A high-resolution spectroscopic study of massive supergiant stars in Per OB1

Definition of the sample, membership, and kinematics

Abel de Burgos Sierra, Ph.D. student

Sergio Simón Díaz, IAC

Expanding the Gaia Legacy
Barcelona 17-19. 2020

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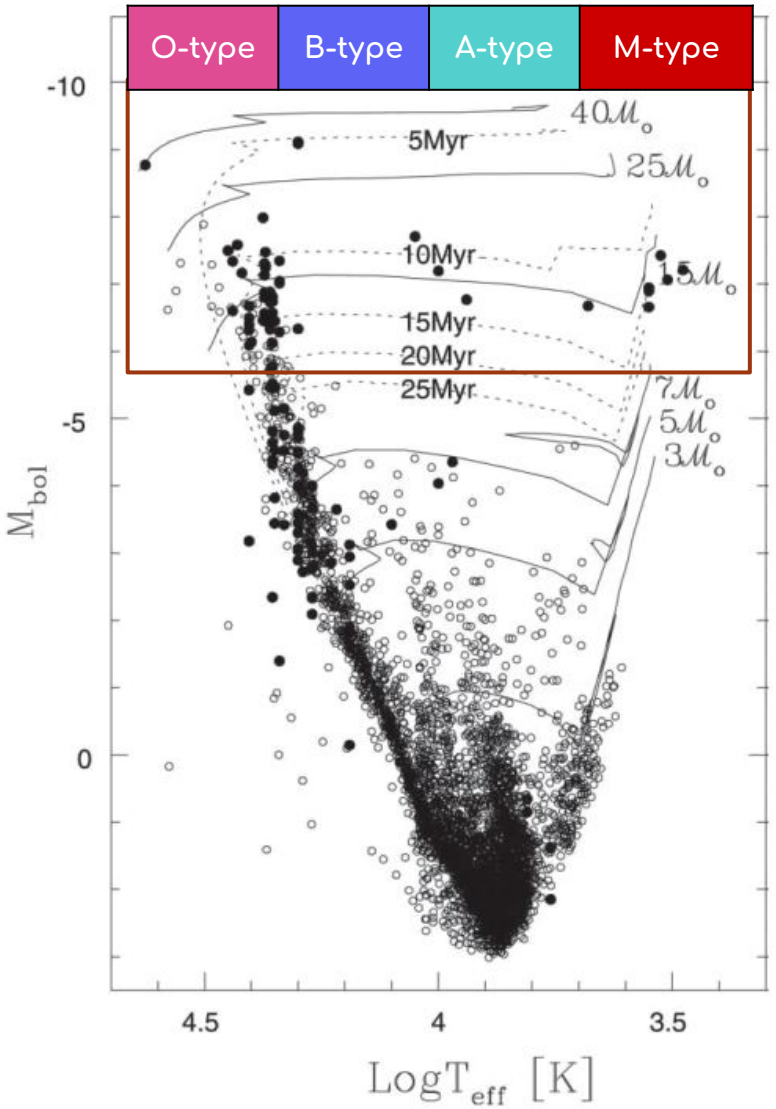
The importance of Per OB1 to study massive star evolution

- Young cluster ~10-20 Myr.
- Many massive stars at different evolutionary stages.
- They all share the same properties: distance, chemical composition, and ages.

HR diagram of h and χ Persei

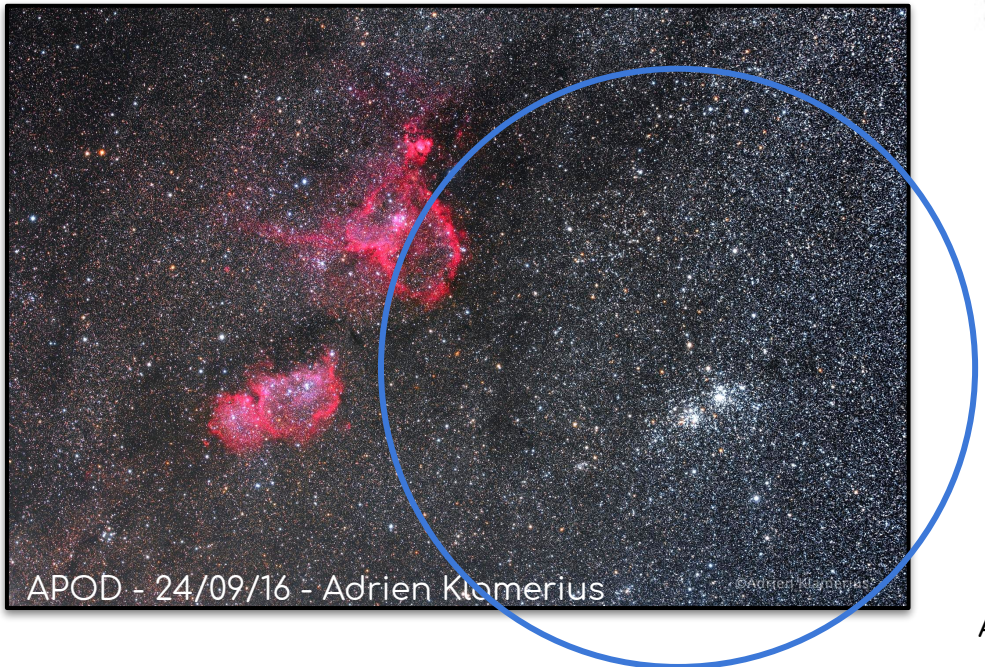


Adapted from Slesnick, C. & Hillenbrand, L. A. 2002

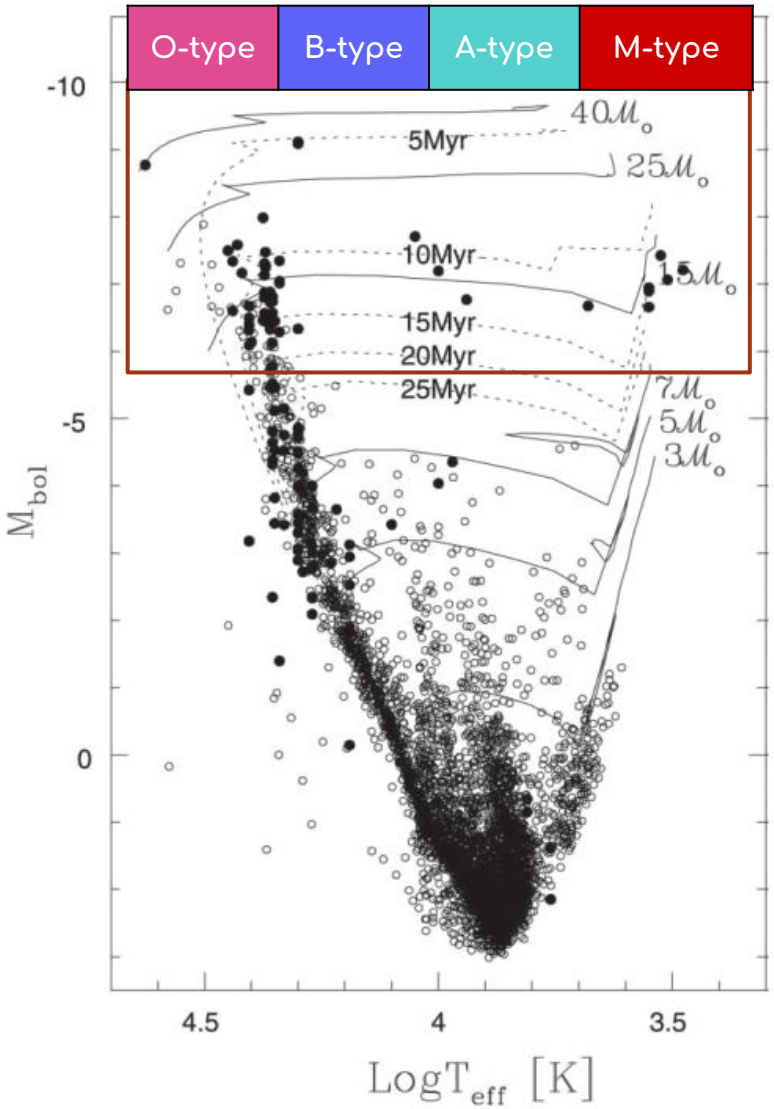
Aiming of this work

The ultimate **goal** is to perform a complete empirical characterization of all massive **members** around its center.

First step: study of membership and kinematics of potential members.



HR diagram of h and χ Persei

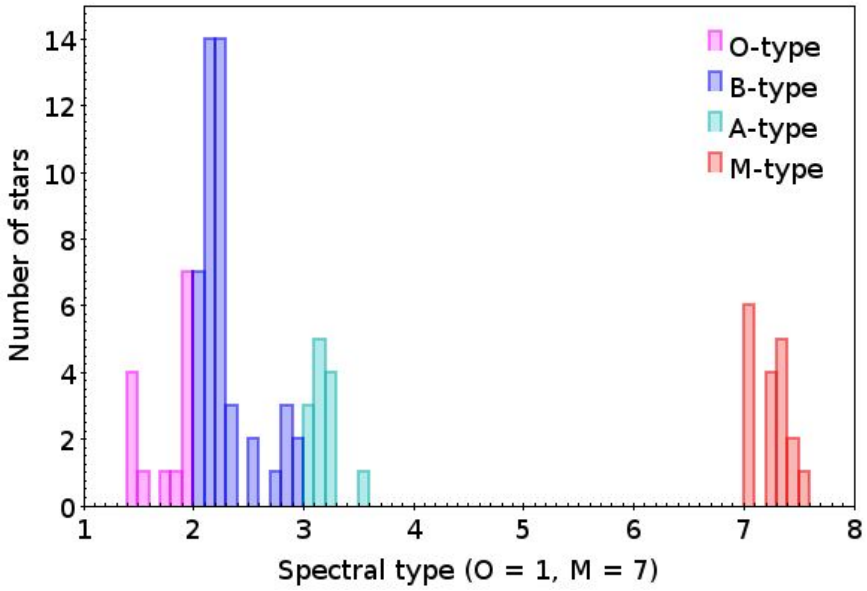


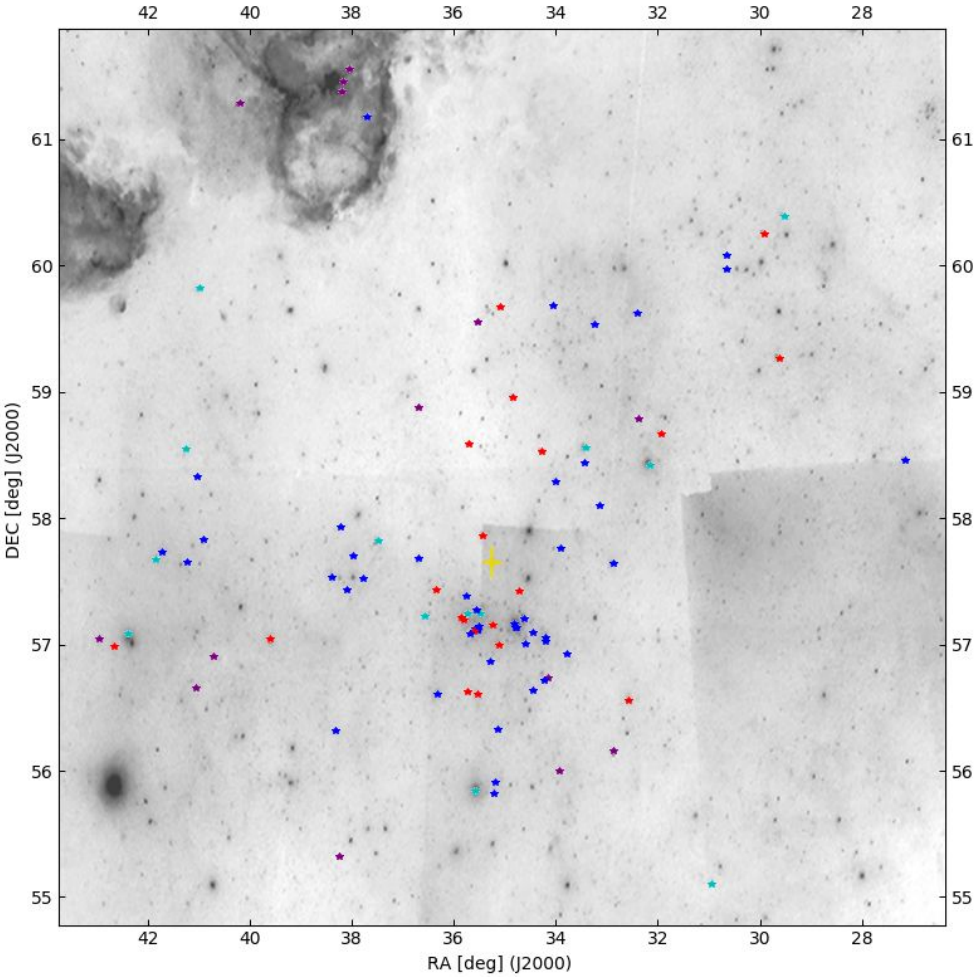
Adapted from Slesnick, C. & Hillenbrand, L. A. 2002

Building up the sample...

Crossmatch between IACOB DB and several catalogs of massive supergiants stars within **4.5** deg around the center.

We found **93** different massive stars with at least one spectrum.



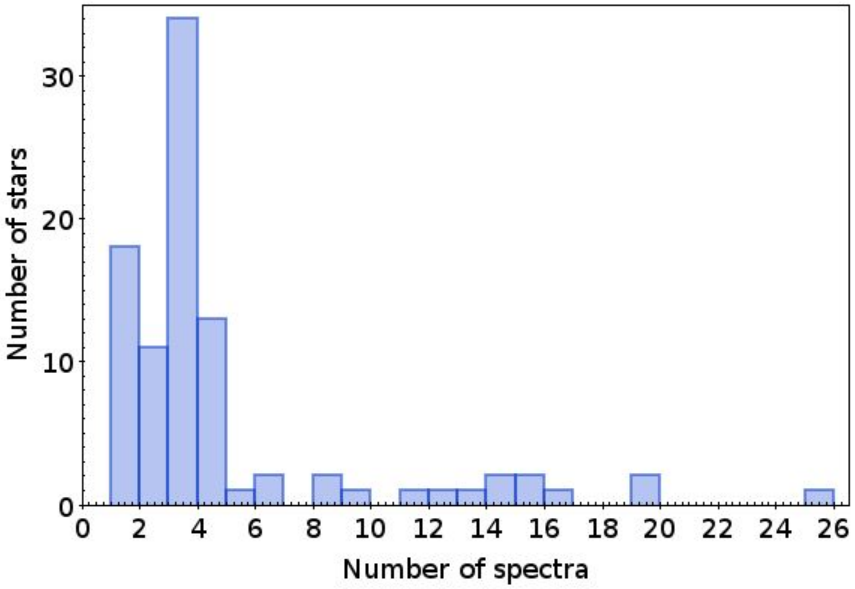


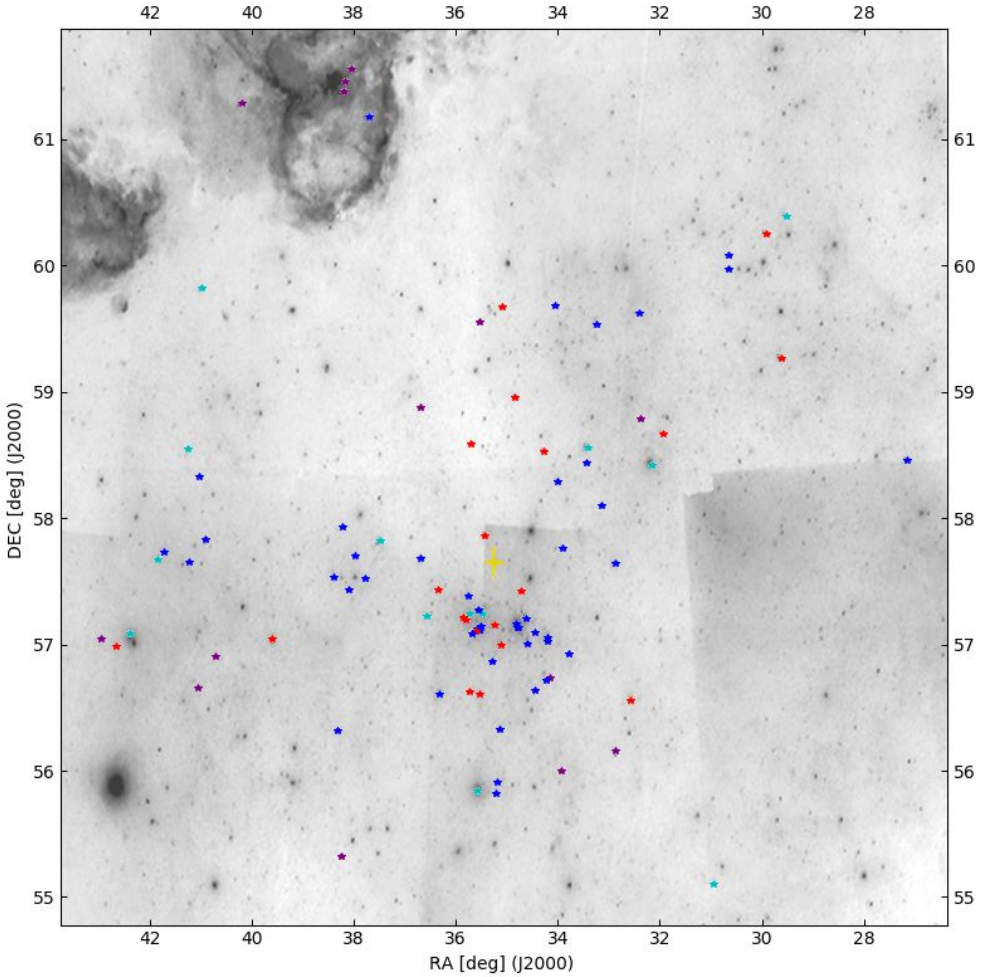
O-type	B-type	A-type	M-type
14 stars	46 stars	13 stars	20 stars

Building up the sample...

Of the **93** stars we found **30** with more than **3** epochs.

We used these spectra for investigating spectroscopic variability and to detect SB1/SB2 binaries.



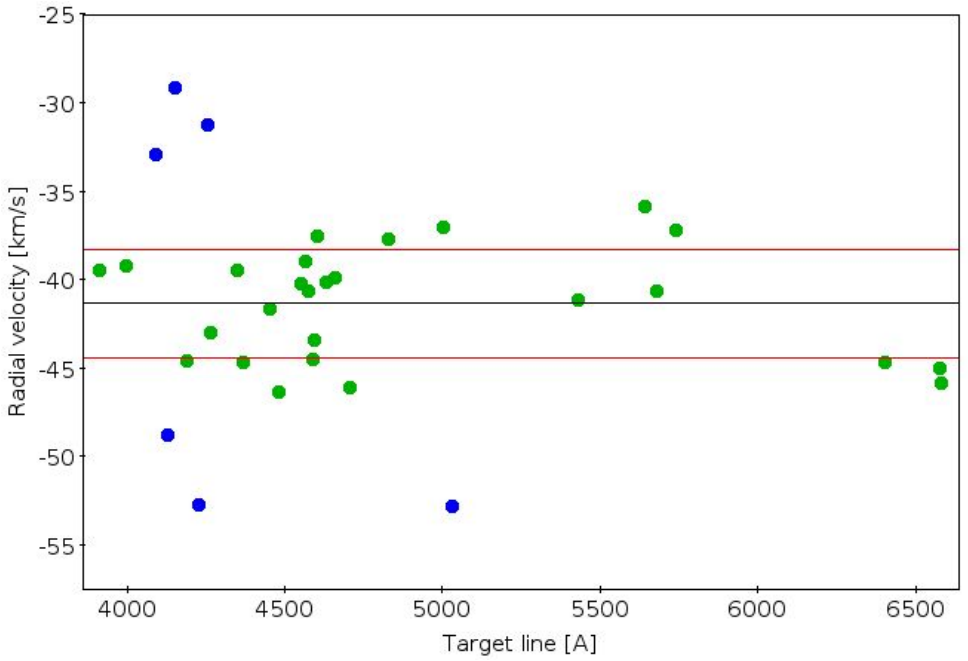


O-type	B-type	A-type	M-type
14 stars	46 stars	13 stars	20 stars

Methodology

RV measurements

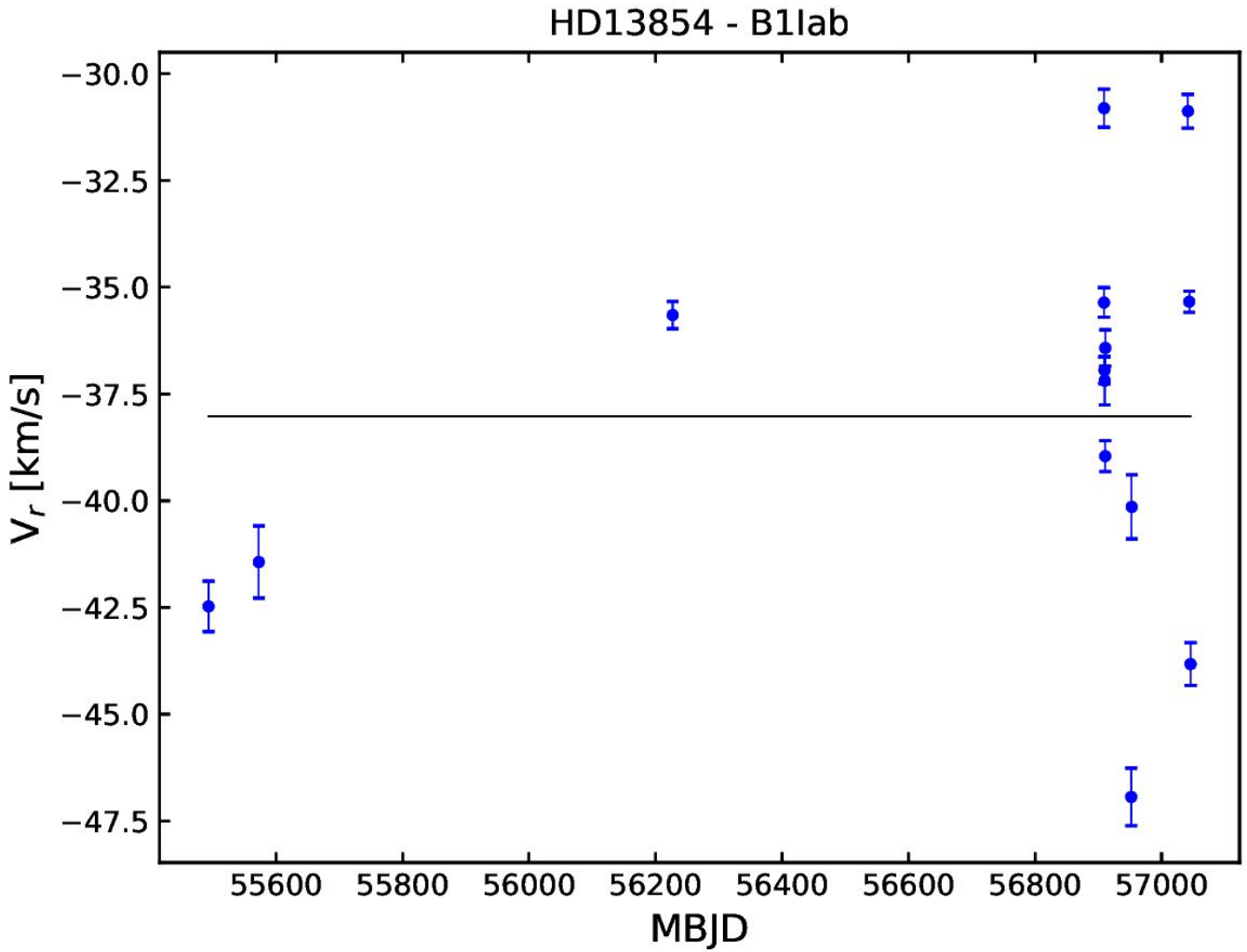
- Catalog of lines with SpT
- Apply correction for heliocentric velocity
- Preliminar initial correction
- RVs for ~40 different lines
- Sigma clipping ~25 lines



Stellar lines	C I-IV, N I-IV, O I-IV, Si I-IV, Mg I-III, S I-III, Fe I-III, Ne I-III, H/He I-II Ni I-III, Ti I-III, Cr I-II, Sc I-II - (Cu I-III, Al I-III, Co I-III, Zn I-III, F I-III, Cl I-III, P I-III)															
✓	Line (Å)	Element	Ref.	O9	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	A0	A1	A2	Q
☐	3911.958	O II	NIII1	0	1+	1+	1+	1+	1+	0	0	0	0	0	0	0	0	3/5
☐	3920.681	C II	NIII1	0	0	0	0	1-	1-	1	1+	1+	1+	1+	1+	1+	1	3/5
☐	3945.232	C II	SPW	0	0	0	0	0	0	0	0	0	0	0.5	1	1+	1+	4/5
☐	3951.965	V II	SPW	0	0	0	0	0	0	0	0	0	0	0	0.5	1	1+	3/5
☐	3961.573	O III	SA3	1	1+	0	0	0	0	0	0	0	0	0	0	0	0	4/5
☐	3994.997	N II	NIII1	0.5	1+	1+	1+	1+	1+	1+	1+	1+	1+	0.5	0	0	0	5/5
☐	4012.496	Cr II	SPW	0	0	0	0	0	0	0	0	0	0	0.5	1+	1+	1+	4/5
☐	4067.031	Ni II	SPW	0	0	0	0	0	0	0	0	0	1	1+	1+	1+	1+	4/5
☐	4088.862	Si IV	SD10	1+	1+	1+	1+	0.5-	0	0	0	0	0	0	0	0	0	5/5
☐	4097.36	N III	SA3	1+	1+	1+	1	0	0	0	0	0	0	0	0	0	0	4/5
☐	4116.103	Si IV	SD10	1+	1+	1+	1+	0	0	0	0	0	0	0	0	0	0	4/5

Methodology

RV measurements (multi-epoch)

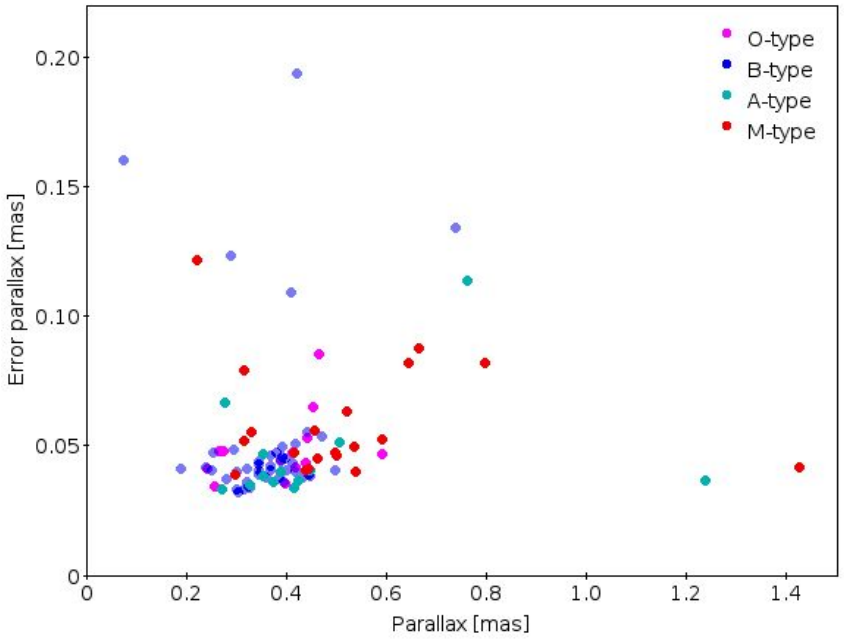


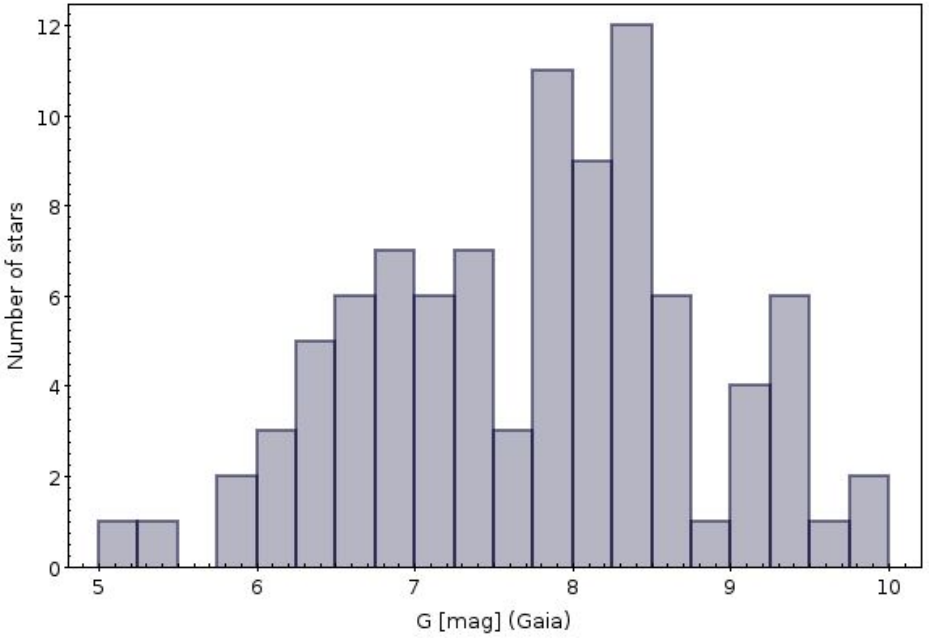
Methodology

Completing the information with Gaia DR2

We have taken into account:

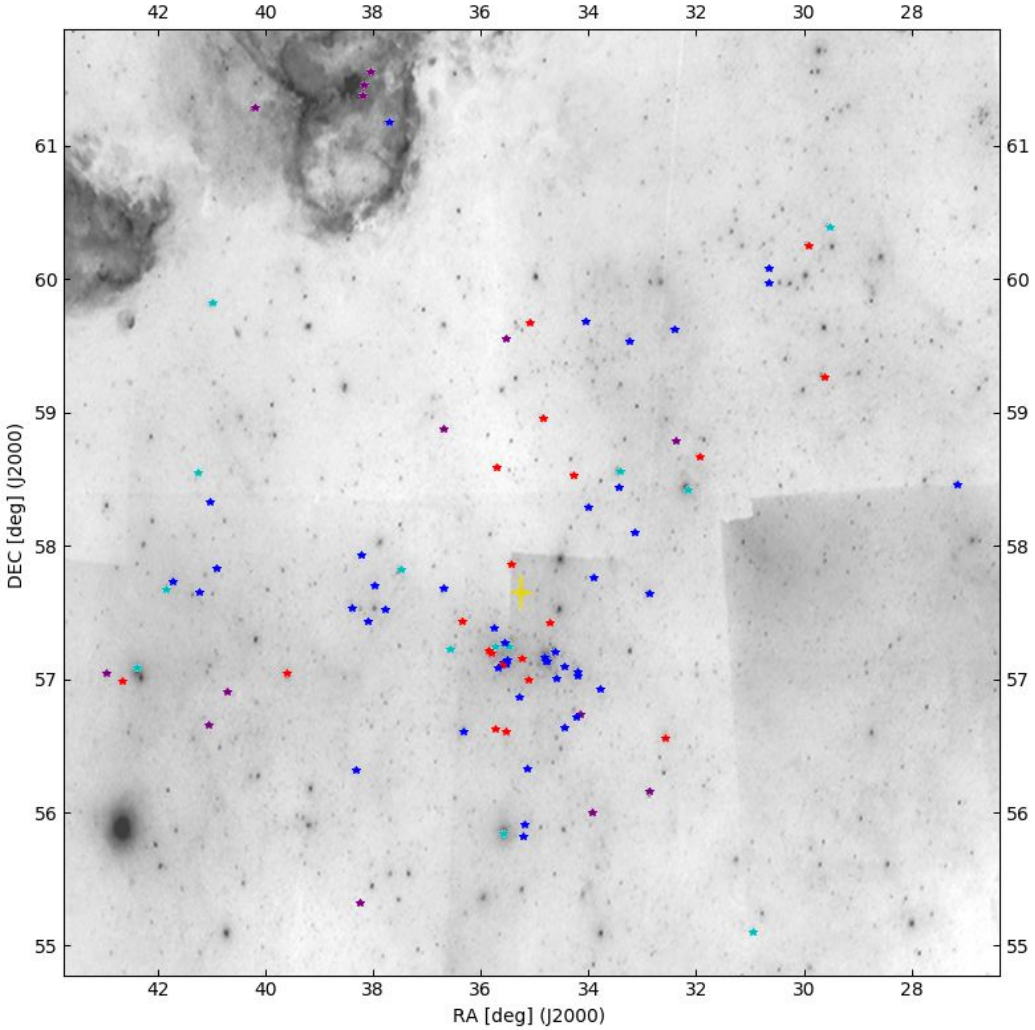
- Parallaxes and proper motions with high errors.
- For bright stars (G mag < 6.5) must be handle with special care.





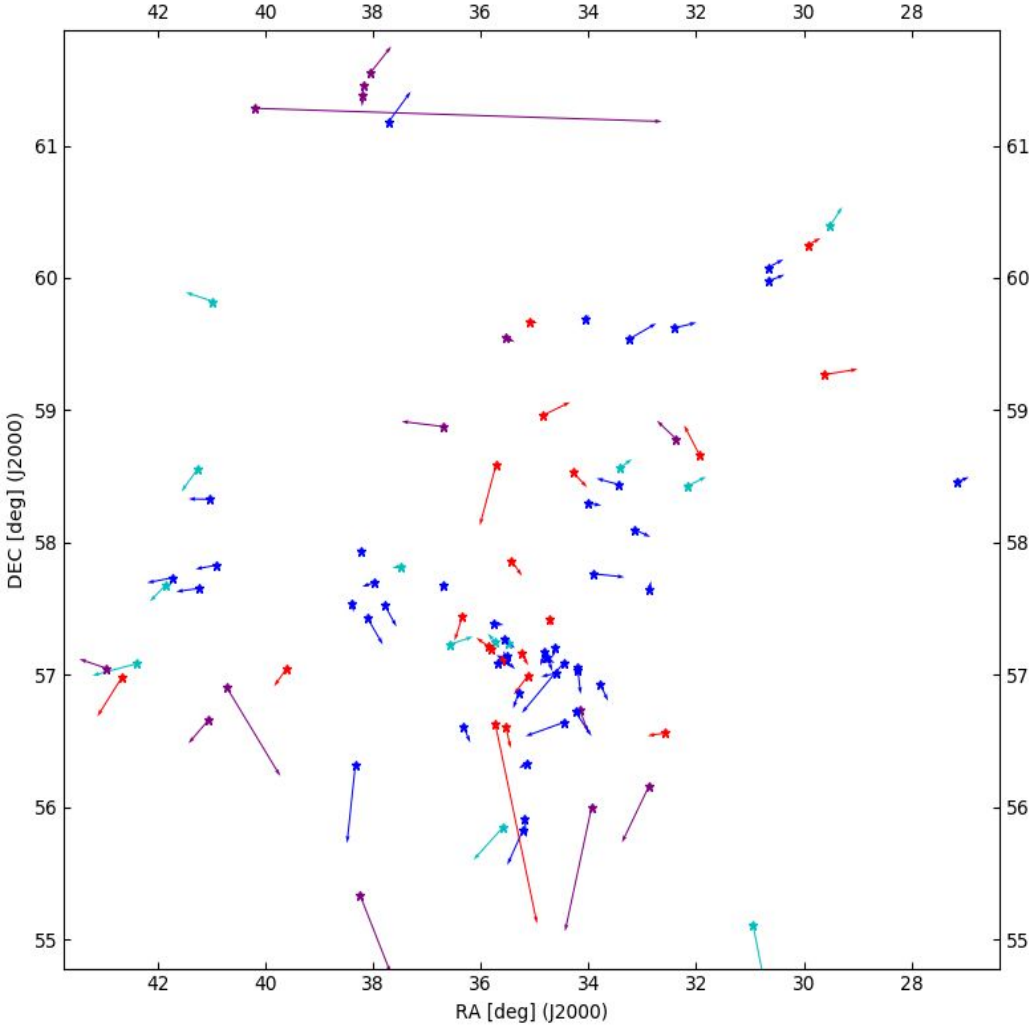
Methodology

Completing the information with Gaia DR2



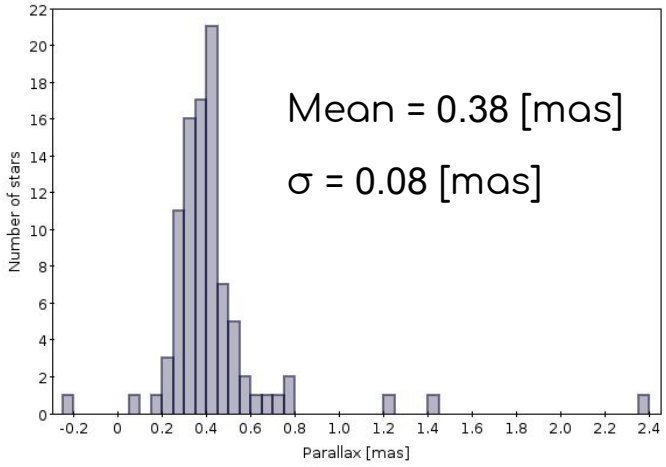
Methodology

Completing the information with Gaia DR2

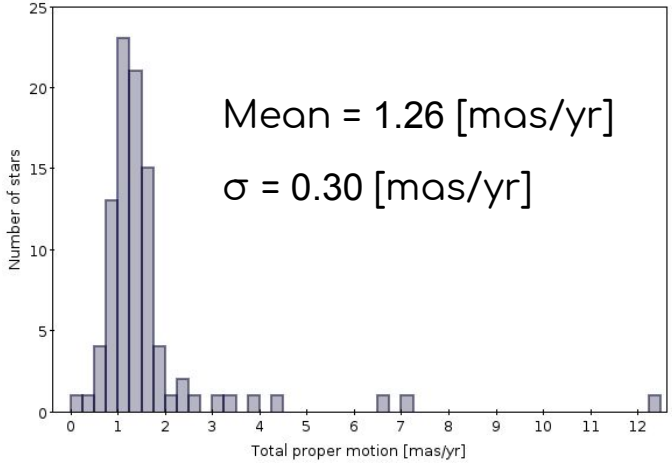


Results: membership and kinematics

Parallax and proper motions



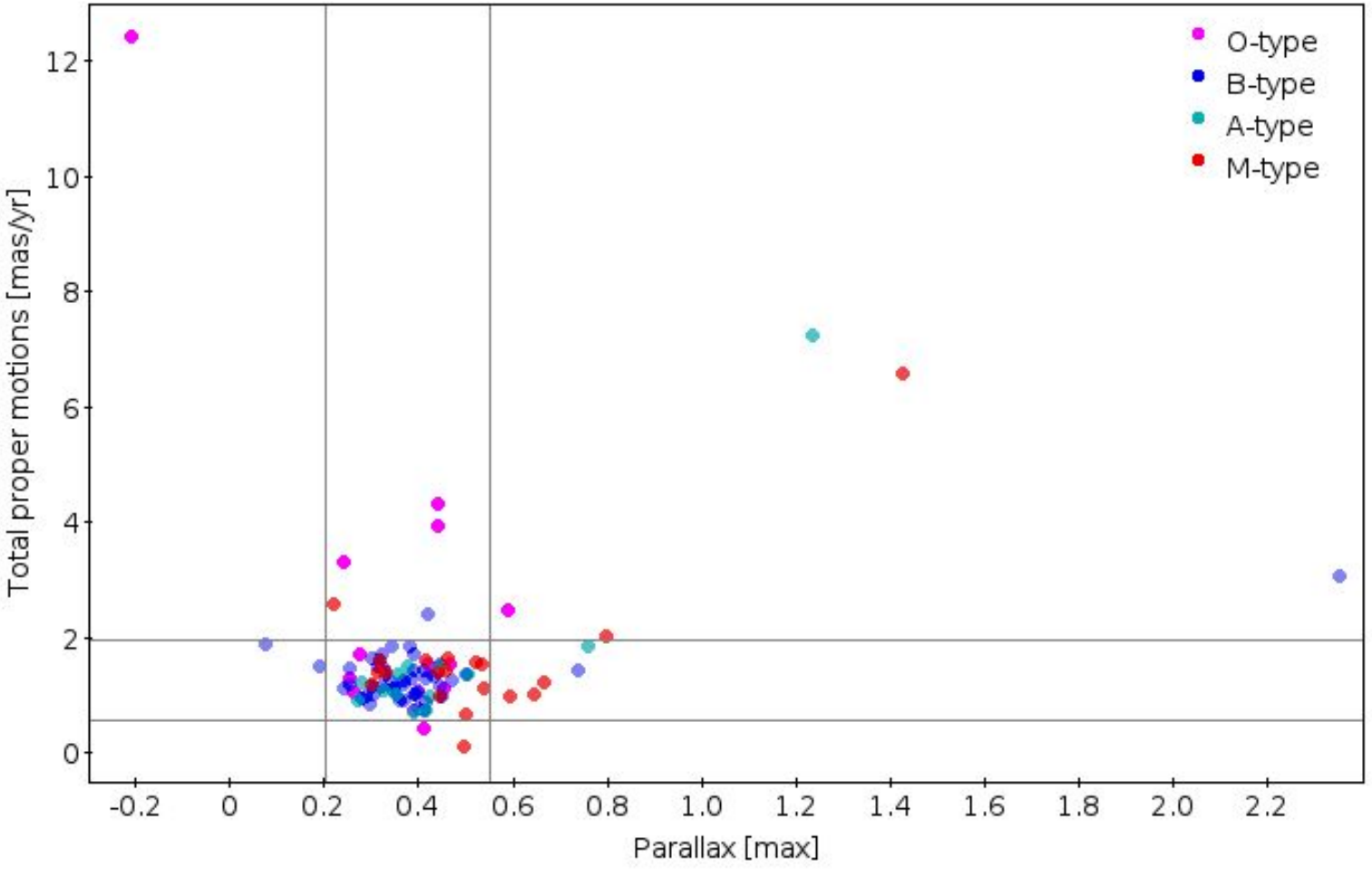
Outliers in parallax			
O-type	B-type	A-type	M-type
2 stars	4 stars	2 stars	5 stars
13 %	8.7 %	15 %	25 %



Outliers in total proper motion			
O-type	B-type	A-type	M-type
6 stars	2 stars	1 stars	3 stars
43 %	4.3 %	7.7 %	15 %

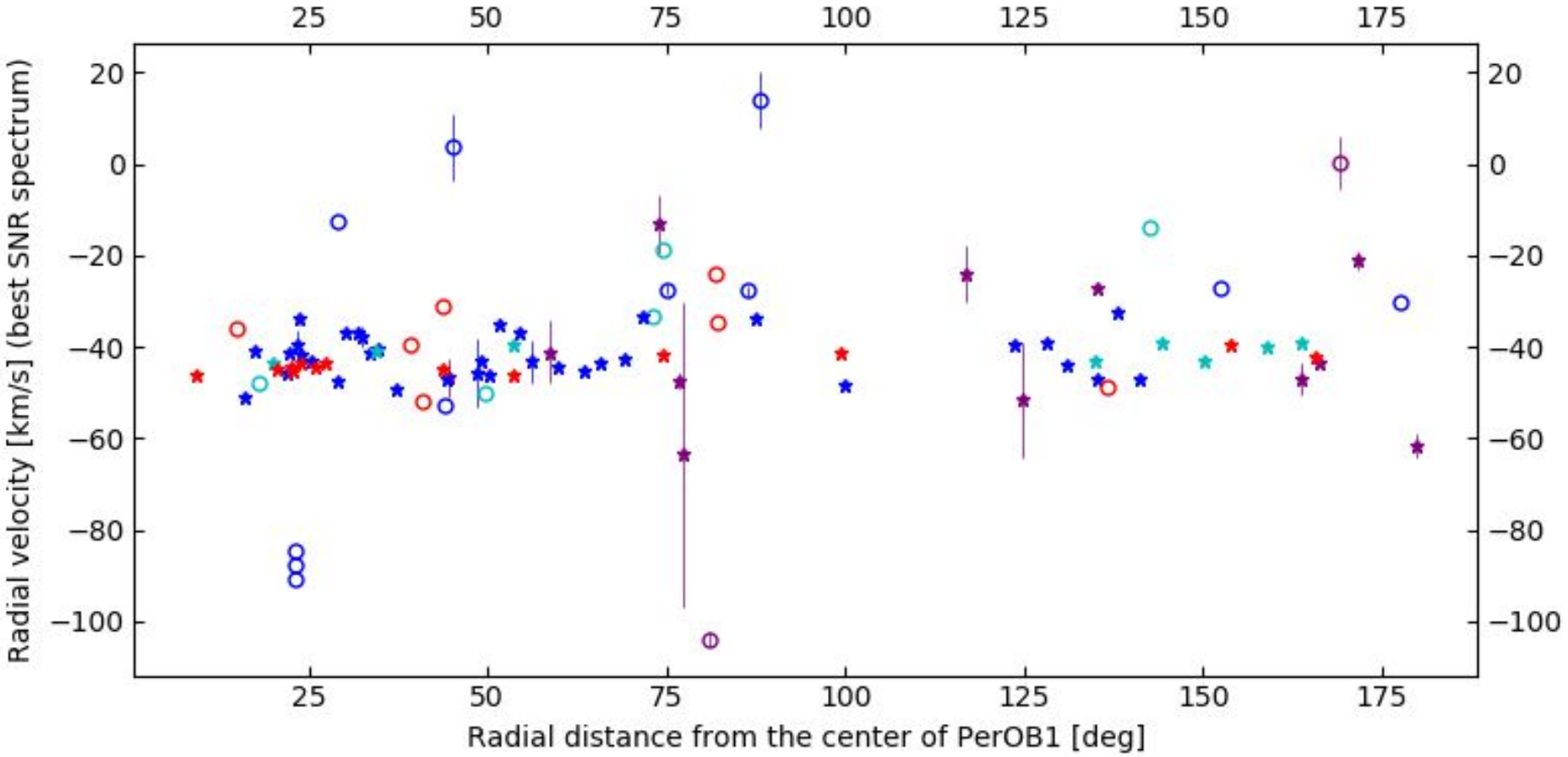
Results: membership and kinematics

Parallax and proper motions



Results: membership and kinematics

Radial velocities



Results: membership and kinematics

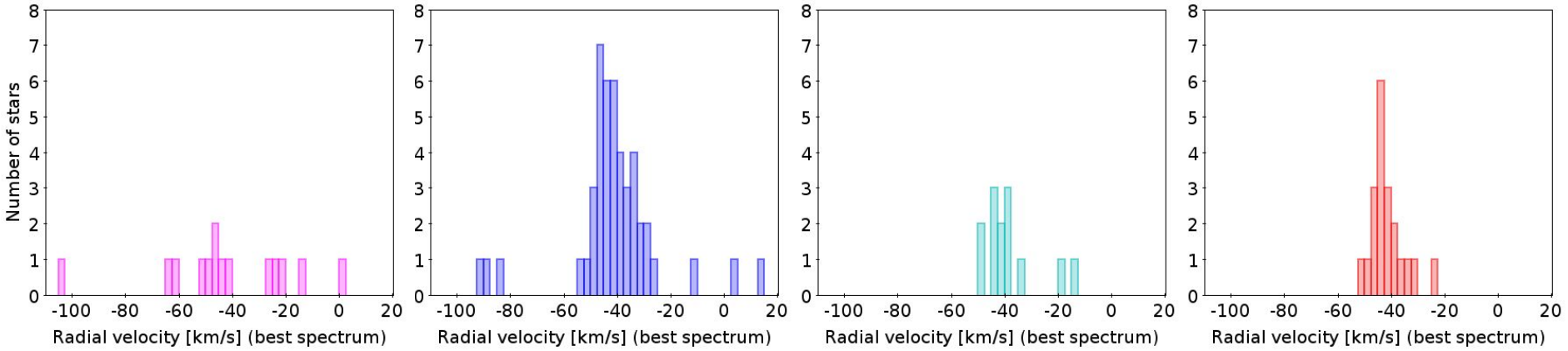
Radial velocities

Mean = - 37 [km/s]
σ = 18 [km/s]

Mean = - 41 [km/s]
σ = 6 [km/s]

Mean = - 42 [km/s]
σ = 4 [km/s]

Mean = - 43 [km/s]
σ = 4 [km/s]

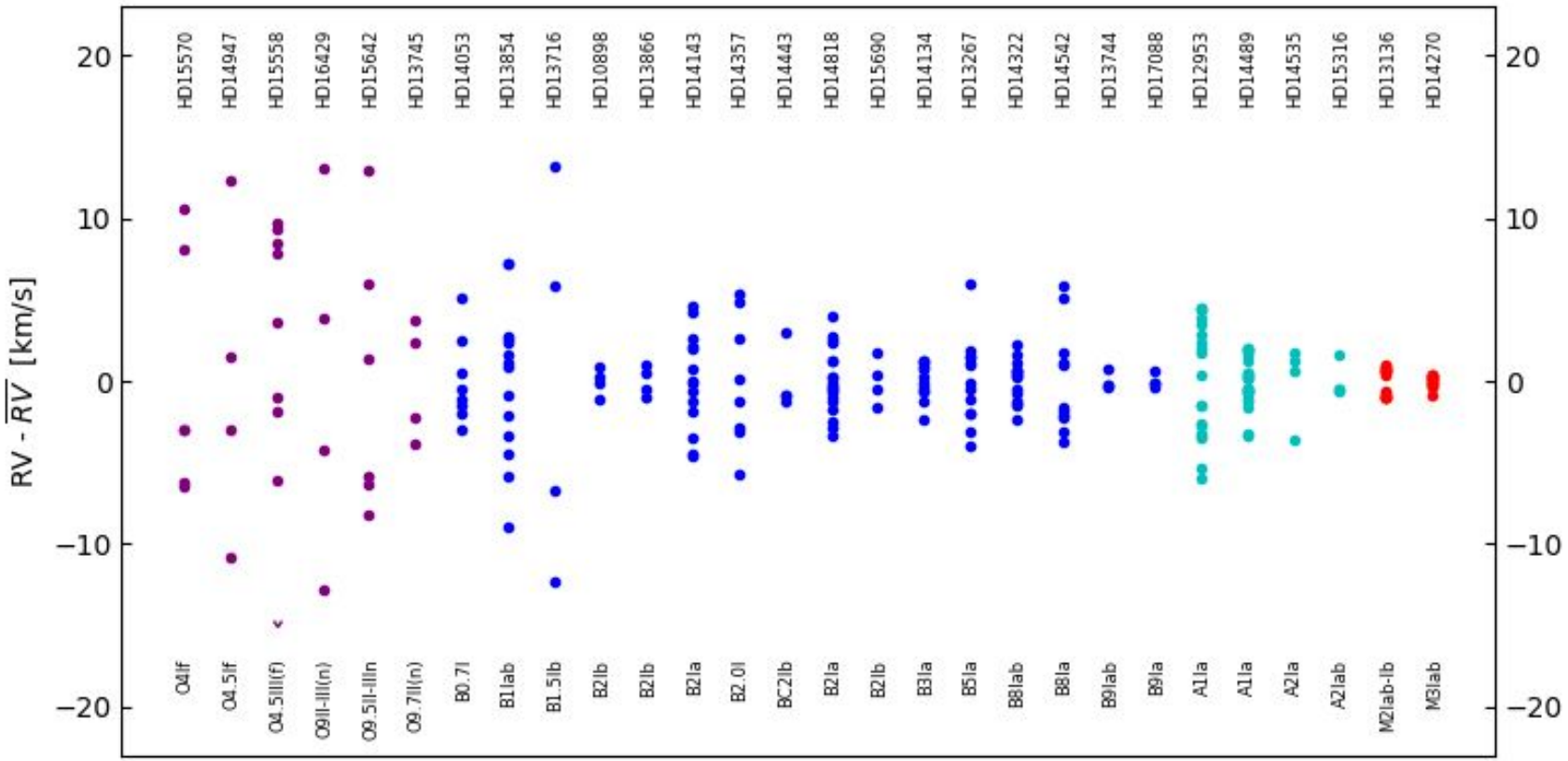


Outliers in radial velocity			
O-type	B-type	A-type	M-type
8? stars	6 stars	2 stars	2 stars
62 %?	13 %	15 %	10 %

Results: membership and kinematics

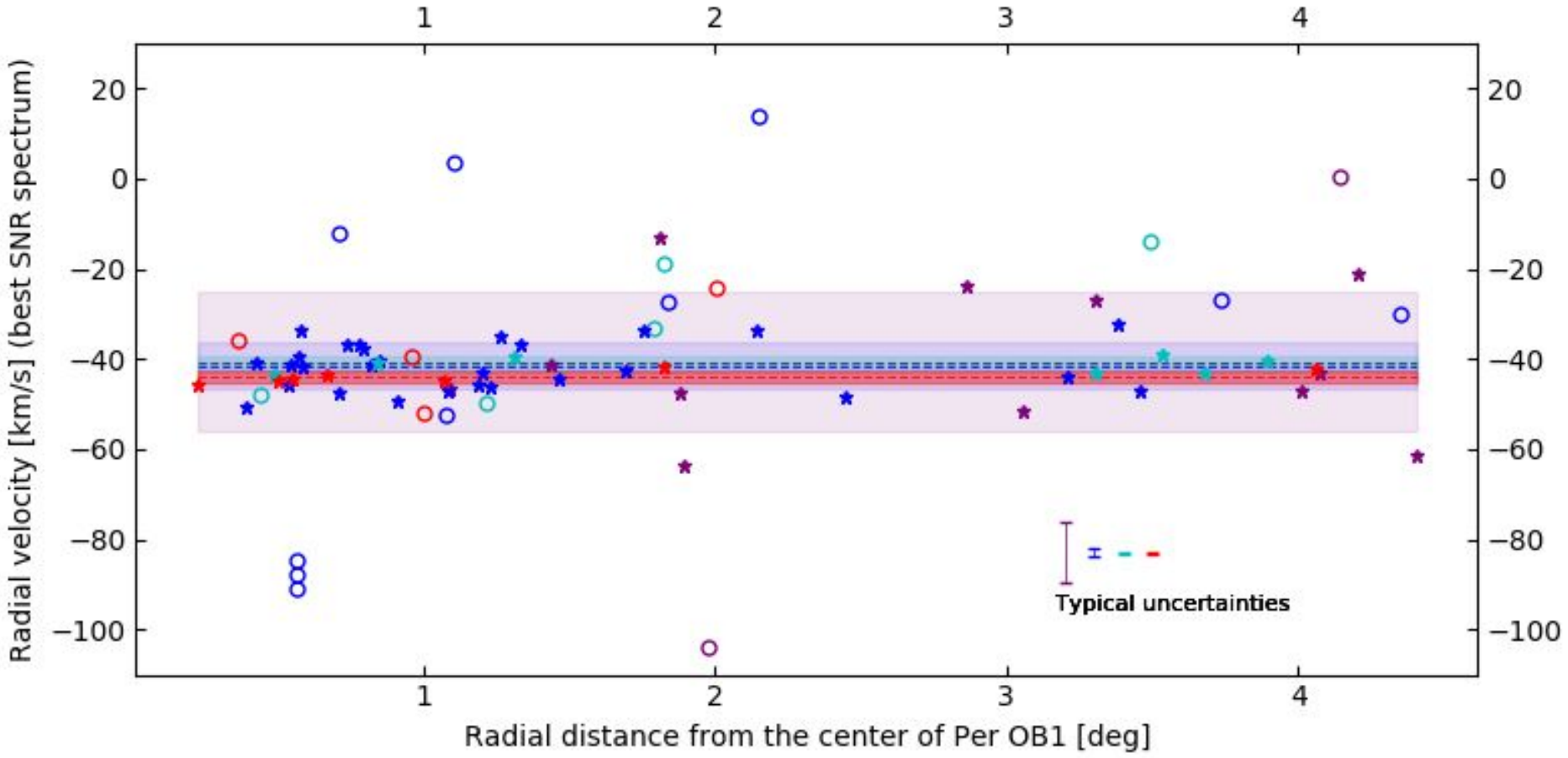
Multi-epoch information

We complement the information using the peak-to-peak variability.



Results: membership and kinematics

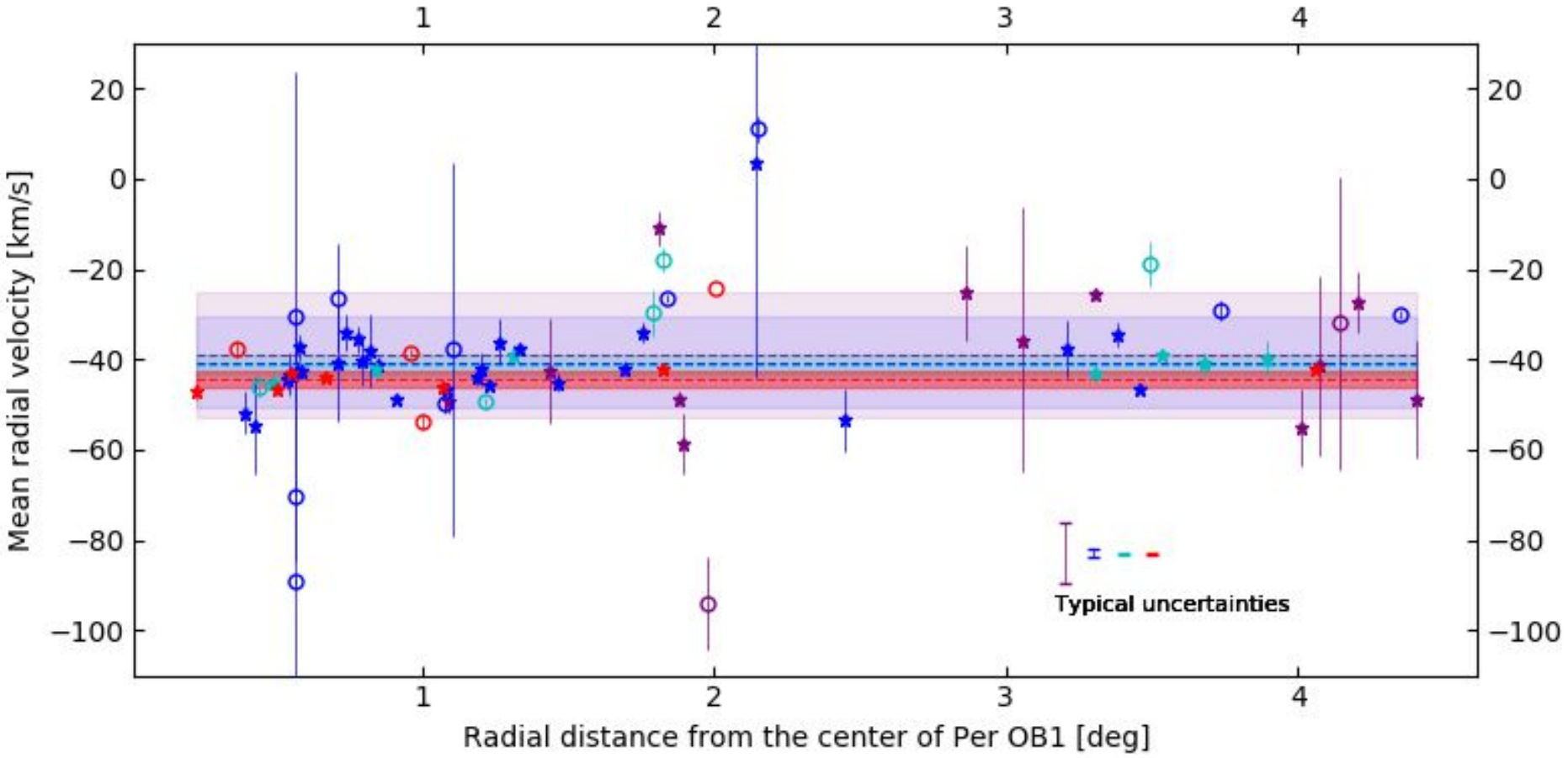
Multi-epoch information



Only stars with multi-epoch (+3 spectra)

Results: membership and kinematics

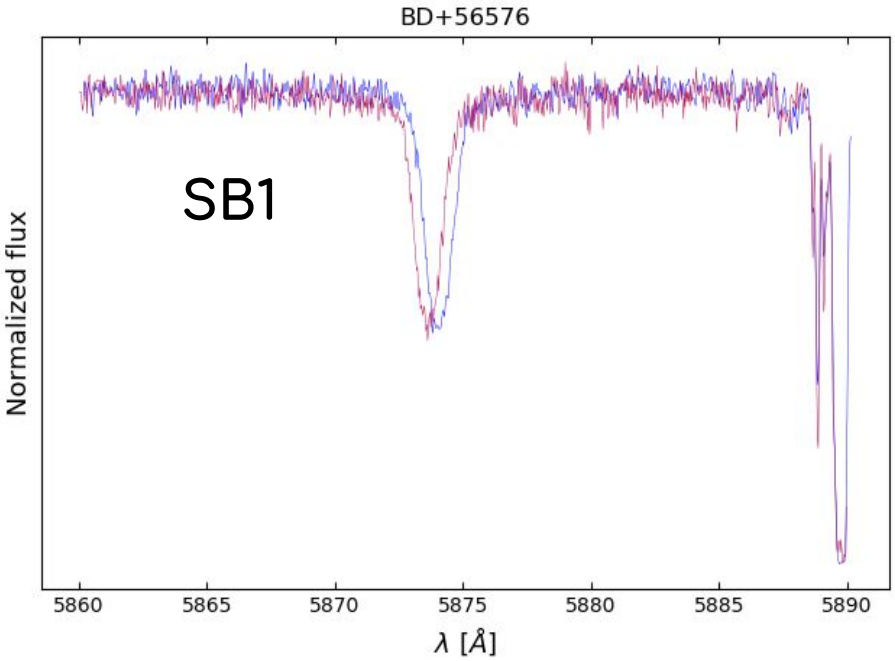
Multi-epoch information

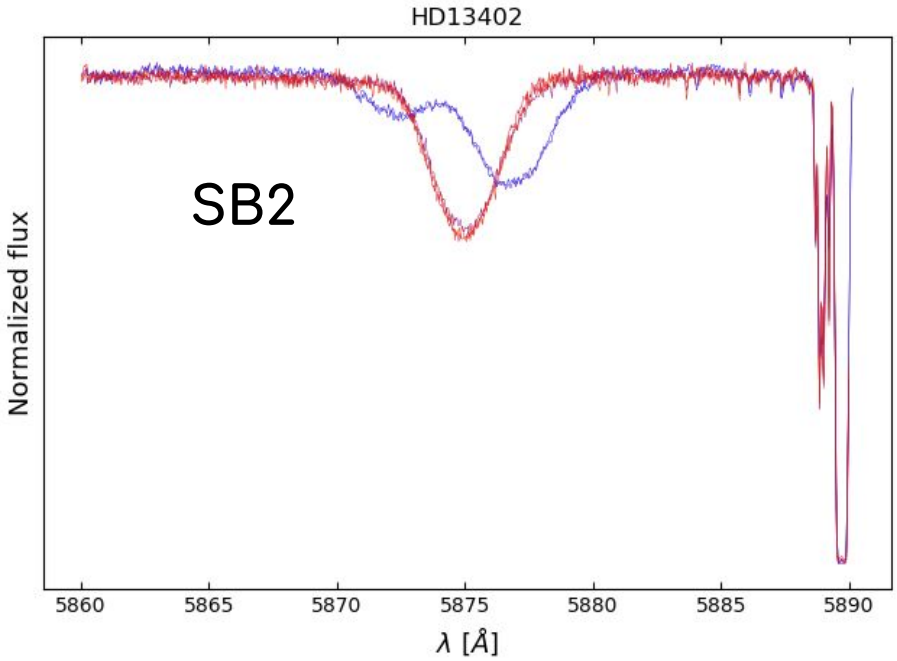


Only stars with multi-epoch (+3 spectra)

Results: membership & kinematics

Final visual inspection of the multi-epoch spectra to separate SB1/SB2





Results: membership & kinematics

Name	SpT	Parallax	Proper motions	Best RV	Multi-epoch	Binary	Comments
HD15558	O	1	1	1	1	SB2	
HD13022	O	1	0	1	--		Walkaway
BD+60498	O	1	1	1	--	SB1	
HD16429	O	0	0	1	1	SB2	Bad Plx. Runaway.
HD13268	O	0	0	0	0	--	
HD13969	B	1	0	0	--	SB1	Walkaway
HD14053	B	1	1	1	1		
HD14322	B	0?	1	1	1		Gmag = 6.6
HD14331	B	1	1	1	--		
BD+56578	B	1	1	0	0		Runaway
HDE232588	A	0	0	0	--		
HD14535	A	1	1	1	1		
HD14489	A	--	1	0	1		Gmag = 5
HD12842	M	1	0	0	0		Runaway
HD14270	M	1	1	1	1		
HD13136	M	0?	1	1	1		Gmag = 6.6

Results: membership & kinematics

	Results from the membership analysis				
	O-type (14 stars)	B-type (46 stars)	A-type (13 stars)	M-type (20 stars)	Total (93 stars)
Members	8	38	11	13	70
Runaways	5	4	0	2	11
Unclear	0	3	1	2	6
Discarded	1	1	1	3	6
SB1 / SB2	2 / 2	4 / 3	0 / 0	0 / 0	6 / 4

Summary and future plans

1) We have investigated the membership and kinematics of **93** massive stars within 4.5 degrees around h + χ Persei.

2) In this work we combine information from ground based high-res spectroscopy together with the Gaia data.

3) We have confirmed **70** of them as members of Per OB1. We discarded **6**.

4) Another **11** are runaways and **6** remain unclear.

5) Among them we identified **6** SB1 and **5** SB2.

6) This information will be used for the interpretation of the subsequent quantitative spectroscopic analysis of the full sample.

7) Results will be confronted with the predictions of evolutionary models.

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Thank you!

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