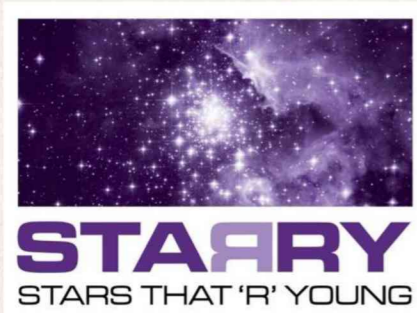


Clustering properties of Herbig Ae/Be stars — CEREAL

Alice Pérez Blanco

René Oudmaijer (University of Leeds), Ricardo Pérez-Martinez (ISDEFE - ESAC)
and Deborah Baines (QUASAR - ESAC)



Isdefe
UNIVERSITY OF LEEDS



This project has received funding from the European Union's Horizon 2020 research and innovation programme under MSCA ITN-EID grant agreement No 676036.

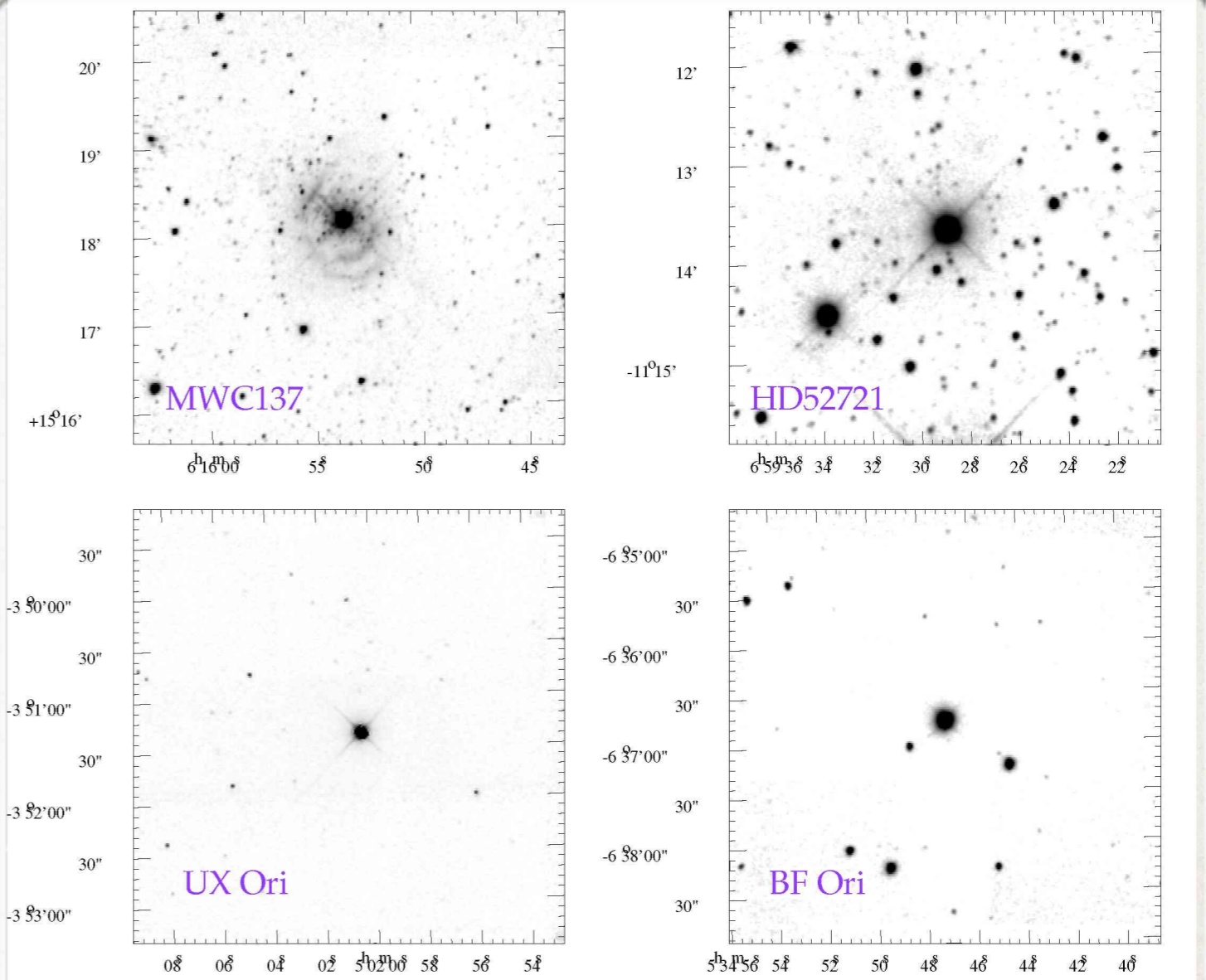
Outline

- ❖ Background.
- ❖ *ClustER* *detEction AL*gorithm (**CEREAL**).
- ❖ CEREAL vs Testi et al 1999.
- ❖ Conclusions.

Background

Lada +93; Hillenbrand + 95; Testi + 97

- ❖ *Testi +99* analyzed the occurrence of young stellar clusters around Herbig Ae/Be stars from near-infrared images.
- ❖ Spectral type range O9 to A7.



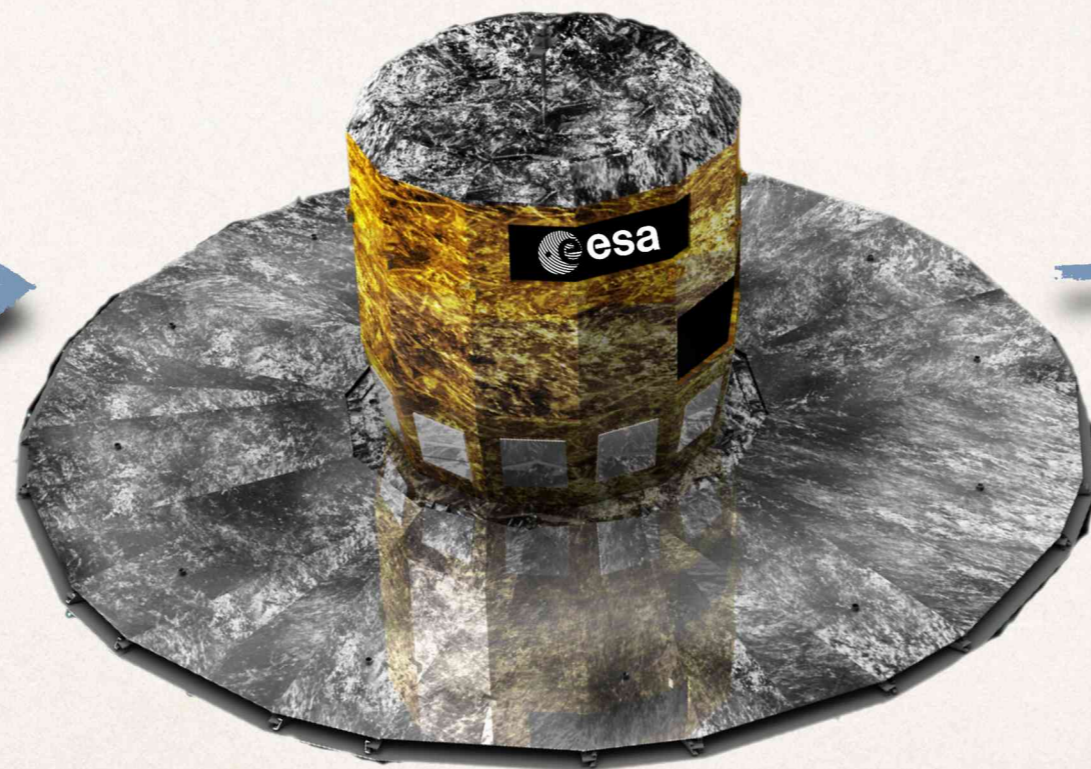
K band images of four Herbig stars.

Clust*ER* det*E*ction *AL*gorithm : CEREAL

Gaia Collaboration+2018; Lindengren+18a; Vioque+18

Semi-automatic code to make selection using the
astrometric parameters.

Targets



RUWE



CEREAL

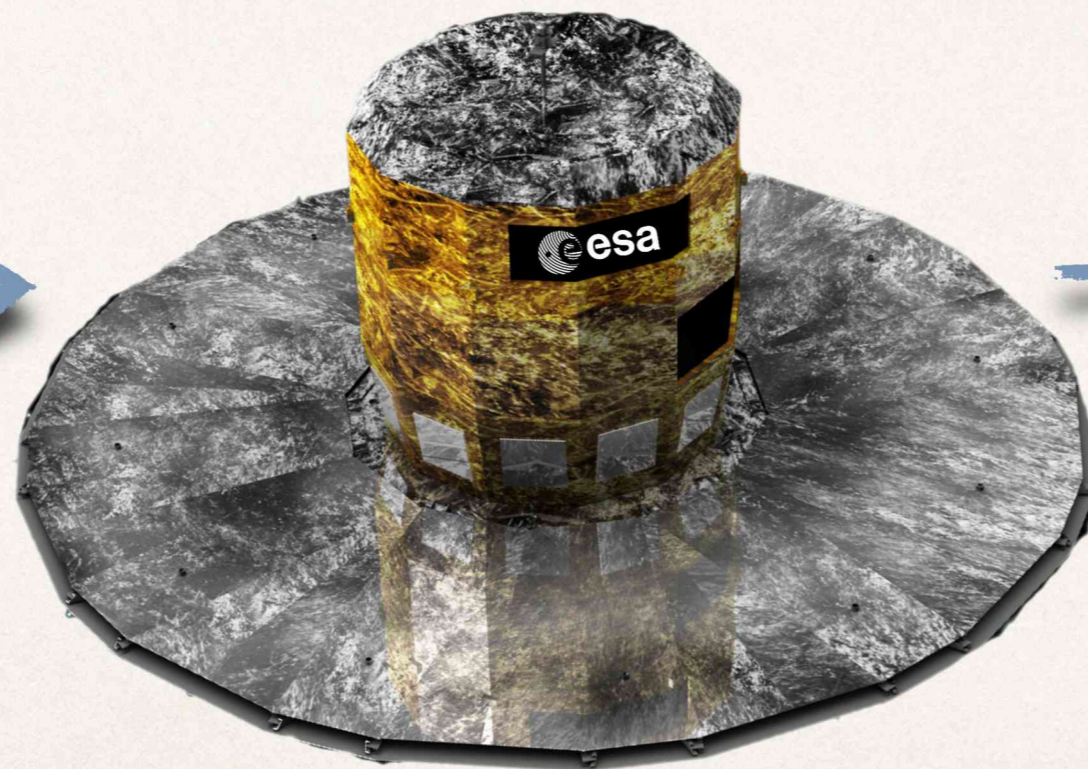
Is the target in a
cluster?
Yes? Maybe? or No?

Clust*ER* det*E*ction *AL*gorithm : CEREAL

Gaia Collaboration+2018; Lindengren+18a; Vioque+18

Semi-automatic code to make selection using the
astrometric parameters.

Targets



RUWE



CEREAL

Is the target in a
cluster?
Yes? Maybe? or No?

Clust*ER* det*E*ction *AL*gorithm : CEREAL

Herbig 60; Thé+94; Che+16; Vioque+18

Following the criteria to identify a HAeBe star defined by *Herbig 1960*, we compiled the known Herbig Ae/Be star candidates.

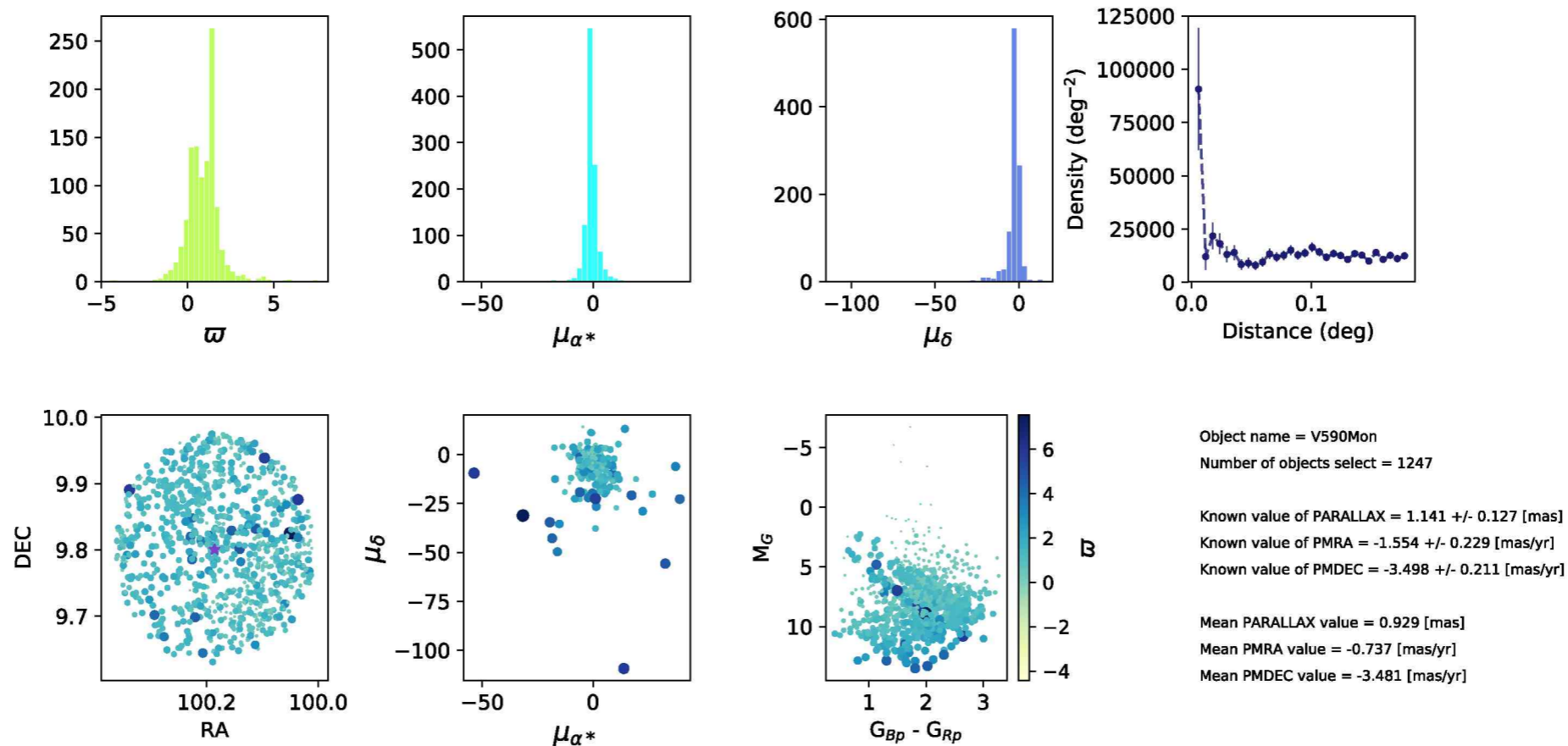
270 stars form the sample, taken from *Chen + 16* and *Vioque + 18*



V590 Mon (LkHA 25)

Monoceros Constellation

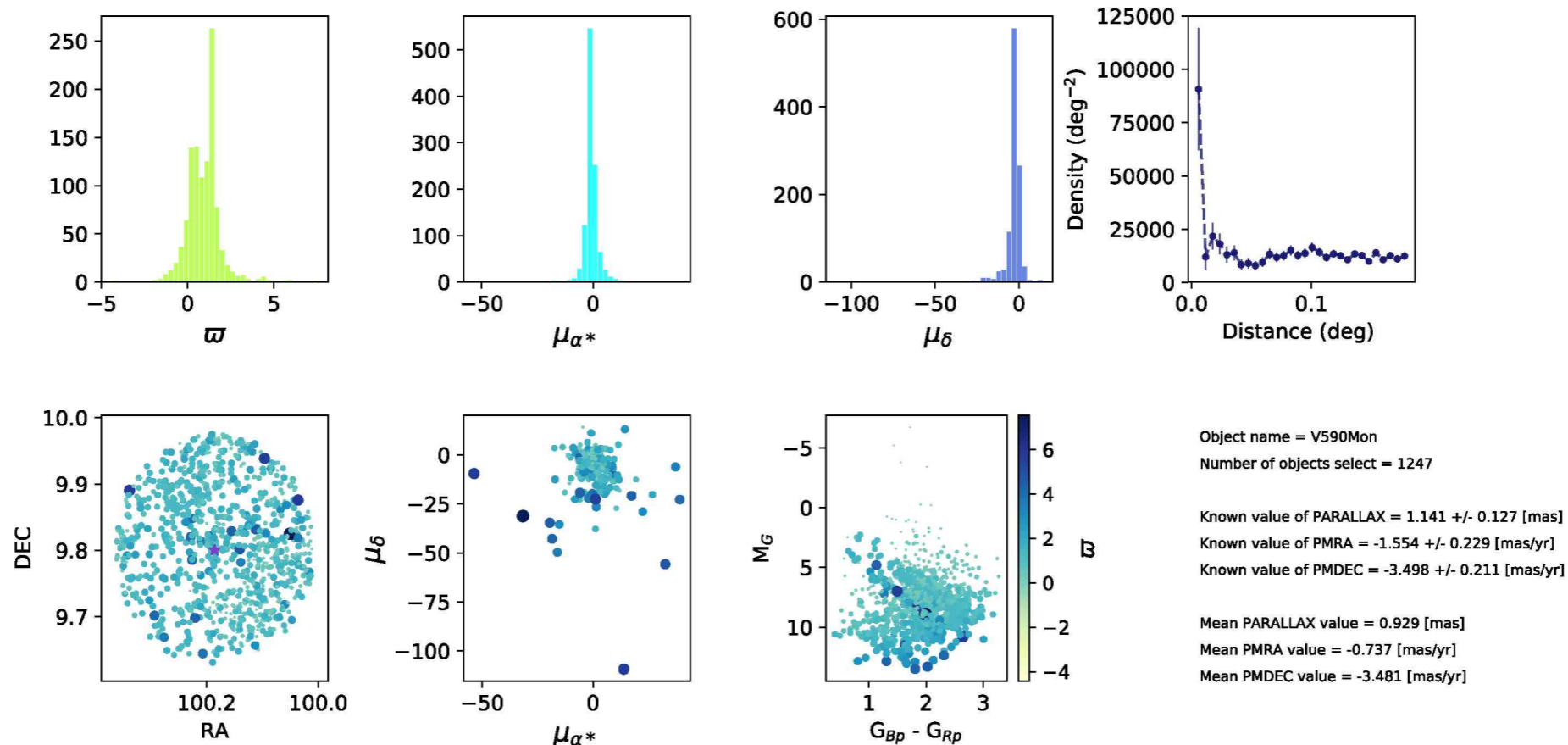
| | | | | | |
|----------|---------------------|-------|-------------------------|-----|-----------|
| Located | NGC 2264 | PMRA | -1.55 ± 0.22 mas/yr | SPT | B7 |
| Parallax | 1.14 ± 0.12 mas | PMDEC | -3.49 ± 0.21 mas/yr | G | 12.74 mag |



V590 Mon (LkHA 25)

Monoceros Constellation

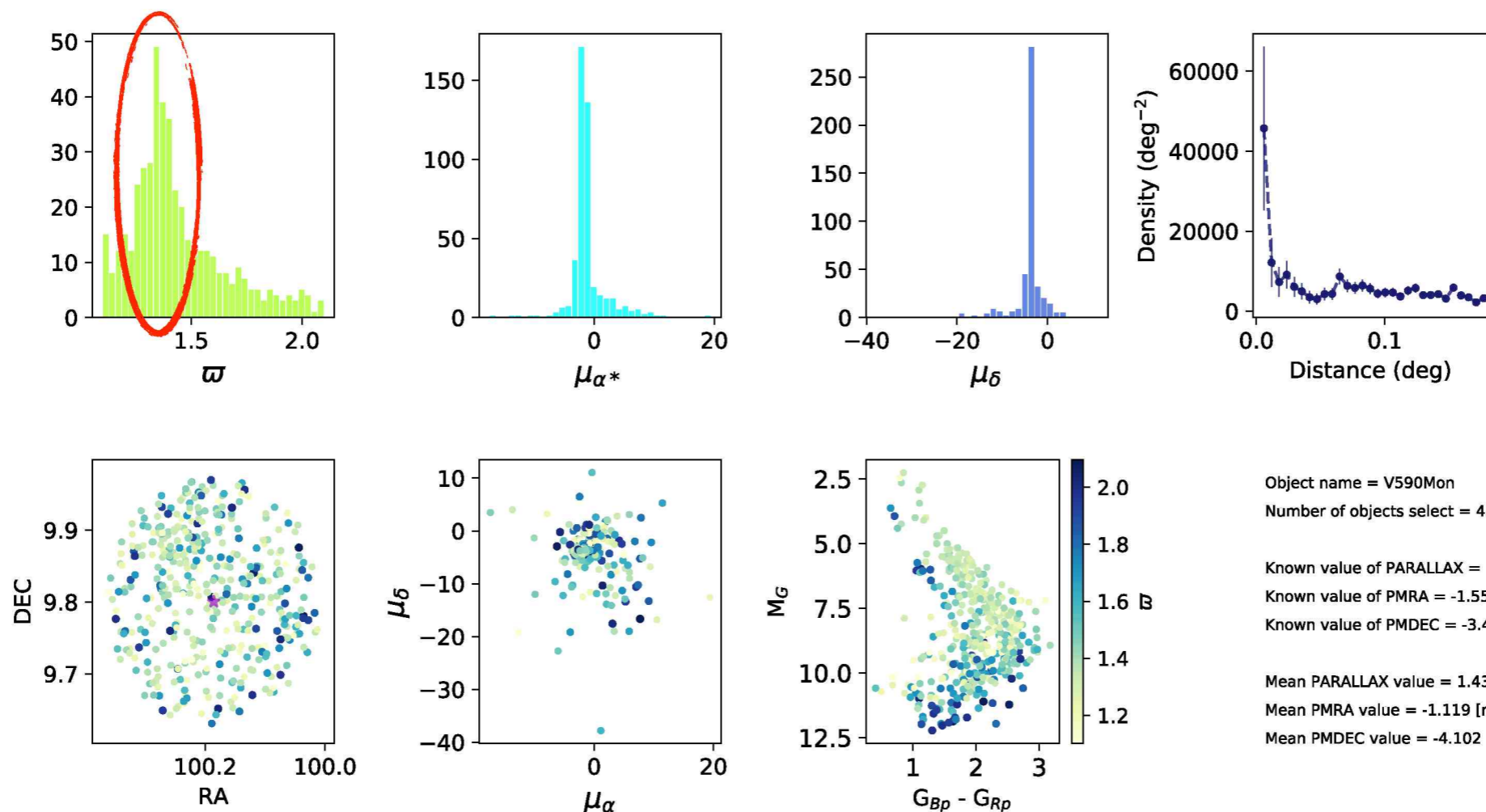
| | | | | | |
|----------|---------------------|-------|-------------------------|-----|-----------|
| Located | NGC 2264 | PMRA | -1.55 ± 0.22 mas/yr | SPT | B7 |
| Parallax | 1.14 ± 0.12 mas | PMDEC | -3.49 ± 0.21 mas/yr | G | 12.74 mag |



V590 Mon (LkHA 25)

Monoceros Constellation

| | | | | | |
|----------|---------------------|-------|-------------------------|-----|-----------|
| Located | NGC 2264 | PMRA | -1.55 ± 0.22 mas/yr | SPT | B7 |
| Parallax | 1.14 ± 0.12 mas | PMDEC | -3.49 ± 0.21 mas/yr | G | 12.74 mag |



Object name = V590Mon
Number of objects select = 451

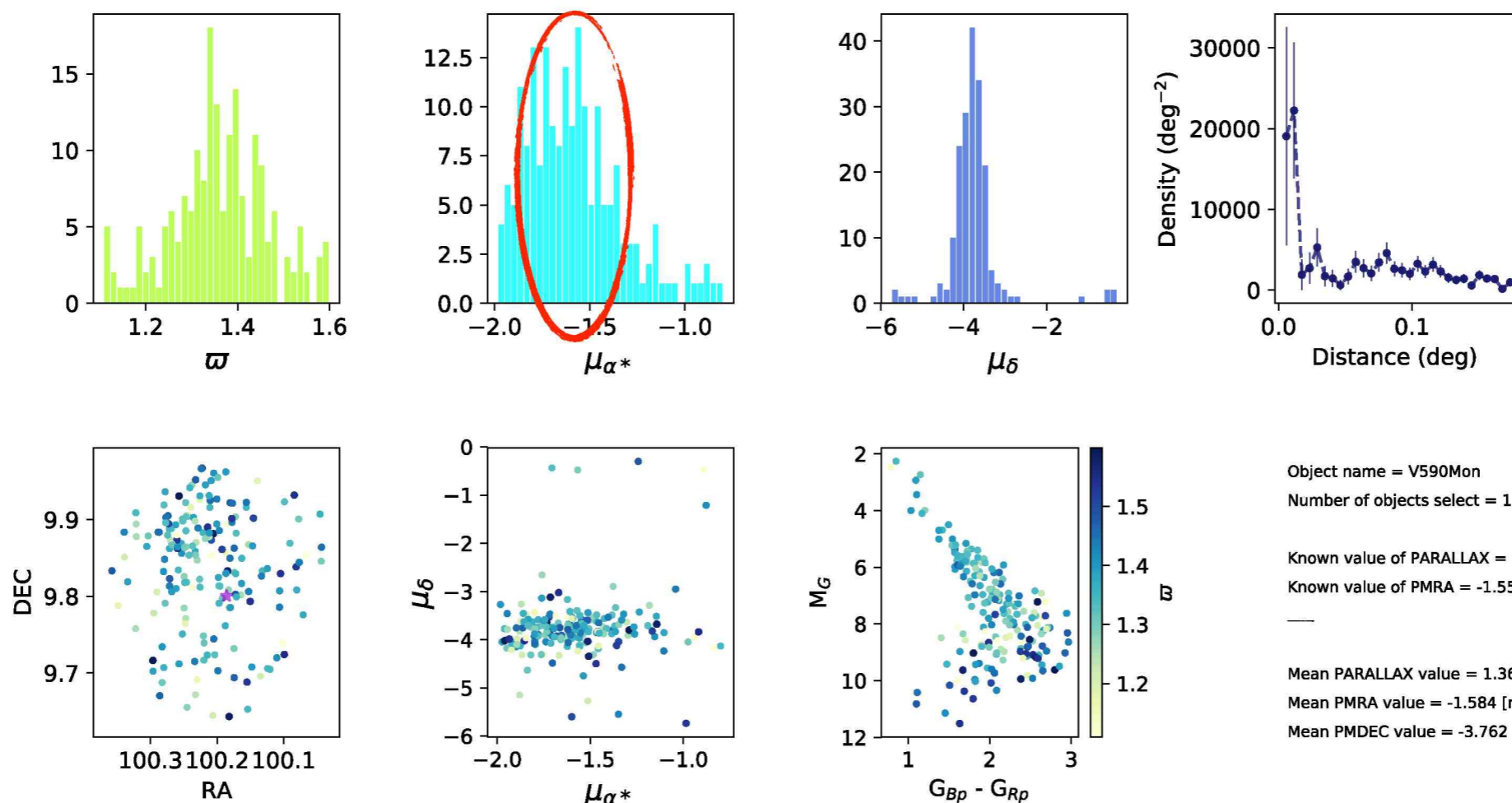
Known value of PARALLAX = 1.141 ± 0.127 [mas]
Known value of PMRA = -1.554 ± 0.229 [mas/yr]
Known value of PMDEC = -3.498 ± 0.211 [mas/yr]

Mean PARALLAX value = 1.437 [mas]
Mean PMRA value = -1.119 [mas/yr]
Mean PMDEC value = -4.102 [mas/yr]

V590 Mon (LkHA 25)

Monoceros Constellation

| | | | | | |
|----------|---------------------|-------|-------------------------|-----|-----------|
| Located | NGC 2264 | PMRA | -1.55 ± 0.22 mas/yr | SPT | B7 |
| Parallax | 1.14 ± 0.12 mas | PMDEC | -3.49 ± 0.21 mas/yr | G | 12.74 mag |



Object name = V590Mon
 Number of objects select = 188

Known value of PARALLAX = 1.141 ± 0.127 [mas]
 Known value of PMRA = -1.554 ± 0.229 [mas/yr]

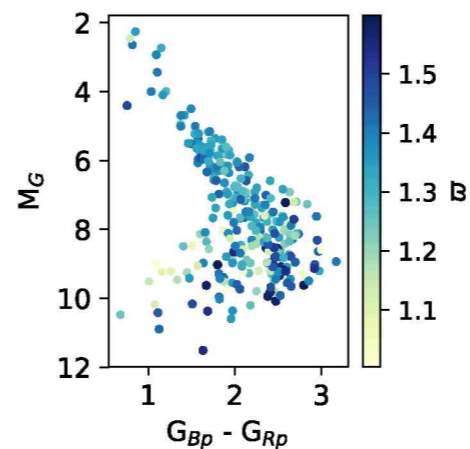
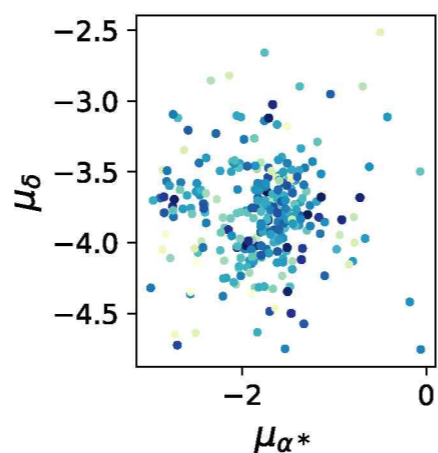
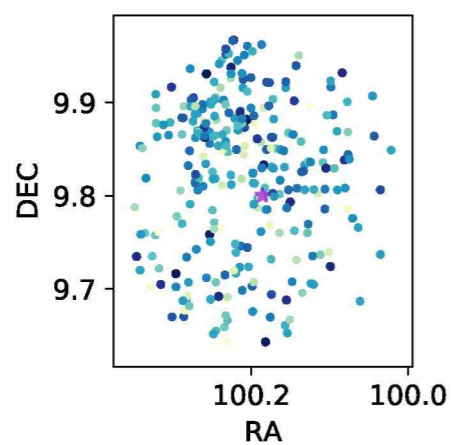
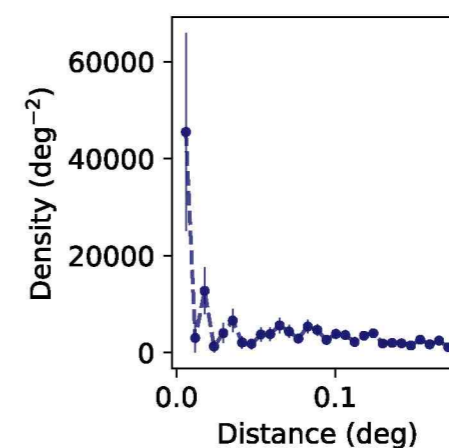
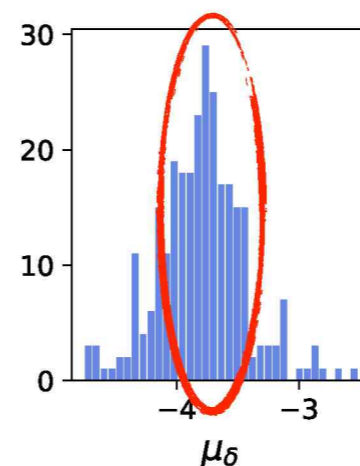
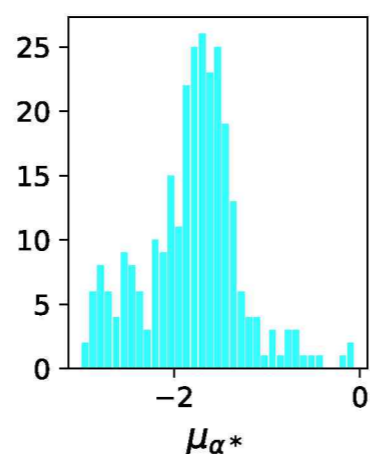
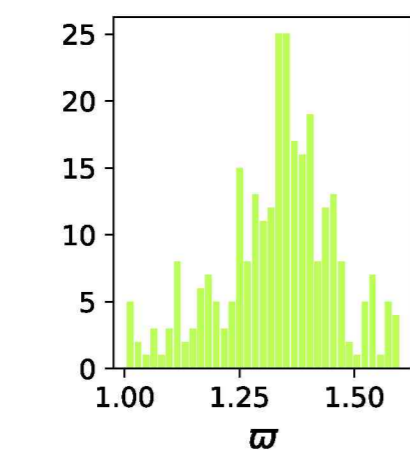
Mean PARALLAX value = 1.361 [mas]
 Mean PMRA value = -1.584 [mas/yr]
 Mean PMDEC value = -3.762 [mas/yr]

V590 Mon (LkHA 25)

Monoceros Constellation

Located NGC 2264 PMRA -1.55 ± 0.22 mas/yr SPT B7

Parallax 1.14 ± 0.12 mas PMDEC -3.49 ± 0.21 mas/yr G 12.74 mag



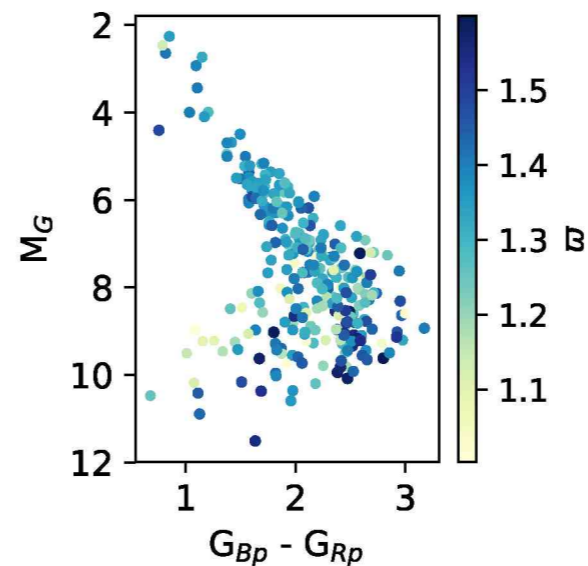
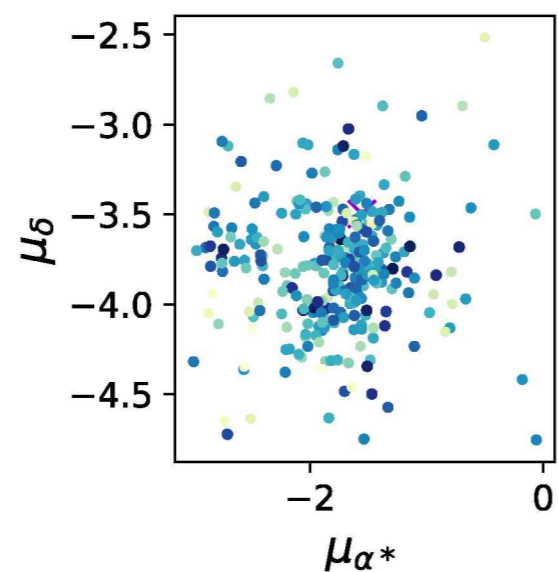
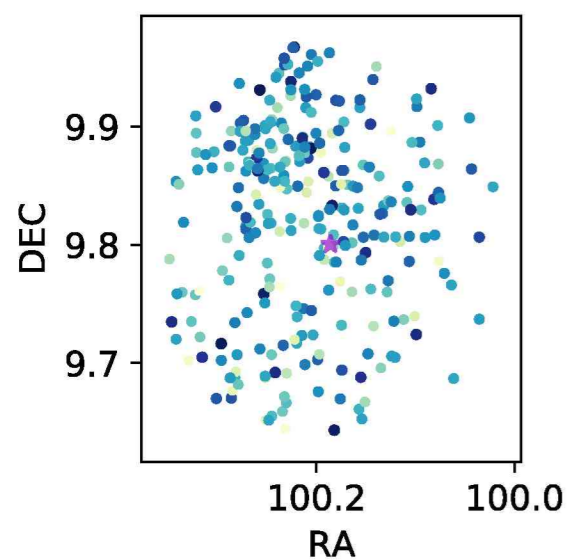
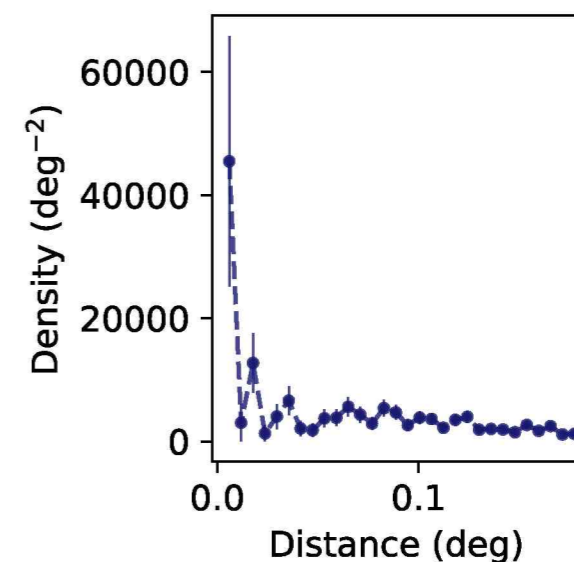
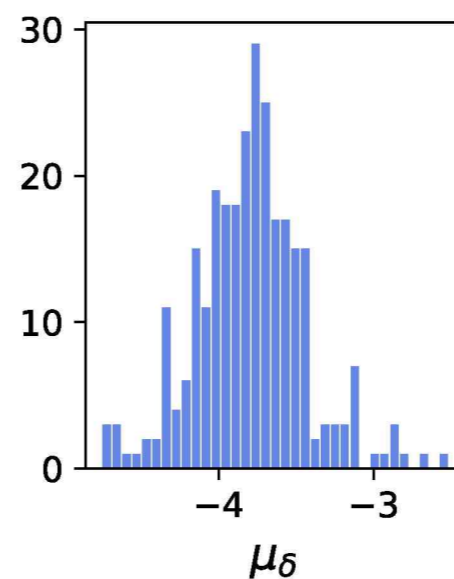
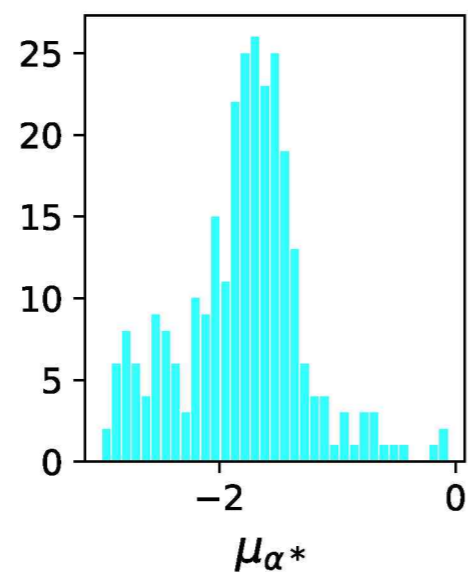
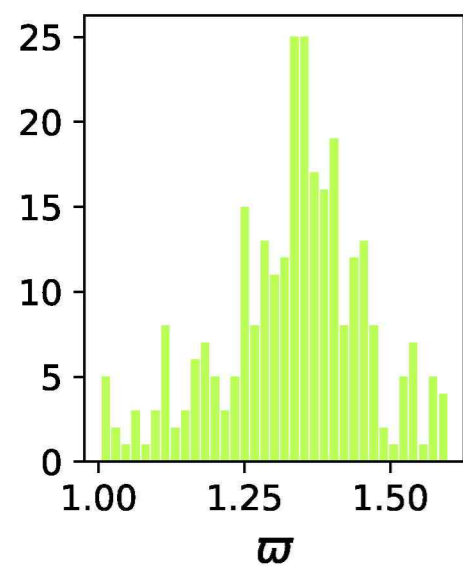
Object name = V590Mon
Number of objects select = 281

Known value of PARALLAX = 1.141 ± 0.127 [mas]
Known value of PMRA = -1.554 ± 0.229 [mas/yr]
Known value of PMDEC = -3.498 ± 0.211 [mas/yr]

Mean PARALLAX value = 1.333 [mas]
Mean PMRA value = -1.804 [mas/yr]
Mean PMDEC value = -3.795 [mas/yr]

V590 Mon (LkHA 25)

Monoceros Constellation



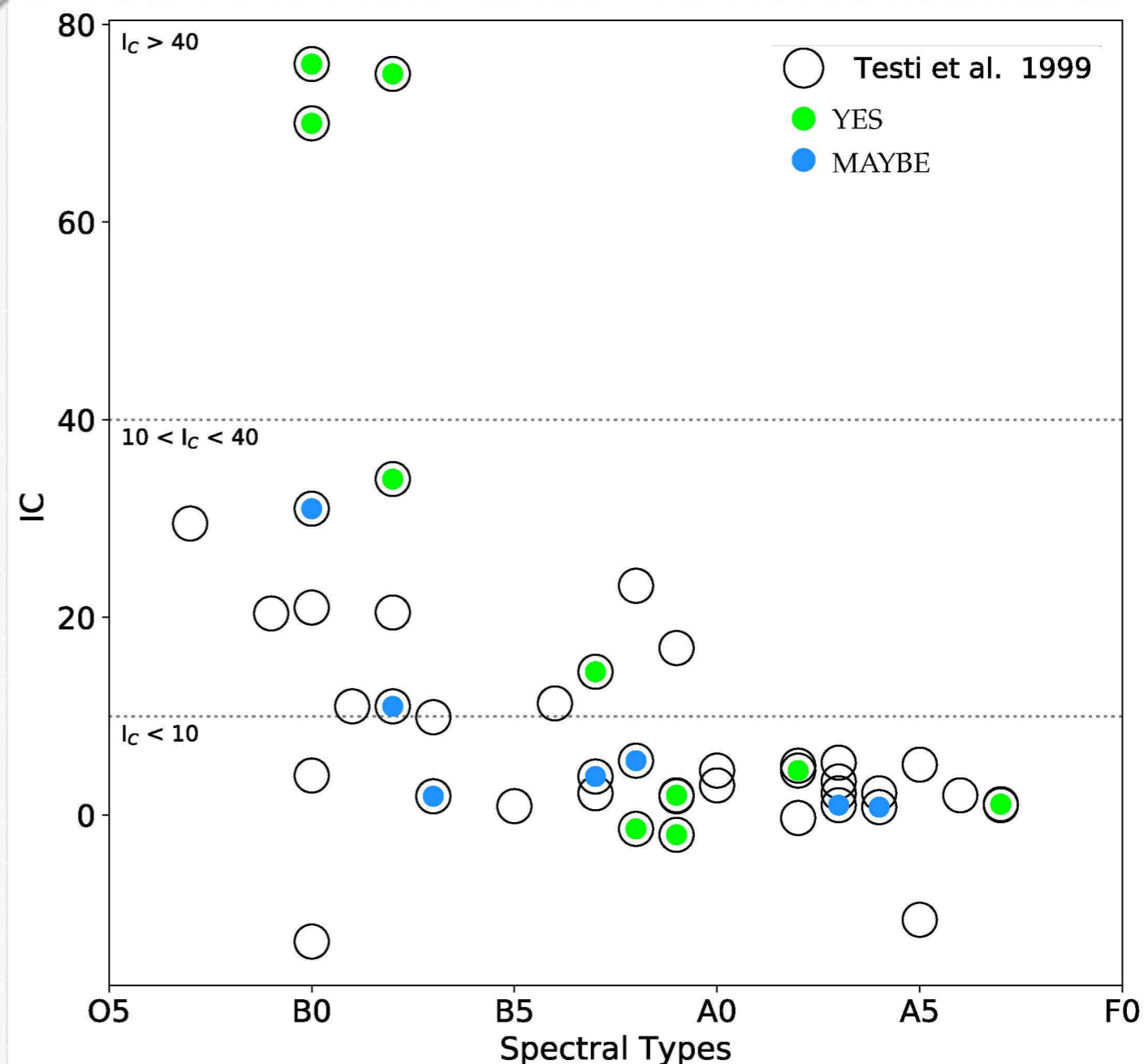
Object name = V590Mon
Final number of objects select = 281
Known value of PARALLAX = 1.141 +/- 0.127 [mas]
Known value of PMRA = -1.554 +/- 0.229 [mas/yr]
Known value of PMDEC = -3.498 +/- 0.211 [mas/yr]

PARALLAX value = 1.352 +/- 0.004 [mas]
PMRA value = -1.798 +/- 0.007 [mas/yr]
PMDEC value = -3.731 +/- 0.006 [mas/yr]

CEREAL vs TESTI

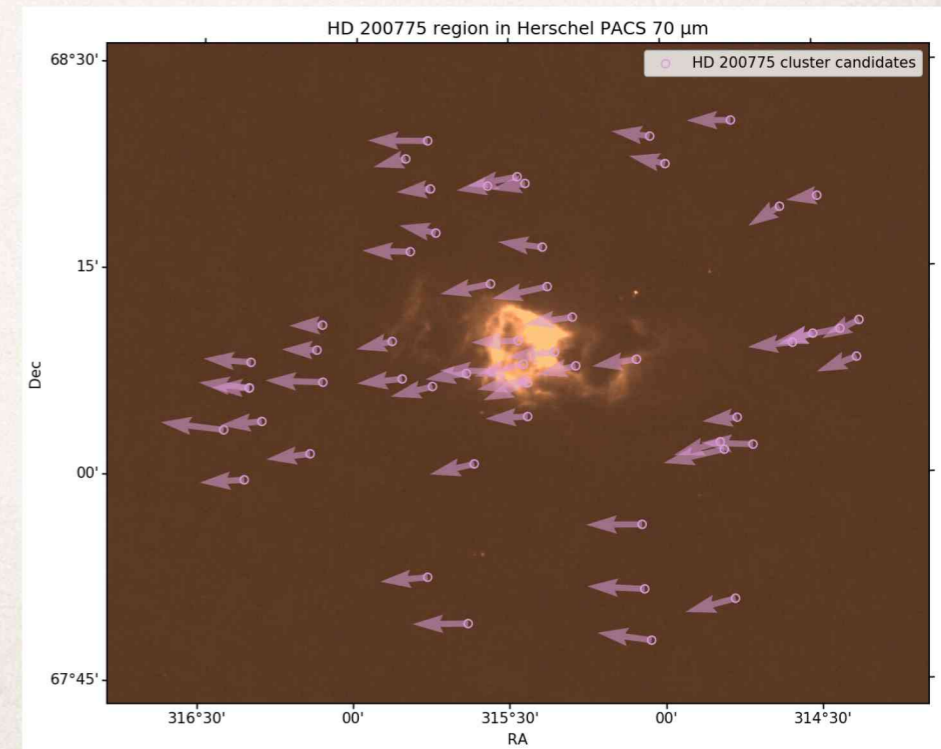
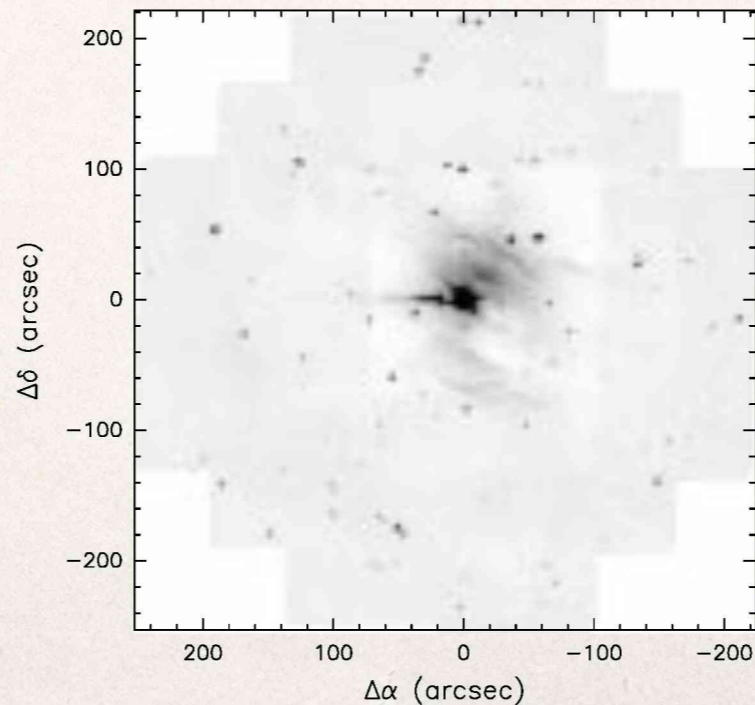
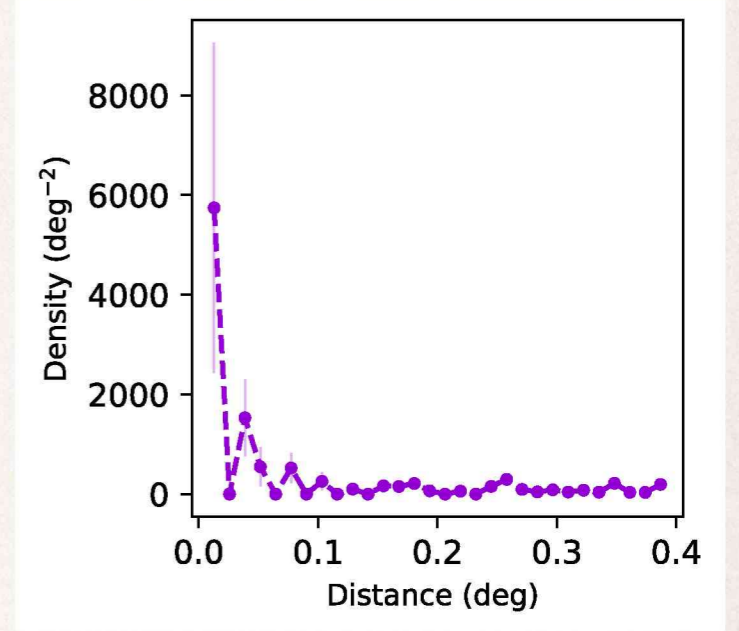
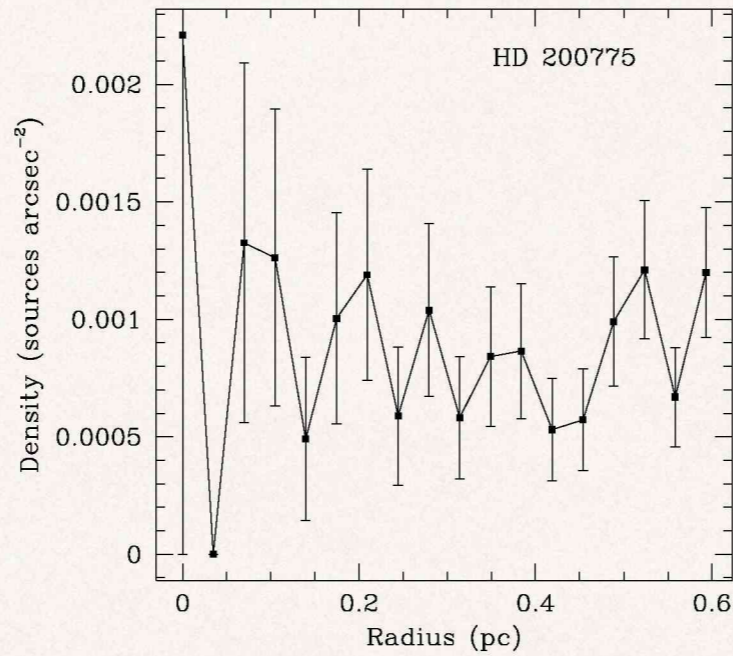
Testi + 99

- ❖ $IC \geq 40$, the Herbig stars are definitely associated with rich clusters;
- ❖ $10 \leq IC \leq 40$ a small cluster may be present;
- ❖ $IC \leq 10$ only small aggregates or background stars in the field are found.



Where do we not agree?

Testi + 99



| | |
|----------|-------------------------|
| PARALLAX | 2.77 ± 0.04 mas |
| PMRA | 8.33 ± 0.07 mas/yr |
| PMDEC | -1.56 ± 0.08 mas/yr |
| SPT | B2 |
| G | 7.15 mag |
| IC | 1.9 |

Conclusion...

- ❖ CEREAL has classified ~ 70 stars to be in a cluster.
- ❖ *As preliminary result: B stars are more likely to be in clusters than A stars. (Testi+99)*
- ❖ Source of contamination: bright source, dust, the field of view...

Conclusion... Future work

- ❖ CEREAL has classified ~ 70 stars to be in a cluster.
- ❖ *As preliminary result: B stars are more likely to be in clusters than A stars. (Testi+99)*
- ❖ Source of contamination: bright source, dust, the field of view...
- ❖ Clustering properties for those HAeBe stars.
- ❖ New HAeBe stars (*Miguel Vioque talk*).
- ❖ Clustering algorithms comparison (*Cánovas+19*).

Conclusion... Future work

- ❖ CEREAL has classified ~ 70 stars to be in a cluster.
- ❖ *As preliminary result: B stars are more likely to be in clusters than A stars. (Testi+99)*
- ❖ Source of contamination: bright source, dust, the field of view...
- ❖ Clustering properties for those HAeBe stars.
- ❖ New HAeBe stars (*Miguel Vioque talk*).
- ❖ Clustering algorithms comparison (*Cánovas+19*).

Thank you!