Joint Analysis of Lensing, Clustering, and Abundance

Jaiyul Yoo

Institute for Theoretical Physics, University of Zürich

Lawrence Berkeley National Laboratory, U.C. Berkeley

Collaboration with Uros Seljak

Cosmic Frontier Workshop, March 7, 2013

I. INTRODUCTION

Unification of LSS Probes

- **various** large-scale structure **probes**:
  - galaxy clustering, weak lensing, counting
  - various combination thereof: *synergy*, *consistency*

- **motivation**:
  - **physical insight** in a model-independent way
  - which method combination is *best?*
  - which *galaxy sample?*
  - extendibility to future survey

Yoo & Seljak 2012, PRD

II. SDSS GALAXY SAMPLES

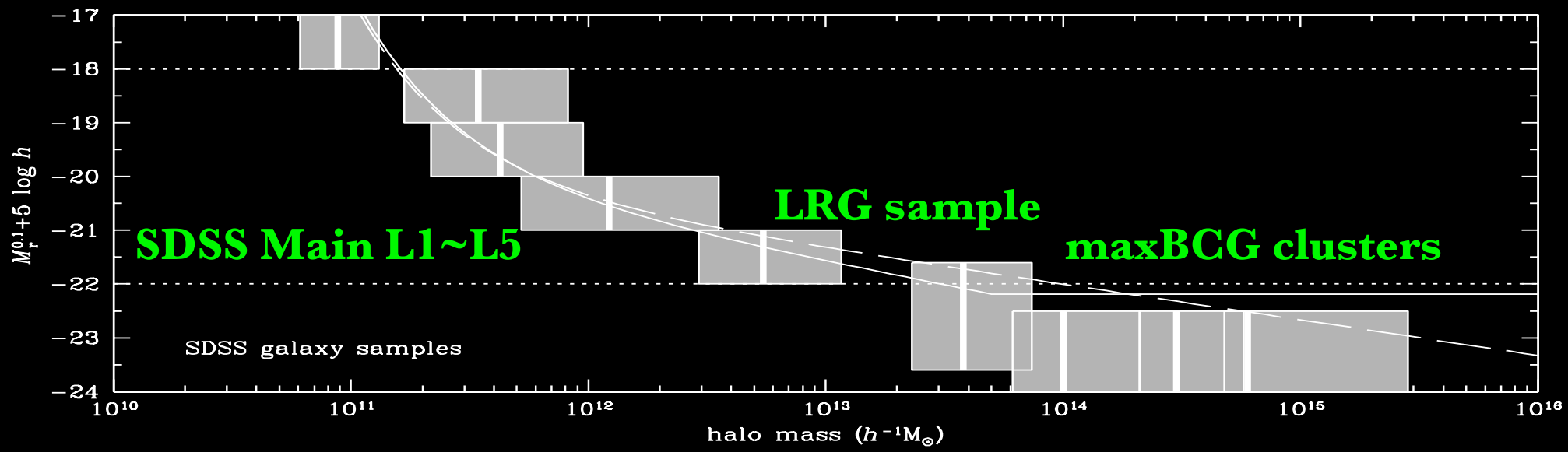
Modeling SDSS Samples

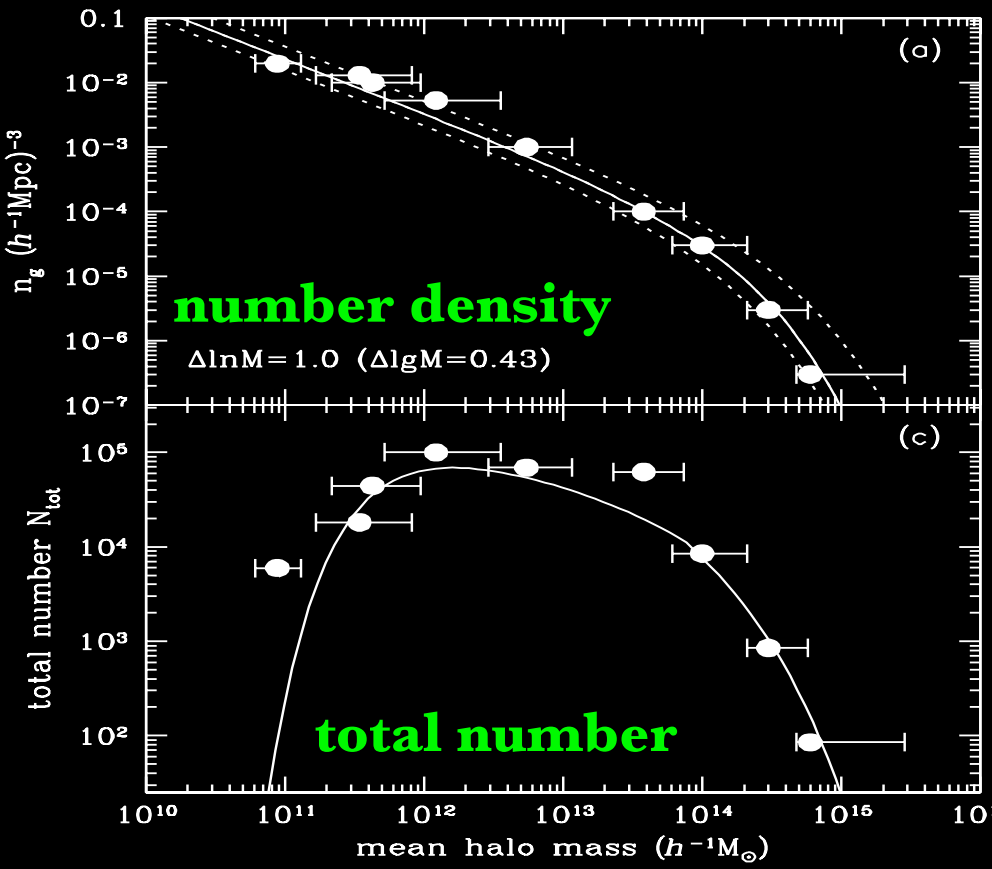
- **observed** SDSS galaxy samples:
  - SDSS Main, LRG, maxBCG (*luminosity*) samples
  - modeled as central galaxies (*mass-bin* halos)
  - *mean mass* from gg lensing, matching *abundance*
  - central galaxy luminosity-mass relation

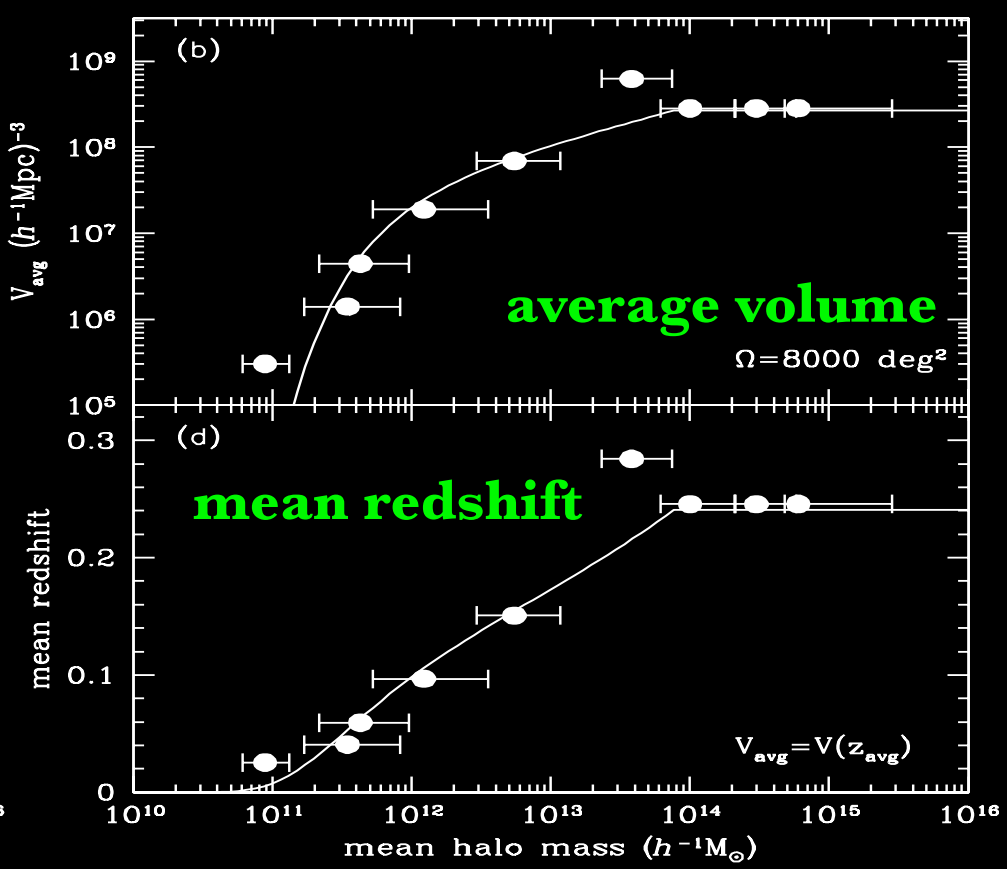
Mandelbaum et al. 2006, 2008, Zehavi et al. 2011

- **continuous mass-bin** samples:
  - approximately matching the SDSS samples
  - for theoretical understanding

II. SDSS GALAXY SAMPLES: VARIOUS LARGE-SCALE STRUCTURE METHODS

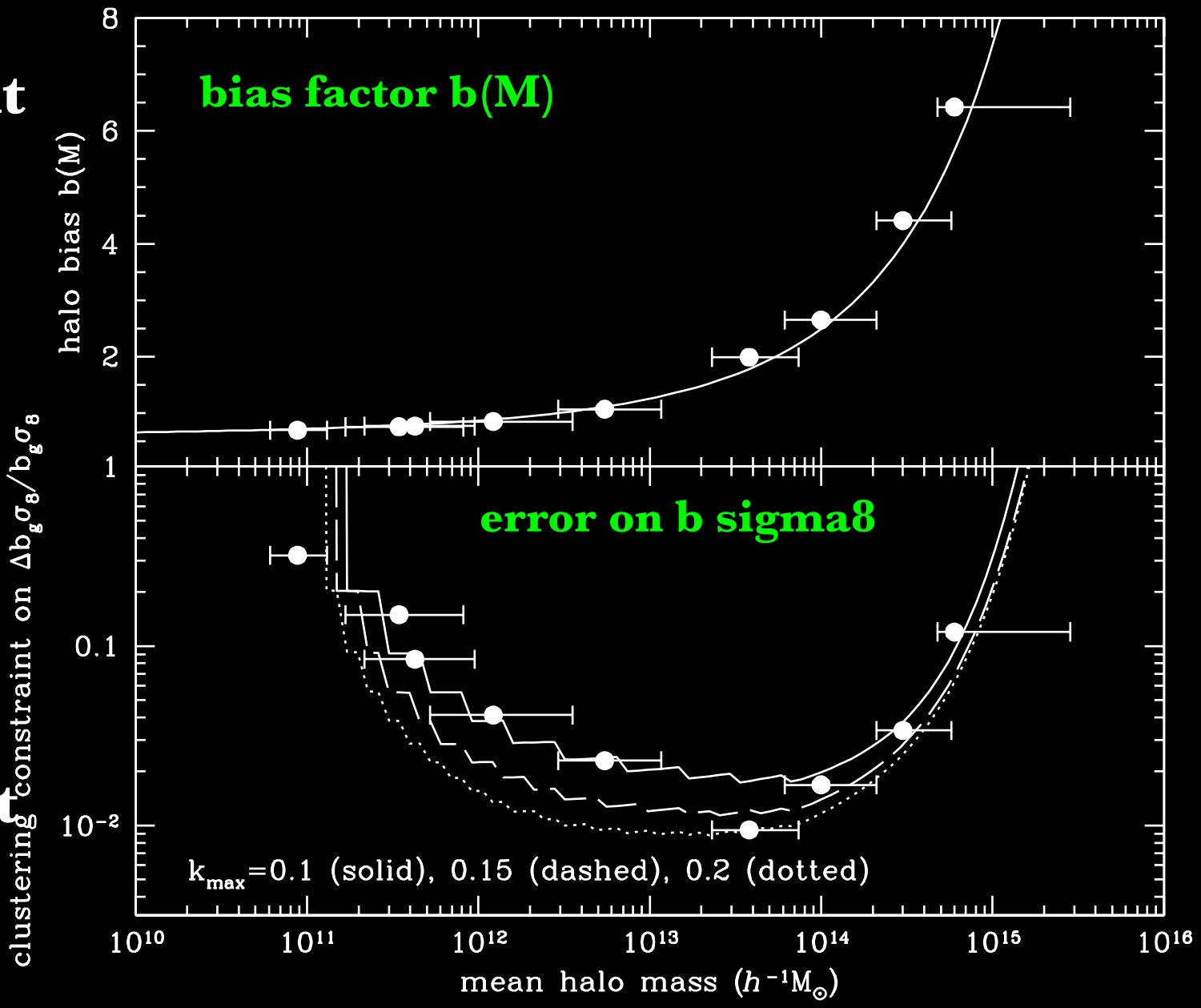






Large-Scale Clustering

- **base** constraint on $b\sigma_8$
- **fainter**: larger sample variance, but lower shot noise
- **brighter**: larger volume, but higher shot noise



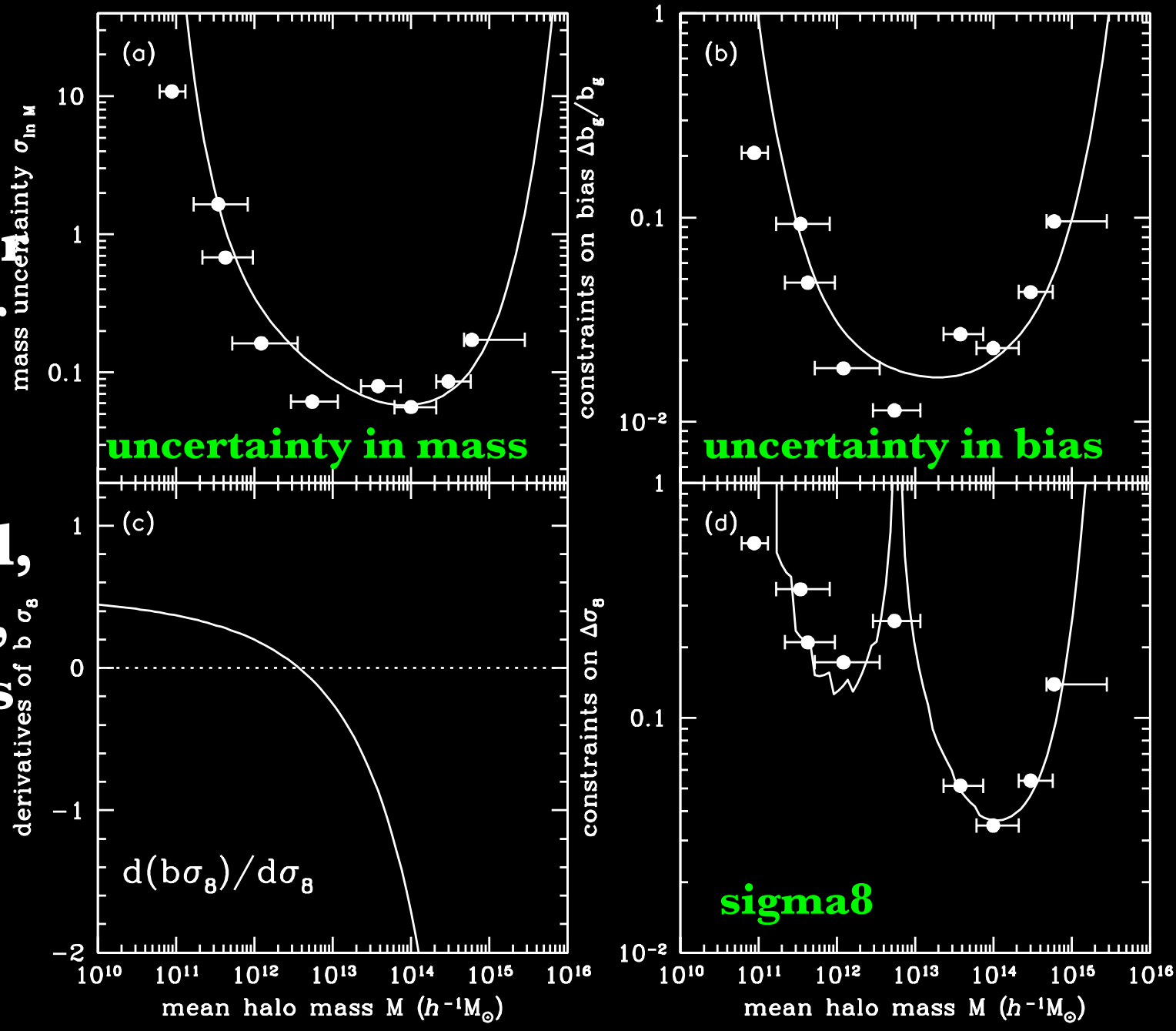
Method I and II

- combine g-g lensing & large-scale clustering
- **large-scale clustering**: constraint on $b\sigma_8$
- method I:
  - **small-scale lensing** to constrain ***mean M***
  - predict b(M) to combine clustering

- method II:
  - **large-scale lensing** to constrain amplitude $b\Omega_m\sigma_8^2$
  - cancel sample variance in clustering and lensing
  - ***independent*** of galaxy bias

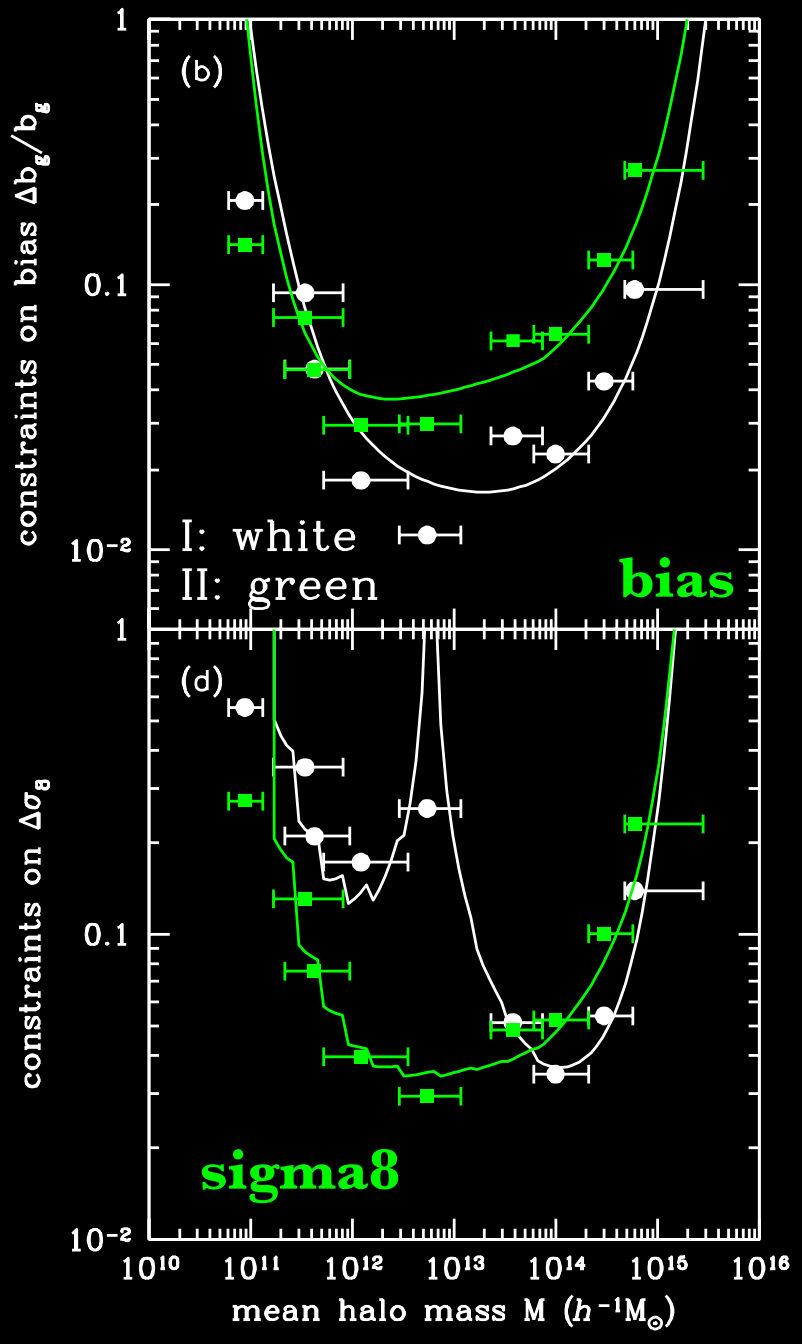
Method I

- measure **mean mass**
- **fainter**: lower signal, fewer lenses
- **brighter**: higher signal, fewer lenses, fewer bg gals
- **LRG** or **maxBCG** yield best constraints



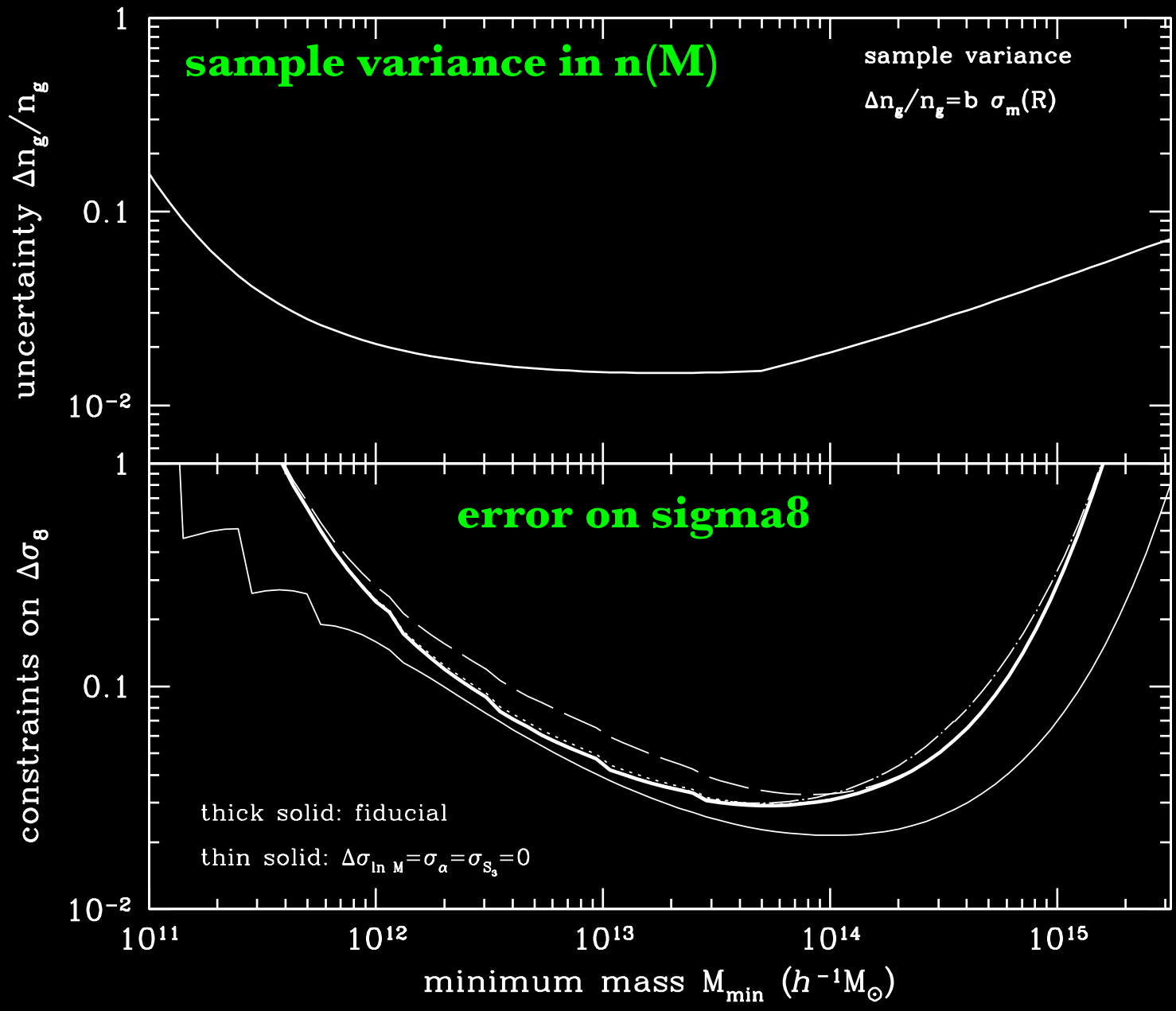
Method II

- measure **cross-correlation**
- ***no modeling*** of galaxy bias
- broad range: L4 ~ maxBCG
- ~5% level systematics in SDSS



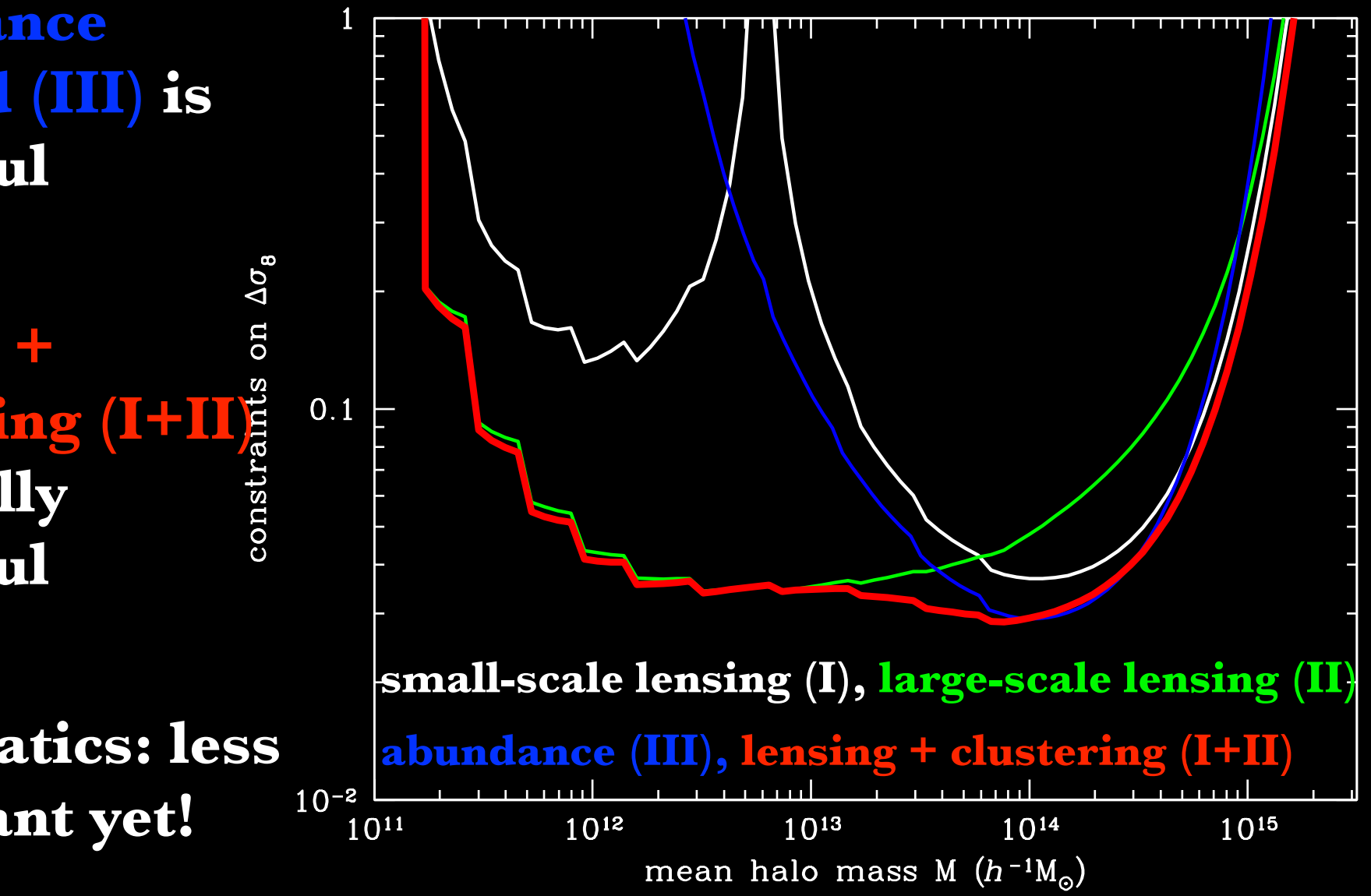
Method III: Abundance

- thresholded sample
- mass-obs. scatter
- **self-calibration:** clustering & lensing
- systematic errors? e.g., **invisible halo, skewness**



Bottom Line in SDSS

- **abundance method (III) is powerful**
- **lensing + clustering (I+II) is equally powerful**
- **systematics: less dominant yet!**



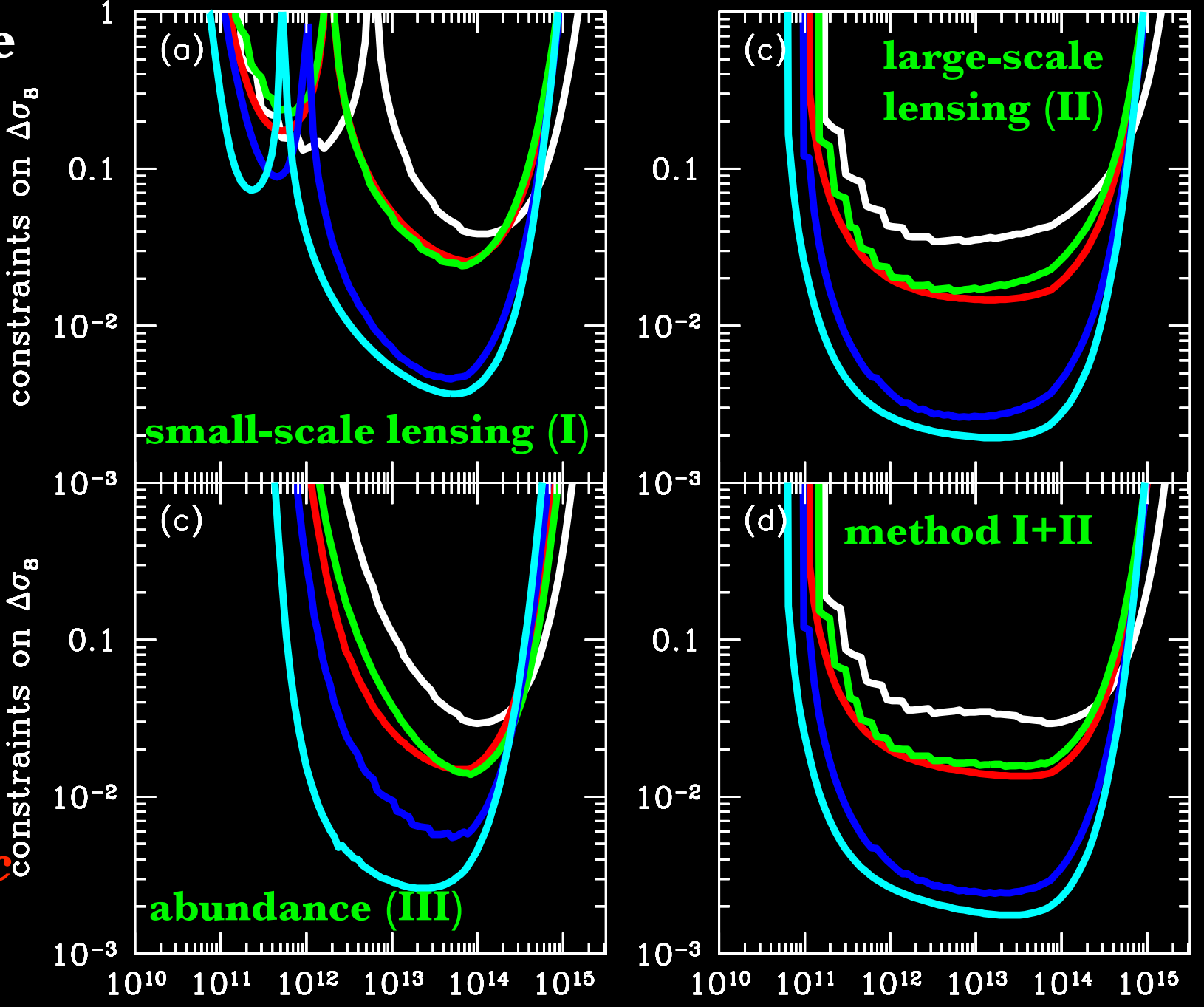
III. FUTURE GALAXY SURVEYS

Extending to Future Surveys

- SDSS vs DES, Euclid, LSST
- Future surveys:
  - significantly **lower threshold** in flux
  - **larger volume**: less sample variance
  - shot noise vs total number
  - photometric vs spectroscopic surveys

- additional method:
  - **cosmic shear** measurements

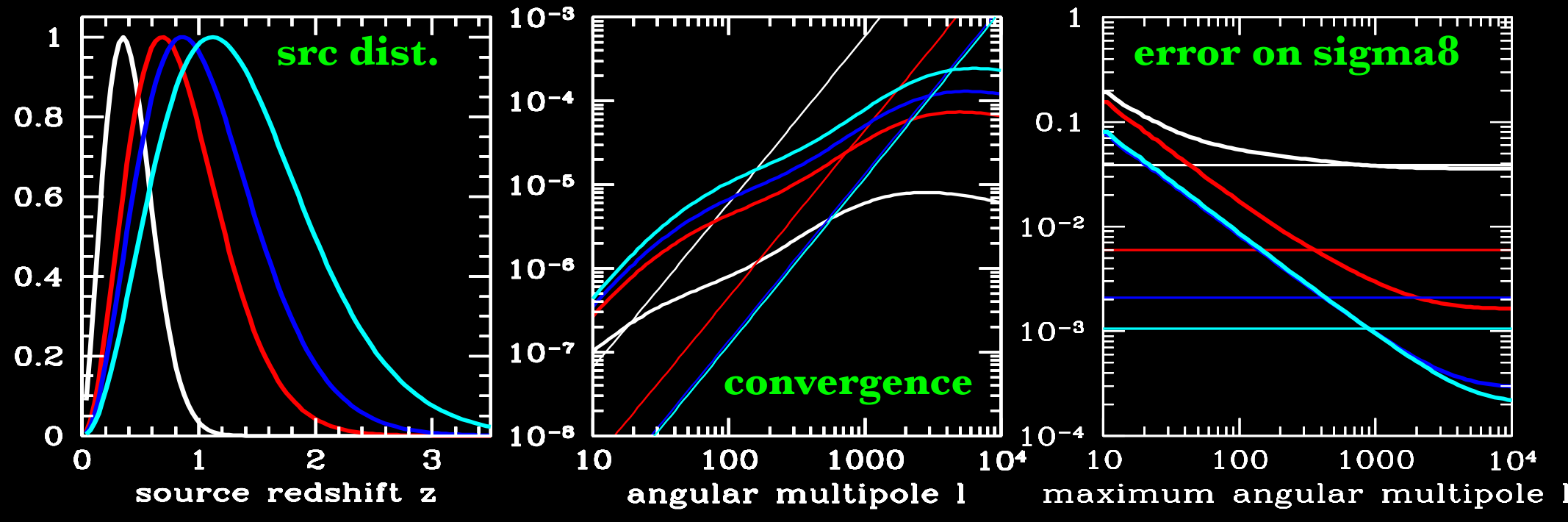
- abundance method (III) is powerful
- lensing + clustering (I+II) is equally powerful
- *systematic* can be important



Cosmic Shear

- statistically *most* powerful LSS probe, *no* galaxy bias
- systematics in measurements, baryon physics
- **non-Gaussian covariance**: set floor

SDSS, DES, Euclid, LSST



Conclusion & Caveats

- purely **statistical**: no systematic errors included
- other ways to extract information on small scales
- **redshift-space distortion**: another powerful probe
  - *nonlinearity*, scale-dependent *bias* on larger scales

- **combination** of g-g lensing and clustering
  - work for a broad mass range with less systematics
  - as *powerful* as abundance or cosmic shear

Joint Analysis of Lensing, Clustering, and Abundance

Jaiyul Yoo

Institute for Theoretical Physics, University of Zürich

Lawrence Berkeley National Laboratory, U.C. Berkeley

Collaboration with Uros Seljak

Cosmic Frontier Workshop, March 7, 2013