DARK ENERGY SPECTROSCOPIC INSTRUMENT

U.S. Department of Energy Office of Science

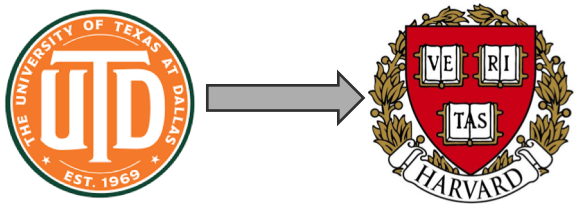
NHFP

NASA Hubble Fellowship Program

Constraining Dark Energy & Modified Gravity with Galaxy Clustering and Weak Lensing

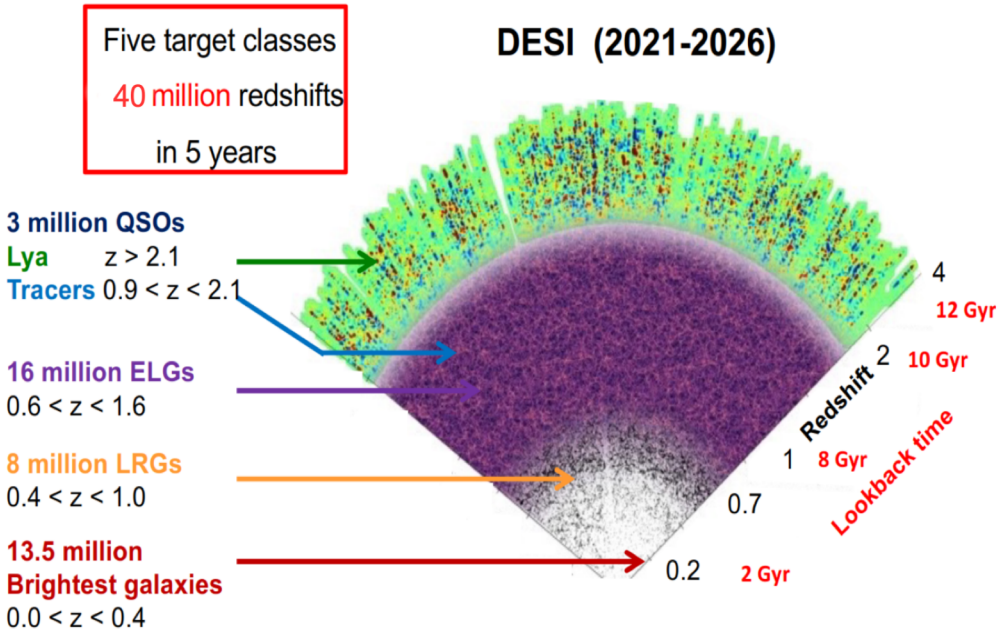
Center for Astrophysics, Harvard University

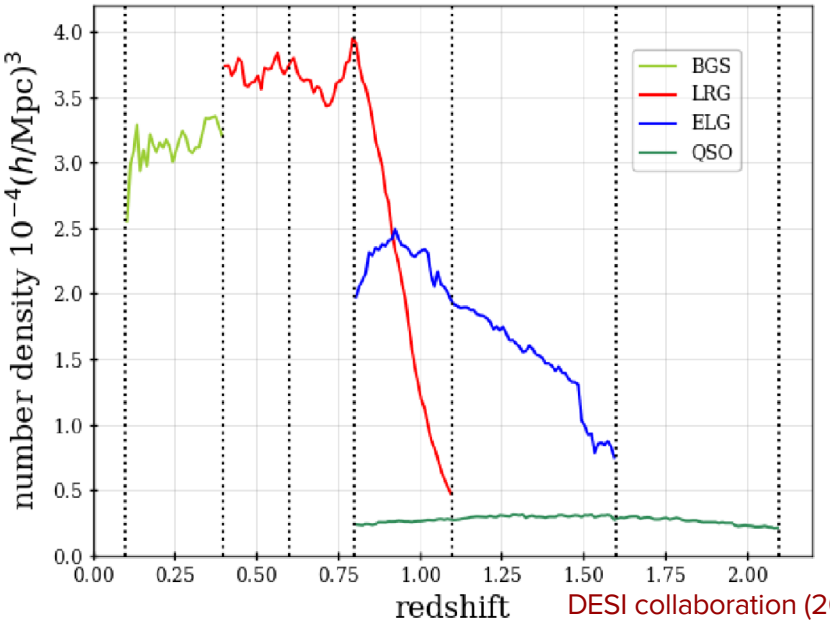
Cristhian Garcia-Quintero



The Dark Energy Spectroscopic Instrument (DESI)

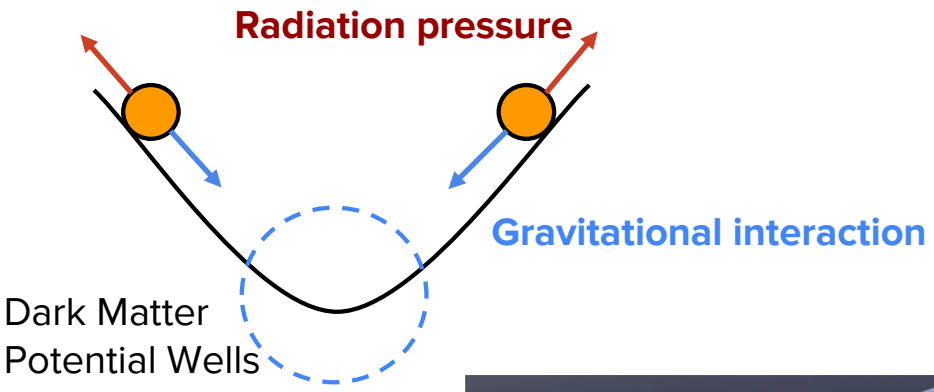
- DESI is a fiber-fed multi-object spectrograph with 5000 fiber positioner robots.
- DESI aims to measure around 40 million redshifts in 5 years of operations.
- DESI will cover 14000 sq deg.

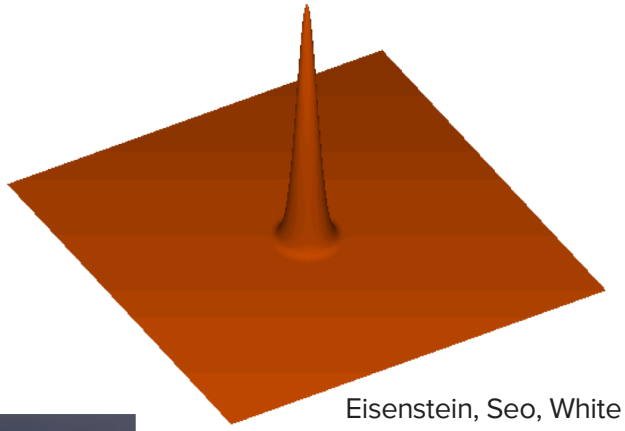




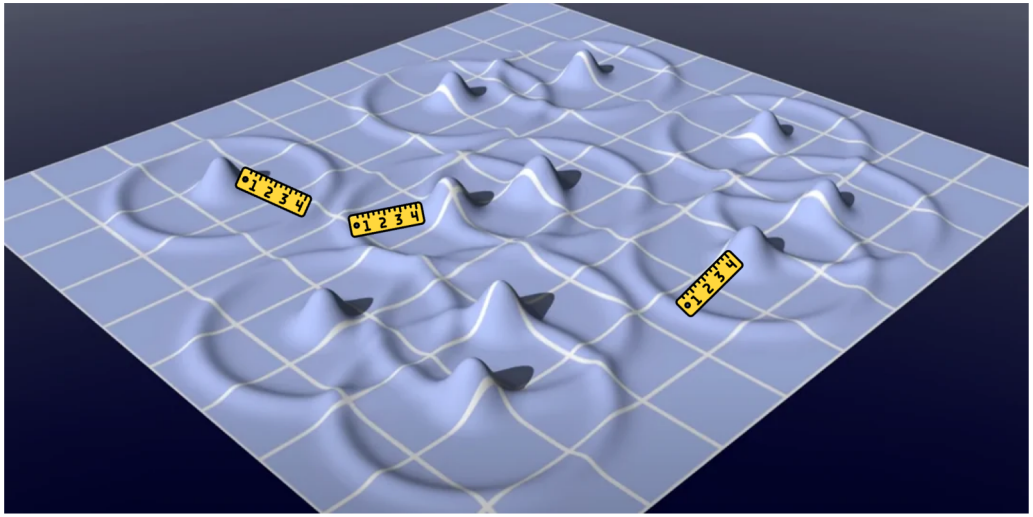
DESI collaboration (2024) [ArXiv:2404.03000]

What DESI can measure? Baryon Acoustic Oscillations (BAO)





Eisenstein, Seo, White et al. 2007



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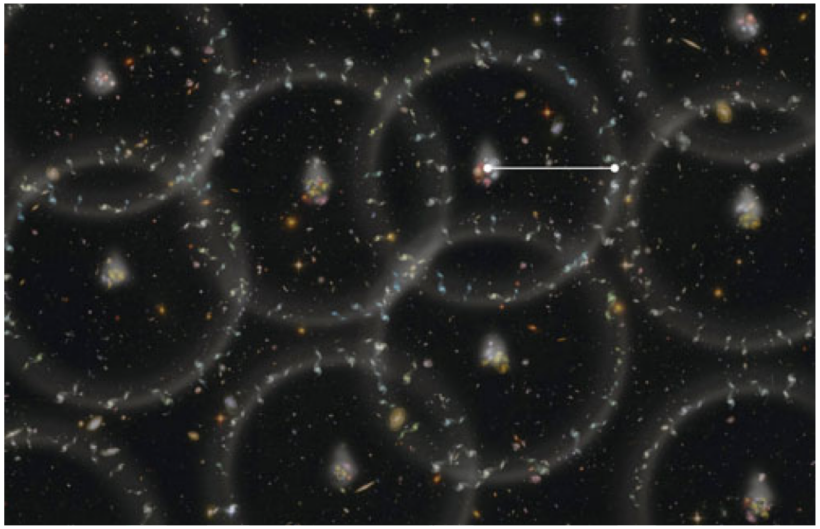
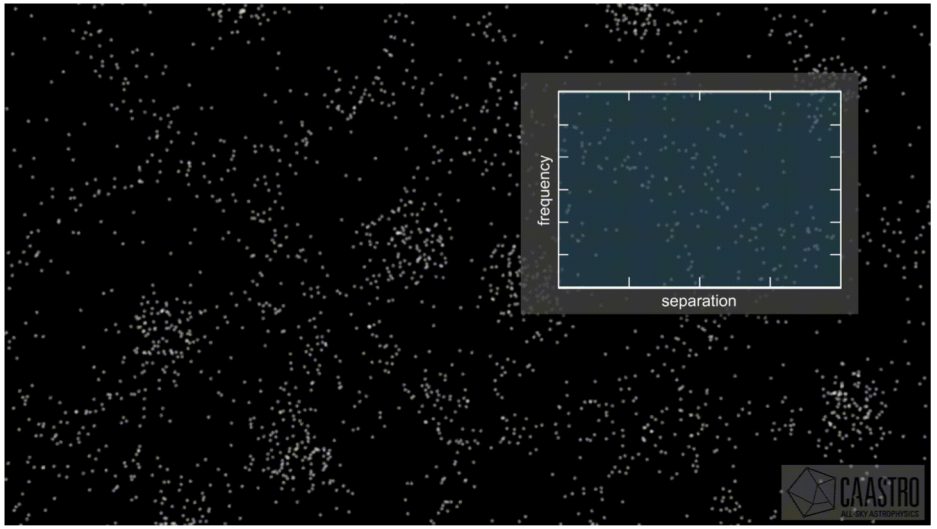
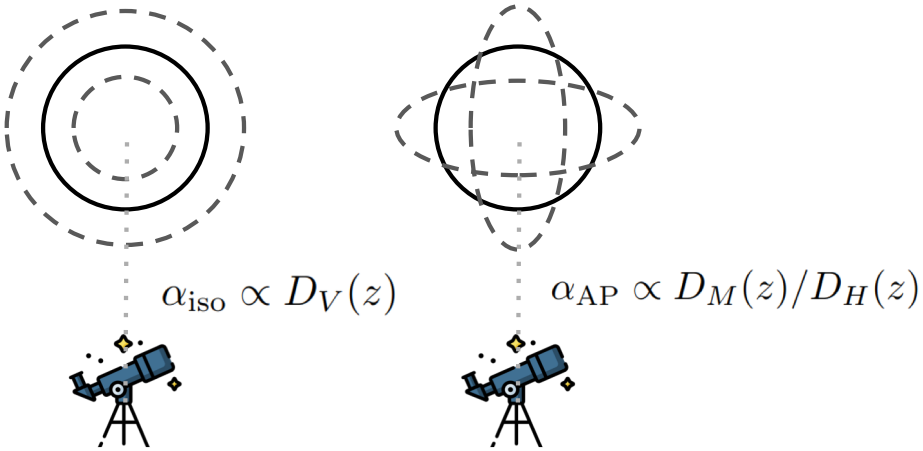
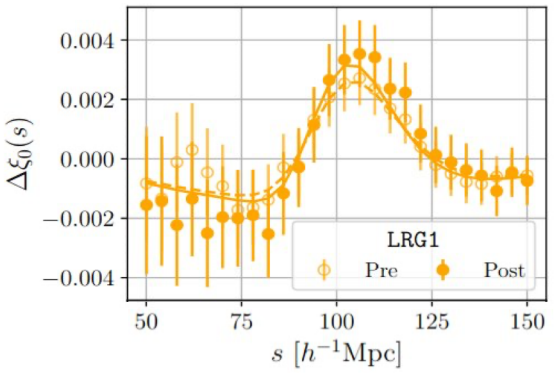






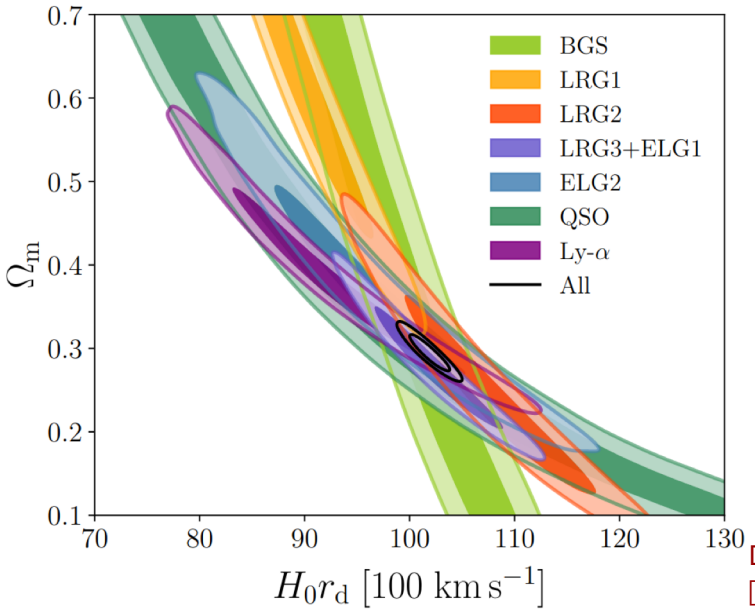


From the Centre of Excellence for All-sky Astrophysics (CAASTRO)

DESI collaboration (2024) [ArXiv:2404.03000]

BAO measurements

- DESI-Y1 shows a better aggregated precision than SDSS.
- First catalog-level BAO blinded analysis.
- First significant detection of BAO through ELG.
- A tension close to 3-σ is observed for the second LRG bin, w.r.t. SDSS (difference consistent with statistical fluctuation).



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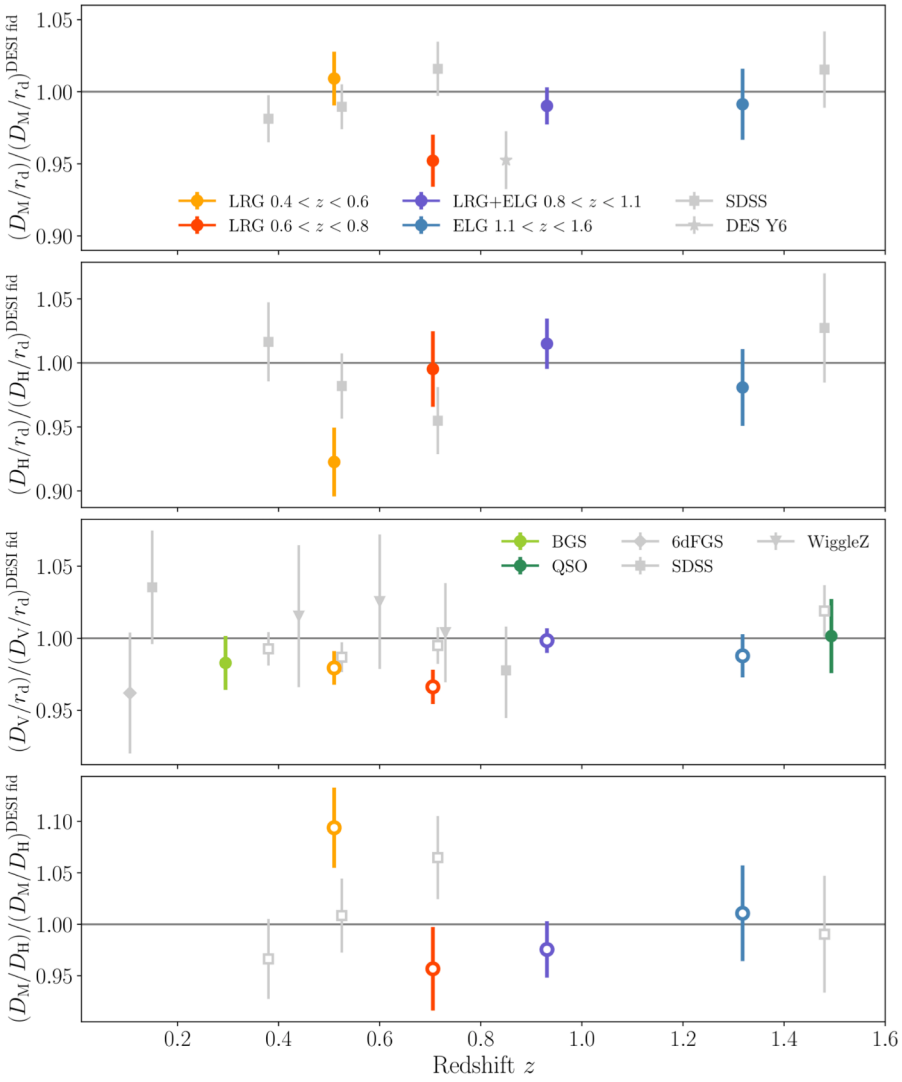

Quantifying BAO Systematics

$$\sigma_{\rm tot} = \sqrt{\sigma^2_{\rm stat} + \sigma^2_{\rm syst}}$$

Systematics
Theoretical
Observational
HOD
Reconstruction
Covariances
Fiducial Cosmology
Observational

Quantifying BAO Systematics

Garcia-Quintero et al. (2024)
Accepted for publication in JCAP
[ArXiv:2404.03009]

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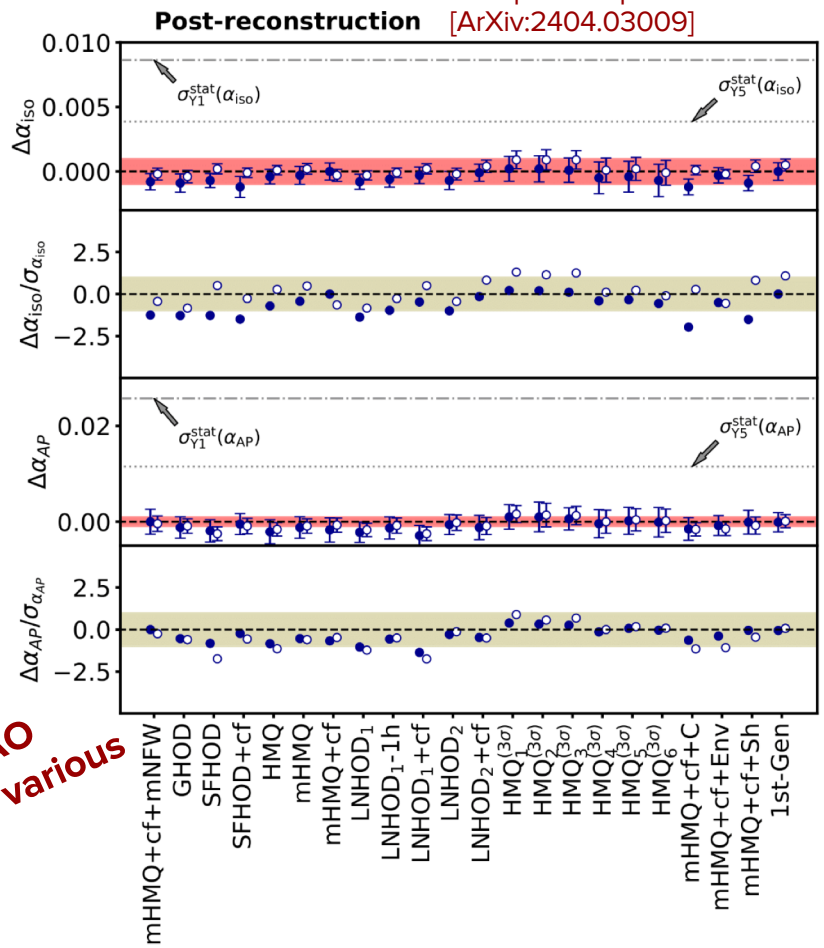

Robustness of BAO analysis against various HOD models

Quantifying BAO Systematics

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Systematics

- Theoretical
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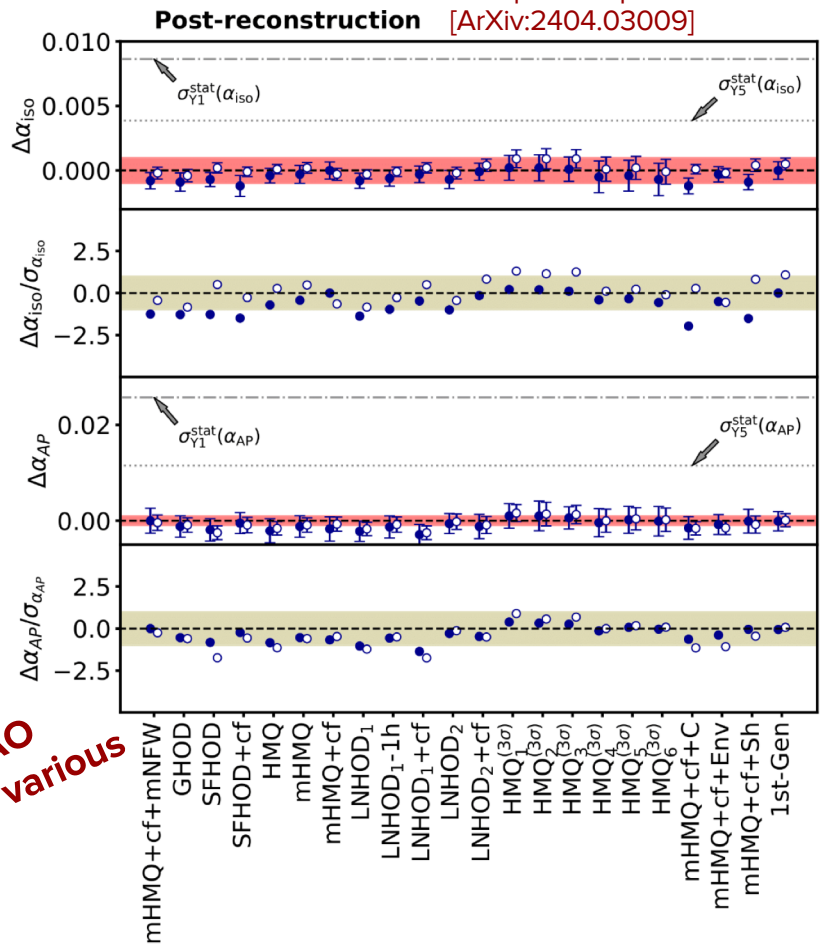
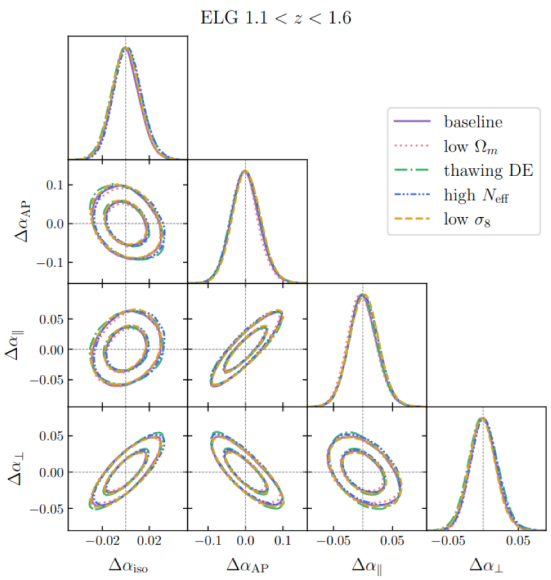


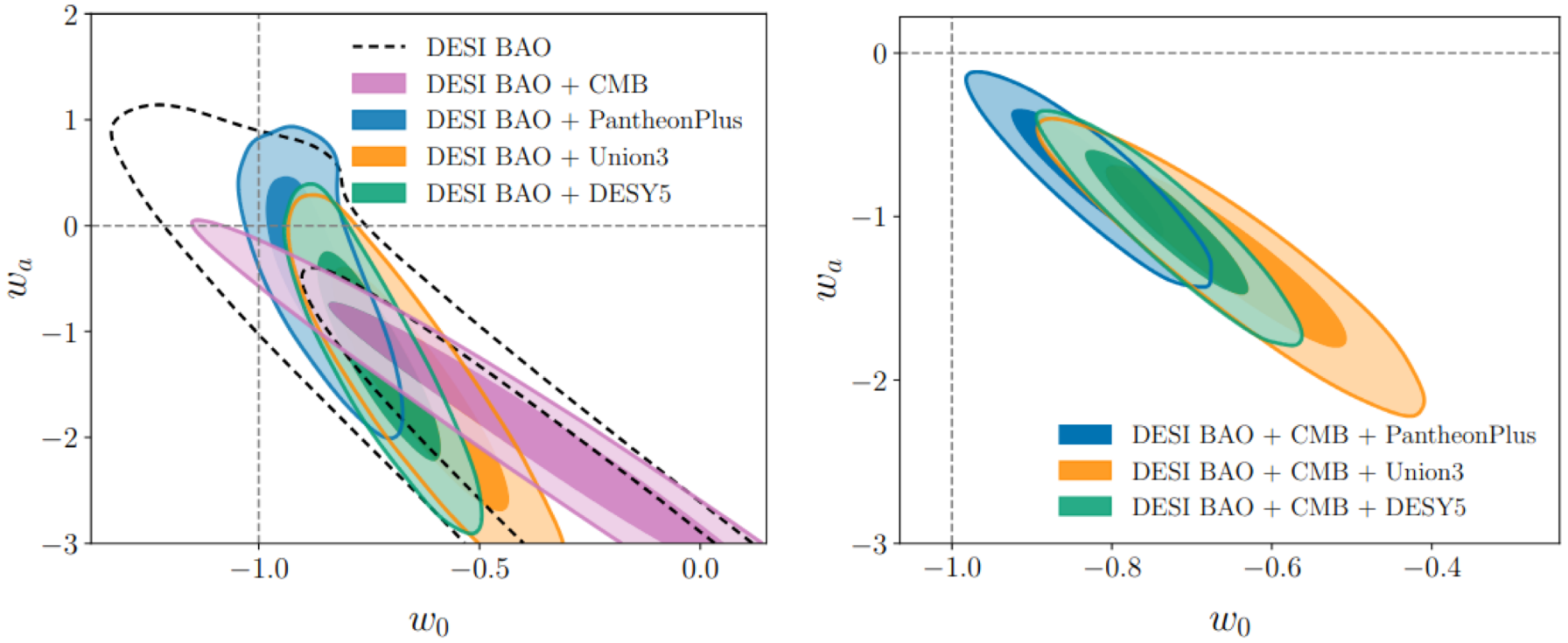
Robustness of BAO analysis against various HOD models

Perez-Fernandez et al. (2024)
Accepted for publication in JCAP
[ArXiv:2406.06085]



Effect of fiducial cosmology

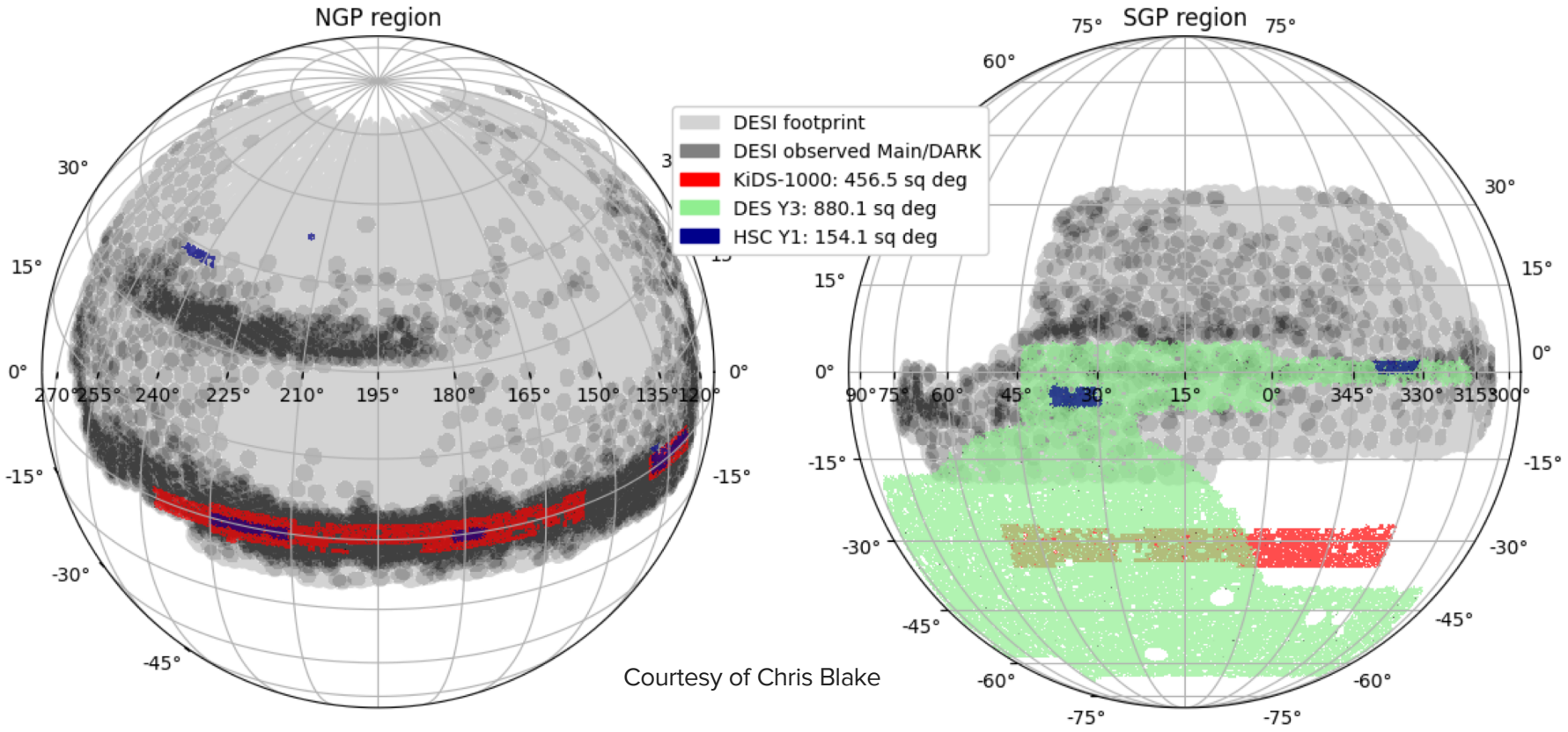
DESI constraints on Dynamical Dark Energy



DESI collaboration (2024)
[ArXiv:2404.03002]

What else we can do with DESI?

How can we fully exploit the DESI measurements?



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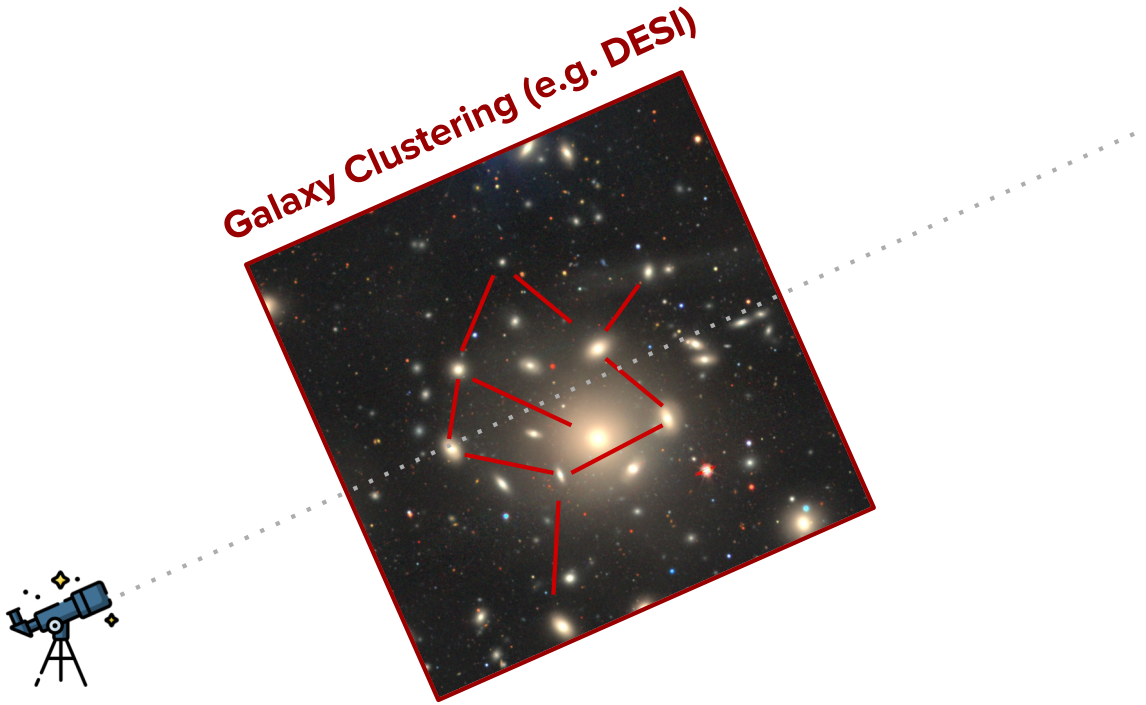

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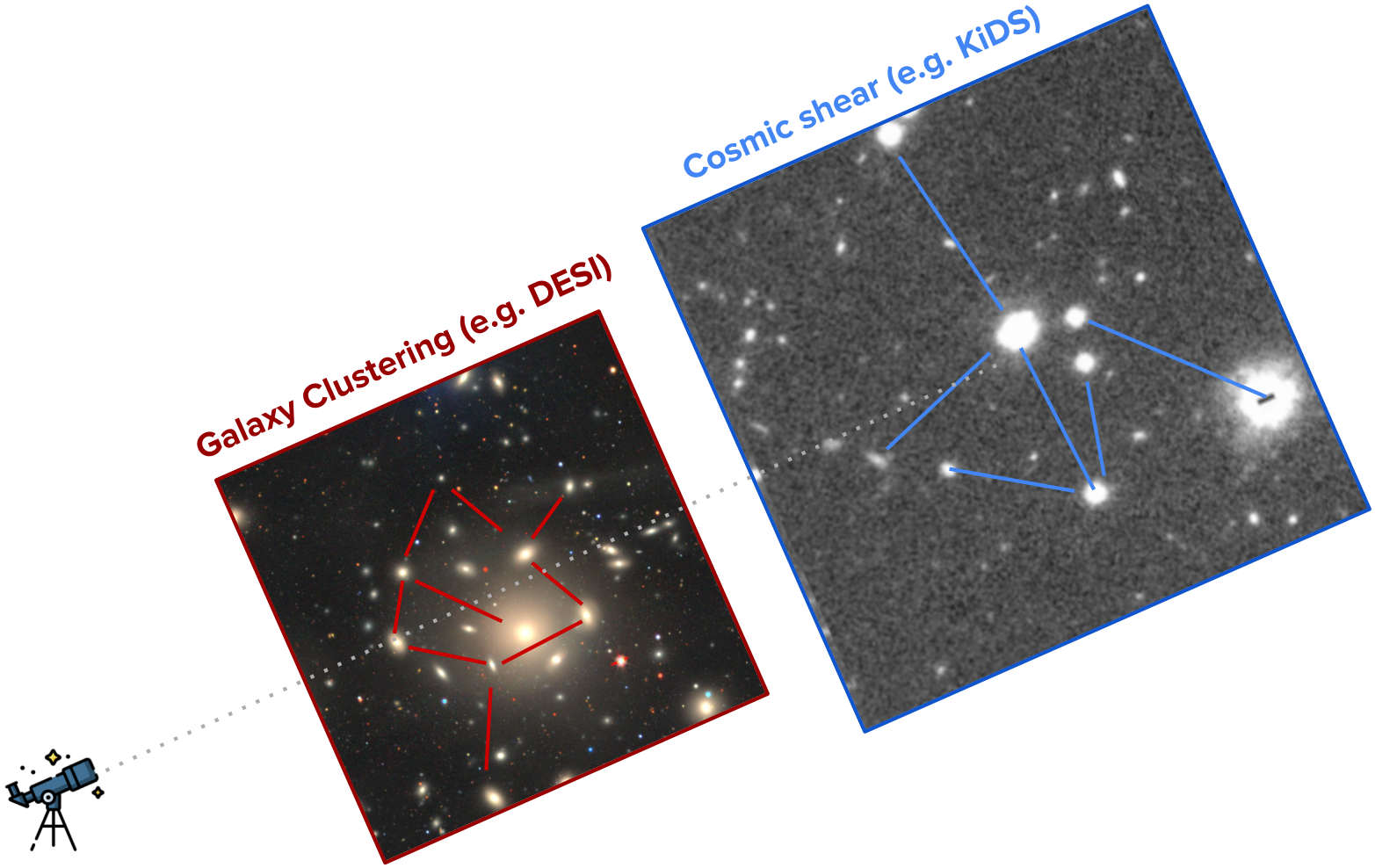

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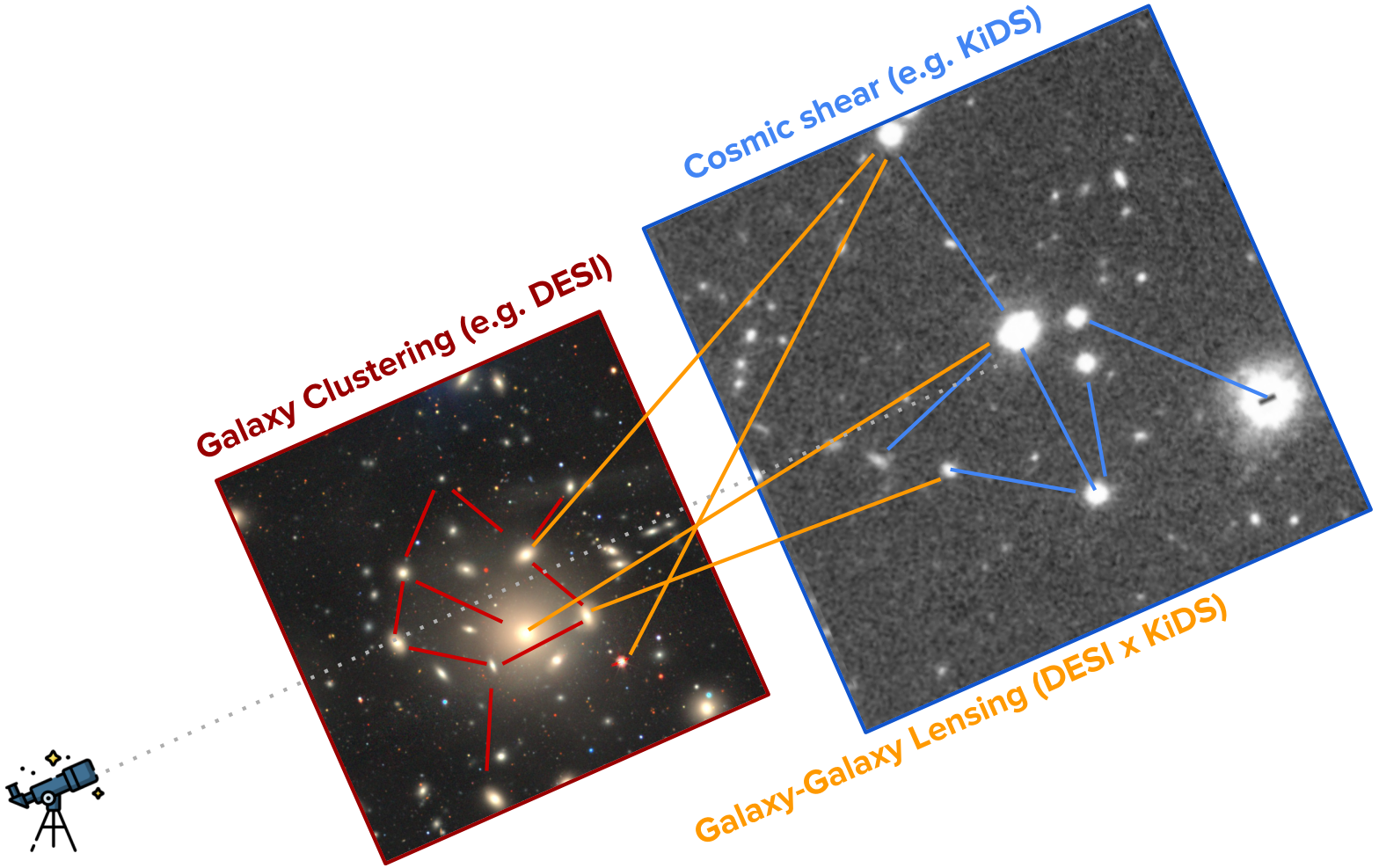

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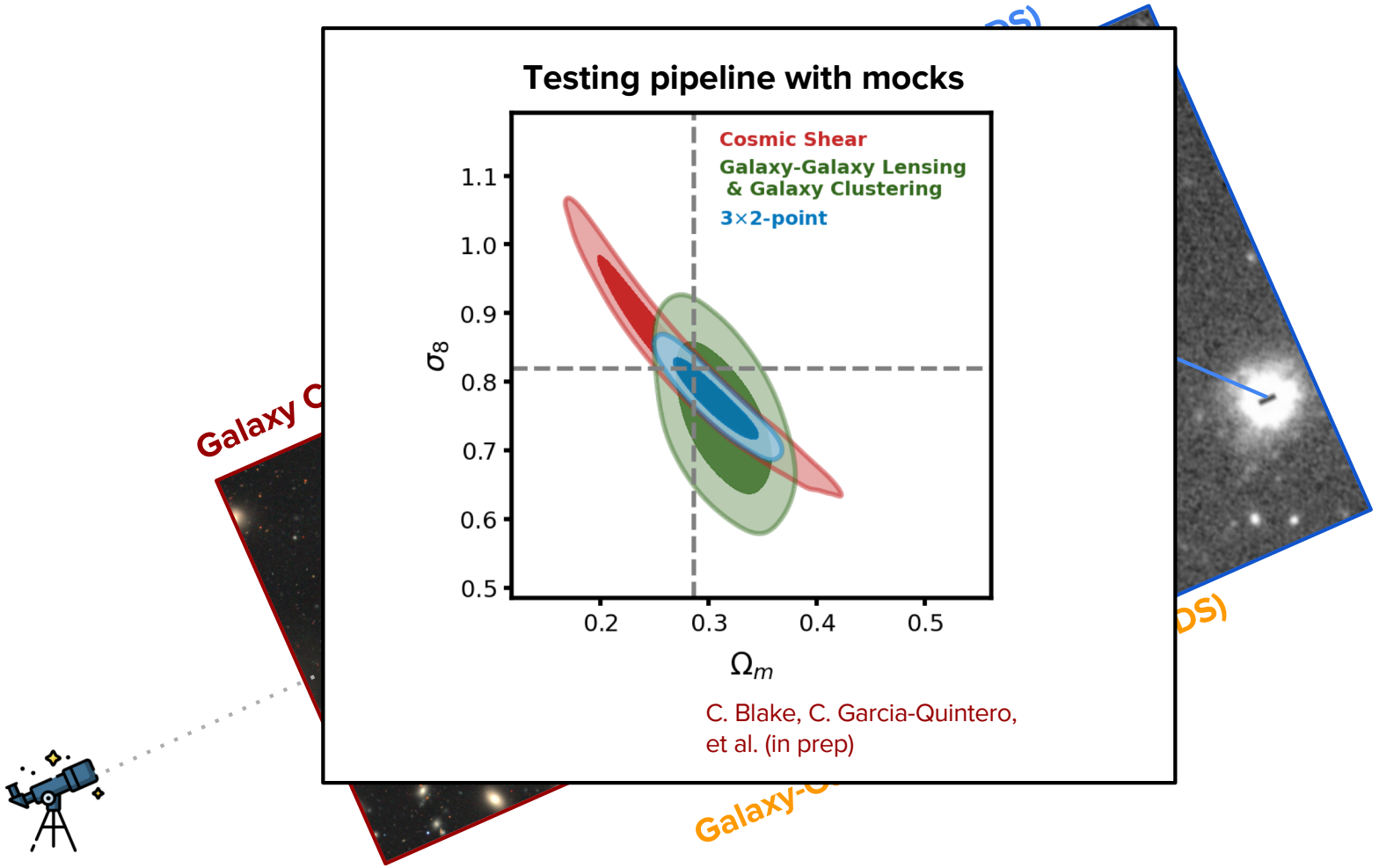


Constraining modified gravity parameters with 3x2-pt statistics

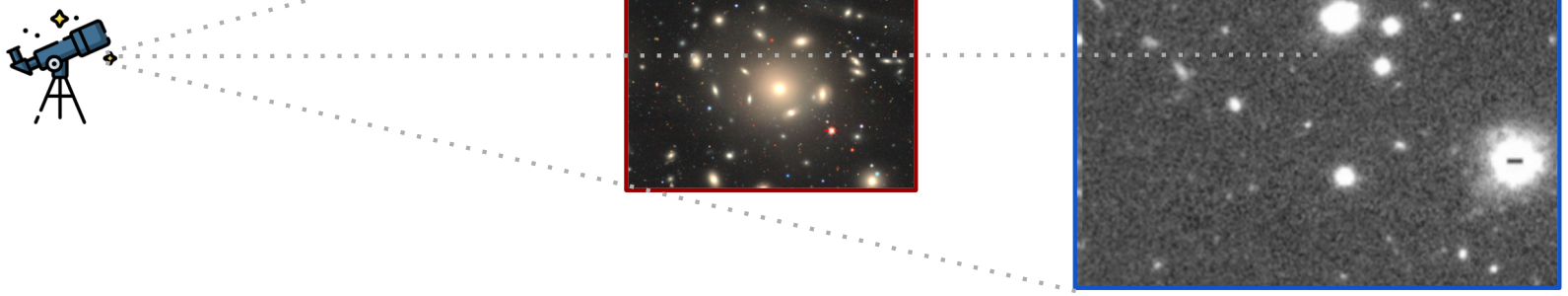
$$k^2\Psi = -4\pi G a^2 \mu(a,k) \sum_i \rho_i \Delta_i$$

Acts as an effective gravitational constant

$$G_{\rm eff}(a) = G \cdot \boldsymbol{\mu(a)}$$

Recover GR if $\mu(a,k) = 1$

$\Sigma(a,k) = 1$



$$k^2(\Phi + \Psi) = -8\pi G a^2 \Sigma(a,k) \sum_i \rho_i \Delta_i$$

Affects the Lensing Weyl Potential

$$\Phi_W = \frac{\Psi + \Phi}{2} \cdot \boldsymbol{\Sigma(a)}$$

Measuring Modified Gravity parameters

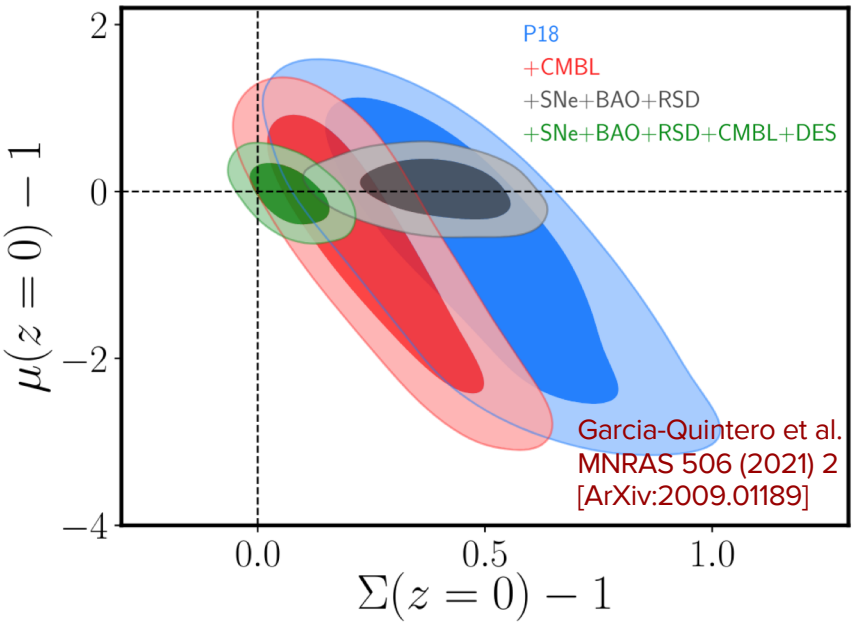
μ(a) : Modifies the growth of density perturbations

$$\frac{df(a)}{d\ln(a)} + f^2 + \left(\frac{\dot{H}}{H^2} + 2\right) f(a) = \frac{3}{2}\boldsymbol{\mu(a)}\Omega_m$$

Σ(a) : Affects the movement of null geodesics

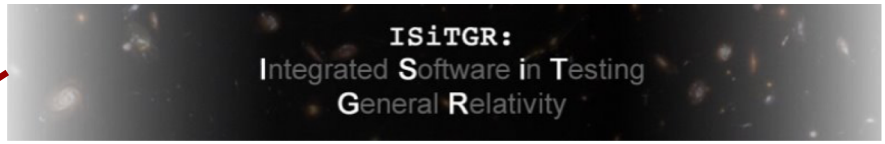
$$C^{ij}_{\kappa\kappa}(\ell) = \int_0^{\chi_H} d\chi \frac{q^i_\kappa(\chi) q^j_\kappa(\chi)}{\chi^2} \boldsymbol{\Sigma^2(\chi(a))} P_m\left(k, \chi(a)\right)$$

$$C^{ij}_{\delta_g\kappa}(\ell) = \int_0^{\chi_H} d\chi \frac{q^i_{\delta_g}(k,\chi) q^j_\kappa(\chi)}{\chi^2} \boldsymbol{\Sigma(\chi(a))} P_m\left(k, \chi(a)\right)$$



Garcia-Quintero et al.
MNRAS 506 (2021) 2
[ArXiv:2009.01189]

Currently integrated into DESI and LSST-DESC cosmological analysis pipeline!

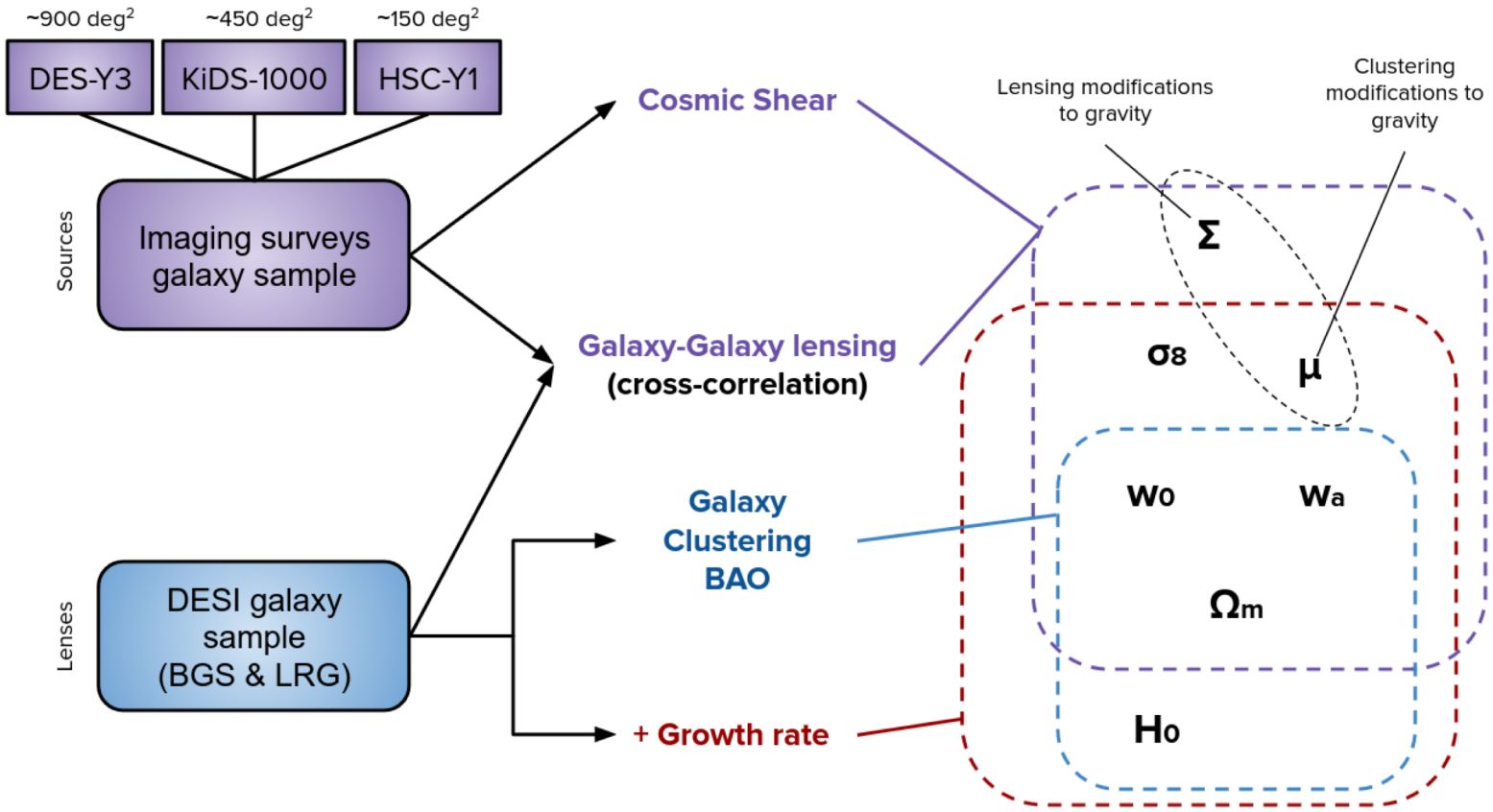


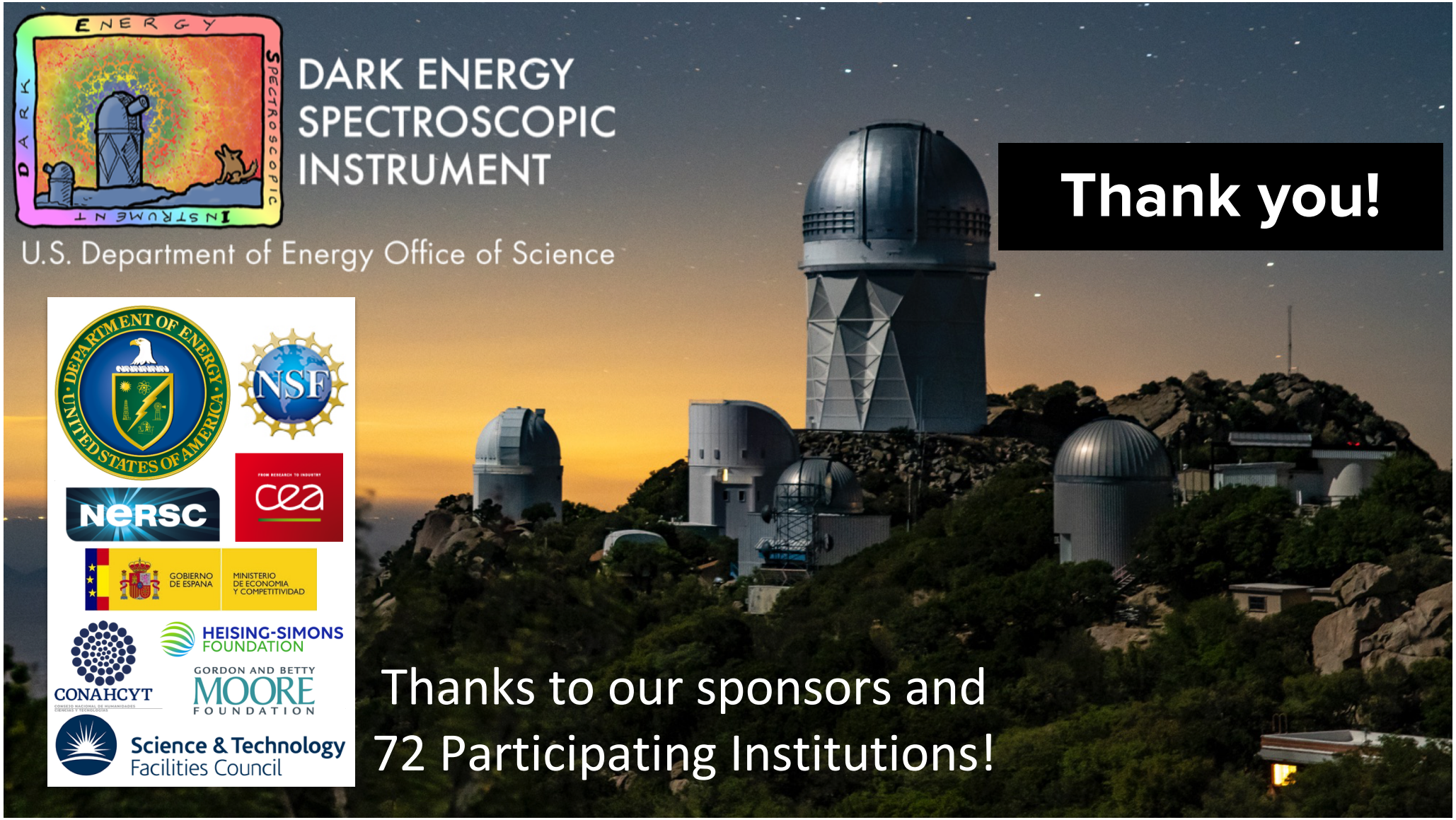
Garcia-Quintero et al.
Phys. Rev. D.100 (2019) 103530
[ArXiv:1908.00290]

Garcia-Quintero et al.
JCAP12 (2020) 018
[ArXiv:2010.12519]

Analysis Outline

Stay Tuned!

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