VISTA VARIABLES IN THE VIA LACTEA

CMDs

Dante Minniti &
VVV Science Team

The VVV Science Team

R. K. Saito[1], M. Hempel[1], D. Minniti[1,2,3], P. W. Lucas[4], M. Rejkuba[5], I. Toledo[6], O. A. Gonzalez[5], J. Alonso-García[1], M. J. Irwin[7], E. Gonzalez-Solares[7], S. T. Hodgkin[7], J. R. Lewis[7], N. Cross[8], V. D. Ivanov[9], E. Kerins[10], J. P. Emerson[11], M. Soto[12], E. B. Amôres[13,14], S. Gurovich[15], I. Dékány[1], R. Angeloni[1], J. C. Beamin[1], M. Catelan[1], N. Padilla[1,16], M. Zoccali[1,17], P. Pietrukowicz[18], C. Moni Bidin[19], F. Mauro[19], D. Geisler[19], S. L. Folkes[20], S. E. Sale[1,20], J. Borissova[20], R. Kurtev[20], A. V. Ahumada[9,15,21], M. V. Alonso[15], A. Adamson[22], J. I. Arias[12], R. M. Bandyopadhyay[23], R. H. Barbá[12,24], B. Barbuy[25], G. L. Baume[26], L. R. Bedin[27], R. Benjamin[28], E. Bica[29], C. Bonatto[29], L. Bronfman[30], G. Carraro[9], A. N. Chenè[19,20], J. J. Clariá[15], J. R. A. Clarke[20], C. Contreras[4], A. Corvillón[1], R. de Grijs[31,32], B. Dias[25], J. E. Drew[4], C. Fariña[26], C. Feinstein[26], E. Fernández-Lajús[26], R. C. Gamen[26], W. Gieren[19], B. Goldman[33], C. González-Fernández[34], R. J. J. Grand[35], G. Gunthardt[15], N. C. Hambly[8], M. M. Hanson[36], K. Helminiak[1], M. G. Hoare[37], L. Huckvale[10], A. Jordán[1], K. Kinemuchi[38], A. Longmore[39], M. López-Corredoira[34,40], T. Maccarone[41], D. Majaess[42], E. Martín[34], N. Masetti[43], R. E. Mennickent[19], I. F. Mirabel[44,45], L. Monaco[9], L. Morelli[46], V. Motta[20], T. Palma[15], M. C. Parisi[15], Q. Parker[47,48], F. Peñaloza[20], G. Pietrzyński[18,19], G. Pignata[49], B. Popescu[36], M. A. Read[8], A. Rojas[1], A. Roman-Lopes[12], M. T. Ruiz[30], I. Saviane[9], M. R. Schreiber[20], A. C. Schröder[50,51], S. Sharma[20,52], M. D. Smith[53], L. Sodré Jr.[25], J. Stead[37], A. W. Stephens[54], M. Tamura[55], C. Tappert[20], M. A. Thompson[4], E. Valenti[5], L. Vanzi[16,56], N. A. Walton[7], W. Weidmann[15], and A. Zijlstra[10]

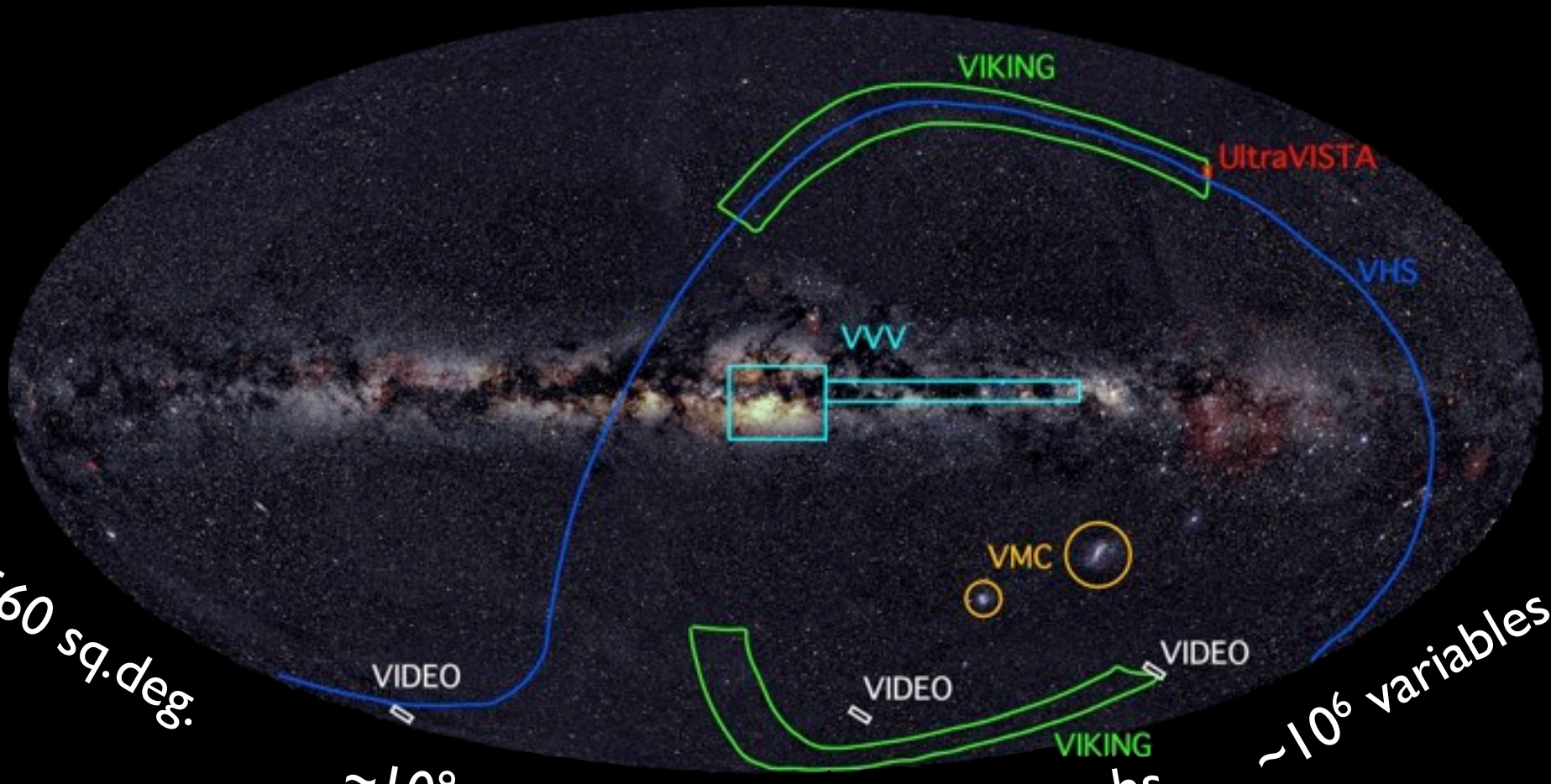
VISTA Telescope

- 4m diameter
- IR optimized
- large field

vvvsurvey.org

VISTA PUBLIC SURVEYS
VISTA VARIABLES IN THE VIA LACTEA

VVV

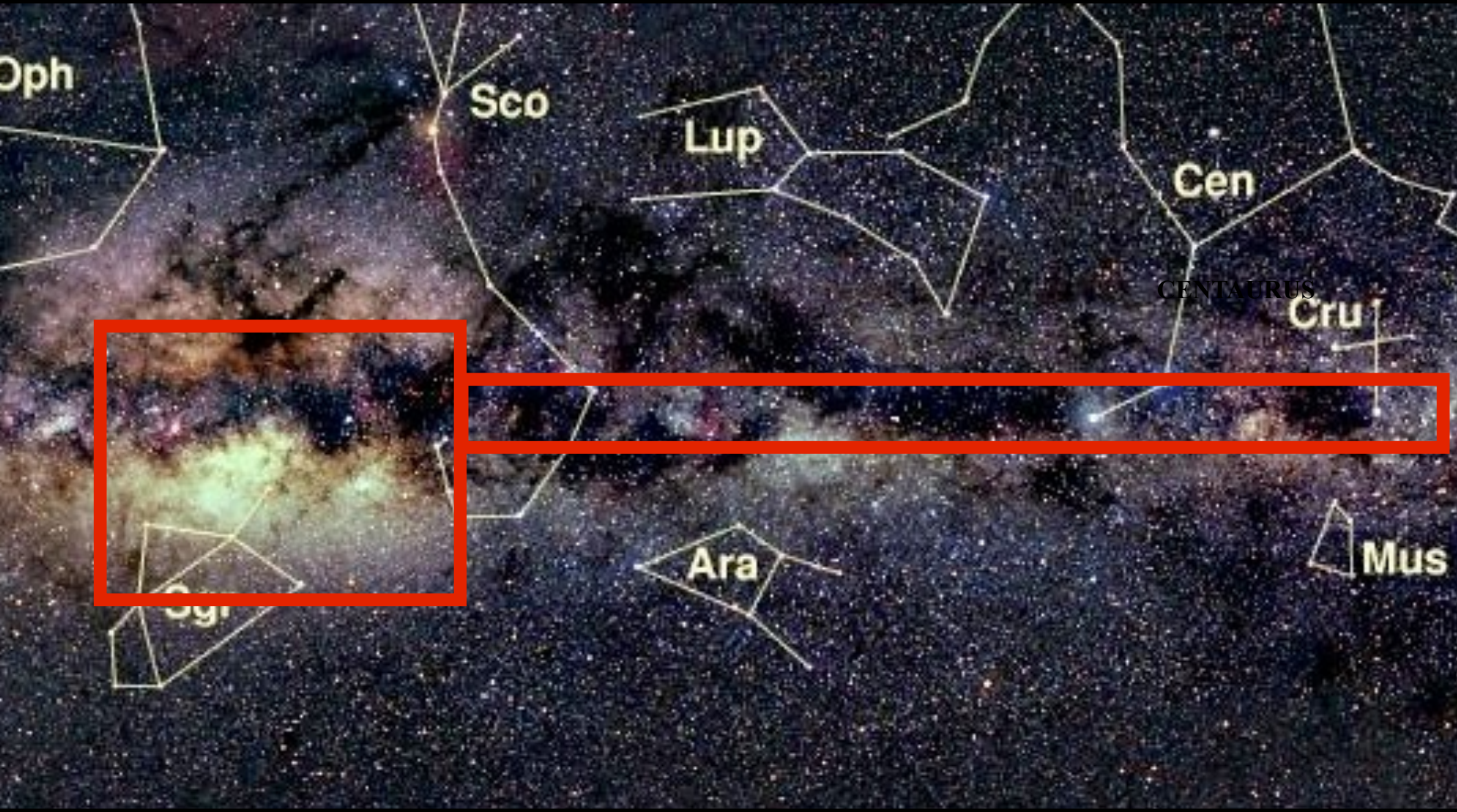


560 sq.deg.

~10^9 stars

~100 epochs

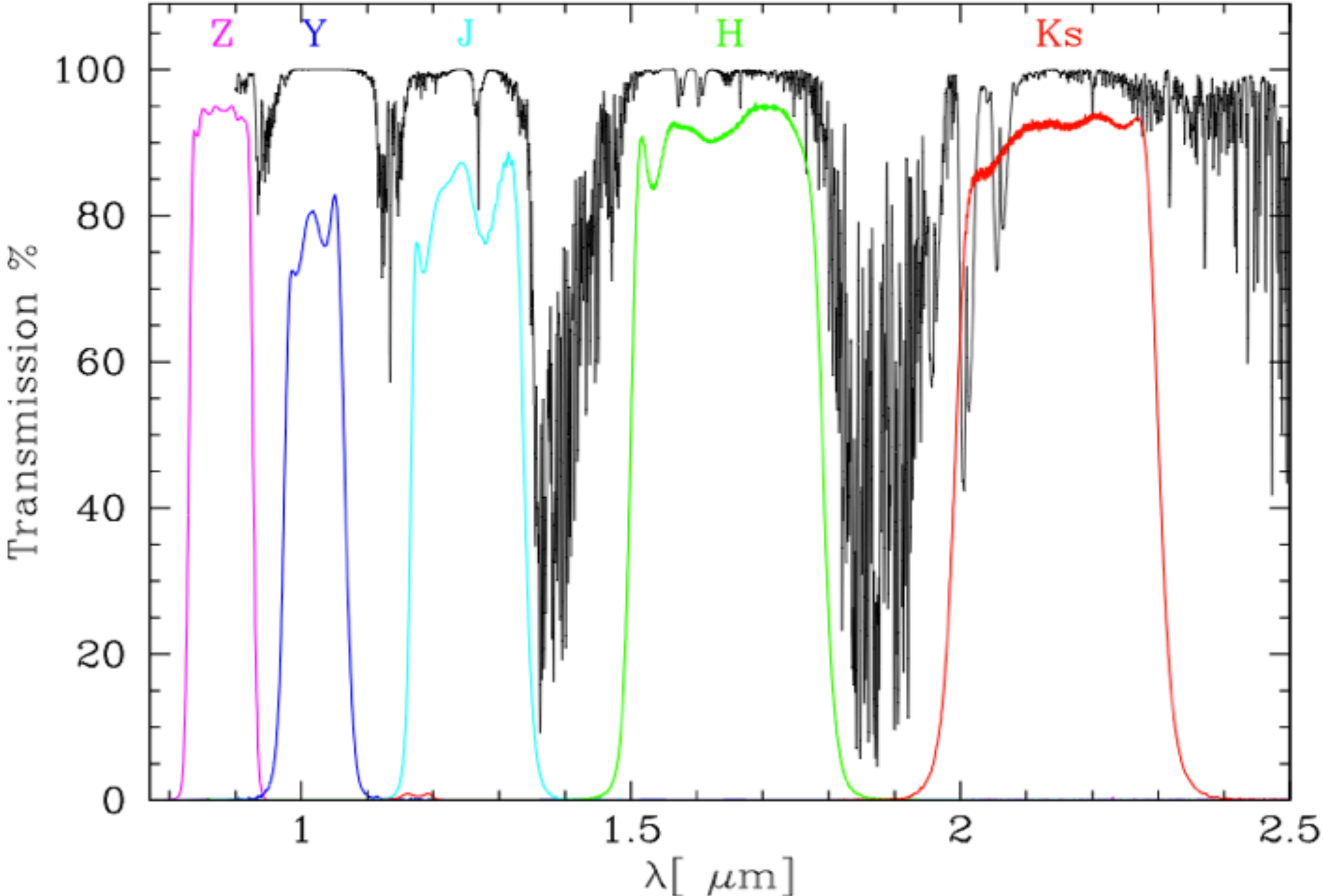
~10^6 variables



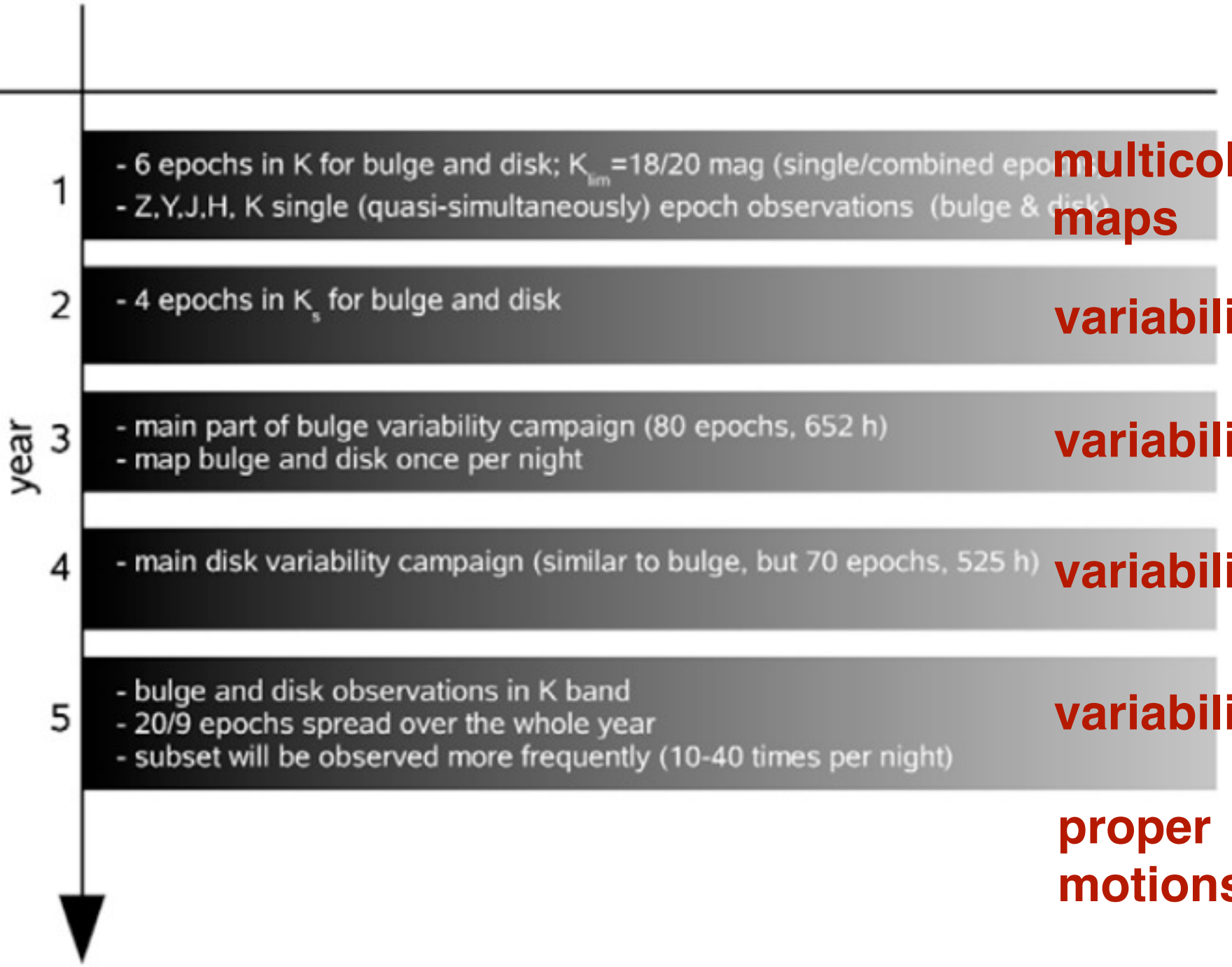
Bulge: $-10.0^\circ < l < +10.4^\circ$; $-10.3^\circ < b < +5.1^\circ$

Disk: $-65.3^\circ < l < -10.0^\circ$; $-2.25^\circ < b < +2.25^\circ$

VISTA filter transmissions



The VVV Survey: Timeline



The VVV Stages

Multicolor Photometry: ZYJHKs

Star clusters, stellar pops, extinction, metallicities, galaxies...

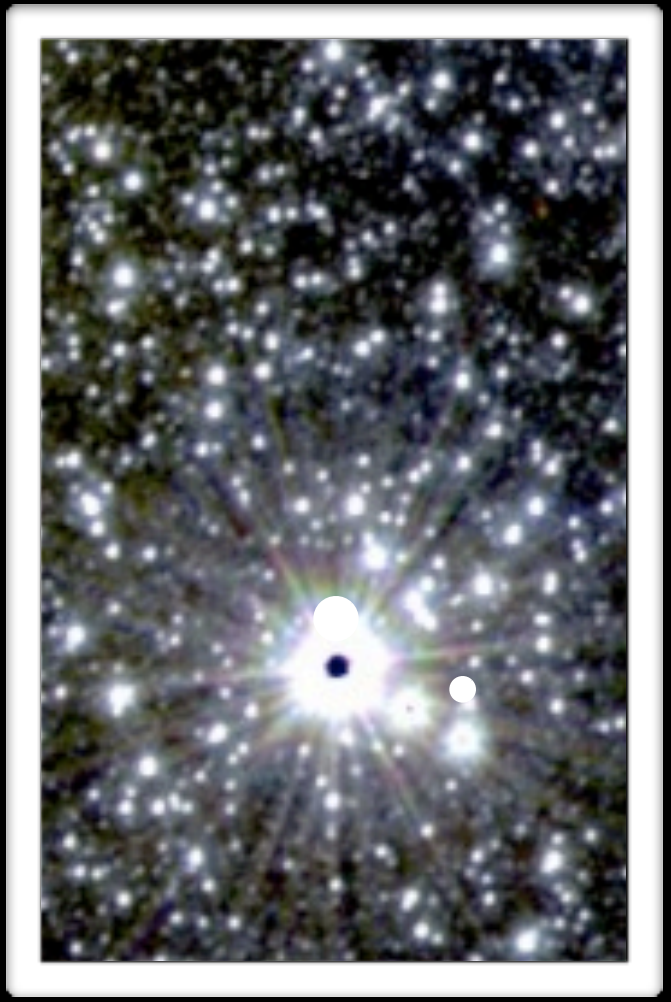
Variability: Ks

LPVs, Cepheids, RR Lyrae, Binaries, Novae, Microlensing...

Proper Motions: Ks

Nearby stars, BDs, WDs, Asteroids, Hyper-Velocity Stars...

DEEPER AND HIGHER RESOLUTION



Main differences with 2MASS

2MASS covers the whole sky, VVV only 1.3%

VVV has higher resolution (0.34”/pix)

VVV is deeper (Ks<18)

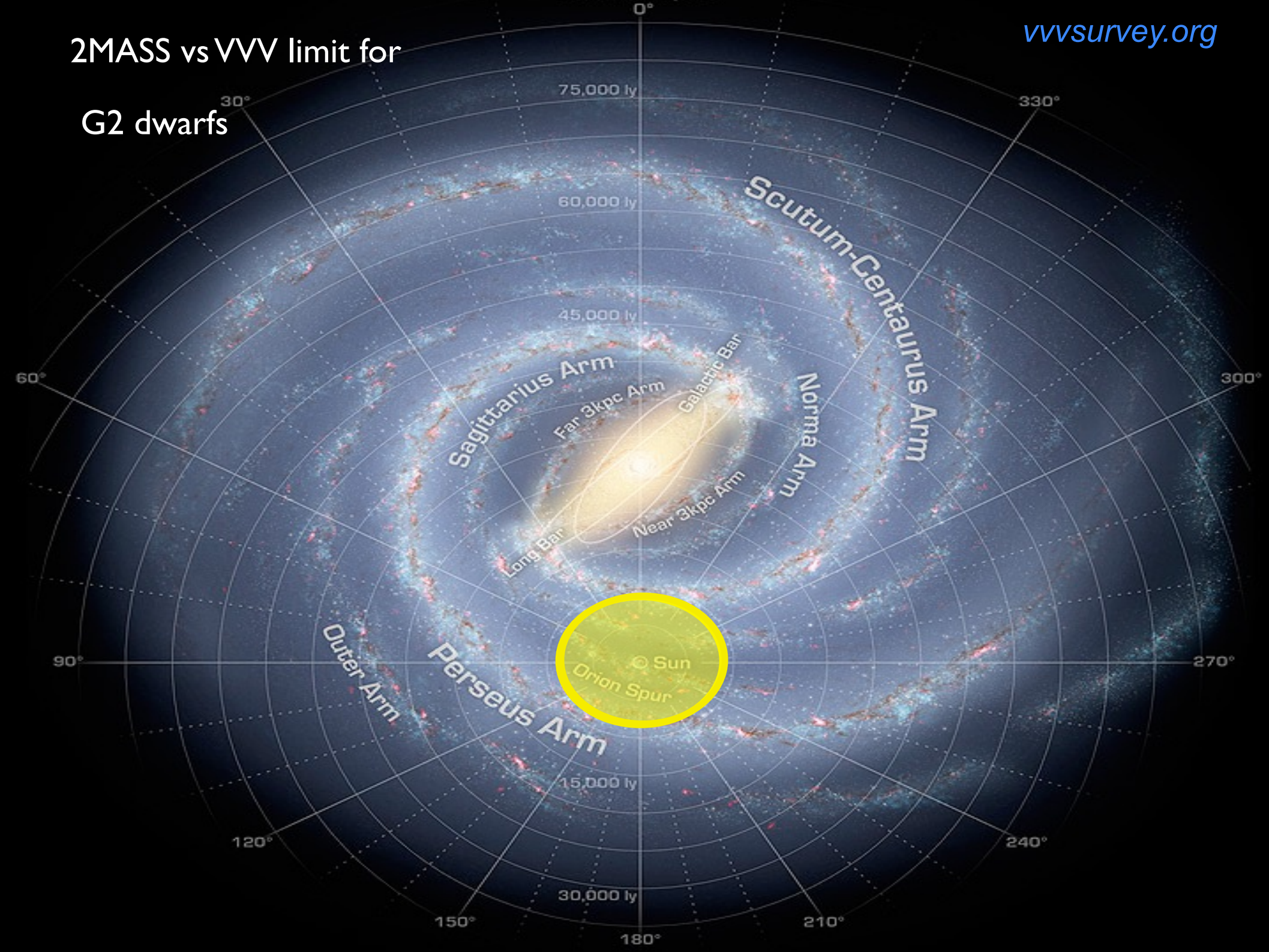
VVV has 5 filters (ZYJHKs)

VVV is a multiepoch survey (~100 epochs)

2MASS vs VVV limit for

G2 dwarfs

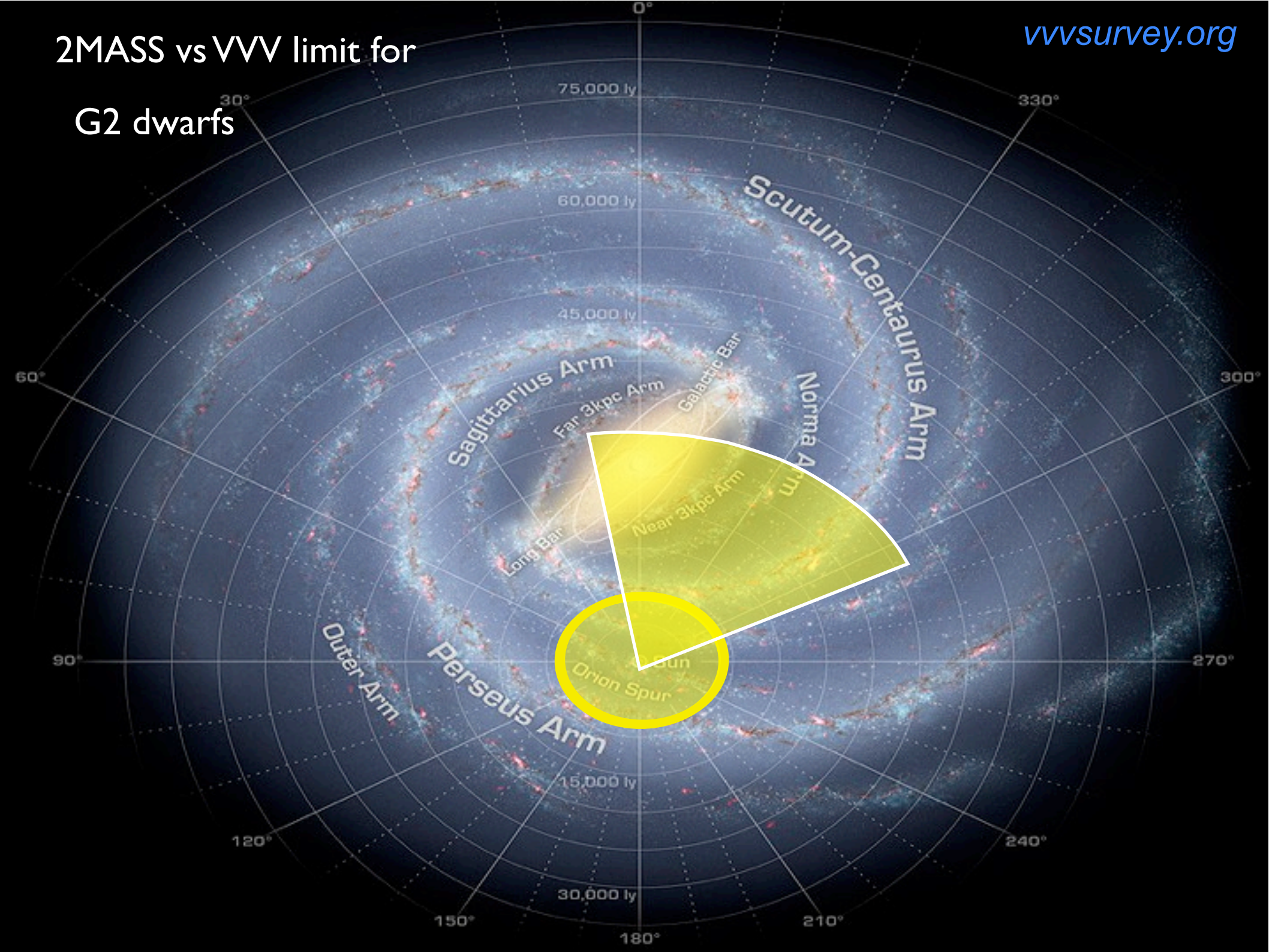
vvvsurvey.org

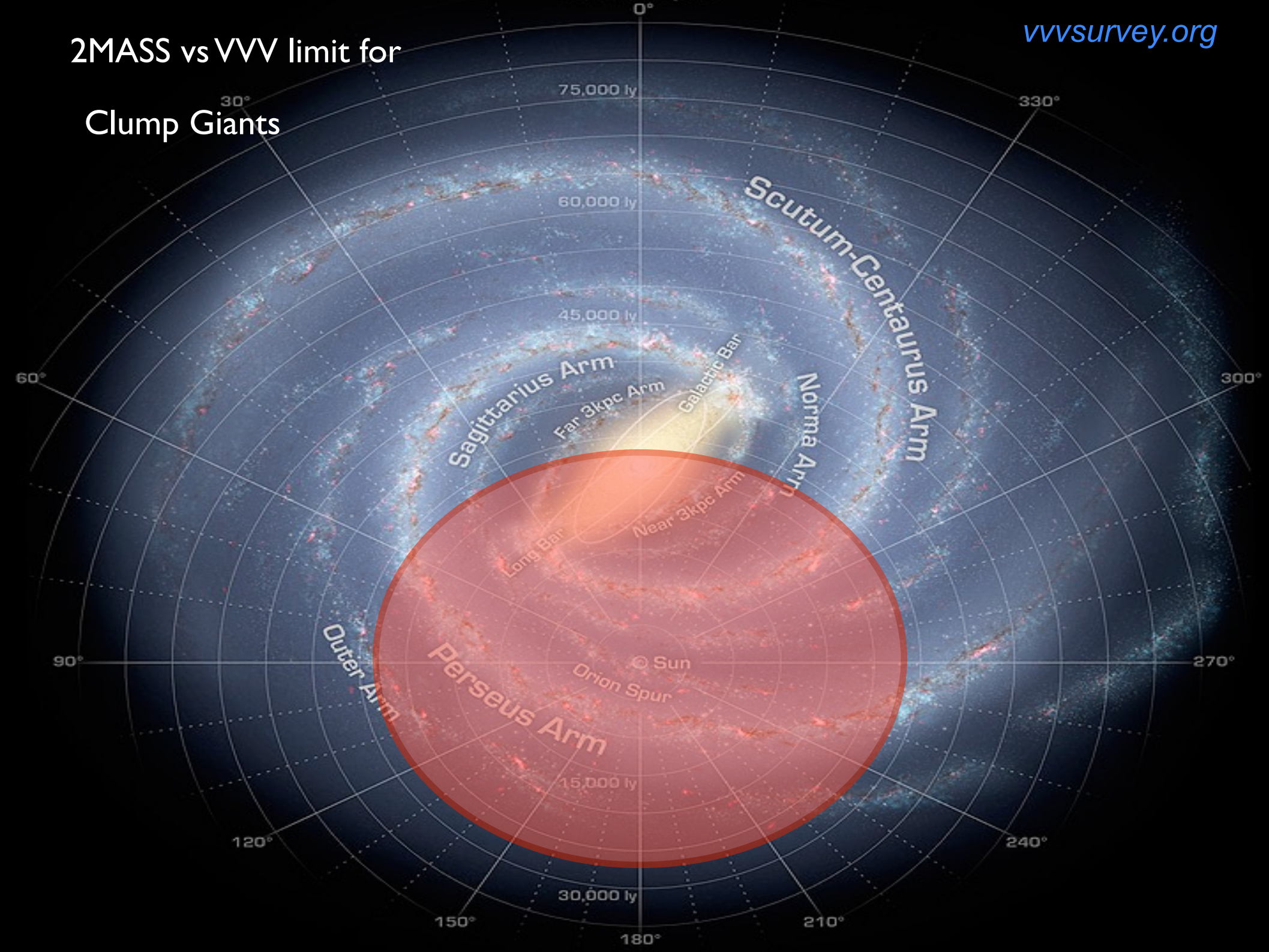


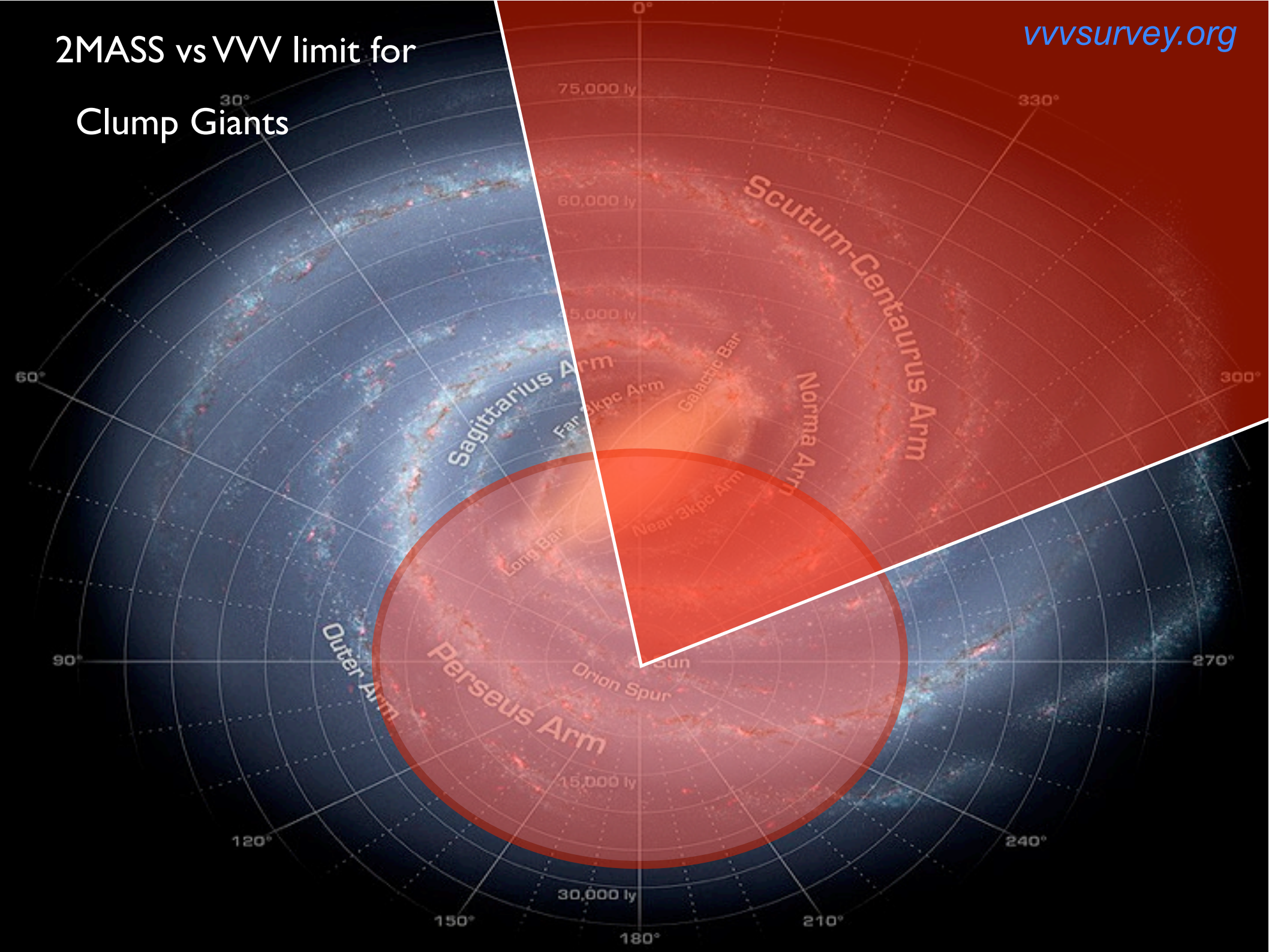
2MASS vs VVV limit for

G2 dwarfs

vvvsurvey.org

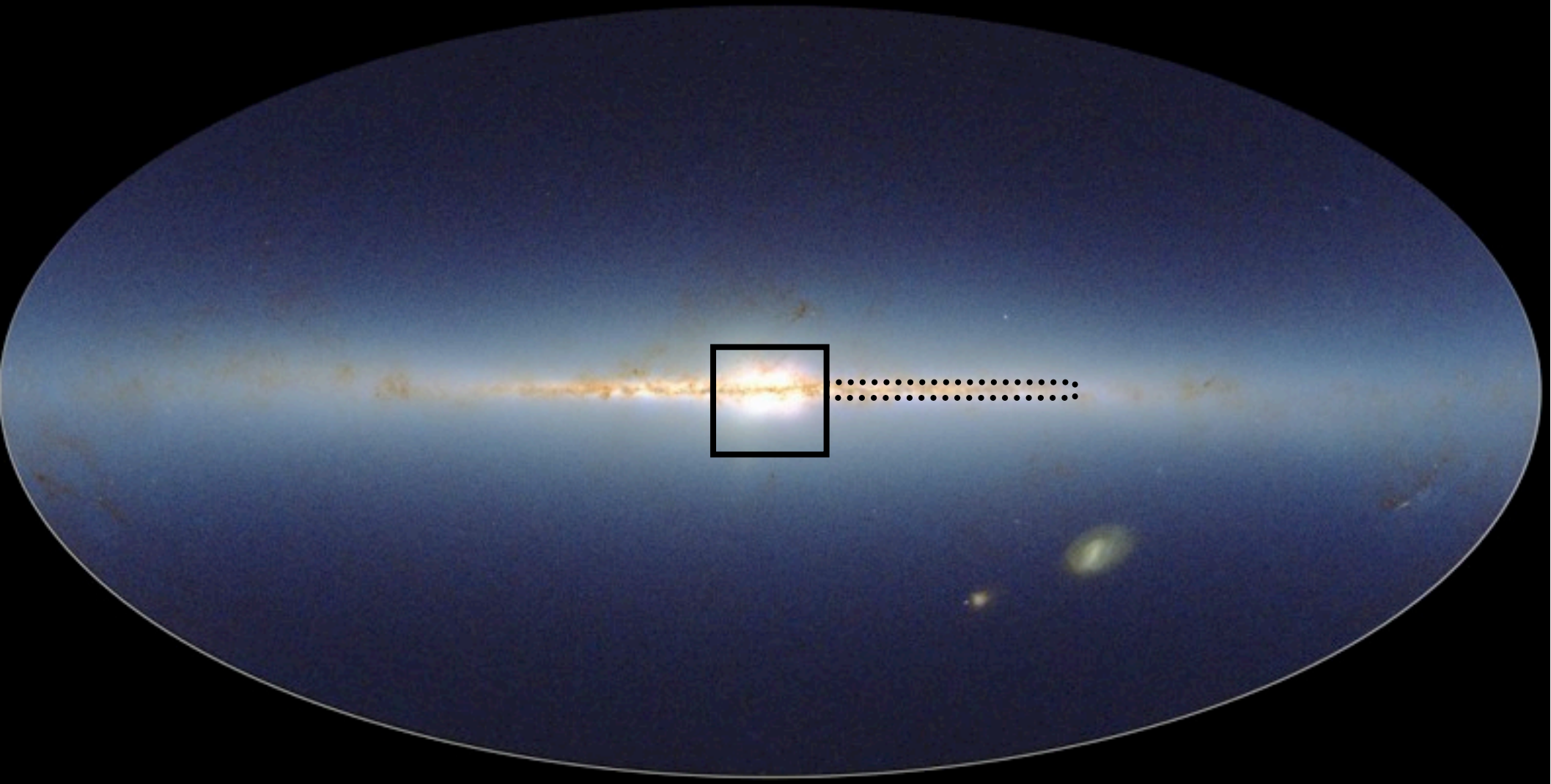



2MASS vs VVV limit for
Clump Giants
vvvsurvey.org
0°
30°
330°
60°
300°
90°
270°
120°
240°
150°
210°
180°
75,000 ly
60,000 ly
45,000 ly
30,000 ly
15,000 ly
Scutum-Centaurus Arm
Sagittarius Arm
Far 3kpc Arm
Galactic Bar
Norma Arm
Near 3kpc Arm
Long Bar
Outer Arm
Perseus Arm
Sun
Orion Spur


2MASS vs VVV limit for
Clump Giants
vvvsurvey.org
Scutum-Centaurus Arm
Sagittarius Arm
Perseus Arm
Outer Arm
Norma Arm
Galactic Bar
Long Bar
Near 3kpc Arm
Orion Spur
Sun
75,000 ly
60,000 ly
30,000 ly
15,000 ly
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°

The photo album of the
MW is not complete yet!!!

vvvsurvey.org



2MASS IMAGE OF THE MILKY WAY

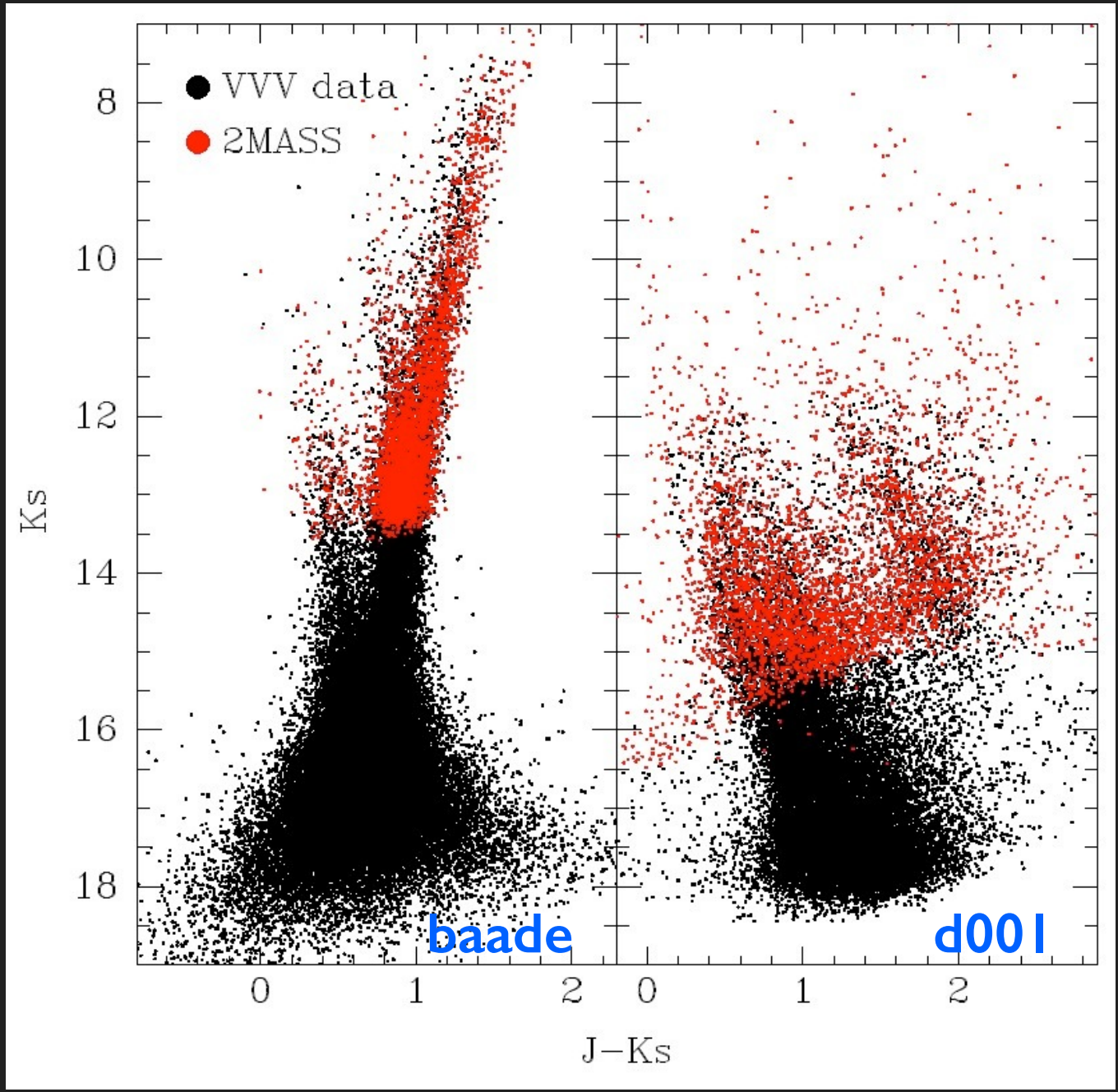
VVV Goal

What is the 3-D structure of the Milky Way

vvvsurvey.org

VVV CMDs

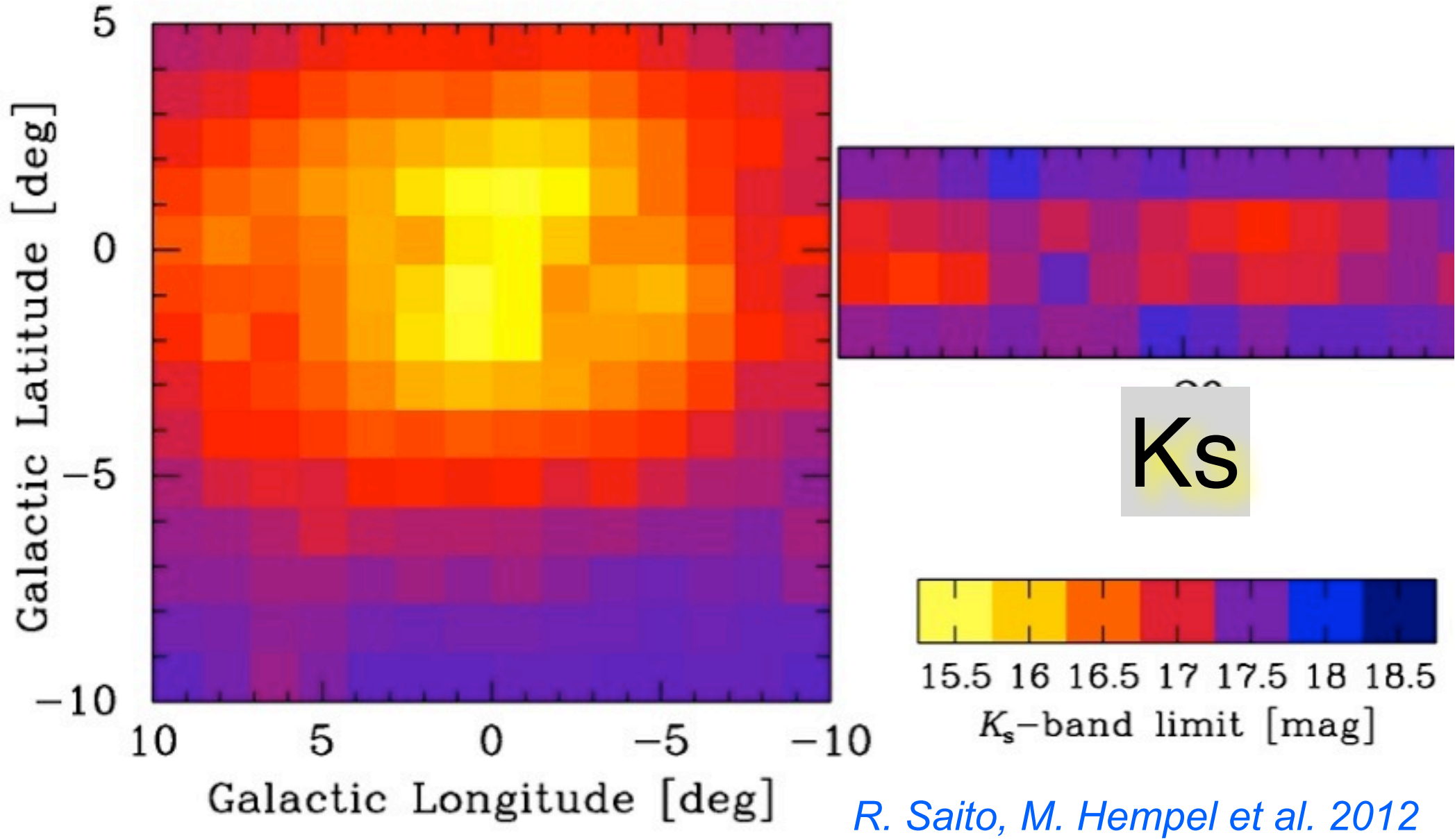
Color-magnitude diagrams of bulge and disk fields compared with 2MASS.



O. Gonzalez & J. Alonso-García

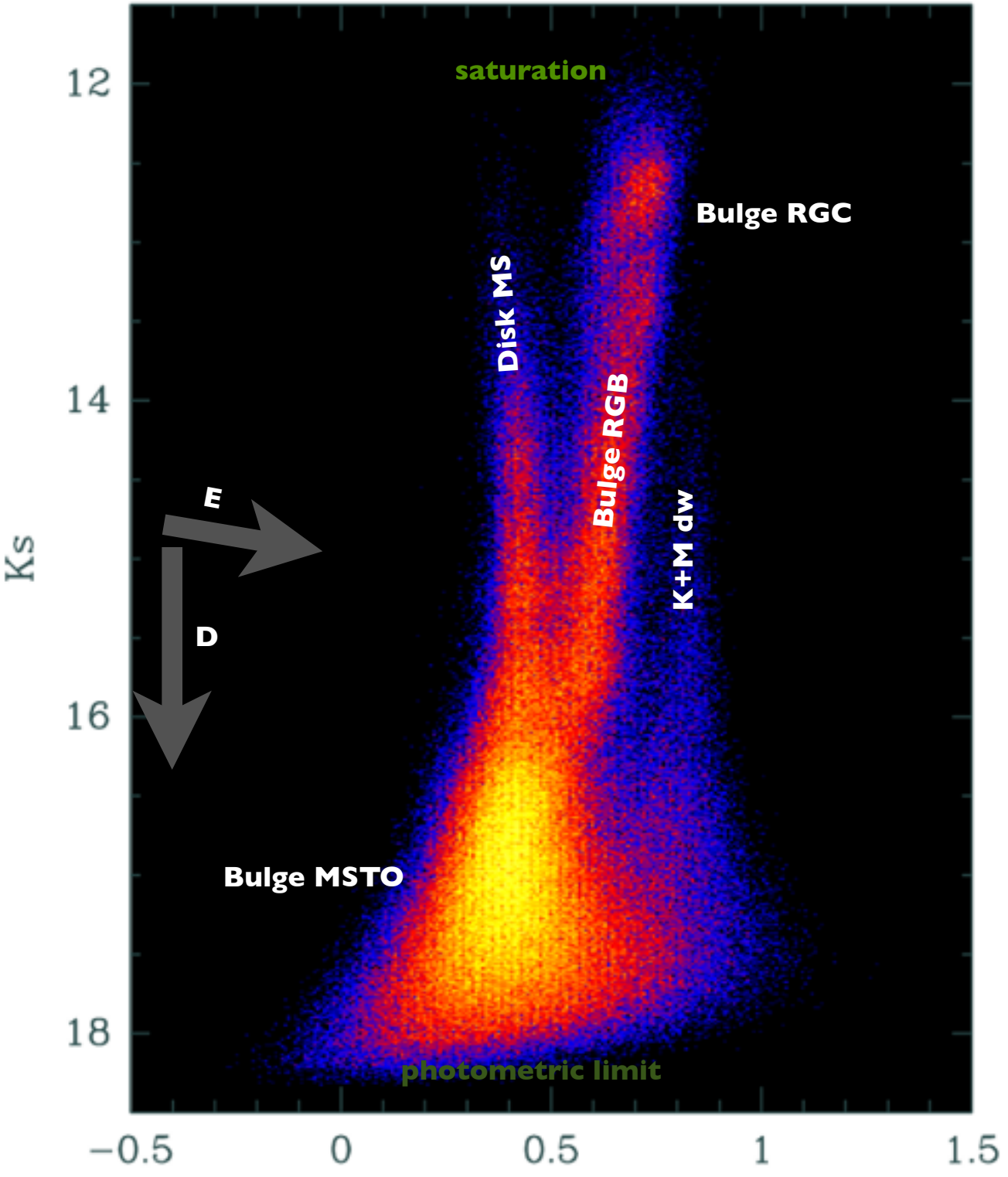
VVV limiting magnitudes

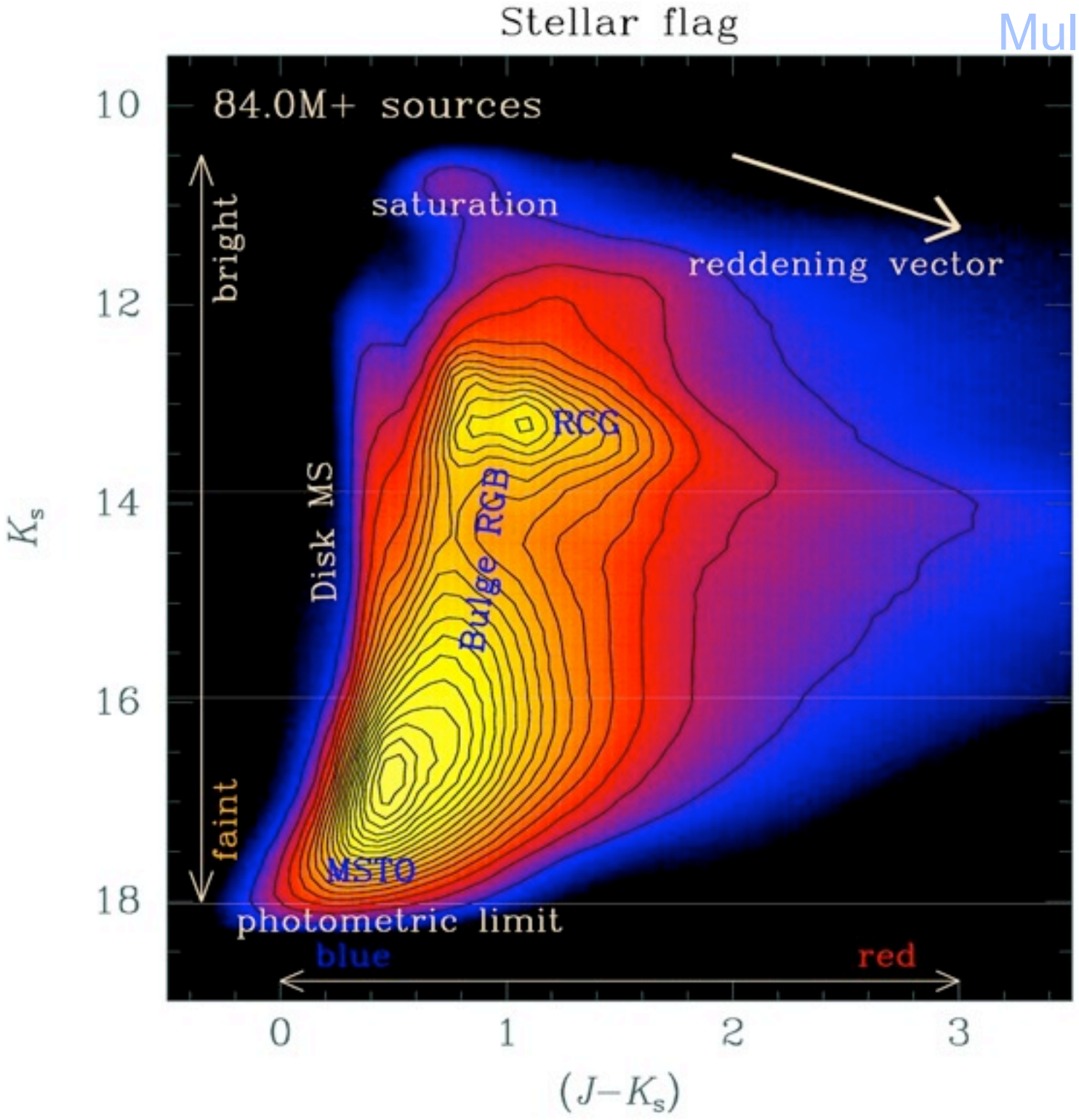
vvvsurvey.org



R. Saito, M. Hempel et al. 2012

VVV 0.3M SINGLE TILE BULGE CMD





VVV 84M STARS BULGE CMD

R. Saito et al. 2012

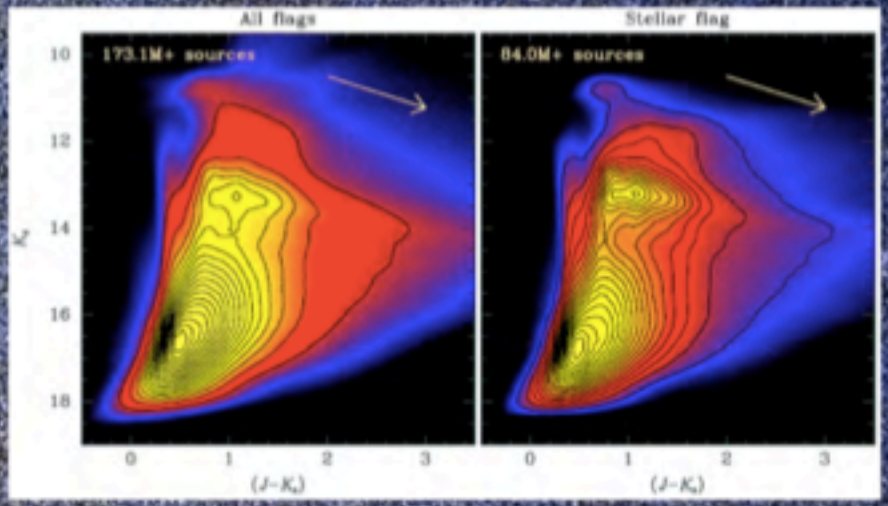
Discoveries

Globular Clusters
Open Clusters (incl. WR clusters)
Galactic Novae and other transients
Nearby Brown Dwarfs
Companions to Nearby Stars
Galaxies & Clusters in the Avoidance Zone
IR Counterparts of High Energy Sources
Candidate microlensing events
Candidate extrasolar planetary transits
Variable stars in clusters

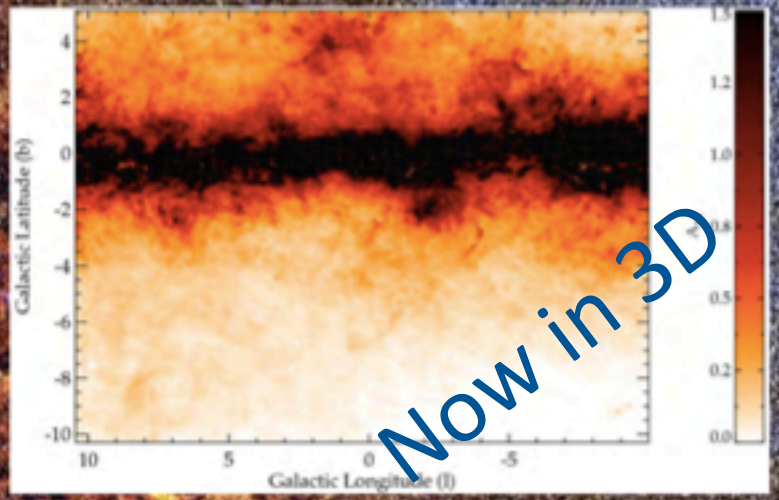
The Milky Way and the Local Group

Science highlights:

84M-star CMD for the inner Milky Way
(Saito et al. 2012, A&A, 545, A147)

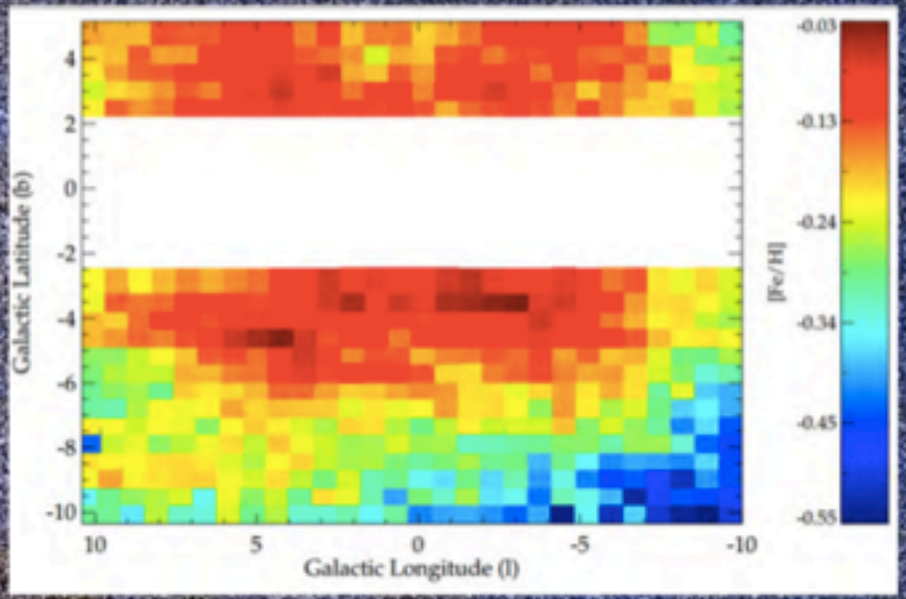


Reddening map for the inner Milky Way
(Gonzalez et al. 2012, A&A, 543, A13)

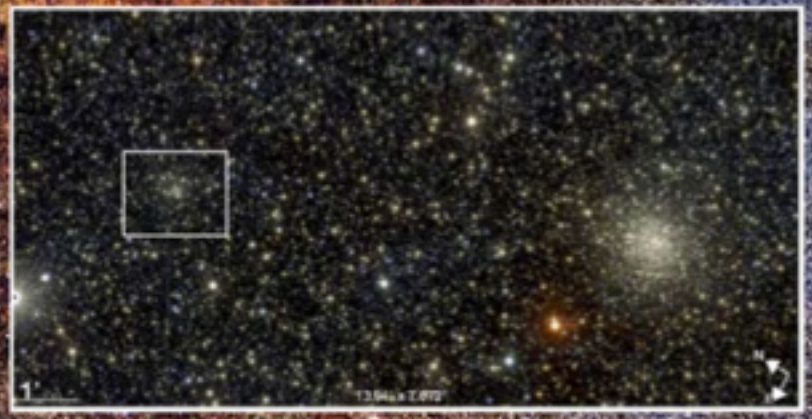


Now in 3D

Metallicity map for the Galactic bulge
(Gonzalez et al. 2013, A&A, 552, A110)



First new globular cluster discovery
(Minniti et al. 2011, A&A, 527, A81)



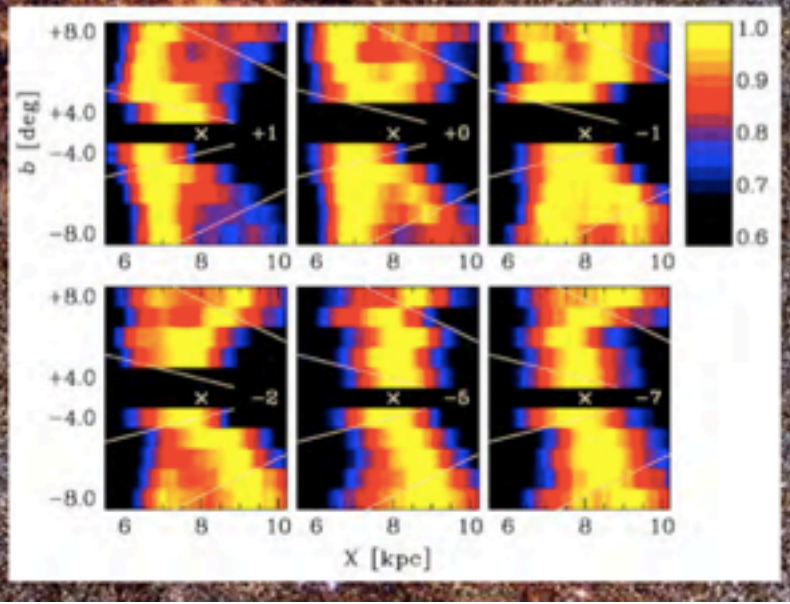
The Milky Way and the Local Group

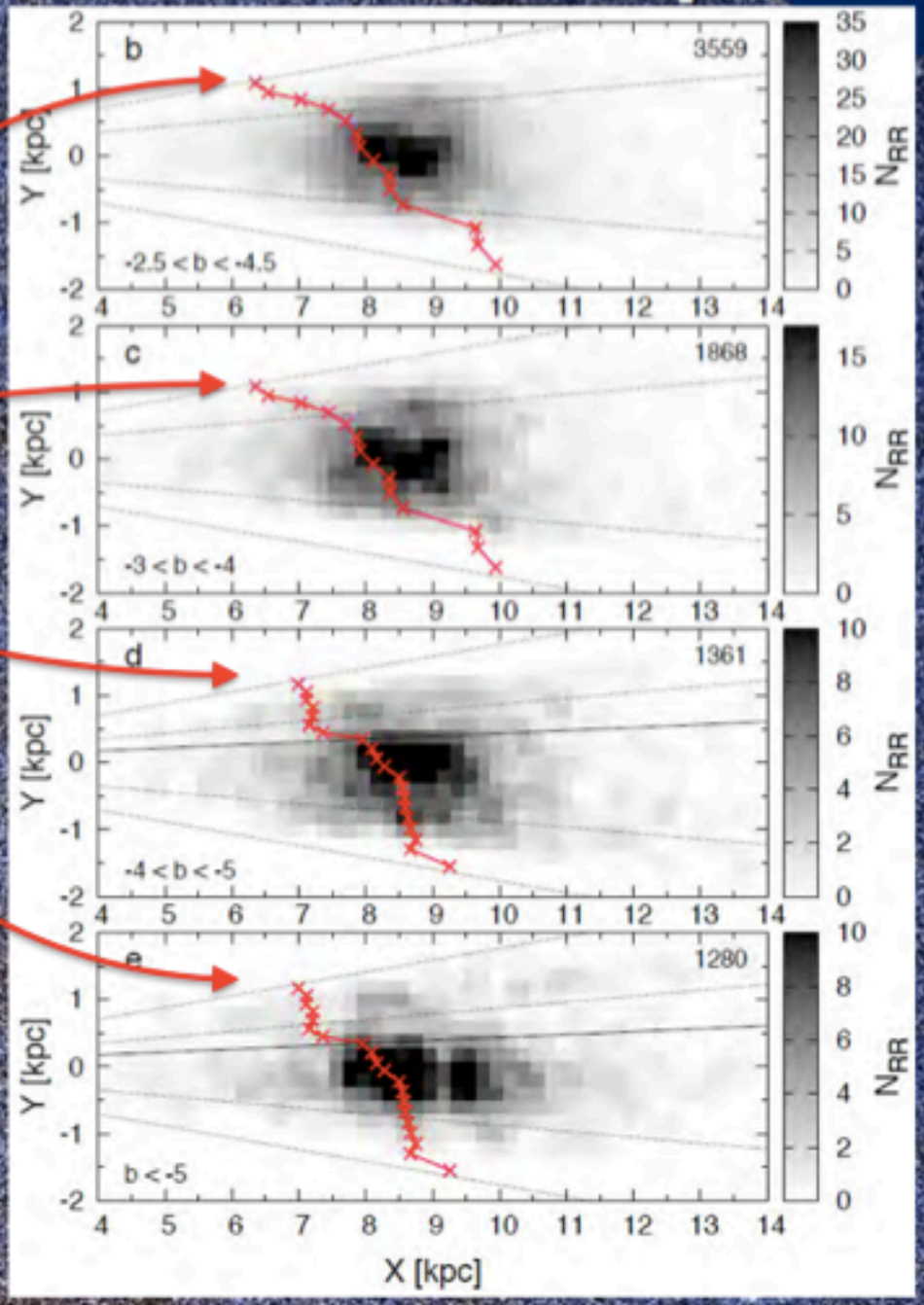
Dékány et al. (2013, ApJ Letters, 776, L19)

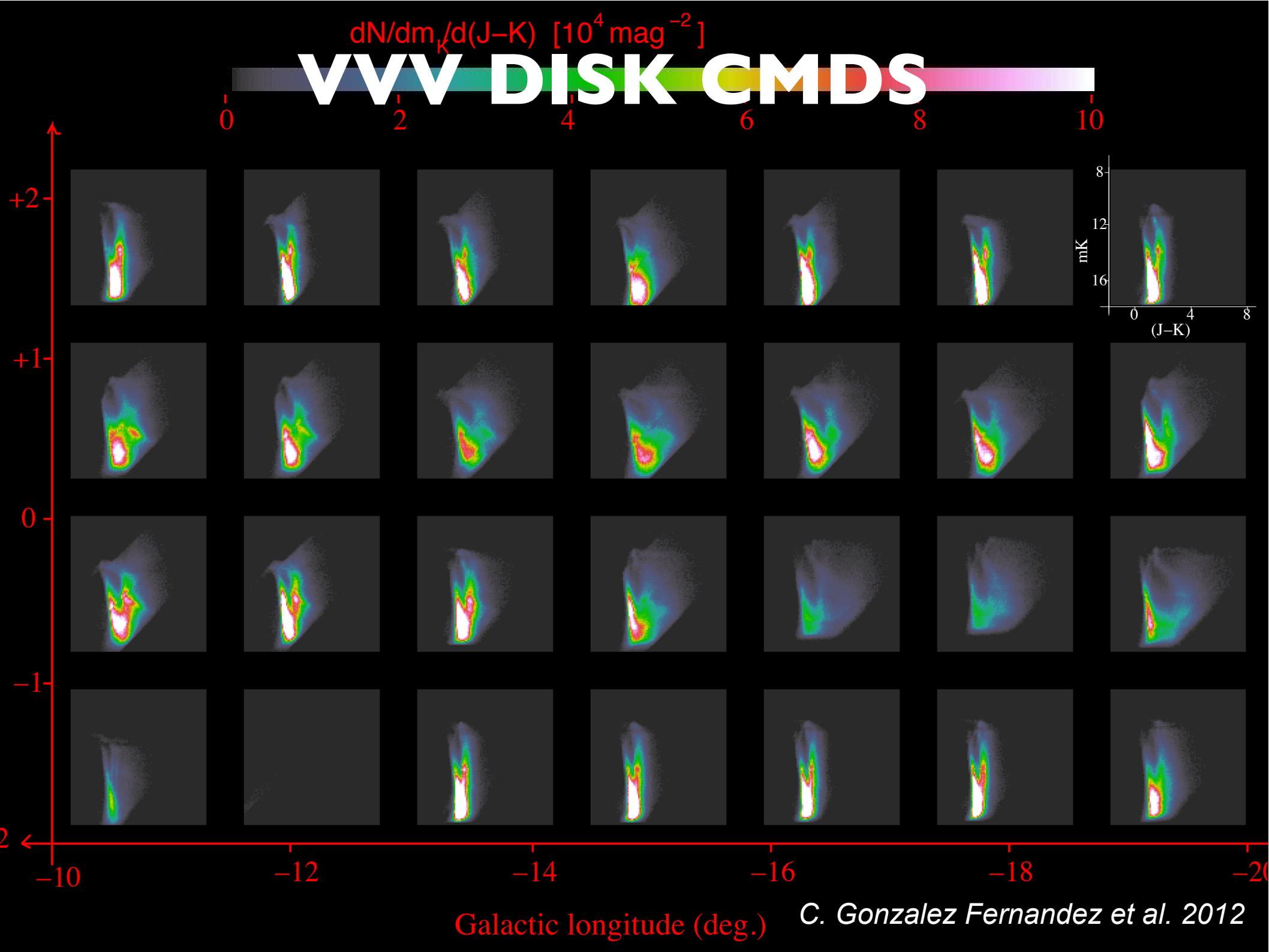
Science highlights:

Position of the long bar (Gonzalez et al. 2011, 2012)

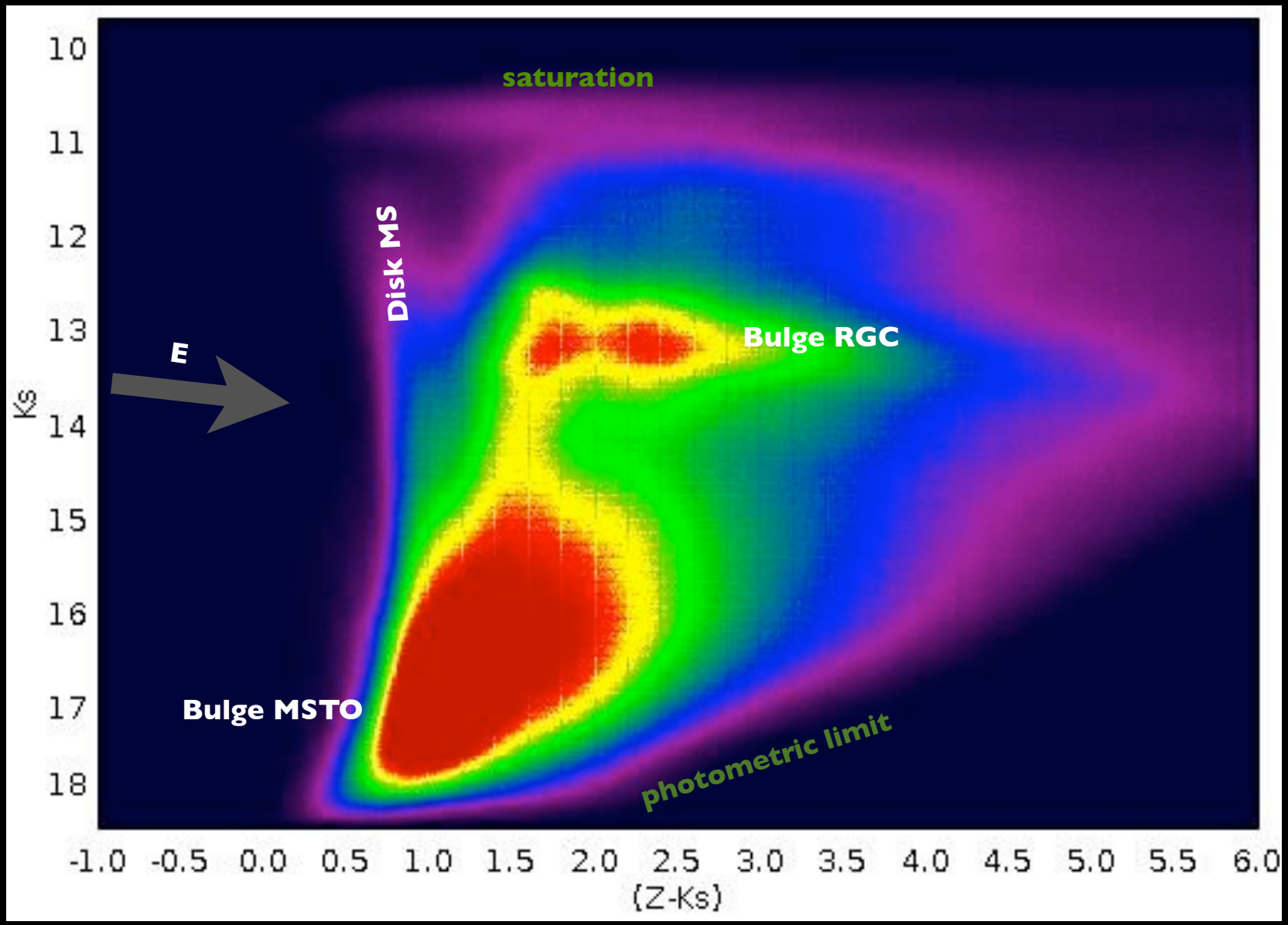
The X-shaped Galactic bulge (Saito et al. 2011, AJ, 142, 76)





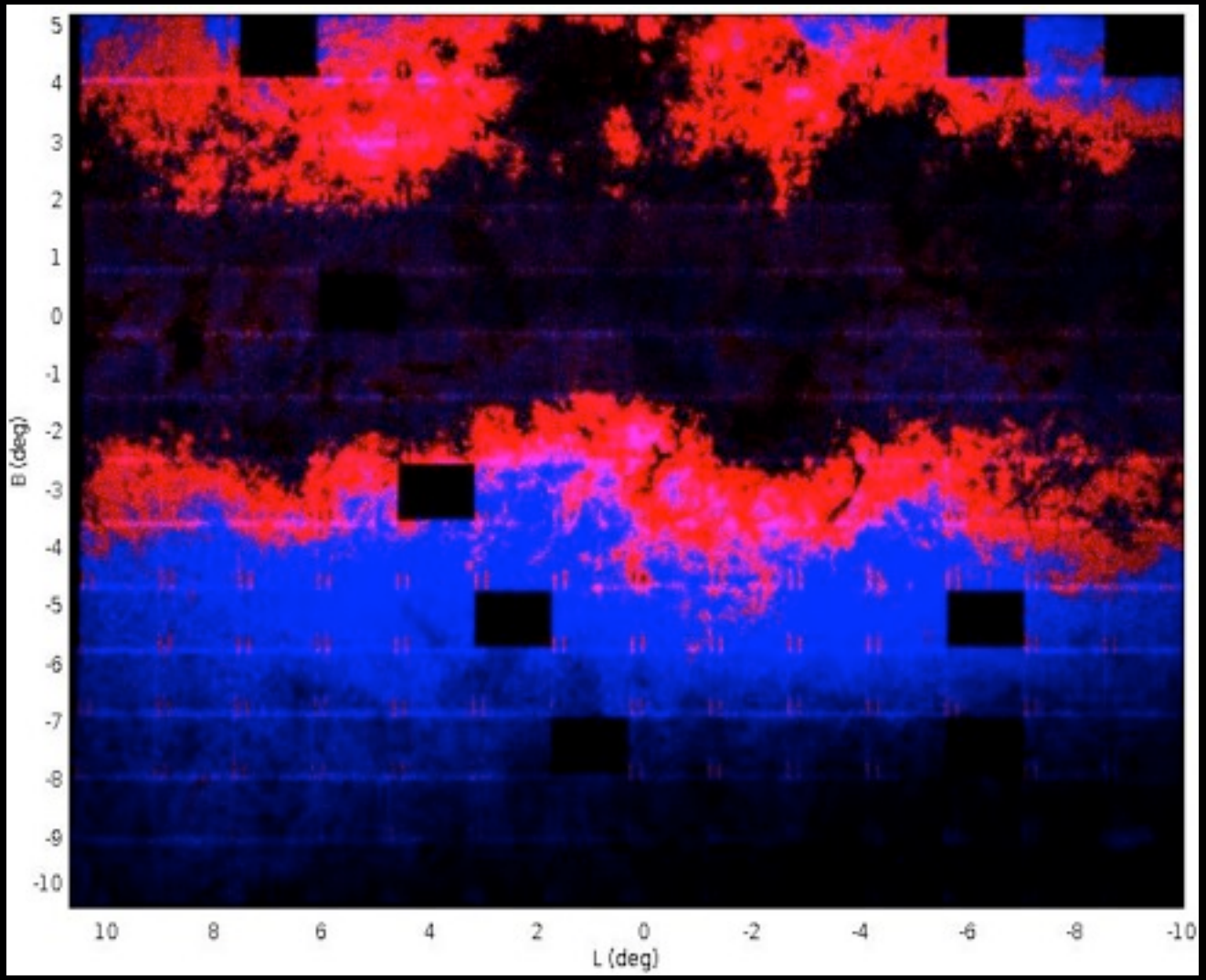

dN/dm_K/d(J–K) [10^4 mag^–2]
VVV DISK CMDS
0
2
4
6
8
10
+2
+1
0
–1
–2
–10
–12
–14
–16
–18
–20
mK
8
12
16
0
4
8
(J–K)
Galactic longitude (deg.)
C. Gonzalez Fernandez et al. 2012

VVV 157M STARS BULGE CMD



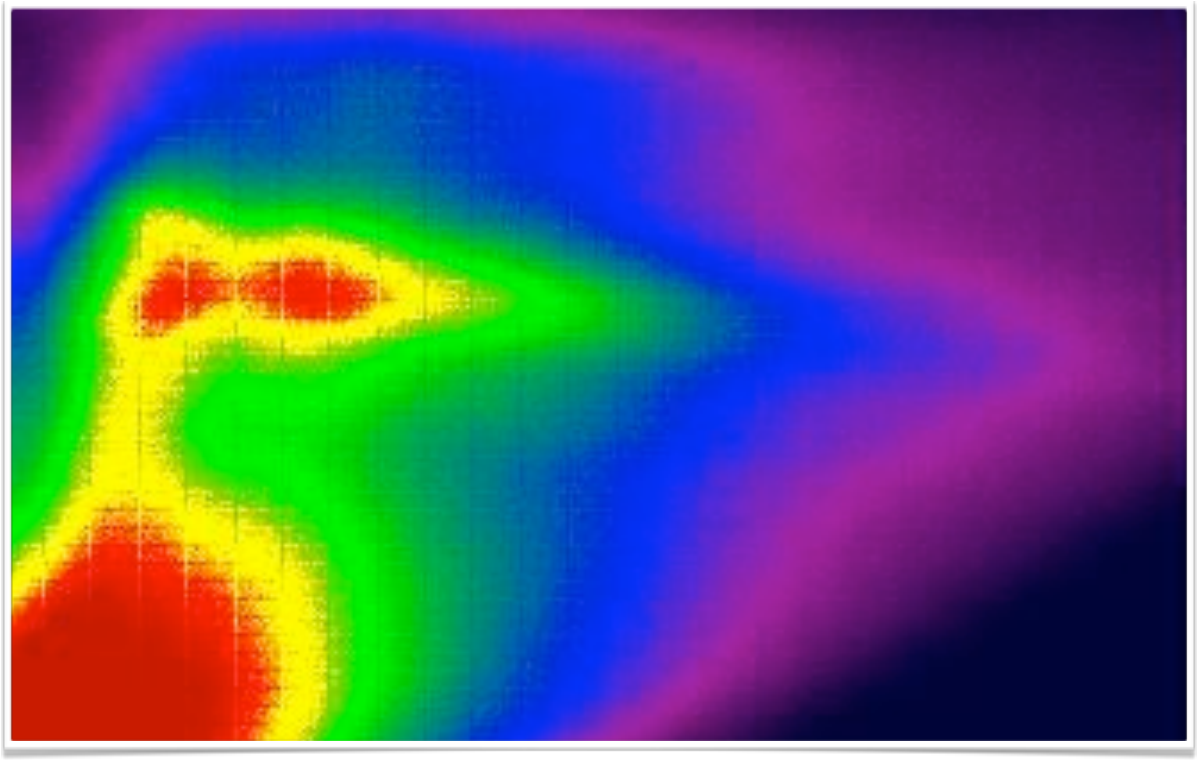
Mean red clump color difference (Z − Ks) = 0.55 mag, equivalent to AV = 2.0 mag

D. Minniti et al. 2014

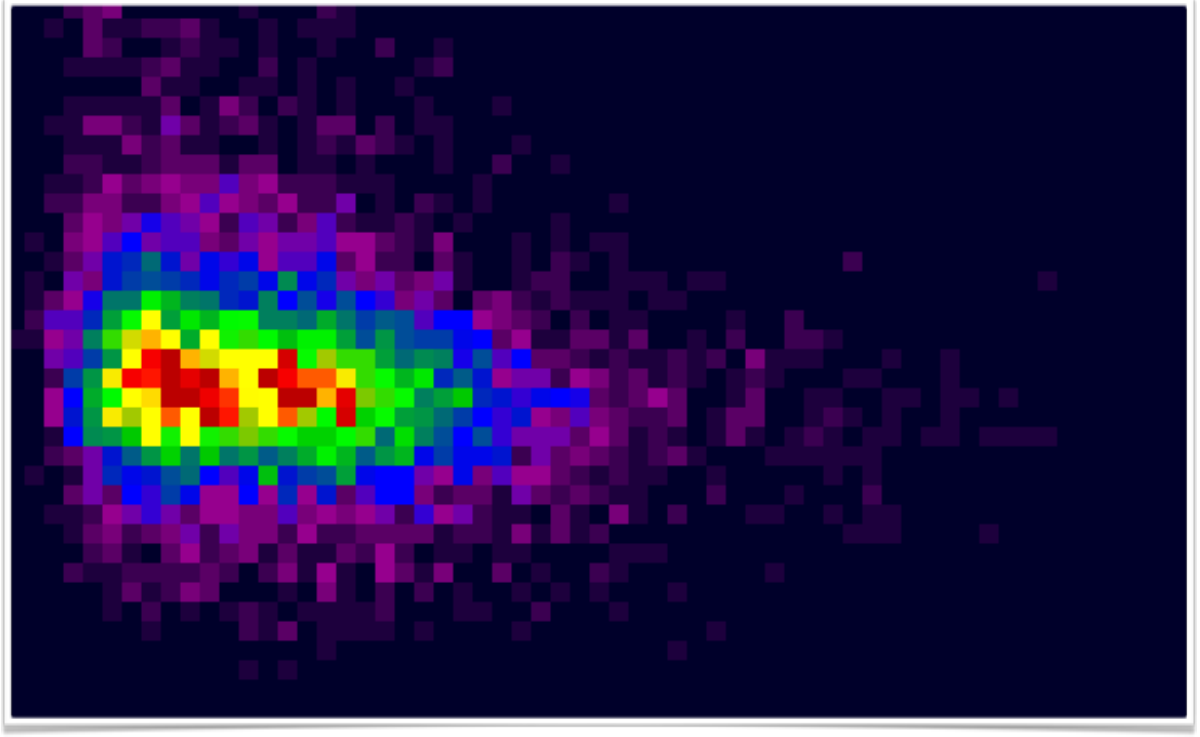


THE CMD REVEALS THE GALACTIC GREAT DARK LANE:
A COHERENT CLOUD STRUCTURE THAT STRETCHES FOR >20 DEG ABOVE AND BELOW THE PLANE OF THE MW

Clump Giants



RR Lyrae



THIS IS REAL !

Is the MW like the Evil Eye Galaxy M64 ?

The VVV Giga CMD

J. Alonso-García, et al. 2015, in prep.

In Z, 667 million

In Y, 707 million

In J, 922 million

In H, 990 million

In Ks,779 million

Combining J and Ks, 614 million

Conclusions

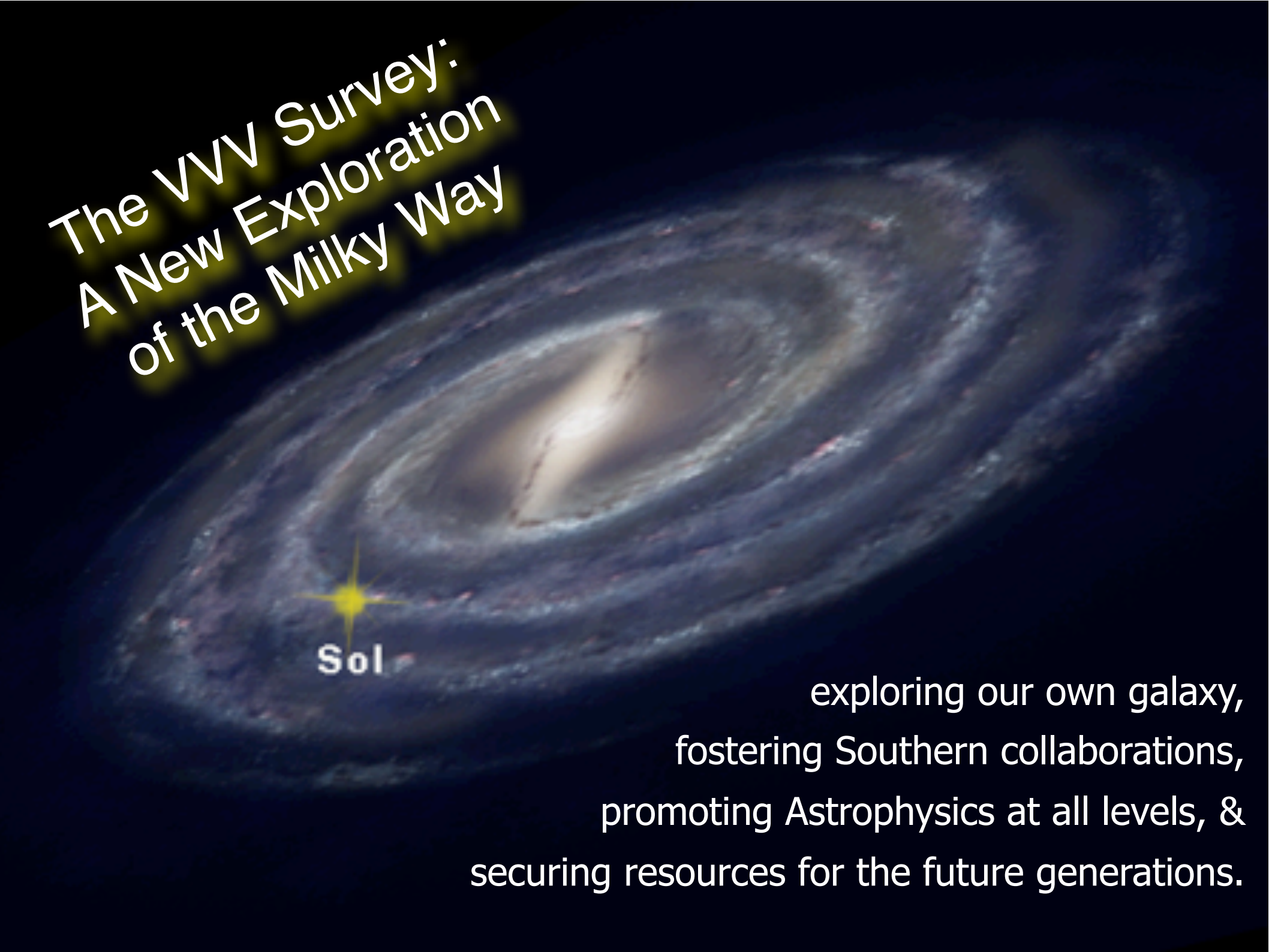
- We are more than half way through the VVV Survey, with everything working well.

- Several discoveries have been made, with many more to come.

- We need help exploiting the VVV database and following up a wide variety of targets.

VVV
Survey

The VVV Survey: A New Exploration of the Milky Way



exploring our own galaxy,
fostering Southern collaborations,
promoting Astrophysics at all levels, &
securing resources for the future generations.

The Milky Way, our Galaxy