

PFS Cosmology: Status and Future Outlook

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July 8th@UTokyo, on-behalf of SSP CO WG



東京大学
THE UNIVERSITY OF TOKYO

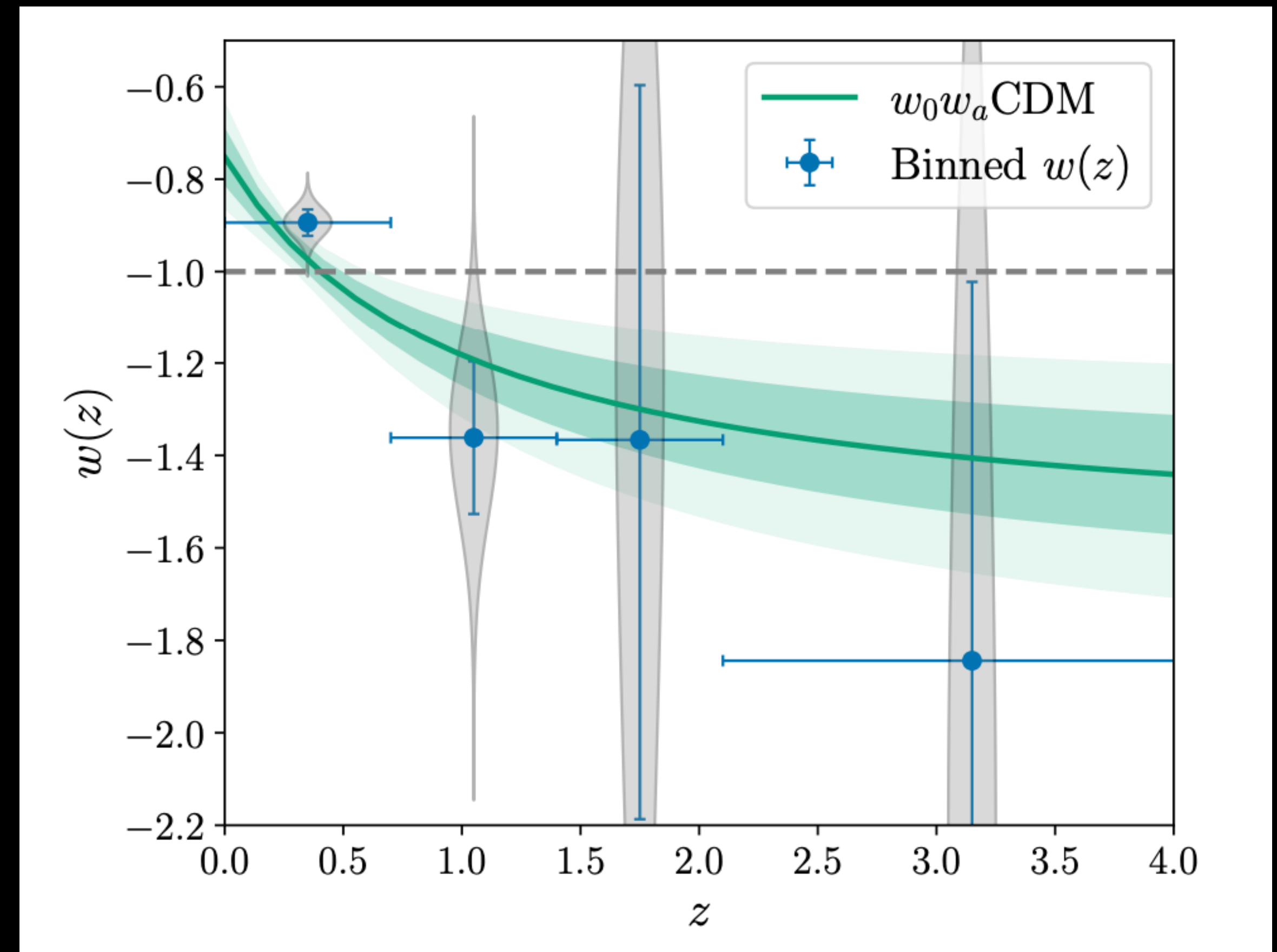
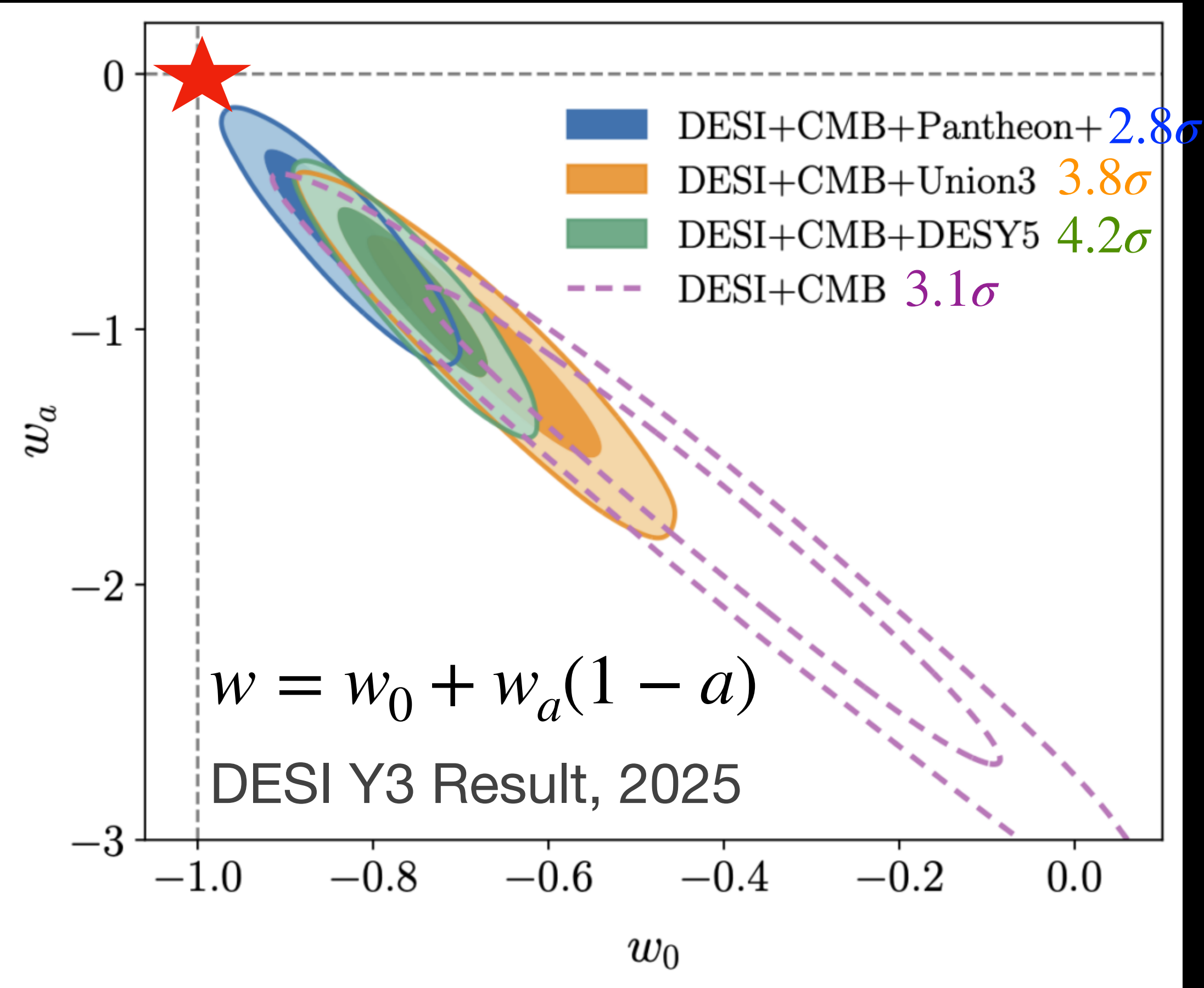


Outline

- Background and Motivation
- PFS Cosmology Science
- Survey Status: target selection and LSS catalog construction
- Future Outlook

Dynamic Dark Energy?

Λ CDM

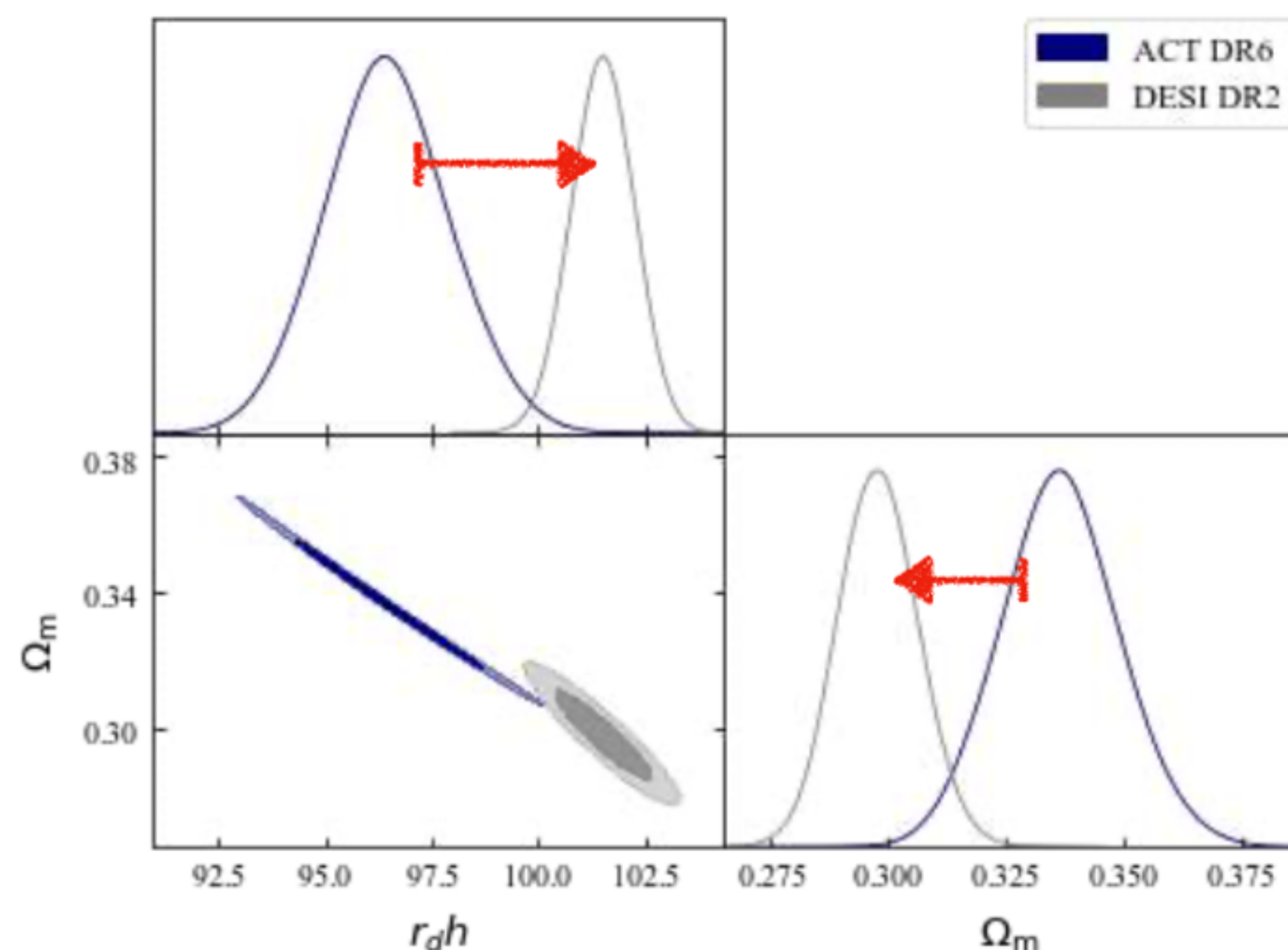


BAO - CMB tension

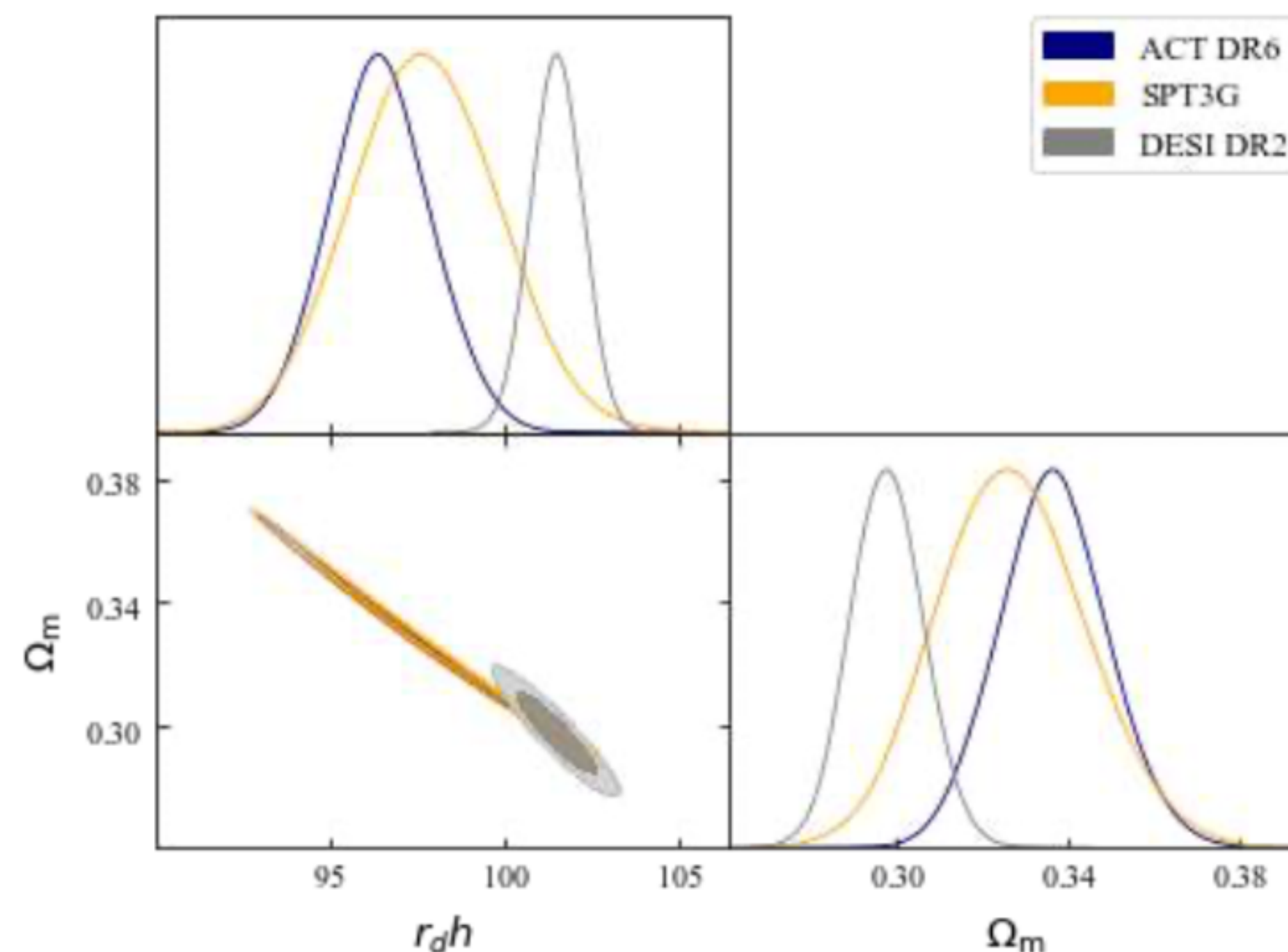
The BAO-CMB Tension and Implications for Inflation
EF, E McDonough, L Balkenhol, R Kallosh, L Knox, and A Linde,
2507.12459

Are **ACT** and **SPT** compatible with **DESI** ?

(or BAO-CM tension or Ω_M tension)



- 2d posteriors show small overlap
- 1d posterior shifted



Discrepancy (or tension) in the values of $r_d h$ and Ω_M measured from CMB and DESI BAO!

Physics or Systematics?

PFS Cosmology: a unique spec-z survey

1

[OII] ELGs, $0.6 < z < 2.4$

Fills the missing high- z LSS-tracer gap (extends to $z = 1.6\text{--}2.4$)

2

High number density

8.2 m aperture $\rightarrow$ also a powerful neutrino-mass probe

3

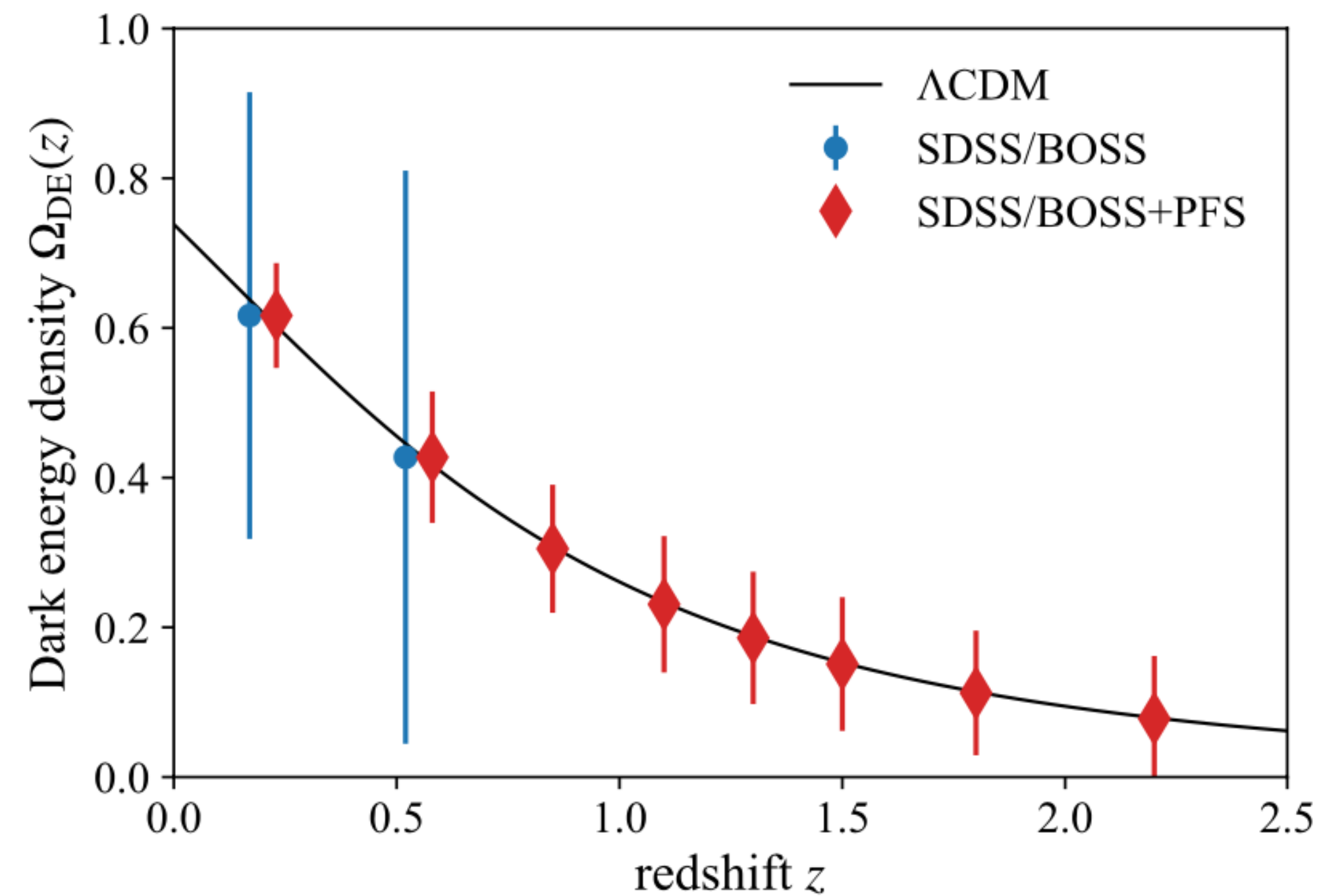
Synergy with HSC / CMB

Shared deep fields $\rightarrow$ lensing & kSZ cross-correlations

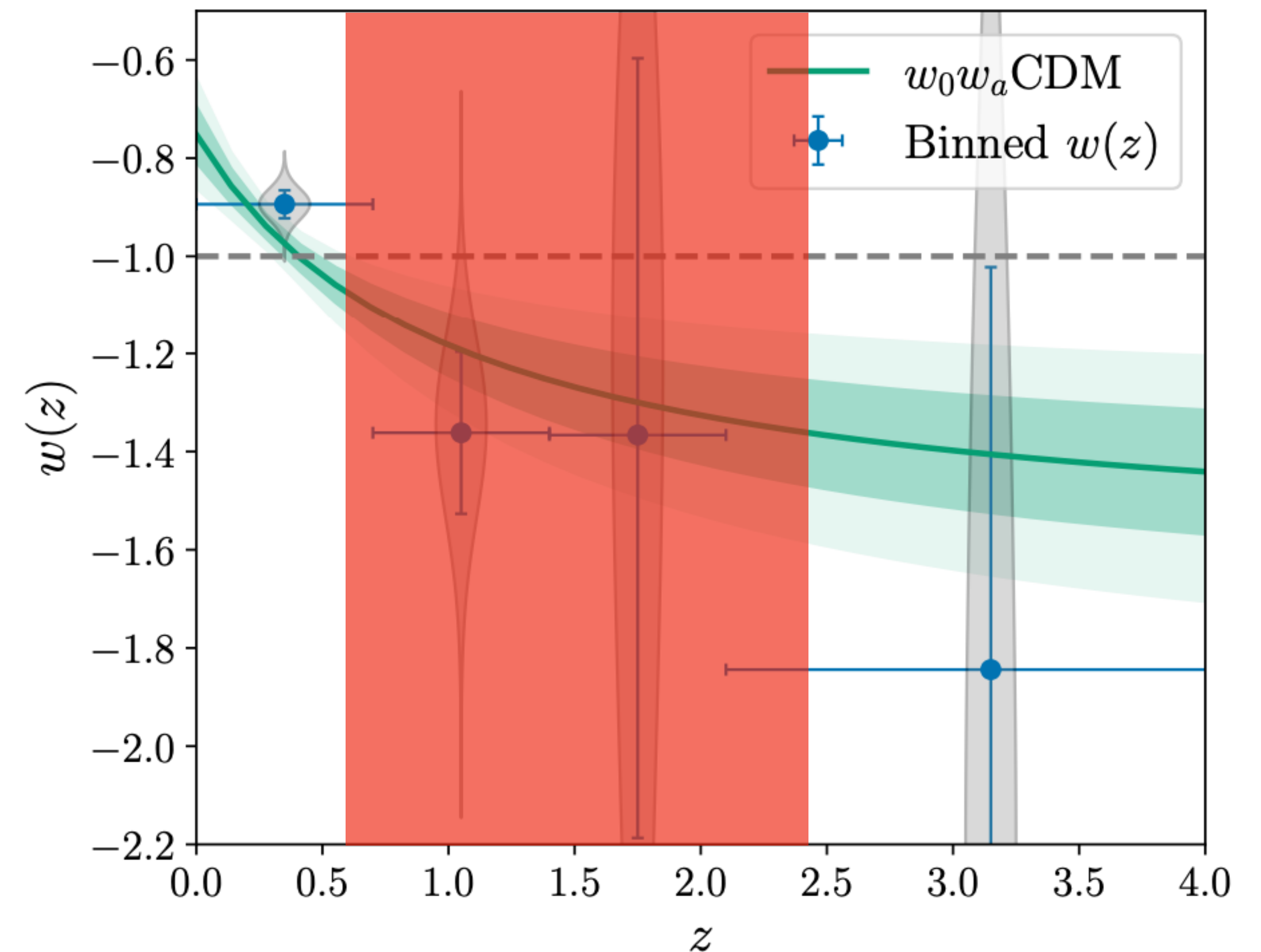
Cross-checking the DESI-CMB tension

Independent geometry (BAO) + growth (RSD) probe over a wide redshift range

Baryon Acoustic Oscillations (BAO)

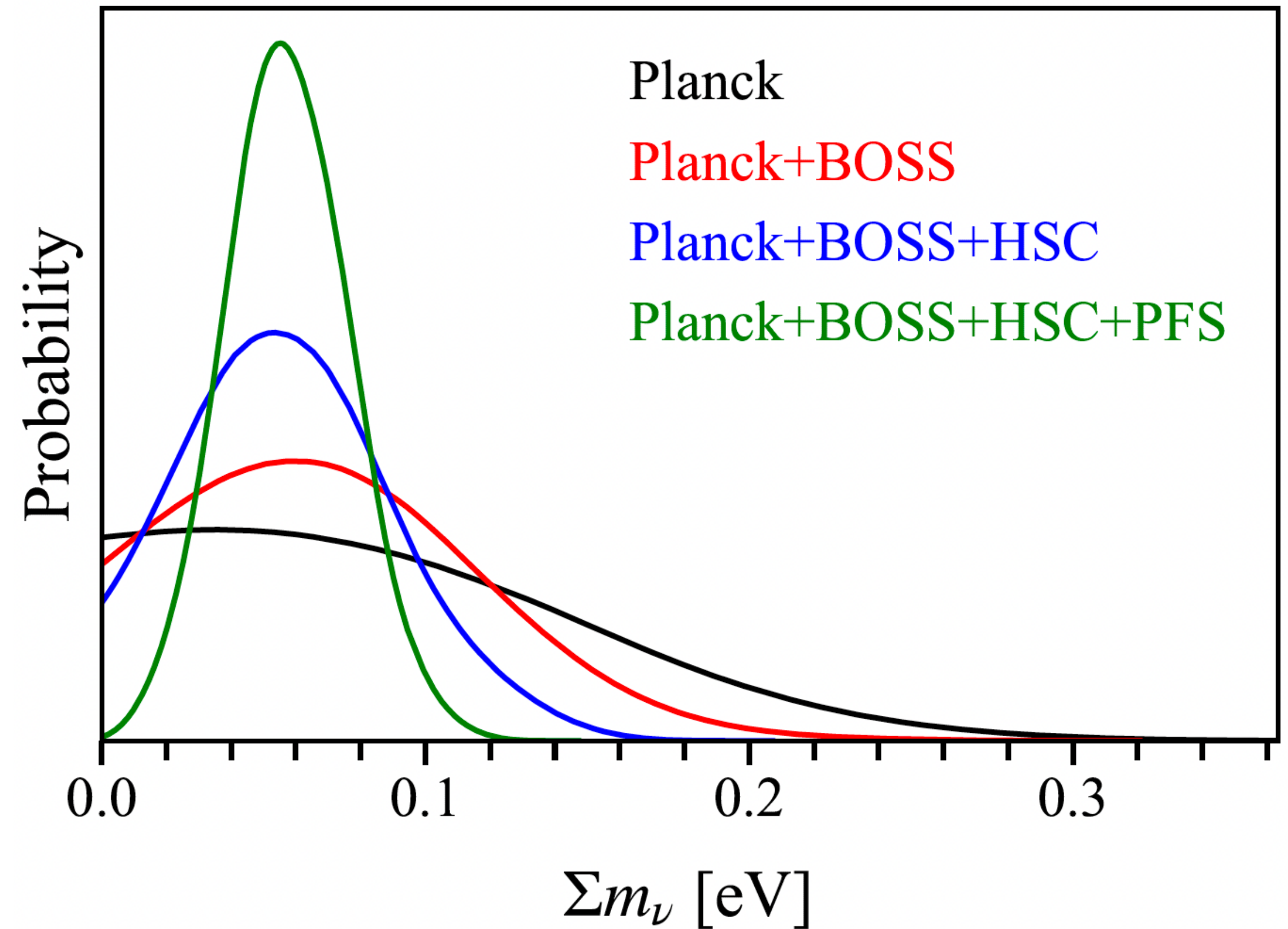
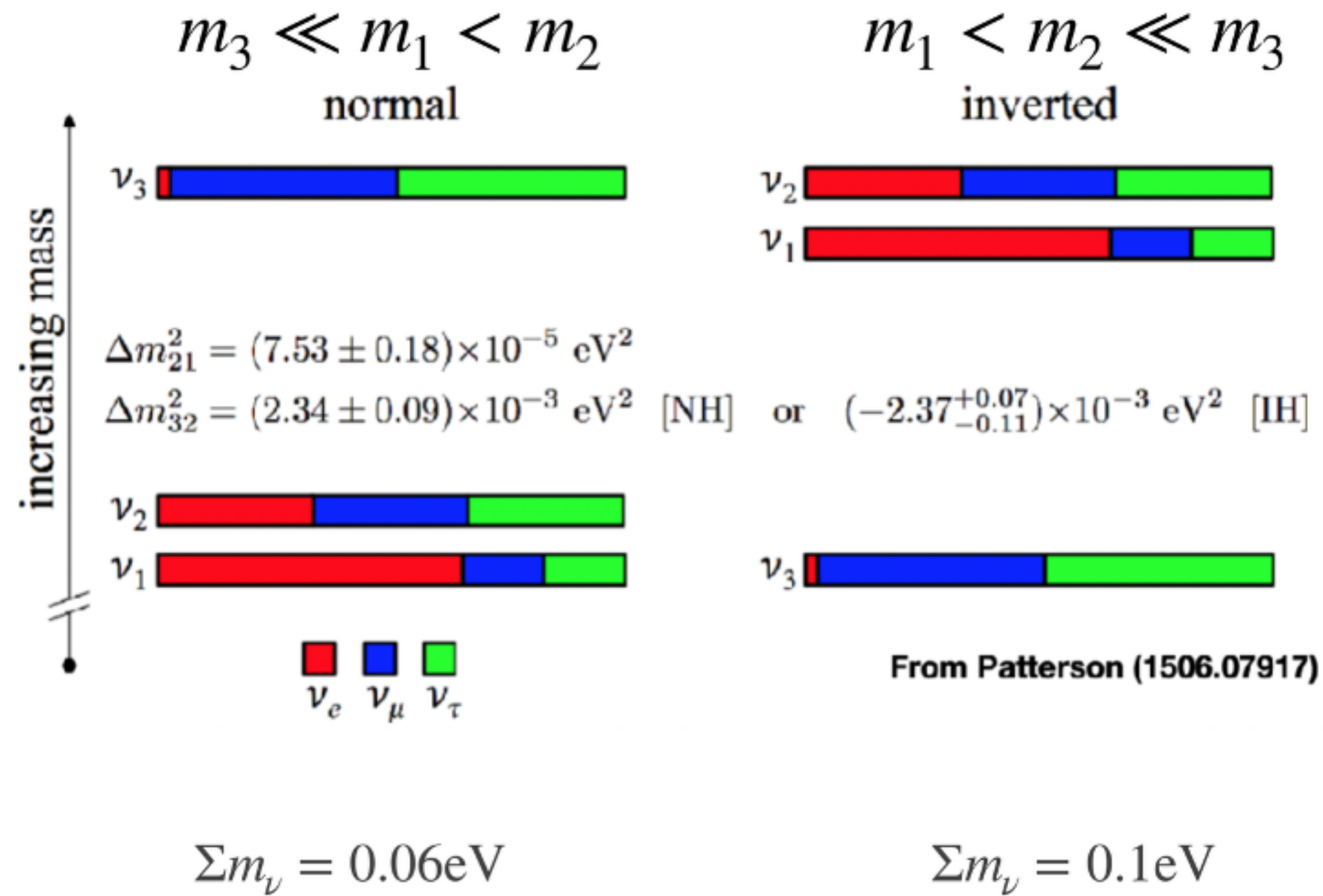


PFS SSP Cosmology:
~ 4M [OII] emission line galaxies, ~7(Gpc/h)³

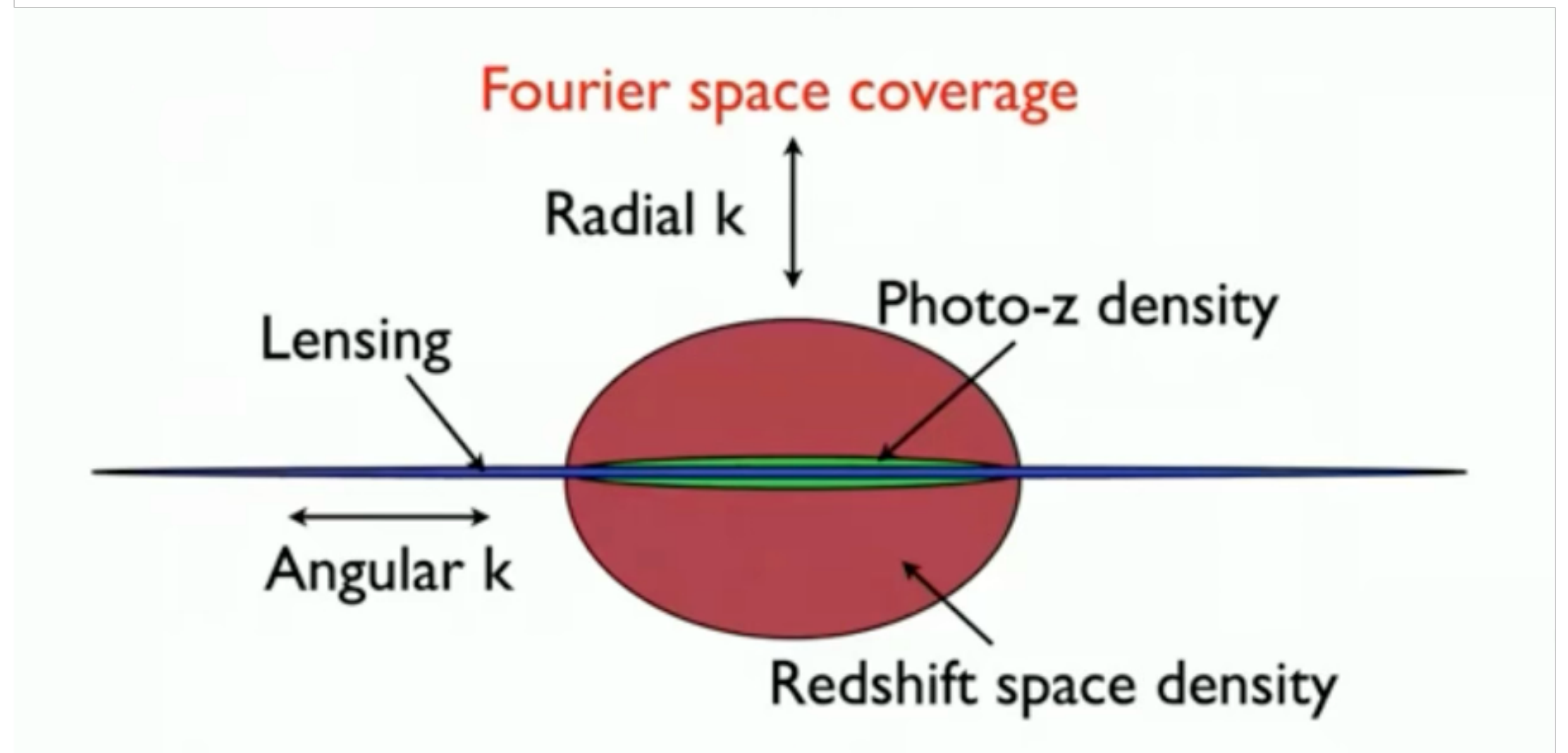
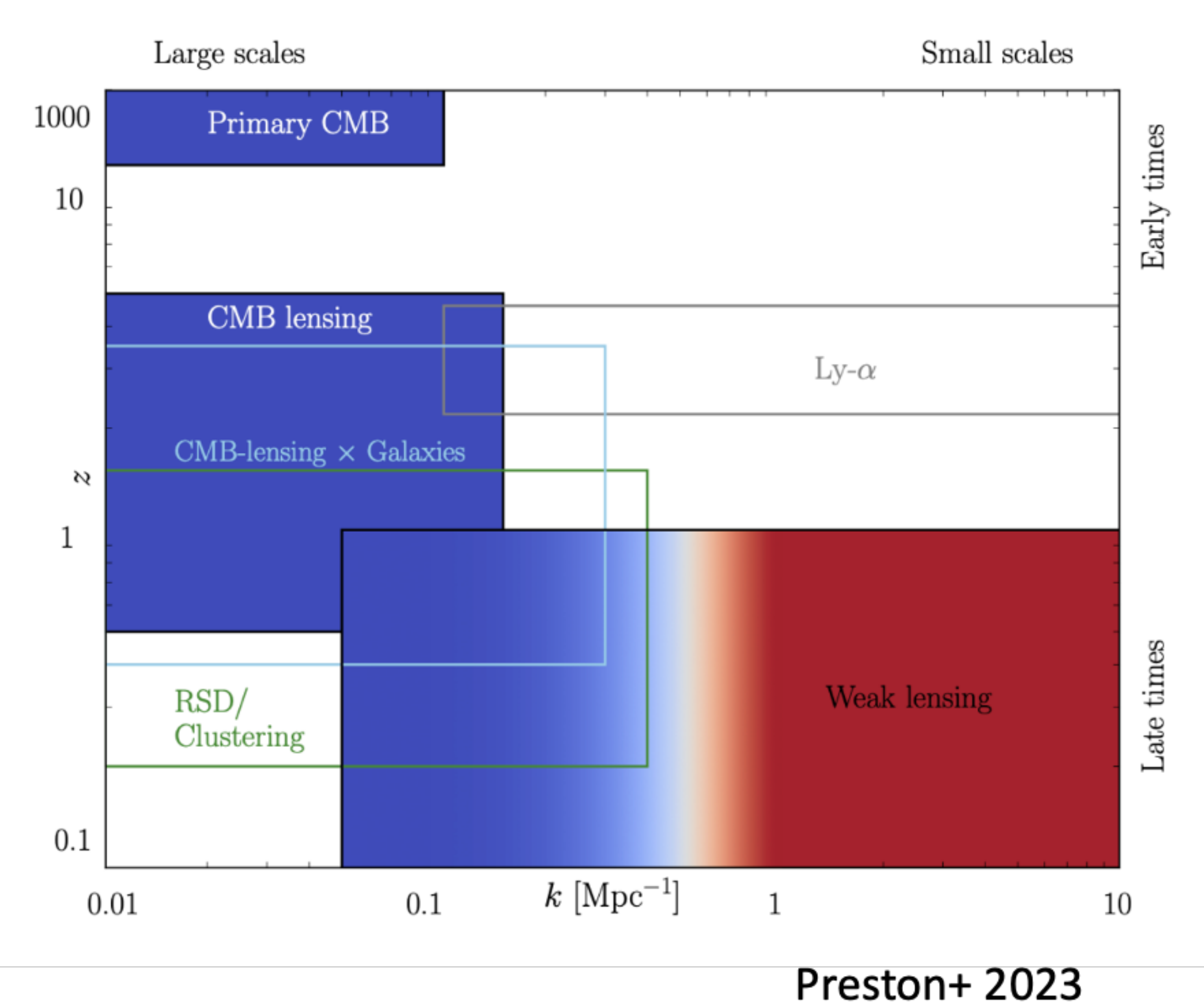


Sunayama+, in prep.

Neutrino Mass



PFS forecast: $\sigma(\Sigma m_\nu) = 0.02 \text{ eV}$ (68% CL)
 +30% from $k_{\text{max}} = 0.2 \rightarrow 0.5 \text{ h/Mpc}$



Credit: Andreu Font-Ribera & Patrick McDonald

Synergy between PFS CO and HSC/ACT/Litebird/SO etc.:

1. Bias free measurement of growth rate:
2. Robust to systematics that don't correlate between two surveys

Test GR

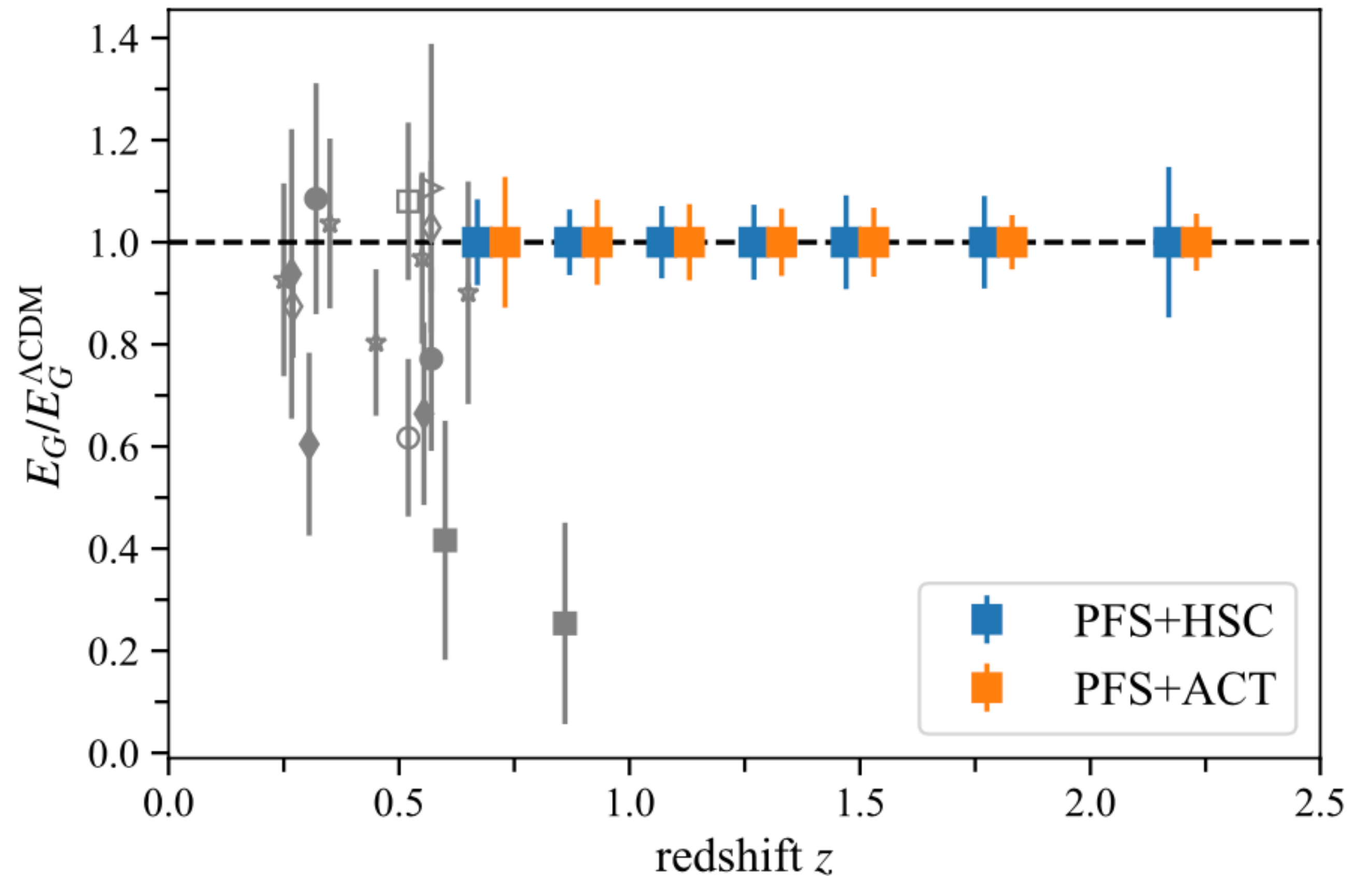
Lensing: how light is bent by gravity

$$E_G(z) = \frac{\nabla^2(\phi - \psi)}{f\delta_m}$$

Clustering: how galaxy moves in gravitational potential

See: Zhang et al. (2007), Reyes et al. (2010)

Reyes et al. 2010; Blake et al. 2016; Pullen et al. 2016a; Alam et al. 2017; de la Torre et al. 2017; Amon et al. 2018; Singh et al. 2019; Jullo et al. 2019; Blake et al. 2020



Model-independent test of GR at cosmological scale; free of galaxy bias uncertainty

Large-scale Structure Catalog

Systematics correction - crucial for robust measurement and cosmology inference

- fiber assignment
- imaging systematics
- redshift failure and uncertainty

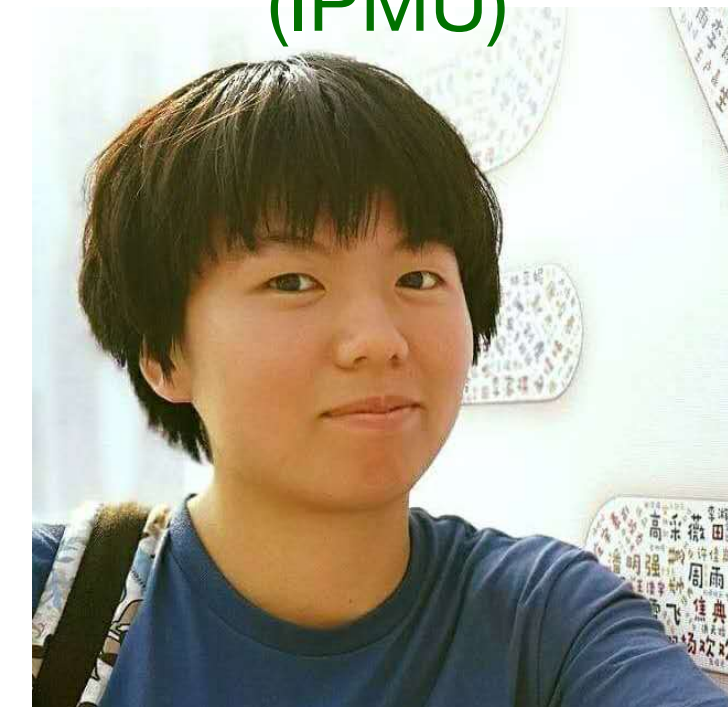
Shintaro Nakano
(IPMU)



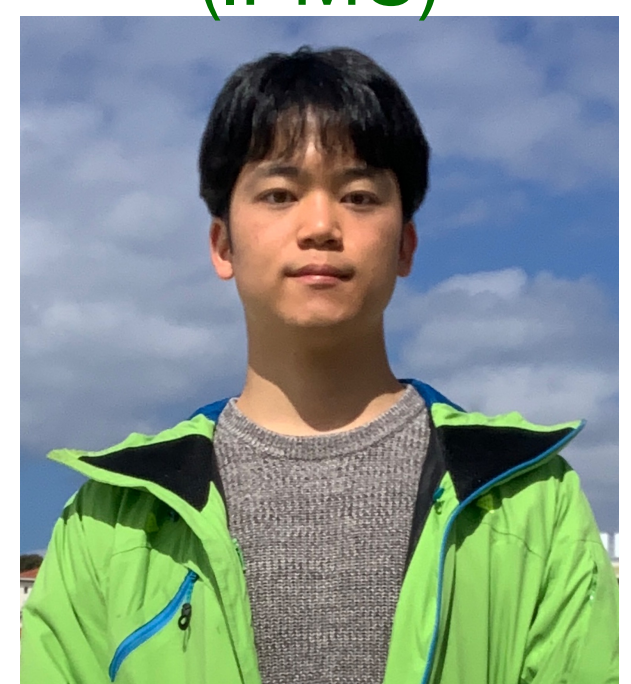
Yuka Yamada
(U. Tokyo)



Jiaxi Yu
(IPMU)

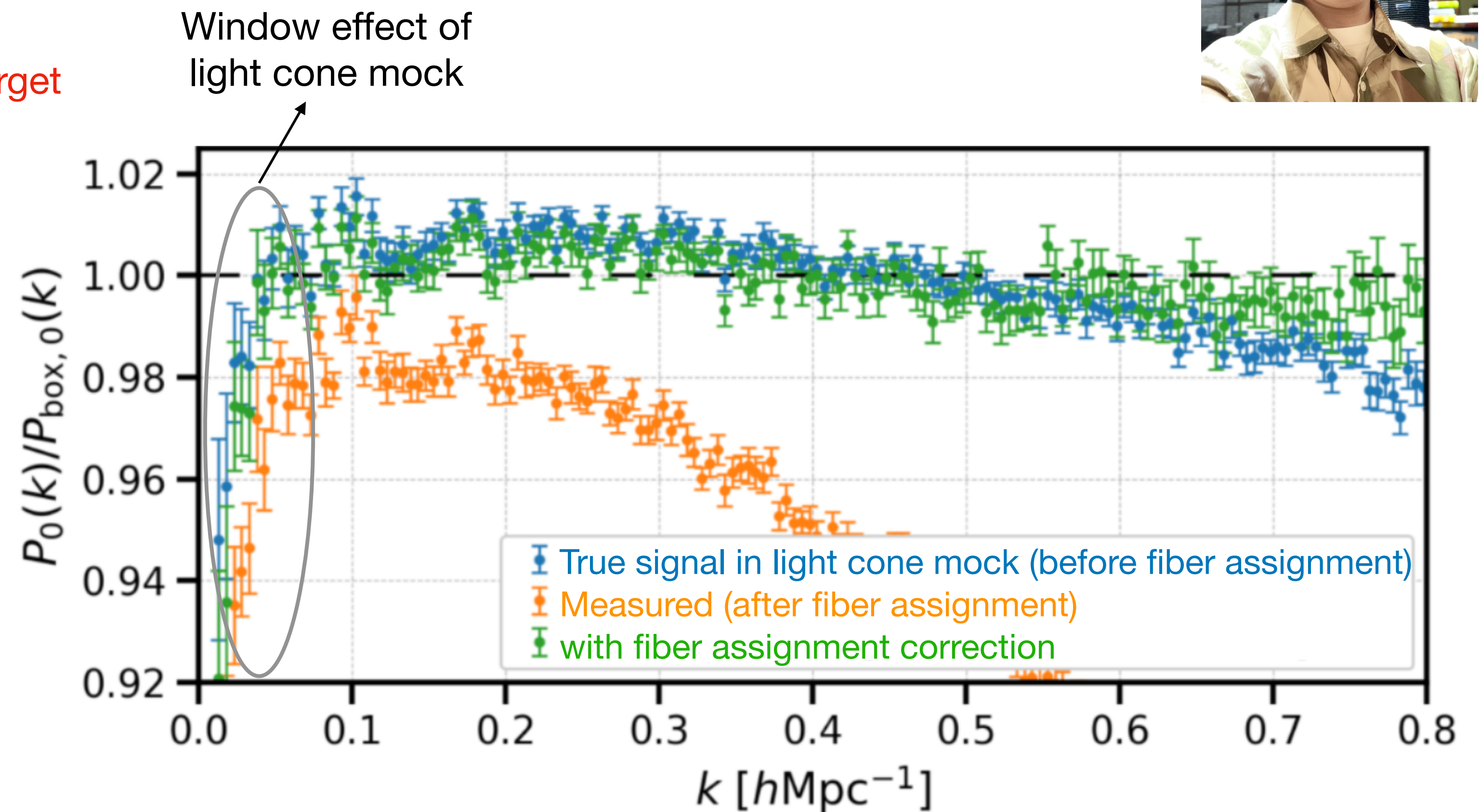
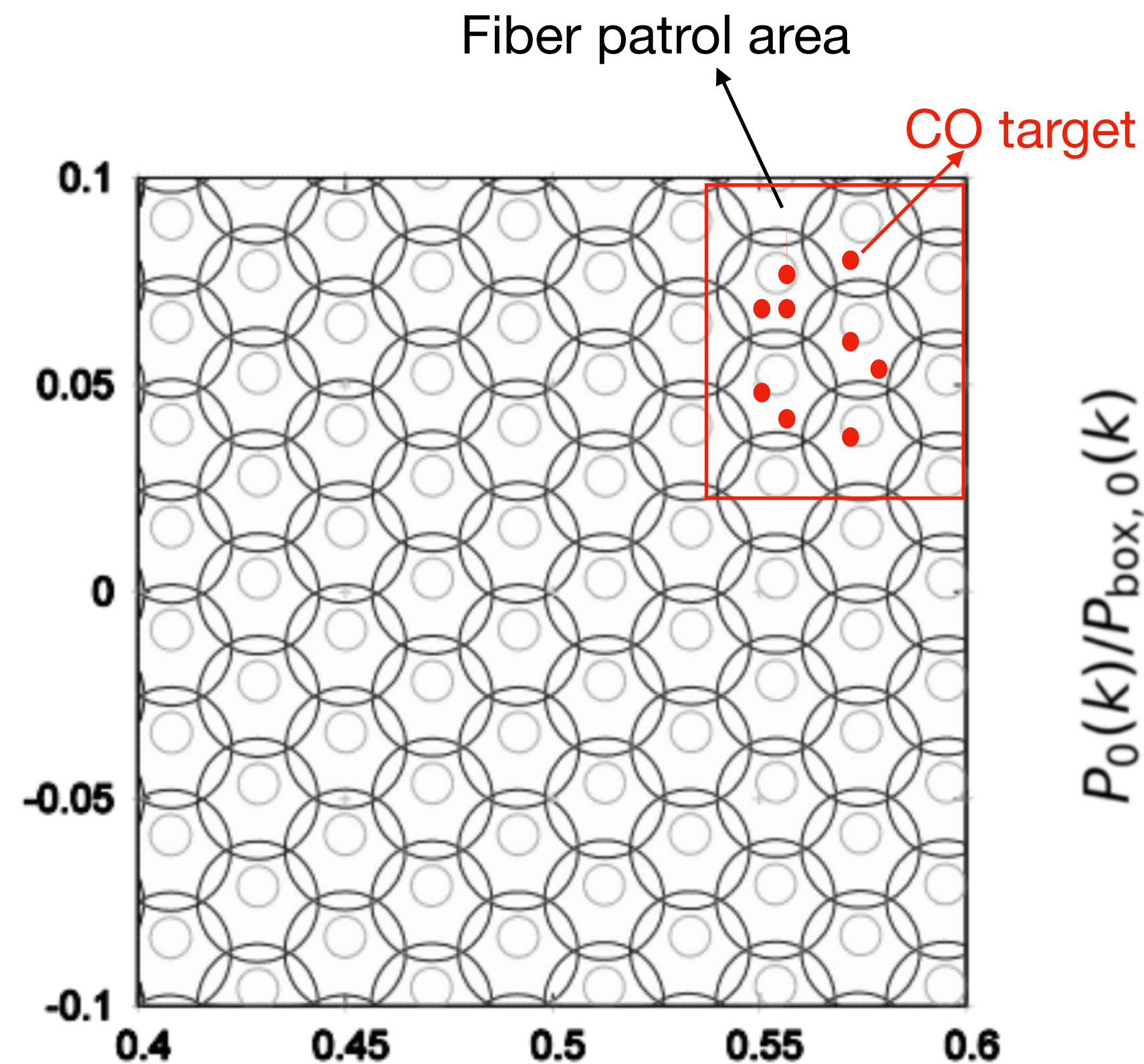


Kota Hayashi
(IPMU)



Correcting the fiber assignment effect

Shintaro Nakano
(IPMU)

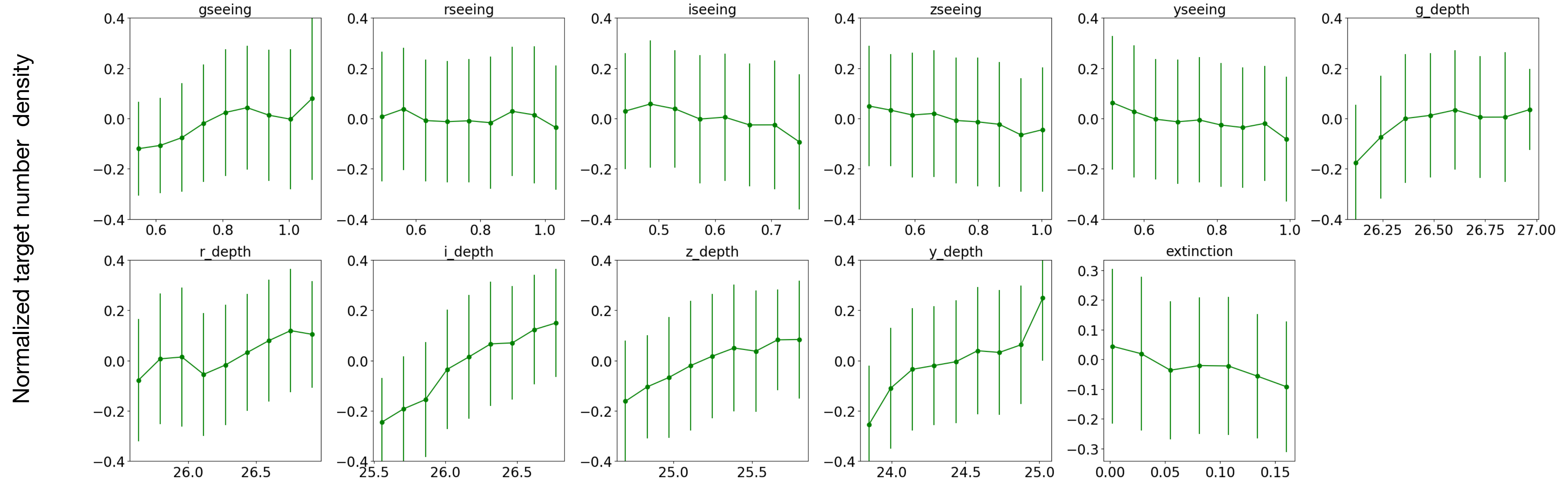


One fiber can only observe one target each time -> artificial selection of the targets -> **direct clustering measurement not representing the true large scale structure clustering signal**

Imaging systematics correction

Note that Hyper Suprime-Cam (HSC) Survey is the deepest ground-based imaging survey prior to Vera C. Rubin Observatory (LSST)

Yuka Yamada
(U. Tokyo)



Targets number density depends on the imaging survey photometry -> clustering signal not caused by the large scale structure

Mock for PFS Cosmology

subWG chair: Ken Osato

- Cosmology analysis pipeline validation
- Covariance matrix calculation

Data Release) <http://skiesanduniverses.org/Simulations/Uchuu/>

Name	#N	Box (Gpc/h)	particle mass ($M_{\odot}/h$)	cosmology	halo finder	merger tree	data public	code	reference
Uchuu	12800 ³	2.0	3.27e8	Planck15	Rockstar	consistent trees	○	GreeM	<u>Ishiyama+ 2021</u>
Darksky	10240 ³	8.0	3.9e10	WMAP9	Rockstar	no	△	2HOT	<u>Skillman+ 2014</u>
Euclid flagship	12600 ³	3.78	2.4e9	Planck15	Rockstar?	no	×	PKD GRAV3	<u>Potter+ 2016</u>
Outer Rim	10240 ³	3.0	1.9e9	WMAP7	FoF	w/o Subhalo	△	HACC	Heitmann+2019

Mucho-Uchuu project

“Mucho” means many in Spanish

Type	#N	Box (Gpc/h)	particle mass ($M_{\odot}/h$)	softening (kpc/h)	merger tree	#snap shots	Fugaku term	#realizations	Target
Large volume	6144 ³	6.0	8.0e10	16	○	25	2024	100	>= LRG
Medium	4096 ³	1.0	1.3e9	8	○	50	2024-2026	~600 (+200~ 400 in 2026)	>= ELG

- For covariance matrix. Running on Fugaku
- Massively parallel TreePM code GreeM (Ishiyama+2009, 2012, 2022)
- MPI-Rockstar (Behroozi+2013, Tokuue+2024) halo/subhalo finder (incl. inertia tensor)
- Planck2018 cosmology, $z_{\text{start}} = 11.5$ and 24 for large and medium, respectively (monofonIC, 3LPT)

Type	Total Rockstar size	#random Sample particles	□ Mass resolution ($M_{\odot}/h$)	□ Spatial resolution (fixed point integer) (kpc/h)	□ Total size of sample particles
Large volume	220 TB	2560 ³	1.1e12	5.7	470 TB
Medium	0.5-1 PB	512 ³	6.4e11	1.9	38-75 TB

Looking forward