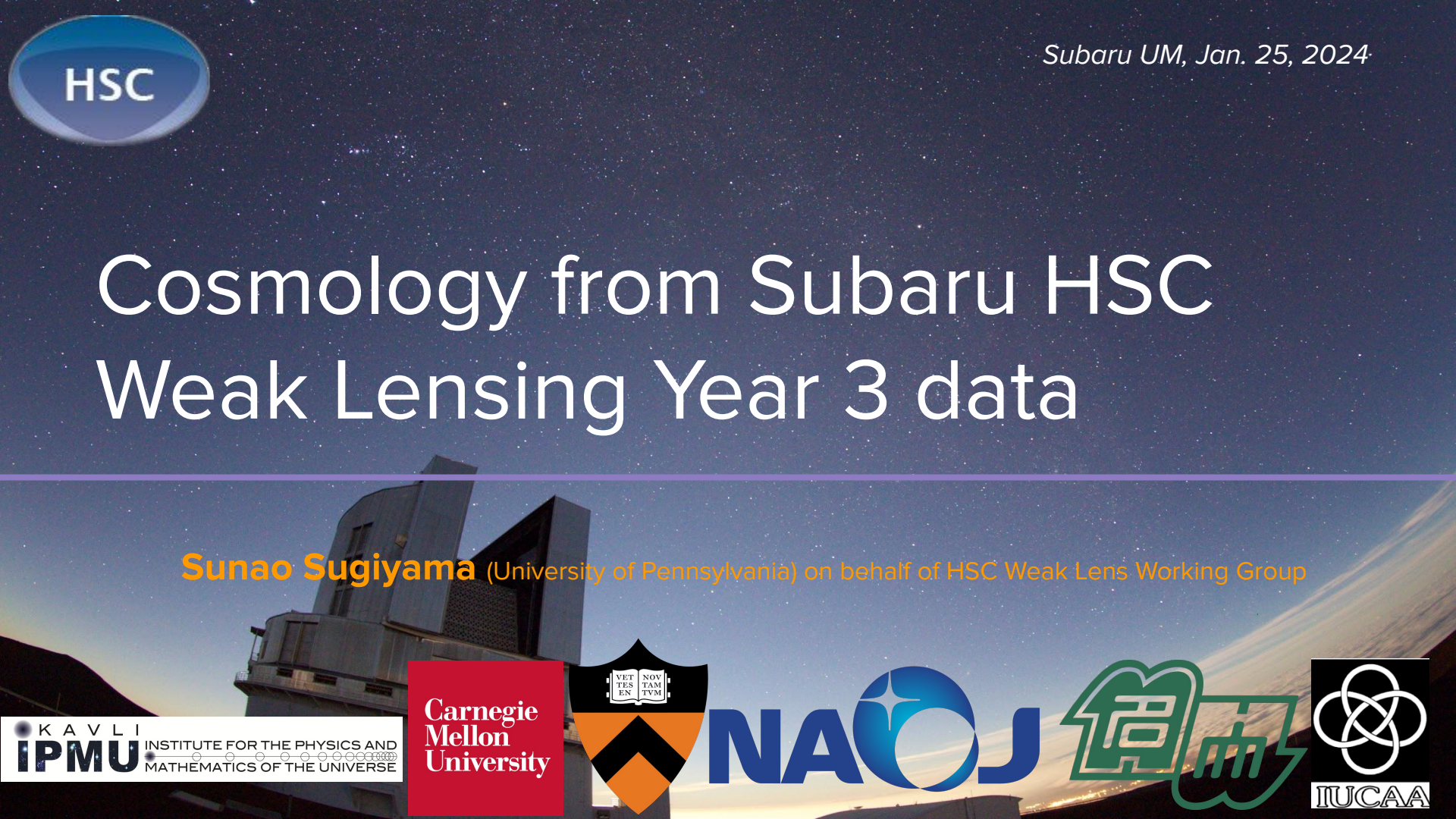
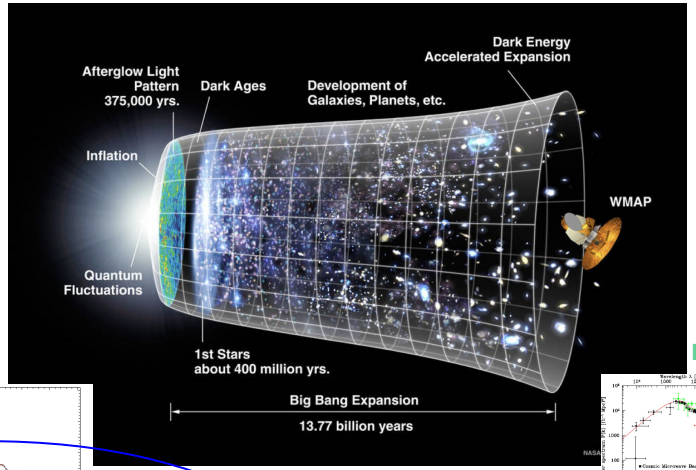

HSC
Subaru UM, Jan. 25, 2024
Cosmology from Subaru HSC Weak Lensing Year 3 data
Sunao Sugiyama (University of Pennsylvania) on behalf of HSC Weak Lens Working Group
KAVLI IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE
Carnegie Mellon University
VET TES EN NOV TAM TVM
NAOJ
IUCAA

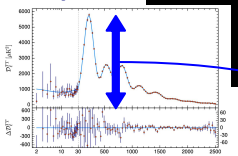
Testing ΛCDM with S_8 tension

$$S_8 \equiv \sigma_8 \sqrt{\Omega_m / 0.3}$$

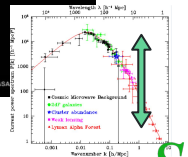
Most of **large-scale structure (LSS) probes** (weak lensing, galaxy clustering, galaxy clusters, etc…) prefer smaller S_8 compared to **CMB**, if we assume ΛCDM is correct.



CMB amplitude

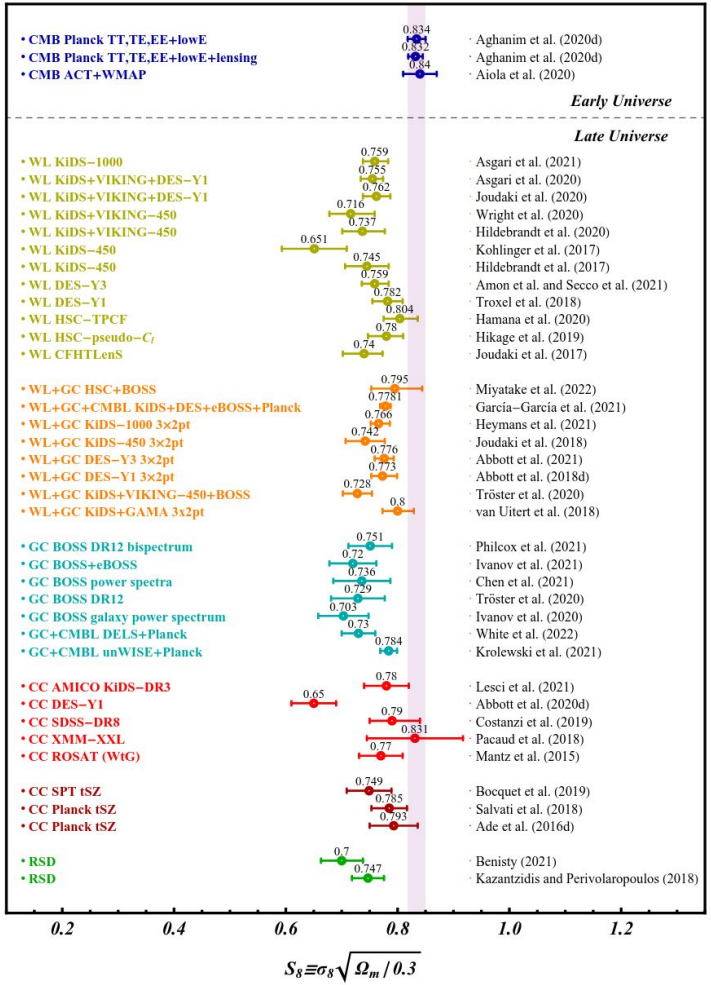


LSS probes



S_8 S_8

Predicting Growth in ΛCDM

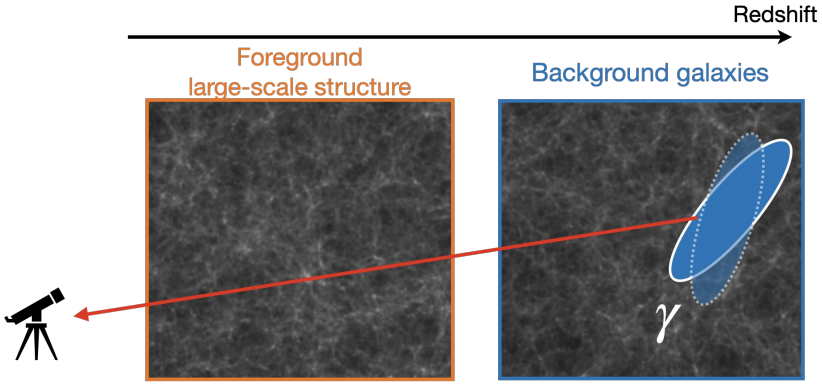


CMB

Large Scale Structure (LSS)

SNOWMASS 2021 Summer Study: Abdalla et al. (2022)

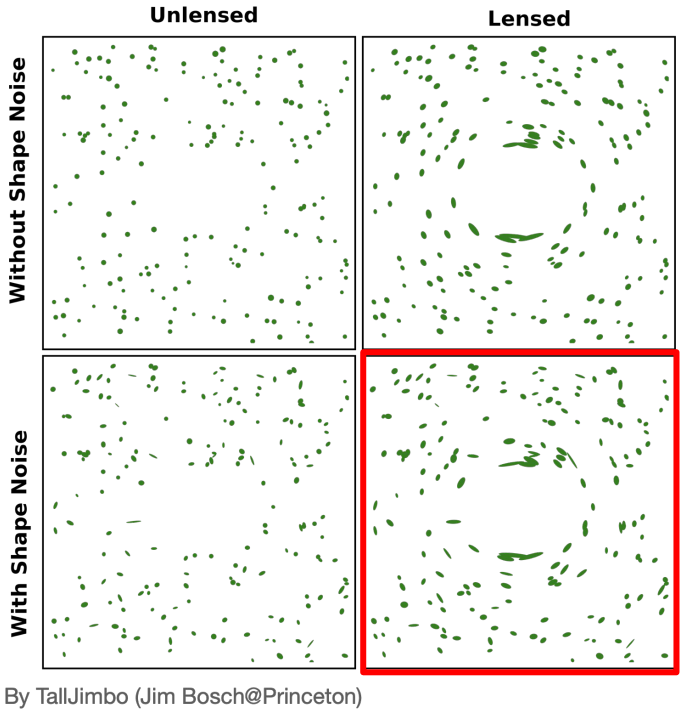
Gravitational weak lensing



The shape distortion of background galaxy by the gravitational lensing effect by foreground matter distribution

$$\gamma = \Omega_{\rm m} \int {\rm d}z \frac{D_{\rm A}(z) D_{\rm A}(z_{\rm s} - z)}{D_{\rm A}(z_{\rm s})} \delta_{\rm m}$$

$$\propto \Omega_{\rm m} \sigma_8$$

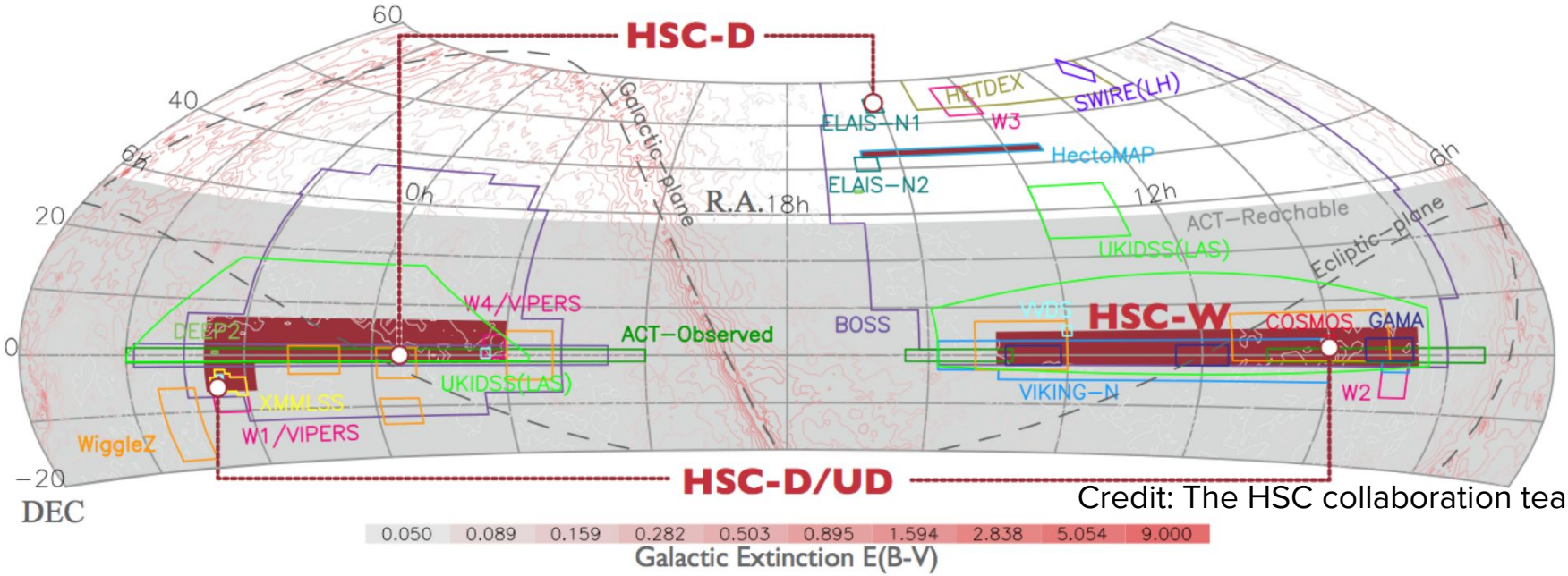


By TallJimbo (Jim Bosch@Princeton)

In reality, the shear by LSS is small.
→ Statistical analysis is essential.

$$\gamma_{\rm obs} = \gamma + \epsilon_{\rm int} \ \text{where} \ \gamma \sim 0.01 \ll \epsilon_{\rm int} \sim 0.2$$

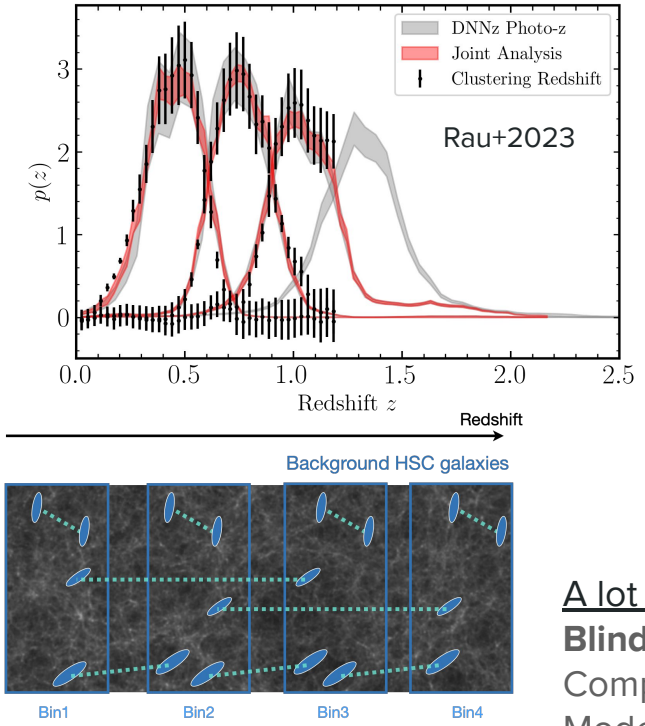
HSC Subaru Strategic Program (SSP) Survey

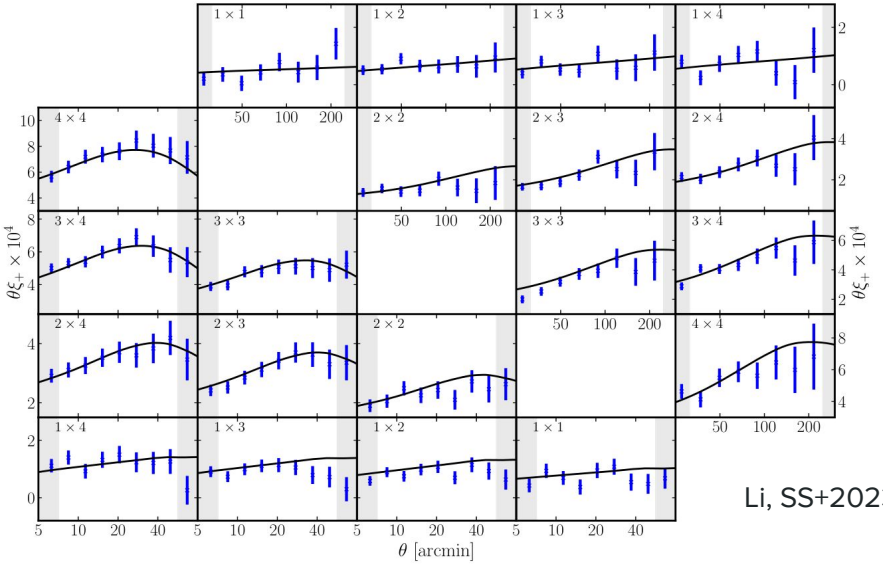


Credit: The HSC collaboration team

- Wide Layer (~1,100 deg^2, grizy, i_{lim}~26) is designed for weak lensing cosmology.
- Overlaps with other major surveys (SDSS/BOSS, ACT, VIKING, GAMA, VVDS, etc...).
- The survey started in 2014 and was completed in 2021.
- **In this talk, we will give results from the data taken until April 2019 (416 deg^2).**

Tomographic cosmic shear analyses





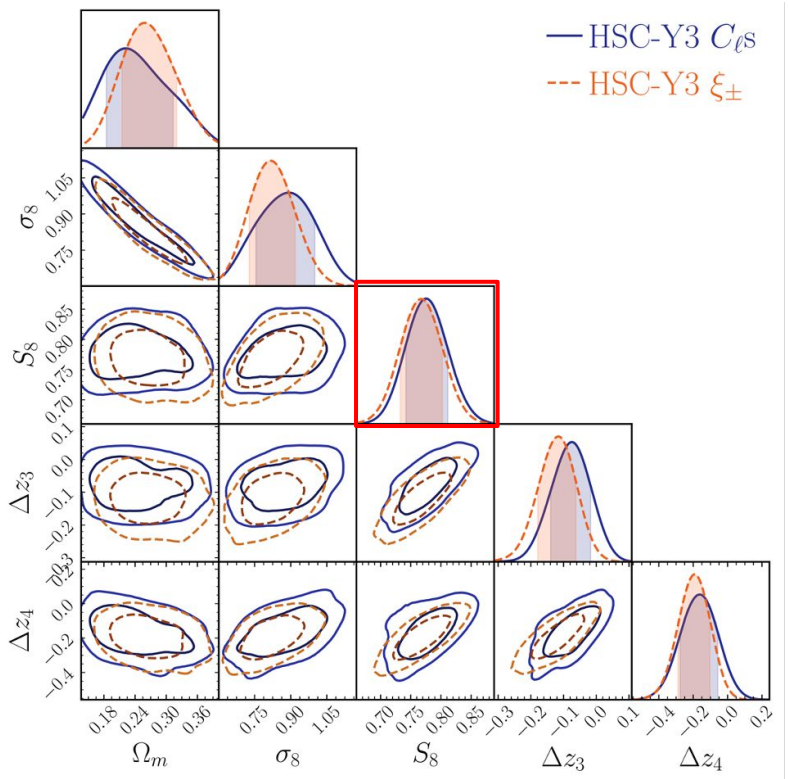
Li, SS+2023

Credit: T. Nishimichi, edited by SS

A lot of effort:

Blind analysis. Systematics null test. Scale cut choice. Comprehensive study in both **real (Li+) and Fourier (Dalal+)** spaces. Modeling choice. Test with mock data. Marginalizing astrophysical effects. 23 params model fitting. Modeling PSF residual (Zhang+).

Cosmology from cosmic shear tomography (Real & Fourier)



Dalal, SS+2023

Fourier Space (Dalal SS+2023):

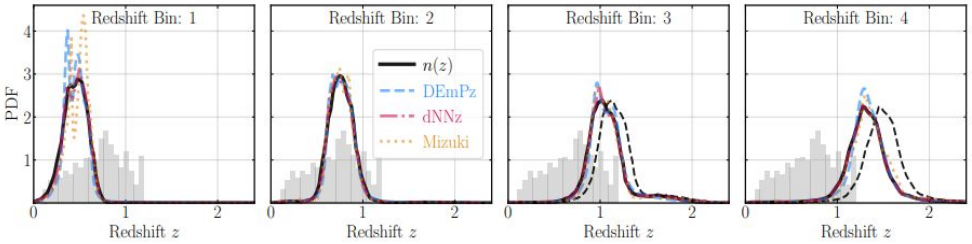
$$S_8 = 0.776^{+0.032}_{-0.033}$$

Real Space (Li, SS+2023):

$$S_8 = 0.769^{+0.031}_{-0.034}$$

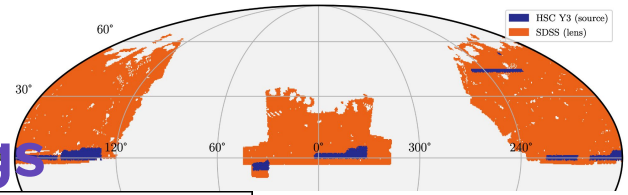
4% constraint!

Posterior indicates that the mean redshifts of two highest redshift bins are ~0.2 higher than the estimate of photo-z based on color data.

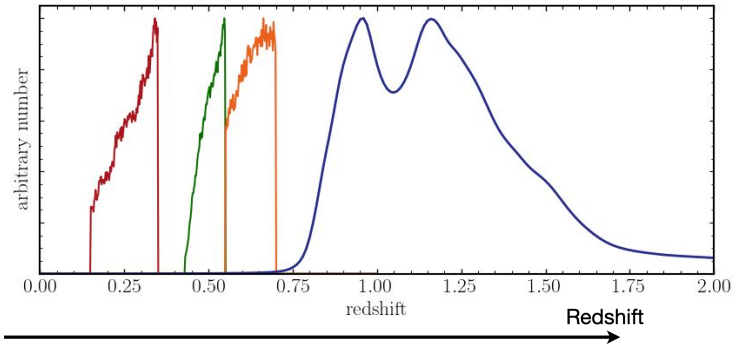


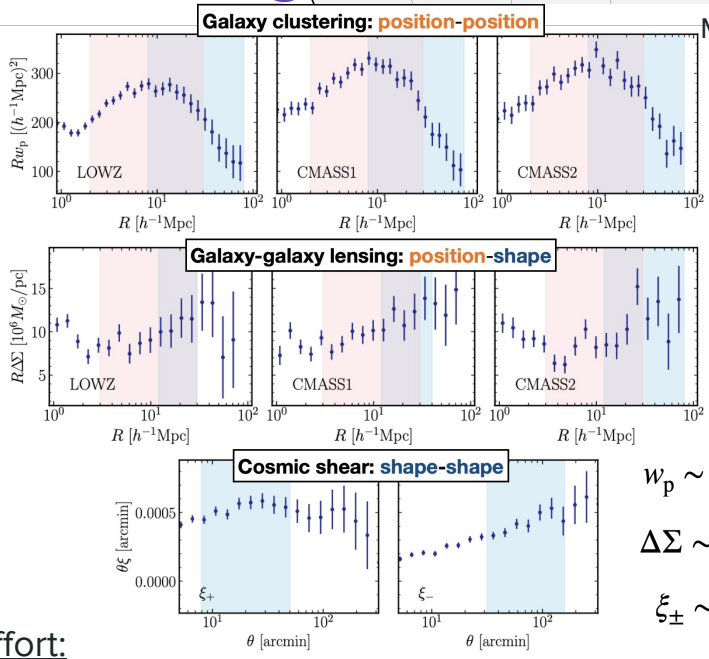
Li, SS+2023

3x2pt analysis with HSC x SDSS catalogs



More, SS+2023





$$\delta_g = b\delta_m$$

$$w_p \sim b^2 \xi_{mm}(r\,|\,\Omega_m, \sigma_8)$$

$$\Delta\Sigma \sim b\xi_{mm}(r\,|\,\Omega_m, \sigma_8)$$

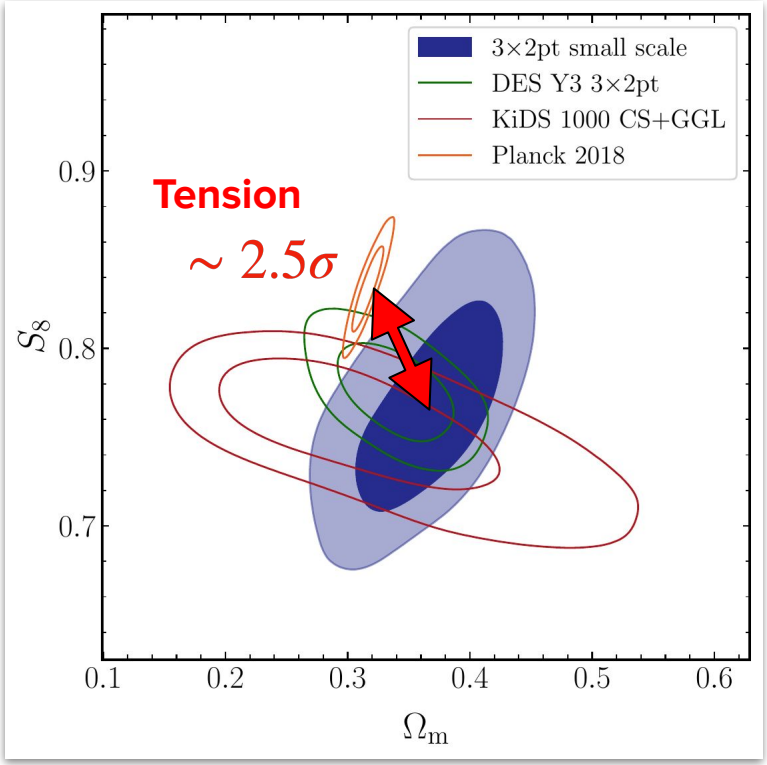
$$\xi_\pm \sim \xi_{mm}(r\,|\,\Omega_m, \sigma_8)$$

<u>A lot of effort:</u>

Blind analysis. Systematics null test. Scale cut choice. Comprehensive study using **small (Miyatake+) vs large (SS+)** scale signal. Test with mock data. 28 params model fitting. Marginalizing over **galaxy bias uncertainty** (connection of galaxy-halo).

Credit: T. Nishimichi, edited by SS

Cosmology from HSC x SDSS 3x2pt without Δz prior



Miyatake, SS+2023

3x2pt analysis result for flat ΛCDM model

$$S_8 = 0.763^{+0.040}_{-0.036}$$

$$\Delta z_{\rm ph} = -0.05 \pm 0.09$$

5% constraint!

- The independent tomographic cosmic shear analyses (Dalal+ 2023, Li+ 2023) also found non-zero Δz at high redshift.
- After unblinding, we found our result is in 2.5σ tension with Planck 2018.

Cosmology Papers using HSC Y3 data

- The three-year shear catalog of the Subaru Hyper Suprime-Cam SSP Survey (Li X., et al. 2022, PASJ, 74, 2)
- A General Framework for Removing Point Spread Function Additive Systematics in Cosmological Weak Lensing Analysis (Zhang T. et al. 2022, MNRAS)
- Weak Lensing Tomographic Redshift Distribution Inference for the Hyper Suprime-Cam Subaru Strategic Program three-year shape catalogue (Rau, M. et al. 2022, MNRAS)
- Hyper Suprime-Cam Year 3 Results: Cosmology from Cosmic Shear Two-Point Correlation Functions (Li X., et al. 2023, PRD)
- Hyper Suprime-Cam Year 3 Results: Cosmology from Cosmic Shear Power Spectra (Dalal R., et al. 2023, PRD)
- Hyper Suprime-Cam Year 3 Results: Measurements of the Clustering of SDSS-BOSS galaxies, galaxy-galaxy lensing and cosmic shear (More S., et al. 2023, PRD)
- Hyper Suprime-Cam Year 3 Results: Cosmology from Galaxy Clustering and Weak Lensing with HSC and SDSS using the Minimal Bias Model (Sugiyama S., et al. 2023, PRD)
- Hyper Suprime-Cam Year 3 Results: Cosmology from Galaxy Clustering and Weak Lensing with HSC and SDSS using the Emulator Based Halo Model (Miyatake H., et al. 2023, PRD)
- Optical Cluster Cosmology with SDSS redMaPPer clusters and HSC-Y3 lensing measurements (Sunayama T., et al. 2023, arxiv:2309.13025)

Summary

- ❑ We carried out the cosmology analyses using HSC Y3 catalog.
- ❑ Measured S_8 values from HSC Y3 analyses are smaller than CMB prediction by ~2.5σ.
- ❑ Cosmology analysis indicates that photo-z of high-z galaxies might be biased.

Ongoing projects

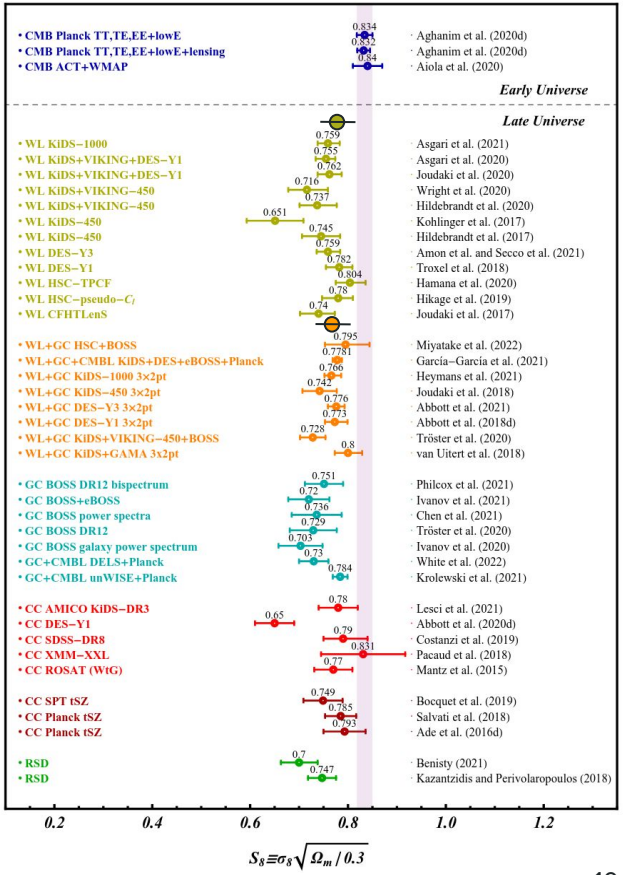
- ❑ Investigation of baryonic effect on cosmic shear (Dalal, Terasawa)
  ➡ for S_8 tension
- ❑ Shear ratio tests (Divya)
  ➡ for photo-z problem
- ❑ + many

HSC-Y3 Cosmic shear analyses:

Dalal et al. (2023)
Li et al. (2023)

HSC-Y3 3x2 pt analyses:

More et al. (2023),
Miyatake et al. (2023)
Sugiyama et al. (2023)



SNOWMASS 2021 Summer study:
Abdalla et al. (2022) + HSC results