Constraints on Cosmology and Baryonic Feedback from the Deep Lens Survey

Mijin Yoon (Yonsei)

Collaborators: M. James Jee (Yonsei), J. Anthony Tyson (UC Davis), Samuel Schmidt (UC Davis), David Wittman (UC Davis), and Ami Choi (Ohio State)

CosKASI Conference 2019, The Correlated Universe, Jeju Island

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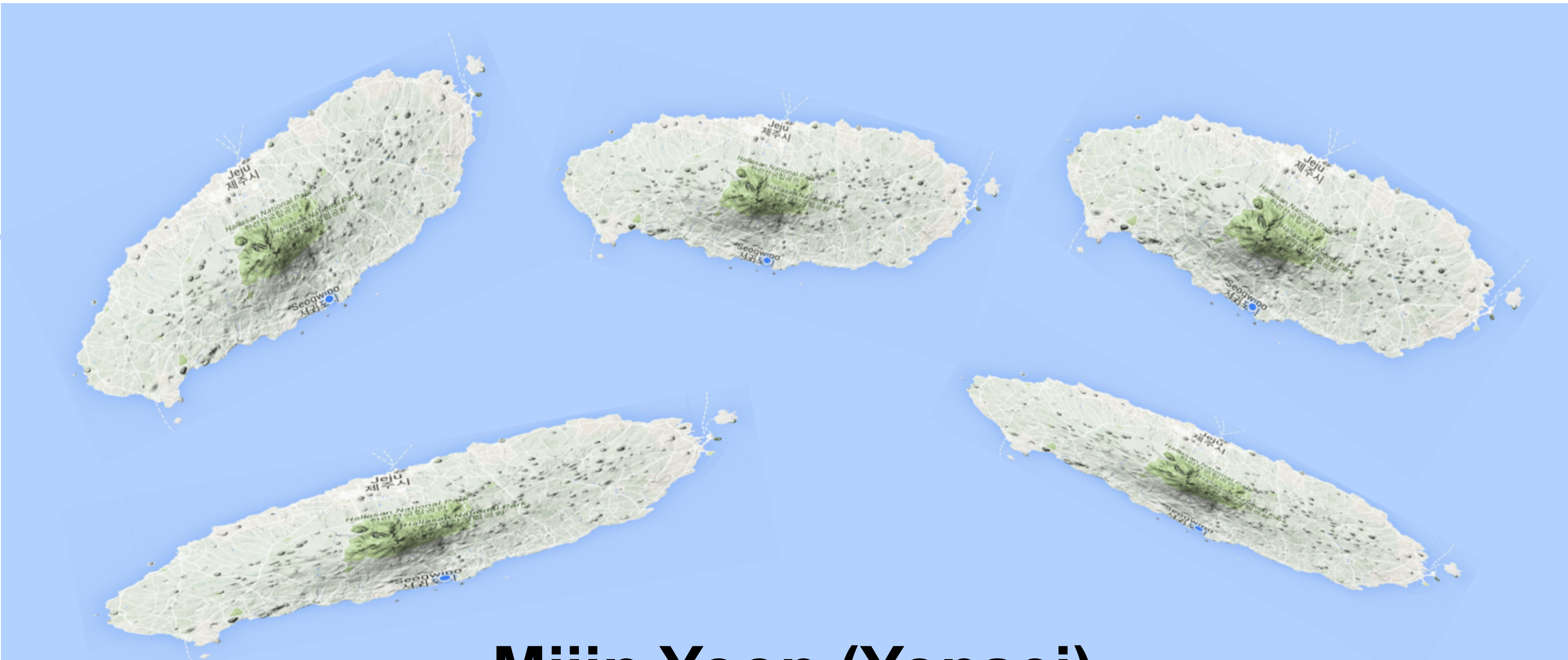

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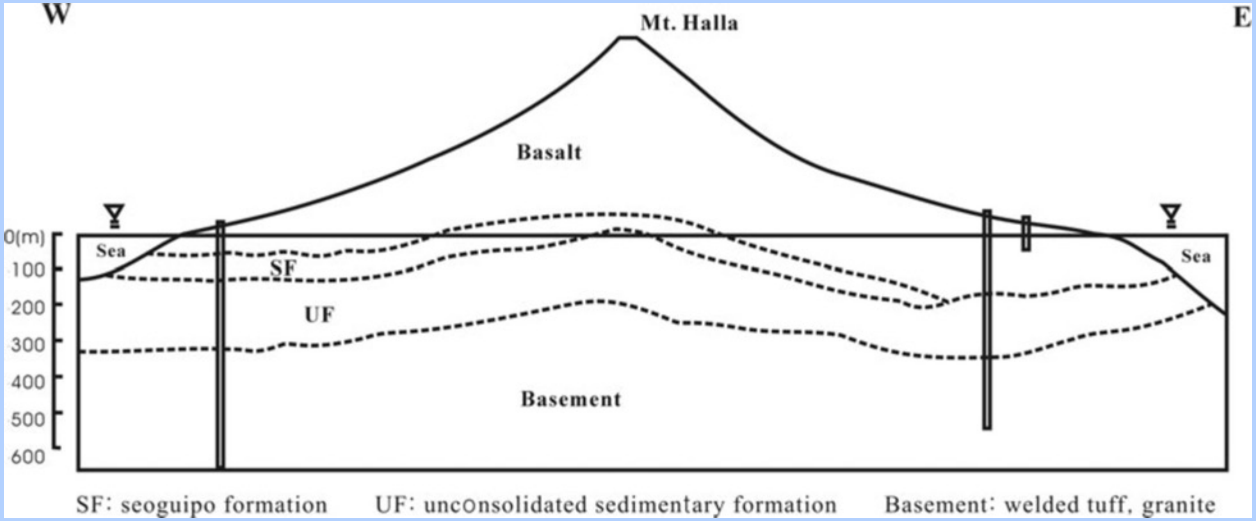

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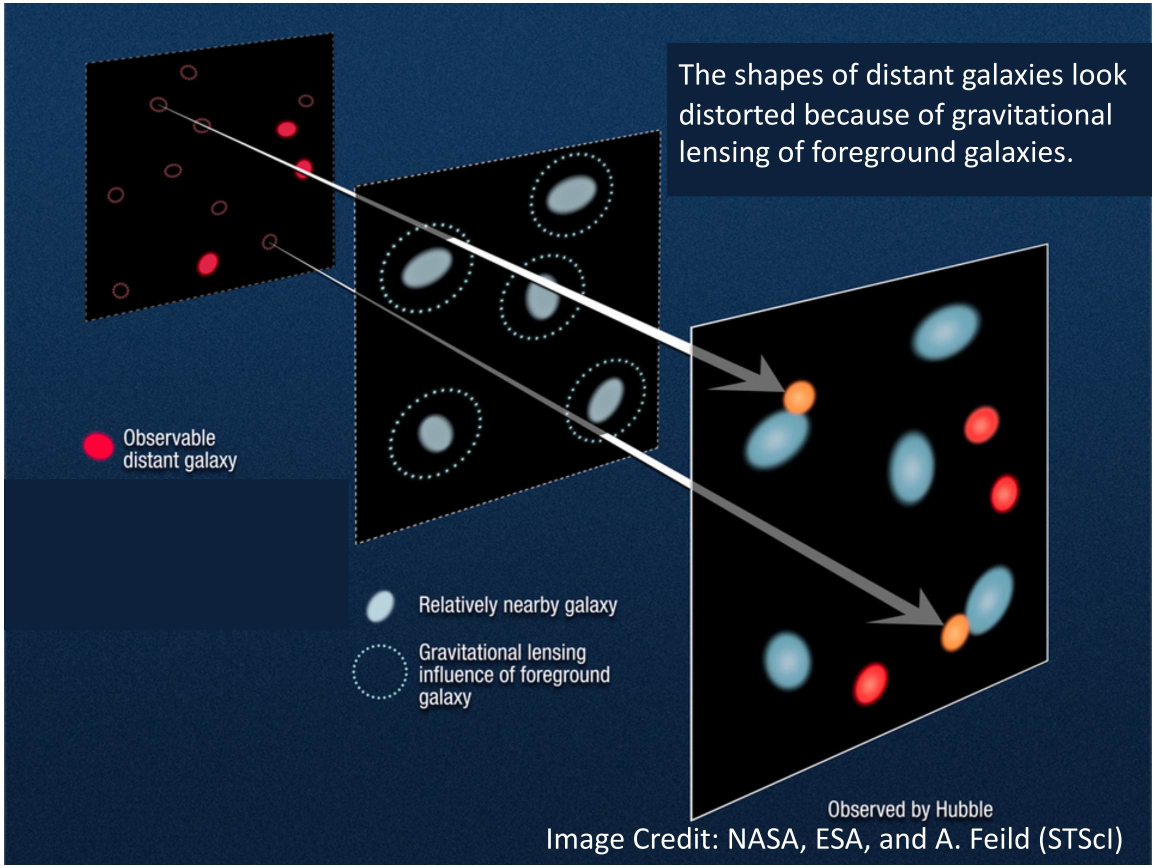
The Correlated Universe



Two types of important info from survey data:

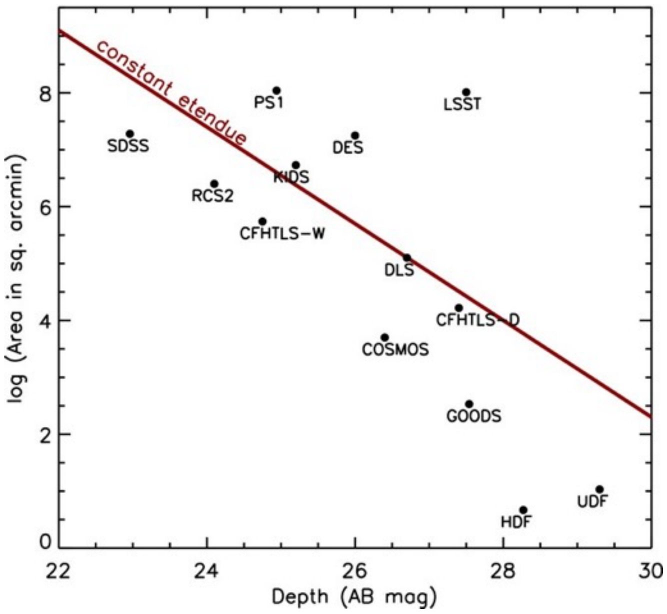
Lens galaxy position
&
Source galaxy shape

- 3 kinds of 2-pt correlations:
  - ✓ Galaxy clustering: Lens galaxy position x Lens galaxy position
  - ✓ Galaxy-galaxy lensing: Lens galaxy position x Source galaxy shape
  - ✓ Cosmic shear: Source galaxy shape x Source galaxy shape

Introduction to Deep Lens Survey (DLS)

- The Deep Lens Survey (DLS)
  - Observed by Mayall (KPNO) and Blanco (CTIO) Telescopes
  - 5 fields in total 20 deg^2
  - 4 band images with 27th mag limit

- DLS is dedicated to depth.
  - Good for accurate shape measurements
  - Optimal for cosmological studies due to long redshift baseline



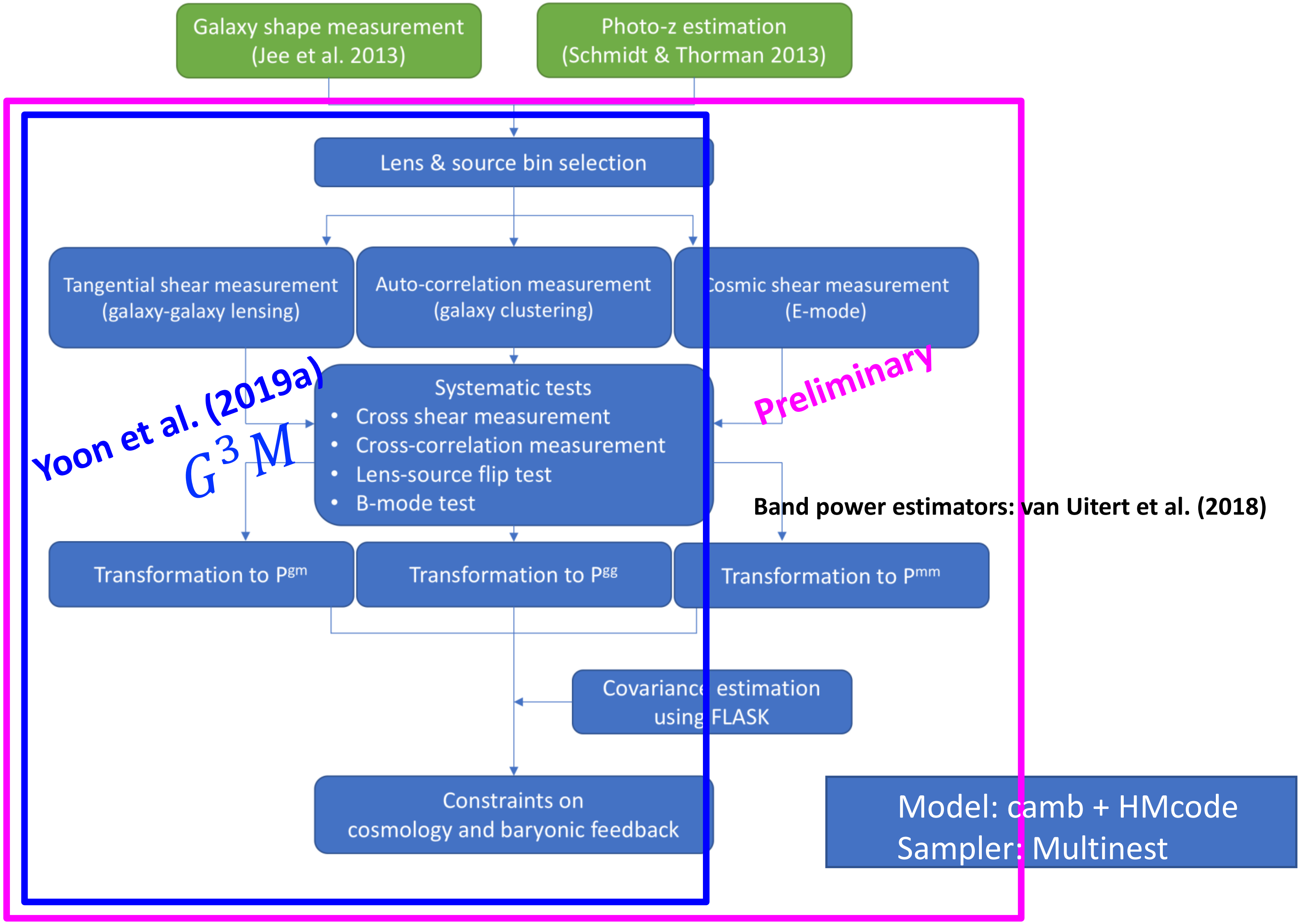
[Jee et al. 2013]

Introduction to Deep Lens Survey (DLS)

- Cosmological studies with the DLS

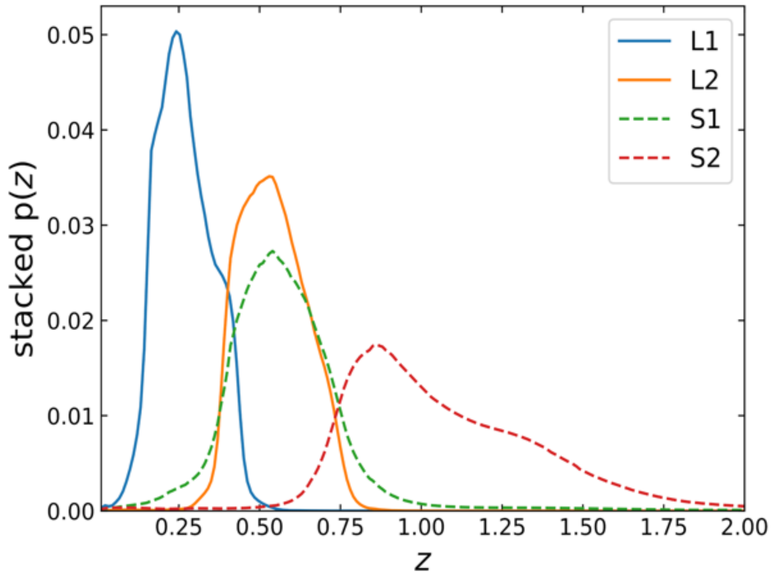
Authors	2-point statistics	S_8
Jee et al. (2013)	Cosmic Shear (2D)	0.82 ± 0.04
Jee et al. (2016)	Cosmic Shear (3D)	$0.818^{+0.034}_{-0.026}$
Yoon et al. (2019a)	GGL + GC (3D)	$0.810^{+0.039}_{-0.031}$
Yoon et al. (in prep.)	GGL + GC + Cosmic Shear (3D) Standard model	$0.832^{+0.031}_{-0.025}$ Preliminary
Sabiu et al. (in prep.)	GGL + GC + Cosmic Shear (3D) Modified gravity	?

DLS Joint Analysis Pipeline



Lens and source bin selection

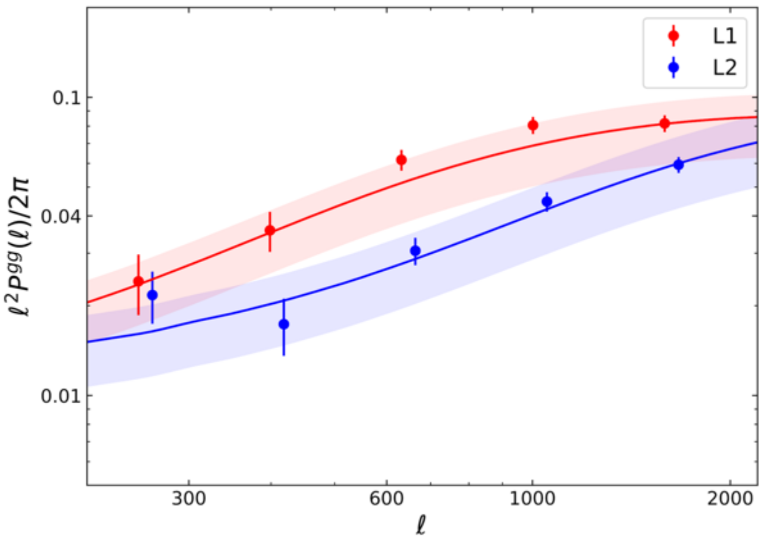
- Selected sample: 2 lens & 2 source bins with ~*1 million galaxies* *(for 24.5th source mag limit)*
  ~*1.2 million galaxies* *(for 26.5th source mag limit)*

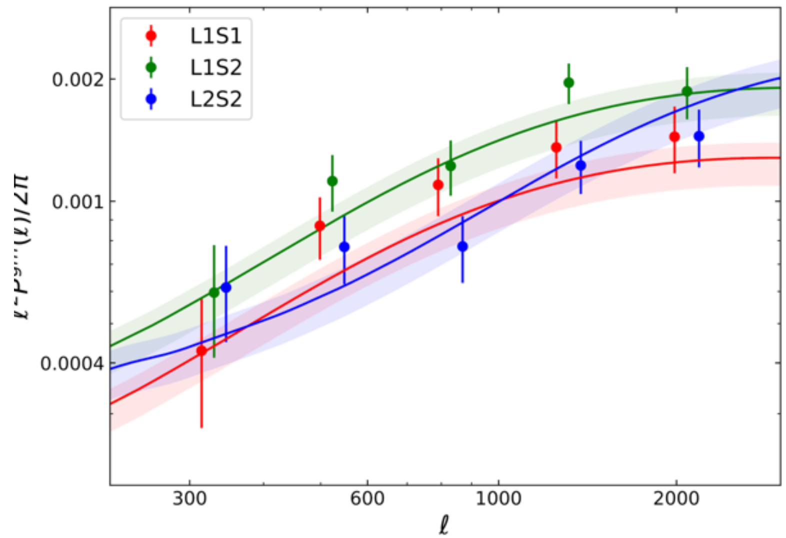


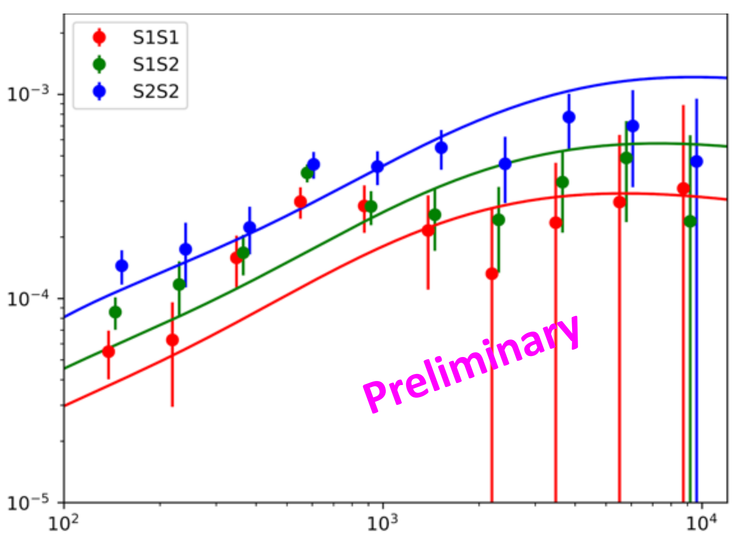
bins		z_b^-	z_b^+	$\langle z \rangle$	m_R^-	m_R^+	# of gal
Lens	L1	0.15	0.4	0.270	18	21	57,802
	L2	0.4	0.75	0.542	18	22	98,267
Source	S1	0.4	0.75	0.642	21	24.5	418,932
	S2	0.75	1.5	1.088	21	24.5	450,353

DLS Band Power Spectra

Band power estimators: van Uitert et al. (2018)

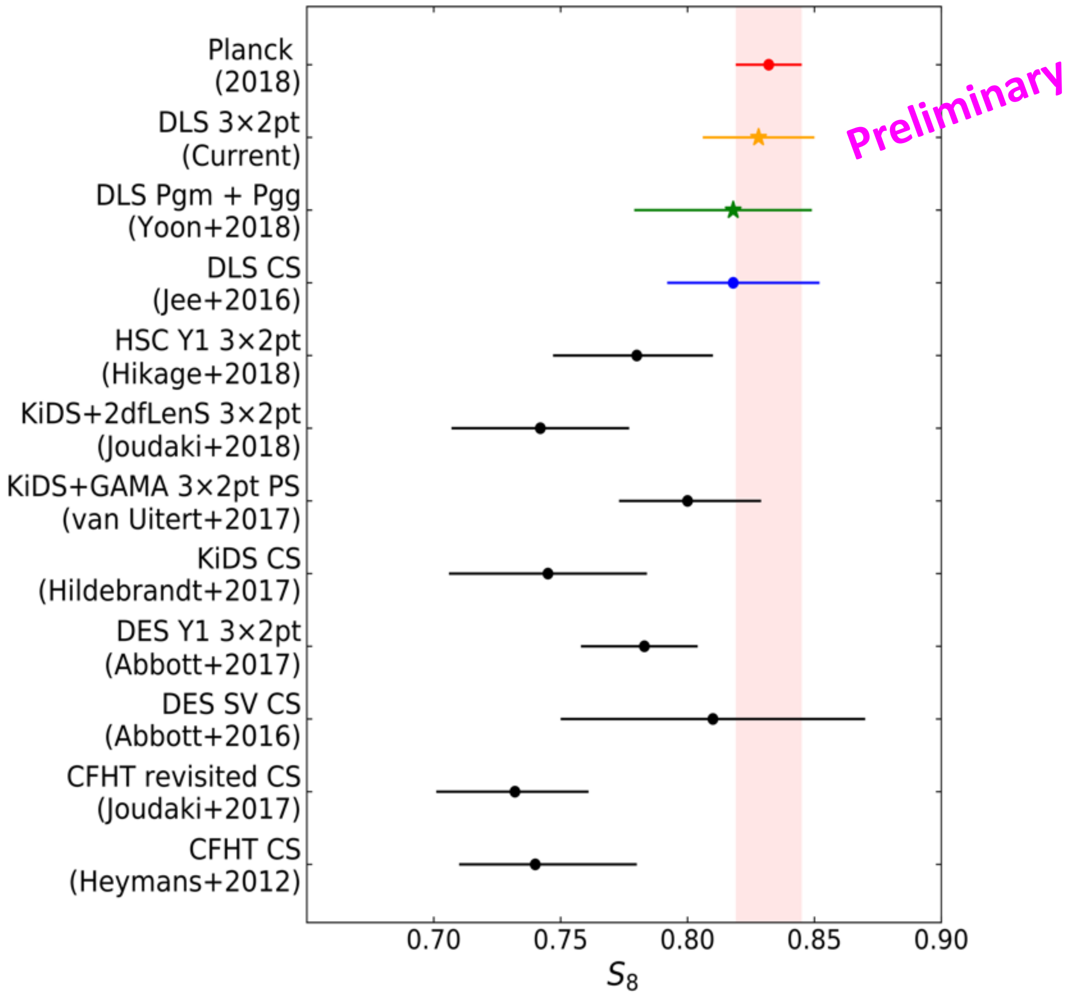




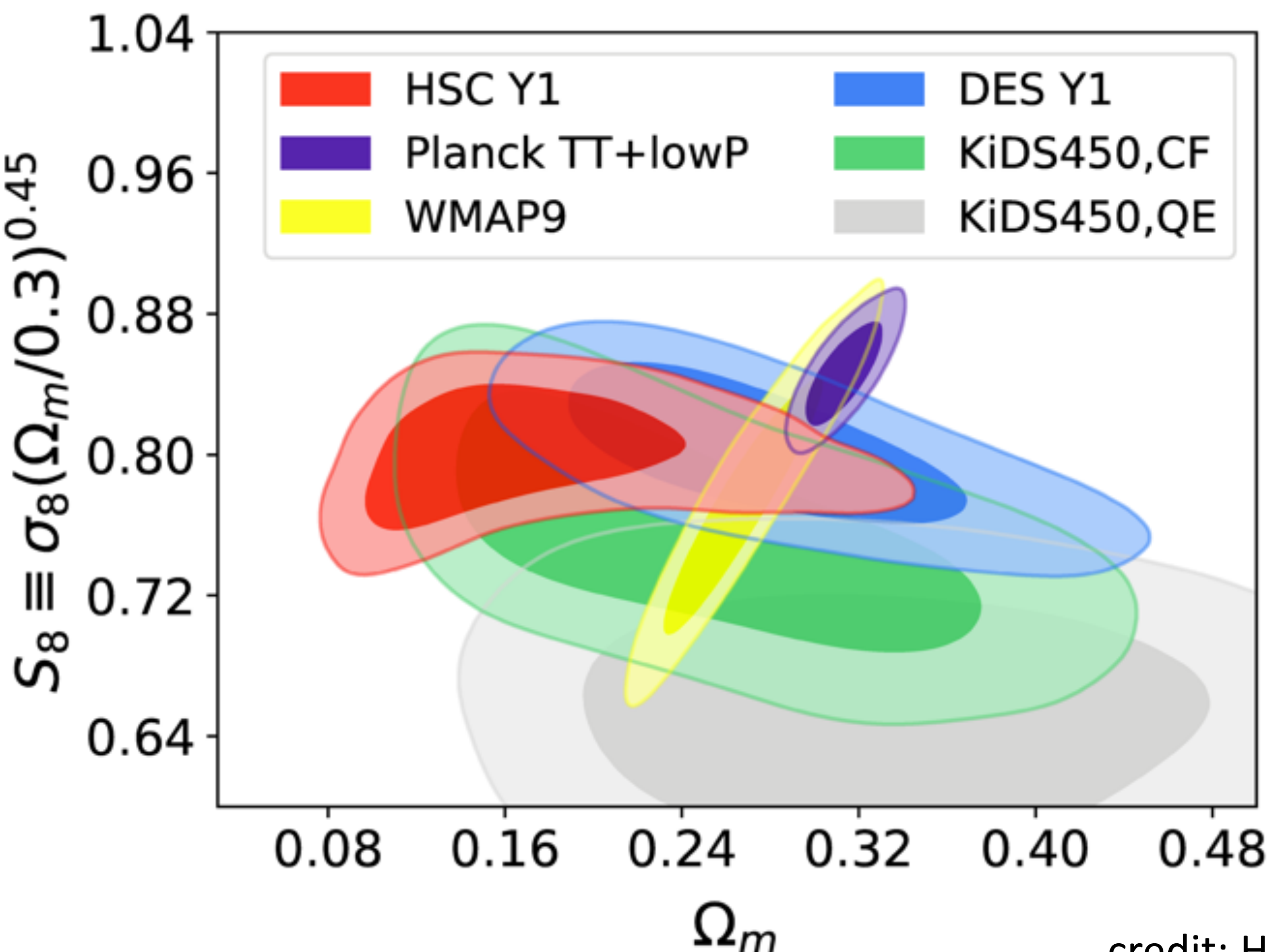


The error bars are estimated by mock catalogs generated based on lognormal distribution.

Cosmological constraints ($S_8 \equiv \sigma_8\sqrt{\frac{\Omega_m}{0.3}}$)

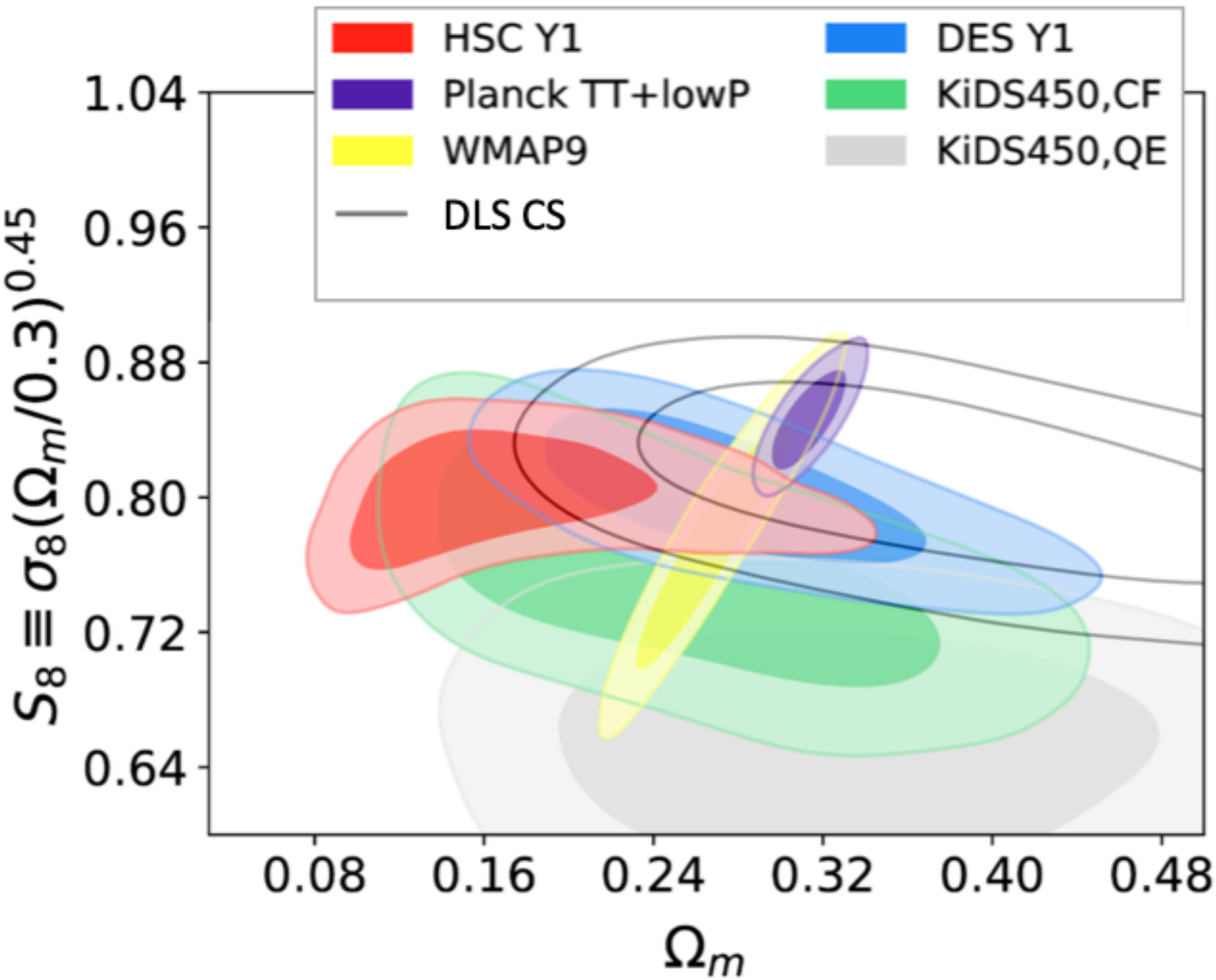


Comparison with other surveys

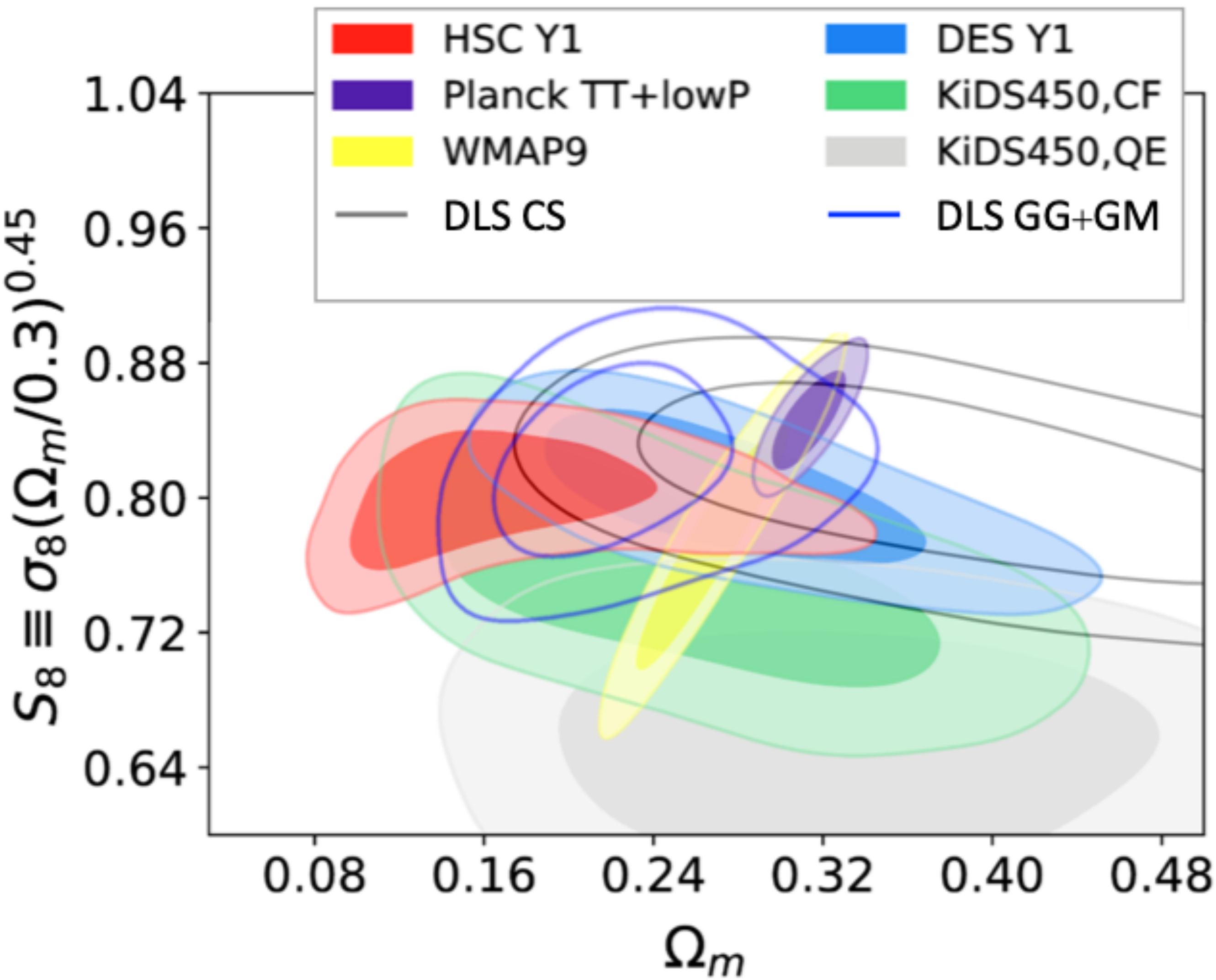


credit: Hikage+2018

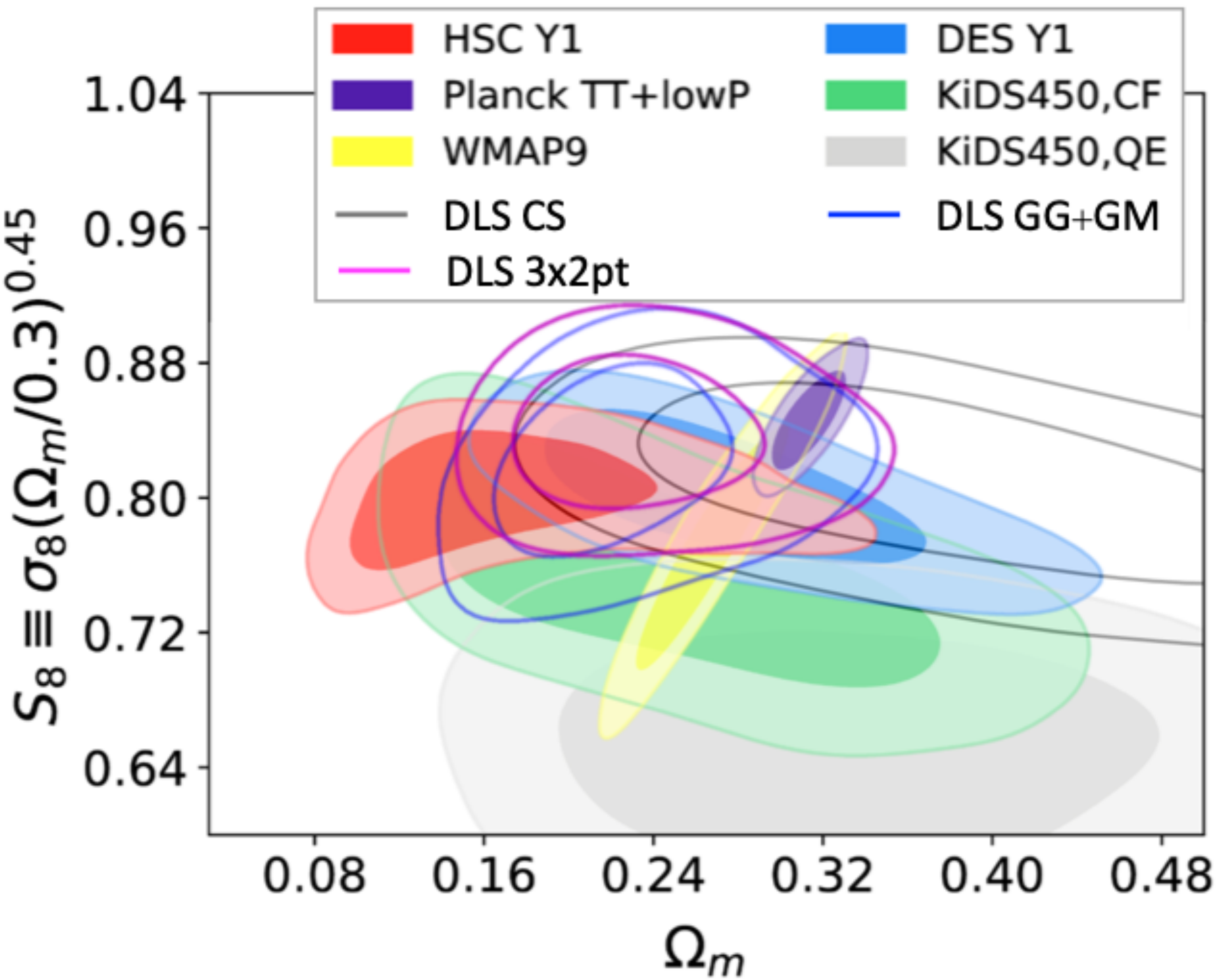
Comparison with other surveys



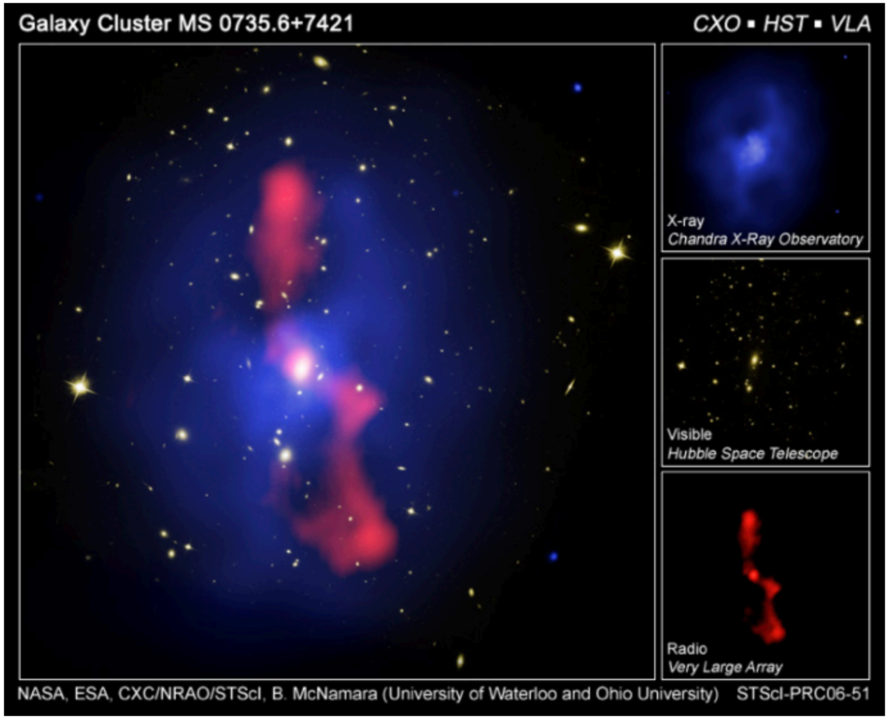
Comparison with other surveys



Comparison with other surveys



Baryonic feedback effect



- AGN interacts with gas in its host galaxy through radiation pressure, winds and jets.
- Including AGN feedback, various baryonic feedbacks can change the mass profile of galaxies.
- Baryonic feedback increases uncertainty in cosmological constraints and is degenerate with models deviated from standard models.
- The DLS is the first survey data that constrained baryonic feedback effect at the same time with cosmological constraints.

Baryonic feedback parameterization

$$\Delta^2(k) = \left((\Delta'^2_{2H})^{\alpha} + (\Delta'^2_{1H})^{\alpha}\right)^{1/\alpha}$$

- Mead et al. (2016): Halo model power spectra with physically motivated parameters are more reliable for high k range than HALOFIT (polynomial-based fitting formula).

Halo model parameters

Fitted to COSMIC EMU (cosmological N-body)

Parameter	Description	Original value	Fitted value	Equation in text
$\Delta_{\rm v}$	Virialized halo overdensity	200	$418 \times \Omega_{\rm m}^{-0.352}(z)$	13
$\delta_{\rm c}$	Linear collapse threshold	1.686	$1.59 + 0.0314 \ln \sigma_8(z)$	17
η	Halo bloating parameter	0	$0.603 - 0.3\,\sigma_8(z)$	26
f	Linear spectrum transition damping factor	0	$0.188 \times \sigma_8^{4.29}(z)$	23
k_*	One-halo damping wavenumber	0	$0.584 \times \sigma_{\rm v}^{-1}(z)$	24
A	Minimum halo concentration	4	3.13	14
α	Quasi-linear one- to two-halo term softening	1	$2.93 \times 1.77^{n_{\rm eff}}$	27

$$c(M,z) = A\,\frac{1+z_f}{1+z}$$

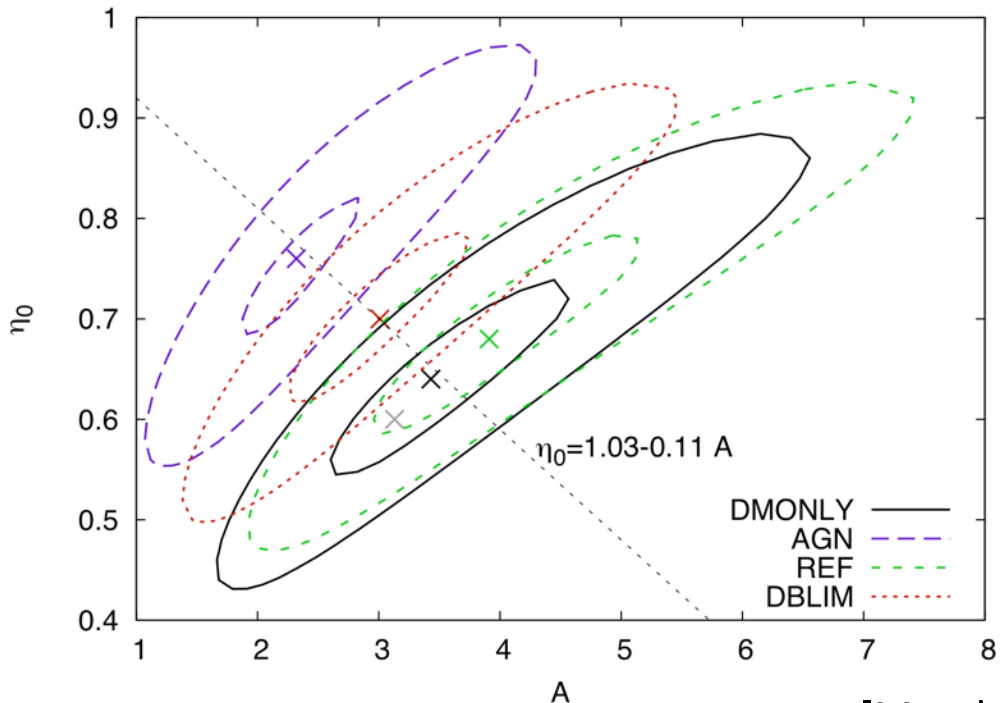
: halo concentration

$W(\nu^{\eta}k, M)$: halo mass profile window

$$\eta = \eta_0 - 0.3\sigma_8(z)$$

- Two parameters are related to the baryonic feedback, and they are not fixed values.

Baryonic feedback parameterization

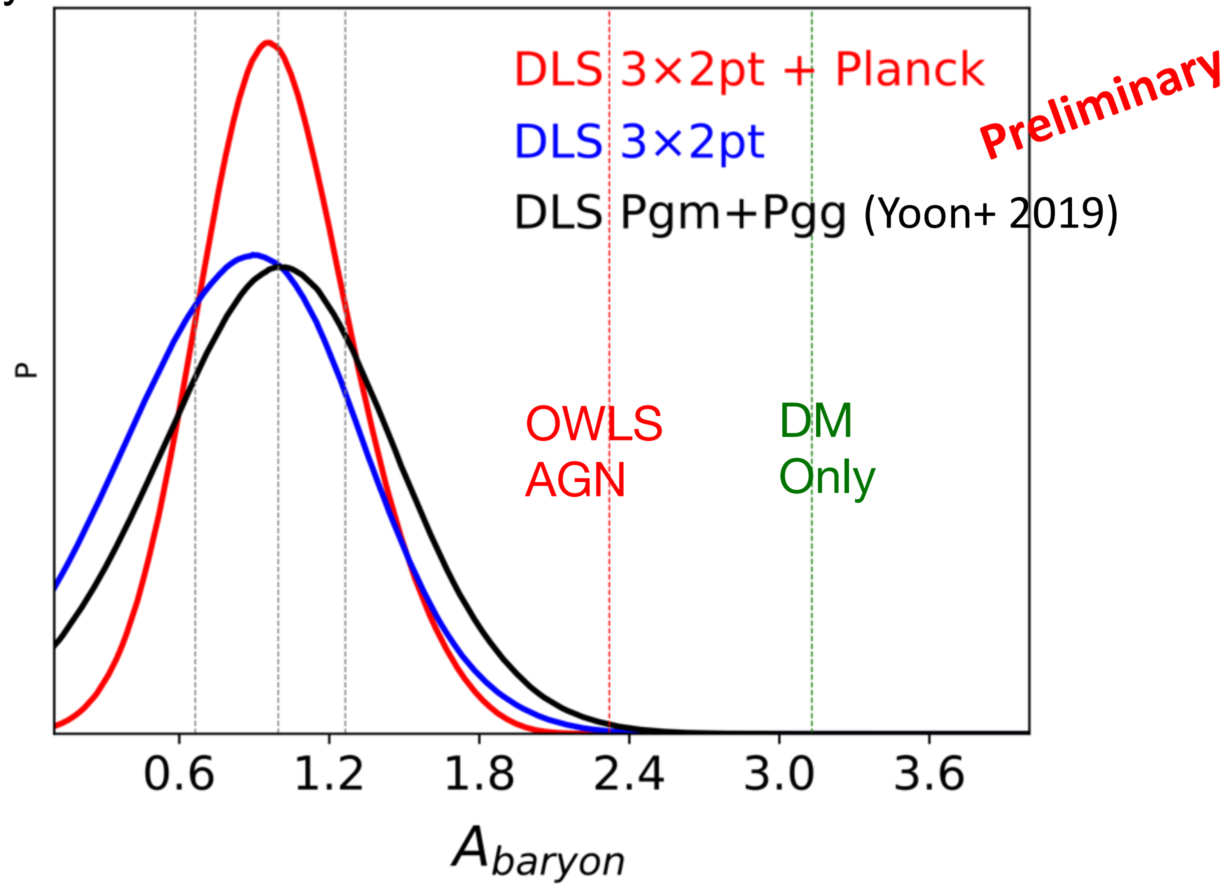


[Mead et al. 2016]

- Based on OWLS (hydrodynamic simulation) with different setting, a relation between the two parameters was determined.
- With this relation, marginalizing over A (concentration) has been a standard method recently.

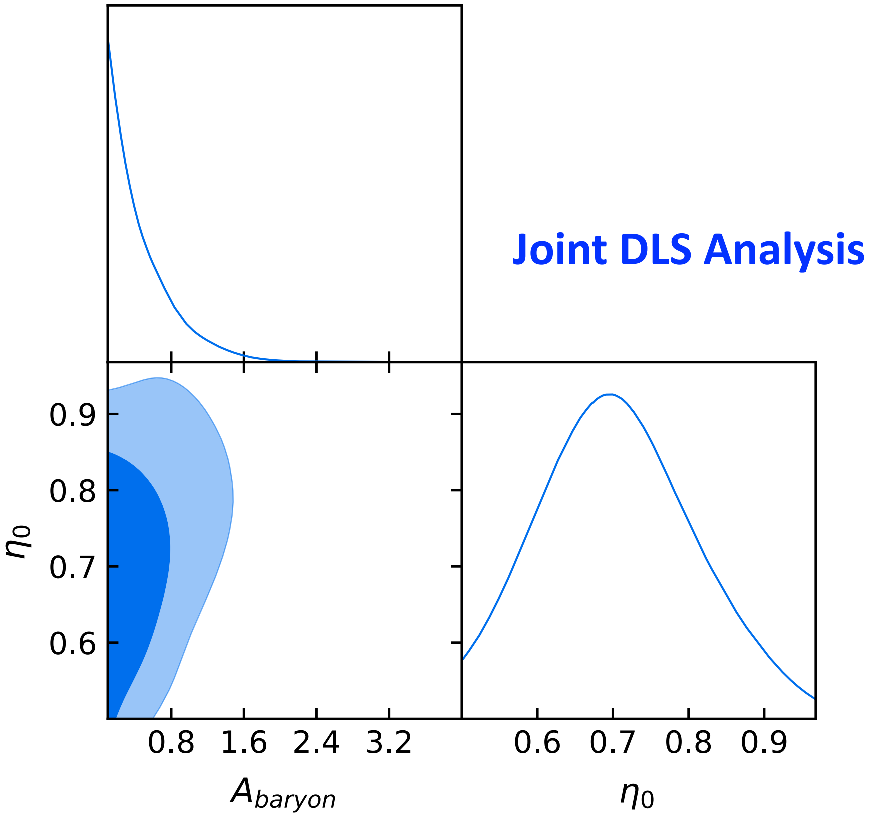
Baryonic feedback and cosmology

- Using a single parameterization (Mead et al. 2016) for baryonic feedbacks, we achieved constraints on a baryonic feedback parameter with the Deep Lens Survey.



Baryonic feedback and cosmology

- For the extended baryonic feedback model: the constraint from two free parameters agree well with the constraint from the 1-parameterization. (Only η_0 gets constrained in this case.)



Conclusions

- We constrained S_8 value ($0.832^{+0.031}_{-0.025}$) tightly from DLS, which does not have any tension with Planck.
- We first achieved a reliable constraint on baryonic feedback parameter (1.00 +/- 0.31).
- The constrained baryonic parameter implies that the actual baryonic feedback may be stronger than the current OWLS simulations.
- We need to understand the baryonic feedback effect better for the future large scale surveys and precision cosmology.