Investigating the formation and dispersion of star clusters with MOONS and 4MOST

G.G. Sacco

The life of a star cluster

Filaments
André+2014
< 1 Myr

Stars and Gas
Muench+ 2008
1-10 Myr

Galactic field
Credit: NASA, ESA
>100 Myr

1. How do clusters form?

2. How and why do clusters disperse?

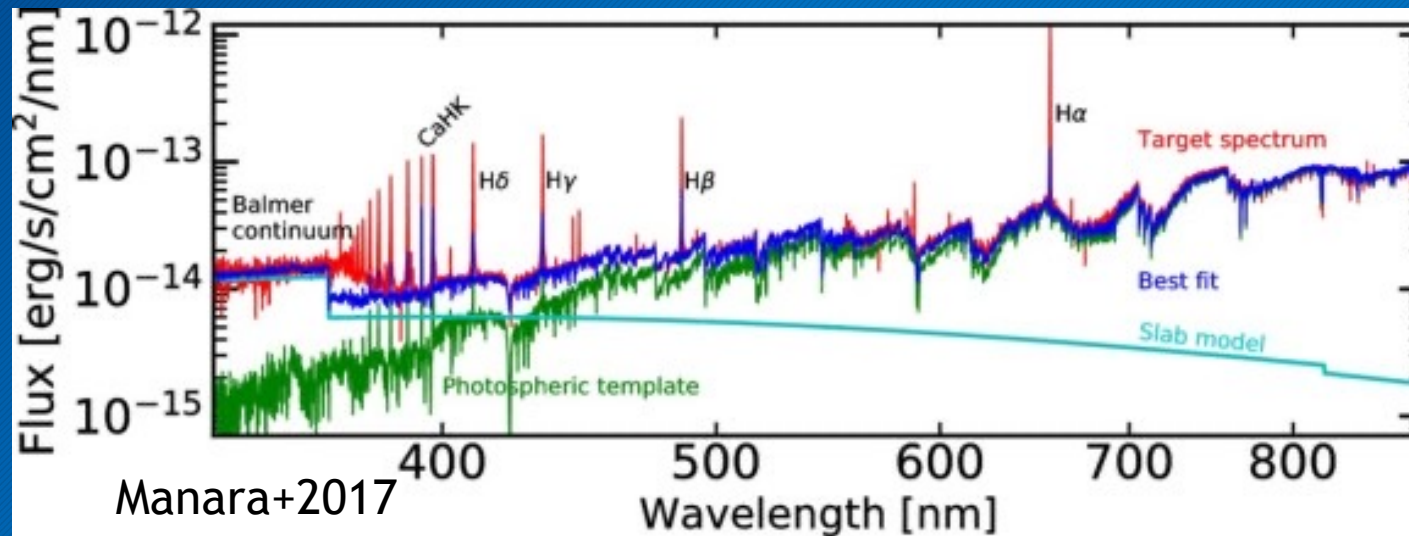3. How does the SF environment influence the properties of stars and planetary systems?

The role of spectroscopy in open cluster studies
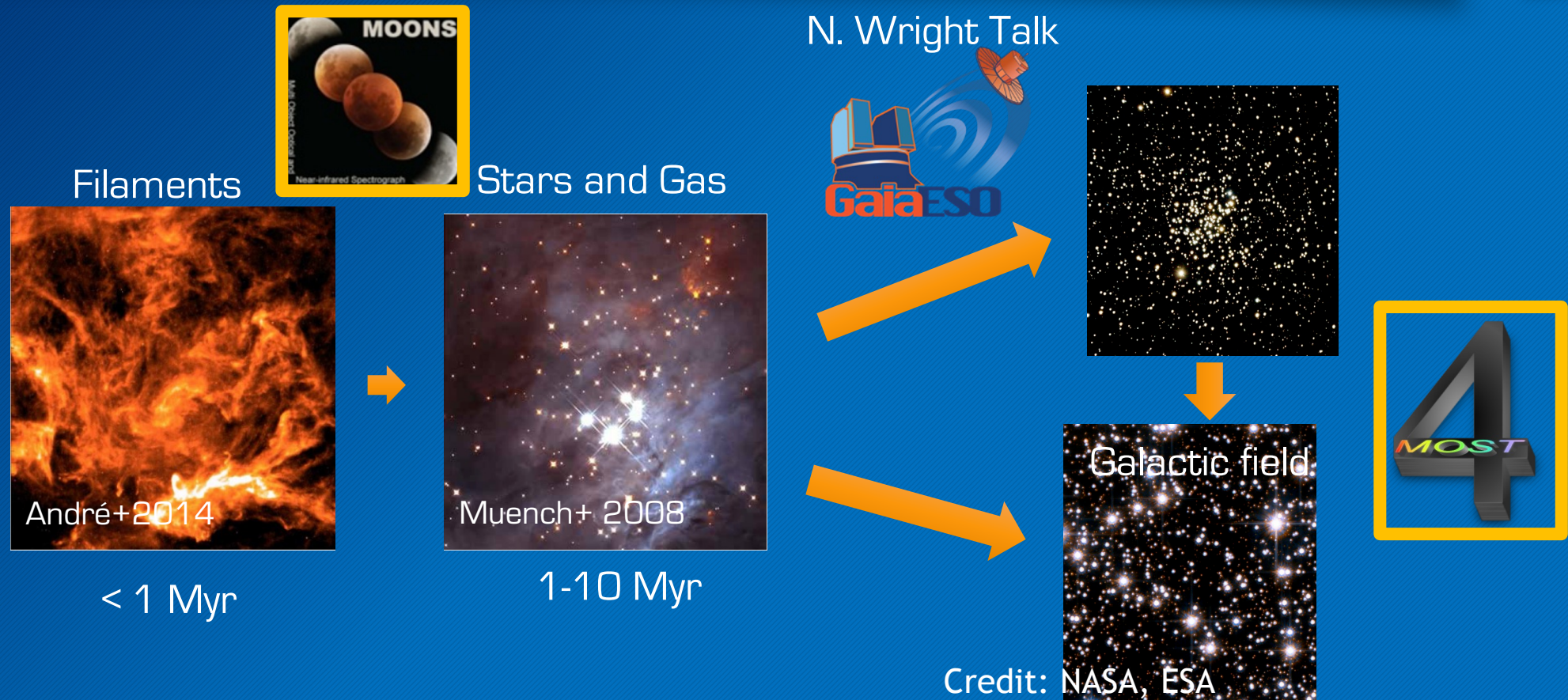
Ages and Masses

Kinematics

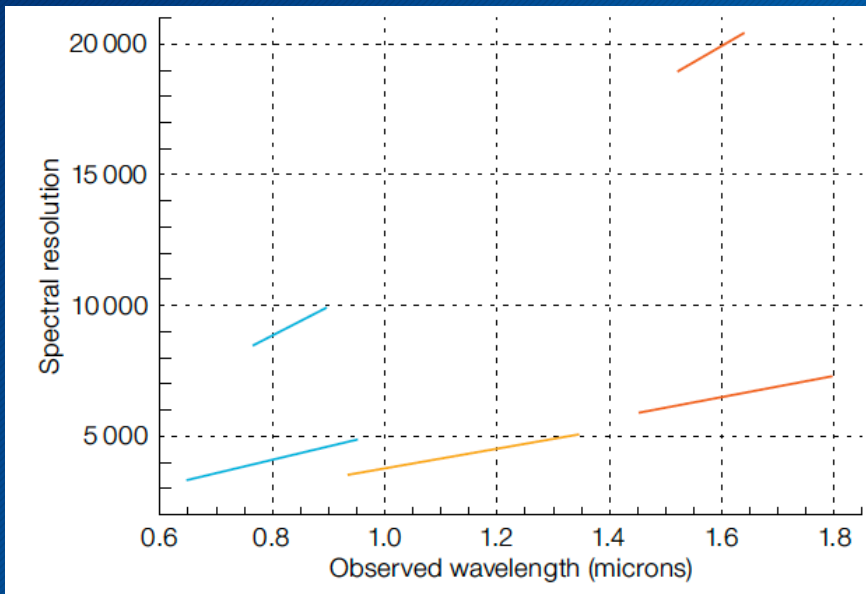Outflow and accretion

Chemical abundances

Nebular emission

Manara+2017

The role of spectroscopy in open cluster studies

N. Wright Talk

Filaments

Stars and Gas

Galactic field

André+2014

Muench+ 2008

< 1 Myr

1-10 Myr

Credit: NASA, ESA

The MOONS spectrograph at the VLT

Cirasuolo et al. 2020

- Telescope: VLT
- FoV: 25 arcmin (diameter)
- Fibers: 1001
- LR coverage: 0.64-1.8 μm
- LR resolution: R_{RI} = 4100, R_{YJ} = 4300, R_H = 6600
- HR coverage: λ_{RI} = 0.76-0.89 μm, λ_{YJ} = 0.93-1.35 μm, λ_H = 1.52-1.64 μm
- HR resolution: R_{RI} = 9200, R_{YJ} = 4300, R_H = 19700

Currently under integration and assembly. Commissioning in 2025

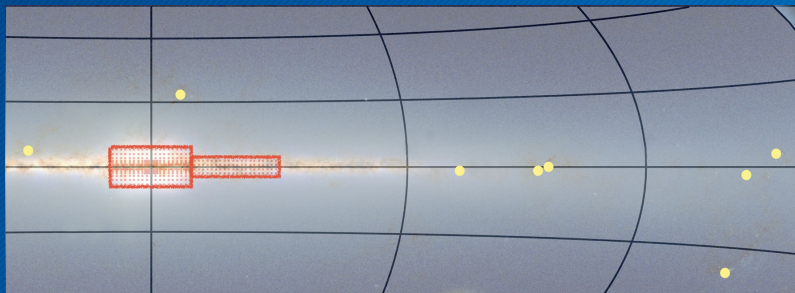# MOONS survey of young star clusters
(S. Randich, K. Biazzo, G. Sacco, B. Nisini)

Five nights Infrared spectroscopic survey of young clusters

- Medium resolution spectroscopy of young embedded populations

- Capabilities to observe to very low mass stars

- Accretion and out flow of very young protostars
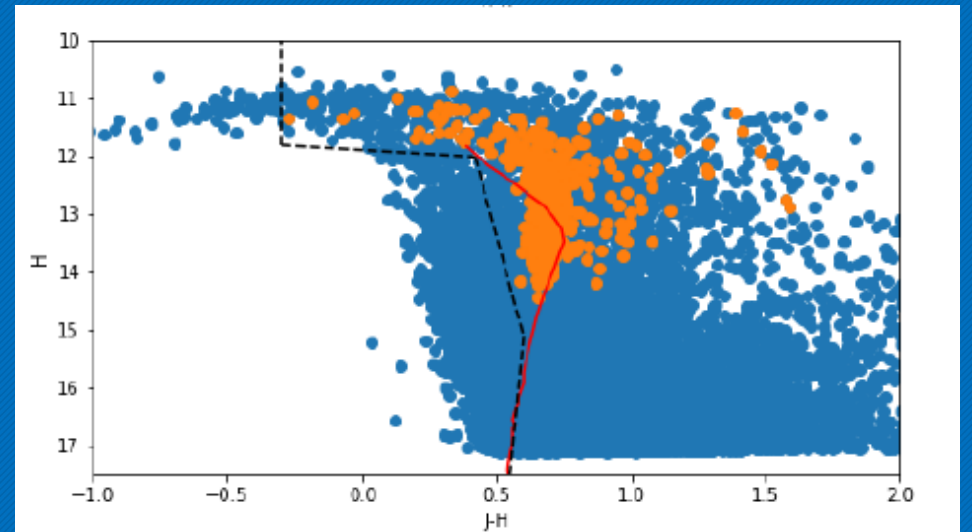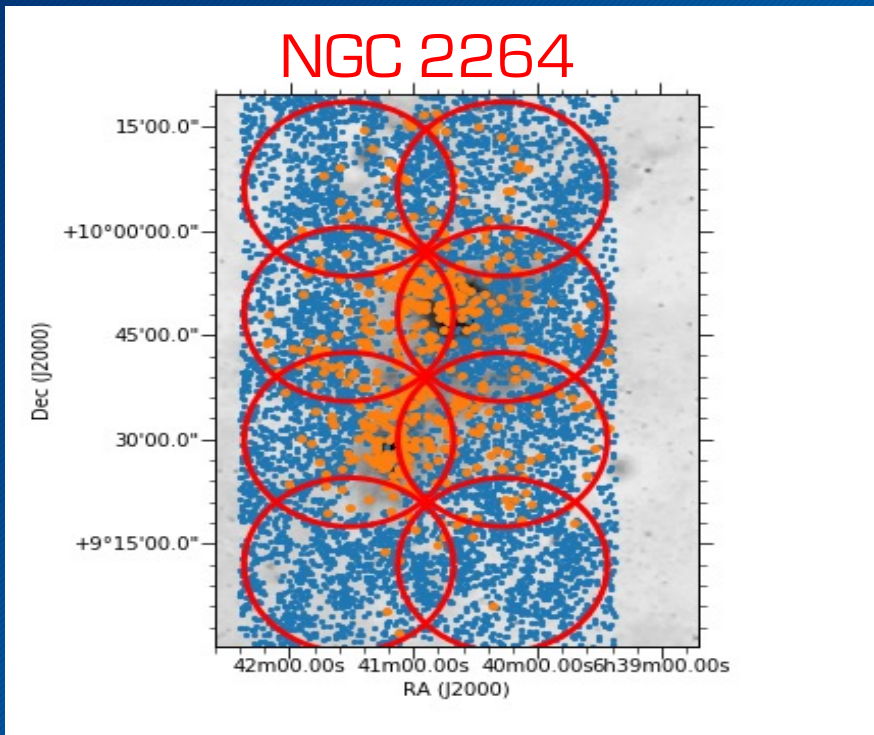
Gonzalez et al. 2020

MOONS survey of young star clusters
(S. Randich, K. Biazzo, G. Sacco, B. Nisini)

NGC 2264

Targets:
About 10 young (age < 3-5 Myr) embedded or partially embedded clusters spanning a large mass range

MOONS survey of young star clusters
(S. Randich, K. Biazzo, G. Sacco, B. Nisini)

Stellar parameters:
- Radial Velocities and *v sin i*
- Stellar parameters (Teff, Log g)
- Mass accretion rates
- Metallicity and abundances

Goals

1. Cluster kinematics at the earliest stages
2. Mass accretion and outflow of protostars in different environments
3. Chemical gradients in very young clusters

The 4MOST spectrograph at VISTA
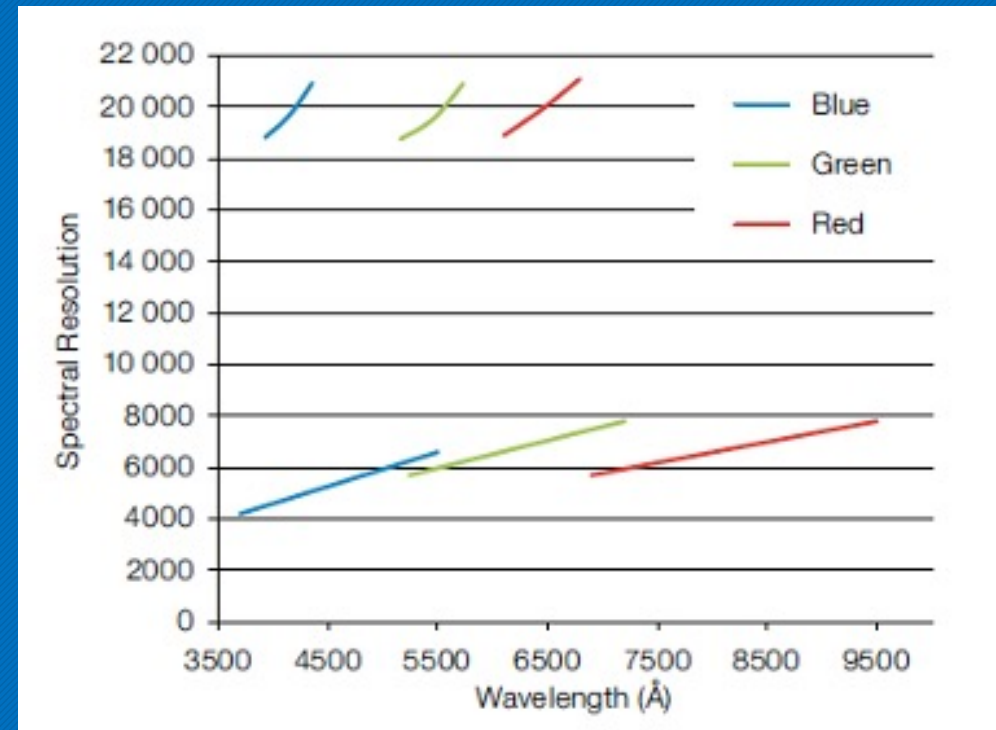
Telescope: VISTA (4m at Paranal)

FoV: 4.2 deg^2

Low res: R ~6500, fibers =1624, band = 3700-9500 Ang
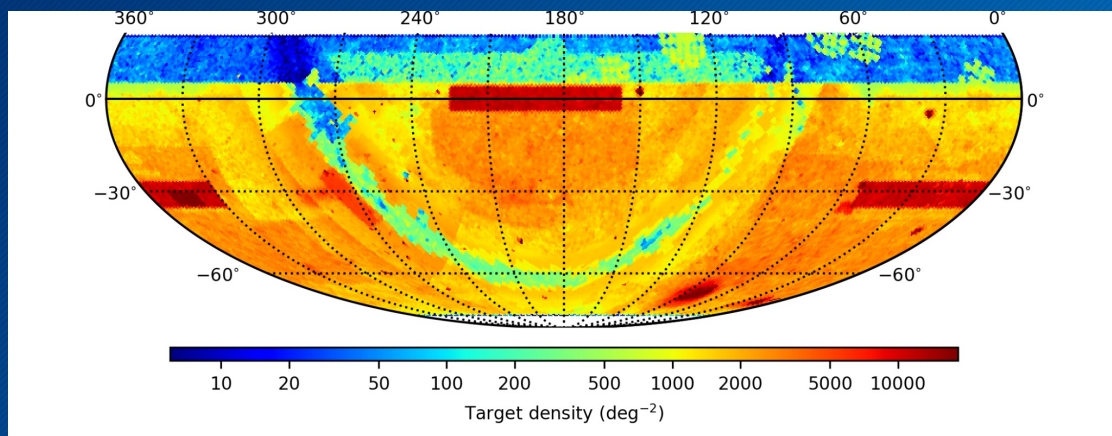
High resolution: R~ 20000, fibers = 812

High res band: 3926-4355, 5160-5730, 6100-6790 Ang

Starting operations: late 2024

(de Jong et et al. 2019)

The 4MOST observation strategy

Target density (deg^{-2})

- 9 Galactic surveys
- 9 Extragalactic Surveys

Observation strategy

- Only survey defined every 5 years
- FoV shared among surveys
- 70% fiber-time for first 5 years for consortium surveys
- 30% fiber-time for community surveys
- Call for LoI for community survey in 2019
- Community survey selected on December 2021 after 2-year long process
- Final strategy discussed by ESO OPC in the spring 2024

The 4MOST Survey of Young Stars (4SYS)

PI : G. Sacco
Co-I: +40

Targets: ~100,000
distance < 500 pc
Age: 1-100 Myr
Area: -70 < DEC < +5 deg
SpT: Later than G7
Mag: 10 < G < 18 mag

(Sacco et et al. 2023)

Goals

1. Space and kinematic distributions within 500 pc

2. Chemical inhomogeneities on scale from a few to 500 pc

3. Star formation history of the solar neighbourhood

4. Origin and properties of current and future targets for exoplanet studies

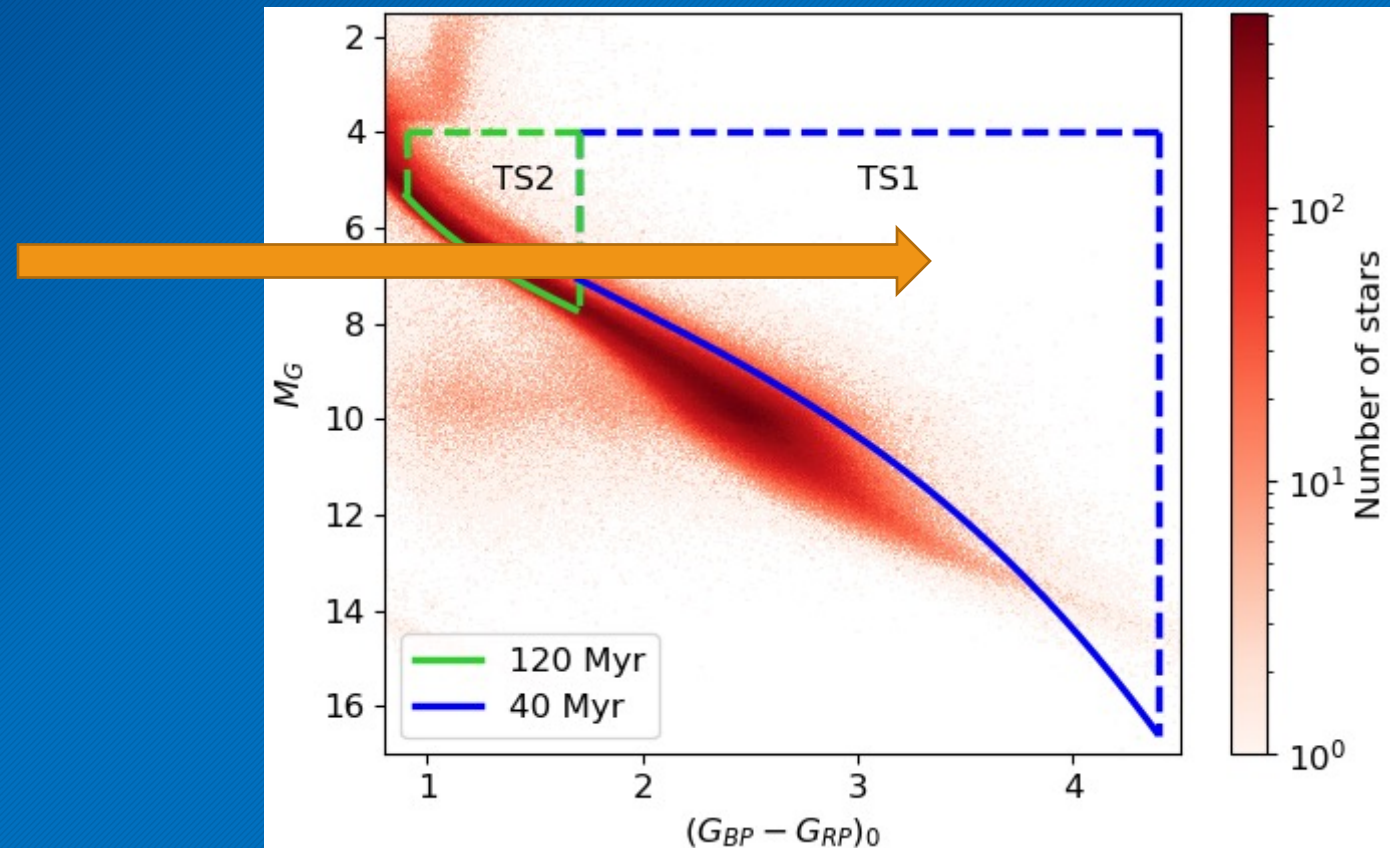5. Largest catalog for studying PMS evolution

4SYS – Target Selection Strategy

Target Sample 1:

- SpT: Later than K7
- Age: < 40 Myr
- Selection: Gaia CMD
- LR and HR
- Subsurveys:
  - TS1_HR (10<G< 15.5)
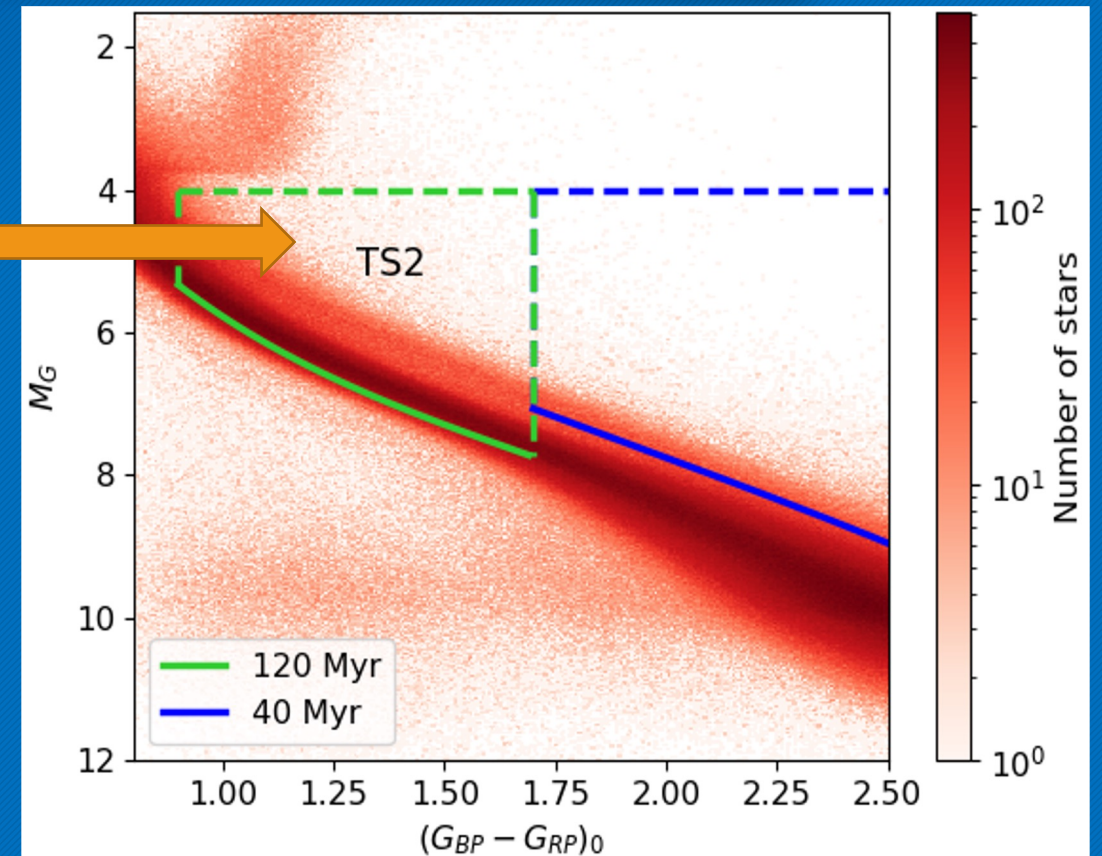 - TS1_LR (15.5<G< 18.)
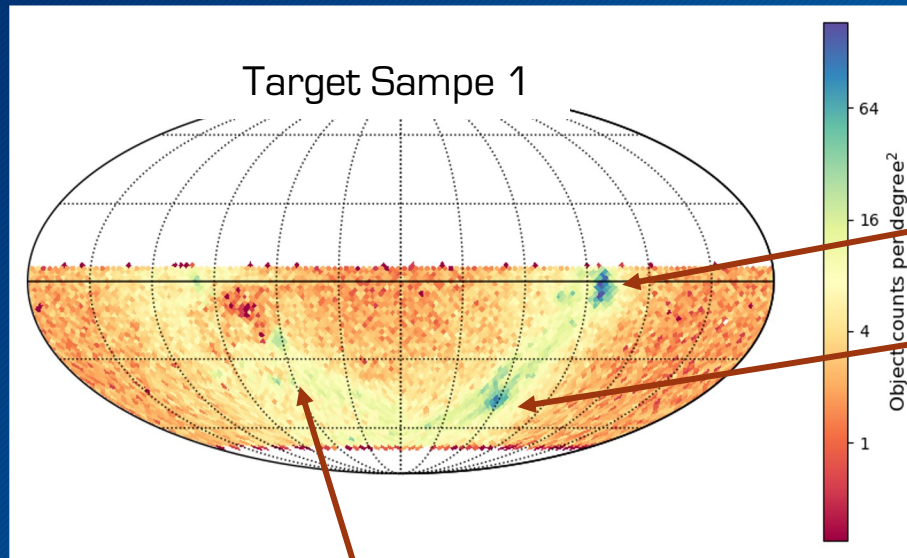- Stars: ~100,000

4SYS – Target Selection Strategy

Target Sample 2:

- SpT: G7-K7
- Age: < 100 Myr
- Selection: Gaia CMD+ eRosita X-ray fluxes or TESS rotation periods
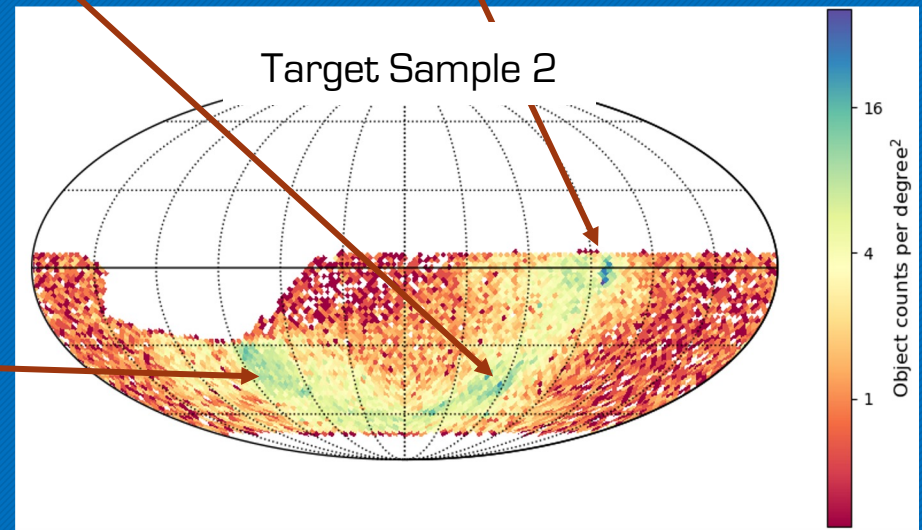- HR
- Subsurveys: TS2_HR
- Stars: ~40,000

4SYS – Target Selection Strategy

4SYS - Data products

- RV and V sini
- Stellar parameters (Teff, log(g), [Fe/H])
- Chemical abundances
- Activity indices (from Ca H &K, Ha, Ca IRT)
- Emission line fluxes

- Catalogue of bona fide young stars
- Mass and ages
- Mass accretion rates

Conclusions

- Spectroscopic observations are giving a fundamental contribution in our understanding of the formation of star clusters

- We will carry out a survey of young star clusters with the new infrared multi-object spectrograph MOONS at the VLT to study the initial conditions of the star formation process

- We will use 4MOST at VISTA to perform a survey of young stars across the whole southern sky to investigate the mechanism leading to cluster dispersion