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BRIDGING THE FIELDS OF ASTEROSEISMOLOGY AND GALACTIC STELLAR POPULATION STUDIES

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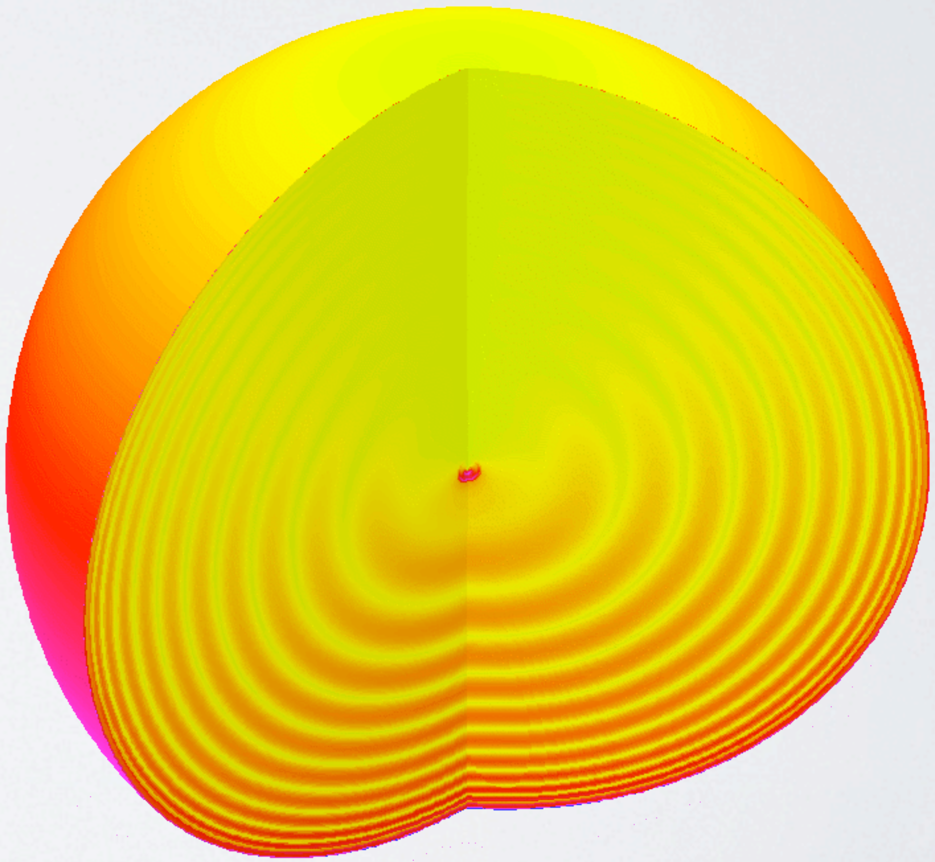
ASTEROSEISMOLOGY

Observations of stars:

- Information generally limited to the superficial layers
- No direct constraints on stellar interior

Study of stellar pulsation modes

Properties of the propagation cavity



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OBSERVATIONS

27cm telescope

polar circular orbit at 896km

launched December 27th 2006

OBSERVATIONS

Kepler

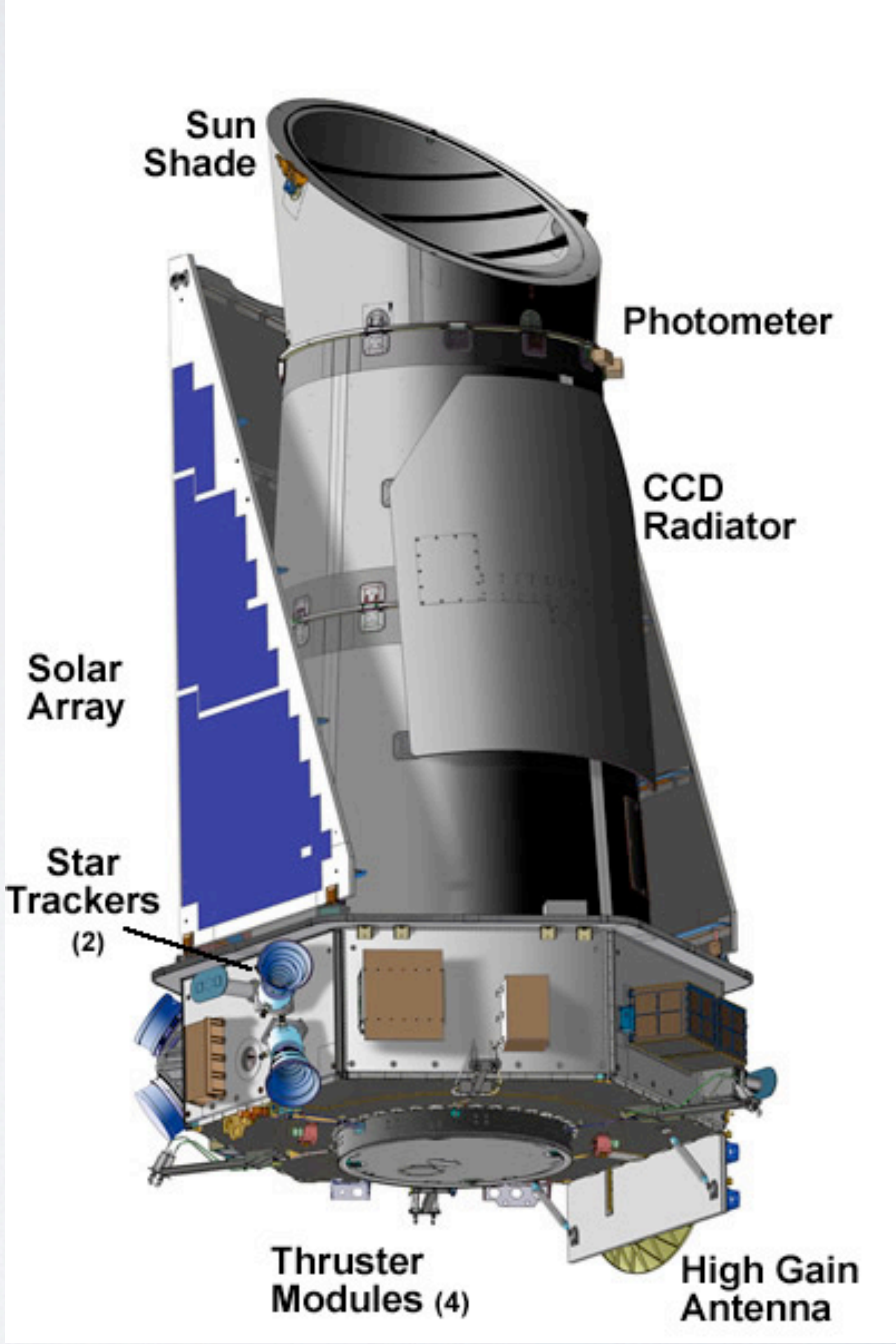
95cm telescope

launched 7 March 2009

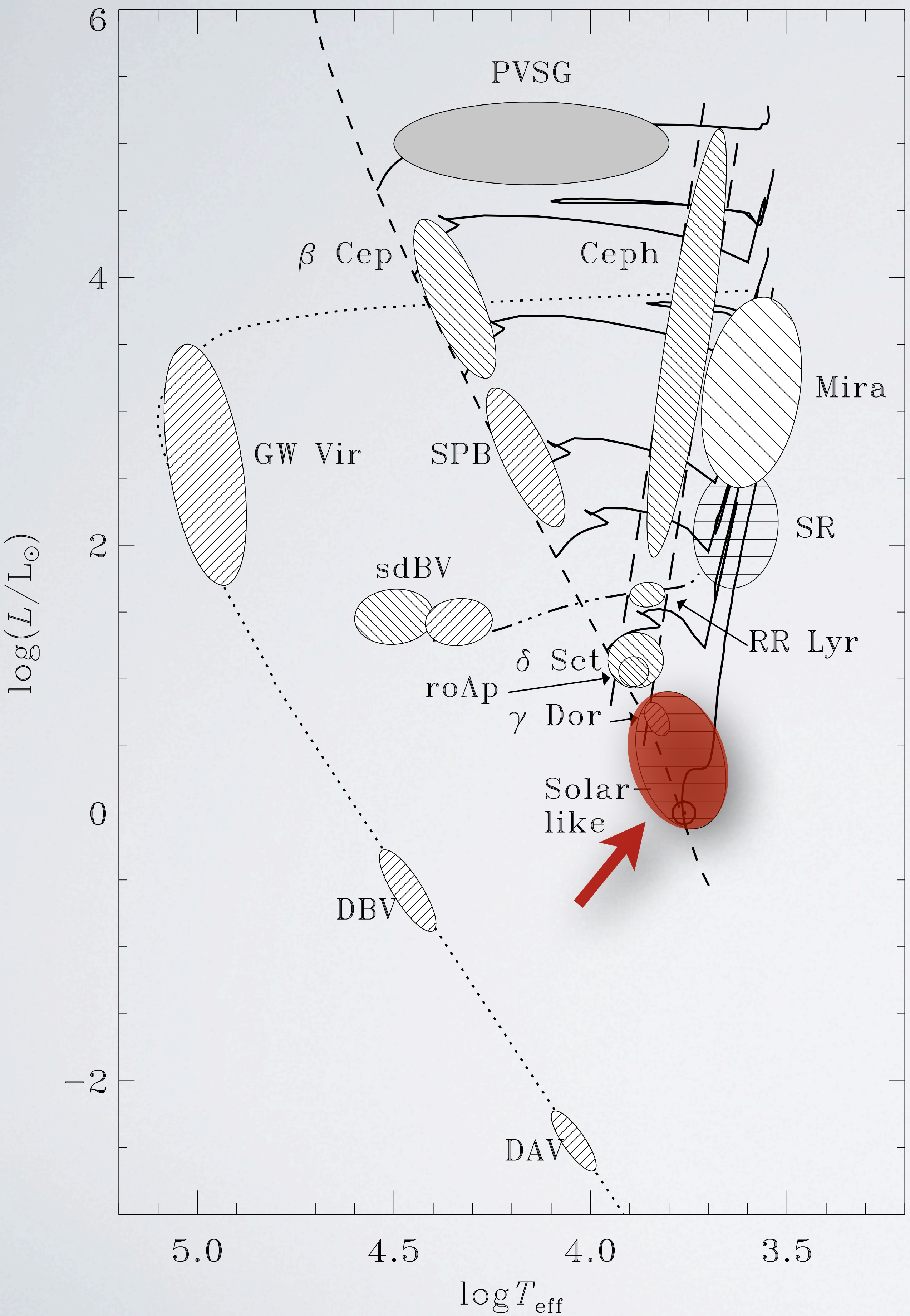
fixed field of view

~130k stars monitored for 3.5+3yrs

magnitude range 7-16



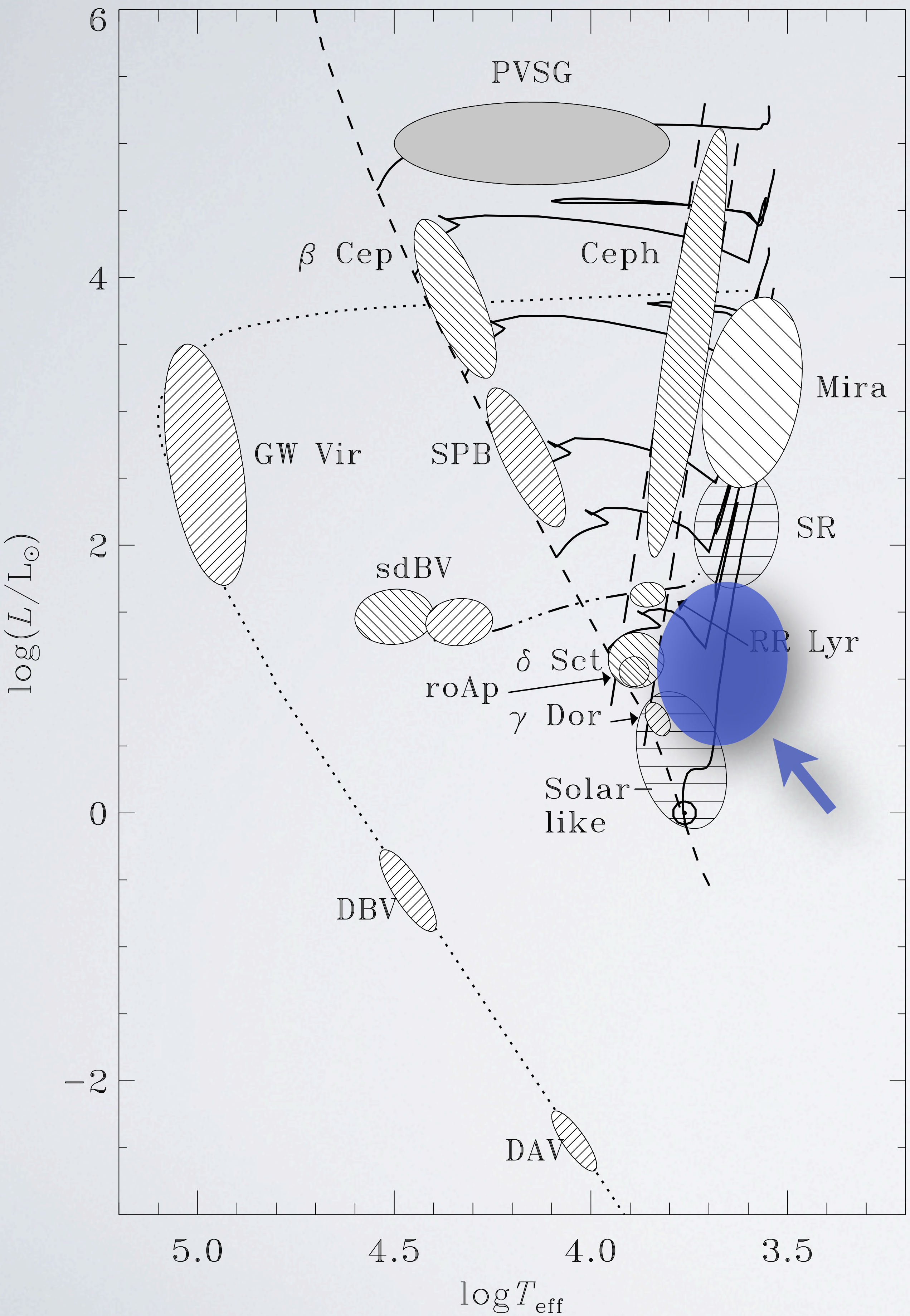
Aerts, Christensen-Dalsgaard & Kurtz 2009



SOLAR-LIKE OSCILLATIONS

1. in solar-like stars
   - acoustic modes
   - $\frac{\delta L}{L}$ ~ few ppm
   - P~3 to 10 min

Aerts, Christensen-Dalsgaard & Kurtz 2009

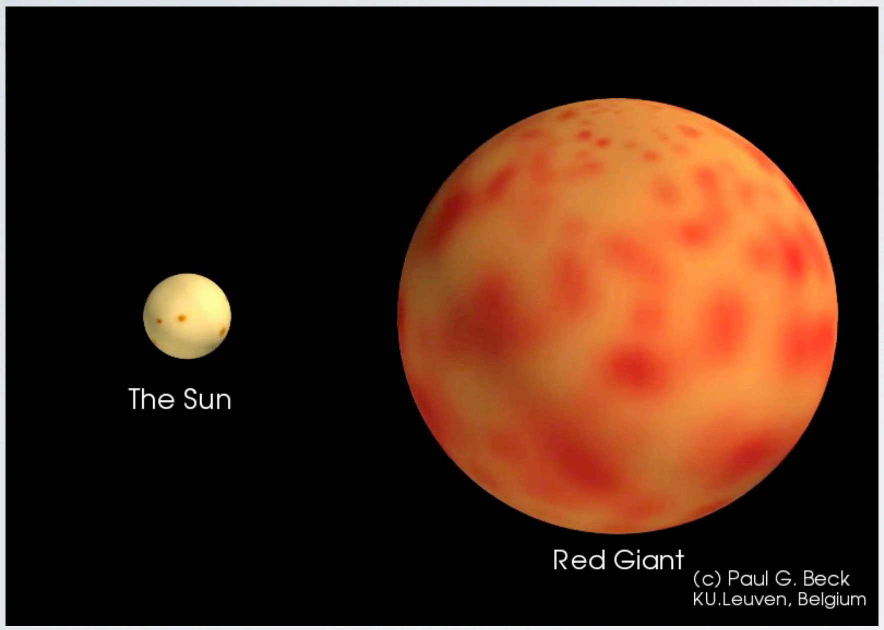


SOLAR-LIKE OSCILLATIONS

2. in G-K giants

- radial and non-radial modes discovery by CoRoT in 2009
- periods ~ hours
- modes: huge diagnostic potential

SEISMOLOGY OF RED GIANTS: HIGHLIGHTS

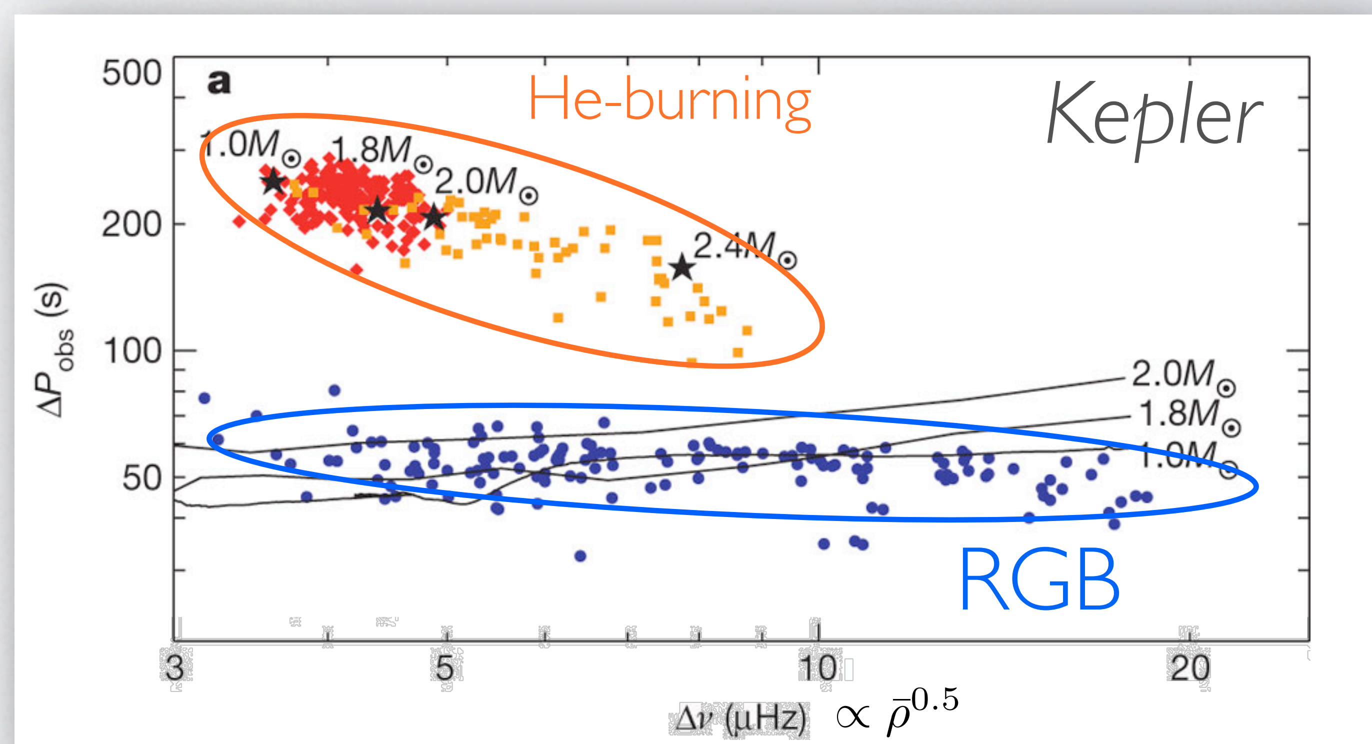


Beck et al 2012 Nature

internal rotation rate

$$\Omega_{\rm core} \sim 10\,\Omega_{\rm env}$$

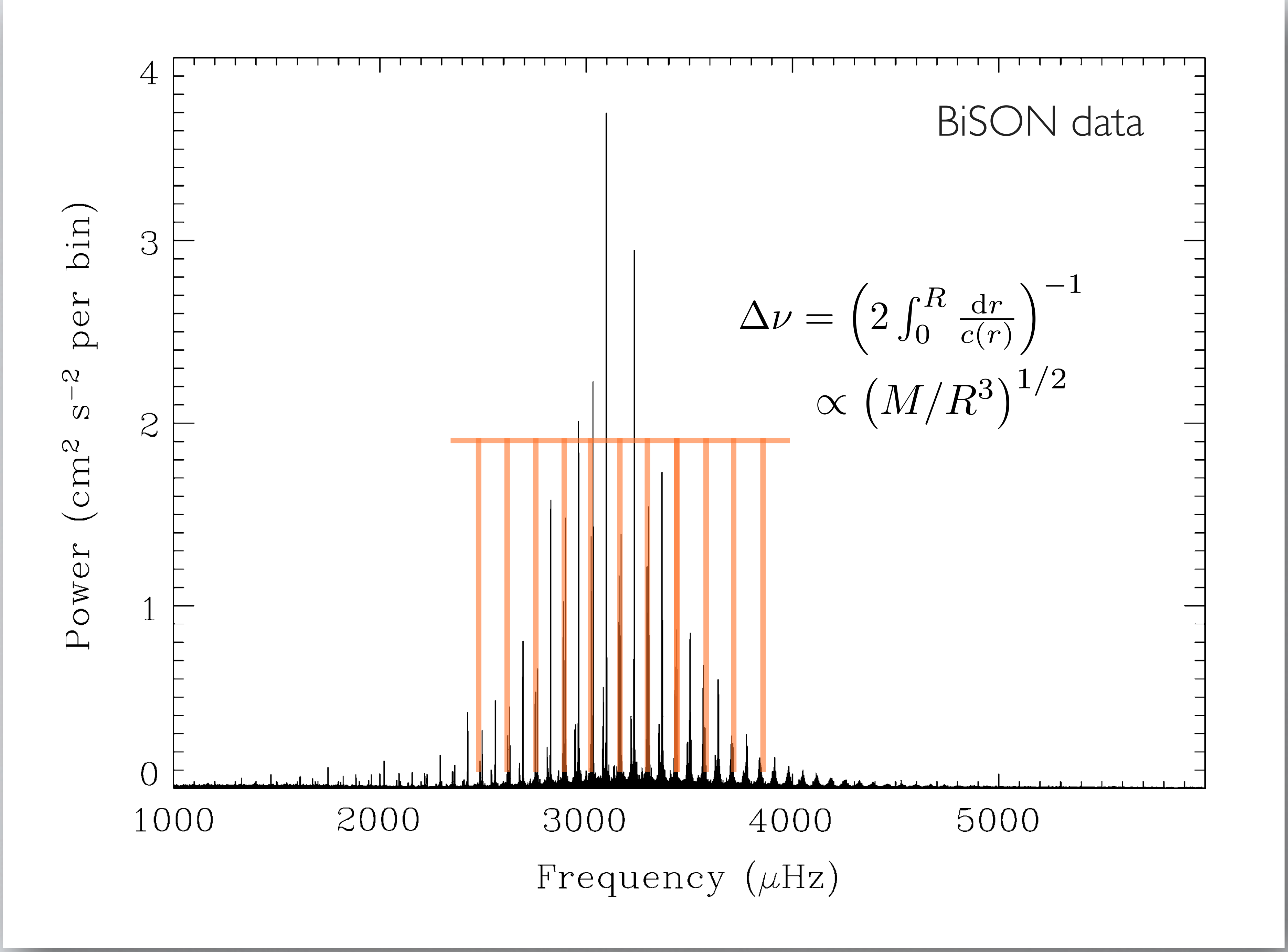
evolutionary state



Bedding et al. 2011, Nature

Solar-like oscillations: average parameters

$\Delta\nu$: large frequency separation



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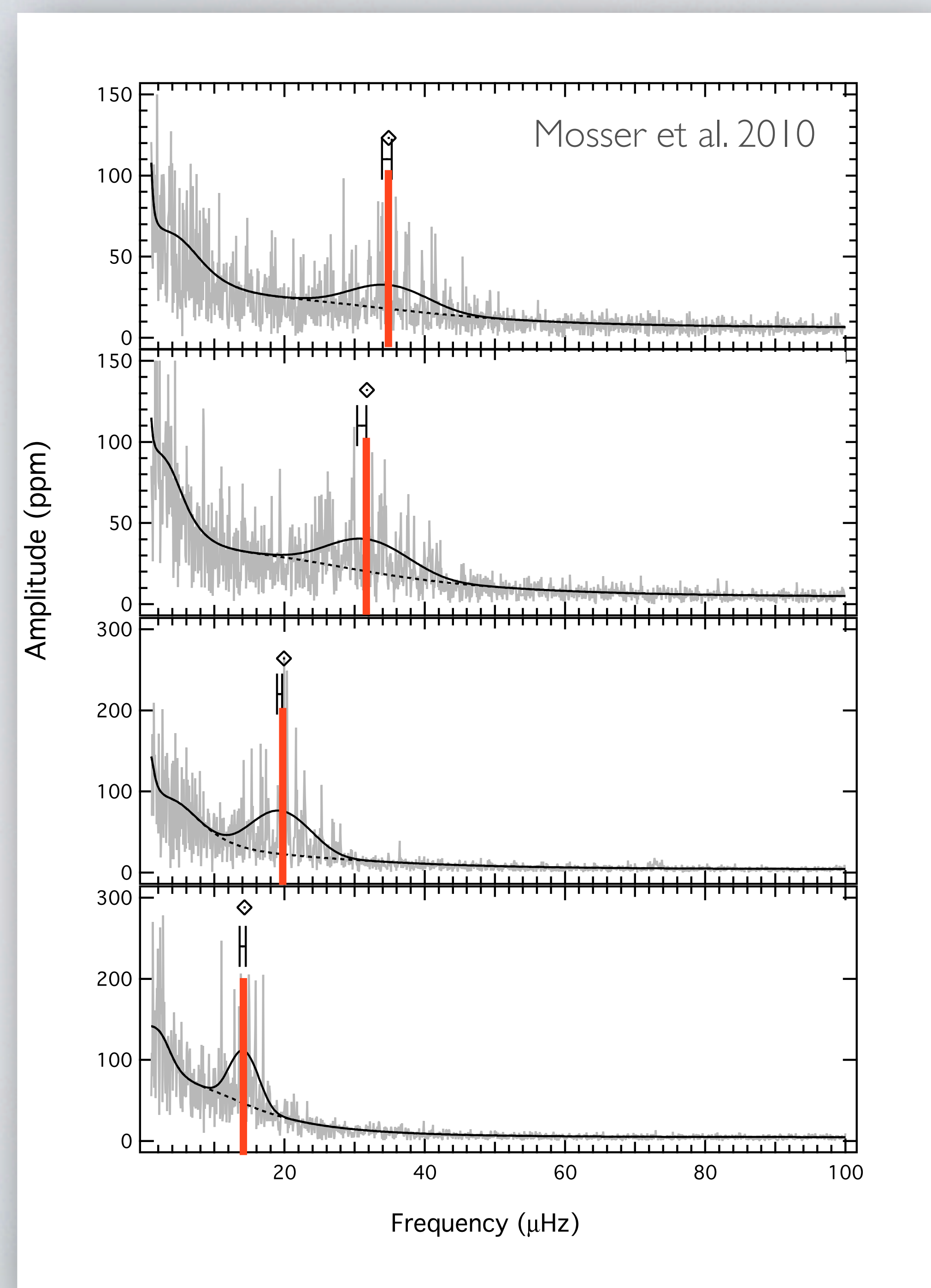
Solar-like oscillations: average parameters

ν_{max}



$$\nu_{max} \simeq \frac{M/\mathrm{M}_{\odot}}{(R/\mathrm{R}_{\odot})^2 \sqrt{T_{\mathrm{eff}}/T_{\mathrm{eff},\odot}}} \nu_{max,\odot}$$

Brown et al. 1991
Kjeldsen&Bedding 1995

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Solar-like oscillations: average parameters

average seismic parameters:

$$\Delta\nu \simeq \sqrt{\frac{M/\mathrm{M}_\odot}{(R/\mathrm{R}_\odot)^3}}\,\Delta\nu_\odot$$

$$\nu_{\mathrm{max}} \simeq \frac{M/\mathrm{M}_\odot}{(R/\mathrm{R}_\odot)^2\sqrt{T_{\mathrm{eff}}/T_{\mathrm{eff},\odot}}}\,\nu_{\mathrm{max},\odot}$$

mass and radius estimate:

$$\left(\frac{R}{\mathrm{R}_\odot}\right) = \left(\frac{\nu_{\mathrm{max}}}{\nu_{\mathrm{max},\odot}}\right)\left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-2}\left(\frac{T_{\mathrm{eff}}}{\mathrm{T}_{\mathrm{eff},\odot}}\right)^{0.5}$$

$$\left(\frac{M}{\mathrm{M}_\odot}\right) = \left(\frac{\nu_{\mathrm{max}}}{\nu_{\mathrm{max},\odot}}\right)^{3}\left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-4}\left(\frac{T_{\mathrm{eff}}}{\mathrm{T}_{\mathrm{eff},\odot}}\right)^{1.5}$$

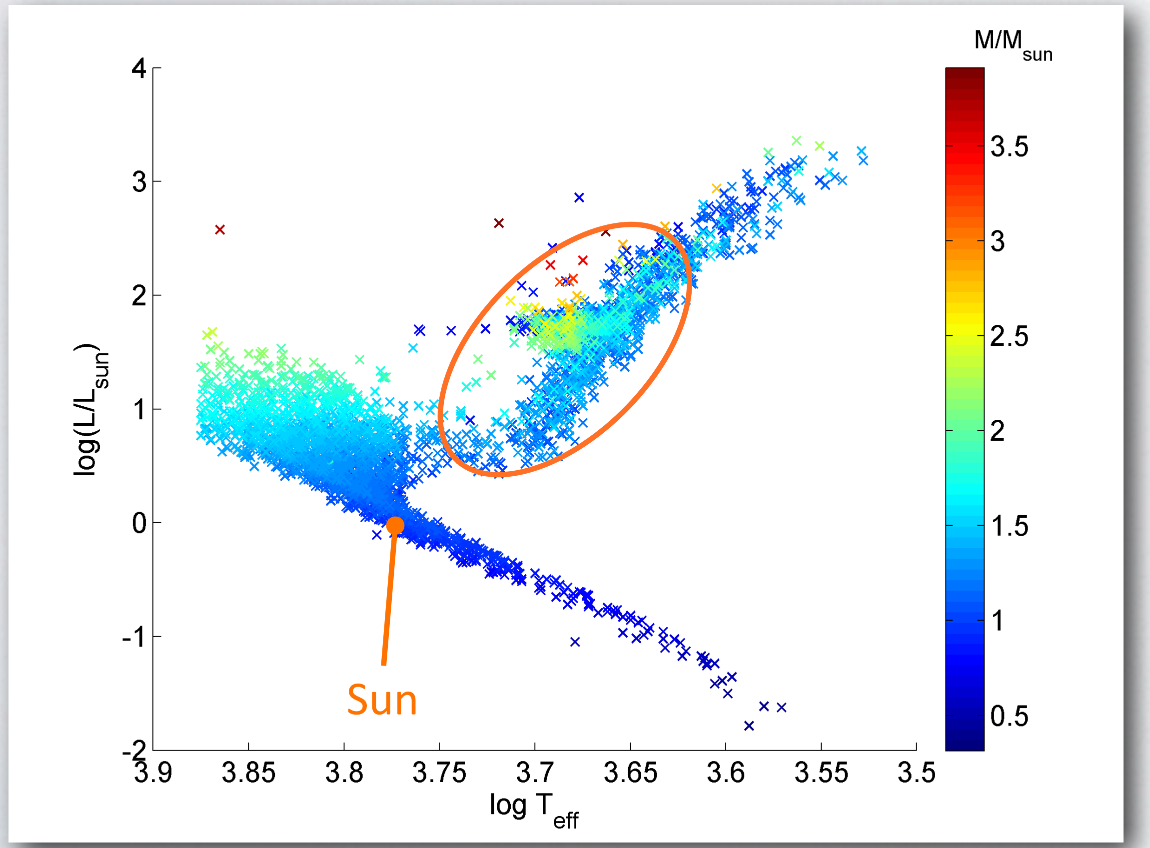
GLOBAL STELLAR PARAMETERS

RADIUS, MASS, SURF. GRAVITY

- M, R, age of planetary host stars
- improve spectroscopic analyses

$$\log g = \log g_{\odot} + \log\left(\frac{\nu_{\rm max}}{\nu_{\rm max,\,\odot}}\right) + \frac{1}{2}\log\left(\frac{T_{\rm eff}}{\mathrm{T}_{\rm eff,\,\odot}}\right)$$

- characterise stellar populations of giants in the MW (~15k stars)



THE ZOO OF RED GIANTS:
A UNIQUE SNAPSHOT OF
STELLAR EVOLUTION

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Testing scaling relations

$$\left(\frac{R}{\mathrm{R}_\odot}\right) = \left(\frac{\nu_{\mathrm{max}}}{\nu_{\mathrm{max},\odot}}\right) \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-2} \left(\frac{T_{\mathrm{eff}}}{\mathrm{T}_{\mathrm{eff},\odot}}\right)^{0.5}$$

$$\left(\frac{M}{\mathrm{M}_\odot}\right) = \left(\frac{\nu_{\mathrm{max}}}{\nu_{\mathrm{max},\odot}}\right)^{3} \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-4} \left(\frac{T_{\mathrm{eff}}}{\mathrm{T}_{\mathrm{eff},\odot}}\right)^{1.5}$$

vs

models (**Δν**) and/or independent measurements of R and M

e.g. nearby stars, clusters

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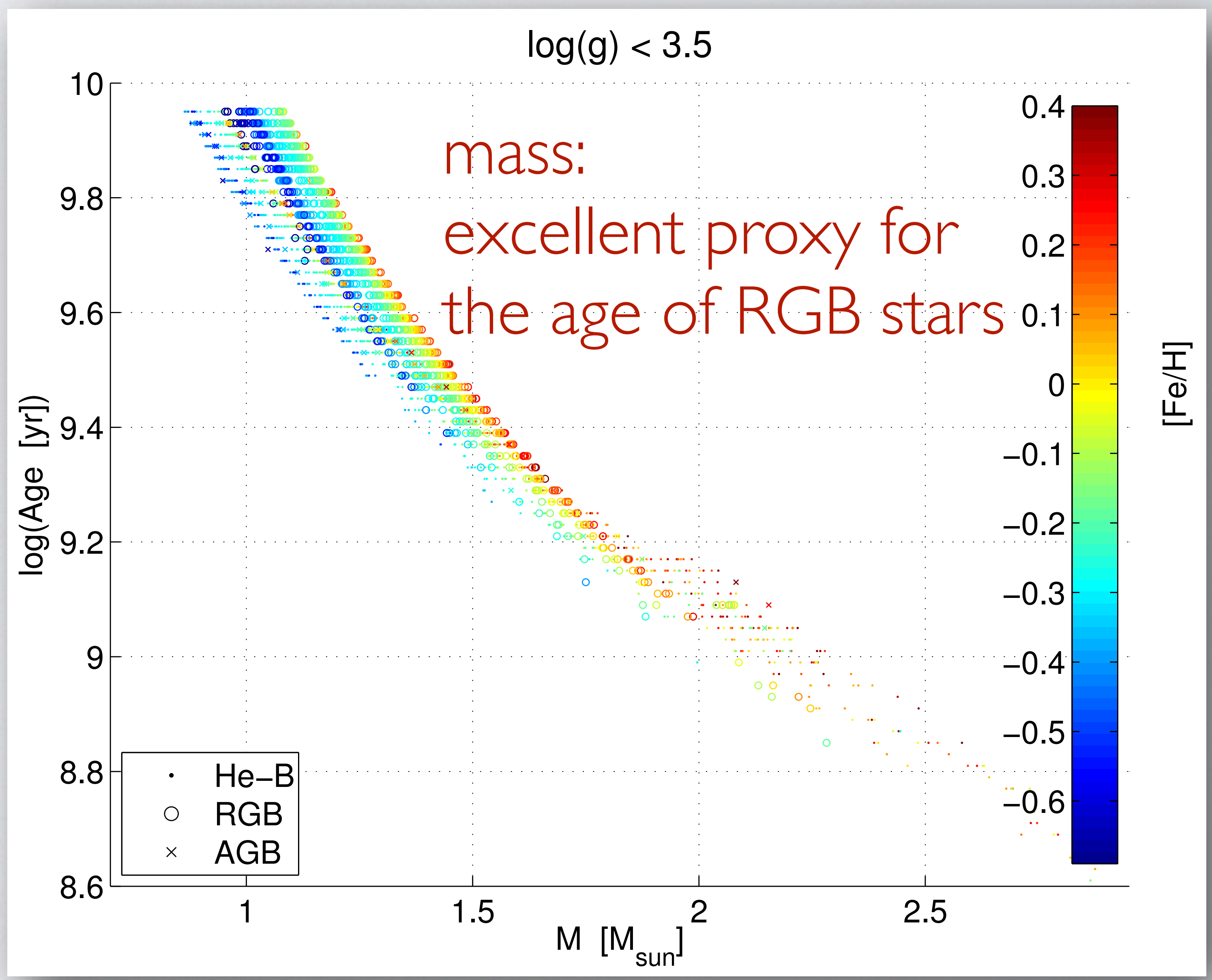
GLOBAL STELLAR PARAMETERS
RADIUS, MASS, SURF. GRAVITY

- Mass ➡ age

Age-mass relation

GIANTS



GLOBAL STELLAR PARAMETERS

RADIUS, MASS, SURF. GRAVITY

- Radius $\Rightarrow$ distance

Pulsating stars as distance indicators:

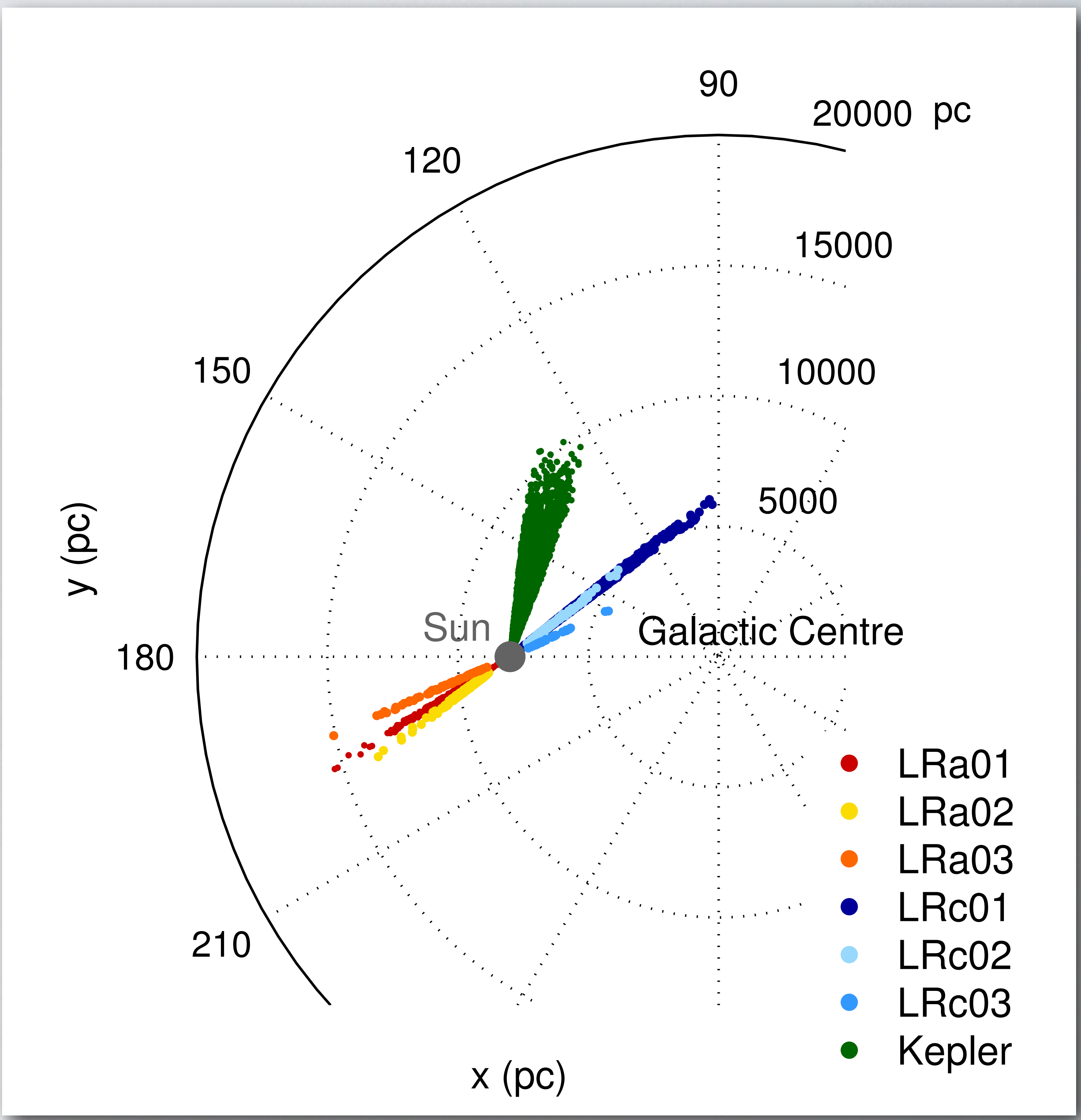
Solar-like oscillations

- Radius + T_{eff} $\Rightarrow$ L
- apparent mag + BC $\Rightarrow$ ℓ

$\Rightarrow$ $d^2 = L/\ell$

DISTANCES

uncertainty ~10%



Miglio et al. 2012

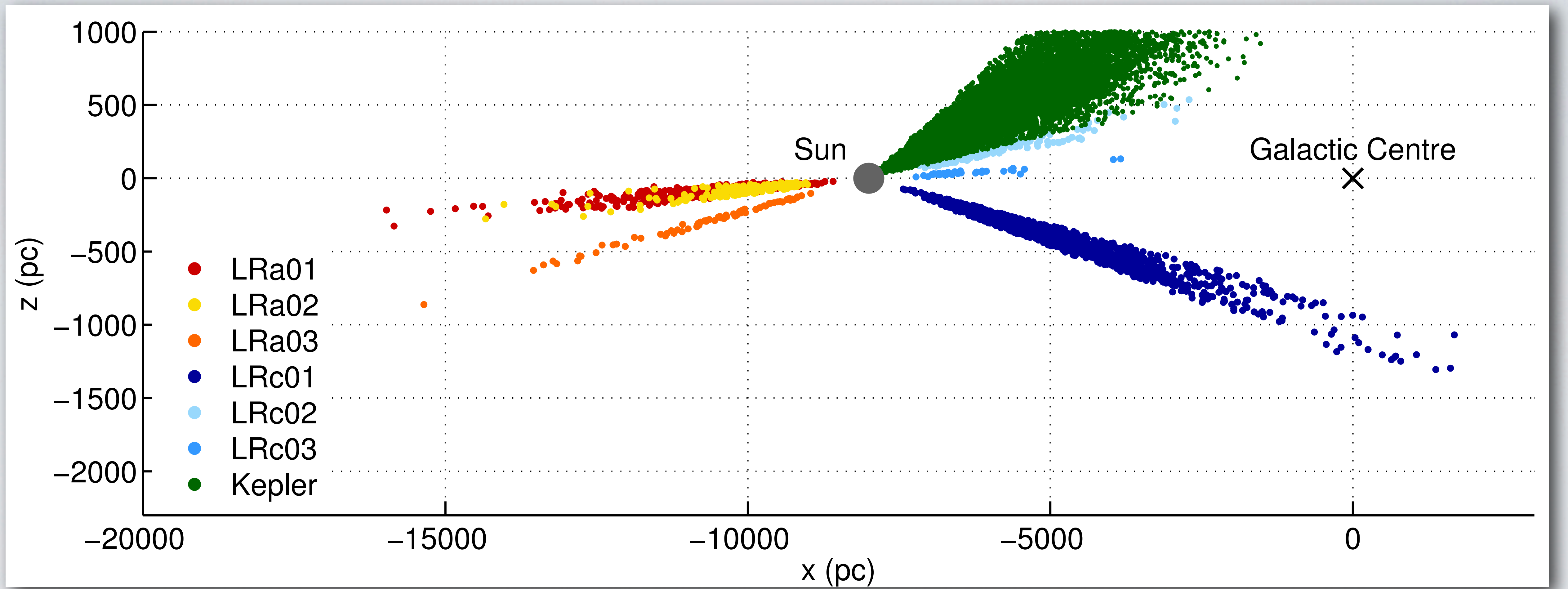
CoRoT LRs: ~ 3000 stars

Mosser et al. 2010

Kepler public data: ~ 10000 stars

Hekker et al. 2011

DISTANCES



Miglio et al. 2012

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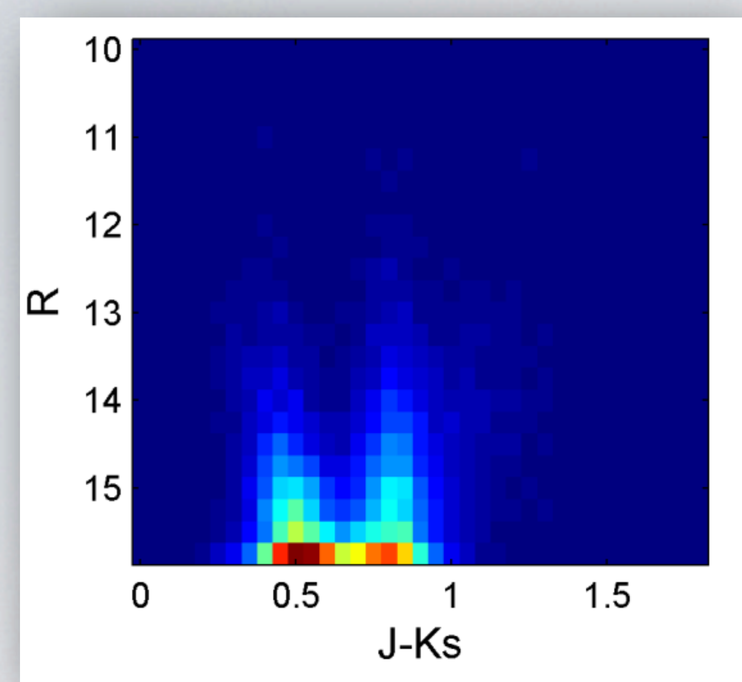
Summary: asteroseismology of stellar populations



+ ν_{max}, $\Delta\nu$ ⇨ Determine global parameters R (distance), M (age)