

# A sequoia in the garden: a dwarf galaxy or a giant globular cluster hidden in the bulge?

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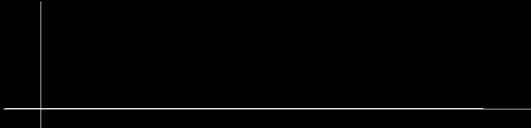
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# Modern Cosmography: Playing the game of big panchromatic all-sky surveys

Cosmography is the science that maps the general features of the cosmos or universe, describing both heaven and Earth.

In Astrophysics, the term is beginning to be used to describe ~~attempts to determine~~ the large-scale matter distribution and kinematics of the observable universe (Wikipedia)



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# Motivation

- Large multi-frequency, synoptic, and all-sky surveys are opening new horizons in the heaven exploration.
- For Galactic Astronomy, relevant are: VVV, UKIDSS, Glimpse, WISE, DECaPS, SkyMapper, PANSTARRS, Herschel, etc.
- Gaia DR2 is opening a Pandora's Box, and transforming our knowledge about the Milky Way structure.
- Tens of large scale new structures discovered.

# DECaPS

- Dark Energy Camera Galactic Plane Survey  
<http://decaps.skymaps.info>
- DECam: 520 mpix, 4-m Blanco Telescope, CTIO (Chile)
- Southern GP, 1000 sq-deg ( $|b| < 4^\circ$ ).
- Very deep, limits  $g \sim 23.7$ ,  $r \sim 22.8$ ,  $i \sim 22.2$ ,  $z \sim 21.8$ , and  $Y \sim 21.0$
- Details in Schlafly et al. 2018.

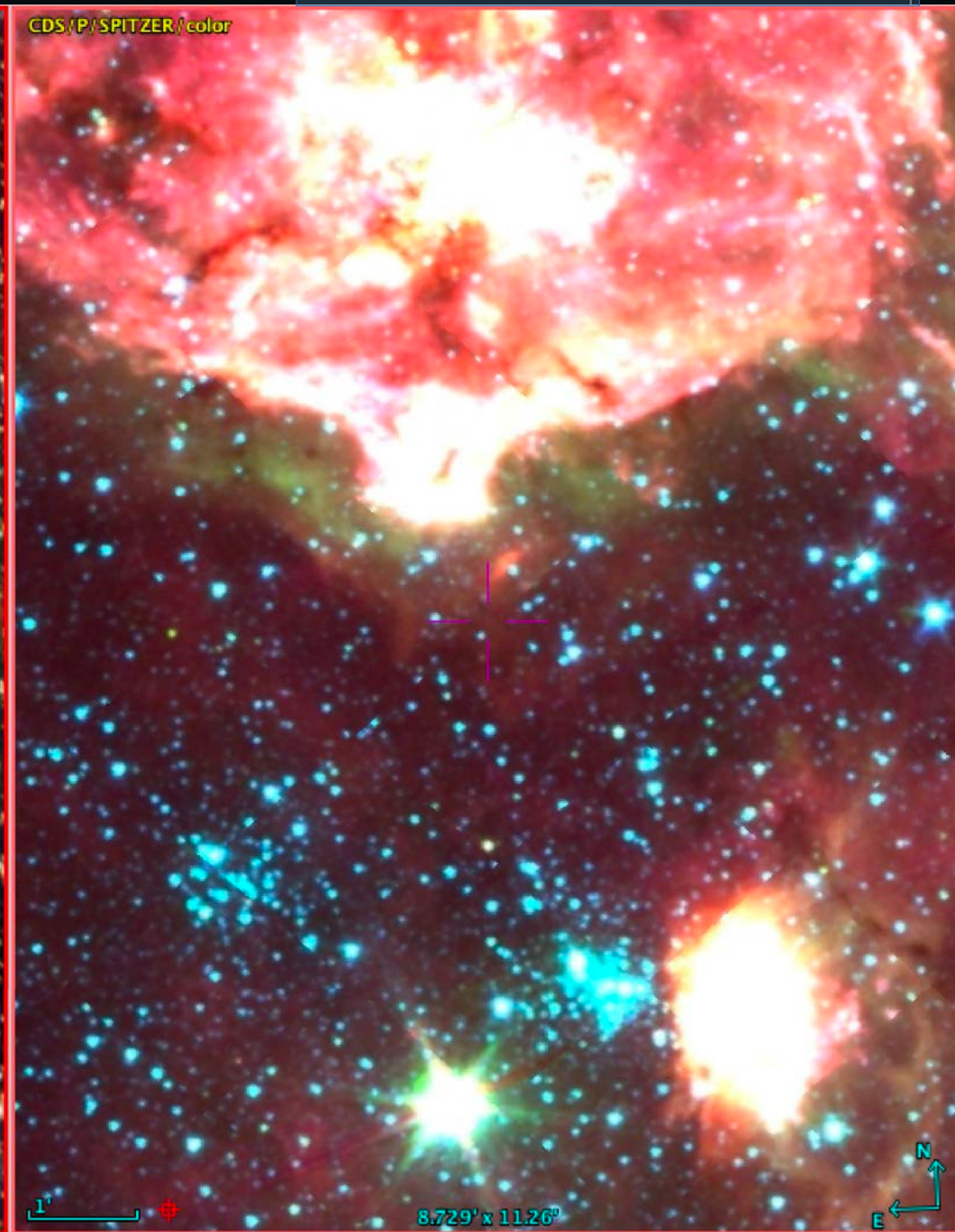
# DECaPS + Aladin

Superb discovery tool  
(+ TopCat)

The screenshot displays the Aladin software interface. At the top, the title bar shows 'Available data → 2 / 2', 'Command', 'Frame Gal', and 'Projection Altoff'. Below this is a list of data sources: DSS-red, PanSTARRS, 2MASS, WISE, GALEX, PLANCK, AKARI, XMM, Fermi, Gaia, and Simbad. The main map area shows a color image of the Milky Way galaxy, with various constellations labeled in yellow: LUP, CEN, ANT, HYA, SCO, NOR, CRU, VEL, CIR, MUS, TRA, ARA, CAR, CRA, APS, CHA, VOL, TEL, PAV, and MEN. A search bar at the bottom right contains the coordinates '305.0 0.0 GAL'. The bottom left corner has a search filter set to 'decaps' and a 'from' dropdown set to '-- all colle...'. The bottom right corner shows a small inset map with coordinates '305.00000 -00.00000' and a zoom level of '100.3 x 65°'. The right sidebar contains a list of filters, including 'Filter 1' with 'CDS / I / 345 / g', 'nasa.heasarc', 'CDS / Simbad', 'CDS / P / allWISE', 'CDS / P / SHS', 'CDS / P / WISE', 'CDS / P / DEC', 'CDS / P / 2MASS', 'CDS / P / PanS', 'CDS / P / skym', 'CDS / P / allW', and 'CDS / P / DM'. The bottom toolbar includes icons for 'select', 'grid', 'study', 'wink', 'north', 'hor', 'multiview', and 'match'.

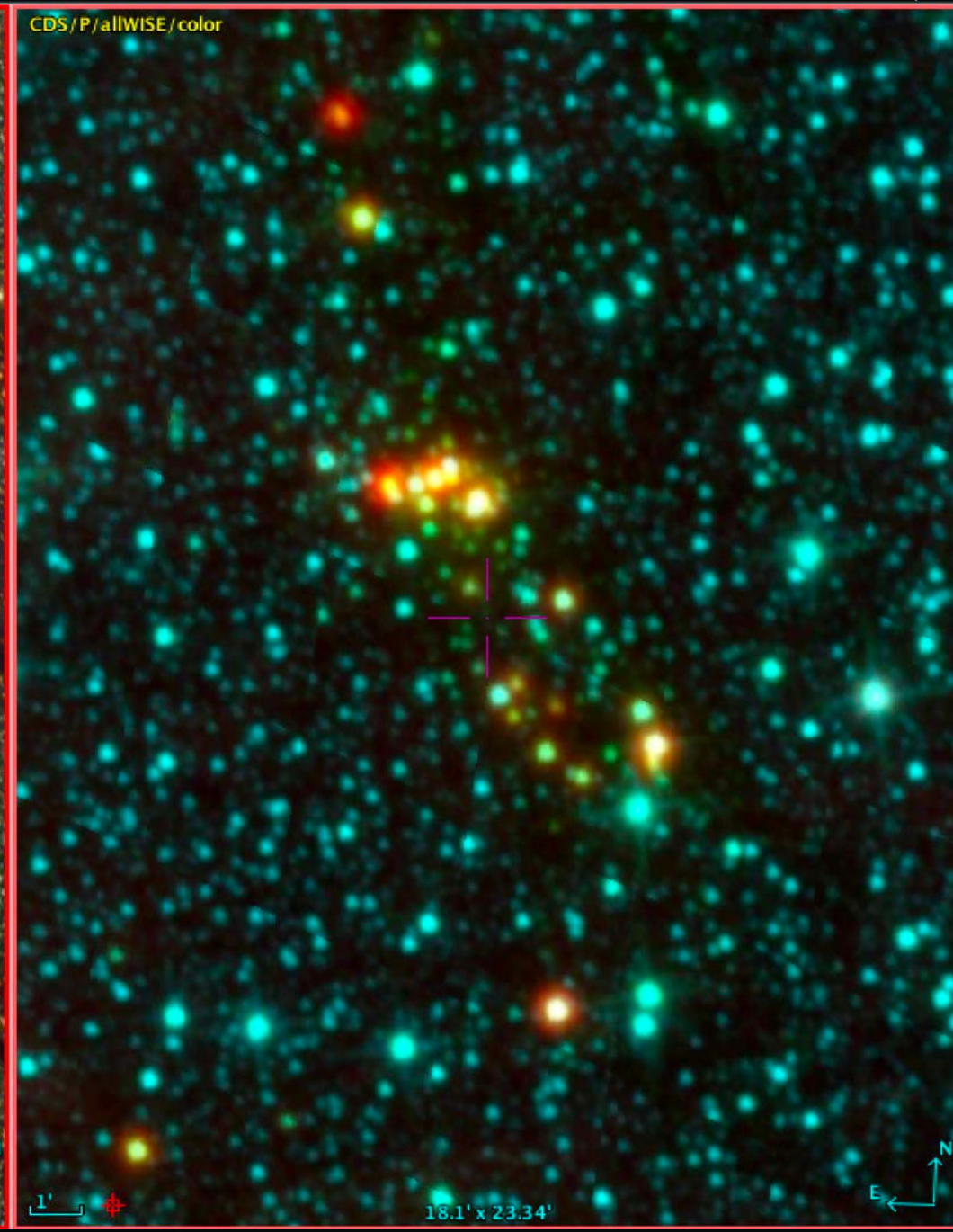
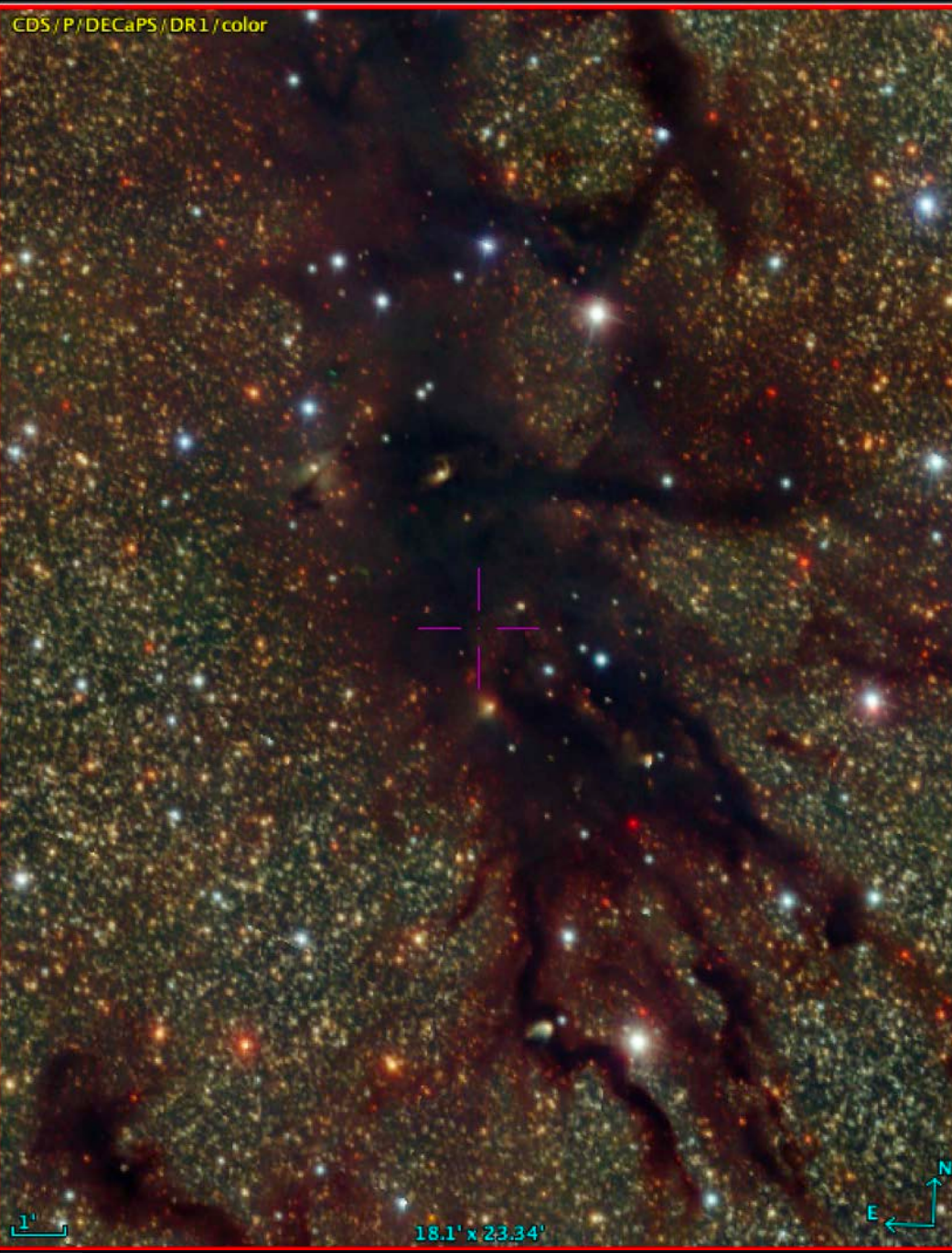
# DECaPS+Glimpse

G305 Complex  
Danks 1 & 2 clusters



# DECaPS+WISE

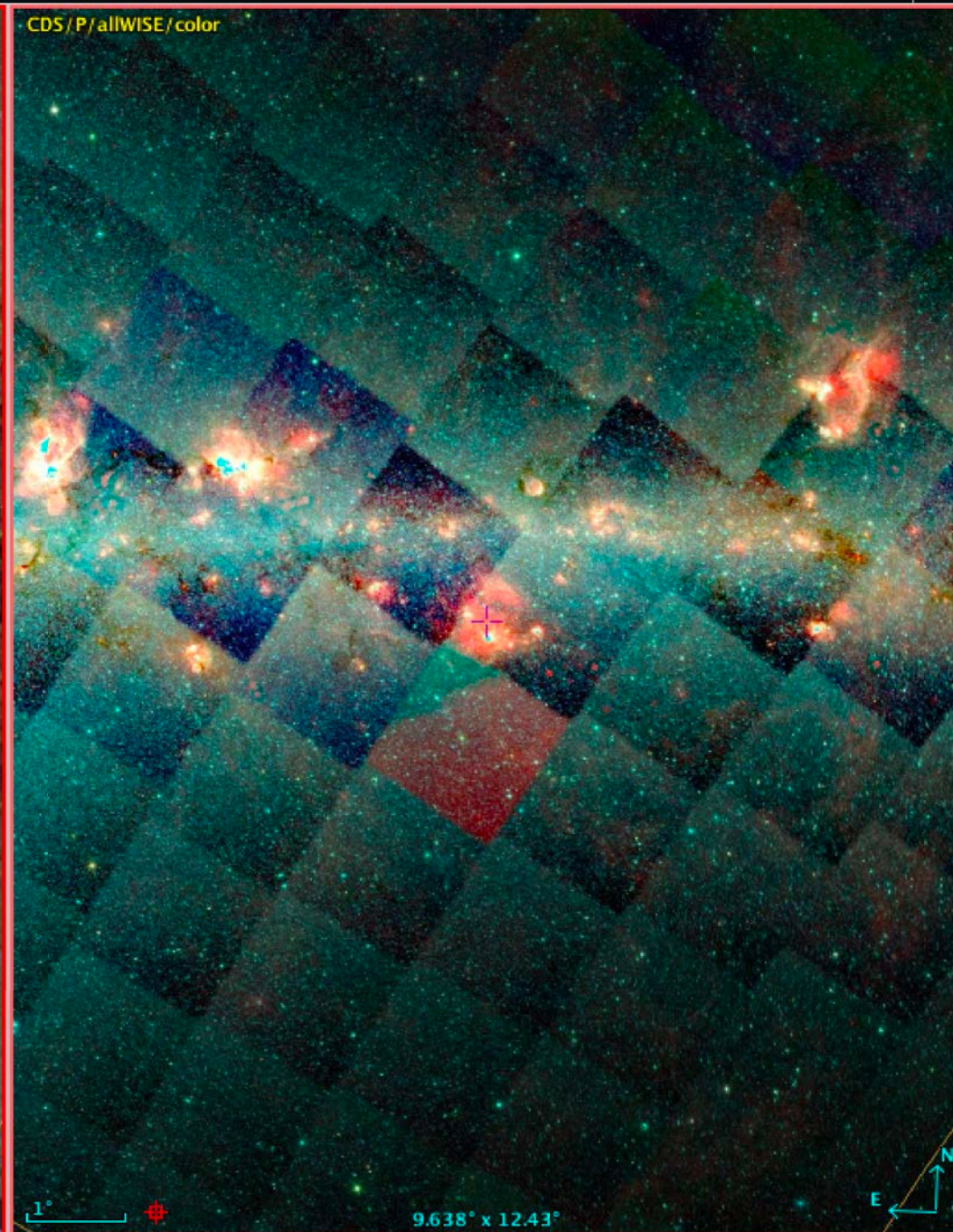
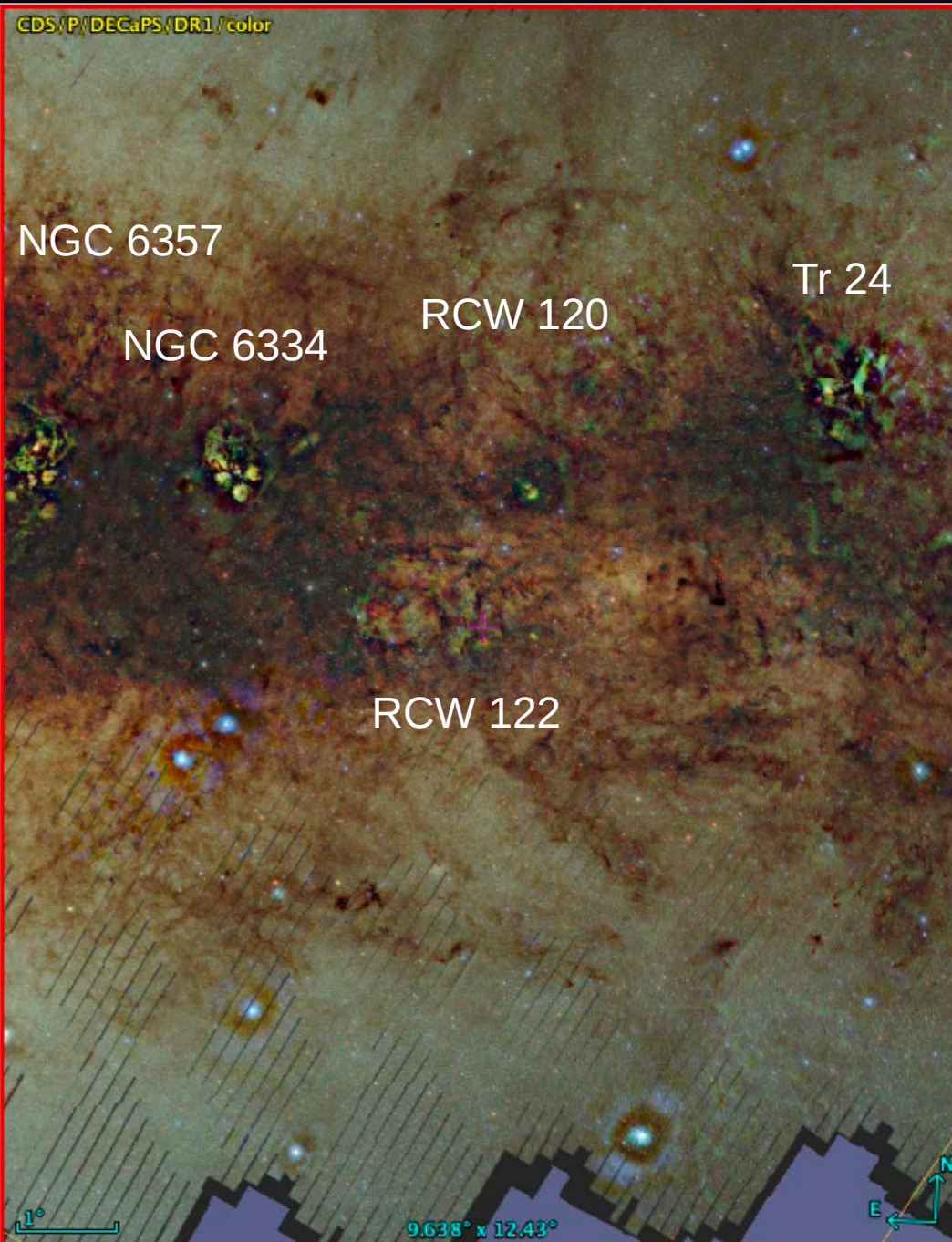
Circinus Molecular Cloud



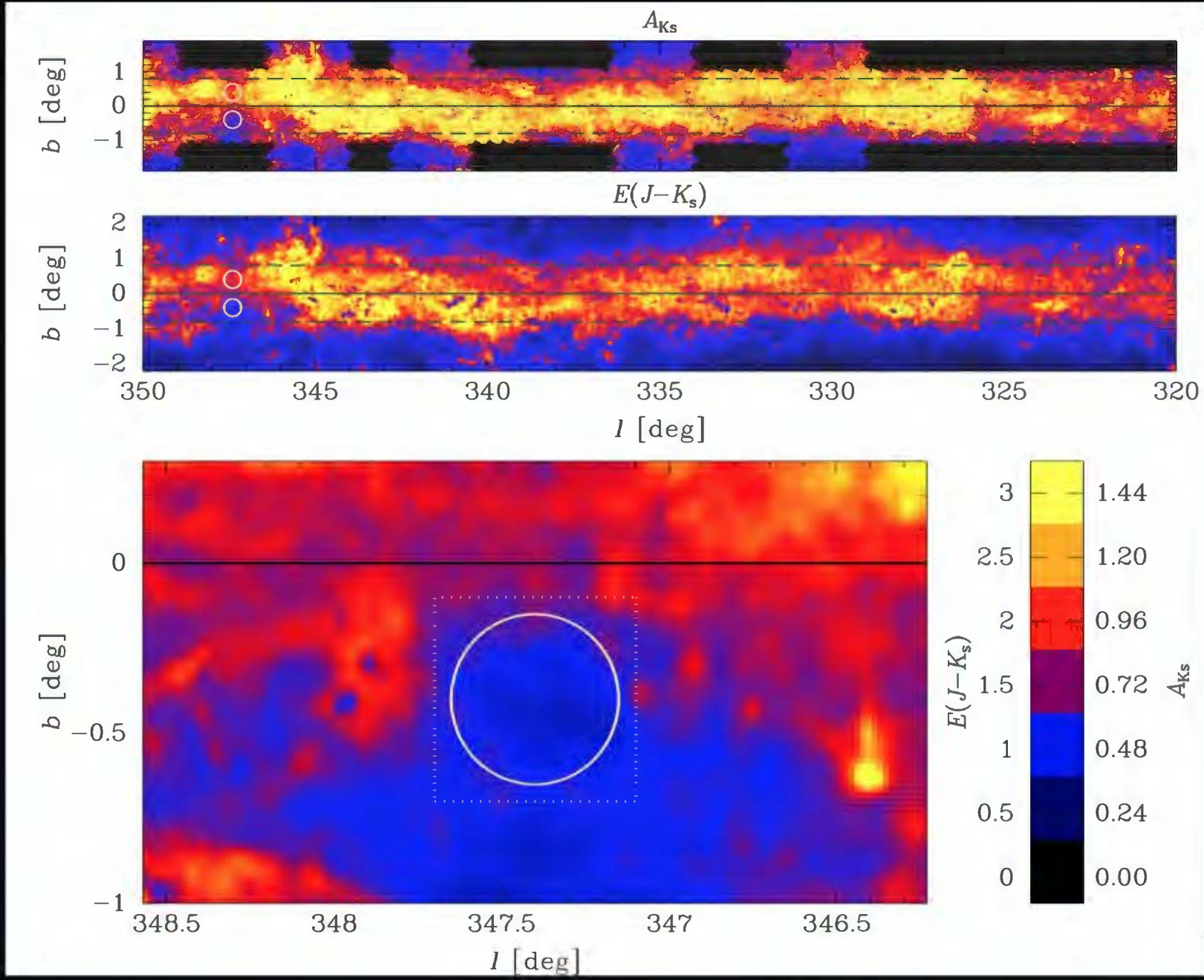


# DECaPS+WISE

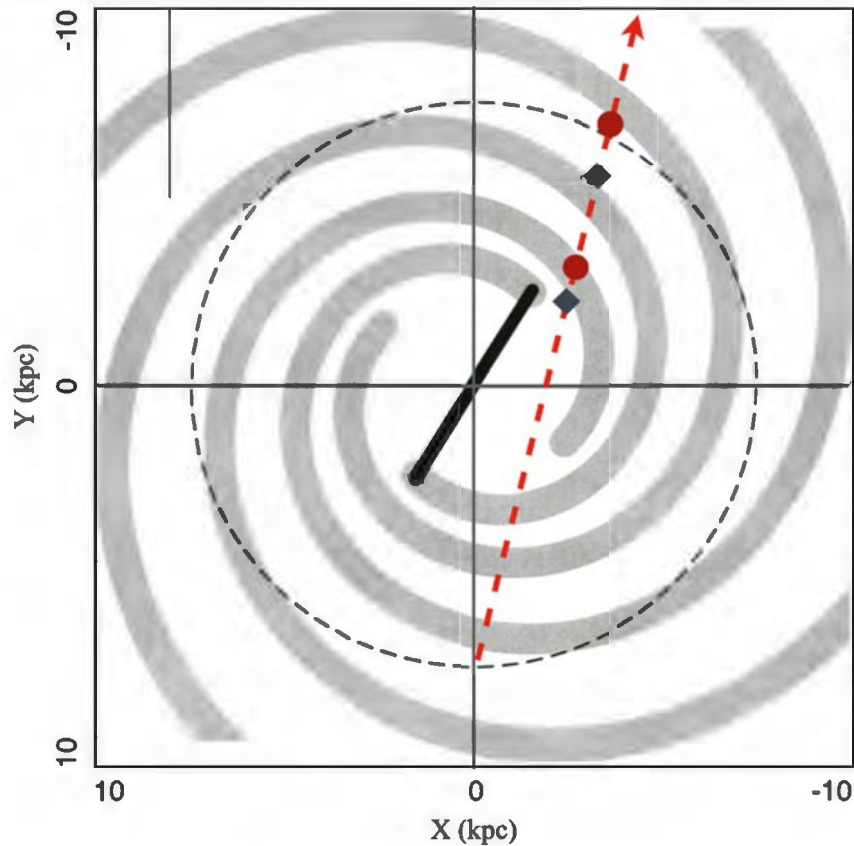
Scorpius VVV Window



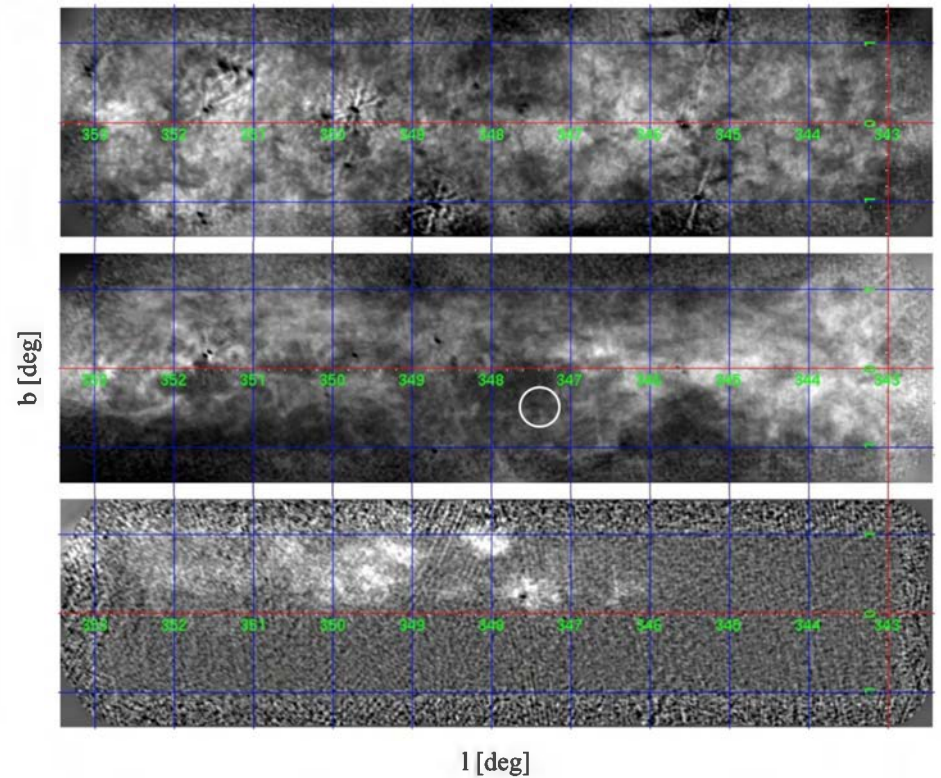
# VVV Window – Minniti et al 2018, A&A, 616, A26



# VVV Window – Minniti et al 2018, A&A, 616, A26

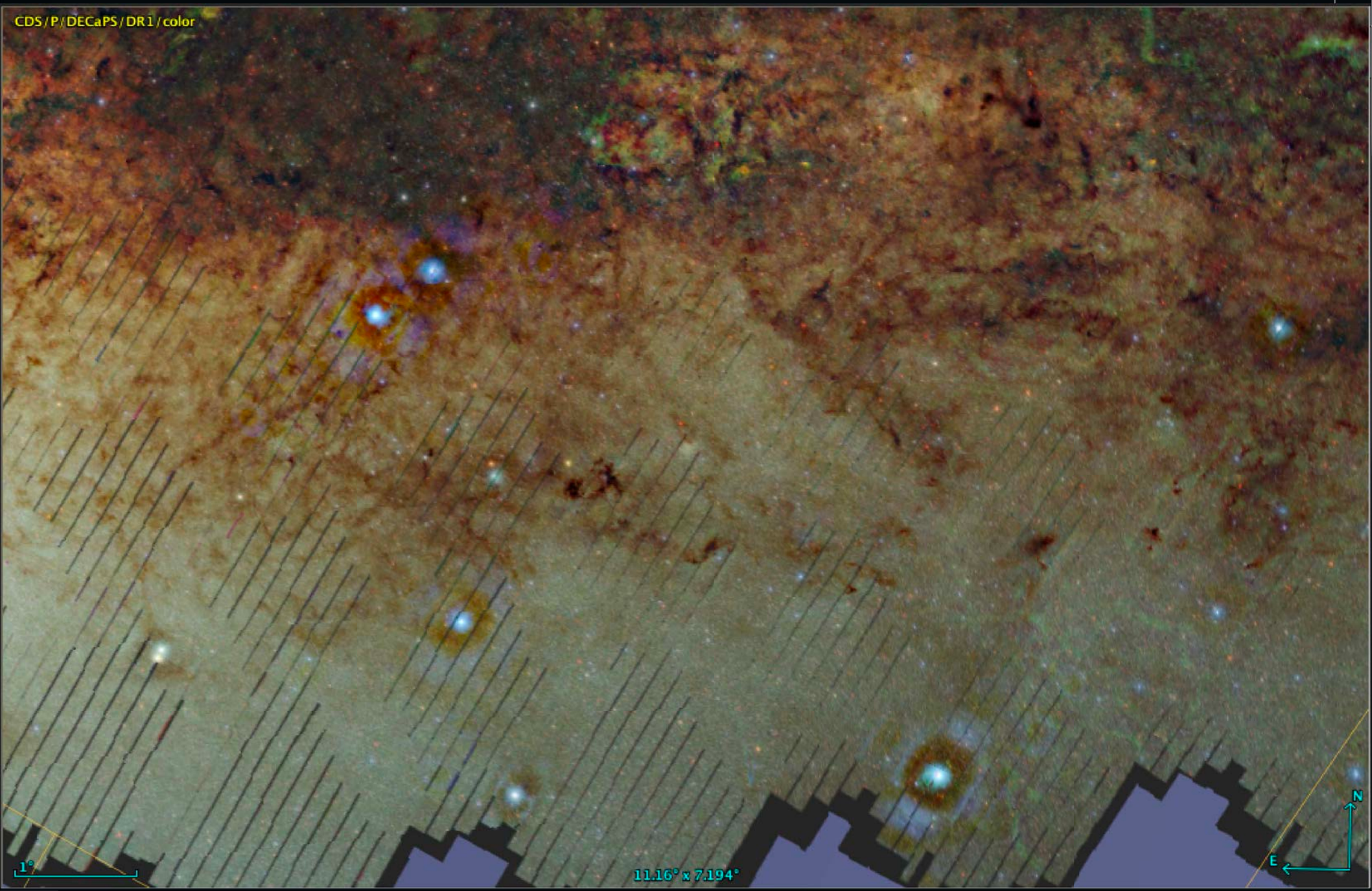


**Fig. 6.** Schematic map of the MW adapted from Vallée (2014) indicating the position of the Sun and the line of sight through the window. We adopted a distance to the Galactic centre of  $R_0 = 8$  kpc. According to this picture, the line of sight should pass through the Sagittarius arm and the end of the long bar, and the far side of the Norma and Scutum-Centaurus arms. Red circles mark corresponding distances for the main peaks using  $A_{K_s} = 0.484 \times E(J - K_s)$ . Using  $A_{K_s} = 0.725 \times E(J - K_s)$  the distances are systematically shorter (black diamonds).

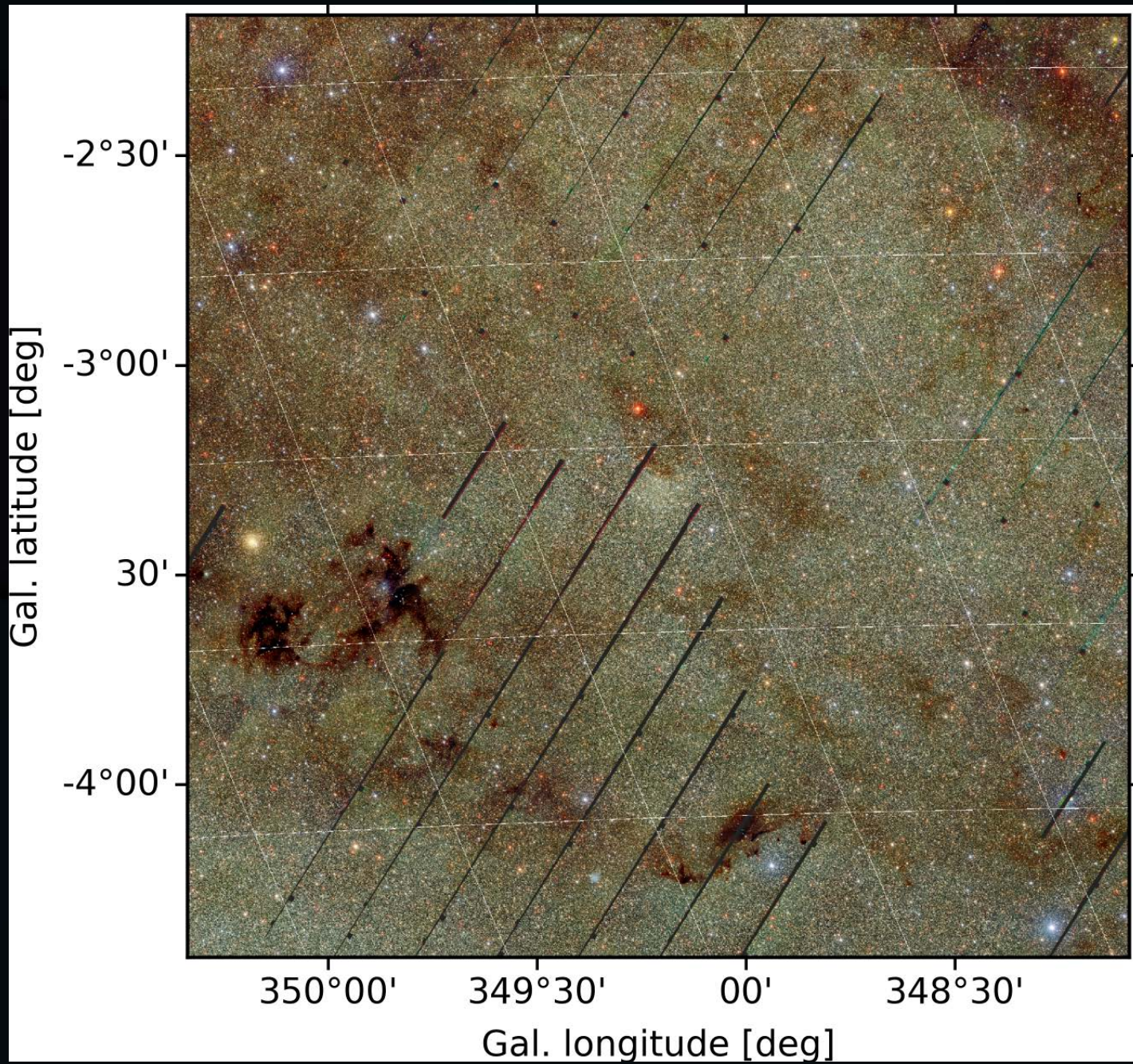


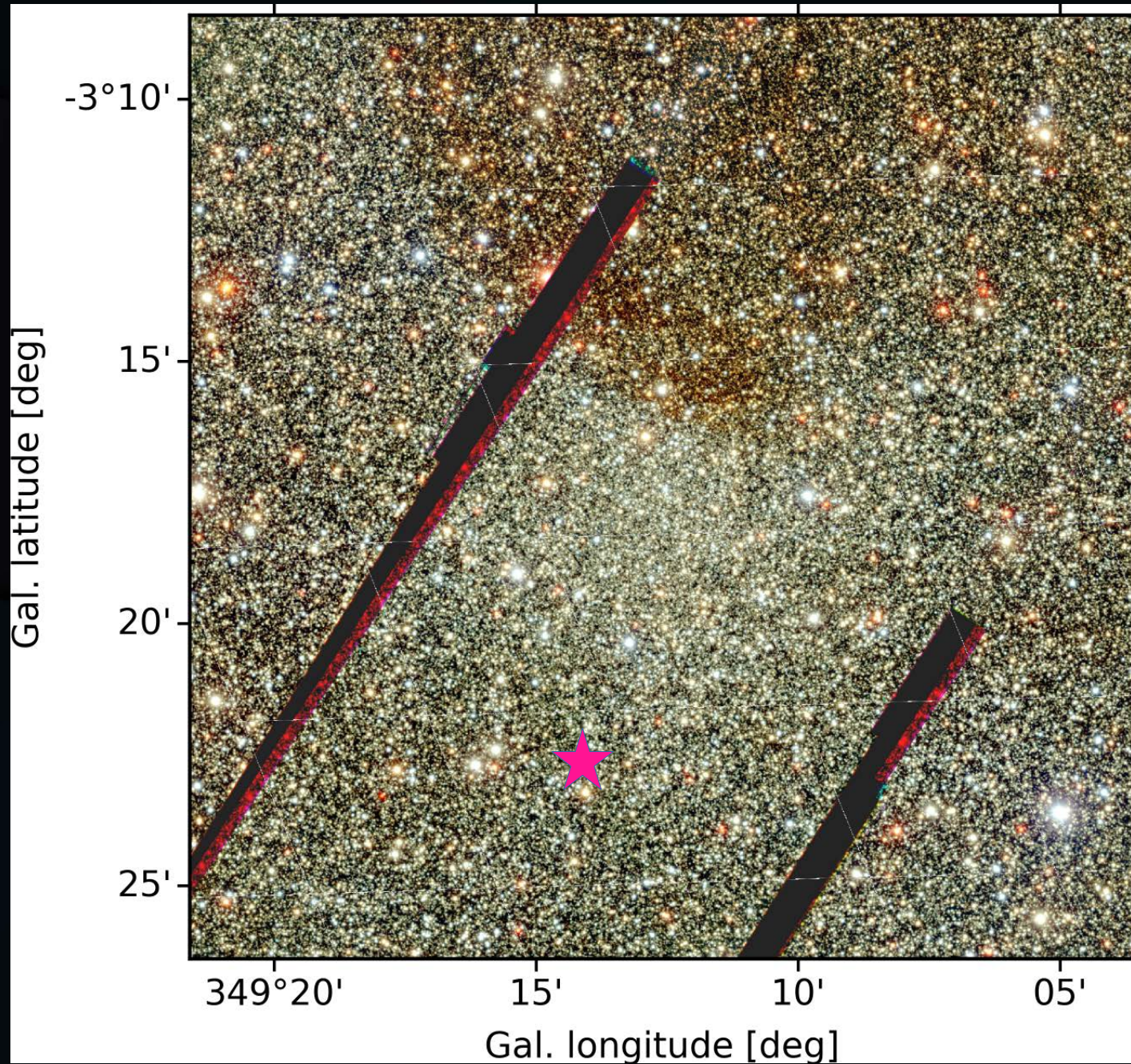
**Fig. 2.** HI maps at different velocities for the inner Galactic plane, for  $342.6 < l < 353.4$  and  $-1.4 < b < 1.4$ . Top: HI emission for velocities between  $-15$  to  $-20$  km/s. Middle: Same for velocities between  $-30$  to  $-42$  km/s. The location of the low extinction window is indicated with the circle. Bottom: Same for velocities between  $-150$  to  $-185$  km/s.

# DECaPS

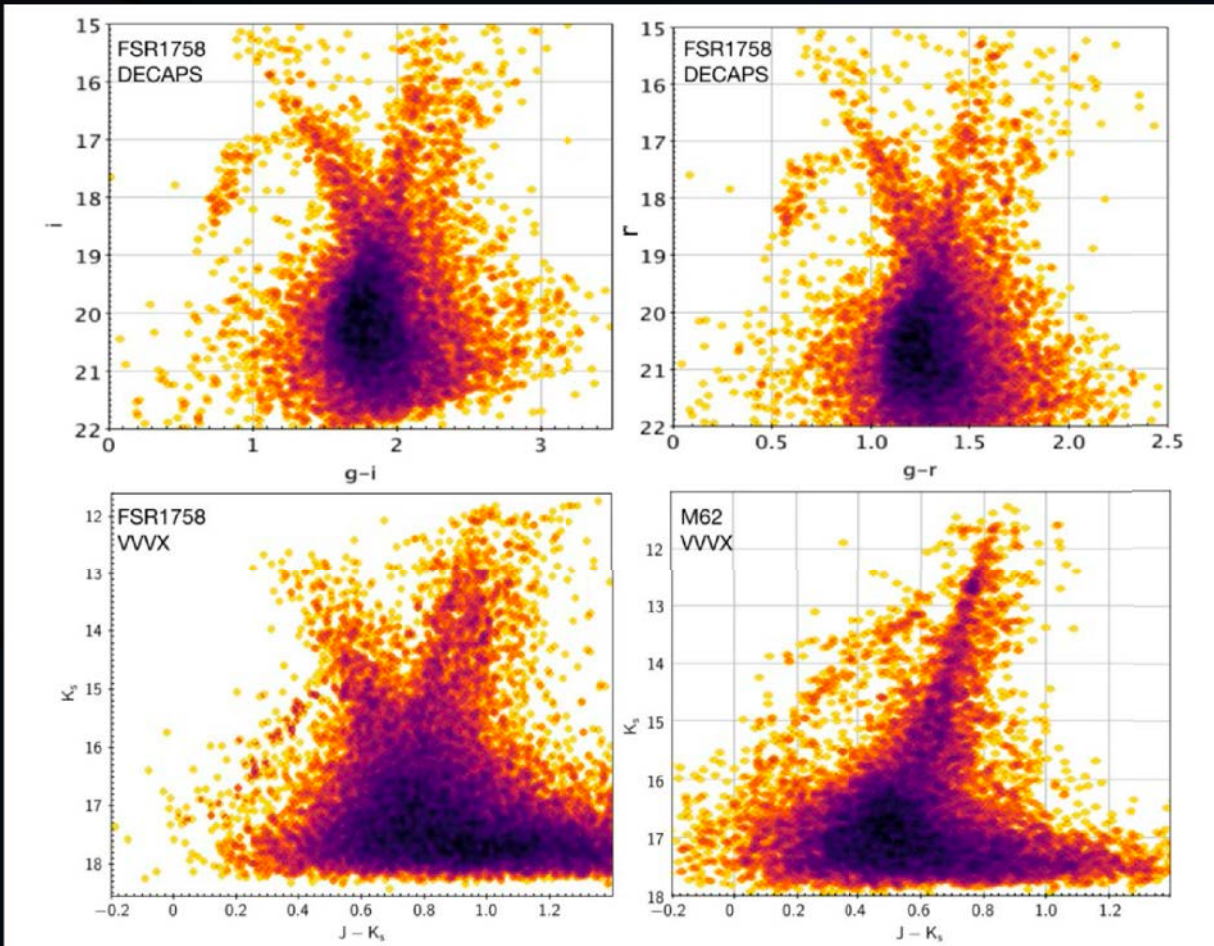


# DECaPS





# DECaPS + VVX



Extended RGB, bluer than field

Prominent BHB, no in the field

RGB bump in  $K=13.4$   $J-K=0.85$

Comparing with NGC 6642,  
NGC 6626

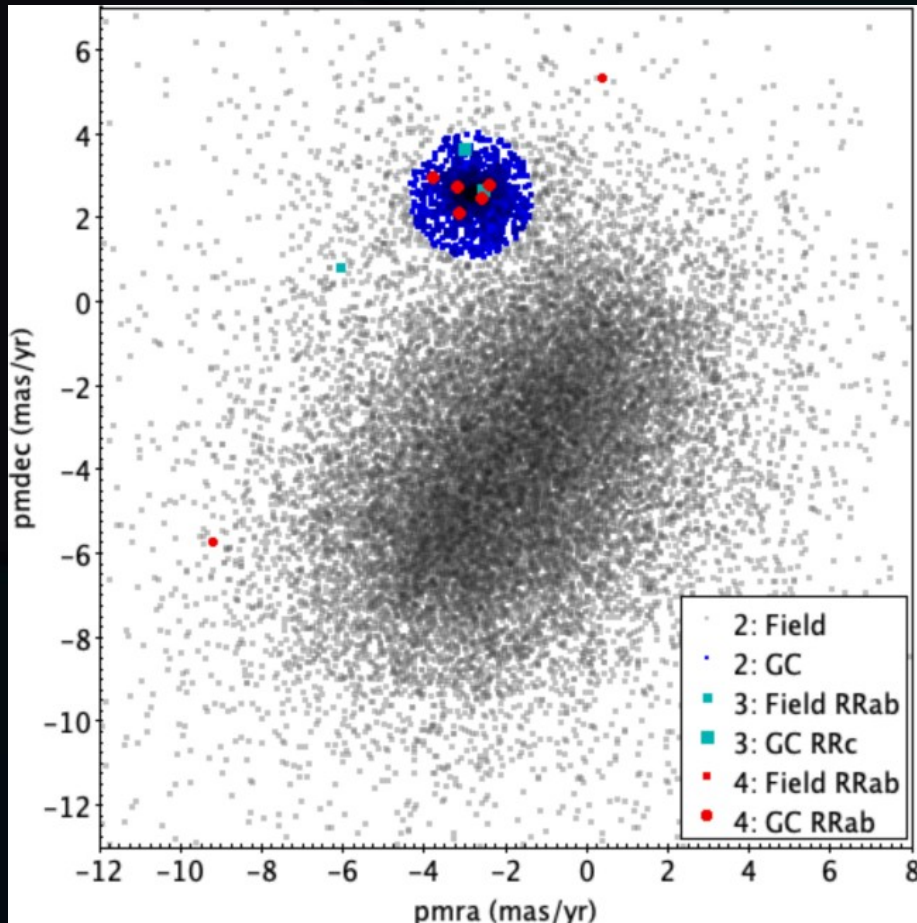
$D = 11.5 \pm 1.0$  kpc

$D_{gal} = 3.7$  kpc  $z = -750$  pc

Comparing with M3, M13

$[Fe/H] = -1.5 \pm 0.3$  dex

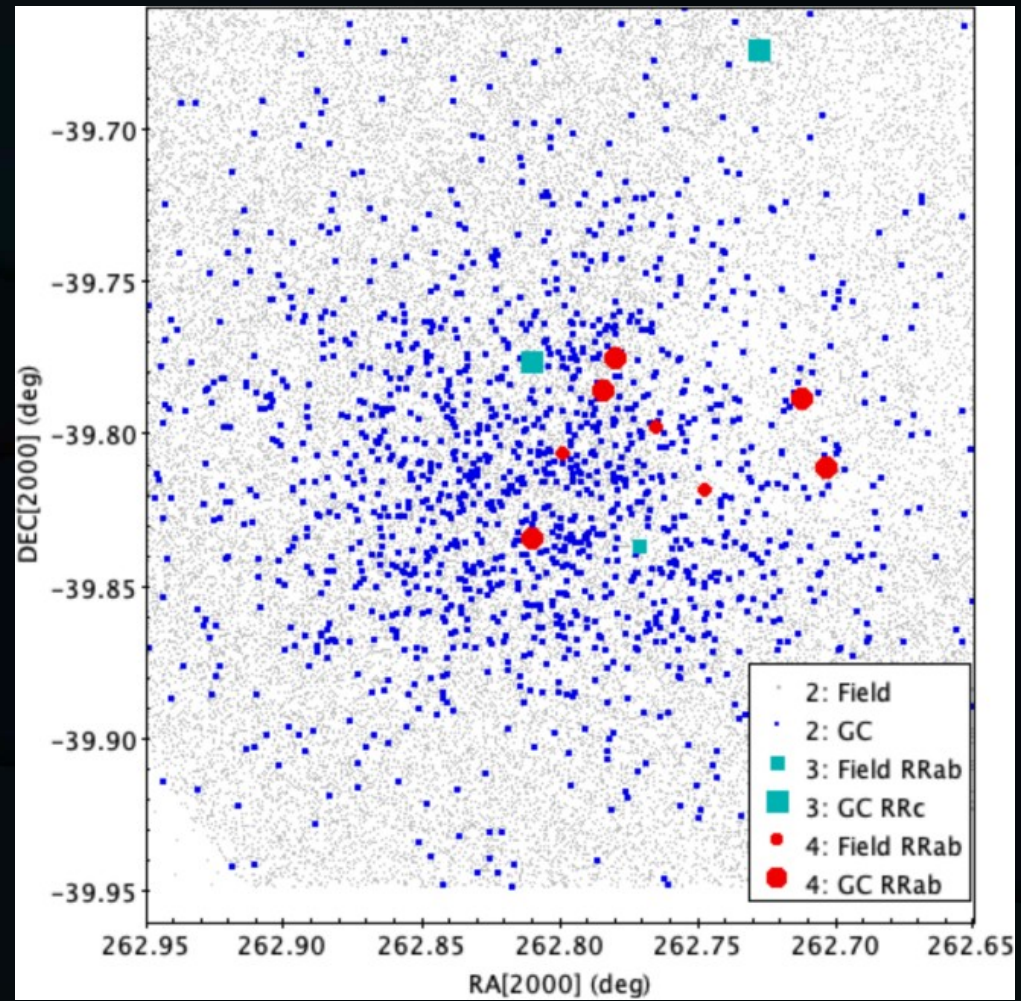
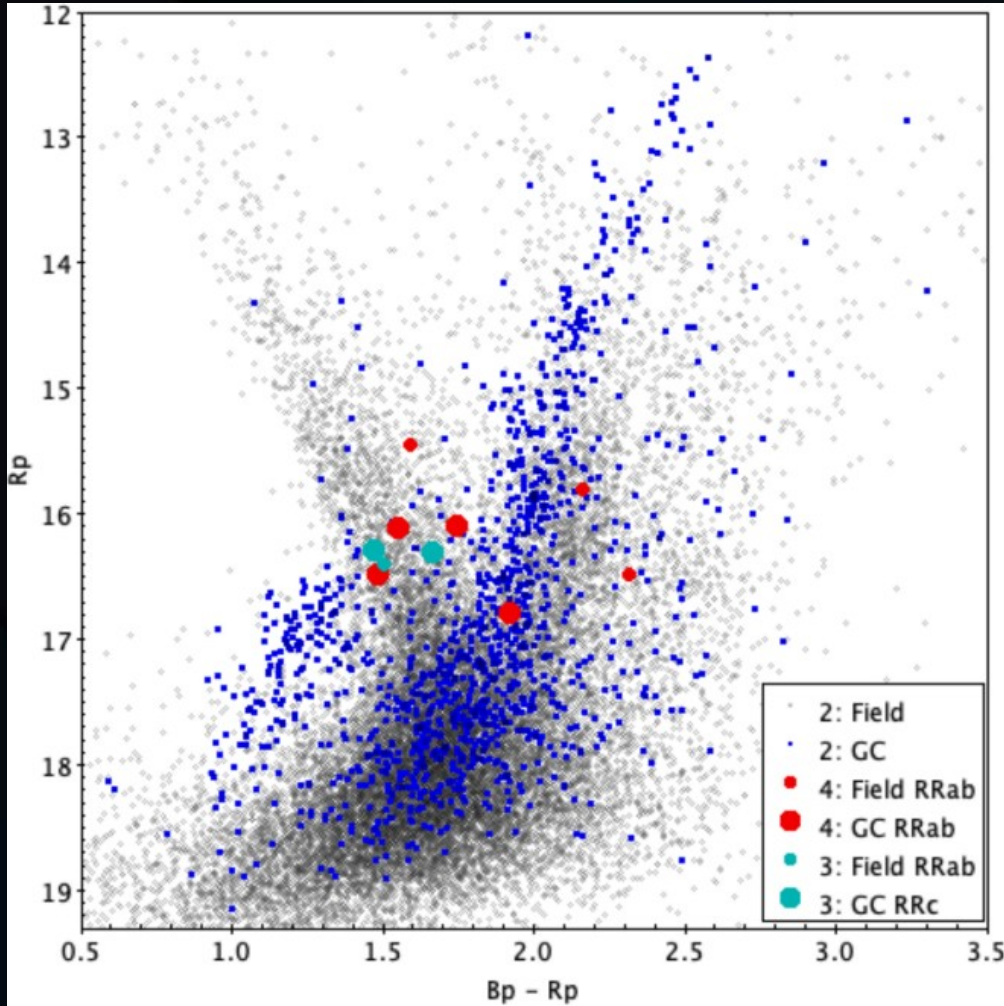
# Gaia's game + OGLE



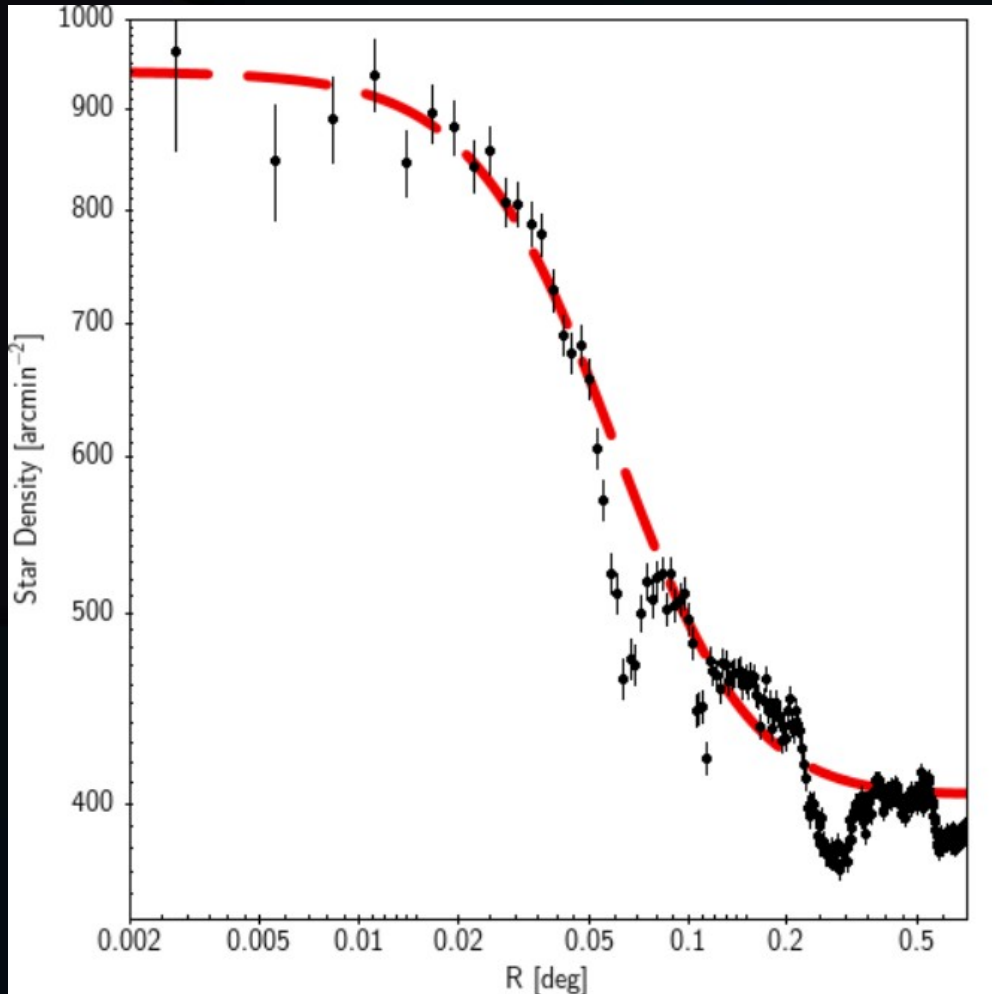
- PM plot, selection  
 $\mu_{\alpha} = -2.85 \text{ mas/a}$   
 $\mu_{\delta} = 2.55 \text{ mas/a}$
- Cantat-Gaudin et al. (2018) also detected this structure in Gaia's properties of 1229 clusters
- RR Lyr stars
- 5 RR-ab stars  $\langle P \rangle = 0.684 \text{ d}$
- Oosterhoff II  $\rightarrow$  metal-poor GC
- $D = 10.1 \pm 1.0 \text{ kpc}$



# Gaia's game + OGLE

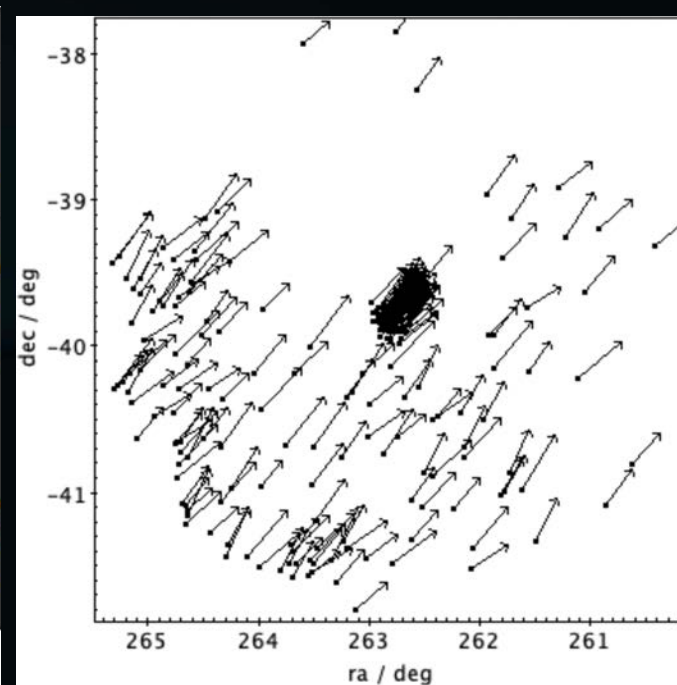
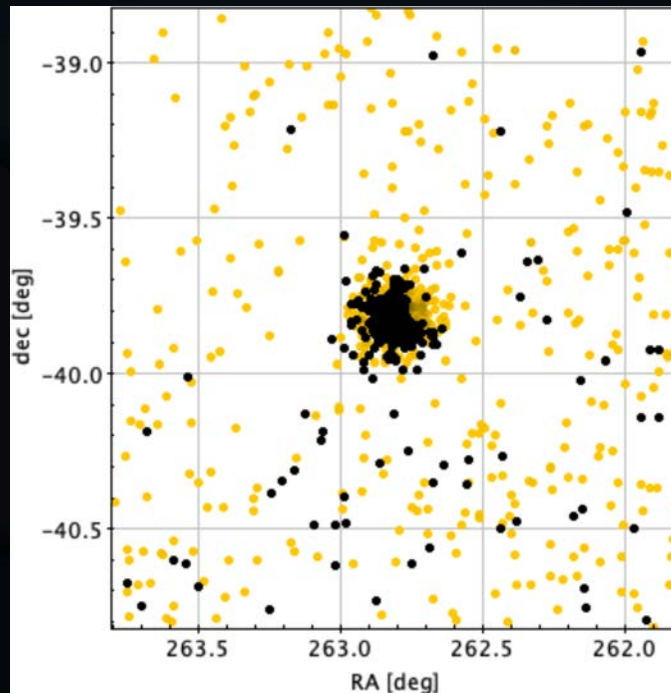
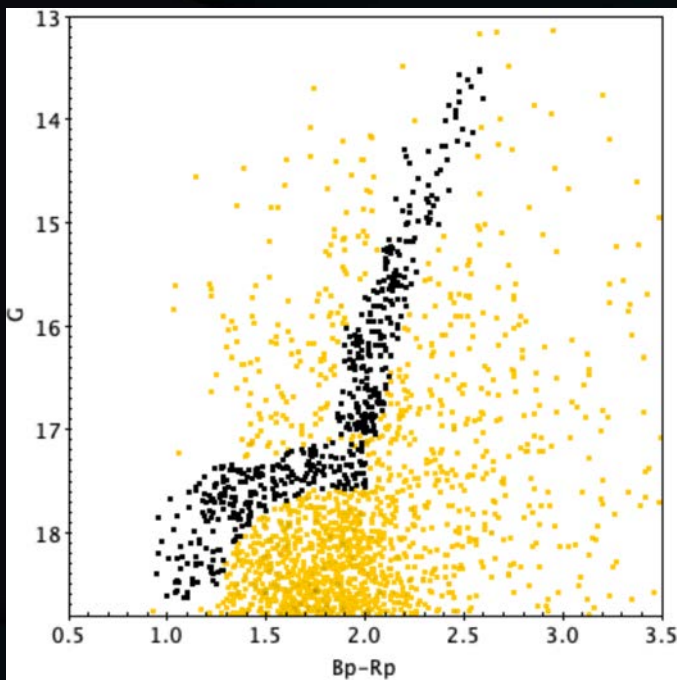


# DECaPS



- King's profile, i-band
  - Core radius: 3' +/- 0.2'
  - Tidal radius: 45' +/- 12'
  - $R_c = 10 \pm 1$  pc
  - $R_t = 150 \pm 40$  pc
- Concentration index: 1.2
  - Typical of GC.
- Luminosity  $M_i < -8.5$
- Very extended, similar to omega Cen

# Gaia's game



GDR2 PM selected stars show an extended tidal tail with similar PMs

RGB and BHB stars are highlighted in black.

# Other GCs in the area

CDS/P/DECaPS/DR1/color

NGC 6380

FSR 1758

Comparison with GC in the area:

NGC 6380, separation  $0.8^\circ$ , but more metal-rich  $[\text{Fe}/\text{H}] = -0.8$  dex, but similar Heliocentric distance.

Ton 2, separation  $1.4^\circ$ , again  $[\text{Fe}/\text{H}] = -0.7$ , closer  $D = 8.2$  kpc.

15'

$1.251^\circ \times 48.4'$



# Conclusions

Large, distinctive stellar structure identified in DECaPS, VVVX images, and GDR2 data.

CMDs produced with DECaPS and VVVX photometry show clear signature of a large metal-poor cluster, with prominent RGB and extended blue BHB.

Estimated heliocentric distance of about 11.0 kpc,  $D_{gal} = 3.7$  kpc,  $z = -0.75$  kpc (from RRab, BHB-RGBb)

Metal-poor  $[Fe/H] = -1.5 \pm 0.3$

$R_c = 10 \pm 1$  pc,  $R_t = 150 \pm 40$  pc,  $c = 1.2$  (typical for GCs)

GDR2 PM selected stars show an extended tidal tail.

FSR 1758 is not related to other GC in the area.

Luminosity, i-band  $M_i < -8.5$ , large size competing with  $\omega$  Cen  $\rightarrow$  very bright GC or dwarf galaxy (Scorpius).

