Benchmark stars for PLATO: an introduction

Objectives of session:

- Agree on definition of benchmark stars for PLATO
- Define selection criteria
- Organisation scheme: a dedicated WP?
- Aims and scope of WP (if any): only collects information or plays an active part in data gathering?

Benchmark stars for PLATO: definition

Usefulness:

Assessing *accuracy* of PLATO products (stellar mass, radius, …) and diagnosing systematic errors.

Definition:

'Star whose properties can be accurately determined using a minimum of theoretical assumptions (i.e., as much model independent as possible), preferably only geometry and Newtonian mechanics'

Counterexample: star with exquisite seismic parameters prior to PLATO launch (e.g., from *Kepler*). Extremely useful for verification purposes but *not* a bona fide benchmark star.

General considerations

- PLATO aims at σR~1-2%, σM~5%, σAge~10%:
  Properties of benchmark stars should be known to (at least) a similar level of accuracy

- Appropriate coverage of the parameter space (Teff, evolutionary status, [Fe/H], …) needed:
  Large number required

- Need to be observed by PLATO from the very beginning to quickly identify data defects and/or flaws in pipelines, and correct them as data are being collected:
  First long-duration run should contain a sufficient number of benchmark stars

- Many more benchmark stars will be identified during development and operation phases (e.g., from long-baseline interferometry):
  Highly dynamical sample bound to quickly evolve

Some benchmark categories

Interferometric targets

Provide: accurate estimates of radius (+ Teff and L)
Needed: angular diameter from interferometric measurements and accurate distance (+ absolute spectrophotometry for Teff and L)
Limitations of technique:
for radius: limb-darkening corrections, calibration issues, …
for Teff and L: reddening, …

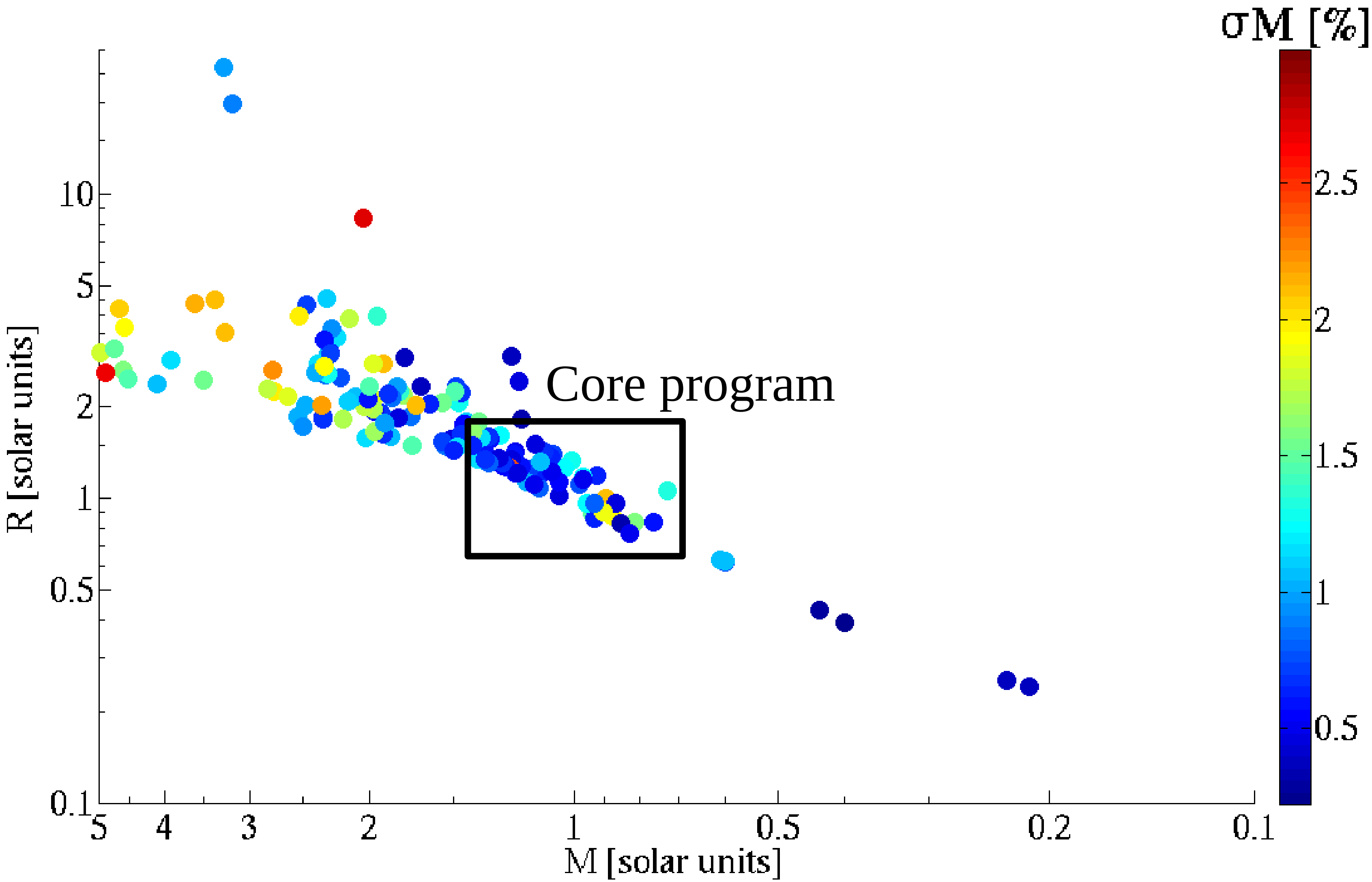
Binaries with interferometric orbits

Provide: total or individual dynamical mass of binary components (typically to ~5-10%; e.g., Appourchaux et al. 2015).
Needed: astrometric orbit from interferometry (+ SB2 RV curve for individual masses)
Limitations of technique: only total mass if no RV curve + only suitable for relatively narrow range of orbital periods

Detached, eclipsing binaries

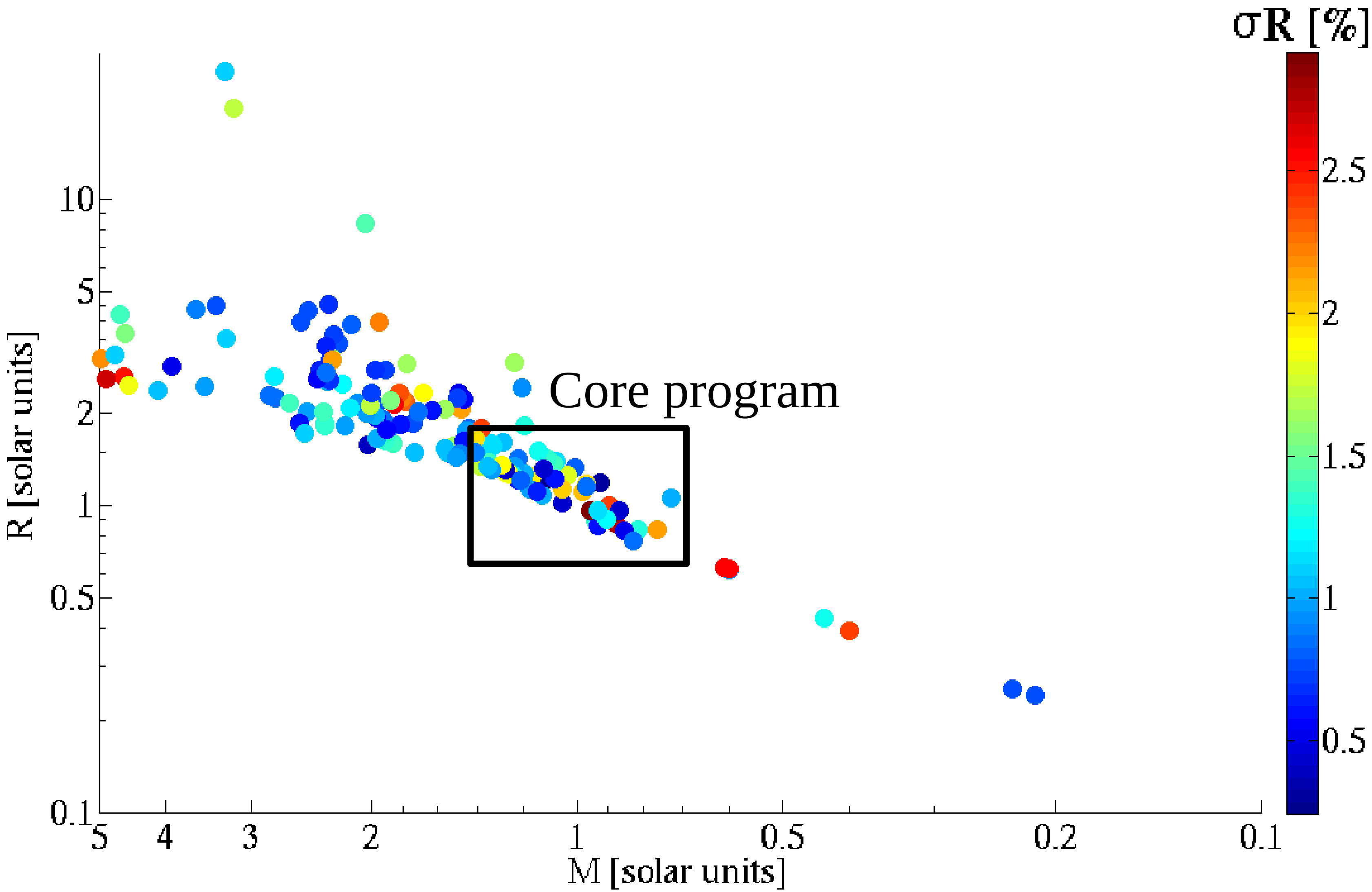
Provide: accurate estimates of mass and radius
Needed: light curve and SB2 RV orbit

Detached, eclipsing binaries



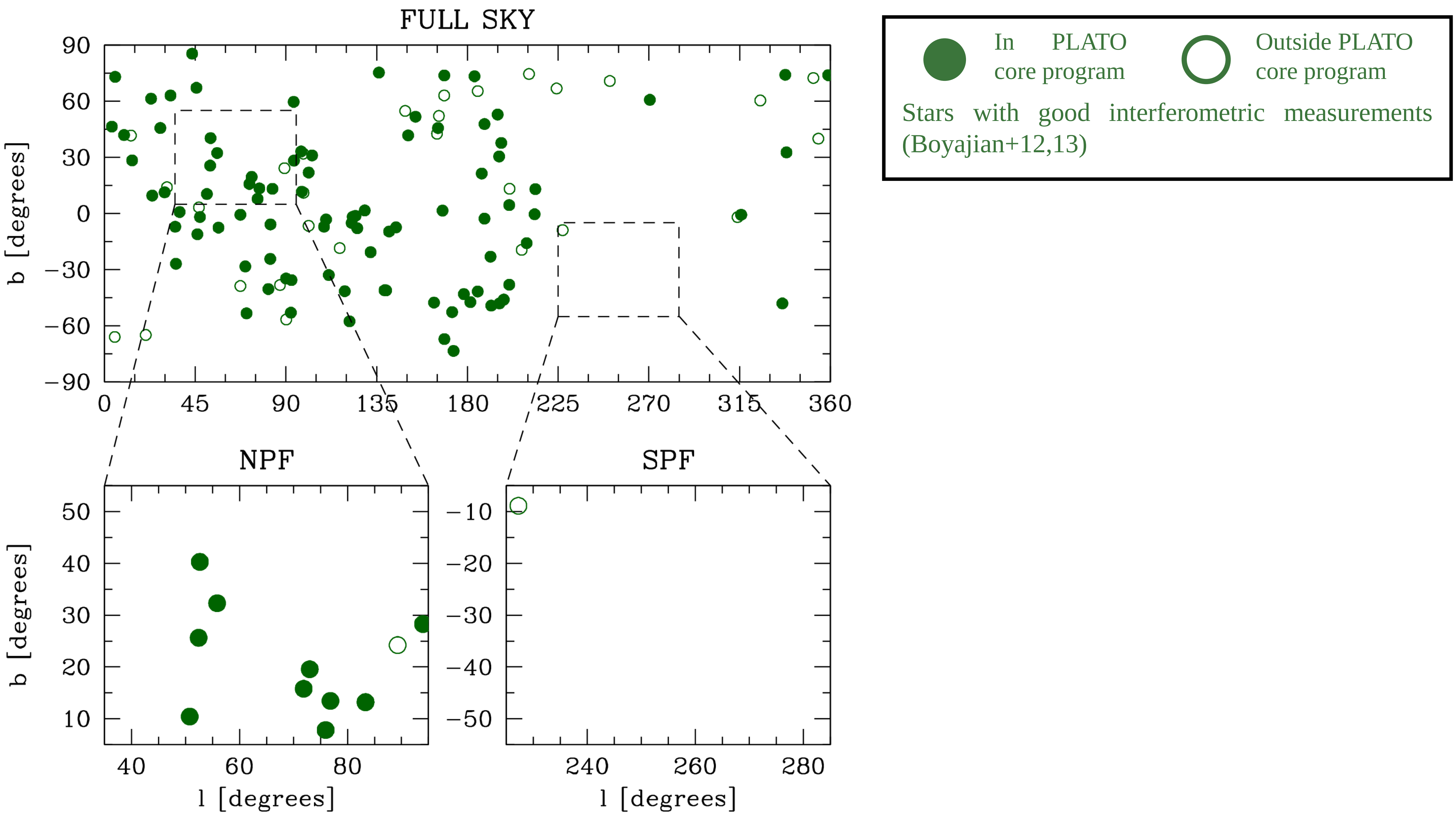
Data from Torres et al. (2010)

Detached, eclipsing binaries

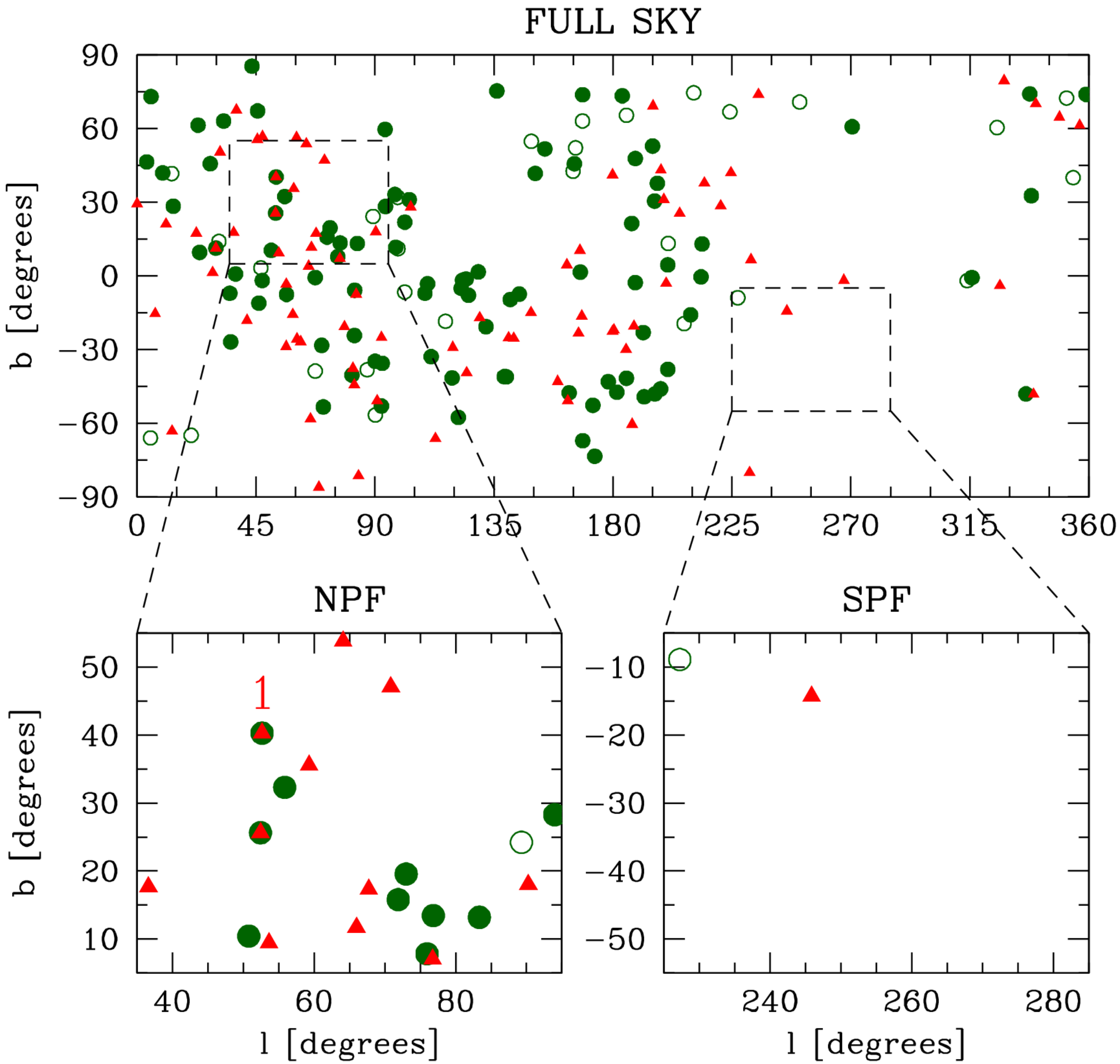


Data from Torres et al. (2010)

Benchmark stars in long-duration PLATO fields



Benchmark stars in long-duration PLATO fields



In PLATO core program — Outside PLATO core program

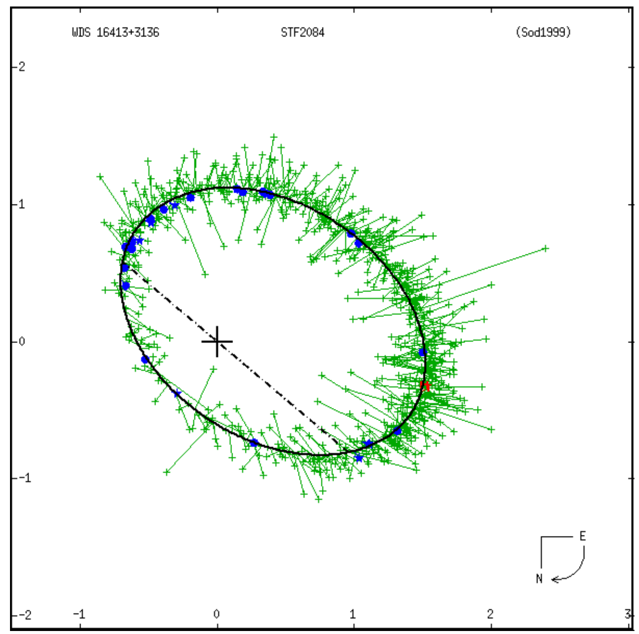
Stars with good interferometric measurements (Boyajian+12,13)

Systems with 'definitive' interferometric orbits in ORB6 catalogue

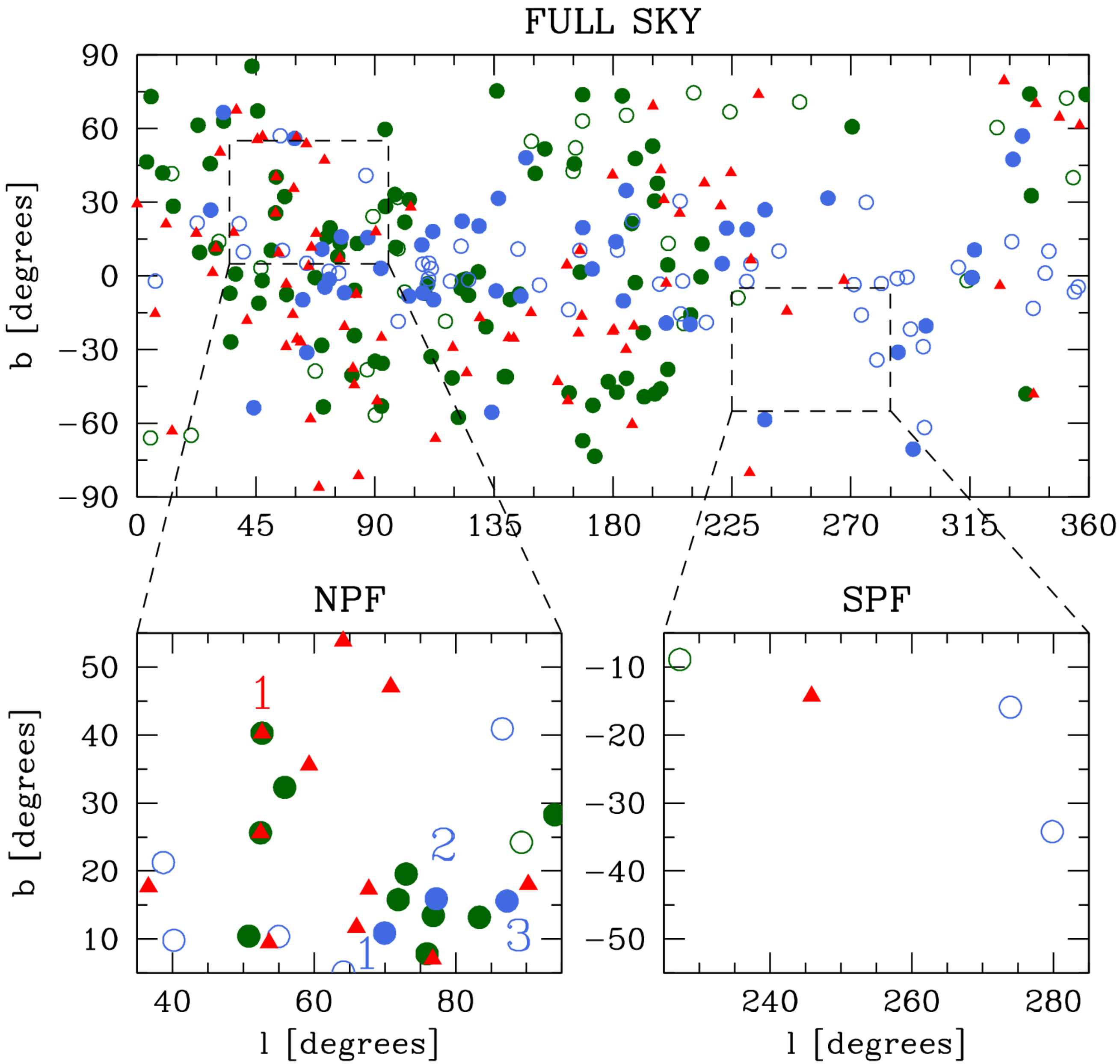
#1 ζ Her (Morel+01)

G0 IV + G7 V, *V*~3.5 and 6.3

σM~11 and 8%



Benchmark stars in long-duration PLATO fields



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Outside PLATO core program

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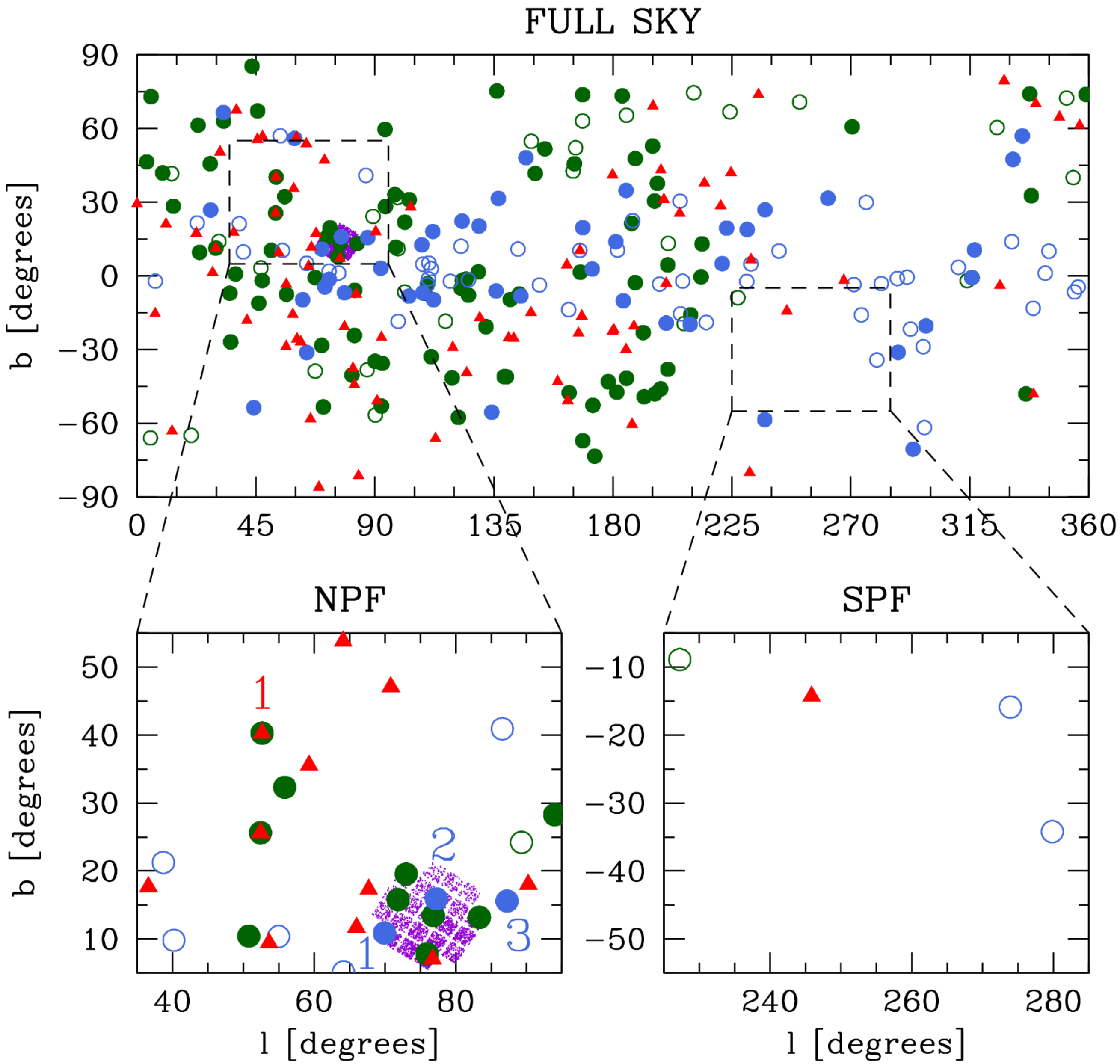
Well-characterised EBs (Torres+10)

#1 V568 Lyr, KIC 2437452
G5V + K3V, *V*~17-18
σM and σR~1%
WAY TOO FAINT!

#2 FL Lyr, KIC 9641031
F8V + G8V, *V*~9-10
σM~1.3% and σR~2.5%

#3 V1143 Cyg
F5V + F5V, *V*~6
σM~1.3% and σR~1.7%

Benchmark stars in long-duration PLATO fields



In PLATO core program
Outside PLATO core program

Stars with good interferometric measurements (Boyajian+12,13)

Systems with ‘definitive’ interferometric orbits in ORB6 catalogue

Well-characterised EBs (Torres+10)

EBs in Kepler field (Kirk+16)

KIC 6131659 (Bass+12)
G5V + K5V, *r*~12.5
σM and σR~1%

KIC 5952403 (Borkovits+13)
G5V + G7V, *V*~7
σM~3-5% and σR~1-3%

KIC 8410637 (Frandsen+13)
F7V+G8III, *V*~11
MS star: σM~1.3% and σR~2.0%

KIC 5023948 (Brewer+16)
F9V + F9V, *V*~17
σM and σR~1%
WAY TOO FAINT!

Some *personal* thoughts

What a (possible) WP dedicated to benchmark stars should be about?

- Maintain a continuously updated database containing accurate and largely model-independent stellar parameters: M, R, and Teff. Benchmarks for activity and metallicity best handled in relevant WPs (WP122 and WP123)?
- Only collect information? Or also play an active part in data gathering? (e.g., set up collaborations with long-baseline interferometric projects to have enough stars in long-duration fields with angular diameters)

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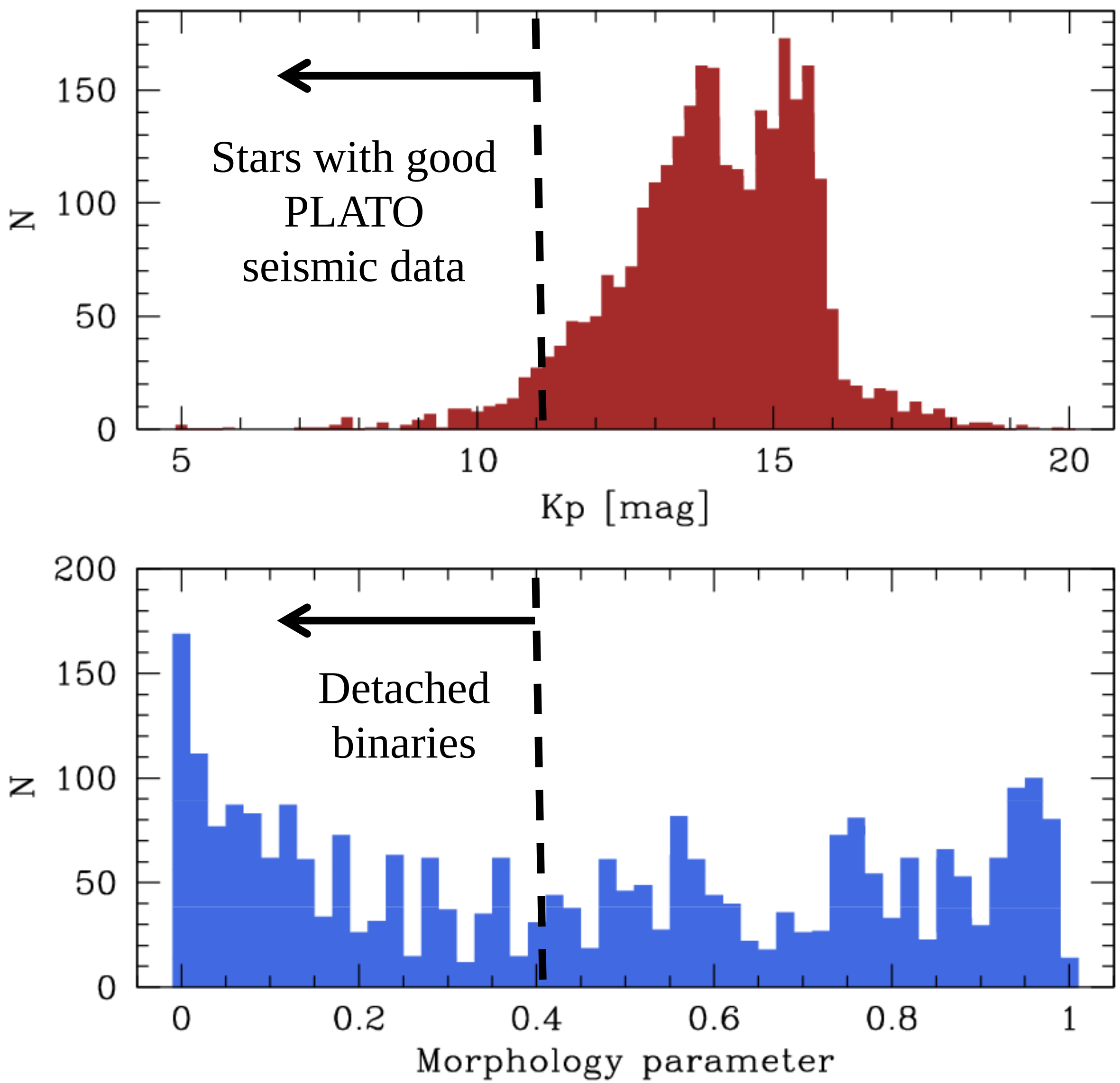
What *Gaia* will bring?

- **Accurate distances.** Given the dramatic advances in long-baseline interferometry, good prospects for a large sample of single stars with accurate radii. Some of them already in first long-duration PLATO field.
- **Significant increase in the number of binaries with astrometric orbits.** Coupled to precise ground-based RV monitoring, will lead to binary components with dynamical masses known down to ~1% (e.g., Halbwachs+14).
- **A catalogue of ~10^6 EBs.** If secondary detected in RVS data and RV curve of sufficient quality, can be coupled to PLATO light curve soon after start of operations to provide accurate M and R. Otherwise, carry out our own preparatory observations?

  pros: good science case, very interesting scientific project in its own right

  cons: possible lack of manpower/expertise, not clear how such activities would fit within PSPM

Eclipsing binaries in Kepler field

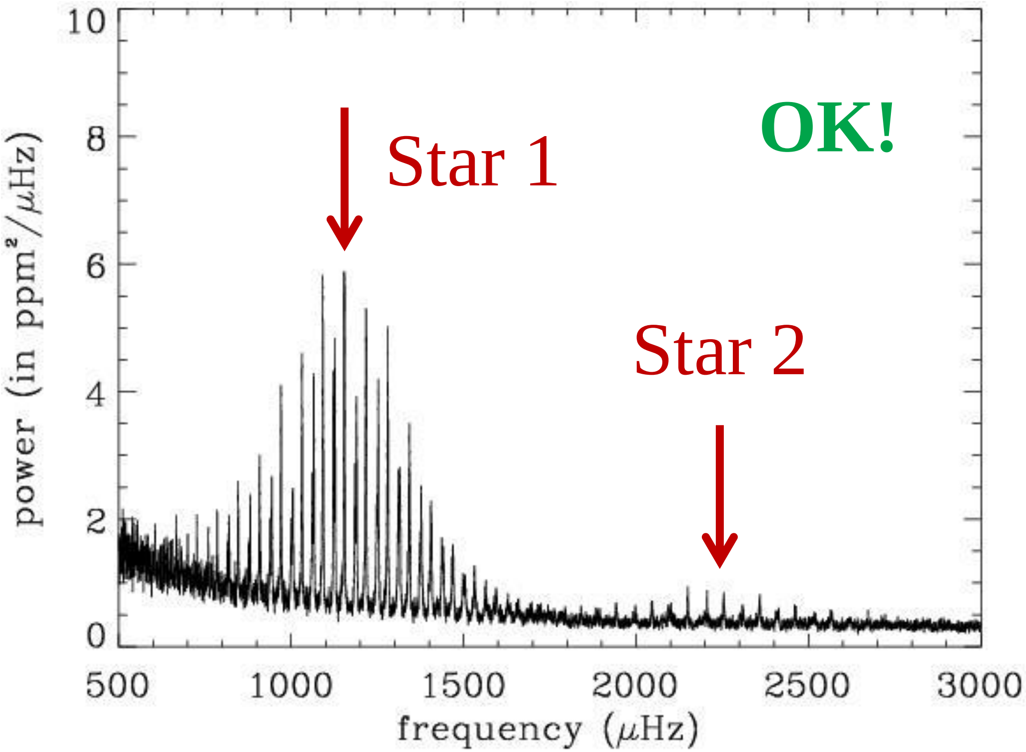


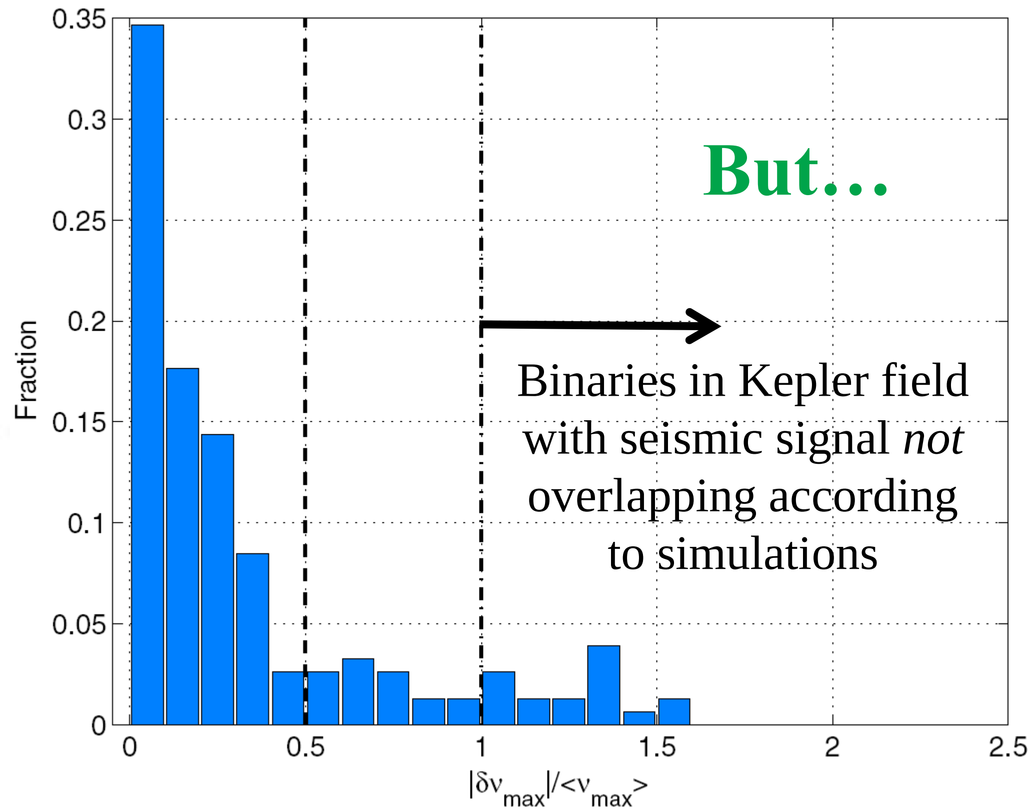
42 detached EBs with *V* < 11

RV monitoring and detailed analysis pending in most cases

Data from Kirk et al. (2016)

Analysis of seismic data for unresolved binaries sometimes difficult?





Appourchaux et al. (2015)

Miglio et al. (2014)