The lithium-rotation connection in the M35 open cluster

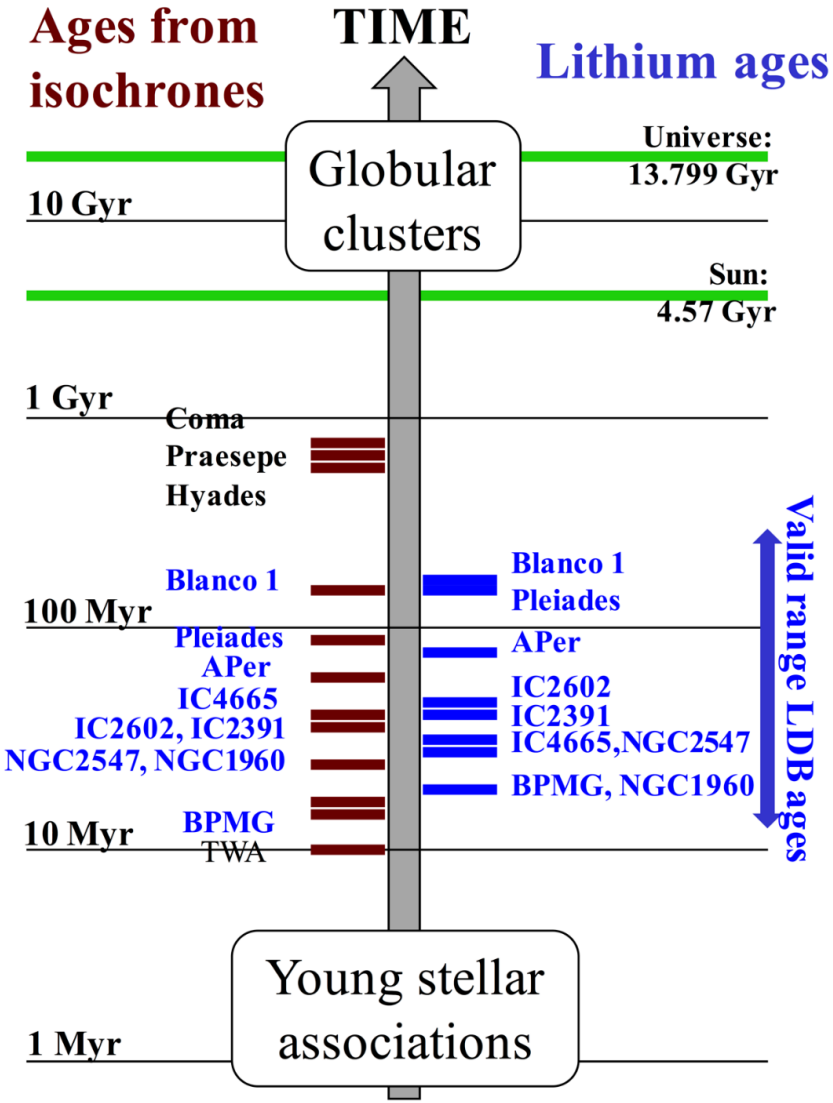
PhD Student: Diego Cuenda Muñoz
Director: David Barrado Navascués

INTRODUCTION

- CHRONOS purpose: deliver a complete, coherent and accurate method to estimate the age of stars and stellar associations over the entire time domain.

- Since lithium surface abundance is an age indicator for G and K stellar types, we have investigated how this parameter is affected by rotation in K dwarfs of M35 open cluster.

https://cab.inta-csic.es/users/barrado/0_CHRONOS/index.html



STEPS

1. **Select** initial sample: Barrado et al. (2001) + Anthony-Twarog et al. (2018).

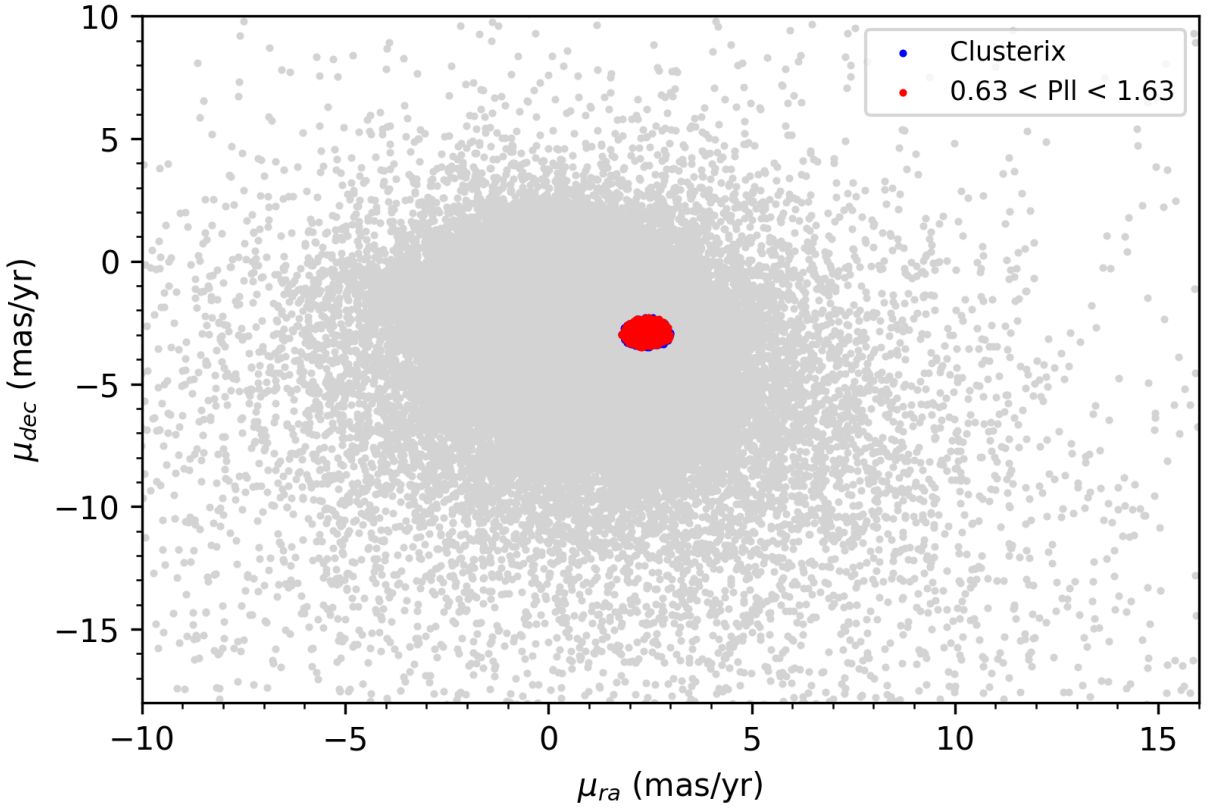
2. **Classify** spectroscopic sample stars into no members, possible members and probable cluster members.

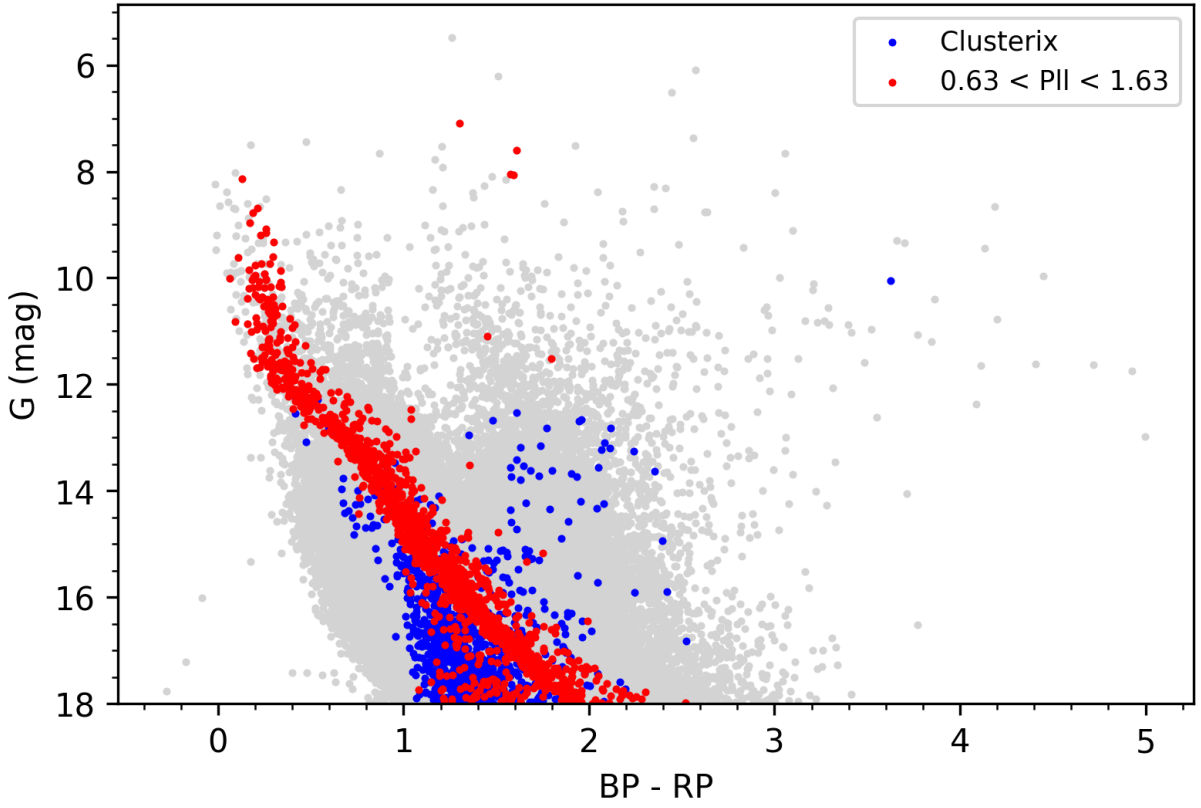
3. **Obtain** rotational periods.

4. **Analyse** the relationship between lithium surface abundance and rotation in M35 K stars.

5. **Compare** with other clusters of similar age.

MEMBERSHIP PROBABILITY

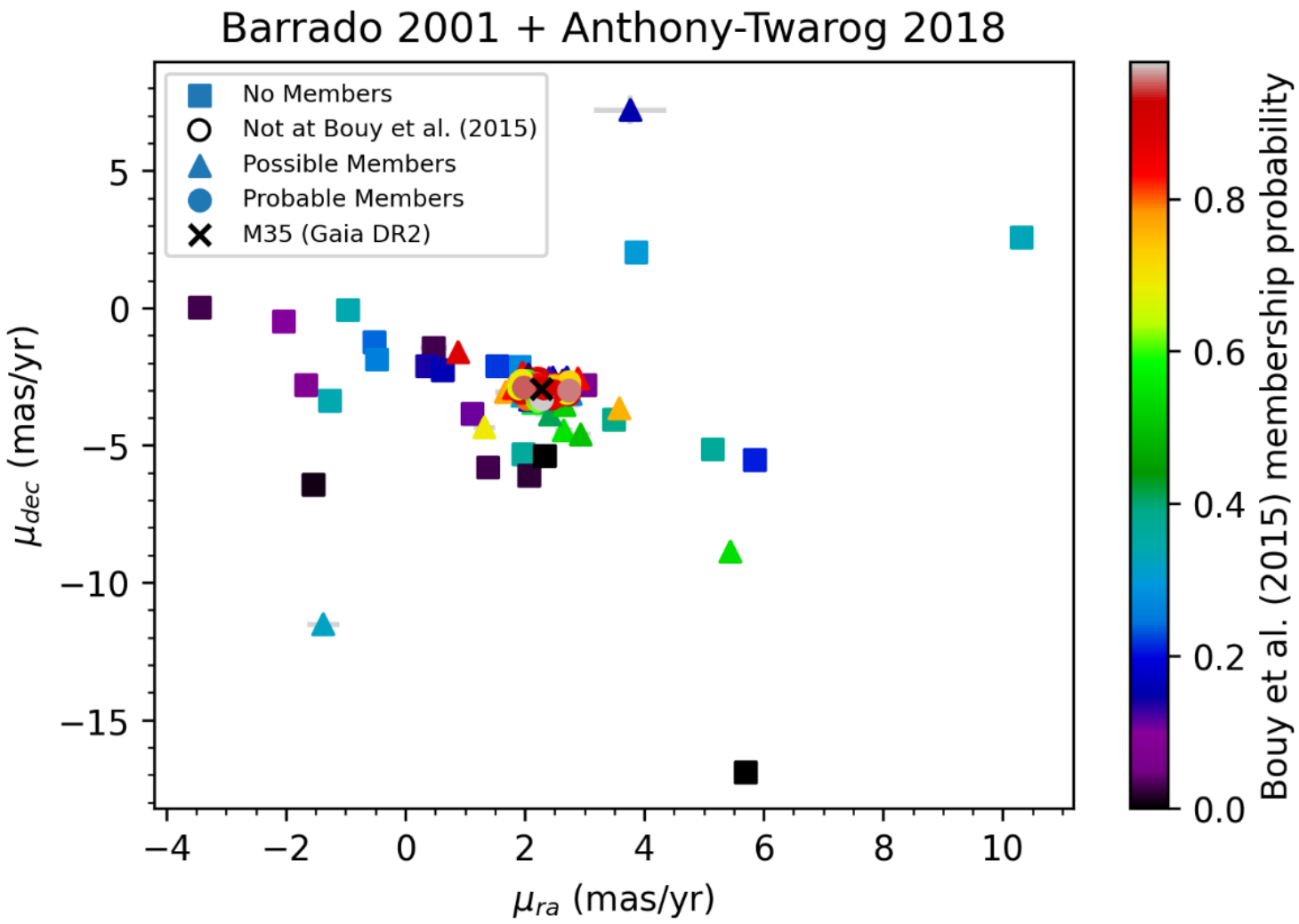




Clusterix 2.0

Balaguer-Núñez et al. (2019)

MEMBERSHIP PROBABILITY



55 probable members

Prob ≥ 0.50 Bouy et al. (2015)

Prob ≥ 0.58 Clusterix 2.0

0.63 < parallax < 1.63

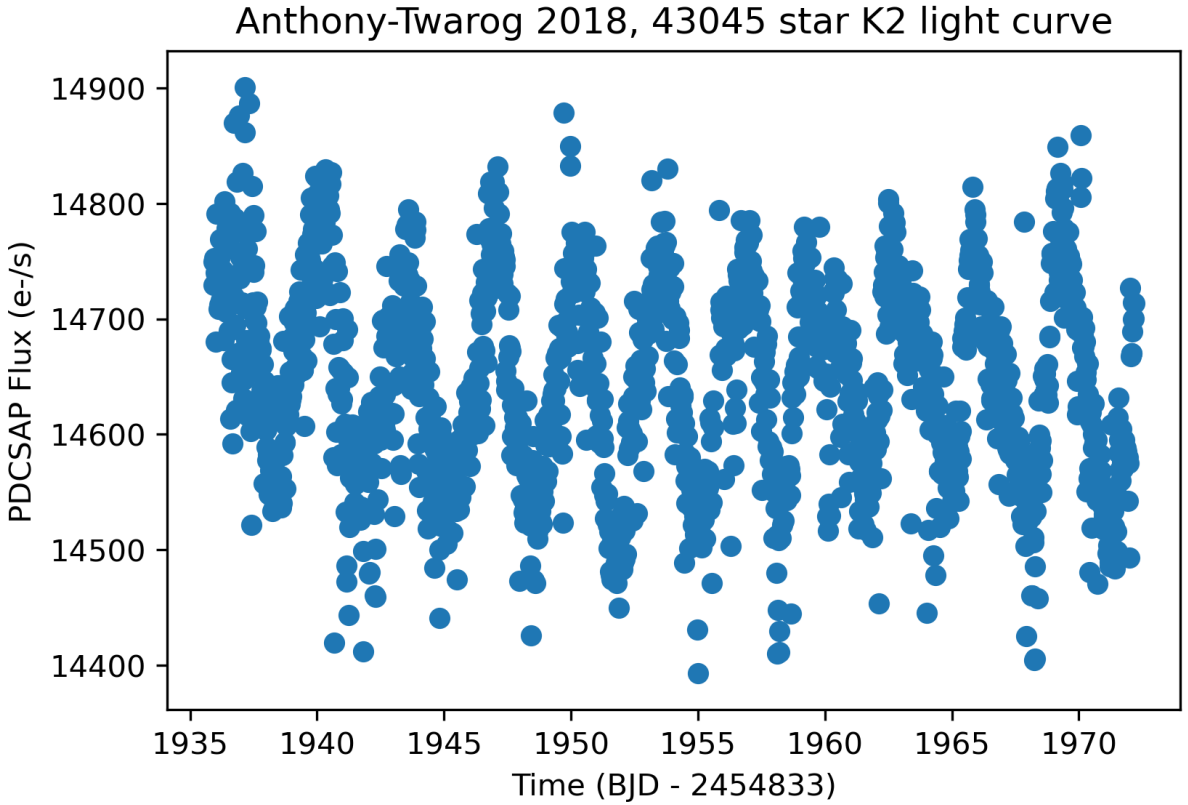
26 no members

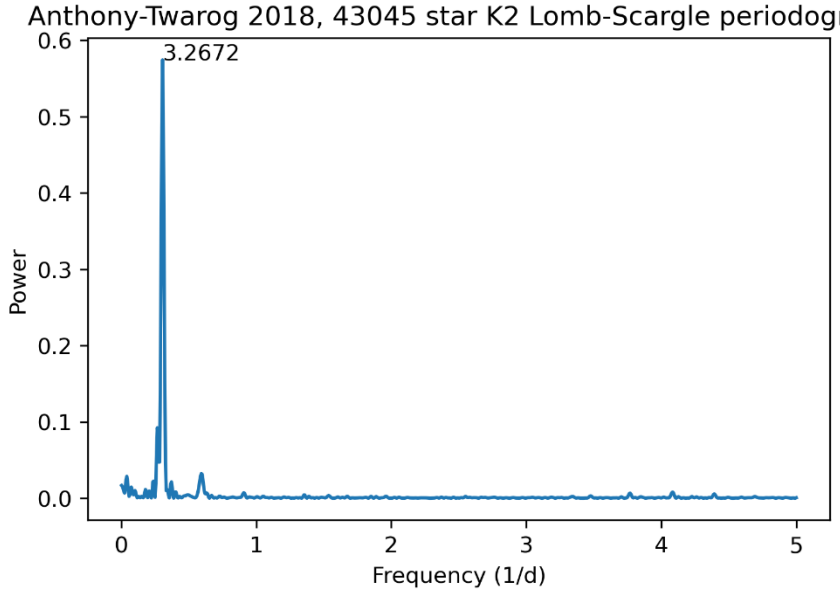
Prob < 0.50 Bouy et al. (2015) +

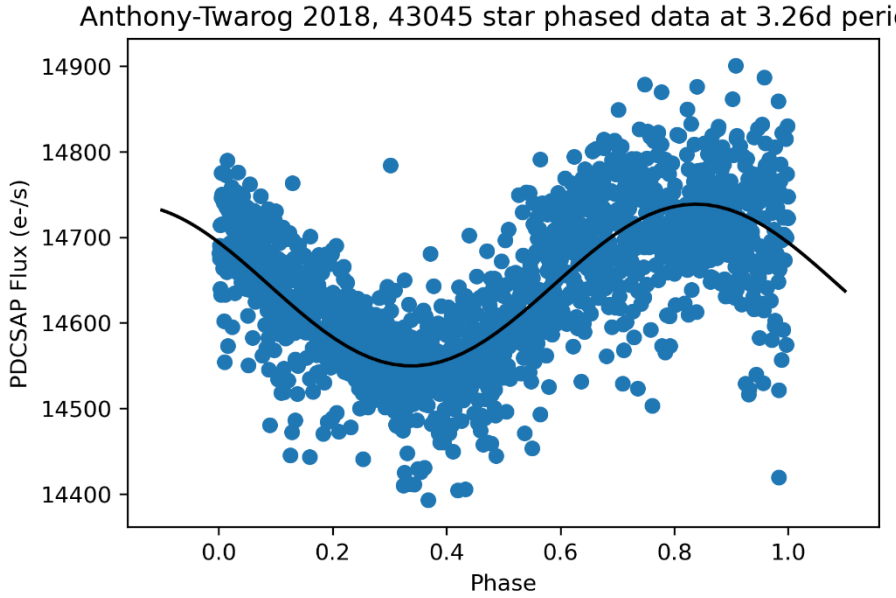
Prob < 0.58 Clusterix 2.0

70 possible members

ROTATIONAL PERIODS

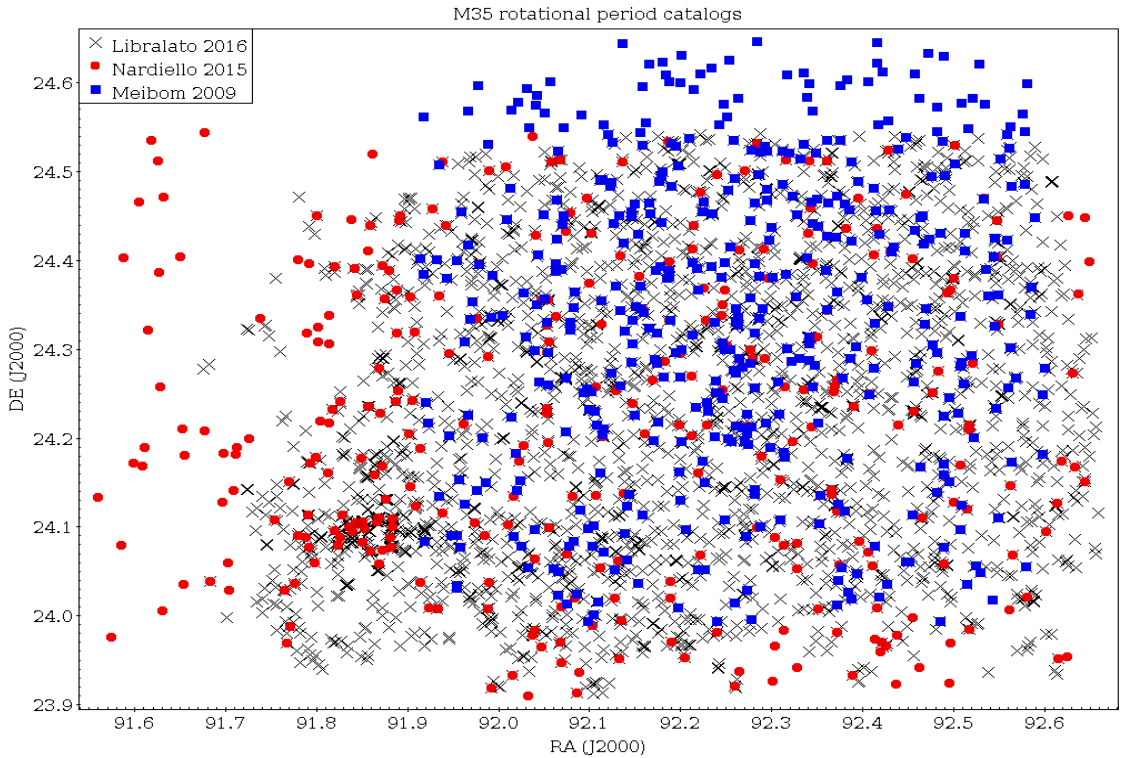




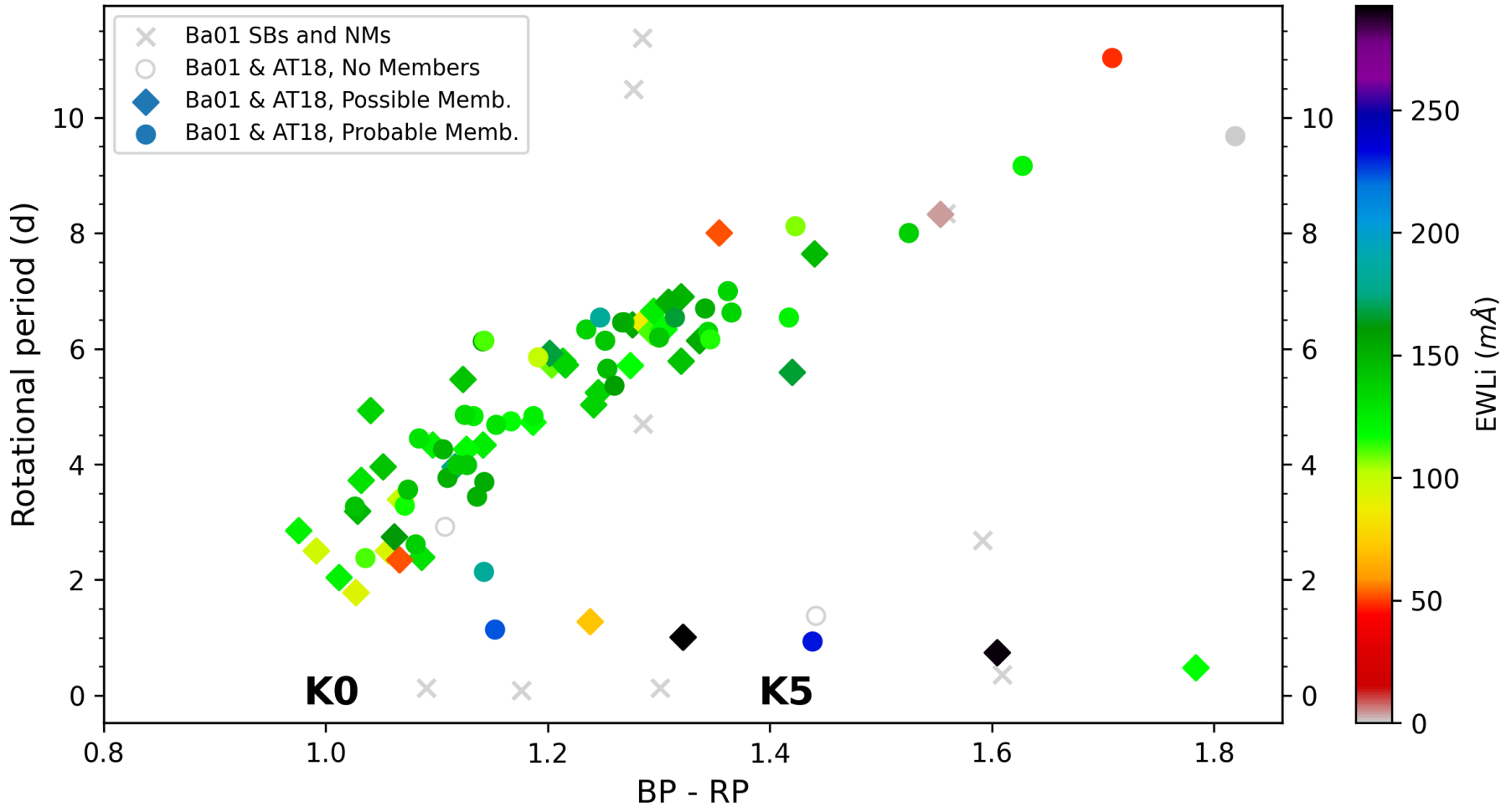


ROTATIONAL PERIODS

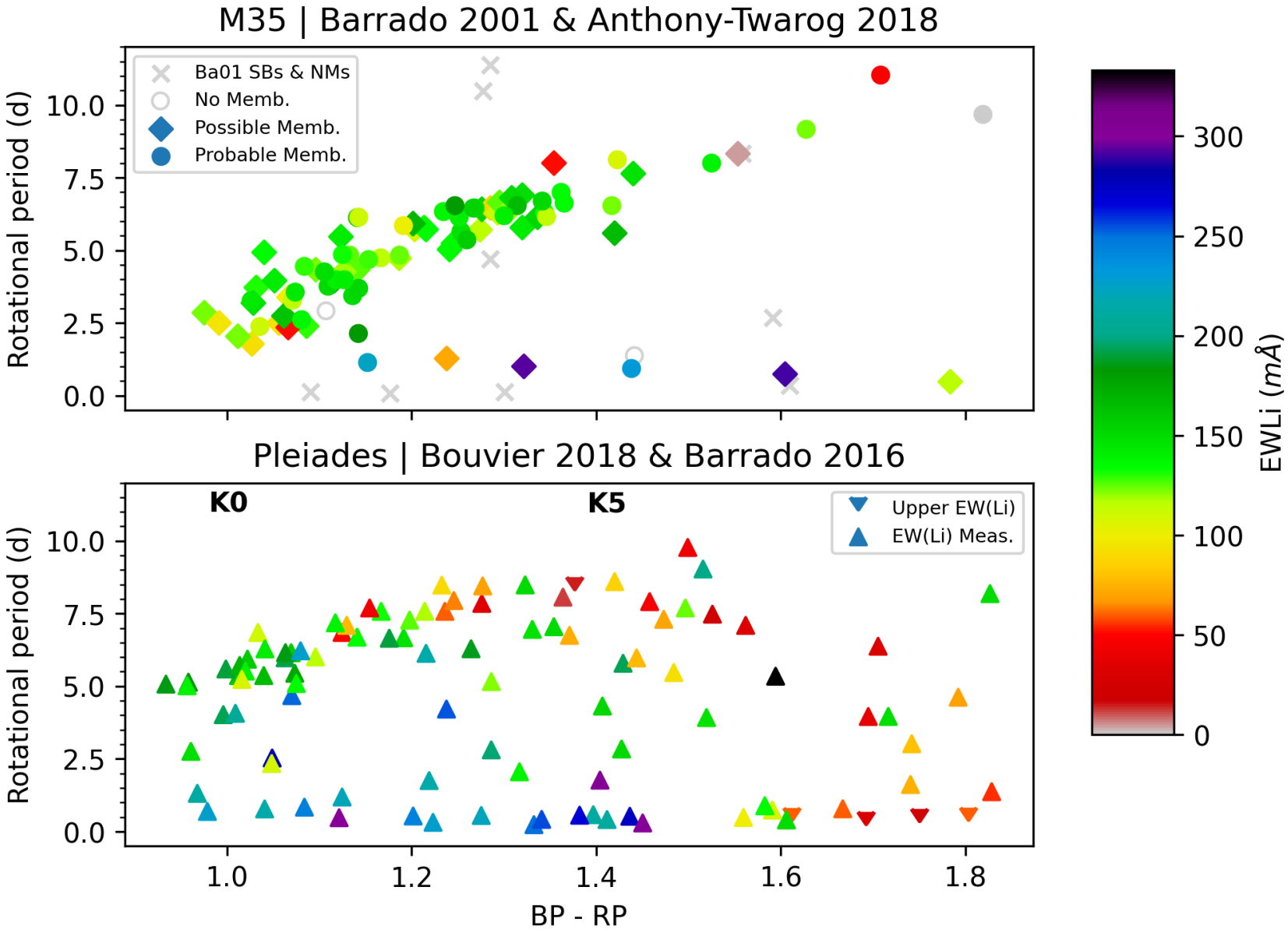
	Paper	Timespan (days)	Field of View	Instrument	Cadence
2	**Libralato 2016**	~ 35	~ 59′ x 38′	K2	Short: 1 min Long: 29 min
1	**Meibom 2009**	Short: 16 Long: 143	~ 40′ x 40′	WIYN 0.9m telescope (Kitt Peak Observatory)	Short: 1 hour Long: 1 day
3	**Nardiello 2015**	~ 10	~ 65′ x 39′	Asiago 67/92 cm Schmidt Telescope (OAPD)	3 min



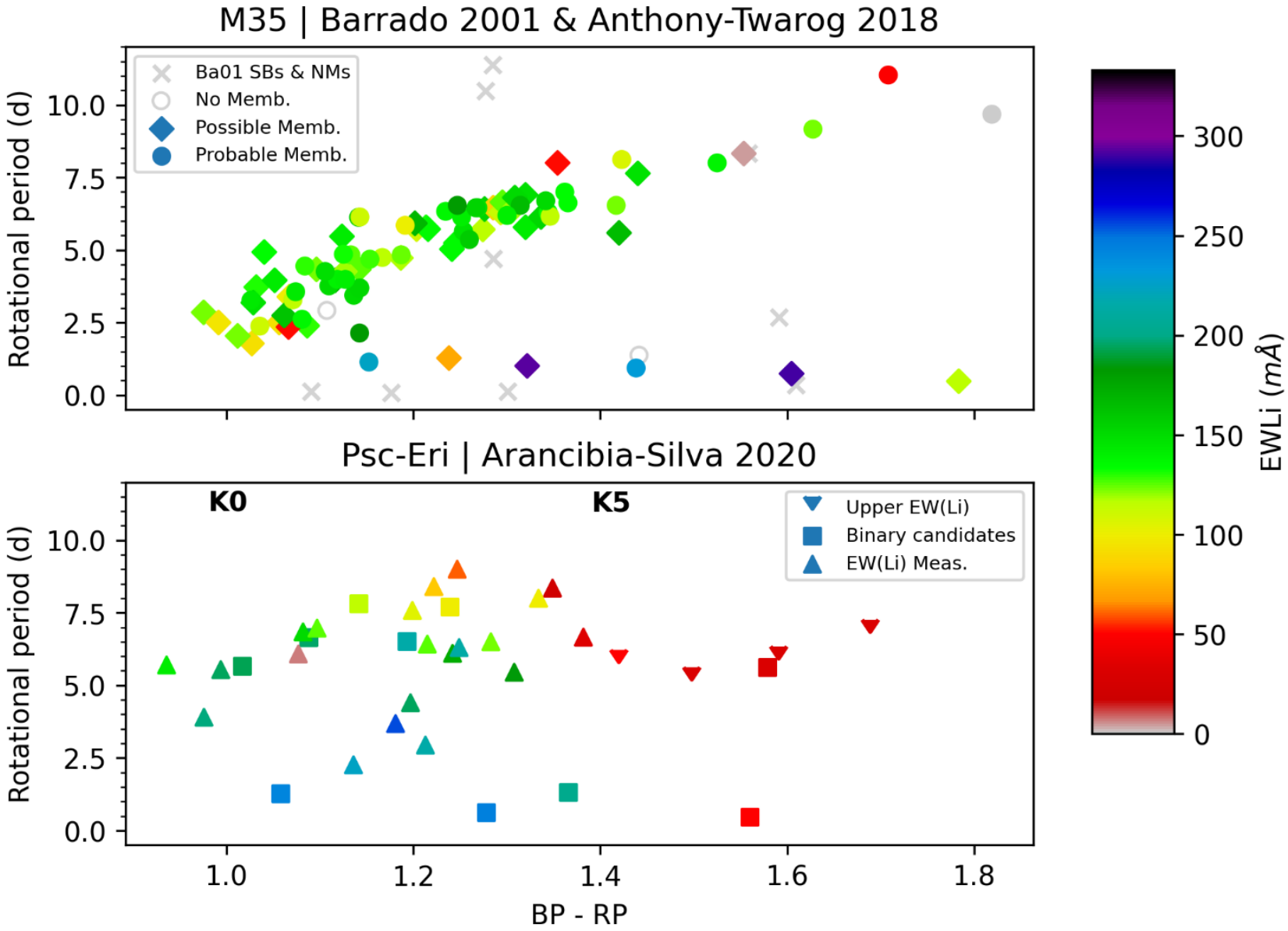
ANALYSIS


Ba01 SBs and NMs
Ba01 & AT18, No Members
Ba01 & AT18, Possible Memb.
Ba01 & AT18, Probable Memb.
Rotational period (d)
BP - RP
EWLi (mÅ)
K0
K5
0
2
4
6
8
10
0.8
1.0
1.2
1.4
1.6
1.8
0
50
100
150
200
250

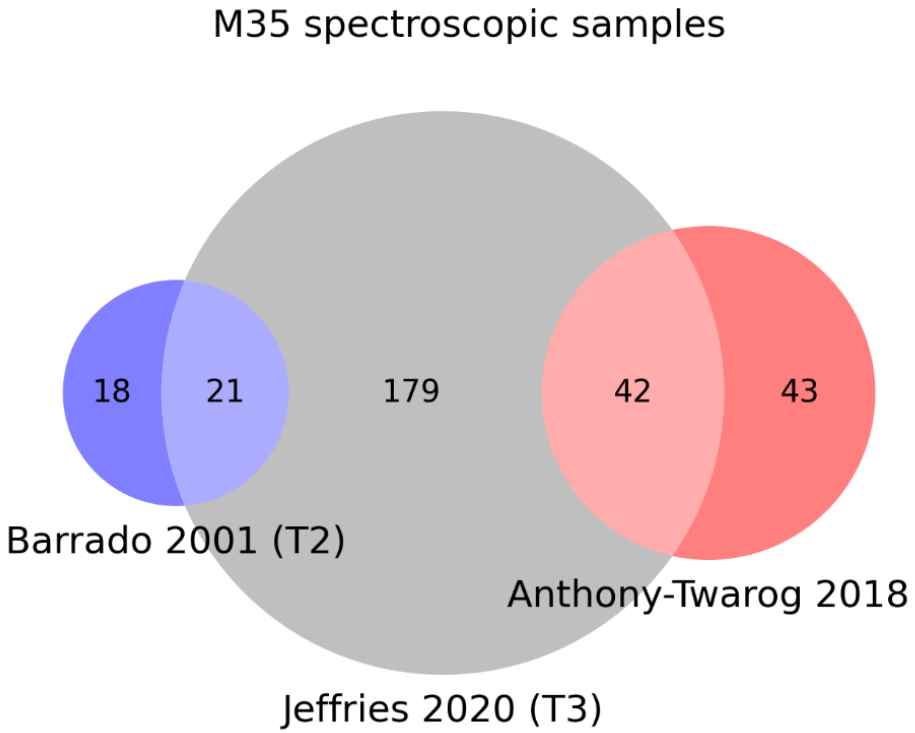
ANALYSIS

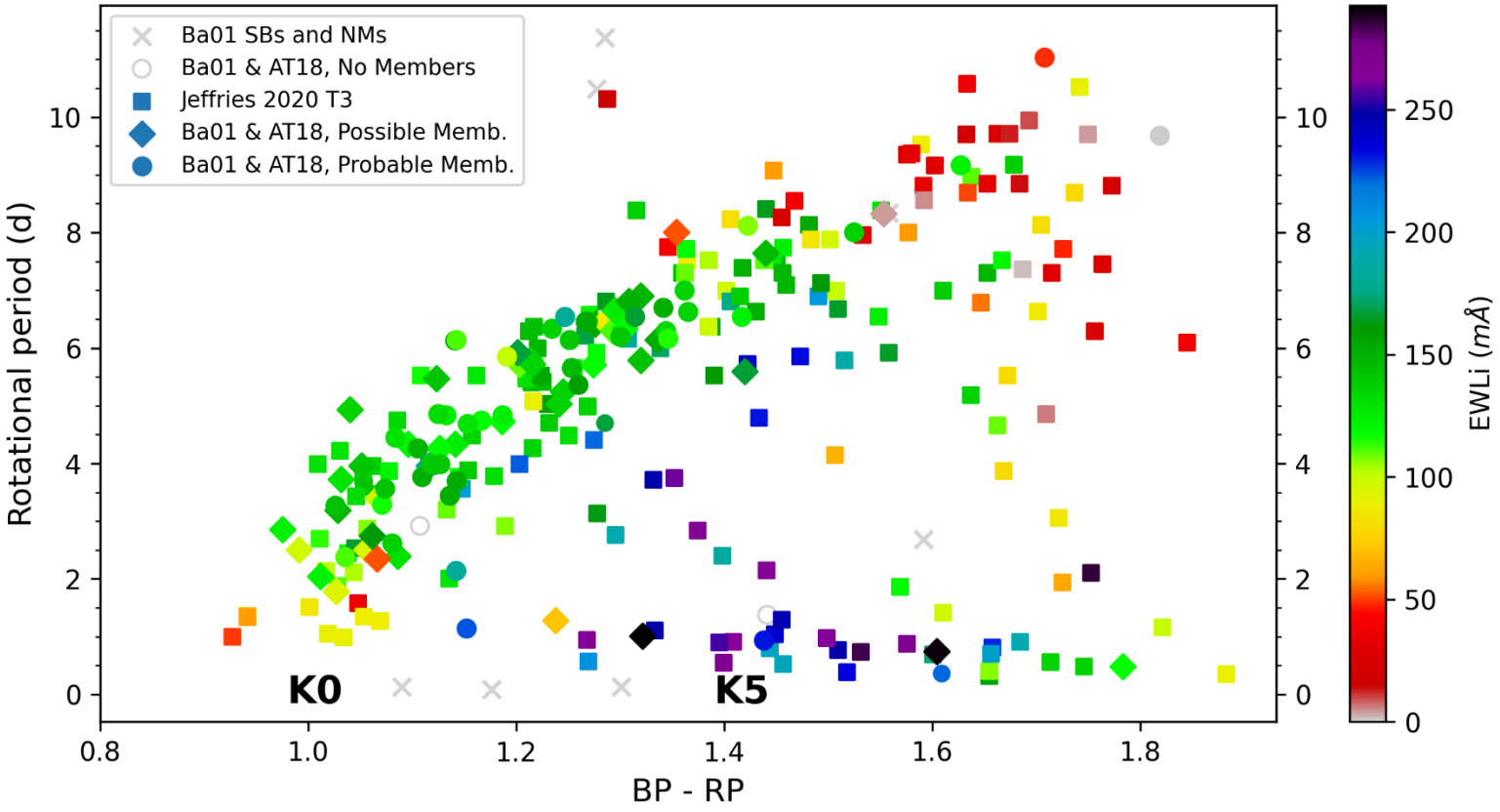

M35 | Barrado 2001 & Anthony-Twarog 2018
Ba01 SBs & NMs
No Memb.
Possible Memb.
Probable Memb.
Rotational period (d)
10.0
7.5
5.0
2.5
0.0
Pleiades | Bouvier 2018 & Barrado 2016
K0
K5
Upper EW(Li)
EW(Li) Meas.
Rotational period (d)
1.0
1.2
1.4
1.6
1.8
BP - RP
300
250
200
150
100
50
0
EWLi (mÅ)

ANALYSIS

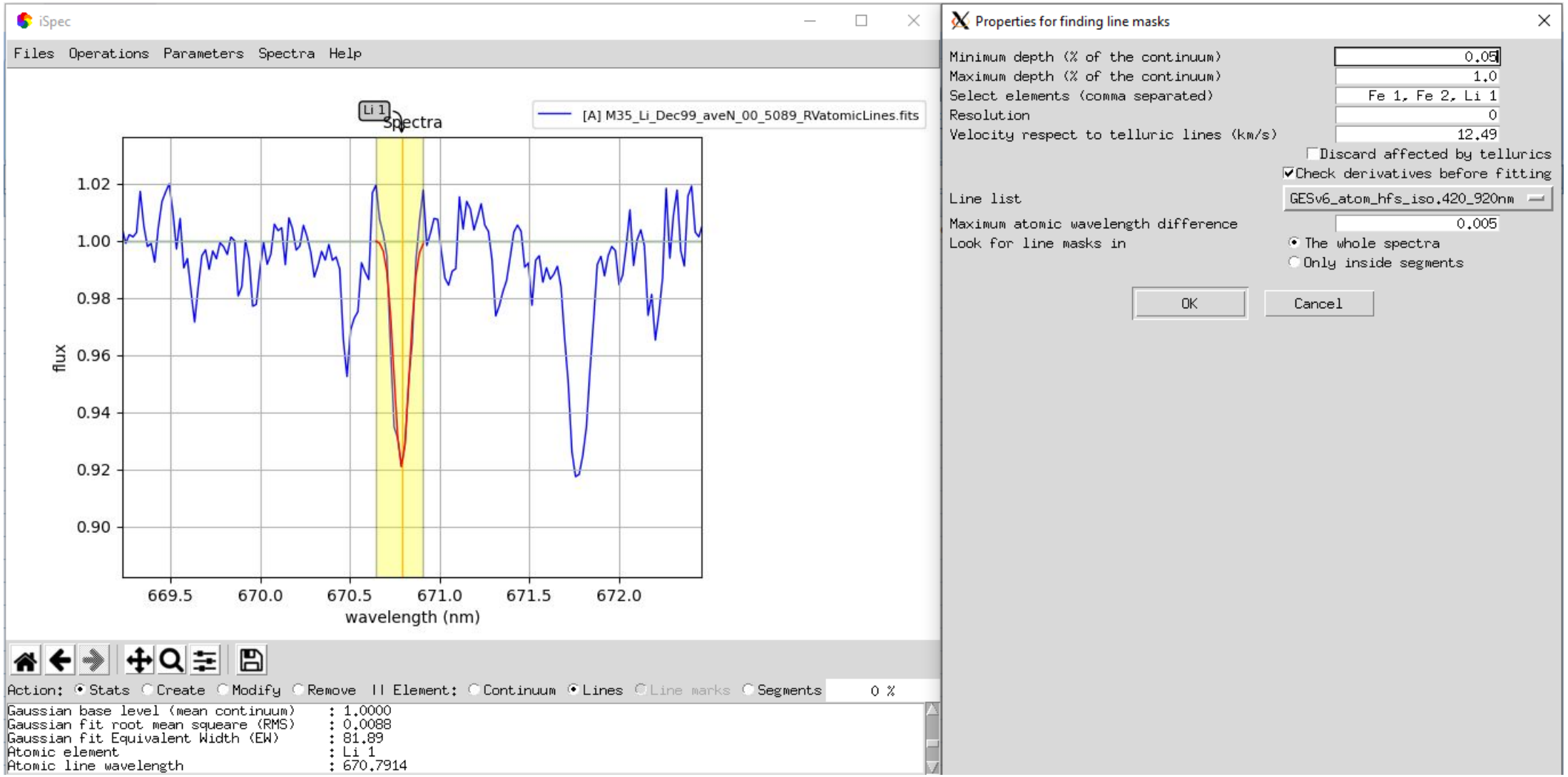

M35 | Barrado 2001 & Anthony-Twarog 2018
Ba01 SBs & NMs
No Memb.
Possible Memb.
Probable Memb.
Rotational period (d)
10.0
7.5
5.0
2.5
0.0
Psc-Eri | Arancibia-Silva 2020
K0
K5
Upper EW(Li)
Binary candidates
EW(Li) Meas.
Rotational period (d)
1.0
1.2
1.4
1.6
1.8
BP - RP
EWLi (mÅ)
300
250
200
150
100
50
0

ANALYSIS


M35 spectroscopic samples
18
21
179
42
43
Barrado 2001 (T2)
Anthony-Twarog 2018
Jeffries 2020 (T3)

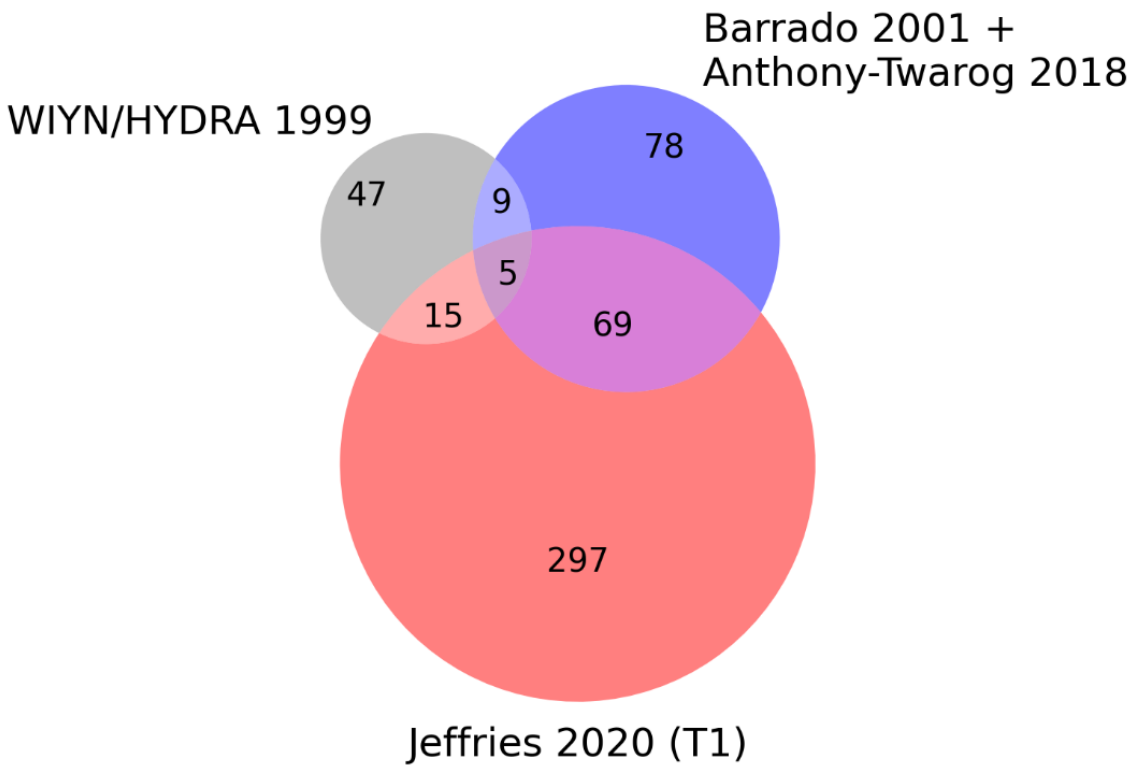

Ba01 SBs and NMs
Ba01 & AT18, No Members
Jeffries 2020 T3
Ba01 & AT18, Possible Memb.
Ba01 & AT18, Probable Memb.
Rotational period (d)
BP - RP
EWLi (mÅ)
K0
K5
0
2
4
6
8
10
0.8
1.0
1.2
1.4
1.6
1.8
0
50
100
150
200
250

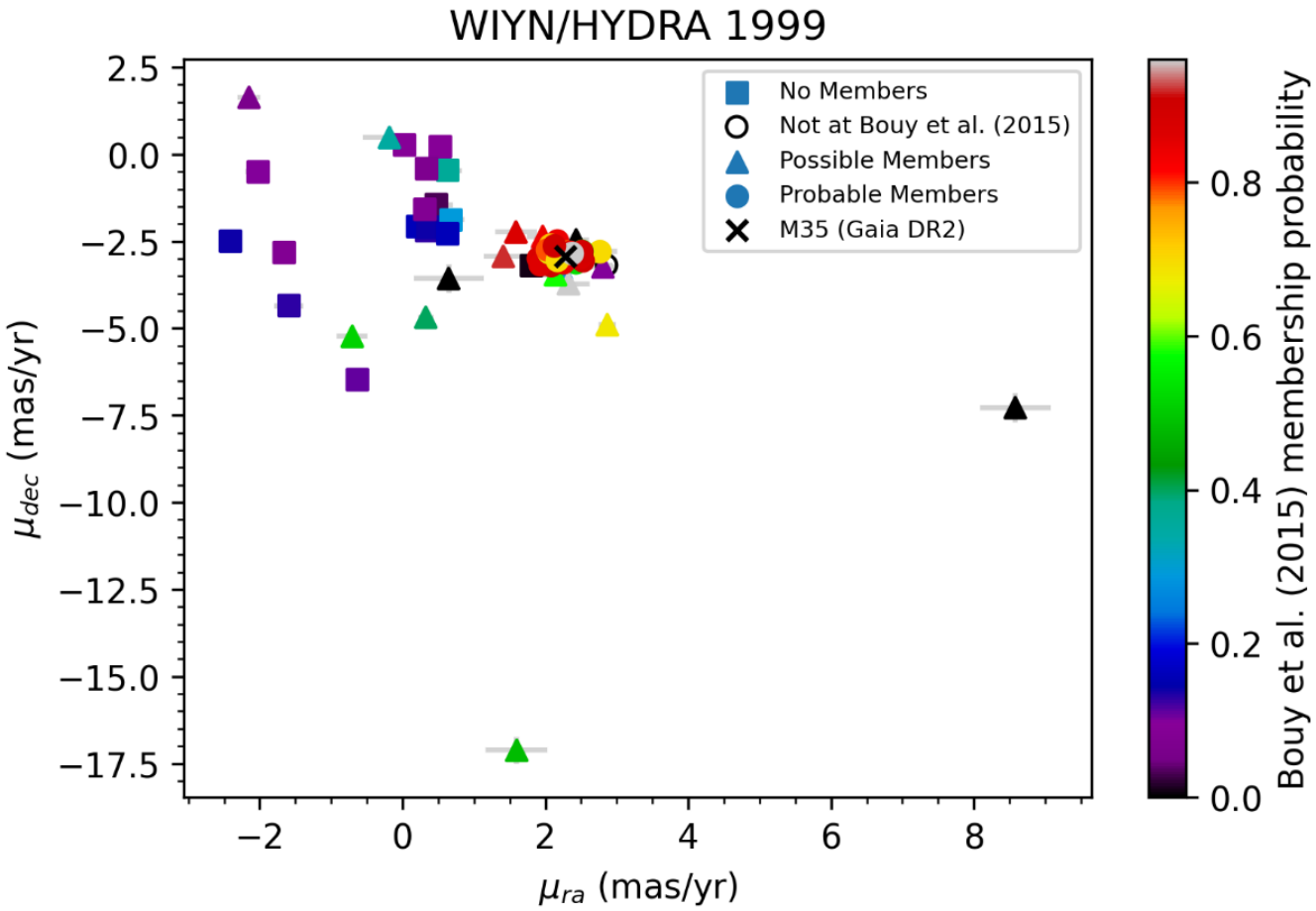
FUTURE WORK



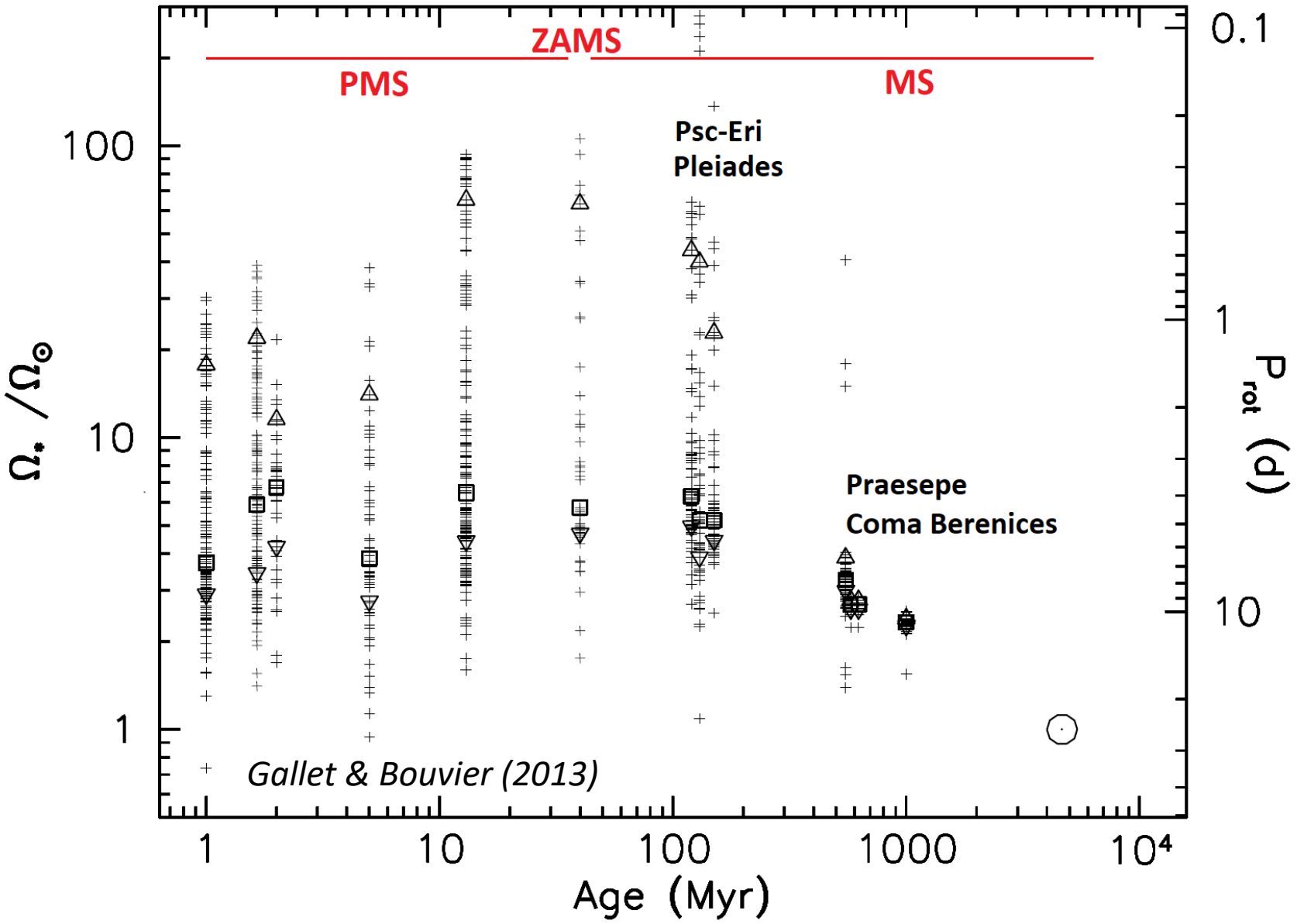
WIYN/HYDRA 1999 + 2001 (February and March)

FUTURE WORK


Barrado 2001 +
Anthony-Twarog 2018
WIYN/HYDRA 1999
47
9
78
5
15
69
297
Jeffries 2020 (T1)

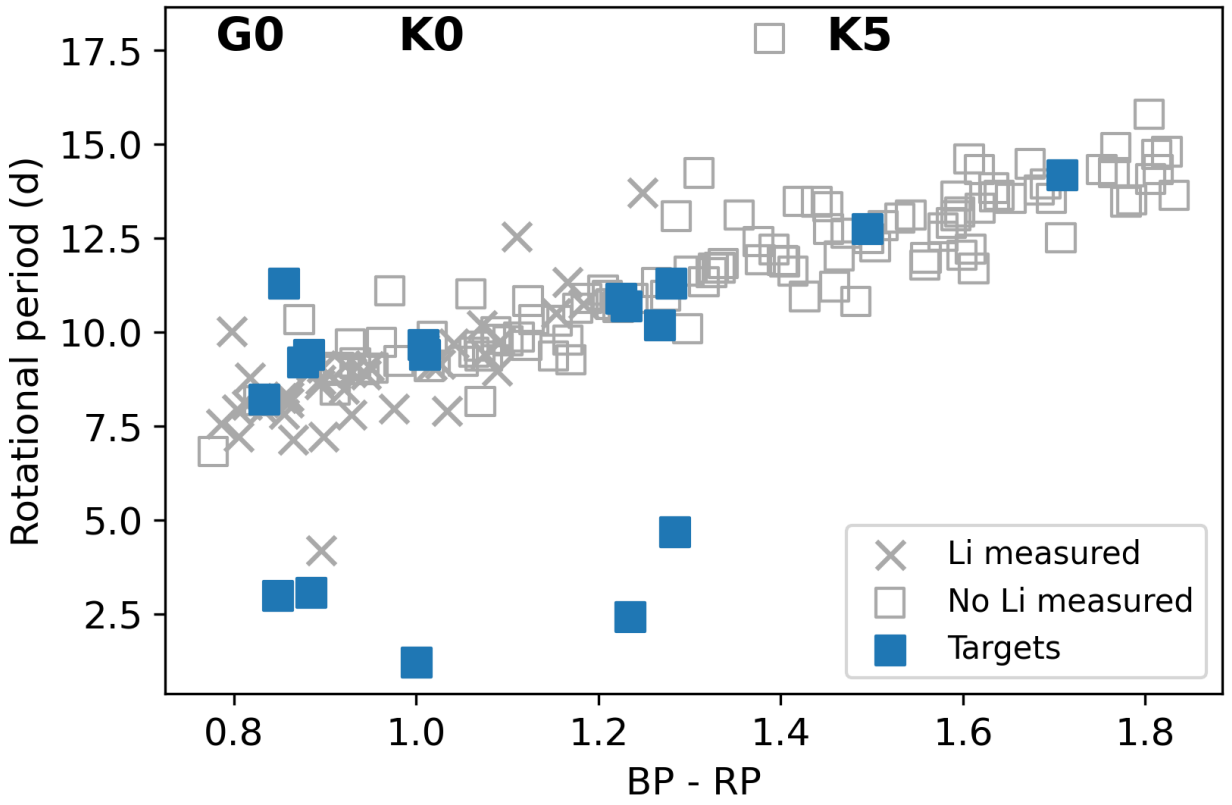

WIYN/HYDRA 1999
No Members
Not at Bouy et al. (2015)
Possible Members
Probable Members
M35 (Gaia DR2)
μ_{dec} (mas/yr)
μ_{ra} (mas/yr)
Bouy et al. (2015) membership probability

FUTURE WORK

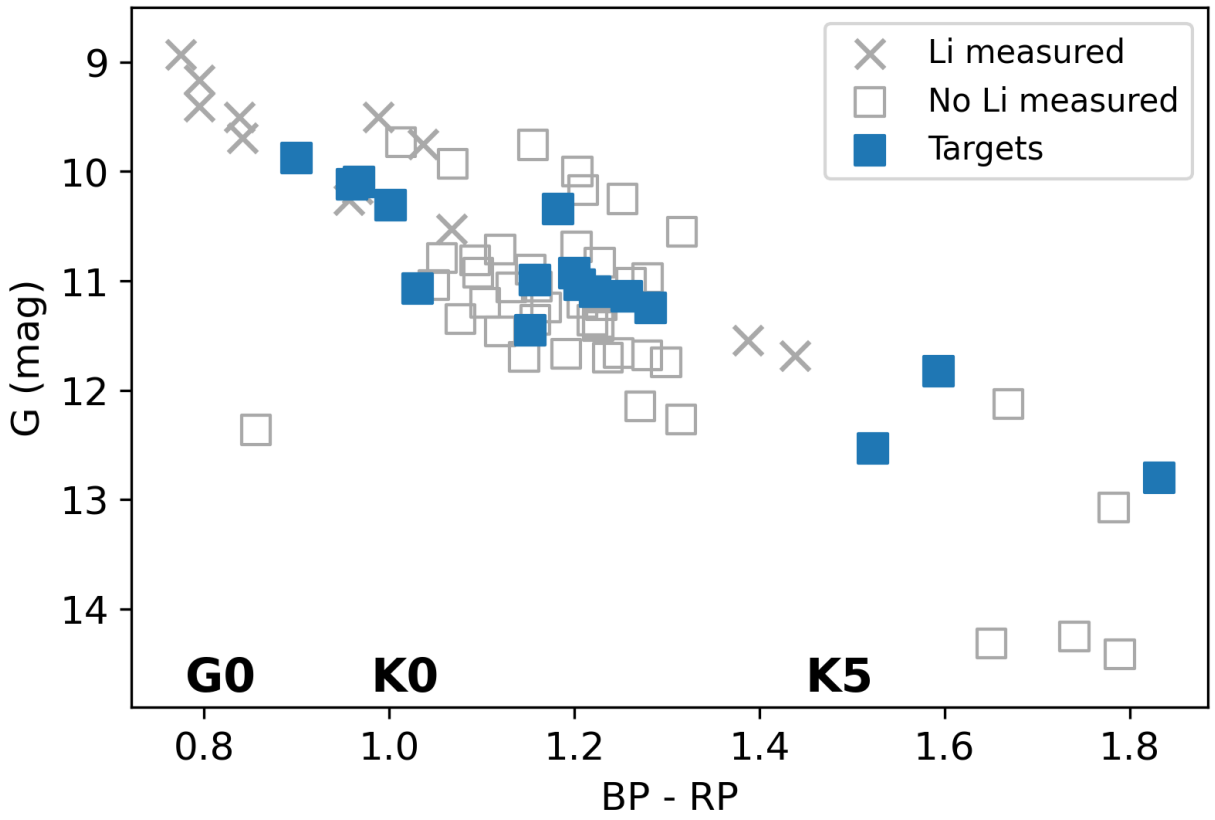

ZAMS
PMS
MS
Psc-Eri
Pleiades
Praesepe
Coma Berenices
Gallet & Bouvier (2013)
100
10
1
0.1
1
10
1
10
100
1000
10⁴
Ω* /Ω⊙
P rot (d)
Age (Myr)

FUTURE WORK

Praesepe



Coma Berenices



SUMMARY

- Lithium depletion is used as one of the best age indicators for G and K stars.
- Rotation has a strong influence on the lithium depletion pattern and this effect must be tackled.
- We have taken advantage of K2 light curves and published data to analyse this relationship in M35.
- The lithium-rotation connection follows the same trend observed in slightly younger clusters and associations.
- New spectroscopic data are needed to completely track the evolution of this connection along the MS.