

# **Summary of Data Management Principles**

## **Dark Energy Survey**

### **V8, 31/01/2025**

This Summary of Data Management Principles (DMP) has been prepared at the request of the DOE Office of High Energy Physics, in support of the DOE Office of Science Statement on Digital Data Management and for reference by those submitting proposals in response to DOE Office of Science Funding Opportunity Announcements.

#### **Experiment description:**

The Dark Energy Survey (DES) comprises two imaging surveys of unprecedented scope and science reach: a wide-area survey and a narrower time-domain survey. The wide-area survey covers 5000 sq. deg. of the South Galactic Cap in 5 optical-near infrared filters (grizY) and will provide images of 300 million galaxies. The time-domain survey covers 30 sq. deg. in 4 filters (griz) and will discover and provide light curves for 3500 type Ia supernovae. These interleaved surveys were carried out on 758 nights spread over 6 observing seasons, using the new Dark Energy Camera (DECam). DECam is a 3 sq. deg. field-of-view, 570-megapixel instrument mounted on the Blanco 4-meter telescope at the NSF's National Optical-Infrared Astronomy Research Laboratory (NOIRLab) Cerro Tololo Inter-American Observatory (CTIO) in northern Chile. DECam was constructed by the DES collaboration to carry out the survey and serves as a facility instrument operated for the astronomy community by NOIRLab. DES survey operations started on Aug. 31, 2013 and ended Jan. 10, 2019; each 105-night observing season runs from August to the following February.

The DES collaboration designed and is using the survey to probe the origin of cosmic acceleration and the nature of dark energy through four complementary methods: galaxy clusters, gravitational lensing, large-scale galaxy clustering (including baryon acoustic oscillations), and supernovae. DES will make a significant advance in the precision and accuracy of dark energy parameter constraints. In so doing, it will also help lay the groundwork for the subsequent experiments LSST and DESI.

#### **DOE's roles in the experiment:**

Construction of the Dark Energy Camera (DECam) instrument and of a number of ancillary hardware systems was supported by the DOE Office of High Energy Physics and led by Fermilab. Maintenance of the Dark Energy Camera was shared between Fermilab/DES, supported by DOE DES operations funds, and CTIO/NOIRLab, through its base funding from the NSF Division of Astronomical Sciences (AST). DOE supports the operation of the experiment, formerly including DES observing, and infrastructure for science operations, including science analysis computing and calibrations, and contributes support to a number of other tasks, including the Project Scientist and weak lensing shear pipeline testing. DOE also provides some support for DES Data Management (DESDM) operations, primarily at Fermilab and formerly at NERSC.

## **Partnerships:**

DOE and NSF are partners in supporting DES operations, with DOE providing support as described above and NSF providing the primary support for DESDM operations through a grant to the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign. The agencies provide oversight through a DOE-NSF Joint Oversight Group that meets periodically with DES Management. In addition, the experiment is governed by the DES Memorandum of Understanding, an agreement between Fermilab, NCSA, and NOIRLab, the three institutions with overall responsibility for construction and operations. The DES Council of Directors of the three MOU institutions meets periodically. There is currently no MOU or statement of principles between NSF and DOE regarding data management.

## **Organization – Agency/Lab level**

As noted above, Fermilab is the lead lab for DOE’s role in DES, providing leadership for the DES collaboration’s role for overall operation of the experiment. NCSA is the lead institution for DESDM operations.

## **Organization – Experiment level**

The DES organization chart as of May 18, 2020 is shown in Fig. 1. The DES Data Management PI leads the NSF-supported Data Management effort at NCSA, with responsibility for developing, operating, and maintaining the DES pipelines and serving internal and external data releases.

## **Collaboration:**

The collaboration comprises roughly 400 scientists (including students and postdocs) at 25 DES institutions and consortia from the U.S., the United Kingdom, Spain, Brazil, Germany, Switzerland, and Australia. The organization of the collaboration is described in the previous section. Collaboration membership is governed by the DES Membership Policy. In addition to those at DES institutions, there are DES collaborators at non-DES institutions who have typically moved from a DES institution and arranged to maintain their participation in the project. In addition to those in the collaboration, there are a number of External Collaborators who have been granted limited data access for particular projects in exchange for providing resources or expertise deemed beneficial to the collaboration.

## **Data policy management:**

The DES Public Data Release Plan is maintained by the DES Project Office (see Fig. 1 below). Some elements of the plan are contained in the DES Memorandum of Understanding and in the 2011 and 2015 proposals submitted to NSF AST to support DESDM operations. The Plan is described in the sections below. Responsibility for making the DES data public rests with the Project Office. Implementation of the Data Release Plan has been assigned to the DESDM team, led by NCSA, and to the Community Science and Data Center (CSDC) at NOIRLab, which will work in collaboration and with LIneA (DES-Brazil).

# DES Organization Chart

Jan. 31, 2025

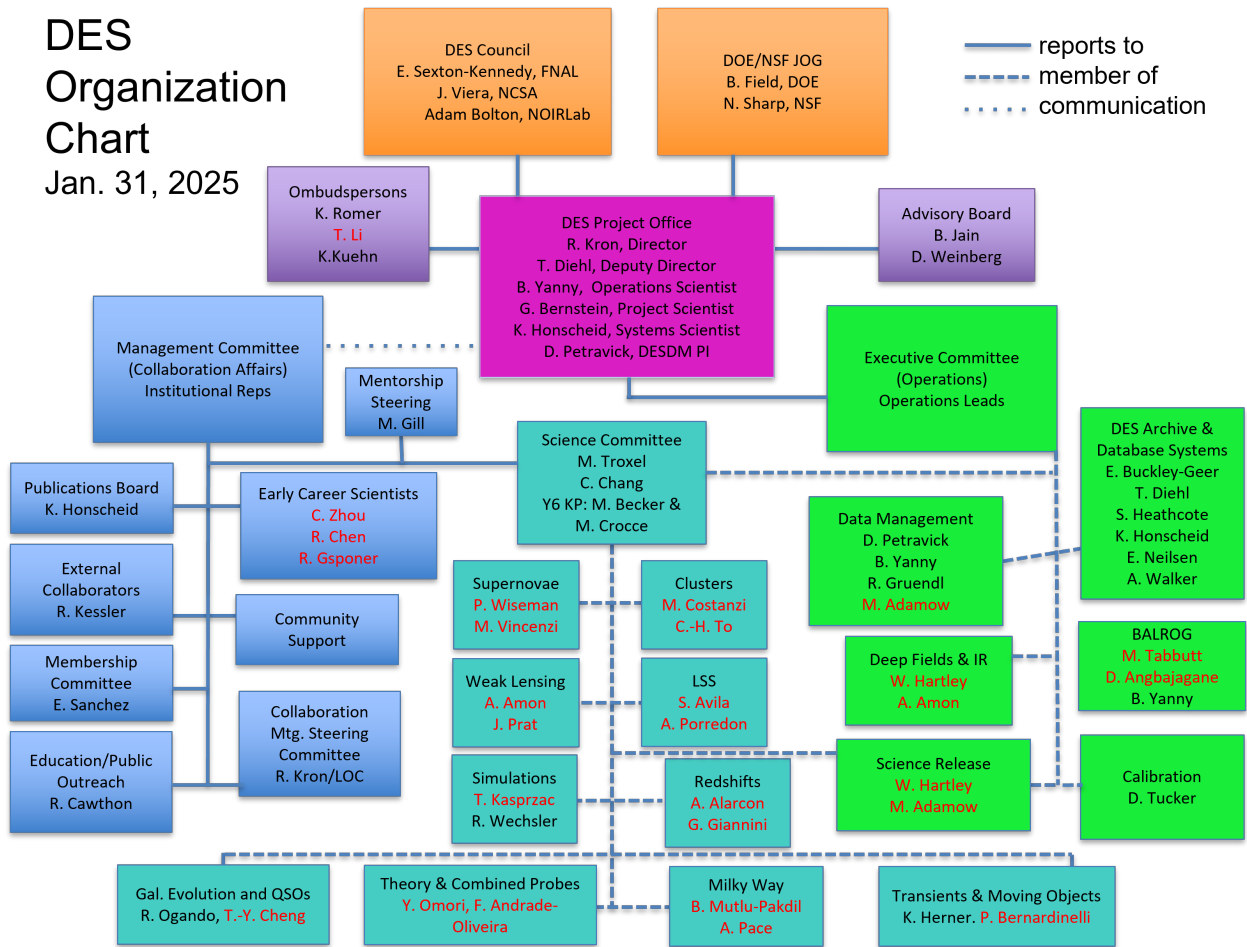


Fig. 1: DES Organization Chart.

## Data Description & Processing:

The DES Data Management system deals with and produces a number of types of data products. When observing for the DES, raw DECam images were sent from CTIO via the NOAO Data Transport System to NCSA for nightly processing by the DESDM system. From these raw exposures, the DESDM system produced reduced (instrumental artifact-removed) single-epoch images and object catalogs derived from them, which were assessed to provide rapid feedback on data quality. The DES Supernova exposures were additionally processed through an image-subtraction pipeline (using previously generated template images) in order to identify transient events and in particular candidate supernovae for spectroscopic follow-up by other telescopes.

DESDM also carries out further processing of the data approximately annually. This includes more refined processing of the raw images and application of global photometric calibration. Also during the off-season, generation of co-added images from multiple exposures of the same

field, and derivation of object catalogs and masks from the co-added images may be carried out. These science-ready object catalogs include a number of measured quantities for each identified object, including different estimates of object flux and classification as a star or galaxy. Additional derived object quantities, such as weak lensing shear estimates, are also ingested into the DESDM database for analysis by the collaboration.

Single-epoch and coadded images are retained on disk in FITS format, which is the standard file format use in astronomy. The FITS format supports image meta-data, which DES populates in a manner that makes the image files useful. Catalogs, masks, and other data are maintained in an Oracle relational database, with access available to all DES collaborators. Additional access and QA tools are provided by the DES Science Portal.

## **Data Products and Releases:**

The publicly released DES data products consist of: (I) raw DECam images taken during DES observing periods; (II) reduced (artifact-removed), calibrated single-epoch images processed by DESDM for both the wide-area survey and the supernova survey; (III) two releases of calibrated, co-added images, as well as parameters describing the detected sources (Source Extractor outputs) and associated data products produced by DESDM; and (IV) time-sensitive alerts with information about transient objects.

### **I. Raw DES Data**

DES agreed to a 12-month proprietary period for raw DES images. NOIRLab managed access to DES raw data, making them automatically available to the general community on a rolling basis via the CSDC 12 months after they are taken.

All raw DECam calibration data (flats, biases, etc.) taken by DES or by community observers have no proprietary period and were made immediately available to the general community via the CSDC, per NOIRLab policy. Moreover, any calibration files supplied by DES were made immediately available to the general community.

All raw DECam data taken during DECam commissioning (Sept.-Oct. 2012) and during Science Verification (Nov. 2012-Feb. 2013, which included both DES and community observations) have no proprietary period and were made immediately available to the general community via the CSDC. This includes Science Verification data processed by NOIRLab through the Community Pipeline.

### **II. DES Reduced Single-Epoch Data Products**

The annual processing after each observing season produces globally calibrated, reduced, single-epoch images. Those images that satisfy the DES criteria for inclusion in the annual internal release for the DES Collaboration, including both the wide-area survey and exposures in the supernova fields, are included in the public release of these reduced images. These reduced images are being made available by NCSA to NOIRLab for public distribution via the CSDC, once their data quality, particularly their photometric accuracy, has been validated by the collaboration. The reduced images from Y1 were released in late 2014-early 2015, roughly 12

months after they were acquired. The planned schedule for release of subsequent years' data is: May 2017 for Y2, Dec. 2017 for Y3, Aug. 2018 for Y4, Aug. 2019 for Y5, and Aug. 2020 for Y6.

### III. Co-added, Calibrated DES Data Products

As described in the DES Public Data Release Plan, DES will make two major releases of co-added, calibrated data products, DR1 and DR2, consistent with the 2011 DESDM Operations Proposal to NSF. Responsibility for serving these releases is split between NCSA and the CSDC. In addition to these two releases of DES survey data, the collaboration also publicly released value-added "Gold" catalogs based on the Science Verification and Y1 data (<https://des.ncsa.illinois.edu/releases>). In a similar way to DR1, it is expected that value-added cosmology catalogs produced in the course of DES science analyses will be associated with the second public release, DR2, and will be similar in content. As for DR1, the timing of the release of these value-added data products will be determined by the respective analyses, but it is expected to coincide with the respective publications.

#### A. DES Public Data Release 1

The first public data release, DR1, includes products derived from DES data taken up through February 2016, namely DESDM-processed co-add images and Source Extractor source parameters and associated data products (masks, quality information, etc.) for data taken during the first three DES seasons and the DES Science Verification period that satisfy the criteria for inclusion in the internal DESDM release to the Collaboration. In addition, DR1 includes co-add images and source parameters of the DES Supernova fields.

The DES DR1 was released in two parts, the first being the DESDM processed files (Jan. 2018) and the second being value-added "Gold" data that support the publications relating to cosmology (Oct. 2018).

#### B. DES Public Data Release 2

The final public data release, DR2, will include DESDM-processed co-add images and Source Extractor source parameters and associated data products for data taken during all DES observing seasons and the DES Science Verification period that satisfy the criteria for inclusion in the internal DESDM releases to the collaboration. Exposures included in DR1 will be reprocessed for DR2. DR2 data cover the wide-area survey footprint to a depth of approximately 8-10 tilings per filter. The planned release date for DR2 is Jan. 2021, in order to give the collaboration time to vet and characterize the data quality in detail.

DR2 will be served and maintained by NCSA for a period of approximately 2 years and will also be served by NOIRLab. Data access will be via http or other standards available at the time. DR2 data products to be released will include fully calibrated coadd image files, masks, weight maps, and catalogs of photometric, astrometric, and other source parameters. The data will be documented to the standards of a peer-reviewed data release document.

### IV. Transient Alerts

The Supernova Working Group have publicly announced supernova candidates detected in the supernova pipeline via periodic astronomer's telegrams (ATELs). In addition, a system called DESAlert had responded to gamma-ray bursts by generating a VOEvent if the source is contained within the area of sky that DES has observed. Starting with DES Year 3, DES publicly announced via a web interface information for bright transient events as soon as they are processed.

### **Plan for Serving Data to the Collaboration and Community:**

Collaboration access to the raw and reduced images and catalogs is provided by NCSA, with additional access tools from the DES Science Portal. Public access to the raw and calibrated single-epoch images is provided by the CSDC web/database interface, which is maintained by NOIRLab. Access to the DR1 and DR2 releases will be via database and Science Portal queries and will be provided by NCSA. As noted above, public access will be via NCSA and NOIRLab.

### **Plan for Archiving Data:**

In addition to the raw and processed single-epoch images, the CSDC will provide long-term preservation and curation and public access to DES DR1 and DR2 with data available from NCSA at the time of the public release. DESDM will ensure that the files are delivered to CSDC with full documentation.

### **Plan for Making Data Used in Publications Available:**

To the extent reasonably possible, we will ensure that the data points shown in simple published graphs (e.g., where two quantities are plotted against each other or histograms) are publicly available in machine readable form, once the corresponding publication has been accepted for publication. For reasons of practicality, this will not include the information in more complex plots such as images and maps. The underlying data products for DES science results will be made available on the timescales described above in the section on Data Products and Releases. In some cases, DES science (not just cosmology) publications are based upon catalogs derived from the DESDM data products. DES is releasing such catalogs along with the catalogs of primary data products (<https://des.ncsa.illinois.edu/releases/other>).

### **Responsiveness to SC Statement on Digital Data Management**

This data management plan follows the SC Statement on Digital Data Management.