VVV Survey

V. D. Ivanov (ESO) and the VVV(X)/VMC teams

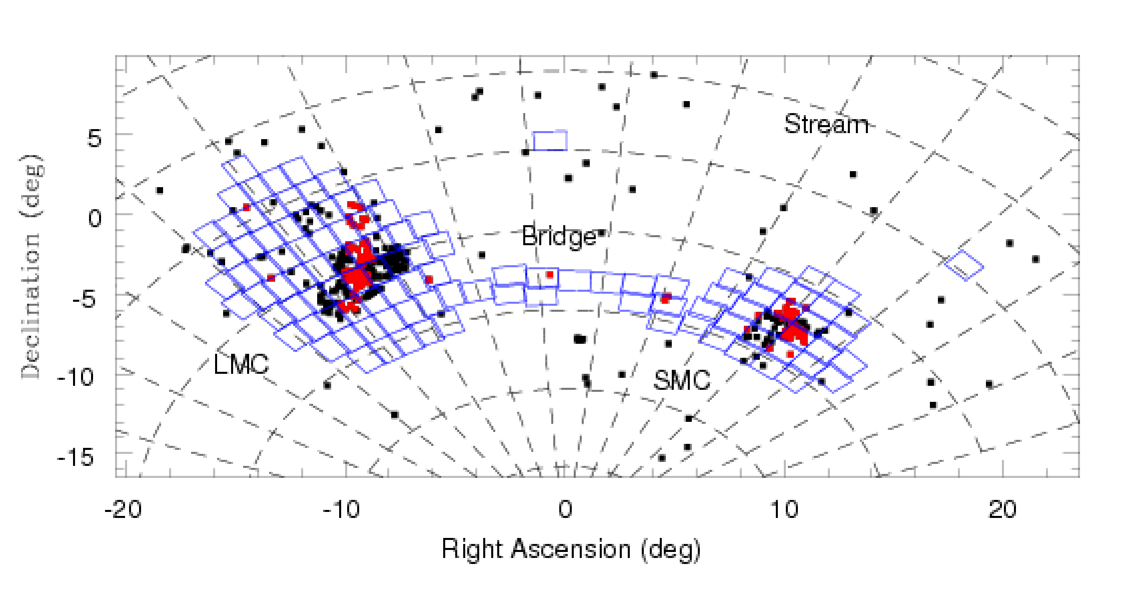
PIs:

VVV: Dante Minniti (Univ. de Catholica)

and Phil Lucas (Univ. of Hertfordshire)

VMC: Maria Rosa Cioni (AIP)

15.02.2018, ESAC



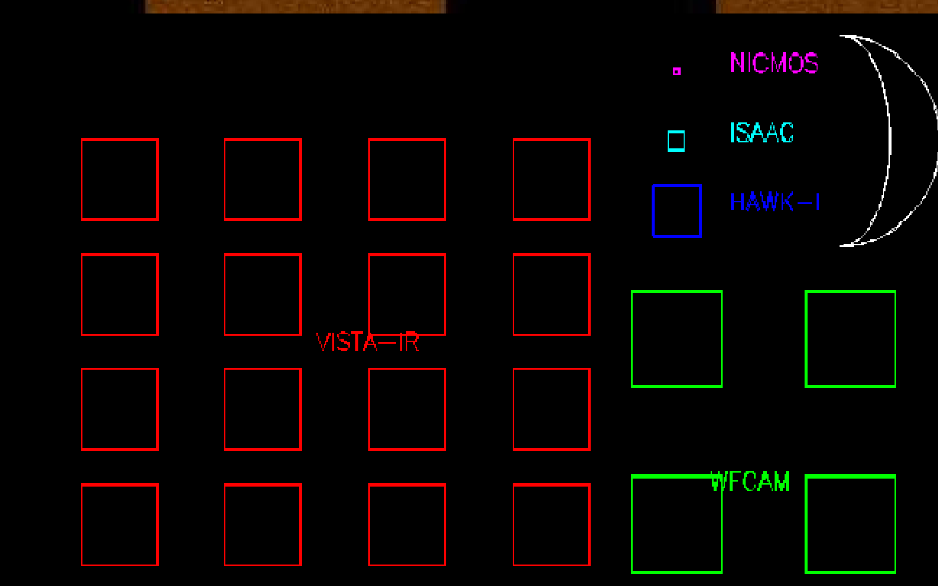
VISTA the telescope

4.1-m
f-ratio 3.25
FOV 1.65 deg,
mean scale 0.34 arcsec/px

Built by an UK consortium (QMUL et al.)

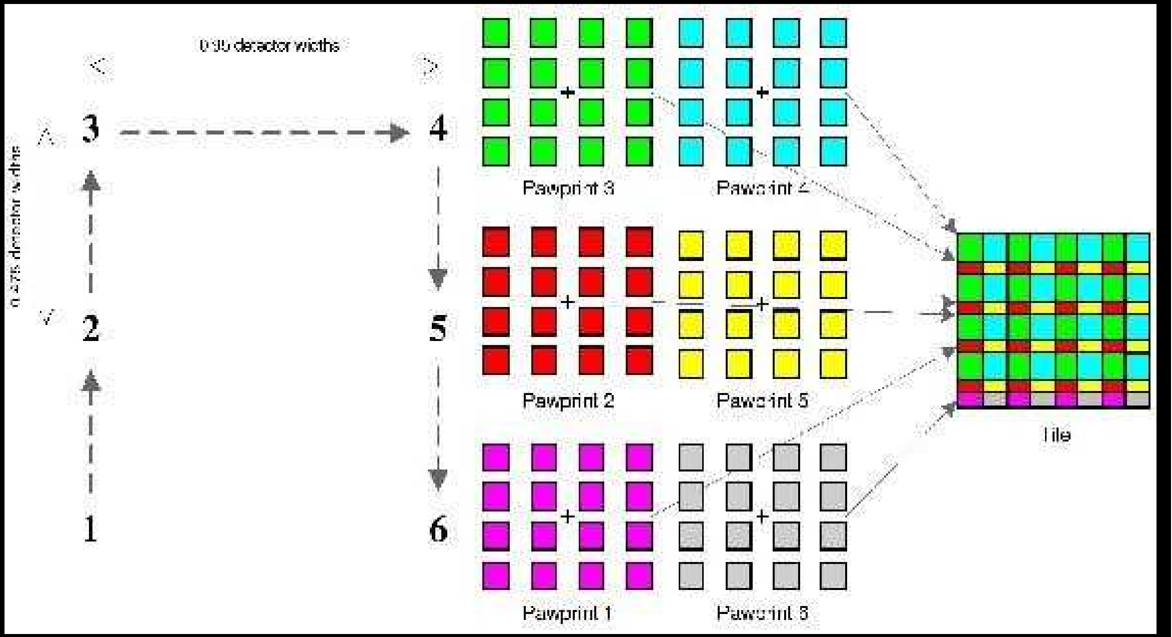
VVV allocation: 193 nights over 5 (7) years

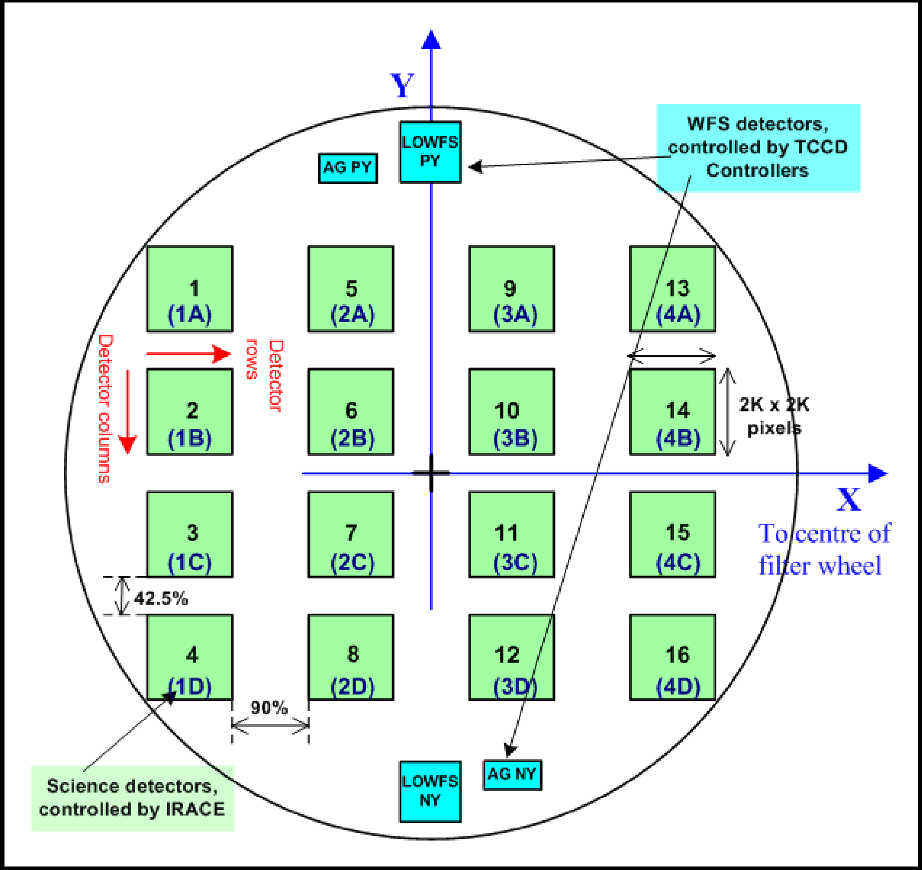
16 VIRGO detectors, 2048x2048 px each, populating ~1x1.5 deg of the focal lane



From Pawprints to Tiles

6 pointings (="paw prints")
to form a contiguous "tile"

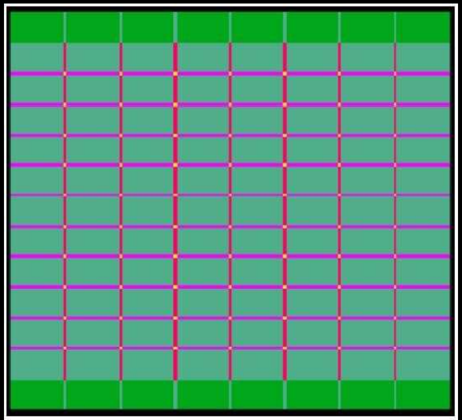




Exposure time coverage (on the right) for a contiguous-coverage tile of 6 pawprints:

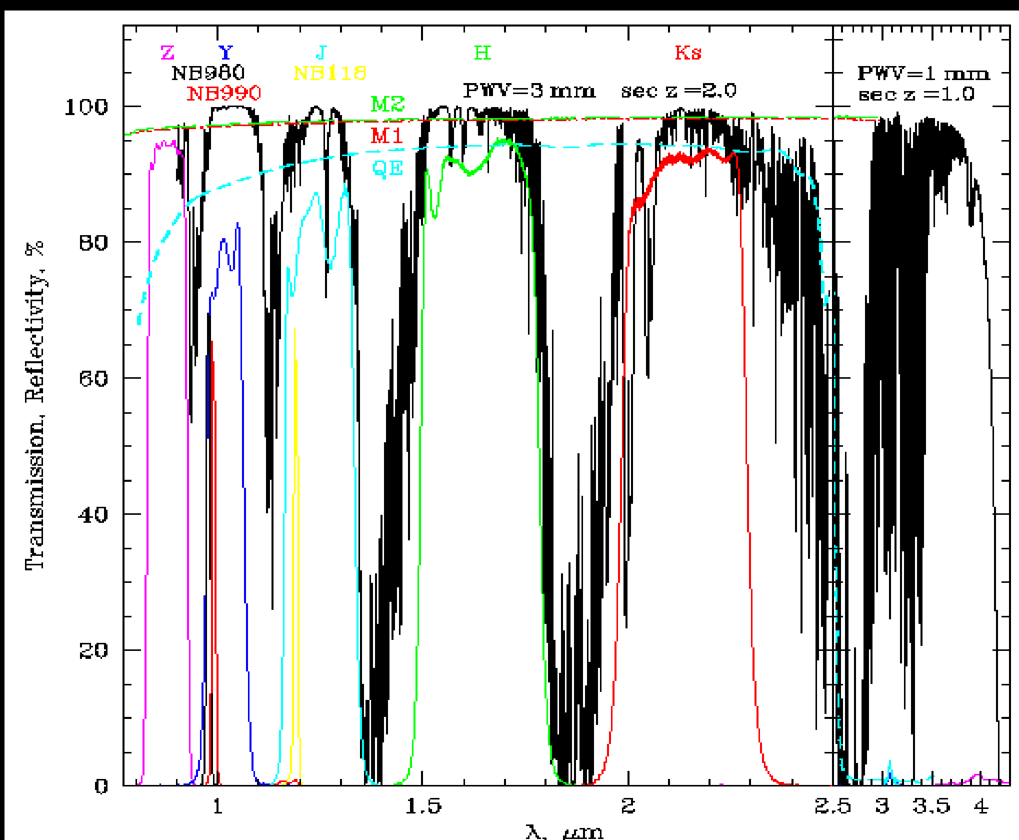
dark green = 1,
light green = 2,
magenta = 3,
red = 4,
yellow = 6.

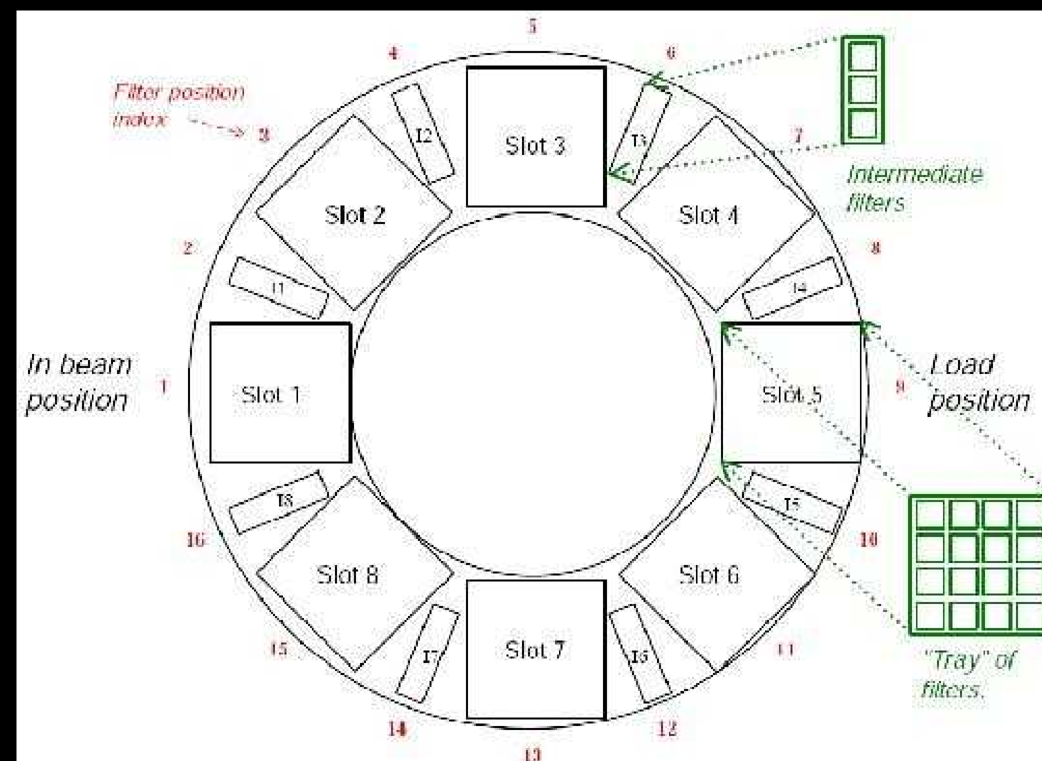
In units of the single-pawprint exposure time.



VIRCAM the camera

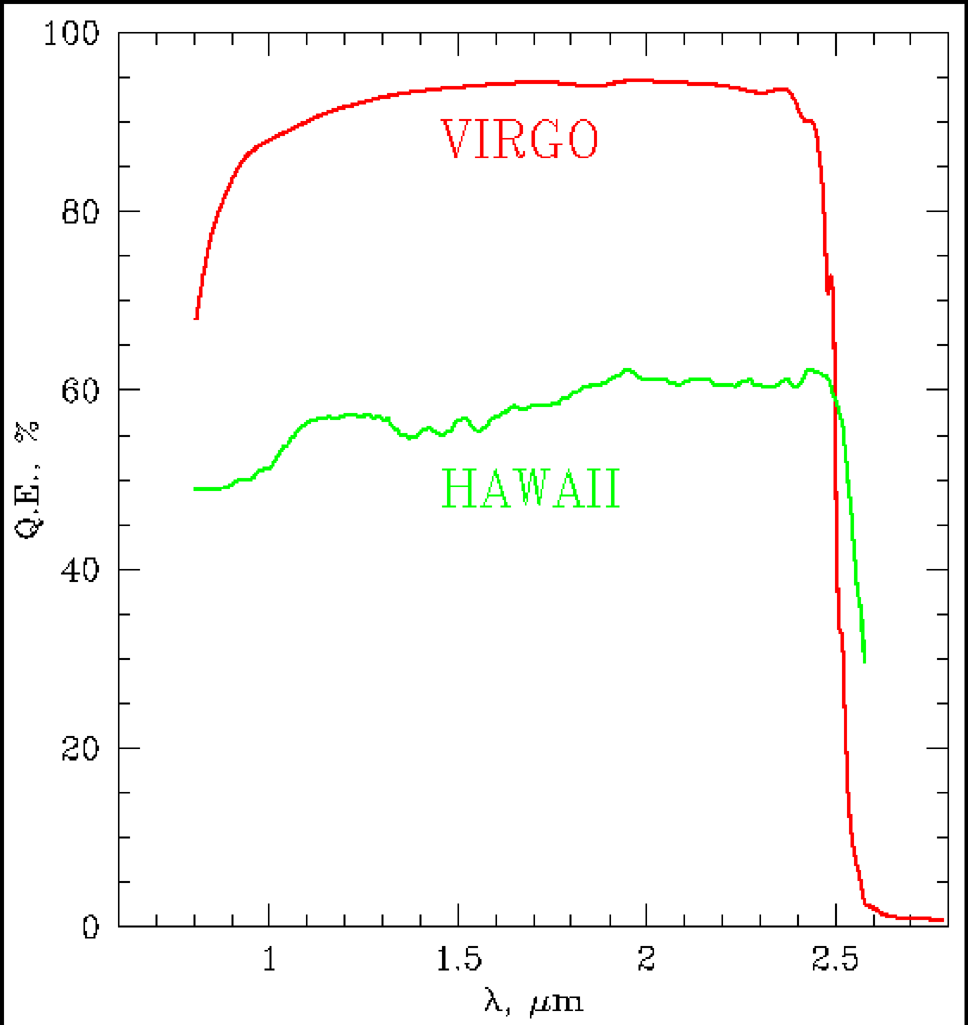
- Filters: ZYJHKs, NB980+NB990, NB118 + visitor's filters (?)

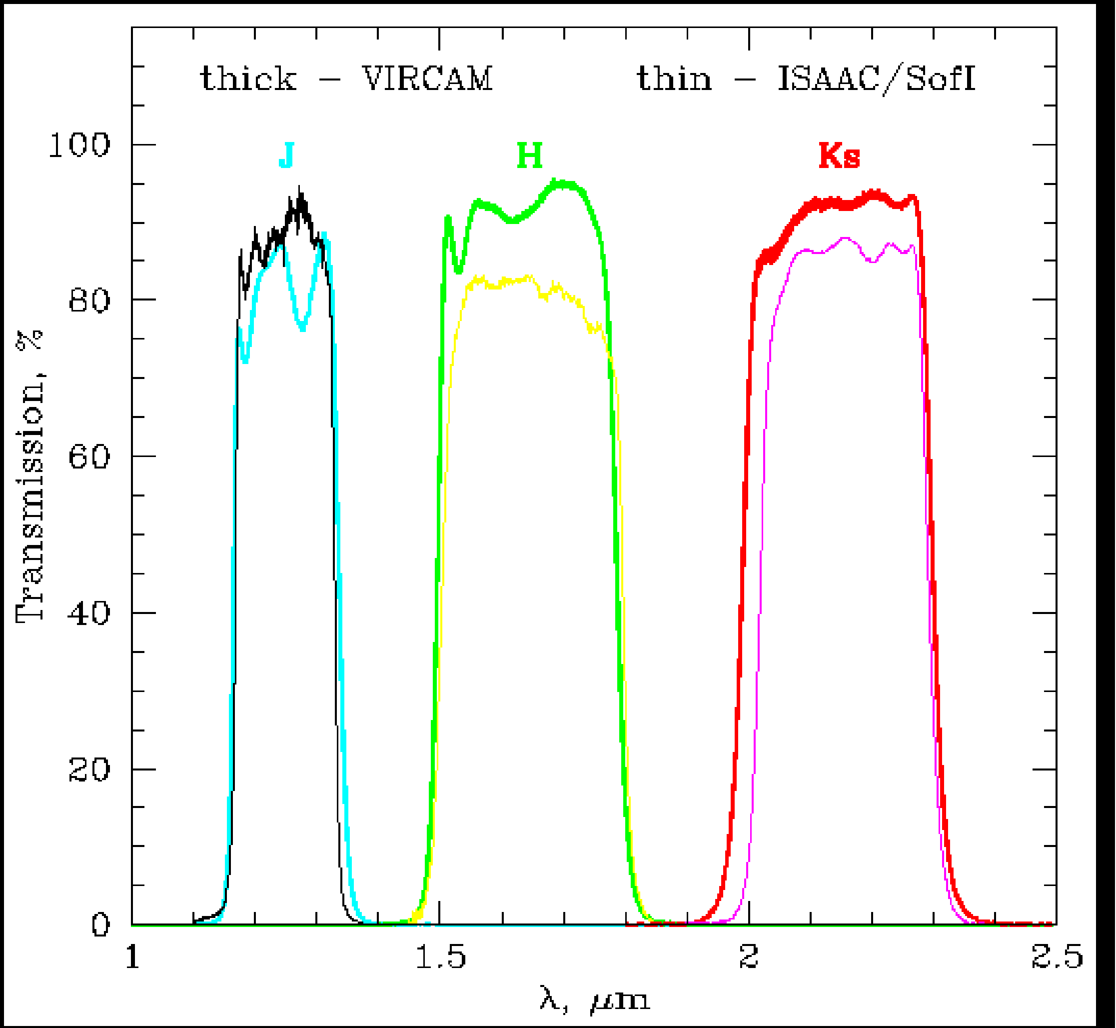




Advanced Hardware

Product of many years of gradual technological improvement:





OPERATIONAL OPTIMIZATION

Back to the future of the semi-classical observing or SciOps 2.0 at VISTA:

--- **no dedicated full night-time support astronomer**

--- **the (super-)TIOs run VISTA (!!!) and do on-the-fly ground-zero QC**

--- the Shift Coordinator prepares the night (flats, std, 1-2 hrs of science)

--- Quality control on the fly (scripts + ftp opslogs + Garching)

--- Intelligent tools: SADT, OT3, Calchecker, pipeline+scripts

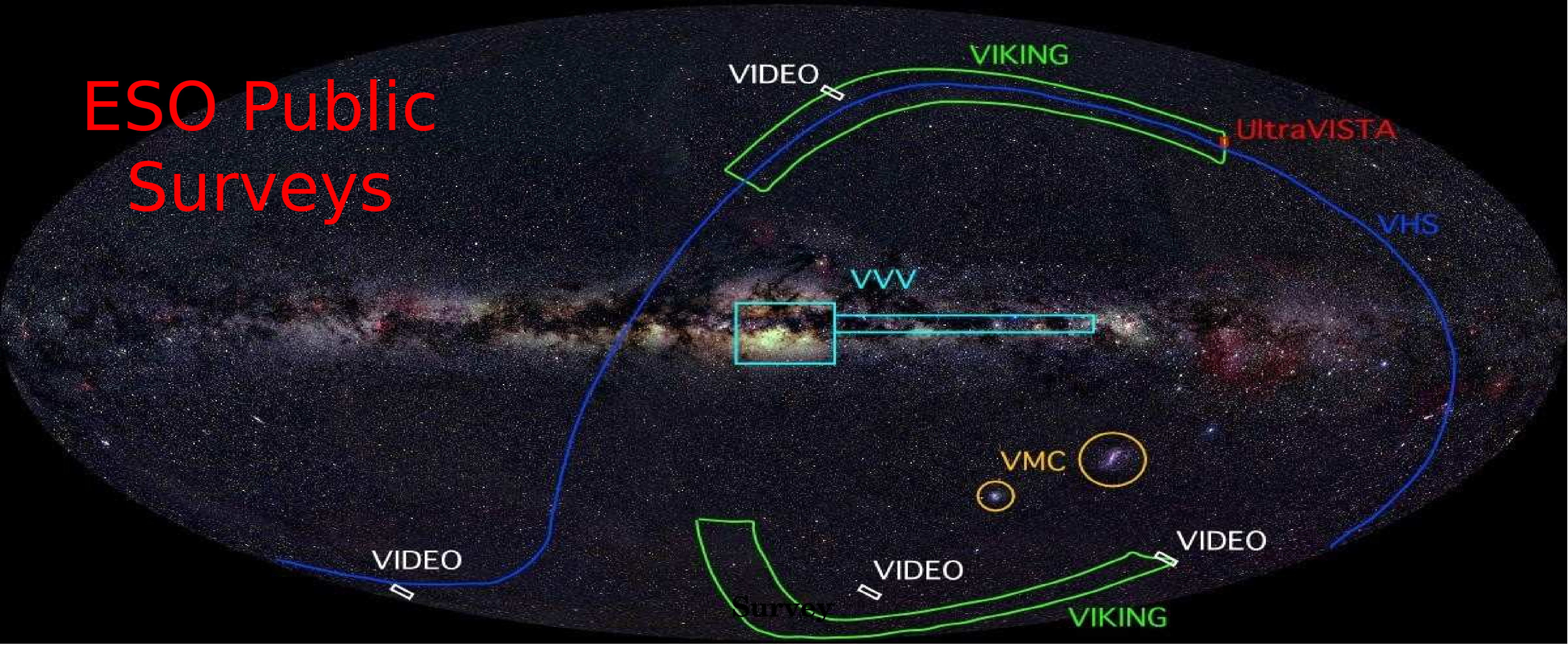
Why?

--- VIRCAM is a simple single-mode instrument

--- only 6+ programs (albeit, many OBs), for now

--- no visitors

ESO Public Surveys



VMC - VISTA Magellanic Survey : PI Maria-Rosa Cioni (Edinburgh) -- This survey will image 184 sq.degr of the Magellanic System, i.e., the LMS, SMC, the Bridge, and the Magellanic Stream in YJKs. Multi-epoch observations will constrain the mean magnitude of short-period variables. The survey will be used to study resolved stellar populations, the star formation history of the system as well as to trace its 3D structure.

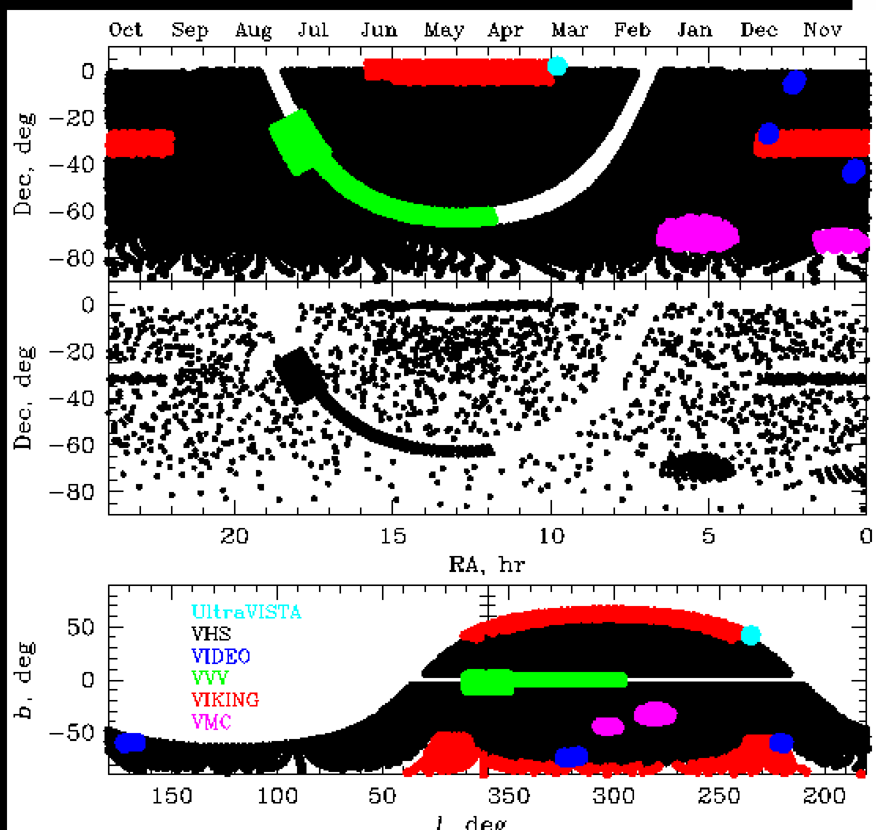
VHS - VISTA Hemisphere Survey : PI Richard McMahon (Cambridge) -- The VHS will image 20 000 sq.degr of the Southern Sky (exception areas covered by the other surveys) in JKs, 4 mag deeper than 2MASS and DENIS. The 5000 square degrees covered by the Dark Energy Survey (DES), another imaging survey scheduled to begin in 2010 at the CTIO 4 metre Blanco telescope, will also be observed in H-band. The area around both of the Galactic Caps will be observed in YH as well to be combined with the data from the VST ATLAS survey. The main science drivers of the VHS include: examining low mass and nearby stars, studying the merger history of the Galaxy, measuring the properties of Dark Energy through the examination of large-scale structure to a redshift of ~1, and searches for high redshift quasars.

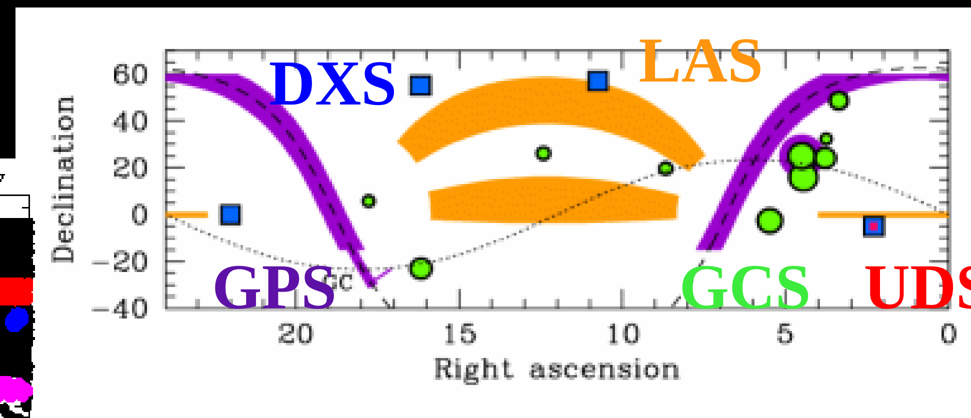
VISTA survey observing strategies			
Survey	**Area (deg^2)**	**Filters and Depth Measure(mag (10σ, AB)**	**Depth (mag)**
Ultra-VISTA	0.73 (ultra-deep)	5α, AB	Y=26.7 J=26.6 H=26.1 K_s=25.6 NB=24.1
VIKING	1500	5α, AB	Z=23.1 Y=22.3 J=22.1 H=21.5 K_s=21.2
VMC	184	10α, Vega	Y=21.9 J=21.4 Ks=20.3
VVV	520	5α, Vega	Z=21.9 Y=21.2 J=20.2 H=18.2 K_s=18.1
VHS	20 000	5α, AB	Y=21.2 Y=21.2 J=21.2 H=20.6 Ks=20.0
VIDEO	15	5α, AB	Z=25.7 Y=24.6 J=24.5 H=24.0 K_s=23.5

UltraVISTA : PIs Jim Dunlop (Edinburgh), Marijn Franx (Leiden), Johan Fynbo (Copenhagen), Olivier LeFevre (Marseilles) -- Ultra-VISTA aims to image one patch of the sky (the COSMOS field) in YJHKs filters plus one NB at Lyα emitters at z~8.8 (~30 are expected to be found). The science goals are: first galaxies, the stellar mass build-up during the peak epoch of star formation activity, and dust obscured star formation.
VIDEO - VISTA Deep Extragalactic Observations Survey : PI Matt Jarvis (Hertfordshire) -- VIDEO is a 15 sq.degr ZYJHKs survey to study galaxy evolution as a function of epoch and environment to redshift of ~4 using AGNs, galaxy cluster evolution, and very massive galaxies. Four fields: CDFS, XMM-Newton LSSS, ISO fielf , and a new field. VIDEO is intermediate between the wide/shallow VIKING and the small/deep Ultra-VISTA.
VIKING - VISTA Kilo-Degree Infrared Galaxy Survey : PI Will Sutherland (Cambridge) -- The VIKING survey provides an NIR complement to the optical KIDS project. VIKING will image the same 1500 sq.degr of the sky in ZYJHKs to a limiting magnitude 1.4 mag deeper than the UKIDSS LAS. The main goal is to obtain accurate photometric redshifts, (z > 1), important for weak lensing analysis and observation of baryon acoustic oscillations. Other goals: hunt for high redshift quasars, galaxy clusters, and the study of galaxy stellar masses.

Wide Infrared Milky Way Surveys

VISTA Surveys



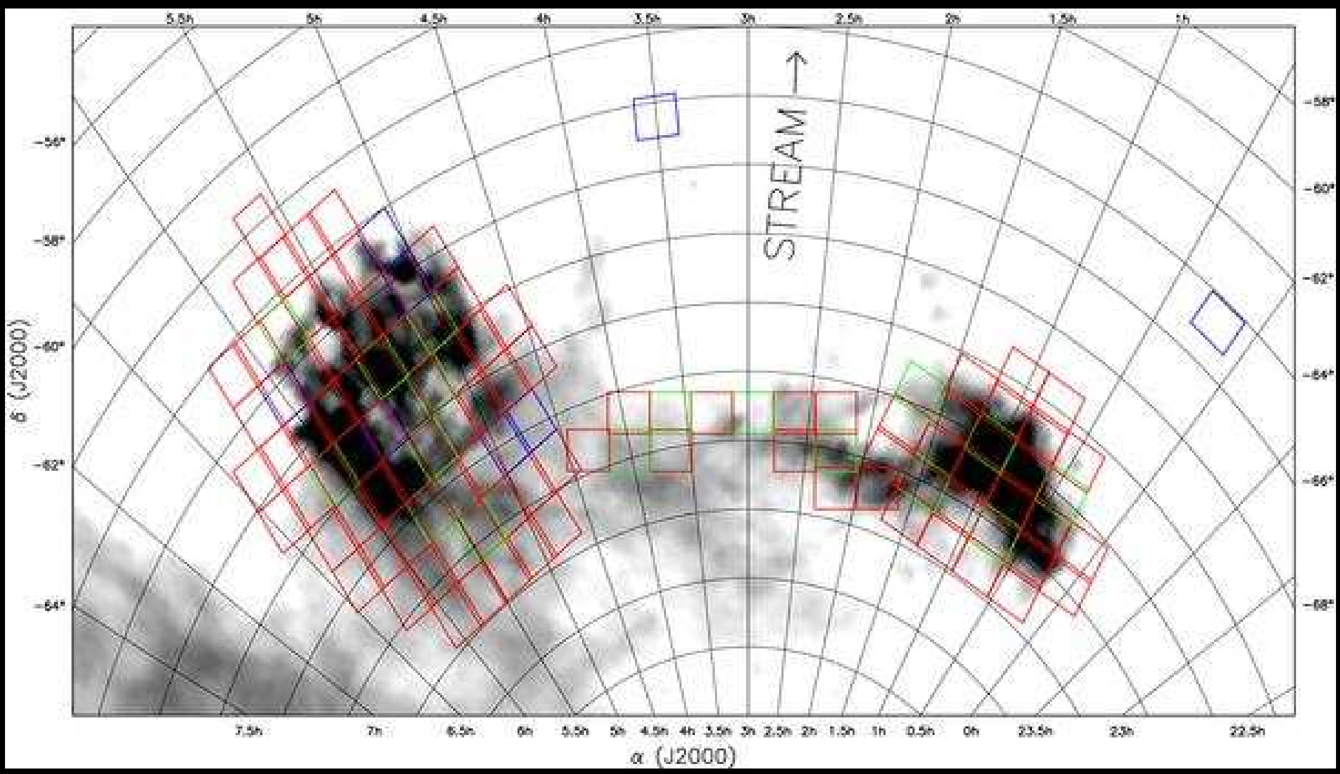


UKIDSS

VISTA Strategy:

- semi-simultaneous YZ and JHKs
- multiple Ks re-visits separated by up to 5 yrs

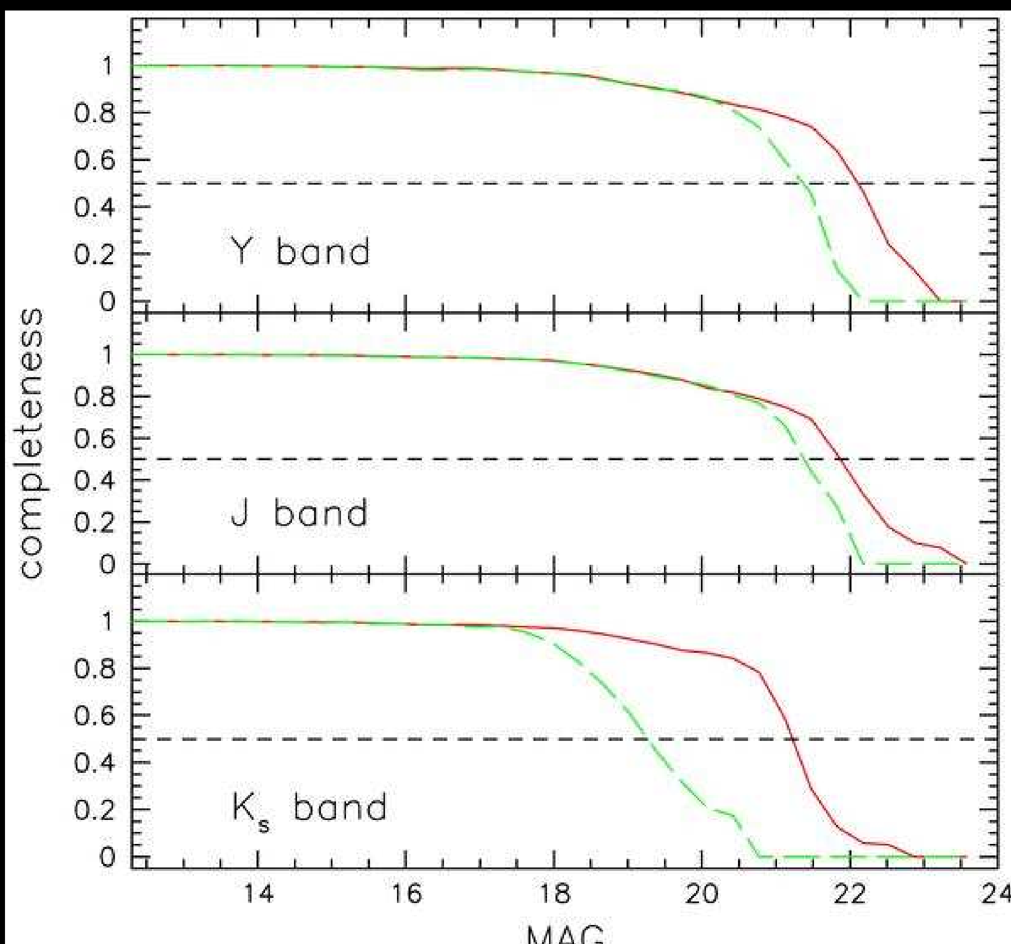
VMC – VISTA Magellanic Clouds ESO public survey

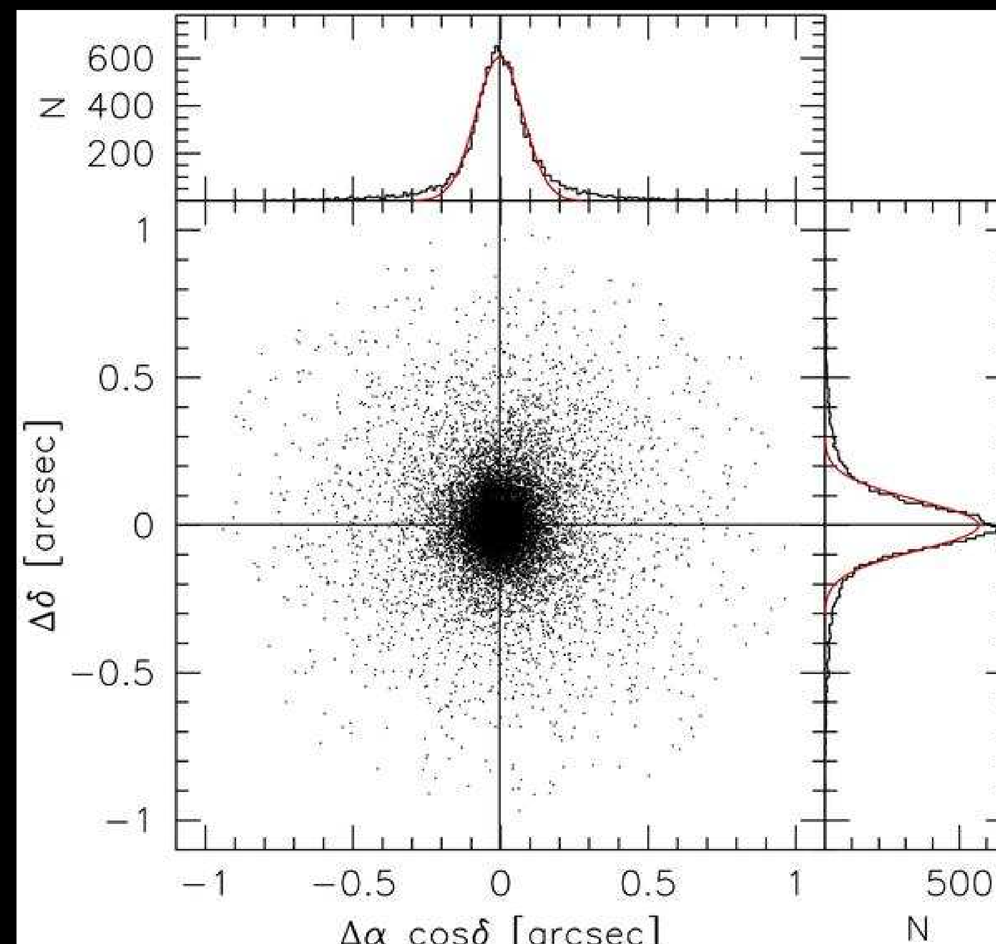


110 tiles,
184 sq. deg
YJKs
12+ Ks epochs

Cioni et al. (2011, A&A, 527, 116)

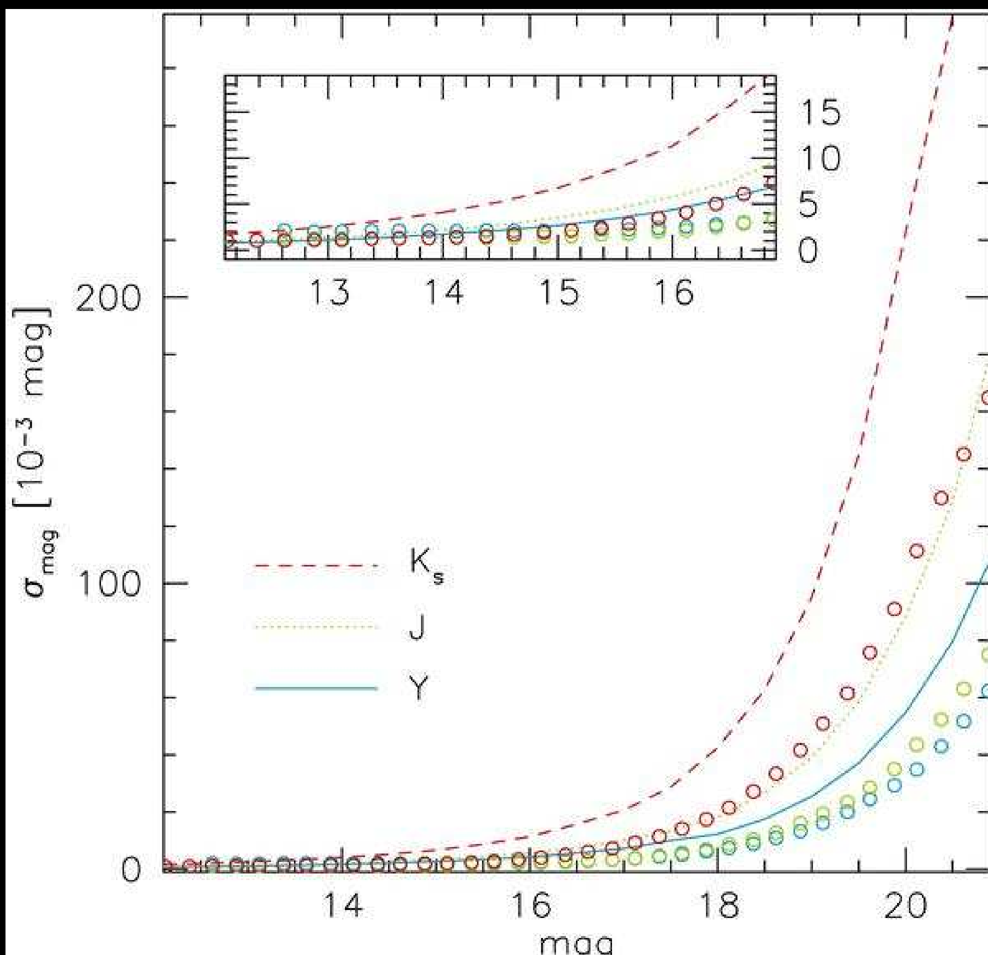
VMC – VISTA Magellanic Clouds ESO public survey

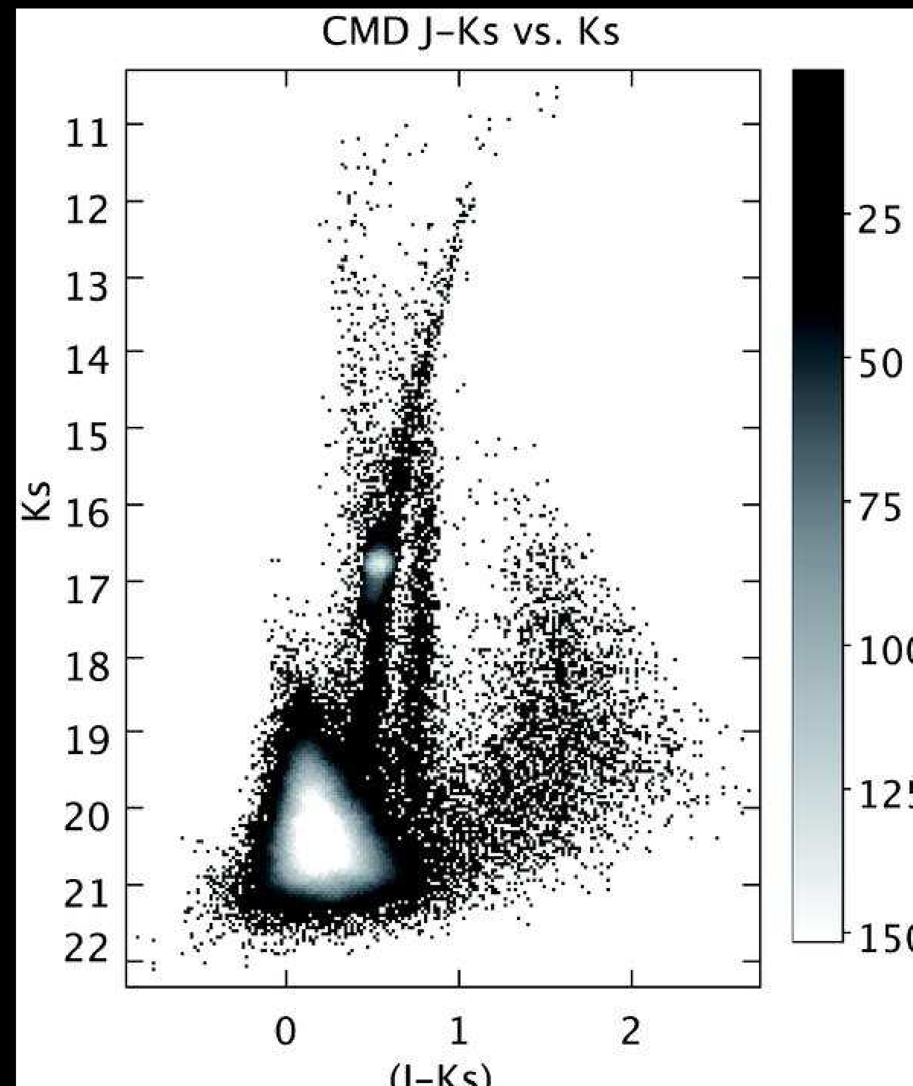




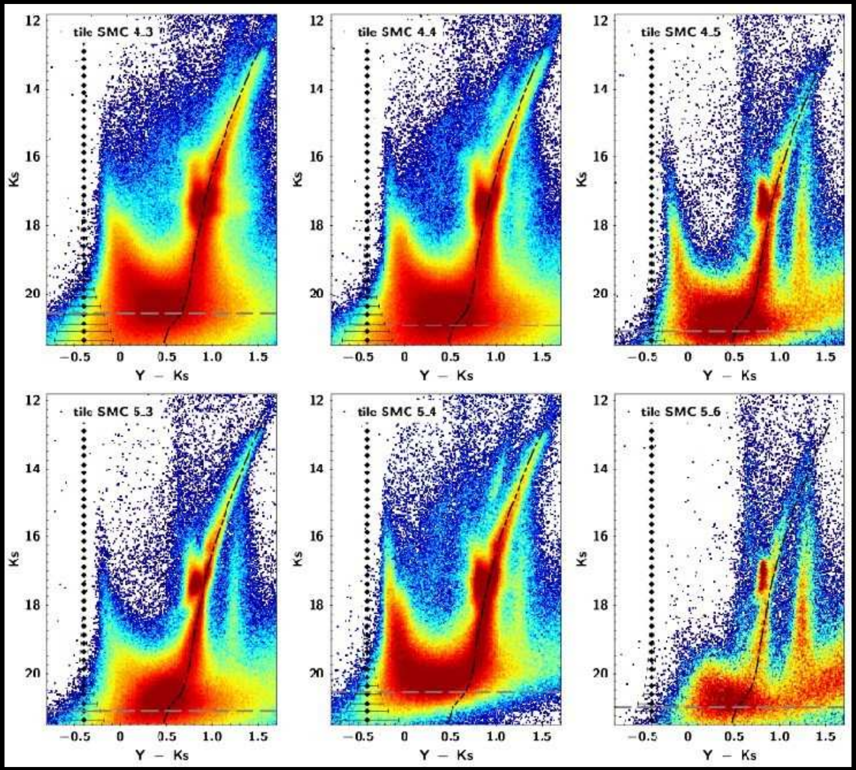
σ=80-85 mas

VMC – VISTA Magellanic Clouds ESO public survey



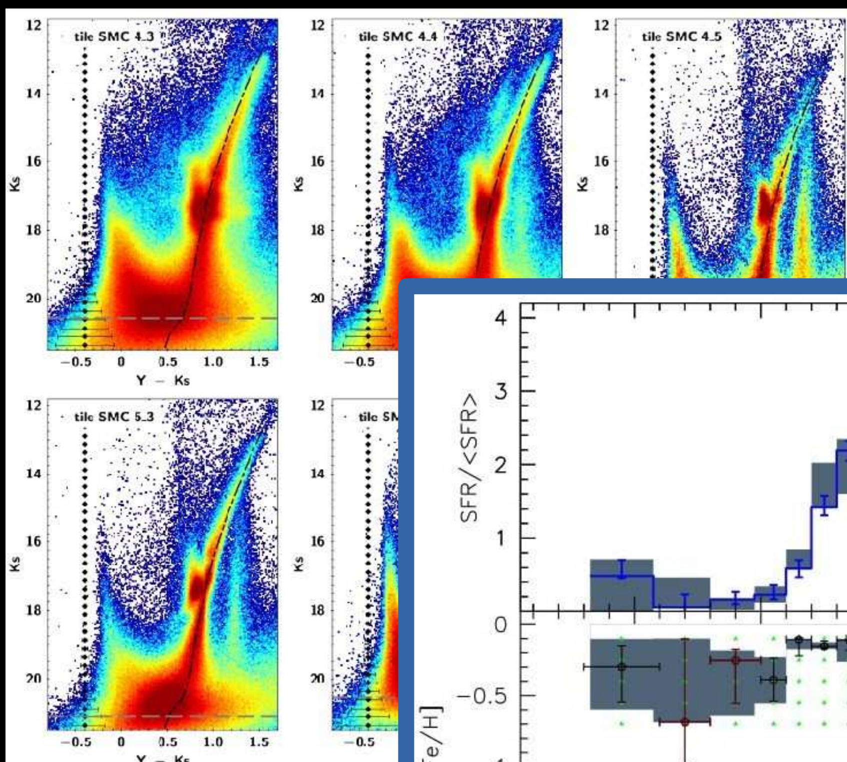


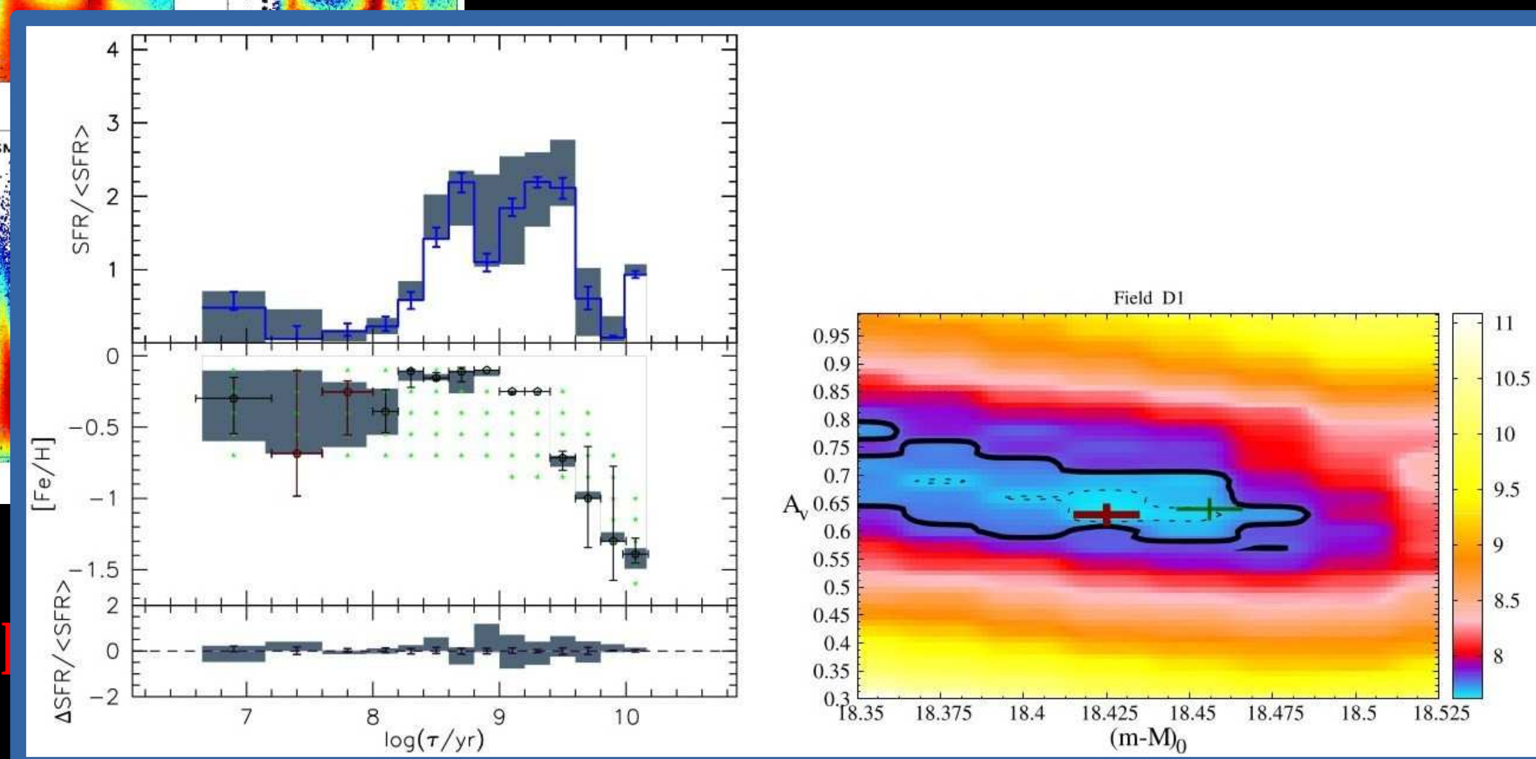
VMC – VISTA Magellanic Clouds ESO public survey



Rubele et al. (2012, 2015, 2018)

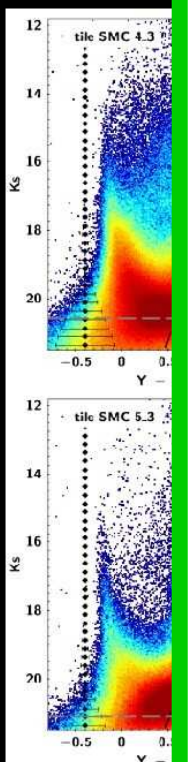
VMC – VISTA Magellanic Clouds ESO public survey

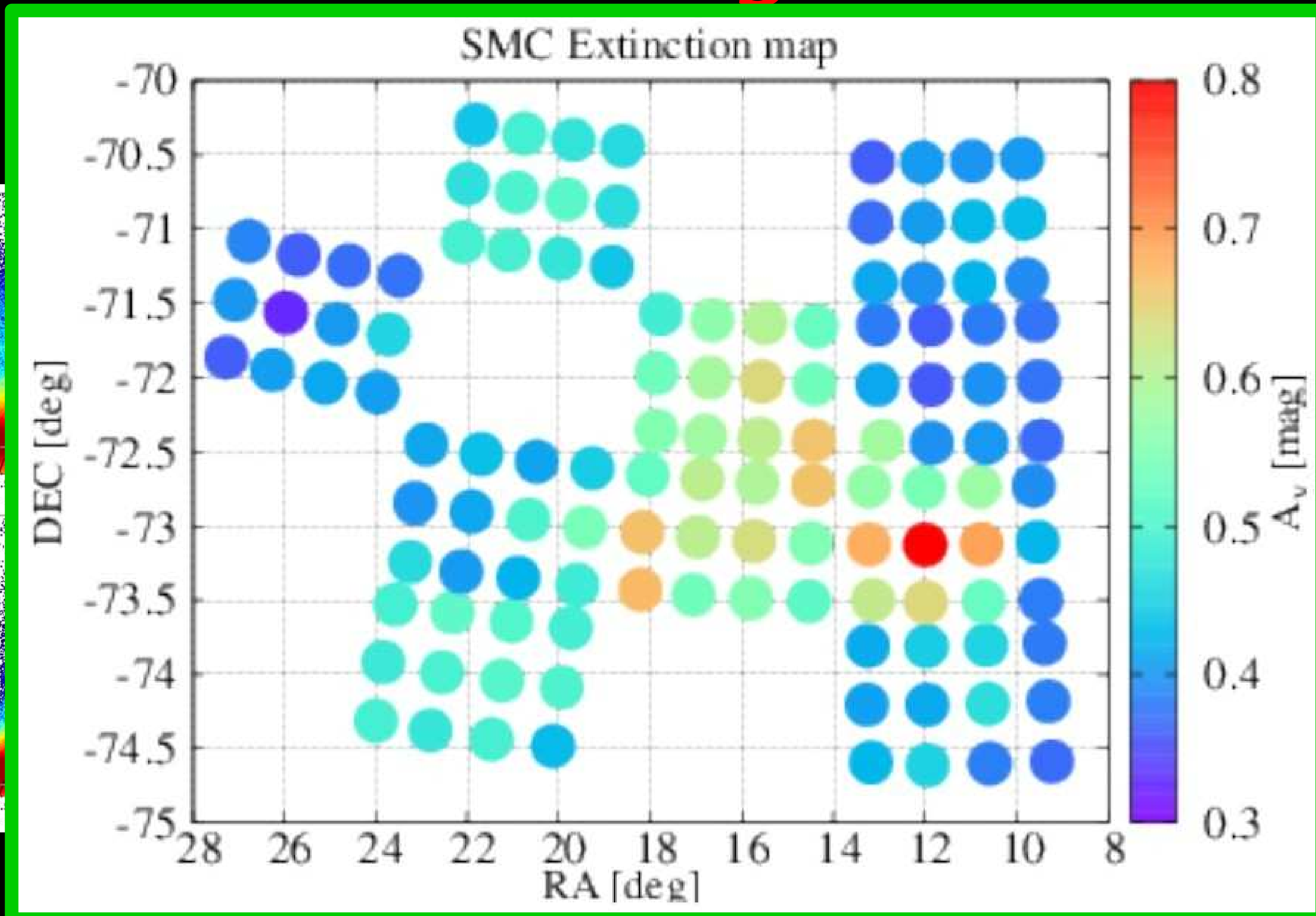


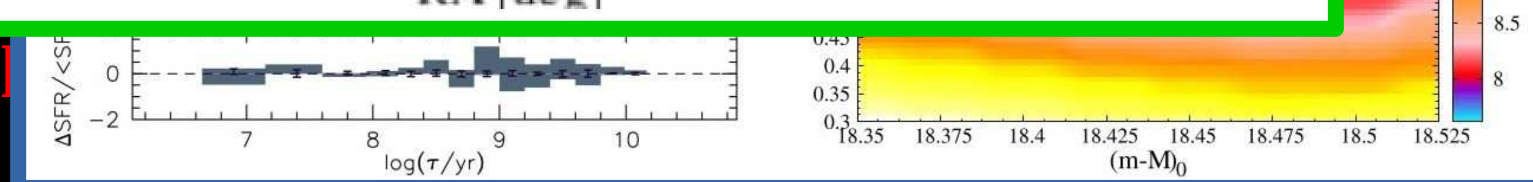


Rubele et al

VMC – VISTA Magellanic Clouds

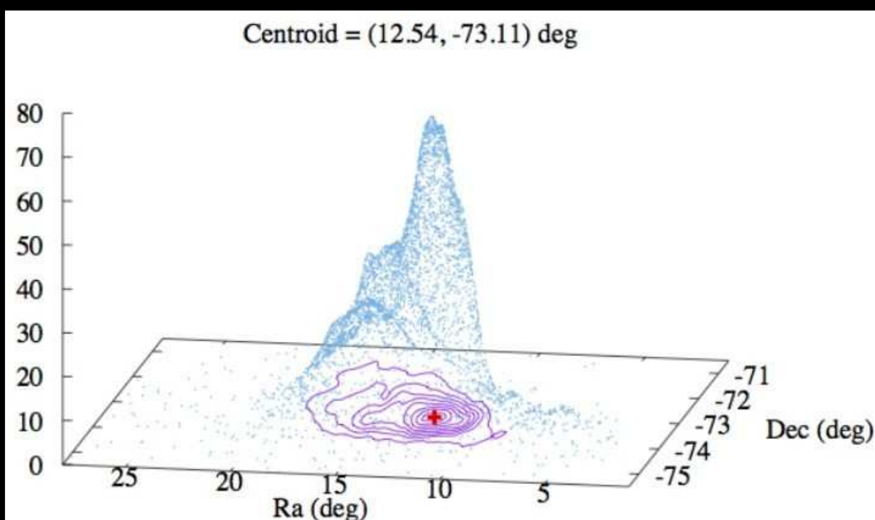






Rubele et al

VMC – VISTA Magellanic Clouds ESO public survey



<= Classical Cepheids

(see also Muraveva et al. 2018 for RR Lyr; Subramanian et al. 2017 for red clump)

Ripepi et al. (2017)

VMC – VISTA Magellanic Clouds

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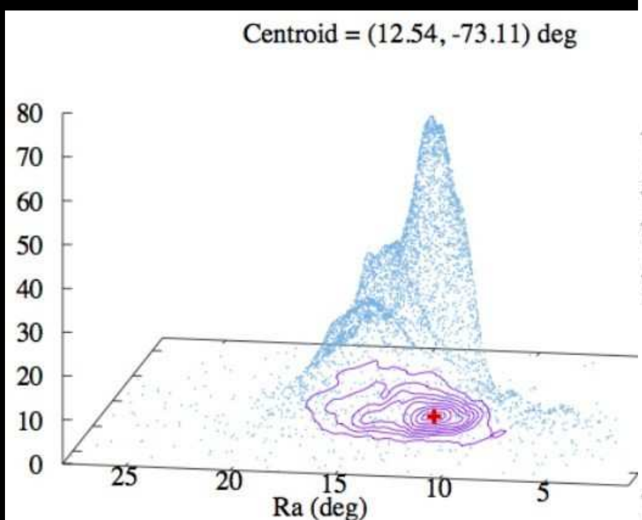
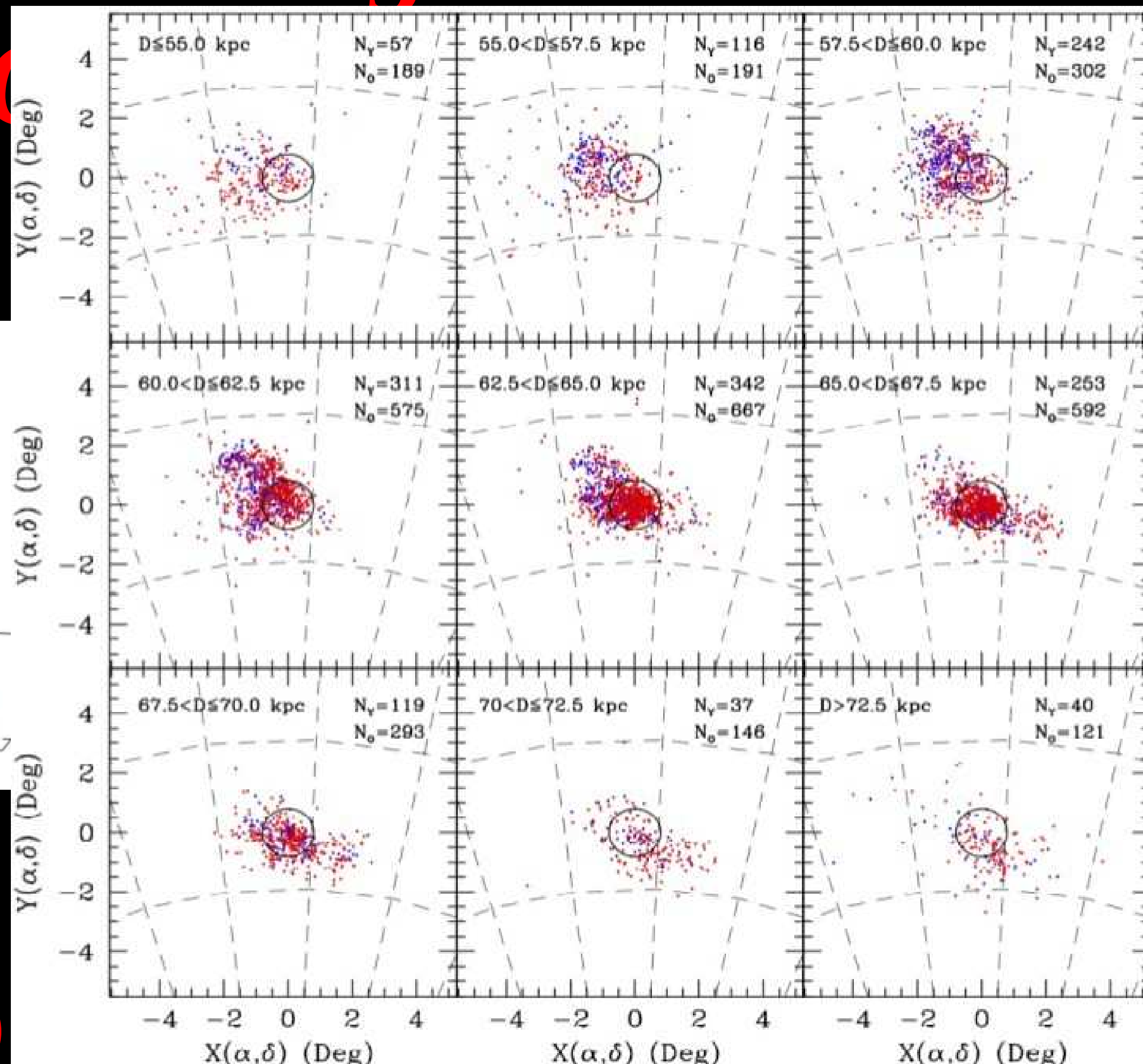
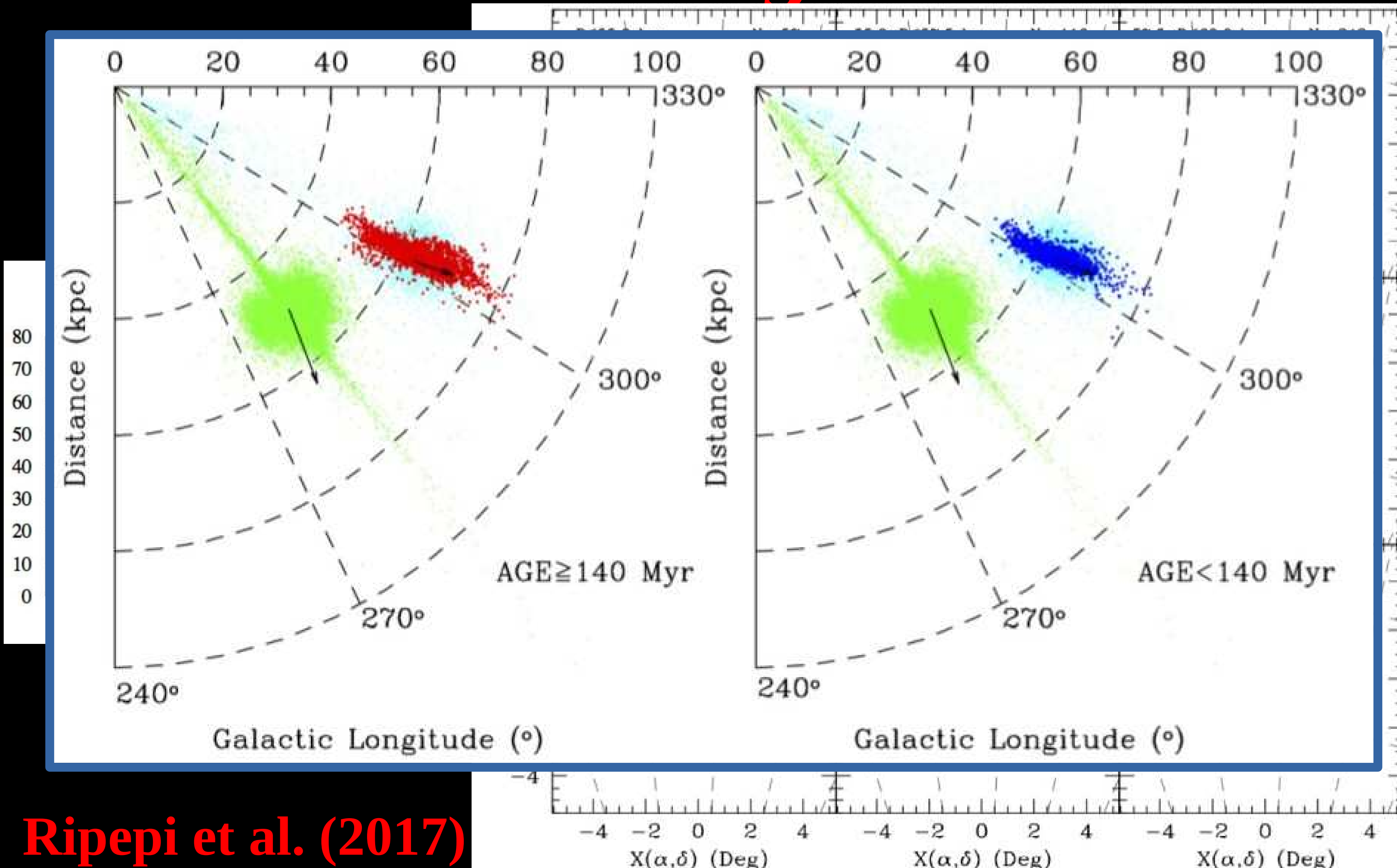




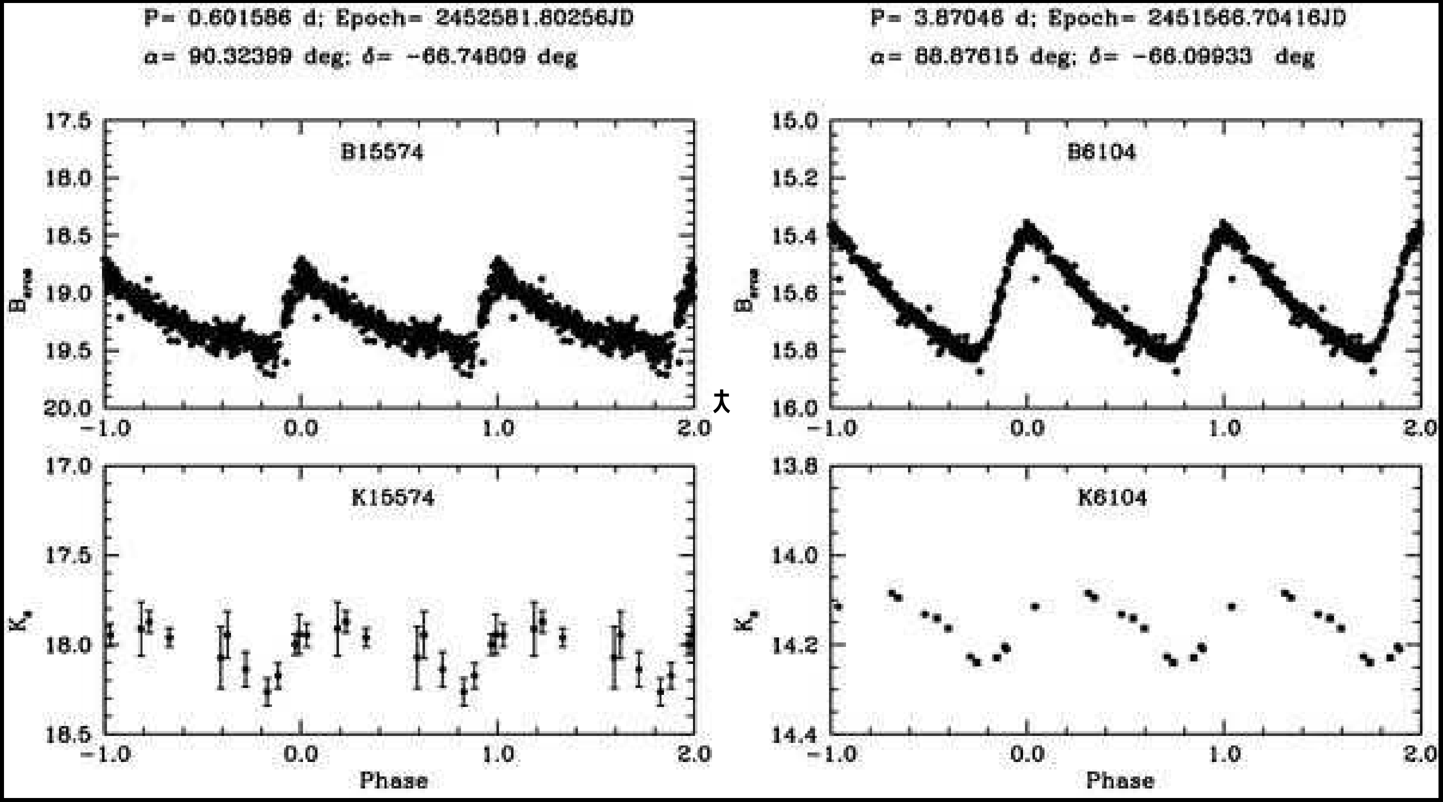
Ripepi et al. (2017)

VMC – VISTA Magellanic Clouds



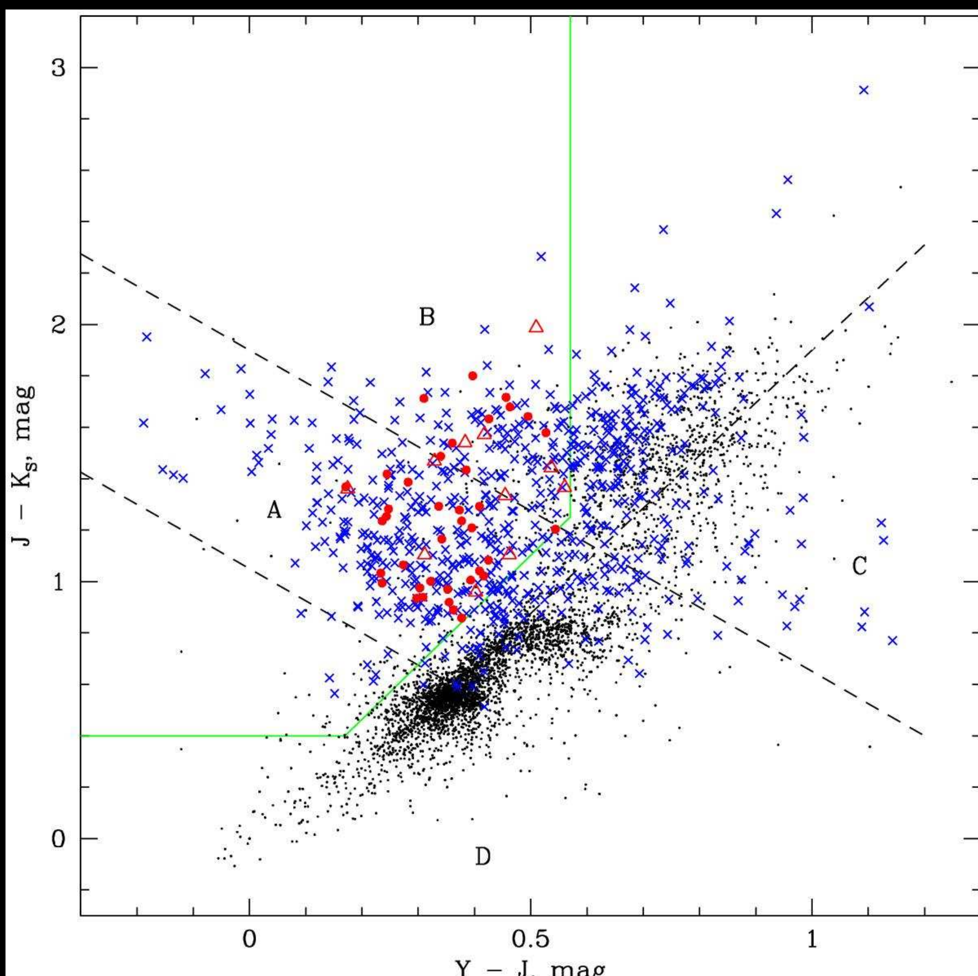
Ripepi et al. (2017)

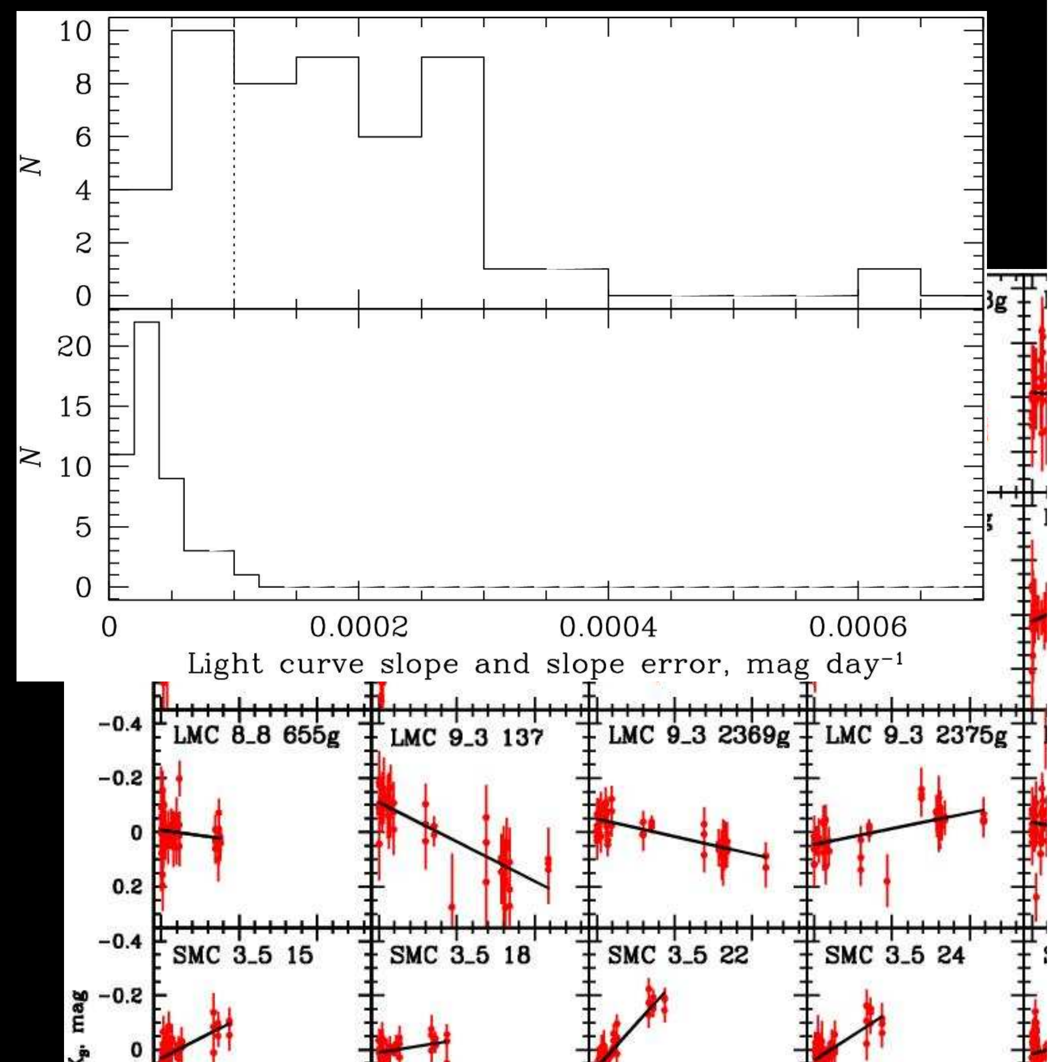
VMC – VISTA Magellanic Clouds ESO public survey



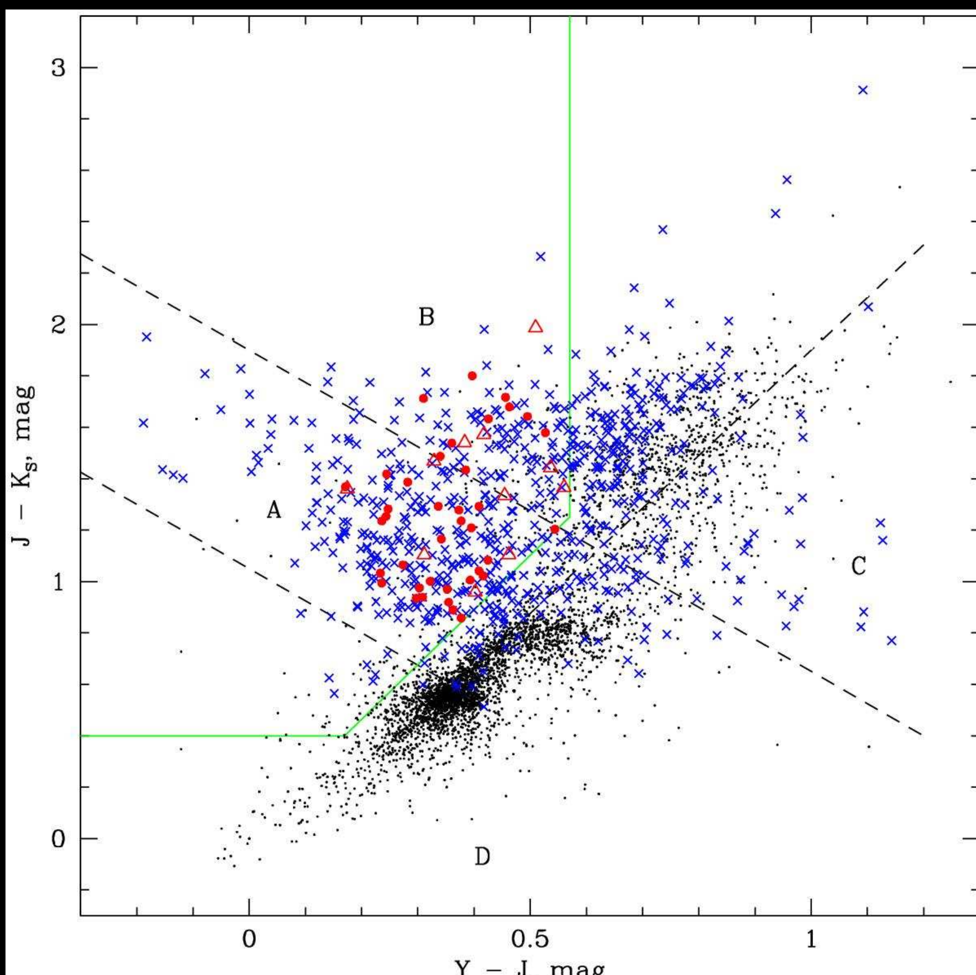
Moretti et al. (2014, 2016), Rippei et al. (2014, 2015, 2016), Marconi et al. (2017)

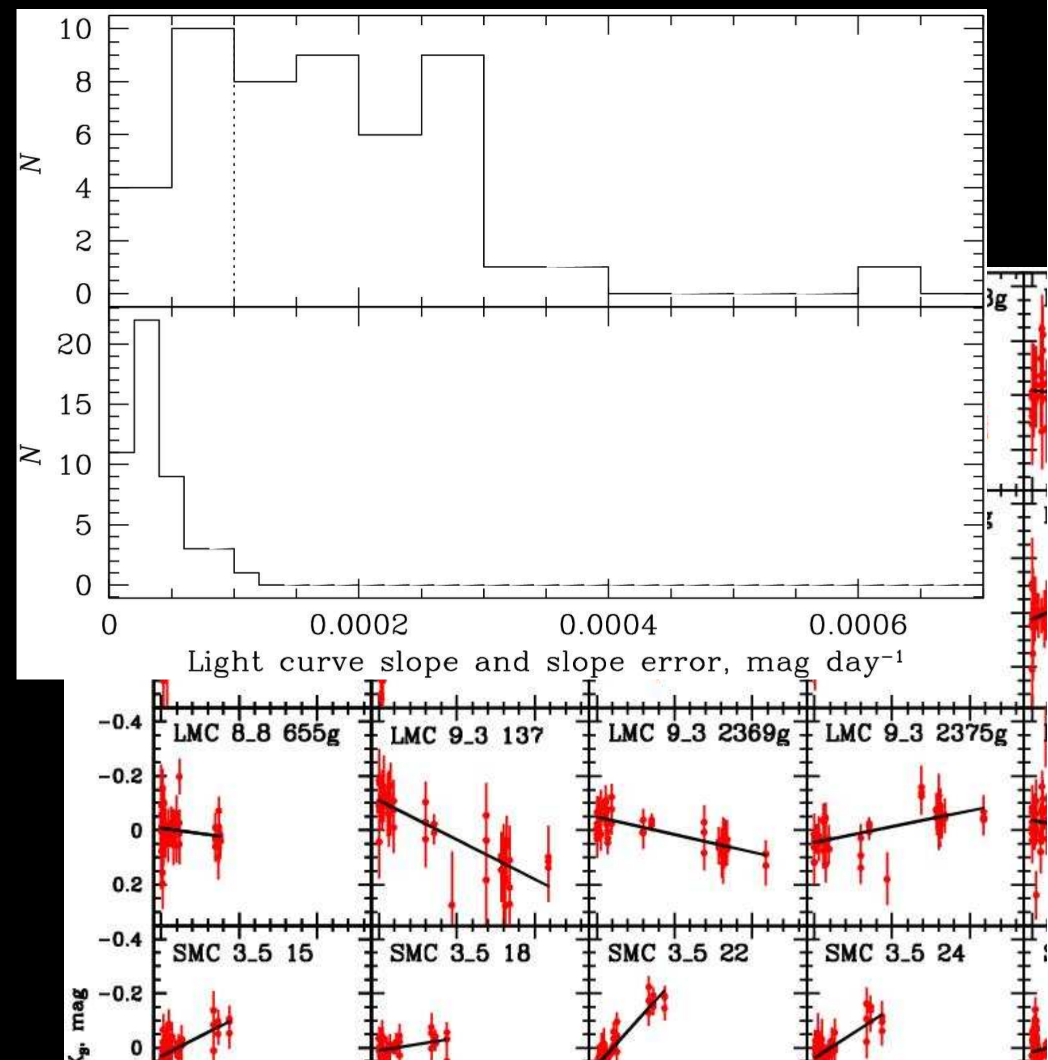
VMC – VISTA Magellanic Clouds ESO public survey





VMC – VISTA Magellanic Clouds ESO public survey





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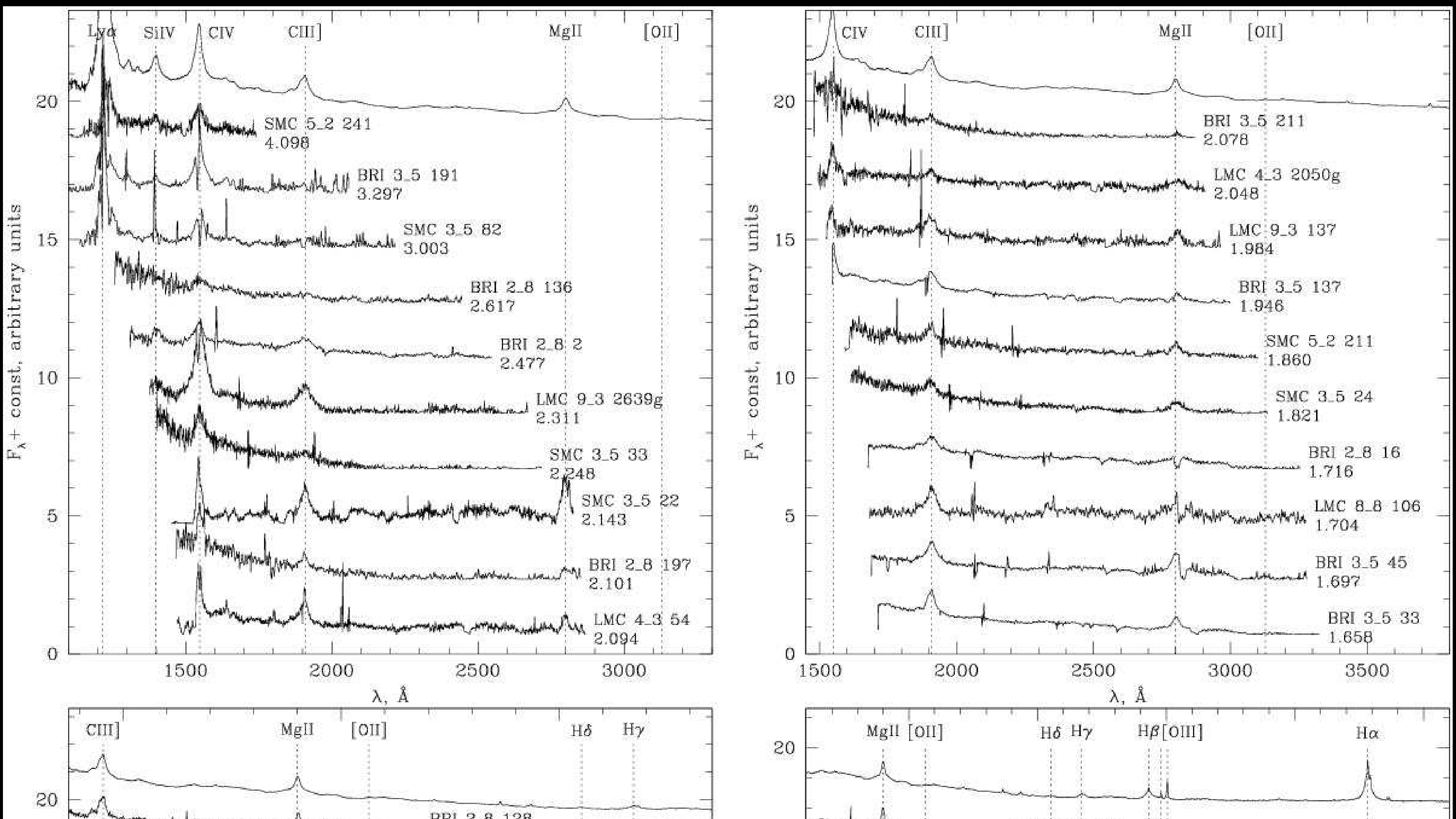

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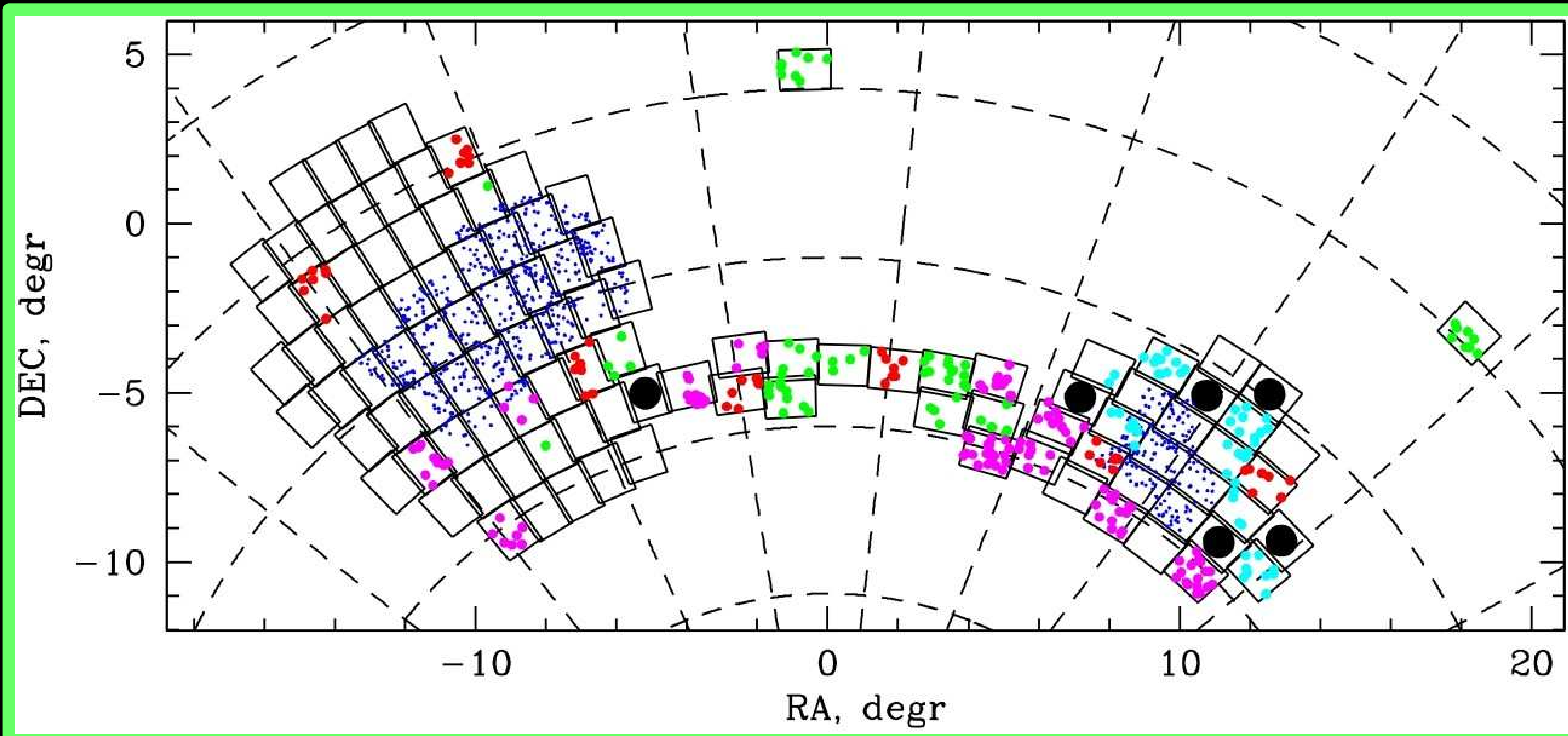
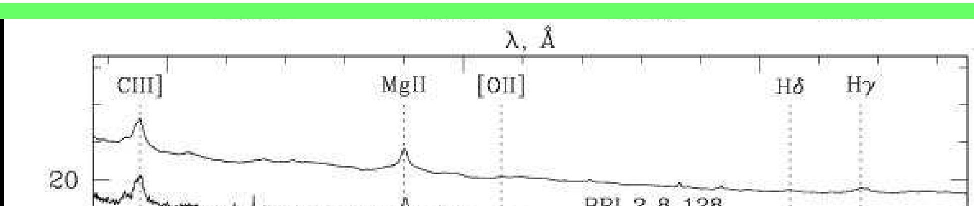
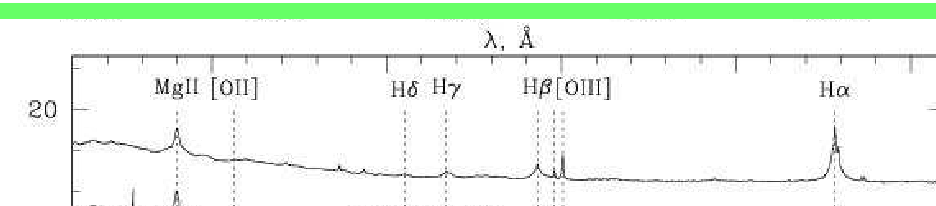


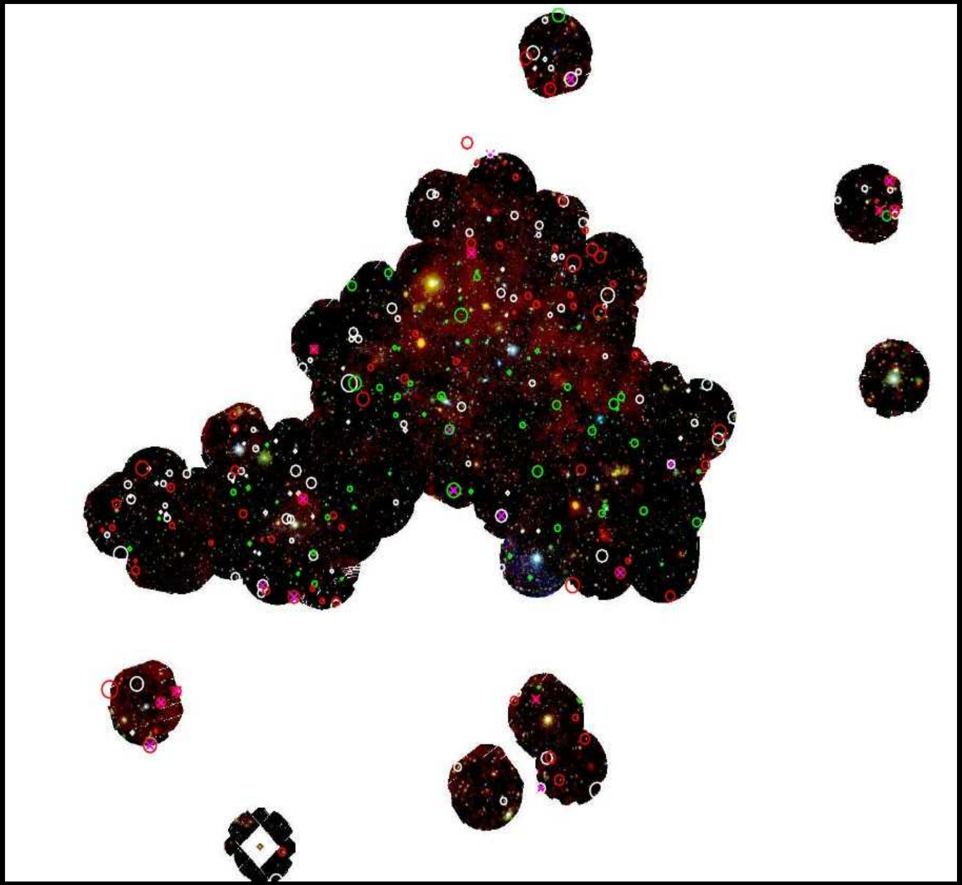




VMC – VISTA Magellanic Clouds ESO public survey

- AGNs behind the SMC from a XMM-Newton survey of the SMC (0.2-12 keV) in X-rays and mid-IR (ALLWISE)

- Identified 270 sources, 78 are new candidates; 20 candidates for highly obscured AGNs, which are rare objects.



Maitra, Haberl, Ivanov, in prep.

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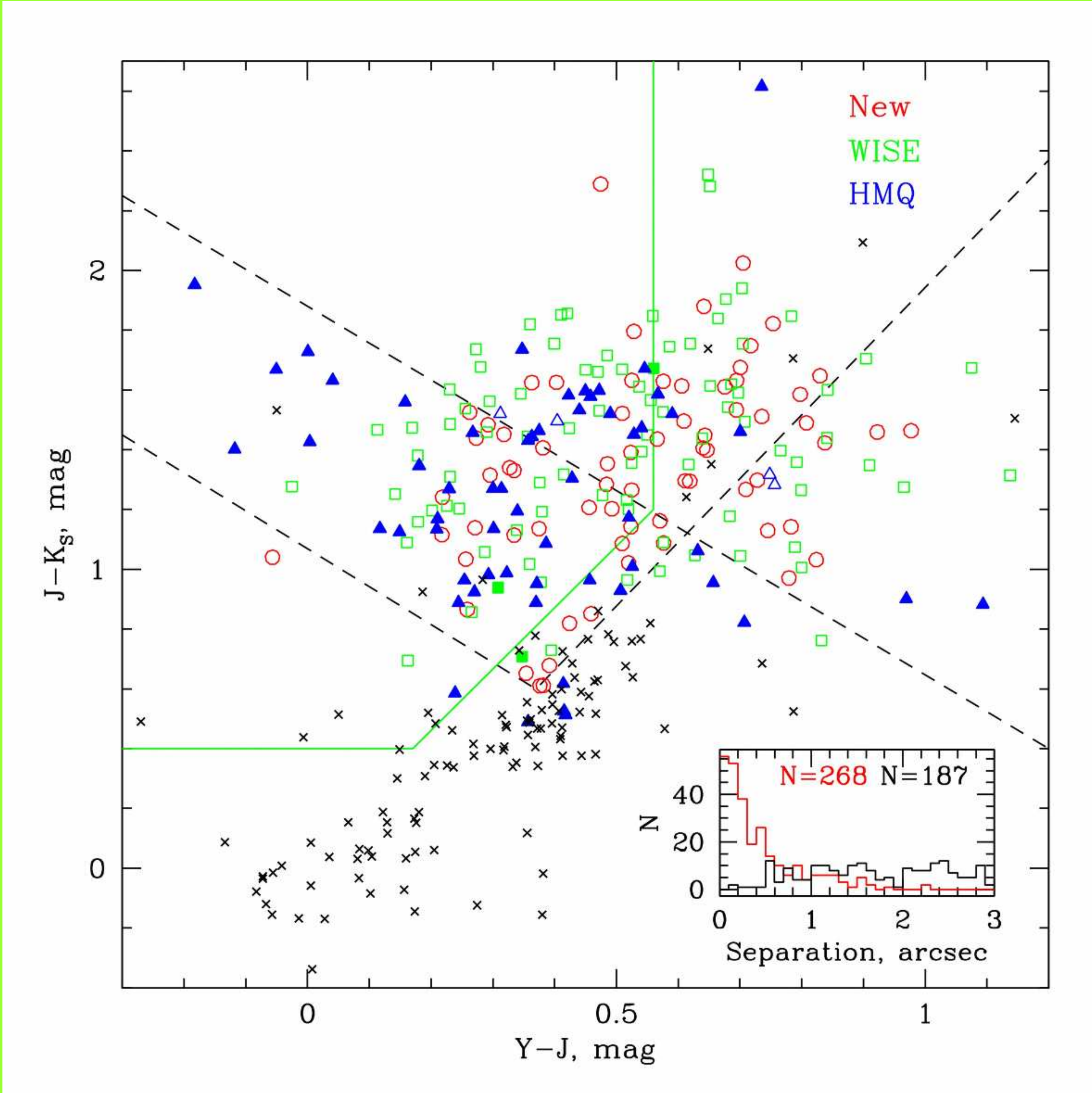

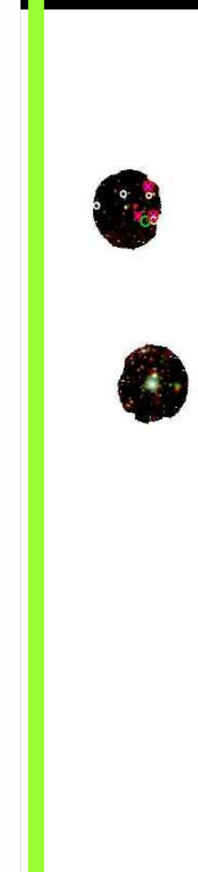

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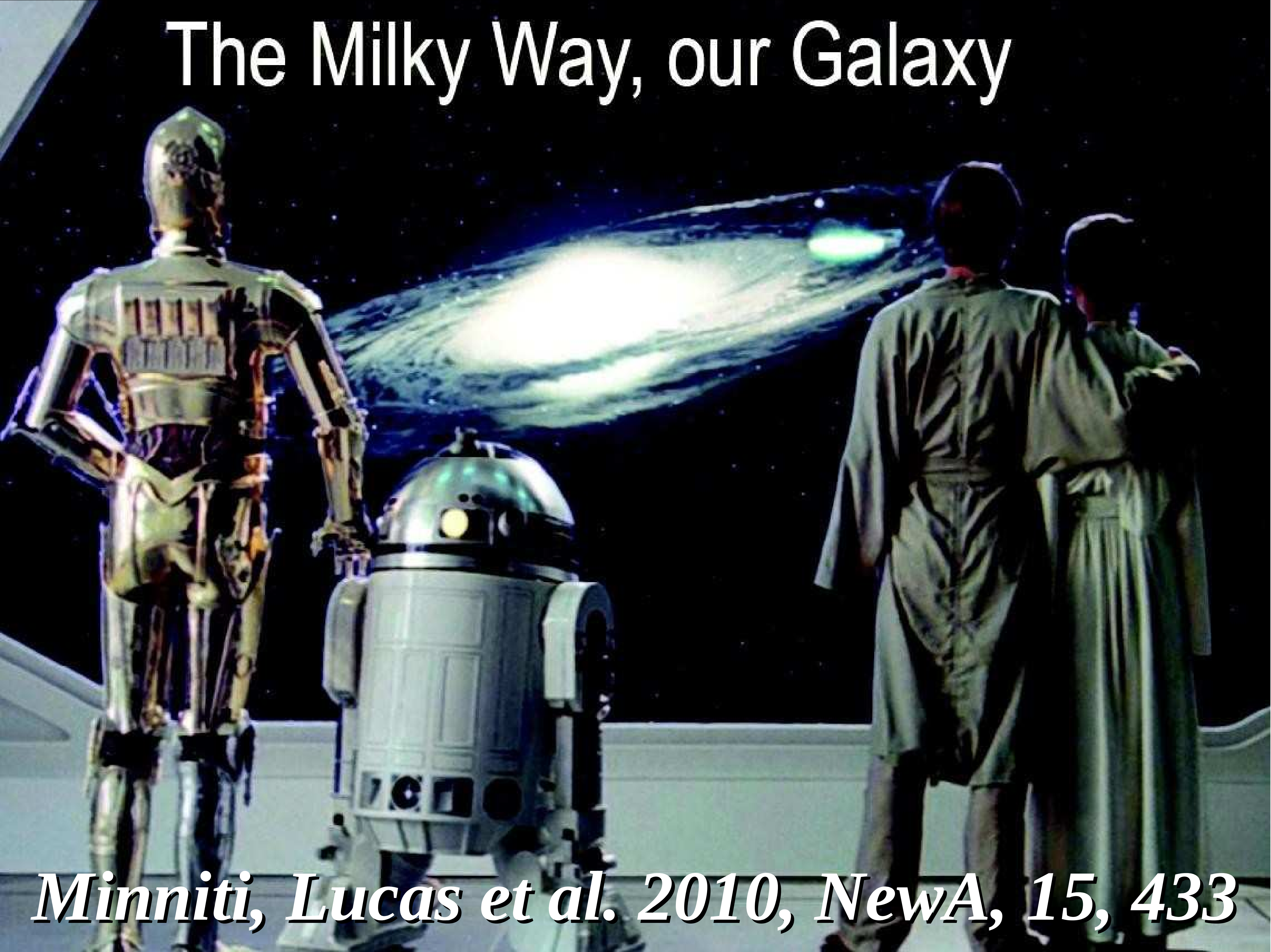
The Milky Way, our Galaxy
Minniti, Lucas et al. 2010, NewA, 15, 433

VVVsurvey.org

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→Maria Messineo (European Southern Observatory, Germany)
→Felix Mirabel (European Southern Observatory, Chile)
→Lorenzo Morelli (Universidad Católica, Chile)
→Tim Naylor (Exeter University, UK)
→Pawel Pietrukowicz (Copernicus Institute, Poland)
→Grzegorz Pietrzynski (Universidad de Concepcion, Chile)
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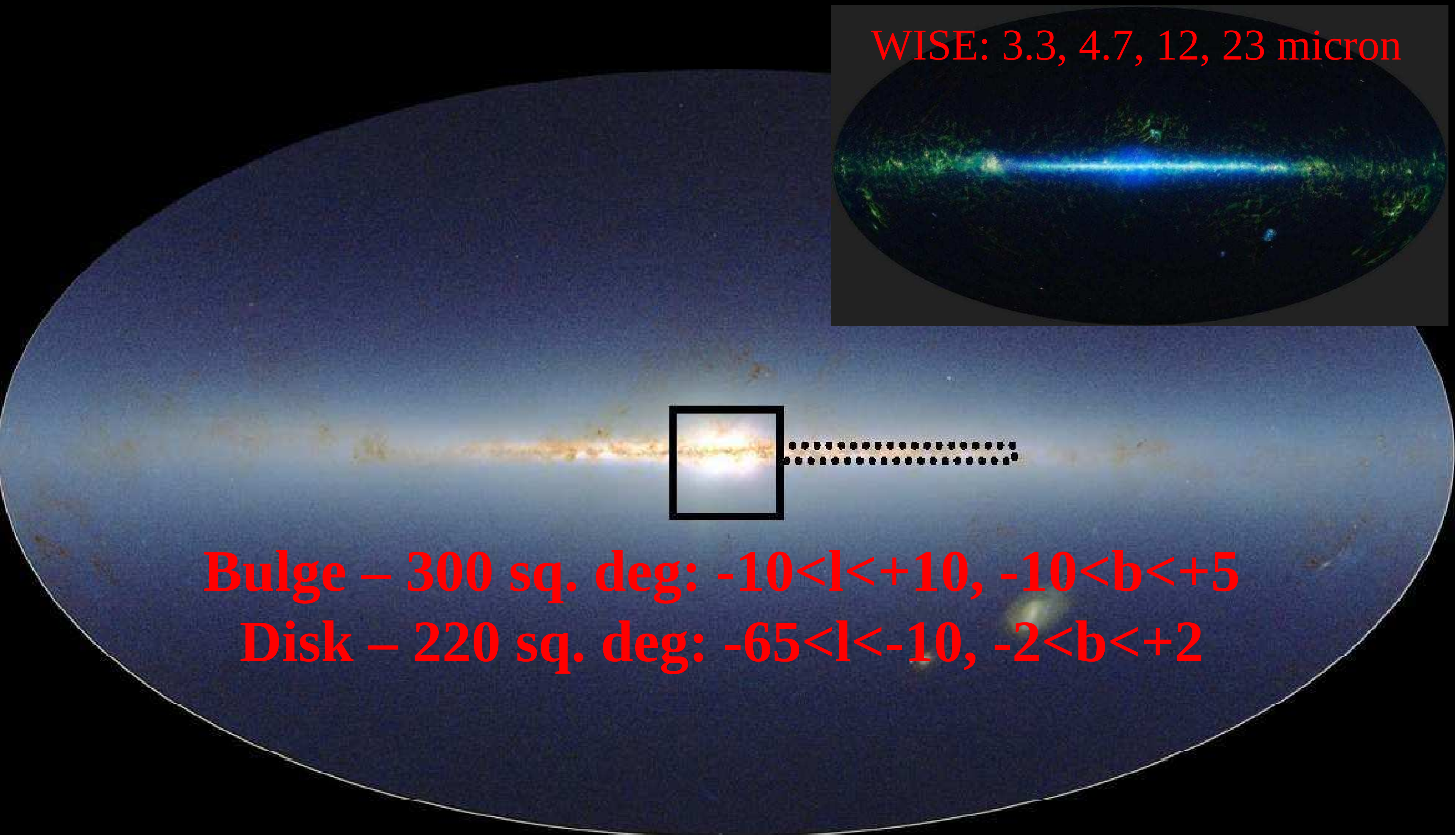
→Mark Thompson (University of Hertfordshire, UK)
→Leonardo Vanzi (European Southern Observatory, Chile)
→Nic Walton (Cambridge University, UK)
→Glenn White (Open University, UK)
→Albert Zijlstra (Manchester University, UK)
→Manuela Zoccali (Universidad Católica, Chile)

VVV Goal

What is the 3-D structure of the Milky Way

Photo album of the MW

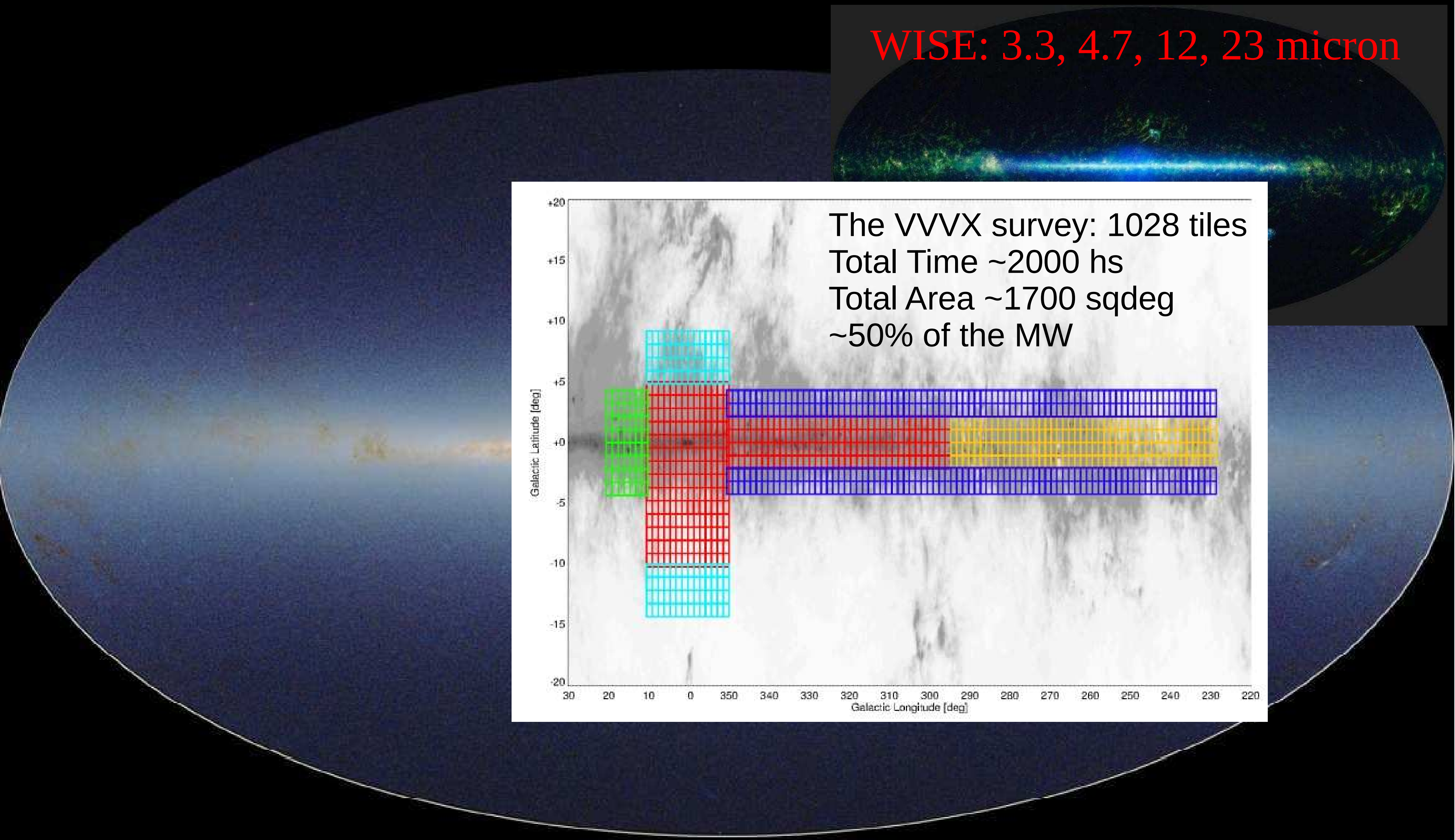
vvvsurvey.org



2MASS JHK 2000

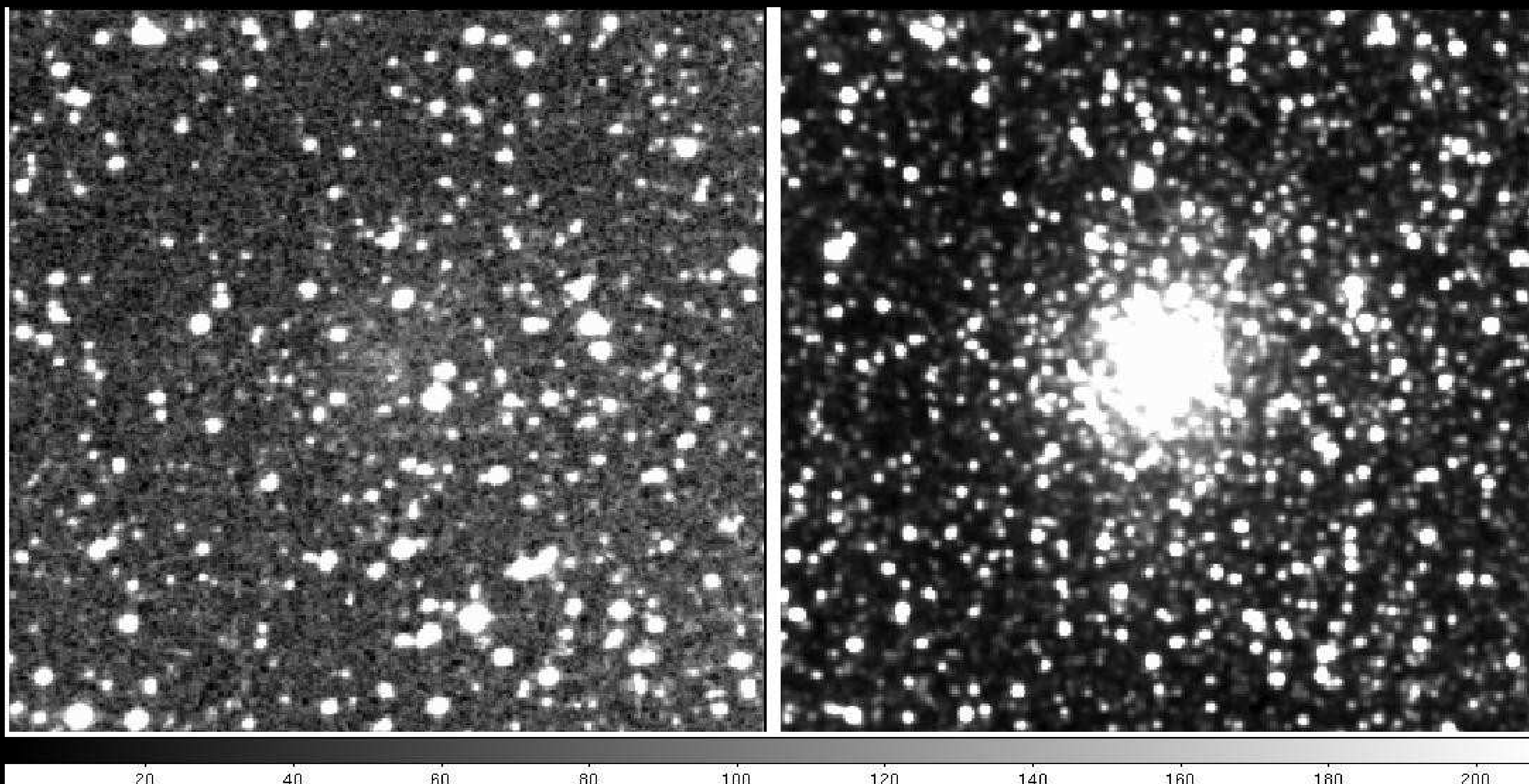
Photo album of the MW

vvvsurvey.org



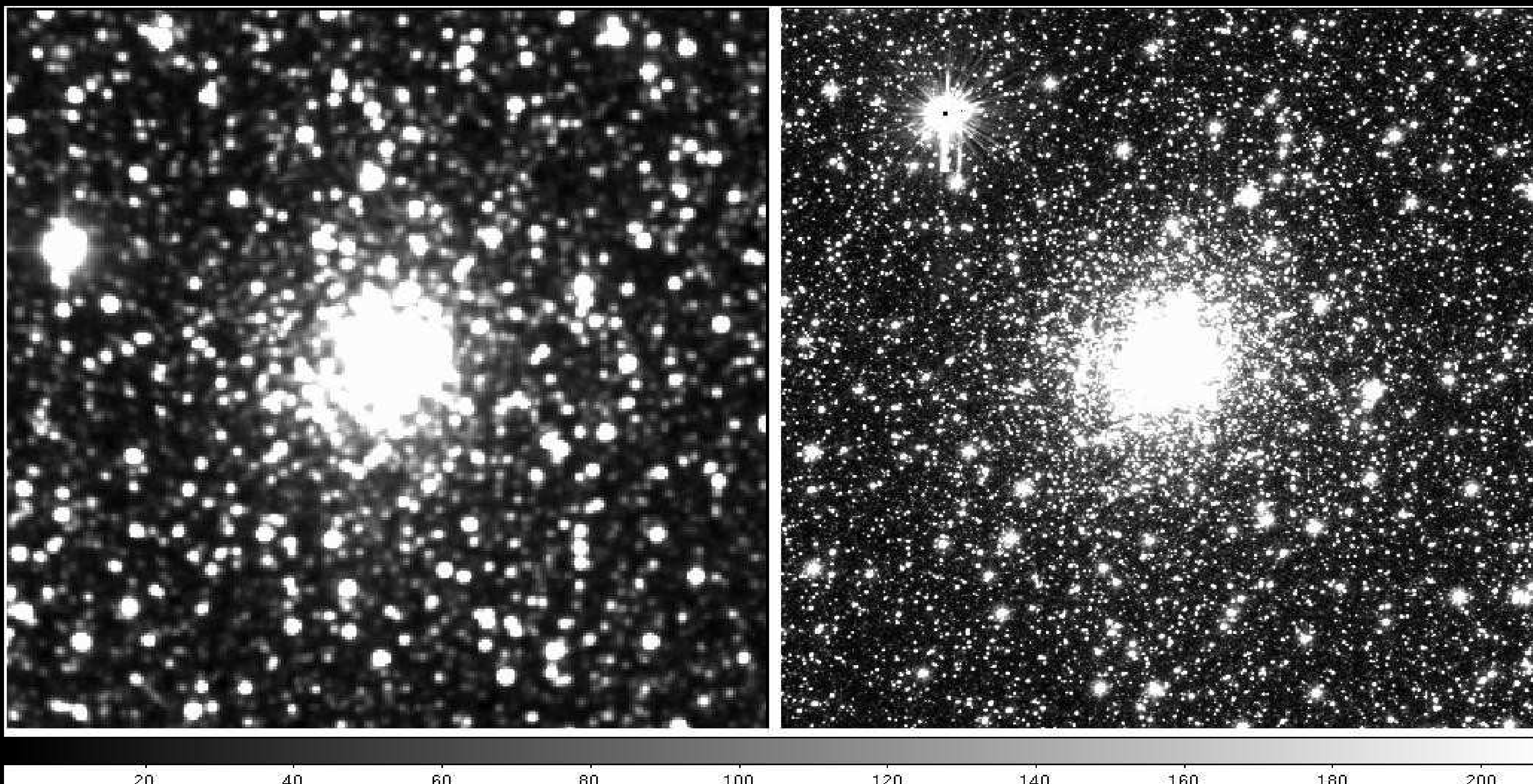
2MASS JHK 2000

Do it in the NIR – to see through!



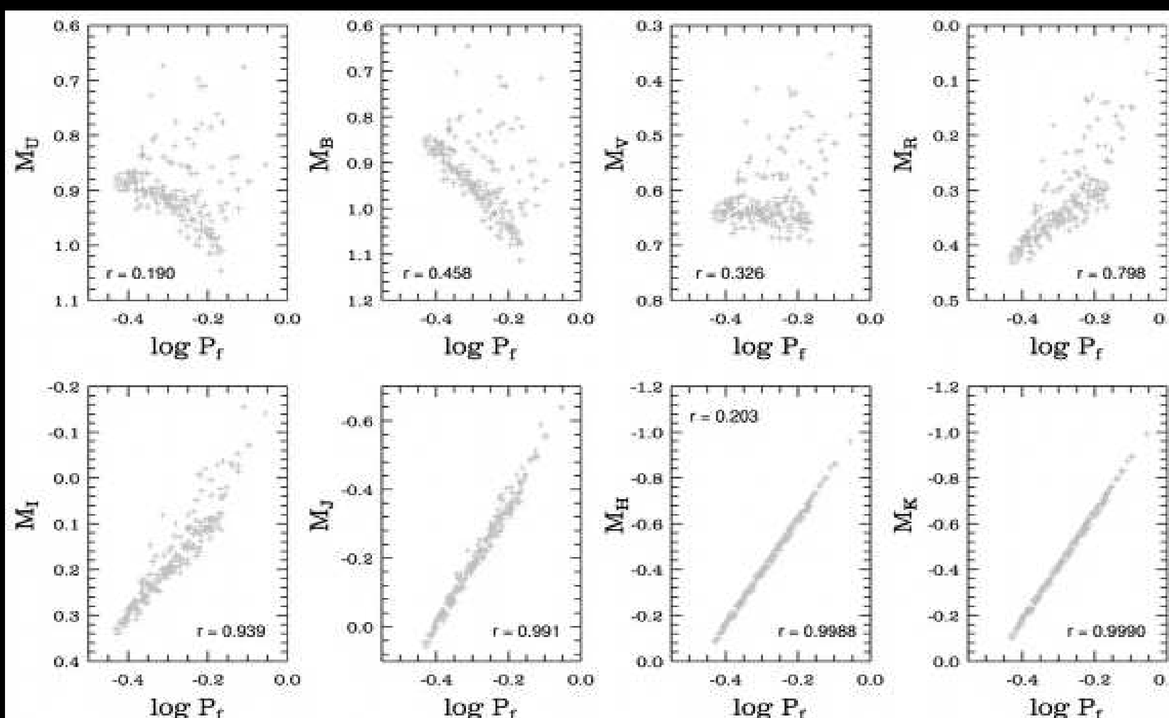
Globular Cluster UKS-1 on DSS2 Red and 2MASS J (5'x5')

Do it with the highest available angular resolution!

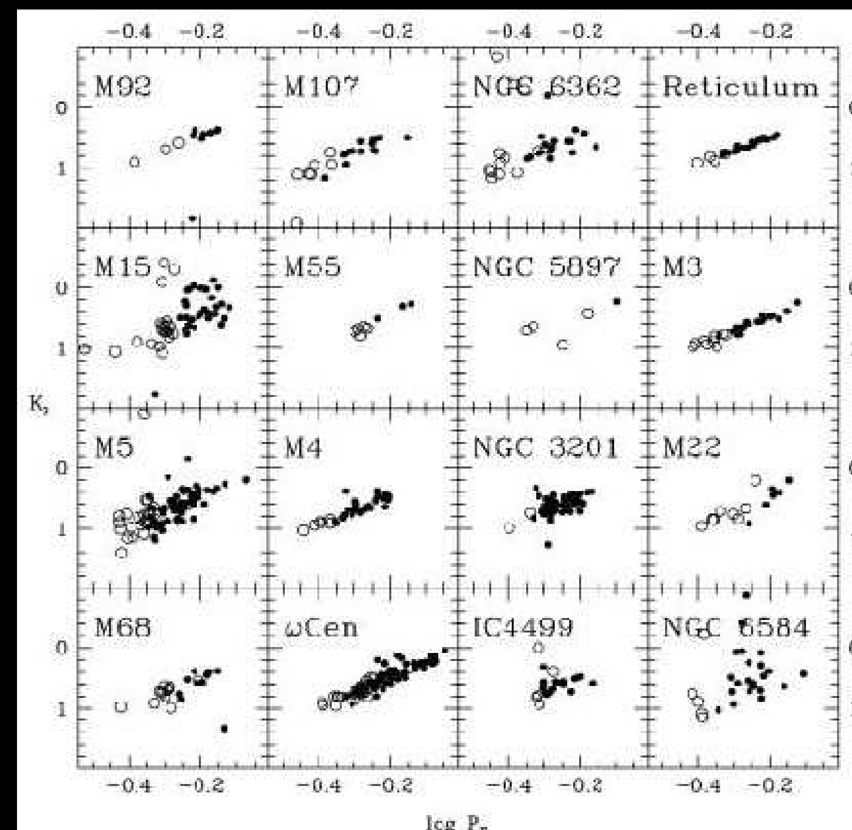


Globular Cluster UKS-1 on 2MASS Ks and VVV Ks (5'x5')

Obtain multiple epochs to do 3D tomography with RR Lyr and Cepheids! ==> ***60-100 epochs***

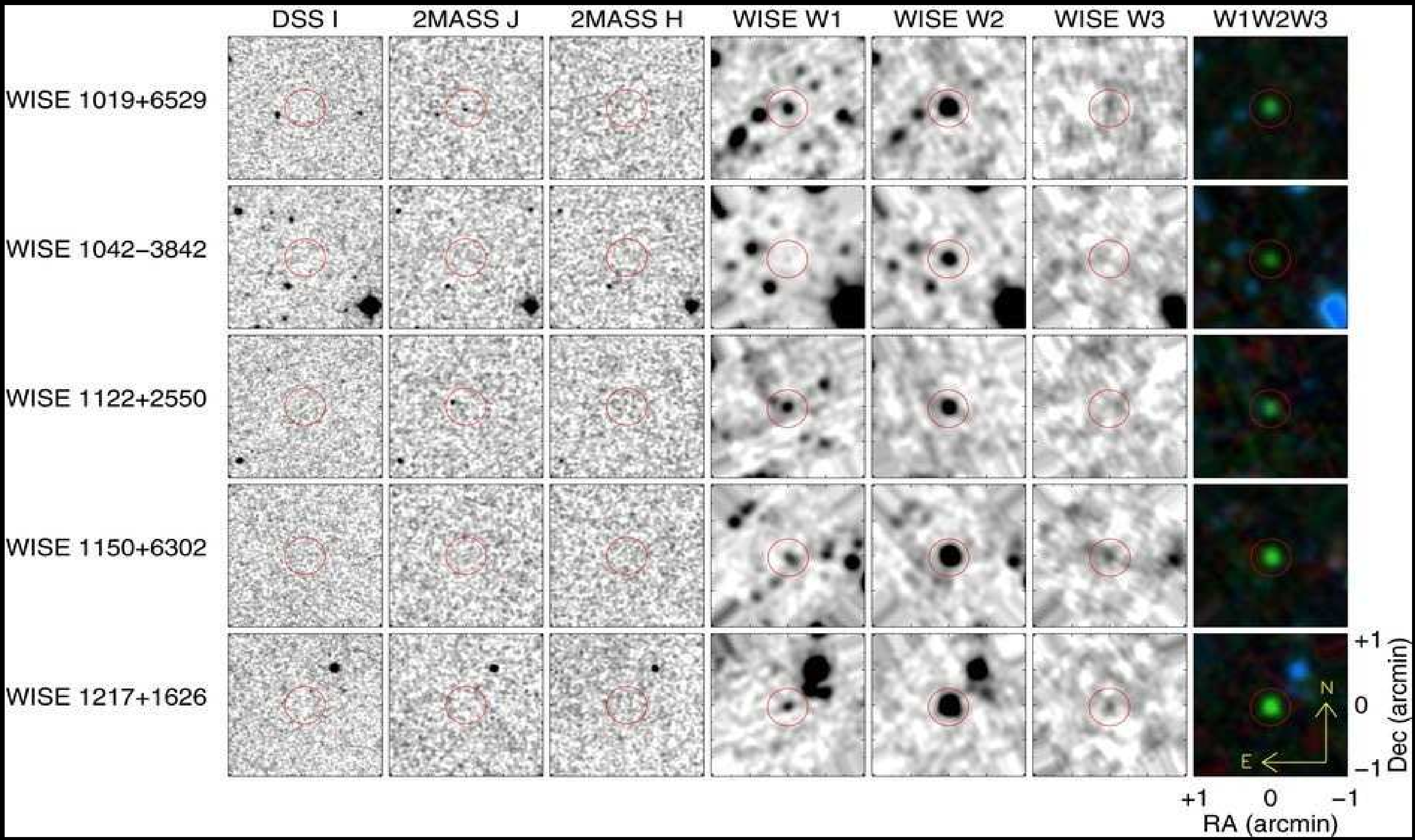


Catalan et al (2006)



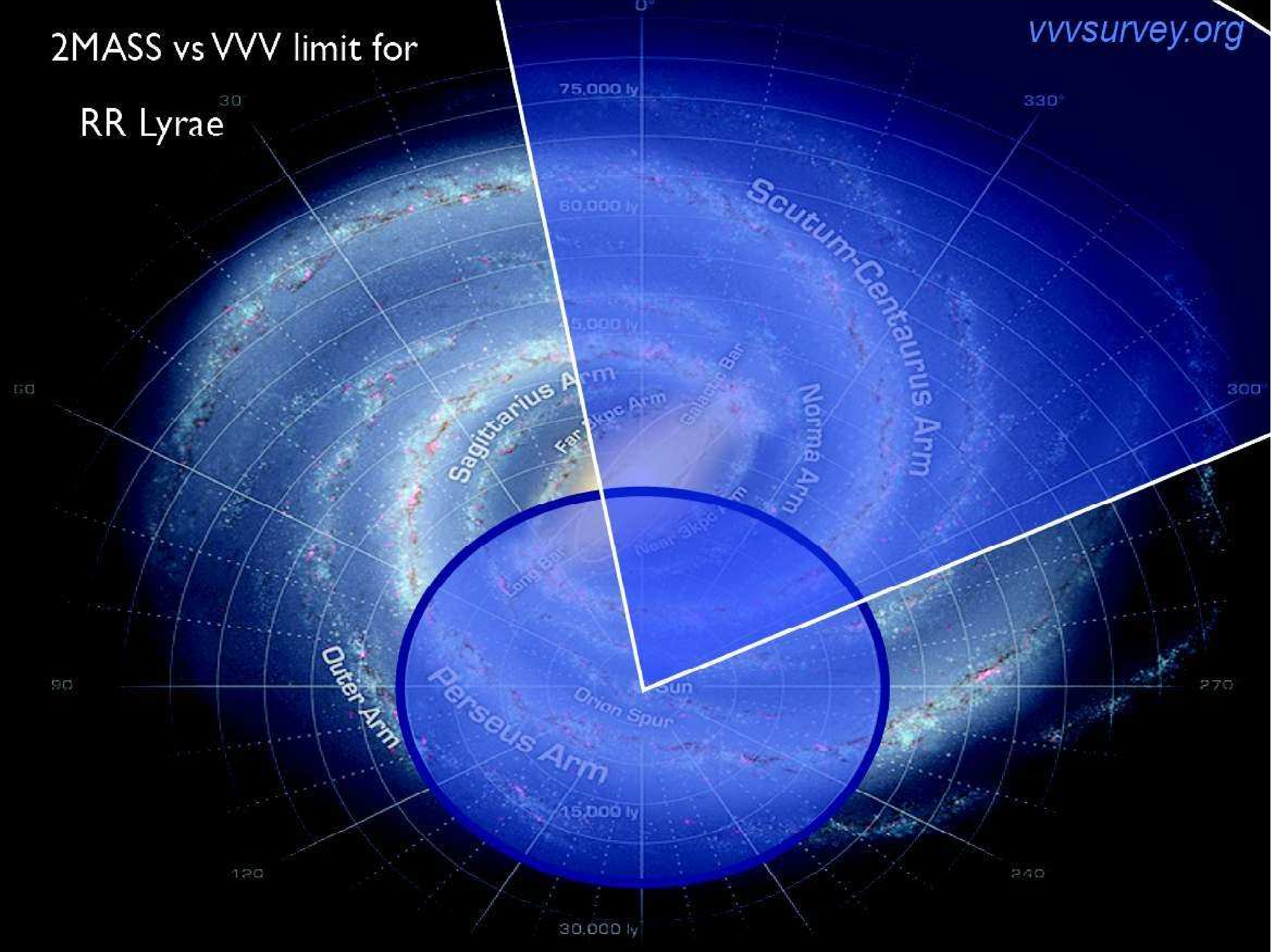
Solima et al. (2006)

... And do it in multiple bands to broaden the community interest in your survey!

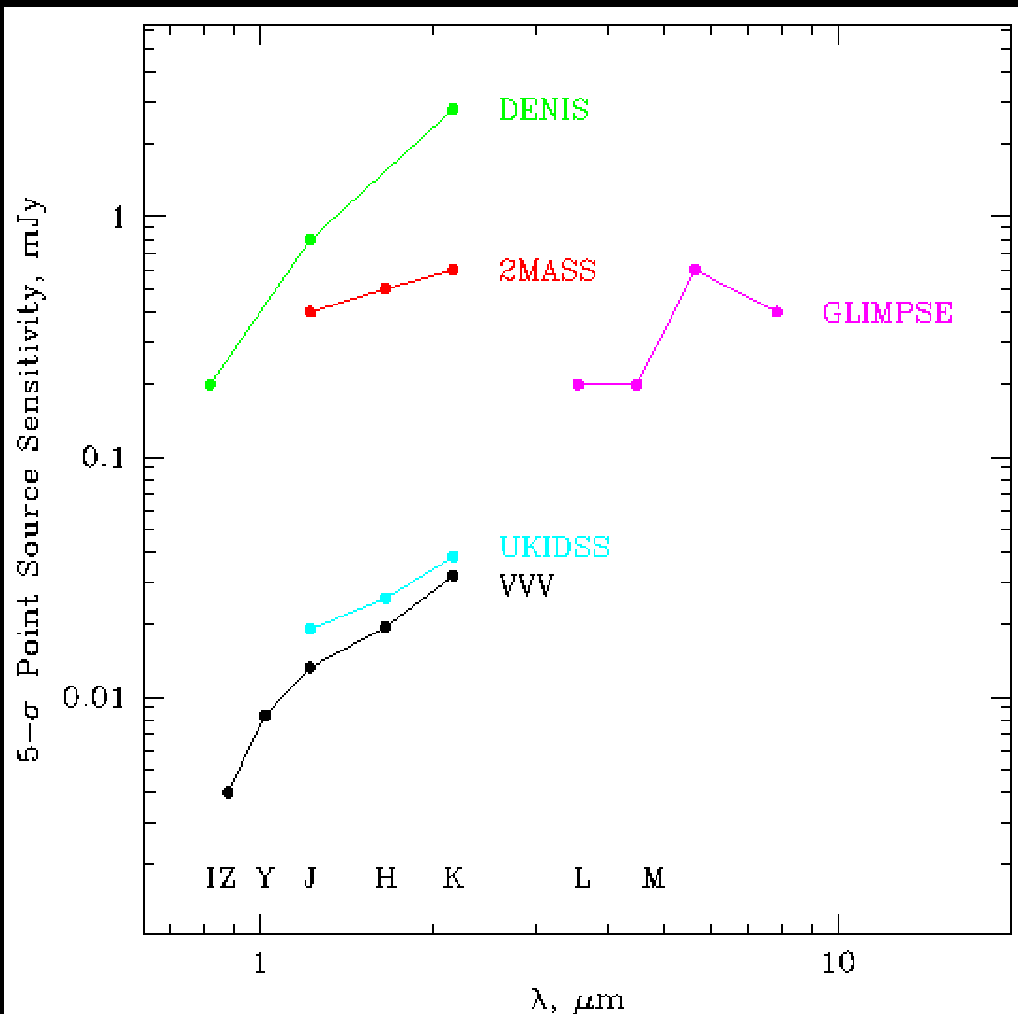


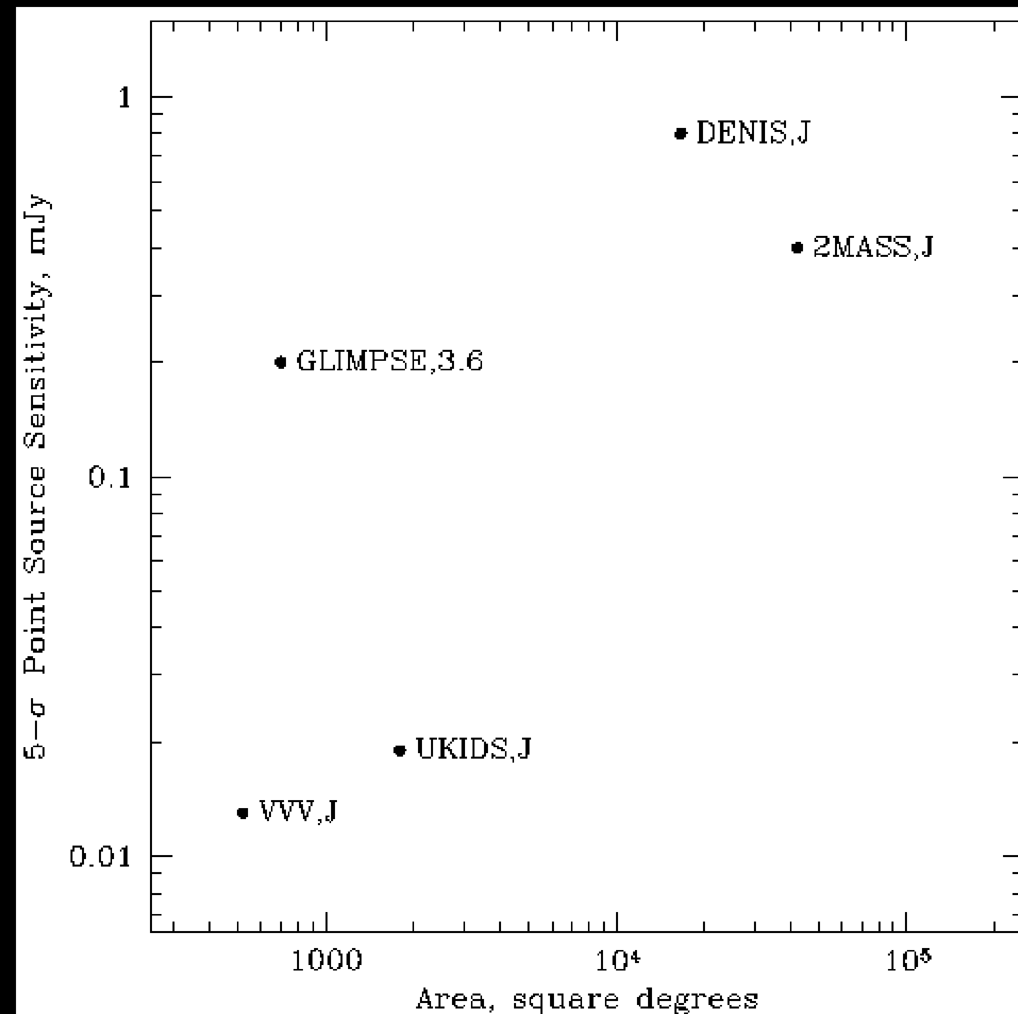
WISE selected brown dwarfs (Kirkpatrick et al. 2011)

2MASS vs VVV limit for RR Lyrae



Wide Infrared Milky Way Surveys





VVV Timeline

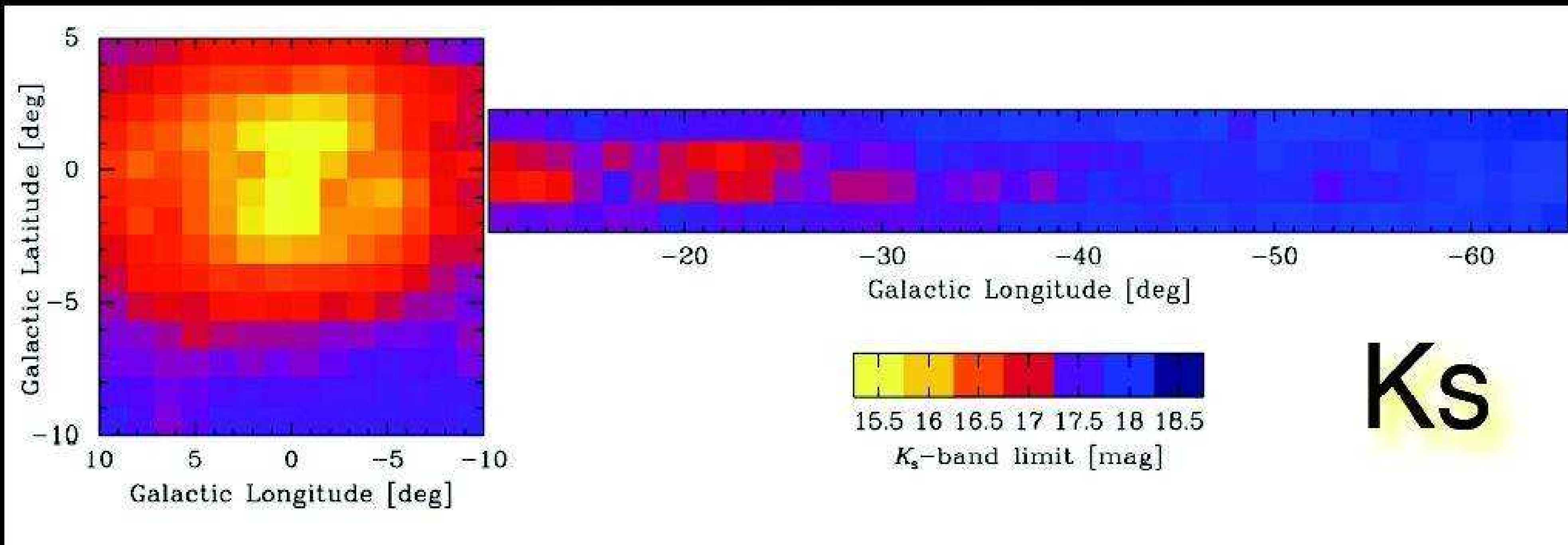
Year			
1	- 6 epochs in K for bulge and disk; K_{lim}=18/20 mag (single/combined epochs) - Z,Y,J,H, K single (quasi-simultaneously) epoch observations (bulge & disk)	multicolor maps	2010
2	- 4 epochs in K_s for bulge and disk	variability	2011
		variability	2012
3	- main part of bulge variability campaign (80 epochs, 652 h) - map bulge and disk once per night	variability	2013
4	- main disk variability campaign (similar to bulge, but 70 epochs, 525 h)	variability	2014
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)	proper motions	2015
			2016
			2017

100% observed
100% reduced
>75% released

VVVX Survey

VVV limiting magnitudes

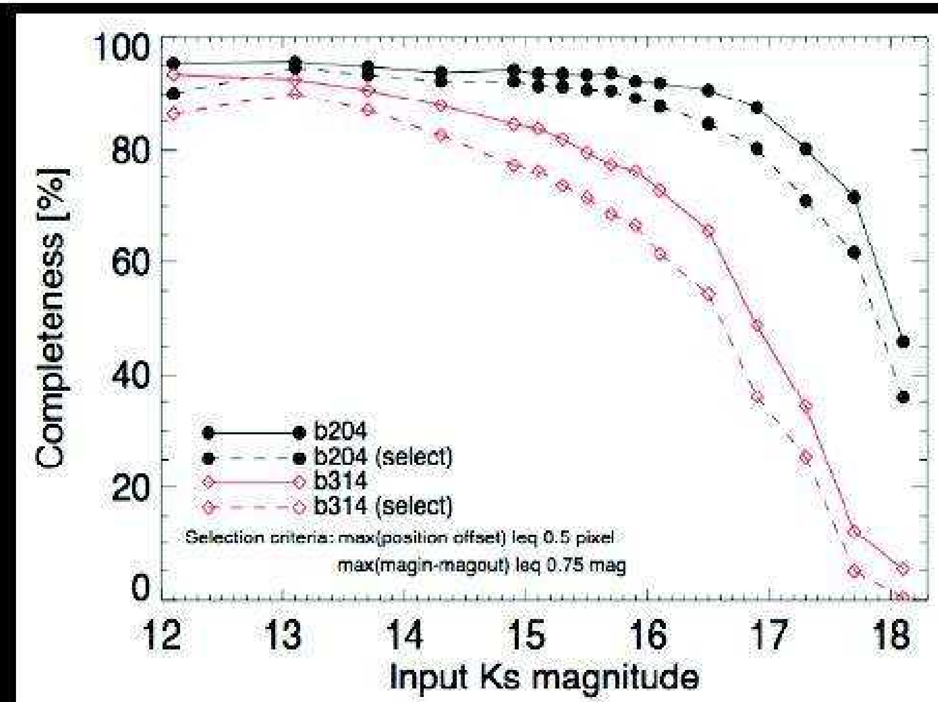
vvvsurvey.org



R. Saito

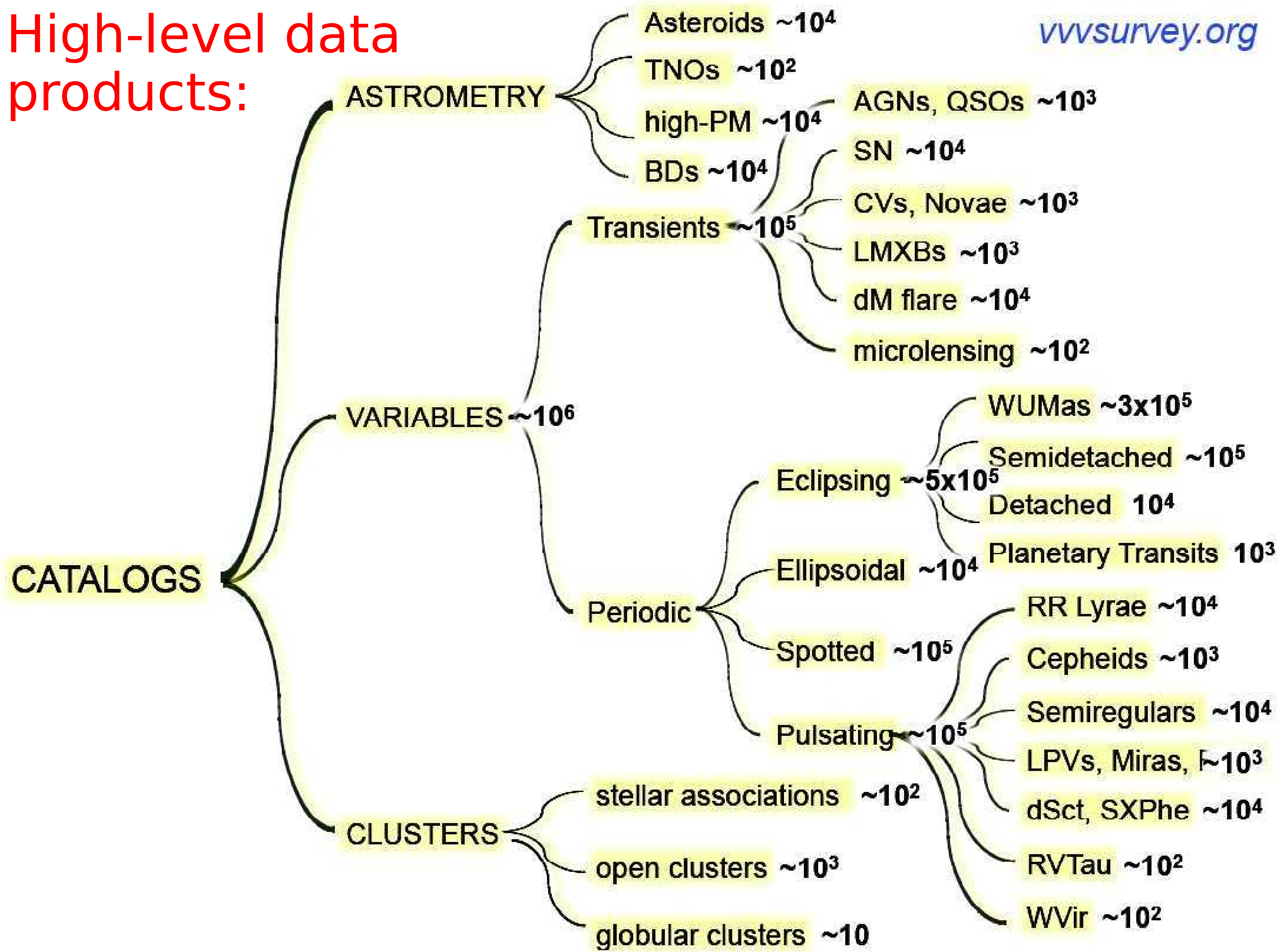
Completeness tests

M. Hempel



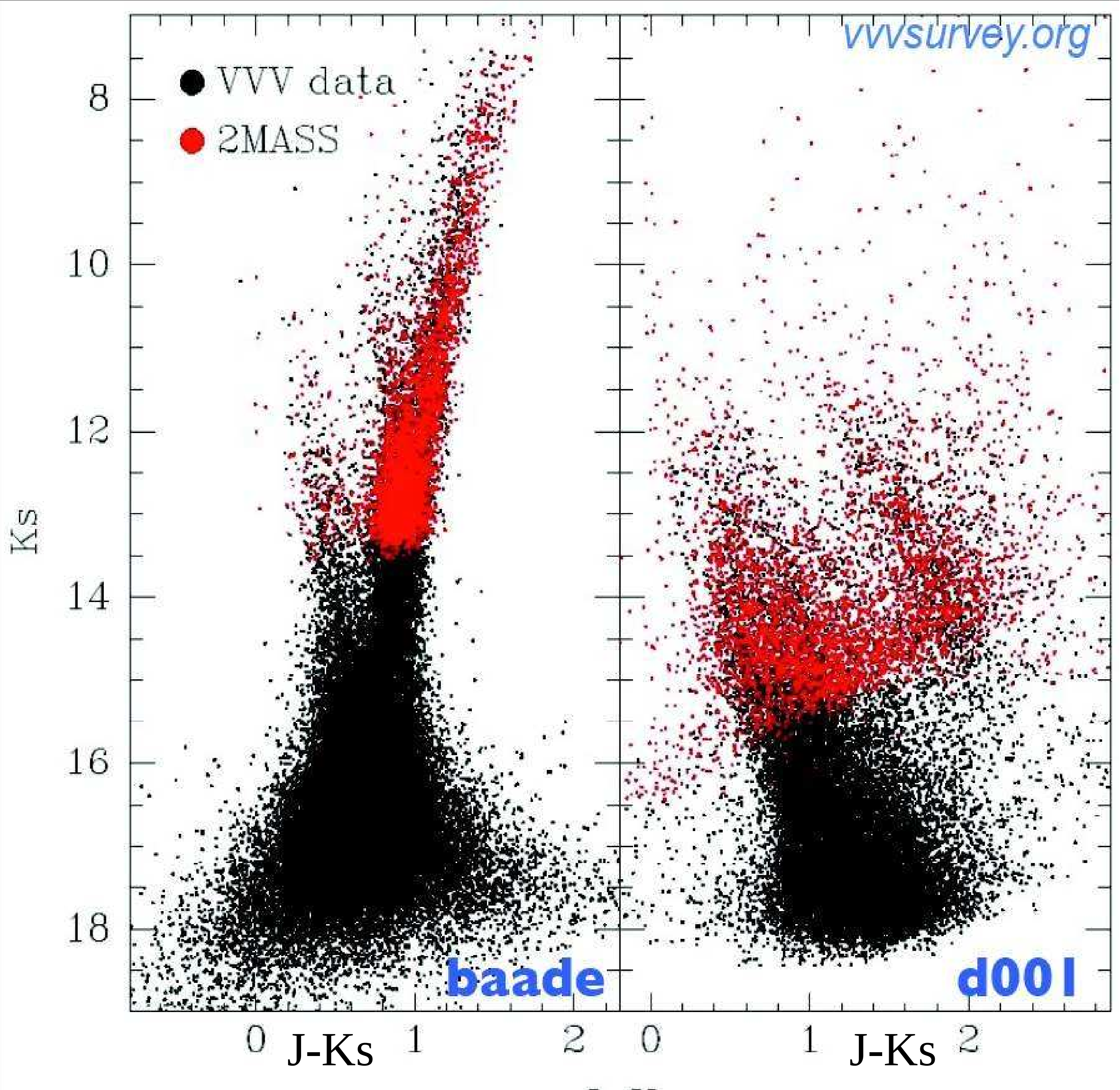
High-level data products:

vvvsurvey.org



VVV CMDs

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



Variability

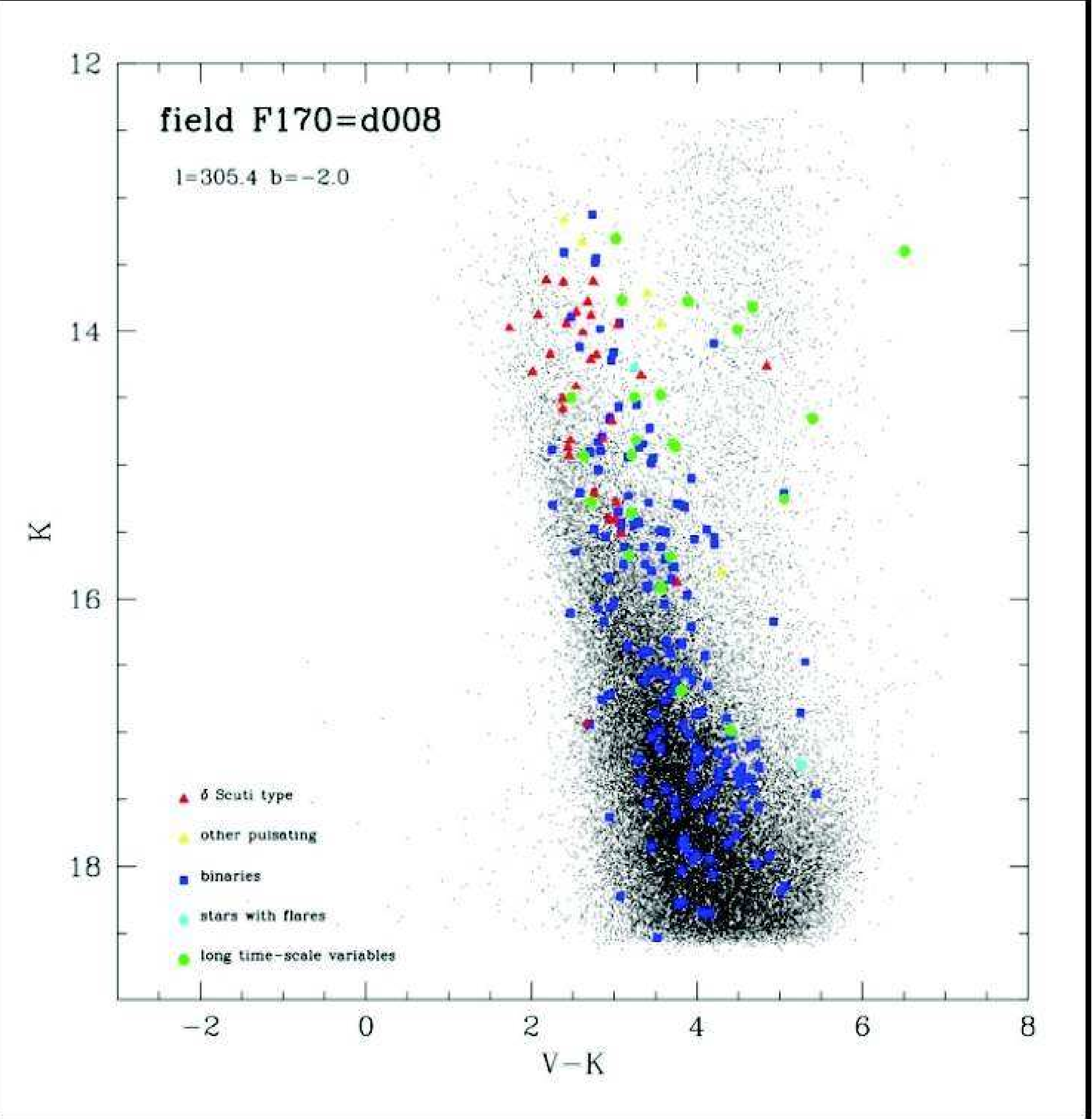
Combined VLT-optical and VISTA-IR photometry

230 new variables from VLT/VIMOS observations matched to VVV IR photometry

Many more than expected!

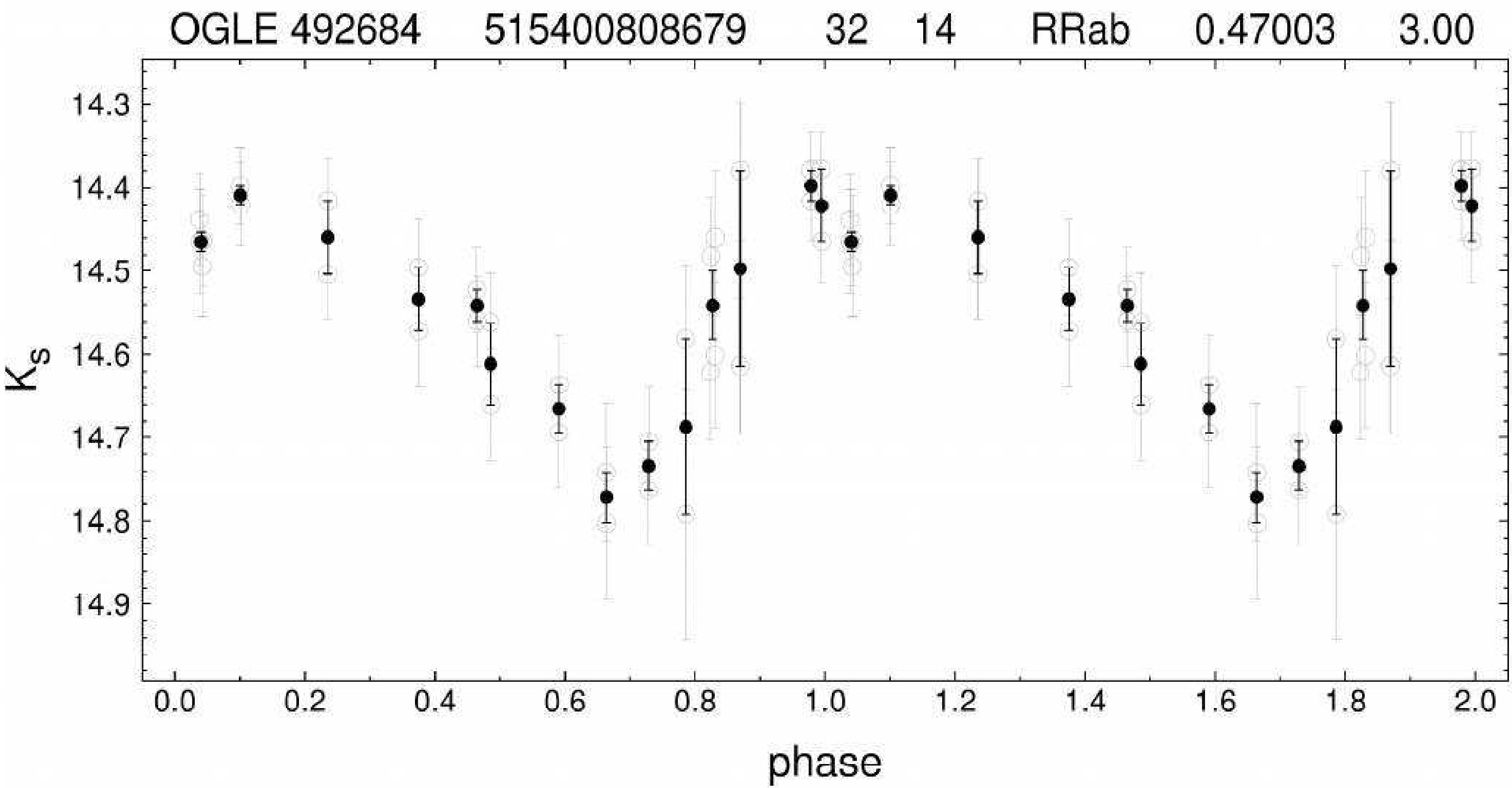
1/1000 → few/1000

Total in VVV Survey ~1 million variables



Pawel Pietrukowicz

A few RR Lyrae light curves



Istvan Dekany

Extreme Variables

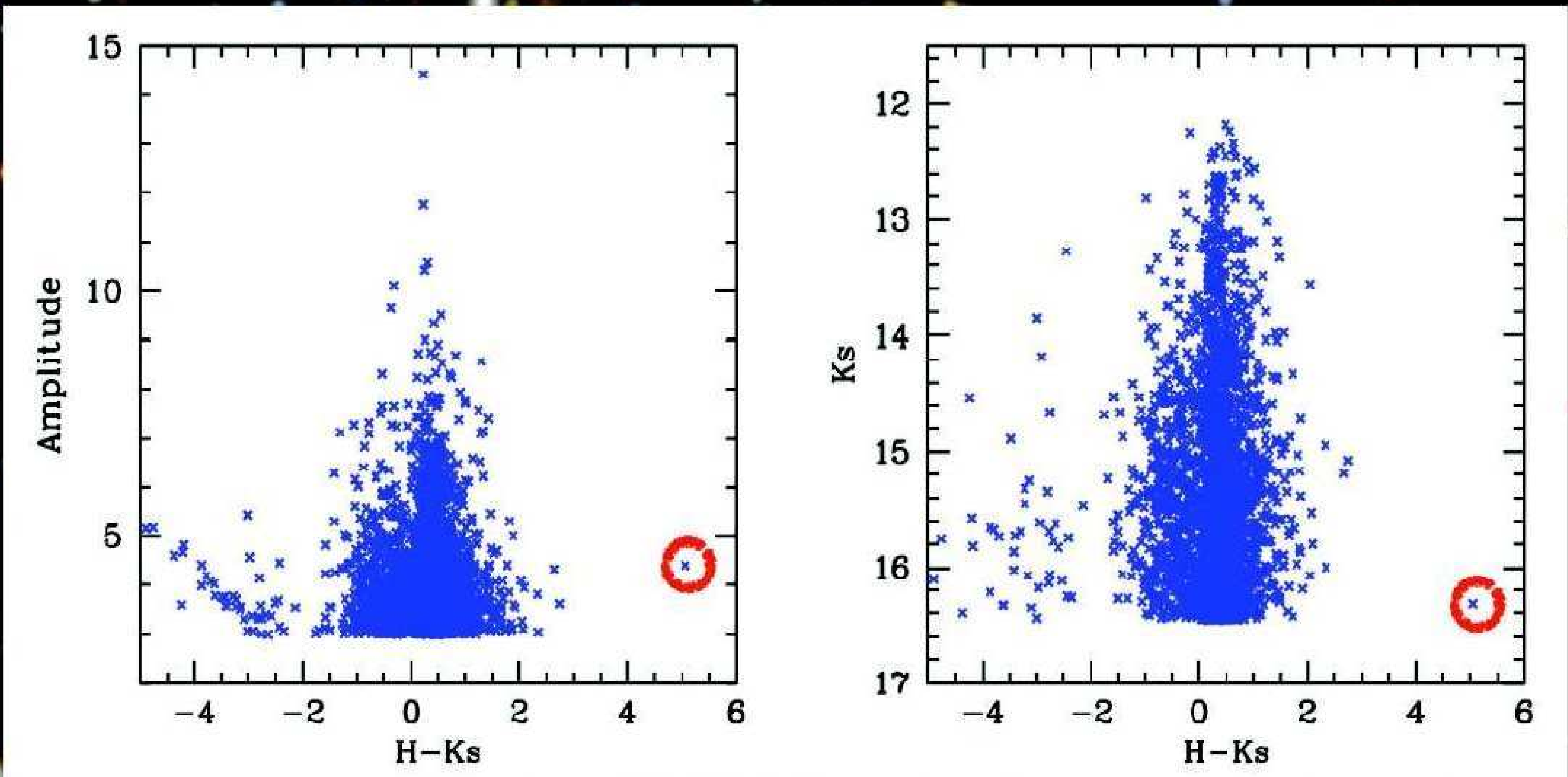
VVV-WIT06

with R. Saito et al.

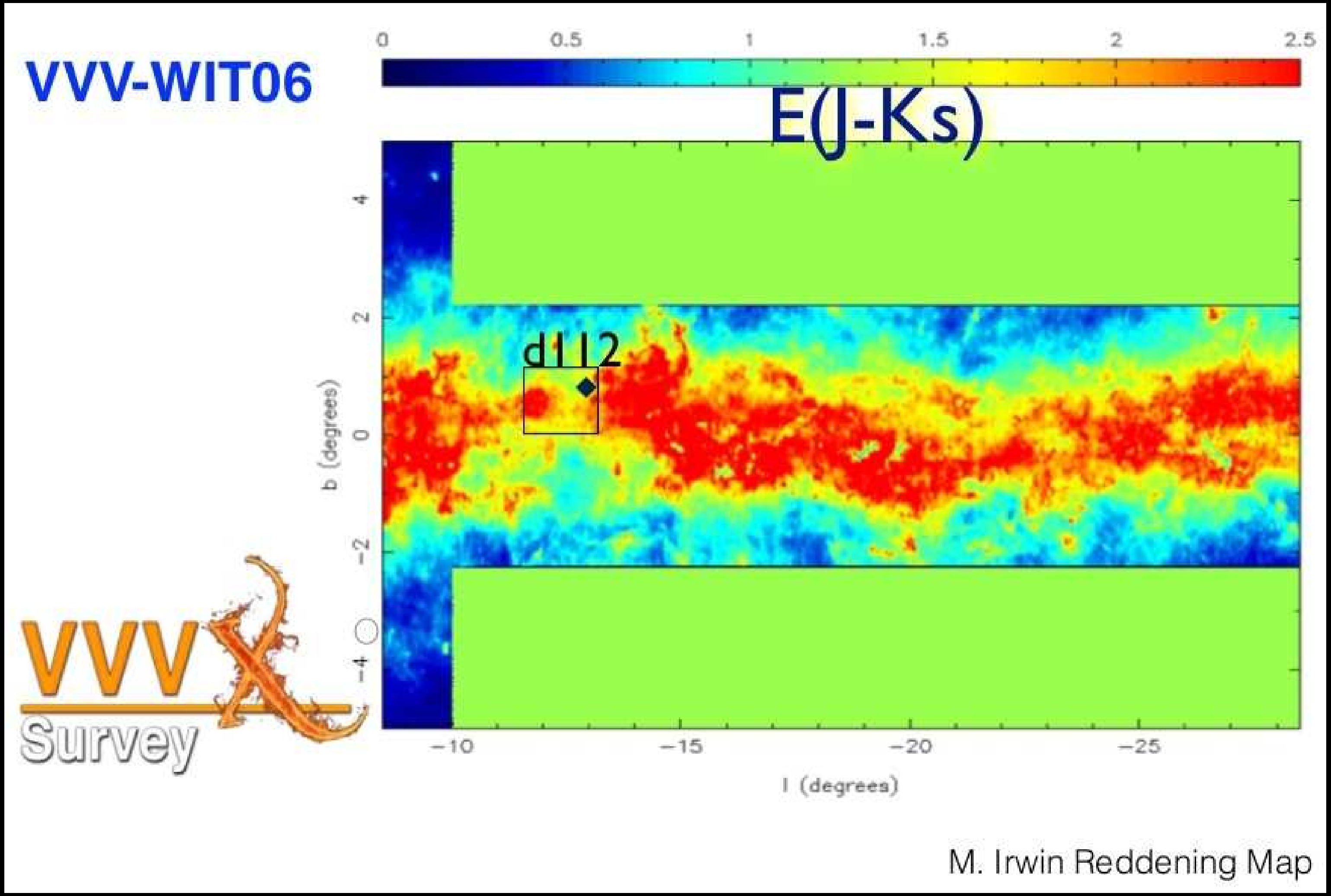
Minniti et al. (2017, ApJ, 849, L23)

Extreme Variables

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

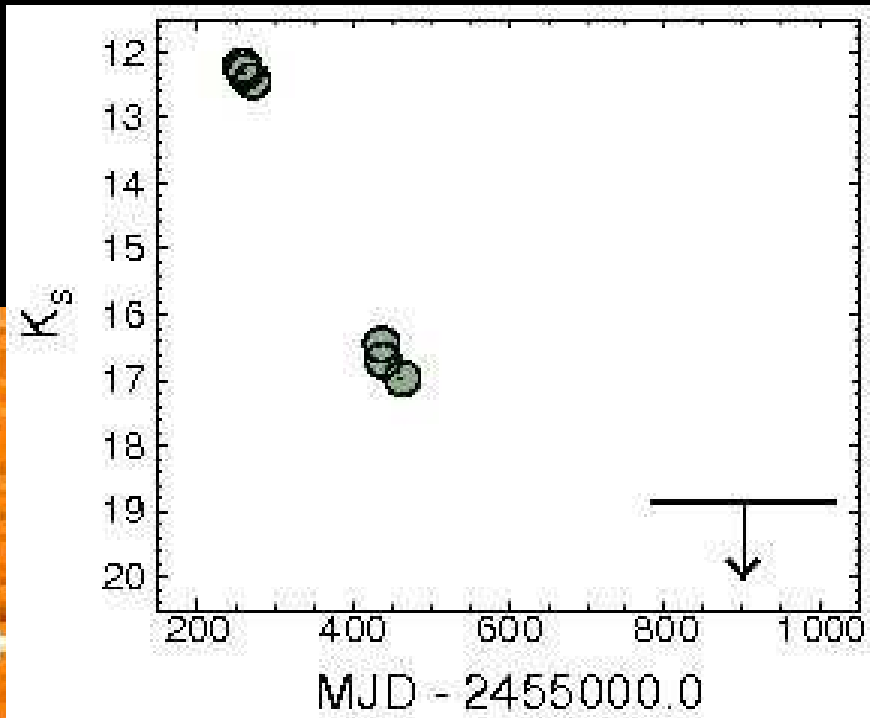


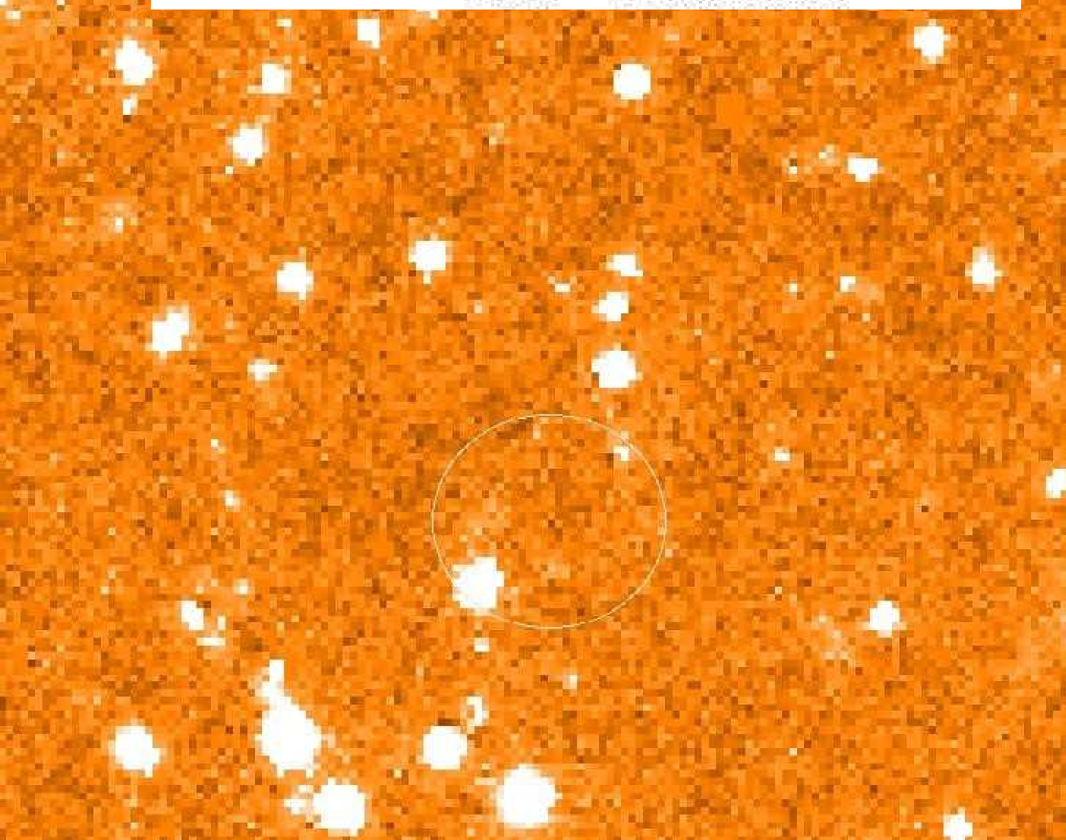
Extreme Variables

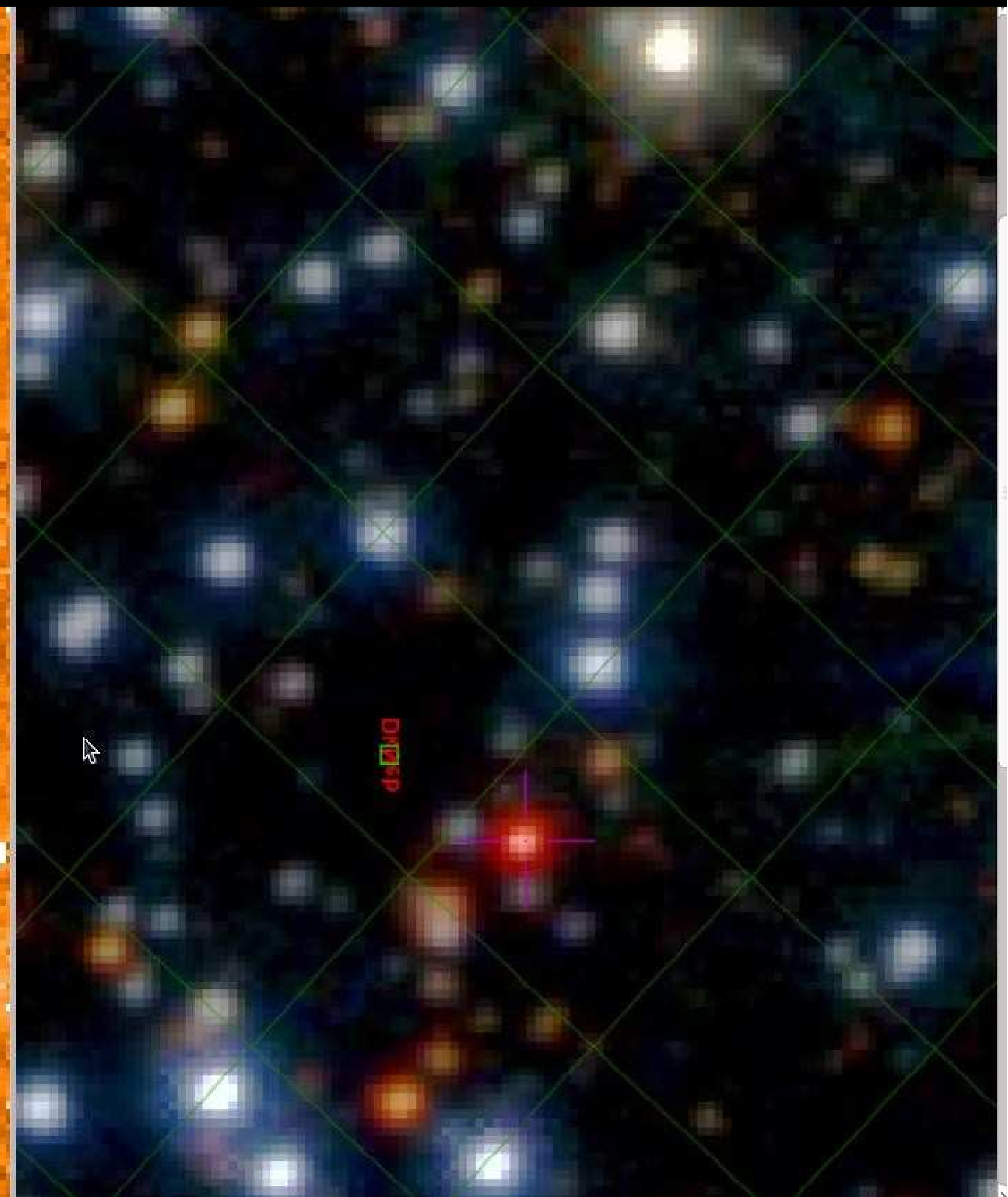


l=347.14539, b=0.88522 => **Av = 10-15 mag**

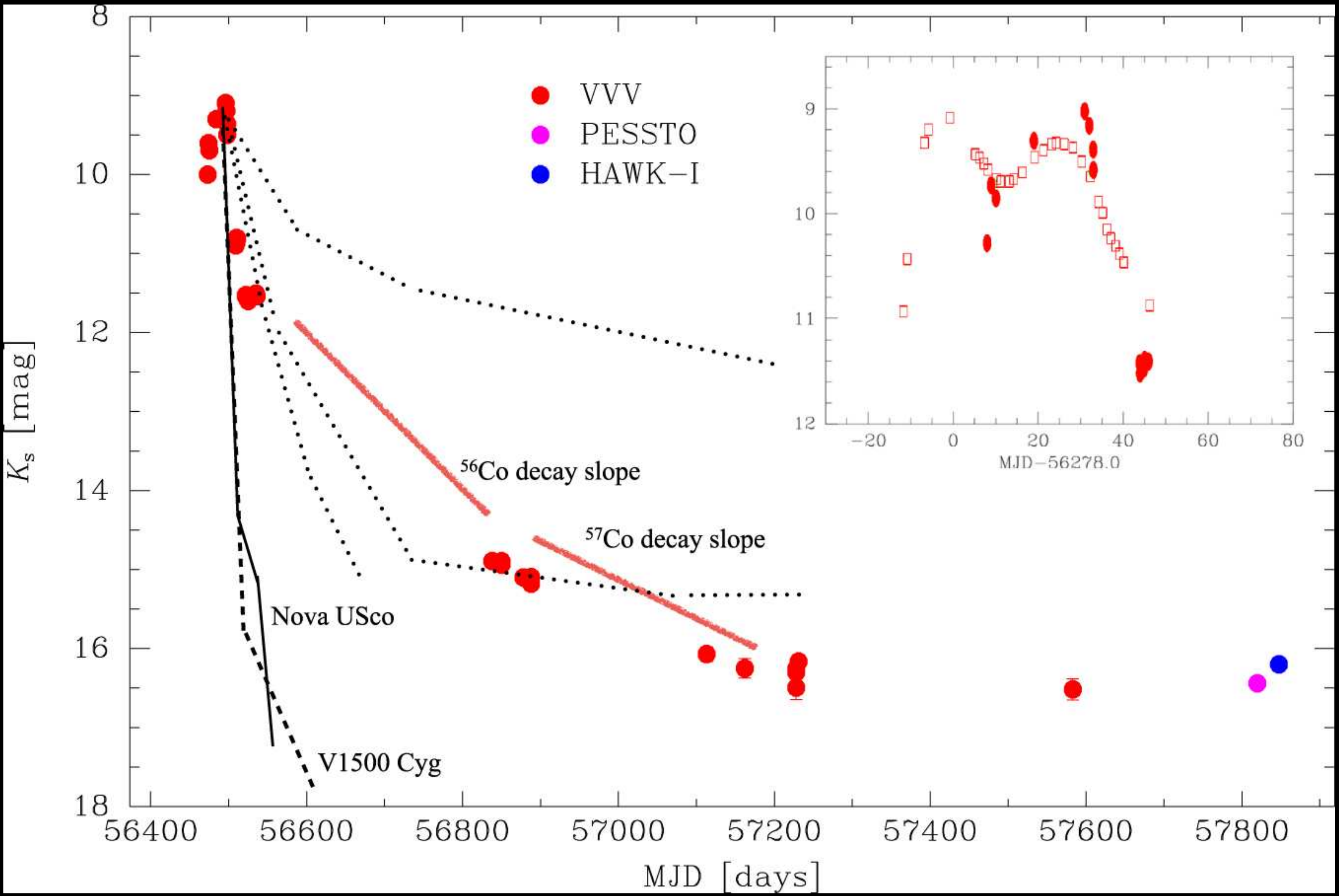
Extreme Variables



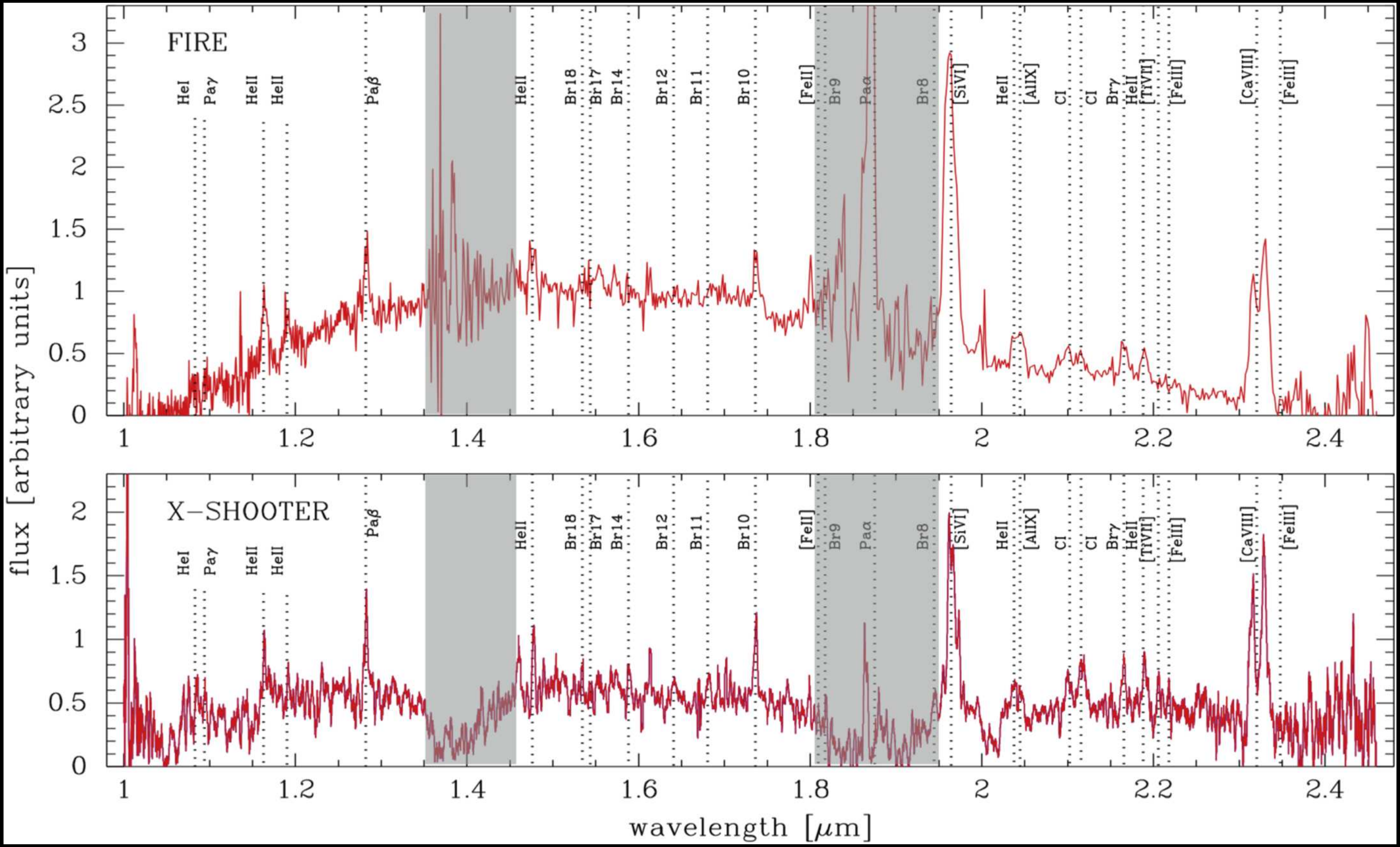




Extreme Variables



Extreme Variables



- broad emission lines (upward of 3000 km /s)

Extreme Variables

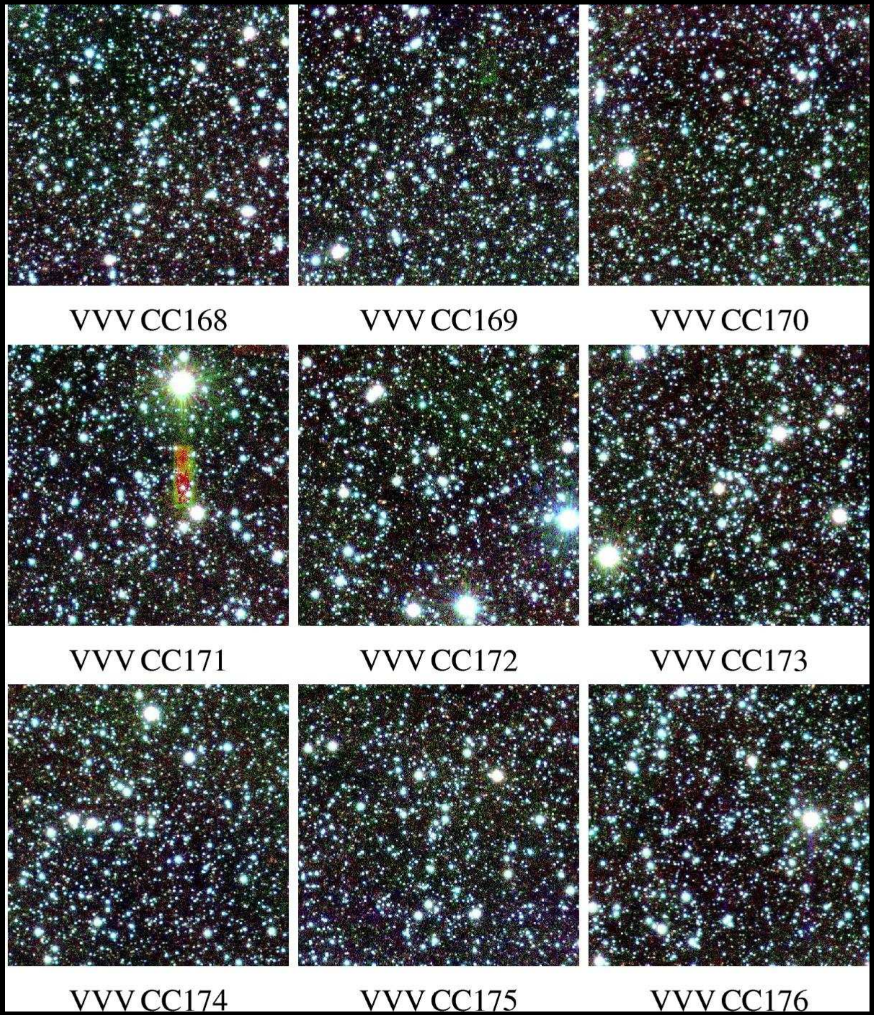
VVV-WIT06 may be:

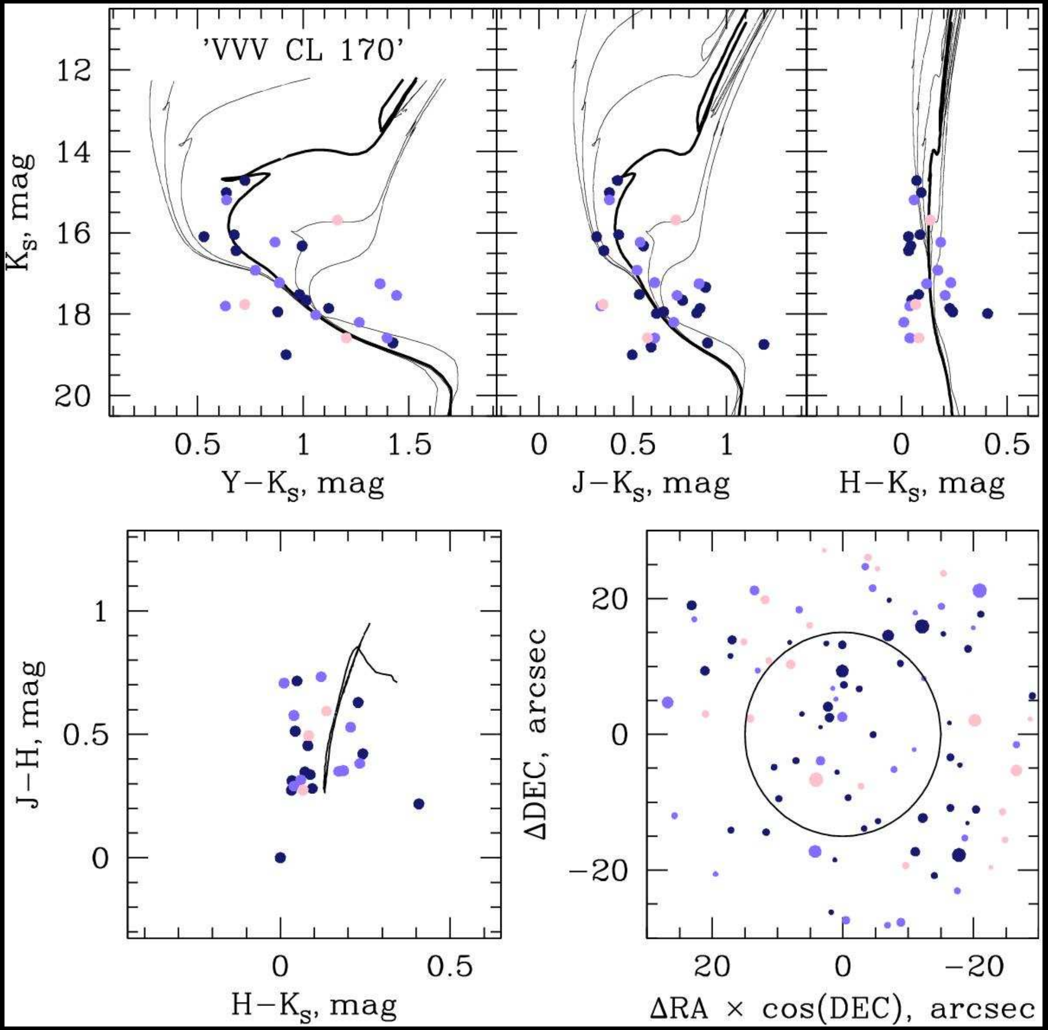
(i) the closest Type I SN observed in about 400 years (0.7-2.2 Mpc),

(ii) an exotic high-amplitude nova that would extend the known realm of such objects, or

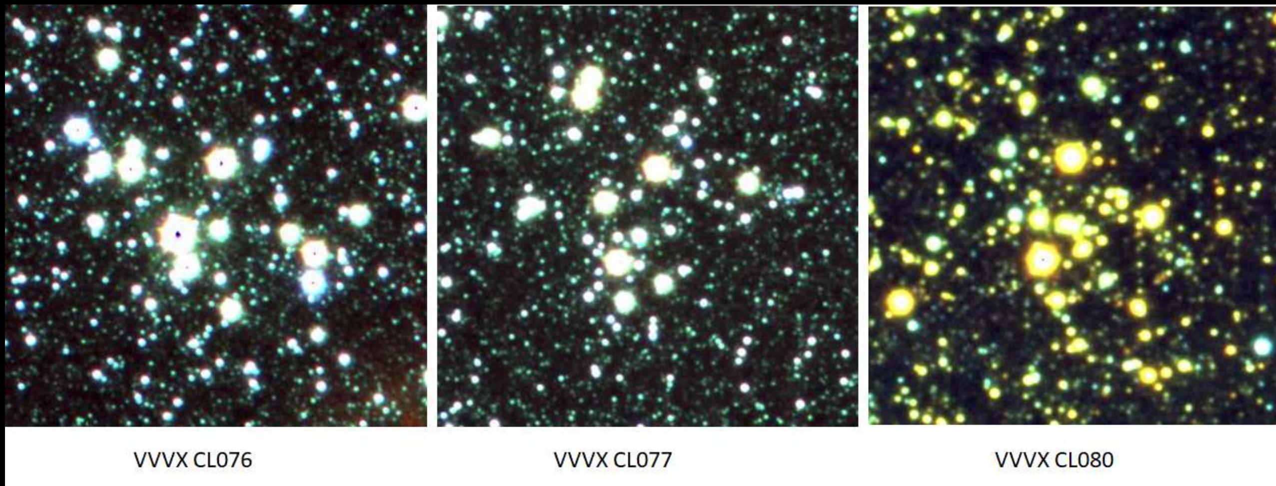
(iii) a stellar merger.

Obscured clusters

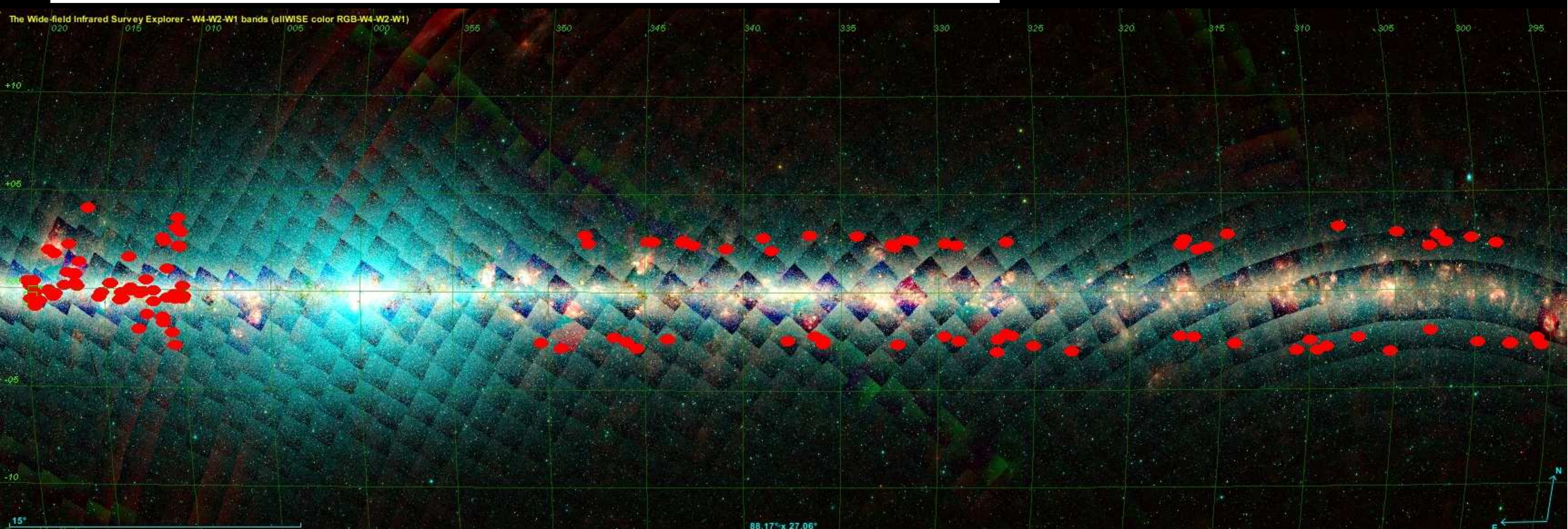




Borissova (2011, 2014, 2018), Minniti et al. (2011), Chene et al. (2012) Ivanov et al. (2017)



Obscured clusters



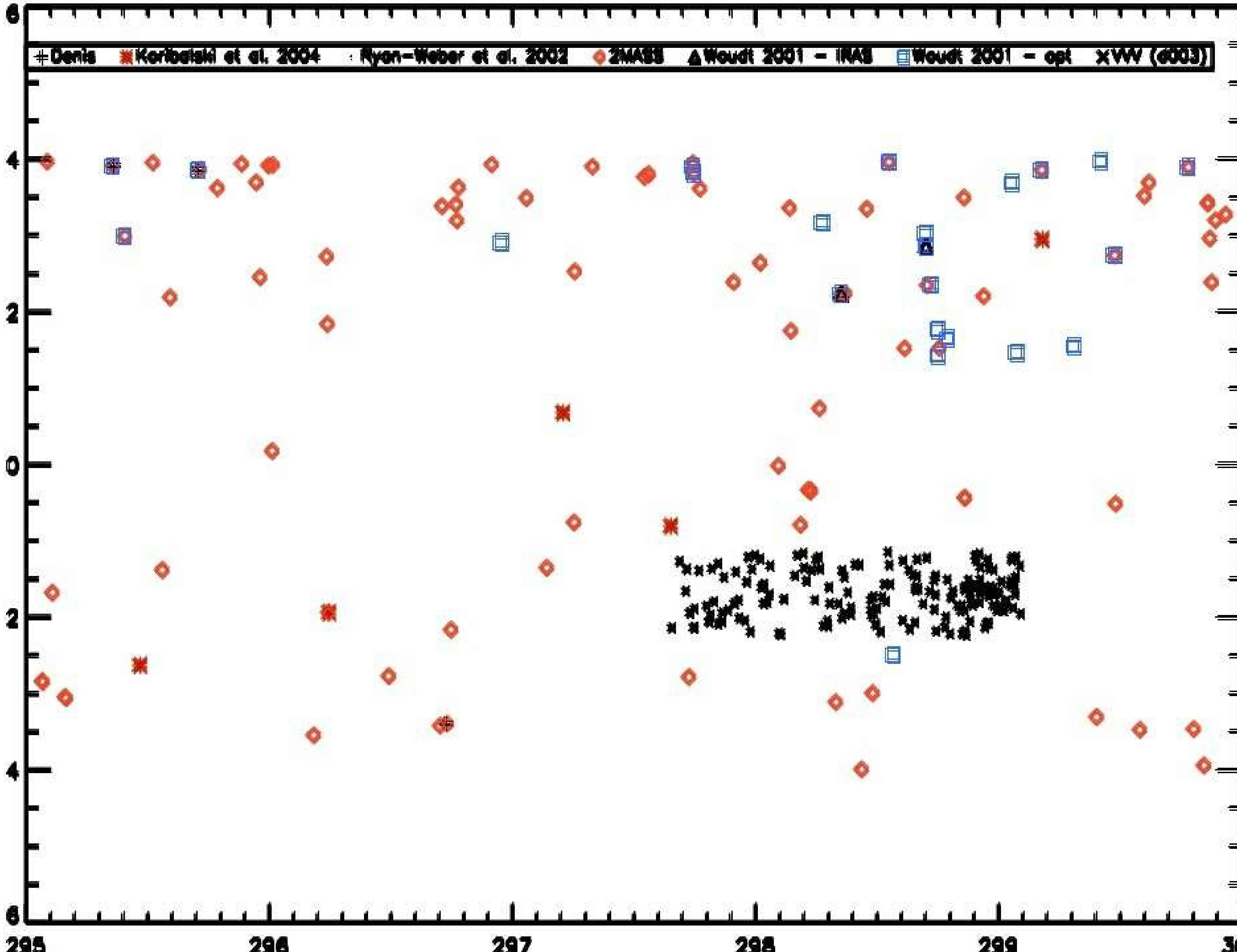
Borissova (2011, 2014, 2018), Minniti et al. (2011), Chene et al. (2012) Ivanov et al. (2017)


~35,000 GALAXIES

Galaxies in Field d003

vvvsurvey.org

Eduardo de Amores

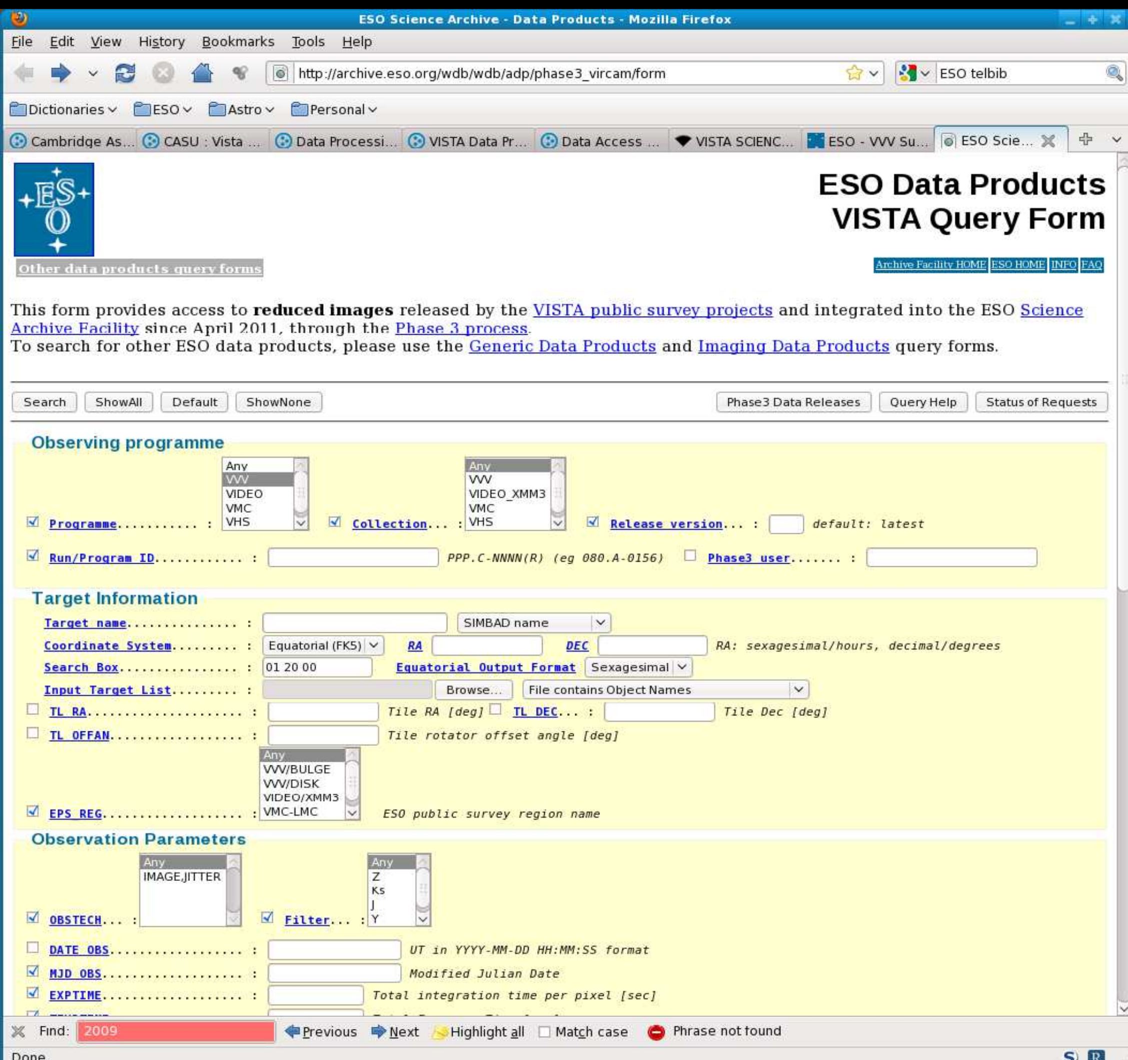


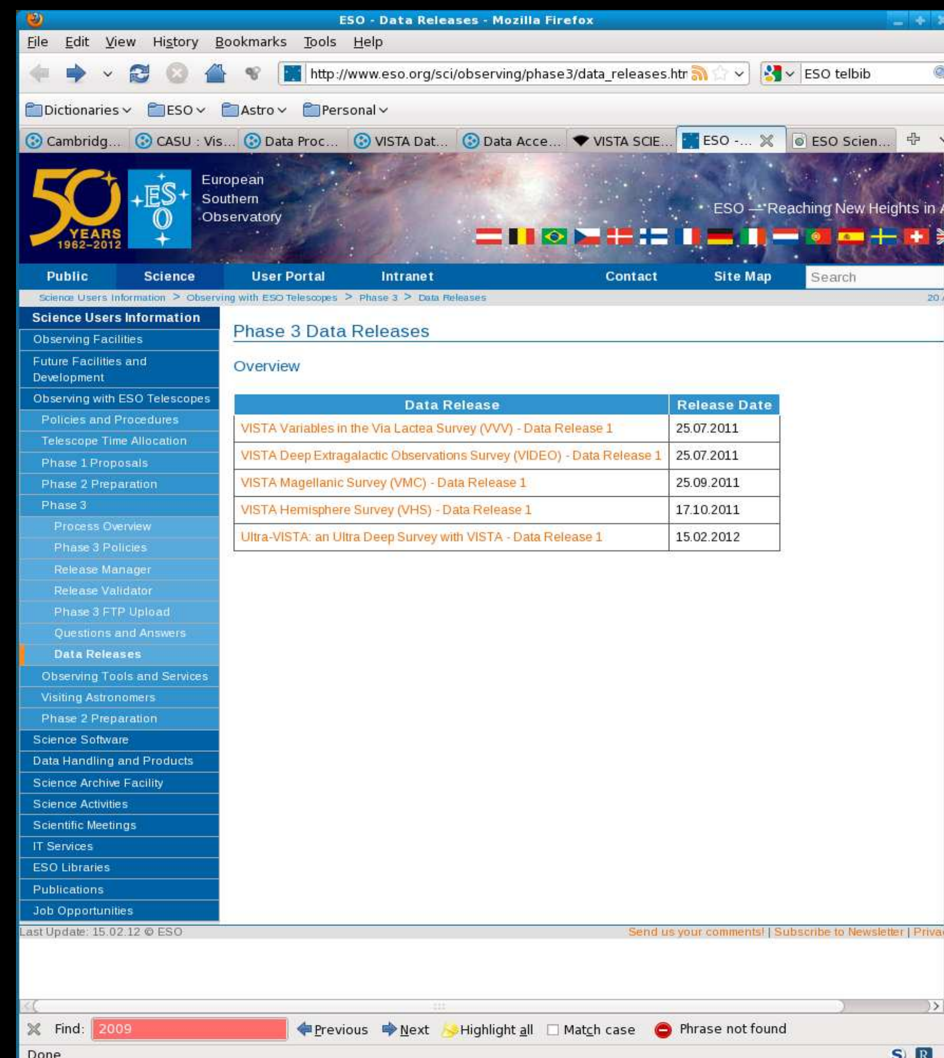

vvvsurvey.org

Background Galaxies

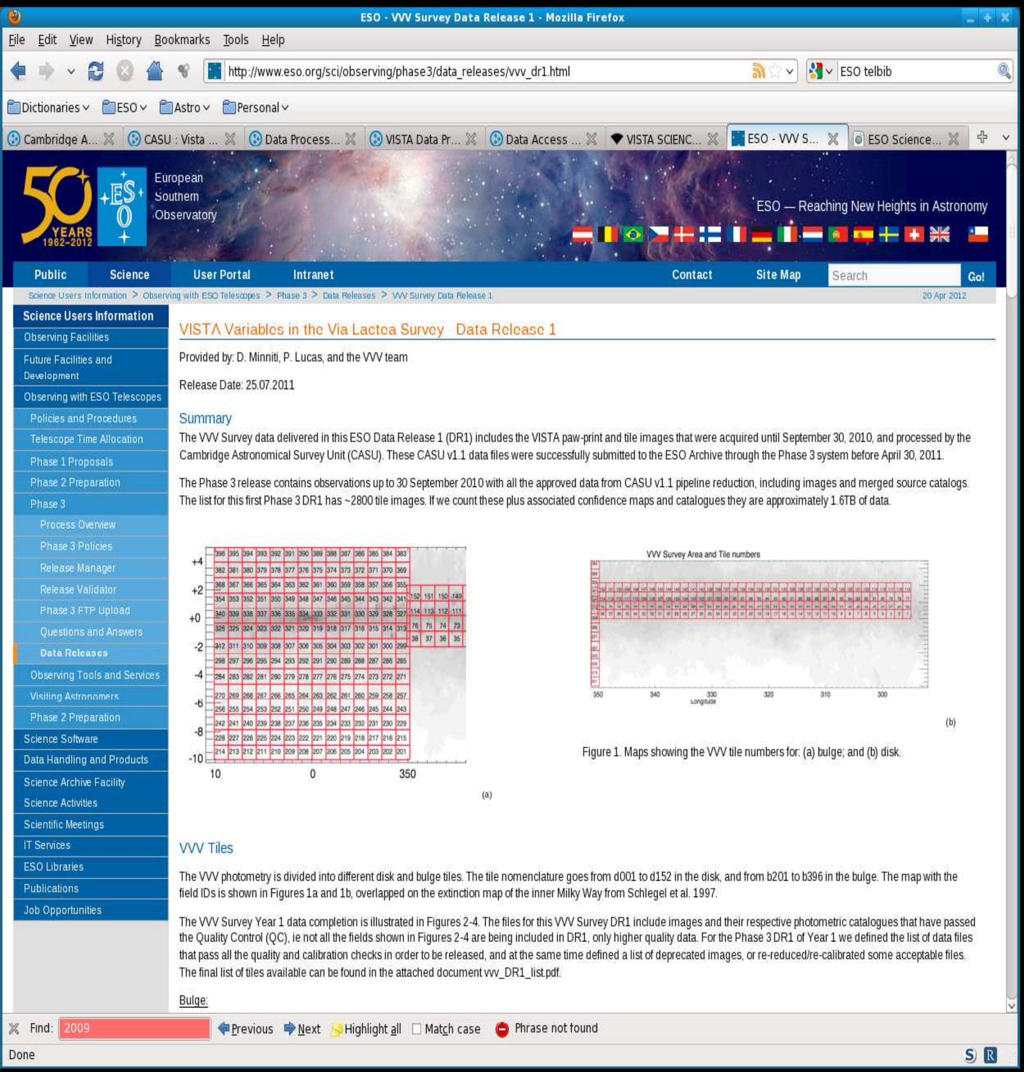
VVV field d003

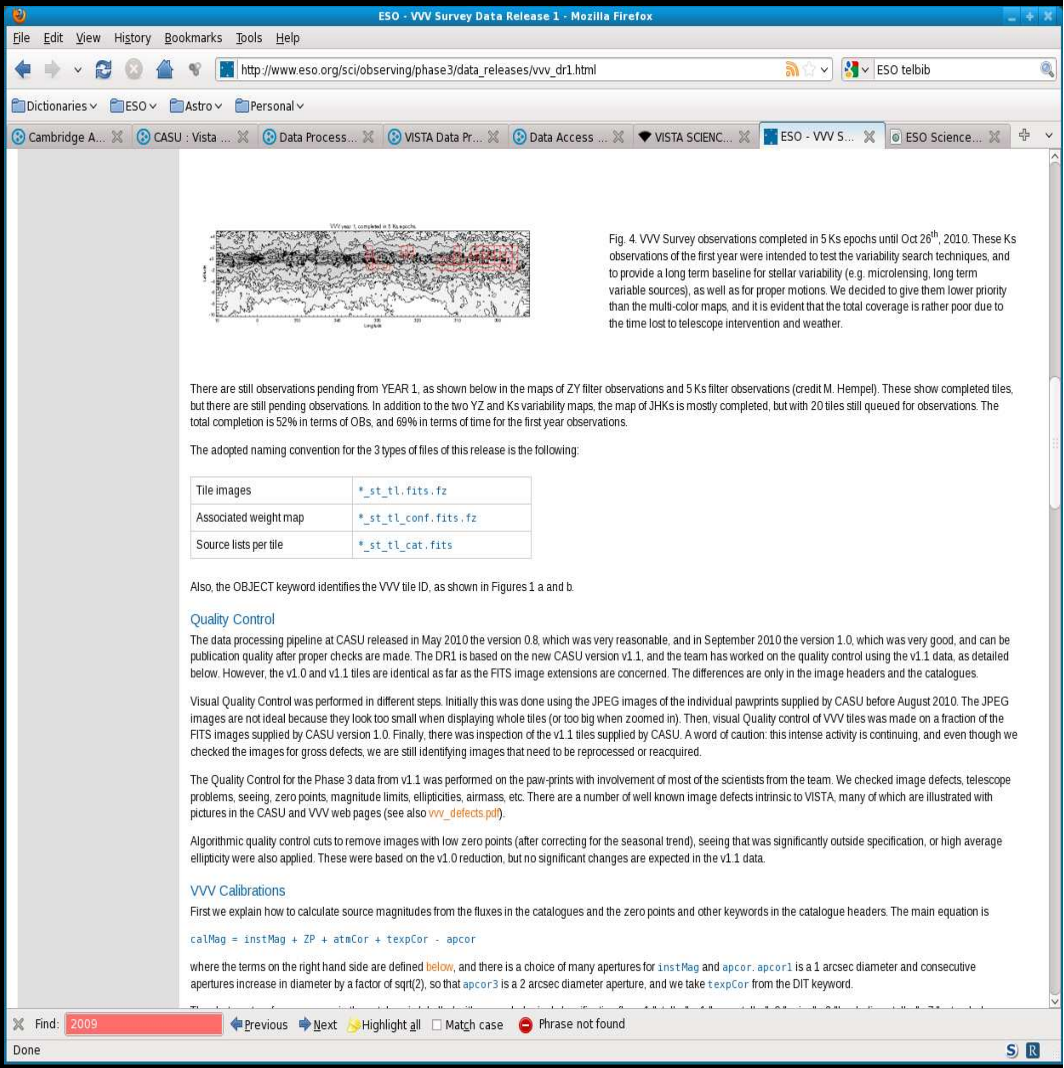
Data Access (= Survey Success)



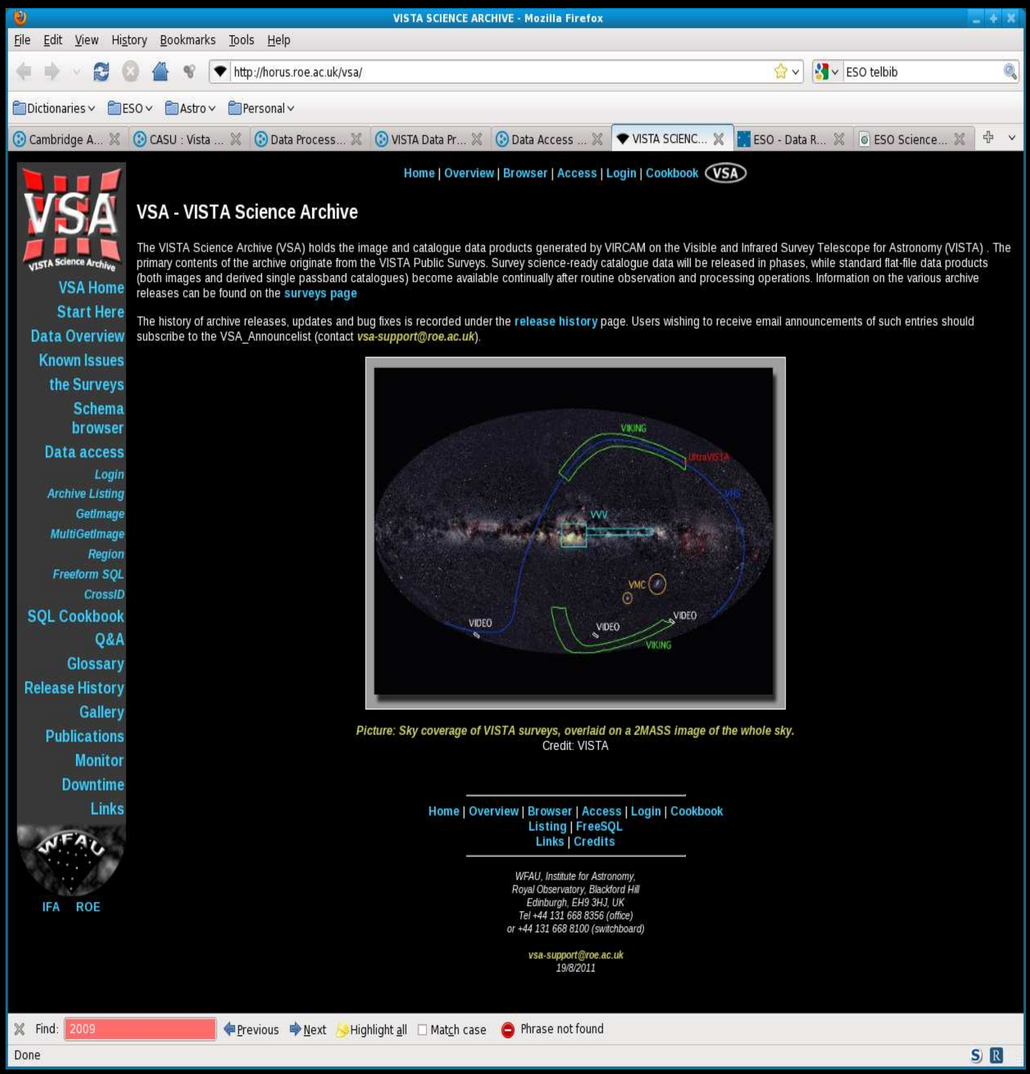


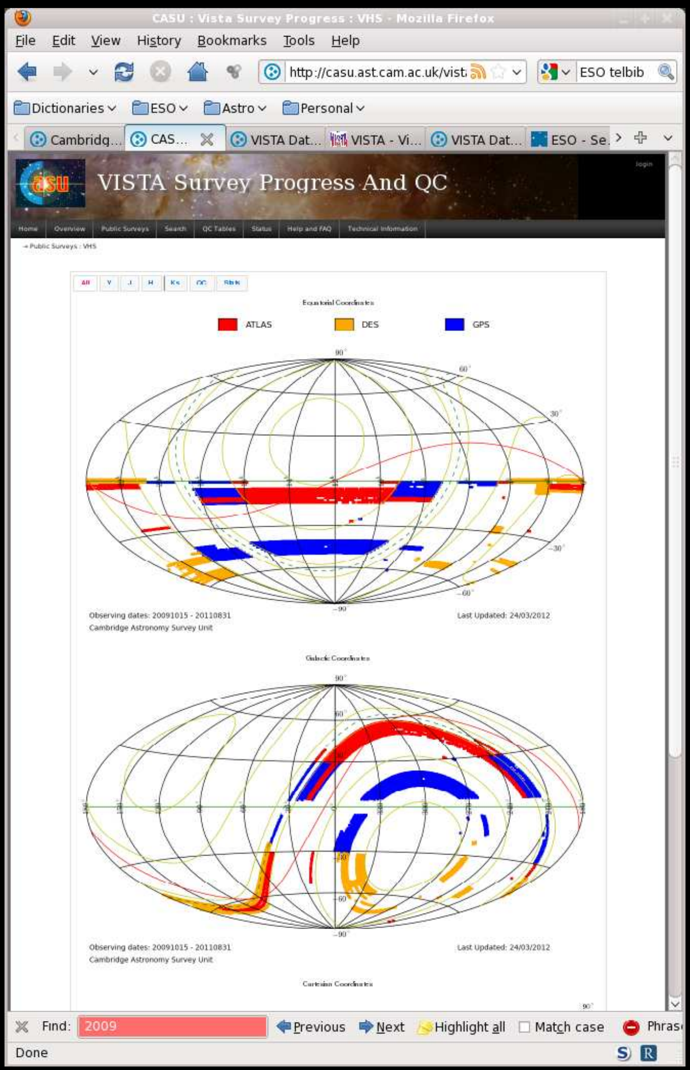
Data Access (= Survey Success)





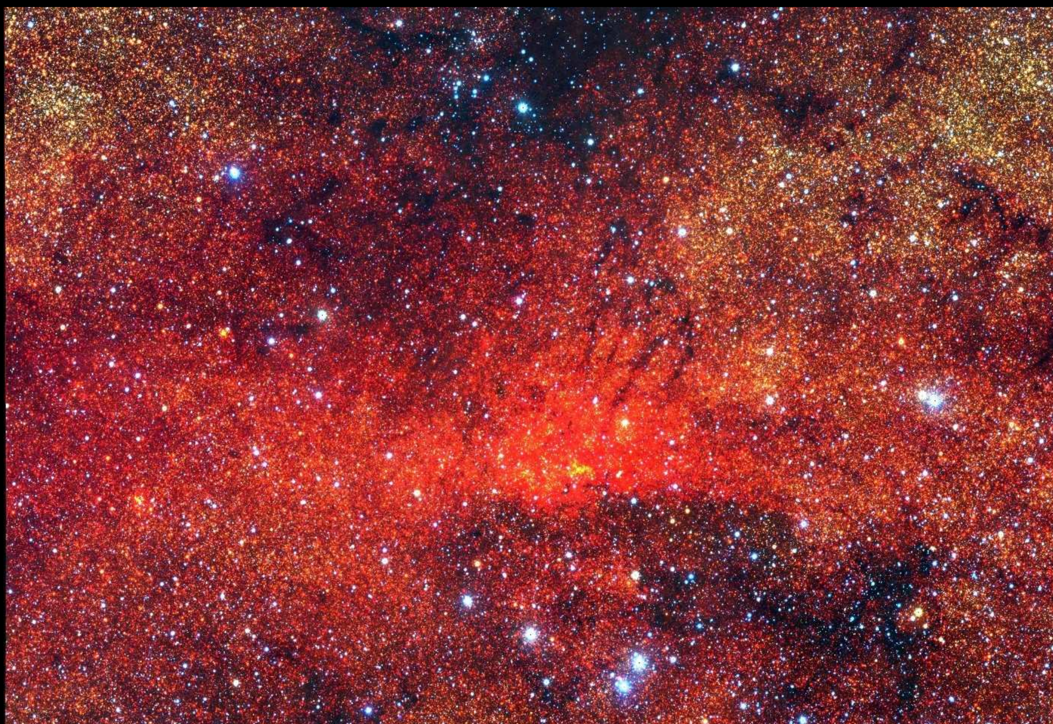
Data Access (= Survey Success)





+ *Visier!*

Summary



Surveys are great!