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The Science Verification public release for the Dark Energy Survey

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Abstract

In this contribution, we present the first public release of catalogs of coadded data and related information from the Dark Energy Survey, from observations corresponding to the Science Verification period which happened prior to the start of the survey. The content of the release is described.

1 Introduction

The Dark Energy Survey (DES) [8][9][1] is a multiband optical and near infrared photometric scan of 5000 square degrees of the southern sky with the main goal of tackling the problem of the nature of dark energy (see e.g. [17]) jointly with a "time-domain" search of 30 square degrees for type Ia supernovae. It is being carried out using DECam [11] from the Blanco telescope at the Cerro Tololo Interamerican Observatory (CTIO) for five years in the period 2013–2018 for approximately 500 nights in total.

During the period between November 1, 2012 and February 22, 2013 more than 10 000 exposures were collected by DECam and subsequently reduced with an early version of the DES Data Management (DESDM) software stack [22][16]. This series of observations constituted the Science Verification (SV) period of the project, aimed at understanding both the overall performance of the camera and the adequacy with real data to achieve the goals of the project. At the same time some interesting science can already be done with this rich dataset (e.g. see [1][7][2]).

Both the raw and reduced single-epoch images are available from the NOAO Science Archive[2]. The area covered by the SV survey was scanned in several tilings, mimicking the process of the wide survey, together with repeated observations of the chosen regions for supernova searches. These tilings and supernova exposures can be stacked together to conform coadded images and related catalogs. The latter product (termed SVA1 from now

[1] http://www.darkenergysurvey.org
[2] http://archive.noao.edu/

on), together with some value-added quantities, has been made public on January 2016, and we describe them here.

All products and additional documentation and help can be found at:

http://des.ncsa.illinois.edu/releases

2 The SVA1 Gold catalog

The SVA1 Gold catalog consists of basic astrometry, photometry, and object classification for 25 227 559 objects. The general distribution of the different regions surveyed is shown in Fig. 1. This catalog was assembled from the SVA1 data set processed with an early version of the DES Data Management system, which included image detrending, astrometric registration, global calibration, and image coaddition. The `SExtractor` toolkit was used to create object catalogs from coadded SV images [5]. The SVA1 Gold catalog has a relative astrometric precision of ~ 100 mas per coordinate (from multiple DES observations of the same object) and an absolute astrometric precision of ~ 200 mas per coordinate compared against the UCAC-4 catalog [25]. Object photometry is provided in the DES g, r, i and z bands.

Photometric calibration was performed in two stages. First, absolute calibrations were performed against a set of photometric standards using a global calibrations module (GCM [24]). After the global calibration, a re-calibration was performed via stellar locus regression (SLR) using the BigMACs code [15]. The SLR zeropoint adjustment used the PSF magnitudes measured for objects classified as stars. Note that the SLR adjustment produces magnitudes that are calibrated to the top of the Galaxy (i.e., corrections for Galactic extinction are already incorporated into the calibration). The calibration uncertainty of the SVA1 Gold catalog is estimated to be $< 2\,\%$. All magnitudes are put on a "picomaggie" system (DES AB magnitudes, zeropoint = 30.0).

Individual DECam exposures were coadded to increase survey depth. During the SV coaddition process, the point spread functions (PSFs) of the individual single-epoch images were not homogenized at the coadd image level. Rather, a parametric model was used to account for spatial variations in the PSF in each coadd image (PSFEx; [4]).

We provide several variables for star galaxy classification including SPREAD_MODEL ([10]), CLASS_STAR ([5]), and MODEST_CLASS (see Section 2.2. of [14]). For simple and robust star-galaxy classification we recommend the MODEST_CLASS variable, which combines information from CLASS_STAR, SPREAD_MODEL, and SPREADERR_MODEL. The MODEST_CLASS galaxy classification is found to have a simultaneous efficiency of $\geq 90\,\%$ for objects with i-band magnitude fainter that 19.

The SVA1 Gold data products cover ~ 250 square degrees with non-uniform depth and data quality with a median 10σ limiting magnitude for galaxies in SVA1 Gold of approximately: $g = 24.0$, $r = 23.8$, $i = 23.0$, $z = 22.3$. The primary science data set can be broken into several fields:

- SPT-E: ~ 160 sq. deg. overlapping the eastern part of the South Pole Telescope foot-

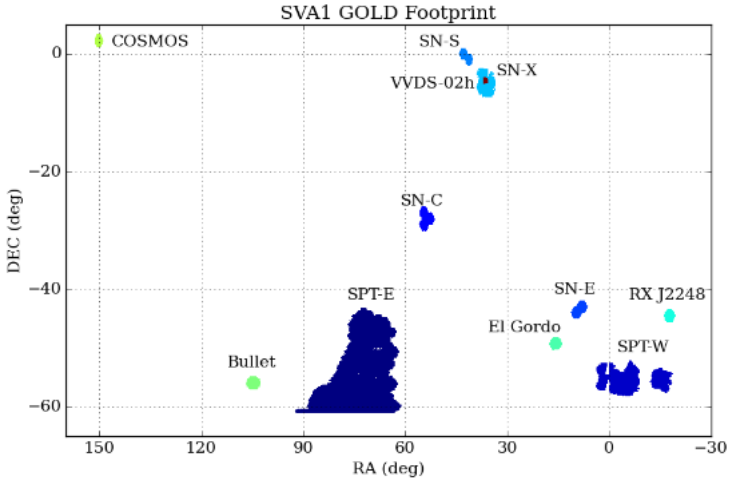

Figure 1: The SVA1 Gold catalog footprint in equatorial coordinates using a cartesian projection.

print.

- SPT-W: ~ 35 sq. deg. overlapping the western part of the South Pole Telescope footprint.
- DES SN: $\sim 5 - 15$ sq. deg. coincident with the DES supernova fields (SN-C, SN-E, SN-S, and SN-X).
- Cluster Fields: ~ 3.5 sq. deg. surrounding each of the rich galaxy clusters RXC J2248, Bullet Cluster, and El Gordo.
- COSMOS: ~ 3.5 sq. deg. of imaging in the COSMOS field reaching 1 mag fainter than the nominal DES depth
- VVDS-02h: ~ 1 sq. deg. of the SN-X fields overlaps the VVDS-02h region.

In addition limiting magnitude maps are provided, together with a footprint describing different regions with possible problems that can be used to define a 'cleaner' subset (both in `HEALPix` format [12]).

3 The SVA1 shear catalogs

Background galaxy shapes are distorted by intervening matter in the line of sight towards these galaxies (a phenomenon dubbed weak lensing shear). The study of the correlations of the imprinted statistical pattern of matter on these shapes is being used as a sensitive tool

to study certain cosmological parameters, such as Ω_m and σ_8. In this release we provide the shear catalogs using two different codes (`im3shape` [26] and `NGMIX` [23]), used to put the first cosmological constraints from DECam data [1]. The details of the generation and validation of these computed datasets is available at [14].

4 The SVA1 photo-z catalog

For this release, four different photometric redshift codes have been made available, after successful validation and checks as described in [21]. These are:

- `ANNZ2`, an ensemble of machine learning methods [20].
- `BPZ`, a template fitting code based on Bayesian inference [3].
- `SKYNET`, a neural network code [13].
- `TPZ`, which uses a random forests based approach [6].

All of them are provided with both peak and mean estimates from the full probability distribution function computed for the object (which are also available in separate files).

5 The SVA1 redMaPPer and redMaGiC catalogs

A catalog of nearly 800 red-sequence clusters found using the redMaPPer cluster finder [19] is part of the release as well, reaching redshifts of $z \sim 0.9$ with very high photo-z accuracy ($\sigma_z/(1+z) \sim 0.02$ using its own estimate for this quantity). This constitutes a very robust and unprecedented deep catalog of optical clusters.

Using the calibration provided by redMaPPer, the redMaGiC catalog [18] was built using the template for red galaxies that the previous algorithm provides. The resulting catalog contains a extremely robust photometric redshift estimation as well, which constitutes one of the key ingredients for a successful classification of objects in photometric redshift bins, for large scale structure studies.

Both catalogs with positions and magnitudes, together with estimated photo-zs and luminosities are accessible from the release website. Masks and random catalogs useful for large scale structure analyses are also available.

6 An open resource for all astronomers

This first taste of what the Dark Energy Survey dataset will offer to the scientific community is available as flat files which are described and can be downloaded at http://des.ncsa.illinois.edu/releases.

The next public release will include data from the first three years of the survey.

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The Collaborating Institutions are Argonne National Laboratory, the University of California at Santa Cruz, the University of Cambridge, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas-Madrid, the University of Chicago, University College London, the DES-Brazil Consortium, the University of Edinburgh, the Eidgenössische Technische Hochschule (ETH) Zürich, Fermi National Accelerator Laboratory, the University of Illinois at Urbana-Champaign, the Institut de Ciències de l'Espai (IEEC/CSIC), the Institut de Física d'Altes Energies, Lawrence Berkeley National Laboratory, the Ludwig-Maximilians Universität München and the associated Excellence Cluster Universe, the University of Michigan, the National Optical Astronomy Observatory, the University of Nottingham, The Ohio State University, the University of Pennsylvania, the University of Portsmouth, SLAC National Accelerator Laboratory, Stanford University, the University of Sussex, Texas A&M University, and the OzDES Membership Consortium.

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References

[1] The Dark Energy Survey Collaboration, 2016, Phys.Rev.D, 94, 022001

[2] Bechtol, K. et al., 2015, ApJ, 807, 50B

[3] Benítez,N., 2000, ApJ, 536, 571

[4] Bertin, E., 2011, ASPC, 442, 435

[5] Bertin, E.& Arnouts, S., 1996, A&AS, 117, 393

[6] Carrasco-Kind, M. & Brunner,R., 2013, MNRAS, 432, 1483

[7] Crocce, M. et al., 2016, MNRAS, 455, 4301

[8] The Dark Energy Survey Collaboration 2005, astro-ph/0510346

[9] The Dark Energy Survey Collaboration 2016, MNRAS, 460, 1270

[10] Desai,S. et al., 2012, ApJ, 757, 1, 83

[11] Flaugher,B. et al., 2015, AJ, 150, 150

[12] Górski,K.M. et al., 2005, ApJ, 622, 759

[13] Graff,P. et al., 2014, MNRAS, 441, 1741

[14] Jarvis, M. et al., 2015, MNRAS, 460, 2245

[15] Kelly,P.L. et al., 2014, MNRAS, 439, 28

[16] Mohr,J. et al., 2012, Proc. SPIE, 8451, 84510D

[17] Mortonson,M., Weinberg,D. & White,M., astro-ph/1401.0046

[18] Rozo, E. et al., 2015, MNRAS, 461, 1431

[19] Rykoff, E. et al., 2016, ApJS, 224, 1

[20] Sadeh,I., Abdalla,F. & Lahav.O., 2015, PASP, 128, 968

[21] Sánchez,C. et al., 2014, MNRAS, 445, 1482

[22] Sevilla,I. et al., 2011, astro-ph/1109.6741

[23] Sheldon, E., 2014, MNRAS, 444, L25

[24] Tucker, D.L. et al., 2007, ASPC, 364, 187

[25] Zacharias, N. et al., 2013, AJ, 145, 44

[26] Zuntz, J. et al., 2013, MNRAS, 434, 1604 Chabrier, G., & Baraffe, I. 2007, ApJ, 661, L81