Cosmology from the Dark Energy Survey: a joint analysis of weak lensing and angular clustering

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on behalf of the Dark Energy Survey collaboration
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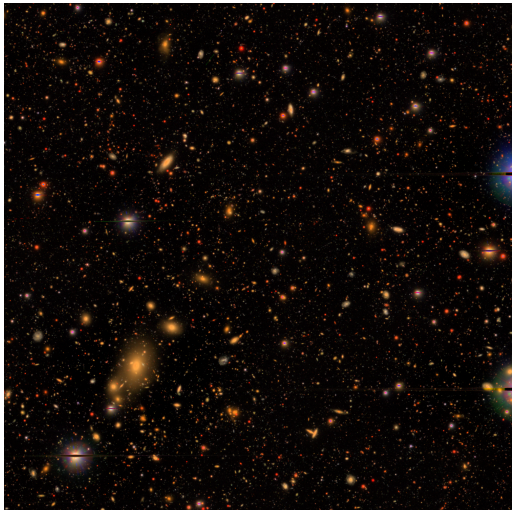
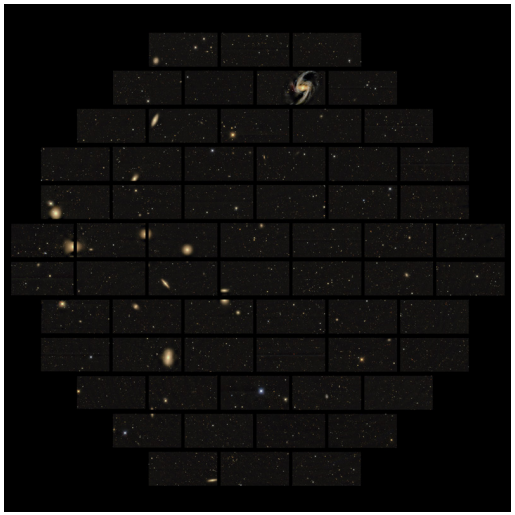
Introduction

Some of the strongest constraints on the sum of the neutrino masses comes from cosmology: $\sum m_\nu < 0.13$ eV (CMB + LSS).

There are several ongoing surveys that will measure the sum of the neutrino masses within the next ∼5 years:



Hyper Suprime Cam Survey

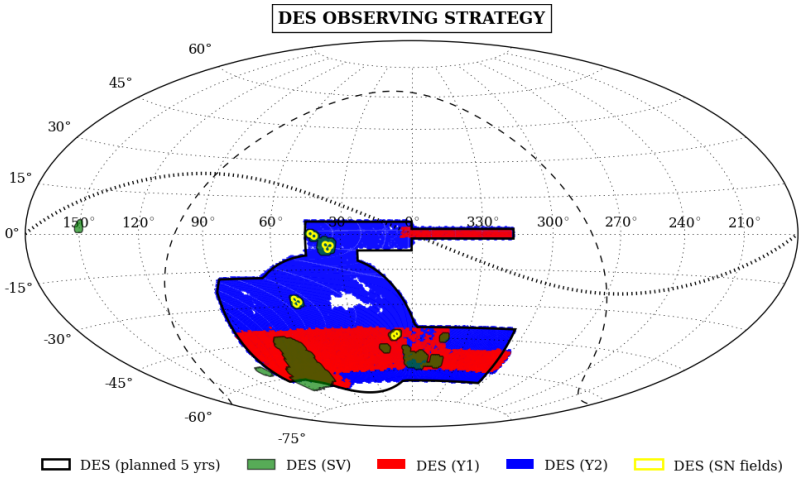


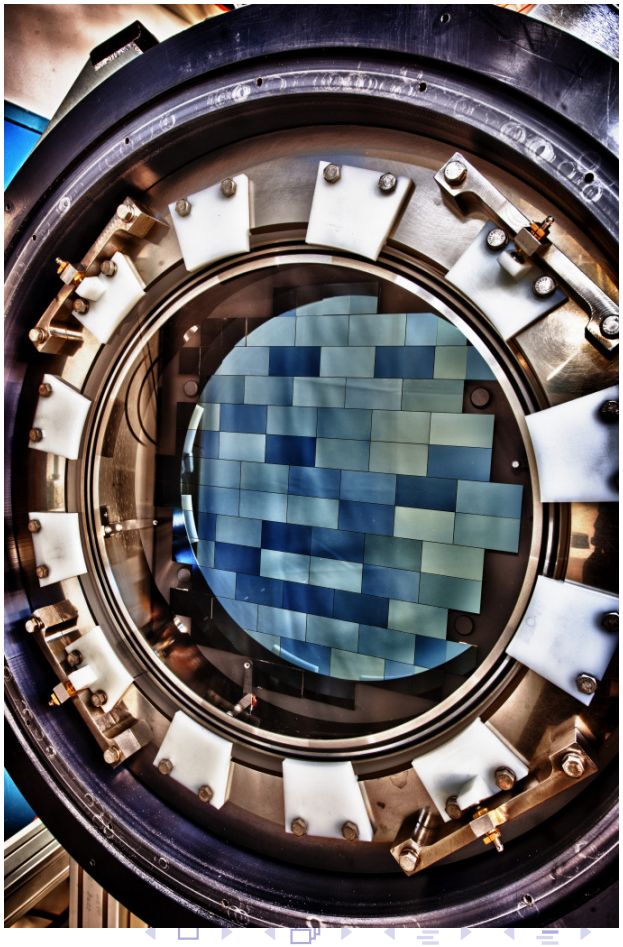
Dark Energy Survey

Kilo Degree Survey

The Dark Energy Survey

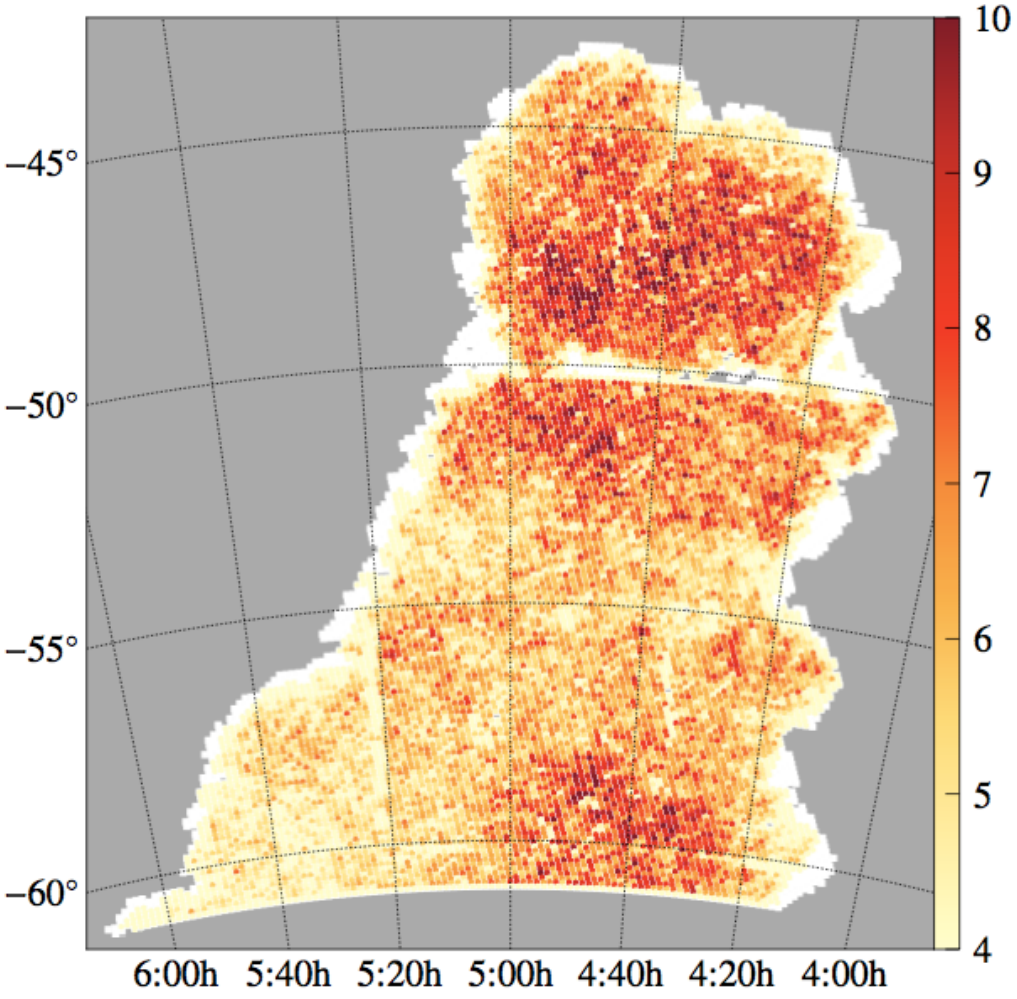
DES is an on-going imaging survey of the Southern Sky using DECam on the 4m Blanco Telescope in Chile.



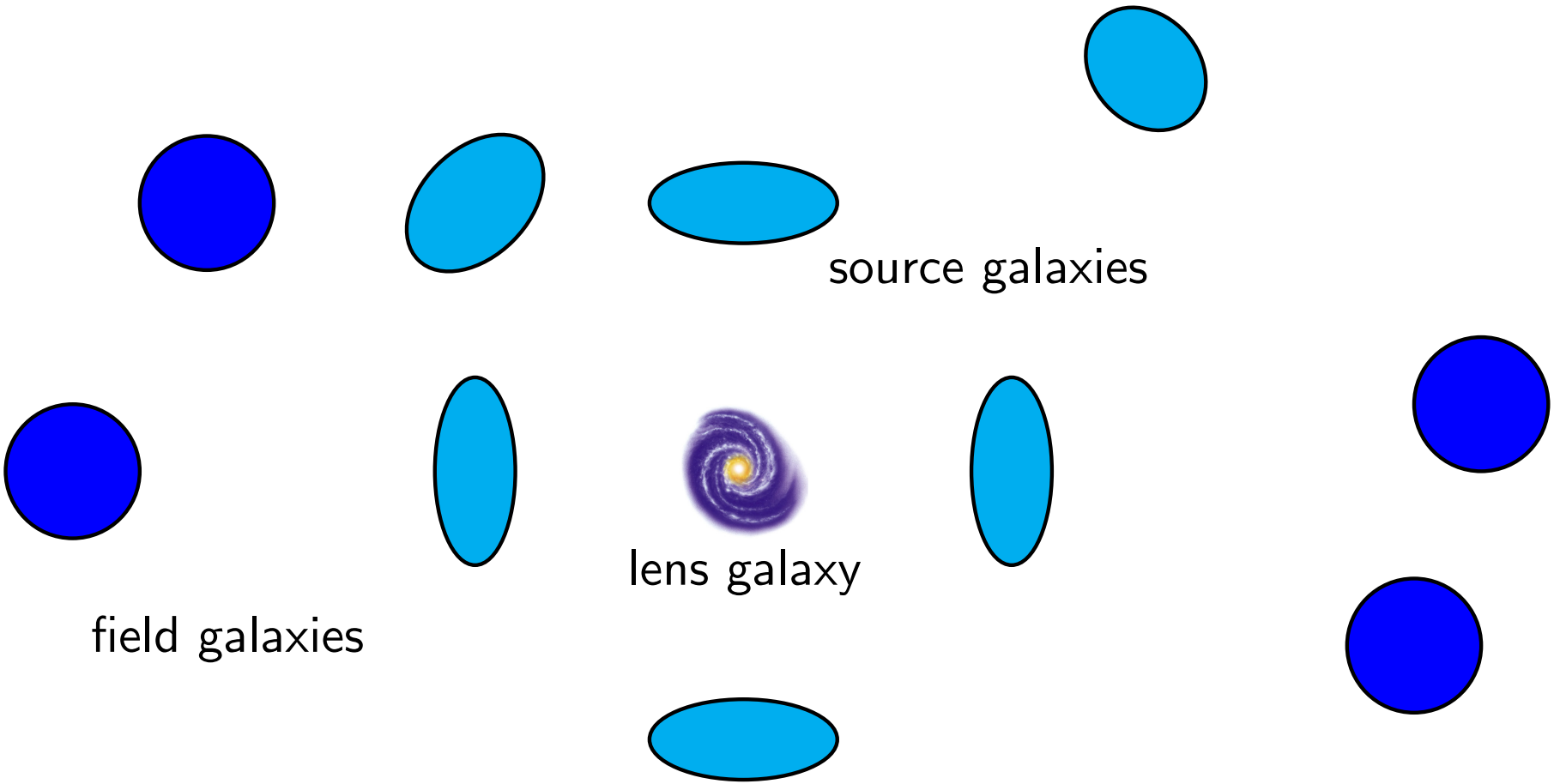


The Dark Energy Survey

We will be using the Science Verification area:

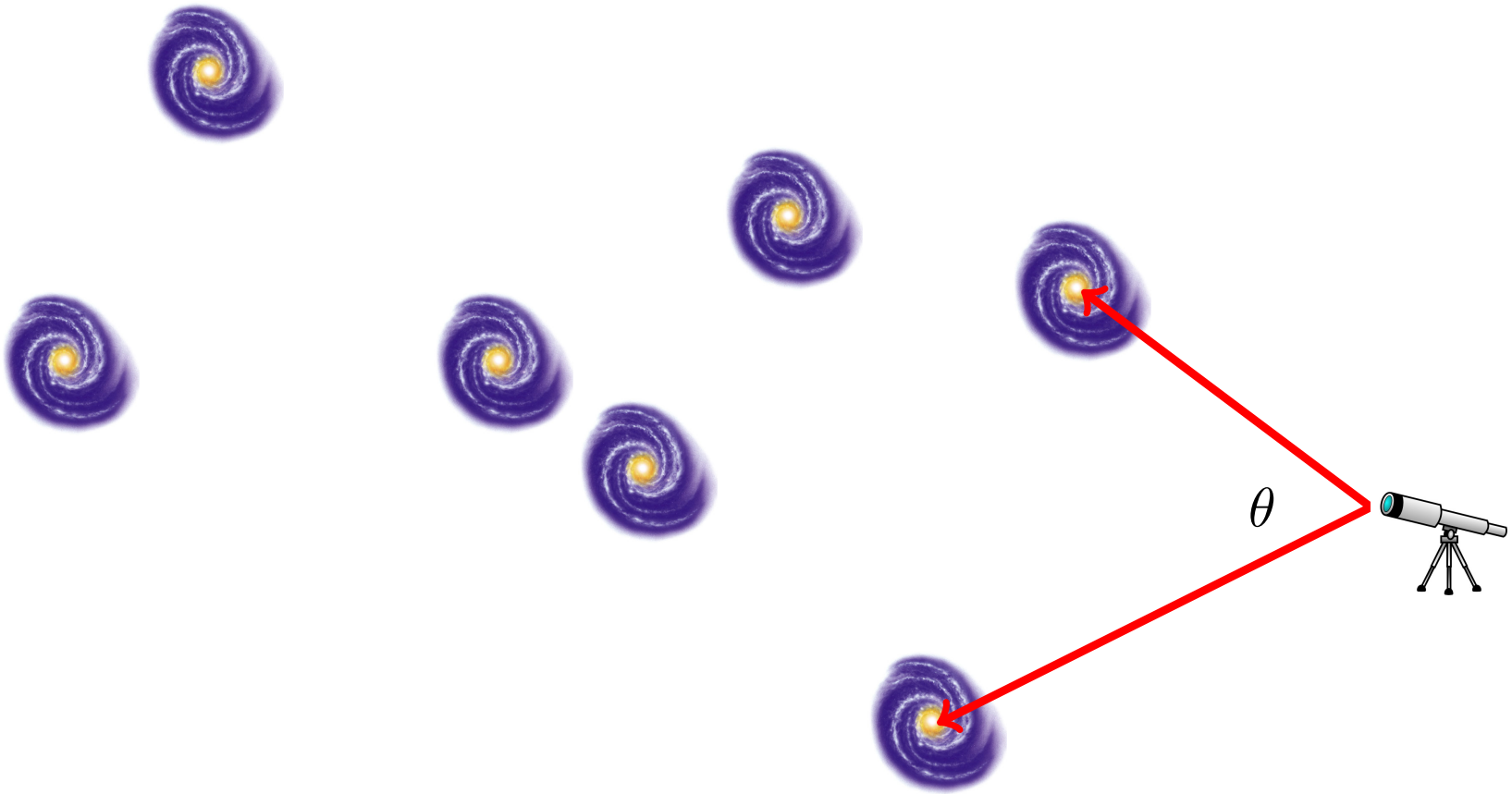


Galaxy-Galaxy Lensing



$$\langle \gamma_t(\theta) \rangle = 6\pi\Omega_m \int d\chi \, n_l(\chi) \frac{f_\chi(\chi', \chi)}{a(\chi)} \int dk \, k \, b \, P_{\delta\delta}(k, \chi) J_2(k, \theta, \chi),$$

Angular Clustering



$$w(\theta) = \frac{1}{2\pi} \int d\chi \left(\frac{n(\chi)}{\chi} \right)^2 \int d\ell \, \ell \, b^2 \, P_{\delta\delta}(\ell/\chi) J_0(\ell\theta)$$

We want to combine measurements of the tangential shear and angular clustering of luminous red galaxies measured from the Dark Energy Survey to constrain cosmology.

Combining probes breaks degeneracies:

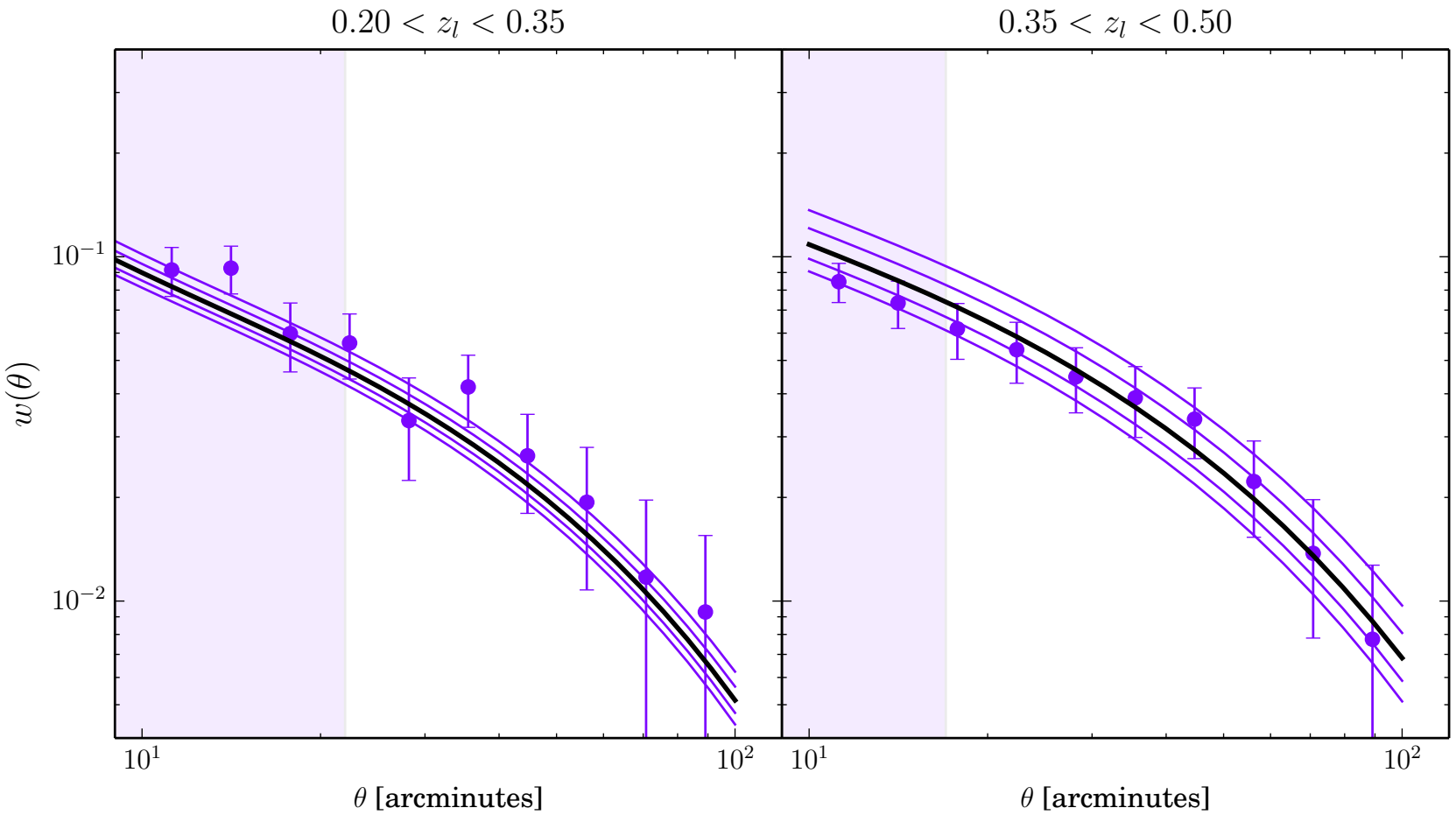
$$w(\theta) \propto b^2 \, {\sigma_8}^2,$$
$$\langle \gamma_t(\theta) \rangle \propto b \, {\sigma_8}^2.$$

Each probe has a different dependence on Ω_m as well.

Because we keep to large scales ($\sim$20' to 90'), we are relatively insulated against non-linear biasing and baryonic effects.

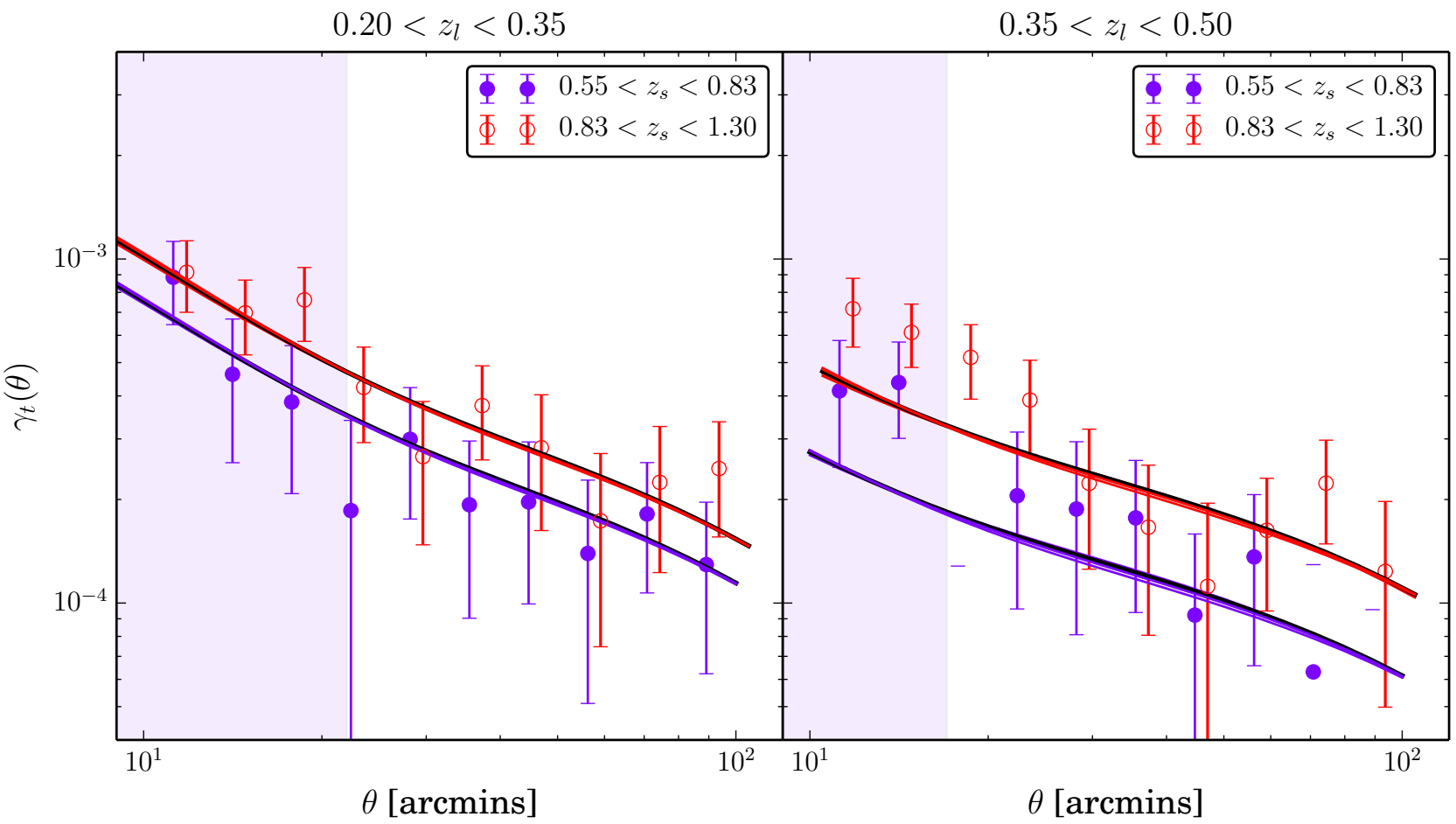
Measurements: Angular Clustering

We have measured the angular clustering of galaxies in two redshift bins:



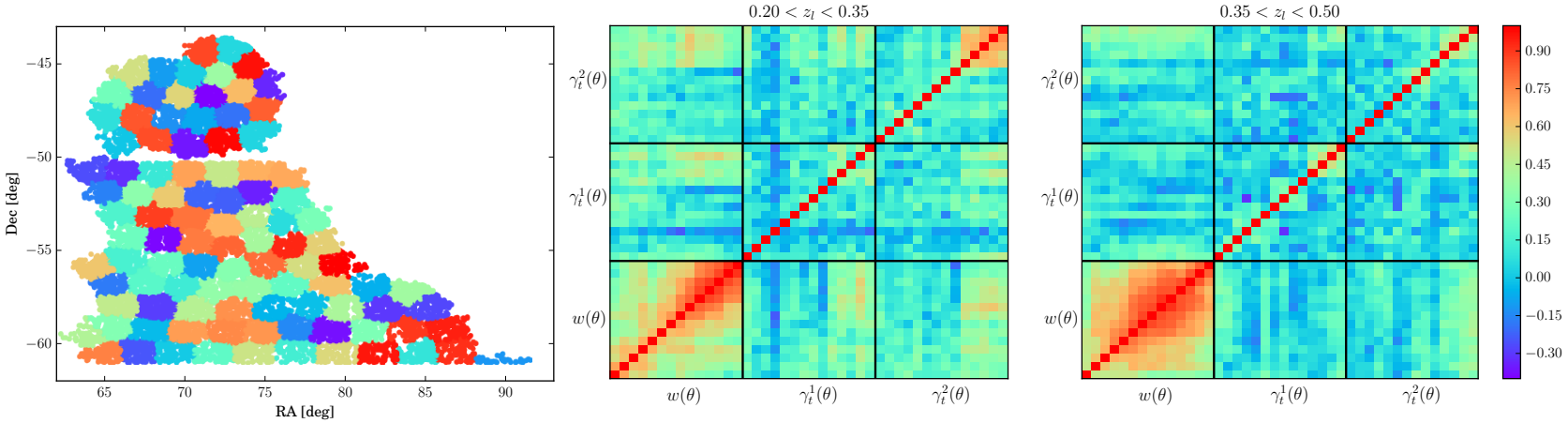
Measurements: Tangential Shear

Using the same galaxies as lenses, we measure the tangential shear of source galaxies around the lens.



Covariances

Covariances are calculated by jackknife resampling of the survey area:

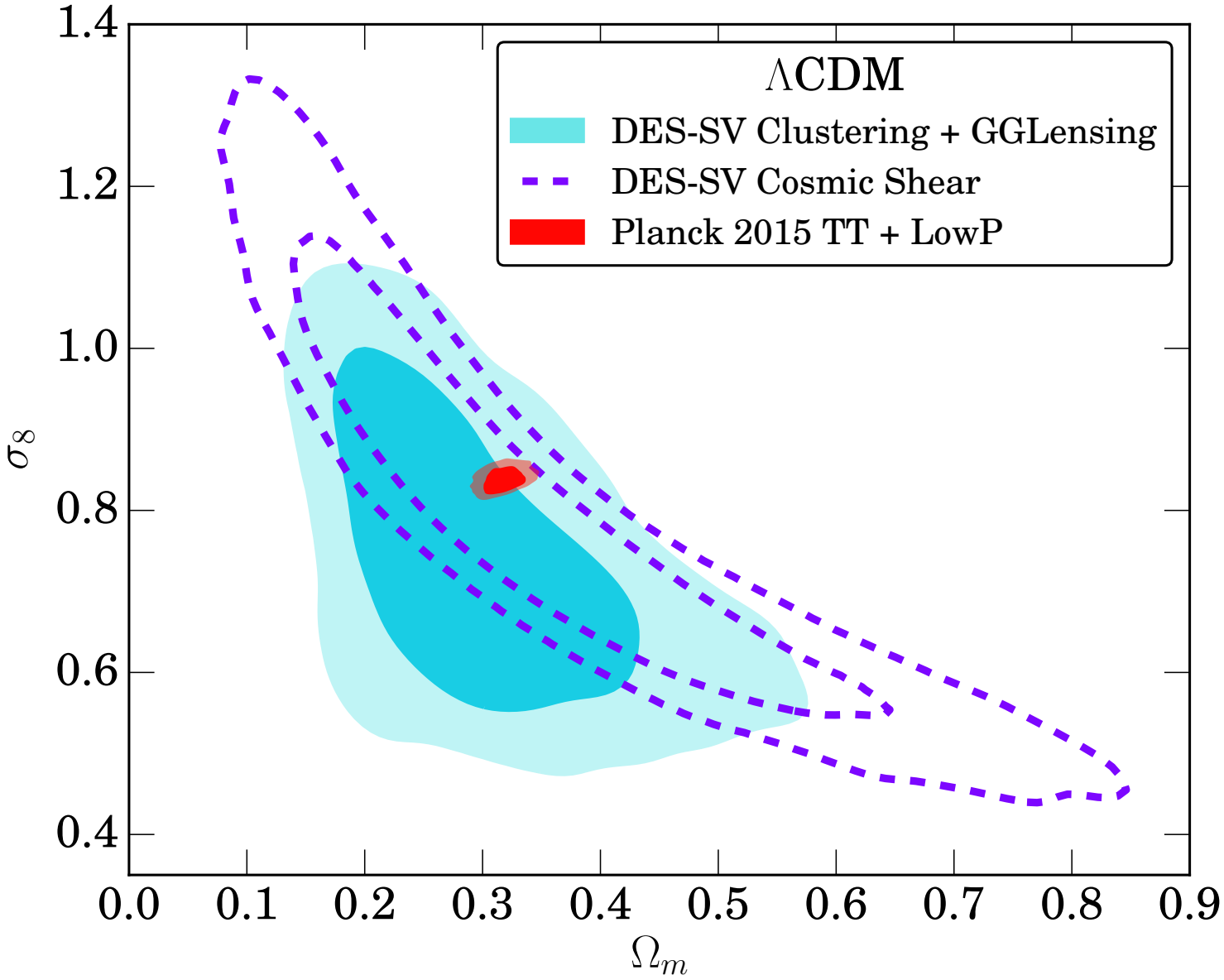


Accounting for Systematic Errors

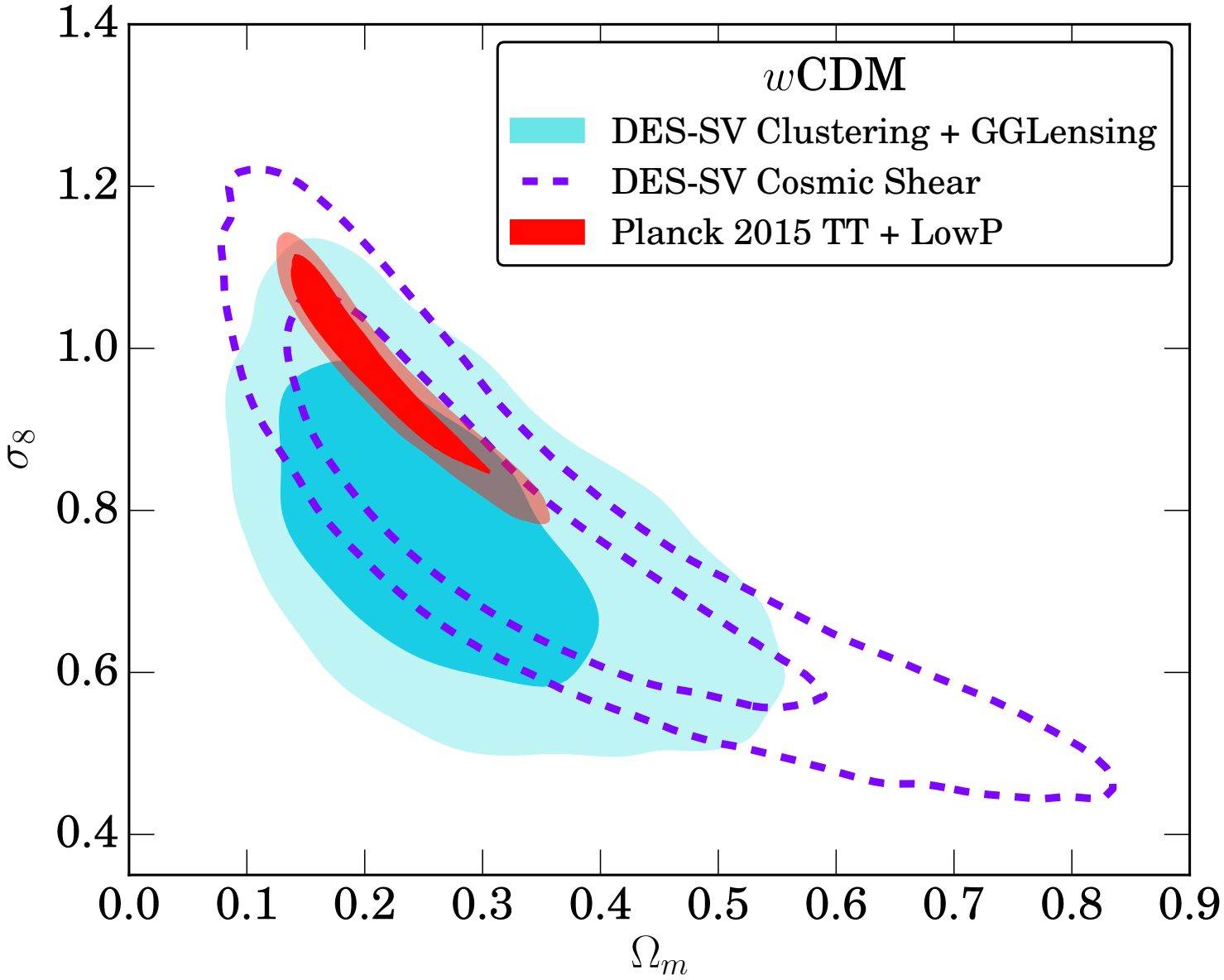
Apart from the usual cosmological parameters, we also include some nuisance parameters to account for various systematics effects:

- **Photo-z errors:** $(n(z) \rightarrow n(z + b_i))$ This accounts for shifts in the distribution of source galaxies as a result of photometric estimation errors.
- **Shear calibration errors:** $(\langle\gamma_t\rangle \rightarrow (1 + m_i)\langle\gamma_t\rangle)$ This accounts for blinding and recommended shear calibration error from Jarvis et al.
- **Observational conditions:** We allow for a constant shift in the amplitude of $\mathrm{w}(\theta)$ to correct for variations in observing conditions, errors in star/galaxy separation, etc.
- **Non-linear biasing:** We use perturbation theory to calculate the next leading order contribution to the galaxy bias (McDonald (2006)).

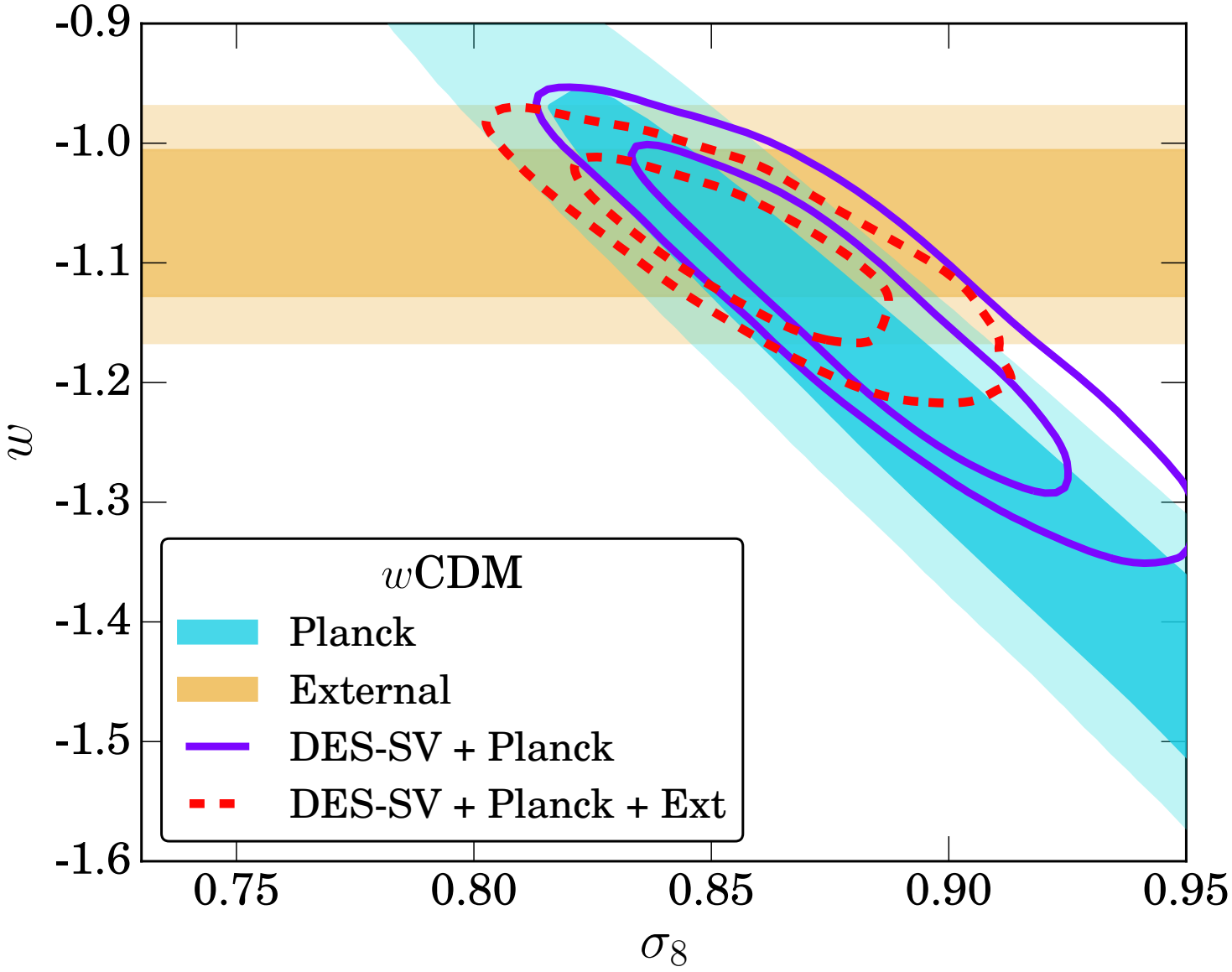
Cosmology: Constraints on σ_8 and Ω_m (ΛCDM)



Cosmology: Constraints on σ_8 and Ω_m (wCDM)

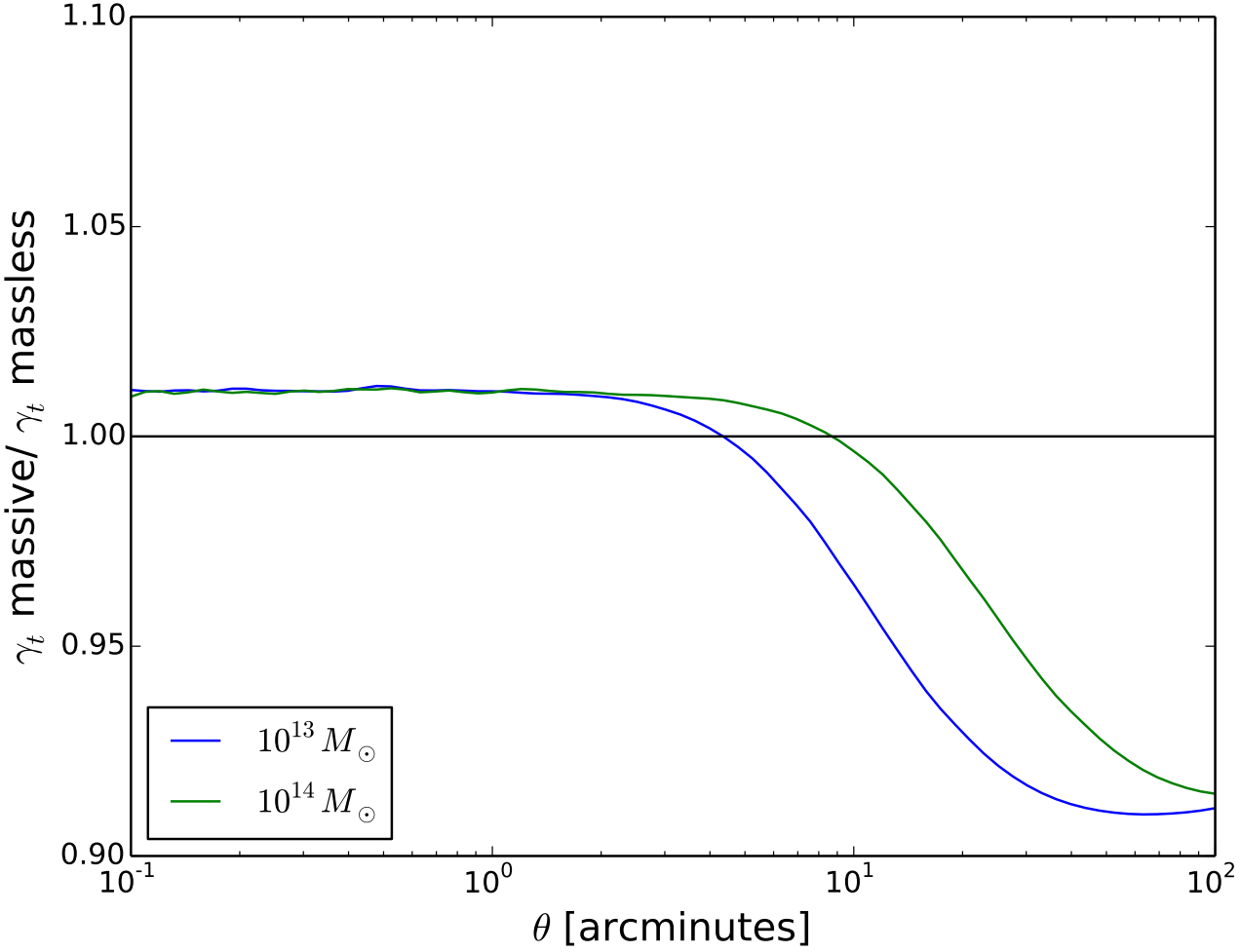


Cosmology: Comparison to external datasets



Sensitivity of WL to massive neutrinos

Galaxy-galaxy lensing is sensitive to the neutrino mass via the matter power spectrum, halo bias and mass function:



Conclusions and Outlook

- By combining angular clustering and galaxy-galaxy lensing, we can break parameter degeneracies to constrain cosmology.
- We have tested our results to be robust against systematic errors.
- DES Y1 data are currently being analyzed - expect new results in Fall 2017!
- Results from the Hyper Suprime Cam Survey will also be released soon!