PLATO hare & hounds: mode frequency extraction

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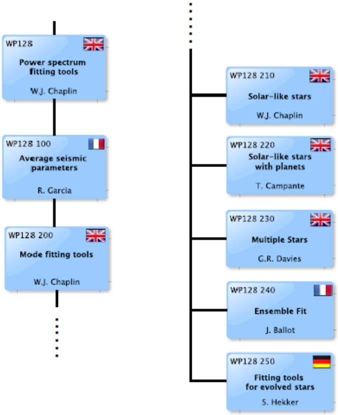
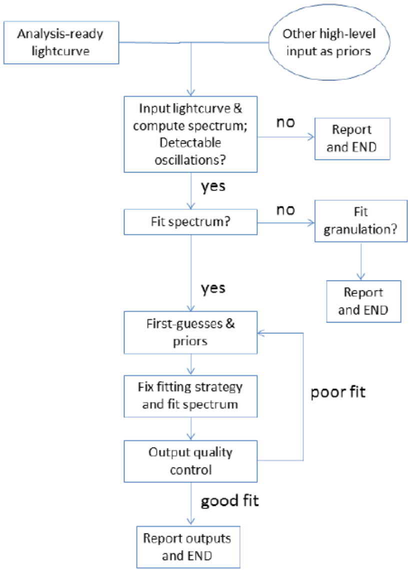
- Procedures and requirements to deliver asteroseismic parameters for solar-type stars
- Firm foundations to build on: *CoRoT* and *Kepler*
- Development of analysis methodologies and pipelines
- Challenges and work to be done are "known unknowns"




Analysis-ready lightcurve
Other high-level input as priors
Input lightcurve & compute spectrum; Detectable oscillations?
no
Report and END
yes
Fit spectrum?
no
Fit granulation?
Report and END
yes
First-guesses & priors
Fix fitting strategy and fit spectrum
poor fit
Output quality control
good fit
Report outputs and END

Inputs

- L1 light curves must be cleaned for:
  - Transits and eclipses
  - Rotational modulation of starspots and active regions
- Available data in the *PLATO* Input Catalog (PIC)

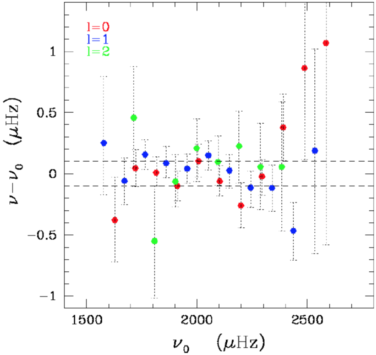
Outputs

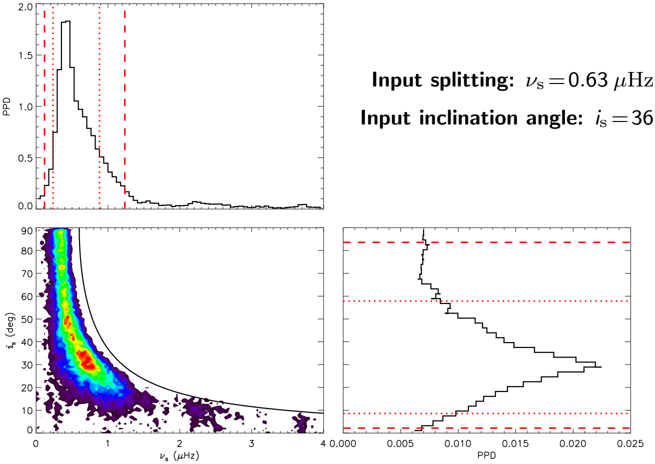
- Asteroseismic parameters:
  - Global parameters (including $\Delta\nu$ and ν_{max})
  - Individual mode parameters (frequencies, amplitudes, linewidths)
  - Other parameters (e.g., frequency splittings, stellar inclination angle, peak asymmetries)
- Granulation parameters
- Probability density functions of, and correlations between, parameters

- Front-to-end automation (see Guy's talk)
- Dealing with a range of intrinsic stellar properties and data quality
- Tensioning complexity of fitting model with data quality
- Validation of uncertainties/confidence intervals
- Tests using:
  - *CoRoT* and *Kepler* data
  - Artificial data (e.g., *PLATO* hare & hounds and AsteroFLAG data)

- Assess accuracy of seismic ages, masses and radii
- Studies use "analysis-ready" simulated light curves
- Noise characteristics follow *PLATO* specifications
- Focus placed on P1 core target stars (F5–K7, $V < 11$, 50-sec cadence)
- Analysis followed WP128 workflow prescription (having employed a Bayesian MCMC peak-bagging procedure)

- HH2a properties:
  - $M = 1.18\,\mathrm{M}_\odot$, $R = 1.34\,\mathrm{R}_\odot$, $t = 3.22$ Gyr
  - Non-standard assumptions concerning efficiency of convection and chemical composition
- $V = 10$ (corresponding to *PLATO* specification)
- $T_{\rm obs} = 24$ months
- **Take-home message:** specification of $\sim 0.1\ \mu$Hz precision near $\nu_{\max}$ satisfied

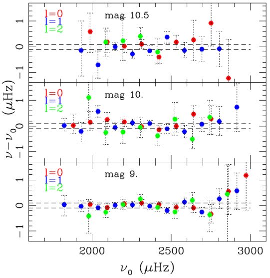


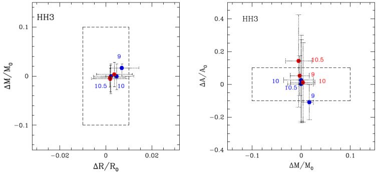


Input splitting: $\nu_{\rm s} = 0.63\ \mu{\rm Hz}$

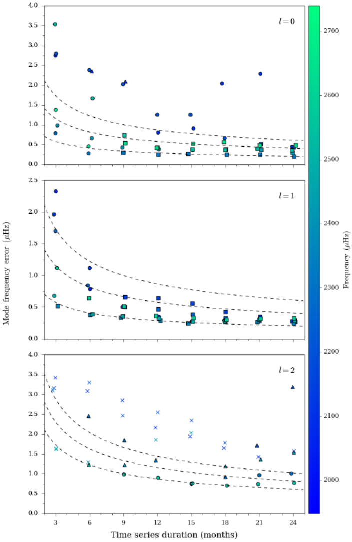
Input inclination angle: $i_{\rm s} = 36^\circ$

- HH2b properties:
  - $M = 1.12\,\mathrm{M}_\odot$, $R = 1.20\,\mathrm{R}_\odot$, $t = 3.44\,\mathrm{Gyr}$
  - Similar to *PLATO* reference star (i.e., a G0V star with $M = 1\,\mathrm{M}_\odot$, $R = 1\,\mathrm{R}_\odot$ and $T_{\mathrm{eff}} = 6000\,\mathrm{K}$)
- $V = \{9, 10, 10.5\}$
- $T_{\mathrm{obs}} = 24\,\mathrm{months}$
- **Take-home message:** number of modes and frequency precision obtained for $V = 10.5$ Sun-like star sufficient to retrieve accurate stellar properties

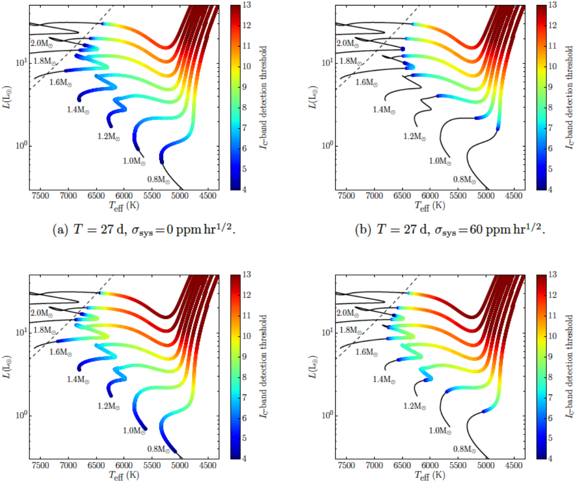




- $V = 10.5$
- $T_{\rm obs} = 3$–$24\,\rm months$ (in steps of $3\,\rm months$)
- **Take-home message:** For this particular setup, 2 years of observations are needed to attain nominal $\sim 0.1\,\mu\rm Hz$ frequency precision



courtesy of M. Lund



(a) $T = 27$ d, $\sigma_{\rm sys} = 0$ ppm hr$^{1/2}$.

(b) $T = 27$ d, $\sigma_{\rm sys} = 60$ ppm hr$^{1/2}$.

(c) $T = 351$ d, $\sigma_{\rm sys} = 0$ ppm hr$^{1/2}$.

(d) $T = 351$ d, $\sigma_{\rm sys} = 60$ ppm hr$^{1/2}$.

Detectability of solar-like oscillations with *TESS* for a 2-min cadence (Campante et al., submitted to ApJ)