

The timescales of protoplanetary disk evolution constrained by Gaia membership analysis



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Main references:

Manara, Prusti, Comeron, Mor et al. 2018, A&A, 615, L1

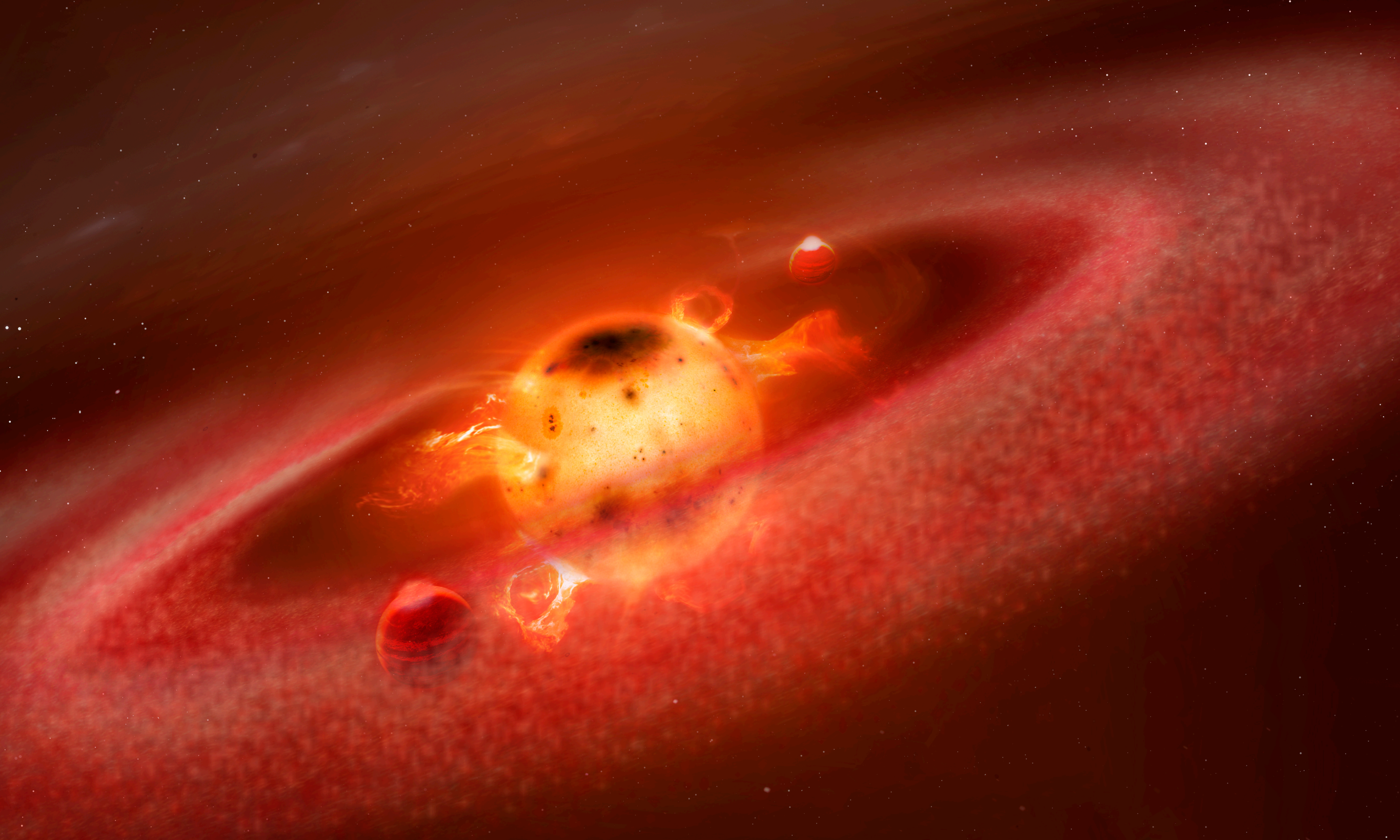
Jerabkova, Beccari, Boffin, Petr-Goetzens, Manara et al. A&A, subm.

Herczeg, Kuhn, Zhou, Hatchell, Manara et al. ApJ, in press, arXiv:1904.04085



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Gaia ESLAB - 09.04.2019



Protoplanetary disks are the place where **planets** are formed.
Their evolution is **KEY** to understand planet formation

OVERVIEW



LIFETIME

1. Disk survival timescale



MASS

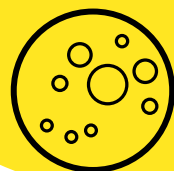
2. Mass available to form planets



EVOLUTION

3. Disk evolution mechanism

CONSTRAINING PLANET FORMATION



OVERVIEW



LIFETIME

1. Disk survival timescale



MASS

2. Mass available to form planets



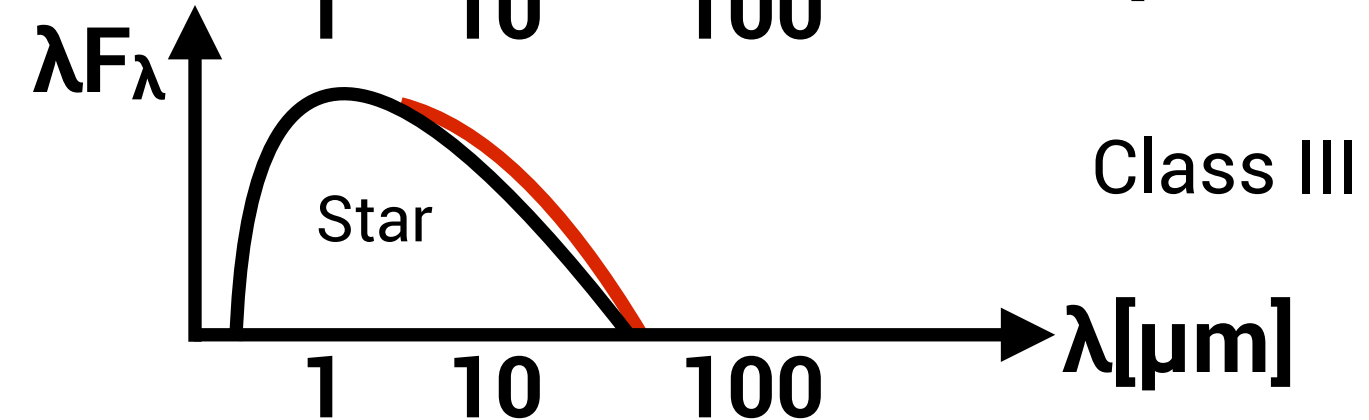
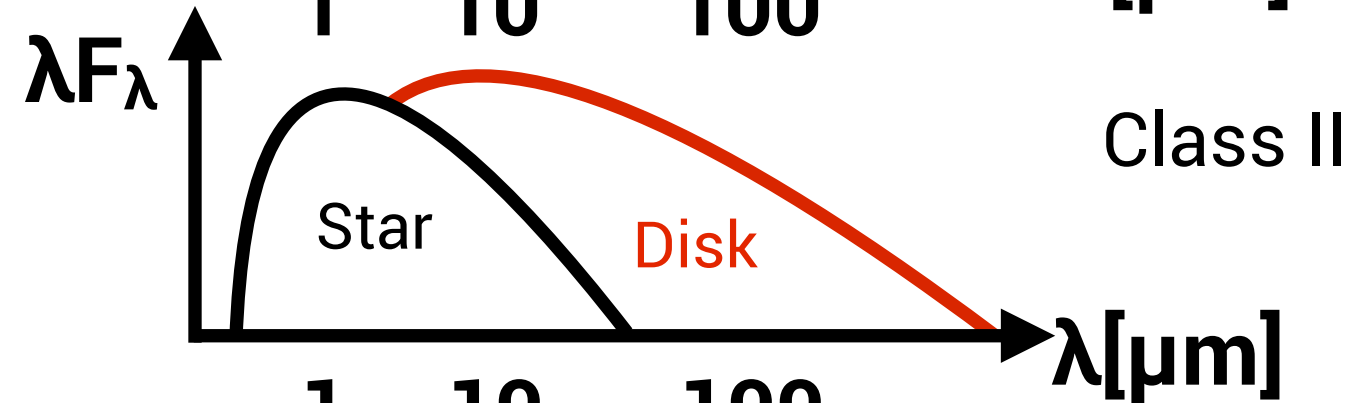
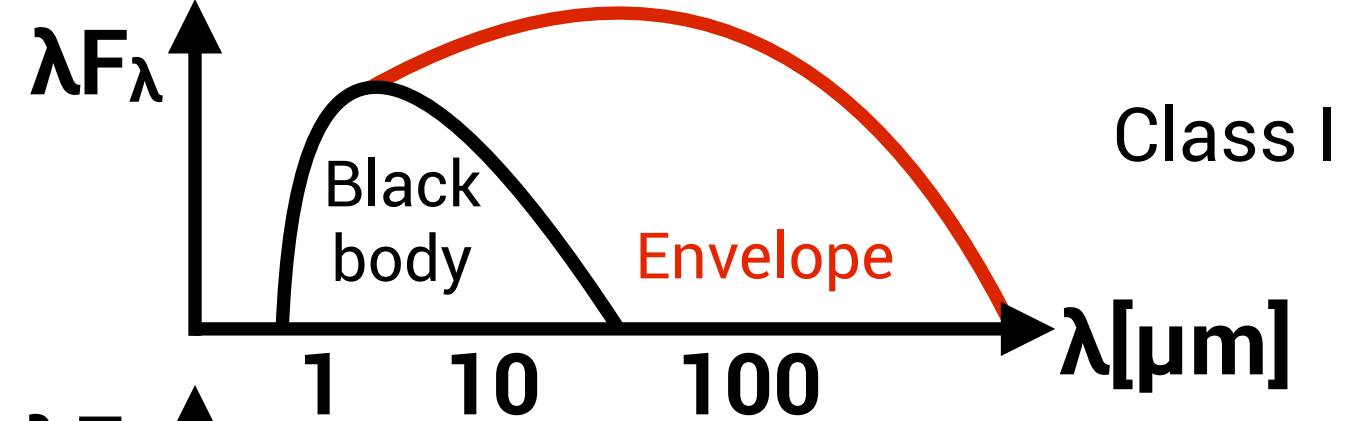
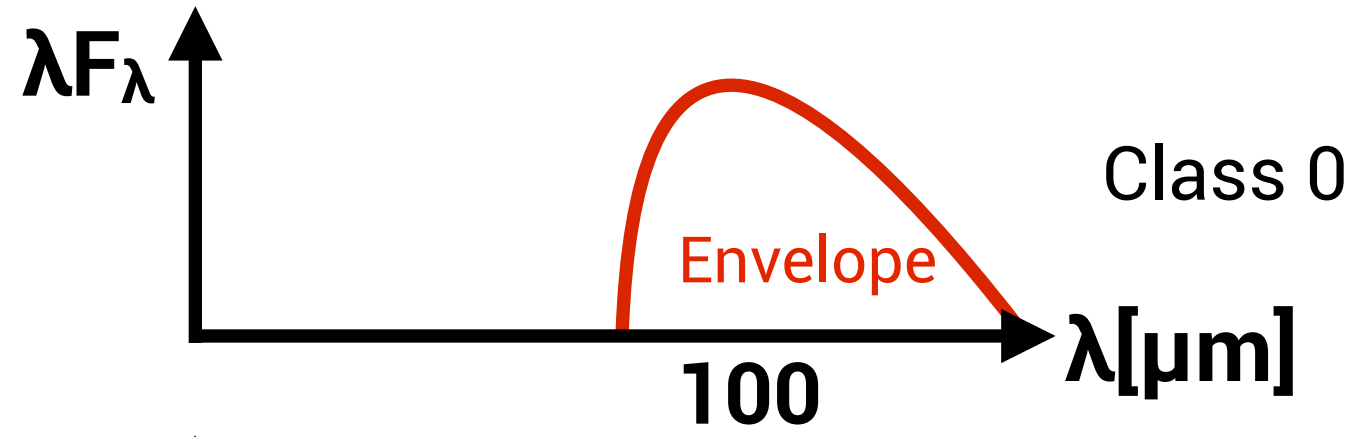
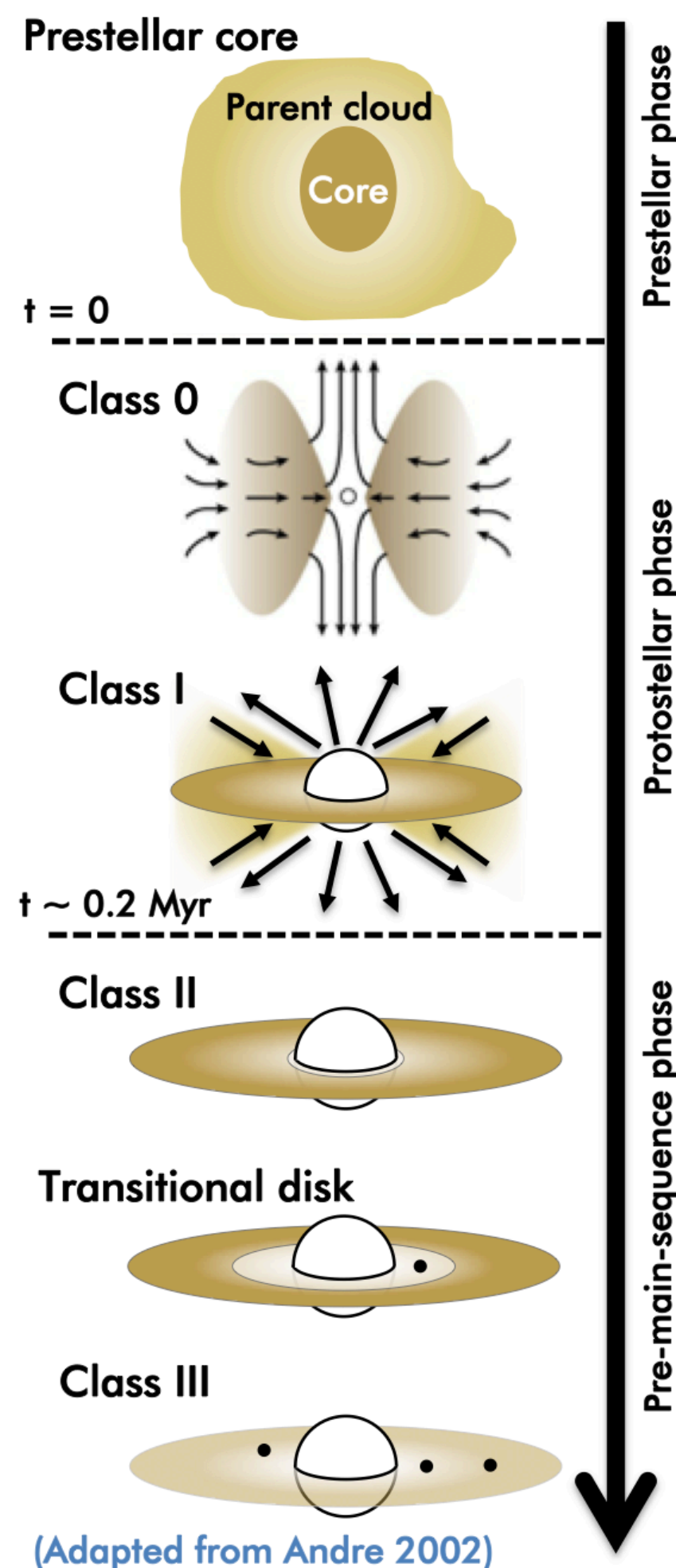
EVOLUTION

3. Disk evolution mechanism

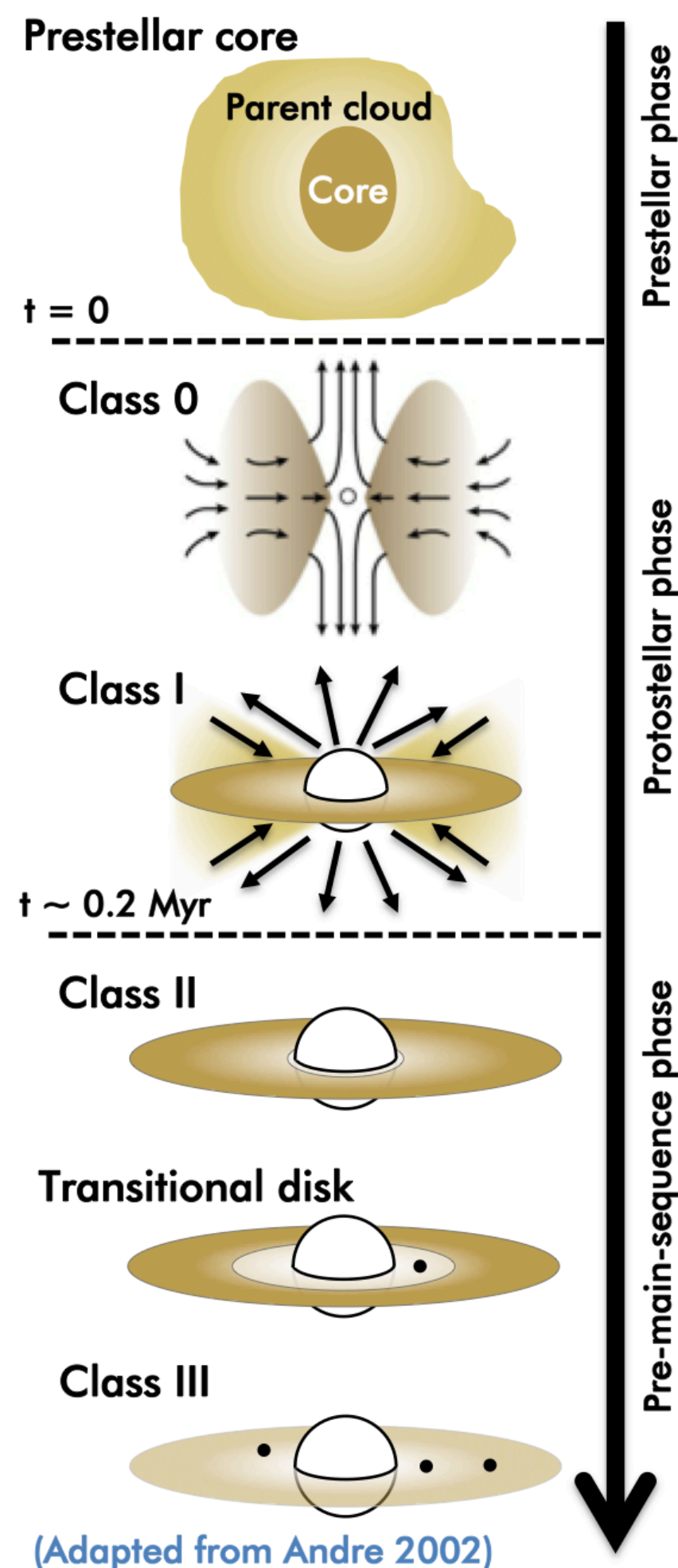
CONSTRAINING PLANET FORMATION



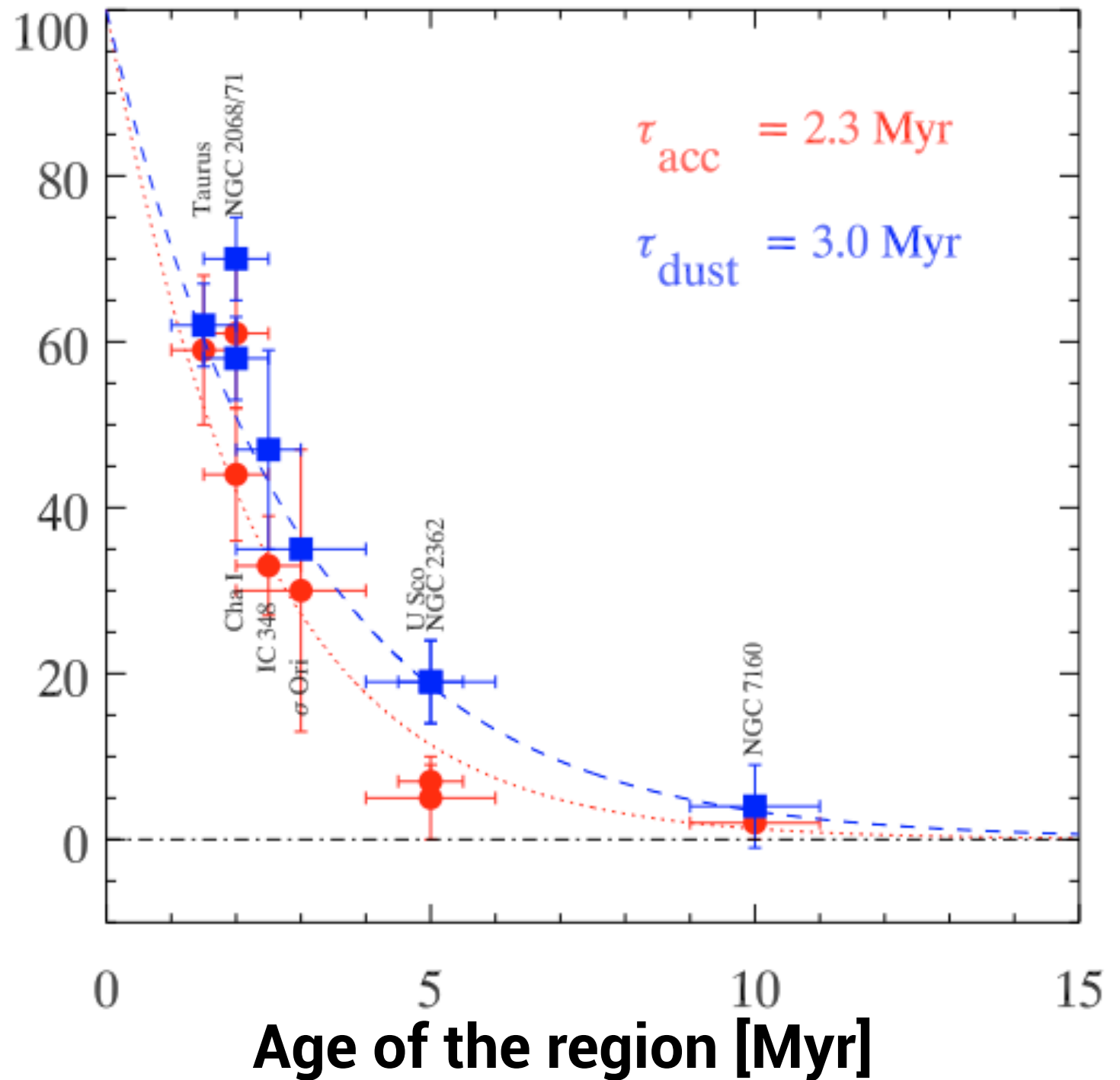
The **evolution** of protoplanetary disks and their typical **lifetime**



The **evolution** of protoplanetary disks and their typical **lifetime**



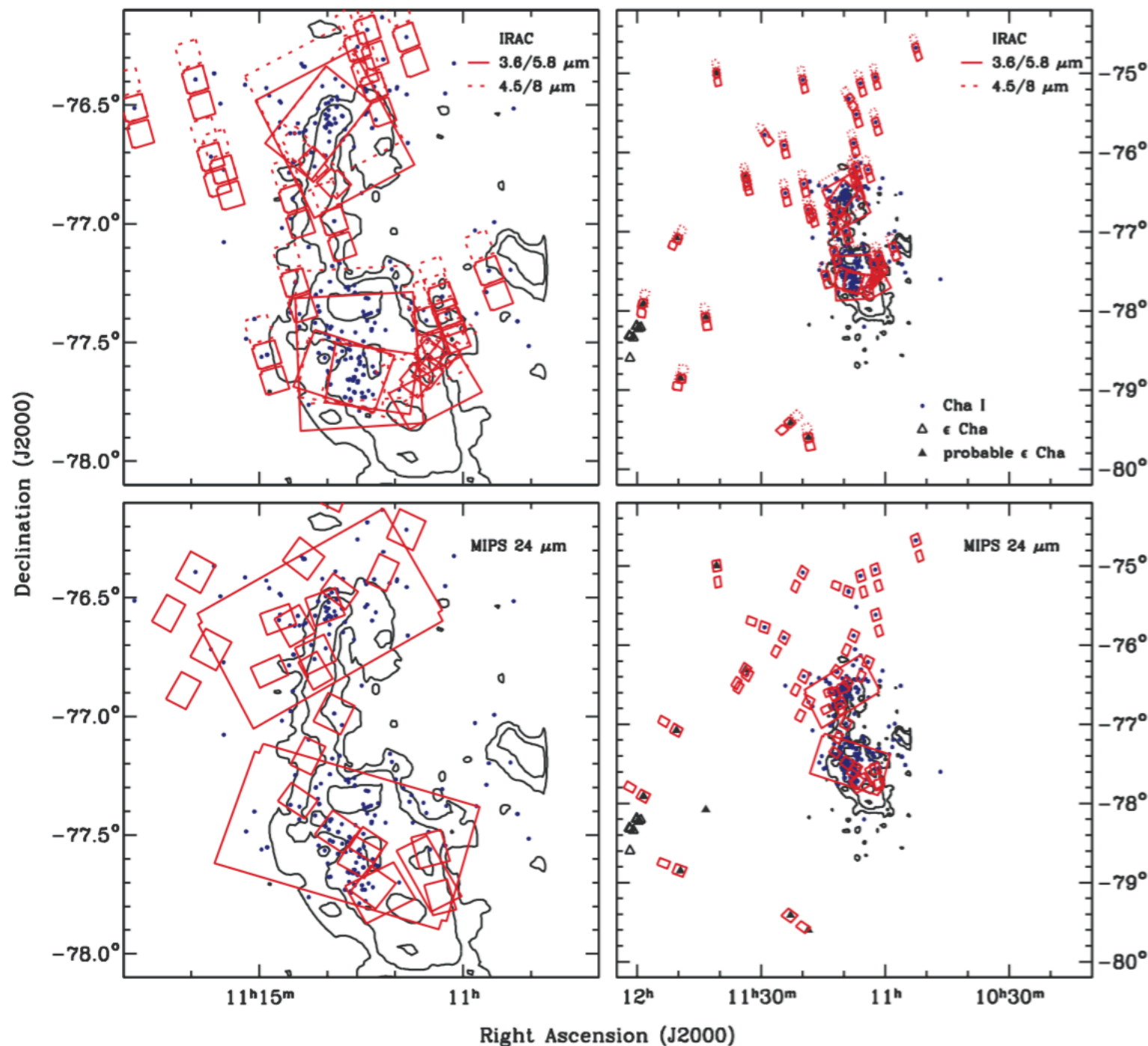
Fraction of stars with optically thick disk



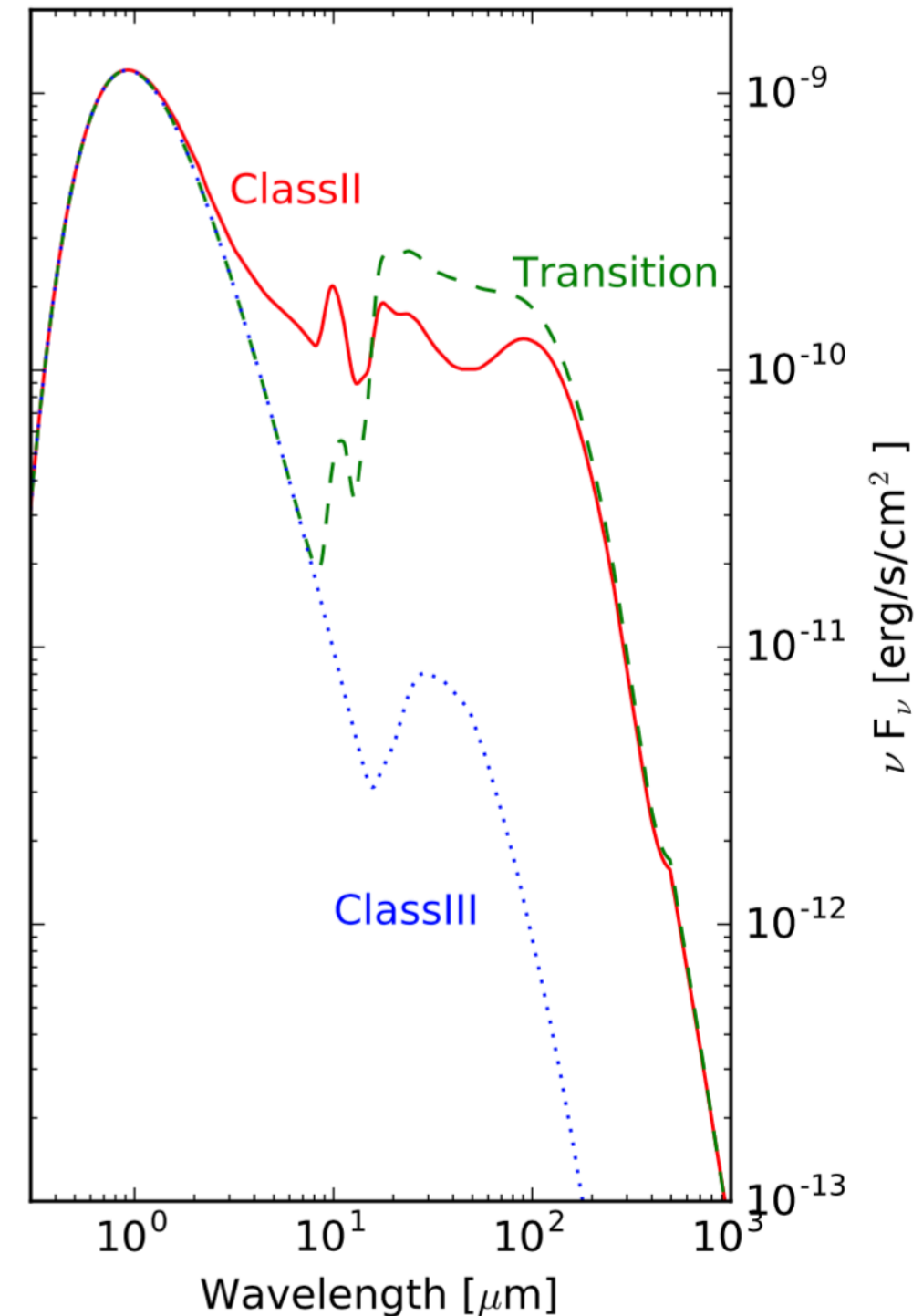
(Fedele et al. 2010, Haisch et al. 2001, Hernandez et al. 2007, Bell et al. 2013)

Detection of young stellar objects from IR-excess

1. Limited coverage of IR surveys
2. Low sensitivity to small IR-excess (e.g., diskless stars)



Chamaeleon I, Luhman et al. 2008



Ercolano & Pascucci 2017

Why do Lupus V-VI have such a low disk fraction?

Total Number of YSO Candidates in the Lupus V and VI Clouds Organized by Lada Class

Lada Class	Lupus I ^a	Lupus III ^a	Lupus IV ^a	Lupus V	Lupus VI	All c2d clouds ^b
I	2 (15%)	2 (3%)	1 (8%)	0	0	165 (16%)
Flat	3 (23%)	6 (9%)	1 (8%)	0	1 (2%)	123 (12%)
II	6 (47%)	41 (59%)	5 (42%)	9 (21%)	5 (11%)	612 (60%)
III	2 (15%)	20 (29%)	5 (42%)	34 (79%)	39 (87%)	124 (12%)
Total	13	69	12	43	45	1024

Table 1: YSO candidates in Lupus (from Spezzi et al. 2011)

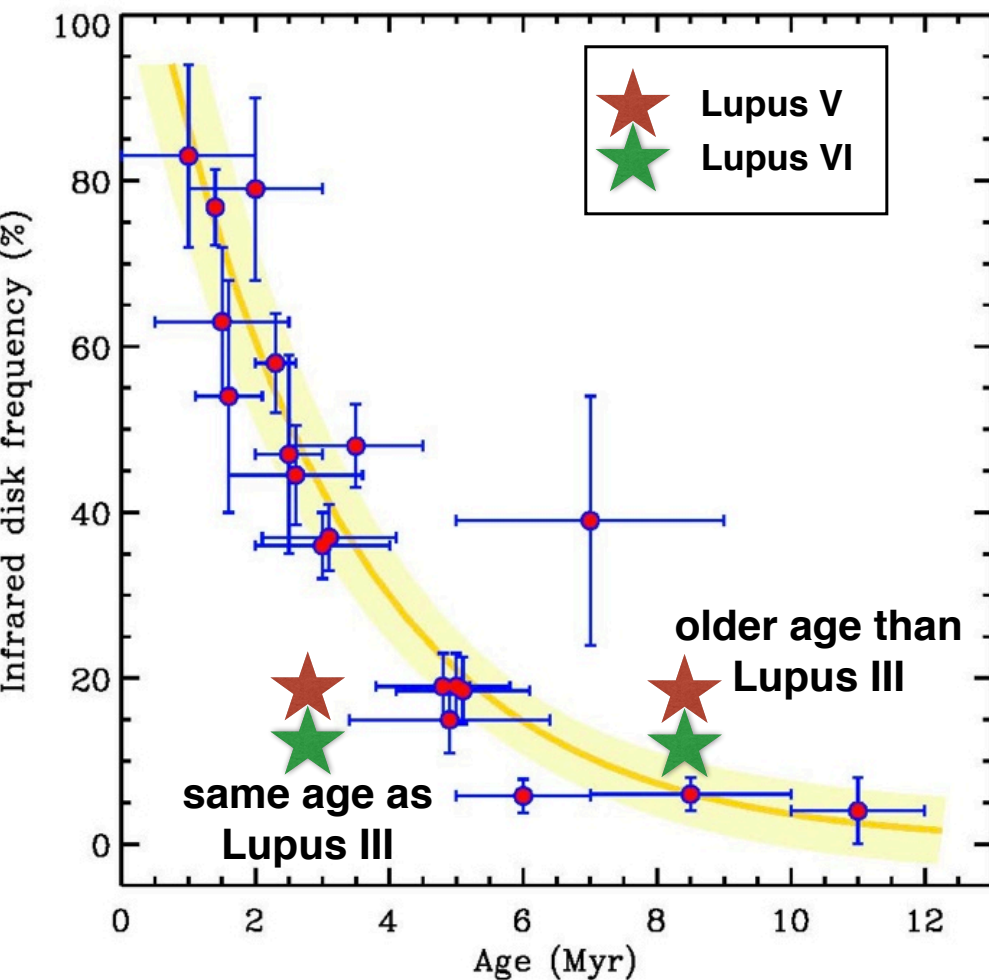


Fig. 1: disk fraction in nearby clusters and possible outcomes of the proposal.

(Adapted from Hernandez et al. 2007)

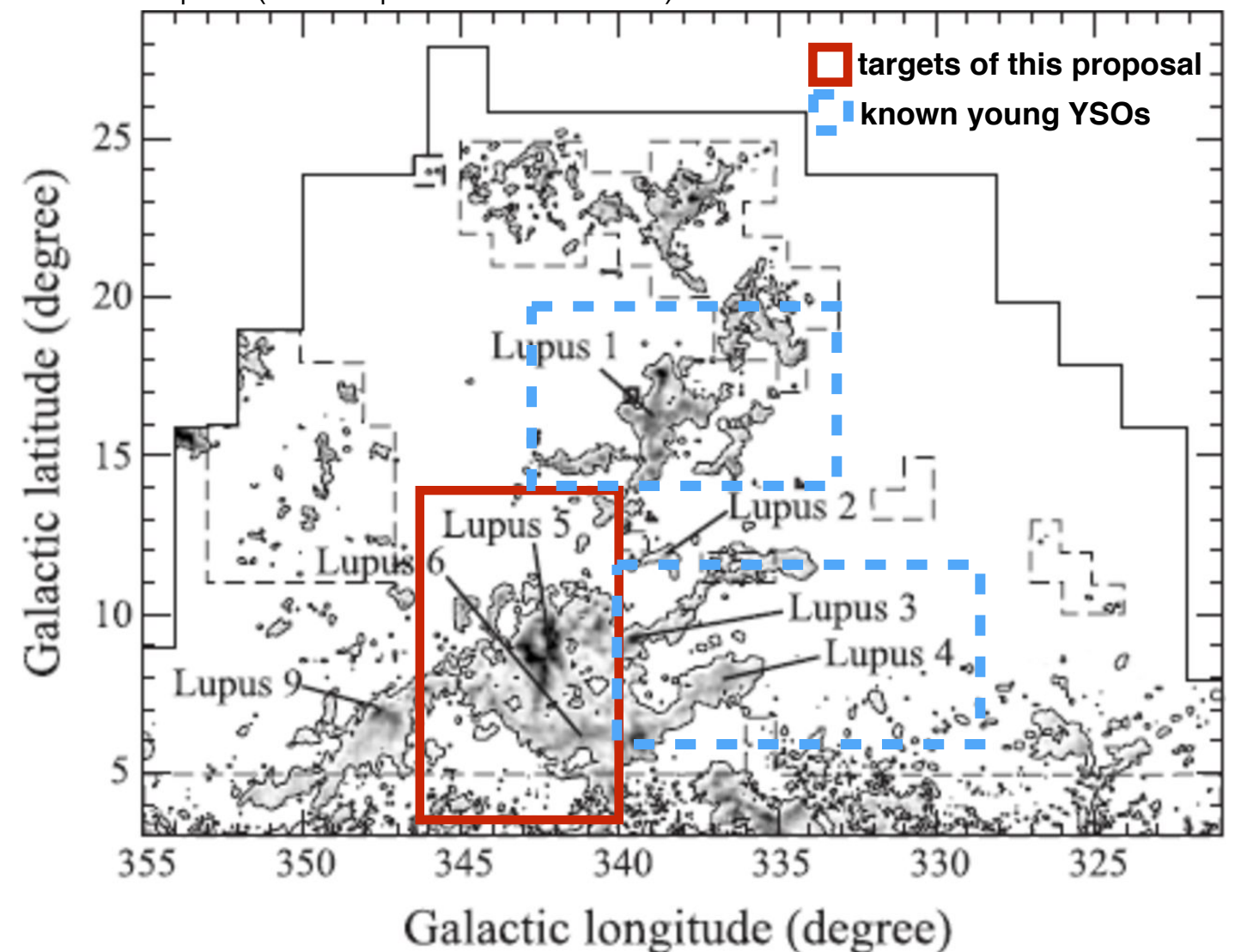
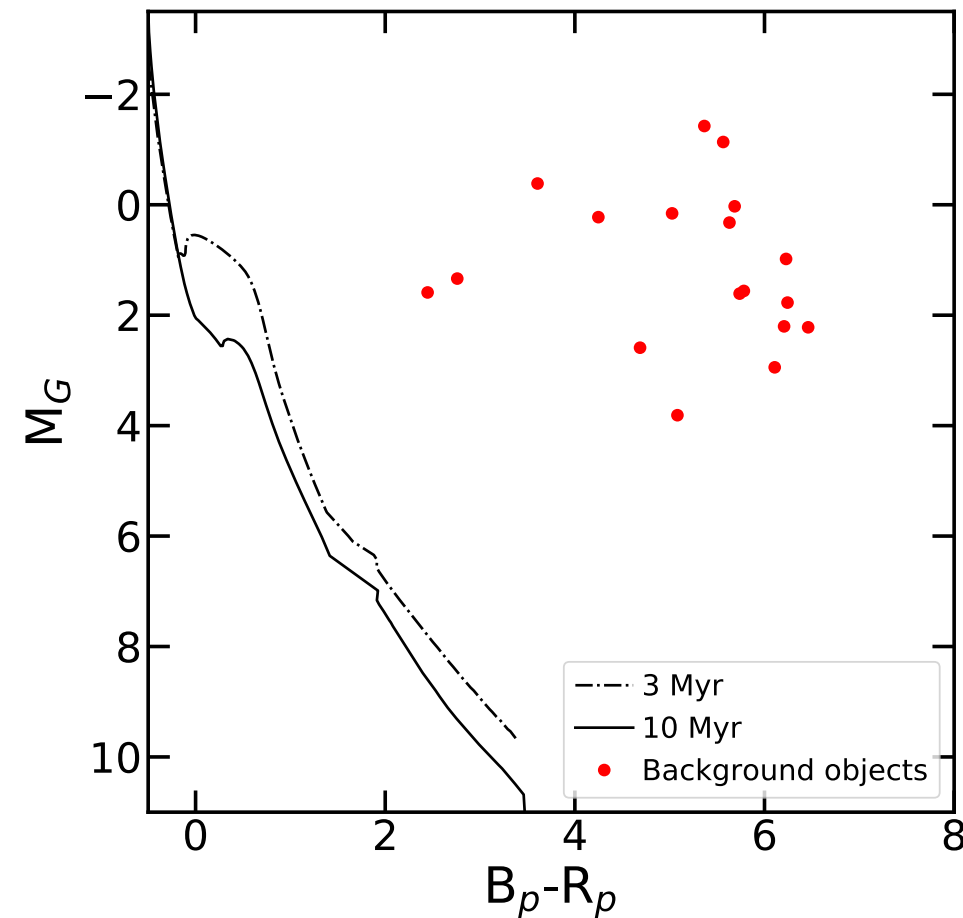
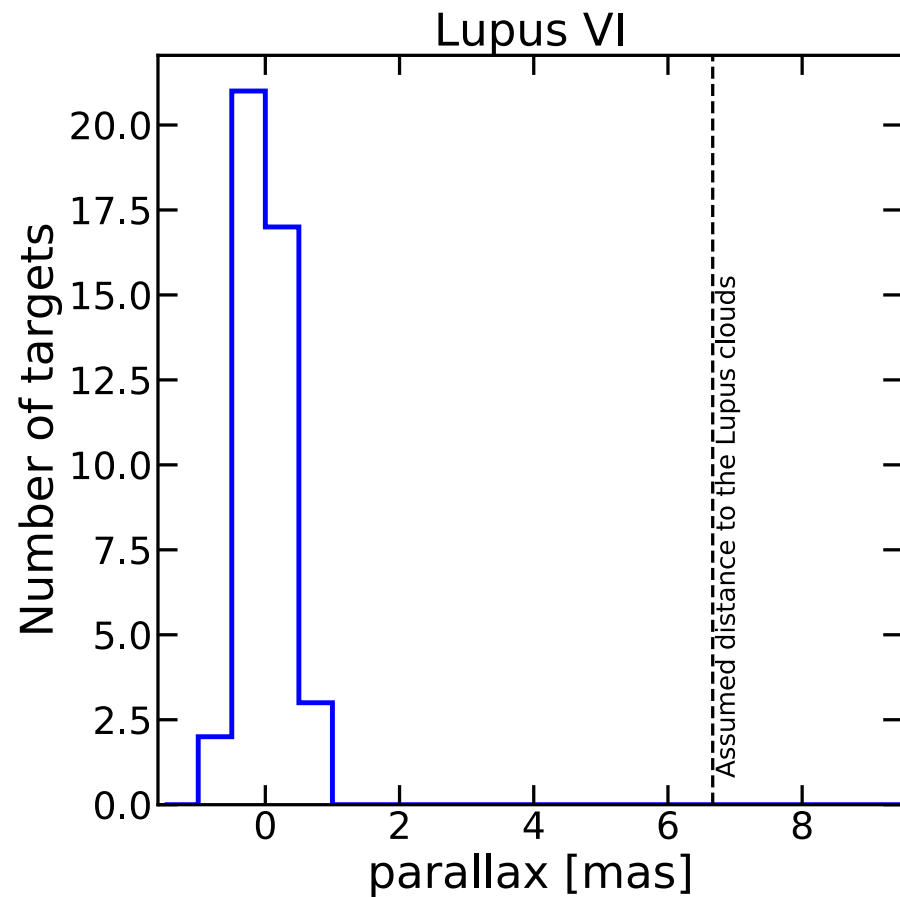
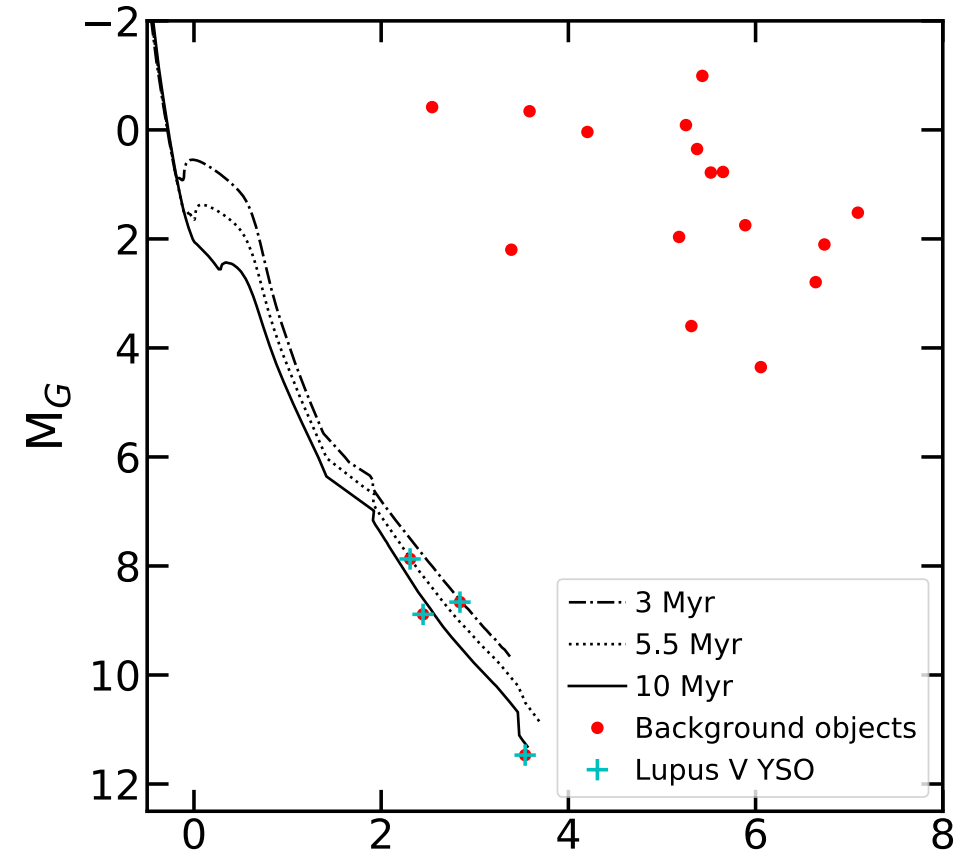
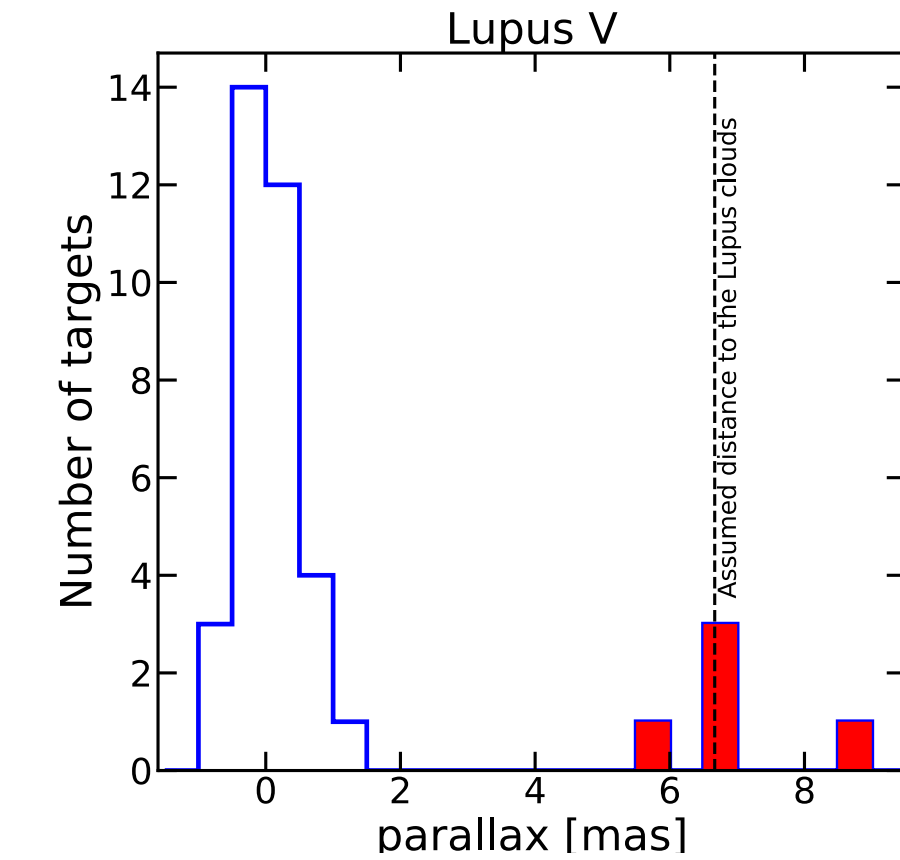


Fig. 2: ^{12}CO integrated intensity map of the Lupus clouds complex (Tachihara et al. 2001).

Most of the candidate YSOs are background giants!



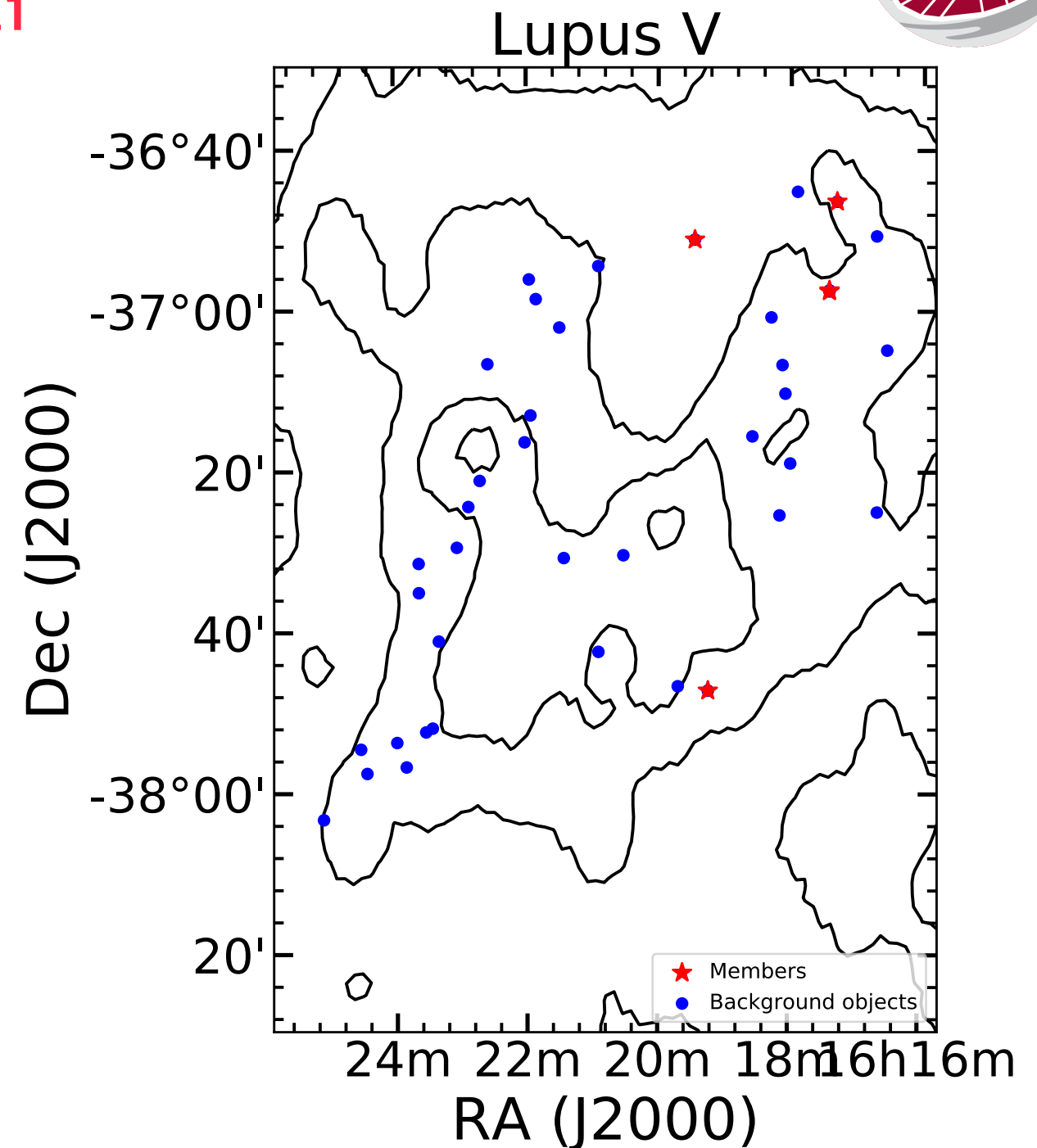
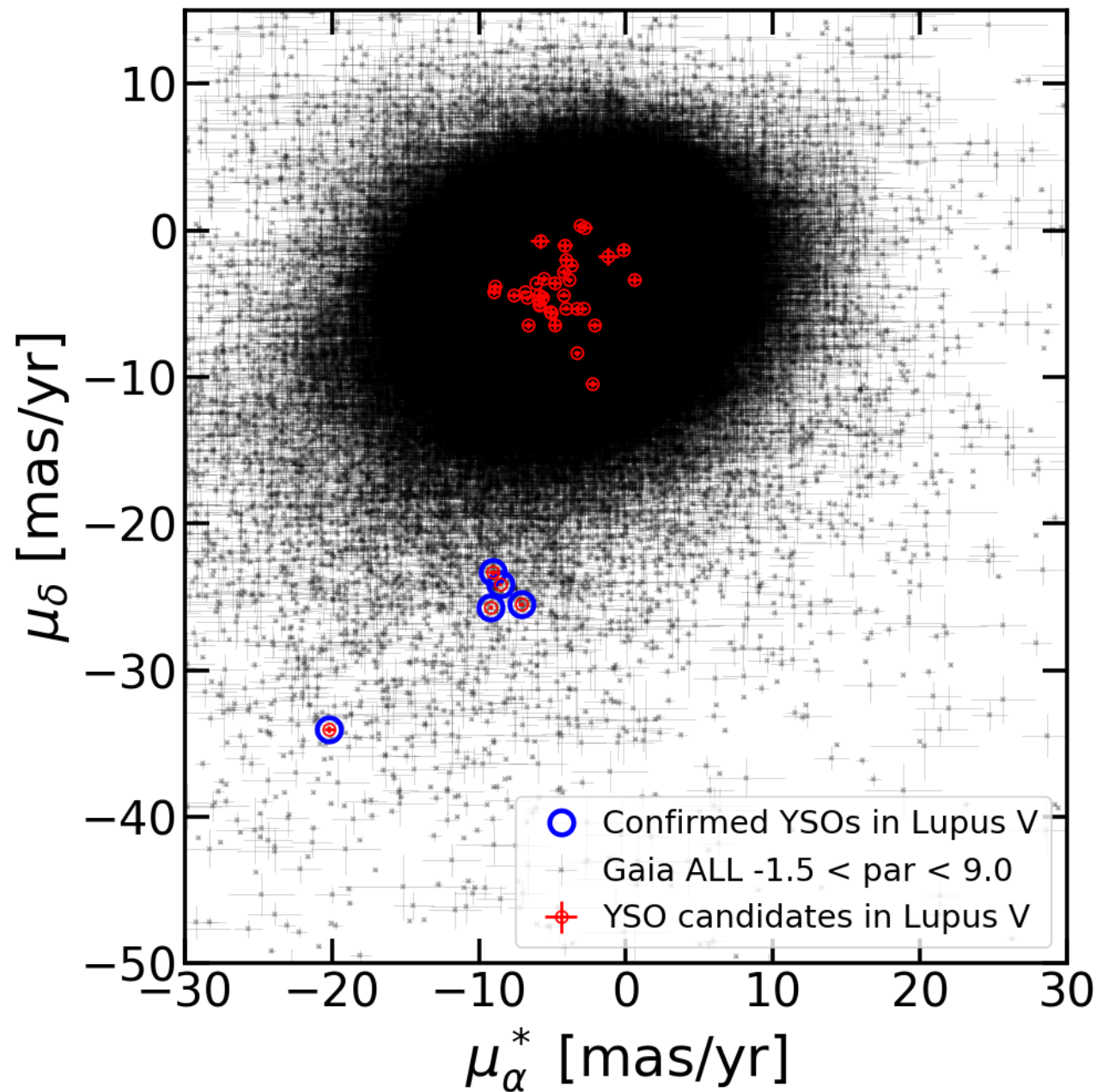
Manara, Prusti, Comeron et al. 2018, A&A, 615, L1



The real members are possibly part of Lupus III



Manara, Prusti, Comeron et al. 2018, A&A, 615, L1



4/5 of the young objects have disk (Class II)

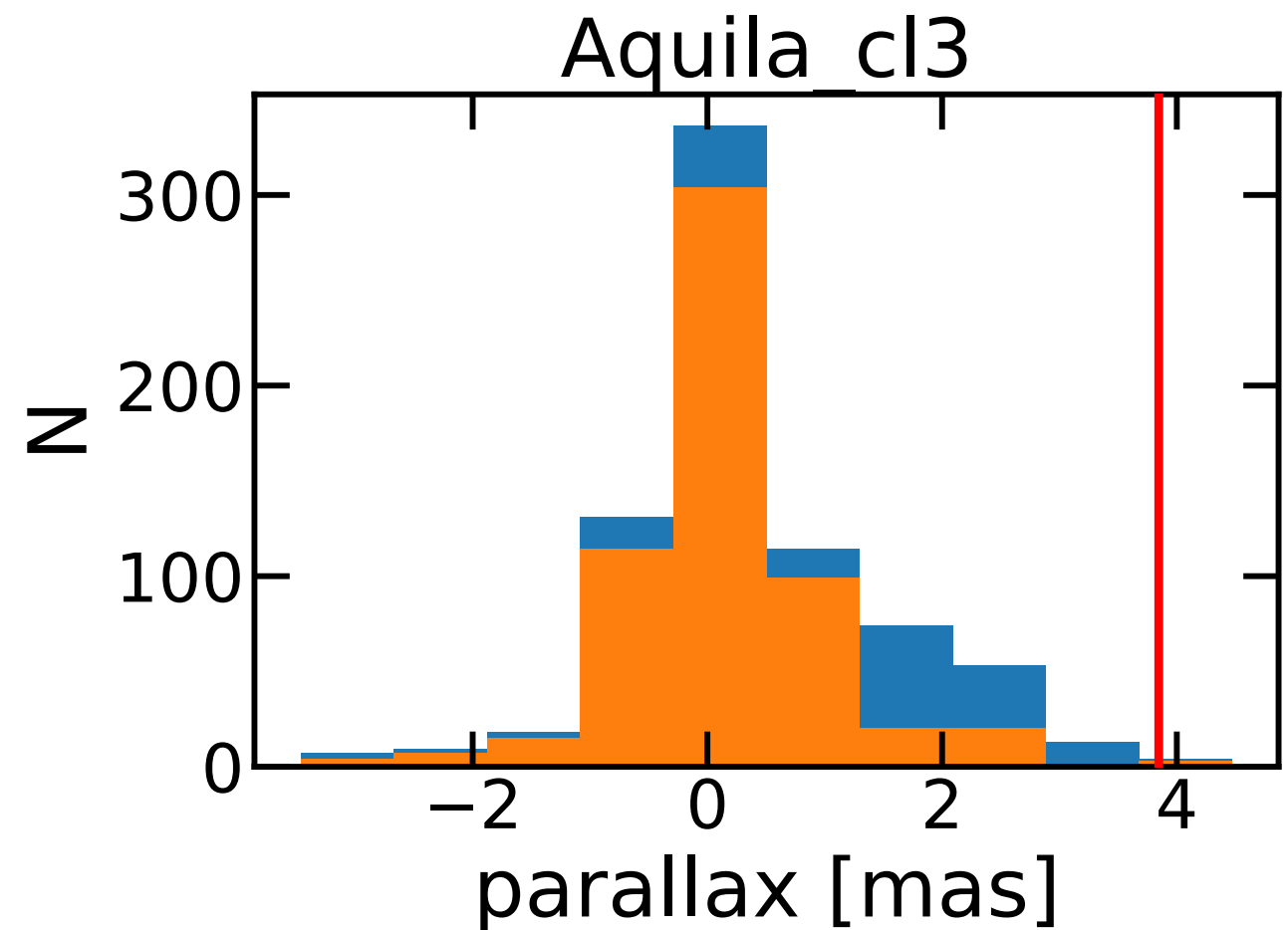
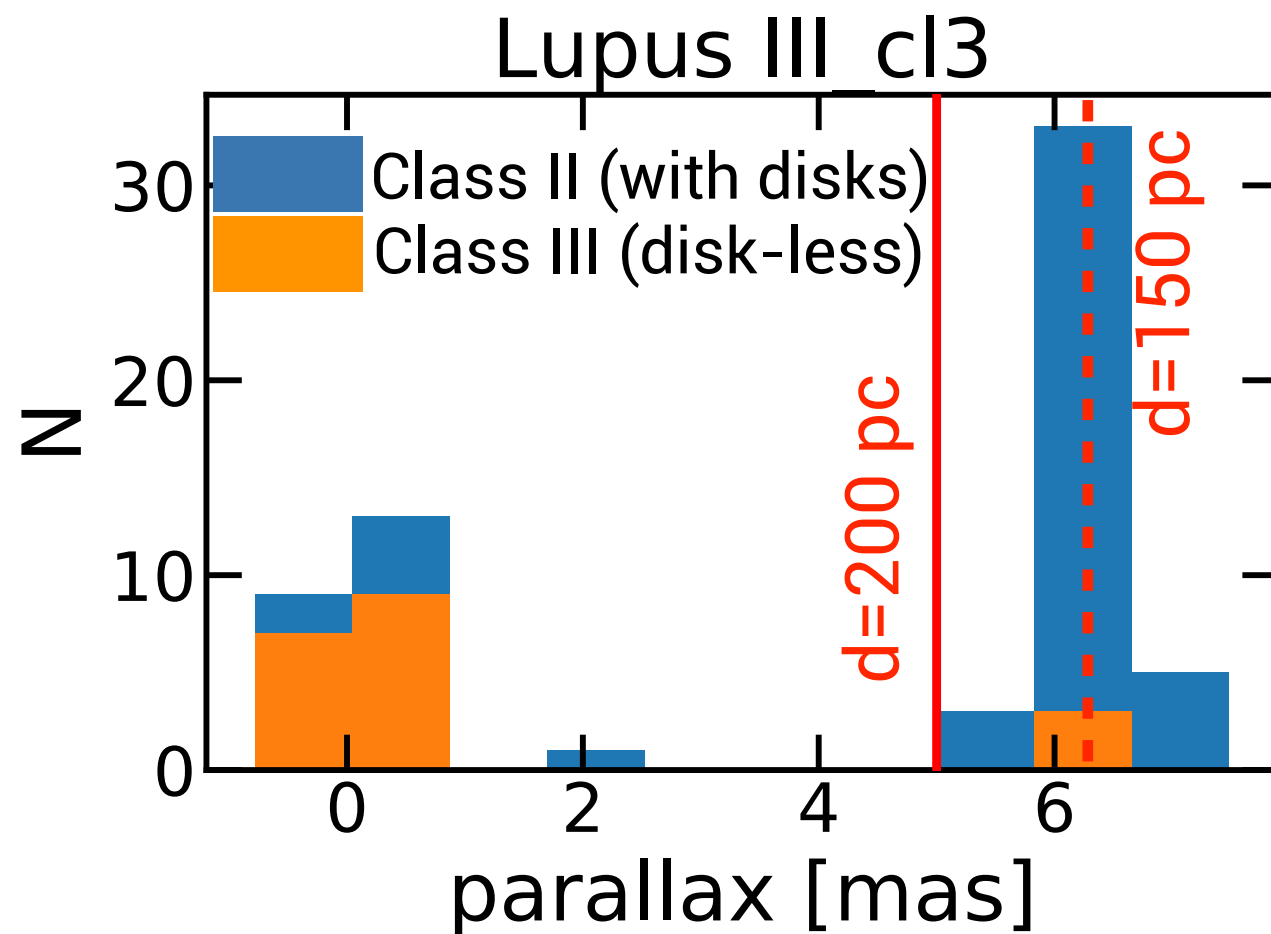
Their kinematic properties and location is compatible with Lupus III

The Lupus V and VI clouds are not forming stars (now)

How many Class III are background contaminants?



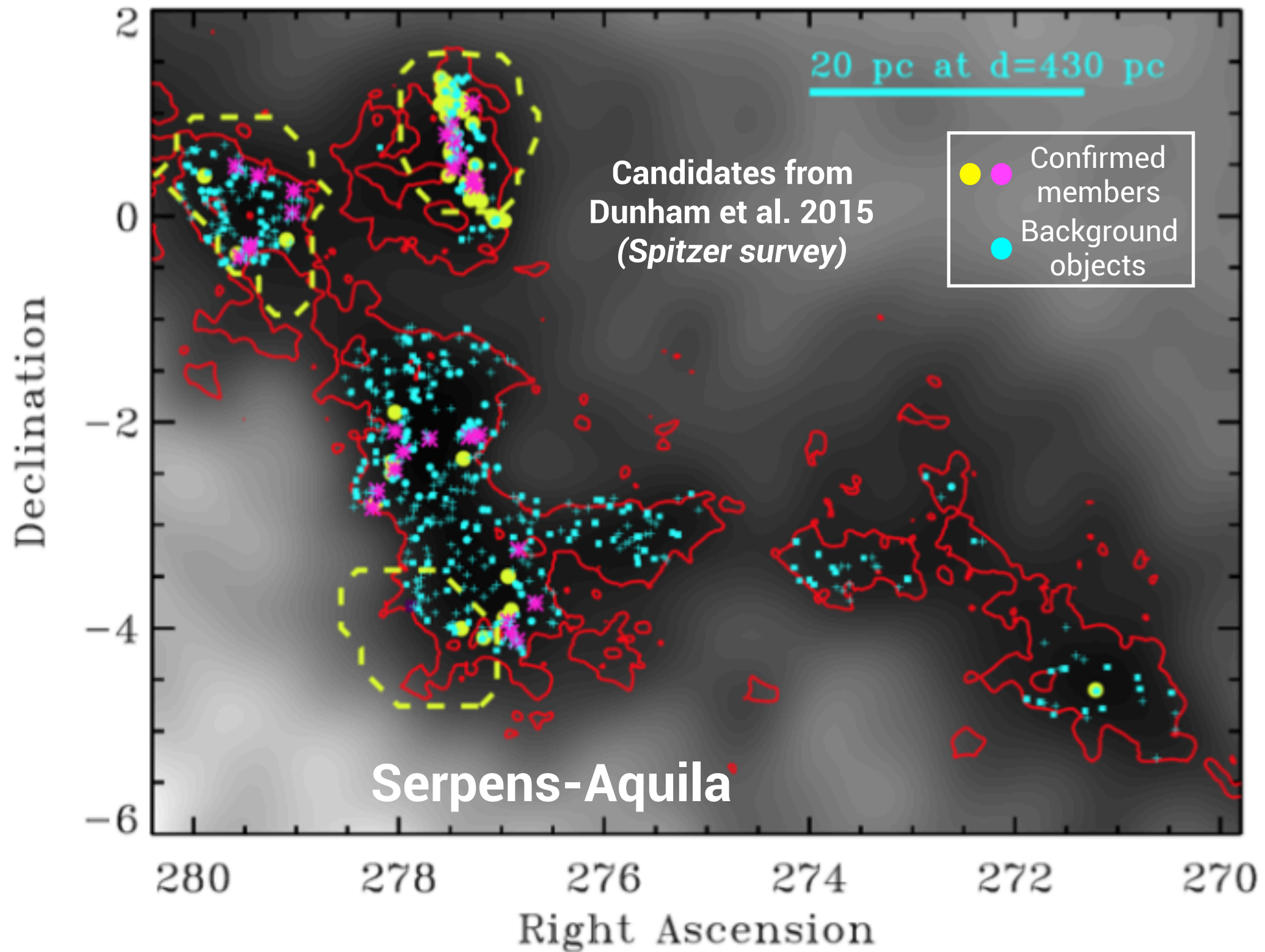
Candidates from Dunham et al. 2015 (Spitzer survey)



Manara et al. in prep

Many Class III (disk-less) young stellar objects candidates seem to be background objects

Many candidate diskless young stars are background objects



Herczeg, ..., Manara, et al., ApJ in press, arXiv:1904.04085

Many Class III (disk-less) young stellar objects candidates seem to be background objects

TAKE HOME

1 Gaia reveals a **VERY HIGH FRACTION** of background contaminants in the IR-based disk-less young stellar objects candidates

2

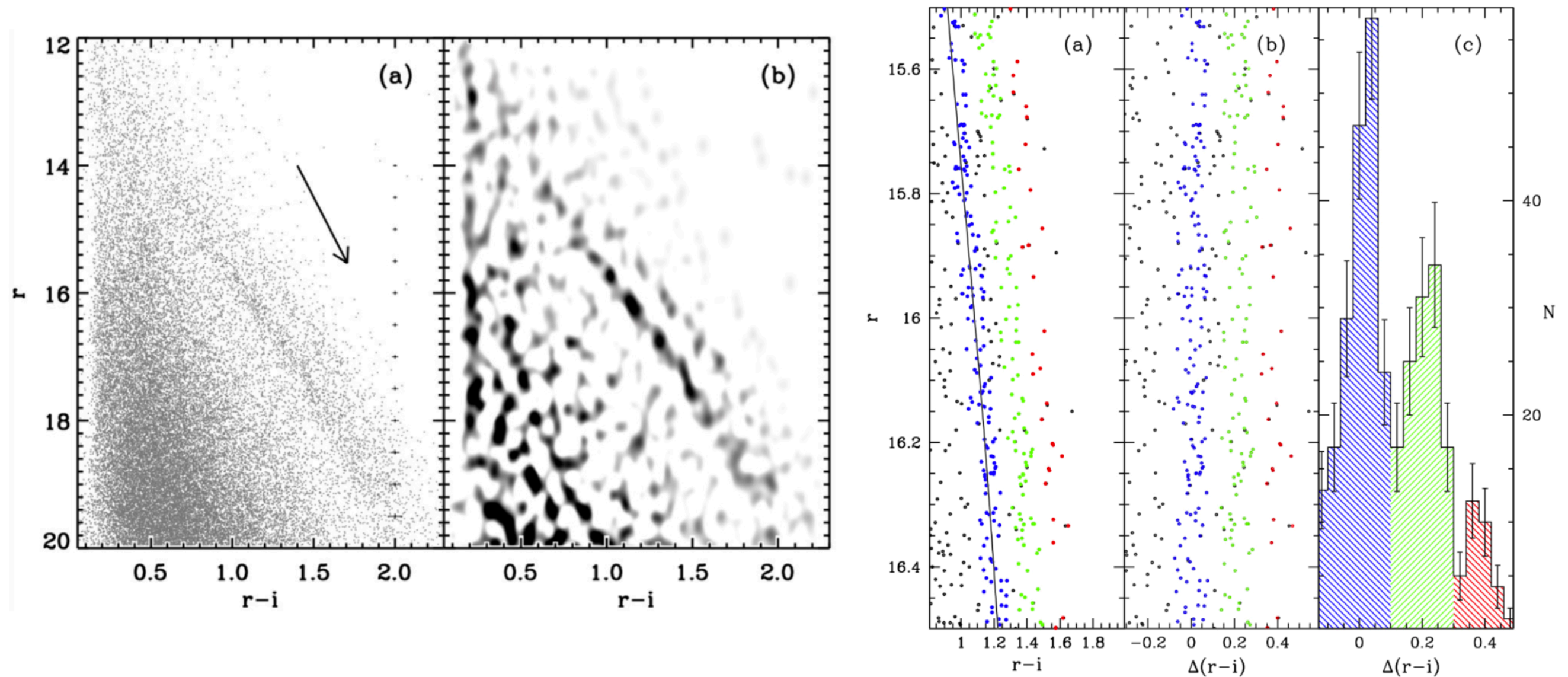


Carlo Felice Manara (ESO Fellow)



**TO MEASURE
DISK LIFETIMES
WE NEED TO KNOW THE
COMPLETE SAMPLES OF
YOUNG STELLAR
OBJECTS**

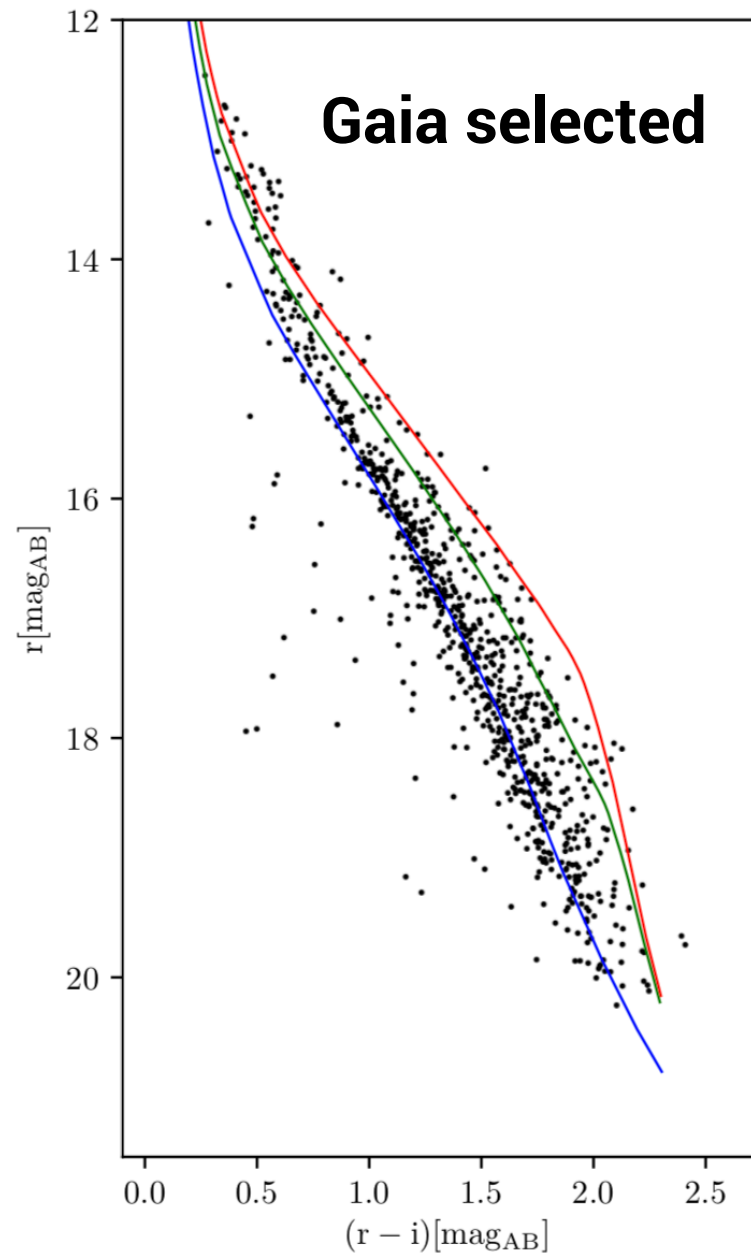
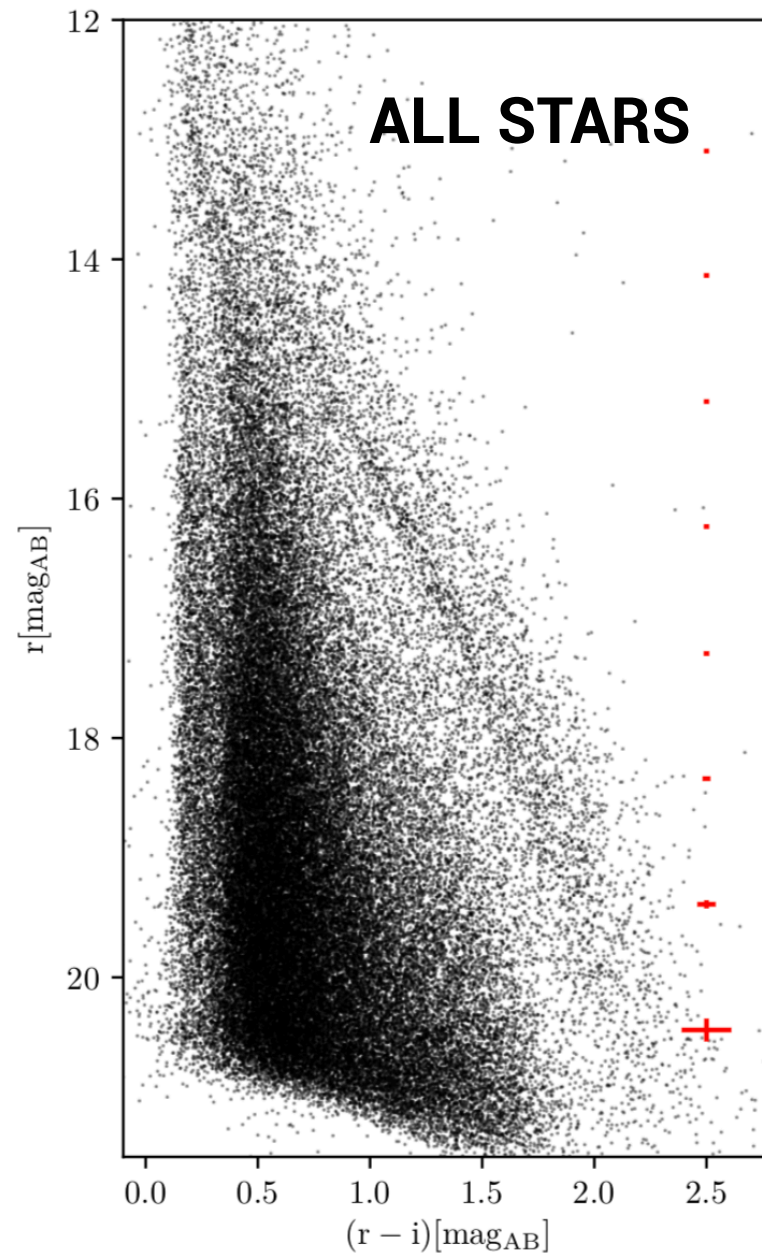
Surveying large fields around star-forming regions



VST/OMEGACAM in a field of
3x3 degrees centered on the Orion Nebula Cluster:
MULTIPLE populations with different ages?

Beccari, ..., Manara et al. 2017, A&A, 604, A22

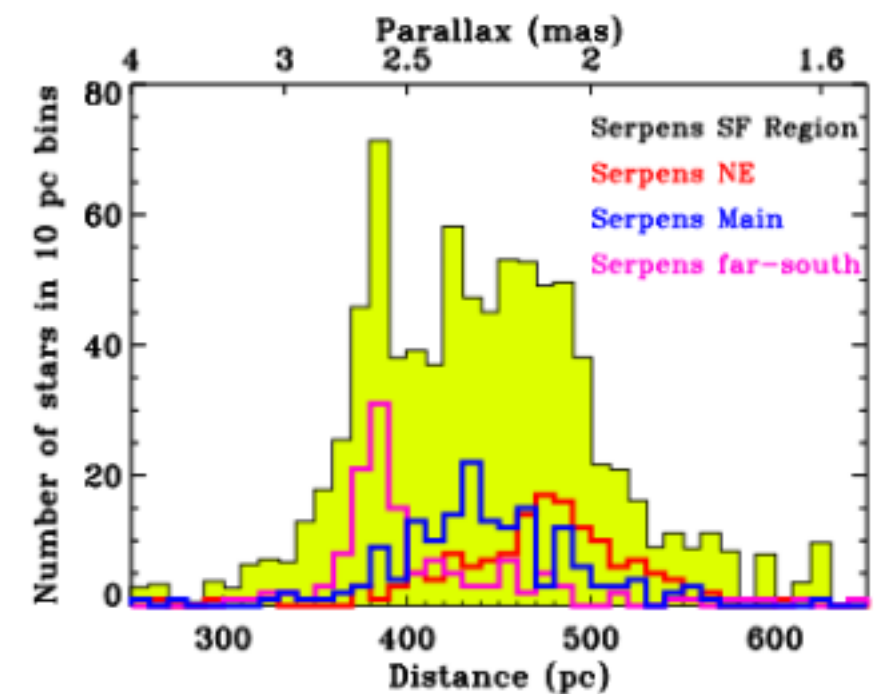
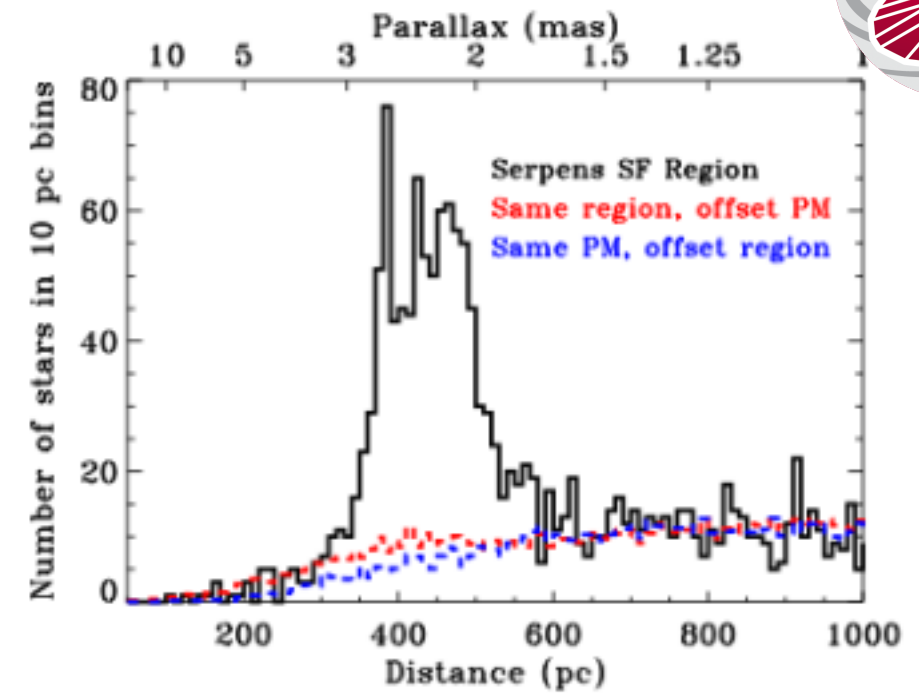
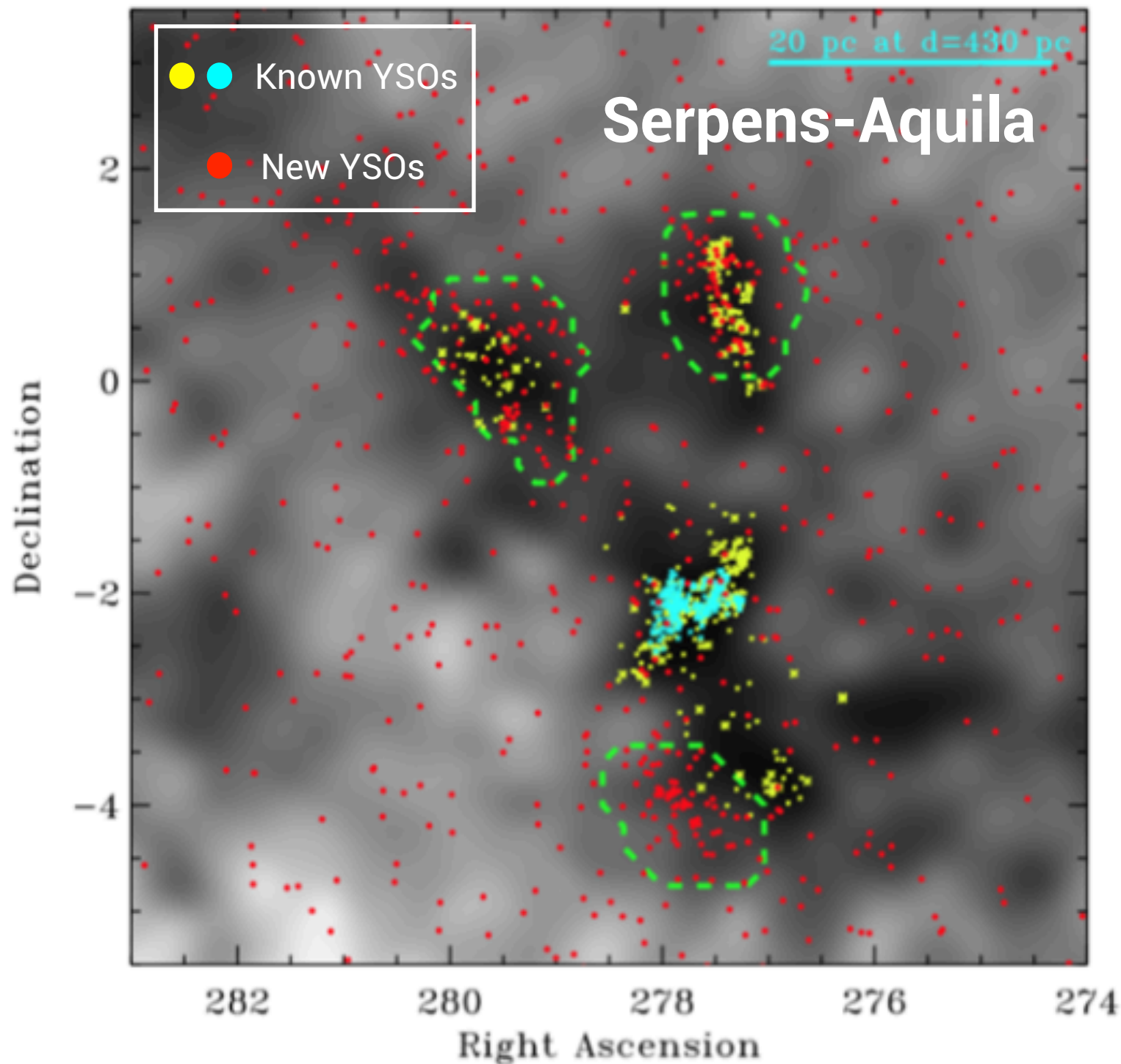
Surveying large fields around star-forming regions



VST/OMEGACAM cleaned using Gaia in a field of
3x3 degrees centered on the Orion Nebula Cluster:
MULTIPLE populations with different ages!

Jerabkova, Beccari, ..., Manara et al. 2019, A&A, in press, arXiv:1905.06974

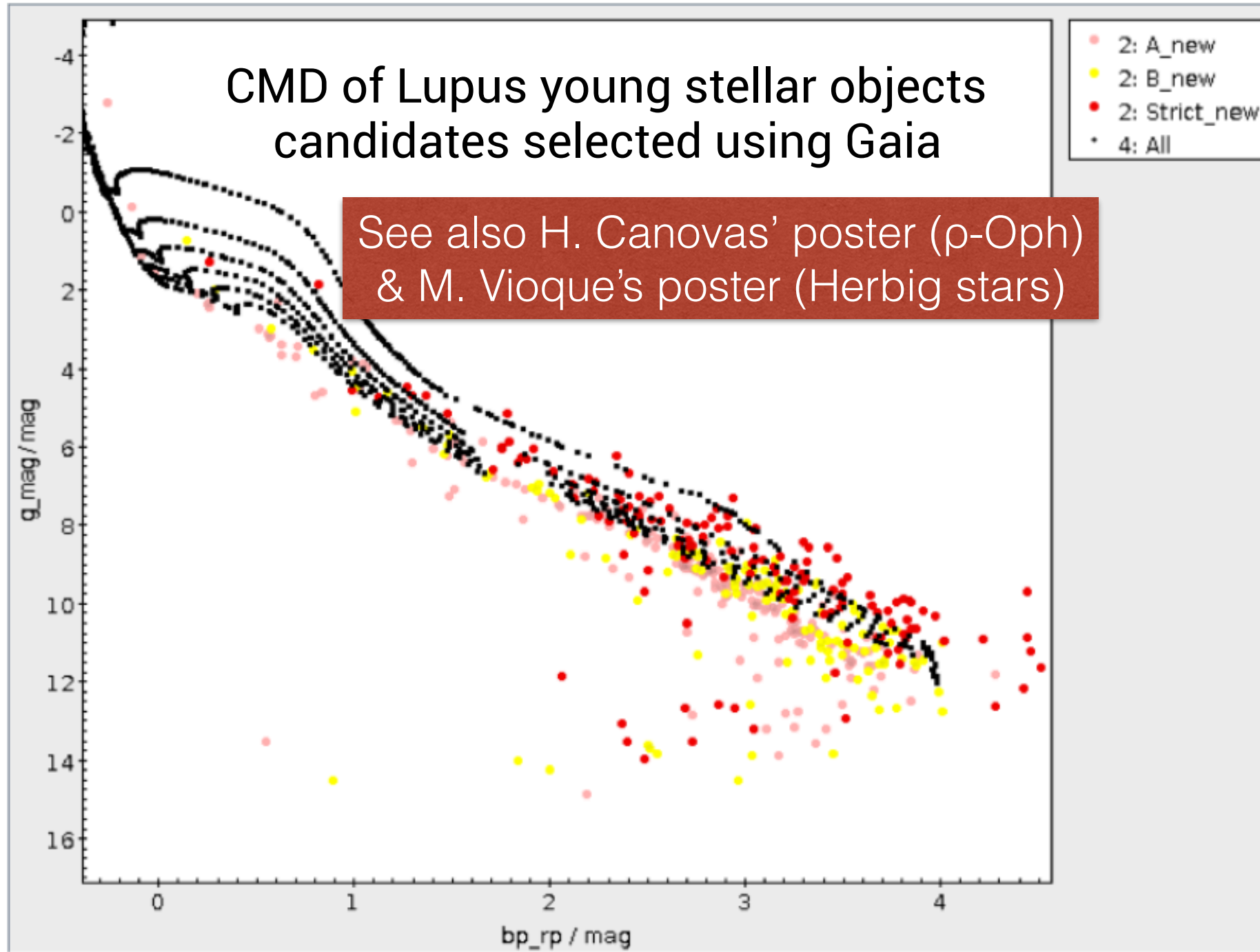
Using Gaia to find ALL members of star-forming regions



Several hundreds **NEW CANDIDATES** young stellar objects are found with Gaia in and around star-forming regions

Herczeg, ..., Manara, et al., ApJ in press, arXiv:1904.04085

Using Gaia to find ALL members of star-forming regions



Selection criteria	tot#	Alcala+Comeron	WISE#	disk#
Strict	149	30	141	109
A	210	3	191	115
B	127	2	109	81

(Number of objects in Alcala+Comeron = 84) → known objects with disks in Lupus

Jonas Biba, high-school student

TAKE HOME

1 Gaia reveals a **VERY HIGH FRACTION** of background contaminants in the IR-based disk-less young stellar objects candidates

2 **CHALLENGE:** In order to estimate the effect of contaminations on disk lifetime estimates we need **COMPLETE** samples of YSOs



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