



# PROPER-MOTION COMPANIONS TO NEARBY STARS IN THE LOCAL ASSOCIATION

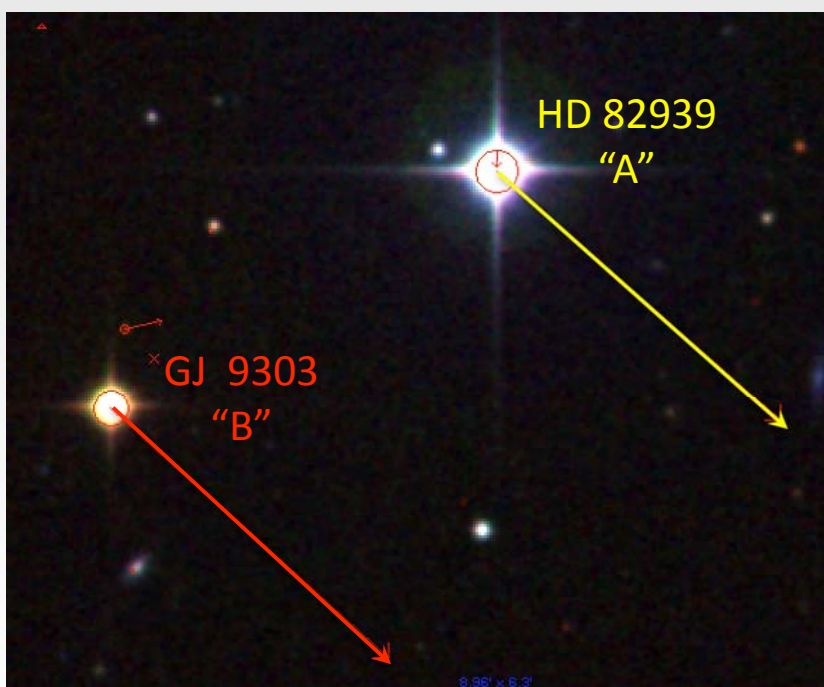
Francisco Javier Alonso Floriano (UCM)

José Antonio Caballero (CAB)

David Montes (UCM)



## Common Proper Motion Companions



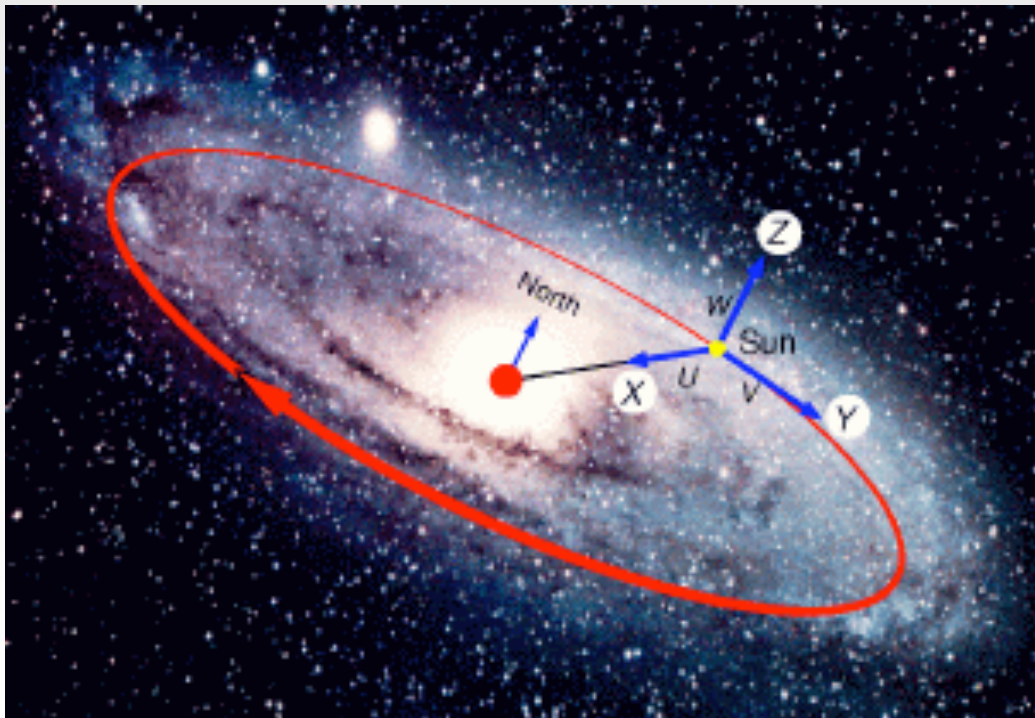
Same  $\mu$

Same  $d$ ?

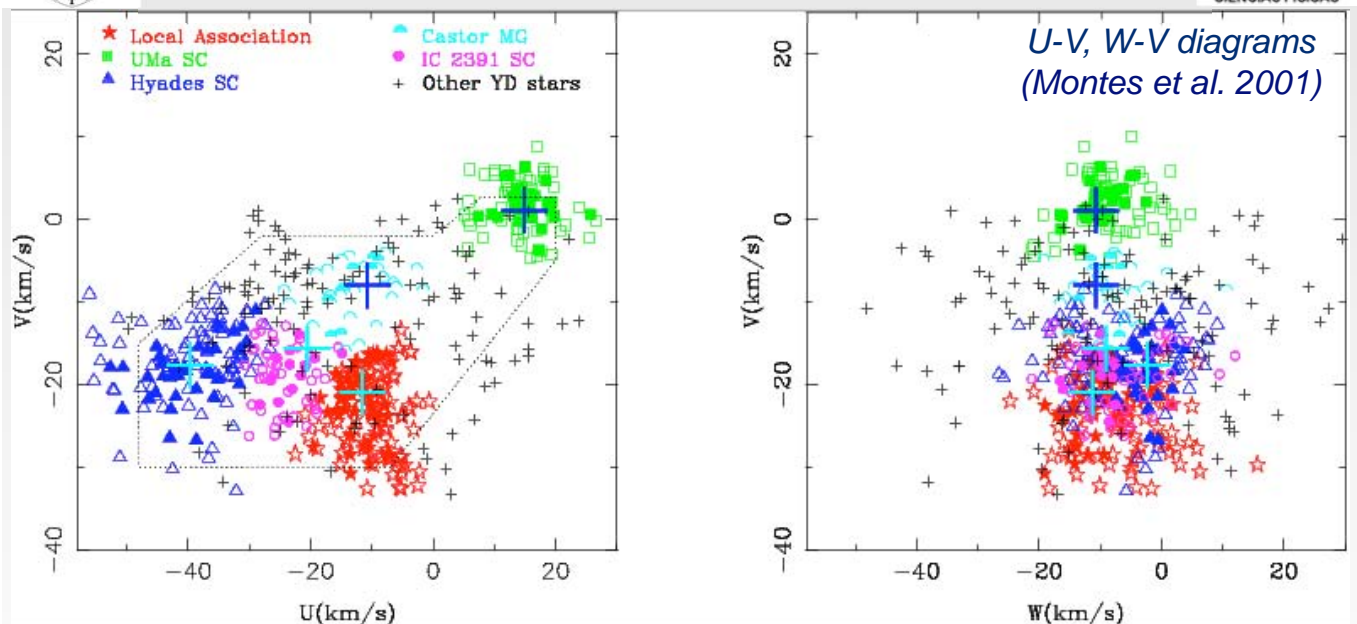
*POSS2UKSTU-IR*  
*POSS2UKSTU-Red*  
*POSS2UKSTU-Blue*

# Stellar Kinematic Groups

Groups of stars with coherent Galactic velocities that may have a common origin



# Stellar Kinematic Groups



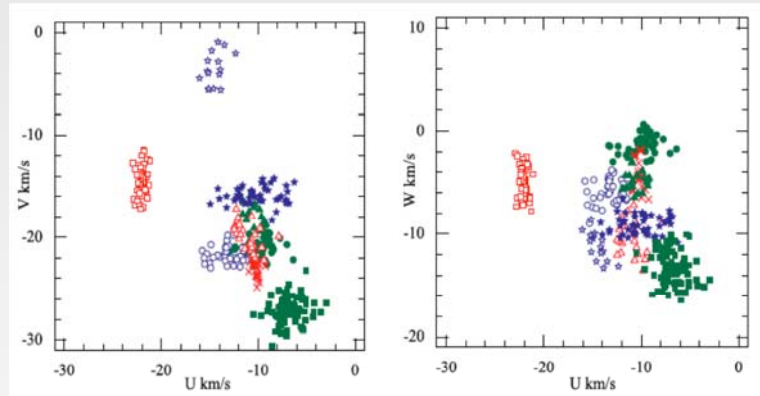
- Local Association (10-150 Ma) ★
- Ursa Major (300 Ma) ■
- Hyades (600 Ma) ▲
- Castor (200 Ma) ◐
- IC 2391 (35-55 Ma) ●
- Other young stars +

# The Local Association and related subgroups

*U-V, U-W diagrams and subgroups of the Local Association*

(Torres et al. 2008)

- $\beta$  Pictoris
- Tucana-Horologium
- Columba
- Carina X
- TW Hydrae
- $\epsilon$  Cha
- AB Doradus



Associations	U (km s <sup>-1</sup> )	V (km s <sup>-1</sup> )	W (km s <sup>-1</sup> )	Age (Ma)
$\beta$ Pictoris	-10.1(2.1)	-15.9(0.8)	-9.2(1.0)	~ 10
Tucana-Horologium	-9.9(1.5)	-20.9(0.8)	-1.4(0.9)	~ 30
Columba	-13.2(1.3)	-21.8(0.8)	-5.9(1.2)	~ 30
Carina	-10.2(0.4)	-23.0(0.8)	-4.4(1.5)	~ 30
TW Hydrae	-10.5(0.9)	-18.0(1.5)	-4.9(0.9)	~ 8
$\epsilon$ Cha	-11.0(1.2)	-19.9(1.2)	-10.4(1.6)	~ 6
AB Doradus	-6.8(1.3)	-27.2(1.2)	-13.3(1.6)	~ 70

## Selection of the sample

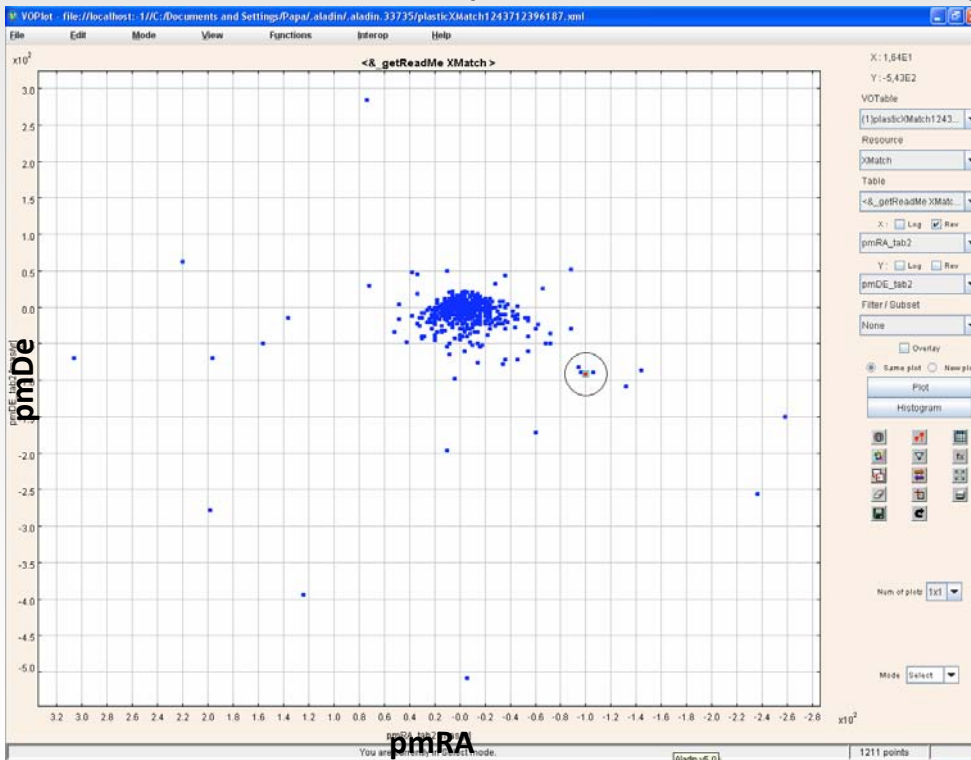
The sample belongs to the Local Association (Montes et al. 2001 and Torres et al. 2008) but we have divided the sample into three groups:

- 210 {
- 44 objects belonging to the subgroup **Tucana-Horologium**
  - 50 objects belonging to the subgroup  **$\beta$  Pictoris**.
  - 116 objects not belonging to the previous subgroup (referred to generically as this sample **Local Association**)



# Example (HD 82939)

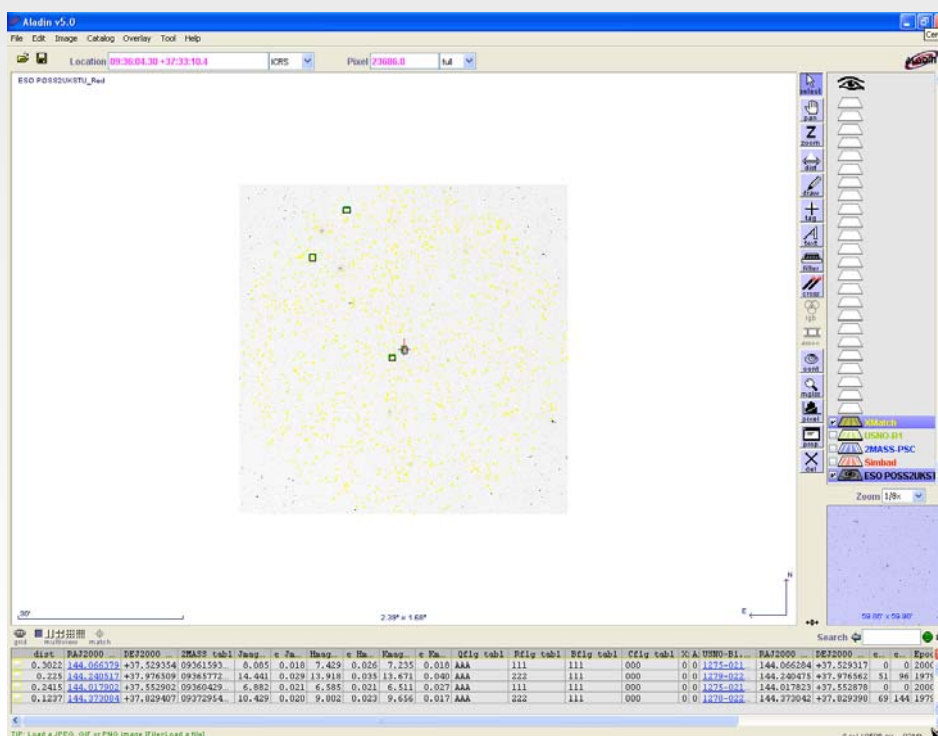
- We search for companions with the same proper motion



- Maximum difference of  $\pm 10$  milliarcseconds per year

# Example (HD 82939)

- Identify candidates: Primary + “secondary” + two unknown sources



- $J > 15.5$  mag object too weak
- The object must correspond to a star well appointed
- Check for proper motion (if it's in Simbad)



# Candidates How Many?

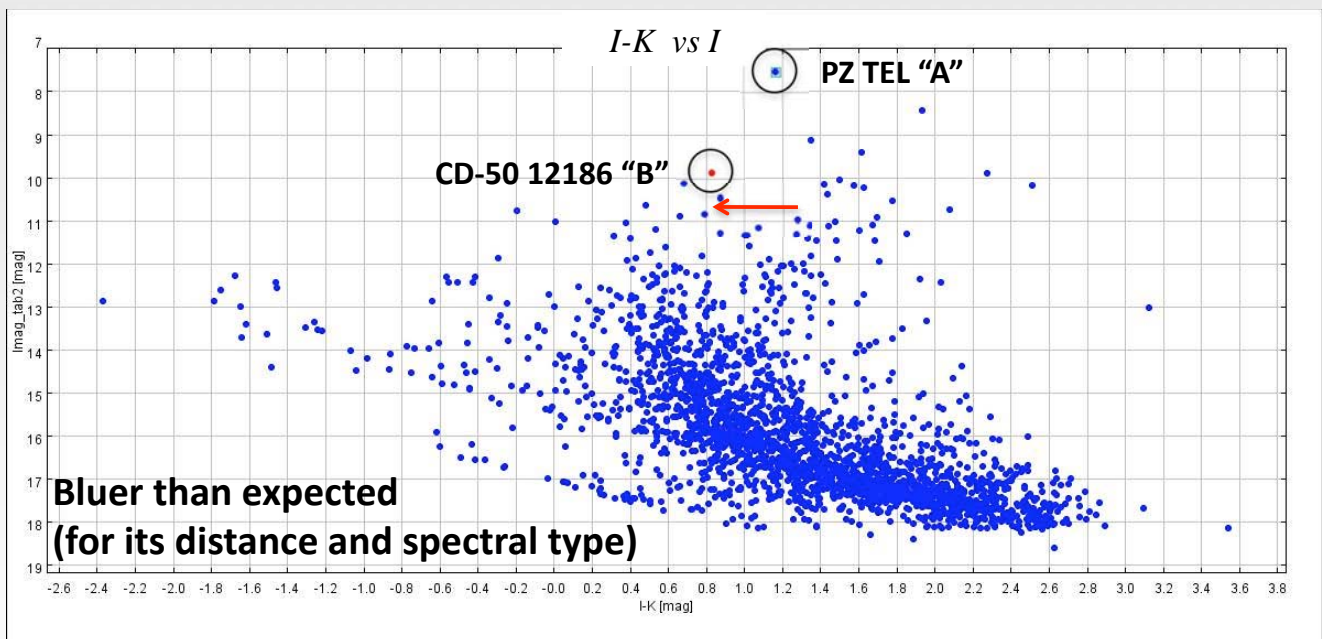


20 LA + 31 Tuc-Hor + 16  $\beta$  Pic =

# 67



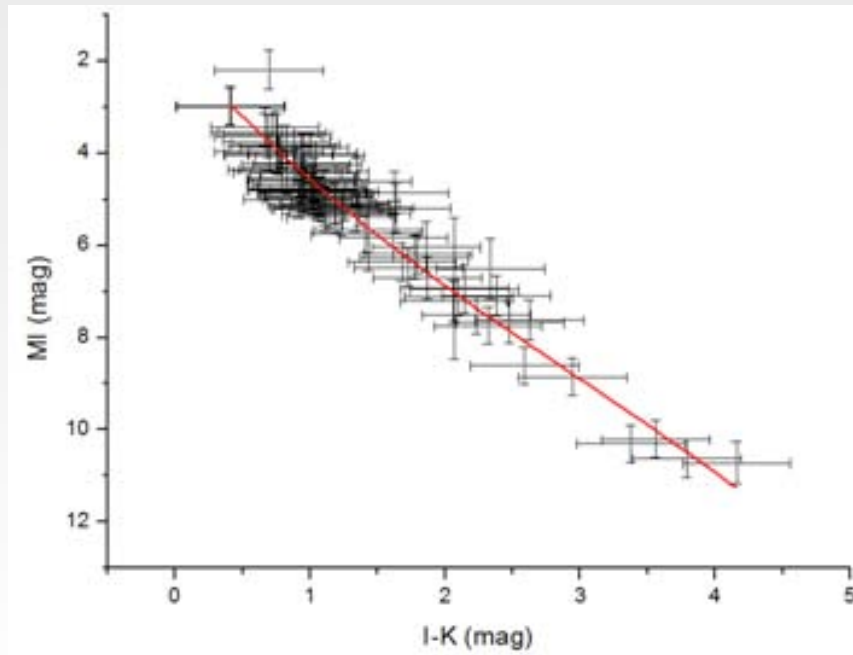
## Rejection: Photometric Distance



- Colours
- Expected magnitudes

# Rejection: Photometric Distance

Photometric distance calculated by fitting the color magnitude diagram ( $I-K$  vs  $M_I$ ). (Torres et al. 2008)



Fitting for the Local Association

## Promising candidates

From 67 candidates, after rejection, we have

**23**

common proper motion companions



# 14 known in Simbad + WDS



	Name	$\rho$ (arcsec)	$\delta\rho$ (arcsec)	$\theta$ (deg)	s(AU)	$\delta s$ (AU)	$\Delta Hp$ (mag)	$\delta\Delta Hp$ (mag)
<b>Local Association</b>								
A	<a href="#">HD 98736 A</a>	5.166	0.024	317	163	8	3	0.12
B	<a href="#">HD 98736 B</a>							
A	<a href="#">HD 199065 A</a>	4.473	0.005	260	228	22	0.62	0.02
B	<a href="#">HD 199065 B</a>							
A	<a href="#">HD 222259 A</a>	5.307	0.006	348	245	15	1.3	0.03
B	<a href="#">HD 222259 B</a>							
A	<a href="#">HD 112733 A</a>	35.1	0.6	81	156	101	0.61	0.005
B	<a href="#">HD 112733 B</a>							
A	<a href="#">HD 221503</a>	8.99	0.017	358	74	1	0.03	0.18
B	<a href="#">HD 221503 BC</a>							
A	<a href="#">V368 Cep A</a>	10.9	0.1	215	215	3	-	-
B	<a href="#">V368 Cep B</a>							
C	<a href="#">NLTT 56725</a>	972	0.6	322	19191	243	-	-
<b>Tucana-Horologium</b>								
A	<a href="#">HD 13246 A</a>	52.52	0.6	62	2362	72	-	-
B	<a href="#">HD 13246 B</a>							
A	$\beta^{01}$ Tuc	553	10	298	25697	747	0.7592	0.0013
B	$\beta^{02}$ Tuc	534	10	296	24814	732	0.5391	0.002
C	$\beta^{03}$ Tuc							
<b><math>\beta</math> Pictoris</b>								
A	<a href="#">BD+30 397 B</a>	21.92	0.6	136	926	84	-	-
B	<a href="#">BD+30 397 A</a>							
A	<a href="#">TX PsA</a>	35.52	0.6	133	838	69	-	-
B	<a href="#">WW PsA</a>							



# New CMPs



8 in the data base Simbad, previously unrelated to each

	Name	$\rho$ (arcsec)	$\delta\rho$ (arcsec)	$\theta$ (deg)	s (AU)	$\delta s$ (AU)	$\Delta Hp$ (mag)	$\delta\Delta Hp$ (mag)
<b>Local Association</b>								
A	<a href="#">HD 82939</a>	163.2	0.6	122	6208	270	2.703	0.005
B	<a href="#">GJ 9303</a>							
A	<a href="#">HD 10008</a>	613.2	0.6	259	145	3	-	-
B	<a href="#">G271-110</a>							
<b>Tucana-Horologium</b>								
A	<a href="#">HD 13183</a>	707	10	104	35491	1500	-	-
B	<a href="#">CD -53 413</a>							
A	<a href="#">CD-53 544</a>	21.75	0.6	11	1131	31	-	-
B	<a href="#">AF Hor</a>							
A	<a href="#">HD 207575</a>	1411	10	65	63636	2441	1.3294	0.001
B	<a href="#">HD 209764</a>							
<b><math>\beta</math> Pictoris</b>								
A	<a href="#">TYC 9073-0762-1</a>	553	10	111	29862	609	-	-
B	<a href="#">HD 173167</a>							
A	$\eta$ Tel	420	10	171	20019	477	2.1034	0.0012
B	<a href="#">HD 181327</a>							
A	<a href="#">HD 199143</a>	328	10	139	15649	477	-	-
B	<a href="#">AZ Cap</a>							



# New CMPs: Tuc-Hor



In Moving Group

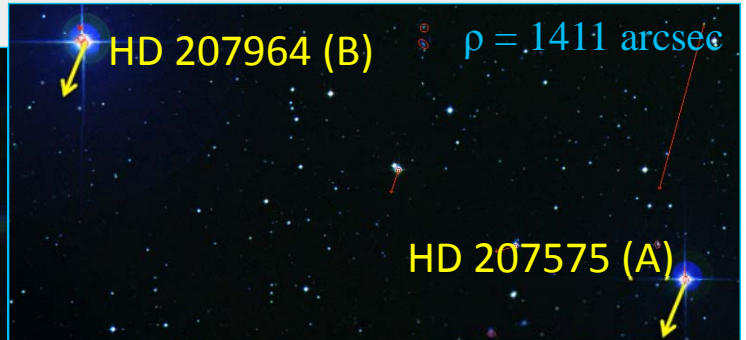
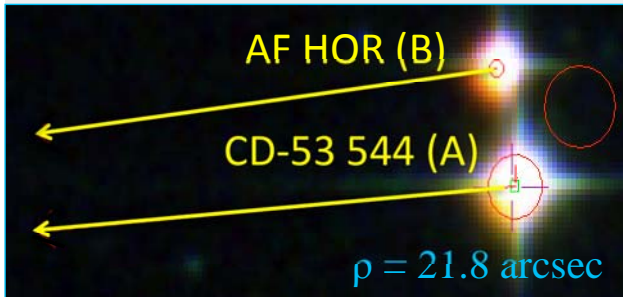
Not in Moving Group (unknown)

Images made by

POSS2UKSTU-IR

POSS2UKSTU-Red

POSS2UKSTU-Blue



# New CMPs: beta Pic



In Moving Group

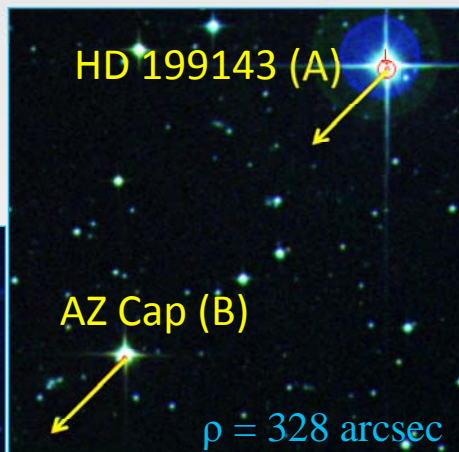
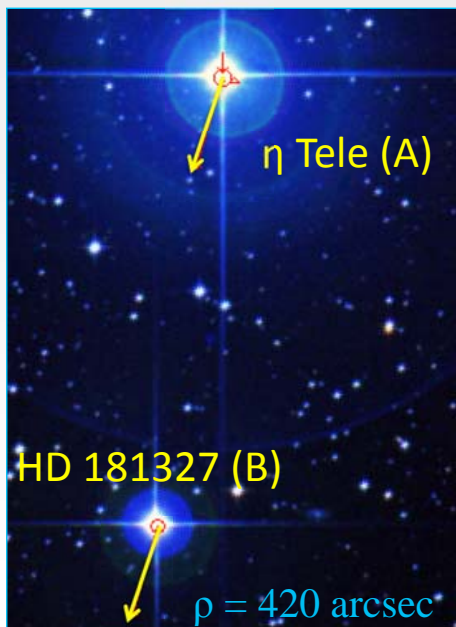
Not in Moving Group (unknown)

Images made by

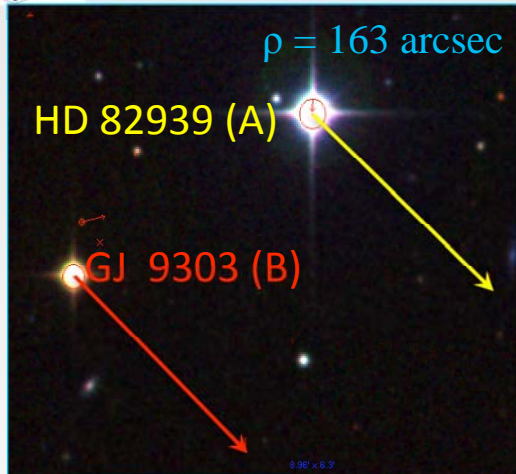
POSS2UKSTU-IR



POSS2UKSTU-Red

POSS2UKSTU-Blue



# New CMPs: LA

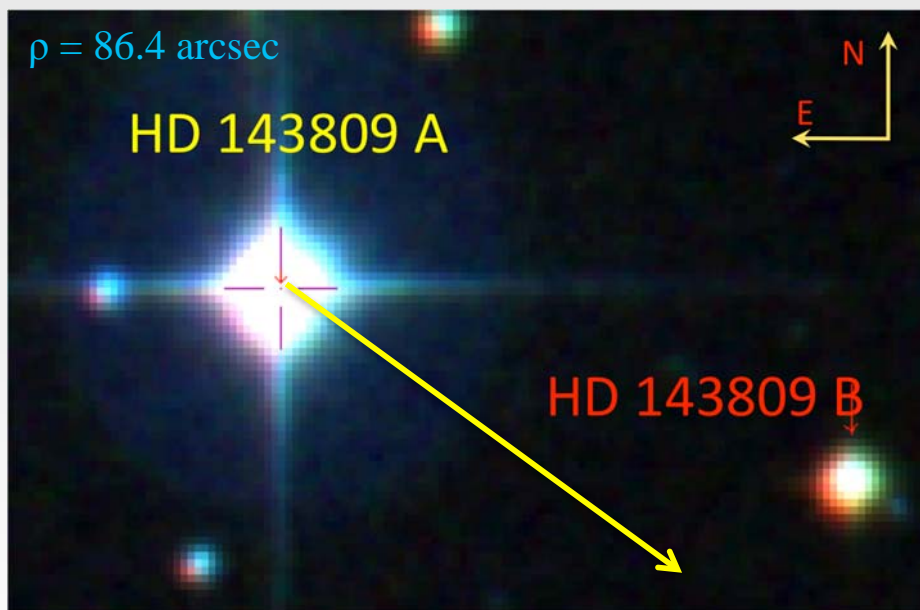


In Moving Group   
Not in Moving Group  
(unknown) 

*Images made by*  
*POSS2UKSTU-IR*  
*POSS2UKSTU-Red*  
*POSS2UKSTU-Blue*



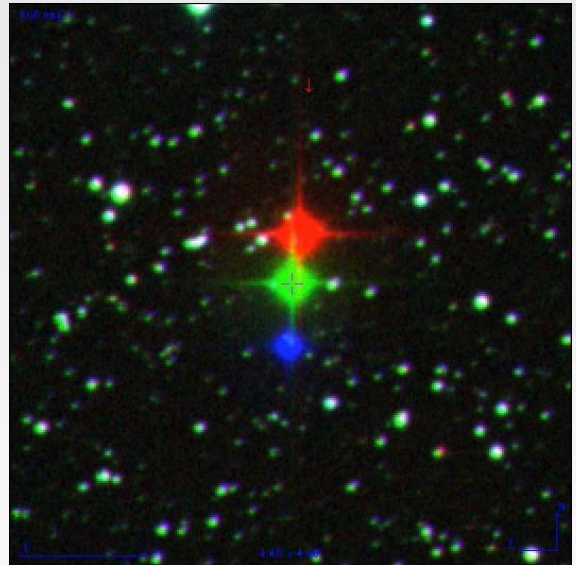
# New CMPs: LA NO Simbad



*Image made by*  
*POSS2UKSTU-IR*  
*POSS2UKSTU-Red*  
*POSS2UKSTU-Blue*

# Follow-up of HD 143809

- Astrometric measurements for HD 143809 B using 9 epochs.
  - 1954.05.25 POSSI Red
  - 1982.06.23 GSC 2.3
  - 1990.06.18 POSSII Blue
  - 1991.06.17 POSSII IR
  - 1994.05.04 POSSII Red
  - 2000.05.01 2MASS
  - 2000.11.27 CMC14
  - 2001.03.19 SDSS 2001.2142
  - 2003.04.27 SDSS 2003.3221
- Proper motions and its standard deviation ( $\sigma$ ) are obtained.
- $\mu_{\alpha} \cos \delta = -51.0 (1.3) \text{ mas/a}$
- $\mu_{\delta} = -40.7 (1.3) \text{ mas/a}$



Example: Barnard Star  
POSS2UKSTU-IR  
POSS2UKSTU-Red  
POSS2UKSTU-Blue  
(at different epochs)

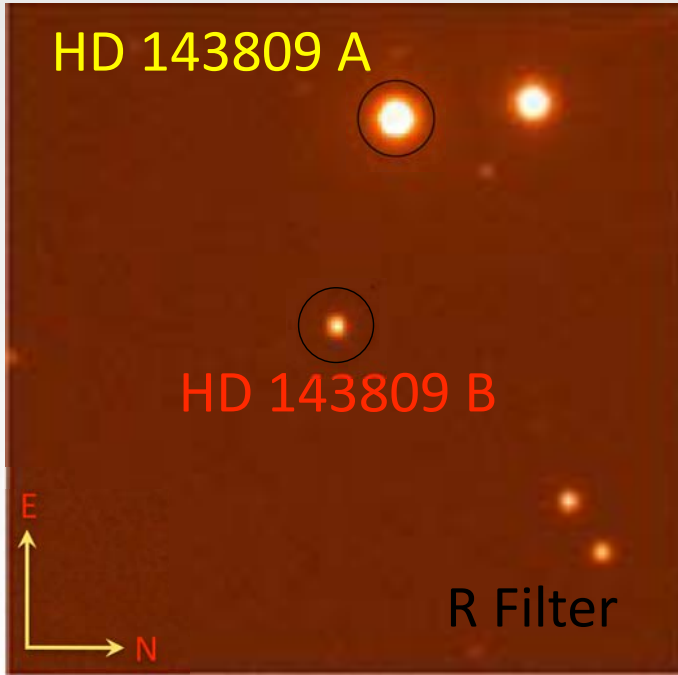
# Follow-up of HD 143809

2.2 m Calar Alto, Almeria, Spain



Image and Spectroscopy taken with the instrument CAFOS

# Image of HD 143809 A & B

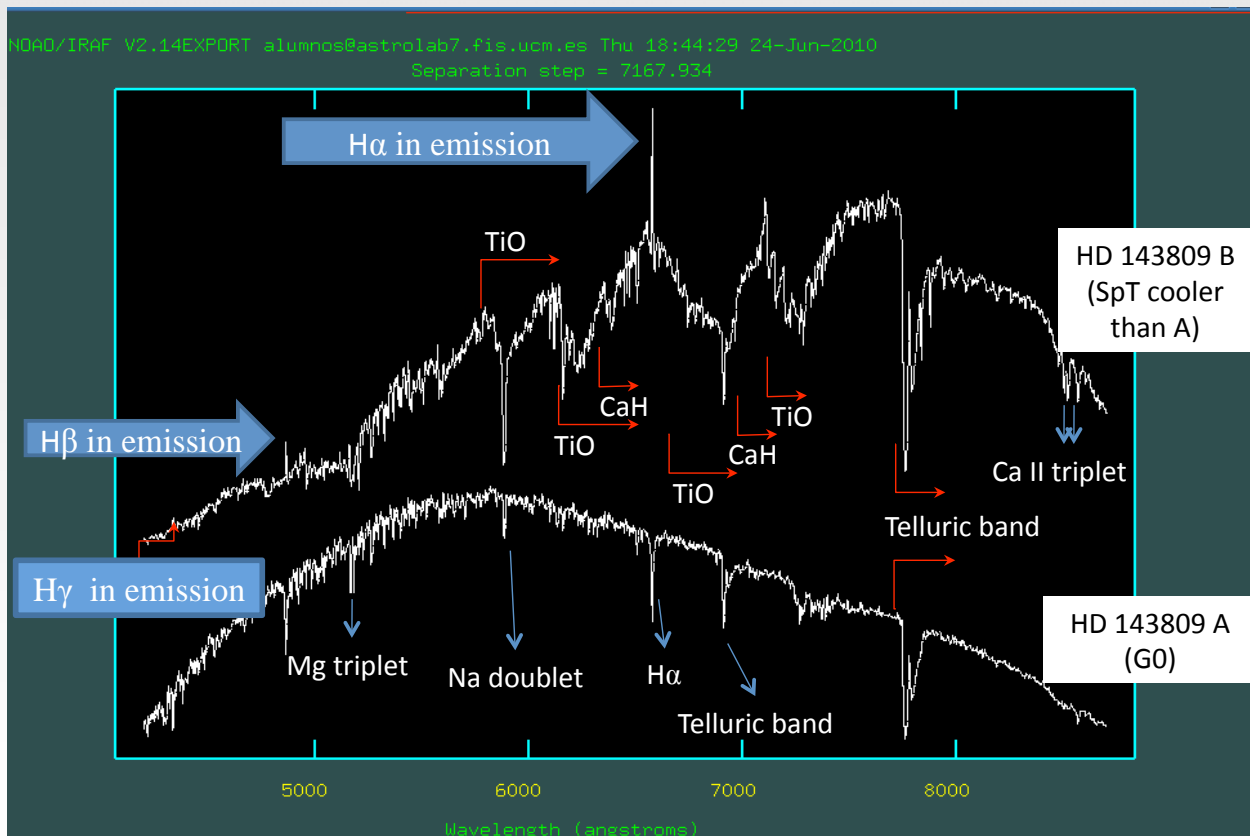


Measured values  
 Values taken from the bibliography

	HD 143809 A	HD 143809 B
<i>B</i>	9.27	14.87
<i>V</i>	8.77	13.65
<i>R</i>	8.70	13.30
<i>I</i>	8.19	11.20
<i>u</i>	10.29	16.86
<i>g</i>	10.52	15.98
<i>r</i>	12.92	13.12
<i>i</i>	8.68	12.24
<i>J</i>	7.74	10.35
<i>H</i>	7.52	9.67
<i>Ks</i>	7.44	9.47

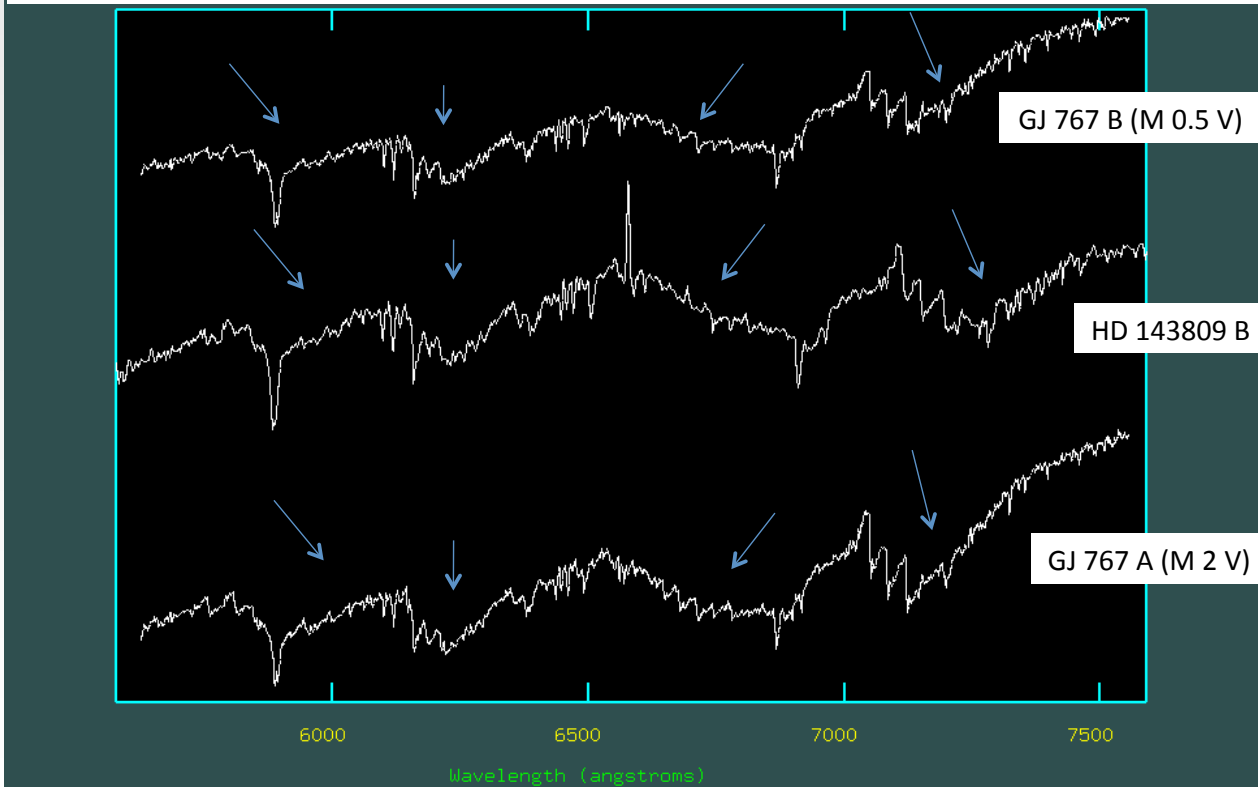
Magnitud of each component in different photometric bands

# Spectroscopy of HD 143809 A & B

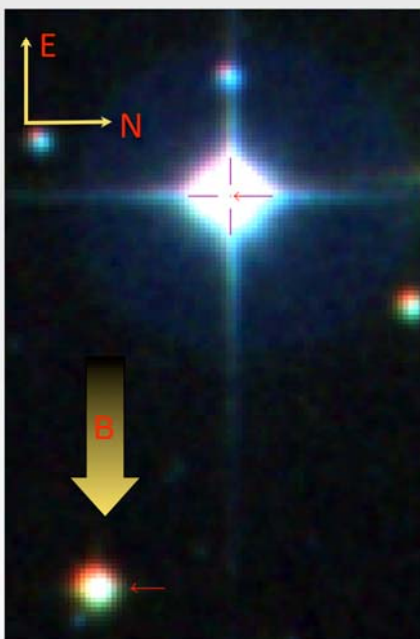


# Spectral Type of HD 143809 B

## Comparison with two spectral type standar stars



## HD 143809 A & B



POSS2UKSTU-IR  
POSS2UKSTU-Red  
POSS2UKSTU-Blue

- **HD 143809A y HD 143809B**

A & B  $\left\{ \begin{array}{l} \rho = 1.44 \text{ arcmin (s = 6800 UA)} \\ \Delta\mu = 2.9 (2.5) \text{ mas/a} \end{array} \right.$

A  $\left\{ \begin{array}{l} d_A (77.6 \pm 8.3 \text{ pc}) \approx d_B \\ \text{EW(Li)} = 103 \text{ m\AA (L\acute{o}pez-Santiago et al. 2010)} \\ \rightarrow \tau \approx 80\text{-}120 \text{ Ma (Montes et al. 2001)} \end{array} \right.$

B  $\left\{ \begin{array}{l} \mu_\alpha \cos\delta = -51.0(1.3) \text{ mas/a} \\ \mu_\delta = -40.7(1.3) \text{ mas/a} \\ \text{H lines in emission} \\ \text{SpT} \approx \text{M1-1.5 V e} \rightarrow d_B = 74.1 \text{ pc} \end{array} \right.$

Young and nearby CPM



# Conclusions



- CPM search on 210 stars
  - 23 candidates confirmed
    - 14 candidates are known common proper motion companions
    - 9 stars are unknown multiple systems:
      - 4 new members in these moving groups
      - 1 candidate not previously described in the literature : **HD 143809B** (follow-up confirmation)
- The results demonstrate the validity of the method