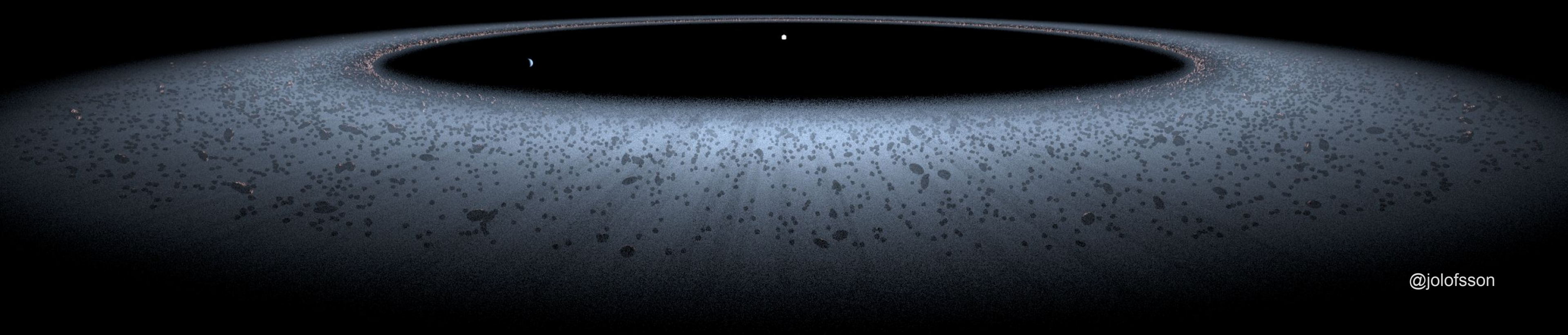
An updated census of spectroscopic binary systems in the young associations

Sebastián Zúñiga-Fernández et al.



Stellar multiple systems

Stellar multiplicity is relevant for understanding a broad range of phenomena.

- Supernova rates.
- Single / Binary stars and multiple systems formation.
- The incidence of stable planetary systems.

It is important to understand binaries and stellar multiplets in the space of **masses**, **composition**, **age**, and **orbital properties**, and how evolves with time.

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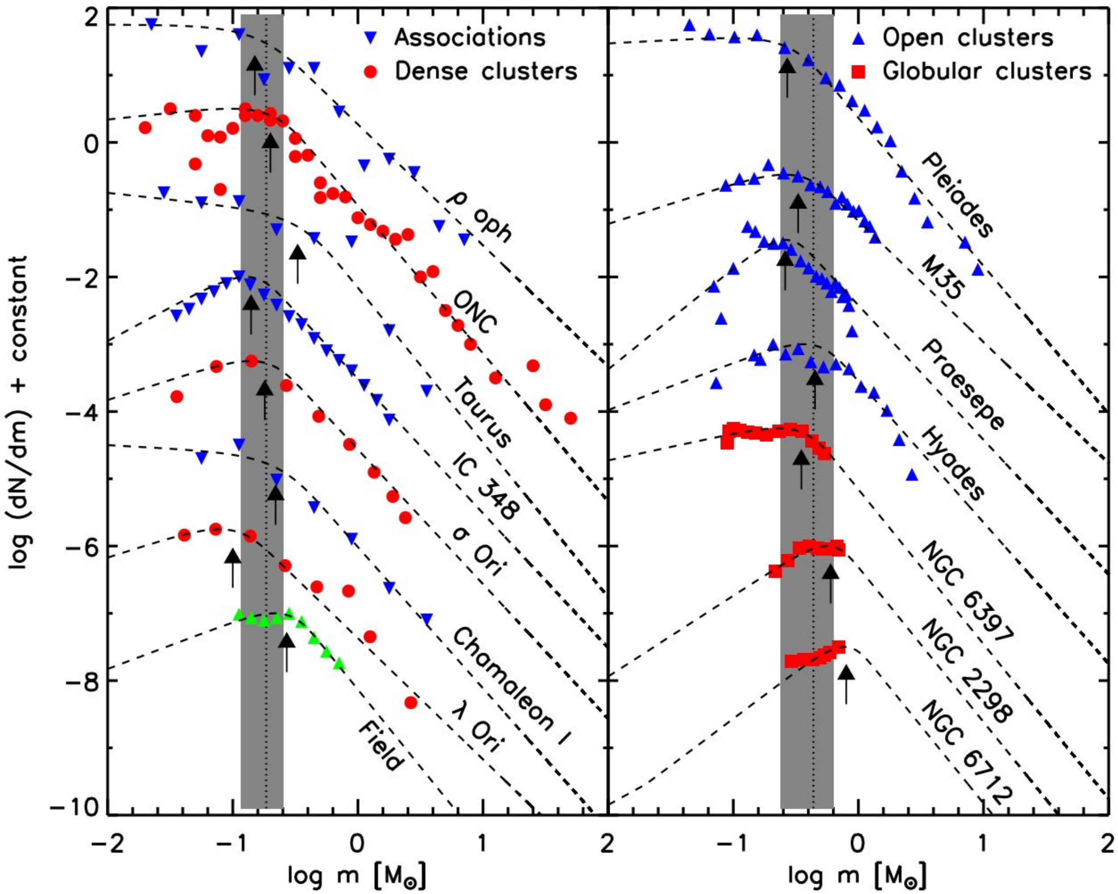
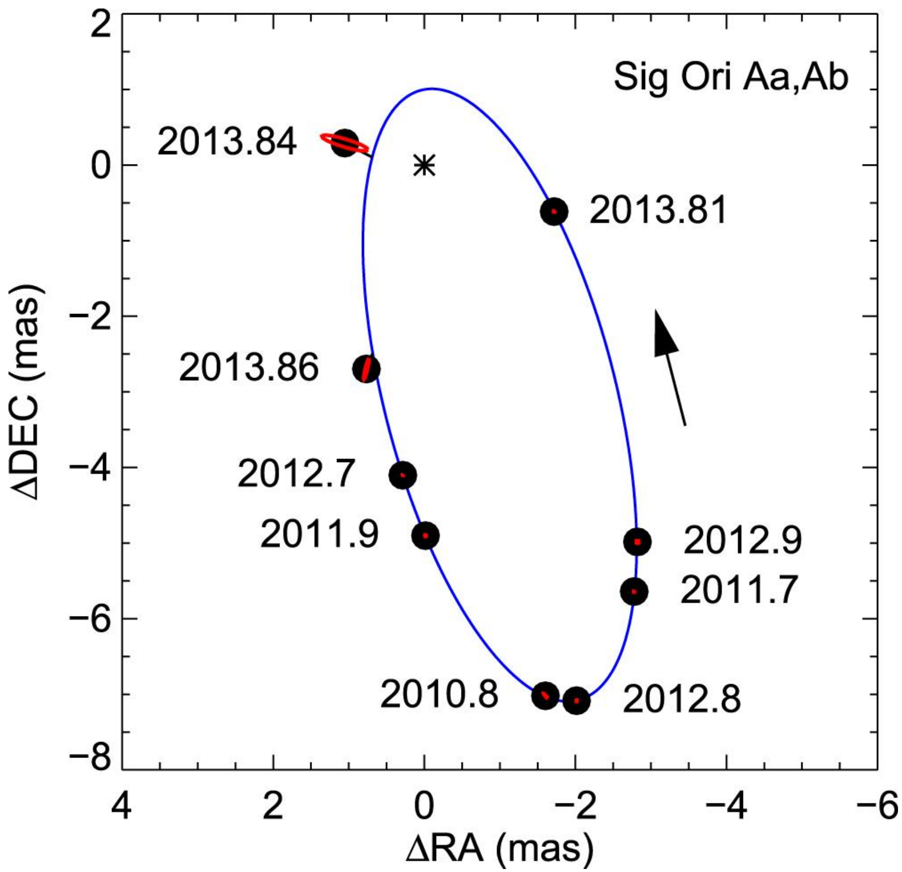


Bastian et al. 2010

Stellar multiple systems

The binary stars provide a model independent technique to estimate stellar masses.



Schaefer et al. 2016

Nearby Young moving groups (NYMGs)

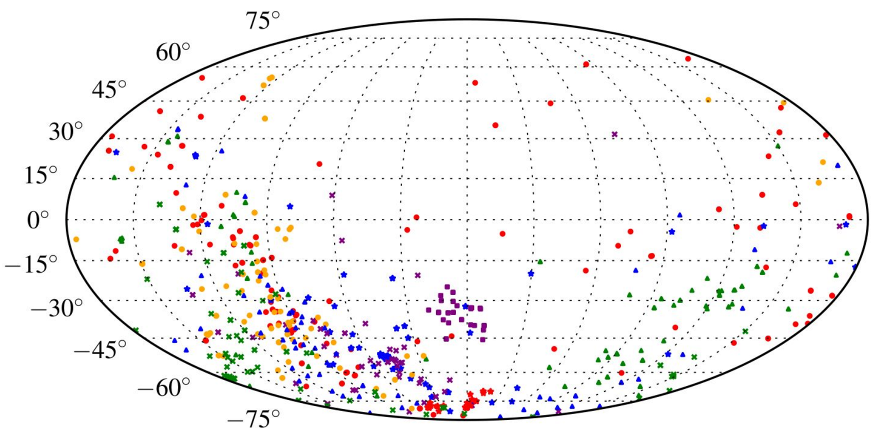


Figure (Credit: P. Elliott): Spatial distribution of the bonafide member targets in 9 young moving groups. AB Doradus: red circles, Argus: blue stars, β-Pic moving group: green triangles, Carina: purple crosses, Columba: orange circles, ε-Cha: red stars, Octans: blue triangles, Tuc-Hor: green crosses and TW Hydrae: purple squares.

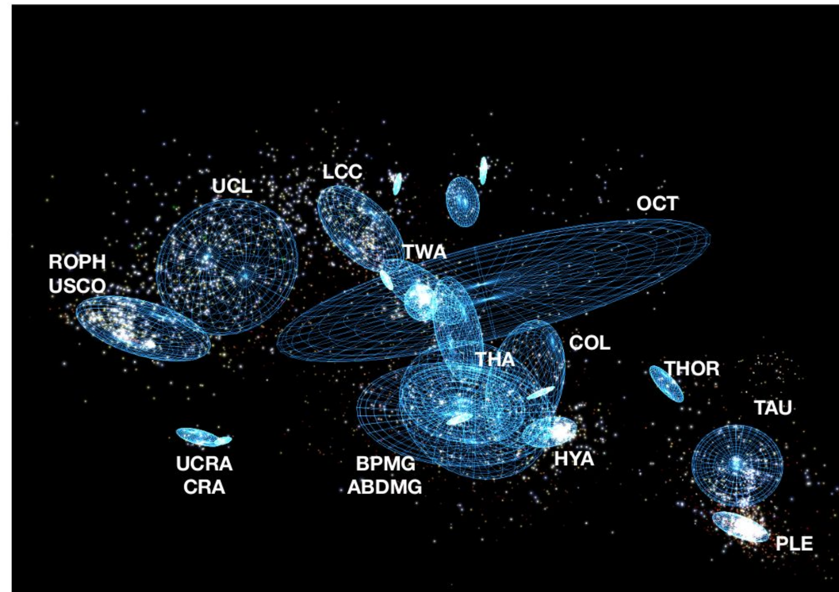


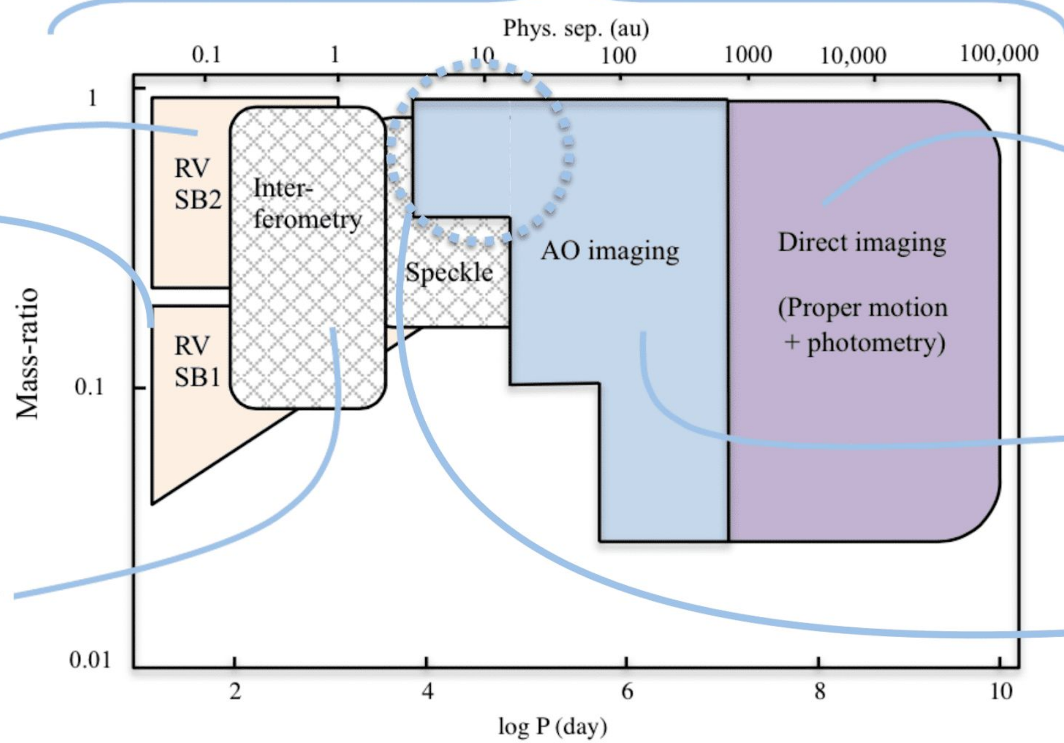
Figure credit: Jacqueline K. Faherty

★ The young associations offer us one of the best opportunities to study the properties of young stellar and sub-stellar objects thanks to their proximity (< 200 pc) and age (~ 5 - 150 Myr).

Data sample selection

- Search for Associations Containing Young Stars (SACY)

Full SACY database:



Elliott, Bayo et al 2014

Elliott, Bayo et al 2016a
Elliott and Bayo 2016b

Elliott, Huélamo, Bouy, Bayo et al 2015

Conducted VLT/ PIONIER

Orbital motion
~12 years NACO + MagAO data

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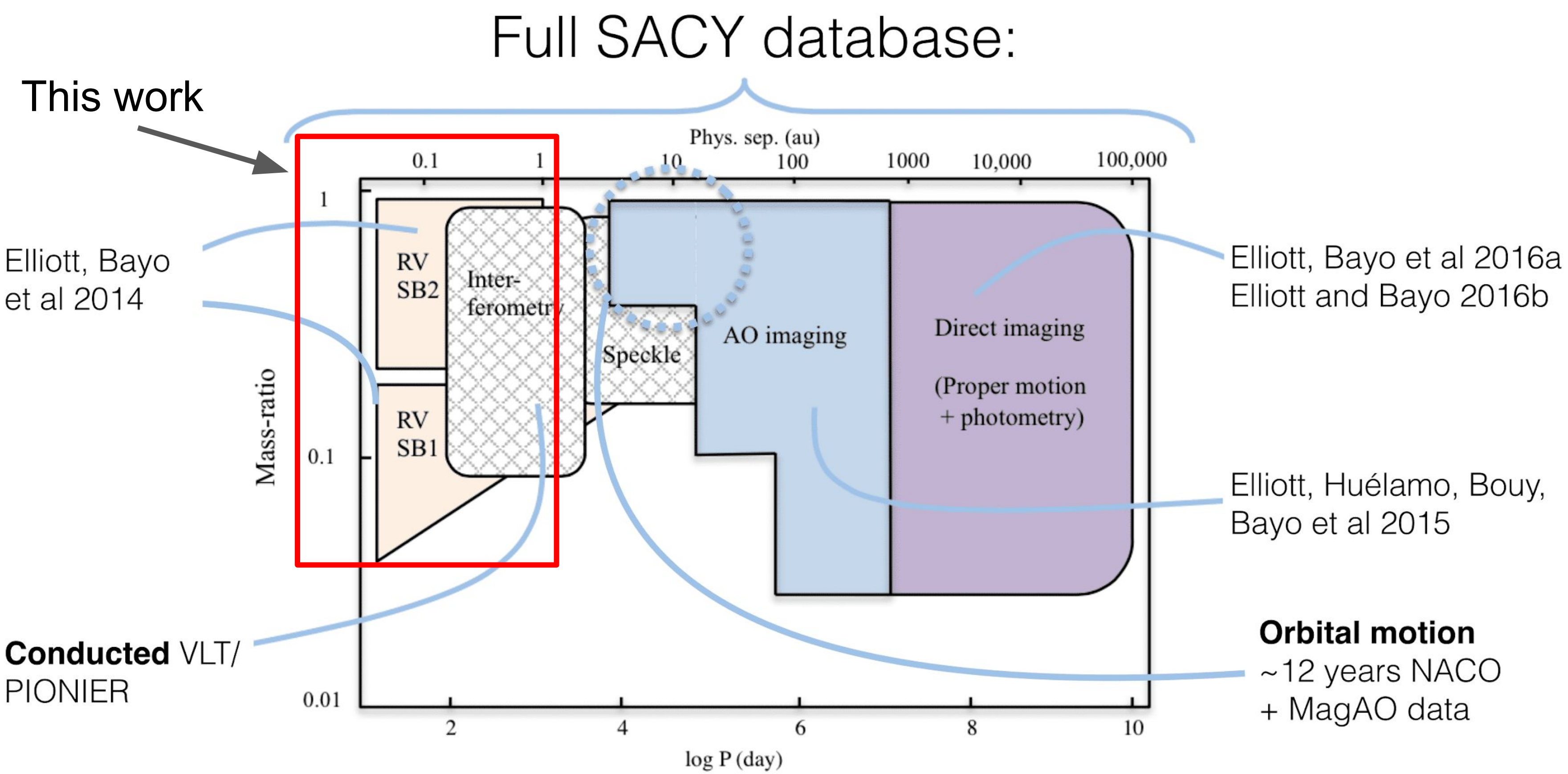

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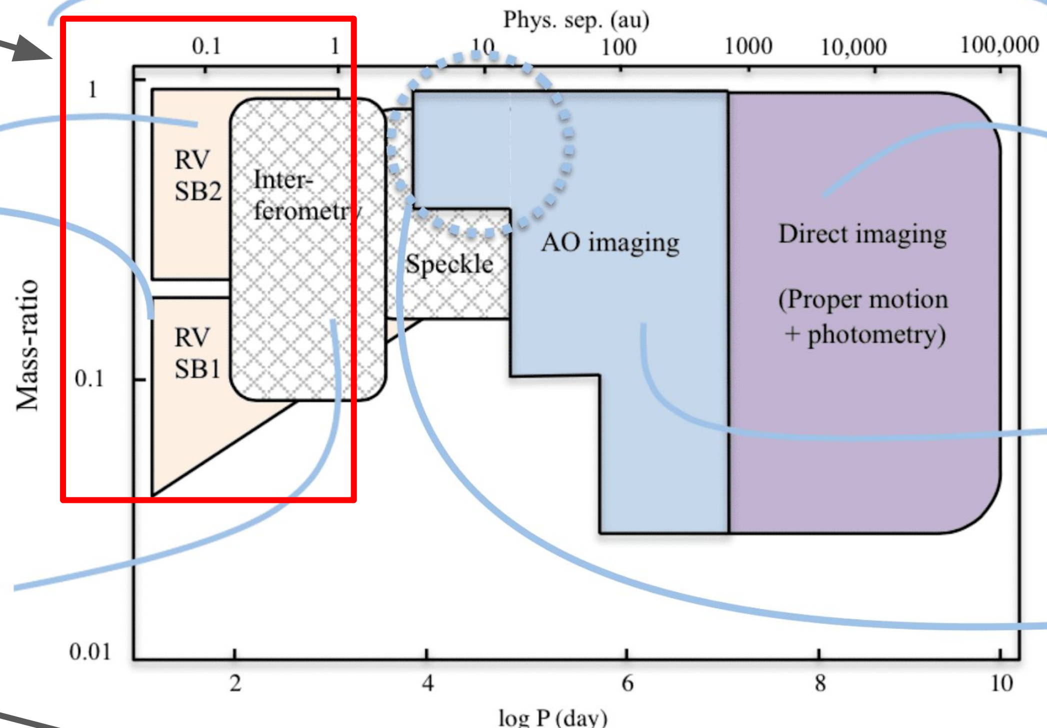

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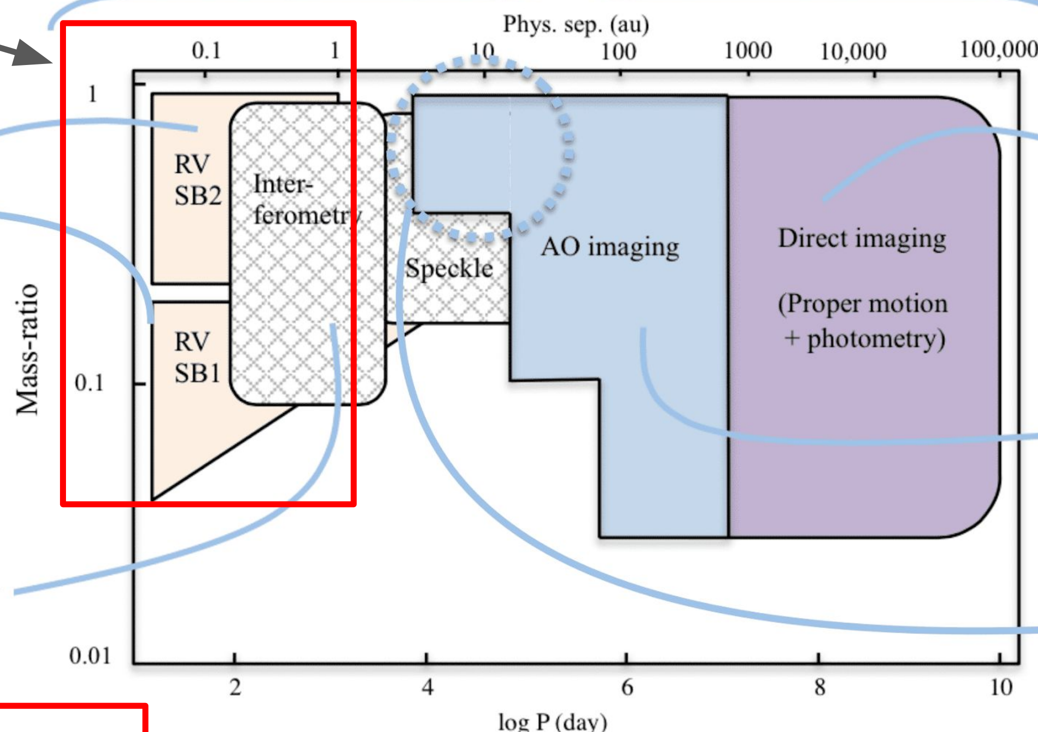

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Preliminary results on Poster N°28 !!

In progress (PhD Thesis)

Observations and data

Previously published data and high resolution spectra publicly available, mainly from:

- Fibre-fed Extended Range Échelle Spectrograph (**FEROS**; R ~ 50,000).
- High Accuracy Radial velocity Planet Searcher (**HARPS**; R ~ 115,000).
- Ultraviolet and Visual Echelle Spectrograph (**UVES**; R ~ 40,000; our own programs).
- **Gaia DR2** (~ 98% of our sample coverage with 37% of objects with Gaia RV estimate).

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- 1375 CCFs for further analysis.
- ~ 400 RV from literature + GDR2.

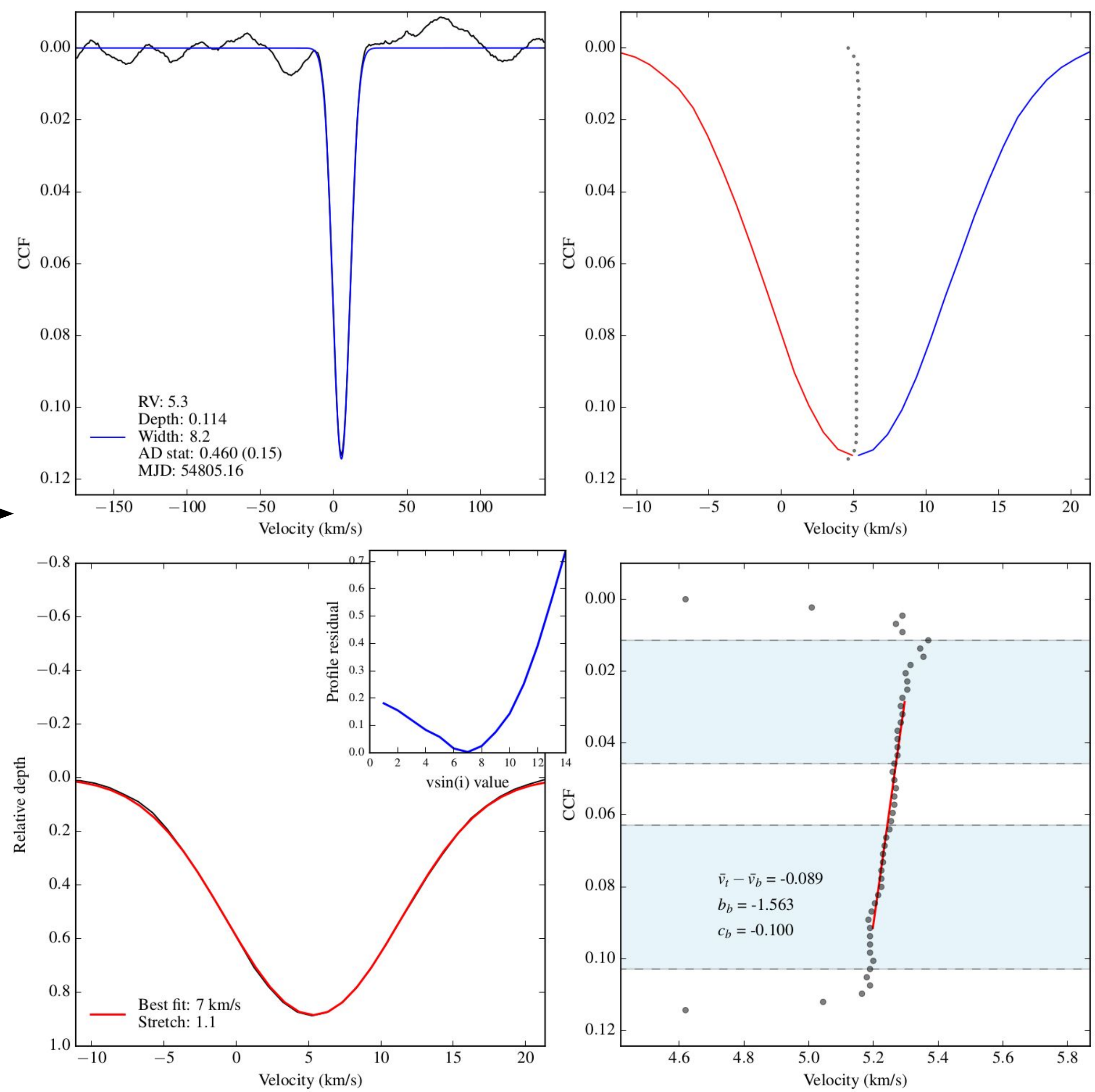
Cross correlation functions profiles

CORAVEL type mask

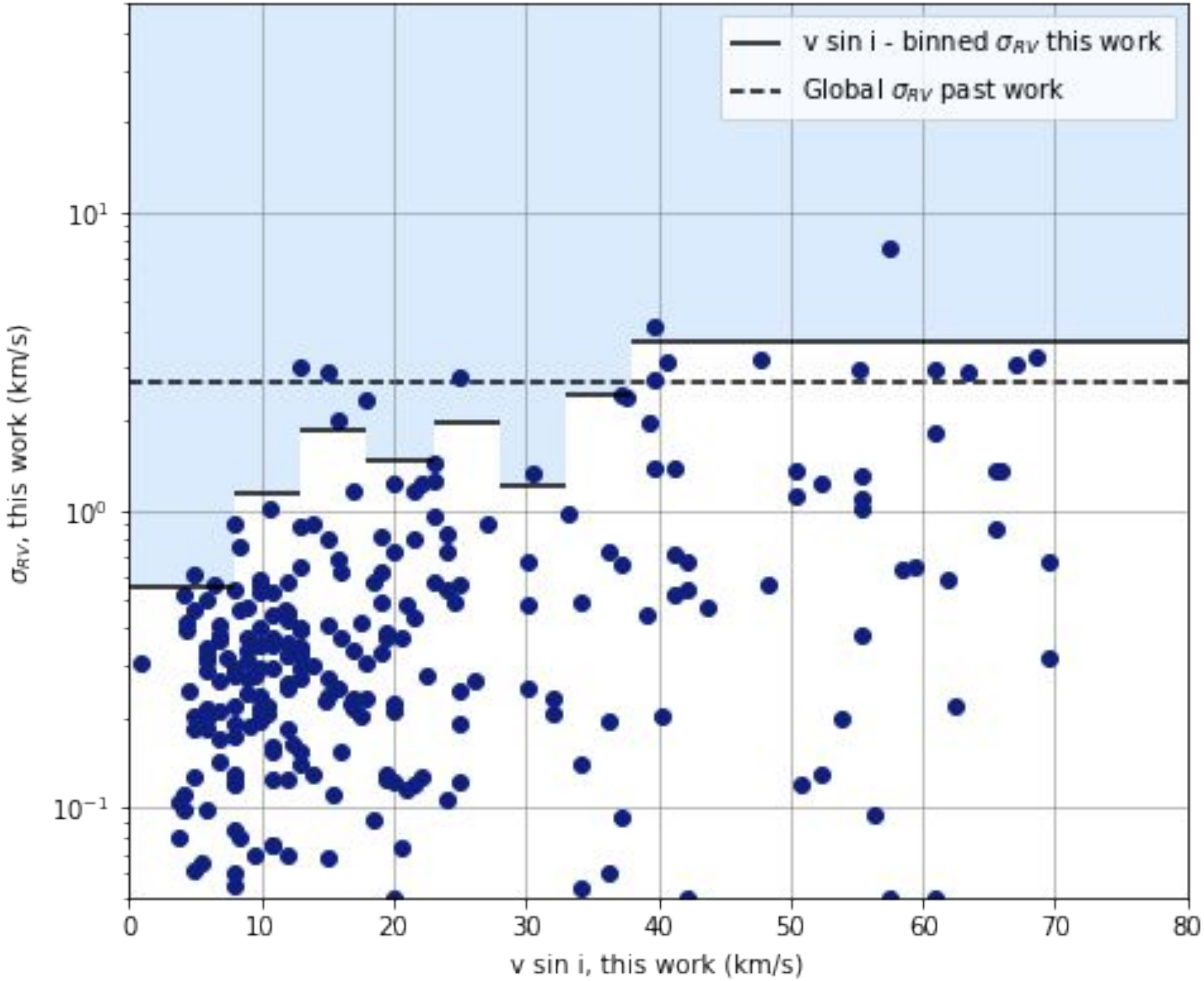
High-order features:

- Bisector inverse slope
- Bisector slope
- Curvature
- A-D statistic
- Profile residual

CCF output example



RV variation as a function of rotation



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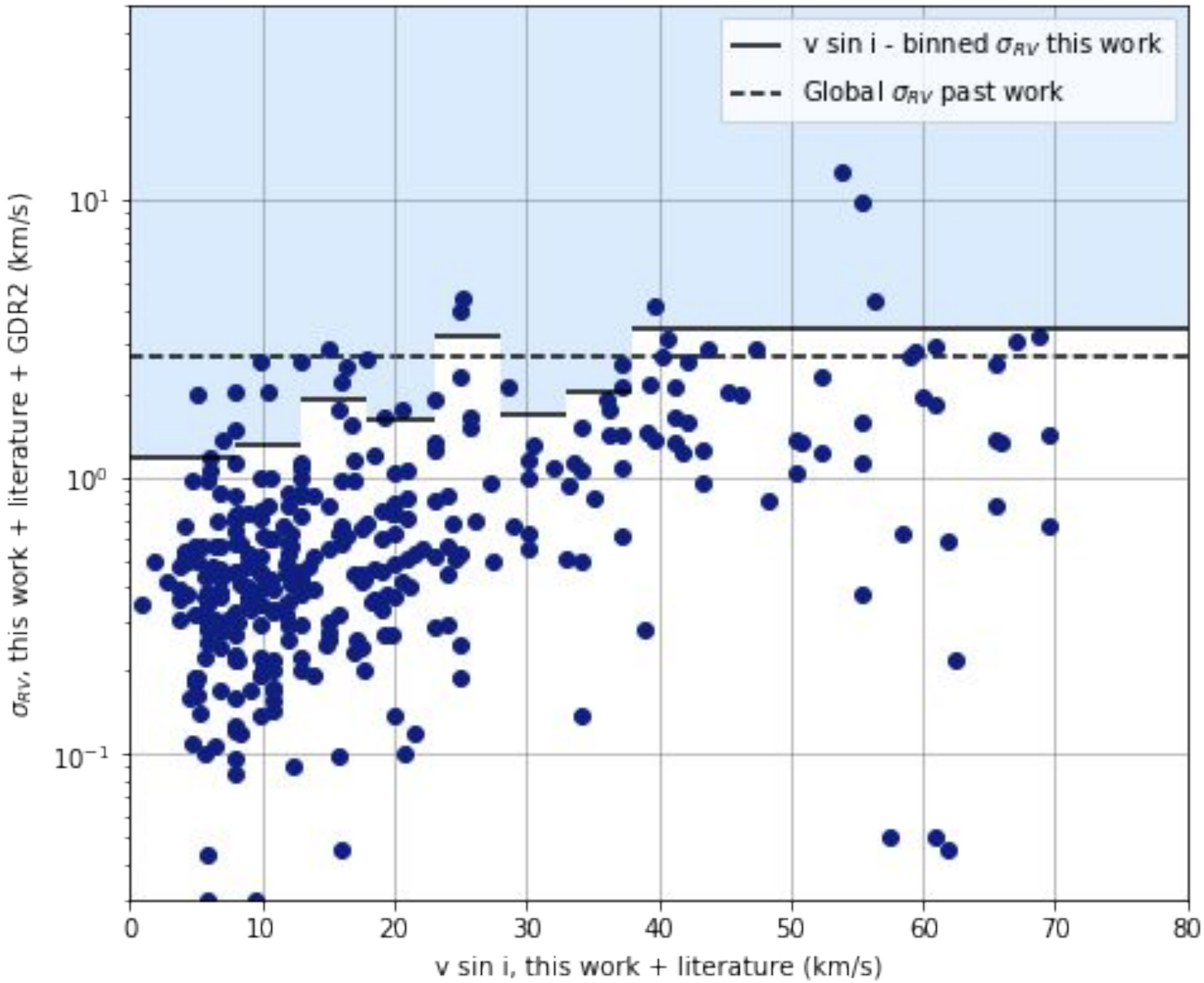
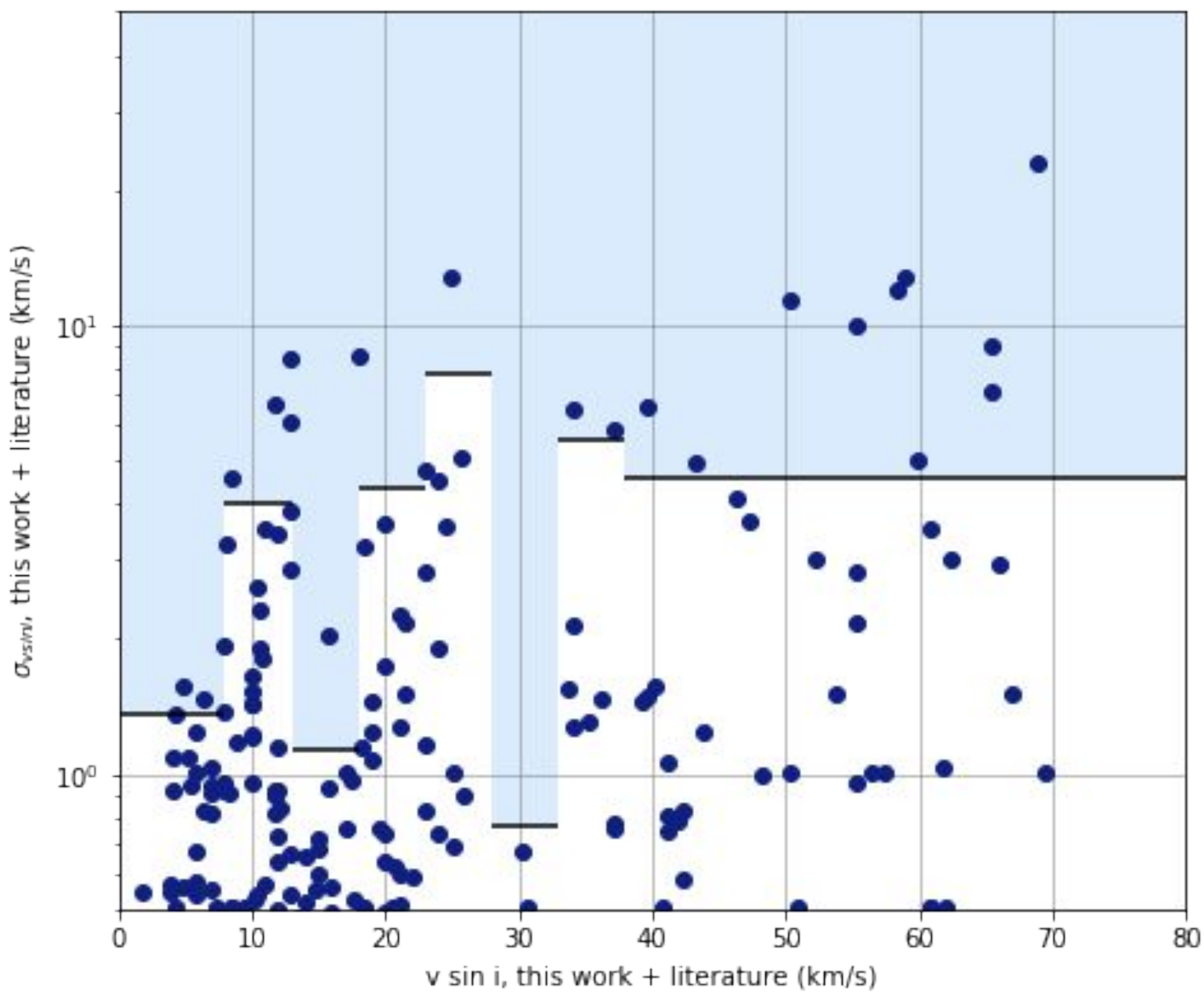
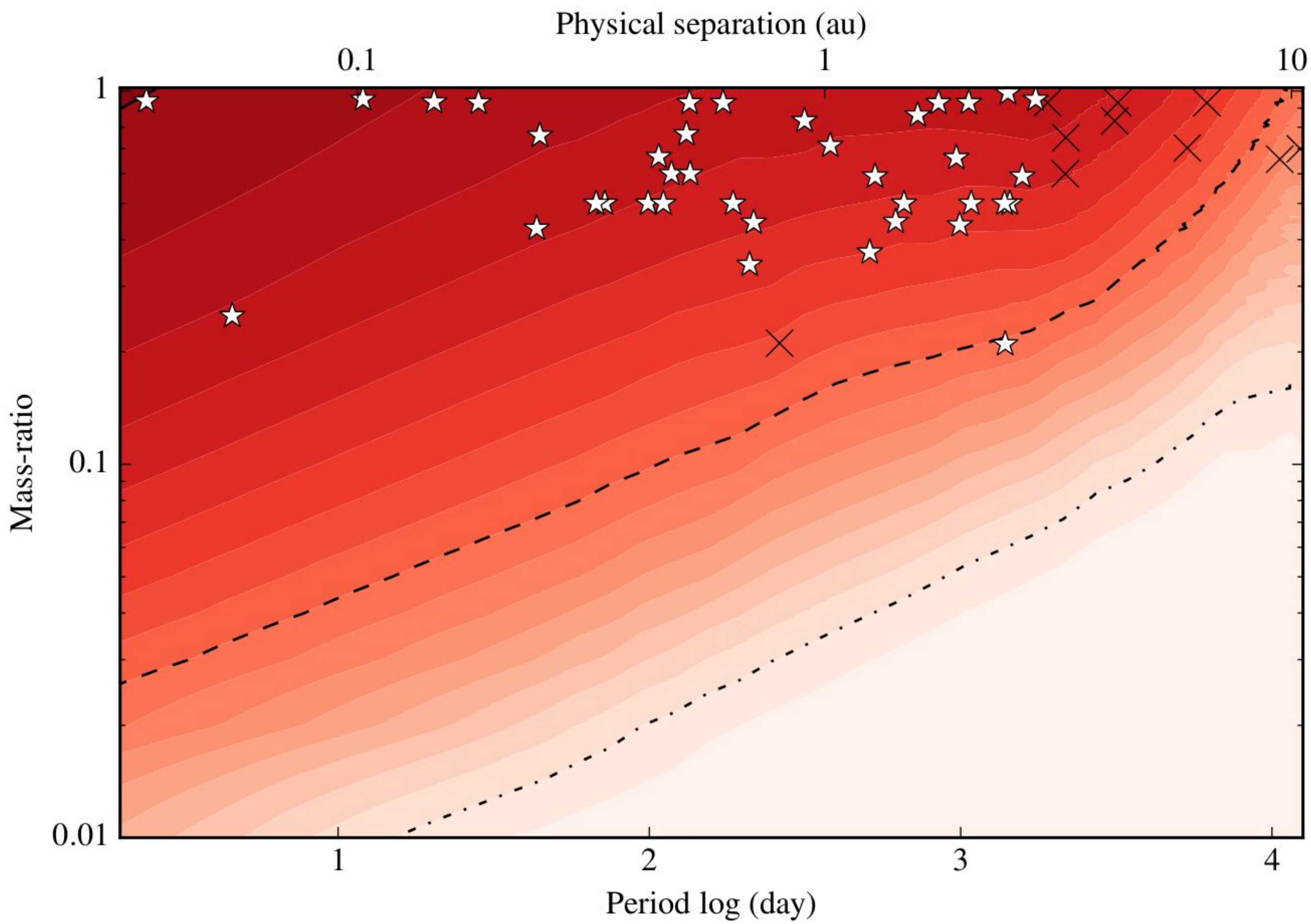


Distinguishing fast rotator from blended binaries

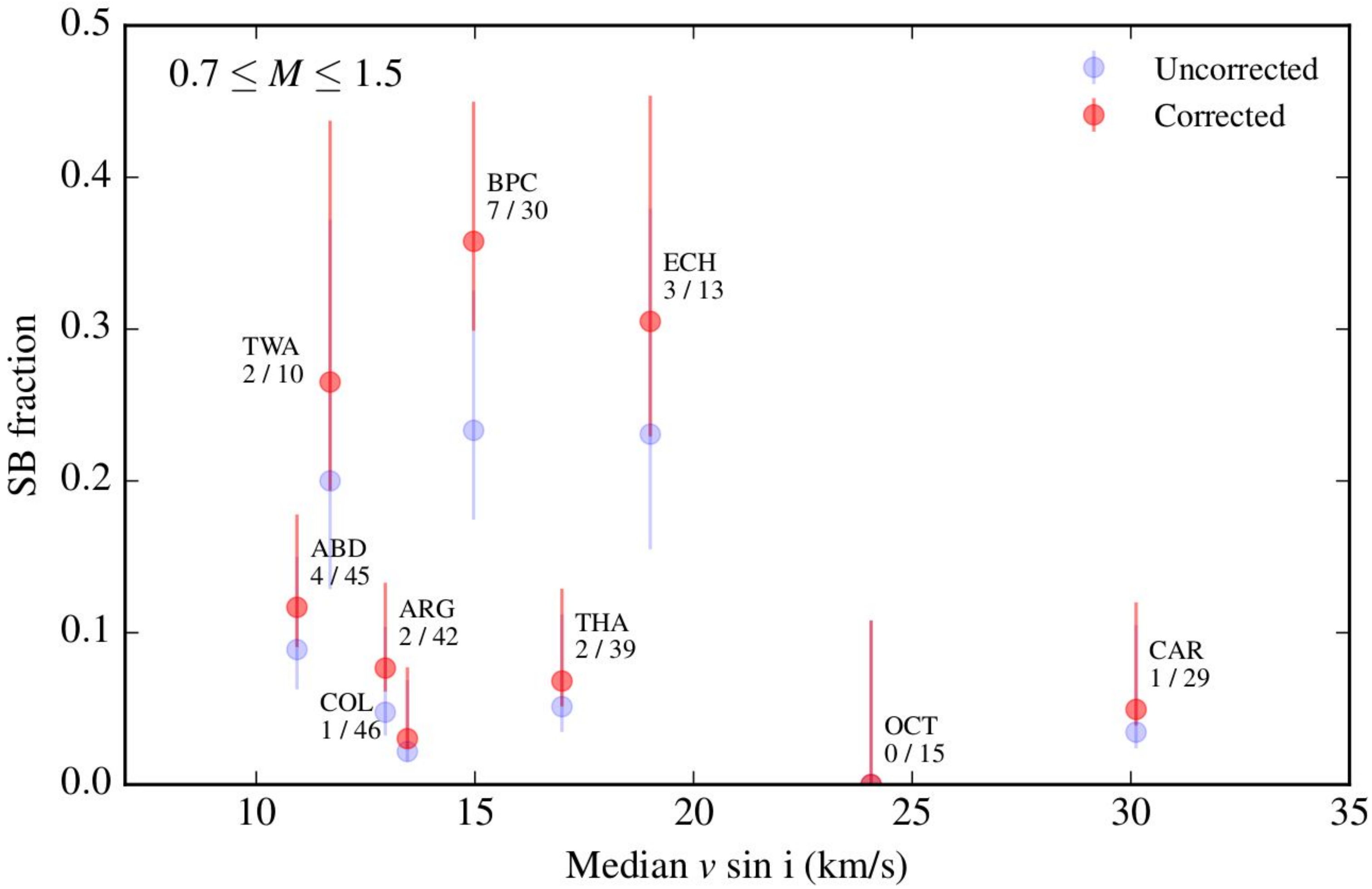


Accounting for observation sensitivity

As in Tokovinin et al. 2014, we use the time span of the observations (T), the number of observations (N) and the standard deviation in the RV measurement (σ) to account this effect.



Updated census of spectroscopic binaries



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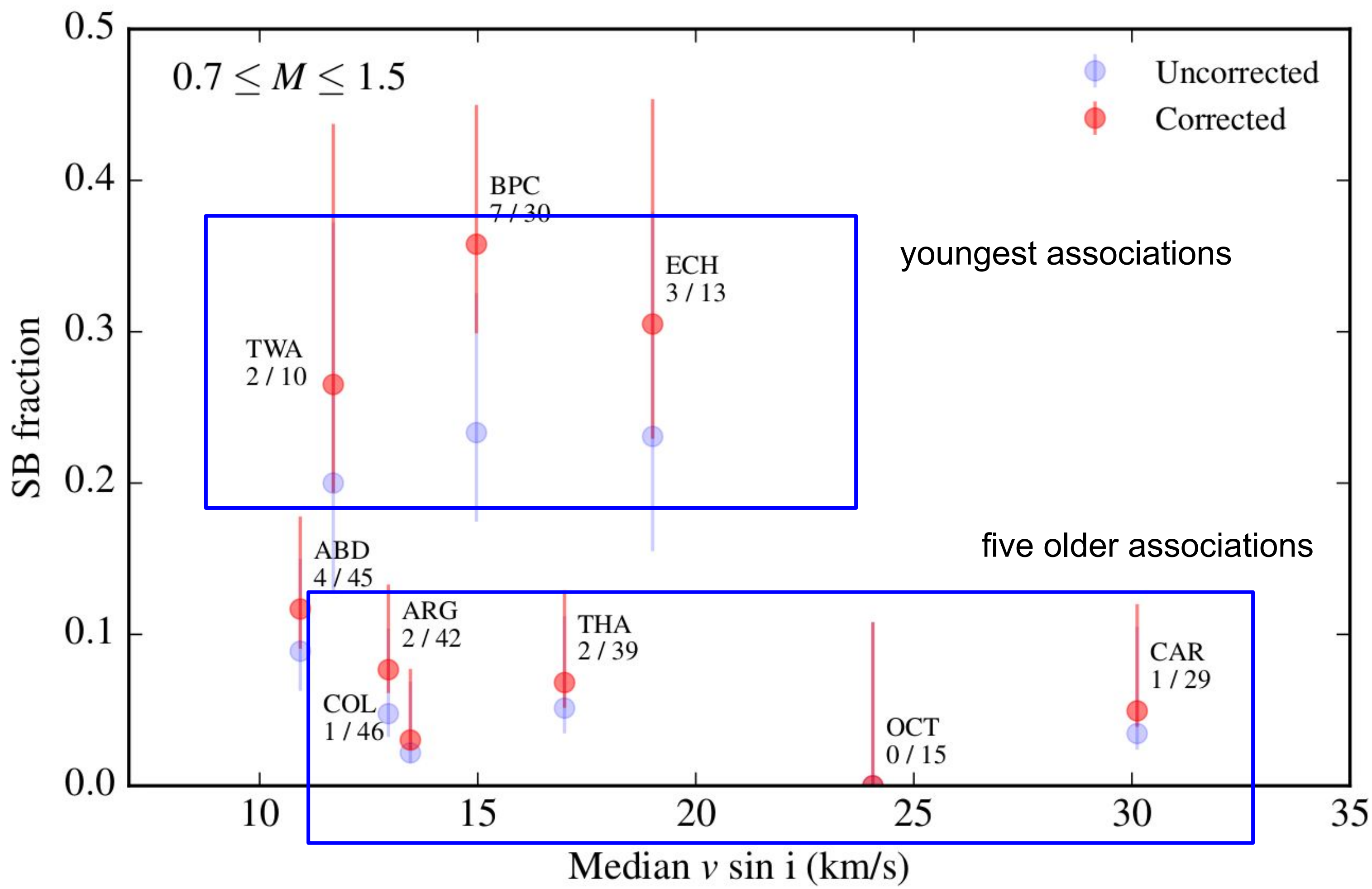
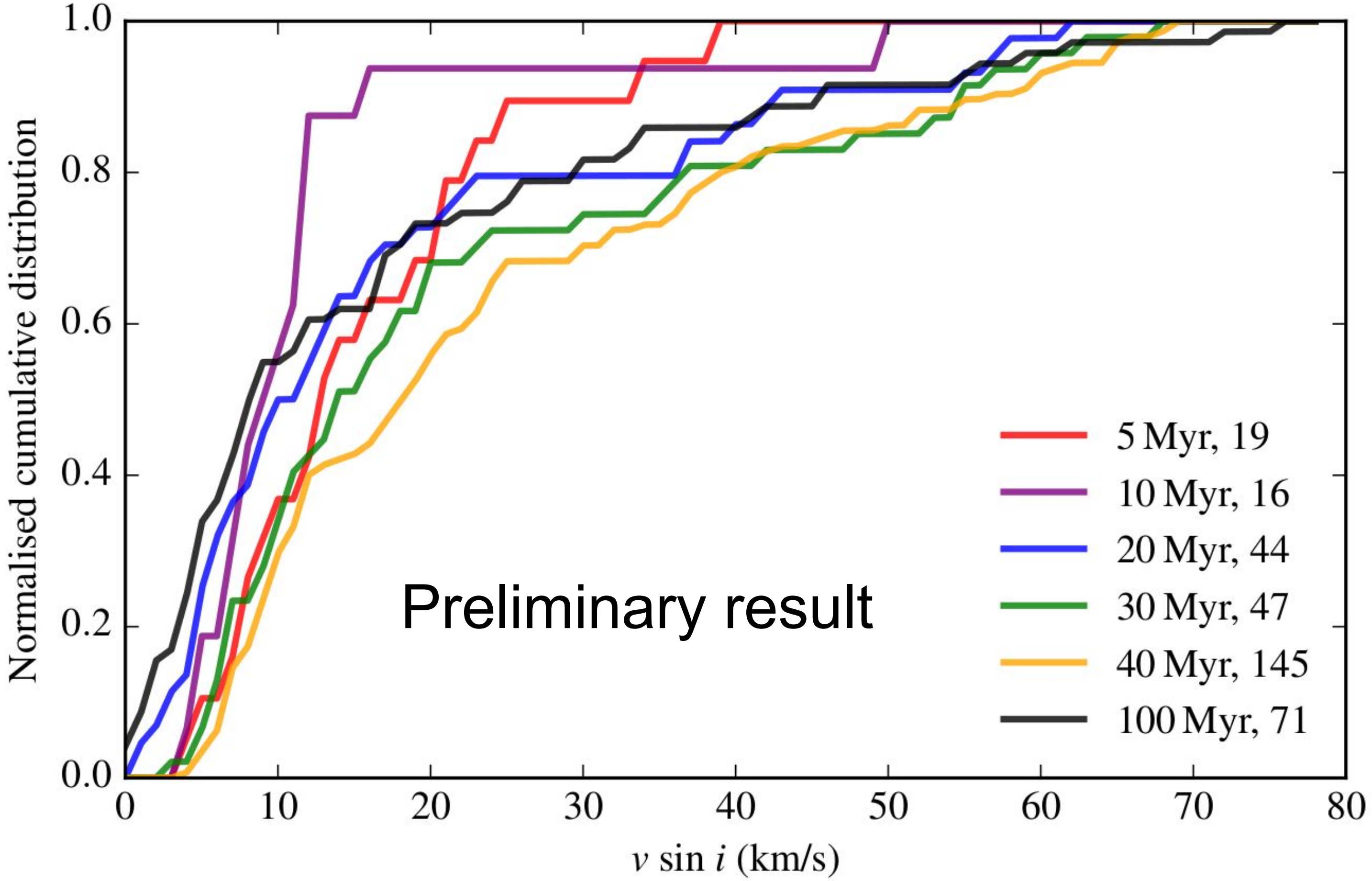


Rotation and age



Summary and remarks

- Out of the 427 objects from the cross-match of our work with the literature, we flagged 68 as potential spectroscopic multiple systems (**S. Zúñiga-Fernández et al. 2019 in prep.**).

- Interestingly the three highest spectroscopic binary fractions are for the three youngest associations (etha-Cha: 0.23, TW Hydrae: 0.20 and β-Pic: 0.23).

- If proven to be a physical result this would imply significant migration of companions beyond ~ 20 Myr.

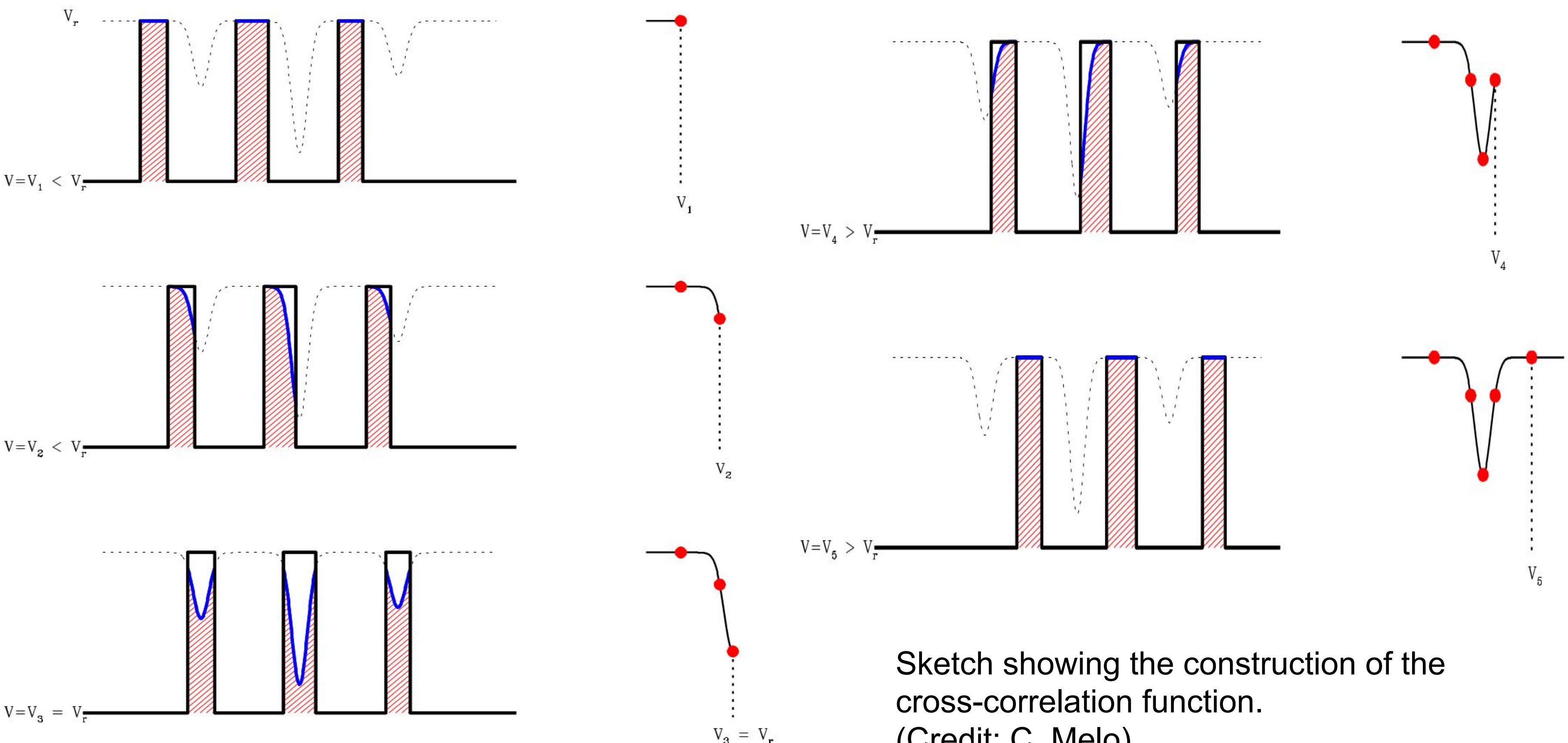
- Preliminary results show dependence between rotation and age (encounters?, detached systems? , influence of the disk?).

- Future studies on statistics of stellar multiple systems is important for several reason, the major ones probably star and planet formation.

- Binary star are natural benchmark to get empirical data of the masses of pre main sequence stars using SACY sample (**Work in progress!**).

Backup slides

CORAVEL-type cross correlation function



Sketch showing the construction of the cross-correlation function.
(Credit: C. Melo)

Examples of the CCF output

Resulting CCF profiles from three different sources. Significant anti-correlation between theBISandRV indicates the radial velocity jitter is most likely a result of stellar activity (Desort et al. 2007).

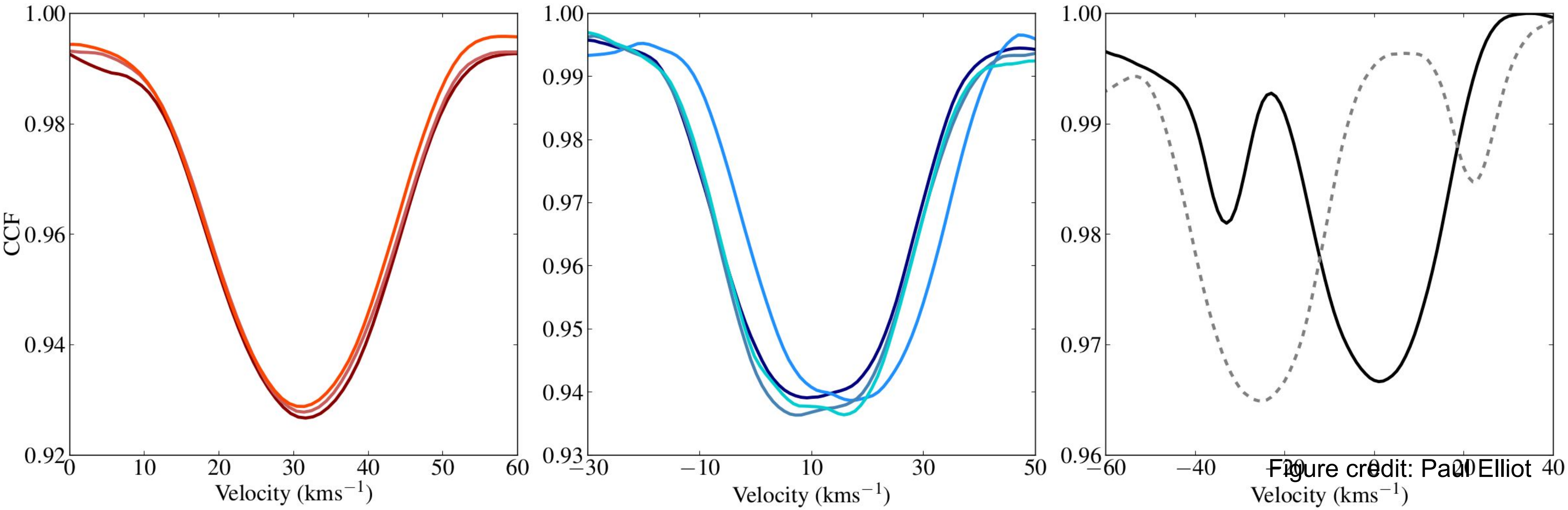
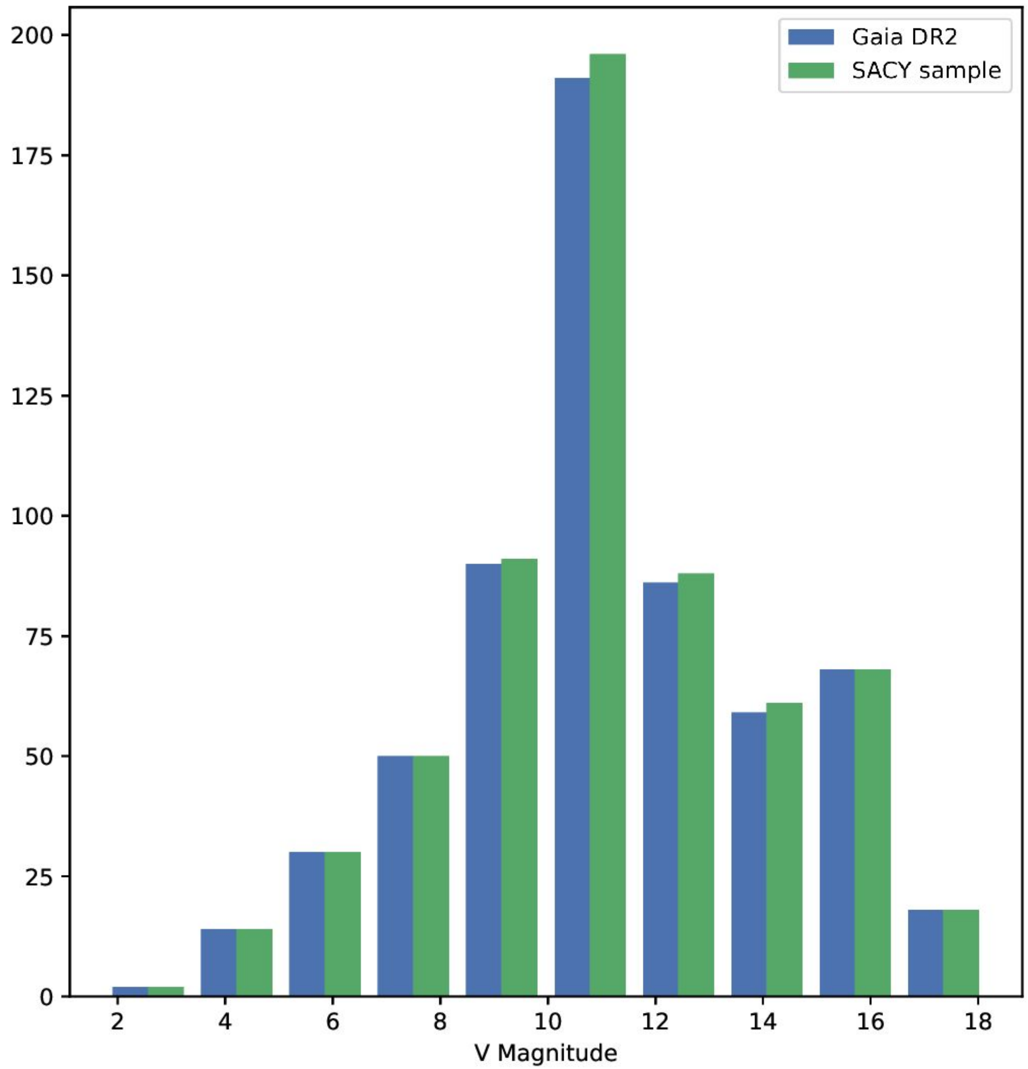


Figure credit: Paul Elliot

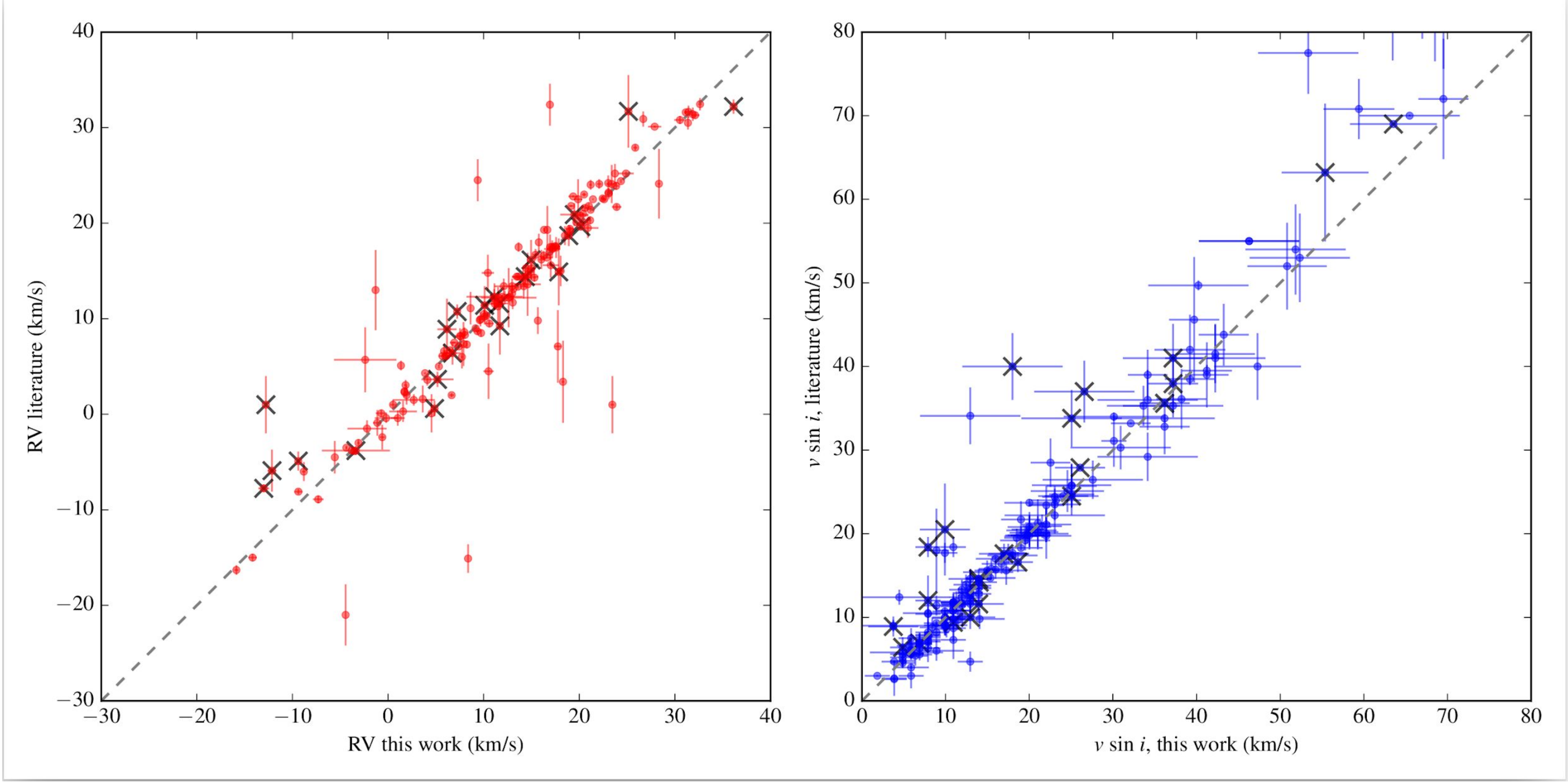
Gaia Data Release 2



Gaia DR2:

- Completness of 98.4 %
- 37.0 % of the objects with Gaia radial velocity estimate.

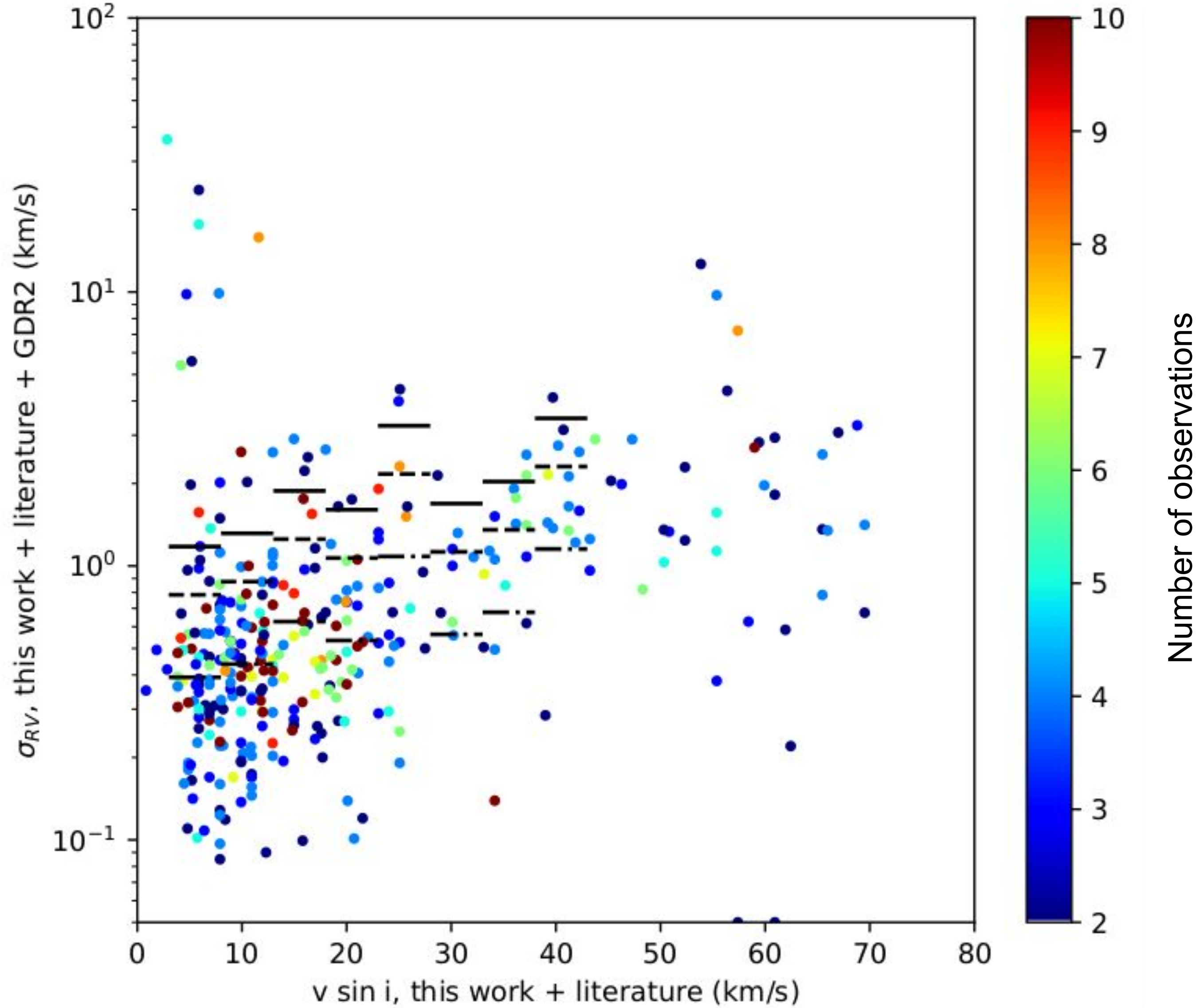
Cross-match with literature



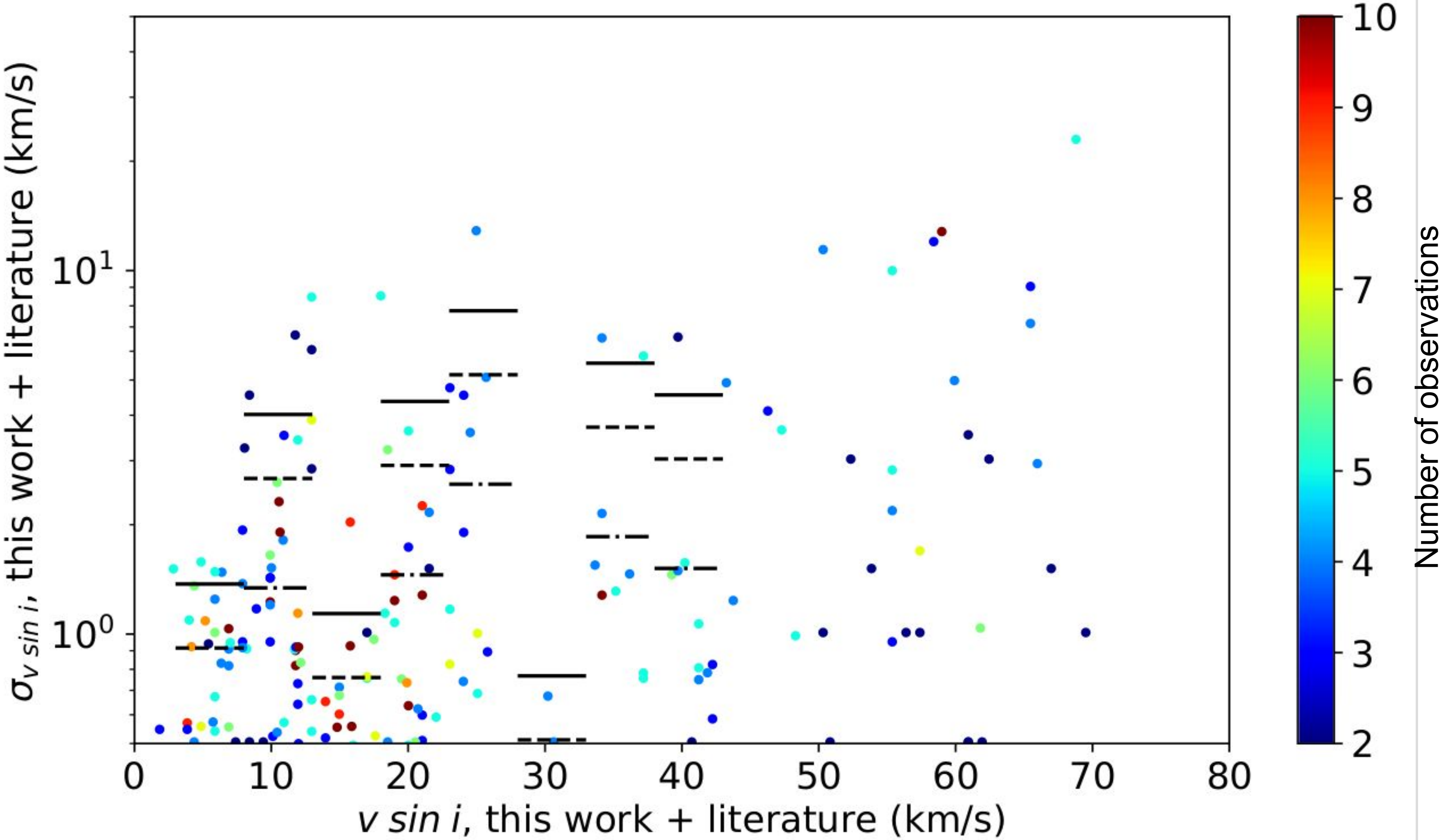
Previously published data

Ref.	Values	Source	MJD-range
Estimated from observation range			
Schlieder et al. (2012)	RV, $v \sin i$	Table 3	54718-55685
Shkolnik et al. (2012)	RV	Table 1[a]	53725-54455
Torres et al. (2006)	RV, $v \sin i$	Section 2.2	51179-53826
Lopez-Santiago et al. (2006)	RV	Section 2[b]	51910-52796
Rodriguez et al. (2013)	RV	Section 3.3	56171-56230
Maldonado et al. (2010)	RV	Table 2	53552-54771
Kiss et al. (2013)	RV	Section 3.1	55013-55669
Reiners & Basri (2009)	RV	Section 2.3	54475-54835
Gontcharov (2006)	RV	Table 5	47892-52275
Exact values for each observation			
Malo et al. (2014)	RV, $v \sin i$	...	54996-56532
Kraus et al. (2014)	RV[c]	...	56124-56327
Montes et al. (2001)	RV	...	51384-51566
Mochnacki et al. (2002)	RV	...	51082-52003
Bailey et al. (2012)	RV, $v \sin i$	...	53327-54963
Desidera et al. (2015)	RV, $v \sin i$	...	53102-55399

Number of observations - RV std



Number of observations - v sin i std



Summary of groups

Ass.	Ass. ID	Age (Myr)	Age ref.	Dist. (pc)	No. of members
AB Dor	ABD	100-150	2,7	49 ± 29	110
Argus	ARG	40-44	1,7	111 ± 47	77
β-Pic	BPC	21-26	1,3,4,7	43 ± 20	73
Carina	CAR	35-45	1,3,7	97 ± 39	50
Columba	COL	35-42	1,3,7	78 ± 25	79
ϵ-Cha	ECH	5-10	1,5,7	106 ± 9	36
Octans	OCT	30-40	1,6,7	111 ± 42	63
Tuc-Hor	THA	33-45	1,3,7	51 ± 10	187
TW Hydrae	TWA	10-12	1,3,7	56 ± 14	27

References. 1: Torres et al. (2006), 2: da Silva et al. (2009), 3: Bell et al. (2015), 4: Binks and Jeffries (2014), 5: Murphy et al. (2013), 6: Murphy and Lawson (2015), 7: Torres et al. in prep.