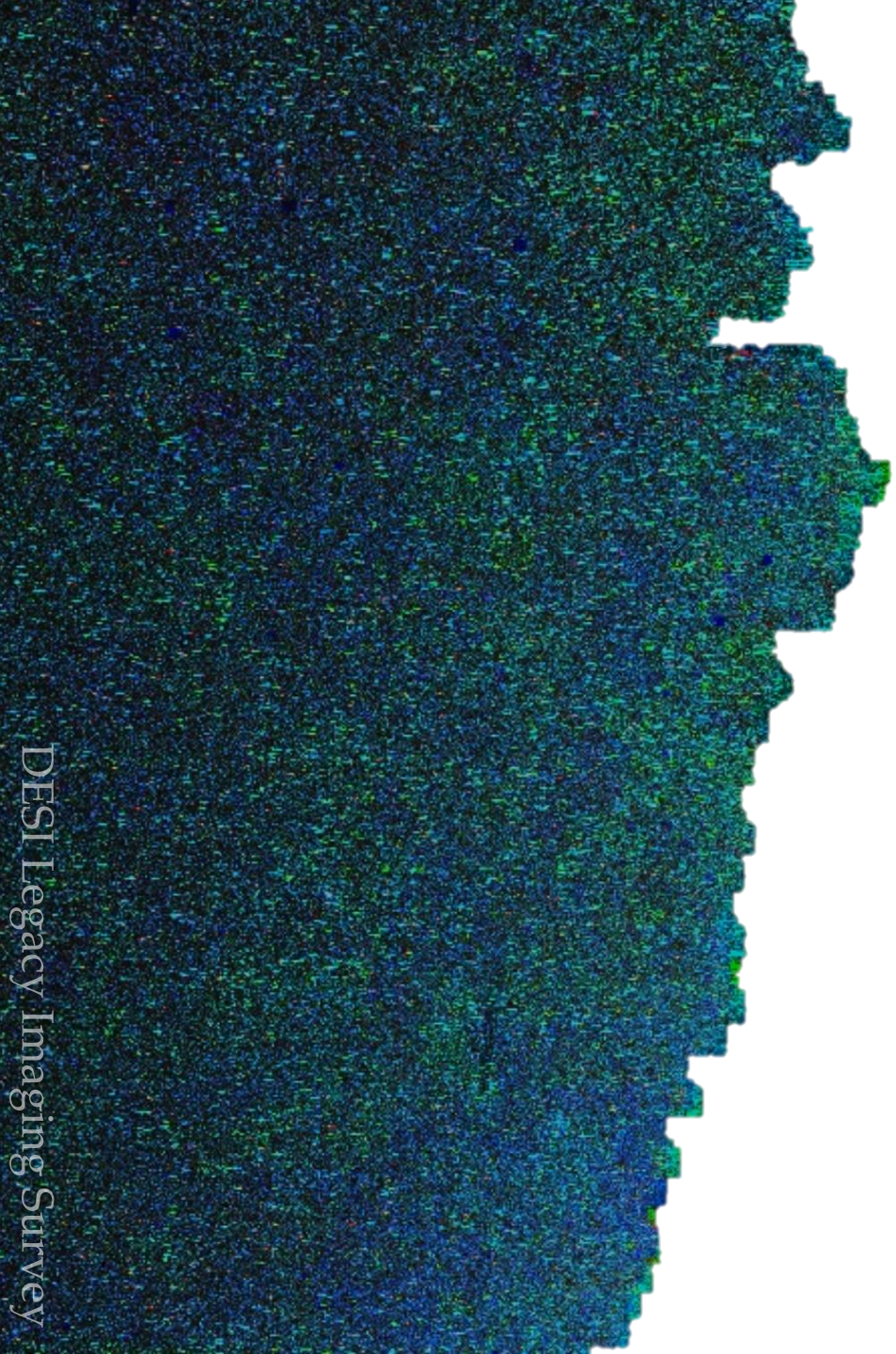


A False Quadrupole

How galaxy tidal alignments contaminate DESI's clustering statistics

Claire Lamman

From galaxies to cosmology with large spectroscopic surveys
07.04.22

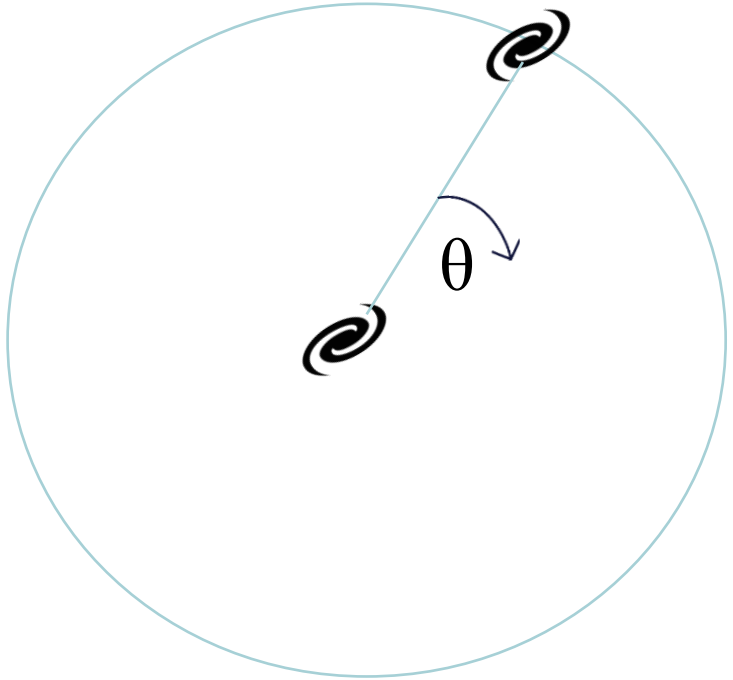
DARK ENERGY SPECTROSCOPIC INSTRUMENT
U.S. Department of Energy Office of Science

CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN

Clustering Statistics

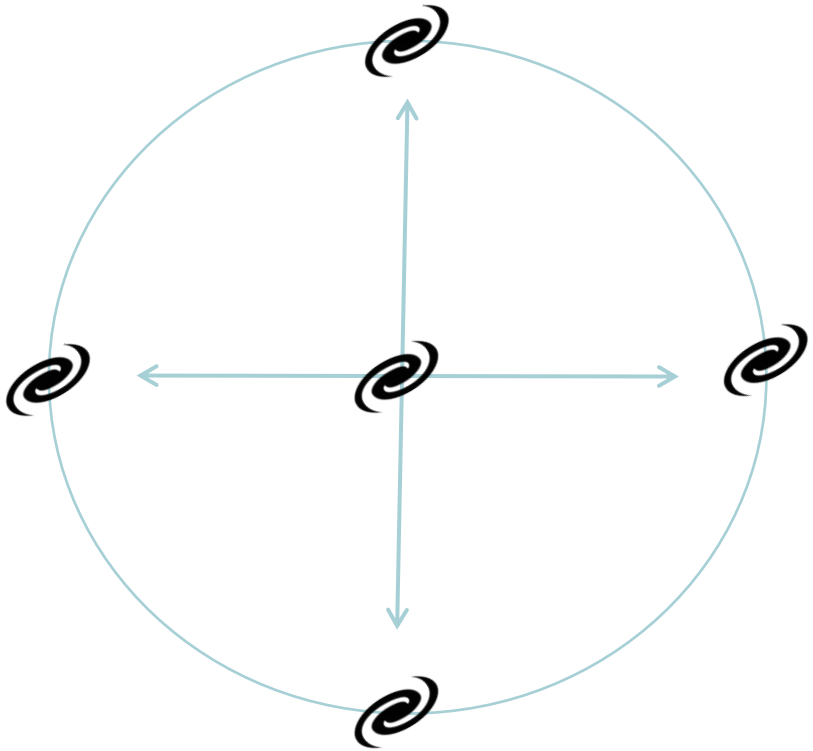
Monopole

ξ_0



Quadrupole

ξ_2

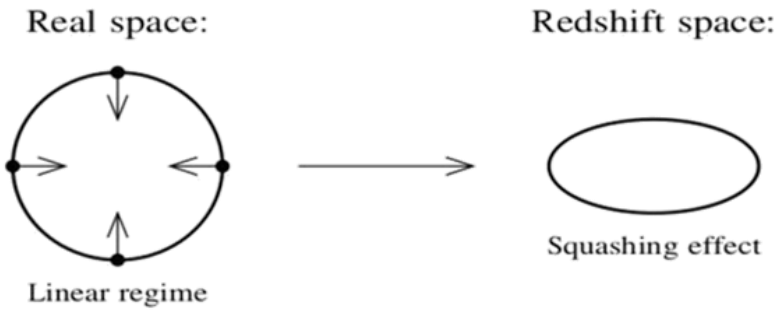


Anisotropic Clustering

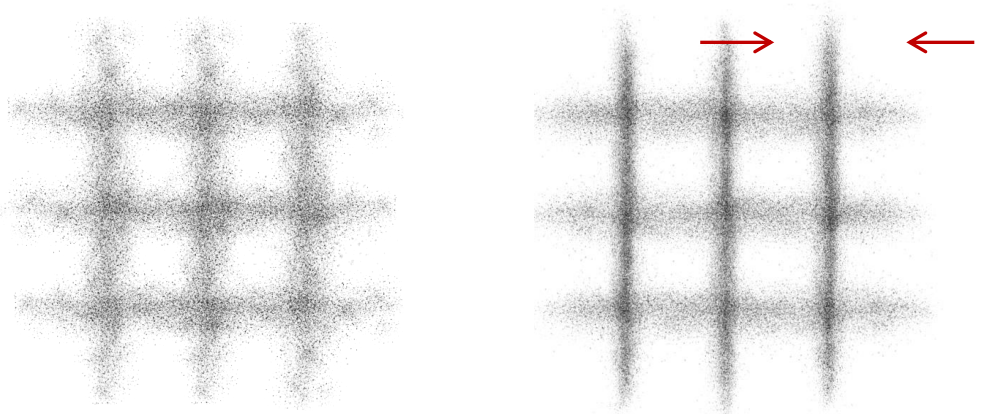
Includes information beyond ξ_0:

1. geometric distortion

2. structure growth rate $f(z)$



LOS →



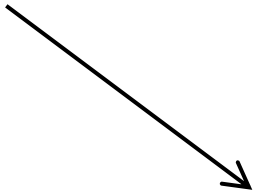
Real Space
$\xi_2 = 0$

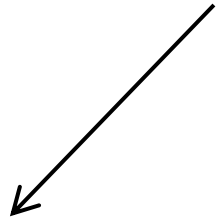
Kaiser Effect
$\xi_2 < 0$

Fake RSD!

Galaxy orientation correlated with LSS

Bias in galaxy orientations from survey





Bias in LSS (specifically $\xi_{2)}$

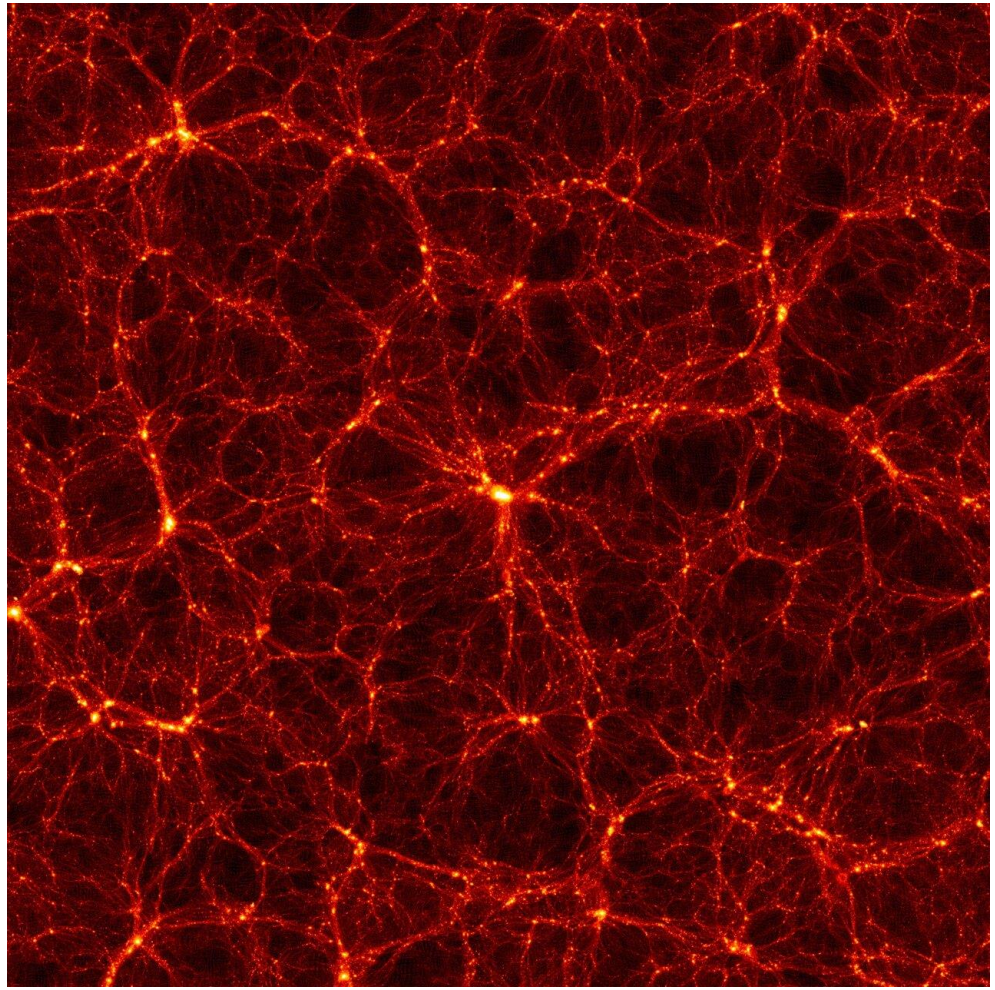
How aperture target selection contaminates RSD measurements

Claire Lamman

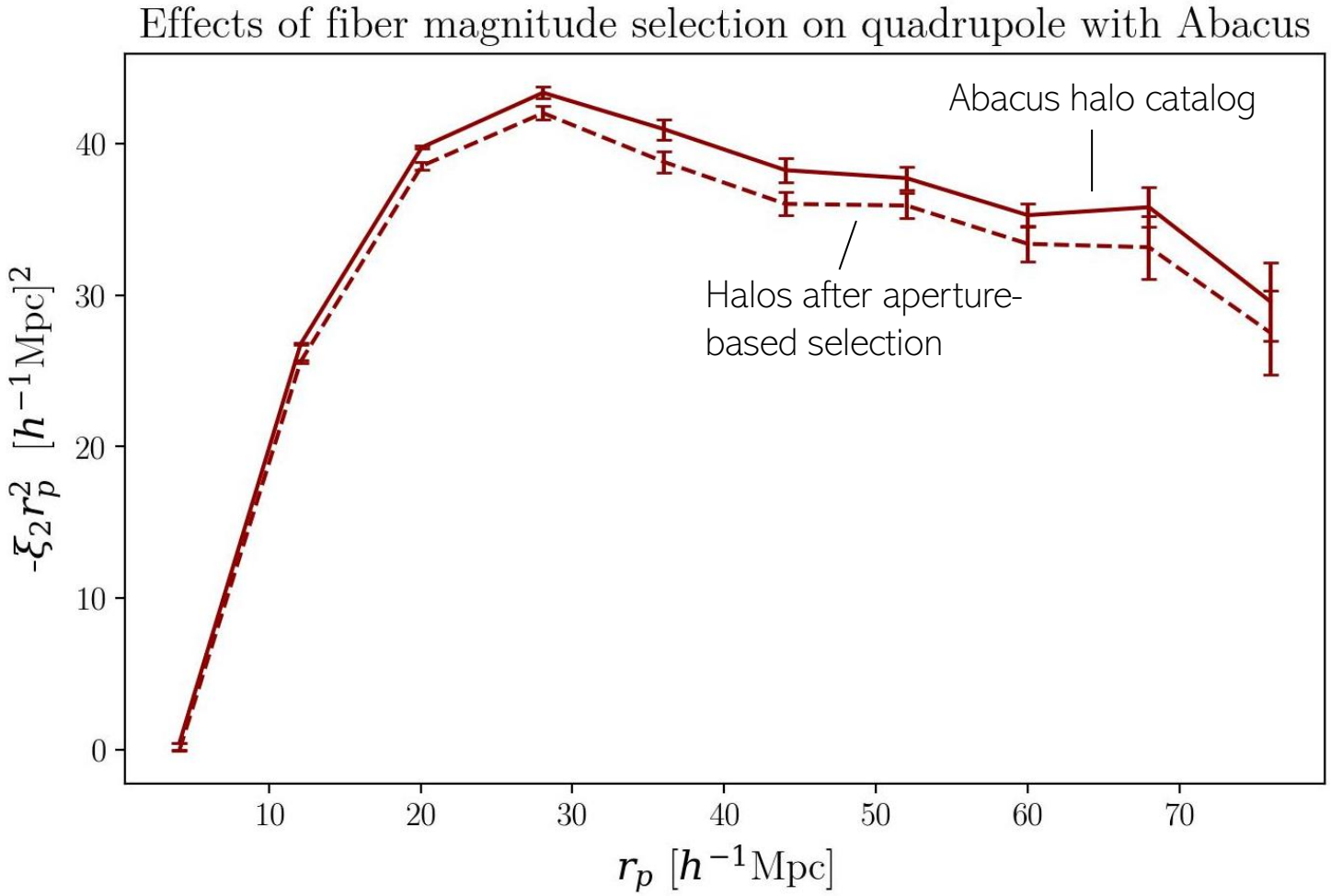
Originally proposed by Hirata 2009

link to video

Demonstration with AbacusSummit Simulations



Lehman Garrison, AbacusSummit
Makismova et al. 2021



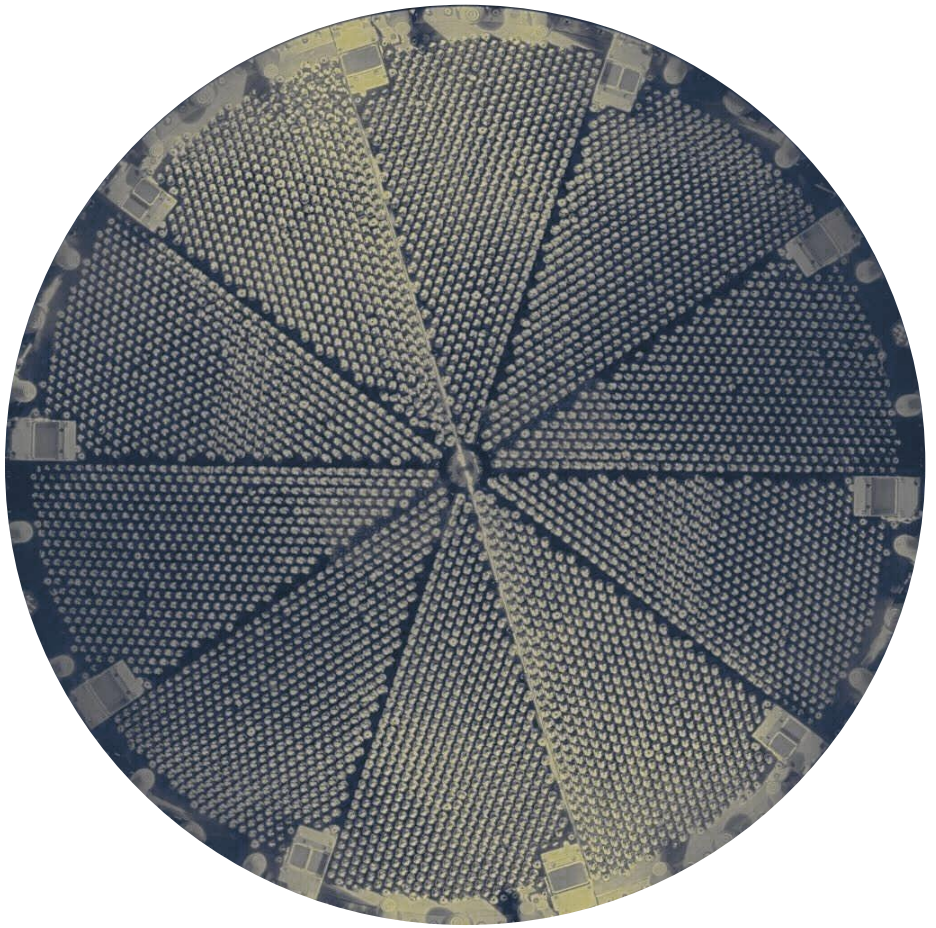
Lamman & Eisenstein, in prep

$$\xi_{\rm GI} = \epsilon_{\rm LRG} \frac{L w_{\times,\rm obs}}{R^2 \frac{d}{dR}\left[\frac{1}{R^2}\Psi\right]} \frac{1}{\langle \epsilon_{zz}^2 \rangle} \int \frac{q^2 dq}{2\pi^2} P(q) j_2(qr)$$

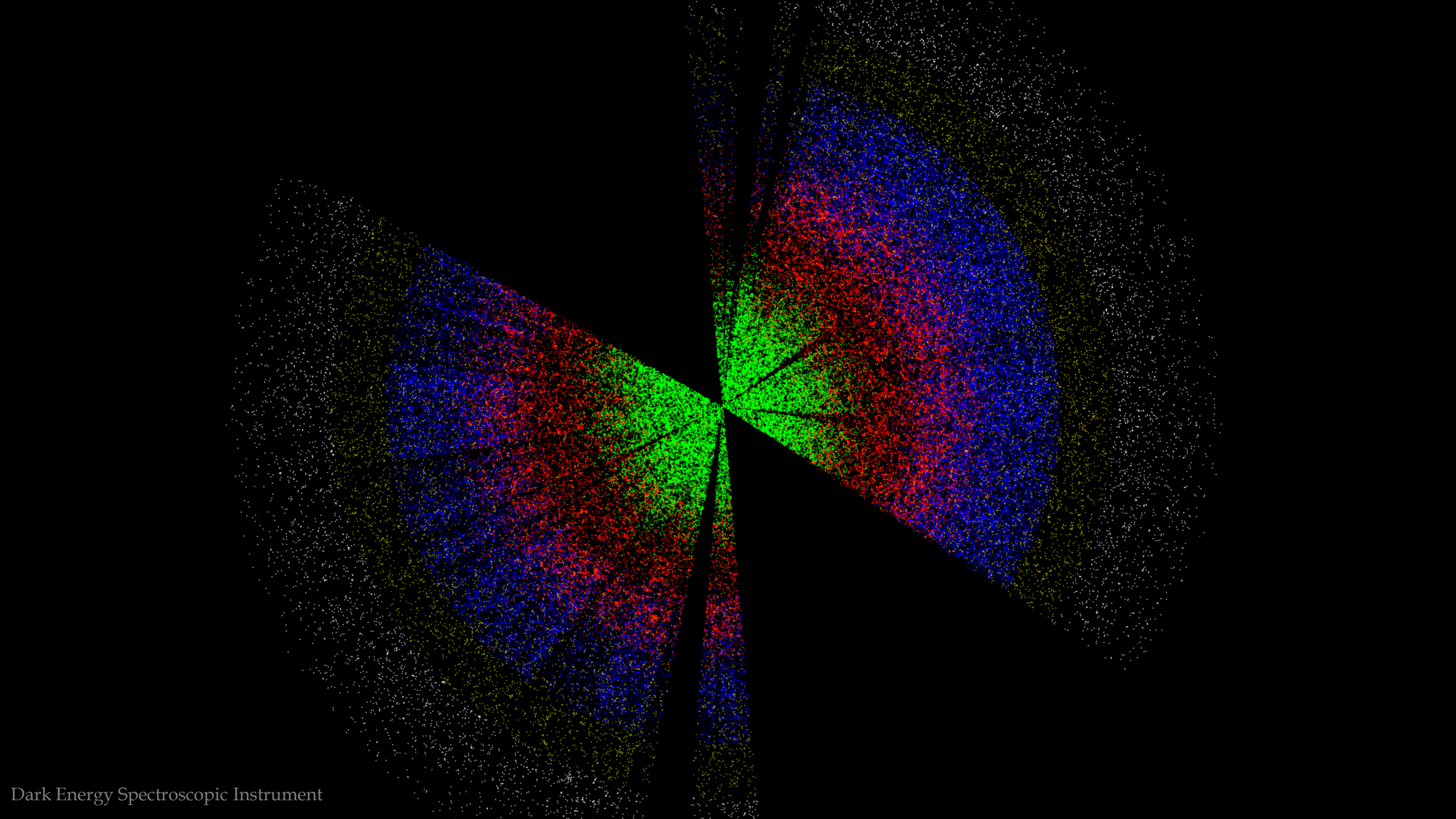
$$\boxed{\xi_{\rm GI} \propto \epsilon_{LRG}\ w_\times}$$

$w_\times$		ϵ_{LRG}		$\xi_{\rm GI}$
LRGs aligned with Tidal Field	+	LRG polarization due to fiber magnitude selection	$\rightarrow$	False ξ_2

Dark Energy Spectroscopic Instrument

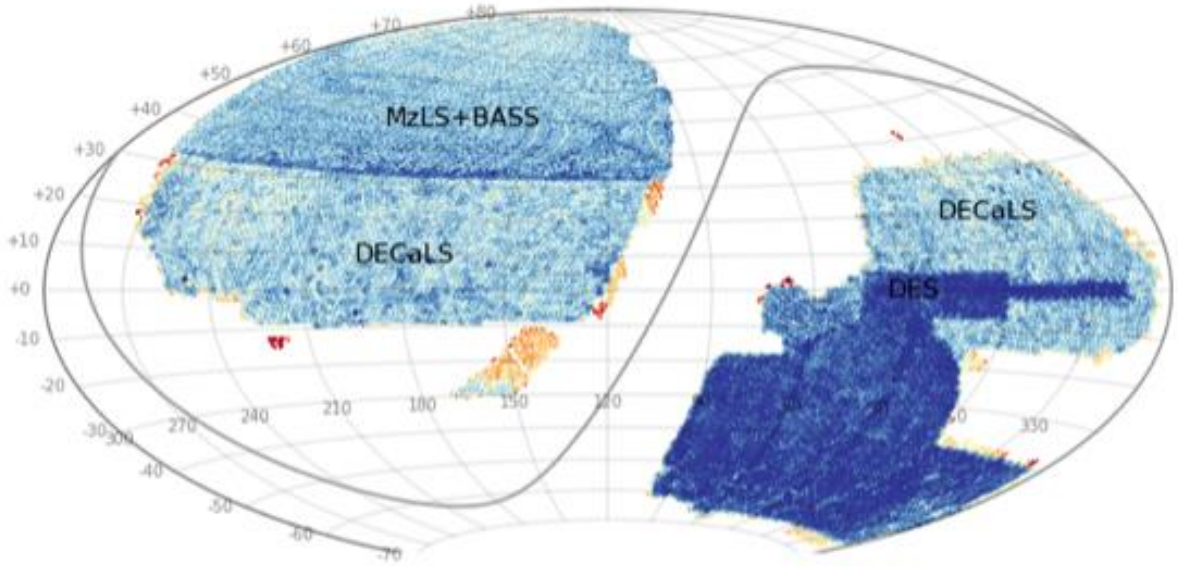


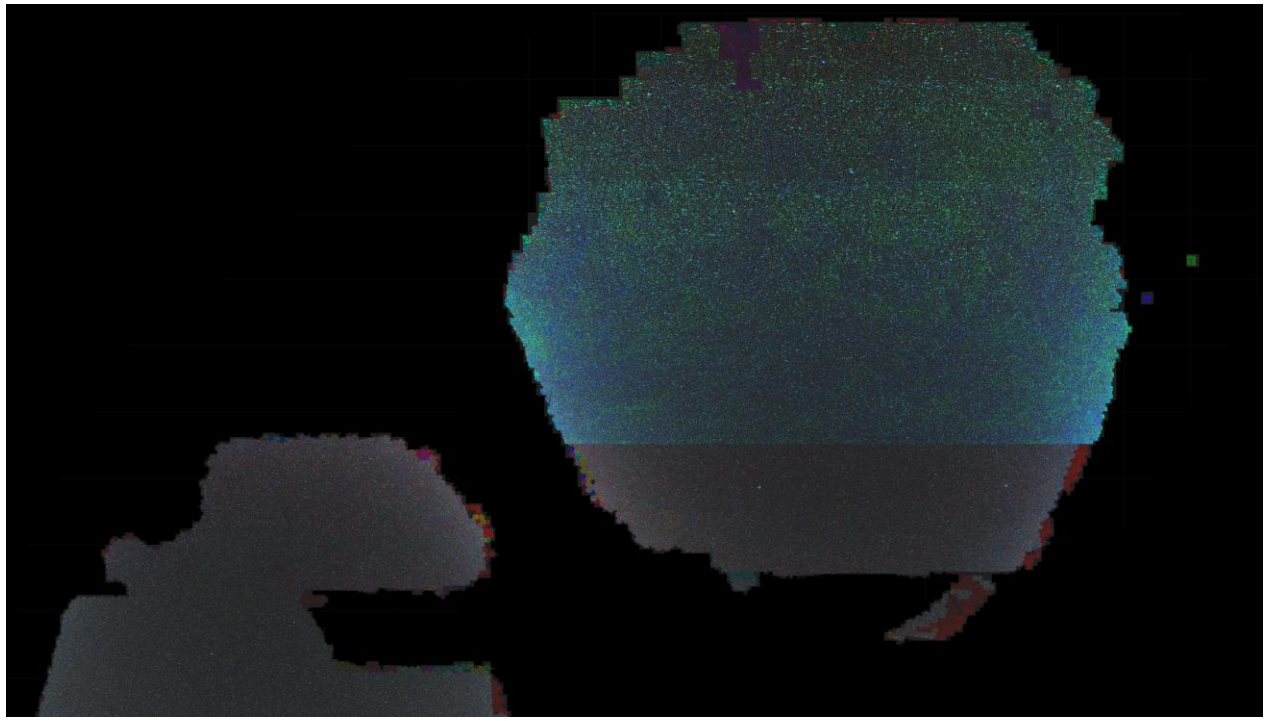
Credit: David Kirkby


Dark Energy Spectroscopic Instrument

legacysurvey.org/viewer

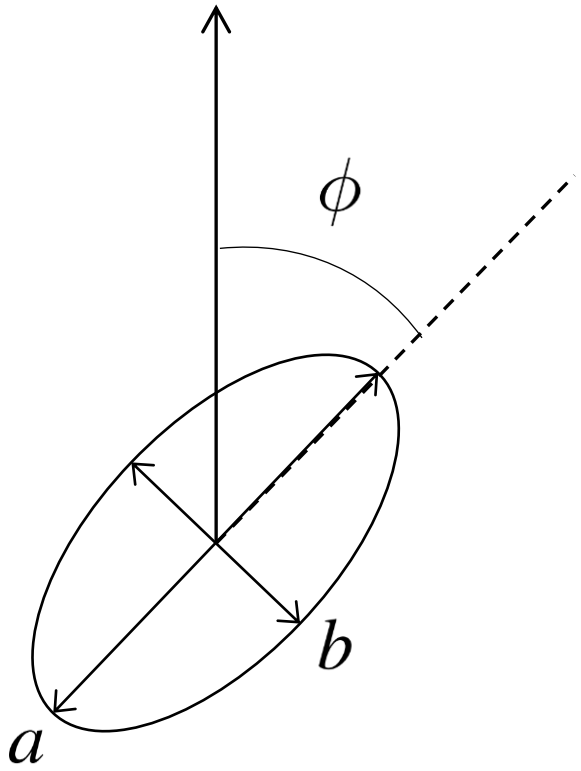
DESI Legacy Imaging Survey





$$\xi_{\rm GI} \propto \epsilon_{LRG}\ w_\times$$

$w_\times$		ϵ_{LRG}		$\xi_{\rm GI}$
LRGs aligned with Tidal Field	+	LRG polarization due to fiber magnitude selection	$\rightarrow$	False ξ_2

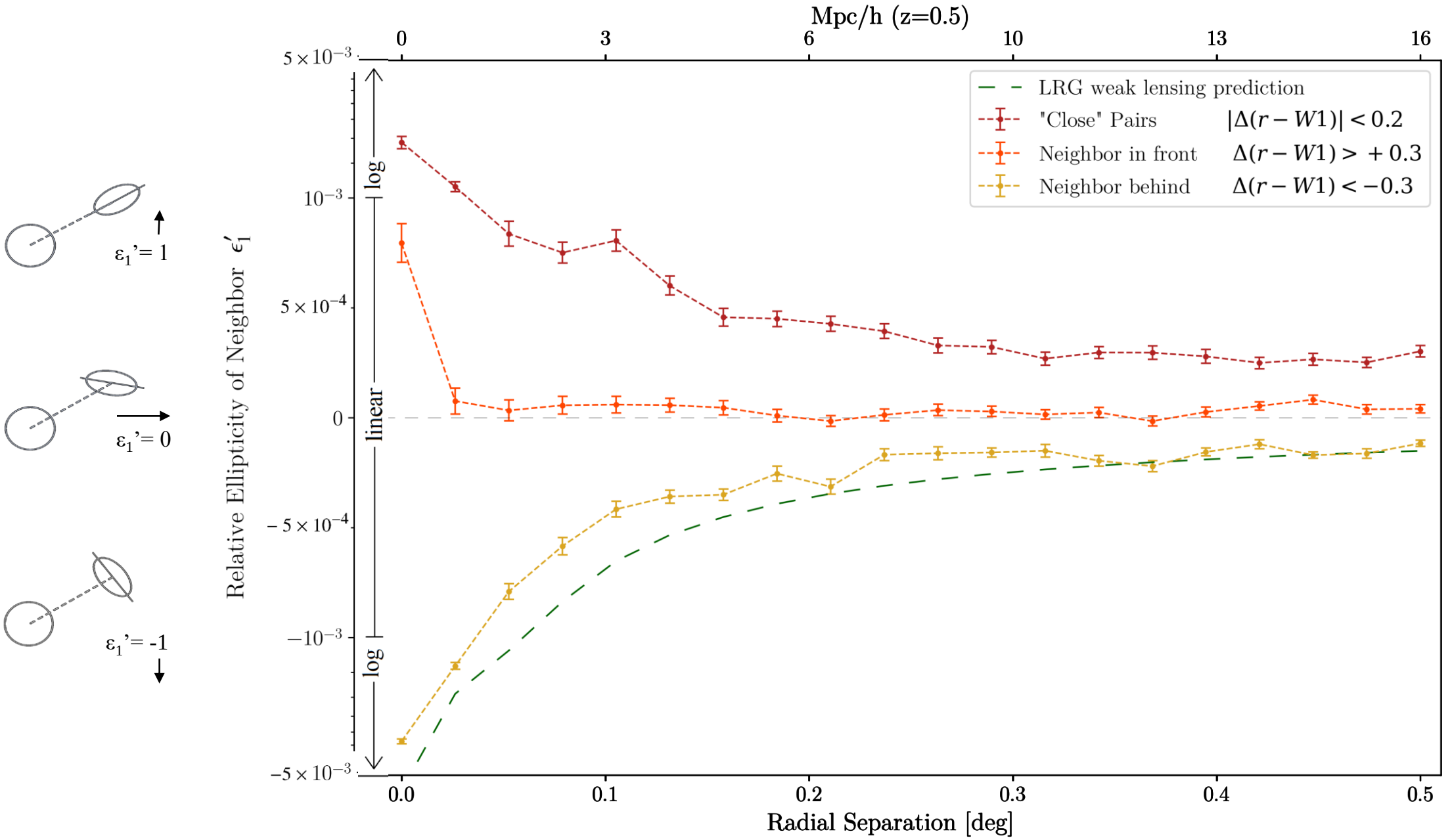


$$\epsilon = \frac{a-b}{a+b} \exp 2i\phi$$

$$\epsilon_1 = Re(\epsilon) = |\epsilon| \cos 2\phi$$

⊗ Line of sight

Shape – Density Alignment $w_\times$



Lamman & Eisenstein, in prep

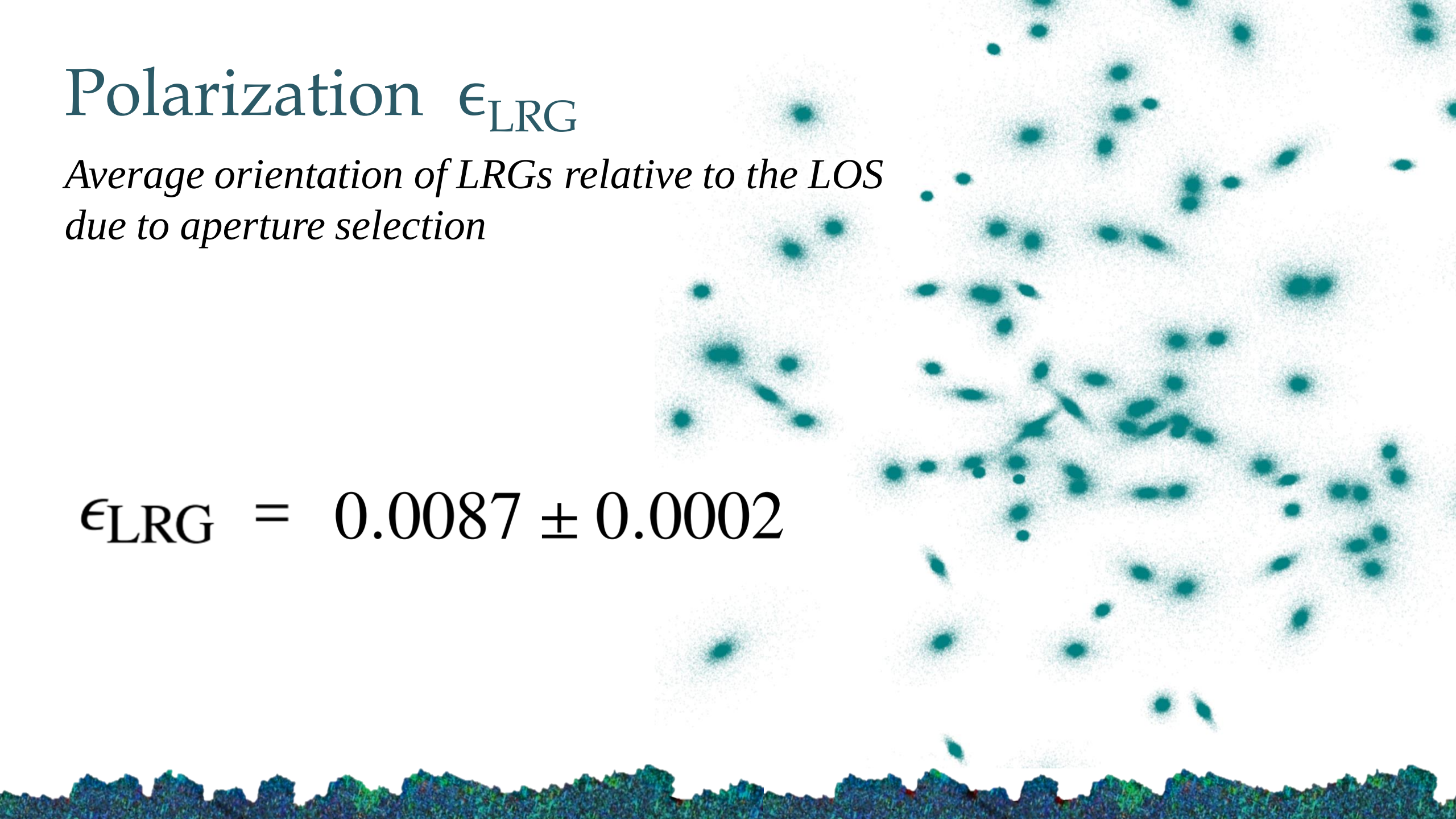
$$\xi_{\rm GI} \propto \epsilon_{LRG}\ w_\times$$

$w_\times$ ϵ_{LRG} $\xi_{\rm GI}$

LRGs aligned with Tidal Field + LRG polarization due to fiber magnitude selection $\rightarrow$ False ξ_2

Polarization ϵ_{LRG}

Average orientation of LRGs relative to the LOS due to aperture selection



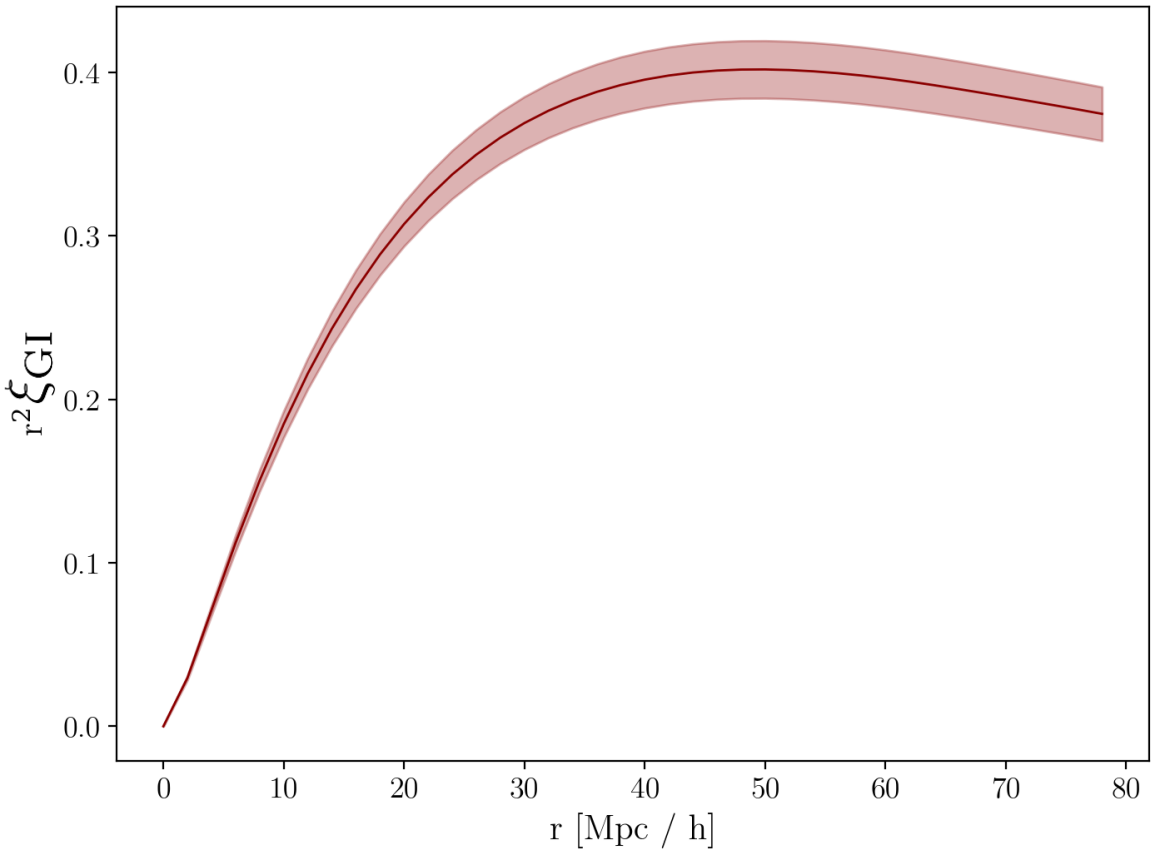
$$\epsilon_{LRG} = 0.0087 \pm 0.0002$$

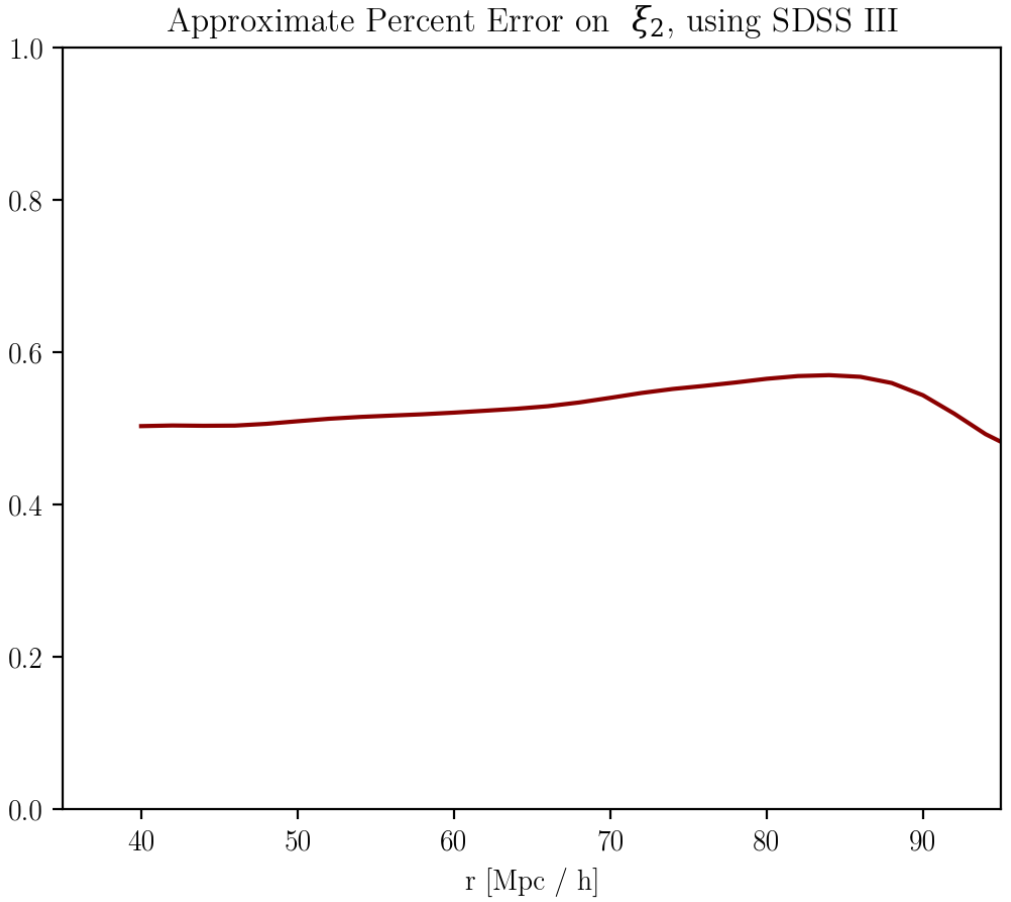
$$\xi_{\rm GI} \propto \epsilon_{LRG}\ w_\times$$

$w_\times$ | ϵ_{LRG} | $\xi_{\rm GI}$

LRGs aligned with Tidal Field + LRG polarization due to fiber magnitude selection $\rightarrow$ False ξ_2

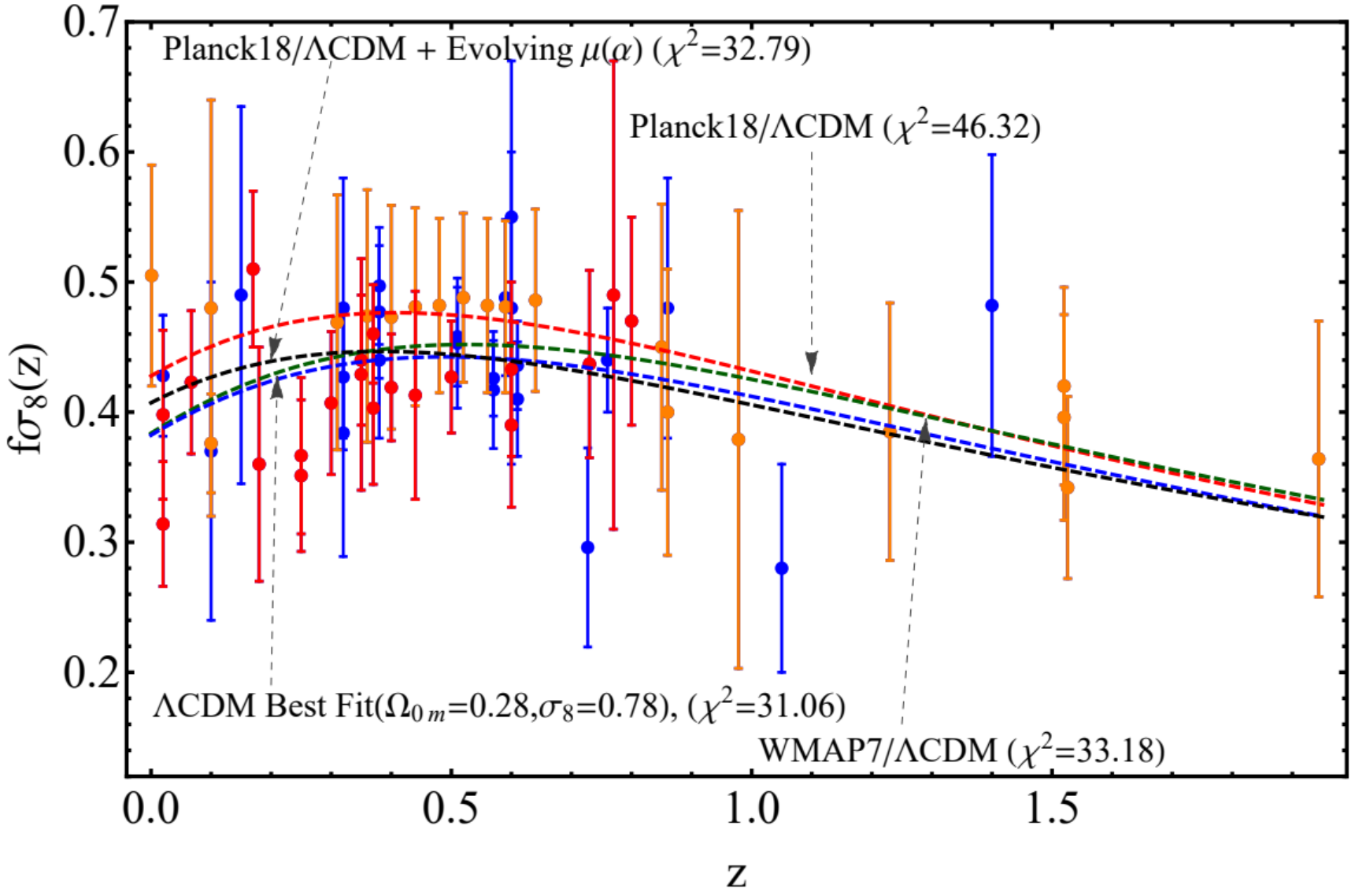
Bias on ξ_2





Lamman & Eisenstein, in prep

Kazantzidis & Perivolaropoulos, 2021



Summary

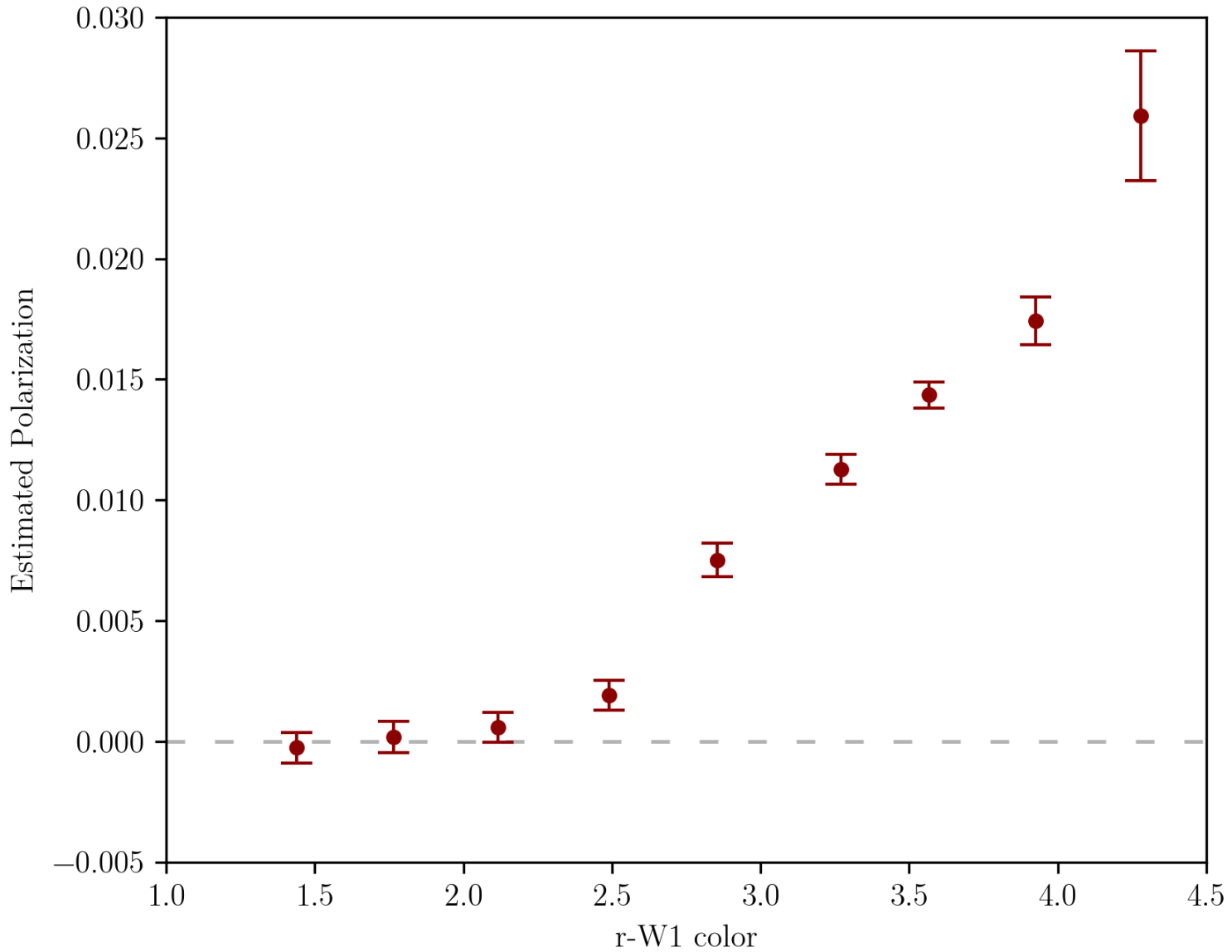
Any survey which:

1. Has an orientation-dependent selection bias
2. Is surveying galaxies with tidal alignments

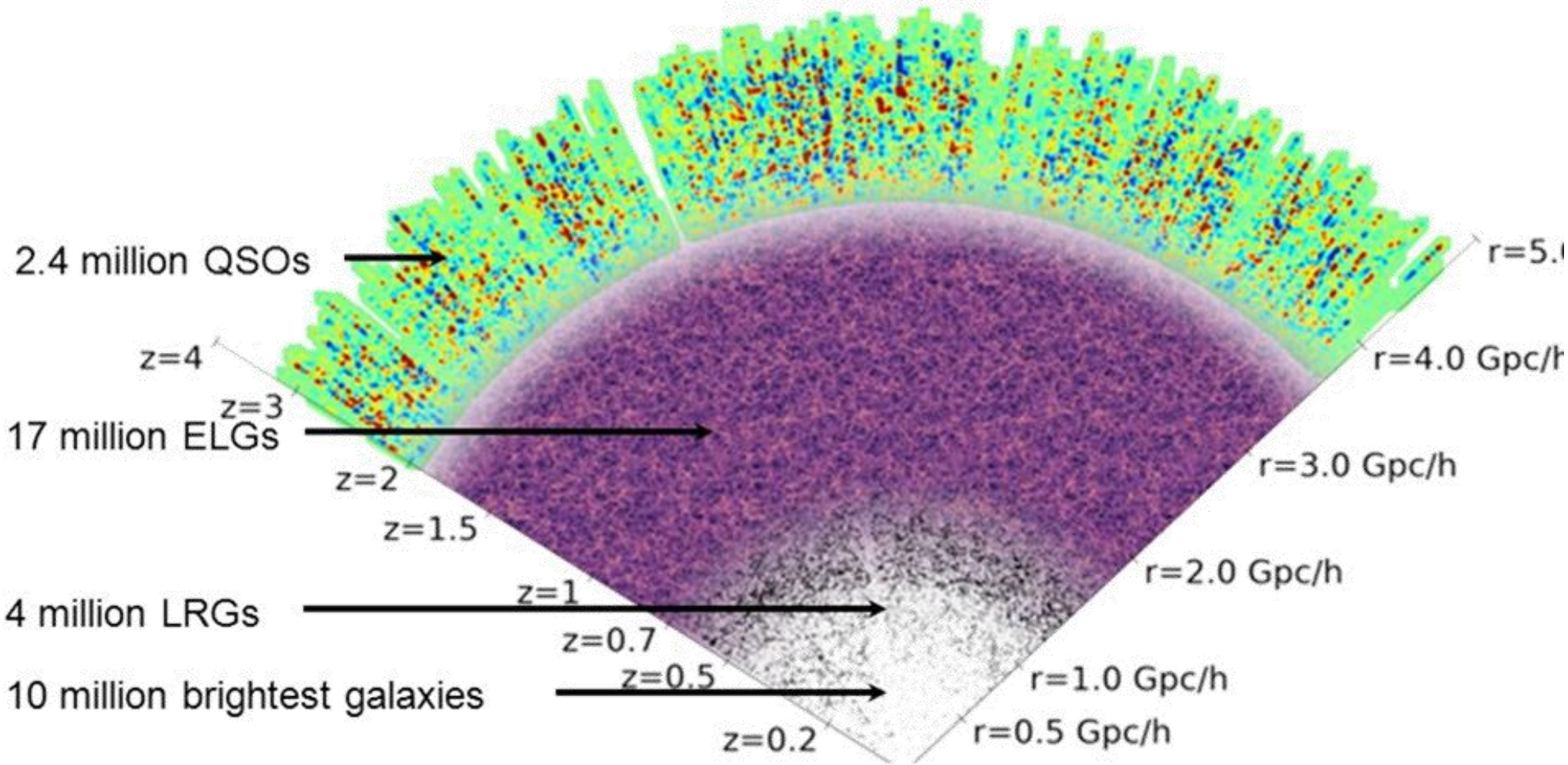
…will have biased RSD measurements

DESI preferentially selects galaxies in density filaments which lie along the LOS.

This dampens ξ_2, and therefore the rate of structure growth, on large scales.



Lamman & Eisenstein, in prep


2.4 million QSOs
17 million ELGs
4 million LRGs
10 million brightest galaxies
z=4
z=3
z=2
z=1.5
z=1
z=0.7
z=0.5
z=0.2
r=4.0 Gpc/h
r=3.0 Gpc/h
r=2.0 Gpc/h
r=1.0 Gpc/h
r=0.5 Gpc/h

Huterer, Kirkby et al. 2015

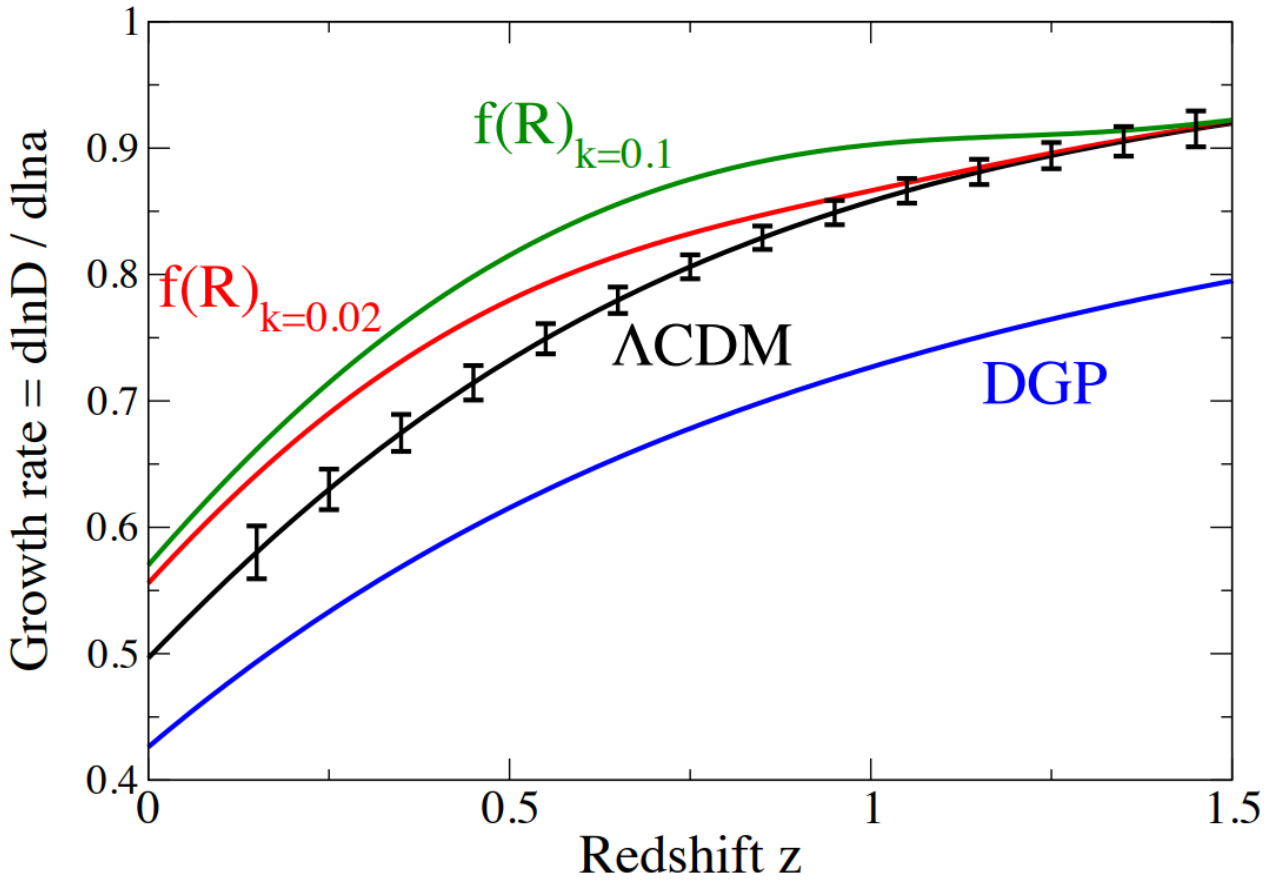


Figure 2. *Constraints on the growth of density fluctuations in the Universe with errors projected from a future survey designed with DESI specifications. The curves show the derivative of the logarithmic growth with respect to the logarithmic scale factor — a quantity readily measured from the clustering of galaxies in redshift space — as a function of redshift. We show theory predictions for the ΛCDM model, as well as for two modified-gravity models: the Dvali-Gabadadze-Porrati braneworld model [3] and the $f(R)$ modification to the Einstein action [4]. Because growth in the $f(R)$ models is generically scale-dependent, we show predictions at two wavenumbers, $k = 0.02\,h\,\mathrm{Mpc}^{-1}$ and $k = 0.1\,h\,\mathrm{Mpc}^{-1}$. LSST projects to impose constraints of similar excellent quality on the growth function $D(a)$.*