# The JCMT Debris Disk Survey Summary

Coordinators: J.Greaves (St. Andrews, UK), W. Holland (ROE, UK) & B. Matthews (HIA, Canada)

The JCMT Debris Disk Survey utilizes 390 hours to observe 500 nearby stars (the 100 nearest M, K, G, F and A stars) to the confusion limit (0.7 mJy beam$^{-1}$ rms) at 850 $\mu$m to detect and map circumstellar dust. This is the first unbiased survey for debris disks since the *InfraRed Astronomical Satellite*, which discovered this class of object around Vega in 1983. Any deep (i.e., 45 minute) observations at 850 or 450 $\mu$m (because 850 $\mu$m is simultaneously observed) with a survey target anywhere in the field of view should be considered a conflict with the survey. Significantly more shallow observations which include these fields should not be considered a conflict (unless their stated goal is detection of a disk around our target star) as they cannot meet the goals of the survey. The survey fields will also be searched for serendipitous detections of high-z galaxies.

## 1. Brief Introduction to Debris Disks and Submillimetre Observations

Debris disks are the dust disks found around many nearby main sequence stars. The dust is short-lived and so must be continuously replenished by the destruction of comets and asteroids in these systems, deduced to lie in fairly narrow belts between tens and hundreds of AU from the host stars. The *InfraRed Astronomical Satellite (IRAS)* was the first and only large unbiased survey of debris disks, showing that they occur around $\sim$ 15% of nearby stars (Aumann et al. 1984). Submillimeter observations have been pivotal in follow-up studies of these disks, having imaged/discovered seven of the ten resolved disks (Holland et al. 1998; Greaves et al. 1998; Sheret et al. 2004), and also determined the mass and temperature and hence radial extension of many of the remainder. Furthermore, there appears to be a substantial population of disks too cold to have been detected by IRAS and which are only accessible to submillimeter observations (Wyatt et al. 2003) surrounding a further 5-15% of stars. The submillimetre regime is ideal for the detection of debris disks because the observed flux contains negligible contributions from the stellar photosphere or background cirrus, unlike the far-IR. The flux detected is completely dominated by the disk, and thus we can survey any star visible to the JCMT.

The study of these disks is revolutionizing our understanding of planet formation. For the ten or so disks which have been resolved, observed structures have even been used to pinpoint the location of unseen planets (e.g., Wyatt 2003). Many more disks have been characterized by their spectral energy distributions (SEDs) showing that they are the extrasolar equivalents of the Kuiper and asteroid belts of the Solar System. The radial locations and masses of these belts, particularly when this information can be compared for stars of different ages, spectral types, multiplicity or known planetary companions, provide vital constraints on planet formation processes and on how the resulting planetary systems subsequently evolve.

## 2. Outline of Science Goals

How diverse are planetary systems, why and where does the Solar System fit in the picture? These questions are the drivers for the Debris Disk Survey.

There are five key goals for this survey:

1. to determine unbiased statistics on the incidence of disks around nearby stars;
2. to constrain disk masses and temperatures for far-IR detections (e.g., *IRAS, ISO, Spitzer, Herschel*);
3. to discover numerous disks too cold to detect in the far-IR;
4. to be the basis of source lists for future high resolution observing campaigns using instruments such as ALMA and *JWST*; and
5. to provide limits on the presence of dust that are vital to future missions such as Darwin and the Terrestrial Planet Finder.

## 3. Observational Strategy

The survey uses SCUBA-2 at 850 $\mu$m in weather bands 2 and 3 to look at the 100 nearest stars observable from the JCMT in each of the spectral types A, F, G, K, and M (no later than M7.0) and in luminosity classes V and IV (for A, F and G stars since they are negligibly off the main sequence on an H-R diagram). K subgiants are excluded because they are more than a magnitude brighter than their main sequence equivalents; there are no M subgiants in the sample. The aim is to obtain samples that are statistically robust and can be inter-compared, while keeping the survey completely unbiased with regard to choices of star. This is a unique feature of our survey; no star is rejected because of any of its intrinsic properties. Therefore, young and old stars, single and multiples, and stars with and without giant planets are included in their natural proportions. The nature of the mass function of stars means that the five sub-samples cover different volumes. The distance limits extend out to 47, 25, 21, 16 and 9 pc for A, F, G, K and M stars respectively. *Every target will be observed down to an rms noise level of 0.7 mJy beam*$^{-1}$ *where background confusion becomes signficant.* We estimate approximately 45 minutes will be required per target to reach this rms level.

The targets are all-sky as the furthest distance is 47 pc so there is no clustering of stars towards the Galactic Plane (see Figure 1). The R.A. range of the targets is thus 0h to 24h, and observing runs at any time of the year will yield suitable targets. The declination limits of $-40^\circ$ to $+80\ ^\circ$ ensure that sources rise to at least $30^\circ$ elevation. We will use the practical strategy of starting at the smallest distances and work outward, while maintaining balance among the spectral types. Thus the best resolved disks will be observed first, and these have the highest priority for follow-up imaging. We will make exceptions to this order only in the rare cases where the full SCUBA-2 field of view is required to image all components of a multiple system (since initially SCUBA-2 will have only one subarray with which to work). The number of ultrawide binaries will be very small ($1-2\%$ of systems, Greaves & Wyatt 2003), meaning only 1-2 targets per spectral class will require all four subarrays.

The allocation of 390 hours includes 330 hours during the first two years of SCUBA-2 operations. Of this time, 270 hours is allocated to weather band 3 ($0.08 < \tau_{\rm 225GHz} < 0.12$) and 60 hours is available within better band 2 ($0.05 < \tau_{\rm 225GHz} < 0.08$) weather. The lowest-elevation stars are prioritised for the best conditions. The number of targets that need close observing constraints (having low elevation and

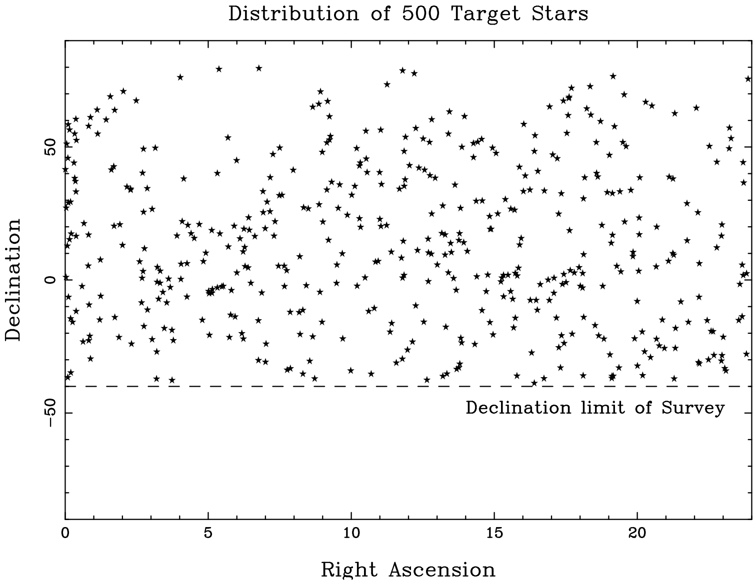

Fig. 1.— The distribution of target sources on the sky is shown. Sources are located in every R.A. and Declination range, so we will be able to observe in all ranges of LST.

thus priority for upper band 2 conditions) is only 10% of the total number of targets. The remaining 60 hours is allocated beyond the first two years of operation in band 2 conditions and will be used to complete the remaining ∼ 15% (furthest) stars and to perform 450 $\mu$m imaging followup on resolved disks.

For a star at a median distance ∼ 15 pc, a 3-$\sigma$ detection of a 2 mJy signal corresponds to 0.002 Earth masses of dust. This is equivalent to the $\epsilon$ Eridani archetype, which lies in the mid-range of dust masses for the handful of detected Sun-like systems (Greaves et al. 2004). The detectable mass is of course modified by dust location and stellar heating, but 15 pc is a useful reference point as it is the far end of planet search distances (the Terrestrial Planet Finder for example). Such limits mean that non-detections result in constraints on dust mass in these systems of typically 200 times the dust content of the solar system, but down to twice the Sun's level for the nearest stars.

## 4. Identification of Conflicts

Any main sequence star of spectral types A, F, G, K or M (earlier than M7) or A, F or G subgiant that lies within our distance and declination constraints will already be one of our approved targets for 850 $\mu$m observations to the confusion limit. Brown dwarfs are actively excluded from our target list, primarily through the cutoff at M7.0V, below which the incidence of brown dwarfs rises significantly and the completeness of the stellar sample becomes an issue. Any 450 $\mu$m observation which would also reach the 850 $\mu$m depth of our survey (i.e., 45 minutes on target) would also be a conflict. A shallow observation at 450 or 850 $\mu$m that happens to include one of our stars should not be considered a conflict, unless it has the stated goal of detecting a debris disk around our target star.

## REFERENCES

Aumann, H.H. et al. 1984, ApJ, 278, 23

Greaves, J.S., et al. 2004, MNRAS, 348, 1097

Greaves, J.S., et al. 1998, ApJ, 506, 133

Greaves, J.S., & Wyatt, M.C. 2003, MNRAS, 345, 1212

Holland, W.S., et al. 1998, Nature, 392, 788

Sheret, I., Dent, W.R.F., & Wyatt, M.C. 2004, MNRAS, 348, 1282

Wyatt, M. 2003, ApJ, 598, 1321

Wyatt M.C., Dent W.R.F., & Greaves J.S. 2003, MNRAS, 342, 876

---

This preprint was prepared with the AAS LaTeX macros v5.0.