THE FUTURE

VVV Survey

Hacia el LSST:

explorando nuestra galaxia,

promoviendo Astrofísica a todo nivel,

incrementando las colaboraciones en el Sur,

y procurando recursos para nuevas generaciones.

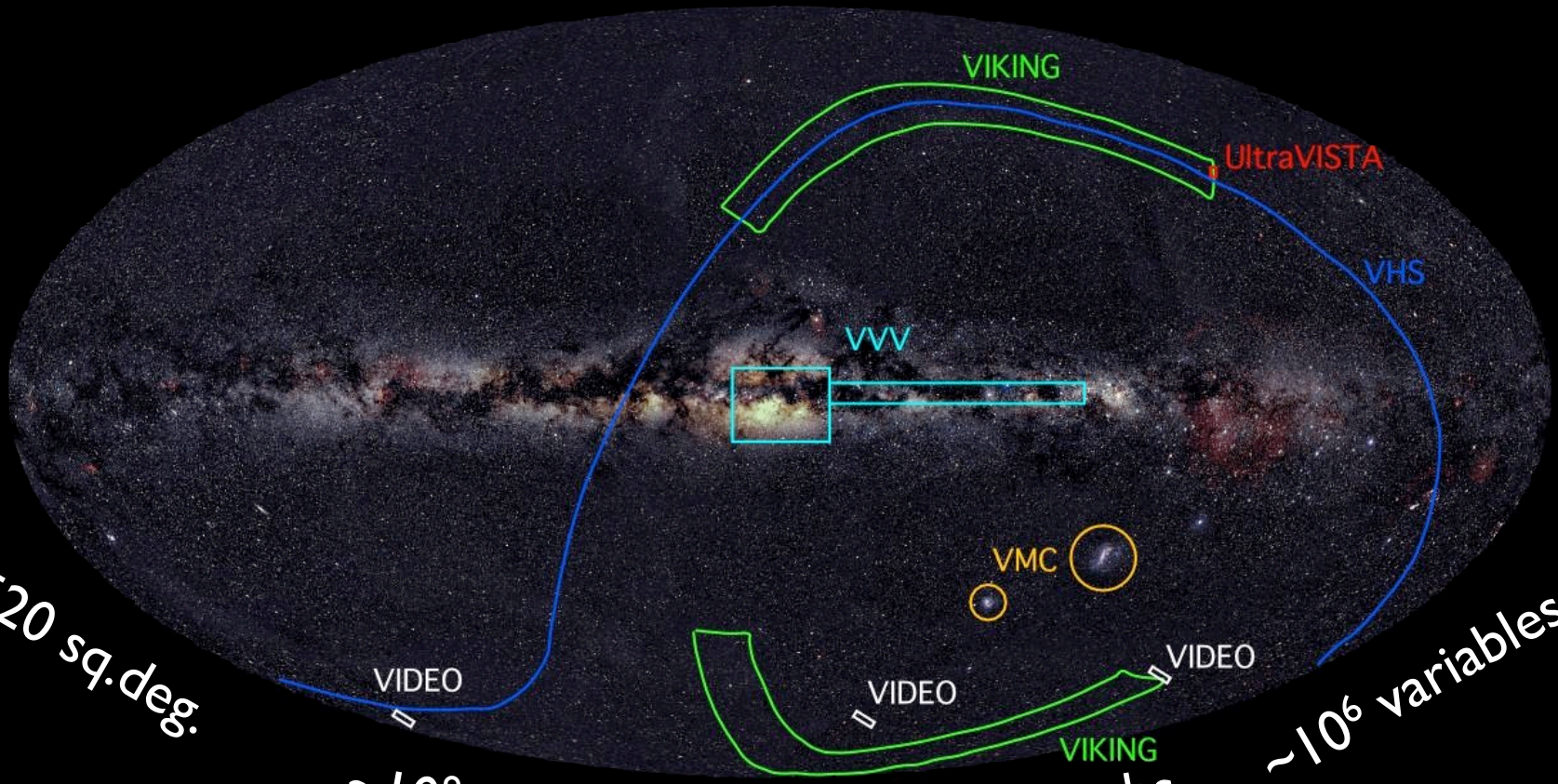
VVV Science Team Members present

Manuela Zoccali
Marcio Catelan
Doug Geisler
Rodolfo Barba
Alexandre Roman-Lopes
Francesco Mauro
Bruno Dias
Sergio Vasquez
Cristian Moni-Bidin
Dariusz Graczyk

Istvan Dekany
Maren Hempel
Javier Alonso
Rodolfo Angeloni
Tali Palma
Celeste Parisi
Valentin Ivanov
Mirko Simunovic
Roger Cohen
Dante Minniti, etc...

VISTA PUBLIC SURVEYS
VISTA VARIABLES IN THE VIA LACTEA

VVV



520 sq.deg.

~10^9 stars

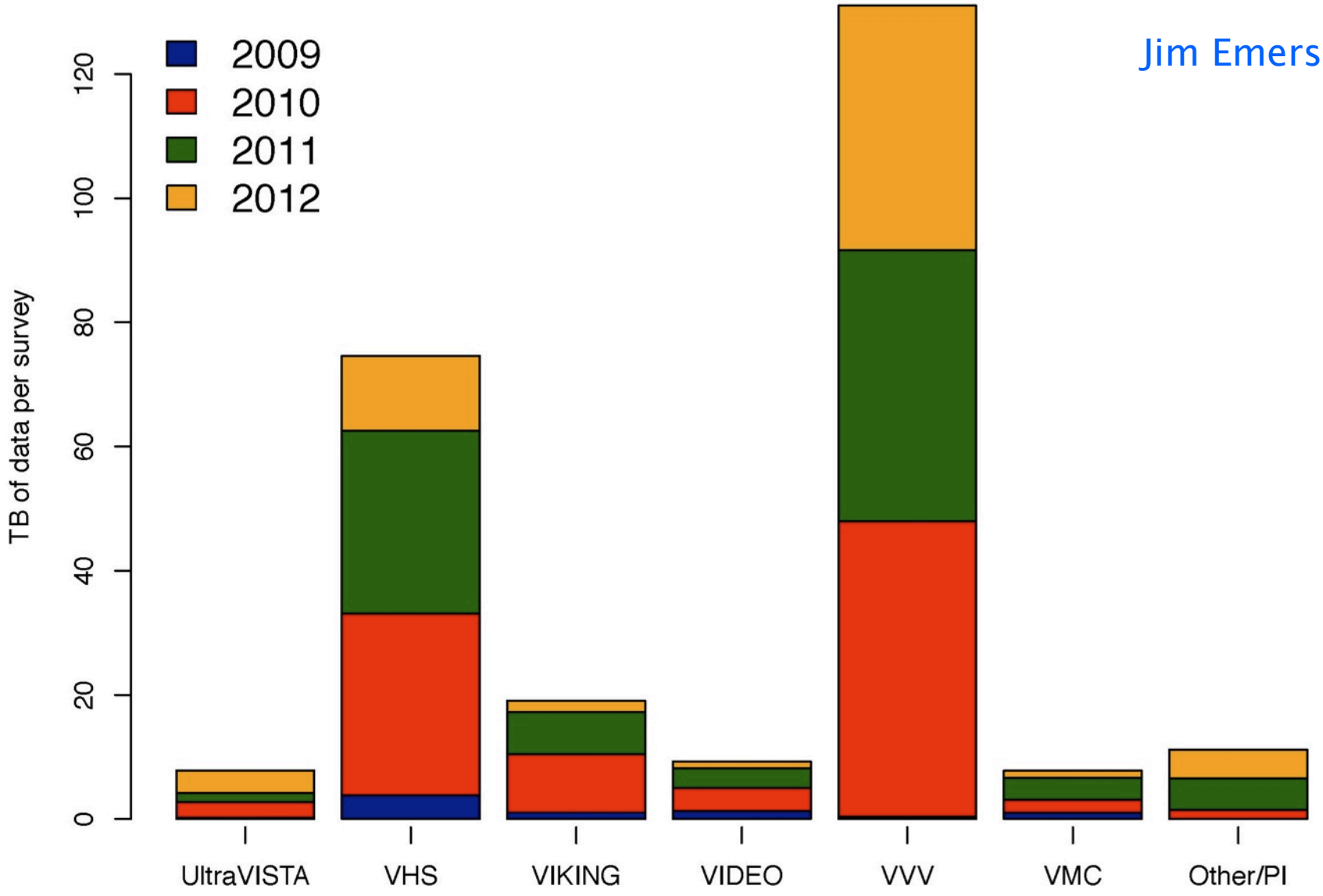
~100 epochs

~10^6 variables

Data Volumes produced by CASU

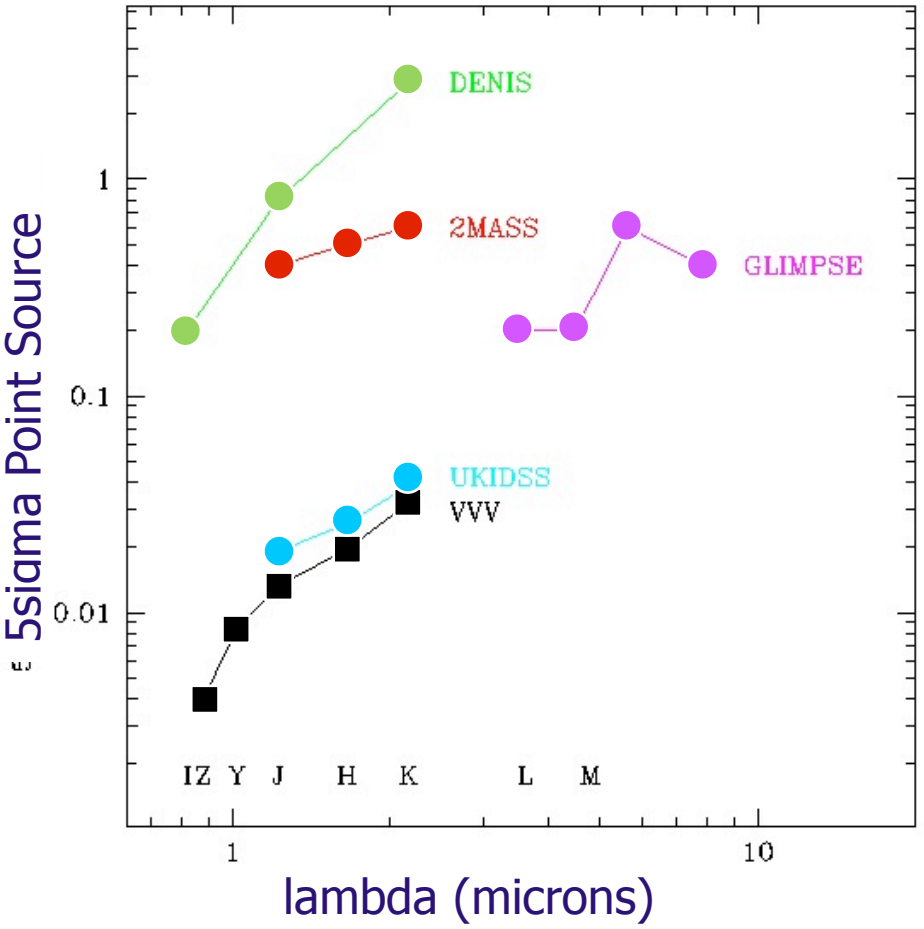
Jim Emerson

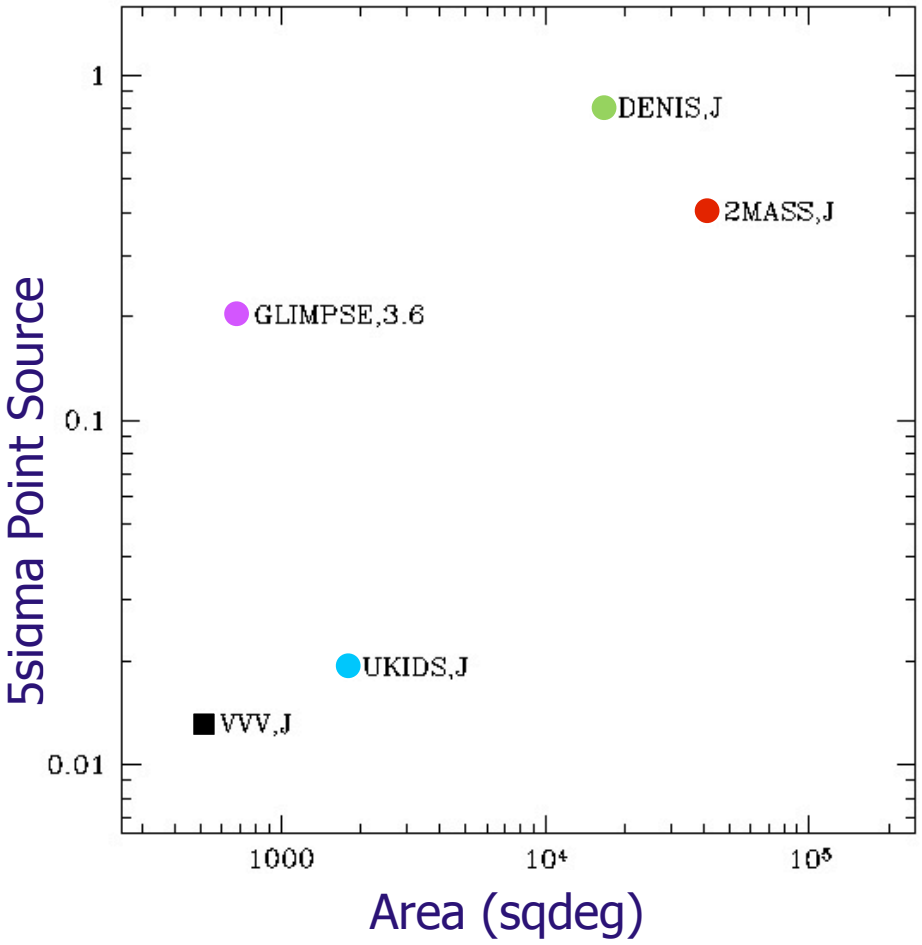
Jim Emerson



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)

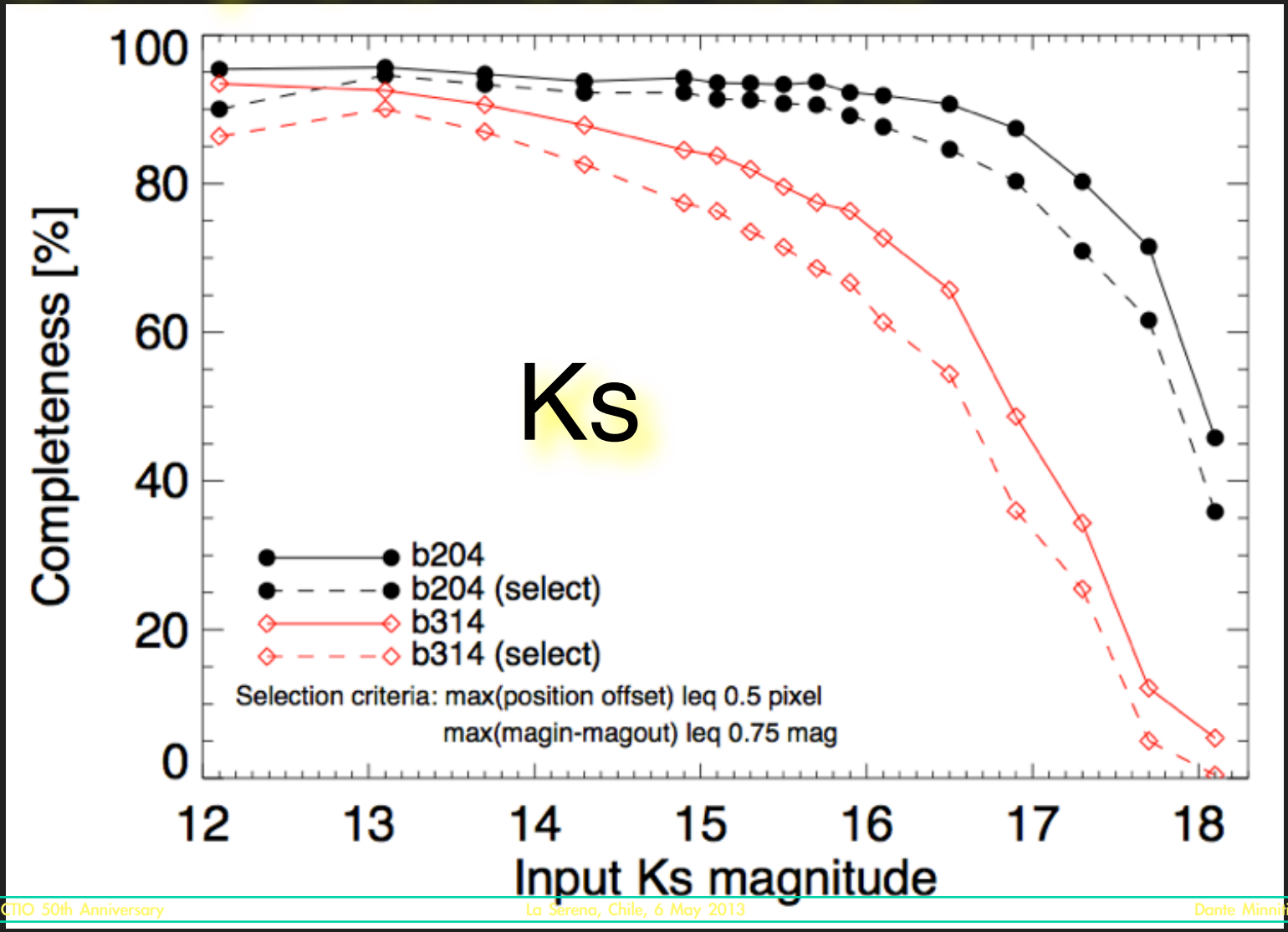
VVV is deeper (Ks<18)

VVV has 5 filters (ZYJHKs)

VVV is a multiepoch survey (~100 epochs)

VVV limiting magnitudes
Completeness tests

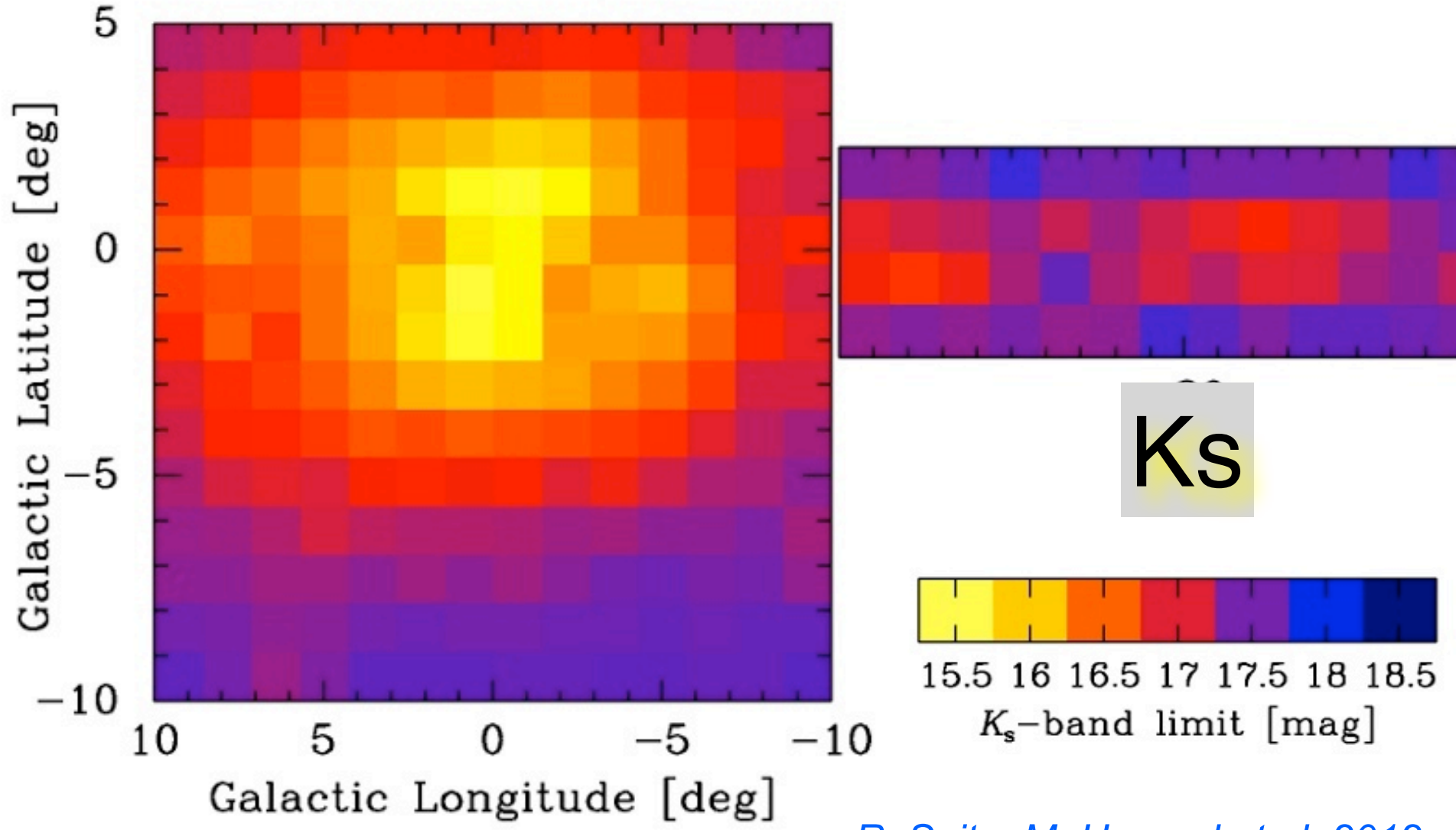
vvvsurvey.org



M. Hempel

VVV limiting magnitudes

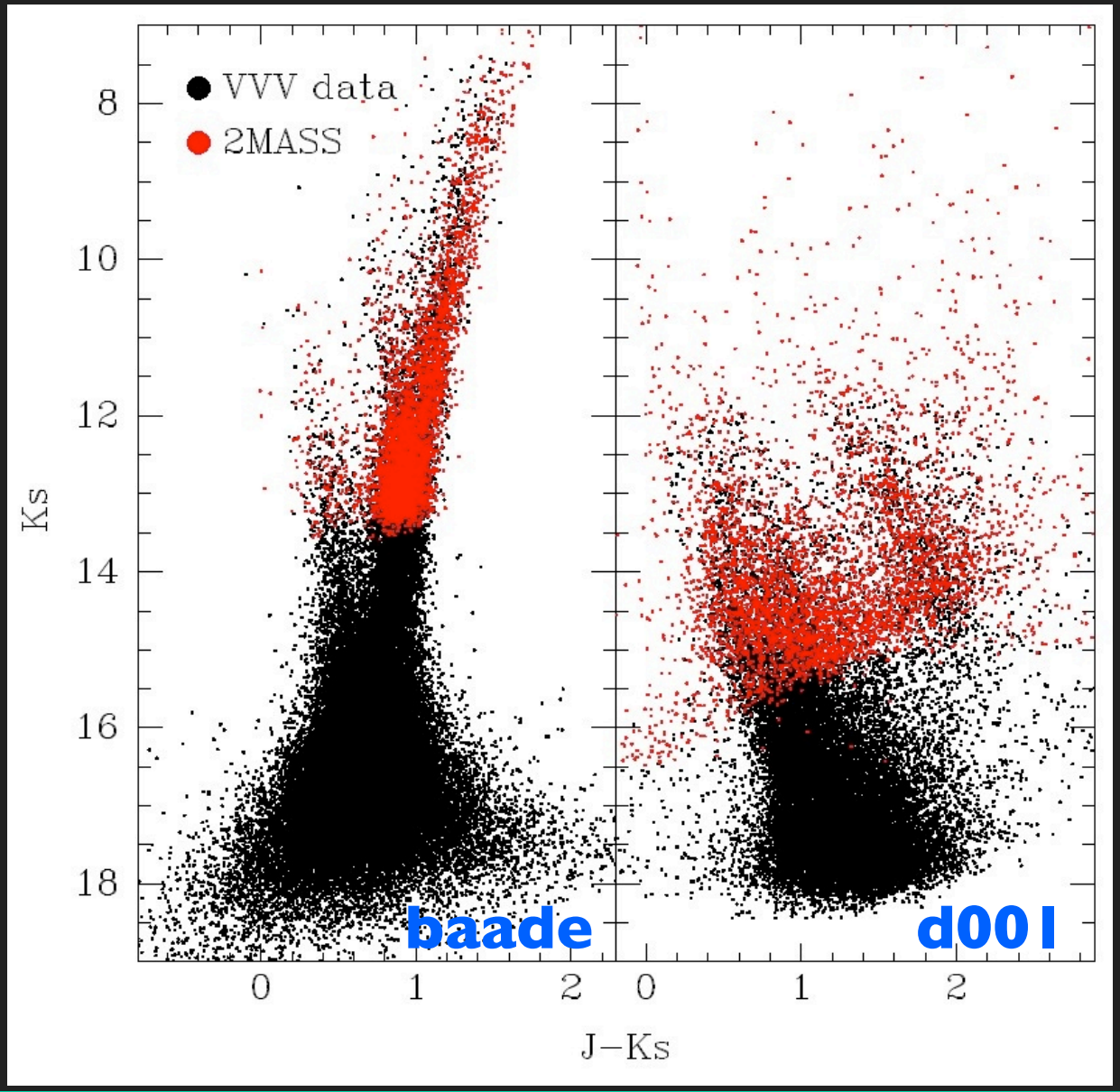
vvvsurvey.org



R. Saito, M. Hempel et al. 2012

VVV CMDs

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



Oscar Gonzalez

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: DR1 Paper, PSP Review, VSA DR2

2013: DR3

2014: ...

2015: ...

2016: End observations

2017+: MOONS, APOGEE-S, LSST...

The VVV Stages

Multicolor Photometry: ZYJHKs

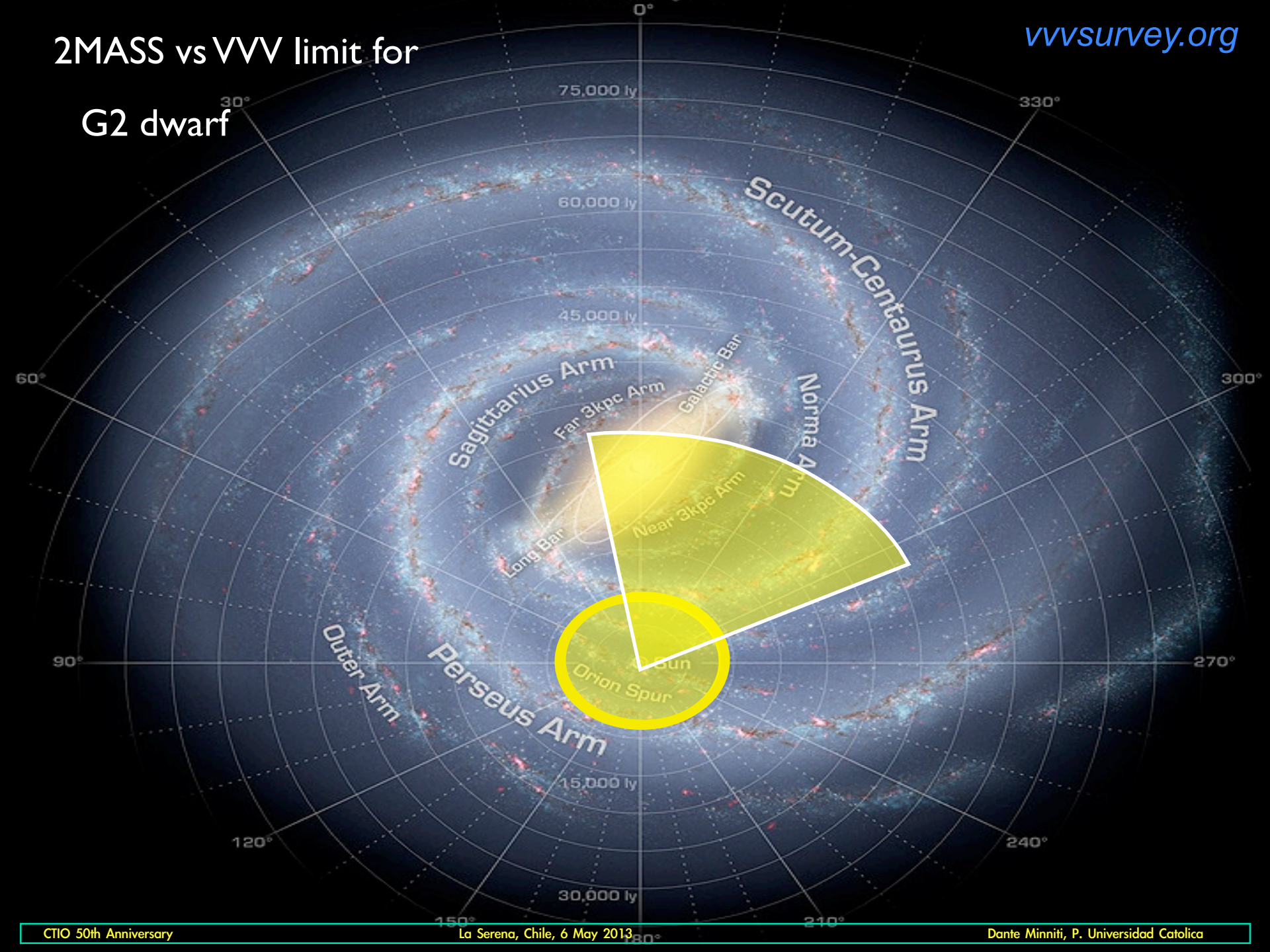
Star clusters, stellar populations, extinction, metallicities...

Variability: Ks

Proper Motions: Ks

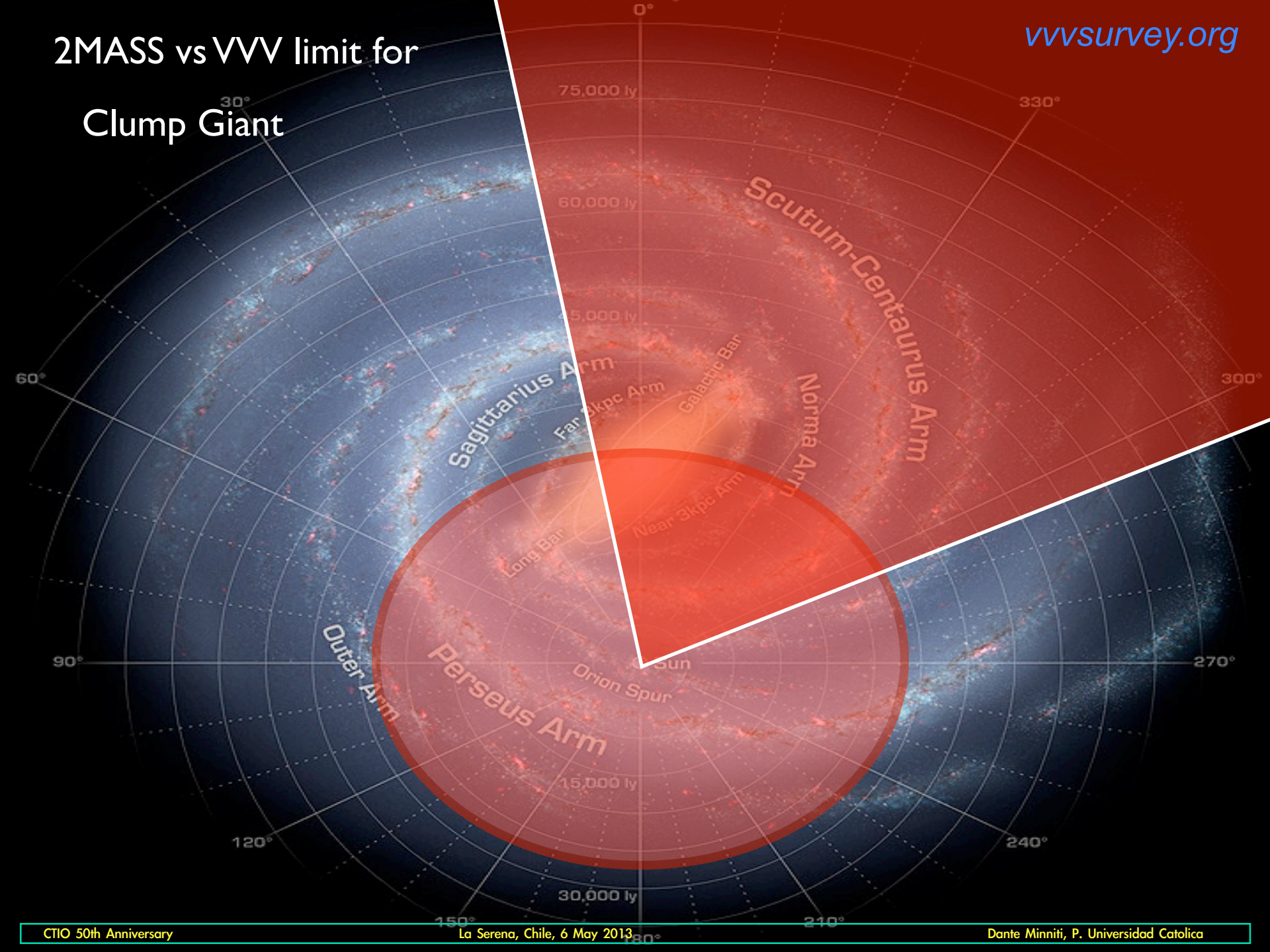
2MASS vs VVV limit for G2 dwarf

vvvsurvey.org



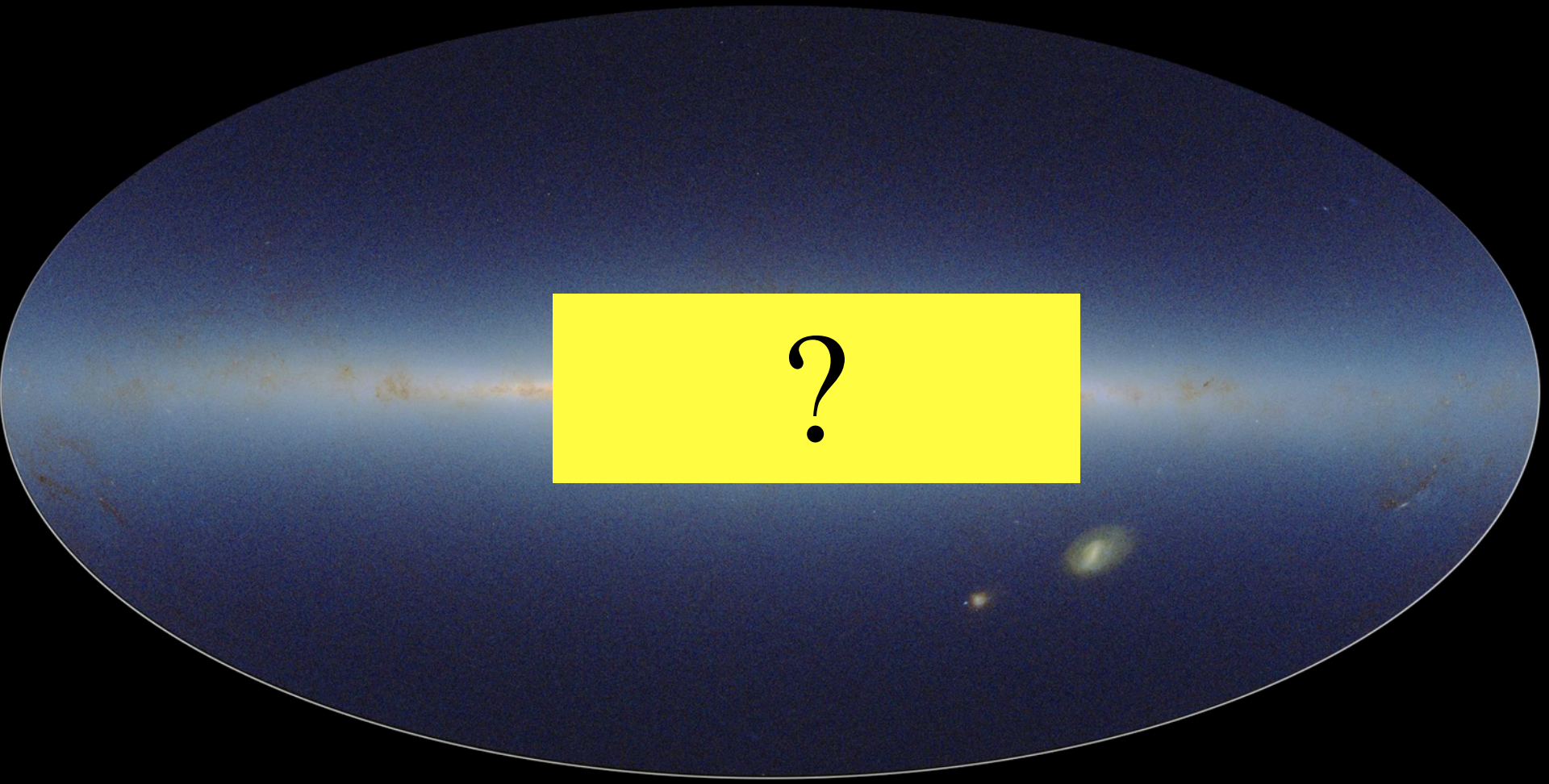
2MASS vs VVV limit for Clump Giant

vvvsurvey.org



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

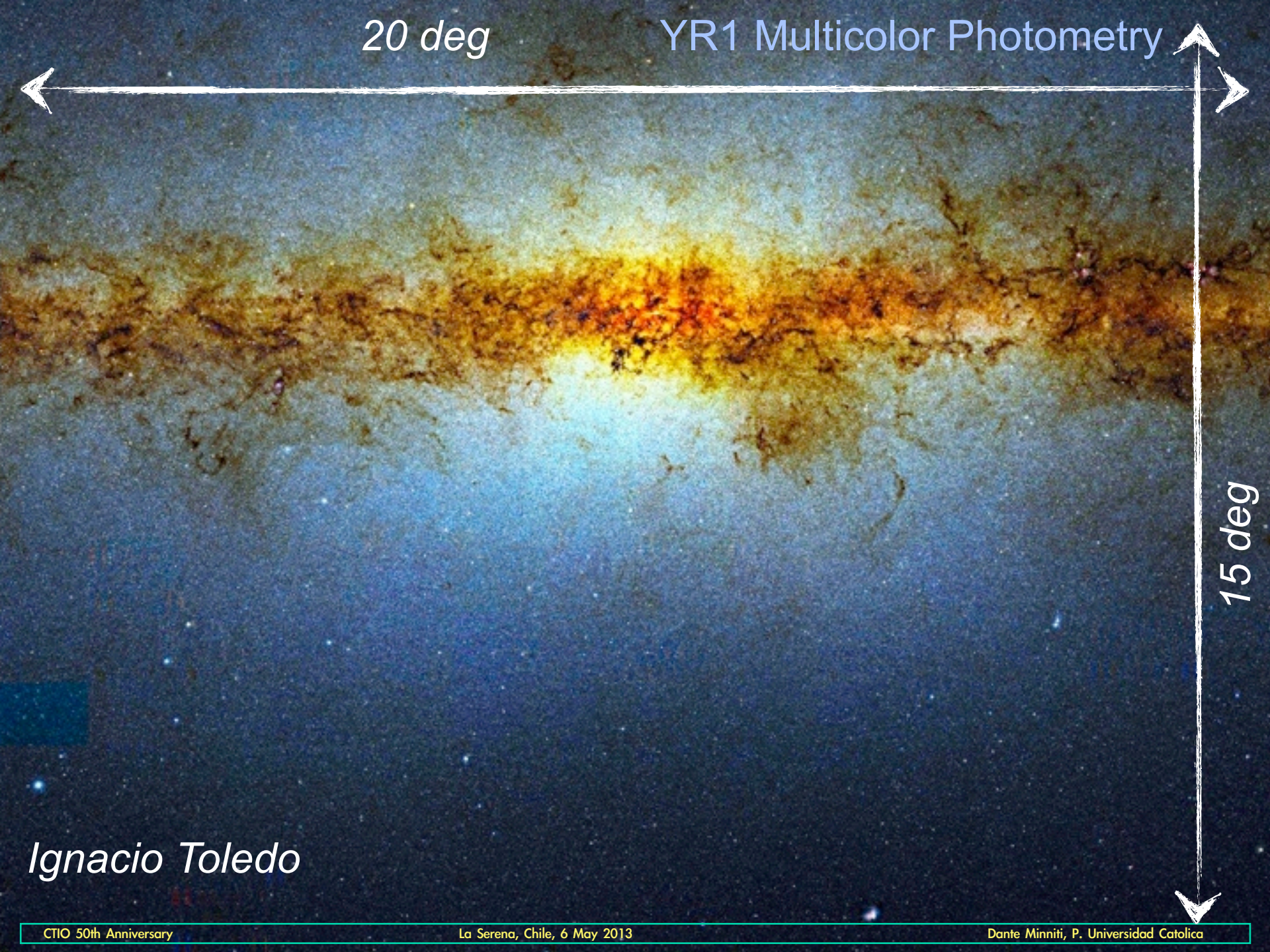
vvvsurvey.org

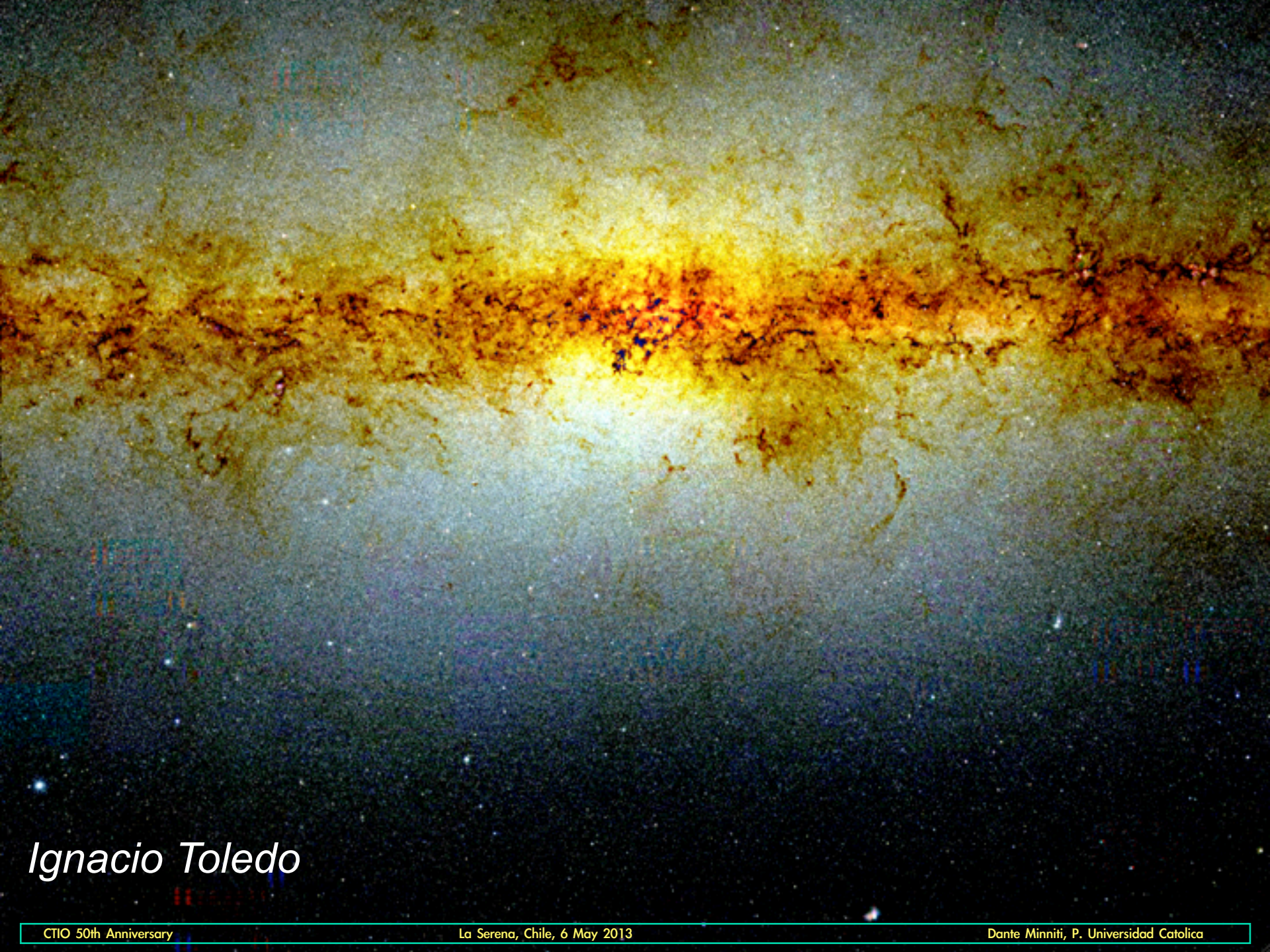


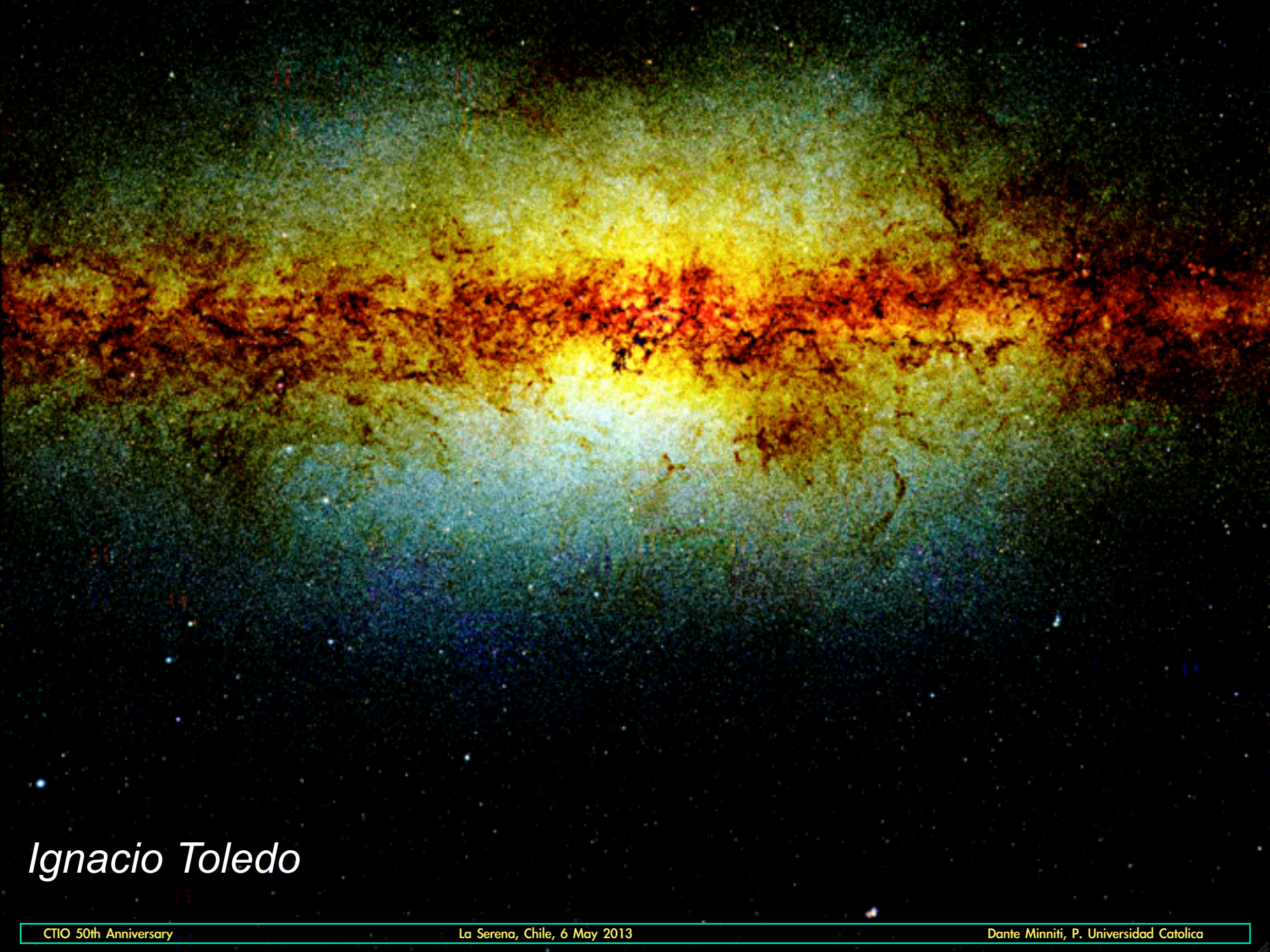
2MASS IMAGE OF THE MILKY WAY

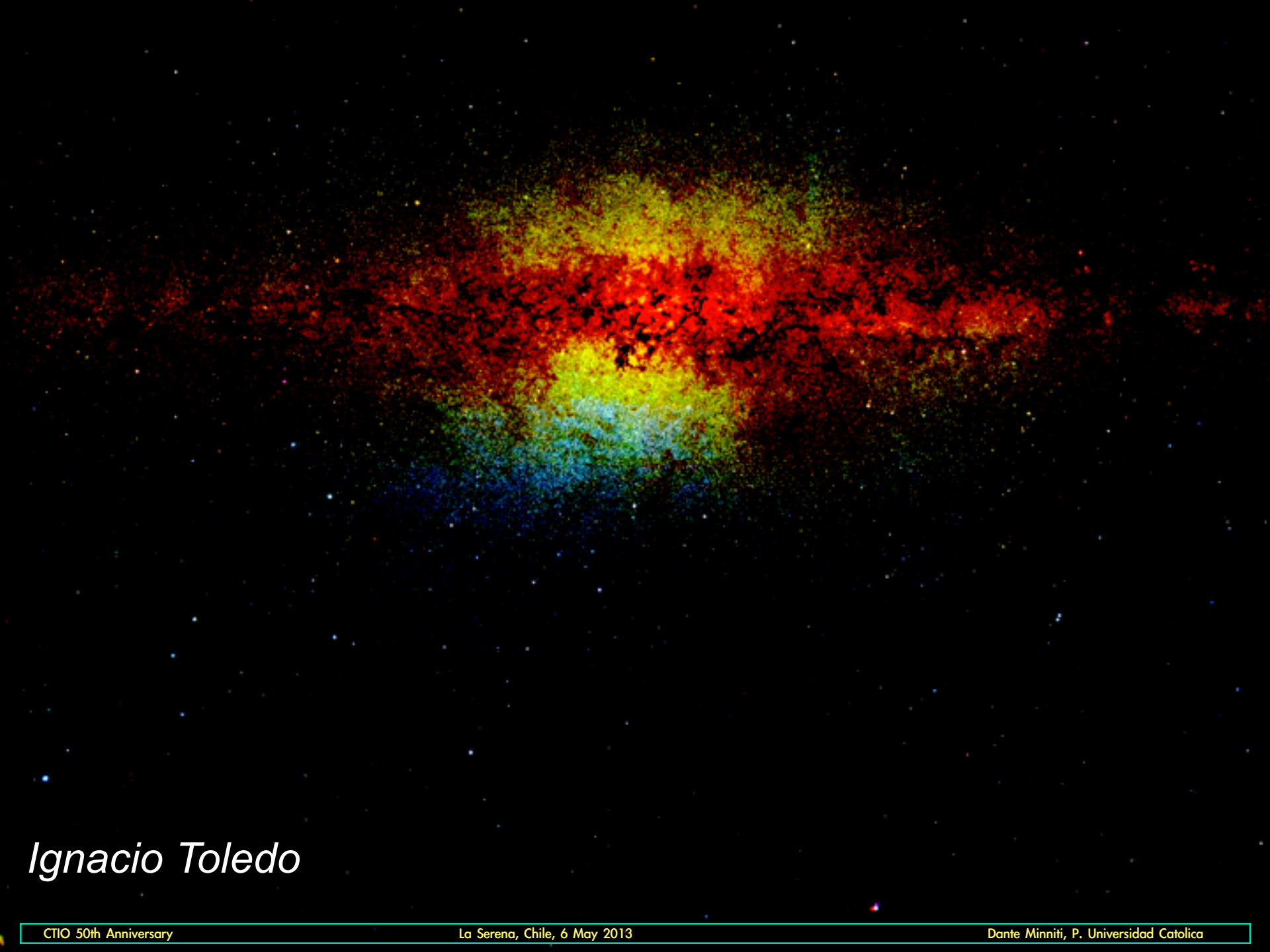
VVV Goal

What is the 3-D structure of the Milky Way


20 deg
YR1 Multicolor Photometry
15 deg
Ignacio Toledo


Ignacio Toledo

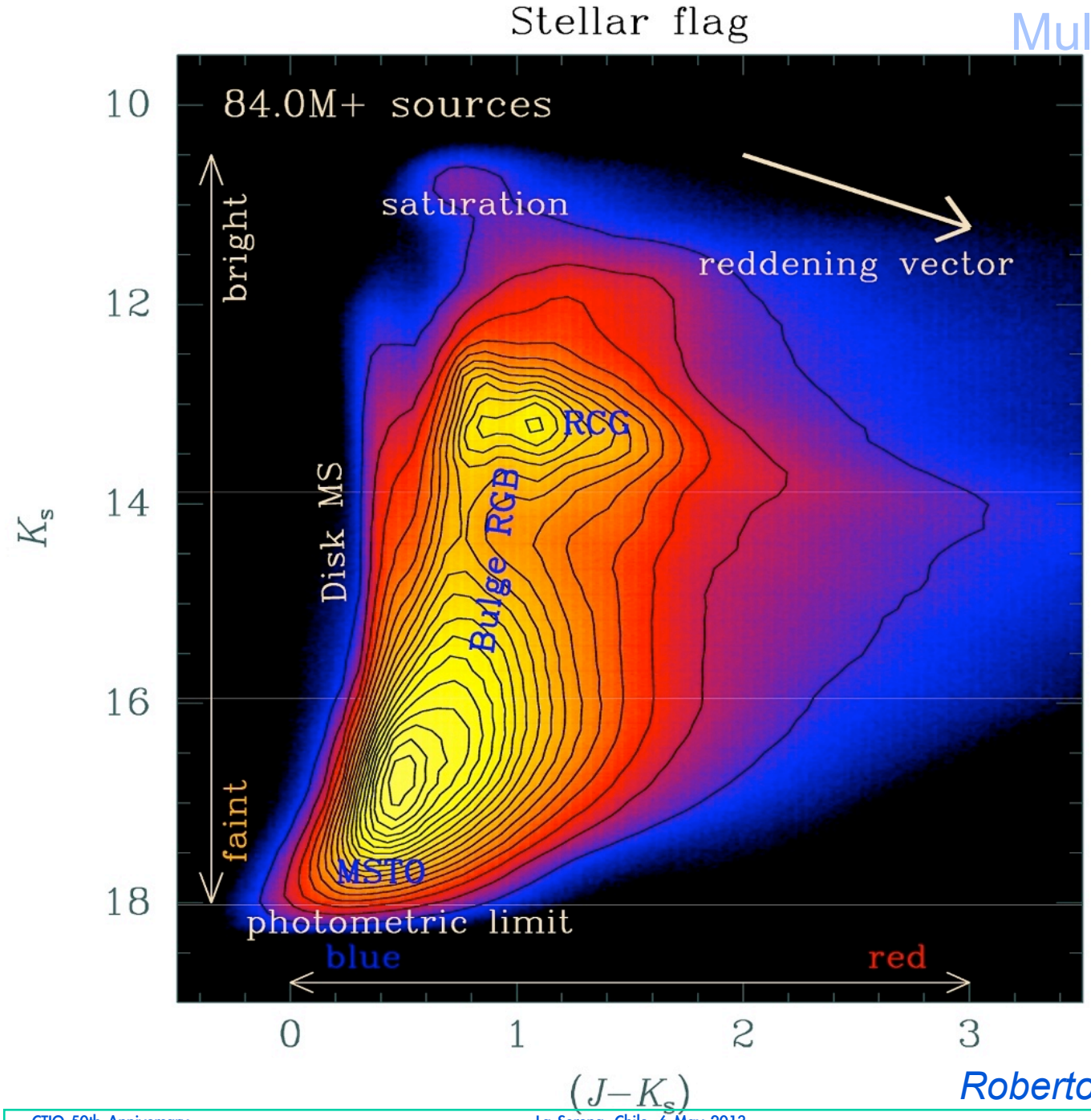

Ignacio Toledo


Ignacio Toledo

ESO noticias

"The news of the image spread like wildfire and it has so far been our most successful press release. To date we have had more than 600 000 visitors to this press release alone — more than double our previous record for a single release."

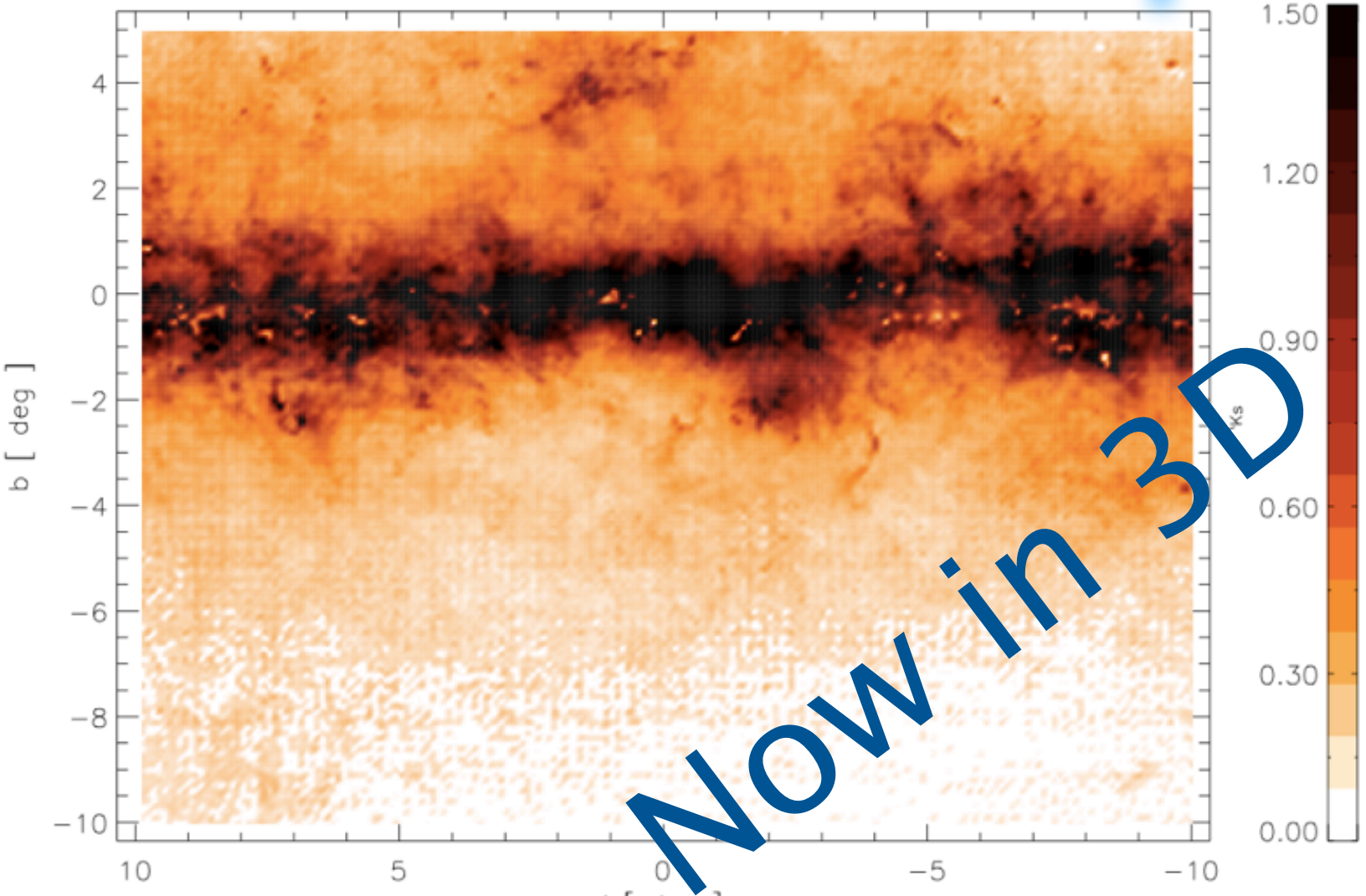
Lars Lindberg Christensen, ESO Outreach
Community Newsletter, November 2012



VVV 84M+ STARS BULGE CMD

Roberto Saito et al. 2012

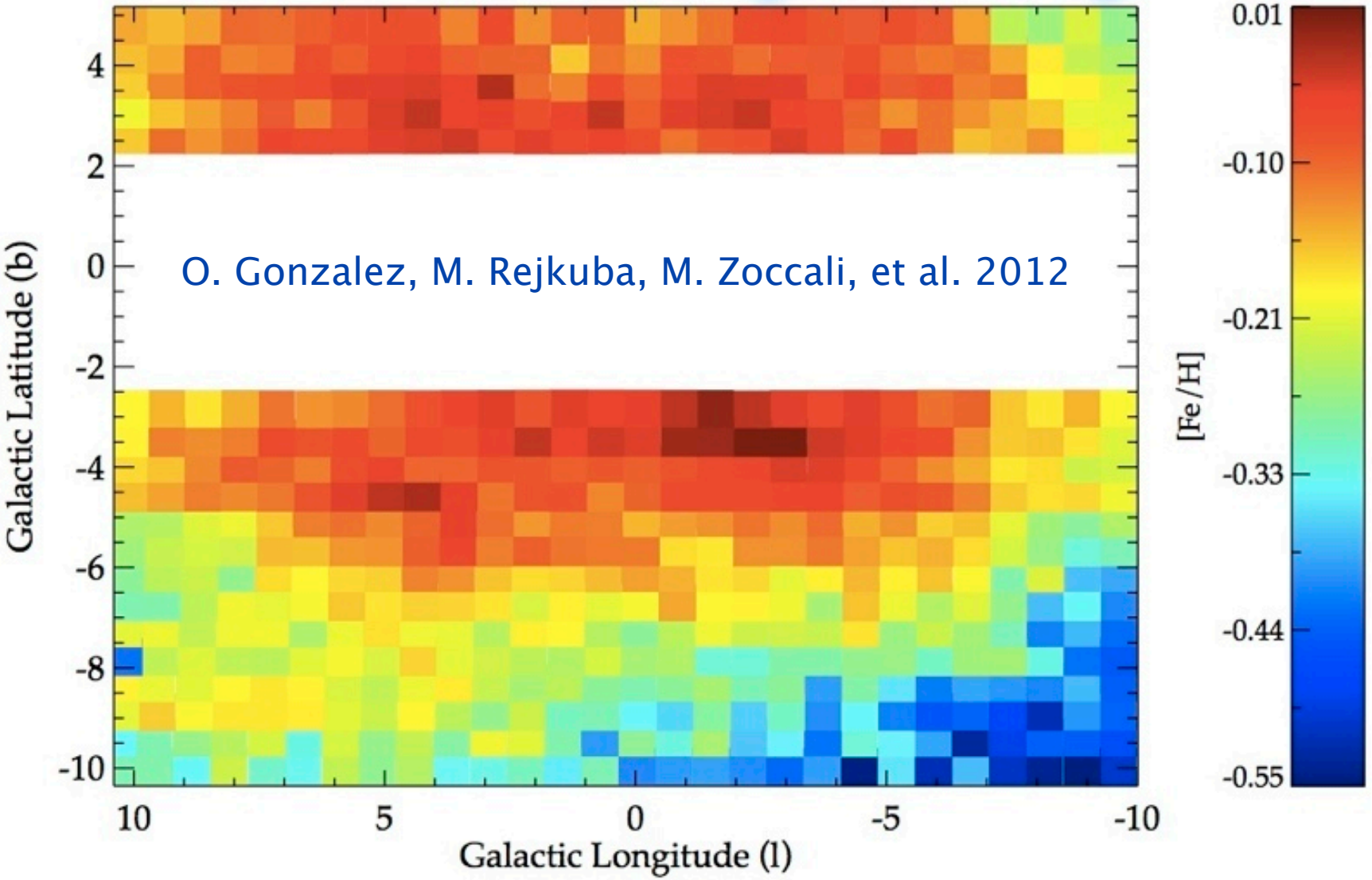
Extinction Maps



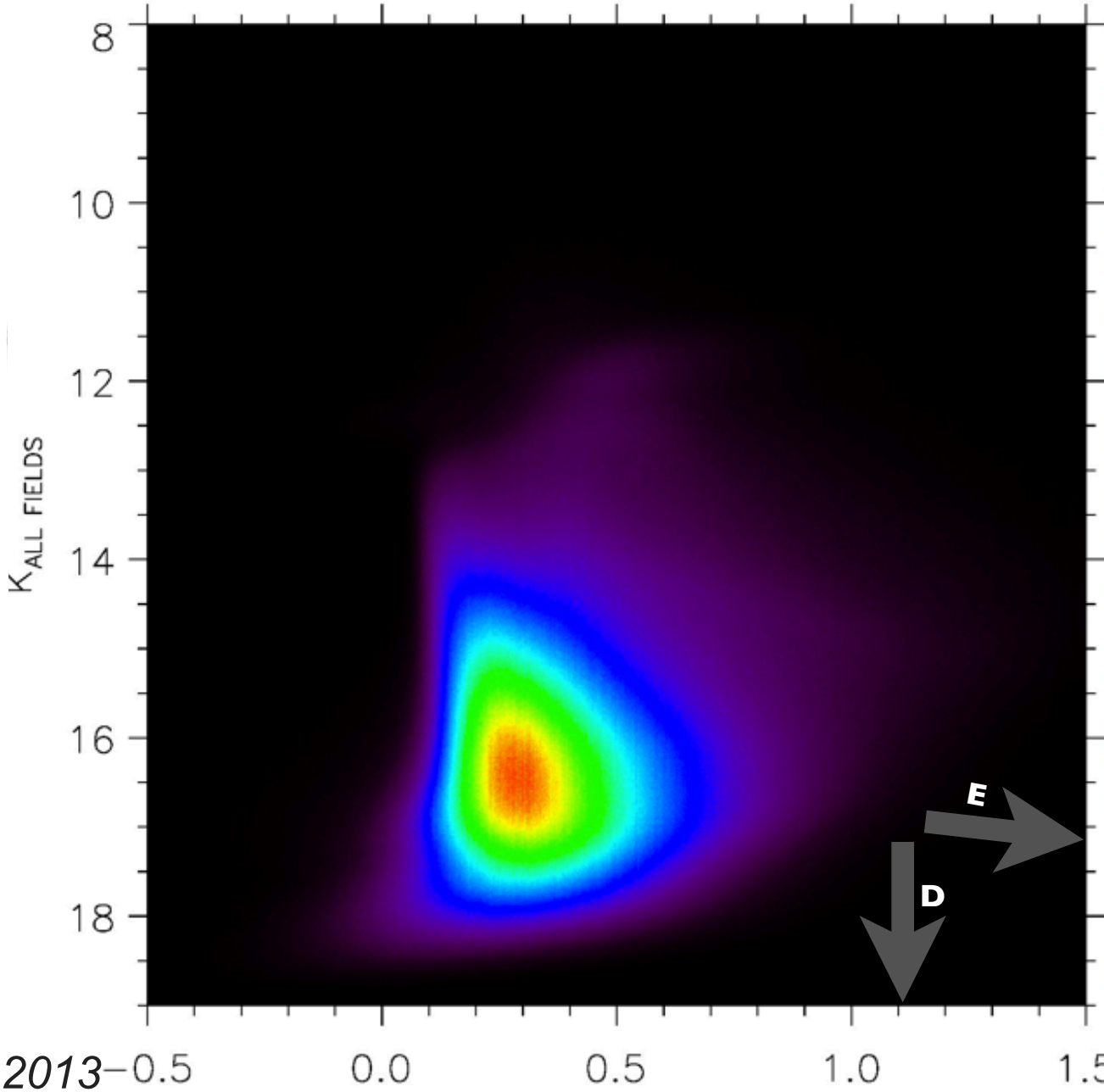
Now in 3D

O. Gonzalez, M. Rejkuba, M. Zoccali, et al. 2012, B. Chen et al. 2013

Metallicity Maps

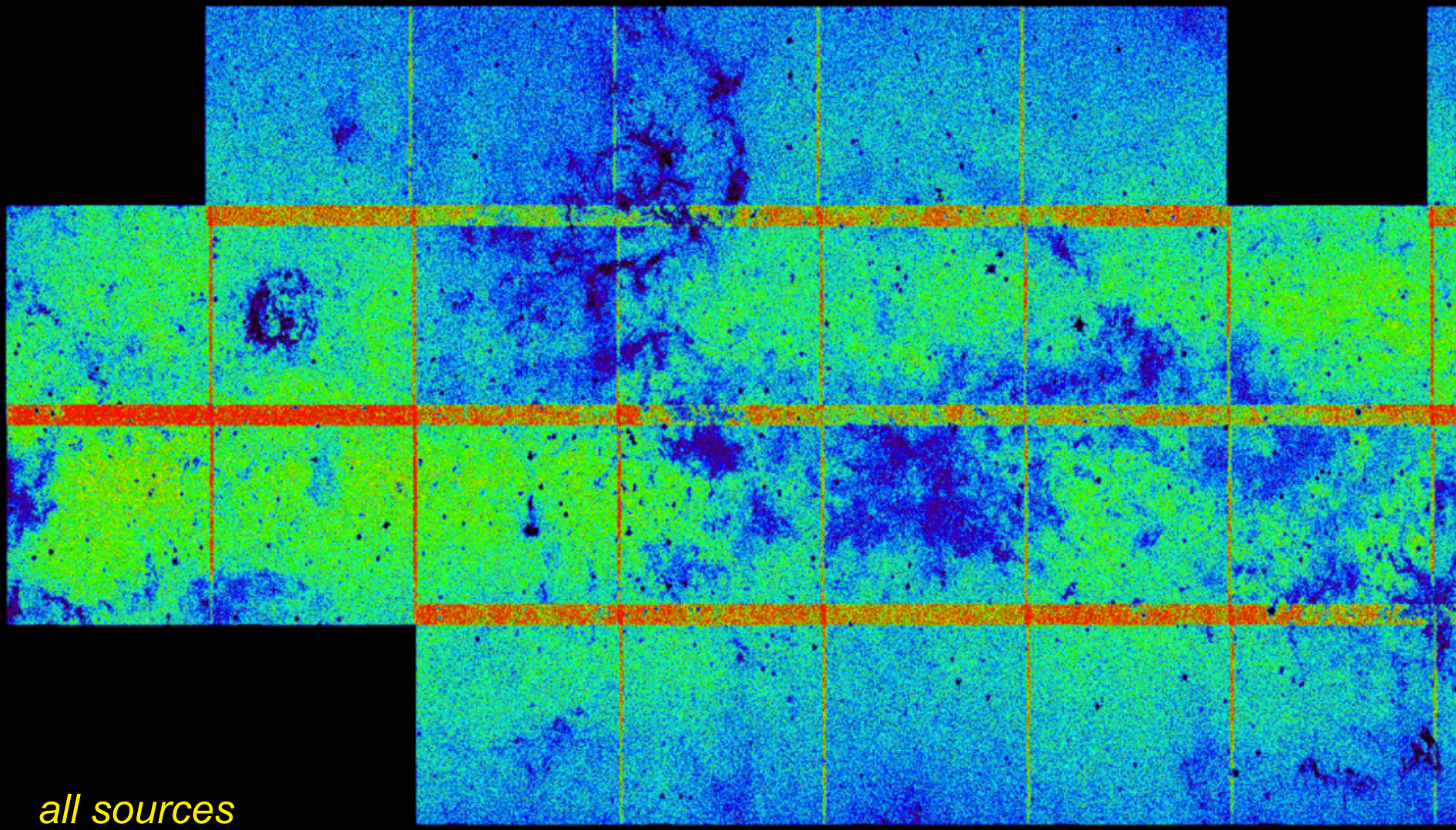


VVV DISK I40M STARS



M. Soto, R. Barba, et al. 2013

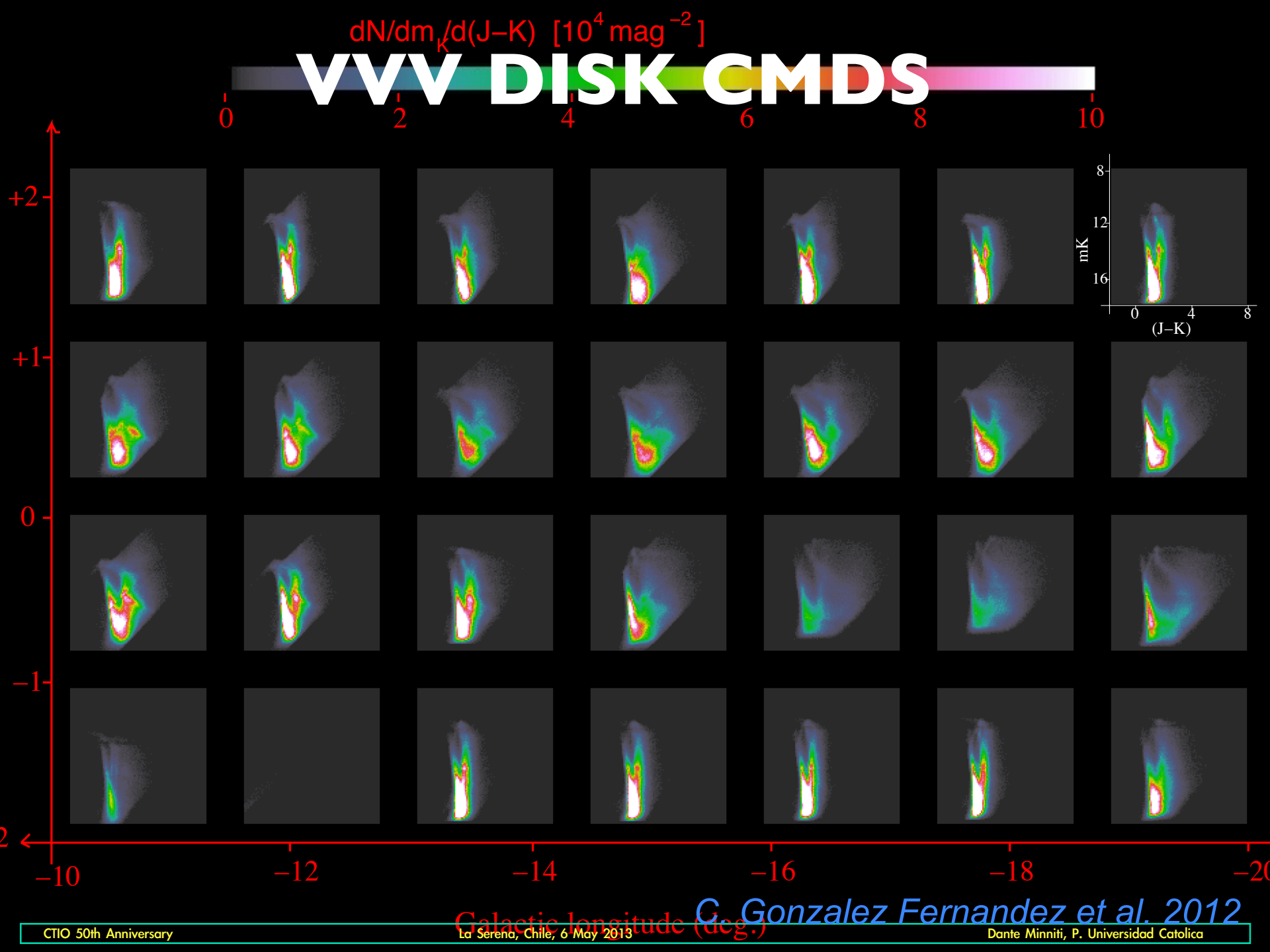
VVV DISK DENSITY MAPS



all sources

M. Soto, R. Barba

VVV DISK CMDS



G. Gonzalez Fernandez et al. 2012

Planetary Nebulae with VVV

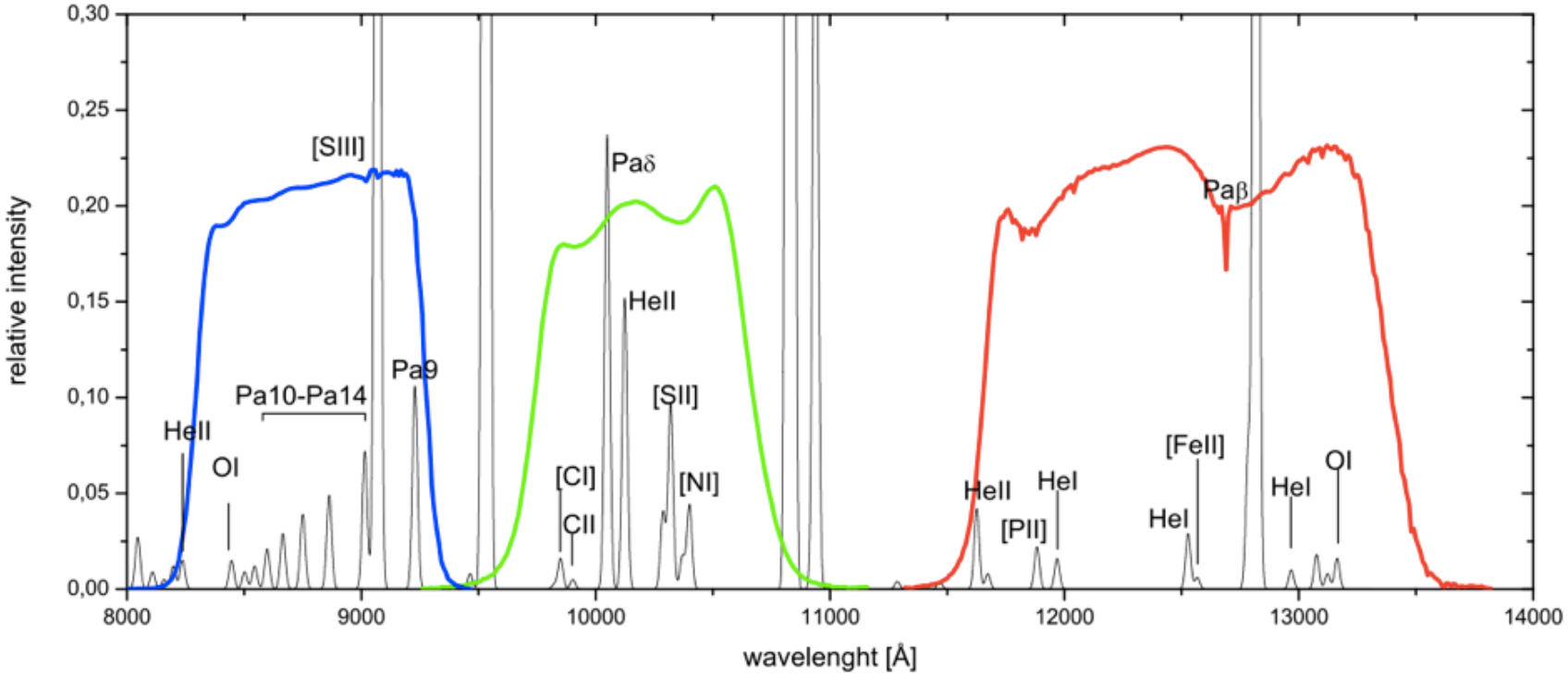


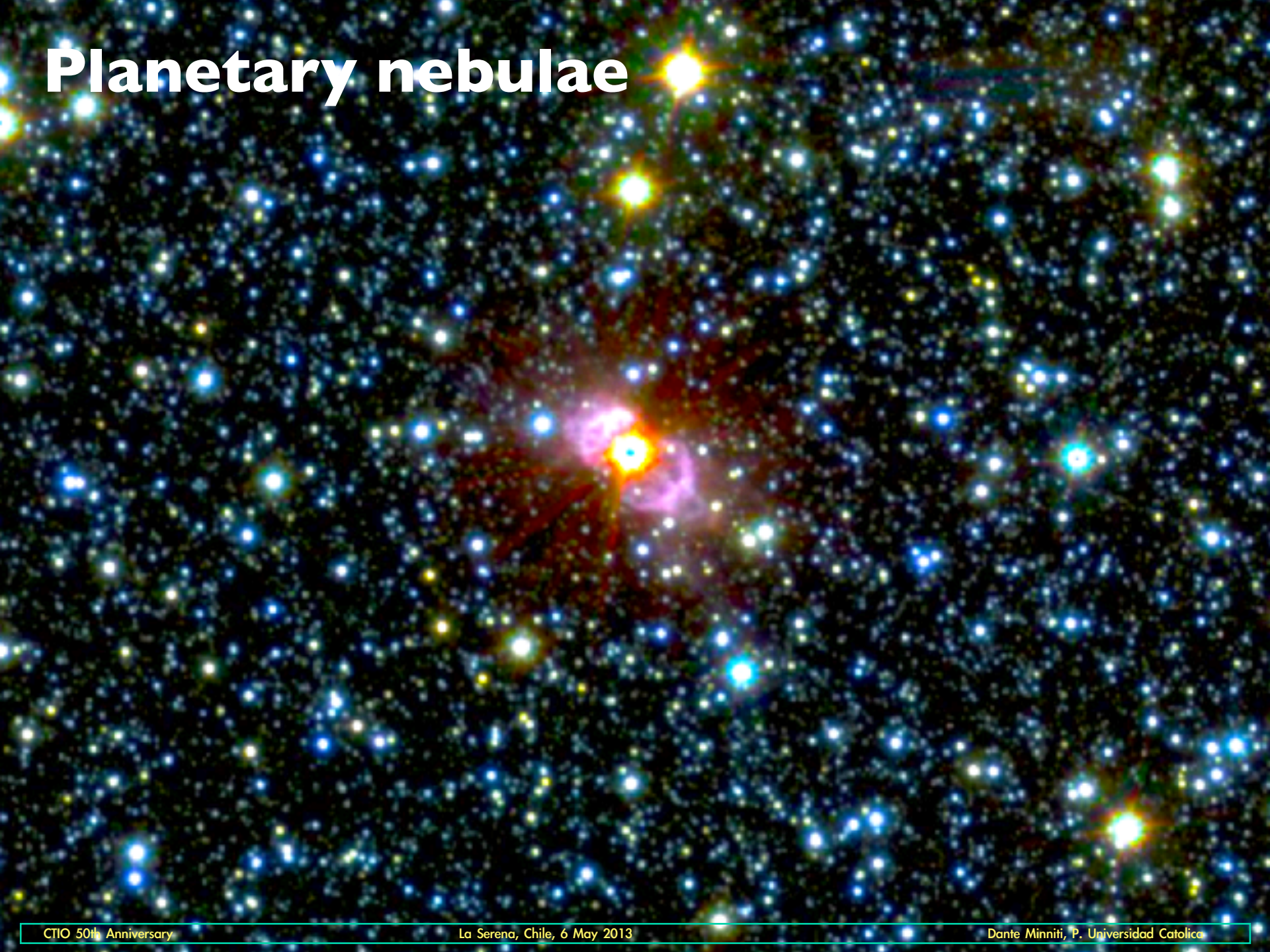
Fig. 1. Transmission curves for the Z, Y and J broad-band filters (the effective wavelengths are 0.878, 1.021 and 1.254 μm respectively). The spectrum of the PN IC 5117 is superimposed (Rudy et al. 2001), scaled to Paβ=1.

W. A. Weidmann, et al. 2013

Planetary nebulae

Planetary nebulae

Planetary nebulae



Star Clusters

Phil Lucas, Jura Borissova, Rudy Kurtev, Marcio Catelan, Francesco Mauro, Doug Geisler, Cristian Moni-Bidin, Bogdan Popesku, Andre Chene, Rodolfo Barba, Alexandre Roman, Margaret Hanson, Javier Alonso, Maren Hempel, Manuela Zoccali, Marina Rejkuba, Eduardo Bica, Beatriz Barbuy, Roberto Saito, Elena Valenti Roger Cohen, Charles Bonatto, Juan Claria, Tali Palma, Celeste Parisi, Julia Arias, ...


VVV Globular Clusters
Javier Alonso

Follow-up of new globular clusters

New candidate GCs

Christian Moni-Bidin, Francesco Mauro, Doug Geisler, et al. 2012

Open Clusters

vvvsurvey.org

Borissova et al. 2011 A&A

Discovery of a hundred new open clusters in the Milky Way.

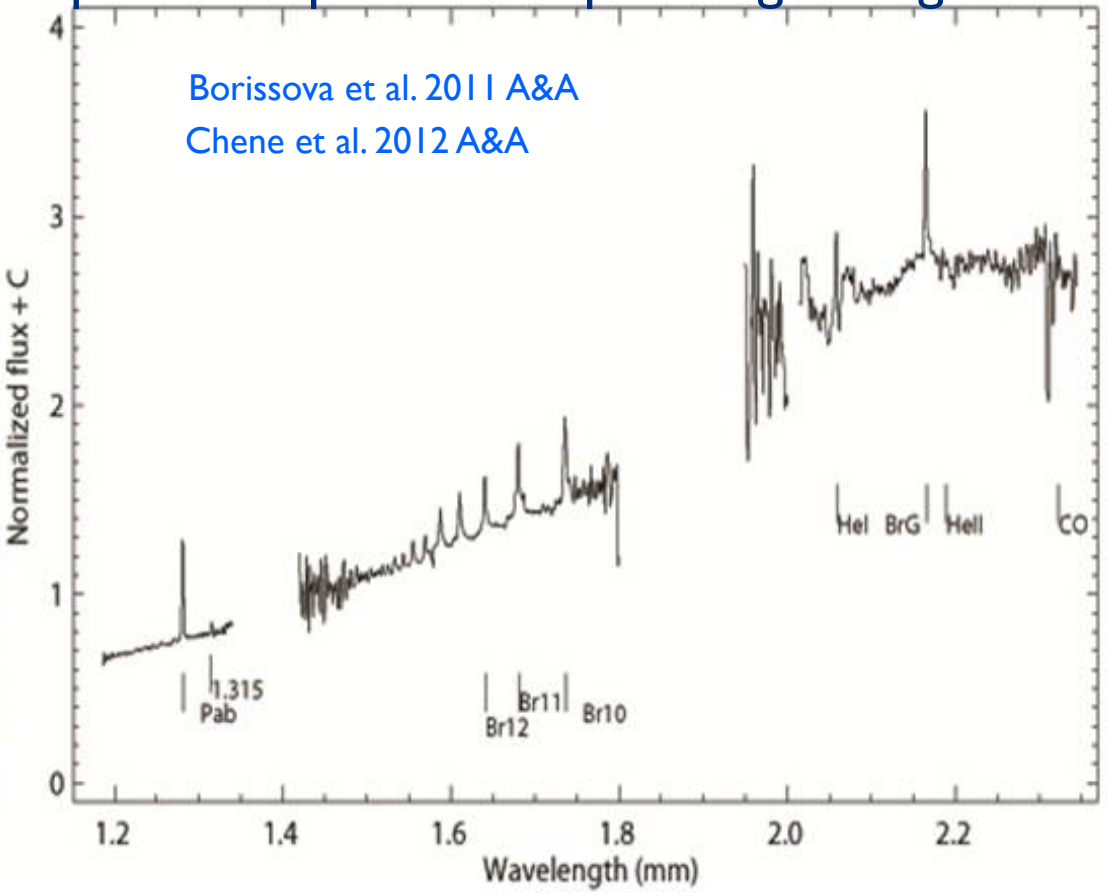
Measure their sizes and reddenings.

Estimate their ages and distances.

Spectroscopic follow up of brightest giants

Borissova et al. 2011 A&A

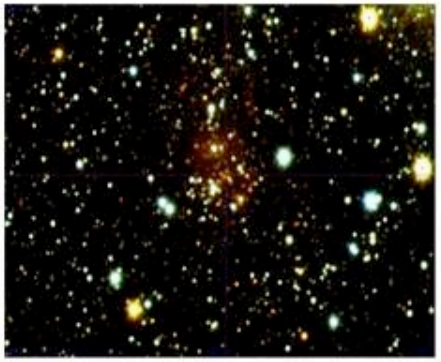
Chene et al. 2012 A&A



CL013

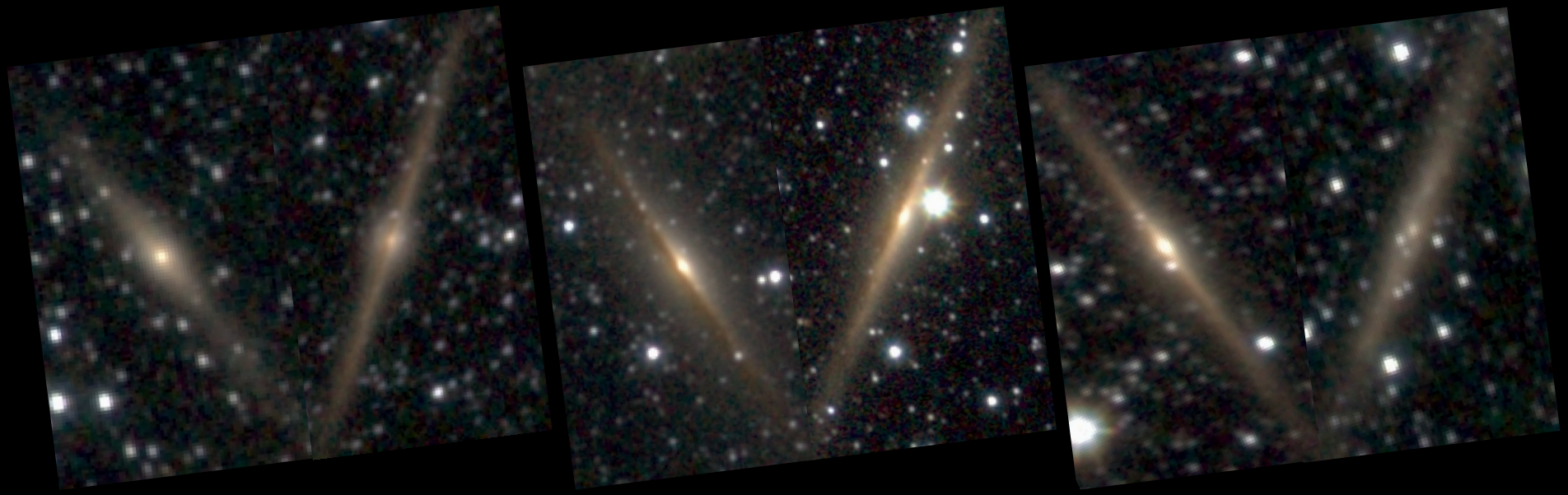
CL014

CL017



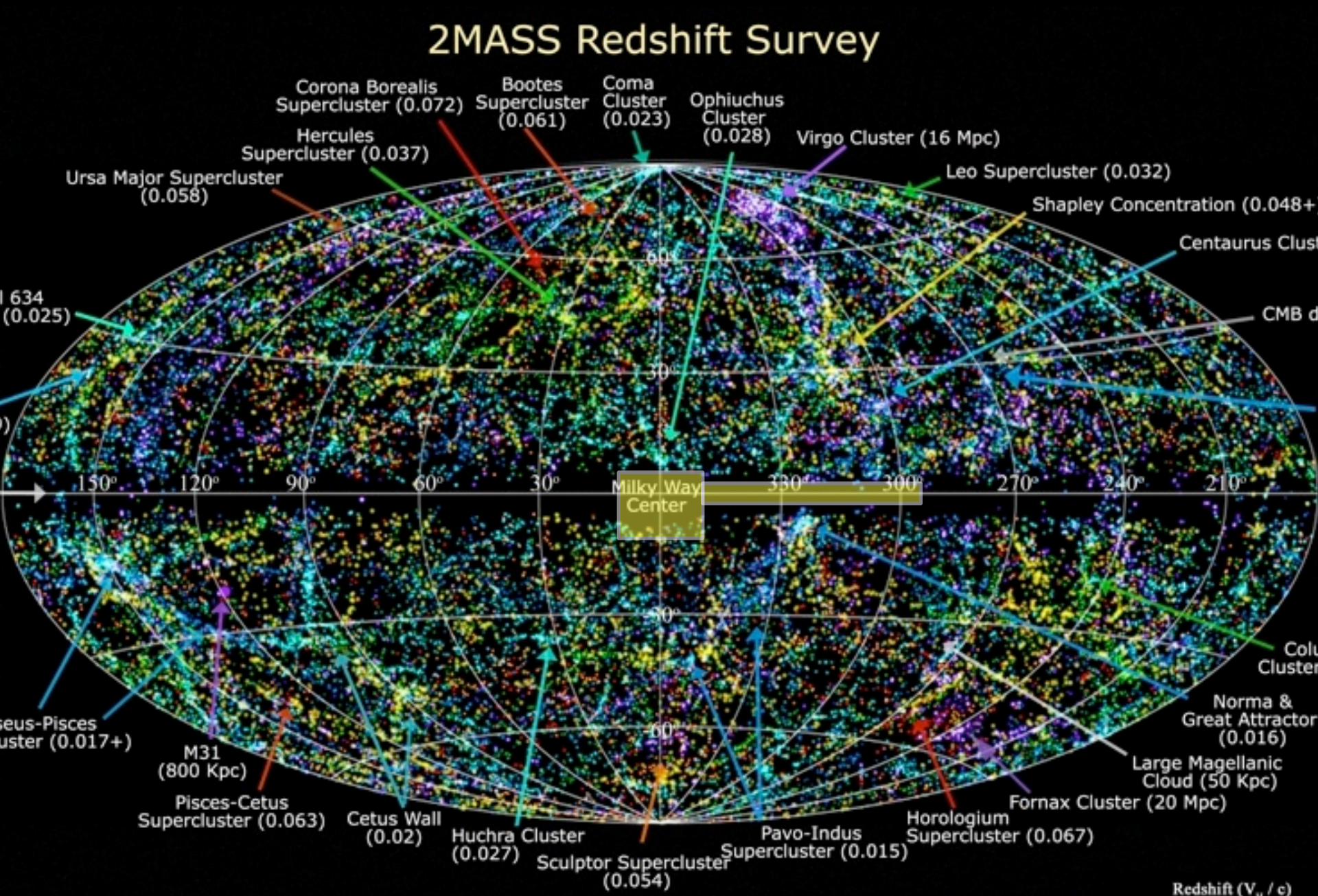
CL018

VVV Galaxies



BEYOND THE MW...

2MASS Redshift Survey

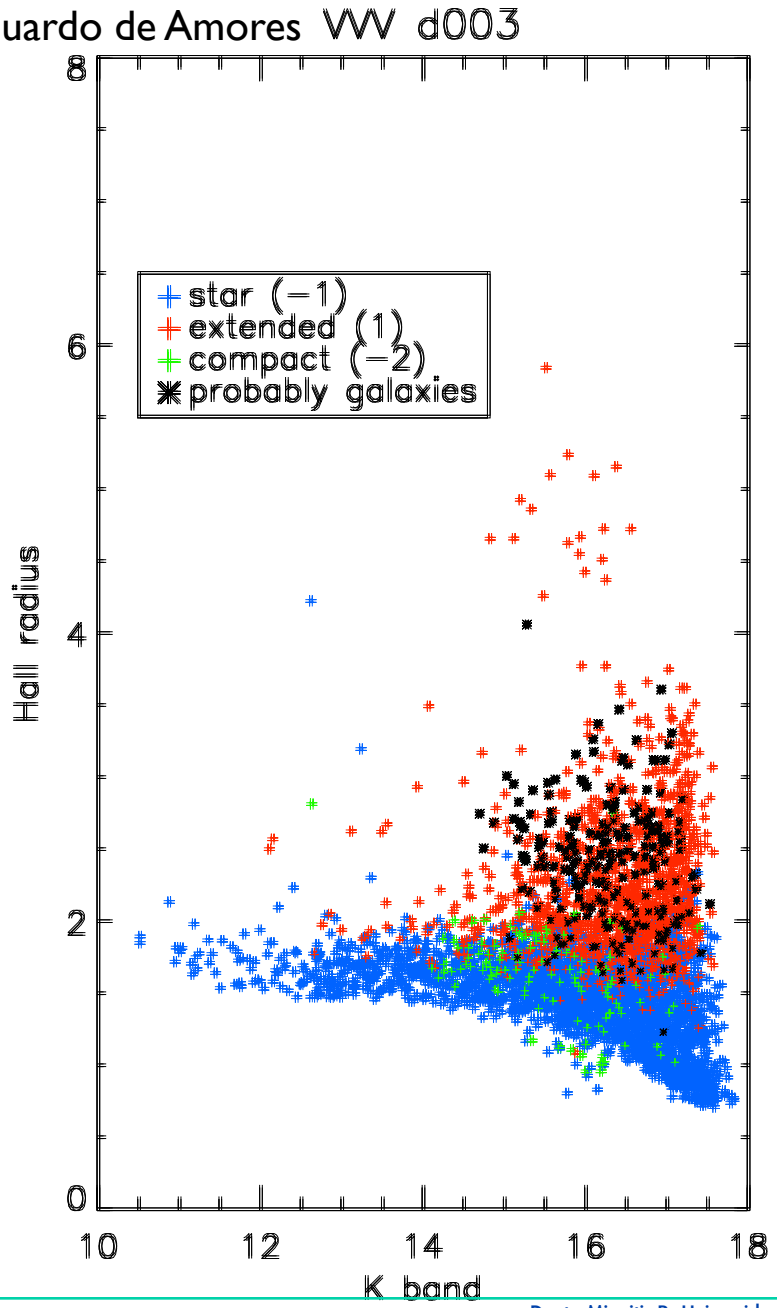


Legend: image shows 2MASS galaxies color coded by the 2MRS redshift (Huchra et al 2011); familiar galaxy clusters/superclusters are labeled (numbers in parenthesis represent redshift).

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, APOGEE-S)

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 [illegible]									13.358

The VVV Stages

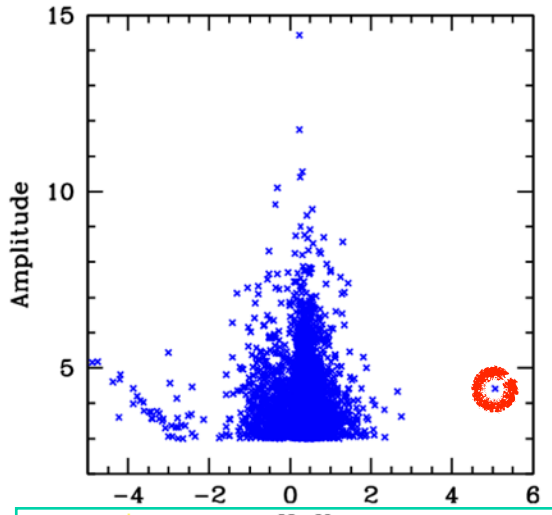
Multicolor Photometry: ZYJHKs

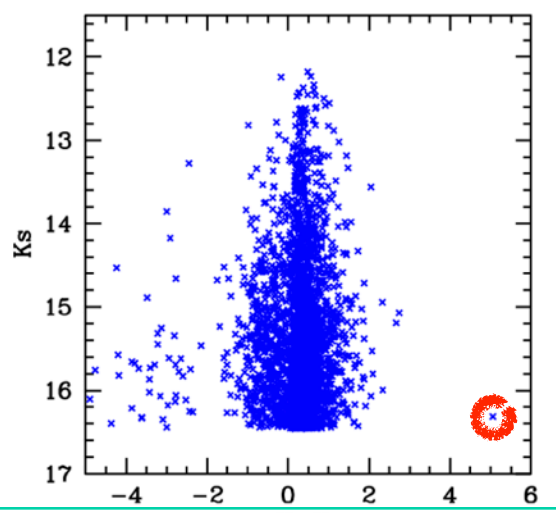
Variability: Ks

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

Proper Motions: Ks

Extreme Variables





The VVV light curves templates project

(R. Angeloni, M. Catelan, I. Dekany, et al.)

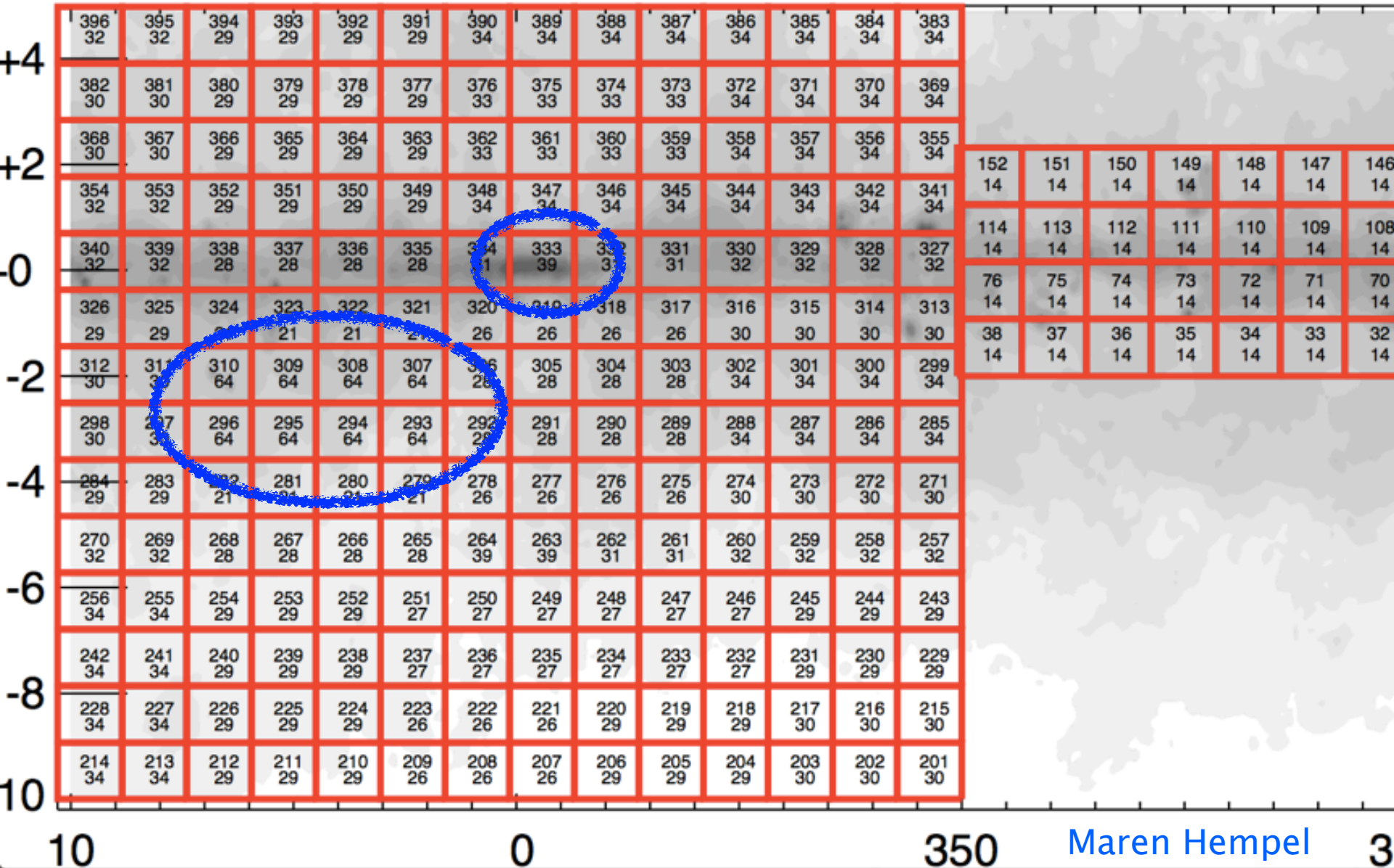
Towards an automated classification of VVV Light curves

Need to classify vast amounts of time series data, with estimated >1 million real variable objects

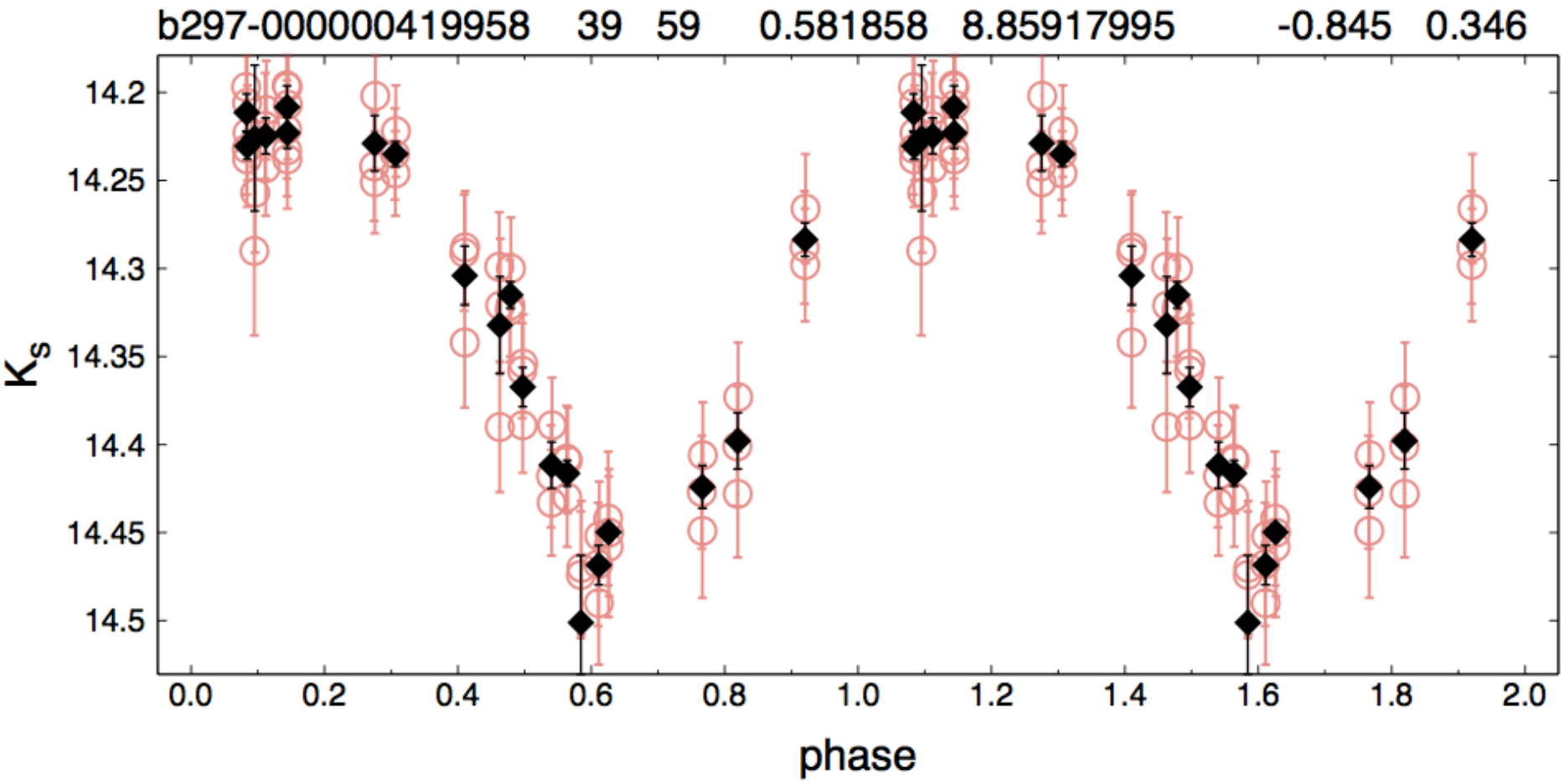
Need for high quality templates in the near-IR

Ongoing observations with a network of telescopes around the world

Number of Epochs: Bulge



Bulge RR Lyrae: P = 0.58 d



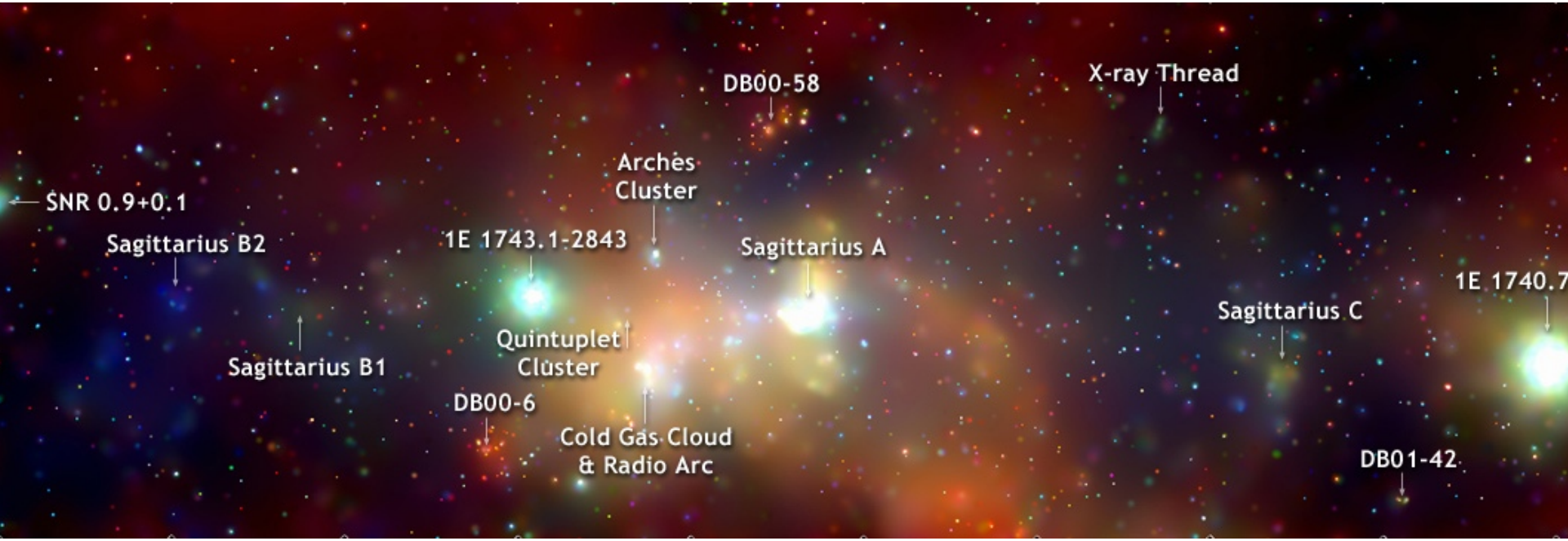
Istvan Dekany

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
Alejandra Rojas

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)

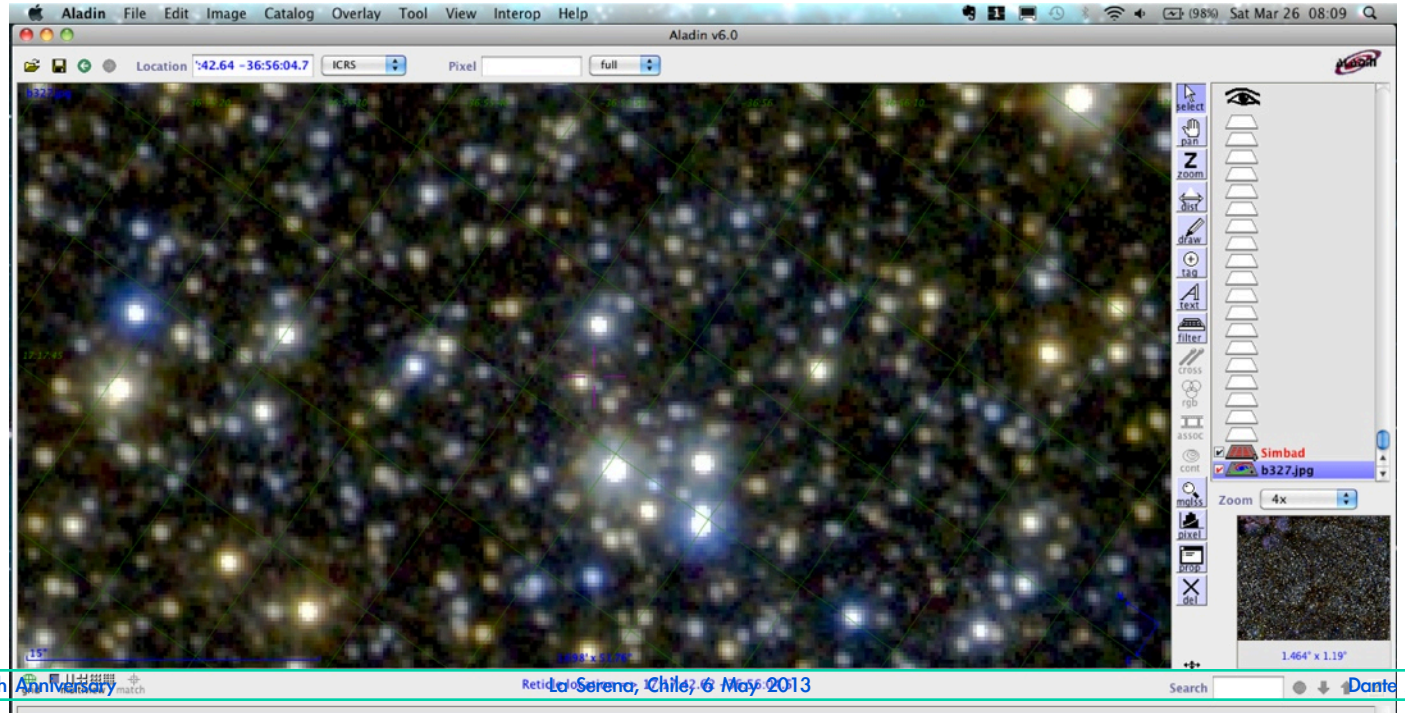
VVV near-infrared observations of the MAXI J1543-564 field

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

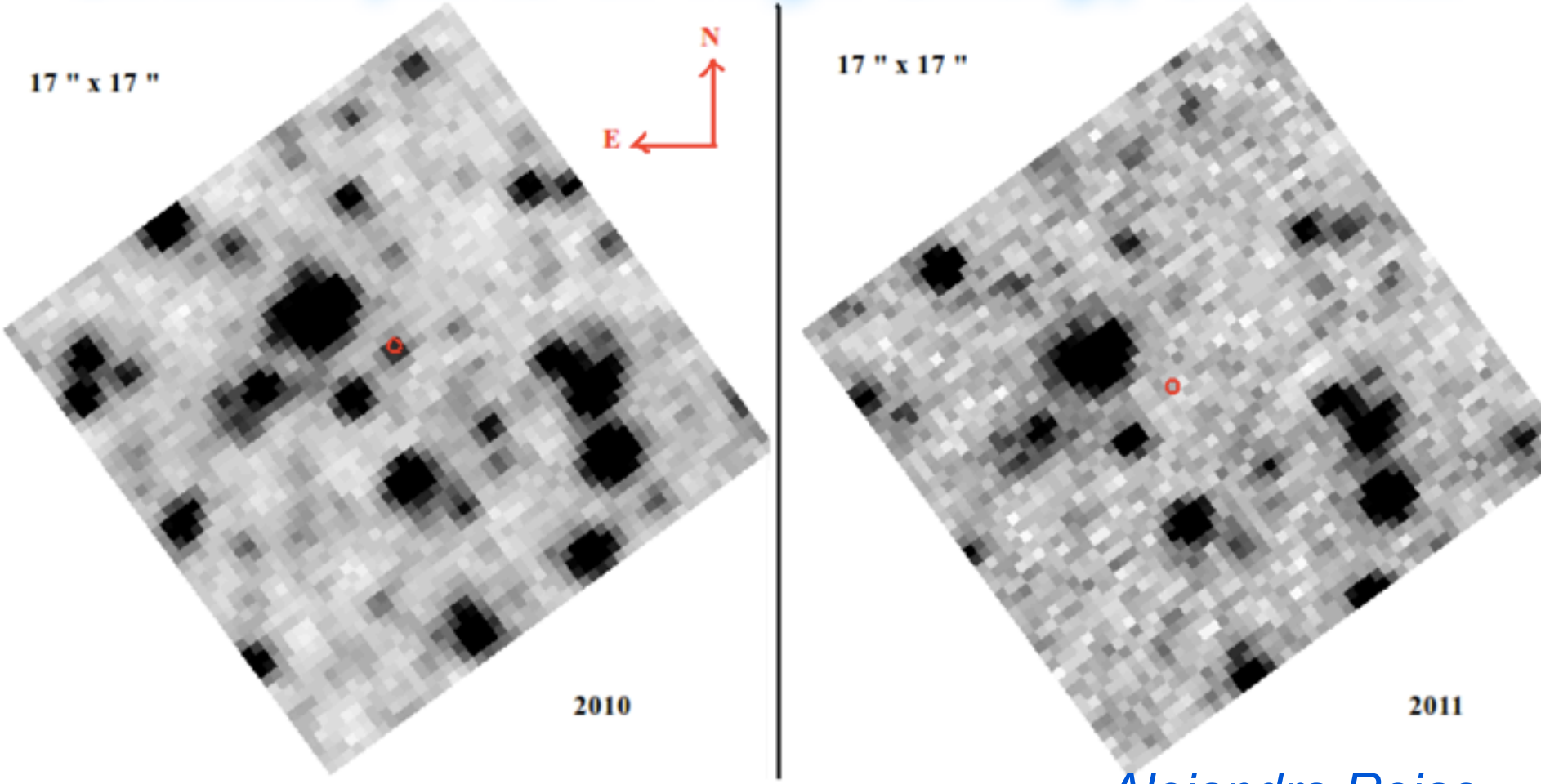
*on **23 May 2011; 11:57 UT***

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

Alejandra Rojas
Nicola Masetti



Counterparts of High Energy Sources



Alejandra Rojas

Figura 2.40: Finding Chart Ks del campo de IGR J17098-3628. El círculo rojo representa la posición precisa en Óptico (incerteza de 0.2 arcsec). **Izquierda:** observación en Ks del 22-04-2010. **Derecha:** una observación del 29-08-2011, donde la fuente no es detectada.

Búsqueda de contrapartes de fuentes de alta energía usando el survey infrarrojo VVV y espectroscopía óptica en CTIO

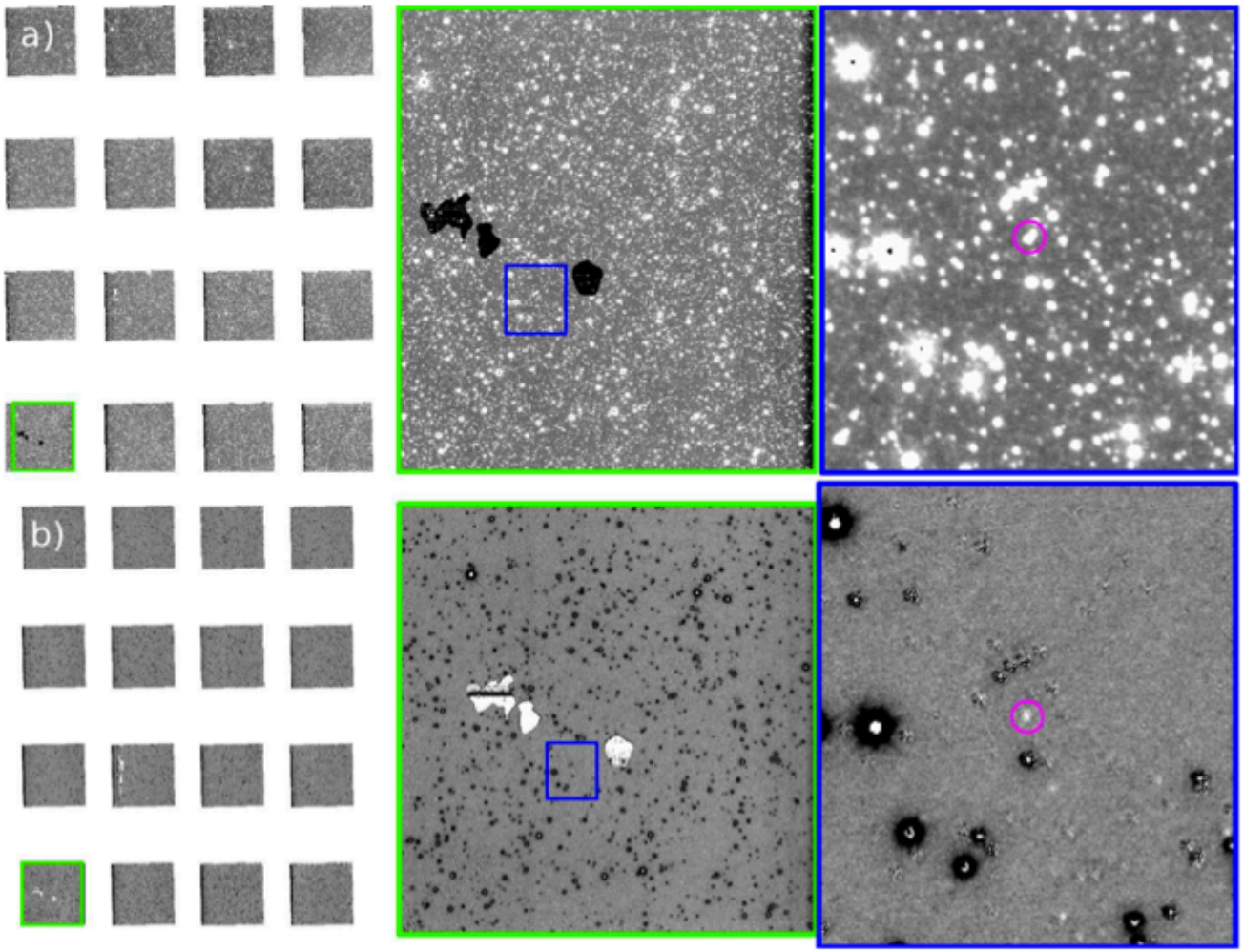
por
Alejandra Rojas Lilayú

Tesis de Magíster
Departamento de Astronomía y Astrofísica

Comisión examinadora:
Dr. Dante Minniti (Prof. guía, PUC, Chile)
Dr. Nicola Masetti (Prof. co-guía; INAF, Italia)
Dra. Isabelle Gavignaud (UNAB, Chile)
Dr. Gaspar Galaz (PUC, Chile)

26 de abril de 2013

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

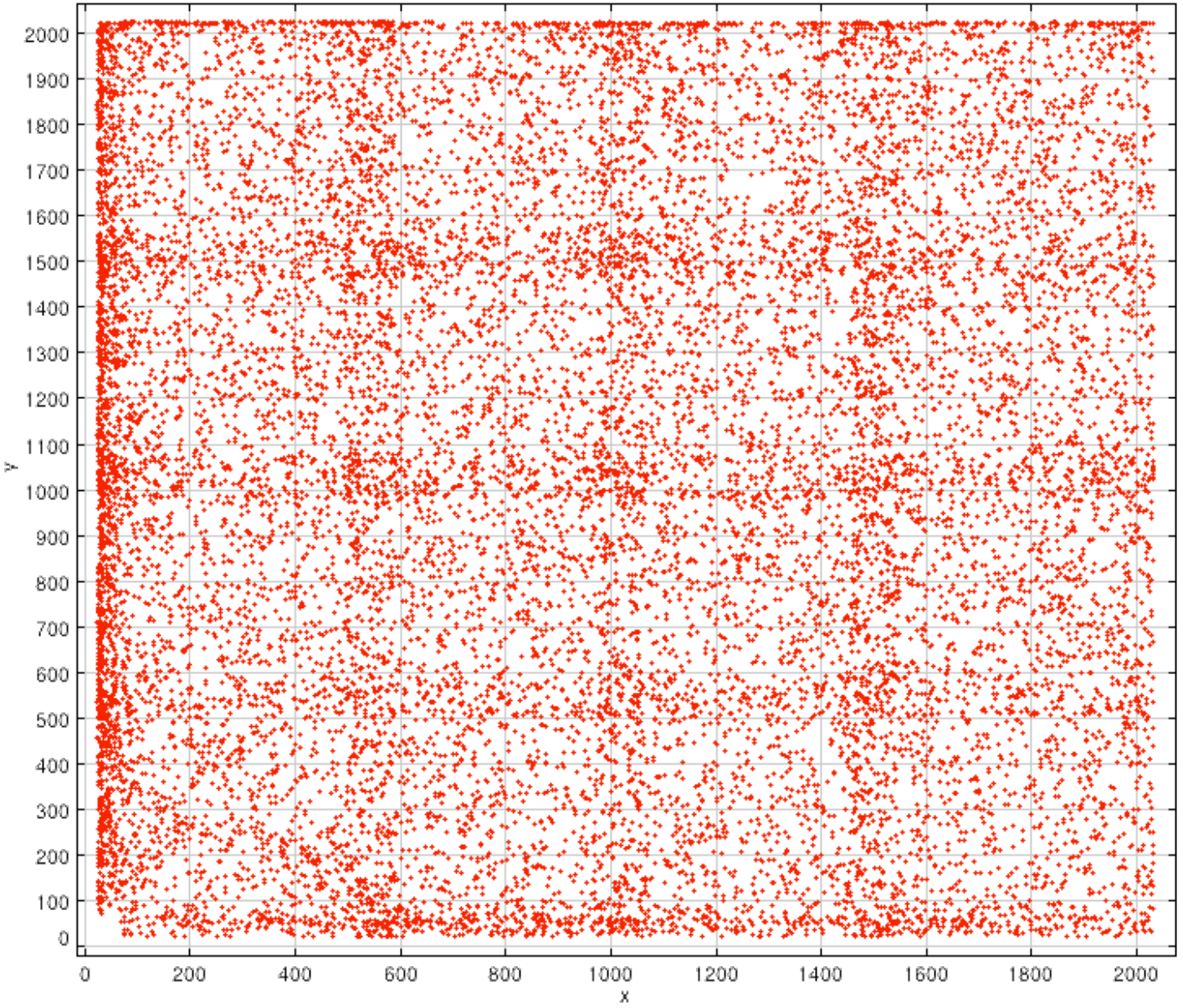
Ks-band Variability

Sep 2012:

DIA pipeline working

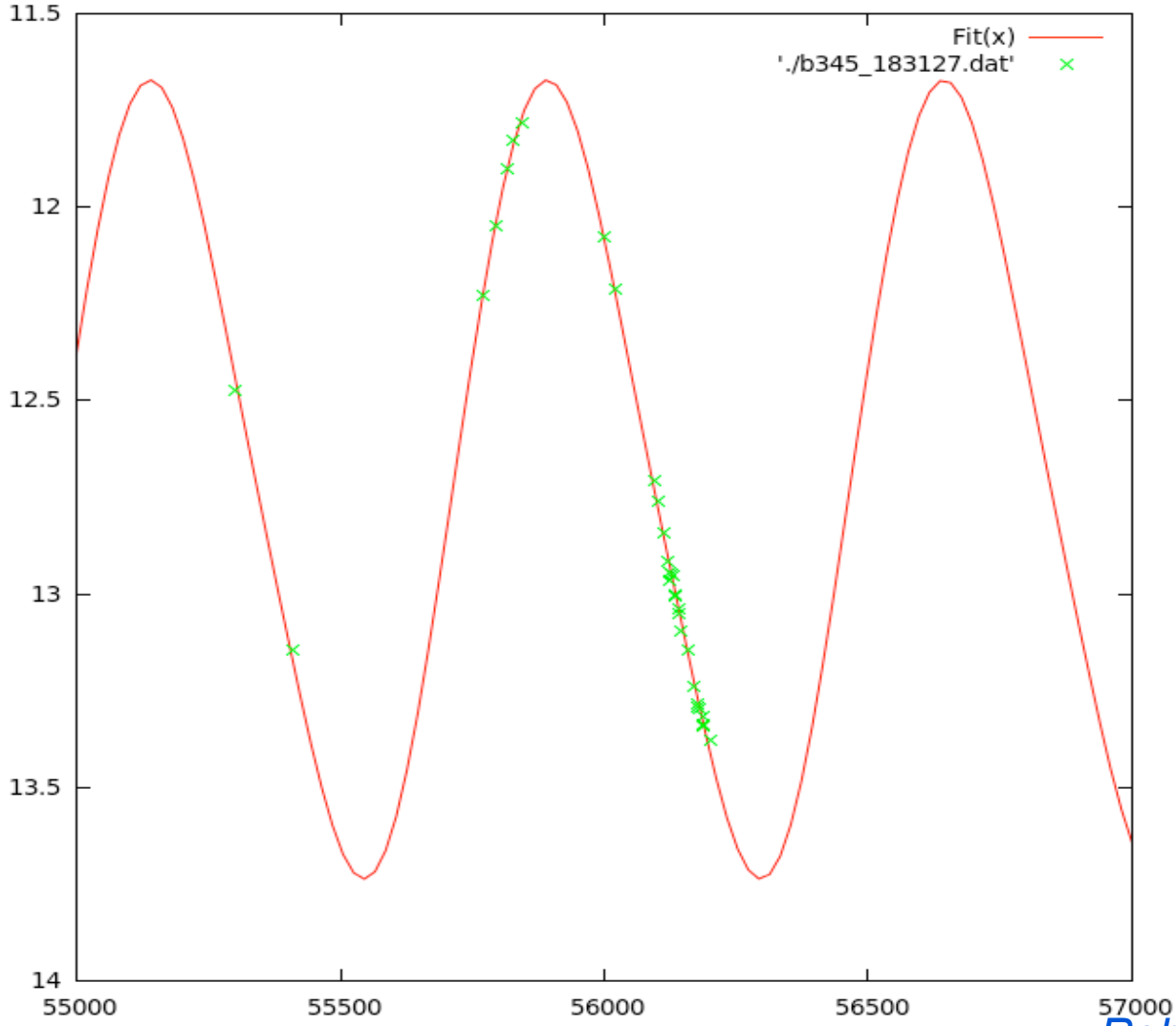
Example:

DIA Variables in tile d068



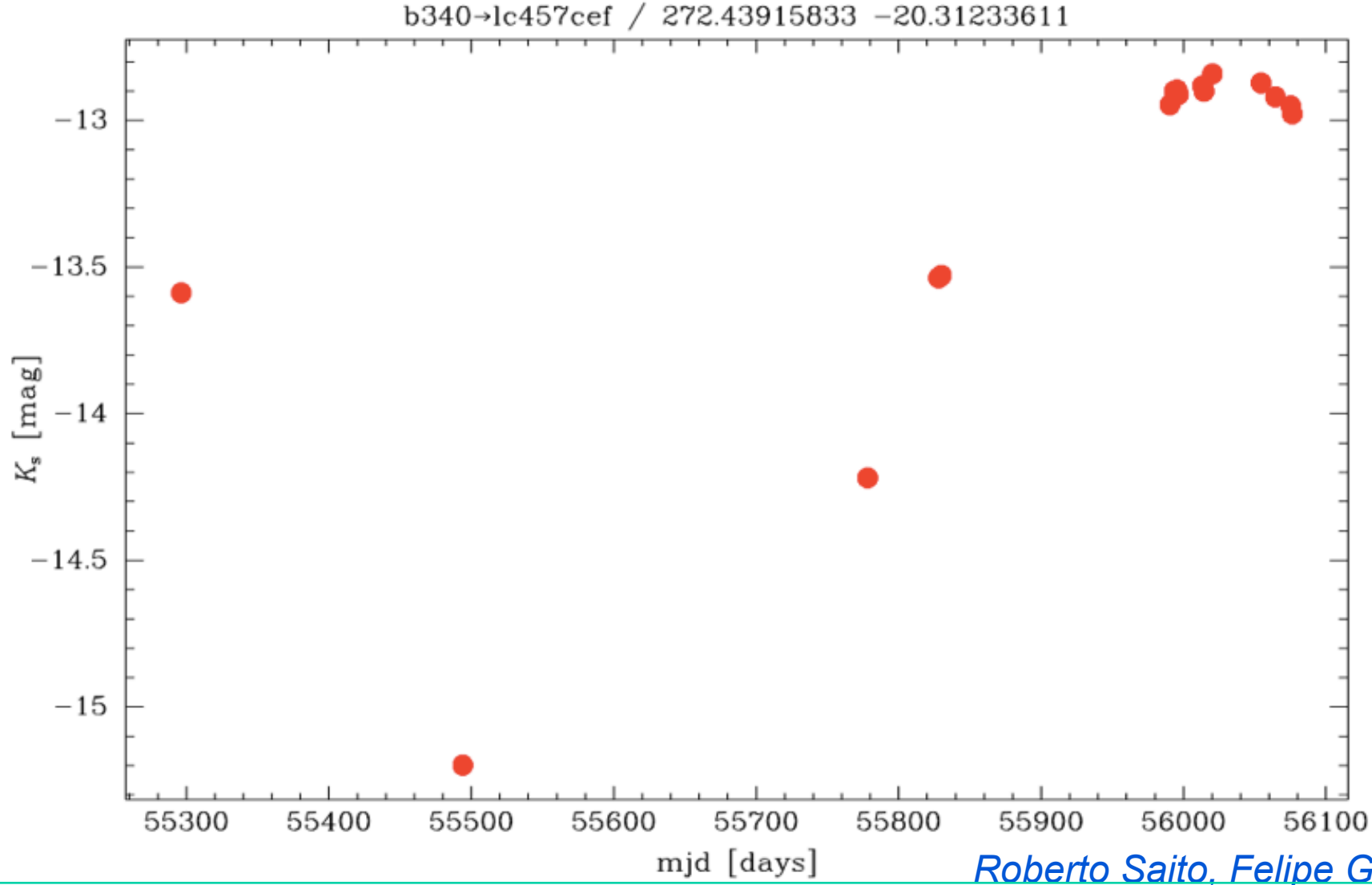
Eamonn Kerins, Leo Huckvale, Phil Lucas

Bulge LPVs: $A_K \sim 2$ mag, $P \sim 750$ d



Roberto Saito, Felipe Gran

Bulge LPVs: $A_K \sim 2$ mag, $P \sim 1{,}000$ d

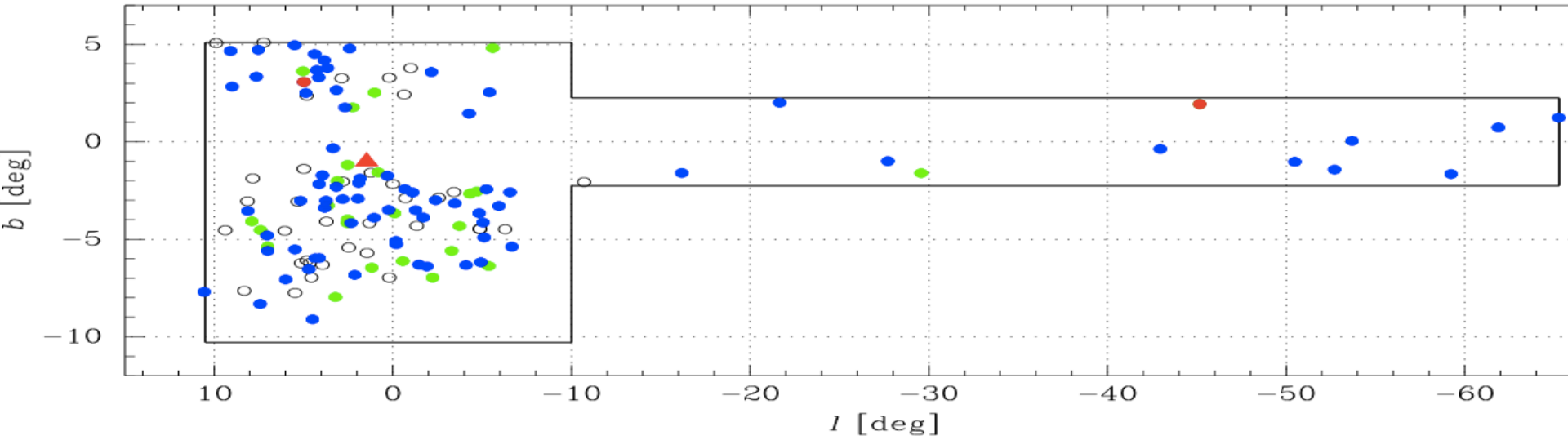


Roberto Saito, Felipe Gran

Novae

Example:

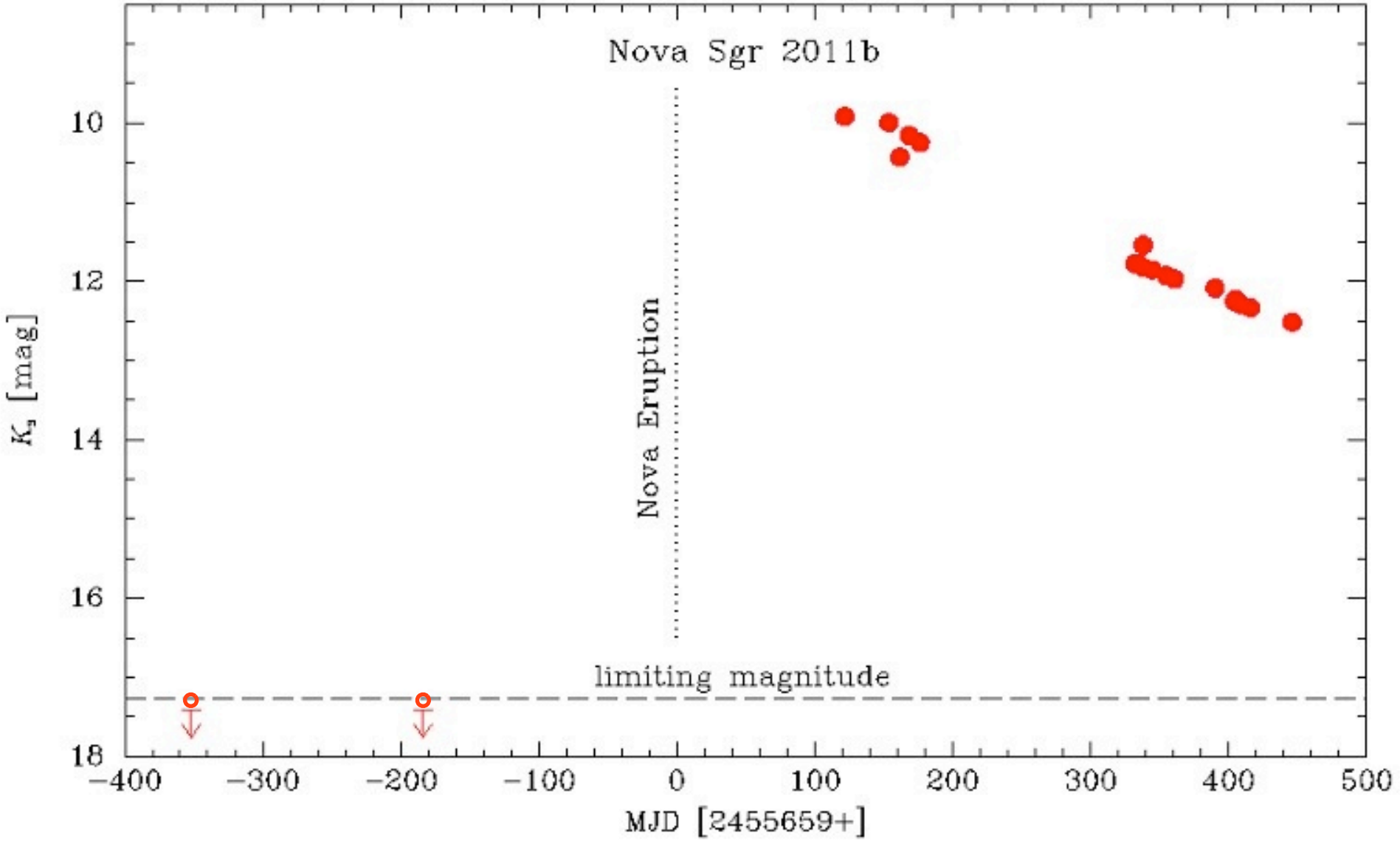
Catalog of 138 Known Galactic Novae



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 et al. 2013

Light curve for Nova Sgr 2011b



Roberto Saito et al. 2013

The Astronomer's Telegram

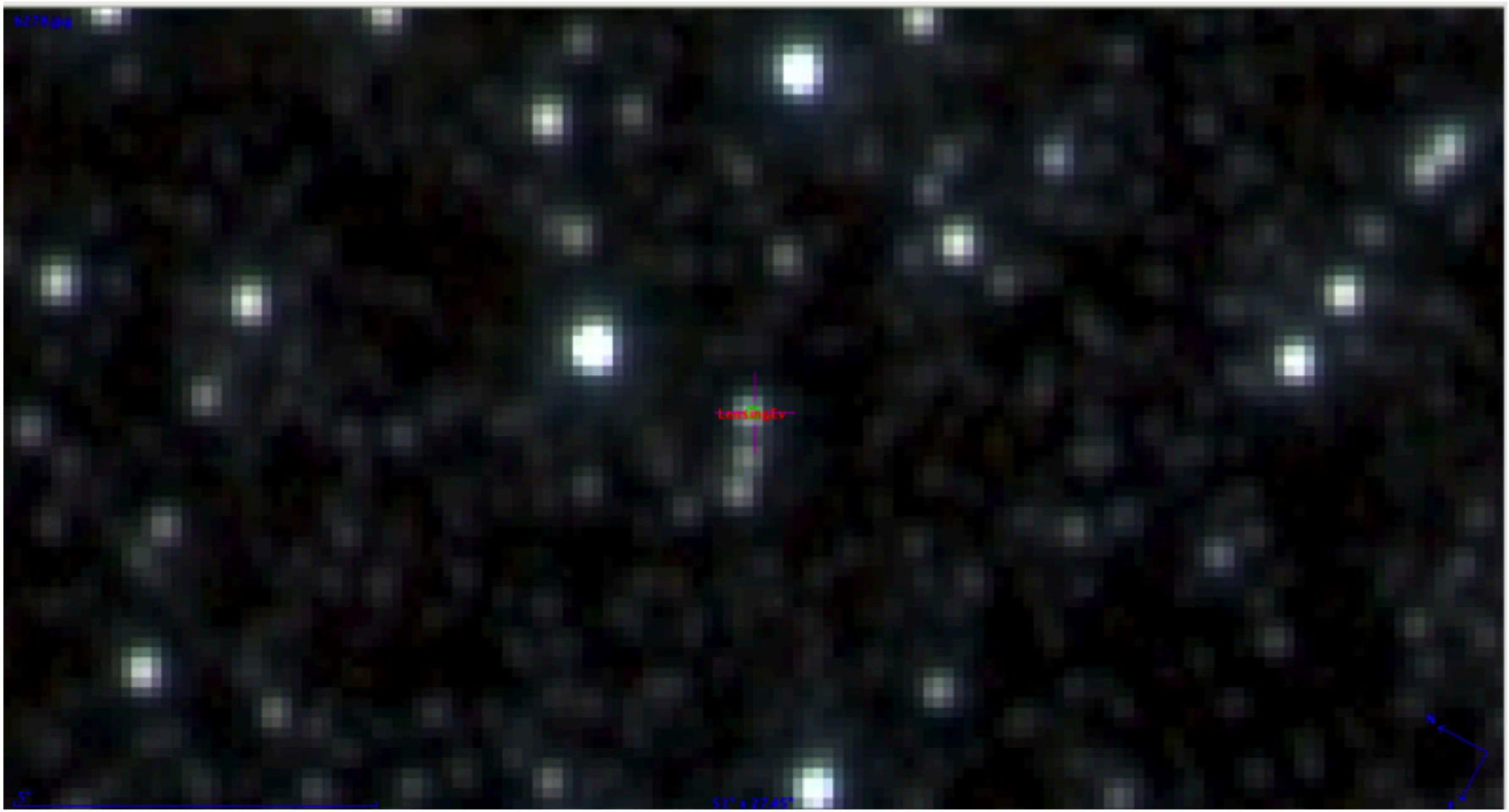
Present Time: 21 Feb 2013; 21:10 UT

VVV-NOV-002: the second Galactic nova candidate discovered in the Milky Way bulge by the VVV Survey

ATel #4830; *R. K. Saito (Pontificia Universidad Catolica de Chile, Universidad de Valparaiso, The Milky Way Millennium Nucleus), D. Minniti (Pontificia Universidad Catolica de Chile, Vatican Observatory, The Milky Way Millennium Nucleus), R. Angeloni (Pontificia Universidad Catolica de Chile) and M. Catelan (Pontificia Universidad Catolica de Chile, The Milky Way Millennium Nucleus)*
*on **21 Feb 2013; 12:30 UT***
Distributed as an Instant Email Notice Transients
Credential Certification: Roberto Saito (rsaito@astro.puc.cl)

Subjects: Infra-Red, Nova, Transient

Known microlensing events

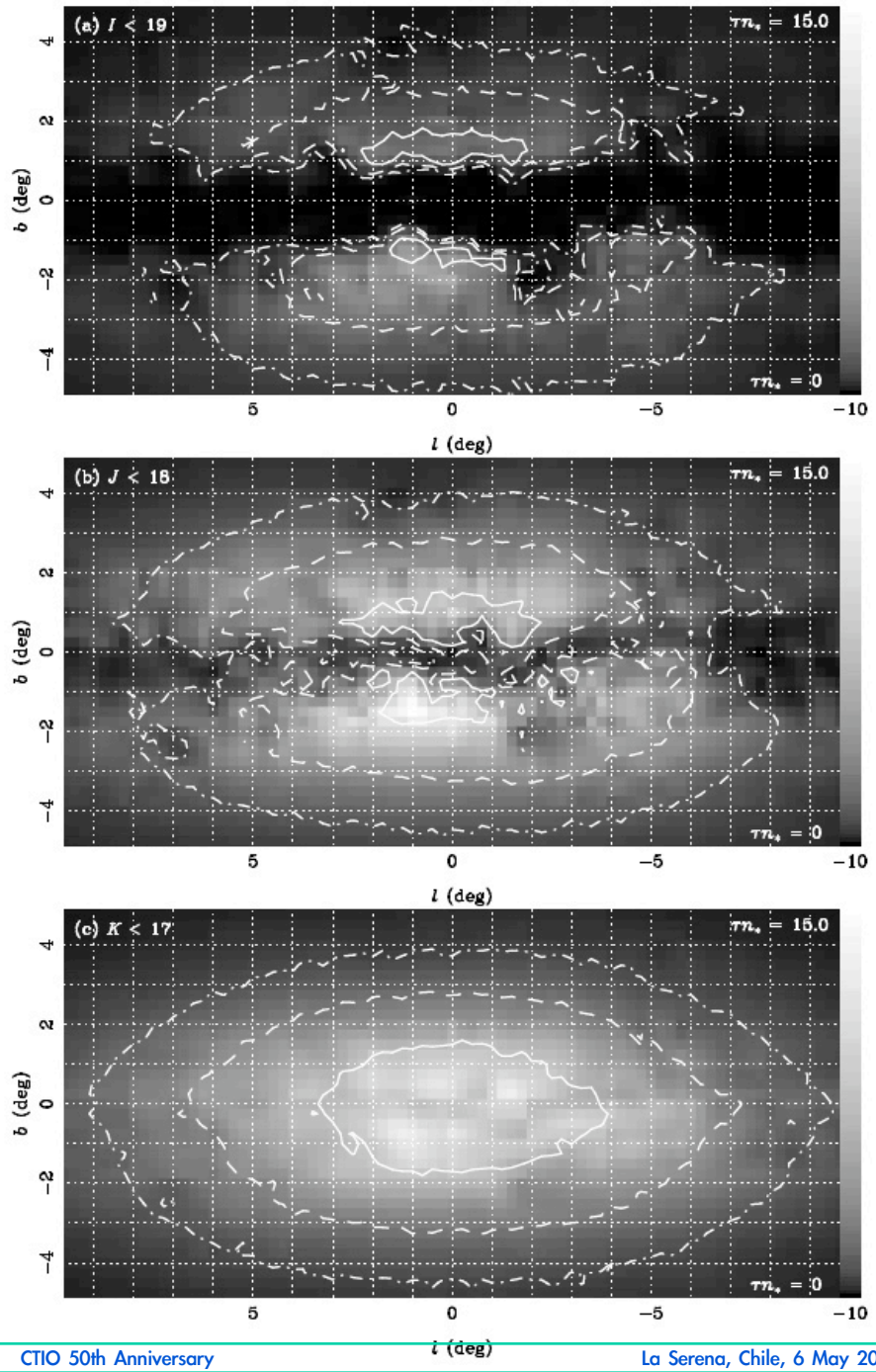


VVV will help to characterize known microlensing events, providing essential complementary data, as well as detecting new long timescale microlensing events.

Microlensing Events

Pawel Pietrukowicz et al. 2012

Optical depth



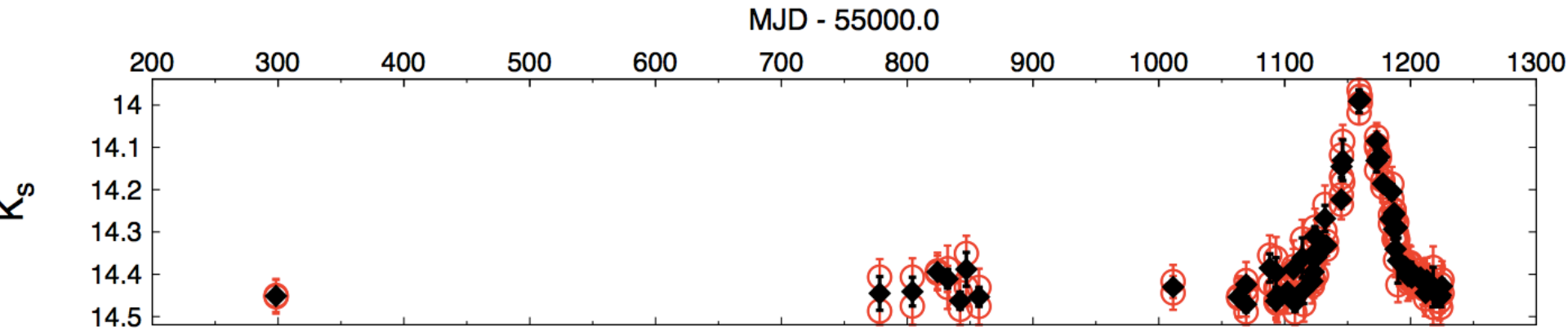
VVV will search for reddened bulge microlensing events, and produce a map of the optical depth T, tracing the 3D bulge mass distribution.

The near-IR advantage:

I, J and Ks-map event rates for sources with K<17.

Contours = 17.5, 35, 52.4 per sqdeg per year.

E. Kerins et al. 2008



Candidate Microlensing events from the VVV Survey

- serendipitous discoveries

- new approach

- proof of concept that allows us to explore the parameter space covered and plan future strategies

- complementary to optical surveys

Eamonn Kerins, Roberto Saito, Istvan Dekany, Veronica Motta, Gabriela Muro, Felipe Gran, Mario Soto, Oscar Gonzalez, Leo Huckvale ...

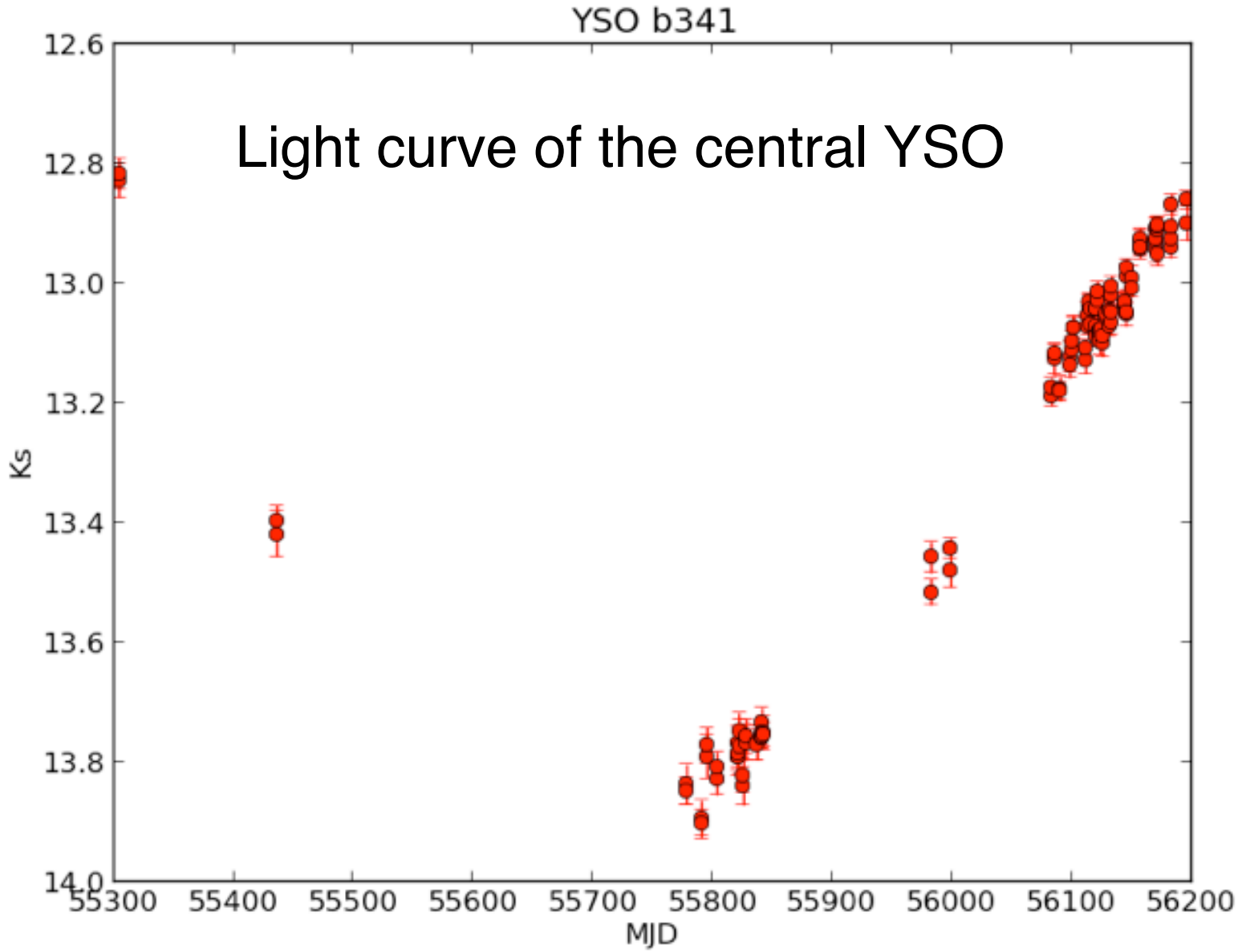
Light Echoes of Bursting YSOs

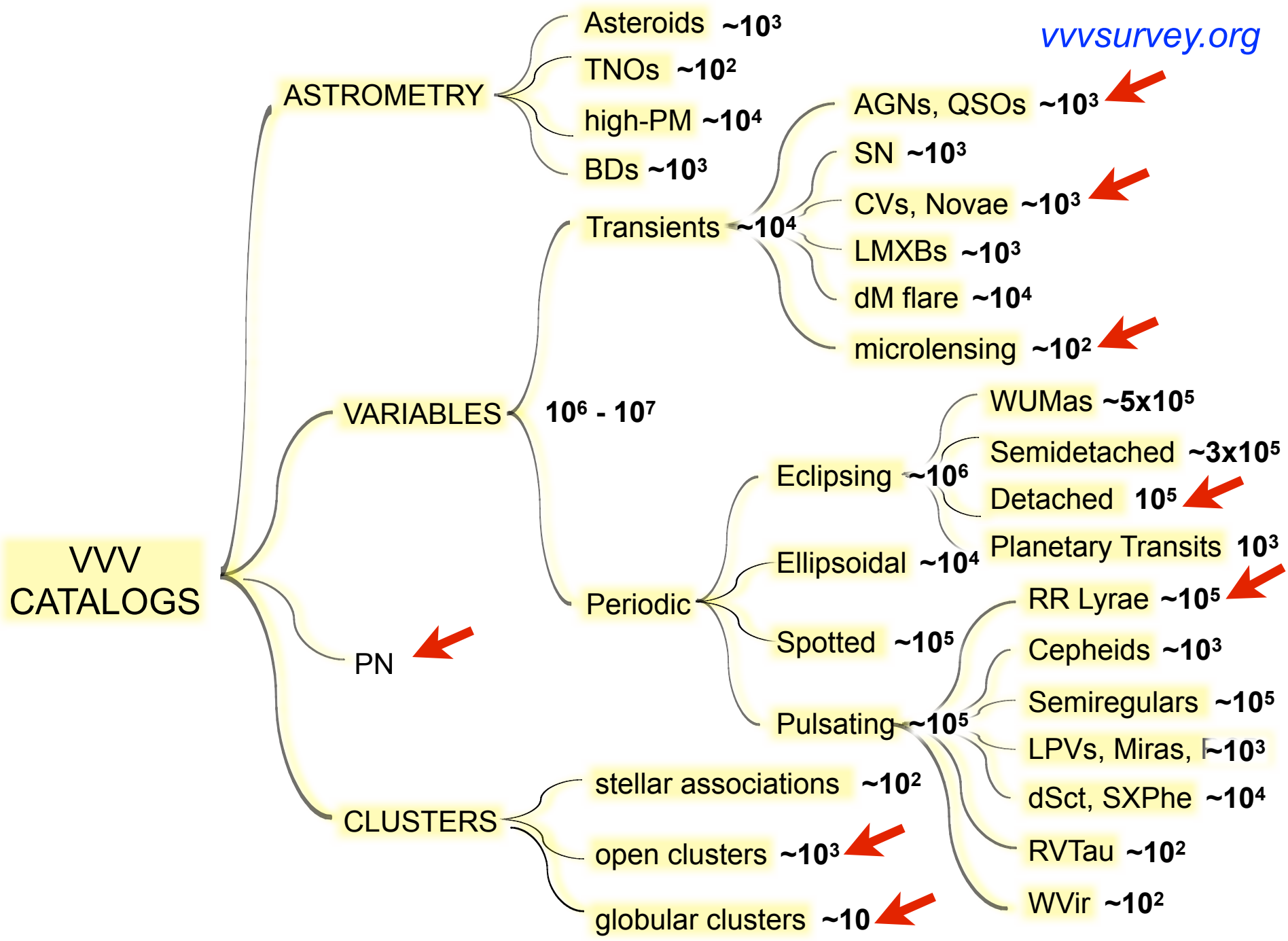
Real color image of YSO and nebula at one epoch

Light Echoes of Bursting YSOs

Light echo: changing nebula illumination at 3 epochs

Light Echoes of Bursting YSOs




vvvsurvey.org
VVV CATALOGS
ASTROMETRY
Asteroids ~10^3
TNOs ~10^2
high-PM ~10^4
BDs ~10^3
VARIABLES
10^6 - 10^7
Transients ~10^4
AGNs, QSOs ~10^3
SN ~10^3
CVs, Novae ~10^3
LMXBs ~10^3
dM flare ~10^4
microlensing ~10^2
Periodic
Eclipsing ~10^6
WUMas ~5x10^5
Semidetached ~3x10^5
Detached 10^5
Planetary Transits 10^3
Ellipsoidal ~10^4
Spotted ~10^5
Pulsating ~10^5
RR Lyrae ~10^5
Cepheids ~10^3
Semiregulars ~10^5
LPVs, Miras, ~10^3
dSct, SXPhe ~10^4
RVTau ~10^2
WVir ~10^2
PN
CLUSTERS
stellar associations ~10^2
open clusters ~10^3
globular clusters ~10

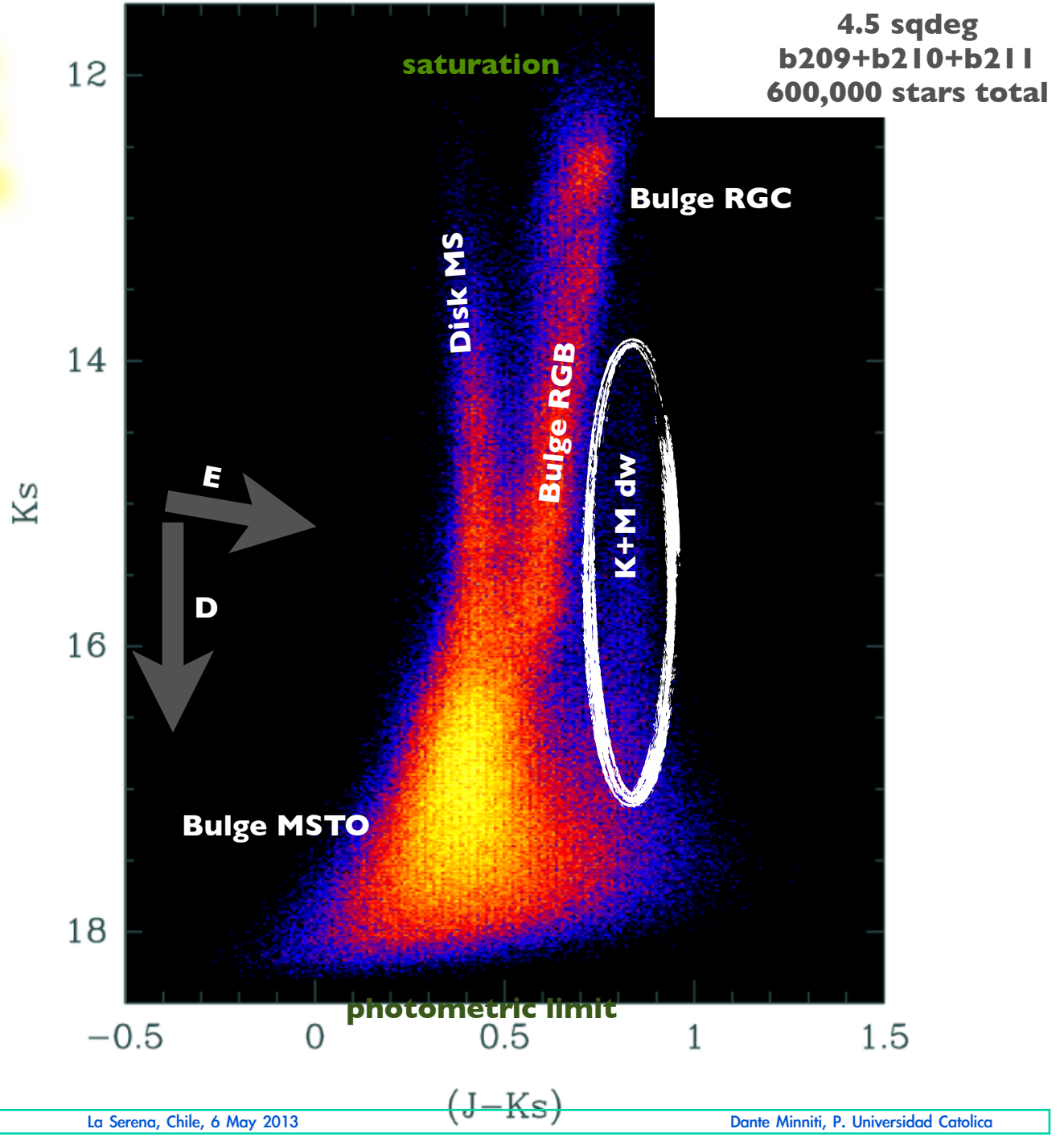
VVV

Exoplanets

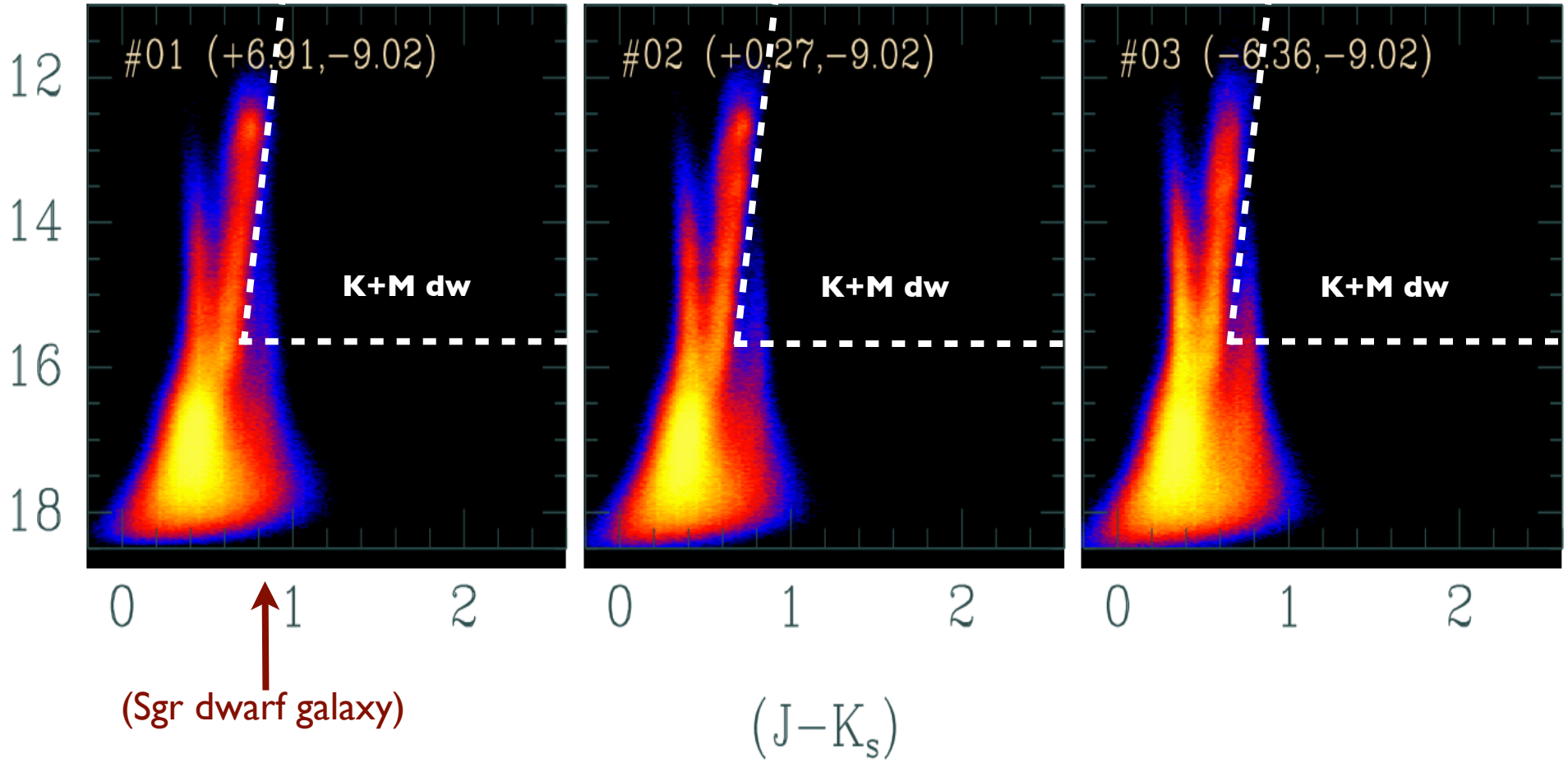
SEARCH FOR TRANSITING EXTRASOLAR PLANETS

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,
Daniela Paz et al.



Selection of nearby late-type stars (spectral types K5 to M)



Late K + M dwarfs N ~ 500,000 with Ks < 16.5
(n ~ 20,000 good candidates per field, 10% of all sources)
Proper motions after a few years (~7 mas/yr)

The VVV Stages

Multicolor Photometry: ZYJHKs

Variability: Ks

Proper Motions: Ks

Nearby stars, BDs, TNOs, Hyper-Velocity Stars...

Proper Motions

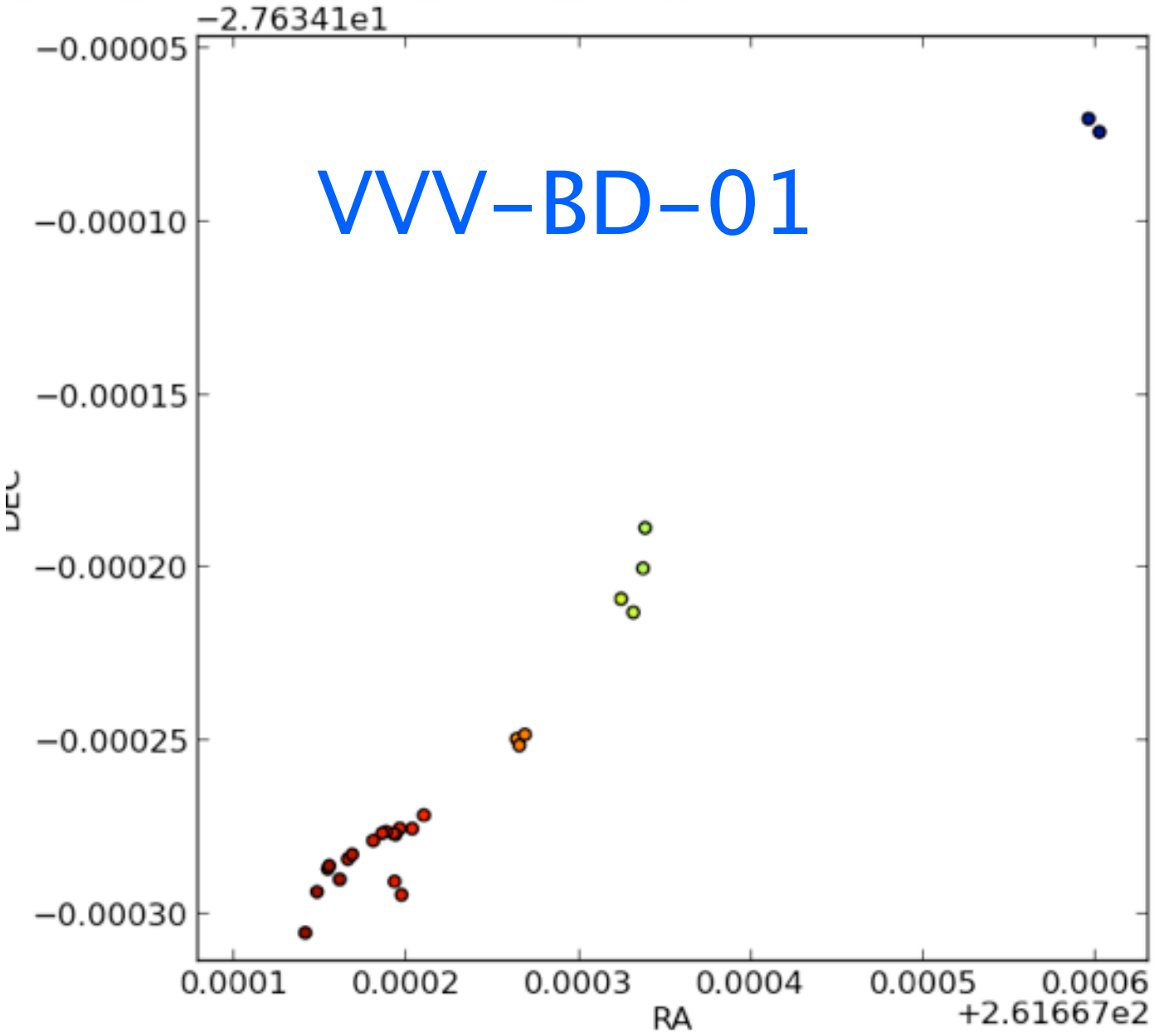
Juan Carlos Beamin

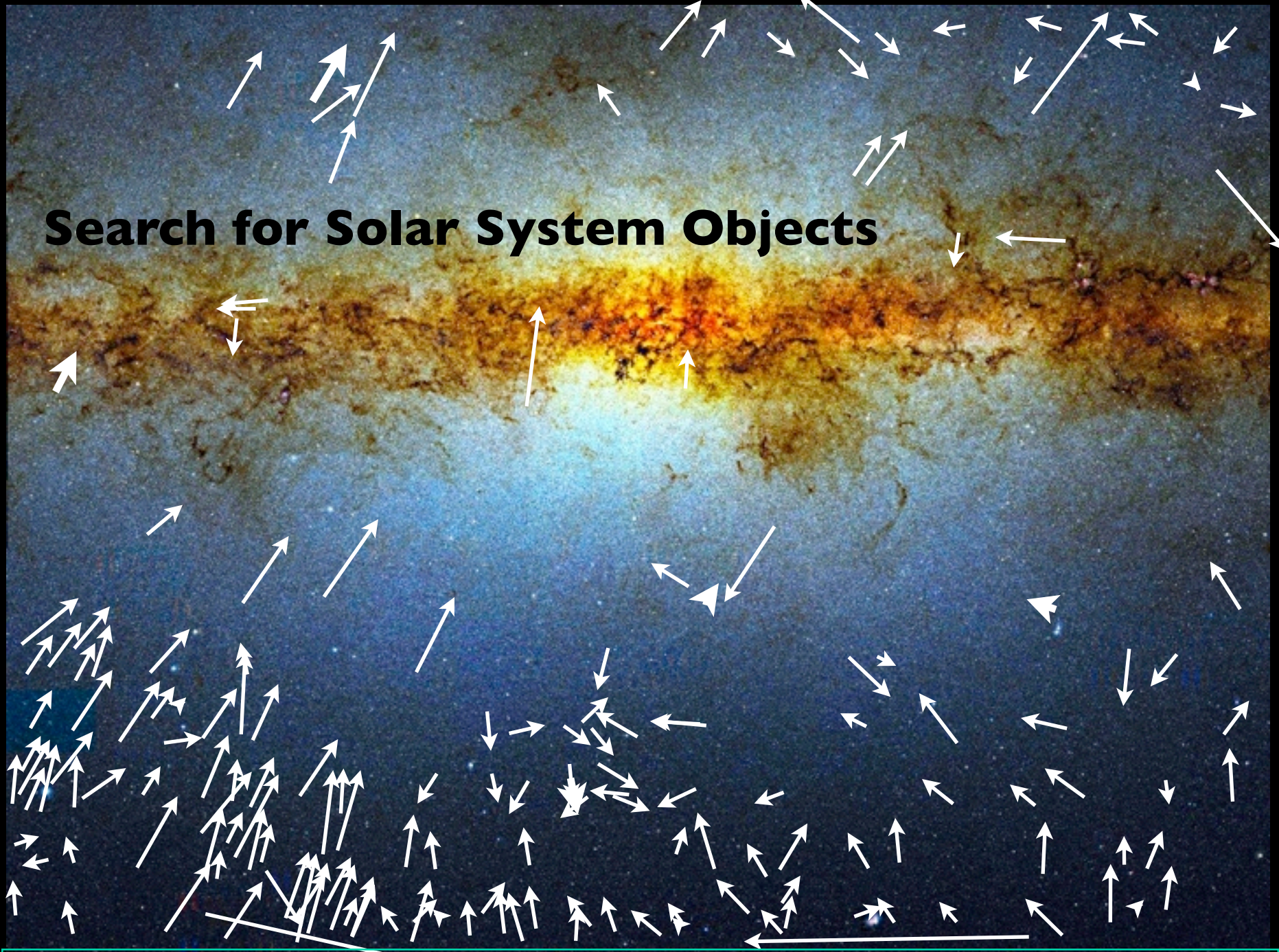
Proper Motions

Search for Brown Dwarfs

Juan Carlos Beamin, Mariusz Grakzyk,
Rudy Kurtev, Valentin Ivanov, et al.

Search for Brown Dwarfs




Search for Solar System Objects

Quasars

The VVV Stages

Multicolor Photometry: ZYJHKs

Star clusters, stellar populations, extinction, metallicities...

Variability: Ks

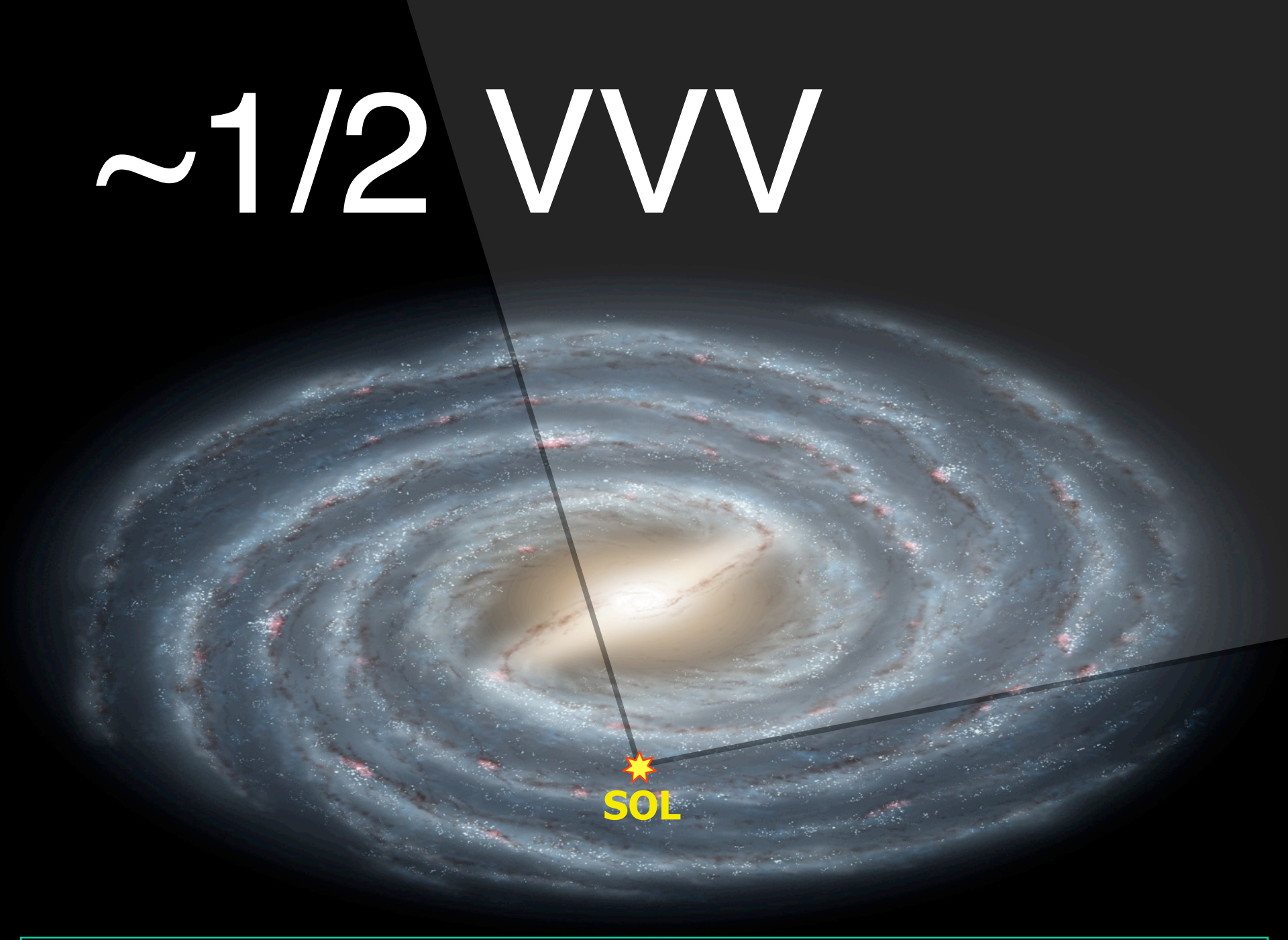
LPVs, Cepheids, RR Lyrae, Binaries, Microlensing...

Proper Motions: Ks

Nearby stars, BDs, TNOs, Hyper-Velocity Stars...

VVV Outreach

~1/2 VVV



Conclusions

- We are about 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.

- We are preparing for 

!!!

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