RADIAL VELOCITY SIMULATIONS OF BLENDED STELLAR SYSTEMS

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OUTLINE

- Introduction to the problem
- The method
  - CCF modelling
  - Comparison with data
- Example: the simple case of HD16702
- A word on photometry.
- Conclusion and Future.

THE PLAGUE, THE PROBLEM

- Blended stellar systems plague transit surveys, producing false positive detections (see, e.g., Brown 2003, Evans & Sackett 2010, Norton & Johnson 2011).

  "*conservative upper limits*": 27% FPP for CoRoT (in fact, much higher), 2% FPP for Kepler. (Norton & Johnson 2011)

  But… Consider larger **effective aperture** of PLATO (~7-8") & "*the radius of possible blends is the largest single factor that can significantly raise the False Positive Probability*".

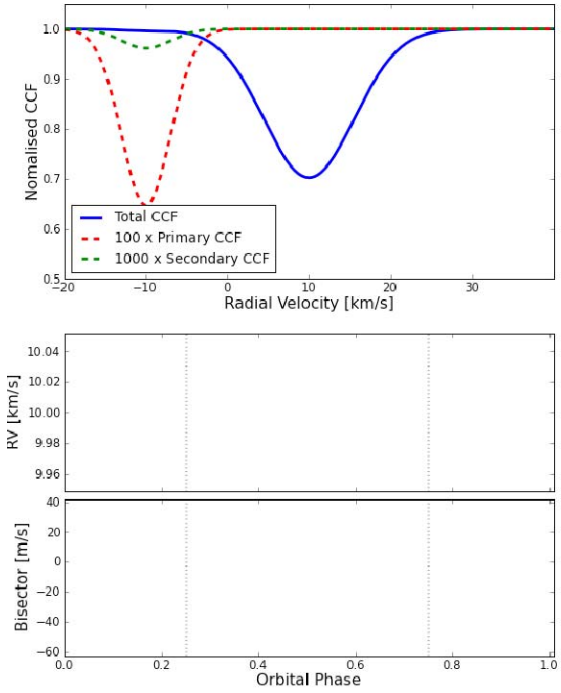
- Consequently, PLATO RV follow-up observations will probably suffer from:
  - No variation cases (i.e. cases where no RV or Biss signal is detected).
  - Pphot != PRV
  - …

- "Traditional" techniques (bisector span, mask effects, P/2-photometry, etc.) are necessary but not sufficient tools to identify the more involved blended systems and secure planetary detection.

- A detailed study of RV is needed in order to **secure** planetary detections, fully exploit data and save telescope time. **Already being done!**

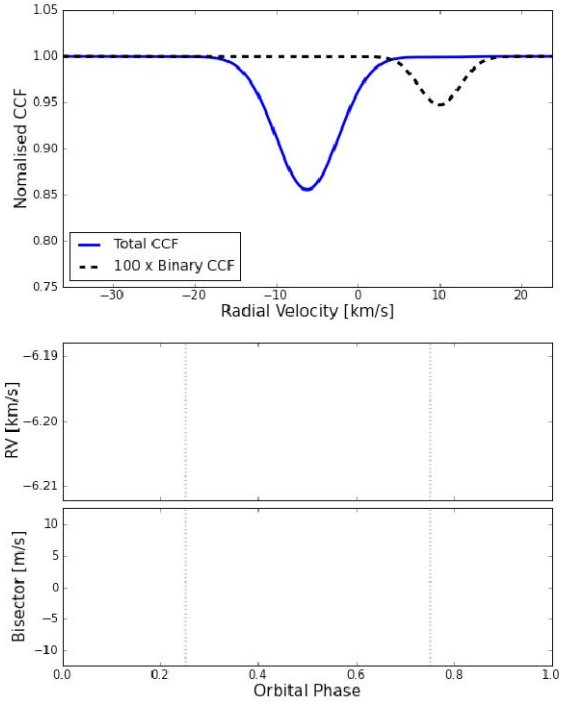
THREE TYPES OF BLEND SCENARIOS

BEB



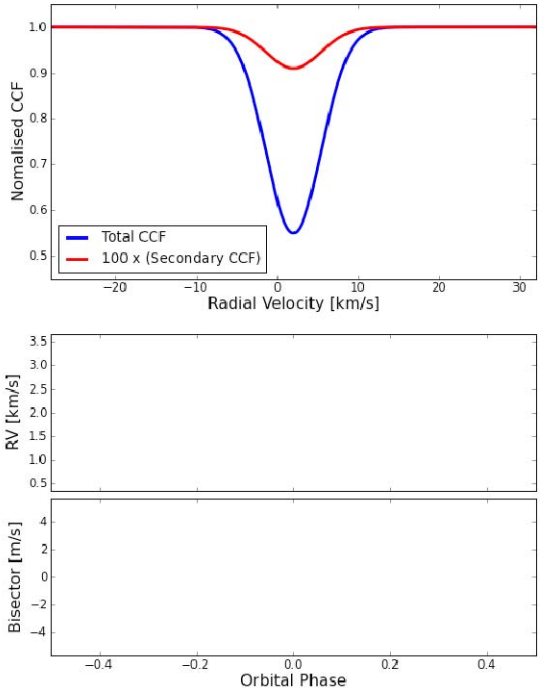
- G-M binary diluted by foreground F star.
- RV amplitude compatible with planet over phases 0.25 and 0.75.
- Fine-tuning was needed.

Triple Systems



- M-M binary and G primary.
- Compatible with NoVar.

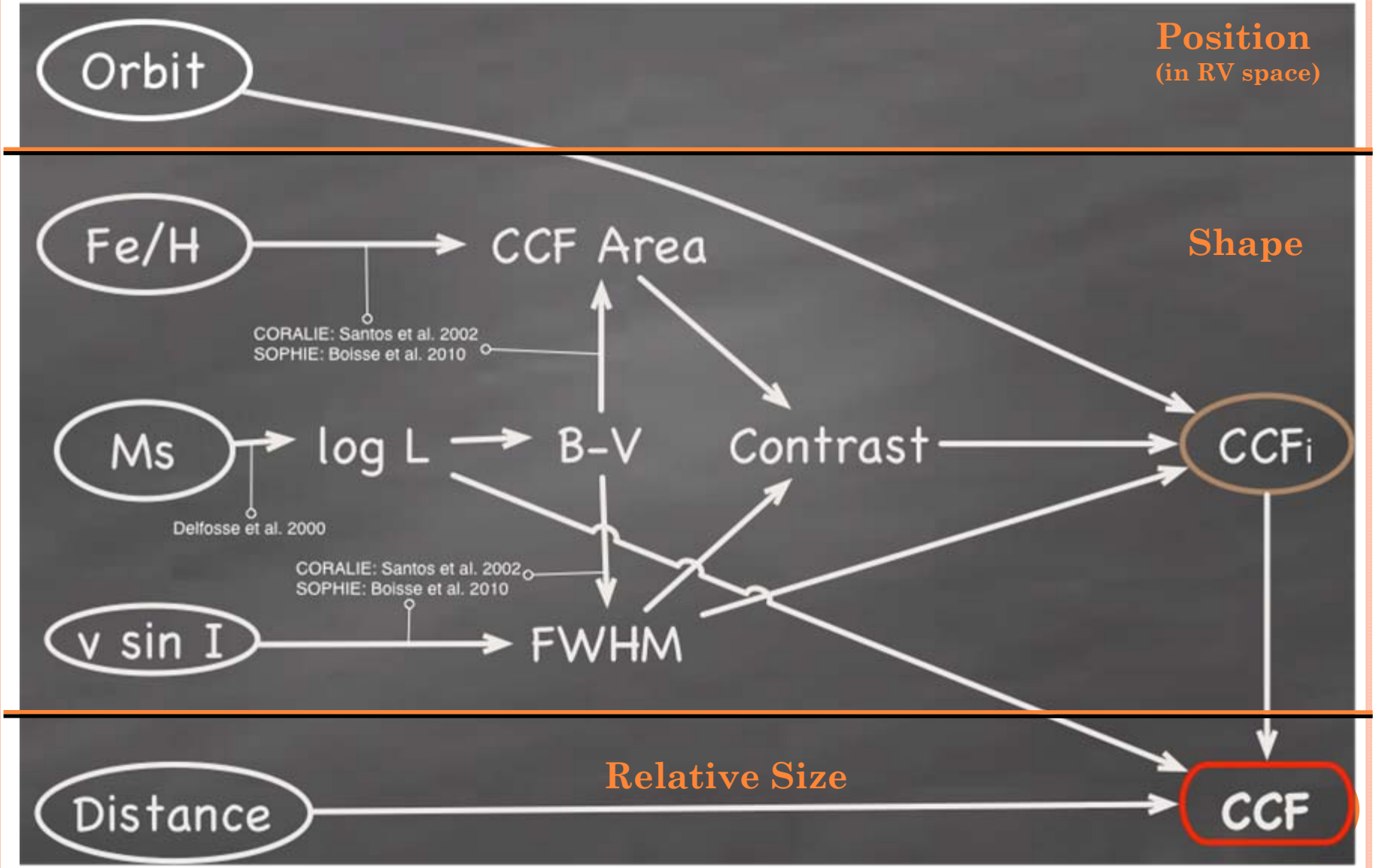
Planet in Binary Stars



- G-M binary with giant transiting planet.
- Small inclination.
- Photometric signal at different period than RV signal.

In all cases, complementary photometric analysis is important.

CCF MODELLING

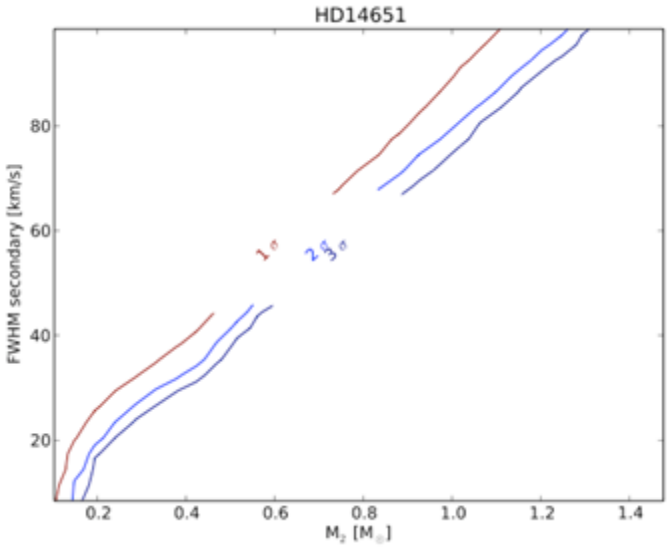


SIMULATIONS AND COMPARISON WITH DATA / HOW TO USE THIS

- Input parameters are drawn randomly from given priors.

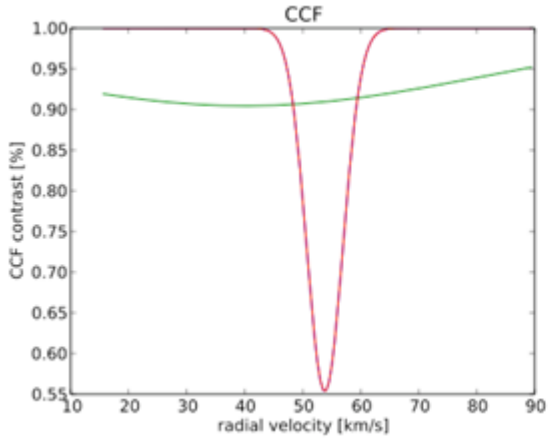
or

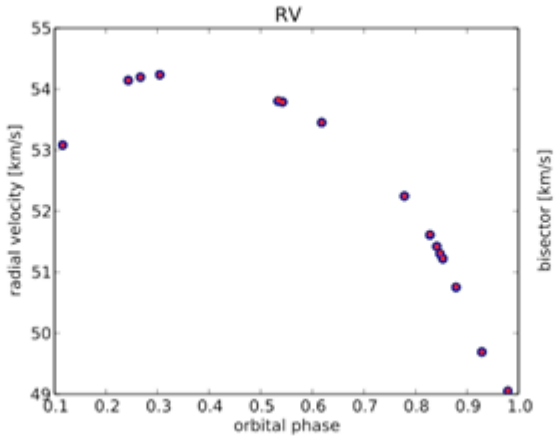
- A grid of models is constructed.

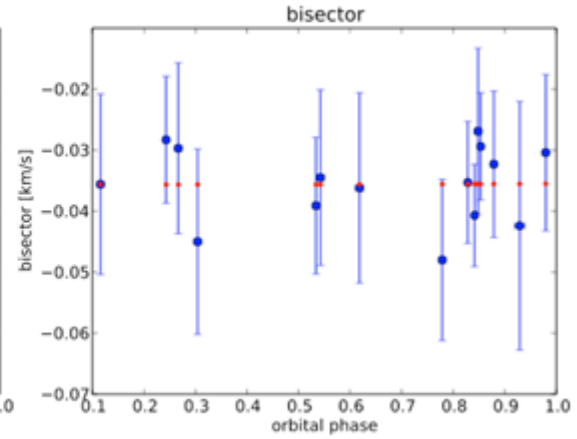


- Synthetic data are obtained mimicking the procedure performed on real data, and compared to real data.
- Likelihood maps are.

- **Bisector Velocity span and RV time series** are usually the constraining datasets.

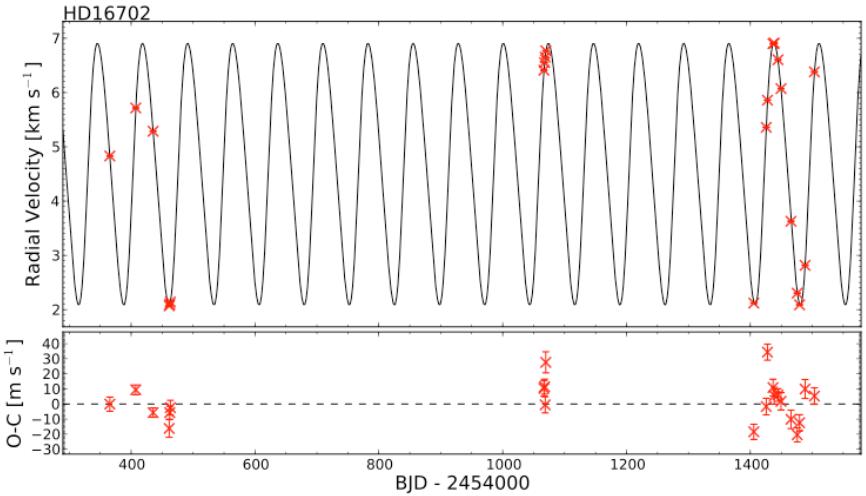






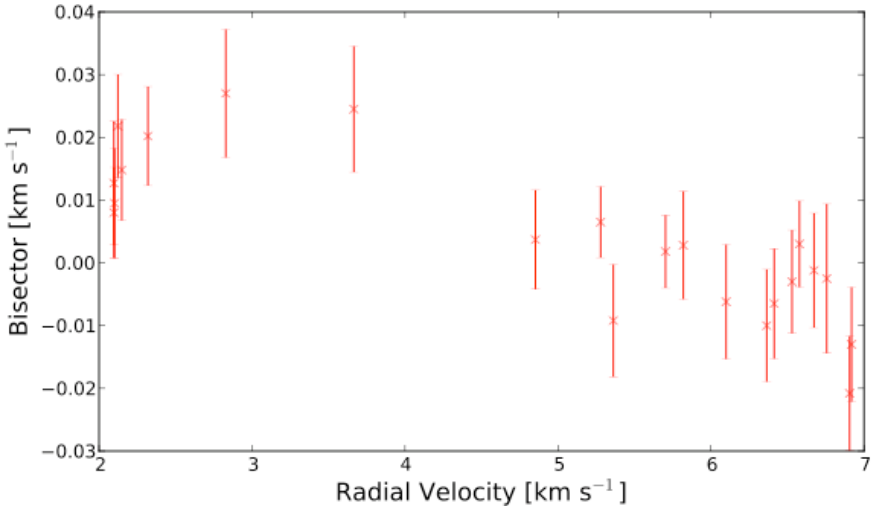
AN EXAMPLE – HD16702

- Brown dwarf candidate detected with SOPHIE. Díaz et al. (in prep.)



- m sin i = 48.6 Mjup; P = 73 days.
- No transits. Only RV available.
- Hipparcos astrometry detects an orbit at the 2.3-sigma level:
- **m in [0.21; 1.01] Msun** (3-sigma)

- Significant bisector effect (Spearman's r = -0.8).



- Also, a mask effect is detected (i.e. RV amplitude depends on numerical mask used for CCF).

- **Can blend simulations provide an equivalent constraint on the mass?**

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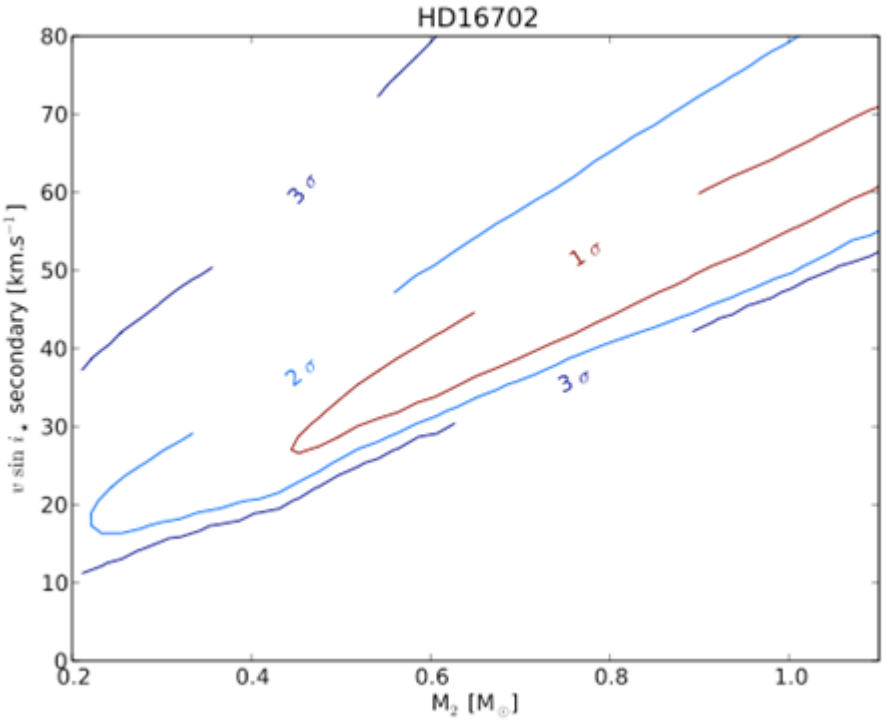
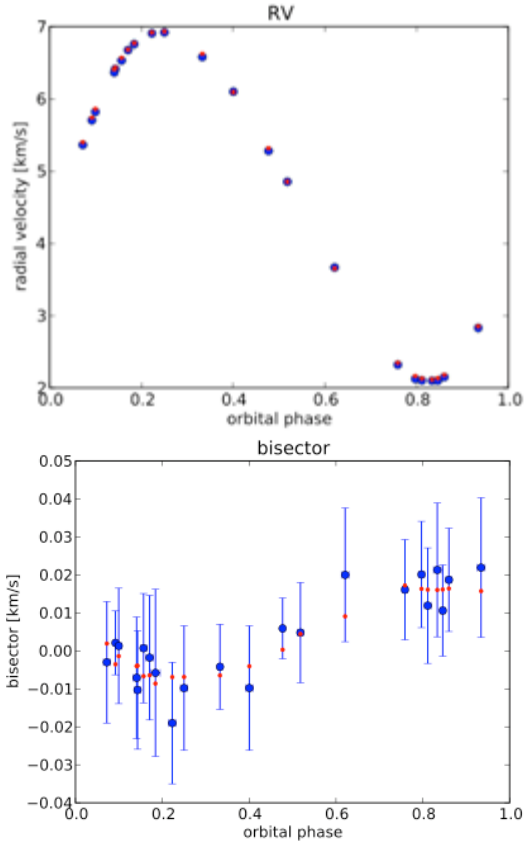




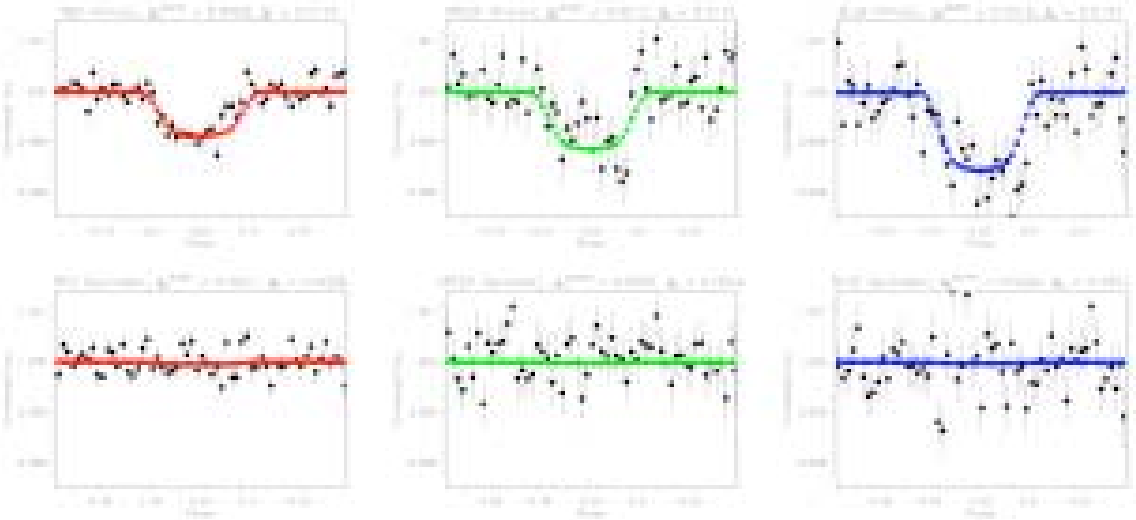
- Uniform Mass distribution.

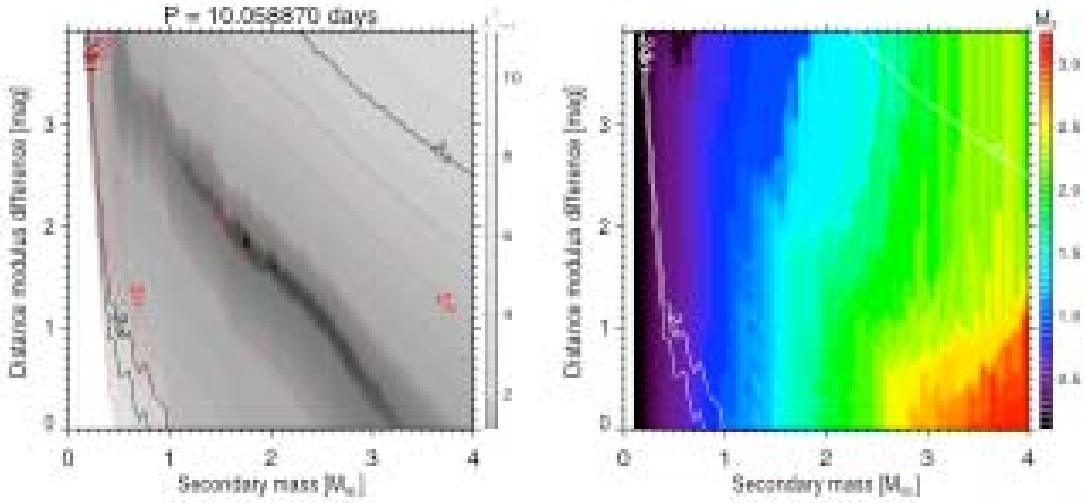
- Uniform v sin I distribution in [0.0; 80] km/s. → Should be coupled with realistic v sin I distribution.

- **Tighter limits** should be possible!

PHOTOMETRY

- Photometric Blend Analysis of blended systems (Torres et al. 2004, 2011)
- Including CoRoT **multi-colour** light curves.





CONCLUSIONS AND BEYOND…

- Simulations of blended stellar systems are able to provide constraints on "*unsolved*" RV follow-up systems, thus saving precious (8m) telescope time, and increasing the scientific return of transiting surveys (and PLATO in particular).

- Precise determination of bisectors, etc. is fundamental. Espresso and Codex should provide this easily. These observables should be readily provided by future RV instrument's pipelines.

- Modelling of mask effects, colour effects, etc. should allow to discard an even larger region of parameter space from RV **alone**.

- Observations at **key orbital phases** should improve rejecting capabilities.

- **Combined Modelling** of photometry, RV, astrometry, and other observations will provide **stronger constraints** on possible mimicking systems. Experience is currently being acquired in "less-than-ultra-precise" conditions for all these areas.