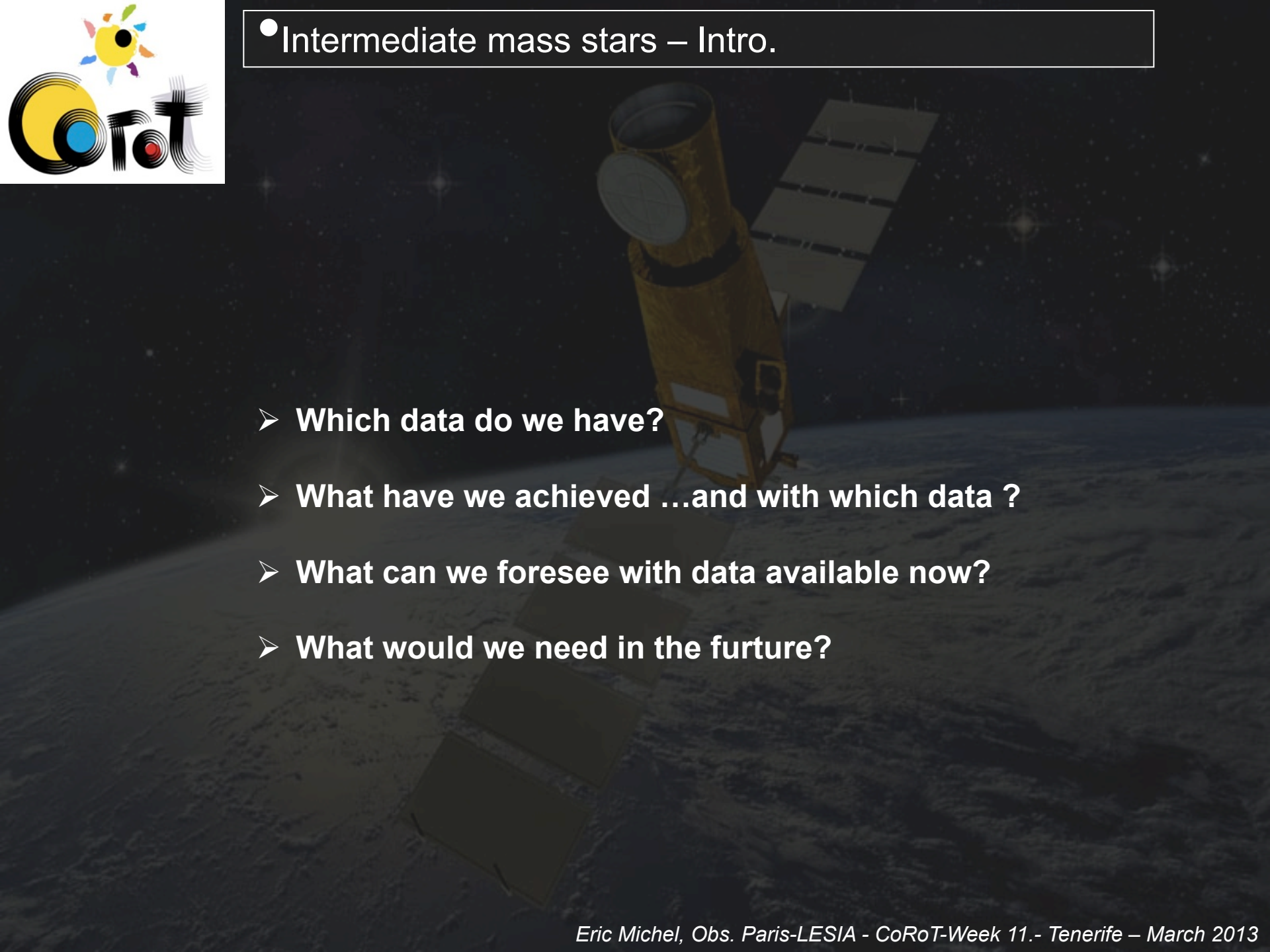
Intermediate mass stars – Intro.



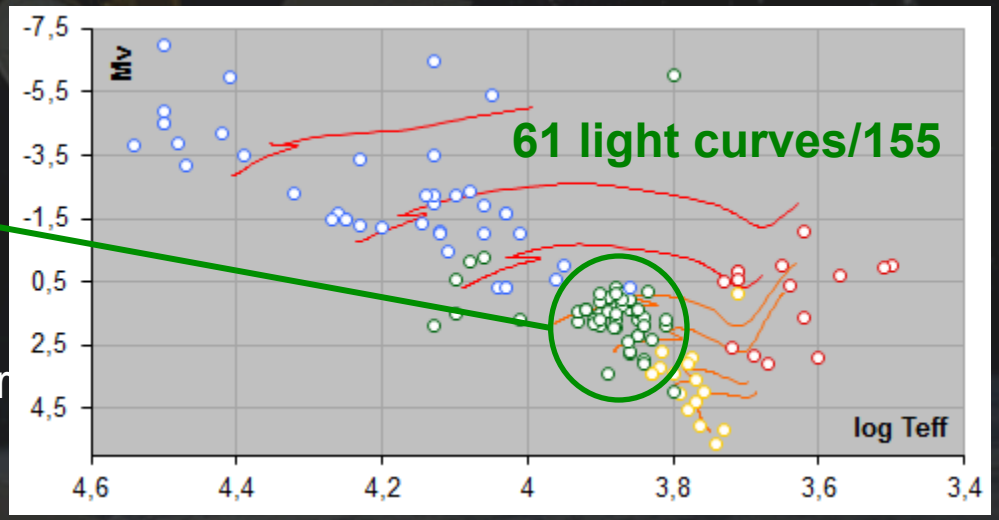
- **Which data do we have?**
- **What have we achieved …and with which data ?**
- **What can we foresee with data available now?**
- **What would we need in the furture?**

Intermediate mass stars – Intro.

Which data do we have?

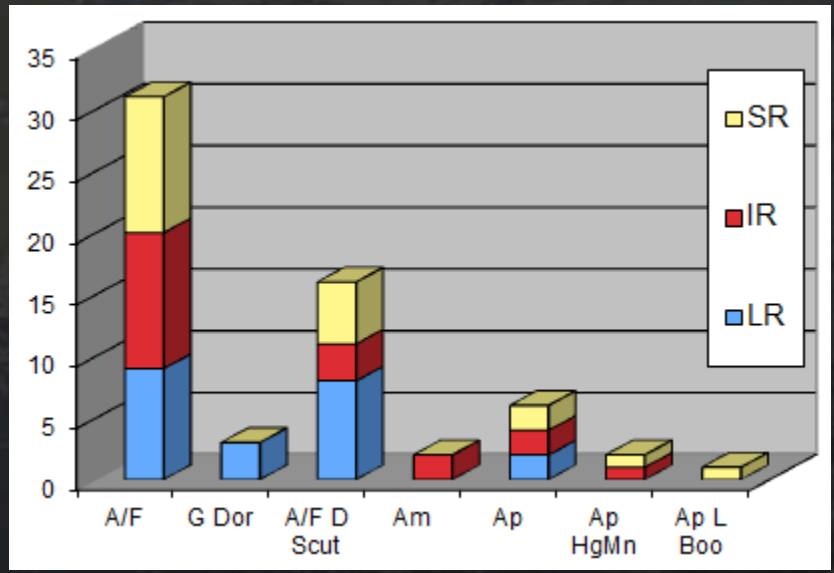
From
www.lesia.obspm.fr/projets/corotswg/

- 61 light curves (among 155, i.e. 39%)
- 2 stars reobserved twice with 2-3 year separation.
- approx. 1/3 in Long Runs, 1/3 in Intermediate Runs, 1/3 in short runs



A	B	C	D	E
Star type	All Runs	LR	IR	SR
A/F	31	9	11	11
G Dor	3	3	0	0
A/F D Scut	16	8	3	5
Am	2	0	2	0
Ap	6	2	2	2
Ap HgMn	2	0	1	1
Ap L Boo	1	0	0	1

61 lc 36% 31% 33%



Intermediate mass stars – Intro.

Which data do we have?

But also:

- EXO-Field: e.g.
  - CVC → ~1800 delta Scuti stars for 80% conf.
    CoRoT/CVC (Debossher et al 09 A&A 506)
  - CVC → …γ Dor…
- Ground-based:
  - GAUDI (high resolution spectra for most of the targets) +
  - ESO-LP (radial velocity sequences, over 7000 spectra for 266 targets, cf E. Poretti)
  - Multi-color photometry: IAA-OSN (cf R. Garido Haba) and CoRoT-Hungarian contribution (cf M. Paparo)

Intermediate mass stars – Intro.

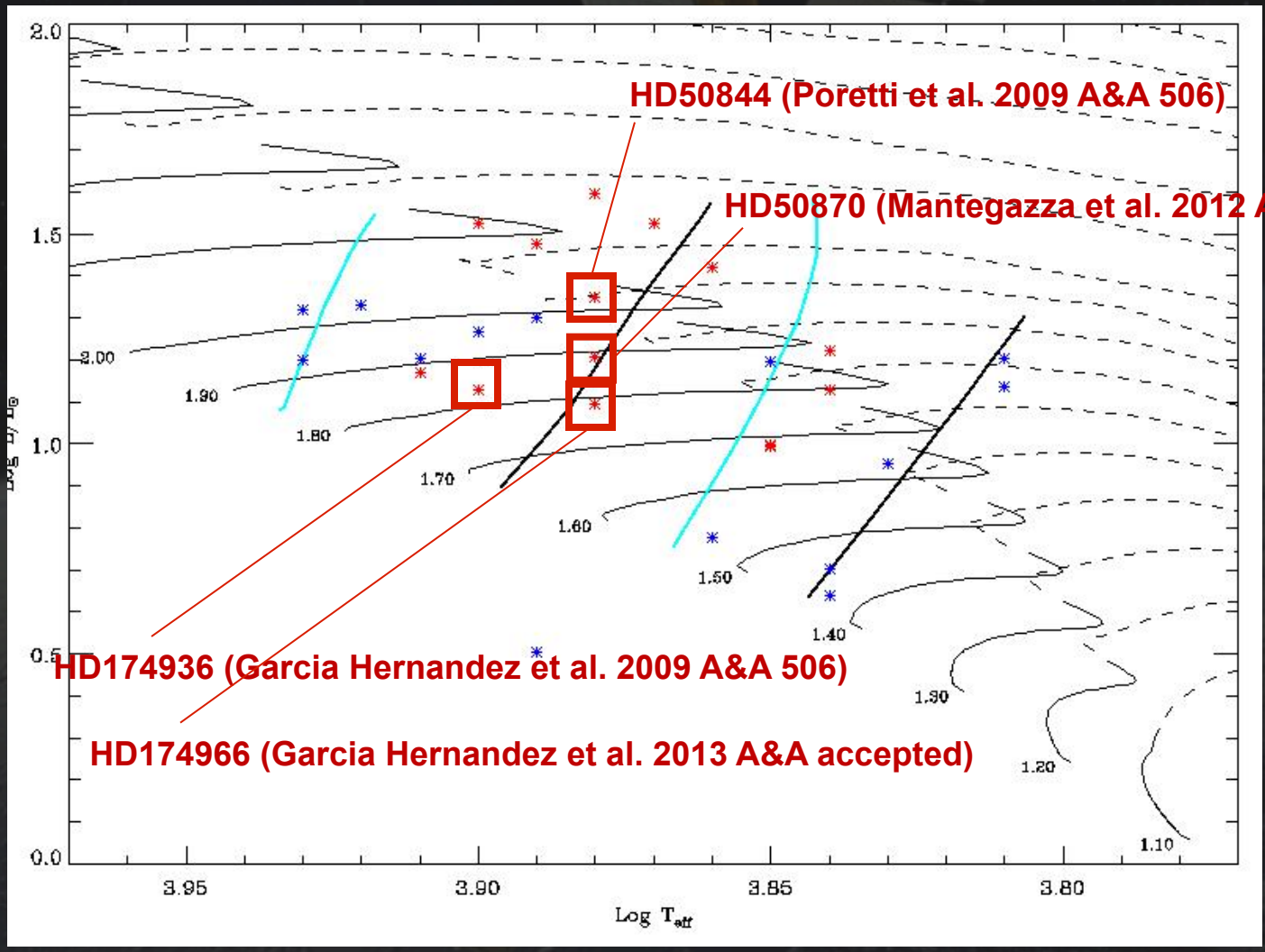
Which data do we have?

And also: theoretical works

- Fast rotation and oscillations:
  - Perturbative approach: …,Dziembowski & Goode 92; Soufi et al 98; Suarez et al 2006 ….
  - Nonperturbative approach: …Lignieres et al. 2006, Reese et al. 2006, 2009,… 2013, Lignieres & Georgeot 2009, Ouazzani et al 2012,…
- Transport of chemical species (‘diffusion’):
  - Rotational mixing: …, Talon & Charbonnel 2008, Eggenberger et al. 2008,… Marques et al. 2012,… Rieutord & Espinosa Lara 2009,…
  - Radiative forces: …, Stift & Alecian 2012,…

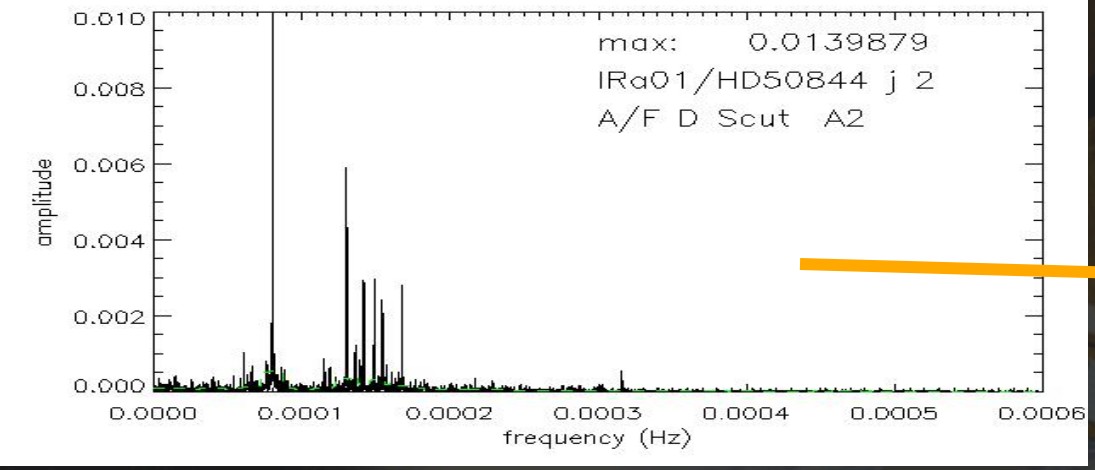
Intermediate mass stars – Intro.

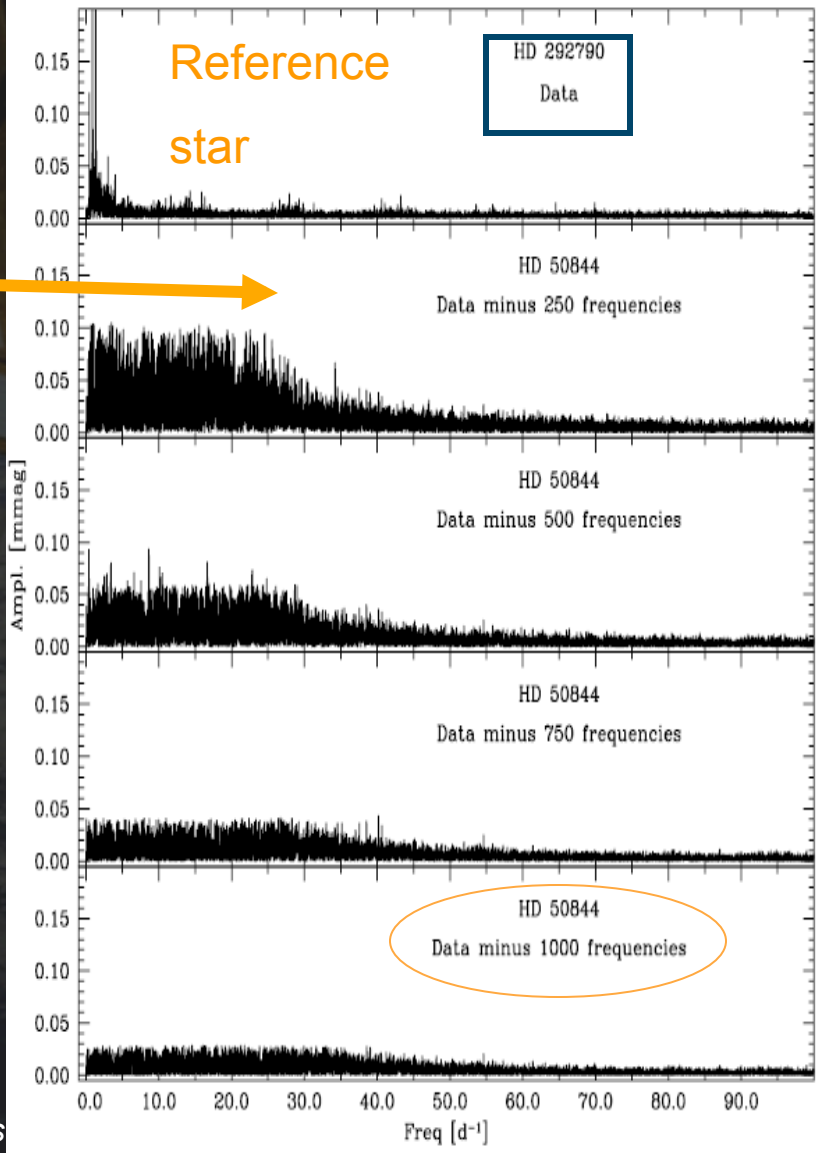
What have we achieved and with which data ?



Intermediate mass stars – Intro.

What have we achieved and with which data ?



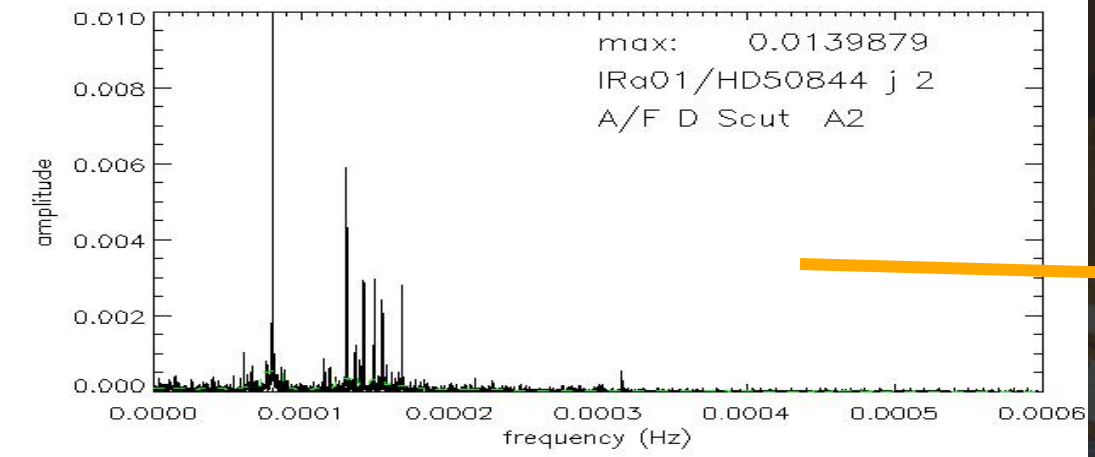


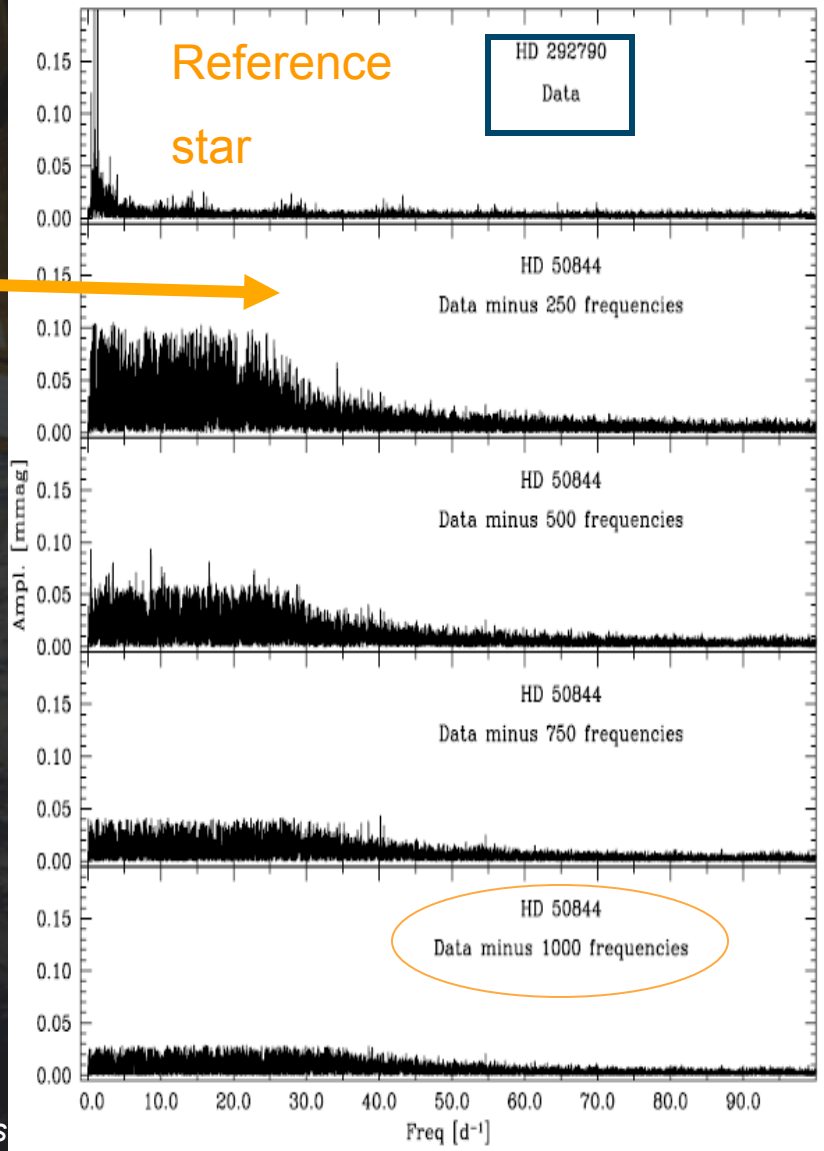
- Hundreds of signif peaks and more under! …
- No variability of main peaks amplitude
- range of observed modes> theor. Unstable
- Spectroscopy LPV → high l modes
- …

(CoRoT, Poretti et al 09 A&A 506)

Intermediate mass stars – Intro.

What have we achieved and with which data ?





- High l modes ?

...consistent with excitation mecanism, with mode visibility estimate and spectroscopic indication,…

- Chaotic modes ? (Ligniere & Georgeot 09)

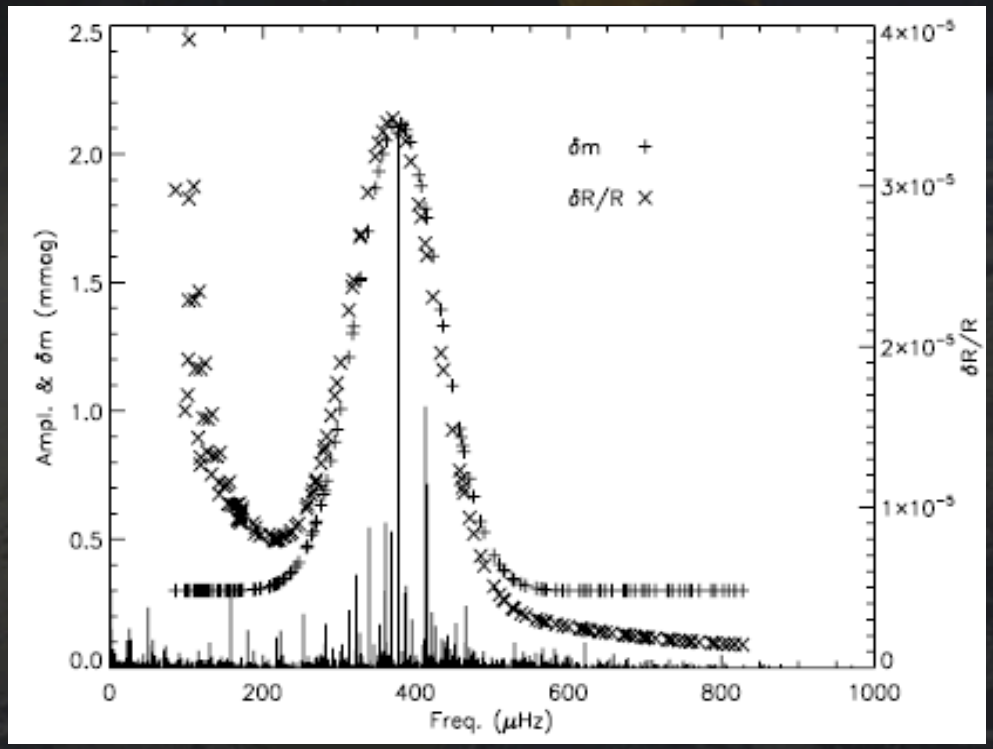
- What is the contribution from ‘stellar noise’, granulation?...

Intermediate mass stars – Intro.

What have we achieved and with which data ?

- **'Has a star enough energy to excite thousand of modes?'**

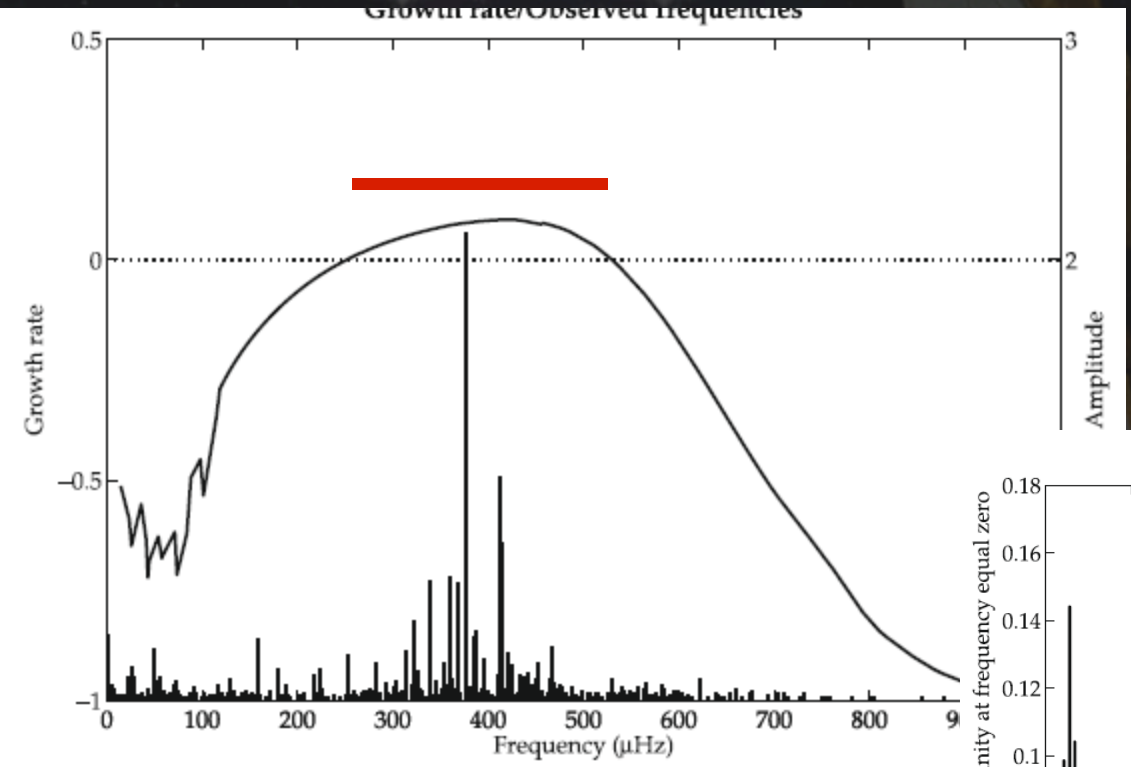
For (l=0,7) in [100,800μHz] → Wtot < 10^{29}erg/s << L(10^{34} erg/s)



(Moya & Rodriguez-Lopez 2010 ApJ 710)…

Intermediate mass stars – Intro.

What have we achieved and with which data ?

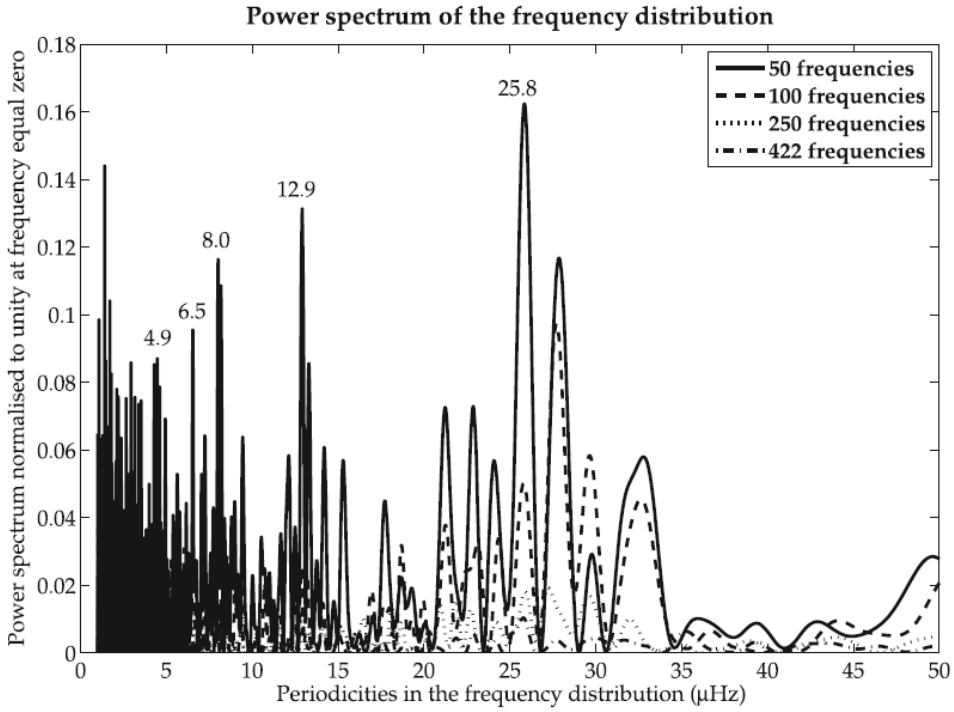


Hundreds of peaks and more…
(CoRoT, Garcia Hernandez et al 09 A&A 506)

for the highest peaks:

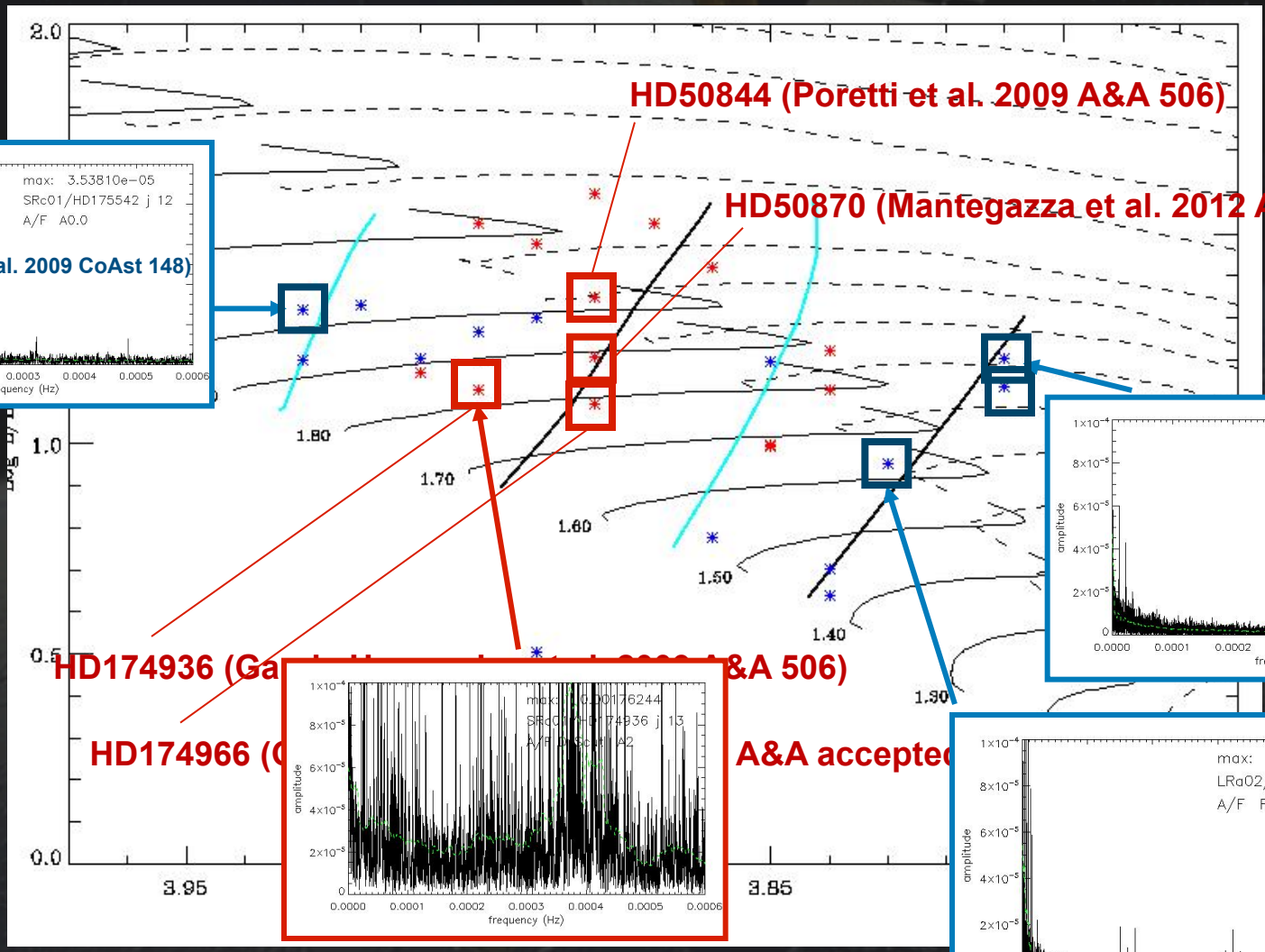
regularity ~ 26 → <Δn> ~52μHz

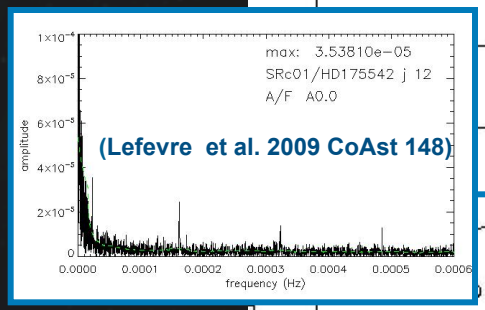
(also present in simu with models)

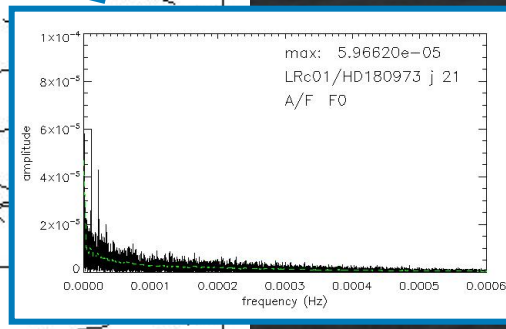


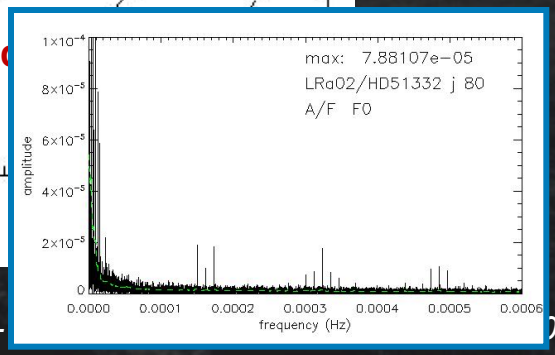
Intermediate mass stars – Intro.

What have we achieved and with which data ?



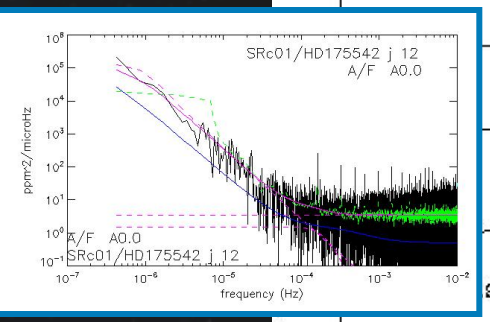


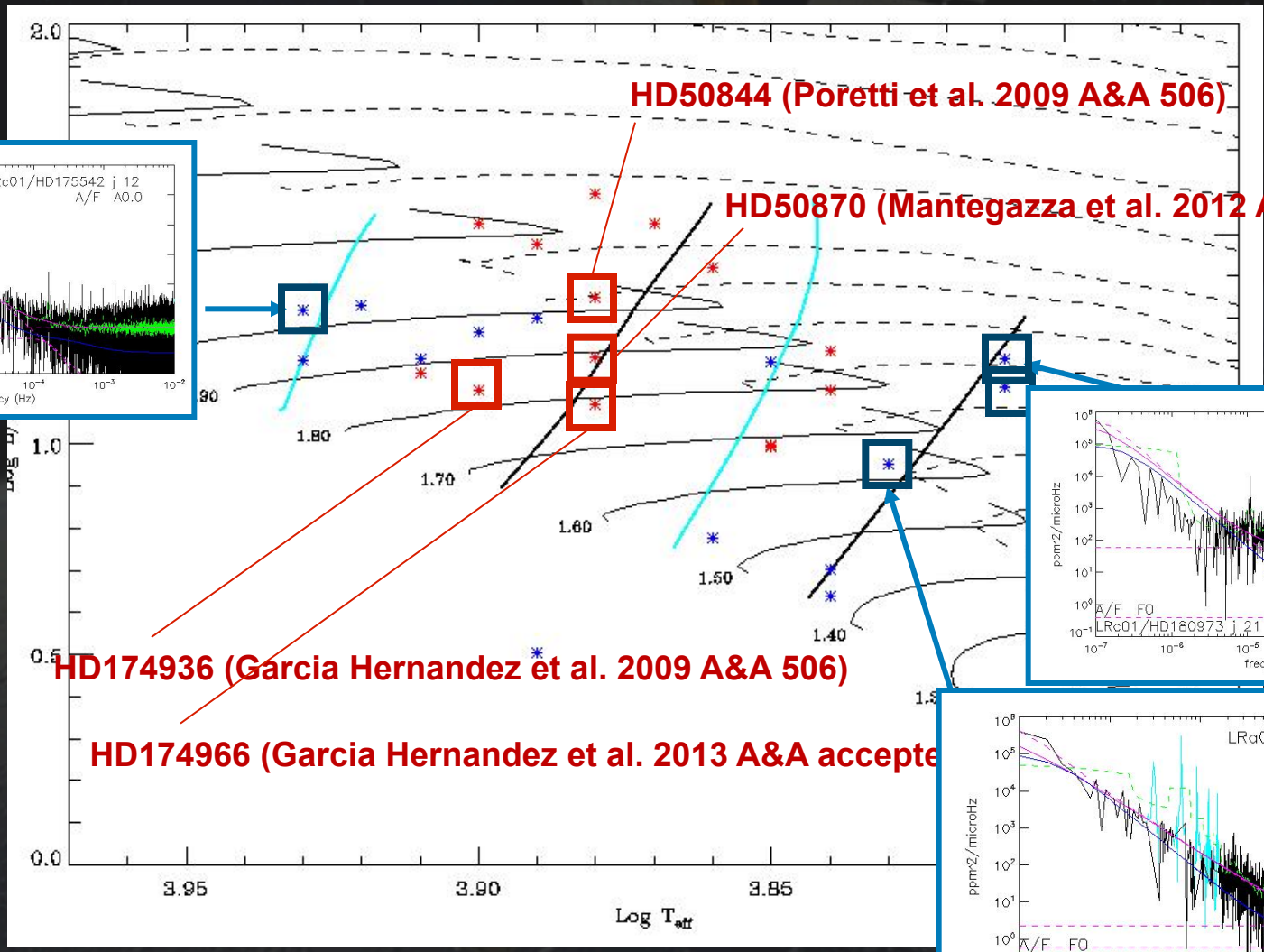


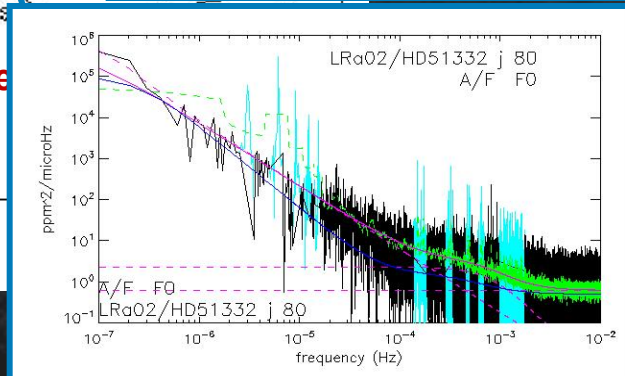


Intermediate mass stars – Intro.

What have we achieved and with which data ?

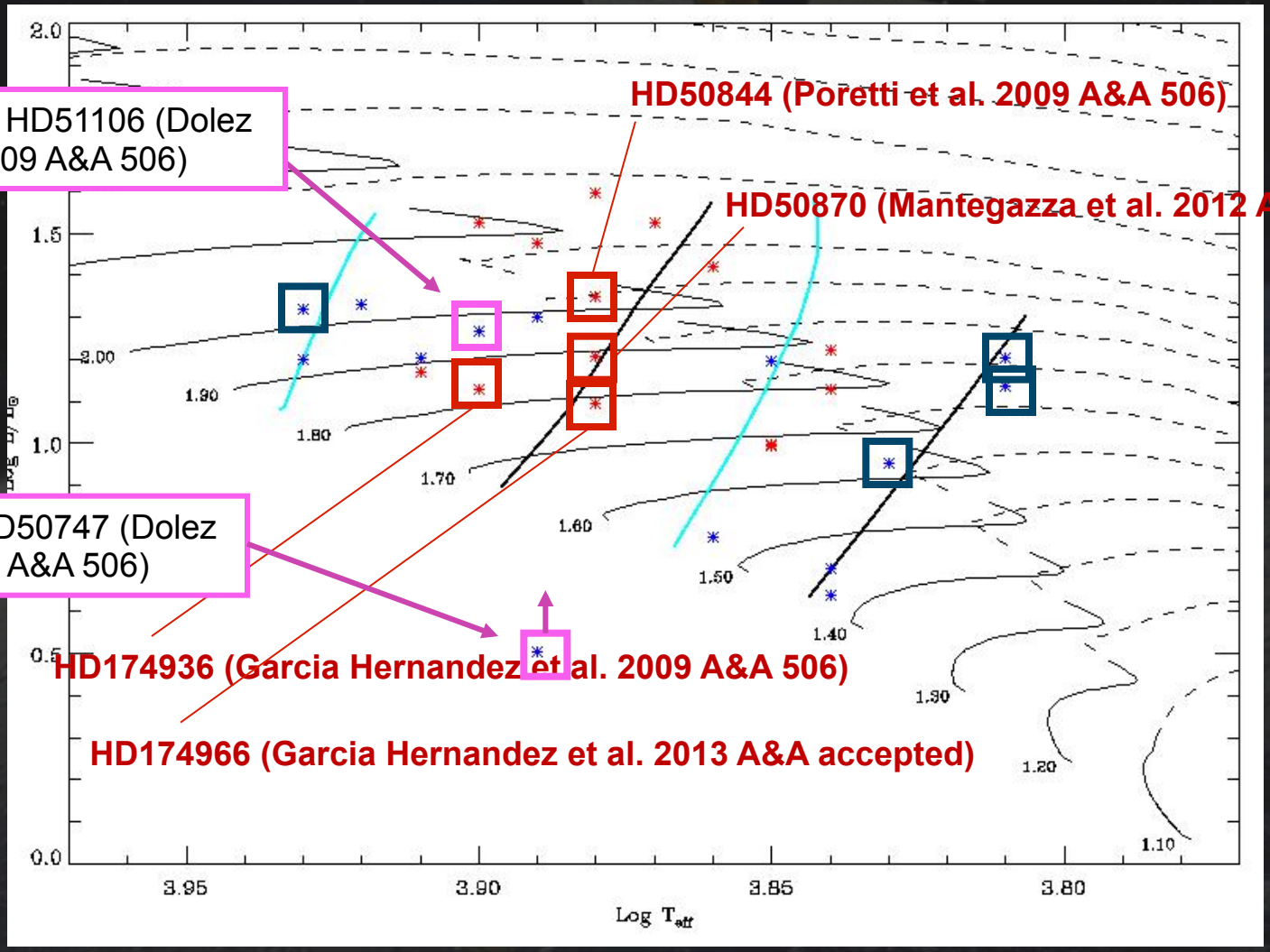




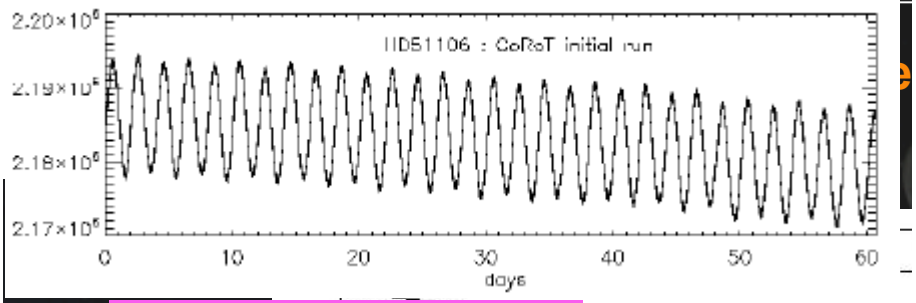


Intermediate mass stars – Intro.

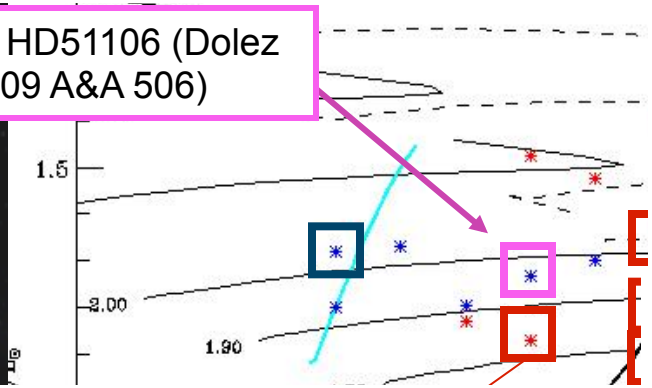
What have we achieved and with which data ?

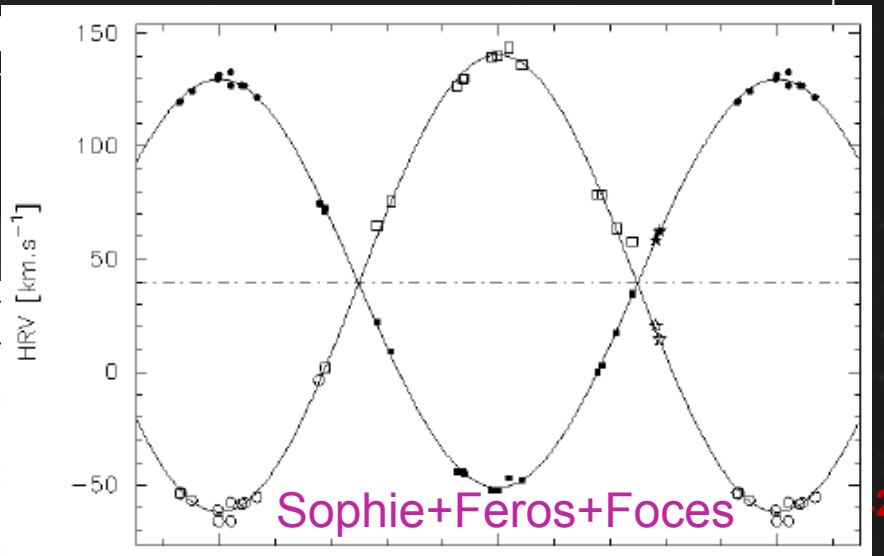


Intermediate mass st



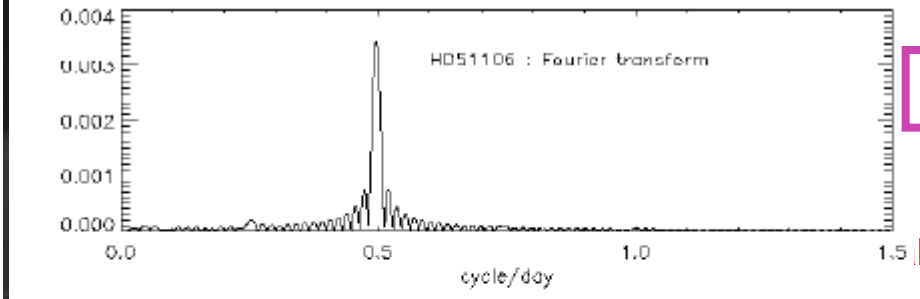
Am star HD51106 (Dolez et al. 2009 A&A 506)



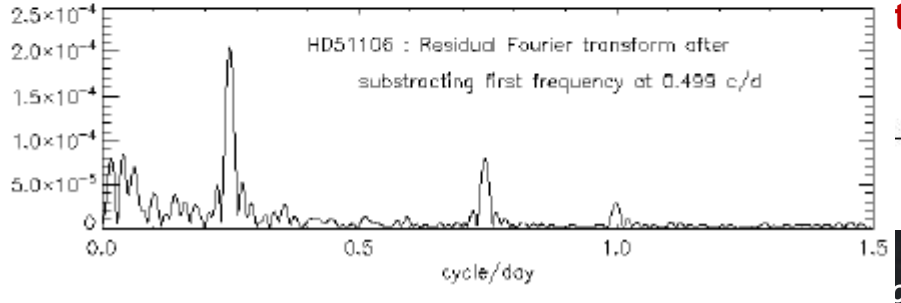


$$M_1 \sin^3 i = 1.55 \pm 0.02\ M_\odot$$
$$M_2 \sin^3 i = 1.38 \pm 0.02\ M_\odot$$

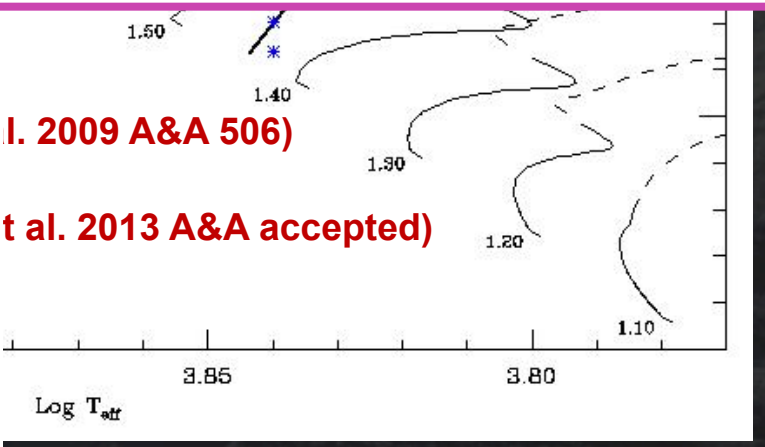
2 Am stars showing Ellipsoidal variation



l. 2009 A&A 506)

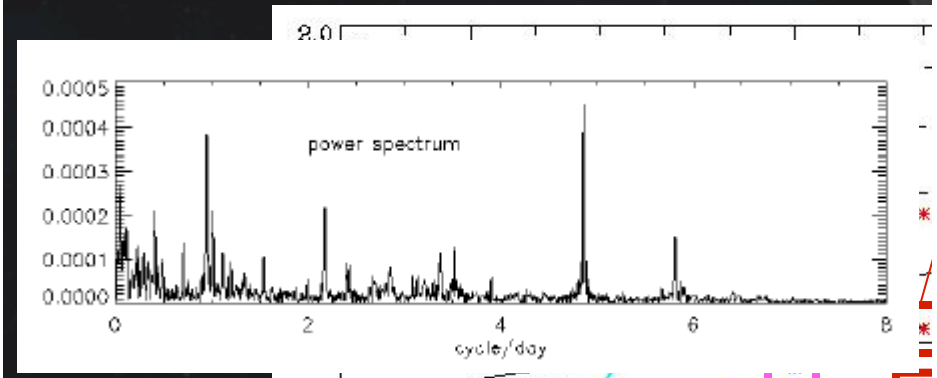


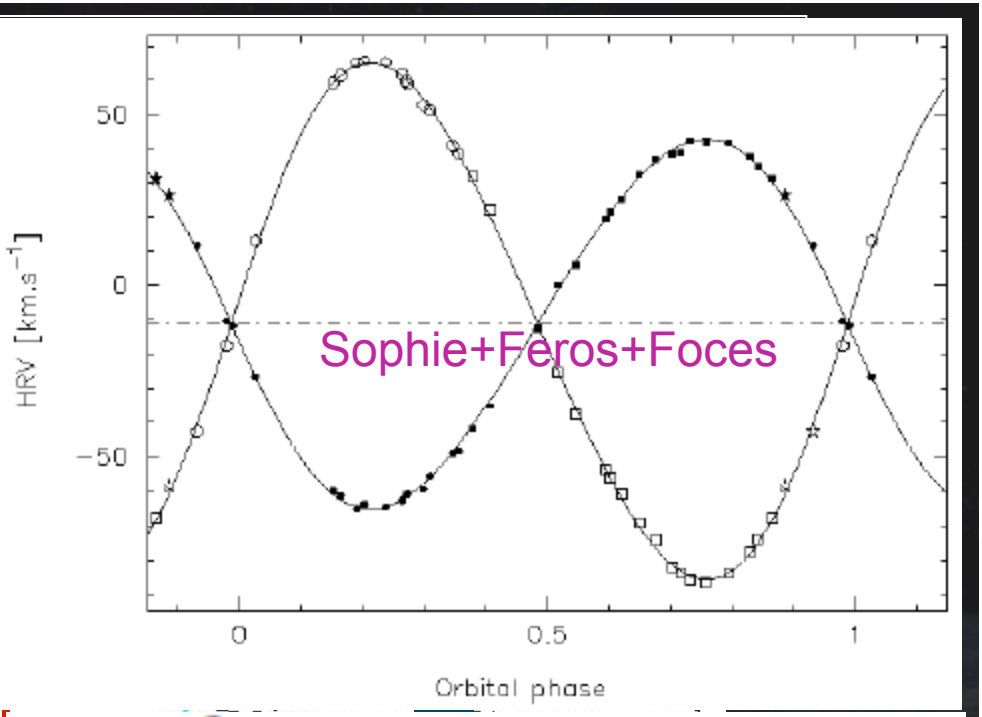
t al. 2013 A&A accepted)



Intermediate mass sta

What have we

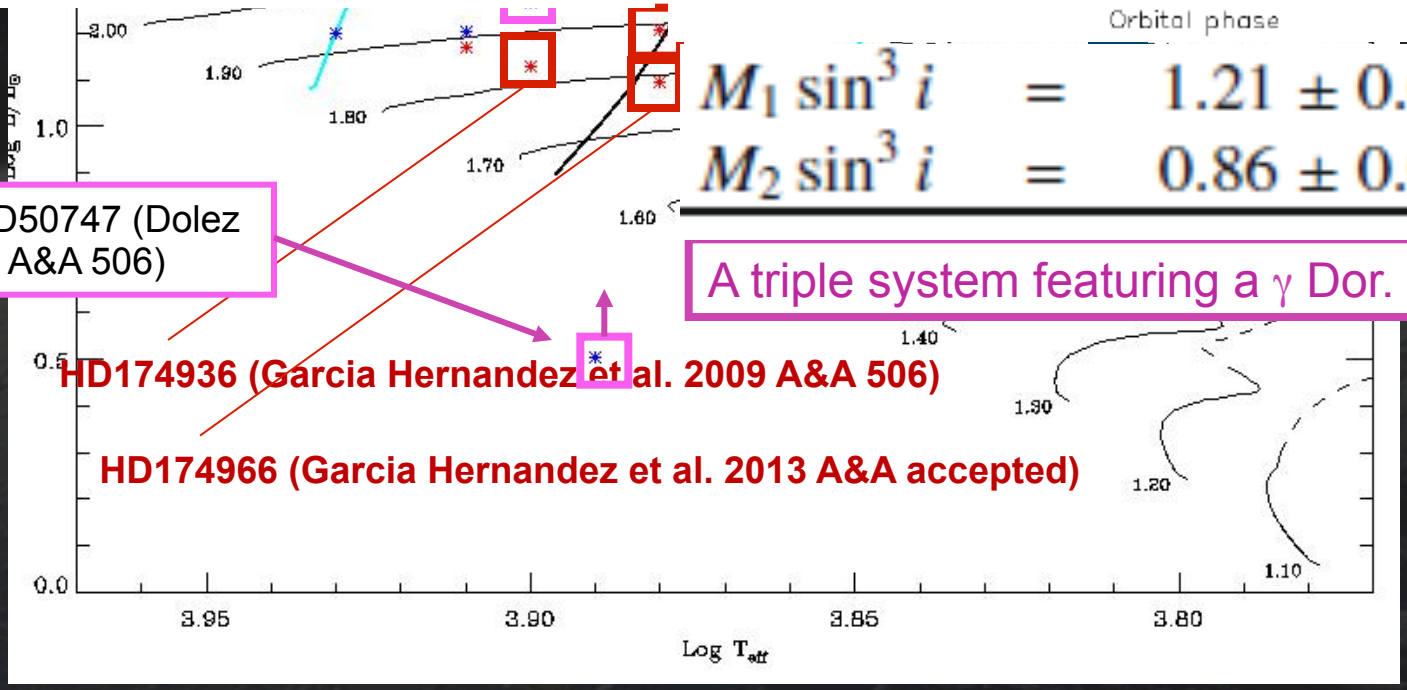




$$M_1 \sin^3 i = 1.21 \pm 0.01\ M_\odot$$
$$M_2 \sin^3 i = 0.86 \pm 0.01\ M_\odot$$

Am star HD50747 (Dolez et al. 2009 A&A 506)

A triple system featuring a γ Dor.

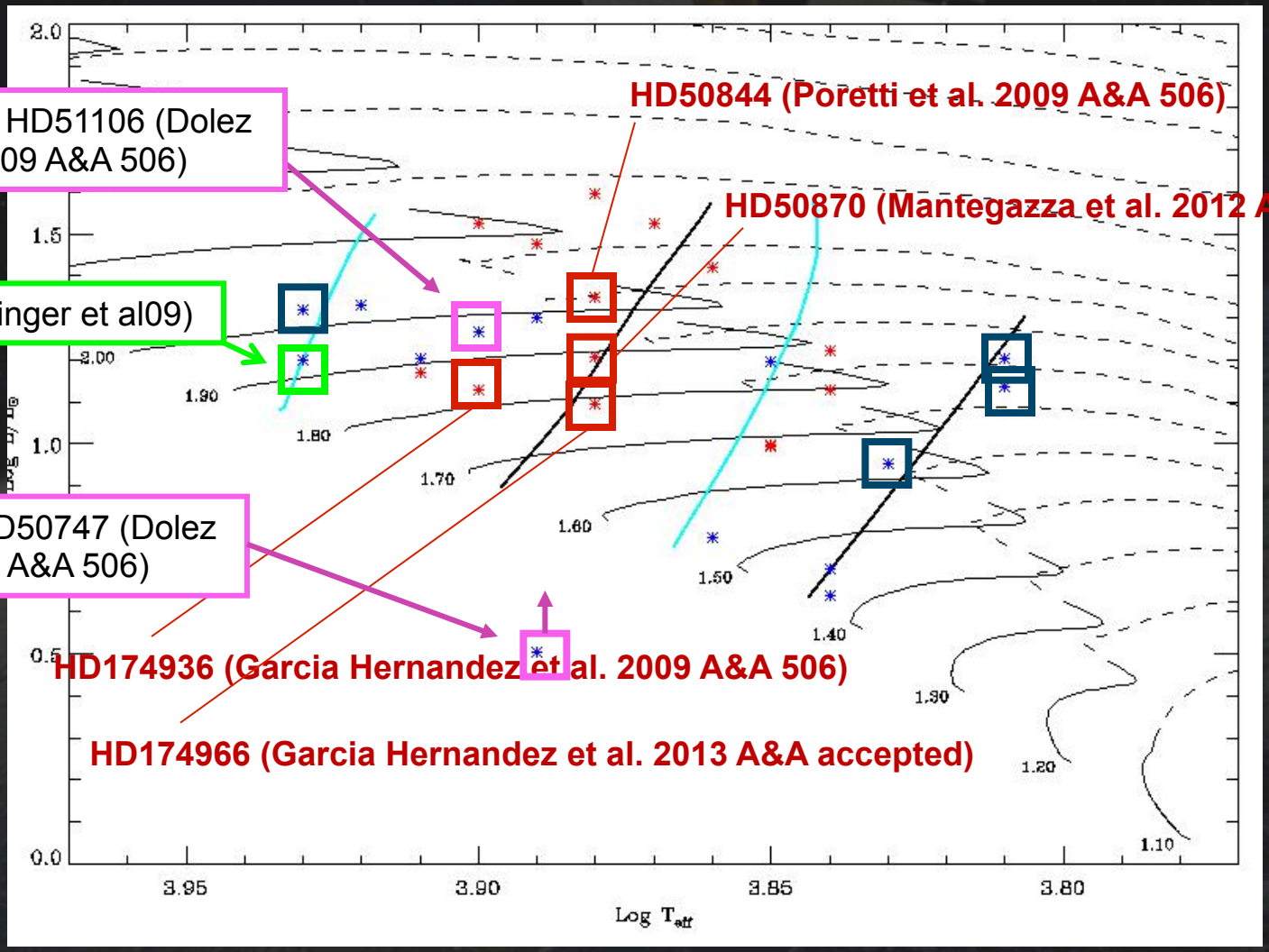


HD174936 (Garcia Hernandez et al. 2009 A&A 506)

HD174966 (Garcia Hernandez et al. 2013 A&A accepted)

Intermediate mass stars – Intro.

What have we achieved and with which data ?



Intermediate mass stars – Intro.

What have we achieved and with which data ?

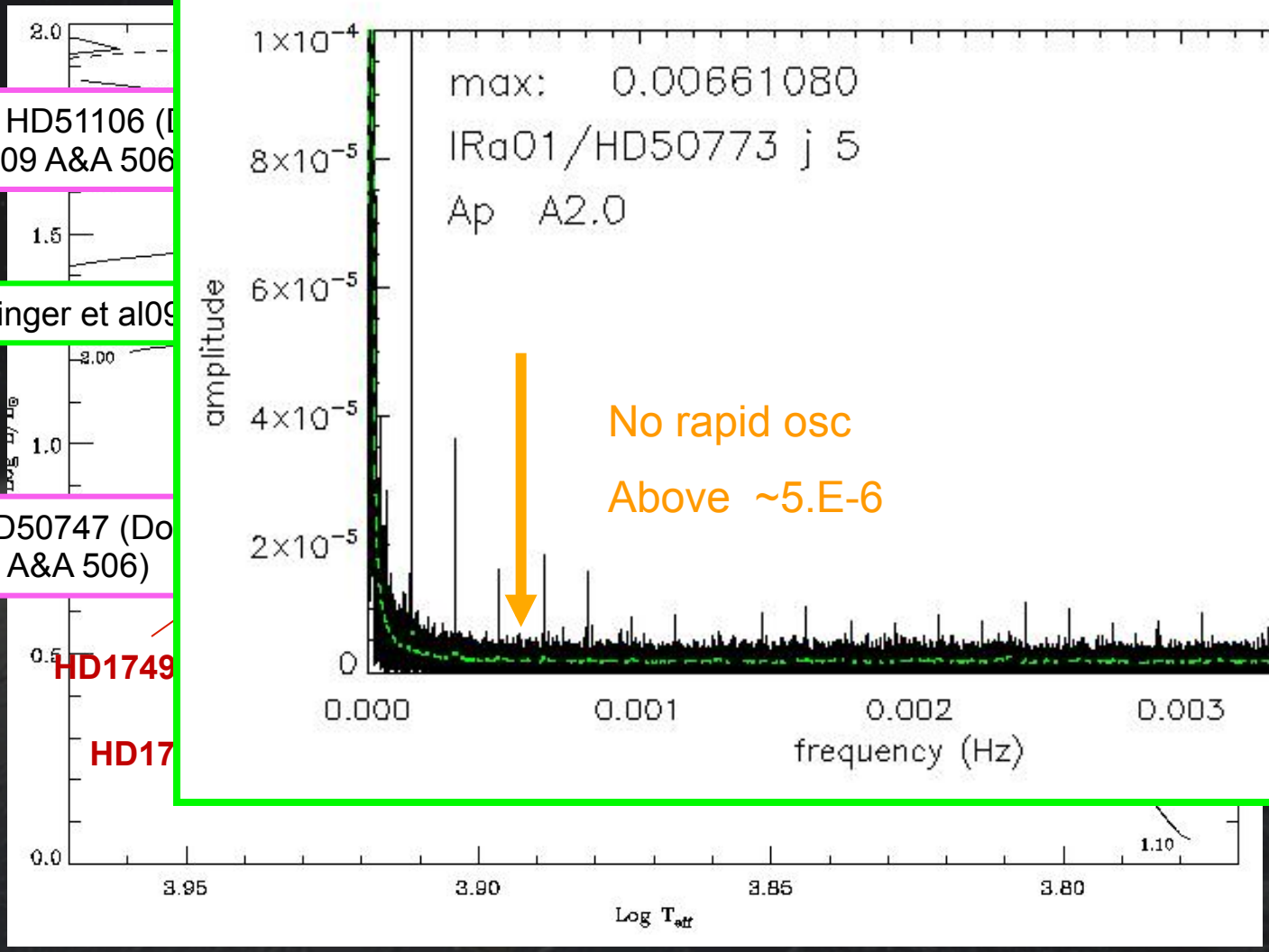
Am star HD51106 (
et al. 2009 A&A 506

CP star (Luftinger et al0

Am star HD50747 (Do
et al. 2009 A&A 506)

HD1749

HD17



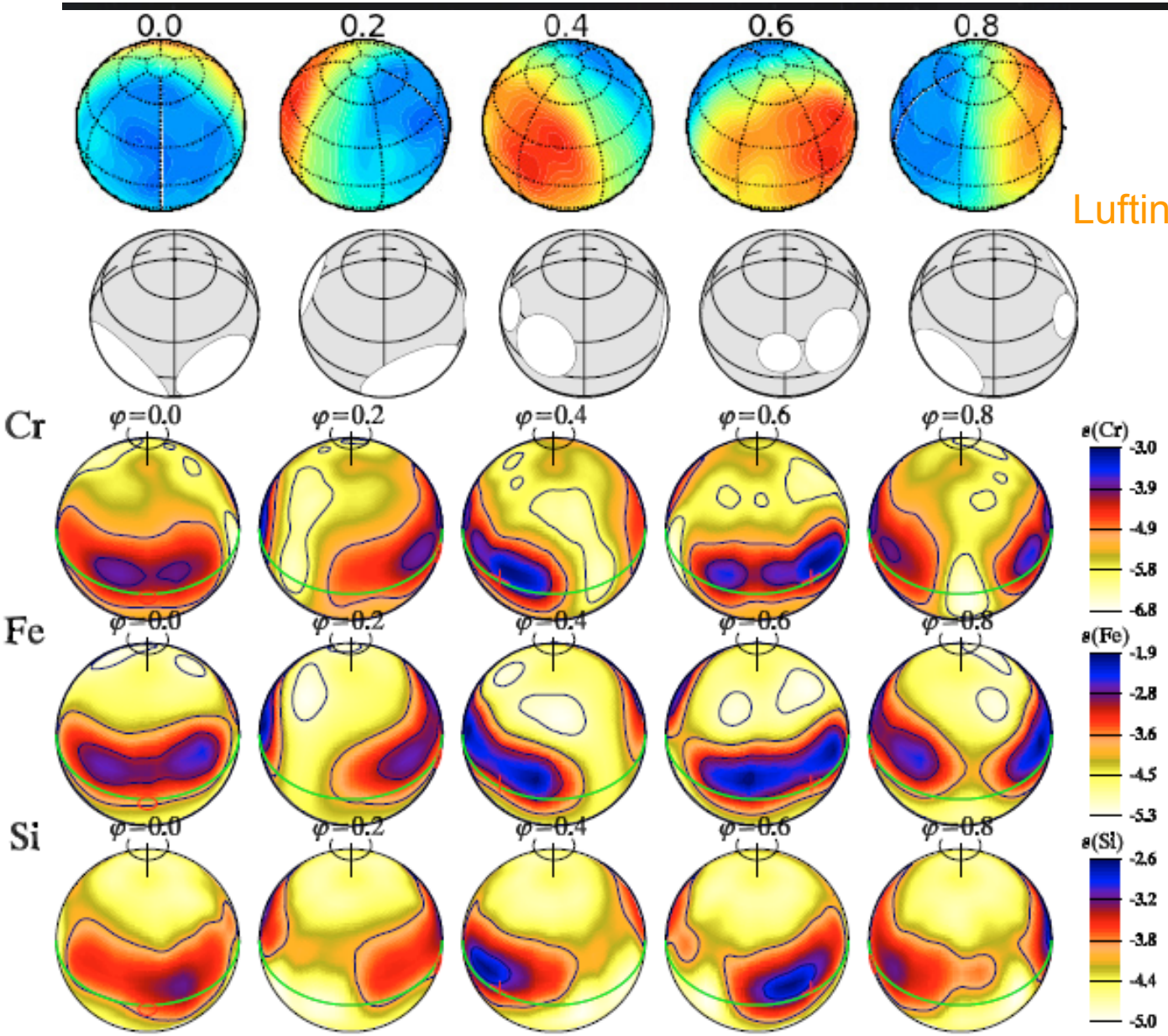
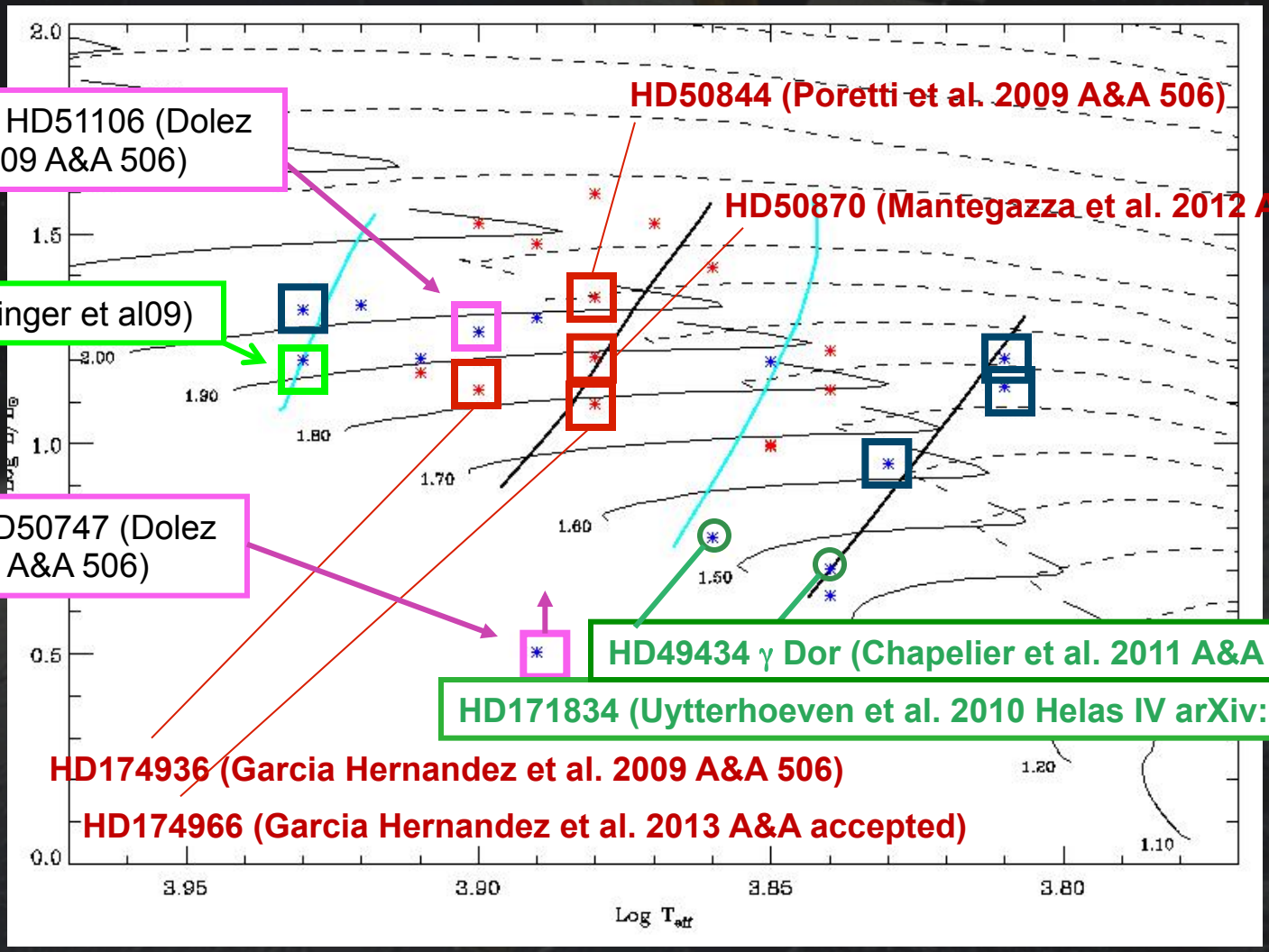


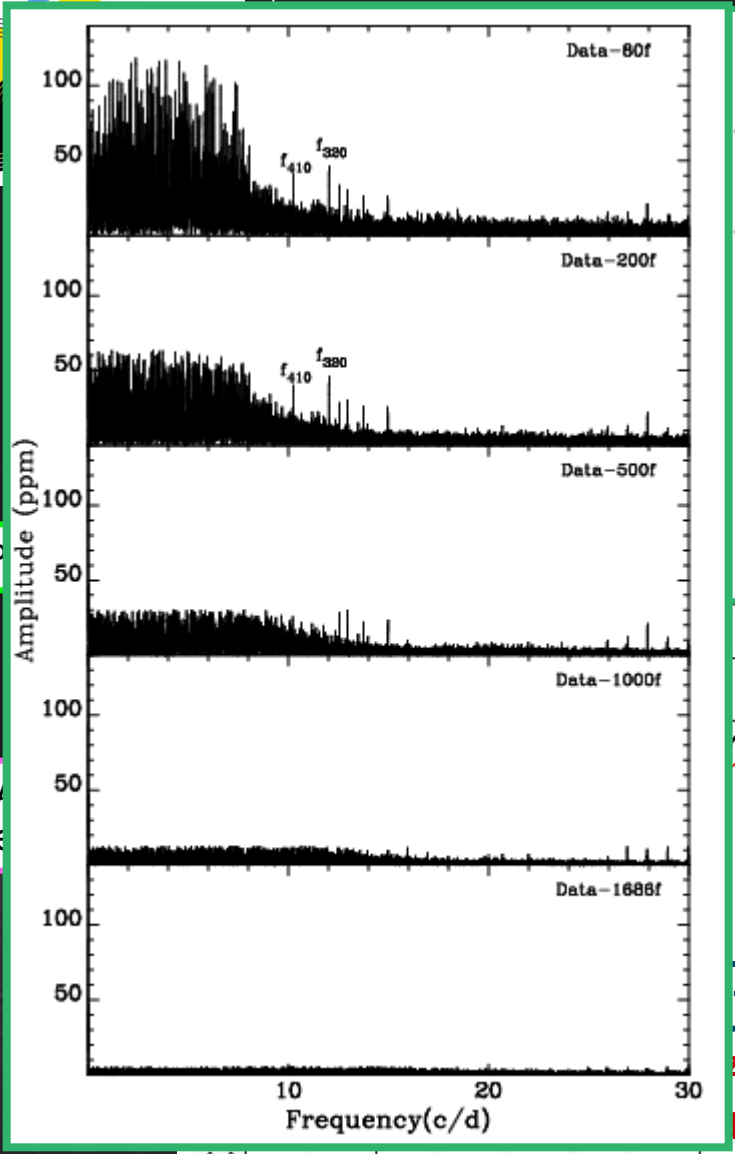
Fig. 7. *Top panel*: radial field component of the magnetic map of HD 50773 (as described in Sect. 5). *Second panel*: locations of the four bright photometric spots, assumed to be of circular shape. Next three panels: abundance distribution of Cr, Fe, and Si at the surface of HD 50773 obtained from the lines listed in Table 6. We show the star at an inclination $i = 40°$. Darker areas in the plots correspond to higher elemental abundances, the corresponding scale is given to *the right of each panel*, and the contours of equal abundance are plotted with steps of 1.0 dex. The circle and the cross indicate the position of the negative and the positive magnetic pole, respectively. All projections are plotted at five equidistant rotation

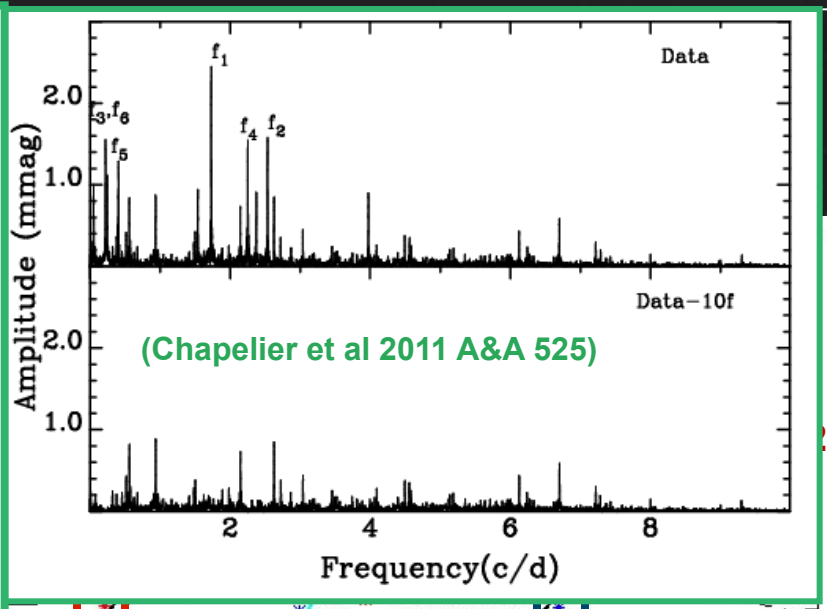
Intermediate mass stars – Intro.

What have we achieved and with which data ?



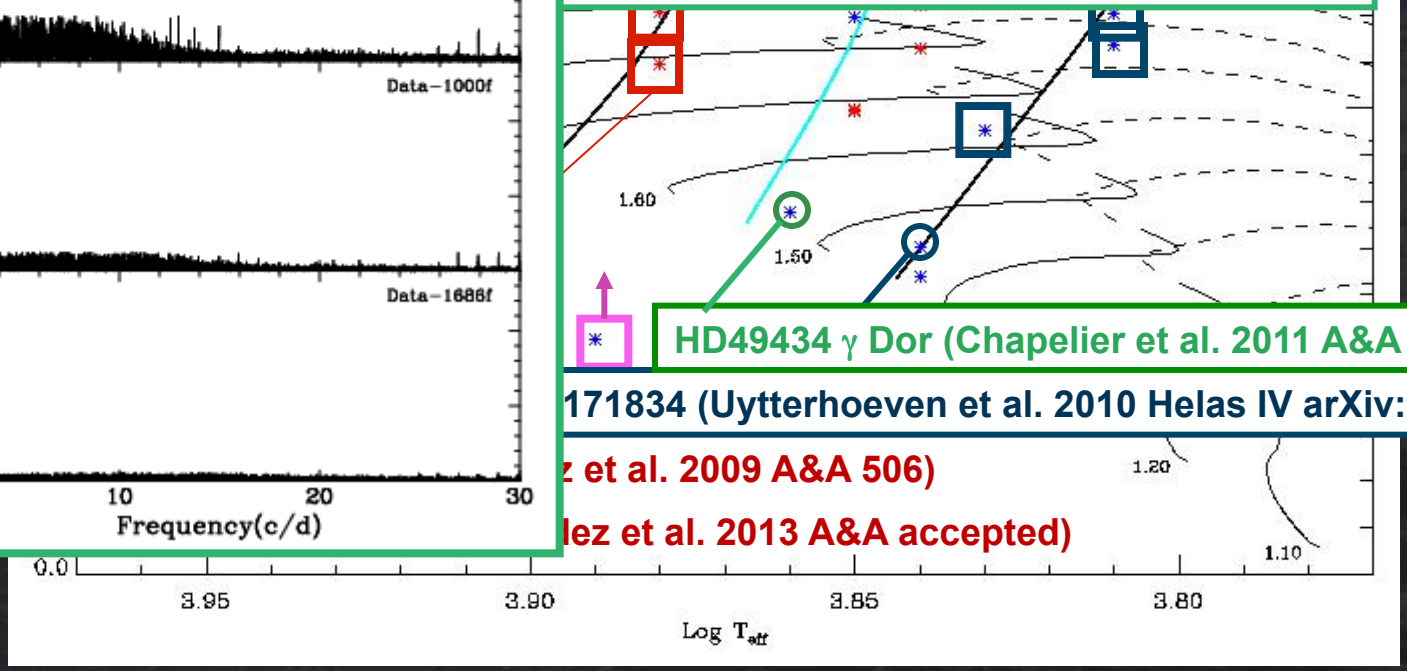
Intermediate mass stars – Intro.





(Chapelier et al 2011 A&A 525)

A&A 542)



HD49434 γ Dor (Chapelier et al. 2011 A&A 525)

171834 (Uytterhoeven et al. 2010 Helas IV arXiv:1111.1840)

et al. 2009 A&A 506)

lez et al. 2013 A&A accepted)

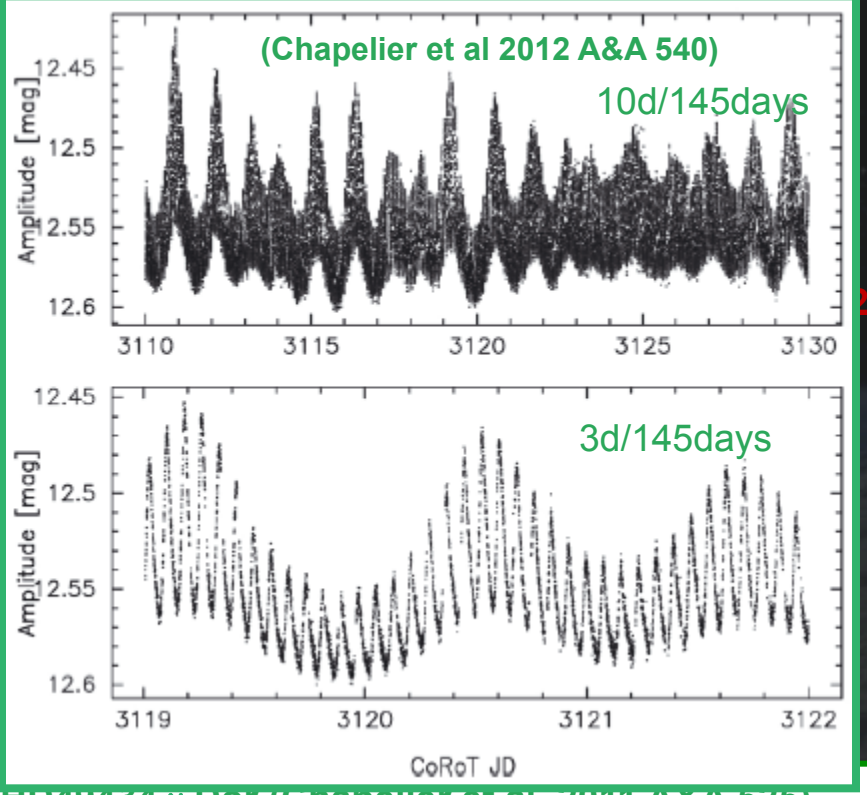
Intermediate mass stars – Intro.

What have we achieved and with which data ?

Rich spectrum

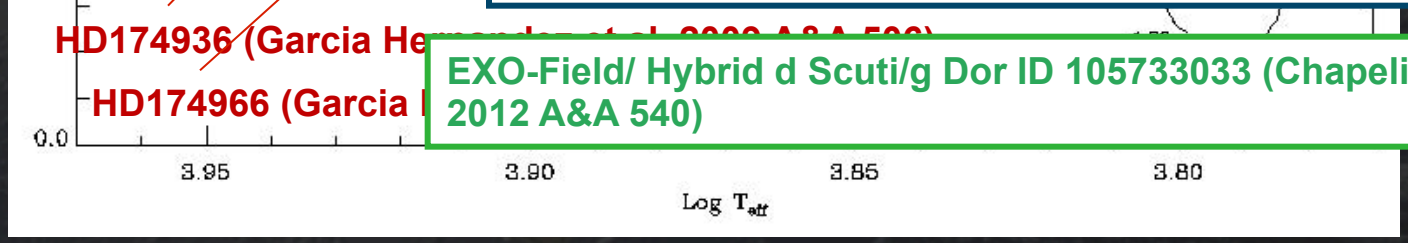
- 198 peaks in γ Dor domain ~[3-45μHz]
  - → 180 'independents', 24 regularly spaced (dP=44.27mn)
  - → same l g-modes
- 246 peaks in δ Sc. Domain ~[115-730]
  - → 59 'independents' and 146 peaks fp= kF+/-fi (F 'radial fund.', fi: strongest g modes)

→ 'long term modulation of the p modes cavity by g modes'



HD49434 γ Dor (Chapelier et al. 2011 A&A 525)

HD171834 (Uytterhoeven et al. 2010 Helas IV arXiv:1111.1840)



EXO-Field/ Hybrid d Scuti/g Dor ID 105733033 (Chapelier et al. 2012 A&A 540)

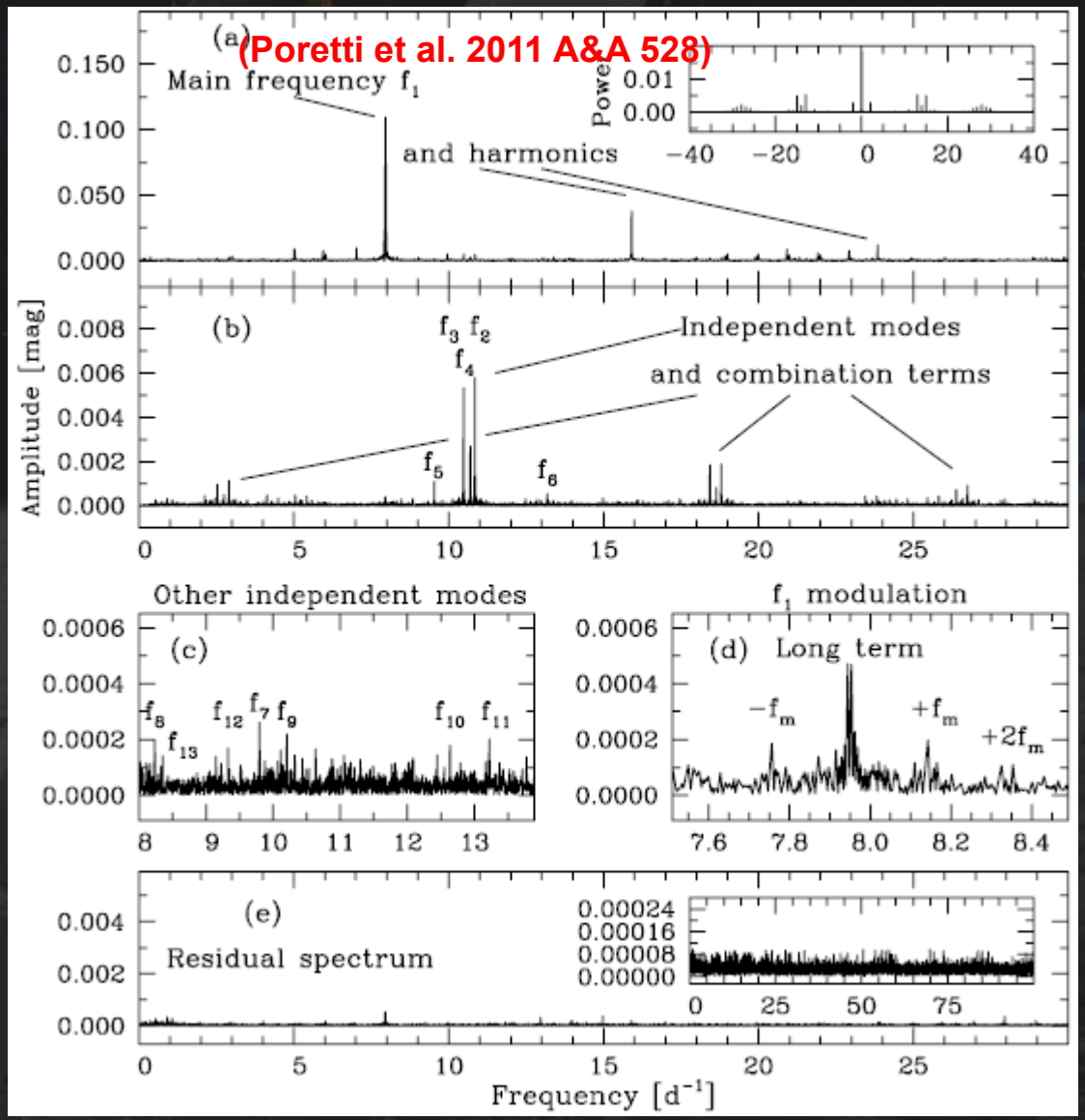
Intermediate mass stars – Intro.

What have we achieved and with which data ?

- **In the EXO-field:**

HADS CoRoT-101155310
152days and noise level ~3x10-5

- One main peak+ up to the 10th harmonics
- 12 independent peaks + combination terms → non radial modes
- Multiplets fm → amplitude modulation of F1…



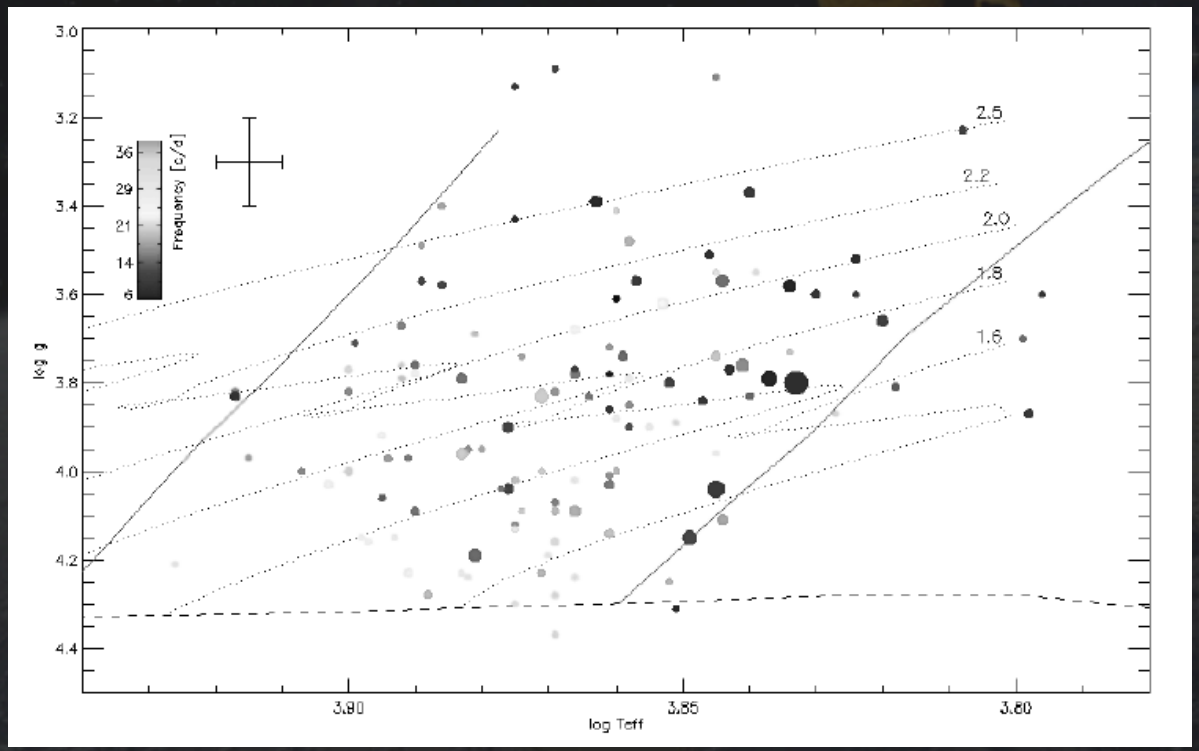
Intermediate mass stars – Intro.

What have we achieved and with which data ?

- In the EXO-field:

  CI: ‘ …the results fit well with these (blue theoretical and red obs) borders’

  ν_{max}: [60-400μHz] A_{max}: [10-4 to a few 10-2]



Kaiser et al. 09: CoRoT/IR01: 10000 stars -(CVC, Debossher et al. 2009)------>397 ‘δ Scuti’ ->127 new with fund parameters

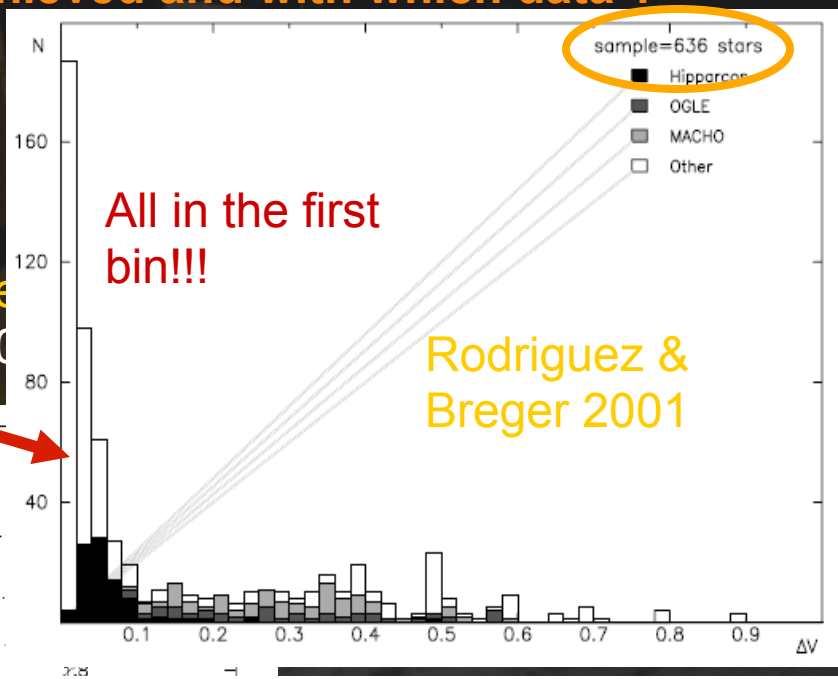
Intermediate mass stars – Intro.

What have we achieved and with which data ?

- **A wealth of new pulsating members:**

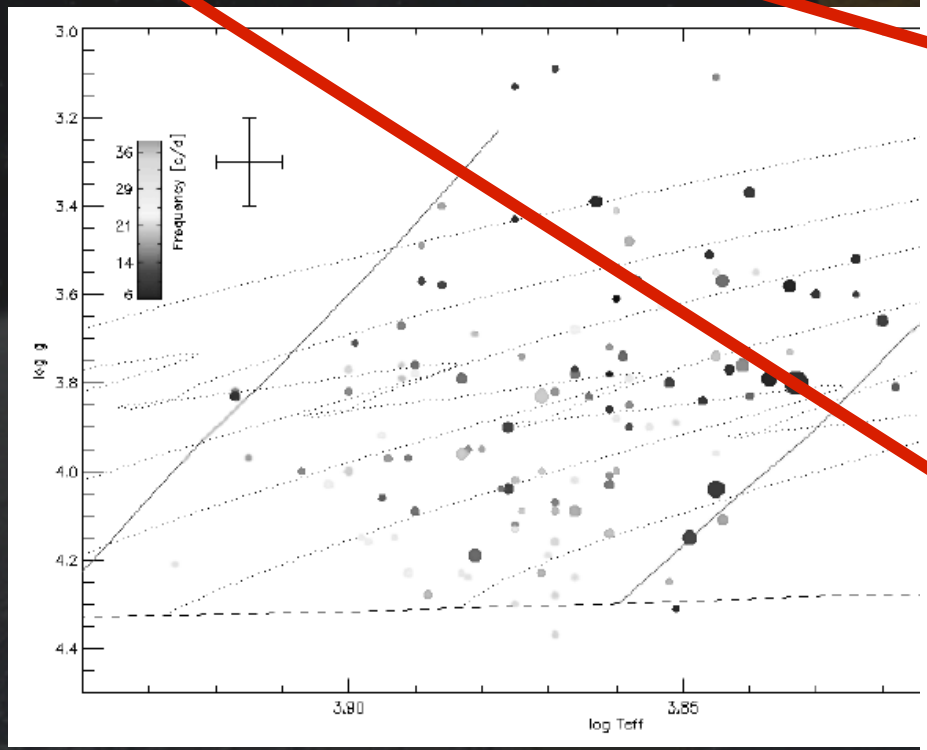
CI: ‘ …the results fit well with these (blue the

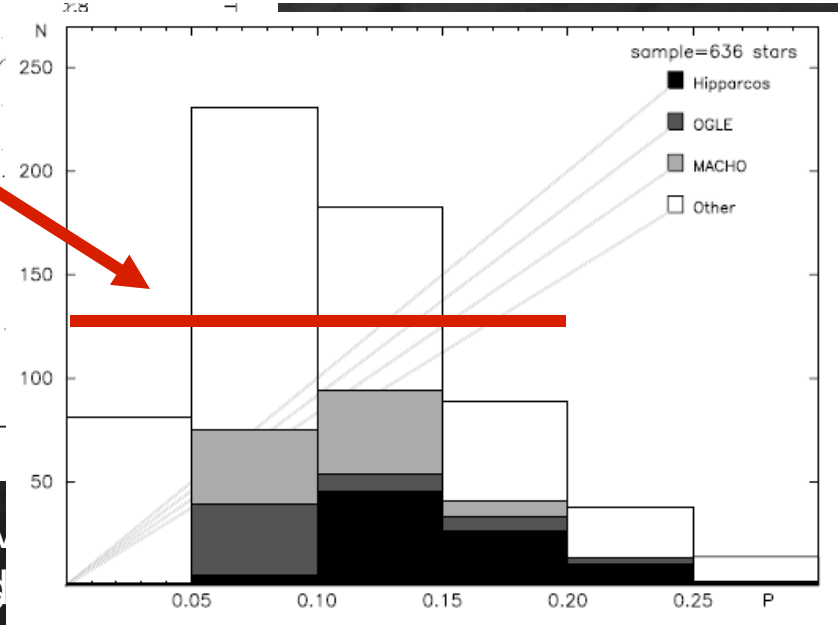
ν_{max}: [60-400μHz] A_{max}: [10-4 to a few 10



All in the first bin!!!

Rodriguez & Breger 2001





Kaiser et al. 09: CoRoT/IR01: 10000 stars -(CV

2009)------->397 ‘δ Scuti’ ->127 new with fund

Eric Michel, 06

Intermediate mass stars – Intro.

What can we foresee with data available now?

- ~4 analysis of individual δ stars on their way: 2 observed two times separated by a few years, one in an eclipsing binary, …
- Regular spacing possibly used as seismic index to help characterizing objects for which other fundamental parameters are poorly determined and interpreted.
- Possibility to measure precisely amplitudes…possible progress in mechanism limiting amplitudes?
- Recognize signature of rotation in oscillation spectra…
- …

Intermediate mass stars – Intro.

What would we need in the furture?

- We need to connect observations with theoretical works

- A slowly rotating δ Scuti star…
- Precise multi-colours photometric times series or long uninterrupted LPV series…
- Stars in clusters or eclipsing binaries…
- …
- Investigate features to be used as seismic indices, to allow large sample studies
- Investigate amplitudes statistics and energetics of the oscillations, selection mecanism…
- …
- Intelligence or by default Luck
- …

And at last…

- A good restaurant for Rafa to invite me…