J-PAS
Javalambre Physics of the Accelerating Universe Astrophysical Survey

Testing gravity with J-PAS

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VII Meeting on Fundamental Cosmology

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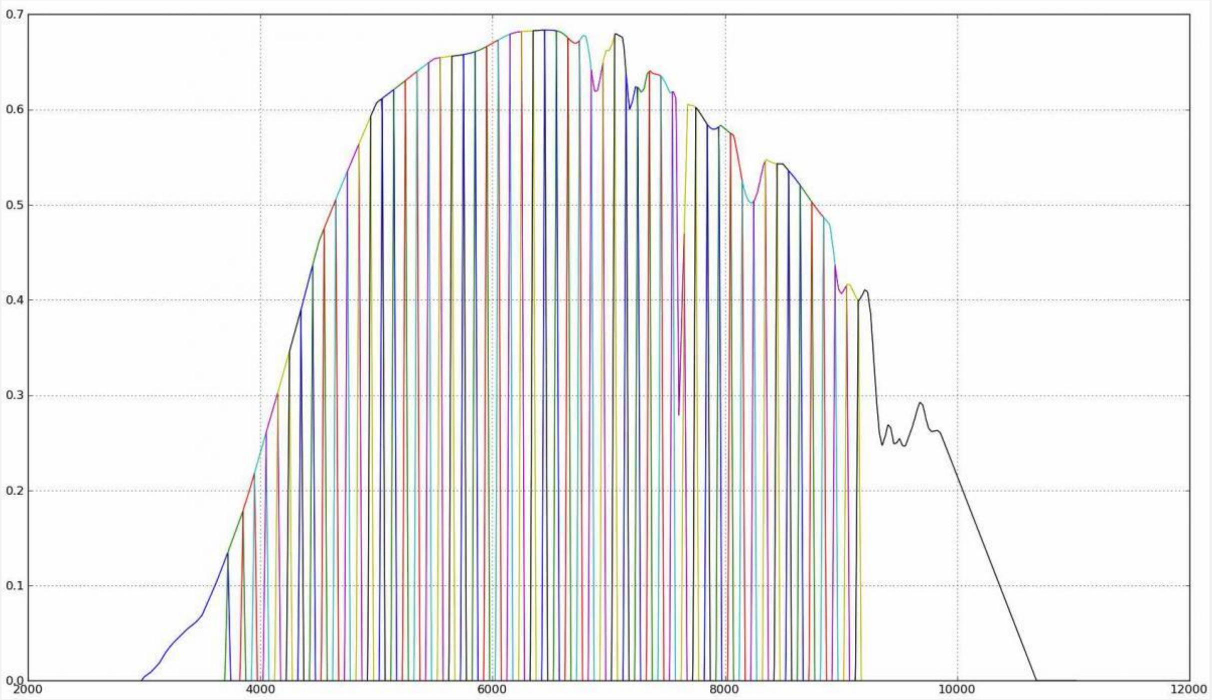
The J-PAS survey

The Javalambre Physics of the Accelerated universe Astrophysical Survey



N. Benítez al. [J-PAS Collaboration], arXiv:1403.5237

- J-PAS is a photometric survey to be conducted at OAJ, Teruel (Spain) by the 2.5 m diameter dedicated Javalambre Survey Telescope (JST/T250).
- JST will be equipped with the Javalambre Panoramic Camera (JPCam), a 4.7 sq. deg. 1.2Gpx camera with **54 narrow- and 4 broad-band** filters covering the optical range.
- JPAS will observe **8500 sq. deg**. starting next year and measure photo-z with **$\delta z=0.003(1+z)$** for 9 x 10^7 ELG and LRG up to z=1.3 and several millions QSO up to z=3.9

The J-PAS survey

Galaxy and QSO number densities

JPAS

$V_{eff} = 14\ Gpc^3$

J-PAS			
z	LRG	ELG	QSO
0.3	226.6	2958.6	0.45
0.5	156.3	1181.1	1.14
0.7	68.8	502.1	1.61
0.9	12.0	138.0	2.27
1.1	0.9	41.2	2.86
1.3	0	6.7	3.60
1.5	0	0	3.60
1.7	0	0	3.21
1.9	0	0	2.86
2.1	0	0	2.55
2.3	0	0	2.27
2.5	0	0	2.03
2.7	0	0	1.81
2.9	0	0	1.61
3.1	0	0	1.43
3.3	0	0	1.28
3.5	0	0	1.14
3.7	0	0	0.91
3.9	0	0	0.72

DESI

DESI				
z	BGS	LRG	ELG	QSO
0.1	2240	0	0	0
0.3	240	0	0	0
0.5	6.3	0	0	0
0.7	0	48.7	69.1	2.75
0.9	0	19.1	81.9	2.60
1.1	0	1.18	47.7	2.55
1.3	0	0	28.2	2.50
1.5	0	0	11.2	2.40
1.7	0	0	1.68	2.30

in $10^{-5}\ (h\ Mpc)^{-3}$ units

Euclid

Euclid	
z	ELG
0.6	356
0.8	242
1.0	181
1.2	144
1.4	99
1.6	66
1.8	33

Testing gravity on cosmological scales

Modified gravity: model independent approach

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$$k^2\Psi \simeq -4\pi G_{\rm eff}\, a^2 \rho_m \delta_m$$

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- Modification of GR parametrized **by two free functions** of time and scale

$$\mu(k,a) = \frac{G_{\rm eff}}{G}$$

Effective Newton constant

$$\eta(k,a) = -\frac{\Phi}{\Psi}$$

Gravitational slip parameter

Pogosian, Silvestri, Buniy , arXiv:1302.1193

Testing gravity on cosmological scales

Modified gravity: model independent approach

GR with smooth DE

$$\mu = \eta = 1$$

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a) Constant μ and η

Testing gravity on cosmological scales

Modified gravity: model independent approach

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b) Time-dependent parametrization:

a) Constant μ and η

$$\mu(a) = 1 + (\mu_0 - 1)\,\frac{1-\Omega_m(a)}{1-\Omega_m},$$

$$\eta(a) = 1 + (\eta_0 - 1)\,\frac{1-\Omega_m(a)}{1-\Omega_m},$$

P.A.R. Ade et al. [Planck collaboration] arXiv:1502.01590

Testing gravity on cosmological scales

Observables

Galaxy power spectrum in redshift space

$$P(k_r, \hat{\mu}_r, z) = \frac{D_{A\,r}^2\, E}{D_A^2\, E_r}\,(b + f\,\hat{\mu}^2)^2\, D^2 \sigma_8^2 \hat{P}(k)\, e^{-k_r^2\,\hat{\mu}_r^2\,\sigma_r^2}$$

Lensing convergence power spectrum

$$P_{ij}(\ell) \simeq H_0 \sum_a \frac{\Delta z_a}{E_a} K_i(z_a) K_j(z_a) L_a^2 \hat{P}\left(\frac{\ell}{\chi(z_a)}\right)$$

where $L = \Omega_m\, D\, \frac{\mu\,(1+\eta)}{2}\, \sigma_8$

$H(z)$ $\mu(k, z)$ $\eta(k, z)$

Testing gravity on cosmological scales

Fisher matrices

Galaxy clustering

$$F^C_{\alpha\beta} = \frac{1}{8\pi^2}\int_{-1}^{1} d\hat{\mu}\int_{k_{\min}}^{\infty} k^2\, V_{eff}\, \left.\frac{\partial \ln(P(k,\hat{\mu},z_a))}{\partial p_\alpha}\right|_r \left.\frac{\partial \ln(P(k,\hat{\mu},z_a))}{\partial p_\beta}\right|_r \mathrm{e}^{-k^2\,\Sigma_\perp^2 - k^2\,\hat{\mu}^2\,(\Sigma_\parallel^2-\Sigma_\perp^2)}\, dk$$

$$V_{eff} = \left(\frac{n(z_a)\,P(k,\hat{\mu},z)}{1+n(z_a)\,P(k,\hat{\mu},z)}\right)^2 V_a$$

Galaxy lensing

$$F^L_{\alpha\beta} = f_{sky}\sum_{\ell}\Delta\ln\ell\,\frac{(2\ell+1)\,\ell}{2}\,\mathrm{Tr}\left[\frac{\partial \mathbf{P}}{\partial p_\alpha}\mathbf{C}^{-1}\frac{\partial \mathbf{P}}{\partial p_\beta}\mathbf{C}^{-1}\right]$$

$$C_{ij} = P_{ij} + \gamma^2_{int}\,\hat{n}_i^{-1}\,\delta_{ij}$$

$$\hat{n}_i = n_\theta\,\frac{\int_{\bar{z}_{i-1}}^{\bar{z}_i} n(z)\,dz}{\int_0^\infty n(z)\,dz}$$

Testing gravity on cosmological scales

Surveys specifications and fiducial cosmology

Clustering

Survey	JPAS	DESI	Euclid
Area (sq. deg)	4000/8500	14000	15000
δz	0.003	0.001	0.001

Fiducial ΛCDM
Planck (2015) cosmology.
Only linear scales

Lensing

Survey	z_{mean}	δz	n_θ^{LRG}	n_θ^{ELG}	$n_\theta^{LRG+ELG}$
JPAS	0.5	0.03	3.25	9.07	12.32
Euclid	0.9	0.05		35	35

Linear bias:

$$b(z) = \frac{b(0)}{D(z)}$$

b(0) = 0.87 for ELG
= 1.7 for LRG
= 1.4 for BGS

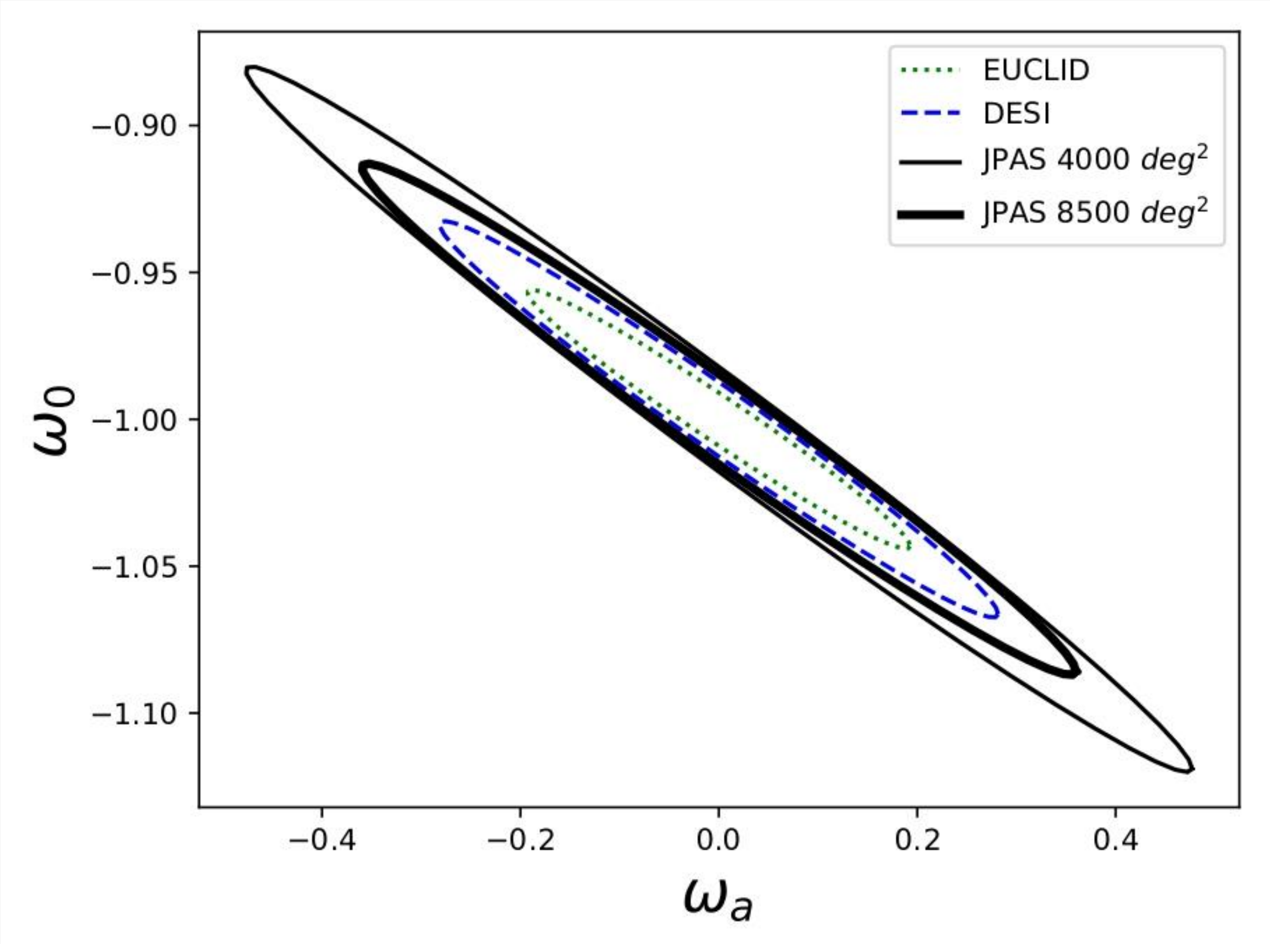
For QSO

$$b(z) = 0.53 + 0.289\,(1+z)^2$$

Testing gravity on cosmological scales

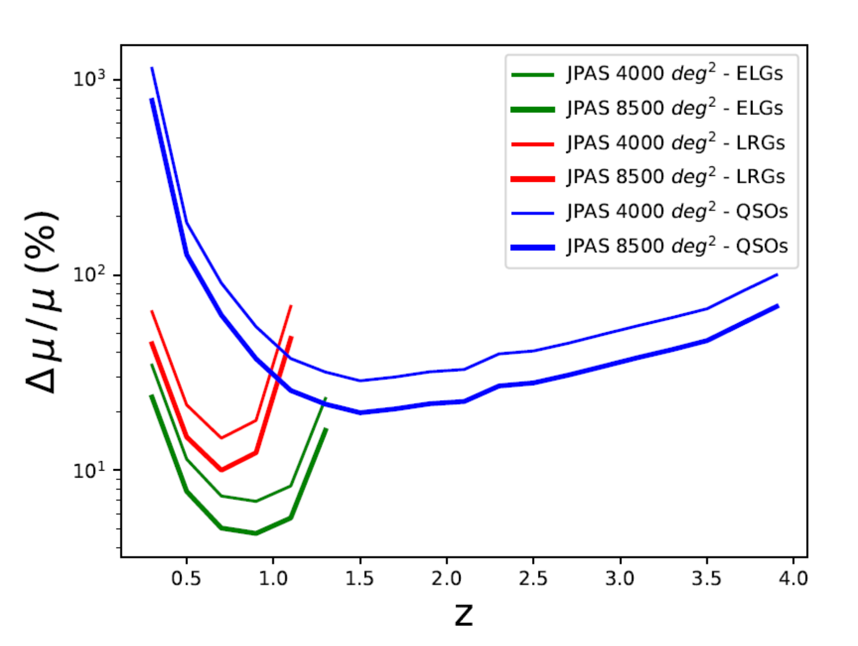
CPL parametrization of Dark Energy

$$\omega(a) = \omega_0 + \omega_a(1 - a)$$



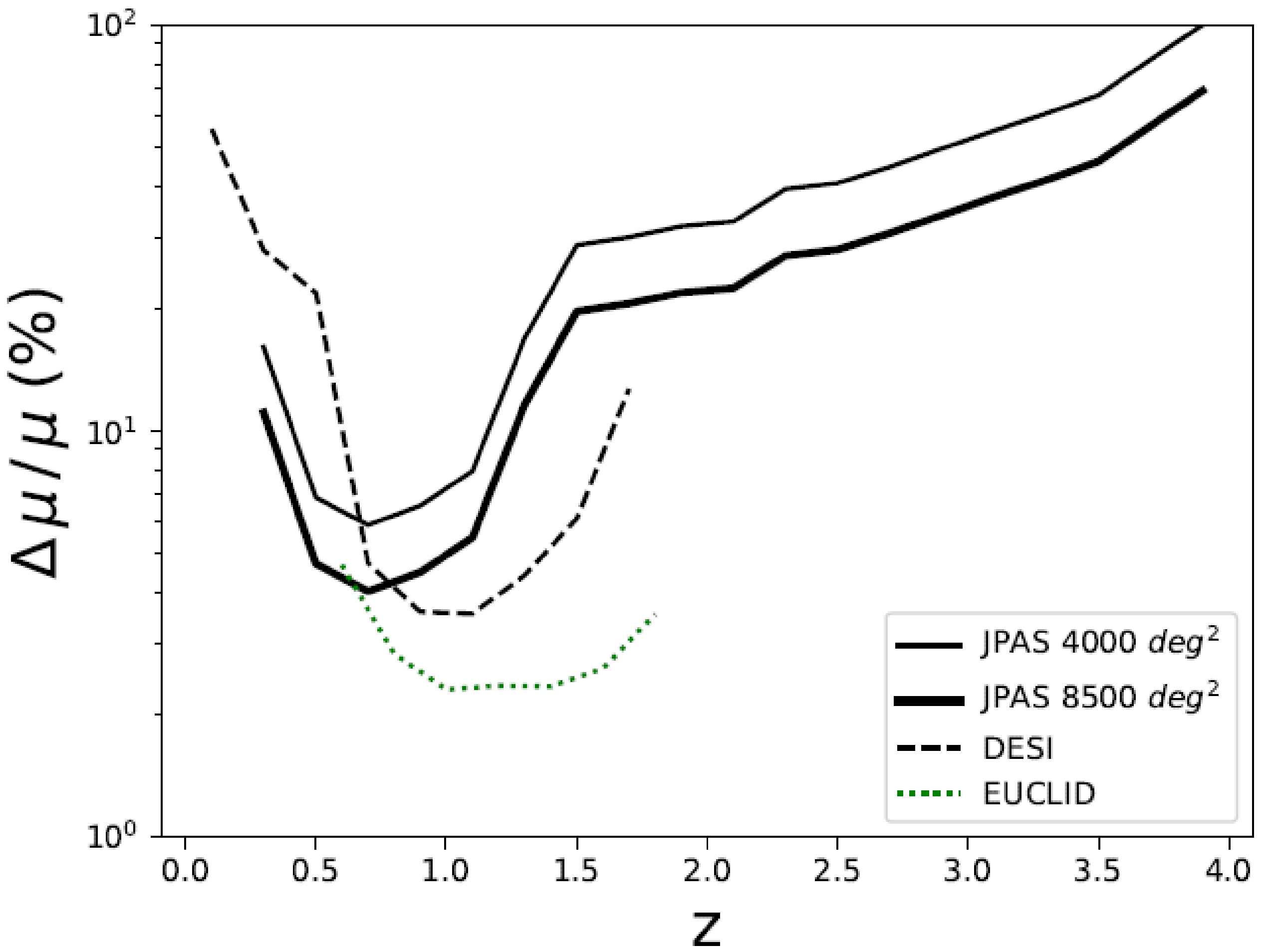
Testing gravity on cosmological scales

Effective Newton constant



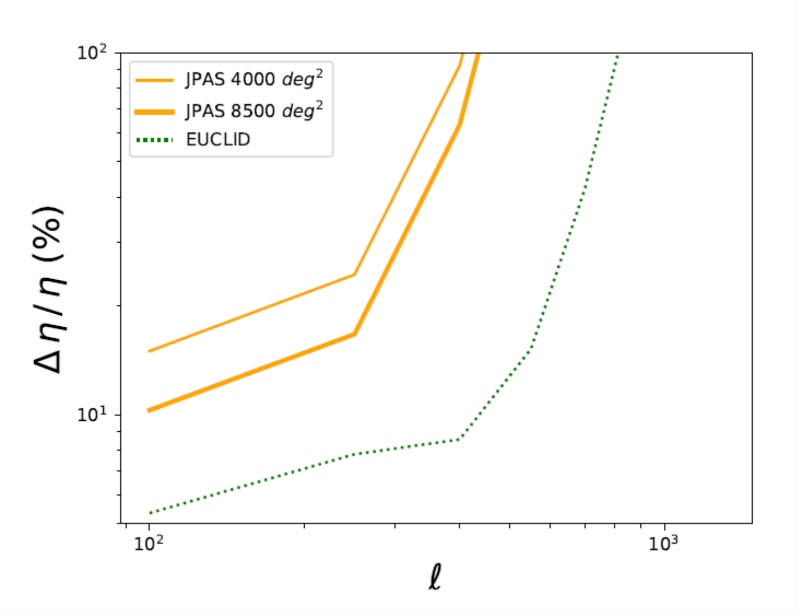
Clustering + lensing:

z	μ	$\Delta\mu/\mu(\%)$
0.30	1	12.0
0.50	1	5.12
0.70	1	4.21
0.90	1	4.59
1.10	1	5.51
1.30	1	11.6



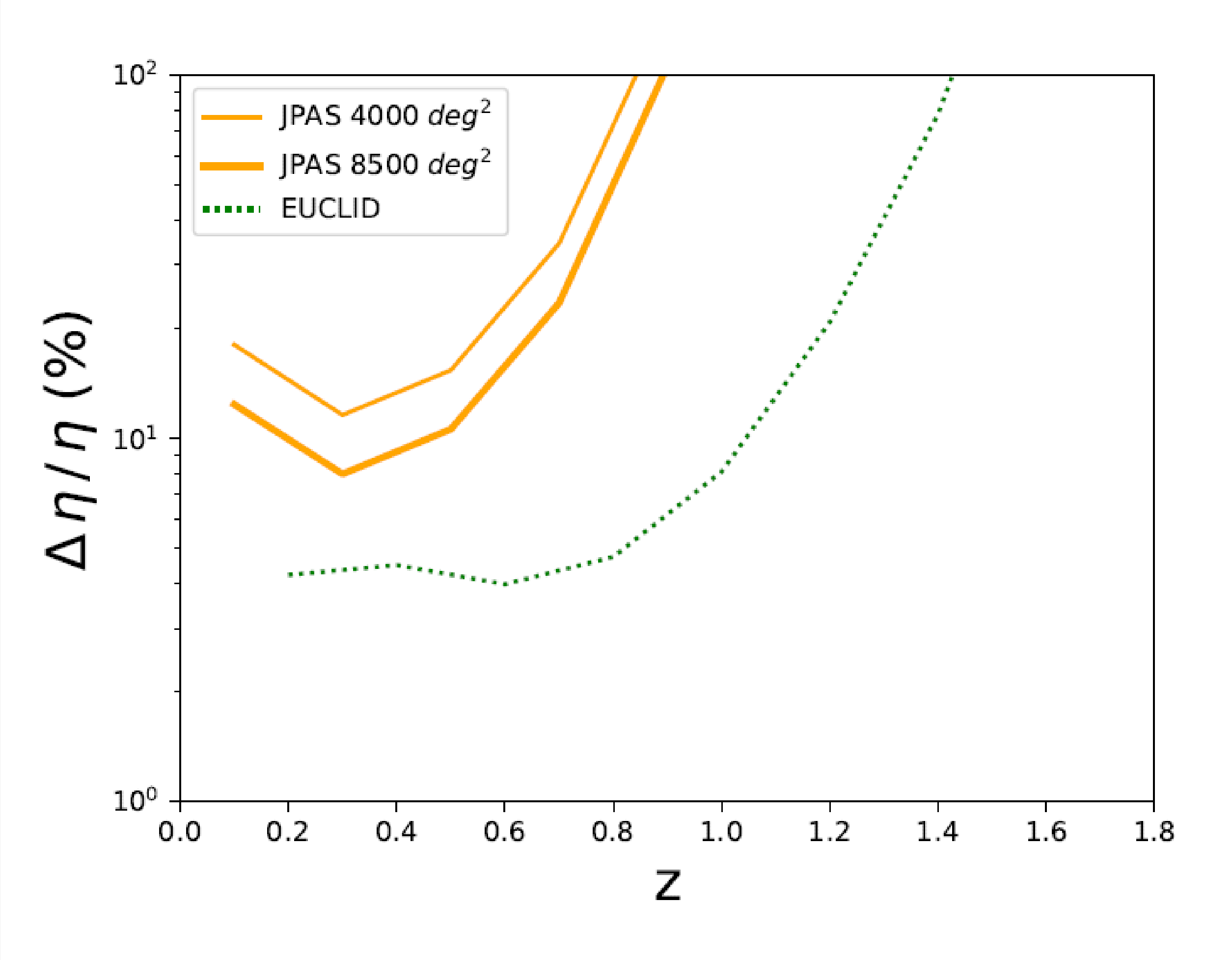
Testing gravity on cosmological scales

Gravitational slip parameter



z	$\Delta\eta/\eta_{8500}(\%)$
0.3	4.28
0.5	6.86
0.7	17.1
0.9	88.8
1.1	-
1.3	-

Lensing+clustering



Testing gravity on cosmological scales

Hubble parameter

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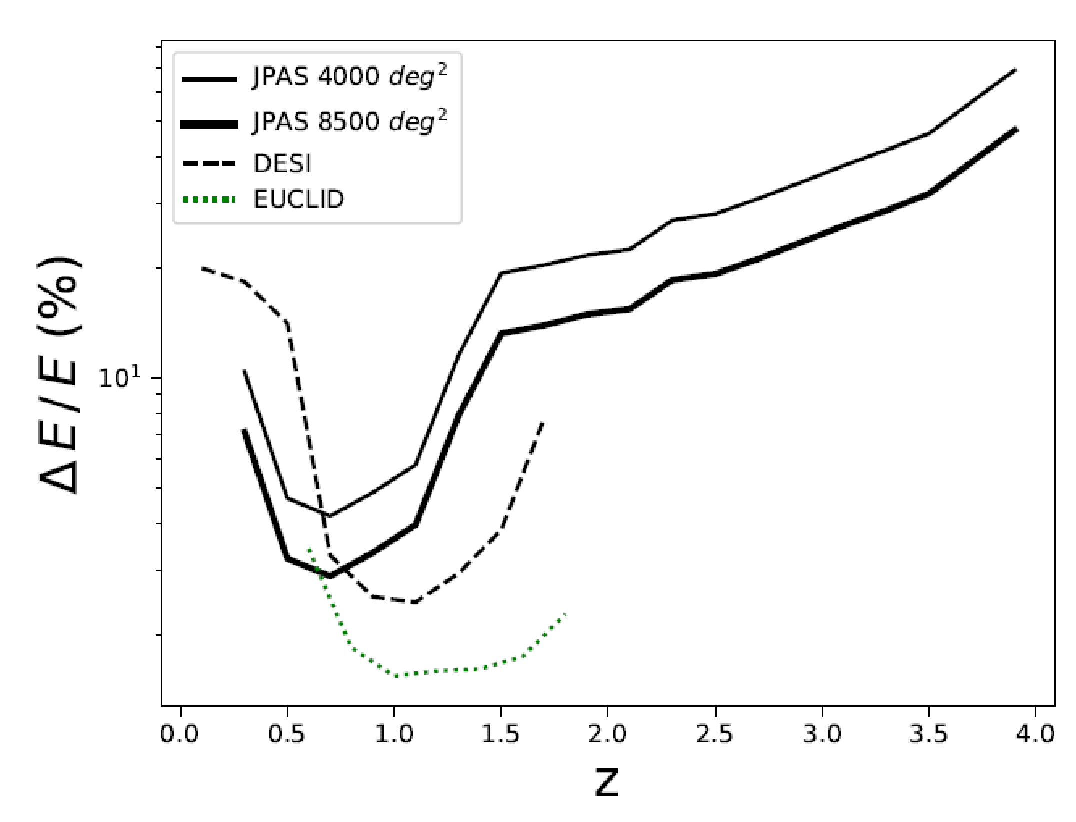

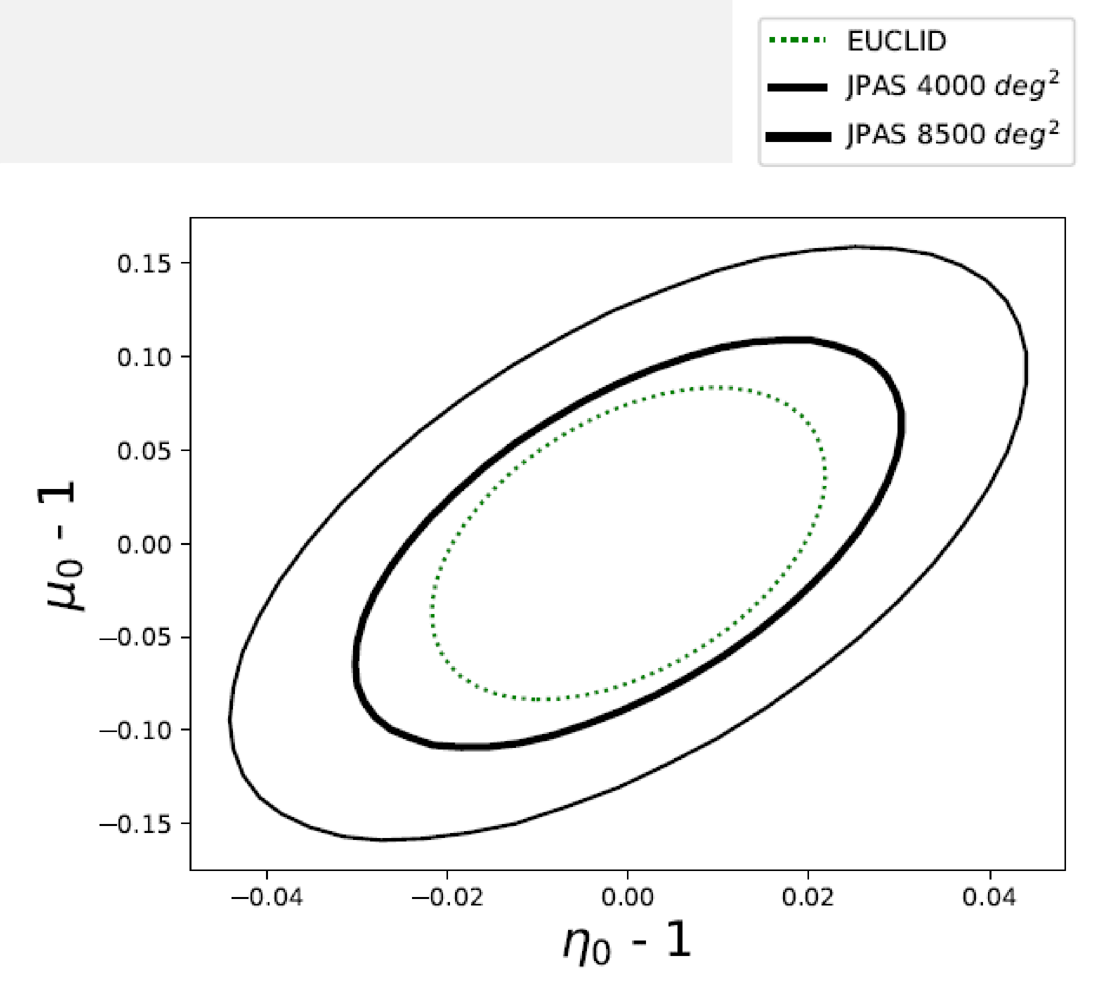

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- Compared to future surveys (DESI and Euclid) JPAS will provide the best precision for measurements below $z = 0.6$ thanks to the large number of ELG detectable in that redshift range