1 KIDS: a 1700-square degree cosmological survey with VST/OmegaCAM

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1.1 Abstract:

We propose a large (1700 square degree) public imaging survey with VST/OmegaCAM, dubbed the Kilo-Degree Survey (KIDS). It targets two regions of the sky where massive redshift surveys have taken place, and where near-infrared surveys will soon begin: an equatorial strip on the North Galactic Cap, and a patch around the South Galactic Pole. Both areas will be surveyed in the five SDSS bands $u'g'r'i'z'$. In terms of area coverage and sensitivity, KIDS interpolates between the ongoing Sloan Imaging Survey, which is about 2.5 magnitude shallower but 6× wider, and the roughly 1 magnitude deeper, 10× smaller-area CFHTLS-Wide survey at CFHT.

The survey has been designed with weak lensing as a major goal. Image quality should be a factor of two better than SDSS, and slightly better than CFHTLS-Wide. It will yield a large, homogeneous dataset with photometry from u' to K, 200,000 spectra of the brightest galaxies in the field. Expected science results include a sample of $z > 6$ quasars, several 1000 galaxy clusters beyond redshift 1, the power spectrum of the galaxy distribution around redshift 1, and a detailed understanding of the structure of galactic halos as function of galaxy type and environment.

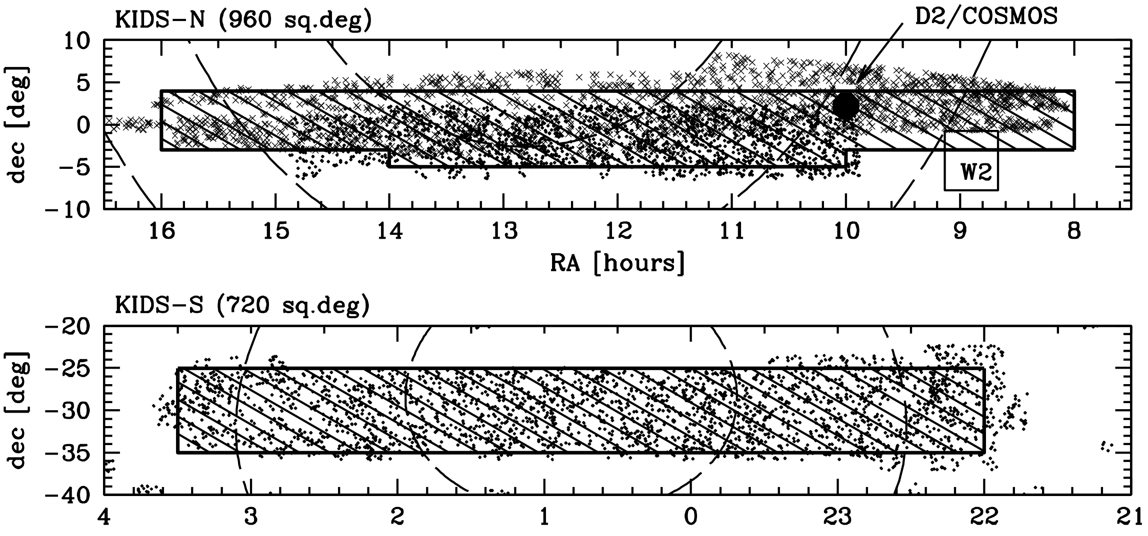

Figure 1: The KIDS patches in the North (top) and South (bottom). A random subset of the publicly available 2dF catalogue is overplotted as dots. In the Northern fields we also plot the SDSS Data Release 3 (crosses), the CFHTLS W2 field, and the deep COSMOS field (not to scale). Contours (dashed) of galactic latitude are also shown: $b = 30, 45, 60$ (N) and $b = -60, -75$ (S). UKIDSS will survey the entire N field, as will SDSS; the S field would be an ideal target for a VISTA survey.

2 Description of the survey:

2.1 Scientific rationale:

Astronomical surveys are an important tool for understanding our universe. In the last decade alone, projects such as the APM survey, the 2dF redshift survey, and the Sloan Digital Sky Survey, have provided a wealth of information that is still being digested. With the VST and OmegaCAM, ESO will soon have the tools to provide a new standard in imaging surveys of the sky. In combination with the near-IR survey UKIDSS, with a possible VISTA survey, and with the VLT itself, the scientific rewards of large surveys will be tremendous.

KIDS, the survey presented here, will yield a uniform-quality, 5-band imaging survey of some 1700 square degrees of sky where 200,000 galaxy redshifts are available. It has been designed with four main scientific goals in mind (weak lensing by galaxy halos; search for very high-redshift QSOs; baryon oscillations on the large-scale galaxy distribution; evolution of galaxies and clusters), and then (slightly) optimised to widen its applicability further. The adopted survey strategy is 'natural' given the properties of OmegaCAM/VST and the existence of SDSS and CFHTLS.

2.1.1 Study the structure of galaxy halos via weak lensing

The dark matter structure formation is by now a well understood process that can be simulated numerically in great detail. Most observations of the large-scale structure, however, rely on galaxies as tracers. The links between dark matter halos and their luminous baryonic components are set by complicated physical processes (e.g., gas and stellar dynamics, cooling, feedback, etc.), which are as yet too complex to model in detail. It is therefore important to make detailed observations of the mass-light relation in galaxies as a benchmark for our understanding of galaxy formation. Galaxy-galaxy lensing (GGL) can, uniquely, provide these observations.

GGL is the weak lensing effect of matter associated with galaxies on image shapes of background galaxies: it measures the correlation between galaxy positions and the tidal gravitational field. The effect can only be detected statistically, since the induced distortions are only a weak perturbation on the many different intrinsic shapes galaxy images can have. It is therefore necessary to average the shapes of many background galaxies projected near many foreground galaxies before the lensing signal can be unambiguously detected and measured. The strength of a large survey such as KIDS is that it allows splitting up the signal over many different classes of galaxies, providing fine resolution in the measurement of galaxy halo properties vs. their morphology, colour, environment, inclination, etc. Compared to the very successful GGL studies with the SDSS (Sheldon et al. 2004; Seljak et al. 2004), KIDS will (i) contain many more foreground-background pairs, with much better image quality, and more favourable lensing geometry (all enhancing S/N), (ii) probe the galaxy population at higher redshift, typically 0.5, (iii) allow a cleaner weeding out of foreground galaxies via accurate 9-band photometric redshifts.

On small scales (3–30$''$), the GGL signal is dominated by the dark matter halo profile of galaxies at radii of 10–100s of kpc. On scales of several arcminutes GGL mainly probes the bias parameter and galaxy-mass correlation coefficient, and on intermediate scales, the distribution of galaxies within their parent group halos dominates. Thus, GGL can test the CDM predictions of a 'universal mass profile' for galaxy dark-matter halos, and determine the relation between the galaxy and dark matter distribution, without simplifying assumptions about the scale- and redshift dependence of the bias factor. Instead, the dependence of the bias factor on redshift, scale and galaxy properties (such as luminosity, SED, morphological type) can be studied without prior assumptions, providing crucial input for the cosmological interpretation of the observed large-scale galaxy distribution. Furthermore, the obtained dependence of the bias on galaxy properties provides highly valuable information about their evolution.

The fact that KIDS targets areas of the sky where wide-field redshift surveys have already been carried out makes it possible to correlate directly the foreground structure with the lensing distortion of background galaxies, and thus to measure the galaxy-mass correlation for galaxy groups, clusters, and even filaments.

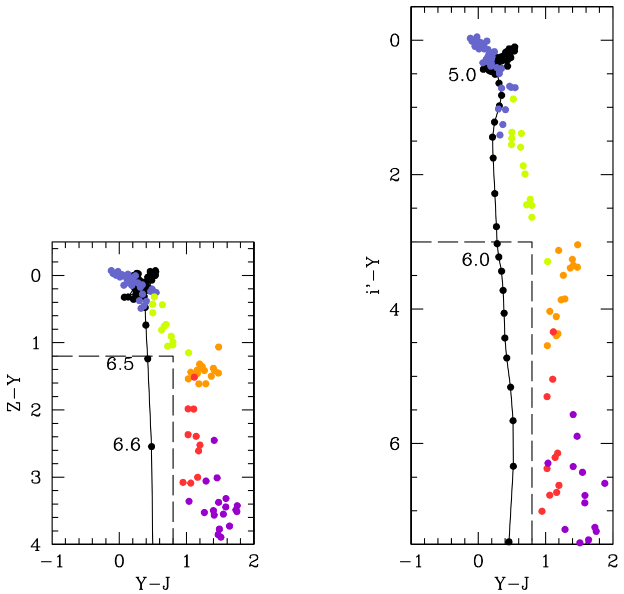

Figure 2: Selection of high-redshift QSOs with optical-infrared colours (Warren & Hewitt 2002). The dashed boxes show the selection criteria. Here the band Z refers to the VST reddest band, slightly different from SDSS z' (and more useful because it has a sharper red cutoff). Code: blue O-K stars, green M stars, orange L dwarfs, red T dwarfs, purple model hypothesised Y dwarfs, black curve quasar colours with dots at $\Delta z = 0.1$. On the left, using Z band; on the right, using i'. KIDS 10-σdetection limits will be 22.5 and 23.5, respectively.

2.1.2 Search for very high-redshift QSOs

High-redshift QSOs are currently our best probes for exploring the epoch of reionization, thought to occur somewhere in the range $z = 6$–30. Where exactly is at present not clear: the SDSS quasars suggest a redshift not far beyond 6, whereas WMAP results point towards a range 11–30. Hence the need for more high-redshift probes of the end of the reionization epoch. A better understanding of the high-redshift QSO luminosity function will also shed light on the question whether it was primarily stars or AGN that ionized the universe.

Currently the most distant known quasar, discovered with SDSS, has $z = 6.4$ (Fan et al., 2003). With KIDS we can hope to discover many more fainter quasars near this redshift, since the survey is about 2.5m deeper in z'. However the limiting redshift is still ~ 6.4 (otherwise Lyα shifts redwards of the survey bands).

By combining optical data with IR data from UKIDSS or VISTA, we can discover higher-redshift quasars with $6.4 < z < 7.2$ using either $i'YJ$ or $z'YJ$ colours, as illustrated in Fig. 2. Extrapolating the luminosity function of Fan et al. (2001) predicts 7 such QSOs in the KIDS survey. This number is limited by the depth of the UKIDSS Y and J exposures; a deeper VISTA survey (as we advocate on KIDS-S) would be expected to yield more.

An interesting (and inevitable!) by-product will be a large sample of extreme brown dwarf candidates.

2.1.3 Study the large-scale angular power spectrum and the equation of state of the dark energy

The evidence that the universe is expanding at an accelerating rate is one of the most surprising discoveries in the history of cosmology, and may well be one of the most profound. Understanding the nature of the dark energy that powers this expansion, and in particular the equation of state w, is one of the biggest problems in physics at the moment. With KIDS we can measure the rate of change of the expansion, and hence w, through mapping of the baryonic acoustic oscillations (amplitude of a few percent) in the large-scale distribution of galaxies.

The oscillations were recently measured at low redshift in the 2dF and SDSS redshift surveys (Cole et al. 2005; Eisenstein et al. 2005). With KIDS we can refine this result by incorporating many more galaxies with accurate photometric redshifts, and by extending the measurement to higher redshift and thus measure the evolution of the oscillation scale and amplitude. The sample size required to detect the power spectrum features with

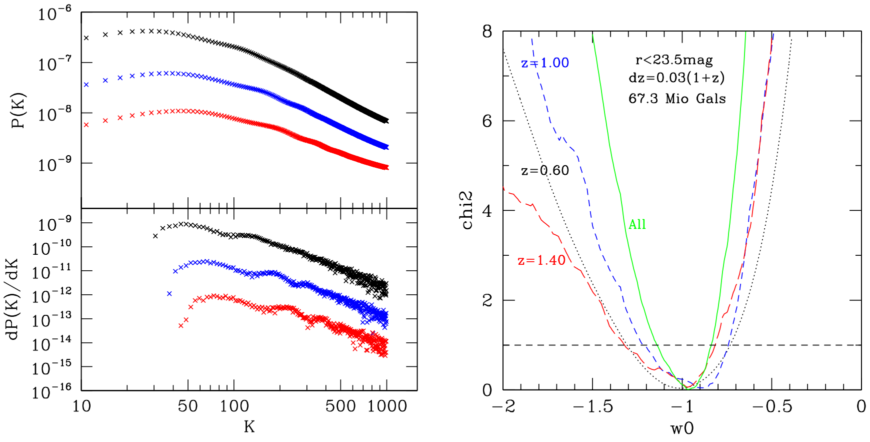

Figure 3: Simulated raw angular power spectrum derived from KIDS for galaxies in redshift slices centered at redshift 0.6, 1 and 1.4 (top to bottom, left panel; arbitrary vertical units) and accuracy of a derived estimate of the equation of state parameter w_0 (right). K is the angular wavenumber in $\deg^{-1}$. The expected error on w_0 is 14%, based on 67 million galaxies with $r' < 23.5$.

high significance (Fig. 3) dictates both the size of the survey (about 2000 square degrees) and the geometry (at least 10 degrees wide). Only on large scales and at high z is the structure growth sufficiently linear that the oscillations can be used as direct cosmological probes.

As shown by Eisenstein et al. (1998) and Seo & Eisenstein (2003), the Hubble parameter and the angular diameter distance can be measured with the baryonic acoustic oscillations imprinted in the large-scale structure of galaxies, where the physical scale of the oscillations is determined by the matter and baryon densities. Furthermore, with imaging surveys the inclusion of both the angular galaxy spectrum and bispectrum allows one to measure and marginalize over possibly complex galaxy bias mechanisms to get robust cosmological constraints (Dolney, Jain & Takada 2004).

For a proper detection of the baryonic oscillations, photometric redshifts with errors $\sigma_z = 0.03 \cdot (1+z)$ are necessary, because otherwise the incoherent projection of three-dimensional power spectra along the line-of-sight yielding the observed angular power spectra, would easily smooth out the small-amplitude baryonic oscillations. We have simulated the measurement of photometric redshifts based on $u'g'r'i'z'$ from KIDS and JHK from UKIDSS and are confident that this accuracy can be achieved (Fig. 4).

We have tested the detectability of the acoustic oscillations with particle simulations. In multi-passband, slice-like imaging surveys covering about 2000 square degrees with survey widths of at least 10 degrees and down to $r_{\rm AB}$ magnitudes of 23.5 mag (20σ), the baryonic oscillations show up very clearly in the two-dimensional power spectra. The redshift-independent part w_0 in $w(z) = w_0 + w_1 \cdot z$ based on semi-analytic models can be measured to better than 15 percent. The observed degeneracy between w_0 and w_1 cannot be broken by KIDS data alone, but by the combination with complementary observations (e.g. cosmic microwave background anisotropies from PLANCK).

The weak lensing analysis of KIDS will provide independent constraints on w, via the geometric dependence of the lensing strength on angular diameter distance to the background galaxies. Different w predict different angular diameter-redshift relations. Preliminary simulations show that the lensing analysis may yield information on w that is at least as accurate as the power spectrum analysis, and essentially independent.

2.1.4 Evolution of Galaxies and Clusters

The depth of KIDS ($r' \simeq 24$, $i' \simeq 23$ at 10-σ) will yield of order 10^8 galaxies to a median redshift of $z \simeq 0.8$, with about 20% of the sample having $1 < z < 1.5$, where the photometric redshifts will have an rms precision of around 5%. This will be 1000 times the number of galaxies at these depths with spectroscopic redshifts, allowing a definitive study to be made of aspects of galaxy evolution that relate directly to nonlinear evolution of the mass distribution:

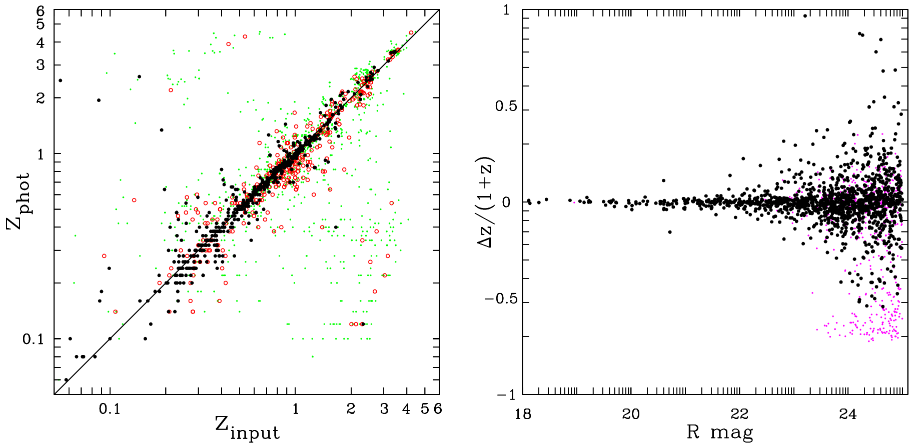

Figure 4: Accuracy of the photometric redshifts that can be derived from KIDS. Left: output photo-z vs input redshift. Heavy dots: $r' < 23.5$; open circles: $23.5 < r' < 24$; small dots $24 < r' < 25$. Right: photometric redshift error for galaxies at $z < 1.5$ (heavy dots) and $z < 6$ (small dots). Simulations following the techniques of Gabasch et al. (2004).

(1) Evolution of the luminosity function as a function of galaxy type, measuring in particular the assembly of early-type stellar systems. This would be the first chance to follow in detail the merging history of CDM sub-halos (KIDS reaches several magnitudes further down the LF than SDSS, for example, and would be a perfect basis for further spectroscopic surveys with 2dF's new AAOMEGA spectrograph, or FLAMES).

(2) Detection of clusters of galaxies. KIDS should provide in excess of 10^4 clusters, of which some 5% are expected to lie at redshift beyond 1. The cluster mass function is exponentially sensitive to the cosmological model, and this could be a very powerful sample.

Both these topics concern the standard assumption that the universe is fragmented into a distribution of CDM halos whose mass function grows hierarchically. One needs to distinguish clearly between freshly-virialized systems such as clusters of galaxies and the subhalos that represent internal structure in such systems. The subhalo mass function is expected to be virtually universal when scaled to the mass of the parent halo (Gao et al. 2004), so characteristic masses of both parent and subhalos should grow with time. Although this theoretical expectation is well established, unambiguous evidence that we have observed the process has been hard to find. For clusters, the main means of generating samples has been through X-ray selection. Interpretation of the data is limited by understanding of the relations between X-ray temperature or luminosity and mass, and how these evolve (e.g. Mullis et al. 2004). For galaxies, it is with some effort possible to estimate stellar masses from photometry, so that the evolution of the stellar mass function can be followed. Of course, the total mass in stars grows with time, so allowance must be made for star-forming activity in the photometric modelling. Nevertheless, it has been claimed that the stellar mass in early-type galaxies grows beyond what can be accounted for in this way, which would be the first solid evidence for the population as a whole that such galaxies do represent merger remnants (Bell et al. 2004).

These studies can be taken much further and treated in a unified way with the KIDS sample. Cluster-finding will be feasible directly using the multicolour data, as has been demonstrated using the SDSS and deeper data (Bahcall et al. 2003; Gladders et al. 2003; Botzler et al. 2004). The red sequence of rich galaxy clusters can be detected readily out to $z = 1.2$–1.4, and we expect to find about 13 clusters per square degrees with masses above $10^{14} M_\odot$ of which two lie at redshifts 1–1.5. The total sample of high-redshift clusters will thus run into the many hundreds, providing an excellent tracer of the large-scale structure, and laboratories for studying galaxy formation in a high-density environment. In addition, KIDS will be well placed to follow up large SZ surveys, particularly from APEX.

Using these samples to measure the cosmological model requires above all a calibration of the relation between mass and empirical richness. Significant progress has been made in this regards for nearby clusters using SDSS data (Popesso et al. 2004ab). Internal to KIDS, lensing measurements will probe the cluster mass distributions, which is a crucial advantage of the unified strategy of high image quality and uniform multi-band photometry in a single survey.

More nearby, the fact that KIDS-S overlaps two nearby superclusters (Pisces-Cetus and Fornax-Eridanus) can be used to study the relation between galaxy properties (particularly star formation rate) and environment, all the way from cluster cores to the poorly-studied cluster infall regions, and to the filaments that connect clusters in the cosmic web, thus probing the relation between the formation of large-scale structure and of galaxies and clusters.

2.1.5 The Galactic White Dwarf Population

The Galactic white dwarf (WD) population is one of the fossils of the star formation history. With KIDS we can (i) define a large sample of disk white dwarfs, and study their space density and kinematics; (ii) search for halo white dwarfs, relics of the stellar halo formation and a potential contributor to galactic dark matter, as suggested by microlensing surveys towards the Magellanic Clouds; and (iii) search for ultra-cool (< 4000K) white dwarfs, which trace the oldest star formation epoch of the disk.

WDs can be identified from their colours. The limiting magnitudes of KIDS will allow us to detect all H (He) WDs within 500 (350) pc with temperature above 4000K. Given the local space density of about $0.005/\mathrm{pc}^3$, this translates to 10 to 50 disk WDs per square degree, and perhaps 7 halo WDs per square degree if this population makes up 5% of the local dark halo. KIDS should see about three times as many white dwarfs as SDSS is expected to find, owing to the greater depth of the survey, and is sufficiently deep to allow the scale height of the population to be measured.

Ultracool white dwarfs are expected to be bluer than their warmer counterparts, due to H_2 collision-induced absorption bands in their atmospheres (Hansen 1998), and present unique colours that stand out from the galaxy population. With its 2 magnitudes greater depth, KIDS is expected to increase the sample of 7 objects identified in SDSS thus far (Gates et al. 2004) significantly, and to find some of the oldest objects in the Galaxy.

Distinguishing between disk and halo WD populations will be possible by determining proper motions from a second-epoch pass over the survey area in the g' band.

2.1.6 The morphology of AGN host galaxies (Radovich)

There is growing evidence that most galaxies host nuclear black holes (BHs). Not all of these galaxies however show evidence for an active galactic nucleus (AGN). The AGN trigger mechanism is still unclear.

From the analysis of SDSS data, Kauffmann et al. (2003) found that AGNs with $0.02 < z < 0.3$ reside, independently from the luminosity, in massive galaxies whose properties are typical of early-type galaxies. The host galaxies of low-luminosity AGNs have stellar populations similar to normal early types, while hosts of high-luminosity AGNs have younger stellar ages, possibly related to recent star-forming events. A similar result has been found by Sanchez et al. (2004) for AGNs at $0.5 < z < 1.1$ in the GEMS survey: a large fraction of them reside in early-type hosts, but with bluer colors than normal galaxies. These results seem to confirm the connection between star formation and AGN, probably by interaction or merging of close companion galaxies.

With KIDS we can probe this connection further, by studying the morphology of spectroscopically-selected AGN from 2DF and SDSS. It will reveal, with overwhelming statistics, the degree to which AGN hosts preferentially show signs of interactions (plumes, tails) and recent star formation (knots, arms, disks, rings).

3 Are there ongoing or planned similar surveys? How will the proposed survey differ from those?

In terms of area and depth, KIDS falls in between two large on-going imaging surveys: Sloan and CFHTLS-Wide. The surveys are compared in Table 1.

Compared to SDSS, KIDS is about 2.5 magnitudes deeper, and image quality will be about a factor two better (seeing $0.7''$ as compared to $1.5''$). A comparison of the expected image qualities is shown in Fig 5. KIDS makes it possible to do high-accuracy weak shear measurements, and to measure detailed morphological information of the sources. As SDSS, KIDS will have spectra for over 100 galaxies per square degree, on average (from the 2dF and SDSS redshift surveys). The Northern patch of KIDS overlaps with SDSS, allowing us to profit from the photometric calibration.

Compared to CFHTLS-Wide, KIDS covers 10 times as much area, about one magnitude less deeply (the difference is greater in u'). Image quality should be slightly better for KIDS ($0.7''$) than for CFHTLS ($0.9''$), if VST/OmegaCAM performs as expected. We have planned a 20 square-degree overlap with one of the CFHTLS-Wide patches in order to be able to cross-check the shape measurements.

A further advantage is the IR coverage of the field that KIDS will have, from UKIDSS in the North and potentially from VISTA in the South.

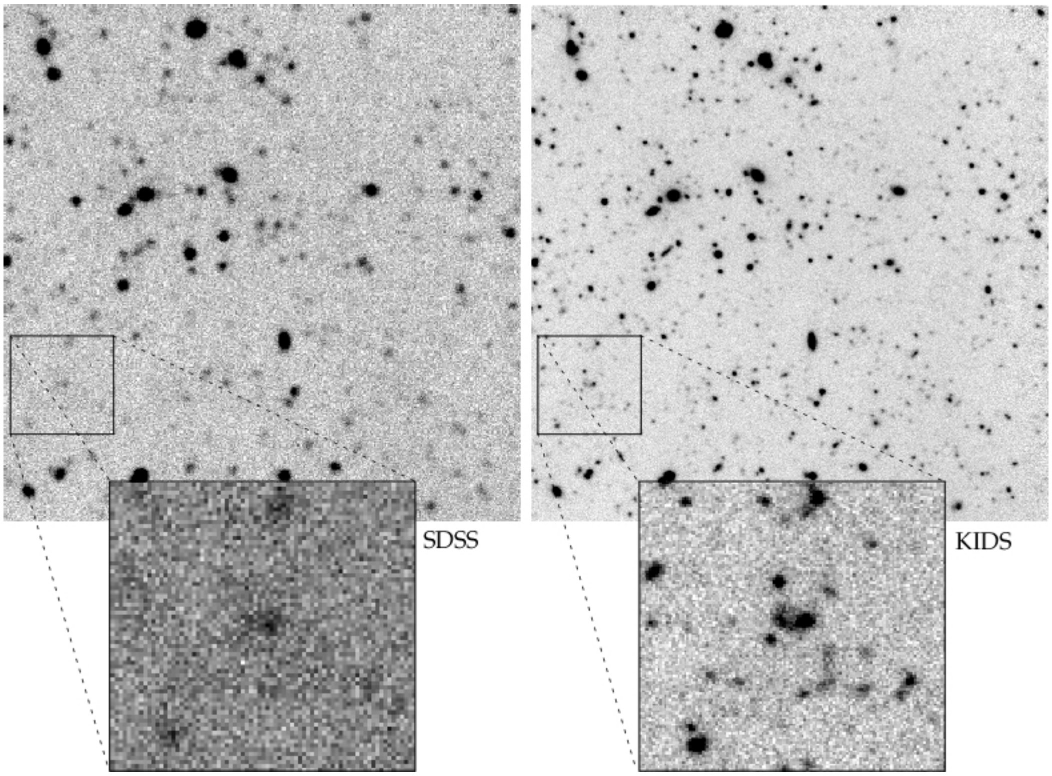

Figure 5: Comparison between the expected image quality of SDSS and KIDS (r' band), obtained by degrading a $2.3' \times 2.3'$ portion of the FORS deep field to the seeing, pixel scale and noise levels expected in either survey. The insets compare two $28'' \times 28''$ sections.

4 Observing strategy:

We have optimized the distribution of exposure time over the five SDSS filters, and matched it to the expected distributions of moon phase and seeing. The total exposure time per field is 2 hrs (+ 30 minutes overhead). The total survey would require 425 nights to complete, plus 20 nights for calibration.

The survey area has been chosen to ensure observability year-round, and to overlap with complementary surveys to enhance its value.

We aim to produce as homogeneous a dataset as possible; this includes trying to ensure that the image quality in any given band is quite uniform over the survey. For example, to maximize the usefulness for weak lensing, our primary science goal, we will take r' data in the best (dark) seeing conditions; bright time will be devoted entirely to z' observations. The worst 20% of seeing ($> 1.1''$) is not used for the survey itself, but a part of it will be employed to establish a quick photometric calibration of the survey area.

Sensitivity calculations are predictions based on our knowledge of the optical components of the system, and will need to be revised after commissioning.

All data will be dithered to ensure near-homogeneous sky coverage.

Table 1: Integration times (excl. overheads) and predicted sensitivities

	KIDS				**Other surveys**	
	Exposure Time	median seeing	$5\text{-}\sigma$, $2''$ aper.mag.lim.		SDSS (AB)	CFHTLS (AB)
Filter	seconds	arcsec	AB	Vega	$5\text{-}\sigma$ PSF	$2''$ $5\text{-}\sigma$
u'	900	1.0	24.8	24.0	21.8	26.1
g'	900	0.75	25.4	25.4	23.0	26.3
r'	1800	0.60	25.2	25.1	22.6	25.6
i'	1080	0.7 (broad)	24.2	23.9	22.0	25.2
z'	2520	0.7 (broad)	23.2	22.7	20.6	24.5
TOTAL	7200					
					UKIDSS(AB)[1]	VISTA(AB)[2]
Y					20.5	22.7
J					20.3	22.5
H					19.7	21.8
Ks					19.7	21.4

[1] UKIDSS sensitivity estimates at time of writing. Awaiting commissioning data.

[2] VISTA sensitivities based on 10 minutes integration times per band.

Table 2: Which filter to use in which sky conditions

	Distribution of time over moon and seeing			
	Seeing $< 0.7''$	Seeing $0.7 - 0.85''$	Seeing $0.85 - 1.1''$	Seeing $> 1.1''$
	(40%)	(20%)	(20%)	(20%)
dark (50%)	r'	g'	u'	unused/calibration
grey (15%)	i'	i'	i'	unused/calibration
bright (35%)	z'	z'	z'	unused/calibration

5 Estimated observing time:

Total observing time per field is 2 hrs, plus overheads, making 4 fields per night. All phases of the moon, and the best 80% of the seeing distribution (better than 1.1") can be used. Transparency should be THN or better, provided the survey area can be photometrically calibrated with a series of quick 5-band exposures over the field. The N patch, which overlaps with SDSS, does not require separate calibration.

The total amount of time required to cover 1700 square degrees is **440 nights**, spread equally over even and odd semesters. The survey could be completed in 3–4 years. The time estimate includes 15 nights needed for a second pass over the survey area in g' at the end of the survey, for proper motion and variability measurements. Photometric calibration of the Southern patch requires a further 20 nights (PHO, any moon phase, poor seeing OK.)

5.1 Time justification:

One of the guiding principles in the design of KIDS was to pick exposure times that are 'natural' for the VST/OmegaCAM, given overheads per exposure, and the requirement to dither the observations in order to cope with cosmetic defects, cosmic rays and gaps in the CCD mosaic. Furthermore we have tried to match the exposure times to the range of conditions that prevail on Paranal.

The distribution of exposure times over the different filters turns out to be optimal for the determination of photometric redshifts as well: the combined $u'g'r'i'z'YJHK$ photometry data will yield photometric redshifts accurate to $\Delta z/(1+z) = 0.05$ for typical $r' = 24$ galaxies, rising to 10% accuracy at $r' = 25$ (numbers quoted are the halfwidth of the central 68% of the error distribution, as derived from extensive simulations based on the FORS Deep Field, see fig. 4). Some representative SED's are shown in fig. 6.

The best seeing time will be devoted to r'. The median redshift of the galaxies in KIDS will be 0.8, providing an excellent sample of background galaxies for lensing studies near $z = 0.5$.

Photometric calibration of the survey will be done via a series of short exposures in the five bands over the field. These can be done in bright time and relatively poor seeing, and need to be interspersed with observations of photometric standards from the SDSS project. The KIDS-N patch overlaps with the SDSS survey itself and does not require this calibration, but the KIDS-S patch (720 square degrees) does. A total exposure time of five minutes in the five bands, plus overheads, means five calibration fields can be done per hour. Regular standard star observations (beyond the standard calibration plan) will require another hour per night. Thus 20 nights (PHO, bright, seeing $< 2''$), are required for this calibration. The advantage is that it allows KIDS observations in THN conditions as well as PHO.

The overall size of the survey was initially set by the area covered in the 2dF redshift survey, but it is also a good match to the science goals. The determination of the angular power spectrum, in particular, requires large contiguous areas so that the clustering on 10-degree scales can be measured well, and a significant clipping of the survey area would render this part of the science goals infeasible. The same is true of the search for high-redshift QSOs: these objects are so rare that the depth and area are both required.

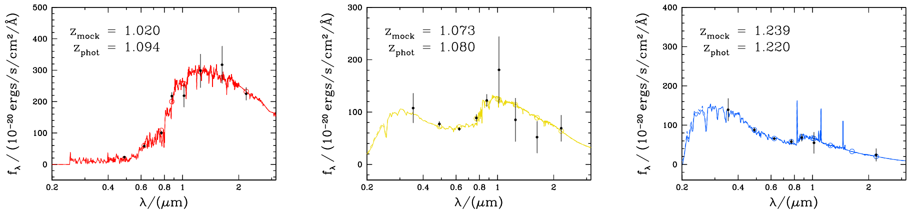

Figure 6: SED's for (left to right) typical elliptical, spiral and starburst galaxies of $r' \simeq 24$ around reshift 1, with simulated KIDS and UKIDSS photometric errors. The input redshift and derived photo-z are shown for each case.

6 Data management plan:

6.1 Team members:

The workload will be spread over a number of participating nodes. This is possible in Astro-WISE, which federates the database in such a way that at all nodes, all work on the KIDS survey taking place at all the nodes is visible and accessible.

The data reduction will be shared by the following six nodes:

Leiden	PI: Kuijken
Total FTE commitment:	2
relevant experience at node:	OmegaCAM, Astro-WISE development; weak lensing
tasks:	coordination; data reduction+QC; astrometry; s/w devel
scientific focus:	weak lensing; galactic structure; faint stellar populations

Groningen	Co-PI: Valentijn
Total FTE commitment:	2.5
relevant experience at node:	OmegaCAM, Astro-WISE definition & development; stellar populations
tasks:	calibration; Astro-WISE support; data reduction+QC
scientific focus:	stellar populations, galaxy evolution

Munich MPE/USM	Co-PI: Bender
Total FTE commitment:	3.5
relevant experience at node:	OmegaCAM, Astro-WISE development; FORS Deep Field
tasks:	data reduction+QC; project management; photo-z's
scientific focus:	galaxy-galaxy lensing, large-scale structure, high-z QSOs, galaxy & AGN evolution

Bonn/Bochum	Co-I: Schneider
Total FTE commitment:	3
relevant experience at node:	WFI data reduction and pipeline development (GaBoDS); weak lensing
tasks:	data reduction+QC
scientific focus:	weak lensing, LSB galaxies, halo stars

INAF-Capodimonte	Co-I: Capaccioli
Total FTE commitment:	2
relevant experience at node:	VST/OmegaCAM, Astro-WISE development; Capodimonte Deep Field (WFI)
tasks:	data reduction+QC
scientific focus:	AGN host morphologies, white dwarfs, weak lensing,

Paris (IAP)	Co-I: Mellier
Total FTE commitment:	2
relevant experience at node:	CFHTLS, CFH12K surveys; Terapix, Astro-WISE development
tasks:	data reduction+QC; software development
scientific focus:	weak lensing, cosmic shear

In addition, the following three nodes in the UK will participate in KIDS by integrating the important near-IR part of the survey:

Cambridge	Co-I: Sutherland
Total FTE commitment:	–
relevant experience at node:	VISTA development; 2dF and APM surveys
tasks:	Provide VISTA survey on KIDS-S
scientific focus:	large-scale structure

London (Imperial)	Co-I: Warren
Total FTE commitment:	–
relevant experience at node:	UKIDSS definition and development; APM surveys
tasks:	Liaison with UKIDSS
scientific focus:	QSO surveys

Edinburgh	Co-I: Peacock
Total FTE commitment:	2
relevant experience at node:	COSMOS survey, 2dF
tasks:	provide integrated optical-IR archive for KIDS/UKIDSS/VISTA
scientific focus:	lensing (2-D and 3-D mass mapping; w), group and cluster properties

6.2 Detailed responsibilities of the team:

The KIDS consortium will be structured around the following management plan. Responsible to ESO, the project PI (K.K.) will be advised by a project board consisting of all the co-PI's, who supervise and coordinate their local resources, and by a science team whose membership may even be external to the KIDS consortium. There will be overlap between these two bodies. Responsible to the PI, the project manager will oversee a number of teams with dedicated survey tasks. Each of these teams, from OB creation to final data quality control, will be assigned a leader who will report to the project manager and the project board. A unique strength of the Astro-WISE system is its use of a federated data base in all of its processing stages. This means that data entered and processed at any node can be readily shared with any other node.

A schematic of this management structure is shown in Fig. 7.

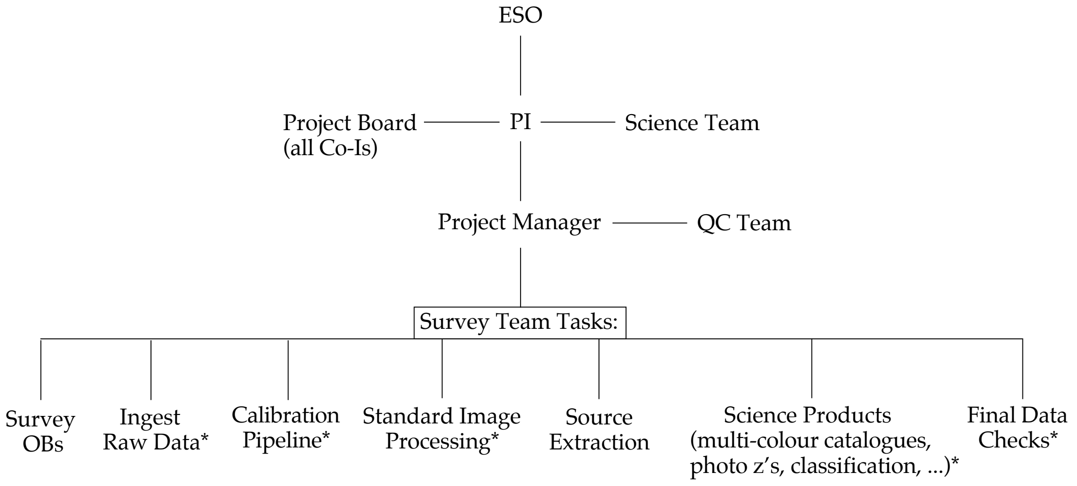

Figure 7: Management structure of KIDS. All survey team tasks marked with an asterisk contain implicit quality control checks intrinsic to the Astro-WISE system.

6.3 Data reduction plan:

The data reduction will be done using the Astro-WISE pipeline and database (for a detailed description of the system see `http://www.Astro-WISE.org/docs/Manual.pdf`). Each site associated with Astro-WISE has a multi-CPU cluster with large RAID array storage dedicated to processing OmegaCAM data. Although all data processing will be solely done using the Astro-WISE system, independent checks of reduction veracity will be done during the initial stages of the survey using both the Bonn and Terapix pipelines.

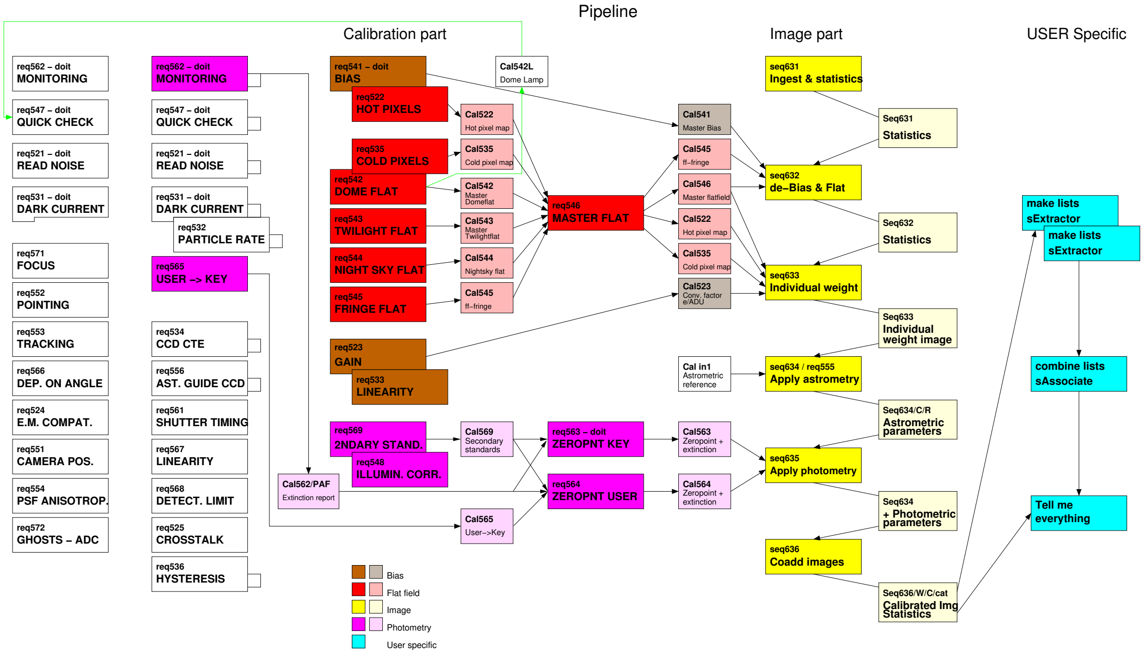

Figure 8: The complete Astro-WISE data model including quality control verifications and science pipelines.

The data will be distributed in sections to each of the partners, with significant overlaps in survey area. This redundancy is a good error checking mechanism and will ensure that all nodes work to homogeneous standards within the Astro-WISE system. As we can expect an observing rate of about two fields in five filters per night, each node will process the equivalent of about 2 square degrees of five-band data per week.

Schematically, we have divided the these processing workflow in the following way:

1. Ingestion of received raw data into Astro-WISE data base (Quality Control):
    - presence of calibration data
    - background levels
    - sensitivity
    - pointing
    - flaws (satellite tracks, aircraft, stellar spikes . . .)
2. Generation of calibration files
    - quality control (checks with previously generated calibration files for trend analysis).
3. Pipeline reduction and calibration of science images (standard processing)
    - bias subtraction, flat-fielding, astrometric and photometric solutions, image re-gridding and co-addition

- quality control:
    - PSF of stacked images compared with individual exposures
    - tests of astrometric accuracy (locally and globally)
    - tests of photometric accuracy (eg. cross-check with SDSS)

4. Visual inspection and masking
5. Generation of single-band SExtractor catalogues
    - quality control via depth determination (eg. number counts, colour-colour turn-over)
6. Association (combination) of five band source catalogues
7. Multi-colour catalogues with aperture-matched photometry
    - computation of preliminary photometric redshifts
8. Final quality control on multi-colour images/catalogues
    - colour-colour diagrams of stars (field effects)
    - distribution of preliminary photometric redshifts
9. Maintenance of survey status, progress, and data delivery
    - feedback to ESO and administration of observing plan
    - confirmation of quality control and instrument health
    - repeat observations for fields that do not meet required depth or quality

6.4 Expected data products:

Data processed with the Astro-WISE pipeline will be delivered to ESO for public dissemination in a progressive manner. This means that once all of the ugriz data has been obtained (to the required quality levels and magnitude limits) for any KIDS pointing, it will be delivered within one year of the last observation in that field. The data delivered will be divided into two categories:

Core Deliverables (within one year)

- Astrometrically and photometrically calibrated, co-added, re-gridded images in five bands, along with their respective weight maps.
- Source catalogues based on individual bands as derived with SExtractor, and compatible with SDSS and UKIDSS catalogue parameters (eg. Petrosian magnitudes).
- Associated source catalogues linking the parameters of individual objects across the five observed bands. The precise format of the integrated catalogues will be discussed with ESO in order to be compatible with its archive, and that of the general VO paradigm. It is also our goal to integrate our images and associated source lists with UKIDSS data in the Edinburgh data base archive.

Advanced Science Products (later than one year, TBD with ESO)

- PSF-matched images among the five observed bands.
- Matched aperture photometry across the nine KIDS/UKIDSS/VISTA bands.
- Associated source catalogues with final photometric redshift determinations.

6.5 General schedule of the project:

This survey can be completed in 4 years, with more-or-less continuous data delivery lagging a year behind the observations.

Because we will be involved in commissioning activities, and given the long development track we have already been through with Astro-WISE, we believe we will be ready for a ‘hot start’ as soon as the VST is released for surveys.

7 Envisaged follow-up:

The VLT follow-up spectroscopy of the KIDS survey has two main aims: (i) to calibrate and validate the data-products delivered by the survey (i.e. the photometric redshifts), and (ii) to identify the very rare objects (QSOs, high-redshift galaxies, high redshift clusters, white and brown dwarfs) that are a prime motivation for the survey.

In addition, we strongly suggest ESO consider a coordinated **120-night VISTA survey** on the 720 square degree KIDS-S patch, reaching to 22.7, 22.5, 21.8, 21.4. This would make a unique combined survey, on a part of the sky that is optimally accessible to the VLT. There is also a case for such a survey on KIDS-N, extending UKIDSS by two magnitudes.

The programme described here is the equivalent of 2 Large Programs, or 32 VLT nights over 2 years, starting from the second year of operations of KIDS. It is hard to do justice to it in one page! Briefly, the aims are as follows.

- **photo-z's:** calibrate ≈ 6500 photometric redshifts with VIMOS spectroscopy down to $I_{\rm VEGA} = 24$ in 16 fields chosen to cover a range of foreground absorption (the main uncertainty in careful photo-z determinations). Experience with the FORS deep field shows that such a detailed comparison is essential if several-percent accuracy is to be achieved (Gabasch et al. 2004, A&A 421, 41).
- **high-z QSOs:** confirm ≈ 7 QSOs at $6 < z < 7$ with $J > 19.5$, drawn from KIDS/UKIDSS colour-selected candidates. Allowing for a factor 5 contamination, we need 2 nights of FORS2 time (35×30 minutes integration) to confirm the objects. The masks will be filled with unusually red galaxies to test the photometric redshifts to the red end and study EROs (extremely red objects) of all kinds. A further 3 nights of VLT optical (FORS2 or UVES) and near-infrared (ISAAC) spectroscopy are needed to follow-up the confirmed QSOs with high signal-to-noise spectroscopy, with 4 hours exposure each.
- **the highest-luminosity galaxies:** confirm the ≈ 5 expected high-luminosity galaxies with $I_{\rm VEGA} < 23.5$ and $z > 5$ spectroscopically (6h FORS2 each), and measure accurate metallicities for the expected two galaxies with $R_{\rm VEGA} < 21$ and $2 < z < 3$ (1h FORS2 for confirmation, plus 8h UVES each, yielding S/N~ 10 at resolution 40,000). The FORS2 masks will be filled with EROs as above. (Expected numbers are based on extrapolation of the FORS deep field LF.)
- **galaxy clusters:** confirm ≈ 8 clusters of galaxies with $z > 1$. Based on structure growth calculations calibrated to Xray cluster counts, KIDS will find ~ 2 massive ($> 10^{14} M_\odot$) clusters per square degree beyond redshift 1, of which ca. 10% should lie beyond $z = 1.3$. We propose to image the 30 most interesting objects with FORS2 in r' and z' (1.5n) to study the red sequence further, and to measure redshifts with FORS1 for the 8 best clusters (3.5n), aiming for 10 redshifts per cluster.
- **ultra-cool white dwarfs:** we expect to find some 80 such objects with $19 < g < 22.5$, scaling from the Gates et al. (2004) result. Spectroscopy of half of them, 1h with FORS1 each, will take 5 nights. The remaining MOS slits will be used to target very blue galaxies in order to test photo-z's and possibly measure metallicities of HII galaxies.
- **ultra-cool brown dwarfs:** As such candidate objects are discovered, we will attempt to trace the brown dwarf sequence beyond T9 down into the hypothesized Y sequence at T<400K. We anticipate spectroscopy of 50 very cool candidates for confirmation (25 hrs total), and detailed spectroscopy and photometry of perhaps 10 confirmed Y dwarfs (further 20 hours).
- **Galaxies in nearby superclusters** VIMOS spectroscopic follow-up of galaxies in "active transition regions" in cluster outskirts to study galaxies in the midst of transforming due to their infall into the high-density cluster regions - stellar population ages and metallicities as well as star formation rates. (2 nights)

8 Other remarks, if any:

The proposing team consists largely of the institutes and people who have invested much in the design and construction of OmegaCAM, including a system to handle the scientific exploitation of the data. We have considerable experience with data from other wide-field imagers (WFI, CFH12K, Megacam), and a track record of publications. We believe we are well-prepared to provide ESO with a survey such as KIDS, and that the combination of instrumental expertise, data reduction experience, and our scientific commitment to the different goals of the project, bodes well for a successful outcome.

While designing KIDS we have had numerous approaches from potential collaborators, which demonstrates to us that there is genuine interest in the community for a survey such as this. We hope to channel this interest into a number of spin-off projects that will provide useful products to the community:

- a combined archive linking spectroscopy and imaging in the KIDS patches (2dF, SDSS in particular)
- a deeper 2dF/AAOMEGA survey with which to probe the galaxy luminosity function to fainter levels, and link variations to the environment
- KIDS/SDSS cross-identifications for variability and proper motion information
- KIDS would provide an excellent complement to an APEX survey for Sunyaev-Zeldovich clusters.

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