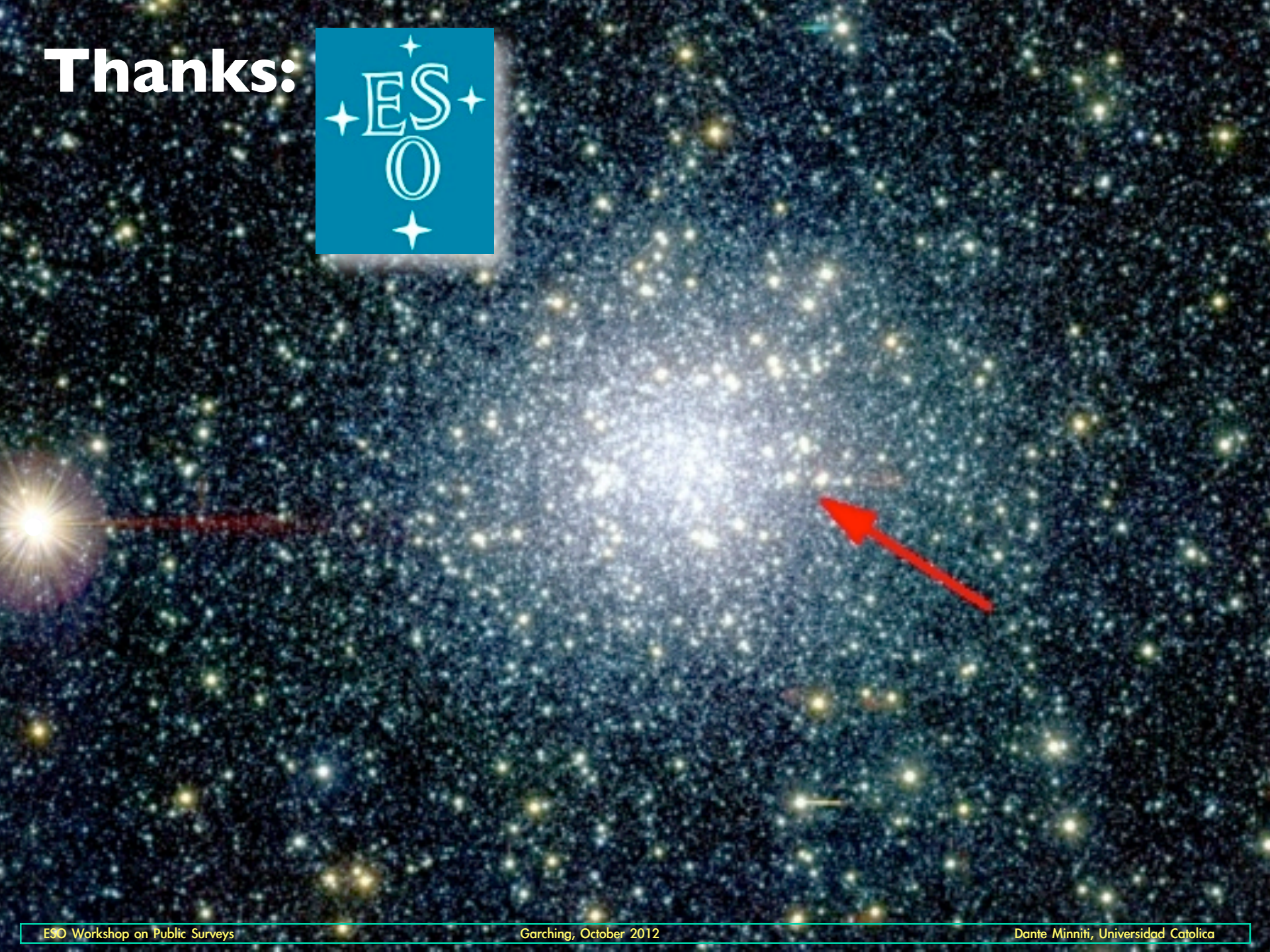

“The purpose of life is the investigation of the Sun, the Moon, and the heavens.”
— Anaxagoras, 459 BC


ESO Workshop on Science from the Next Generation Imaging and Spectroscopic Surveys
Garching, Germany
15-19 Oct 2012
SOL
VVV Survey
Acknowledgments

Thanks:



Thanks:

Thanks:

Thanks:

Thanks:

Thanks:

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Thanks:

Thanks:

Thanks:


UNIVERSIDAD ANDRES BELLO
TRADICION Y MODERNIDAD
UNIVERSIDAD
ANDRES BELLO

Thanks:

Thanks:

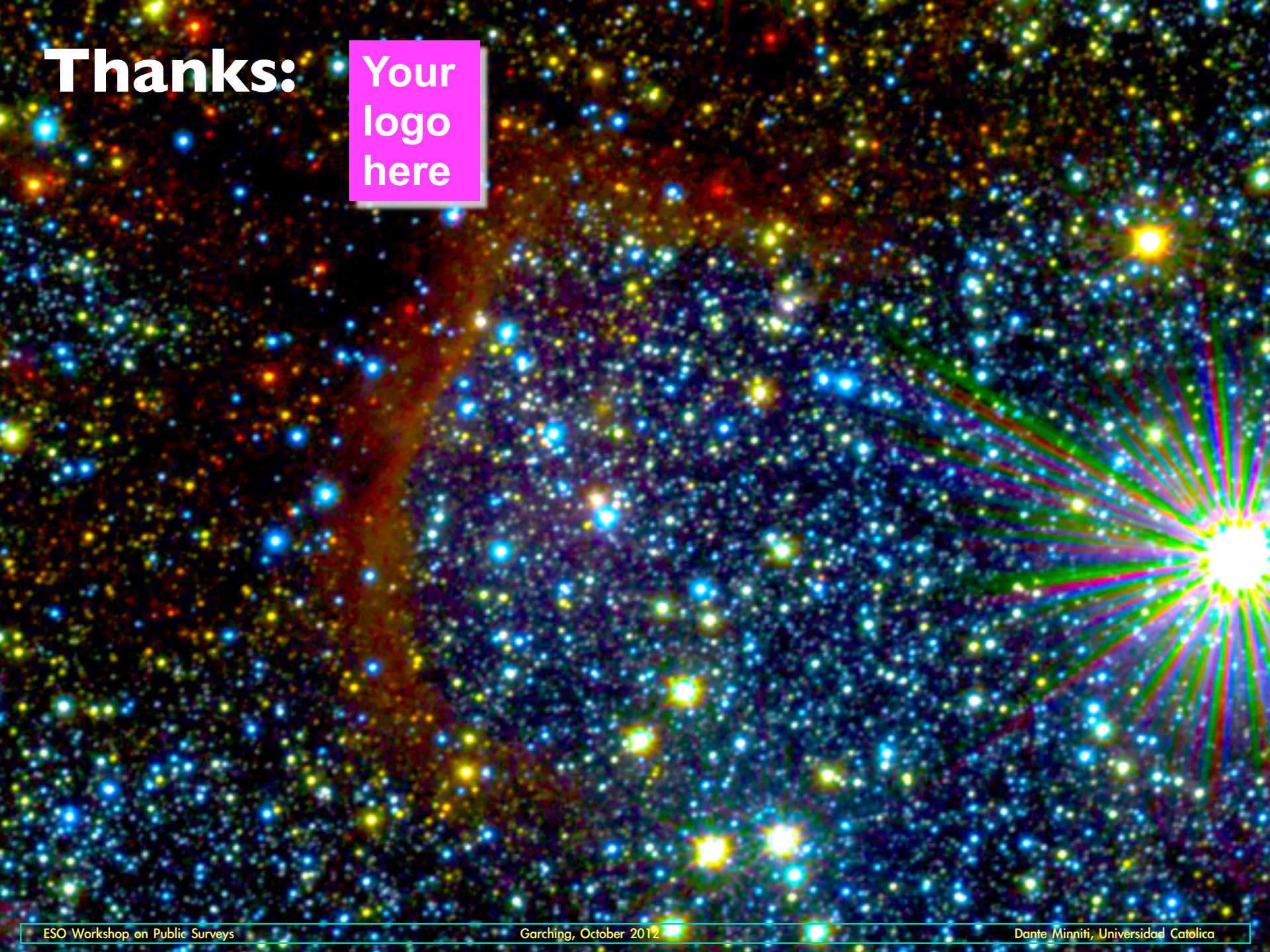
Vatican Obs.

Thanks:


CONICYT
COMISIÓN NACIONAL DE INVESTIGACIÓN
CIENTÍFICA Y TECNOLÓGICA

Thanks:

Thanks:



Congrats to ESO*!!!

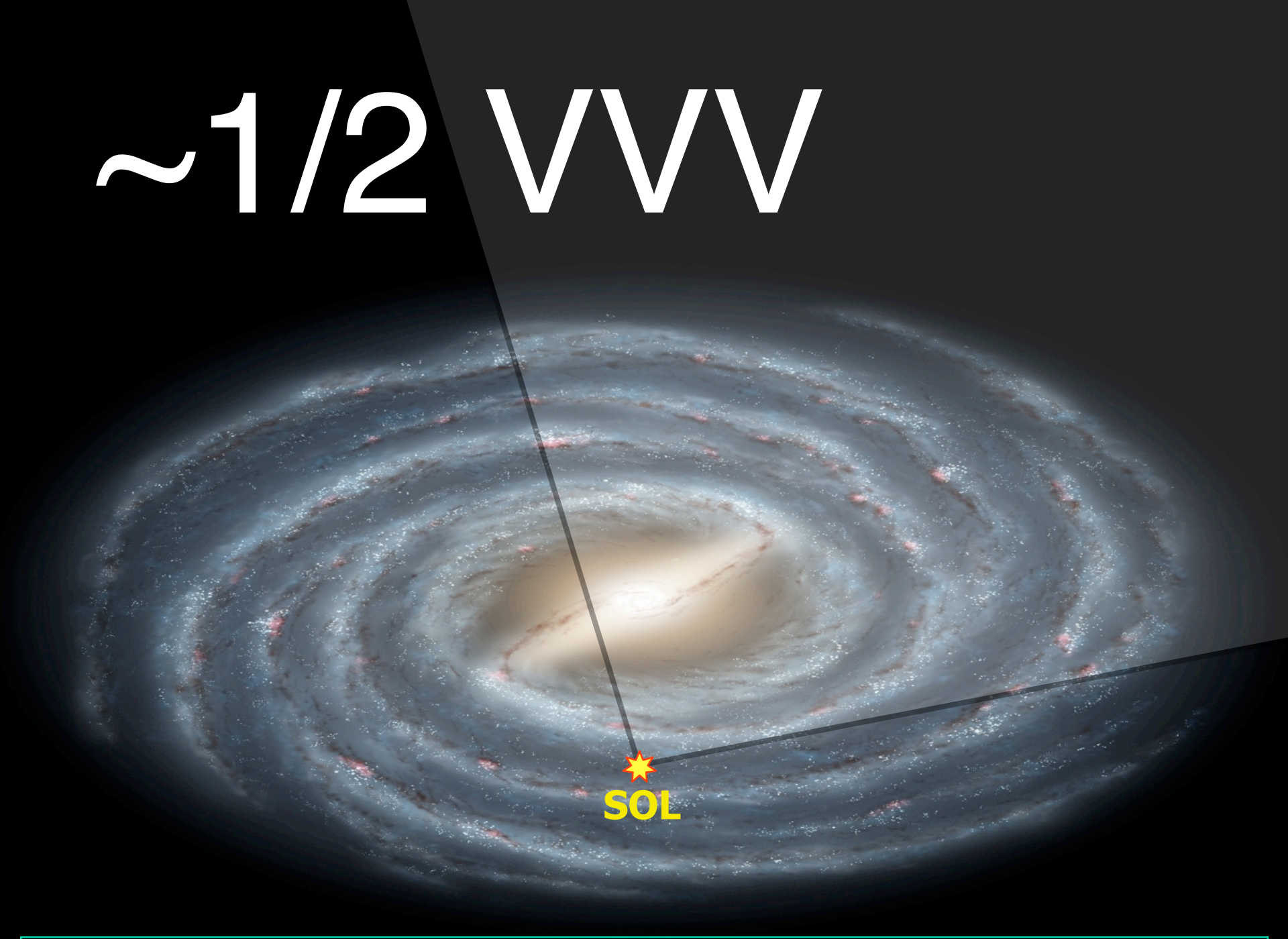
A few years ago ESO decided to embark on large public surveys.

Many of these surveys are now successful, and several others are on the way.

ESO became world leader on large surveys.

* PSP (Public Surveys Panel)
STC (Science and Technology Committee)
OPC (Observing Proposals Committee)
ASG (Archive Science Group)
USG (Users Support Group)
PO (Paranal Observatory)

~1/2 VVV

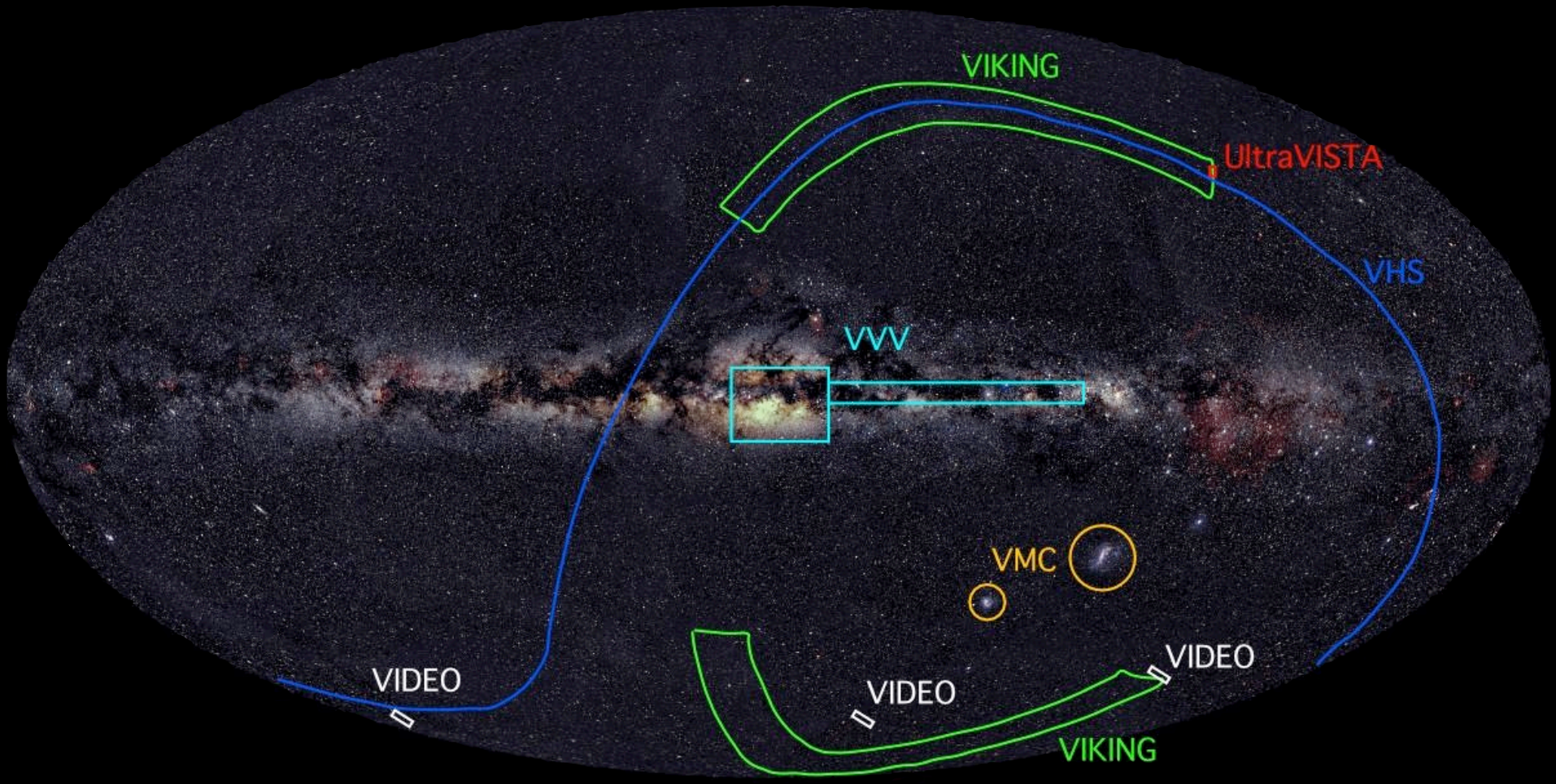


VVV Goal

What is the 3-D structure of the Milky Way

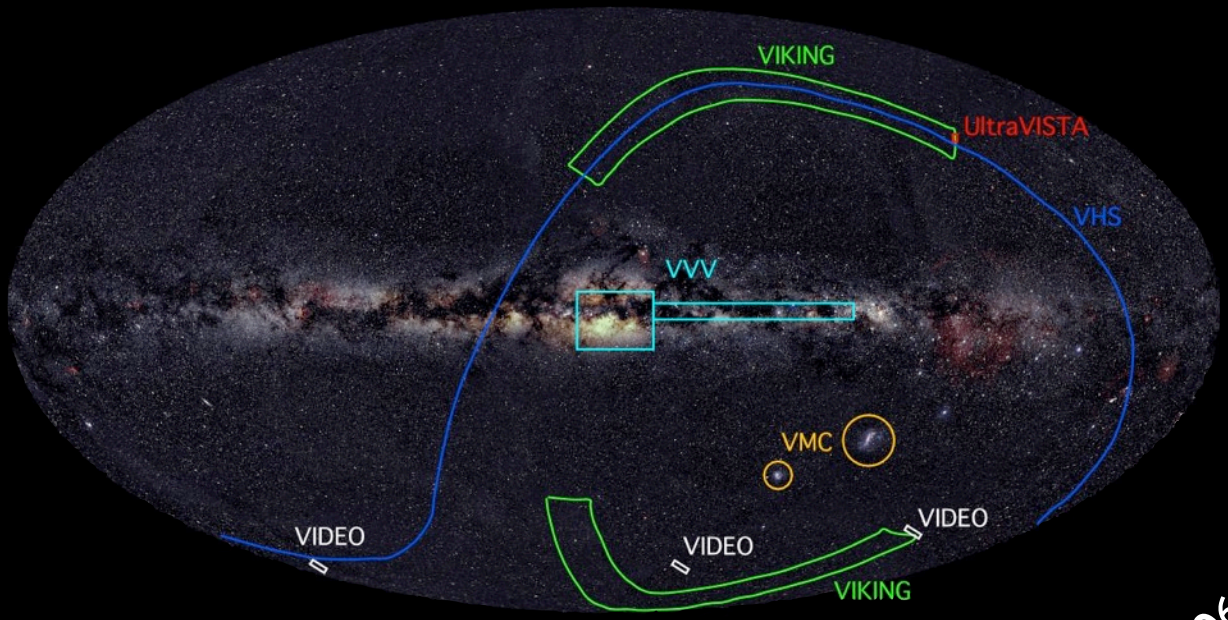
The Milky Way, our Galaxy

VISTA PUBLIC SURVEYS
VISTA VARIABLES IN THE VIA LACTEA



VISTA PUBLIC SURVEYS
VISTA VARIABLES IN THE VIA LACTEA

VVV



520 sq.deg.

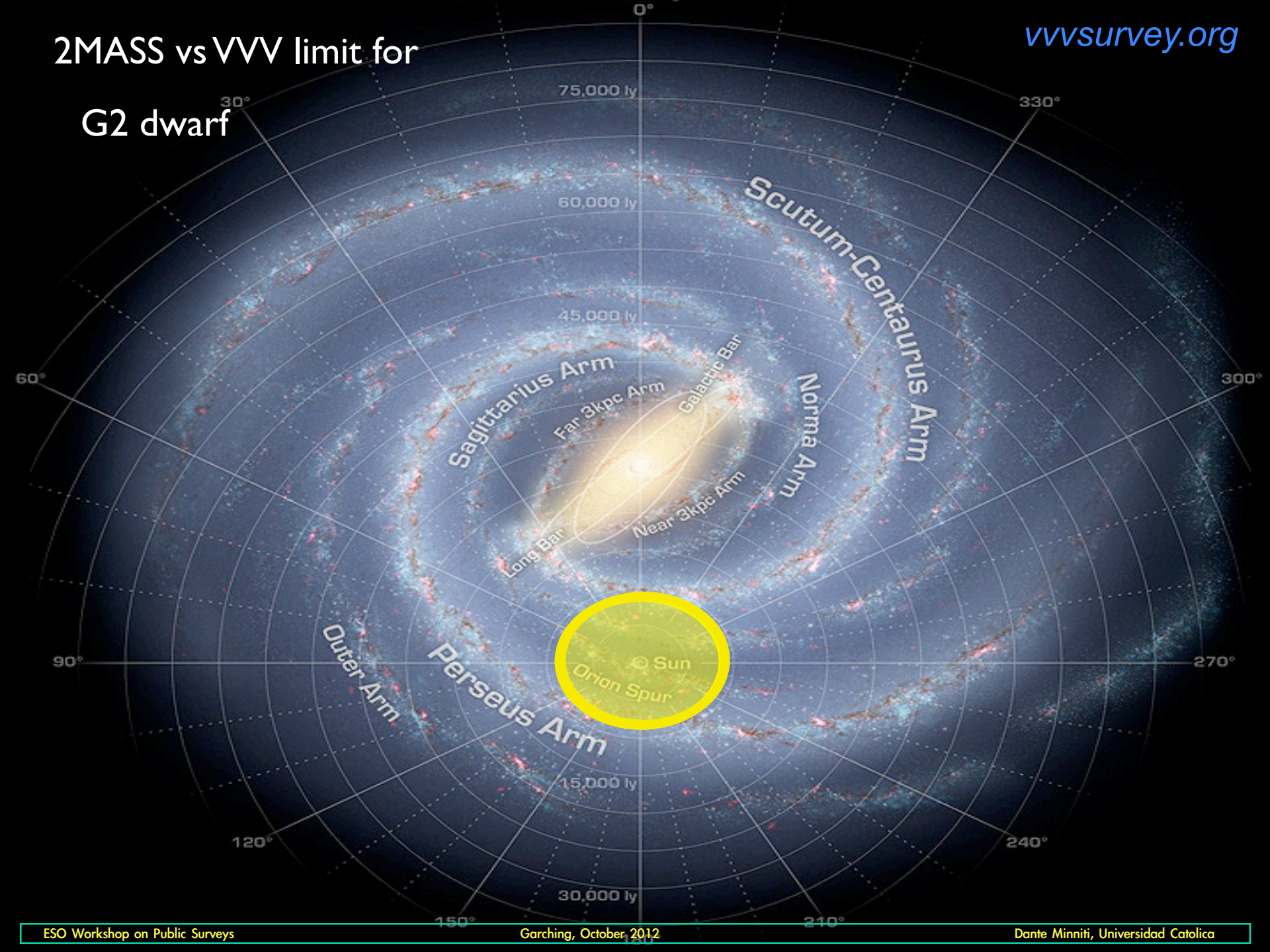
~10^9 stars

~100 epochs

~10^6 variables

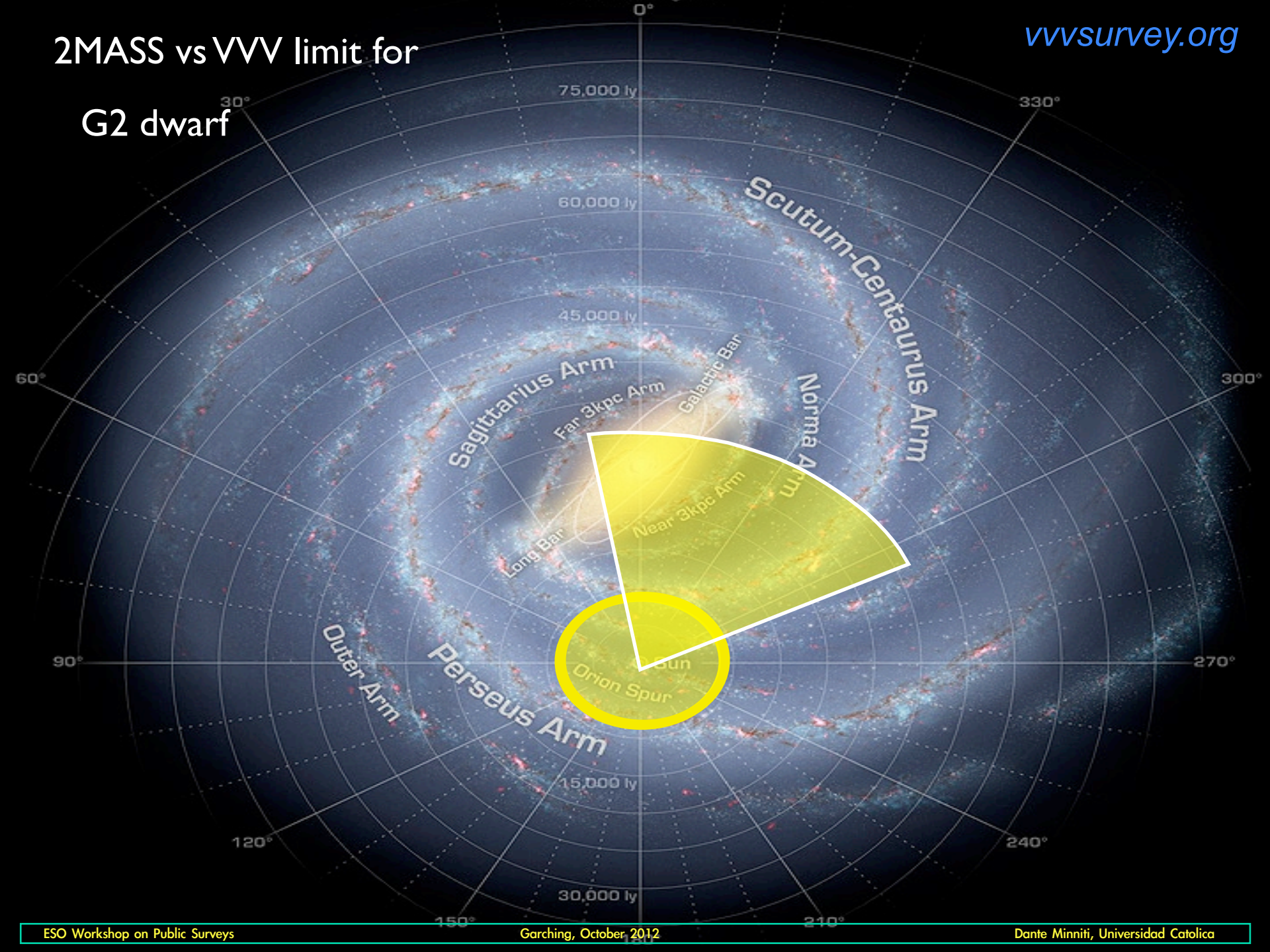
2MASS vs VVV limit for G2 dwarf

vvvsurvey.org



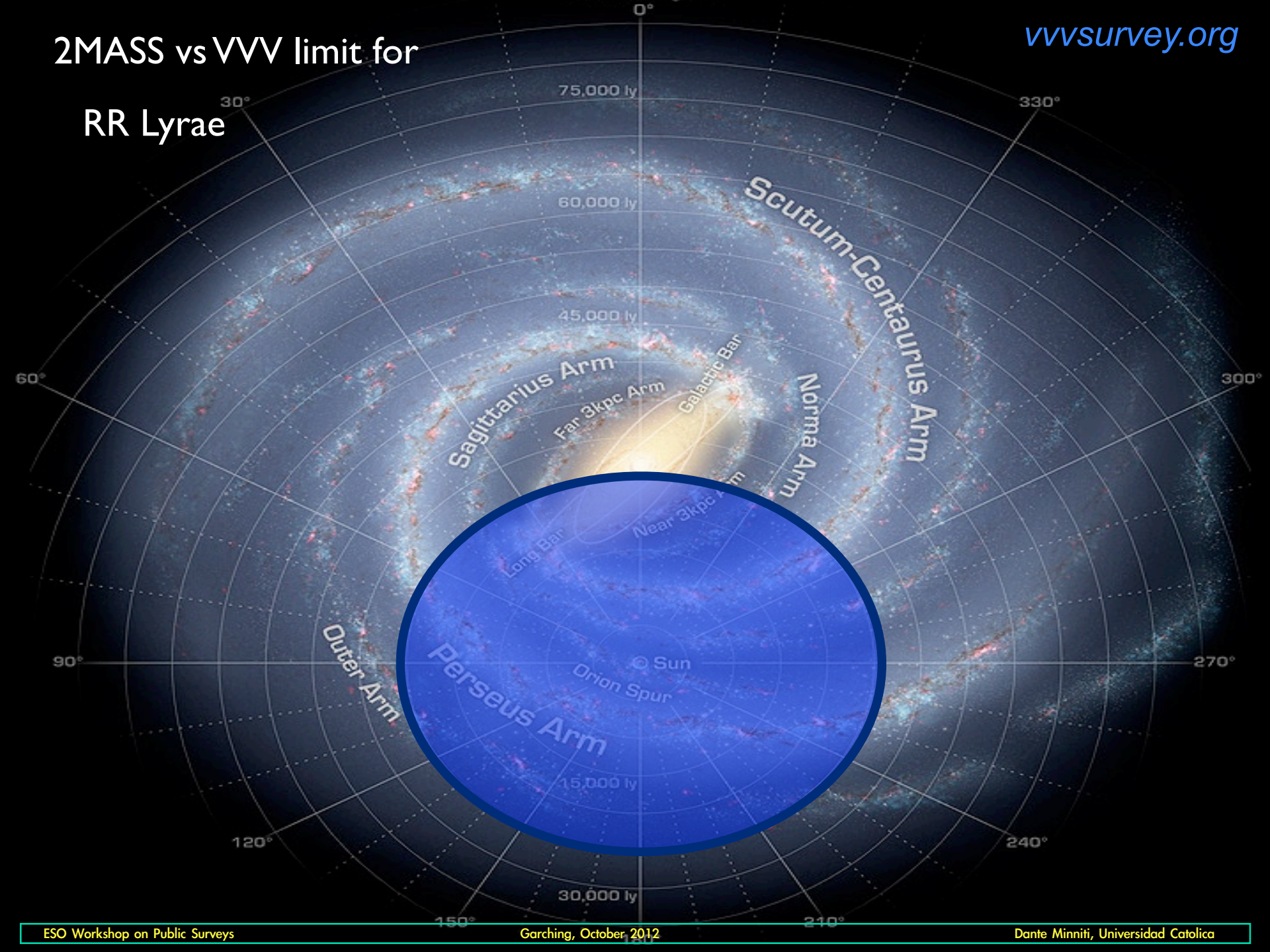
2MASS vs VVV limit for G2 dwarf

vvvsurvey.org

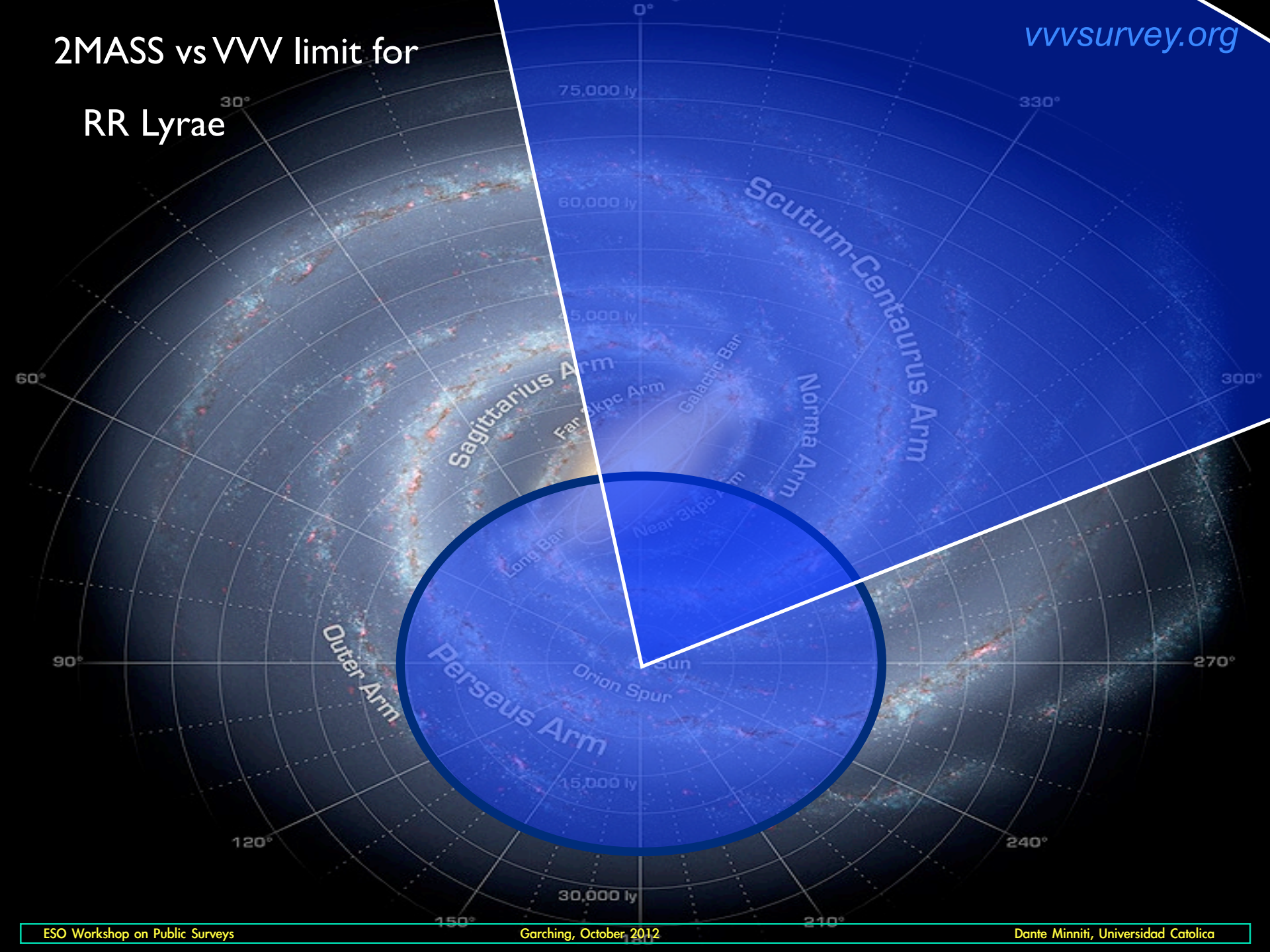


2MASS vs VVV limit for RR Lyrae

vvvsurvey.org

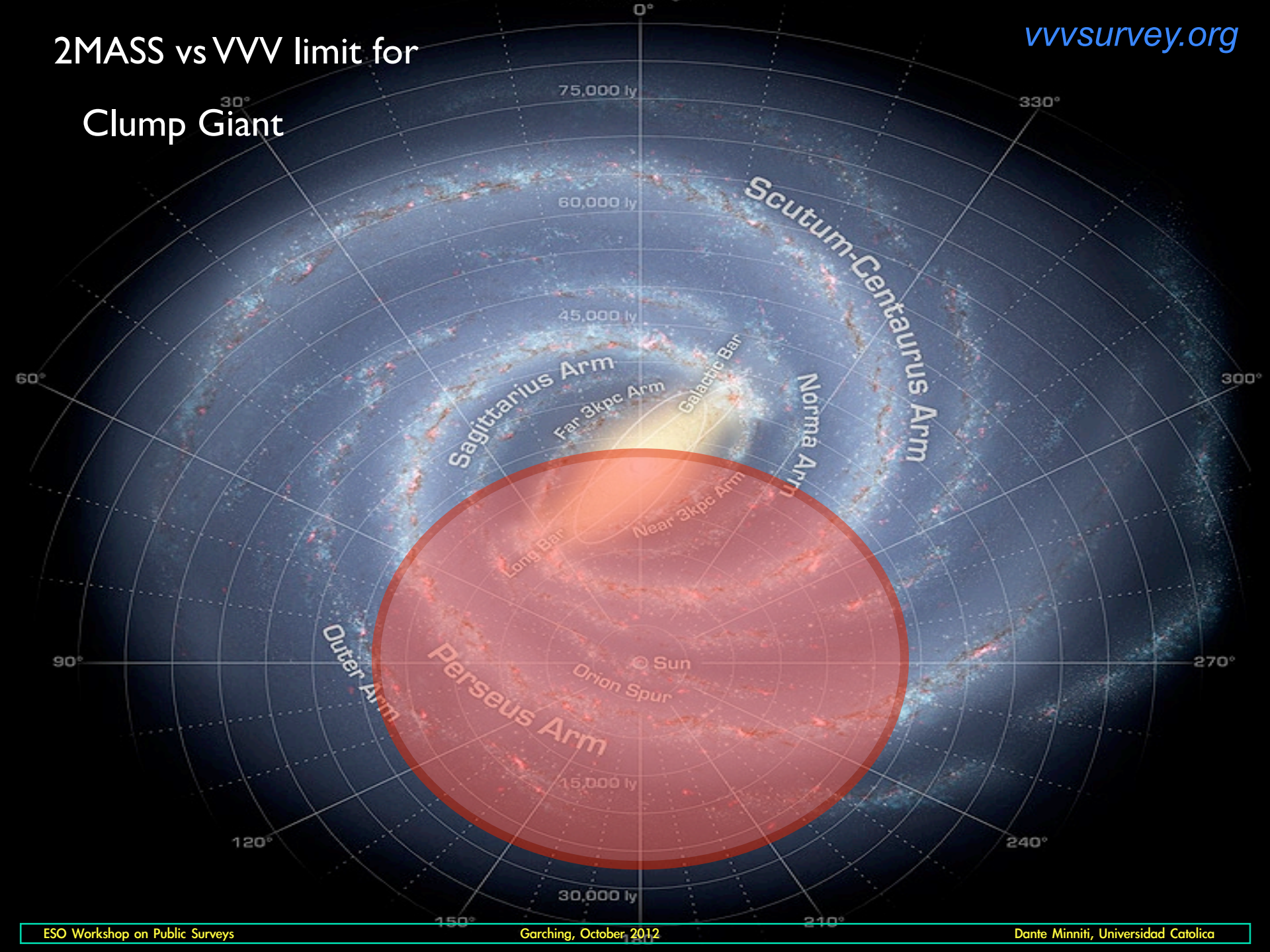


2MASS vs VVV limit for RR Lyrae



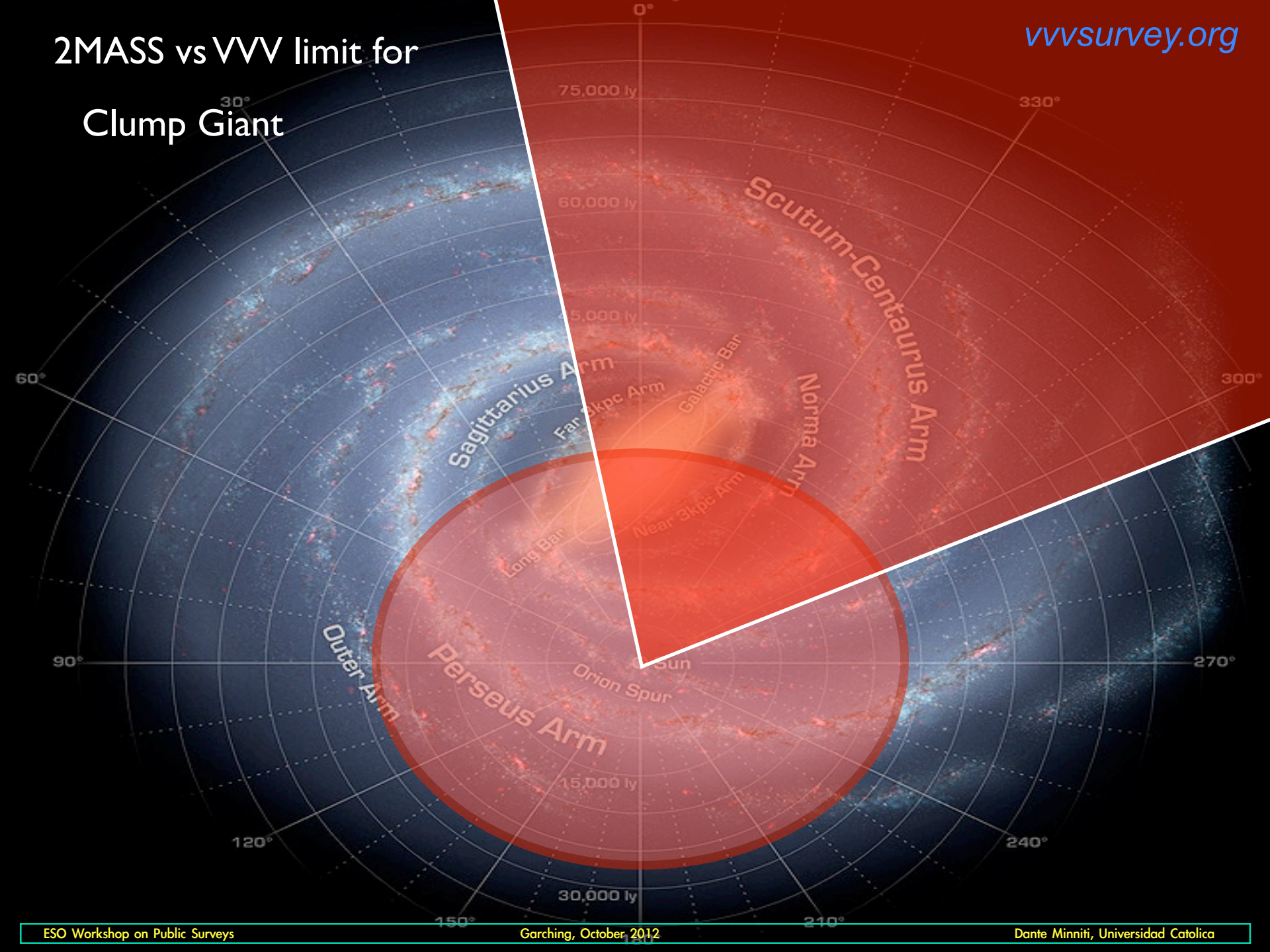
2MASS vs VVV limit for Clump Giant

vvvsurvey.org



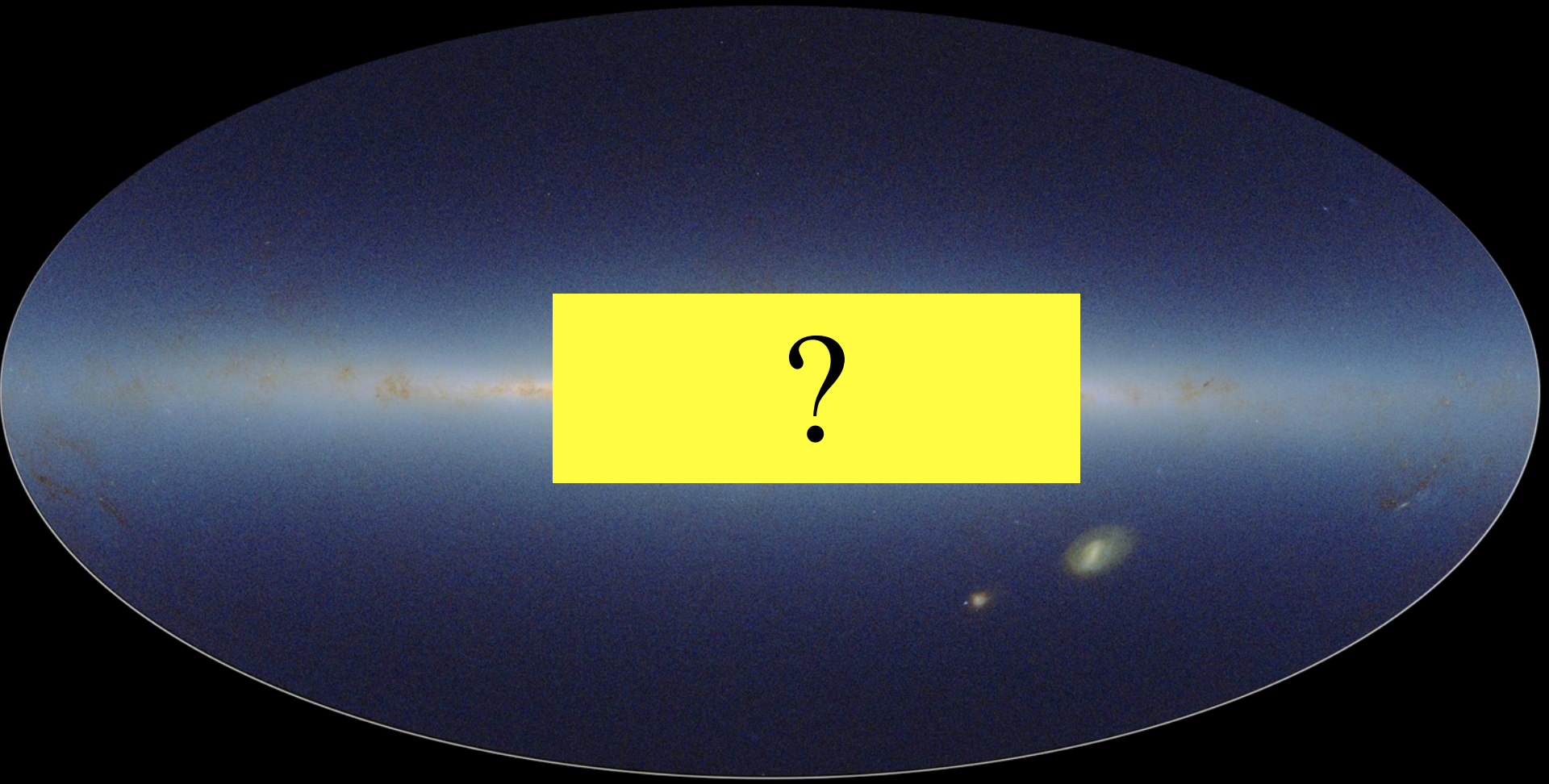
2MASS vs VVV limit for Clump Giant

vvvsurvey.org



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

vvvsurvey.org



VVV ZYJHKs

History:

Nr of papers:

2006: VVV Proposal

2008: Approved by PSP, OPC, ESO

2009: Dry runs

2010: Start observations, Paper 1

2011: CASU DR1

2012: Paper 2, PSP Review, VSA DR1

2013:

2014:

2015:

2016: End observations

The VVV Science Team

The VVV Science Team

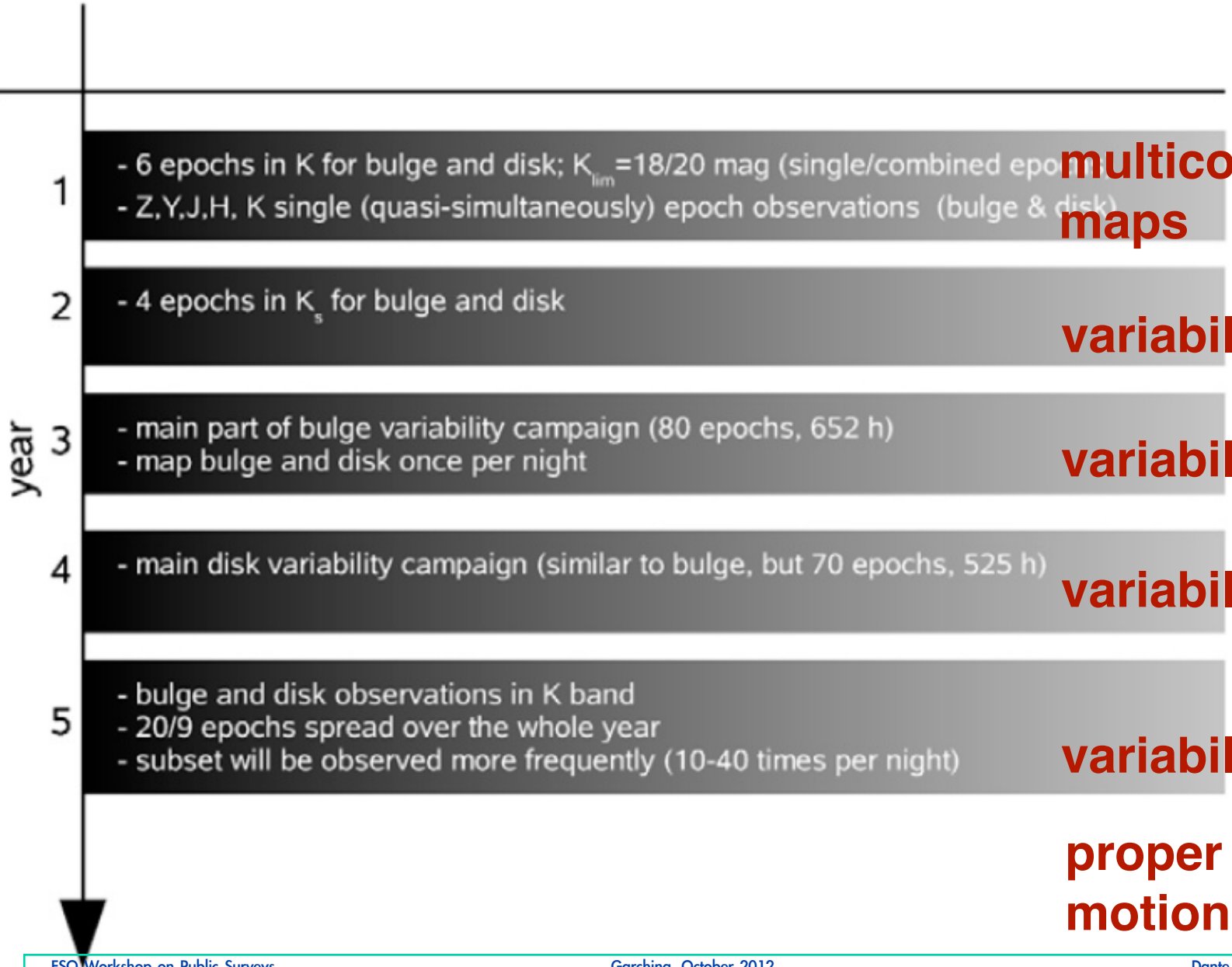
VVV Stages:

Multicolor photometry

Ks-band Variability

Proper motions

The VVV Survey: Timeline

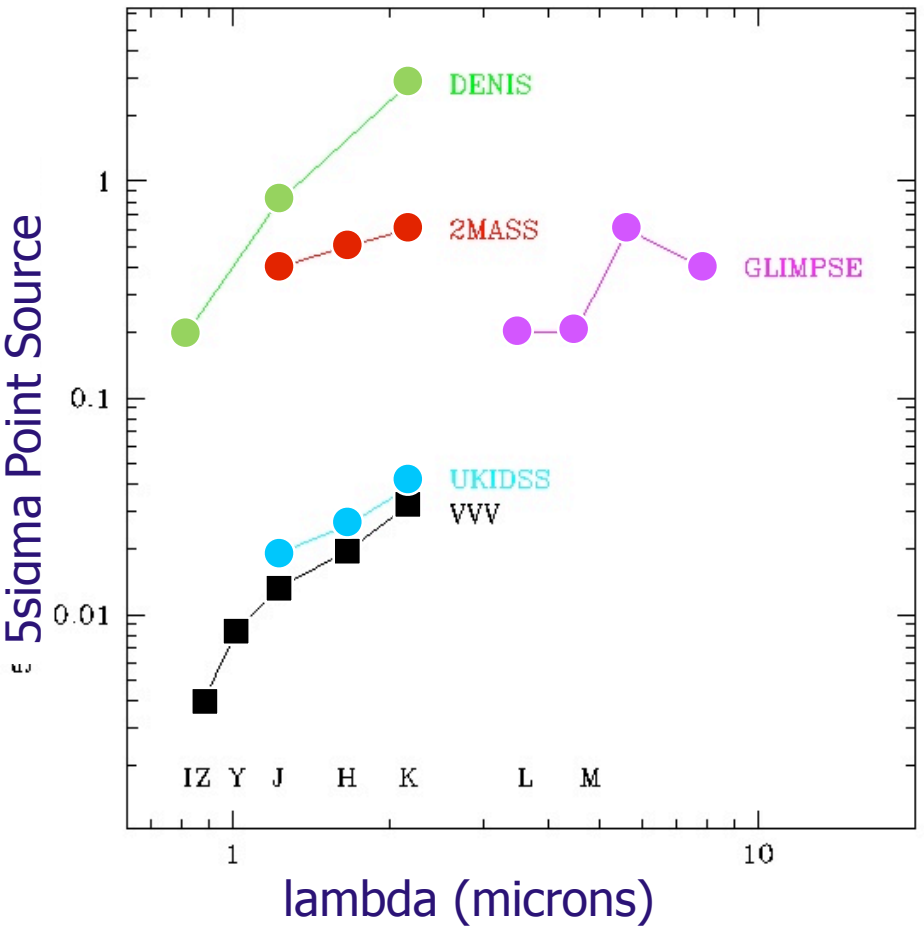


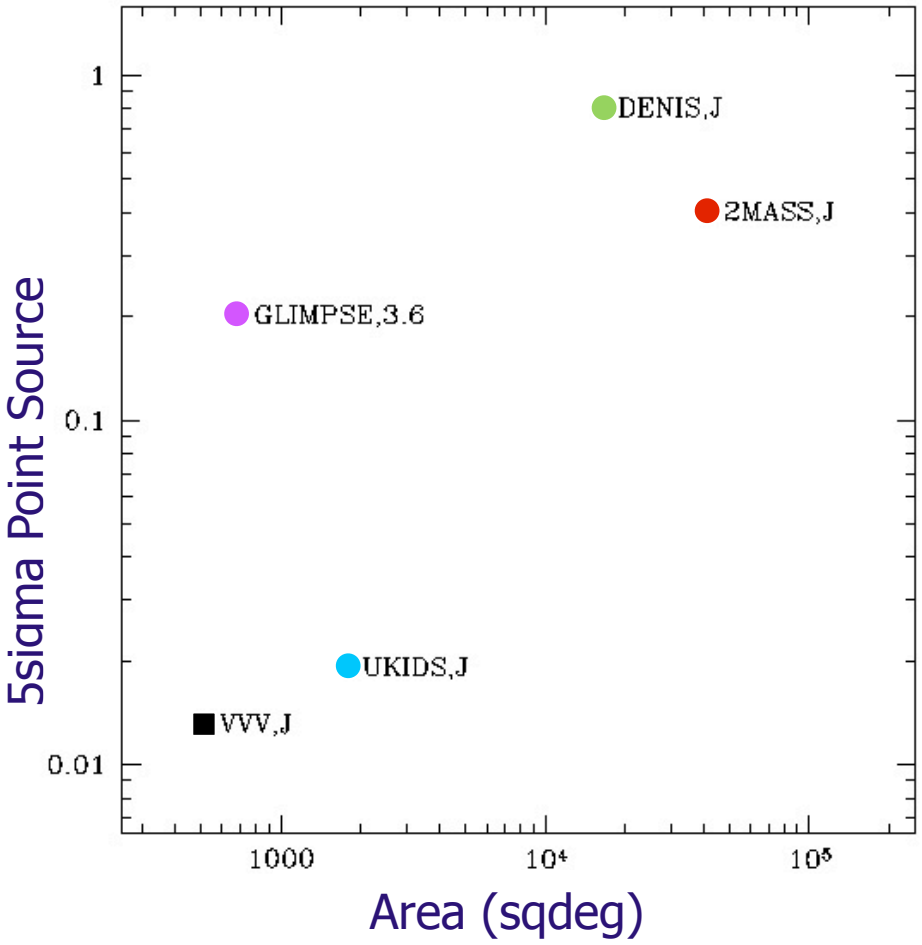
VVV Stages:

Multicolor photometry

VVV In Context

vvvsurvey.org





Valentin Ivanov

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)

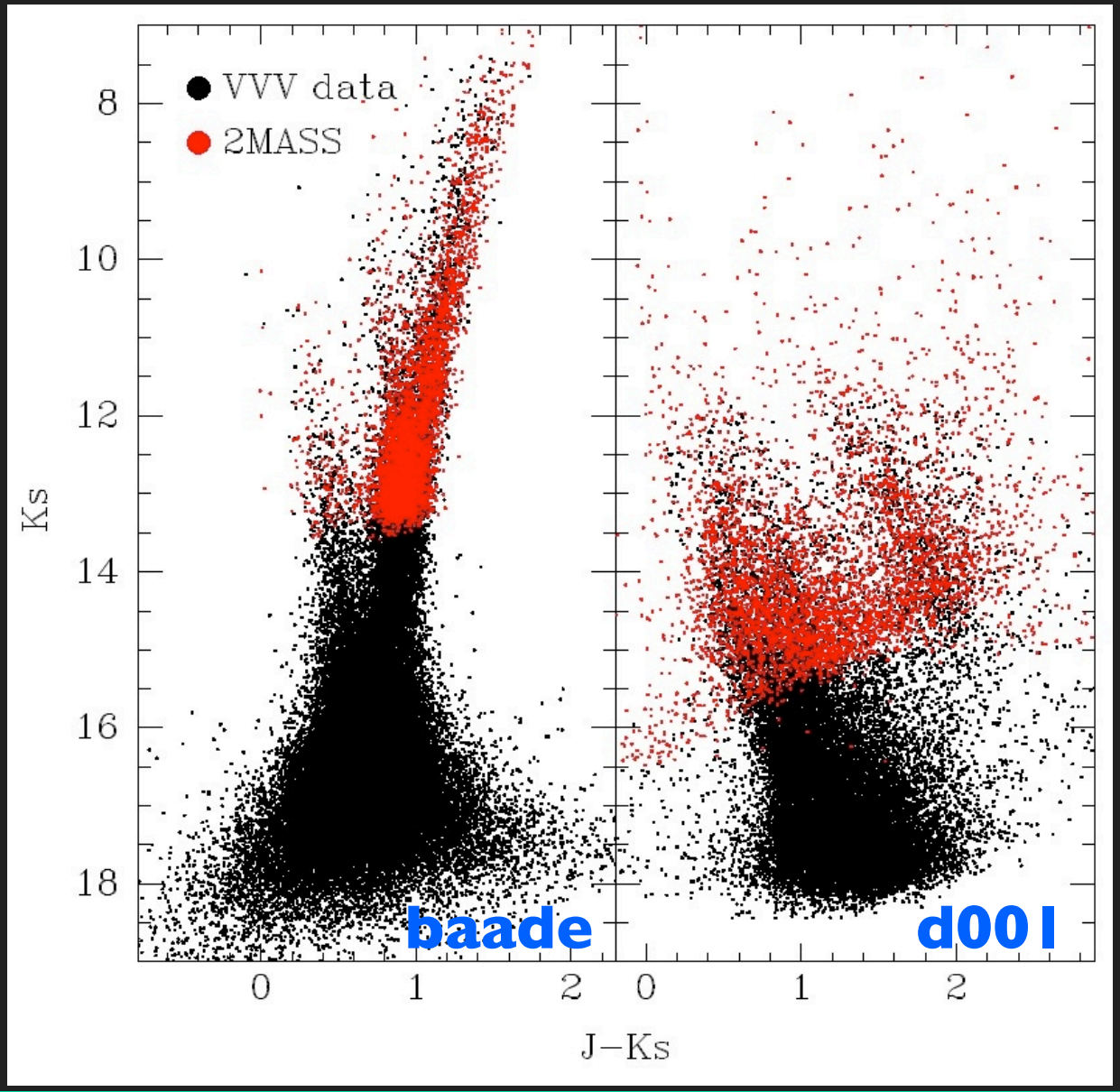
VVV has 5 filters (ZYJHKs)

VVV is a multiepoch survey (~100 epochs)

All in all the VVV survey is 2x bigger than 2MASS

VVV CMDs

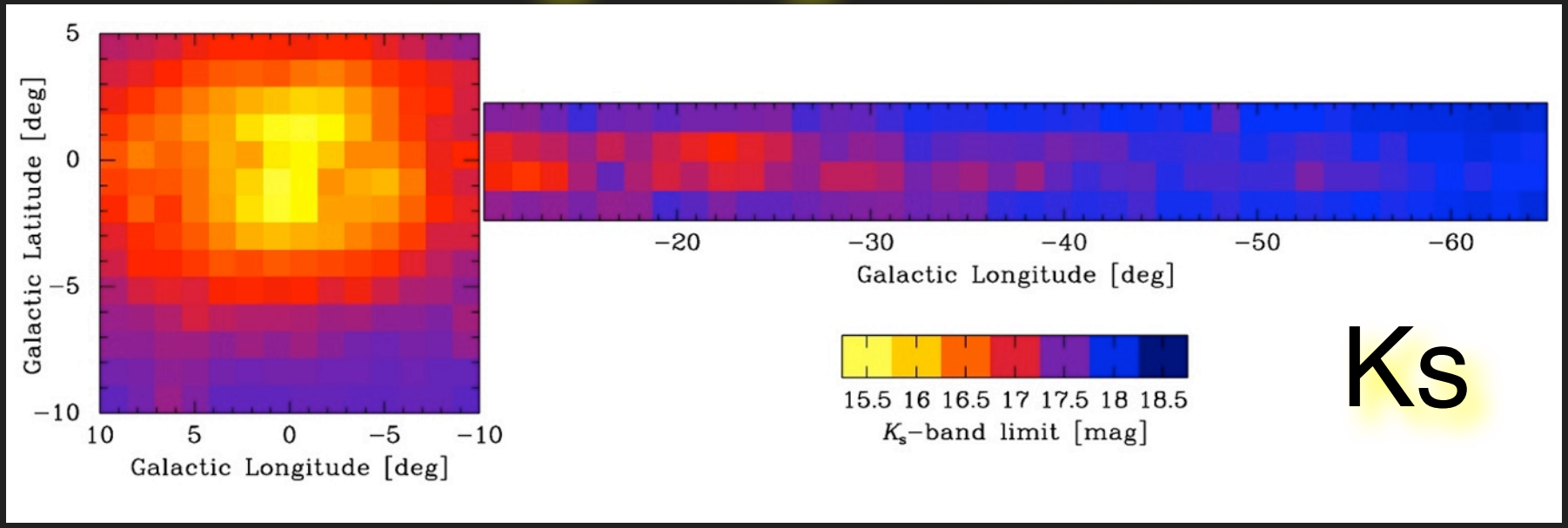
Color-magnitude diagrams of bulge and disk fields compared with 2MASS.



Oscar Gonzalez

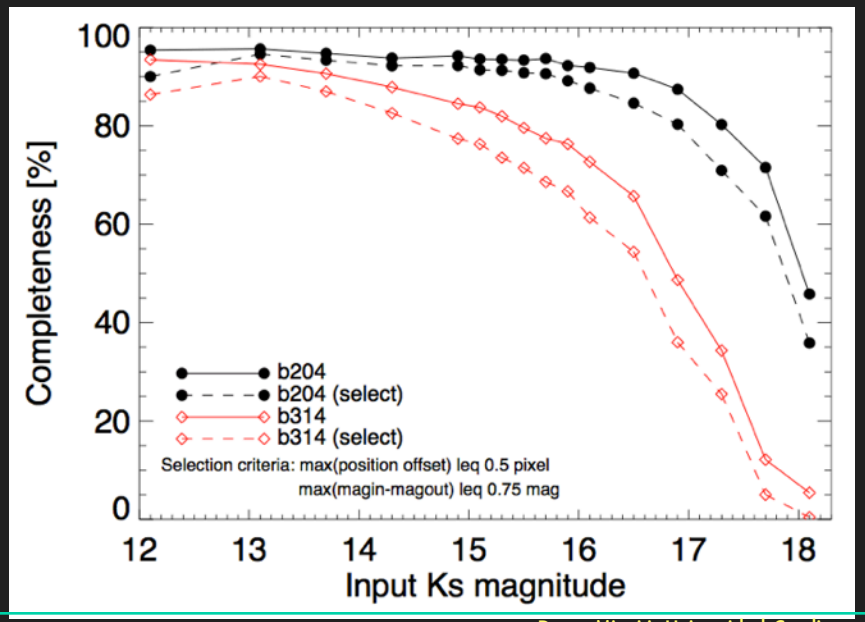
VVV limiting magnitudes

vvvsurvey.org

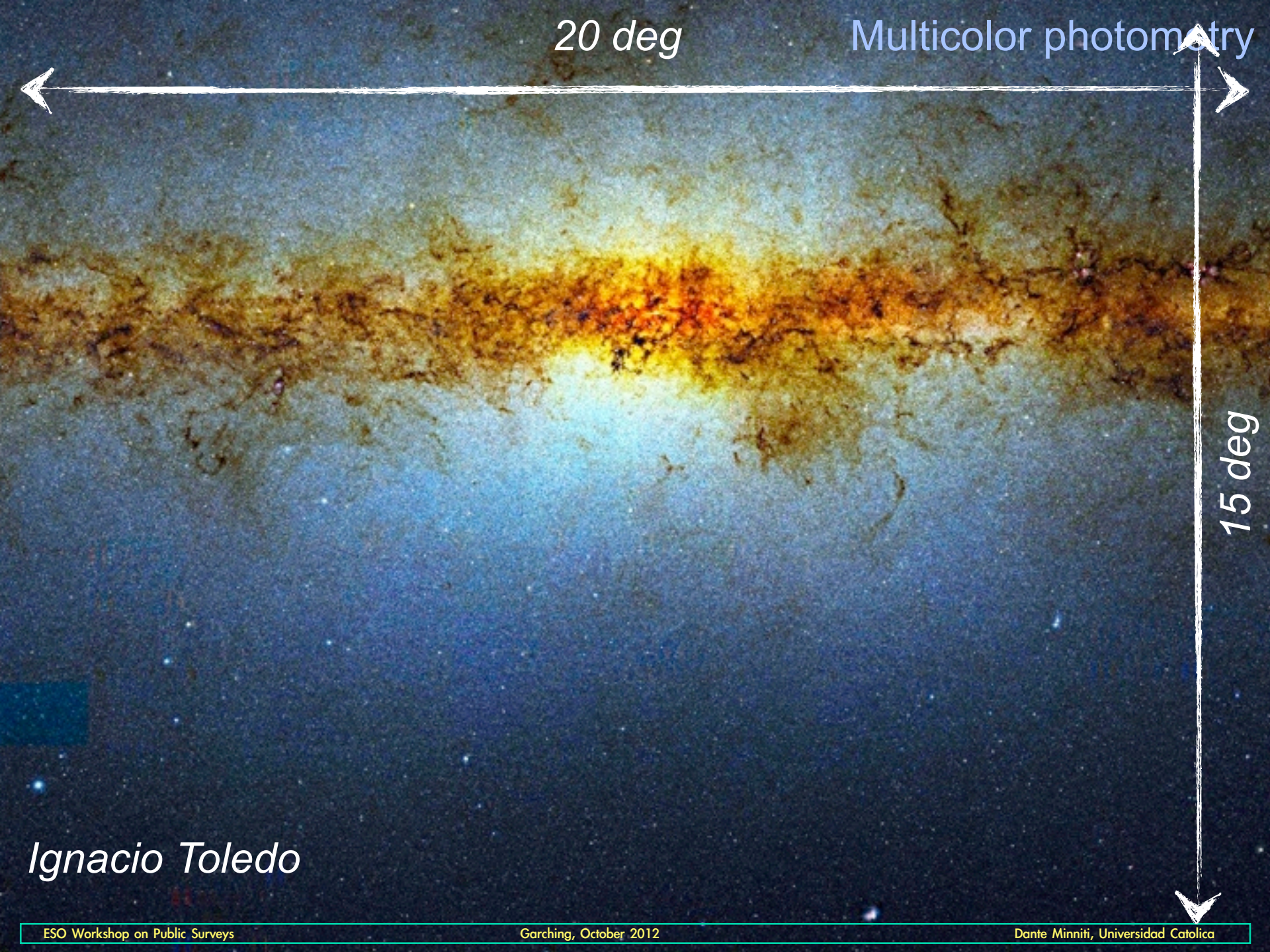


R. Saito

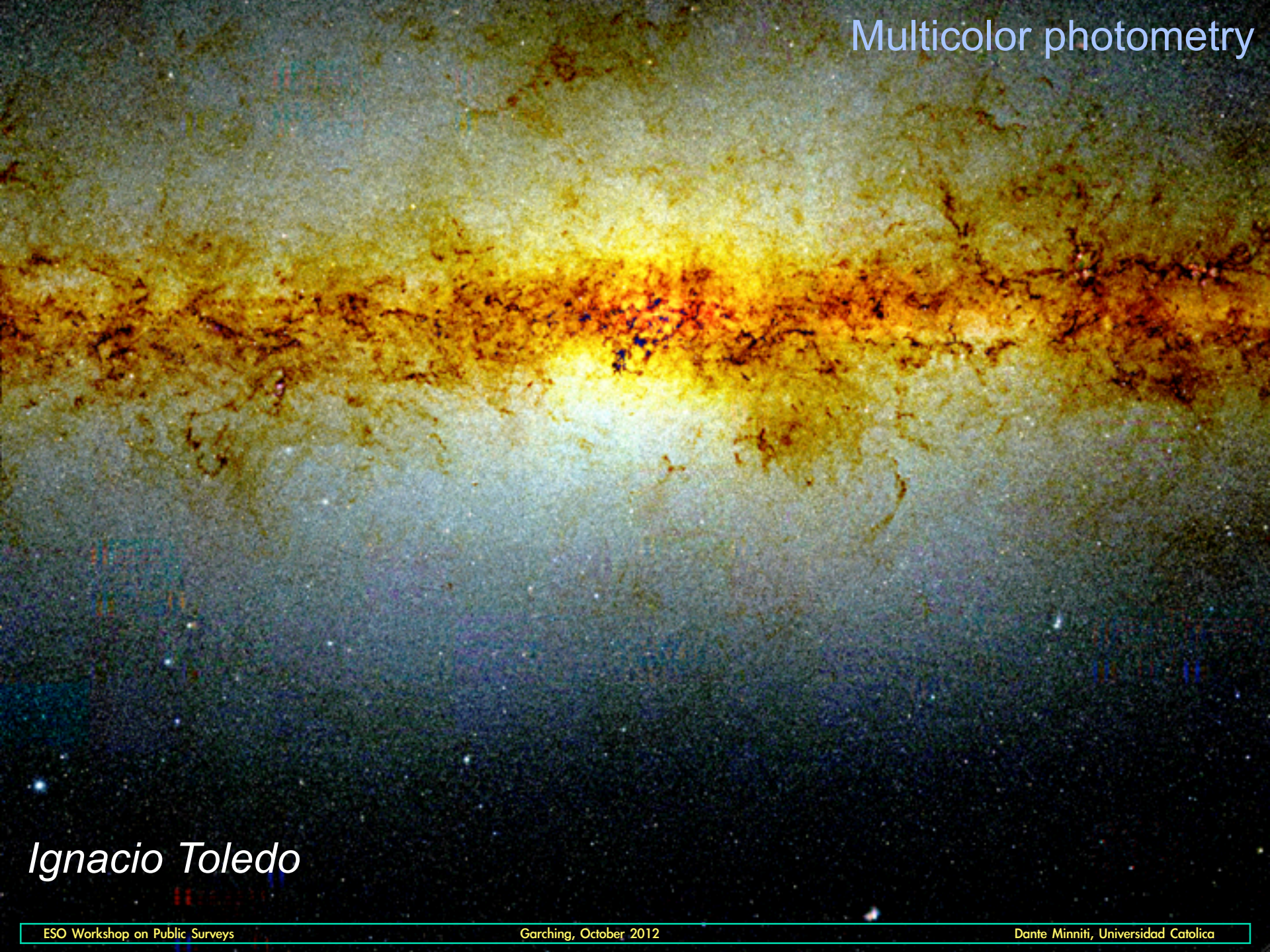
Completeness tests



M. Hempel

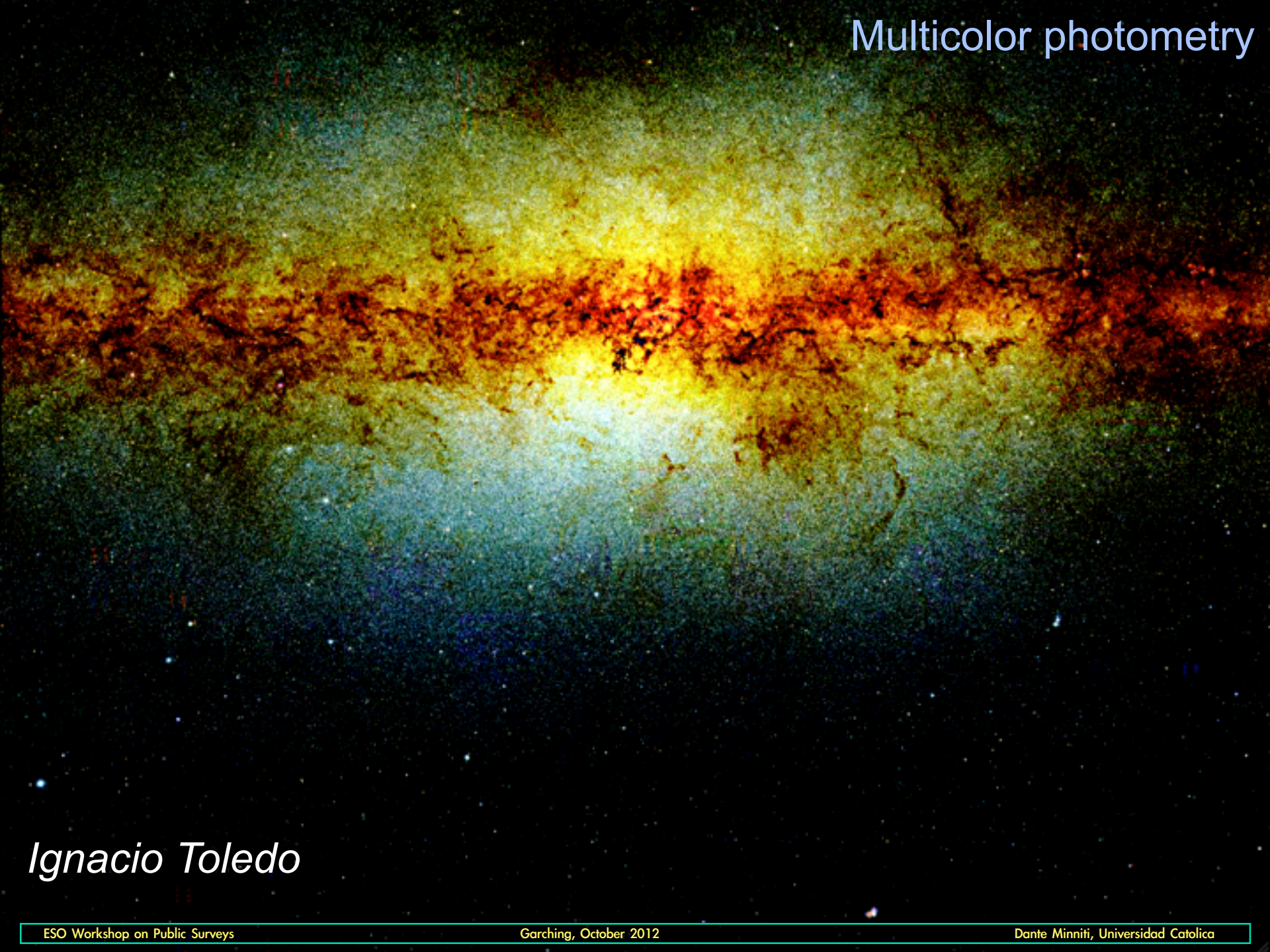

20 deg
Multicolor photometry
15 deg
Ignacio Toledo

Multicolor photometry



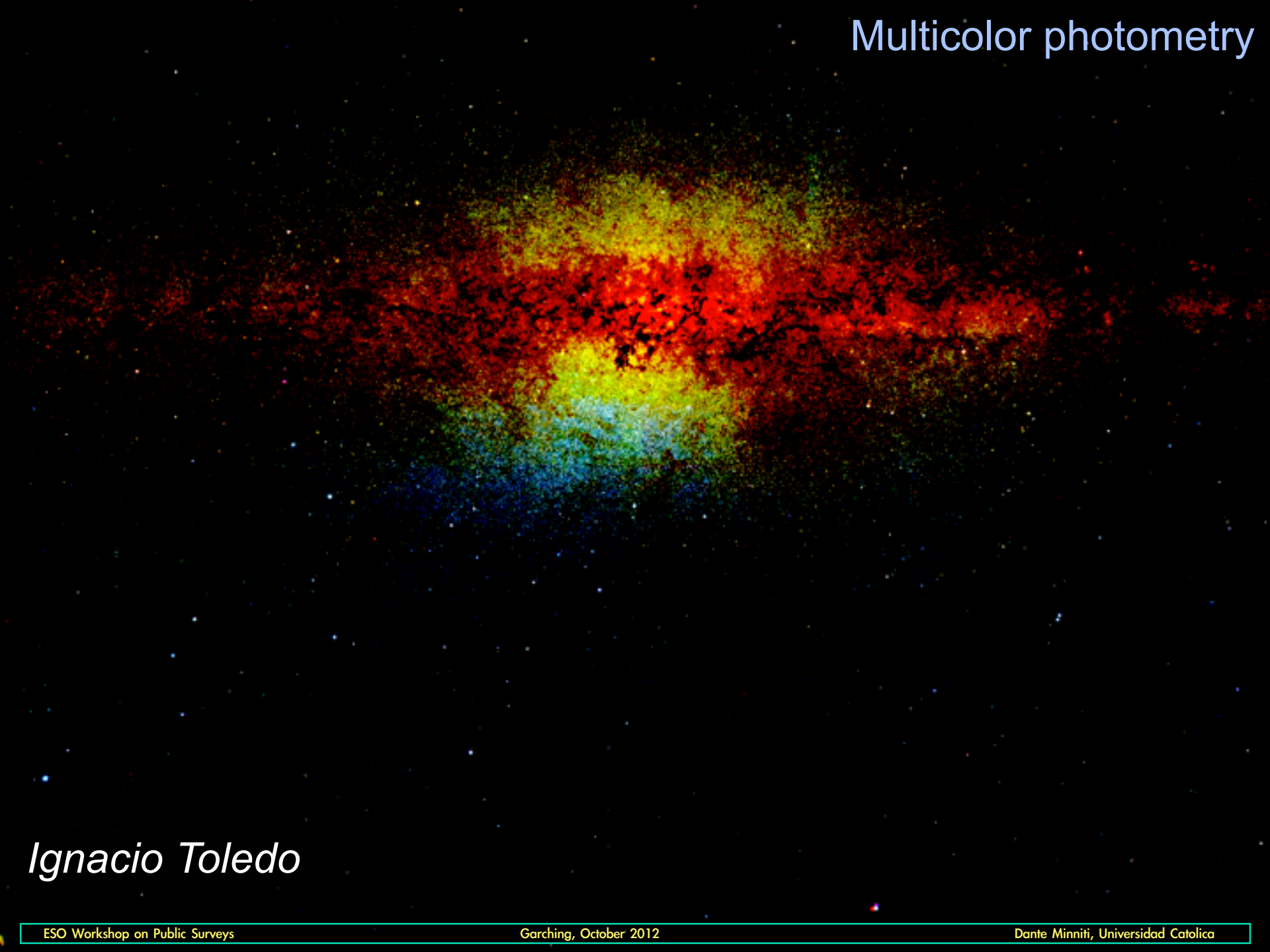
Ignacio Toledo

Multicolor photometry



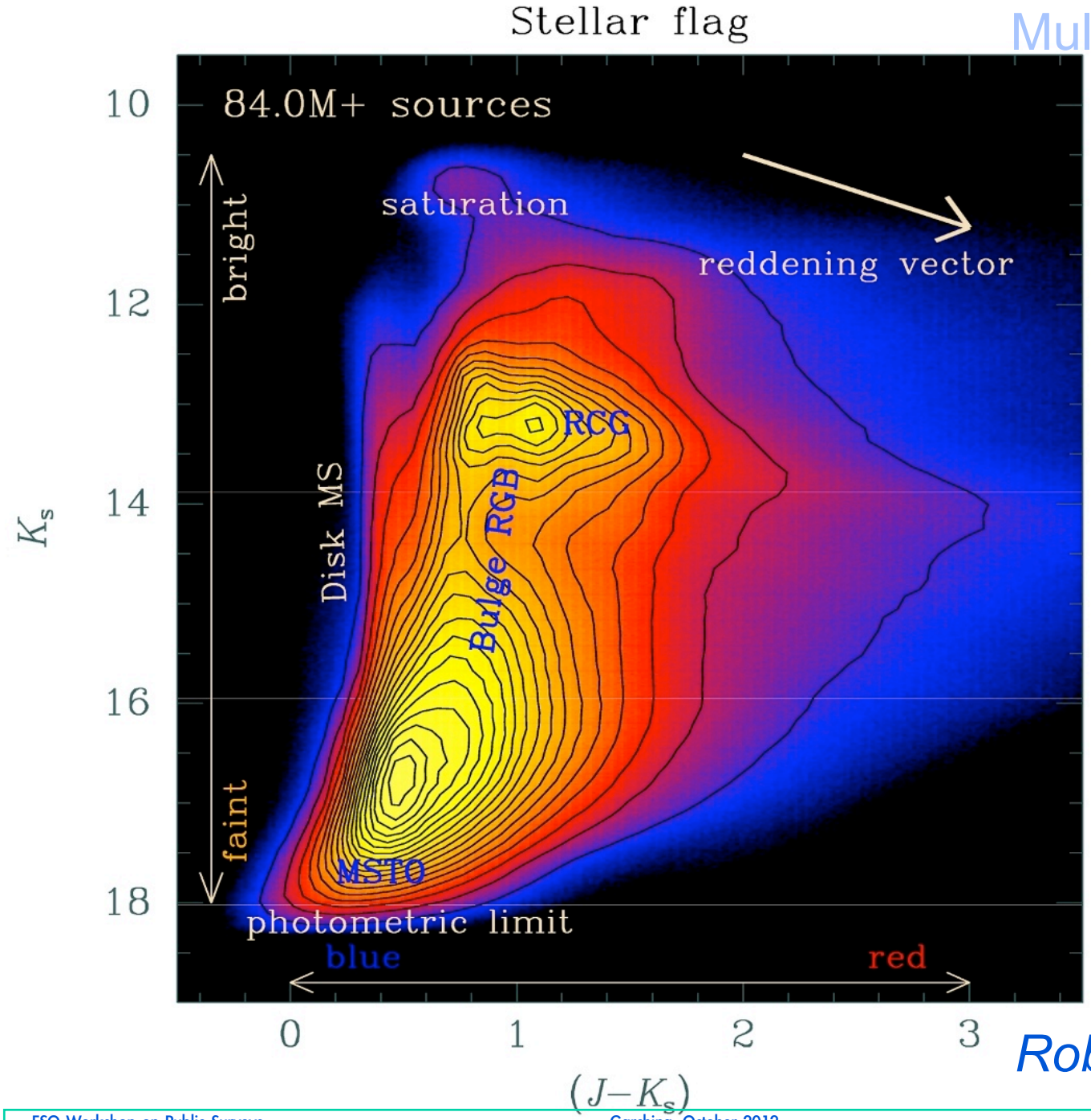
Ignacio Toledo

Multicolor photometry



Ignacio Toledo

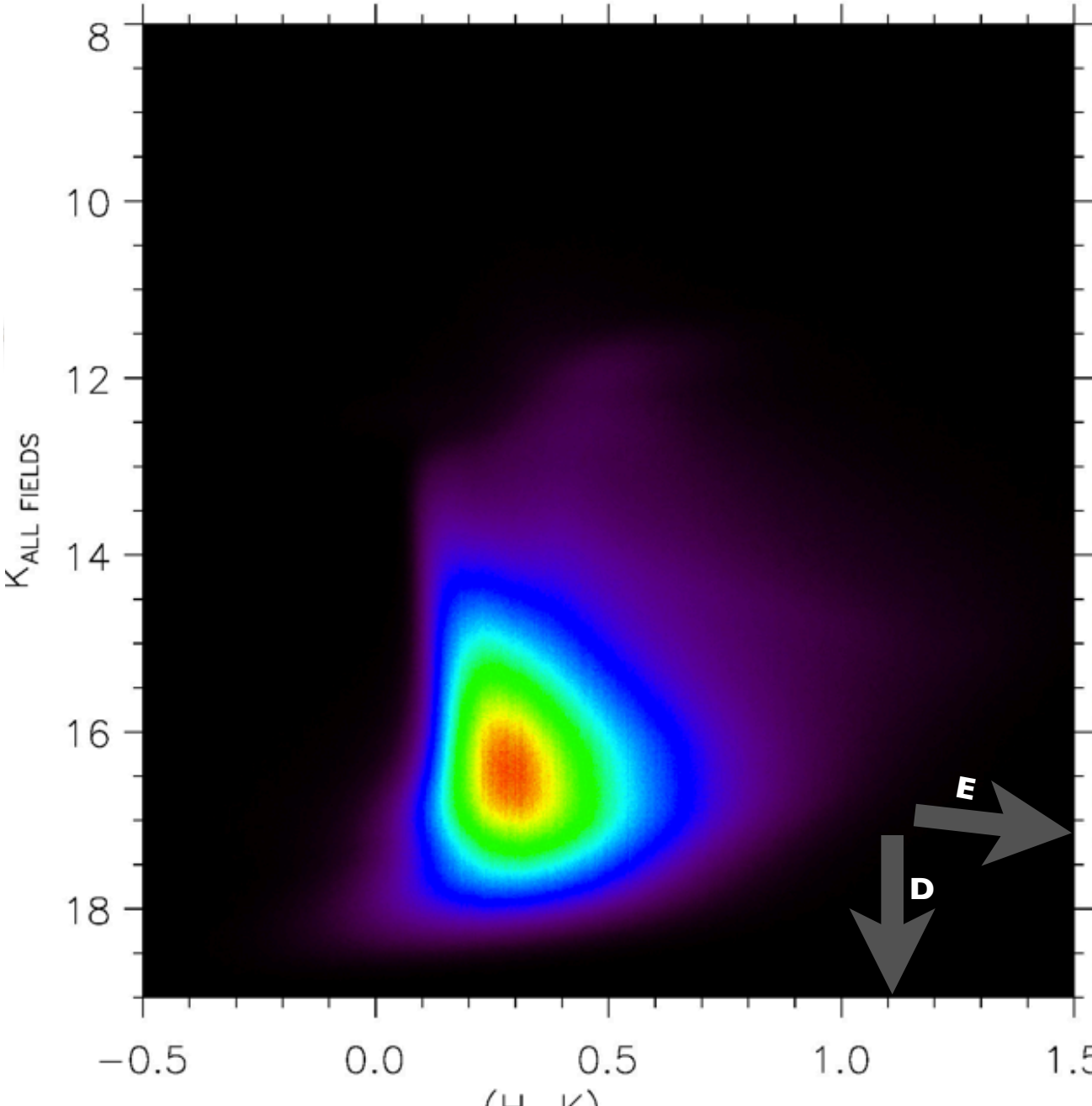

Multicolor photometry
Ignacio Toledo
N
E



VVV 84M+ STARS BULGE CMD

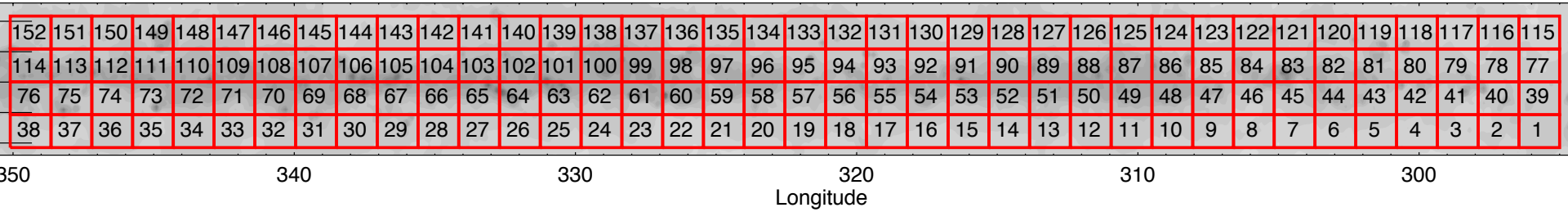
Roberto Saito

VVV DISK 140M STARS

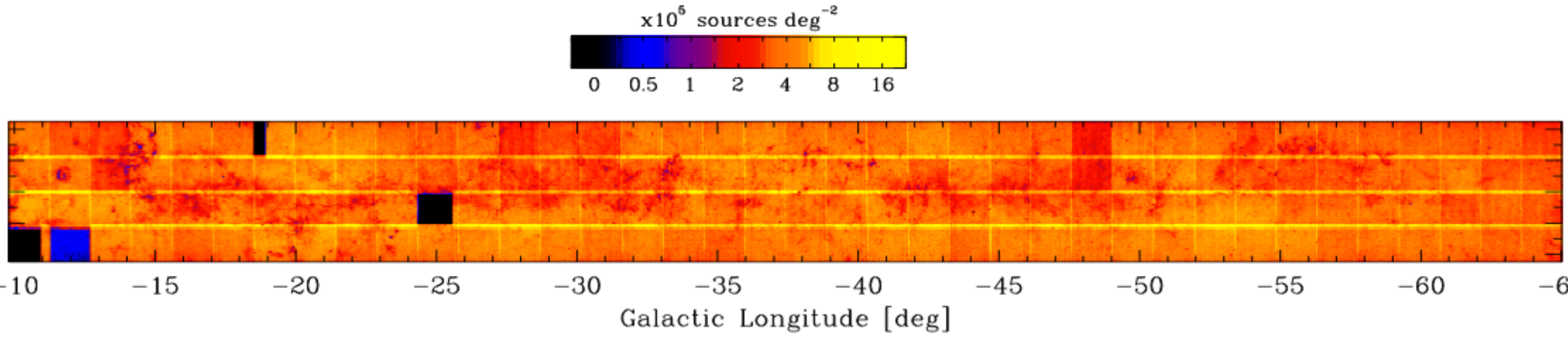


M. Soto, R. Barba

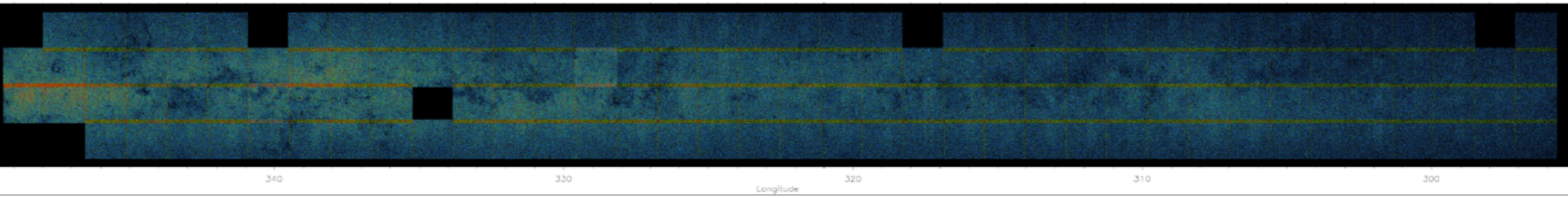
tile IDs



all stars



red giants

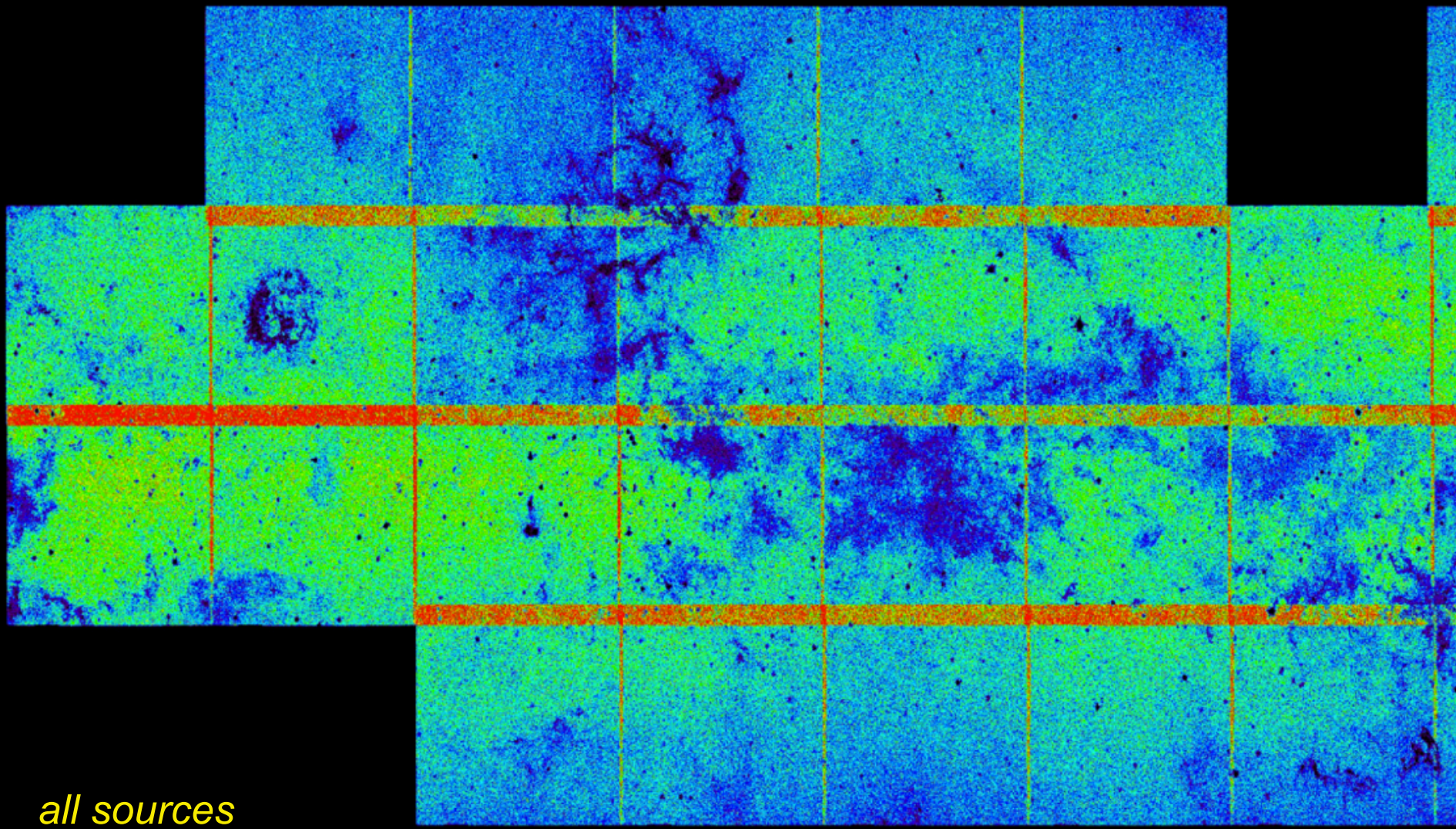


152 disk tiles covering 275 sqdeg

vvvsurvey.org

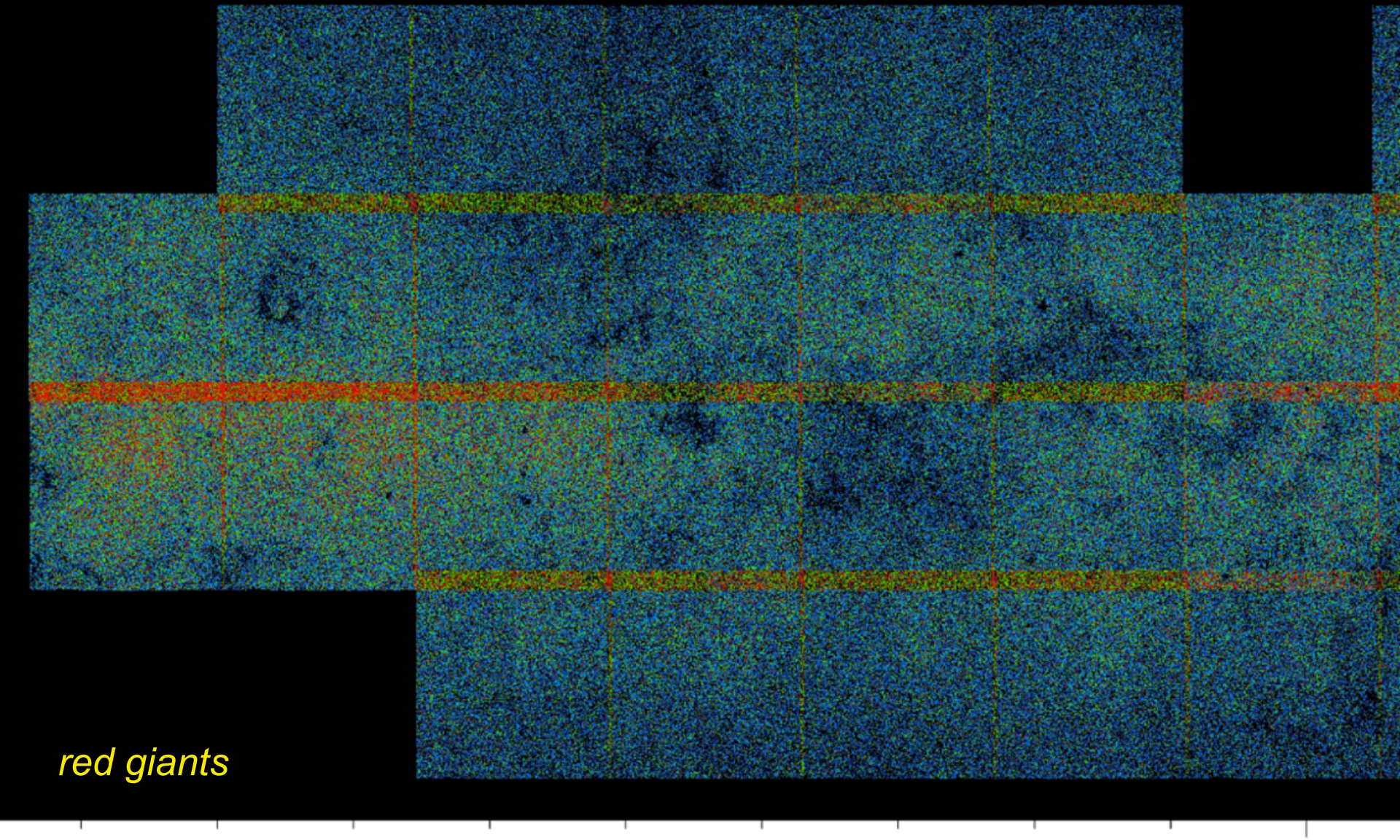
M. Soto, R. Barba, M. Hempel

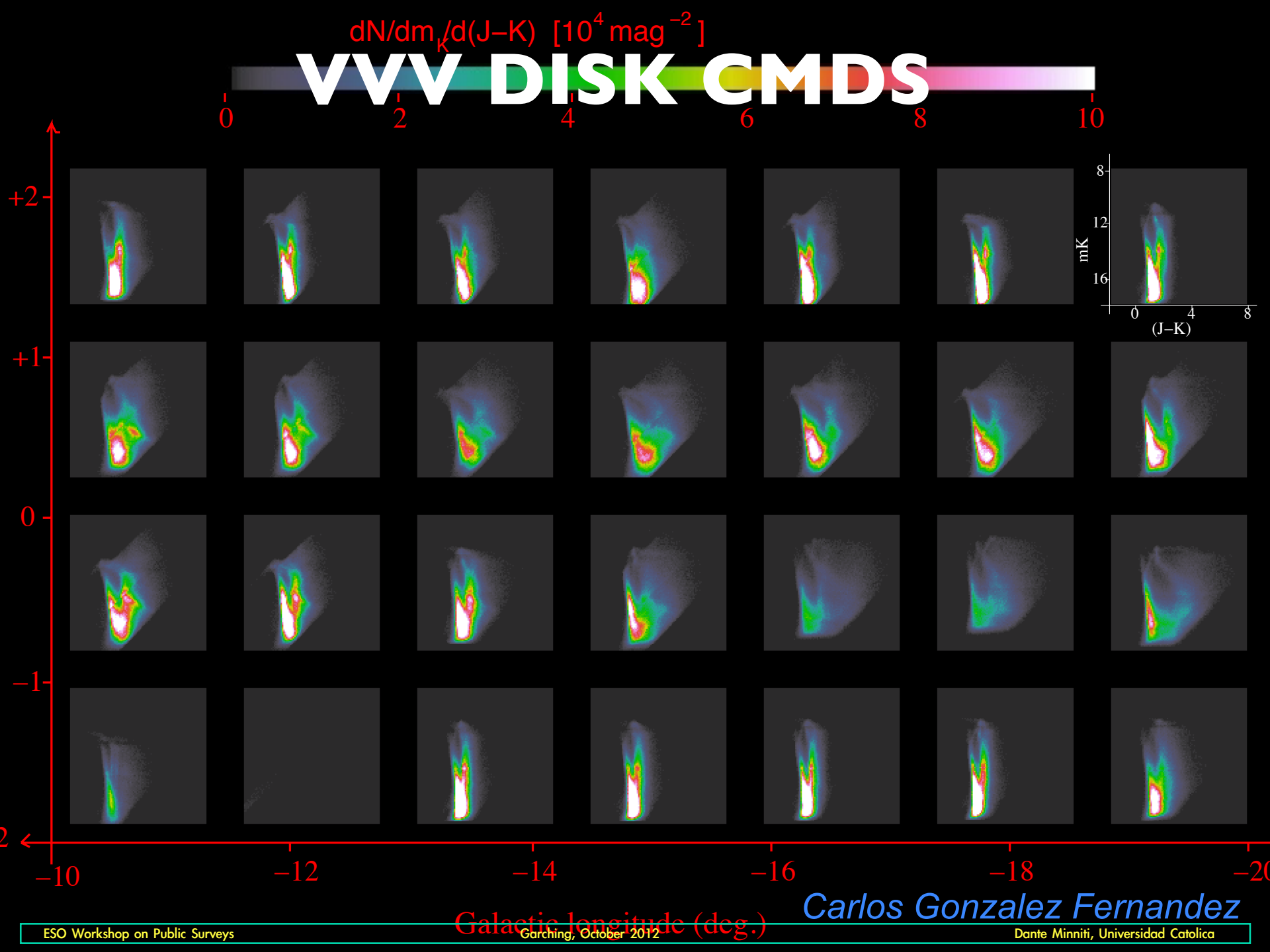
VVV DISK DENSITY MAPS



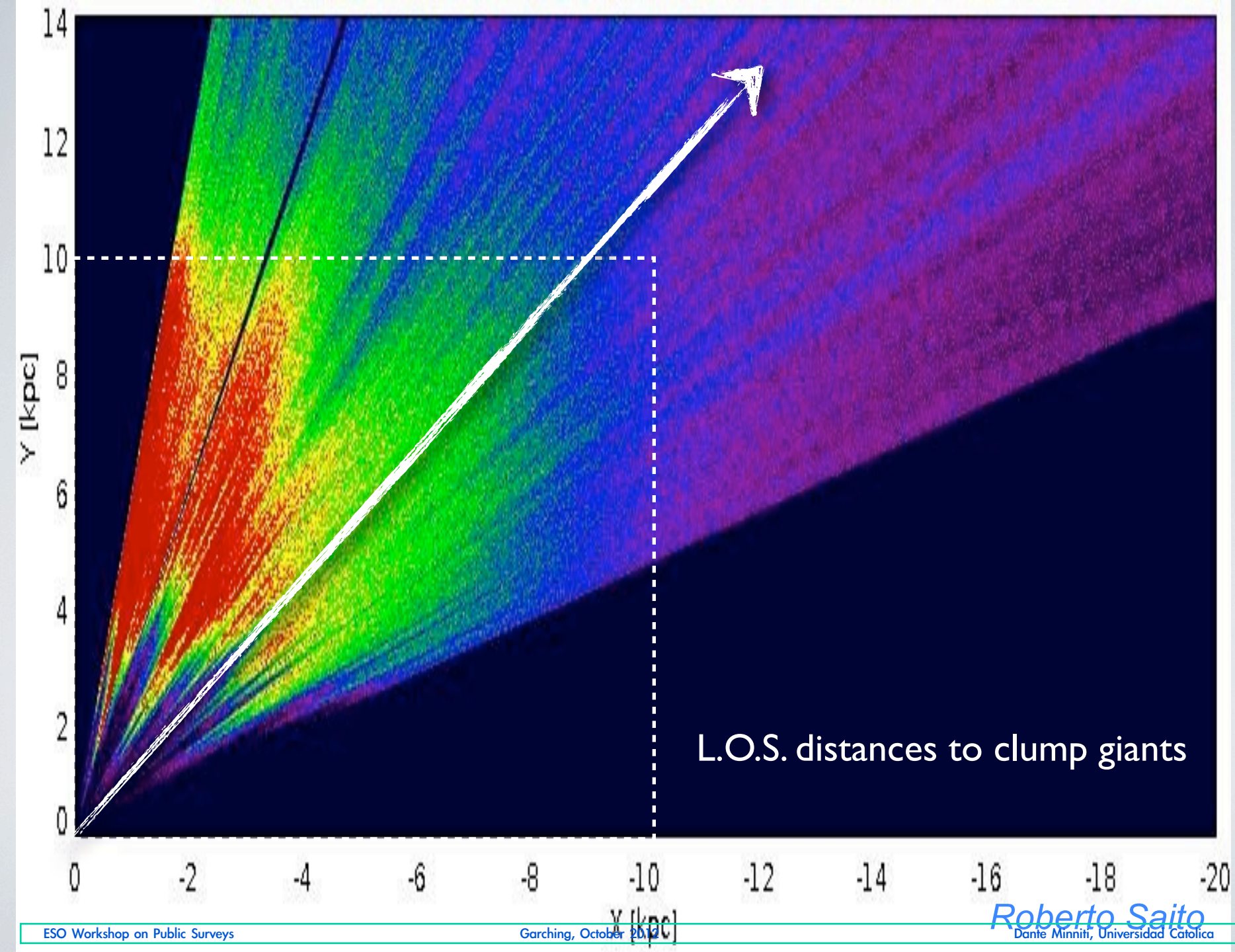
all sources

VVV DISK DENSITY MAPS



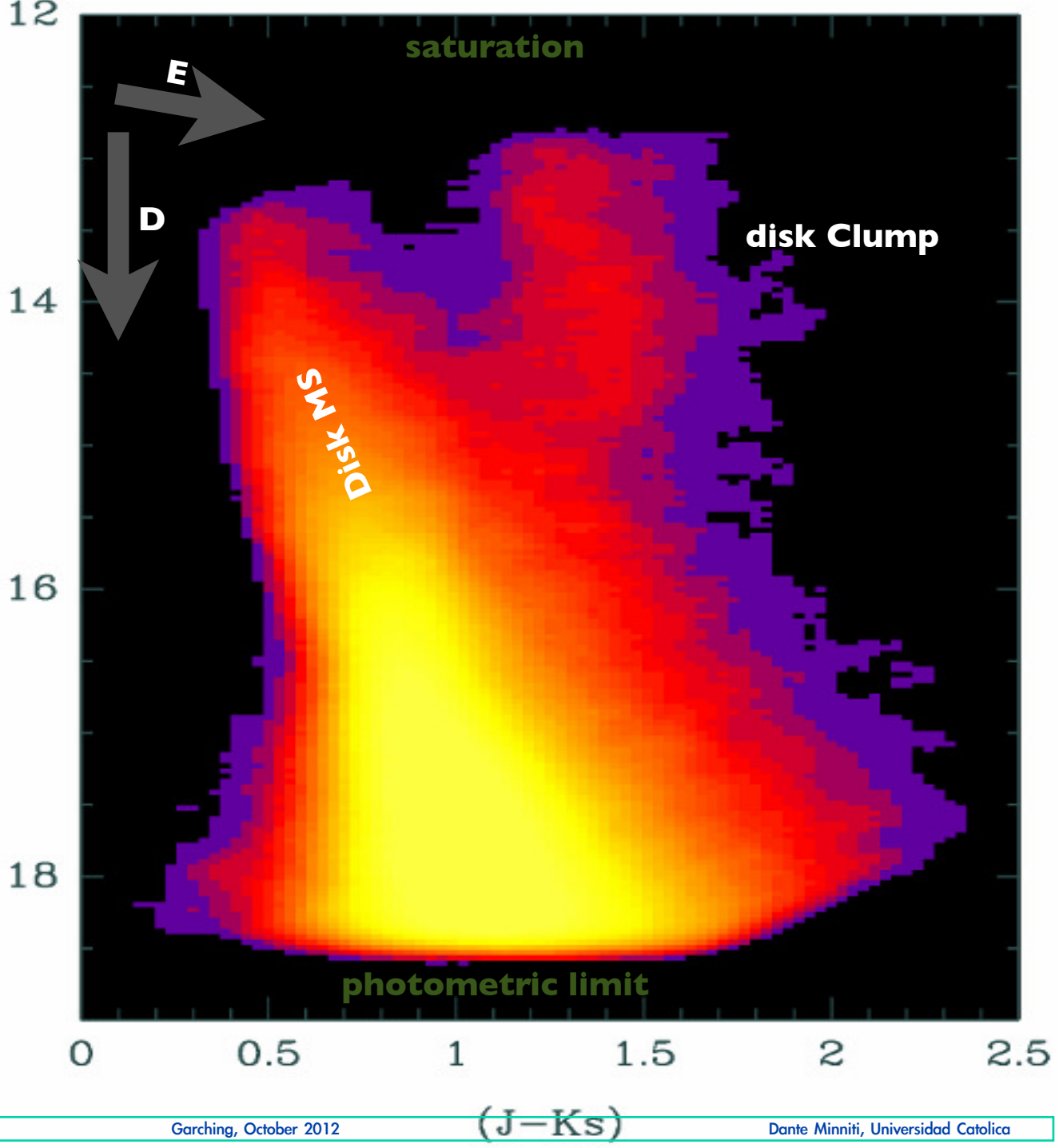


Carlos Gonzalez Fernandez


14
12
10
8
6
4
2
0
Y [kpc]
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
X [kpc]
L.O.S. distances to clump giants

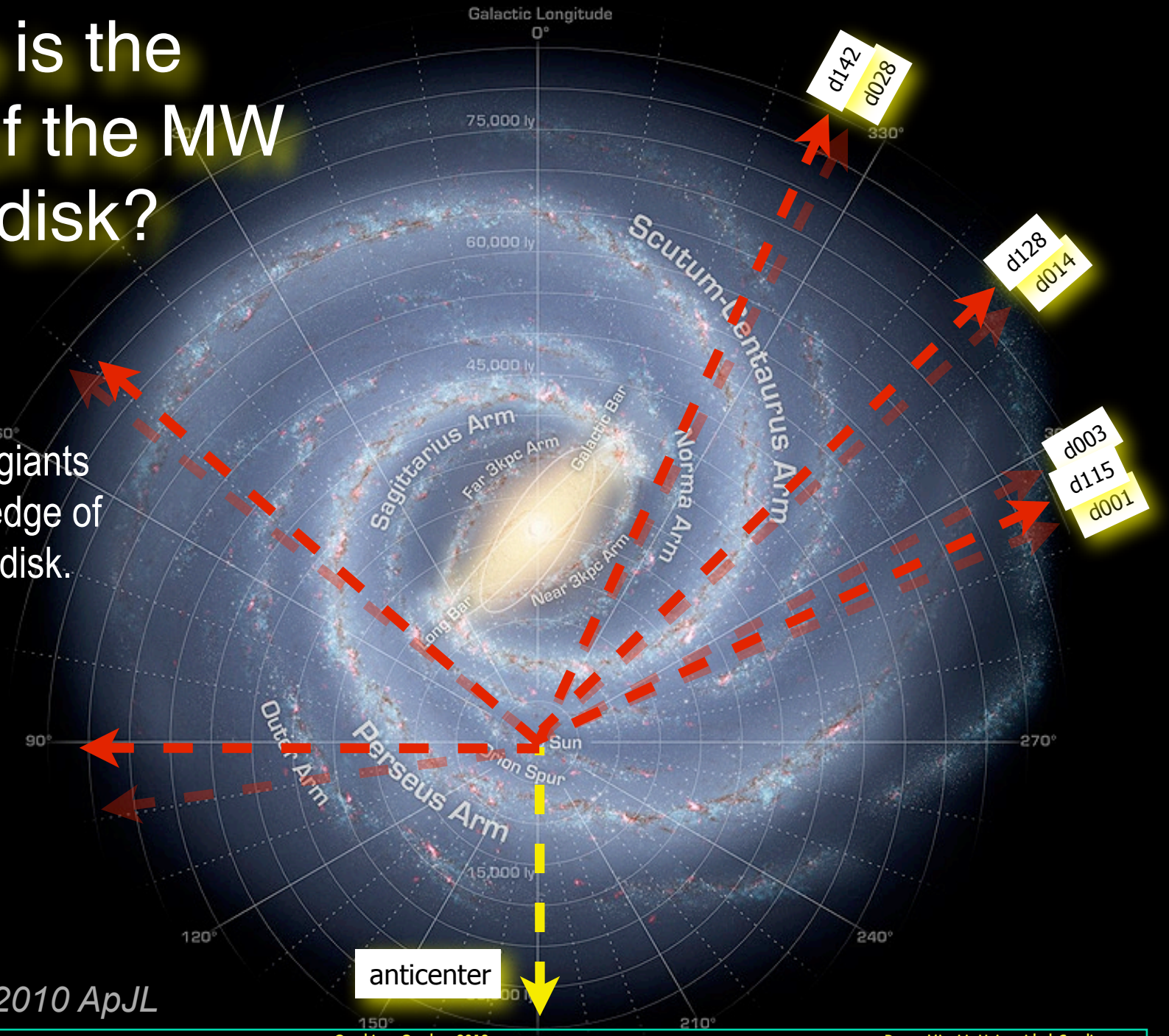
VVV 0.5M+ STARS DISK CMD

d003 field



Where is the edge of the MW stellar disk?

Use of clump giants to detect the edge of the old stellar disk.



Minniti et al. 2010 ApJL

VVV Globular Clusters

How many GCs in the MW?

New candidate GCs

Christian Moni-Bidin, Francesco Mauro, Doug Geisler, et al. 2011

Open Clusters

vvvsurvey.org

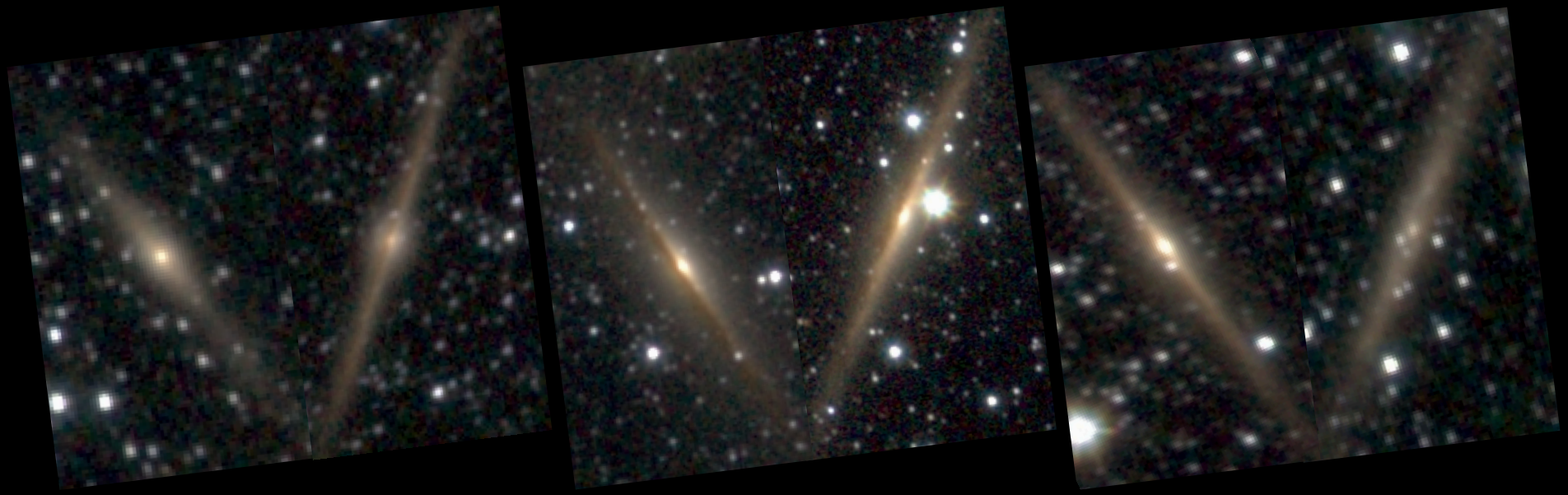
Borissova et al. 2011 A&A

Discovery of 96 new open clusters in the Milky Way.

Measure their sizes and reddenings.

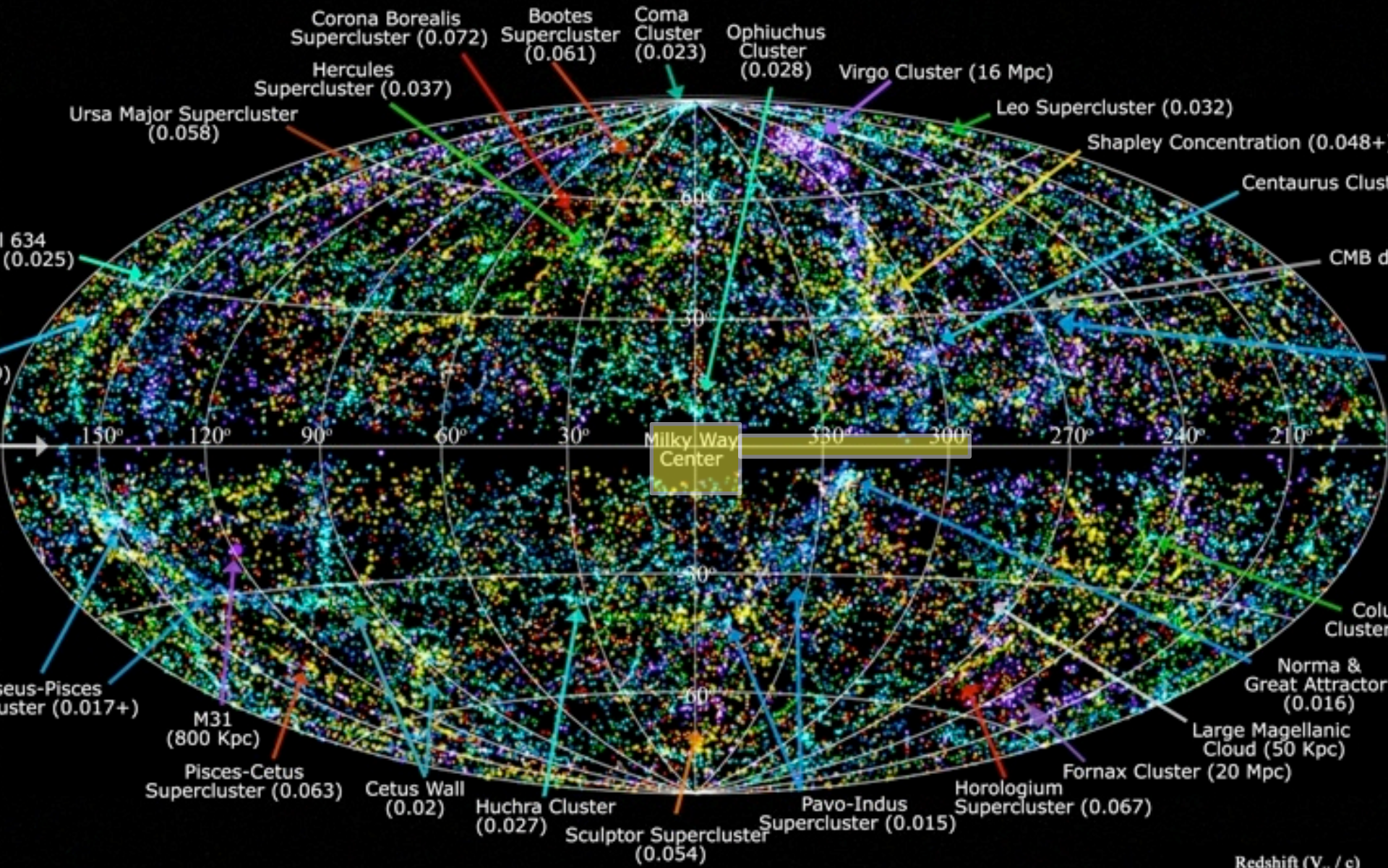
Estimate their ages and distances.

VVV Galaxies



BEYOND THE MW...

2MASS Redshift Survey

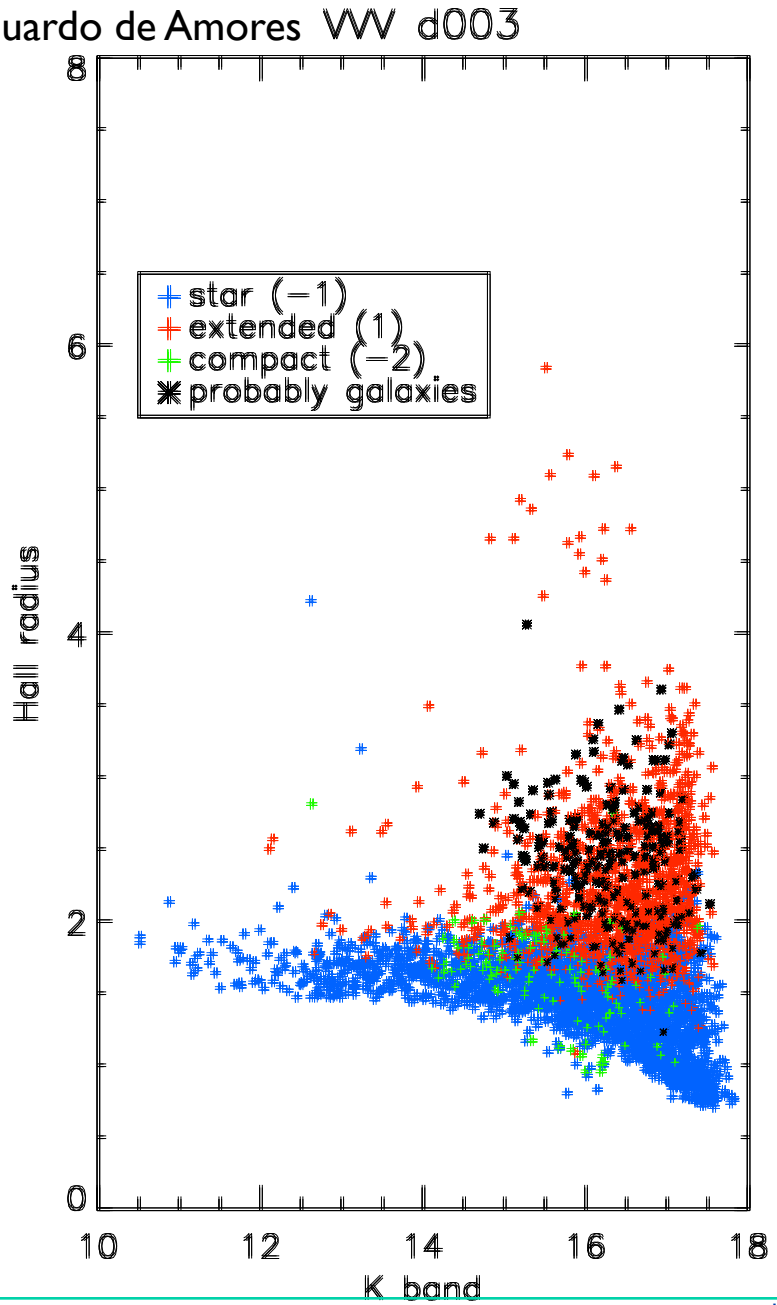


Legend: image shows 2MASS galaxies color coded by the 2MRS redshift (Huchra et al 2011); familiar galaxy clusters/superclusters are labeled (numbers in parenthesis represent redshift).

Graphic created by T. Jarrett (IPAC/Caltech)

How Many Galaxies in the VVV Survey?

Eduardo de Amores et al.
2012 MNRAS




~35,000 GALAXIES

NOT A GALAXY...

NEED FOR NEAR-IR SPECTROSCOPIC FOLLOW-UP (MOONS)

match

VVV field b343-irg

MAIN ID	OTYPE	RA	DEC	COO ...	COO ...	C...	PMRA	PMDEC	B	V	R	J
2MASX J17244259-3410...	Galaxy	17 24 42.598	-34 10 19.09									7.864
2MASX J17244573-3411...	Galaxy	17 24 45.740	-34 11 07.09									7.066
2MASX J17244582-3410...	Galaxy	17 24 45.820	-34 10 00.09									13.358

Not only...

but also:

OUTREACH

- products for planetaria
- PRs with science discoveries
- large multicolor posters, maps and prints
- web based pictures and data access
- projects for high school students
- involvement of amateur astronomers
- Google sky or somesuch
- variable stars Zoo, VVV@home

New book:


VVV SCIENCE TEAM
VISTAS DE LA GALAXIA
Dante Minniti
Joyce Pullen
Ignacio Toledo

From: **Facebook** <notification+oc1=l1=f@facebookmail.com>
Date: Wed, Jul 11, 2012 at 5:15 AM
Subject: Your Weekly Facebook Page Update
To: Roberto Saito <robsaito@gmail.com>

facebook

Hi Roberto,

Here is this week's summary for your Facebook Page:

The VISTA Variables in the Vía Láctea Survey (VVV)

New Likes	Talking About This	Weekly Total Reach
2	62 +181.8%	1,559 +73.0%

See All Insights · Promote Page

Manage Your Page

Roberto Saito

VVV Stages:

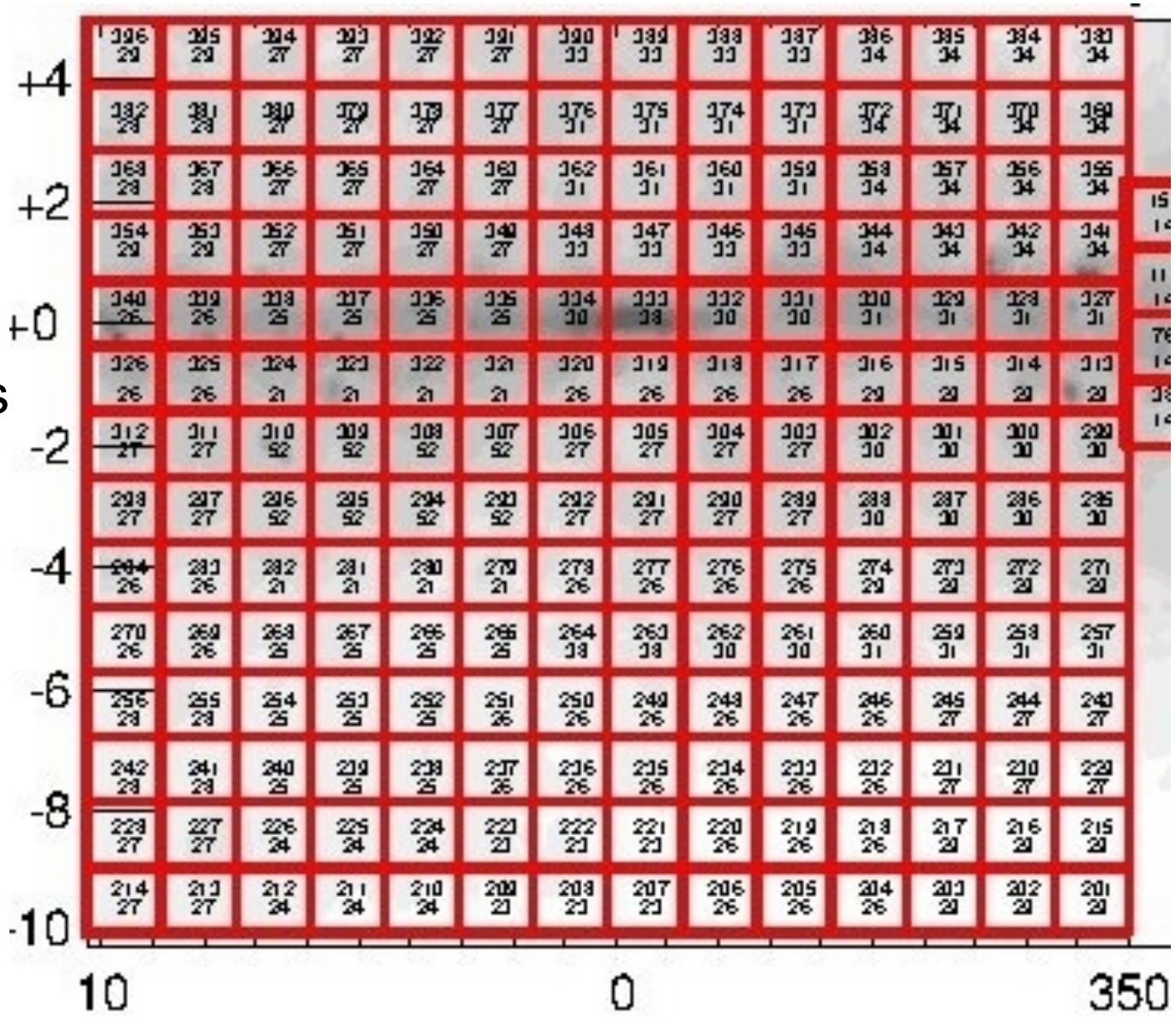
Ks-band Variability

Ks-band Variability

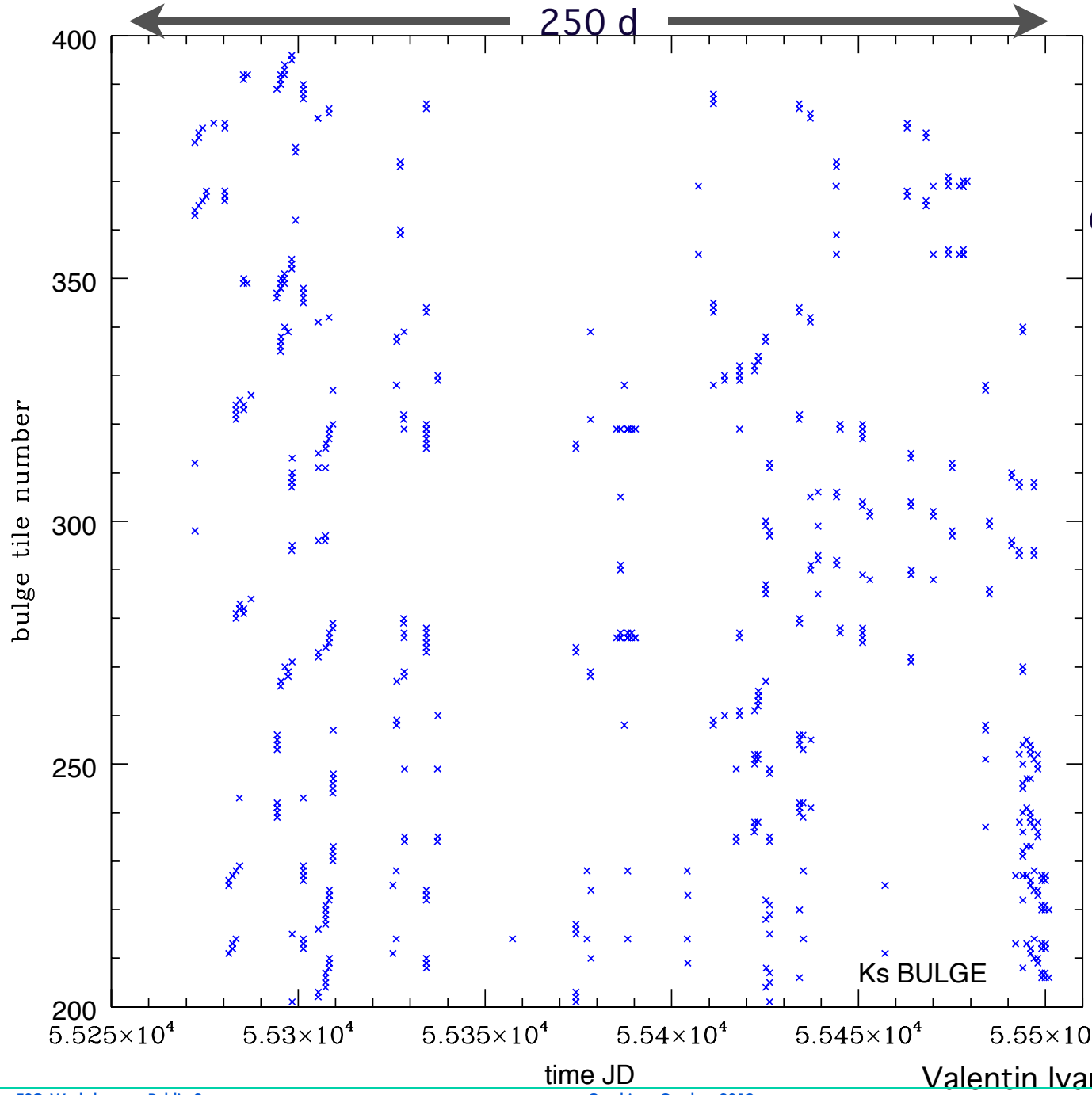
Bulge

Ks-band

observed epochs



Maren Hempel

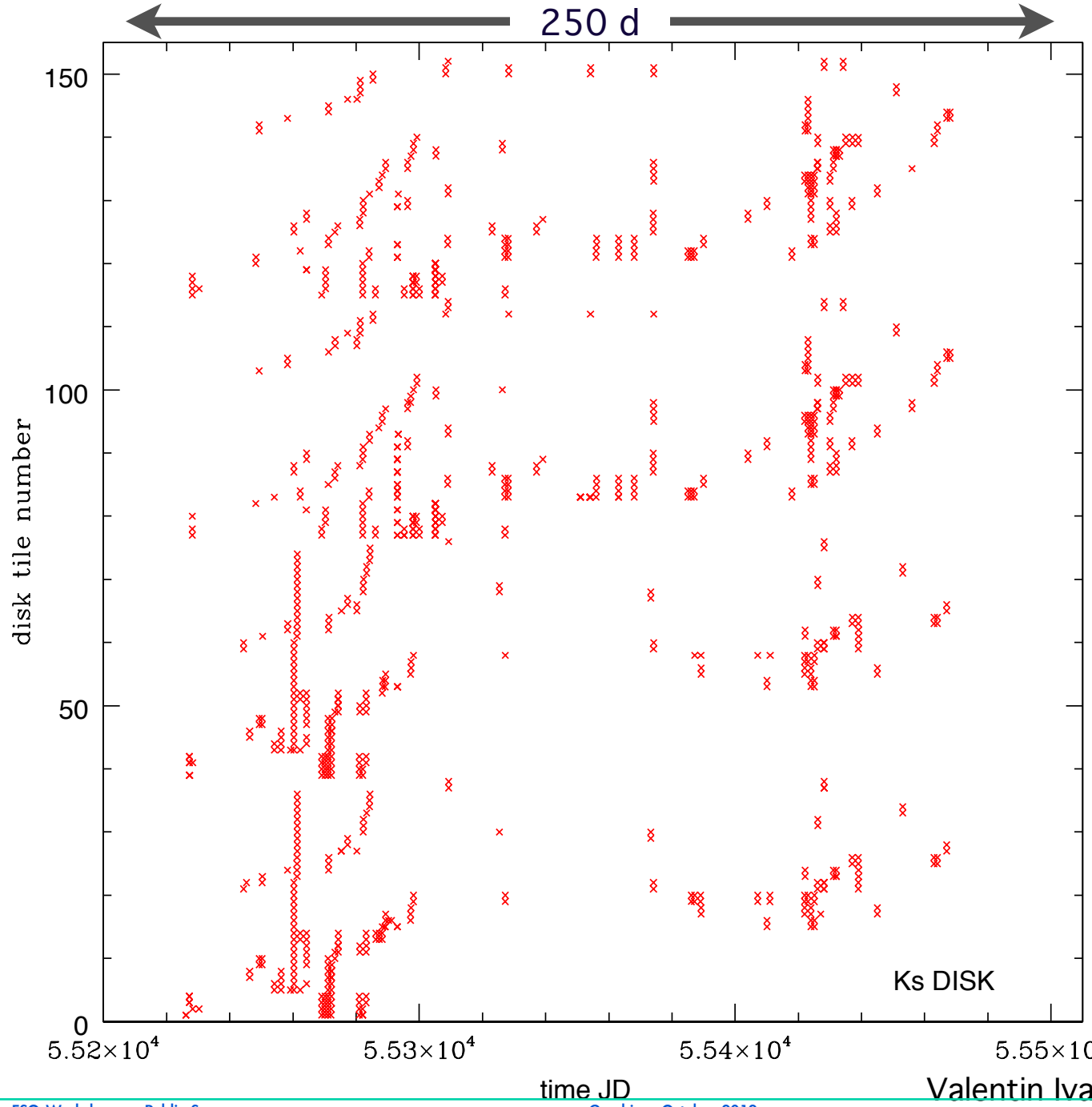


Bulge Variability observations YR1

The observation epochs for a specific field are randomized (otherwise the survey would require many more years).

The big problem is aliasing, this is why we need many epochs.

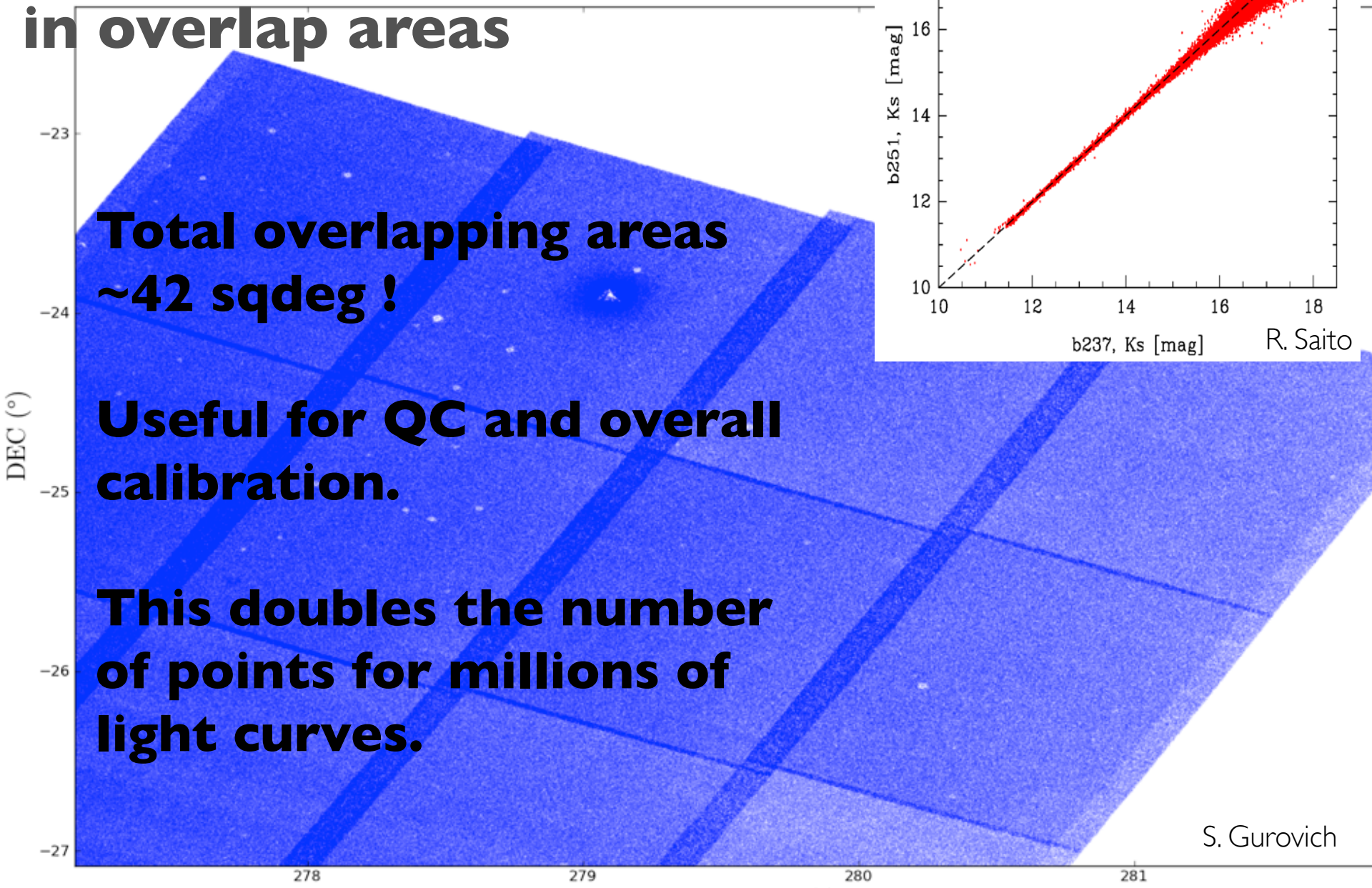
Disk Variability observations YRI



The observation epochs for a specific field are randomized (otherwise the survey would require many more years).

The big problem is aliasing, this is why we need many epochs.

Astrometry & photometry in overlap areas



Total overlapping areas ~42 sqdeg !

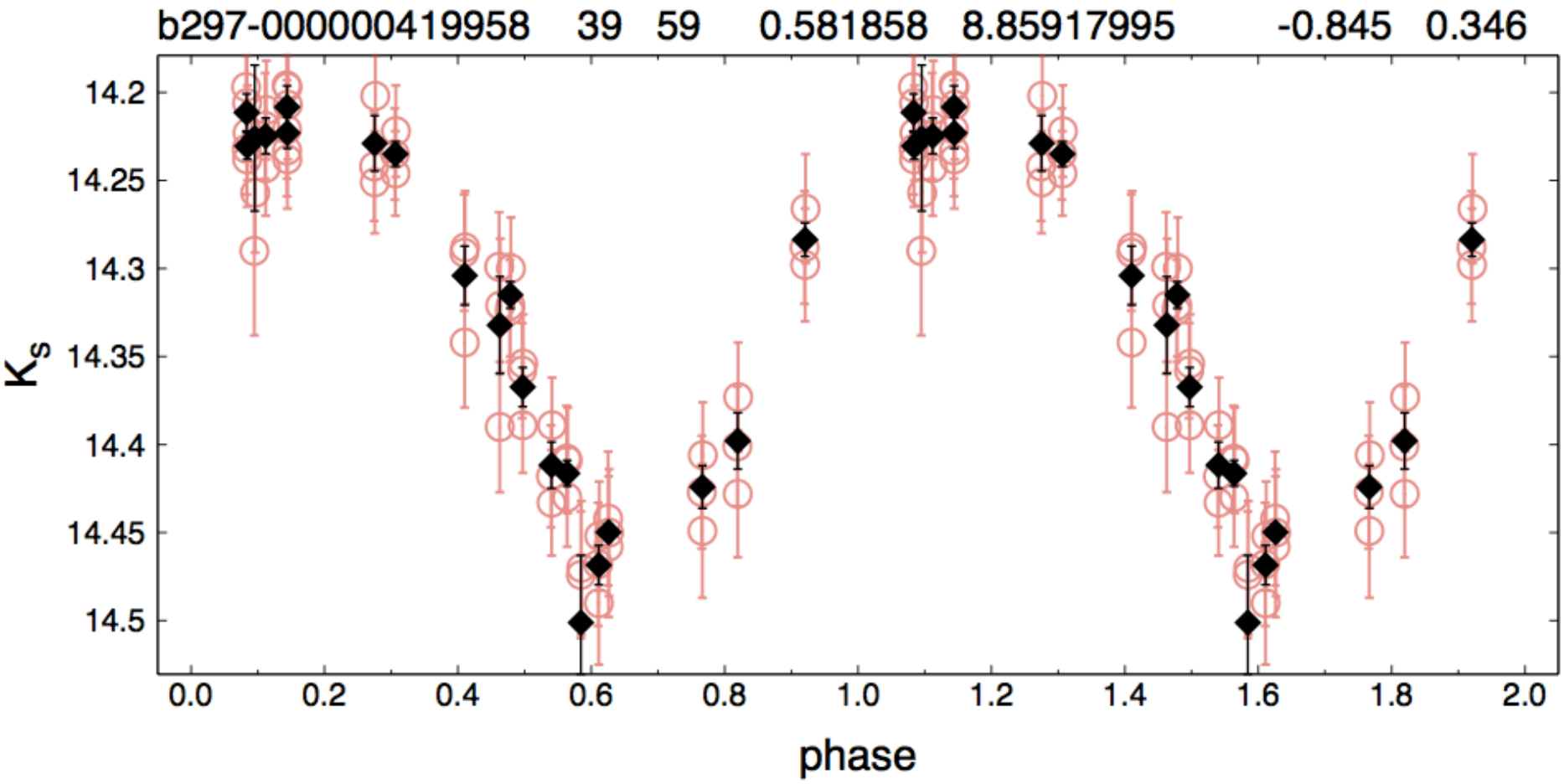
Useful for QC and overall calibration.

This doubles the number of points for millions of light curves.

R. Saito

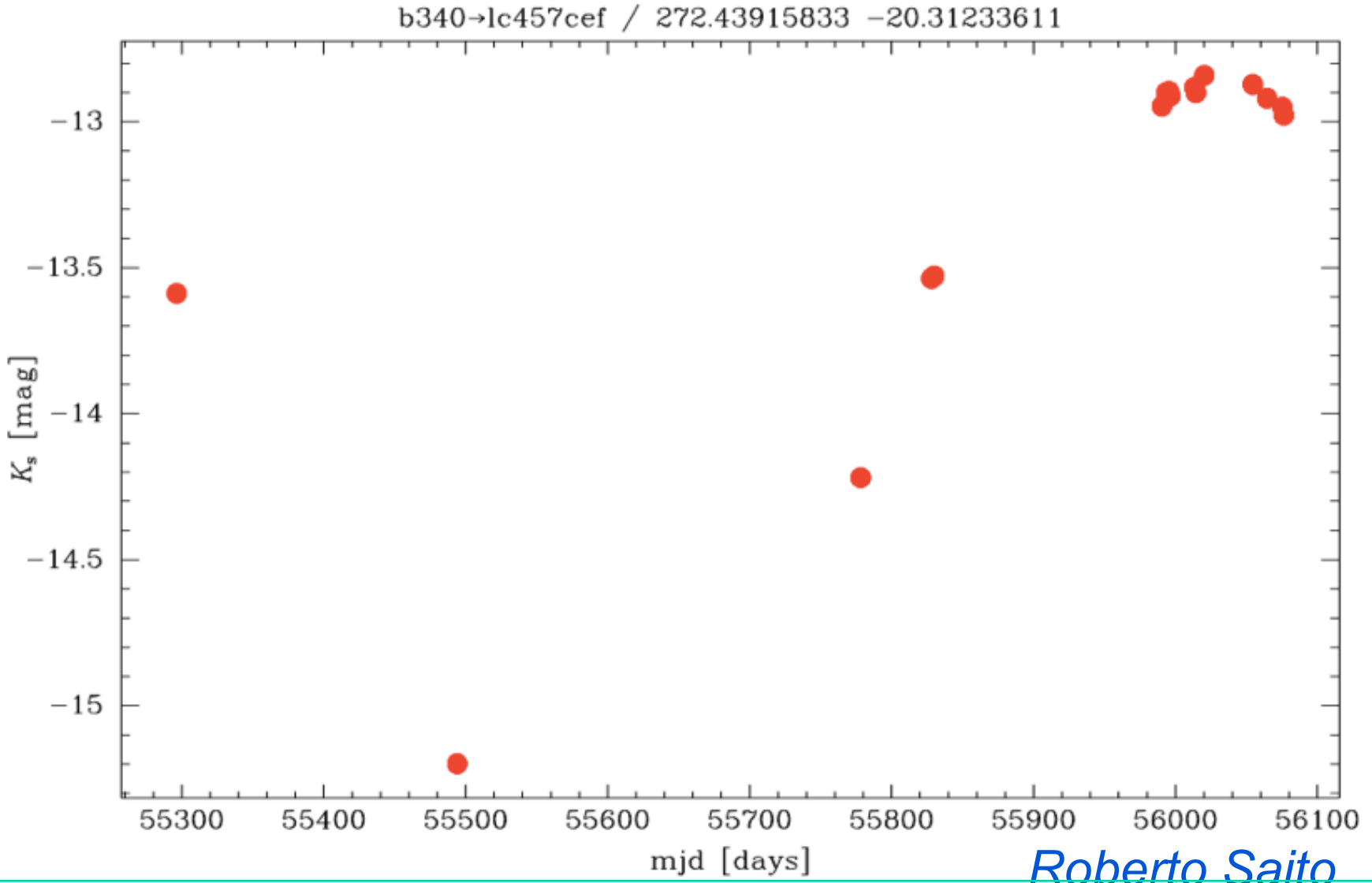
S. Gurovich

Bulge RR Lyrae: P = 0.58 d



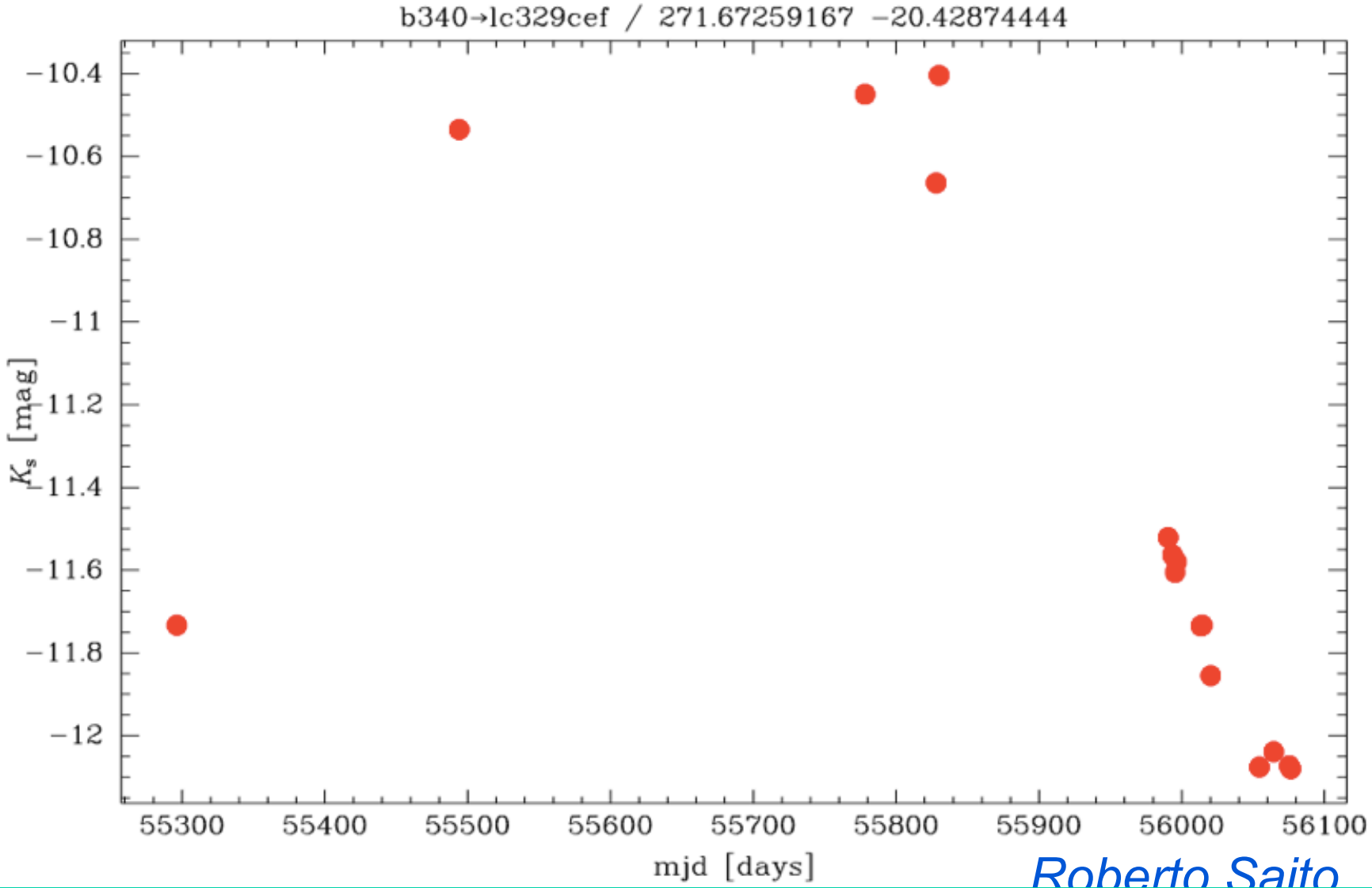
Istvan Dekany

Bulge LPVs: P ~ 1,000 d



Roberto Saito
Dante Minniti, Universidad Catolica

Bulge LPVs: P > 1,500 d



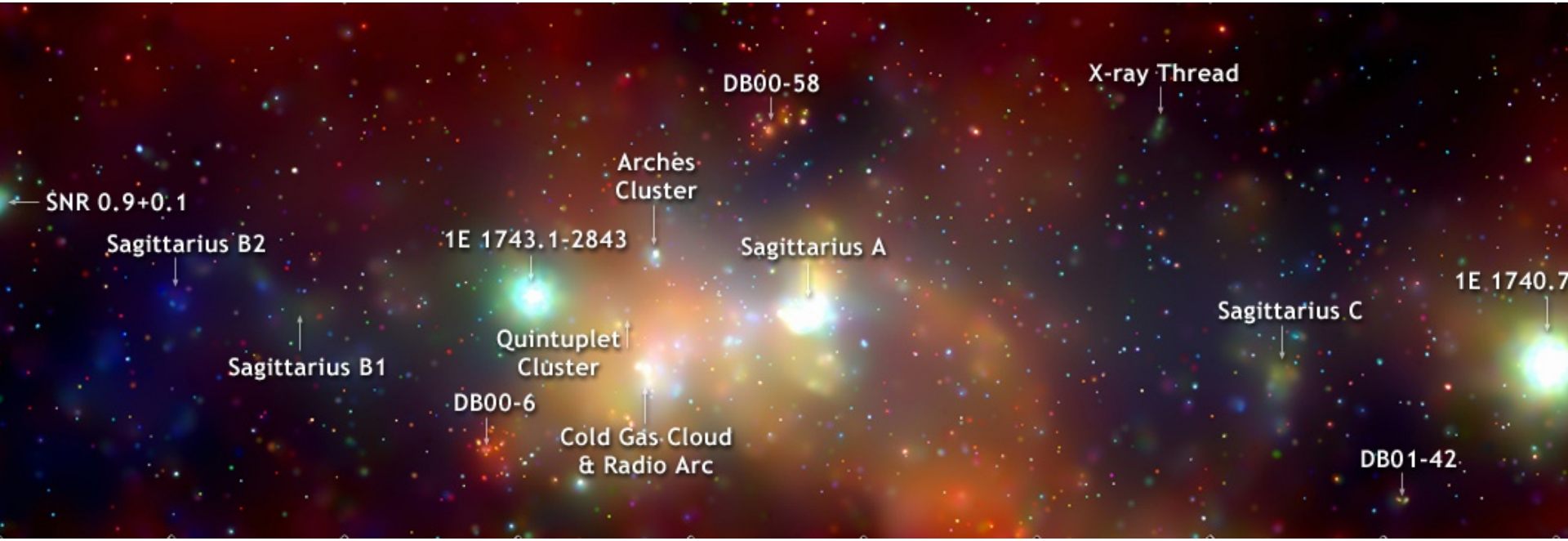
Roberto Saito

High Energy Sources

vvvsurvey.org

Follow-up of sources from CHANDRA, INTEGRAL, FERMI, SPITZER, ALMA,...

CSO



Credit: NASA/UMass/D.Wang et al.

VVV will also monitor the variability around the Galactic Center.

Sandra Greiss

High Energy Sources

vvvsurvey.org

VVV near-infrared observations of the IGR J17177-3656 field

ATel #3275; *A. Rojas (PUC, Santiago), N. Masetti (INAF/IASF, Bologna) and D. Minniti (PUC, Santiago)*

*on **12 Apr 2011; 08:37 UT***

Credential Certification: Nicola Masetti (masetti@iasfbo.inaf.it)

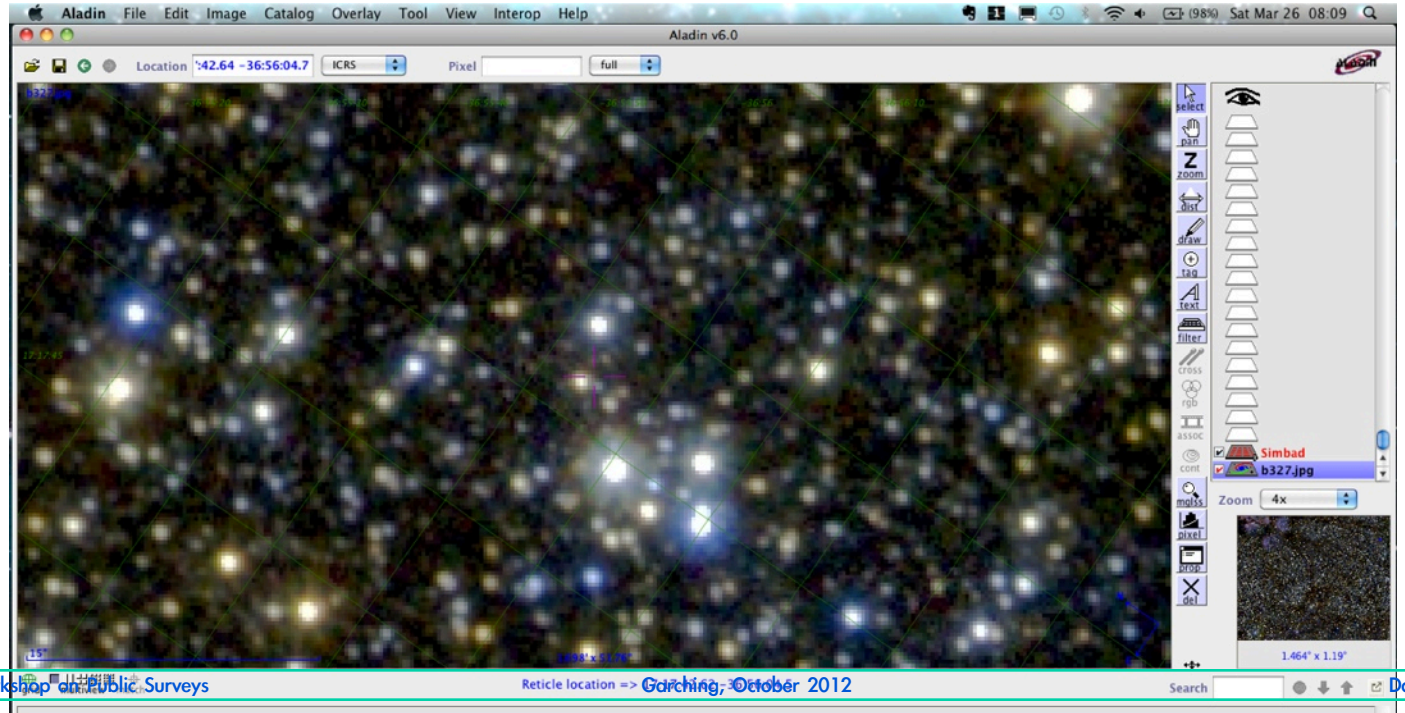
VVV near-infrared observations of the MAXI J1543-564 field

ATel #3372; *A.F. Rojas (PUC, Santiago), N. Masetti (INAF/IASF, Bologna) and D. Minniti (PUC, Santiago)*

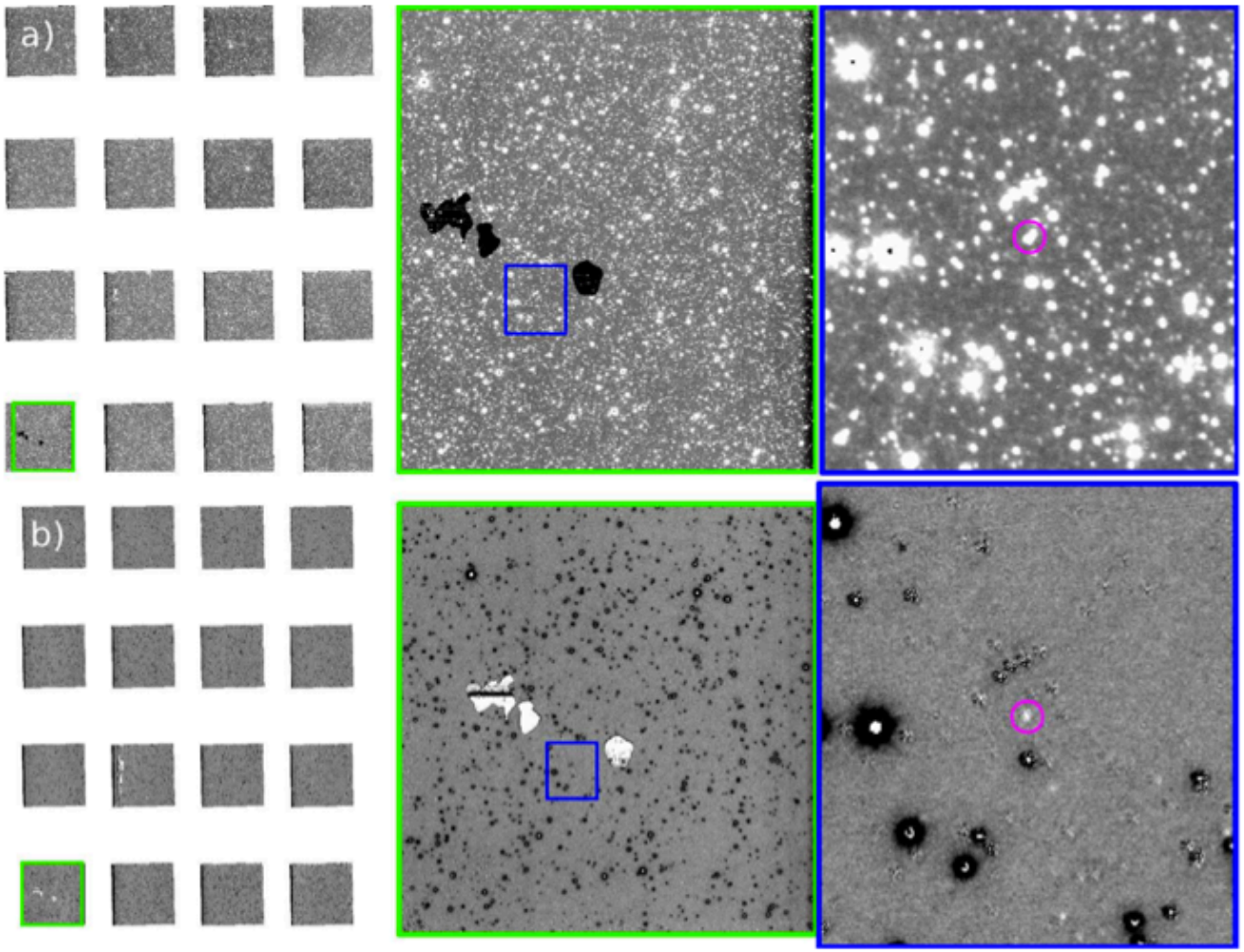
*on **23 May 2011; 11:57 UT***

Credential Certification: Nicola Masetti (masetti@iasfbo.inaf.it)

Alejandra Rojas
Nicola Masetti



DIA photometry



Main DIA problem: undersampling

Total in VVV Survey ~few millions of variables

Method based on Alard & Lupton 1998 ApJ

Fig. 17. (a) A K_s band pawprint from one VVV SV bulge field epoch showing views of: the full pawprint (left); a zoom into Array 1 (middle); and a further zoom centred on a circled variable object (right). (b) The bottom row shows the respective difference image views.

(Eamonn Kerins, Leo Huckvale)

DIA photometry

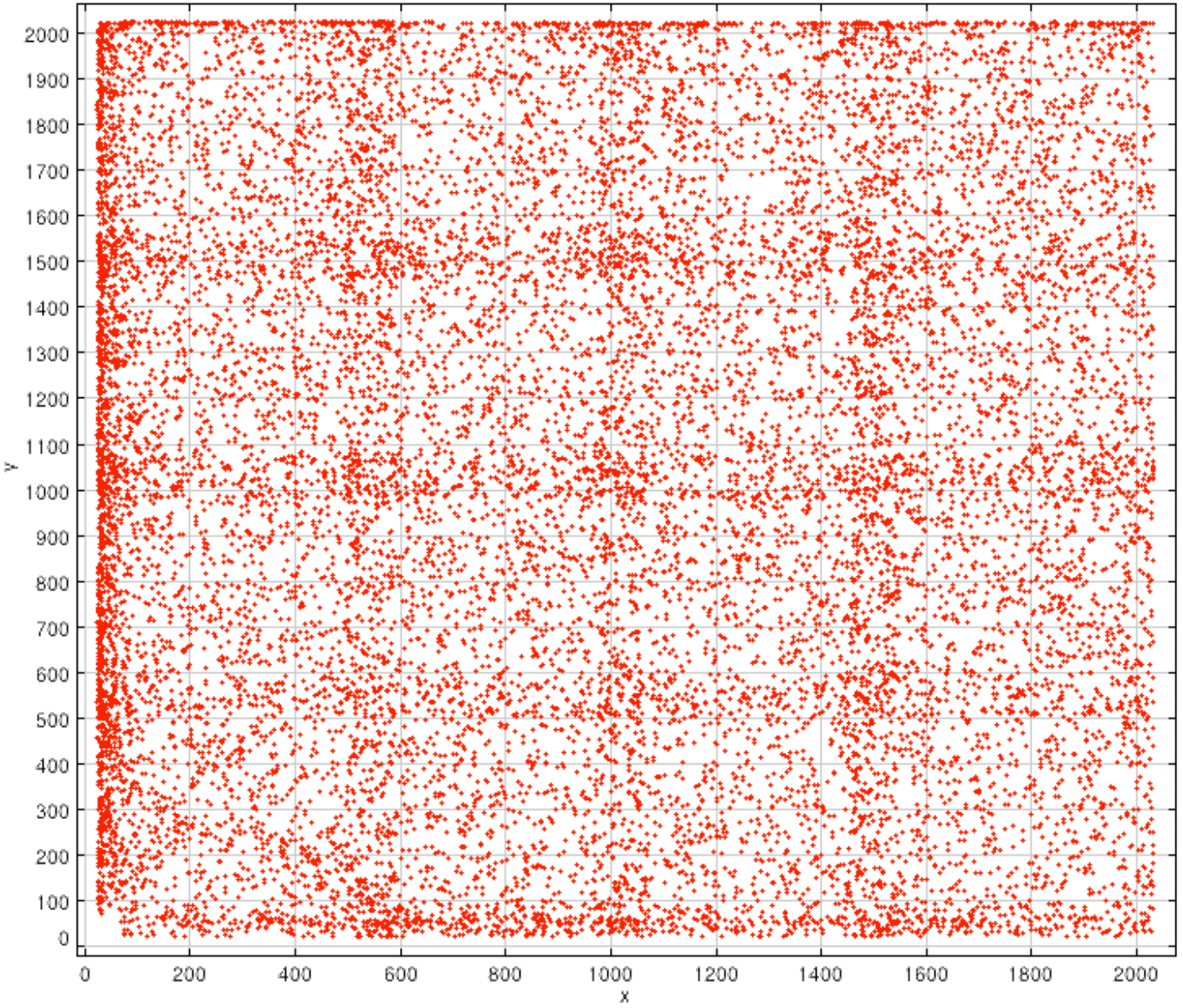
Ks-band Variability

Sep 2012:

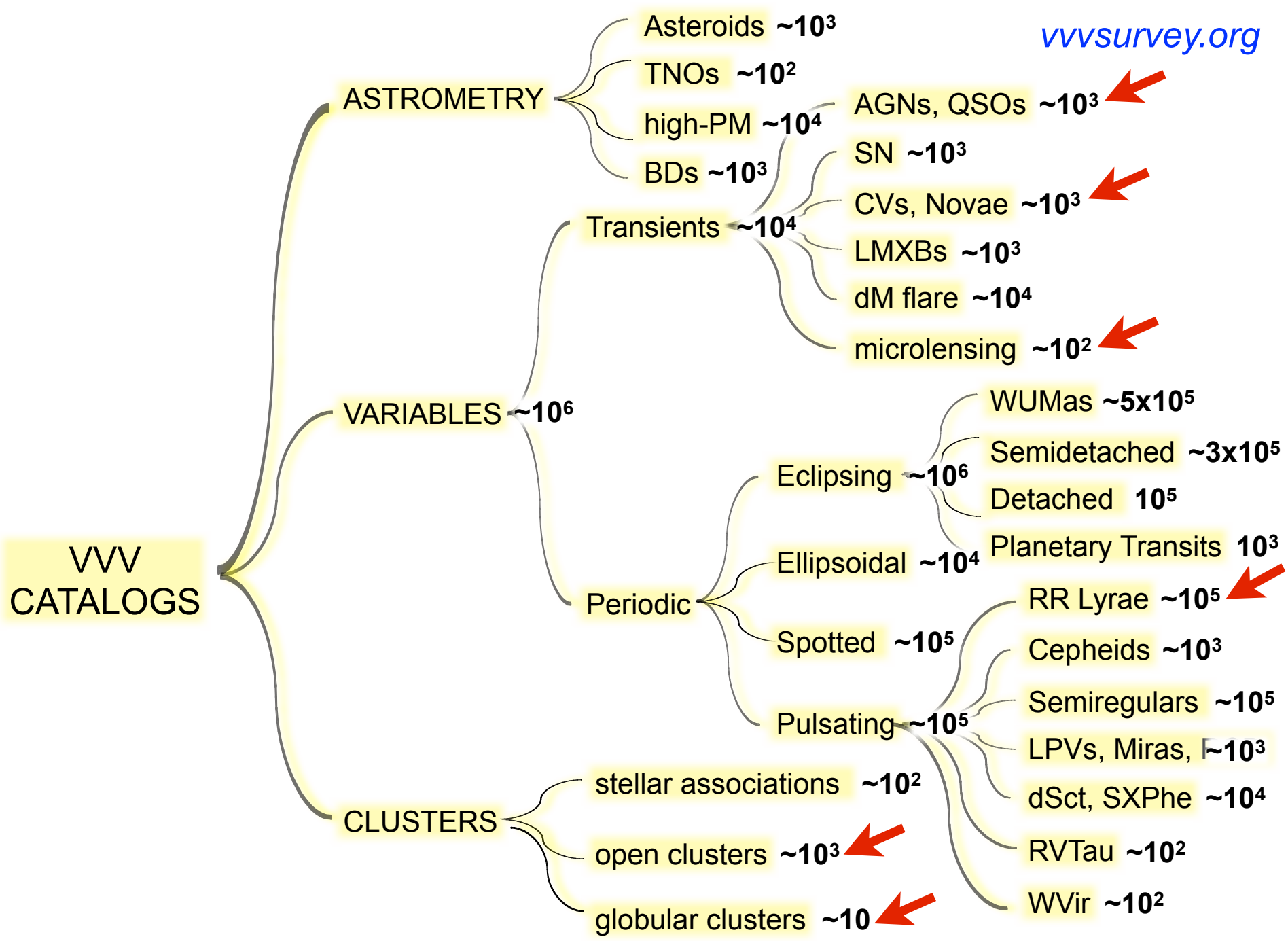
DIA pipeline working

Example:

DIA Variables in tile d068



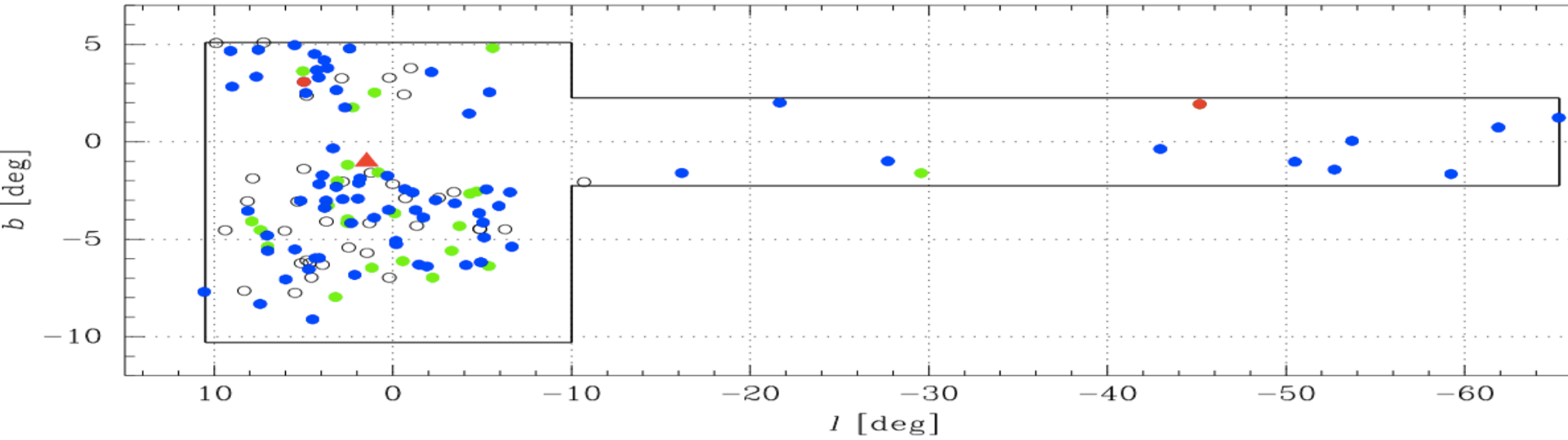
Eamonn Kerins, Leo Huckvale, Phil Lucas


vvvsurvey.org
VVV CATALOGS
ASTROMETRY
Asteroids ~10³
TNOs ~10²
high-PM ~10⁴
BDs ~10³
VARIABLES ~10⁶
Transients ~10⁴
AGNs, QSOs ~10³
SN ~10³
CVs, Novae ~10³
LMXBs ~10³
dM flare ~10⁴
microlensing ~10²
Periodic
Eclipsing ~10⁶
WUMas ~5x10⁵
Semidetached ~3x10⁵
Detached 10⁵
Planetary Transits 10³
Ellipsoidal ~10⁴
Spotted ~10⁵
Pulsating ~10⁵
RR Lyrae ~10⁵
Cepheids ~10³
Semiregulars ~10⁵
LPVs, Miras, ~10³
dSct, SXPhe ~10⁴
RVTau ~10²
WVir ~10²
CLUSTERS
stellar associations ~10²
open clusters ~10³
globular clusters ~10

Novae

Example:

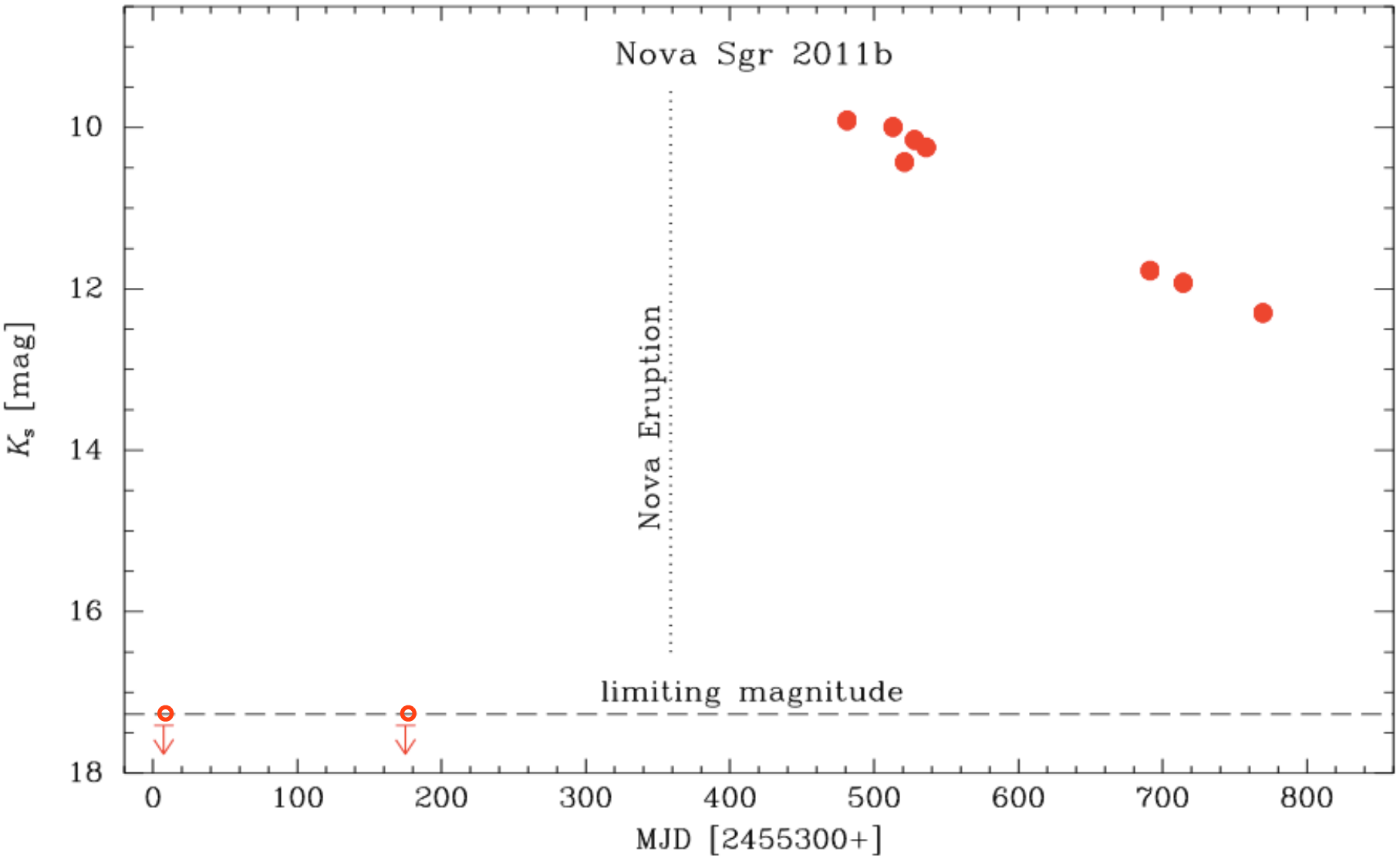
Catalog of 138 Known Galactic Novae



Spatial distribution of known Galactic novae in the VVV area. There is an avoidance zone in the Galactic plane, where the extinction is highest. The VVV Survey can discover many novae in the most obscured regions of the Milky Way.

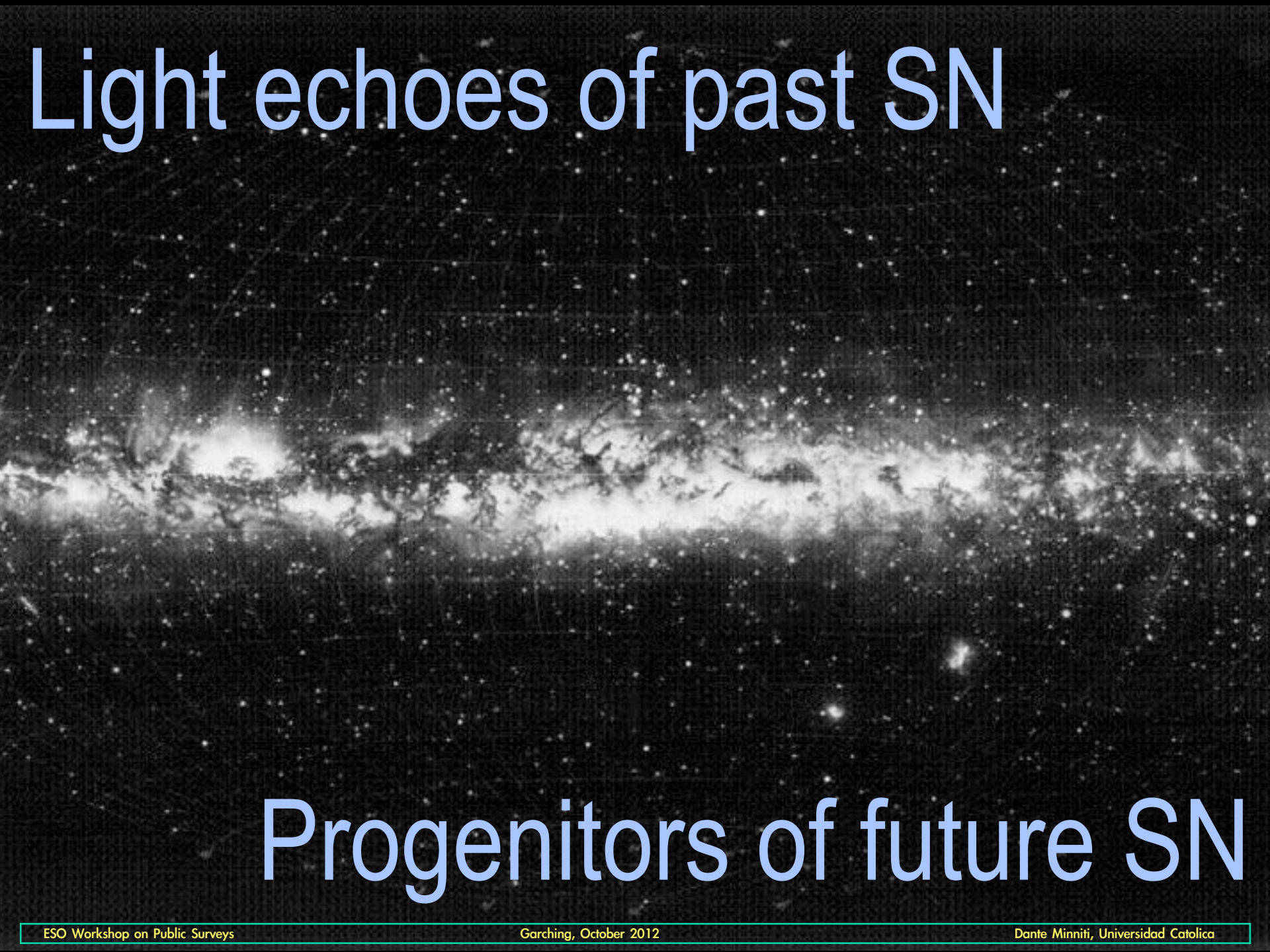
Roberto Saito

Light curve for Nova Sgr 2011b



Roberto Saito

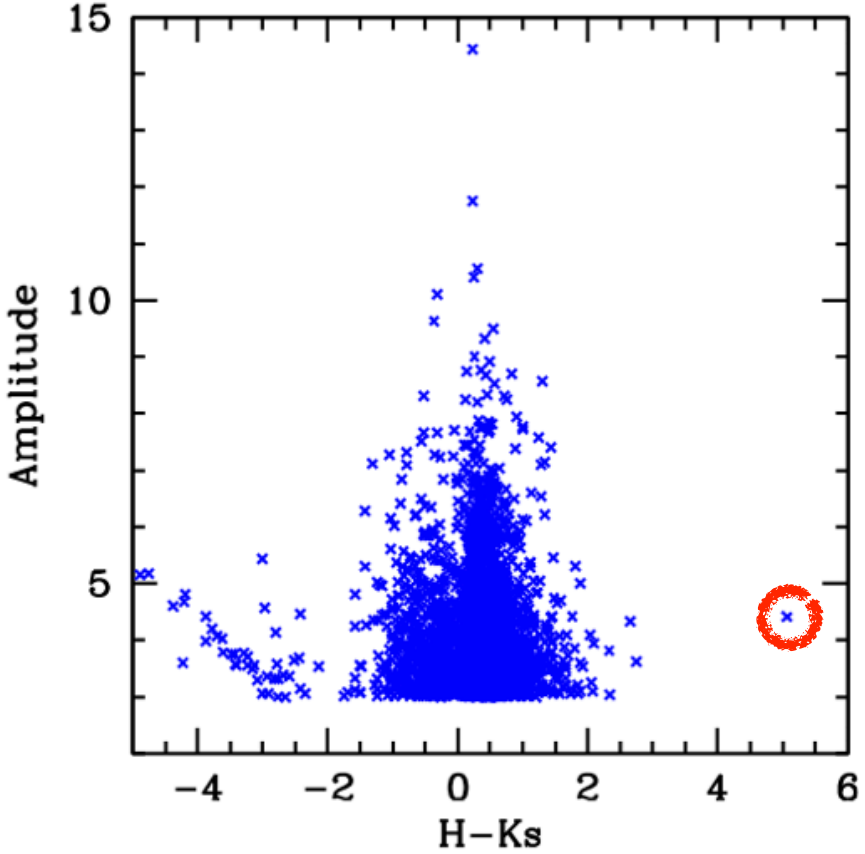
Light echoes of past SN

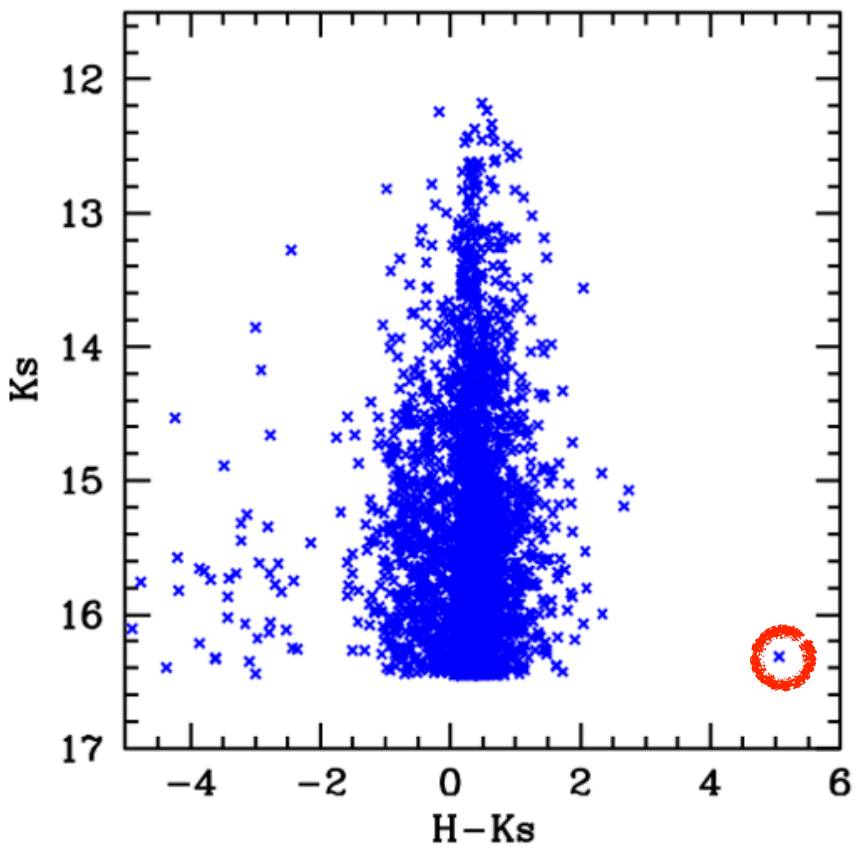


Progenitors of future SN

Extreme Variables

- *very rare (<10^-6)*
- *different types: dN, RCB, FUOri...*





Extreme Variables

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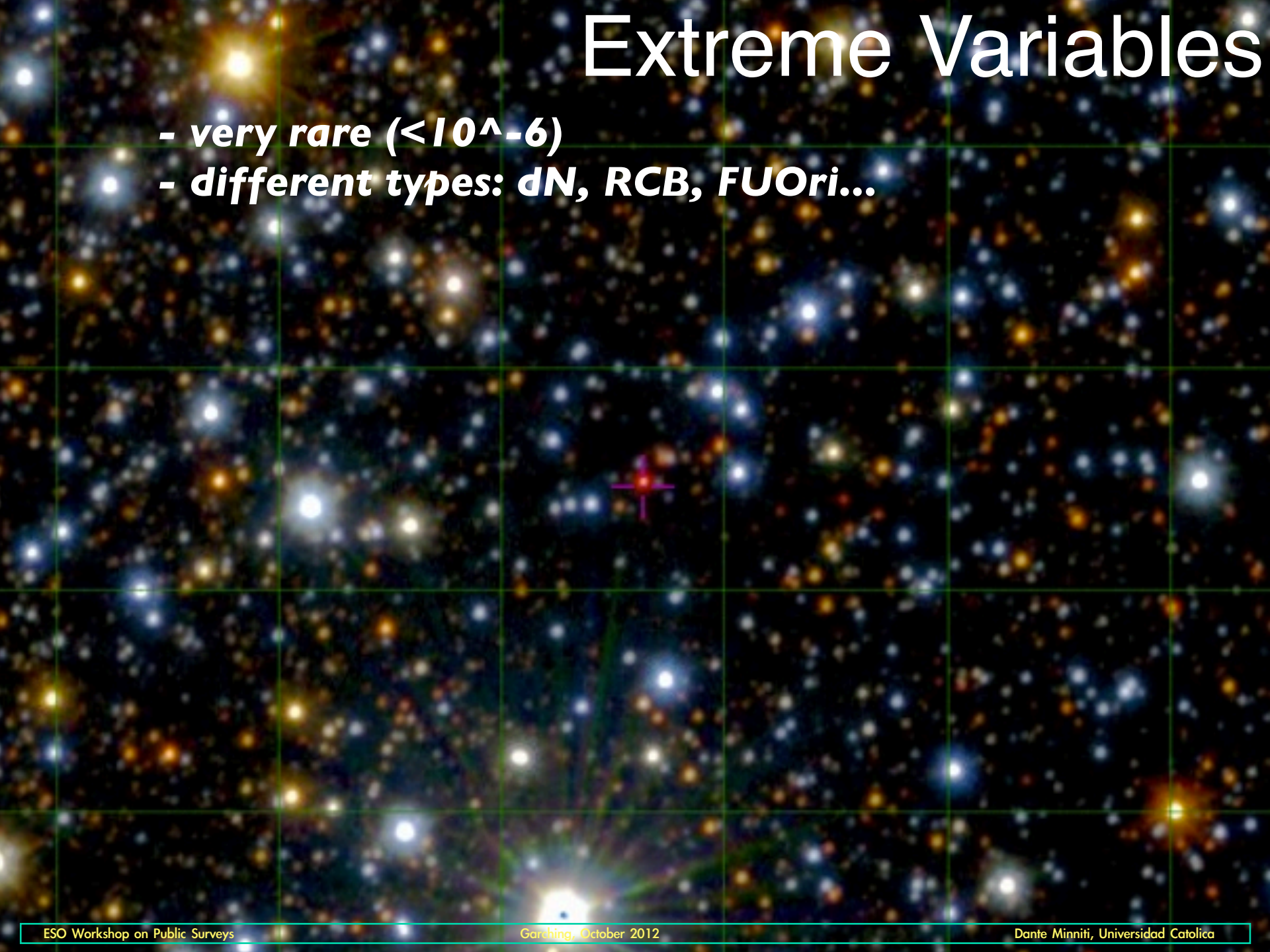
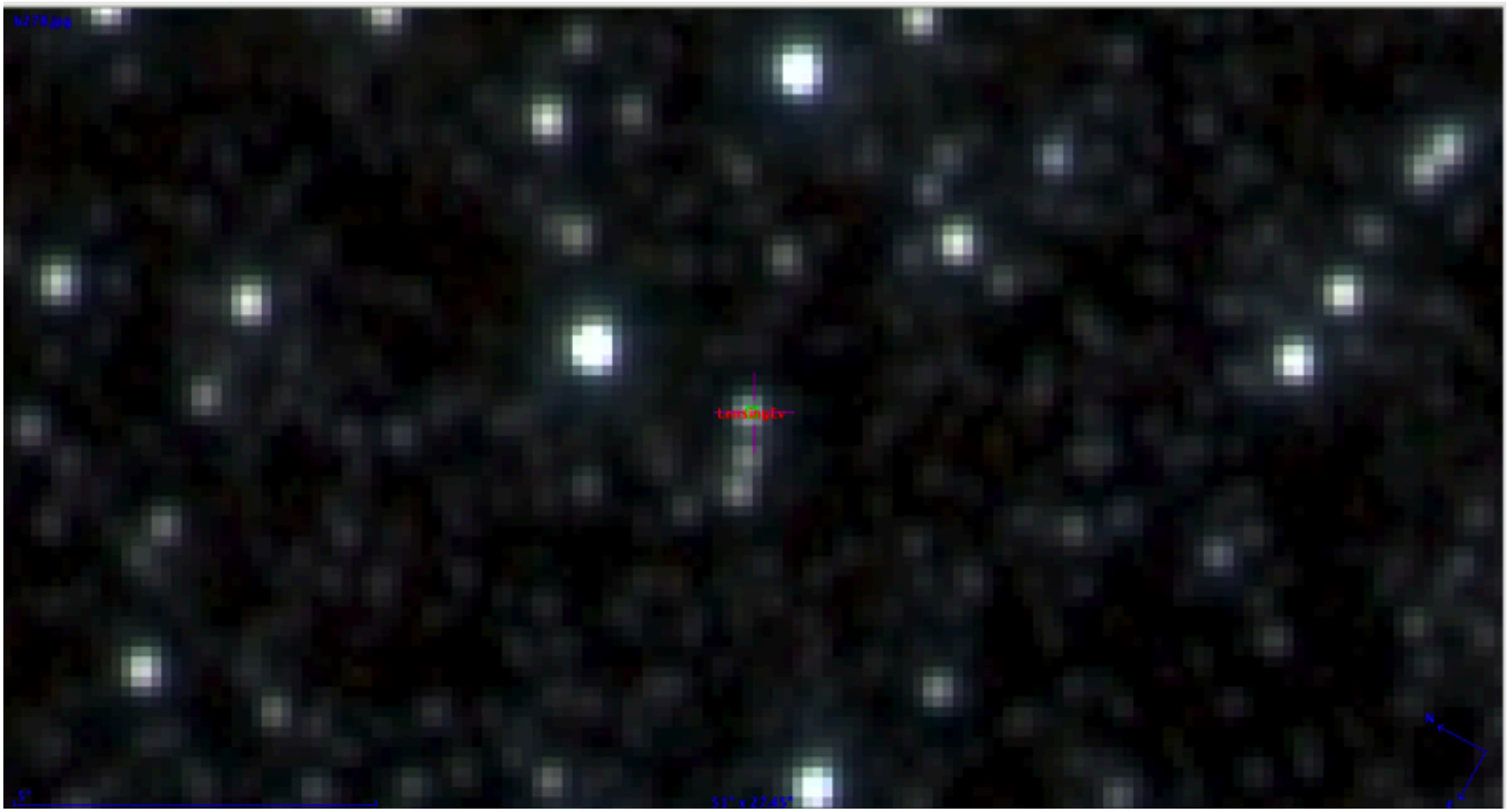


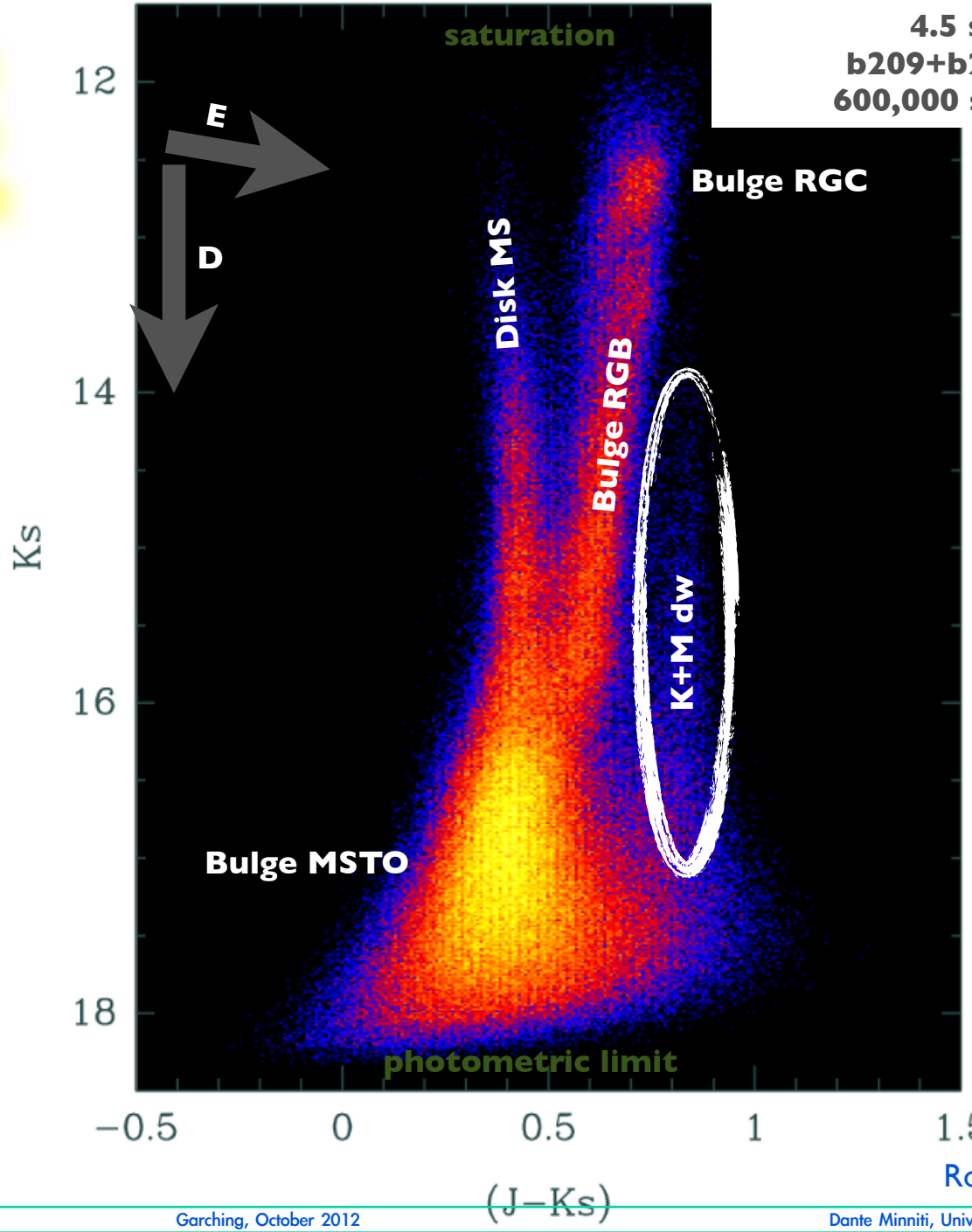
Known microlensing events



VVV will help to characterize known microlensing events, providing essential complementary data, as well as detecting new long timescale microlensing events.

SEARCH FOR TRANSITING EXTRASOLAR PLANETS

Main motivation: to build up the statistics by selecting a very large sample of small stars (K-M types) to search for extrasolar planetary transits



Roberto Saito

QSOs behind GCs

Importance of QSOs:
they provide an absolute reference for proper motions

Trace orbits of bulge globular clusters, compare with field

VVV Stages:

Proper motions

Proper Motions: VVV and 2MASS

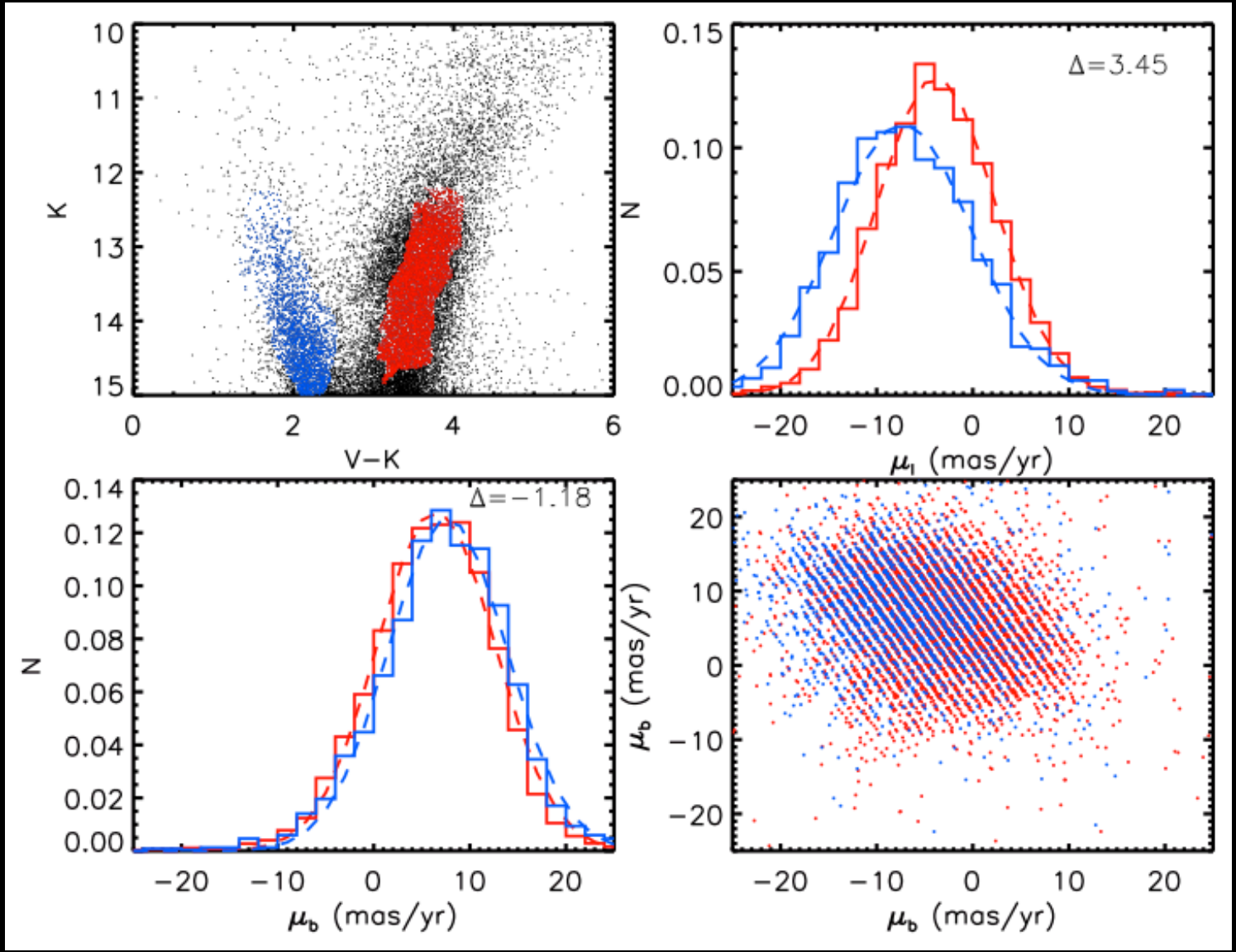
Oscar Gonzalez

Observations
2MASS:
1998-2000

Observations
VVV 1st Yr:
2010

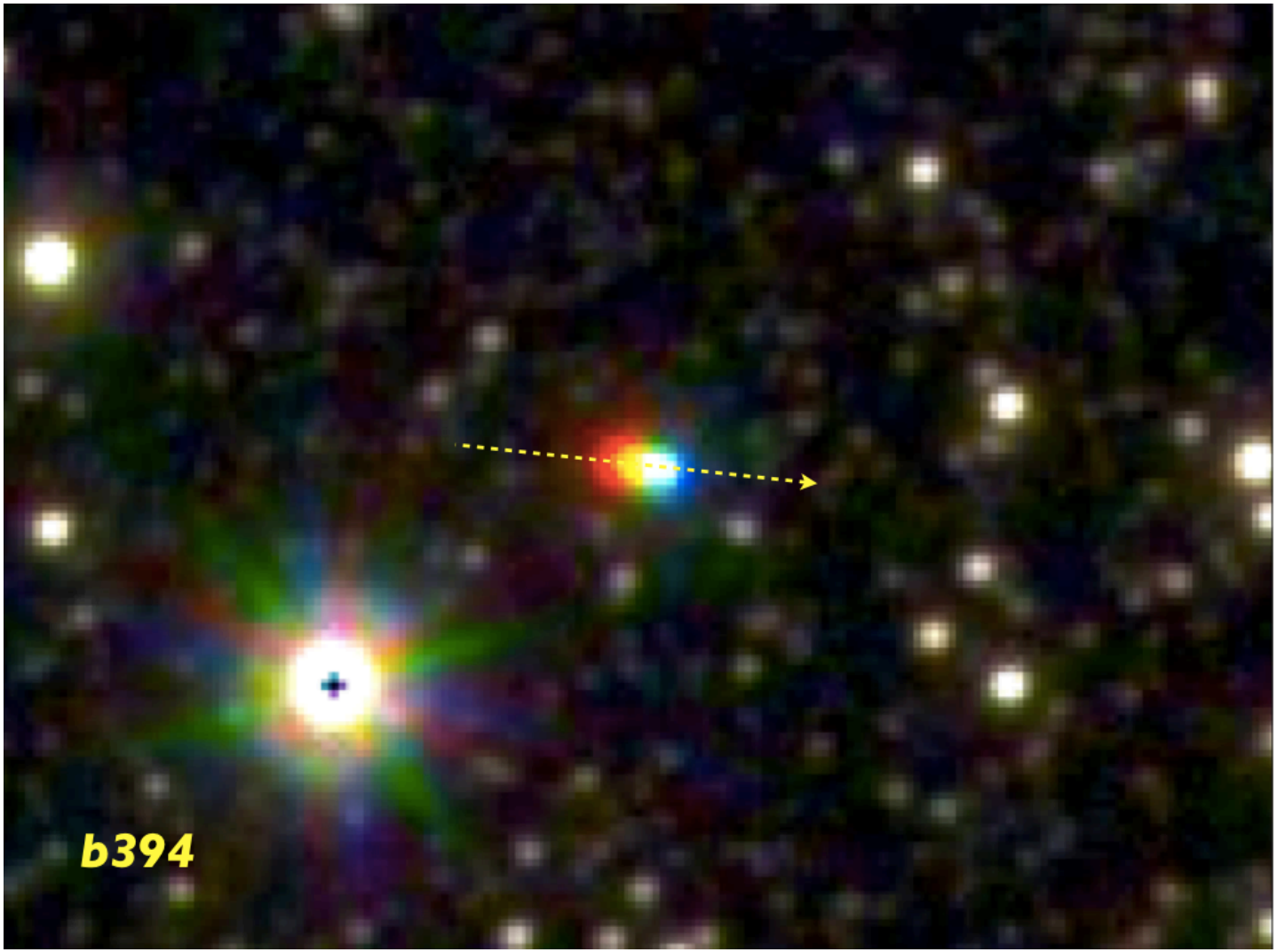
Disk vs Bulge
populations:

the mean
differences
for a field on the
minor axis can be
clearly measured



The proper motions would allow the kinematic separation between populations

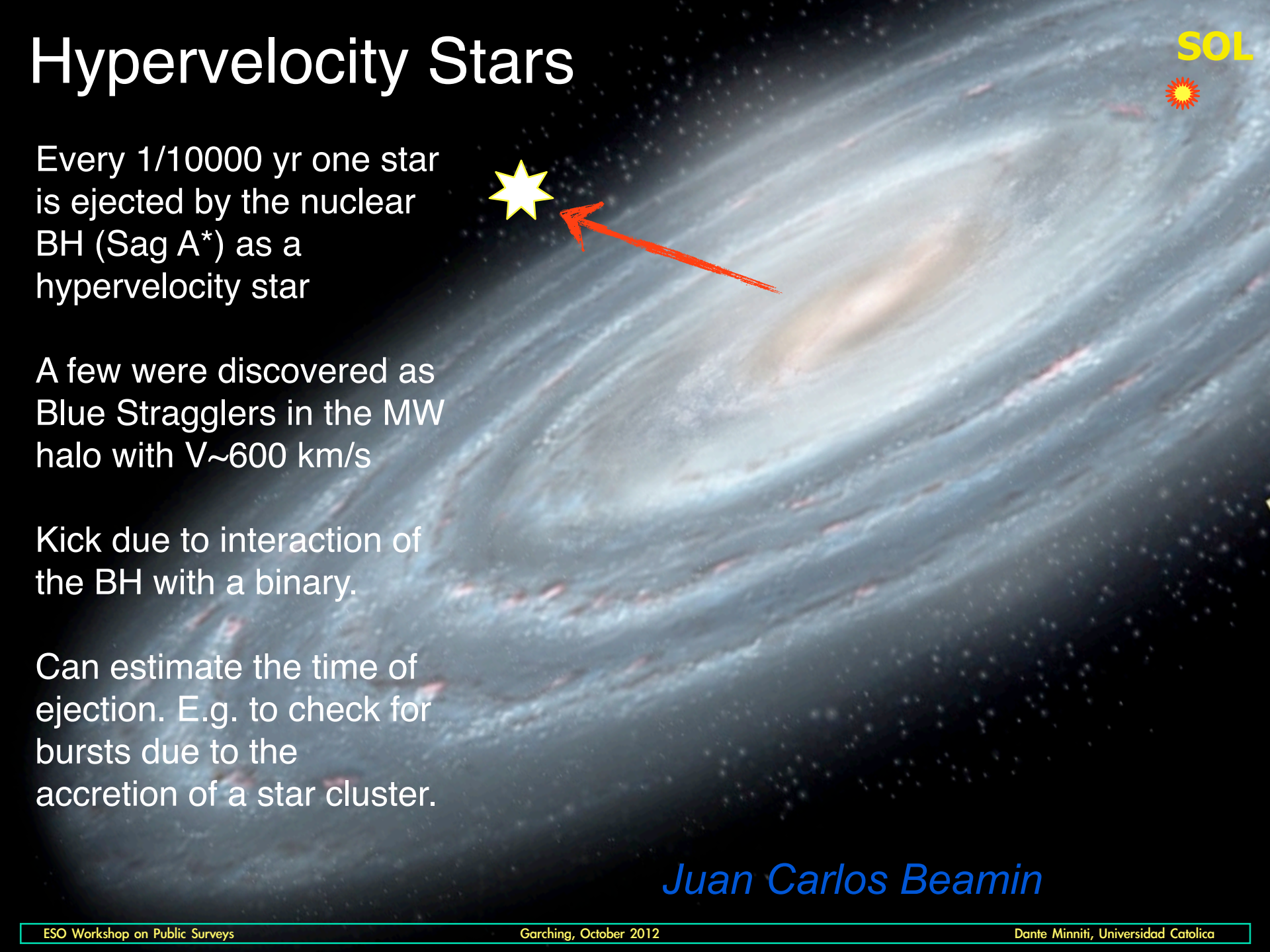
Proper Motions



Discovery of a faint nearby star with high proper motion

Juan Carlos Beamin

Hypervelocity Stars



Every 1/10000 yr one star is ejected by the nuclear BH (Sag A*) as a hypervelocity star

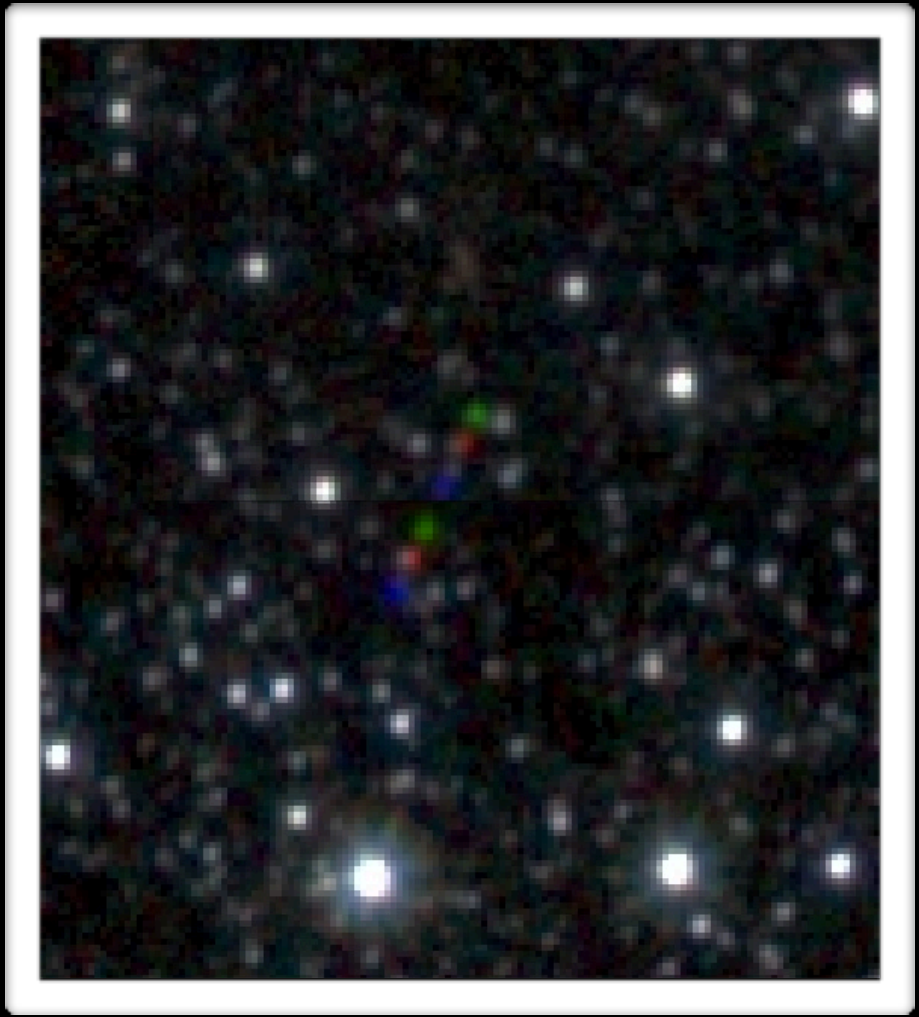
A few were discovered as Blue Stragglers in the MW halo with V~600 km/s

Kick due to interaction of the BH with a binary.

Can estimate the time of ejection. E.g. to check for bursts due to the accretion of a star cluster.

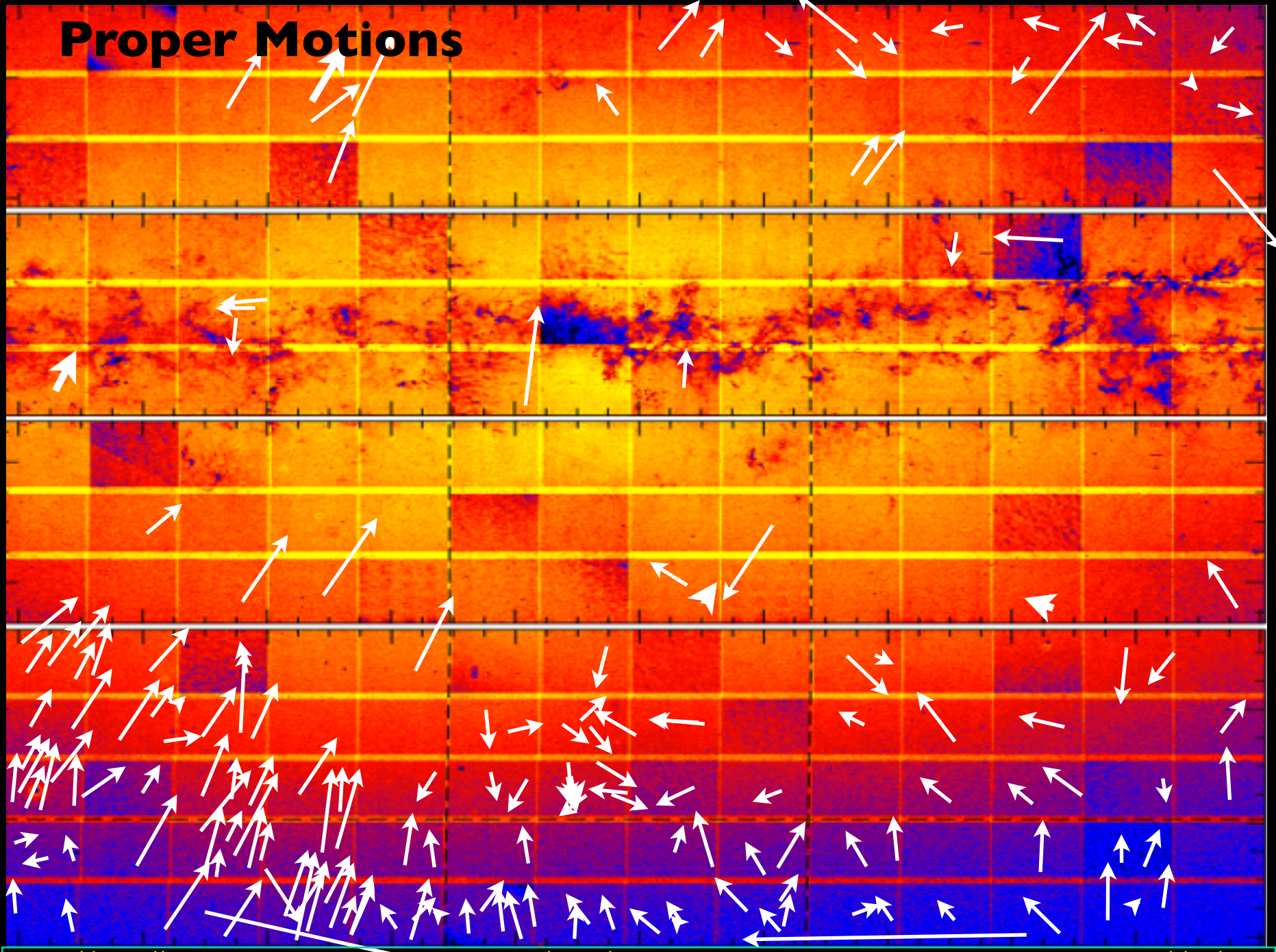
Juan Carlos Beamin

Proper Motions



MOVING SOLAR SYSTEM OBJECTS

Proper Motions



~1/2 VVV

vvvsurvey.org

- Observations: OK, we are almost half way done.
- Photometry: OK, several options available.
- Variability: OK, good start, many more epochs needed.
- Astrometry: OK, longer baseline needed.

The data are of very high quality, and the VVV will be able to accomplish its goals.

Many studies started, initial discoveries made, papers being published, interesting thesis topics...

The Scientist (Coldplay)
"Nobody said it was easy
No one ever said it would be so hard
I'm going back to the start"

VVV contribution to astronomy:

Stellar populations, Galactic structure, star clusters, SFRs, ISM, asteroids, TNOs, NEOs, nearby stars, microlensing, proper motions, pulsating variables, clump giants, binary stars, BDs, exoplanets, SNe, PN, WDs, XRBs, Galactic center, galaxies, AGNs, QSOs...

NOW

ALMA

MOONS

GAIA

LSST

ELTs

NGST

ESO Workshop on Science from the Next Generation Imaging and Spectroscopic Surveys

Garching, Germany
15-19 Oct 2012

ATTENDING VVV SCIENCE TEAM MEMBERS

01. Jura Borissova (Univ. Valparaiso, Chile)
02. Nick Cross (VSA - Royal Observatory Edinburgh, UK)
03. Istvan Dekany (Univ. Catolica, Chile)
04. Jim Emerson (Queen Mary Univ. London, UK)
05. Eduardo Gonzalez (CASU - Cambridge Univ., UK)
06. Sandra Greiss (Univ. Warwick, UK)
07. Maren Hempel (Univ. Catolica, Chile)
08. Leo Huckvale (Univ. Manchester, UK)
09. Mike Irwin (CASU - Cambridge Univ., UK)
10. Valentin Ivanov (European Southern Observatory, Chile)
11. Phil Lucas (Univ. Hertfordshire, UK)
12. Dante Minniti (Univ. Catolica, Chile)
14. Marina Rejkuba (European Southern Observatory, Germany)
15. Roberto Saito (Univ. Catolica, Chile)

Questions

1. Where does the survey stand scientifically compared to other survey projects?
The VVV Survey is unique, it stands alone.
Other relevant surveys are:

- GAIA is very complementary to VVV (we observe reddened regions), and we are already giving input targets for spectroscopy.

- Future multi-object IR spectrographs, which would be perfect for VVV follow-up *(MOONS)*.

- Future LSST variability in the optical.

Questions

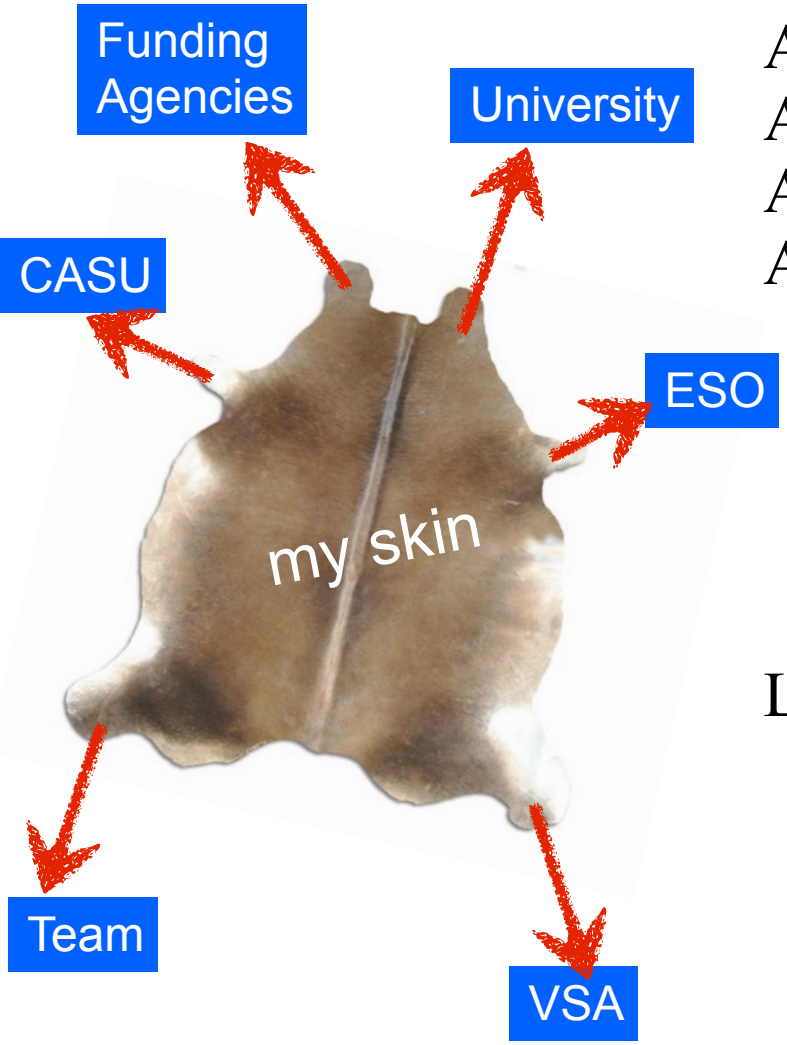
2. How much of the survey has been completed?
About 50% in total, (100% for YR1 and YR2).

What is the current prognosis for completion?
Forecast observations completion by ~mid-2016.

What could be done to speed it up?
There is no need to speed it up. Doing this would hinder proper motions and long term variability.

What could be cut without serious impact to the science?
Nothing, anything that is cut would mean a huge waste of invested resources, time and effort.

The VVV Survey:



A big responsibility to ESO.
A big commitment to the funding agencies.
A big commitment to our Universities.
A huge investment of resources for years:

- time
- funding
- space
- equipment
- people (profs, postdocs, students, admin)

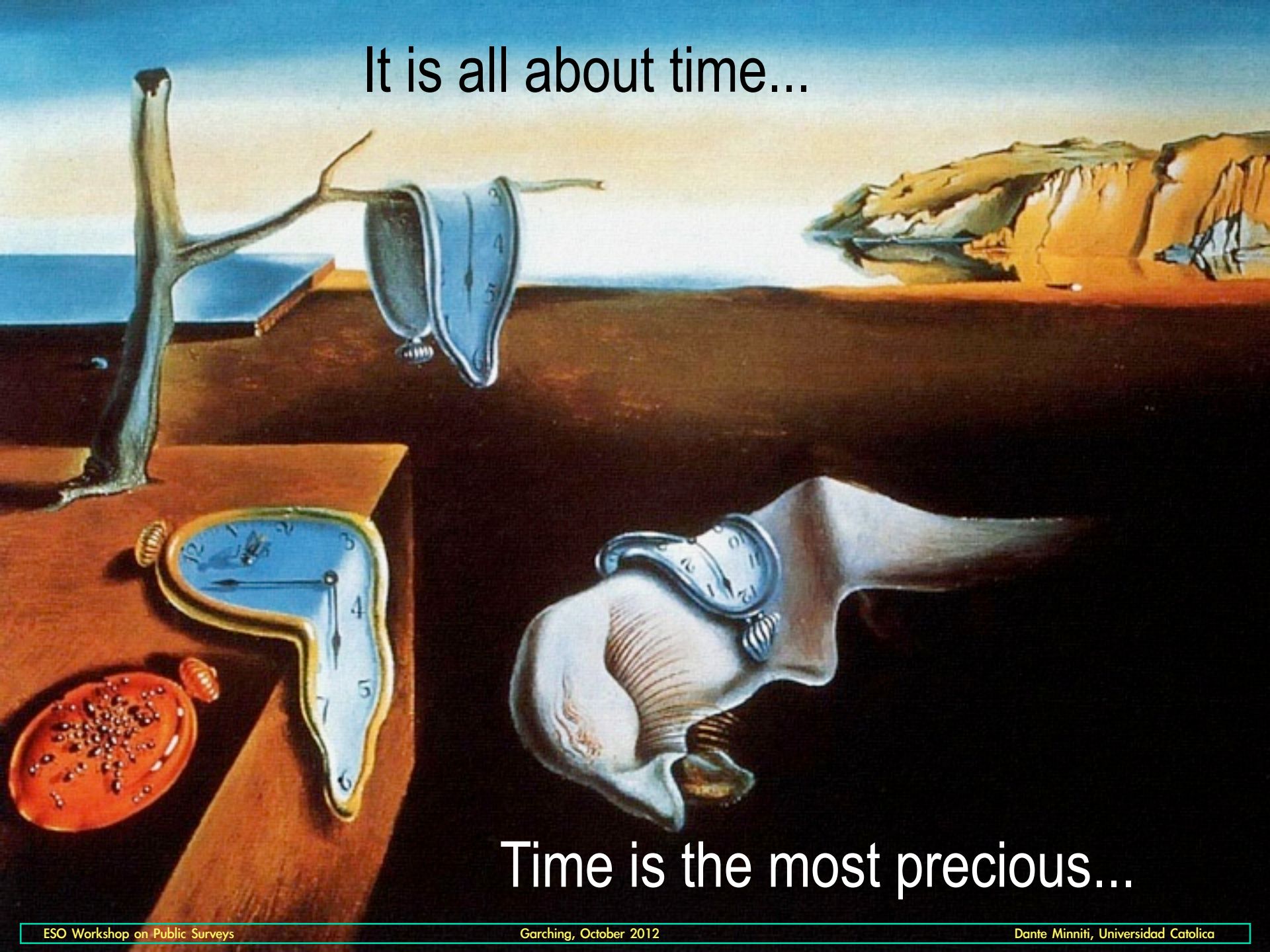
Let´s make it work!

Questions

3. The survey team's response to the VISTA PSP feedback of November 2011.
Nothing. This was a very positive report.

4. What would the PI like to change in the survey observing strategy to make it more scientifically productive and to complete it sooner?
Not much...
There is no need to complete it sooner: the longer time baseline benefits long term variability and proper motions.

It is all about time...



Time is the most precious...