UNIVERSITY OF PORTSMOUTH

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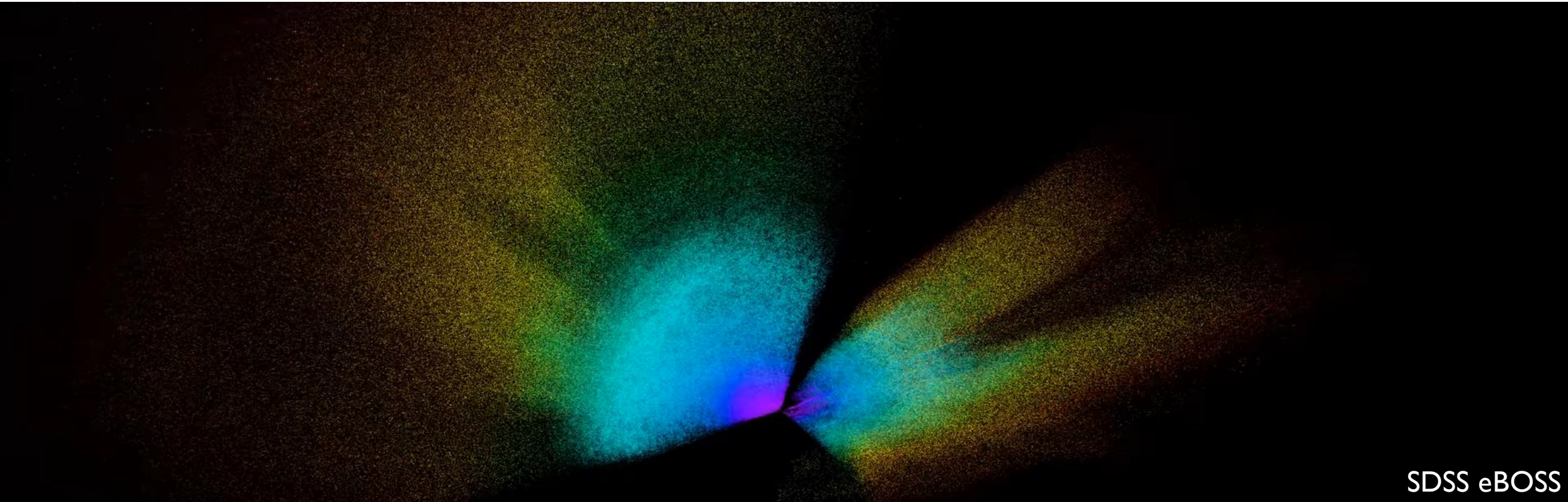
TENSIONS IN COSMOLOGY
CORFU

EARLY DARK ENERGY IN THE LIGHT OF LARGE SCALE STRUCTURE DATA

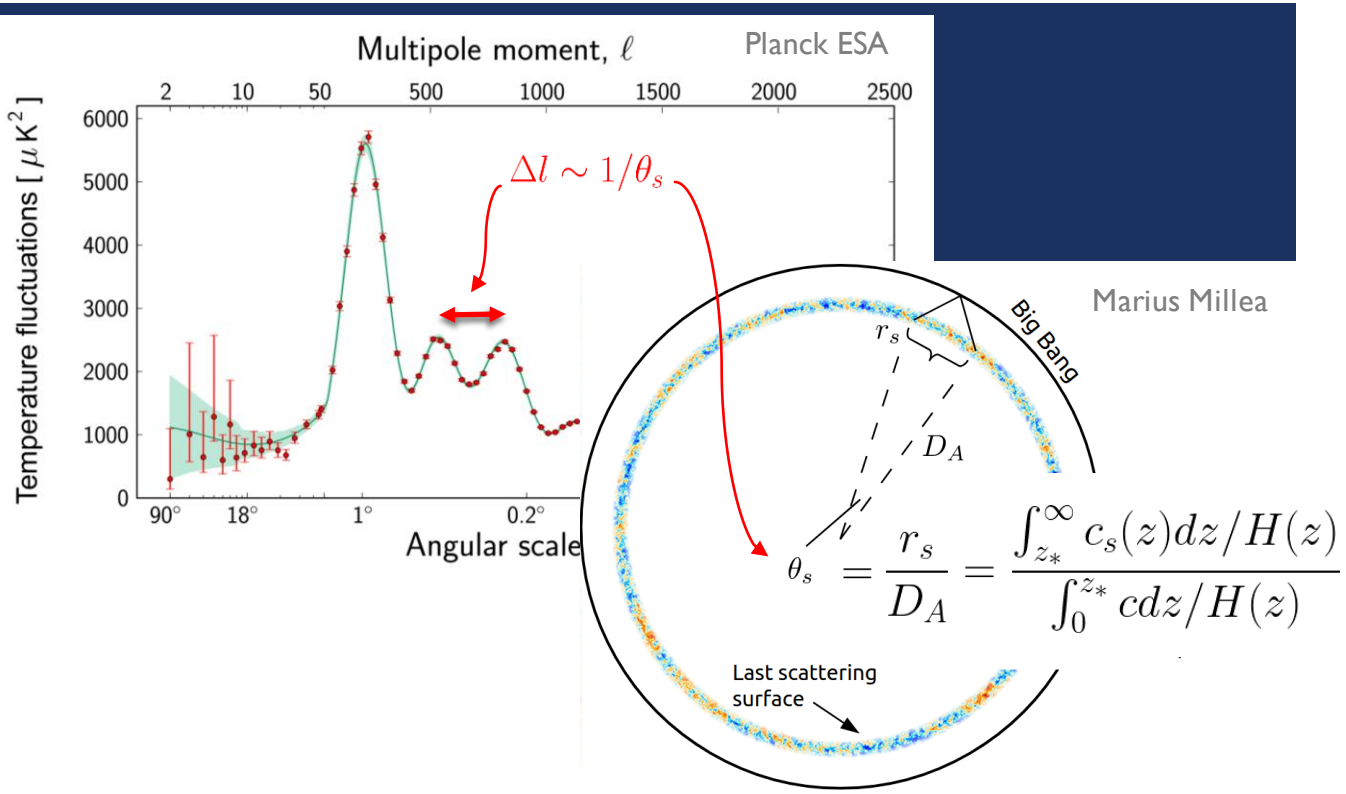


EARLY DARK ENERGY

Including **new components prior to recombination** is one of the most likely category of solution to the H0 tension. (Hubble Hunter's Guide, 2019)

Early Dark Energy (V. Poulin et al., 2019)
axion-like particle with periodic potential

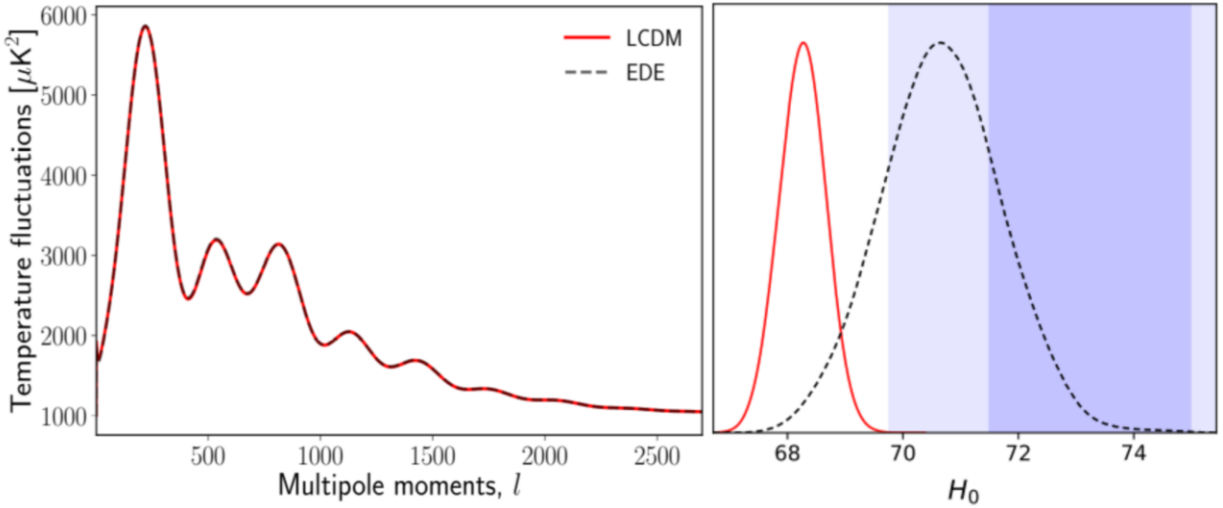
$$V(\phi) = V_0(1-\cos\theta)^3, \quad V_0 = m^2 f^2$$



3 additional parameter to LCDM:

f_{EDE}	Fractional energy density
z_c	Critical redshift
θ_i	Initial field displacement

Fits CMB while giving **higher H0** value

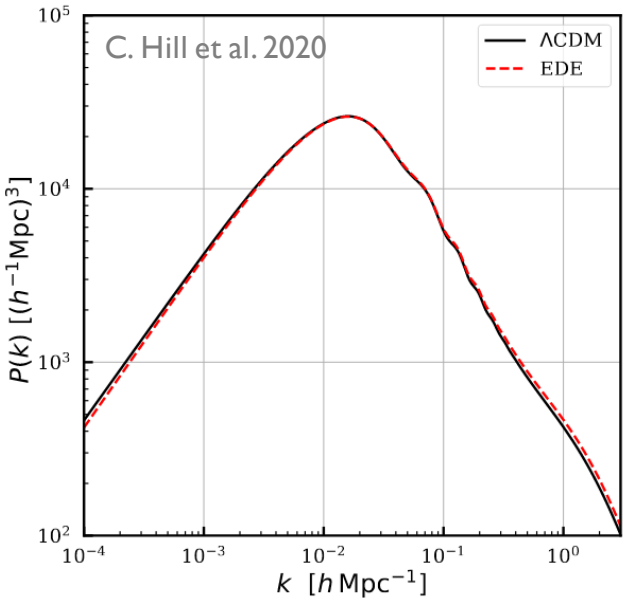


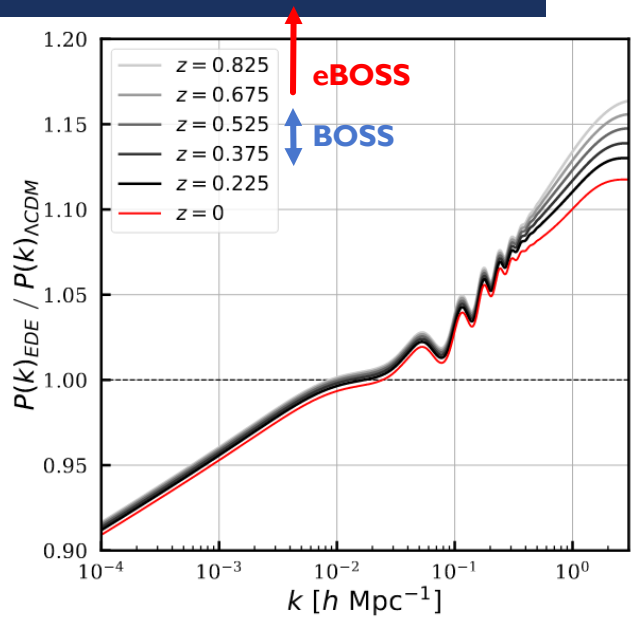
EARLY DARK ENERGY

EDE suppresses growth of perturbations at early time

➡ Model compensates this by increasing n_s and ω_{cdm}

EDE worsens the σ_8 tension





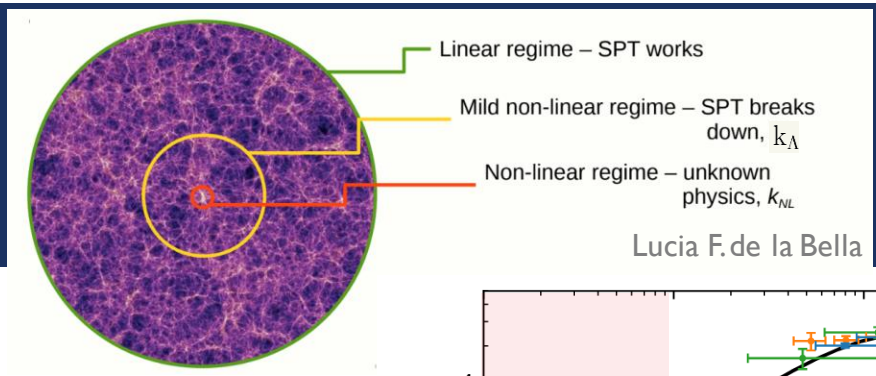
Goal of this Project:
Use eBOSS full shape analysis to put constraints on EDE

➡ LSS data especially sensitive to σ_8

➡ eBOSS: $z_{eff} = [0.698, 0.86, 1.48]$

➡ Full shape: access to smaller scales

COSMOLOGY FROM LARGE SCALE STRUCTURE



Full shape analysis:

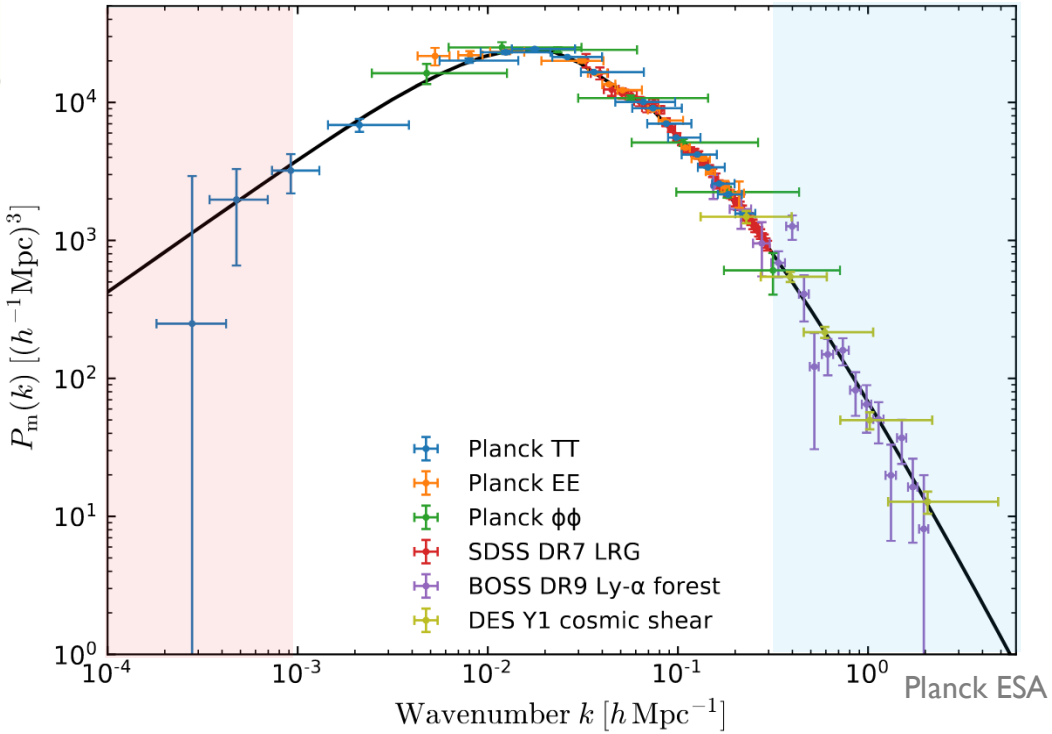
Modelling multipole moments of galaxy power spectrum in redshift space based on 1-loop perturbation theory

Effective Field Theory of Large Scale Structure

(d'Amico et al. 2019, Ivanov et al. 2019)

SPT(1-loop) + UV counterterms + IR resummation
Stochastic counterterms
Non – linear bias
Multipole expansion

$$P_{g,l}(k) = P^{lin}_{g,l}(k) + P^{1-loop}_{g,l}(k) + P^{ctr}_{g,l}(k) + P^{sto}_{g,l}(k)$$



Standard Perturbation Theory

IR

EFT:

$$P(k) = P_{lin}(k) + P_{22,\Lambda}(k) + 2P_{13,\Lambda}$$

UV

$$-\frac{c^2_{ctr}}{k^2_{NL}}k^2 P_{lin}(k)$$

COSMOLOGY FROM LARGE SCALE STRUCTURE

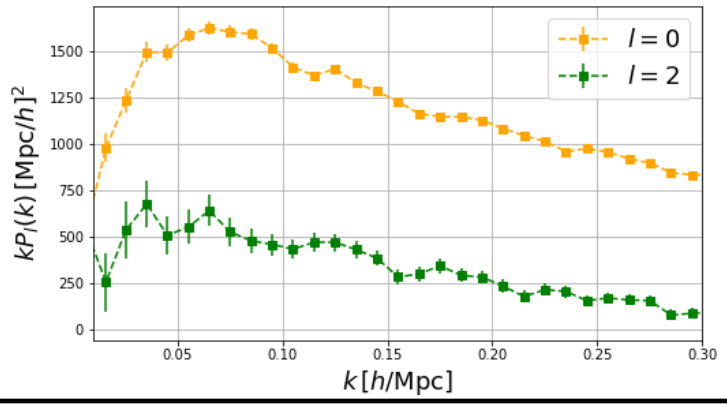
CLASS_EDE (Hill et al. 2020)

Gives P_{lin} including the evolution of EDE scalar field

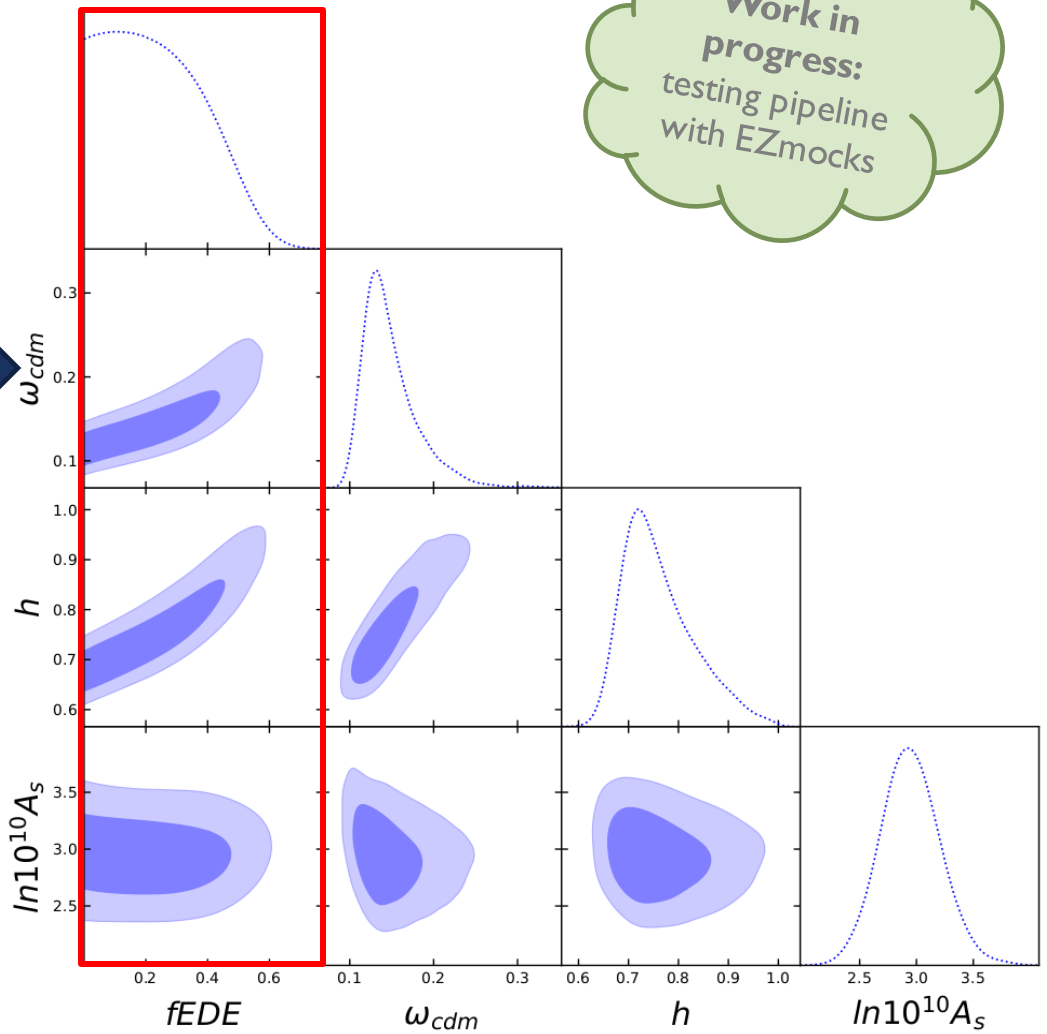
PyBird (D'Amico et al. 2020)

$$P_{g,l}(k) = P^{lin}_{g,l}(k) + P^{1-loop}_{g,l}(k) + P^{ctr}_{g,l}(k) + P^{sto}_{g,l}(k)$$

eBOSS DR16 Spectra (Dawson et al. 2016)



MCMC Sampler: Montepython (Audren et al. 2012)



Work in progress: testing pipeline with EZmocks

WORK IN PROGRESS

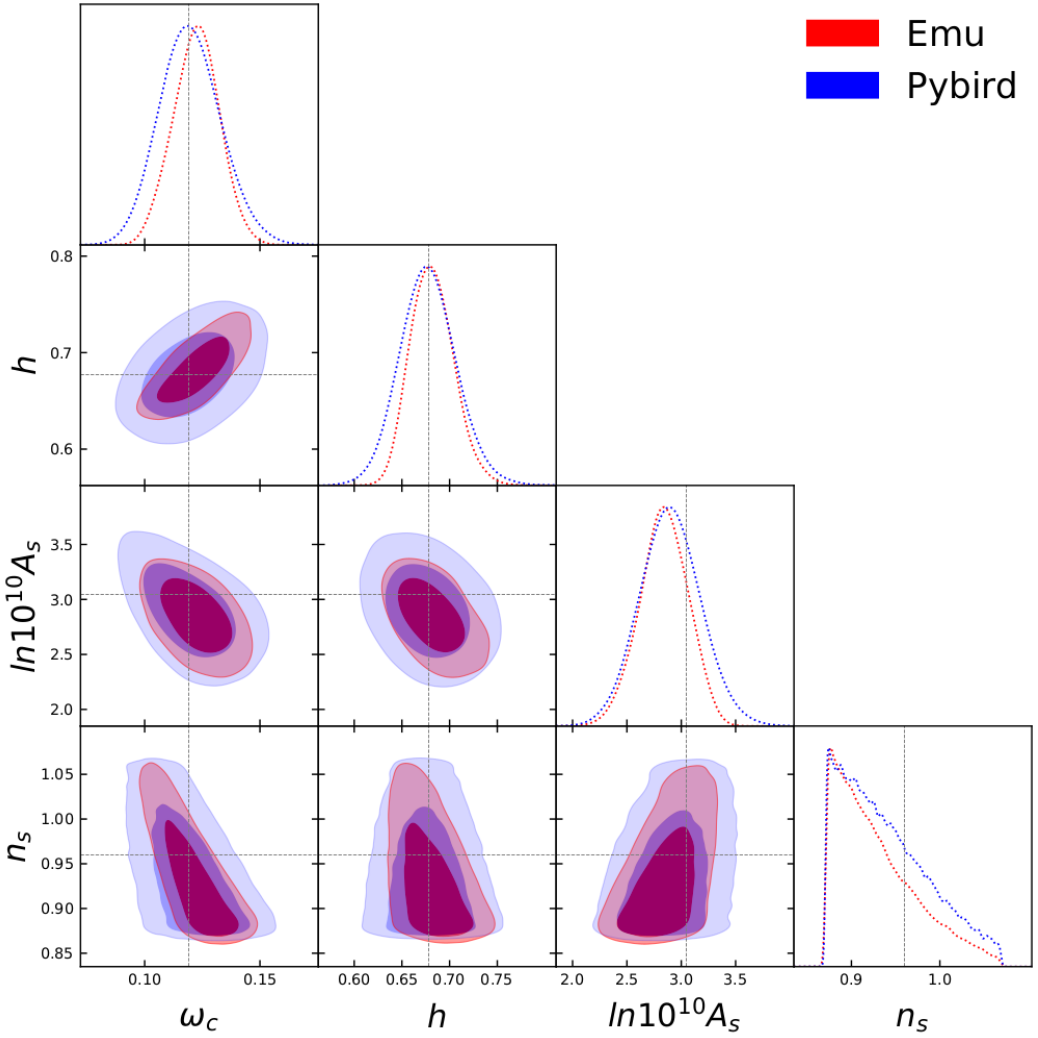
Accelerated Analysis:
Emulator **Matryoshka** (Donald-McCann et al. 2021)

EFTofLSS:

- Find appropriate kmax
- Investigate EFT prior effects (D'Amico et al. 2022, Simon et al. 2022)

EDE:

- Investigate volume effects on z_c, θ_i
- Profile likelihood (Herold et al. 2021):
  Bayesian approach ⟶ Frequentist approach



CONCLUSION

- EDE is one of the **most promising solutions** for the H0 tensions
- Ongoing discussion if EDE can fit LSS
- **Full shape analysis** of high redshift data (eBOSS, DESI) can place strong constraints on H0 and EDE parameter
- **Emulator** for a **faster analysis**

Any Questions?

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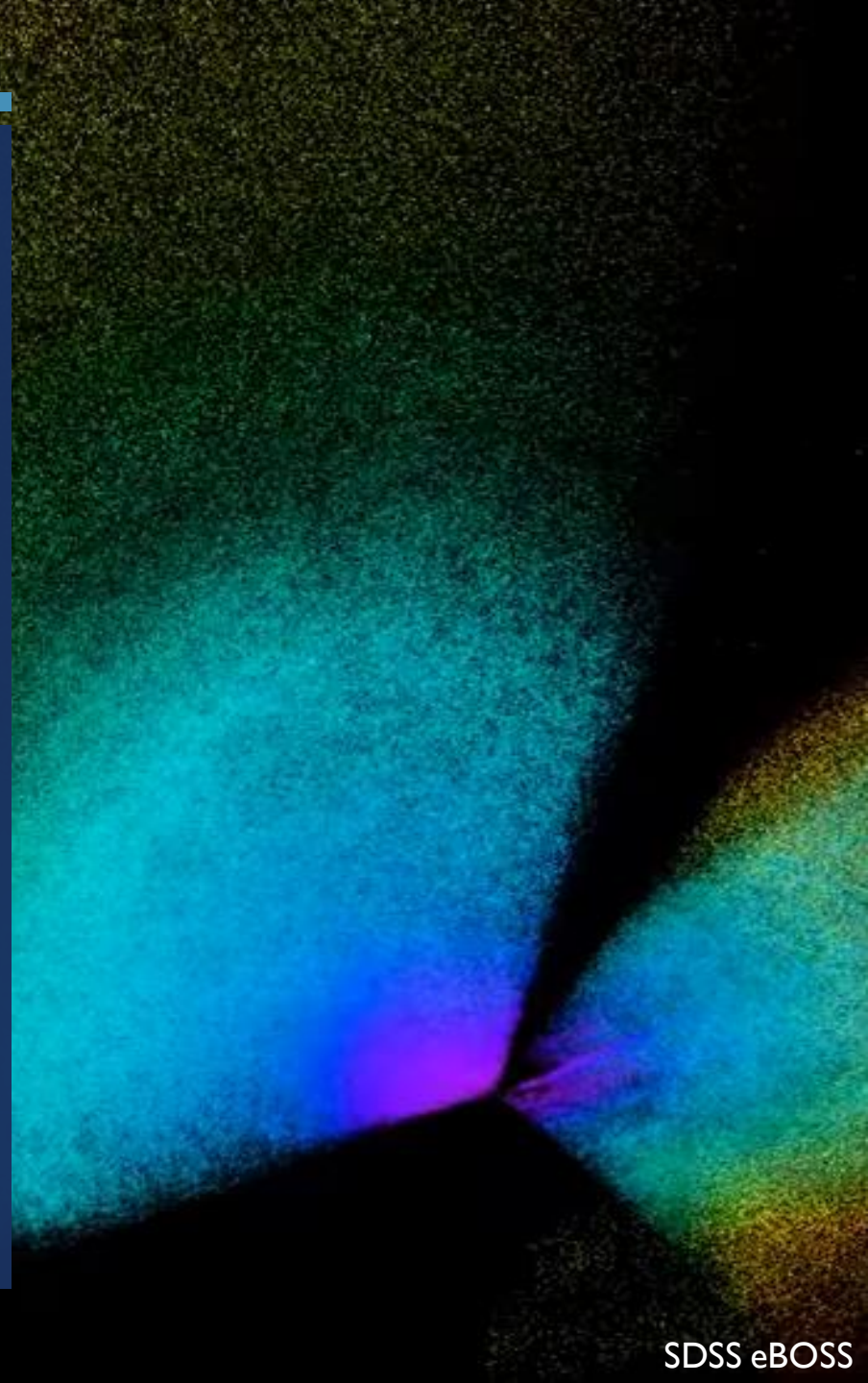

SDSS eBOSS