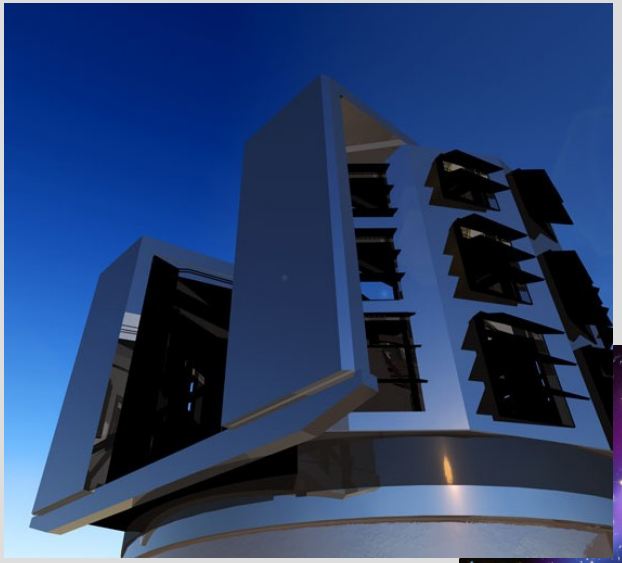
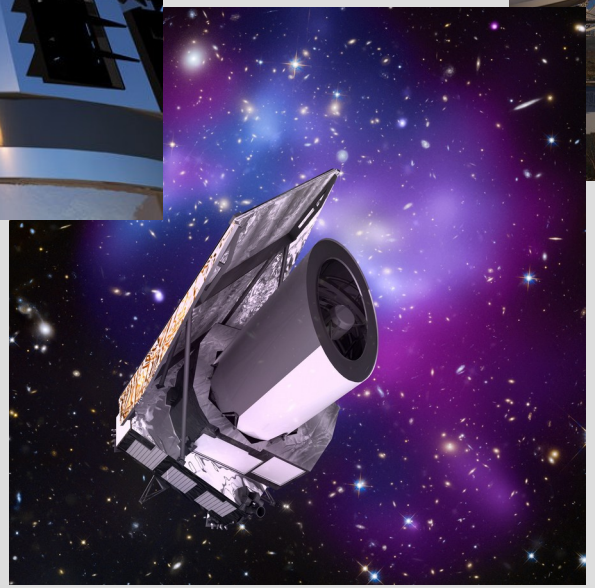
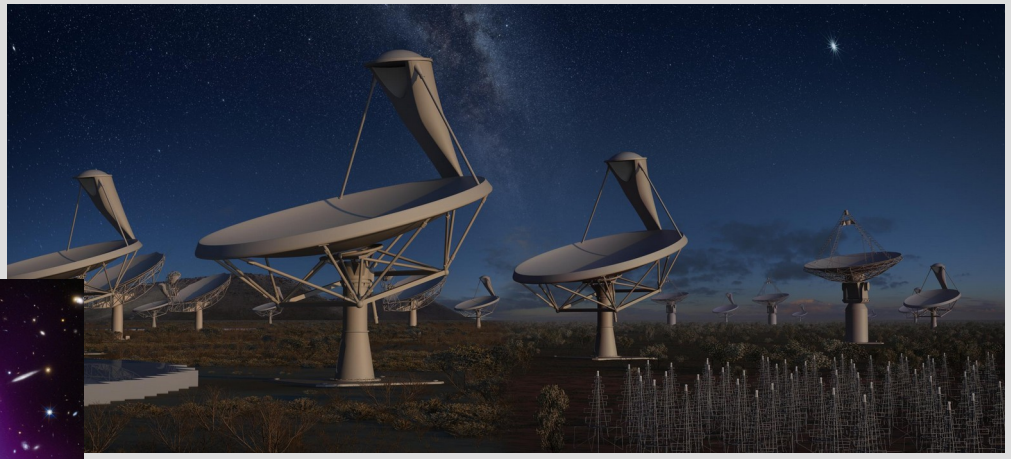
Testing gravity with E_G:

Mapping theory onto observation







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January 28, 2017

Images: http://www.euclid-ec.org/ , http://www.lsst.org/, https://www.skatelescope.org

Cosmological Observables

1. Galaxy clustering

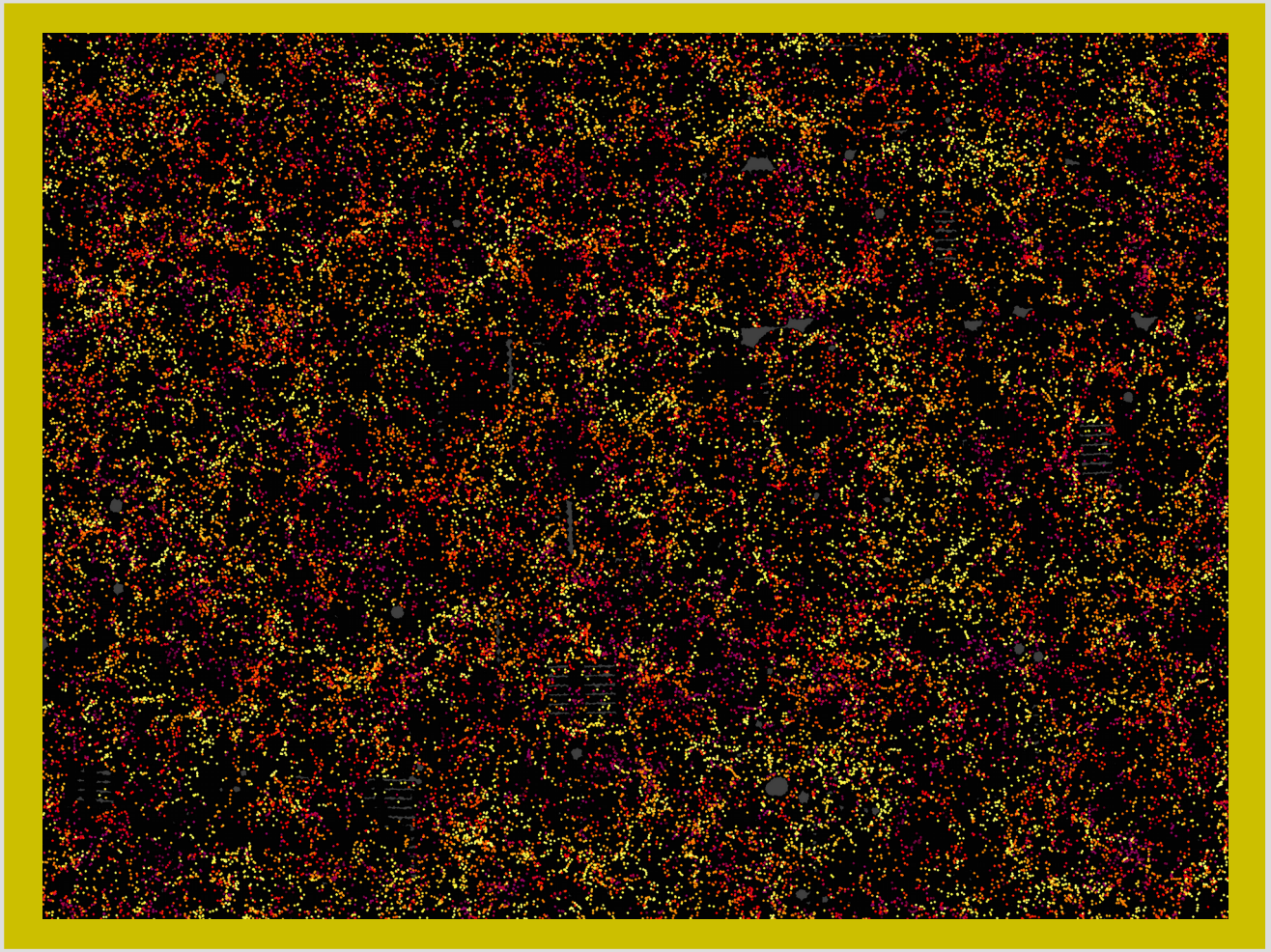

Image: Daniel Eisenstein & the SDSS III Collaboration

Cosmological Observables

1. Galaxy clustering

2. Weak gravitational lensing

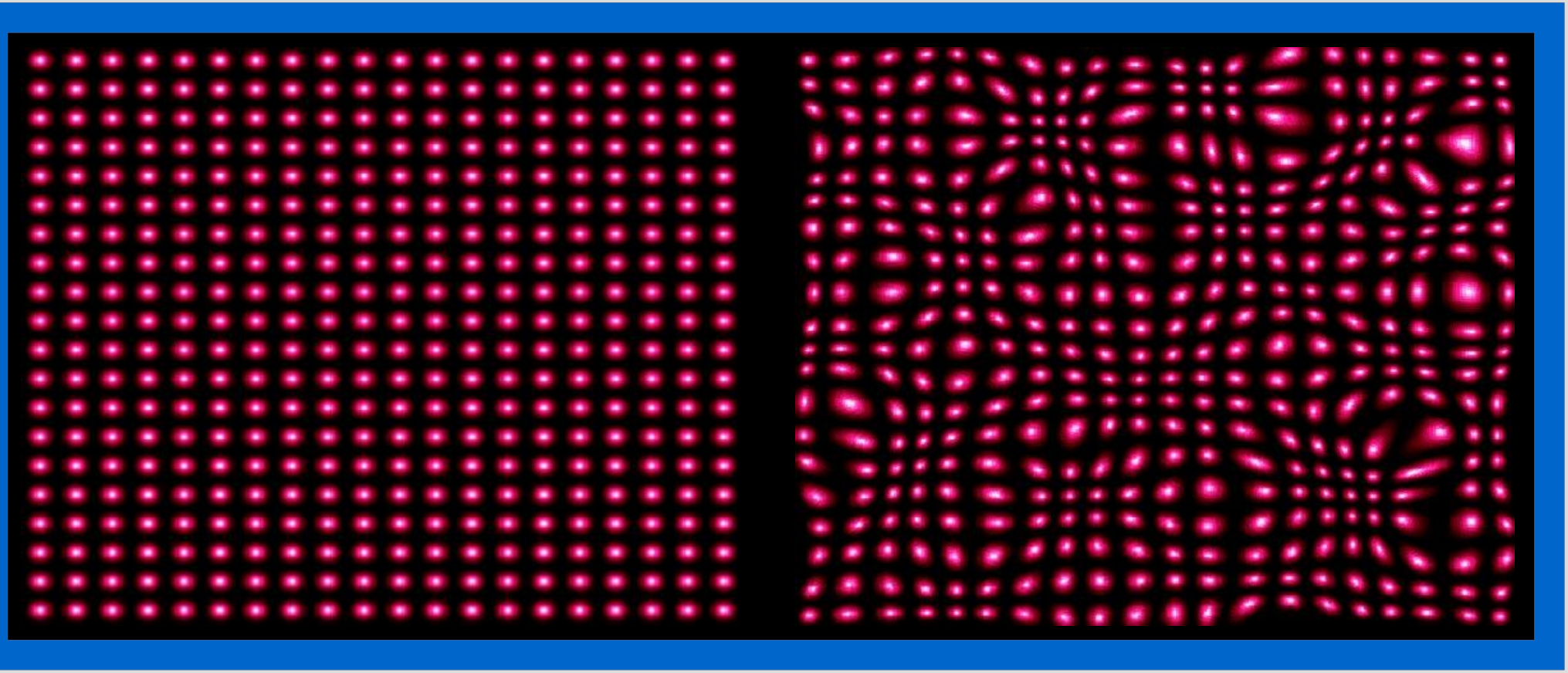

Image: iCosmo group (http://gravitationallensing.pbworks.com)

Cosmological Observables

1. Galaxy clustering

2. Weak gravitational lensing

3. Redshift-space distortions

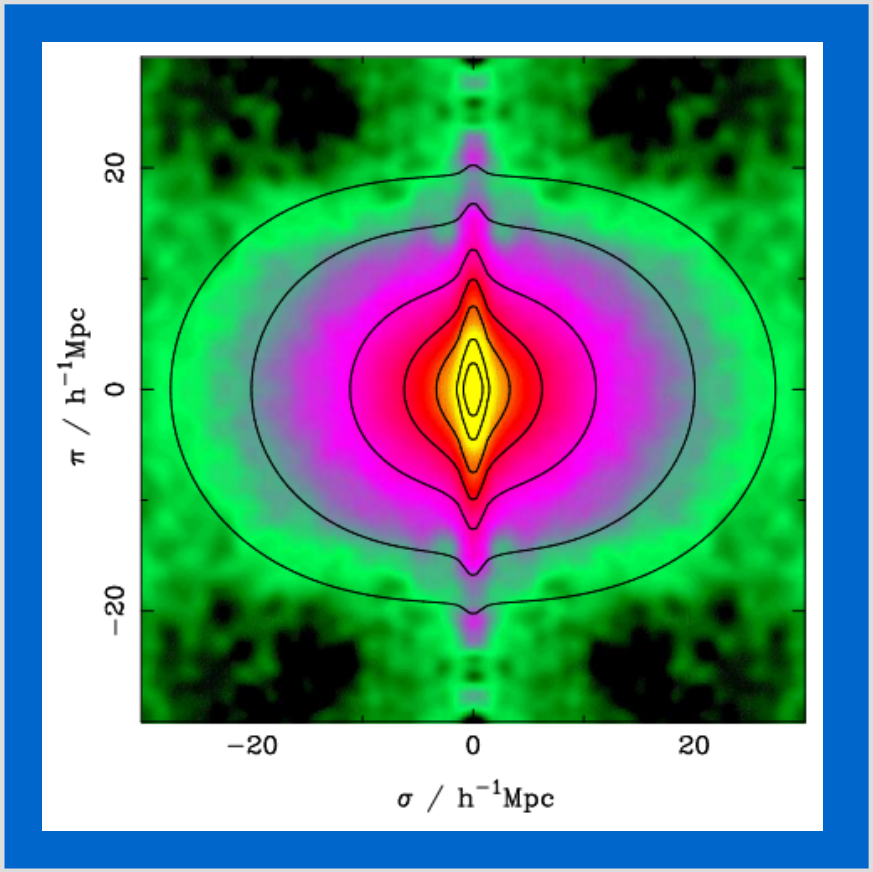

Image: Peacock et. al. 2001, astro-ph/0103143

E_G: Original Definition

Zhang et al. 2007, 0704.1932

$$\hat{E}_G = \frac{C_{\kappa g}(l, \Delta l)}{3H_0^2 a^{-1} \Sigma_\alpha f_\alpha(l, \Delta l) P_{vg}^\alpha}$$

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GALAXY POSITIONS
x
GALAXY LENSING

E_G: Original Definition

Zhang et al. 2007, 0704.1932

$$\hat{E}_G = \frac{C_{\kappa g}(l, \Delta l)}{3H_0^2 a^{-1} \Sigma_\alpha f_\alpha(l, \Delta l) P_{vg}^\alpha}$$

GALAXY POSITIONS
x
GALAXY LENSING

GALAXY POSITIONS
x
GALAXY VELOCITIES

E_G: Original Definition

Zhang et al. 2007, 0704.1932

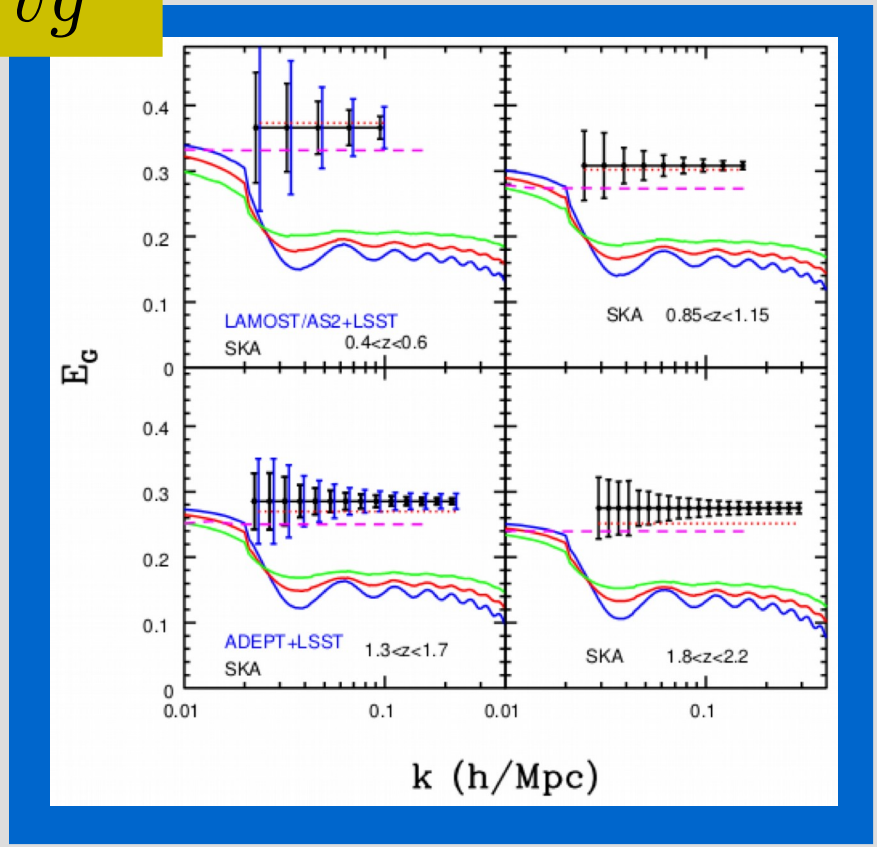
$$\hat{E}_G = \frac{C_{\kappa g}(l, \Delta l)}{3H_0^2 a^{-1} \Sigma_\alpha f_\alpha(l, \Delta l) P_{vg}^\alpha}$$

Solid, flat - GR

Dashed - f(R)

Dotted - DGP

Solid, oscillatory - TeVeS



E_G: Observational Definition

Reyes et al. 2010, 1003.2185

$$E_G(R) = \frac{\Upsilon_{gm}(R)}{\beta \Upsilon_{gg}(R)}$$

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GALAXY POSITIONS
x
GALAXY LENSING

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GALAXY POSITIONS
x
GALAXY LENSING

GALAXY POSITIONS
x
GALAXY POSITIONS

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$$E_G(R) = \frac{\Upsilon_{gm}(R)}{\beta \Upsilon_{gg}(R)}$$

GALAXY POSITIONS
x
GALAXY LENSING

LARGE-SCALE
GROWTH RATE
OF STRUCTURE

LARGE-SCALE
GALAXY BIAS

GALAXY POSITIONS
x
GALAXY POSITIONS

E_G: Observational Definition

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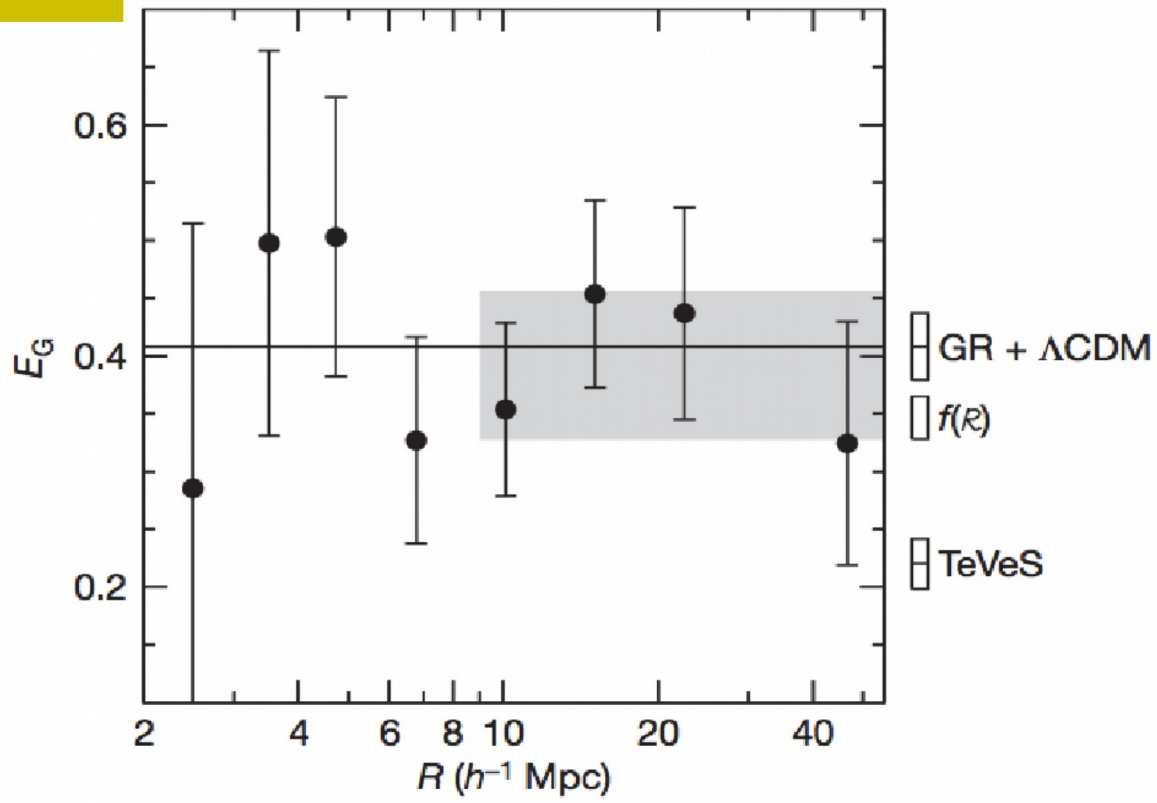
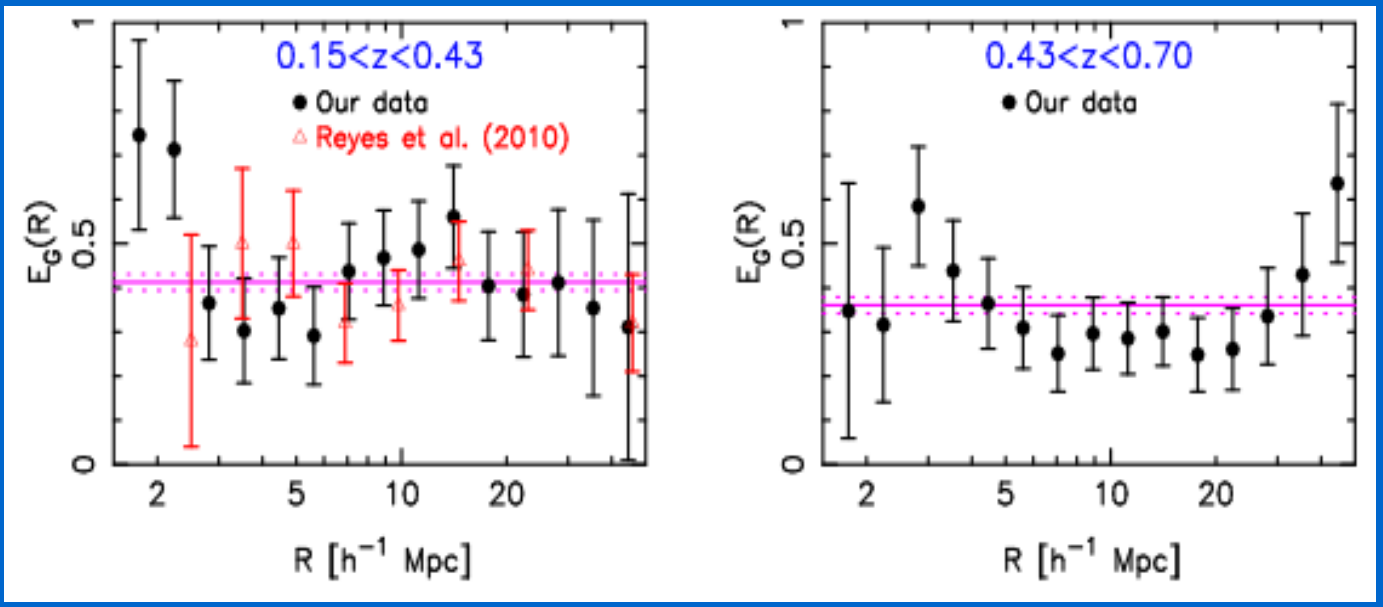
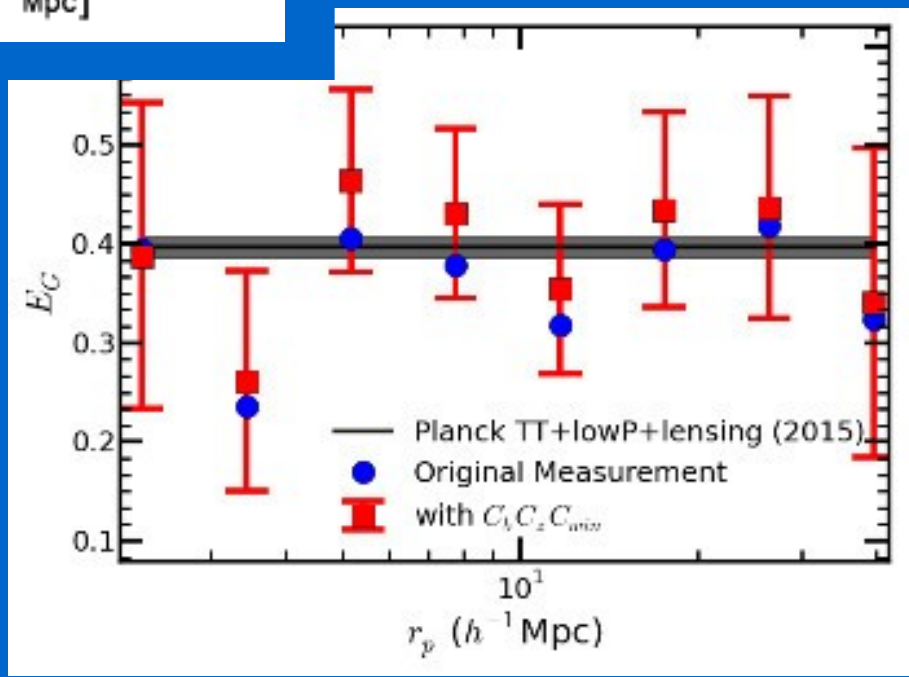


E_G: Current Measurements



Blake et al. 2015
(RCSLenS)
1507.03086

Alam et al. 2016
1610.09410



See also: Pullen et al. 2015, 1511.04457

A new theoretical expression

DL, Ferreira & Heymans 2015. 1510.04287

$$E_G(R, R_0, P, b(k)) = \frac{\Upsilon_{gm}(R, R_0, b(k))}{\beta(b)\Upsilon_{gg}(R, R_0, b(k), P)}$$

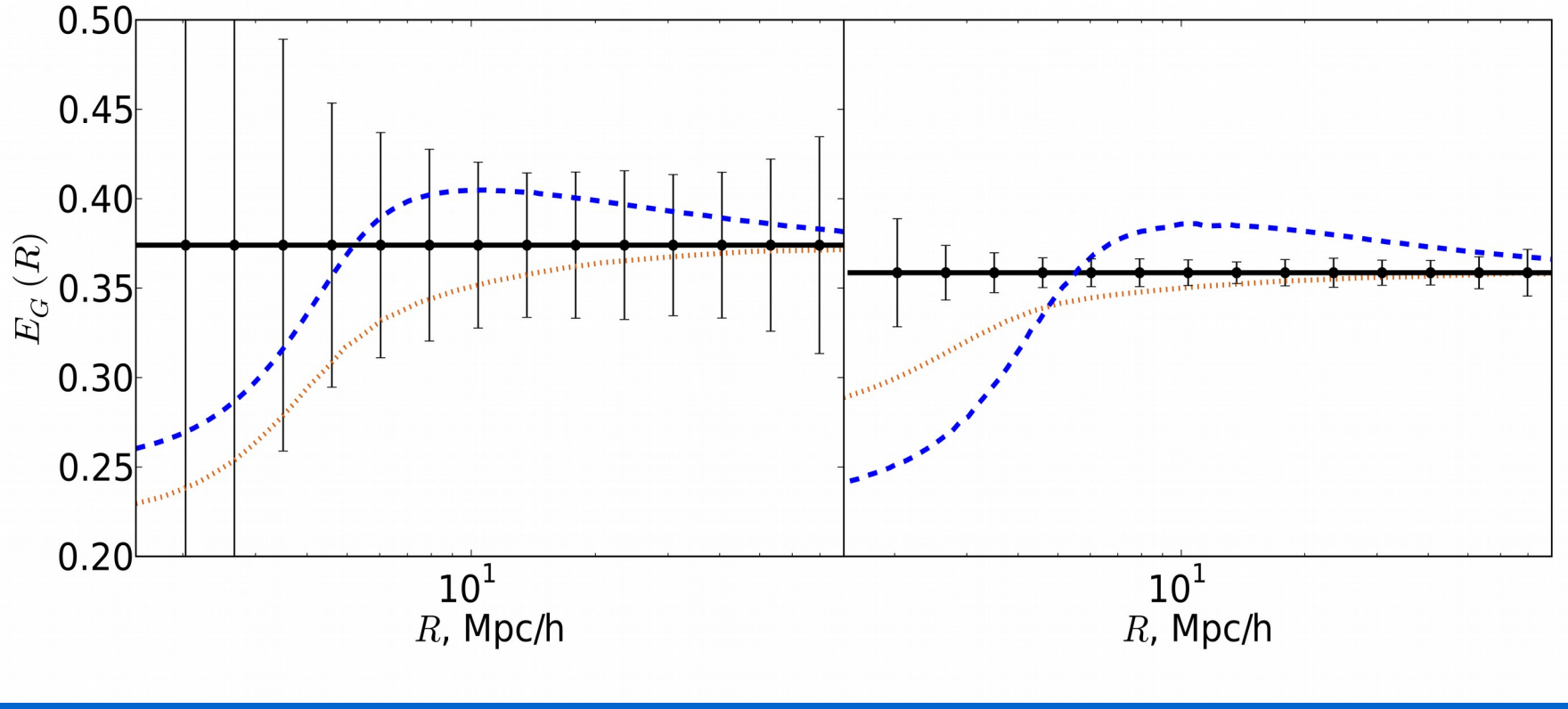
$R_0 =$ Minimum separation

$P =$ Projection length

$b(k) =$ Scale-dependent bias

Scale-dependent bias

DL, Ferreira & Heymans 2015. 1510.04287



DETF4 + DESI

LSST + SKA2

Blue dashed: 2dFGRS b(k). Orange dotted: Power-law b(k).

Conclusion

To use E_G with future datasets: we need to mitigate theoretical uncertainties.

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Other Work on Gravity

Recent / ongoing work:

- E_G in quasistatic modified gravity (*DL, Ferreira & Heymans 2015*)
- E_G in hydro simulations (*In progress, DL, Chisari, Codis, Devriendt*)
- Forecast constraints on Ω_K with w_0 & w_a (*DL, Bull & Allison 2016*)
- Constraining intrinsic alignments (*In progress, DL, Mandelbaum, ...*)

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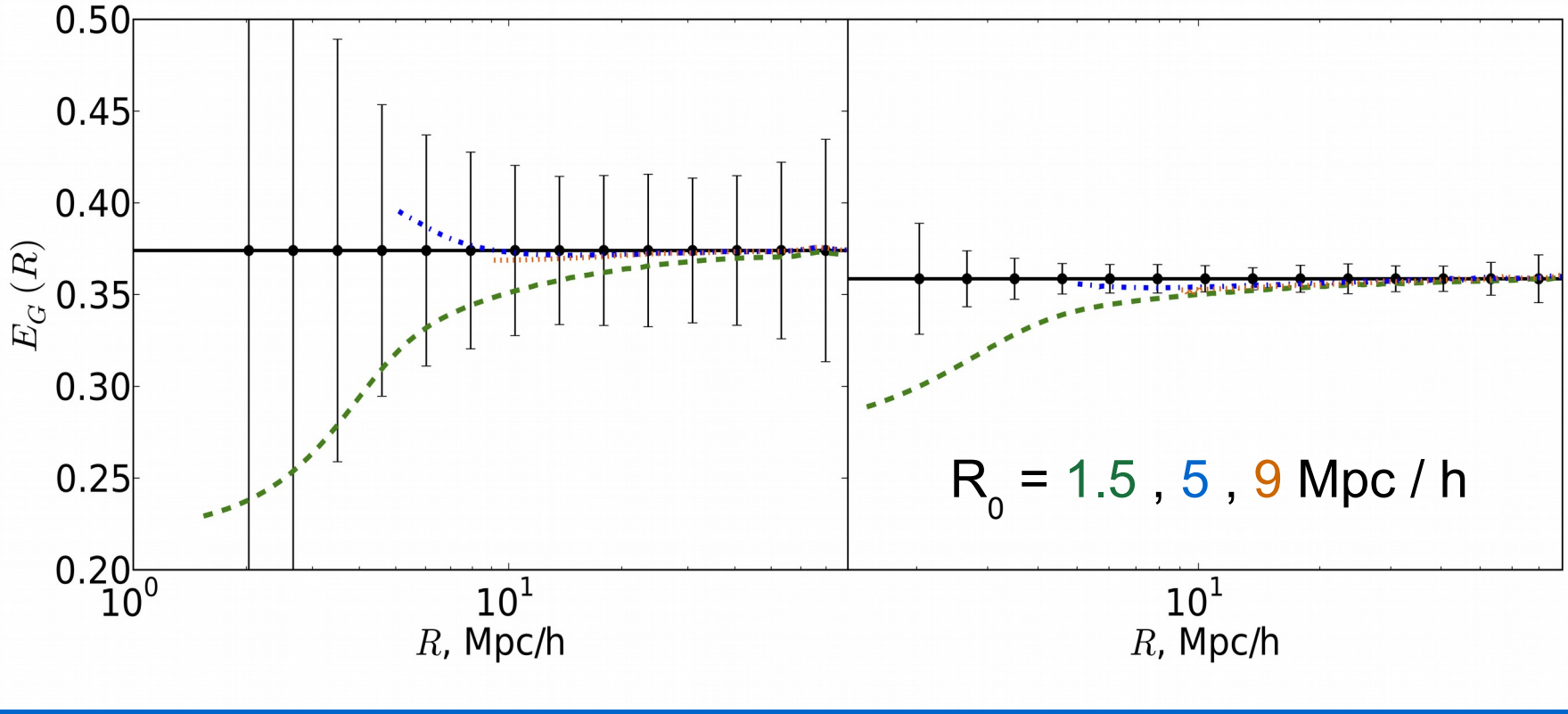
Back-up Slides

R_0 : Minimum Separation

DL, Ferreira & Heymans 2015. 1510.04287

Power-law b(k)



DETF4 + DESI

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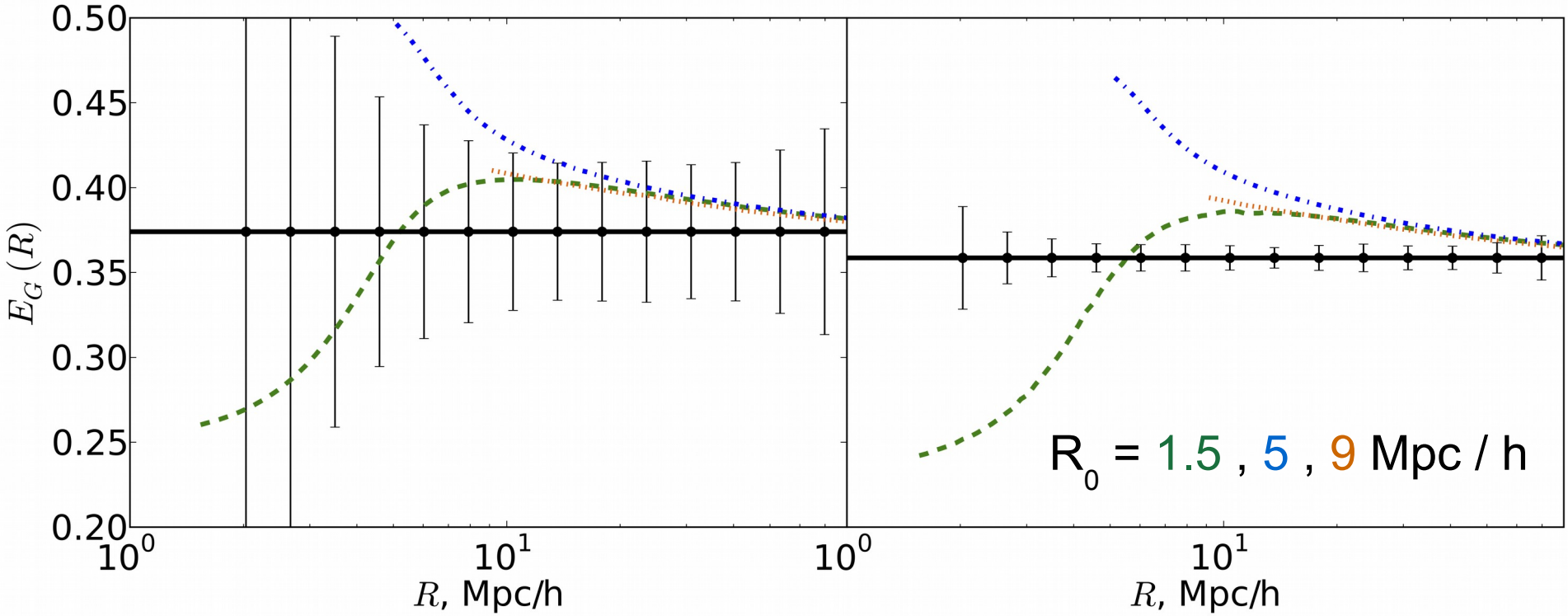
R_0 : Minimum Separation

DL, Ferreira & Heymans 2015. 1510.04287

2dFGRS b(k)

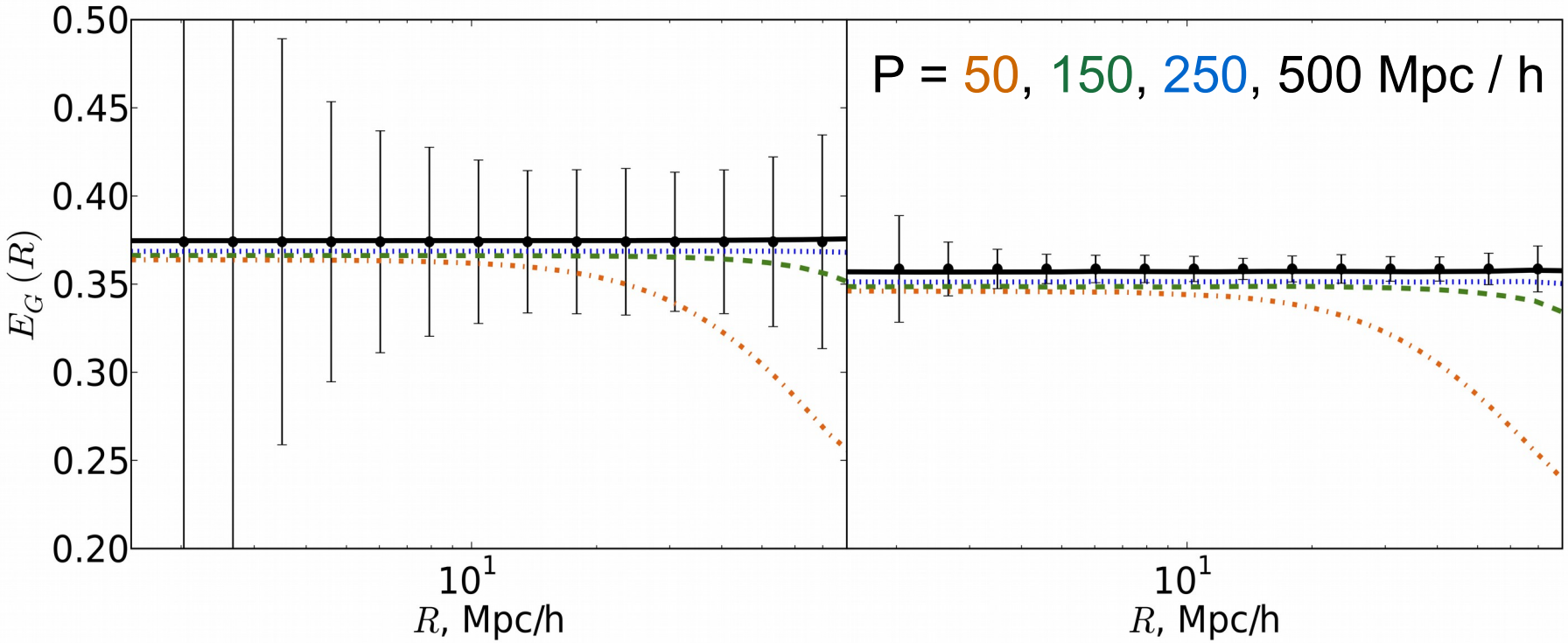


DETF4 + DESI

LSST + SKA2

P : Projection length

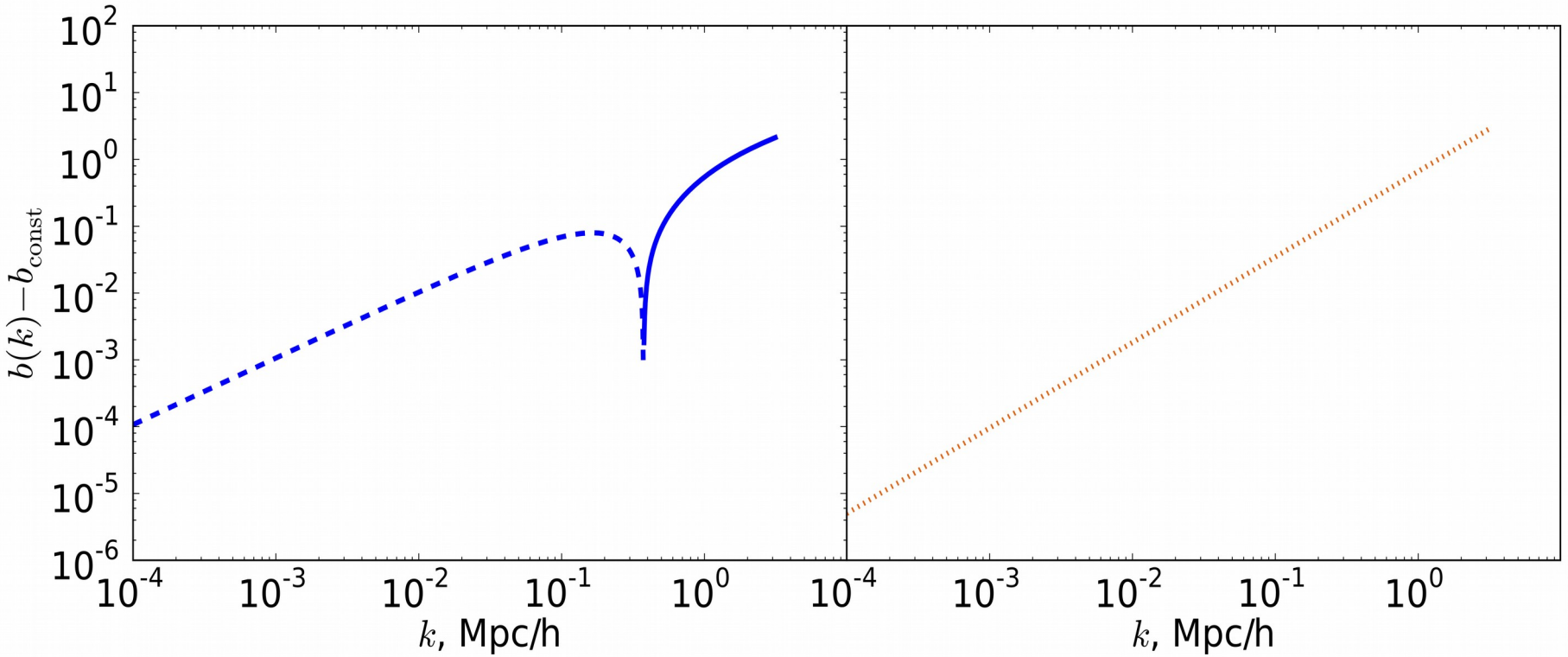
DL, Ferreira & Heymans 2015. 1510.04287



DETF4 + DESI

LSST + SKA2

Scale-dependent bias



2DFGRS

$$b(k) = b_c \sqrt{\frac{1 + Qk^2}{1 + Ak}}$$

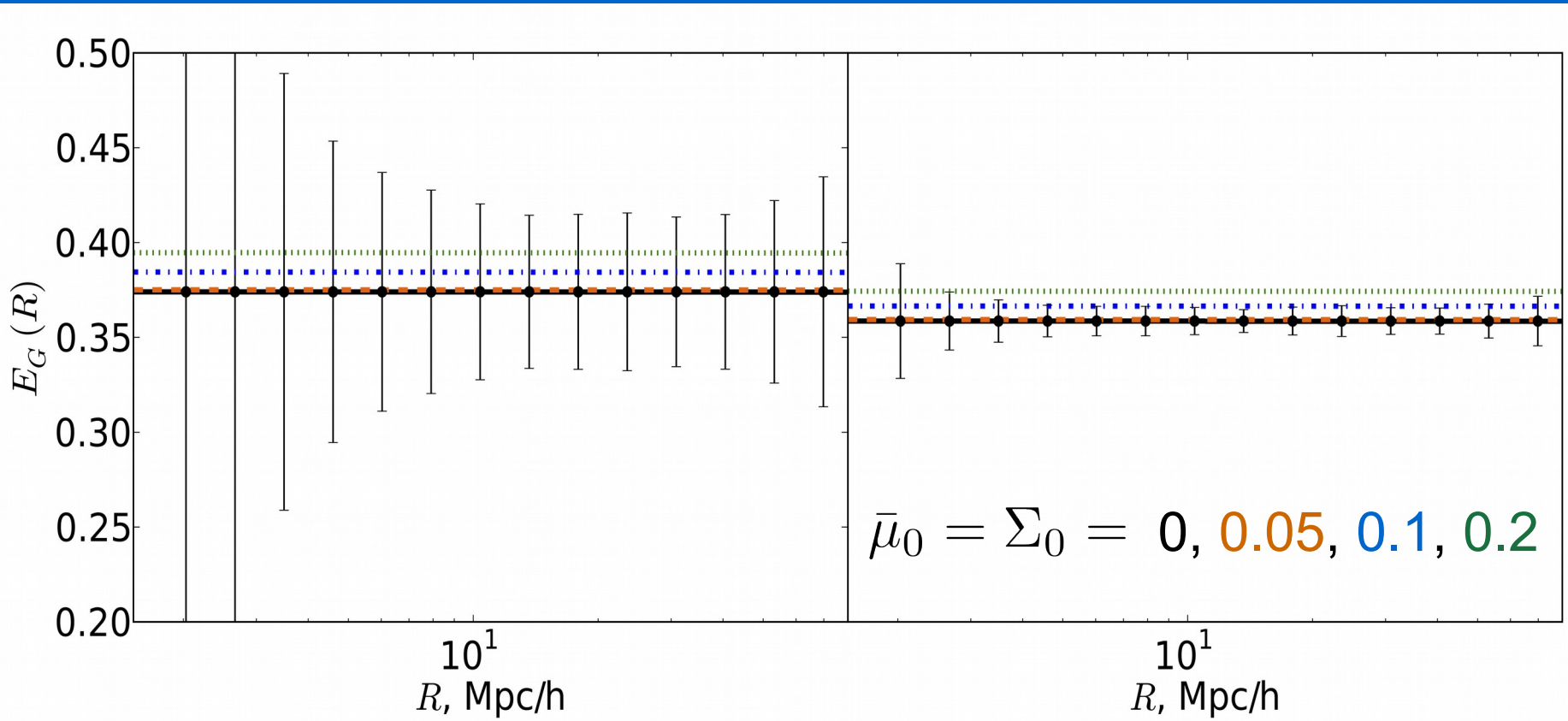
Power-law

$$b(k) = b_0 + b_1 k^n$$

Parameter values from Amendola et al. 2015, 1502.03994

E_G in QS modified gravity

DL, Ferreira & Heymans 2015. 1510.04287



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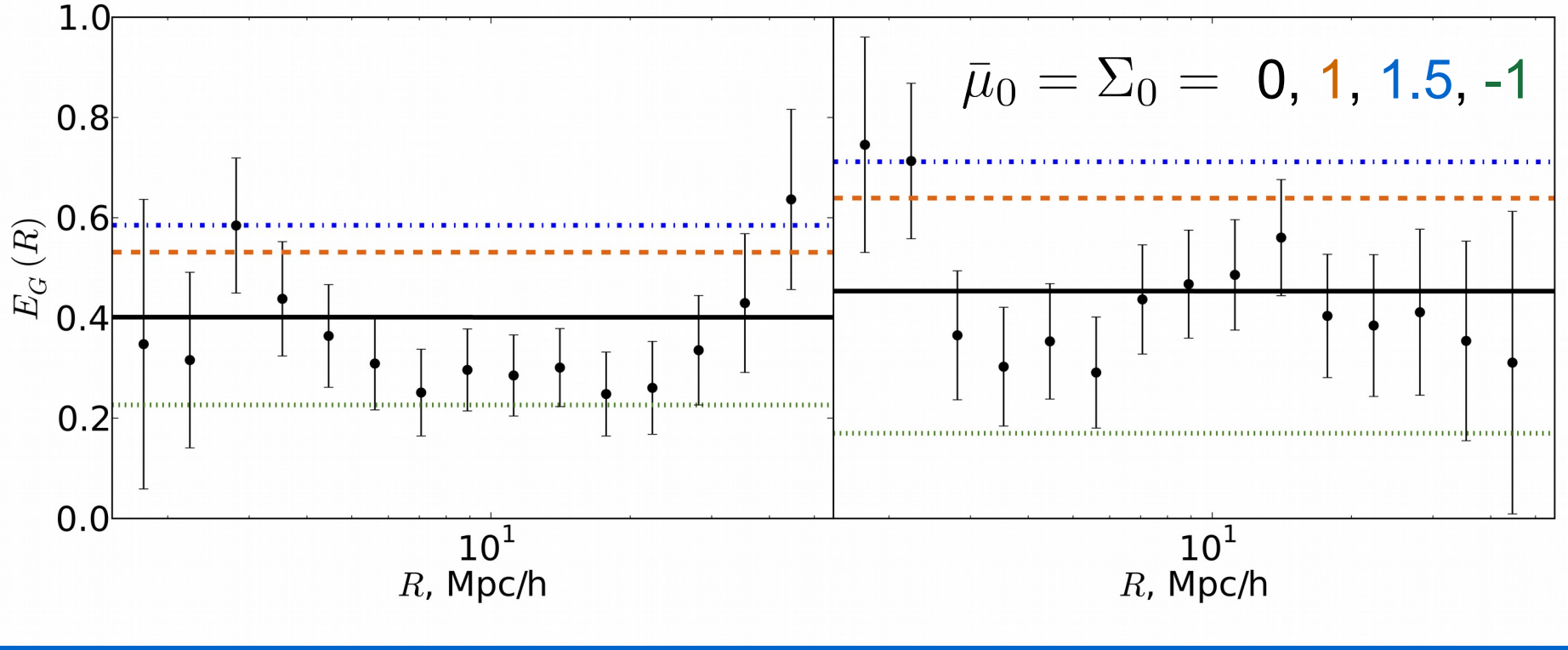
E_G in QS modified gravity

Blake et al. 2015 (RCSLenS) 1507.03086
DL, Ferreira & Heymans 2015. 1510.04287



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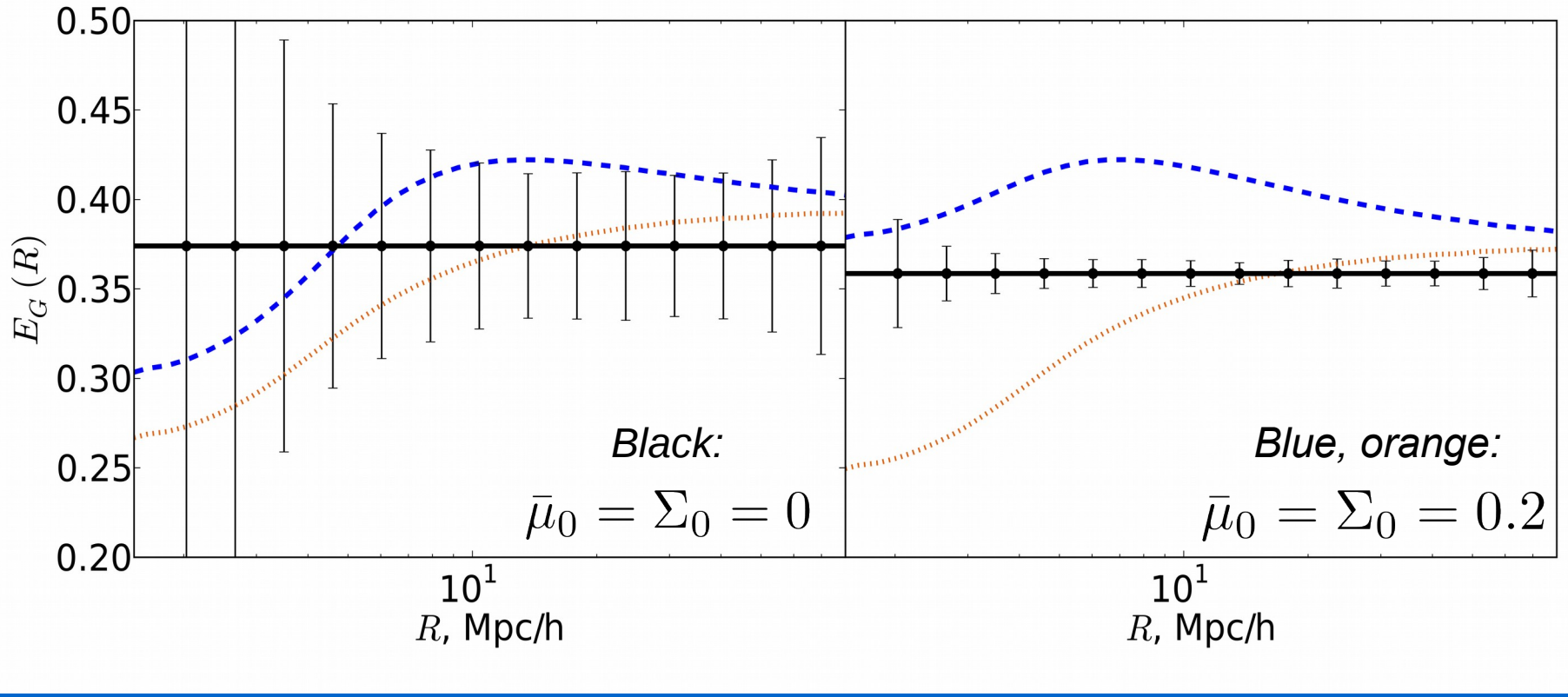


DETF4 + DESI

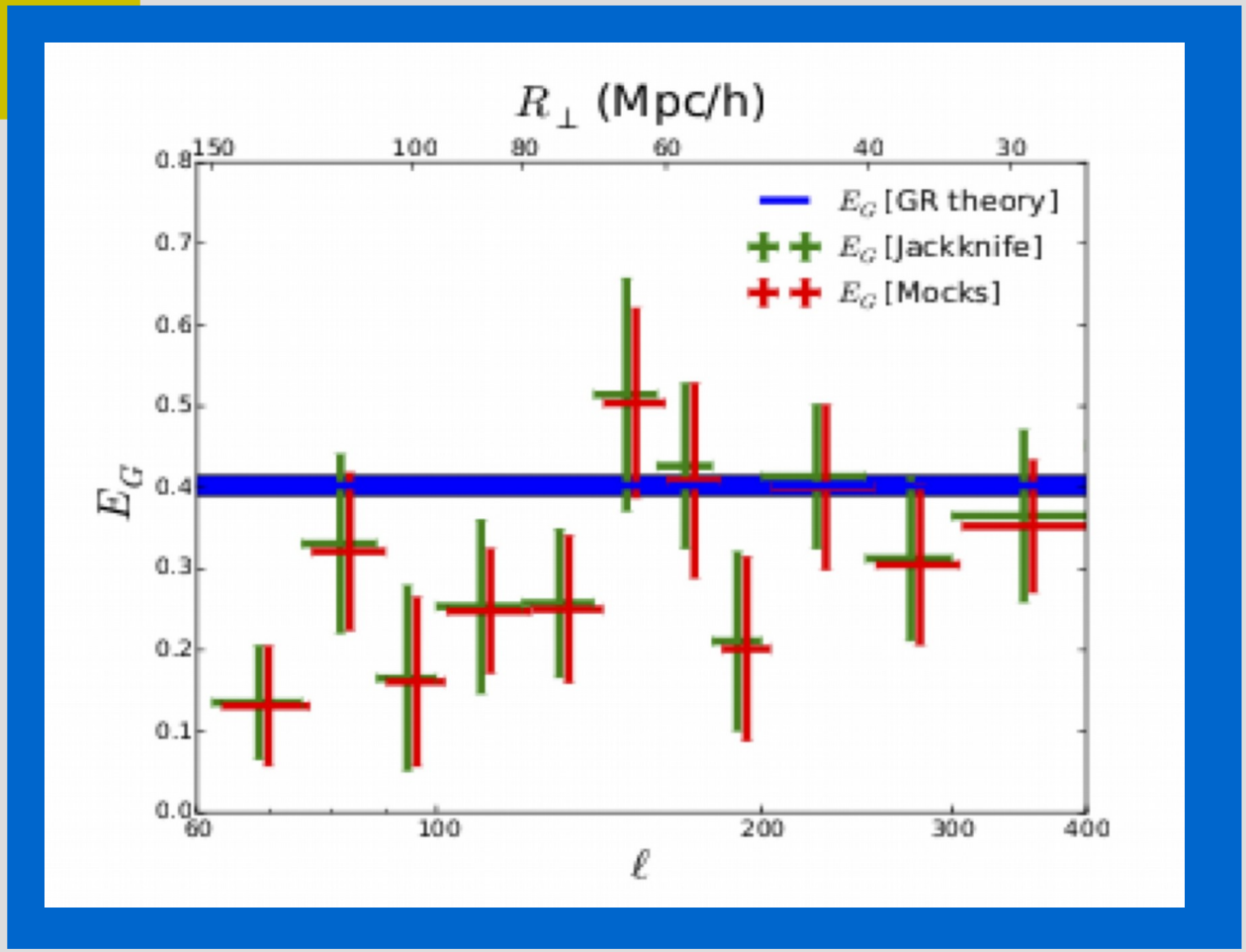
LSST + SKA2

Blue dashed: 2dFGRS b(k). Orange dotted: Power-law b(k).

Other work on E_G

$$E_G(\ell) = \Gamma \frac{C_\ell^{\kappa g}}{\beta C_\ell^{gg}}$$

Pullen et al. 2014, 1412.4454,
Pullen et al. 2015, 1511.04457



Other work on E_G

$$E_G(\ell) = \Gamma \frac{C_\ell^{\kappa g}}{\beta C_\ell^{gg}}$$

Pourtsidou 2015, 1511.05927