

# From Simulations to Early Data: Galaxy Cluster Cosmology with LSST-DESC

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on behalf of the LSST-DESC Cluster working group  
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# Legacy Survey of Space and Time (LSST)

## NSF-DOE Vera Rubin Observatory

*Cerro Pachón, Chile*

- 8.4-meter telescope
- Wide-field sky survey



## LSST Camera

*Largest Ever Build*

- 32000 Megapixels
- New image every ~40 s
- 3 nights → Southern sky
- 6 filters: u, g, r, i, z, y  
(~320–1050 nm)



# Legacy Survey of Space and Time (LSST)

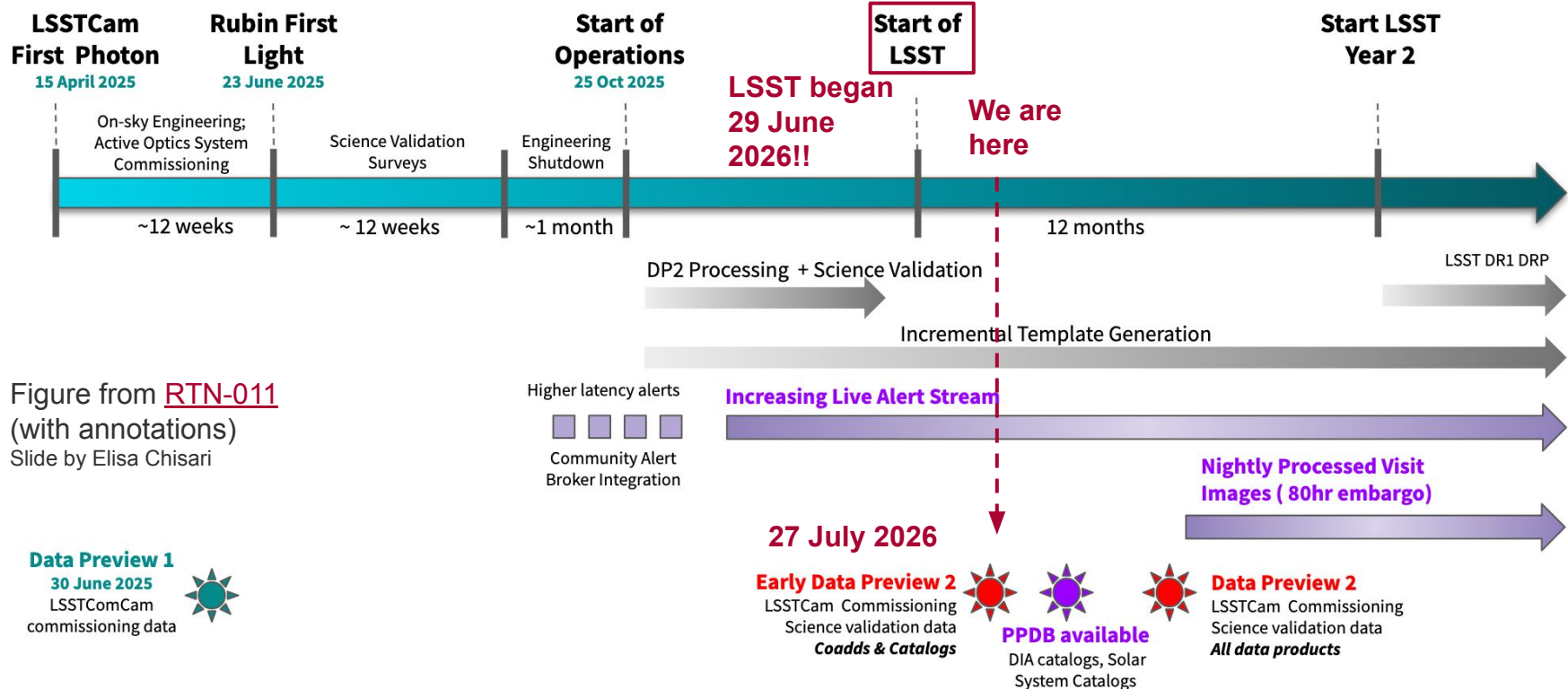


Figure from [RTN-011](#)  
(with annotations)  
Slide by Elisa Chisari



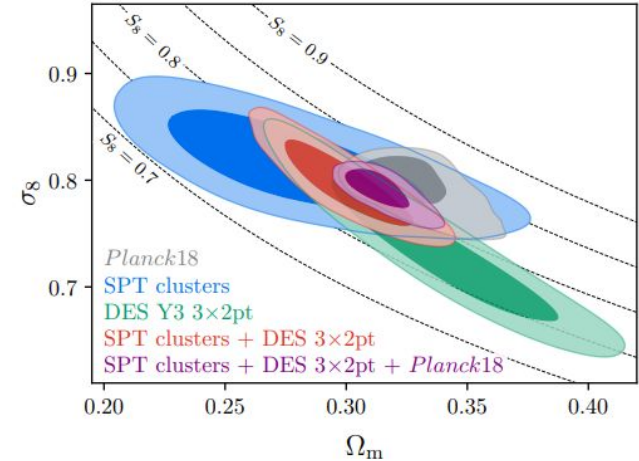
**DP2 COSMOS**

**gri -> (~60, 100, 90) visits each  
(26.6, 26.2, 25.9) 5-sigma point source depth  
Similar HSC-Wide depth with few visits**

# Cosmology with galaxy clusters

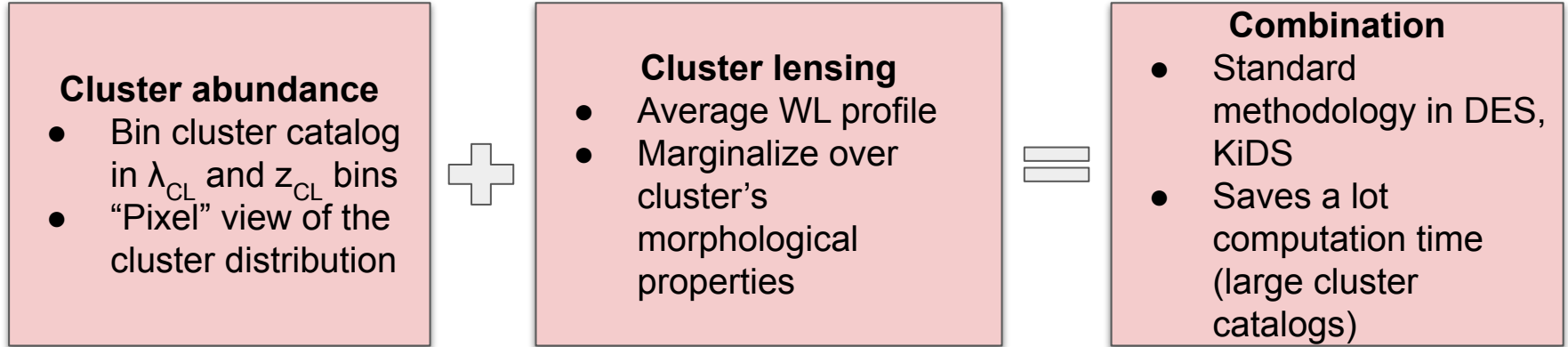
- Most massive collapsed structures  $\rightarrow$  sensitive to  $\sigma_8$  and  $\Omega_m$
- ~85% dark matter, ~14% gas, ~1% galaxies
- Probe to dark matter, LSS formation
- CL Abundance + CL Weak Lensing
- Complementary to 3 $\times$ 2pt: orthogonal systematics
- LSST expects ~100,000 clusters detected

Bocquet25+

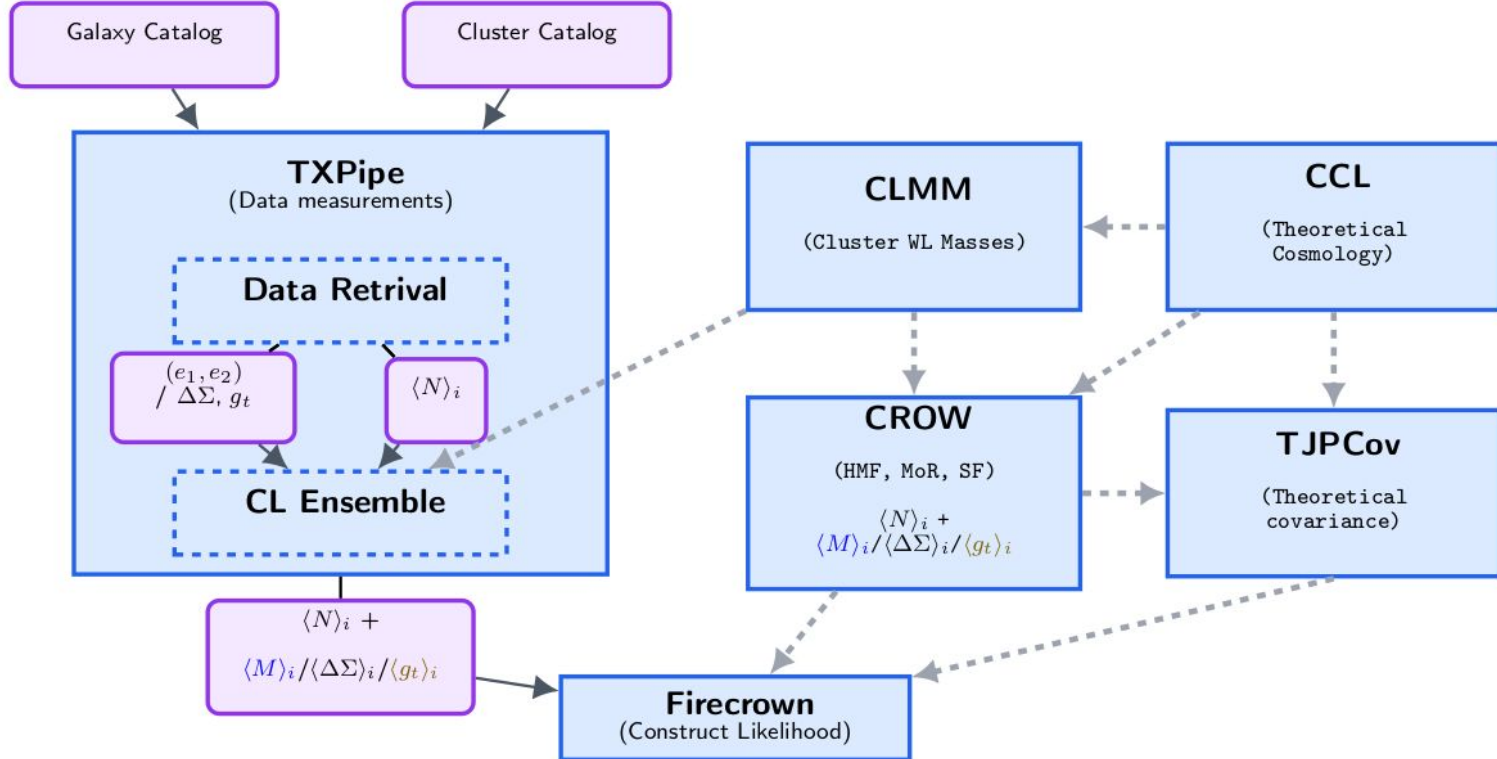


# Cosmology with galaxy clusters

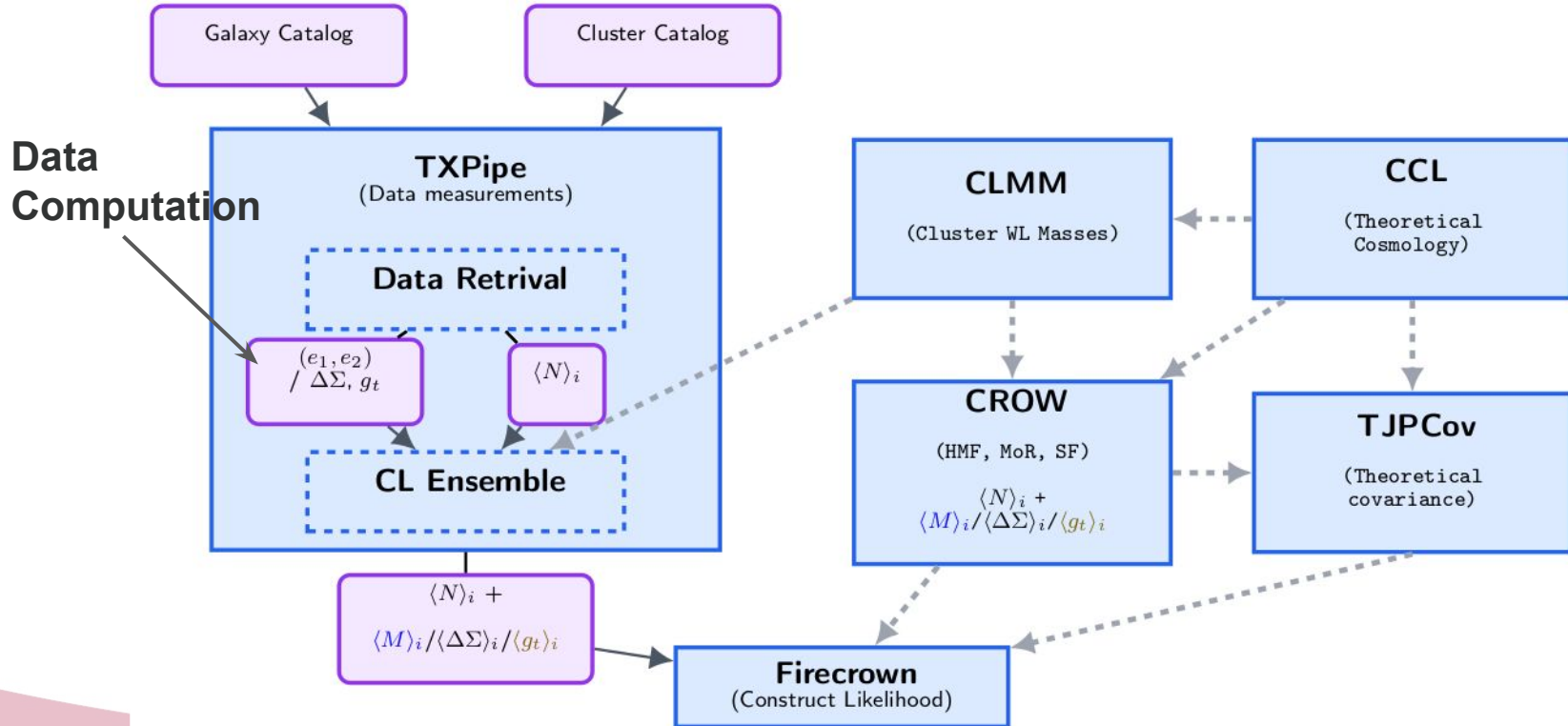
## Our methodology so far: Binned approach



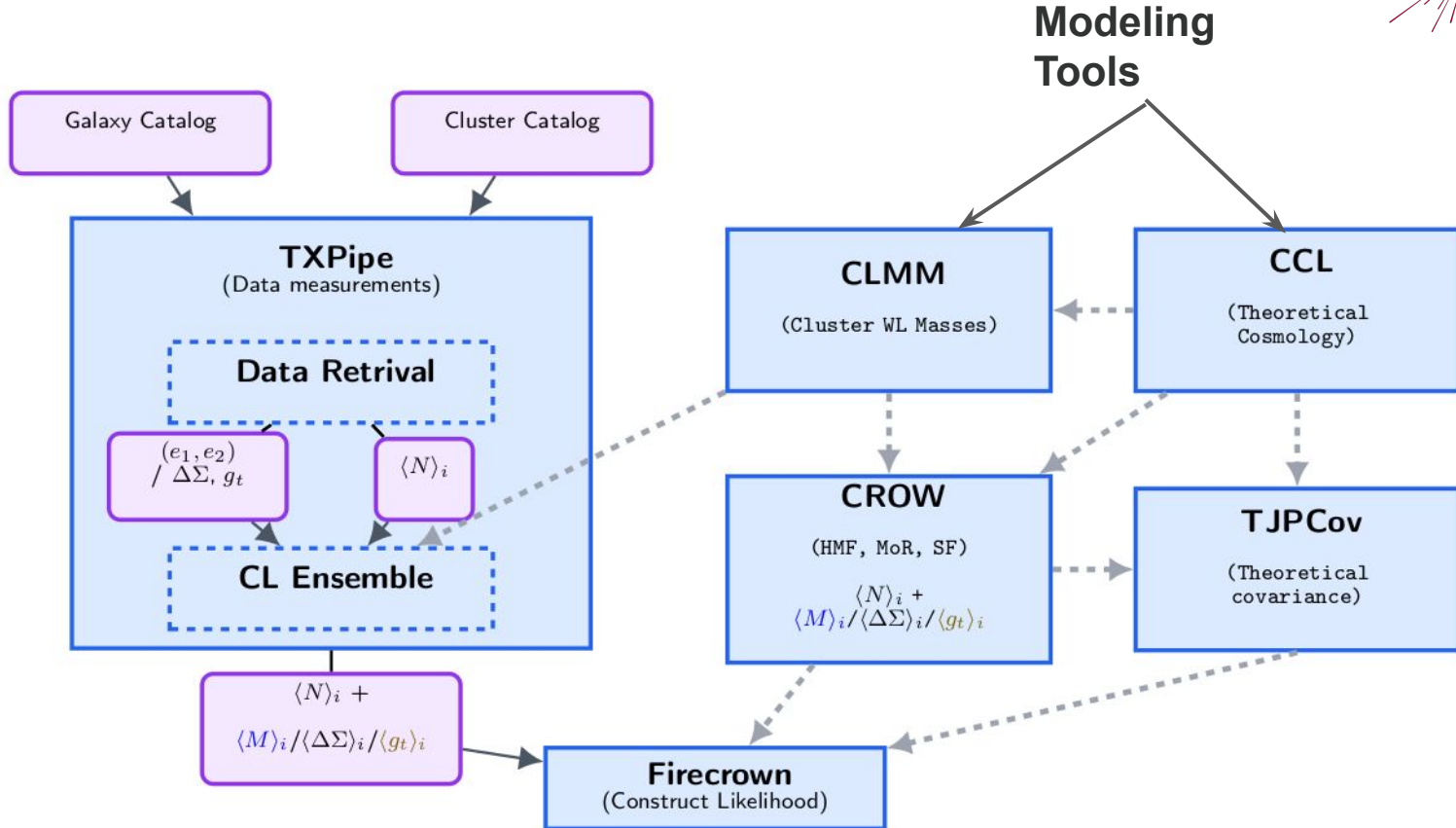
# Current status of the DESC Cluster Pipeline



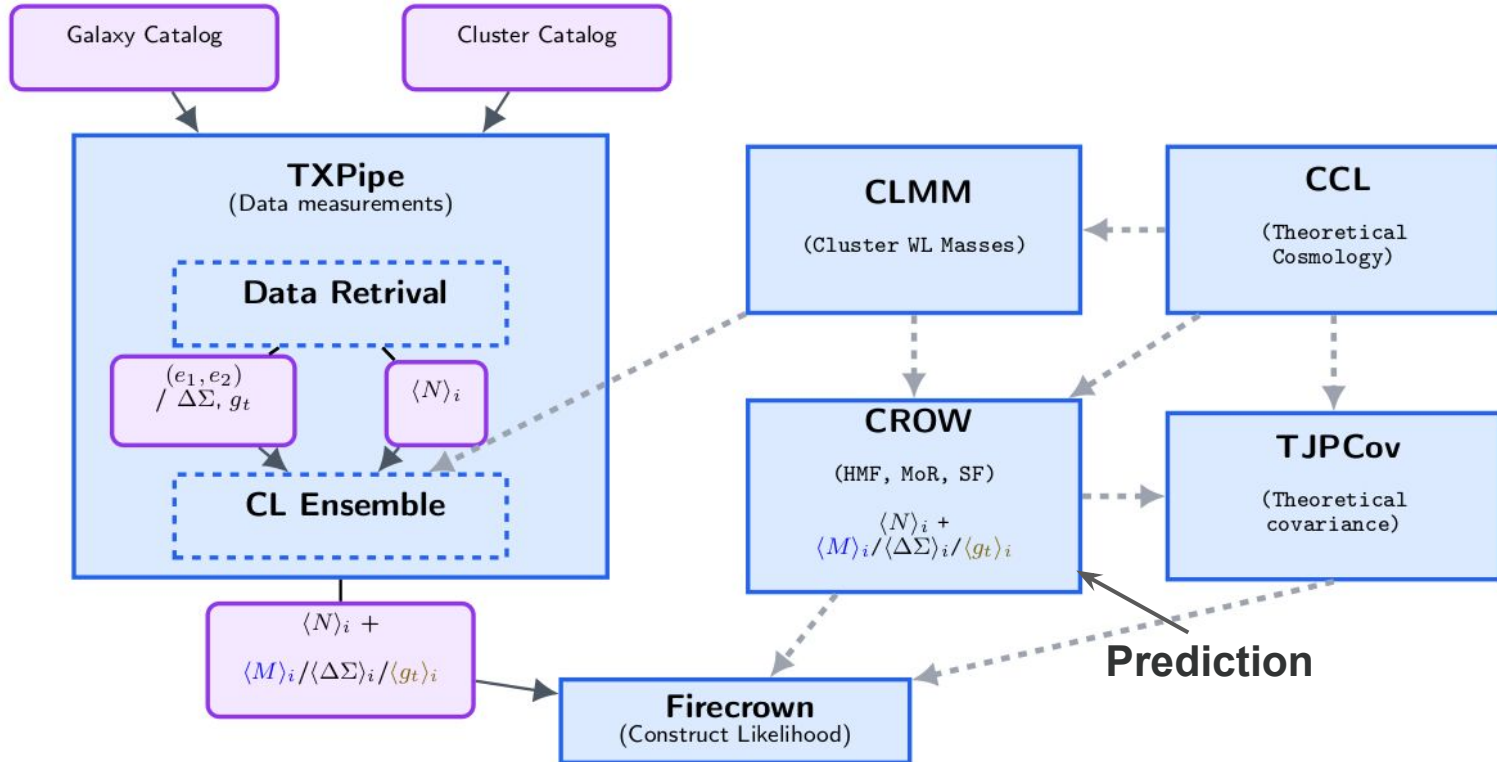
# Current status of the DESC Cluster Pipeline

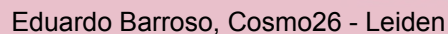


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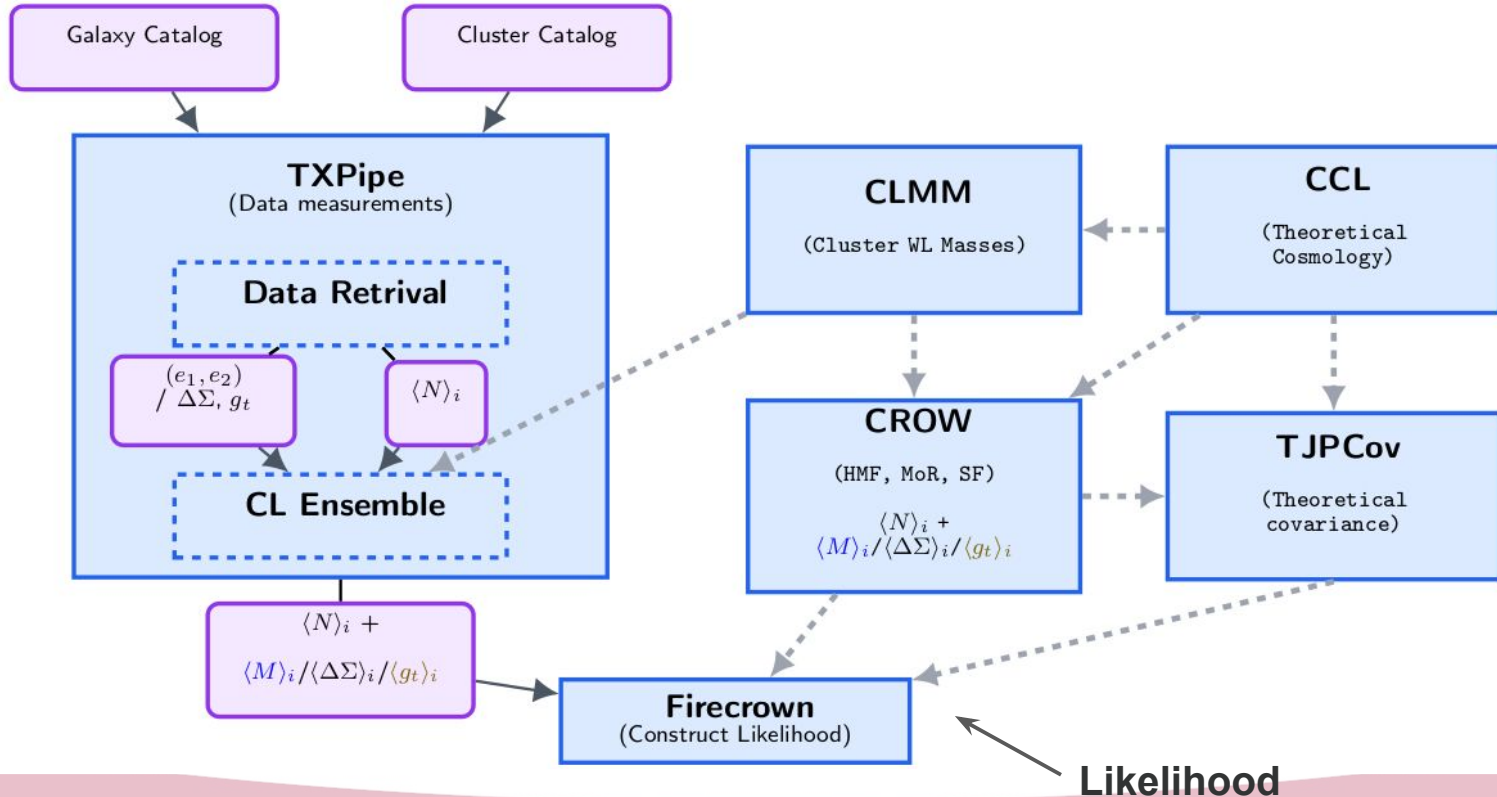


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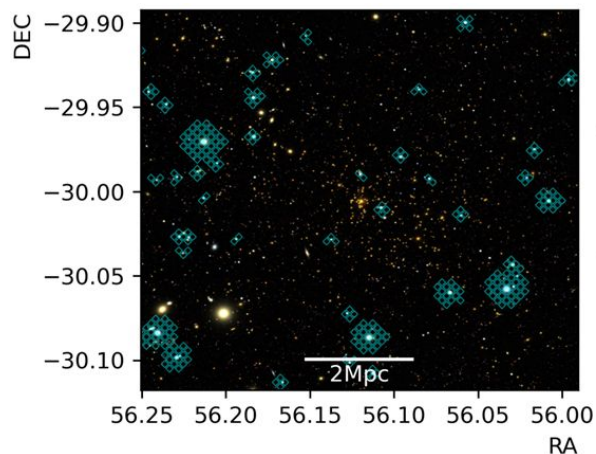


# Validation on simulations

# WaZP cluster finder applied to DC2

## Characterizing the WaZP Cluster Finder on LSST Simulated Images

R. Solomon<sup>1,5</sup>, M. Aguena<sup>2,3</sup>, C. Benoist<sup>4</sup>, T. Guillemin<sup>1</sup>, E. J. Barroso<sup>1</sup>, D. Boutigny<sup>1</sup>, L. da Costa<sup>2</sup>, N. Amouroux<sup>1</sup>, and S. J. Schmidt<sup>6</sup>



Largest DC2 WaZP cluster with masks

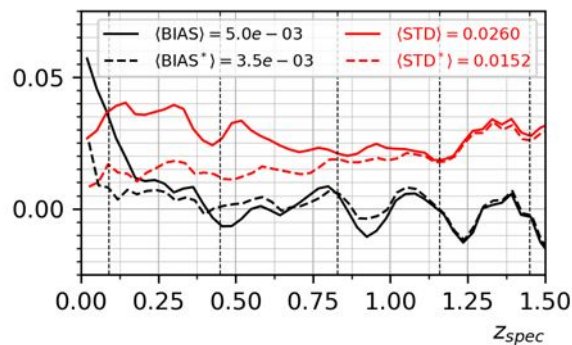
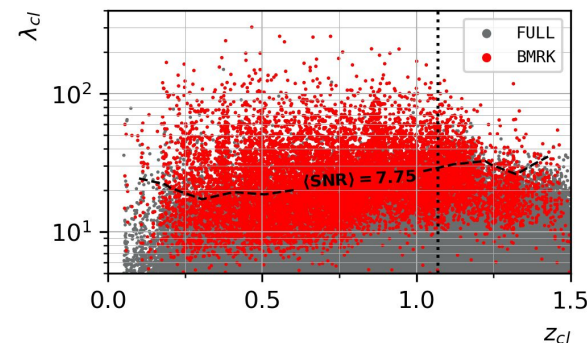


Photo-z performance  
(TPZ with a special configuration)



Full 0.99 complete, 0.21 pure  
BMRK 0.78 complete, 0.75 pure

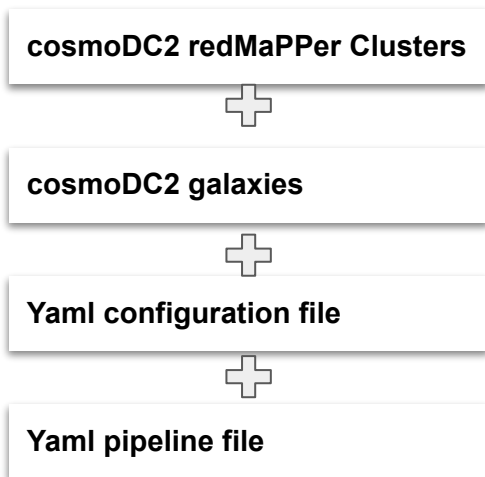
**WaZP DC2 paper in DESC internal review**

# End-to-end LSST DESC Cluster pipeline

## Project

- **Goal:** Unify all DESC cluster-cosmology tools into one automated, end-to-end pipeline
- **Motivation:** consistent systematics across probes, less human error, reproducible, modular
- **First time these tools are validated as one integrated system, not separately!!**

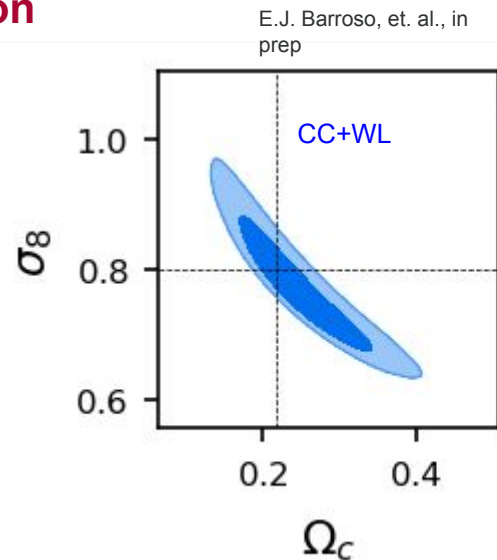
## Validation with cosmoDC2 simulation



### Binned analysis

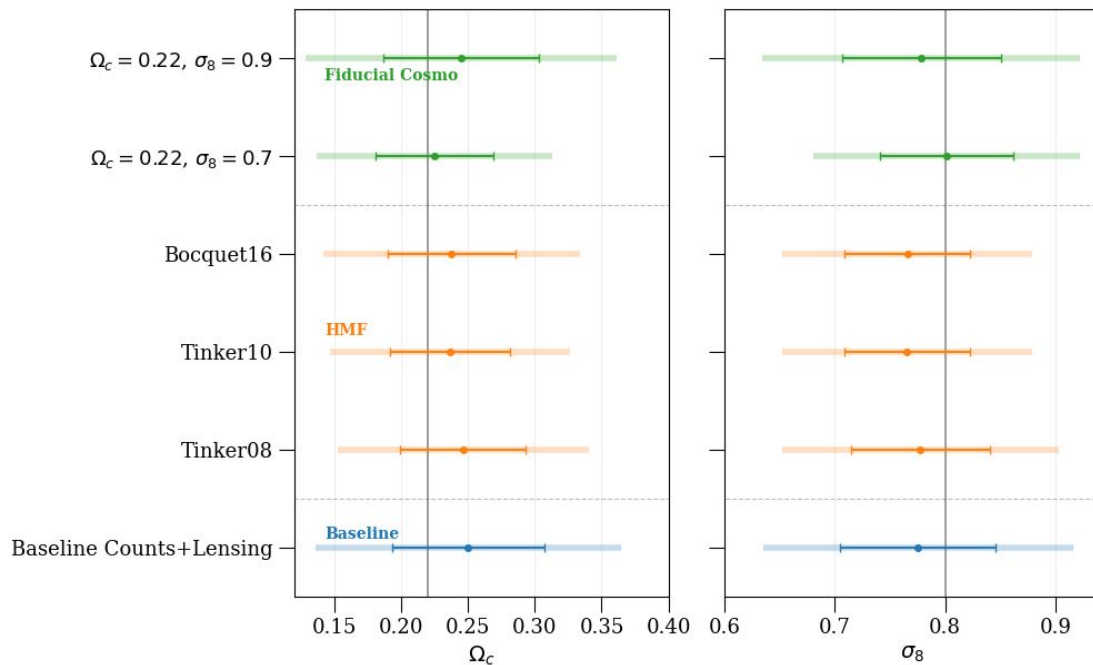


$\Omega_m, \sigma_8 + 6$  MoR parameters sampled



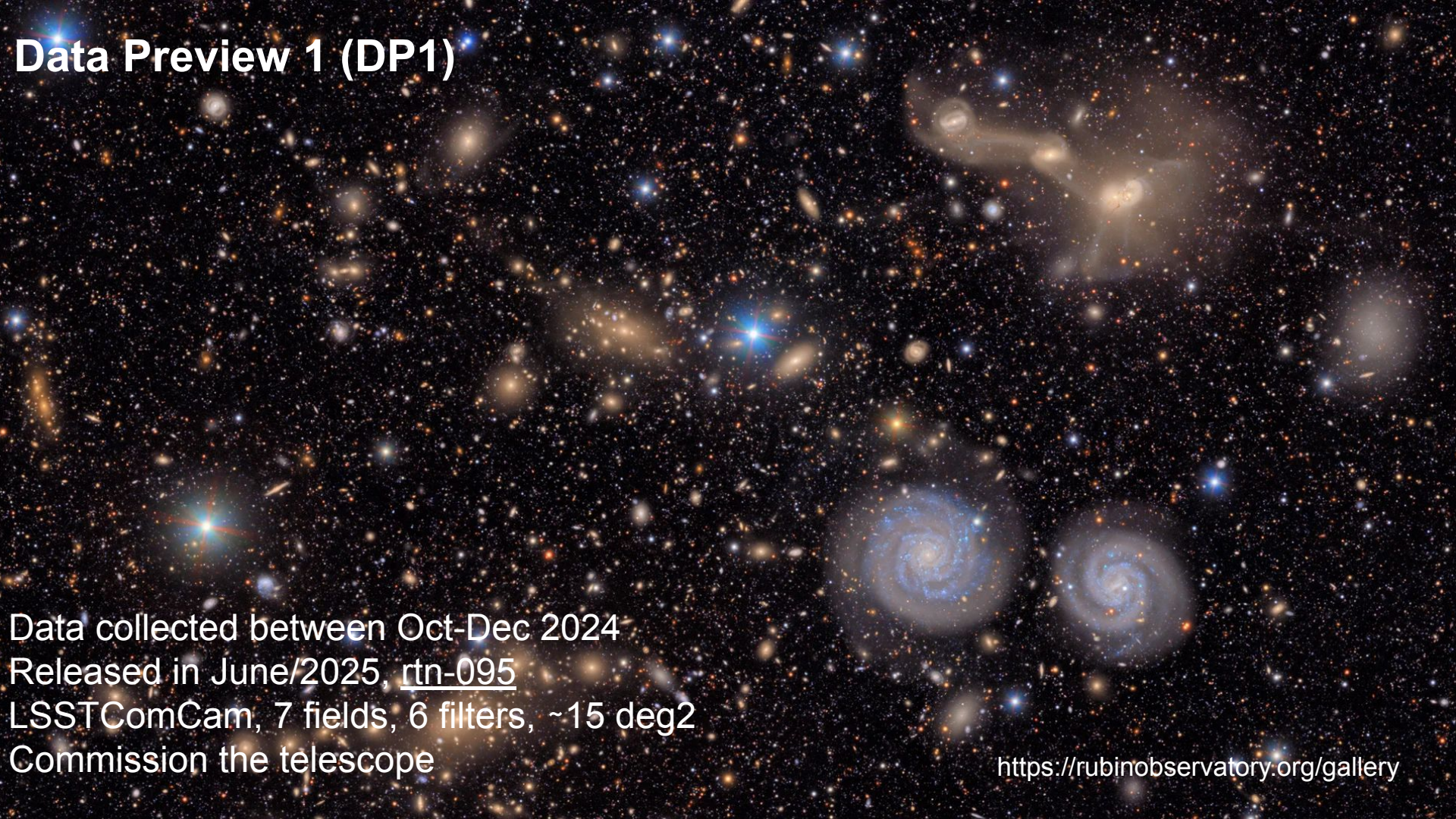
# End-to-end LSST DESC Cluster pipeline

## Validation with cosmoDC2 simulation



- Modular pipeline
- Different configuration choices
- **v1 pipeline** and results presented in *E. J. Barroso et al*, in preparation, being finalized!!

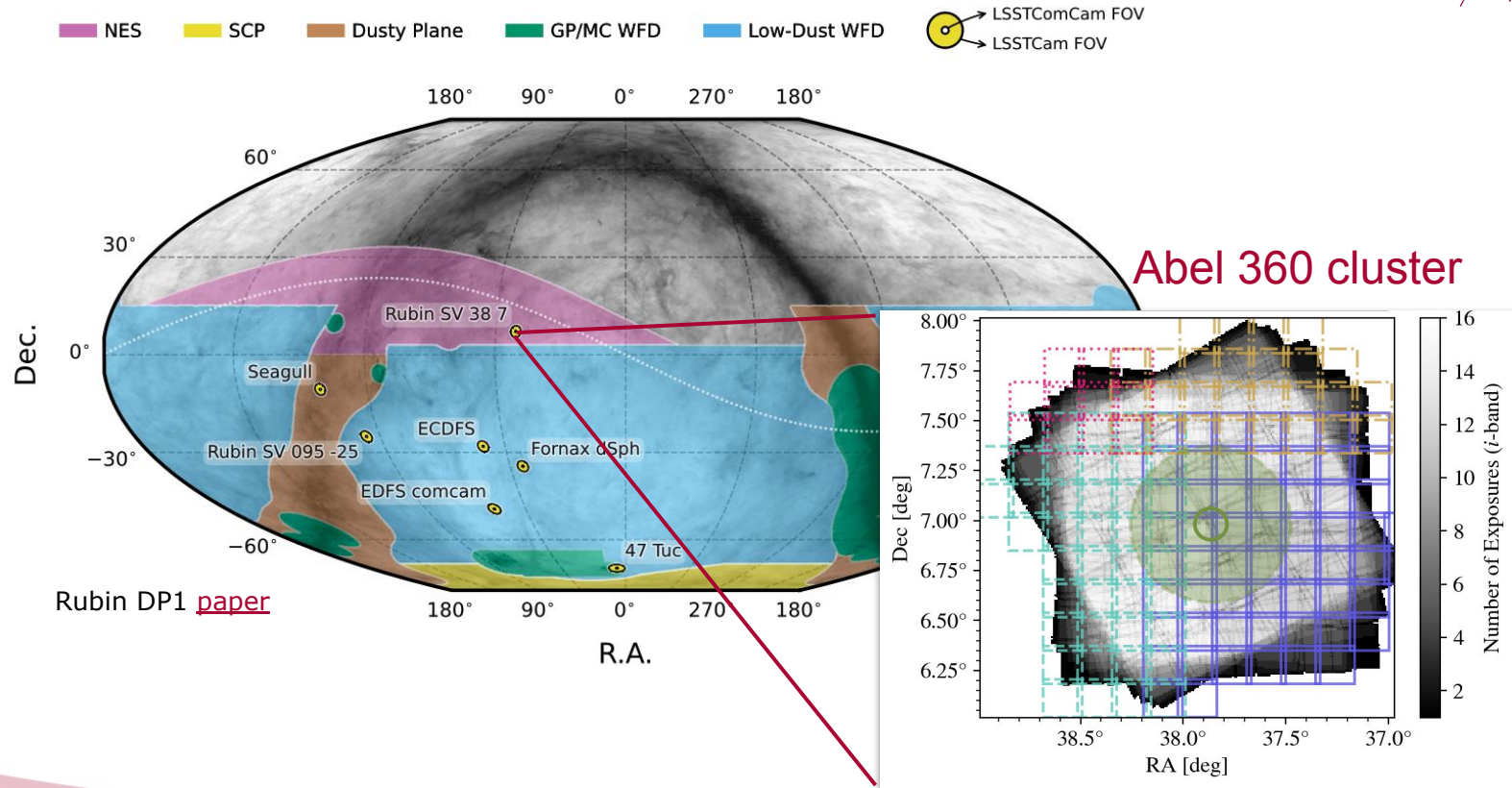
# Data Preview 1 (DP1)



Data collected between Oct-Dec 2024  
Released in June/2025, rtn-095  
LSSTComCam, 7 fields, 6 filters, ~15 deg<sup>2</sup>  
Commission the telescope

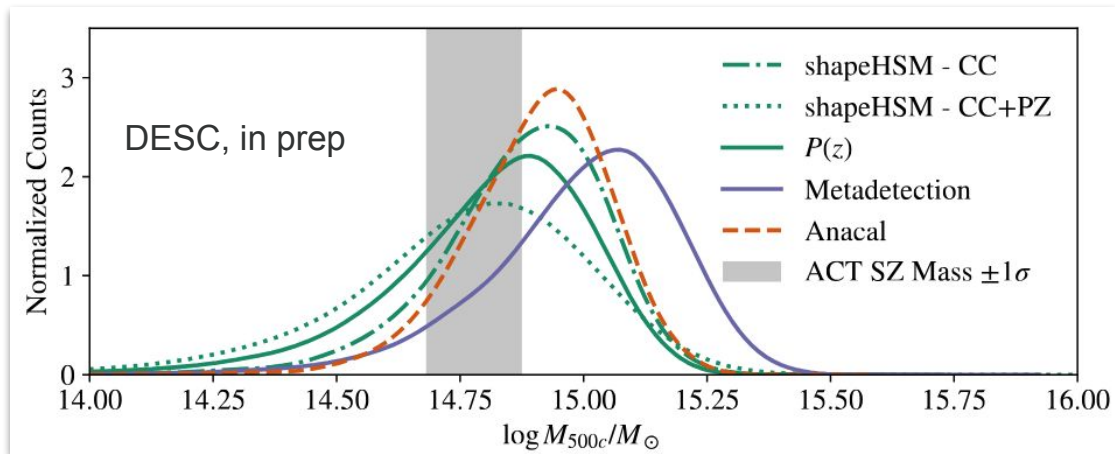
<https://rubinobservatory.org/gallery>

# Data Preview 1 (DP1)



# DP1 Abel 360 project

- **Goal:** Study a known cluster with LSST DP1 data
- Same DESC tools but not the end-to-end pipeline
- Significant detection of tangential shear signal for samples



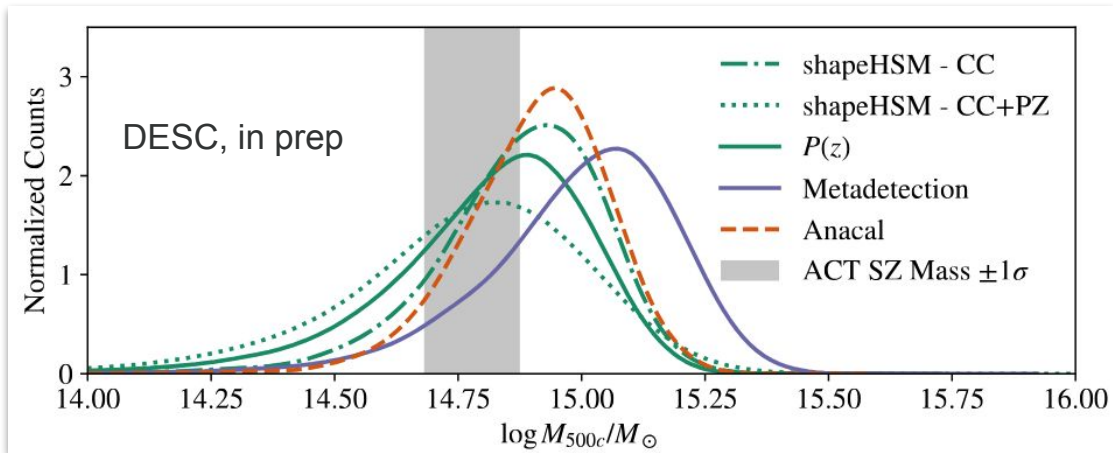
All mass estimates agree within  $1\sigma$

Reasonable agreement with the SZ mass from ACT DR5.

# DP1 Abel 360 project

- **Goal:** Study a known cluster with LSST DP1 data
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- Significant detection of tangential shear signal for samples

- Measure shear profile
- Estimate weak lensing mass
- Test science pipelines (photometry/photoz, PSF correction, etc)

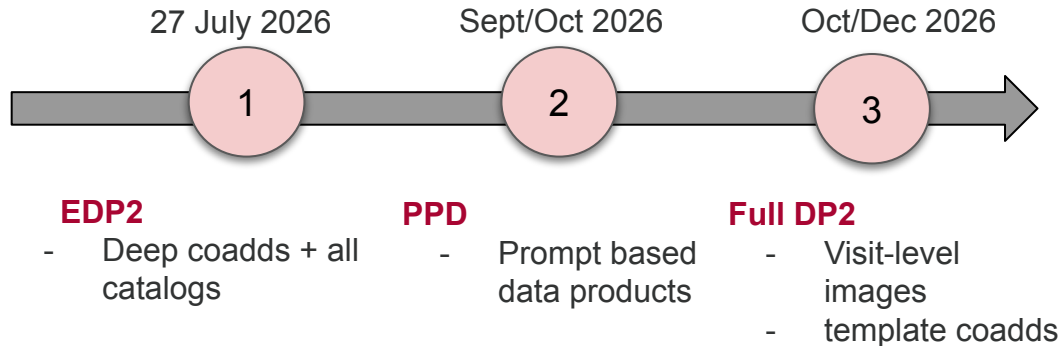


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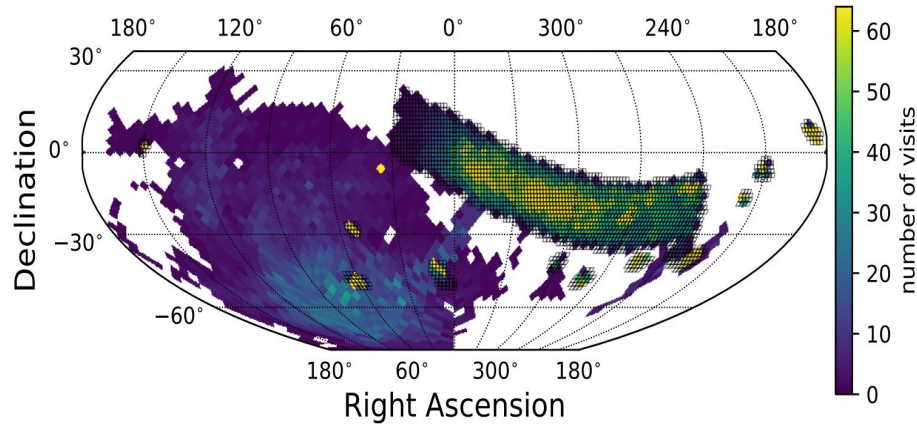
## Data Preview 2 (DP2)

- LSSTCam commissioning + Science Validation data (17 Apr – 21 Sep 2025) + early operations (25 Oct 2025 – 6 Jan 2026)
- ~30,000 science visits
- ~15 000 deg<sup>2</sup>,  $\ln \geq 1$  filter
- ~3 000 deg<sup>2</sup>, Coadded (all 6 bands)



## Data Preview 2 (DP2)

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| Subset                 | N visits | u    | g    | r    | i    | z    | y     |
|------------------------|----------|------|------|------|------|------|-------|
| 3 000 deg <sup>2</sup> | 38       | 24.2 | 25.0 | 24.9 | 24.5 | 23.8 | 22.26 |
| 750 deg <sup>2</sup>   | 56       | 24.4 | 25.2 | 25.2 | 24.8 | 24.0 | 23    |
| 300 deg <sup>2</sup>   | 64       | 24.5 | 25.2 | 25   | 24.9 | 24.1 | 23    |

300 deg<sup>2</sup> = Y1 depth in all bands

Figure and information from [RTN-011](#)

# LSST-DESC Clusters DP2 Project



**DP2 Cluster Key Project:** Perform a WL mass calibration analysis in DP2 on known and DESC-detected clusters.\*

Estimate the WL masses using cluster catalogs from:

1. legacy surveys such as ACT, DES, and HSC
2. DESC CL finding algorithms, such as redMaPPer and WaZP, run on DP2.

## Analysis Steps

**Cluster detection & characterization**

redMaPPer/ WaZP run on DP2

\*This is a cross WG project (shear calibration, foreground masking, redshift catalog, ...)

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## Analysis Steps

### Data vector generation

Different estimators (  $\Delta\Sigma$  vs  $g_t$  )  
shear calibrations  
tomographic bin vs individual photo-z

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## Analysis Steps

### Covariance calculation

Data-driven (Jackknife) vs. Theoretical

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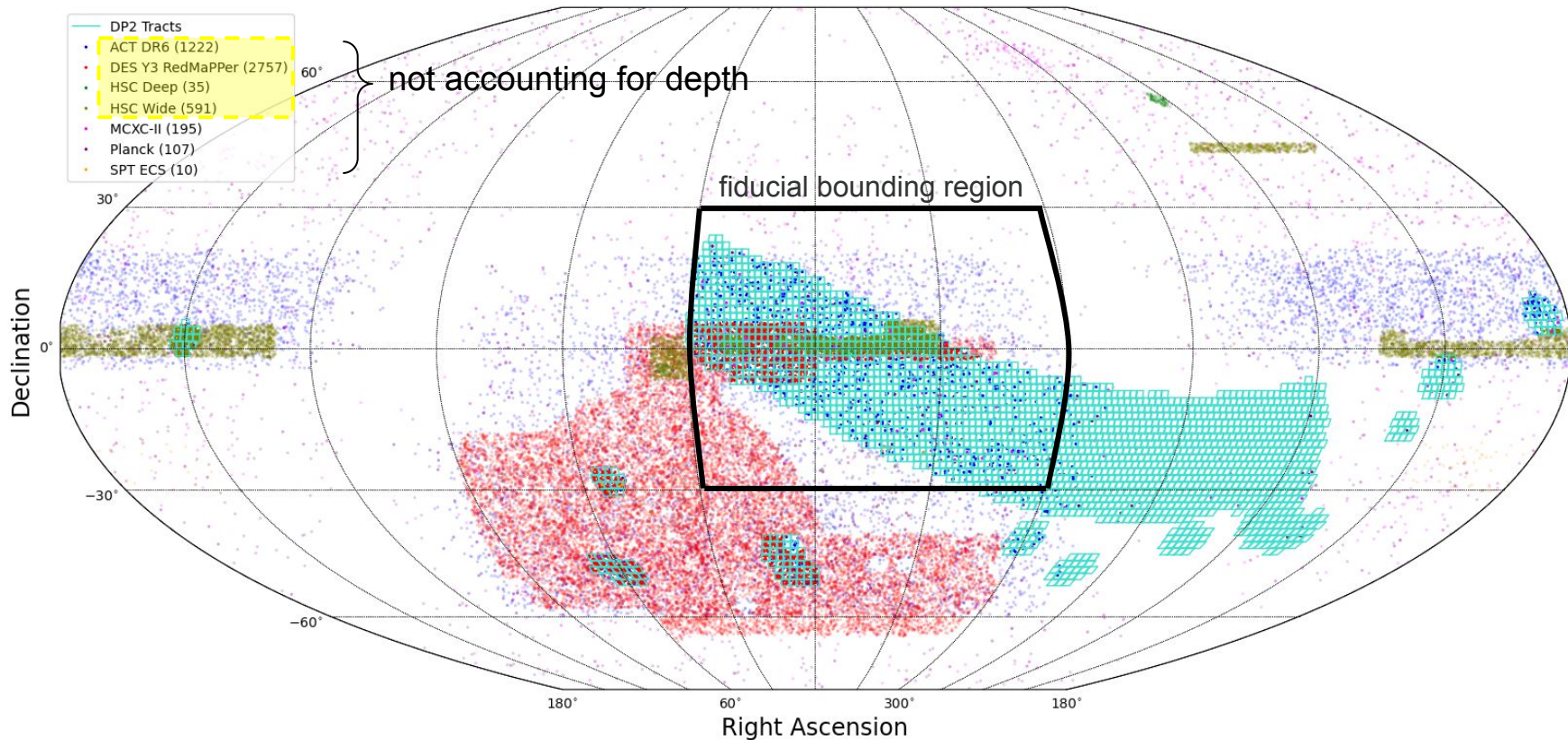
## Analysis Steps

### Modeling and fitting

HMF, scaling relation, halo profile,  
systematics (miscentering, boost factor,  
projection...)

\*This is a cross WG project (shear calibration, foreground masking, redshift catalog, ...)

# Known Clusters



# Summary

## 1. LSST DESC Cluster simulation validation

### a. Wazp on DC2

- Successfully run the Wazp cluster finder on DC2 simulation (R.Solomon et. al., under collaboration review)

### b. End-to-end LSST DESC cluster pipeline

- Fully first version connected to DESC tools
- This pipeline can be applied to DP2 with minor implementations
- v1 pipeline and results presented in *E. J. Barroso, et al.* in preparation, being finalized

## 2. DP1 with A360

- First WL signal detection and first cluster mass estimate with Rubin data!
- DESC, et. al., in prep

## 3. DP2 Cluster Key project

- WL mass calibration analysis in DP2
- First use of the pipeline to real data
- We will test the readiness of our tools, LSST systematics and prepare for DR1

# Thank you for the attention!

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