



DARK ENERGY
SURVEY

Calibration & PreCam

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DES Collaboration Meeting
CIEMAT, 6 May 2010

Outline:

- I. Calibration Plan Overview
- II. Updates



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PART I:

DES Calibrations Plan: A Quick Overview



Basic DES Observing Strategy

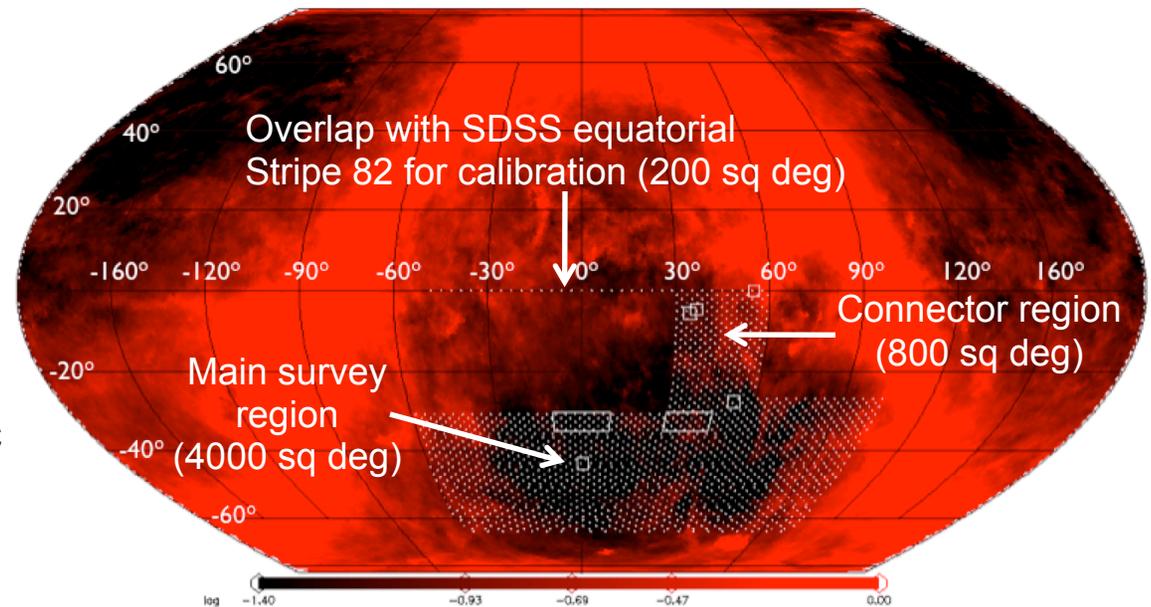
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Observing Strategy

- 100 sec exposures (nominally)
- 2 filters per pointing (typically)
 - *gr* in dark time
 - *izy* in bright time
- Multiple overlapping tilings (layers) to optimize photometric calibrations
- 2 survey tilings/filter/year
- All-sky photometric accuracy
 - Requirement: 2%
 - Goal: 1%

Survey Area

Credit: J. Annis



Total Area: 5000 sq deg



DES Calibrations Plan in 6 Points

(For details, see DES-doc#4378)

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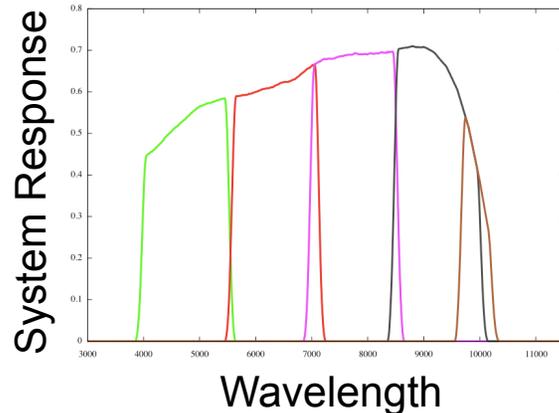
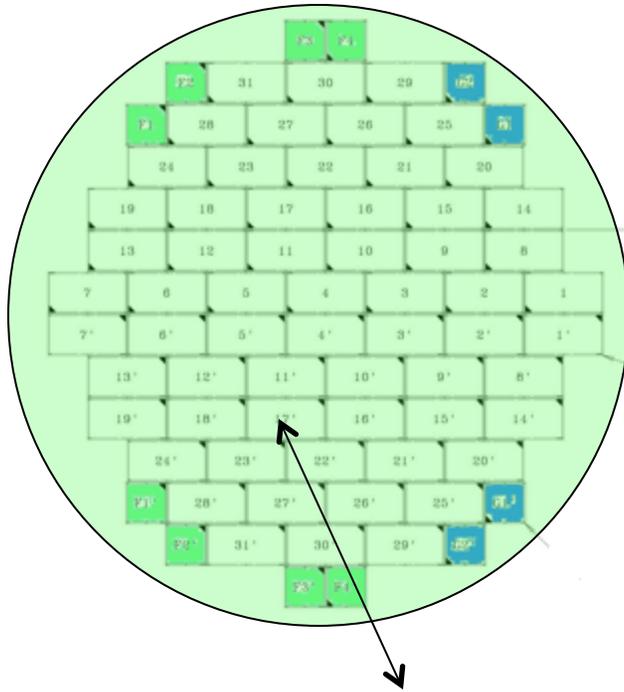
1. **Instrumental Calibration (Nightly & Periodic):** Create biases, dome flats, linearity curves, cross-talk coefficients, system response maps.
2. **Photometric Monitoring:** Monitor sky with 10 μ m All-Sky Cloud Camera.
3. **Nightly and Intermediate Calibrations:** Observe standard star fields with DECam during evening and morning twilight and at least once in the middle of the night; fit photometric equation; apply the results to the data.
4. **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.
5. **Global Absolute Calibrations:** Use DECam observations of spectro-photometric standards in combination with measurements of the full DECam system response map to tie the DES photometry onto an AB magnitude system.
6. **PreCam Survey:** Use *grizy* standards from PreCam Survey for nightly calibrations and calibrated PreCam fields to improve the DES Global Relative Calibrations.



1. Instrumental Calibration: An Example of Periodic Instr. Calibration

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Spectrophotometric System Response Map (instrumentation being dev'd for DES by Darren DePoy)



- It is expected that the shape of the system response will be a function of position on the focal plane.
- Therefore, the system response map from the spectrophotometric calibration system will be important for Global Absolute Calibration, catalog and image co-adds, enhanced calibration of specific classes of astronomical objects, and system performance tracking over time.
- This would typically be a once-a-month calibration, taking several hours to measure all 5 DES filters.

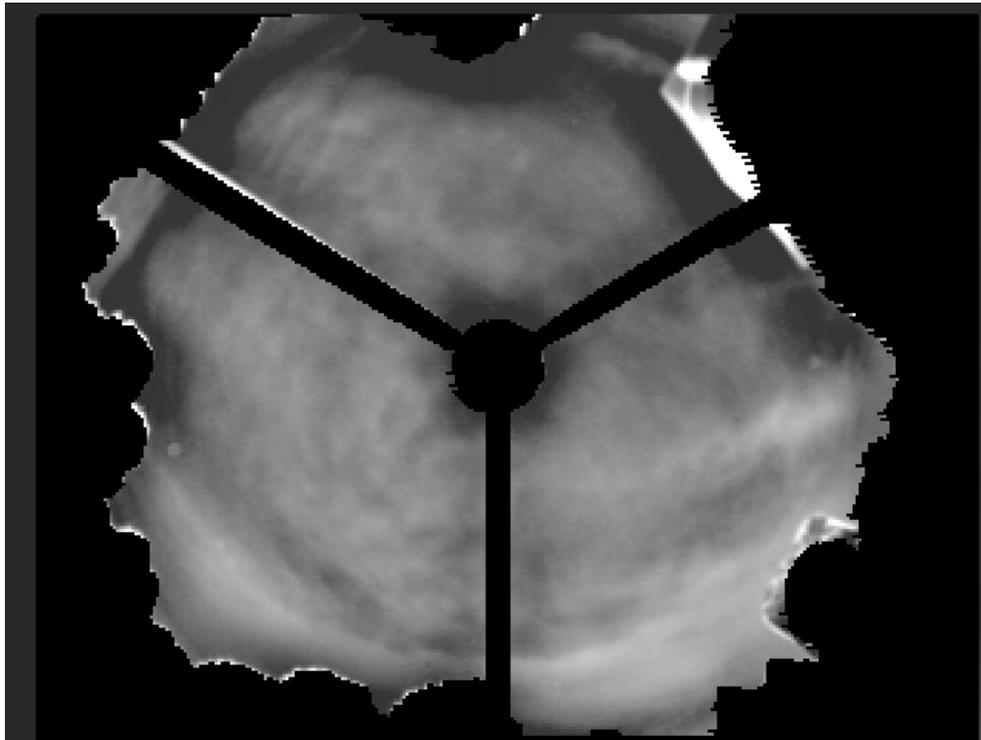


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2. Photometric Monitoring: The 10 micron All-Sky Camera

10 micron All-Sky Camera

- Provides real-time estimates of sky conditions for survey strategy
- Provides a measure of the photometric quality of an image for off-line processing
- Detects even light cirrus under a full range of moon phases (no moon to full moon)



APO 10 micron all-sky camera: “cirrusy” conditions

The DES Camera: “RASICAM”

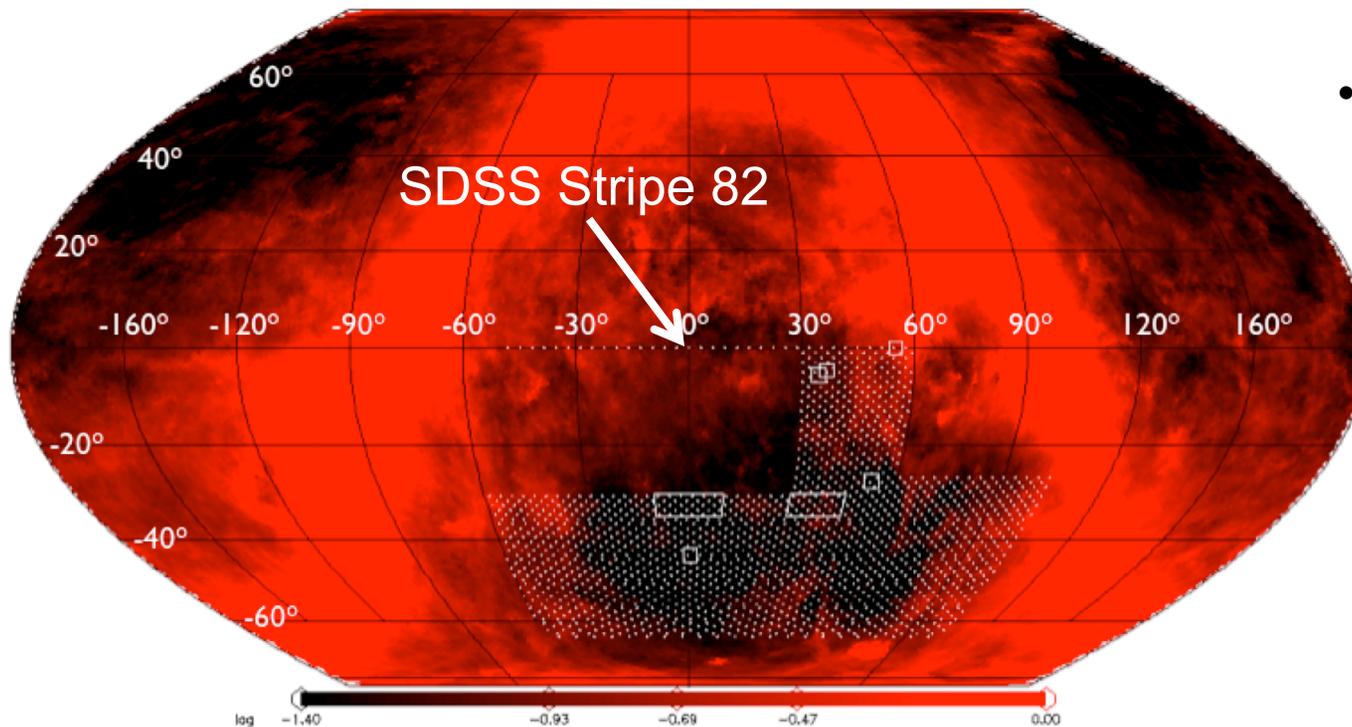
- “Radiometric All-Sky Infrared CAMera”
- Web interface for observers
- Photometricity flag(s) passed to each exposures FITS header via SISPI for use by DESDM
 - Nightly calibrations
 - Global relative calibrations



3. Nightly/Intermediate Calibrations: Standard Stars

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- **SDSS Stripe 82 Standards**
 - $\sim 10^6$ tertiary *ugriz* standards
 - $r = 14.5 - 21$
 - ~ 4000 per sq deg
 - See Ivezić et al. (2007)
- **Southern u'g'r'i'z' Standards**
 - ≈ 15 13.5'x13.5' fields in DES footprint
 - $r = 9 - 18$
 - Typically tens of stds. per field
 - http://www-star.fnal.gov/Southern_ugriz/



- **y-band Standards**
 - Under development
 - UKIDSS observations in Stripe 82
 - CTIO-1m
 - **PreCam observations**



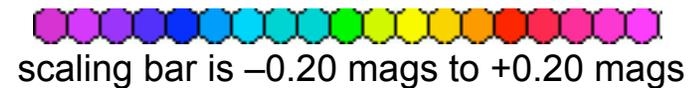
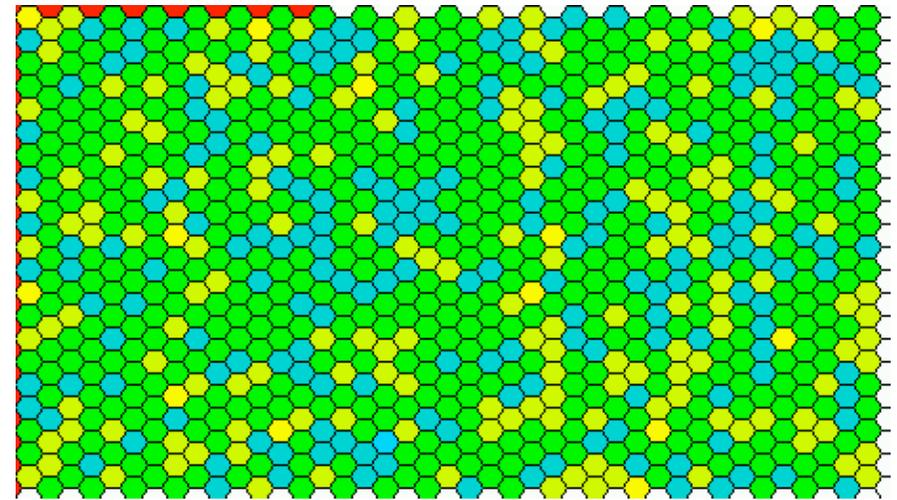
4. Global Relative Calibrations: The Need and The Strategy

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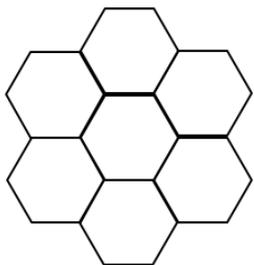
We want to remove field-to-field
zeropoint offsets to achieve a uniformly
“flat” all-sky relative calibration of the full
DES survey, but...

DES will not always observe under truly
photometric conditions... →

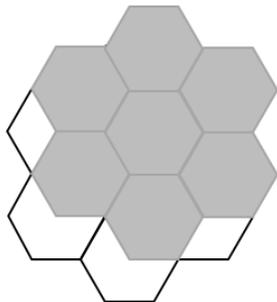
...and, even under photometric
conditions, zeropoints can vary by 1-2%
rms field-to-field.



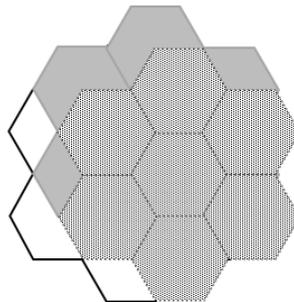
1 tiling



2 tilings



3 tilings



The solution: multiple tilings of the
survey area, with large offsets between
tilings.

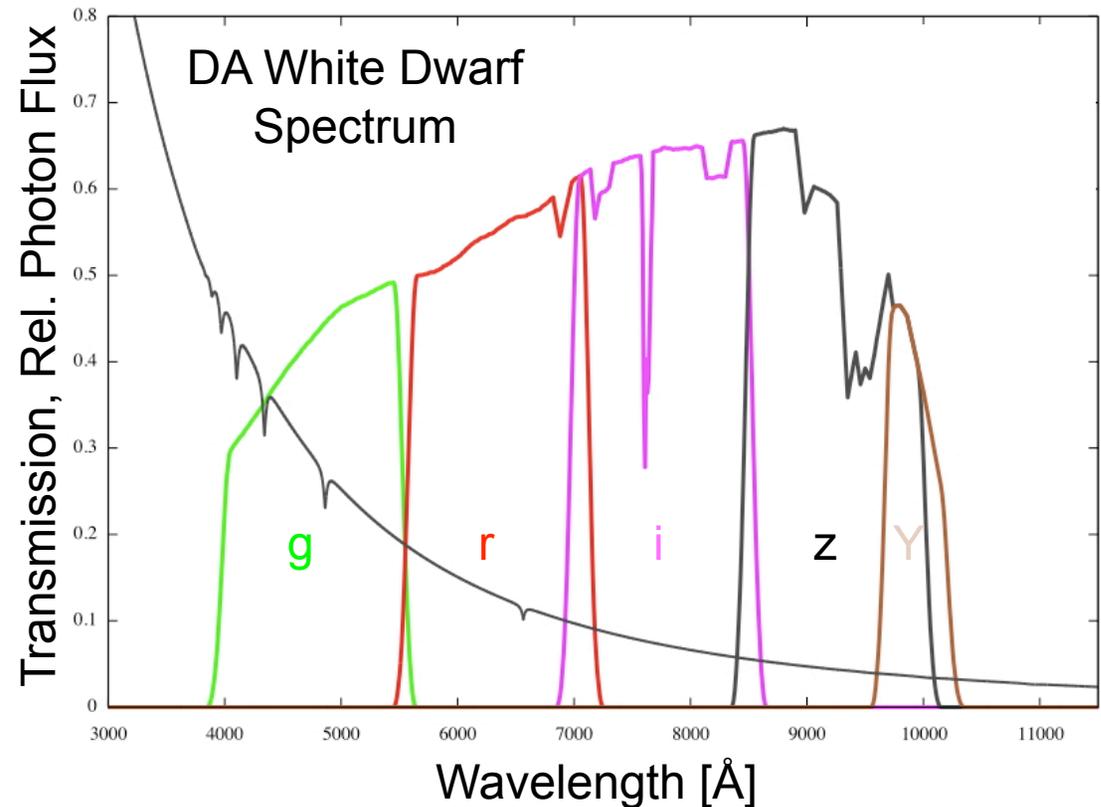
We cover the sky twice per year per
filter. It takes ~ 1700 hexes to tile the
whole survey area.



5. Global Absolute Calibrations: Basic Method

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- Compare the synthetic magnitudes to the measured magnitudes of one or more spectrophotometric standard stars observed by the DECam.
- The differences are the zeropoint offsets needed to tie the DES mags to an absolute flux in physical units (e.g., $\text{ergs s}^{-1} \text{cm}^{-2} \text{\AA}^{-1}$).
- Absolute calibration requires accurately measured total system response for each filter passband as well as one or more well calibrated spectrophotometric standard stars.





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6. The PreCam Survey: What is it?



Courtesy: NOAO/AURA/NSF

PreCam Survey: a quick, bright survey in the DES footprint using a 4kx4k camera composed of DECam CCDs – the “PreCam” – mounted on the University of Michigan Dept. of Astronomy’s Curtis-Schmidt Telescope at CTIO. Observations are scheduled to take place in Aug/Sep 2010 and Nov 2010 - Jan 2011. It is a new component to DES calibrations.



6. The PreCam Survey: Number of Nights for Completion

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- For baseline instrument (2 DECam 2k x 4k CCDs):
 - FOV of $1.6^\circ \times 1.6^\circ$ (2.56 sq deg) at a pixel scale of 1.4 arcsec/pixel
 - 1950 fields to cover 5000 sq deg; including 50% overlap \rightarrow 2925 fields
 - At 8.6 min per field (exposure times+readout+slew times), it would take 60 nights to perform a “1.5-pass” PreCam Survey in all 5 DES filters
 - Add various additional overheads $\rightarrow \approx$ 100 scheduled nights

Baseline PreCam Survey Point-Source Magnitude Limits (optimized to achieve S/N=50 at DES saturation + 1.5mag)

Band	Exposure time [seconds]	PreCam saturation limit	PreCam mag limit S/N=50	Number of usable stars per sq deg (SGP)
g	36	12.8	17.8	186
r	51	13.2	17.8	265
i	65	13.4	17.7	344
z	162	14.1	17.5	317
y	73	11.6	14.3	150



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6. The PreCam Survey: Benefits to DES

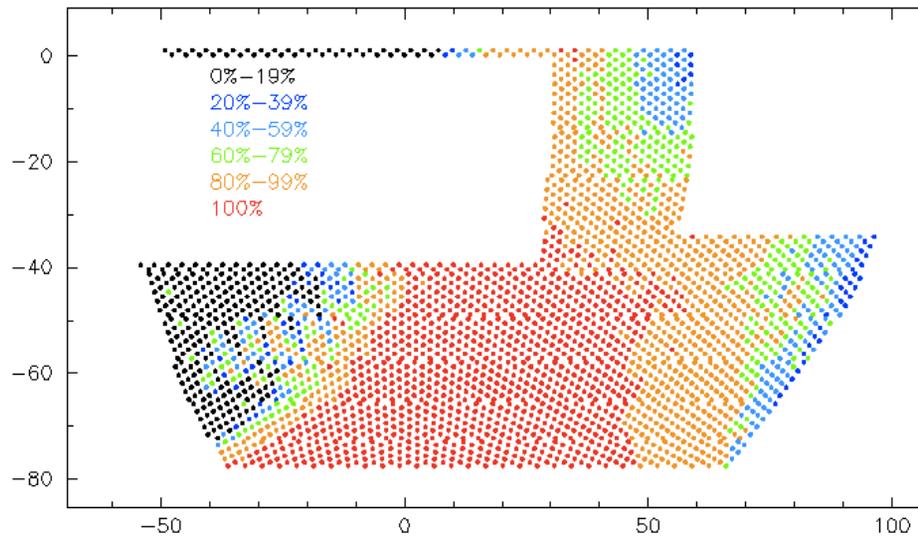
1. Early on-sky tests with a “1/32nd scale” DECam
2. Stars that can be used for “quick look” diagnostics of the DES data in during DES operations
3. DES *grizy* standard stars (*y*-band in particular), supplementing the Stripe 82 standards and Smith et al. Southern *u'g'r'i'z* standards and permitting a much finer time-resolution of extinction measurements during DES operations
4. Determinations of the transformations between SDSS *griz* and DES *griz* (via observations in SDSS Stripe 82)
5. Identification of candidate DA white dwarfs (in conjunction with SkyMapper *u*), useful for DES absolute calibrations
6. Bright science in DES *grizy* (e.g., star clusters in DES footprint)



6. The PreCam Survey: Two Alternative Strategies

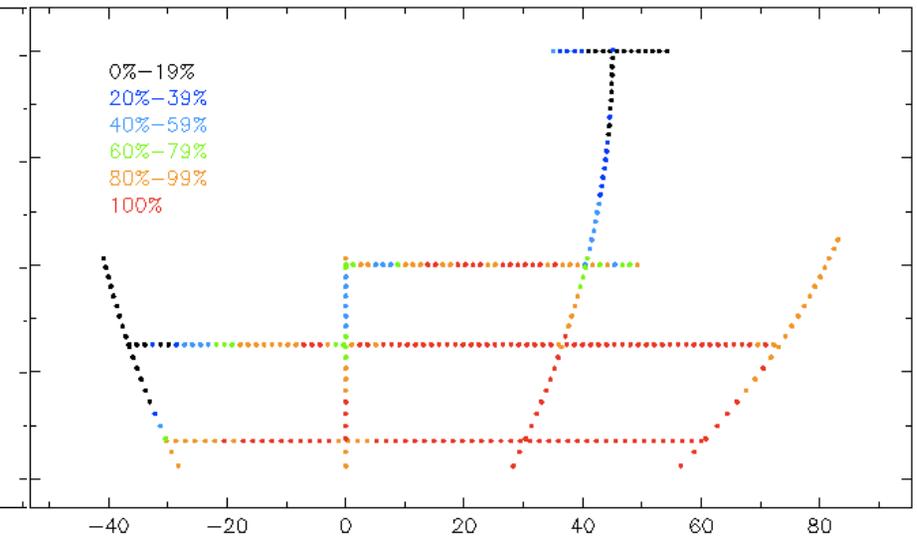
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Filled Survey



Cover full DES footprint

Rib and Keel Survey



**Cover 1/10th of the
DES footprint 10x**

PreCam Observing Strategy Simulations
by Jim Annis and Tom Carter



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6. The PreCam Survey: Alternative Strategies (Pros and Cons)

Full Footprint

Pro:

- Calibrated PreCam stars in each DES pointing.
 - A measure of the extinction for every DES pointing (very fine time resolution of the atmospheric transparency)
 - Quick Look stellar diagnostics for every DES pointing

Con:

- Internal PreCam calibrations heavily dependent on small field-to-field overlaps at the edges (flat-fielding errors and/or errors due to non-photometric observations might dominate).

Rib & Keel

Pro:

- Multiple tilings with large offsets should beat down any flat-fielding and errors and any errors due to non-photometric conditions

Con:

- No longer have PreCam-calibrated stars in every DES pointing

Recently completed simulations indicate that the Rib & Keel appears to be the better option for calibrating DES (see DES-doc#4365 and DES-doc#4377), especially against pathological flat-fielding errors.



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PART II:

Updates

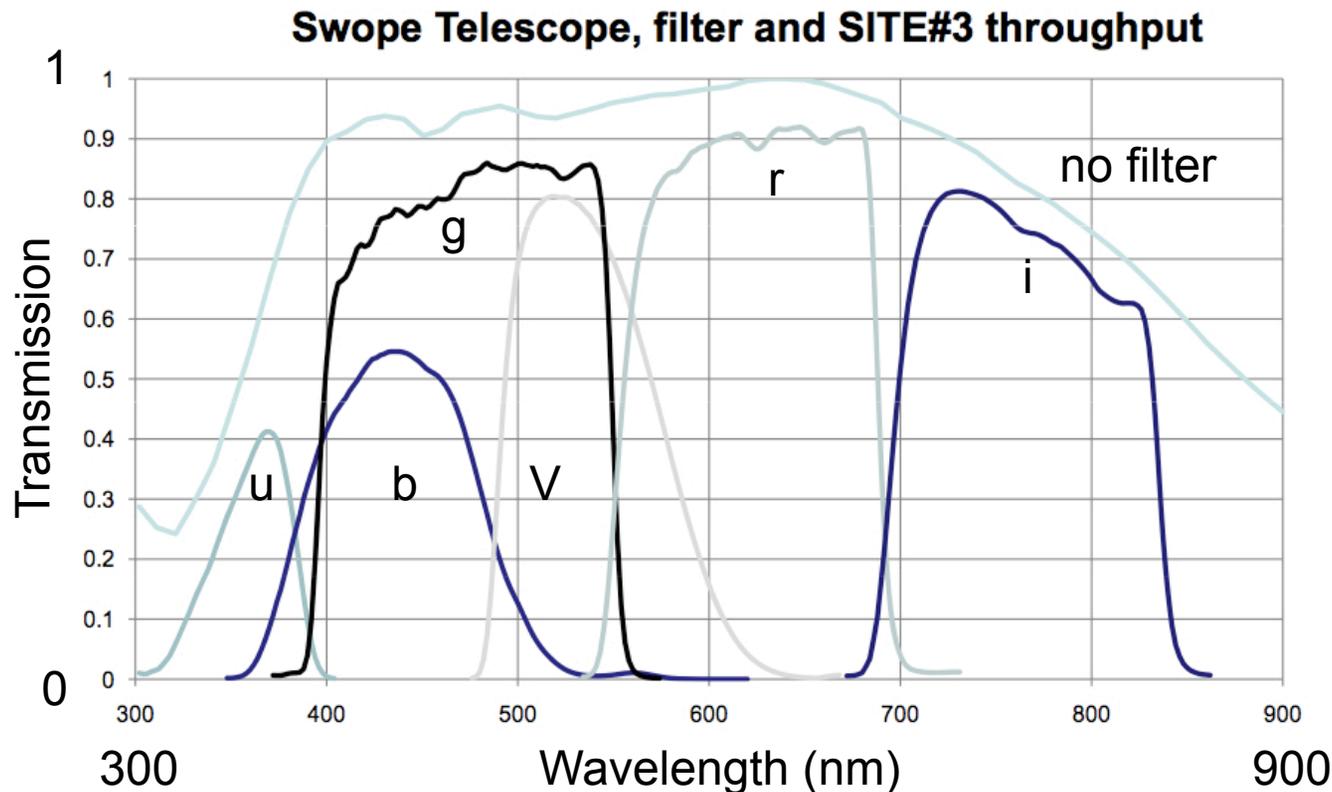


Spectrophotometric Calibration System

(credit: Darren DePoy)

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- A prototype system has been assembled and tested in the lab at Texas A&M.
- This prototype system was shipped and tested on the Las Campanas Swope 1m telescope in January 2011.



- Good repeatability (1% precision)
- Blanco system to be installed over the course of 2010 Q3 through 2011 Q2 and tested on Mosaic (or other imager) ASAP
- See DES-doc#4338



PreCam Hardware

(credit: Kyler Kuehn, Steve Kuhlmann, Darren DePoy, and others)

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There was a PreCam Mechanical Design Review on March 2, 2010 (see DES-doc#4190, 4191, 4200).

Current Status of PreCam Hardware:

- [Camera and Electronics](#) – much progress (ask Kyler!) (DES-doc#4377, 4431)
- [Shutter](#) – two shutters from same manufacturer have been procured and are being tested (one at ANL, one at Texas A&M) (DES-doc#4431)
- [DES grizy Filters \(4in square\)](#) at Texas A&M (DES-doc#4295)
- [New folding flat \(secondary mirror\) and support structure](#) – mirror ordered and should be delivered to Texas A&M in late May, support structure being designed (DES-doc#3695)
- [Dome flat screen and lamps](#) – screen complete and ready for shipping; illumination system under construction (DES-doc#3605)



PreCam Pipeline

(credit: Marcio Maia + DES-Brazil PreCam Team)

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- The DES-Brazil PreCam team has developed a pipeline for processing the PreCam Survey data, and has tested it on the November 2009 CTIO-1m + DECam CCD data.
- DES-Brazil team has requested input from DES Calibrations Scientist for optimizing pipeline.
- Pipeline is on-target for PreCam Survey operations.
- See DES-doc#4425 for details.

01

Instrument	Filter	RA	DEC	Tot-expt (s)	HI Column	l (deg)	b (deg)	Extinction	Mean (counts)	Sigma (counts)	Noise (counts)
DECam	z	58.7488	0.0901	45	---	188.9909	-37.7746	---	43204.9	10760.4	1135.1

Raw Field Image

Reduced Field Image

Weight Image

Concluido



Cloud Camera

(credit: Peter Lewis, Howard Rogers, and Rafe Schindler)

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- Cloud Camera (“RASICAM”) under construction at SLAC.
- RASICAM “I/O” Review March 24, 2010, with participation by Russet McMillan (APO3.5m Observing Specialist) as an outside reviewer.



From March 10, 2010 SLAC Today article

- Cloud camera is on-target for arrival at CTIO in early-August and being generally operational by late-August.
- Thus, the cloud camera should be ready in time for PreCam post-commissioning survey operations (c. Sept 1).



DES Calibrations Review: April 22, 2010

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- Reviewers: Steve Kent (chair), Rebecca Bernstein, John Marriner, Alistair Walker, Brian Yanny
- (Abridged) Charge:
 1. Are the scientific requirements on calibration the right ones?
 2. Are all the calibration methodologies/elements necessary and sufficient to deliver the calibration requirements?
 3. Is there a viable plan to implement and carry out those methodologies within the resources we have allocated to the project?
 4. Is the test and verification plan necessary and sufficient to determine if the requirements are being met?
 5. Is the plan for calibration, data processing, and for production of calibrated DES data sound?
- See close-out slides at DES-doc#4397.
- Detailed report from the Review Committee is forthcoming.



July 4-10 CTIO-1m Observing Run

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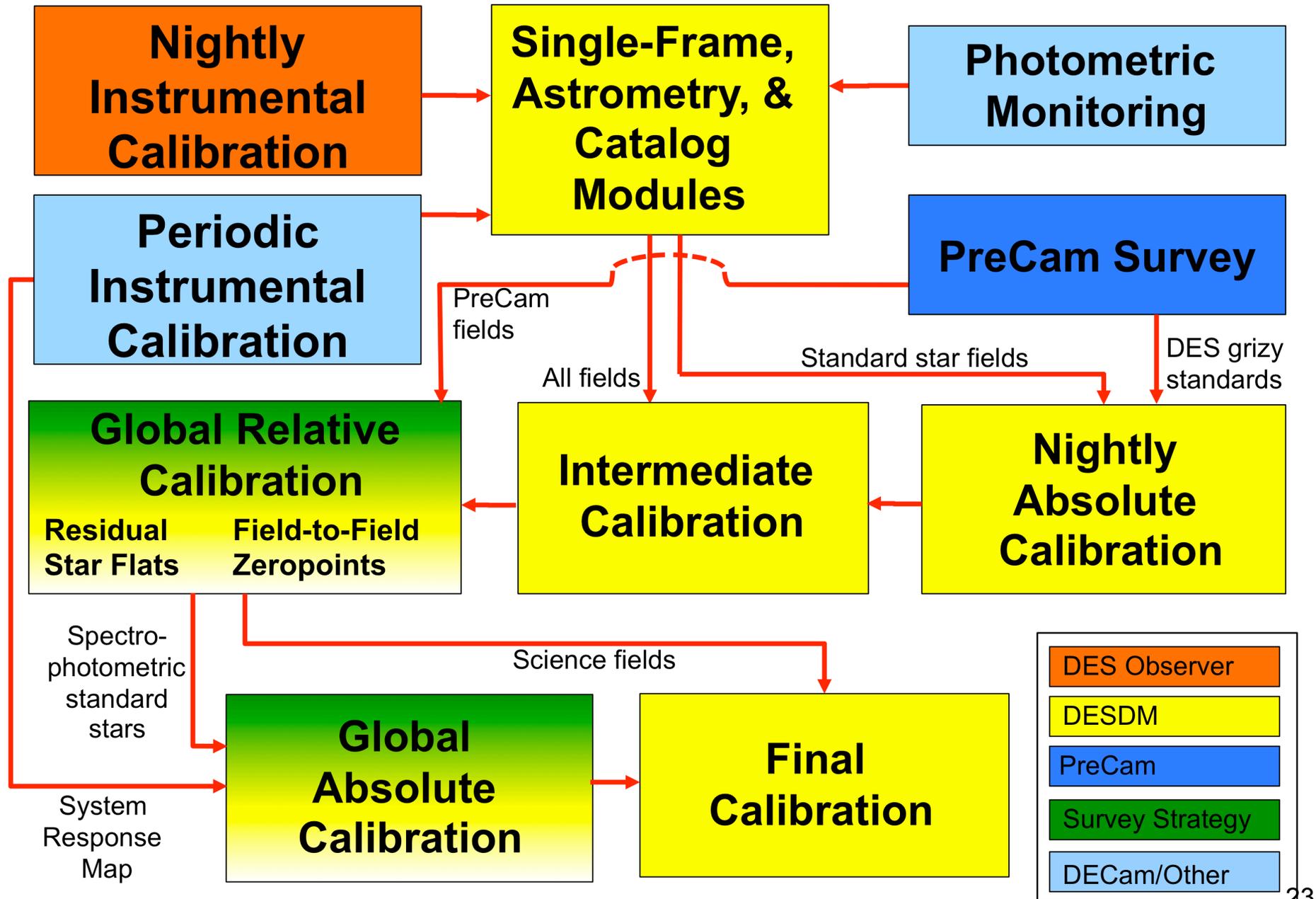
- First chance to take observations with both a DECam CCD and a set of DES grizy filters!
- Targets:
 - White Dwarfs
 - Fields in SDSS Stripe 82
 - Smith et al. Southern $u'g'r'i'z'$ standard star fields
 - Variety of astronomical objects in DES filter system.
- Goals:
 - Calculate SDSS $\leftarrow \rightarrow$ DES transformation equations
 - Establish an initial set of DES *grizy* standards
 - Characterize a set of stars, galaxies, and QSOs in the DES *grizy* filter system.



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Extra Slides

DES Photometric Calibrations Flow Diagram (v4.1)



DES Photometric Calibrations Flow Diagram (v4.1)

