The ESO Public Surveys — Review of Milestones and Completion

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In 2013 the eleven currently ongoing ESO public surveys successfully completed the submission and publication of their science data products via the ESO Science Archive Facility. An overview of the public survey projects in terms of telescope time allocation, observation progress and expected date of completion is presented. The science data products available in the ESO archive and their usage by the astronomical community are discussed with regard to the legacy value and scientific impact of these projects. This overview represents a natural introduction to the special section of the *Messenger* dedicated to the ESO public survey projects, in which the survey teams present their scientific aims and selected results in a series of dedicated articles.

Introduction

The ESO public surveys are very large programmes that last longer than two years and provide a legacy for the astronomical community at large. The start and implementation of the public surveys is linked to the operational deployment of the dedicated survey telescopes at ESO. The first suite of public survey programmes specifically designed for the VLT Infrared Survey Telescope for Astronomy (VISTA) and the VLT Survey Telescope (VST) started in 2010 and 2011, respectively, as these telescopes entered operations. With the successful start of these imaging public surveys, ESO also initiated spectroscopic public surveys on two other telescopes at the La Silla Paranal Observatory.

The six near-infrared (NIR) imaging public surveys on VISTA (VHS, UltraVISTA, VIDEO, VVV, VMC and VIKING) and three optical imaging public surveys on VST (KiDS, VST ATLAS and VPHAS+) have strong synergies between their wavelength and area coverage (Arnaboldi et al., 2007). These projects range from shallow whole hemisphere — wide area — to deep pencil beam surveys, and their scientific drivers include a broad range of fundamental astrophysics topics, ranging from the nature of dark energy, the formation and evolution of galaxies, detailed studies of the structure of the Milky Way, to the universality of the stellar initial mass function. Two spectroscopic surveys started in 2012: the Gaia–ESO survey is devoted to the dynamics and chemical evolution of the Milky Way; the PESSTO survey investigates transient objects and, in particular, the physics of supernova explosions. For an overview of the scientific goals of the public surveys, their observing strategies and first results, readers are directed to the following contributions of the survey teams in this issue. (For the survey VISTA Variables in the *Via Lactea* [VVV], a half-way progress report will be presented in the next *Messenger* issue.)

The main difference between the public surveys and the other ESO observing programmes (in particular Large Programmes that may also have observations spanning several years) is that all raw data are immediately public and available worldwide through the ESO Science Archive Facility (SAF) and, even more importantly, the commitment made by the survey teams to deliver science data products and catalogues to ESO with yearly releases. The reduced and calibrated images and/or spectra, as well as catalogues listing physical properties of surveyed targets, are made available to the astronomical community through the SAF. In this article, we present the current status of the surveys and estimate the year of completion for the imaging public surveys that are carried out in service mode. The delivery and publication of data products through the SAF closes the loop with the community and we present the current status of the Phase 3 delivery for the eleven public surveys. We conclude with an overview of the data downloaded by the community in terms of data volume and data product types.

Telescope time allocation to ESO public surveys

The VISTA surveys started after the end of the dry-run period on 1 April 2010. VISTA has a 4.1-metre diameter primary mirror and is equipped with a near infrared camera VIRCAM (VISTA InfraRed CAMera) with a 1.65-degree diameter field of view (Emerson et al., 2006). The six VISTA public surveys are well into their fourth year of operation. The overall time allocations for these surveys are comparable, except for the VHS (VISTA Hemisphere Survey), which requires 3400 hrs for completion, according to its survey management plan. The VHS takes up 23 % of the telescope time, while about 13 % goes on each of the other surveys; in addition up to 5 % of the time is allocated to Chilean and 5 % to open-time programmes. Figure 1 shows a summary pie chart of the time allocation to the surveys and Chilean and open time as a percentage of the total available VISTA time.

The VST public surveys started on 15 October 2011 in service mode, following the successful commissioning of the VST on Paranal. The VST is a 2.6-metre modified Ritchey–Chrétien alt-azimuth telescope (Arnaboldi et al., 1998) equipped with a 1 × 1 degree optical imager

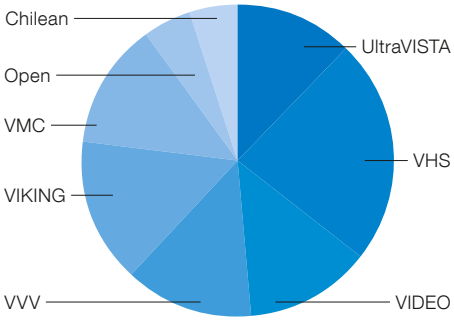


Figure 1. Pie chart showing the time allocation as a percentage of the total available time to the six imaging surveys and open time on VISTA.

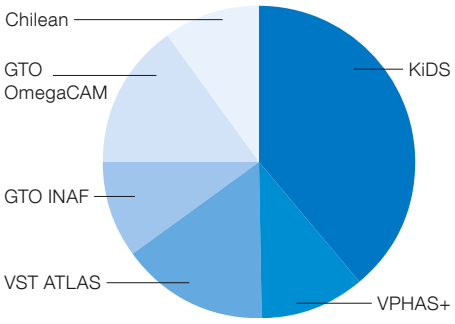


Figure 2. Pie chart showing the time allocation as percentage of the total available time for the VST.

OmegaCAM (Kuijken, 2011). An overview of OmegaCAM's scientific operations is given in Mieske et al. in this issue (p. 12). The VST surveys are starting their third year of operation. KiDS is the largest survey, requiring 3225 hrs to completion, or 39% of the time, followed by 15% for VST ATLAS and 11% for VPHAS+. The time allocated to Chilean programmes (10%), and Guaranteed Time Observations (GTO) of the OmegaCAM consortium (15%) and the Italian National Institute of Astrophysics (INAF; 10%) make up for a sizable fraction of the available telescope time, which has an important impact on the speed of completion. Figure 2 is a summary pie chart of the time allocation of the VST surveys as a percentage of the total available VST time for the public surveys, Chilean and GTO programmes.

The first spectroscopic public survey, the Gaia–ESO survey, started operation on 1 January 2012 on FLAMES at the VLT Unit Telescope 2 (Kueyen) on Paranal. The data acquisition for this survey is carried out in visitor mode and the time allocation of the survey entails 60 nights each year, for an overall assignment over four years initially, with another year pending a review of the survey progress and delivered data. Thus far 105 nights have been allocated to the Gaia–ESO survey. The PESSTO survey started operation on 1 April 2012, on EFOSC and SOFI at the New Technology Telescope (NTT) on La Silla. The data acquisition for this survey is also carried out in visitor mode. The time allocation for the survey includes 90 nights each year, with an allocation of 60/30 nights in odd and even periods respectively, for an overall assignment over four years, also with another year pending a successful review. Thus far 120 nights have been allocated to this project.

Progress and estimated completion time for imaging surveys

An integral part of the approval of public survey projects is the review of their survey management plans (SMPs), which outline the plans for telescope time allocation and observing constraints over the years. Additional information on quality control and pipeline data reduction, survey resource allocation for the survey execution (full-time equivalent [FTE] allocation), the timeline for the delivery and the description of the data products for publication in the SAF are all part of the SMPs. Hence the SMPs have become the benchmark that is used to compute the progress of the public surveys and they represent the basis for estimating their completion time. In service mode, the basic observation unit is the observation block (OB) and the time charged to the programme is accounted for in terms of the number of successfully completed OBs. This includes the shutter open time (exposure time) and the relevant overheads provided in the execution time reporting module, which is part of the observation preparation software (P2PP3).

Successfully completed OBs are executed observations that fulfil the requested observing constraints according to stringent quality control (QC) criteria that are explained extensively elsewhere[1]. Further information on the VST/OmegaCAM QC process, which was designed following the QC for VISTA/VIRCAM observations, is given in the article by Mieske et al. (p. 12). In the following, the fraction of the completion for a survey is computed as a fraction of the total execution time in hours for the completed OBs normalised by the total time in hours requested in the approved SMPs. The cumulative diagrams for the percentage of completion are shown in Figures 3 and 4 for the VISTA and VST surveys, respectively.

VISTA — The six VISTA surveys are progressing at a similar pace. As for any new telescope the start of VISTA operations required some adjustments. After

Figure 3. Graph of the percentage completion for the VISTA surveys as a function of date.

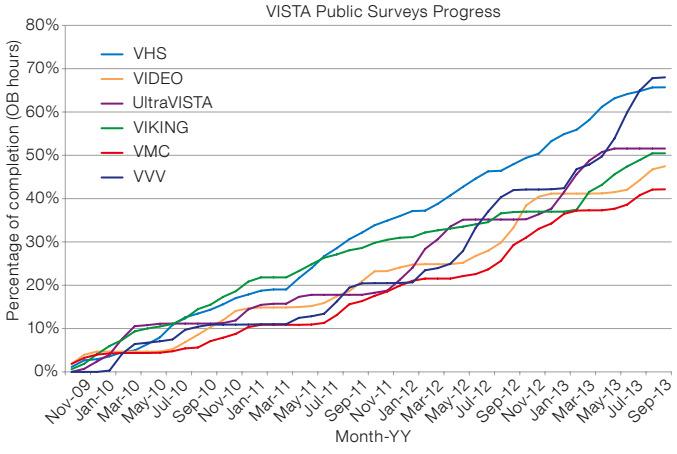
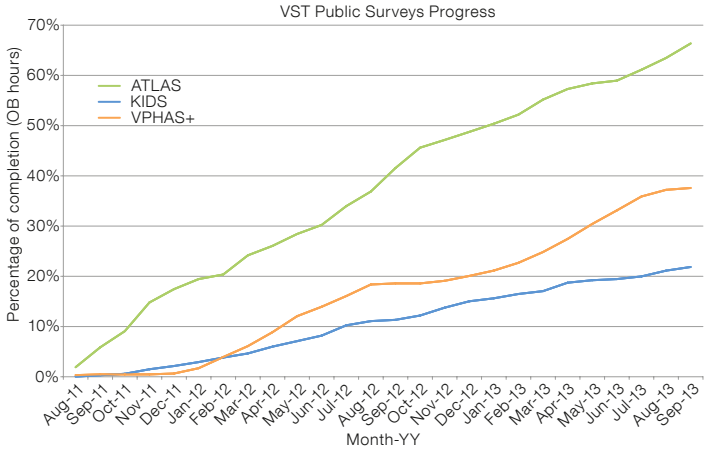


Figure 4. Graph of the percentage completion for the VST surveys as a function of date.



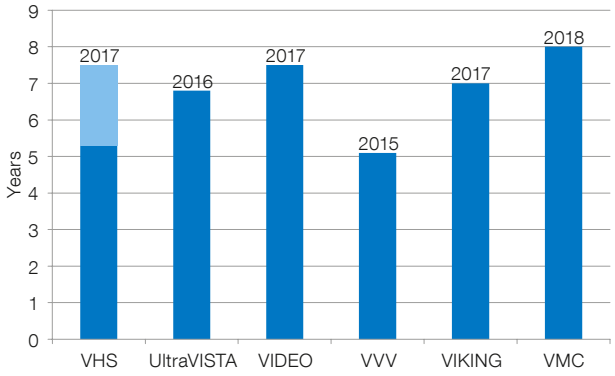


Figure 5. Expected completion time, in years and by year of completion, for the VISTA surveys. For VHS the time to completion for the whole area coverage is indicated in light blue. T = 0 refers to the start of scientific operations, i.e., April 2010.

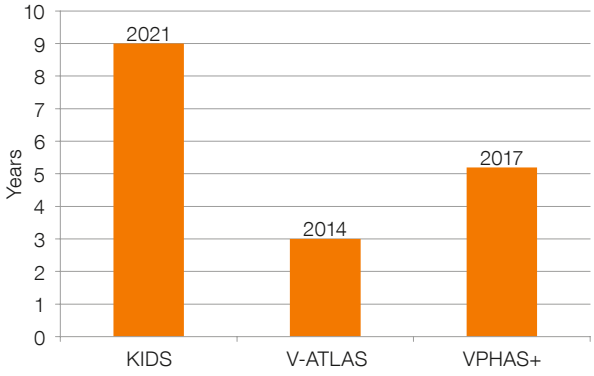


Figure 6. Expected completion time, in years and by year of completion, for the VST surveys. T = 0 refers to the start of scientific operations, i.e., October 2011.

major technical interventions in 2010 (camera shim installation and horizontal re-centring) and 2011 (primary and secondary mirror recoating and extended recovery), operational procedures were adopted to increase the speed of execution and reduce the number of repeated OBs. The current completion rate for the VVV and VHS surveys is more than 67 %, while the percentage of completion is in the range 52 % to 42 % for the other surveys (UltraVISTA, VIKING, VIDEO and VMC).

VST — For the VST surveys, the percentages of completion are 66 % for VST ATLAS, 22 % for KiDS and 38 % for VPHAS+. Of the three VST surveys, KiDS has the tightest requirements in terms of Moon illumination (dark time) and seeing constraints. It is also, by far, the largest survey on the VST and thus, even if it uses a comparable fraction of time per year to the other surveys, its overall completion is much smaller. Furthermore the right ascension/declination distribution of the target fields overlaps with those of approved GTO projects. Strategies are being implemented to mitigate the competition, and speed up the data acquisition for KiDS, and also improve the overall observation progress on the VST. For more details see Mieske et al. (p. 12).

Taking account of the above percentages of completion for each survey and the start of operation of each survey telescope, and assuming the same observation progress as previously, we can evaluate the date of completion for the VST and VISTA surveys. Figures 5 and 6 show the expected completion time in years and the year of completion for the nine imaging surveys. We expect the VVV, VHS and VST ATLAS to be completed by 2015, with the other surveys coming to completion in the following years, with KiDS completed in 2021. For VHS, two numbers are shown in Figure 5: the completion in 2015 is based on the 3400 hours requested in the SMP, but since the overheads were not known at the time of writing the SMP, this survey will actually need about two years longer to cover the entire southern hemisphere, as shown by the light blue bar. It is important to point out that these projections do not automatically translate into telescope time allocated to these surveys. These estimates are upper limits since, as one survey finishes, the others may progress faster, which is not explicitly taken into account in the simple extrapolation above. The legacy value and the scientific excellence of the survey programmes are considered by the public survey panels organised by ESO and these completion dates are presented at major peer reviews. The public survey panels are asked to issue informed recommendations on the continuation of survey programmes, or their termination, should they consider any of them not scientifically competitive at the time of the review.

Publication and download of science data products from ESO public surveys

The ESO policies in place to manage the public survey projects monitor the delivery of data products for ingestion and publication via the SAF. Additional allocation of telescope time is conditional on the submission of data products via Phase 3. Phase 3 concludes the process started with the submission of the letter of intent, followed by Phase 1 (proposal preparation and submission) and the preparation and submission of OBs for observations in service mode, i.e., Phase 2. As a result of Phase 3, the community can access and download the data products from the SAF and is able to carry out independent science projects in addition to those targeted by the survey teams (c.f., Arnaboldi et al., 2011).

Survey	Bands	Sky coverage* (sq.deg)	Data volume (GB)
VHS	*YJHKs*	4210	8511
VIKING	*ZYJHKs*	235	288
VVV	*ZYJHKs*	564	2877
VMC	*YJKs*	3.6	26
Ultra-VISTA	*YJHKs*	1.8	86
VIDEO	*YJHKs*	1.8	24
ATLAS	*ugriz*	2341	3015
VPHAS+	*ugri,* Hα	375	747
KIDS	*ugri*	56	701

Table 1. Summary of VISTA and VST public survey products in the ESO science archive (Status: 25 October 2013).

*The quoted sky coverage is the total geometric area of images, which normally differs from the nominal survey area.

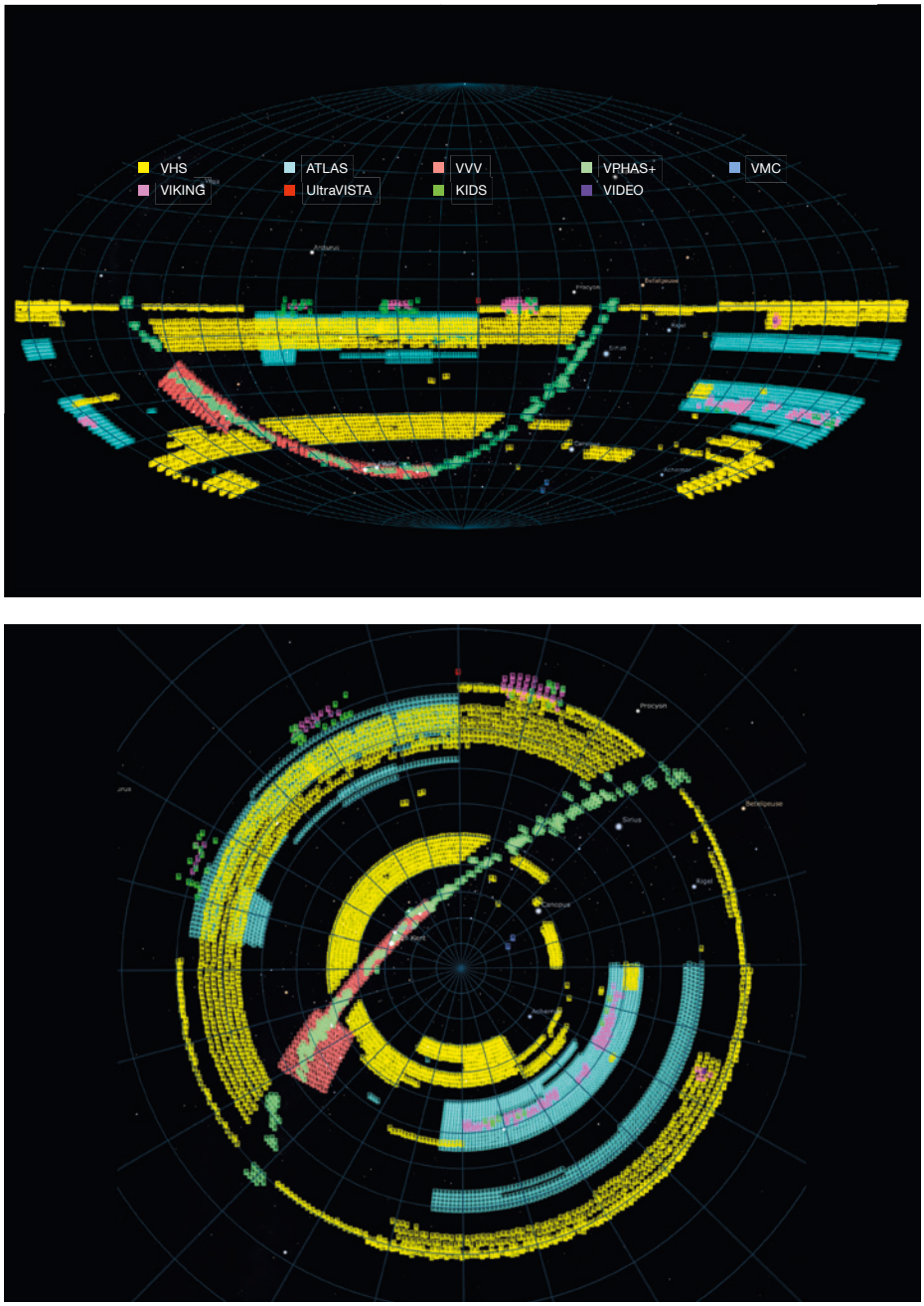


Figure 7. Sky coverage of ESO public survey products is shown in two projections. Upper: Full sky (Hammer–Aitoff projection); lower: Southern hemisphere (stereographic projection).

The year 2013 has been very important for Phase 3 activities, as all eleven ESO public surveys submitted and published their data products via the SAF. The milestones for Phase 3 were the second VISTA submission for images and source lists, and the first submission for catalogues. The first data release of the VST surveys was announced in September 2013. The spectroscopic public surveys are actively going through the process of content validation and it is planned that they will reach publication via the SAF by December 2013. Thus far, a total volume of 16 TB of data products — images, weight maps, source lists and catalogues — is now available and fully searchable via dedicated query interfaces. In Table 1 we provide an overview of the data volume, wavelength and sky coverage of the data releases from the imaging surveys. Further information and detailed descriptions of the data releases from the ESO public surveys are available[2].

Public survey data are published through the ESO archive interfaces conjointly with other products such as the stream for the ultraviolet and visual echelle spectrograph (UVES) data that results from the in-house generation of science data products. All Phase 3 data products comply with the established standard for ESO science data products, thereby guaranteeing uniformity in terms of data format and characterisation across the ESO archive.

Figure 7 illustrates the current sky coverage of the ESO survey products in two projections. More than 4500 square degrees in the NIR bands and 2400 square degrees in the optical bands have been covered by data products, which are now accessible via the query interfaces of the SAF.

Merit parameters for ESO public surveys are the number of refereed publications by ESO survey teams and archive users, the number of press releases and the cumulative download of data products from the ESO archive. There are now 71 refereed publications from the survey teams with a significant increase in the number of refereed publications (+ 200 %) since November 2012, including from four archive users, i.e., researchers who are not members of the survey teams. The contribution by Wegg & Gerhard (p. 54) is an example of exciting scientific results achieved using ESO archive data products (in this case from the VVV survey). There also are more than ten press releases based on VISTA data and more than four press releases for the VST.

The parameters on the data download by the community also demonstrate a strong interest. The cumulative download from the SAF since December 2011 amounts to more than 6.8 TB of data products and ~ 27 000 files. In Figures 8 and 9 these numbers are differentiated per survey project and data product type, respectively. The community is clearly eager to access the data, with the largest

volume download coming from VVV, UltraVISTA and KiDS; see Figure 8. The largest volume download for products is for the source lists, followed by the tile images. We believe that catalogues will represent very valuable assets, as they are the highest level products for the surveys. In this respect, we are working hard to reach a critical data volume soon, with the ingestion of the VIKING, VVV and VMC catalogues so that the community can benefit even more from the joint effort of ESO and the survey teams.

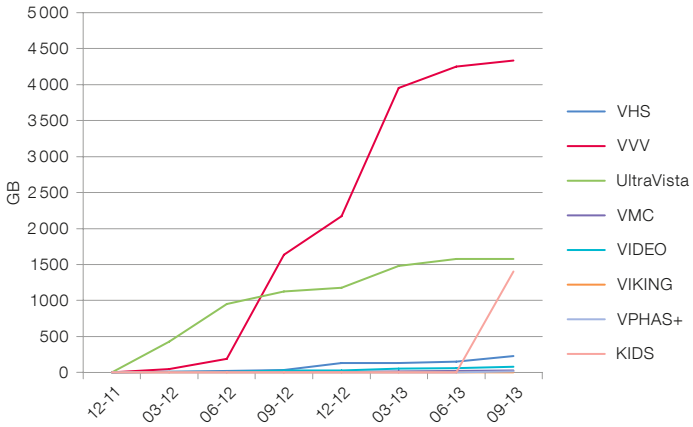


Figure 8. Data volume download for the imaging public surveys.

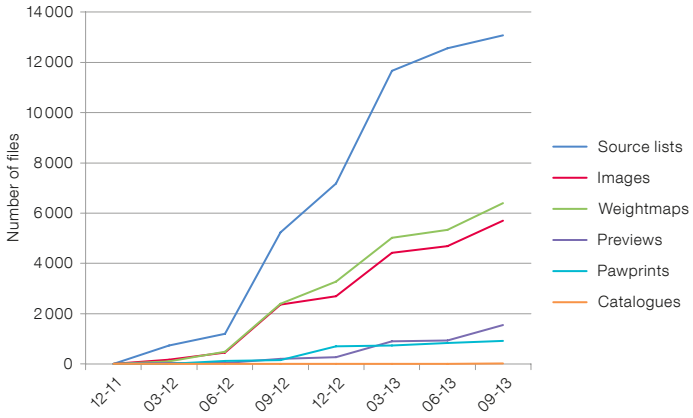


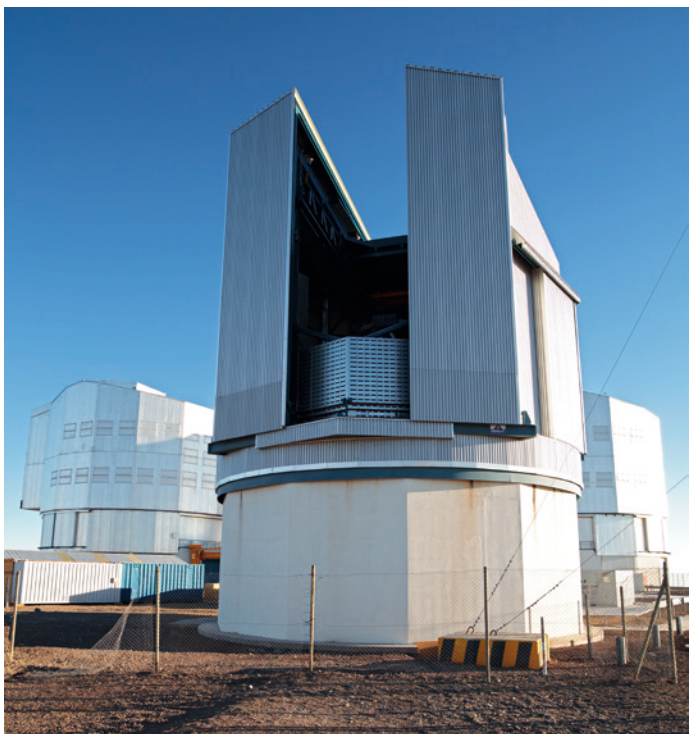
Figure 9. Number of files downloaded for the different data product types from the ESO SAF for the public imaging surveys.

References

Arnaboldi, M. et al. 1998, The Messenger, 93, 30
Arnaboldi, M. et al. 2007, The Messenger, 127, 28
Arnaboldi, M. et al. 2011, The Messenger, 144, 17
Emerson, J., McPherson, A. & Sutherland, W. 2006, The Messenger, 126, 41
Kuijken, K. 2011, The Messenger, 146, 8

Links

[1] Quality control criteria: http://www.eso.org/sci/observing/phase2/SMGuidelines/ConstraintsSet.VIRCAM.html
[2] Phase 3 data releases: http://www.eso.org/sci/observing/phase3/data_releases.html



The 2.6-metre VLT Survey Telescope (VST) is shown in its enclosure on Cerro Paranal. In the background are the nearby VLT Unit Telescopes 3 (Melipal, to the right) and 4 (Yepun, left).