

**BPG**  
**2021**

# Michel Aguena



**PS: CLMM, Cluster Detection Validation**  
**Science: WaZP on DC2**

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# CLuster Mass Modeling

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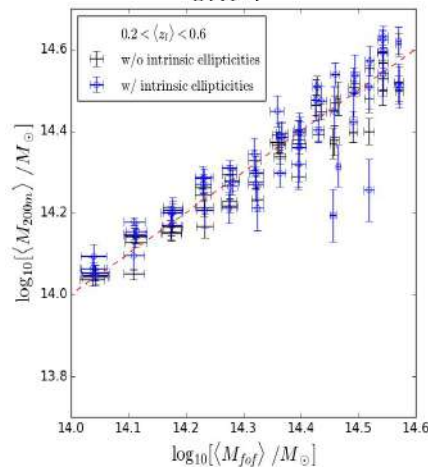
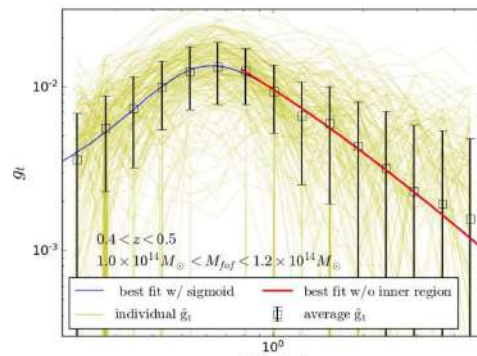
Michel Aguena + CLMMers

# Intro



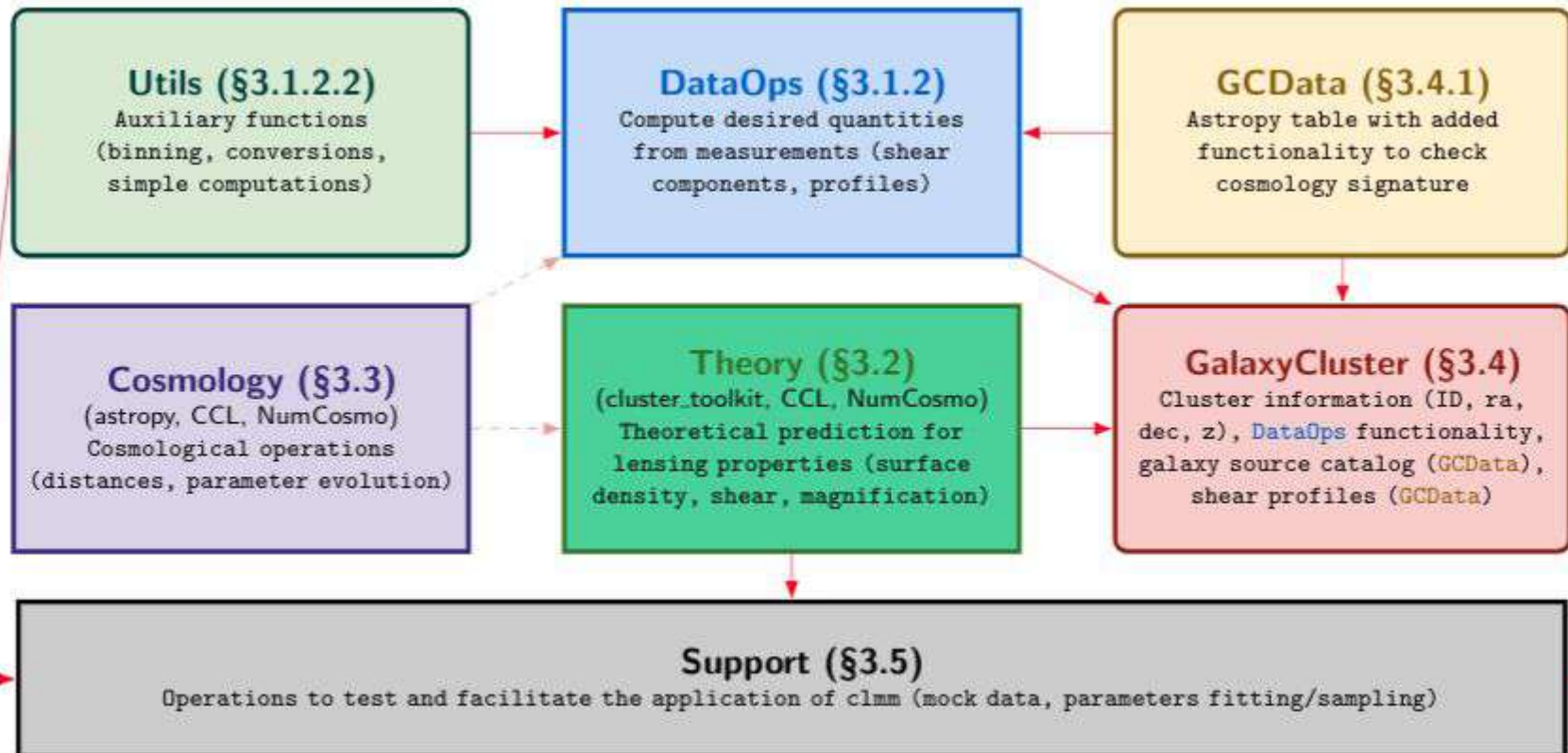
## What is clmm?

- DESC software being developed by a large group of researchers (+), that meets DESC software standards (unit tests+documentation)
- Package to constrain cluster mass from weak lensing (shear) measurements
- Fit shear radial profile (angular or physical)
- Compatible with different backends for cosmology (astropy, CCL, NumCosmo) and mass modeling (cluster\_toolkit, CCL, NumCosmo)
- Fits the mass on individual cluster basis, stacking planned for the future



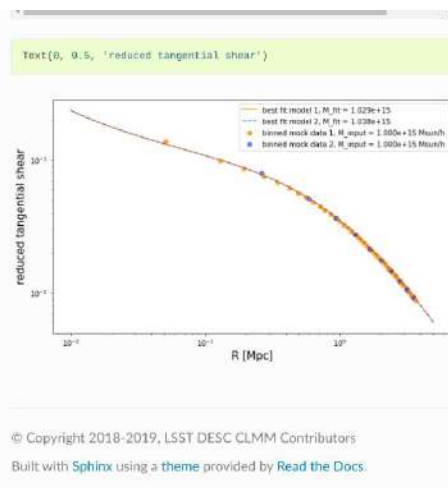
Reconstructed  $M_{200,m}$  correlates with DC2 halo  $M_{fof}$

# CLMM architecture



# Demonstration and Documentation

- Code on DESC github:  
<https://github.com/LSSTDESC/CLMM>
- Notebooks:  
<https://github.com/LSSTDESC/CLMM/tree/master/examples>
- Documentation in code
- CLMM Docs and Demos on DESC:  
<http://lsstdesc.org/CLMM/>



```
clmm.modeling.get_critical_surface_density(cosmo, z_cluster, z_source) [source]
```

Computes the critical surface density

$$\Sigma_{\text{crit}} = \frac{c^2}{4\pi G} \frac{D_s}{D_L D_{LS}}$$

Parameters:

- `cosmo` (`pyccr.core.Cosmology object`) – CCL Cosmology object
- `z_cluster` (`float`) – Galaxy cluster redshift
- `z_source` (`array_like, float`) – Background source galaxy redshift(s)

Returns: `sigma_c` – Cosmology-dependent critical surface density in units of  $M_{\odot} \text{Mpc}^{-2}$

Return type: `float`

Notes

We will need  $\gamma_{\infty}$  and  $\kappa_{\infty}$  for alternative `z_src_models` using  $\beta_g$ .

# Validation



LSSTDESC / CLMM

Unwatch 24 Star 9 Fork 8

Code Issues 30 Pull requests 1 Actions Projects 4 Wiki Security Insights

master 55 branches 3 tags

Go to file Add file Code

About

hsinfan1996 Issue/313/fix optimization 2 (#324) ✓ All checks have passed  
2 successful checks

- clmm Issue/312/mock data extra (#316)
- docs Issue/320/rm galaxycluster from dataops (#321)
- examples Issue/313/fix optimization 2 (#324)
- tests Issue/320/rm galaxycluster from dataops (#321) 7 days ago

continuous-integration/travis-ci/push — The Travis... Details

coverage/coveralls — Coverage remained the same ... Details

### COVERALLS

- 85.96 lsst/
- 96.99 modbackend/
- 100.0 \_\_init\_\_.py
- 100.0 clmm\_cosmo.py
- 100.0 clmm\_modeling.py
- 100.0 constants.py
- 100.0 dataops.py
- 100.0 galaxycluster.py
- 100.0 gdata.py
- 95.45 modeling.py
- 0.0 plotting.py
- 100.0 utils.py

# PS: Cluster Detection Validation

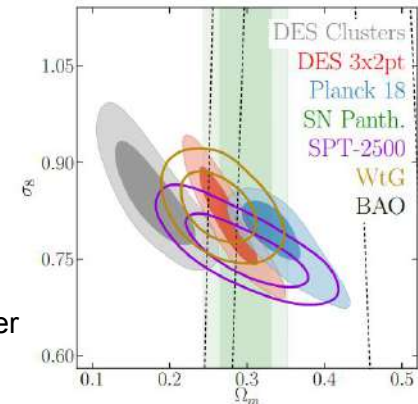
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# Goals



- We expect many cluster catalogs to be produced during the LSST duration (several cluster finders+10 years of observation+simulations)
- Making sure these catalogs meet some minimum quality requirements
- Evaluating important properties of each catalog (selection function, mass proxy, scaling relations)
- Cross-validating catalogs and using feedback information to improve detection and characterization of clusters
- Create a validated, documented and open source repository to be used by the collaboration and the general scientific community

[Dark Energy Survey Year 1 Results: Cosmological Constraints from Cluster Abundances and Weak Lensing](#) (redMaPPer clusters, WL Masses)





# Validating Catalogs

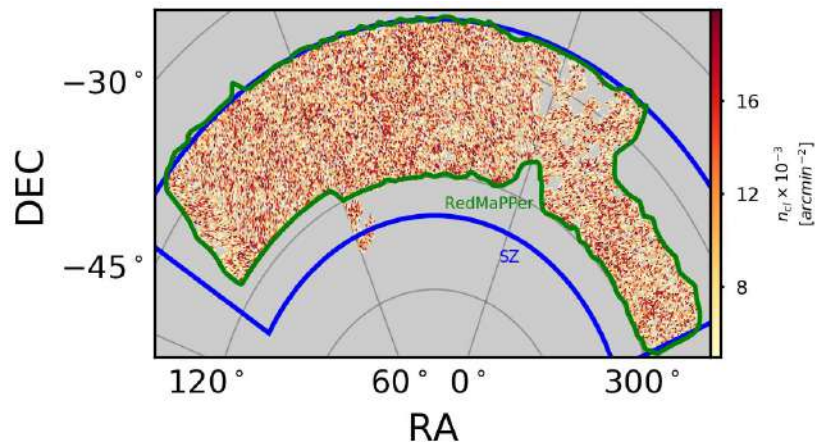
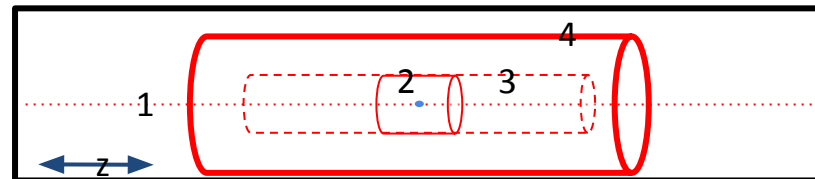


- Self-check
  - General distributions (redshift, mass proxy, magnitudes, colors)
  - Overlap of clusters on the same catalog
- Simulation
  - Matching with Dark Matter Halos
  - Selection function (completeness, purity, fragmentation, overmerging)
  - Cluster-halo relations (mass proxy, size, orientation, redshift)
- Observation
  - Matching with other wavelength clusters (x-ray, sz)
  - Cross matching optical catalogs produced

# Matching Catalogs

- Matching method:
  - Spatial (angular, 3D, 2D+z)
  - Membership
- Types of matching considered:
  - Unique/multiple match
  - One way/cross match
- Sky coverage:
  - Footprints of catalogs
  - Cover fraction
  - Maximum redshift

4 step matching



The WaZP galaxy cluster sample of the Dark Energy Survey Year 1 ([2008.08711](#))

# Software development



- Regular meeting with WG and pipeline conveners to direct code development
- GitHub repository for code versioning
- Documentation
- Unit tests and coverage



## clmm.galaxycluster module

@file galaxycluster.py The GalaxyCluster class

```
class clmm.galaxycluster.GalaxyCluster(*args, **kwargs) \[source\]
```

Bases: `object`

Object that contains the galaxy cluster metadata and background galaxy data

- Variables:
- `unique_id` (*int or string*) – Unique identifier of the galaxy cluster
  - `ra` (*float*) – Right ascension of galaxy cluster center (in degrees)
  - `dec` (*float*) – Declination of galaxy cluster center (in degrees)
  - `z` (*float*) – Redshift of galaxy cluster center
  - `galcat` (*GCDData*) – Table of background galaxy data containing at least galaxy\_id, ra, dec, e1, e2, z

```
add_critical_surface_density(cosmo) \[source\]
```

Computes the critical surface density for each galaxy in `galcat`. It only runs if input `cosmo != galcat.cosmo` or if `sigma_c` not in `galcat`.

Parameters: `cosmo` (*clmm.Cosmology object*) – CLMM Cosmology object

Returns:

Return type: `None`

**COVERALLS**

BUILD TYPE	COMMITTED BY	COMMIT MESSAGE	RUN DETAILS
push github	GitHub	add lowercase fix (#370)	1149 of 1149 relevant lines covered (100.0%) 1.0 hits per line

**JOB**

COVERAGE	JOB	FILES COVERED	RAN
100.0	528018681.1	23	01 Feb 2021 08:00PM UTC

**SOURCE FILES ON BUILD 528018681**

TREE	LIST 23	CHANGED 10	SOURCE CHANGED 10	COVERAGE CHANGED 6
100.0	clmm/			
100.0	cosmology/			
100.0	dataops/			
100.0	plotting/			
100.0	support/			
100.0	theory/			

# Science: WaZP on DC2

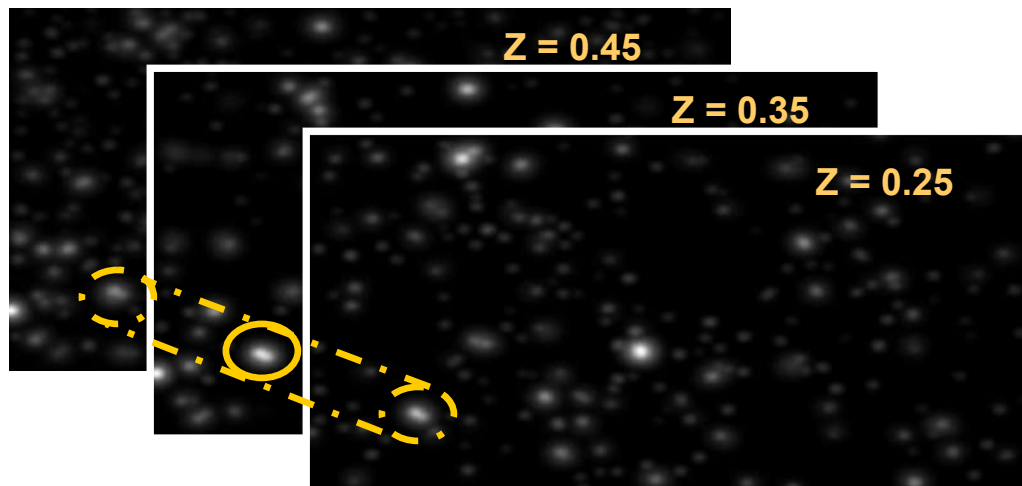
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Michel Aguena + Brazil CWG

# Wavelet Z-Photometric (WaZP)



- Galaxies are selected in redshift slices based on PDZ's from photoz algorithms
- Clusters are detected as overdensities in wavelet based density maps
- No assumption on the galaxy populations of clusters (e.g. red sequence)
- Produces cluster membership probabilities for galaxies

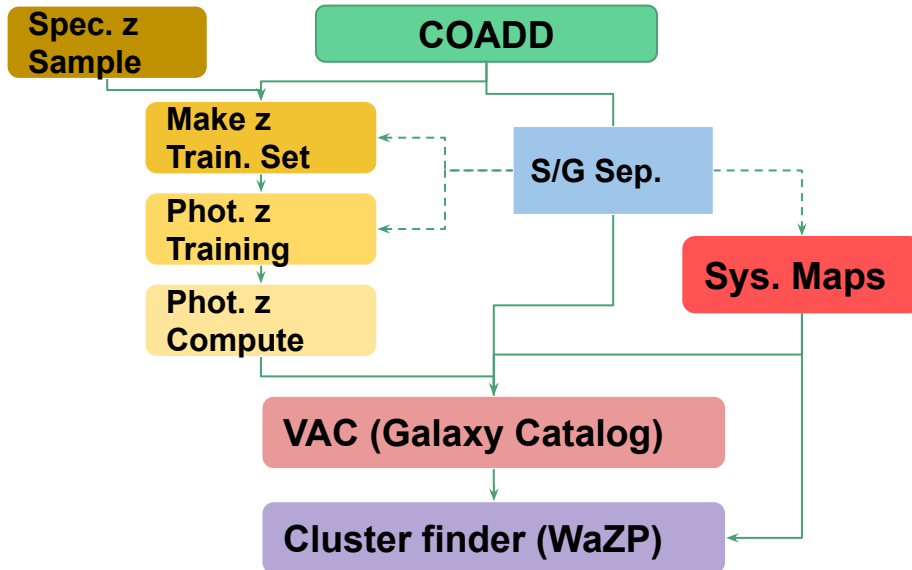


*A 3 deg<sup>2</sup> tile*

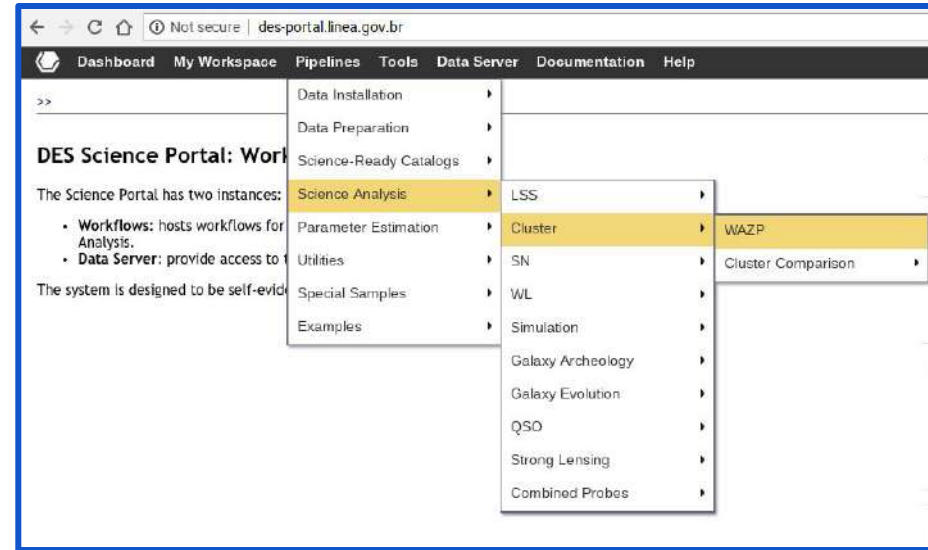
# Producing Catalogs



## Data workflow



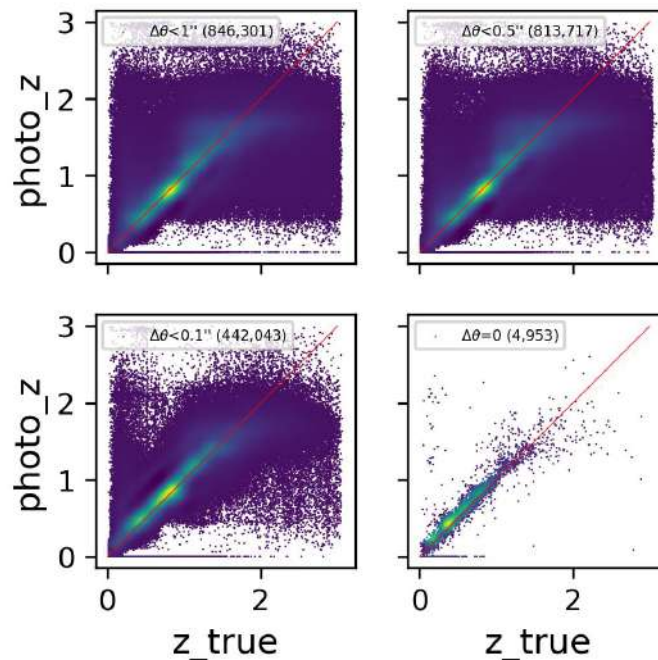
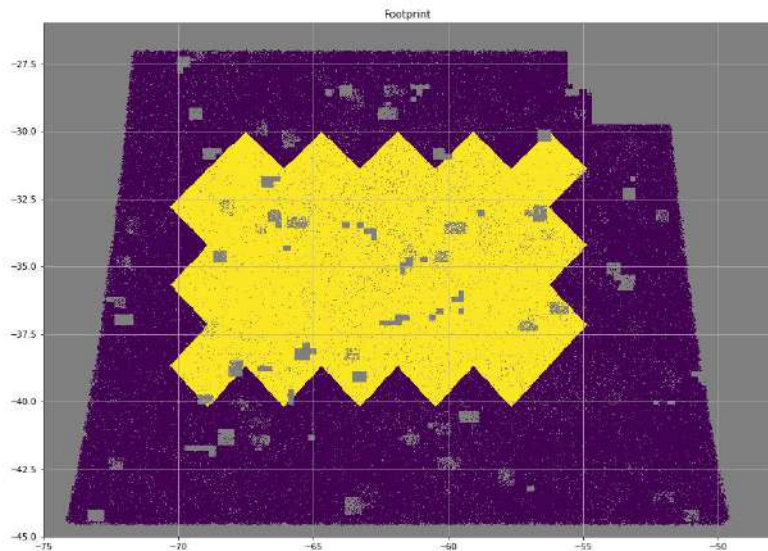
## LineA Science Portal



- Run the WaZP both truth and image simulated catalogs
- Compare with Halos and RedMaPPer
- Evaluate the impact of photo-z (true  $z$  X gaussian  $p_z$  X real photo-z X full pdf) on:
  - cluster detection purity and completeness
  - richness estimation
  - mass-richness scaling relation
  - selection function
  - membership assignment of cluster members, which can then be directly compared to the redMaPPer clusters.
- Evaluate limitations - physical and algorithmic assumptions of CF
- Construct path for cosmology

# DC2

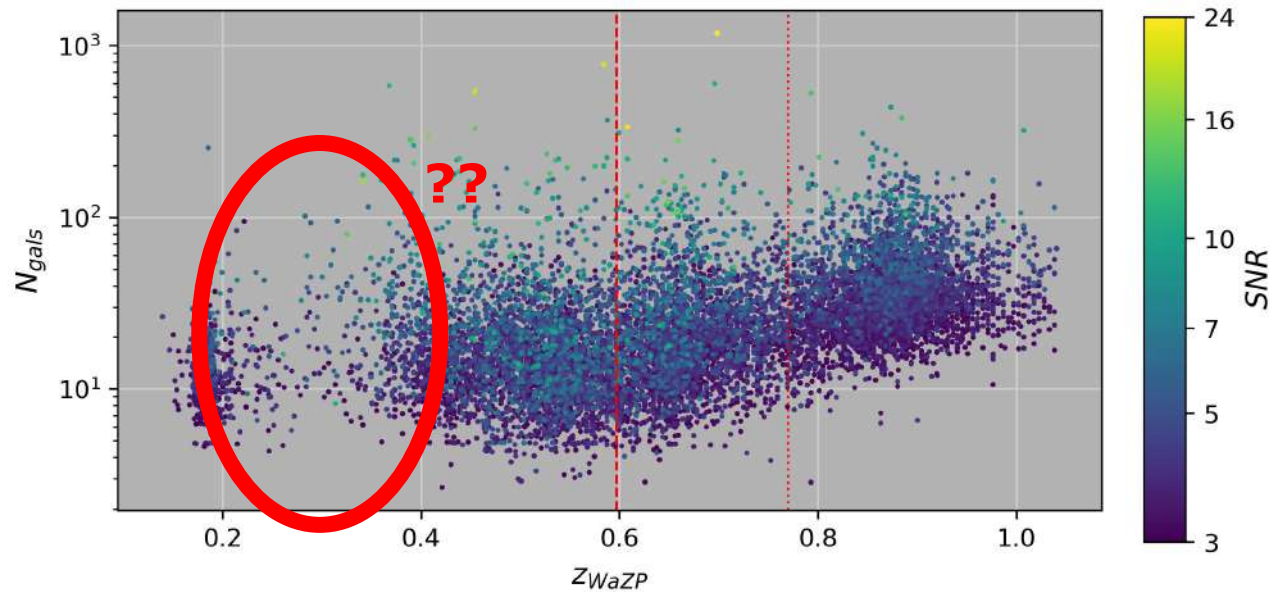
- Run 2.2i dr3 - photo-z
- Defining Small Region
- Preparing LIneA's infrastructure for DC2
- Matched with true catalogs (thanks to J. Sanchez)





# DC2 - WaZP

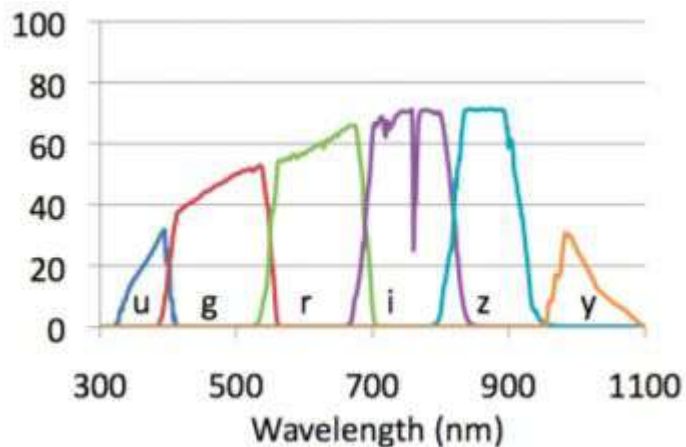
- First WaZP run



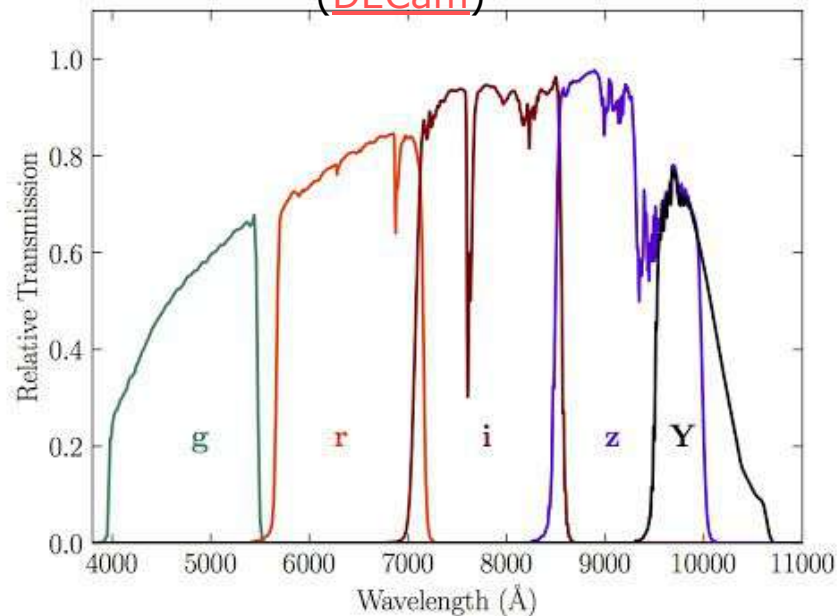
# DC2

- Internal calibration has to be updated for LSST magnitudes

LSST (Science book)

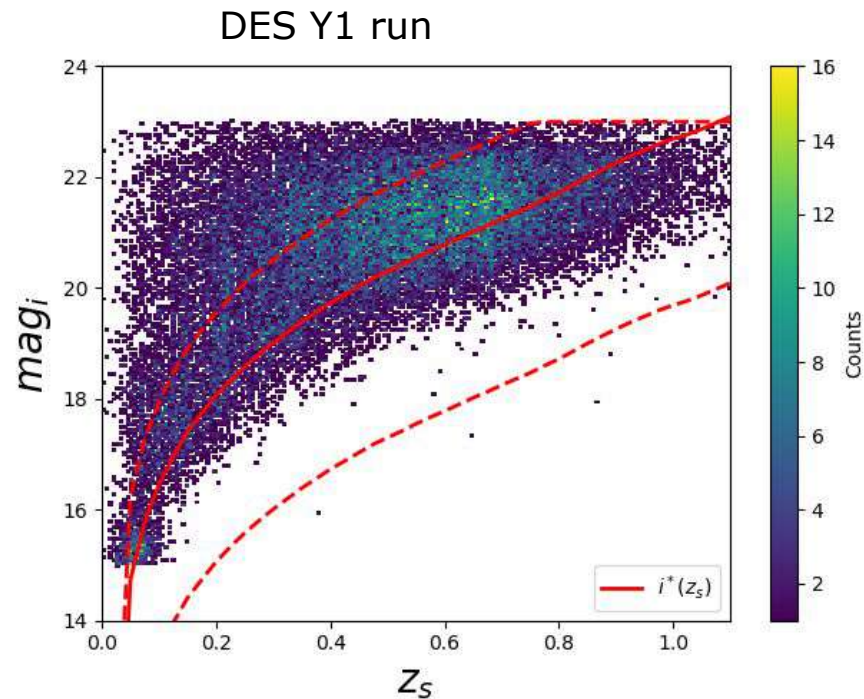
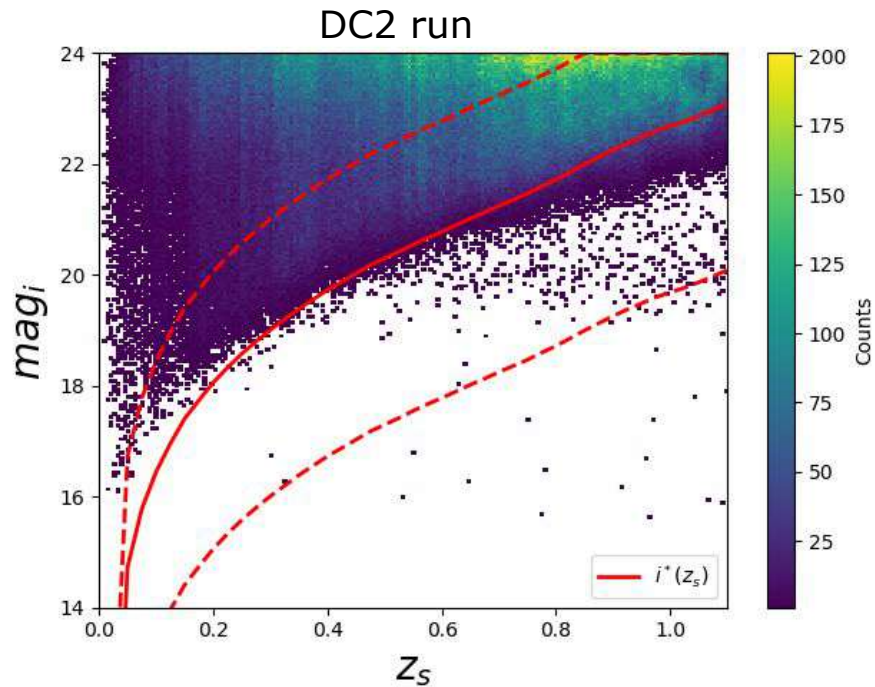


DES  
(DECam)



# DC2

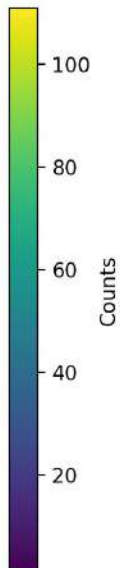
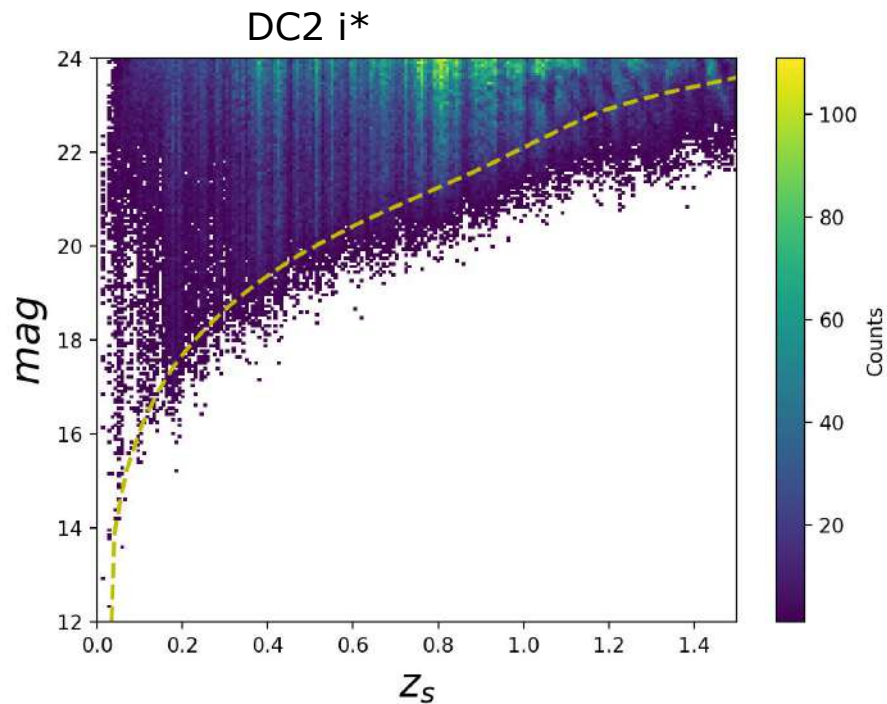
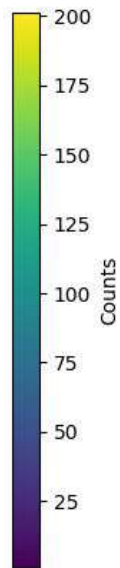
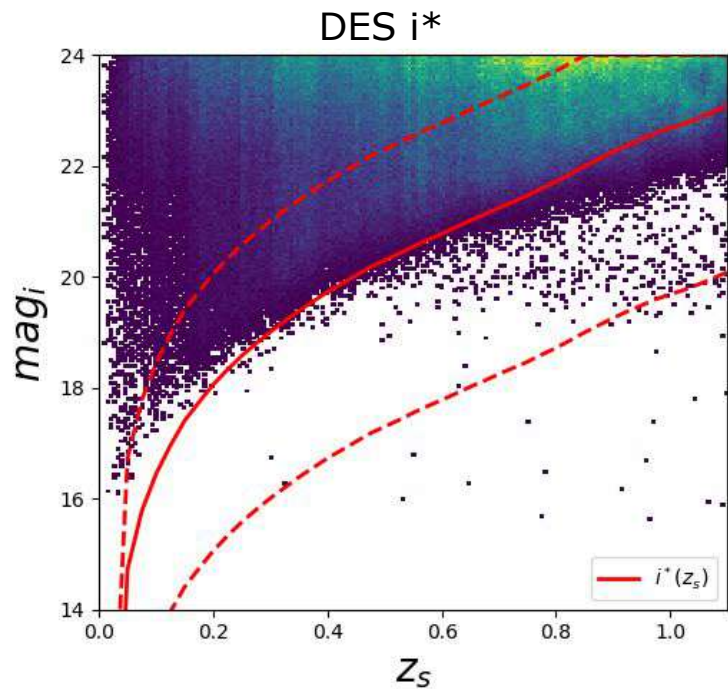
- Effect of magnitude calibration on detection



# DC2



- Effect of magnitude calibration on detection



# DC2



- Review Sample
  - cosmoDC2 v.1.1.4
    - Extragalactic Catalog
    - Image Simulation
      - DR3 (Y2)
      - DR6 (Y5)
- Provide feedback to the CSS (Cosmological and Survey Simulations) Working Group

