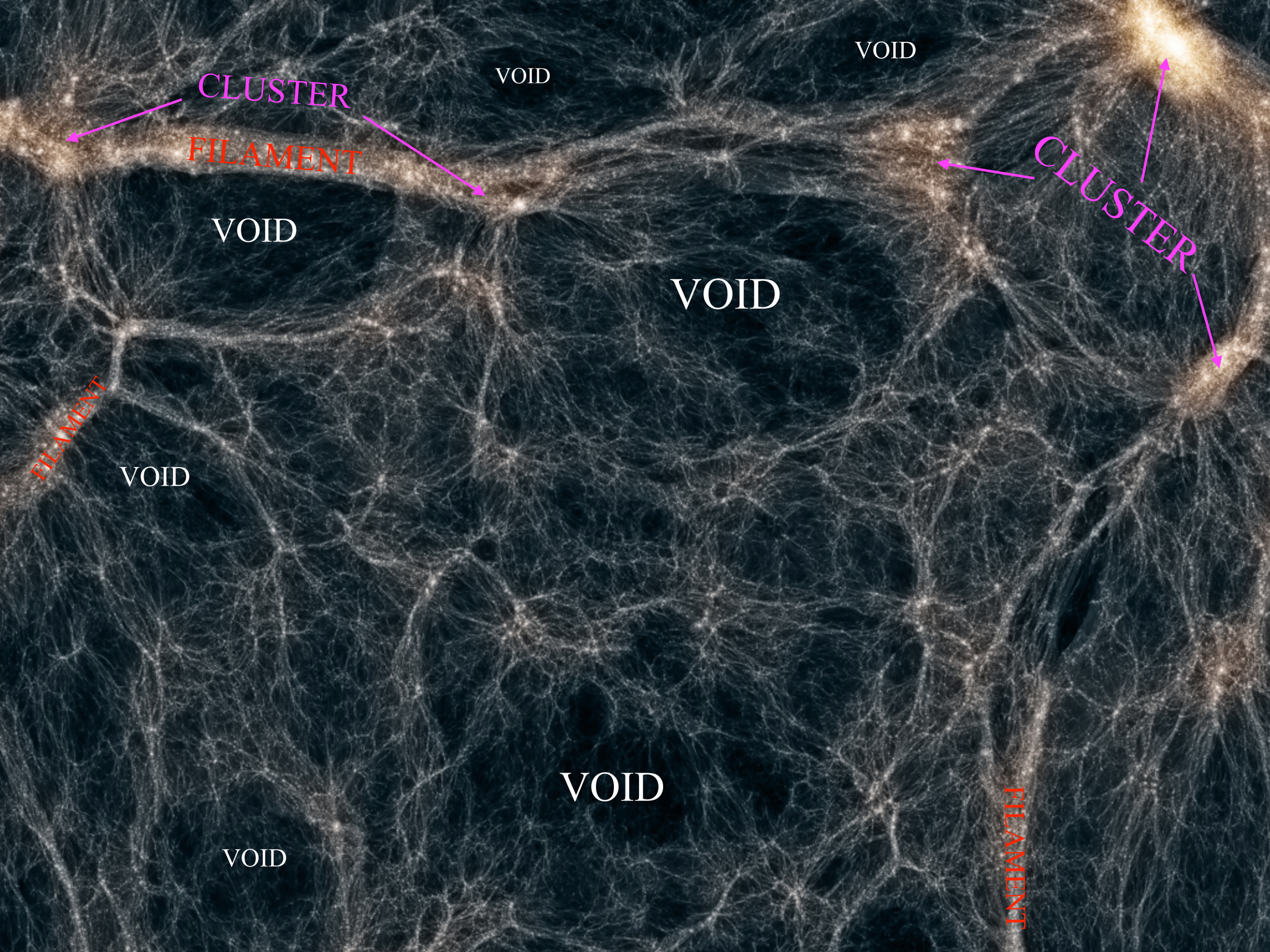
# Modelling the Vast, Expanding Emptiness of the Cosmic Web

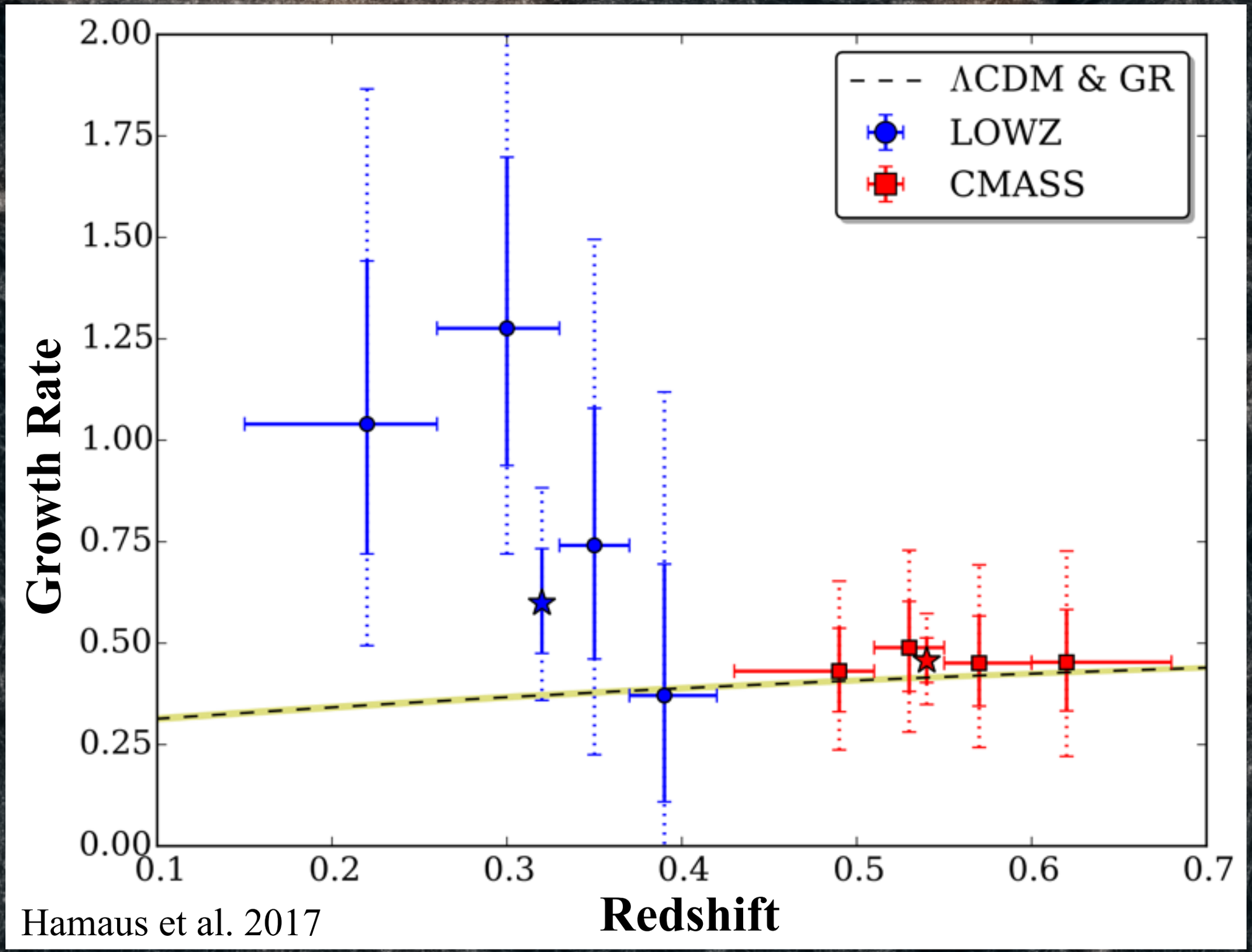
**Vasiliy Demchenko**
with Yan-Chuan Cai and Catherine Heymans
University of Edinburgh

DEX XV
University of Edinburgh
07/01/2019

Image credit: Teyssier and Pontoon (ChaNGa)

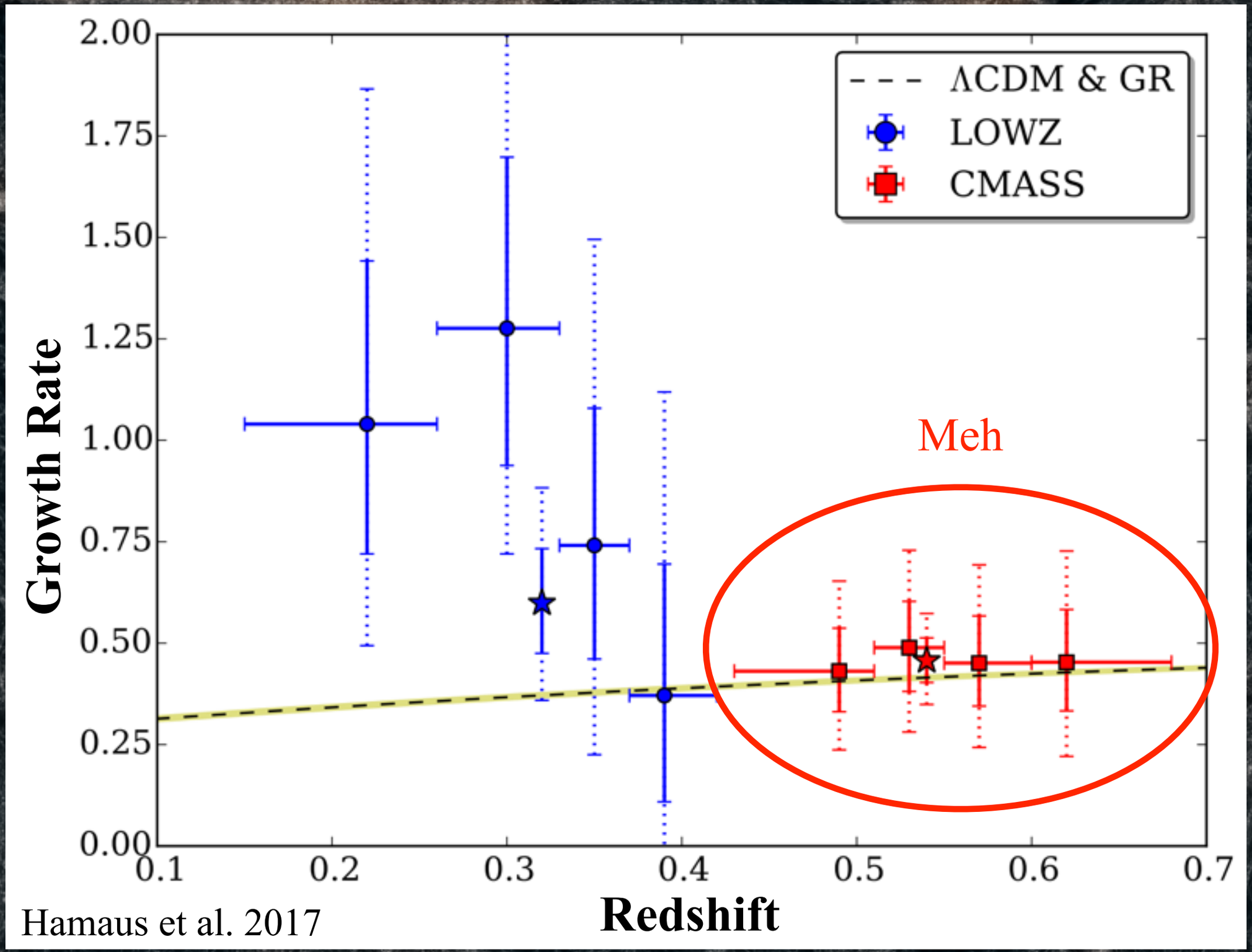

CLUSTER
FILAMENT
VOID
VOID
VOID
CLUSTER
VOID
FILAMENT
VOID
VOID
VOID
FILAMENT

# RSD around Voids



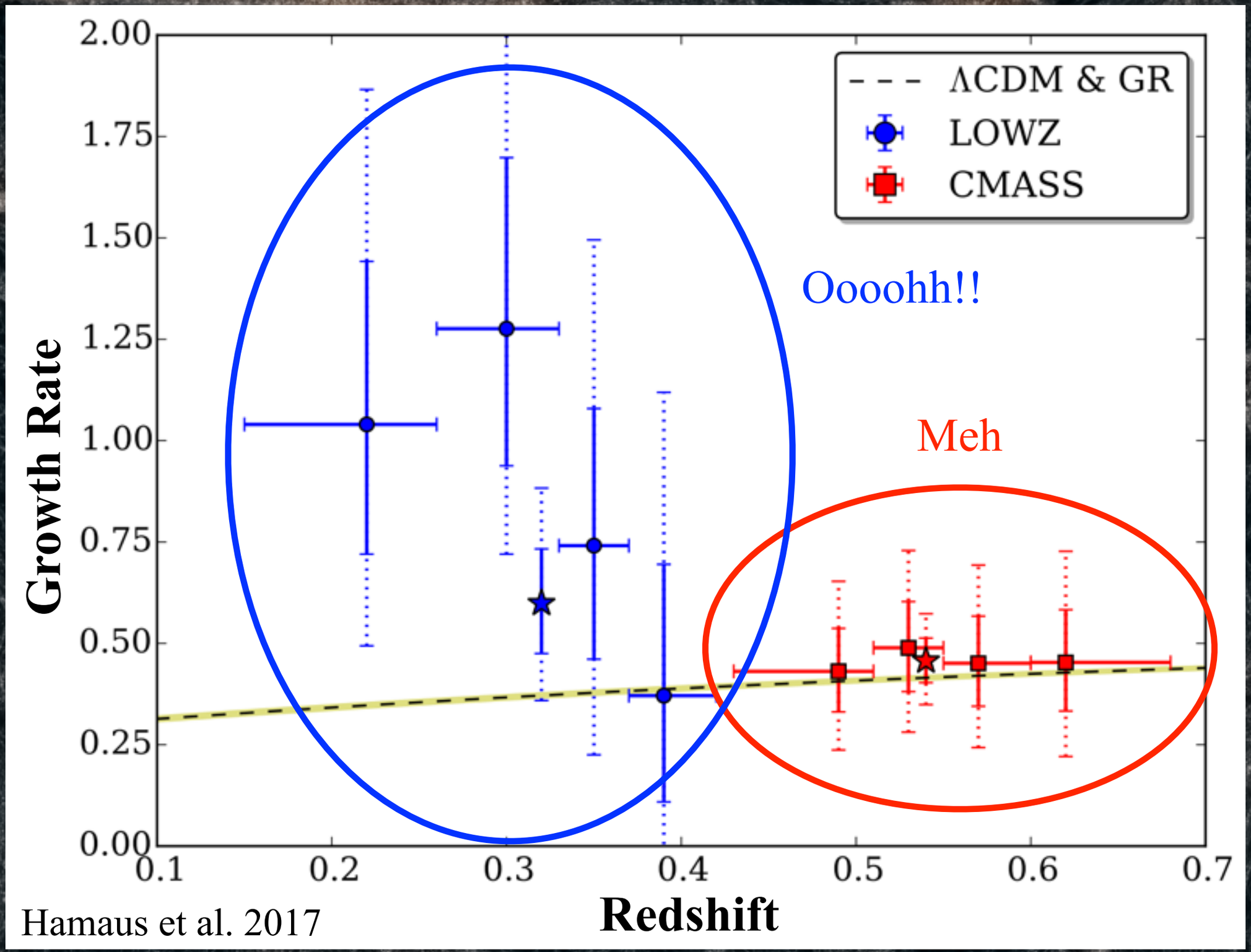

Hamaus et al. 2017

# RSD around Voids



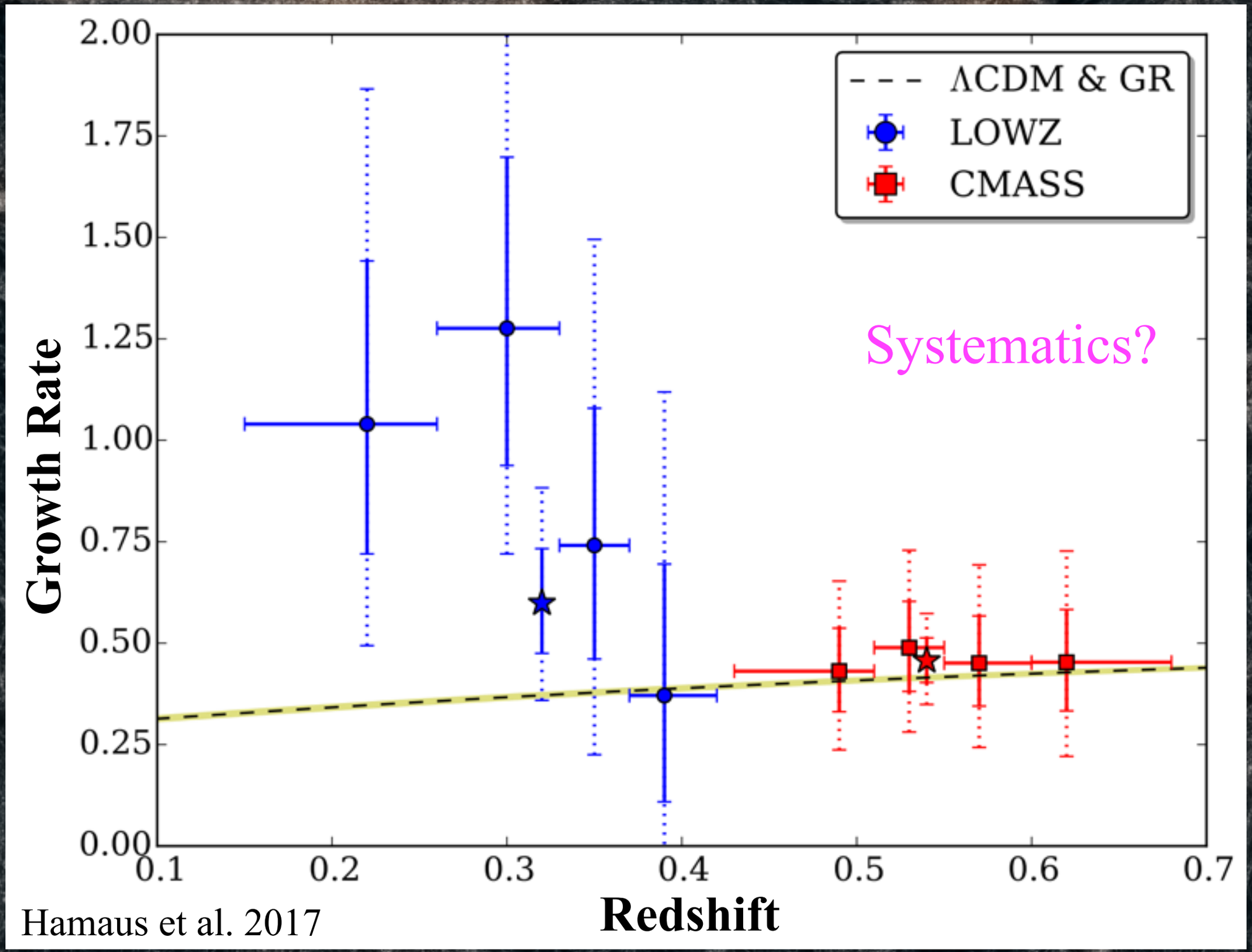

Hamaus et al. 2017

# RSD around Voids



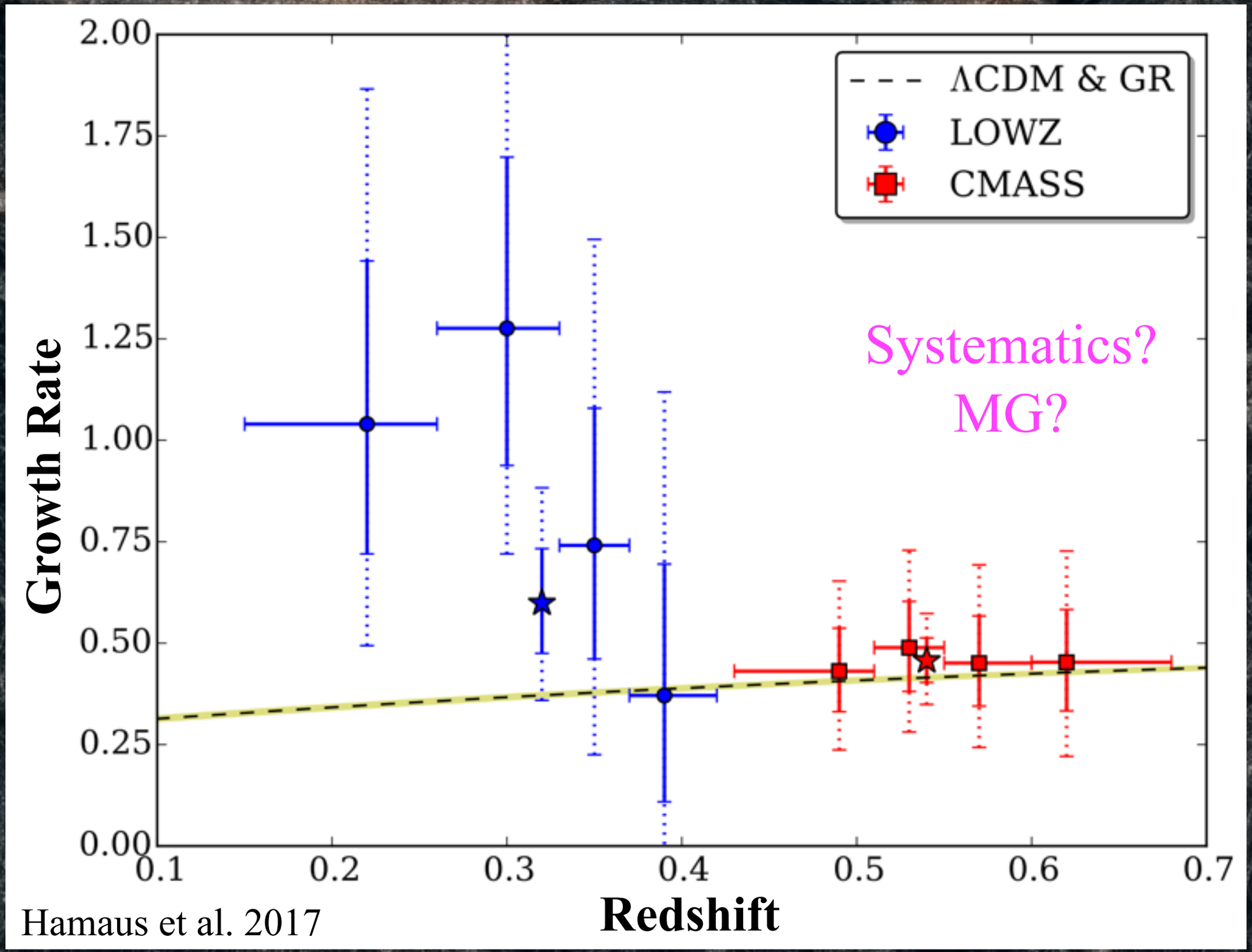

Hamaus et al. 2017

# RSD around Voids



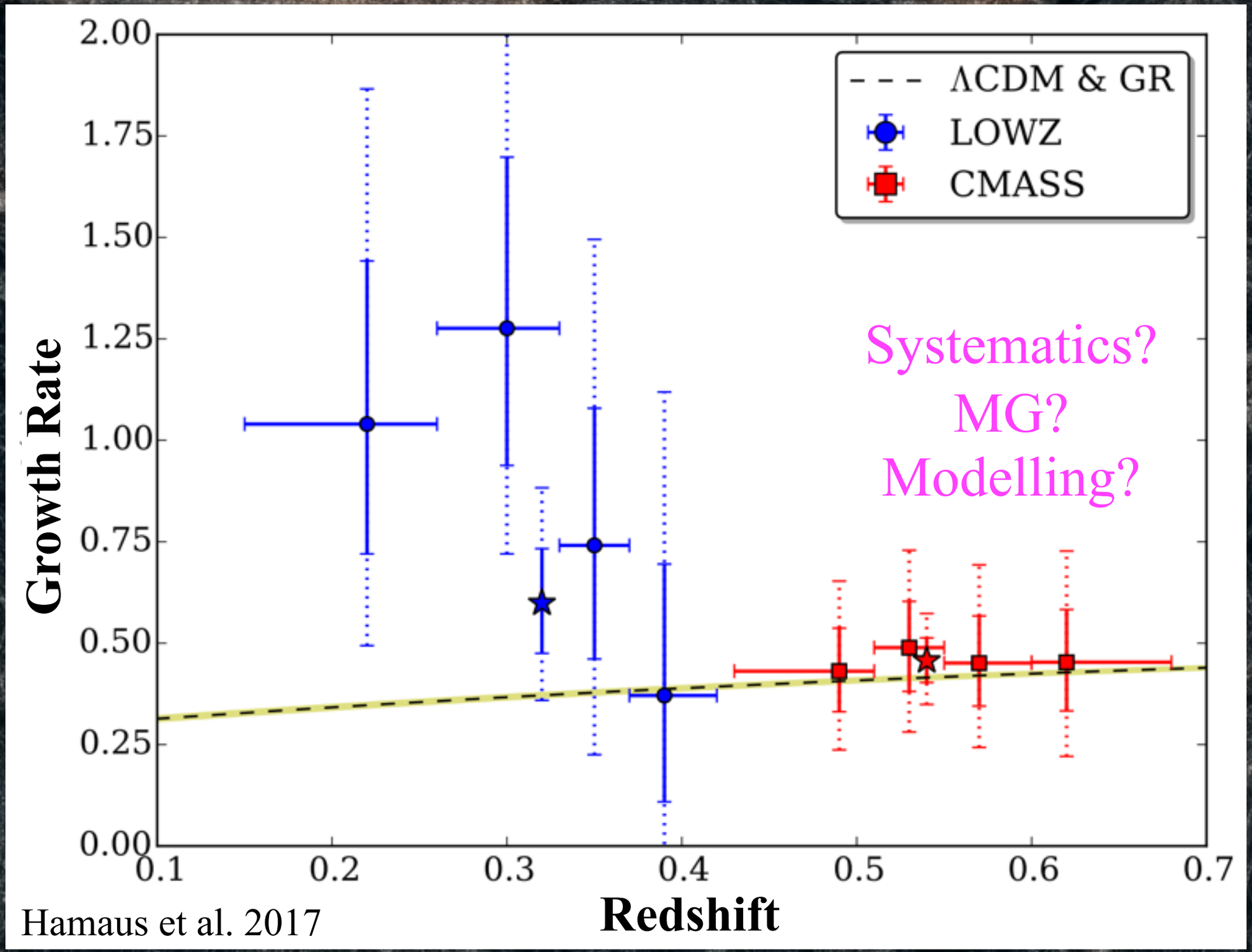

Hamaus et al. 2017

# RSD around Voids




Hamaus et al. 2017

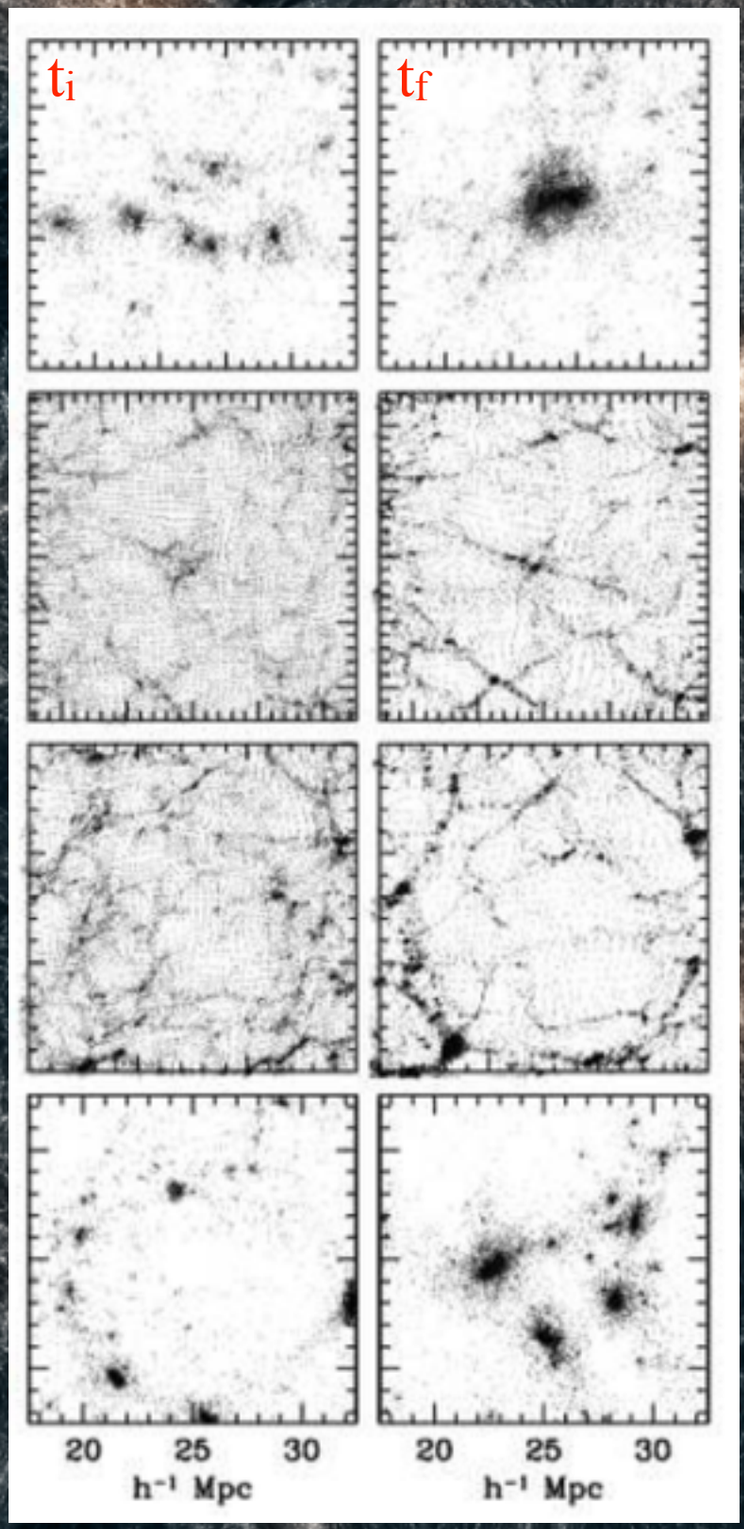
# RSD around Voids




Hamaus et al. 2017

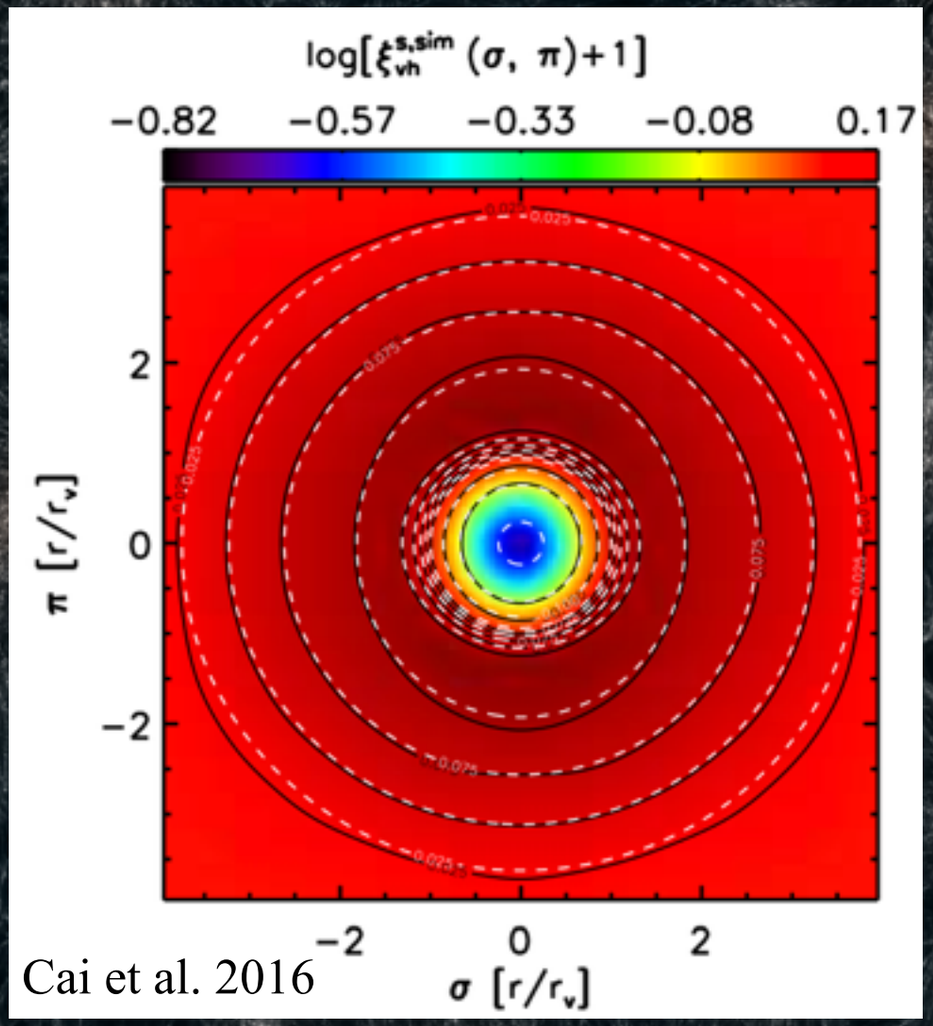
# The Spherical Model

- Press & Schechter 1974 Excursion Set
- Extended to voids by Sheth & van de Weygaert 2003
- Analogous to halo mass function and spherical collapse threshold, $\delta_c$




See **Demchenko** et al. 2016 (ArXiV: 1605.05286)

# Linear Growth Rate




Cai et al. 2016

RSD growth rate estimator

$$\tilde{G}(f) = \frac{\xi_2^s(r)}{\xi_0^s(r) - \frac{3}{r^3}\int_0^r \xi_0^s(r')r'^2 dr'} = \frac{2f}{3+f}.$$

Cai et al 2016

# Linear Growth Rate

- GR
  - Independent of equation-of-state i.e. $\gamma = 0.55$ holds
  - Independent of environment

- MG
  - $\gamma$ could differ from 0.55 (Linder & Cahn 2007)
  - Screening mechanisms

RSD growth rate estimator

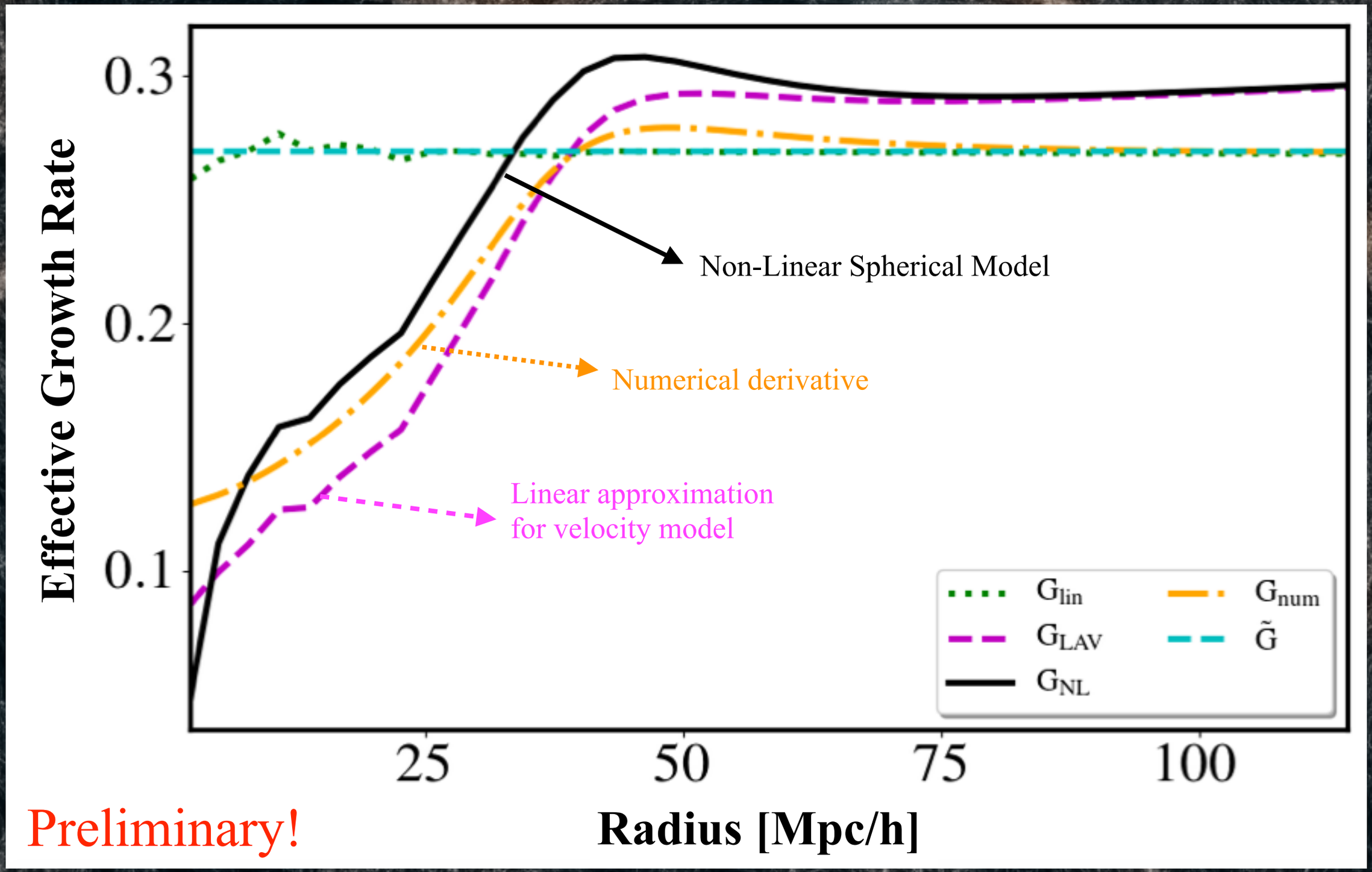
$$\tilde{G} = \frac{2f}{3+f}$$

Linear growth rate

$$f = \Omega_{\rm m}^{0.55}$$

Cai et al 2016

# Spherical Model RSD




Preliminary!

# Conclusions

- Measuring linear growth rate from void RSD can lead to an understanding of gravity

- Spherical model provides non-linear peculiar velocities for voids, alleviating any linear approximations in RSD modelling

- Can be used to measure the density-dependent growth rate and Density Split Statistics!

Image: Raphaël Errani

# Thank You!!