The 4MOST Survey of Young Stars (4SYS)

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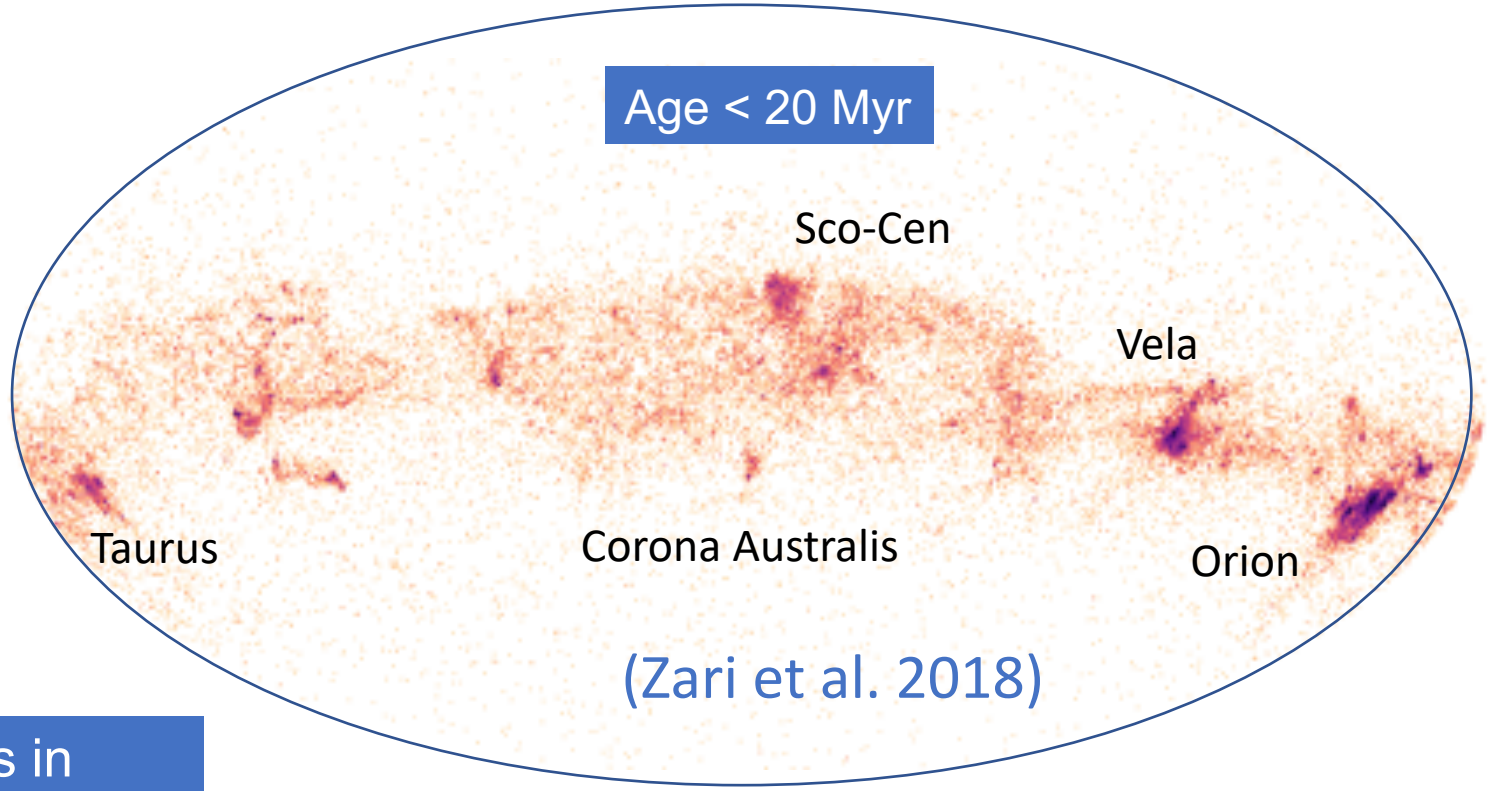
Young stars in the solar neighbourhood

<u>The solar neighbourhood is the best place to:</u>

- ✓ Investigate star formation in different environments
- ✓ Study the formation of planets
- ✓ Understand the pre-main sequence evolution



- Spectroscopic surveys limited to stars in clusters
- Catalogs based on astrometry and photometry contaminated and biased
- RVs, parameters and chemical abundances unavailable and inaccurate

We need 4SYS!

The Origin of the Galactic field

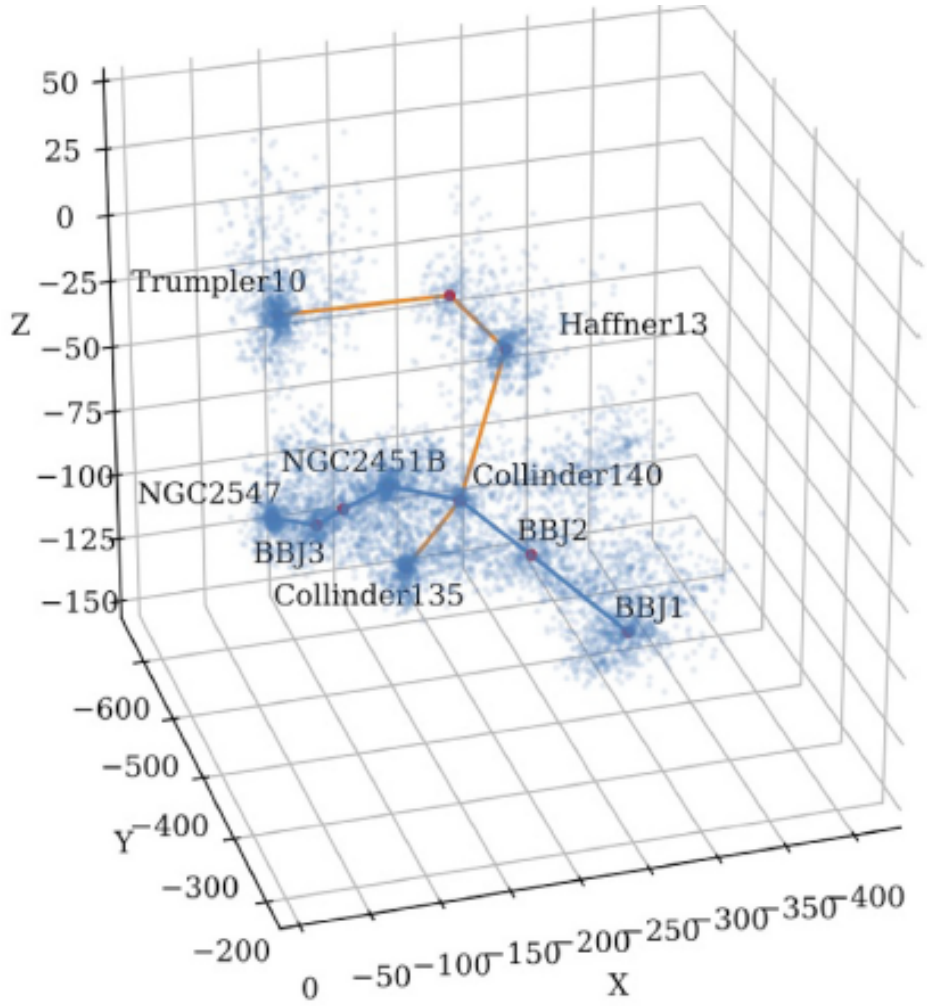
Not all stars form in clusters

(e.g. Wright & Mamajeck 2018, Jarabkova et al. 2019 Ward et al. 2020, Beccari et al. 2020)

Young clusters and associations are expanding but not clear what is driving the expansion

(e.g. Bravi et al. 2018, Franciosini et al. 2018, Kuhn et al. 2019, Wright et al. 2019, Armstrong et al. 2020)

Where do stars form and how do they disperse in the field?

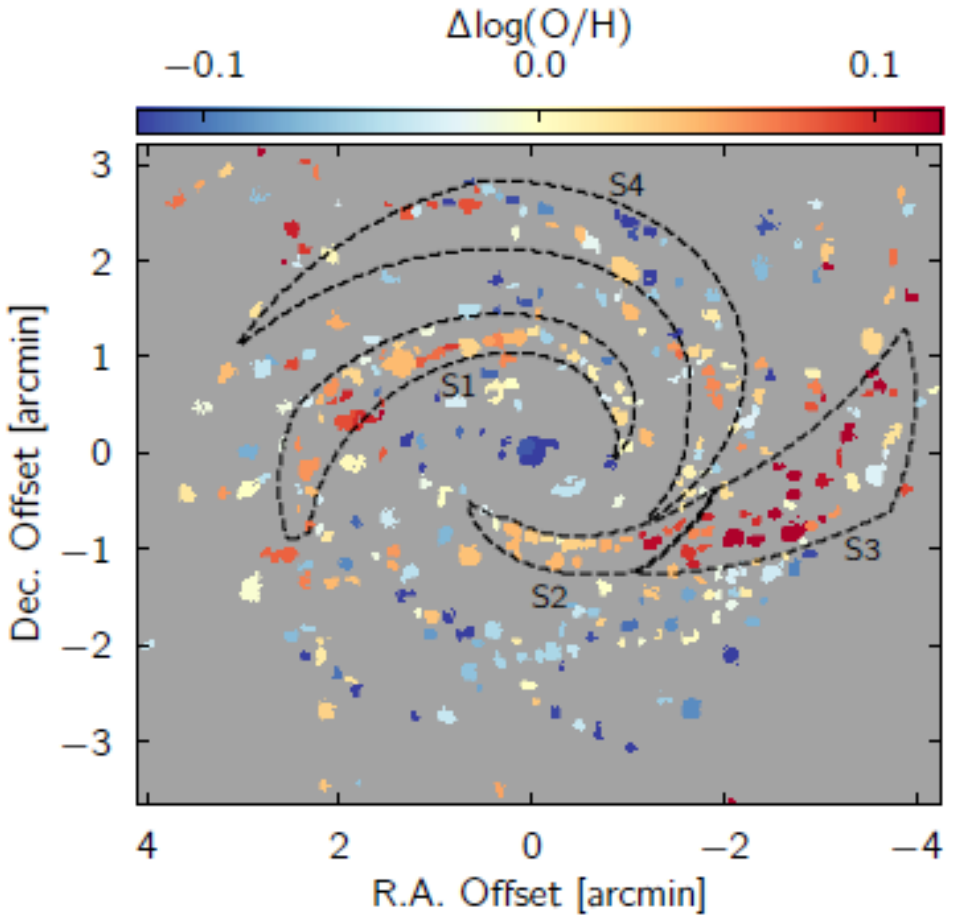


(Beccari et al. 2020)

The Origin of the Galactic field

Chemical properties of young stars can be influenced by the recent passage through the spiral arm

(e.g. Ho et al. 2018, Sanchez-Menguiano 2020)

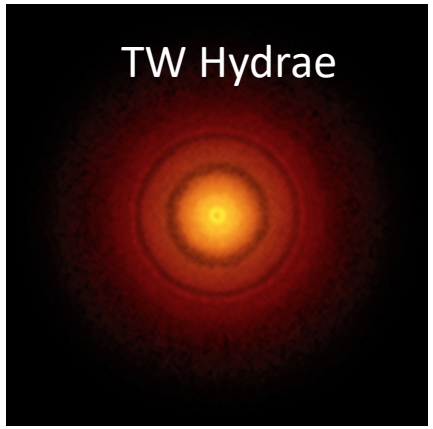


(Ho et al. 2018)

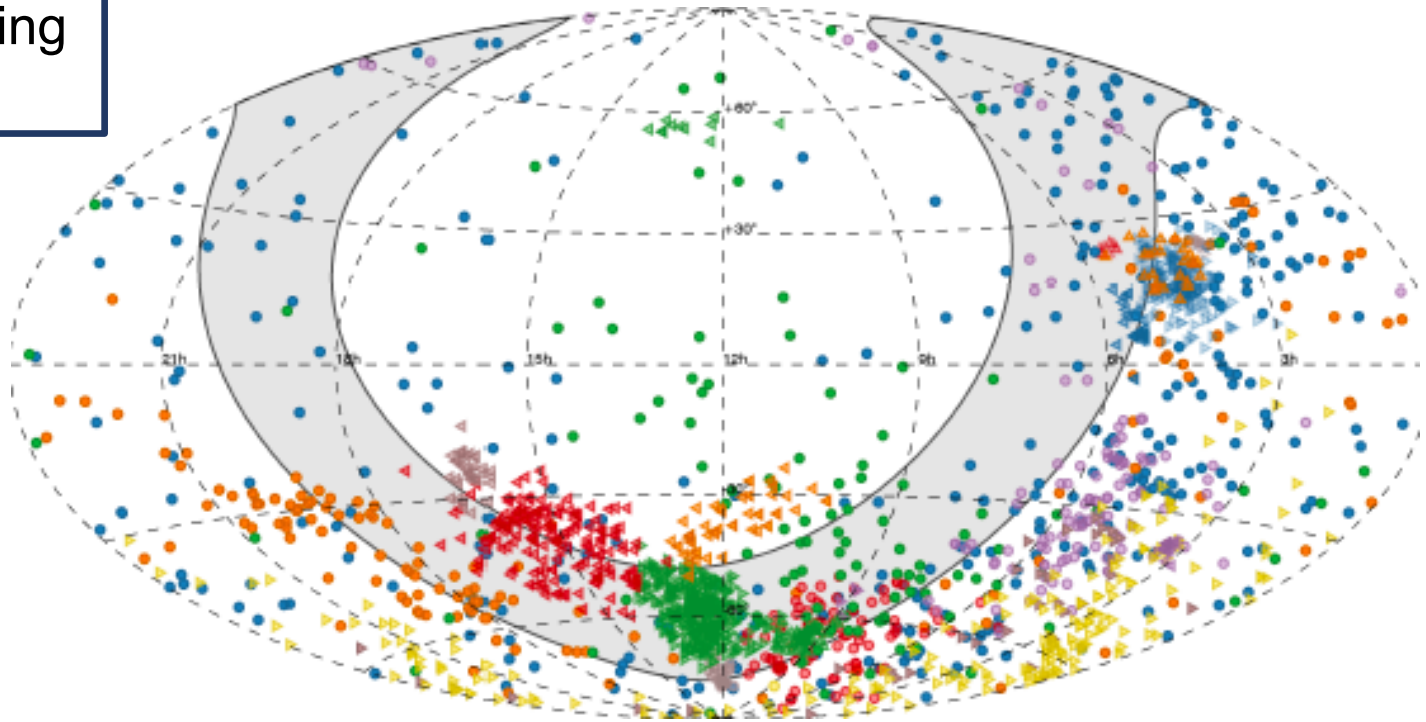
What is the effect of the star formation environment on stellar abundance?

The origin and the properties of targets for exoplanet studies

- Nearby young stars are the best targets for imaging disk and exoplanets.
- Nearby young stars are members of moving group and associations



(Andrews et al. 2016)



(Kastner et al. 2019)

Are these stars young solar analogs?

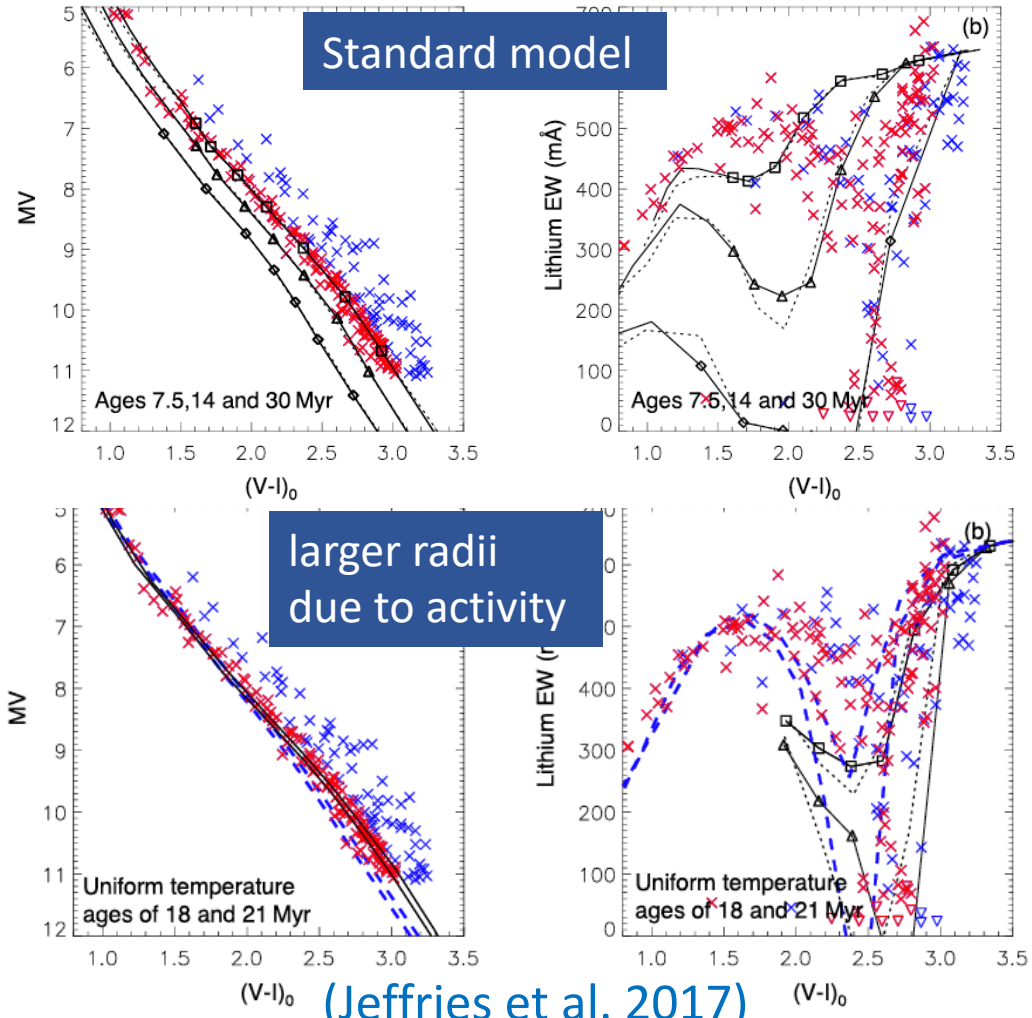
Do we know mass and ages of these stars?

The missing ingredients in Pre-Main sequence evolution

Traditional Pre-Main Sequence models are missing important components of stellar physics (e.g. Kraus et al. 2016, Jeffries et al. 2017, Bouvier et al. 2018,)

Can we measure mass and age of PMS stars?

What is the effect of magnetism and rotation PMS evolution?



(Jeffries et al. 2017)

The 4MOST Survey of Young Stars (4SYS)

4SYS target sample

- Age 1-100 Myr
- Distance < 500 pc
- SpT G7 to M5
- N. stars LRS ~90000
- N. stars HRS ~110000
- Mag LRS 15 < G < 18.5 mag
- Mag HRS 10 < G < 15 mag

4SYS target selection

CMD (Gaia+infared survey)+Periods (TESS)+Xray luminosity (e-ROSITA)

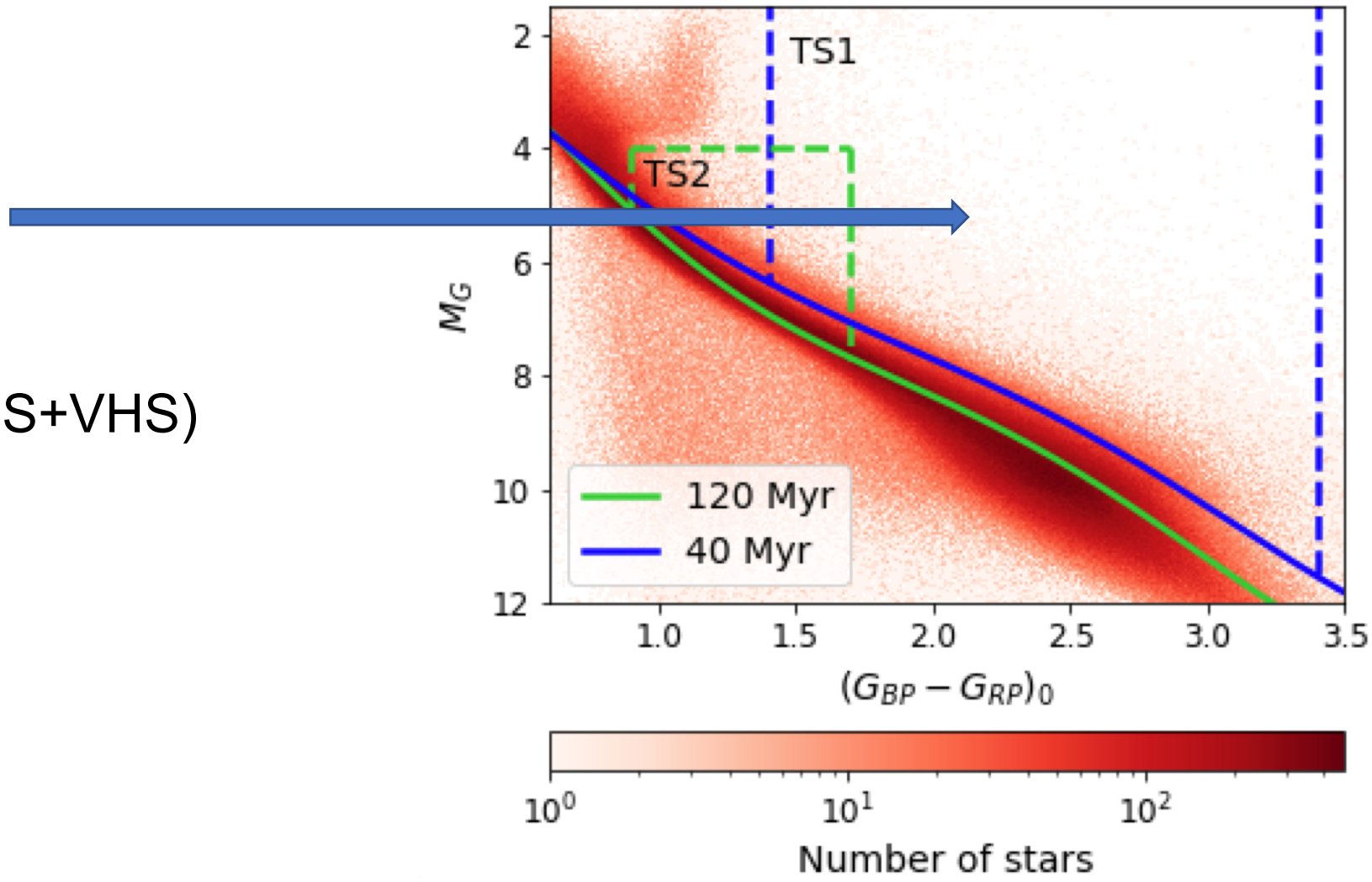
Goals

1. Largest unbiased census of PMS stars in the solar neighbourhood
2. Space and kinematic distributions of young stars on scales from a few to 500 pc
3. Chemical inhomogeneities on scale from a few to 500 pc
4. Star formation history of the solar neighbourhood
5. Origin and properties of current and future targets for exoplanet studies
6. Largest catalog for studying PMS evolution

Target selection strategy

Target sample 1

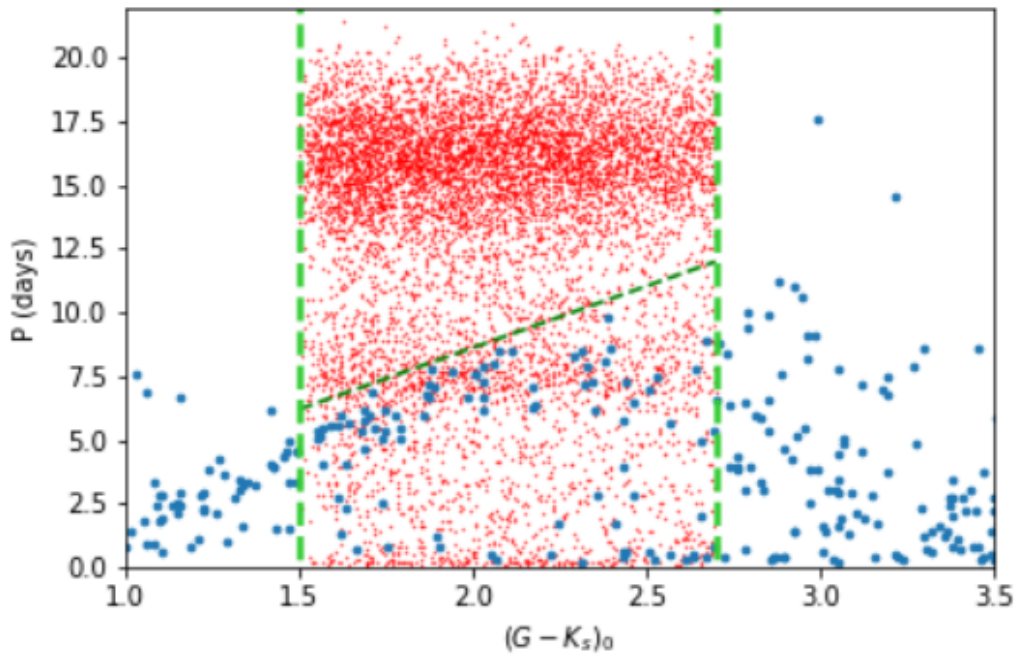
Age < 40 Myr
SpT: K5 to M5
Method: CMD (Gaia+2MASS+VHS)
Resolution: LRS+HRS
-70 < DEC < 5 deg

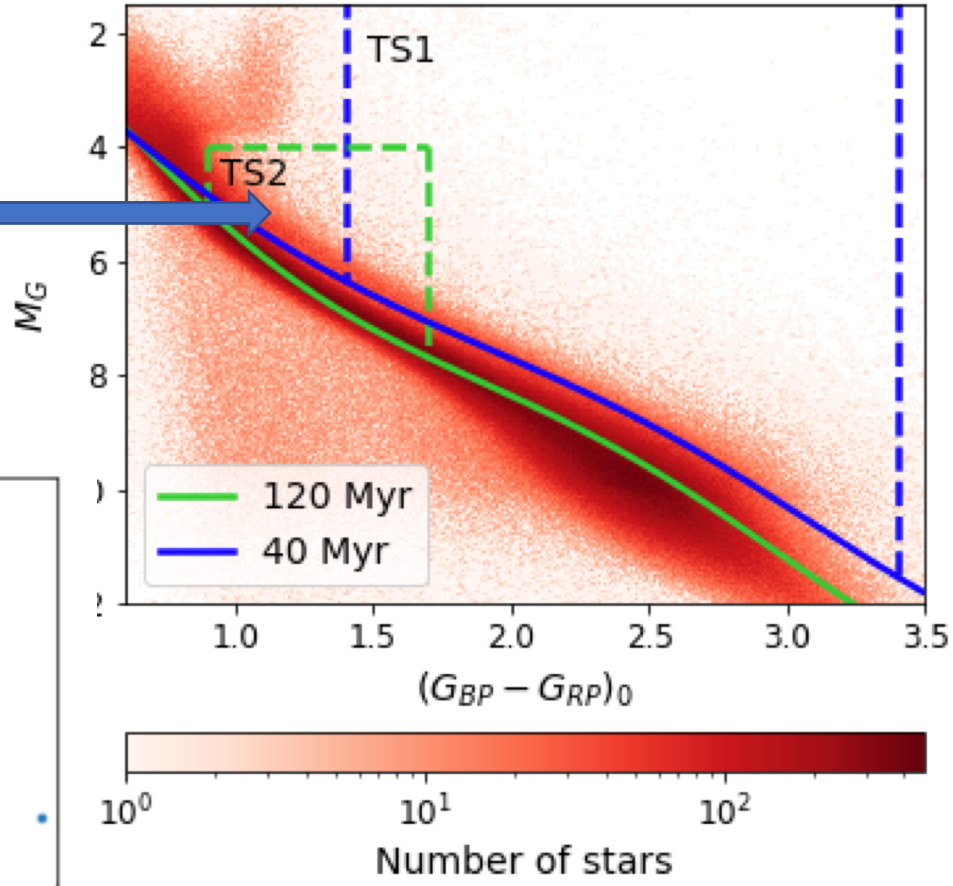


Target selection strategy

Target sample 2

Age < 100 Myr
SpT: G5 to K7
Method: CMD + Period (TESS)+X-ray luminosities (e-ROSITA)
Resolution: HRS
-70 < DEC < 5 deg



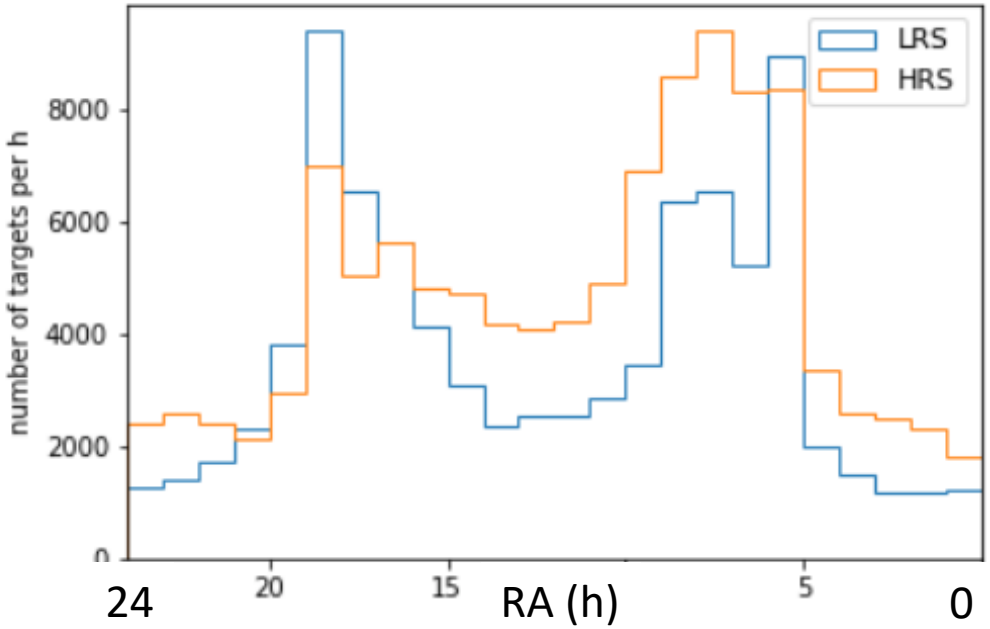


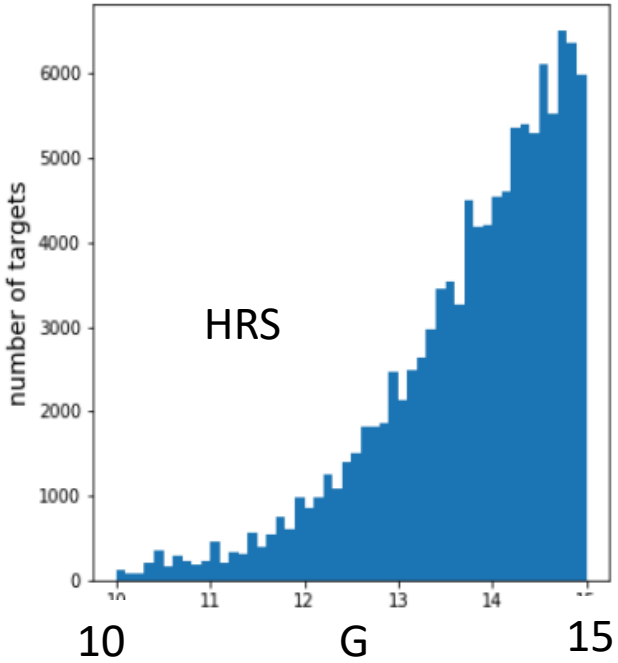
Survey Metrics

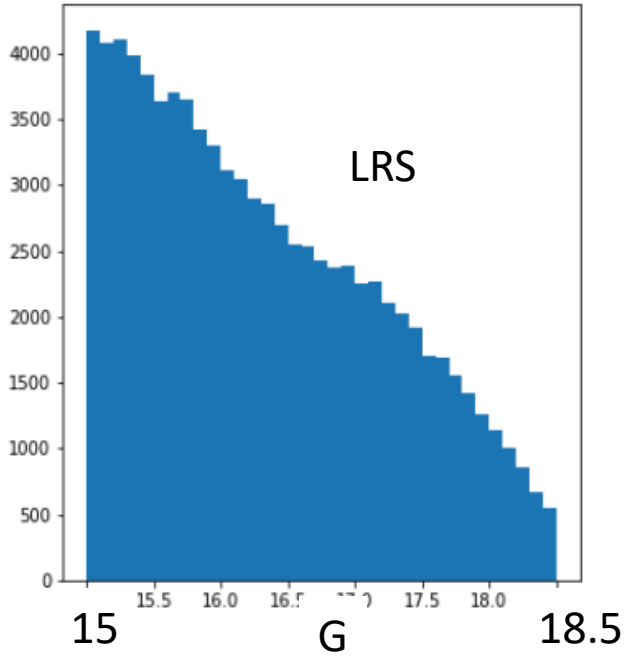
Exposure times

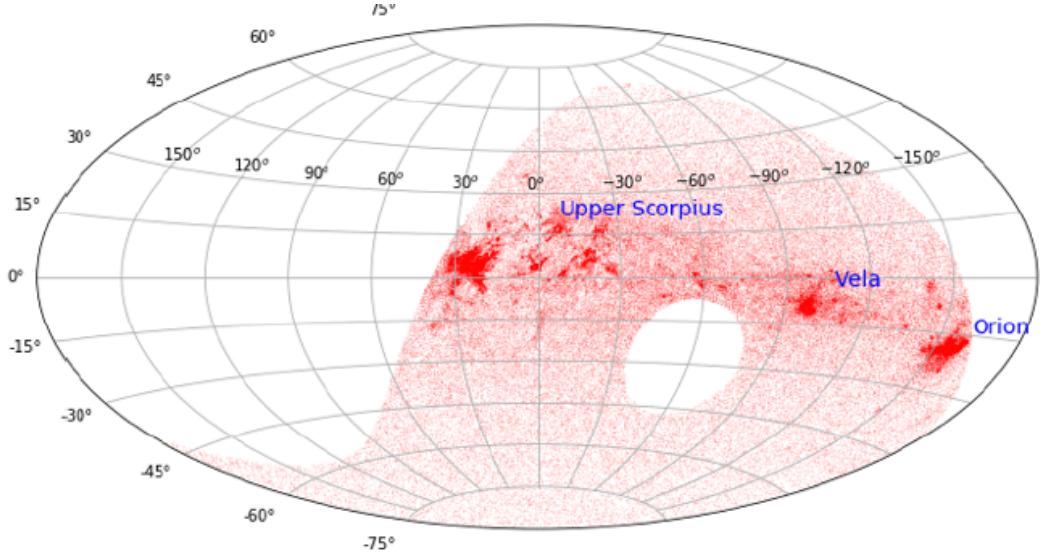
LRS = 74000 fiber hours

HRS = 42000 fiber hours









Survey Products

ALL OBSERVED STARS

1. Catalog of young stars within 500 pc (selected by Li and gravity diagnostics)
2. Radial velocities ($\Delta RV < 1\ km/s$)
3. Teff, Log g, [Fe/H] ($\Delta Teff = 50 - 150\ K, \Delta Log\ g = 0.1 - 0.2\ dex, \Delta[Fe/H]$=0.1 dex)
4. Abundances of up 15 elements (alpha, iron peak, neutron capture/only HRS)
5. *v sin i (~10% precision), f*luxes of emission lines due to accretion and activity

ONLY BONA-FIDE YOUNG STARS

1. *Masses, radii, ages* using homogeneous models calibrated using clusters and moving groups
2. *Accretion and activity parameters* (e.g. Mass Accretion rates, FWZI(Hα), R'$_{H\alpha}$)

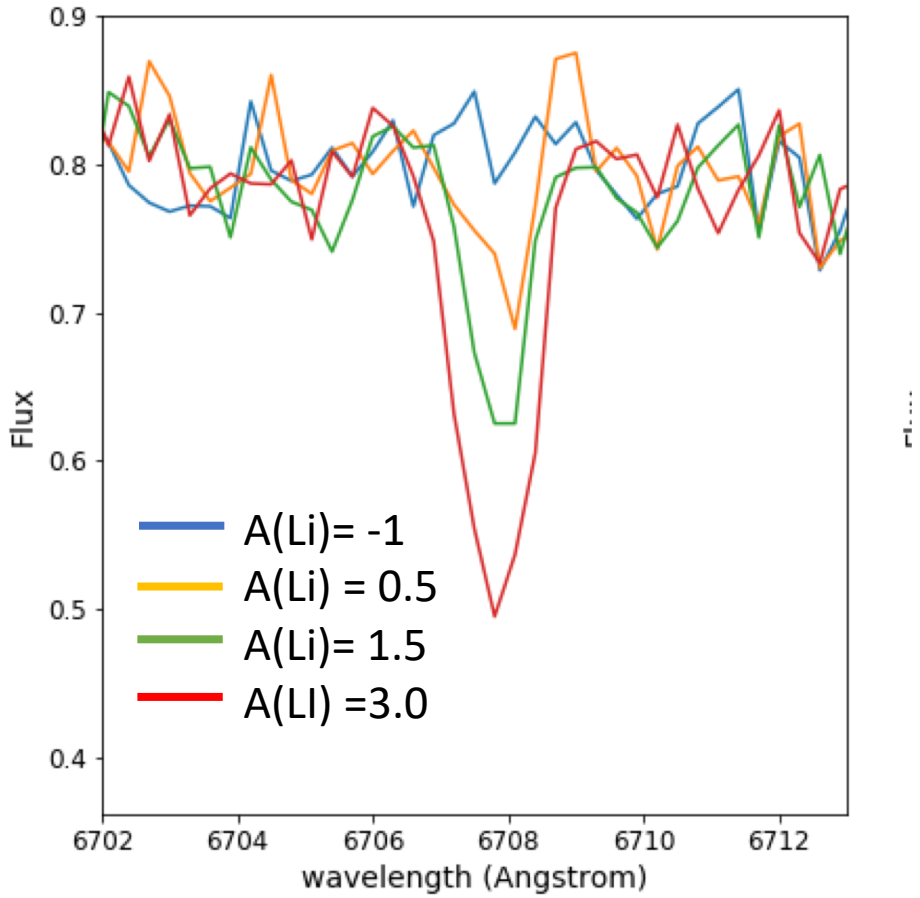
The 4SYS Team will develop specific pipeline to derive all these products and will collaborate with the consortium for cross-calibration and consistency

Required SNR

LRS
SNR > 50 per Å at 670 nm

HRS
SNR > 100 per Å at 500 nm

Based on simulations



Based on most demanding requirements:

- LRS: Detection of youth diagnostics
- HRS:Chemical abundances

Team

4SYS

Target Selection (Leads: R. Jeffries/A. Binks)

- Target selection
- Selection function

WP1

Spectral Analysis
(Leads: L. Magrini/F. Damiani)

- High Resolution spectra
- Low resolution spectra
- Accretion and activity

WP2

Modeling and Statistical analysis
(Leads: H. Bouy & R. Parker)

- Stellar dynamics
- Stellar evolution
- Statistical analysis

WP4

Quality Control & Validation
(Lead: B. Stelzer)

WP3

Consortium

IWG2: Survey Strategy & Simulations

IWG4: Selection function

IWG7: Galactic Pipeline

IWG9: Object classification

IWG5: Science Simulations

Synergy with other surveys & legacy

VISIONS
The VISTA Star Formation atlas

Photometry/Astrometry star forming regions

GaiaESO

Spectroscopy star clusters

MOONS
Multi Object Optical and Near-infrared Spectrograph

Spectroscopy embedded clusters

gaia

Astrometry
Photometry

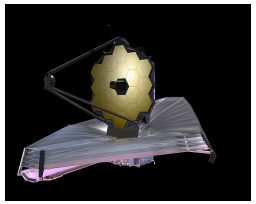
4SYS

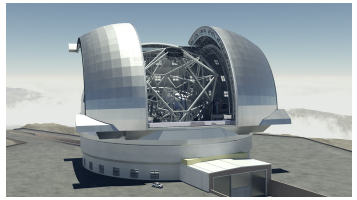
TESS

Exoplanet detection, Rotation periods
Asteroseismology,

eROSITA

X-ray Luminosities, magnetic activity, early environment of exoplanets





Rubin Observatory

Photometric periods
Accretion rates variability

Synergies/complementarity with the consortium surveys

No scientific overlap and almost no target overlap

Scientific and technical synergies with *4MIDABLE* surveys

- ✓ Effect of star formation on stellar chemistry
- ✓ Properties of the solar neighborhood with a sample not affected by migration
- ✓ Tools and expertise to analyze young stars in the 4MIDABLE sample (Synergies with 4SITE)
- ✓ Determination of parameters (e.g. stellar activity) not currently included among the L2 products