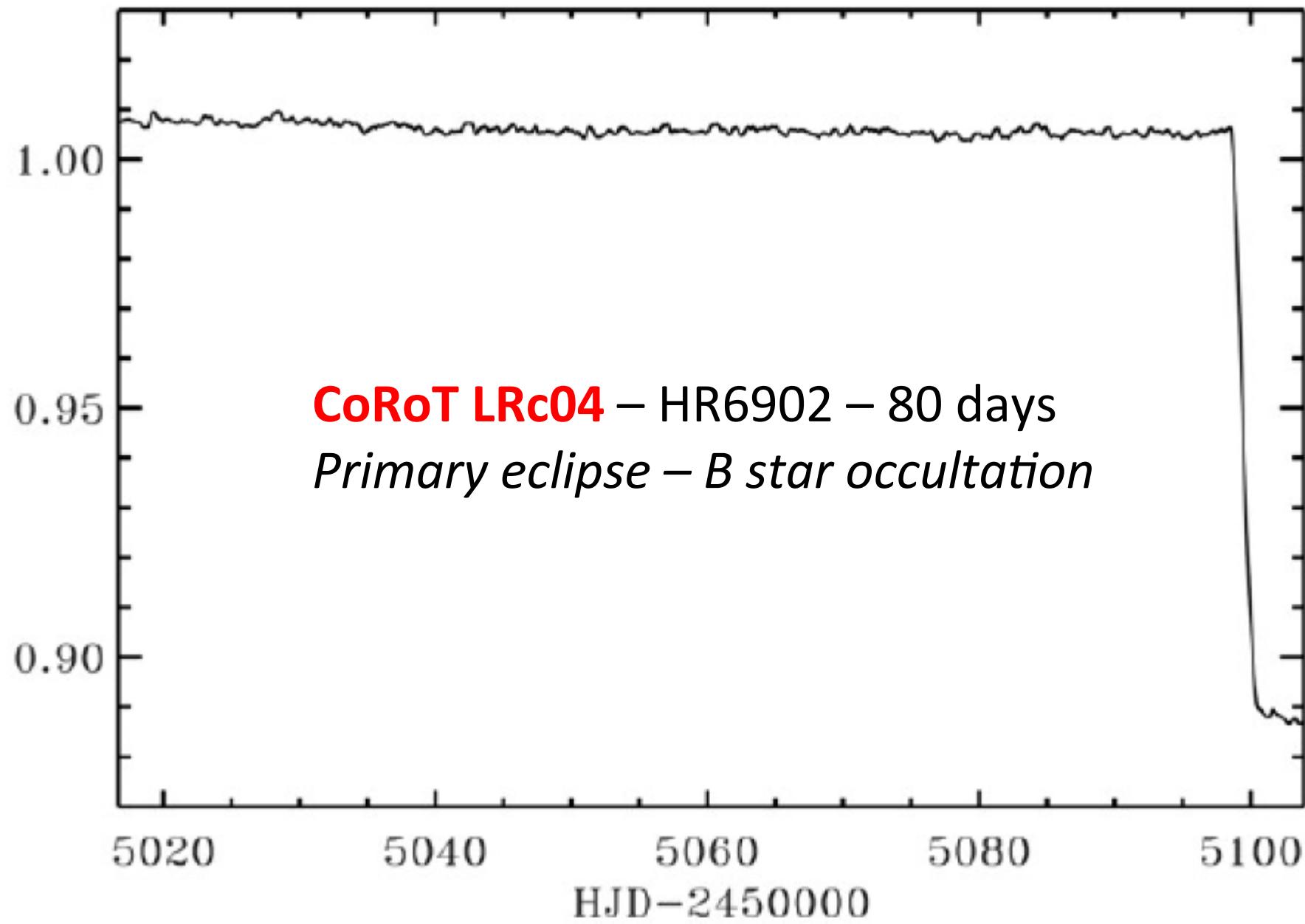
C. Maceroni, J. Montalban, A. Miglio,
T. Morel, B. Mosser, E. Poretti & RG WG team

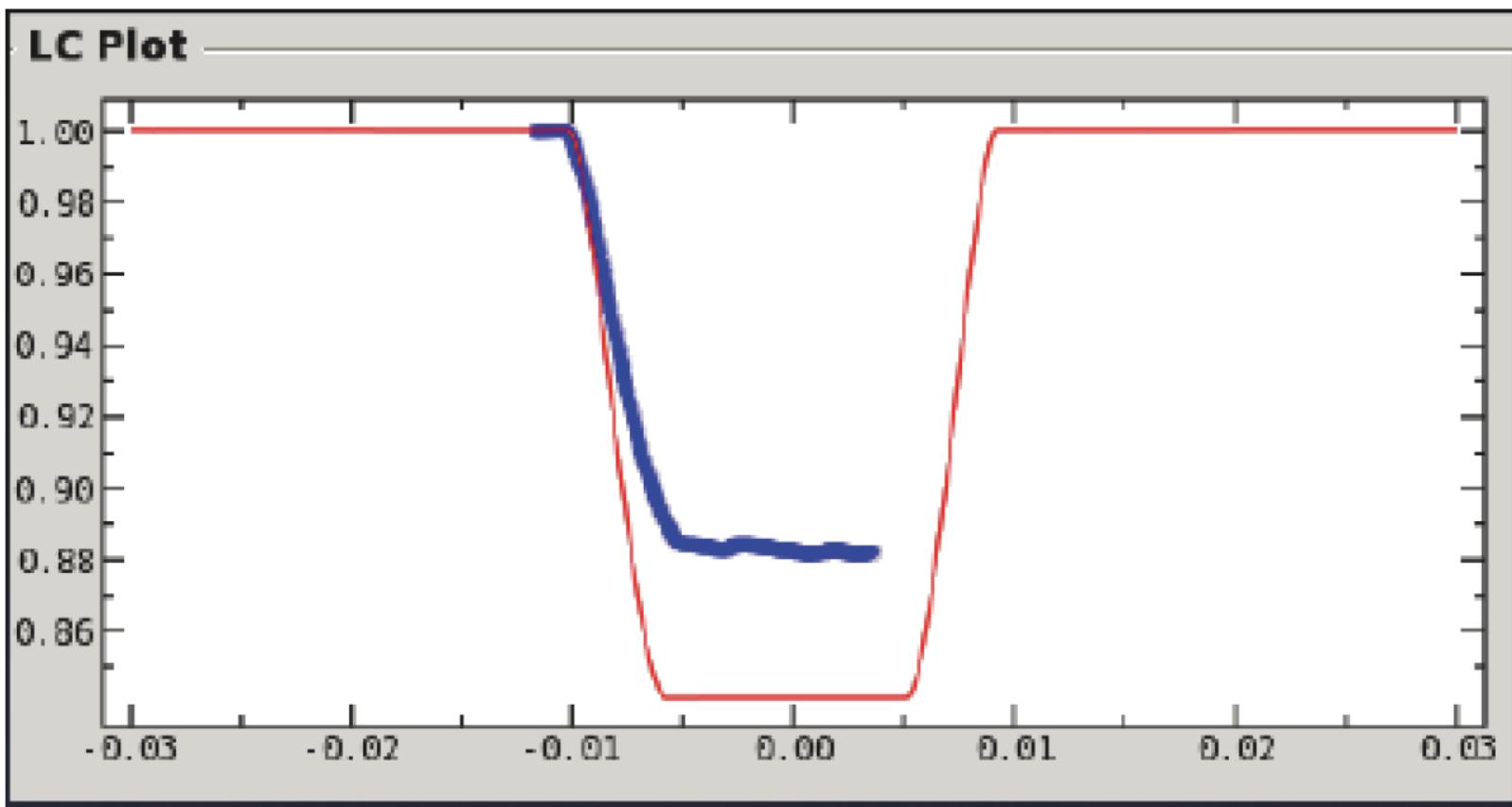
HR 6902 – eclipsing binary RG+B-type



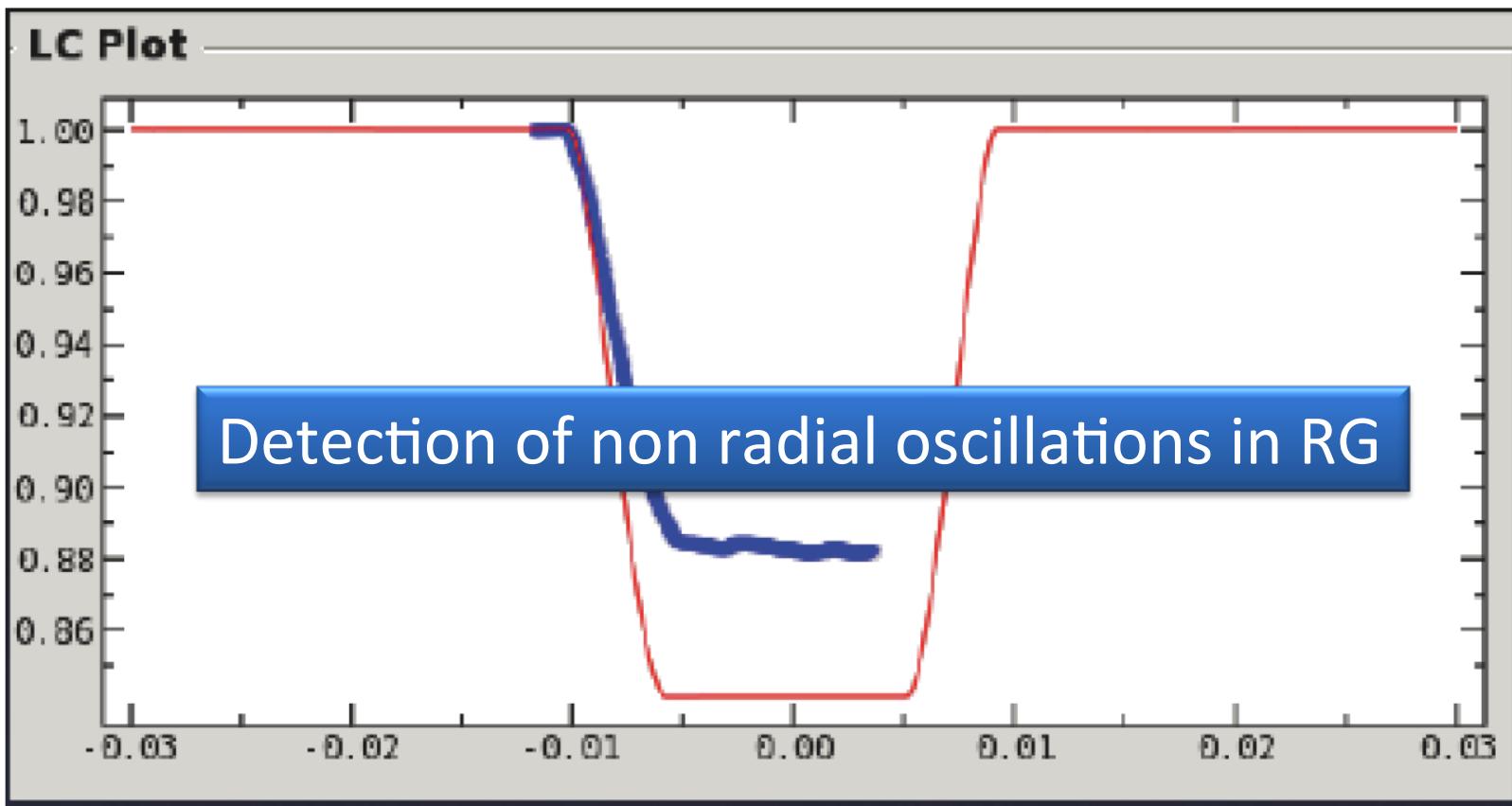
HR 6902 – eclipsing binary RG+B-type







- PHOEBE light curve with Griffin et al. (1995) parameters
- CoRoT LRc04 light curve



- PHOEBE light curve with Griffin et al. (1995) parameters
- CoRoT LRc04 light curve

Primary eclipse unobservable for years

Min I (B star occultation)

JD	date (yyyy-mm-dd hh)
2455103.180	2009-09-28 16.32
2455488.180	2010-10-18 16.32
2455873.180	2011-11-07 16.32
2456258.180	2012-11-26 16.32
2456643.180	2013-12-16 16.32
2457028.180	2015-01-05 16.32
2457413.180	2016-01-25 16.32
2457798.180	2017-02-13 16.32
2458183.180	2018-03-05 16.32
2458568.180	2019-03-25 16.32
2458953.180	2020-04-13 16.32

Secondary eclipse observable next summer

Min II (B star transit on RG disc)

JD	date (yyyy-mm-dd hh)	
2455359.432	2010-06-11 22.37	
2455744.432	2011-07-01 22.37	
2456129.432	2012-07-20 22.37	Next summer CoRoT long run
2456514.432	2013-08-09 22.37	
2456899.432	2014-08-29 22.37	
2457284.432	2015-09-18 22.37	
2457669.432	2016-10-07 22.37	
2458054.432	2017-10-27 22.37	
2458439.432	2018-11-16 22.37	
2458824.432	2019-12-06 22.37	
2459209.432	2020-12-25 22.37	