



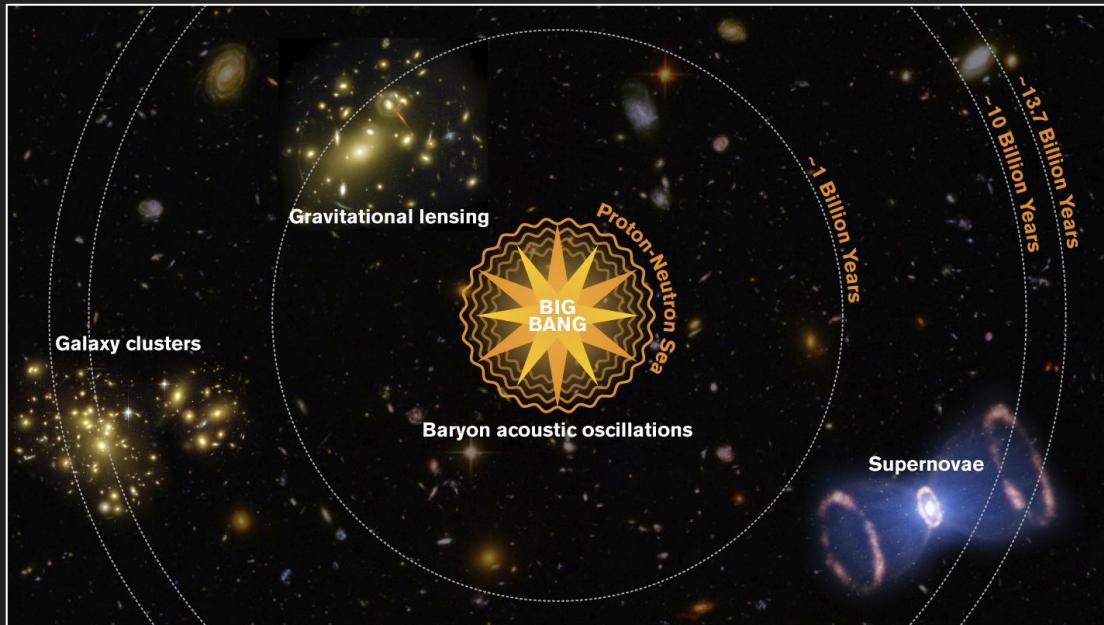
# The Dark Energy Survey Public Data Release 1

Matias Carrasco Kind (NCSA/UIUC)  
and the DR1 Release Team

<https://des.ncsa.illinois.edu/>

# The Science

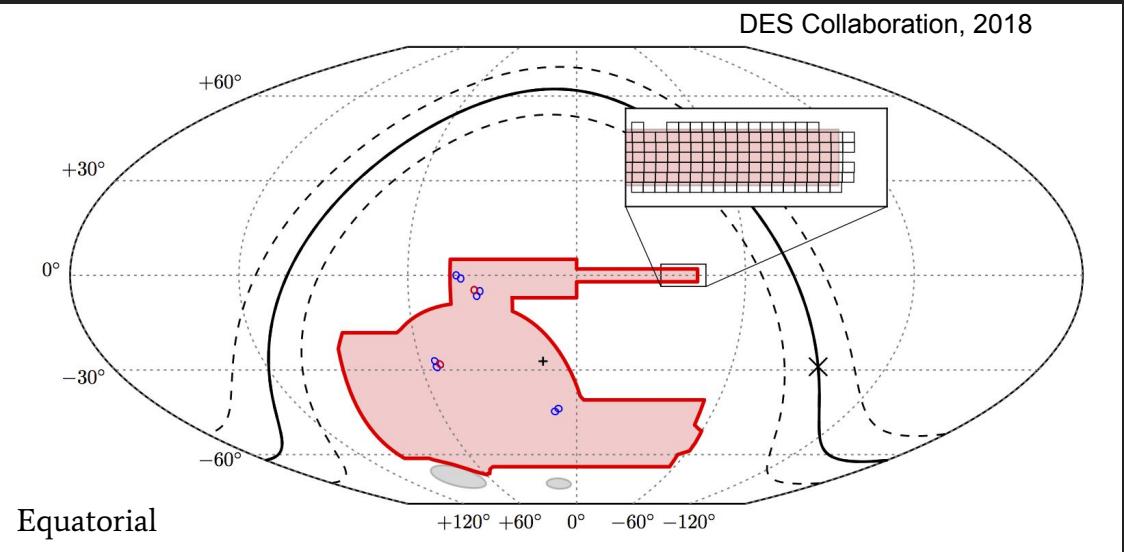
DES is designed to improve our understanding of **cosmic acceleration** and the **nature of dark energy** using four complementary probes of the expansion history and growth of cosmic structure



... and like other cosmic surveys, the DES data enable a wide range of additional science ranging from the Solar System to the high-redshift Universe

See also *The Dark Energy Survey: more than dark energy - an overview*  
[DES Collaboration, arXiv:1601.00329](https://arxiv.org/abs/1601.00329)

# The Survey



## Dark Energy Survey (DES)

Wide-field Survey:  $5000 \text{ deg}^2$ , 10 visits in each of *grizY*

Target S/N = 10 coadd depth  $\sim 24$  mag

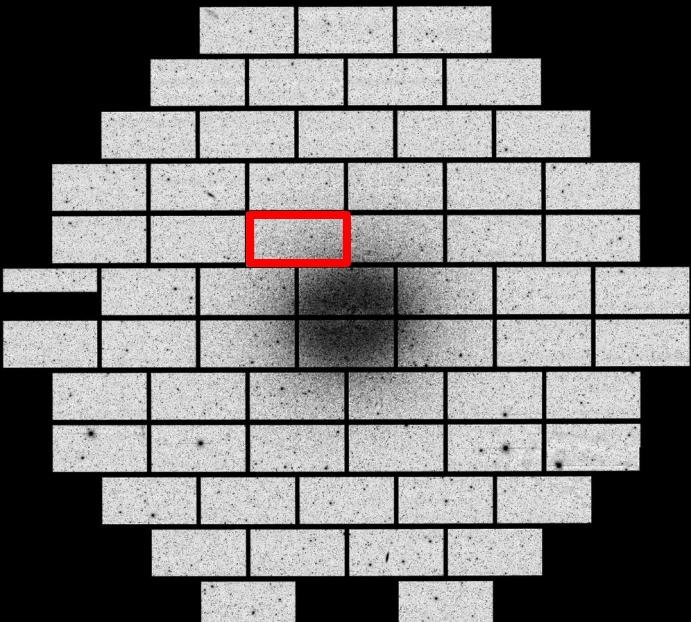
Supernova Survey:  $27 \text{ deg}^2$ , observed at weekly cadence

## Dark Energy Camera (DECam)

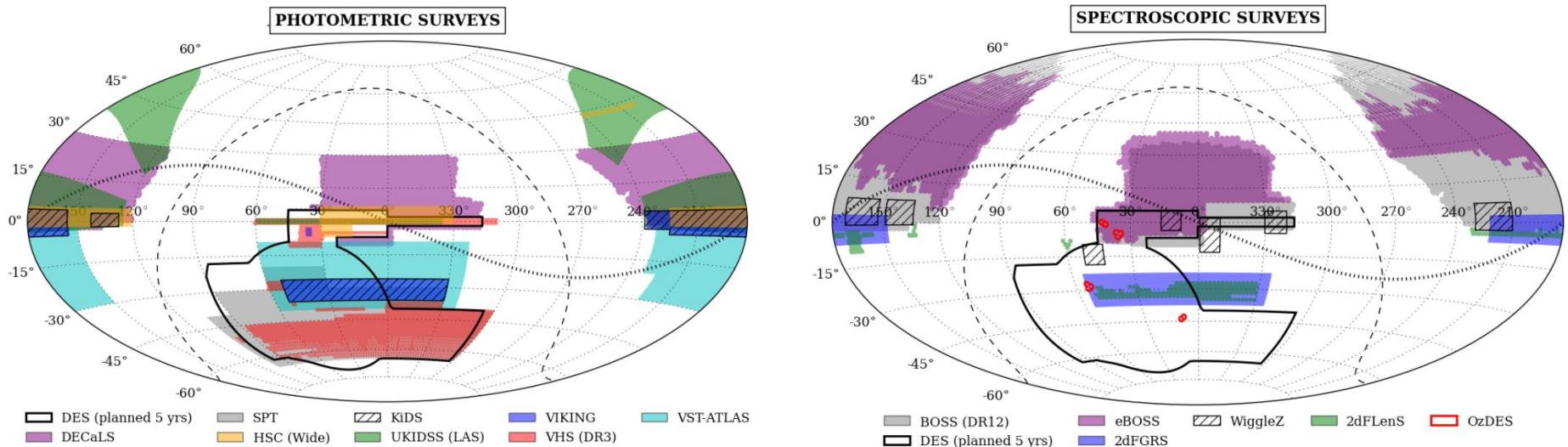
(Flaugh, B. et al. 2015)

570 Mpix camera on  
**Blanco 4-m telescope at CTIO**

$3 \text{ deg}^2$  field of view, 62 science CCDs

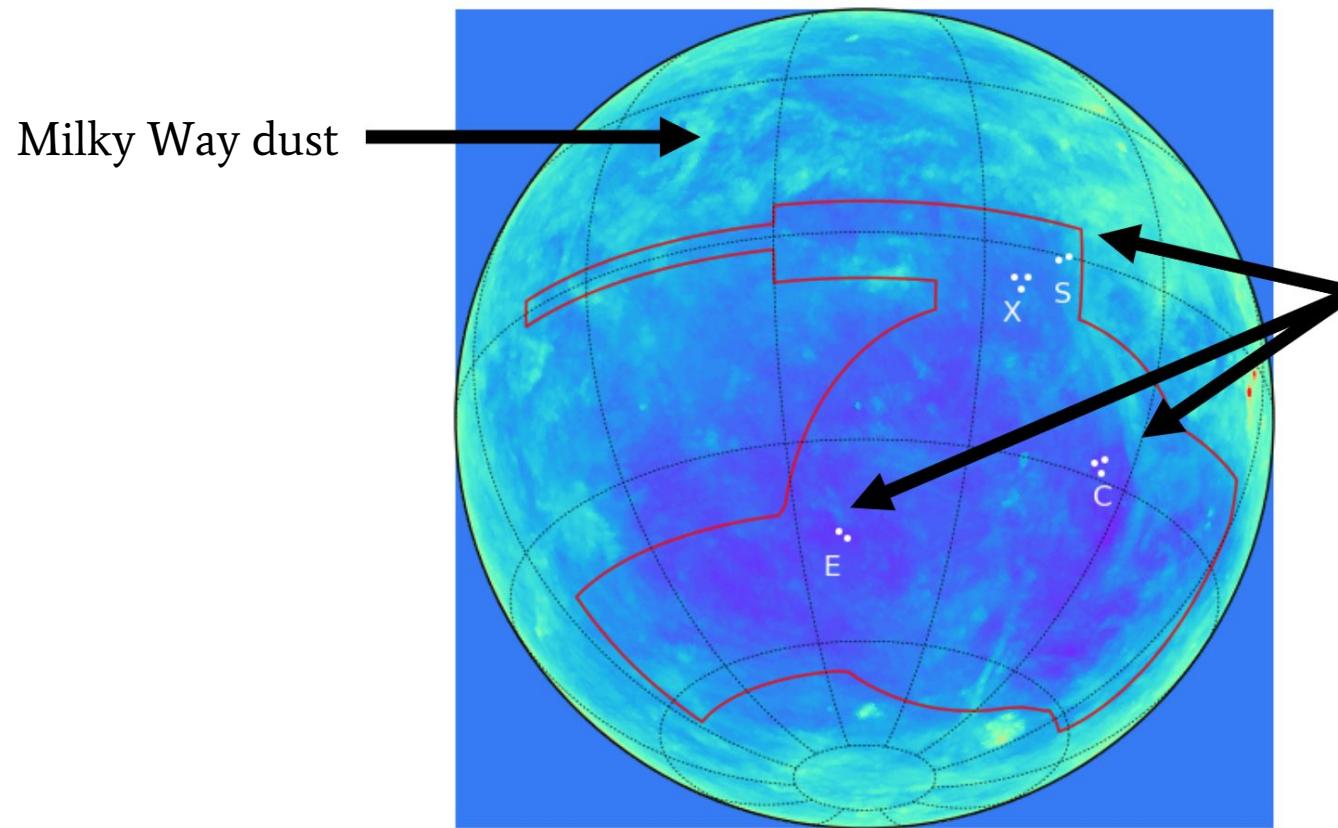


# The Survey

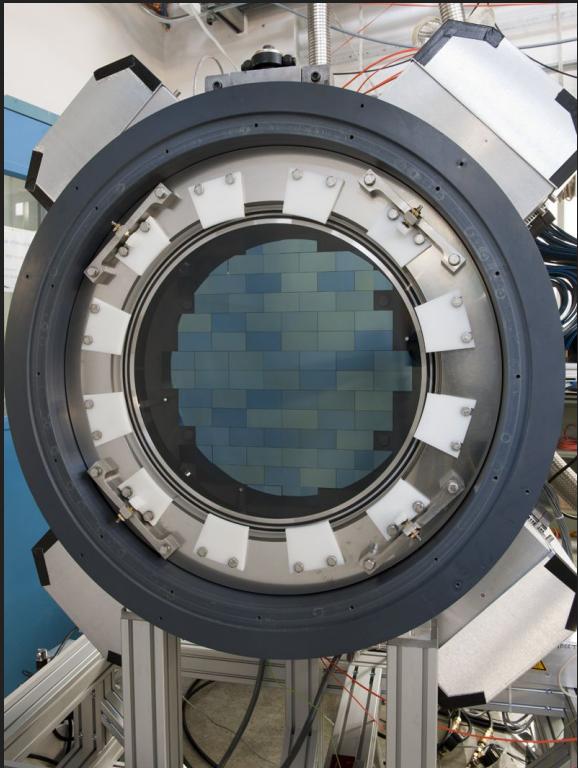


Overlapping with other surveys

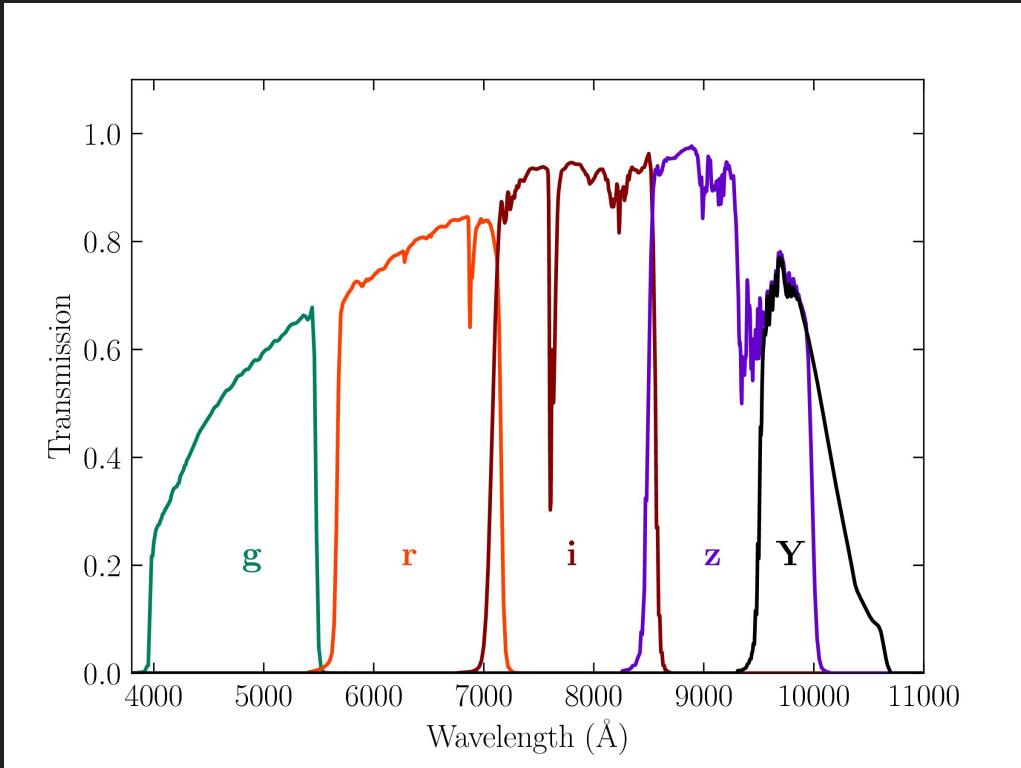
# The Survey



# The Camera -- DECam



570 Mpix camera, 3 deg<sup>2</sup> field of view

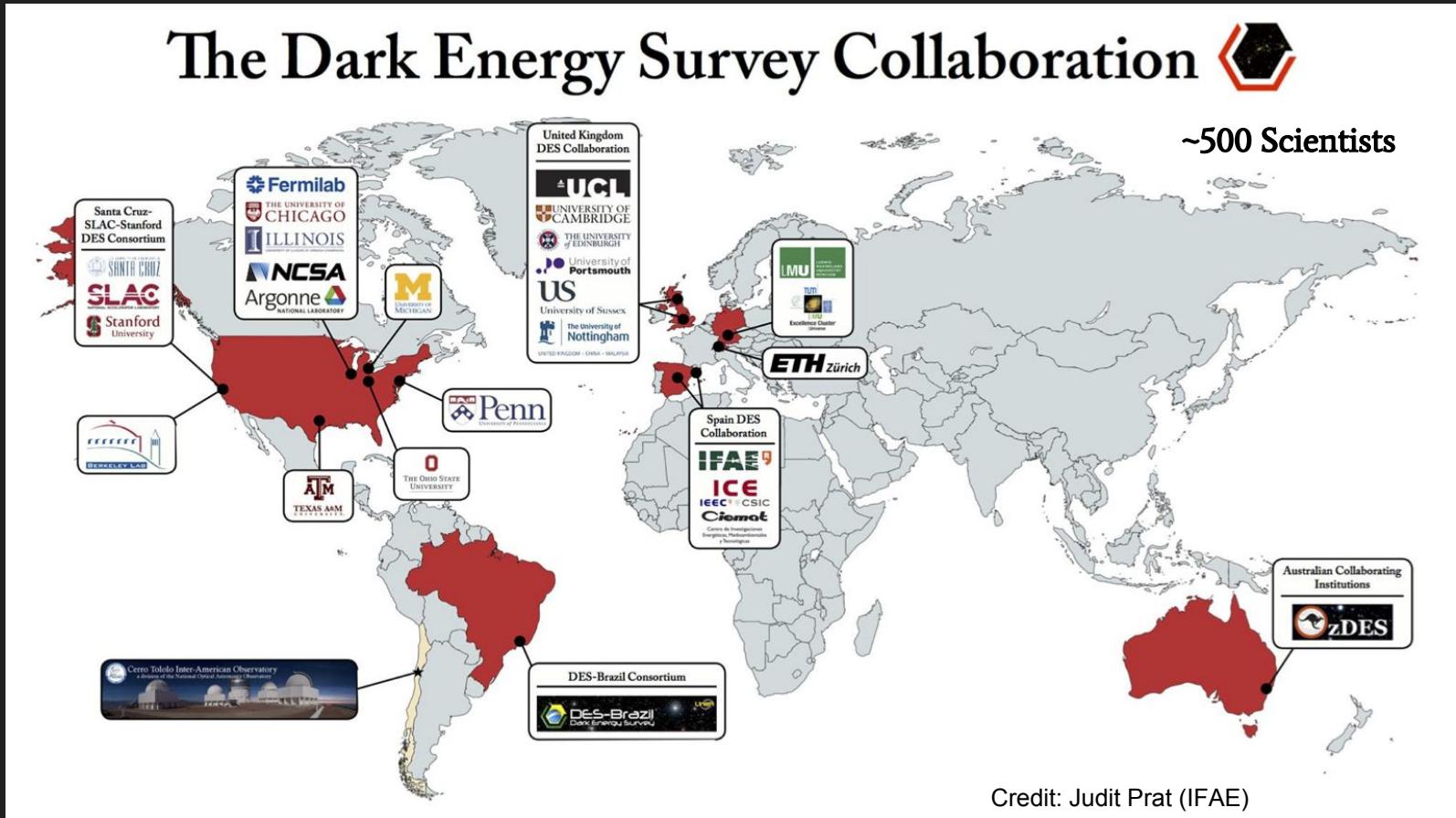


DES uses 5 broadband optical and near-IR filters

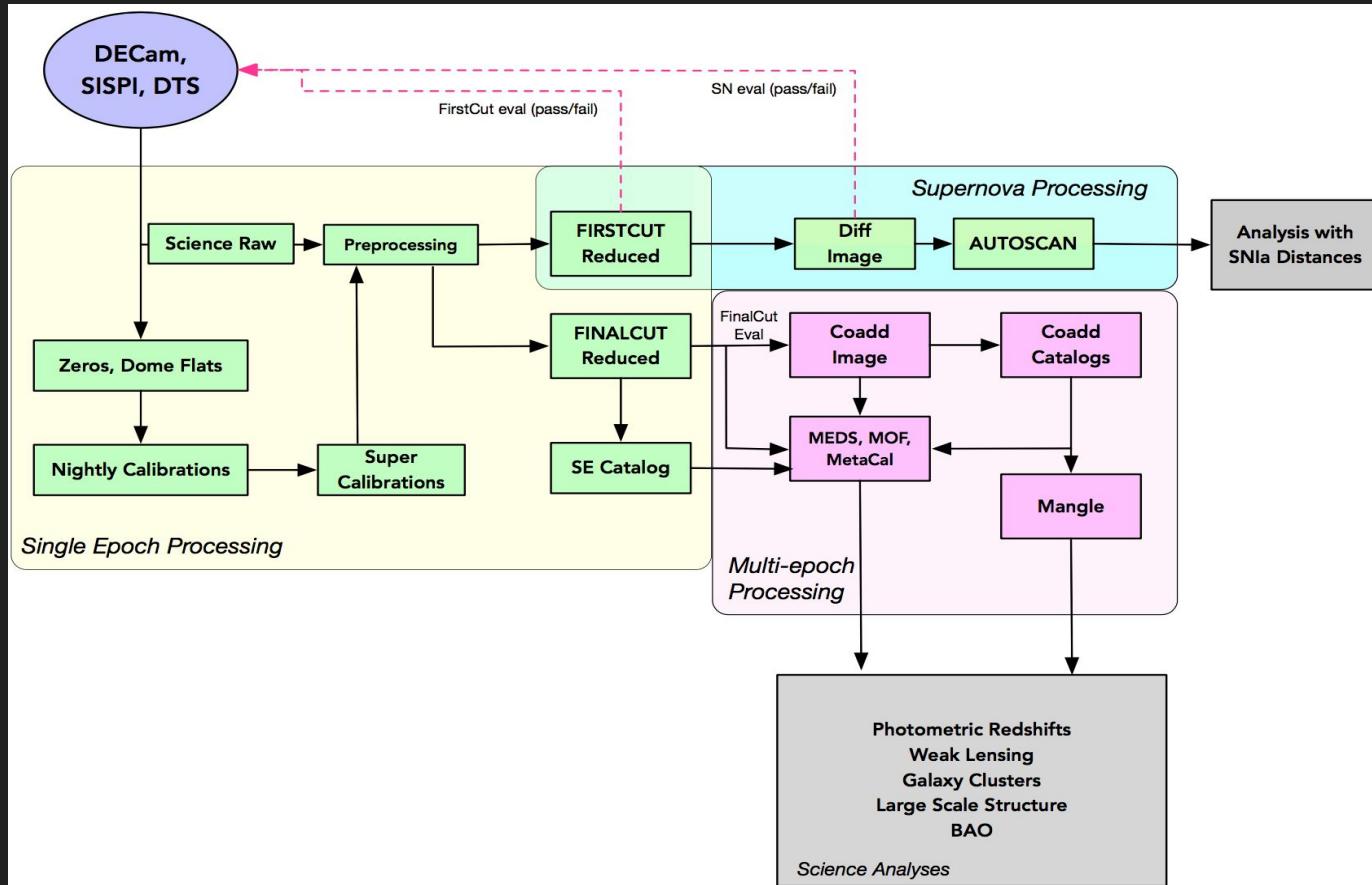
# The Collaboration

## The Dark Energy Survey Collaboration

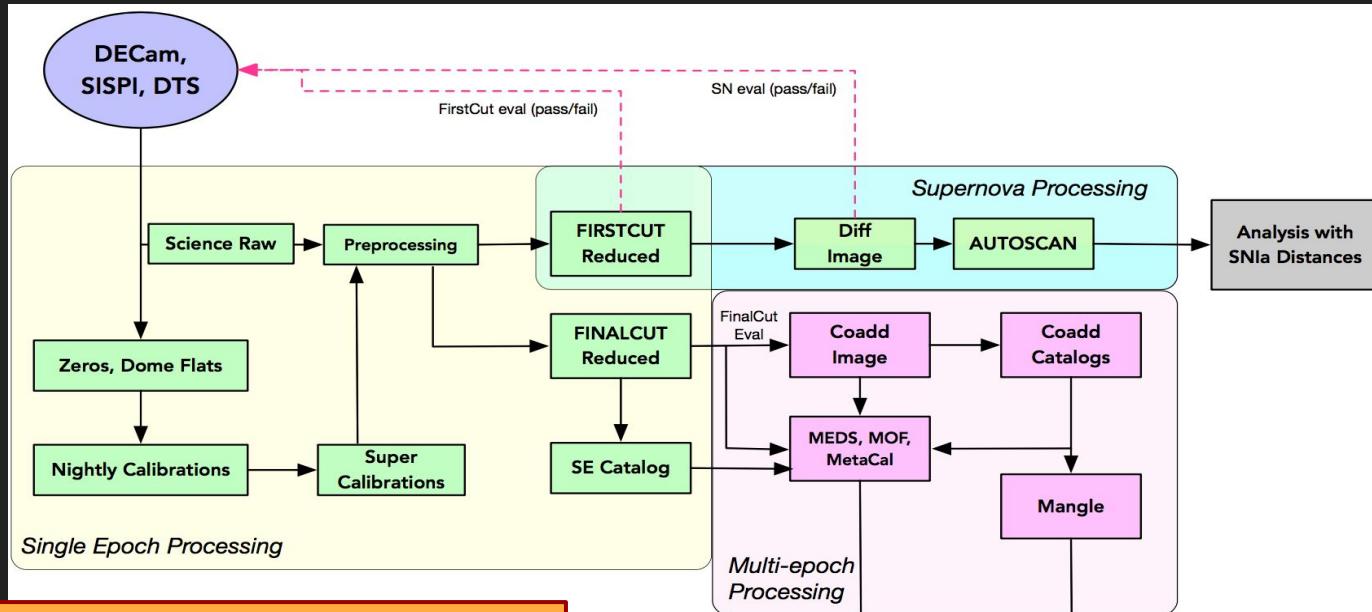
~500 Scientists



# The Processing Pipelines @ NCSA



# The Processing Pipelines @ NCSA



Full details of DESDM processing pipeline in  
Morganson et al. 2018 (arXiv: 1801.03177)

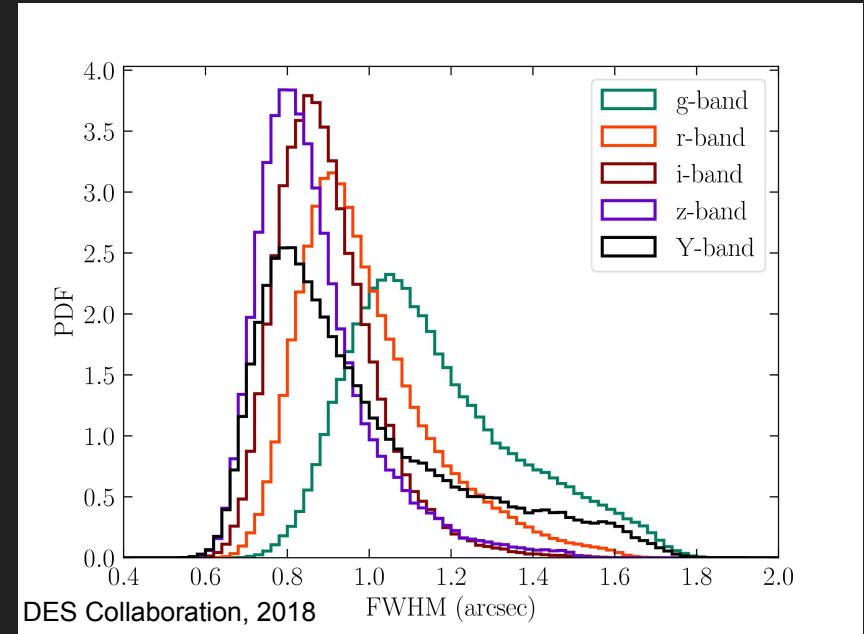
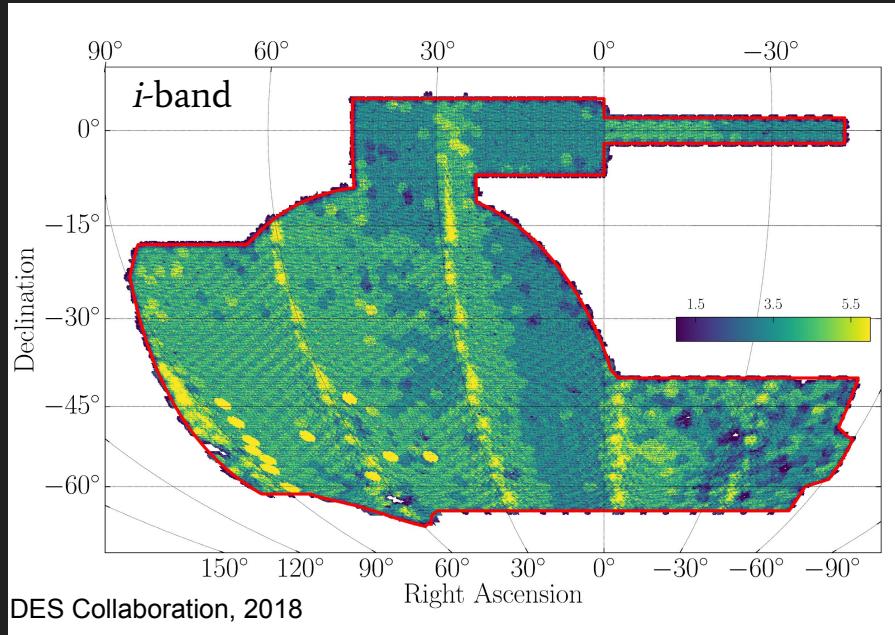


<https://github.com/DarkEnergySurvey>

# Wide-field Survey Y1-Y3 → DES DR1



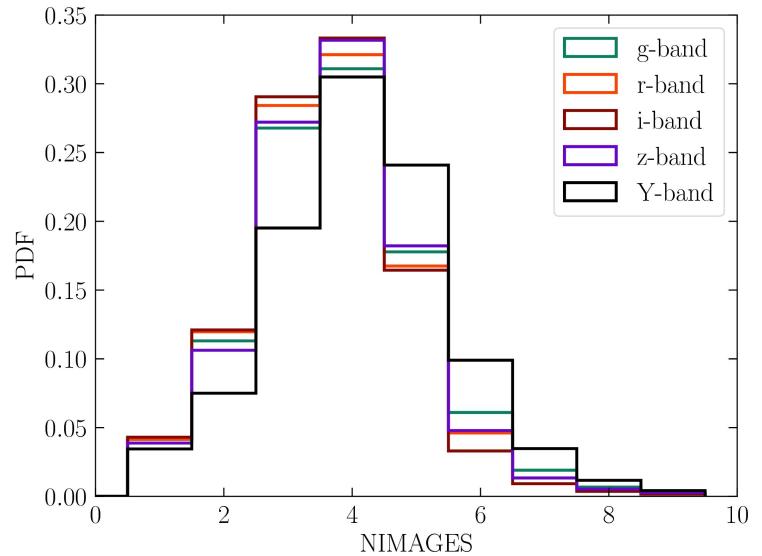
DES DR1 is based on the first three years of wide-field survey



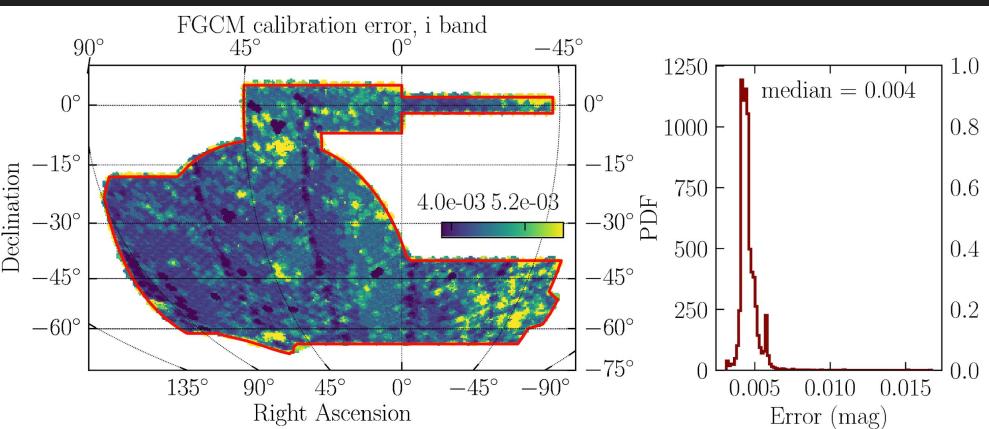
Typically 3-5 overlapping exposures in each of the grizY bands in each part of the footprint

Observe in *riz* bands during periods of best seeing  
Delivered PSF FWHM  $\sim 0.9$  arcsec

# DES DR1 properties



Typically 3-5 overlapping exposures  
in each of the *grizY* bands in each  
part of the footprint

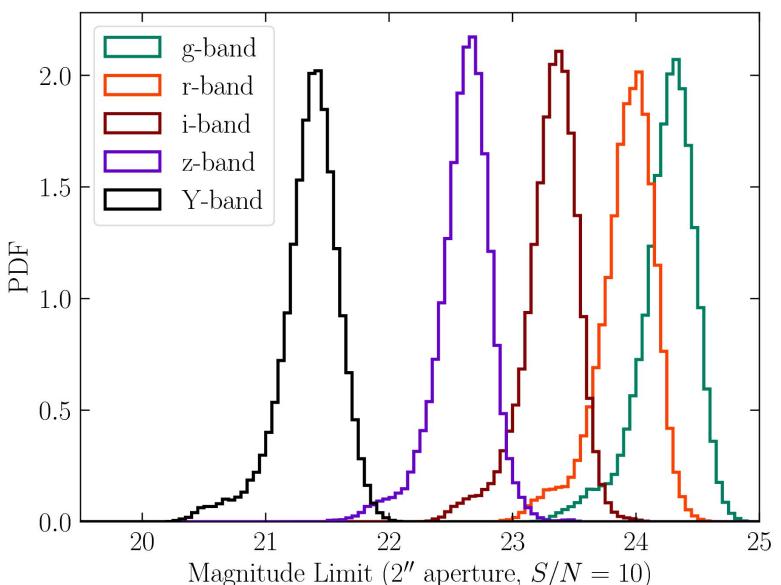


Statistical uncertainty of coadd zeropoints in the i-band  
estimated from the FGCM photometric calibration

# DES DR1 properties

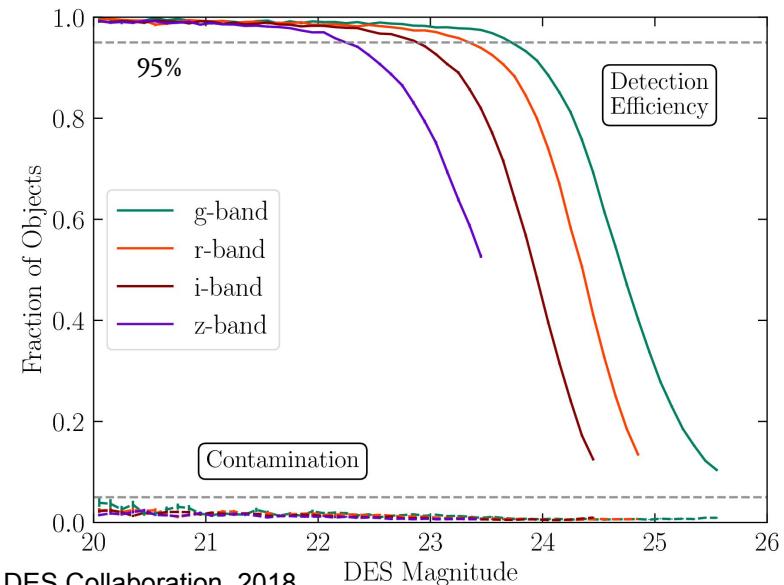
Distribution of depth corresponding to  
signal-to-noise = 10 for a 2" aperture

DES Collaboration, 2018

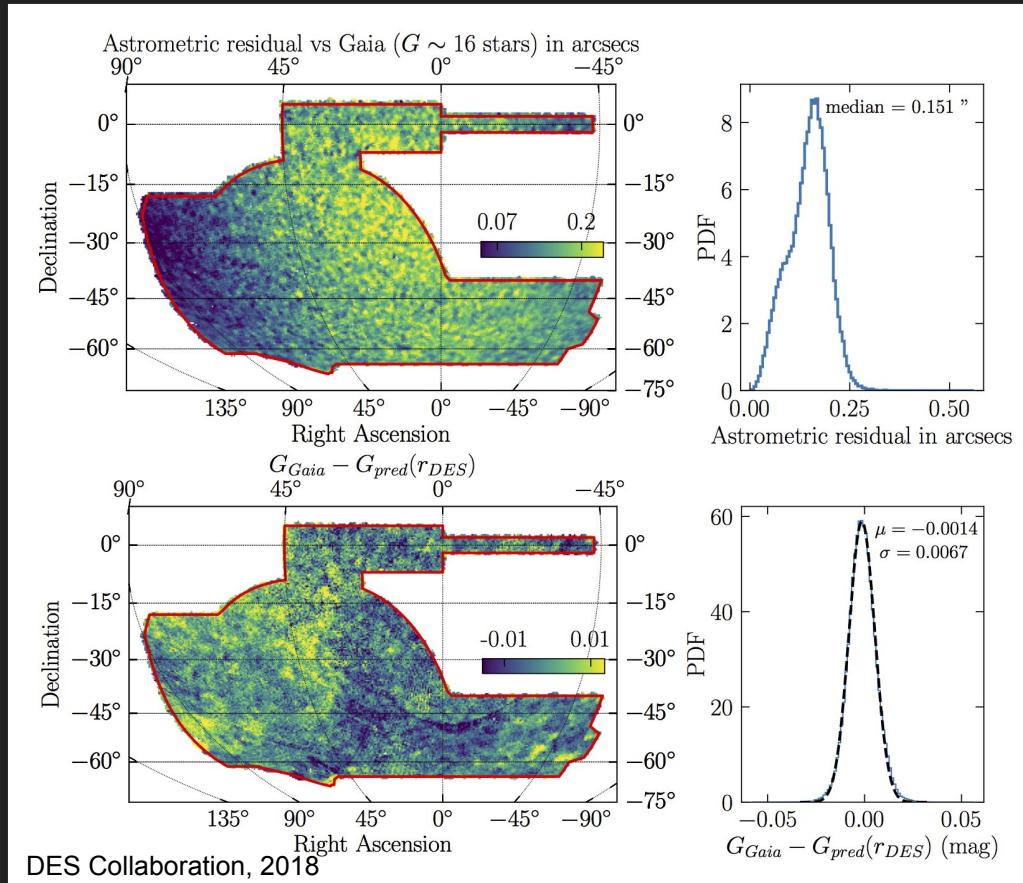


Detection Completeness vs. CFHTLenS  
(Erben et al. 2013)

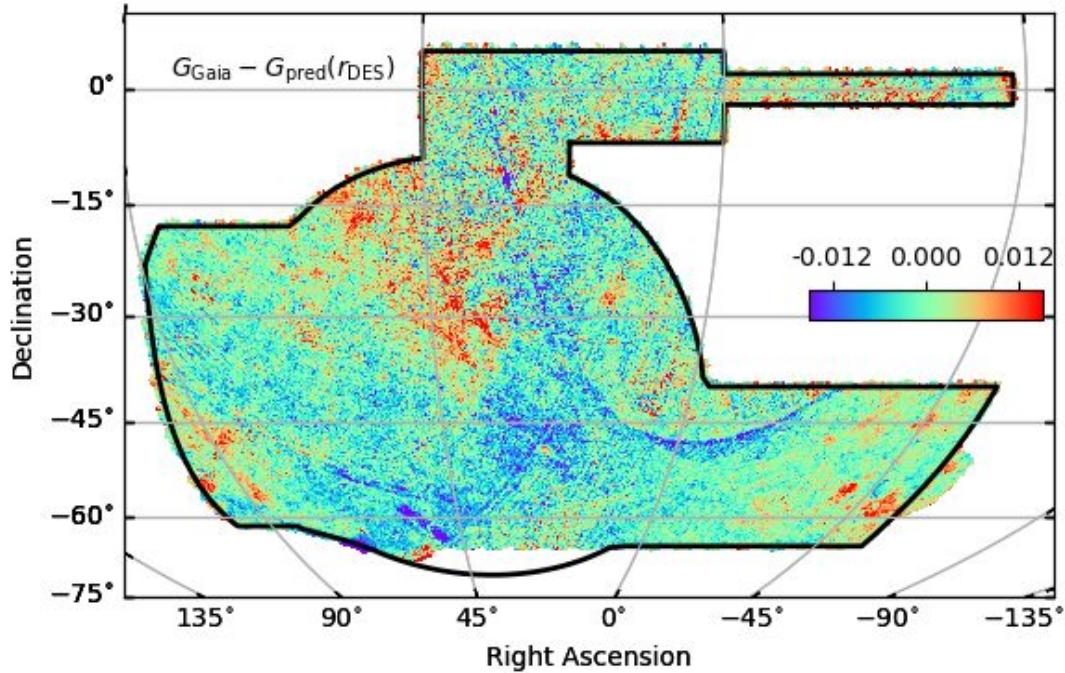
DES Collaboration, 2018



# Astrometric and Photometric Precision

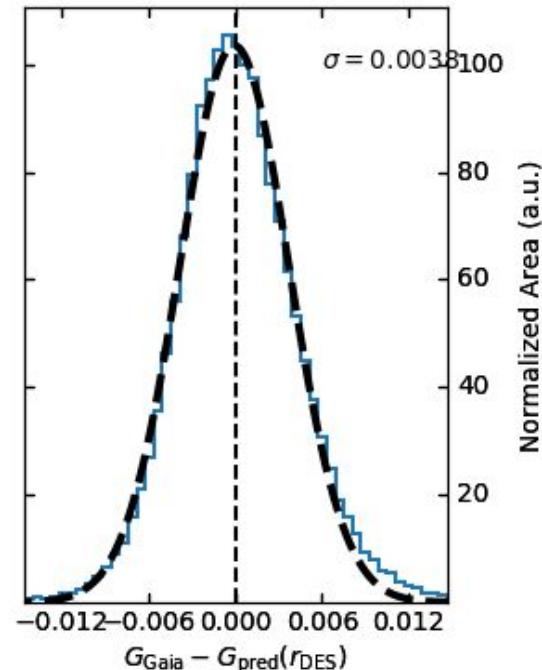
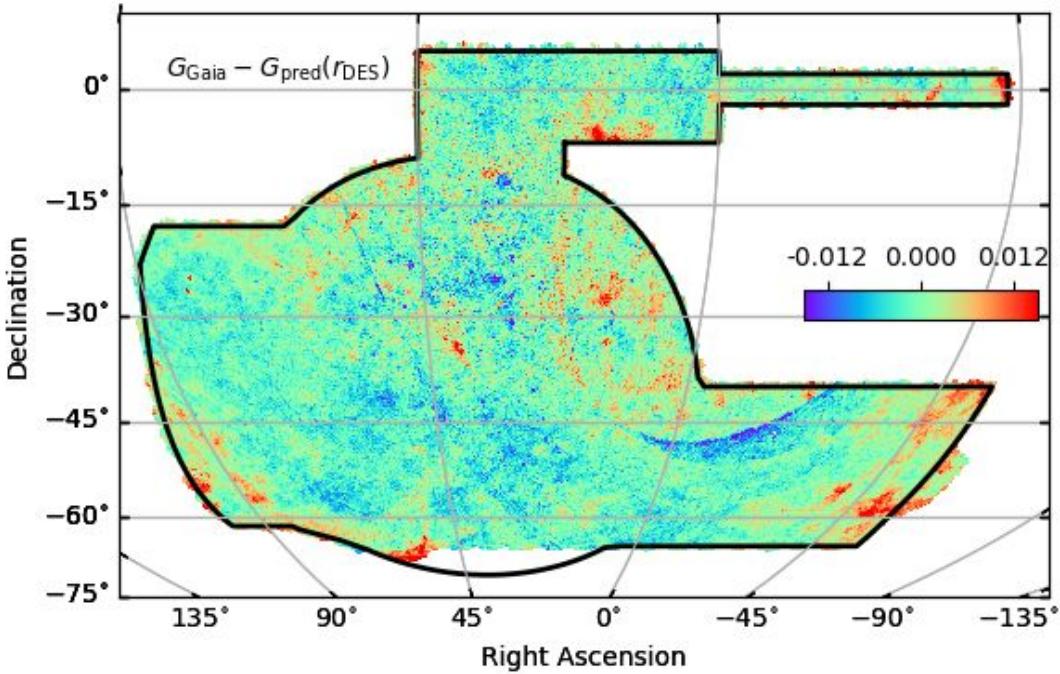


# Astrometric and Photometric Precision



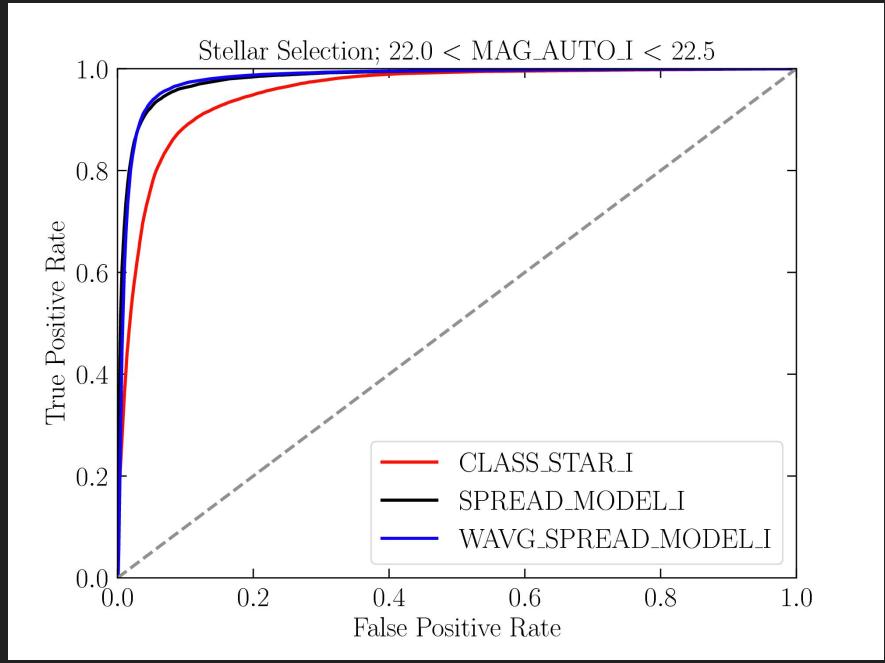
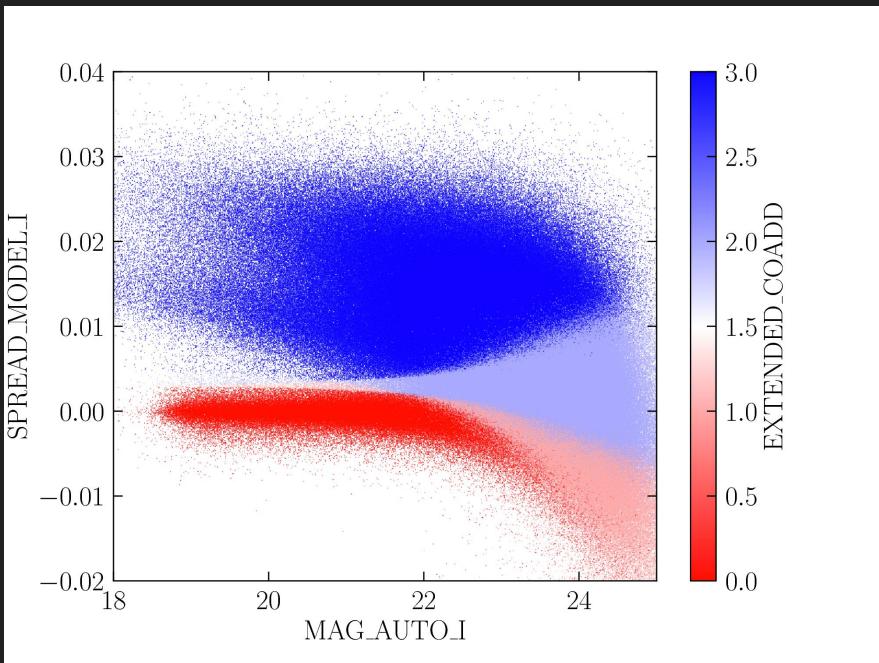
DES r band vs Gaia DR1 , RMS ~ 5.1 mmag

# Astrometric and Photometric Precision



DES r band vs Gaia DR2 , RMS ~ 3.8 mmag

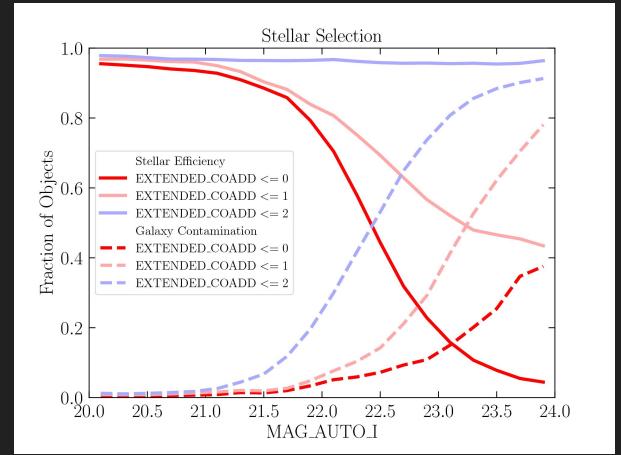
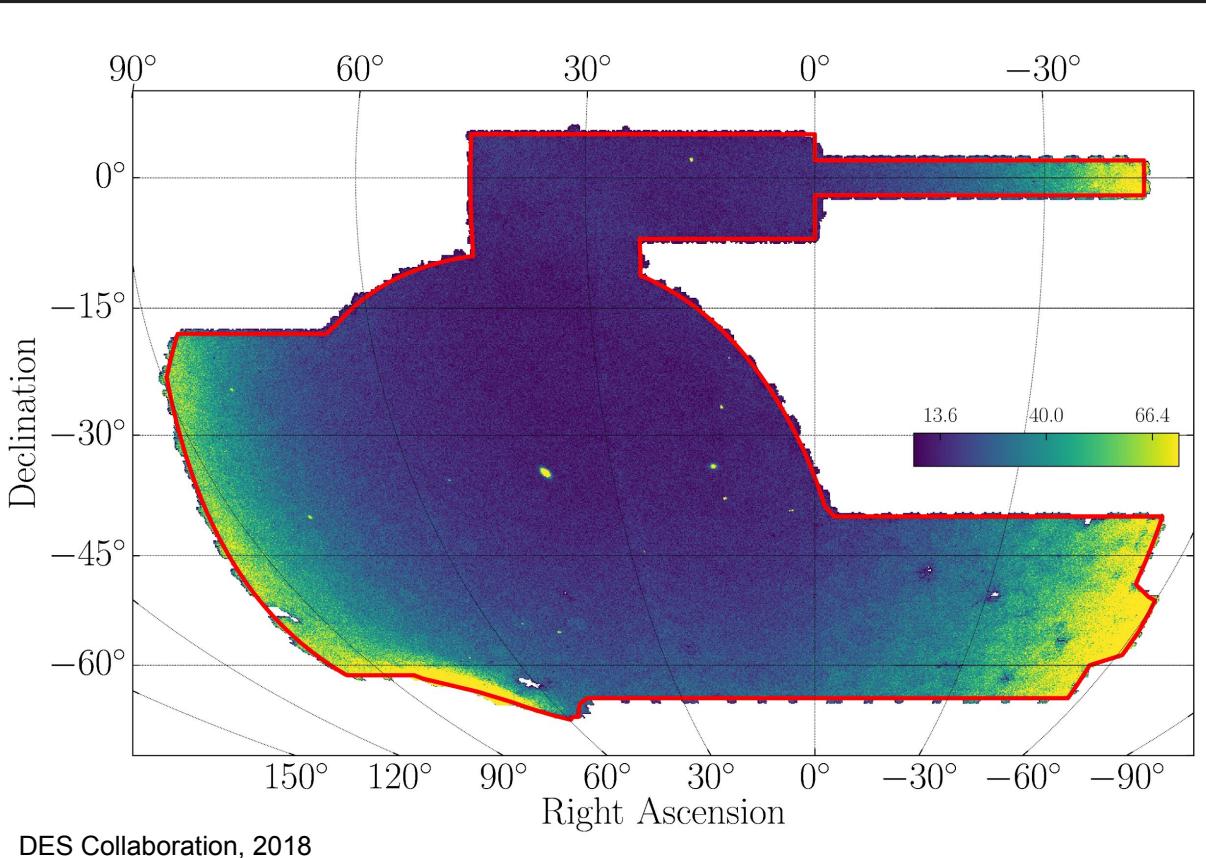
# Object Classification



It is recommended to use `SPREAD_MODEL` over `CLASS_STAR` for star-galaxy separation

```
EXTENDED_COADD = ((SPREAD_MODEL_I + 3 * SPREADERR_MODEL_I) > 0.005) + ((SPREAD_MODEL_I + SPREADERR_MODEL_I) > 0.003)
+ ((SPREAD_MODEL_I - SPREADERR_MODEL_I) > 0.003)
```

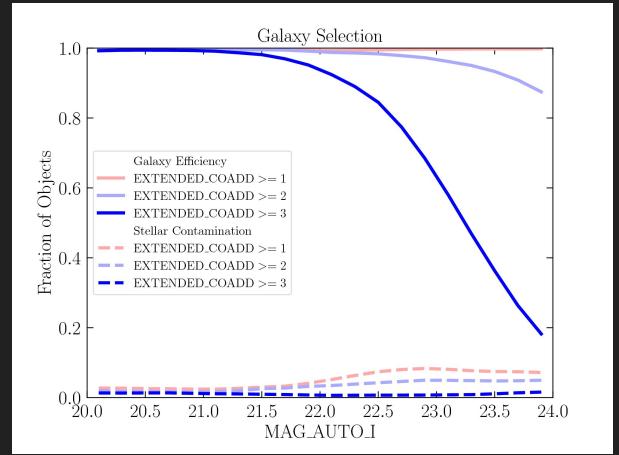
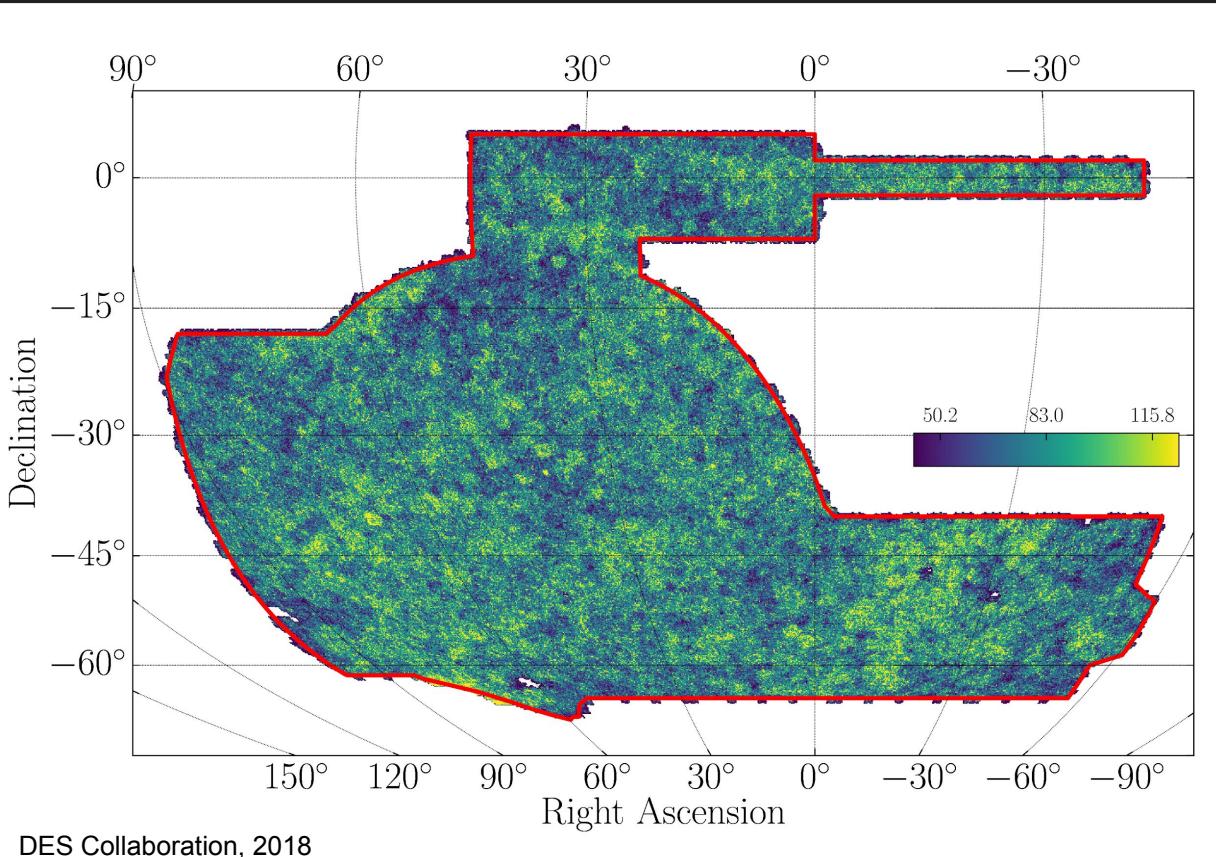
# Object Classification: Stars



Tune selection according to science case:

Benchmark stellar sample:  
 ~80M objects  
 >90% efficiency, <3% contamination  
 for  $i < 22.5$  mag

# Object Classification: Galaxies



Tune selection according to science case:

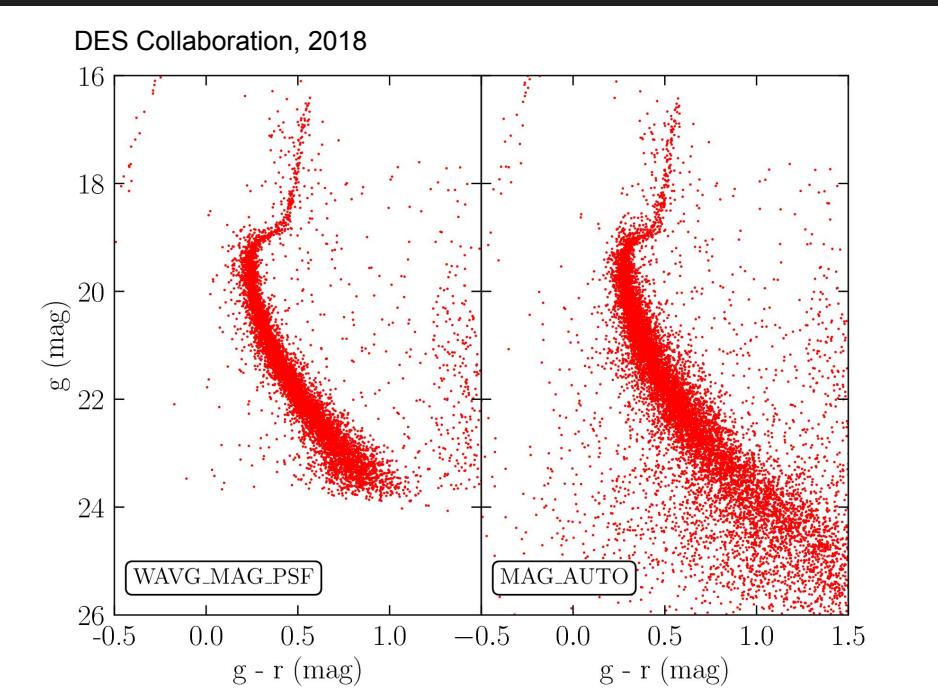
Benchmark galaxy sample:  
 $\sim 310\text{M}$  objects  
 >99% efficiency, <3% contamination  
 for  $i < 22.5$  mag

# Known Issues: PSF Model

PSF can be problematic across boundaries in exposure, quantities based on PSF Modeling need careful analysis.

DES DR1 does not include the coadd MAG\_PSF quantities.

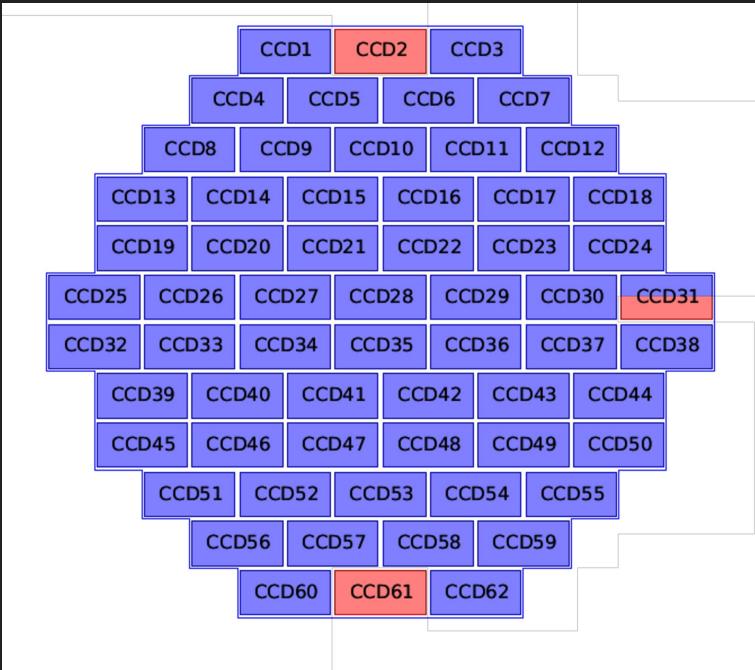
For studies of **point-like sources**, we recommend the use of **WAVG\_MAG\_PSF** (bright sources) or **MAG\_AUTO** and **MAG\_APER** (faint sources).



15' x 15' box centered on the M2. WAVG\_MAG\_PSF (left) yields a tighter locus but does not extend as deep as the MAG\_AUTO (right)

# Known Issues: DECam CCDs

DECam focal plain chips layout. Each of the 62 rectangles represents a CCD which is in turn read by two amplifiers (along the long direction).



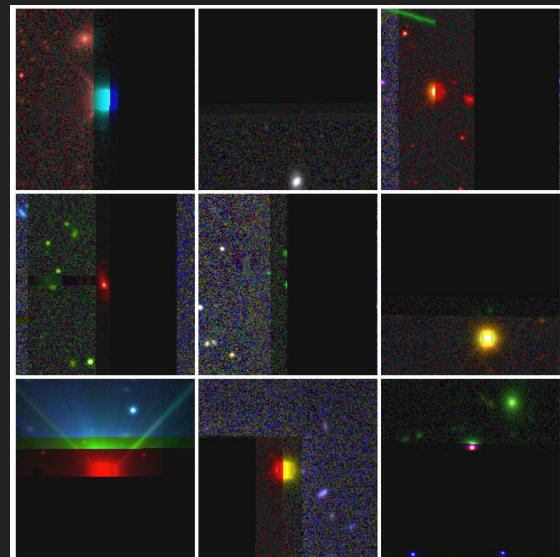
CCDs 2 and 61 have been inactive for most of DES. Amplifier A of CCD 31 has unpredictable gain and has not been processed by DES. These areas are marked in red.

# Known Issues: IMAFLAGS\_ISO

~2.3% with IMAFLAGS\_ISO in at least one of the grizY bands.

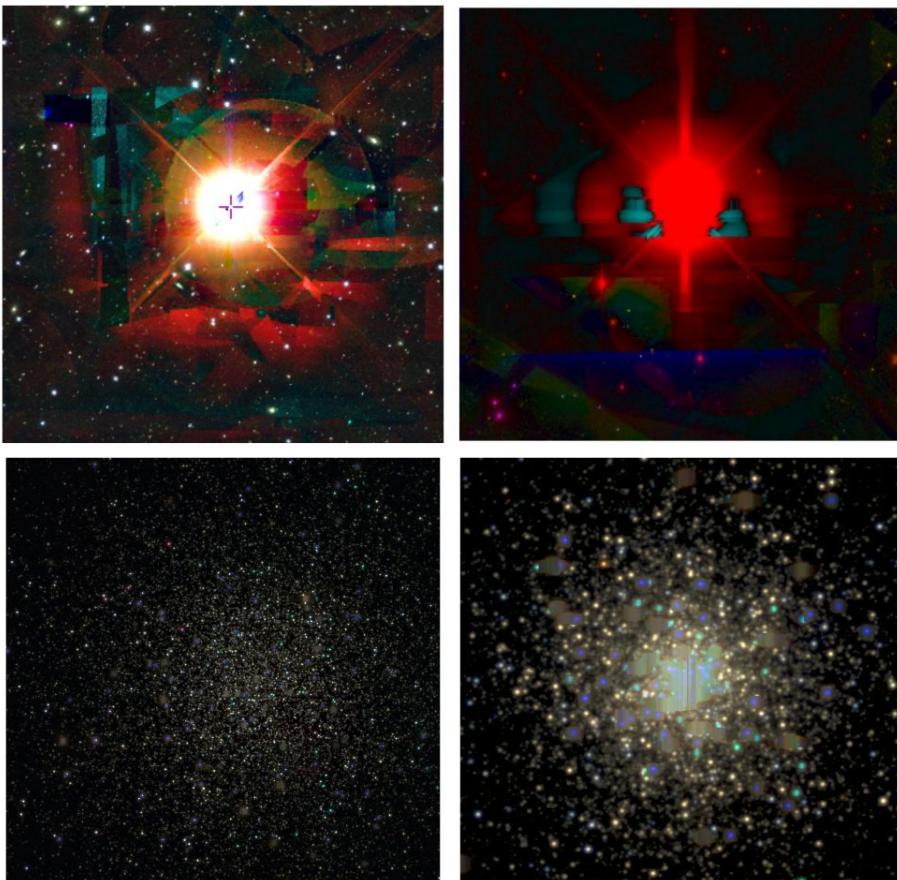
~0.1% have artifacts in all 5 bands.  
Most of the objects with IMAFLAGS\_ISO = 1 are saturated stars .

A smaller fraction are missing imaging data in one or more of the bands, and usually have NITER\_MODEL = 0 (didn't converge)



# Known Issues: Bright Objects

Examples of very bright stars, R Dor (30' cutout; top left) and  $\alpha$  Phe (14' cutout; top right) and globular clusters, NGC 288 (8' cutout; bottom left) and NGC 1904 (2.5' cutout; bottom right), found within the DES DR1 footprint.



# DES DR1 Summary Statistics



The Dark Energy Survey

DES vision circa 2005

[arXiv:astro-ph/0510346](https://arxiv.org/abs/astro-ph/0510346)

Brenna Flaugher  
for the Dark Energy Survey Collaboration\*

*Fermilab  
M.S. 310, Box 500  
Batavia, IL 60510, USA*

Dark Energy is the dominant constituent of the universe and we have little understanding of it. We describe a new project aimed at measuring the dark energy equation of state parameter,  $w$ , to a statistical precision of  $\sim 5\%$ , with four separate techniques. The survey will image  $5000 \text{ deg}^2$  in the southern sky and collect 300 million galaxies, 30,000 galaxy clusters, and 2000 Type Ia supernovae. The survey will be carried out using a new  $3 \text{ deg}^2$  mosaic camera mounted at the prime focus of the 4m Blanco telescope at CTIO.

*Keywords:* Dark energy ; galaxies; supernovae.

# DES DR1 Summary Statistics

Parameter	Value
Observations (3 years of operations)	345 distinct nights from Aug 2013 to Feb 2016
Number of DECam Exposures	~39,000
Sky Coverage in <i>grizY</i>	5186 deg <sup>2</sup>
Delivered Seeing (FWHM)	$g = 1.21, r = 0.96, i = 0.88, z = 0.84, Y = 0.90$ arcsec
Coadd Astrometric Precision (vs Gaia)	151 mas
Coadd Photometric Precision	< 1 % in <i>grizY</i>
Coadd depth (S/N = 10 in 1.95" Aperture)	$g = 24.3, r = 24.1, i = 23.4, z = 22.7, Y = 21.4$ mag
Distinct Coadd Objects in 10,338 tiles	~400M: ~310M galaxies and ~80M stars after basic quality cuts ~ 35,000 clusters @ $z \sim 1$

Largest photometric dataset to date at the achieved depth and photometric precision

# DES DR1 Products and Services

- **Catalogs:** Year 3 Catalogs based on SExtractor
- **Images:** Year 3 Coadd images, Y1-Y2-Y3 Single-epoch calibrated images
- **Bulk Data Access:** Coadd tile-based image and catalog files
- **Interfaces:** SQL Web Client, File access, Cutout server, Image exploration, Landing release page, Jupyter Notebooks, Science Portal, NOAO Data Lab
- **Documentation:** DR1 paper (tonight), Web documentation, Table Schemas, Interface and software, DR1 Standard Bandpasses
- **Software:** Main components of pipeline on Github. Minimal usage information
- **Support:** Limited collaboration support (similar to SV) and institutional (NCSA, NOAO, LIneA) support for tools

# DES DR1 Data Access

Three complementary web-based platforms: <https://des.ncsa.illinois.edu/releases/dr1/dr1-access>



## DES Data Management

- Home
- Releases ▾
- Get Help
- Acknowledgements
- About Us

### DR1 Data Access

If you'd like to access the images and catalogs from DES DR1, please use the complementary set of tools created by a collaborative effort between NCSA, NOAO, and LIneA. These tools allow the users to access, obtain, visualize, and explore DES DR1 products. When using DES data and/or DES access tools please consider the notes in the [Acknowledgement](#) page. Click on the logos below to start exploring DES data tools. Follow the links below to learn more about each tool and their functionalities.



NCSA DESaccess



NOAO DataLab



DES-BRAZIL  
LIneA Science Server

# DES DR1 Data Access



## Interactive Sky Viewer

SQL Web Client with example queries and schema browser

DARK ENERGY SURVEY desaccess

Query box

Insert your query in the box below. Data results for "Quick" Jobs (30 sec.) will be displayed at the bottom.

```
1 --  
2 -- Example Query --  
3 -- This query selects stars around the center of globular cluster M2  
4 SELECT  
5 COADD_OBJECT_ID,RA,DEC,  
6 MAG_AUTO_G,G,  
7 MAG_AUTO_R,R,  
8 WAVG_MAG_PSF_G,G_PSF,  
9 WAVG_MAG_PSF_R,R_PSF  
10 FROM DR1_MAIN  
11 WHERE  
12 RA between 323.36-0.12 and 323.36+0.12 and  
13 DEC between -0.82-0.12 and -0.82+0.12 and  
14 WAVG_SPREAD_MODEL_I + 3.0*WAVG_SPREADERR_MODEL_I < 0.005 and  
15 MAG_SPREAD_MODEL_I < 1 and
```

Job bf77d647-cd58-4b87-a576-6791da11e655 submitted

Submit Job Clear Check Quick  
Output file  
Output file (.csv, fits, .h5) globular\_cluster\_test.fits



## Disclaimer & attribution

If you use this notebook for your published science, please acknowledge the following:

- Data Lab concept paper: Fitzpatrick et al., "The NOAO Data Laboratory: a conceptual overview", SPIE, 9149, 2014, <http://dx.doi.org/10.1117/12.2057445>
- Data Lab disclaimer: <http://datalab.noao.edu/known-issues.php>

## Imports and setup

```
In [339]: # Python 2/3 compatibility  
from __future__ import print_function # to use print() as a function in Python 2  
#from __future__ import division # if you need Python 3 division behavior in Python 2  
  
try:  
    input = raw_input # use 'input' function in both Python 2 and 3  
except NameError:  
    pass  
  
# std lib  
from getpass import getpass  
  
# 3rd party  
import pandas as pd  
import numpy as np  
import pylab as plt  
import matplotlib  
from astropy import utils, io, convolution, stats  
%matplotlib inline  
  
# Data Lab  
from dl import authClient as ac, queryClient as qc, storeClient as sc, helpers
```

Jupyter Notebooks and computing environment

# Thanks!



<https://des.ncsa.illinois.edu/>

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DRI Release Scientist

# Extra Slides

