
VIKING
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with executive team of Konrad Kuijken, Simon Driver, Steve Eales, Richard McMahon and Will Sutherland

# VIKING – living in the “middle kingdom”

The deep and deeper Vista surveys VIDEO and UltraVISTA do not sample a sufficiently large volume at z>1 and z>7 to detect many massive clusters or rare QSOs.

And the wide, shallow Hemisphere survey isn’t deep enough to detect either.

Therefore there is a gap in the depth/area combination for an intermediate survey – VIKING.

# VIKING specs

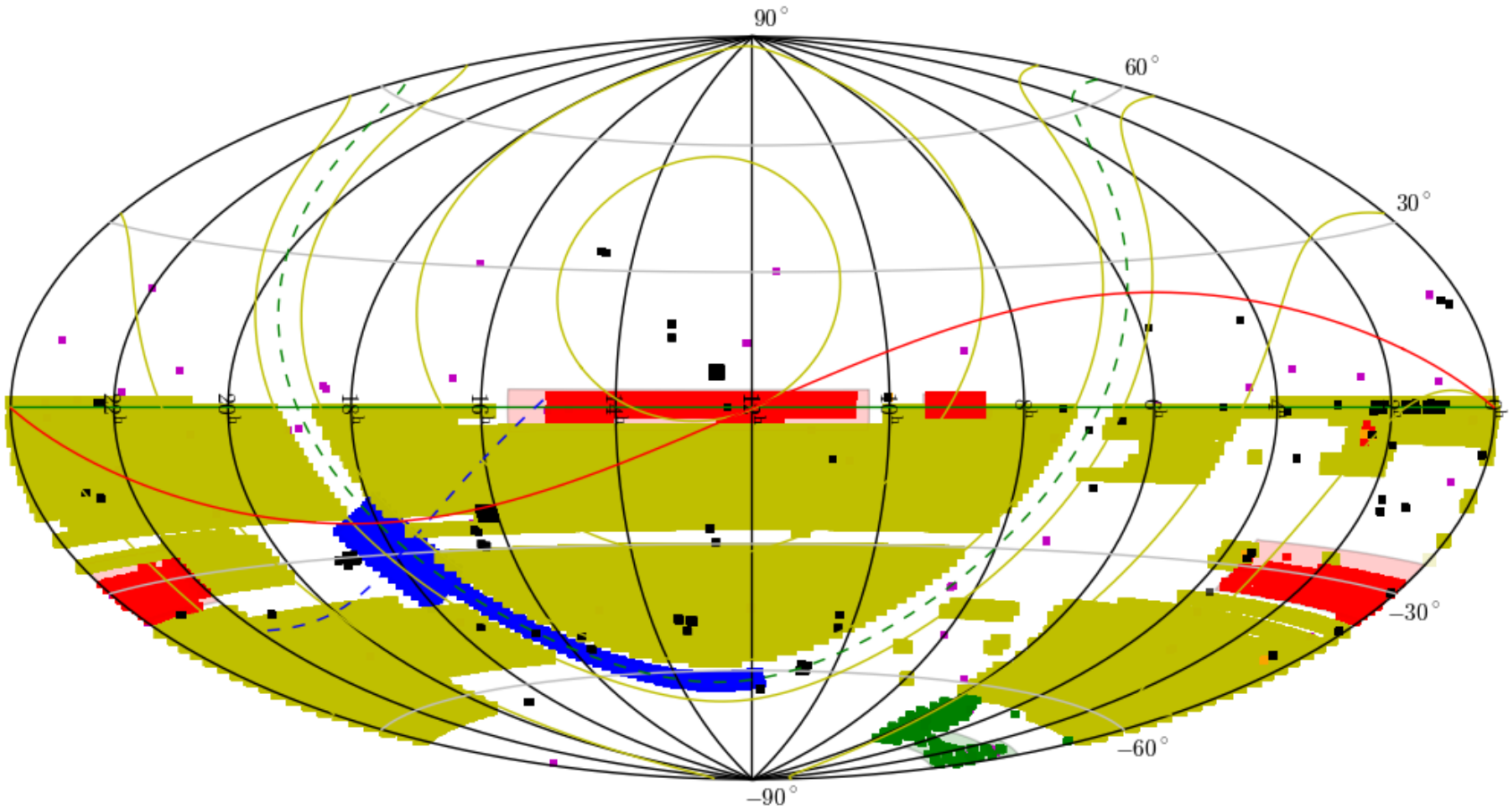
The goal of VIKING is to detect L* galaxies around z=1 and the brightest QSOs at z>7.

| Filter | Exp. time (sec) | Med.seeing (arcsec) | $5\sigma, 2''$ aperture mag. (AB) | (Vega) | $f_\lambda$ ($10^{-20}$ erg s$^{-1}$ cm$^{-2}$ Å$^{-1}$) | UKIDSS (Vega; actual) |
|---|---|---|---|---|---|---|
| Z | 500 | 0.8 | 23.1 | 22.6 | 75 | – |
| Y | 400 | 0.8 | 22.3 | 21.7 | 114 | 20.2 |
| J | 400 ($2 \times 200$) | 0.8 | 22.1 | 21.3 | 94 | 19.6 |
| H | 300 | 0.8 | 21.5 | 20.2 | 94 | 18.7 |
| $K_s$ | 500 | 0.8 | 21.2 | 19.4 | 77 | 18.2 |
| $i$ (KIDS) | 1080 | 0.7 | 24.1 | 23.8 | 40 | – |

The VIKING survey area will be 1,500 sq.deg.

NB VIKING priorities are NIR-centric and different from KiDS

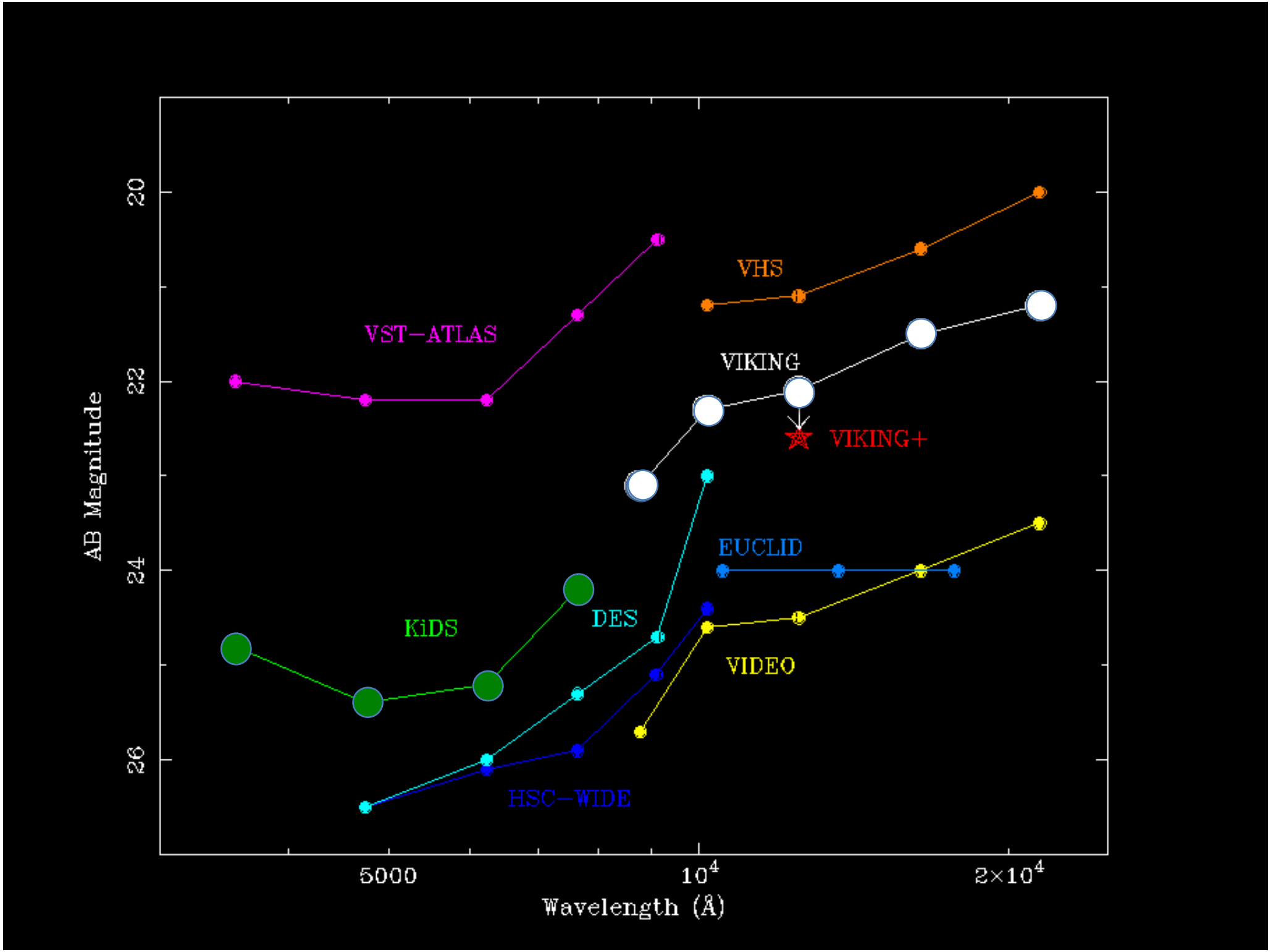
# Sky Coverage

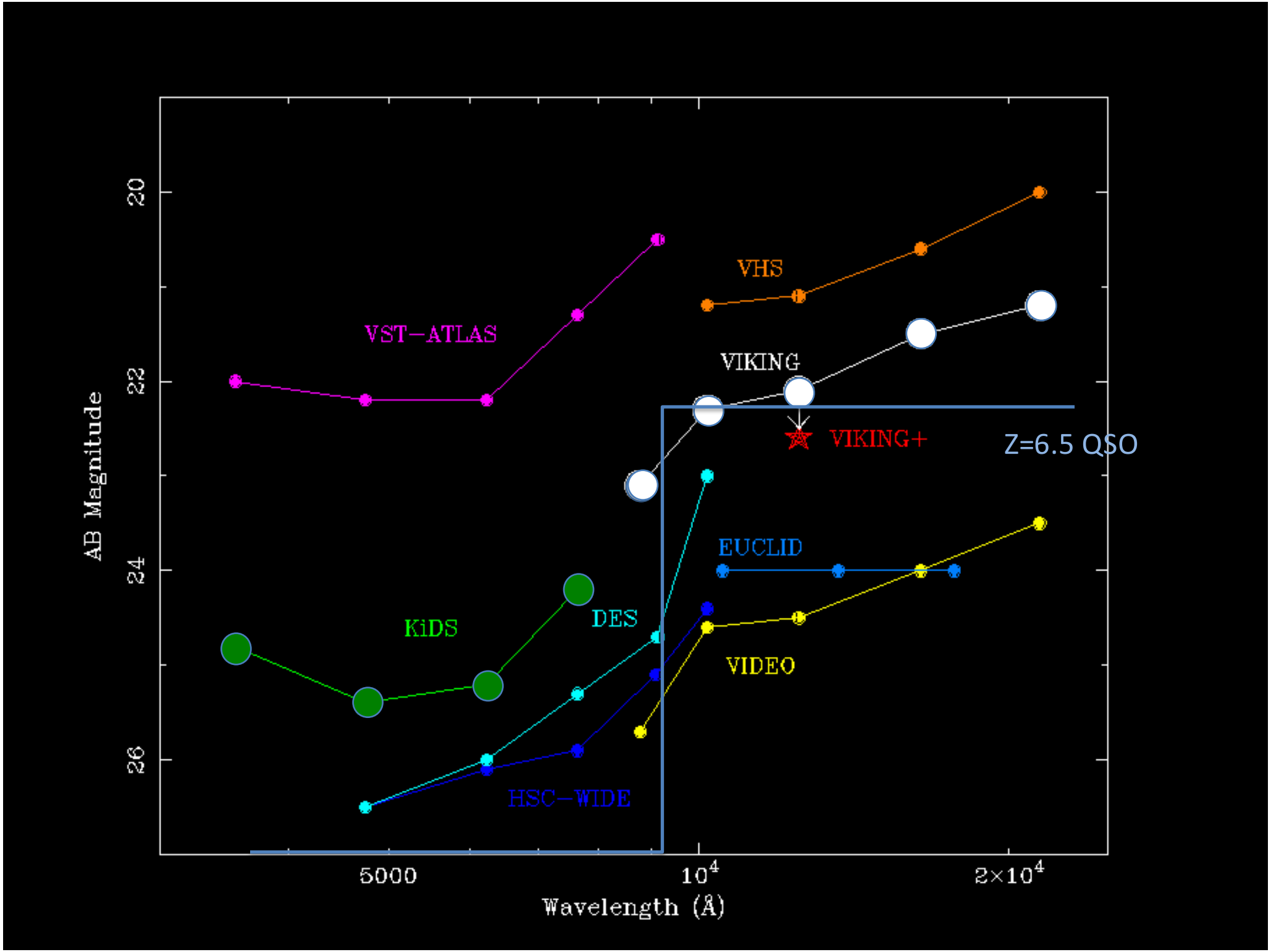


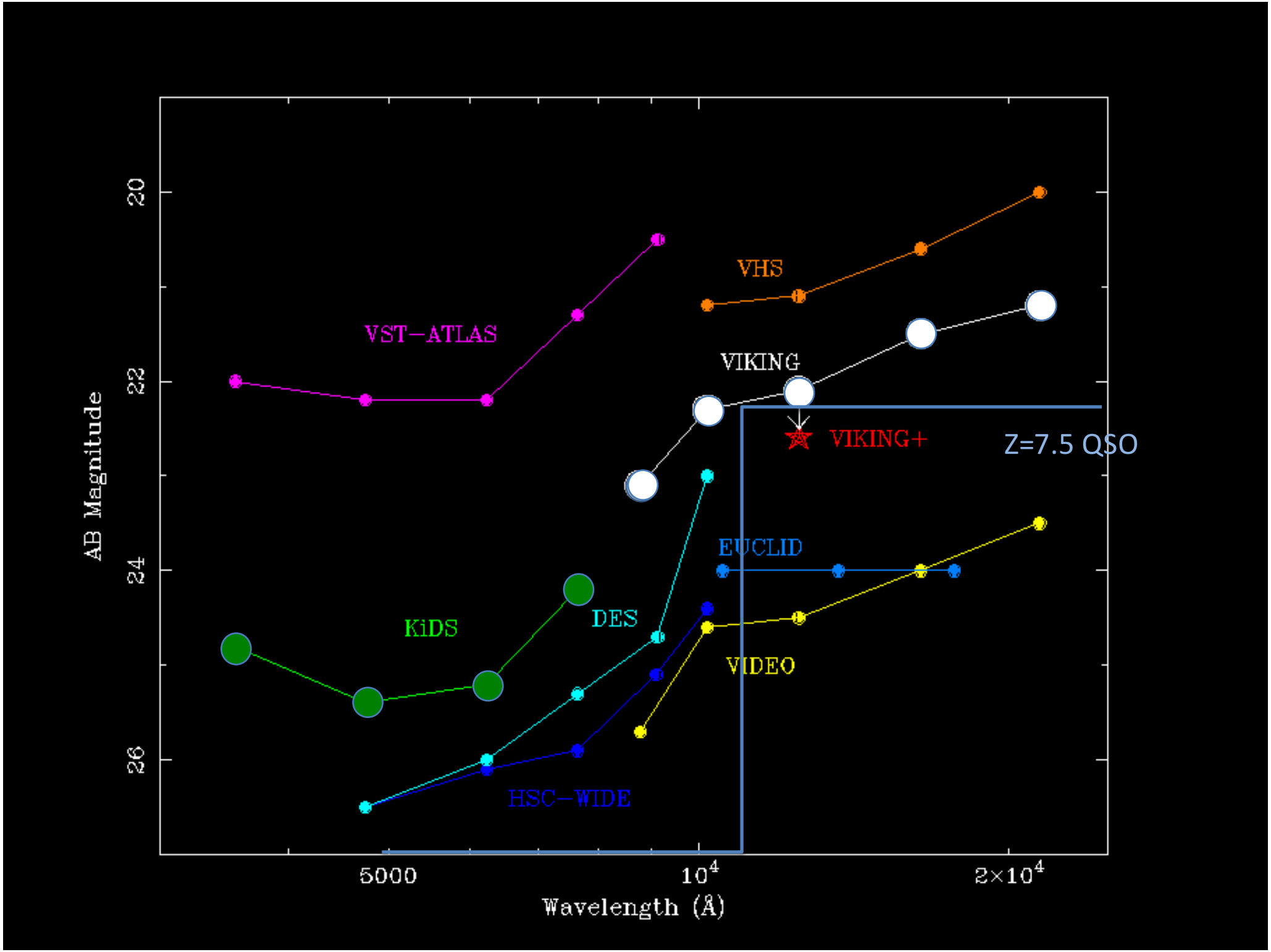

Observing dates: 20091015 - 20141031

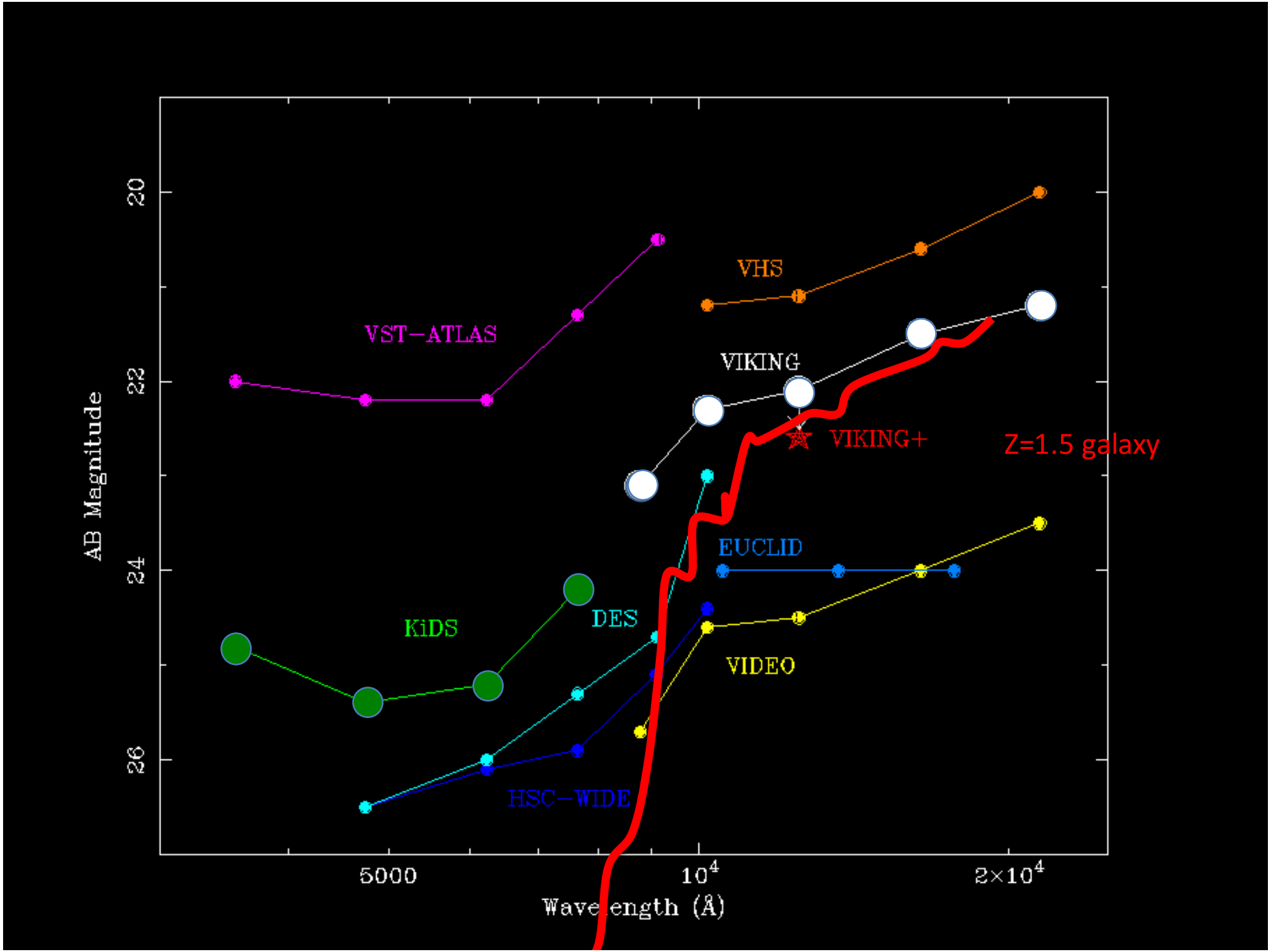
Cambridge Astronomy Survey Unit

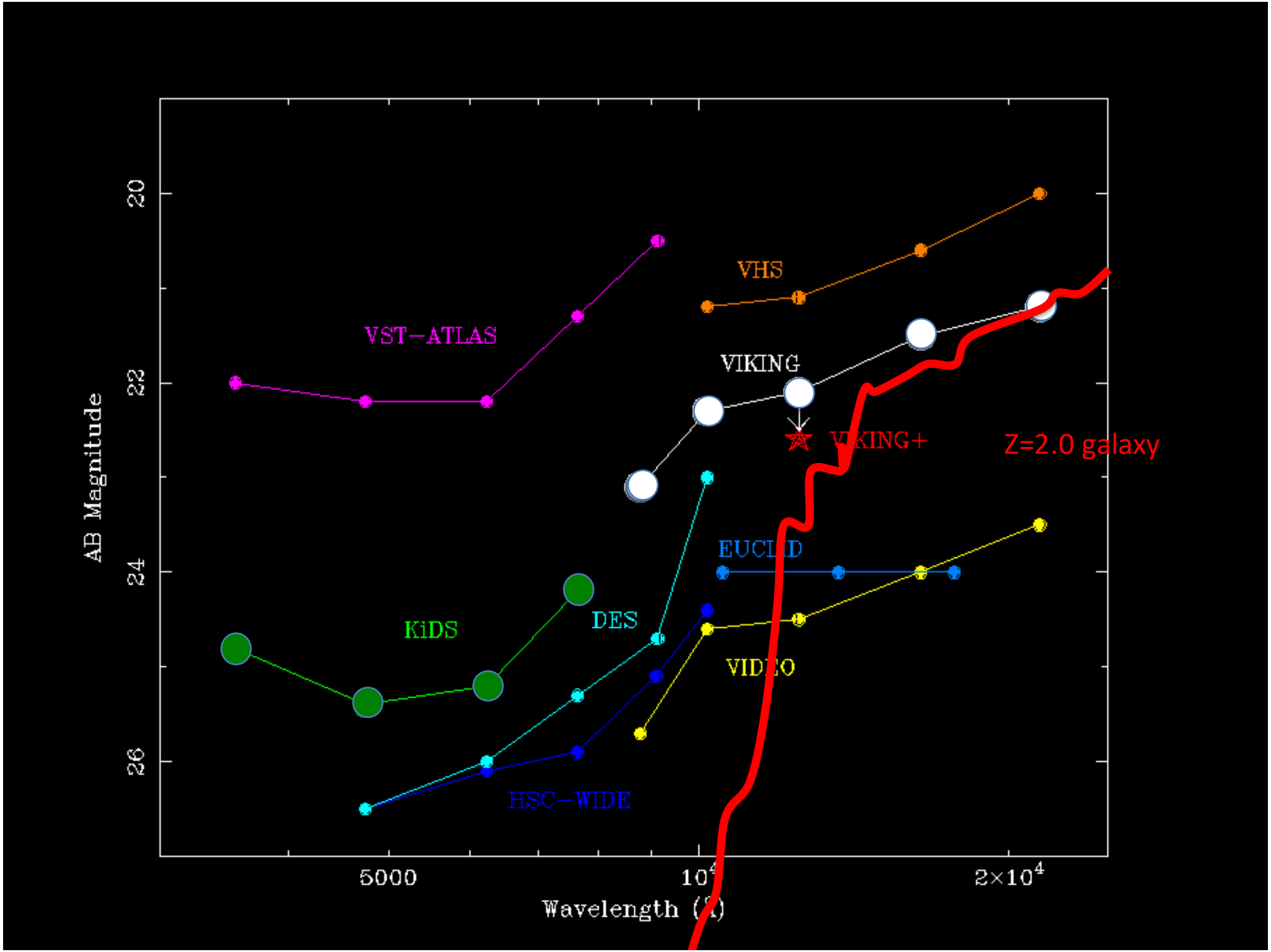
Last Updated: 20/02/2015

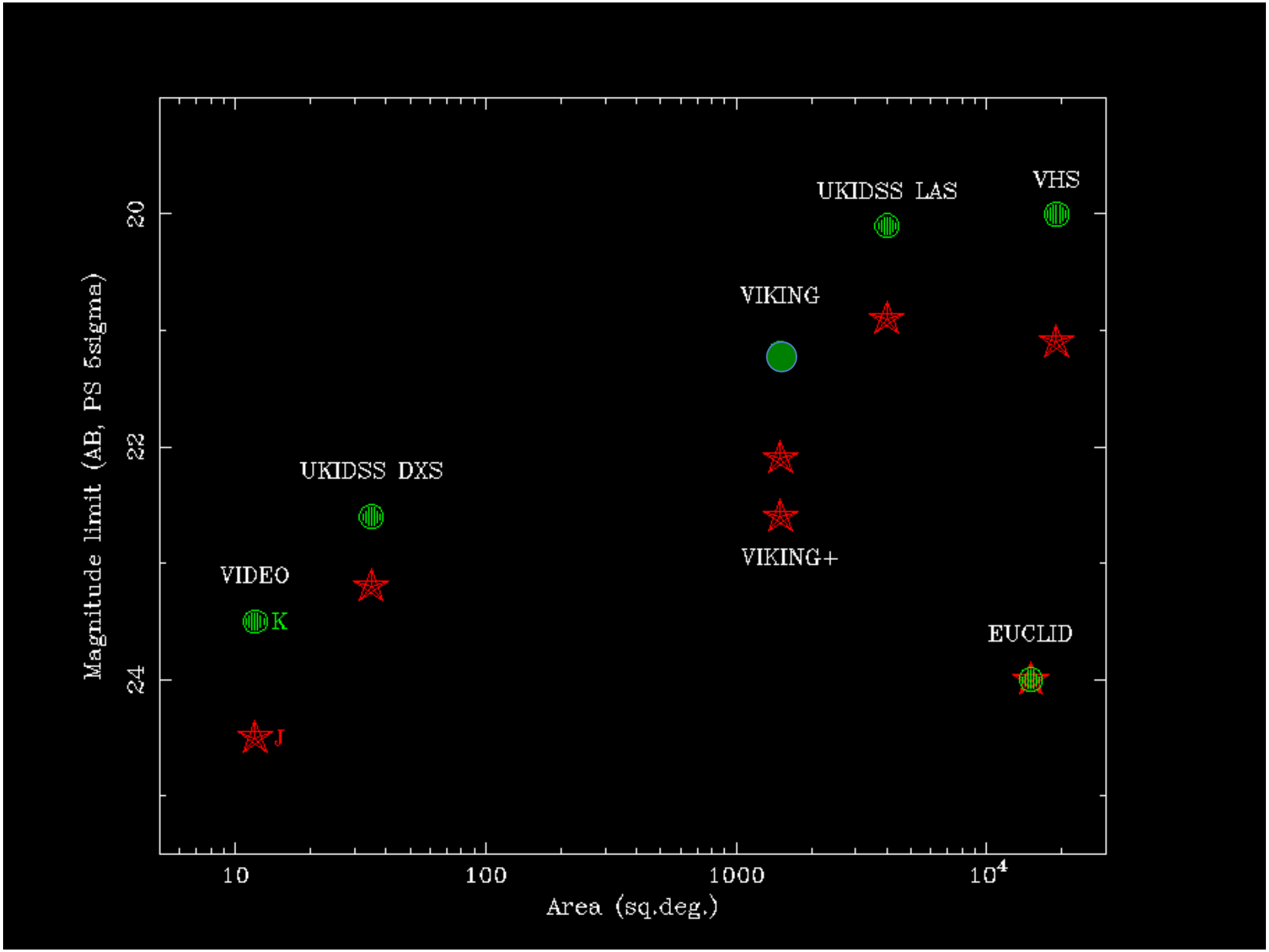

AB Magnitude
20
22
24
26
5000
$10^4$
$2\times10^4$
Wavelength (Å)
VST−ATLAS
VHS
VIKING
VIKING+
EUCLID
KiDS
DES
VIDEO
HSC−WIDE


VST−ATLAS
VHS
VIKING
VIKING+
Z=6.5 QSO
EUCLID
KiDS
DES
VIDEO
HSC−WIDE
AB Magnitude
20
22
24
26
5000
10^4
2×10^4
Wavelength (Å)


AB Magnitude
20
22
24
26
5000
$10^4$
$2\times10^4$
Wavelength (Å)
VST−ATLAS
VHS
VIKING
VIKING+
Z=7.5 QSO
EUCLID
KiDS
DES
VIDEO
HSC−WIDE


AB Magnitude
20
22
24
26
5000
$10^4$
$2\times10^4$
Wavelength (Å)
VST−ATLAS
VHS
VIKING
VIKING+
Z=1.5 galaxy
EUCLID
KiDS
DES
VIDEO
HSC−WIDE


AB Magnitude
20
22
24
26
5000
2×10^4
Wavelength (Å)
VST−ATLAS
VHS
VIKING
VIKING+
Z=2.0 galaxy
EUCLID
KiDS
DES
VIDEO
HSC−WIDE


UKIDSS LAS
VHS
VIKING
UKIDSS DXS
VIDEO
K
VIKING+
EUCLID
J
Magnitude limit (AB, PS 5sigma)
20
22
24
10
100
1000
$10^4$
Area (sq.deg.)

# VIKING status

The VIKING survey is currently 80% complete in area and should be almost 90% complete at the end of P97 (i.e. >1300 of 1500sq.deg. observed).

The remaining ~135 fields would require about 335hrs to execute in P98 and beyond (i.e. more than our usual allocation per Period).

This would also take us past our original requested allocation of time.

There is one declination strip in the SGP VIKING area that we haven't started yet that would mean dropping the survey area to ~1425sq.deg.

# VIKING status

This de-scoped request would still need 210hrs to create a uniform boundary to the survey.

Also there is a small tail of poor quality observations (3-5% of tiles) that is mostly due to a few exposures in a full OB. Revisiting these fields to create the best quality legacy imaging would require 60-120hrs to “clip” this tail.

[VIKING and VHS are unique in the Vista Surveys as they have “single visit” strategies so more prone to catastrophic failures in data quality.]

# VIKING in a wider context

The VIKING survey is now part of a much broader, multi-frequency suite of surveys:

KiDS – a four band VST survey that covers the same footprint as VIKING (see next talk!)

GAMA – AAT AAOmega survey

H-ATLAS – Herschel wide area survey

WALLABY – ASKAP HI survey

HyperSuprimeCam – Subaru optical surveys

*“Build it and they shall come…..!”*

# Science Exploitation

The main science goals of VIKING (clusters, clustering, distant QSOs, multi-wavelength ids) are best addressed when the full complement of supporting data are available.

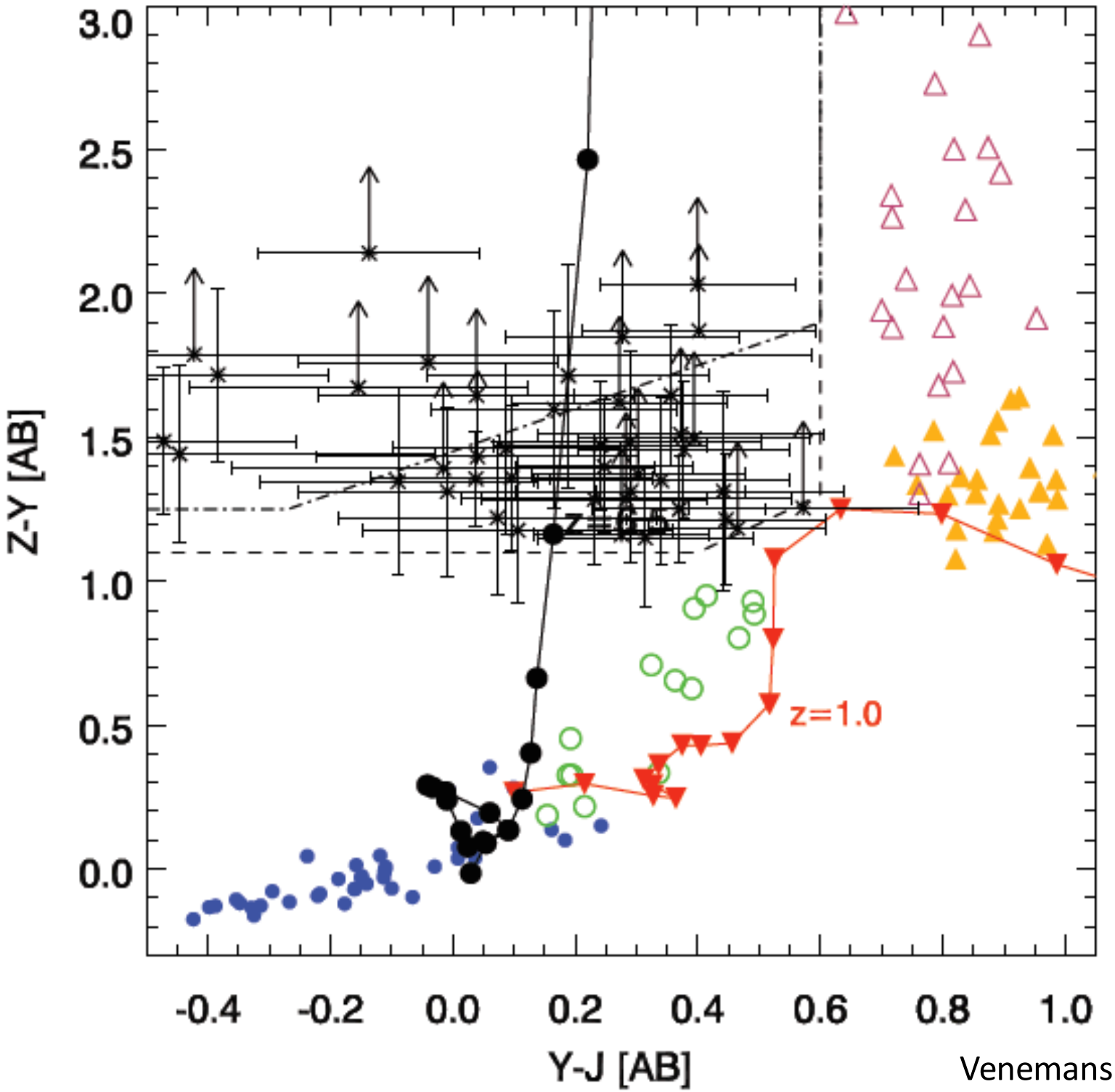
However, the VIKING data have been put to very good use as the survey has grown….

# z>6.5 QSO searches

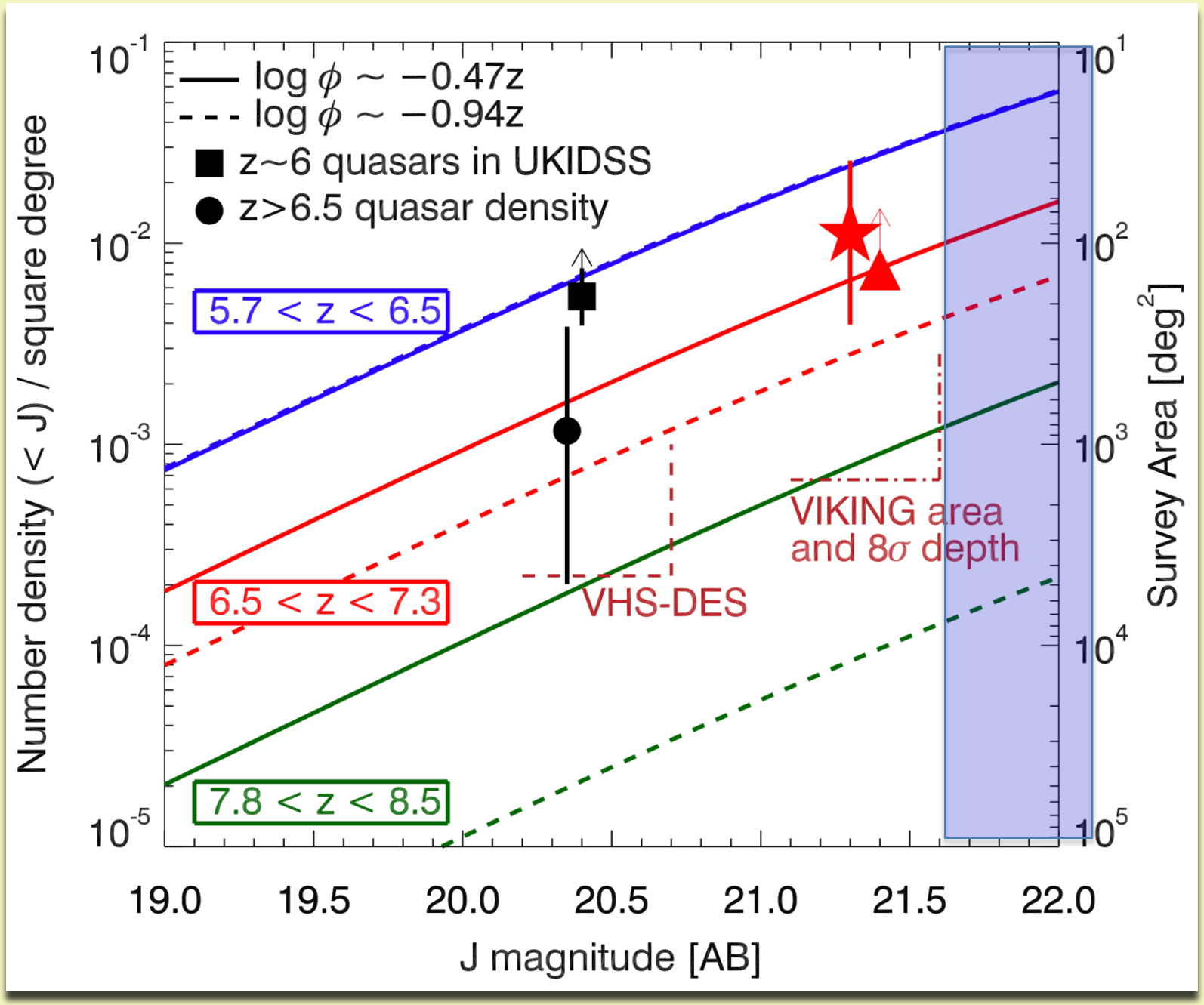
VIKING depth sits (by definition) close to the optimum limit to detect the brightest QSOs at z>6.5.

Bram Venemans (Heidelberg) has already given his review of this work which saves us some time!

However, I will highlight one aspect of this that is important for a potential extension of VIKING in the second round of Vista surveys.



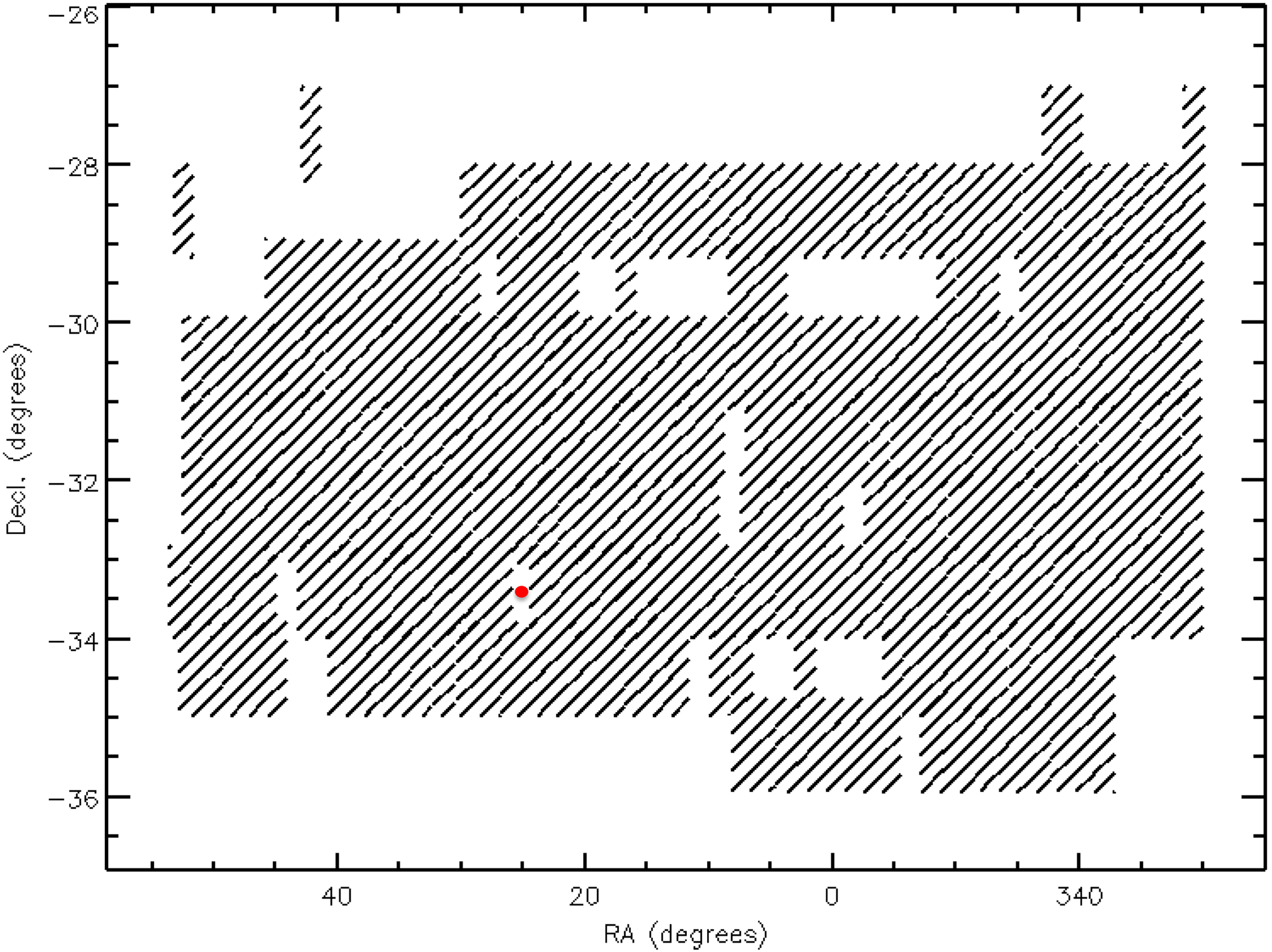

Venemans et al 2013


log φ ~ −0.47z
log φ ~ −0.94z
z~6 quasars in UKIDSS
z>6.5 quasar density
5.7 < z < 6.5
6.5 < z < 7.3
7.8 < z < 8.5
VHS-DES
VIKING area
and 8σ depth
Number density (< J) / square degree
Survey Area [deg²]
J magnitude [AB]
10⁻¹
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10¹
10²
10³
10⁴
10⁵
19.0
19.5
20.0
20.5
21.0
21.5
22.0

# An aside on area coverage

One of the z>6.5 QSOs that was discovered with PanSTARRS-1 sits within the VIKING SGP area.

However, the Murphy's Law was in operation so this object falls in one of the few tiles that are not complete!


−26
−28
−30
−32
−34
−36
Decl. (degrees)
40
20
0
340
RA (degrees)

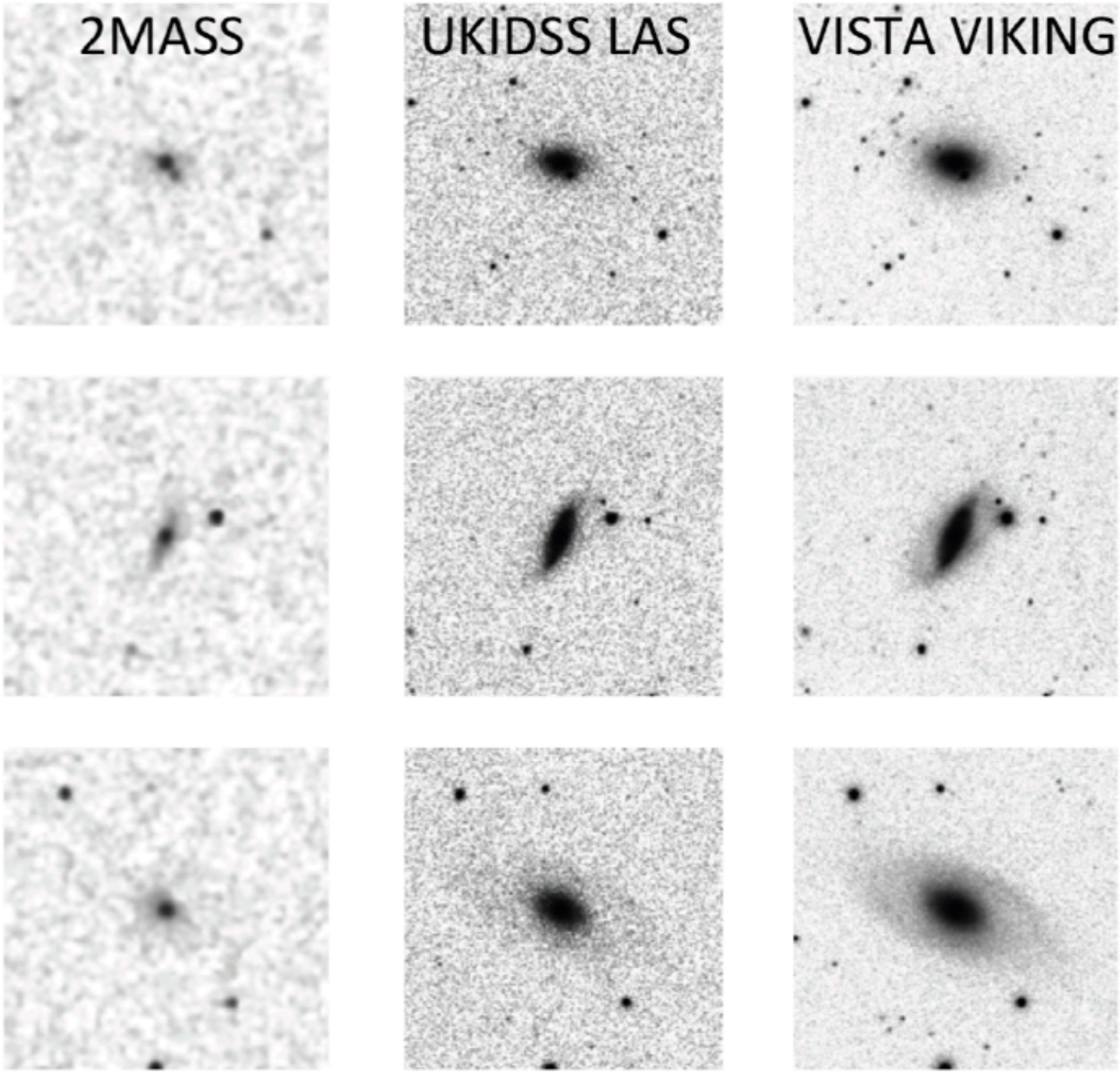
# Where to push forward

Considering the power of colour selection for z>6.5 QSOs and low mass stars and the massive improvements in z and Y that HSC and DES will make in the next 3-4 years over the VIKING footprint, it is the depth in J that limits our ability to select candidates.

Therefore, obtaining a 0.5mag improvement in J (i.e. adding 600s to the existing 400s) would at least double the number of z>6.5 QSOs and improve the chances of selecting one at z>7.5.

# The more local Universe

At the opposite extreme, the additional depth of VIKING over UKIDSS LAS or the VHS means that the surface brightness sensitivity is significantly better. So for brighter galaxies at $z<0.2$ NIR morphological parameters can be extracted.




See Andrews et al 2014 PASA 31, 4

# GAMA

The parameters extracted from the imaging (total stellar mass, bulge-to-disk ratio, etc) are a key component of the GAMA project (PIs Driver and Hopkins) that covers a significant part of the VIKING area with AAOmega to recover spectra for a much denser sampling than traditional redshift surveys.

GAMA will be complemented with WALLABY that will recover the HI emission of $z<0.25$ galaxies and extended in WAVES with 4MOST.

# GAMA Data Release

In August this year the GAMA team made a major data release and the press release was widely covered!

International Centre for Radio Astronomy Research

**Media Alert**
**Under embargo until:**
**August 10th - 10:00 HST (Honolulu), 16:00 EDT (New York), 21:00 BST (London)**
**August 11th - 04:00 AWST (Perth), 06:00 AEST (Sydney)**

# Scientists measure Slow Death of the Universe

An international team of astronomers studying 200,000 galaxies has measured the energy generated within a large portion of space more precisely than ever before, discovering that it's only half what it was 2 billion years ago and fading – the Universe is slowly dying.

Researchers from the International Centre for Radio Astronomy Research (ICRAR) in Western Australia used seven of the world's most powerful telescopes to observe galaxies at 21 different wavelengths from the far ultraviolet to the far infrared.

Initial observations were conducted using the Anglo-Australian Telescope in New South Wales and supporting observations were made by two orbiting space telescopes operated by NASA and another belonging to the European Space Agency.

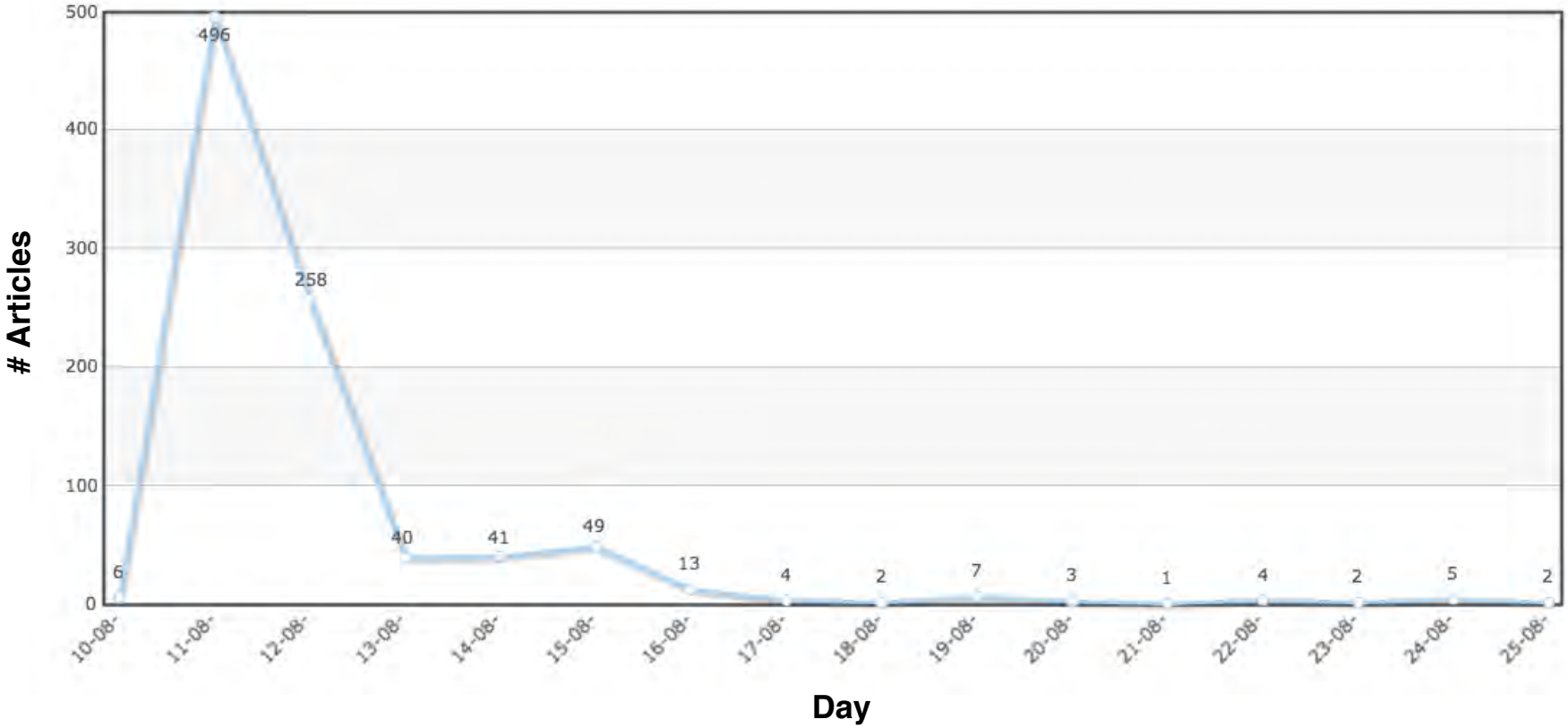
The research is part of the Galaxy and Mass Assembly (GAMA) project, the largest multi-wavelength survey ever put together.

"We used as many space and ground-based telescopes we could get our hands on, to measure the energy output of over 200,000 galaxies across as broad a wavelength range as possible," says ICRAR Professor Simon Driver, who presented the findings at the International Astronomical Union's General Assembly in Honolulu.

The survey data, released to astronomers around the world, includes 200,000 galaxies each measured at 21 wavelengths from the ultraviolet to the far infrared and will help scientists better understand how

## Global Reach

946 articles have appeared in 73 countries between August 10th to September 2nd.




| Country | Hits |
|---|---|
| Algeria | 1 |
| Angola | 1 |
| Argentina | 12 |

# Online Articles (a sample)


New York Post
**Scientists have pinpointed when the world will end**
http://nypost.com/2015/08/12/the-universe-is-past-its-prime-and-slowly-dying/


BBC
**Fading cosmos quantified in 21 colours**
http://www.bbc.com/news/science-environment-33846857


CNN
**'The Universe is slowly dying,' study shows with unprecedented precision.**
http://edition.cnn.com/2015/08/10/us/universe-dying/


Scientific American
**It's Official: The Universe Is Dying Slowly**
http://www.scientificamerican.com/article/it-s-official-the-universe-is-dying-slowly/


10. Aug
12. Aug
14. Aug
16. Aug
18. Aug
Tweets (20 most recent)
Don't panic, but the universe is slowly dying http://t.co/1zJlVlDAiA via @ConversationEDU
@mwanje_richard
August 17, 2015
theconversation.com
29,51
www.sciencealert.com
24,35
qz.com
23,69
www.timeslive.co.za
6,98
Other
17,55


79 God
@TheTweetOfGod
Follow
The universe is slowly dying. Have a good day.
RETWEETS
2,235
FAVORITES
3,042
10:55 PM - 13 Aug 2015


JIM PARSONS
AN ACT OF GOD
God
@TheTweetOfGod
I'm your dope-ass divinity, trollin' with My trinity, droppin' top tweets in your immediate vicinity, flingin' fly phrases from the fringes of infinity.
Followed by Rakesh Nath and 6 others
TWEETS
10K
FOLLOWING
2
FOLLOWERS
2.04M

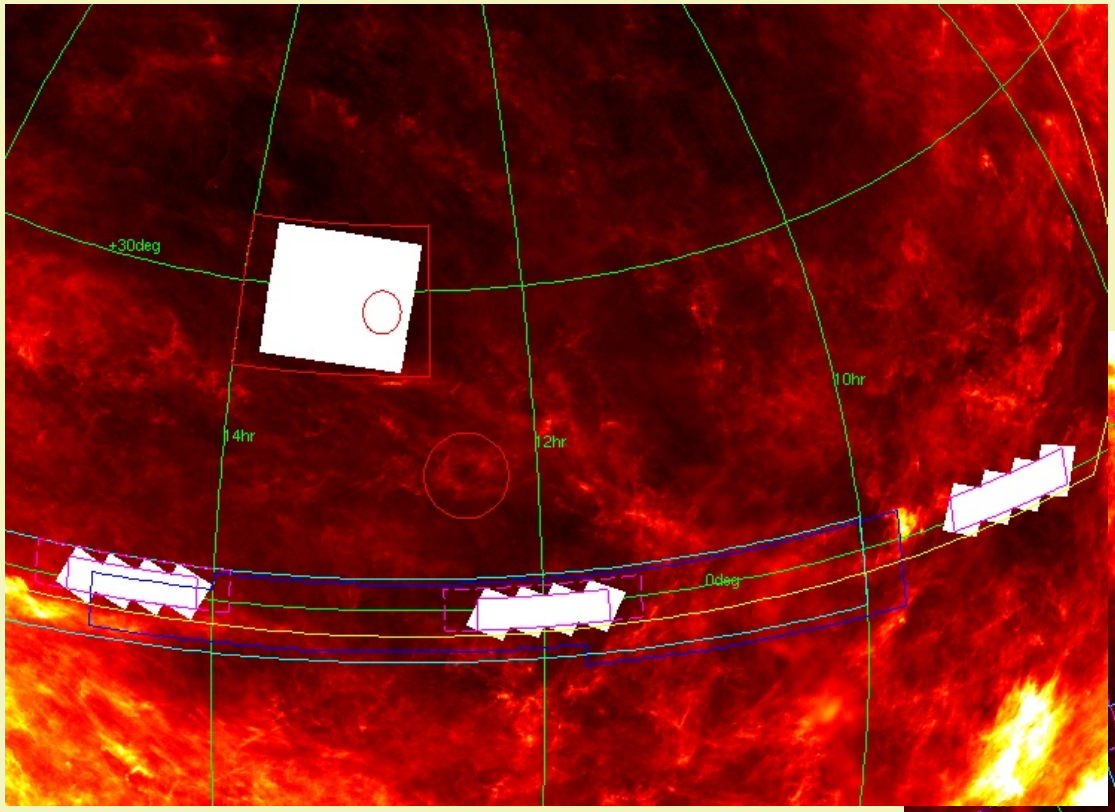
# Herschel-ATLAS

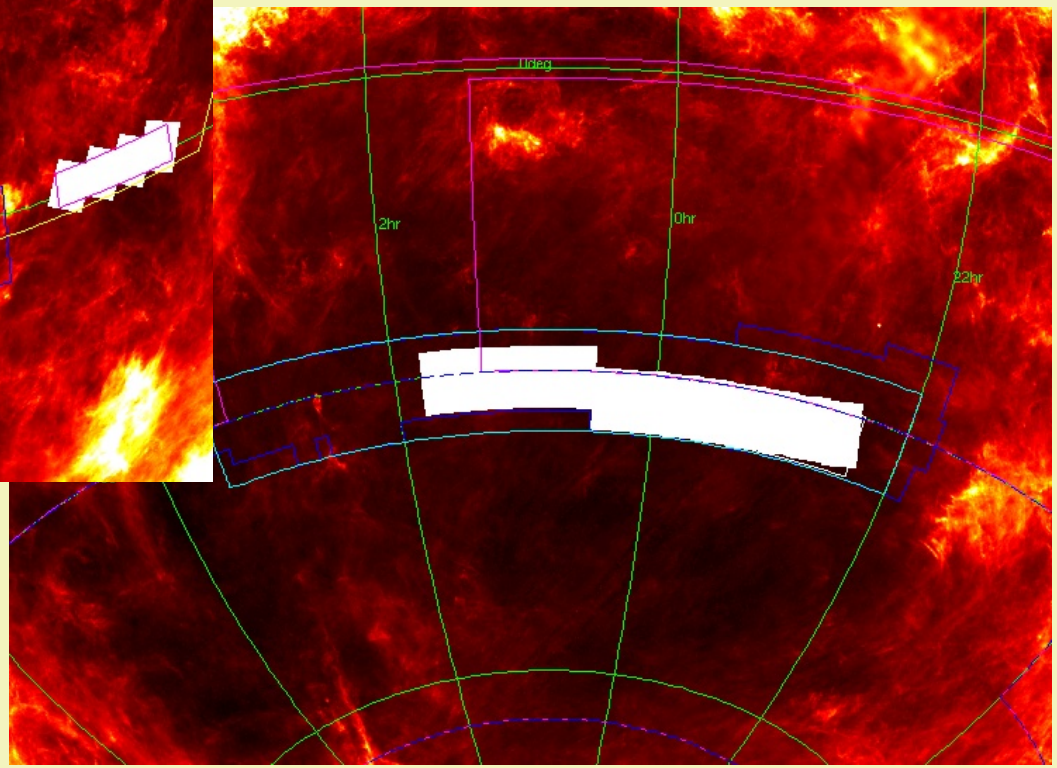
The largest Open Time Key Projects with Herschel was H-ATLAS (PI Eales). It covers ~550 sq deg of which 400 is in the VIKING footprint.

The wide redshift range of the Herschel sources plus the prominence that lensed sources have means that NIR imaging is crucial to the identification of these sources.

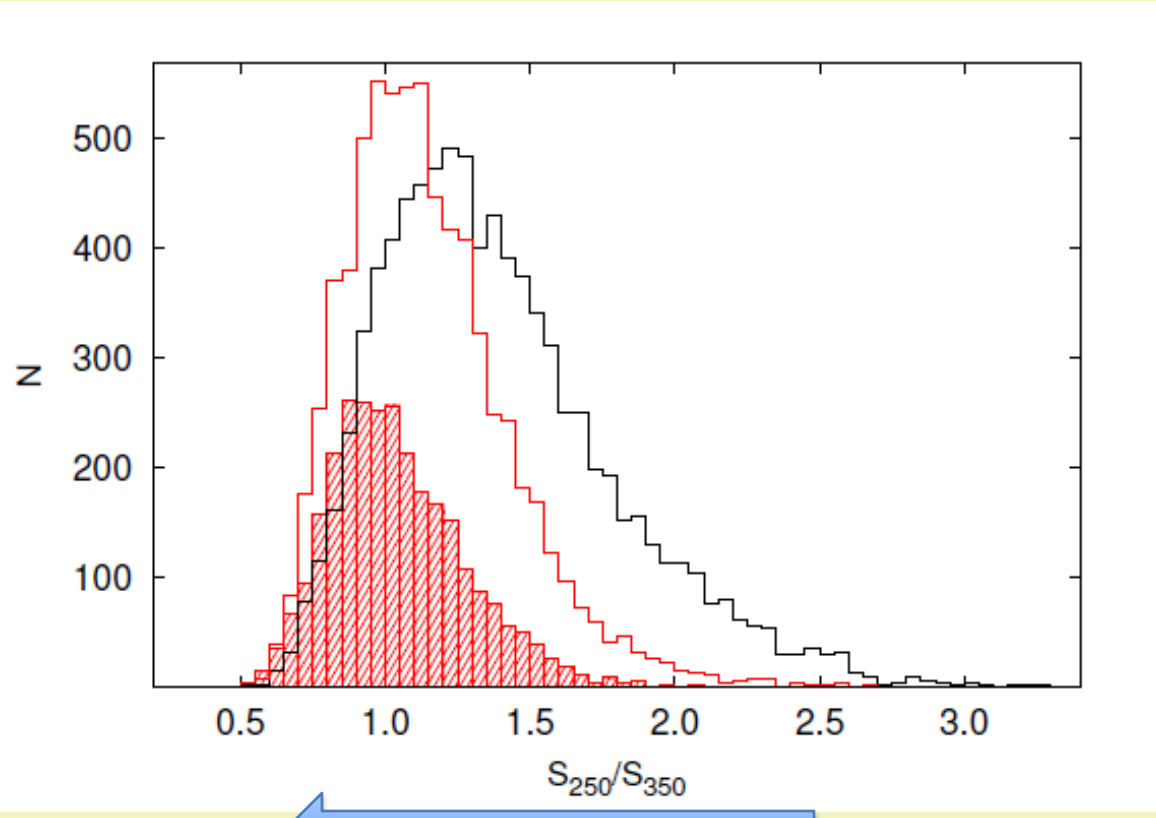
# Herschel-ATLAS sky coverage.

Colourmap = 100um cirrus
White = H-ATLAS
Purple = DES
Light blue = VIKING
Green = RA/Dec lines.



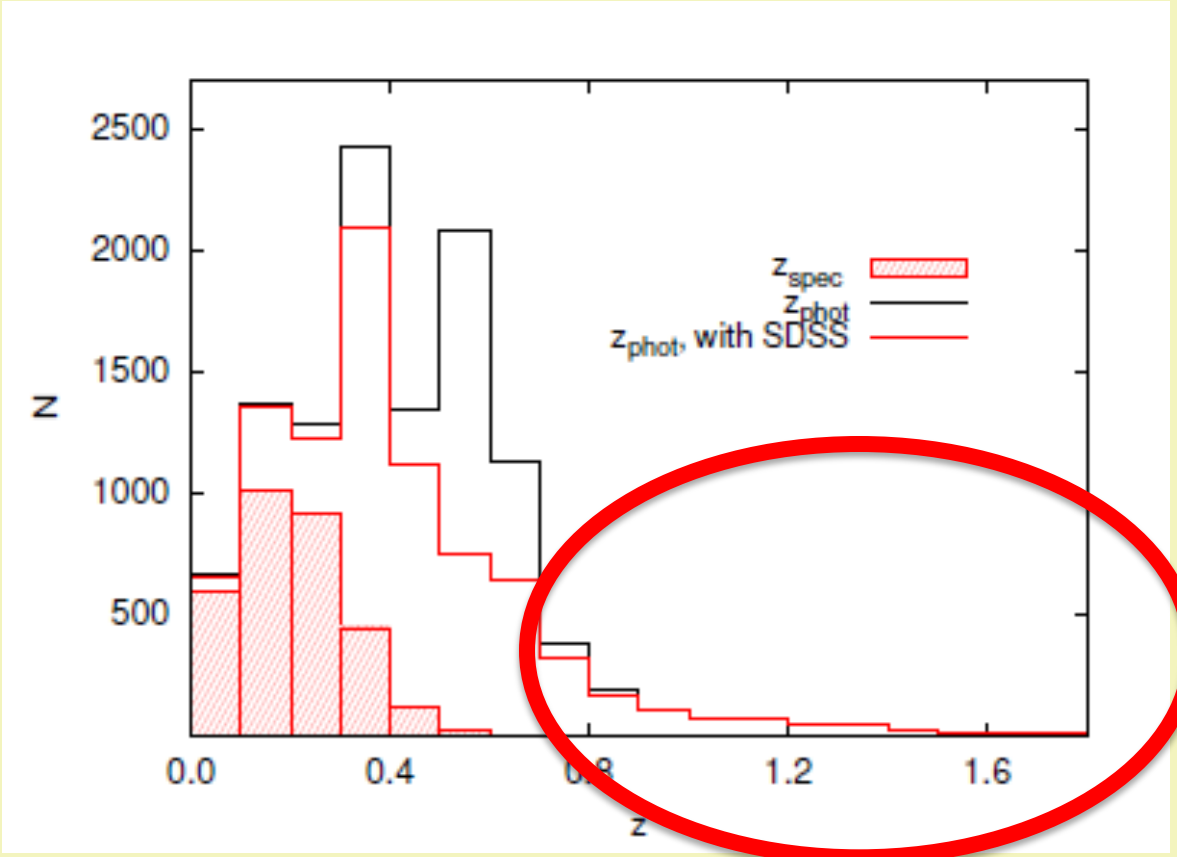
# VIKING Identifications for H-ATLAS submm galaxies (Fleuren et al 2012):

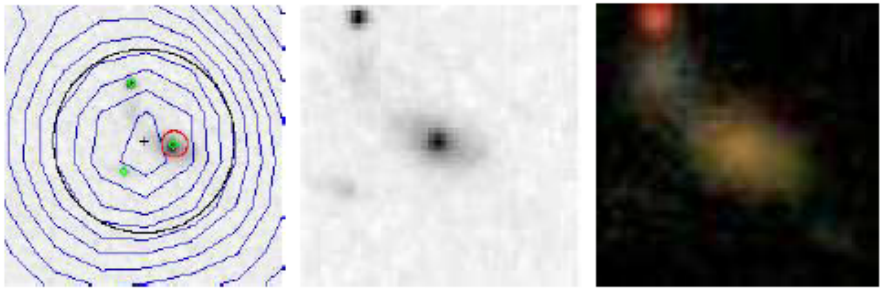



Black: reliable ID
Red: low-rel ID(s)
Hatched: blank

Increasing redshift

Redshift distribution for H-ATLAS reliable ID's.

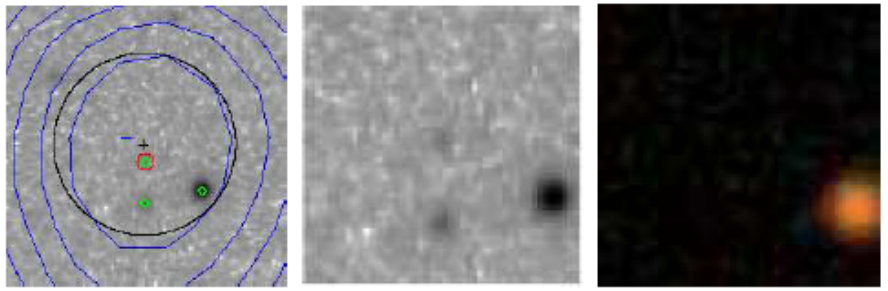




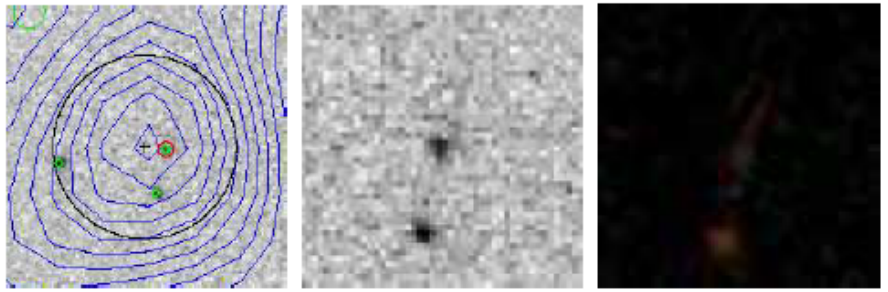
J085116.1-001410: $z_{spec}$ = 0.268

J084706.4+021212: $z_{spec}$ = 0.074

Contours: Herschel
Left/middle: VIKING Ks
Right: SDSS

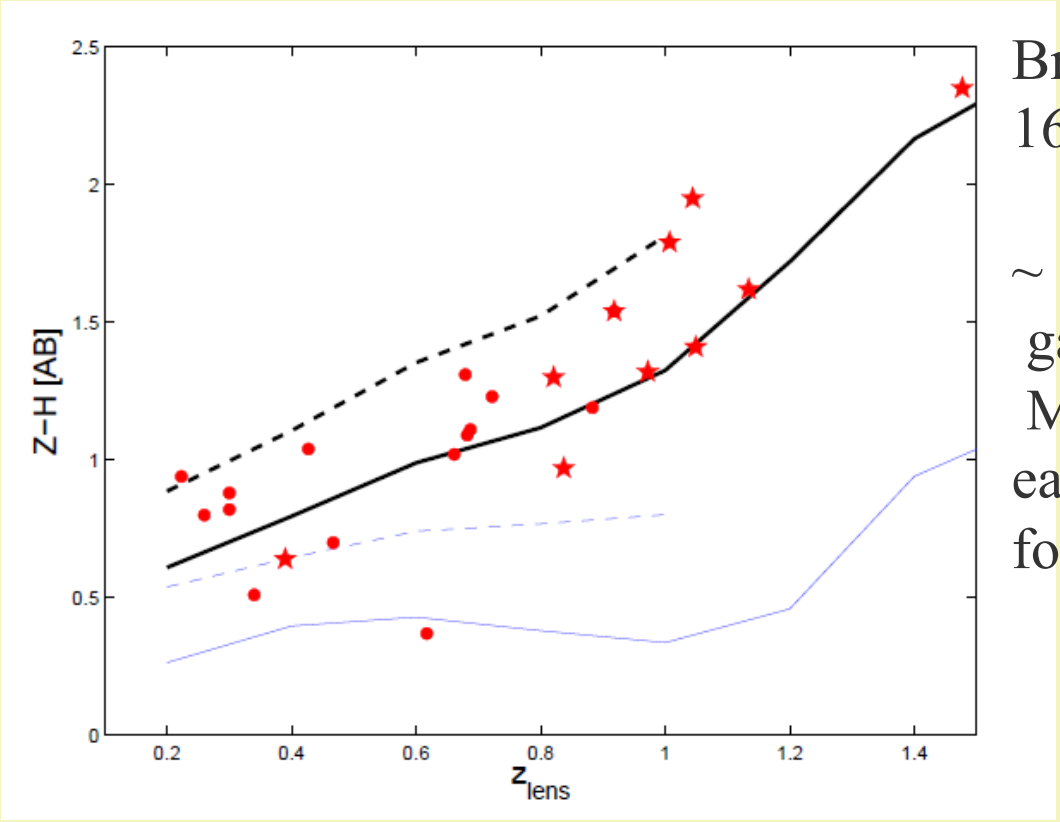


J083848.1+014536: $z_{phot}$ = 0.546



J091858.3+013454: $z_{phot}$ = 0.814

# Herschel-ATLAS Lensed Object Survey (HALOs) :




Bright SMGs in
16 sq.deg SDP field.

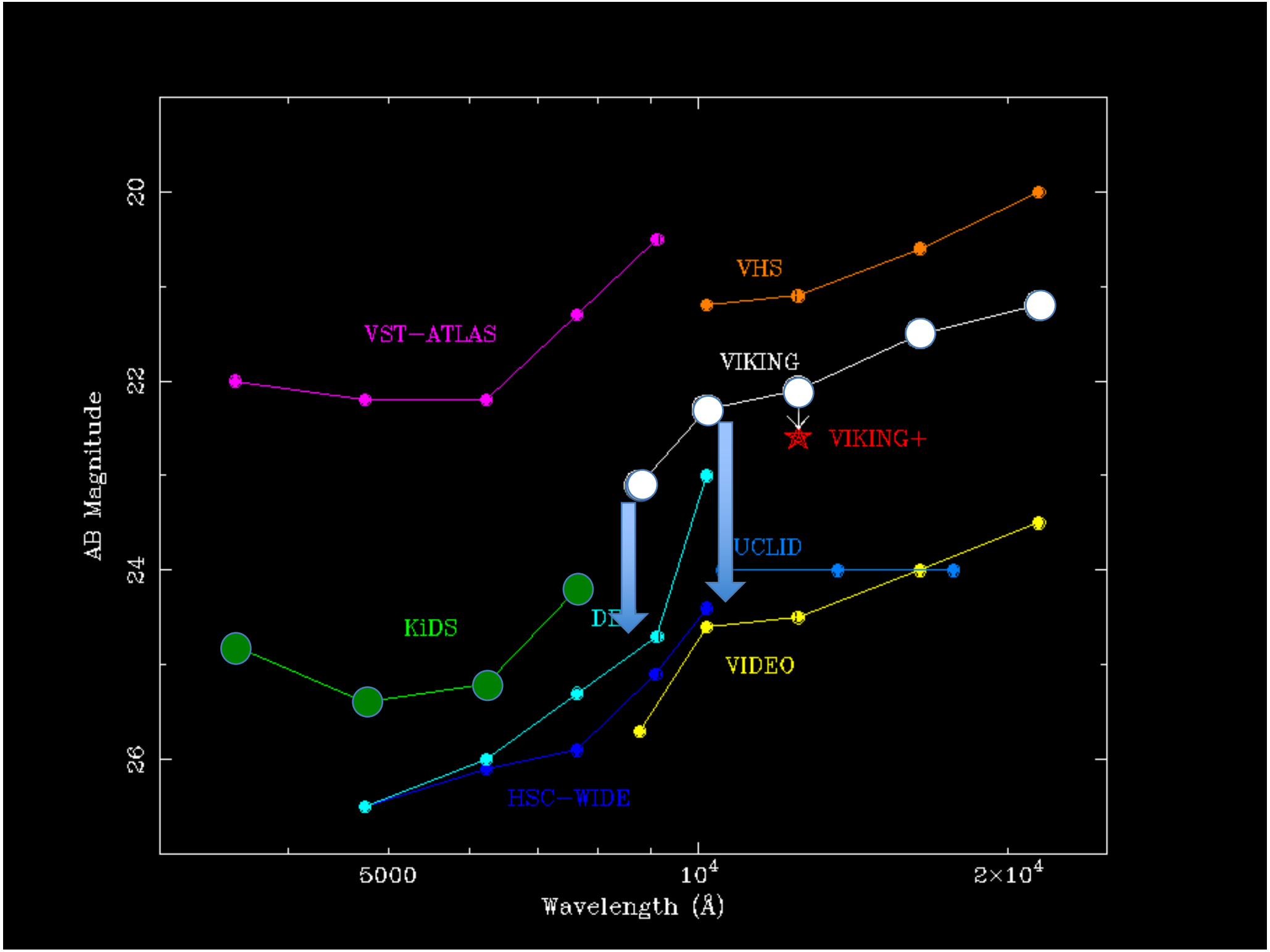
~ 32 with VIKING
galaxies nearby.
Mainly consistent with
early-types, as expected
for lensing .

# The imaging future

The northern VIKING/KiDS area is covered by the HyperSuprimeCam Wide survey area which will deliver data in grizY to 26.5, 26.1, 25.9, 25.1 and 24.4 (cf KiDS 24.8, 25.4, 25.2, 24.2 and VIKING Y of 22.3) so 1.7, 0.7, 0.7, 0.9 and 2.1mag improvement.

The southern VIKING/KiDS area will be covered by DES to almost the same depth so deeper z and Y data will be available for the full VIKING survey.

Looking further ahead LSST will cover all of the southern sky to an AB depth of 26.1-27.5 in ugrizy.


VST−ATLAS
VHS
VIKING
VIKING+
UCLID
KiDS
DE
VIDEO
HSC−WIDE
AB Magnitude
20
22
24
26
5000
10^4
2×10^4
Wavelength (Å)

# The imaging future

The possibility that the *Spitzer* warm mission will be extended beyond 2016 offers the opportunity to survey most of the VIKING/KiDS area at 3.6 and 4.5μm to the same AB depth as our J data.

Ultimately *Euclid* will cover all of the VIKING/KiDS area (and much more) but the breadth of the wavelength coverage that we have stimulated by "staking out" a 1500sq.deg survey area will give this area a longer term legacy value into the 2030's.

# The spectroscopic future

VIKING covers important scales in area and depth that match the design of many of the new spectroscopic surveys that are being proposed with new spectrographs such as 4MOST, MOONS and PFS.

# Crowd sourcing

With the Letters of Intent due in just over a week, we are finalising our arguments for an extension to VIKING.

I would like to like to take this opportunity to make an unscientific poll of the esteemed and knowledgeable audience to determine if we are getting our message across…..

# Crowd sourcing

We set the VIKING colS a question that sums up the main choice for VIKING (but it applies to all Vista surveys at some level):

A) Do we survey more area to the same depth and filters?

B) Do we survey the same area deeper with fewer (or one) filter?

Hands up for A)….

# Conclusions

VIKING is nearing completion and our haystack is now piled sufficiently high.

It’s now time to find the needles….