PHYSICS

DARK ENERGY SPECTROSCOPIC INSTRUMENT
U.S. Department of Energy Office of Science

Constraining Late-Time Cosmology with DESI DR2

COSMO'25

Carnegie Mellon University

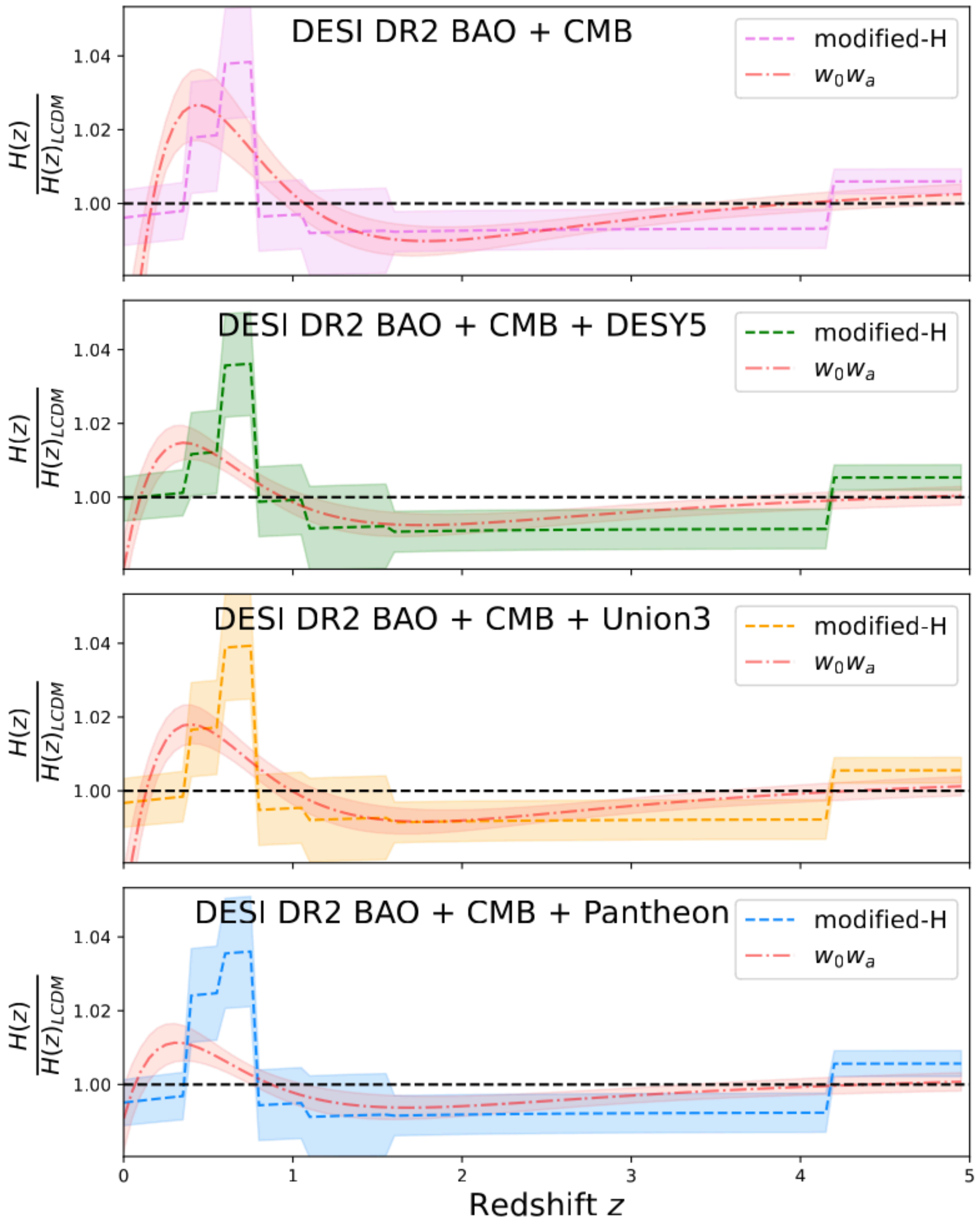
15th October 2025

Prakhar Bansal
2nd Year PhD Sudent
Advisor: Dragan Huterer

1. Expansion History Preferences of DESI DR2 and external data

Phys. Rev. D 112, 023528

Results



Modified-H Model

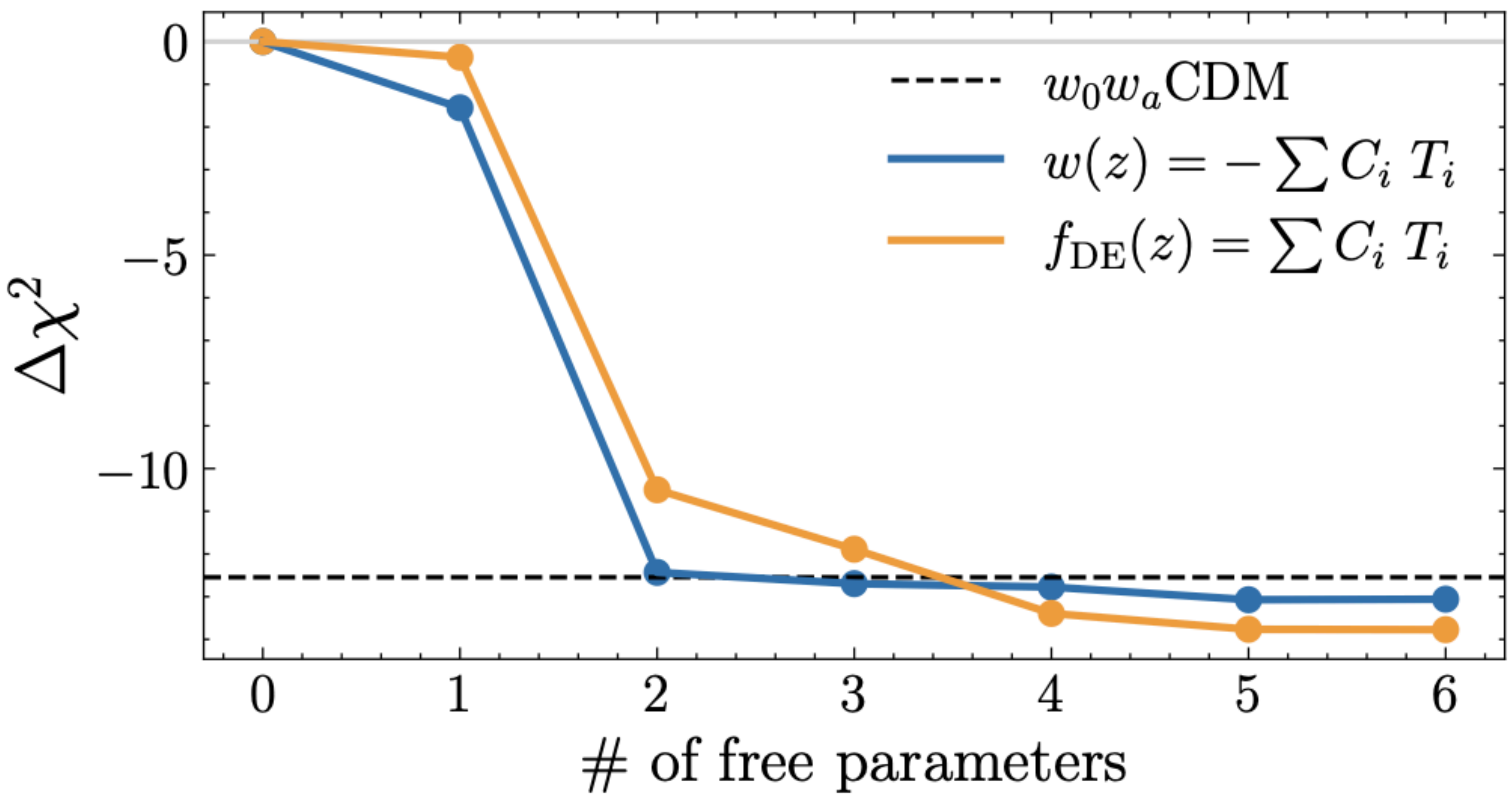
$$H(z) = H(z)^{LCDM}(1 + \alpha_i)$$

6 free parameters
(as opposed to 2 in $w_0 w_A$)

$w_0 w_a$ parametrization is flexible enough to model the DESI data favoured expansion history!!

Bansal & Huterer, Phys. Rev. D 112, 023528

…Later confirmed by independent studies



Lodha++, Phys. Rev. D 112, 083511

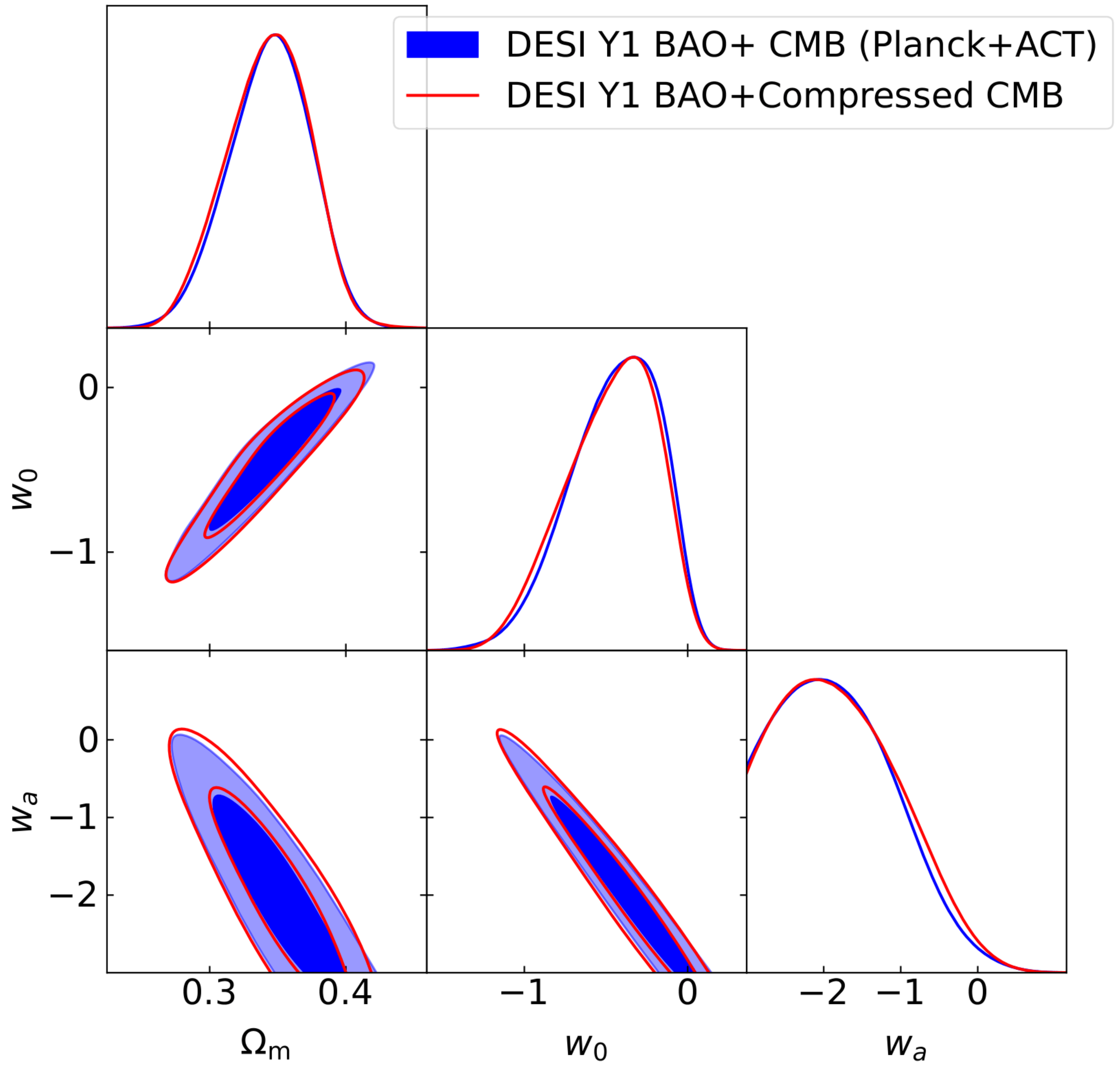
Corollary: CMB Compression

$$\mathbf{v}_{\rm CMB} \equiv (R, \ell_a, \Omega_b h^2)$$

- Useful for non-physical models for which the CMB power spectrum cannot be evaluated

- Means and Covariances calculated from Planck+ACT6 lensing LCDM chains

- Validated against LCDM and w0wa CDM full CMB constraints



Bansal & Huterer, Phys. Rev. D 112, 023528

2. The challenges with Late Time solutions for the Hubble Tension

(In Prep)

Hubble Tension as "M" tension

$$\mu = 5\log_{10}(d_L) + 25$$

$$m_{app} = \mu + M_{abs}$$

$$m_{app} = 5\log_{10}(d_L) + 25 + M_{abs}$$

$$m_{app} = 5\log_{10}(H_0 d_L) - 5\log_{10} H_0 + 25 + M_{abs}$$

$$m_{app} = 5\log H_0 d_L + \mathscr{M}$$

Marginalized over in std analyses

$\{$SN Properties, $H_0\}$

$\{\Omega_M, \Omega_K, w_0, w_a \ldots\}$

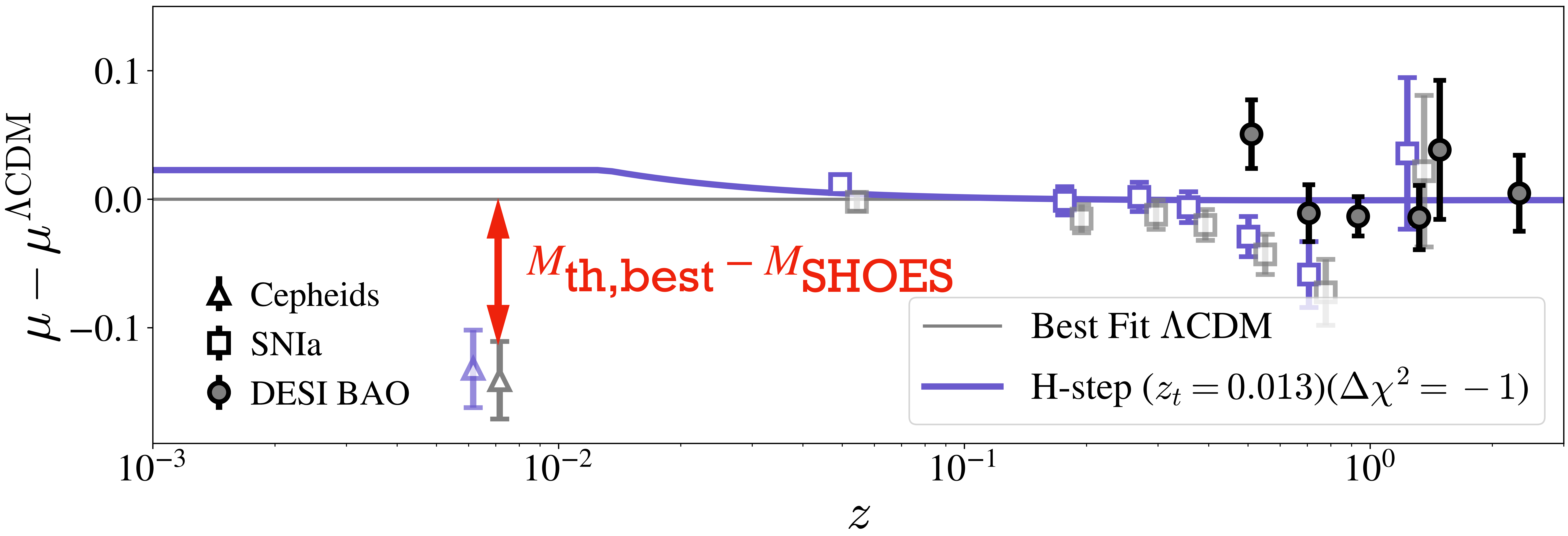
Hubble Tension as “M” tension

Fixing M to SHOES Best-fit value

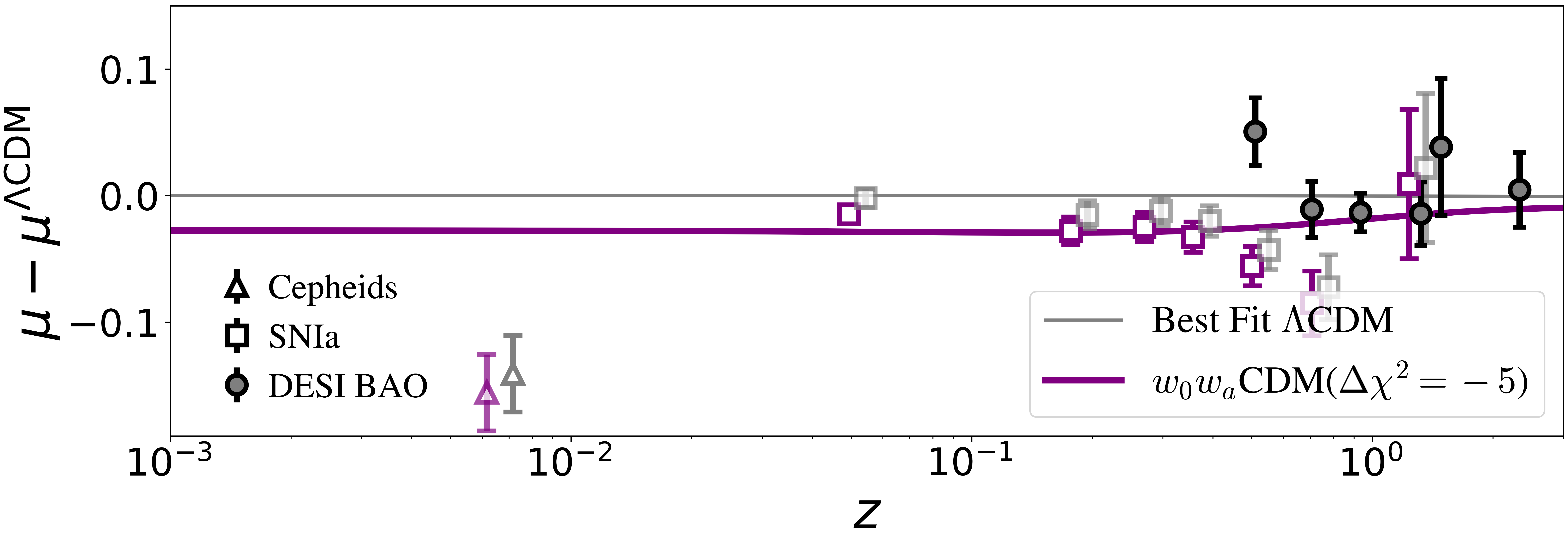
Hubble Tension as “M” tension

Allowing M to be a free parameter

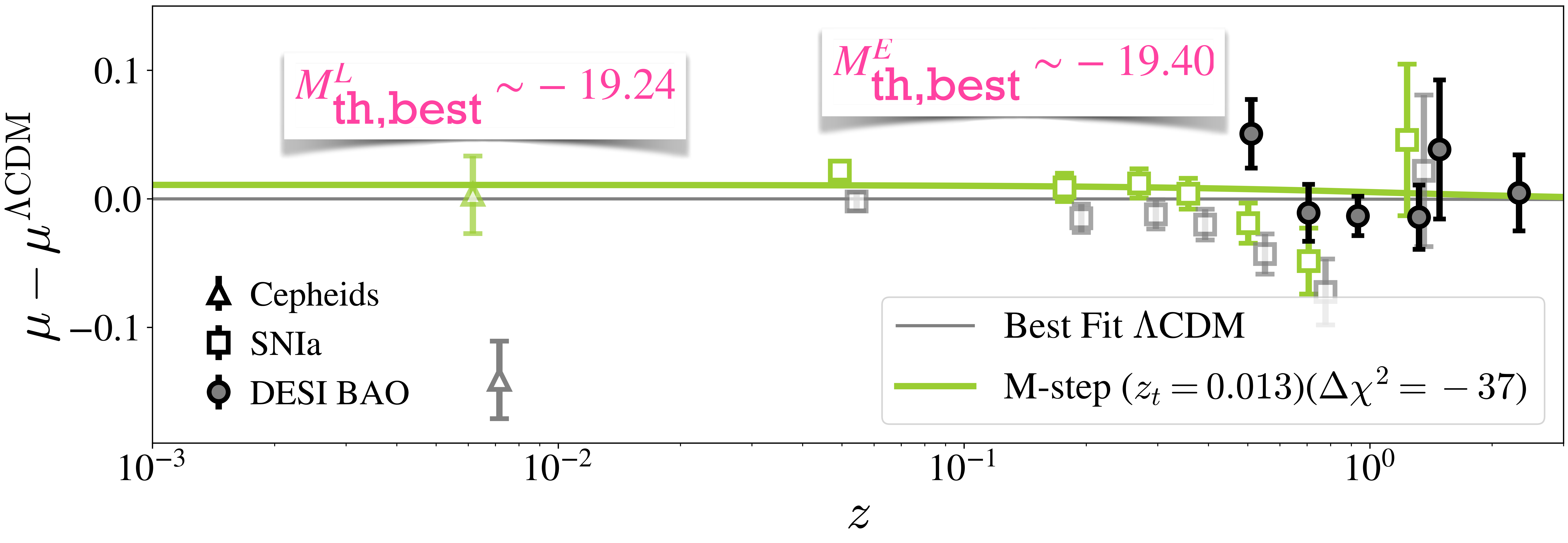
A simple expansion history modification cannot resolve this tension



A simple expansion history modification cannot resolve this tension



Allowing for a break in SNIa absolute magnitude significantly improves the $\Delta\chi^2$



DARK ENERGY SPECTROSCOPIC INSTRUMENT
U.S. Department of Energy Office of Science

3. Full shape with FOLPSD

(In Prep)

(with U. Andrade, H. Noriega, A. Aviles & Issac Garzon)

FOLPS

Fast computation of non-linear power spectrum in cosmologies with massive neutrinos

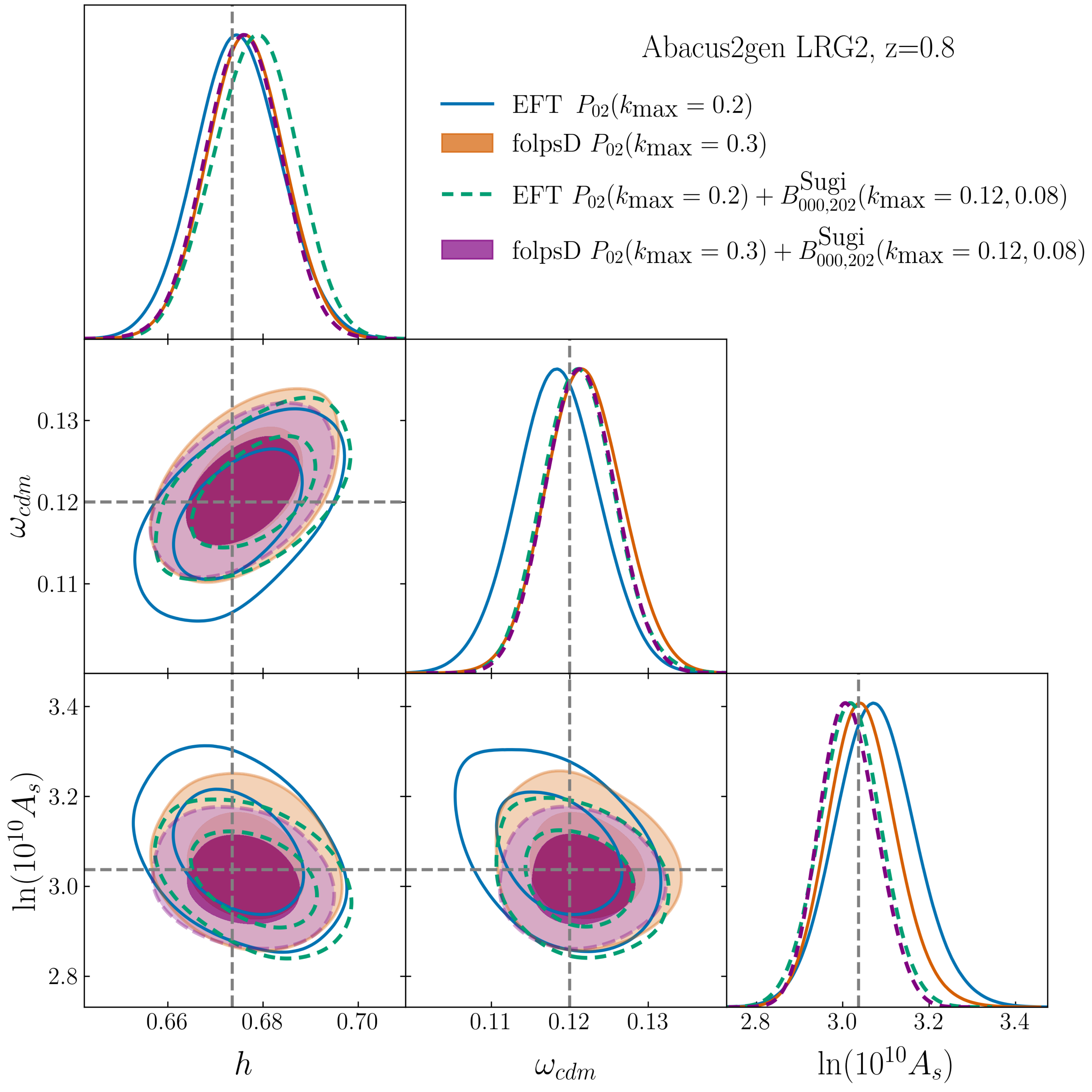
Hernán E. Noriega,[a,b] **Alejandro Aviles,**[b,c,1] **Sebastien Fromenteau,**[d] **Mariana Vargas-Magaña**[a]

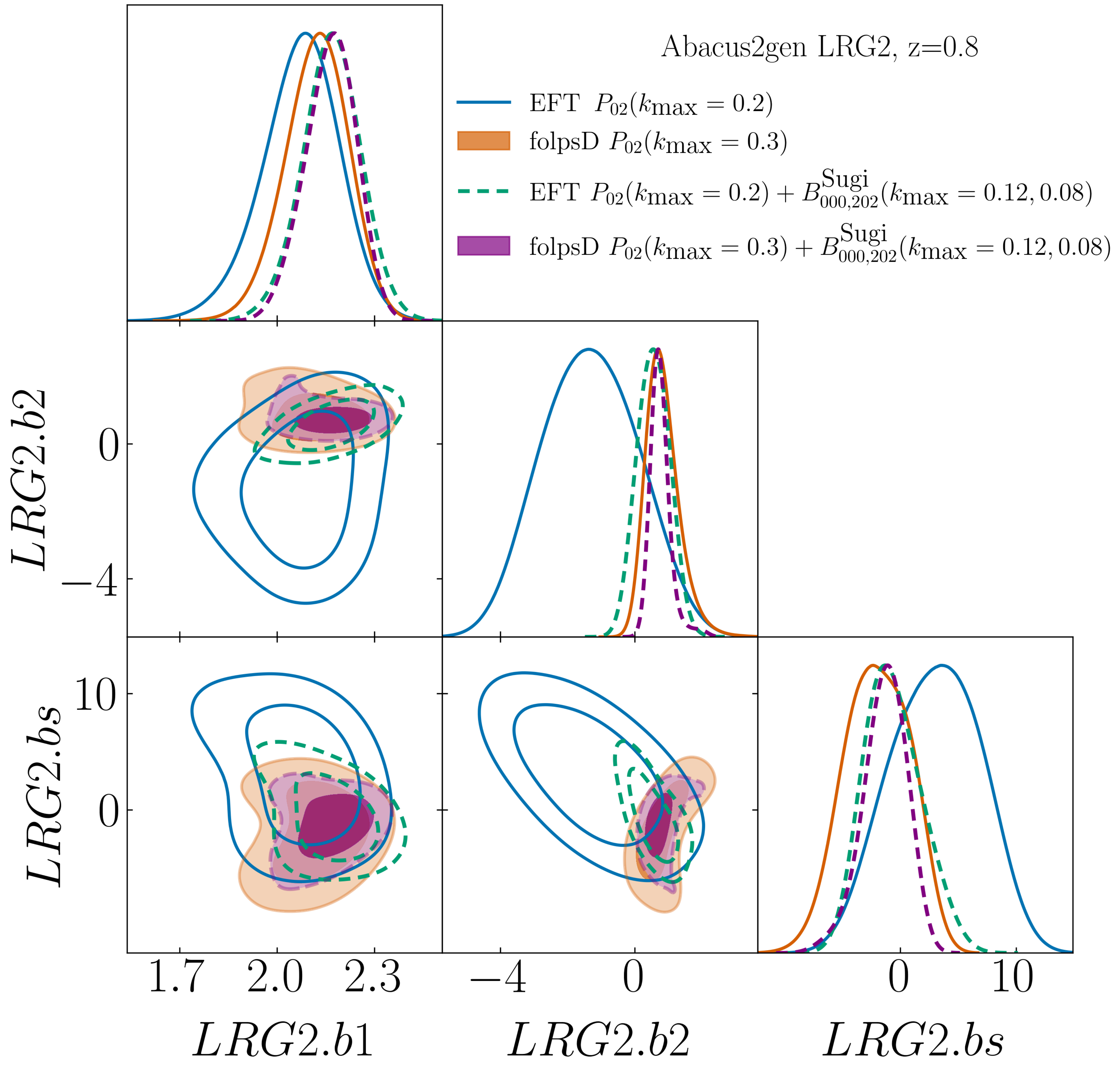
- EFT based code
- Massive ν and Modified gravity models
- Computationally very fast (~ 0.2s/ PS)

FOLPS-D

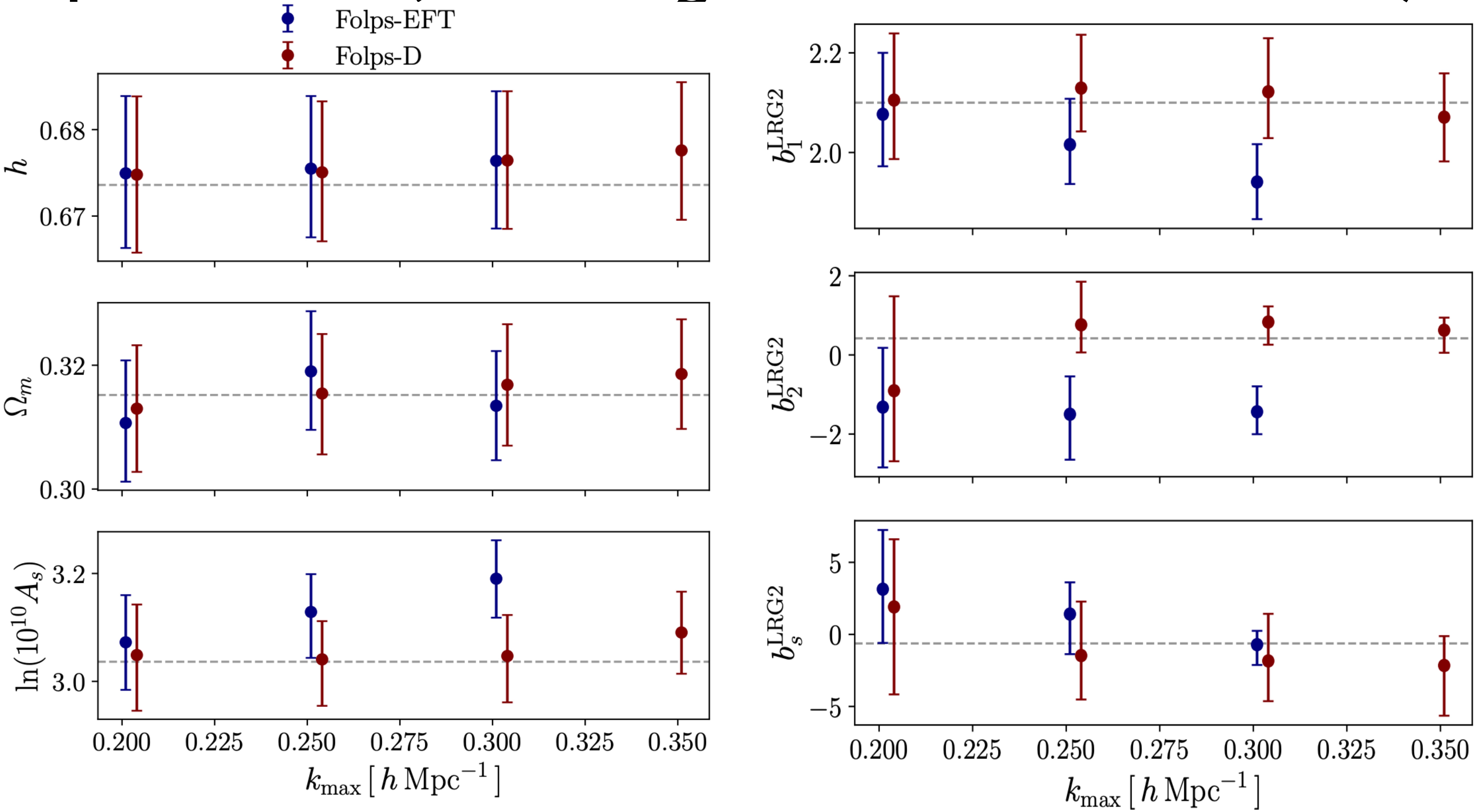
- Paper in preparation
- Bispectrum included
- EFT + a phenomenological damping term
- The pheno. damping term allows modelling upto higher k ($k_{max} \sim 0.30$ as opposed to 0.20 in EFT)
- Even faster (~ 0.1s/ PS, 0.02s/ BS)

FolpsD vs EFT (Abacus2gen Mocks LRG2 z0.800)

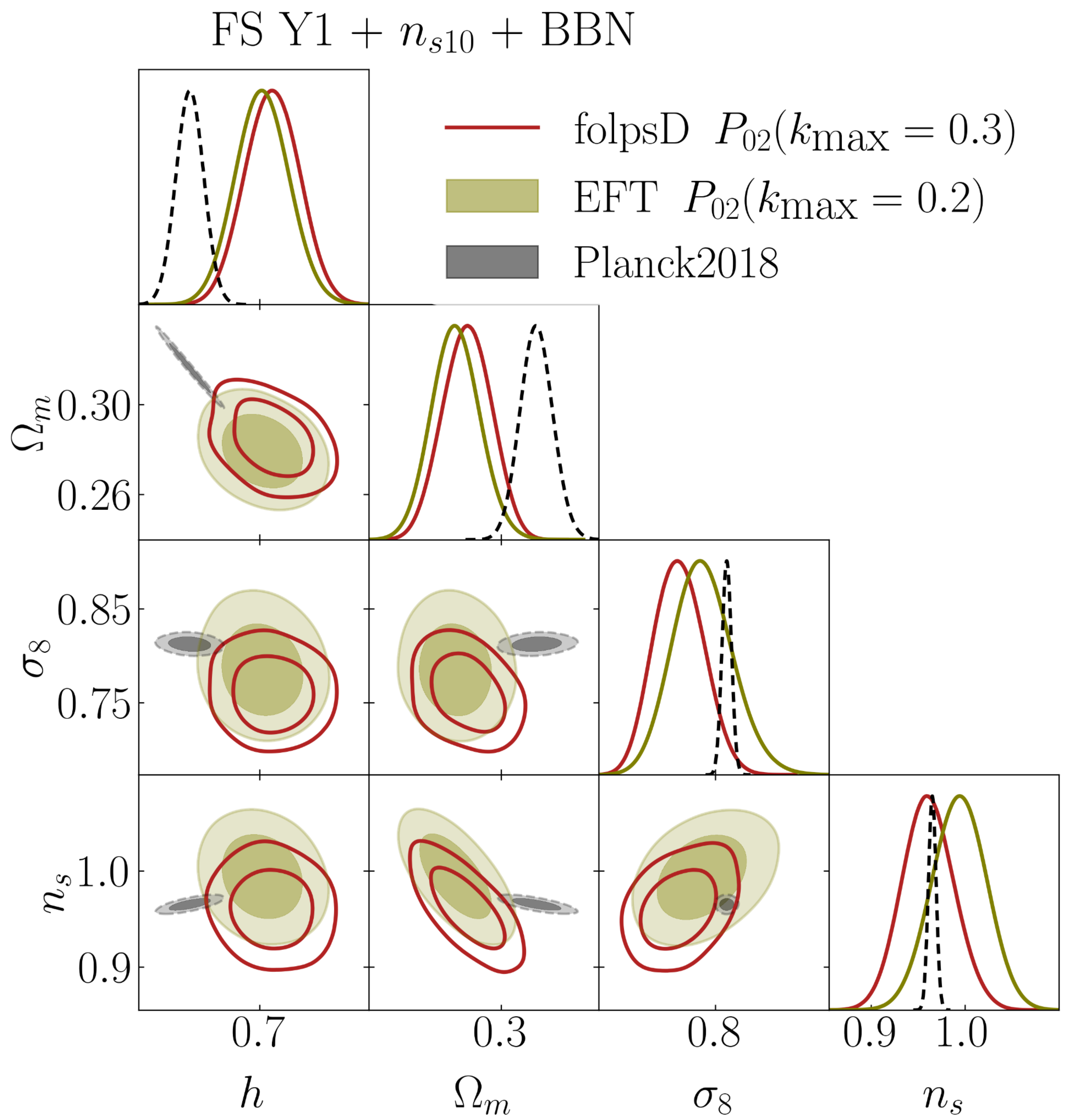




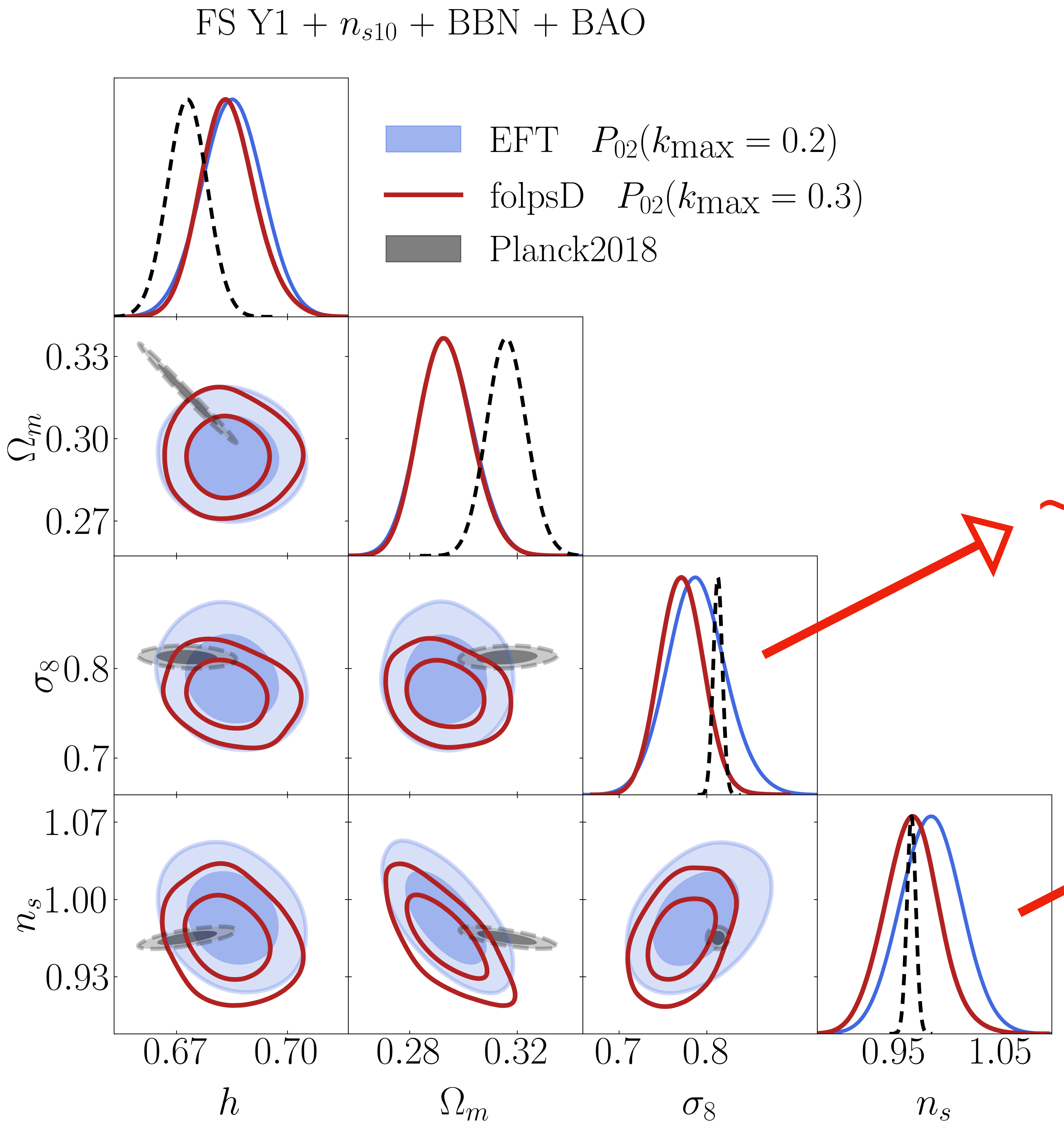
FolpsD vs EFT (Abacus2gen Mocks LRG2 z0.800)



FolpsD vs EFT (DESI Y1 Full Shape)



FolpsD vs EFT (DESI Y1 Full Shape + BAO)



~25 % improvement in σ_8

~8 % improvement in n_s

Thank You!
Questions?

Extra Slides

Compressed CMB

$$\mathbf{v}_{\mathrm{CMB}} \equiv \begin{pmatrix} R \\ \ell_a \\ \Omega_b h^2 \end{pmatrix} = \begin{pmatrix} 1.7504 \\ 301.77 \\ 0.022371 \end{pmatrix}$$

$$R = 100\sqrt{\Omega_b + \Omega_{cdm} + \Omega_{\nu,\mathrm{m}}}\,hD_{M*}/c$$

$$\ell_a = \pi D_{M*}/r_*,$$

$R \rightarrow$ Shift Parameter

$\ell \rightarrow$ Angular Accoustic Scale

EFT vs FOLPS-D

FolpsD = Damping($k_{||}$) x Folps

$$P(k,\mu) = \mathscr{D}(k^2\mu^2)\Big[P_K(k,\mu) + P_{\text{1-loop}}(k,\mu)\Big] + P^{\text{LO}}_{\text{ctr}}(k,\mu) + P_{\text{shot}}(k,\mu)\,.$$

$$\mathscr{D}(x^2) = \frac{1}{1+x^2},$$

$$x^2 = (X_{\text{FoG,p}}\, f\sigma_v k\mu)^2,$$