The VISTA-VIKING survey: White paper for XMM survey workshop .

PI: W. Sutherland, Queen Mary, University of London (QMUL), U.K.
On behalf of the VIKING collaboration.

Abstract

The VIKING survey (VISTA Kilo-degree INfrared Galaxy survey) is one of the six VISTA Public Surveys recently approved by ESO, which will share most of the first five years on the new VISTA 4-m survey telescope at Paranal. VIKING will survey two stripes of high galactic latitude sky totalling $\approx 1500\,\mathrm{deg}^2$, in five near-IR passbands (Z,Y,J,H,$\mathrm{K_s}$). The VST-KIDS survey (PI: Kuijken) will survey the same areas in u, g, r, i to give a 9-band combined survey, ≈ 2 mag deeper than Sloan and 1.3 mag deeper than UKIDSS Large Area Survey.

The two selected stripes give good year-round observability from Chilean sites, and have spectroscopic coverage from SDSS or 2dF or both. There is also substantial overlap with planned future surveys including AAOmega-GAMA, the South Pole Telescope SZ survey, the CTIO Dark Energy Survey, Pan-STARRS, and the recently approved Herschel "H1K" survey (now $\approx 550\,\mathrm{deg}^2$).

1 VIKING overview

1.1 VISTA status

VISTA [1,2,3] is the new 4-metre wide-field survey telescope on Paranal, to be commissioned after arrival of the primary mirror expected in March 2008. It has a very wide-field ($0.6\,\mathrm{deg}^2$) infrared camera, and most of the first five years will be shared by six large Public Surveys [4] selected by the ESO Public Surveys Panel.

1.2 Observing strategy

The VIKING survey will use VISTA to image $1500\,\mathrm{deg}^2$ of high-galactic latitude sky in five near-IR passbands to "intermediate" depth; combined with the VST-KIDS survey of the same area in visible u, g, r, i bands, this will produce a unique 9-band survey. The area/depth combination will fill the large gap in parameter space between the "deep" $30 - 100\,\mathrm{deg}^2$ surveys such as CFHLS-Wide, UKIDSS-DXS, Spitzer-SWIRE, Herschel-HerMES, VISTA-VIDEO etc, and the very wide but relatively shallow surveys such as SDSS, 2MASS, VISTA Hemisphere survey, and SkyMapper which cover 10,000 – 41,000 deg^2.

The typical exposure times will be $6 - 8$ minutes per band with VISTA, and $10 - 30$ minutes per band for VST visible bands, each split into $\approx 5 - 8$ jittered exposures giving ample redundancy against cosmic rays, chip defects and gaps etc. Thus, VIKING will have a depth advantage of over 4 magnitudes relative to 2MASS, ≈ 1.3 magnitudes relative to the UKIDSS Large Area Survey [5], and the KIDS data will have a gain ≈ 2 magnitudes relative to SDSS imaging. Depths per band are listed in Table 1.

Our two selected stripes have many positive features including low cirrus, very good observability from Chilean sites e.g. VLT and ALMA, spectroscopic coverage from 2dFGRS and/or SDSS, and significant overlap with other surveys e.g. 2SLAQ, the approved AAOmega-GAMA [6], and the GALEX Medium Imaging Survey.

Also, we note that a major 600-hour Herschel key project (H1K [1], PIs S. Eales and L. Dunne, ref. [7]) has

[1] The H1K name may be replaced since the area coverage approved is $550\,\mathrm{deg}^2$.

Table 1: Magnitude limits for KIDS and VIKING in the 9 passbands: limits are 5σ detection in AB magnitudes, assuming realistic efficiency models and typical 0.8 arcsec image quality.

	VST-KIDS				VISTA-VIKING				
Passband:	u	g	r	i	Z	Y	J	H	K_s
Depth (AB):	24.8	25.3	25.1	24.1	23.1	22.3	22.1	21.5	21.2
Comparison:	SDSS + 2.0 mag				UKIDSS + 1.3 mag				

just been approved to survey $\approx 550\,\mathrm{deg}^2$ total in 5 far-IR/submm bands from $100 - 500\,\mu$m. Approximately $400\,\mathrm{deg}^2$ of H1K area will be within VIKING+KIDS coverage (with the remaining $150\,\mathrm{deg}^2$ near $\delta \approx +30^\circ$ for complementarity with LOFAR and other Northern telescopes).

1.3 VIKING science

The full list of VIKING science goals is broad and only a short overview can be provided here. Briefly, the goals include:

- Dark matter via weak lensing tomography: the excellent image quality of VST is expected to be important here. The lensing shape measurements are primarily from VST r-band, but the VIKING data at longer wavelengths will contribute to the essential photometric redshifts.
- Galaxy-galaxy lensing: the cross-correlation between foreground galaxies in the redshift surveys, and background galaxy shapes, will probe dark halo profiles to high precision.
- Dark energy: using photometric redshifts to slice the galaxy distribution into narrow redshift slices, spherical harmonic analysis can reveal the baryon acoustic oscillation peak for constraints on the dark energy equation of state w.
- Quasars at $z > 6 - 7.5$. The VIKING data will select quasars by near-IR colours beyond the current Sloan limit of $z \sim 6.4$, which was set by the red cutoff of CCDs near $0.95\,\mu$m. Models are uncertain, but we expect ~ 25 such quasars compared to ~ 10 in the ongoing UKIDSS-LAS.
- Moderate z quasars/AGN. With the increased depth compared to SDSS, we will be able to extend the existing SDSS quasar colour-selection over 2 mags fainter, probing correspondingly further down the luminosity function at any given redshift. Clearly full spectroscopic coverage may be impractical, but significant subsamples can be covered e.g. with AAOmega or new VLT instruments. There is very good potential synergy with an XMM survey here.
- Reddened quasars. Quasars with moderate dust obscuration may be missed by visible-colour selection, but can be well separated from normal stars by the "KX" method (e.g. ref [8]).
- Galaxy clusters: our area/depth combination will yield over 10,000 clusters, with ~ 500 at $z > 1$. Clusters may be selected from optical-IR photometric redshifts alone, but combination with S-Z surveys (e.g. South Pole Telescope) or X-ray surveys will be especially powerful.
- Galaxy evolution: we will have a large sample of galaxies at intermediate redshifts $\sim 0.3 - 1.0$ observed across a wide span of rest wavelength, probing the rapid falloff in the star-formation rate over this era.
- Galaxy morphologies: at $z < 0.1$, VIKING will contain $\sim 100,000$ galaxies with spectroscopic redshifts, imaged with sub-kpc resolution and $3\times$ fainter surface brightness limit than SDSS, and near-IR bands also. This will form a fundamental resource for structural studies, disk-halo decomposition and the morphology-density relation.

- Galactic halo: we can search for halo stars such as BHB stars and carbon stars to very large radii > 100kpc.
- Ultracool brown dwarfs: selecting by near-IR colours will give very large samples of L and T dwarfs, and possibly a few of the undiscovered "Y" class beyond the coolest now known.

Clearly it appears that the cluster and AGN science above offers the most potential synergy for an XMM survey, but other areas may also benefit.

1.4 Sky Coverage

As shown in Fig.1, VIKING will survey two elongated stripes each $\approx 75°$ in RA and $10°$ wide in Dec. The SGP stripe is centred near $\delta = -31°$, and the NGP stripe is centred at $\delta = 0°$. These are essentially the best regions of high-latitude sky from Chilean sites, since the SGP stripe passes near the Chilean zenith and has very low HI/cirrus foreground, while the NGP stripe on the Equator forms a good compromise between airmass and Galactic HI/cirrus foreground, and has good complementary data.

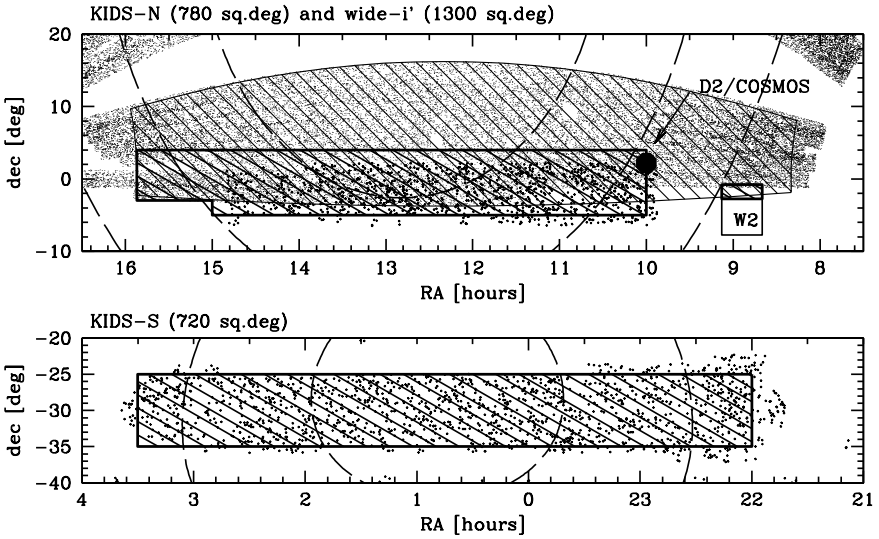

Figure 1: The sky coverage of the VIKING and KIDS surveys (thick line) in the North (top) and South (bottom) galactic caps. The CFHLS-W2 and COSMOS fields are labelled. A random subsample of SDSS (small dots) and 2dFGRS (large dots) redshifts are plotted.

The approximate coordinate ranges are:

NGP: $10^h < \mathrm{RA} < 15^h$, $-5° < \delta < +4°$, plus $15^h < \mathrm{RA} < 15^h50$, $-3° < \delta < +4°$, and $8^h36 < \mathrm{RA} < 9^h24$, $-1° < \delta < +2°$.

SGP: $22^h < \mathrm{RA} < 03^h30$, $-36° \lesssim \delta \lesssim -26°$. (Exact Dec boundaries are TBC subject to South Pole Telescope and DES final plans, but will be close to this).

1.5 The Herschel overlap

The ESO Public Surveys Panel has approved VIKING to be carried out over a 5-year period, subject to annual reviews. Clearly plans might possibly evolve over this long timescale, but we have a well-defined 2-year plan to cover the "highest priority" $600\,\mathrm{deg}^2$ subset of our area: this is the subset with the most overlap with planned future data, and will include all of the $\approx 400\,\mathrm{deg}^2$ of overlap with the Herschel H1K survey.

The VIKING 2-year plan comprises:

- The southern portion of the SGP stripe: this will also overlap with the ongoing South Pole Telescope Sunyaev-Zeldovich survey and (from 2011) the Dark Energy Survey. This area is $22^h < \mathrm{RA} < 03.5^h$, $-36^\circ < \delta < -30^\circ$.
- The central portion of the NGP stripe at $11^h20^m < \mathrm{RA} < 15^h$, $-2^\circ < \delta < +2^\circ$, plus the 9^h outrigger field. This includes all of the approved GAMA medium-deep spectroscopic survey, and is within the 2dFGRS-SDSS overlap region and has good coverage from GALEX-MIS.

Concerning the Herschel coverage: the precise boundaries of the Herschel fields are still under discussion as of Jan. 2008 to fit inside the approved 600 hour allocation, but they will comprise $\approx 400\,\mathrm{deg}^2$ inside the above KIDS+VIKING 2-year plan regions, plus an additional $\approx 150\,\mathrm{deg}^2$ near the North Galactic Pole at $\delta \sim +27$.

2 Implications for XMM survey

Clearly, the full VIKING-KIDS $1500\,\mathrm{deg}^2$ is much larger than appears practical with an XMM survey, but a significant fraction of the $\approx 400\,\mathrm{deg}^2$ VIKING-Herschel overlap region could be covered.

In the event that the XMM survey is close to $100\,\mathrm{deg}^2$, then the SWIRE and Herschel-HerMES survey areas totalling $70\,\mathrm{deg}^2$ are obvious potential targets. However, we note that only $31\,\mathrm{deg}^2$ of HerMES coverage is visible from Chile, of which $11\,\mathrm{deg}^2$ has already been surveyed by XMM (the XMM-LSS and COSMOS fields). Thus, southern or equatorial survey fields in addition to HerMES are required if the XMM-XXL survey is to remain mostly observable from Chile.

Simply expanding the XMM-LSS field is clearly one option, but this is likely to be problematic for ground-based followup, due to probable scheduling conflicts with the deep VVDS and WFCAM-UDS subfields within XMM-LSS, and the very high demand HUDF/CDF-S/GOODS-S field at nearby $\mathrm{RA} = 03.5^h$.

The VIKING+KIDS+Herschel overlap regions will provide $400\,\mathrm{deg}^2$ of coverage, with data expected by around 2010. These appear very suitable candidate areas for a wide XMM survey. The SGP stripe is particularly attractive due to the favourable Dec from Chile, very low foregrounds and planned South Pole Telescope SZ coverage. The Western part of this stripe from $22^h - 00.5^h$ has little scheduling conflict with the high-priority deep fields, so is perhaps the best available region outside the HerMES fields. The NGP-equatorial regions common to VIKING, KIDS, Herschel, and GAMA have somewhat higher HI foreground, but are complementary for scheduling and provide excellent observability from both hemispheres.

Thus, for a large-area XMM survey, dividing area between HerMES Southern fields, the VIKING/Herschel SGP stripe, and VIKING/Herschel/GAMA equatorial fields may be a good balance.

References

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[2] Emerson, J., McPherson, A., Sutherland, W., 2006. *ESO Messenger*, 126, 41.

[3] `http://www.vista.ac.uk`

[4] Arnaboldi, M., Neeser, M. *et al.* , 2007. *ESO Messenger*, 127, 28.

[5] `http://www.ukidss.org/surveys/las/las.html`

[6] `http://star-www.st-and.ac.uk/ spd3/gama/`

[7] `http://www.astro.cardiff.ac.uk/groups/egalactic/galaxies/herschel/h1k.pdf`

[8] Warren, S., Hewett, P., Foltz, C., *et al.* , 2000. *MNRAS*, 312, 827.