Continuing Kepler's Legacy: PAVO follow-up of K2 & SONG targets

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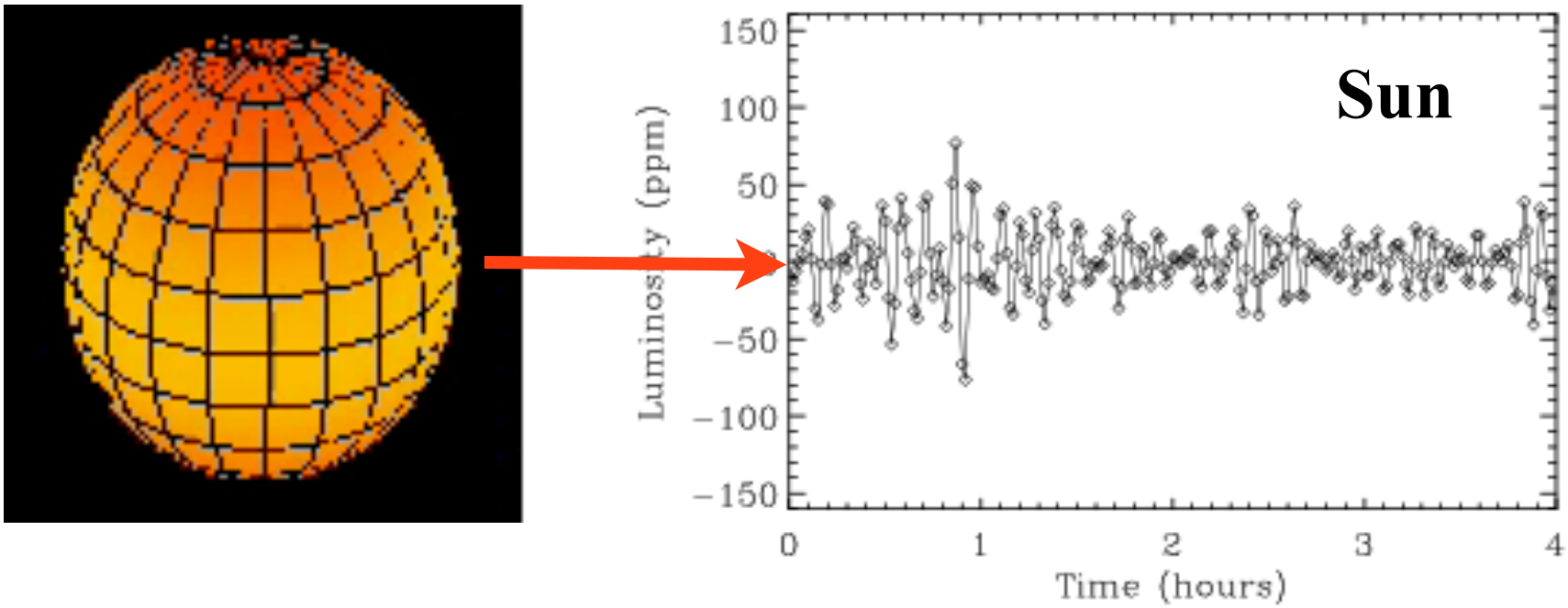
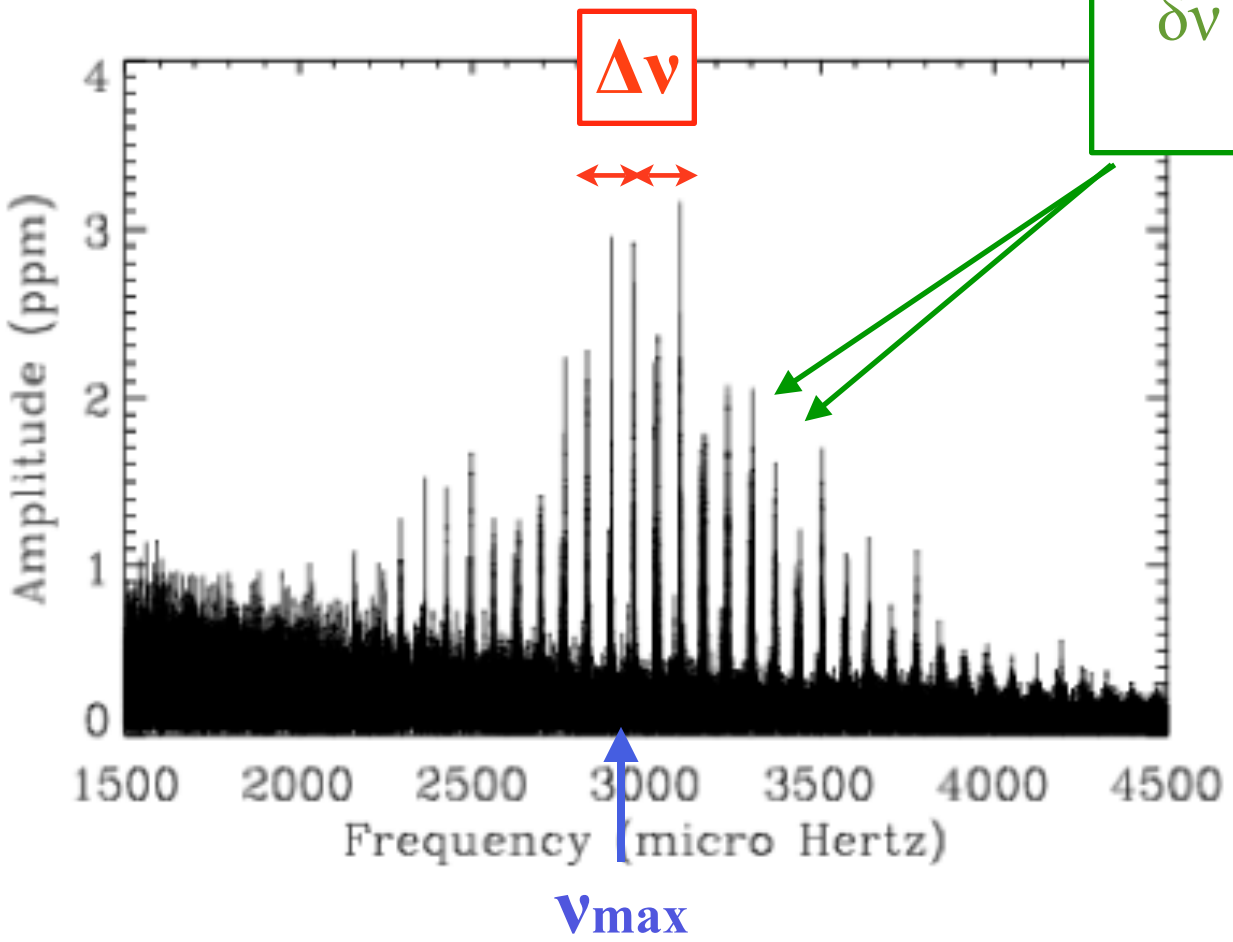
and the CHARA team

The PAVO Asteroseismology Program



oscillations are standing sound waves excited by surface convection in low-mass stars

$$\Delta\nu = (2\int dr/c_s)^{-1} \propto (M/R^3)^{1/2}\,(\text{density})$$



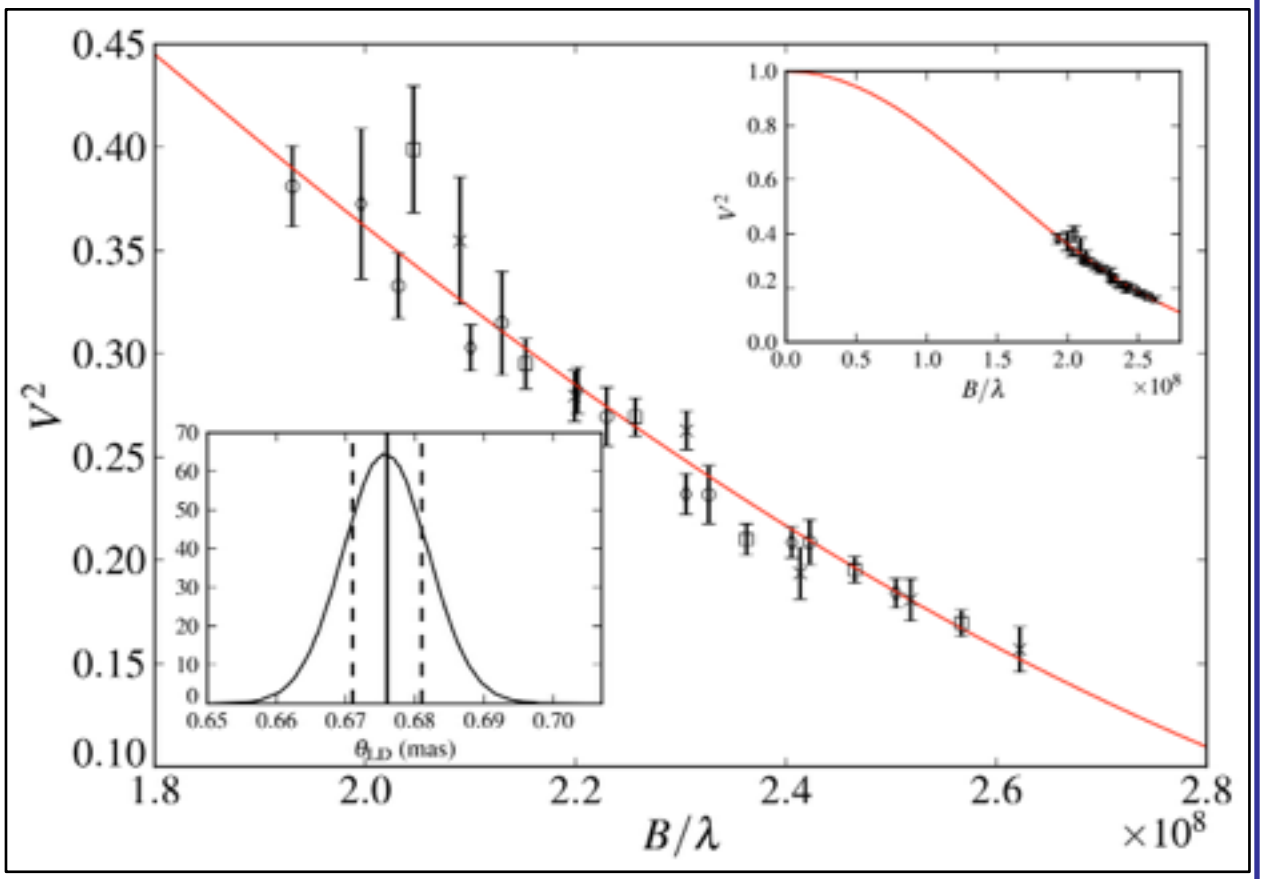
Interferometry allows to:

- test seismic radii
- derive model-independent masses
- improve seismic modeling

$$\nu_{max} \propto g\, T_{eff}^{0.5} \propto M\, R^{-2}\, T_{eff}^{0.5}\ (\text{gravity})$$

18 Sco revisited

- First published PAVO result
- 4 scans, but only 1 night!
- seismology based on ~2 weeks of HARPS RVs



Bazot et al. 2009

18 Sco revisited

$\theta_{LD,2009}$=
0.676±0.006 mas

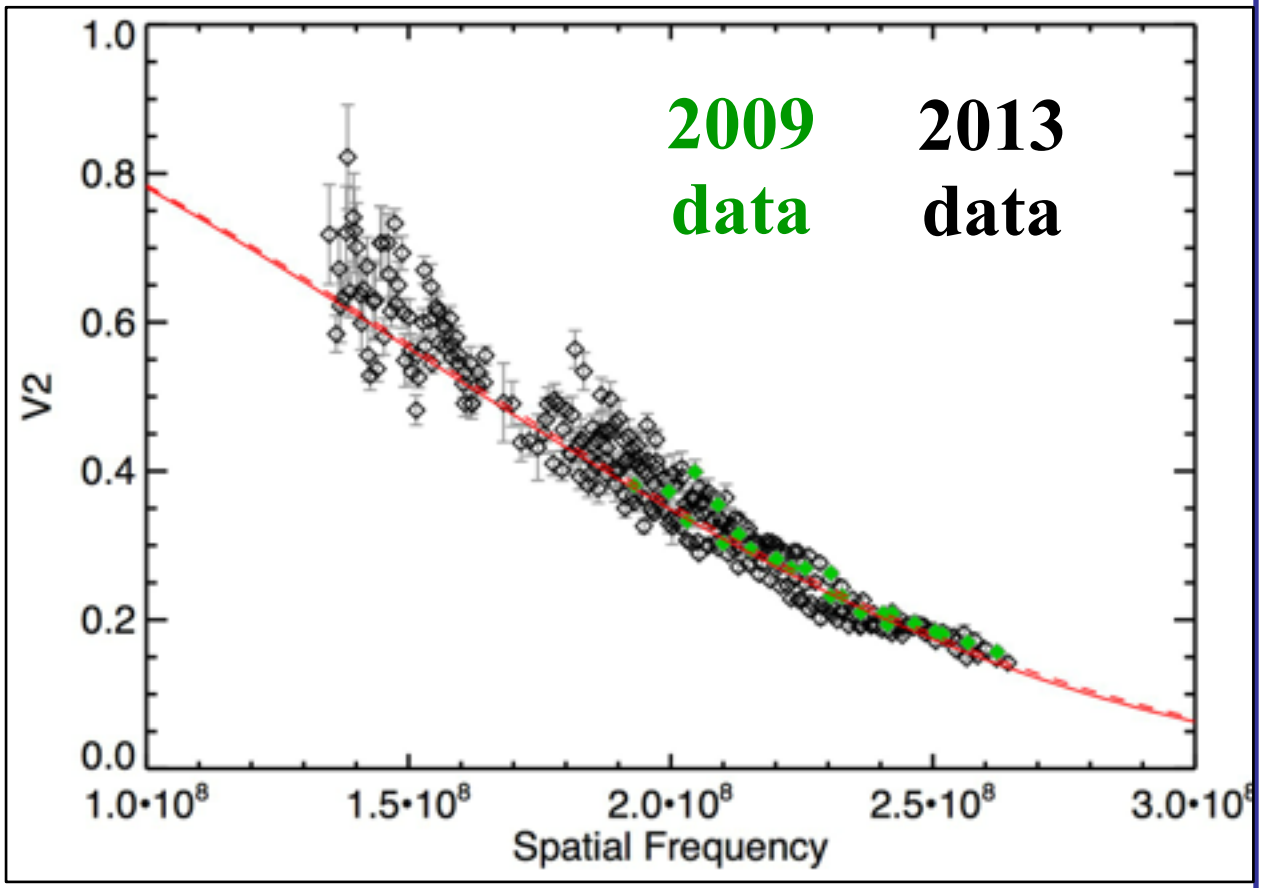
didn't properly account for uncertainties

$\theta_{LD,2013}$=
0.682±0.008 mas

limited by cal uncertainties

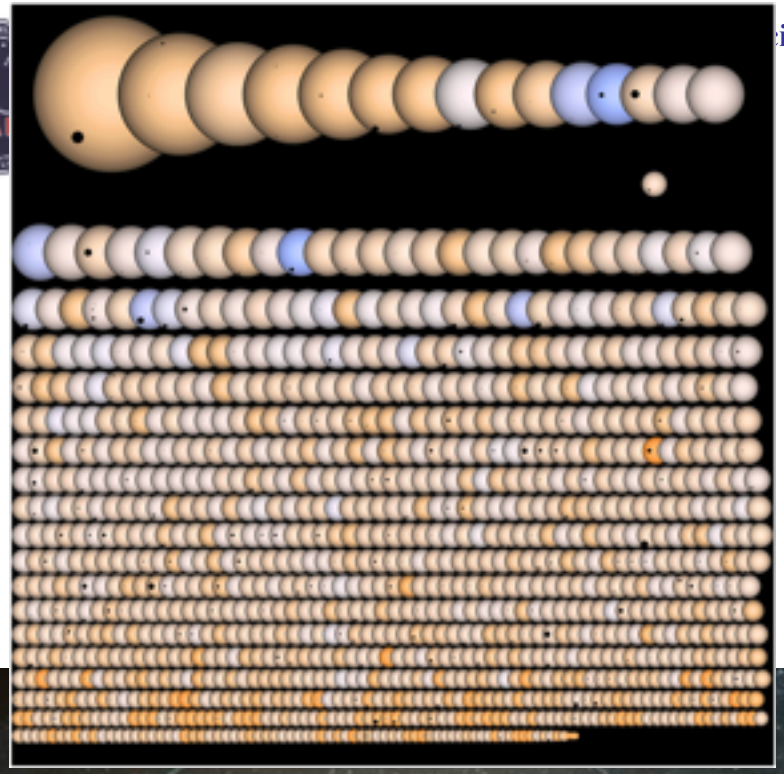
$R/R_\odot$=1.02±0.01
$M/M_\odot$=1.05±0.04

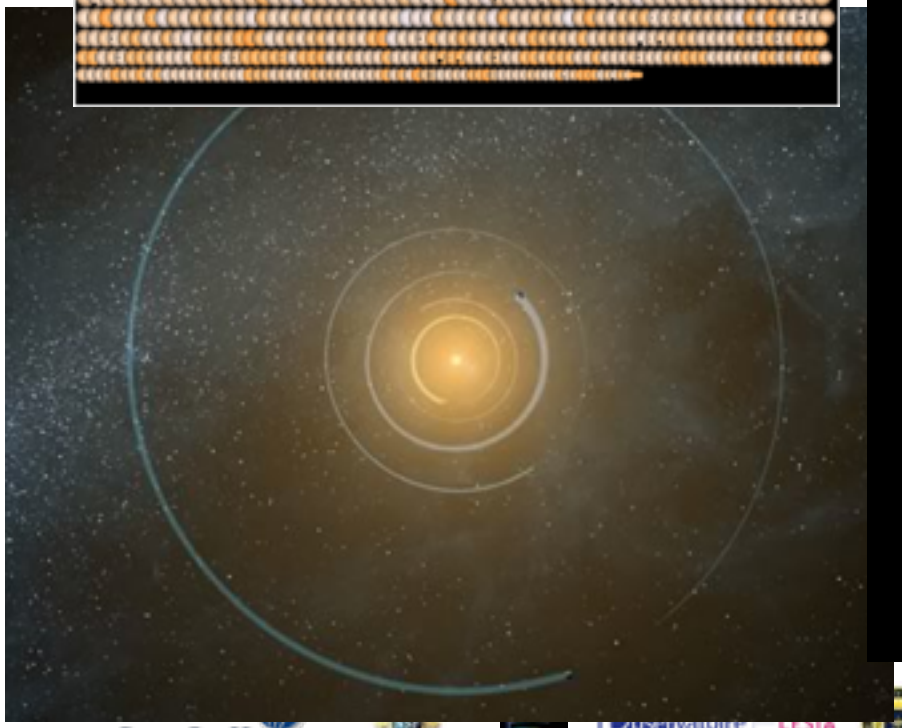
limited by seismic data!

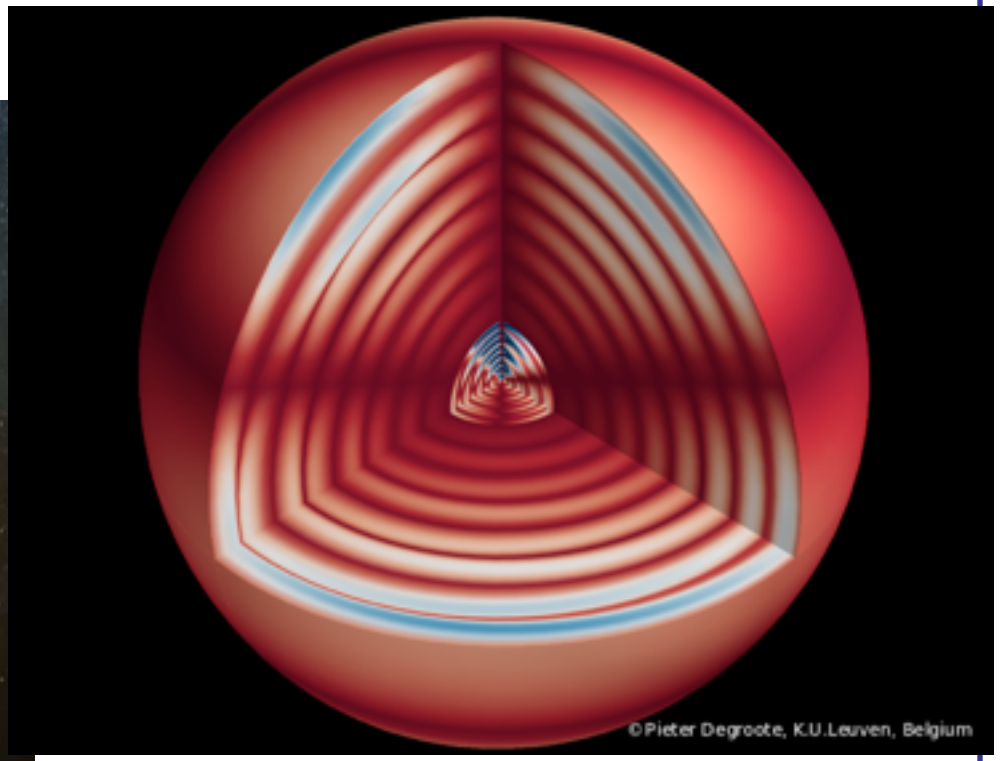


T. White, Bazot et al. in prep

Better Seismic Data: The Kepler Revolution ….



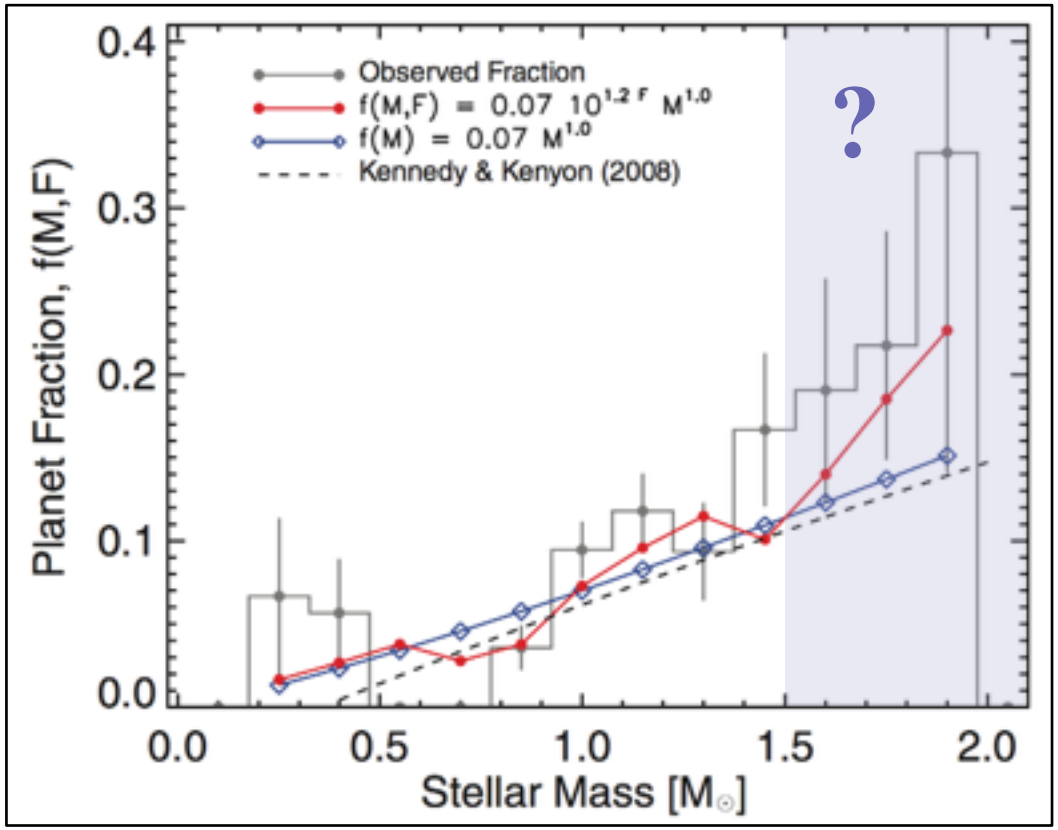




HD185351 & the Subgiant Mass Controversy

- Gas giant planet occurrence increases with host mass (core accretion)
- However, >1.5$M_\odot$ "retired A stars" have been called into question:

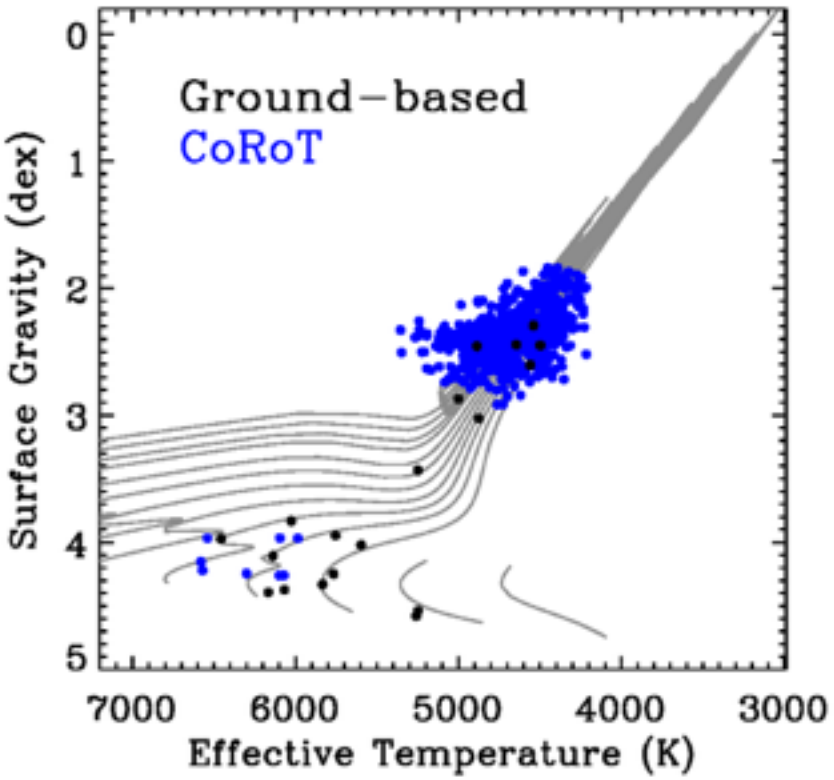
Lloyd (2011)
Johnson et al. (2013)
Lloyd (2013)
Johnson & Wright (2014)

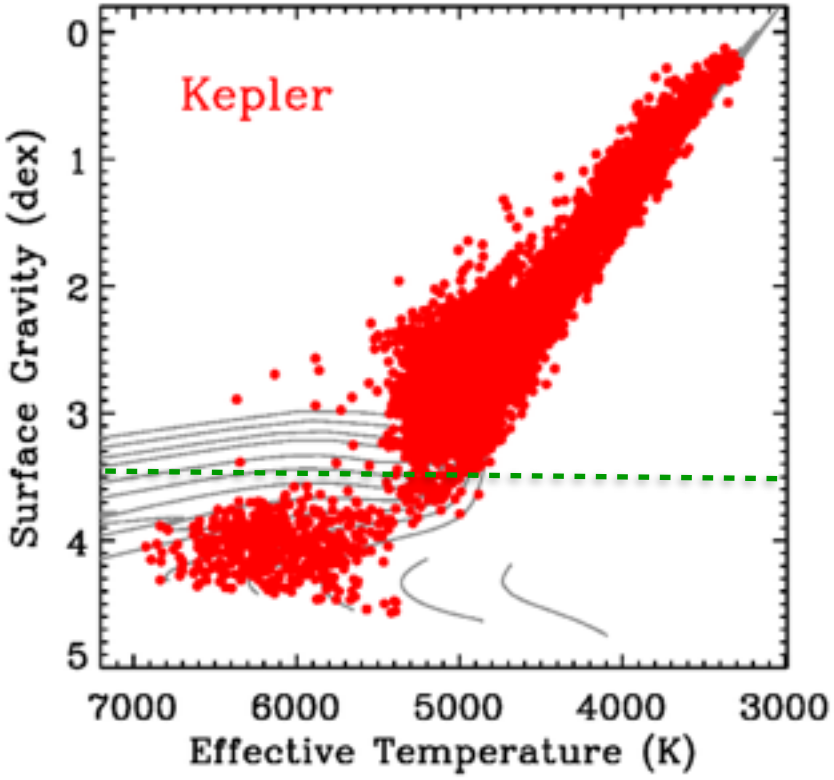


Johnson et al. 2009

2 Slides removed since results aren't public yet - contact danxhuber@gmail.com if interested

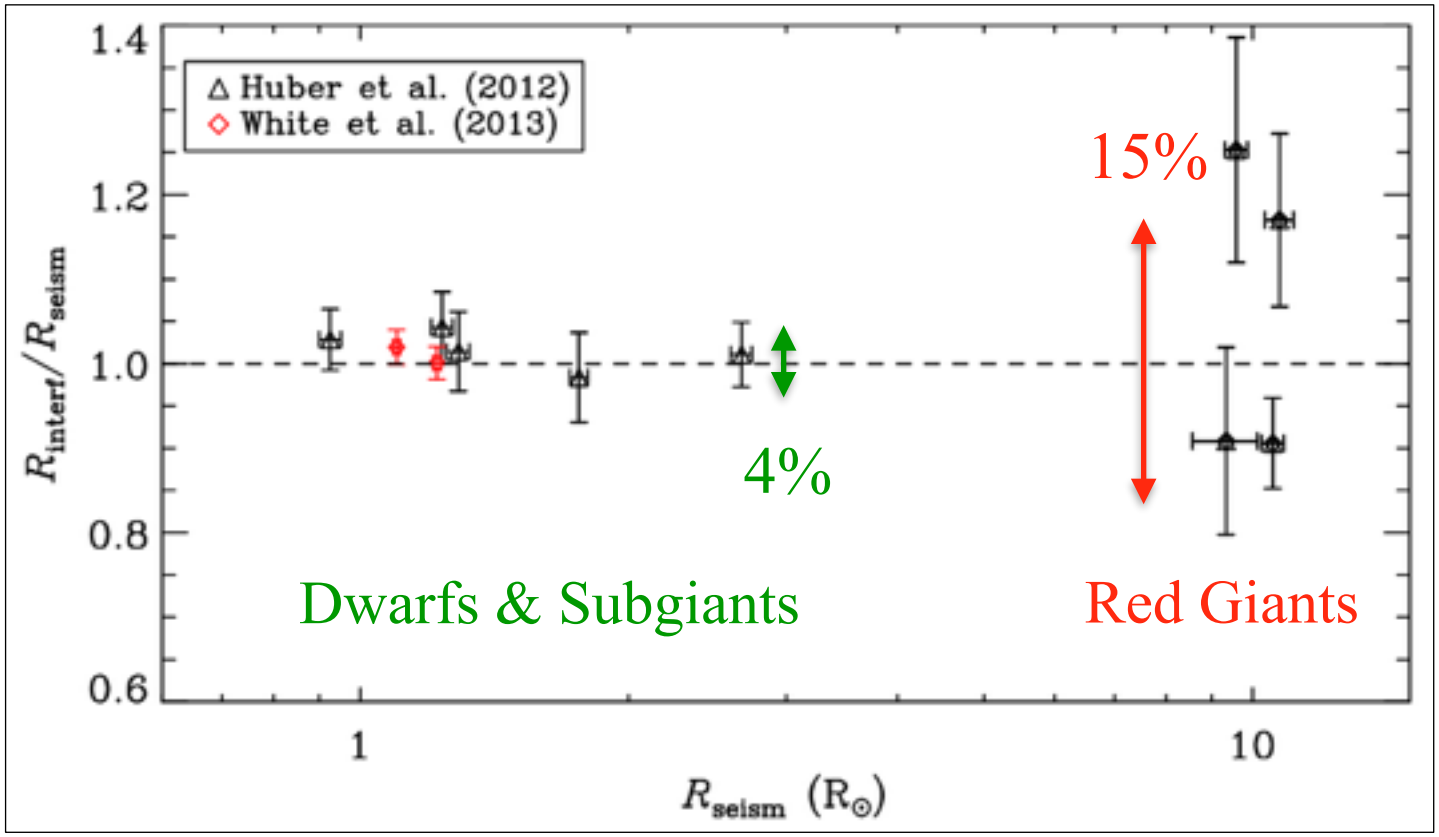
The importance of giant stars





97% of Kepler detections are giants; in principle allows to derive ages for thousands of seismic giants (T_{eff} + abundances from APOGEE, SAGA & GALAH) ➔ "Galactic Archeology"

The importance of giant stars



Kepler giants are limited by parallax precision, other giants are limited by seismic data (e.g. Baines et al. 2014)
Solution: observe brightest giants in the Kepler field. However ….

Kepler Space Telescope's Planet-Hunting Days May Be Numbered, NASA Announces

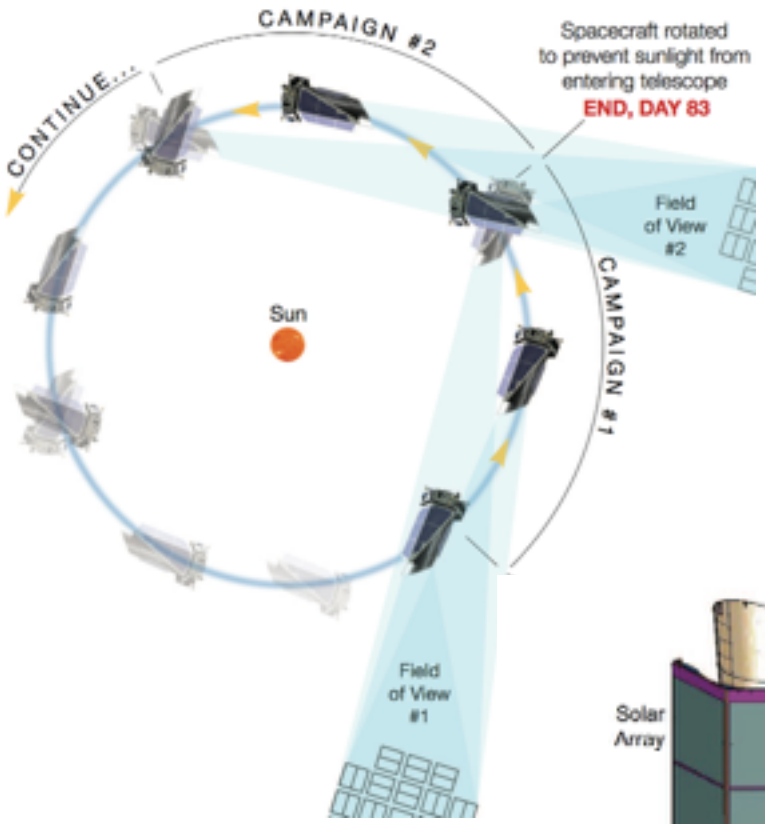
Kepler's Broken Wheels Leave Earth Without a Planet-Spotter

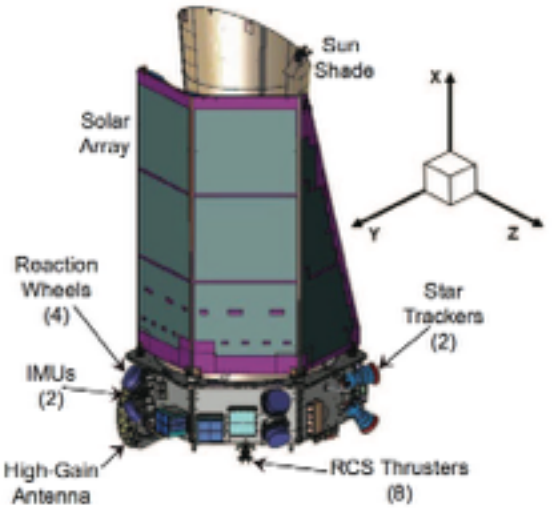
NASA calls off attempts to fix Kepler space telescope

NASA Kepler telescope broken, no more planet exploration

Kepler's Ecliptic Plane Mission

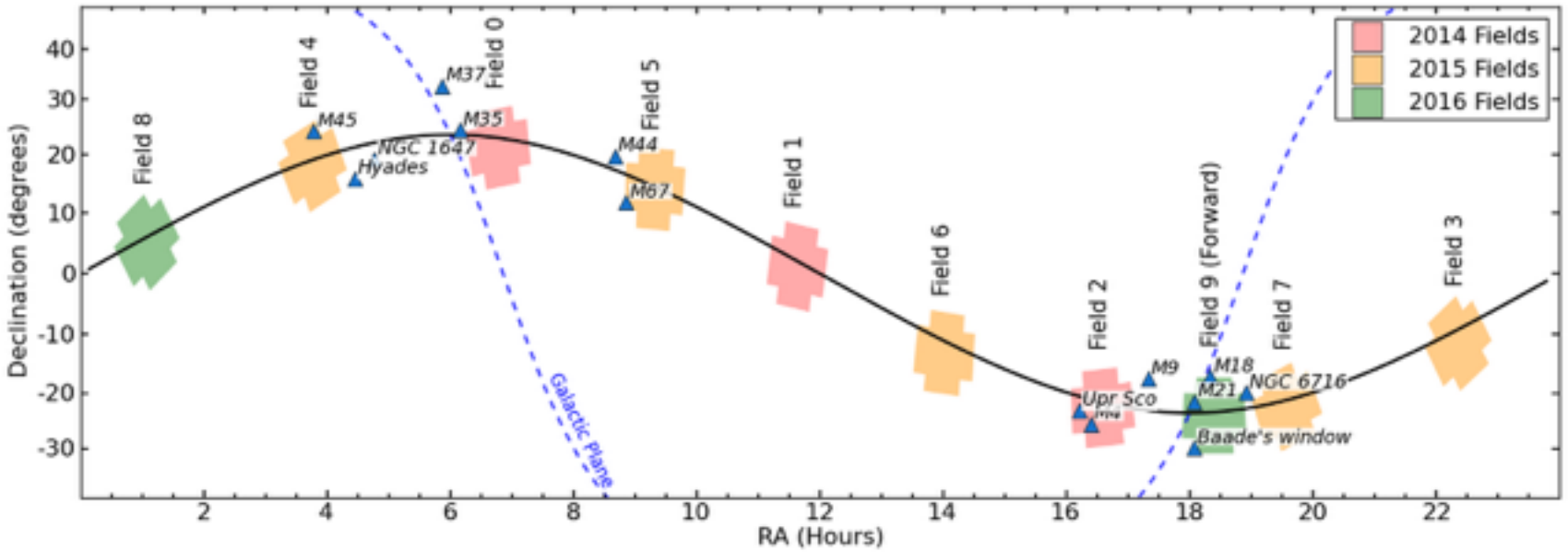
- Observe fields along the ecliptic plane
- Balance solar pressure around roll-angle (X-Y plane) of spacecraft, adjust with thruster firings
- ~80 day campaigns in each ecliptic field





Howell et al. 2014
Putnam & Wiemer 2014

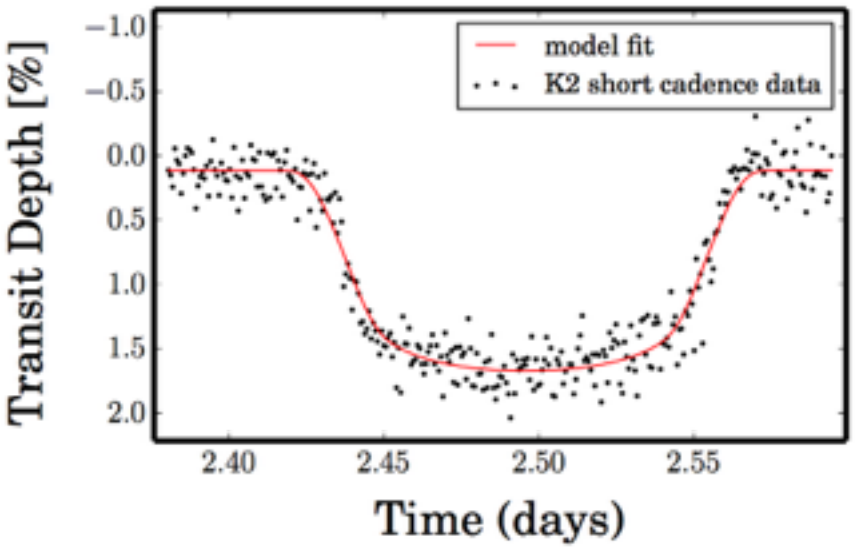
Kepler's Ecliptic Plane Mission



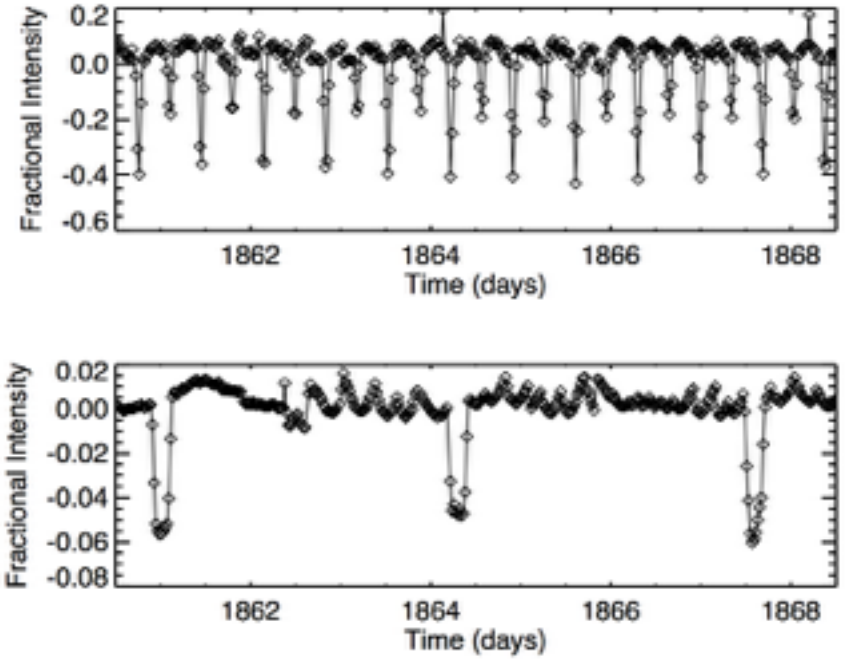
- Rich science fields: M35 (observed right now = C0), Pleiades, upper Sco; input on upcoming field positions is welcome!
- ~20000-30000 targets per campaign (larger apertures mostly due to spacecraft drift); **all targets are selected by the community**

http://keplerscience.arc.nasa.gov/K2

Early Results: Transits & Eclipses



WASP-28
(V=12, ~1 R_J, 3.4 d)



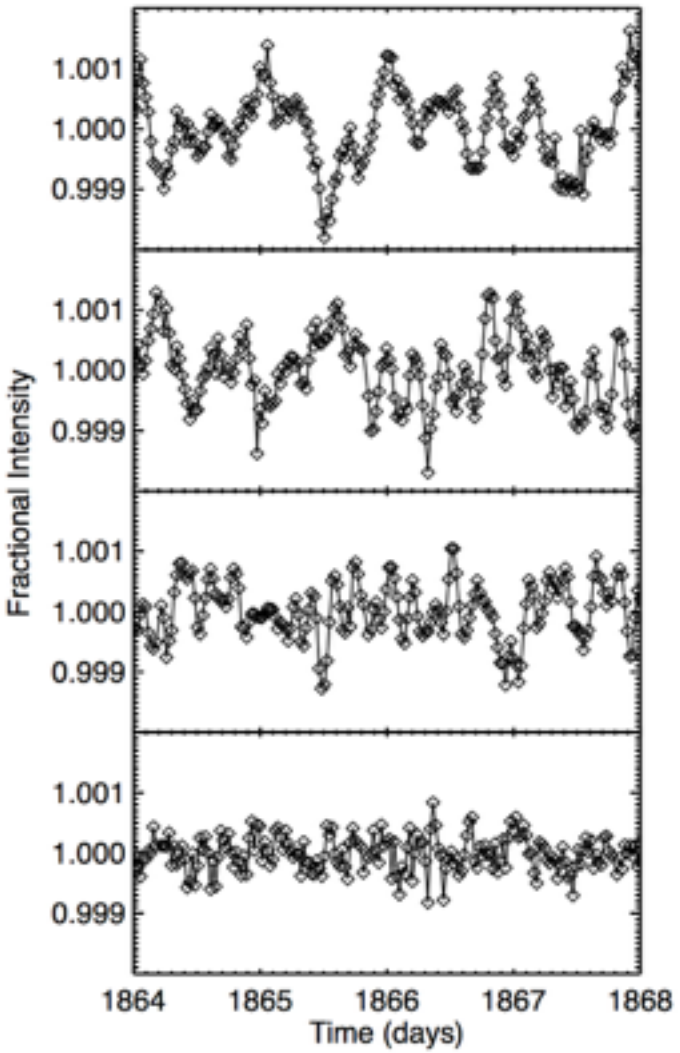
~12th mag EBs

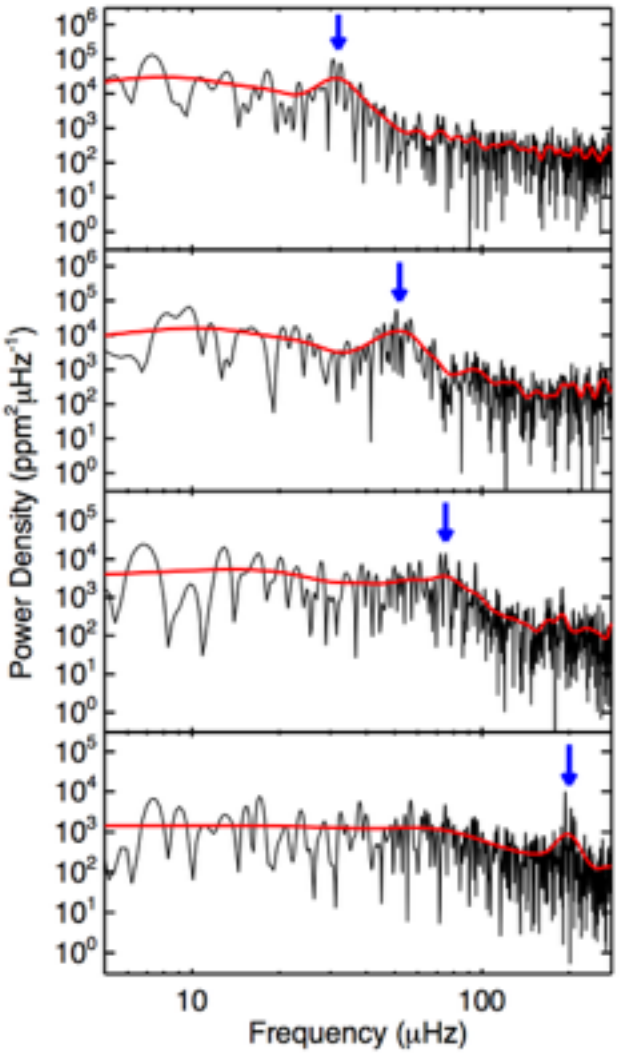
current performance estimates are within a factor of 2 of Kepler precision (~60 ppm for 12th mag)

10 days engineering test data

Early Results: Oscillating Giants

Luminosity



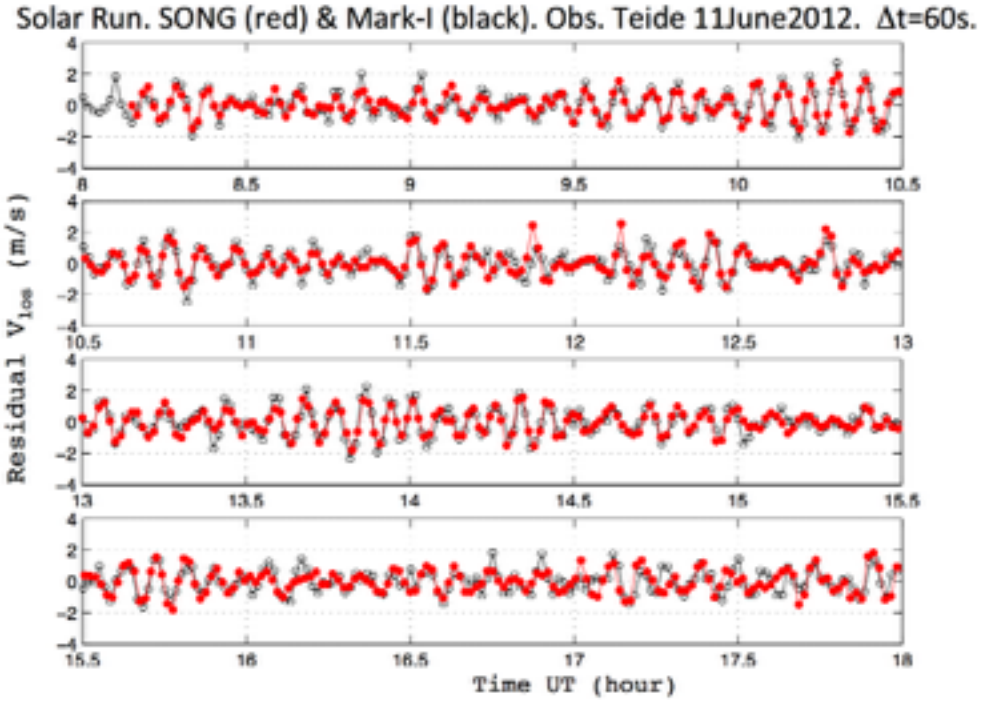


Oscillation Frequency (ν_{max})

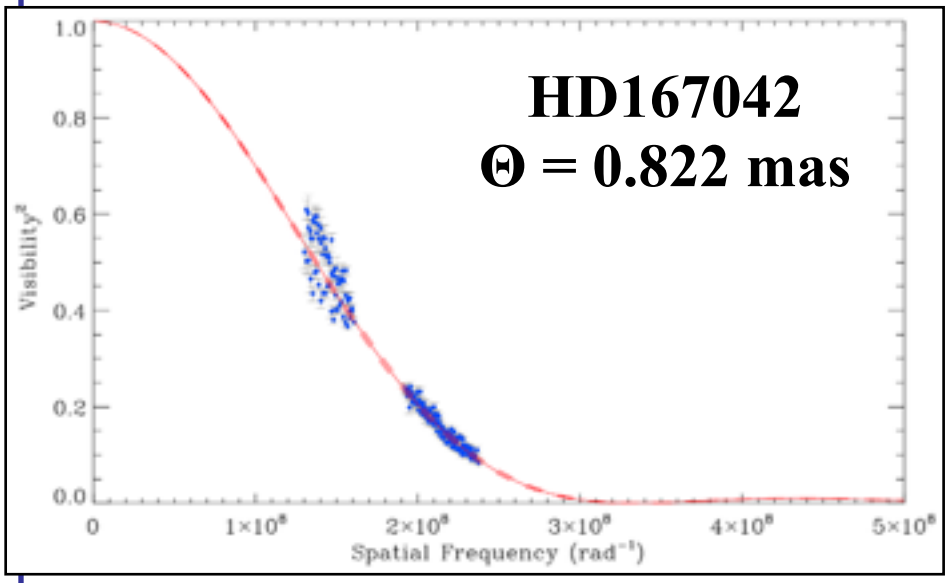
10 days of engineering test data

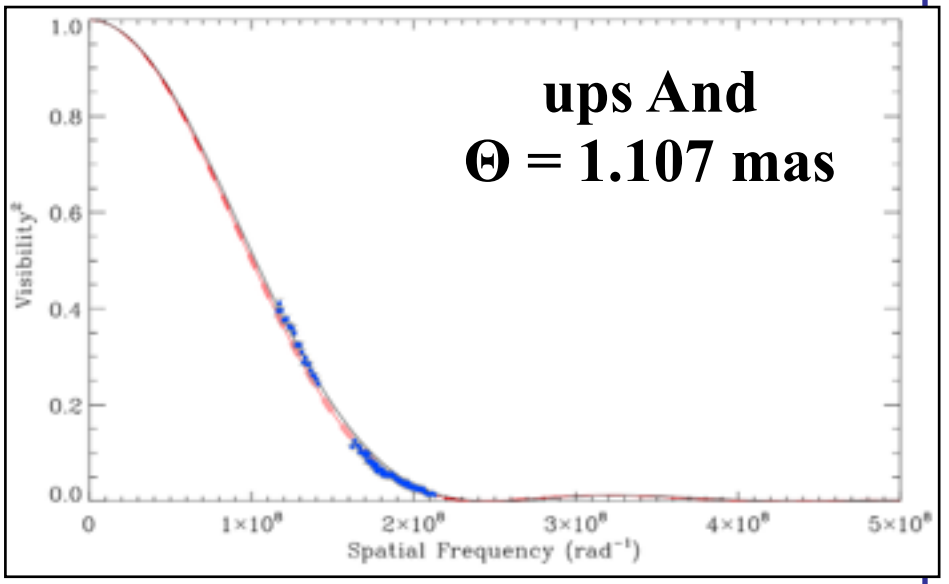
The SONG follow-up program

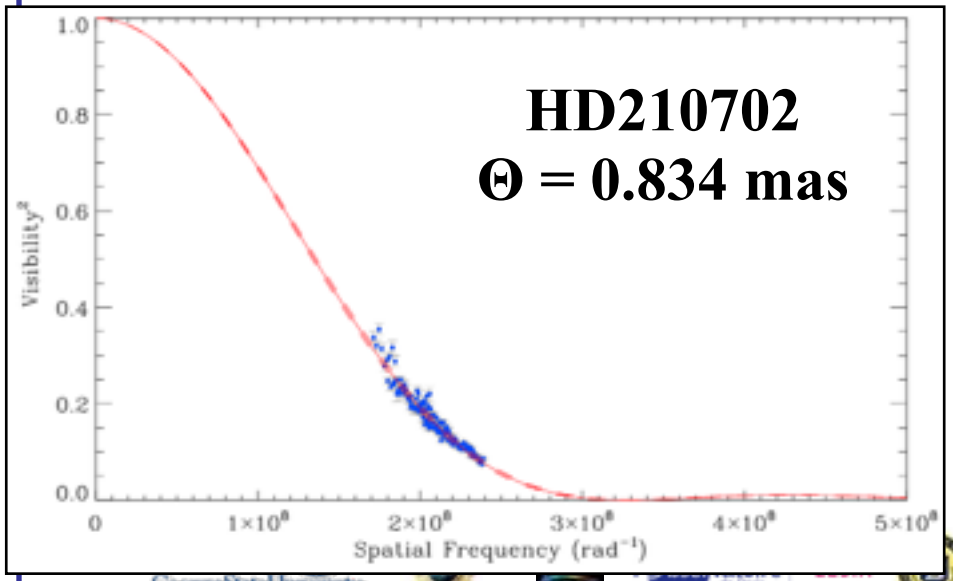
- SONG = Stellar Observations Network Group
- Network of 8 1-m class telescopes for asteroseismology and exoplanet detection; 2 nodes active: Tenerife & China
- bright giants with precise parallaxes!



The SONG follow-up program







~1-2% radii of dwarf and giant SONG targets (all of them are also exoplanet hosts)

Tim White, in prep

Observing Summary & Papers

Year	*# Nights Sem. 1 (% clear)*	*# Nights Sem. 2 (% clear)*
2009	*7 (100%)*	*3 (0%)*
2010	*4 (100%)*	*3 (0%)*
2011	*5 (90%)*	*3 (0%)*
2012	*6 (100%)*	*6 (15%)*
2013	*5 (80%)*	*4 (0%)*

- **18 Sco (Bazot et al. 2011, A&A)**
- **Trinity (Derekas et al. 2011, Science)**
- **Kepler-21 (Huber et al. 2012, MNRAS)**
- **Kepler ensemble (Huber et al. 2012b, ApJ)**
- **theta & 16 Cyg (White et al., 2013, ApJ)**
- **HD185351 (Johnson et al., ApJ, submitted)**
- 18 Sco follow-up (Bazot et al., in prep)
- SONG follow-up (White et al., in prep)