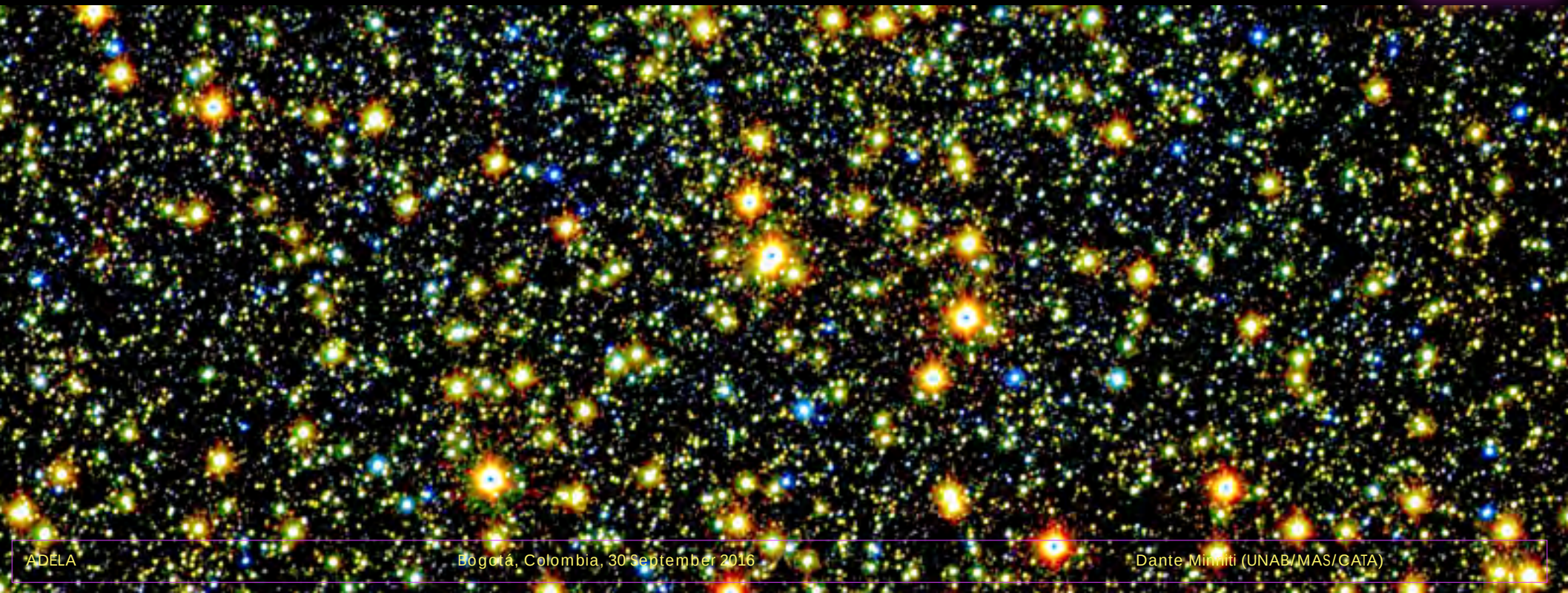
ADELA 2016 — Bogotá, Colombia

The VVV Survey Extension: RRLyrae, Cepheids and more

Dante Minniti



The VVV Science Team

Dante Minniti

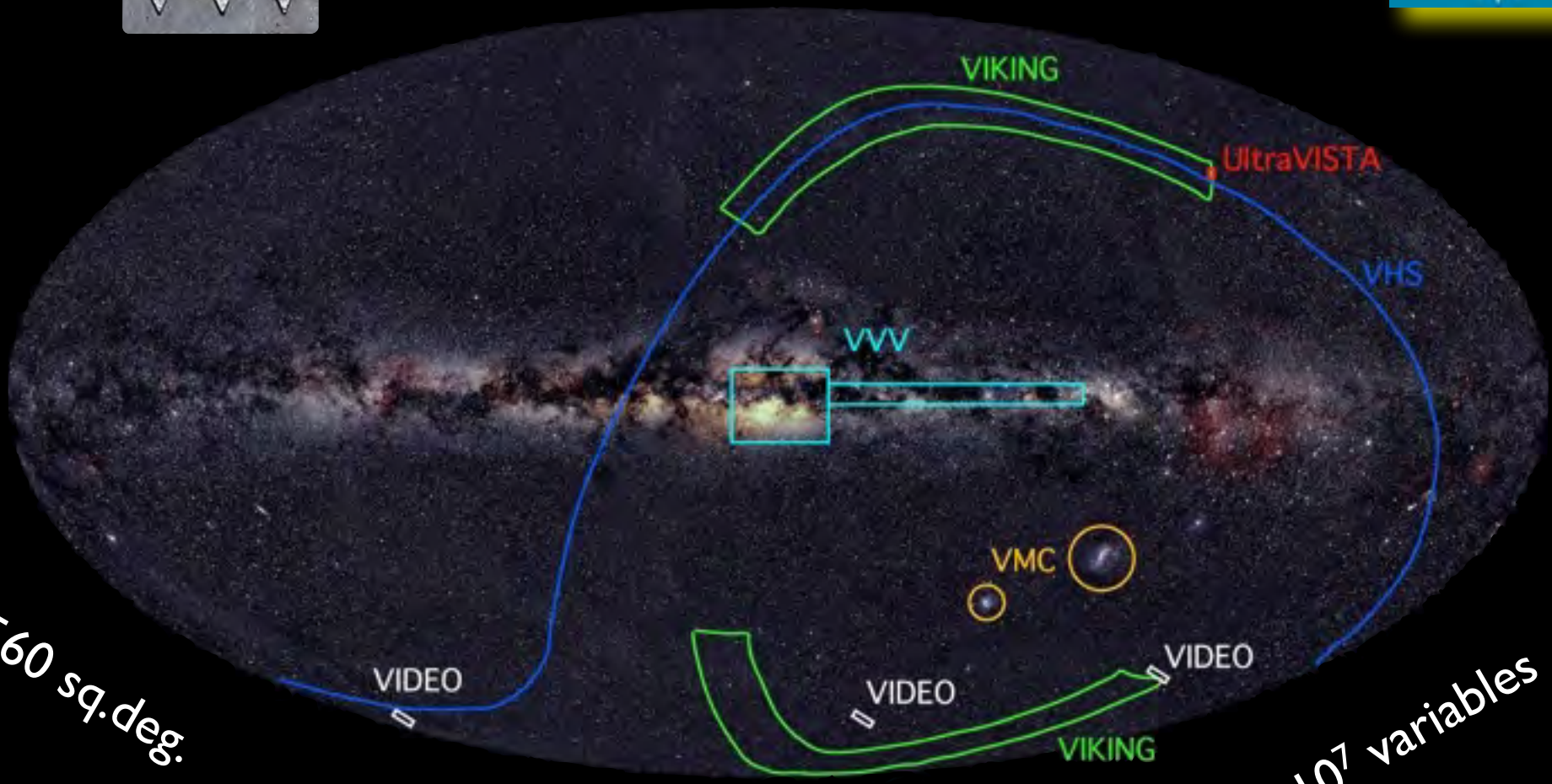
R. K. Saito[1], M. Hempel[1], D. Minniti[1,2,3], P. W. Lucas[4], M. Rejkuba[5], I. Toledo[6], O. A. Gonzalez[5], J. Alonso-García[1], M. J. Irwin[7], E. Gonzalez-Solares[7], S. T. Hodgkin[7], J. R. Lewis[7], N. Cross[8], V. D. Ivanov[9], E. Kerins[10], J. P. Emerson[11], M. Soto[12], E. B. Amôres[13,14], 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]

VVV Latest Results

1. RR Lyrae in the Bulge-Halo Transition Region
2. Cepheids in the Inner Bulge
3. Galactic Disk RR Lyrae
4. RR Lyrae in the Galactic Center
5. Structure of the Milky Way Bulge
6. Dust Distribution and the Reddening Laws
7. Catalog of Proper Motions and Parallaxes
8. Hundreds of New Star Clusters
9. Template Light Curves
10. The Mass of the Milky Way Bulge

The VVV Extended Survey

VISTA PUBLIC SURVEYS
VISTA VARIABLES IN THE VIA LACTEA



560 sq.deg.

~10^9 stars

~100 epochs

~10^7 variables

VISTA Telescope

- 4m diameter
- IR optimized
- large field

vvvsurvey.org

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

vvvsurvey.org

2MASS IMAGE OF THE MILKY WAY

Goal

What is the 3-D structure of the Milky Way

DEEPER AND HIGHER RESOLUTION

Main differences with 2MASS

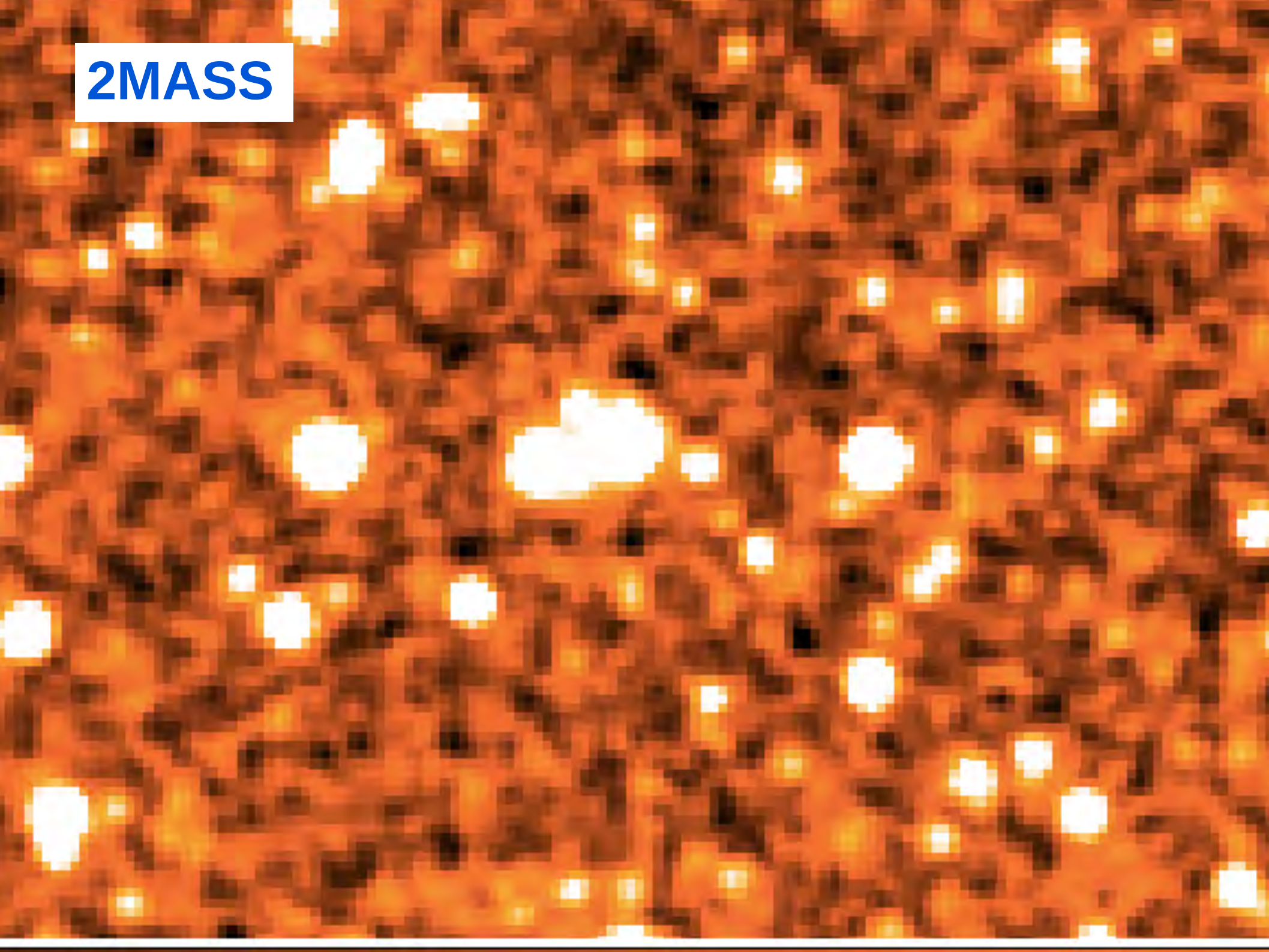
2MASS covers the whole sky, VVV only 1.3%

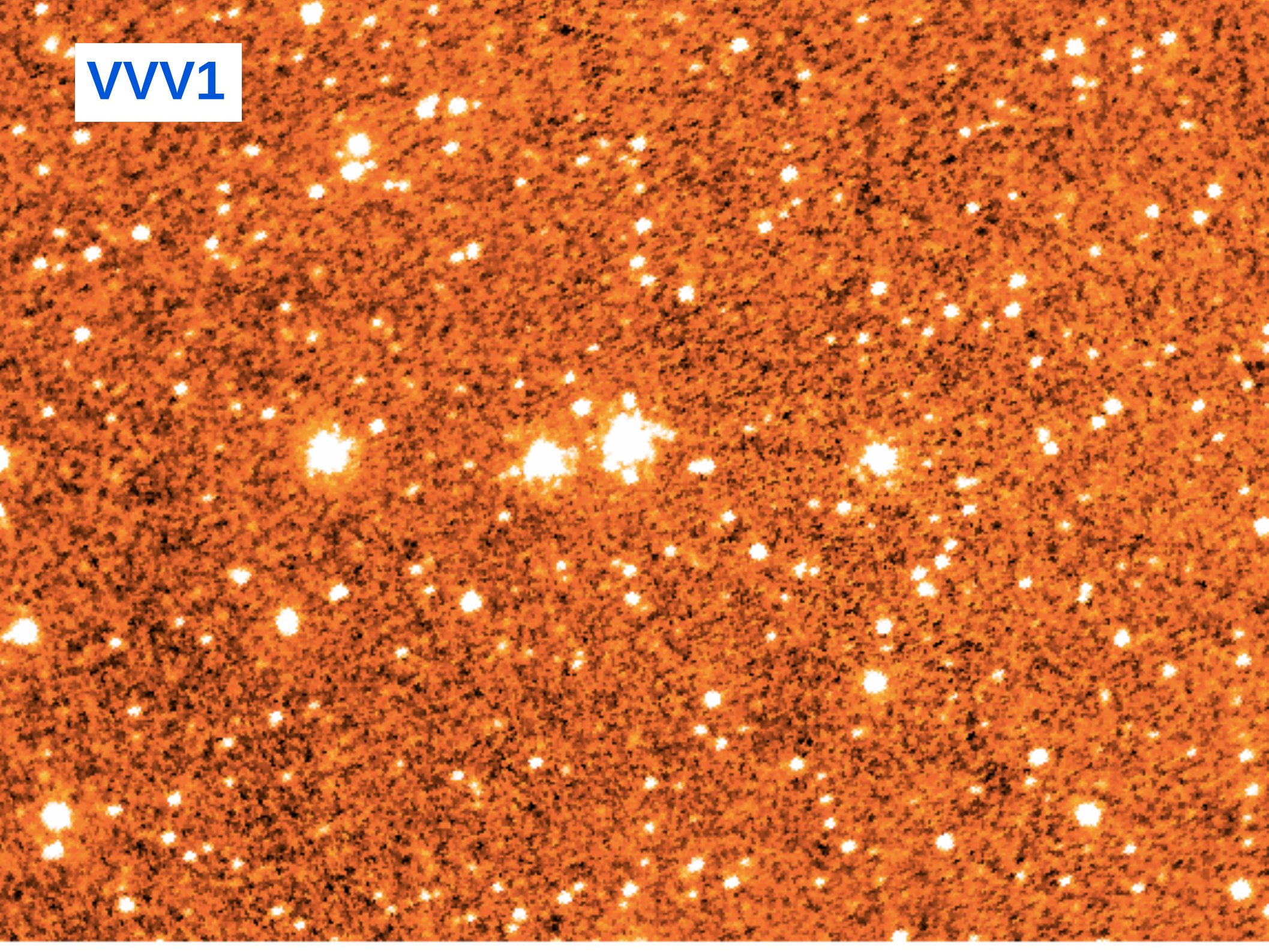
VVV has higher resolution (0.34”/pix)

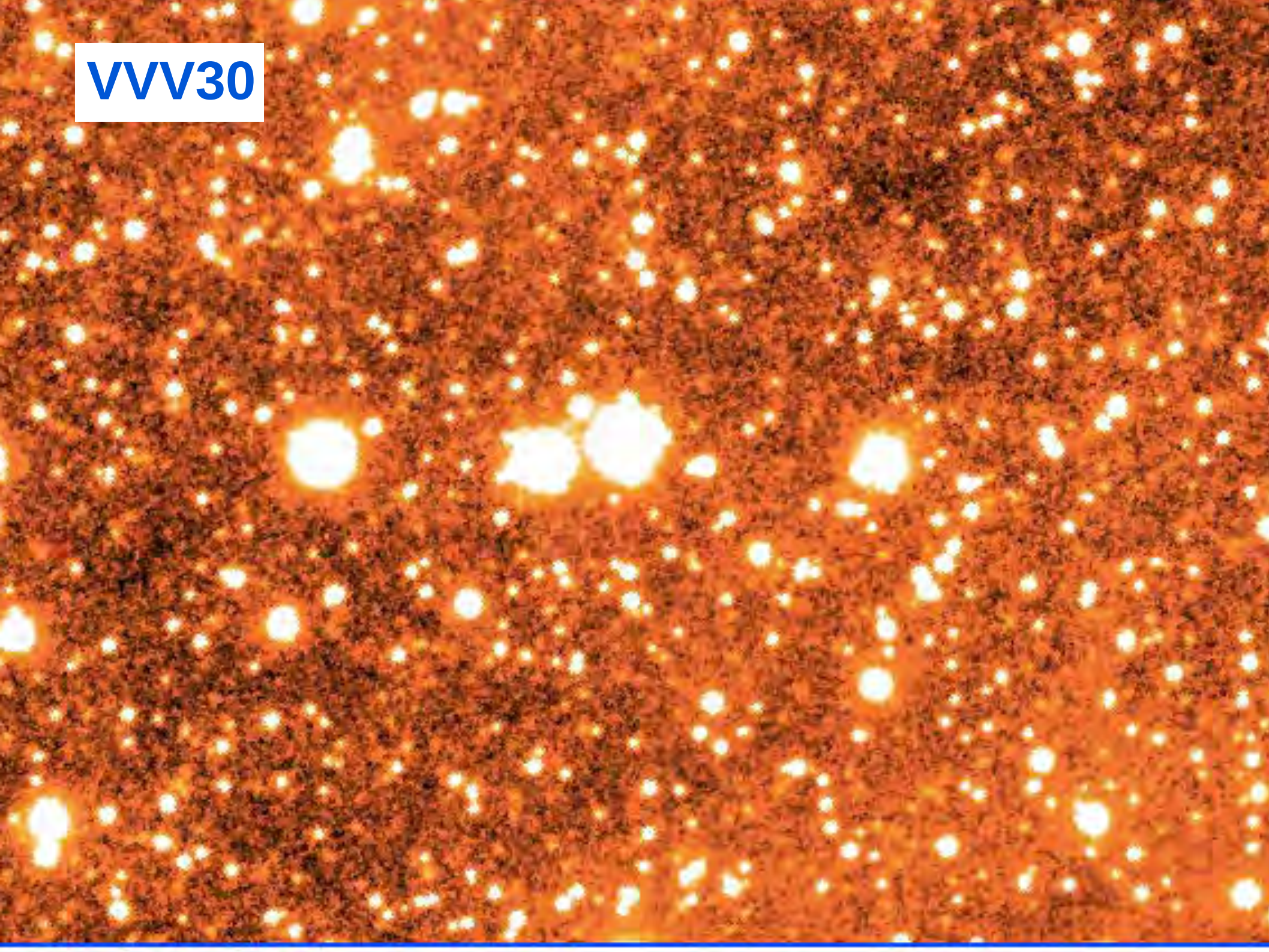
VVV is deeper (Ks<18)

VVV has 5 filters (ZYJHKs)

VVV is a multiepoch survey (~100 epochs)

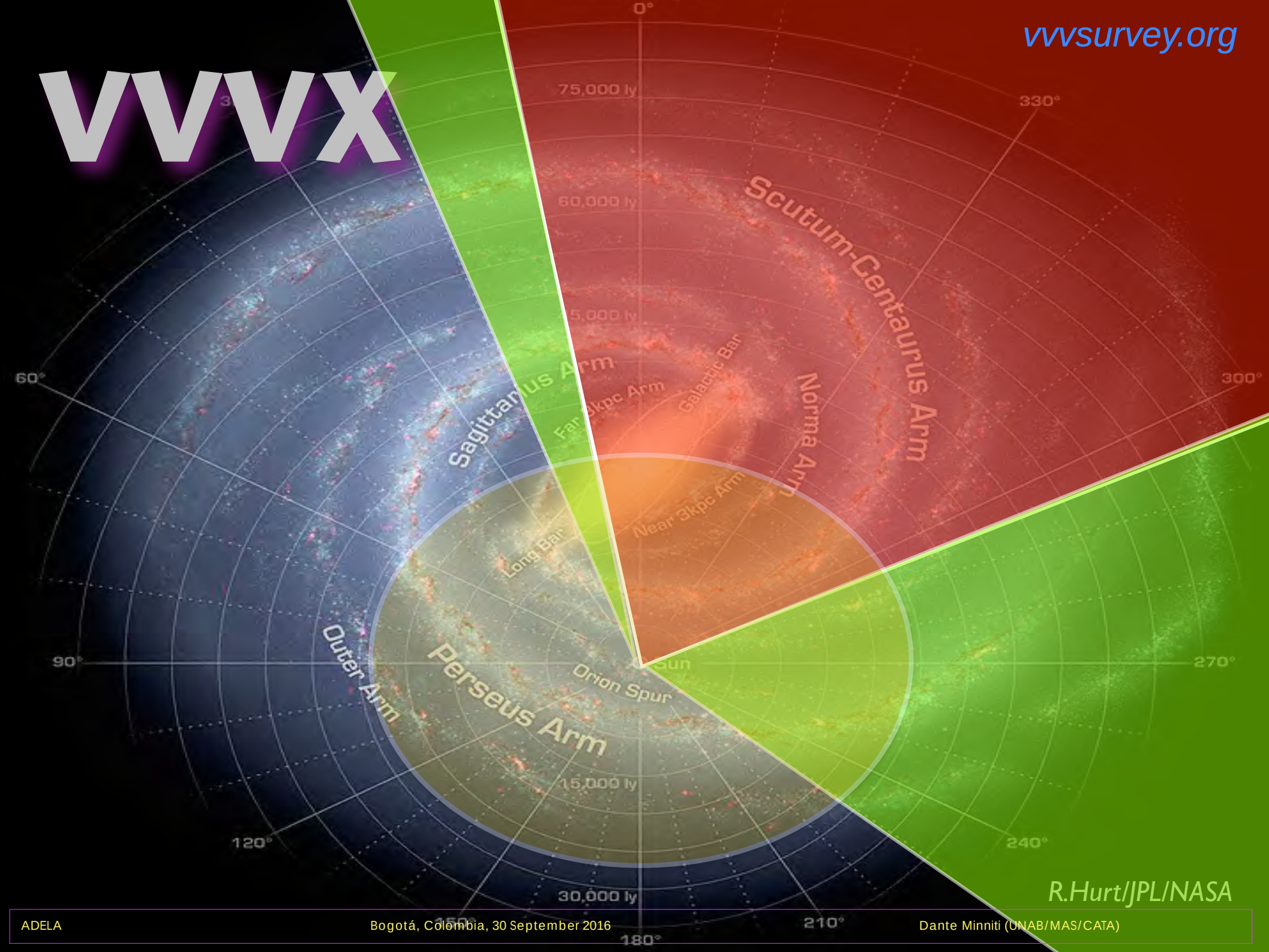

2MASS


VVV1


VVV30

VVVX

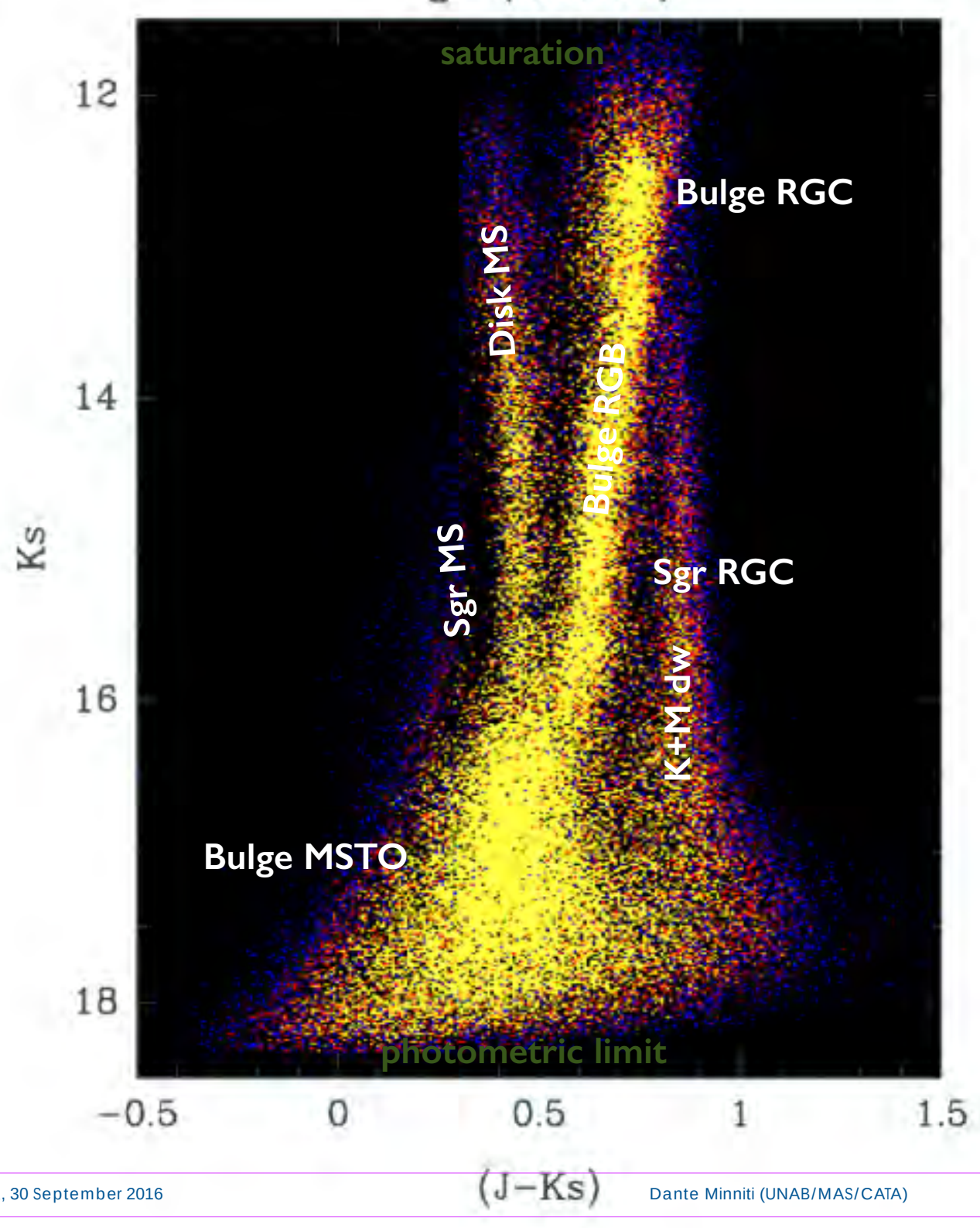
vvvsurvey.org



R.Hurt/JPL/NASA

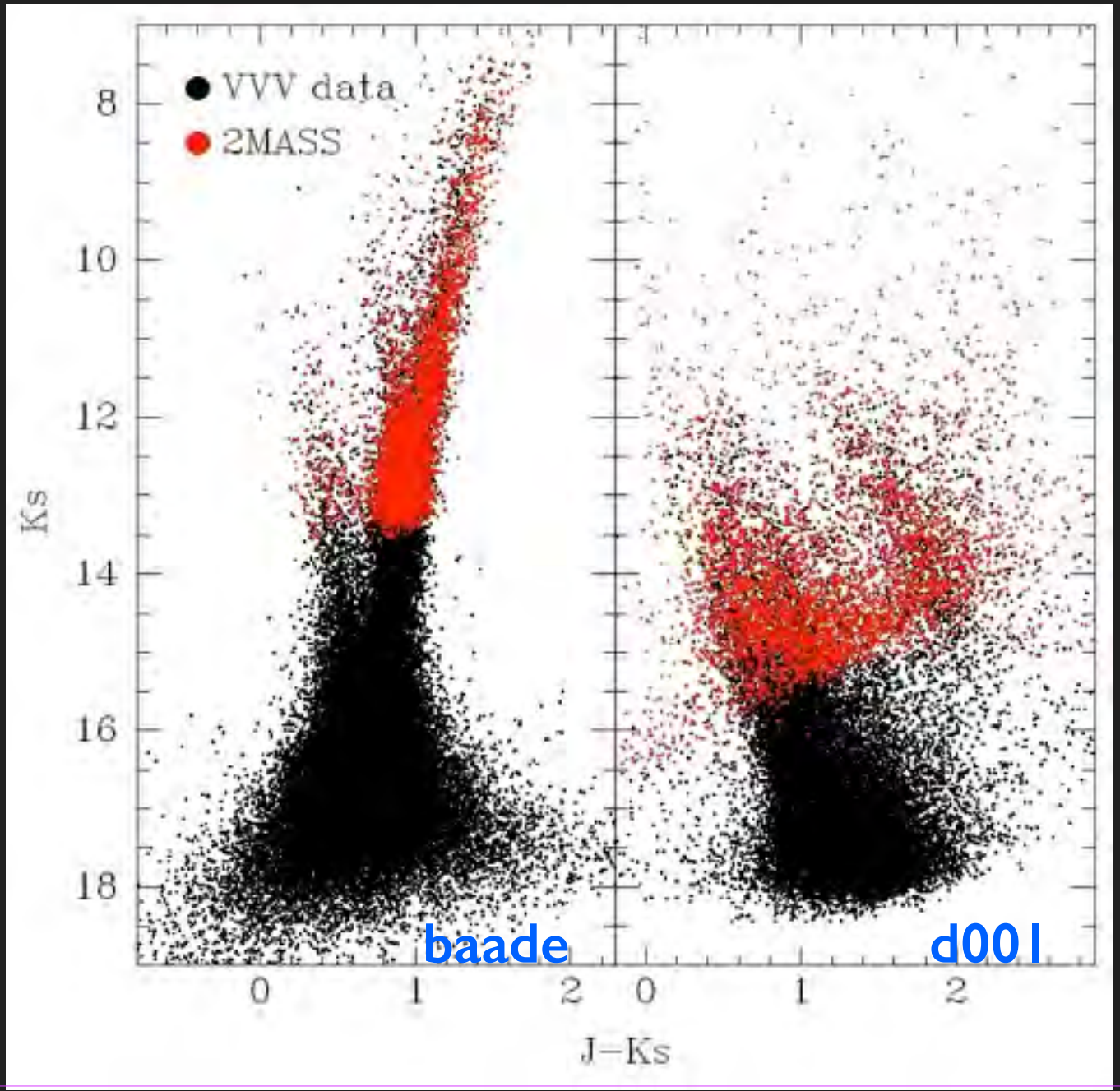
VVV STARS CMD

outer bulge fields
b209-b211

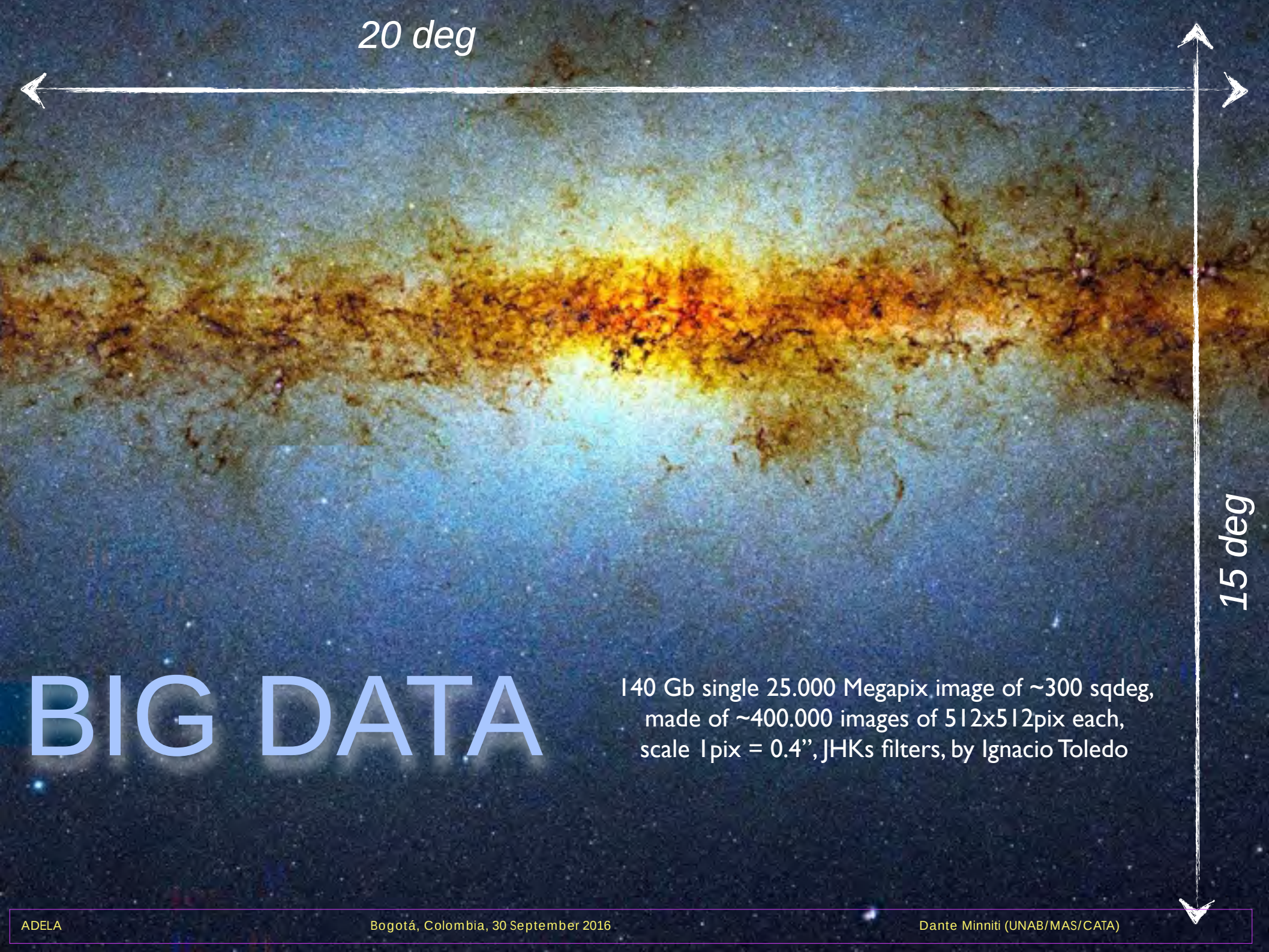


CMDs

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



Oscar Gonzalez

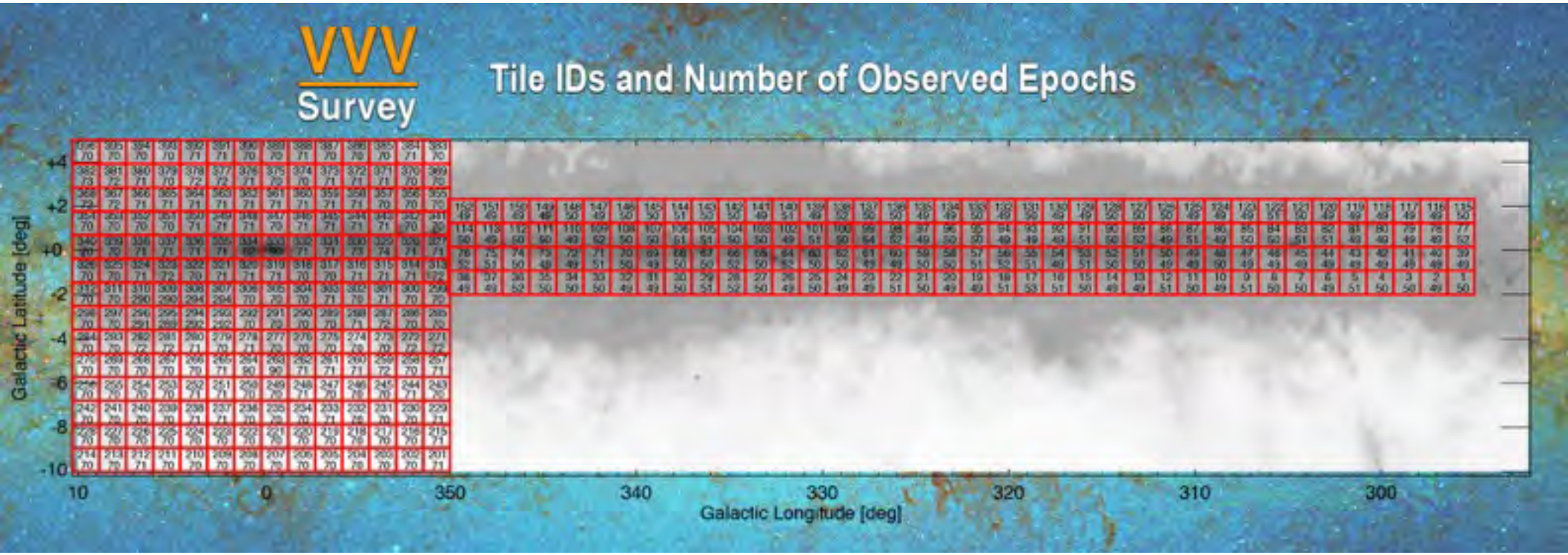


BIG DATA

140 Gb single 25.000 Megapix image of ~300 sqdeg,
made of ~400.000 images of 512x512pix each,
scale 1pix = 0.4", JHKs filters, by Ignacio Toledo

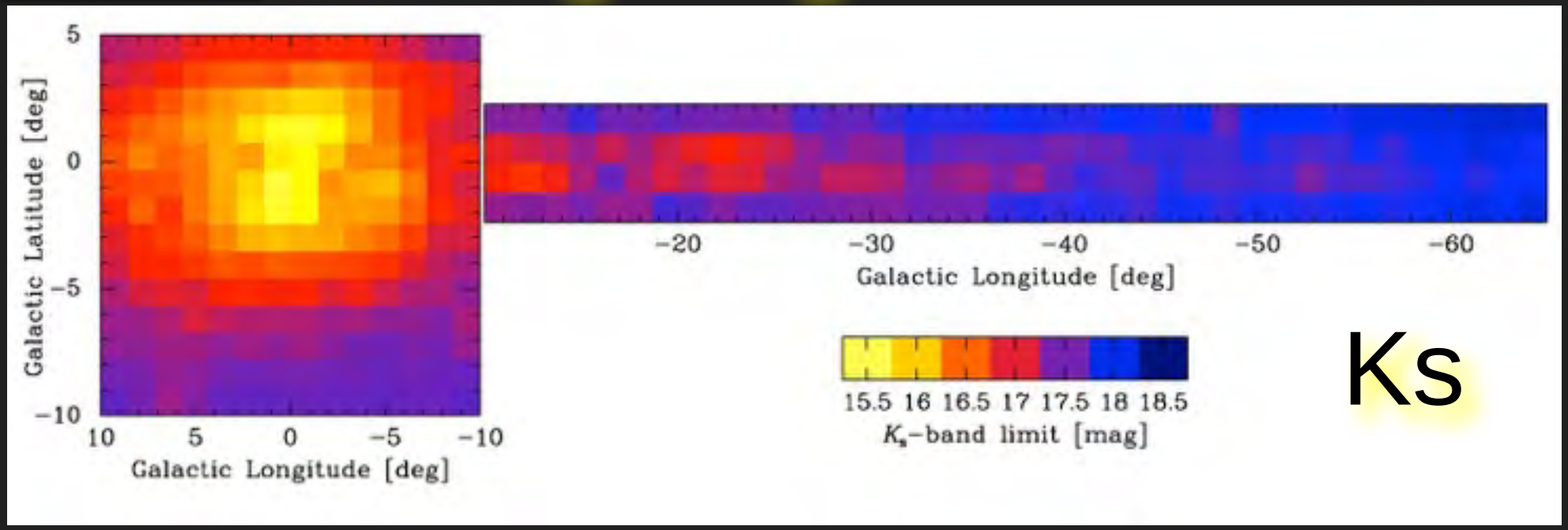
BIG DATA

Problems for:
handling,
bookkeeping,
etc.



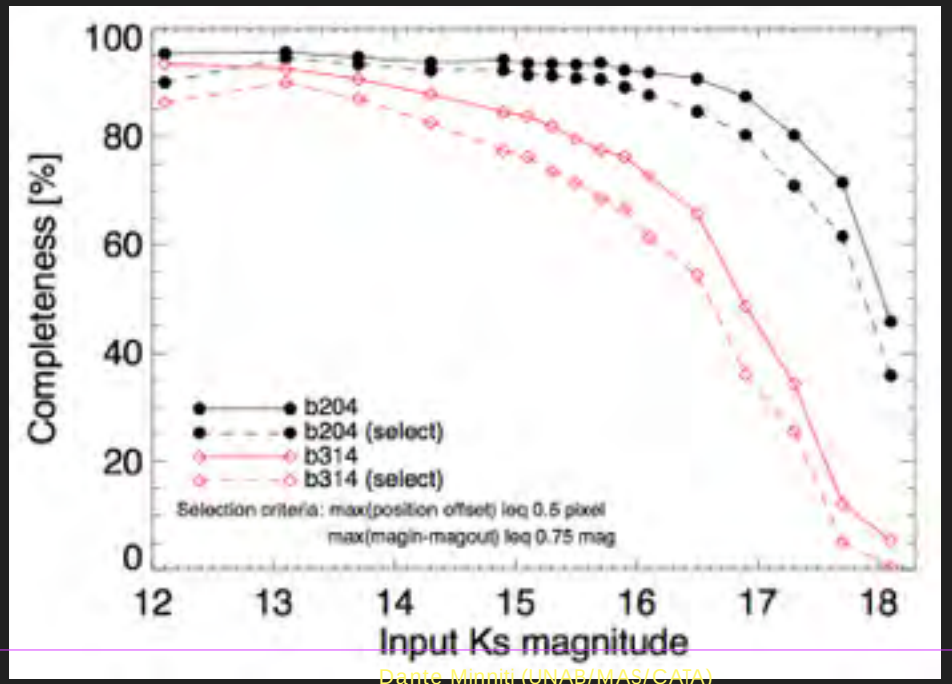
limiting magnitudes

vvvsurvey.org



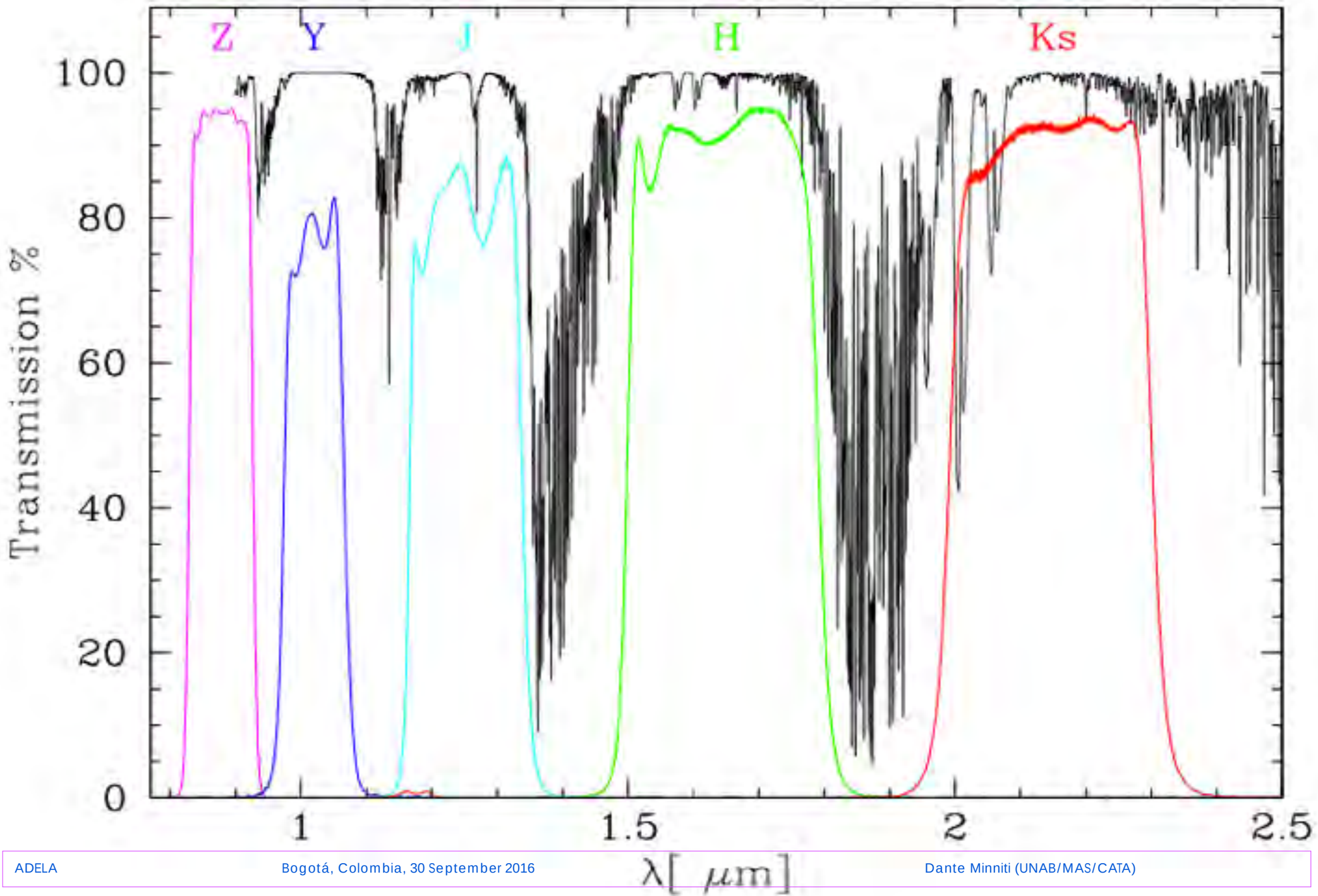
R. Saito

Completeness tests



M. Hempel, E. Valenti

VISTA filter transmissions



VVV Star Clusters

NEW SCIENCE

~100 papers

Many discoveries

Hundreds of New Star clusters

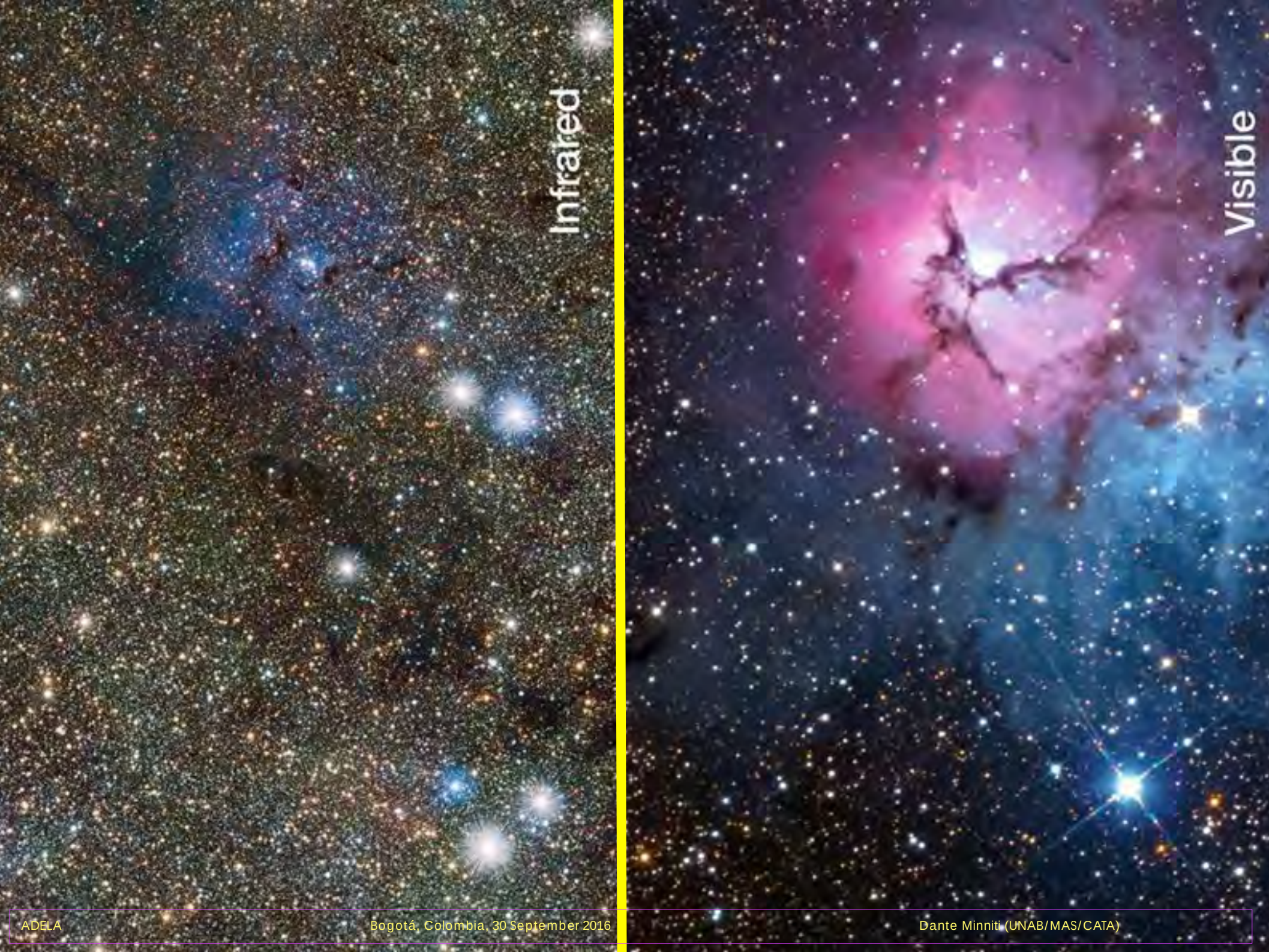
Borissova et al. 2015 A&A (arXiv:1406.7051)
Barba et al. 2015 A&A (arXiv:1505.02764)

Discovery of >700 star clusters.

Make CMDs and measure their proper motions, sizes and reddenings.

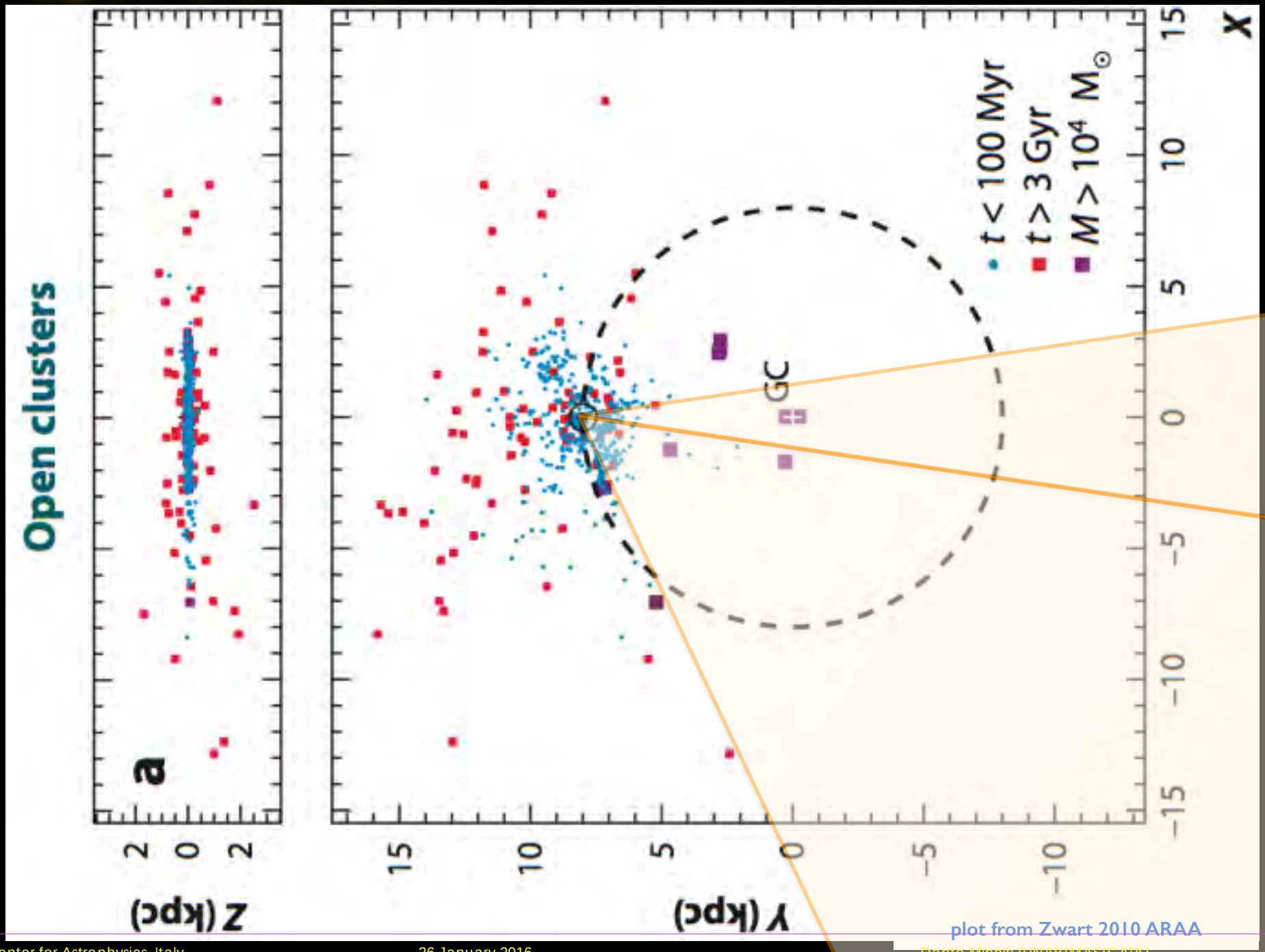
Estimate their ages, masses, and distances.

Spectroscopic follow-up: measure their chemical compositions and VRs.


Infrared
Visible

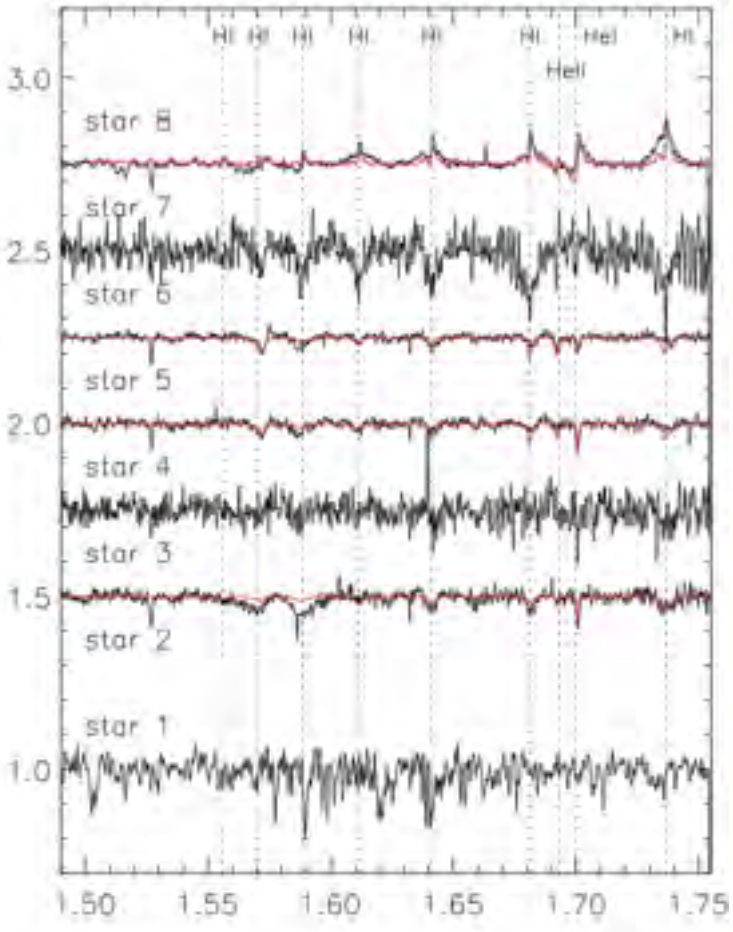
Open Clusters

P. Zwarts, ARAA 2013



plot from Zwart 2010 ARAA

A Very Massive Star Candidate



A. Chené et al. (2015)

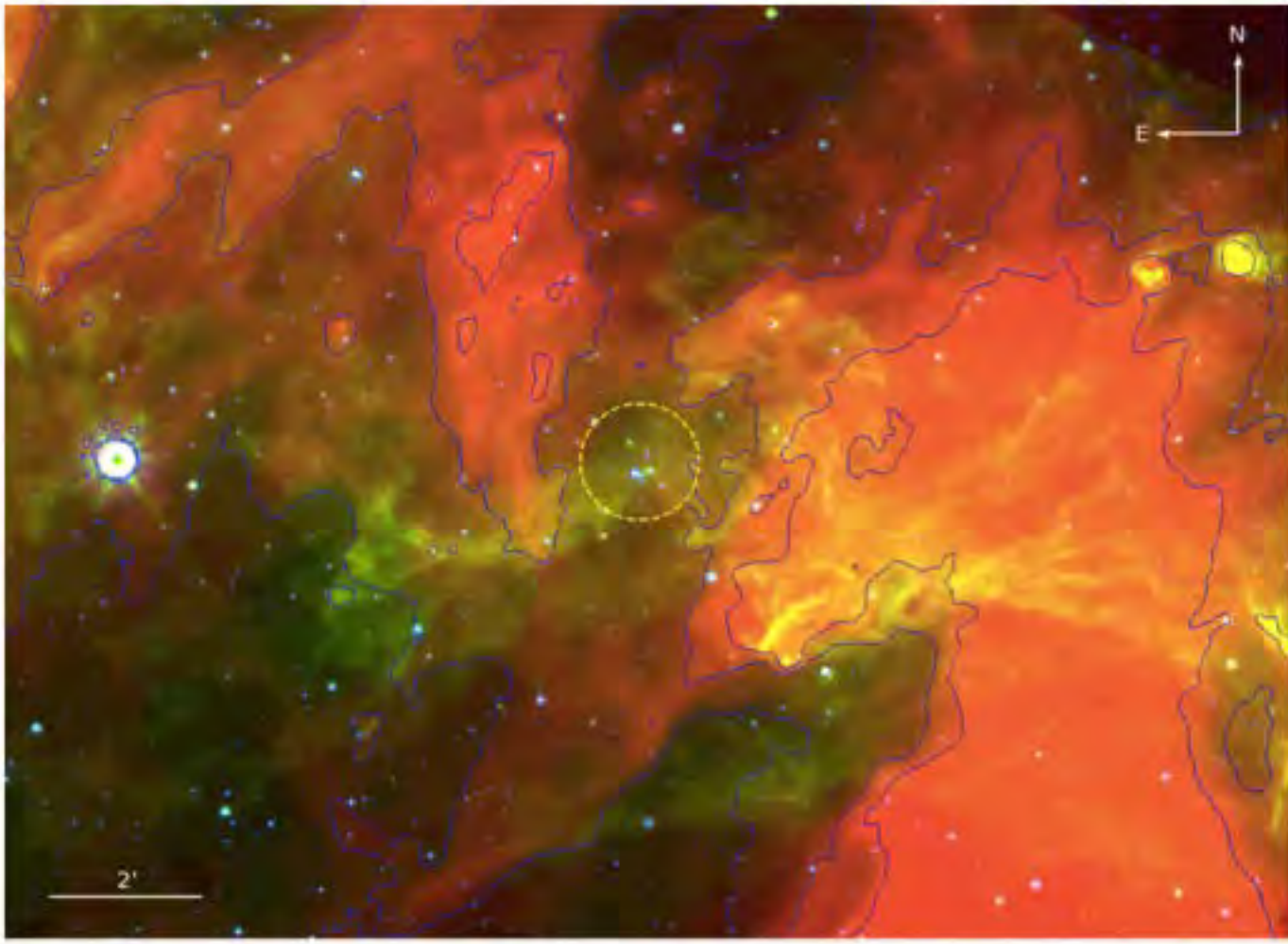


Fig. 7. Three-color K_S (blue), GLIMPSE 8 μm (green), and MIPS 24 μm (red) images of the region around VVV CL041. Blue lines are showing the 90, 170 and 250 MJy/sr contours in the MIPS image. The cluster is indicated by a yellow, dashed circle.

A Very Massive Star Candidate

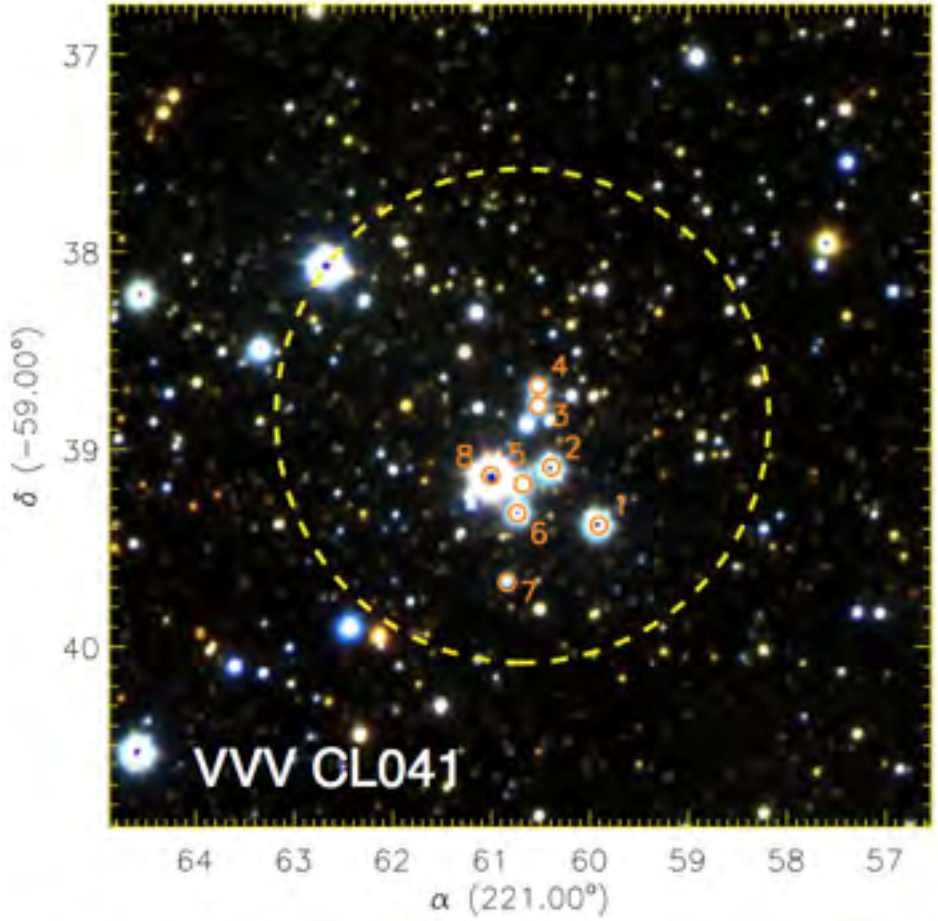


Fig. 1. JHK_s false-colour images of VVV CL041. Stars marked with red circles were observed using near-IR spectrographs. Yellow dashed circles indicate the angular sizes of the cluster (see Section 3). Coordinates are given in the J2000 system.

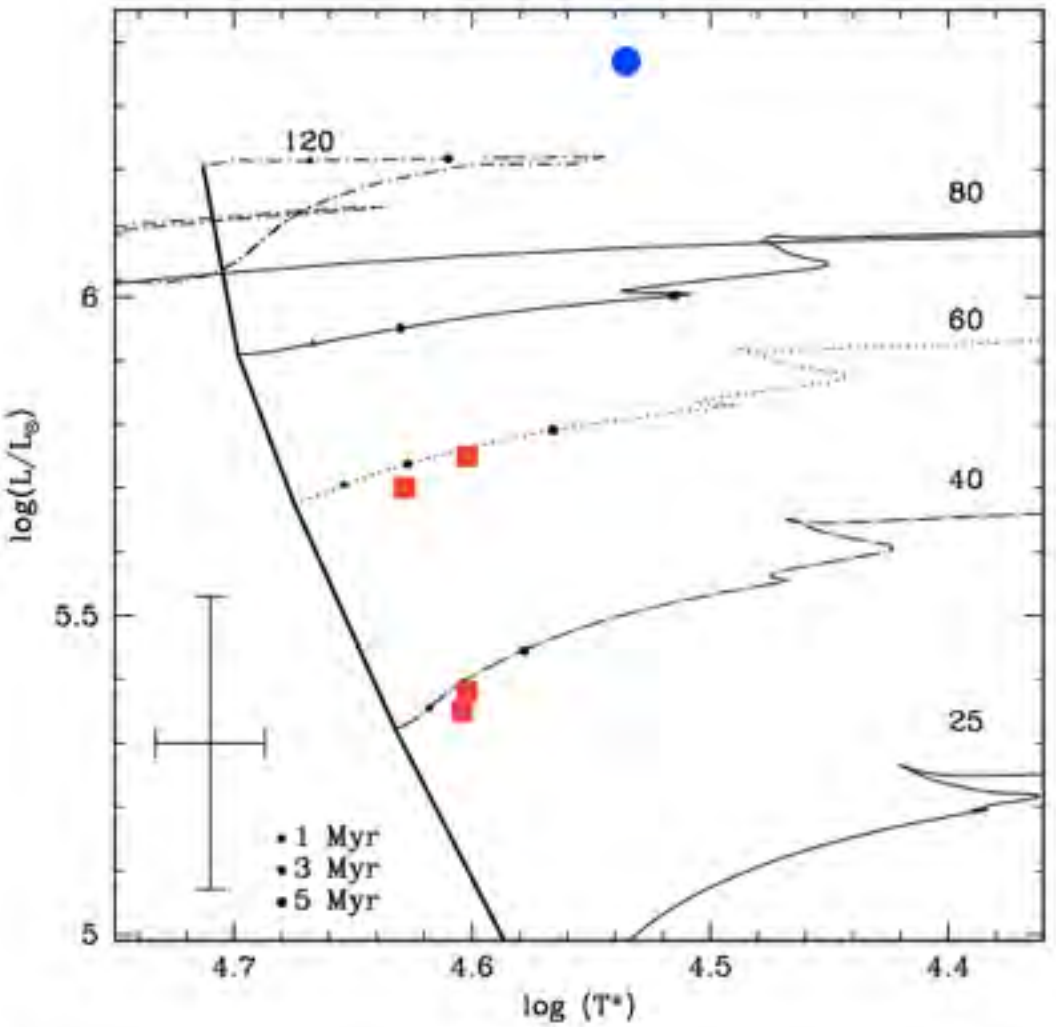
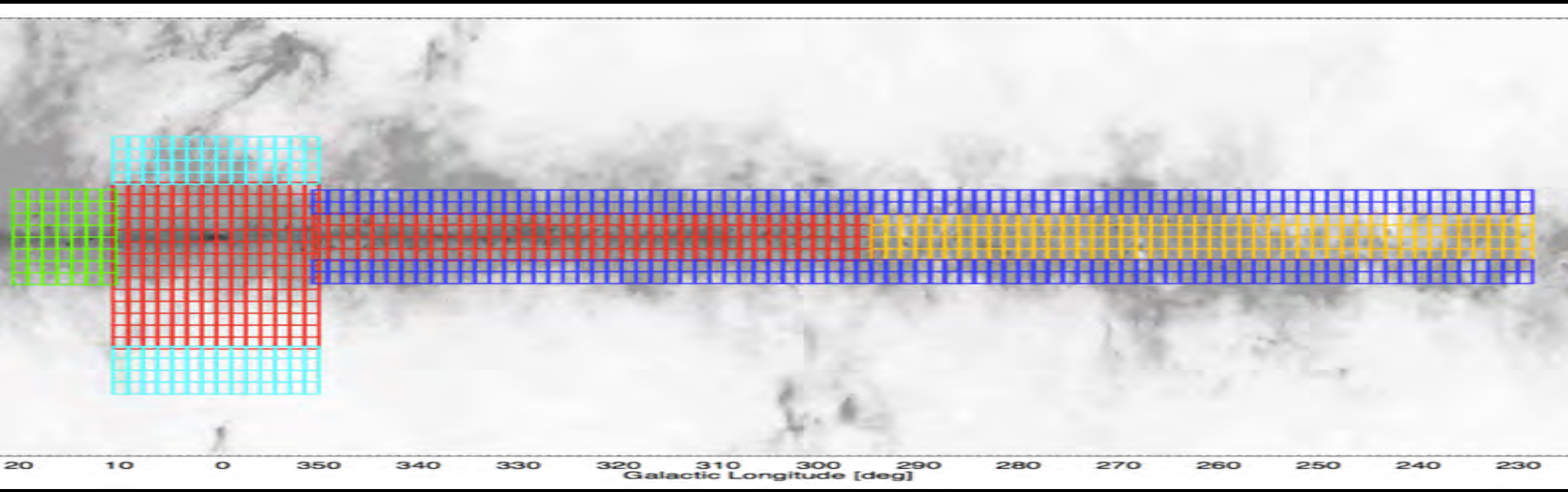
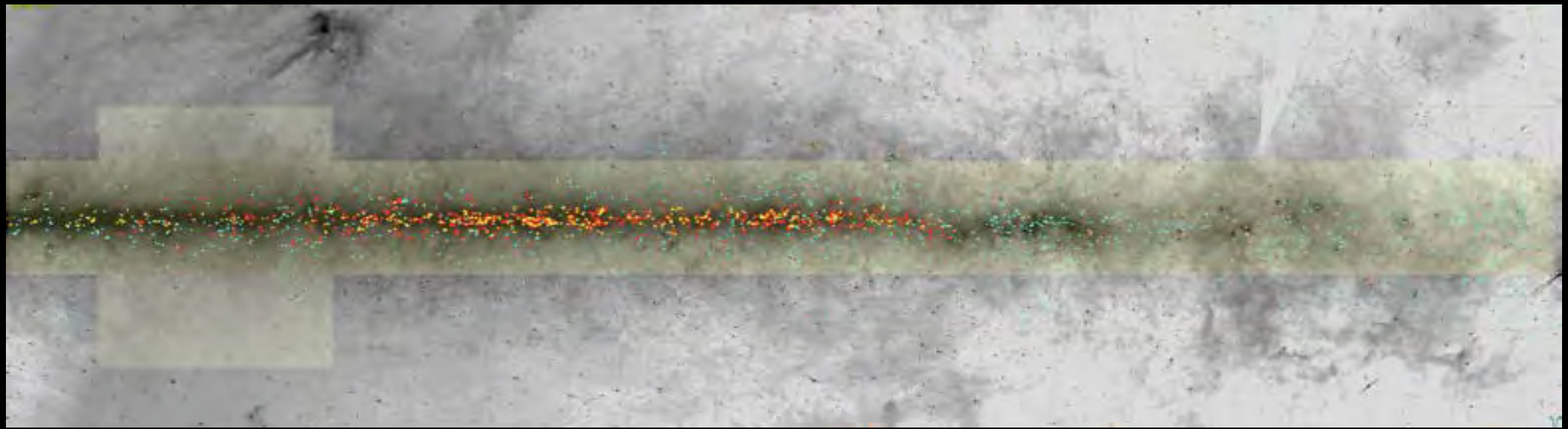


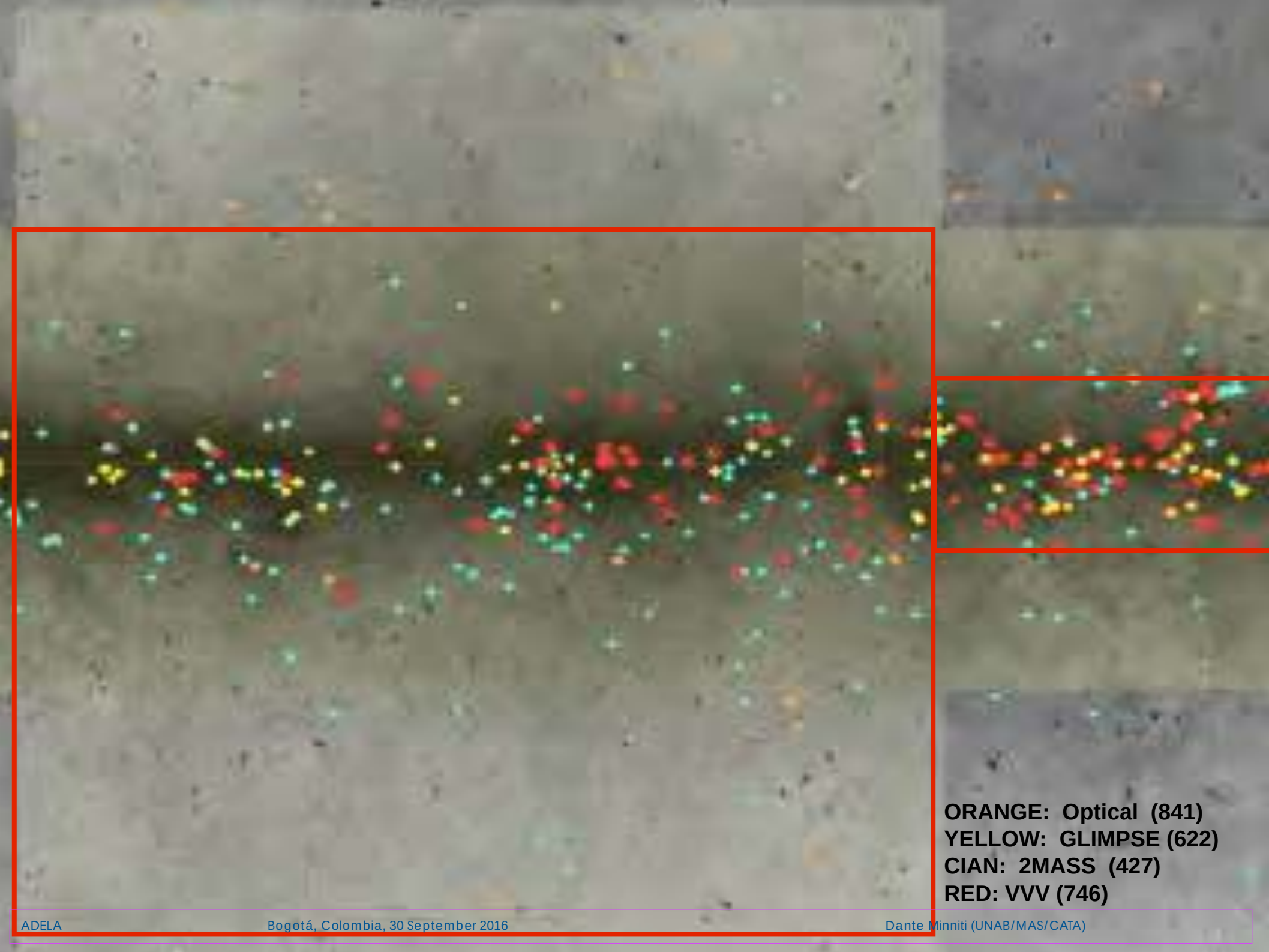
Fig. 6. HR diagram with the O and WNh stars shown respectively by squares and circles. The evolutionary tracks are from Chieffi & Limongi (2013). They include rotation. The symbols along the tracks correspond to ages of 1, 3 and 5 Myr.

A. Chené et al. (2015)



J. Borissova, S. Ramirez, A. Chene, R. Kurtev, R. Barba, T. Palma et al.




ORANGE: Optical (841)
YELLOW: GLIMPSE (622)
CIAN: 2MASS (427)
RED: VVV (746)

VVV
Variables

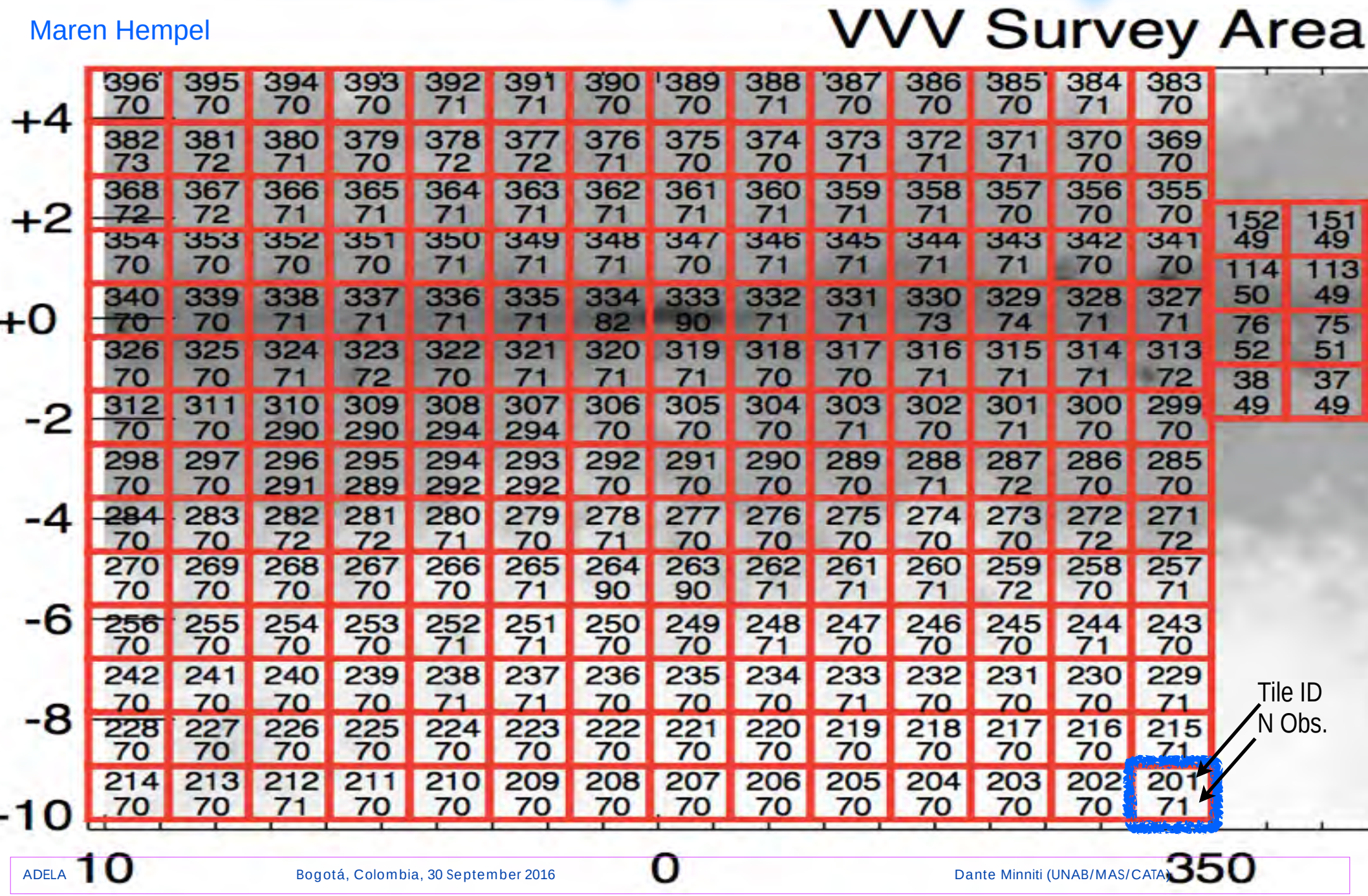
Timeline

year

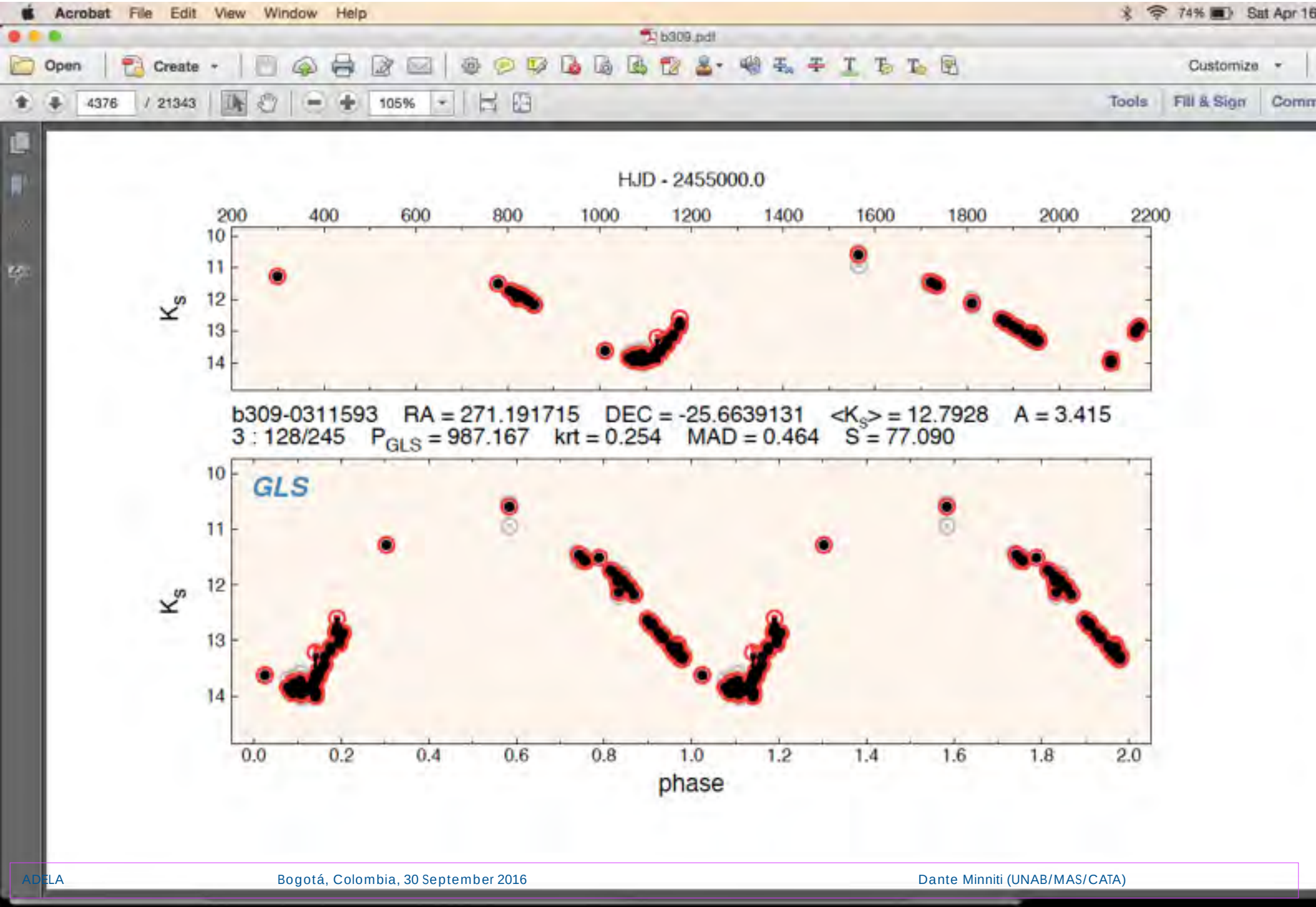
1	- 6 epochs in K for bulge and disk; K_{lim}=18/20 mag (single/combined epochs) - Z,Y,J,H, K single (quasi-simultaneously) epoch observations (bulge & disk)	multicolor maps	2010
2	- 4 epochs in K_s for bulge and disk	variability	2011
3	- main part of bulge variability campaign (80 epochs, 652 h) - map bulge and disk once per night	variability	2012
4	- main disk variability campaign (similar to bulge, but 70 epochs, 525 h)	variability	2013
5	- bulge and disk observations in K band - 20/9 epochs spread over the whole year - subset will be observed more frequently (10-40 times per night)	variability	2014
		proper motions	2015
			...

Number of Epochs: MW Bulge

Maren Hempel



Mira LPV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10 11 12 13 14
K_s
b309-0311593 RA = 271.191715 DEC = -25.6639131 <K_s> = 12.7928 A = 3.415
3 : 128/245 P_{GLS} = 987.167 krt = 0.254 MAD = 0.464 S = 77.090
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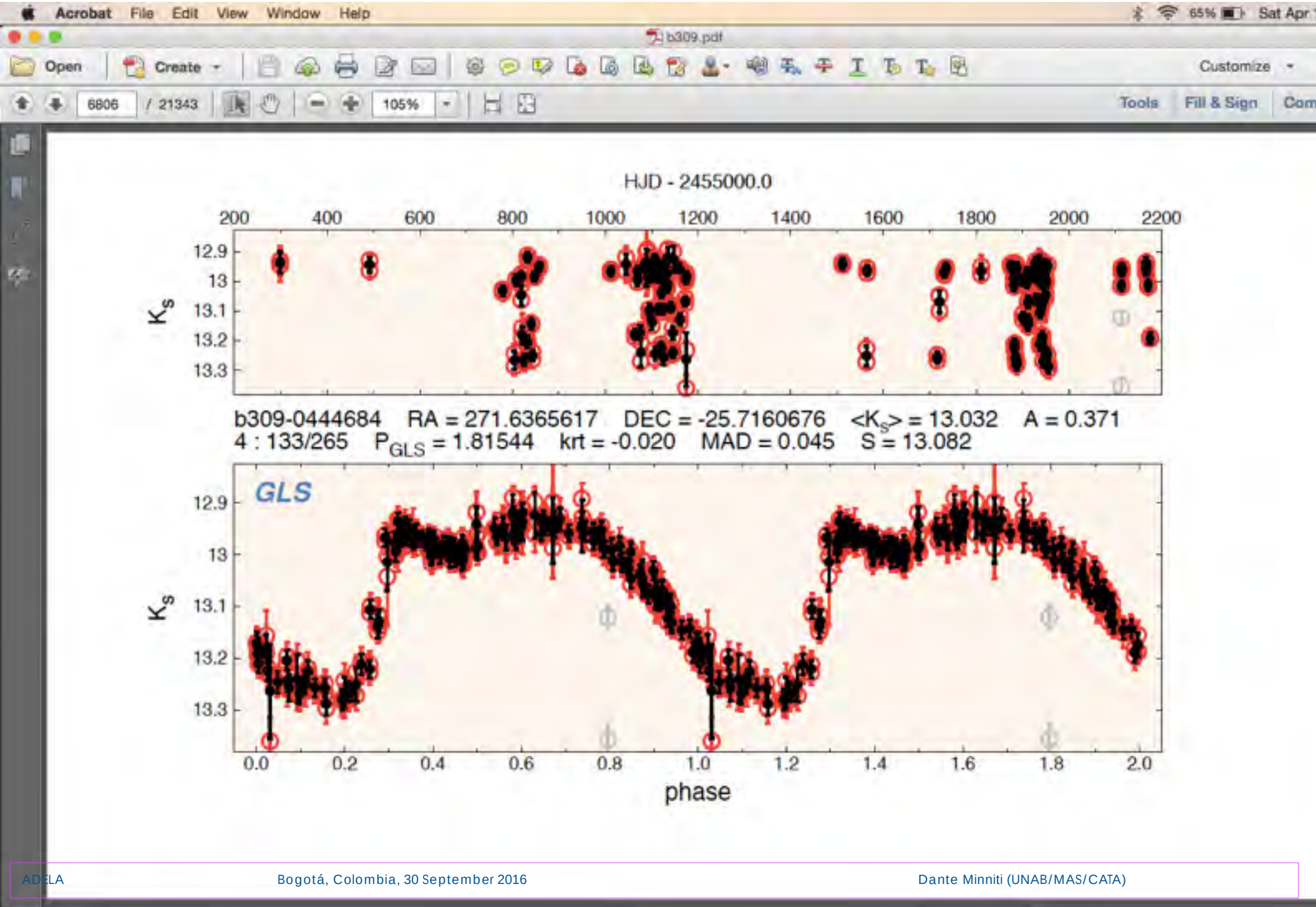
phase

RV Tau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HJD - 2455000.0
200 400 600 800 1000 1200 1400 1600 1800 2000 2200
12.9 13 13.1 13.2 13.3
K_S
b309-0444684 RA = 271.6365617 DEC = -25.7160676 <K_S> = 13.032 A = 0.371
4 : 133/265 P_{GLS} = 1.81544 krt = -0.020 MAD = 0.045 S = 13.082
GLS
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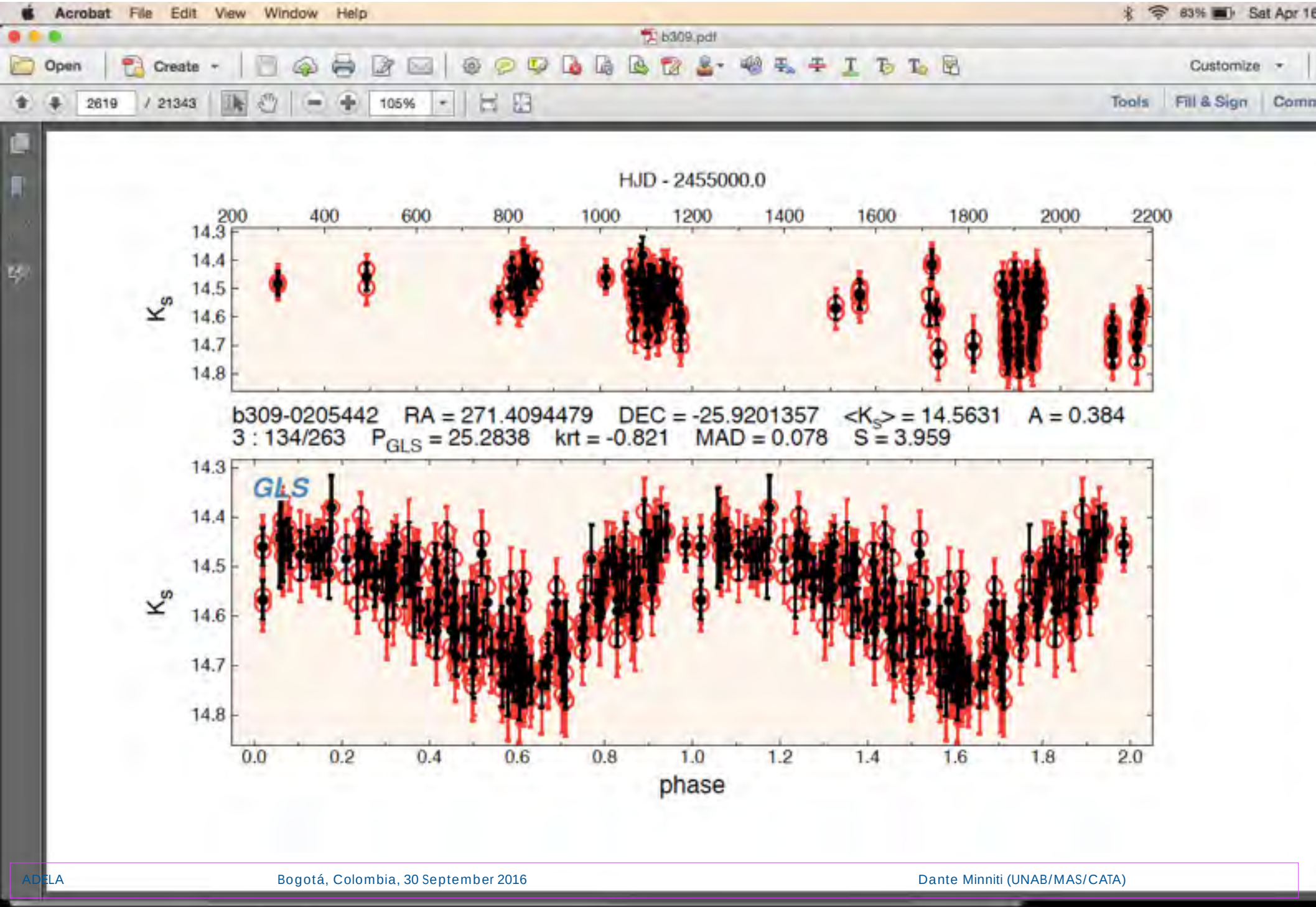
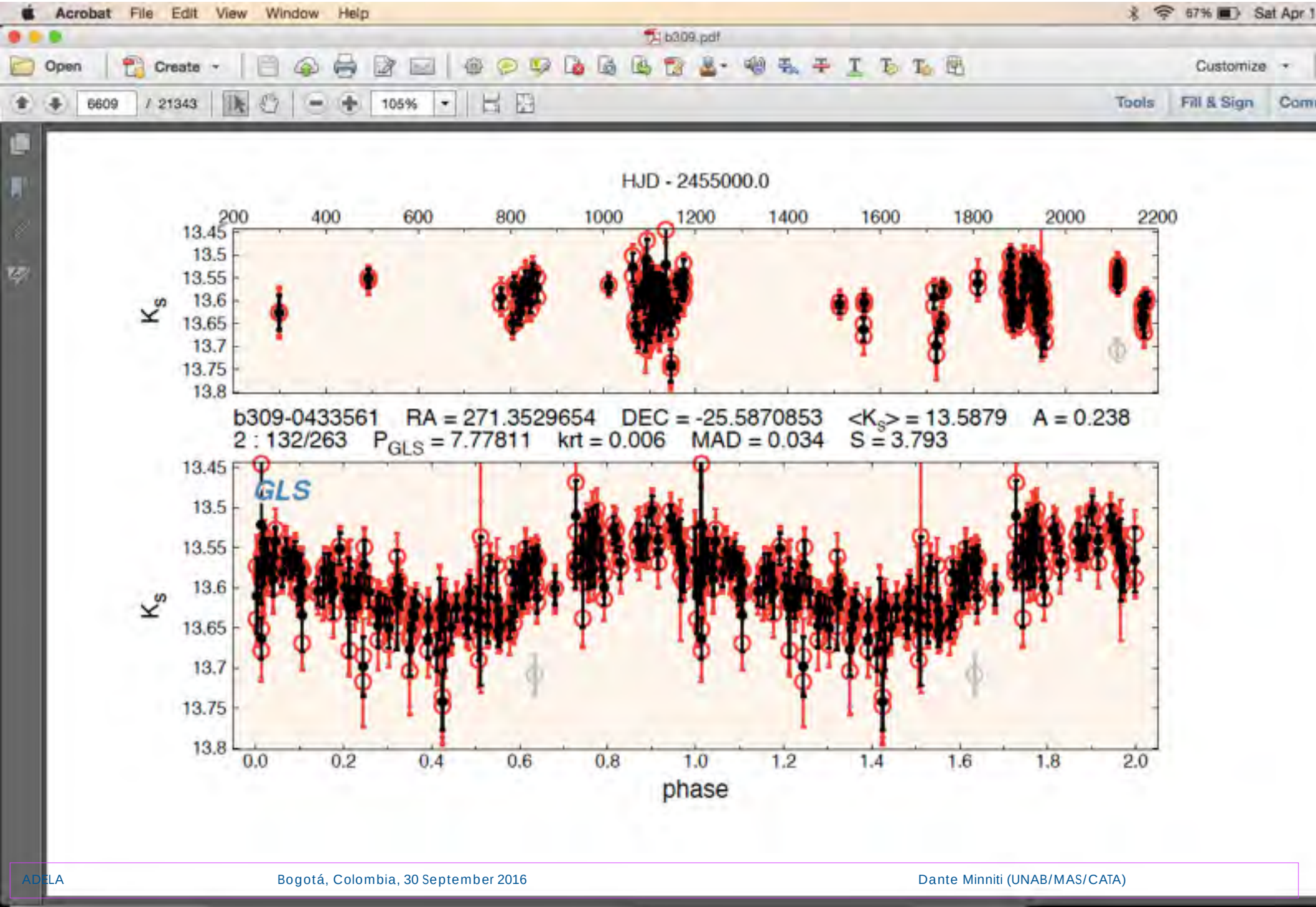
phase

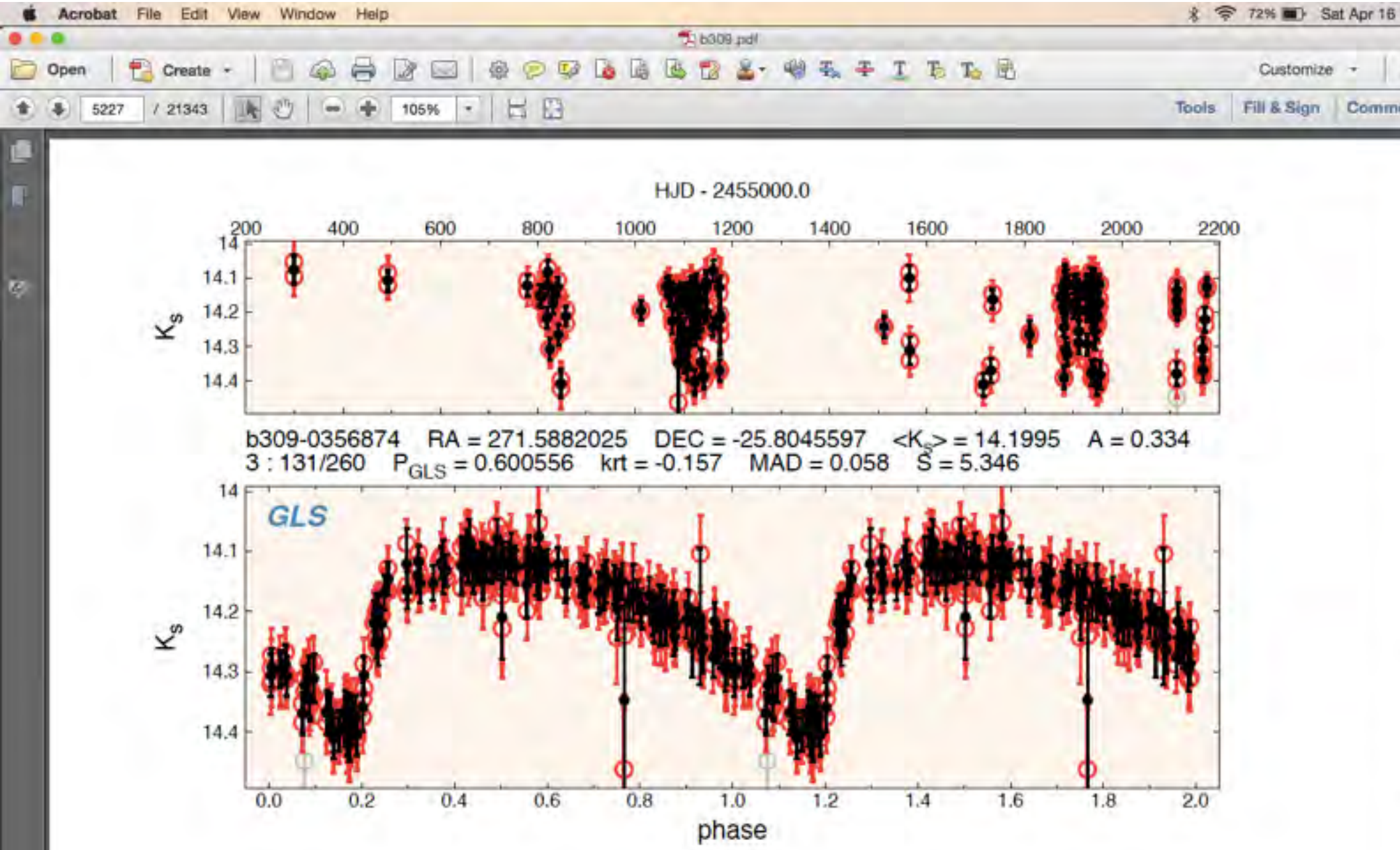
Cepheid type I



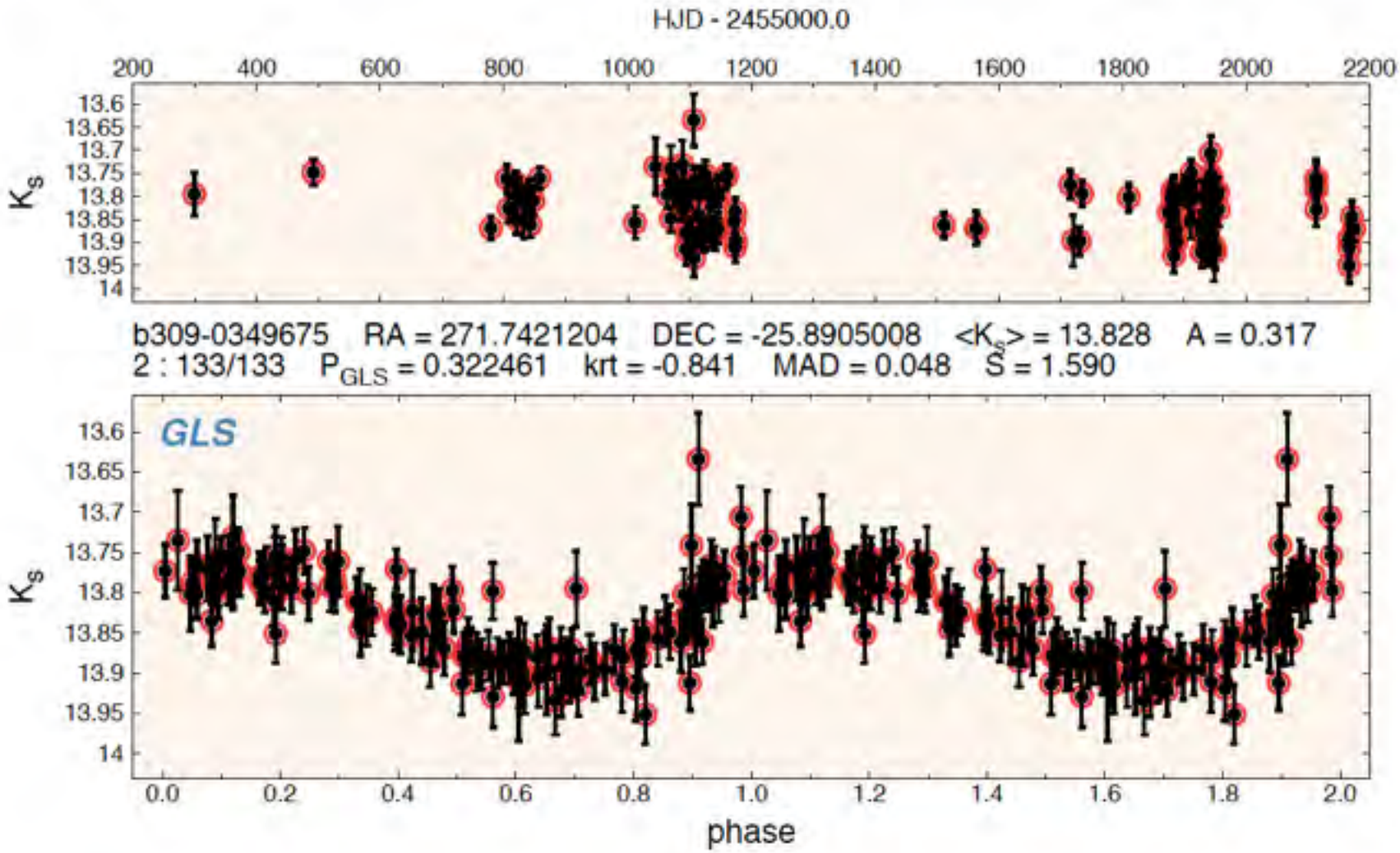
Cepheid type II



RR Lyrae type ab



RR Lyrae RRc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2000
2200
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13.8
13.85
13.9
13.95
14
K_s
b309-0349675 RA = 271.7421204 DEC = -25.8905008 <K_s> = 13.828 A = 0.317
2 : 133/133 P_{GLS} = 0.322461 krt = -0.841 MAD = 0.048 S = 1.590
GLS
0.0
0.2
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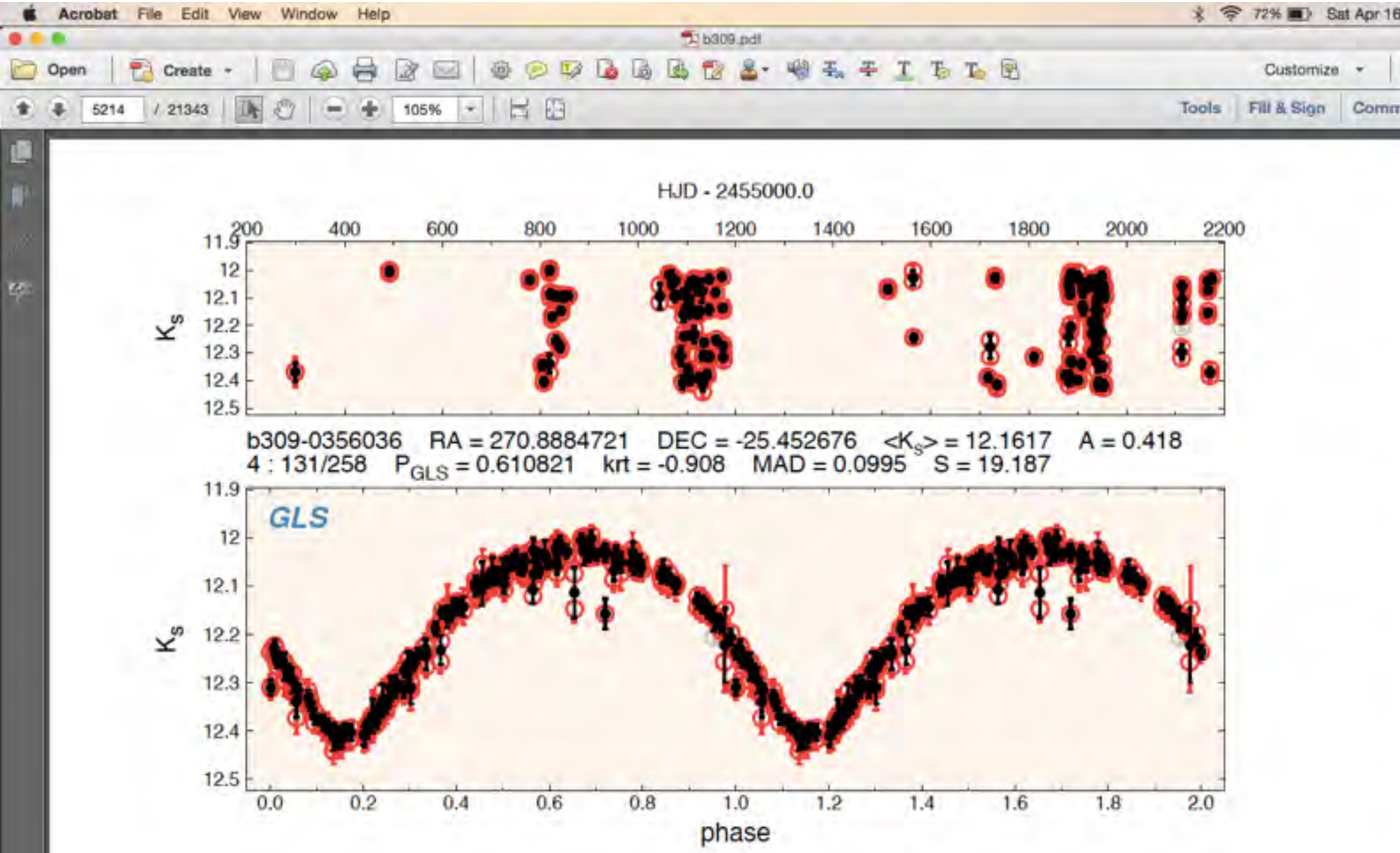
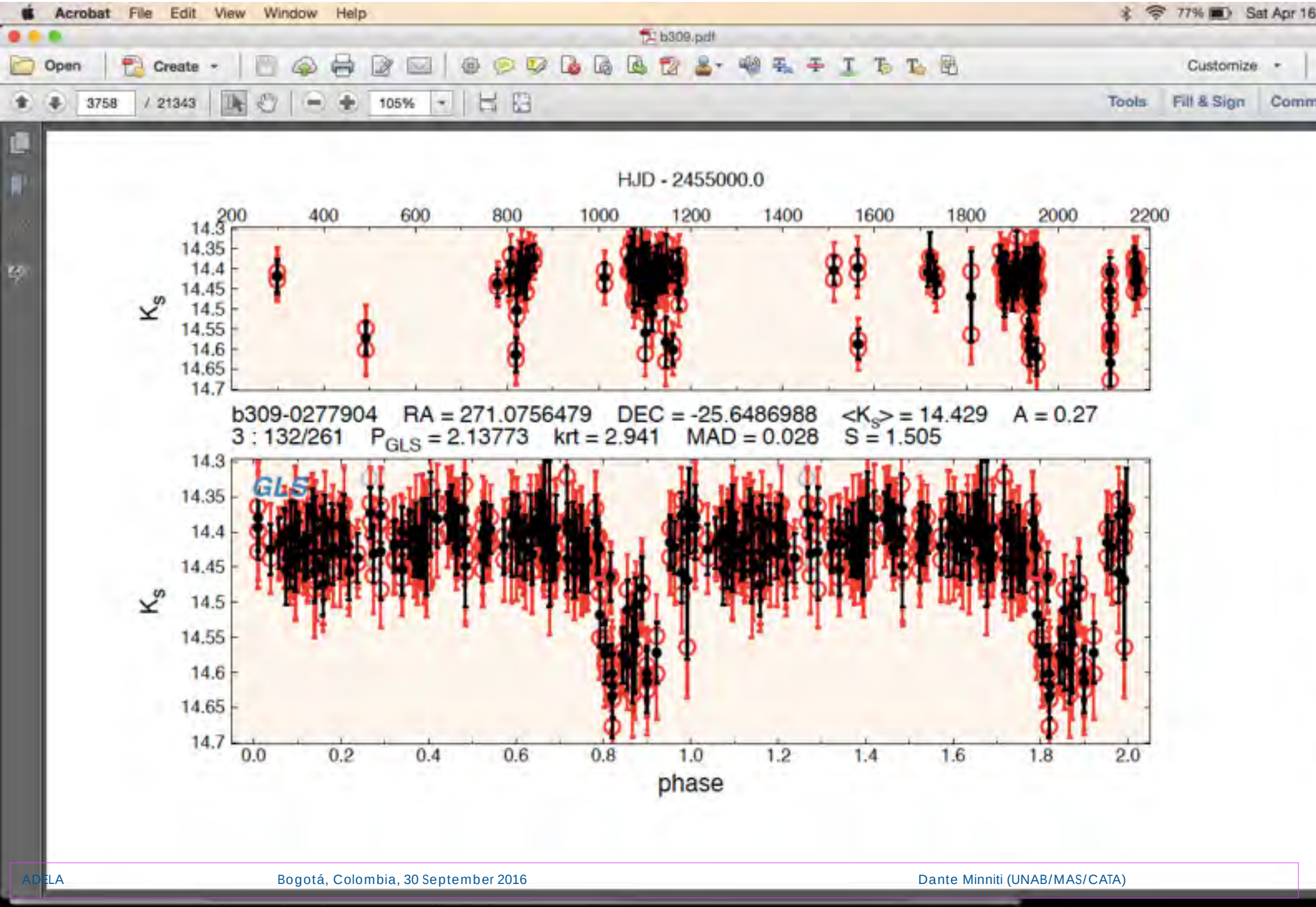
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
phase

WUMa with RR Lyrae period/amplitude



EB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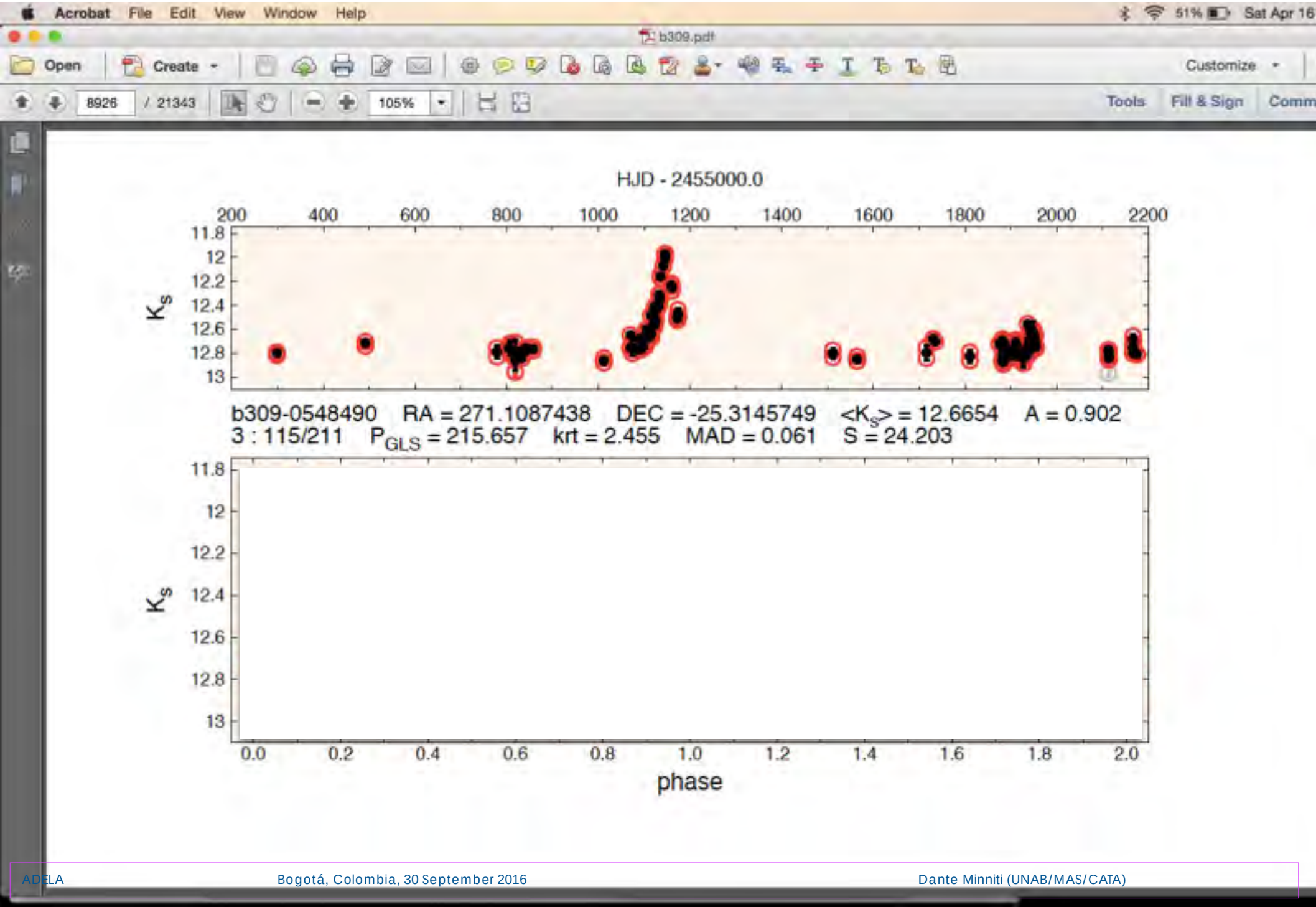
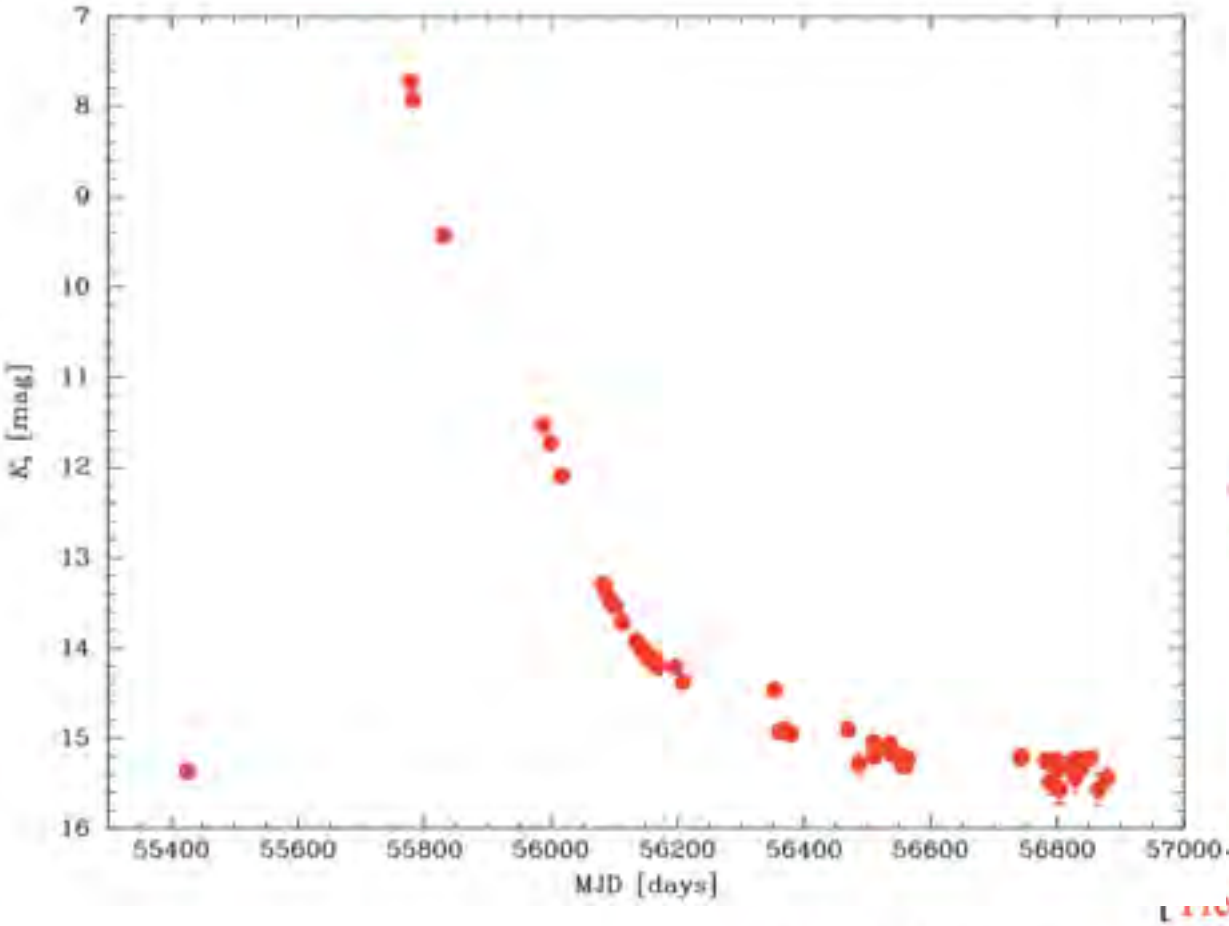
HJD - 2455000.0
200 400 600 800 1000 1200 1400 1600 1800 2000 2200
14.3 14.35 14.4 14.45 14.5 14.55 14.6 14.65 14.7
K_s
b309-0277904 RA = 271.0756479 DEC = -25.6486988 <K_s> = 14.429 A = 0.27
3 : 132/261 P_{GLS} = 2.13773 krt = 2.941 MAD = 0.028 S = 1.505
GLS
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0
phase

Microlensing event



VVV NOVA Hunters



The Astronomer's Telegram

Post | Search | Policies
Credential | Feeds | Email

6 Apr 2015; 02:19 UT

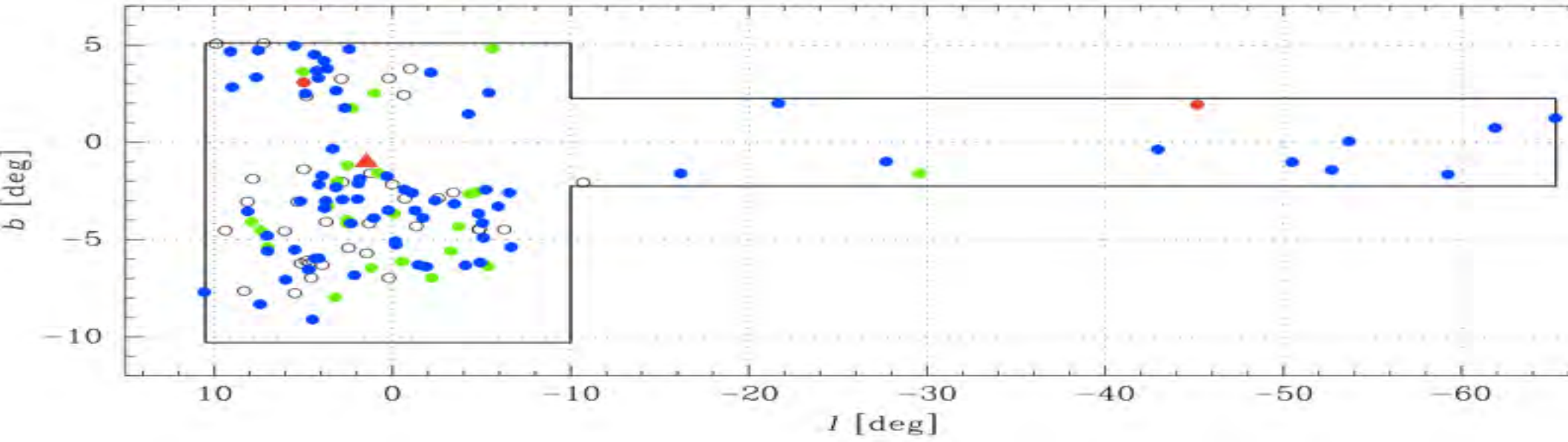
[Previous | Next | ADS]

VVV-NOV-006: the sixth Galactic nova candidate discovered by the VVV Survey

ATel #7241; *K. Montenegro (Universidad Andres Bello), D. Minniti (Universidad Andres Bello, Vatican Observatory, Millennium Institute of Astrophysics), R. K. Saito (Universidade Federal de Sergipe)*
on 17 Mar 2015; 21:46 UT

VVV NOVA Hunters

Catalog of 138 Known Galactic Novae *Roberto Saito et al. A&A, 2013*



Spatial distribution of known Galactic novae in the VVV area.

They avoid the Galactic plane, where the extinction is highest.

We are discovering novae in the most obscured regions of the Milky Way.

N(VVVNovae) = 20 so far!

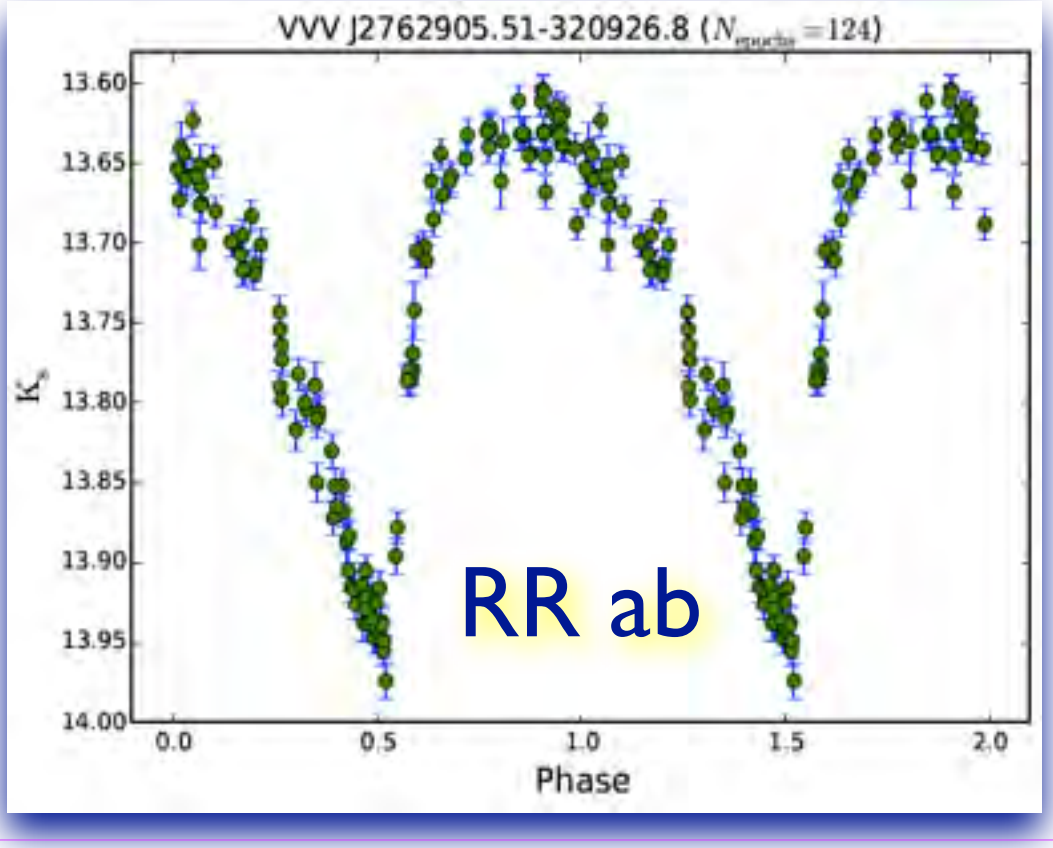
Template Light Curves Database

Angeloni et al. 2014, A&A 567, 100 (arXiv:1405.4517)

The VVV Templates Project Towards an Automated Classification of VVV Light-Curves: Building a database of stellar variability in the near-infrared. Our database contains near-IR light-curves for:

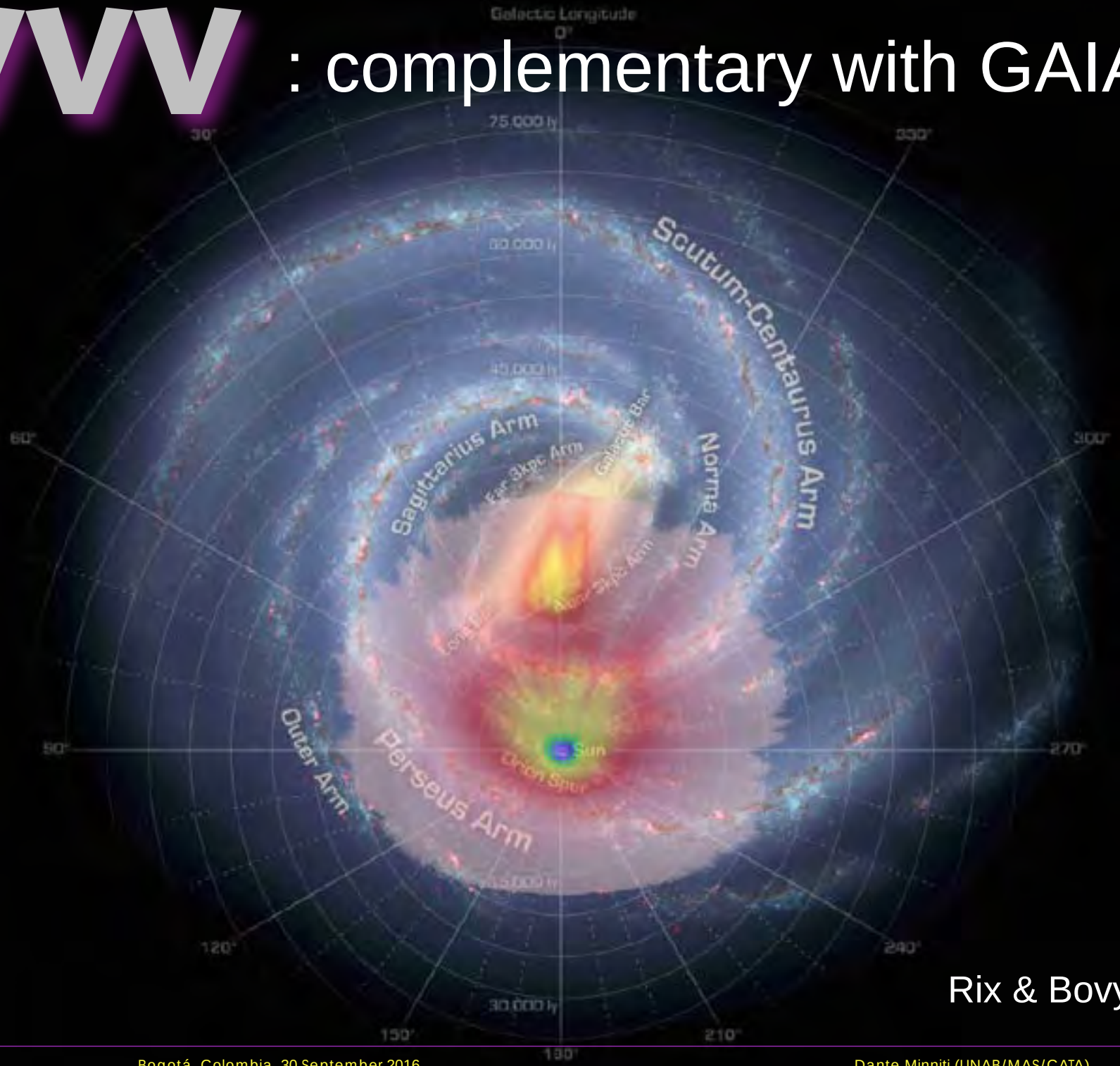
RR Lyrae
Cepheids
Eclipsing Binaries
Delta Scutis
Cataclysmic Variables
etc.

vvvsurvey.org



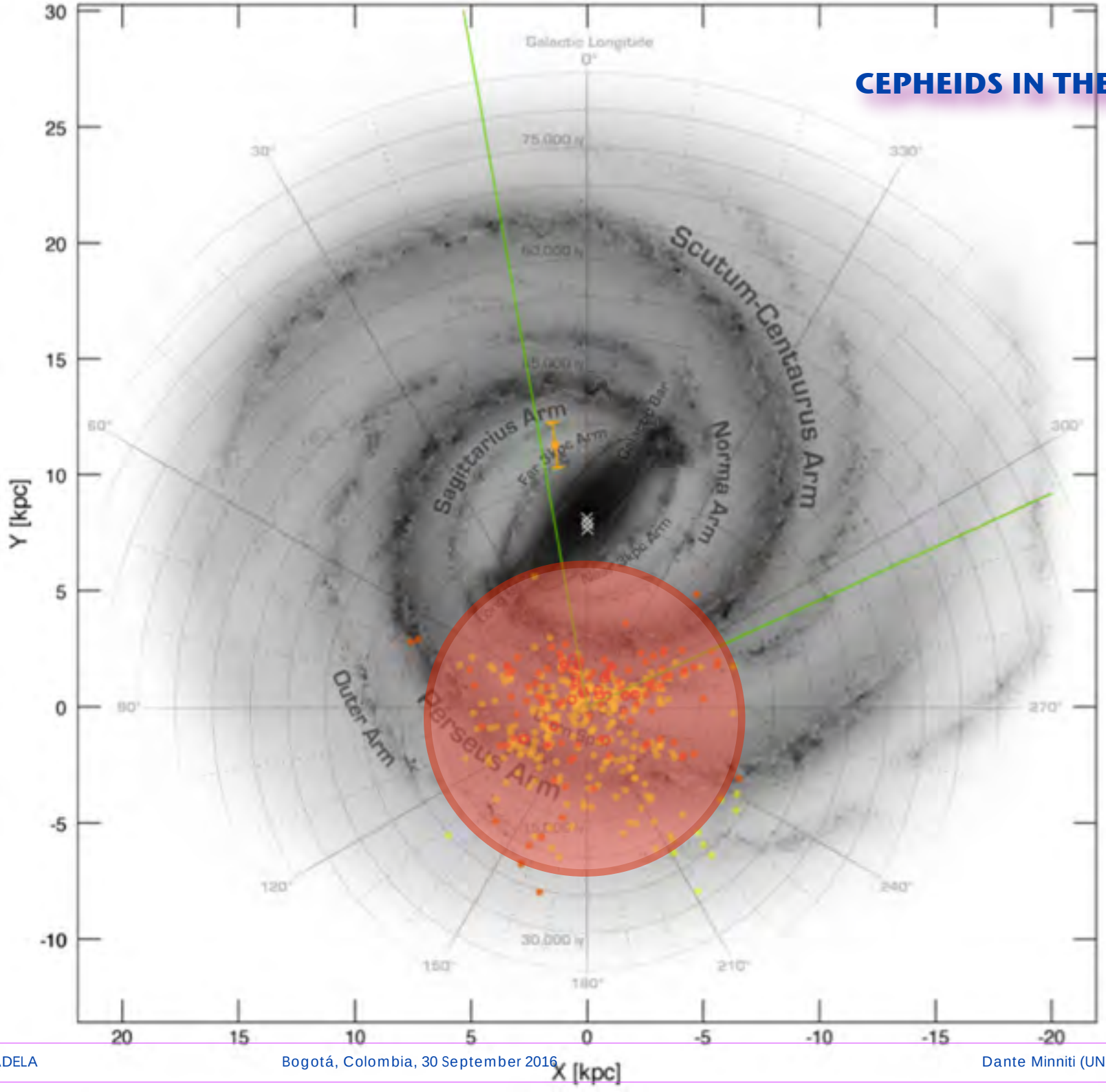
VVV Cepheids

VVV : complementary with GAIA



Rix & Bovy 2014

CEPHEIDS IN THE GALACTIC DISK



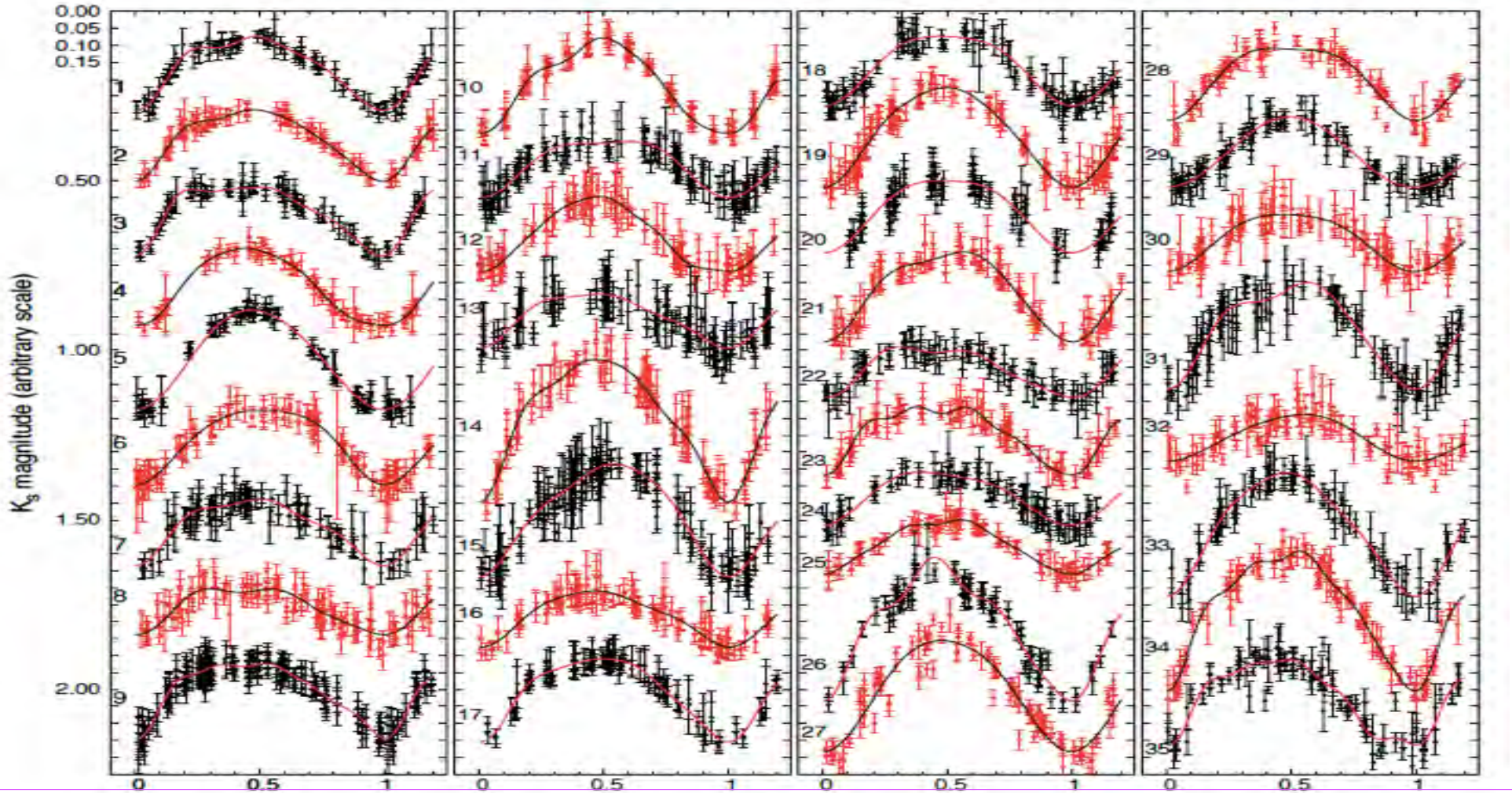
I. Dekany et al.
ApJL 2015

Cepheids in the Inner Bulge

Dekany et al. 2015 ApJL (arXiv:1509.08402)

Main problem:

To separate classical Cepheids from Type II Cepheids (WVir)



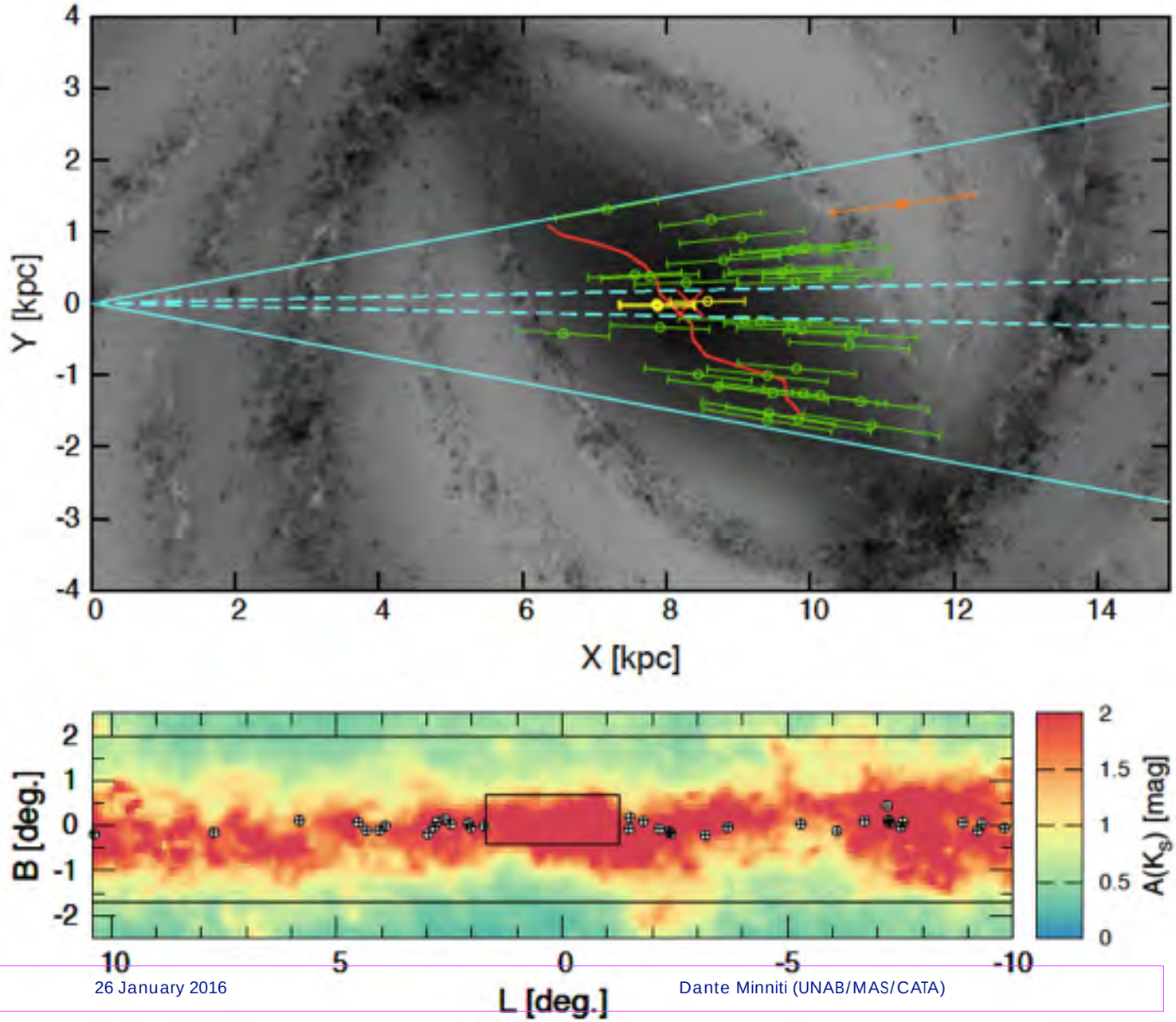
Cepheids in the Inner Bulge

Dekany et al. 2015 ApJL (arXiv:1509.08402)

Found a population of Classical Cepheids in the Galactic mid-plane, well within the bulge (35 Cepheids).

They trace a young and thin stellar disk all the way to the Galactic center.

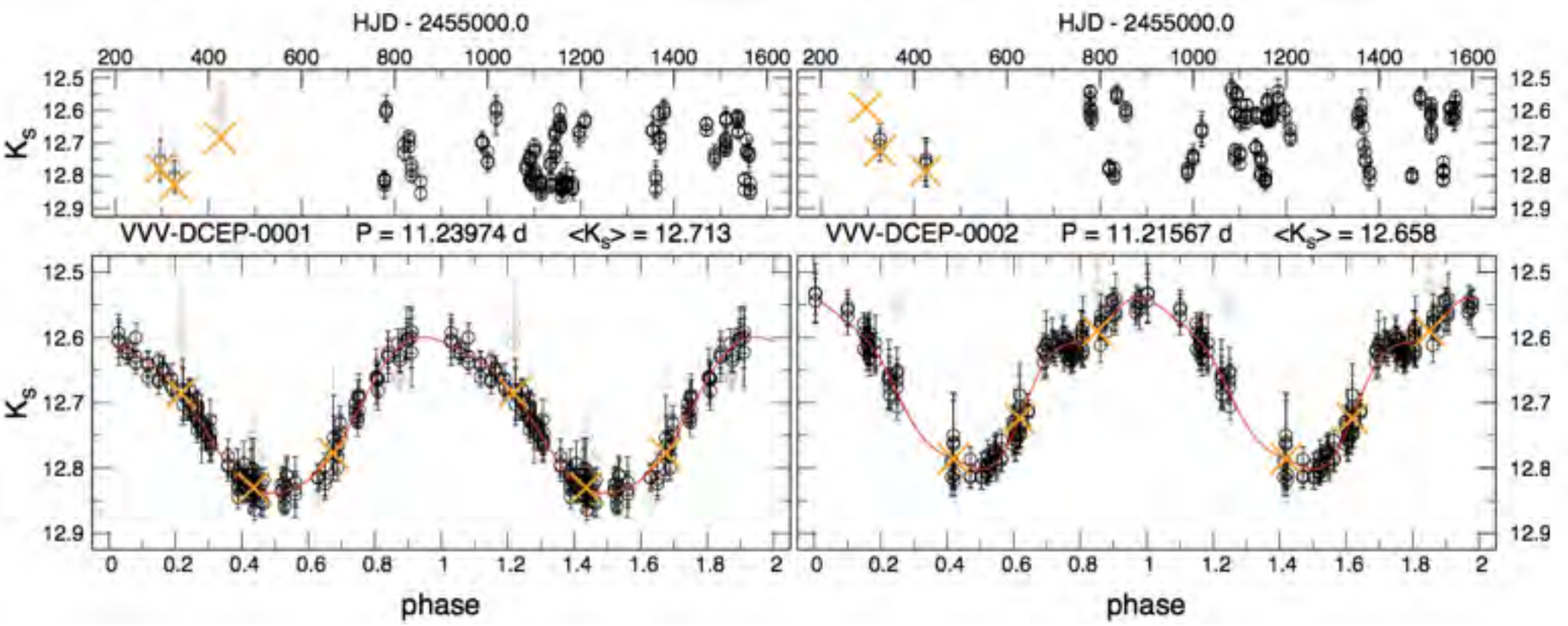
Their period (age) spread indicate a continuous supply of newly formed stars over the past ~100 Myrs.



BIG DATA

Problems for:
analysing,
visualising
etc.

CEPHEIDS IN THE GALACTIC DISK

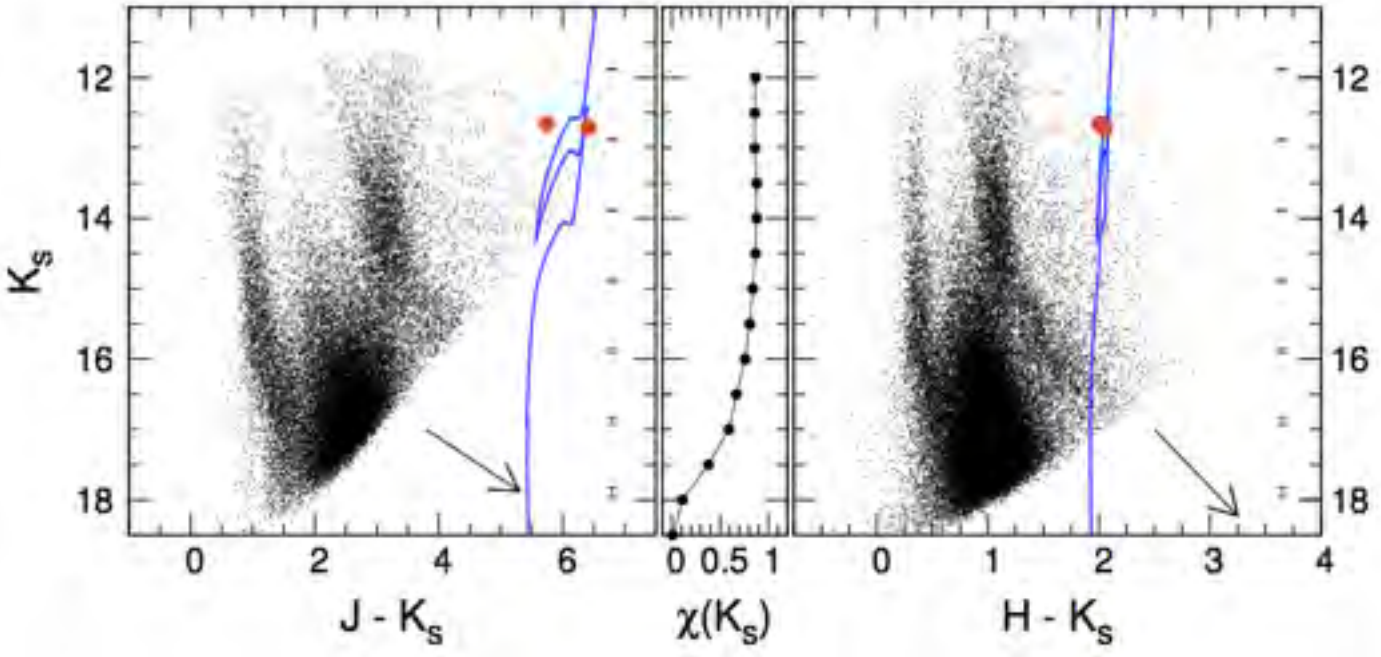


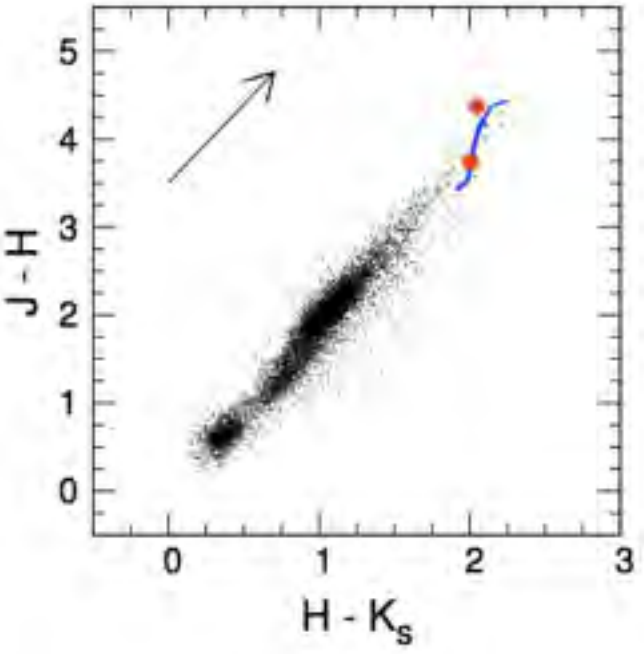
I. Dekany et al.
ApJL 2015

Star	α [hms]	δ [dms]	l [deg]	b [deg]	period [d]
C1	18:01:24.49	-22:54:44.6	6.99047	0.00055	11.23974
C2	18:01:25.09	-22:54:28.3	6.99555	0.00079	11.21567

CEPHEIDS IN THE GALACTIC DISK

AN INVISIBLE MASSIVE OPEN CLUSTER HIDDEN BEHIND Av~32





I. Dekany et al.
ApJL 2015

Star	$a_{tot.}$[a] (K_s)	$\langle K_s \rangle$	$\langle H-K_s \rangle$	$\langle J-K_s \rangle$	$E(H-K_s)$	$A(K_s)$[b]	R [pc]
C1	0.24	12.71	2.05	6.42	2.00	3.27	11337
C2	0.26	12.66	2.01	5.75	1.96	3.20	11397

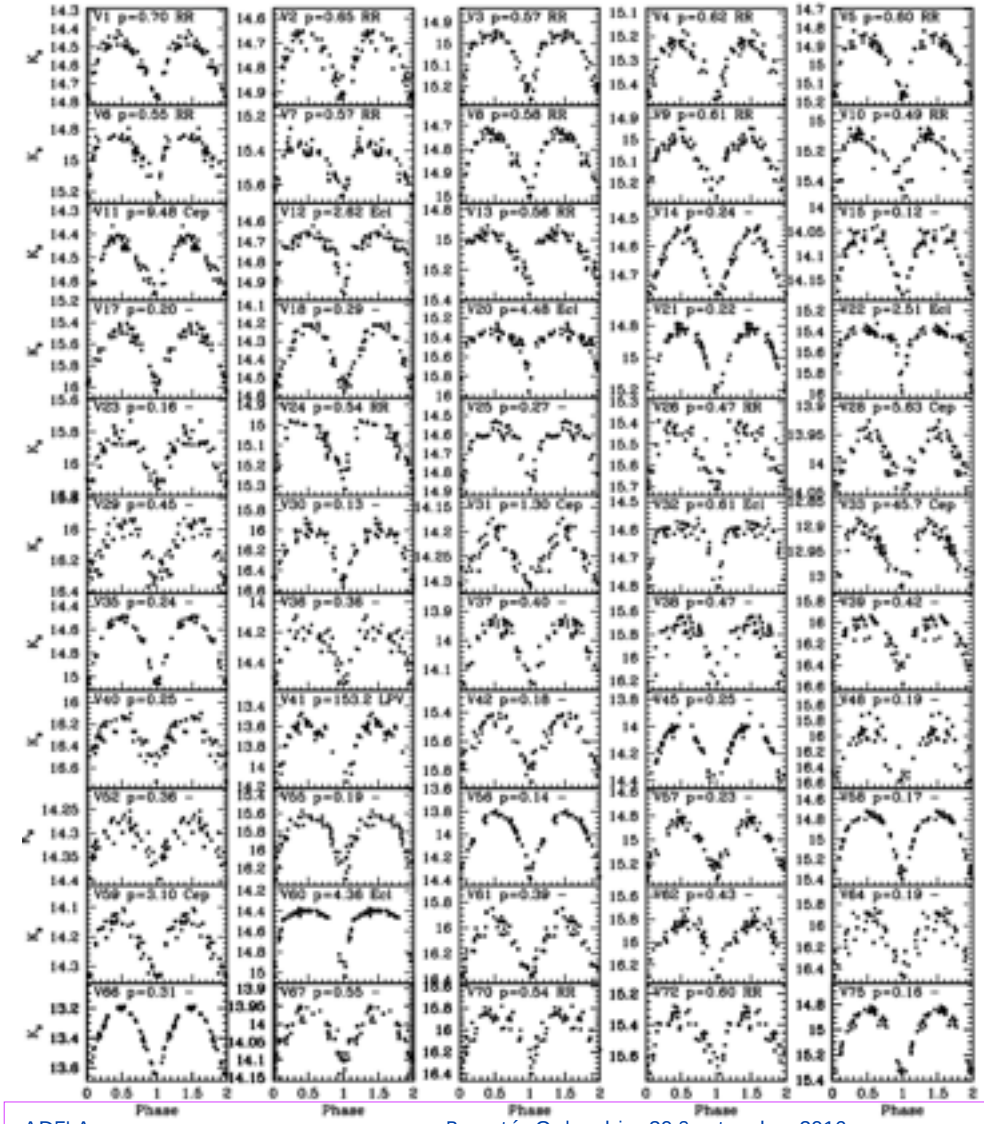
VVV

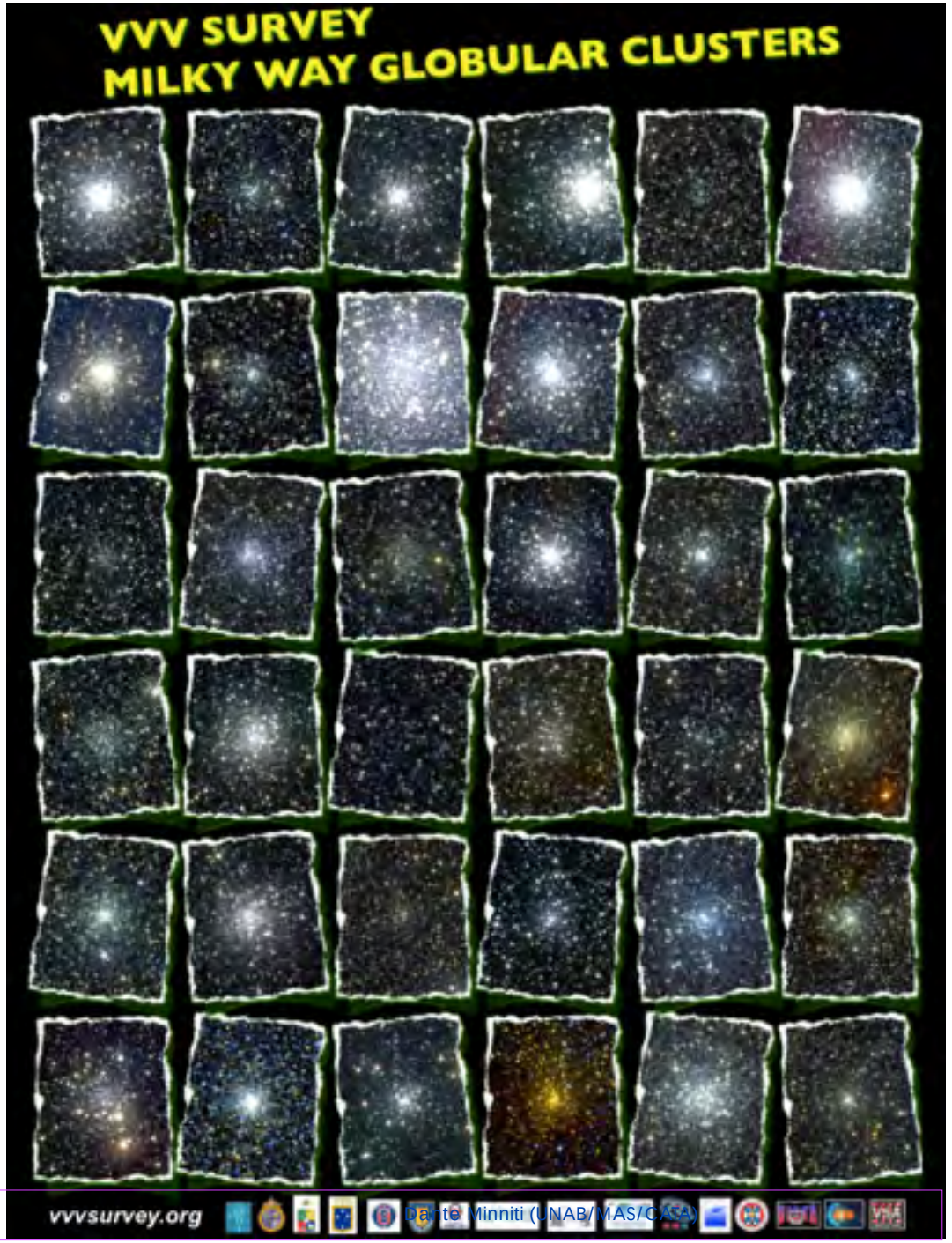
RRLyrae

Variable stars in the VVV globular clusters. I. 2MASS-GC02 and Terzan 10

J. Alonso-Garcia et al. (AJ 2014)

RR Lyrae in GCs






Extremely Reddened Globular Clusters
2MASS-GC02 Distance 4.9 kpc
7.1 kpc

Variable stars in the VVV globular clusters. 2MASS-GC02

J. Alonso-Garcia et al. (AJ 2014)

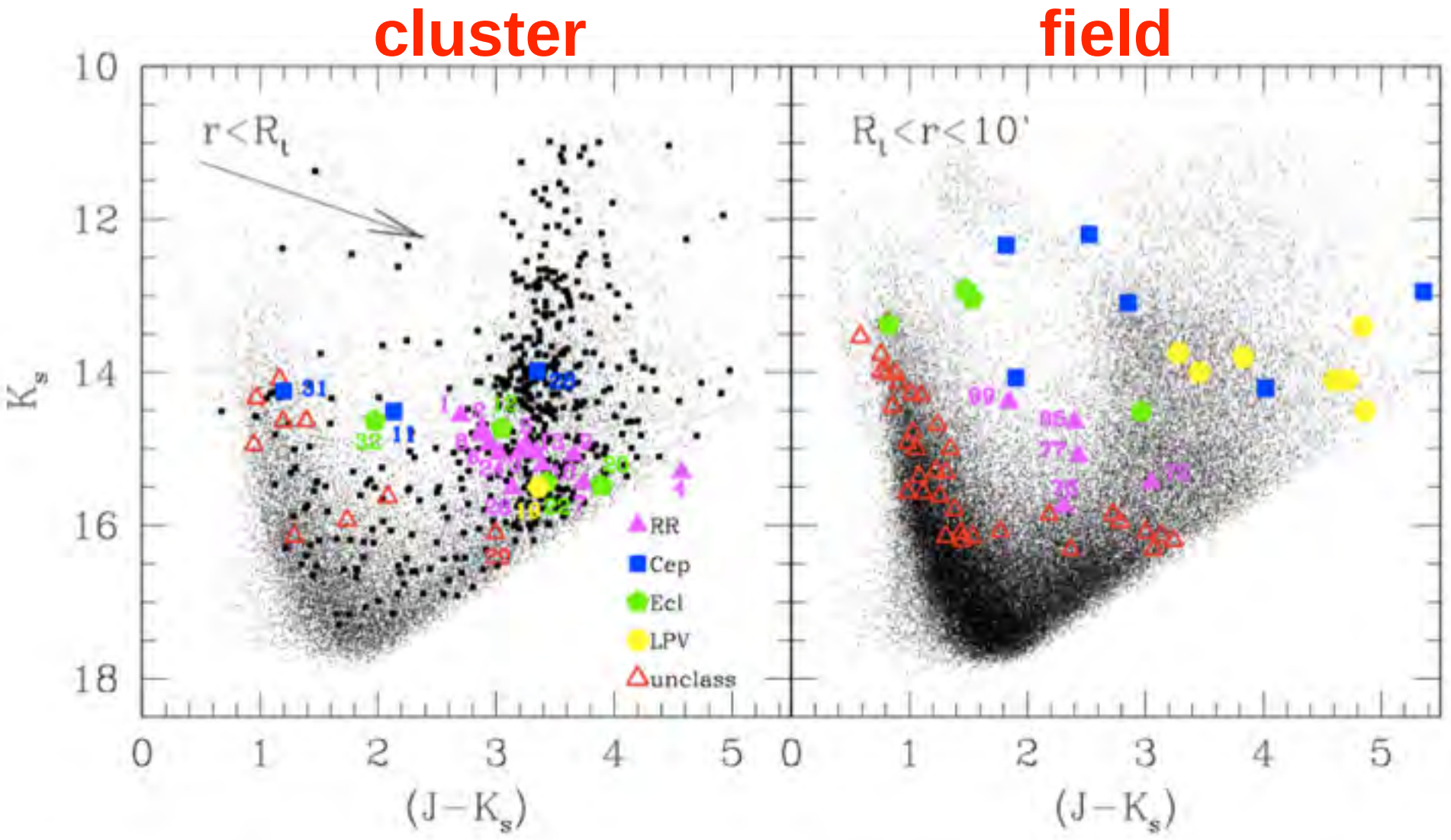
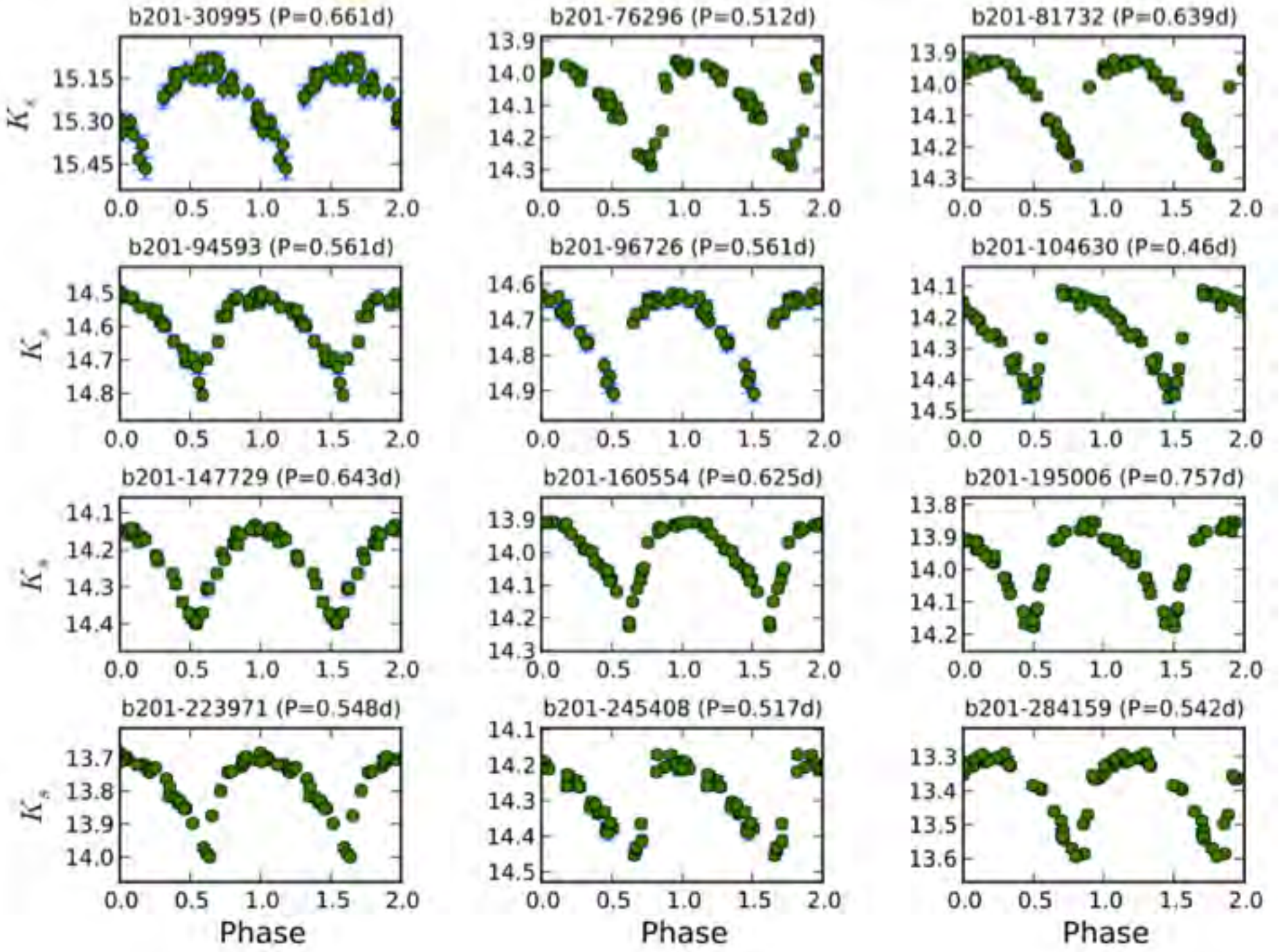


Fig. 1.— $J-K_s$ vs. K_s CMDs of 2MASS-GC02, out to its tidal radius $r_t = 4.9'$ (left), and of its surrounding region (right). The arrow shows the reddening vector according to Nishiyama

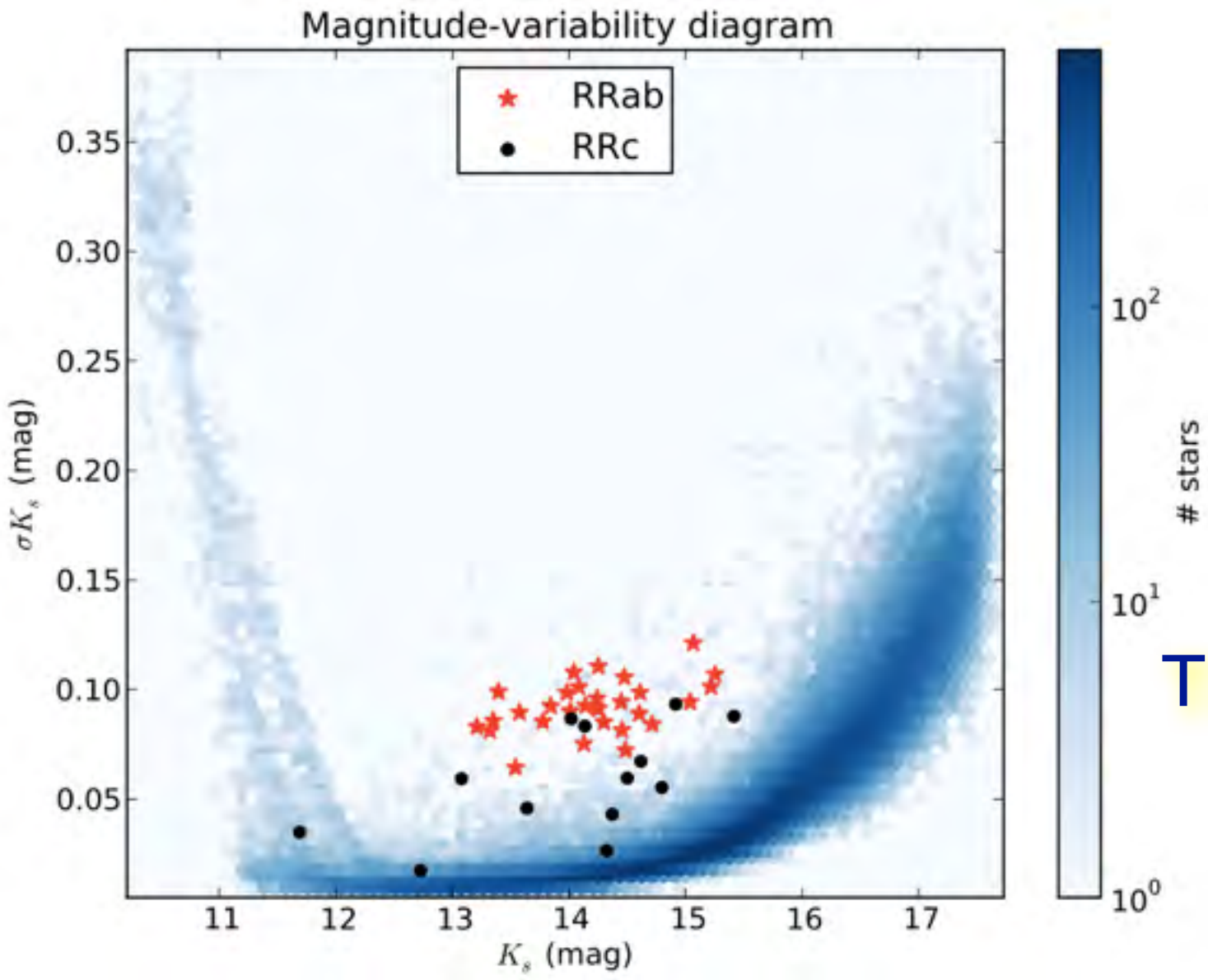
Bulge RR Lyrae

F. Gran, et al. 2014, A&A



Bulge RR Lyrae

F. Gran, et al. 2014, A&A

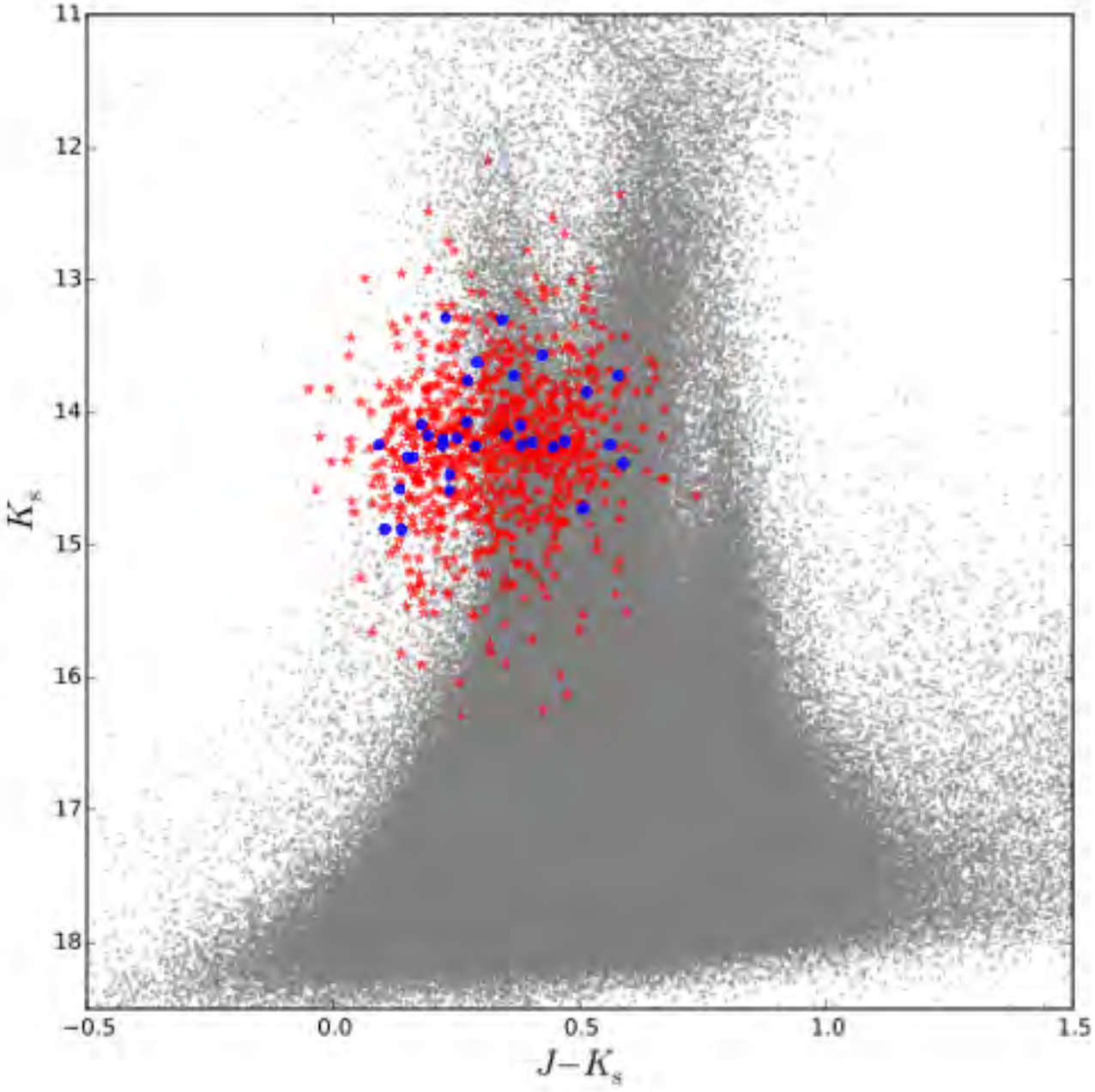


Tile d201

We find ~1 RR Lyrae variable star for every 10,000 stars measured.

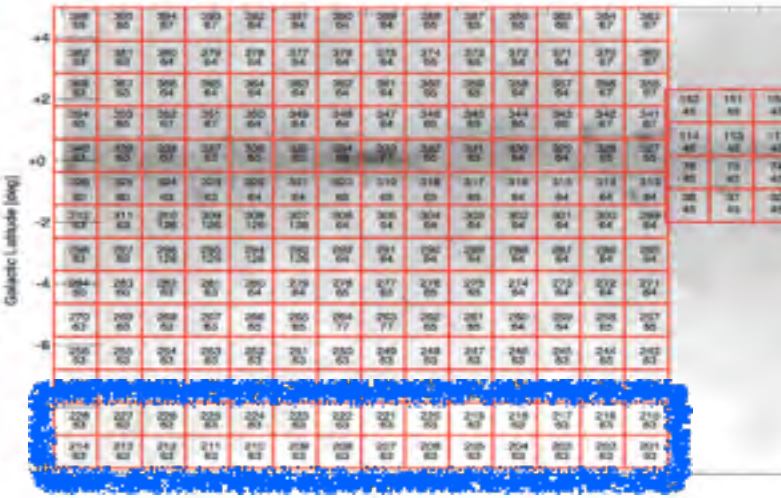
Bulge RR Lyrae

F. Gran, et al. A&A, 2016

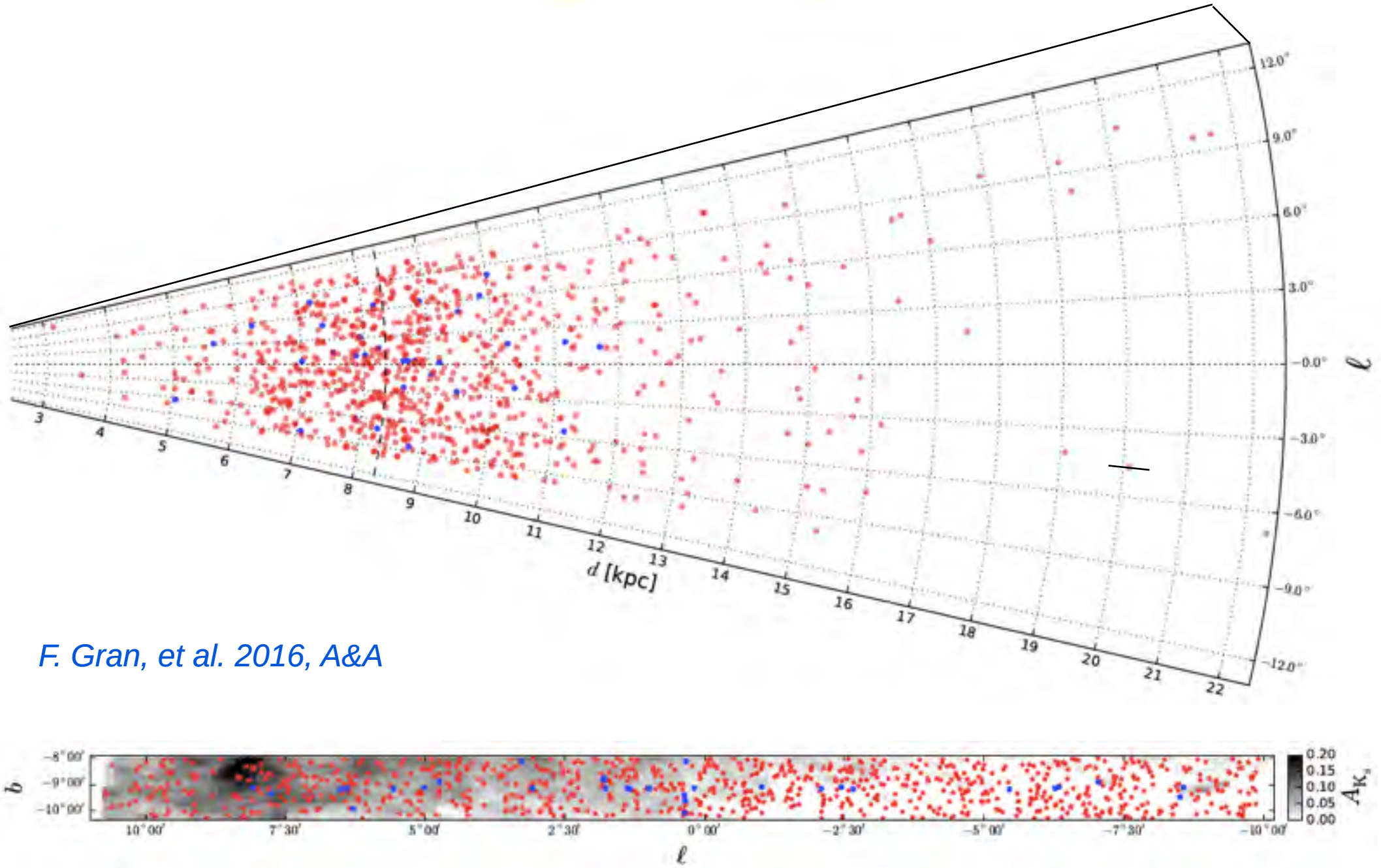


- RR Lyrae are metal-poor, and represent an old and metal-poor stellar population.

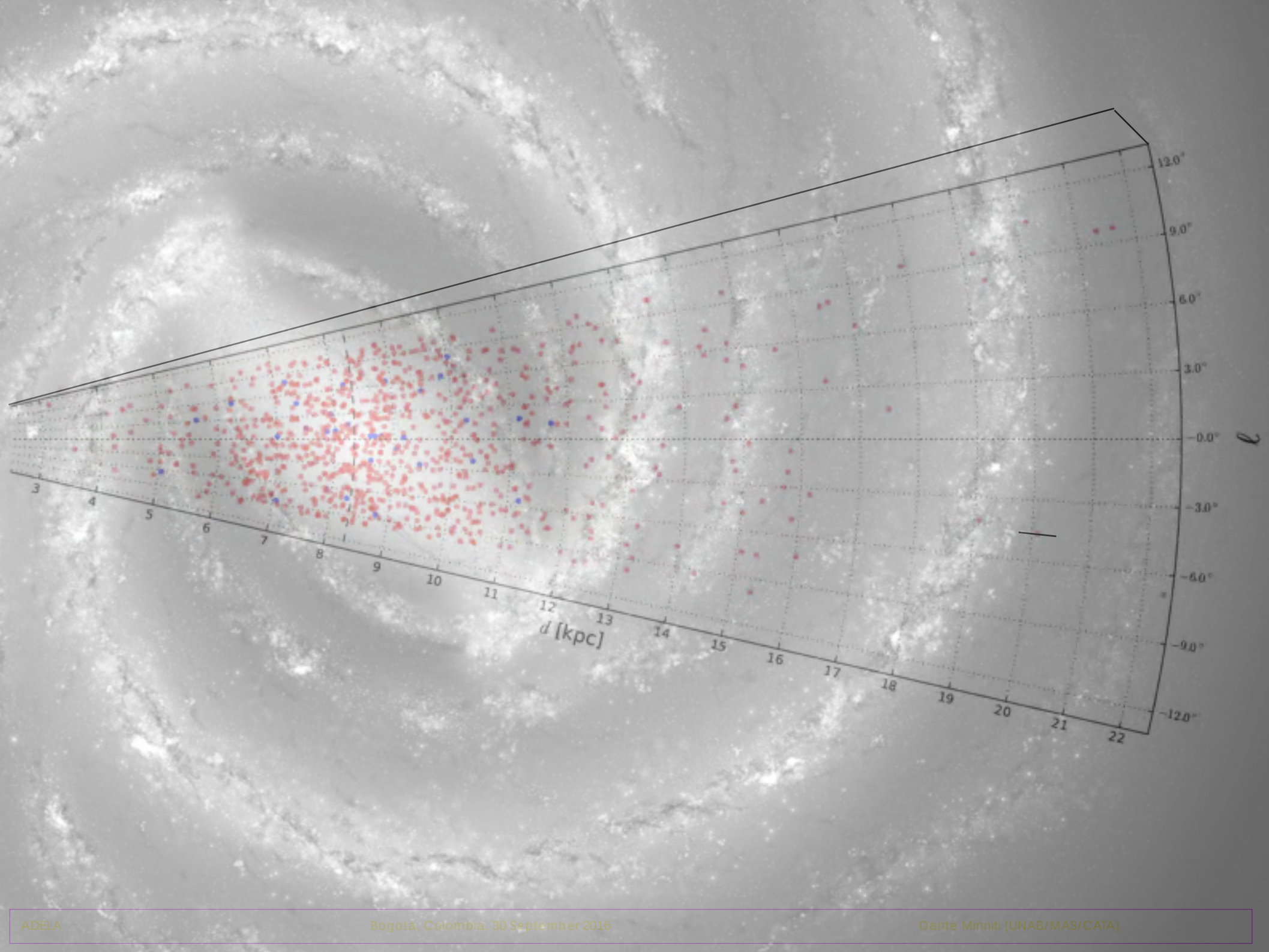
- RR Lyrae stars are excellent distance indicators.



Bulge RR Lyrae



F. Gran, et al. 2016, A&A


12.0°
9.0°
6.0°
3.0°
0.0°
−3.0°
−6.0°
−9.0°
−12.0°
b
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
d [kpc]

Bulge RR Lyrae

The VVV distance distribution of known bulge RR Lyrae is different from the clump giants!

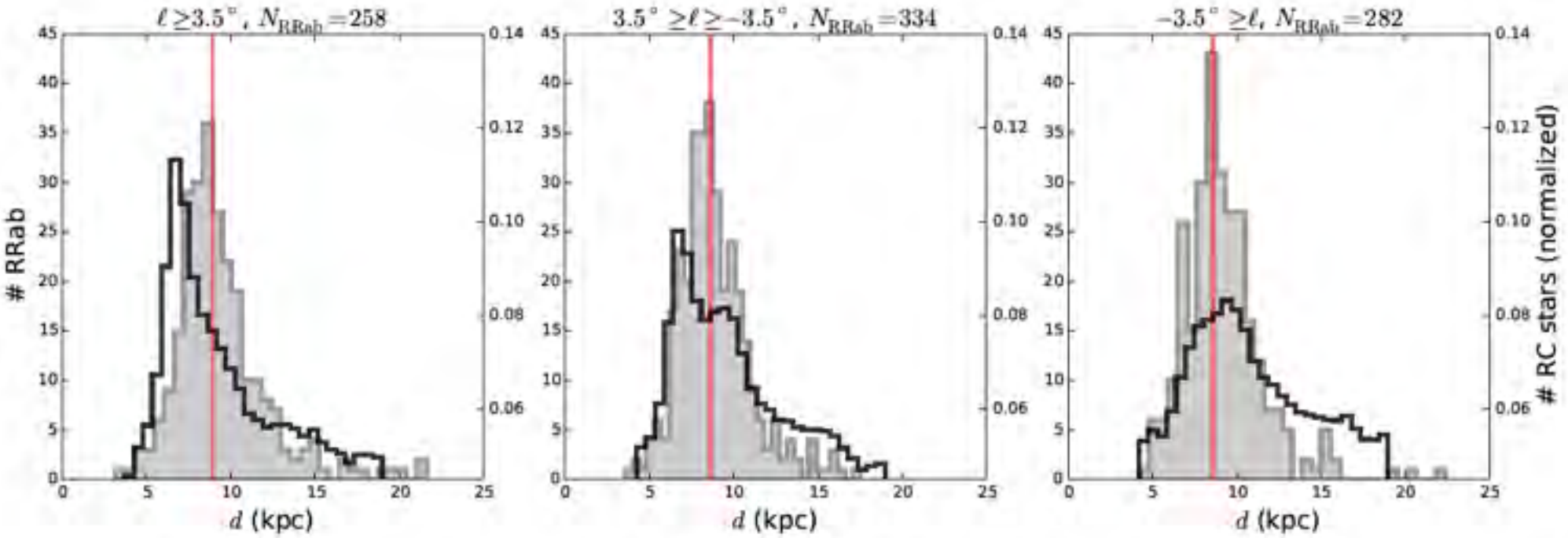


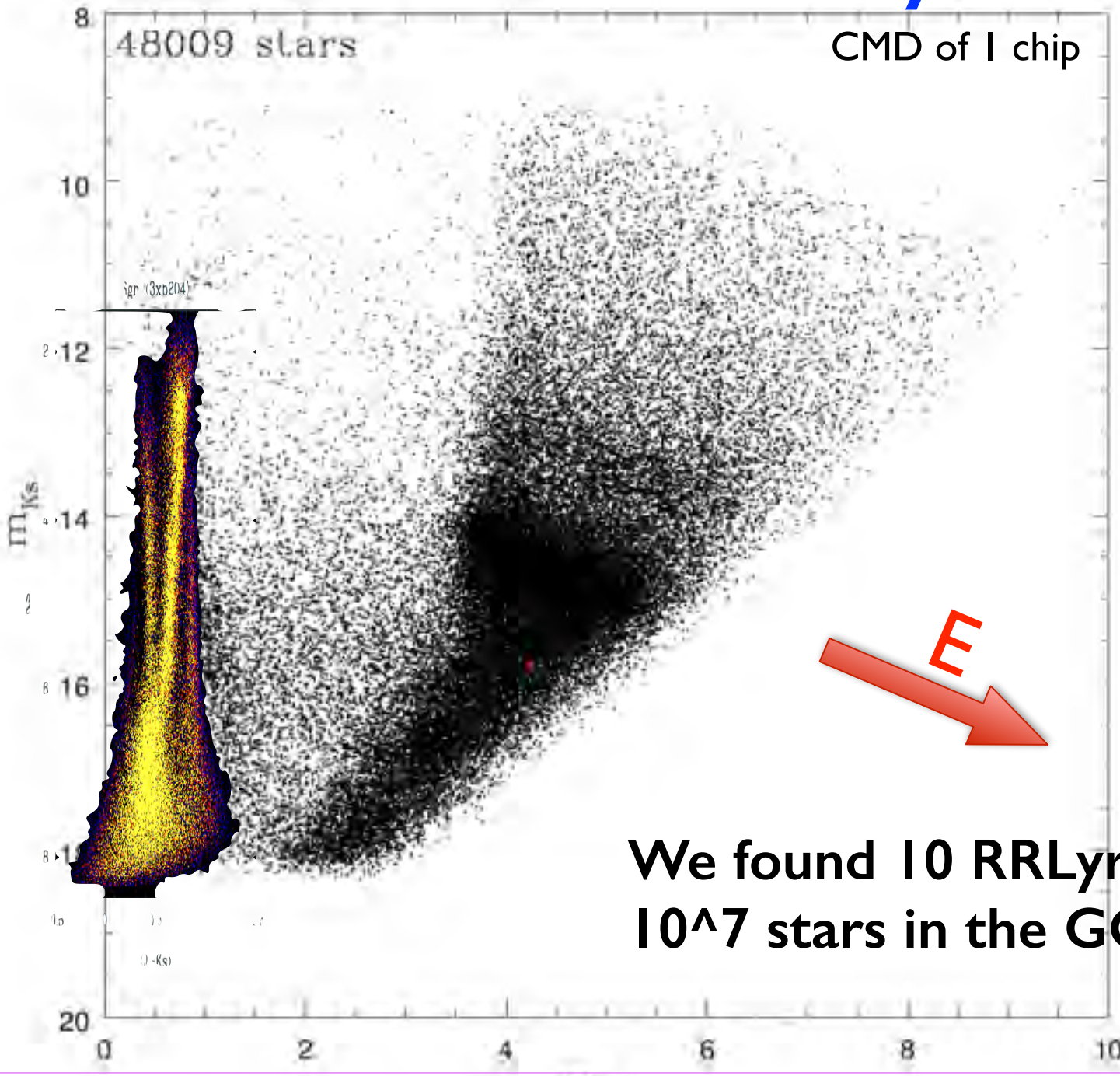
Fig. 8. Histogram of distances of RR Lyrae (gray filled) and RC stars (black steps) as function of galactic latitude (ℓ). Since the total number of RC stars in the same areas overwhelms the number of RR Lyrae, the histogram showing their distribution in distance was normalized for visualization purposes. The vertical line represents the RR Lyrae median distance of each region.

Galactic Center RRLyrae

D. Minniti, R. Contreras, et al.
(2016, ApJ Letters)

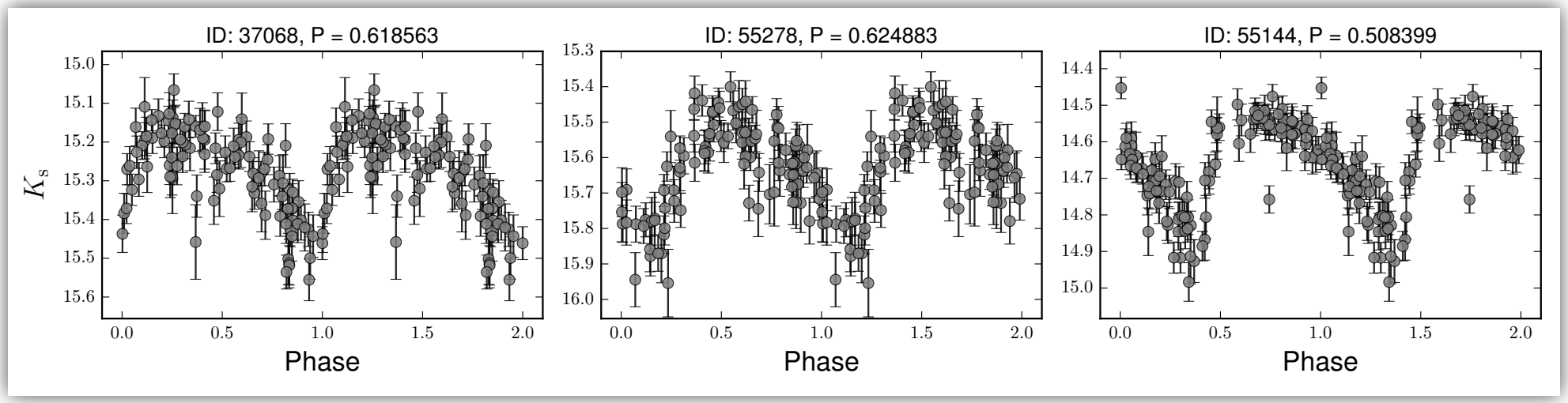
VVV Image of the Galactic center

Galactic Center RR Lyrae



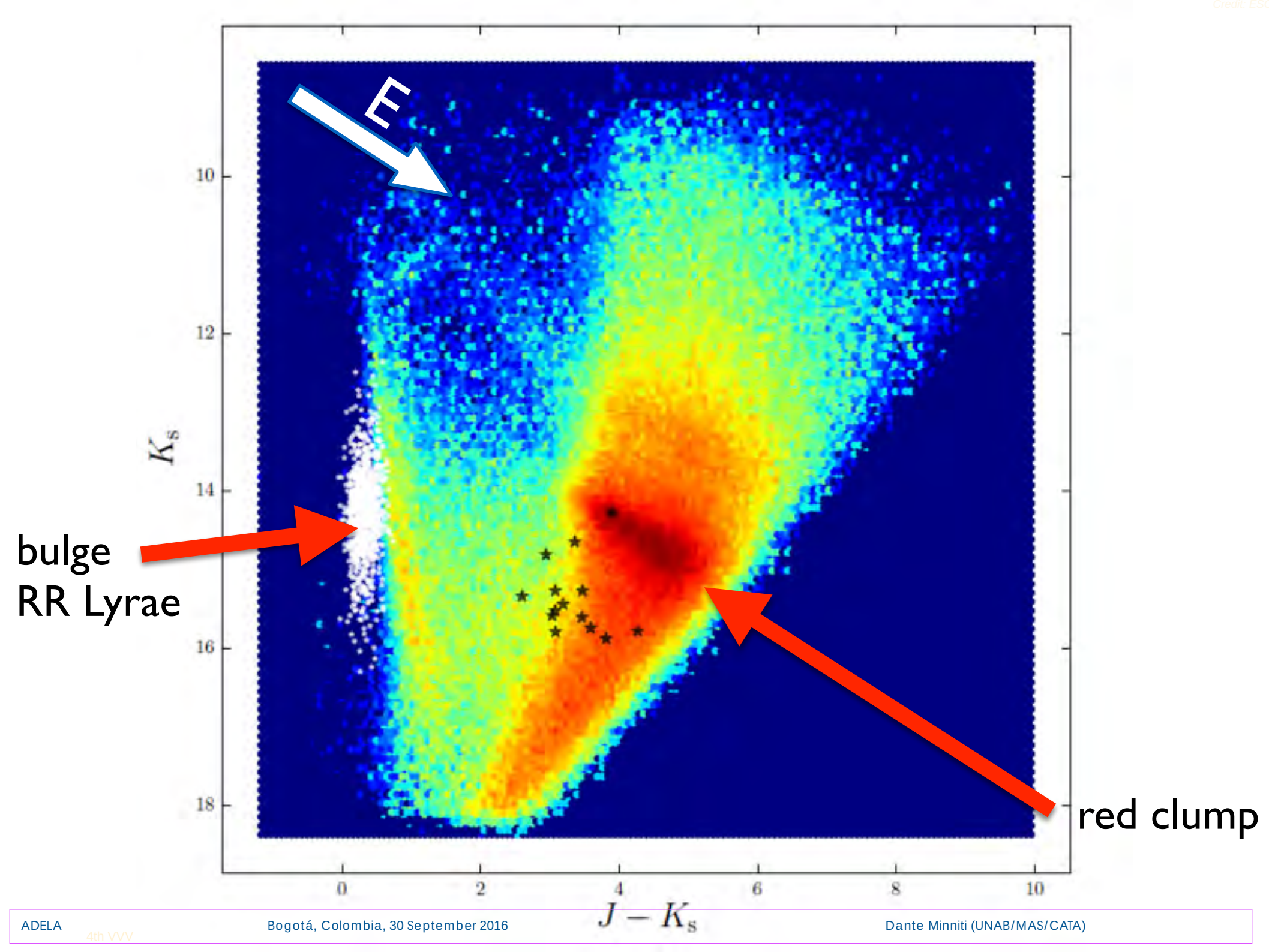
We found 10 RRLyrae out of 10^7 stars in the GC region

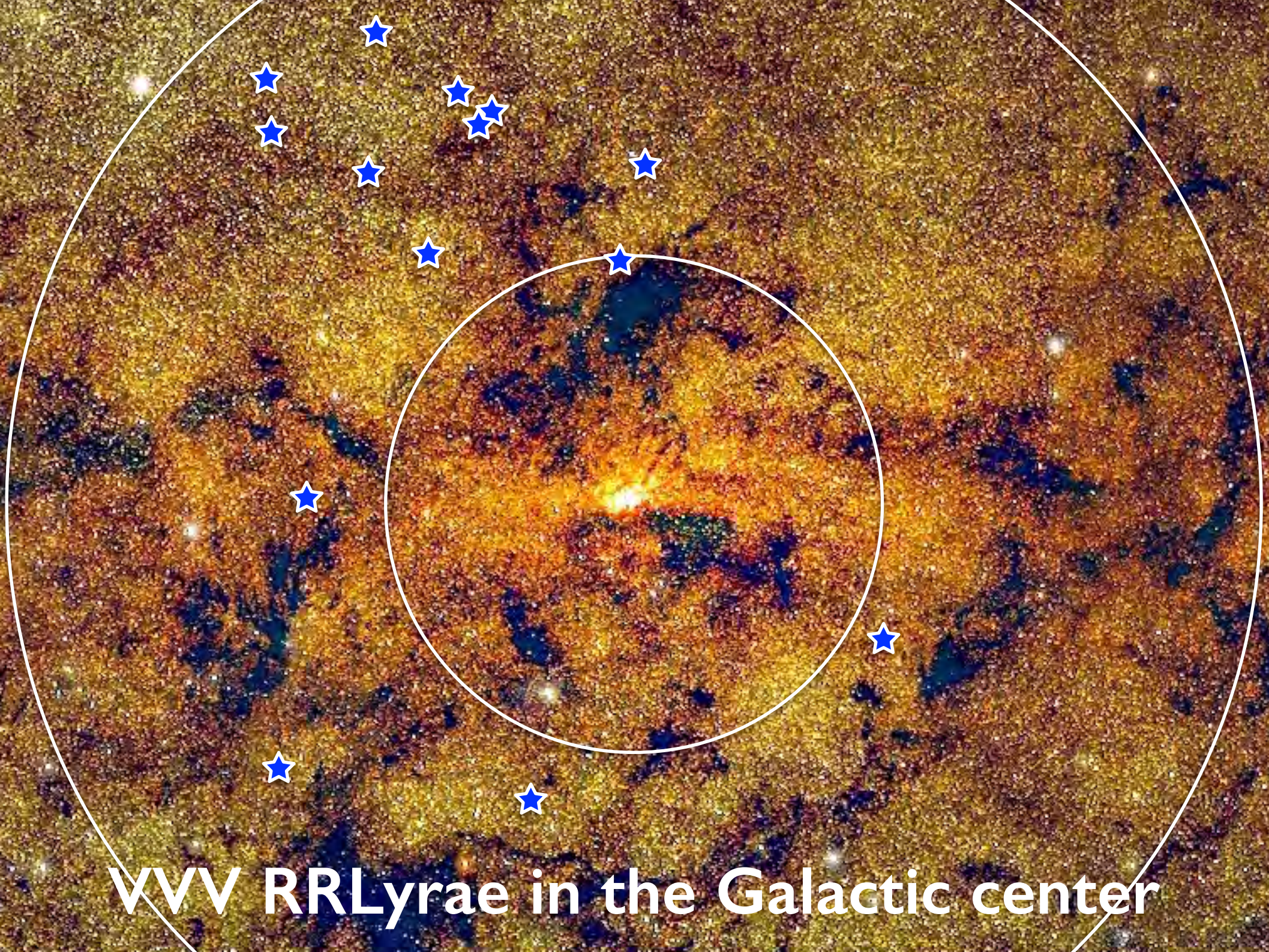
Galactic Center RR Lyrae



Typical light curves

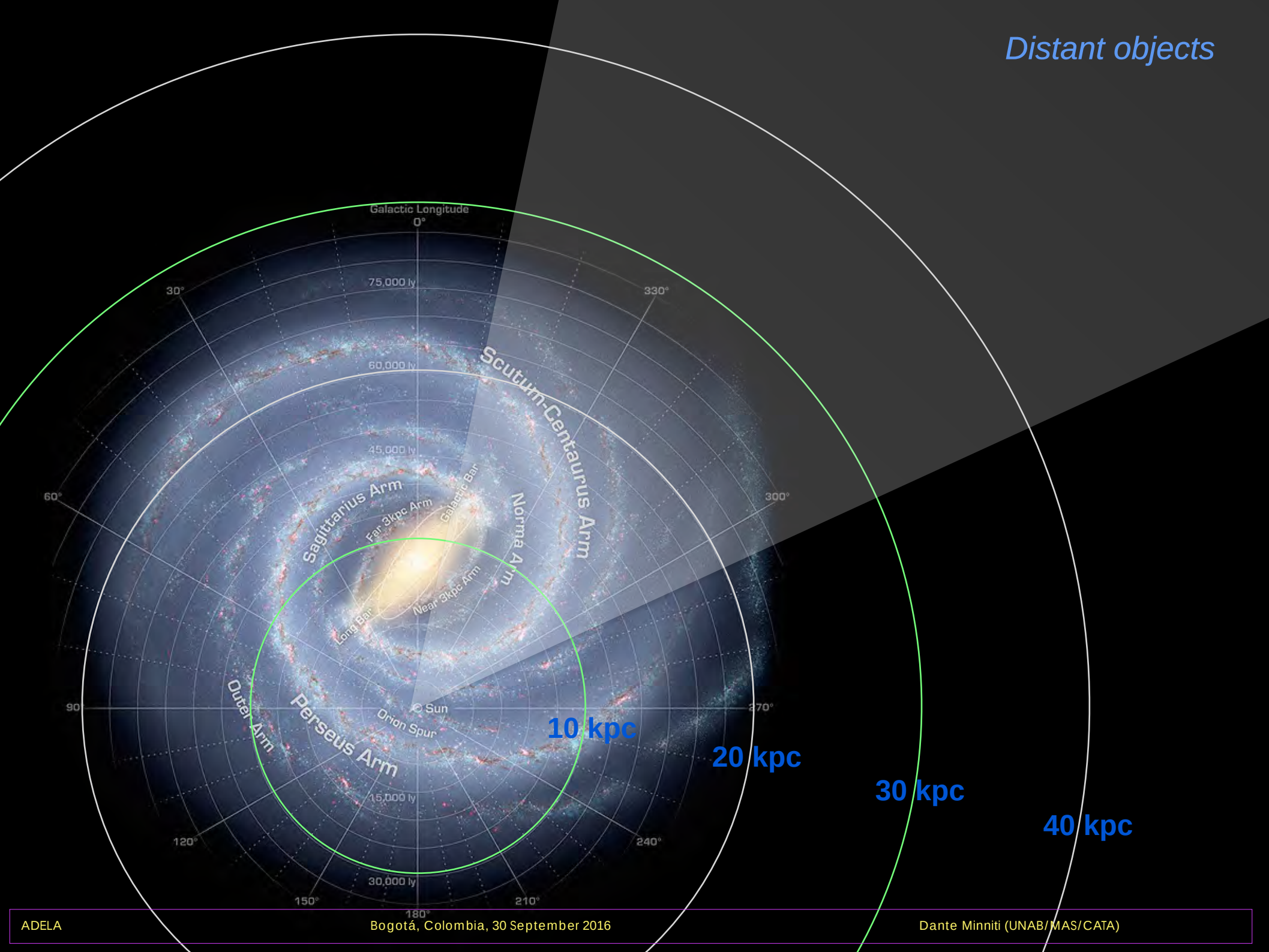
- clear discrimination from contact binaries
- somewhat noisier than typical VVV bulge RR Lyrae
- period distribution indicates an Oosterhoff type I population


E
bulge
RR Lyrae
red clump
K_s
$J - K_s$
10
12
14
16
18
0
2
4
6
8
10

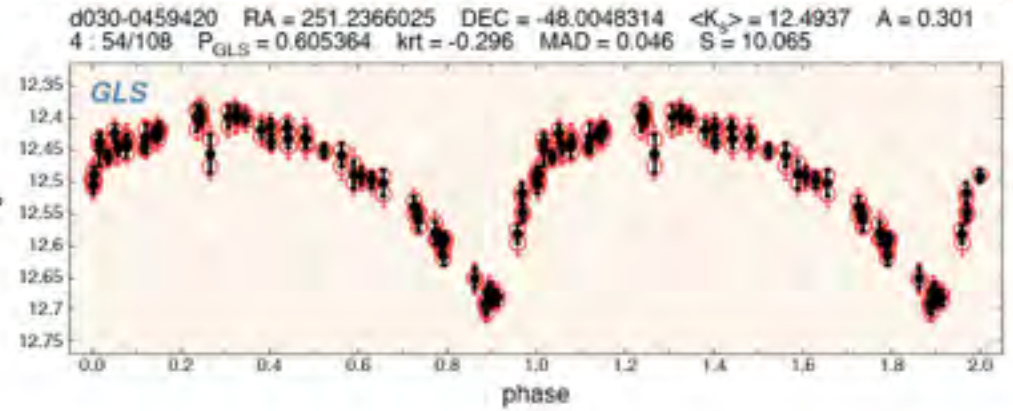

VVV RRLyrae in the Galactic center

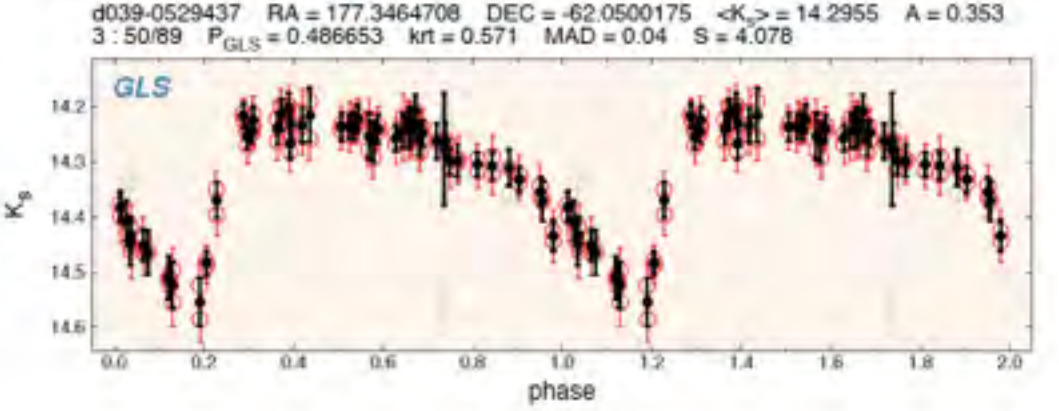
Galactic Disk RRLyrae

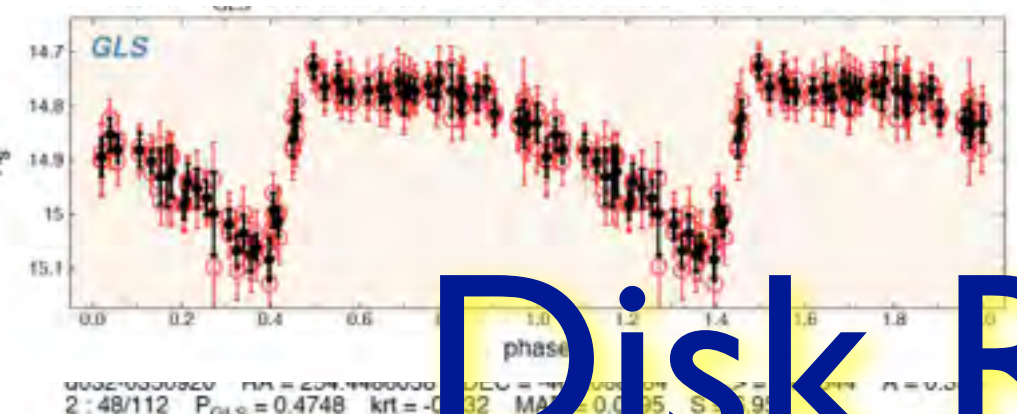
Distant objects

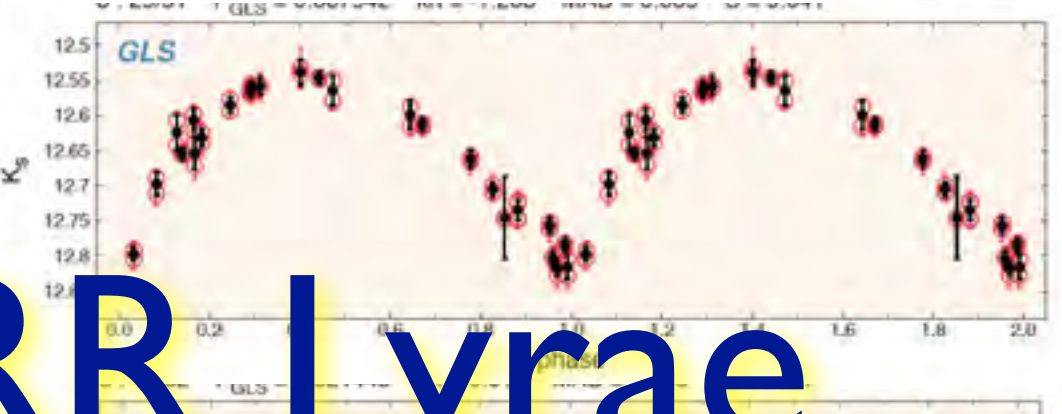


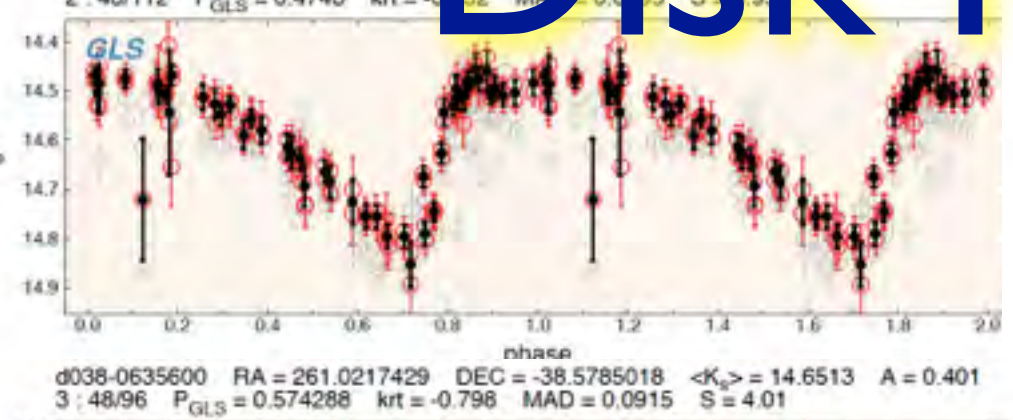
Disk RR Lyrae

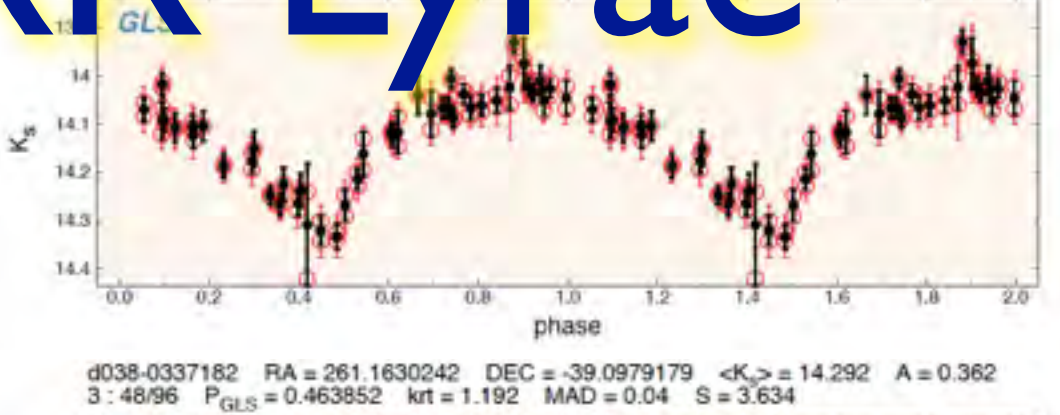


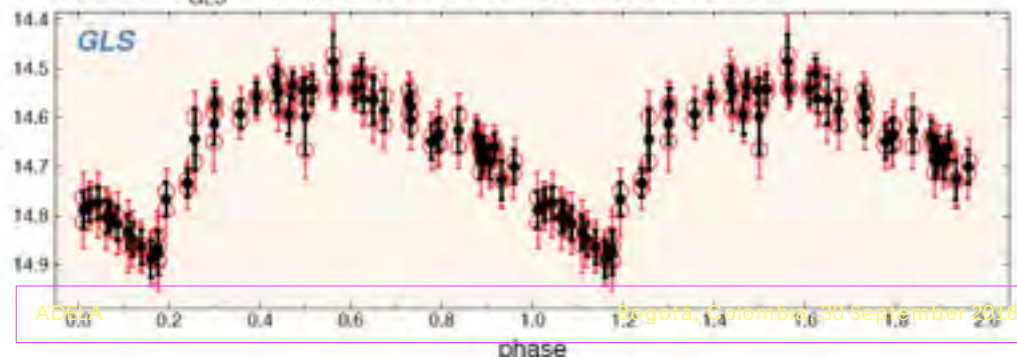


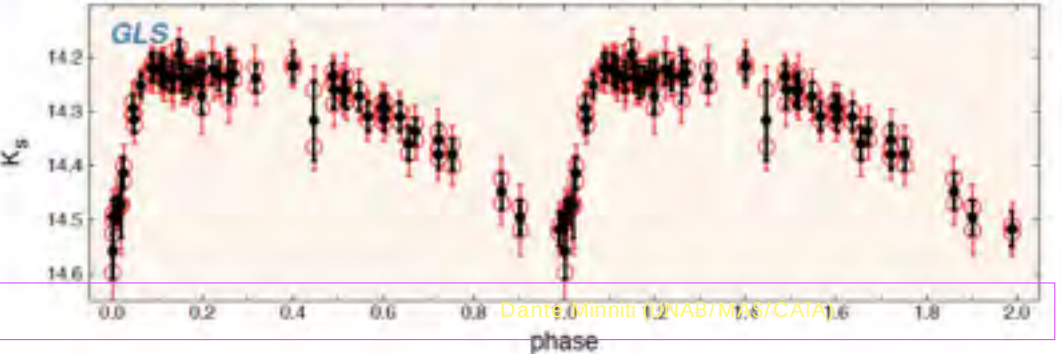




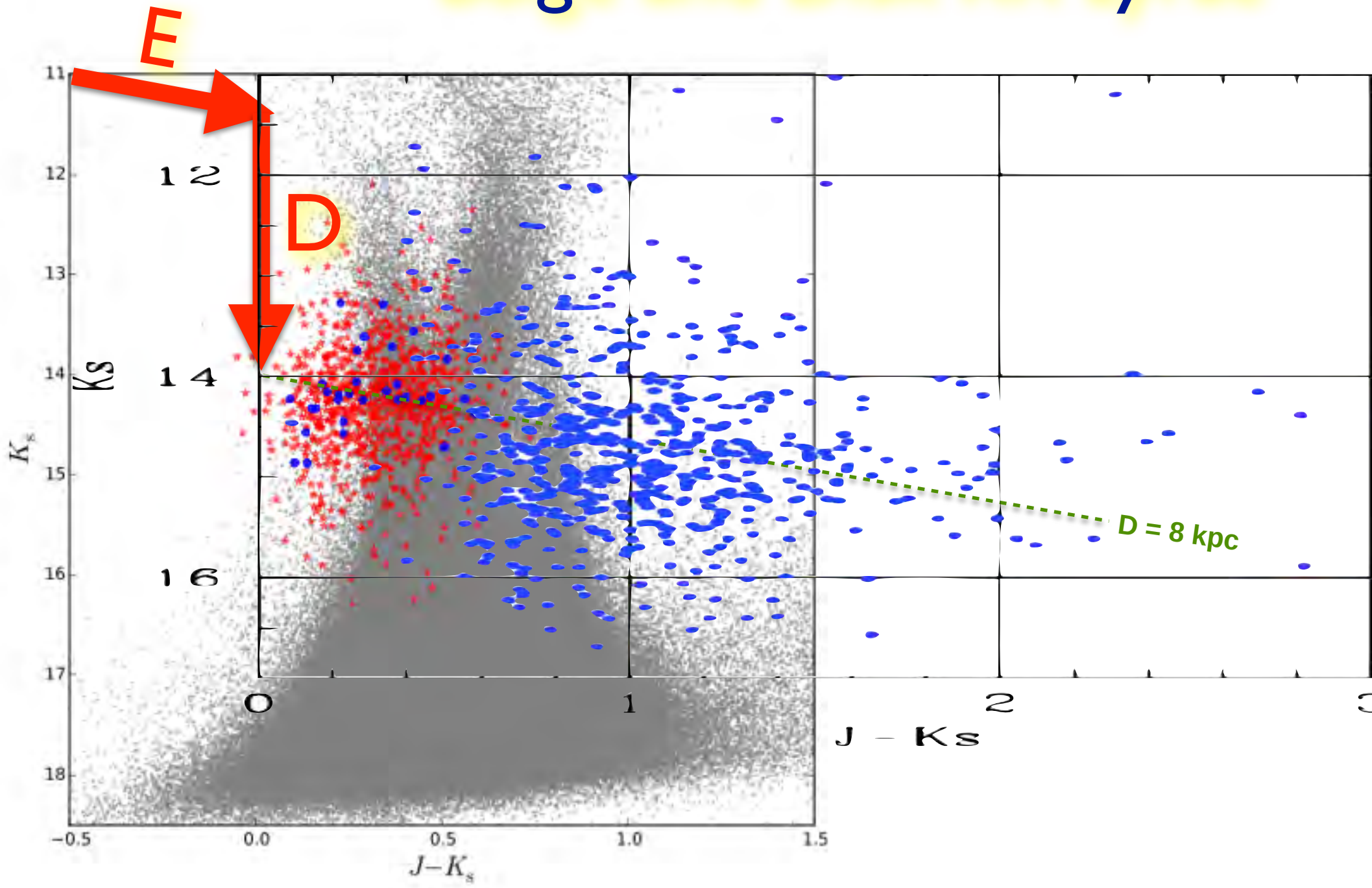






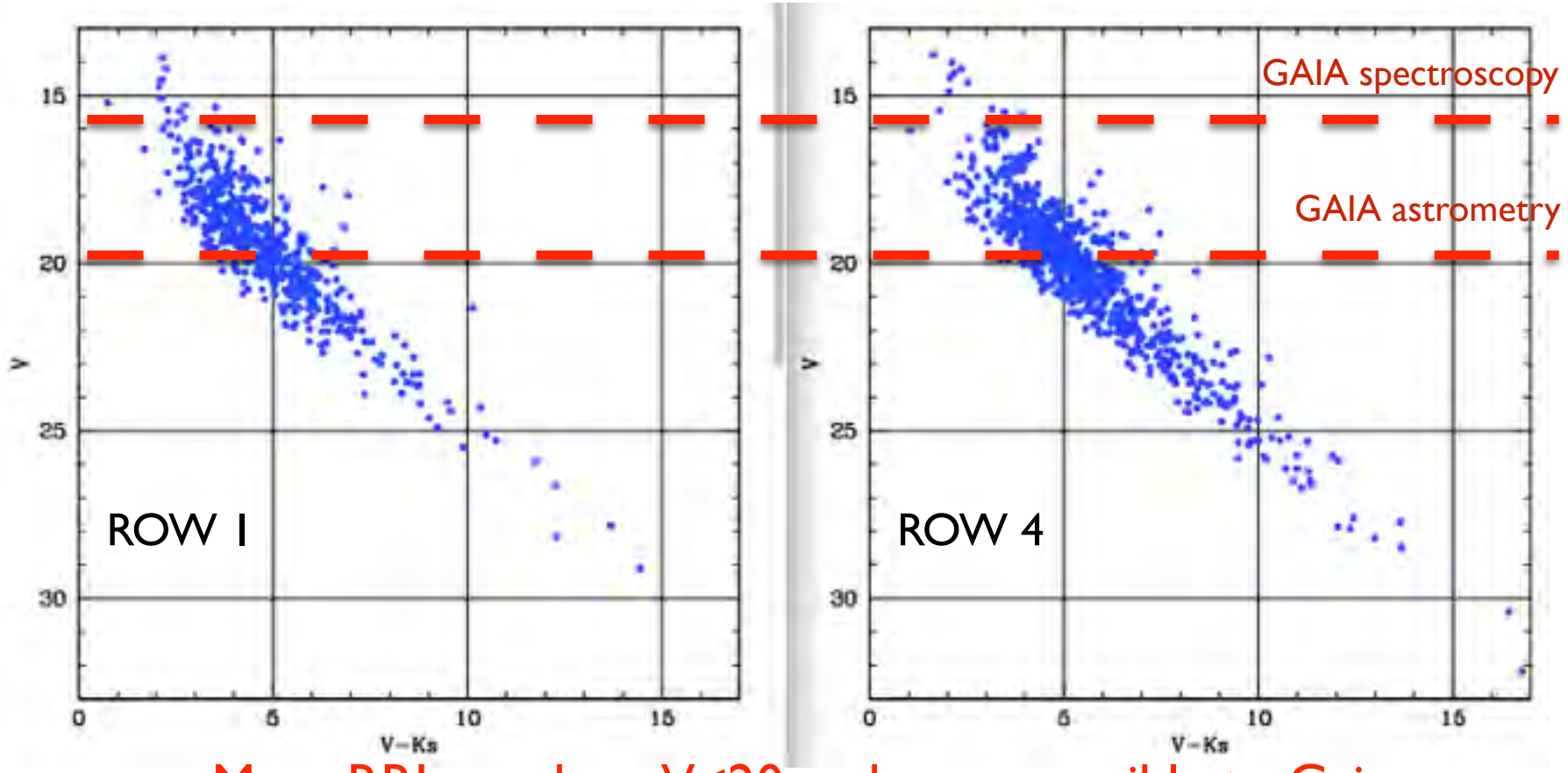


Bulge and Disk RR Lyrae



Disk RR Lyrae CMD

DISTANCES: using P-L of Muraveva et al. 2015
mean colors of Galactic RRLyr that are unreddened (Eb-v~0.015)
the intrinsic V-K color for RRab is Mv-Mk=1.006
Mk=Ks-Ak=Ks-0.528Ej-k for Nishiyama
Mk=Ks-Ak=Ks-0.72Ej-k for Cardelli
To estimate visual mags we use
Mv=Ks-0.528(J-Ks-0.15)+1.0
where (J-Ks)o = 0.15 is assumed to be the color of an unreddened RRLyr

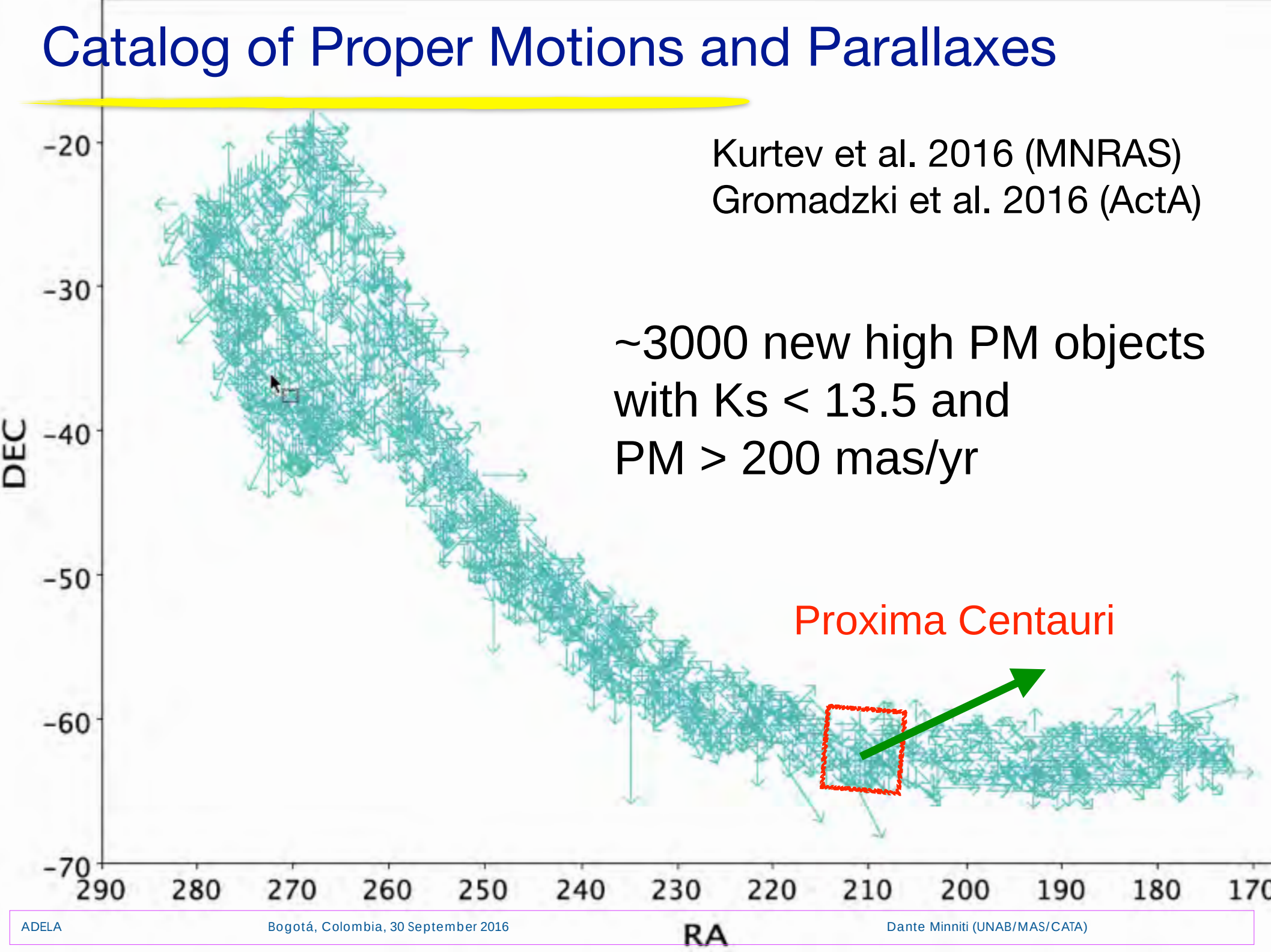


Many RRLyrae have V<20 and are accessible to Gaia

VVV Proper Motions

Please see Rudy Kurtev´s poster downstairs

Catalog of Proper Motions and Parallaxes



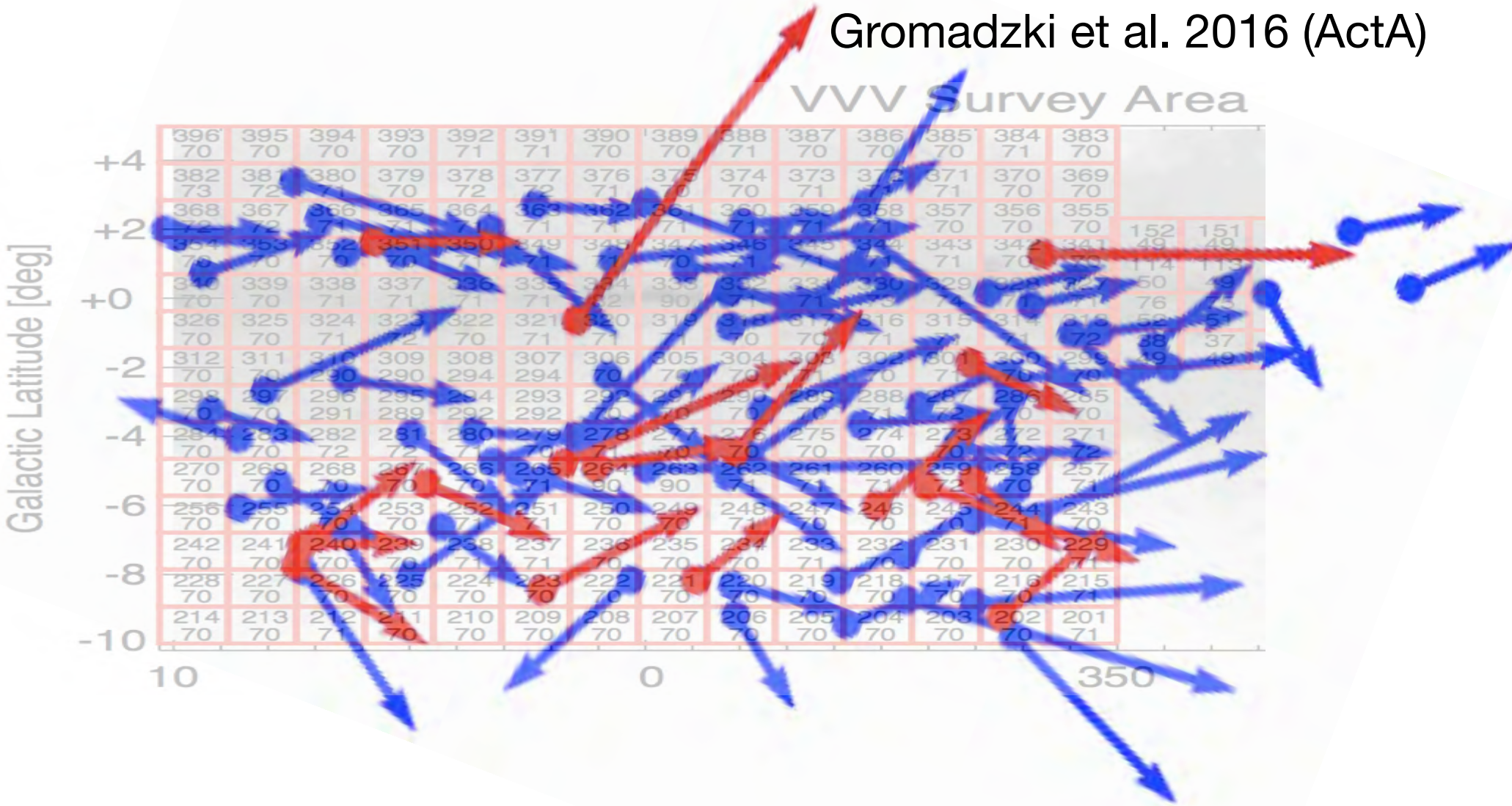
Kurtev et al. 2016 (MNRAS)
Gromadzki et al. 2016 (ActA)

~3000 new high PM objects
with Ks < 13.5 and
PM > 200 mas/yr

Proxima Centauri

Catalog of Proper Motions and Parallaxes

Kurtev et al. 2016 (MNRAS)
Gromadzki et al. 2016 (ActA)



~200 objects with good parallaxes

VVV Proper Motions

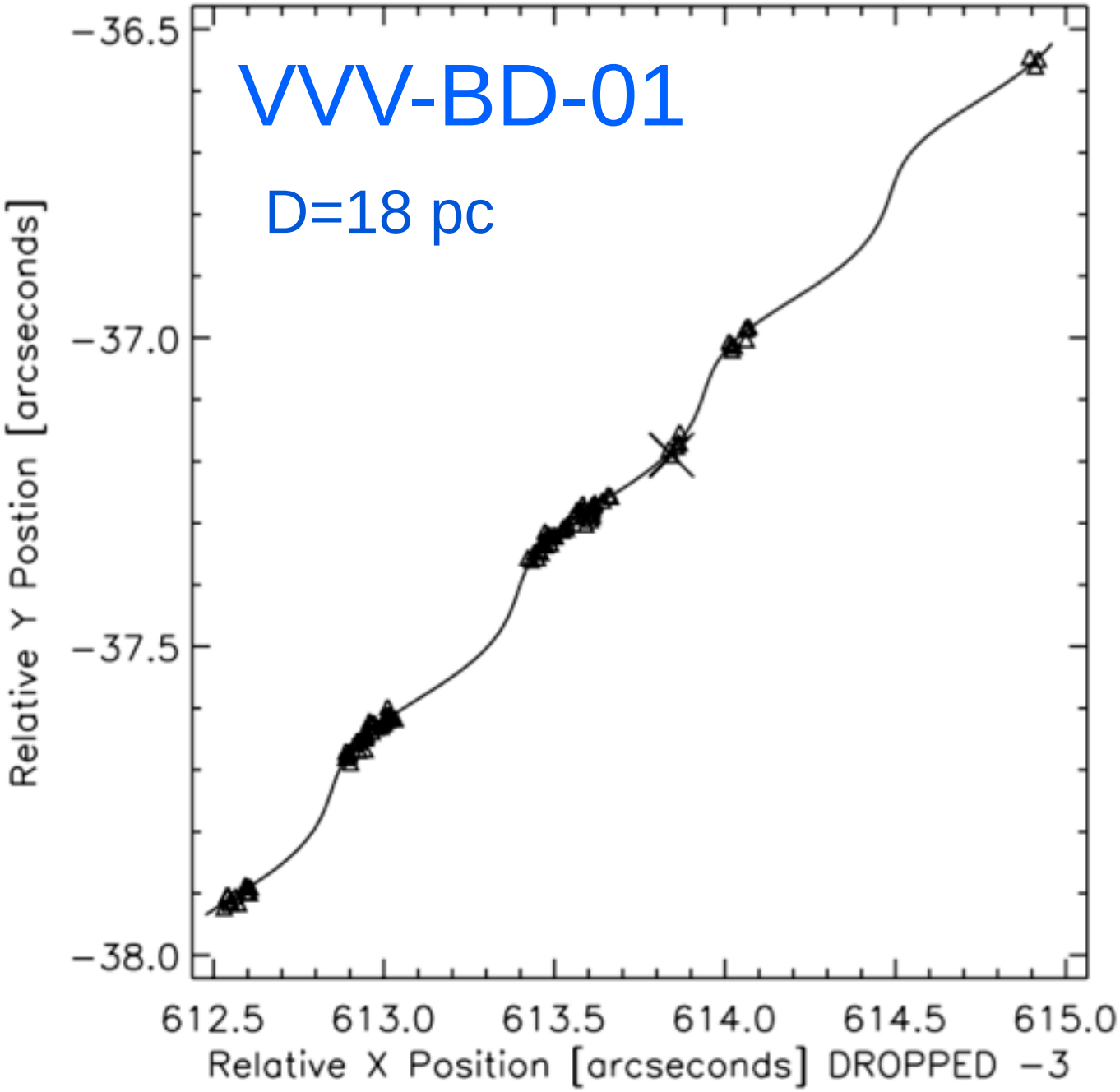
Search for Brown Dwarfs

R. Kurtev, P. Lucas, M. Gromadzki, J. C. Beamin,
V. Ivanov, et al.

Search for Brown Dwarfs

a peculiar new solar neighbour showing parallactic motion

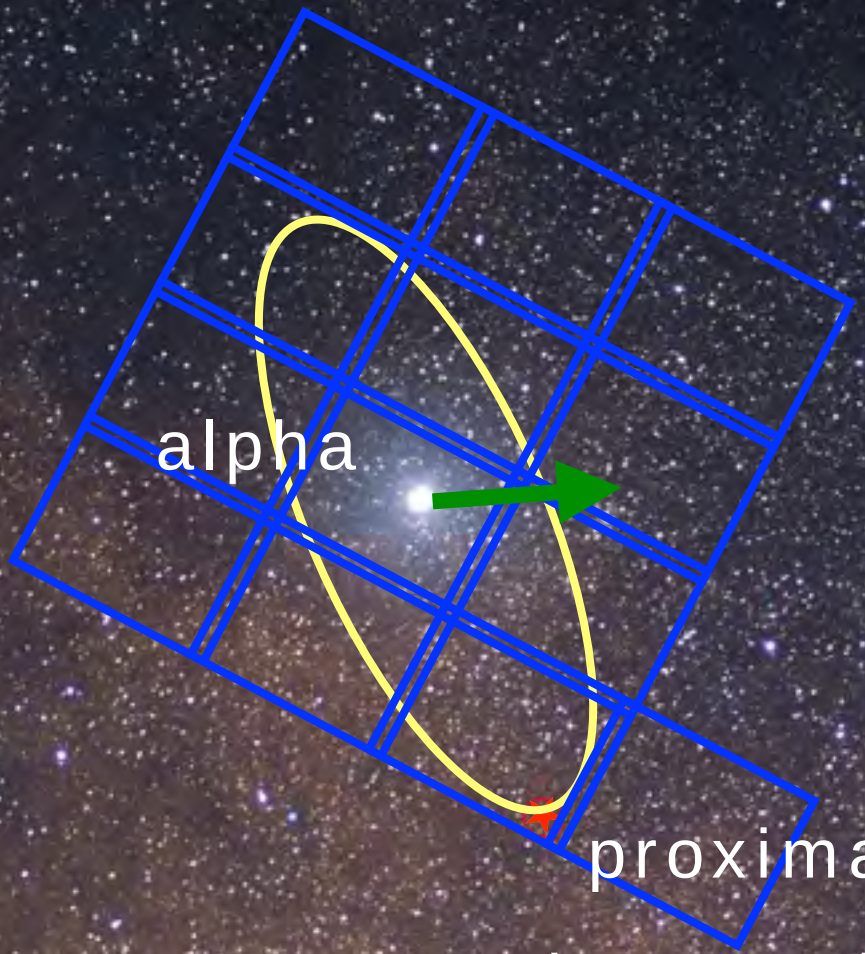
J. C. Beamin, et al.
(2014, A&A Letters)



Please see Juan Carlos Beamin´s poster downstairs


Search for Companions
V. Ivanov et al. 2015

The Alpha Cen System

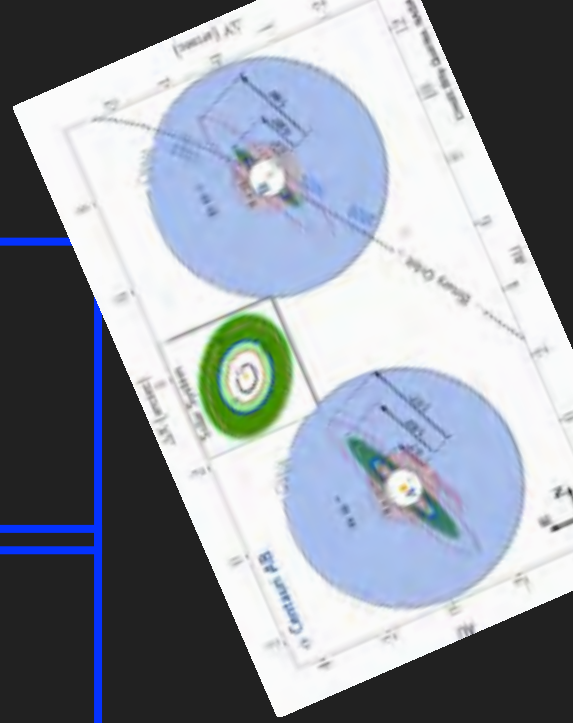


beta

Separation = 2.2 deg = 15000 AU = 0.06 pc

Deep and Wide VVV Search

~20 sqdeg, Ks_{lim}~17.5



130 129 128

92 91 90

54 53 52

16 15 14 13

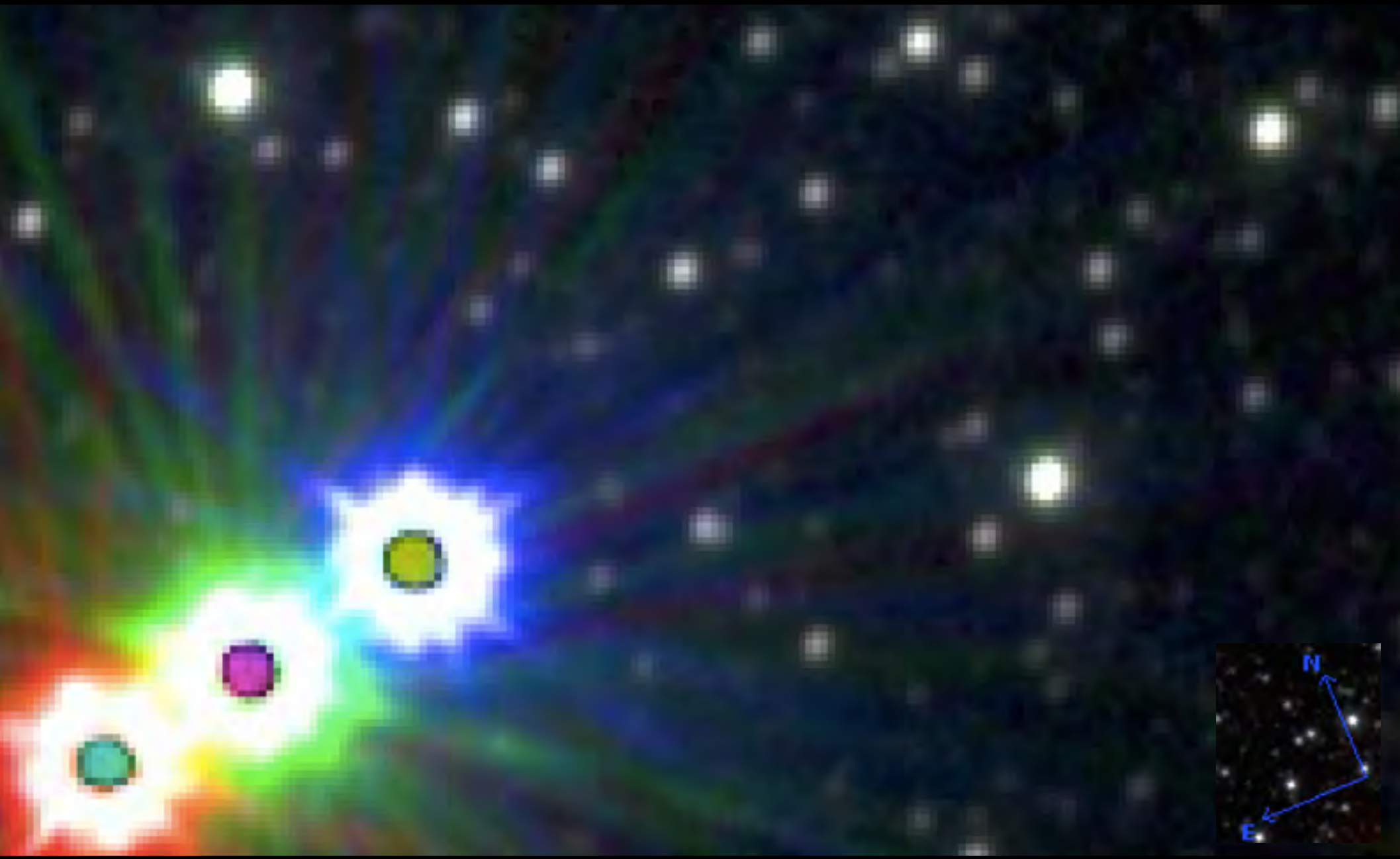
1 deg

N

E

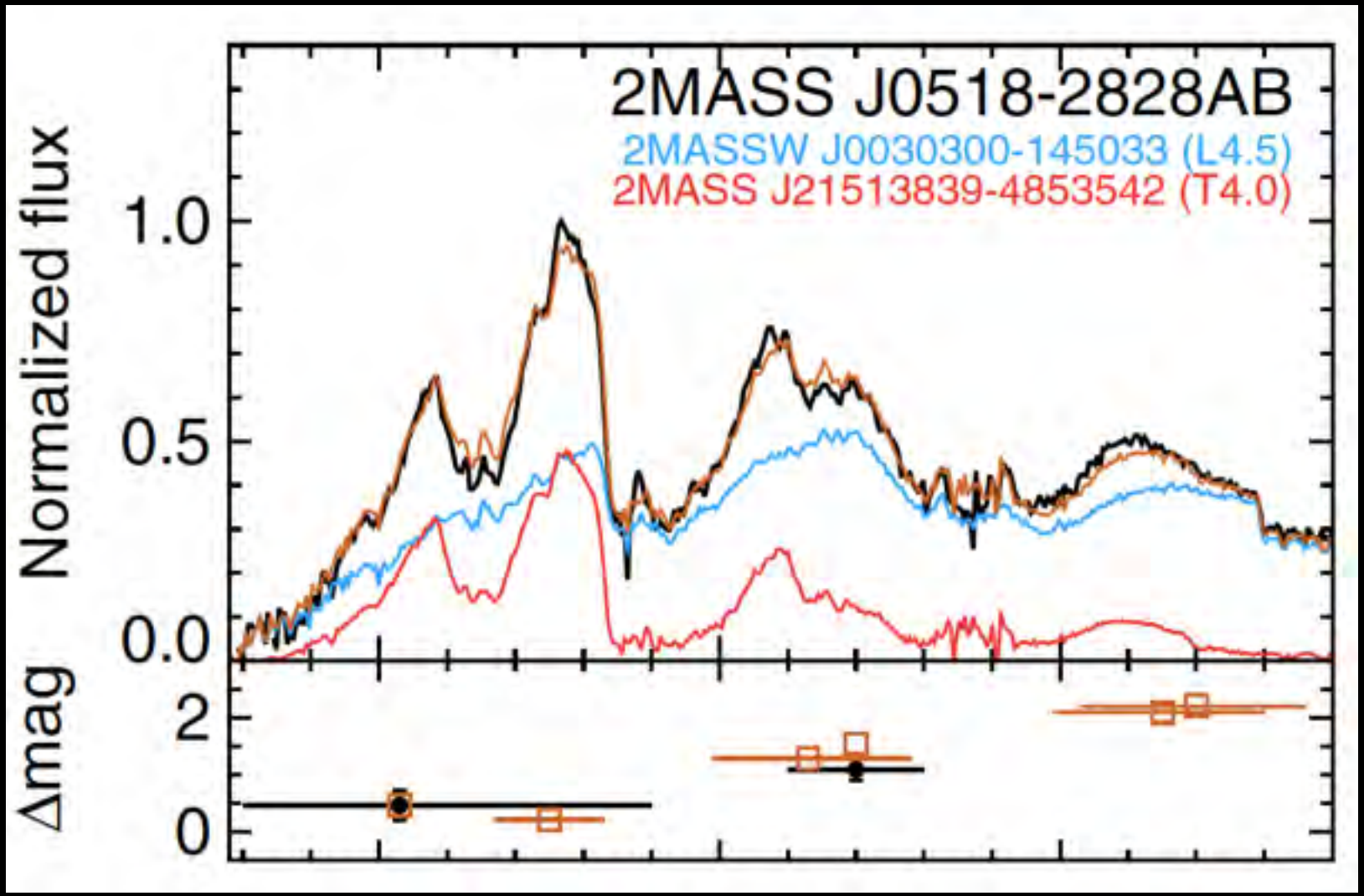

Proxima Cen
The nearest star
distance = 4.24 ly
discovery: 1915
Proxima Cen b:
a rocky planet in the HZ
discovery: 2016

Proxima Centauri
Ks-band images 2010-2012-2014 K_{lim}=17.5



Known BDs

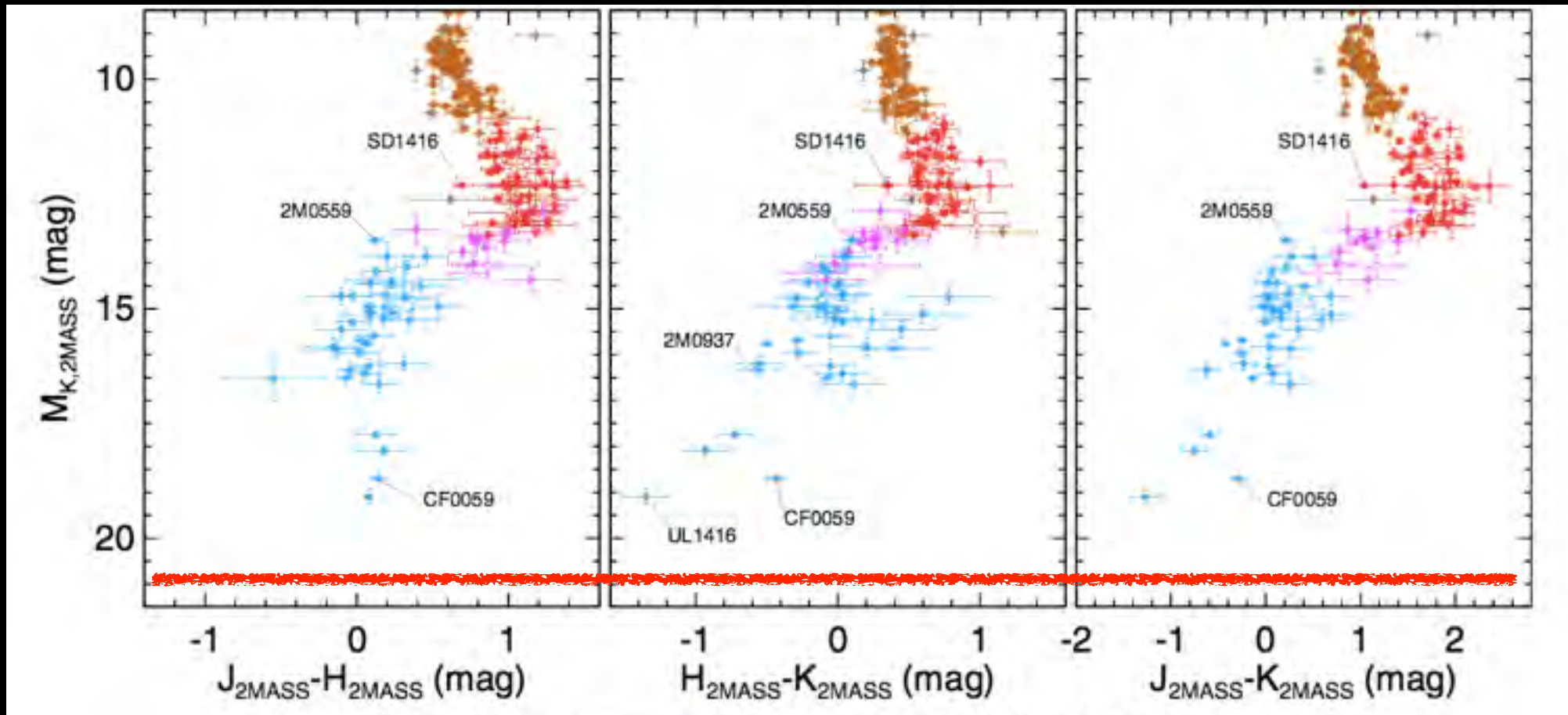
- L´s are brighter in Ks
- T´s are brighter in J
- Y´s are faint…



Dupuy & Liu 2012 ApJ

Known BDs

- L´s are brighter in Ks
- T´s are brighter in J
- Y´s are faint…



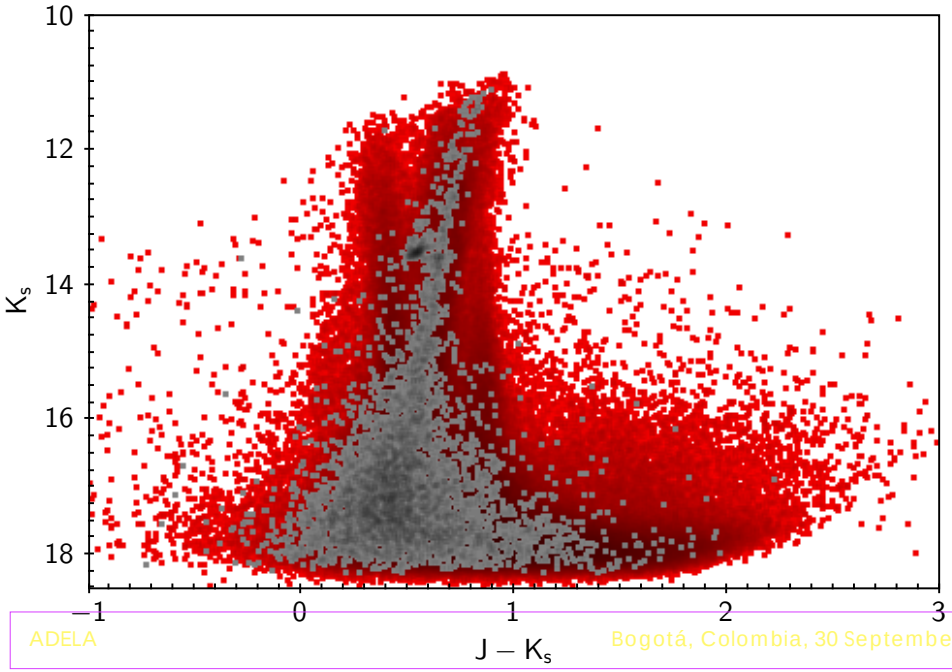
Dupuy & Liu 2012 ApJ

Difficult to visualize large amounts of data…
Movies by Joyce Pullen

The VVV Giga Bulge CMD

DoPhot PSF photometry of the bulge

J. Alonso, et al. 2016, in preparation



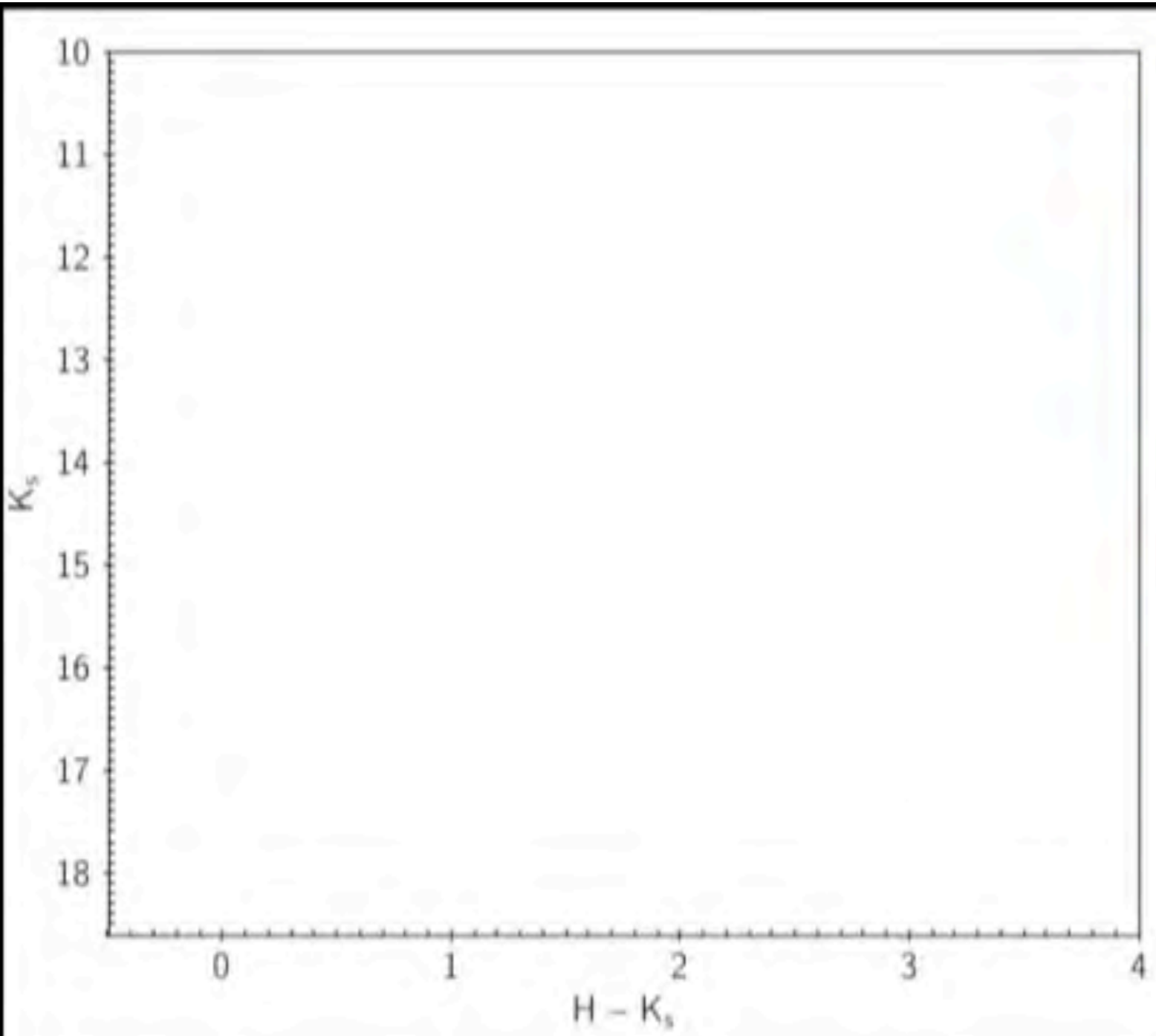
In Z, 667 million sources

In Y, 707 million sources

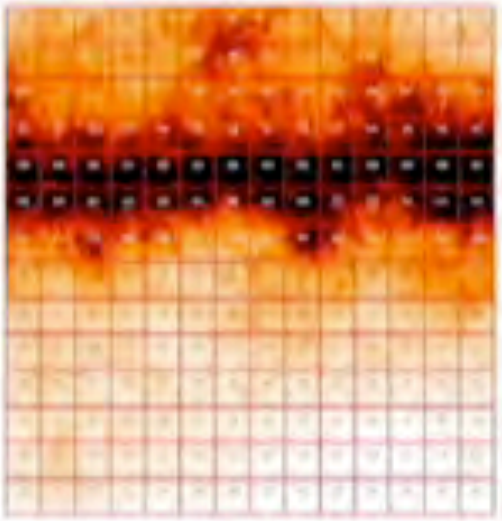
In J, 922 million sources

In H, 990 million sources

In Ks, 779 million sources



VVV Survey

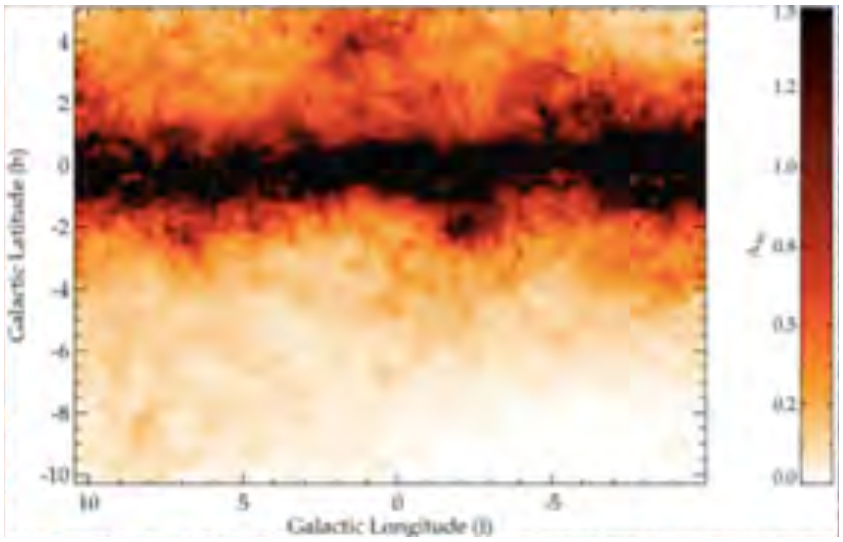


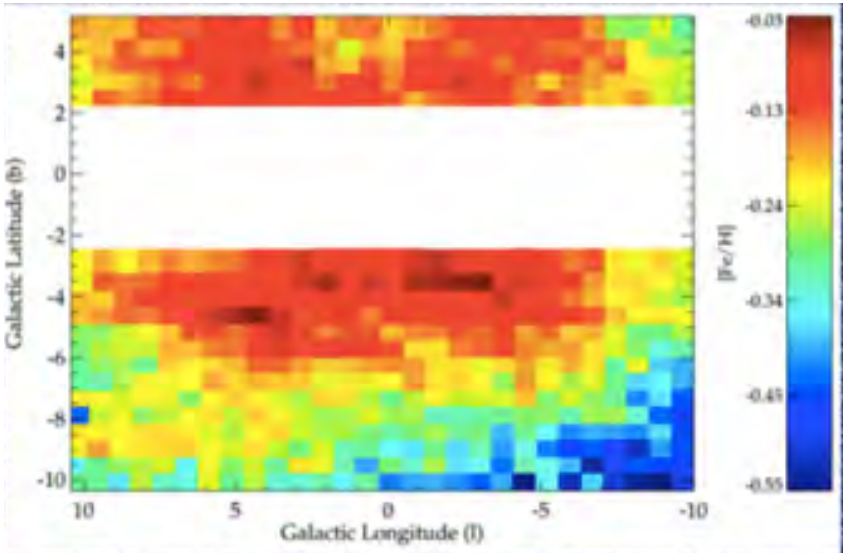
201

Structure of the Milky Way Bulge

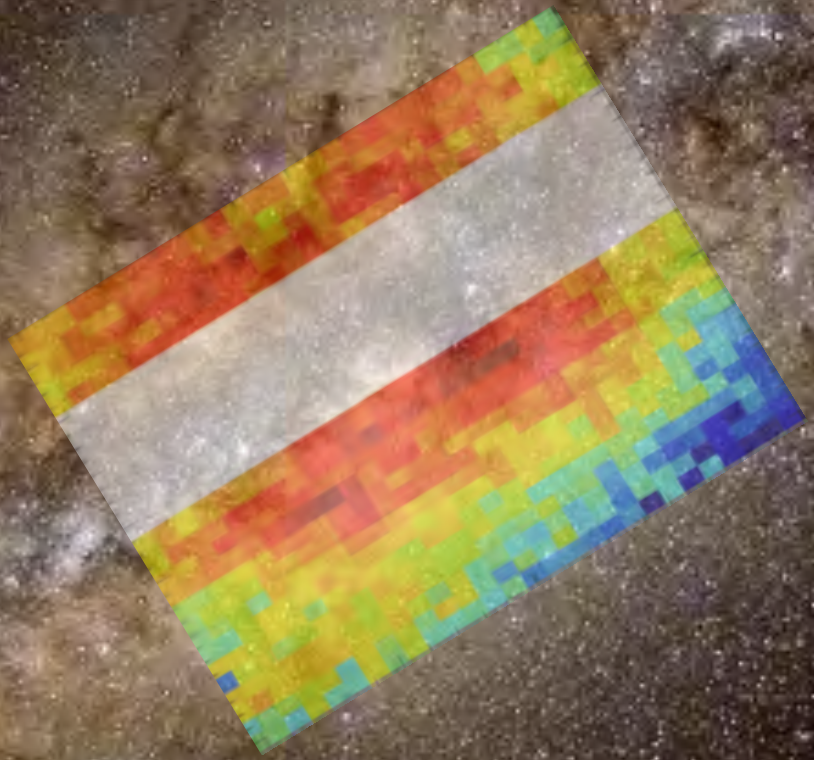
Gonzalez et al. 2015, A&A (arXiv.1510.05943)
Valenti et al. 2013, A&A, 559, 98 (arXiv:1309.4570)
Dekany et al. 2013, ApJL, 776, L19 (arXiv:1309.5933)
Vazquez et al. 2013, A&A, 555A, 91V (arXiv:1304.6427)
Saito et al. 2013, A&A, 545, 147, 201 (arXiv:1208.5178)
Gonzalez et al. 2013 A&A, 552, 110 (arXiv:1302.0243)
Gonzalez et al. 2012 A&A, 543, 13 (arXiv:1204.4004)

The global photometric reddening and metallicity maps of the MW bulge





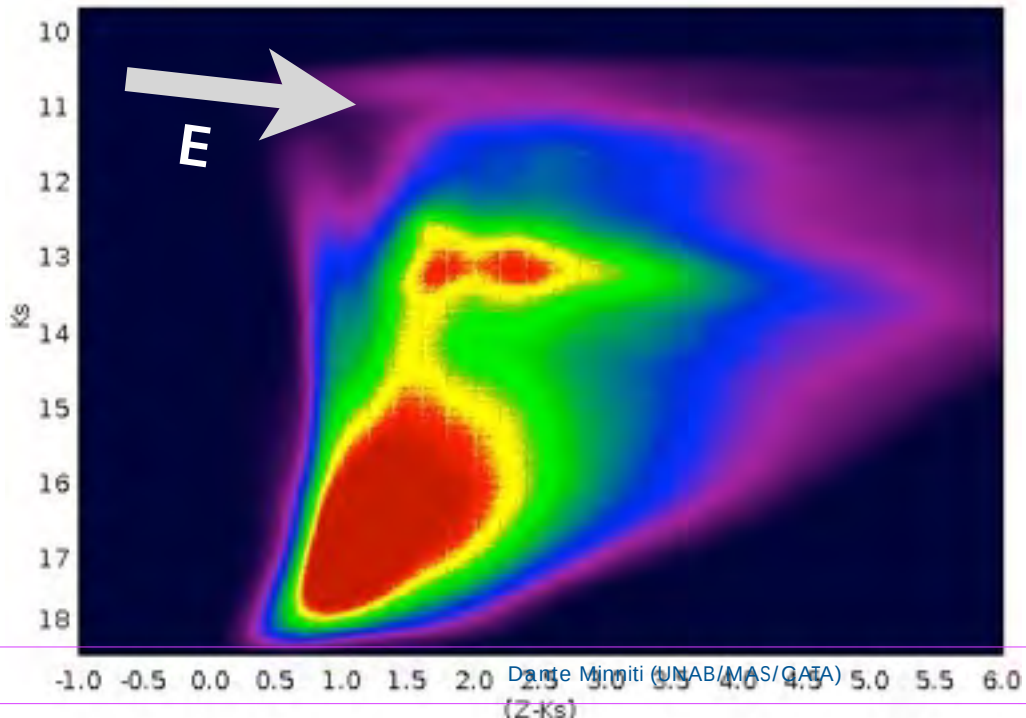
Structure of the Milky Way Bulge



Dust Distribution and the Reddening Laws

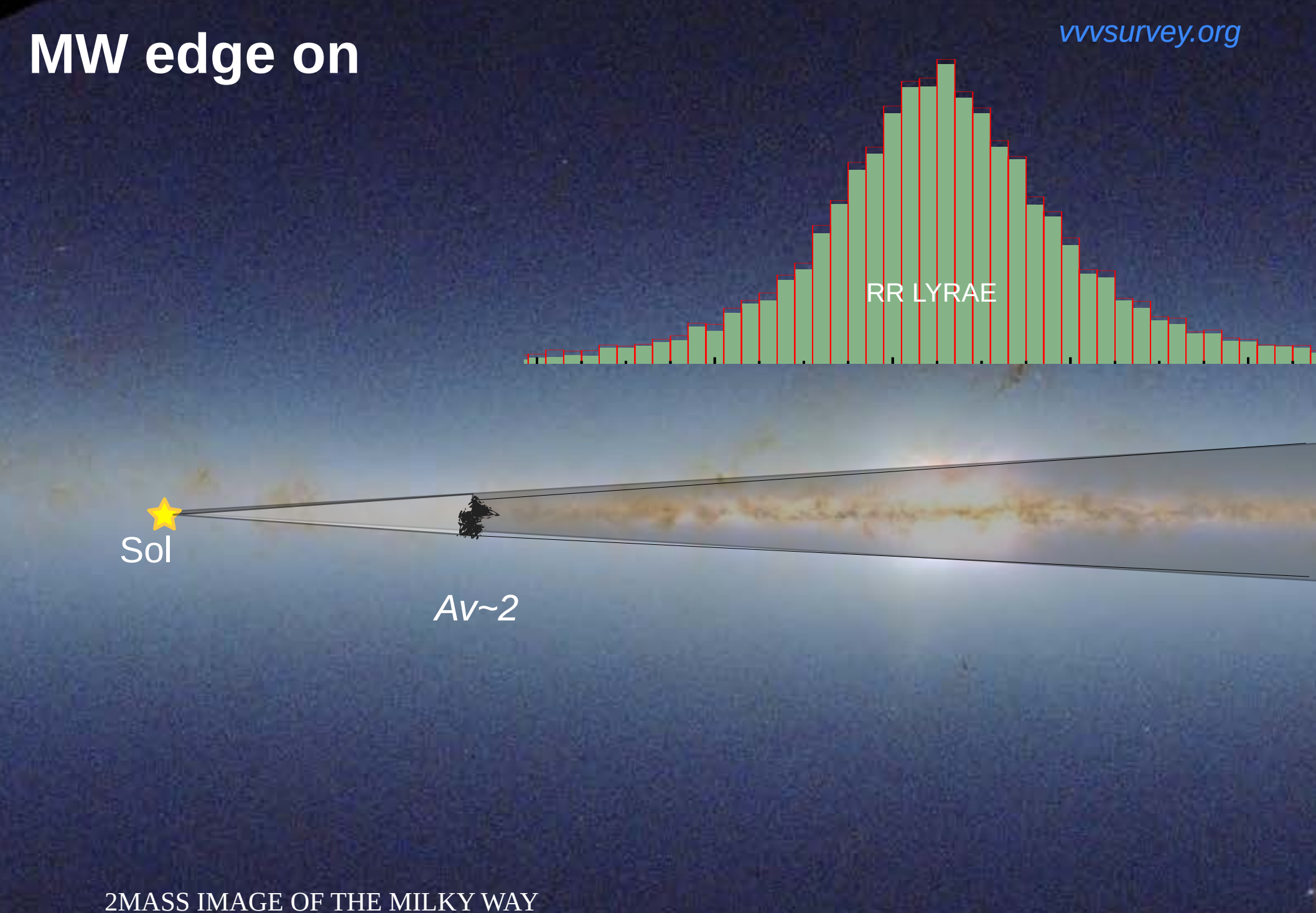
Gonzalez et al. 2012, A&A, 543, 13 (arXiv:1204.4004)
The first global photometric metallicity map of the Galactic bulge
Gonzalez et al. 2013, A&A, 552A, 110G (arXiv:1302.0243)
Chen et al. 2013, A&A, 550, 42 (arXiv:1211.3092)
Schultheis et al. 2014, A&A 566, 120 (arXiv:1405.0503)
Mapping the Milky Way Bulge at high resolution: the 3D dust extinction, CO and X factor maps
Minniti et al. 2015, A&A, 571, A91 (arXiv:1409.5836)
Nataf et al. 2015 ApJ in press (arXiv:1510.01321)
Interstellar Extinction Curve Variations Toward the Inner Milky Way

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



MW edge on

vvvsurvey.org

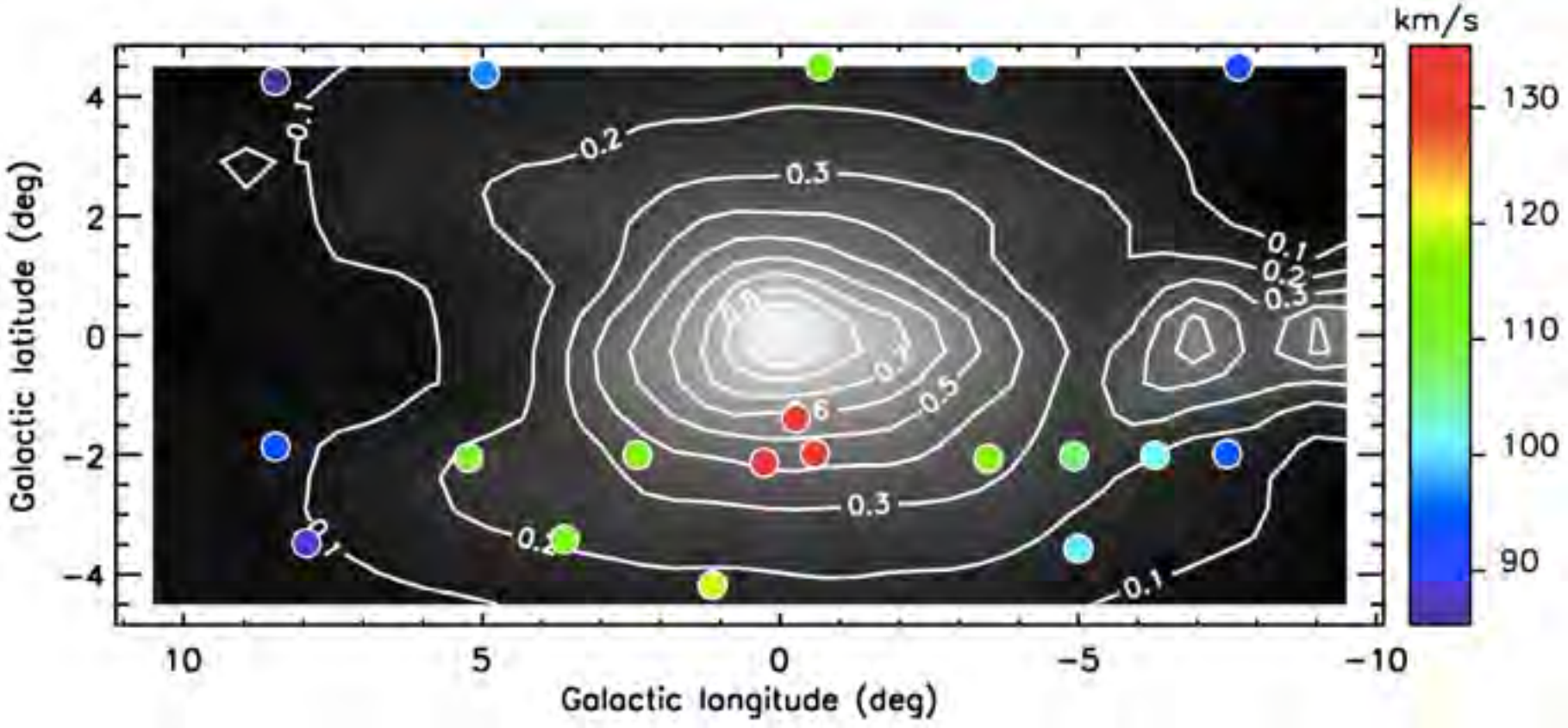


2MASS IMAGE OF THE MILKY WAY

The Mass of the Galactic Bulge

The Mass of the Milky Way Bulge

Valenti et al. 2016, A&A (arXiv:1510.07425)



The mass of stars and remnants within $(|b| < 9.5°, |l| < 10°)$ is $2.0 \pm 0.3 \times 10^{10} M_{\odot}$

Discoveries

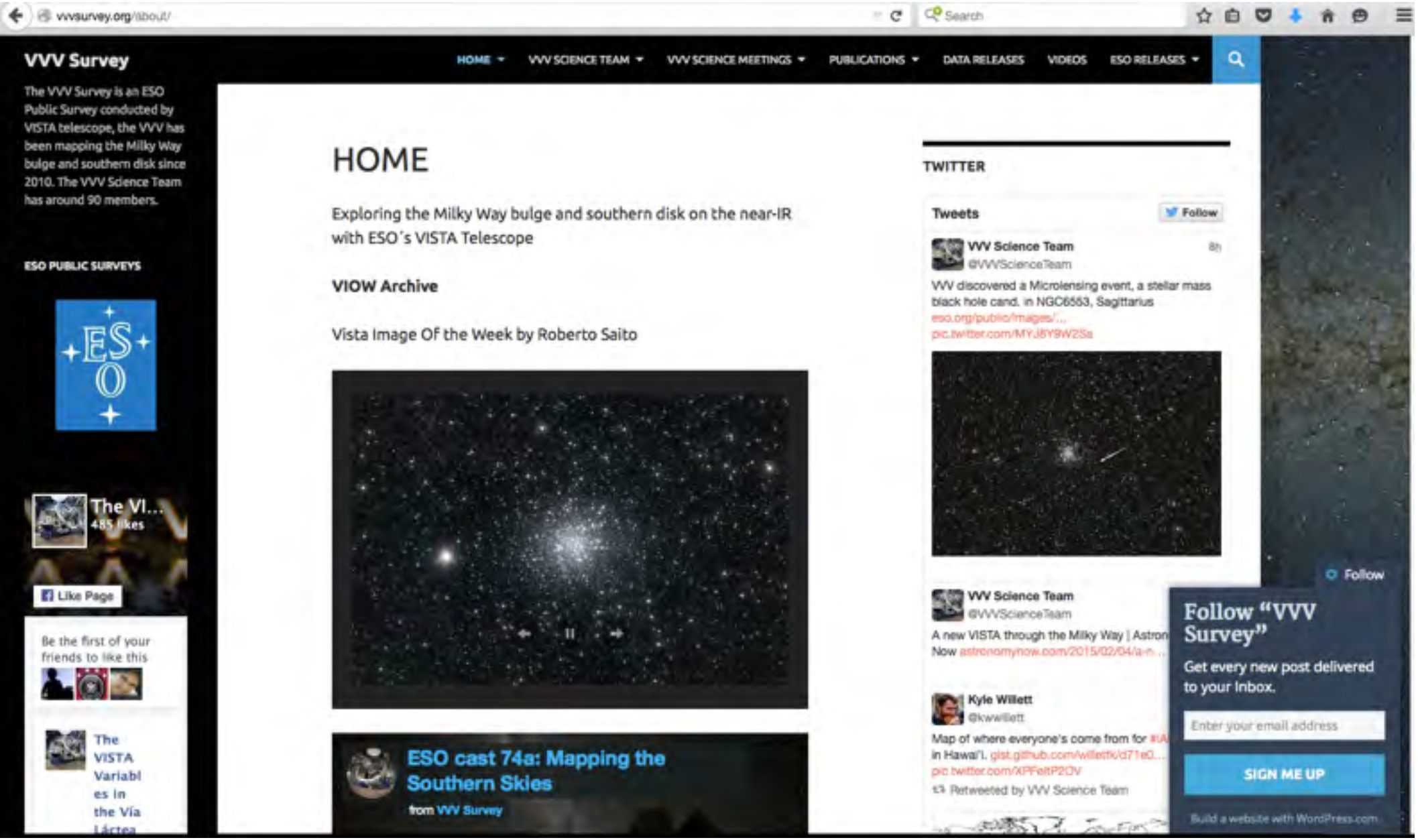
MW Bulge Structure
Globular Clusters
Open Clusters (incl. WR clusters)
Variable stars in clusters
Galactic Novae and other transients
Nearby Brown Dwarfs
Companions to Nearby Stars
Galaxies in the Avoidance Zone
IR Counterparts of High Energy Sources
Candidate microlensing events
Candidate extrasolar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

MANY OTHER DIFFERENT ACTIVITIES…

Workshops
Public talks
School teachers
Student involvement
Presence in the social media (facebook, twitter, etc)
Press releases
Videos
Scientific movies
Posters, handouts
Books

AND BEYOND
ASTRONOMY and ART
Paintings
Music

vvvsurvey.org



archive.eso.org

Data Releases

European Southern Observatory

Public | Science | User Portal | Contact

Science Users Information > Science Publications > Science Announcements > New Imaging Data Release for the VVV Public Survey

Science Users Information

- Observing Facilities
- Future Facilities and Development
- Observing with ESO Telescopes
- Science Software
- Data Handling and Products
- Science Archive Facility
- Science Activities
- Science Publications
- **Science Announcements**
- ESO Science Newsletter
- The Messenger
- ESO Annual Reports
- Science and Technical Meetings
- IT Services
- Libraries
- Job Opportunities

New Imaging Data Release for the VVV Public Survey

Published: 25 Mar 2015

VVV DR4

The VISTA Variables in the Via Lactea Survey (VVV) is a wide area, near-infrared (*Z*, *Y*, *J*, *H*, *Ks*), multi-epoch imaging surve
coverage of 540 square degrees. This new Phase 3 release (VVV DR4) contains observations up to 30 September 2013 with
and includes images and single-band source catalogues. It replaces the previous releases that had been processed with pre
new data, mainly increasing the number of epochs for the *Ks* band.

Images and source lists can be queried and downloaded from the Science Archive Facility. For more information please refer

The VVV Survey Model of Collaboration

which are the policies, processes and procedures that set the proper conditions for scientific research and the ideal enviroment to foster a behaviour ready for collaboration

policies provide the structure that governs this body and *pipelines* provide confidence on the data and the procedures that it goes through

communication, workshops and clusters are social bearings that led to trust, collaboration and openness within the team

COMMUNICATION

- Open discussions within the team
- Drive attention to our work & traffic to the website
- Press releases on VVV discoveries

e.g. VVV/D. Minniti/I. Toledo Allsky image is the most downloaded image in ESO history

ESO M. Arnaboldi | CASU M. Irwin | VSA N. Cross

POLICIES

Authorship Policy:

"...as flexible as possible in order to stimulate large numbers of papers and minimize potential conflicts that may emerge in such a large and varied collaboration. We discarded the requirement that all papers be signed by the whole collaboration, because this is unfair for people who do most of the work"

e.g.

The student of a VVV Science Team Member is considered a Science Team Member

New Postdocs working on the VVV and funded by the project will automatically become VVV Science Team Members

Other people can be considered as Associate Science Team Members as long as they collaborate with a Science Team Member

The PhD student thesis must be protected: nobody can scoop a thesis result. The advisor can ask for a very specific topic to be "reserved" for the student to lead. This has to happen in a reasonable time, because nobody can reserve anything for more than one year.

PIPELINES

Science Team Achievements:

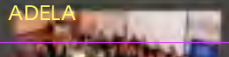
- ✔ Do-Phot (J. Alonso-García)
- ✔ SkZ Pipeline (F. Mauro)
- ✔ Stellar variability classification
- ✔ Light curve classifiers & period finders
- ✔ Cluster analysis (J. Borissova)
- ✔ Proper motion (R. Kurtev, J.C. Beamin
- ✔ Multicolor (R. Saito, S. Gurovich)
- ✔ Variables (I. Dekany, R. Saito)
- ✔ DIA (E. Kerins)

Provide targets for other spectroscopic surveys:
GIBS
APOGEE
ESO-GAIA
near future: MOONS & 4MOST

WORKSHOPS

The purpose of the VVV Science Meetings is to bring together the team to share their advances, promote the discussion on their topics and share the difficulties they have found during the year





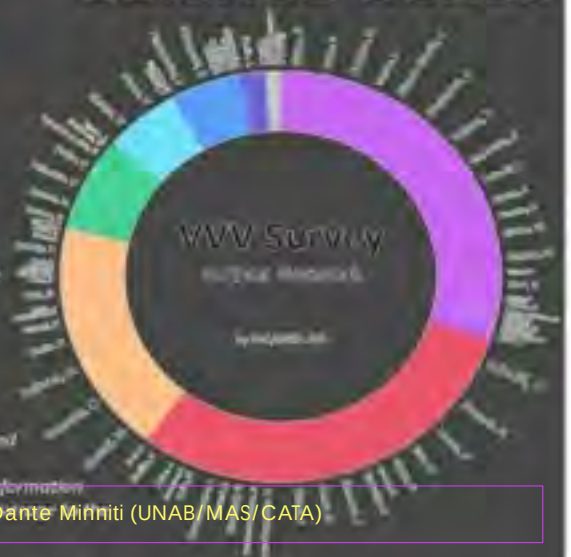
up to date 9 meetings:

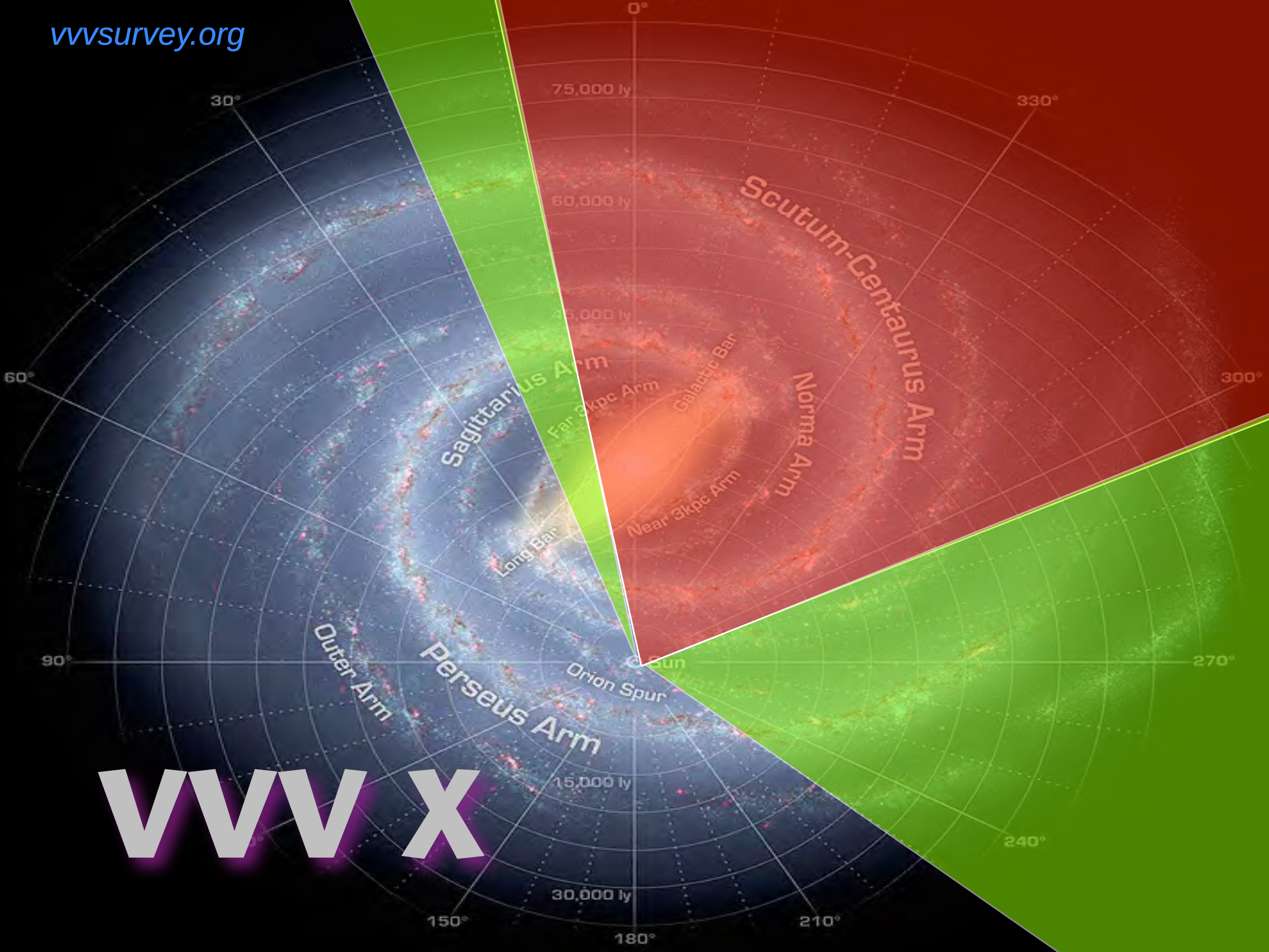
1st VVV Conference, March 2010, Viña del Mar, Chile
2nd VVV Science Meeting, July 2011, Hertfordshire, UK
3rd VVV Science Meeting, March 2012, Viña del Mar, Chile
4th VVV Meeting, March 2013, Viña del Mar, Chile
5th VVV Science Meeting, March 2014, Con-Con, Chile
6th VVV Science Meeting, April 2015, Puerto Varas, Chile
Vatican VVV Workshop, May 2015, Vatican City
Local VVV Workshop, August 2015, Santiago, Chile


CLUSTERS

1. To find RR Lyrae in the bulge
2. To identify variable stars belonging to known star clusters.
3. To find eclipsing binaries in large numbers.
4. To find rare variable sources.
5. To search for microlensing event.
6. To monitor variability around the Galactic center
7. To search for new star clusters of different ages and identify their variable star members.
8. To provide complementary near-IR multi-colour information (reddening, temperatures, luminosities) and time-domain information to the following past and on-going surveys

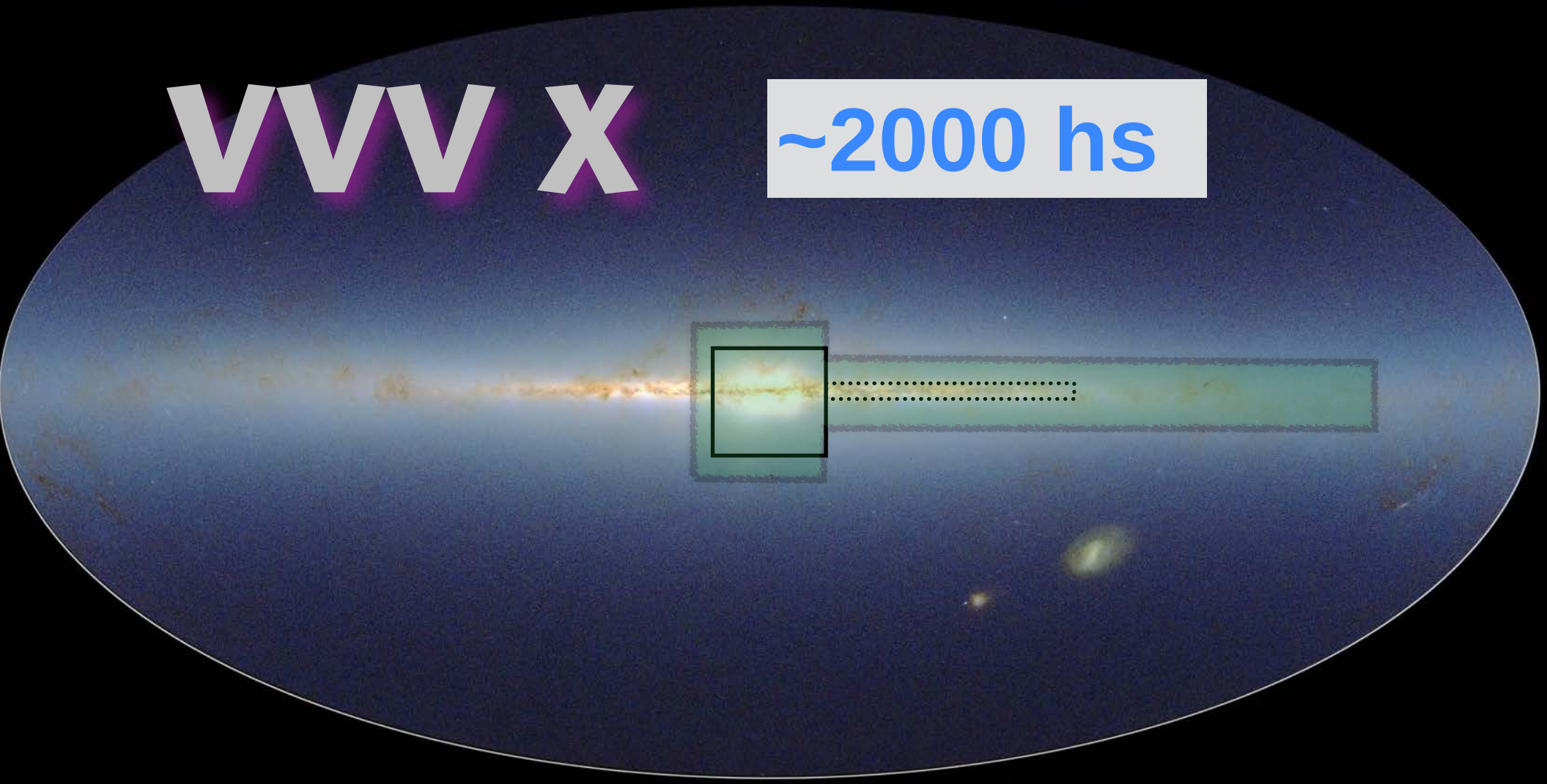
SCIENCE GOALS




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

VVV X

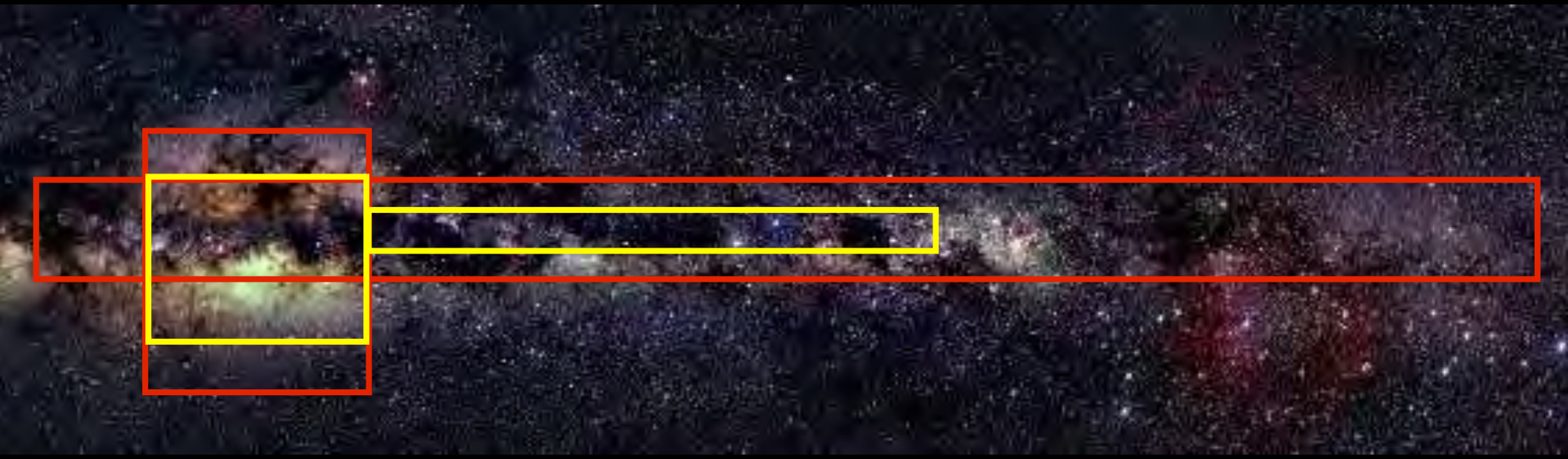
~2000 hs



~50% of the MW

VVV X

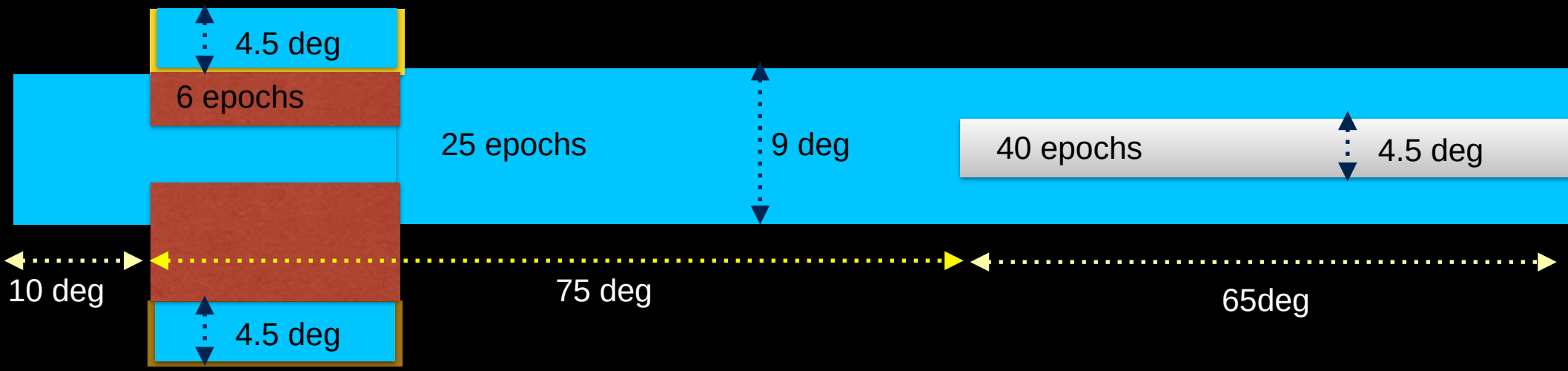
The VVV Extended Survey



BIG DATA

VVV X

Total Area = 1720 sqdeg
Total Time ~ 2000 hs



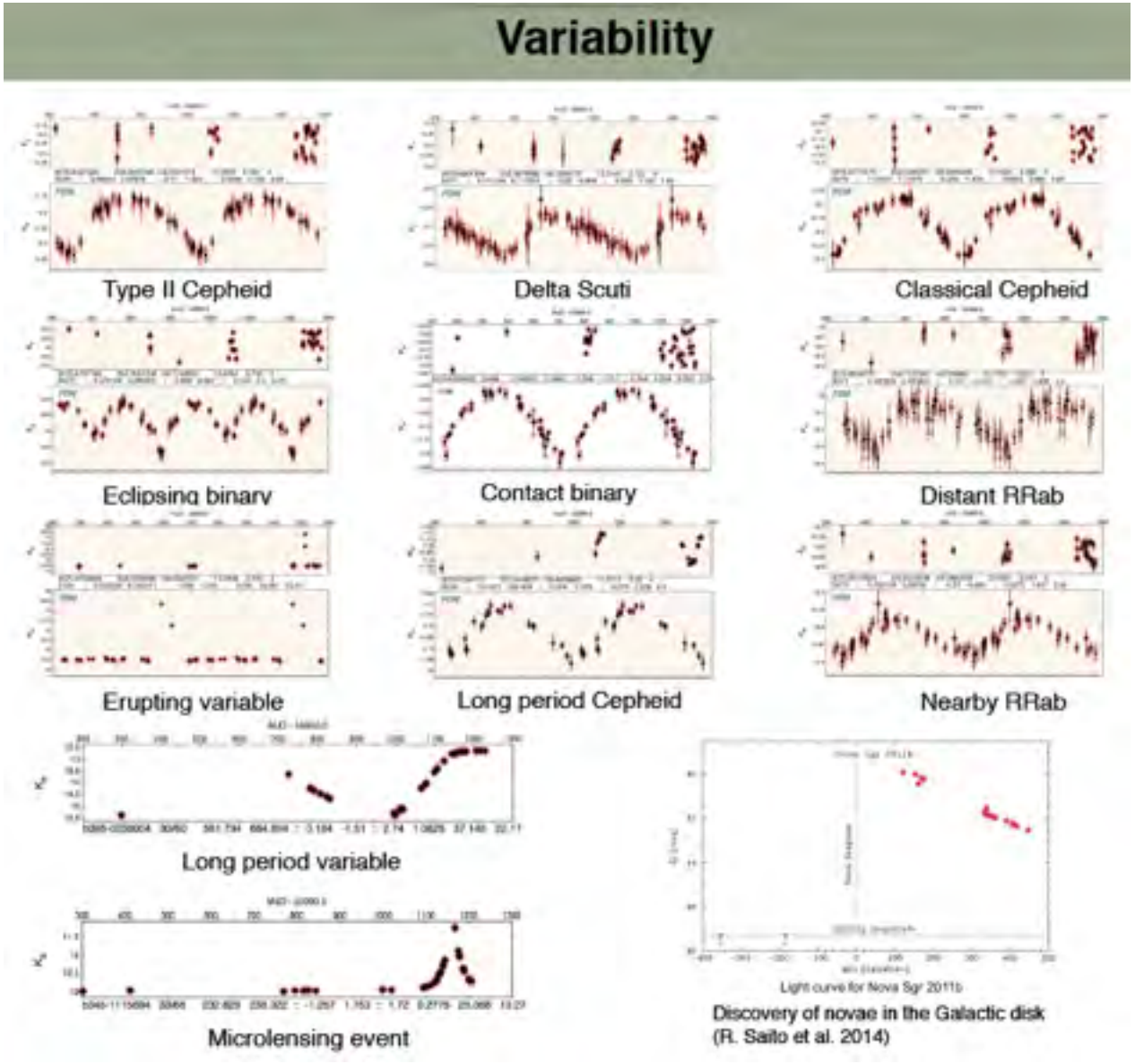
180 sqdeg = 126 tiles - 6 Ks epochs + JJJJJHHHKs

1148 sqdeg = 722 tiles - 25 Ks epochs + JJJJJHHHKs

292 sqdeg = 180 tiles - 40 Ks epochs + JJJJJHHHKs

Science VVV X

Galactic structure
stellar populations
star formation
star clusters
variable stars
microlensing
exoplanets-BDs
proper motions
bulge-halo connection
disk-bulge connection
spiral arms
warp, flare



VVV X

A new near infrared survey of the inner regions of the Milky Way

Credito: Joyce Pullen

The vvv x Survey: A New Exploration of the Milky Way

discovering our own galaxy,
fostering international collaborations,
promoting Astrophysics at every level, &
securing resources for the future generations.