The Dark Energy Camera (DECam) and Dark Energy Survey (DES)

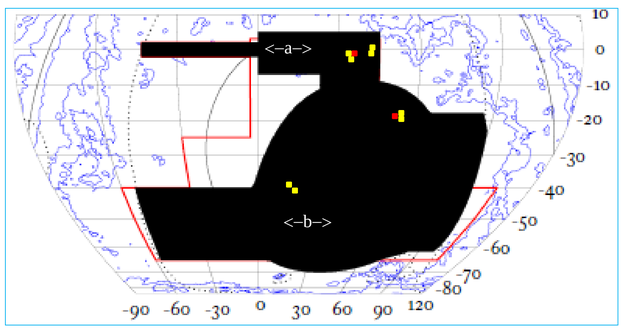
The Dark Energy Survey (DES) is a next generation optical survey aimed at understanding the accelerating expansion rate of the universe using four complementary methods: weak gravitational lensing, galaxy cluster counts, baryon acoustic oscillations, and Type Ia supernovae. To perform the survey, the DES Collaboration built the Dark Energy Camera (DECam), a 3 square degree, 570 Megapixel CCD camera that was installed at the prime focus of the Blanco 4-meter telescope at the Cerro Tololo Inter-American Observatory to perform a 5000 sq-degree wide-field survey and 30 sq-degree supernova survey during 525 nights over the next five years. DES started its first observing season on August 31, 2013 and will observe for 105 nights through mid-February 2014. This poster presentation will describe DES, the performance of the DECam instrument, and the progress and status of the DES.

H. T. Diehl[1] for the Dark Energy Survey Collaboration

Argonne National Laboratory, Brazil-DES Consortium, Cerro Tololo Inter-American Observatory/NOAO, CIEMAT, ETH-Zuerich, [1]Fermi National Accelerator Laboratory, Institut d'Estudis Espacials de Catalunya, Institut de Fisica d'Altes Energies, Lawrence Berkeley Laboratory, NCSA, Ohio State University, SLAC, Spain-DES Consortium, Stanford University, Texas A&M University, University of California Santa Cruz, University of Cambridge, University College London, University of Chicago, University of Edinburgh, University of Illinois Urbana-Champaign, University of Michigan, University of Nottingham, University of Pennsylvania, University of Portsmouth, Universitat-Sternwarte Munchen. University of Sussex

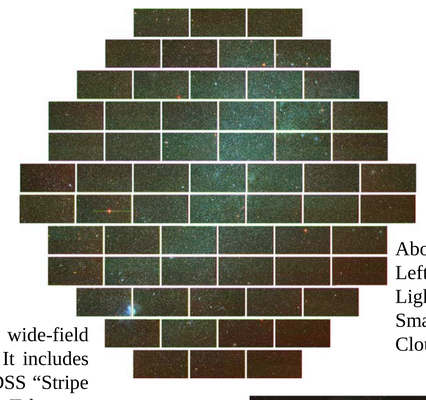
The Dark Energy Survey

DES will use the camera for 525 nights from Sept. to Feb. in 2013-2018 to map approximately 300M galaxies to z ~1.2 and about 30,000 galaxy clusters in 5000 sq.deg. wide-field survey of the southern galactic cap. A 30 sq.deg. time-domain survey will identify 4000 well-sampled type IA SNe in 10 fields. The main science driver is the characterization of the dark energy equation of state through measurements of weak-gravitational lensing, baryon acoustic oscillations, galaxy cluster formation and SNae.



DES Footprint

Left. The footprint of the wide-field survey is shown in black. It includes overlap with the optical SDSS "Stripe 82" (a), with the South Pole Telescope CMB survey field (b). The 10 SNa fields are shown as colored squares at their approximate locations. The "Deep" ("Shallow") fields are in red (yellow). The red-outlined area is the original survey plat.



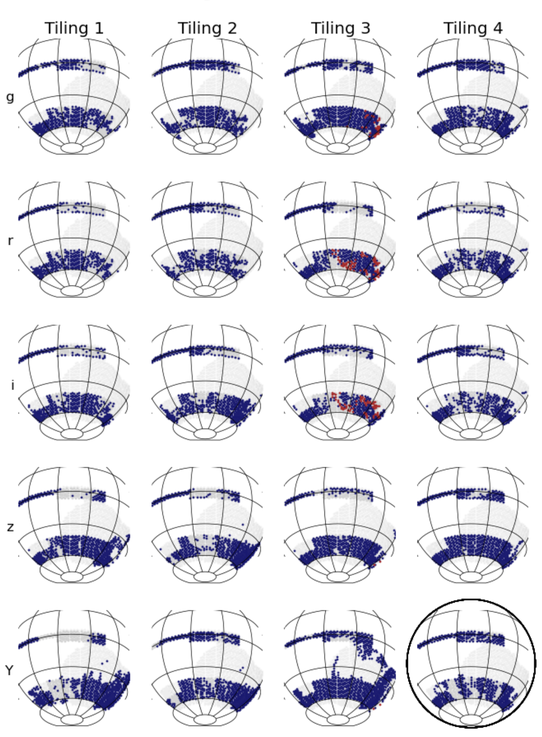
Above: a DECam CCD
Left: Sept. 2012 "1st Light" image of the Small Magellanic Cloud.

Right: Sept. 2012 "1st Light" image cutout of NGC 1365 in the Foxnax Cluster. See more images from DECam at the two URLs darkenergydetectives.org/ and www.darkenergysurvey.org/dark-energy-camera-mosaic /

DES 1st Season: Aug. 31 to Feb. 9

Daily Operations and OBSTAC

Observations are carried out by a team typically of 3 DES collaboration members, present at the telescope, for periods ranging from a few days to a few weeks. "Observer 1" drives the camera and is responsible for making sure images are being recorded efficiently. "Observer 2" performs on-the-fly data-quality checks. The "Run Manager" has experience with these roles and is responsible for making sure the observers understand their jobs. He or she also has experience-enough to solve some problems, should any arise during the night, and to know when remote experts need to be contacted.



Typical Daily/Nightly Observing Schedule (12/28/2013)

Daily Operations Meeting 16:00 CTIO Local Time
- Includes participation from remotely-located DECam or Operations Experts and from the Data Management Team

Implement Data Quality for Prior Processed Data
Afternoon calibrations: Dome Flats and Bias Frames
Evening Standards:
- SDSSJ2300-0000 – Yzirg
- SDSSJ0000-0000 – Yzirg
- SDSSJ0200-0000 – Yzirg

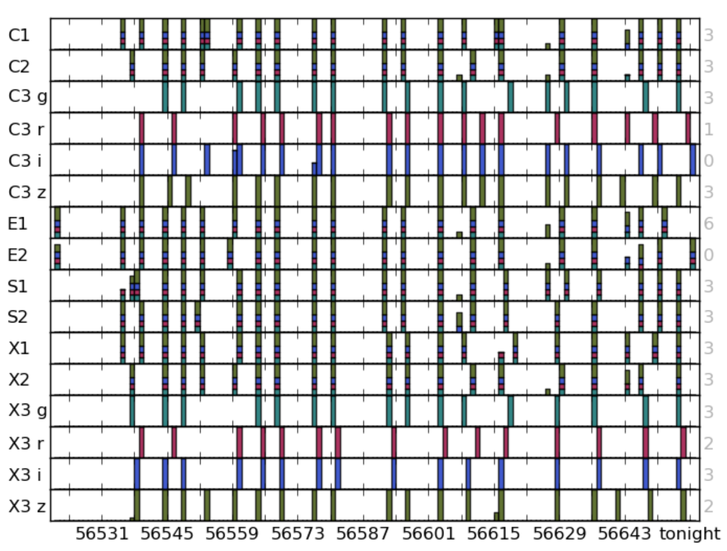
Defocus script run
ObsTac observing began at 01:09 UTC – exposure 260149
- SN-C3 – r
- Switch to wide field survey 01:35 UTC – exposure 269153

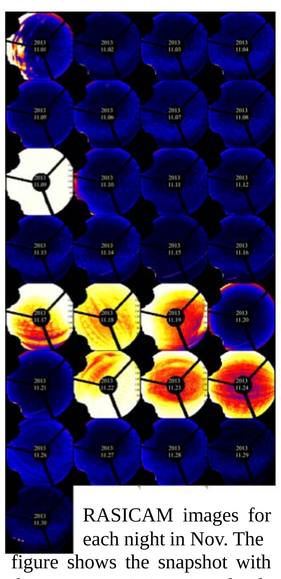
ObsTac observing end at 08:30 UT – exposure 269353
Morning standards:
- E6-A – grizY
- SDSSJ1227-0000 – grizY
- SDSSJ0958-0010 – grizY

Morning calibrations: Dome Flats and Bias Frames

Observations sequences are selected by the "Observer Tactician" **(OBSTAC)**, a computer algorithm developed in coordination with simulations of the survey to maximize the survey efficiency. The algorithm that OBSTAC uses is as follows. We observe under the first of these conditions that is satisfied.

1. Observe SN fields that have not been observed in the past 6 or more nights.
2. Observe g,r,i,z, or Y-band in Wide-Field (WF) if the current seeing (projected to i-band at zenith) is better than 1.1". The field and filter selected depends on the brightness and proximity to the Moon as well as other factors. The g-band and r-band are reserved for dark-sky conditions. The z-band, i-band, and Y-band images are preferred next.
3. Observe a SN field not observed in the past 4 or more nights.
4. Observe in r- or z-band in WF if conditions are better than 1.6" (projected to i-band at zenith). This condition was added during mid-November, 2013.
5. Observe in g- or Y-band in WF if seeing < 10".
6. Observe SN X3.





RASICAM images for each night in Nov. The figure shows the snapshot with the most variation in clouds during a given night. The Chilean nights of the 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 10th, 11th, 12th, 13th, 14th, 15th, 16th, 21st, 26th, 27th, 28th, 29th, and 30th are cloud-free as indicated by the black and dark blue color.

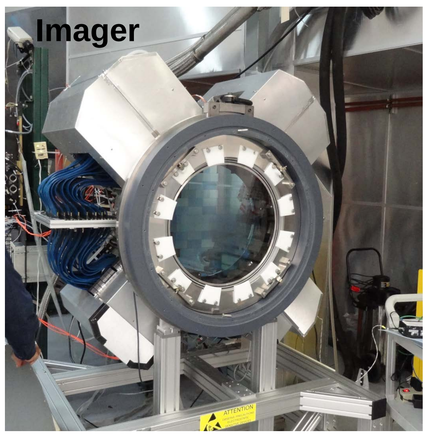
Above Left: The figure shows the 4 "tilings" in each of 5 filters that the collaboration plans to observe for the wide-field survey during DES Season 1 (Y1). The full DES field is shown in light-grey. The dark-grey is the area we expect to observe during Y1. The light blue is that part that has been observed so far in Y1. The red tiles are the ones observed during the night just concluded. This is from the night concluding on Dec. 30th.

Directly Above: The cadence of the SNe survey. The y-axis is the field. The color of the bar indicates the filter: g,r,i,z. The RHS indicates how many nights have elapsed (before this night) since the field was most recently observed. A "6" indicates the field will be observed this night under OBSTAC Condition 1.

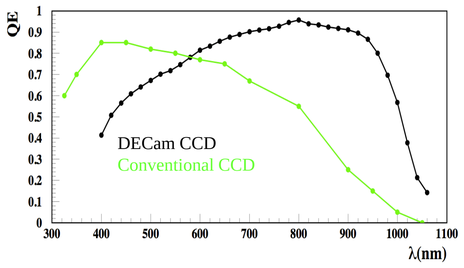
DES Timeline

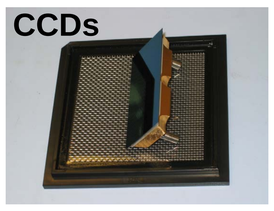
Sept 2012 DECam "1st Light"
Oct. 2012 Commissioning
Nov 2012 – Feb 2013 DES Science Verification
Aug. 31, 2013 – Feb. 9, 2014 DES 1st season
Sept. 2014 to Feb. 2018 DES seasons 2-5.

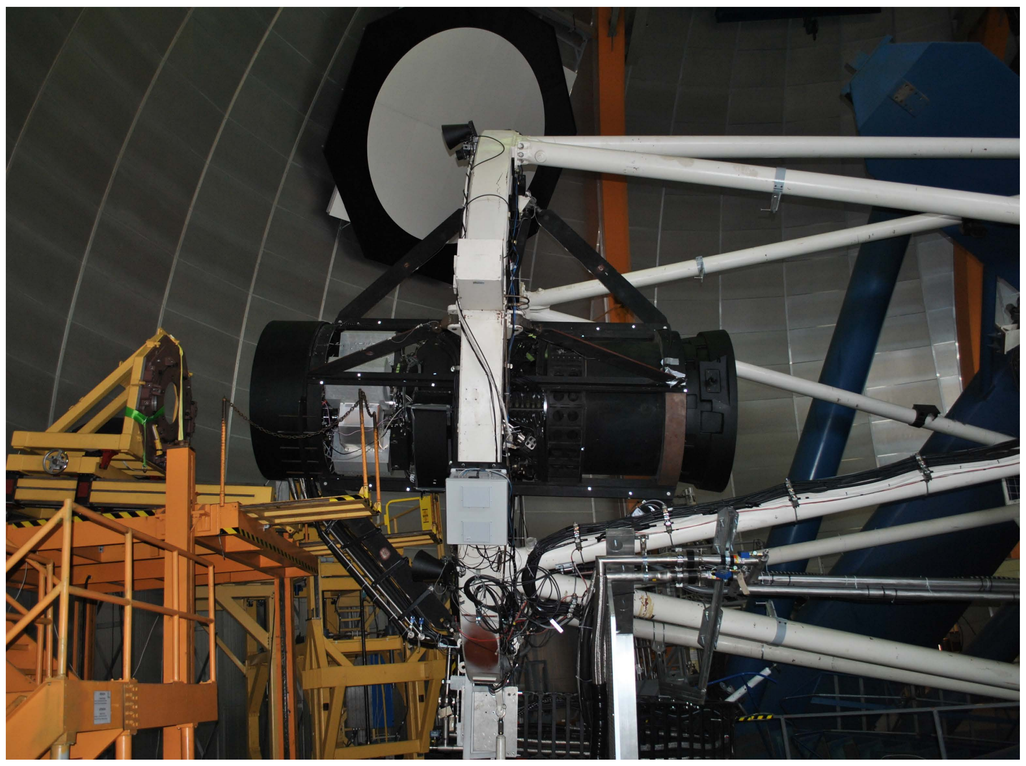
The Dark Energy Camera



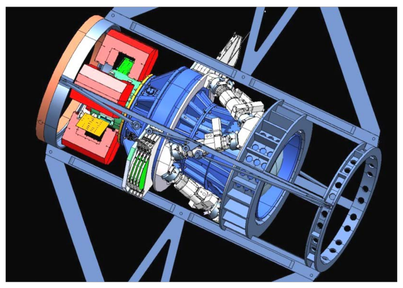
The DECAM imager (above) has a focal plane 45 cm in diameter and 3-square-degree FOV. The last optical element also serves as the Dewar window. There are 62 2kx4k CCDs for imaging and 12 2kx2k CCDs for focus and guiding. The CCDs themselves are thick, fully-depleted red-sensitive 4-side-buttable devices. The DECam CCDs have excellent QE in the red and near-IR in comparison with conventional astronomical CCDs.





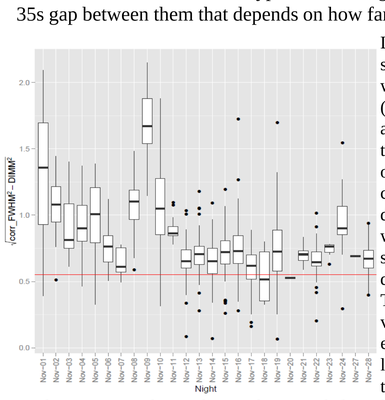


The Dark Energy Camera (above) mounted at the prime focus of the Blanco 4m Telescope at CTIO. The primary mirror is just to the right of the photo. The light enters the 5-element optical corrector from the RHS of the camera. The imager Dewar and electronics are on the LHS of the camera. The orange and yellow-colored contraptions to the left of the camera comprise the imager handing system and access platforms and the F/8 (secondary) mirror handling system. The cartoon key (right) shows, approximately right to left, the fins and support cage (blue-grey), the hexapod actuators (white) that move the camera for focus, the corrector barrel (blue), the hexapod (white), the filter-changer and shutter, the imager Dewar (green), and the readout electronics crates (red). The first optical element, which is pointed at the telescope's 4m mirror, is barely visible in the end of the barrel on the right. The length is roughly 11 feet and the mass roughly 16,500 lbs.



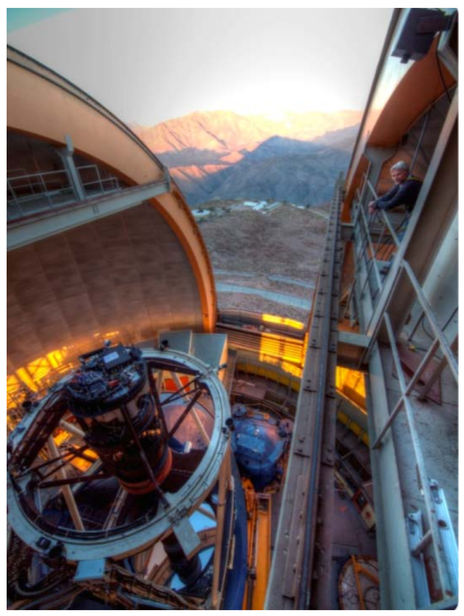
Date	Total HRs	Hrs Observed	Hrs Lost Telescope	Hrs Lost Camera	Hrs Lost Operator	Hrs Lost Weather
August	11	7	0	0	0	4
Sept.	240	188	1	5	0	46
October	151	109	13	1	2	27
Novem.	141	117	2	16	0	7
Decem.	182	172	2	1	0	7
Total	**725**	**592**	**18**	**23**	**2**	**90**
%	**100**	**82**	**2**	**3**	**0**	**13**

Above: Chart, by month, of what happened during DES observing through 12/29/2013. The weather was unusually poor during September through the end of October. During observing the shutter is open 62-68% of the "Hrs Observed". The typical WF images are 90s long with a 26-35s gap between them that depends on how far the telescope has to slew.



Left: This plot is to show whether the seeing achieved by DES is as good as what is expected from the current sky (DIMM measurement) plus the allowed specification for the rest of the known contributors, including the optical corrector. The Y-axis is the contribution to the seeing that is not due to the sky, corrected to i-band wavelengths at zenith, in units arc-seconds. The x-axis is the date. The dark band is the median for the night. The box is the ±1 quartile range. The vertical bars are the full range excluding outliers. The horizontal red line is the specification for the rest of the known contributors. The point is that we want the median to be at or below the red line. There is some expected variation because the DIMM is pointing near the zenith and DECam is pointing somewhere else in the sky. Improvements include more aggressive mirror cooling algorithm and repair of dome floor cooling system from ~Nov. 10th. Other improvements in during Season 1 include replacement of the Dome position encoders in December and improvements to the Dome environmental systems that are ongoing.

The Blanco Telescope at CTIO



The 150" Blanco Telescope at Cerro Tololo. The photo shows the telescope and camera, which is an equatorial horseshoe mount peeking out the dome slit. You can see the primary mirror near the bottom of the telescope. The photo is taken from the crane platform near the top of the dome.

Summary

"Season 1" of The Dark Energy Survey started on August 31st, 2013 and is nearly complete. It is the first of 5 such observing seasons. The DES typically provides a team of 3 observers drawn from volunteers within the Collaboration. Nightly observing fields are scheduled by computer algorithm optimized by performing survey simulations. The rate of progress towards completion of the survey has increased since early-November with improvements to the dome and mirror environmental controls coinciding with an improvement in the typical weather. By Feb. 10th, 2014 we will have observed 105 nights during this season.