1 SHARKS: Southern *H*-ATLAS Regions K_s-band Survey

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On behalf of the SHARKS collaboration

1.1 Abstract

SHARKS is a wide and deep VISTA public survey over the SGP and GAMA *Herschel*-ATLAS fields in the K_s band covering $\sim 300\,\mathrm{deg}^2$ to a 5σ depth of $K_s \sim 22.7$ AB mag in 1200 h. The SHARKS fields have been and will be covered by a number of future deep and/or wide far-IR and radio surveys. Our motivations are 1) to provide the best possible counterpart identification for $\sim 90\%$ of the sources detected at $0 < z < 3$ by *H*-ATLAS, ASKAP, SKA and LOFAR; 2) to produce a sample of a thousand strong lenses for cosmography studies; 3) to study the evolution of the most massive structures in the Universe. The depth of the deepest available observations over the proposed fields (VIKING survey, $m_{Ks} < 21.2$ AB mag at 5σ) is not enough to accomplish any of these aims. The SHARKS fields will also overlap with future LSST (optical) and EUCLID (near-IR - but not K_s) observations, representing a perfect complementary dataset with an enormous legacy.

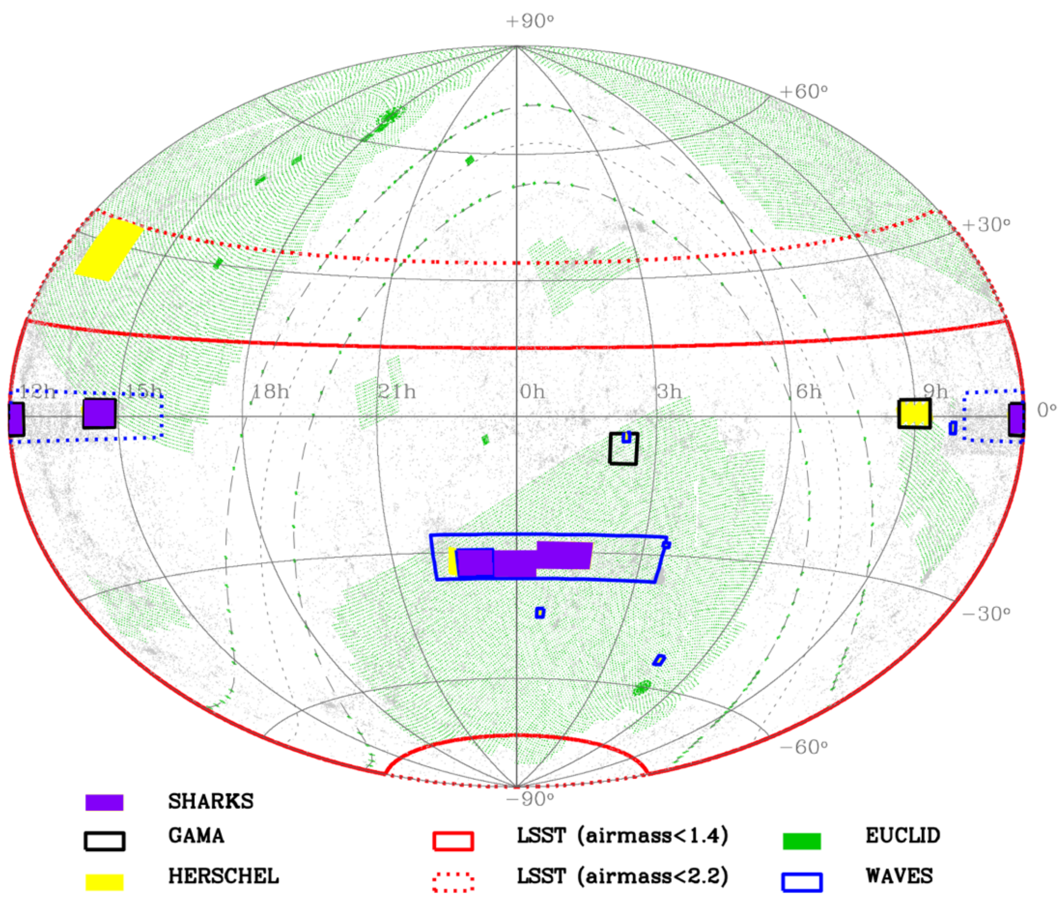

Figure 1: Coverage of the SHARKS fields with future missions, including EUCLID, LSST and WAVES).

Table 1: Existing and future surveys overlapping with SHARKS

Survey	Frequency	Overlapping Area	Depth (5σ)
H-ATLAS	$100-500\,\mu$m	100% in SGP and GAMA	$\sim 30\,$mJy at $250\,\mu$m
EMU	$\sim 1.3\,$GHz	100% in SGP and GAMA	$\sim 50\,\mu$Jy at 20 cm
LOFAR Tier 2	$\sim 150\,$MHz	100% in GAMA	$\sim 0.1\,$mJy at 150 MHz
WALLABY	HI survey	100% in SGP	$M_{\rm HI} > 10^8 M_*$
DINGO	HI survey	100% in SGP and GAMA	$M_{\rm HI} > 10^7 M_*$
GALEX MIS	UV phot.	100% in SGP and GAMA	$\sim 22.7\,$AB mag
Deep-WAVES	optical spec.	100% in SGP	$r < 22\,$ABmag
WEAVE	optical spec.	100% in GAMA	
LSST	u,g,R,I,z phot.	100% in SGP and GAMA	$\sim$ 26-27 AB mag
EUCLID	Y, J, H phot.	100% in SGP	$\sim 24\,$AB mag

2 Survey Observing Strategy

We explain in this section the survey observing strategy that we will follow in SHARKS, including the field selection, the proposed depth, the time justification, and the scheduling requirements.

Field selection: The SHARKS fields have been chosen to overlap with three fields of the *H*–ATLAS survey (Eales et al. 2010, PASP, 122, 499; Bourne et al. 2016 – arXiv:160609254B; Valiante et al. 2016 – arXiv:160609615V). *H*–ATLAS is the widest survey carried out by the *Herschel* Space Observatory and has mapped $\sim 600\,\mathrm{deg}^2$ in five far-IR photometric bands, from $160\,\mu$m to $500\,\mu$m, with PACS and SPIRE instruments. *H*–ATLAS has detected approximately 400,000 galaxies from the nearby Universe out to redshifts of 6, when the Universe was less than a billion years old. SHARKS will observe all equatorial and southern *H*–ATLAS fields except GAMA 9, which is much contaminated by galactic cirrus emission. In this way, SHARKS will cover (see Fig. 1): GAMA 12 (centered at RA: 12:00:00, Dec: +00:00:00), GAMA 15 (centered at RA: 14:30:00, Dec: +00:00:00), and the South Galactic Pole (centered at SGP – RA: 02:09:00, Dec: −32:54:50). The two GAMA fields will cover $\sim 75\,\mathrm{deg}^2$ in total ($\sim 37.5\,\mathrm{deg}^2$ each), whereas the SGP will cover $\sim 225\,\mathrm{deg}^2$. Among the proposed 1200 h, 300 h will be dedicated to the two GAMA fields, while SGP will be observed for 900 h.

In addition to the overlap with the *H*–ATLAS survey, the choice of the SHARKS fields has been based on the number of current and future multi–wavelength surveys that have been or will be carried out over those regions, including a variety of radio continuum (EMU or LOFAR Tier 2) and line (WALLABY or DINGO) surveys with the ASKAP, SKA and LOFAR. EUCLID will also observe the SGP field in three near-IR bands (Y, J, and H). However, EUCLID will not observe in K_s and here SHARKS represents an important complementary dataset. In addition to these observations, GAMA 12, GAMA 15 and SGP fields will be covered by LSST, which will provide optical photometry (u, g, R, I, and z bands), while Deep-WAVES and WEAVE will provide optical spectroscopy. There are also available GALEX far- and near-UV observations from the MIS survey. All surveys that have been or will be carried out over the SHARKS fields are summarized in Table 1. It should be pointed out that we have chosen to carry out this survey in K_s band because this band optimizes the identification of *H*-ATLAS and radio sources as revealed by ongoing work finding *H*-ATLAS counterparts in VIKING (Furlanetto et al. in prep). Furthermore, EUCLID (whose observations will start well after SHARKS is complete) will not observe in K_s, making SHARKS a complementary survey (with an important legacy) for the study of the high-redshift Universe in combination with LSST, among others.

Proposed depth: One of the main aims of SHARKS is to detect most *H*-ATLAS, EMU and LOFAR sources at $1 < z < 3$ and the most extreme starbursts at $z > 3$. In order to do this, we need to reach $\sim 22.7\,$AB mag at 5σ. This is illustrated in Figure 2, where we show the distribution of K_s band magnitude as a function of redshift for a sample of *H*-ATLAS sources with VLA counterparts. It can be seen that galaxies which are detectable with VIKING are preferentially located at $z < 1$, whereas the deeper SHARKS observations will detect dusty starbursts up to $z \sim 3$, and the most massive systems at $z > 3$. From the radio perspective, the

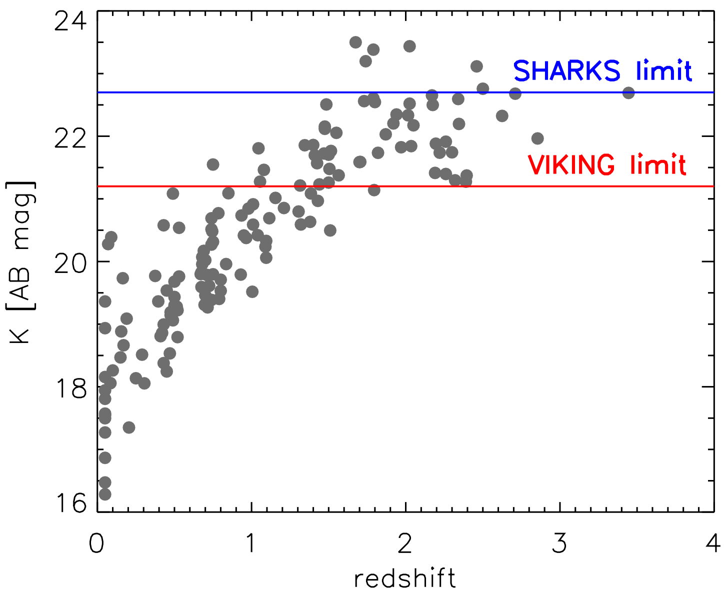

Figure 2: K_s–band magnitude as a function of redshift for *H*-ATLAS sources with VLA counterparts in the SXDF and COSMOS fields. This Figure clearly illustrates the need for deeper Ks-band imaging. The VIKING survey is highly incomplete at $z > 1$. The much deeper SHARKS observations will enable to detect 90% of all star-forming, obscured *H*-ATLAS sources, and also the most extreme populations at $z > 3$.

same picture emerges. The EMU team have shown that 90% of radio sources with $S_{1.4} > 60\,\mu$Jy are detected in the K_s band at $K_{s,\,\mathrm{pet}}$(AB) < 22.6 (McAlpine et al. 2012, MNRAS, 423, 132 – see also Fig. 2). Luchsinger et al. (2015, arXiv:1507.01144) show the K-z relation for SFGs, AGNs and QSOs at $z < 4$ selected from a radio survey at a similar depth as EMU. All their sources are brighter than 22.7 AB mag and, therefore, will be detected by SHARKS.

2.1 Scheduling requirements

The scheduling of the observations will be done following the observability of each SHARKS field on each observing period. This is summarized in Table 2, where the fields shown on each period are those observable in that period. In order to make the explanation of the scheduling easier, we have divided the large SGP area into three sub–areas according to their average RA (SGP1, SGP2, and SGP3). Each GAMA field is observable during three semesters (GAMA 12 during P100, P102, and P104; G15 during P99, P101, and P103). Therefore, we propose to observe each of them during 50 h on each semester. The three SGP pointings are observable between July and November, covering the end of one period and the beginning of the following one. Given their position on the sky, we propose to prioritize SGP1 on P99, P101, and P103 (so 100h on this field per period), SGP3 on P100, P102, and P104 (100h per period), whereas SGP2 will be observed between P99 and P100, between P101 and P102, and between P103 and P104. It should be noted that the only scheduling requirement which has been changed with respect to the proposal is the shift of the observations in P98 to P104.

Except December and January, time can be scheduled at any month. Since we will be carrying out observations in K_s band, we do not require any moon restriction. Also, our seeing limitation ($< 1.2''$) is moderate. We note that the seeing limitation in the original proposal has been degraded in the SGP field to $< 1.2''$ because of the over-subscription in the RA bin around 23h and 0–01h. Furthermore, non-photometric time can be used, since the main photometric calibration is expected to be zero-pointed from VIKING (which observed the same area with the same instrument, filter, and sky conditions). Therefore, our survey offers good flexibility for the VISTA scheduling.

Time justification: According to the VIRCAM exposure time calculator, in order to reach the required K_s band limiting magnitude of ~ 22.7 AB mag at 5σ for a point-like source (most high-redshift galaxies detected by SHARKS will be point-like at $\sim 1''$ seeing) we need to integrate ~ 1.4 h on each pixel. This means, including the overheads indicated by the phase 2 tool for the already submitted OBs for P98, ~ 6.2 h per tile, which can be comfortably observed with 7 OBs of ~ 53 min each. This observing time includes all estimated overheads associated with each OB (slewing, acquisition, jittering, detector readouts, etc), but excludes overheads for the VIRCAM Calibration Plan. Night time calibration overheads thus reduce the available hours per night pro-rata among all programmes. The GAMA fields (GAMA 12 and GAMA 15) have 75 deg^2, and the SGP has 225 deg^2, so 300 deg^2 is the total area covered by SHARKS. With these numbers, the total requested time is 1200 h. Table 2 includes the on-source time and the total exposure time (including overheads) for each field on each period. We have included in Table 2 the awarded early allocation during P98, consisting in 100 h to observe the SGP 3 field. The hours observed during this early allocation will be reduced to the awarded allocation for field SGP 3 during P104.

The observing strategy of the survey is based on the philosophy of, for the same field, observing each pointing (composed by seven OBs) down to the full depth before proceeding to observe another pointing which is observable during the same time. Of course, it will be always possible to stop the execution of one pointing if the field is two low and start observing a new pointing in another region of the sky which is visible, but once the first field is observable again, we will prioritize observations in that pointing instead of a close one. This might happen for example in mid-April 2018, where GAMA 12 starts being low from the middle of the night when GAMA 15 is high. In this case the execution of the current tile in GAMA 12 will be stopped and observations will point to GAMA 15. Then, when GAMA 12 is observable again we will start from the next OB in the OB group with respect to the one which was observed the last. Our proposed observing/scheduling technique ensures maps down to the full depth several nights after the first OB of a given pointing has been completed. This will maximize the science output of the survey since it will be possible to work on the science goals from the first day the data start being taken. This requirement also makes the amount of final data products increase almost linearly with time and that the periodic data releases contain uniformly covered areas of the sky (see §8).

2.2 Observing requirements

At the beginning of the survey we will prioritize the pointings to maximize the science output and to show the potential of the survey to study high-redshift starbursts. Since SHARKS observations will probably start during P98, the first field observed will be SGP. During the last years, this field has been extensively observed by our team with different telescopes and in almost all frequencies relevant to galaxy evolution. Particularly important for the science output of SHARKS is that we have conducted PdBI/NOEMA, EVLA, and ALMA deep observations targeting different samples of star-forming galaxies, including sources in the Thousand Lens Survey (TLS – a large continuum VLA survey aimed at providing a lens cosmographic analysis of the Universe) or the most luminous starbursts of the early Universe (Oteo et al. 2016, ApJ, 827, 34, Fudamoto et al. in prep). The first SHARKS pointings will observe sources that have been observed with all those mentioned facilities/surveys. In this way, once the first OBs are complete and provide full-depth maps, the SHARKS data will be combined with all those previous observations to highlight the potential and the scientific output of the survey.

3 Survey data calibration needs

The flux calibration of the data will be carried out in the CASU pipeline (see §4.1) by using 2MASS as a reference. In addition to this, and thanks to the availability of VIKING K_s band data (taken with the same telescope, instrument, filter and sky conditions) over the entire SHARKS area, we will also calibrate SHARKS data using VIKING as a reference. Both flux calibration will be compared during the quality control of the data. Therefore, non-photometric time can be used. No special calibration is needed.

Table 2: Scheduling plan of SHARKS

Period	Target name	RA	DEC	Filter setup	Tot. exp. time [hrs]	Tot. exec.[1] time [hrs]	Seeing/FLI/ transparency
P98	SGP 3	~ 01	-30	K_s	~ 70	~ 100	$< 1.2''$/No restriction/THN
Total over P98					~ 70	~ 100	
P99	GAMA 15	~ 15	-00	K_s	~ 35	~ 50	$< 1''$/No restriction/THN
P99	SGP 1	~ 23	-30	K_s	~ 70	~ 100	$< 1.2''$/No restriction/THN
P99	SGP 2	~ 00	-30	K_s	~ 35	~ 50	$< 1.2''$/No restriction/THN
Total over P99					~ 140	~ 200	
P100	SGP 2	~ 00	-30	K_s	~ 35	~ 50	$< 1.2''$/No restriction/THN
P100	SGP 3	~ 01	-30	K_s	~ 70	~ 100	$< 1.2''$/No restriction/THN
P100	GAMA 12	~ 12	-00	K_s	~ 35	~ 50	$< 1''$/No restriction/THN
Total over P100					~ 140	~ 200	
P101	GAMA 15	~ 15	-00	K_s	~ 35	~ 50	$< 1''$/No restriction/THN
P101	SGP 1	~ 23	-30	K_s	~ 70	~ 100	$< 1.2''$/No restriction/THN
P101	SGP 2	~ 00	-30	K_s	~ 35	~ 50	$< 1.2''$/No restriction/THN
Total over P101					~ 140	~ 200	
P102	SGP 2	~ 00	-30	K_s	~ 35	~ 50	$< 1.2''$/No restriction/THN
P102	SGP 3	~ 01	-30	K_s	~ 70	~ 100	$< 1.2''$/No restriction/THN
P102	GAMA 12	~ 12	-00	K_s	~ 35	~ 50	$< 1''$/No restriction/THN
Total over P102					~ 140	~ 200	
P103	GAMA 15	~ 15	-00	K_s	~ 35	~ 50	$< 1''$/No restriction/THN
P103	SGP 1	~ 23	-30	K_s	~ 70	~ 100	$< 1.2''$/No restriction/THN
P103	SGP 2	~ 00	-30	K_s	~ 35	~ 50	$< 1.2''$/No restriction/THN
Total over P103					~ 140	~ 200	
P104	SGP 2	~ 00	-30	K_s	~ 35	~ 50	$< 1.2''$/No restriction/THN
P104	SGP 3	~ 01	-30	K_s	~ 70	~ 100	$< 1.2''$/No restriction/THN
P104	GAMA 12	~ 12	-00	K_s	~ 35	~ 50	$< 1''$/No restriction/THN
Total over P104					~ 140	~ 200	
Total over Survey					~ 840	~ 1200	

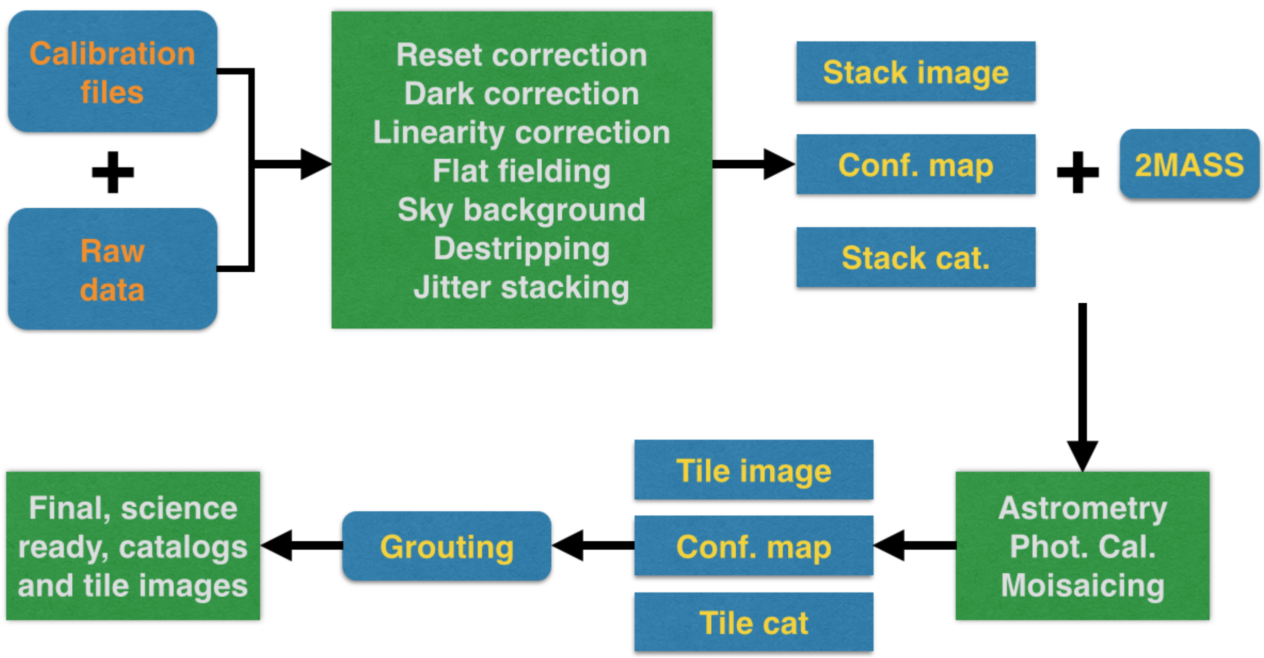

Figure 3: Block diagram showing the SHARKS data reduction procedure, which will be carried out by CASU.

4 Data reduction process

We plan to use the VISTA Data Flow System (VDFS; Emerson et al. 2004, SPIE, 5493, 401; Irwin et al. 2004, SPIE, 5493, 411; Hambly et al. 2004, SPIE, 5493, 423) as the core of our data reduction. This will include: pipeline processing from raw frames to source catalogues; delivery of agreed data products (see §7) to the ESO Science Archive; production of a purpose-built IVOA compliant science archive with advanced data-mining services and enhanced data products including federation of VISTA survey products with SDSS survey products. The standardised agreed data products produced by VDFS will be delivered to ESO, with a copy remaining at the Science Archive in Edinburgh.

Data reduction will be carried out by the VDFS team, and augmented by individuals from our team, in particular for product definition and Quality Control. We divide the plan into two distinct but intimately related parts: pipeline processing (§4.1) and science archiving (§4.2).

4.1 Pipeline processing

During the observations, the data from VISTA are assessed for quality control on site in real time using a simplified data reduction pipeline. Then the data will be sent to Garching by ftp, where the data will be included in the ESO raw data archive and a second pipeline is run. This second pipeline run is needed to monitor the instrumental response, generate calibration information and provide a library calibration frames for the pipeline at the telescope. Once the data has been uploaded to the ESO raw data archive, the data will be sent to Cambridge, also via ftp transfer, where the data science reduction is carried out by the Cambridge Astronomy Survey Unit (CASU). It should be noted that the science pipeline is able to process data from an entire night or more as a single entity and hence it is possible to use information which is not considered in the quality-control pipelines, providing much better image quality.

Figure 3 schematizes the main steps of the data calibration process. These include:

- **Reset correction:** Reset frames are taken for each exposure and will be subtracted in the data acquisition system.
- **Dark correction:** The dark current will be estimated from a series of exposures taken with a dark filter inserted. Subtracting a mean dark frame also corrects several other additive electronic effects.
- **Linearity correction:** We will correct the non linearity of the response of the VISTA detectors by using a linearity calibration table, derived from a series of dome flats of varying exposure time at constant illumination level.
- **Flat field correction:** This will be done done dividing each image by a mean twilight flat-field image. This removes the small scale variations in the detector as well as the large scale vignetting profile of the camera. The global flatfield properties of each detector will be also use to gain-normalise each detector to a common (median) system.
- **Sky background correction:** This will remove the large scale spatial background emission that comes from the atmosphere as well as several remaining additive effects. The background map will be estimated using several different algorithms that combine the science images themselves with rejection or masking.
- **Destripe:** This step will be included to remove the low-level horizontal stripe pattern which is introduced into the image background by the readout electronics for the VISTA detectors.
- **Jitter stacking:** At this point in the reduction the jitter series is shifted and combined to form a single image stack, using positions of detected objects on all the detectors to compute the shifts. This allows bad pixel regions in one exposure to be rejected in favour of good pixels in other exposures.
- **Catalogue generation:** Objects will be extracted on the stacked images and their properties (positions, fluxes, or shape descriptors) will be stored and used for the astrometric and photometric calibration.
- **Astrometric and photometric calibration:** The objects extracted in the previous step will be then matched to their counterparts in the 2MASS point source catalogue. Because 2MASS has such a high degree of internal consistency it is possible to calibrate the world coordinate system of VISTA images to better than 50 milli-arcseconds. The 2MASS magnitudes are also used in conjunction with colour equations to provide photometric zeropoints to an accuracy of 1-2% (depending upon the wave band). This 2MASS-based astrometric and photometric calibration will be compared with VIKING K_s images.
- **Tiling and grouting:** In these last steps, the astrometrically and photometrically calibrated paw prints will be combined into tiles, so the overlap areas in the VISTA paw prints are filled to form a uniform and homogeneous image. Then we will remove the effects of the time variation of the point spread function and any variation in the magnitude zero-point in the VISTA tiles (grouting). Once this has been done, source extraction will be carried out again in order to generate the final science catalogs.

The processing of data is monitored using web pages that are automatically updated when new raw data are received or when a night of data is processed. The catalogue information forms the basis for the various QC plots and summary statistics. It is worth noting that during commissioning and testing of the instrument evidence of detector crosstalk and sky fringing was not found. Hence it will not be necessary to deal with them in the pipeline. Evidence of persistence, which manifests itself as a glow on a detector where a bright object was recently observed, was also searched but for the VISTA detectors this represents a very small effect which only occurred when extremely bright stars (which are rare) are observed. In practice this effect is negligible and will be ignored during pipeline processing.

4.2 Science archiving

Our data will be included as part of the VISTA Science Archive, curated by the Wide-Field Astronomy Unit (WFAU) in Edinburgh. The concept of the science archive (SA, see Hambly et al. 2004, SPIE, 5493, 423) is

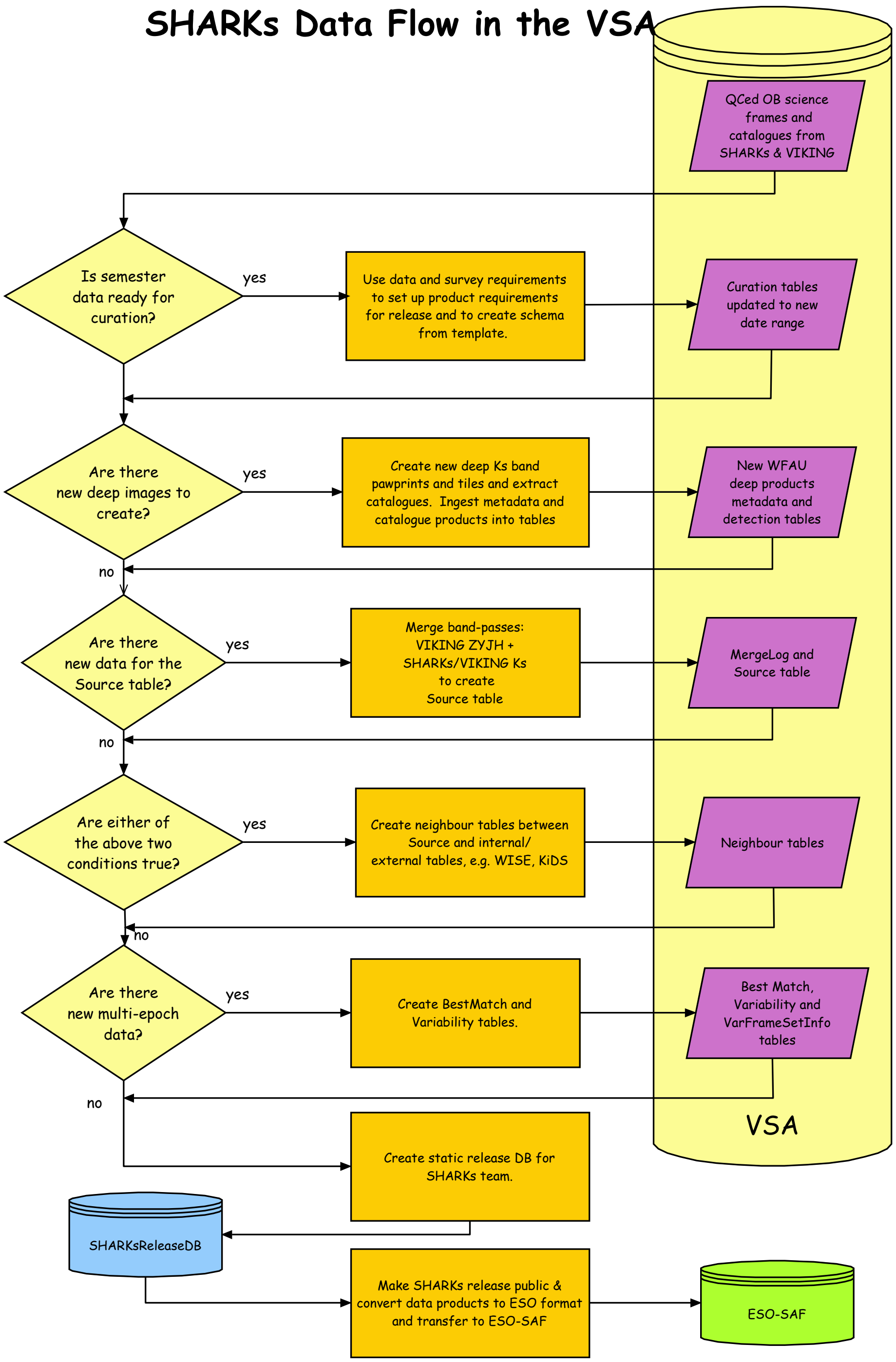

Figure 4: Block diagram showing the SHARKS data flow in the VSA.

key to the successful exploitation of wide-field imaging survey datasets. The SA ingests the products of pipeline processing (instrumentally corrected images, derived source catalogues, and all associated metadata – see §4.1) into a database, and then goes on to curate them and produce enhanced database-driven products. In the VDFS science archive, the curation process includes (see diagram in Fig. 4):

- Individual passband frame association
- Source association to provide multi-colour source lists.
- Quality Control feature, which will be defined by the SHARKS team and supported by the VSA team.
- Generation of new images products, including the combination of SHARKS and VIKING.
- Ingestion of value added products produced by the consortium, e.g. photo-z catalogues. Our survey is intrinsically a multi-wavelength project and most science will come from the linking of SHARKS data with other large catalogues, and the VSA is designed to enable such links.
- Creation of static database for SHARKS team
- Make SHARKS release public and convert the data products to ESO format and transfer to the ESO science archive.

The VSA has a user–friendly interface based on SQL queries; both simple and advanced interfaces are available, with the simple interface for ease of use while the advance interface exposes the full relational database structure to the user enabling more complex queries and manipulation.

5 Manpower and hardware capabilities devoted to data reduction and quality assessment

As the PI of the survey, Iván Oteo will oversee the progress on the observations, data reduction process, quality assessment and the preparation of data releases. In order to do this, he will be in close collaboration with many other team members, specially with the CASU and WFAU teams on charge of the data reduction. Table 3 provides a list of the key team members responsible for survey strategy, OB preparation, data handling, pipeline processing, quality control and science assessment. It should be noted that only the main leaders of each function are included, but these will all work in close collaboration with other SHARKS team members, and in particular with students and post-docs which already belong to the team: A. Manilla-Robles, J. Greenslade, A. Muñoz, P. Hurley, J. Scudder, C. Furlanetto, S. Duivenvoorden, T. Hughes, and R. Leiton. Furthermore, it is expected that future students and post-doc can join the team with fundings obtained from several external resources and based on the scientific exploitation of SHARKS. We note that our team is formed by long—experienced researchers in all SHARKS science goals, as well as experts in near-IR observations who have been heavily involved in the previous photometric VISTA PS (VIDEO and VIKING in particular). One of the positive points of SHARKS is the important legacy that will provide to current and future multi-wavelength surveys. For this reason we have also included in Table 3 a list of the team members who will be the main contact to all those surveys. The FTE contributions from the team members are listed in Table 3. Co–investigators without a listed FTE are those who will not be involved in the execution of SHARKS on the weekly or monthly basis. Their contributions will consist of attendance to team meetings and the availability of their broad range of expertise, mainly their connection with other multi–wavelength surveys.

OB preparation: The OB preparation will be carried out by the initial VIKING PI, William Sutherland (see Table 3) who was on charge on the OB preparation in VIKING. The last version of the Survey Areas Definition Tool (SADT) will be used. It should be noted that, despite VIKING and SHARKS overlap in area, we cannot use the same VIKING pointings in SHARKS because the guiding star catalog has been updated since the VIKING OBs were created.

OPC reports: The PI of the survey will be on charge of writing the OPC reports (see Table 3), both every six months and yearly for the November OPC. Each OPC report will include a detailed description of the data observed until each report submission deadline, including the status of the observations, the data calibration progress, creation of science maps, photometric catalogs, and the delivery of the data to ESO. Each OPC report will also include the latest science results with the aim of showing the potential of the survey.

Data preparation: In addition to the data archiving in the VISTA Science Archive (see §4), we will provide the required data products to ESO. These will include the science maps and the photometric catalogs (see also §7 for more details). Furthermore, we will release all SHARKS maps and catalogs through a dedicated website at the same time that the data are released to ESO. The catalogs in this website will include multi-wavelength photometry of all SHARKS-detected objects in other near-IR, optical, and UV bands, taking data from previous VISTA and VST Public Surveys (VIKING and KIDS) and other current and future surveys in the SHARKS fields. We will also provide the near-IR identification of all *H*-ATLAS sources covered by the SHARKS observations, including a matching probability. These source identifications will be updated and improved once data from the deep radio surveys in the SHARKS field become available, whose data will be also included in the released catalogs.

6 Data quality assessment process

The data quality assessment will be carried out by Steve Maddox in close collaboration with Thomas Hughes and Roger Leiton. All these team members have extensive expertise in image treatment, data mining, and photometric techniques. We will explore every individual data sets as soon as they are processed by the pipeline. We will monitor the seeing of each image in order to confirm that they meet the survey requirements, we will check the quality of the data reduction (including bias, flat-field subtraction, cosmic rays rejection, etc) and the photometric calibration (which will be zero-pointed using VIKING as a reference). These tasks will be done both for the individual exposures and for the combined images (SHARKS alone and SHARKS plus VIKING). After each tile is complete, we will also check whether we reach the required sensitivity to ensure that all the science goals of the survey can be accomplished. This detailed data quality assessment will be key to ensure the delivery of very high-quality data products to the community.

7 External Data products and Phase 3 compliance

The survey OBs will become part of the standard VISTA queue schedule, and as the observations build up we will be able to start building the data products of the survey, at the same time that producing science (much of the science analysis can progress in parallel without waiting for the survey completion). The data products of SHARKS will consist in:

1. Instrumentally corrected frames (pawprints, tiles, etc) along with header descriptors propagated from the instrument and processing steps (science frames and calibration frames).
2. Statistical confidence maps for each frame.
3. Stacked images data for jittered observations, based on individual OBs.
4. Full-depth images after combination of all seven tiles on each pointing.
5. Data Quality Control database, whose main parameters (including FWHM PSF, zero-point, etc) will be included in the header of the released images.
6. Derived catalogues (source detections from science frames with standard isophotal parameters, model profile fitted parameters, image classification, etc.)

Table 3: Allocation of resources within the team

Name	Function	Affiliation	Country	FTE
I. Oteo	PI	University of Edinburgh, ESO	UK, Germany	0.4
L. Dunne	Management group	University of Edinburgh	UK	0.2
S. Eales	Management group	Cardiff University	UK	0.1
R. Ivison	Management group	ESO, University of Edinburgh	Germany, UK	0.1
S. Maddox	Phase 3	University of Edinburgh	UK	0.2
I. Oteo	OPC reports	University of Edinburgh, ESO	UK, Germany	0.1
S. Eales	Multi-wavelength photometry	Cardiff University	UK	0.1
E. Valiante	Multi-wavelength photometry	Cardiff University	UK	0.1
S. Dye	Lens cosmography	University of Nottingham	UK	0.1
A. Manilla-Robles	Lens cosmography	ESO	Germany	0.1
D. Clements	High-z clusters - Planck	Imperial College London	UK	0.1
Josh Greenslade	High-z clusters - Planck	Imperial College London	UK	0.1
Alejandra Muñoz	Cosmological simulations	Universidad de Valparaíso	Chile	0.1
I. Oteo	Dusty, high-z galaxies	University of Edinburgh, ESO	UK, Germany	0.1
H. Dannerbauer	Dusty, high-z galaxies	IAC	Spain	0.1
E. Ibar	Local galaxies	IAC	Spain	0.1
W. Sutherland	Phase 2	QMUL	UK	0.1
P. Hurley	*Herschel* source ID	University of Sussex	UK	0.1
J. Scudder	*Herschel* source ID	University of Sussex	UK	0.1
C. Furlanetto	*Herschel* source ID	University of Nottingham	UK	0.1
S. Duivenvoorden	Source de–blending	University of Sussex	UK	0.1
Thomas Hughes	Data quality	Universidad de Valparaíso	Chile	0.1
Roger Leiton	Data quality	Universidad de Valparaíso	Chile	0.1
A. Bayo	VO connectivity	Universidad de Valparaíso	Chile	0.1
M. Irwin	CASU contact	University of Cambridge	UK	0.1
E. Gonzalez	CASU contact	University of Cambridge	UK	0.1
C. Gonzalez	CASU contact	University of Cambridge	UK	0.1
B. Mann	WFAU contact	Royal Observatory, Edinburgh	UK	0.2
N. Cross	WFAU contact	Royal Observatory, Edinburgh	UK	0.2
A. Edge	VIKING contact	Durham University	UK	–
S. Driver	WAVES/GAMA contact	University of Western Australia	Australia	–
D. Smith	LOFAR/WEAVE contact	University of Hertfordshire	UK	–
N. Seymour	EMU contact	Curtin University	Australia	–
M. Hardcastle	LOFAR contact	University of Hertfordshire	UK	–
M. Vaccari	HELP contact	University of the Western Cape	South Africa	–
S. Oliver	HELP contact	University of Sussex	UK	–
M. Jarvis	VIDEO and MeerKAT contact	University of Oxford	UK	–
L. Davies	WAVES-Deep contact	University of Western Australia	Australia	–
A. Robotham	WAVES-Wide contact	University of Western Australia	Australia	–

7. Database-driven image products (stacks, mosaics, difference images, image cut-outs)
8. SHARKS multi-wavelength catalog including counterpart identification and photometry (or upper limits for faint SHARKS sources with no counterpart) in different UV/optical/near-IR surveys (see above), as well as counterpart identification in *Herschel* images and in the future radio surveys which will be carried out over the SHARKS fields.

It should be pointed out that due to the adopted observing strategy we will not be able to provide variable source catalogs with SHARKS data only. However, due to the time gap between VIKING and SHARKS we will be able to provide a list of variable sources in K_s band which, due to the limited depth of VIKING, will only include the brightest variable sources in SHARKS.

Furthermore, the images and catalogs will be made to be compatible with the virtual observatory (VO). The VO commitment will consist on having a dedicated archive of both, images and catalogs, curated and regularly maintained that will be registered in a VO registry to facilitate the access to any VO tool. The access then should incorporate TAP and SIAP (database and image access protocols).

8 Delivery timeline of data products to the ESO archive

We plan phased data releases to ESO via the Phase 3 system (ftp transfer and using the Release Manager) and through a dedicated website at intervals during the survey, before the start of each new observing period, as follows:

- T0: Official start of the survey, in P99. It should be noted, as commented earlier, that we have been notified that SHARKS will likely start during P98. However, the delivery times count from the official start for the survey in P99, which is the period which has been assumed as a reference in this section.
- T0 + 18 months: first data release (DR1) of science products from the first year of survey (P99 and P100) observations. We anticipate that standard science products can be released to the PI of the survey within 1–2 months of raw data arriving in the UK. Therefore, the first data release (after allowing for 3–4 months of data inspection, quality control, etc.) will happen 6 months after the first year of observations has been completed. The DR1 will likely include science frames at full depth that will be able to be used by our science team and the community in general.
- T0 + 30 months: DR2 of science products corresponding to P99, P100, P101 and P102 (the first two years of observations) incorporating improved reductions based on experience as survey proceeds.
- T0 + 42 months: Final data release of the survey (P99+P100+P101+P102+P103+P104).

We envisage that the first SHARKS publication will happen together with DR1. This paper will detail the observation strategy and the data reduction and will contain the DR1 maps taken during the first year of observations and their scientific exploitation in combination with the already available radio and (sub)–mm imaging from the EVLA and ALMA, respectively. This publication will highlight the potential and legacy of SHARKS and will serve as a presentation of the survey to the community for further exploitation.