Cosmology Seminar

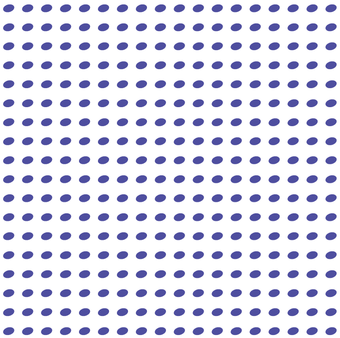
IfA Edinburgh

Predicting weak-lensing covariance with a fast simulator

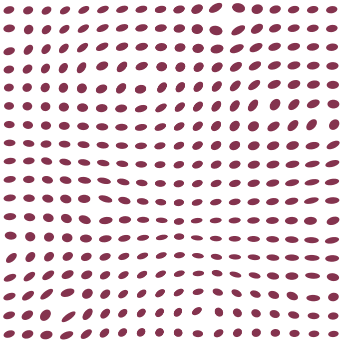
Chieh-An Lin (Linc)

September 12th, 2018

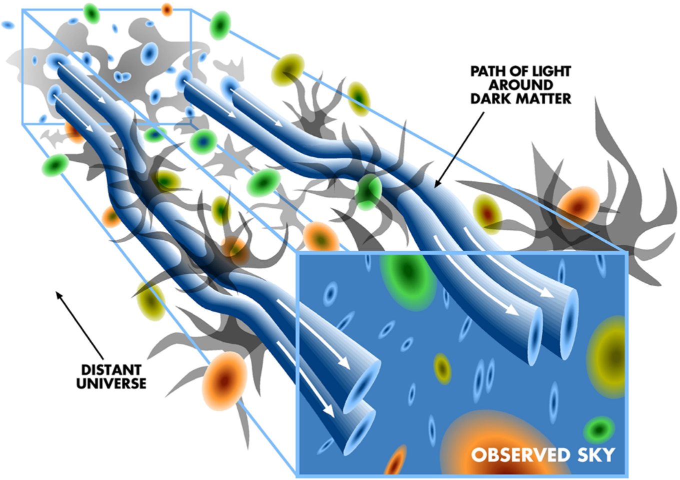
University College London



Unlensed sources

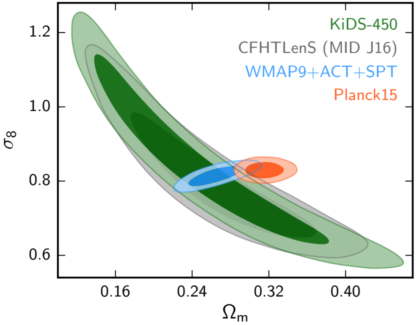


Weak lensing

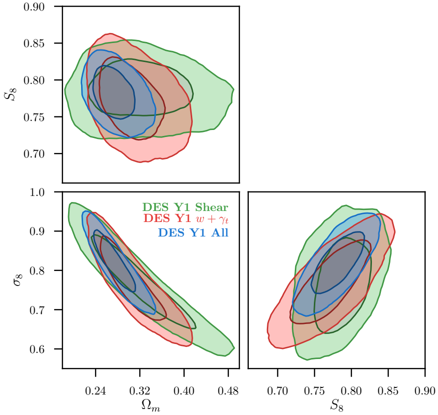

PATH OF LIGHT
AROUND
DARK MATTER
DISTANT
UNIVERSE
OBSERVED SKY

Source: LSST

Recent results from 2PCF

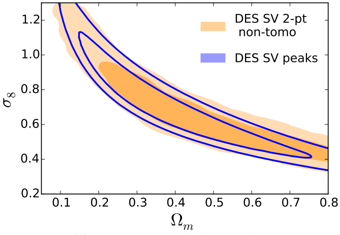


Hildebrandt et al. (2017)

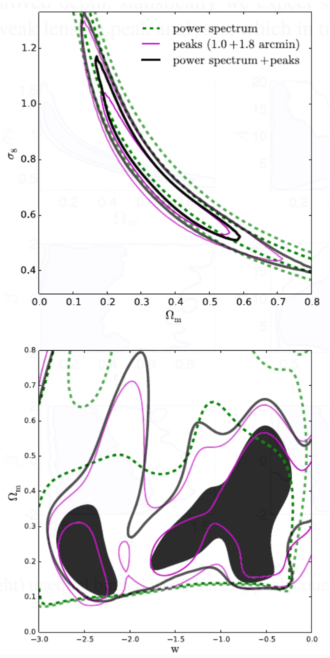


DES Collaboration (2018)

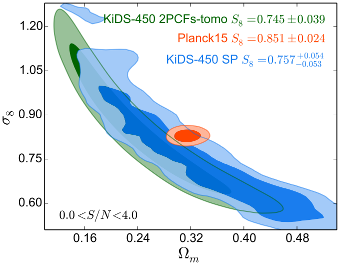
Recent results from peaks



Kacprzak et al. (2016)

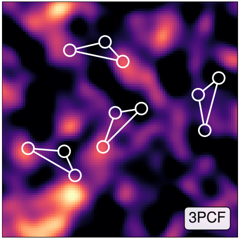


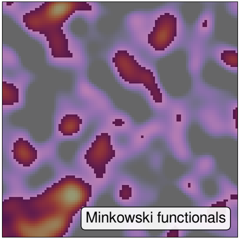
Liu et al. (2015)

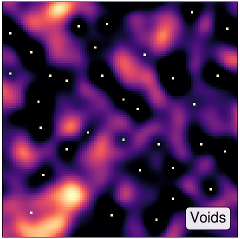


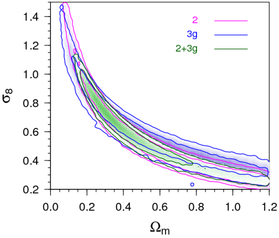
Martinet et al. (2018)

Other higher-order statistics

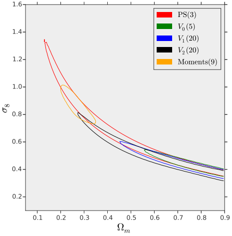




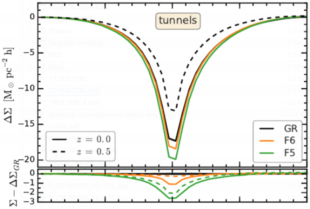




Fu et al. (2014)



Petri et al. (2015)



Cautun et al. (2018)

I have a dream...

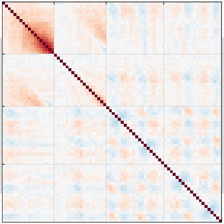
... that all statistics will one day live in the same likelihood
where they will not be judged by their order
but by their degeneracy-breaking character.

(From an anonymous lenser in a sleepy seminar?)

Covariance is the key

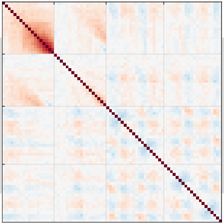
Analytical calculations

- Challenging for higher-order statistics
- Cross-correlating terms?
- Different survey effects



Covariance is the key

Analytical calculations



- Challenging for higher-order statistics
- Cross-correlating terms?
- Different survey effects

N-body simulations

- Large-scale limitation: box size
- Small-scale limitation: particle mass
- Time, time, & time

Challenges

How to estimate the cross-correlations between different WL statistics?

How to do it efficiently?

Solution: fast simulator

Three advantages

- Fast: orders of magnitude faster than N-body sims
- Flexible: ability to account for survey effects
- Full cross-correlations

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Three scientific goals

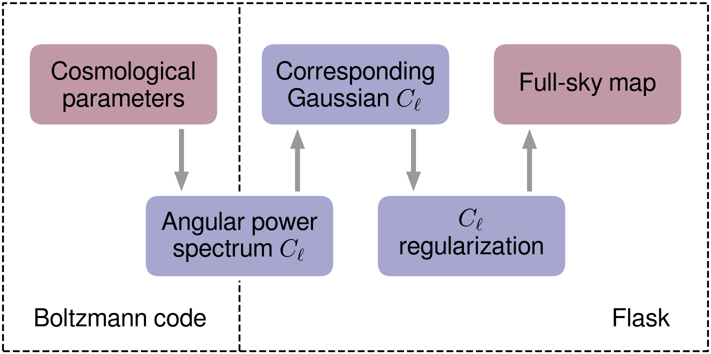
- High-risk: good accuracy of model prediction
- Middle-risk: good covariance accuracy
- Low-risk: physically-motivated model for related studies

Methodology

Xavier, Abdalla, & Joachimi (2016)

Flask

Fast simulations of full-sky lognormal fields



Halo model

But the lognormal approximation breaks on small scales

$\Rightarrow$ Let's take advantage of the halo model:

- Mass function
- Density profiles
- Clustering

How to determine clustering?

Populate halos with conditional mass functions:

$$n(M|\delta) = \Gamma(M|\delta)\, n(M)$$

where $\Gamma(M|\delta)$ is measured from N-body simulations

Underlying assumption

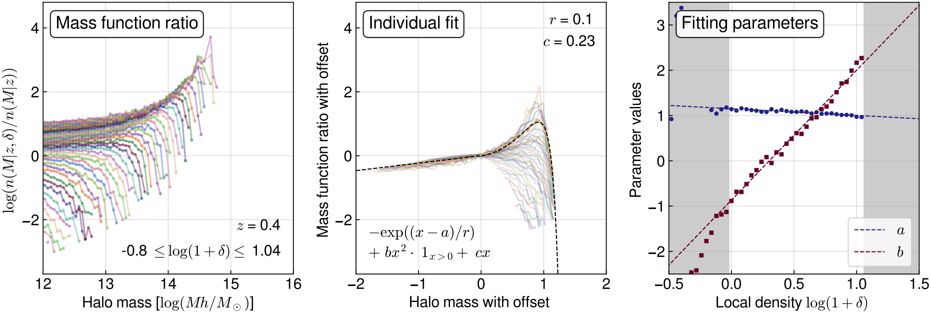
Halo population depends on the environment rather than on cosmology

How to determine clustering?

Populate halos with conditional mass functions:

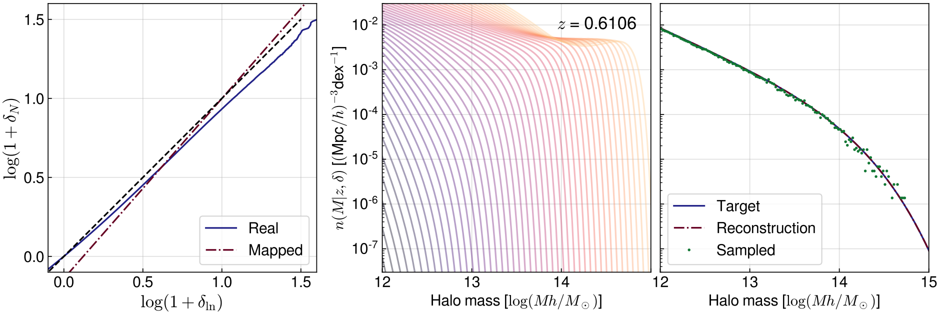
$$n(M|\delta) = \Gamma(M|\delta)\, n(M)$$

where $\Gamma(M|\delta)$ is measured from N-body simulations

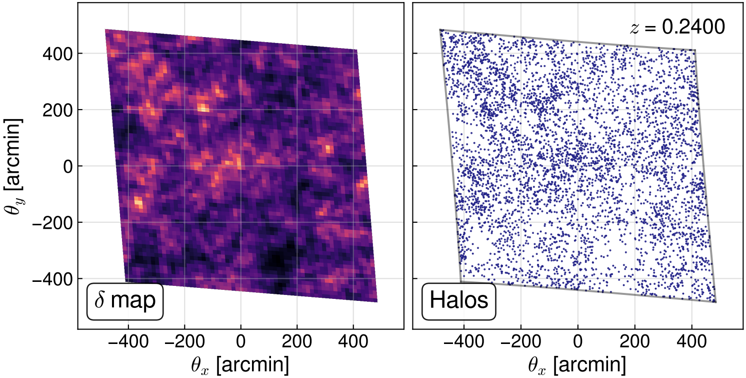


Caveats

- Different cosmologies
- Smoothing volume correspondence
- pdf(δ) from lognormal is not pdf(δ) from N-body



Halo clustering



Camelus: halo model & lensing computation
(Lin & Kilbinger 2015a, b)

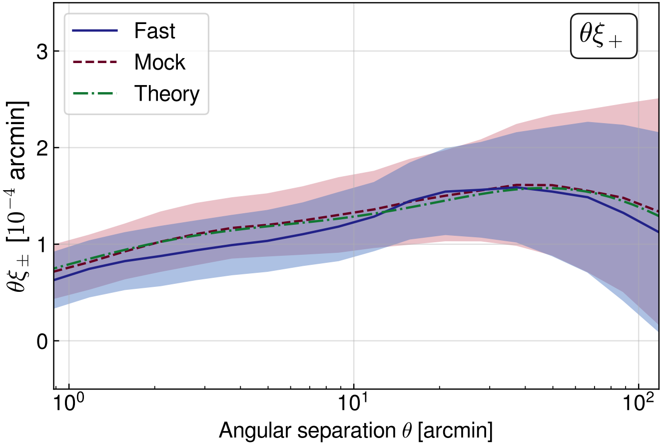
Results

Blue = fast simulator = Flask + Camelus

Red = N-body mocks = the SLICS suite

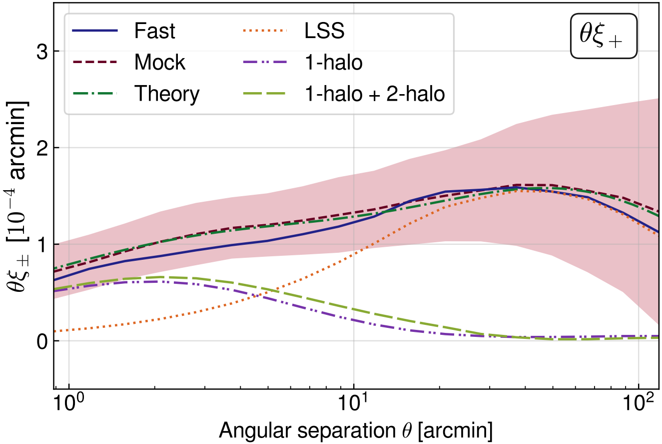
Green = theory = Nicaea (only for $\xi_{+/-}$)

Results on ξ_+



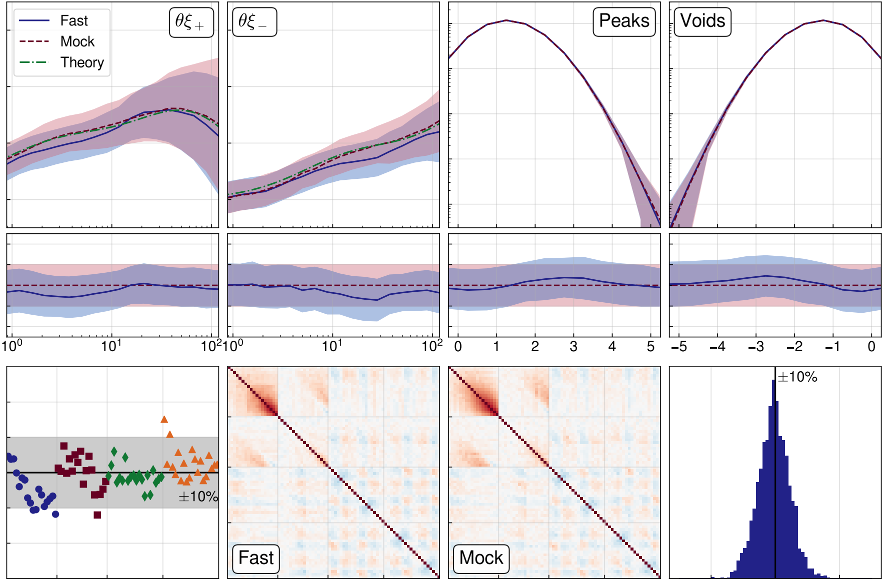
Lin et al. in prep.

Results on ξ_+



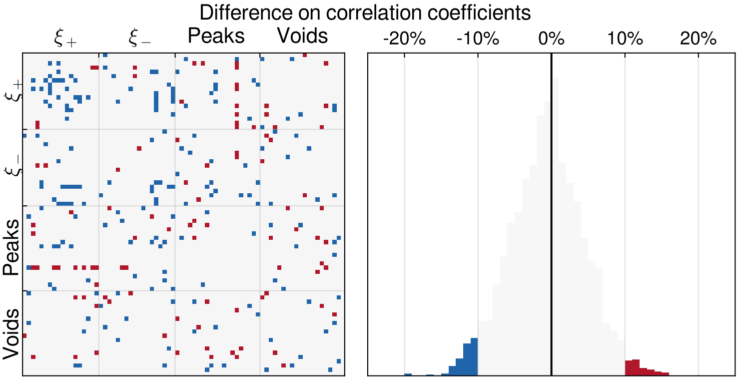
Lin et al. in prep.

Results



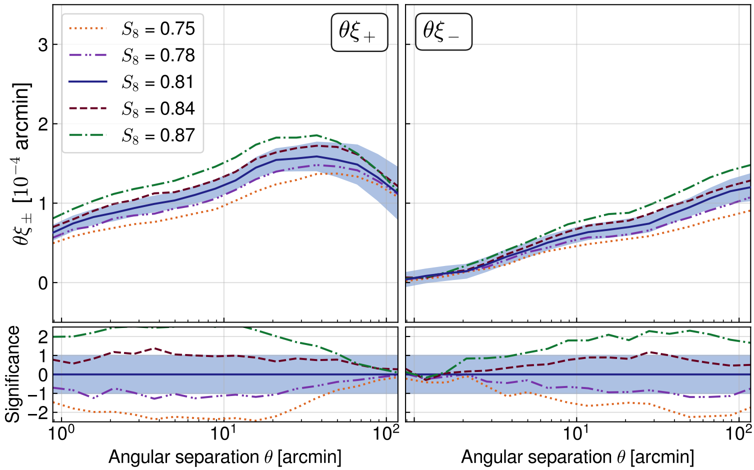
Where are the largest coefficient differences?

Lin et al. in prep.



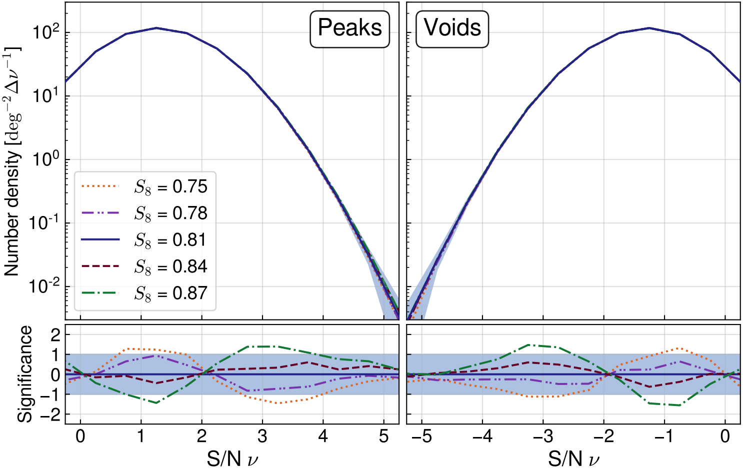
Lin et al. in prep.

Cosmological sensitivity



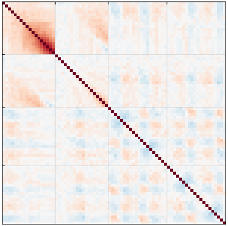
Lin et al. in prep.

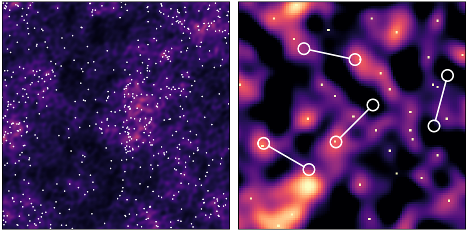
Cosmological sensitivity



Summary

- A fast simulator for WL statistics
- Lognormal fields & halo model
- Useful for covariance estimation
- Could be improved for model prediction





Collaborators

Shadab Alam

Catherine Heymans

Joachim Harnois-Déraps

Backup slides

Reshift dependence of fitting parameters