A deep multiwavelength study of young stellar population in Cygnus OB2

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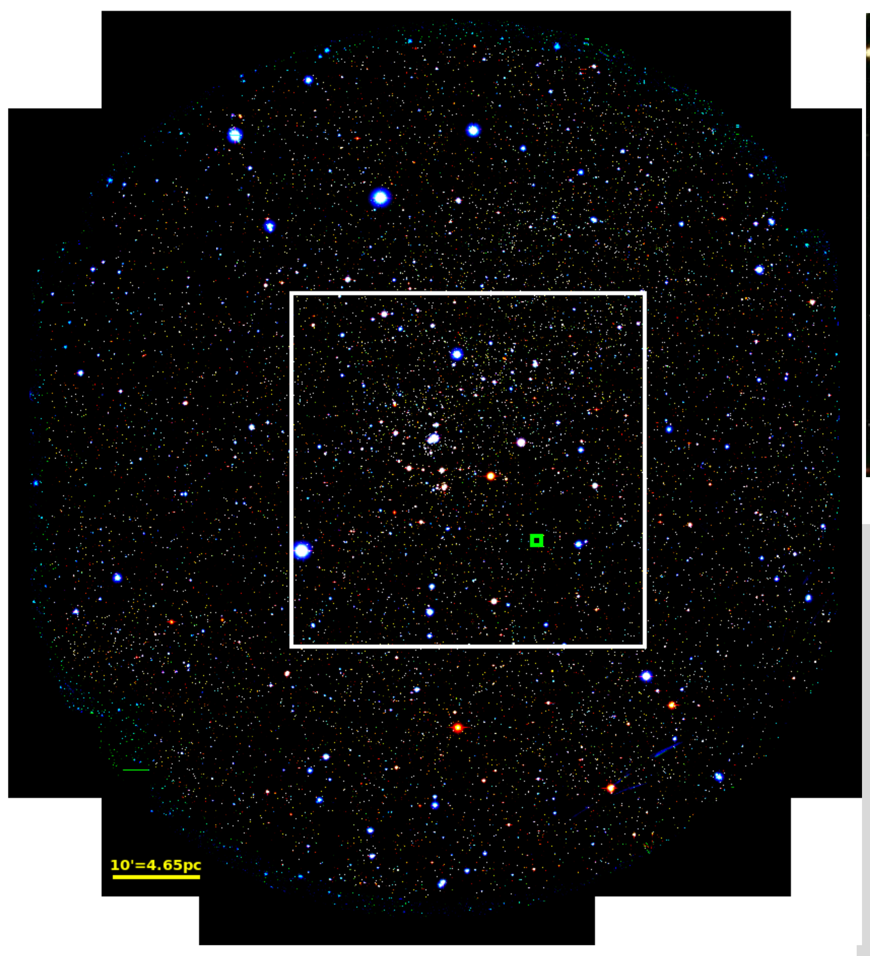
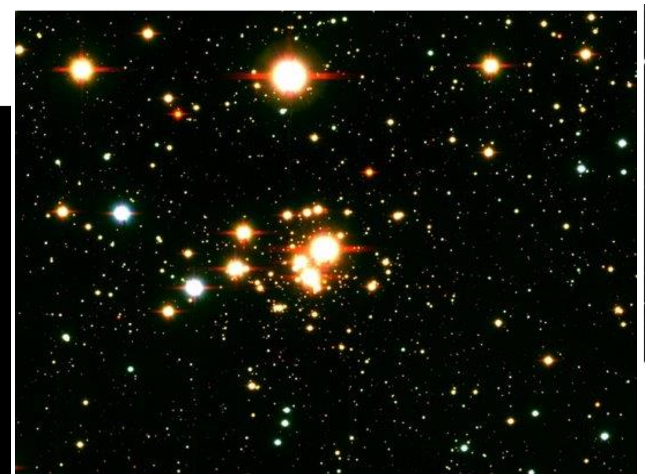
Star Formation: From Clouds To Disks (18^{th}-21^{st} October 2021)

Abstract:

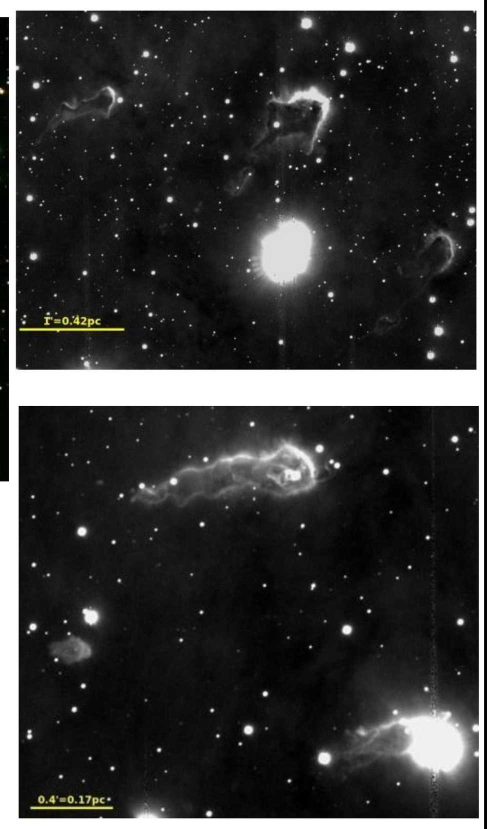
- The effect of cluster environment on circumstellar disk evolution decisive for star and planet formation.
- We study the role of feedback-driven environment on disk population in Cygnus OB2 using **the pioneering wide-field and highly sensitive optical observations** with Subaru Hyper Suprime-Cam (HSC) along with deep near-IR (UKIDSS), mid-IR (Spitzer) and Chandra X-ray photometry.
- The age of the central 18' field decontaminated region is estimated $\sim 5 \pm 2$ Myrs.
- We identify circumstellar disk population in the target region and classify them into the class I and class II sources based on their IR excess.
- We obtain the disk fraction as ~ 14% and observe the spatial variation of disk fraction across the region as a function of incident UV flux.
- We further aim to identify the sub-stellar population and obtain the IMF in the low-mass regime in one of the most massive regions outside the solar neighborhood.

Cygnus OB2: *A feedback driven proto-globular cluster*





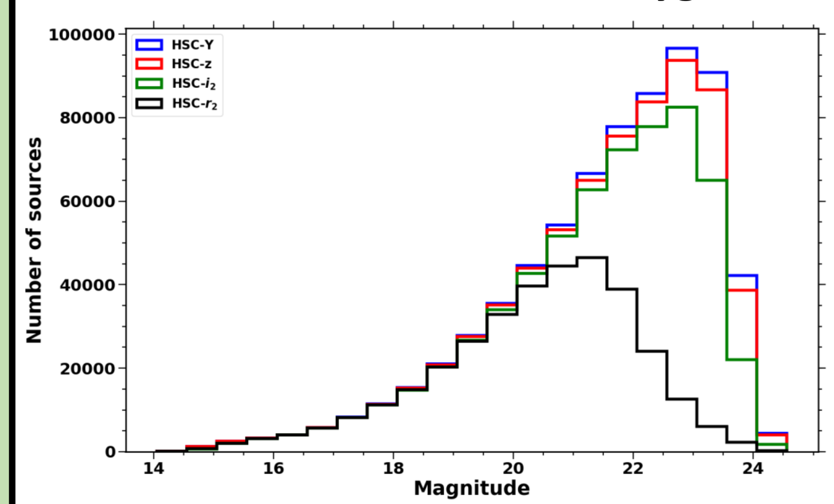
- A young massive Galactic cluster at 1.6 kpc, age 3-5 Myrs.
- Rich in OB-stars implying pre-main sequence population affected by extreme UV environment.[1]

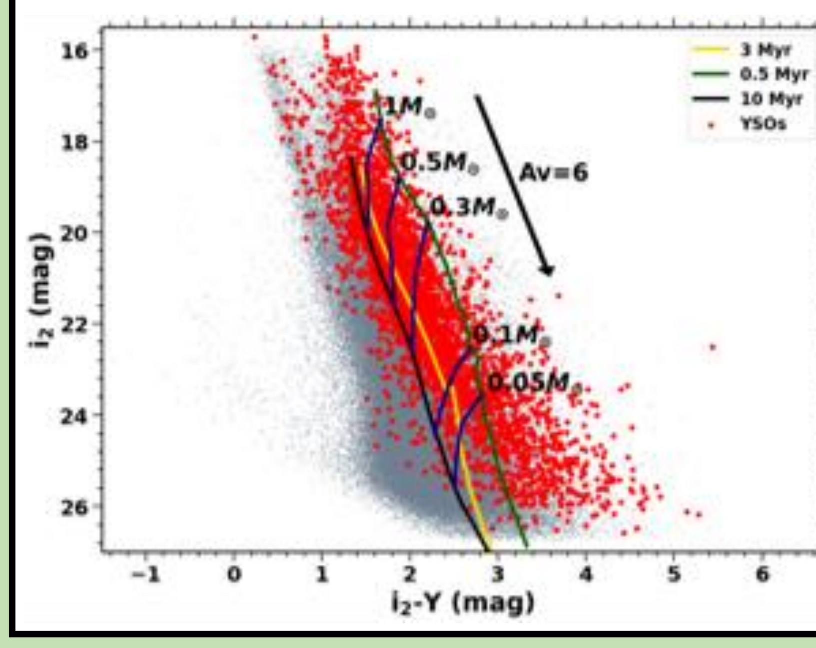


HSC images of few proplyds in Cygnus OB2

An RGB image with HSC r_2, i_2 and Y-band of (*Left*) the whole 1.5^o diameter region. The white box covers central 30'x30' area *(Centre)* RGB image of the central 15'x10' region of Cygnus OB2.

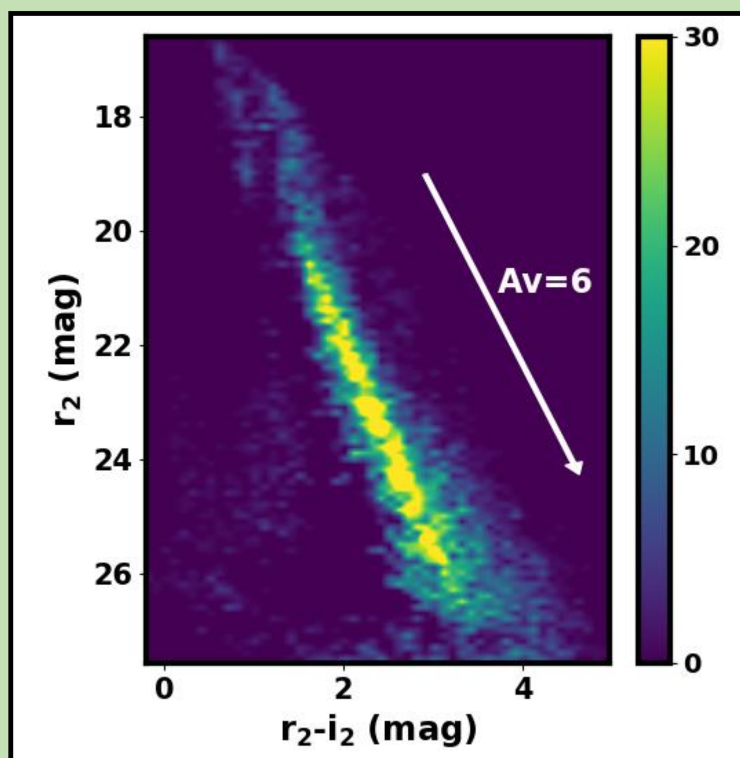
Subaru HSC observations of Cygnus OB2

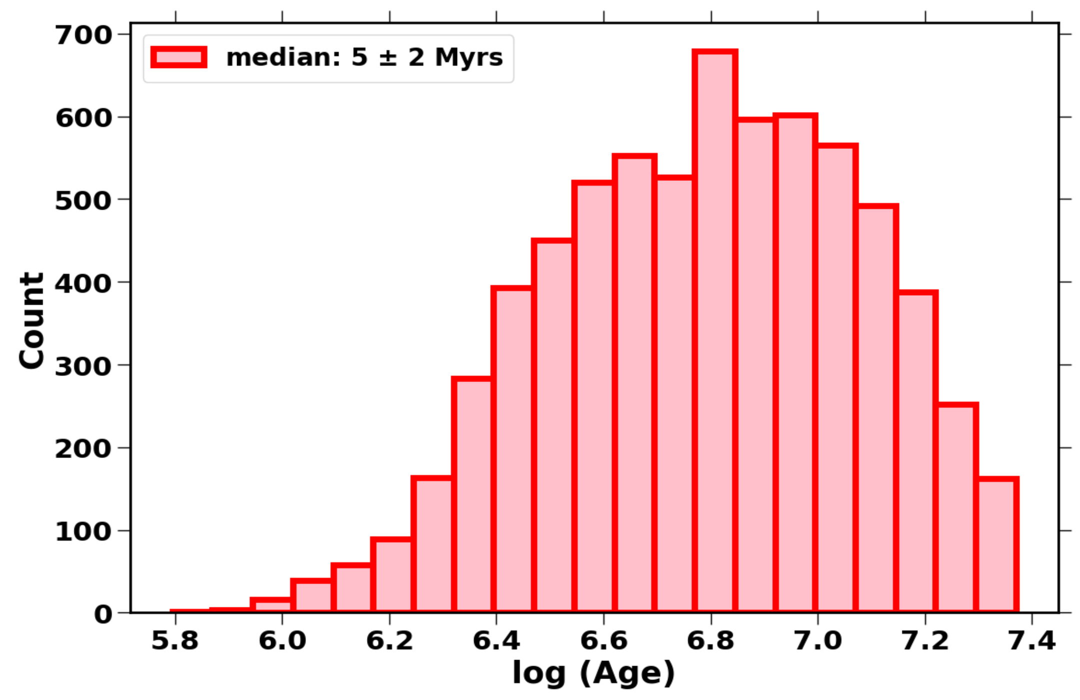




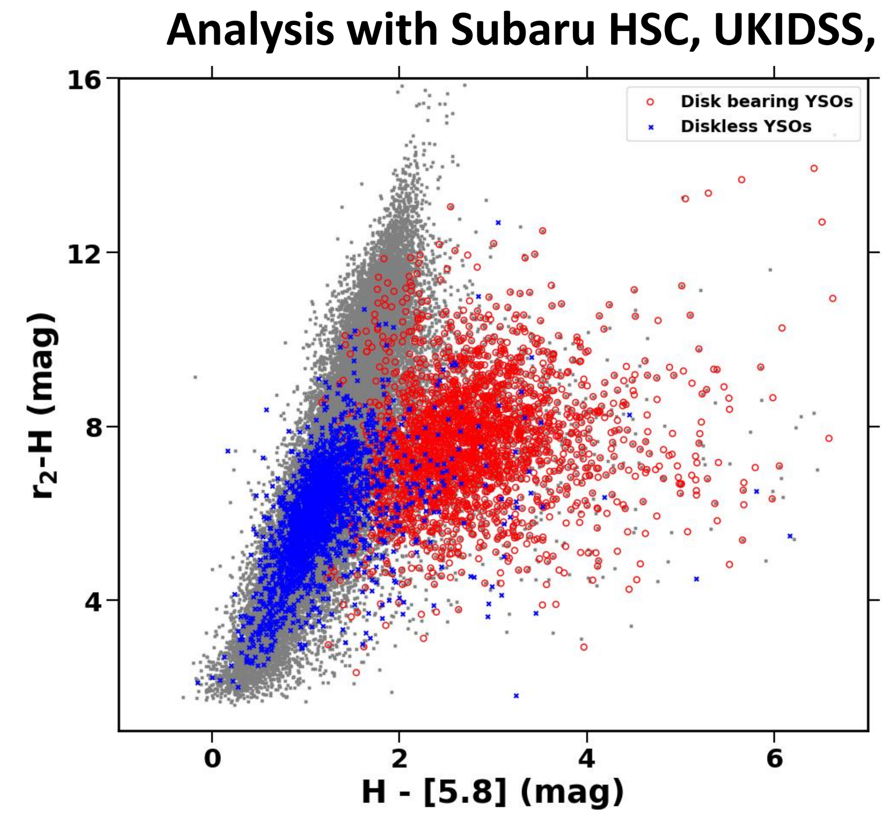
- The deepest and the widest optical (r_2, i_2 , z and Y-band) observations of any Galactic star forming region.
- ~ 713,529 sources observed in 1.5^o diameter region centred at Cygnus OB2 with $i_2 \sim 27^m$ (≤ 0.06 M$_\odot$).
- HSC photometry $\sim 3^m - 5^m$ deeper than previous Pan-STARRS and GTC/OSIRIS photometry.

Top: **Histogram shows completeness of HSC filters. *Bottom*: i_2-Y vs i_2 CMD for entire 1.5^o diameter region overplotted with YSOs and BHAC15[2]isochrones and evolutionary tracks.**

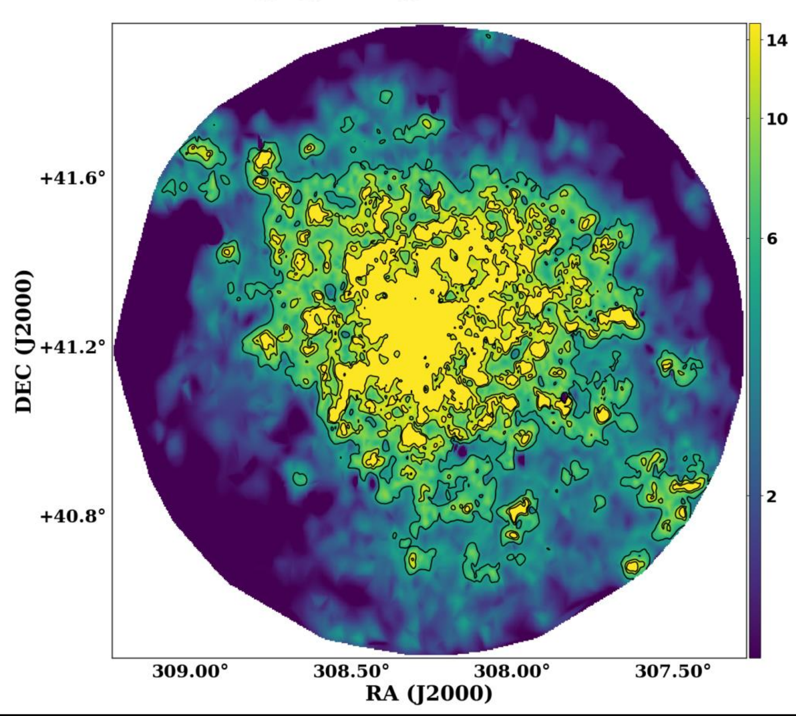


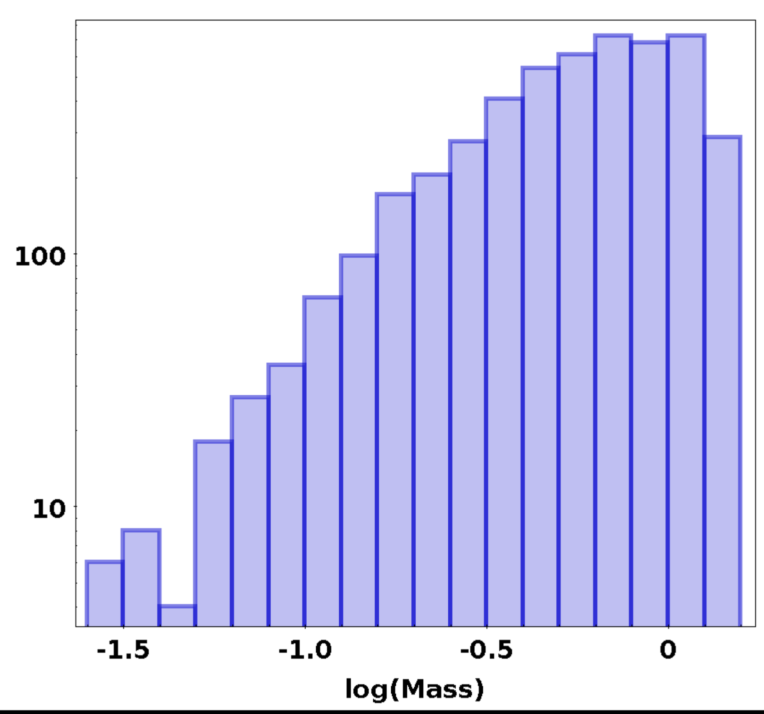


Analysis with Subaru HSC, UKIDSS, Spitzer and Chandra data



- Statistical field decontamination of the central 18' region of Cygnus OB2.
- The median age of the central 18' region $\sim 5 \pm 2$ Myrs
- We detect ~ 4200 disk bearing YSOs in the entire region using UKIDSS near and Spitzer mid-IR data[3].
- Mean mass of the YSOs ~ 0.5 M$_\odot$

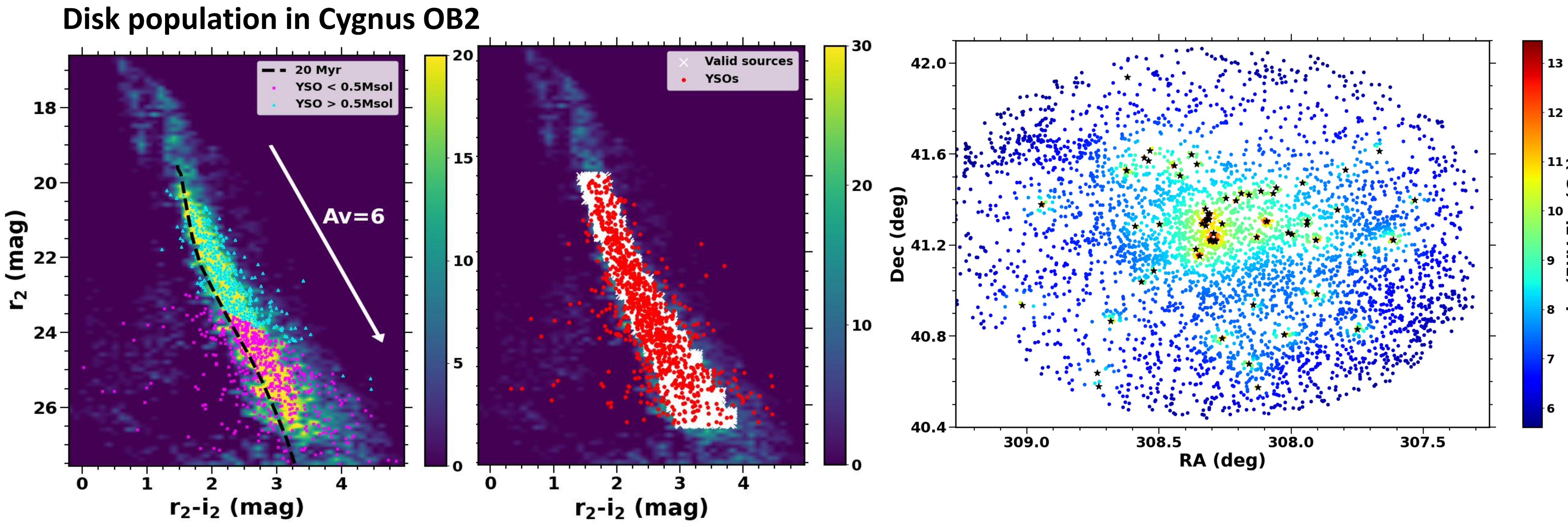




- ~ 3500 diskless YSOs identified using the Chandra X-ray data[4].
- Random spatial distribution of YSOs observed across the OB association except for the clustering towards the centre

***Top Left*: Hess plot of r_2 - i_2 vs r_2 CMD for the field subtracted sources in the central 18' region. *Centre*: Histogram for age distribution of sources. *Top Right*: (H-[5.8]) vs (r_2-H) two-color plot overplotted with identified disk bearing (red) and diskless (blue) YSOs. *Bottom Left*: Spatial map for the distribution of YSOs in the region. *Bottom Right*: Histogram for mass distribution of the YSOs.**

Disk population in Cygnus OB2



Left: **r_2 - i_2 vs r_2 CMD overplotted with YSOs of mass < 0.5 $M_\odot$ (magenta) and > 0.5 $M_\odot$ (green). *Centre*: r_2 - i_2 vs r_2 CMD of field subtracted sources overplotted with sample of stars used to calculate disk fraction (white cross) and YSOs (red dots). *Right*: Spatial distribution of disk sources based on the received FUV flux from massive stars (Black) in the region . The colorbar represents the log (FUV_{flux}) in the units of Habing flux (G_0).**

- Approximately, ~ 65% of disk bearing sources have age < 3 Myrs and mass < 0.5 M$_\odot$.
- The disk fraction in the central 18' region is estimated to be 14 %

Summary and Future works

- We perform a deep multi-wavelength study with deep HSC optical, UKIDSS NIR, Spitzer MIR and Chandra X-ray data to identify YSOs in the feedback affected environment ($5G_0 \leq \log(\mathrm{flux_{FUV}}) \leq 13G_0$) of Cygnus OB2.
- Sources reaching down to brown dwarf limit (≤ 0.07 M$_\odot$) detected with Subaru HSC optical data.
- We estimate the age of the central 18' region of Cygnus OB2 to be ~ 5 Myrs.
- We identify ~ 4500 disk bearing and ~ 3500 diskless with a disk fraction of ~ 14%.
- Further, we aim to analyse the variation of circumstellar disk fraction as a function of age and mass.
- We also aim to identify sub-stellar sources, star to brown dwarf ratio and obtain the IMF Cygnus OB2.

References

1) Guarcello et al. 2016 (2) Baraffe et al. 2015 (3) Gutermuth et al. 2009 (4) Wright et al. 2012 (5) Gupta et al. 2021, MNRAS, accepted for publication *arXiv link: http://arxiv.org/abs/2109.11009*

Acknowledgements

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