1. Description of the proposed programme (max. 6 pages)

1.1 Scientific Goals:

Approximately half the energy emitted since the big bang by all the objects in the universe has been absorbed by dust and then reradiated between 60 and 500 μm, a wavelength range in which the universe is still largely unexplored[1,2]. At these wavelengths, we know remarkably little even about the nearby universe. While the Sloan Digital Sky Survey (SDSS) and the 2dF Galaxy Redshift Survey (2dFGRS) have revolutionized our knowledge of the optical properties of the local universe[3−8] (Fig. 1), most of our information about the $\simeq$50% of the star formation that is hidden by dust[2,9] is still based on the IRAS survey carried out in the 1980s. Although IRAS detected the dust in thousands of galaxies, it only detected those with large amounts of dust, and even then was only sensitive to the $\simeq$10% (by mass) of dust warm enough to radiate in the far-IR[10].

The ideal way to carry out an unbiased census of dust in the nearby universe would be to conduct a 'blind' submm survey, but until the advent of Herschel it has not been possible to survey enough area of sky to sample a representative volume of the local universe. The only estimates of the local submm luminosity function, which is crucial for modelling the properties of the high-z dusty universe, have therefore come from a very small ($\sim$55) sample of galaxies detected in the ISO 170 μm FIRBACK survey[11] and from targeted submm observations of $\sim$200 galaxies selected in other wavebands[12,13]. We currently do not know much more about dust in the local universe than a few crude and inconsistent estimates (Fig. 1) of this very basic statistical function together with maps of the dust in a few hundred galaxies, virtually all already known from IRAS to contain large amounts of dust. Because of this problem of mapping a large enough area of sky, we arguably know more, through the deep submm/mm[14,15] and Spitzer surveys[16], about dust in the early universe than in the universe today.

We propose to use Herschel to survey 1000 square degrees in five photometric bands, the first survey of such a large area of sky in this crucial wavelength range. The Herschel 1000-Degree Survey (H1K) will cover 15 times the area of the GT extragalactic survey, HERMES, and >100 times the area of earlier submm surveys. Our flagship science project is the submm equivalent of the Sloan photometric survey, a census of the dust and dust-obscured star formation in $\sim 10^5$ galaxies in the nearby ($z < 0.3$) universe. However, we have many other science goals, all of which are only possible with a survey of such a large area of sky. We will use the H1K to determine the nature of $\simeq$1000 highly-confused Planck sources, and by determining the relative contributions of dusty galaxies and the SZ effect in Planck sources, we will make it possible to measure the number-density and bulk flows of clusters in the high-z universe—two fundamental tests of the cosmological paradigm. We will also use the H1K in key projects to investigate the evolution of the mass profiles of galaxies, the relation between the formation of stars and black holes in quasars, and the large-scale structure of the universe on 100-1000 Mpc scales. Finally, we will carry out the first census of prestellar cores and protostars at high galactic latitudes. The survey will also be of unprecedented legacy value. Our fields contain $> 10^5$ redshifts and are the best-studied fields of this size. They will be the targets of surveys being carried out with VST, VISTA, UKIRT and the South Pole Telescope and will be the natural targets of many other future surveys, including ones carried out with LOFAR and the two SKA precursor telescopes in the south. As this is the only AO for Herschel key projects, this may well be the last opportunity to obtain a substantial amount of complementary far-IR/submm data for these surveys until the launch of future space missions. We propose to carry out parallel surveys with SPIRE in three bands and PACS in two bands. The programme will require 1120.2 hours of observing time and reach a 5σ sensitivity level of 67, 94, 45, 62 and 53 mJy at 100, 160, 250, 350 and 500 μm, respectively, which is >2 times the expected confusion level in all bands.

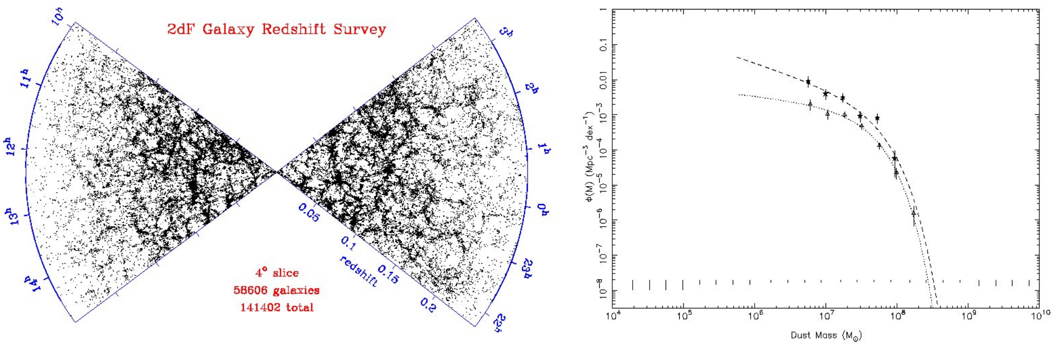

Fig. 1: Left panel—*Map made by the 2dFGRS team of the galaxies in the southern H1K field.* **Right panel**—*Recent estimates of the dust-mass function in the local universe from targeted observations of an IRAS sample (triangles)*[12] *and from an optical sample (stars)*[13]*. The error bars at the bottom of the figure show the accuracy and range of the dust-mass function that will be measured by the H1K.*

1.2 Exploitation Plan:

Programme A: The Local Universe: The H1K will be the first submm survey large enough to detect a significant number of galaxies in the nearby universe, between 40,000 and 140,000 individual galaxies out to z $\sim$ 0.3 (see §2). By carrying out H1K in the fields surveyed in the SDSS and the 2dFGRS, we estimate that $\simeq$ 50% will already have redshifts, including $\simeq$95% of those at $z < 0.1$ (§2). The Akari all-sky survey will detect large numbers of galaxies in the local universe but, with a sensitivity ∼10 times poorer than the H1K, will not be well-matched to the existing redshift surveys, and like IRAS it will miss the cold ($T < 20K$) dust. Some representative projects for which we will use H1K data are:

- **Luminosity functions and dust along the Hubble sequence** We will make the first accurate estimate of the local submm luminosity and dust-mass functions down to dust masses of $\sim 10^{4.5}$ $M_\odot$ (Fig. 1). One crucial difference between the submm and optical LF is that the most numerous (dwarfs) and most luminous (ellipticals) objects from the optical LF will be represented in a very different way in the submm LF, as dwarfs and ellipticals contain very little dust. Reproducing the optical LF was a key test for semi-analytic models of galaxy formation and evolution[17], a test only passed by including feedback in the models. The H1K luminosity function will provide a similar test for semi-analytic models that include the effect of dust[18]. We will also use the 2dFGRS/SDSS database to investigate how the dust content of galaxies depends on Hubble type, metallicity, and past star-formation history. In the very local ($z < 0.01$) universe, the H1K will detect dwarfs and ellipticals, populations in which at present we know very little about the dust and ISM. Our 'blind' survey of these objects will complement the targeted observations being carried out in GT.

- **Revealing the stolen starlight** Optical astronomers have been trying for half a century to quantify the effects of dust on galaxies with limited success[19,20]. The implications for extragalactic astronomy are potentially large, with a recent study[21] concluding that the optical LF is significantly altered by dust extinction and that even bulges suffer as much as 2 mag of extinction at certain inclinations. A powerful (and the simplest) way to measure these effects is to use the energy-balance technique of comparing the total dust emission to the total unobscured starlight. In this case it is critical to include the cold dust traced by SPIRE since many 'normal' galaxies would have their bolometric dust luminosity severely underestimated if IRAS fluxes alone were used. The H1K will give us these complete dust SEDs and, with modern datasets (GALEX, 2dFGRS/SDSS, 2MASS/UKIDSS), we will for the first time have complete optical to near-IR coverage of the unobscured starlight for at least 10^4 galaxies.

- **Environmental dependence of star formation and downsizing** Using the SDSS and 2dFGRS 3D maps (Fig. 1), we will investigate how the dust-obscured star formation depends on the local and large-scale environment. This complements previous optical studies[22,23], because our observations will be much more sensitive to starbursts, which may well have a different environmental dependence from quiescent star formation. Because there are ≃120 clusters of Abell richness 1 or greater, including the Coma cluster, in our survey region, we will be able to extend our investigation of dust-obscured star formation to extremely dense regions. This will provide an excellent zero redshift benchmark for studies of clusters at higher redshifts. We can also study how star formation may be 'quenched' in denser environments—a key ingredient in downsizing models of galaxy formation[6,24]—and whether the low-z part of the 'old, red and dead' population really are old and dead and not just red due to dusty star formation.

- **Evolution of dust and obscured star formation** We will investigate how the dust content of the universe and dust-obscured star formation has changed during the last three billion years. This will finally follow up an important discovery from IRAS that there is strong evolution in the luminosity function at a suprisingly low redshift[25], a phenomenon which also may have been seen in the SDSS[26]. A natural prediction of down-sizing is that the evolution should be associated with lower luminosity systems than at high redshift. We will test this prediction, and also use the 2dFGRS/SDSS 3D maps to investigate the environmental dependence of the evolution.

The H1K contains far more information than the $\sim 10^5$ detections of individual galaxies. By coadding or 'stacking' the observations we can measure the average flux of a population of sources[27,28] and, as the noise from extragalactic confusion integrates down as $\sim 1/\sqrt{N}$, we can derive these average properties at levels well below the confusion limit ($\sim 1/2$ the H1K flux limit). We will use stacking to measure the dust content and dust-obscured star formation in classes of galaxy that are hard to detect individually, including dwarf irregulars and ellipticals, and also use this technique to extend to higher redshift our investigation of galaxy types which can be detected but only at low redshifts, such as cluster ellipticals.

Another possibility is that of detecting intracluster dust. The intracluster medium consists largely of material lost by galaxies and therefore it should contain some dust, since the lifetime of dust grains in the IGM is $\sim 10^8$ yr. A few controversial detections of dust have been made in the Coma cluster from ISO observations of dust emission[29] and in the M81 group from the colours of background galaxies[30], but other studies have failed to detect dust at the expected level, leading to claims that the IGM is a factor 100 deficient in dust compared to the galactic ISM[31]. These techniques are ultimately limited by the uncertain correction for the effect of foreground cirrus. By removing the individual sources from a SPIRE map of a cluster and then smoothing the residual emission, we will be able to reach a sensitivity sufficient to detect dust like that claimed for Coma[29]. This will not solve the problem of foreground galactic dust, but by comparing the stacked signal over all the clusters with the average signal over control fields, we should be able to answer the question of whether clusters are truly deficient in dust.

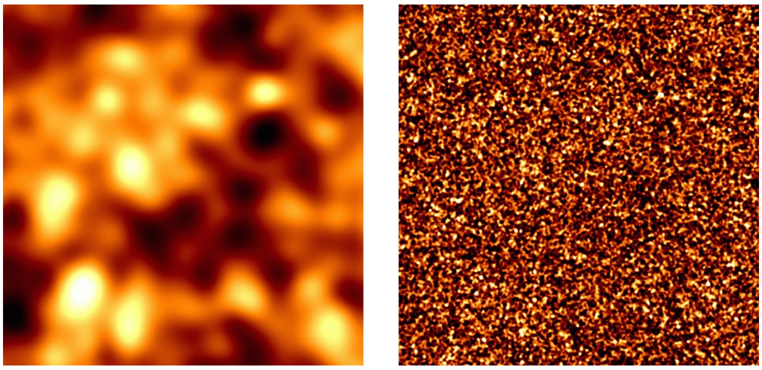

Fig. 2: *Simulation of a* 1×1 *deg*^{2} *field as seen by Planck (left) and the H1K (right)*[38].

B: The H1K-Planck Collaboration: The Planck High-Frequency Instrument (HFI; P.I. Puget)[32] will survey the whole sky in six bands (3, 2.1, 1.4, 0.85, 0.55, 0.35 mm), the first survey of the whole sky at these wavelengths. One of the survey's main goals is to detect thousands of high-z clusters through the Sunyaev-Zeldovich (SZ) effect, the change in brightness of the CMB towards a rich cluster of galaxies due to scattering of CMB photons by hot electrons in the intracluster medium. The Planck cluster sample will be of great importance for cosmologists, because the number-density of clusters as a function of redshift depends critically on the cosmological model[33,34]. It should also be possible, because the spectral shape of the SZ effect depends on the peculiar motion of the cluster, to measure bulk flows in the universe[35], which is another critical test of the cosmological paradigm. A major problem, however, is the contamination of the SZ effect by thermal emission from dusty galaxies within the large (5-10 arcmin) Planck beam, because there is evidence that even at moderate redshift the combined emission from dust in cluster galaxies is comparable to the SZ effect in the 0.85-mm band, and much greater in the two shorter wavelength bands[36]. There is zero SZ effect at 1.4 mm, which leaves only the two long-wavelength bands with little contribution from dusty galaxies, but as these also have the worst angular resolution there is the additional problem of confusion with nonthermal radio sources.

The poor angular resolution of Planck means the HFI surveys will be limited by source confusion rather than instrumental noise at all wavelengths, with simulations predicting 5σ detection limits at 0.35 and 0.5 mm of $\sim$1 Jy and 0.5 Jy, respectively, about five times worse than the instrumental noise limits[37]. Figure 2 shows a simulation of what Planck and the H1K will see at 0.35 mm, which includes primary CMB anisotropies, the SZ effect, the clustering of high-z dusty galaxies, the lensing of high-z galaxies by clusters and instrumental noise[38]. A detailed comparison of the two images shows that the point sources in the Planck map are almost always composed of multiple confused sources, and the simulations predict that this will be true in the three short-wavelength bands, suggesting that the Planck point-source catalogue in these bands will be of limited value without follow-up high-resolution observations.

The combination of the Planck all-sky maps in the two short-wavelength bands with the H1K maps of one fortieth of the sky in the same bands, but with much better resolution and sensitivity than Planck, will be a powerful combination for tackling these issues. This approach of carrying out a high-resolution survey of 1/40 of the Planck sky has the major advantages over targeted follow-up Herschel observations of Planck sources that there are no problems with the respective mission timescales and no biases towards certain categories of source. On a technical but important level, the H1K will allow the Planck team to detemine the effectiveness of their source-detection and deconvolution techniques and to measure flux and position errors rather than having to rely on simulations[39], but there are also some key scientific projects:

- It will be possible to determine the composition of the Planck point sources at 0.35 and 0.5 mm in the H1K survey region. The exact number of sources is very uncertain, since nobody has surveyed the sky at these wavelengths, but our latest simulations suggest about one Planck source per square degree[38]. If the Planck sources turn out to be an interesting population (dust sources in high-z clusters or background dust sources lensed by high-z clusters are two exciting possibilities[38]), it will be possible to use the Planck sources in the 39/40 of the sky not covered by the H1K as a way of finding high-z clusters.

- It will be possible to 'decontaminate' the Planck SZ signals by removing the effect of the thermal emission from dusty galaxies, using the spectral shape of the emission in the H1K bands to extrapolate into the other Planck bands. We will be able to correct the SZ signal individually for the 50-100 SZ sources expected to fall within the H1K fields (latest estimates from the Planck science team) and statistically for the rest of the Planck cluster sample, which will make it possible to use the cluster sample for tests of the cosmological paradigm.

C: The Herschel Lens Survey: In principle, gravitational lensing is a powerful way of investigating the evolution in the mass profiles of galaxies, a fundamental test of models of structure formation. In practice, it has proved very hard to assemble the necessary large sample of lenses. The most ambitious programme to date searched for lenses among flat-spectrum radio sources, but after high-resolution radio observations found only 22 lenses out of 16000 radio sources—a success rate of 0.14%[40].

Submm surveys are possibly the ideal way to find lenses. The large negative K-correction means that sources are generally at $z \geq 1$ with flux depending on luminosity but largely independent of redshift. A bright submm source is thus likely to have both a high redshift, with a large optical depth to lensing, and a high luminosity. Because luminosity functions always fall off steeply at high luminosities, if the estimated luminosity of the source is high enough it is almost certain to be a lens. Models by different groups[41,42] imply that at high flux densities the percentage of lensed sources should be extremely high. The model in Figure 3, for example, predicts that at $S_{500\mu m} > 100$ mJy the sources should be a mixture of lensed high-z galaxies, nearby galaxies and flat-spectrum radio sources. Since the latter two catagories are easy to remove (by using the submm flux ratio or the presence of a bright galaxy), the lens yield is close to 100%. These models predict that the H1K will contain $\sim$ 3000, 1600 and 700 strongly-lensed galaxies at 250, 350 and 500μm, respectively, with a lens yield ranging from 1% at 250 μm to close to 100% at 500 μm . Note that because the number of sources with $S_{500\mu m} > 100$mJy scales with the survey area, the H1K will contain $\simeq$15 times more lenses than HERMES.

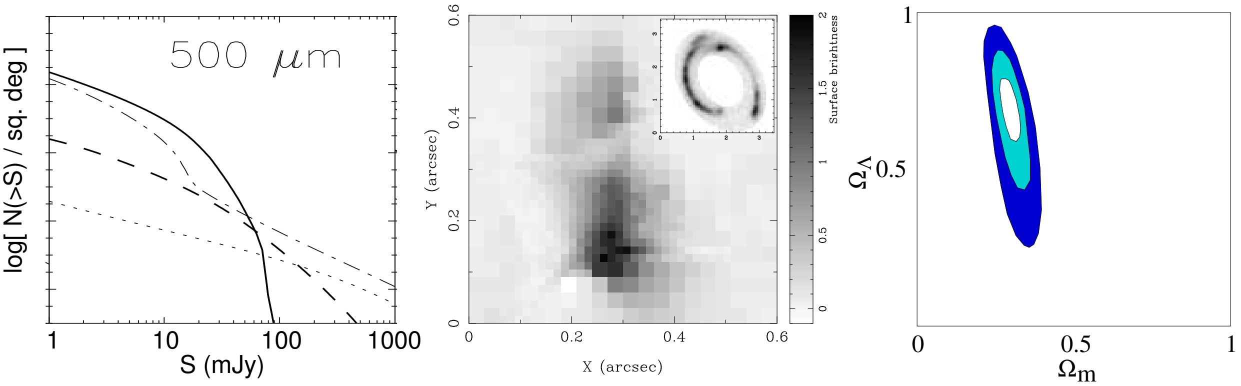

Fig. 3: Left panel—*Predicted number of sources as a function of 500 μm flux density*[41] *(high-z galaxies—solid curve; low-z galaxies—dot dashed; flat-spectrum radio sources—dots; lensed sources—dashed.* **Middle panel**—*Reconstruction from the lensed image (inset) of the unlensed source*[44,45]**Right panel**—The 1σ, 2σ and 3σ constraints on Ω_M and Ω_Λ from the H1K lens sample.

We will use the models to guide us where to look for lenses, but we will need to make follow-up observations to confirm that a source is a lens and to achieve the scientific goals below. Fortunately, a source with $S_{500\mu m} \sim 100$ mJy will be easy to map; a 30-minute observation with the Submillimetre Array, a one-hour observation with the VLA or a $\simeq$1-min observation with ALMA will be enough to confirm a source is a lens and to map the image structure (Fig. 3). We will use 4-metre optical/IR telescopes to measure the redshift and light profile of the lens and 8-10m optical/IR telescopes to measure the redshift of the source, which should be easier than for SCUBA sources[43] because of the lensing magnification. We will use the sample to produce the first lensing estimates of $\Omega_{\rm M}$ and Ω_Λ (Fig. 3), but our main projects will be the following:

- We will use the lens sample to study the evolution of the galaxy mass profiles from z $\sim$ 1.5 to the present day. We will use proven techniques[44,45] to reconstruct separately the dark-matter halo and baryonic component of each lens, which will allow us to observe directly the build-up of stellar mass and its interplay with dark matter halos over the last 70% of the universe's history.
- We will reconstruct the lensed sources (Fig. 3) to study the properties of high-z dust sources well below the confusion limit, a technique first used in the SCUBA surveys[46]. With lens magnifications often in excess of 10, we will be able to detect sources at $S_{250\mu m} \sim$ 4mJy, similar to the flux limit of the deeperst PACS GT surveys, but with the advantage that the H1K sources will be selected from a much larger volume and thus represent a fairer sample of the universe.

D: AGN: One of the most significant discoveries of recent years was that most nearby galaxies contain a black hole, and that the mass of the black hole is strongly correlated with the mass of the surrounding spheroid of stars[47], because it implies that the formation of the two are connected. Earlier submm studies have detected $\simeq$5-10% of high-z quasars[48,49], and the detected quasars are sufficiently bright dust sources that almost all the emission must come from a starburst—again consistent with the idea that the formation of the stars and the black hole are connected. We will investigate the relationship between the star formation and the black hole and how this relationship changes over time by observing a very large sample of quasars drawn from the SDSS. We will use the optical/X-ray continuum to estimate the energy output of the AGN, the width of the Hβ and

MgII emission lines to estimate the black hole mass[50] and the H1K fluxes to estimate the luminosity of the surrounding starburst.

Figure 4 shows quasars drawn from the Palomar Green (PG) survey and the SDSS as a function of redshift and optical luminosity. Because of the strong correlation between luminosity and redshift in any flux-limited sample, it is crucial to observe more than one sample, so that one can compare quasars with the same optical luminosity at different redshifts and vice versa. The detection rate of PG quasars by IRAS and ISO is $\simeq$80%[51]. We will use the H1K to extend far-IR/submm observations to the more distant SDSS quasars. Using the results of a pilot study with the Spitzer legacy survey SWIRE[52], we estimate that we will detect $\simeq$440 quasars at $z < 3$ and $\simeq$ 210 quasars at $z > 3$, which is $\simeq$15 times greater than the number of existing detections of high-z quasars. We will also have the major advantage over previous studies that we will be able to investigate the remaining 20000 SDSS quasars in the H1K fields statistically by dividing the L-z plane into bins of optical luminosity and redshift and use stacking (see above) to measure the average dust emission from the quasars in each bin. A natural legacy extension of this project would be to perform a similar analysis on other classes of AGN, in particular the obscured AGN that will be detected in the hard X-rays by Spectrum-Roentgen-Gamma (launch 2012).

E: Large-Scale Structure: We estimate[65,66] that the H1K will detect $\sim$400,000 sources with a median redshift of $\sim$1 and will therefore contain a large amount of information about large-scale structure upto a scale of $\simeq$1000 Mpc at z $\sim$ 1, much larger than the scale accessible with HERMES. Many exciting projects, such as searches for baryonic oscillations, will only become possible in the future, as the near-IR (VISTA,UKIDSS) and optical (VST, Pan-STARRS, the Dark Energy Survey) surveys eventually provide photometric redshift estimates for most of the sources. We leave these projects to legacy teams (see below). In the meantime, the H1K team will concentrate on two LSS projects. We will measure the angular correlation function of the sources on a scale much larger than possible with HERMES, allowing us to estimate the masses of the dark-matter halos and to discriminate between competing models of galaxy formation (Fig. 4). The individual sources, however, only represent $\simeq$10% of the background radiation at the Herschel wavelengths[37], and so the unresolved background contains a wealth of further information. We will therefore investigate the clustering properties of the intensity distribution on the maps after the high S/N sources have been removed. This is a powerful technique for investigating the spatial distribution of the energy hidden below the confusion limit[54,55] and has been successfully applied to Spitzer maps[56]. We will use the strength of the fluctuations on large angular scales (linear regime) to determine the average halo mass of the sources representing the 90% of the background radiation that is below the Herschel confusion limit. We will use the strength of the fluctuations on small angular scales (non-linear regime) to estimate the halo occupancy distribution (see [55] for more details).

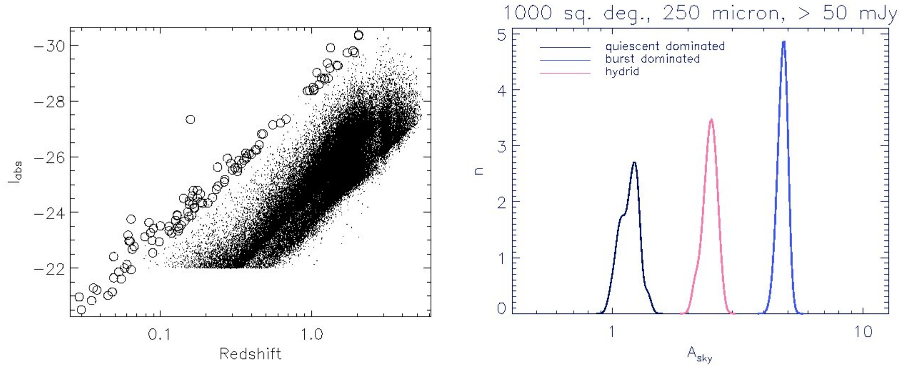

Fig. 4: Left panel—*The distribution of PG (circle) and SDSS (point) quasars as a function of redshift and luminosity.* **Right panel**—*The amplitude of the angular correlation function (A_{sky}) that will be measured by the H1K (100 Monte-Carlo realisations) for three different galaxy evolution models (see [53] for more details).*

F: Dust and Protostars: Observational studies of star formation, including the Herschel GT programme, have focused on dense regions at low galactic latitude because these are easiest to find; optical searches for dark clouds require a dense background of stars and the most sensitive CO surveys have been at low latitudes. These studies invariably conclude that stars form in large groups. There are only a few results that contradict the consensus that star formation is a group phenomenon occurring in giant molecular clouds: a few molecular clouds at high latitude[57], the discovery of a prestellar core in a Bok globule[58] and some nearby young T Tauri stars a long way from any molecular cloud[59]. We are in an excellent position to test this consensus because we are looking at very high latitudes, where even at the poles the IRAS survey showed there is large amounts of dust. At the very least, the H1K will be the most sensitive survey ever of high latitude dust. We will have as good sensitivity to low surface-brightess features as IRAS and Planck, but we will be able to detect the cold dust that IRAS missed—and we will of course have 12 times better resolution than IRAS and 15 times the resolution of Planck (the power spectrum of the IRAS maps - $P(k) = Ak^{\gamma}$ with $\gamma \sim -3.5$[60] - implies that there should be lots of structure on the scale of the Herschel beam). We will carry out two very basic scientific projects. First, because the dust disks in galaxies are very thin, and so the dust at high latitude must be very close to us ($\sim$<0.5 kpc), we will be able to carry out a census of all prestellar cores and protostars in our fields down to $\sim 0.002\ M_{\odot}$— well below the brown dwarf limit and in the Jupiter regime (assumptions: $T = 20$K and a standard gas-to-dust ratio). Second, without the projection effects of looking through large column densities of dust at low latitudes, we will be able to make an unprecedented study of the physical processes occurring in interstellar dust, mapping the structure on all scales but also using the spectral energy distributions to investigate the temperature and physical composition of the dust.

1.3 Other Facilities: With the exception of Programme C, which requires follow-up observations (see above), we can achieve our science goals with no additional data, although we intend to obtain spectroscopy of *all* the northern and equatorial H1K sources with the new 4000-fibre (5 degree field) spectrometer, LAMOST, at the National Astronomical Observatories of China (P.I. Zhao). The GAMA survey scheduled at the AAT (P.I. Driver) will provide redshifts for an additional $\simeq$7000 H1K sources (§2).

Legacy Science: In the next decade our fields will be surveyed in the near-IR by VISTA and UKIDSS, at optical wavelengths by the VST, pan-STARRS and the Dark Energy Survey, at mm wavelengths by the South Pole Telescope, and in the radio by LOFAR, the Karoo Array Telescope (KAT) and the Australia SKA Pathfinder Telescope (ASKAP) [see §3.3 for more details]. Because these are already the best-studied fields in the sky of this size, they will definitely also be the targets of other surveys. We do not have the space (or the imagination) to describe all the possible legacy projects, but here are a few. **L1:** KAT and ASKAP will measure the atomic hydrogen in tens of thousands of galaxies. By combining these measurements with the H1K and SDSS/2dFRGS results, it will be possible to examine the connections between the different ISM phases and star formation in the nearby universe. **L2:** It will be possible to estimate redshifts for $\sim 10^7$ galaxies detected by the near-IR/optical surveys in the H1K fields, and thus to map out the 3D structure of the universe out to $z \sim 1.5$. The H1K data will show where the star-forming galaxies are within this structure, extending the investigation of the environmental dependence of star formation (A) to very early times. **L3:** A powerful way of probing the equation of state of dark energy is to measure the positions of the peaks in the galaxy power spectrum (the baryonic oscillations) as a function of redshift[61]. Although the redshift distribution of the H1K galaxies has not yet been measured, our models suggest that the H1K will be better than other surveys[62] for measuring these oscillations at $z > 1.2$. **L4:** The H1K will detect $\simeq$300 asteroids[63,64], and it will also be possible to use the H1K to look for dwarf planets in the Kuiper Belt, albeit over only 1/40 of the sky.

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2. Technical Implementation (max. 3 pages)

2.1 Observations Strategy:

For most of the H1K programmes, the bigger the survey area the better and the precise sensitivity limit does not matter too much; for example, the number of Planck sources simply scales with the area of the survey. The key elements of the H1K strategy, however, are dictated by the requirements of Programme A. This programme has three basic requirements: **1)** To provide a survey of dust-obscured star formation in the local universe to complement the SDSS and 2dFGRS, we need to detect a similar number of galaxies: $\sim 10^5$. We estimate that with this total number of sources we will be able to estimate the overall dust-mass function with adequate precision (better than 10%) over the range $10^{4.5} < M_D < 10^{10}\ M_\odot$ (Fig. 1). Over a smaller range ($10^6 < M_D < 10^9\ M_\odot$), we will be able to determine how the dust-mass function depends on other parameters, such as environment, the total number of sources being enough for us to split the sources into four classes and still estimate the dust-mass function with 10% precision in 15 mass bins over this restricted mass range. **2)** We wish to achieve the programme's science goals without the need of carrying out lengthy follow-up programmes, and so we need to rely as far as possible on existing data, in particular the SDSS and 2dFGRS redshifts. **3)** We need accurate estimates of the dust masses and bolometric luminosities of the galaxies, and so we need flux measurements on both sides of the peak of the dust SED.

Because of requirement 3, we propose to carry out parallel PACS and SPIRE surveys (pMode), using fast-scanning (60 arcsec s^{-1}) to cover the largest possible area. The drawback of fast-scanning is some degradation of the point spread function in the shortest PACS band, but our modelling has shown that we get equally accurate estimates of the bolometric luminosity of nearby galaxies if we use the 85-130 μm band rather than the 60-85 μm band. Although it is currently not known whether $1/f$ noise will be a serious problem, as a conservative measure we propose to make two orthogonal scans of each field, allowing us to 'cross-link' the data. These choices will give 5σ limits at 100, 160, 250, 350 and 500 μm of 67, 94, 45, 62 and 53 mJy, respectively. These flux limits are > 2 the expected 5σ confusion limits in all bands (Hspot estimate). The H1K depths in PACS and SPIRE are well-matched. SPIRE/250 is our most sensitive band and is longwards of the SED peak. Based on real SEDs of galaxies in the Virgo cluster, we estimate $\simeq$80% of the 250 μm detections will also be detected in the shorter-wavelength PACS band. We note that the Akari all-sky survey is expected to reach a sensitivity $\simeq$5 times worse than our PACS limits, and so will not be able to provide the short-wavelength measurements.

With the flux limits set by these choices, the remaining question is how big an area of sky do we need to cover. Our predictions of the number of sources that will be detected by the H1K are uncertain, because our knowledge of both the local luminosity function and cosmic evolution, which is important even at low redshift[25], is still very poor (measuring these, of course, is one of the goals of the survey). The best estimate of the local luminosity function comes from the SCUBA Local Universe and Galaxy Survey (SLUGS), a programme of targeted submm observations of an IRAS-selected and an optically-selected sample of nearby galaxies[12,13], although this estimate is likely to be an underestimate because these samples may not include galaxies that would be detected in a 'blind' submm survey, but would have a low probability of being included in small samples selected in other wavebands. Using this luminosity function, we estimate that a survey of 1000 deg^2 would detect $\simeq$41,000 sources at $z < 0.3$ if we make the conservative assumption of no evolution and $\simeq$140,000 sources if we assume a simple evolutionary model consistent with previous observations[25,65]. Therefore we can satisfy the first requirement by a survey of this area. The total number of sources at all redshifts detected by the H1K is also uncertain, but three separate estimates— (a) an empirical scaling from the results of the Spitzer Legacy Survey, SWIRE; (b) an estimate from evolutionary models based on SLUGS[65]; (c) an estimate from the phenomenological models of Lagache and collaborators [66]—are in the range 250,000-600,000.

This survey also satisfies the second requirement. Because all the SLUGS sources have observed optical-near-IR spectral energy distributions, it is easy to use the evolutionary models based on SLUGS[65], which are consistent with existing far-IR/submm datasets, to predict the magnitude distribution of the H1K sources in any optical or near-IR band. By comparing these with the magnitude limits and sampling strategies for the redshift surveys, it is possible to estimate the percentage of H1K sources that will already have SDSS and 2dFGRS redshifts. For the fields covered by the 2dFGRS, we estimate that 92% of the H1K sources at $z < 0.1$ will already have redshifts, 77% of the sources at $z < 0.2$ and 57% at $z < 0.3$. For the fields covered by the SDSS, the corresponding percentages are 88%, 66% and 46%. Note that the two lowest redshift bins are the crucial ones, because the number of galaxies with SDSS or 2dFGRS redshifts declines rapidly at $z > 0.2$ (Fig. 1). Using the same models, we predict that the new GAMA redshift survey starting soon at the AAT will provide close to 100% redshifts for all the H1K sources at $z < 0.3$ in 150 deg^2 of the total survey area.

Our fields have been chosen to be the best-studied large fields at high galactic latitudes. With a view to the legacy value of the H1K in providing far-IR/submm coverage of fields accessible to all telescopes, we have chosen three fields, one in the south, one in the north and one on the equator. All fields contain relatively weak emission from galactic cirrus and are thus good targets for far-IR/submm surveys. More details of how the H1K complements existing and future surveys in other wavebands is given in §3.3.

- **The southern field: $22^{\mathbf{h}} < \mathbf{RA} < 3^{\mathbf{h}}30^{\mathbf{m}}, -30^\circ > \delta > -36^\circ$ (437 $\mathbf{deg}^2$)** This field is close to the South Galactic Pole and has been surveyed by the 2dFGRS. It will soon be surveyed in four optical bands by the KIDS legacy survey (VST) and in five near-IR bands by the VIKING legacy survey (VISTA). We have chosen the declination limits, so that the field is accessible from the south pole, and it will be part of the SZ survey by the South Pole Telescope. There is also access to ALMA and the SKA-precursor telescopes (ASKAP and KAT).
- **The equatorial field: $8^{\mathbf{h}}40^{\mathbf{m}} < \mathbf{RA} < 9^{\mathbf{h}}24^{\mathbf{m}}, -1^\circ < \delta < 2^\circ$ and $11^{\mathbf{h}}30^{\mathbf{m}} < \mathbf{RA} < 15^{\mathbf{h}}, -2^\circ < \delta < 2^\circ$ (237 $\mathbf{deg}^2$).** This field has been surveyed by the SDSS and 2dFGRS. It will soon be surveyed in four optical bands by the KIDS legacy survey (VST) and in five near-IR bands by the VIKING legacy survey (VISTA). Within the field there are three 50 deg^2 subfields that will be surveyed in the GAMA redshift survey about to be started on the AAT (P.I. Driver), which will yield $\simeq 10^5$ redshifts, including $\simeq$7000 for H1K sources (see above). The smaller subfield above is one of the GAMA fields. There is also access to ALMA, SCUBA-2, Pan-STARRS, and the SKA-precursor telescopes.
- **The northern field: $12^{\mathbf{h}}30^{\mathbf{m}} < \mathbf{RA} < 14^{\mathbf{h}}03^{\mathbf{m}}, 23^\circ\ 30' < \delta < 41^\circ$ (348 $\mathbf{deg}^2$)** This field crosses the North Galactic Pole and was surveyed in the SDSS. It will be surveyed in four near-IR bands with UKIRT as part of the UKIDSS legacy survey. It is the obvious target for a survey with the new low-frequency array telescope (LOFAR). It is also accessible to SCUBA-2, Pan-STARRS, and the southern half is accessible to ALMA.

Detailed Survey Strategy: Because of the limit on the time for an individual AOR, the fields must be observed using a set of smaller 'tiles'. We have devised the most efficient way to observe all three fields, which is shown schematically in Figure 5. Each region is covered by two scans in orthogonal directions to minimise the effects of 1/f noise, and the regions overlap enough that the allowed rotation on the sky will not create large gaps.

2.2 Observation Time Requirements:

All observations are carried out in SPIRE/PACS parallel mode (PMode). The scan speed is 60 arcsec/sec. The sizes of the tiles vary depending on the area to be tiled. Tiles are as large as they can possibly be and (a) fit within the 18 hr time limit and (b) fit within the field boundaries in an efficient way. This gives us the most efficient strategy as observing efficiency increases with the size of the map. As far as possble, we have arranged that the joins between the tiles do not overlap in the nominal and orthogonal directions, as this should ensure a more uniform coverage.

The tile sizes requested are given below along with the observation time per tile and the total time request for each field (from HSpot, including all overhead and penalties). N=nominal, O=orthogonal
NGP: N [540' x 232'] @ 62317 s x 10 = 173.10 hrs; O [575' x 223'] @ 63668 s x 10 = 176.86 hrs
SGP: N [710' x 185'] @ 64569 s x 12 = 215.23 hrs; O [360' x 227'] @ 43519 s x 19 = 229.68 hrs
Equator: N [232' x 232'] @ 31148 s x 15 = 129.78 hrs; O [232' x 232'] @ 31261 s x 8 + 31681 s x 7 = 131.07 hrs
GAMA: N [232' x 210'] @ 28568 s x 4 = 31.74 hrs; O [232' x 210'] @ 29471 s x 4 = 32.75 hrs

Total time: = 1120.2 hrs (from HSpot).

2.3 Time Constraints:

As we are tiling a large and often elongated area which needs to fit within specific RA/Dec boundaries in order to overlap with multi-wavelength complementary data (e.g. 2dF spectra), we have to specify 'array with sky' constraints for most of the AORs. In order to have as uniform coverage as possible with minimal gaps, the rotation of the tiles on the sky must be quite tightly constrained.

For each field we have used a simulation to generate tile boundaries for a specified tolerance around the desired optimum scan angle (e.g +/- 2 degrees). We have used these simulations to choose the angle constraints and the field sizes for the AORs. Fig 5 shows how the tiling will work for a typical realisation of our optimum constraints. There is a trade-off between having more overlap area (time wasted) or a tighter constraint on the angle. We have opted here for a constraint of +/- 2 degrees in the NGP and SGP and +/- 5 degrees across the equator. This produces visibility windows in Hspot of typically 4-6 days every 6 months for the NGP and SGP and significantly longer on the equator. If the constraints on the NGP/SGP are relaxed to +/- 5 degrees, our 'worst case' and 'typical' maps could look like Fig 6. This is not ideal in terms of observing efficiency, and we would not achieve uniform coverage of the full survey area, but in the event of our optimum case being unschedulable then we will work closely with the telescope schedulers to find the next best solution.

The equatorial and GAMA fields are nearer to the ecliptic and also have square tiles. In these fields the nominal and orthogonal scans for each tile have been concatenated in HSpot (as described in the PM manual) and so only incur the observatory overhead once for each tile. Not all of these tiles rotate much due to their position, and so only some require the 'array with sky' constraints.

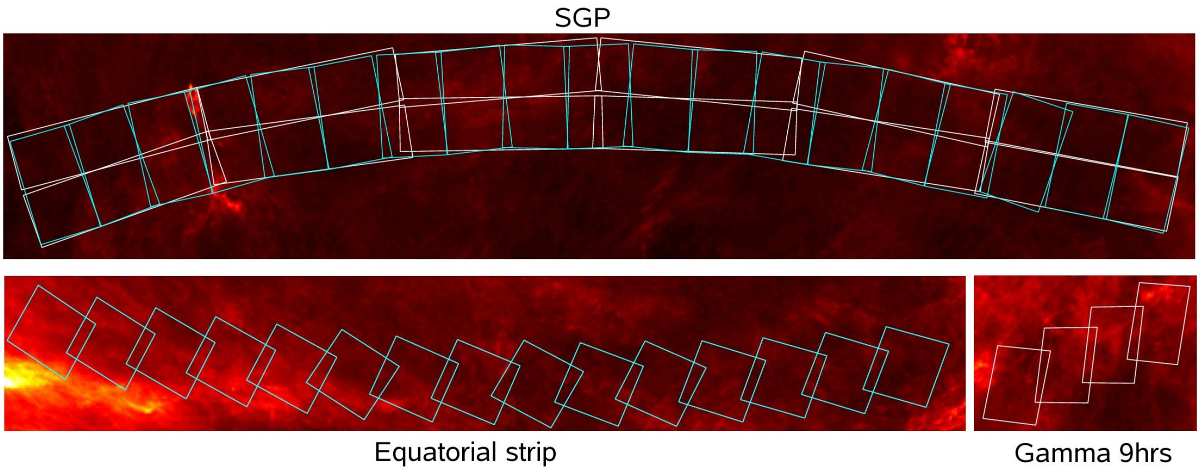
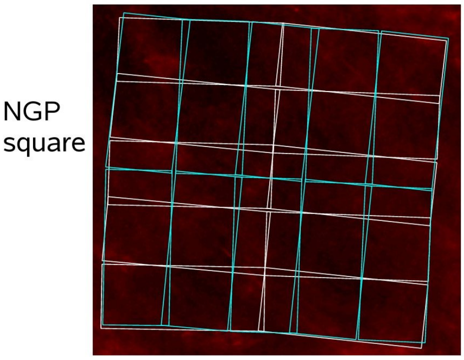


Fig. 5—*Fields for the H1K survey superimposed on the IRAS 100μm maps. The white lines show the nominal scans, the cyan lines the orthogonal scans. For the equatorial fields, the nominal and orthogonal scans cover almost exactly the same fields, and the AORs have been concatenated in Hspot. The tiles are the exact size requested in Hspot, and so there is a larger region around each for which we may get PACS and SPIRE data. The orientation of the tiles has been constrained within Hspot and the figures above show a randomised set of angles from within this range to give a realistic idea of the coverage we expect.*



2.4 Robustness:

Our science goals are best served by observing more area rather than greater depth. Thus if sensitivities are less than predicted, we would opt to keep the area the same and still do two orthogonal scans. If sensitivities are improved over predictions, then we will see deeper in the same area, as we are already performing the minimum number of scans (2). This will of course benefit all the science projects. In the event of catastrophic instrument failure of either PACS or SPIRE, we request our observing mode be changed to scan-map mode.

If PACS fails, we would lose the ability to measure dust temperatures and bolometric luminosities so accurately, which is important for programmes A, D and F, but other programmes would be largely unaffected. In this case, we would request an increase in survey area (with a consequent loss in sensitivity), which would improve the statistics on the lensing and Planck projects without unduly affecting the other programmes.

If SPIRE fails, then more of the science is affected - most notably there will be no lensing or Planck programmes. We would still have the most sensitive survey to dust-obscured star formation in the local universe and, critically, the only large-area survey to this depth at a wavelength longer than the peak in the warm dust spectral energy distribution ($\simeq$170 μm).

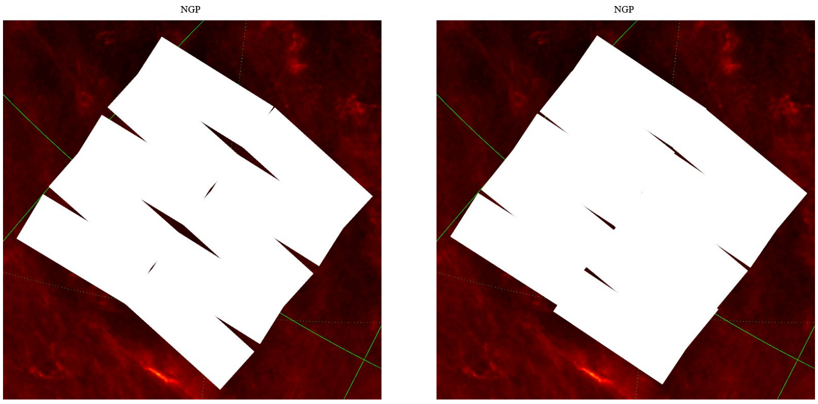


Fig. 6—*NGP orthogonal coverage with ±5° constraints: worst case (left) and typical (right)*

3. Data Processing Plans (max. 2 pages)

3.1 Data Processing Plans:

The starting point of our data reduction procedure are Level 1 products (calibrated PACS and SPIRE timeline products) produced by the official SPG pipeline. We will re-run the PACS and SPIRE pipelines from Level 0 to Level 1 if problems are found in Level 1 products or are reported in quality control reports; we will also re-run the pipelines when updated software and/or calibrations become available through the ICC before the official releases. The second step consists of combining calibrated timelines for each field into maps for each band. Our plan is to use the MADMap software in the Herschel DP system, which experiments within the GT team have shown is the optimum way of making maps.

We will extract sources from the maps using the point-source extraction software produced by the GT teams and/or by the SPIRE and PACS ICCs. We will also evaluate other available source extraction software. We will produce the following legacy data products:

Table 1: Data Products

Name	Description	Minimum Parameters
SCAT	SPIRE Source Catalogues	Positions, Fluxes, errors, SNRs, etc.
SMAP	SPIRE Maps	Maps of flux, S/N and coverage
PCAT	PACS Source Catalogues	Positions, Fluxes, errors, SNRs, etc.
PMAP	PACS maps	Maps of flux, S/N and coverage
SPCAT	SPIRE/PACS band-merged catalogues	Positions, Fluxes, errors, SNRs, etc.

Our Herschel data catalogues (SCAT/PCAT) will consist of independent catalogues containing sources selected from data at one wavelength without reference to any other. Associated with these catalogues will be a *validation* analysis, including assessments of the completeness and reliability of the catalogues. The preliminary maps (SMAP/PMAP) released in the first data release (see below) will be suitable for assessing the reliability of the point-source catalogues. The final maps released in the second data release will be suitable for extended source analysis (Programme A), the analysis of fluctuations in the extragalactic background radiation (Programme E) and legacy projects that look at extended source structure. The SPCAT product will include all Herschel bands. Upper limits will be listed for sources detected in some Herschel bands but not others.

The data products will be released in a format suitable for immediate incorporation into virtual observatories (e.g. binary FITS tables and FITS files). We will produce documentation to accompany the legacy products. We intend to archive the data at the US Herschel Science Centre (US) and at the Wide-Field Astronomy Unit in Edinburgh in addition to the ESA-provided archive. The data will of course be made available to all national archives and virtual observatories.

Each deliverable product will be the responsibility of a group within the team and will have an identified project manager. The delivery of the product will be defined by a "work flow" with work-packages assigned to specific members of the team. One institute within each team will not take part in the data reduction, but will be responsible for the validation of the data, ensuring an unbiased assessment of product quality. We expect that the US groups in the H1K team will be responsible for ≃25% of the total work in basic data reduction and in carrying out Programmes A-F.

The table below lists the institutions that will play a key part in various aspects of the data reduction, although we emphasise that we expect many more institutions than this to play a role in the data reduction. The resources listed are for the whole consortium and are a conservative estimate of the personnel that will be available for delivering the legacy products. We have based this on the existing post-docs at consortium institutions plus the US post-docs that will be available to our US co-investigators if the proposal is successful. Our total available post-doc effort within the H1K is about twice the amount listed in the table, because we of course need personnel to work on the science programmes. We also note that, if the proposal is accepted, we will be in a strong position to bid for additional resources from the various grant agencies outside the US.

Table 2: Data Reduction Responsibilities and Resources

Data Product	Lead	Institutions (Alphabetical Order)	Manager	Resources (2009-2011)
SCAT	Imperial	Cardiff,Imperial,IAS,IPAC,JPL,SISSA	Clements	15 sy total
PCAT	Garching	Bonn,Garching,Ghent,IPAC,Leiden	Mueller	15 sy total
SMAP	Imperial	Cardiff,Imperial,IAS,IPAC,JPL,OU,SISSA	Clements	15 sy total
PMAP	Garching	Bonn,Garching,Ghent,IPAC,Leiden,OU	Mueller	15 sy total
SPCAT	OU	Cardiff,MPE,Nottingham,OU	Serjeant	6 sy total

Our proposed schedule for the release of legacy products is as follows:

3. Data Processing plans (cont.)

Data Release 0: We shall release a limited amount of data at the time of the special Herschel editions of the various journals, for which we also intend to produce papers. The released data will help the community design legacy projects that will be possible with the full H1K dataset. The data making up this release will of necessity be a restricted subset defined by what data is available and can be processed in time.

Data Release 1: This will occur 6 months after the final observation of the H1K. It will consist of source catalogues, both individual and band-merged, and the basic maps. The maps will be good enough to assess the reliability of individual sources, but they will not be of high enough quality to carry out large-scale structure projects, such as looking at the fluctuations in the background radiation.

Data Release 2: This will occur 18 months after the final observation of the H1K and will consist of the final catalogues and maps.

3.2 Product generation justification:

Any software and analysis tools we develop will be released to the wider community. We will provide documentation at the same standard as the documentation of the SPG pipeline tools provided by the SPIRE Instrument Control Centre (ICC). Our software releases will be coordinated with the appropriate ICC (PACS or SPIRE).

3.3 Archival Value:

Our fields are the best-studied fields of this size in the sky. Each field has been observed either in the Sloan Digital Sky Survey or the 2dF Galaxy Redshift Survey or in both. There are also many other surveys about to start which will add to the archival value of the H1K. We give below some more details of these surveys, and Figure 7 illustrates the overlap of these surveys with the H1K fields.

- The **GAMA** survey (P.I. Driver) will use AAOmega on the AAT to obtain $\sim 10^5$ redshifts in our equatorial field. We estimate that this will provide $\simeq$7000 additional redshifts for the H1K sources.
- The **VIKING** survey (VISTA, P.I. Sutherland) will survey the southern and equatorial fields in Z, Y, J, H and K down to AB magnitudes of 23.1, 22.4, 22.2, 21.6 and 21.3, respectively (5σ). This survey will start in 2008.
- The **KIDS** legacy survey (VST) will survey the southern and equatorial fields in u, g, r and i down to about 2 mags fainter than the Sloan Digital Sky Survey. The survey will start in 2008.
- The **South Pole Telescope** will survey 4000 deg^2 of the southern sky, including the southern H1K field, at millimetre wavelengths to look for Sunyaev-Zeldovich sources.
- The **low-frequency array telescope (LOFAR)** in the Netherlands will carry out deep surveys at radio wavelengths of parts of the northern sky. Our northern field is one of the obvious targets, and field selection is under discussion within the LOFAR consortium (members: Jarvis, Rawlings and Eales). The first high-quality LOFAR image was obtained in April 2007.
- The **Karoo Array Telescope**, currently under construction in South Africa, will be able to observe HI in galaxies out to z $\sim$ 0.6. The southern and equatorial H1K fields are obvious targets.
- The **Dark Energy Survey** will survey 5000 deg^2 of the southern sky, including the southern H1K field, in g, r, i and z.

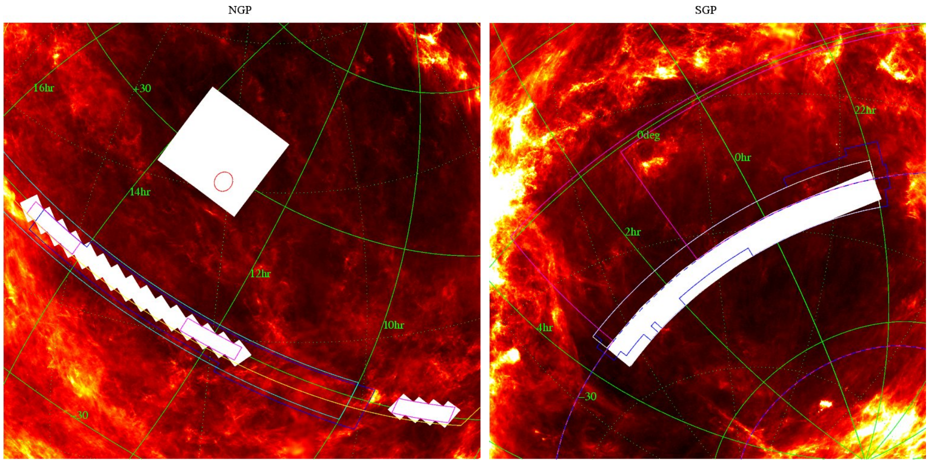


Fig. 7—*The ancillary data that will be available for the H1K fields (white blocks) superimposed on the IRAS 100 μm map. In the north the outlines of the other surveys are: 2dFGRS—continuous blue; VIKING/KIDS—cyan; GAMA—magenta ; SDSS—yellow. The red circle shows the area covered by the Coma cluster. In the south the surveys are: 2dFGRS—continuous blue; VIKING/KIDS—cyan; Dark Energy Survey—magenta; South Pole Telescope—dashed blue.*

4. Management and Outreach Plans (max. 2 pages)

4.1 Management Remarks:

The H1K team has extensive experience of far-IR and submm surveys, both on the ground and in space. Members have played important roles and often led many of the most important surveys in these wavebands over the last two decades, including ones with IRAS (QDOT, PSC-z), ISO (ELAIS, HDF-N), SCUBA (HDF, 8-mJy, CUDSS, SHADES), MAMBO and BLAST. Several team members have also played important roles in the Spitzer legacy survey, the Spitzer Wide-Area Infrared Extragalactic survey (SWIRE). Our team contains key members of the Herschel science teams (PACS and SPIRE) and the Planck science team. We therefore have expertise in every aspect of these instruments, although we emphasise that $\simeq$60% of the H1K co-investigators are from outside the Planck and Herschel science teams. The H1K team also includes members of some key theoretical groups (Durham, Edinburgh, Innsbruck) and the leaders of the GAMA, VIKING and UKIDSS surveys.

Given the size and scope of the project—six separate science programmes plus delivery of legacy products—we have decided on the following organizational structure for the H1K.

The H1K will have two joint principal investigators, each being responsible for a separate facet of the H1K. Loretta Dunne will be responsible for the scientific direction of our flagship science project, the survey of the local universe. Steve Eales will be responsible for the delivery of legacy data products to the community. His membership of the SPIRE science team and his location at the SPIRE P.I. institute will help in the timely and efficient delivery of data products.

The decision-making body within the H1K will be the executive committee. This will consist of LD and SE, Asantha Cooray, the US P.I. (see below), the leaders of the science teams (see below) and the leaders of the three processing teams. This committee will manage the production of legacy products and perform the overall direction of the science programme. In making decisions, the executive committee will consider three objectives: (1) to deliver legacy products on schedule; (2) to produce the best possible science (programmes A to F); (3) to ensure a just return, in terms of authorship of papers, for the work done by students, post-docs and other team members on the science programmes and in the delivery of data products.

The provisional leaders of the science teams are:

- Programme A (*The Local Universe*): Loretta Dunne and Steve Eales
- Programme B (*The H1K-Planck Collaboration*): Gianfranco De Zotti and Dave Clements
- Programme C (*The Herschel Lens Survey*): Mattia Negrello and Simon Dye
- Programme D (*AGN*) Steve Serjeant and Matt Jarvis
- Programme E (*Large-Scale Structure*): Asantha Cooray and Steve Maddox
- Programme F (*Dust and Protostars*): Mark Thompson and Guilaine Lagache

Concurrently with this proposal, US participants from five institutions (Caltech/JPL, Cornell, Irvine, NASA Ames, and NASA Goddard) are submitting a joint funding request to NASA HSC to obtain support for their participation in H1K with Asantha Cooray as the US-based NASA P.I. The overall request is for two new full-time post-docs and significant partial support for another post-doc to work on H1K from 2009 to 2011, partial support for several senior scientists, support for graduate students, and resources for travel, computing and data storage. NASA P.I. Cooray is a member of the US SPIRE science team and is responsible for the scientific and administrative conduct of the US team's participation in H1K. Cooray will also be the main team contact for coordinating H1K activities (data release, outreach) with the NHSC. Within the US team, Caltech/IPAC participants will be heavily involved with delivering SMAP and SCAT products and will validate them for the collaboration, and the Irvine team will jointly lead large-scale structure studies in Programme E. The overall effort in data analysis and science study is estimated by the two survey P.I.s and the executive committee to be about 25% of the total work for this survey.

4.2 Outreach:

We will publicise our work through press releases, public WWW pages, talks to schools, astronomical societies and more general audiences, coordinating our efforts with those of national agencies (STFC, CNRS, NSERC, NASA etc.) and ESA to ensure we reach the largest possible audience. We will make a special effort at outreach around key dates, such as launch and the H1K first science release, and we will hold a press conference at the time of the first science release. The H1K team will make use of the resources developed by IPAC for publicising FIR astronomy (e.g. Cool Cosmos), but we will also develop our own materials.

We will make a special effort to reach audiences through broadcast media. We have a particular opportunity here because the Open University is one of our co-I. institutions. The OU funds about 30 broadcasting projects every year, mainly prime time TV and radio, with direct input from academic staff. Serjeant is Deputy Associate Dean (science broadcasting) at the OU and also has oversight of astronomy broadcasting through his role as

Director of External Relations (Physics & Astronomy); we anticipate many opportunities to enrich and inform the programming output with this Herschel key project.

As far as possible, we will try to integrate our outreach activities with the school curricula of the countries that form the H1K consortium. We will work closely with other groups in the astronomy community with experience at effective outreach. As an example, in the UK, we will work with the Faulkes Telescope Team and the science communication company, Science Made Simple, both of which are based in Cardiff and who have extensive experience in developing innovative outreach material that nevertheless fits within the UK school curriculum. We note that co-P.I. Loretta Dunne has taught in schools and that co-P.I. Steve Eales gives frequent school talks.

In the US, as one example of our outreach activities, we will take part in an existing Education and Public Outreach effort funded by NASA for high school students. The University of California runs a summer programme (COSMOS) for high school students on several UC campuses that includes a space science and astronomy component (www.ucop.edu/cosmos). Asantha Cooray will work with COSMOS educators at UC campuses to introduce into the curriculum a one-week activity focussed on the H1K but that gives the students a general introduction to far-IR/submm astronomy.

5. List of Consortium Members

Babar Ali (NASA Herschel Science Centre—senior scientist) is the leader of the NHSC/PACS group and works extensively with the PACS Instrument Control Center and ESA's Herschel Science Centre to provide expertise on PACS observation planning, data reduction and analysis to the US astronomy community. Dr. Ali's research area is Galactic star-formation. He is a key member of the team responsible for PACS data reduction.
Alexander Amblard (UC Irvine, US—staff) has extensive background in analyzing CMB data (Archeops and Planck preparation) as well as cosmological simulations, notably to study weak lensing. He will be working on analysing the fluctuations in the background radiation (Programme E).
Paola Andreani (ESO, Germnay—staff) is European ALMA Regional Centre Manager and is a co-I on PACS. She carries out research into galaxy clusters and the evolution of quasars and galaxies.
Itziar Aretxaga (INAOE, Mexico—faculty) is a member of LMT (Large Millimeter Telescope) instrument team and a collaborator on BLAST (Balloon-borne Large-Aperture Submillimeter Telescope). She has research interests in the connection between AGN and starbursts and in galaxy formation.
Robbie Auld (Cardiff, UK—post-doc) is a member of the European SKA design team and has a lot of experience in HI astronomy. He will use existing HI surveys to measure HI masses for the galaxies we find in Programme A.
Maarten Baes (Ghent, Belgium—faculty) has experience in constructing 3D dust radiative transfer models of galaxies, which will be used in interpreting the spectral energy distributions of galaxies measured in Programme A.
Elizabeth Barton (UC, Irvine, US—post-doc) has led studies on low- and intermediate-redshift galaxy interactions. She is currently working on combining cosmological simulations with observational datasets to isolate the effects of interactions from other environmental processes.
Carlton Baugh (Durham, UK—faculty) works on semi-analytical models of galaxy formation and on combining these with N-body simulations to build mock catalogues. He has worked with Lacey & Frenk to produce models which include the repossessing of starlight by dust using GRASIL. This work will be used in Programme A.
George Bendo (Imperial College, UK—post-doc) has experience in studying the spectral energy distributions and spatial distribution of dust in nearby galaxies. As a member of the Instrument Control Centre for SPIRE, he will assist with the SPIRE data reduction.
Dominic Benford (Goddard Space Flight Center, USA—staff) has pursued research in observational cosmology and infrared instrumentation for the last 15 years. He is currently the Deputy P.I. of the Destiny dark energy mission (under concept development), is Instrument Scientist for the SAFIRE instrument for SOFIA, is involved with constructing and operating several millimeter-wave cameras, and is on the science team for WISE. His research interests include studies of redshifted thermal emission from distant galaxies and quasars, the star formation history of the universe, and large scale structure traced by weak lensing.
Frank Bertoldi (Bonn, Germany—faculty) leads the radioastronomy group at Bonn University. His expertise is in bolometer and interferometric observations of distant QSOs and starbursts, and in SZ observations of galaxy clusters. He led the develpment of data analysis software for the APEX bolometer cameras.
Mark Birkinshaw (Bristol, UK—faculty) is an expert on AGN and galaxy clusters. He was one of the first astronomers to observe the Sunyaev-Zel'dovich effect and is currently continuing this work with AMiBA and OCRA. His knowledge of clusters and SZ astronomy will be an asset in Project B.
Andrew Blain (Caltech, US—faculty) works on observational and theoretical investigations of galaxy evolution, especially as traced by far-infrared-dominated objects. He is a member of the Science Team for SPIRE, and for the NASA WISE survey, due for launch in 2009. He has a lot of experience in lensing projects, which will be used in programme C.
Jamie Bock (JPL, US—senior research scientist) is US P.I. of the SPIRE instrument, responsible for the SPIRE focal plane arrays and cryogenic readout electronics, and a co-I. of the Planck HFI. He is interested in studies of the far-infrared extragalactic background in discrete sources and fluctuations of the background, and provides expertise in scan-mapping. He will be one of the key members in the team responsible for reducing the SPIRE data.
Alessandro Boselli (Marseille, France—faculty) has experience in multifrequency analysis of large samples of galaxies (UV to radio), in ISM physics and in investigating galaxy evolution. He an associate astronomer on SPIRE and, with Eales, the joint leader of the GT programme, the Herschel Reference Survey, a programme of targeted observations of nearby galaxies.
Malcolm Bremmer (Bristol, UK—faculty) carries out research into the evolution and formation of galaxies, with a particular interest in the very high-redshift universe and galaxy clusters. His experience with high-redshift clusters found in the XMM-LSS survey will be particularly useful in Project B.
Carrie Bridge (Spitzer Science Centre, IPAC,US—post-doc) studies galaxy evolution, with particular interest in galaxy merging and its impact on star formation and AGN. She is has experience with optical to far-IR data and has worked on multi-wavelength surveys such as the CFHTLS, LCIRS, and is the P.I. of the SCOPIC (Study of Close Optical Pairs Imaged in the CFHTLS) program.
Veronique Buat (Marseilles, France—faculty) is an expert in UV (GALEX) and IR (IRAS, Spitzer) studies of galaxies. Her experience in combining UV and IR data to investigate the dust in galaxies will be used in Project A.
Denis Burgarella (Marseilles, France—faculty) carries out research into galaxy evolution, using a combination of UV (GALEX), optical and far-IR (Spitzer) observations. He is a member of the Akari Mission Program and the SPICA study team.
Ray Carlberg (Toronto, Canada—faculty) was a leader of the CNOC cluster survey, the CNOC2 field galaxy survey and the Las Campanas Infrared Survey, which led to the Gemini Deep Deep Survey. Recently he has concentrated on the supernova legacy survey component (SNLS) of the CFHT Legacy Survey, leading a group of post-docs in Toronto. He is interested in cosmology and the mechanisms of galaxy formation and evolution.
Nieves Castro-Rodriguez (IAC, Spain—post-doc) has worked on near-IR instrumentation for ground based tele-

scopes and surveys (DeNIS, TMGS). She also carries out research into the structures of spiral galaxies and into galaxy and cluster evolution.

Pierre Chanial (Imperial College, UK—staff) carries out research into spectral energy distributiosn of galaxies. He is in charge of map making in the SPIRE Instrument Control Centre, and he will be a key individual in the team responsible for the SPIRE data reduction.

Dave Clements (Imperial College, UK—staff) is an expert in the far-IR/submm properties of galaxies and in the multiwavelength study of ULIRGs. He is leading the study of nearby galaxies with Planck. He is also in charge of the SPIRE pipeline processing software as DAPSAS (London) Manager. This includes work on mapmaking software which will be critically important for this project. He will manage the the reduction of the SPIRE data. He is also the joint leader of the H1K-Planck collaboration (Programme B).

Asantha Cooray (UC Irvine, US—faculty) has worked on predictions of the clustering of far-IR sources and unresolved fluctuations and contributed to the development of the halo model for galaxy statistics. He is the joint leader of the H1K large-scale structure team (Programme E) and is the US P.I.

Luca Cortese (Cardiff, UK—post-doc) is a scientific associate of the GALEX mission. His main research interests are in the multi-wavelength study of environmental influences on galaxy evolution and in the attenuation of UV emission by dust in star forming galaxies.

Gavin Dalton (Oxford, UK—faculty) has worked in visible/near-IR survey cosmology for 20 years, including the 2dFGRS, UKIDSS, VISTA and FMOS surveys. He is currently co-I. on four of the six ESO public surveys planned for VISTA, and co-P.I. of the FAST-SOUND large scale structure survey proposed for SUBARU's FMOS instrument.

Helmut Dannerbauer (MPIA, Germany—post-doc) is an expert on local ULIRGs and on submm/mm bright galaxies and QSOs at high redshift. He is a member of the PACS Instrument Control Centre as Instrument Specialist and Calibration Scientist. He is a key member of the team responsible for the PACS data reduction.

Jon Davies (Cardiff, UK—faculty) led the group carrying out most of the early SCUBA observations of nearby galaxies. He is P.I. of the Arecibo AGES HI survey. His experience of HI observations of the nearby universe will be an asset in Programme A.

Gianfranco De Zotti (INAF, Padova, Italy—faculty) is an expert in physical models of the multifrequency evolution of extragalactic sources (galaxies and AGNs, including radio sources) and in the clustering properties of extragalactic sources, particularly in the far-IR/sub-mm region. He is a Planck co-I. and has been coordinating, with J. Delabrouille, the Planck working group responsible for producing simulations of the sky (including zodiacal light, Galactic emissions, extragalactic point sources and SZ effects) over the whole frequency range covered by Planck (30 -860 GHz; 1 cm -350 μm) and in constructing algorithms for separation of all foreground emissions present in Planck maps. He is the joint leader of the H1K-Planck collaboration (Project B).

Hervé Dole (IAS, France—faculty) has extensive experience in IR/submm cosmological data (ISO, Spitzer). He recently constrained the cosmic far-infrared background shape using a stacking analysis, and participated in the analysis of CfIRB fluctuation with Spitzer. His experience in stacking will be invaluable in several projects. principally A and D.

Simon Driver (St. Andrews, UK—faculty) is an expert on the properties, evolution and formation of galaxies from an empirical perspective and based predominantly on optical and near-IR data. He is P.I. of the GAMA survey which has been approved for time on the AAT and which will be providing $\simeq$7000 redshifts for the H1K. He is co-I on the VISTA infrared survey, VIKING, that will cover the southern and equatorial H1K fields.

Jim Dunlop (UBC, Canada—Canada Research Chair) has worked in extragalactic astronomy and observational cosmology for over 20 years, and has played a leading role in the study of galaxy and AGN evolution via surveys at radio, submm, infrared and optical wavelengths. He is currently P.I. of the SCUBA HAlf Degree Exragalactic Survey (SHADES), co-P.I. of the SCUBA-2 Cosmology Legacy Survey, P.I. of the Spitzer Legacy Survey of the UKIDSS UDS field, and co-P.I. of the UltraVista near-infrared survey of the COSMOS field.

Simon Dye (Cardiff, UK—post-doc) is an expert in gravitational lensing. In particular, he was one of the inventors of the semi-linear inversion method that we will use to reconstruct the structures of the lensed sources. He is the joint leader of our lensing programme (Programme C).

Loretta Dunne (Nottingham, UK—faculty) is an expert in submm and far-IR galaxy studies, both in the local and distant universe. She led the SCUBA Local Universe Galaxy Survey, which produced the first direct measurements of the submm luminosity and dust mass functions. She was also a co-I. in the CUDSS and SHADES deep submm surveys, the JMCT Nearby Galaxy Legacy Survey and the SCUBA-2 Cosmology Legacy Survey. She is the co-P.I. of the H1K, with particular responsibility for the scientific leadership of Programme A.

Steve Eales (Cardiff, UK—faculty) has extensive experience in submm astronomy. He was the joint leader (with Simon Lilly) of the Canada-UK Deep Submillimetre Survey. He is also a co-I in the SHADES deep submm survey, the JCMT Nearby Galaxy Legacy Survey and the SCUBA-2 Cosmology Legacy Survey. He is an associate astronomer in the SPIRE science team and joint leader (with Boselli) of the GT programme, the Herschel Reference Survey, a programme of targeted observations of low-z galaxies. He is co-P.I. of the H1K, with particular responsibility for the delivery of the legacy data products. His location at the SPIRE P.I. institute will be of great practical benefit in carrying this out in an efficient and timely way.

Nye Evans (Keele, UK—faculty) works on IR and sub-mm observations of evolved stars in the field and in globular clusters and on classical and recurrent novae. He has an interest in the way in which evolved and eruptive stars sculpt the surrounding medium, and has participated in a sub-mm survey of the Galactic Plane with JCMT/SCUBA and SEST.

Duncan Farrah (Sussex, UK—STFC Advanced Fellow) works on observational studies of the relationship between the formation and evolution of active galaxies and the evolution of large-scale structures at high redshift, particularly at infrared wavelengths. He is leading the data reduction and analysis effort for a 292 hour Spitzer imaging survey of the UKIDSS Ultra Deep Survey field, and is leading two major mid-IR spectroscopic surveys of high redshift galaxies.

5. List of Consortium Members (cont.)

Dave Frayer (NASA Herschel Science Center, US—staff) is a PACS scientist and is involved in the development of the PACS mapping modules for the pipeline with the Instrument Control Centre. He was the P.I. of the ultra-deep Spitzer-70μm surveys of the GOODS-N+S fields and has extensive experience in carrying out 70μm and 160μm data reduction for the xFLS, GOODS, FIDEL, S-COSMOS, SWIRE, and GOALS Spitzer programs. He is a key member of the team responsible for the PACS data reduction.

Carlos Frenk (Durham, UK—faculty) works on modelling the formation of galaxies and large-scale structure. He uses cosmological simulations (including N-body and hydrodynamic methods) and semi-analytic techniques to make theoretical predictions, based on the cold dark matter cosmological model, that can be directly compared with observations over the entire wavelength range, from the UV to the sub-mm. He has participated in a number of large galaxy surveys such as QDOT, PSCZ and 2dFGRS. His work on semi-analytic simulations will be used in Programme A.

Yu Gao (Purple Mountain Observatory, China—staff) will work on a follow-up spectroscopic programme to obtain redshifts for the H1K sources, using the new 4000-fibre spectrometer, LAMOST, at the National Astronomical Observatories of China.

Jonathan P. Gardner (Goddard, US—staff) is an expert on galaxy luminosity functions and galaxy counts. He is the Deputy Senior Project Scientist for the James Webb Space Telescope and the Chief of the Observational Cosmology Laboratory at NASA-Goddard. He will facilitate the follow-up of this proposal's discoveries by JWST.

Walter Gear (Cardiff, UK—faculty) has worked in extragalactic submm astronomy for over 20 years, including leading the SCUBA camera team. He has led long-standing studies of both AGN and the ISM of nearby galaxies, and was part of the CUDSS survey team with Eales and also the SHADES survey. He is a co-I on the SPIRE instrument team. His in-depth knowledge of both the hardware and software of submm cameras will be a substantial help to the team responsible for generating the H1K legacy products.

Eduardo Gonzalez-Solares (Institute of Astronomy, Cambridge,UK—post-doc) has worked in the ELAIS (ISO) and SWIRE (Spitzer) extragalactic mid- and far-IR surveys and played a leading role in the optical and near-IR identification and follow-up observations of the detected sources.

Matt Griffin (Cardiff, UK—faculty) is P.I. of SPIRE and has had experience with IRAS, ISO and Spitzer. He was a co-I. on the SWIRE Legacy Survey. His knowledge of every aspect of SPIRE will be a substantial asset in carrying out the H1K.

Evanthia Hatziminaoglou (ESO, Germnay—staff) has experience in the efficient delivery of legacy surveys, including the ESO Imaging Survey and the Spitzer Wide InfraRed Extragalactic Survey (SWIRE). She is an associate astronomer for SPIRE and helped to construct the SPIRE data reduction pipeline.

Dave Hughes (INAOE, Mexico—faculty) is the LMT (Large Millimeter Telescope) Project Scientist, and a co-investigator on BLAST (Balloon-borne Large-Aperture Submillimeter Telescope) and ACT (Atacama Cosmology Telescope). He works on the formation and evolution of submillimeter galaxies and clusters.

Rob Ivison (Astronomy Technology Centre, UK—staff) has investigated the properties of submillimetre galaxies since their discovery in 1997. He has particular expertise in deep radio observations, which will be invaluable in several of the science programmes, in particular Programme C.

Matt Jarvis (U. Herts, UK—faculty) is one of the members of the LOFAR UK management committee and also a member of the SKA science working group. He will help to coordinate future radio surveys with the H1K. He is also co-I on the VISTA-VIKING survey which will survey southern and equatorial H1K fields in five optical and infrared bands. He is the joint leader of our AGN programme (D).

Tim Jenness (Joint Astronomy Center, US—staff) is an expert in submm data reduction having experience with both SCUBA and SCUBA-2. He is also working on variability of blazar sources and submm calibration.

Woong-Seob Jeong (ISAS/JAXA, Japan—post-doc) has experience in far-IR survey processing and data simulations. He is working on AKARI/FIS far-IR all-sky survey.

Sebastian Jester (MPIA, Germany—post-doc) is an expert on optical quasar sureys and member of the SDSS and Pan-STARRS1 collaborations.

Cedric Lacey (Durham, UK—staff) is an expert on theoretical modelling of galaxy formation and evolution. He works on making multi-wavelength predictions of galaxy evolution by combining semi-analytical models of galaxy formation in the CDM framework with radiative transfer calculations of the effects of dust in galaxies, which self-consistently predict galaxy SEDs from the far-UV to the sub-mm. This work will be used extensively in Programme A.

Guilaine Lagache (IAS, France—faculty) is a specialist on the galactic and cosmic diffuse emissions from the IR to the mm (intensities and anisotropies). She is also studying the population of galaxies responsible for the cosmic infrared background (observations and modelisations). She has great experience in data reduction and analysis (e.g. IRAS, COBE, ISO/ISOPHOT, Archeops, Spitzer). She is strongly involved in the Planck project (HFI core team member, photometric calibration). She is the joint leader of our programme on dust and protostars (F).

Andrea Lapi (SISSA, Italy—post-doc) carries out research into galaxy formation and evolution models.

Andy Lawrence (Edinburgh, UK—faculty) is a multi-wavelength astronomer who has three decades of experience in sky surveys, from X-rays through the infra-red to the submm. He is currently P.I. of the UKIRT Infra-Red Deep Sky Survey (UKIDSS), has overall responsibility for the WFCAM science archive, and leads the UK's participation in the international Virtual Observatory initiative.

Myung Gyoon Lee (Seoul National University, Korea—faculty) has worked in extragalactic astronomy and observational cosmology for over 20 years, and is the P.I. of the long term project FOREVER (formation and evolution of galaxies in clusters). He is in charge of the low-redshift clusters in CLEVL, an Akari mission programme.

Lerothodi Leeuw (NASA/Ames, US—post-doc) is an expert in the far-IR/submm properties of nearby galaxies and in the multiwavelength study of elliptical galaxies and active galactic nuclei (AGN).

Steve Maddox (Nottingham, UK—faculty) has extensive experience in the design of photometric and spectroscopic galaxy surveys, optical and near-IR observations and data reduction and statistical analysis of survey data, including estimation of galaxy counts, luminosity functions, correlation functions and other clustering statistics. He led the APM Galaxy Survey and 2dF Galaxy Redshift Survey, and was involved with the PSCz survey. He is the joint leader of our programme on large-scale structure (E).

Bob Mann (Edinburgh, UK—faculty) is a Planck Scientist and is responsible for the collection of optical/near-IR data in support of analysis by the Planck consortium of galaxy clusters and secondary anistropies, notably through his membership of the Pan-STARRS PS1 Science Consortium. His active involvement in the on-going development of the global Virtual Observatory and his expertise in sky survey data management will contribute to ensuring the legacy value of the H1K.

Phil Mauskopf (Cardiff, UK—faculty) has worked on the development of novel instrumentation for far-IR/mm astronomy and the use of this instrumentation to investigate the global properties of the universe and the formation and evolution of structure. He was a founding member and UK-P.I. of the BOOMERANG collaboration that was one of the first instruments to characterise the CMB temperature and polarisation anisotropies.

Thomas Mueller (MPE Garching, Germany—staff) is an expert in solar system astronomy. He is also a member of the PACS instrument team. His expertise on all aspects of PACS will be a substantial asset in reducing the H1K PACS data, which he will manage.

Takao Nakagawa (ISAS/JAXA, Japan—staff) carries out galaxy evolution research through infrared observations. He is a co-PI of the AKARI all-sky survey.

Kouichiro Nakanishi (Nobeyama Radio Observatory, Japan—staff) carries out research into interstellar matter of starburst galaxies in the local and distant universe. He is also involved in the development of mm and submm telescopes.

Kirpal Nandra (Imperial, UK—faculty) carries out research into active galactic nuclei, in particular their relationship to galaxy evolution and their contribution to the extragalactic background. He is P.I. of the Chandra AEGIS survey.

Mattia Negrello (OU, UK—post-doc) is an expert in the modeling of the statistical properties of submm galaxies. His models of the effect of lensing on the submm source counts have shown that the yield of gravitational lenses in samples of bright Herschel sources should be very high. He is the joint leader of the H1K lensing team (C).

Alain Omont (IAP, France—faculty) has worked for 15 years on millimetre studies of high redshift QSOs and galaxies. He is currently involved in various projects in this field with IRAM-MAMBO and IRAM-PdBI and LABOCA, especially for follow-up of sources found in wide-area surveys such as SWIRE and CFHTLS.

Mathew Page (UCL, UK—faculty) has worked on extragalactic surveys ranging in wavelength from the submillimetre to the X-ray. His particular interest is in the evolution of massive black holes and their role in galaxy formation. He is head of the Astrophysics Group at MSSL-UCL, and a co-I. on the Herschel SPIRE instrument team.

Soojong Pak (Kyung Hee University, South Korea—faculty) has extensive experience in infrared astronomical instrumentation. Since Feb 2000, he has participated in the Japanese infrared space telescope project, Akari.

Pasquale Panuzzo (CEA Saclay, France—staff) has expertise in nebular astrophysics, in dust radiative transfer and population synthesis modelling. He is a SPIRE associate scientist, and full-time developer of SPIRE data reduction software. He also helped in developing the PACS simulator and is contributing to the HCSS development. He is a key member of both our PACS and SPIRE data-reduction teams.

Guillaume Patanchon (Laboratoire APC, Paris—faculty) is a member of the BLAST and Planck consortia. She has spent the last few years developing a map-making code for BLAST, which produces data very similar to SPIRE data.

John Peacock (Edinburgh, UK—faculty) is experienced in the confrontation of theoretical models of cosmological structure formation with data from galaxy surveys. Following the success of the 2dF Galaxy Redshift Survey, he is currently working on next-generation deeper redshift surveys (COSMOS, GAMA) and large imaging surveys (Pan-STARRS). The tools he has developed during the course of this work will be invaluable in Programme E.

Chris Pearson (Rutherford-Appleton Laboratory, UK—staff) is an expert in far-IR/submm source count modelling and galaxy evolution. He is a member of the Instrument Control Centre for SPIRE at the Rutherford Appleton Laboratory.

Ismael Perez Fournon (IAC, Spain—faculty) works on infrared and multi-wavelength extragalactic surveys (ELAIS, ISOCAM GT surveys, SWIRE, HerMES, PEP, RIXOS, AXIS, VISTA-VHS, etc.). He is co-I. on Spitzer/SWIRE and Herschel/SPIRE and responsible for the Spanish contribution to the Instrument Control Centres of SPIRE and PACS.

Steve Phillipps (Bristol, UK—faculty) uses optical observations to carry out research into dwarf galaxies, the galaxy luminosity function and galaxy evolution.

Michael Pohlen (Cardiff, UK—post-doc) is the so-called ‘scan map champion’, the main expert in the SPIRE science team on this observing mode and its optimisation. Pohlen will play a central part in the team reposible for reducing the H1K SPIRE data.

Cristina Popescu (University of Central Lancashire, UK—faculty) has developed models for the transfer of radiation and dust emission in galaxies and in hot plasmas, which will be used for the extraction of physical parameters from the SEDs of galaxies measured in Programe A. She is part of the GAMA survey which will be covered by the H1K.

Jean-Loup Puget (IAS, France—faculty) worked on the ISO mid- and far-IR cosmological surveys. He led the team who identified for the first time the cosmic infrared background (CIB) in the COBE-FIRAS data. Since then he has worked with Guilaine Lagache and Hervé Dole on various issues related to the CIB intensity, anisotropies and studies of the nature of the sources. He is the P.I. of the Planck High Frequency Instrument which will provide original data on the power spectrum of the CIB at millimeter wavelengths to be analysed in close connection with the Herschel cosmological surveys. He is also interested in photometric cross calibration issues between Herschel and Planck HFI at overlapping frequencies.

Steve Rawlings (Oxford, UK—faculty) has two decade of experience in exploiting large radio surveys. He currently leads European efforts to simulate the sky to be seen by the SKA and its pathfinders. His main contribution to the H1K will be in organising the analysis of radio data across the survey region from existing facilities (e.g. GMRT) and from planned facilities (e.g. SKA pathfinders).

Giulia Rodighiero (Padua, Italy—postdoc) has experience in IR data processing, in particular data from the ISO and Spitzer deep surveys. She is currently a member of the PACS Instrument Control Centre.

Michael Rowan-Robinson (Imperial College, UK—faculty) has worked on far infrared and submillimetre surveys for 30 years, especialy with IRAS, ISO, Spitzer and SCUBA. He led the ELAIS survey and is Deputy-P.I. on SWIRE.

Anne Sansom (UCLAN, UK—faculty) works with multi-waveband observations to characterize the gas and dust properties in nearby early-type galaxies, as a function of galaxy age. She is an expert at measuring stellar population ages and abundances from optical spectroscopy.

Douglas Scott (UBC, Canada—faculty) is the science lead for the SCUBA-2 data reduction software team and is a coordinator of the SCUBA-2 "SASSy" legacy survey, as well as being a Co-I. on Planck and an associate scientist on SPIRE. He has 15 years of experience in reducing and analysing CMB and sub-mm data.

Stephen Serjeant (OU, UK—faculty) is co-P.I. of the SCUBA-2 All Sky Survey, and is a coordinator of the JCMT Nearby Galaxies Legacy Survey. He is a member of the Akari guaranteed time team, and is leading many areas of Akari's science exploitation. He serves as deputy P.I. for the Planck project on high-z galaxies (working group 6). He led the data analysis for the pioneering submm survey of the Hubble Deep Field North, and subsequently made several important contributions to submm data analysis. He will manage the production of the joint PACS/SPIRE catalogues and is the joint leader of the H1K AGN programme (D).

Bernhard Schulz (IPAC, US—staff) is the leader of the SPIRE instrument team at the NASA Herschel Science Center at IPAC and is an expert in infrared space instrumentation and data analysis. He is a key member of the team that will reduce the SPIRE data.

Ian Smail (Durham, UK—faculty) has investigated the properties of submillimetre galaxies since their discovery in 1997. He is the external project scientist for SCUBA-2 and is leading wide-field SCUBA-2 and LABOCA submillimetre surveys which have direct relevance to the scientific goals of the H1K.

Jason Stevens (Herts, UK—faculty) is an expert in AGN and in the role they play in galaxy formation and evolution. He has extensive experience in far-IR and submm astronomy.

Will Sutherland (QMUL, UK—faculty) has extensive experience in large-scale structure and galaxy surveys including the 2dFGRS. He has been VISTA Project Scientist since 2000, and is the P.I. of the approved VISTA-VIKING survey which will survey the H1K southern and equatorial fields in five optical and near-IR bands.

Tsutomu Takeuchi (Nagoya, Japan—faculty) works on the formation and evolution of galaxies, using both observations and theoretical modeling. He is one of the members of the Japanese Akari team.

Jonathan Tedds (Leicester, UK—faculty) carries out multi wavelength research on galaxies, jointly leading the the XMM Wide Angle Survey (XWAS), which is based on 2dF follow-up of XMM observations. He also leads the UK effort for the European Virtual Observatory Data Centre Alliance.

Pasquale Temi (NASA Ames, US—staff) is currently the Facility Project Scientist for the Stratospheric Observatory for Infrared Astronomy (SOFIA). His research interests are in the formations and evolution of Elliptical Galaxies.

Mark Thompson (Herts, UK—faculty) is the the co-P.I. of the SCUBA-2 All-Sky Survey (SASSy). He is the joint leader of our programme to look for prestellar core and protostars at high galactic latitude (F).

Richard Tuffs (Max Planck Institute fuer Kernphysik, Germany—staff) has extensive experience in spaceborne FIR astronomy, including development of interactive and pipeline science data analysis for the ISOPHOT instrument. His interests include developing models for the interpretation of dust emission in and around galaxies, which will be used to interpret the SED of galaxies measured in Programme A. He is part of the GAMA survey which will be covered by the H1K.

Mattia Vaccari (Padova, Italy—post-doc) led the ELAIS 15 μm data analysis effort and co-led the SWIRE MIPS 70 and 160 μm data analysis effort. He is a SPIRE associate scientist.

Ivan Valtchanov (ESA, Netherlands—staff) has experience in multi-wavelength data reduction and analysis of galaxy clusters. He is currently an Instrument and Calibration Scientist for the SPIRE instrument on-board Herschel.

Paul van der Werf (Leiden, Netherlands—faculty) carries out research into starburst galaxies and ultra-luminous infrared galaxies (ULIRGs) at low and high redshift, the evolution of dusty galaxies, the interstellar medium of the Milky Way and other galaxies, and infrared instrumentation. He is one of the P.I.'s of the SCUBA-2 Cosmology Legacy Survey.

Eelco van Kampen (Innsbruck, Austria—faculty) is a galaxy formation theorist and observer, with extensive experience in simulating and observing galaxy clusters, sub-mm galaxies, and gravitational lensing. The Innsbruck models will be used in our programme on large-scale structure (E).

Aprajita Verma (Oxford, UK, Post-doc) carries out research into galaxy evolution. She was a member of the team that carried out the European Large Area ISO Survey, and has been a key member of the ISO-SWS team and the ISO Spectrometer Data Centre.

Catherine Vlahakis (Leiden, Netherlands—post-doc) has experience in submm/mm extragalactic astronomy and in the study of dust in local and high-z galaxies, including observations with LABOCA, SCUBA and MAMBO.

Glenn White (OU, UK—faculty) has worked on mm, summ and far-IR galactic and extragalactic submm astronomy for over 20 years, including ground and spaced based instrumentation development. He is also an Associate member on the SPIRE instrument team, a co-I. on the PLANCK HFI instrument, and a member of the AKARI far-IR all sky survey experiment.

Kevin Xu (National Herschel Science Centre, USA—staff) carries out research on the far-IR properties of galaxies, at both low and high redshift. He will contribute to both the H1K data reduction and science analysis.

Yong Heng Zhao (National Astronomical Observatories, China—staff) is the director of LAMOST, the new 4000-fibre spectrometer at the National Astronomical Observatories of China. We will use this instrument, which has a five-degree field, to follow up all the H1K sources in the northern and equatorial fields.

6. Observations Summary List

AOT	Time (hr)	SSOs	Timings	Groupings	Follow-up
SPParallel	1120.2		73	38	

Notes (if applicable): PACS filters to be used are 110 and 170 microns

7. Alternative Observations Summary List

AOT	Time (hr)	SSOs	Timings	Groupings	Follow-up
SPhoto					

Notes (if applicable): Alternative notes.