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SURVEY

Integrating the DECal System Response Measurements into DESDM: Some Thoughts

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DES SIWG Telecon

14 July 2011

The Need for a System Response Map

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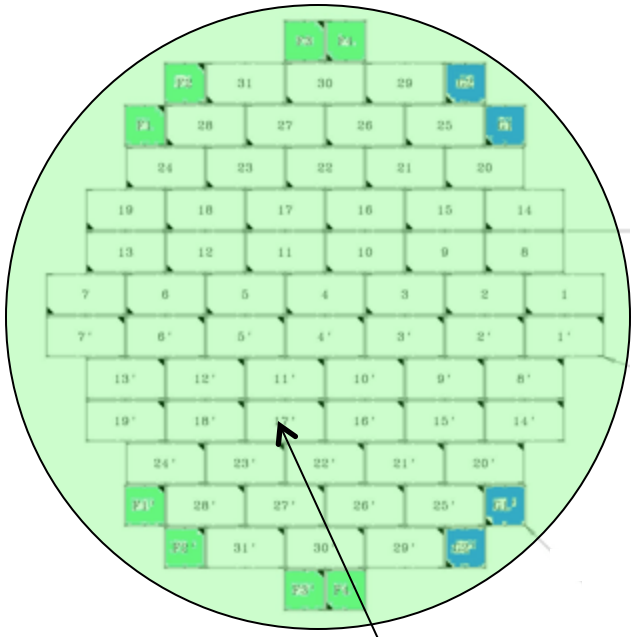

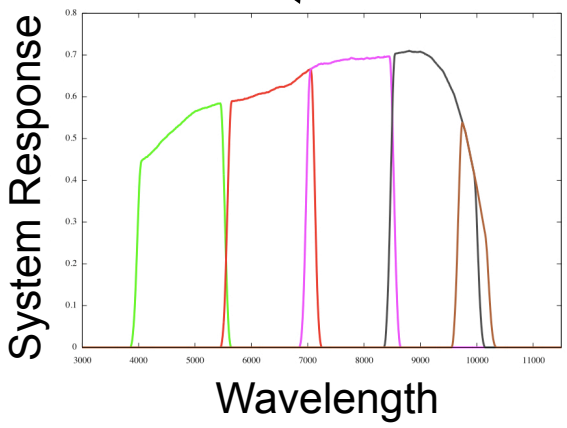

- There will be noticeable variations in the system response across the focal plane due to (1) CCD-to-CCD QE variations, (2) spatial non-uniformities in the coatings on C1-C5 optical elements, and (3) **spatial non-uniformities in the transmission curves of the filters**.
- Therefore, the shape of the system response response function will be a function of position on the focal plane.
- Therefore, the measured brightness of an object will depend on its position on the focal plane and on its color (shape of its spectrum).
  - Important for Global Absolute Calibration, for catalog and image co-adds, for enhanced calibration of specific classes of astronomical objects, and for tracking the system performance over time.
  - TBD: How coarse can the System Response Map be (pixel-by-pixel, CCD-by-CCD, or…)?

The Total System Response

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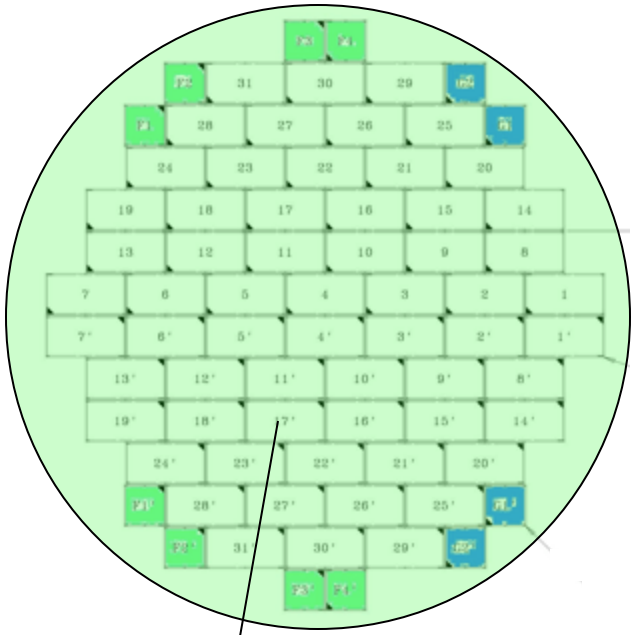
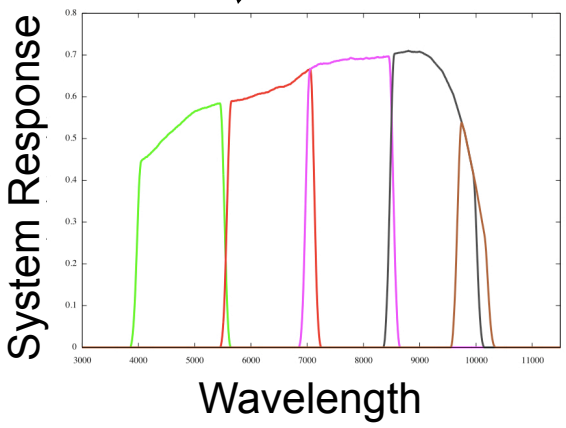


- For the Total System Response, we will combine:
  - the System Response Map of the CCDs+filters+optics nearest in time to the spectrophotometric standard star observations
  - a mean atmospheric transmission curve appropriate for CTIO



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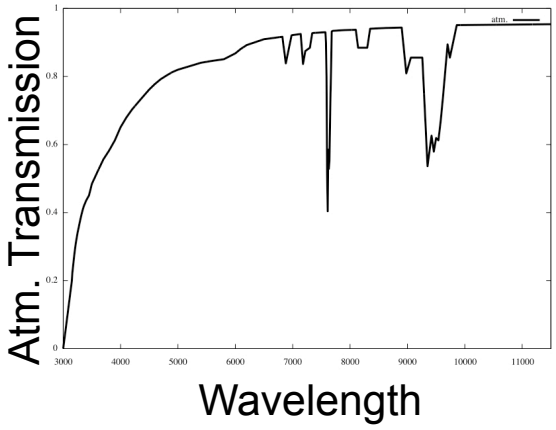

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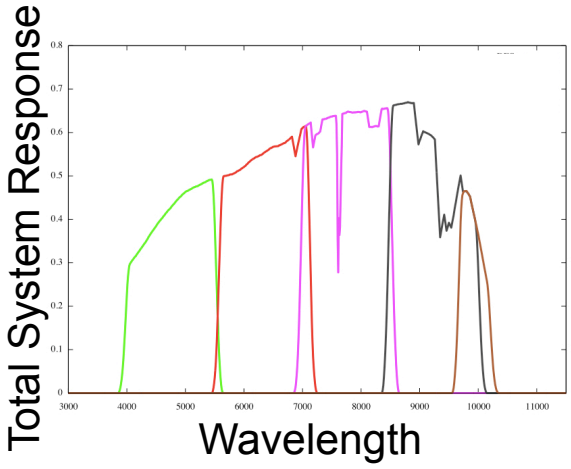

The Total System Response and the Single-Epoch DES Images

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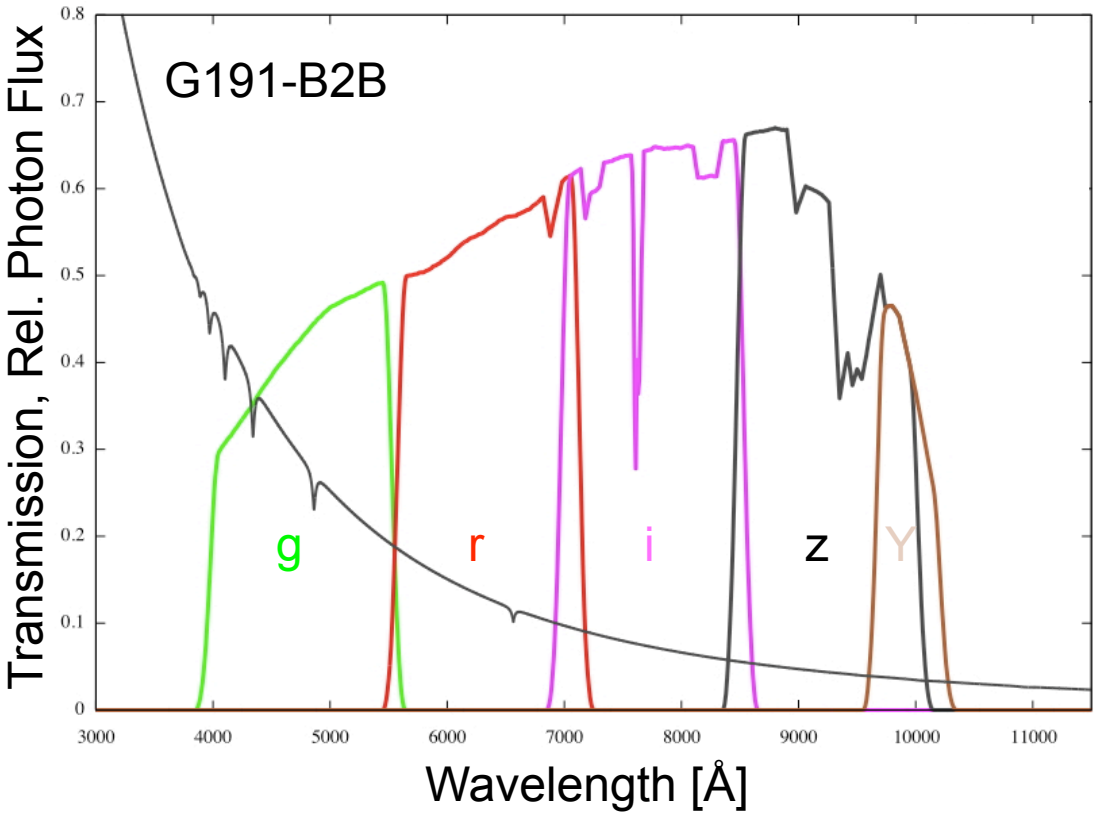
Global Absolute Calibration

- 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., ergs s^{-1} cm^{-2} $Å^{-1}$).
- Absolute calibration requires accurately measured total system response for each filter passband as well as one or more well calibrated spectrophotometric standard stars.



Final Calibration

- Apply the magnitude zeropoint offsets to all the catalog data.

- *Code for these steps has not yet been implemented.*

Spatial System Response Inhomogeneities and the Image-level Co-add

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How to coadd images when there are non-negligible variations in the system response across the focal plane?

- *"In traditional coadds, one averages first and asks questions later. That is, one does the coadd and then attempts a color term correction at the catalog level. It is unclear whether we can get away with this."*
  -- Jim Annis
- If one ignores the spatial variation in the system response function across the focal plane, the photometry in the resulting coadd suffers.
  - Use image coadds for object detection, and (averaged?) single-epoch catalog data for the photometry?
  - Use (x,y) maps of the system response system response somehow in the image coadds? How?

Spatial System Response Inhomogeneities and the Image-level Co-add

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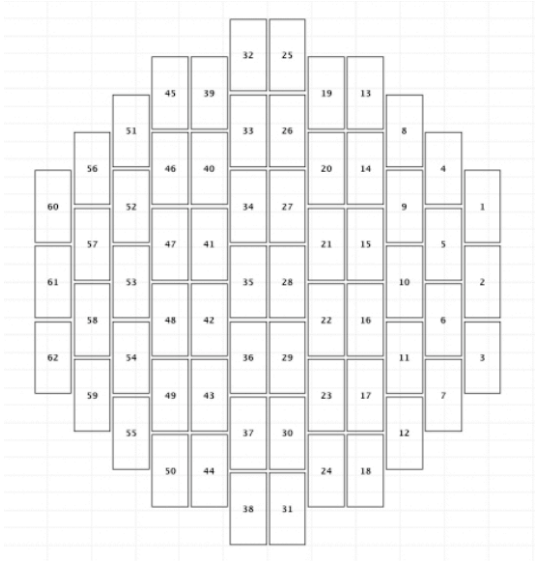
A DECam Science Exposure



Spatial System Response Inhomogeneities and the Image-level Co-add

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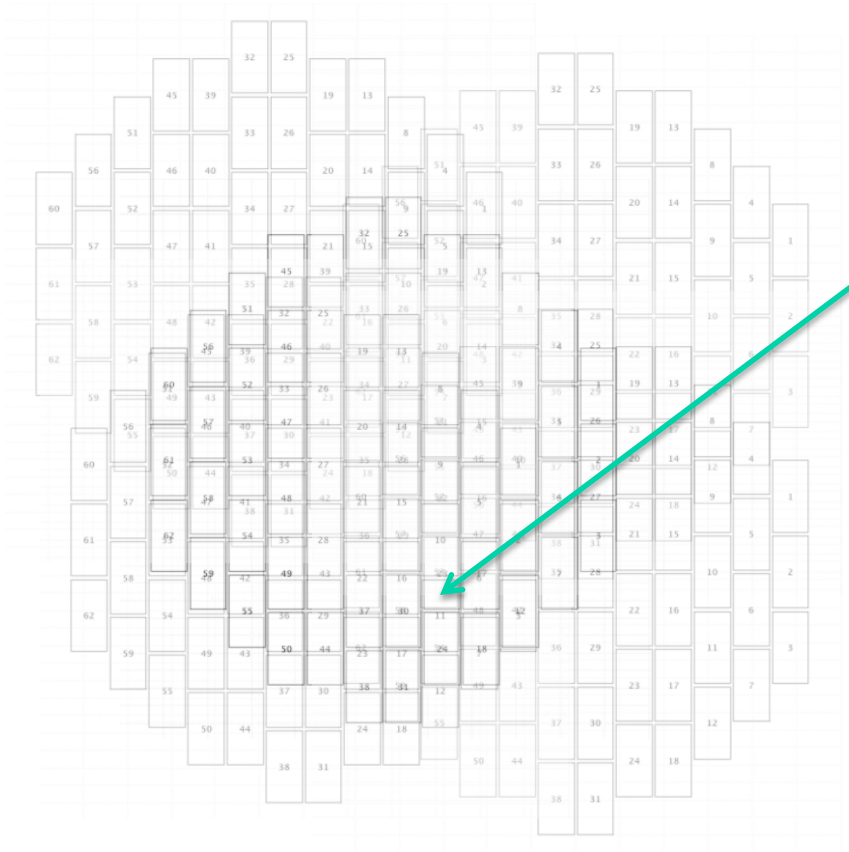
After several overlapping exposures…



Effective total system response for co-add at this point is an average of the single-epoch DECal spectrophotometric measurements from all the overlapping CCD images at this point.

We can use Molly Swanson's Mangle masks to determine which CCDs contribute to a given point, in order to know which system response curves to average together for a given point on a co-added image.

DECal at the Telescope: System Summary

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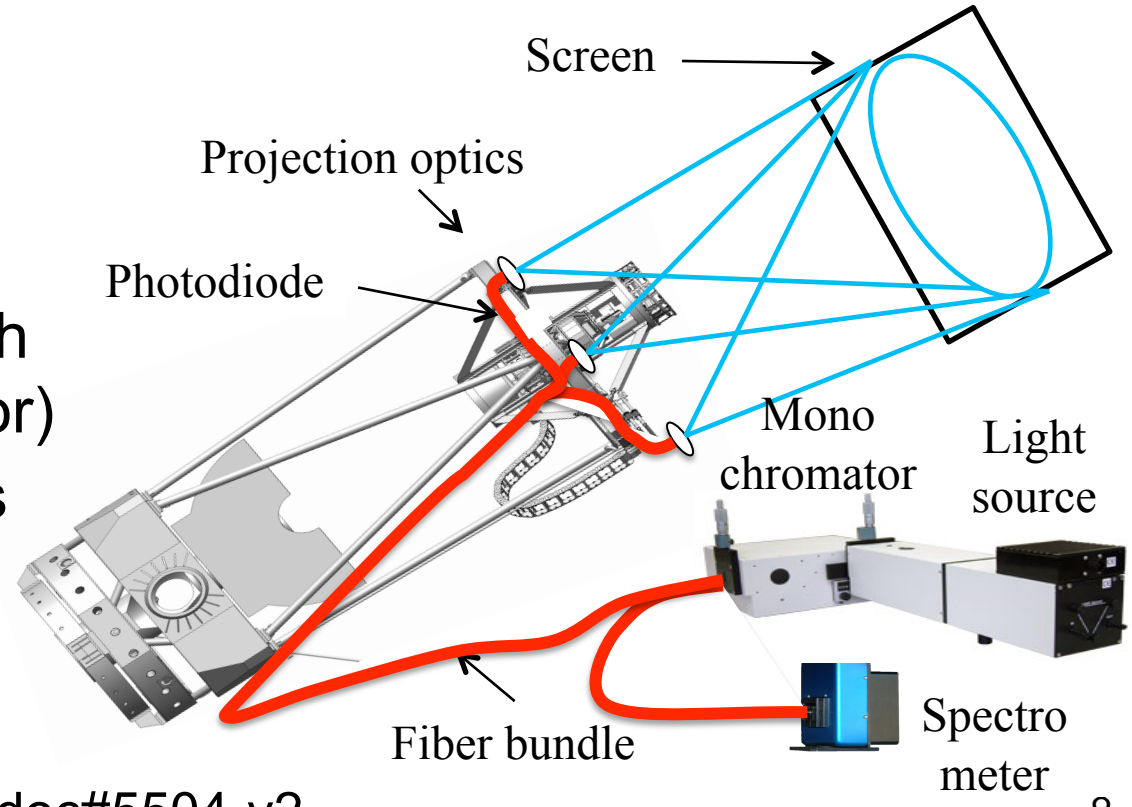
- Flat field screen
- Daily flat field system
  - LED flat field lamps
- Spectrophotometric calibration system
  - Long fiber bundle
  - Monochromator (with spectrometer monitor)
  - Monitor photodiodes



Credit: Jennifer Marshall, DES-doc#5504-v2

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DECal At the Telescope: DECal Procedures

From Jennifer Marshall's e-mail of July 6

DECal procedures, to be completed by communication through SISPI:
Point telescope at ff screen
Start loop
Set monochromator wavelength
Turn on monochromator output to illuminate screen
Begin taking photodiode "light" data
Take DECam image
Simultaneously take spectrum with spectrometer
Reduce spectrometer output in real time and record median wavelength and reduced spectrum to disk
Turn off monochromator output
Begin taking photodiode "dark" data
Take DECam dark image (if necessary)
Change monochromator output to next wavelength
End loop
At the end of loop, reduce photodiode data (automatically) and write text file with results.

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DECal At the Telescope: Computers and Data Products

From Jennifer Marshall's e-mail of July 6

DECal computers:
There is only one computer associated with DECal. It operates the monochromator, spectrometer, and photodiodes. It runs a Labview program that operates all of these systems, which SISPI should be able to communicate with.

DECal data products:
DECam light (and dark) images (fits files)
Spectrometer image (IMG file, reduced by spectrometer software)
Spectrometer/photodiode parameters (text file)
Raw photodiode outputs (text files)
Net voltage, a reduced version of the photodiode outputs (text file)

DECal in DESDM: The Single-Epoch Response Curve Module

(a.k.a. “George I”)

1. Process the raw DECal outputs and subsequently generate system response curves from a given DECal spectrophotometry run.
   - List of processing steps (and/or code?) to be provided by TAMU.

2. Ingest the system response curves into the DESDM database.
   - This requires at least one new table into the DESDM database, including the following information
     - Time-stamp of the DECal spectrophotometry run
     - CCD ID number
     - Filter name
     - 30 or so points making up the response curve for that filter (wavelength, system throughput at that wavelength)

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DECal in DESDM: The Coadd Response Curve Module

(a.k.a. "George II")

1. Query the Mangle Mask for a given RA,DEC in the coadd to identify which CCD images were coadded at that particular RA,DEC.
   - Also need the dates of observation for these CCD images

2. Use the CCD image id's to query the DECal response curve table(s) to identify the response curves associated with those particular CCD images.

3. Perform some sort of weighted average of the response curves from the previous step to act as the effective response curve for that RA,DEC of the coadd.

4. Calculate an effective instrumental color term ("b") coefficient for calibrating coadd magnitudes based on stellar SEDs (see Huan Lin's filter inhomogeneity talks, e.g., DES-doc#4371).

5. Ingest mean response curves and "b"-term coefficients into a table in the DESDM database (per Mangle Mask "molygon"?) that is accessible to the Science Working Groups for their general use.

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DECal in DESDM: Additional Items and Concerns

1. It is likely that we will want to add a column to the DESDM images table that acts as a pointer to the appropriate DECal system response curve for each CCD image.

2. We currently do not have DECal response curves, but, until we do, we could conceivably use the “b”-term coefficients in the DESDM psfmit table as a proxy for building up the infrastructure for these two new DESDM modules.

3. The DES Calibrations Scientist’s time is already overcommitted with PreCam, updates to the Photometric Standards Module and Global Calibrations Module (especially with regards to Star Flats), etc.
    1. Additional help is needed.
    2. Bob Nichol, during his plenary talk at Portsmouth, offered SNWG help for calibrations… and accurate system response curves are critical for the very stringent absolute color and flux calibrations requirements for the DES SNIa science…

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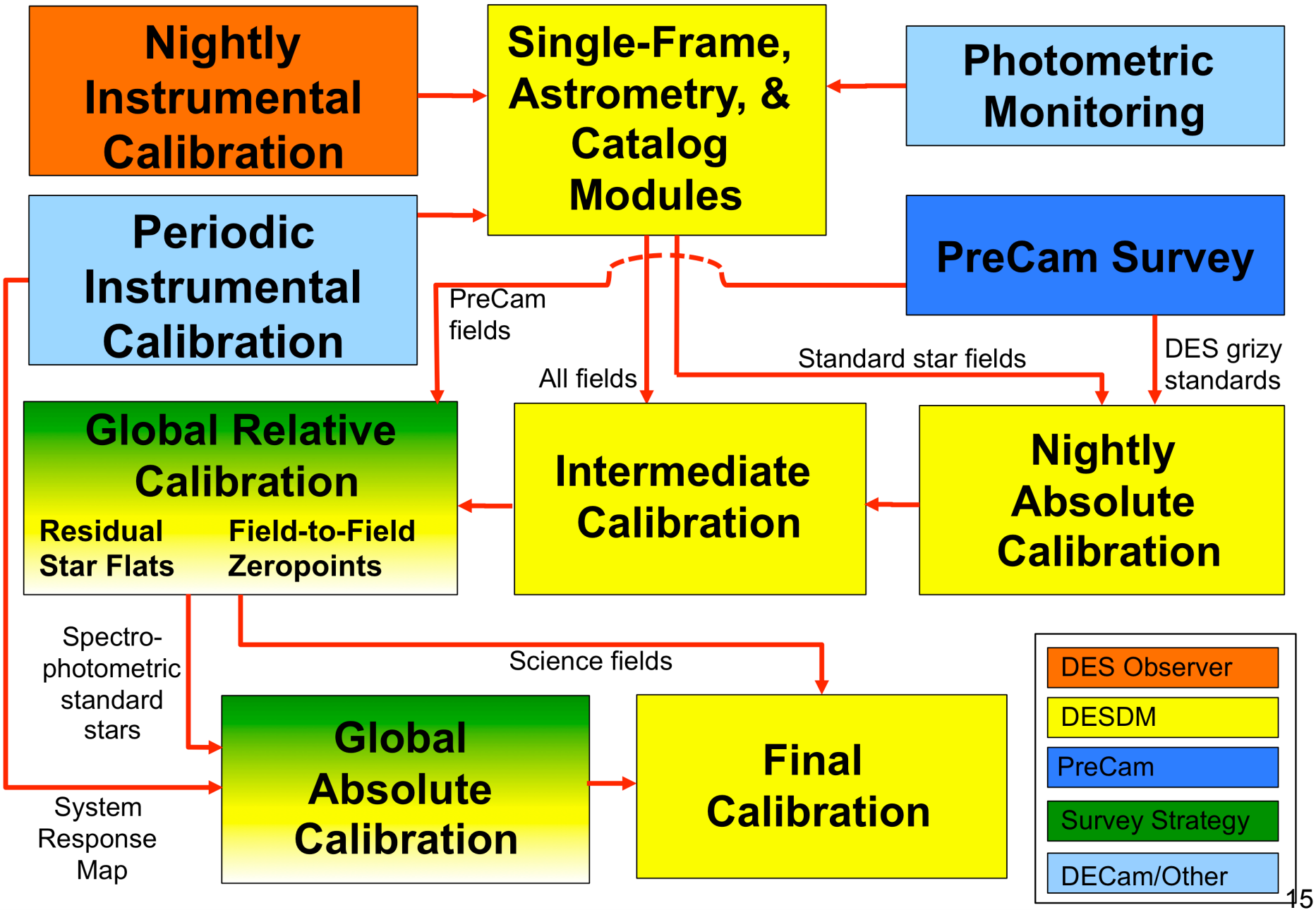
Extra Slides

DES Photometric Calibrations Flow Diagram (v4.1)



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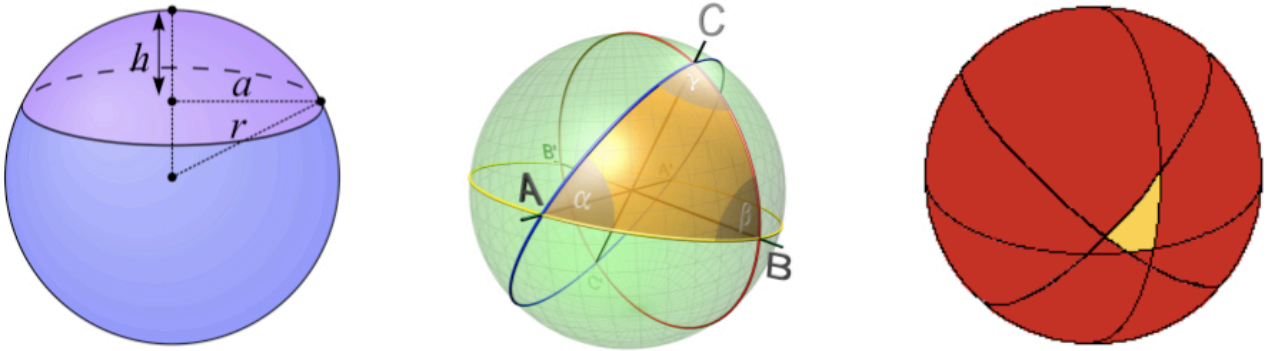
Mangle Masks

(Credit: Molly Swanson, DES-doc#5651)

What is mangle?

- Mangle software manages "masks": piecewise-constant functions on a sphere (magnitude limit, completeness, etc.)
- Elements of mask are "polygons": intersection of spherical caps



- CCD rectangles=intersection of 4 great-circle caps
- Mangle tasks:
  - Split polygons into non-overlapping regions
  - Given an (RA, dec), output what polygons it is in
  - Make random samples with varying weight in each region
  - Convert polygons to HEALPix format
  - And more!

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Mangle Masks

(Credit: Molly Swanson, DES-doc#5651)

Mangle masks in DES

Purpose:

- Provide catalog-level information on survey depth and other parameters as a function of sky position
- Will be used in conjunction with the object catalog

Steps to create magnitude limit mask:

1. Get **CCDgons**, weights, zeropoints from DESDM
2. Use mangle to resolve **CCDgons** into **molygons**
3. Calculate coadd weight by adding overlapping weights
4. Cut out star holes using **stargons** to make **holymolygons**
5. Cut off $\sim 1'$ edges of each tile mask using **tolygons**
6. Combine tile masks into mask for full sample
7. Calculate magnitude limit from weight

Mangle Masks

(Credit: Molly Swanson, DES-doc#5651)

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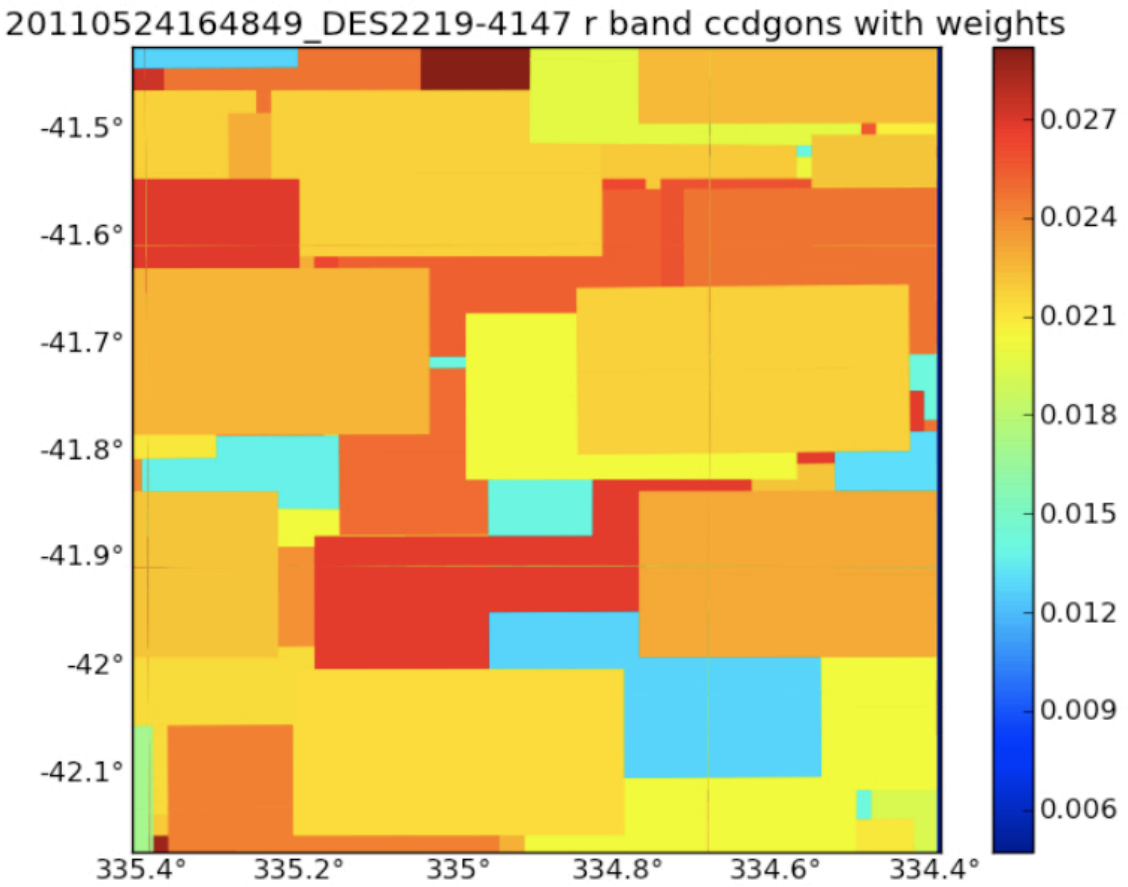
Overlapping CCD footprints: CCDGONS



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Mangle Masks

(Credit: Molly Swanson, DES-doc#5651)

Resolve into non-overlapping MOLYGONS