Combining Probes in the Dark Energy Survey

Theory & Combined Probes Working Group

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Cosmological Survey Inference System (CosmoSIS)

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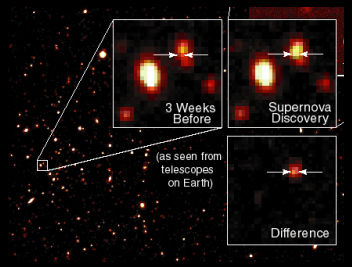
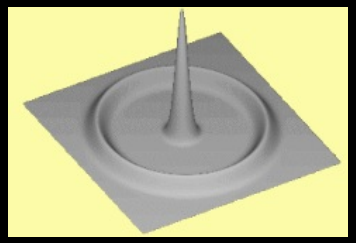
* Here # Applying for a job!

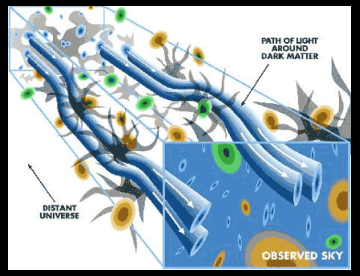
4 Independent probes plus uncorrelated CMB → Constraints on *w*



Supernova Brightness

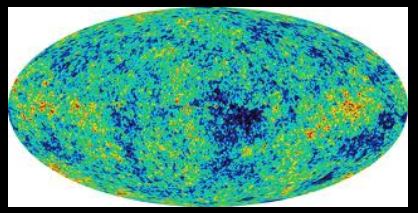


Baryon Acoustic Oscillations

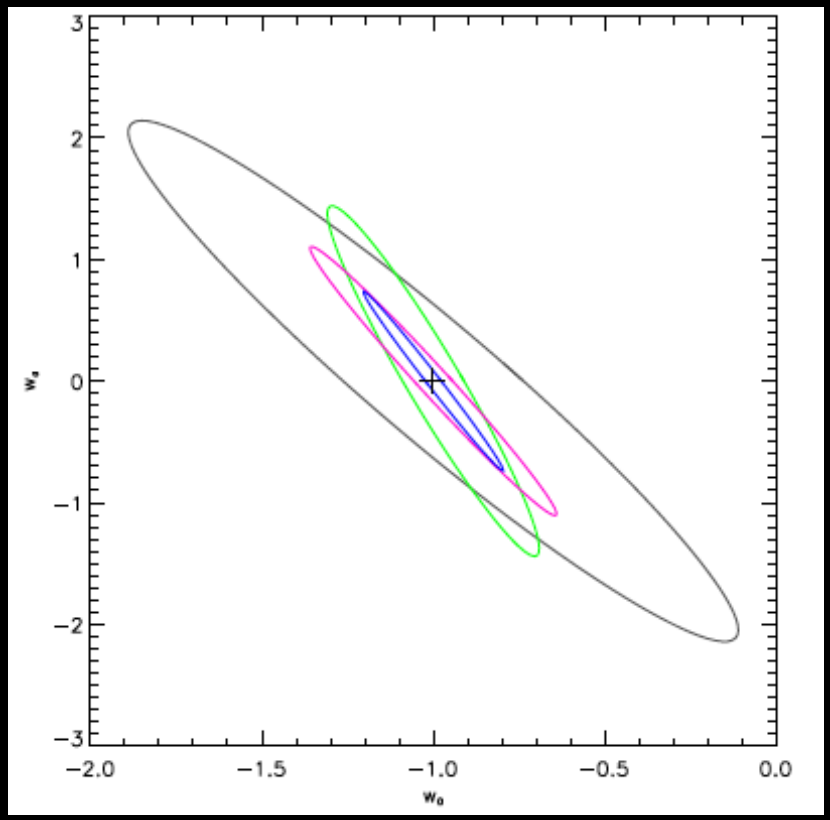


Gravitational Lensing

Galaxy Cluster Abundance



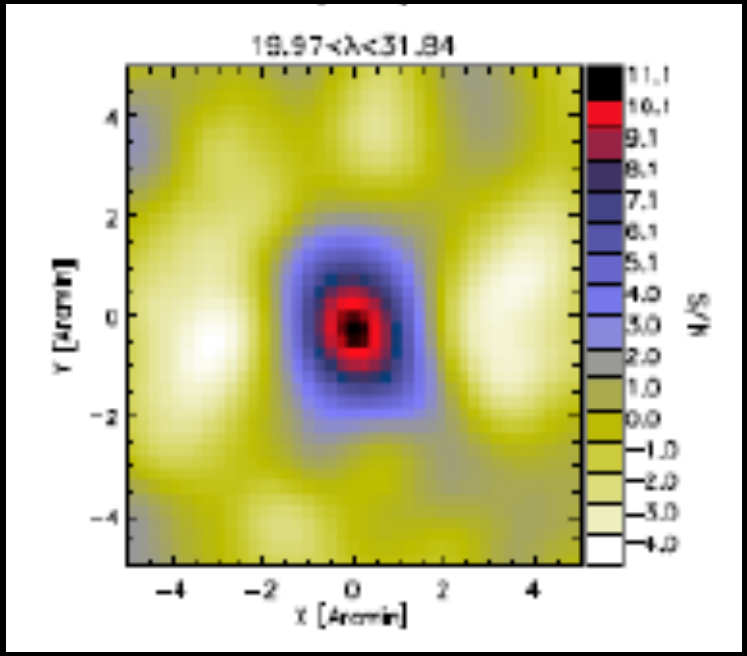
Cosmic Microwave Background



4 Independent probes plus ~~uncorrelated~~ CMB → Constraints on *w*

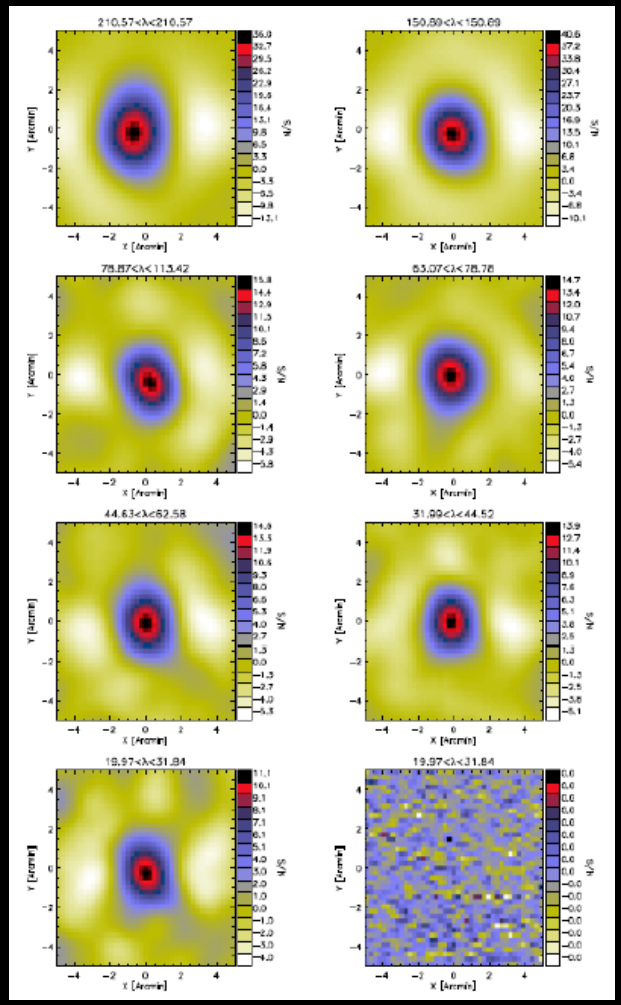
Sunyaev-Zel'dovich Effect

- Eew hundred stacked clusters (516 total) from DES Science Verification data
- Sensitive to pressure profile, which in turn depends on mass



4 Independent probes plus ~~uncorrelated~~ CMB → Constraints on *w*

- Stacked clusters (516 total) binned in richness
- SZ signal grows with richness
- Multi-wavelength approach to beat down cluster systematics associated with mass observable



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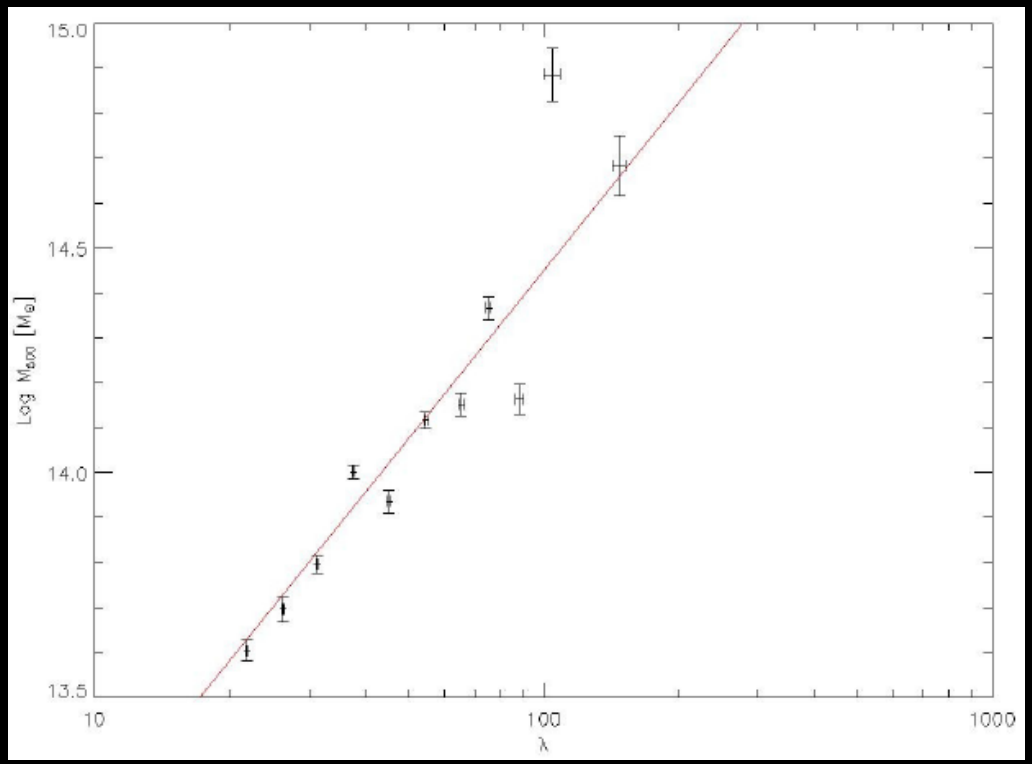
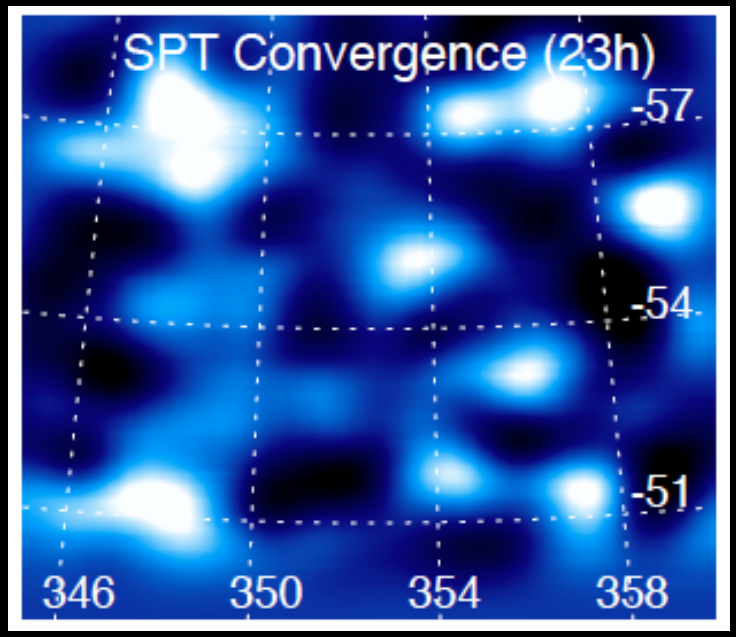
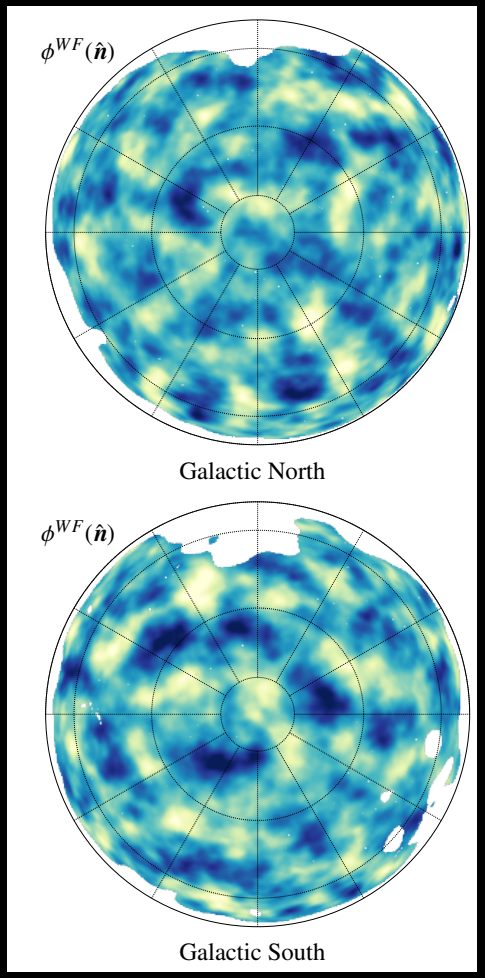


4 Independent probes plus ~~uncorrelated~~ CMB → Constraints on *w*

Lensing of the CMB by Large Scale Structure





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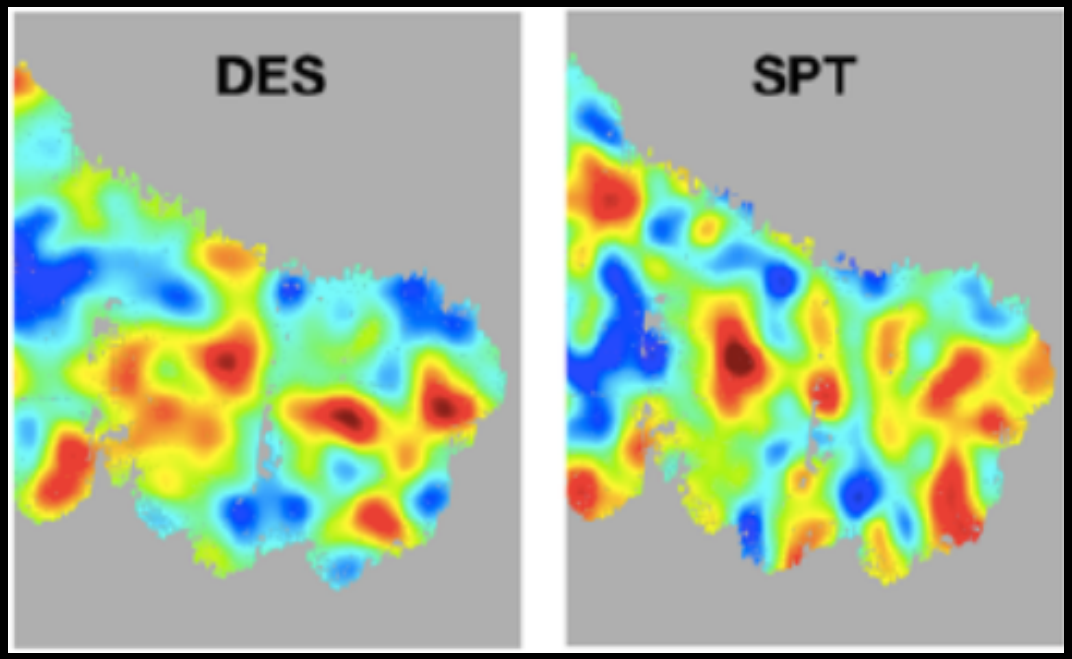

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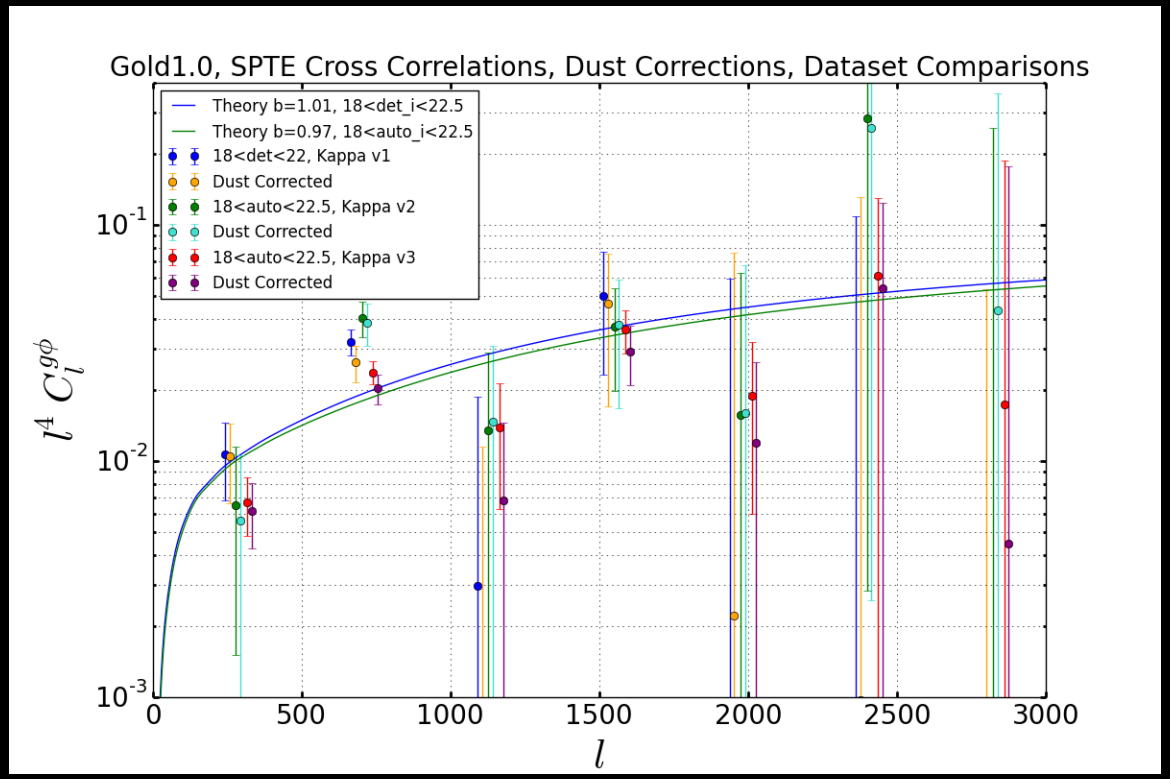
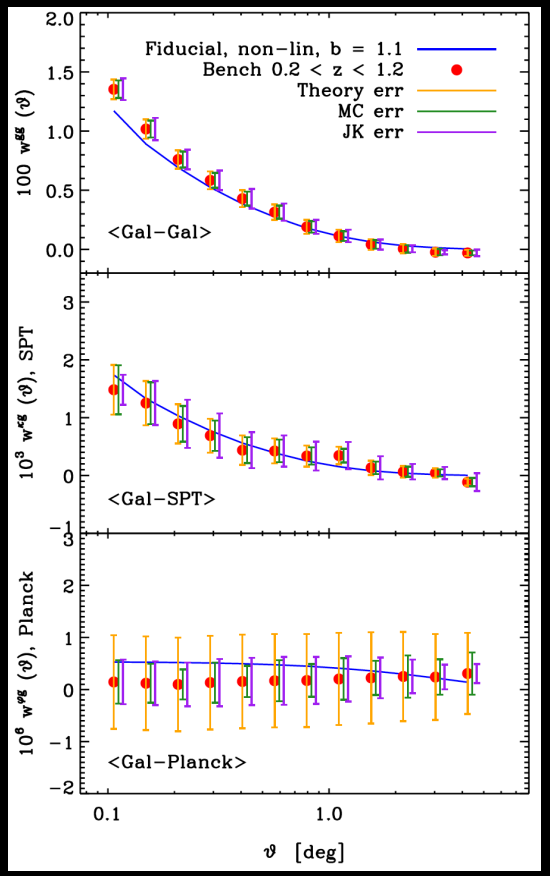




Will teach us about galaxy bias

DES\CMB	κ Map	Temperature	SZ Source Profile	Lensing of Dipole
Galaxy Map	Galaxy over-density and CMB kappa map	ISW and Diffuse SZ	• LRG • Clusters • Galaxies in SPT Selected Clusters	Clusters
Shear Map	DES cosmic shear with CMB kappa map	Might pick up ISW and Diffuse SZ	This would probe <Phi x Pressure>	Might be interesting to think about this
Tangential Shear [g-g lensing; cluster lensing]	Might be interesting to do "CMB kappa"-lensing	Probes <\Delta\Sigma x Pressure>	Cluster lensing of SZ-detected clusters:	

4 ~~Independent~~ probes plus ~~uncorrelated~~ CMB → Constraints on *w*

- **Simply multiplying likelihoods is incorrect: all probes are correlated with one another**
- **Canonical example: Lensing and Large Scale Structure:**

$$\langle \delta\kappa \rangle = \langle \delta_{fg}\kappa_{bg} \rangle + \langle \delta_{bg}\kappa_{fg} \rangle + \langle \delta_{bg}\kappa_{bg} \rangle + \langle \delta_{fg}\kappa_{fg} \rangle$$

Galaxy-galaxy lensing: Foreground over-density responsible for lensing of background galaxies

Magnification: Background over-density is (de-)magnified by foreground and background kappa maps

Lens-Source coupling: Background over-density affects background kappa map

4 ~~Independent~~ probes plus ~~uncorrelated~~ CMB → Constraints on ~~w~~= GR vs MG

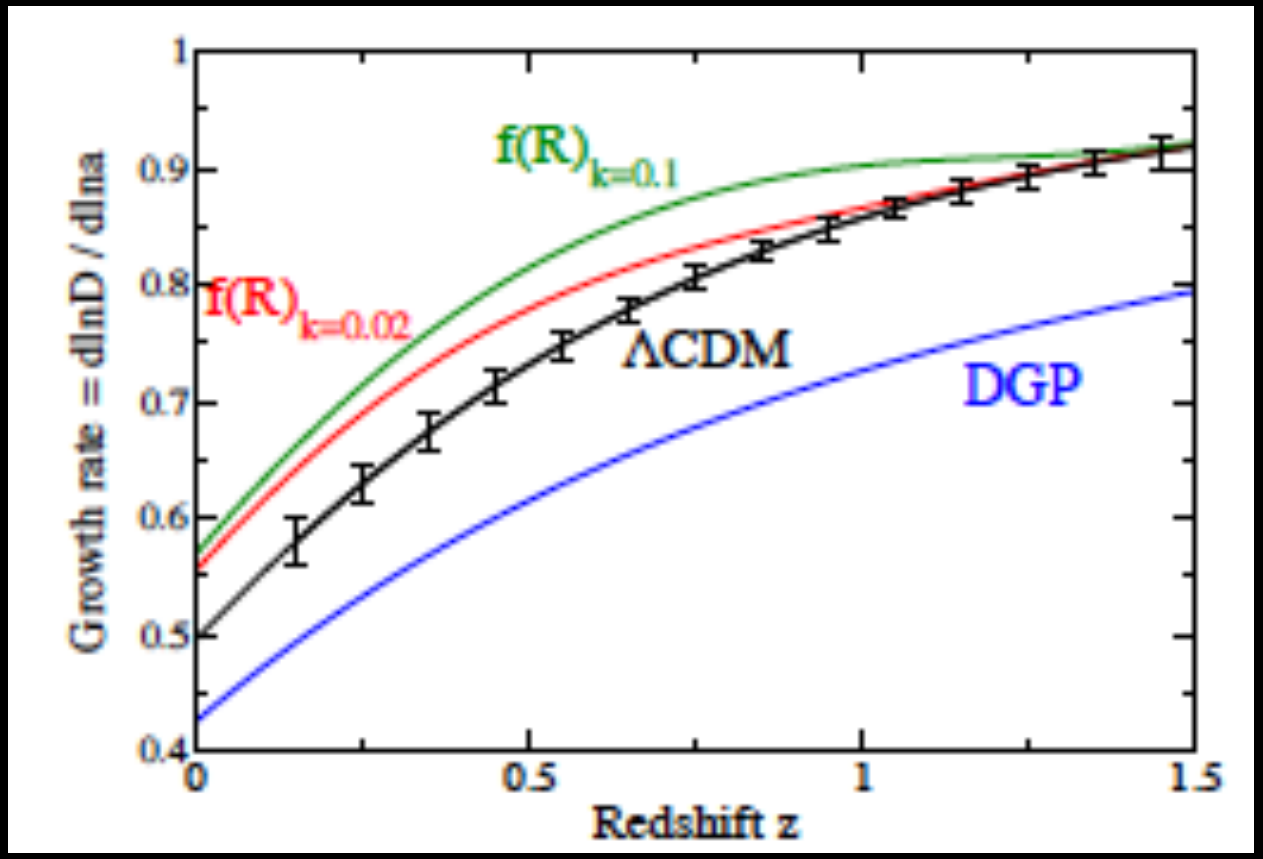
Can explain acceleration without dark energy (w) by modifying GR:

$$S = \frac{1}{16\pi G}\int d^4x\sqrt{-g}\left[R + f(R)\right] + \int d^4x\sqrt{-g}L_m$$

Many ways to modify gravity to fit expansion history: *Trodden, Matas, Stefanyszyn, Park, Salgado, Erickcek, …*

4 ~~Independent~~ probes plus ~~uncorrelated~~ CMB → Constraints on ~~≠~~ GR vs MG

Fix expansion history: differentiate between DE +GR and MG using growth of structure



Huterer et al. 2014

Lensing + LSS as a probe of Growth

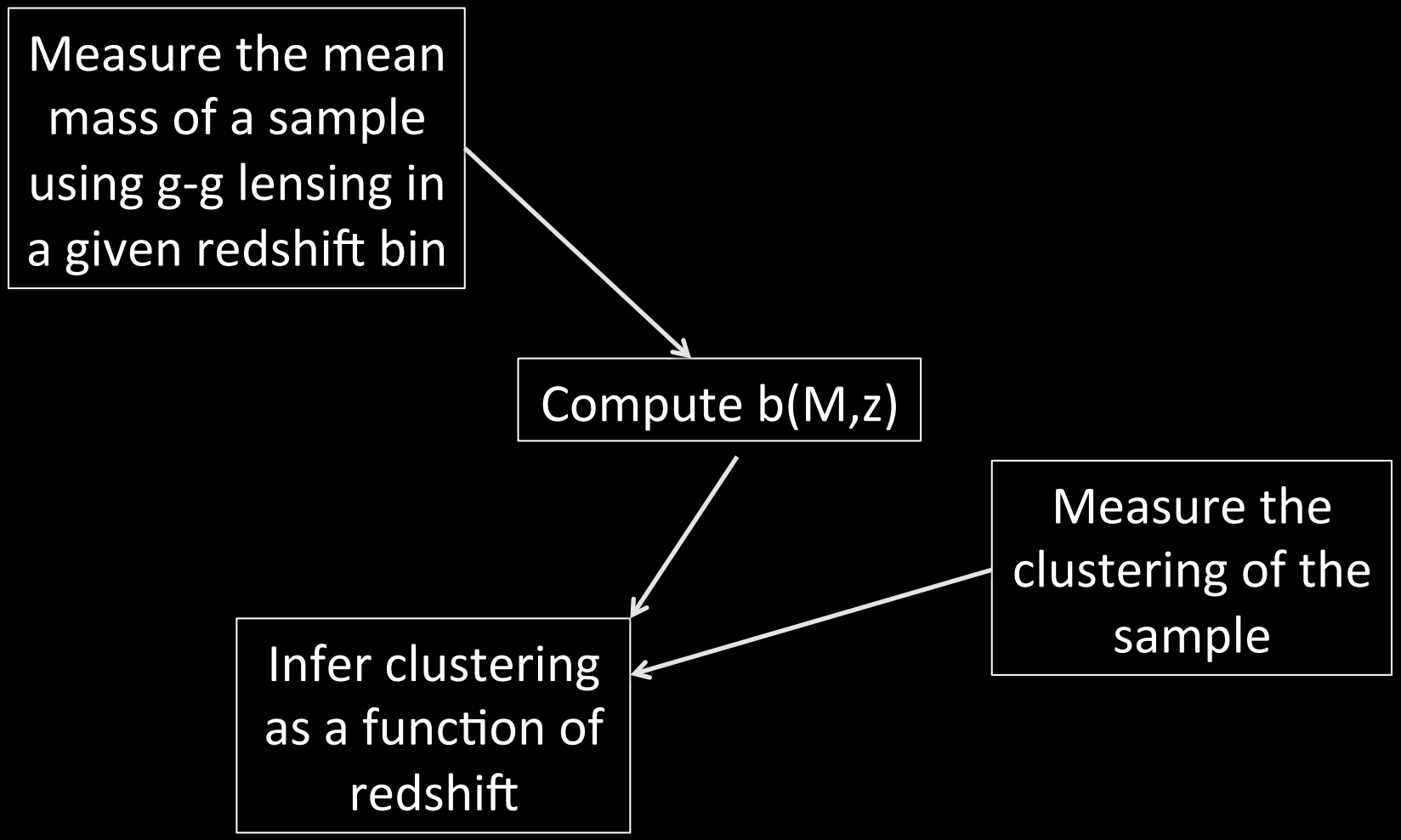
(Yoo & Seljak; Oguri and Takada; van den Bosch, More, Cacciato, Mo, Yang)

- Use shear of background galaxies to estimate mass of foreground galaxies
- There is a theoretical prediction, calibrated off simulations, for b(M)
- Use the large scale distribution of the foreground galaxies (whose mass is now known) to infer the matter power spectrum

$$P(k,z) = \frac{P_{gg}(k,z)}{b_g^2(M)}$$

→ Amplitude of fluctuations as a function of redshift

Lensing + LSS as a probe of Growth



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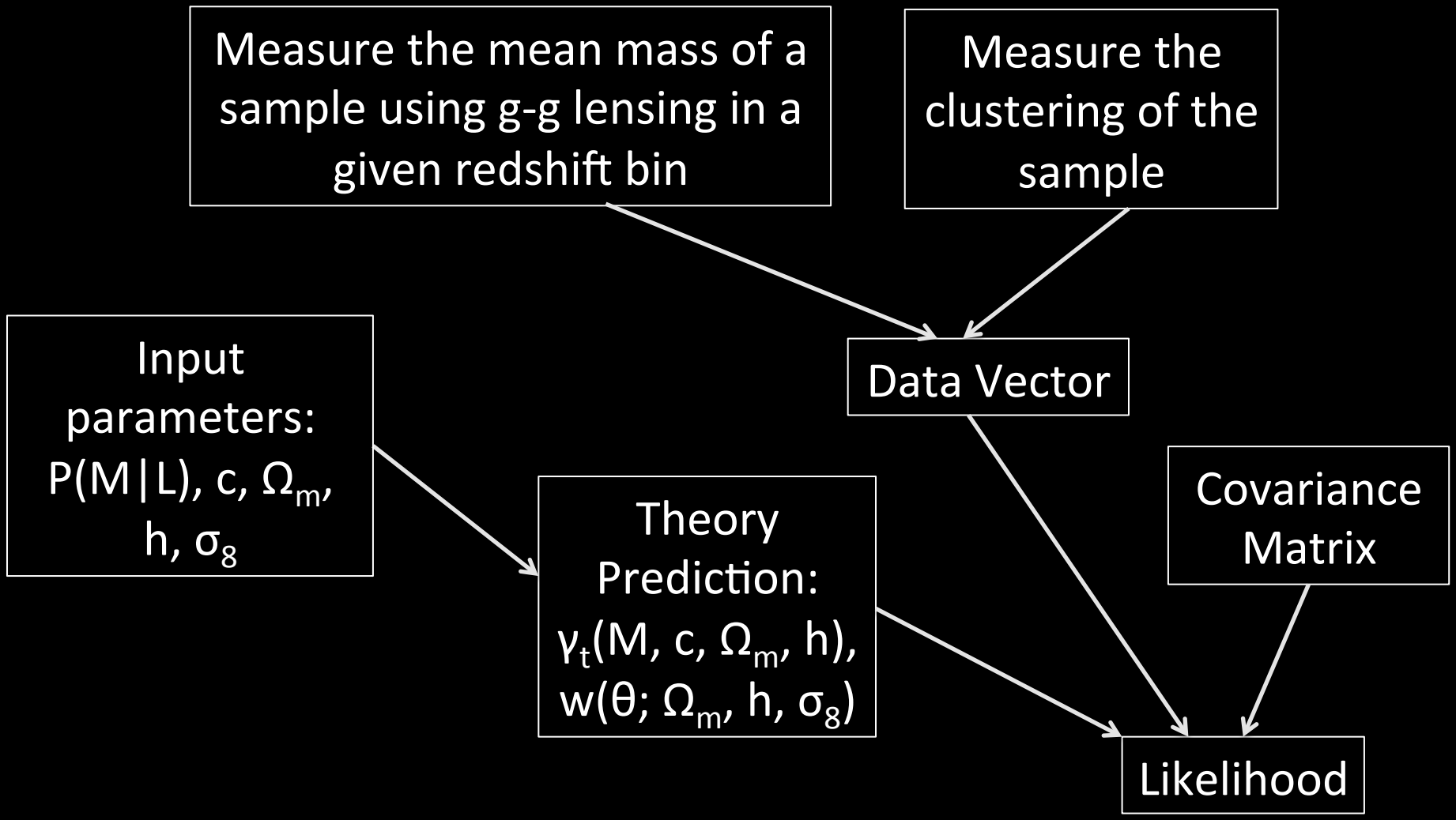
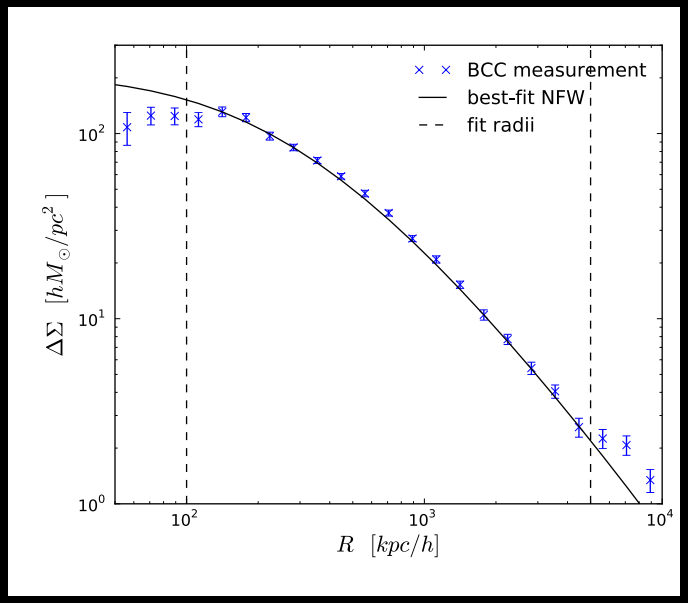
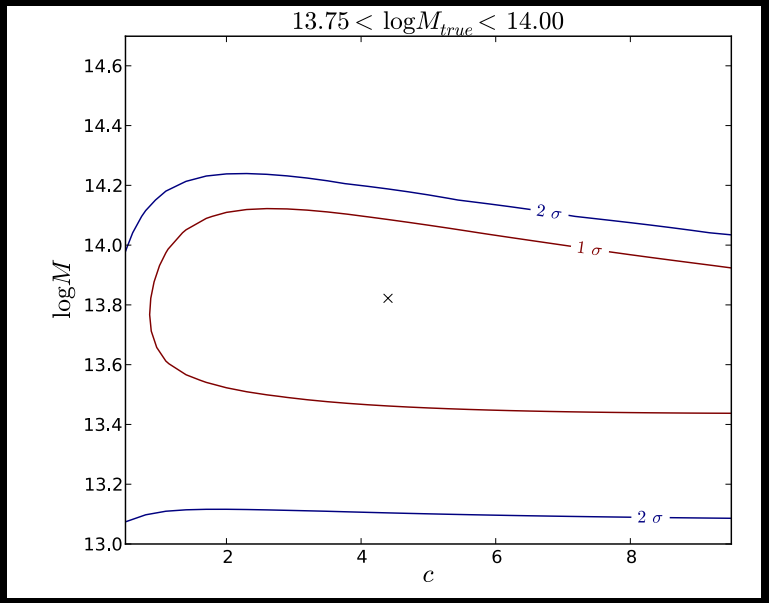
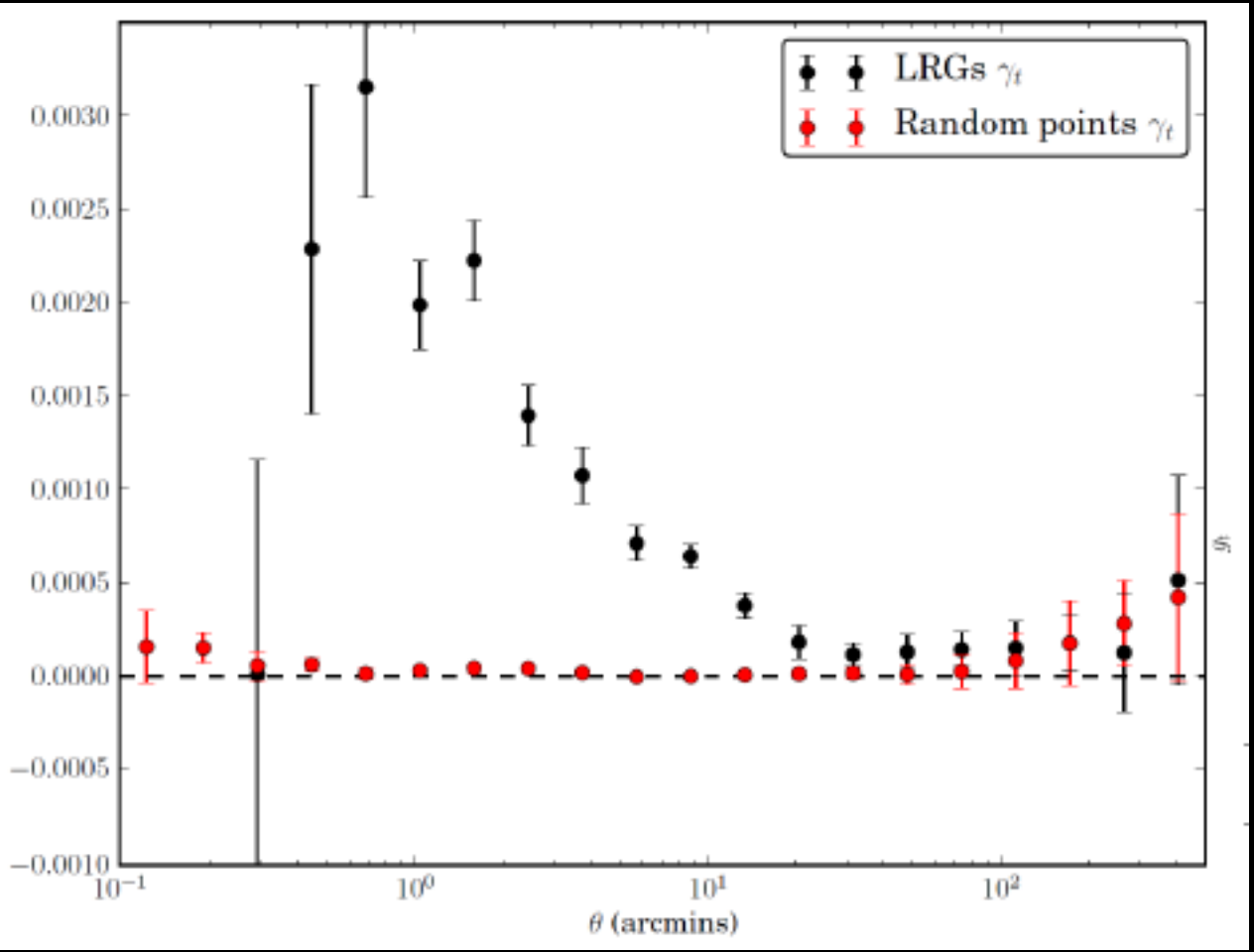


Galaxy-Galaxy Lensing: Simulations



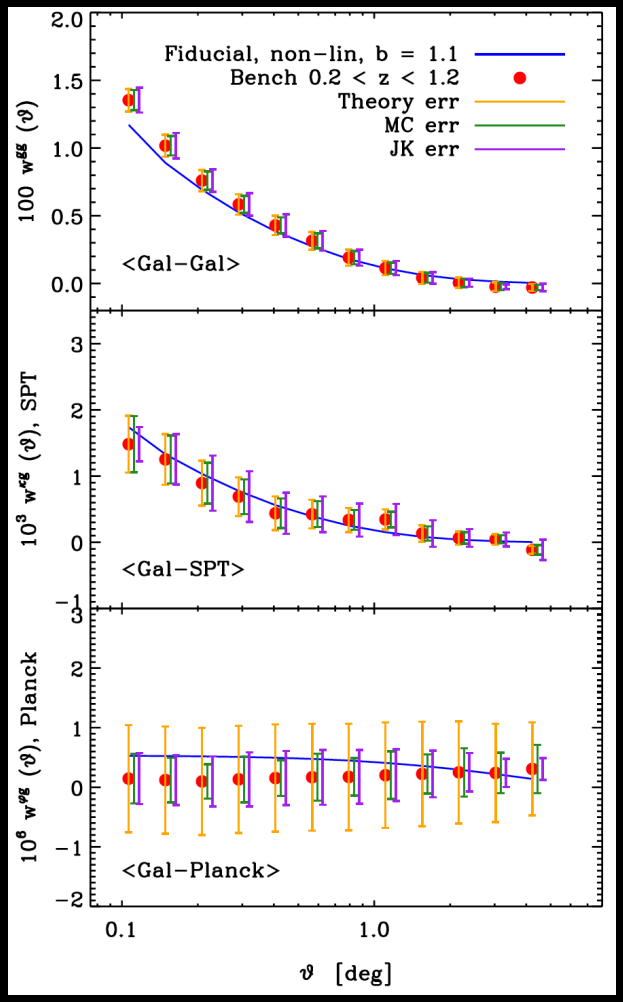


Galaxy-Galaxy Lensing: SV Data

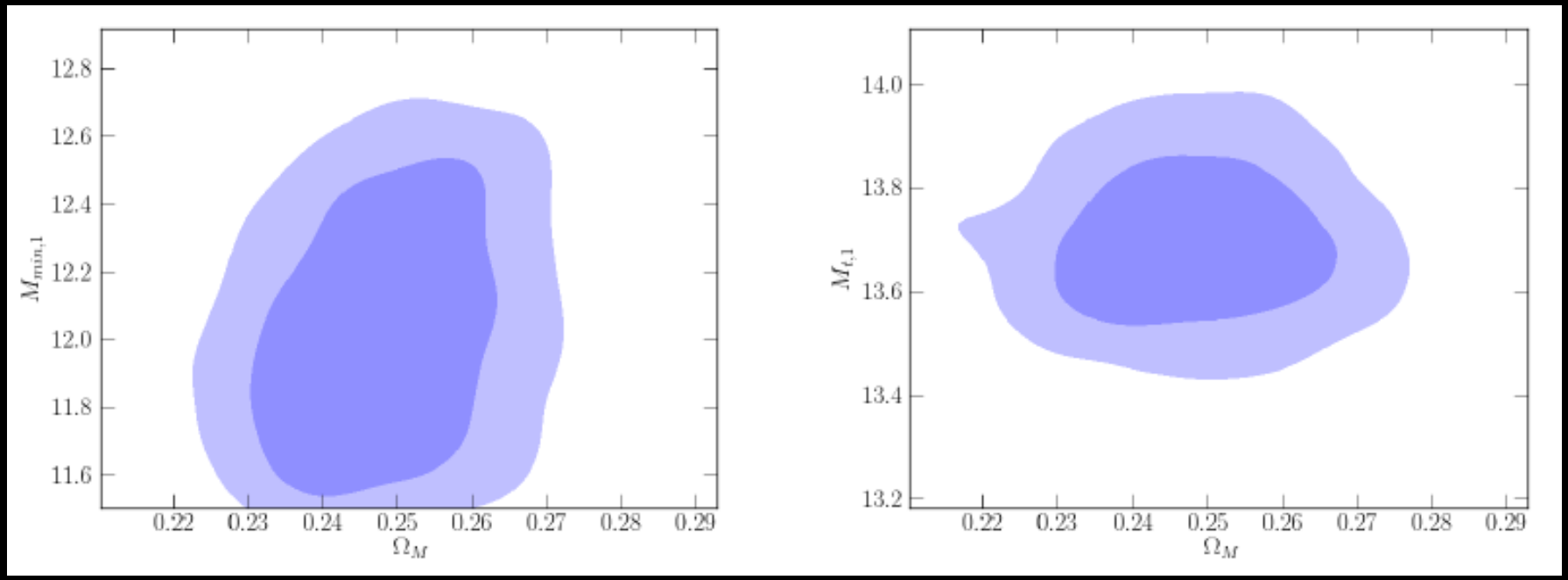


Galaxy Clustering Data

See Talk by Flavia Sobreira on Friday for details, further results

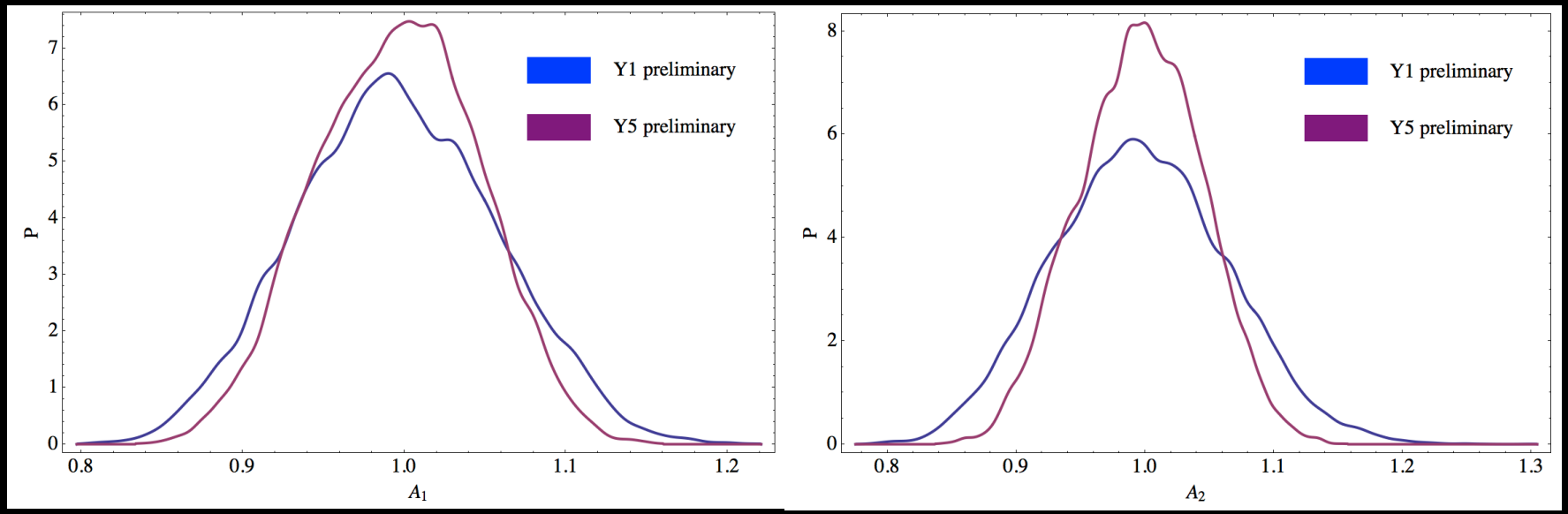


Preliminary Projections on Simulations



See Poster by Youngsoo Park*#

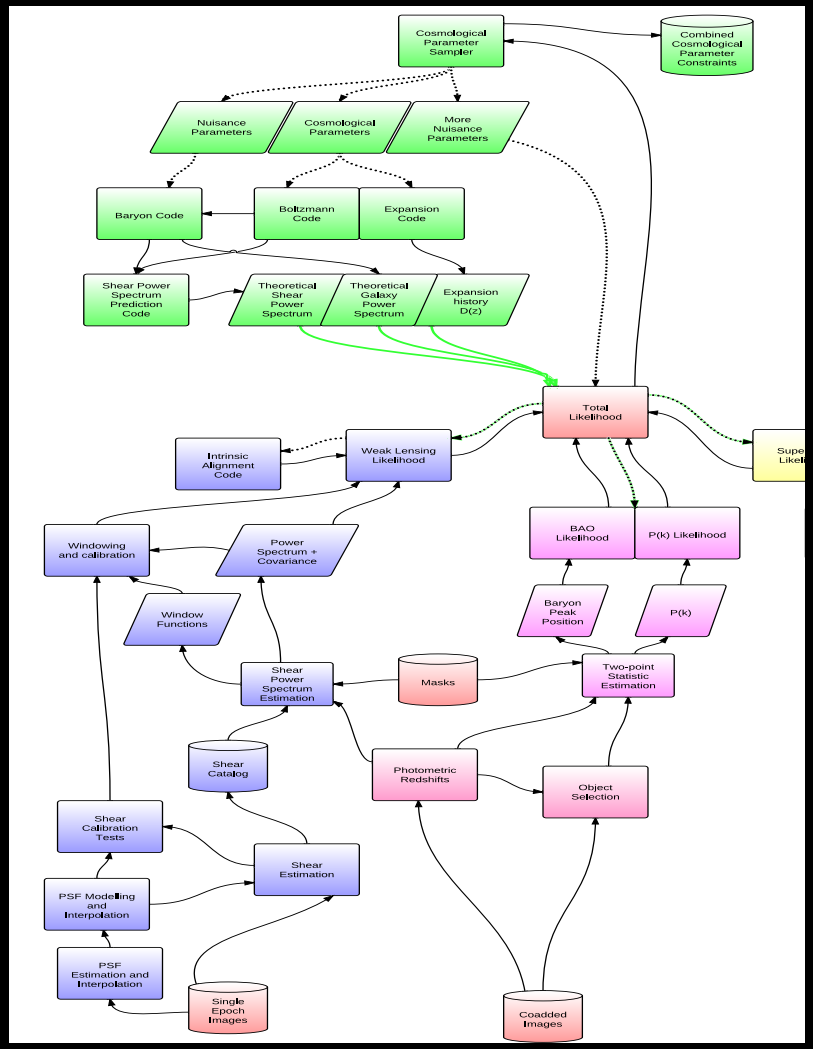
Preliminary Projections on Simulations



Aim to constrain growth at the 10% level; should get competitive constraint even with SV data

CosmoSIS: Cosmological Survey Inference System

- Designed by Theory & Combined Probes Working Group in DES to help the collaboration work together to extract tightest constrains on dark energy
- Software Framework that empowers multiple users to develop and share code, combine analyses, and produce robust cosmological parameter constraints: cosmoMC on steroids!
- Already in use in DES, but gaining traction with the broader community (breakout workshop in May; talks at DESI, LSST, FNAL Users meeting)



https://bitbucket.org/joezuntz/cosmosis/wiki/Home or contact me