

# Galaxy Cluster Cosmology:

## Results from DES and Preparation for LSST

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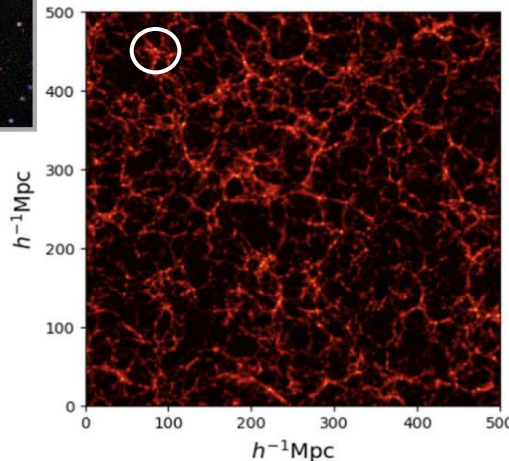


Background: Cerro Tololo and Cerro Pachón  
Credit: NOIRLab/NSF/AURA/P. Horálek

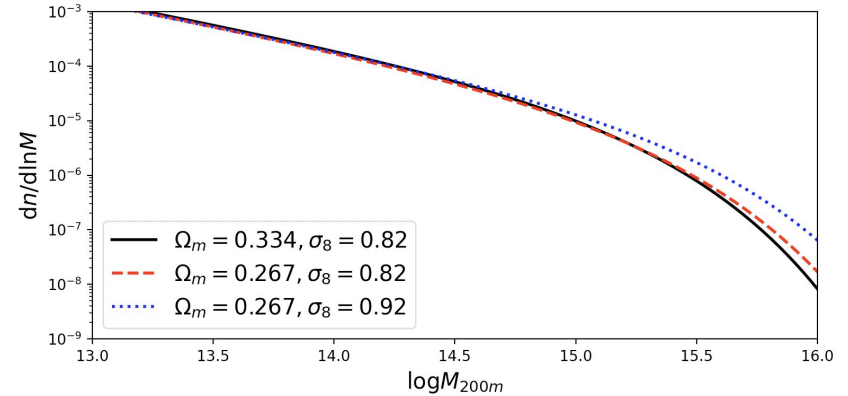
# Galaxy cluster abundance is a sensitive cosmology probe for optical surveys.



A galaxy cluster in DES observation (Melchior+)

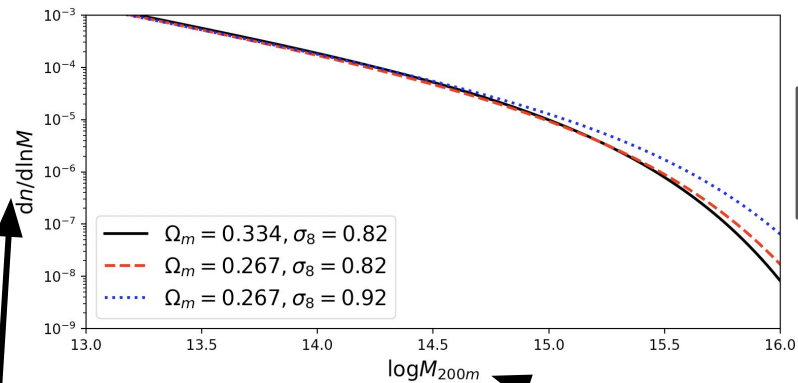


Galaxy clusters in a Quijote simulation (Villaescusa-Navarro+ 2020)

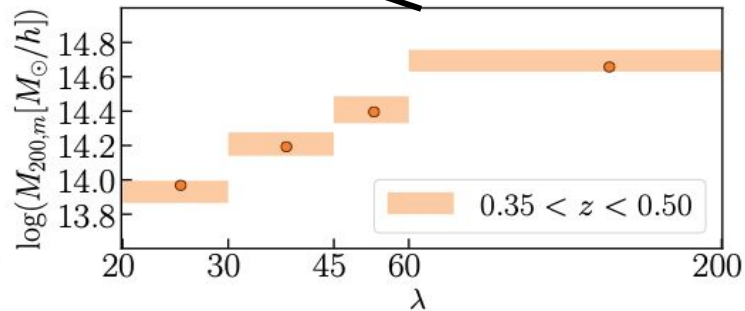
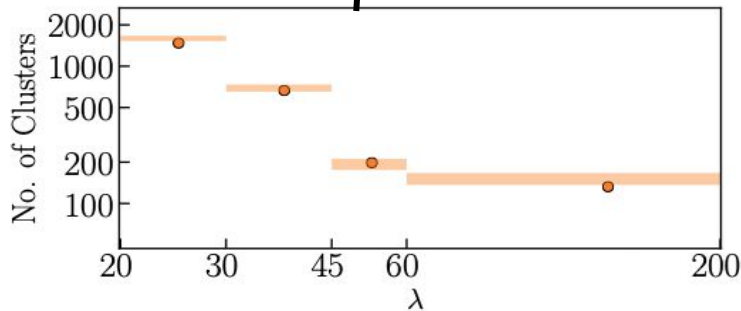


Theoretical halo mass function (Tinker+, 2008)

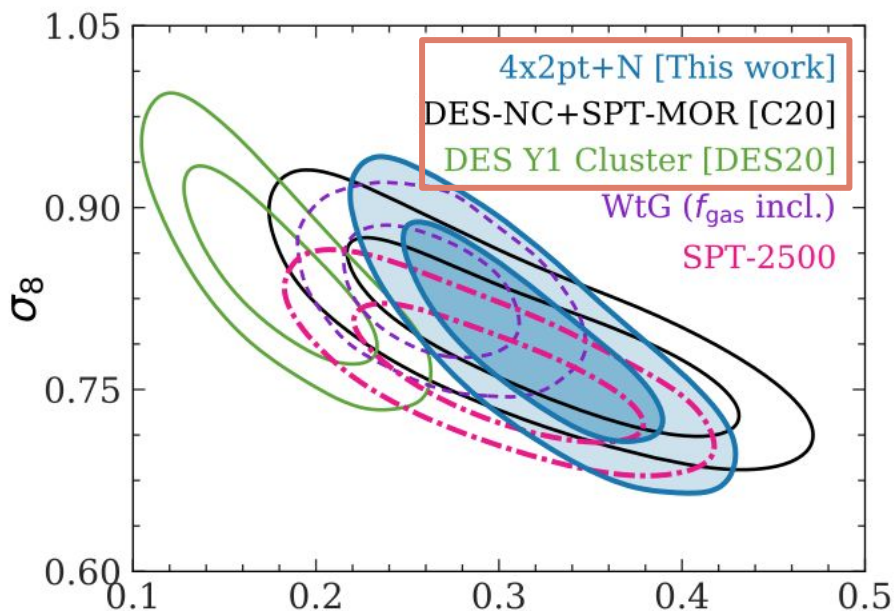
# (Some) Ingredients for galaxy cluster cosmology: cluster number counts and “mass” measurements.



DES data vector  
(Abbot+, arXiv:2002.1112)



# (Some) Galaxy cluster cosmology results from DES



Credit: **Chun-Hao To**,  
arXiv:2010.01138

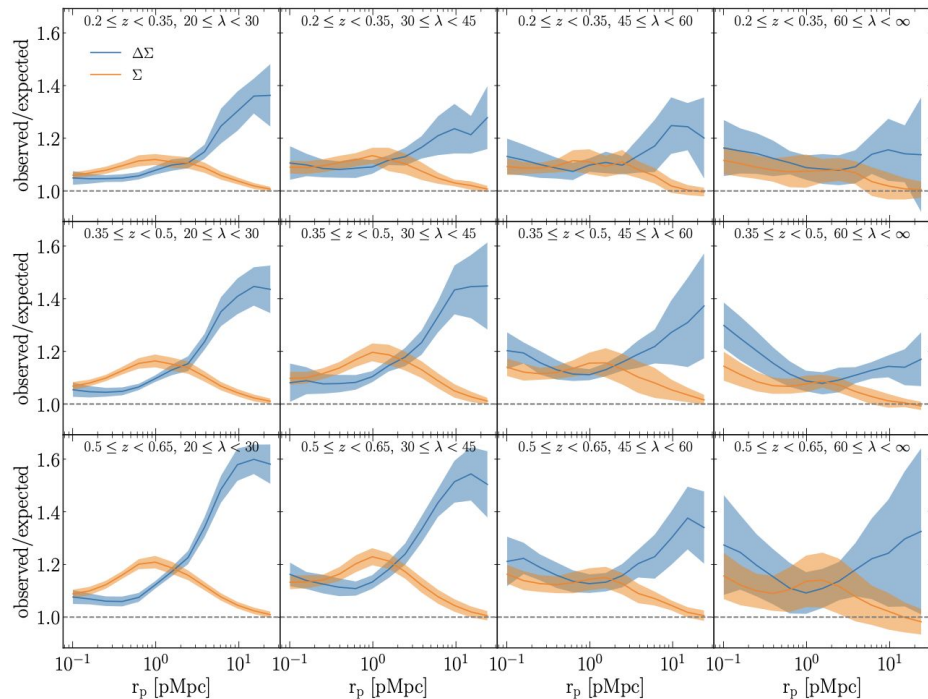
Multiple ways to constrain cosmology:

- DES number counts+ weak lensing measured cluster masses [DES Y1 Cluster]
- DES number counts + cluster mass relations from multiwavelength analyses (SPT) [DES-NC+SPT-MOR]
- DES number counts + 2-pt correlations (galaxy clustering, cluster–galaxy cross-correlation, cluster auto-correlation, and cluster lensing) [4x2pt+N]
- Multiwavelength analyses with with SZe and X-ray selected clusters (SPT, eROSITA, ACT ...)

Galaxy cluster mass modeling is an important part of the cosmology analysis.



# Galaxy cluster mass modeling – an important part of the cosmology analysis.



Credit: Hao-Yi Wu+,  
arXiv:2203.05416

Modeling the mass density profiles of the clusters need to consider a few physical effects.

- Projection of structures (left figure)
- Triaxial shape of clusters.
- Miscentering.
- Cluster galaxy contaminations.
- ...

# From DES to LSST

DES

Full data set finalized.

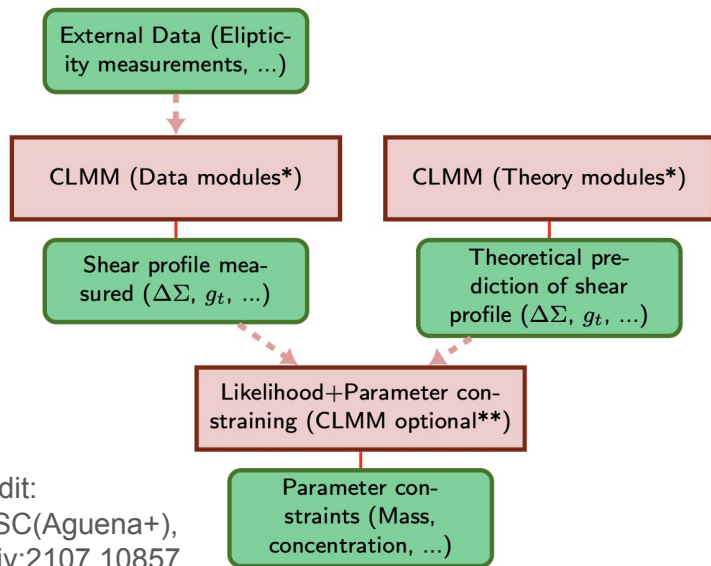
LSST of the Vera Rubin observatory

Dark Energy Science Collaboration  
(DESC)

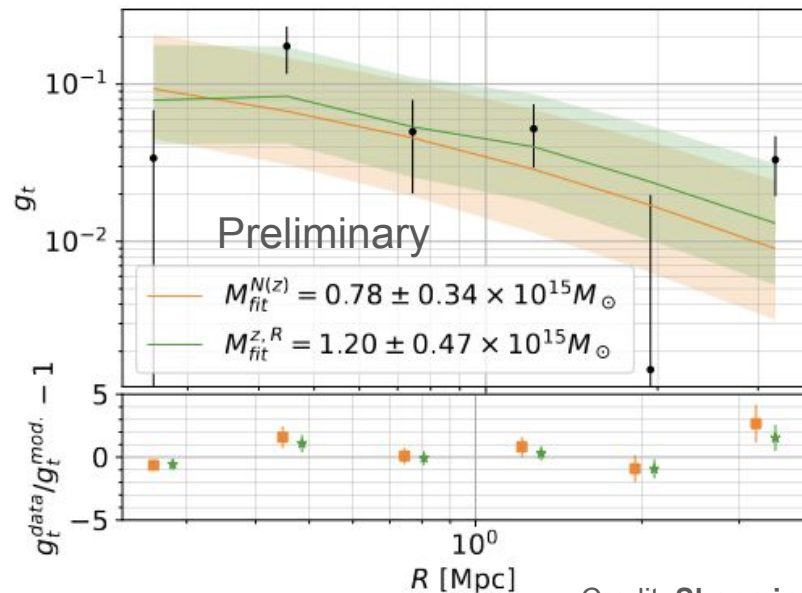
Analyses being tested on simulations  
and precursor data sets.

# Moving towards LSST – galaxy cluster mass modeling

- Galaxy cluster mass modeling has been developed into a [software package](#) (CLMM) by the LSST Dark Energy Science Collaboration (DESC).
- The analyses are being tested on simulations and precursor data sets (incl. DES).



Credit:  
DESC(Aguena+),  
arXiv:2107.10857

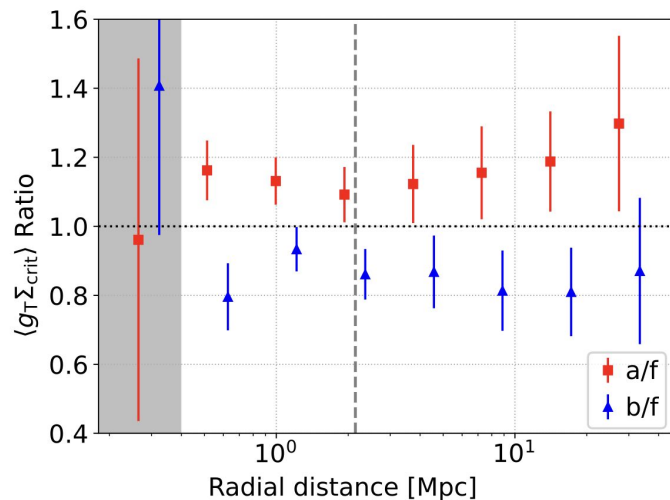


Credit: Shenming Fu

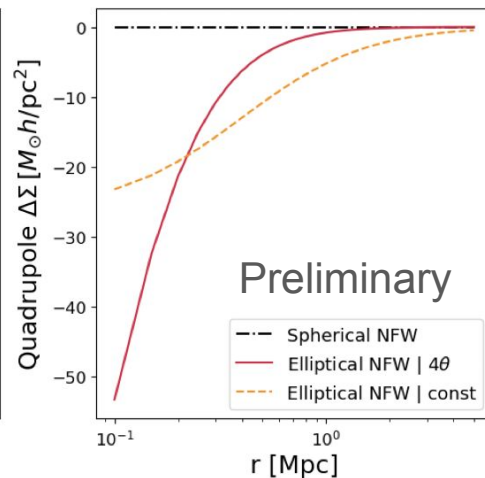
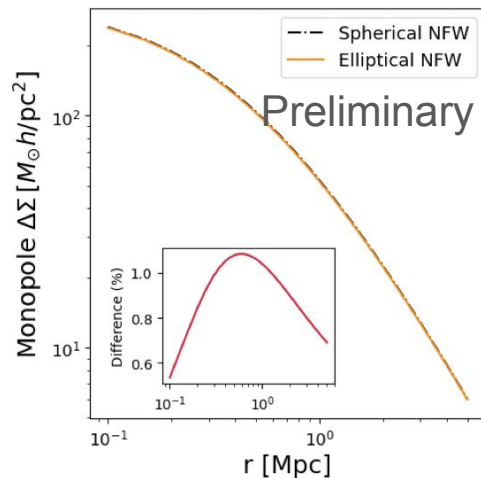
# Galaxy cluster mass modeling – triaxiality

Studies with both DES data and LSST sims demonstrate how the cluster mass signals change depending on the viewing angles.

Triaxiality models being implemented and tested in CLMM.



Credit: **Shenming Fu**+, arXiv: 2307.11835



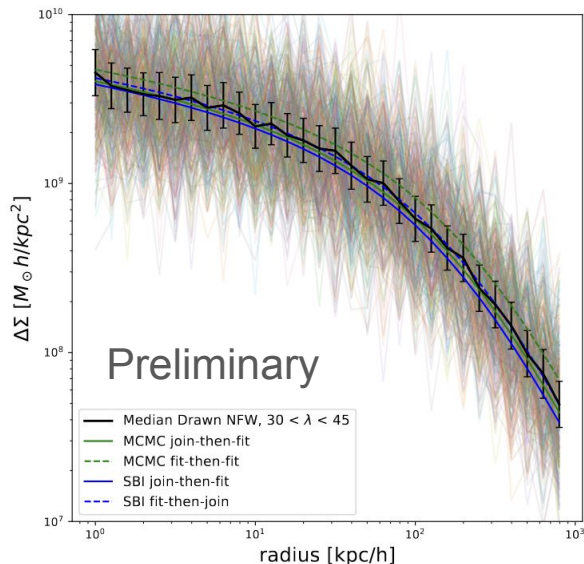
Credit: **Rad Srinivasan**



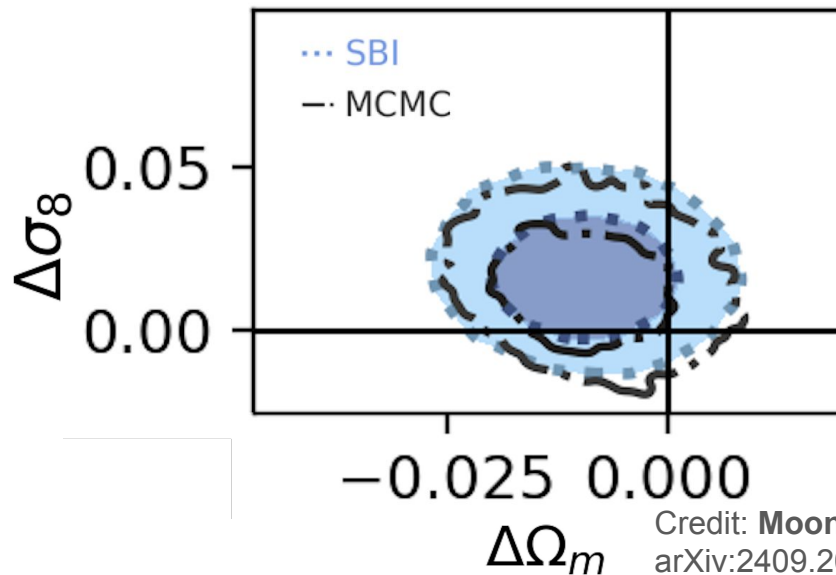
# Moving towards LSST – new methods

Simulation-Based Inference (SBI), as an alternative method to Markov Chain Monte Carlo (MCMC), is being implemented for:

Cluster mass modeling (left figure), and cosmology analyses (right figure).



Credit: Akum Gill



Credit: Moonzarin Reza+,  
arXiv:2409.20507

# From DES to LSST

DES

Full data set finalized.

LSST

Dark Energy Science Collaboration  
(DESC)

Analyses being tested on simulations  
and precursor data sets.

Background: Cerro Tololo and Cerro Pachón  
**Credit:**NOIRLab/NSF/AURA/P. Horálek