Cosmological constraints with weak-lensing peak counts using approximate Bayesian computation

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Introduction

- Weak-lensing peaks trace high-density regions. They probe the mass function and cosmology.
- Modelling peak counts is challenging. Analytical approaches struggle to incorporate real-world effects. N-body simulations are too time-consuming.
- We propose a fast stochastic approach to model peak-count predictions. We use it to constrain cosmology.

Our model

Hypotheses

- Diffuse, unbound matter contributes little to peak counts
- Spatial correlation of halos has a minor influence

Advantages

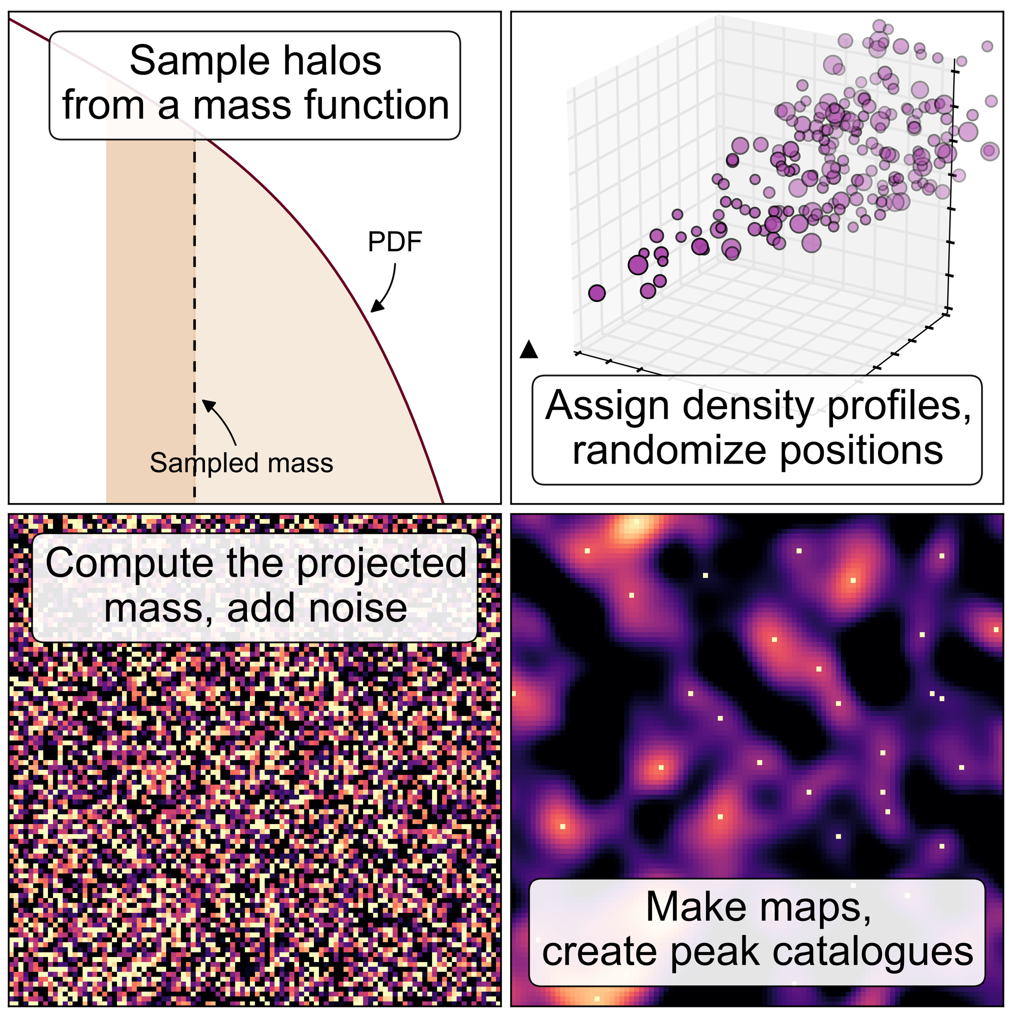
- Fast — few seconds for creating a 36-deg^2 field
- Flexible — include observational effects in a forward calculation
- Full PDF information — free from the Gaussian likelihood assumption

Public code

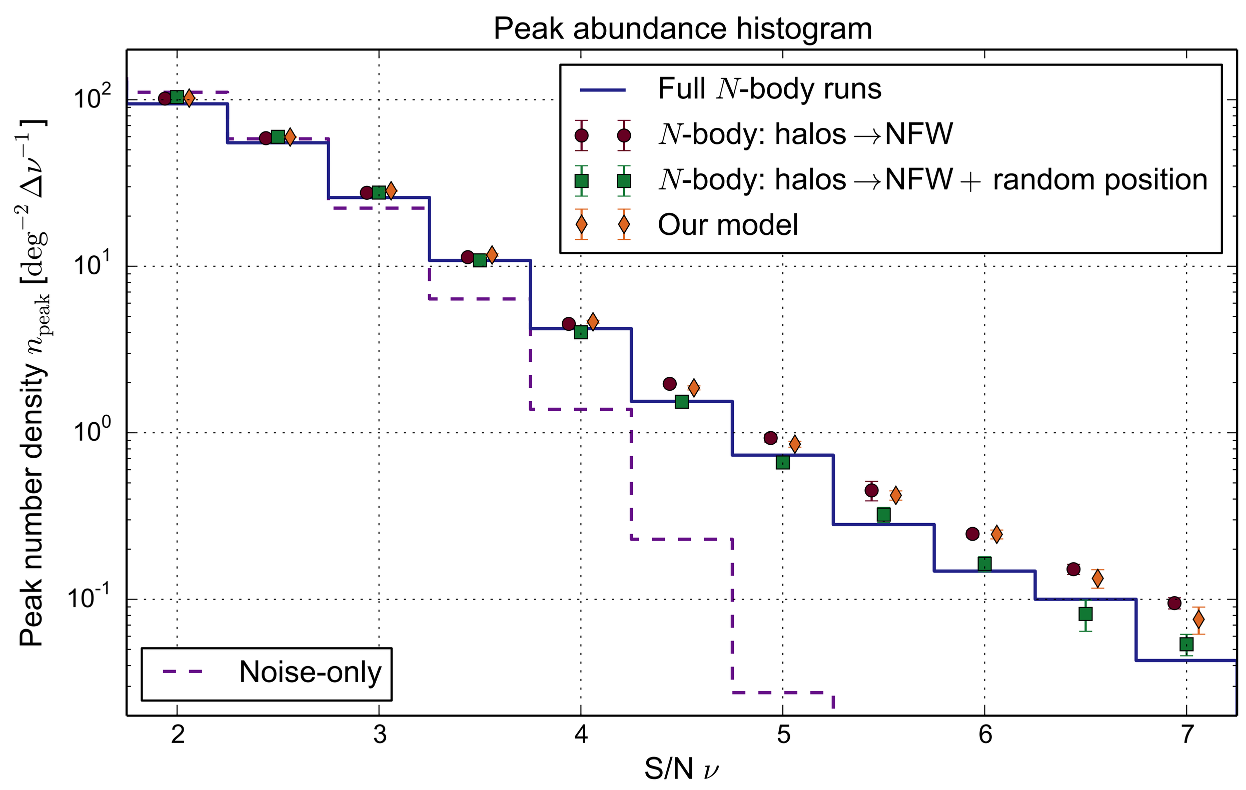
CAMELUS

http://github.com/Linc-tw/camelus/

Steps



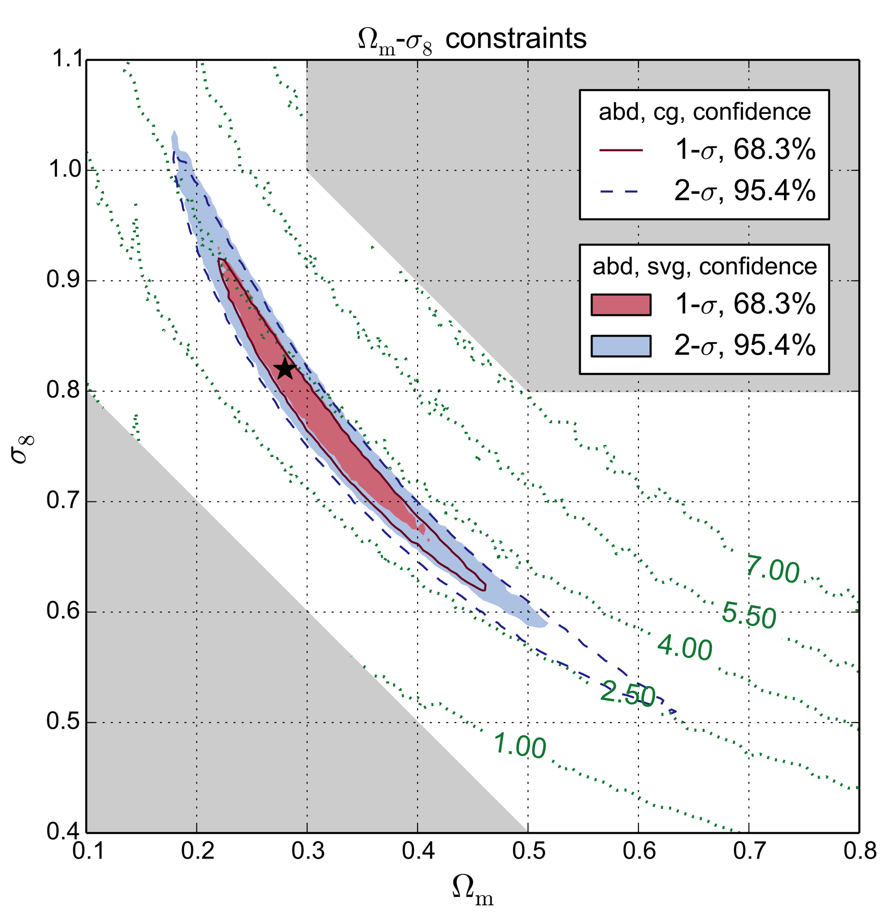
Validation



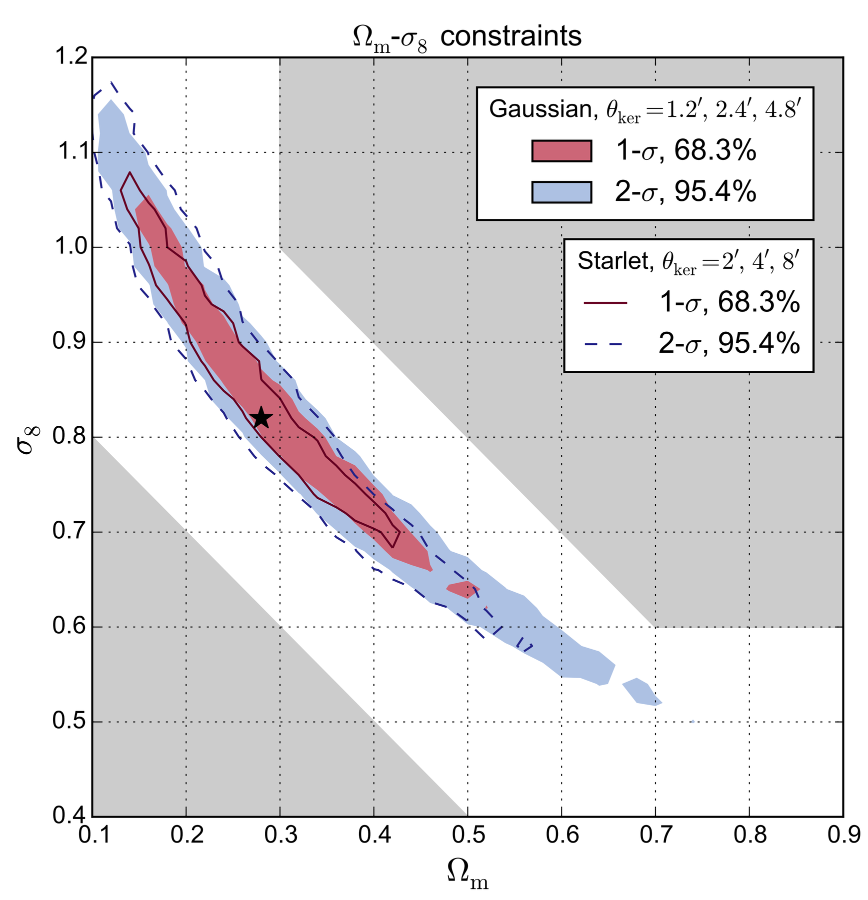
A good agreement between our model and N-body simulations.

We found that replacing N-body halos by NFW profiles and position decorrelation are compensated effects.

Other tests with our model



Covariances depend on cosmology



Compensated filters are better

Acknowledgements

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Approximate Bayesian computation (ABC)

ABC is a **likelihood-free** parameter inference method with an accept-reject process.

Requirements

- Stochastic model $P(\cdot\,|\boldsymbol{\pi})$
- Distance $|\boldsymbol{x} - \boldsymbol{y}|$
- Tolerance level ϵ

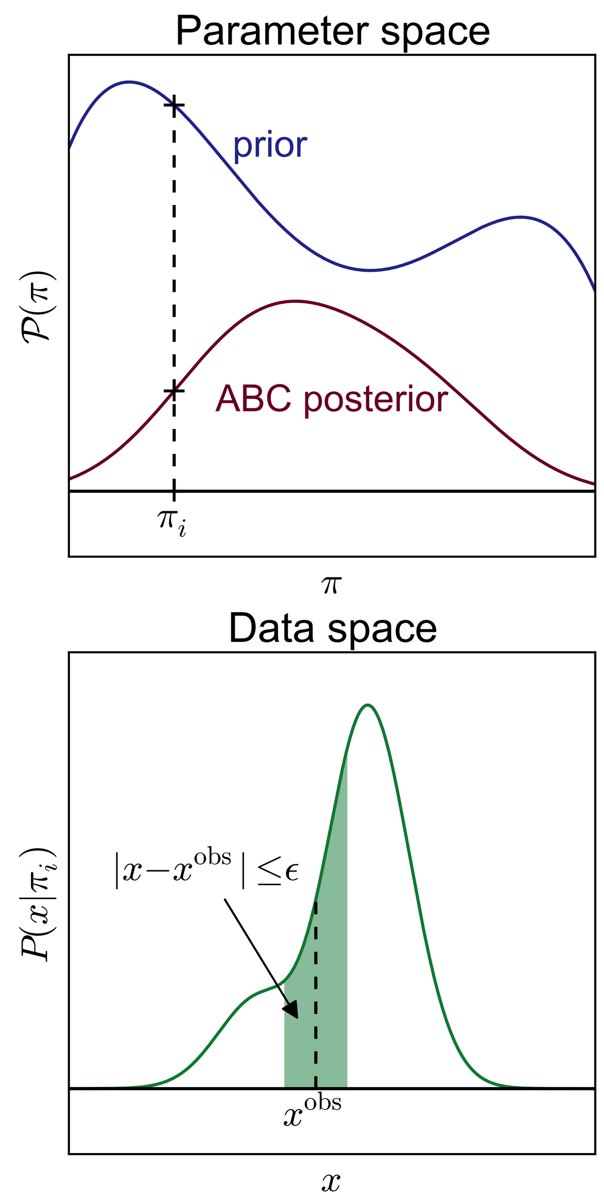
Steps

- Draw a $\boldsymbol{\pi}$ from the prior
- Draw a $\boldsymbol{x}$ from the model $P(\cdot\,|\boldsymbol{\pi})$
- Accept $\boldsymbol{\pi}$ if $|\boldsymbol{x} - \boldsymbol{x}^{\mathrm{obs}}| \leq \epsilon$
- Reject otherwise
- Repeat

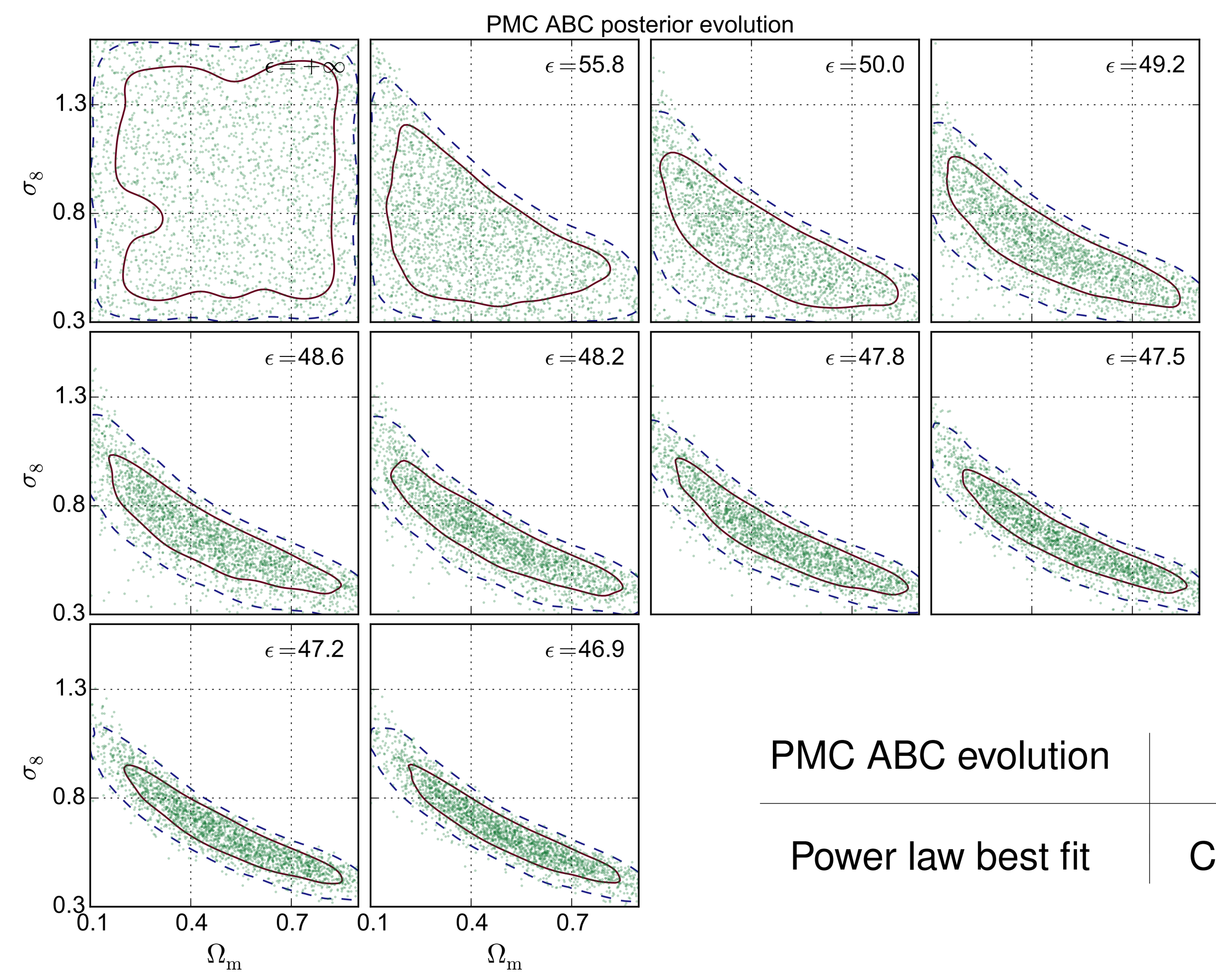
Why does this work? Because:

Distribution of accepted $\boldsymbol{\pi}$ = prior × green areas
≈ prior × 2ϵ × likelihood
∝ posterior

How to choose ϵ? — population Monte Carlo (PMC)



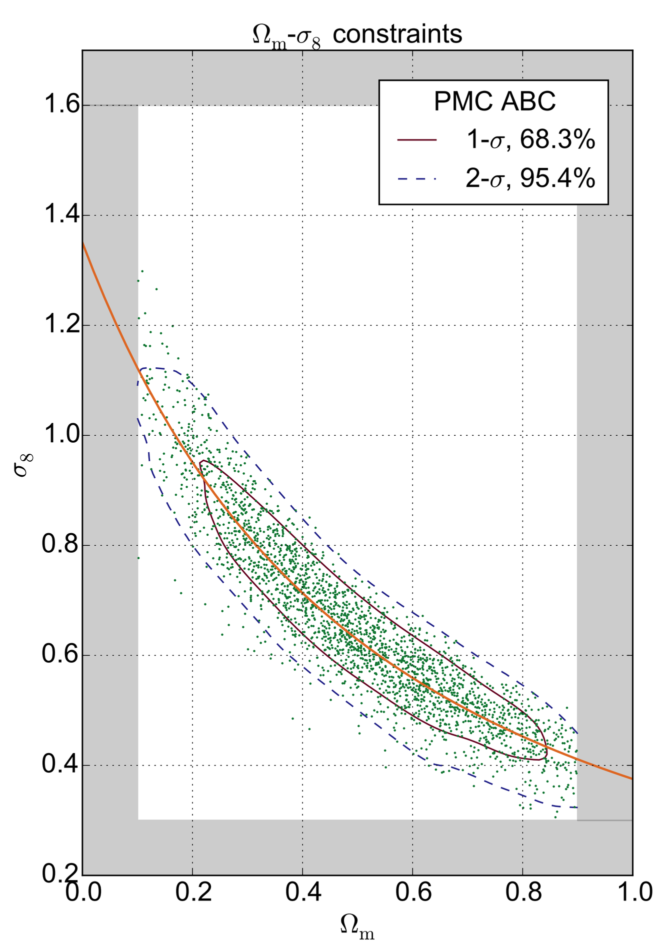
Preliminary results on data

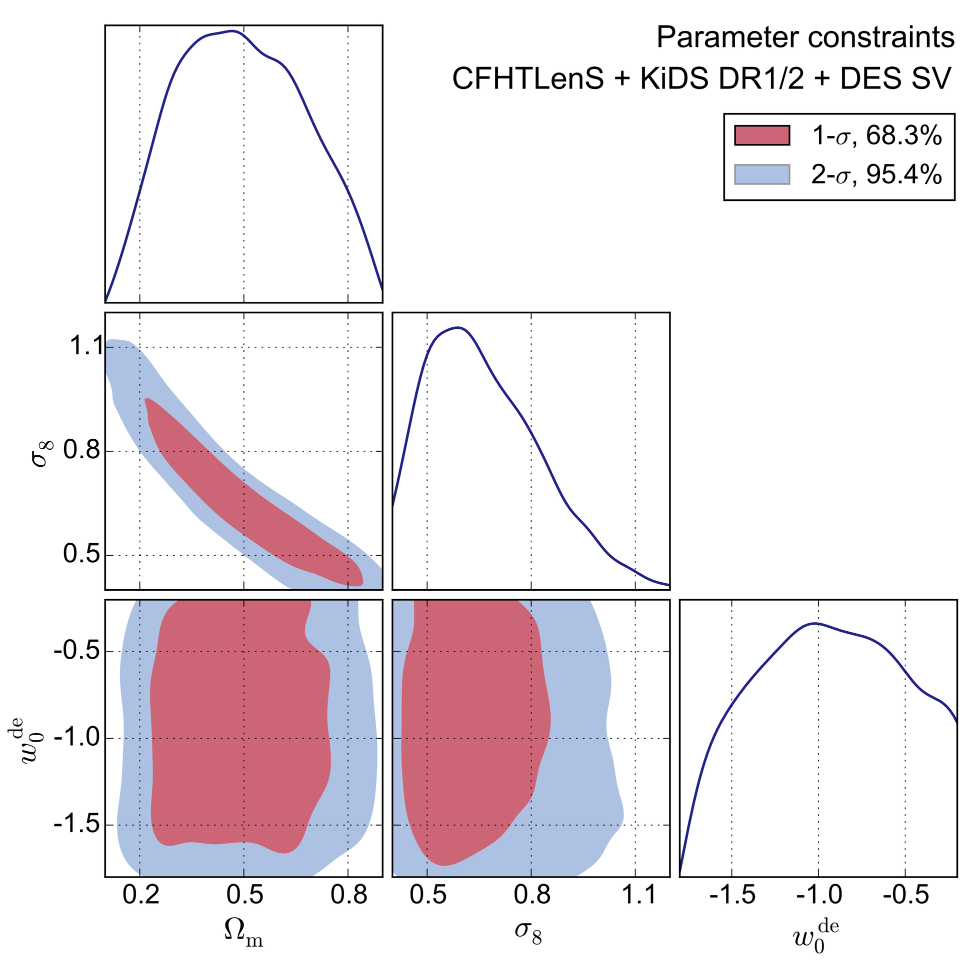


Three data sets:

- CFHTLenS
- KiDS DR1/2
- DES SV

PMC ABC evolution	
Power law best fit	Constraints with w_0^{de}





Summary

- Our fast and flexible model to predict weak-lensing peak counts that provides the full PDF information
- A powerful likelihood-free constraint technique: approximate Bayesian computation
- Preliminary cosmological constraints with CFHTLenS-KiDS-DES data sets

References

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