DETERMINING COSMOLOGICAL PARAMETERS WITH COSMIC VOIDS

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NON FIDUCIAL COSMOLOGY

ALCOCK-PACZYŃSKI TEST

WITH COSMIC VOIDS

PRECEDENTS:

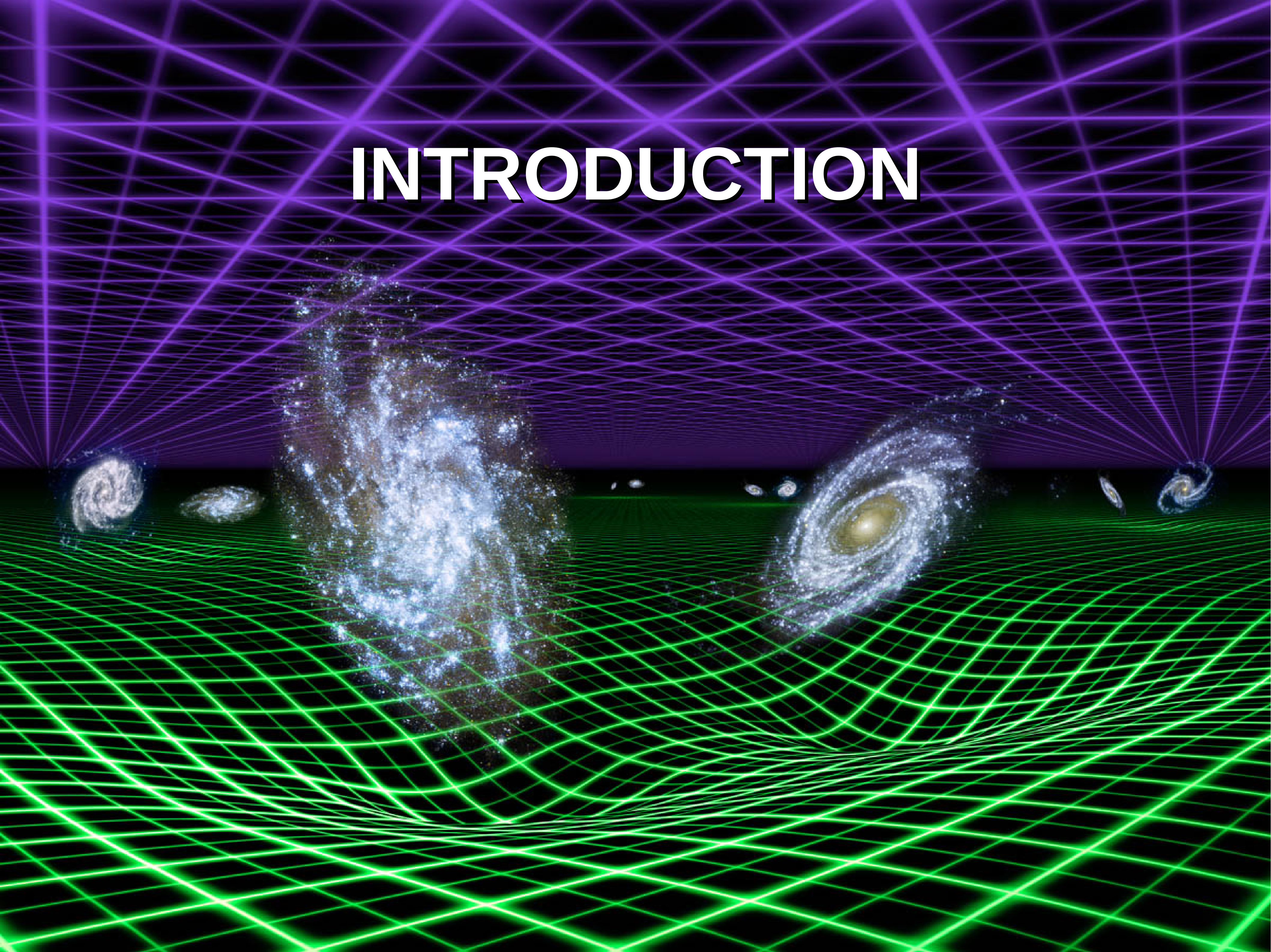
Lavaux et al. (2012); Sutter et al. (2014)

Cai et al. (2016)

Hamaus et al. (2015, 2016)

Figure from Euclid Project (ESA)

INTRODUCTION

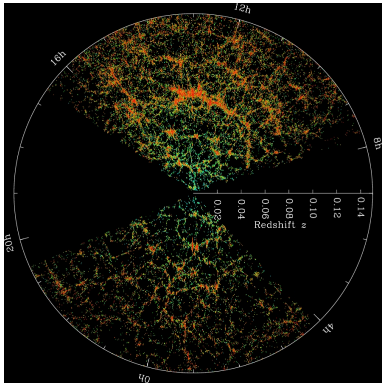


Voids as cosmological laboratories

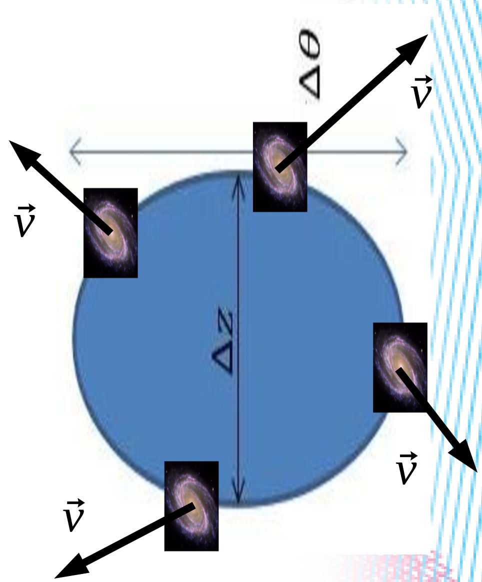
Voids are the **subdense regiosns** of the universe.

As fundamental components of the large scale structure of the universe, they contain invaluable informaction about its fundamental properties:

- **Geometry**
- **Energy and matter content** $(H_{0,}\Omega_m, \Omega_\Lambda)$
- **Nature of gravitation**



SDSS
Abazajian et al. (2009)



FUNDAMENTAL OBSERVABLES:
ANGULES AND REDSHIFTS (Δθ,Δz)

REDSHIFT SURVEYS OF GALAXIES

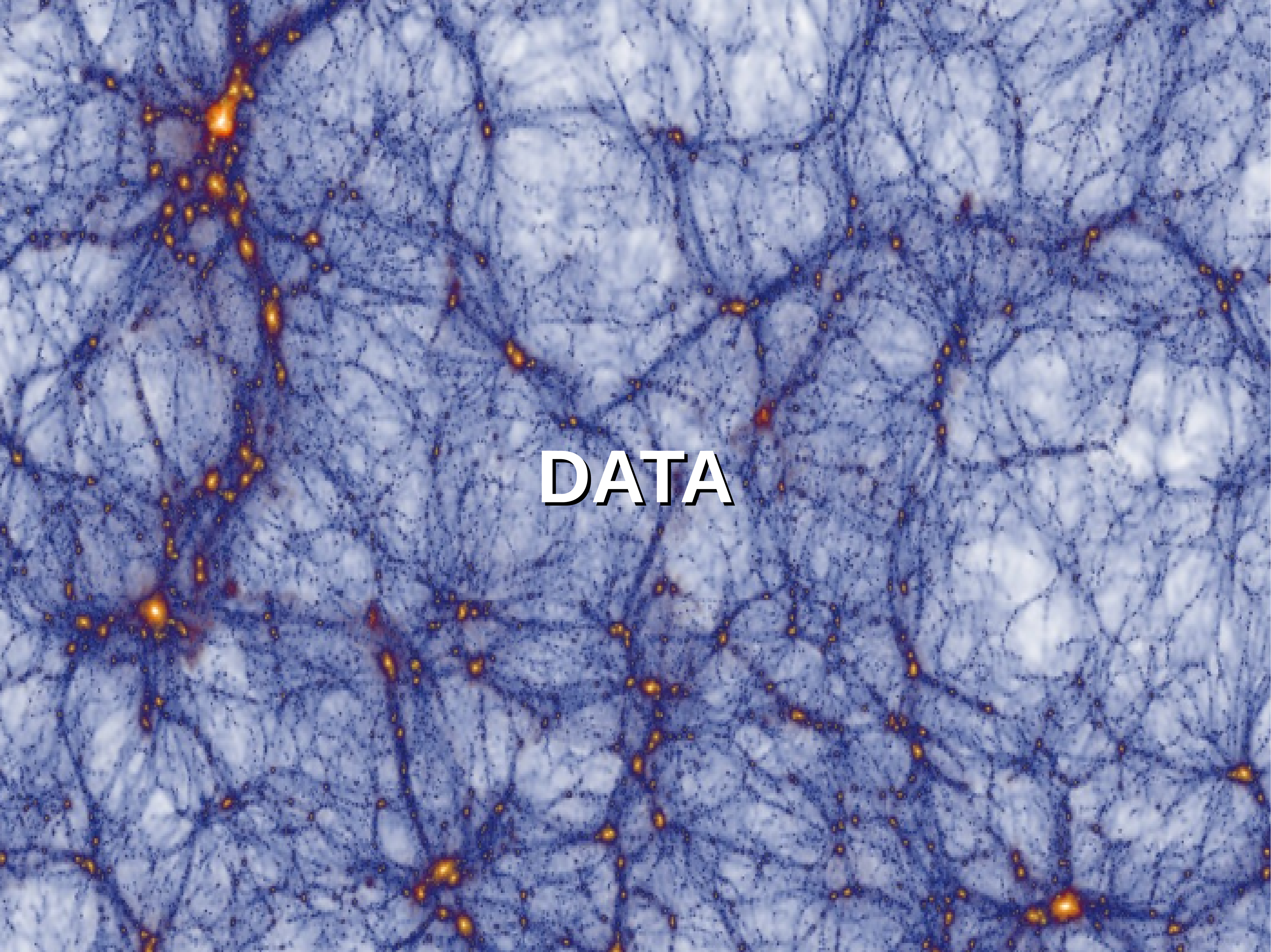
REDSHIFT SPACE DISTORTIONS (RSD)

GEOMETRIC DISTORTIONS (GD)

$$(\Delta\theta, \Delta z) \rightarrow (\sigma, \pi)[h^{-1} Mpc]$$

(Alcock & Paczyński 1979)

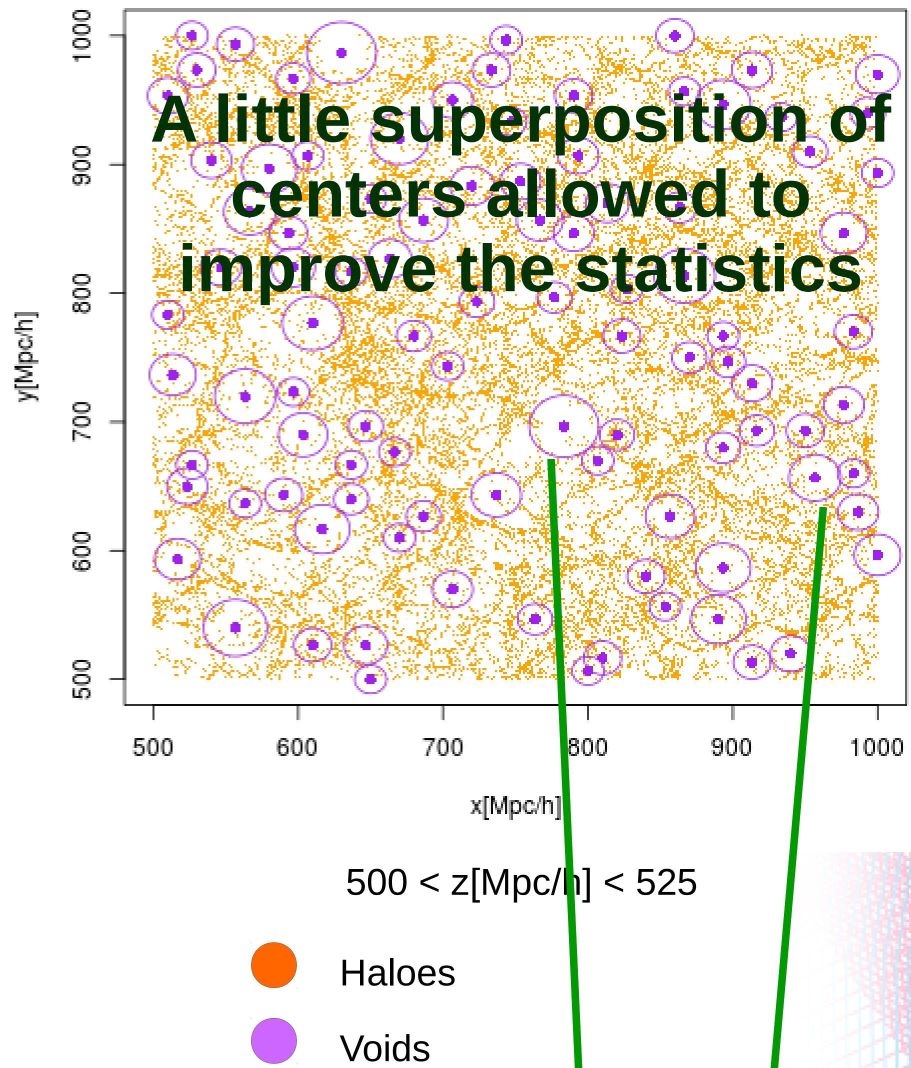
COSMOLOGICAL INFORMATION


DATA

Siumulated voids

SIMULATION	
Name	**Millennium XXL** Angulo et al. (2012)
Cosmology	• $\Omega_m = 0.25$ • $\Omega_\Lambda = 0.75$ • $H_0 = 73$ km s^{-1} Mpc^{-1}
Dimensions	3 h^{-1} Gpc size
Particles	**Dark matter haloes**
Snapshots	**0.5; 1; 1.5**
Impact	**Resolution and volume (future surveys)**

VOIDS	
Identificator	Modified version of Padilla et al. (2005)
Description	**Subdense spheres**
Radius criterion	**20% mean integrated density** of the universe



VOID IN VOID SAMPLE

VOID IN CLOUD SAMPLE

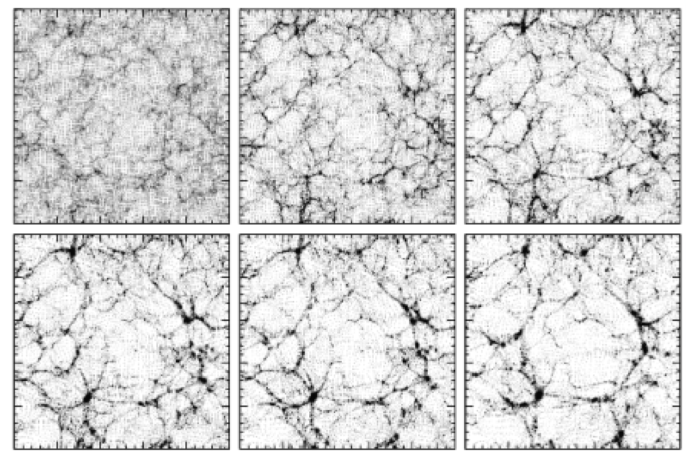
Enviroment and dynamics

Sheth & van de Weygaert (2004)

Ceccarelli et al. (2013)

Paz et al. (2013)

ENVIROMENT ⇨ DYNAMICS



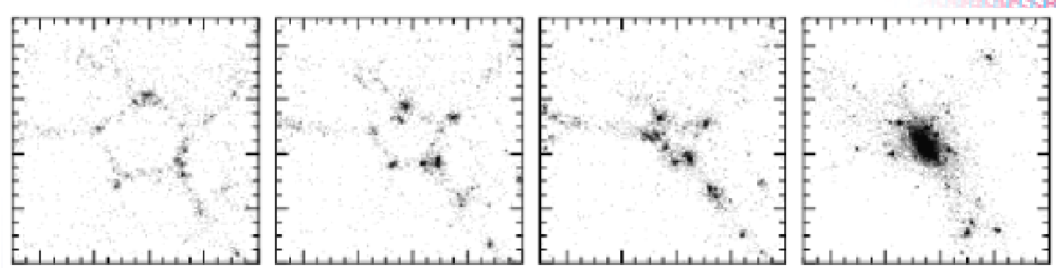
SUBDENSE → EXPANSION

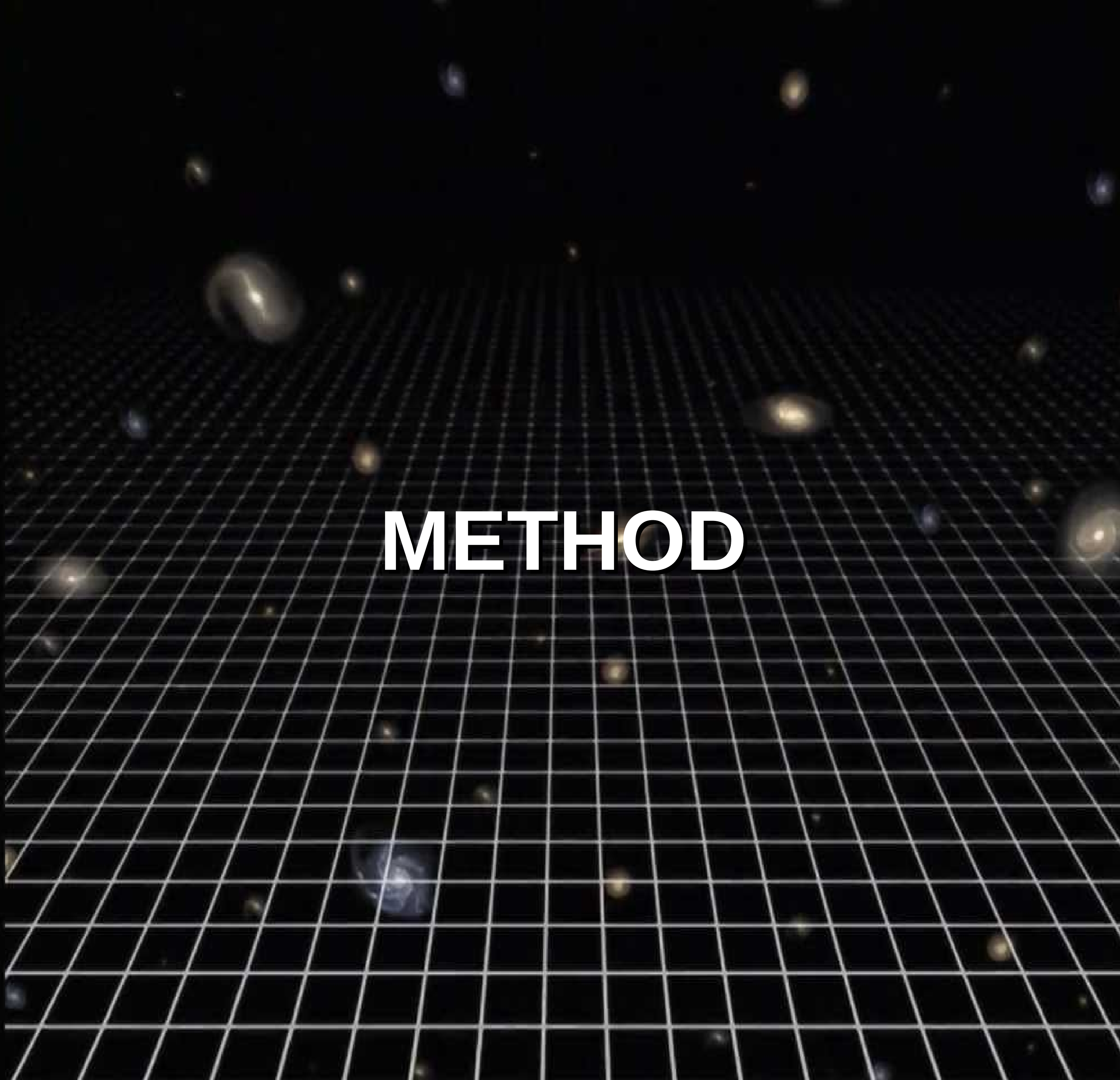
VOID-IN-VOID

ENVIROMENT

VOID-IN-CLOUD

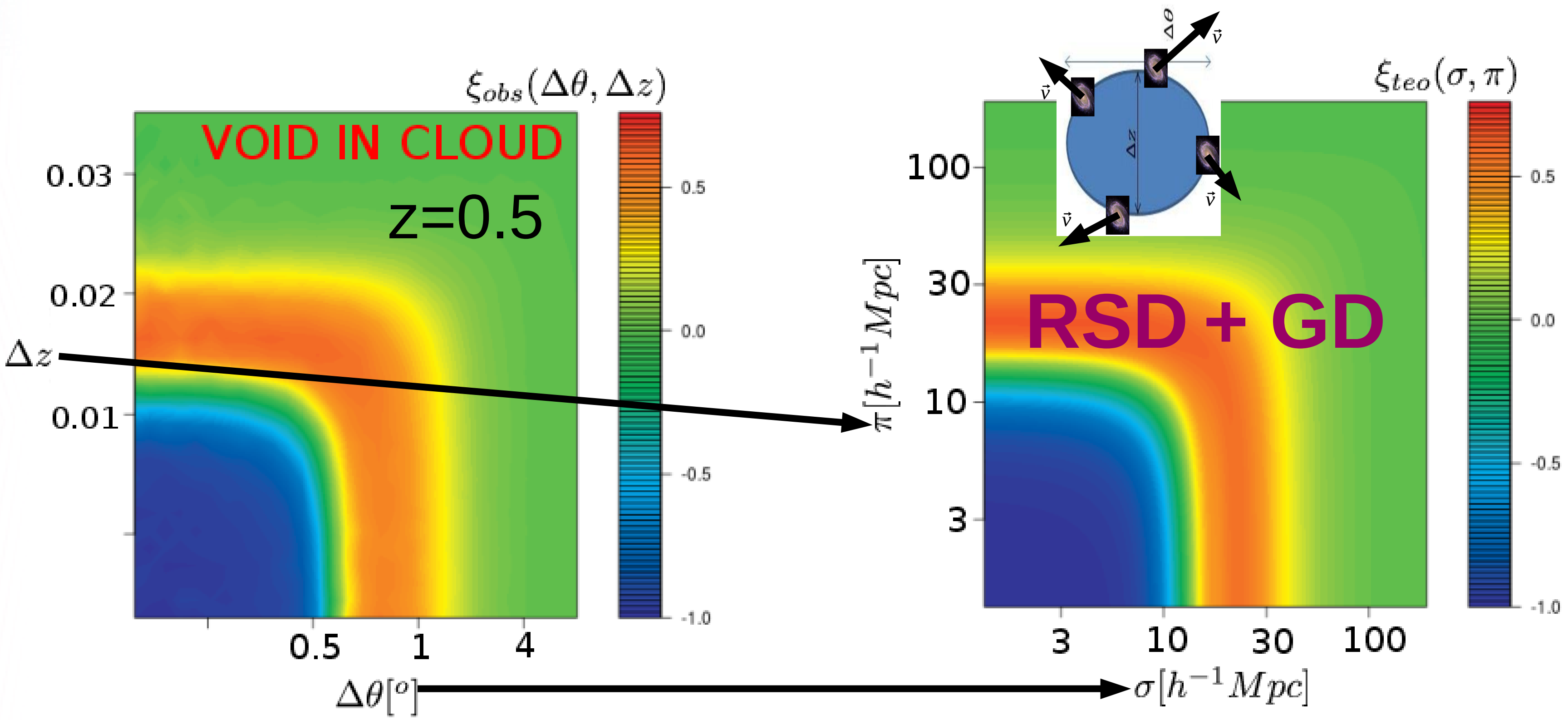
OVERDENSE → COLLAPSE





METHOD

The idea



ANISOTROPIC MAP

COSMOLOGICAL PARAMETERS IN THE MODEL

The model

STRONG REDSHIFT DEPENDENCE!!

RSD (Paz et al. 2013; Hamaus et al. 2016)

$$1+\xi(\sigma,\pi)=\int \frac{1}{\sqrt{2\pi}\sigma_v}\exp\left[-\frac{\left(v_{\parallel}-v(r)\frac{r_{\parallel}}{r}\right)^2}{2\sigma_v^{\,2}}\right][1+\xi(r)]\,d^3v_{\parallel}$$

$$\xi(r)=\frac{1}{3r^2}\frac{d}{dr}\left(r^3\Delta(r)\right)$$

$$v(r)=-\frac{1}{3}\frac{H(z)}{(1+z)}r\,b\,\Delta(r)f(z,\Omega) \qquad f(z,\Omega)=\left(\frac{\Omega_m(1+z)^3}{\Omega_m(1+z)^3+\Omega_\Lambda}\right)^{0.55}$$

$$\Delta(r)=sigmoid(r,R,S)+gaussian(r,R,S,P,W)$$

COSMOLOGICAL PARAMETERS:

- Ω_m: matter density
- b: bias
- σ_V: velocity dispersion

AUXILIARY PARAMETERS:

R, S, P, W

GD (THIS WORK)

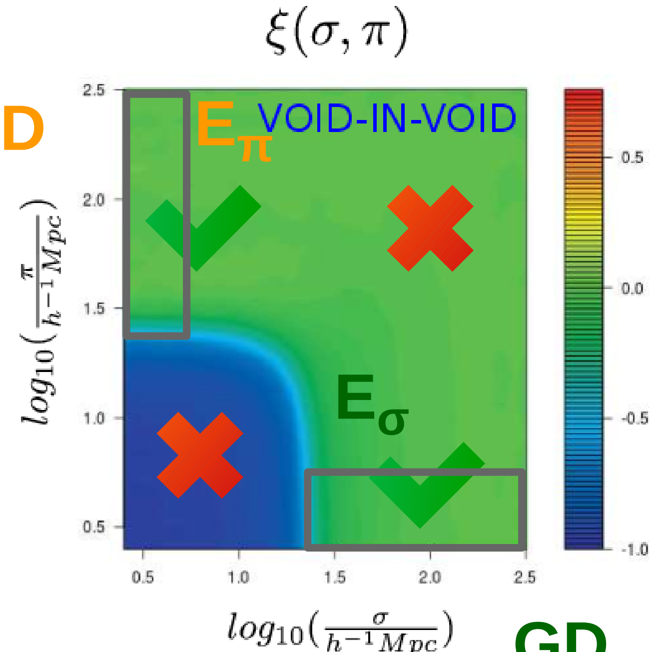
$$(\Delta\theta,\Delta z)\rightarrow(\sigma,\pi)[h^{-1}Mpc]$$

$$\begin{cases}\sigma=D_A\Delta\theta=\dfrac{c\,\Delta\theta}{H_0(1+z)}\displaystyle\int_0^z\frac{dz'}{\sqrt{\Omega_m(1+z')^3+\Omega_\Lambda}}\\[2ex] \pi=\dfrac{dd_{com}}{dz}\Delta z=\dfrac{c\,\Delta z}{H_0\sqrt{\Omega_m(1+z)^3+\Omega_\Lambda}}\end{cases}$$

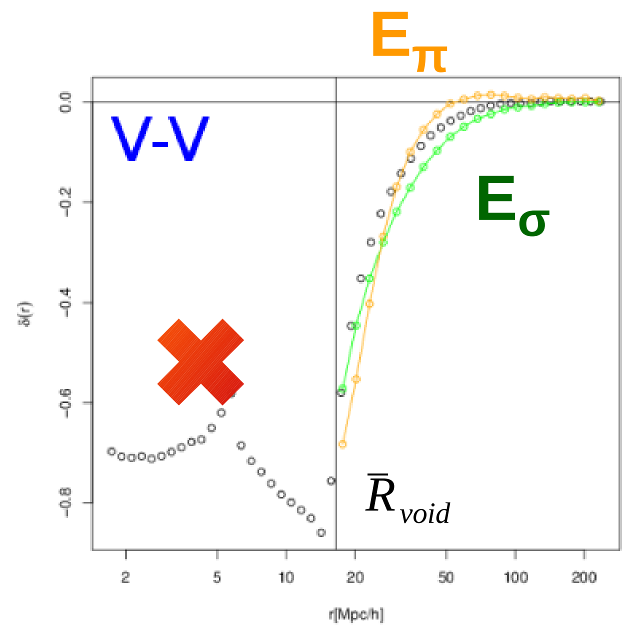
ΛCDM - FLAT

Voids edges

RSD + GD

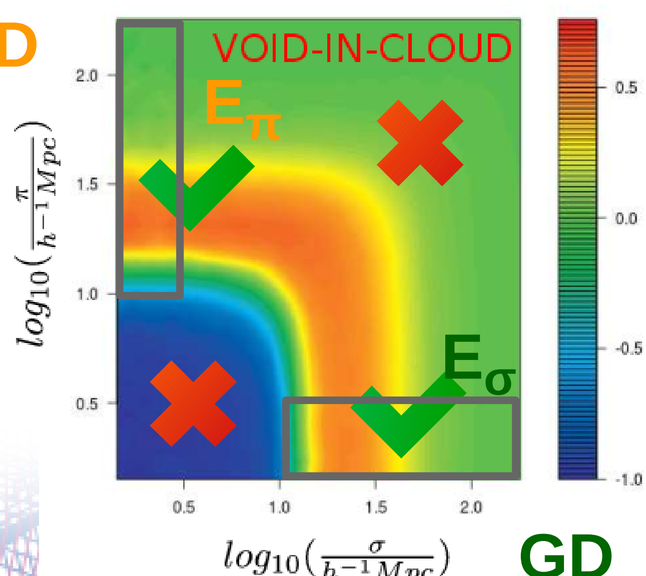


GD

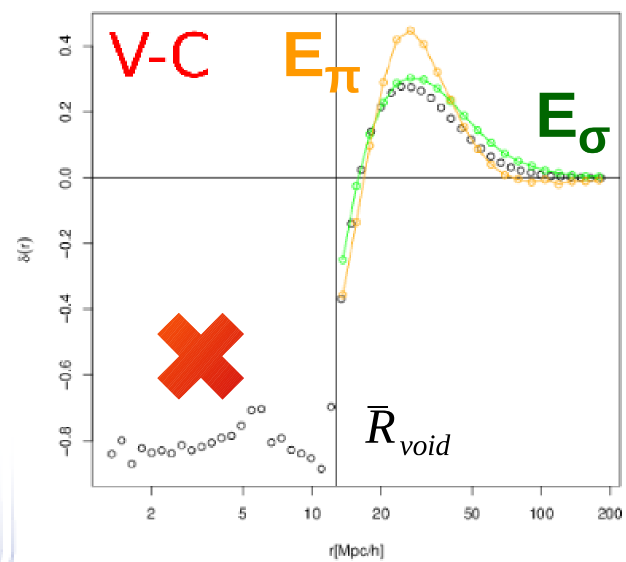


z=0.5

RSD + GD



GD

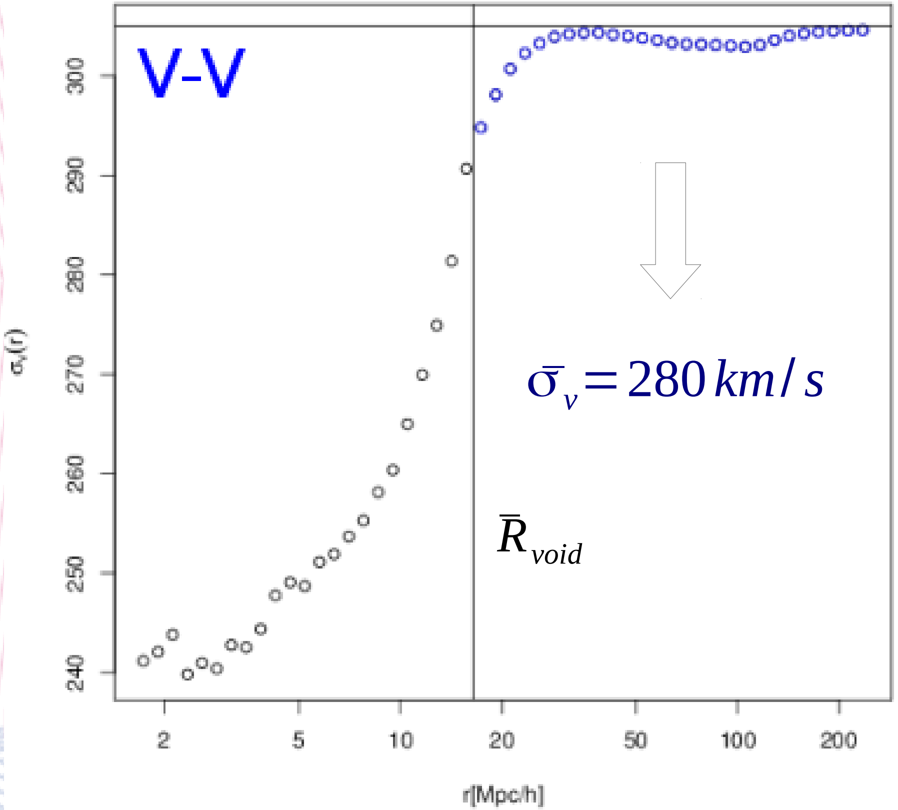


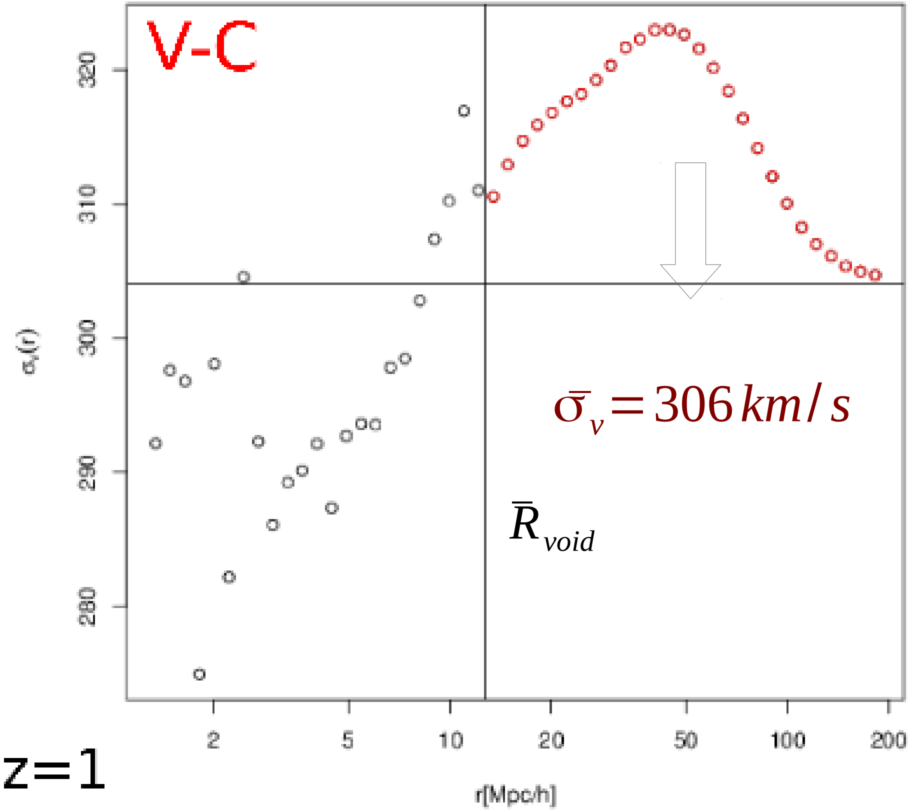

RESULTS

Degeneration with σ_v

$z=0.5$ $\bar{\sigma}_v = 292\,km/s$

$z=0.5$ $\bar{\sigma}_v = 326\,km/s$





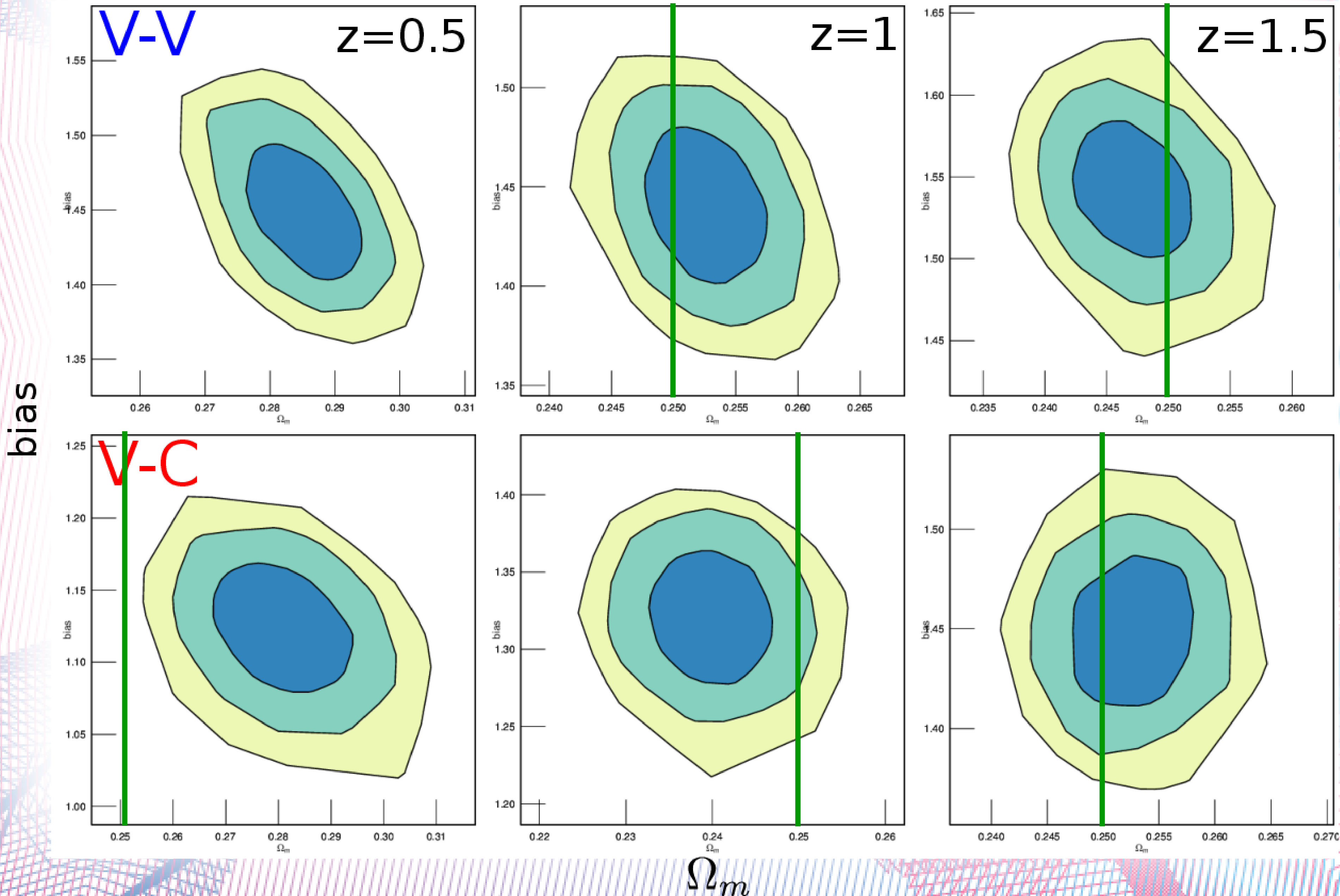
z=1

$z=1.5$ $\bar{\sigma}_v = 261\,km/s$

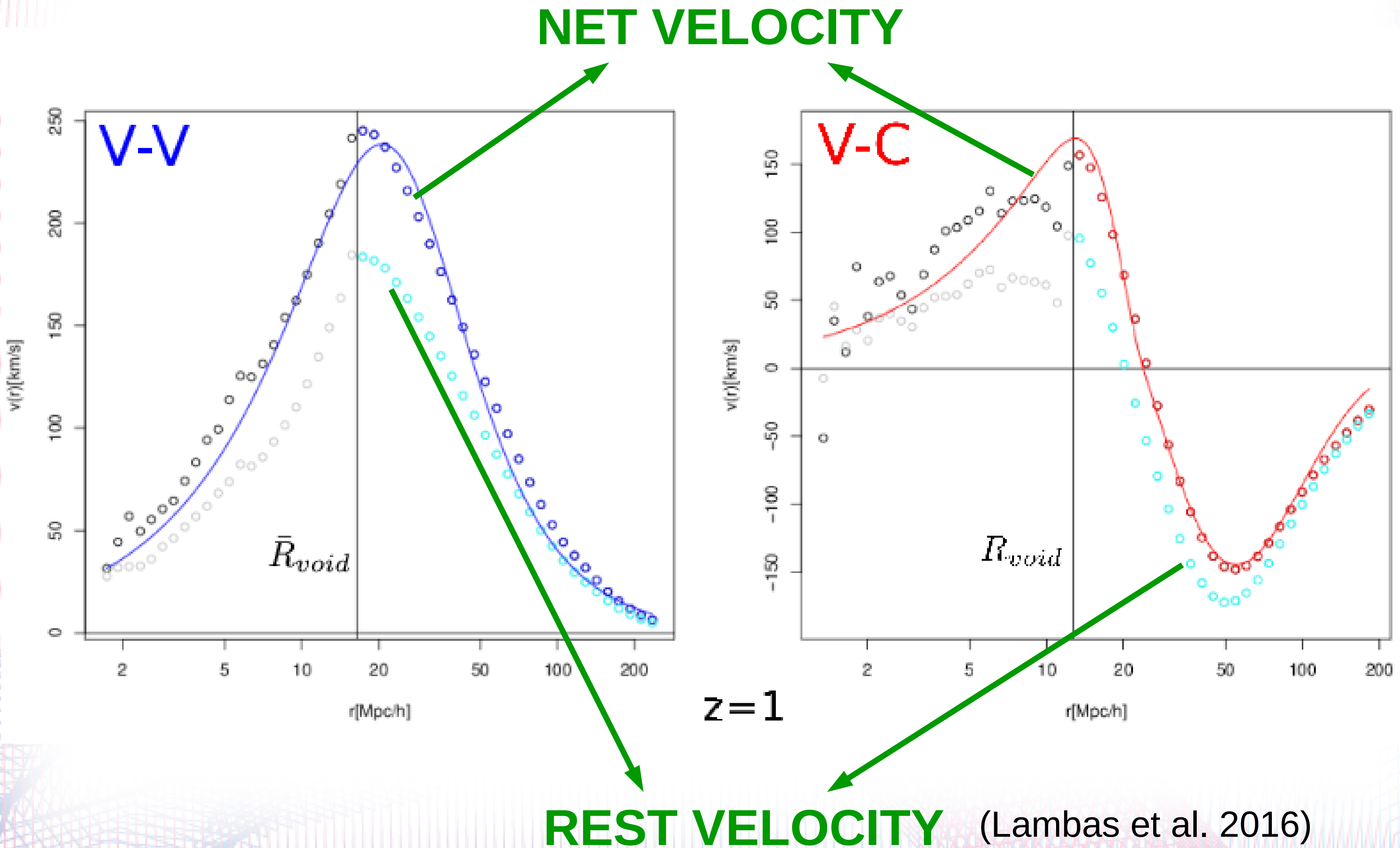
$z=1.5$ $\bar{\sigma}_v = 280\,km/s$

Likelihood projections

$\Omega_m^{MXXL} = 0.25$



Net velocity vs Rest velocity



(Lambas et al. 2016)

CONCLUSIONS

- We are developing a cosmological test that **not** depends on a **fiducial cosmology**.
- Its based on the **Alcock-Paczyński** (1979) effect on cosmic voids.
- We used the two main parts of the correlation fucntion (**voids edges**).
- We tested the method on the **MXXL simulation**.
- We still have difficulties with:
  - **velocity dispersion**,
  - **velocity profiles** (net vs rest).

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THANKS FOR YOUR ATTENTION