

# A Fruitful Collaboration between ESO and the Max Planck Computing and Data Facility

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The ESO Science Archive Facility (SAF), contains all La Silla Paranal Observatory raw data, as well as, more recently introduced, processed data created at ESO with state-of-the-art pipelines or returned by the astronomical community. The SAF has been established for over 20 years and its current holding exceeds 700 terabytes. An overview of the content of the SAF and the preservation of its content is provided. The latest development to ensure the preservation of the SAF data, provision of an independent backup copy of the whole SAF at the Max Planck Computing and Data Facility in Garching, is described.

## The ESO Science Archive Facility

The SAF is the unique access point to ESO data via services that are increasingly used by the community. The ESO SAF currently contains about 700 TB of ESO data in the form of more than 40 million distinct files. About twice this amount of data is actually stored, as a second copy of all archived files is present in the system. The data from over 20 individual instruments, spread among the three ESO sites — namely Paranal, La Silla, and APEX — are transferred continuously via the network from Chile to Garching. Ninety per cent of the files reach Garching in less than 15 minutes. Once saved in the SAF, these data are then published, in the sense that authorised users can download them. Projections show that with the arrival of the next few instruments, which will generate large amounts of data, the SAF will reach its first petabyte in 2018.

The SAF is the one and only access point to all La Silla Paranal Observatory raw data and to processed data thereof. Figure 1 shows the current web interface to the SAF and its collections<sup>1</sup>. As well as raw data from the observatory, data

Category	Access Point	Data collection	Data Type	Instruments
LPO Raw Data	Raw data query form (all instruments) Instrument specific query forms Direct retrieval of raw data by file name	All ESO raw data	Various	Many La Silla Paranal instruments
LPO Data Products	Phase 3 main query form Phase 3 imaging query form Phase 3 spectral query form Phase 3 VIRCAM-specific query form	Phase 3 Data Products (ESO public surveys; ESO pipeline-reduced products; Large programs: GOODS, zCOSMOS, etc.)	Currently, Imaging and Spectroscopy	Pipeline products for UVES, XSHOOTER, HARPS, and more to come.
[Description of reduced data products types]	Catalogue Facility query interface	Phase 3 Catalogues [ESO User Portal authentication required also when browsing]	Catalogues	Various
	FEROS and HARPS-Polarimetry pipeline processed data query form	FEROS and HARPS-Polarimetry pipeline processed data	Spectroscopy	FEROS, HARPS-Polarimetry, HARPS reduced calibrations (other HARPS see Phase3 above)
	Other Advanced Data Products (available only as downloadable packages, no query form)	Various (30 Doradus, Corot, GaBoDs, etc.)	Spectroscopy Imaging Flux maps	FEROS, HARPS-Polarimetry, HARPS reduced calibrations (other HARPS see Phase3 above)
	Science Verification, Commissioning, EIS, etc. (no query form)	Full list of available data packages	Various	Many
APEX Quick Look Products	APEX query form	APEX	Heterodyne, Bolometer	APEX-2A, LABOCA, SABOCA, SHeFI

products are generated either by the community (Arnaboldi et al., 2014) or produced in-house (Romaniello et al., 2016a). Recent analysis on downloads of these data products as well as the raw data have shown that the SAF is a very popular science resource in itself, aggregating a new astronomical community and attracting new registrations to the user portal at a rate of a couple per day (Romaniello et al., 2016b).

In order for this mine of scientific data to be available to users, the archived data need to be preserved. The SAF content resides in a data centre at ESO where machines run continuously (Figure 2). The ESO archive system is based on software developed at ESO called NGAS (Next Generation Archive System; Wicenc et al., 2007), also used by the ALMA Science Archive<sup>2</sup>. The system uses the RAID5 technology, which ensures data redundancy. The second copy in the system, produced for any newly archived data within the hour, provides additional redundancy.

But this of course is not enough. To ensure data preservation and availability, one must also plan against major disaster or long-lasting disruption, while hoping to never experience such an event. That is where the collaboration between ESO

Figure 1. The ESO Science Archive Facility homepage.

and the Max Planck Computing and Data Facility comes in, where a backup copy of all ESO data now resides.

## The Max Planck Computing and Data Facility

The Max Planck Computing and Data Facility (MPCDF, formerly known as Rechenzentrum Garching [RZG]) is the main computing centre of the Max Planck Society. The MPCDF provides computing and data management services for all Max Planck Institutes across Germany in many fields of science, including materials and life sciences, theoretical chemistry, polymer research, astrophysics, plasma physics and others.

Apart from several mid-range Linux computer clusters, the MPCDF operates a supercomputer, currently an IBM iDataPlex system with Intel Ivy Bridge processors and Nvidia K20X GPUs. In total there are about 83 000 cores with a main memory of 280 terabytes and a peak performance of about 2.8 petaflop s<sup>-1</sup>, making it one of the fastest computers in Germany. In close collaboration with scientists, the MPCDF also develops and

optimises algorithms and programs for high performance computing.

The MPCDF data science team supports the development and deployment of data management solutions for big data projects. Large amounts of experimental data and data from supercomputer simulations are managed and stored in three tape libraries in two different locations, with a total capacity of about 40 000 tapes. One of the libraries is shown in Figure 3. The combined amount of backup and archive data stored at the MPCDF currently totals over 50 petabytes, with a current growth rate of almost 1.5 petabytes per month.

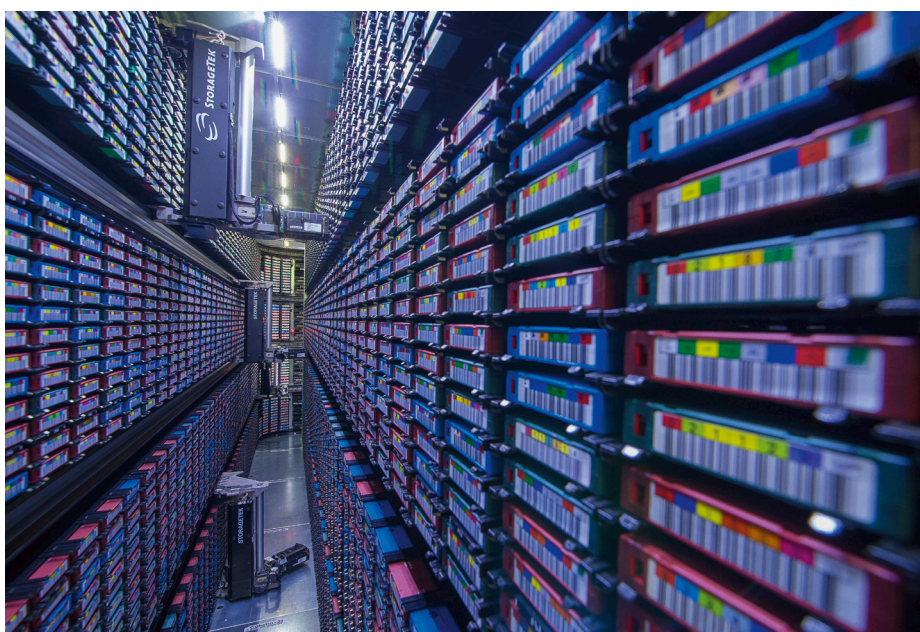
An important requirement of some of the stored data is its long-term availability. This is especially true for the humanities because of the irreproducibility of the data, for example, scans of valuable documents from the Max Planck Institute for Art History or recordings of endangered human languages from the Max Planck Institute for Psycholinguistics. Through redundancy at the logical and at the physical level, the storage of data for a period of time that surpasses the typical life-cycle of the hardware and software components employed can be guaranteed, with the goal of keeping the data forever. Some of the data still stored at MPCDF originated in the early 1980s, almost 40 years ago.

### Implementation of a collaboration

The possibility of storing a backup copy of the ESO archive at the MPCDF was first discussed between ESO and the MPCDF in November 2012. The agreement signed thereafter by both parties stipulated that the MPCDF offered to save a backup copy in their tape library of all ESO's archived data. ESO developed in-house an automatic procedure for transferring the data to the MPCDF. The replication of archived data then started on 7 May 2015 and, as planned, it took eight months to handle the backlog (at that point in time 690 terabytes of data were replicated). As of 20 January 2016, the backlog has been cleared, and the replication process is now operational, meaning that all newly archived data are backed up in near real time at



Figure 2. An image of the ESO Data Centre where the SAF content resides.



the MPCDF. This process has been working non-stop and flawlessly since then.

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Finally, this article is an opportunity for ESO to say a big thank you to the MPCDF for this very fruitful and successful collaboration, which is also, and not least, of long-term benefit to all of the SAF users.

Figure 3. One of the tape libraries at Max Planck Computing and Data Facility (MPCDF) on the Garching Research Campus.

### References

- Arnaboldi, M. et al. 2014, *The Messenger*, 156, 24
- Romaniello, M. et al. 2016a, in prep.
- Romaniello, M. et al. 2016b, *The Messenger*, 163, 5
- Wicenec, A. et al. 2007, *The Messenger*, 129, 27

### Links

- <sup>1</sup> ESO SAF: <http://archive.eso.org/>
- <sup>2</sup> ALMA Science Archive: <http://almascience.eso.org/alma-data/archive>