Advancements in the DESC Cluster Pipeline: Current State and Cosmological Analysis with Firecrown

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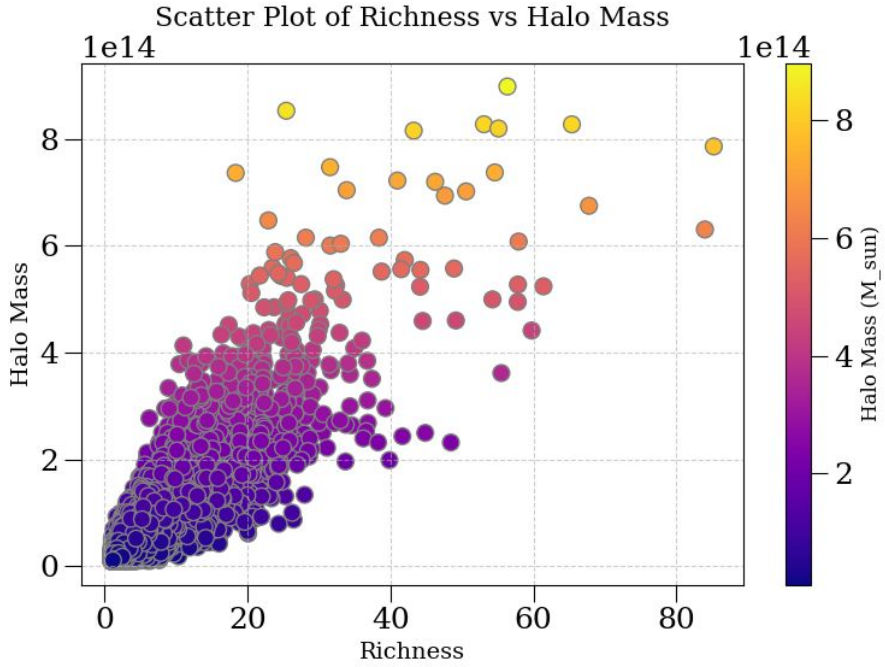
Galaxy clusters

- Galaxy clusters are the biggest gravitational bounded object in the universe and thus is a good candidate for analysing Large Scale Structure Formation (LSS)

- No direct detections of some of the clusters features needed for predictions (for instance, their mass)

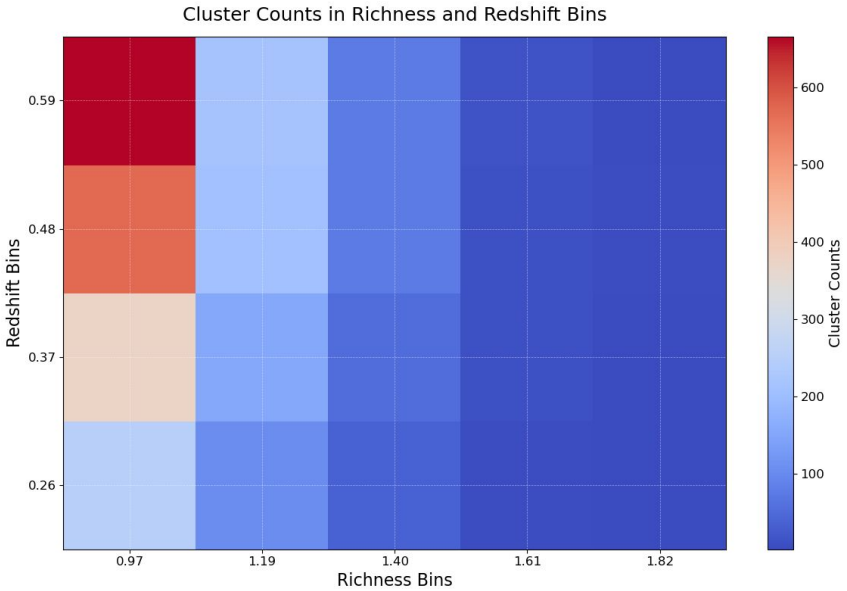
- 2 probes: number of clusters in the sky and the lensing signal from source galaxies behind the cluster



Cluster Number Counts

Given a sky area, redshift and richness bins:

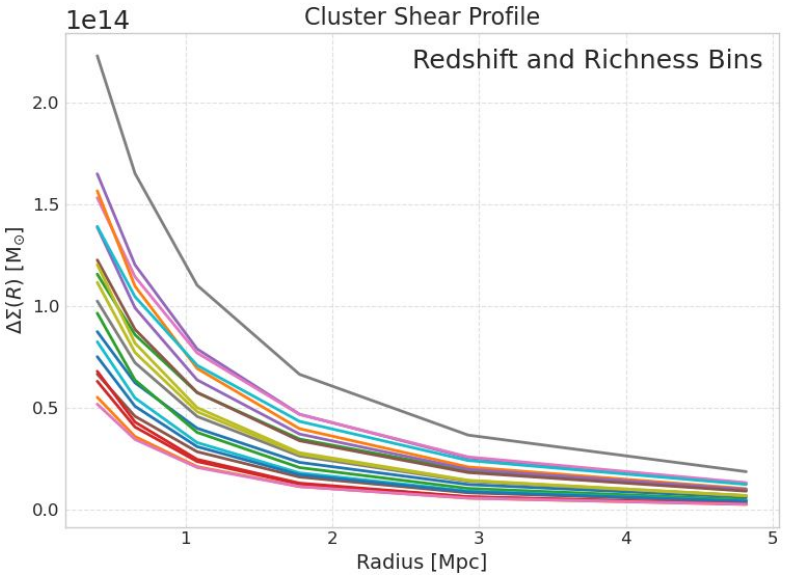
- The number **N** of clusters in the bins



Cluster Shear Profile

Given a sky area, redshift, richness and radius bins:

- The stacked excess density surface mass in each bin

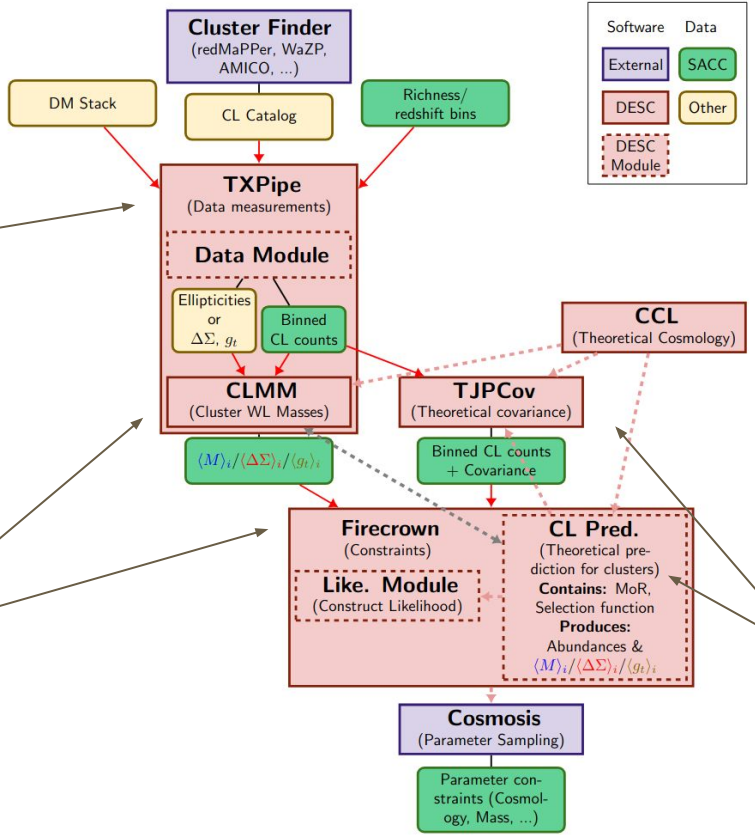


Galaxy clusters in LSST-DESC working group

- A primary goal is to obtain constraints on Ω_m and σ_8 from the Λ - CDM
- For the analysis we need:
  - Data (simulations for the moment)
  - Organize the data into catalogs with the needed information
  - Make the theoretical predictions (counts, weak lensing, covariance)
  - Implement the likelihood between data and prediction
  - Run an MCMC

- We need a pipeline that is able to go from a cluster catalog to the above constraints, while maintaining consistency. The catalog must have information about:
  - Mass
  - Redshift
  - Shear signal

The Desc Cluster Pipeline



TXPipe processes/generates cluster catalogs.

Firecrown is Python package that offers the DESC framework for implementing likelihood

CCL is a public, standardized library used for calculating key cosmological observables.

CL prediction module contains extra cluster calculations needed for the analysis

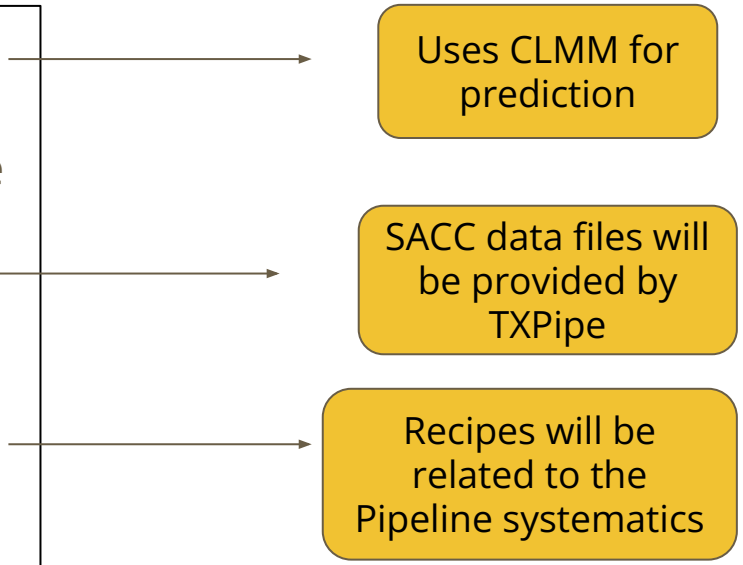
Firecrown

Python package that offers the DESC framework for implementing likelihood

Key properties	Relevant cluster codes
• Dedicated likelihood implementations for 3x2 point, weak lensing, cluster counts, supernova, etc. • Connection with cosmosis (MCMC) and NumCosmo. • Data Reading	**Cluster theory model** • Cluster counts prediction implementation • Cluster shear prediction implementation
	Cluster Statistics FIles
	Likelihood construction, data reading/writing for different data types.

Firecrown Shear Implementation

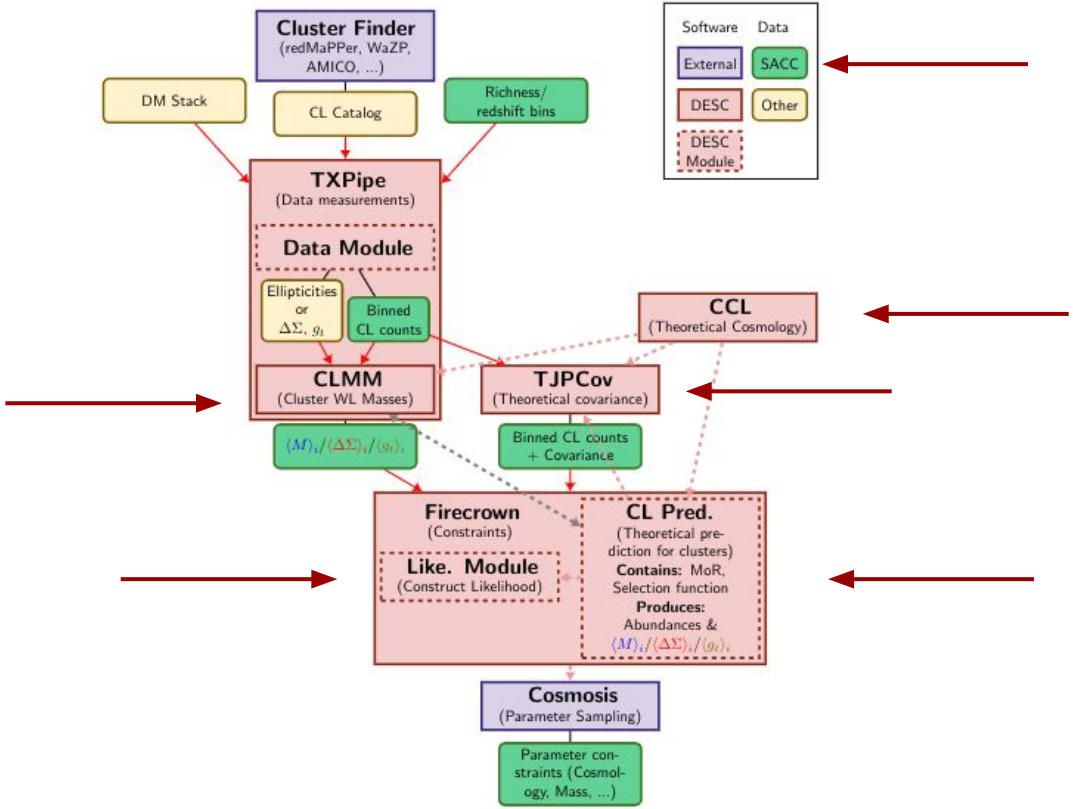
- Added theory predictions to compute shear signal
- Add code to read and organize new data from the SACC format
- Create a recipe for theoretical prediction
- Create new statistics object that will call the recipe



Testing the Pipeline

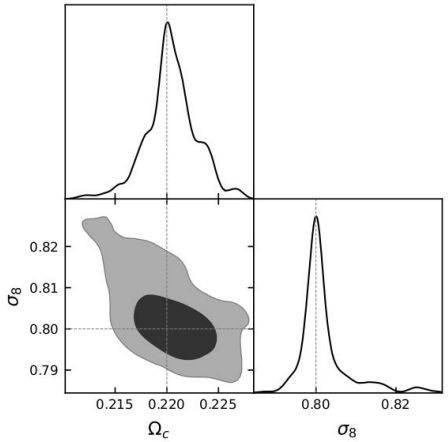
- This analysis is using 5 different modules of the cluster pipeline: CLMM, CCL, SACC, TJPCov and Firecrown (which includes the prediction module)

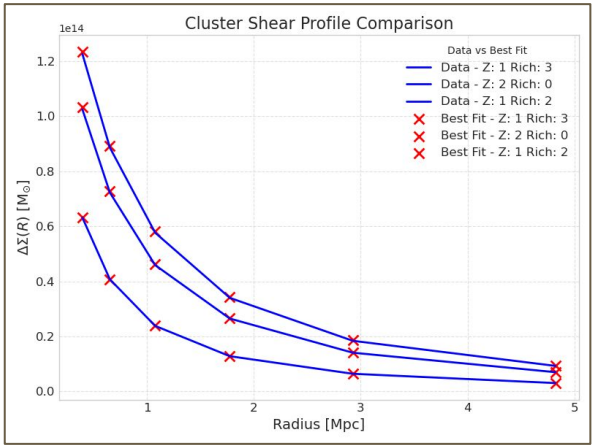
- Future tests will also include TXPipe



Validation with mock data: step 1

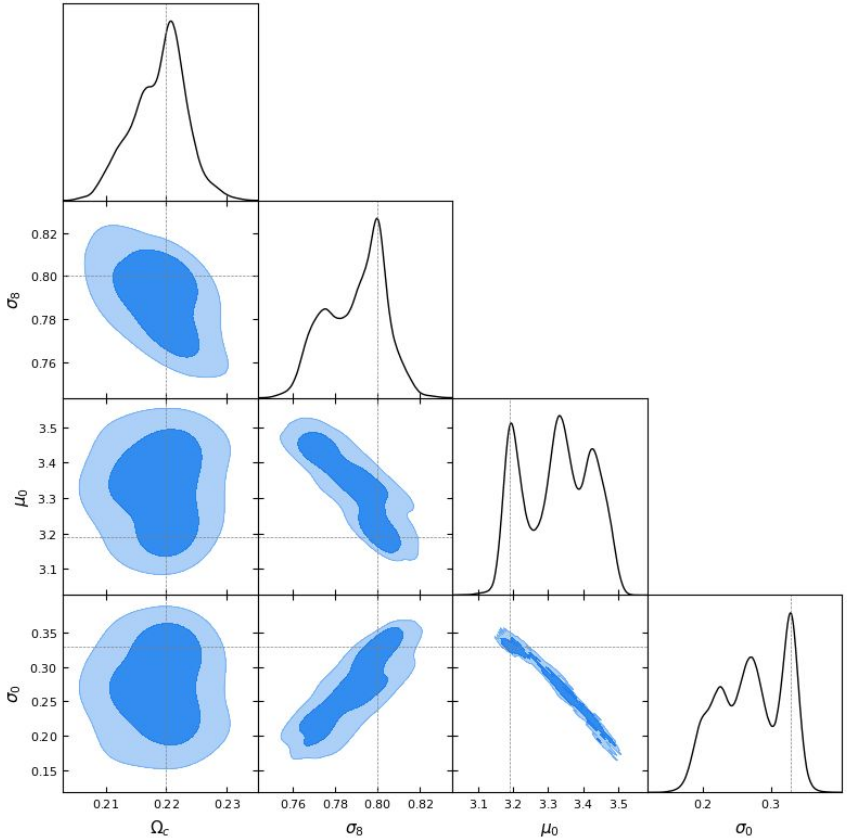
- Generated only shear data with NumCosmo and CLMM
- Run Firecrown with same systematics with free cosmology to be fitted
- We were able to obtain the right parameters in the 2σ - region





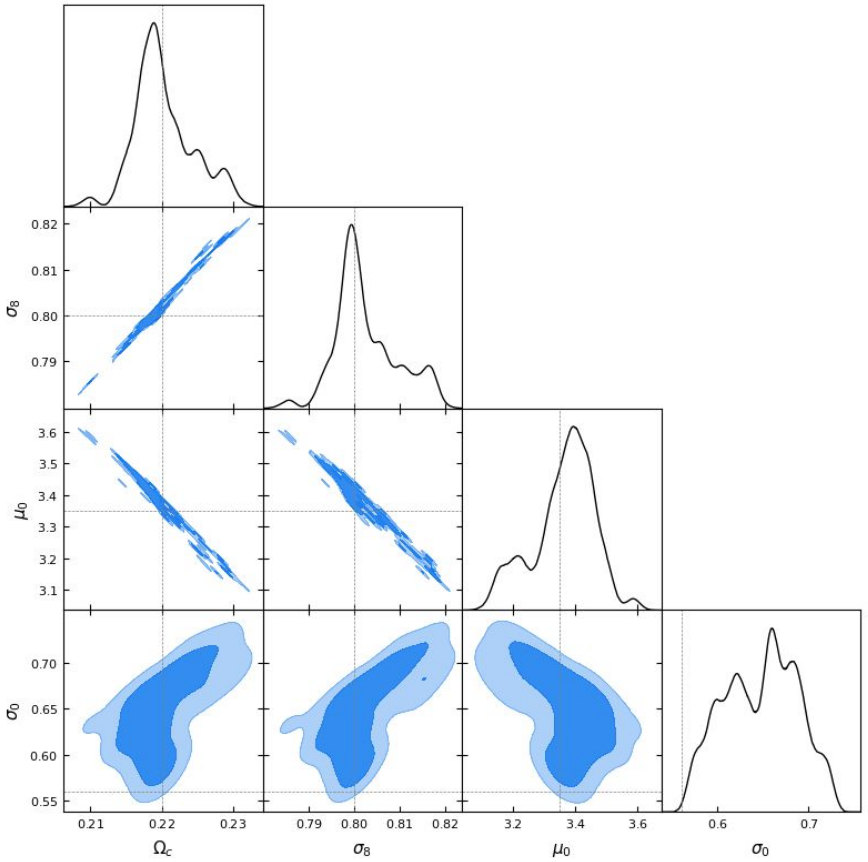
Validation with mock data: step 2

- Same analysis but with counts and shear data
- Run Firecrown to fit both the cosmology and the mass-richness relation
- We were able to obtain the right parameters in the 2σ - region

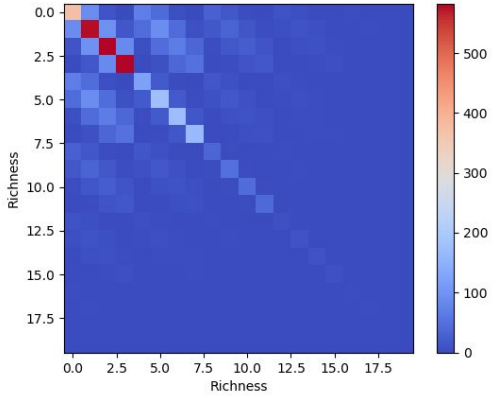


Run on cosmodc2 data

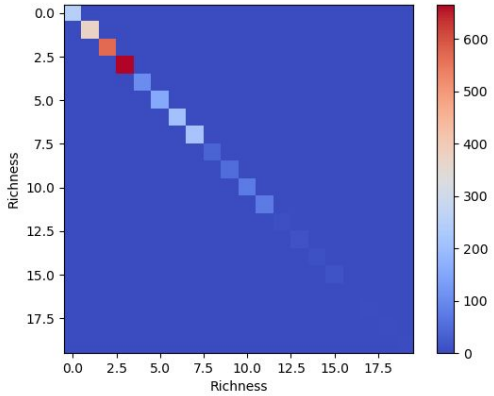
- Analysis done with RedMapper cosmoDC2 catalog
- Run Firecrown to fit both the cosmology and the mass-richness relation
- Ongoing analysis. Computing time around 20h
- We were able to obtain the right parameters in the 2σ - region



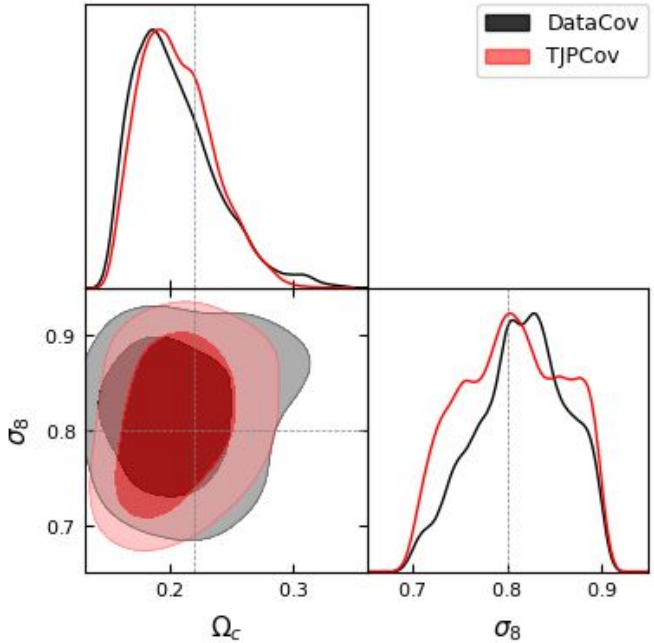
TJPCov Covariance



Counts theoretical covariance from TJPCov



Data covariance



Next goals

- Test consistency used throughout the pipeline
- Connect with TXPipe
- Implement Covariance calculations for shear profile in TJPCov
- Implement systematics (boost factor, selection function, misscentering)
- Create a package to run different parts of the pipeline with the same configurations