HOBYS: the *Herschel* imaging survey of OB Young Stellar objects

Proposal for a Guaranteed Time Key Programme using 126 hours distributed as follows:
- 85 hours of SPIRE Guaranteed Time attributed to the SAG 3 (Star Formation) team,
- 19 hours of PACS Guaranteed Time owned by the LAM/OAMP Marseille,
- 22 hours of Guaranteed Time owned by the *Herschel* Science Centre (HSC).

NB: HOTAC members can contact the coordinators of the "HOBYS" GT Key Programme to access extinction maps on our dedicated website (http://starformation-herschel.iap.fr/).

Table 1: Investigators of the "HOBYS" Key Programme

Name	Affiliation	E-mail address
F. Motte	CEA Saclay/AIM	frederique.motte@cea.fr
A. Zavagno	LAM/OAMP Marseille	Annie.Zavagno@oamp.fr
S. Bontemps	Bordeaux/Saclay	bontemps@obs.u-bordeaux1.fr
A. Abergel	IAS Orsay	abergel@ias.u-psud.fr
P. Ade	Cardiff University	p.ade@astro.cf.ac.uk
Ph. André	CEA Saclay	pandre@cea.fr
J.-P. Baluteau	LAM/OAMP Marseille	jean-paul.baluteau@oamp.fr
J.-Ph. Bernard	CESR Toulouse	Jean-Philippe.Bernard@cesr.fr
L. Cambrésy	CDS Strasbourg	cambresy@newb6.u-strasbg.fr
P. Cox	IRAM Grenoble	cox@iram.fr
L. Deharveng	LAM/OAMP Marseille	Lise.Deharveng@oamp.fr
J. Di Francesco	Herzberg Victoria	james.difrancesco@nrc-cnrc.gc.ca
A. Di Giorgio	IFSI Rome	Anna.DiGiorgio@ifsi-roma.inaf.it
T. Giannini	INAF-Rome	giannini@mporzio.astro.it
M. Griffin	Cardiff University	Matt.Griffin@astro.cf.ac.uk
P. Hargrave	Cardiff University	p.hargrave@astro.cf.ac.uk
M. Huang	NAOC Beijing	mhuang@bao.ac.cn
J. Kirk	Cardiff University	Jason.Kirk@astro.cf.ac.uk
S. Leeks	HSC	sleeks@sciops.esa.int
J. Li	NAOC Beijing	ljz@bao.ac.cn
A. Marston	HSC	tmarston@sciops.esa.int
P. Martin	CITA Toronto	pgmartin@cita.utoronto.ca
A. Men'schikov	CEA Saclay	alexander.menshchikov@cea.fr
V. Minier	CEA Saclay	vminier@cea.fr
S. Molinari	IFSI Rome	molinari@ifsi-roma.inaf.it
G. Olofsson	Stockholm Observatory	olofsson@astro.su.se
A. Omont	IAP Paris	omont@iap.fr
P. Persi	IASF-Roma/INAF	paolo.persi@iasf-roma.inaf.it
S. Pezzuto	IFSI Rome	pezzuto@ifsi-roma.inaf.it
D. Russeil	LAM/OAMP Marseille	delphine.russeil@oamp.fr
P. Saraceno	IFSI Rome	Paolo.Saraceno@ifsi-roma.inaf.it
M. Sauvage	CEA Saclay	marc.sauvage@cea.fr
N. Schneider	CEA Saclay	nschneid@cea.fr
B. Sibthorpe	Cardiff University	bruce.sibthorpe@astro.cf.ac.uk
L. Spinoglio	IFSI Rome	luigi@ifsi.rm.cnr.it
L. Testi	INAF Arcetri	lt@arcetri.astro.it
D. Teyssier	HSC	dteyssier@sciops.esa.int
R. Vavrek	HSC	rvavrek@sciops.esa.int
D. Ward-Thompson	Cardiff University	Derek.Ward-Thompson@astro.cf.ac.uk
G. White	RAL	g.j.white@open.ac.uk
C. Wilson	McMaster University	wilson@physics.mcmaster.ca
A. Woodcraft	UKATC	Adam.Woodcraft@astro.cf.ac.uk

Abstract

With its unprecedented spatial resolution in the critical $75 - 500$ μm wavelength range, *Herschel* will provide a unique opportunity to determine, for the first time, the fundamental properties of the precursors of OB stars at distances out to a few kpc. The imaging speed of SPIRE and PACS in the parallel mode will enable us to map the entire extent of massive cloud complexes and detect the massive young stellar objects which have been overlooked by *IRAS* and *Spitzer*, i.e. the high-mass infrared-quiet protostars and pre-stellar cores.

We propose to use SPIRE and PACS to image essentially all of the regions forming OB-type stars at distances < 3 kpc from the Sun (total area of 22 deg^2). To complement this imaging survey, we propose to take smaller photometric and spectroscopic maps with PACS toward a handful of isolated regions that display triggered star formation.

The 75/110/170 μm PACS and 250/350/500 μm SPIRE images of this project will provide an unbiased census of both massive pre-stellar cores and massive Class 0-like protostars, and will trace the large-scale emission of the surrounding clouds. This survey will yield for the first time accurate far-infrared photometry, and thus good luminosity and mass estimates, for a comprehensive, homogeneous sample of OB-type young stellar objects at all evolutionary stages. The multi-wavelength imaging will also reveal spatial variations of the cloud temperature close to H II regions and OB associations. These data, along with the detailed photometric and spectroscopic study of a few prototypical regions of induced star formation, will allow us to determine the importance of external triggers for high-mass star formation in the nearest massive molecular cloud complexes.

This *Herschel* Key Programme is crucially needed to better understand the formation of OB-type stars and will provide the basis for many follow-up studies. In addition, the data will provide templates for galactic studies of star formation, both in our Galaxy and others.

1 Science Rationale

1.1 Scientific Background: High-Mass Star Formation

Though fewer in numbers compared to lower-mass stars, high-mass stars play a major role in the energy budget of galaxies. *Our current understanding of the high-mass star formation process remains very schematic, especially concerning its earliest phases.* Like low-mass stars, high-mass stars (OB, $> 8\ M_{\odot}$) form in dense cores within molecular cloud complexes. Unlike low-mass stars, however, massive young stellar objects (MYSOs) reach the zero-age main sequence (ZAMS) while still deeply embedded and building up their final masses. At this point, the copious UV flux emitted by a central OB star heats and ionizes its surroundings, creating an H II region. Radiation pressure from an 8-10 $M_{\odot}$ MYSO, however, is expected to slow down and halt the accretion of cloud material (e.g., Stahler et al. 2000). The formation of higher-mass stars therefore poses a specific theoretical problem.

• **The earliest phases of OB star formation:** Observationally, once newborn massive stars have developed an ultracompact H II (UCH II) region, they are easily detectable in the infrared and radio centimeter continuum (e.g., Churchwell et al. 1990). The precursors to UCH II regions (the so-called massive protostars, see Kurtz et al. 2000) and the even earlier stage of massive pre-stellar (or starless) cores are best detected via far-infrared or (sub)millimeter dust continuum. Several candidate massive protostars have been identified as bright and red *IRAS* sources (e.g., Molinari et al. 2000; Beuther et al. 2002), but the youngest massive protostars are colder and hence inconspicuous in the mid-infrared bands of *IRAS*, *MSX* or *Spitzer* (i.e., reminiscent of low- to intermediate-mass Class 0 protostars; see André et al. 2000). A recent millimeter imaging survey of the entire Cygnus X molecular complex has indeed revealed a handful of massive Class 0-like protostars (Motte et al. 2003, 2007, Fig. 1; see also serendipitous discoveries by e.g. Molinari et al. 1998; Sandell & Sievers 2004). Despite the growing number of objects loosely described as candidate massive pre-stellar cloud cores in the literature (like *ISO*/*MSX* IR dark clouds, e.g,. Carey et al. 2000; Rathborne et al. 2004; Thompson et al. 2005), convincing proof that these objects are truly pre-stellar in nature and will indeed form high-mass stars remains elusive.

• **Evolutionary sequence for high-mass star formation:** Three types of evolutionary diagnostics have been proposed: (1) In theory, the development of an H II region leads to the empirical classification from initially hypercompact H II (HCH II) regions to UCH II regions, compact H II regions, and then classical H II regions (Keto 2003 and references therein); (2) Since the warm inner parts of high-mass protostellar envelopes evolve with time, the physical and chemical properties of a hot core (e.g., its size, temperature, molecular abundances, and associated masers) can in principle be used as a clock (e.g. Helmich & van Dishoeck 1997; Garay & Lizano 1999); (3) Inspired by the sequence from Class 0 to Class I observed for low-mass protostars (e.g. André et al. 2000), the ratio of submillimeter to bolometric luminosity has also been employed for OB-type protostellar objects (e.g., Molinari et al. 1998; Motte et al. 2003). Unfortunately, it is currently impossible to build quantitative evolutionary diagrams such as the $M_{\rm env} - L_{\rm bol}$ diagram for lower mass young stellar objects (see André & Montmerle 1994; Saraceno et al. 1996), due to the lack of accurate luminosity and envelope mass estimates.

• **Induced massive star formation:** Giant molecular cloud complexes where high-mass stars form are exposed to spiral arm passages, shocks from OB stellar winds and ionization fronts or supernova explosions. These phenomena may even trigger massive star formation, but the exact role of each of them is difficult to disentangle, due to non-exclusive signatures such as compression, heating and turbulence injection within the complex interstellar medium. The role of UV radiation and stellar winds as dynamical triggers is more established, as shown recently in a study of several Galactic H II regions with simple morphology (Deharveng et al. 2003, 2005; Zavagno et al. 2006, 2007). In this case, the formation of massive stars occurs via the fragmentation of the dense shocked layer of neutral gas at the edges of expanding H II regions ("collect and collapse" scenario).

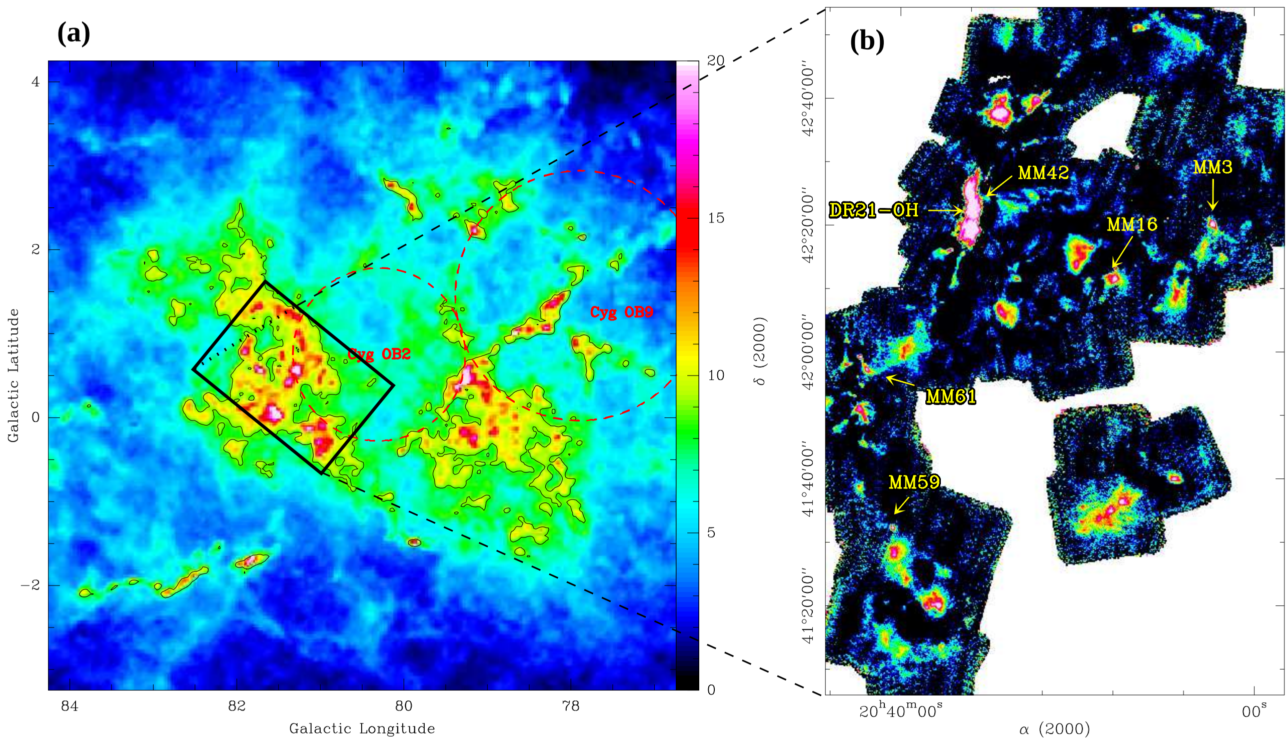

Figure 1: The Cygnus X high-mass star-forming complex: **(a)** Near-infrared extinction map derived by Bontemps et al. using 2MASS data. The contours outline $A_V > 10$ mag regions selected for the MAMBO-2 imaging. **(b)** 1.2 mm continuum map taken with MAMBO-2 at the IRAM 30 m telescope (Motte et al. 2007). Note the number and large variety of cloud structures detected at 1.2 mm, some of which are influenced by the nearby OB association Cyg OB2.

1.2 Open Issues

The following questions represent the most important unknowns related to massive star formation. They will be addressed by us with the proposed *Herschel* survey complemented by necessary spectroscopic and/or higher-angular resolution follow-ups.

• **What physical mechanism forms high-mass stars?** The main physical process leading to stellar masses $> 8M_\odot$ is still under debate. There are two competing families of models: accretion versus coalescence. In the first scenario, a high-mass star forms via a scaled-up version of the process at work for low-mass protostars. A single, massive starless core ($\sim 0.01 - 0.1$ pc in size) gravitationally collapses and the resulting high accretion rate ($> 10^{-3}$ $M_\odot$/yr) is strong enough to overcome radiation pressure (e.g., McKee & Tan 2003), or the accretion is possibly channeled through a disk (Yorke & Sonnhalter 2002), to form a single high-mass star. In the second scenario, a massive star forms from the coalescence of several lower-mass protostars (e.g., Bonnell et al. 2001). In a protocluster ($\sim 0.1 - 1$ pc in size), numerous starless cores first collapse to form intermediate-mass protostars, which then fall into the inner part of the protocluster (~ 0.1 pc in size) and merge into high-mass stars. A combination of both processes is also conceivable as suggested by recent observations and SPH hydrodynamical modeling (Peretto et al. 2007).

• **What are the initial conditions of OB star formation?** Since the earliest phases of high-mass star formation (pre-stellar cores and young protostars) have essentially escaped observations up to now, the initial conditions of this process remain enigmatic. Do singular massive pre-stellar cores exist? Are these hotter, denser, more turbulent, more magnetized, or more dynamic (e.g., externally compressed) than their low-mass analogs? Do their characteristics permit the development of accretion rates ∼100 times higher than those of lower-mass protostars? Will they allow an effective coalescence of protostars in their inner parts? Do O-type (> 20 $M_\odot$) and B-type stars form out of qualitatively similar initial conditions? On larger spatial scales, what are the characteristics of molecular cloud complexes in terms of temperature, density, and velocity structure, as well as non-thermal support and degree of fragmentation?

• **What is the evolutionary path leading to OB stars?**

The evolutionary scenarios proposed up to now for OB star formation are plagued by very low-number statistics and blurred by a general lack of angular resolution. What is the lifetime of each embedded phase of the high-mass star formation process? What is the real far-infrared to submillimeter photometry of any type of high-mass young stars (infrared-bright, infrared-quiet, hot cores, UCH II regions)? How do the spectral energy distributions (SED) of high-mass pre-stellar and protostellar objects evolve with time? How do they differ with final stellar mass? How does a population of massive protostars evolve in a $M_{\rm env} - L_{\rm bol}$ diagram?

• **How important are external triggers for high-mass star formation?** The impact of external triggers on clouds may be either destructive or constructive for massive star formation (Gorti & Hollenbach 2002). When constructive (see Elmegreen 1998 for a review), how does the initial high-mass pre-stellar core form? Do external disturbances precipitate its collapse? In the constructive "collect and collapse" mode, a massive star forms in a compressed layer accumulated at the periphery of a developed H II region between the ionization and shock fronts (cf. Elmegreen & Lada 1977). What are the physical conditions of the gas and dust in the hot photodissociation region (PDR)? Do the characteristics of the fragments formed via the "collect and collapse" process definitively favor the formation of massive stars, as suggested by recent observations (Deharveng et al. 2003, 2005; Zavagno et al. 2006, 2007)?

1.3 The Uniqueness of SPIRE and PACS Observations

With SPIRE and PACS, *Herschel* is a unique facility for large-scale far-infrared imaging and spectroscopic mapping studies of the earliest phases of OB star formation. It will have four main advantages:

1. **The SPIRE and PACS photometric bands (75–500 μm)** are ideally suited for probing the earliest stages of high-mass stars because protostellar objects are known to be cold ($\sim 20-50$ K) and pre-stellar cores might be even colder ($\sim$10 K). Since the corresponding spectral energy distributions of such objects peak between 100 μm and 300 μm, they are perfectly sampled by 5 PACS and SPIRE photometric bands (see Fig. 2). Covering this unique wavelength range with good spatial resolution will allow robust measurements of bolometric luminosities. At present, only crude and systematically overestimated values are available, using low-resolution *IRAS* 60 μm and 100 μm fluxes and typically one 850 μm or 1.2 mm measurement. *Spitzer* observations could help in some cases but the *Spitzer* angular resolution at 70 μm and 160 μm are $20''$ and $50''$ respectively, compared to *Herschel* resolutions at 75 μm and 170 μm of $5''$ and $12''$ respectively.
2. **The $5-36''$ resolution of PACS and SPIRE at 75-500 μm** will allow us to probe dense structures typically $\sim 0.04-0.3$ pc in diameter, in many molecular cloud complexes at intermediate Galactic distances (i.e., <3 kpc; see Sect. 1.4.1). While insufficient to separate individual condensations in the innermost parts of dense protoclusters (Hillenbrand & Hartmann 1998), this resolution will still greatly minimize confusion from source crowding. Indeed, while pre-stellar condensations and Class 0 objects have diameters $\sim 0.01-0.1$ pc (e.g., Motte & André 2001), sub-clustering is found on somewhat larger scales, e.g., a few 0.1 pc (the size of small clusters around Herbig Ae/Be stars; Testi et al. 1999). Moreover, high-mass protostars in a given region may be more widely separated from one another than their low-mass counterparts because they are much rarer. Therefore, a spatial resolution of ~ 0.1 pc should be good enough to identify the sub-cluster units associated with individual high-mass protostars in a protocluster. This resolution is a physically decisive improvement over *IRAS* or *Spitzer*.
3. **The SPIRE and PACS imaging speed** provides a unique opportunity to image tens of square degrees at far-infrared/submillimeter wavelengths in a reasonable amount of time. Furthermore, SPIRE and PACS imaging will preserve cloud structure up to ~ 1 deg (e.g., ~ 30 pc at 1.7 kpc). Such structure is impossible to retain in ground-based observations where data reduction performed to subtract atmospheric emission necessarily filters out large-scale, low surface brightness

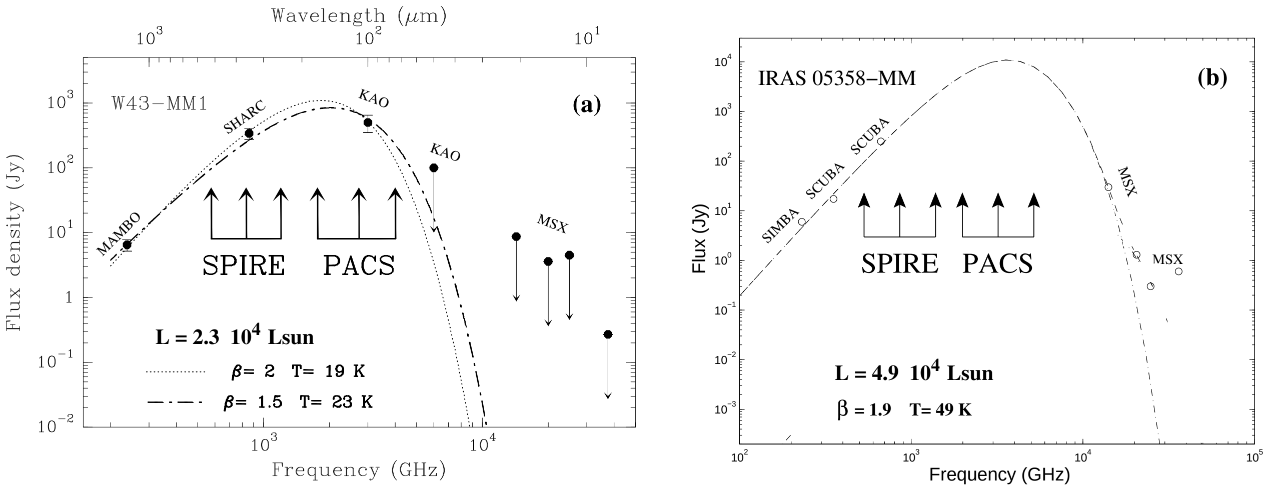

Figure 2: Spectral energy distributions of the massive Class 0-like sub-cluster W43-MM1 (**a**, Motte et al. 2003) and the infrared protostar IRAS 05358-MM (**b**, Minier et al. 2005) compared with greybody models. While W43-MM1 is relatively well documented, far-infrared flux measurements of *IRAS* 05358-MM are needed to constrain its bolometric luminosity.

structures (i.e., $> 5' - 10'$ scales with SCUBA and MAMBO-2). In particular, the unmatched spatial dynamic range of SPIRE and PACS will be a key advantage to probe the formation of sub-cluster dense cores and the importance of external triggers.

4. **The PACS spectro-imager and SPIRE-FTS can probe key line diagnostics** of PDRs (Giannini et al. 2000) and ionized regions, as well as absorption lines of light hydrides tracing molecular clouds (Goicoechea et al. 2004) observed toward H II regions. Therefore, PACS spectrometer and SPIRE-FTS are ideal tools to study H II regions surrounded by molecular rings.

1.4 Well-Suited Samples of Massive Star-Forming Regions

1.4.1 A Complete Sample of High-Mass Star-Forming Complexes at < 3 kpc

To answer the questions raised in Sect. 1.2, we propose to survey a carefully chosen and essentially complete sample of massive star-forming complexes out to 3 kpc, i.e., at intermediate Galactic distances (see Sect. 2.1.1 and Table 2). *Herschel* will have sufficient spatial resolution to probe sub-clustering in such massive star-forming complexes, yielding a statistically significant view of the embedded phases of high-mass star formation.

The molecular cloud complexes listed in Table 2 are the main sites of high-mass star formation in the Galactic neighborhood at distances < 3 kpc. Integrating the estimated star formation rate in the Galactic disk (McKee & Williams 1997) within a volume with 3 kpc radius suggests a star formation rate (SFR) of $\sim 0.2\ M_{\odot}$/yr in the selected molecular cloud complexes, corresponding to $\sim 1/20$ of the total SFR in our Galaxy. With this estimate, we can evaluate the number of objects expected in each MYSO phase assuming a standard initial mass function (e.g., Kroupa 2001) and plausible lifetimes. The evolutionary timescales of high-mass protostars are often expected to be significantly shorter than those of low-mass protostars. The UCH II lifetime, however, is observed to be ten times longer than predicted ($\sim 10^5$ yr, Wood & Churchwell 1989). Based on the low-number statistics of *IRAS* samples, the lifetime of the massive protostellar phase is estimated to be $0.2 - 6 \times 10^4$ yr (Kurtz et al. 2000) but new models argue for $\sim 5 \times 10^5$ yr (e.g., Keto, 2003). For simplicity, we thus adopt in Table 1 the same lifetimes as for low-mass pre-stellar cores, Class 0 and Class I protostars, i.e., $\sim 3 \times 10^5$ yr, $\sim 3 \times 10^4$ yr, and $\sim 3 \times 10^5$ yr respectively (cf. André et al. 2000 and the GT Key Programme proposal "Probing the Origin of the IMF").

As summarized by Table 1, the sample of Table 2 should be sufficiently large to study well the protostellar precursors of O-type stars ($\sim 50\ M_\odot$).

Table 1: Predicted numbers of OB-like YSOs in the targeted complexes of Table 2.

Source	Spectral type	B3–B1	O9–O7	O6–O3	O3–O1	Total
	Final mass	$8-20\ M_\odot$	$20-50\ M_\odot$	$50-100\ M_\odot$	$>100\ M_\odot$	$>8\ M_\odot$
Pre-stellar core		480	150	40	30	700
Class 0-like protostar		48	15	4	3	70
Infrared protostar		480	150	40	30	700
UCH II region		160	50	15	10	235

1.4.2 A Complementary Sample of Triggered Star Formation Regions

To assess the importance of triggers in high-mass star-forming complexes, we propose a detailed study of relatively isolated H II regions that represent clear examples of triggered massive star formation (see Fig. 3 and e.g. Zavagno et al. 2006, 2007). They will serve as templates in the search for sites of induced star formation in the extensive survey of massive cloud complexes described in Sect. 1.4.1.

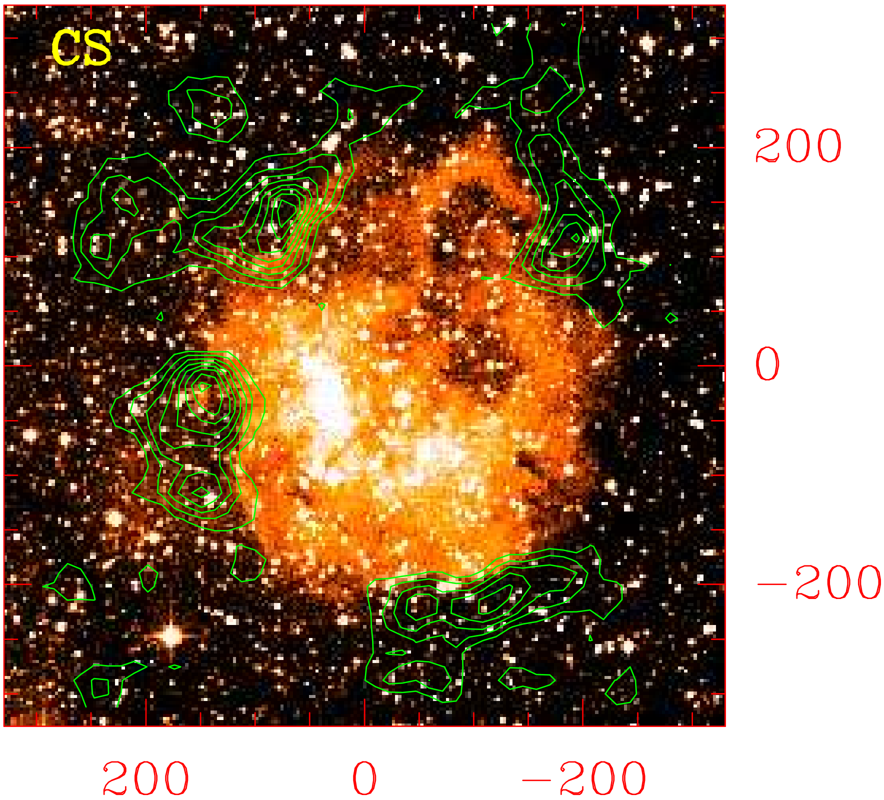

Figure 3: Triggered massive star formation in Sh 2-104: Fragmented molecular ring as observed in CS (2-1) (green contours) at the IRAM 30 m (Deharveng et al. 2003). Note that the eastern condensation contains a compact H II region while others are potential sites of high-mass star formation.

1.5 Science Exploitation Plan and Complementary Studies

The proposed *Herschel* survey will be of great interest not only for our team but to the astronomical community at large. It will reveal a more complete view of high-mass star formation (see Sect. 1.5.1) and give clues to several related issues (see Sect. 6.2). Below, we give details of our exploitation plan (steps 1 to 6) and some ideas for natural follow-up projects the community may wish to pursue (step 7 and partly steps 3 and 6):

1. **The first complete sample of OB-type MYSOs:** Each SPIRE and PACS map we obtain will provide a large, complete sample of compact, massive cloud fragments which are probable sites of future or on-going OB star formation. The pre- or proto-stellar cores in each cloud will be typically surrounded by filamentary structures which themselves are likely under the influence of external triggers. Using accurate temperatures (see step 3), we will also derive the accurate masses of these sources and constrain directly the initial conditions of OB star formation.

2. **Lifetimes of young embedded massive stars:** The Key Programme team will make extensive use of published catalogs (e.g., water and methanol maser catalogs) and archival data (e.g., mid-infrared images of *MSX* and *Spitzer*) to determine the nature of newly detected *Herschel* sources, i.e., pre-stellar, protostellar or UCH II region. Consequently, our consortium will produce a unique list of candidate massive Class 0-like protostars and high-mass pre-stellar cores. With this sample, we will then statistically derive the relative evolutionary timescale of every class of embedded OB stars, as well as the lifetimes of starless cloud structures.

3. **Spectral energy distributions:** With both SPIRE and PACS measurements, we will derive reliable estimates of the luminosities and dust temperatures of both compact sources and extended cloud structures. The ratios of submillimeter to bolometric luminosities will be measured to better separate the massive Class 0-like protostars from the more-evolved infrared protostars. We expect the community to make complementary studies with MAMBO-2 on IRAM 30m (1.3 mm), SCUBA2 on JCMT (850 μm and 450 μm), LABOCA on APEX (870 μm), and *Spitzer* to constrain further properties of the dust (i.e., temperature and emissivity).

4. **Evolutionary diagrams:** We will then use the derived luminosities and envelope masses from the complete and comprehensive sample of MYSOs discovered by *Herschel* to build a $M_{\rm env} - L_{\rm bol}$ diagram. We will use this diagram to test high-mass star formation models and the chemical and maser clocks proposed for the earliest phases of high-mass star formation. Our team will build a more robust evolutionary scenario for massive protostars by studying variations with time of their masses, densities, luminosities, temperatures and SEDs, as measured by *Herschel*.

5. **Triggered high-mass star formation in template H II regions:** Our consortium will use combined SPIRE and PACS data to characterize the physical conditions toward the regions presented in Table 3. In particular, we expect to determine the initial conditions that favor triggered high-mass star formation in the immediate surroundings of H II regions.

6. **Impact of external triggers on parent clouds:** We will use existing surveys (e.g., 2MASS, *MSX*, GLIMPSE) to locate and characterize the OB star clusters, H II regions, and supernova remnants. These potential sources of external triggering will be related to the dust properties and density structure of the targeted clouds (revealed by SPIRE and PACS) along with their velocity structure (obtained from complementary molecular line data). Thanks to the experience gained in step 5, we expect to identify bona-fide candidate sites of triggered high-mass star formation. By investigating the impact of triggers on the scale of entire molecular cloud complexes, our Key Programme team will quantify for the first time the importance of triggering in the formation of massive stars.

7. **Follow-up studies:** The large sample of relatively nearby high-mass young stellar objects identified in this Key Programme will provide a unique database for follow-up studies. We expect the community will want to make follow-up (sub)millimeter line observations with HIFI, ground-based radio telescopes, and interferometers such as ALMA. For example, high-resolution studies with ALMA of kinematics within the high-mass pre-stellar cores and Class 0 objects found by this Key Programme should finally settle the issue of whether accretion or coalescence is the main physical process at work in high-mass star formation.

The "HOBYS" GT Key Programme will make large-scale multi-wavelength images at 75, 110, 170, 250, 350, and 500 μm and spectral data-cubes covering the 55-210 μm range. It will require a total of 126 hours of *Herschel* observation.

2 Technical Implementation

2.1 Source List

Large-scale imaging surveys (100h): Due to the form of the initial mass function (e.g., Kroupa 2001), high-mass stars are much rarer than low-mass stars. Therefore, a wide volume of Galactic space must be sampled to find a statistically significant number of MYSOs. For instance, the nearest giant molecular cloud, Orion at ∼500 pc, is known to contain only a handful of embedded MYSOs. Beyond 3 kpc from the Sun, however, *Herschel* studies will be seriously hampered by the lack of sufficient spatial resolution (see Sect. 1.3.2 above). Surveying the molecular cloud complexes at 1-3 kpc distances is the optimal solution since it samples a significant fraction of the (active) Galaxy volume (estimated to be of the order of 1/20) with an adequate spatial resolution.

Based on a dust extinction image of the Galactic plane (Bontemps et al. 2007 in prep., using the 2MASS catalog) and confirmed by CO surveys, we have built a complete sample of the molecular complexes which are more massive than Orion and located at less than 3 kpc. These 9 complexes (see Table 2) contain 32 times more mass than Orion and 4 of them are among the most massive giant molecular clouds known to date ($\geq 10^6\ M_\odot$). Two slightly less massive complexes located at shorter distances (Vela and MonR1/R2/NGC 2264) have been added to bridge our results with the studies of low-mass star-forming regions at less than 500 pc proposed by "Gould Belt" GT Key Programme.

Table 2: Molecular cloud complexes proposed for *Herschel* imaging

Molecular complexes	D (kpc)	Gas mass[a] ($M_\odot$)	$A_V > 10$ area (deg^2)	Ref.[b]	Comments on the star-forming region (SFR)	Responsible team
Vela	0.7	$> 5 \times 10^5$	2.4	1	Intermediate-mass SFR near a supernova bubble	Rome/Saclay
MonR1/R2 /NGC 2264	0.8	2.5×10^5	2.0	2,3	Two concentrated intermediate-mass SFRs	Cardiff/Saclay
Rosette	1.6	3.5×10^5	1.0	4, 5	A relatively isolated high-mass SFR	Saclay/Canada
Cygnus X	1.7	4×10^6	6.3	6	The richest nearby high-mass SFR, triggered by Cyg OB2	Saclay/HSC
M16/M17 /Sh40	1.7	1.5×10^6	2.2	7	Rich part of the Sagittarius arm with 2 reference SFRs	HSC/RAL
NGC 6334 /NGC 6357	1.7	1.3×10^6	3.2	7	Network of 3 high-mass SFRs in the Carina-Sagittarius arm	Marseille/Rome RAL/Marseille
W3/KR140	2.2	2×10^5	1.6	8,9	Reference high-mass SFR in the Perseus arm	Canada/Rome
NGC 7538	2.8	1×10^6	0.6	10	Reference high-mass SFR in the Perseus arm	Canada/Cardiff
W48	3.0	8×10^5	2.8	7	Massive complex in the Galactic molecular ring	Saclay/Rome

[a] The masses are obtained from the extinction maps and found to be similar to the ones derived using CO surveys for e.g. Rosette, Cygnus X, and NGC 7538.

[b] References: (1) Yamagushi et al. (1999); (2) Margulis et al. (1989); (3) Leung & Thaddeus (1992); (4) Williams et al. (1995); (5) Heyer et al. (2006); (6) Schneider et al. 2006 (7) Bontemps et al. in prep; (8) Lada et al. (1978); (9) Carpenter et al. (2000); (10) Ungerechts et al. (2000).

Detailed spectro-photometric studies (26h): A promising sample of Galactic H II regions displaying triggered massive-star formation has recently been identified (Deharveng et al. 2003, 2005; Zavagno et al. 2006, 2007). In these regions, the "collect and collapse" triggering process (Elmegreen & Lada 1977) may be at work. Since they exhibit a simple geometry, i.e., a round ionized zone surrounded by an annular PDR harboring pre-stellar fragments and at least one bright infrared point source (see Fig. 3), they provide excellent constraints for triggered star formation models.

Table 3: H II regions displaying triggered star formation, proposed for PACS observations

	Central H II region Name	RA (2000)	Dec (2000)	Distance (kpc)	Responsible team
1	Sh 104	20:17:42	+36:45:25	4.0	Marseille
2	RCW 79	13:40:17	−61:44:00	4.0	Marseille
3	RCW 82	13:59:29	−61:23:40	2.9	Marseille
4	RCW 120	17:12:23	−38:27:43	1.3	Marseille
5	RCW 71	12:50:21	−61:34:58	2.1	Marseille
6	AFGL 4029	03:01:32	+60:29:12	2.0	Marseille
7	IRAS 16132−5039	16:17:00	−50:48:06	3.7	Marseille
8	Sh 241	06:03:58	+30:15:25	4.7	Marseille
9	M 16	18:18:48	−13:49:00	1.7	HSC

2.2 Observing Strategy

Large-scale imaging surveys (100h): Our main goal is to survey the precursors of OB-type stars in the critical $75 - 500$ μm wavelength range with the best possible angular resolution. We thus propose to image the complexes of Table 2 down to their $A_V \sim 10$ mag level with both the PACS and SPIRE cameras and at all 6 wavelengths (75, 110, 170, 250, 350, 500 μm). This way, *Herschel* will determine, for the first time, the fundamental properties (luminosity, mass) of massive young stellar objects at distances out to a few kpc. Besides, to recognize and study the link between large-scale filaments and the high-mass star-forming sites we aim at detecting extended emission up to a few parsecs (i.e. $\geq 10'$ at 1.7 kpc), at least in some of the bands.

Since the targeted areas are large ($\sim$ 2 deg^2 each, see extinction maps on http://starformation-herschel.iap.fr/ and Table 2), the most effective way to get a full coverage with SPIRE and PACS is to use the parallel mode. In order to preserve the PACS 75 and 110 μm spatial resolutions, a slow speed of $20''$/sec is required. In addition we plan to use new compression modes that preserve the PACS angular resolution despite the low data transmission rate of PACS in the parallel mode. These modes will keep an equivalent 10 Hz measurement rate on the sky by transfering only half of the readings with a sparsed algorithm (Vavrek et al.; J.L. Starck, priv. com.). A single coverage is enough for MYSOs since an 8 $M_\odot$ compact source typically corresponds to a $> 50\sigma$ detection at 250 μm (assuming $T_d = 20$ K and $d = 1.7$ kpc). Since we need two coverages to have the three PACS bands, we propose to make two perpendicular sets of scanned maps (cross-linked maps) in parallel mode using PACS first at 75/170 μm and then at 110/170 μm. The two cross-linked coverages will be concatenated in order to assure that the scan directions are orthogonal. The “cross-linking” obtained for 4 out of the 6 *Herschel* images will ensure to recover the extended emission at least for $\lambda \geq 170\,\mu$m.

Detailed spectro-photometric studies (26h): Our goal is to derive the physical conditions inside the different zones where the “collect and collapse” process is suspected to occur (see Sect. 2.1 and Fig 3). In fact, both the dust continuum and far-infrared line emissions are required to measure the temperature and density of the gas and the dust, and ultimately constrain their variations through the representative media. We therefore propose (1) to make maps in the PACS 110 and 170 μm bands and (2) to use the spectro-imaging capability of PACS to get a complete view of the gas (through cooling lines and PDR diagnostic lines) and dust properties in the 55-210 μm range. These observations will be complemented by SPIRE photometric and FTS spectroscopic measurements made as part of the SPIRE GT Key Programme “Evolution of interstellar dust” (Abergel et al.). SPIRE-FTS observations of M16 will be done in our proposal, in order to obtain a whole set of data on this template region.

Photometric mapping with PACS: This has to be done homogeneously for all sources, except for M16 which is imaged in the “large-scale imaging survey” part of the proposal. We propose to use PACS at 110 and 170 μm and a medium scanning speed ($30''$/sec) for making small (typically $20' \times 20'$) square images with an homogeneous coverage. Two crossed-linked maps are planned for each source (one oriented at 45 deg and the other at 135 degrees), they will be concatenated to assure they will be done with the same position angle.

PACS range spectroscopy: A full spectral scan will be performed on representative positions, for each sources in the range spectroscopy mode of PACS. The full coverage of the PACS range will assure to cover all cooling lines (OH at 119.23 μm and 119.44 μm, CH at 149.09 μm and 149.39 μm and H_2O at 179.53 μm), and all PDR and ionized region diagnostics lines ([OI] 63 μm and 146 μm, [CII] 158 μm, [NII] 122 μm and 205 μm, [NIII] 57 μm and [OIII] 88 μm). In order to get a full coverage of the 3 grating orders, two scans are required (1: 55-72 + 105-210 μm and 2: 72-105 + 105-210 μm). The two observations will be concatenated to ensure that each PACS pixel will observe the same region during the full spectral scan. Note that the spatial coverage is under-sampled at mostly all wavelengths with a pixel size of 9.5$''$ (i.e. the angular resolution of *Herschel* at $\sim$ 140 μm). Since the spatial sampling of the (spectro-)images is not necessary to achieve our scientific goals, we have chosen not to make dithering maps (too time consuming) to recover the spatial sampling. In spectro-imaging with PACS, we will point typically three representative locations per target (see Table 5 in Appendix B for details).

2.3 Observing Time Requirement

Large-scale imaging surveys (100h): The typical time requested to make two cross-linked coverages of 2 deg^2 is 8 hours (including integration time and instrument overheads). For most of the regions to be mapped (see Table 4), we can cover the selected ($A_V > 10$ mag) areas with maps which do not depend on the observation date. Therefore, the observatory overheads usually are 1×180 sec for the two concatenated cross-linked coverages. A few regions however require time constraints (typically one month per visibility window) to optimize the scientifically useful coverage. Altogether imaging all the complexes of Table 4 require a total time of 106.9 hours with HSpot 2.0 (see Table 4, see attached AORs). The slewing overheads may however be significantly reduced for the phase 2 release (see the *Herschel* note HSC/MEM/0891 of 9/2/07 by G. Pilbratt) and in the case of slewing overheads reduced by a factor of 3, the total time would only be of 90.6 hours. We therefore conclude that 100 hours are necessary and sufficient to perform the large-scale imaging survey we propose with SPIRE and PACS. We will thus fine-tune the exact total area to be mapped (between 21 and 24 deg^2) depending on the final slewing overheads at phase 2.

Detailed spectro-photometric studies (26h):

Photometric mapping with PACS: The required sensitivity level is set by the need to detect an intermediate- to high-mass protostellar core in our distant sources (up to 4 kpc). With the minimum of two cross-linked coverages with PACS, we should reach a typical 1σ rms of 14 mJy at 170 μm (with the two maps) leading to a 3σ detection level of 5 $M_\odot$ at 4 kpc (assuming a dust temperature of 20 K) which is enough for our science goal. In order to image the 9 regions, we finally require between 3.5 hours (optimistic case) and 5 hours (nominal case, i.e. time returned by HSpot 2.0) depending on the possibility to divide by 3 the instrumental overheads.

PACS range spectroscopy: Typical predicted intensity for the main cooling lines in the selected hot PDRs are of the order of 10^{-16} W m^{-2} for the [CII] 158 μm line and [OI] 145.5 μm line. Depending on the wavelength, rms values of about 5×10^{-18} W m^{-2} are obtained with a single range spectroscopic scan with PACS leading to 20σ. A single coverage is therefore enough. The total time returned by HSpot 2.0 for a complete spectrum (range 1 + range 2) on one position is 2780 s. A typical AOR is given in attachment for Sh 104. We will point typically three representative locations per target (7 for M16) leading to a total of 27 positions for the PACS spectroscopy of hot PDR sample, for a total time of 20.8 hours (see Table 5 in Appendix B for details). To get an homogeneous dataset on M16 (see above and the GT KP "Evolution of interstellar dust", Abergel et al.), SPIRE-FTS spectroscopy will be done at high spectral resolution for a total time of 2.5 hours (see Table 5 for details).

The total observing time for the Hot PDR sample is 28.3 hours (nominal case) or 26.8 hours (optimistic case). We will optimize the number of regions observed (8 or 9) depending on the final slewing overheads at phase 2 to fit in the 26-allocated hours.

The total requested time for the GT Key Programme "HOBYS" is 126 hours. Small changes in sensitivity of the SPIRE or PACS instruments will not be an issue (see above).

3 Data Processing and Archival Value

3.1 Data Processing

3.1.1 Map making and Spectral-cubes building

- **Map making**
  Our main focus is on bright compact sources (i.e. high-mass protostars or pre-stellar cores) for which the maps and spectra delivered by the *Herschel* SPIRE and PACS pipelines should already be good enough. In particular, we have made imaging simulations (see Sect. 4.2) and checked that our observing strategy (fast-scanning in parallel mode) is adapted not to substantially degrade the PACS 75 μm angular resolution ($< 10\%$, Billot et al. in prep.).

  Besides, our project aims at characterizing the fainter extended emission of clouds physically connected to protostars and pre-stellar cores. In collaboration with SAG 4 (ISM) members and mathematicians with strong experience in signal processing, we are working on optimizing the map-making process, and especially the treatment of the 1/f noise, to preserve the extended emission (e.g. Rodet et al. 2005).

- **Spectral-cube making**
  For most of our goals, the PACS spectrometer pipeline should be good enough to reduce and analyze the spectral cubes our team will obtain around H II regions. However, we are making efforts at LAM/OAMP to develop specific tools (VO compatible) to improve the calibration of the extended emission and extract weak lines from the continuum. Sarah Leeks' (from HSC) expertise in the ISO-LWS data analysis and our expertise on FTS data analysis will greatly help.

3.1.2 Source Extraction

The ability to accurately identify objects in images observed with the SPIRE and PACS photometers is essential for rapid data exploration. In that spirit, our team has developed a data analysis process for both SPIRE and PACS. First, synthetic skies are created to serve as input for software that simulates the instrument observation and reduction. The produced images are then analyzed by various source extraction algorithms, including background subtraction.

- **Synthetic skies modeling the continuum emission of molecular cloud complexes**
  Numerical radiative transfer modeling is used for detailed simulation of the star-forming regions to be observed and will be employed throughout all the phases of the project. At the stage of preparation of the observations, we compute spherical models of four realistic populations of several hundred starless prestellar cores and protostars with central accretion energy source, as well as realistic interstellar cirrus emission background (Men'schikov et al. in prep.). The populations are quasi-randomly distributed over the cloud in such a way as to best represent low- to high-mass star-forming regions with numbers according to the current best model of stellar mass function, from 0.01 to 10 $M_\odot$.

- **Simulation of *Herschel* observations and data reduction**
  The synthetic sky produced in this way serves as input for the SPIRE or PACS software simulator (Sibthorpe et al. 2004; Ali et al. priv. comm.) that is designed to produce realistic images, taking into account instrumental effects (e.g. uncorrelated 1/f noise) and observing modes. The simulator allows to test data reduction techniques and operating modes, and to evaluate instrument systematics.

- **Source Extraction**
  In order to detect - and distinguish - compact and extended sources in SPIRE/PACS images, an automatic, objective routine is required that includes a well-grounded background subtraction. Based on our experience with multi-resolution techniques (Motte et al. 2001, 2007), we

employ this method to decompose simulated images in multi-resolution wavelet planes (Starck & Murtagh 2006) containing small to large structures. The sources themselves are extracted using well-known algorithms like Gaussclumps (Stutzki & Güsten 1990) or Clumpfind (Williams et al. 1994). These programs, however, have to be adapted to our specific requirements and tested thoroughly.

Besides, we are using the approach of multiresolution filtering and source extraction provided by SExtractor ("Source Extractor", Bertin & Arnouts 1996). Standard wavelet, morphological component analysis and entropy filtering have been used on individual images. Taking advantage of the double image mode of SExtractor (detection made on one image can be be used as a template for another image of the same region but at a different wavelength), we work on improving detection by using data with highest Signal-to-Noise, contrast or resolution for other less good images taken at different wavelengths. The next step will be to test new techniques of detection on multi wavelength data cubes, using the multiresolution approach or segmentation through a Markov chain (Salzenstein et al. 2004).

- **Comparison and optimization of map-making and source extraction techniques**
The fact that we accurately know all the properties of synthetic skies gives a unique and indispensable opportunity for testing the pipelines and map-making algorithms. Simulated sky is also a perfect tool for optimizing background subtraction, source extraction, and extraction completeness levels. Last, but not least, it is an extremely valuable tool for devising best methods of the derivation of the physical parameters of sources (density and temperature structure, masses) and for most accurate reconstruction of the protostellar mass function, along with realistic uncertainties.

3.2 Archival Value of the Survey

Although the main objective of this Key Programme is understanding the origins of high-mass star formation, this study is also valuable for related subjects.

- When combining the "HOBYS" and "Gould Belt" Key Programmes, essentially all of the molecular cloud complexes up to 3 kpc will be fully imaged at unprecedented sensitivity and spatial resolution in the far-infrared. This is by itself a unique database for all studies of star formation and interstellar medium, and will remain for at least one decade.

- **Dust properties in OB star-forming regions:** Molecular cloud complexes where OB stars are forming also contain H II regions and OB clusters. These can power ionizing fronts and shock waves that propagate through the clouds. Dust properties (such as the grain size distribution and the dust temperature) are believed to change through these interactions, as well as through high-mass star formation. The multi-wavelength photometric study proposed here will constrain these changes, in a way complementary to the Key Programme "Evolution of Dust."

- **High-mass star formation template for our Galaxy and nearby galaxies:** Some of the most prominent cloud complexes of Table 2 constitute the nearest spiral arm of our Galaxy, i.e., the Carina-Sagittarius arm located at l=340 deg (2 kpc) to l=40 deg (3 kpc). While the complexes at ~1.7 kpc distance are located in the outer Galaxy, those at 3 kpc belong to the so-called molecular ring. Therefore, this Key Programme will help relate OB star formation activity to Galactic-scale properties, such as potential triggers and the variations of their efficiency along a Galactic arm. The survey can thus provide a crucial template for any larger-scale study of star formation, both in our Galaxy (e.g., the Hi-GAL Open Time Key Programme to be proposed by Molinari et al.) and other nearby galaxies.

4 Management and Outreach Plans

4.1 Consortium Ressources and Management Plans

The "HOBYS" Key Programme is managed by three coordinators (F. Motte, A. Zavagno, and S. Bontemps) following the rules defined in the Constitution given in Appendix C. We have two transverse technical working groups, one for data simulations (e.g. B. Sibthorpe, A. Men'shchikov et al.), the other for our dedicated pipeline (e.g. P. Martin, G. White et al.). We also plan to set up at least three transverse science working groups in the near future, one on pre-stellar cores, the second on protostars, and the last one on H II regions.

The Consortium is organized in localized sub-teams responsible for the work (data reduction, analysis, and publication) on the various regions of the survey (see breakdown in Tables 2 and 3). Here is a short description of the strengths of the various sub-teams making up the Consortium. Our Consortium has the experience and resources required to process the proposed observations and deliver a useful legacy product to the astronomical community. A summary of the *minimum* resources in terms of FTEs committed to both "Gould Belt" and "HOBYS" GT Key Programmes by the various members of our Consortium is provided in Appendix A.

CEA Saclay team: The CEA Saclay sub-team is currently composed of 6 staff researchers (Ph. André, A. Men'shchikov, V. Minier, F. Motte, M. Sauvage, N. Schneider) and 1 PhD student. Staff researchers from Bordeaux observatory (S. Bontemps) and IAS Orsay (A. Abergel) are closely collaborating with Saclay on the present "HOBYS" Key Programme as well as the related "Gould Belt" Key Programme. The above-mentioned staff members will devote 50%-80% of their time to these projects. For more than 10 years, their main scientific interest has been in the identification and modeling of the earliest phases of the star formation process, for both low- and high-mass objects. They all have a long-term expertise and good publication record in submillimeter (line and continuum) and infrared studies, e.g., using facilities such as the IRAM 30 m telescope and Plateau de Bure interferometer, as well as ISOCAM on *ISO*. The Saclay laboratory is currently building ArTeMiS, a ground-based submm camera using a PACS-like filled bolometer array which recently achieved first light on the APEX 12 m telescope. Two staff members (André and Minier) are strongly involved in ArTeMiS. It is anticipated that the dedicated map-making routines developed for ArTeMiS can be used in the first version of the pipeline employed to produce PACS images for the present project.

IFSI and INAF Rome team: The INAF/IFSI team is composed of 6 staff researchers (P. Saraceno, M. Benedettini, A. DiGiorgio, S. Molinari, S. Pezzuto, L. Spinoglio) and 1 PhD student. The team collaborates with L. Testi (Arcetri Obs.) on both the "Gould Belt" and "HOBYS" Key Programmes and appointed two consultants for two regions of the "HOBYS" project (T. Giannini and P. Persi both from INAF/IFSI). All of the team members will devote at least 50% of their time to both projects. The team has expertise in observations and modeling of star-forming regions both in spectroscopy and continuum, from the near-infrared to the radio range. The specific scientific interests are in the earliest stages of low- and high-mass star formation, and the chemistry of the ISM, circumstellar envelopes and shock regions.

Cardiff University and the RAL teams: The Cardiff University team is composed of 3 academic staff (P. Ade, M. Griffin and D. Ward-Thompson) and 3 post-doctoral research staff (P. Hargrave, B. Sibthorpe and J. Kirk). The RAL team consists of one academic researcher (G White) and one PhD student. The RAL and Cardiff teams collaborate closely. The academic staff will devote up to 50% of their time on the "Gould Belt" and "HOBYS" Key Programmes, and the post-doctoral staff will devote up to 100% of their time to *Herschel* post-launch. The scientific interests include star formation, molecular clouds, and dust in the ISM. All staff members have long publication records in these fields. Their previous infrared and submm expertise includes working with (and assisting in building) *IRAS*, *ISO*, SCUBA and numerous other instruments and telescopes.

HSC team: The HSC team is composed of 4 staff members (S. Leeks, A. Marston, D. Teyssier, R.

Vavrek) who are all Instrument and Calibration Scientists on *Herschel*. All staff researchers have long experience in IR data (ground and space based) photometric and spectroscopic analysis. Our scientific expertise concerns Galactic astronomy, ranging from Galactic structure, Galactic ISM, massive-star formation, PDRs and H II regions. During the exploitation of Herschel data, two of the involved people will dedicate 100% of their research time to the "HOBYS" and "Gould Belt" Key Programmes. While the other two named persons will dedicate 30research time to the "HOBYS" Key Programme.

Canadian (Herzberg Victoria, CITA Toronto, McMaster University) team: The Canadian team consists of 3 academic staff (J. Di Francesco, P. Martin, and C. Wilson) and one postdoc. Their main scientific interests are in prestellar cores, molecular clouds, and interstellar medium both in our Galaxy and nearby galaxies. They are all involved with the closely-related SCUBA-2 Legacy Surveys. Martin and one postdoc are involved with BLAST (stratospheric telescope equipped with a SPIRE-like bolometer array) and has recently obtained observations of star-forming regions with this instrument. The dedicated map-making routines developed for BLAST can be used in the first version of the pipeline employed to produce SPIRE images for the present project.

LAM/OAMP team: The LAM team is composed of 4 staff researchers (J.-P. Baluteau, L. Deharveng, D. Russeil, A. Zavagno), one Ph.D student, and expect to be joined by 1 post-doctoral researcher from May 2007. During the exploitation of *Herschel* data, all involved people will dedicate between 80% and 100% of their research time to the "Gould Belt", "HOBYS" and "Evolution of interstellar dust" (Abergel et al.) Key Programmes. All staff researchers have long experience in (ground- and space-based) photometric and spectroscopic taken at infrared wavelengths. Their scientific expertise concerns the Galactic structure, the ISM, massive star formation and H II regions.

4.2 Outreach Activities

The extensive survey of nearby molecular cloud complexes planned in the present *Herschel* GT Key Programme is expected to produce several breakthroughs in our understanding of the birthplaces of high-mass stars. Full exploitation of this survey will require expertise in space techniques, infrared and submillimeter instrumentation, image processing, as well as physics and chemistry, to collect, reduce and interpret the survey data. Besides the impact of new discoveries on the star formation process and the resulting spectacular images, the products of this Key Programme can potentially be used as basic material to attract young people in all fields of physics, chemistry, computer science and engineering. This is an important issue in Europe where students become less attracted by scientific studies at the University level.

We are planning to reach people and communicate them our discoveries through four major media: Internet (web site), newspapers and radio networks (press releases) and TV networks (video releases). This Outreach effort will be coordinated by Vincent Minier. Our Internet web site (http://starformation-herschel.iap.fr/) will be the major instrument of our educational and public outreach effort. To date, the web page is mainly designed for preparing the Key programmes. By the end of 2007, an Outreach section will be added that will be organized in three main sections:

- News from Space: main discoveries, most recent press and video release.
- Infrared and submillimeter astronomy introduction: basic information on Infrared, the IR universe, space techniques and the *Herschel* Space Observatory.
- Educational and public outreach for general public (image gallery with accessible captions for non-scientists and children), for students in science (images with captions, scientific explanations and detailed descriptions of the physics involved), for educators (same as for students, plus electronic text books and educational material for school children) and for media (press releases, video releases).

Our web site is designed first in English and French, and may be translated locally in other European languages. Press releases will be delivered nationally to media through the public relation office in each institute of the consortium.

References

Aannestad, P. A., Emery, R. J. 2003, A&A, 406, 155
André, P., Montmerle, T. 1994, ApJ, 420, 837
André, P., Ward-Thompson, D., Barsony, M. 2000, in Protostars & Planets IV, 59
Bertin, E., Arnouts, S. 1996, A&A Suppl., 117, 393
Beuther, H., Schilke, P., Menten, K. M., Motte, F., Sridharan, T. K., Wyrowski, F. 2002, ApJ, 566, 945
Billot, N., Okumura, K., Sauvage, M. 2005, Review on PACS bolometers time constant, SAp-FIRST-NB-0688-05
Bonnell, I. A., Bate, M. R., Clarke, C. J., Pringle, J. E. 2001, MNRAS, 323, 794
Carey, S. J., Feldman, P. A., Redman, R. O., Egan, M. P., MacLeod, J. M., Price, S. D. 2000, ApJ, 543, L157
Carpenter, J. M., Heyer, M. H., Snell, R. L. 2000, ApJS, 130, 381
Churchwell, E., Walmsley, C. M., Cesaroni, R. 1990, A&AS, 83, 119
Deharveng, L., Lefloch, B., Zavagno, A., Caplan, J., Whitworth, A. P., Nadeau, D., Martin, S. 2003, A&A, 408, L25
Deharveng, L., Zavagno, A., Caplan, J. 2005, A&A, 433, 565
Elmegreen, B. G., Lada, C. J. 1977, ApJ, 214, 725
Elmegreen, B. G. 1998, ASP Conf. Series, 148, 150
Garay, G., Lizano, S. 1999, PASP, 111, 1049
Giannini, T., Nisini, B., Lorenzetti, D., Di Giorgio, A. M., Spinoglio, L., et al. 2000, A&A, 358, 310
Goicoechea, J.R.; Rodriguez-Fernandez, N.J., Cernicharo, J. 2004, ApJ, 600, 214
Gorti, U., Hollenbach, D. 2002, ApJ, 573, 215
Helmich, F. P., van Dishoek, E. F. 1997, A&AS, 124, 205
Heyer, M., Williams, J., Brunt, C., 2006, ApJ, 643, 956
Hillenbrand, L. A., Hartmann, L. W. 1998, ApJ, 492, 540
Keto, E. 2003, ApJ, 599, 1196
Kroupa, P. 2001, MNRAS, 322, 231
Kurtz, S., Cesaroni, R., Churchwell, E., Hofner, P., Walmsley, C. M. 2000, in Protostars & Planets IV, p. 299
Lada, C. J., Elmegreen, B. G., Cong, H.-I., Thaddeus, P. 1978, ApJL, 226, L39
Leung, H. O., Thaddeus, P. 1992, ApJS, 81, 267
Margulis, M., Lada, C. J., Young, E. T. 1989, ApJ, 345, 906
McKee, C. F., Williams, J. P. 1997, ApJ, 476, 144
McKee, C. F., Tan, J. C. 2003, ApJ, 585, 850
Minier, V., Burton, M. G., Hill, T., Pestalozzi, M. R., Purcell, C. R., et al. 2005, A&A, 429, 945
Molinari, S., Brand, J., Cesaroni, R., Palla, F. 2000, A&A, 355, 617
Molinari, S., Testi, L., Brand, J., Cesaroni, R., Palla, F. 1998, ApJ, 505, L39
Motte, F., André, P., Neri, R. 1998, A&A, 336, 150
Motte, F., André, P. 2001, A&A, 365, 440
Motte, F., Schilke, P., Lis, D. C. 2003, ApJ, 582, 277
Motte, F., Bontemps, S., Schilke, P., Schneider, N., Menten, K. M., Broguière D. 2007, A&A, submitted
Peretto, N., Hennebelle, P., André, P., 2007, A&A, 464, 983
Rathborne, J. M., Simon, R., Jackson, J. M., Shah, R. Y. 2004, ASP Conf. Ser. 322, p. 273
Rodet, T., et al. 2005, Proc. GRETSI, 133
Salzenstein, F. Collet., C., Petremand, M., 2004, NDEG1, Vol.21, pp.37-54
Sandell, G., Sievers, A. 2004, ApJ, 600, 269
Saraceno, P., André, P., Ceccarelli, C., Griffin, M., Molinari, S. 1996, A&A, 309, 827
Schneider, N., Bontemps, S., Simon, R., Jakob, R., Motte, F., Miller, M., Kramer, C. 2006, A&A, 458, 855
Sibthorpe, B., Woodcraft, A., Griffin, M., et al., 2004, Proc. SPIE 5847
Starck, J.-L., Murtagh, F. 2006, Astronomical image and data analysis, Astronomy and astrophysics library, Berlin: Springer
Stahler, S. W., Palla, F., Ho, P. T. P. 2000, in Protostars & Planets IV, 327
Stutzki, J., Güsten, R., 1990, ApJ, 356, 513
Testi, L., Palla, F., Natta, A. 1999, A&A, 342, 515
Thompson, M. A., Gibb, A.G., Hatchell, J. H., Wyrowski, F., Pillai, T. 2005, ESA SP-577, p. 425
Ungerechts, H., Umbanhowar, P., Thaddeus, P. 2000, ApJ, 537, 221
Williams, J., De Geus, E.J., Blitz, L., 1994, ApJ, 428, 693
Williams, J., Blitz, L., Stark, A., 1995, ApJ, 451, 252
Wood, D. O. S., Churchwell, E. 1989, ApJ, 340, 265
Yorke, H. W., Sonnhalter, C. 2002, ApJ, 569, 846
Zavagno, A., Deharveng, L., Comeron, F., Brand, J., Massi, F., Caplan, J., Russeil, D. 2006, A&A, 446, 171
Zavagno, A., Pomarès, M., Deharveng, L., Hosokaw, T., Russeil, D., Caplan, J., 2007, A&A, submitted

Appendix A: List of Consortium Members with Associated Roles

Name	Affiliation	Status	Expertise	Role	Involvement
F. Motte	CEA Saclay/AIM	Staff	Protoclusters (high-mass)	Coordinator	80%
A. Zavagno	LAM/OAMP Marseille	Staff	Triggered star formation	Coordinator	40%
S. Bontemps	Bordeaux/Saclay	Staff	High-mass protostars	Coordinator	40%
A. Abergel	IAS Orsay	Staff	Interstellar dust	Extended emission	20%
P. Ade	Cardiff University	staff		Calibration	10%
Ph. André	CEA Saclay	Staff	Protostars, prestellar cores	SAG Coordinator	60%
J.-P. Baluteau	LAM/OAMP Marseille	Staff	ISM	Spec. follow-ups	10%
J.-Ph. Bernard	CESR Toulouse	Staff	ISM	Polar. follow-ups	10%
L. Cambrésy	CDS Strasbourg	Staff	Extinction maps	Archiving	20%
P. Cox	IRAM Grenoble	Staff	ISM	PdB follow-ups	5%
L. Deharveng	LAM/OAMP Marseille	Staff	Triggered star formation		10%
J. Di Francesco	Herzberg Victoria	Staff	Prestellar cores	Sub-team leader	50%
A. Di Giorgio	IFSI Rome	Staff	PMS objects	SPIRE A.S.	20%
T. Giannini	INAF-Rome	Staff	Herbig Ae/Be stars	Cons. Vela	20%
M. Griffin	Cardiff University	Staff	Protostars/Calibration	Simulations/Calibration	15%
P. Hargrave	Cardiff University	Postdoc	Instrument/Calibration	Calibration	10%
M. Huang	NAOC Beijing	Staff	Compact HII regions	SPIRE A.S.	15%
J. Kirk	Cardiff University	Postdoc	Prestellar cores	Data reduction	80%
S. Leeks	HSC	Staff	H II regions	Sub-team leader	20%
J. Li	NAOC Beijing	Staff	Young star clusters	SPIRE W.M.	20%
A. Marston	HSC	Staff	Massive star formation		10%
P. Martin	CITA Toronto	Staff	ISM dust	Map making	20%
A. Men'schikov	CEA Saclay	Staff	Radiative transfer	Simulations/Modeling	70%
V. Minier	CEA Saclay	Staff	High-mass protostars	Website/Outreach	50%
S. Molinari	IFSI Rome	Staff	High-mass protostars	Link with Hi-Gal	50%
G. Olofsson	Stockholm Obs.	Staff	Circumstellar disks	SPIRE Co.I.	20%
A. Omont	IAP Paris	Staff	Stellar populations	SPIRE A.S.	5%
P. Persi	IASF-Roma/INAF	Staff	High-mass protostars	Cons. NGC6334	20%
S. Pezzuto	IFSI Rome	Staff	Circumstellar disks	SPIRE Co.I.	20%
D. Russeil	LAM/OAMP Marseille	Staff	Galactic HII regions	Sub-team leader	20%
P. Saraceno	IFSI Rome	Staff	Infrared observations	SAG Coordinator	50%
M. Sauvage	CEA Saclay	Staff	Extragal. star clusters	PACS support	20%
N. Schneider	CEA Saclay	Staff	Molecular clouds	Sub-team leader	70%
B. Sibthorpe	Cardiff University	Postdoc	Prestellar cores	Data simulations	20%
L. Spinoglio	IFSI Rome	Staff	Extragal. star formation		10%
L. Testi	INAF Arcetri	Staff	Protoclusters		30%
D. Teyssier	HSC	Staff	IR dark clouds	Sub-team leader	5%
R. Vavrek	HSC	Staff	Cloud structure		20%
D. Ward-Thompson	Cardiff University	Staff	Prestellar cores	Sub-team leader	30%
G. White	RAL	Staff	Triggered star formation	Sub-team leader	20%
C. Wilson	McMaster University	Staff	Extragal. star formation	Link with SAG 2	20%
A. Woodcraft	UKATC	Staff	Bolometers	Calibration	10%

The Key Programme Coordinator, F. Motte is an Associate Scientist of the SPIRE consortium and a member of the SPIRE ICC group. She has long worked on the earliest phases of low-mass star formation in protoclusters, mostly to constrain the origin of the stellar IMF (e.g. Motte et al. 1998). More recently, her work is focussed on searching the high-mass infrared-quiet protostars and pre-stellar cores, using large-scale imagings of nearby molecular complexes at (sub-)millimeter wavelegths (Motte et al. 2007).

The Key Programme Co-coordinator, A. Zavagno is an Associate Scientist of the SPIRE consortium and is associated with the PACS Consortium. She is also involved in the SPIRE GT key programme "Evolution of interstellar dust" (Abergel et al.). She is an expert in triggered star formation in the immediate surroundings of H II r egions (Zavagno et al. 2006, 2007). She is using infrared to (sub-)millimeter continuum and line observations to constrain the "collect and collapse" process.

The Key Programme Co-coordinator, S. Bontemps is an Associate Scientist of the SPIRE consortium and is also involved in the HIFI GT key programme "WISH" (van Dishoeck et al.). He is an expert in the earliest stages of star formation, including outflows and multi-wavelength observations of protostars. His main interest is on understanding the high-mass star formation process at the scale of giant molecular complexes (e.g. extinction maps). He has been involved in the *ISO* GT programmes (Bontemps et al. 2001).

P. Ade is a co-I of the SPIRE Consortium and a member of the SPIRE Instrument team. He has 135 refereed publications and has worked on many other far-infrared & sub-mmillimeter satellites and instruments, including *IRAS*, *ISO*, SCUBA & SCUBA-2

Ph. André, is a co-I of the SPIRE Consortium and the coordinator of the SAG 3 (Star Formation) team of SPIRE. He is an expert in the earliest stages of star formation and has nearly twenty years of experience in mm/submm observations. He introduced the concept of Class 0 protostars and wrote several review papers on prestellar cores and protostars.

L. Deharveng is an expert in the physics of Galactic ionized regions and triggered star formation on the broders of these regions. She has long-term expertise in multi-wavelength data analysis and interpretation which will be of great help in our cross-correlation analysis.

J. Di Francesco is the Canadian coordinator of the SCUBA-2 Legacy Survey that will map several of the clouds in the "HOBYS" GT Key Programme. He has been investigating prestellar cores and their molecular environment using multifrequency line and continuum observations, including from the SMA, JCMT, and *Spitzer*.

A. M. Di Giorgio is also member of the HIFI Consortium. She has experience in spectrophotometric data analysis with particular interest in crowded fields image processing. She is the responsible of the OBSW development for the HIFI instrument and is involved in the star forming regions studies at IFSI.

T. Giannini is a SPIRE consultant for the Vela region. Her interests are focussed on star formation studies including the earliest phases of high-mass star formation, embedded clusters and jet/outflows phenomena. She has a wide experience with both ground-based (e.g. ISAAC, ApeX) and space-borne telescopes (*Spitzer*, *ISO*).

M. Griffin is the PI of the SPIRE instrument and has 66 refereed publications. Has worked on many other far-infrared and sub-millimeter satellites and instruments, including *IRAS*, *ISO*, SCUBA, and SCUBA-2.

P. Hargrave is a member of the SPIRE Instrument and ICC teams. He has 7 scientific publications and has worked on other far-infrared and sub-millimeter satellites and instruments, including *ISO* and SCUBA

M. Huang is a SPIRE ICC scientist which has years of experience in infrared spectroscopic astronomy, with e.g. ISO/LWS. His main scientific interest is on H II regions.

J. Kirk has 15 refereed publications. Has worked on other far-infrared and sub-millimeter satellites and instruments, including *ISO* and SCUBA.

J. Li is a working member of SAG 3 (Star Formation) science team of SPIRE and the Rosette Molecular Complex is among the most favorite of his regions of study.

S. Leeks works in the Herschel Science Centre as a SPIRE instrument and Calibration Scientist. She is an expert in H II regions and PDRs, and has an extensive experience of spectroscopic analysis of ISO/LWS infrared observations.

A. P. Marston works in the Herschel Science Centre as a HIFI instrument and Calibration Scientist. Major areas of research include massive stars, their evolution and circumstellar media. He is a co-I on several *Spitzer* programs and was a member of the GLIMPSE Legacy team up to leaving the US.

P. Martin's interests range over interstellar dust, molecular clouds and prestellar condensations, and PDRs and HII regions. His experience with the Canadian Galactic Plane Survey and its VLA counterpart brings useful perspective, and recent observations of star-forming regions with BLAST are directly relevant to this proposal.

A. Men'shchikov is a working member of SAG 3 (Star Formation) with an extensive expertise in 1D/2D radiative transfer modeling of dust continuum and reconstruction of physical properties of protostars (as well as circumstellar material around evolved stars).

V. Minier is an expert in star formation studies in the Southern Hemisphere through spectral line and continuum observations from thermal infrared to microwave. He will be the coordinator of the Outreach effort for the Gould Belt and OB Star Formation key projects.

S. Molinari is leading a consortium planning to submit the major OT Key Programme of *Herschel* called "Hi-GAL". He is an expert in the earliest stages of massive star formation, with a long-term experience in photometric and spectroscopic observations of star-forming regions from the infrared to the radio.

P. Persi is a SPIRE consultant for the NGC 6334 region. He is an expert in infrared observations of star forming regions. He has been CoI of the ISOCAM instrument on board of the *ISO* satellite. He wrote a review paper on the massive star forming region NGC 6334 that will be published in the Handbook of star forming regions.

S. Pezzuto is responsible of the PACS DPU OBSW and member of the SPIRE ICC group. He works in the field of star formation and has experience of observing from optical to radio wavelengths. He is currently involved in the development of a photometric tool to classify young stellar objects in different evolutionary phases.

D. Russeil is an expert in the Galactic structure and dynamics. She has a long-term expertise in optical and IR analysis of Galactic H II regions. Her expertise will be of great help when resolving distance ambiguity and analysing the neutral environment of selected regions, using H I data.

P. Saraceno is a co-I of both the SPIRE and the PACS Consortium and the co-coordinator of the SAG 3 (Star Formation) team of SPIRE. He has a long-term experience in far-infrared space astronomy, and, in particular, led a major GT core program on young stellar objects with the ISO-LWS.

M. Sauvage is a co-I of the PACS instrument and an Instrument and Calibration Scientist for both the SPIRE and PACS instruments. His main scientific interest is on extragalactic star formation, and particularly super star clusters.

N. Schneider is a working member of SAG 3 (Star Formation) team. She is an expert of multi-wavelengths studies of molecular clouds and Photon Dominated Regions. She studied in detail the Cygnus X and Rosette complexes in molecular lines and FIR atomic finestructure lines.

B. Sibthorpe has built the SPIRE simulator and has a number of SPIE publications. He has worked on other far-infrared & sub-millimeter satellites and instruments, including ISO & SCUBA

L. Spinoglio's main scientific interests are focussed on the star formation process in our Galaxy and in external galaxies. He has expertise in modeling infrared spectroscopic and photometric data of astronomical sources using photoionization and radiative transfer models.

L. Testi's main research activities are related to the formation and early evolution of stars, stellar clusters, and substellar objects as well as the properties and evolution of circumstellar disks. He is coauthor of more than 95 refereed publications; he has been and is involved in major scientific projects with *ISO*, VLTI, and *Spitzer*.

D. Teyssier works in the Herschel Science Centre as a HIFI instrument and Calibration Scientist. His main scientifc interest has been on infrared dark clouds (IRDCs) and PDRs as observed in infrared and (sub-)millimeter continuum.

R. Vavrek is an Instrument and Calibration Scientist for the PACS instrument in the Herschel Science Centre. His main scientifc interest is on structural analysis of complex self-similar objects such as molecular clouds and he has been involved in search for infrared dark clouds (IRDCs) based on far-infrared data.

D. Ward-Thompson has 96 refereed publications. He is an expert of pre-stellar cores and has worked on many other far-infrared & sub-millimeter satellites and instruments, including *IRAS*, *ISO* & SCUBA.

G. White has over 30 years experience in mm and submm astronomy of star formation regions and the interstellar medium. He has over 200 publications in related fields, and was involved in *IRAS*, *ISO*, and many ground based submm telescope projects and instrumentation.

C. Wilson's interests are in interstellar medium and star formation in both our own and other galaxies. Her leadership role in the Herschel GT KP on very nearby galaxies will enable a good flow of ideas and information between the Key Programmes proposed in the SAG 2 (Nearby Galaxies) and SAG 3 (Star Formation).

Relevant publications:

André, P., Ward-Thompson, D., Barsony, M. 2000, in Protostars & Planets IV, 59
Beltrán, M. T., Cesaroni, R., Codella, C., Testi, L., Furuya, R. S., & Olmi, L. 2006, Nature 443, 427
Bontemps, S., André, P., Kaas, A. A., Nordh, L., Olofsson, G., et al. 2001, A&A.,372, 173
Deharveng, L., Lefloch, B., Zavagno, A., Caplan, J., Whitworth, A. P., Nadeau, D., Martin, S. 2003, A&A, 408, L25
Deharveng, L., Zavagno, A., Caplan, J. 2005, A&A, 433, 565
Marston et al. 2004, ApJS, 154, 333
Men'shchikov, A.B., Miroshnichenko A.S. 2005, A&A 443, 211
Men'shchikov, A.B., et al. 2002, A&A, 393, 867 Motte, F., André, P., Neri, R. 1998, A&A, 336, 150
Motte, F., Bontemps, S., Schilke, P., Schneider, N., Menten, K. M., Broguière D. 2007, A&A, submitted
Schneider, N., Bontemps, S., Simon, R., Jakob, R., Motte, F., Miller, M., Kramer, C. 2006, A&A, 458, 855
Testi, L., & Sargent, A. I. 1998, ApJ 508, L91 Teyssier, D.; Hennebelle, P.; Pérault, M., A&A 382, 624
Ward-Thompson, D., André, P., Crutcher et al. 2007, in Protostars and Planets V
Zavagno, A., Deharveng, L., Comeron, F., Brand, J., Massi, F., Caplan, J., Russeil, D. 2006, A&A, 446, 171
Zavagno, A., Pomarès, M., Deharveng, L., Hosokaw, T., Russeil, D., Caplan, J., 2007, A&A, submitted

Appendix B: Observation Summary Table

Table 4: List of targets and planned observations with SPIRE and PACS in parallel mode

Target	RA/Dec (J2000)	size[a]	scan direction	PACS filter	observation[b] time (h)	observatory overhead (s)
Vela	$6^h00^m00^s$,–43°52′00″	160′×55′	nominal	75	4.92(4.48)	600
		55′×160′	orthogonal[c]	110	5.89(4.89)	
MonR1	$6^h32^m20^s$, 10°33′00″	45′×45′	nominal	75	1.86(1.52)	180
		45′×45′	orthogonal	110	1.87(1.52)	
MonR2	$6^h07^m40^s$,–6°17′00″	40′×40′	nominal	75	1.62(1.30)	180
		40′×40′	orthogonal	110	1.62(1.30)	
NGC 2264	$6^h41^m15^s$, 9°33′00″	60′×60′	nominal	75	2.72(2.28)	180
		60′×60′	orthogonal	110	2.72(2.28)	
Rosette	$6^h34^m20^s$, 4°07′00″	60′×60′	nominal	75	2.72(2.28)	180
		60′×60′	orthogonal	110	2.72(2.28)	
Cygnus North	$20^h38^m30^s$, 42°00′00″	90′×120′	nominal	75	6.16(5.36)	600
		120′×90′	orthogonal	110	5.84(5.19)	
Cygnus South	$20^h33^m30^s$, 39°16′00″	80′×150′	nominal	75	7.00(6.03)	600
		150′×80′	orthogonal	110	6.39(5.77)	
M16	$18^h19^m25^s$,–13°48′00″	60′×30′	nominal	75	1.63(1.37)	180
		30′×60′	orthogonal	110	1.95(1.52)	
M17	$18^h19^m00^s$,–16°41′00″	50′×90′	nominal	75	3.37(2.77)	180
		90′×50′	orthogonal	110	3.04(2.64)	
Sh40	$18^h12^m25^s$,–17°21′00″	30′×50′	nominal	75	1.69(1.32)	180
		50′×30′	orthogonal	110	1.48(1.22)	
NGC 6334	$17^h19^m55^s$,–35°50′00″	65′×100′	nominal	75	4.27(3.61)	180
		100′×65′	orthogonal	110	4.01(3.51)	
NGC 6357	$17^h25^m00^s$,–34°30′00″	70′×70′	nominal	75	3.37(2.87)	180
		70′×70′	orthogonal	110	3.39(2.87)	
W3	$2^h23^m10^s$, 61°37′00″	75′×75′	nominal	75	3.72(3.19)	180
		75′×75′	orthogonal	110	3.73(3.19)	
NGC 7538	$23^h15^m20^s$, 61°30′00″	45′×45′	nominal	75	1.86(1.52)	180
		45′×45′	orthogonal	110	1.87(1.52)	
W48	$18^h57^m50^s$, 1°10′00″	100′×100′	nominal	75	5.62(4.93)	180
		100′×100′	orthogonal	110	5.65(4.94)	
Entire survey		21.9 sq.deg.			104.7(89.47)	1.1

[a] Actual size on sky. Due to a bug in HSpot 2.0, we follow the recommendations given on the *Herschel* website and add 26′ to the height of the map to compute the time.

[b] Observation time = Total time − Observatory overhead; the number in brackets is the observation time but with instrument overheads divided by 3 (see Herschel observation planning note HSC/MEM/0891 by G. Pilbratt, 9.2.2007)

[c] Due to a bug in HSpot 2.0, the time was calculated with nominal scan direction (coverage is in orthogonal direction).

Table 5: Summary for observations of H II regions displaying triggered star formation

	Name	PACS mapping		PACS spectroscopy	
		Map size	Total time[a] Nominal (optimistic)	Number of positions[b]	HSpot time
1	Sh 104	$15' \times 15'$	1900 s (1294 s)	3	8340 s
2	RCW 79	$25' \times 25'$	3480 s (2500 s)	3	8340 s
3	RCW 82	$20' \times 20'$	2630 s (1836 s)	3	8340 s
4	RCW 120	$30' \times 30'$	4450 s (3284 s)	3	8340 s
5	RCW 71	$5' \times 5'$	800 s (566 s)	2	5560 s
6	AFGL 4029	$20' \times 20'$	2630 s (1836 s)	2	5560 s
7	IRAS 16132−5039	$5' \times 5'$	800 s (566 s)	2	5560 s
8	Sh 241	$10' \times 10'$	645 s (870 s)	2	5560 s
9	M 16	done	0 s	7	19460 s
PACS total			5 h (3.5 h)	27	20.8 h

	Name	SPIRE mapping		SPIRE-FTS spectroscopy	
		Map size	Total time	Nb of positions	HSpot time
1	M 16[c]	done	0 s	6	8956 s
SPIRE total			0 h	6	2.5 h

[a] The time is given for two maps in the nominal case (time returned by HSpot) and in the optimistic case (given in parentheses).

[b] All the PACS spectroscopy is done in range mode (range 1: 55-72 + 105-210 μm and range 2: 72-105 + 105-210 μm) , with the Nyquist sampling.

[c] SPIRE-FTS spectroscopy will be done on M16 at high spectral resolution. Six positions will be observed: five with the intermediate spatial sampling, taking 1512.2 s each, and 1 (off) position with sparse spatial sampling but with 6 repetitions, taking 1395.2 s.

Appendix C: Constitution for the "HOBYS" consortium

1. Participants and time contributions

1. The *Herschel* imaging survey of OB Young Stellar objects ("HOBYS" for short) is a Guaranteed Time Key Programme jointly proposed by the SPIRE and PACS consortia, and the *Herschel* Science Centre.
2. The total observing time is 126 hours, based on the following time contributions:
   a. 85 hr of SPIRE GT from SPIRE SAG 3 (Star Formation) team
   b. 19 hr of PACS GT from LAM/OAMP Marseille
   c. 22 hr of GT from HSC (15 hr for "large-scale imaging surveys" + 7 hr for "detailed spectro-photometric studies")

2. Scientific Responsibilities in the Key Programme "HOBYS"

1. The programme shall be led by three coordinators: Frédérique Motte, Annie Zavagno, and Sylvain Bontemps.
2. The coordinators F. Motte and S. Bontemps, in consultation with the SAG 3 and three members from HSC, shall make all decisions related to the 85 hours of SPIRE GT and the 15 hours of HSC GT dedicated to "large-scale imaging surveys".
3. The coordinator A. Zavagno, in consultation with LAM/OAMP researchers and one member from HSC, shall make all decisions related to the 19 hours of PACS GT and the 7 hours of HSC GT dedicated to "detailed spectro-photometric studies".
4. For each specific target, scientist(s) shall be nominated to lead all aspects of the work related. The assignment of leadership roles will take into account the wish of individuals, their expertise, their contributions, and the balance of institutional contributions to the total observing time of the Key Programme.
5. The target leaders (identified in § 2.4) will be responsible for programming the observations and reducing the data. These steps will be done in agreement with and in the timeline decided by the coordinators to ensure the homogeneity of the database produced by the Key Programme.

3 Data and Publication Rights

1. Observations made with the 85 hours of SPIRE GT and 15 hours of HSC GT dedicated to "large-scale imaging surveys" shall have data and publication rights governed by the rules of the SPIRE consortium. For this Key Programme, three HSC members shall have equivalent rights to those given to SPIRE Associate Scientists in SAG 3.
2. Observations made with the 19 hours of PACS GT and the 7 hours of HSC GT dedicated to "detailed spectro-photometric studies" shall be the property of LAM/OAMP Marseille and HSC according to the distribution of PACS responsibilities given in the proposal (§ 2.4).