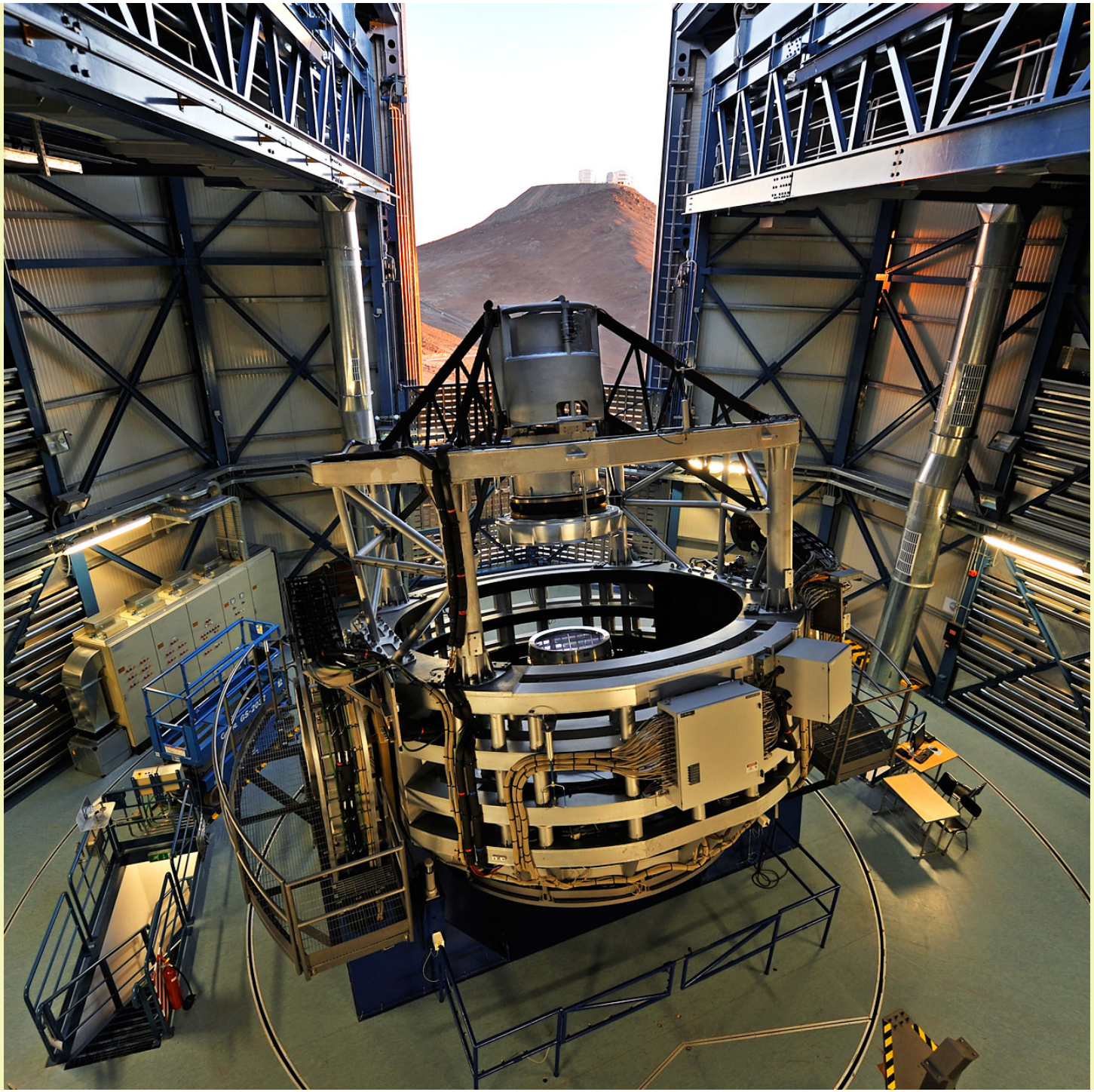
VIKING: the VISTA Kilo-degree INfrared Galaxy survey

Will Sutherland (VIKING co-PI)

and the VIKING team

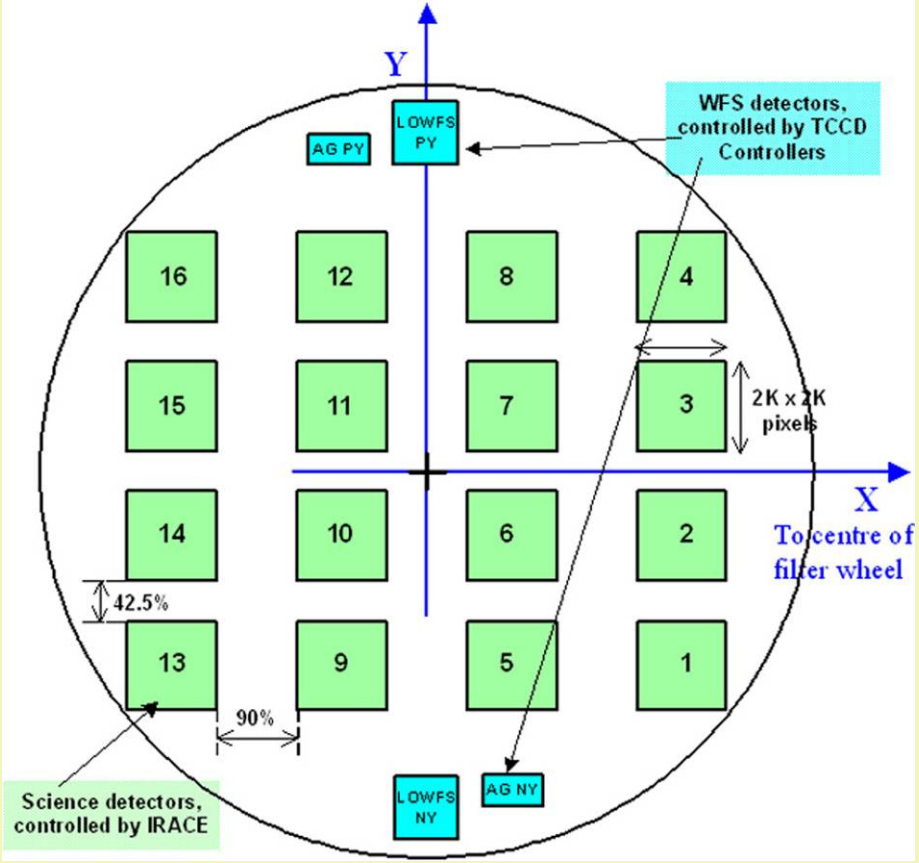
VIKING basics:

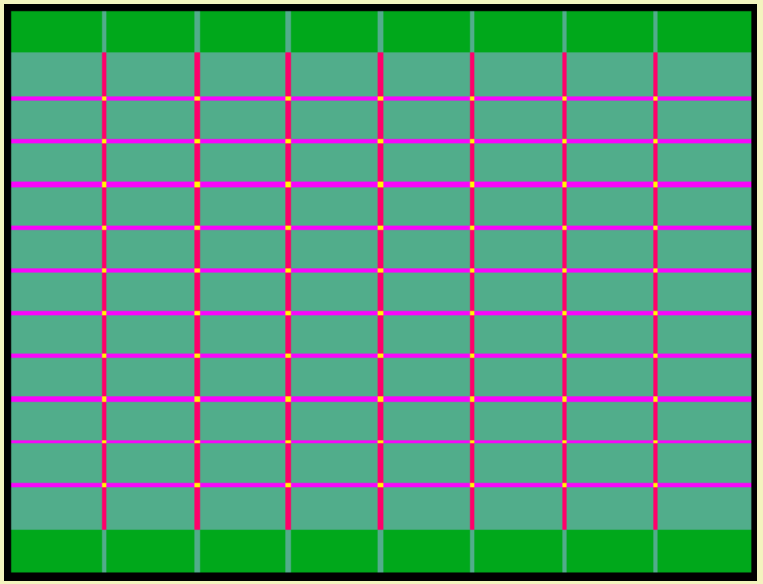
- 1500 deg^2 , high |b|, in two stripes, NGP + SGP.
- Area matches 2dFGRS and VST-KIDS.
  - Optimal for Southern followup: VLT, ALMA, etc.
  - NGP stripe on Equator: overlaps UKIDSS, Sloan, GAMA-1.
  - SGP stripe: overlaps DES, GAMA-2.
- 9-band combined survey: ugri (KIDS), ZYJHK$_s$ (VIKING)
  - Depth: ~ Sloan + 2 mag, UKIDSS-LAS + 1.2 mag .
  - ~ 220 nights of VISTA time total.
- PI: A. Edge. Co-PIs: WJS, K. Kuijken, S.Driver, S.Eales
  - 30 co-I's (expanding…)



IR focal plane:

- **16 arrays, 67 Mpix = 0.60 deg^2 = 2150 arcmin^2 on-pixels , 0.34 arcsec/pixel.**
  - 6 offset `pawprints' gives 1.5 x 1.0 deg$^2$ `tile' , every star covered by ≥ 2 pawprints.





VIKING Exposure times + depths.

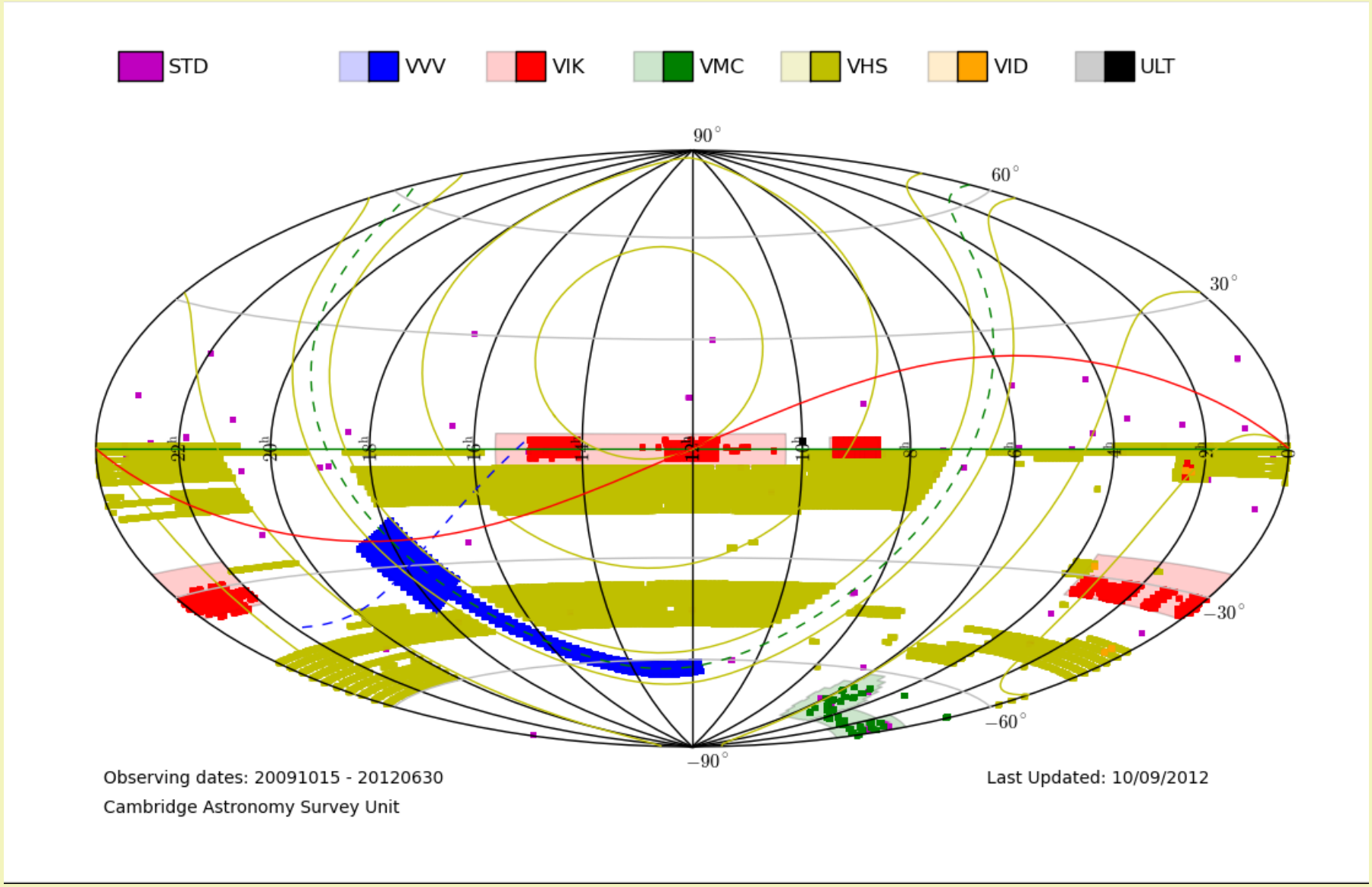
Filter	Exp. time (sec)	Med.seeing (arcsec)	$5\sigma, 2''$ aperture mag. (AB)	(Vega)	f_λ (10^{-20} erg s^{-1} cm^{-2} Å^{-1})	UKIDSS (Vega; actual)
Z	500	0.8	23.1	22.6	75	–
Y	400	0.8	22.3	21.7	114	20.2
J	400 (2×200)	0.8	22.1	21.3	94	19.6
H	300	0.8	21.5	20.2	94	18.7
K_s	500	0.8	21.2	19.4	77	18.2
i (KIDS)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

VIKING typical total ~ 400 sec per filter per sky point.

2 visits per tile, Z,Y, J_1 (dark/grey time); J_2,H,Ks (any Moon)
50s or 60s per jitter position, 8 or 6 total jitters per sky pixel.
J split between two visits, 200 sec each, for optimal rare-object searches – flag variable/moving objects.

8σ depth ~ zCOSMOS-bright, ~ 1000x area.

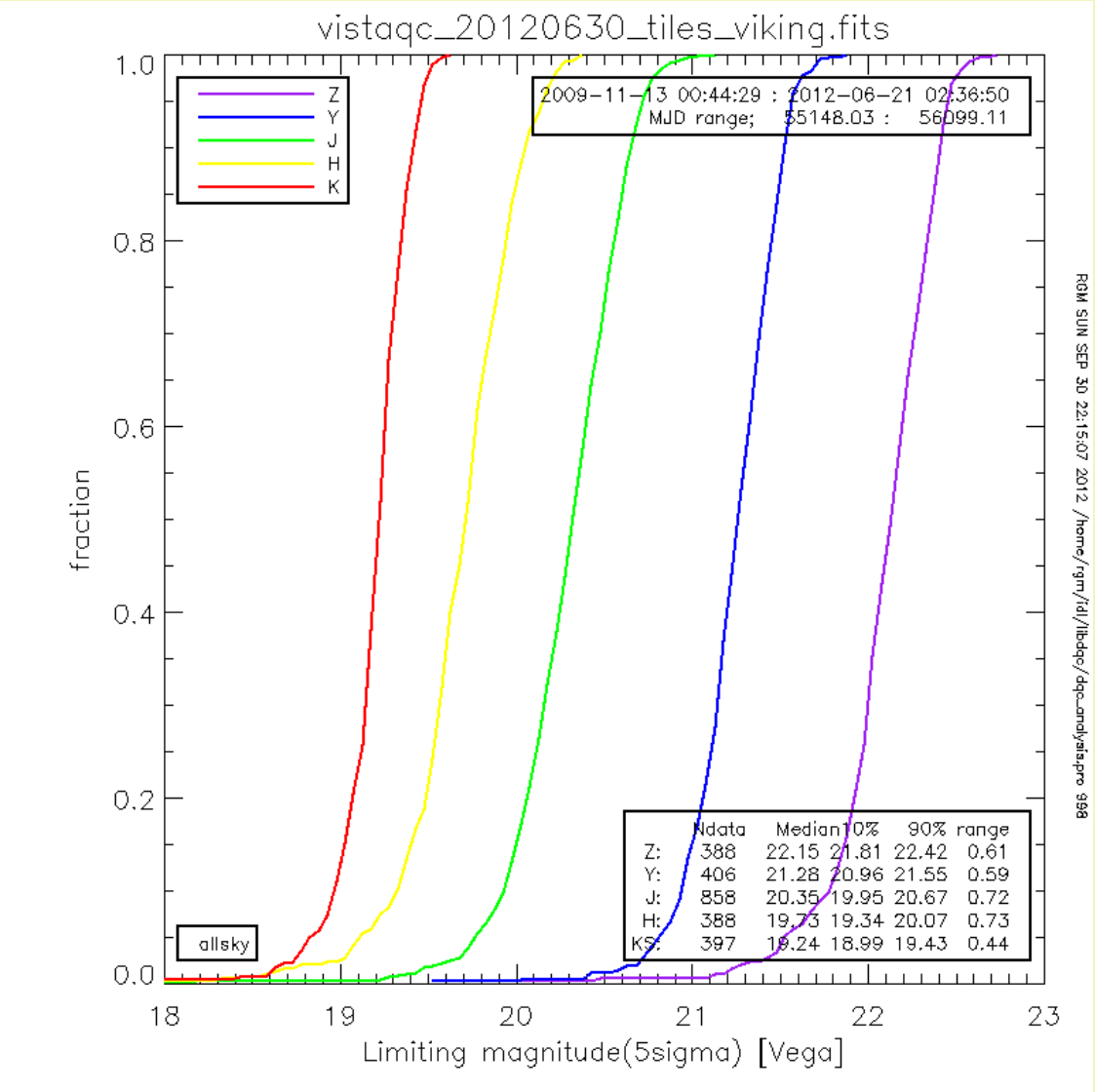
Sky coverage (June 2012)



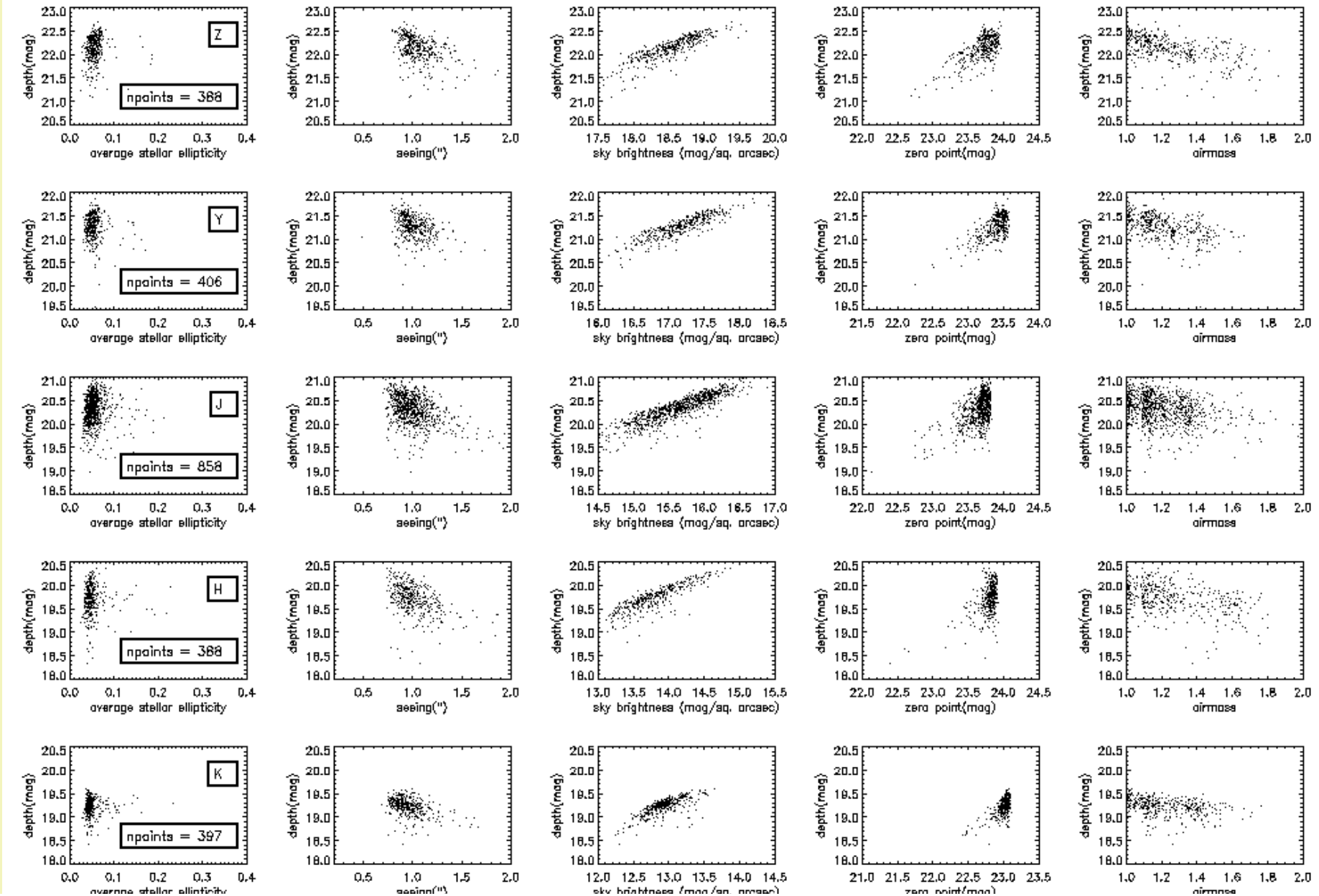
Data processing status

- VIKING using “standard” VDFS, CASU pipeline + WFAU archive.
- No major issues identified at present; builds on proven UKIDSS-LAS experience, with minor differences:
  - Persistence and cross-talk both substantially improved.
  - More jitters per sky point in VIKING (~ 8).
  - Two J epochs per sky point.
  - Detector cosmetics (dead/hot pixels) somewhat worse, but mostly stable – except for bad half in detector#16.
- Data volumes smaller than VHS, VMC ; sky-subtraction less critical than VIDEO, UltraVISTA.

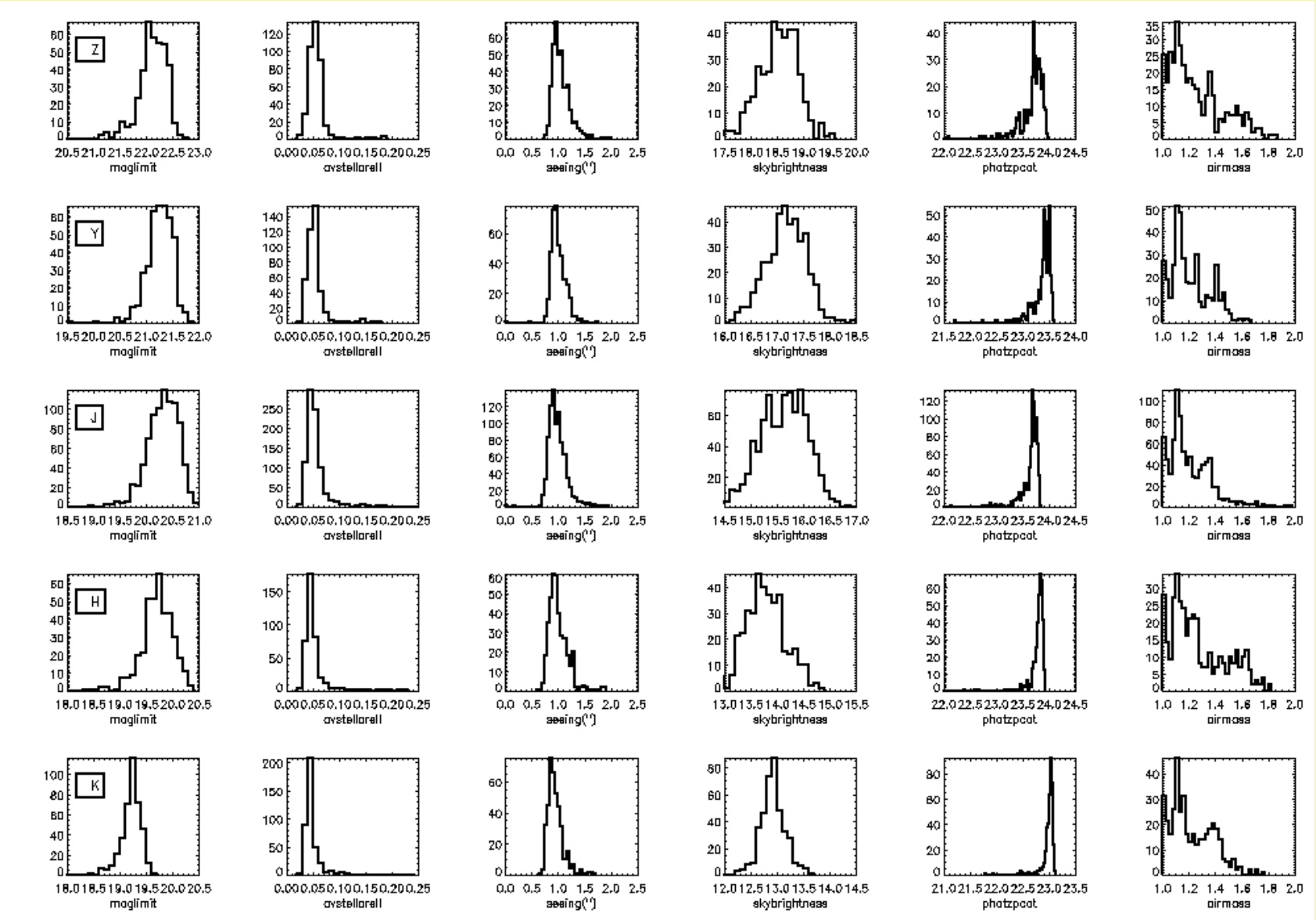
Mag. limit distribution over tiles



Mag. limits vs observing conditions



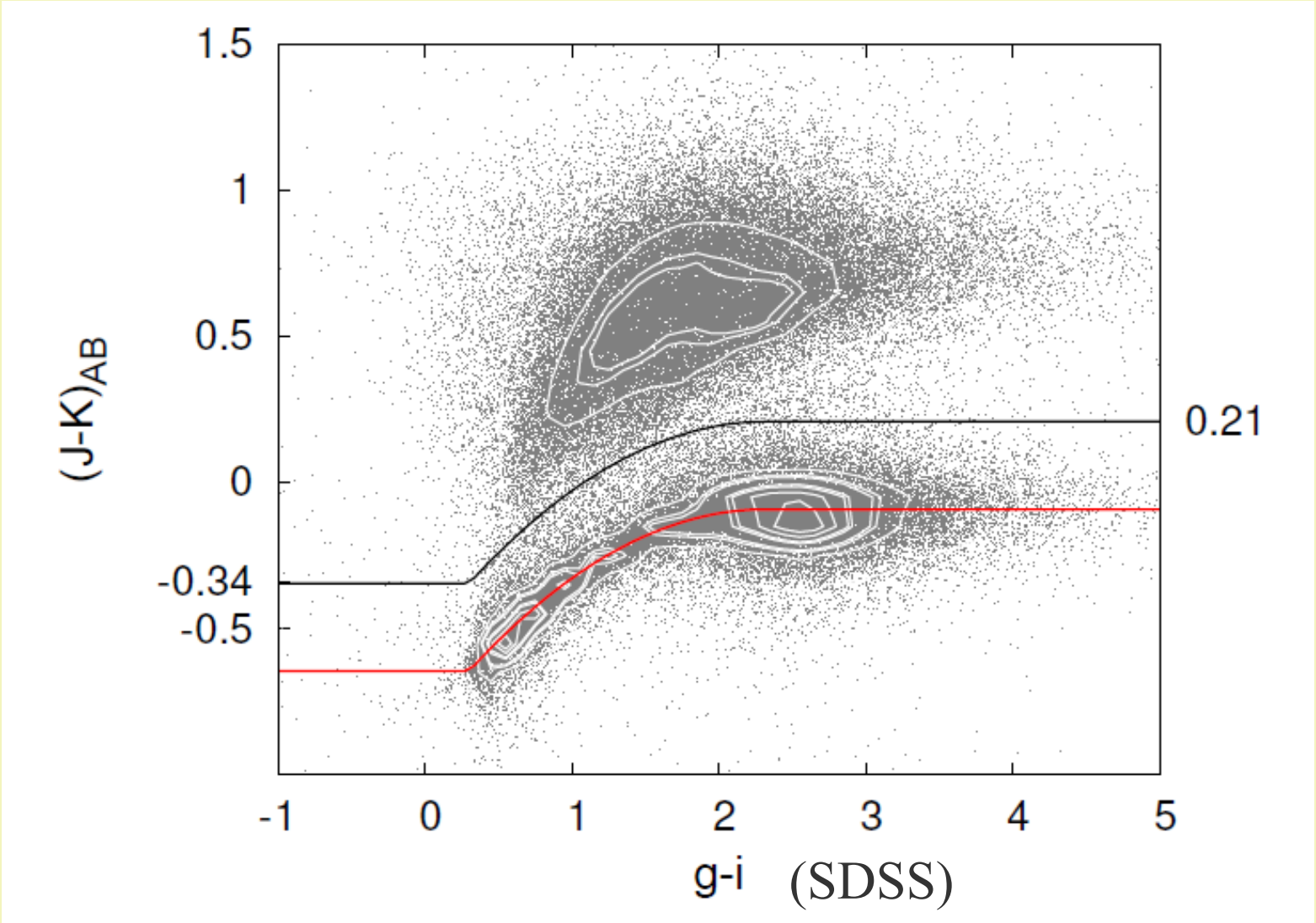
Per-tile histograms



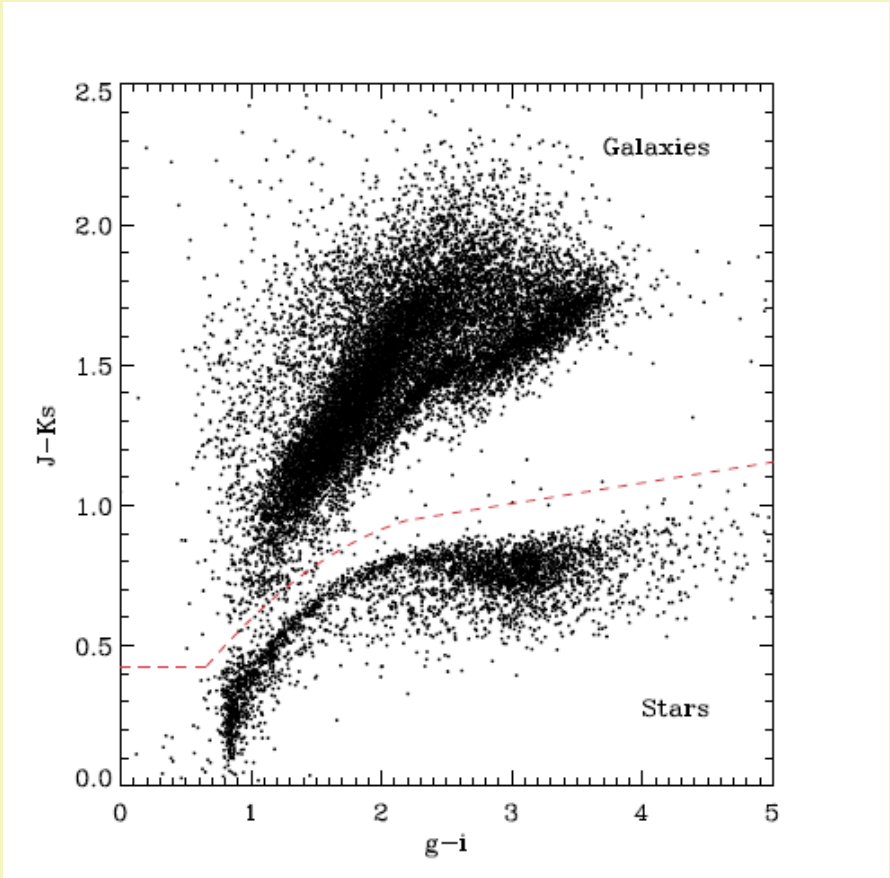
QC ongoing:

- Image quality pretty good: median ~ 0.9 arcsec, 90% < 1.1 arcsec.
- Most analysis so far based on processed pawprint images and band-merged single-pawprint catalogues from VSA.
  - Tiles exist at VSA , but some issues with checkerboard background; tile-based catalogues not yet band-merged.
- Astrometry: very good. Bright stars show mean offset ~ 0.03 arcsec in overlap regions.
- Photometry: stability very good. Offset vs UKIDSS LAS stable to ~ 0.03 mag across many pawprints. Some systematic offsets ~ 0.08 – 0.1 mag at Z,Y bands: need more work on colour terms.
- Depth: median depth ~ 0.2 – 0.3 mag worse than ETC predictions. (Slightly larger aperture corrections, mean sky brightness a bit higher) .

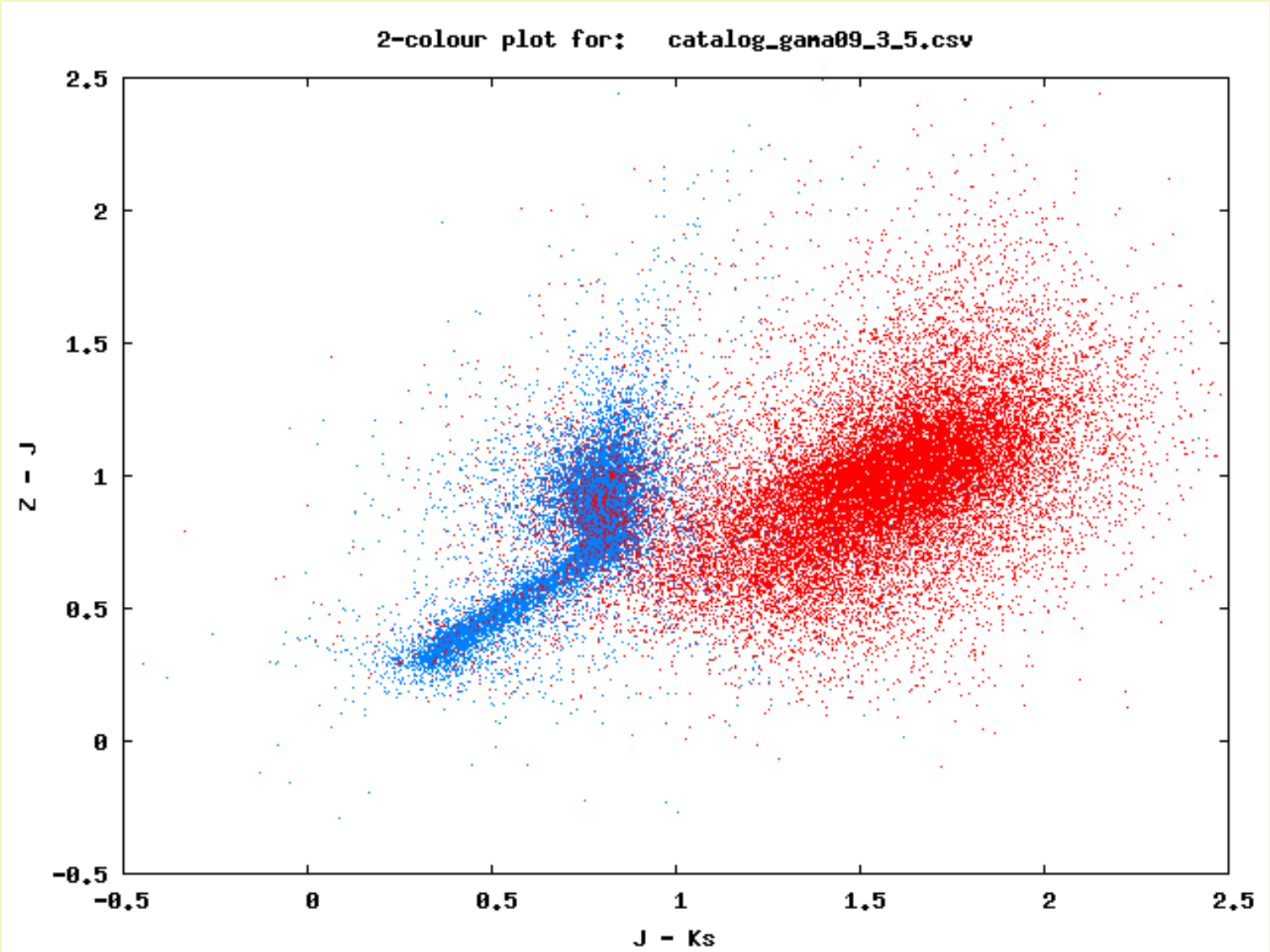
giJK two-colour diagram (Fleuren et al 2012):



clean star/galaxy separation: cf Baldry et al 2010, GAMA

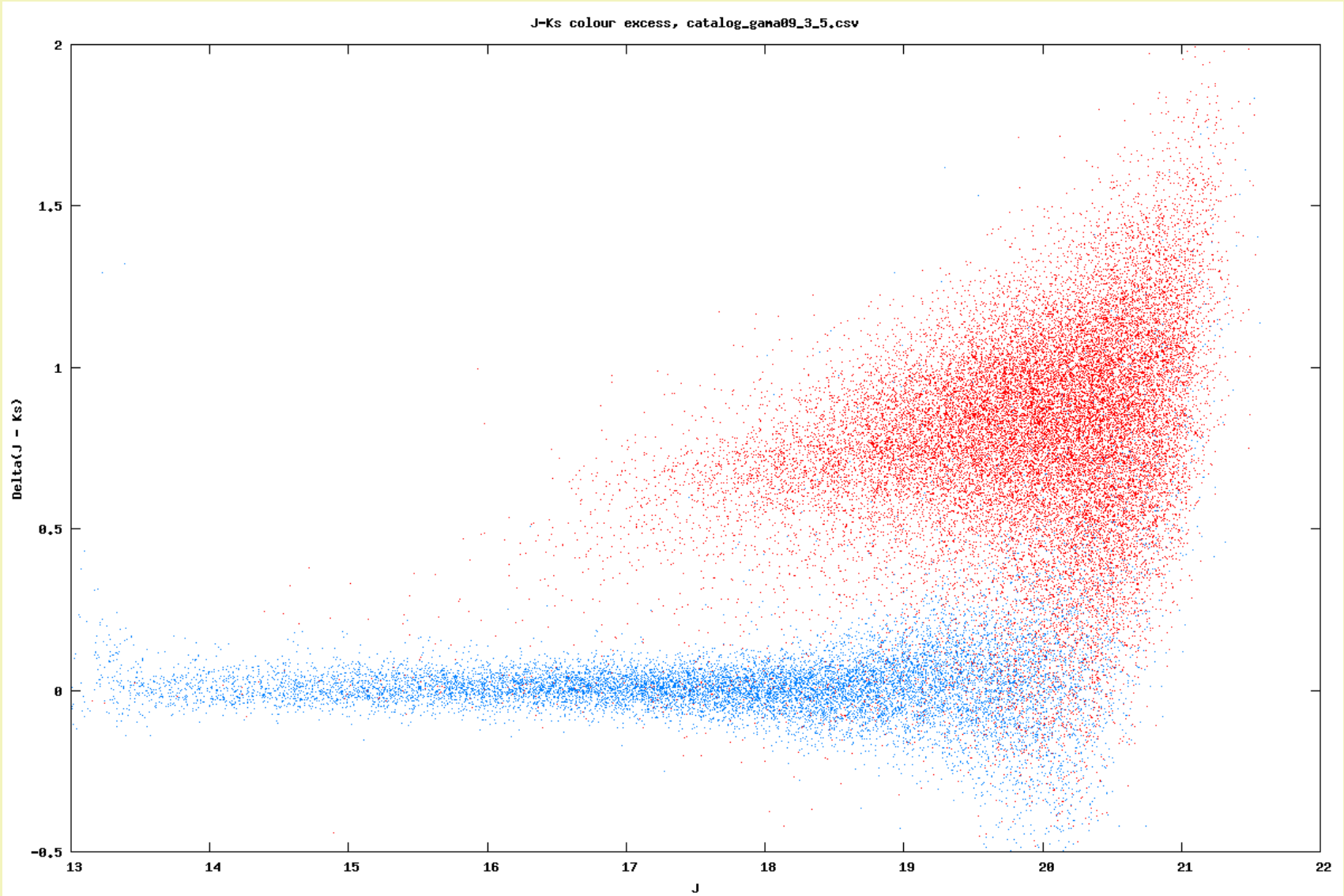


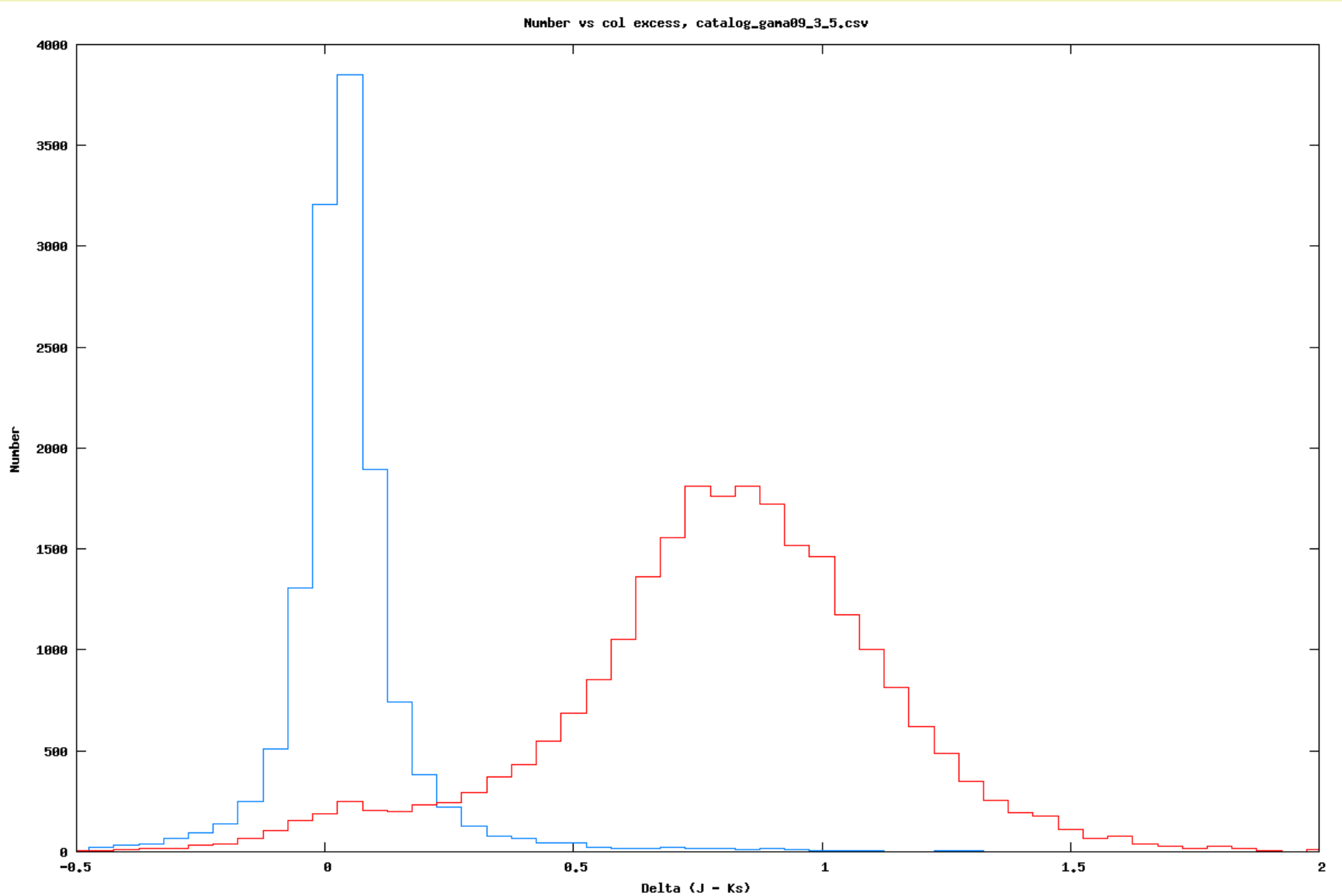
One tile: VIKING objects, with VIDEO+CFHLS deep photometry.



Blue: point-like . Red = extended .

J mag vs (J-Ks) distance from stellar locus



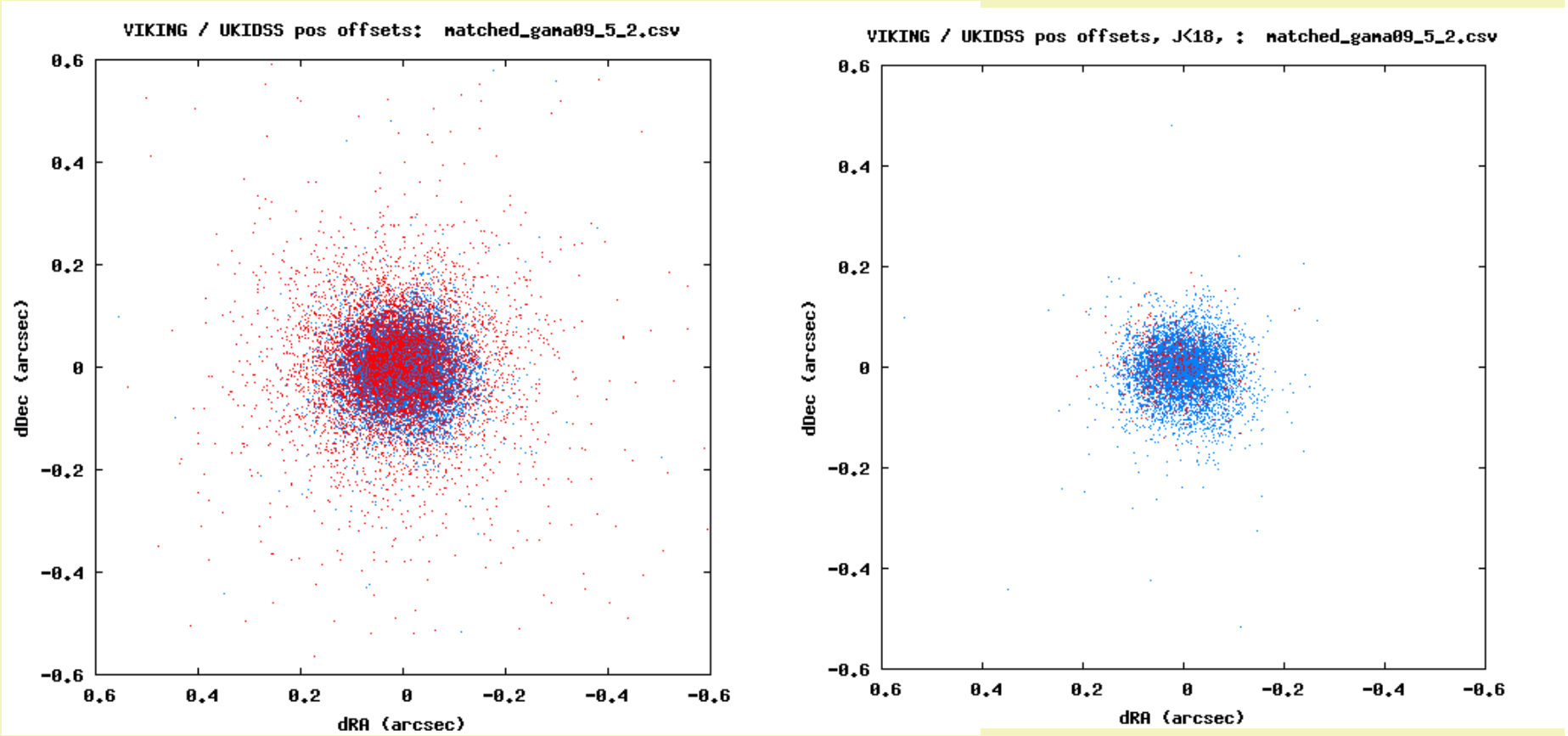

Number vs col excess, catalog_gama09_3_5.csv
Number
4000
3500
3000
2500
2000
1500
1000
500
0
-0.5
0
0.5
1
1.5
2
Delta (J - Ks)

Investigation of “discrepant” classifications

- Investigated ~ 1000 objects where morphological and 2-colour classifications disagree.
- “Blue extended objects” : a few are real low-z late-type galaxies… most are blended stars, stars in halos of bright stars, etc.
- “Red point sources” … most are apparently stellar. Some will be QSOs, plus fraction TBC of compact galaxies.

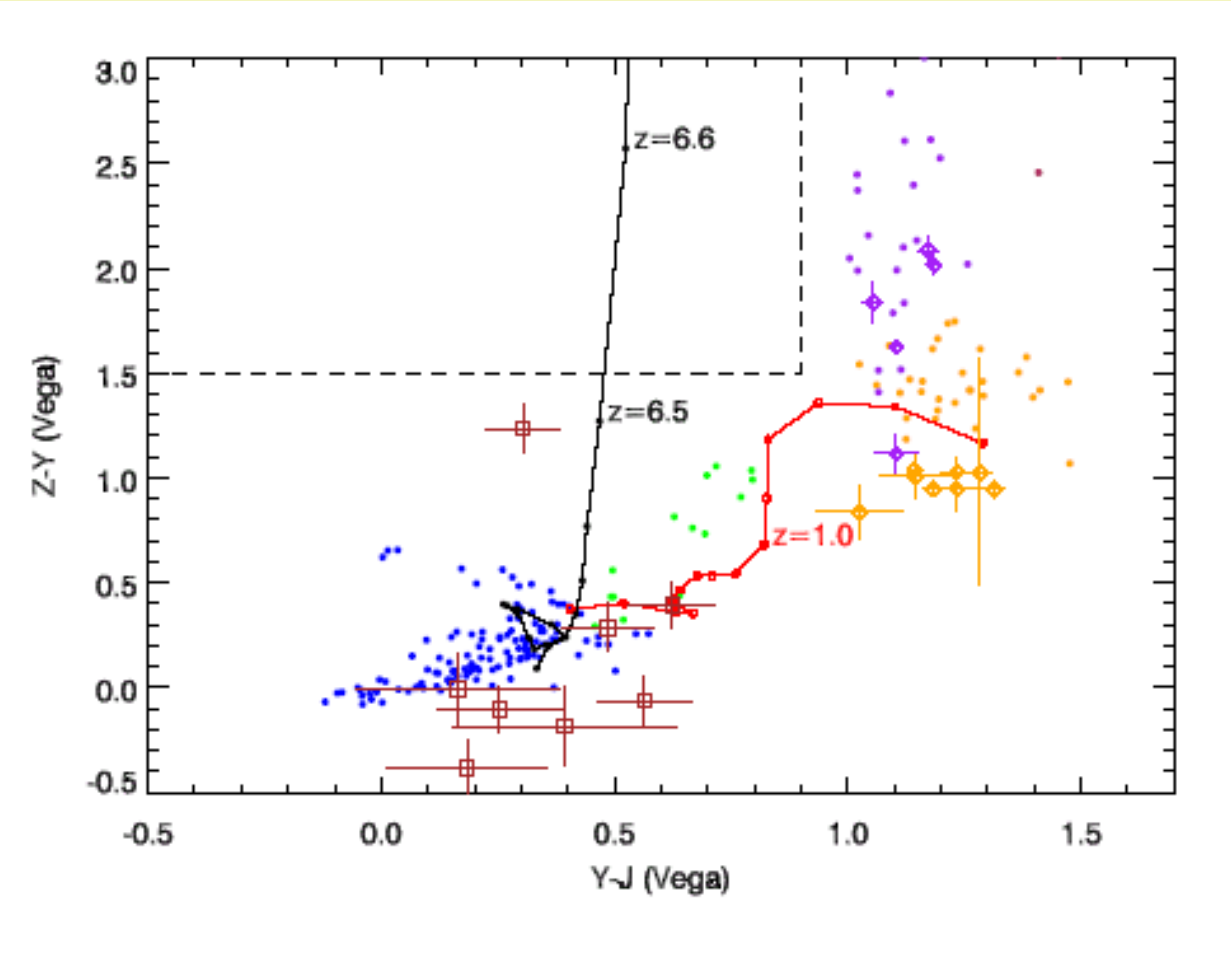
- Conclusion: a combined colour+morph. classification can give highly complete galaxy samples, or very pure star samples; e.g. useful for weak lensing.

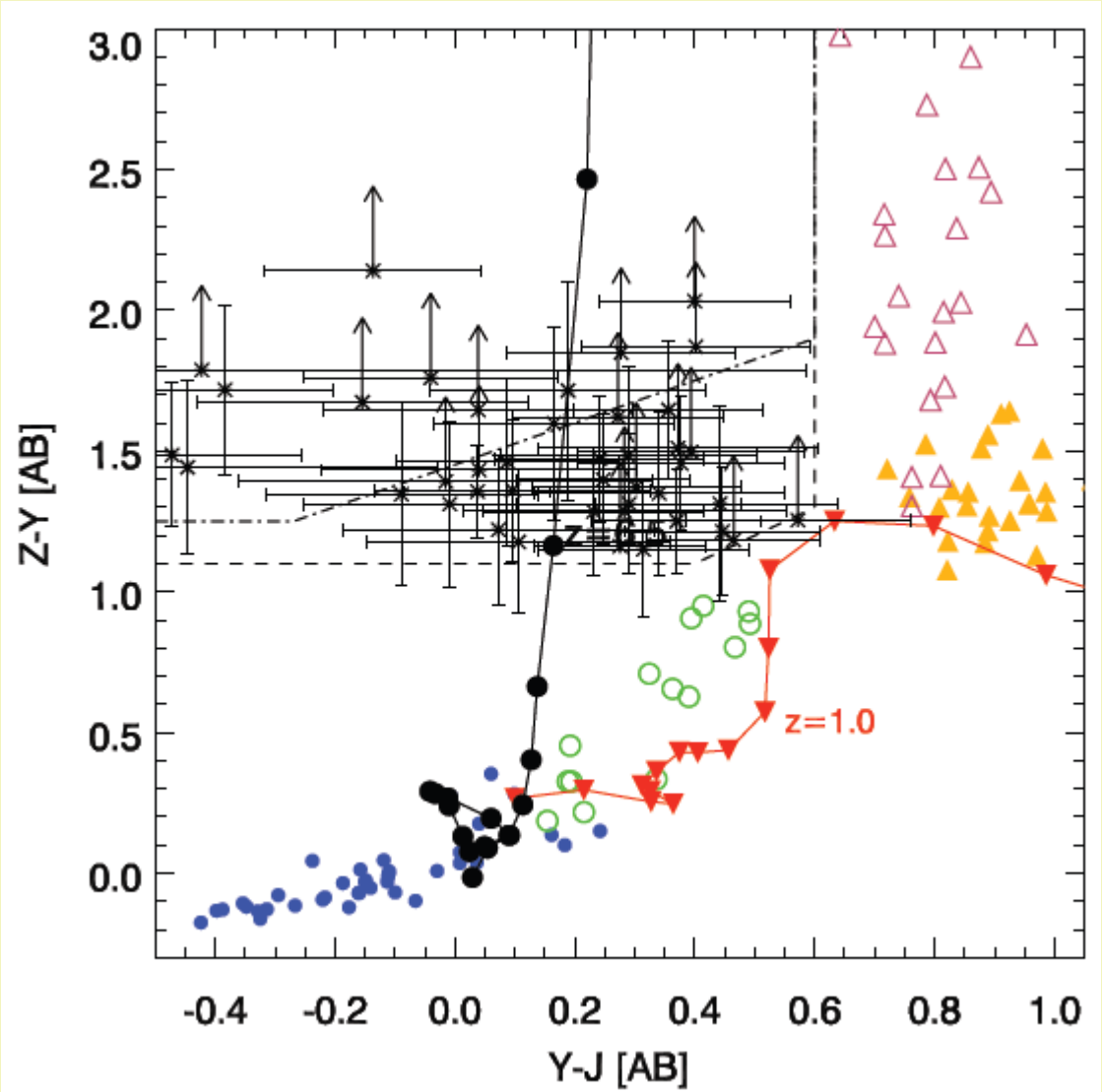
Astrometry: VIKING-UKIDSS RA/Dec offsets



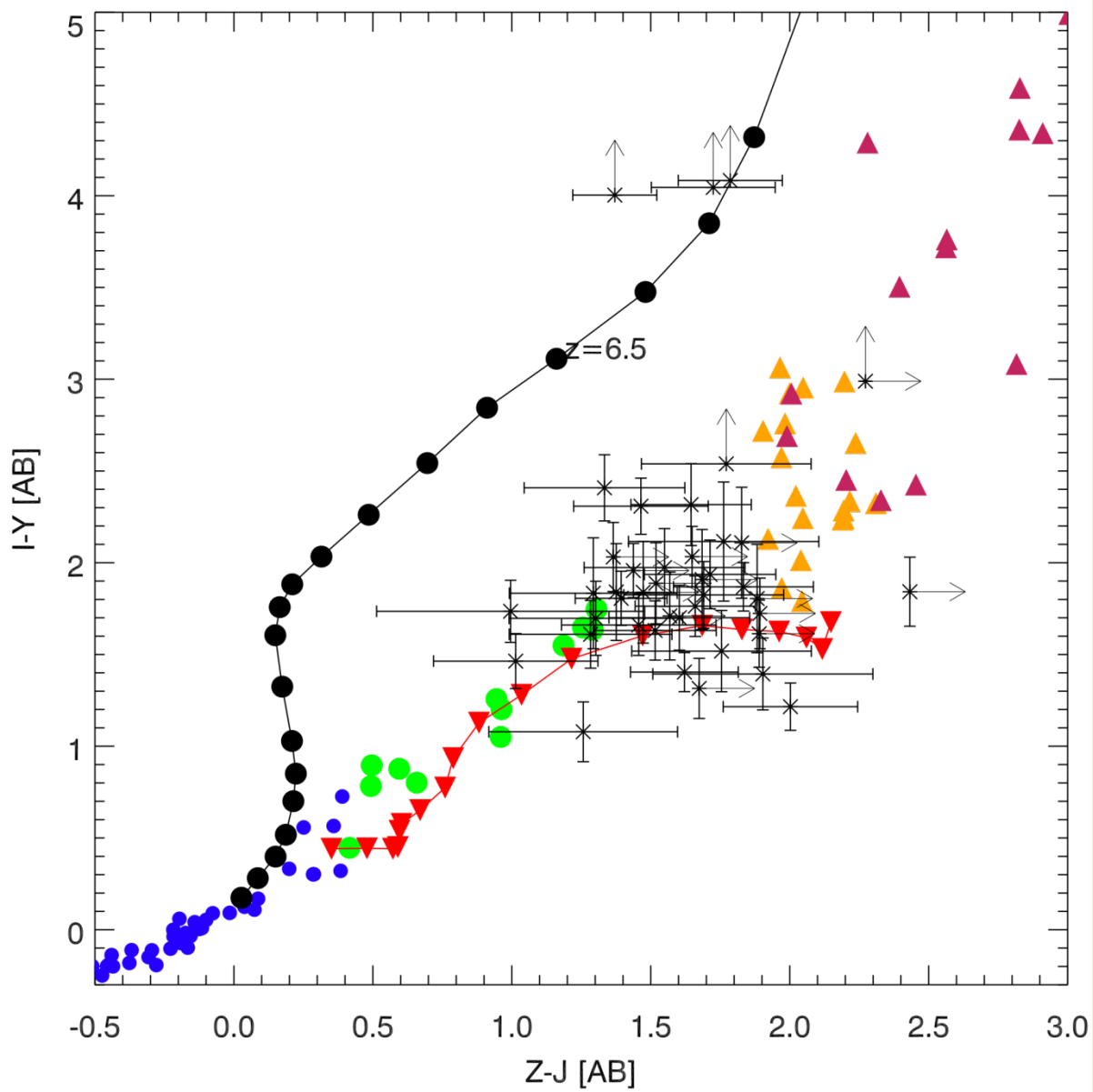
VIKING Science drivers (1)

z> 6.5 quasars, ultracool brown dwarfs:
colour selection in Z,Y,J :

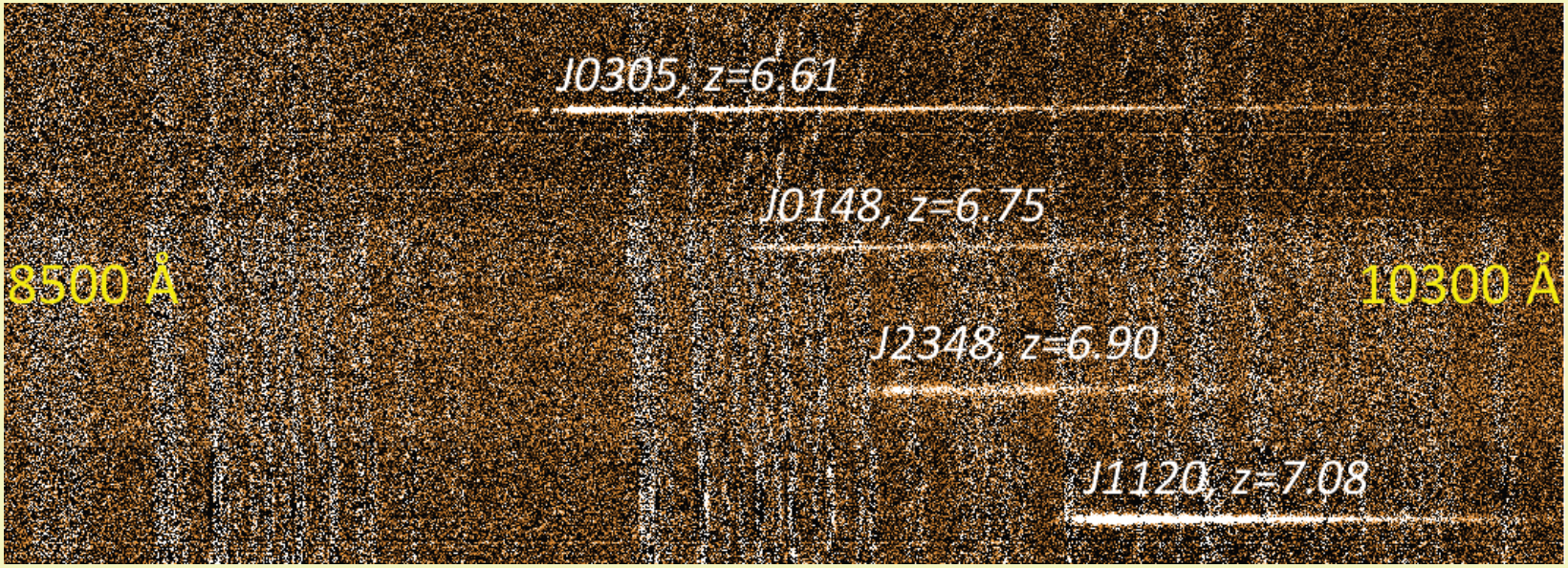



3.0
2.5
2.0
1.5
1.0
0.5
0.0
Z-Y [AB]
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Y-J [AB]
z=1.0

45 VIKING Quasar candidates – NTT i, z followup. (Bram Venemans + Joe Findlay) .



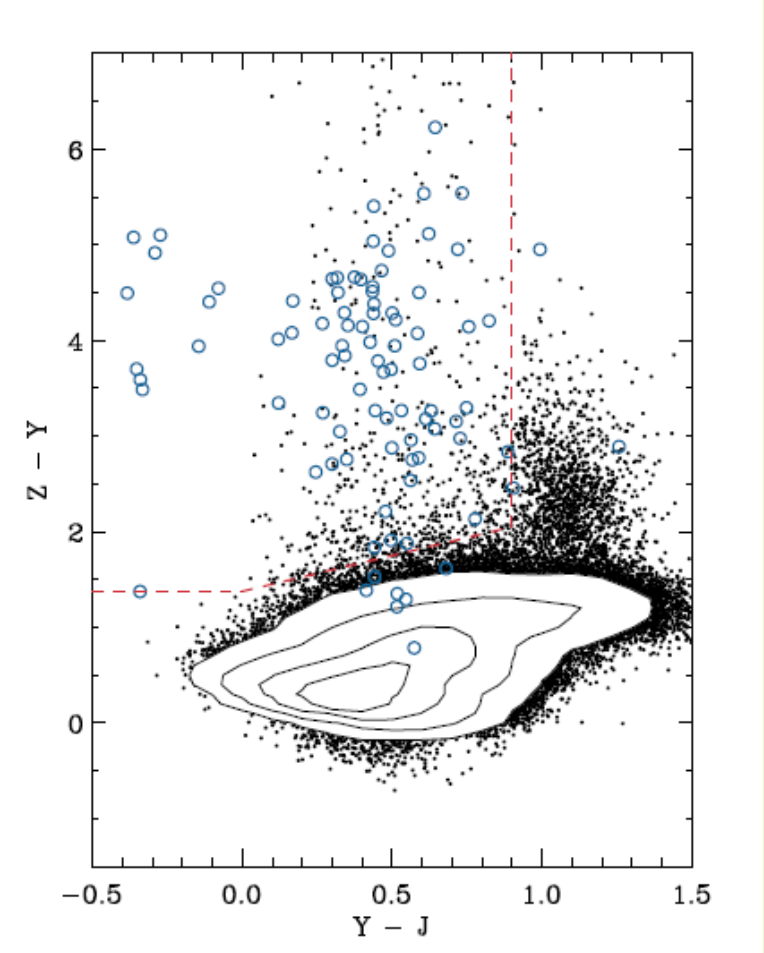
VLT-FORS2 confirmation spectra, z > 6.5 quasars

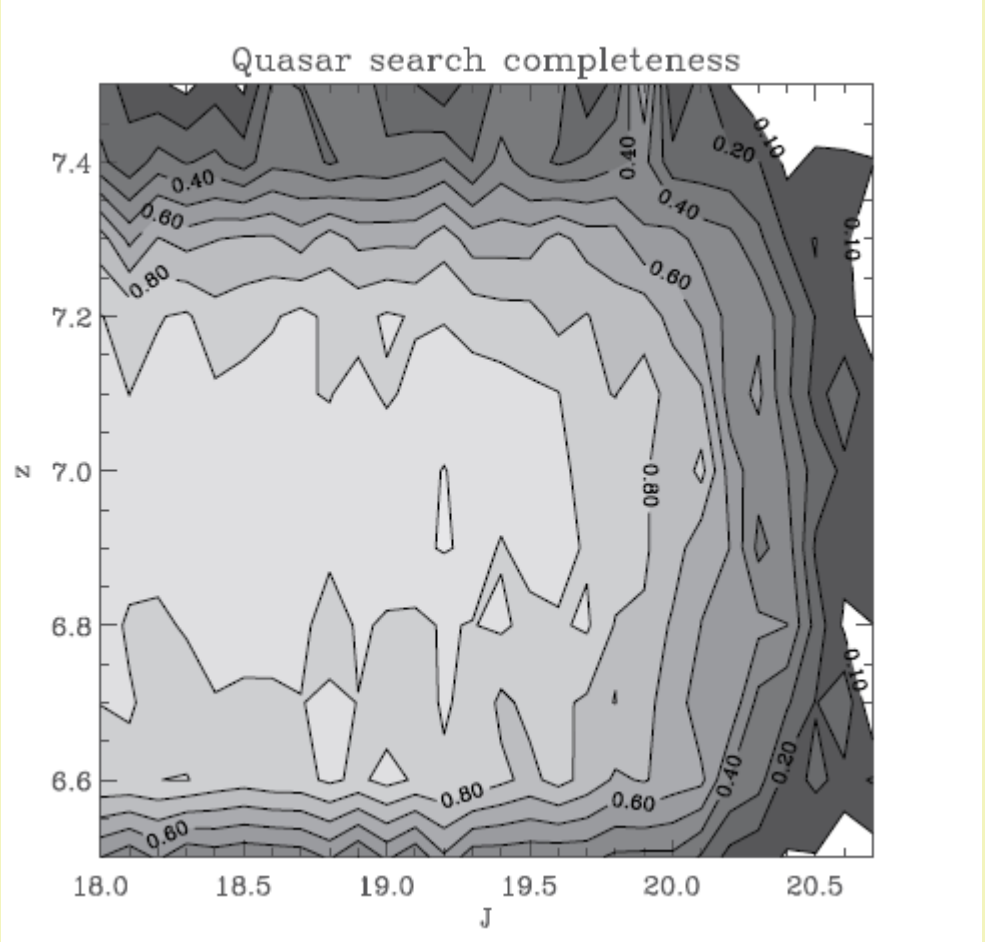


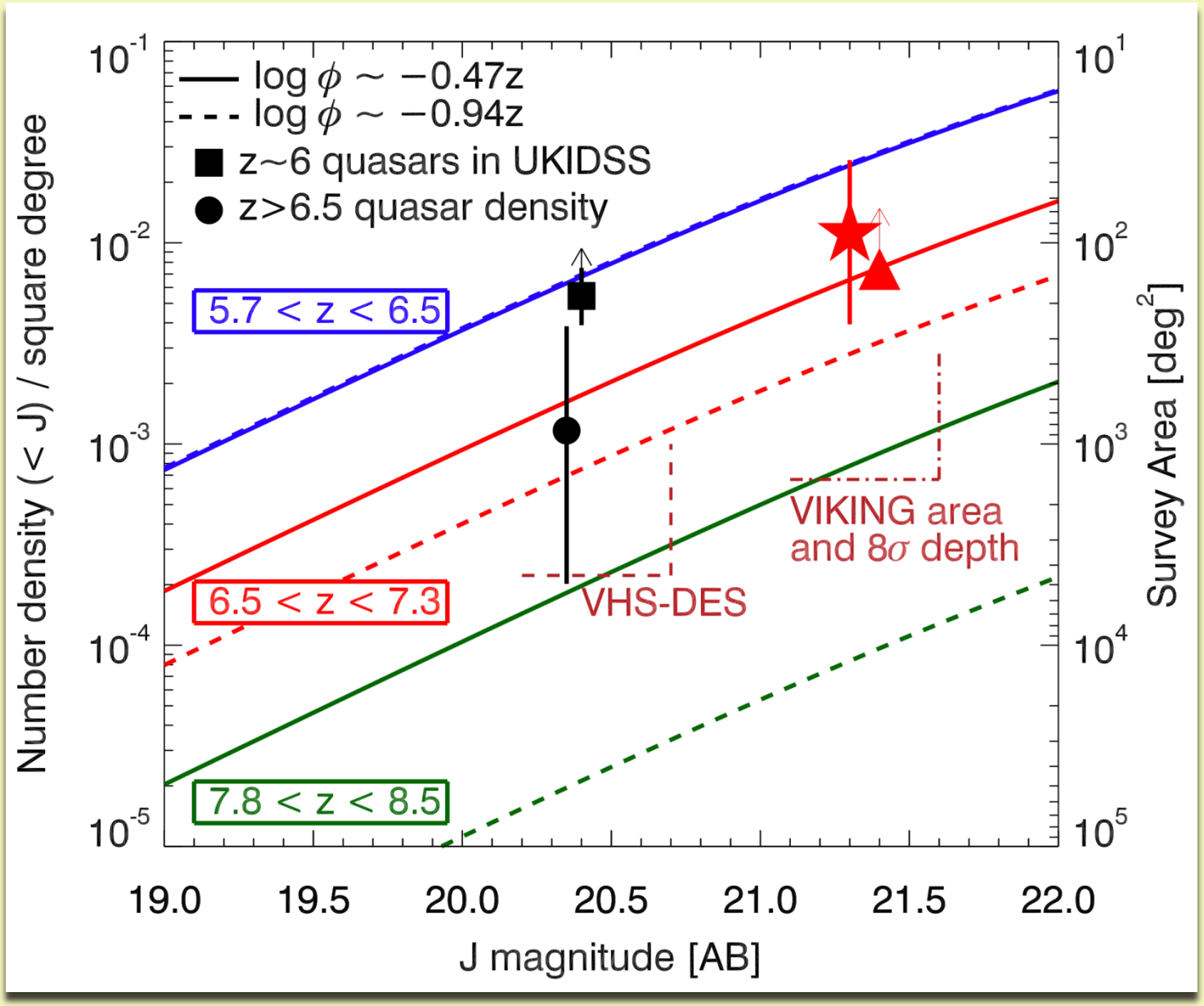
(Upper 3 are VIKING discoveries; ULAS J1120 from UKIDSS)

Yield per spectrum is good: 5 FORS spectra, 3 quasars so far.
Few more candidates in the queue …

Quasar selection simulations, completeness model (Findlay et al 2012).






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 [deg^2]
J magnitude [AB]
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
19.0
19.5
20.0
20.5
21.0
21.5
22.0

VIKING science – II

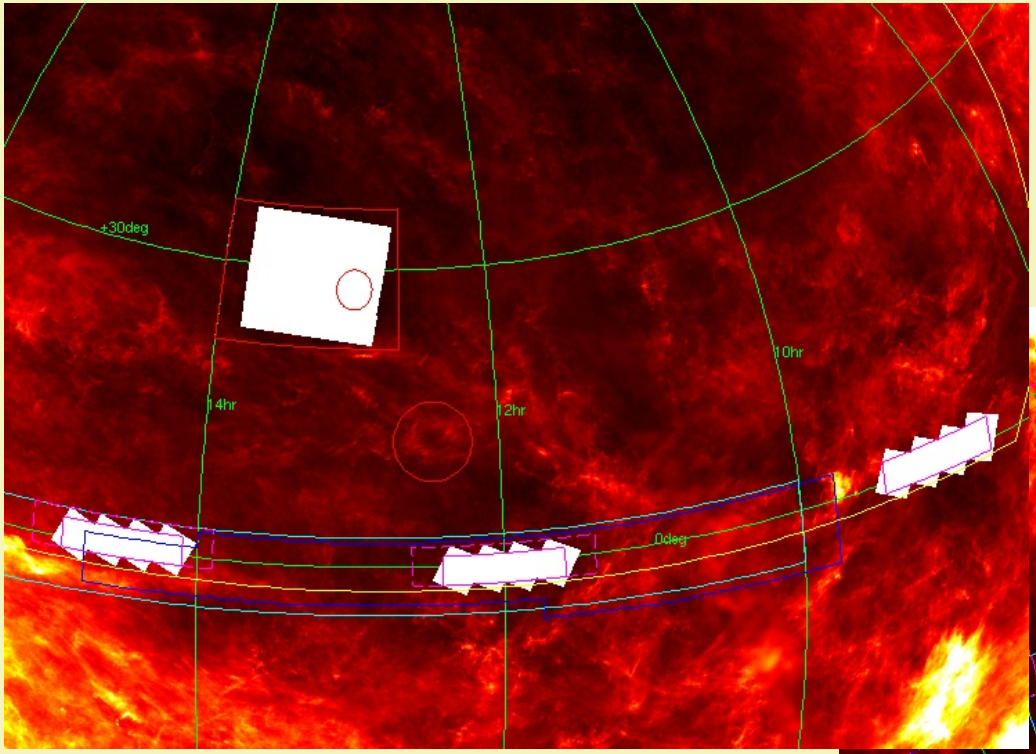
- Herschel-ATLAS identifications (S. Fleuren).
  - 21,000 submm sources in GAMA-09 field (48 sq.deg).
  - 72% statistically detected, 50% have reliable single-object VIKING ID's.
- Galaxy evolution:
  - Intermediate between "local" SDSS and "deep" few deg^2 VVDS, DEEP2, COSMOS , VIDEO ;
  - Probe evolution at z ~ 0.2 – 0.8 , in *restframe* 0.4 – 1.2 μm.
- Galaxy Morphologies:
  - ~ 100,000 galaxies at z < 0.1 ; 2x better resolution and 4x deeper surface brightness limit cf SDSS.
  - Fundamental local benchmark sample probing all environments.

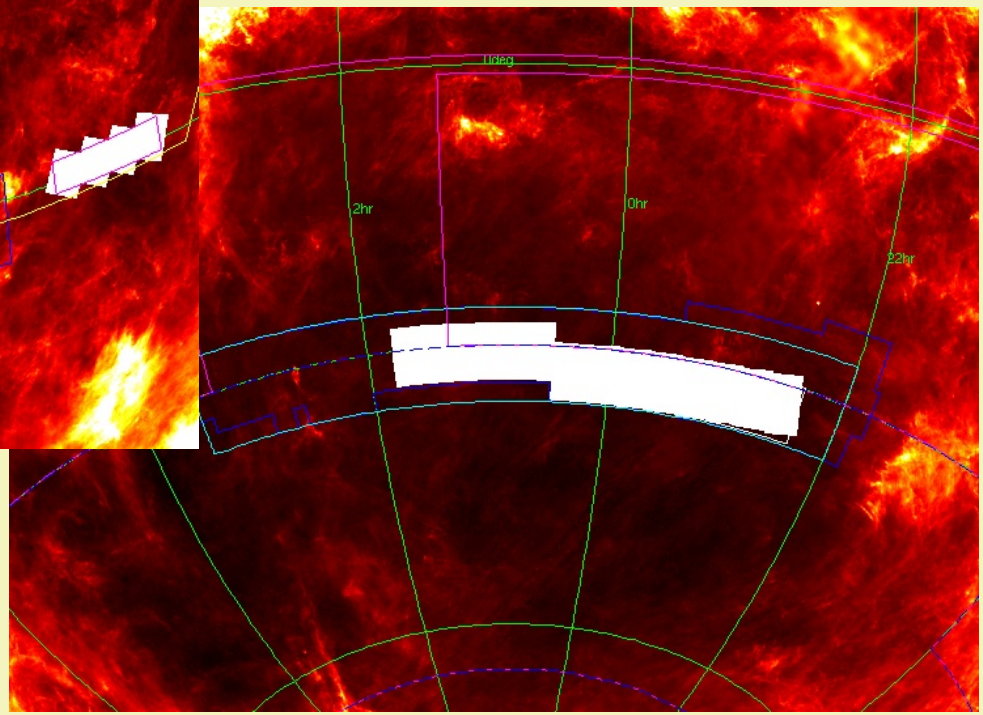
Synergy with Herschel-ATLAS

- Herschel-ATLAS = Advanced Terahertz Large Area Survey (PIs S.Eales, L.Dunne).
- ATLAS = 550 deg^2 , 600 hours in "Pmode" ; the largest Herschel Open Time project.
- 5 bands (100, 160, 250, 350, 500 μm) to ~ 30 mJy; spans peak of dust SED from z ~ 0 to z ~ 2.
- 400 deg^2 of ATLAS is inside VIKING footprint ; VIKING has prioritised this area – mostly done.
- Expect to detect ~ 2/3 of > 200,000 ATLAS sources. Non-detections will have $\nu f_\nu(FIR) / \nu f_\nu (NIR) > 40$.

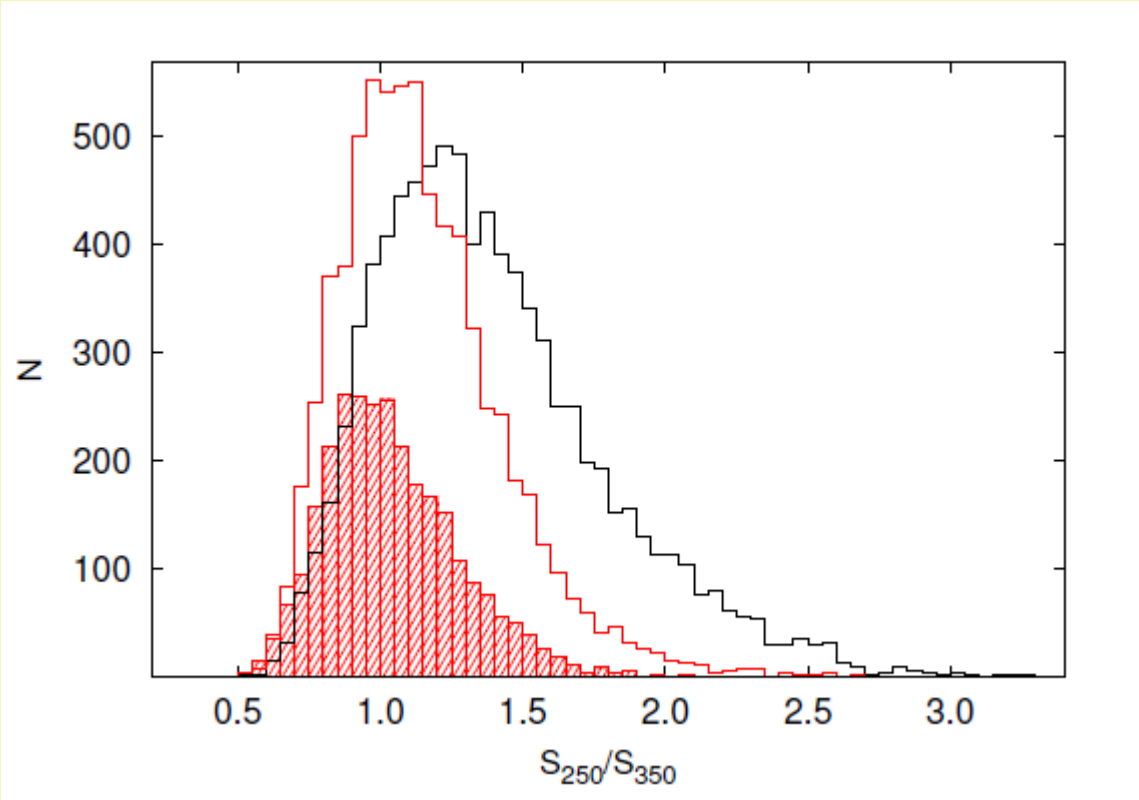
Herschel-ATLAS sky coverage.

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

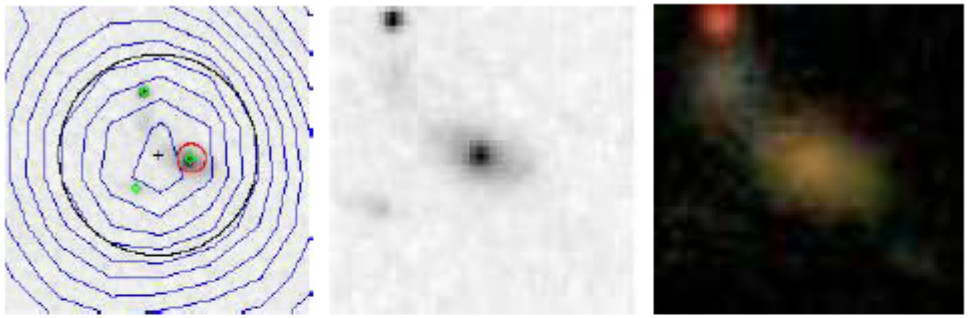




VIKING Identifications for H-ATLAS submm galaxies (Fleuren et al 2012):



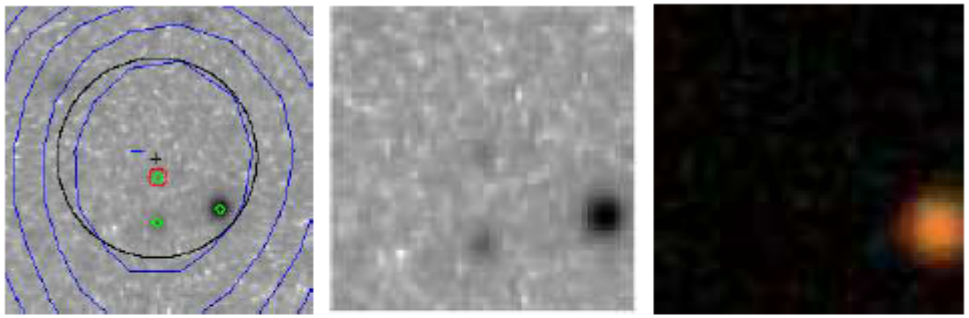
Black: reliable ID
Red: low-rel ID(s)
Hatched: blank



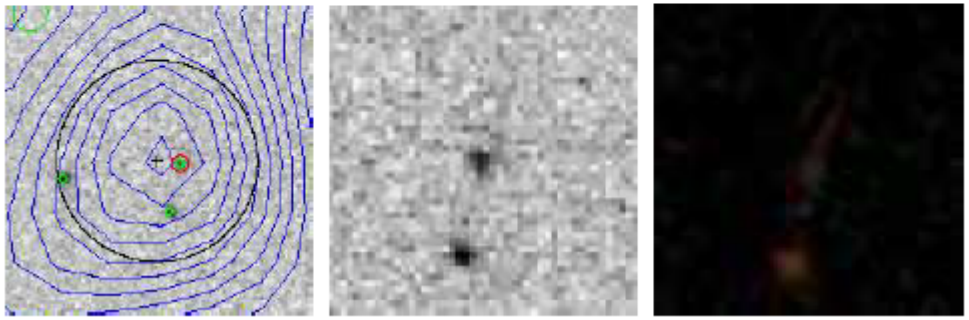
J085116.1-001410: z_{spec} = 0.268

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

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

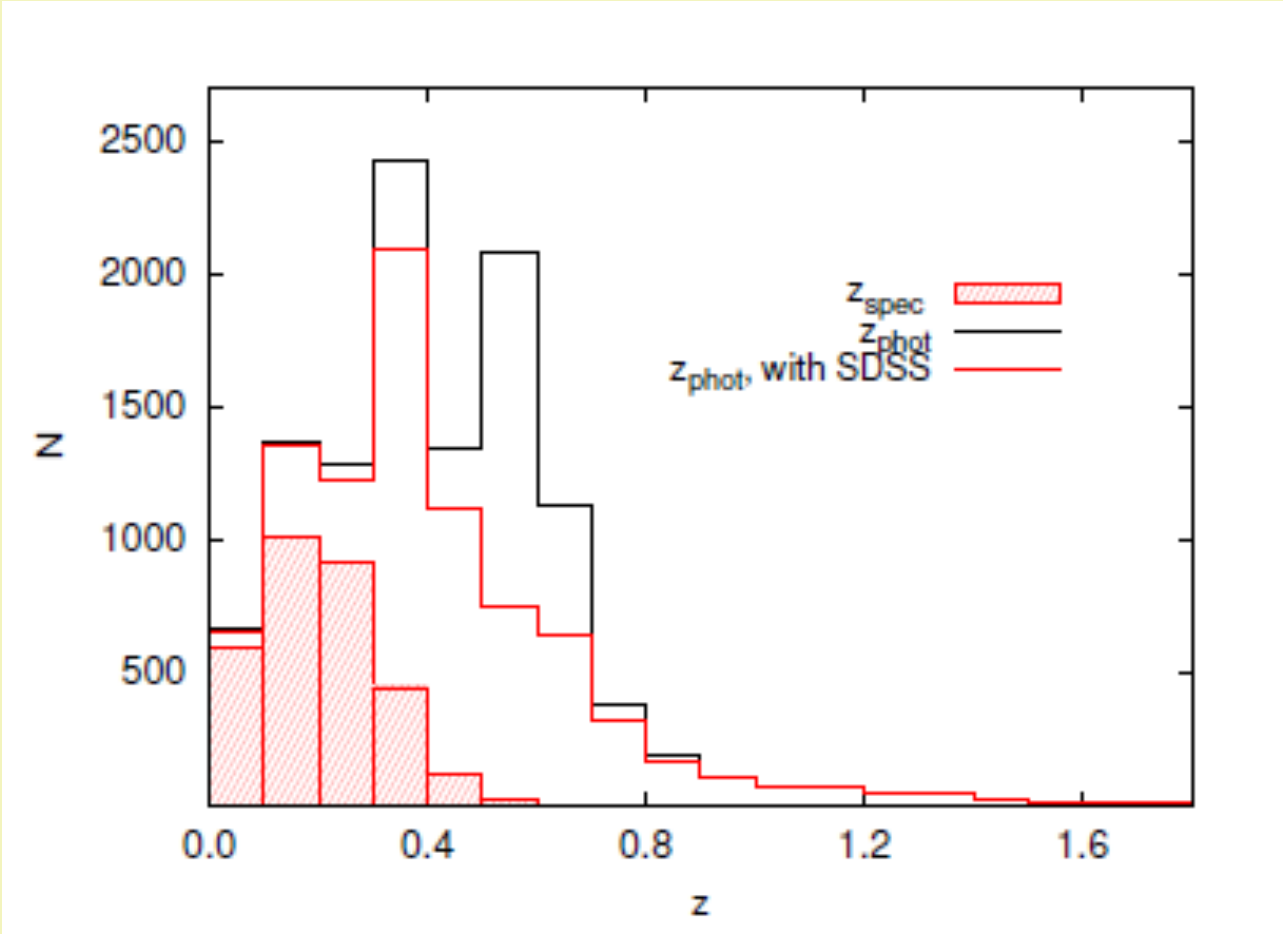


J083848.1+014536: z_{phot} = 0.546



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

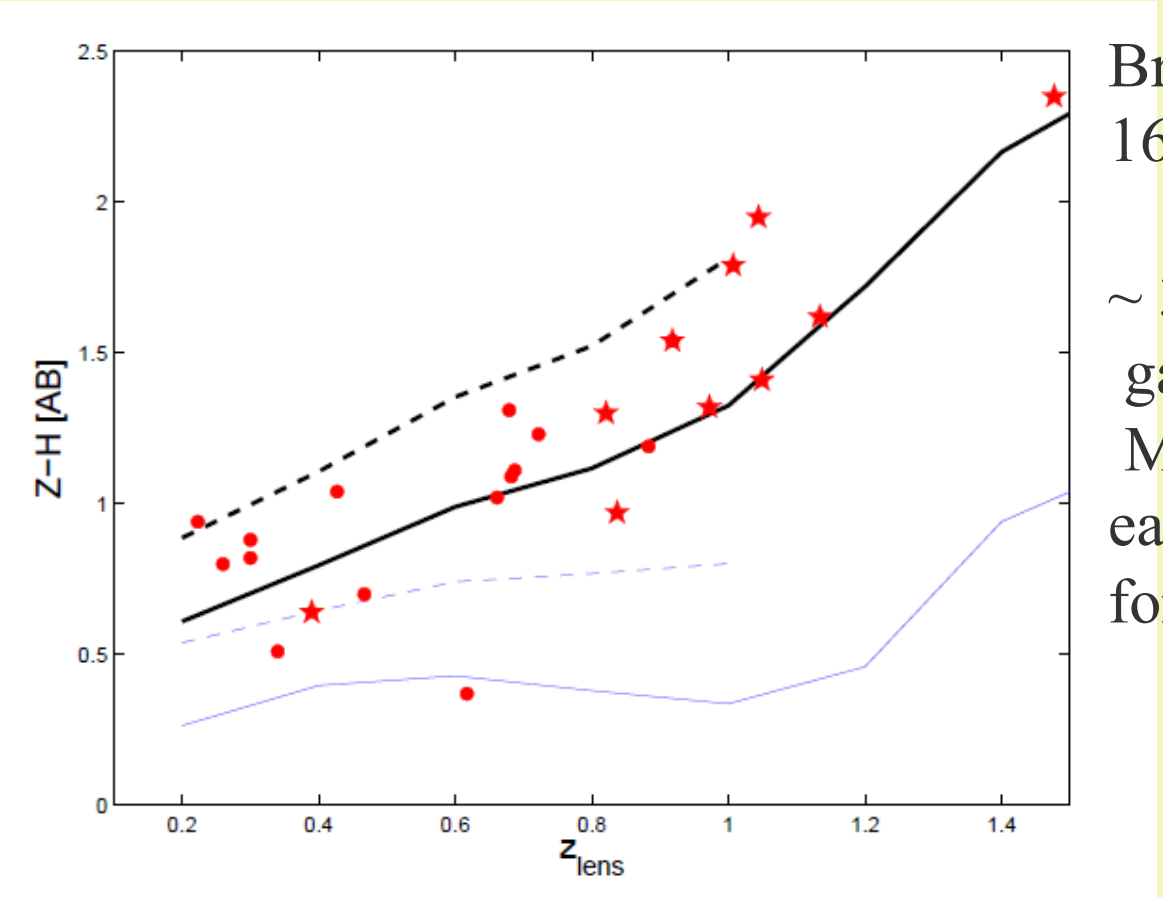
Redshift distribution for H-ATLAS reliable ID's.



Herschel-ATLAS Lensed Object Survey (HALOs) : (Gonzalez-Nuevo et al 2012)

- H-ATLAS successful at finding lensed SMGs: 5 confirmed lenses in first 3% of the area (Negrello et al 2010): expect 150 lens systems in full H-ATLAS.
- Improved selection using H-ATLAS + VIKING can reach fainter submm fluxes, potentially 1000 lens systems.
- Joint selection: f_350 > 80 mJy, colours indicating high-z source, plus VIKING red galaxy within 4 arcsec (candidate lens).
- A short ALMA image (~ 2 mins) can show high confidence lensing: e.g. multiple submm peaks on either side of VIKING galaxy.

Herschel-ATLAS Lensed Object Survey (HALOs) :

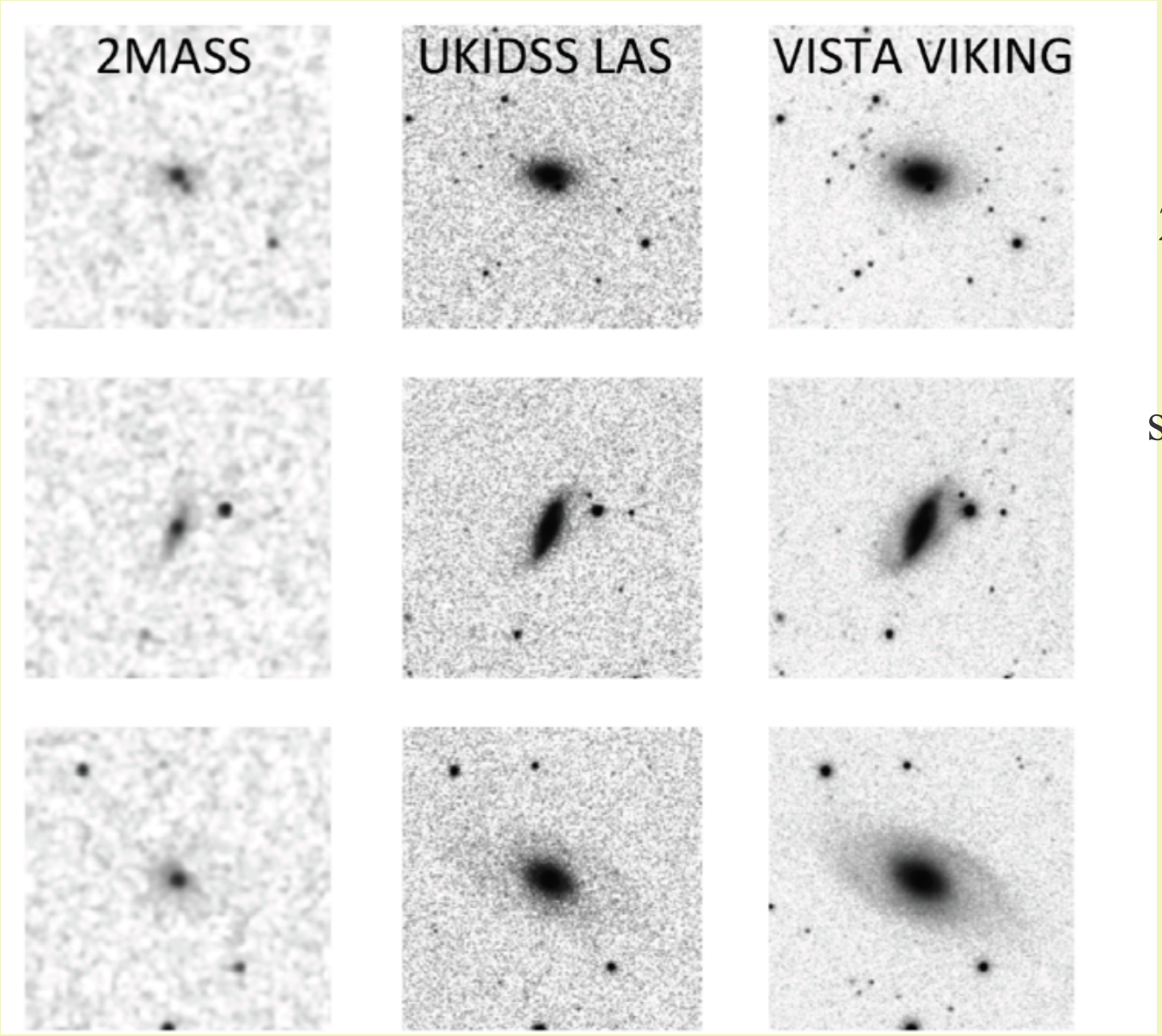


Bright SMGs in
16 sq.deg SDP field.

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

Synergy with GAMA

- GAMA = Galaxy and Mass Assembly.
- Redshift survey of ~ 250,000 galaxies to r ~ 19.8 with AAT – AAOmega.
- PI: Simon Driver
- Lots of multiwavelength coverage: GALEX, KiDS/ VIKING, Herschel-ATLAS, future ASKAP DINGO.
- Multiple visits: no close-pair avoidance as SDSS, 2dF.
- The definitive census of the z ~ 0.1 galaxy population.



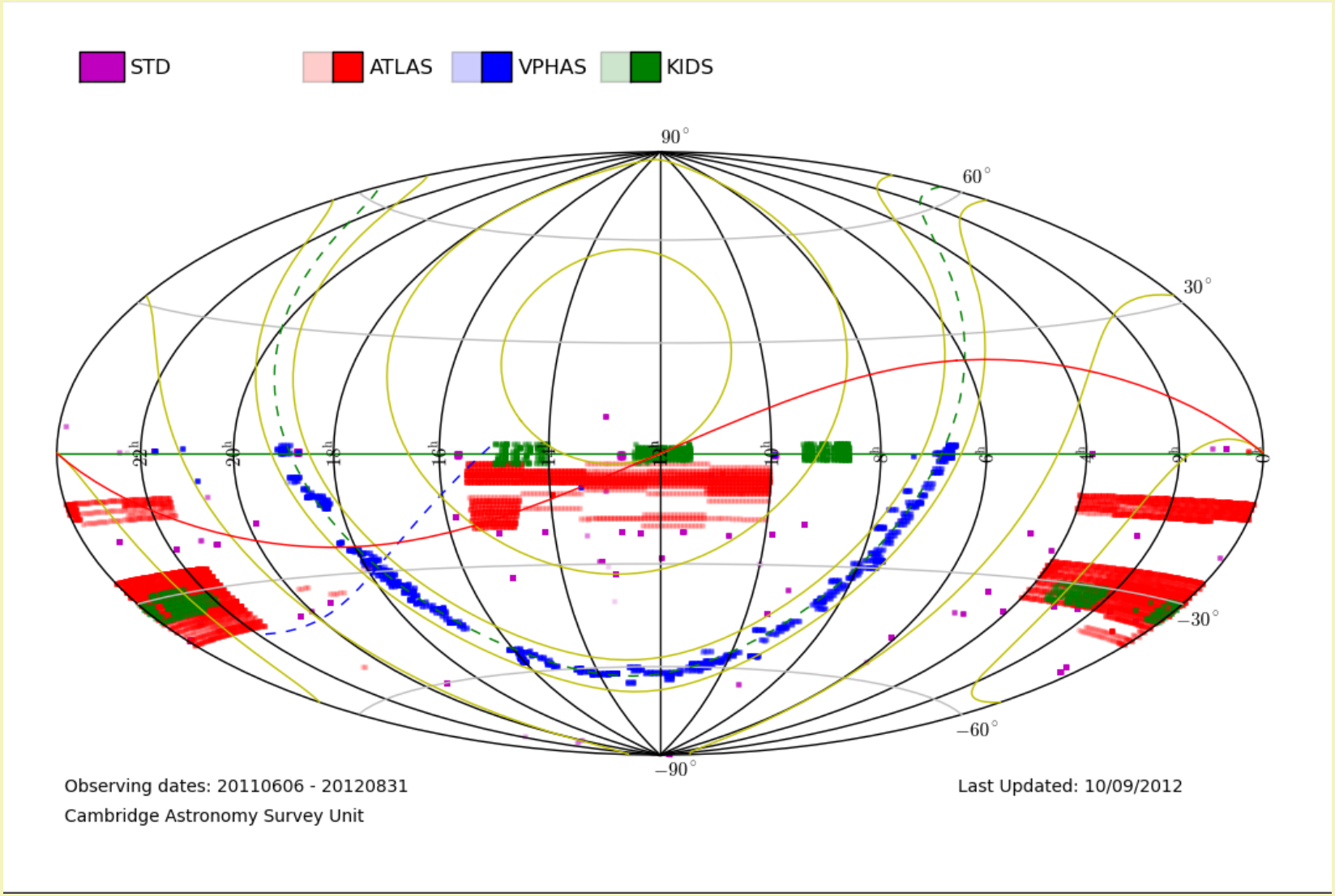
GAMA:
250,000 galaxies
with spectro-z's,
UV, Opt/IR,
submm and radio.

(Andrews et al 2012, in prep)

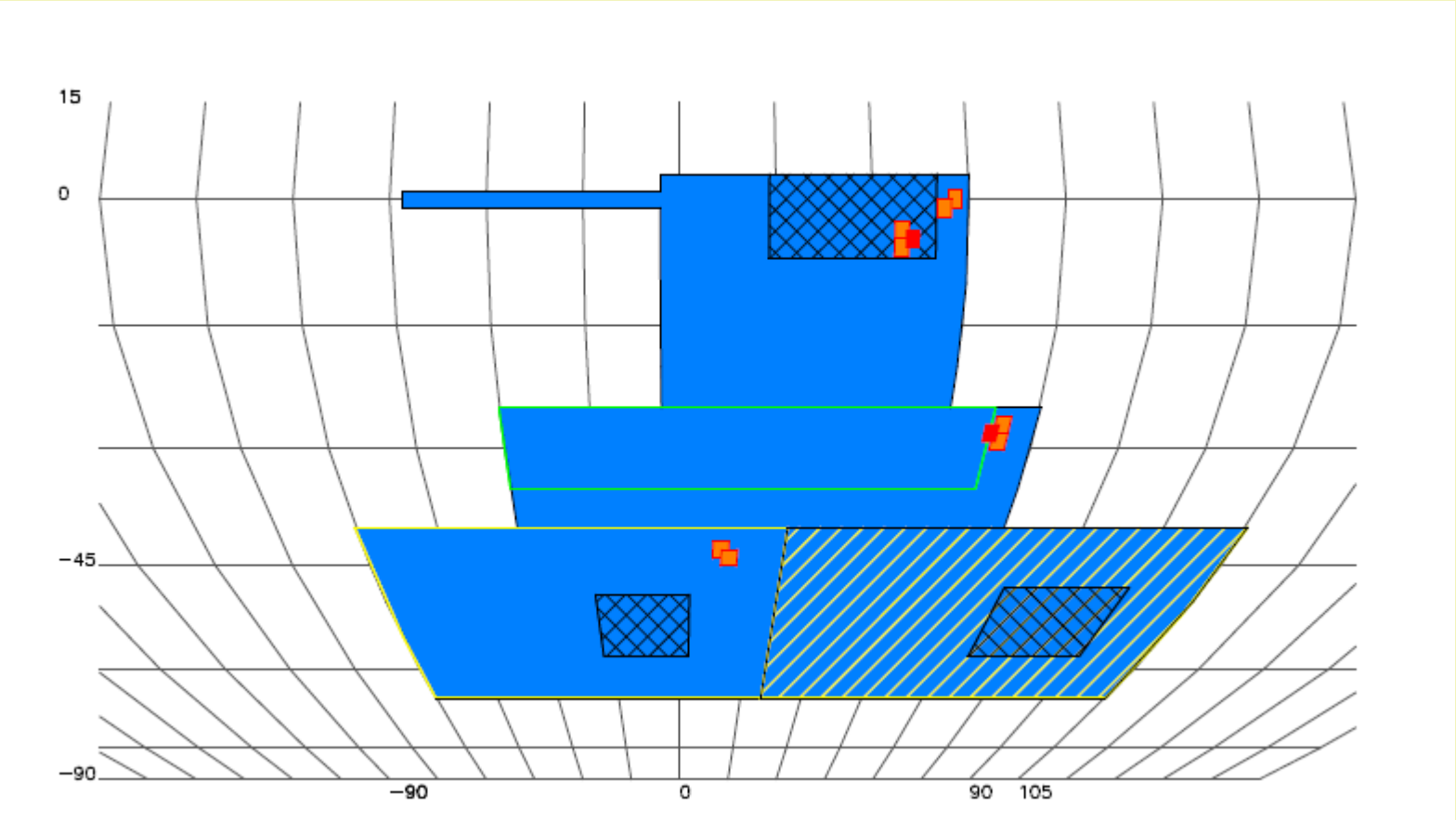
Lots more multiwavelength data soon…

- KiDS is observing, ugri, gradually catching up in area.
  - i-band coverage pretty good, others smaller.
- DES and HyperSuprime about to start…
  - DES will cover VIKING-S, HSC (probably) VIKING-N.
- WISE full-sky data release was out in Apr. 12. Cross-match is pending in next VSA data release.
  - VIKING should detect “almost all” WISE sources within coverage– eventually over 12 million.
  - WISE is more sensitive for Y-dwarfs; but cross-match will give large sample of robust L/T-dwarfs.
- eROSITA launch 2014 :
  - VIKING/KIDS will provide lots of cluster photo-z’s, and identifications for AGNs.

VST sky coverage – (Aug 2012)

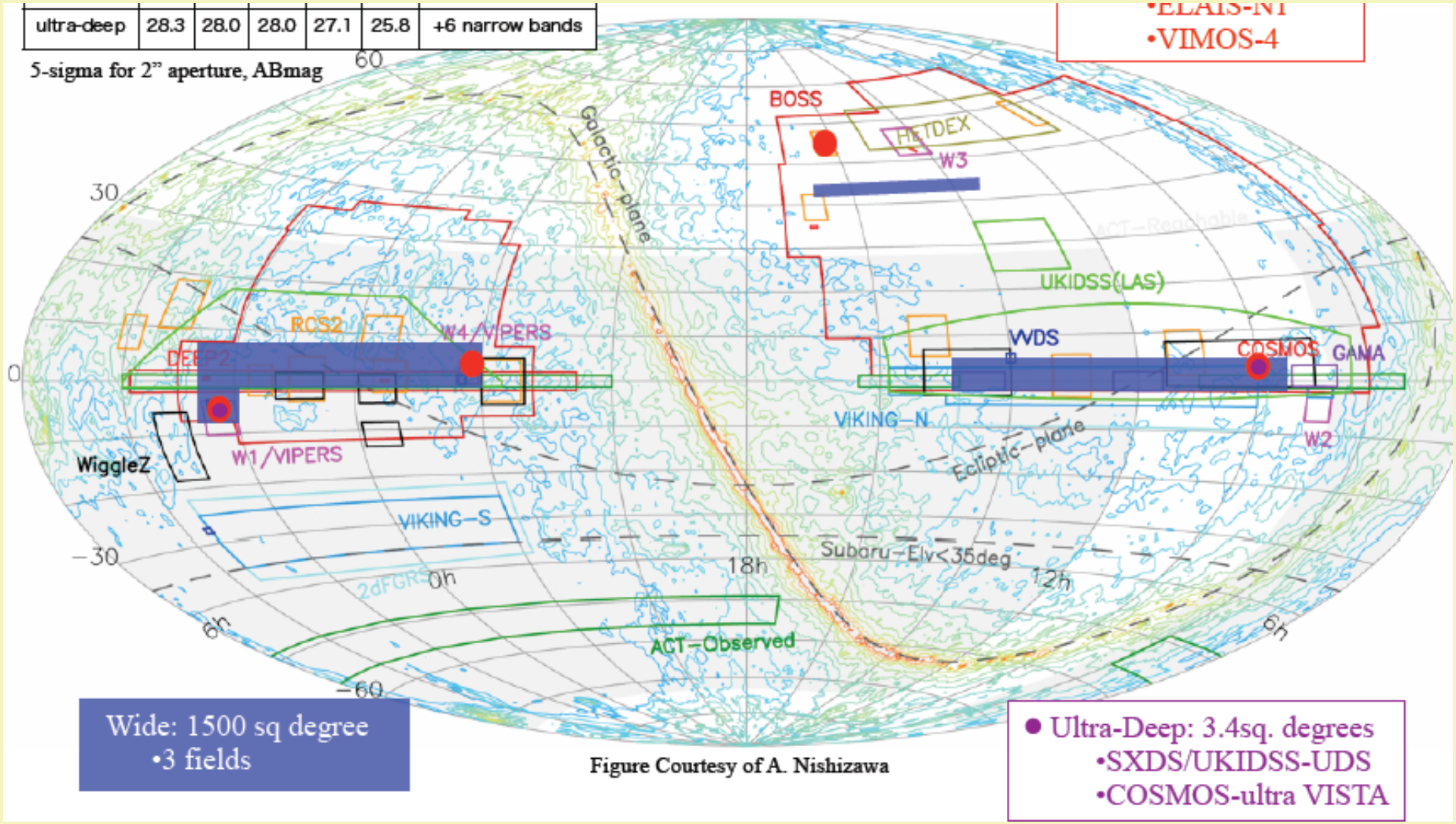


DES planned footprint (RA/Dec) :



Green = VIKING-S,
hatched = year-1,
yellow/red = SN fields

Hypersuprime-Cam provisional coverage plan (Miyazaki)



Summary:

- Nearly 400 deg^2 observed so far, including most of Herschel-ATLAS.

- Data quality is generally fine ; depth slightly worse than predicted, due to known factors

- High-z quasars are a science highlight : 3 out of 4 known at $z > 6.5$.

- Projected reliable ID's for 100,000 Herschel sub-mm sources to $z \sim 1$.

- Projected selection of ~ 1000 candidate gravitationally lensed SMGs: bright and excellent ALMA targets, ~ 2 min snapshots sufficient to confirm lens morphology.

- Several analyses have been stalled by absence of adequately deep visible data: recently changing:
  - VST KIDS now well under way.
  - DES and Hypersuprime first light in Sept 2012 …

Extra slides after here ...

Sample images: SGP, 1 detector, ~ 1/40,000 survey

Y

Ks

Fornax publicity image