The SCUBA-2 “All-Sky” Survey

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The sub-millimetre wavelength regime is perhaps the most poorly explored over large areas of the sky, despite the considerable effort that has been expended in making deep maps over small regions. As a consequence the properties of the sub-millimetre sky as a whole, and of rare bright objects in particular, remains largely unknown. Here we describe a forthcoming survey (the SCUBA-2 “All-Sky” Survey, or SASSy) designed to address this issue by making a large-area map of approximately one-fifth of the sky visible from the JCMT (or \( \sim 4800 \) square degrees) down to a 1\( \sigma \) noise level of 30 mJy/beam. This map forms the pilot for a much larger survey, which will potentially map the remaining sky visible from the JCMT, with the region also visible to ALMA as a priority. SASSy has been awarded 500 hours for the 4800 square degree pilot phase and will commence after the commissioning of SCUBA-2, expected in early 2008.

Subject headings:
1. Introduction: The JCMT Legacy Surveys

The James Clerk Maxwell Telescope (JCMT) is in the process of upgrading its instrument suite to include the new wide-field bolometer camera SCUBA-2 (the Sub-mm Common-User Bolometer Array 2; [Holland et al. 2006]). The radically new set of detectors at the heart of SCUBA-2 and its large instantaneous field of view (50 square arcminintes) gives SCUBA-2 a mapping speed some three orders of magnitude larger than its predecessor SCUBA. This vast increase in mapping speed will bring about a new era of wide-field sub-millimetre astronomy and finally brings about the possibility of deep (tenss of mJy) surveys encompassing significant fractions of the sky. Recognising the unique capabilities of SCUBA-2 and the new heterodyne array HARP-B ([Smith et al. 2003]) the JCMT Board called upon the JCMT community to identify and propose an innovative programme of large-scale Legacy Surveys. The JCMT Legacy Survey Programme [1] has recently been ratified by the JCMT Board and consists of seven individual survey projects stretching from an in-depth spectral survey of the 350 GHz band toward a number of star-forming regions and PDRs (the Spectral Legacy Survey; [Plume et al. 2007]) to a nested series of deep 450 & 850 μm cosmology surveys (the JCMT Cosmology Survey). In this paper we describe perhaps one of the most ambitious JCMT Legacy Surveys, a project to map a large fraction of the sky: the SCUBA-2 “All-Sky” Survey, or SASSy.

SASSy is a project designed to use SCUBA-2 to map roughly one-fifth of the sky visible from the JCMT (4,800 square degrees) down to an r.m.s. level of 30 mJy at 850 μm over a two year pilot phase. This pilot phase is intended as a pathfinder to a much larger area survey, perhaps encompassing the entire sky visible from JCMT (23,000 square degrees). We will use the results from the pilot phase to inform the design and strategy of the later

[1] Further details of the JCMT Legacy Survey Programme may be found at http://www.jach.hawaii.edu/JCMT/surveys
survey. SASSy has been awarded 500 hours in which to carry out this two year pilot phase and uses a novel approach to carry out the survey in sub-optimal weather (JCMT Grade 4 weather; $0.12 \leq \tau_{225\text{GHz}} \leq 0.2$). This allows us not only to carry out such a large-area survey at minimal cost to the telescope programme but to also provide an ideal poor-weather backup project, enhancing the productivity of the JCMT’s flexible scheduling. The SASSy Consortium includes over forty astronomers from the UK, Canada & the Netherlands and is led by four coordinators representing the galactic & extragalactic science communities: Mark Thompson, Stephen Serjeant, Tim Jenness & Douglas Scott. SASSy will commence with the rest of the JCMT Legacy Survey programme immediately subsequent to SCUBA-2 commissioning on the JCMT, which is expected to be completed in early 2008.

1.1. The need for an all-sky sub-mm survey

The submillimetre sky remains the most poorly surveyed to date, in contrast to the very successful IRAS (Beichmann et al. 1988), 2MASS (Cutri et al. 2003) and Digitised Sky Survey (DSS) surveys of the mid/far-infrared, near-infrared and visible-wavelength sky. IRAS in particular has proved to be a valuable resource in fields as diverse as solar system studies, star formation and interacting galaxies. The legacy value of these large-scale surveys cannot be understated: even now, over 20 years after the IRAS mission ended, IRAS data are still in active use (e.g. Hwang et al. 2007; Garay et al. 2007; Lowe & Gledhill 2007), and IRAS has generated $>40,000$ citations in refereed journals alone to date. However, whilst IRAS was responsible for ushering in a new era in infrared astronomy, its main limiting factor was the relatively small size of its primary mirror, which imposed the twin problems of coarse angular resolution (typically $\sim3\times5'$ at $100\mu\text{m}$) and limited sensitivity. The strong desire of the astronomical community to overcome these issues can be evidenced in the development of new IRAS resolution enhancement techniques (HIRES,
The four infrared bands surveyed by IRAS opened the window upon the warm and luminous Universe of comets, debris disks, young stellar objects and ultraluminous starbursts. But in the post-IRAS era the development of ground-based millimetre and sub-millimetre astronomy, and in particular the deployment of bolometer arrays like SCUBA, began to reveal a much colder, darker Universe of prestellar and starless cores, infrared-dark molecular clouds, cold dust in nearby galaxies and high-redshift sub-mm galaxies that were either too cold or too faint to be detected by IRAS. Only a miniscule fraction of the submillimetre sky has been explored to any level of detail: although the COBE mission made an all-sky sub-mm map, it did so with only 7° angular resolution (Fixsen et al. 1996). The Planck Surveyor satellite (Tauber 2004) will extend the IRAS infrared coverage to the sub-mm wavelength range. However, Planck’s angular resolution of 5’ in the sub-mm wavelength bands will not improve upon the angular resolution of IRAS and this low angular resolution will subject Planck data to considerable confusion, both within the crowded Galactic plane and to considerable distances away from the plane (here due to cirrus confusion). This not only limits the production of a point source catalogue from Planck data but it is also a factor in the subtraction of the galactic foreground from the CMB measurements which is Planck’s primary goal. So whilst Planck will provide data of exquisite sensitivity and wavelength coverage over the entire sky, the low angular resolution of the satellite limits the study of galactic and extragalactic sources to regions of relatively low cirrus and confusion noise.

The fact that Planck and the Herschel Space Observatory (Pilbratt 2004) share the
same launch vehicle brings about a third area of difficulty. Both missions will begin science operations at approximately the same time, implying that Planck will not be able to act in the same pathfinding role for Herschel that the IRAS satellite did for ISO. The Planck Science Team are investing considerable effort into producing an Early Release Compact Source Catalogue (ERCSC) some 22–24 months post-launch in order to meet the final Herschel Announcement of Opportunity and aid the Herschel community in planning final Herschel observations. However, the ERCSC will be shallower than the final catalogue by approximately an order of magnitude. Only the brightest sources found by Planck will be available for Herschel follow-up before the cryogen supply on Herschel is depleted and the mission is over.

There is thus a pressing need for a sub-millimetre sky survey that is both timely (to capitalise upon Herschel’s limited lifetime) and possesses high angular resolution (to address problems of source confusion and cirrus noise). The sub-millimetre wavelength regime acts as an optically thin tracer of cold dust and as a redshifted tracer of far-infrared emission from distant high-luminosity galaxies and a large area unbiased sub-mm survey will revolutionise many fields in galactic and extragalactic astronomy from the formation of massive stars to the number counts of furiously star-forming galaxies. Such a timely survey has many legacy benefits to a number of planned facilities beyond Herschel; it will act as a sub-mm finding chart for the ALMA interferometer, will provide formidable aid to many of the science goals of Planck by virtue of allowing high resolution foreground subtraction, and will supply lists of potential pointing and flux calibrators to millimetre & sub-millimetre facilities worldwide. SASSy and SCUBA-2 offer the unique opportunity to achieve these goals and add considerable value to some of the most important new facilities in sub-millimetre & far-infrared astronomy (Herschel, ALMA & Planck).
2. Survey Strategy

Even though SCUBA-2 has a mapping power a thousand times greater than that of SCUBA, a considerable amount of time is still required to map sky areas of several thousands of square degrees. One of the major difficulties in designing SASSy was to minimise the impact of such a large-scale survey on the demands for telescope time (particularly in the era of large-scale Legacy Surveys) whilst maximising the potential science benefits that the survey could bring. It was decided that the central role of SASSy was to be a pure detection experiment aimed at relatively bright galactic and extragalactic sources. By restricting SASSy to 850 \( \mu \text{m} \) observations alone, it becomes possible to use the capabilities of SCUBA-2 to work in less favourable weather conditions than the traditional weather bands usually reserved for SCUBA, which not only increases the observing efficiency of the facility by increasing the amount of available observing time, but also provides a poor weather fallback project against which other observations can be flexibly scheduled.

There are four new qualities of SCUBA-2 which make this possible: *i*) the SCUBA-2 detectors sample data at 200 Hz, which is faster than the “knee” in the atmospheric power spectrum *ii*) SCUBA-2 has many more pixels than SCUBA, which will improve the cancellation of sky noise; *iii*) the SCUBA-2 pixels are inherently more sensitive than those of SCUBA (by around a factor of 3–5); and *iv*) the total power operation of SCUBA-2 removes the need for multiple scans to remove chopping artefacts. All in all these features combine to make Grade 4 SCUBA-2 850 \( \mu \text{m} \) operations roughly equivalent to SCUBA in Grade 2 weather. Working in Grade 4 weather conditions does not compromise the science goals of SASSy; the forecast sensitivity and mapping speed of SCUBA-2 and scan-rate means that it is possible to reach a 1\( \sigma \) noise of 30 mJy/beam over the survey area within a reasonable period.

Using a conservatively scaled Noise Equivalent Flux Density (NEFD) of 50 mJy Hz\(^{-1/2}\)
for $\tau_{225\text{GHz}} = 0.2$ and an observing efficiency of 60% we estimate that we will be able to map an area of 10 square degrees to an r.m.s. noise level of 30 mJy/beam in one hour of observing time. This sensitivity level is desirable for a number of reasons: it is directly comparable to the end-of-mission sensitivity of the 850 $\mu$m channel of Planck Surveyor (Tauber 2004); it is similar to many of the earlier unbiased star formation surveys with SCUBA (e.g. Mitchell et al. 2001; Johnstone et al. 2004; Hatchell et al. 2005); 5 $\sigma$ detections from this flux level (i.e. 150 mJy/beam) are at the level at which the number counts of sub-mm galaxies are at their most uncertain (see Sect. 3 and 4) and at which the number of gravitationally lensed sources peaks (according to the model of Perrotta et al. 2003); and it is sufficient to detect solar-mass star-forming cores out to a distance of 1 kpc and massive star-forming cores ($\sim 400 M_\odot$) to the far edge of the Galaxy. This sensitivity level is also a natural choice in terms of likely observing modes as it represents the noise level obtained by mapping a given region three times at the nominal scan rate of SCUBA-2.

We will operate SASSy in fully flexibly-scheduled mode to optimise the efficiency of the survey, i.e. target fields will be selected based purely upon the current weather conditions (within our allocated band $0.12 \leq \tau_{225\text{GHz}} \leq 0.2$) and elevation. We will also use the full width of our weather band to ensure an even survey depth: fields at high airmass will be mapped at low values of $\tau_{225\text{GHz}}$ and vice versa.

### 2.1. 2 year pilot phase

In common with many of the other JCMT Legacy Surveys SASSy is split into a two year pilot phase and a follow-on phase. During its 2 year pilot phase SASSy will concentrate upon mapping two 10° wide strips of sky encompassing 4850 square degrees, or roughly a fifth of the sky visible to the JCMT. Both strips will be mapped to the same depth of 30 mJy/beam. Each of these strips is shown in Figure 1 with a scale representation of the 25
square degree area that SCUBA mapped in its 8 year lifetime. The average depth of the entire 25 square degree SCUBA archive is \( \sim 30 \text{ mJy/beam} \) (Johnstone, priv. comm.) and so the pilot phase of SASSy may be thought of as compiling the equivalent of 194 SCUBA archives in just 2 years. The pilot phase allows us to complete a number of the science goals of SASSy (see Sect. 3) and will provide early self-contained source catalogues from each mapped strip.

The first \( 10^\circ \) wide strip is centred on the Galactic plane, running from \( 0^\circ \leq l \leq 245^\circ \) and with \( |b| \leq 5 \). This strip is informally known as GP-Wide and is perfectly matched in latitude to the MSX mid-infrared (Price et al. 2001) and UKIDSS near-infrared Galactic Plane Surveys (Warren et al. 2007). The second strip is perpendicular to the Galactic Plane and takes the form of a great circle passing through the North Ecliptic Pole (at \( l = 96^\circ \)), North Galactic Pole and South Galactic Pole. This strip is informally known as Pole-to-Pole and is truncated at both ends by the declination limit of the survey (\( \delta \geq -30^\circ \)). As SASSy will be observed in Grade 4 weather we have chosen stringent declination limits to avoid observing low-lying target fields with too large an airmass. The Pole-to-Pole strip is chosen to pass over the North Ecliptic Pole as this is where the Planck Surveyor will obtain one of its deepest survey regions (Taufen 2004). In addition, a number of high-latitude cloud complexes are known to lie within the Pole-to-Pole strip, including a portion of the largest and most molecule-rich complex, MBM 53–55 (Chastain et al. 2006), and the Pegasus and Lacertae high-latitude clouds (Dame et al. 2001).

SASSy has been awarded 500 hours of Grade 4 weather to complete this 2 year pilot phase, which should commence with the successful commissioning of SCUBA-2 on the JCMT in early 2008.
2.2. The “All-Sky” Survey phase

We will use the results from the 2 year pilot survey to inform our later strategy for a larger area survey. The source counts of bright sub-mm galaxies and isolated protostars are currently extremely uncertain and the data from the pilot survey are needed to plan the most effective followup survey, e.g. whether to go deeper or shallower, or to prioritise areas such as low galactic latitudes, etc. One option for the following survey (shown in Fig. 2) is to cover the remaining sky visible from the JCMT to the same target depth as the pilot survey, i.e. to a depth of 30 mJy, focusing first on the region of sky visible to both ALMA and the JCMT (an equatorial band with $-30^\circ \leq \delta \leq +40^\circ$), then completing the northern cap which is not visible from ALMA ($+40^\circ \leq \delta \leq +70^\circ$). The extreme northern latitudes ($\delta \geq 70^\circ$) lie outside our elevation limits for the survey, although if it becomes desirable to complete the survey to high latitude it is possible to achieve this at lower elevation in better weather conditions. This strategy allows us to focus our attention upon those regions of sky which offer the most legacy benefit to future facilities such as ALMA and CCAT, whilst maintaining a sufficient survey depth to achieve the unbiased survey of star formation that is the central goal of SASSy.

Fig. 1.— Two views of the IRAS 100 $\mu$m sky survey, showing the areas to be mapped during the 2 year pilot phase of SASSy. Each strip is $10^\circ$ wide and is terminated by the planned declination limit of the survey ($\delta \geq -30^\circ$). The GP-Wide is centred on the Galactic Plane running from $0 \leq l \leq 245$ and the Pole-to-Pole strip is centred on the North Ecliptic Pole ($l = 96^\circ$). For comparison, the black central square shows to approximate scale the 25 square degree area that was mapped by SCUBA in its entire 8 year lifetime.
3. Science Goals of SASSy

The main science goal of SASSy is to perform an unbiased search for star formation across the sky, whether the star formation is located in massive Infrared Dark Clouds (IRDCs), in known molecular clouds, isolated from known regions, or in furiously star-forming galaxies at high redshift. Our secondary goal is to search for emission from cold dust that was missed by IRAS, either due to its low sensitivity to cold dust or its high level of confusion, and hence to reveal the presence of as yet unknown cold molecular cloud cores in our Galaxy and cold dust in nearby galaxies. To achieve these goals we will produce a sensitive large-area unbiased 850 µm map of a large fraction of the sky (ultimately all of the sky visible from the JCMT), exploiting the two properties of 850 µm emission as both an optically thin mass tracer in the local Universe and as a redshifted tracer of the strong far-infrared emission from distant ultraluminous galaxies. The organisation and science working groups of SASSy are split into galactic and extragalactic science themes and we outline the science goals of each theme below.

3.1. Galactic Science Goals

The main Galactic science goal of SASSy is simply to answer the question: where do stars form in our Galaxy? The major sites of star formation as revealed by IRAS are dark and giant molecular clouds, but in more recent years it has become apparent that stars...
are forming in a range of environments unseen by IRAS, e.g. IRDCs (Carey et al. 2000), high galactic latitude molecular ”cirrus” clouds (Heithausen et al. 2002), and isolated regions far from known star-forming complexes (e.g. the distributed T-Tauri problem of Feigelson 1996). One recently discovered and telling example is the isolated candidate class I protostar, 2MASS 0347392+311912, found by Young et al. (2006) during the Spitzer Legacy Survey Cores to Disks. This object was discovered accidentally during ancillary SCUBA observations of Perseus molecular cloud cores when the coordinates of a core within Perseus were incorrectly entered. 2MASS 0347392+311912 lies some 30′ from the bulk of the molecular gas in the Perseus East complex (as shown in Fig. 3) but has an SED characteristic of a class I protostar with an 850 µm flux of over 0.2 Jy (Young et al. 2006). However, 2MASS 0347392+311912 is but one example of a serendipitous discovery; how many more isolated examples of star formation are there in our Galaxy and what is the fraction of stars that form in such isolated environments?

SASSy aims to answer these questions by providing a relatively unbiased volume-limited sample of star forming cores (like 2MASS 0347392+311912), in the sense that 850 µm continuum emission is sensitive to both the warm and cold proto- and prestellar dust cores enshrouding the early stages of star formation. Such a survey will reveal the whole panoply of Galactic star formation from isolated star-forming regions, to diffuse high latitude clouds and giant molecular clouds. Comprehending star formation in all its environments is crucial to our understanding of the formation of molecular clouds and their evolution throughout the galactic ecology. We will obtain a true volume-limited sample only with the results from the “All-Sky” survey, but in the pilot phase we will begin by compiling censuses of IRDCs

Fig. 3.— The Eastern half of the Perseus molecular cloud in $^{13}$CO J=1–0 emission, taken by the COMPLETE survey (Ridge et al. 2006). The circle indicates the position of the SCUBA detection of 2MASS 0347392+311912 by Young et al. (2006).
found in the GP-Wide strip and high-latitude star formation in the Pole-to-Pole strip.

IRDCs were first found as patches of extinction in the mid-infrared MSX Galactic Plane survey (Egan et al. 1998). Since their discovery a number of IRDCs have been shown to be dense, cold, gravitationally bound molecular cloud cores that may be intimately involved with the earliest stages of massive star formation (Price et al. 2002; Pillai et al. 2006; Rathborne et al. 2006). Over 10,000 candidate IRDCs have been identified in the MSX Galactic Plane survey (Simon et al. 2006), but because these objects have only been observed in extinction against the Galactic Plane we cannot be certain of their true distribution. In order to be detected in mid-IR extinction the IRDCs must be highly contrasted against the diffuse emission from the Galactic Plane. IRDCs that are distant (with most of the diffuse emission along the line of sight in the foreground) or IRDCs located in the Outer Galaxy (where the diffuse emission is weak) were not detected by MSX. This effect can be seen in Fig. 7 of Simon et al. (2006), where the distribution of IRDCs is seen to clearly follow that of the diffuse Galactic emission in both galactic latitude and longitude. Indeed, less than 1% of the known IRDCs are located in the Outer Galaxy. An uncertain fraction of the candidate IRDCs found by Simon et al. (2006) may simply be voids in the complex small-scale emission of the Galactic Plane.

Obtaining a reliable catalogue of IRDCs which reveals their true distribution in the Galaxy, their physical properties and their star-forming nature is crucial to understanding the relationship of these clouds to the star formation cycle and to Galactic evolution as a whole. IRDCs are known to emit strongly in sub-mm continuum (Rathborne et al. 2006) and as the GP-Wide strip of SASSy is perfectly matched in latitude to the MSX Galactic Plane survey strip ($|b| \leq 5^\circ$) we will be able to compile such a catalogue of IRDCs by comparing the SASSy 850 µm images with the MSX Galactic Plane Survey mid-IR images.

In the Pole-to-Pole strip we will investigate the star-forming potential of high-latitude
clouds by performing an unbiased search for protostellar cores and sub-Jeans mass cores within and near these clouds. A number of known high-latitude clouds lie within the Pole-to-Pole strip, including the eastern portion of the MBM53–55 complex, the Lacertae and G272.9+29.3 clouds, and the MBM26, 32–33, 43 and 44 clouds. These high-latitude clouds form a distinctly local population approximately 200 pc distant and the sensitivity limits of SASSy are such that we will be sensitive to sub-Jeans mass cores and circumstellar discs such as those found in MBM12 by Hogerheijde et al. (2003). SASSy will thus perform a sensitive search of these clouds for dust emission from both embedded cores and young stellar objects. We will correlate the positions of detected objects in SASSy against the known high latitude clouds from Magnani et al. (1996) and Dobashi et al. (2005) to determine whether there is indeed an unknown population of star formation in high-latitude cirrus clouds or small molecular cloudlets.

3.2. Extragalactic Science Goals

The main extragalactic science goals of SASSy are to discover new and extreme populations of rare galaxies and to provide high-resolution maps of Galactic foregrounds as an input to Planck Surveyor. By virtue of the extremely large area that will be surveyed, SASSy has a tremendous potential for detecting objects that are too rare to have been found in the current and planned deep pencil-beam extragalactic surveys (e.g. the 8mJy survey, Scott et al. 2002; SHADES, Mortier et al. 2005). These rare sources include extreme luminosity galaxies at high redshift, strong gravitational lenses and potential cold local ultraluminous galaxies. The depth of SASSy is carefully optimised to detect extragalactic populations that are inaccessible to the JCMT Cosmology Legacy Survey. Between 0.2 and 1 source (Rowan-Robinson 2001; Pearson 2005 respectively) at a flux level of 150 mJy is expected to be found in the 20 square degree JCMT Cosmology Survey, whereas in the
130 times larger Pole-to-Pole strip we would expect to find between 30 and 130 sources for these two representative models. SASSy is thus a valuable adjunct to much deeper narrower surveys and the ensemble of surveys makes it possible to sample the complete range of sub-millimetre galaxy properties.

The 2300 square degrees of the Pole-to-Pole strip at $z > 0.5$ comprises a comoving volume some six times that of the entire $z < 0.5$ Universe. For the sky visible from JCMT this rises to some 54 times the $z < 0.5$ comoving volume. With SASSy we will therefore have the remarkable potential to find galaxies that are too rare to have any local counterparts. By sampling these extreme objects, the properties and trends which are only weakly apparent in the existing SCUBA population will become much more apparent. We will confirm the high redshift of detected objects using a new photometric redshift estimator; objects detected by SASSy but undetected by the Akari survey must be high-redshift ($z \gtrsim 2$) hyperluminous systems. The high-luminosity galaxies detected by SASSy will also be much easier follow-up targets than other SCUBA/SCUBA-2 galaxy populations, e.g. to determine redshifts without recourse to optical IDs via millimetre-wave CO lines (providing a bright target list for commissioning the ALMA CO redshift technique).

The right-hand panel of Fig. 4 shows the current constraints on the sub-mm number counts for high-redshift objects, compared to several source count models (Rowan-Robinson 2001; Pearson 2005; Granato et al. 2001) which have been constrained to reproduce the observed $<10$ mJy counts, and reproduce them very well. However, at higher fluxes they diverge wildly. The left-hand panel of Fig. 4 shows the Pearson and Rowan-Robinson models plotted against the observational constraints of high-redshift SCUBA galaxy surveys (Scott et al. 2002; Cowie et al. 2002; Barger et al. 1999; Webb et al. 2003; Barnard et al. 2004); local galaxy source counts derived by Serjeant & Harrison (2005); an estimate of the radio-loud AGN source counts derived from SED fits to the objects listed in
Fig. 4.— (Left) Integral source counts, normalised to the Euclidean slope. The red curve is the prediction from Rowan-Robinson (2001), and the green curve is from Pearson (2005). (Right), as left, except the Pearson and Rowan-Robinson models have been restricted to $z > 0.5$, and in addition are overplotted: a Schechter function fit (blue) to the high-$z$ counts; a broken power-law fit (magenta); and the Granato et al. (2001) model (brown, extrapolated from published curve at fluxes >30mJy).
the WMAP point source catalogue; and an estimate of the radio source counts derived from BOOMERANG. Local galaxies are distributed with a Euclidean slope, i.e. along a horizontal line, while deviations above the horizontal line are indications of high-redshift, high-luminosity populations. There is a substantial gap between the high-redshift and low-redshift populations (at $S_{850} \sim 0.1 \, \text{Jy}$) which no previous survey has been able to constrain.

The main physical differences between the models lie in the assumptions on the feedback processes and IMFs. Even at the $\sim 10 \, \text{mJy}$ level, these processes are parameterised in an “ad hoc” and semi-empirical way. SASSy will be the first survey to determine whether feedback processes provide an upper limit to the star formation rate in a galaxy and the first survey to uncover the source counts in the 150 mJy regime on the approach to the Euclidean slope, that is missing from both panels in Fig. 4.

The high redshift luminous sub-mm galaxies that SASSy will detect are highly likely to be strongly gravitationally lensed and SASSy offers a unique survey for rare high luminosity strong lenses. The statistics of these lensing sources are a powerful probe of the geometry of the Universe (e.g. Gott et al. 1989; Fukugita et al. 1992). This is illustrated in Fig. 5, which shows the Granato et al. (2004) model scaled to the source counts of Coppin et al. (2006). SASSy will detect on the order of 40 strongly lensed (i.e. gravitational amplification $\geq 2$) proto-spheroidal galaxies in the “All-Sky” Survey phase (Negrello et al. 2007). SASSy is thus ideally placed to find this undiscovered population of bright lensed sub-millimetre galaxies and to use them to place new constraints on cosmological parameters such as $\Omega_\Lambda$.

High redshift sub-mm galaxies will form an important component of SASSy, but we expect that the majority of extragalactic sources detected by SASSy will be bright flat-spectrum blazars (otherwise known as BL Lac objects or blazars). According to the predictions of Negrello et al. (2007) and de Zotti et al. (2003) at a limiting flux level of
Fig. 5.— Source counts from Coppin et al. (2006) plotted with a solid line showing source count models of high-z protospheroids from Granato et al. (2004), rescaled to fit the source counts of Coppin et al. (2006). The dashed line shows the prediction for strongly lensed protospheroids from Negrello et al. (2007). The vertical line shows the 5σ depth of SASSy. The Negrello et al. (2007) model predicts that on the order of 40 strongly lensed protospheroids will be detected in the “All-Sky” phase.
150 mJy/beam we will detect on the order of 0.054 blazars deg$^{-2}$, which evaluates to 200-300 bright blazars in the GP-Wide and Pole-to-Pole strips. Recent wide-field MAMBO observations have uncovered a surprising overdensity of millimetre bright blazars (Voss et al. 2006) and SASSy will confirm the number counts of these bright blazars. Sub-mm bright blazars are excellent candidates for ALMA phase calibrators due to their high brightness temperatures and consequent small emitting areas (Holdaway et al. 2004). The 20 000 square degrees of the "All-Sky" phase of SASSy will contain on the order of a thousand new potential phase calibrators for ALMA.

Finally, SASSy will also search for the existence of cold local galaxies that were not detected by IRAS. Sub-millimetre surveys of the local Universe have so far mainly been based upon the IRAS point source catalogue (e.g. SLUGS; Dunne et al. 2000) or on HI catalogues (e.g. SINGS; Kennicutt et al. 2003). However, recent searches for Type Ia supernova hosts have been uncovering galaxies dominated by cold $\sim$20 K dust, and with high $L_{850}$ at $z=0.5$ (Farrah et al. 2004). Similar galaxies at $z=0.1$ would have $F_{60} \sim 70$mJy, and so would not appear in any of the IRAS galaxy catalogues, but they would have 850$\mu$m fluxes detectable by SASSy. Are there populations of cold, ultraluminous galaxies in the local (i.e. $z \sim 0.1$) Universe? The only way to determine this is with a large area, shallow survey such as SASSy.

### 3.3. Legacy value

The wide area coverage and unbiased nature of SASSy will not only be instrumental in addressing the Galactic and Extragalactic science goals outlined above, but will also be of significant value to the wider astronomical community. IRAS shows the enduring value of wide area surveys in new wavelength ranges; the IRAS mission has generated over 40 000 citations since its launch over 20 years ago and the rate of these citations has remained
almost constant over the years, reflecting the strong legacy value of IRAS data to the entire astronomical community. SASSy aims to fulfil a similar goal in the sub-millimetre.

SASSy will act as a finder chart of bright sub-mm sources for ALMA and future instruments, will provide target lists of dense galactic cores and luminous galaxies for future study with infrared, radio and millimetre facilities, will supply catalogues of compact and point-like sub-mm sources that could be used as flux and pointing calibrators by millimetre and sub-millimetre telescopes worldwide (including CCAT, LMT, ALMA and Planck Surveyor). SASSy will also supply a map of the cold dust emission at small scales over a large fraction of the sky and, as such, will be a valuable addition to the all-sky dust extinction maps that the GAIA mission will produce and a valuable augmentation to the Virtual Observatory at sub-mm wavelengths. It is the hope of the SASSy Consortium that data from SASSy will be used as a lasting legacy well beyond the lifetime of the JCMT.

4. Survey Timeline & Data Products

SASSy will commence with the rest of the JCMT Legacy Survey programme following the successful commissioning of SCUBA-2, which is currently in the final stages of assembly for delivery to the telescope in late 2007. Full survey operations are expected to commence in early 2008 after the installation of the full complement of SCUBA-2 sub-arrays. We thus expect to complete the pilot phase of SASSy, along with the remaining JCMT Legacy Surveys, mid-way through 2010. The JCMT Board has agreed a proprietary period of one year following the acquisition of the last JCMT Legacy Survey data and so the raw and reduced data will nominally be released in 2011. The data products returned from SASSy will take the form of compact and point source catalogues at 850 $\mu$m and image tiles. To achieve our science goals we will also need to discriminate between galactic and extragalactic 850 $\mu$m emission, particularly at high galactic latitudes. For this we will use existing archival
CO and HI surveys (e.g. the International Galactic Plane Survey\(^2\)) to correlate the 850 µm emission against, obtaining new data at high latitudes where necessary.

However, our goal is to release data from SASSy in advance of this date, available manpower permitting. As already mentioned in the Introduction, SASSy offers the crucial opportunity to provide a sub-millimetre survey catalogue before the final Herschel Announcement of Opportunity. We will release our data in advance of this Announcement so that the wider community can fully exploit the legacy of SASSy with Herschel. In addition, it may be possible to complete the pilot phase of SASSy early as we will be observing in a fully flexibly-scheduled mode. The Mauna Kea weather statistics over the last several years suggests that 15–20% of time falls within the Grade 4 weather band. Assuming 300 observing nights per year, this results in \(~500\) hours of Grade 4 observing time per year. If the pressure upon the Grade 4 weather band is low (for example, following the retirement of the low frequency single-pixel receivers on JCMT) then the pilot phase of SASSy may be completed well within 2 years.

\(^2\)http://www.ras.ucalgary.ca/IGPS/
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