Prime Focus Spectrograph

SuMIRe

Prime Focus Spectrograph: Cosmology Program

On behalf of the PFS Cosmology Science Working Group

Tomomi Sunayama
(Nagoya U./Kavli IPMU)

Ryu Makiya
(ASIAA/Kavli IPMU)

Cosmology SWG Co-chairs

Eiichiro Komatsu (Max-Planck-Institute for Astrophysics / Kavli IPMU)
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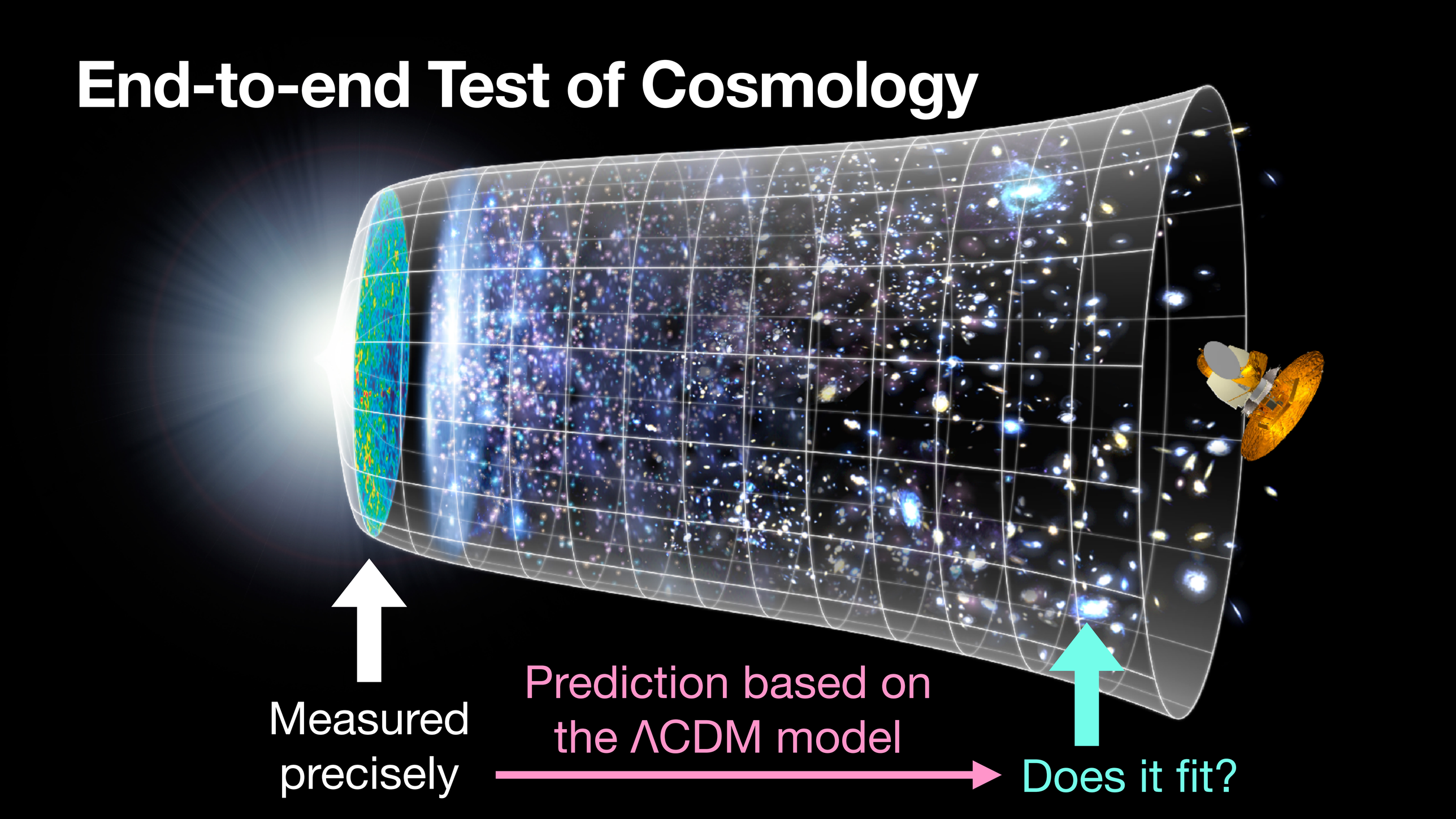
PFS Cosmology Program

In a nutshell

- Accurate and robust cosmological constraints using the ***single* tracer ([OII] emission line galaxies)** to map **evolution** of the large-scale structure of the Universe in a wide range of redshifts, **0.6 < z < 2.4**, over 1400 deg^2.
  - *Measure the distance scales and the growth of structure.*
- A unique and powerful combination with the weak lensing data of HSC as well as with the lensing of the cosmic microwave background.
- The two main science themes:
  - **To falsify the standard ΛCDM model** by measuring time-evolving dark energy and testing General Relativity
  - **To measure the neutrino mass** with sensitivity of $\sum m_\nu = 0.06 \pm 0.02$ eV (68%CL).

End-to-end Test of Cosmology

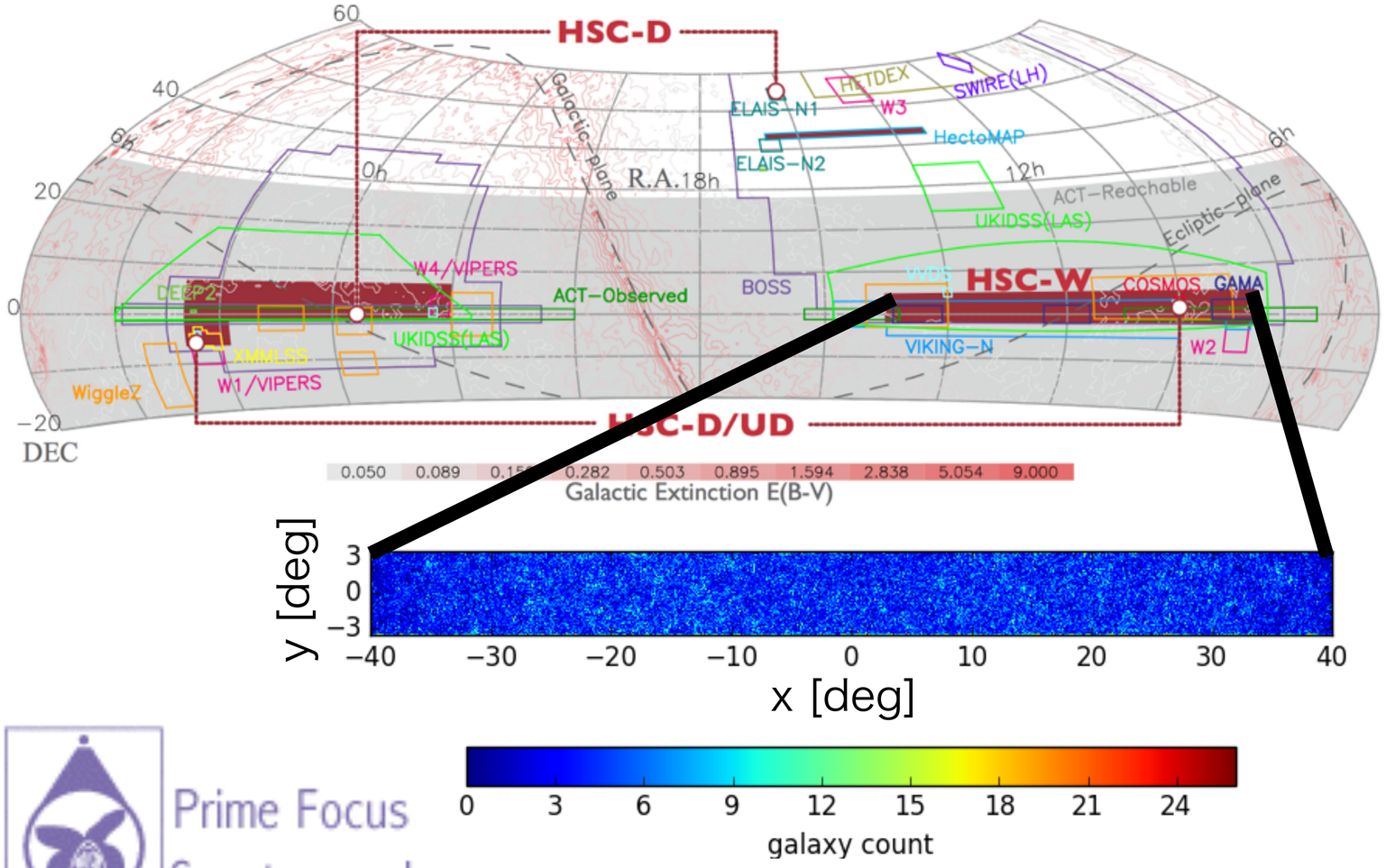


The current status of the E2E test

- There is an indication that **the end-to-end test is failing for a flat ΛCDM cosmology.**
  - Two tensions: H_0 and $S_8 = \sigma_8 \Omega_m^{0.5}$.
  - **The Hubble constant tension:** H_0 predicted from the CMB data does not agree with that from the late-time measurements (distance ladder, gravitational lensing).
  - **The density fluctuation amplitude tension:** S_8 predicted from the CMB data does not agree with that from the late-time measurements (weak gravitational lensing, the abundance of galaxy clusters).

PFS can address these tensions by measuring the distances and the growth of structure over a wide redshift range (0.6<z<2.4) using the *single* tracer ([OII] emitting galaxies).

simulated galaxy map
z = 1.5, spring field



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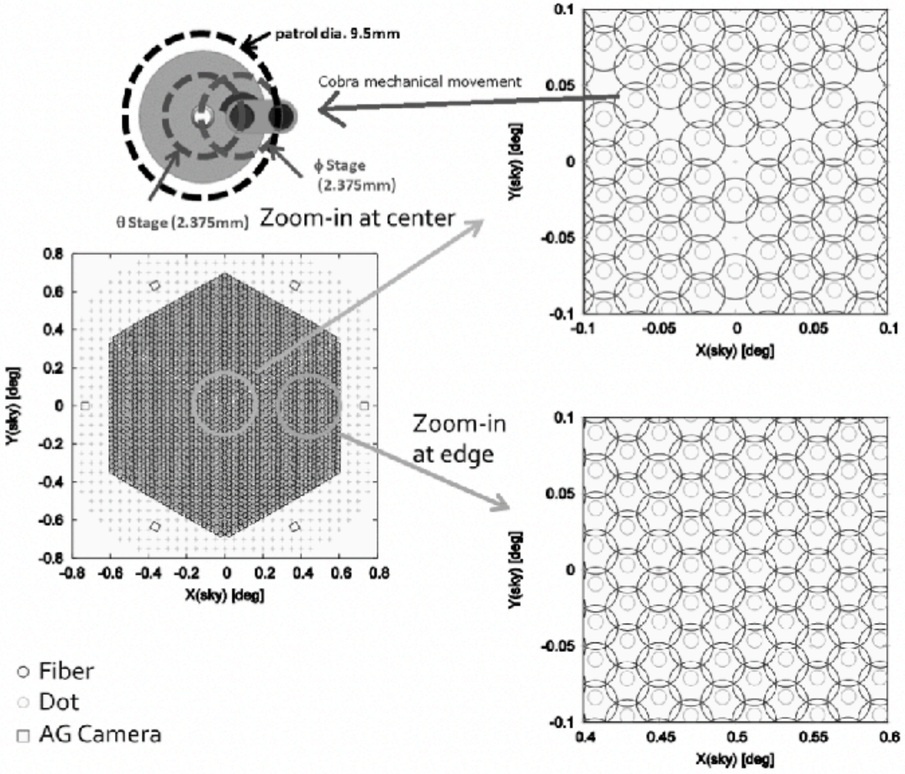
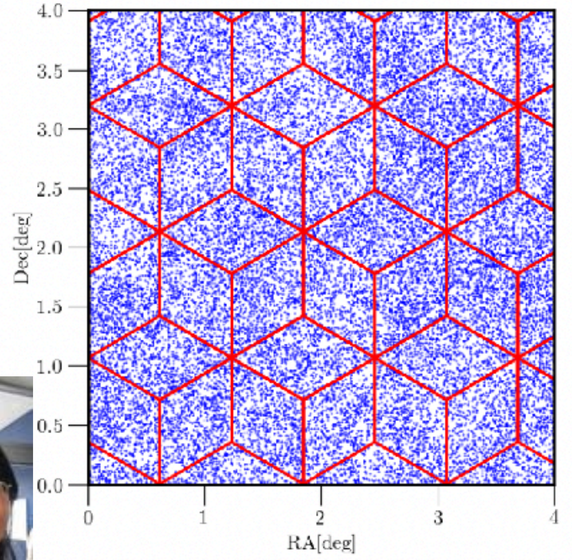


Sunayama et al. (2020)

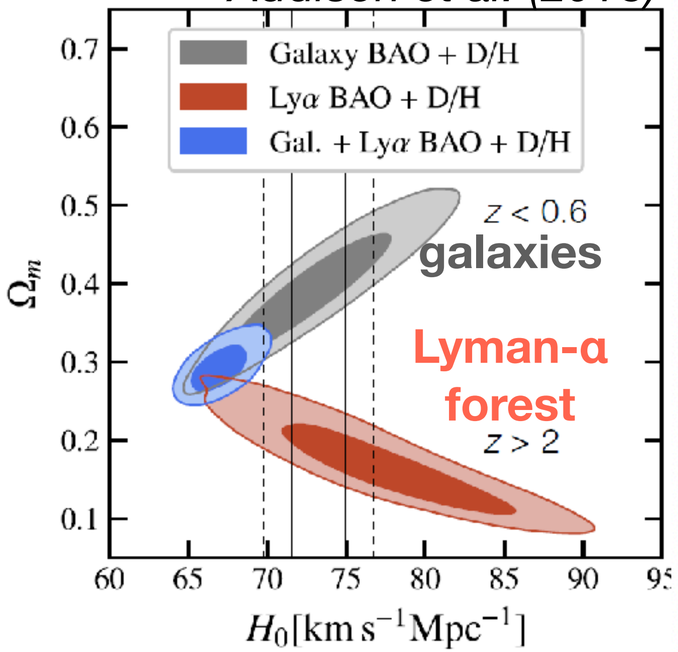


Each direction is visited twice
(15 minutes exposure each)

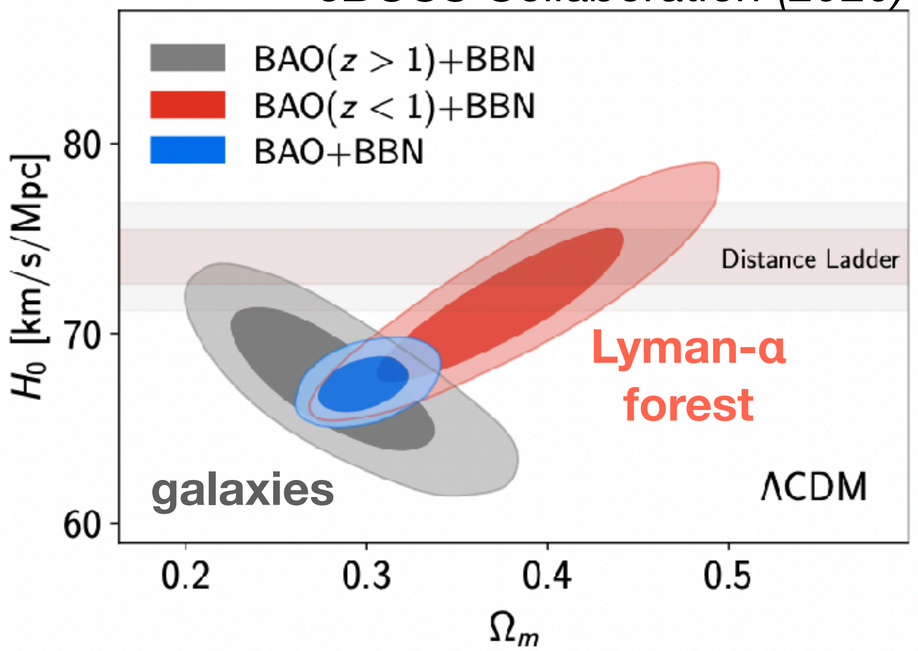
Distance measurements

Internal cross check

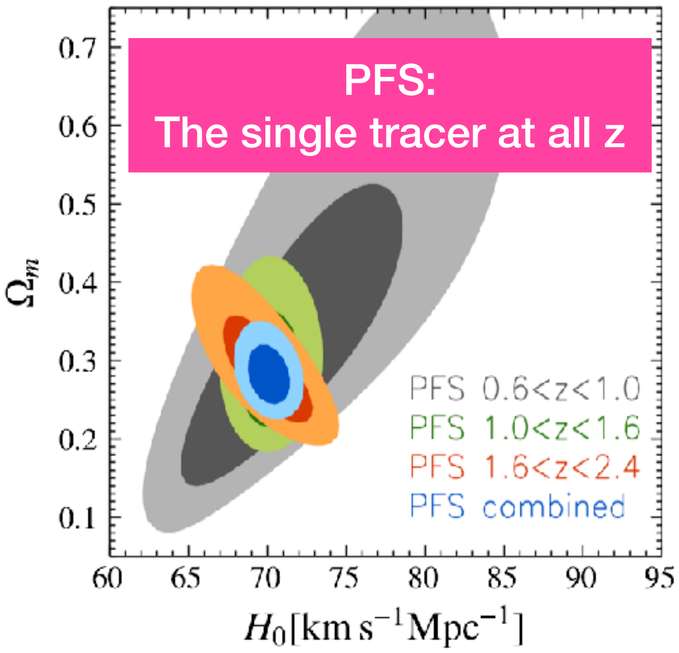
Addison et al. (2018)



eBOSS Collaboration (2020)



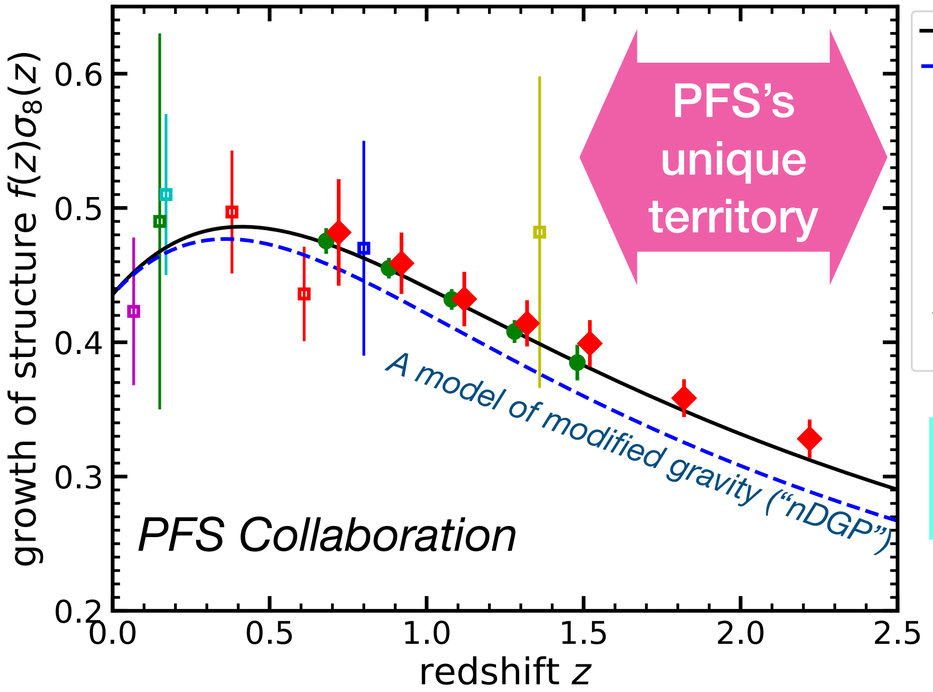
PFS Collaboration



- Are the large-scale structure data telling us the consistent story?
  - So far, the distance measurements from the Baryon Acoustic Oscillation (BAO) come from two very different tracers: galaxies at low z, and Lyman-α forest from high z.
  - The PFS can get BAO measurements at all z from the single tracer. **Robust cosmology!**

Density fluctuation growth measurements

The widest redshift coverage by the single experiment



PFS and **DESI** forecasts are computed using the same methodology [P(k) + B(k1,k2,k3)]

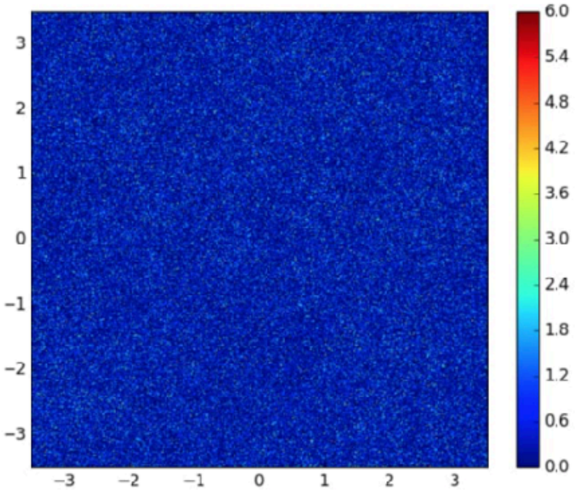
- k_{max} = 0.2 Mpc/h
- Linear and non-linear galaxy bias parameters and the FoG parameter marginalised over

- The history of the growth of structure over a wide redshift range.
- Complementarity to DESI: **DESI at low z (z<1.5)**, **PFS at high z (z>1.5).**
  - We do not yet know how to extract the growth information from Lyman-α forest.

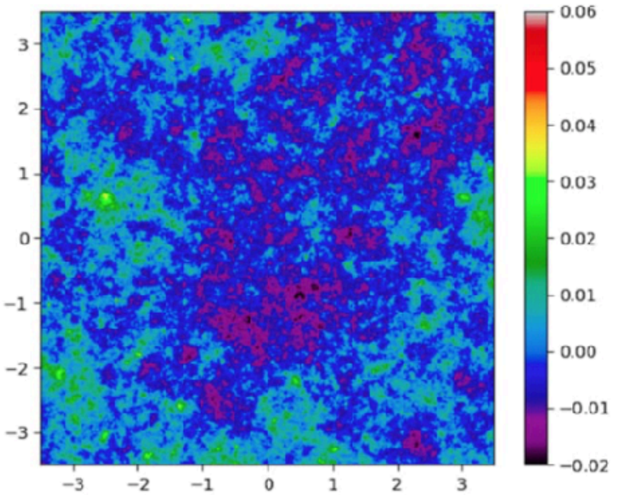
Synergy with the HSC lensing survey

Unique and powerful duo

- The major advantage of the PFS is that (by design) it has the full overlap with the high quality HSC imaging data. They benefit each other:
  - HSC gets spectroscopic redshifts for calibrating the photo-z required for the weak lensing analysis.
- PFS gets target galaxies, and improves the cosmological constraints by including lensing cross-correlation with galaxies.



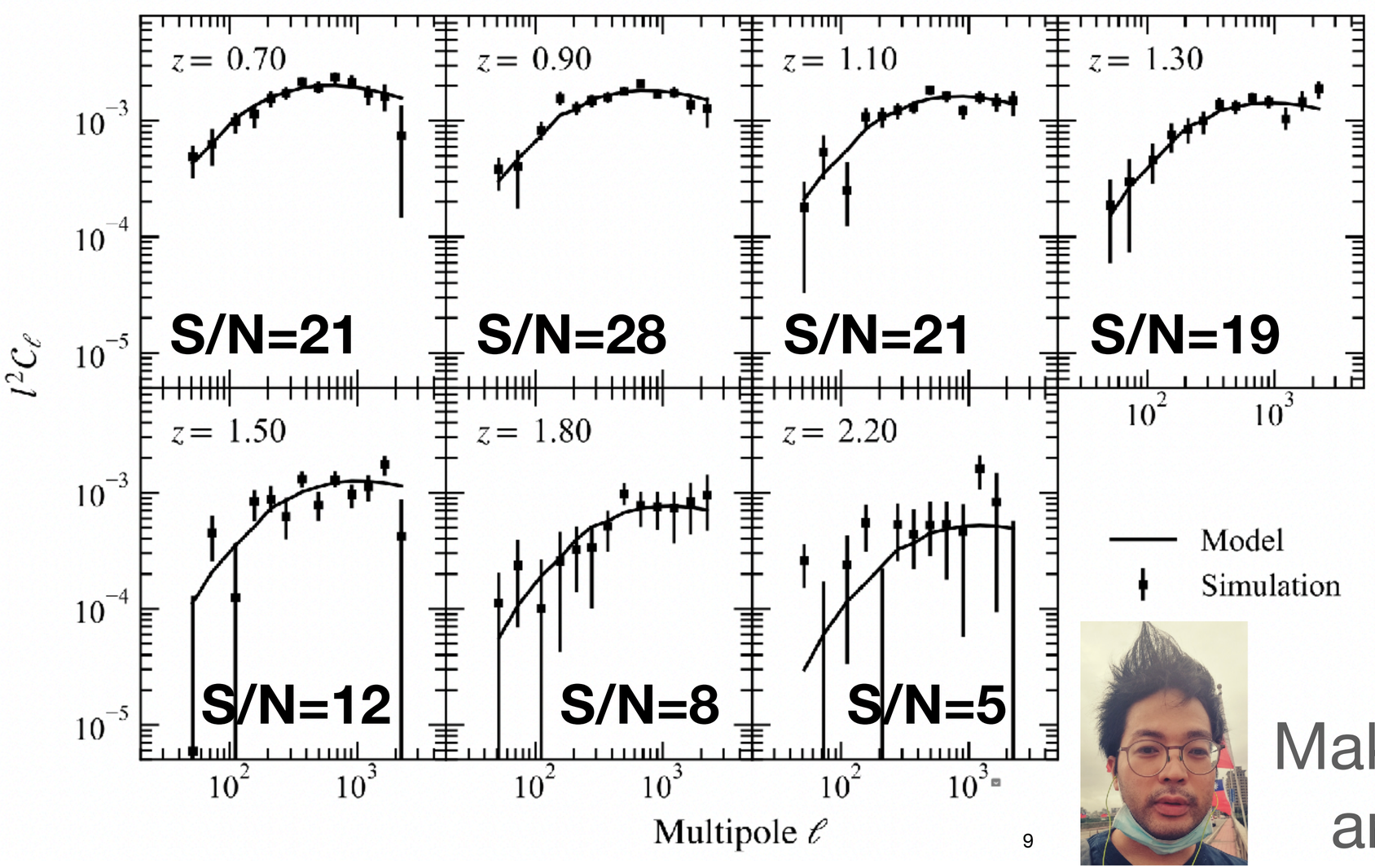
PFS galaxies



HSC lensing

Galaxy-lensing cross-correlation forecast

Lot of signals!

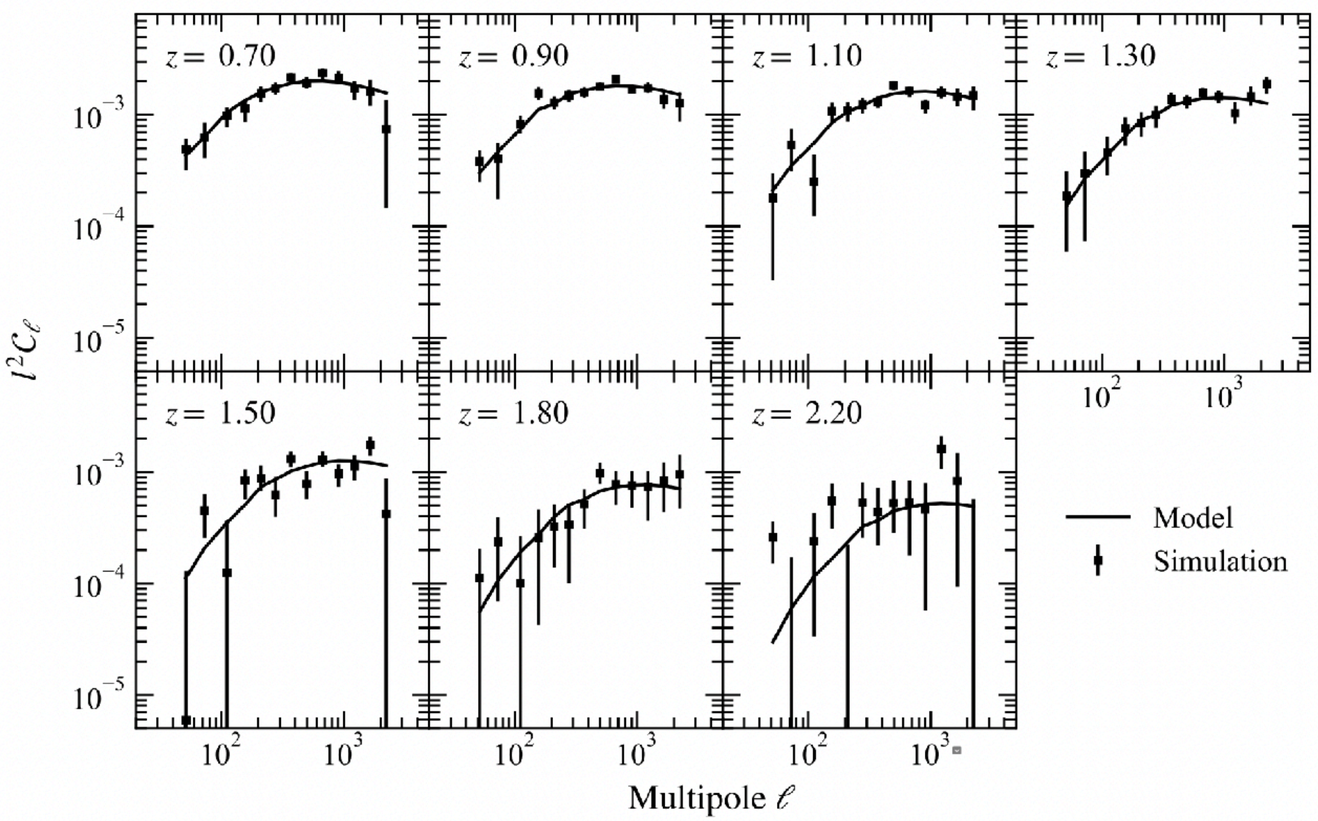


- We can detect the cross-correlation between galaxies and lensing fields **at all redshift bins.**
- We can also cross-correlate galaxies with the CMB lensing (e.g., ACT and Simons Observatory)
  - *Useful for high z bins*

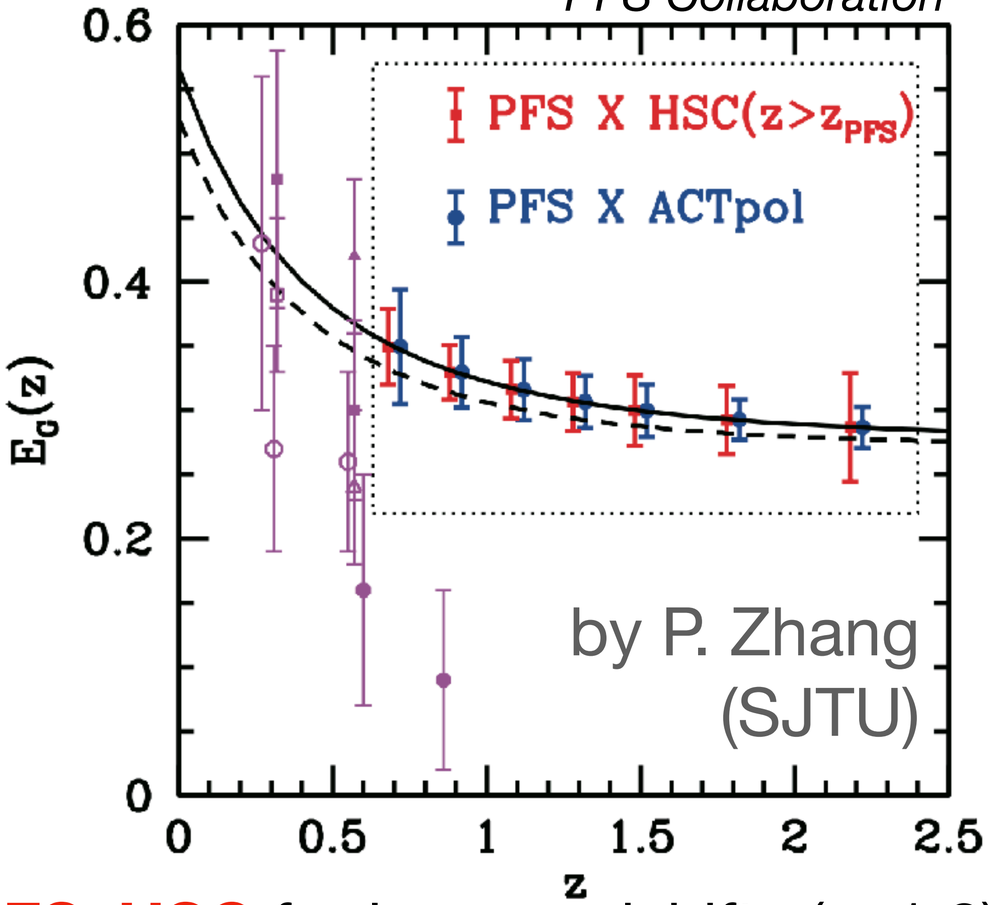
Makiya, Kayo and EK
arXiv:2008.13195

Testing GR using the "E_G" statistics

Out to the unprecedentedly high redshift!



PFS Collaboration

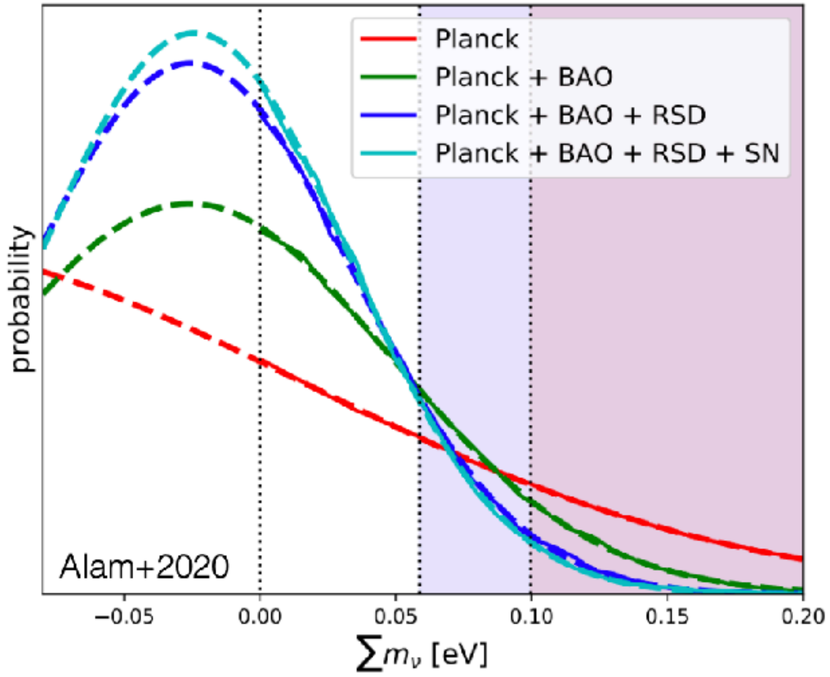


- **PFSxHSC** for lower redshifts (z<1.2)
- **PFSxCMB** for higher redshifts

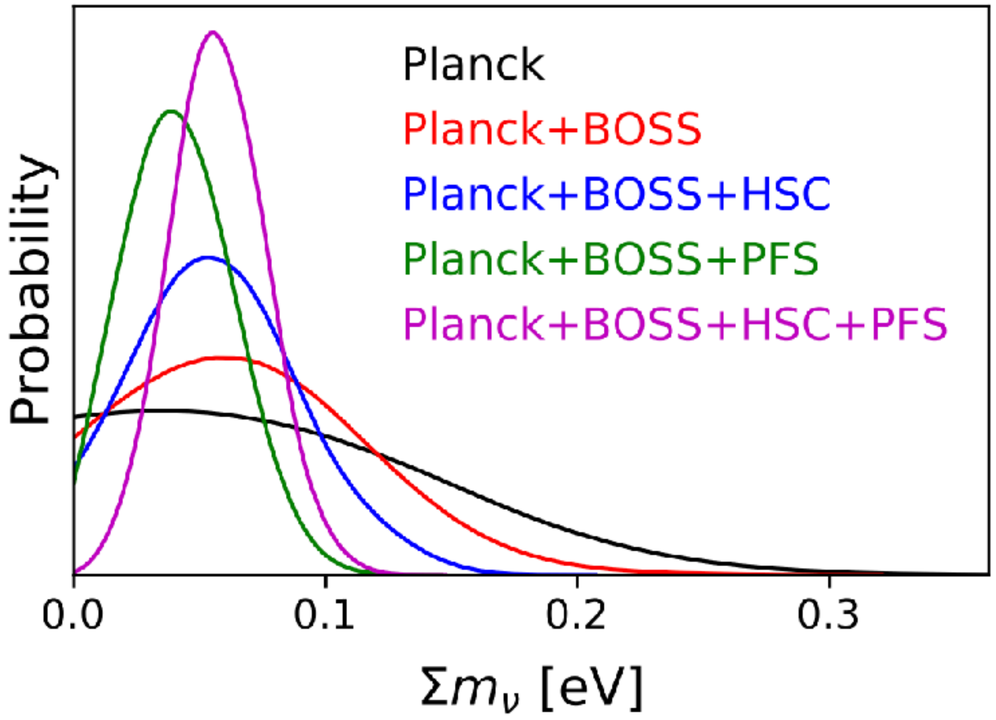
Measuring the mass of neutrinos

The guaranteed signal in the large-scale structure

eBOSS Collaboration (2020)



PFS Collaboration



- PFS+HSC(+CMB+existing LSS data) is powerful enough to measure the neutrino mass at 3-σ, even for the minimal neutrino mass.

$$\sum m_\nu = 0.06 \pm 0.02 \text{ eV}$$ **[68%CL]**

$$0.02 < \sum m_\nu < 0.10 \text{ eV}$$ **[95%CL]**

Summary

The PFS Cosmology Program

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