32 - DES Produtos Primários

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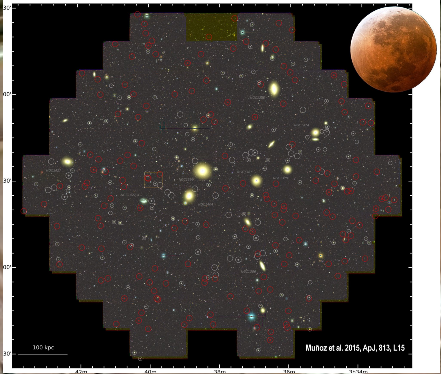
DES 101
[Basic info about DES]

DES in numbers



Victor Blanco 4m telescope at CTIO

DECam 520Mpixels and 3 sq deg

g, r, i, z, Y filters

5 000 square degrees

DECam - CTIO 525 nights

27 sq degrees (10 DECam fields) in griz fields with high cadencee

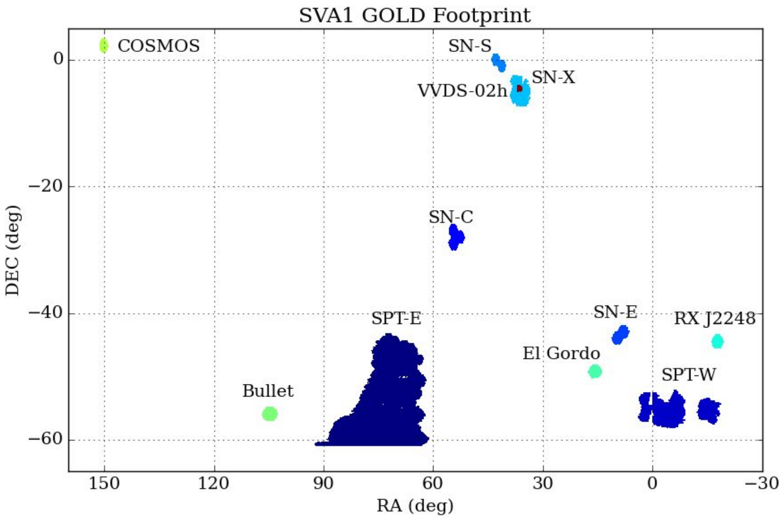
DES: years and epochs

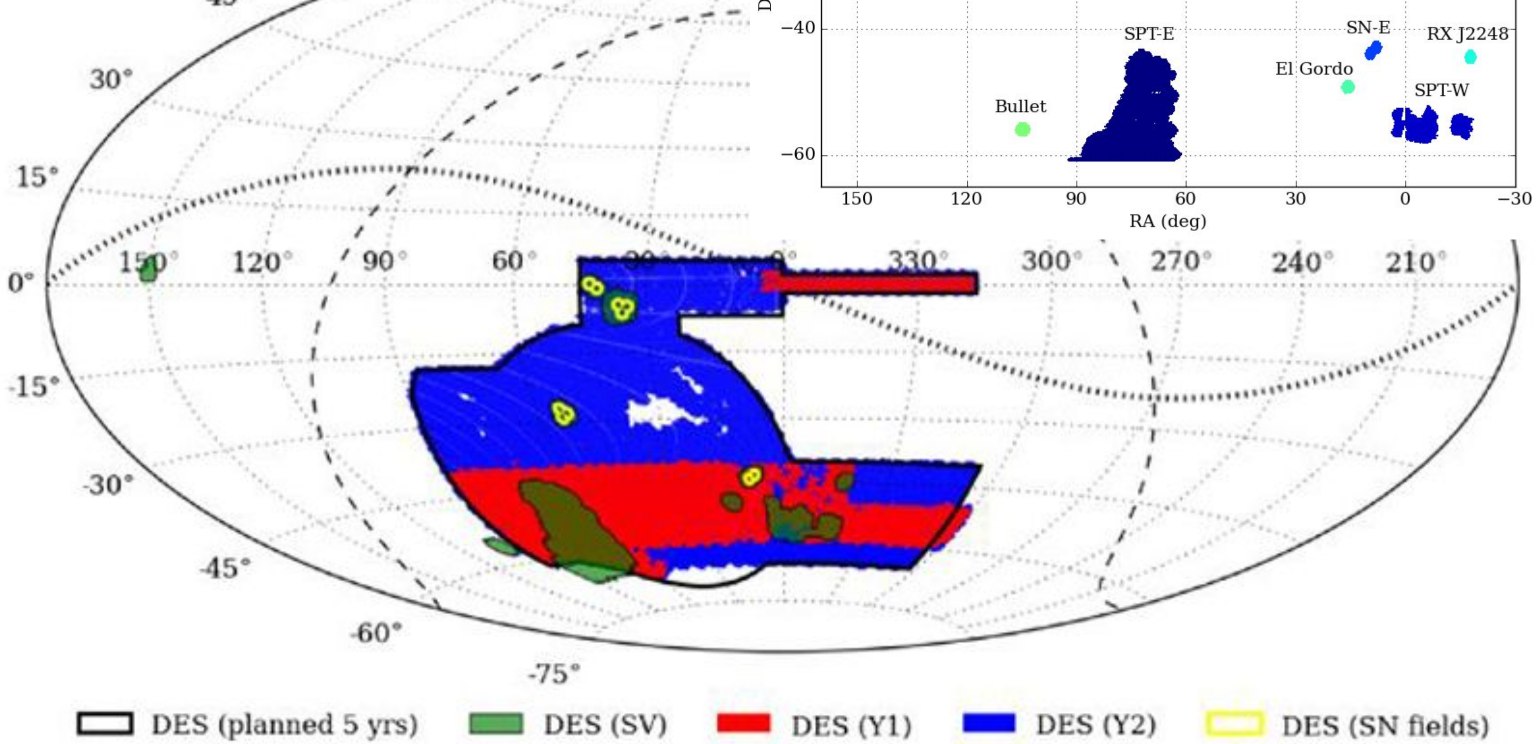
A List of Epoch Names, Begin Dates, and End Dates

Epoch Name	Begin Date	End Date
SVE1	2012 Nov 09	2013 Feb 22
Y1E1	2013 Aug 15	2013 Nov 28
Y1E2	2013 Nov 30	2014 Feb 12
Y2E1	2014 Aug 06	2014 Nov 30
Y2E2	2014 Dec 04	2015 May 18
Y3E1	2015 Jul 31	2016 Feb 23
Y4E1	2016 Aug 13	2016 Dec 31
Y4E2	2017 Jan 01	2017 Feb 18
Y5E1	2017 Aug 15	2017 Sep 04
Y5E2	2017 Sep 04	...

Note. Date are in year month day format. The epochs are named for the survey year in which they were taken (with science verification data Called SV) and then the epoch number within that year. So Y4E2 is the second epoch from the fourth year of the survey.

DES (main) releases





https://physics.aps.org/articles/v12/48

DES Y3

DES Y3A2 *(release: 12 Jun 2017)*

https://cdcvs.fnal.gov/redmine/projects/des-y3/wiki

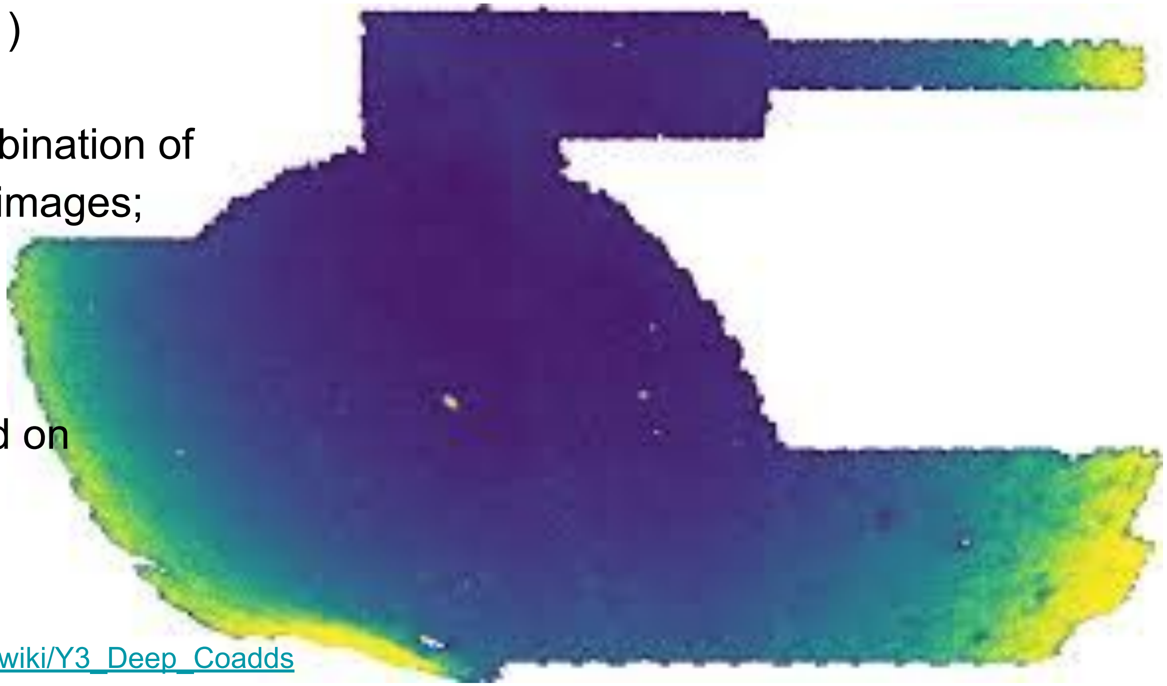
Morganson et al. 2018 describes pipeline for Y1A1 -> Y3 (including DES-DR1)

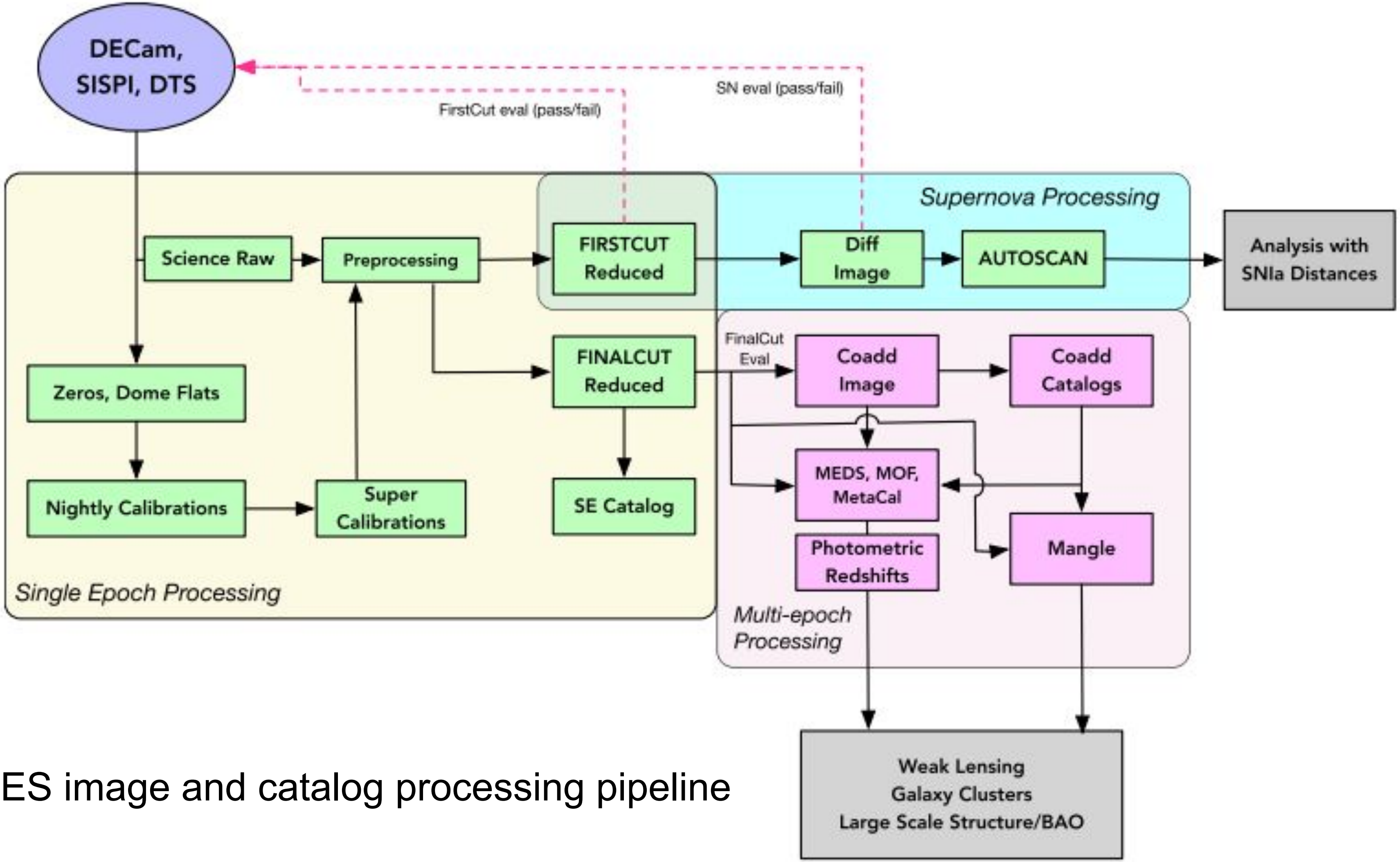
[Y2Q1 catalog level coadd] combination of SExtractor photometry over SE images;

Full DES footprint;

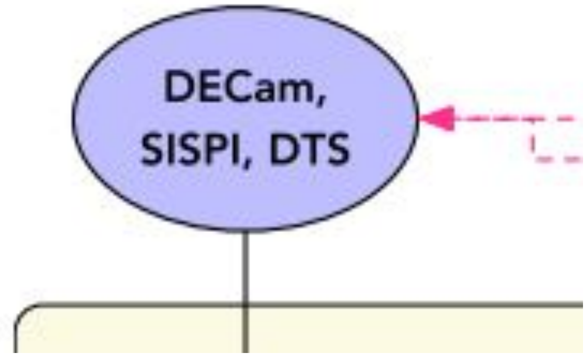
Improvements: MOF/SOF based on detections on the co-add tiles;

Y3 Deep field coadds:
https://cdcvs.fnal.gov/redmine/projects/des-y3/wiki/Y3_Deep_Coadds





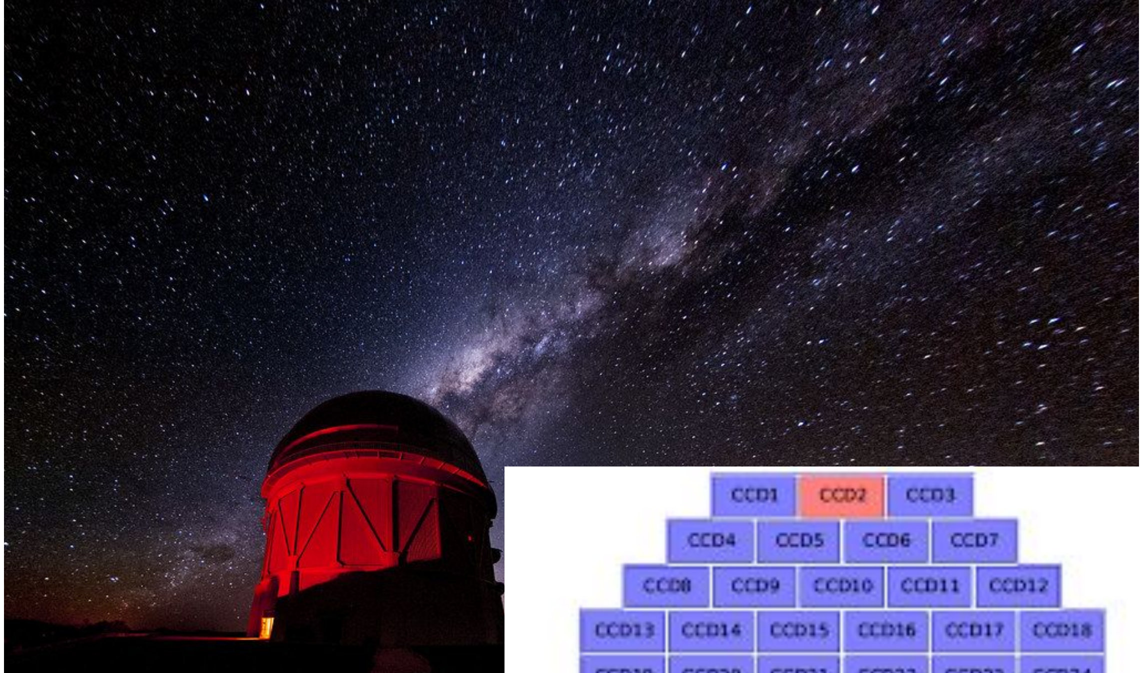
DES image and catalog processing pipeline

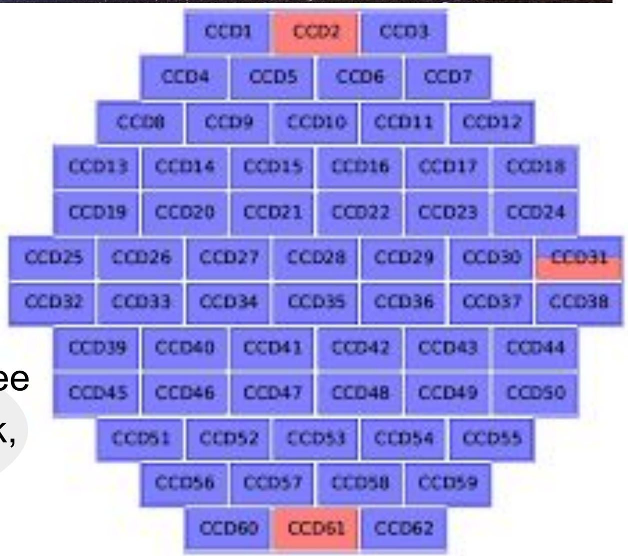


What are the DECam images?

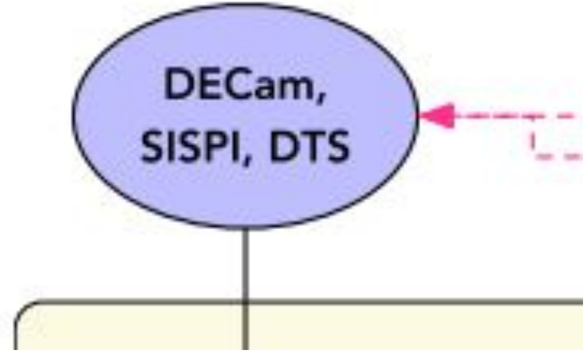
Raw images in grizY (science)
Dome flat (calibration)
Bias or zero (calibration)

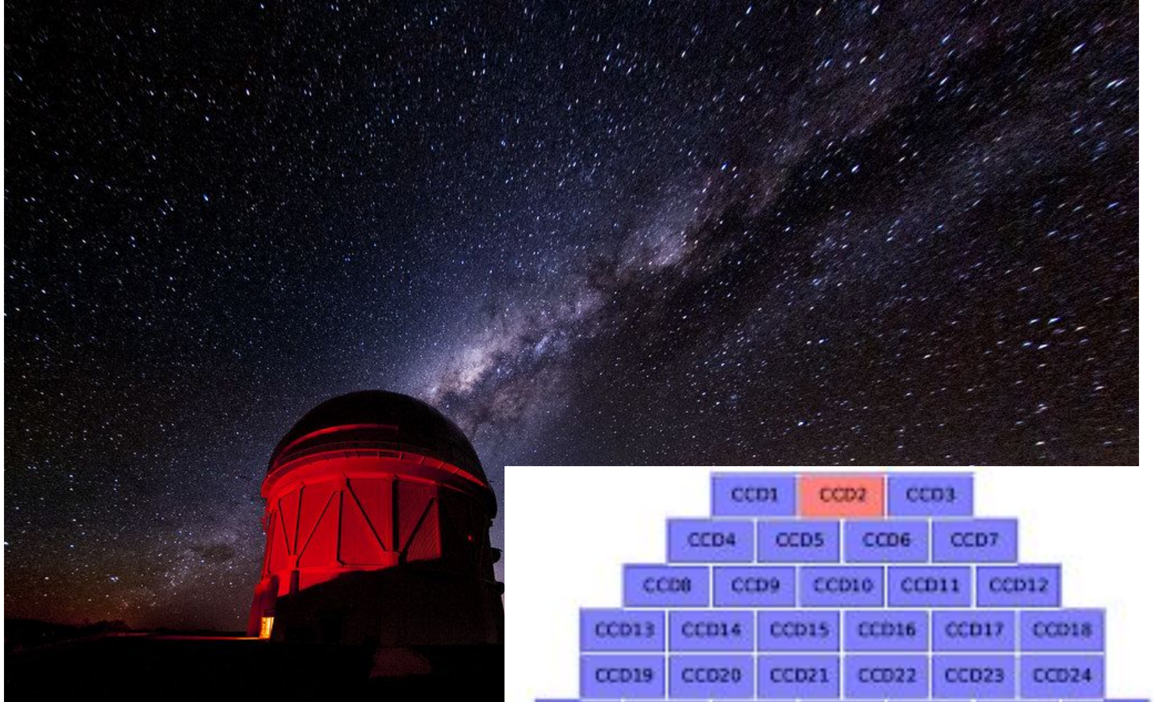
After each observation, the Survey Image System Process Integration (SISPI; Honscheid et al. 2012) transfers the raw exposures to the NOAO via the Data Transport System (DTS; Fitzpatrick 2010) for archiving.

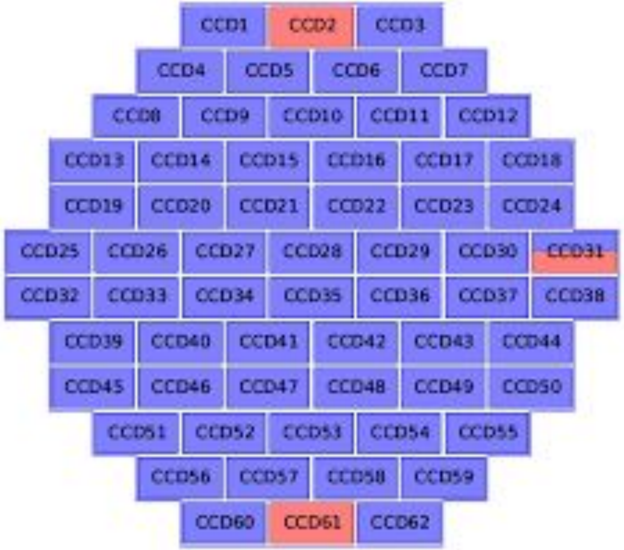




Each CCD image consists of a three layer FITS file including flux, mask, and weight HDUs.







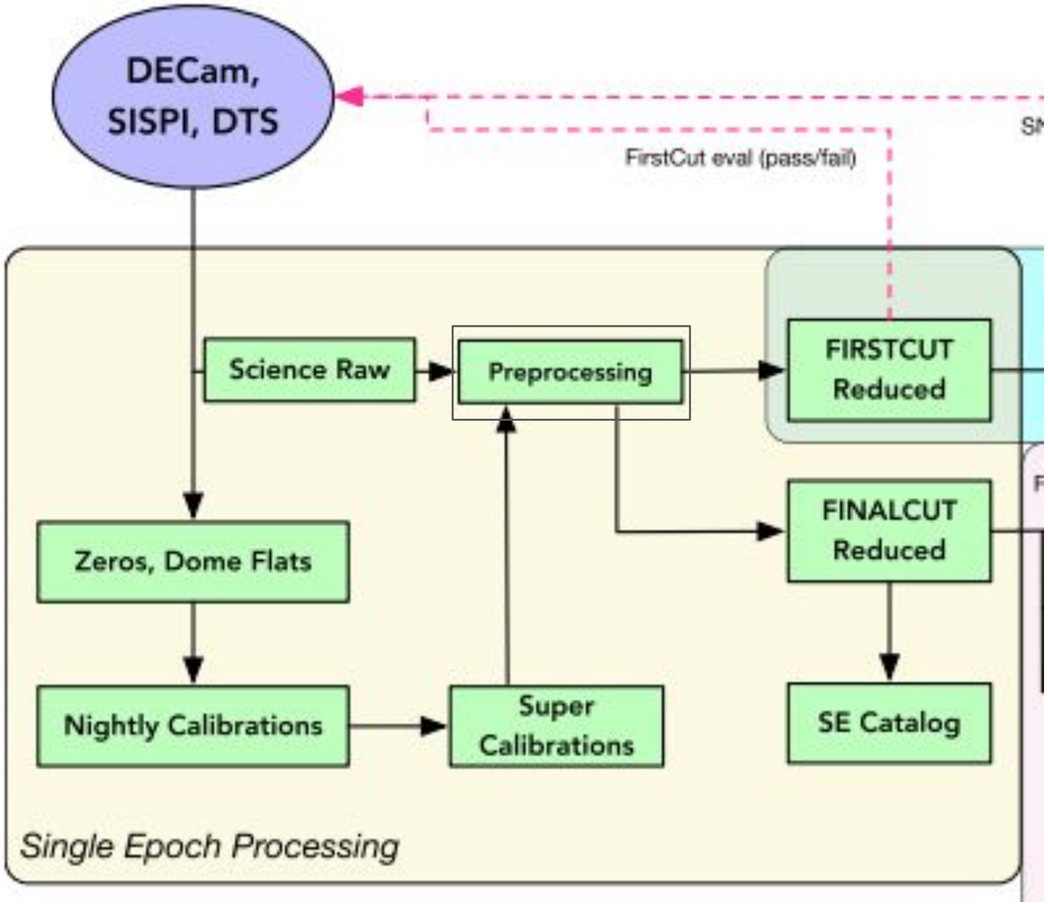
Where are the DECam images?

Publicly available at
archive.noao.edu

Y3A2 tiles using DES-easyaccess:

Tiles for Y3A2 via easyaccess: (example:
> easyaccess -c select TILENAME from Y3A2_COADDTILE_GEOM [where ABS(RA_CENT - 1) < 0.1 AND ABS(DEC_CENT - 1 < 0.1];> out_list.tab

Info about coadded tile images:
> easyaccess -c select PATH, FILENAME, COMPRESSION from Y3A2_FILE_ARCHIVE_INFO;> info.tab"



DES-specific tool, PIXCORRECT (next slide) applies the following operations:

1. Subtract a bias image.
2. Apply a nonlinearity correction.
3. Mask saturated pixels.
4. Apply a bit mask to the science image.
5. Correct bit mask columns where appropriate.
6. Apply a gain corrections.
7. Apply a brighter-fatter correction.
8. Divide by the dome flat.

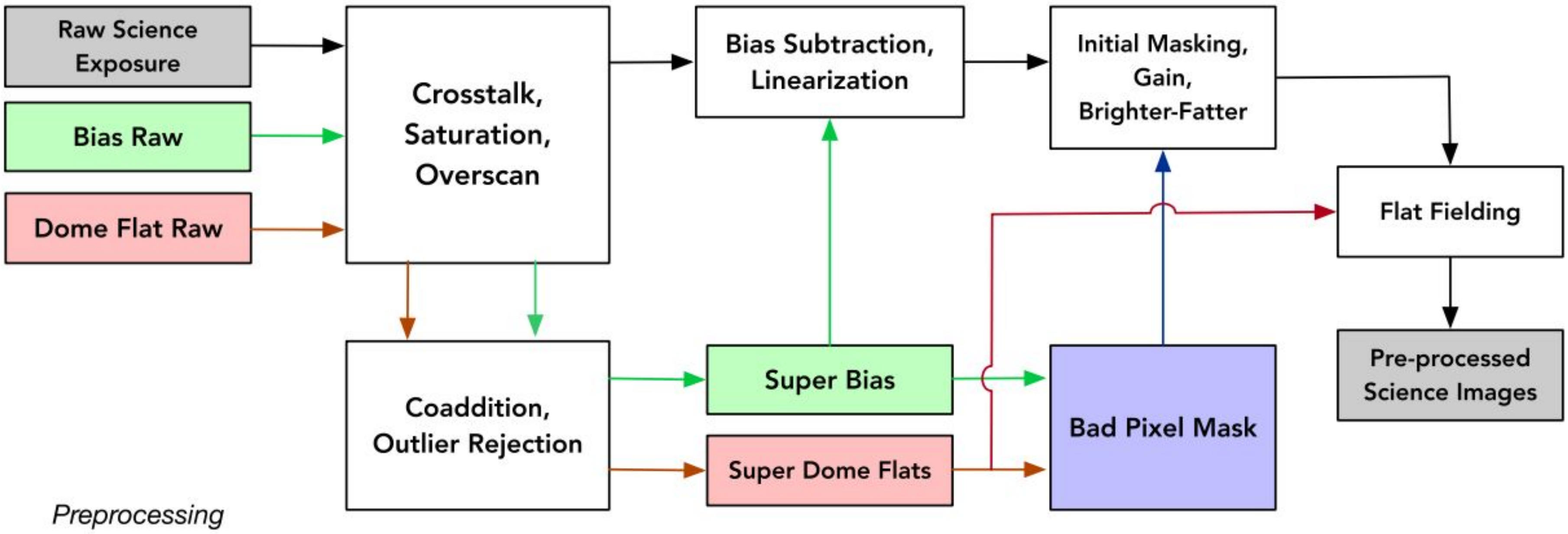
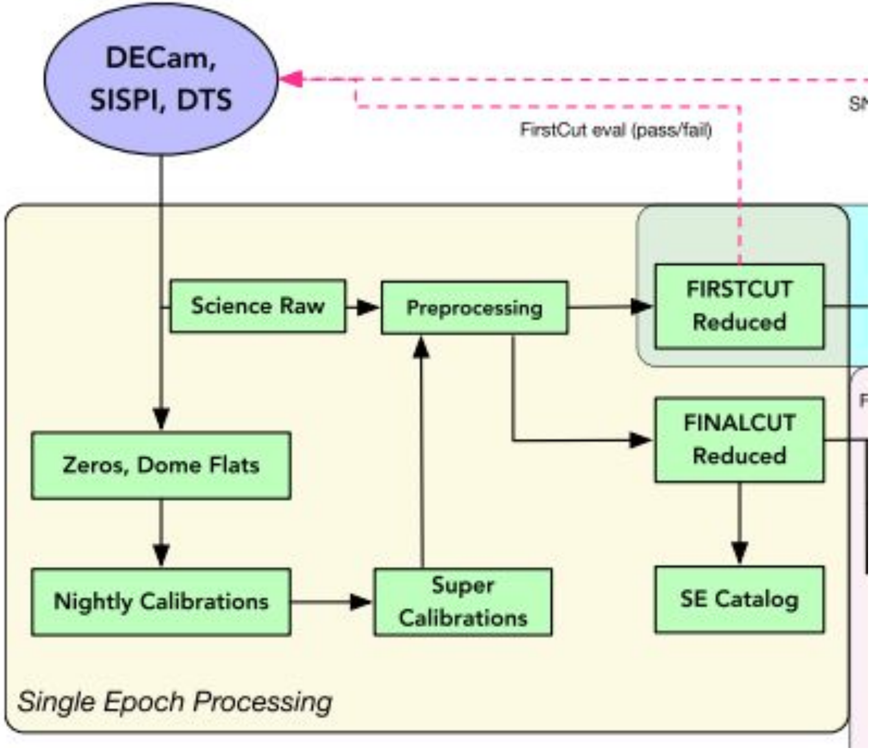


Figure 5. Diagram of the Preprocessing applied to every exposure. This is a "zoom in" of the the Preprocessing box in Figure 3. This includes our initial masking and detrending with bias and flat images (green and red arrows, respectively). Preprocessed exposures are then processed with the First Cut or Final Cut pipeline. (A color version of this figure is available in the online journal.)



First Cut: process all DES exposures within a few hours of acquisition so that they can be evaluated for depth and image quality.

Final Cut vs. First Cut: [hours/months later,] Improved version of the pipeline, nightly/super calibration images+FGCM.

The basic outline of the First Cut pipeline is

1. calculate initial astrometry solution (Sextractor and SCamp);
2. mask saturated pixels and associated bleed trails;
3. fit and subtract sky background;
4. divide out star flat (a modified template from dome flats to astronomical images);
5. mask cosmic rays and satellites;
6. model the point-spread function (PSF);
7. produce single-epoch catalogs;
8. evaluate image data quality.

The weight plane layer is initially set to the inverse variance weight calculated from the sum of the variance in the number of photoelectrons in each pixel and the variance of the readout noise. This weight is used in initial masking and to fit the sky background. After fitting the sky background, the weight layer of each image is replaced by the inverse variance of the best-fit sky model in photoelectrons.

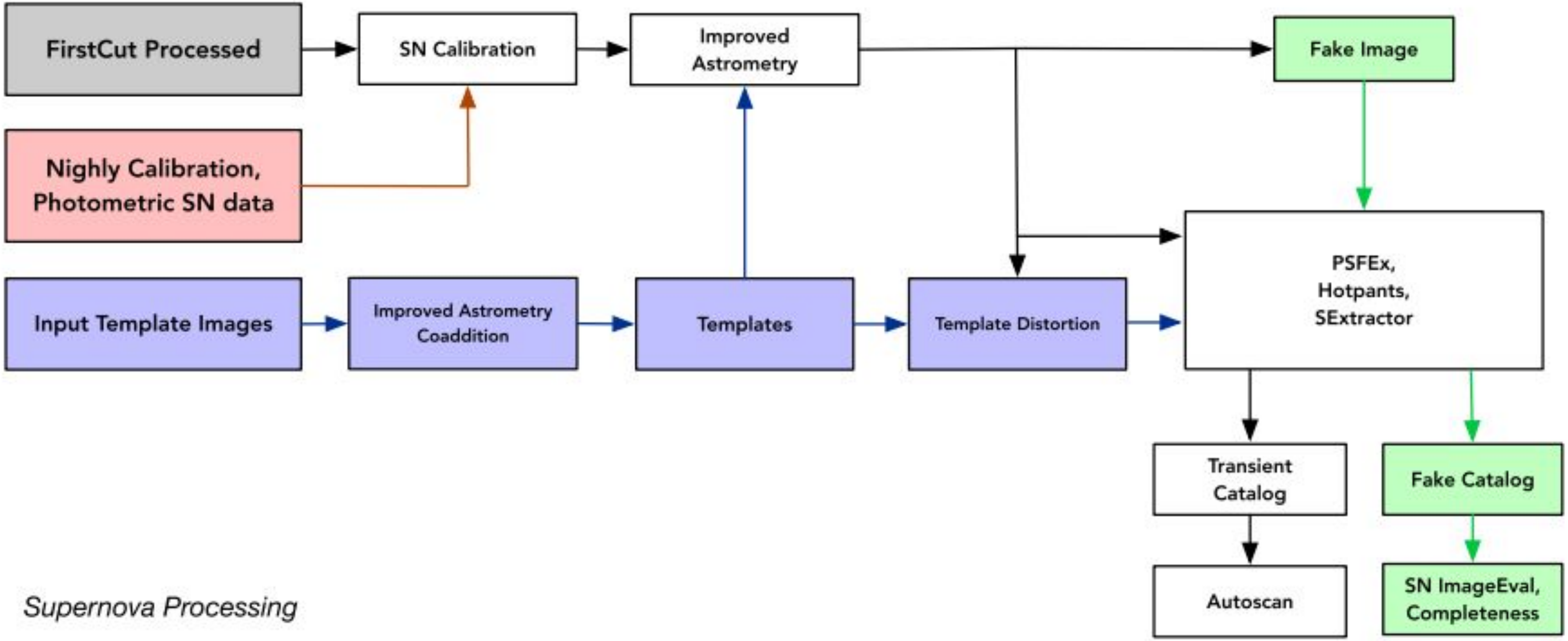
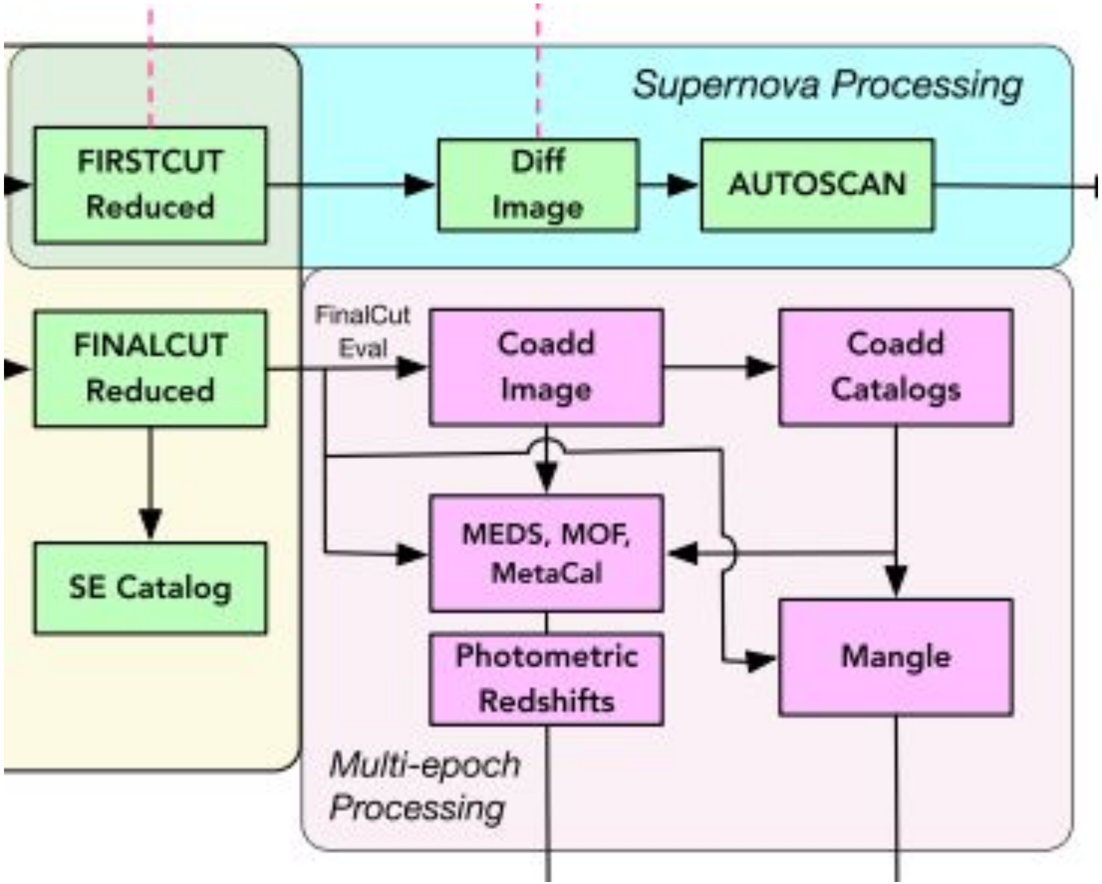


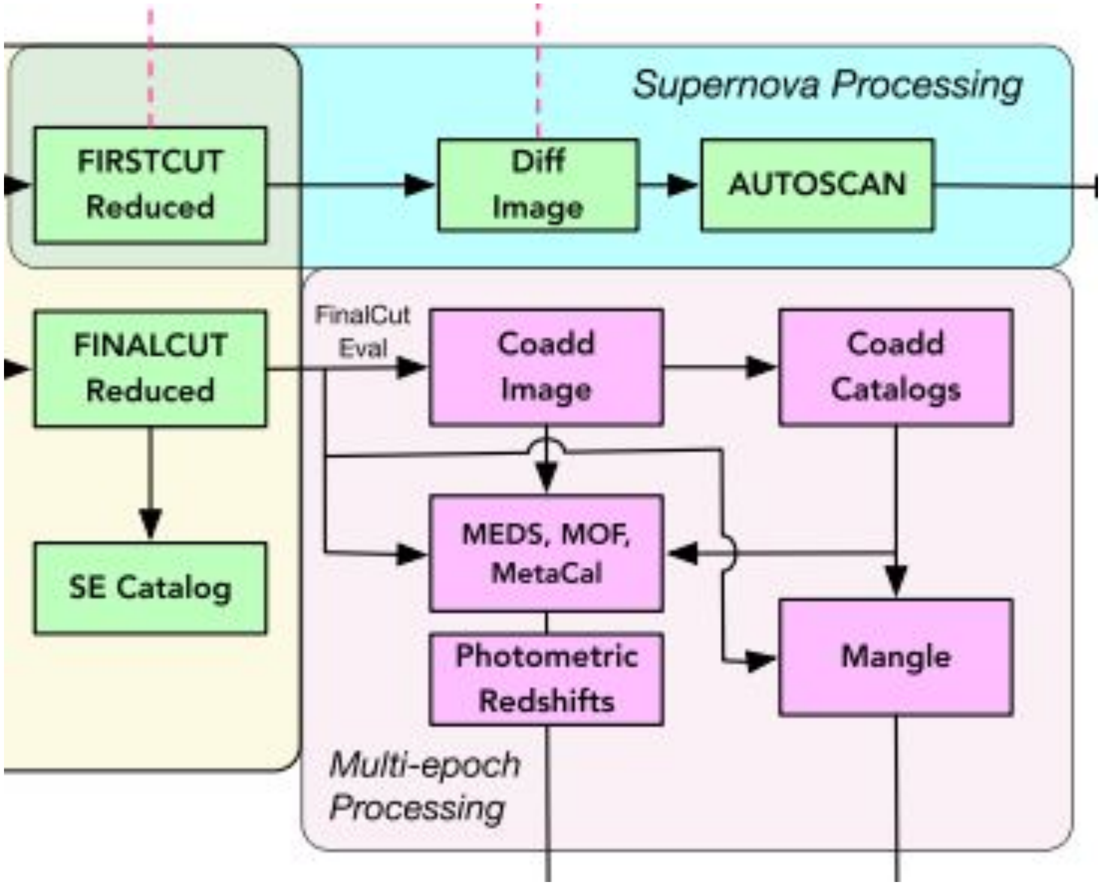
Figure 7. Diagram of the difference image processing used to detect supernovae and other transient in the DES supernova fields. (A color version of this figure is available in the online journal.)



Scientific Analysis

Coadd tiles

We do not repeat the masking, calibration or other image processing. We first divide the sky into “coadd tiles” and work with all acceptable exposures within each tile. We optimize the coadds by refining the astrometry (comparing to 2MASS stars). We then resample the individual exposures, assemble the coadded images, model the coadded PSF and finally create output catalogs.



Coadd catalogs

- Coadded images produced using SEXTRACTOR;

- *riz* detection image to find and localize sources (S/N>10)

- SEXTRACTOR (dual image mode): *r+i+z* detection image to define position and the single-band images to obtain photometry.

- DES Y1+Y2+Y3 are comprised of ~400M objects.

- These catalogs comprise our primary object tables, and we add a series of useful quantities to the objects within them.

Mangle masks

During co-add production, mangle masks were created at the level of co-add tiles;

1. Polygons are created with 4 corners of each CCD image and assigned a weight equal to the median value of pixels in the CCD weight plane;
2. Satellite streaks are represented by polygons, and the area of these polygons is removed from the single epoch CCD polygon.
3. Polygons were trimmed to fit the tile boundaries.
4. Polygons were subdivided into disjoint regions with the balkanize command.
5. Regions around bright stars and bleed trails are removed from the mangle mask on the coadded images.
6. The mangle co-add weight map is converted into a 10σ limiting magnitude map for a 2″ diameter aperture*

$$m_{\rm lim} = m_{\rm ZP} - 2.5\log\left(10\sqrt{\pi\frac{(D/2)^2}{\omega_{\rm pix}^2}\frac{1}{w_{\rm tot}}}\right),$$

where m_{ZP} = 30 is the tile zero-point, D = 2″, ωpix = 0.263 is the pixel size, and w_{tot} is the total weight of the polygon. This definition of the magnitude limit corresponds to the MAG_APER_4 quantity measured by SExtractor.

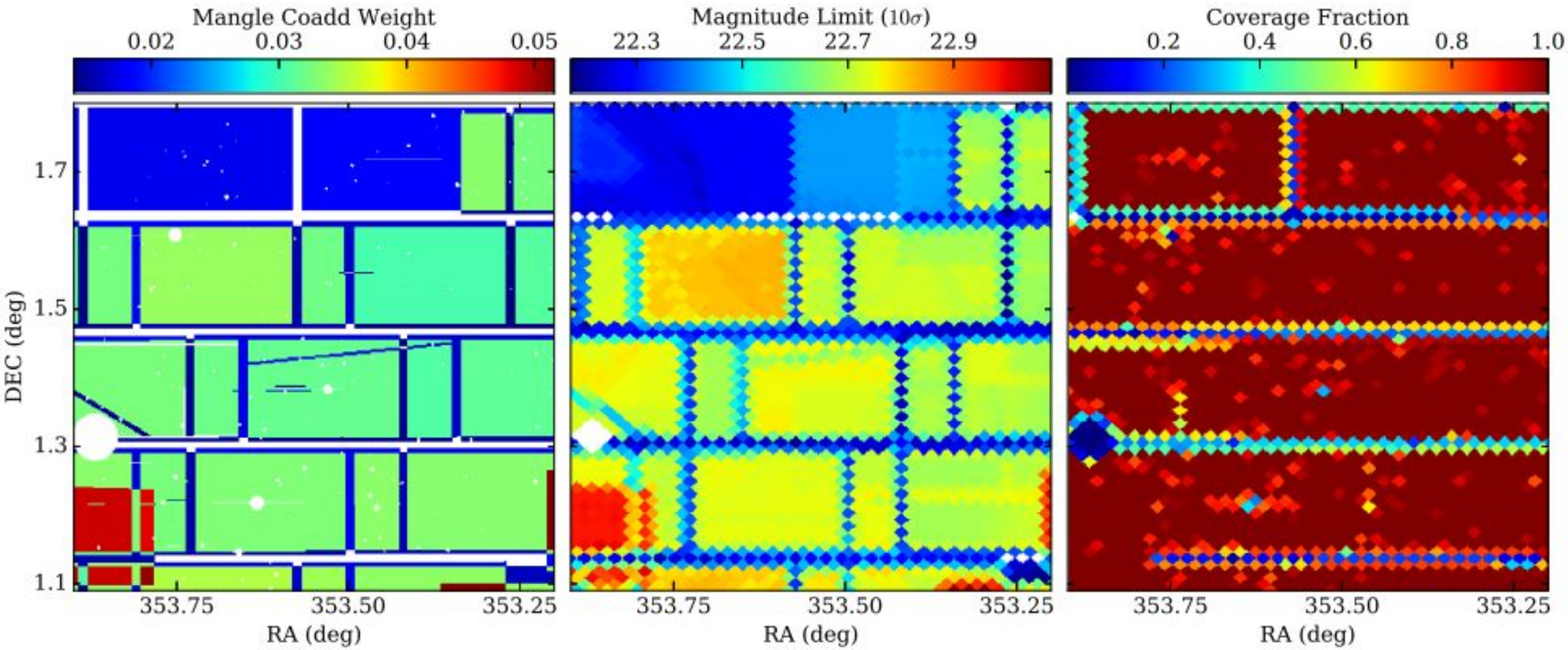


Figure 9. Coverage and depth maps for a single Y1A1 co-add tile. Left: vectorized `mangle` weight map for an *r*-band co-add tile. Satellite trails, star masks, and chip gaps are stored at full resolution. Middle: pixelized 10σ limiting magnitude map for galaxies using `HEALPix` at `nside` = 4096. Right: pixelized map of the coverage fraction at `HEALPix` `nside` = 4096. This tile is located on the border of the Y1A1 footprint and has been chosen for illustrative purposes owing to its variable depth and incomplete coverage.

Depth map for galaxies (Y1)

- Described in Rykoff et al. (2015);
- Galaxies are selected using the MODEST_CLASS SG classifier and trained a random forest model to predict the 10σ limiting magnitude as a function of observing conditions (PSF FWHM, sky brightness, airmass, and exposure time for each band);
- The training was performed on coarse HEALPix pixels (nside = 1024, 3’ each side, with > 100 galaxies). Once trained, the model was applied to the pixels at the full mask resolution of nside = 4096. The magnitude limits are derived for both co-add AUTO magnitudes and MOF.

Depth map (Y1) - example

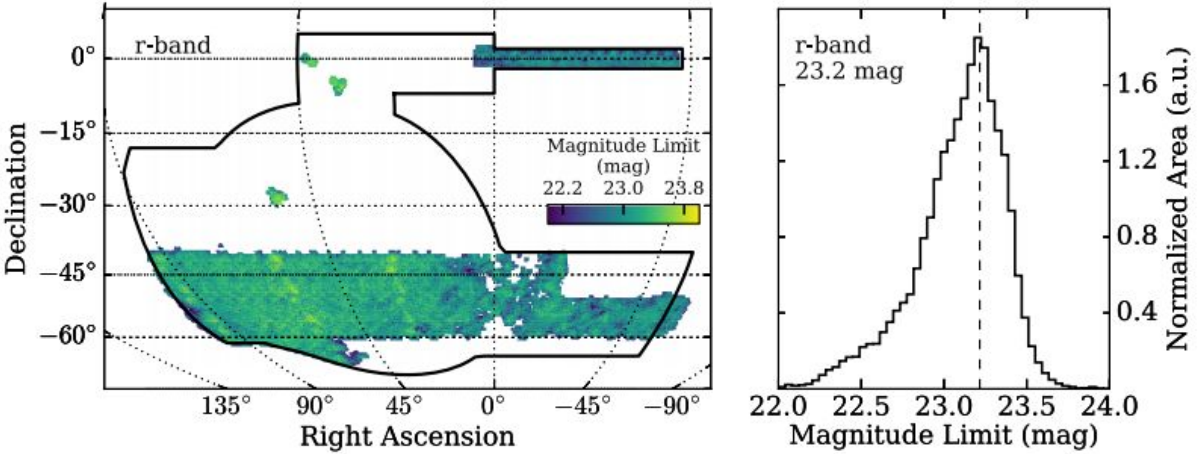


Figure 10. Sky map and normalized histogram for the r-band 10σ limiting magnitude (MAG_AUTO) derived in HEALPix pixels over the Y1A1 GOLD footprint. The mode of the limiting magnitude distribution is shown in the right panel. The derivation of the limiting magnitude is described in Section 7.1. Similar figures for other bands are shown in Appendix C.

Depth maps (Y3)

Version 2.2.1

Mag_auto, MOF and SOF (filtered by MOF_ and SOF_flags)

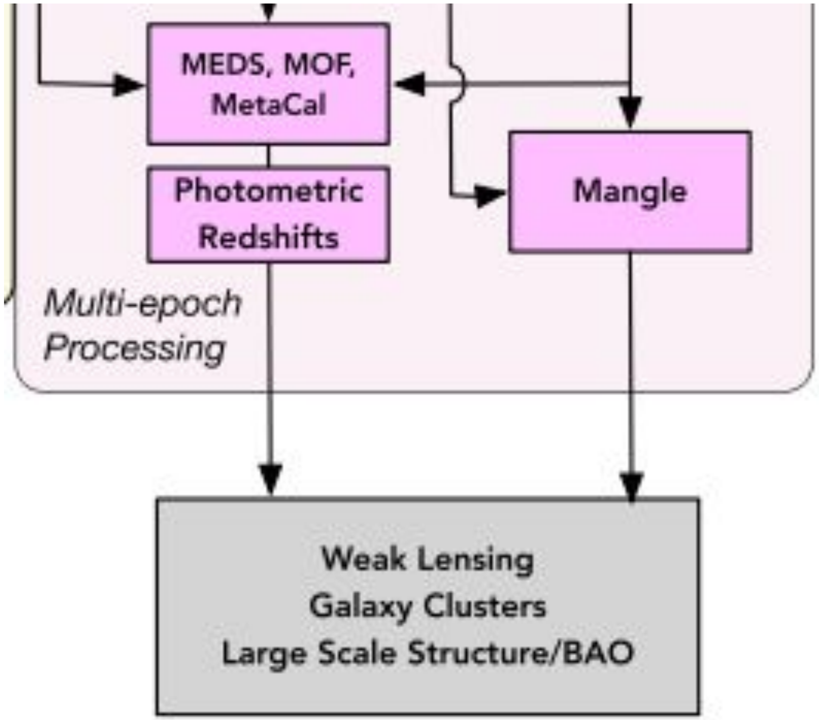
Repository:

https://cdcvs.fnal.gov/redmine/projects/des-sci-release/repository/show/users/erykoff/des_depth

Redmine page:

https://cdcvs.fnal.gov/redmine/projects/des-y3/wiki/Gold_22_AutoMOFSOF_Depth_Maps

Primary Products - (close to) the end



MEDs: Multi-epoch Data Structure (Jarvis et al. 2016) postage stamps of every object;

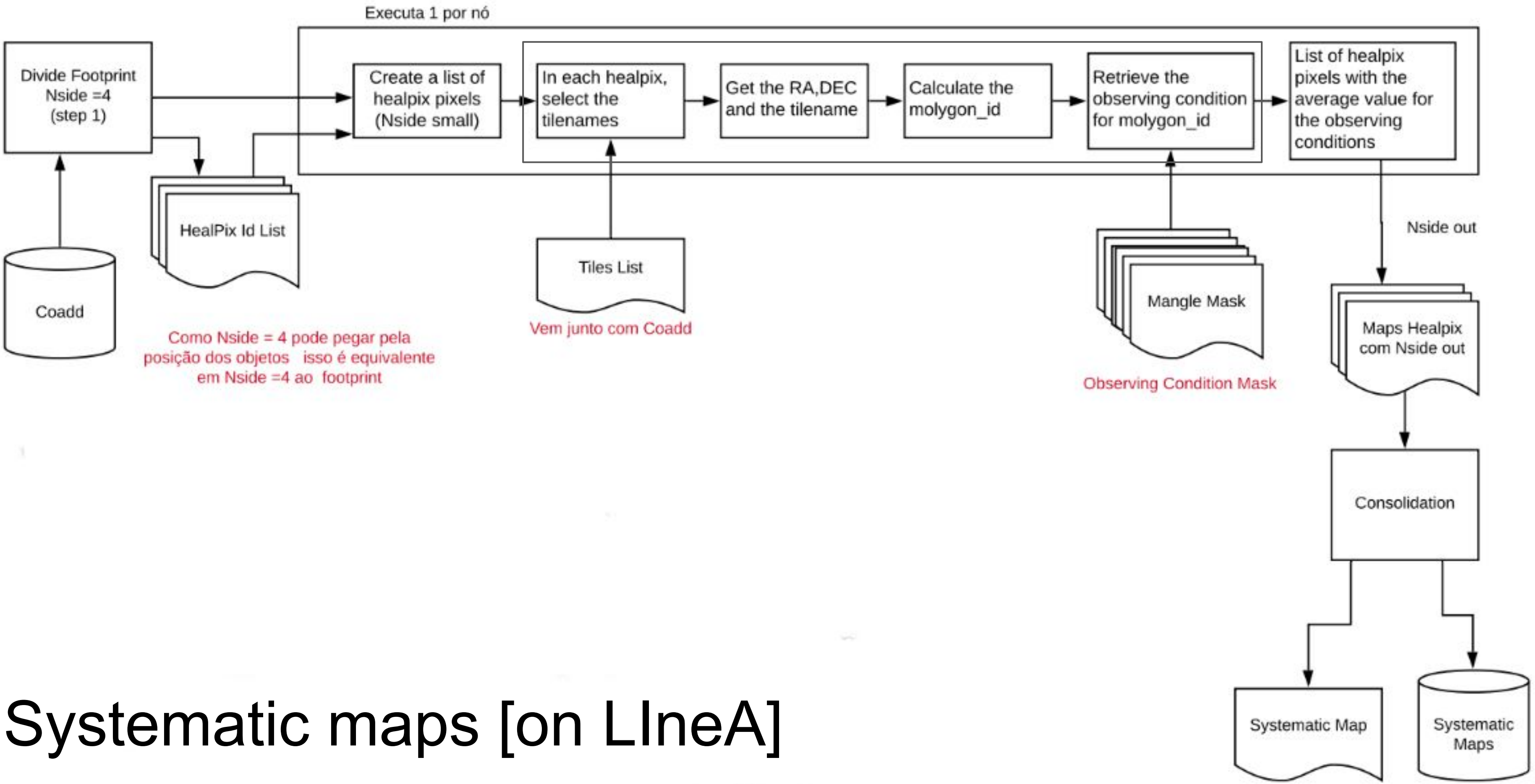
MOF: Improved photometric and morphological measurement with multi-epoch, multi-object fitting (Drlica-Wagner 2018), and Metacalibration (Metacal; Sheldon & Huff 2017), a technique to accurately measure weak gravitational lensing shear.

Systematic maps deal with:

1. EXPTIME SUM
2. TEFF* EXPTIME SUM
3. TEFF* WMEAN
4. TEFF* MIN
5. TEFF* MAX
6. AIRMASS WMEAN
7. AIRMASS MIN
8. AIRMASS MAX
9. FWHM WMEAN
10. FWHM MIN
11. FWHM MAX
12. FWHM FLUXRAD WMEAN
13. FWHM FLUXRAD MIN
14. FWHM FLUXRAD MAX
15. SKY BRIGTHNESS WMEAN

TEFF* (0-1) is the ratio between the actual exposure time and the exposure time necessary to achieve the same signal-to-noise for point sources observed in nominal conditions (best=1).

16. SKYVAR UNCERTAINTY
17. SKYVAR MIN (Y3)
18. SKYVAR MAX (Y3)
19. SKYVAR WMEAN (Y3)
20. SKYVAR SQRT WMEAN (Y3)
21. SKYSIGMA MIN (Y5 or Y6)
22. SKYSIGMA MAX (Y5 or Y6)
23. SKYSIGMA WMEAN (Y5 or Y6)
24. SIGMA MAG ZERO QSUM
25. FGCM GRY WMEAN
26. FGCM GRY MIN
27. N IMAGES (Y3)



Systematic maps [on LIneA]

Systematic maps [on LIneA]

[Info from UM003-2018/Systematic Maps]:

The pipeline works as follows:

1) First the footprint is divided into healpix cells of nside=4 (parallelization) sky_partitioner
2) Create a list of healpix pixels at nside_small = N*nside (where N and nside are `Times the Healpix map for small resolution` and `nside` from the configuration) that resides in the healpix pixel at nside=4 sky_partitioner
3) [In each node] In each healpix pixel at nside=4, select the tilenames that have overlap with the healpix pixel. sky_partitioner
4) [In each node] For each of the small pixels (at nside_small), get the RA,DEC of the center of the pixel and find the tilename where it resides systematic_maps_creator - doL/combL
5) [In each node] Once we know the tilename where it resides, we can calculate the molygon_id associated to the coordinates. systematic_maps_creator - doL/combL
6) [In each node] Retrieve for a given small pixel the observing condition of interest for the given molygon_id systematic_maps_creator - doL/combL
7) [In each node] The huge pixel map is degraded to the final nside selected in the configuration. systematic_maps_creator DESm2h_y3a1.py
8) [In each node] We end with a list of healpix pixels id at nside_out, with the average value for the given observing conditions at the center of the pixel. Ex: nside_tiny= 32768, nside_out=4096 systematic_maps_creator - doL/combL
9) [Consolidation] After completion of the parallel part, one fits file is created per observation condition.
10) [Consolidation] The healpix maps are saved in fits files and ingested into DB
11) [Consolidation] Finally the productlog is produced

Systematic maps - Inputs

(from UM003/2018 with a few changes)

- A mangle polygon file with the shape of DES footprint. It is fixed independent of the list of tiles we give as inputs and should not change as a function or release. It is saved in `/home/carnero/y3_systematics/pol_files/Y3A1_footprint_tolys.pol`. Y6 footprint = Y3 footprint;

- List of tiles that makes the Y3 or Y6 release. It is an ascii file, which at the moment is installed in the directory of `components/systematic_maps_creator/etc`. The list is called `Y3A1_tiles_list_portal.csv`, containing 3 columns: TILENAME, PATH, COADDTILE_ID. The TILENAME is the name of the tile, path is of the form: `TILENAME/csv`, which reads from `/archive/staging/DES/Y3A2_COADD/Y3A2_COADD/masks`. Finally, COADDTILE_ID is an internal DESDM run ID. List of tiles for Y6 available using easyaccess;

- Directories in `/archive/staging/DES/Y3A2_COADD/Y3A2_COADD/masks/TILENAME/` containing 6 directories: `csv, g, r, i, z, Y`. The csv directory contains fundamental quantities for the tile. The ones that we actually use, are the directories g,r,i,z,Y. In each directory, there are some files that are important for the systematic pipeline:
    - *.fits: any fits file containing a list of molygon_ID with some observing conditions.
    - *_bleedmask.pol containing information about bleed trails and cosmic rays.
    - *_maglims.pol containing the depth at 10sigma for an aperture of 2”.
    - *_starmask.pol: containing the bright star mask.
    - Y6: All of the files above are (or will be) stored at https://desar2.cosmology.illinois.edu/DESFiles/

Y3 Gold 2.2

Link: https://cdcvs.fnal.gov/redmine/projects/des-y3/wiki/Y3_Gold_release

The GOLD catalog is intended to be the basis for cosmology analyses with the Dark Energy Survey data.

The GOLD catalog consists of a validated object catalog with a set of quality control flags and additional auxiliary data. The **current GOLD catalog (v2.2)** is a new table with a subset of columns:

- **Y3A2_COADD_OBJECT_SUMMARY**
- **Y3A2_MOF**
- **Y3A2_SOF**
- **Y3_GOLDVAC_2_2**

History:

- 14 May 2018: **v2.2, current version**, available as `Y3_GOLD_2_2` in the dessci database. Fixes small z-band calibration offsets, BPZ performance and a few minor issues.
- 18 January 2018: v2.0, available as `Y3_GOLD_2_0` in the dessci database.
- 14 August 2017: v1.0, available as `Y3_GOLD_1_0`. An overview of Y3 GOLD v1.0 was presented at the DES collaboration-wide telecon on 14 August 2017. Y3 GOLD v1.0 was a materialized view of `Y3A2_COADD_OBJECT_SUMMARY`, `Y3A2_MOF` (an earlier version), and `Y3_GOLDVAC_1_0`.

Y3 Gold v2.2

- Y3 Gold contains every unique coadd object from Y3A2_COADD_OBJECT_SUMMARY.

  (1): FLAGS_FOOTPRINT = 1 and FLAGS_FOREGROUND = 0 and bitand(FLAGS_GOLD, 120) = 0 and bitand(FLAGS_BADREGIONS,1) = 0; (120 = sum of bits 8+16+32+64)

  (2): FLAGS_FOOTPRINT = 1 and FLAGS_FOREGROUND = 0 and bitand(FLAGS_GOLD, 121) = 0 and bitand(FLAGS_BADREGIONS,2) = 0; (121 = sum of bits 1+8+16+32+64)

  (3): FLAGS_FOOTPRINT = 1 and FLAGS_FOREGROUND = 0 and bitand(FLAGS_GOLD, 122) = 0 and EXTENDED_CLASS_MASH_SOF = 3; (122 = sum of bits 2+8+16+32+64)

  (4): FLAGS_FOOTPRINT = 1 and FLAGS_FOREGROUND = 0 and bitand(FLAGS_GOLD, 124) = 0 and EXTENDED_CLASS_MASH_SOF = 0; (124 = sum of bits 4+8+16+32+64)

Selection	Number of objects
All coadd objects	399263026
And FLAGS_FOOTPRINT = 1	388181028
And FLAGS_FOREGROUND = 0	338713572
Good for SExtractor based analysis(1)	333246422
Good for MOF analysis(2)	326049983
Good for pure galaxy SOF analysis(3)	226581329
Good for pure star SOF analysis(4)	37266079

Y3 Gold v2.2 - Star/galaxy separation

The set of EXTENDED classifiers:

- 0 (high confidence stars), 1 (candidate stars), 2 (mostly galaxies), 3 (high confidence galaxies), and -9 (no data)
- If you are using **SExtractor** quantities, use either EXTENDED_CLASS_COADD or EXTENDED_CLASS_WAVG
- If you are using **MOF** quantities, use EXTENDED_CLASS_MASH_MOF (defaults to SOF or SExtractor if MOF unavailable) or EXTENDED_CLASS_MOF
- If you are using **SOF** quantities, use EXTENDED_CLASS_MASH_SOF (defaults to SExtractor if SOF unavailable) or EXTENDED_CLASS_SOF

Procedure for new columns

1. Create in your database schema a table with the format COADD_OBJECT_ID, RA, DEC, TILENAME, [new columns]. The table can be created as an ASCII or FITS file locally in your computer and uploaded via easyaccess (example, link) or sqlloader.

2. Create a wiki page with documentation and any validation tests hanging from the Y3 Gold release page. An example is the current photo-z catalog.

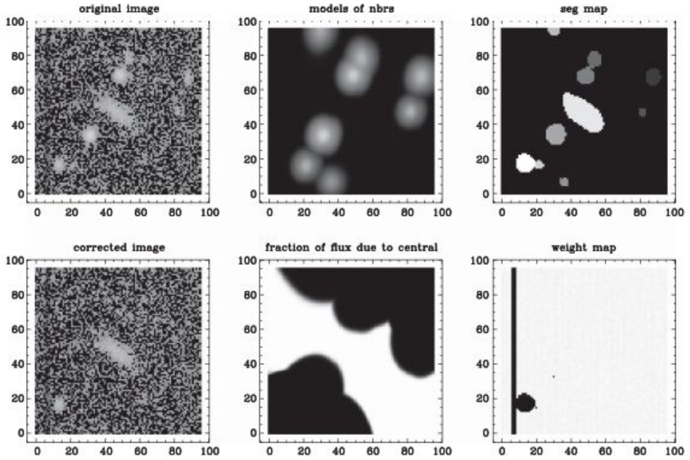
3. Contact the Science Release leads to discuss and announce your new table, to eventually incorporate it to GOLD if appropriate.

Y3 Gold v2.2 - MOF and SOF

MOF - Multi-epoch, multi-object fit -- our very best (in principle), deepest magnitude(s) for galaxies and stars

SOF - Multi-epoch, single-object fit -- masking, but no subtraction of neighbors when assigning flux -- faster, more robust version of MOF

Firstly, the group of objects is identified using FoF algorithm/ initial model to each member, masking the light of neighbors → Bright of the objects is fit in *griz* bands and measured with a disk (exp) and bulge (deV) model, subtracting the light of the neighbors → Repeated until convergence (max=15) → Serve as input for new fittings (common center, ell, overall scale and fluxes to each band) using deV profile



Y3 Gold v2.2 - S/G

- CLASS_STAR
- SEXTRACTOR
- MODEST_CLASS
- EXTENDED_CLASS_COADD - Using the spread_model quantity from Sextractor photometry
- EXTENDED_CLASS_MOF - Using size parameter from MOF photometry
- EXTENDED_CLASS_WAVG - Using the spread_model property from WAVG photometry
- EXTENDED_CLASS_MASH - Using MOF else WAVG else COADD
-

- 0: high confidence stars;
- 1: candidate stars;
- 2: mostly galaxies;
- 3: high confidence galaxies;
- -9: No data;

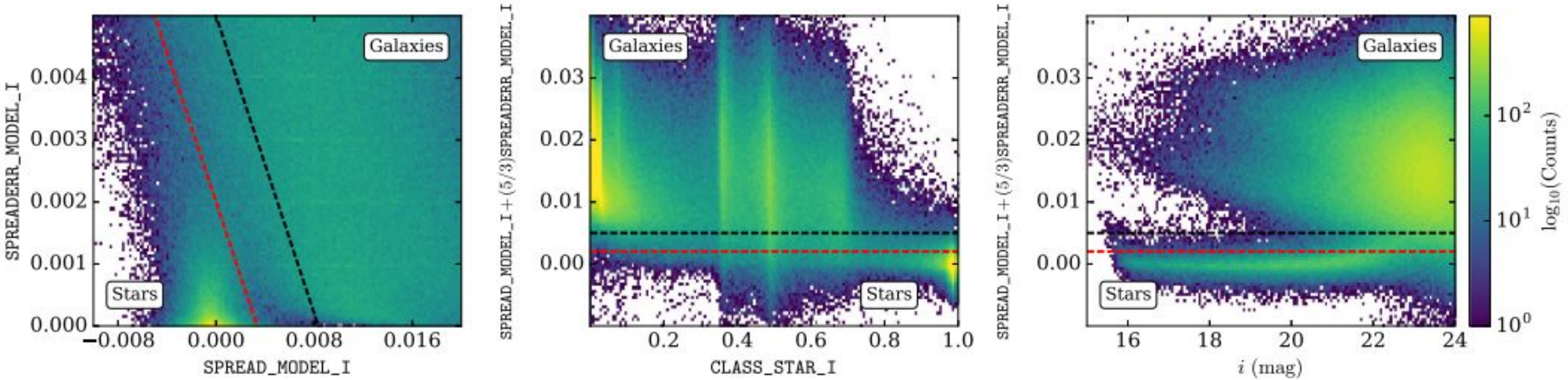
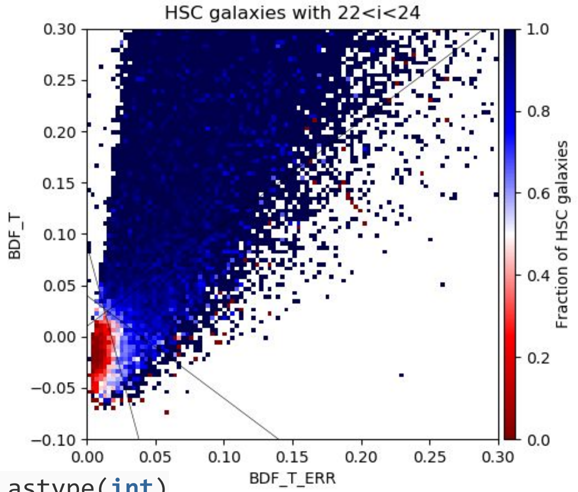


Figure 12. MODEST_CLASS star–galaxy selection for objects in a ~13 deg^2 region centered on $\alpha_{2000}, \delta_{2000} = (51°, -45°)$. The left panel shows the distribution of spread_model_i and its error. The middle panel compares the distribution of the SExtractor neural-network classifier, class_star, with the MODEST_CLASS selection criteria. The right panel shows a tight stellar locus in the i-band magnitude compared against the MODEST_CLASS criteria. In all panels the black (red) lines correspond to the pure (complete) galaxy selection threshold applied on MODEST_CLASS.

Y3 Gold v2.2 - extended S/G classifier




```
-    0: high confidence stars;
-    1: candidate stars;
-    2: mostly galaxies;
-    3: high confidence galaxies;
-    -9: No data;

     CM_T = Composite Model Fit
```

MOF

```
selection_1 = (d_des['CM_T'] + 5. * d_des['CM_T_err']) > 0.1
selection_2 = (d_des['CM_T'] + 1. * d_des['CM_T_err']) > 0.05
selection_3 = (d_des['CM_T'] - 1. * d_des['CM_T_err']) > 0.02
ext_mof = selection_1.astype(int) + selection_2.astype(int) + selection_3.astype(int)
```

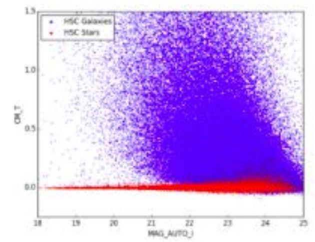
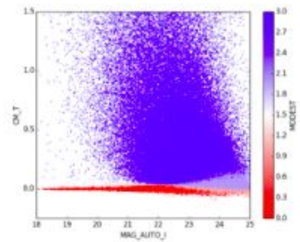
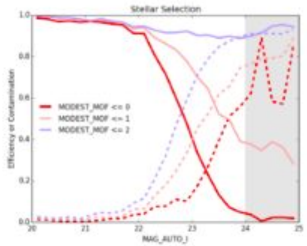
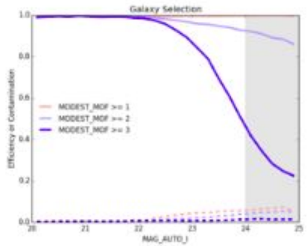
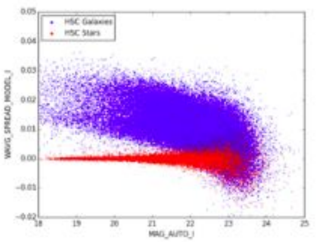
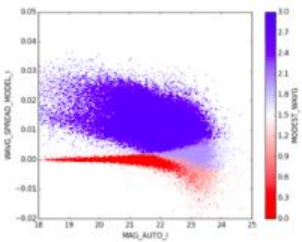
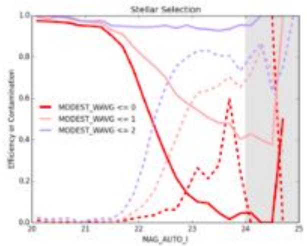
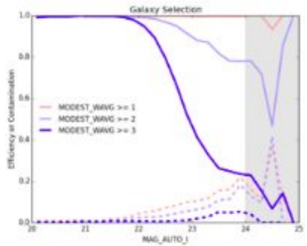
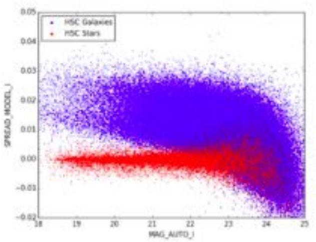
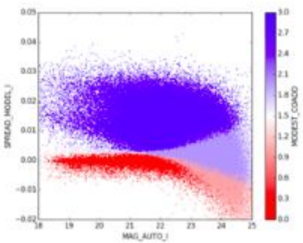
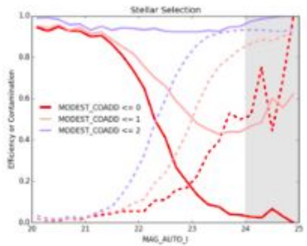
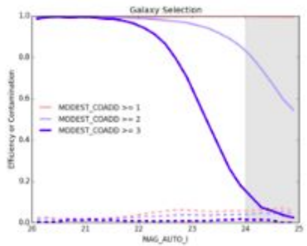
WAVG

```
selection_1 = (d_des['wavg_spread_model_i'] + 3. * d_des['wavg_spreaderr_model_i']) > 0.005
selection_2 = (d_des['wavg_spread_model_i'] + 1. * d_des['wavg_spreaderr_model_i']) > 0.003
selection_3 = (d_des['wavg_spread_model_i'] - 1. * d_des['wavg_spreaderr_model_i']) > 0.001
ext_wavg = selection_1.astype(int) + selection_2.astype(int) + selection_3.astype(int)
```

COADD

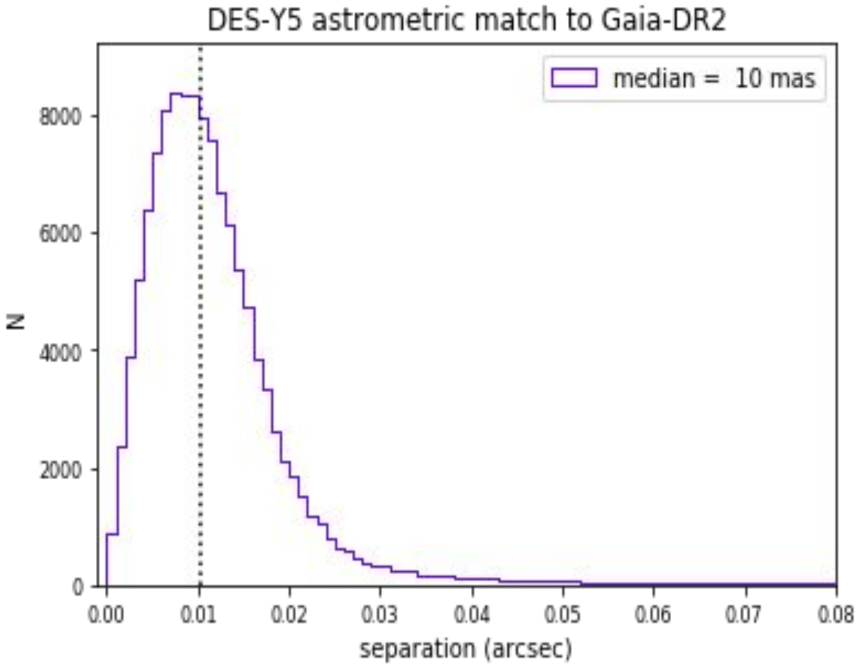
```
selection_1 = (d_des['spread_model_i'] + 3. * d_des['spreaderr_model_i']) > 0.005
selection_2 = (d_des['spread_model_i'] + 1. * d_des['spreaderr_model_i']) > 0.003
selection_3 = (d_des['spread_model_i'] - 1. * d_des['spreaderr_model_i']) > 0.002
ext_coadd = selection_1.astype(int) + selection_2.astype(int) + selection_3.astype(int)
```

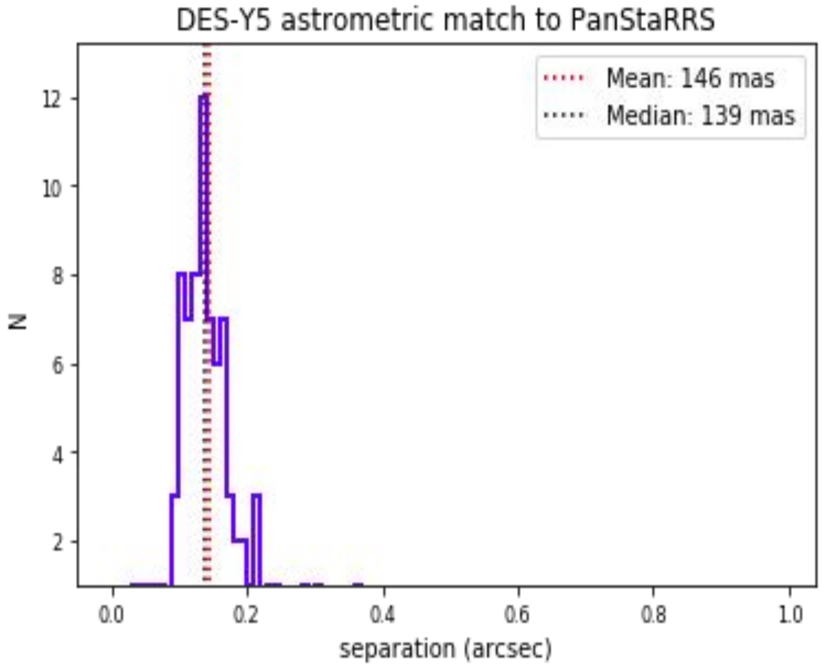
Y3 Gold v2.2 - extended S/G classifiers

Quantity	HSC Classification	EXT Classification	Stellar Selection: Efficiency/Contamination	Galaxy Selection: Efficiency/Contamination
MOF				
WAVG				
COADD				

DES Y6

Astrometry based on Gaia DR2 (no more based on UCAC-4/2MASS)





Questions?

Thank you!