The Photometric Calibration of the Dark Energy Survey

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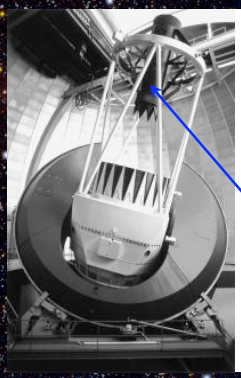


Purpose of the DES

Perform a 5000 sq deg *grizy* imaging survey of the Southern Galactic Cap down to ~24th mag (10σ, galaxies) in order to probe the nature of the Dark Energy by constraining its equation of state parameter *w* and its energy density.

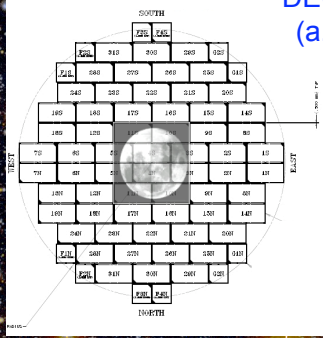
New Equipment

Replace the Prime Focus cage on the CTIO Blanco 4m telescope with a new 3 sq deg optical CCD camera (DECam).

Survey Period

30% of the telescope time (525 nights) from 2011-2016 (September - February)

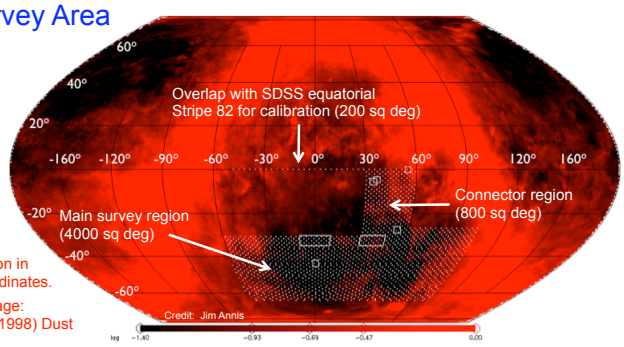
DECam Focal Plane (a.k.a., "The Hex")



- 62 2kx4k Science CCDs (520 Megapixels)
- 8 2kx2k Focus/Alignment CCDs
- 4 2kx2k Guide CCDs
- FOV: 2.2° in diameter (3 sq deg in area)
- 0.27 arcsec/pixel
- Red-sensitive (QE > 50% at 1 micron)

DES Survey Area

5000 sq deg



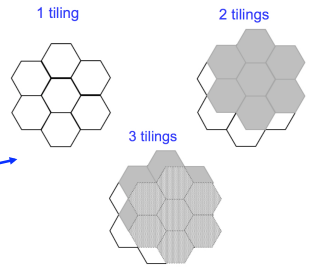
All-Sky Projection in Equatorial Coordinates.

Background image: Schlegel et al. (1998) Dust Map.

DES Observing Strategy

- 100-sec science exposures (nominally)
- 2 filters per pointing (typically)
  - *gr* in dark time
  - *izy* in bright time
- Cover survey area twice per year per filter
  - Each full coverage of the survey area is called a "tiling"
  - It takes 1650 hexes to tile the whole survey area.
- Multiple overlapping tilings (layers) with large overlaps to optimize photometric calibrations
- All-sky photometric accuracy
  - Requirement: 2%
  - Goal: 1%

Zooming in on part of the survey area…



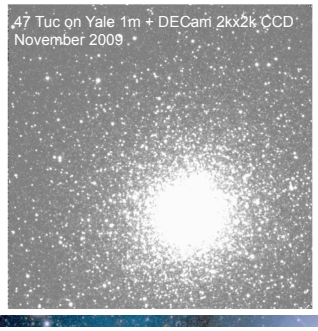
DES Baseline Calibrations Plan in 4 Points

(Tucker et al. 2007, ASP Conf. Ser. 364, pp. 187-199 [astro-ph/0611137])

1. Photometric Monitoring: Use a 10μm All-Sky Cloud Camera to monitor sky conditions throughout the night.
2. Nightly or Intermediate Calibrations: Observe standard star fields with DECam during evening and morning twilight and at least once in the middle of the night.
3. Global Relative Calibrations: Use the extensive overlaps between exposures over multiple tilings to tie together the DES photometry onto an internally consistent system across the entire DES footprint.
4. Global Absolute Calibrations: Use DECam observations of White Dwarf standards [see poster #470.08] in combination with measurements of the full DECam system response to tie the DES photometry onto an AB magnitude system.

Ancillary Observations on the SMARTS/Yale 1-m at CTIO

- Previous runs in April 2008, October 2008, June 2009, and November 2009 provided first on-sky tests of the DECam CCDs, as well as initial test data with the SDSS *ugriz*, Kitt Peak BVR_cI_c, and Thuan-Gunn *griz* filter sets plus a narrow-band filter centered at 945nm.
- For our upcoming 2010A run, scheduled for July 4-10, we will have a set of 4-inch DES *grizy* filters. Goals for this run include an initial determination of SDSS ←→ DES transformations, initial measurements of DES *y*-band standards, and initial characterization of the DES *grizy* colors of various astronomical objects.



PreCam Survey

- The DES project has approached the University of Michigan's Dept. of Astronomy about possible use of the 0.6-m Curtis-Schmidt telescope on Cerro Tololo for calibration studies. The telescope is currently dedicated to studies of orbital debris (PI: Patrick Seitzer), funded by NASA's Orbital Debris Program Office at the Johnson Space Center. The proposed DES usage of the Curtis-Schmidt would be during times of light usage of the telescope for orbital debris studies.
- PreCam Survey is a proposed quick, bright survey in the DES footprint using a small mosaic of DECam CCDs – the "PreCam" – mounted on the Curtis-Schmidt telescope at CTIO. The proposed time-windows for observations would be in Aug/Sep 2010 and in Nov 2010—Jan 2011.
- The PreCam instrument, which is being constructed at ANL, is a 4kx4k camera using DECam CCDs. On the Curtis-Schmidt, this instrument would have a FOV of 1.6°x1.6° (2.56 sq deg) and a pixel scale of 1.4 arcsec/pixel.

PreCam Survey Benefits and Strategies

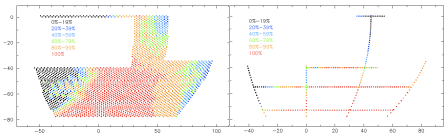
Benefits to DES

- PreCam will be effectively a 1/32nd scale version of DECam, and thus useful for testing of DECam systems before DECam commissioning.
- The PreCam Survey will provide hundreds of stars per square degree within the DES footprint and in the DES *grizy* filter system that can be used as extinction standards and *y*-band standards for DES.
- The PreCam Survey will provide an additional data set to help with the global relative calibrations of DES.

Two Alternative PreCam Survey Strategies

- We are currently investigating two alternative strategies for the PreCam Survey. Either strategy would require 100 scheduled nights on the Curtis-Schmidt telescope.

Full Footprint Strategy | Rib and Keel Strategy



Cover full DES footprint in a single pass | **Cover 1/10th of the DES footprint 10x**

PreCam Observing Strategy Simulations by Jim Annis and Tom Carter

DES Collaboration: Fermilab, University of Illinois at Urbana-Champaign, University of Chicago, Lawrence Berkeley National Laboratory, National Optical Astronomy Observatory, Spain DES Collaboration, United Kingdom DES Collaboration, University of Michigan, DES-Brazil Consortium, University of Pennsylvania, Argonne National Laboratory, Ohio State University, and Santa Cruz-SLAC-Stanford DES Consortium.

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