VOIDS AND SUPERSTRUCTURES

Correlations and induced large-scale velocity flows

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FUTURE VIRIALIZED STRUCTURES (FVSs)

- Luparello et al. (2011)

Identification method developed to ensure that the superstructures will be virialized systems in the future.

*Largest overdense structures in the universe;

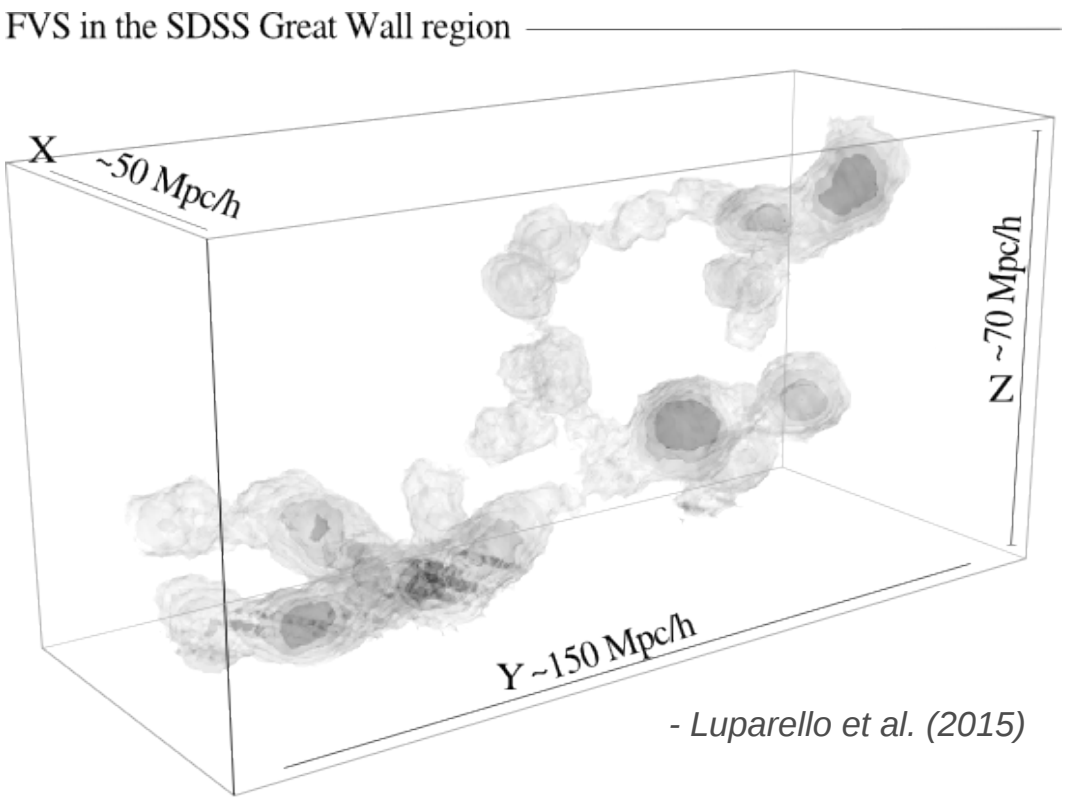
*Still forming, lack of dynamical equilibrium;

*Complex morphologies, filamentary or spider-like;

*One or more dense nuclei, with very bright galaxies;

*Host a variety of galaxies, groups and clusters;

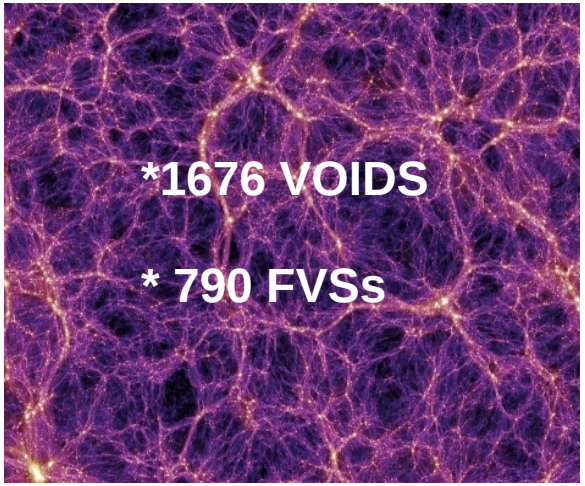
*Sizes from ~20 to 150 Mpc.



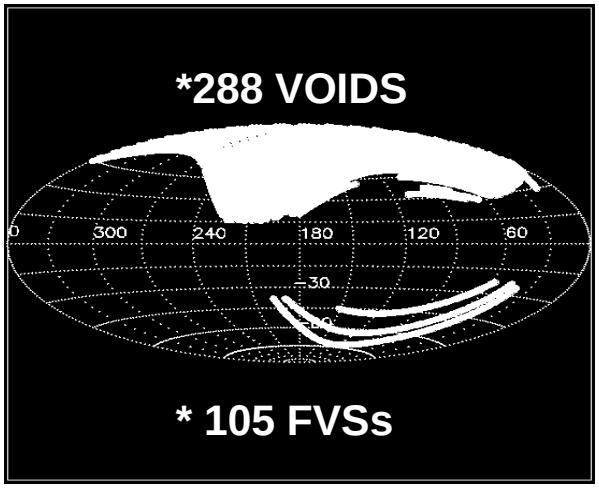
- Luparello et al. (2015)

VOID IDENTIFICATION: Ruiz et al., 2015 **+ FVSs IDENTIFICATION**: Luparello et al., 2011

Millennium simulation *(Spriengel et al.,2005)* **+ SAM** *(Guo et al., 2011)*	**SDSS DR7** *(Abazajian et al.,2009)* **+LINEARIZED VELOCITY FIELD** *(Wang et al., 2012)*



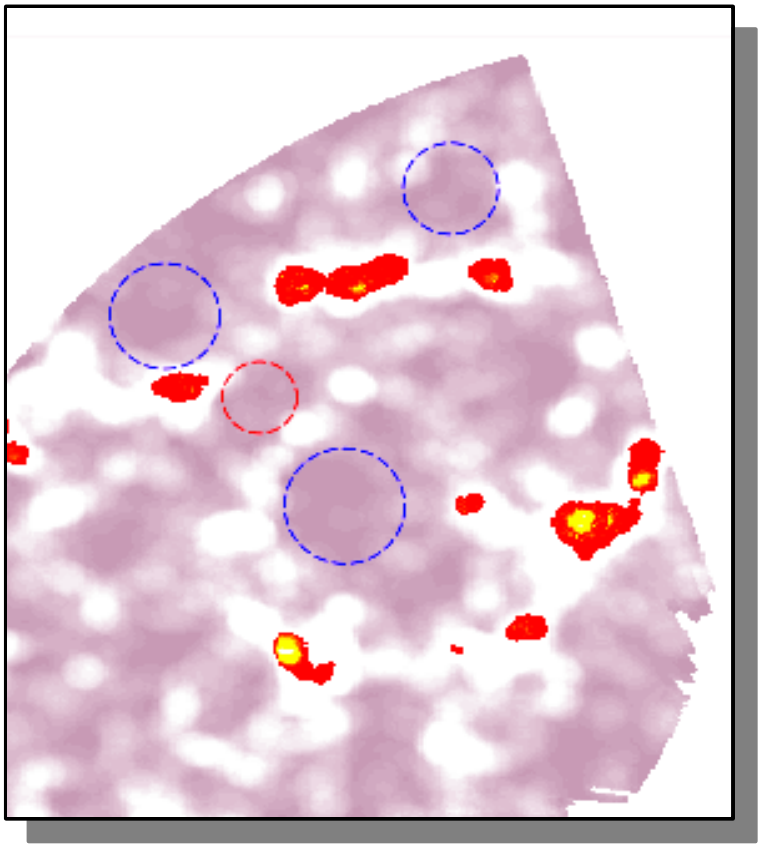
(6 times more volume)



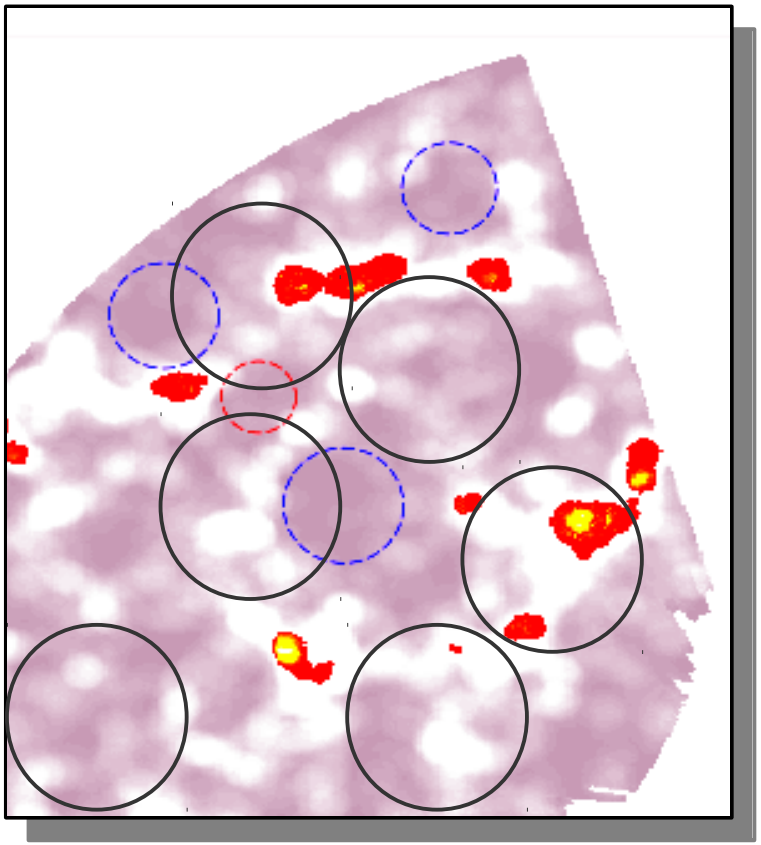
1.

SPATIAL DISTRIBUTION OF VOIDS RELATIVE TO FVSs

COMPUTING PROBABILITIES



COMPUTING PROBABILITIES *(with random spheres)*



$$P(\text{void} \cap \text{FVS}) \simeq \frac{N_{\text{void} \cap \text{FVS}}}{N_T},$$

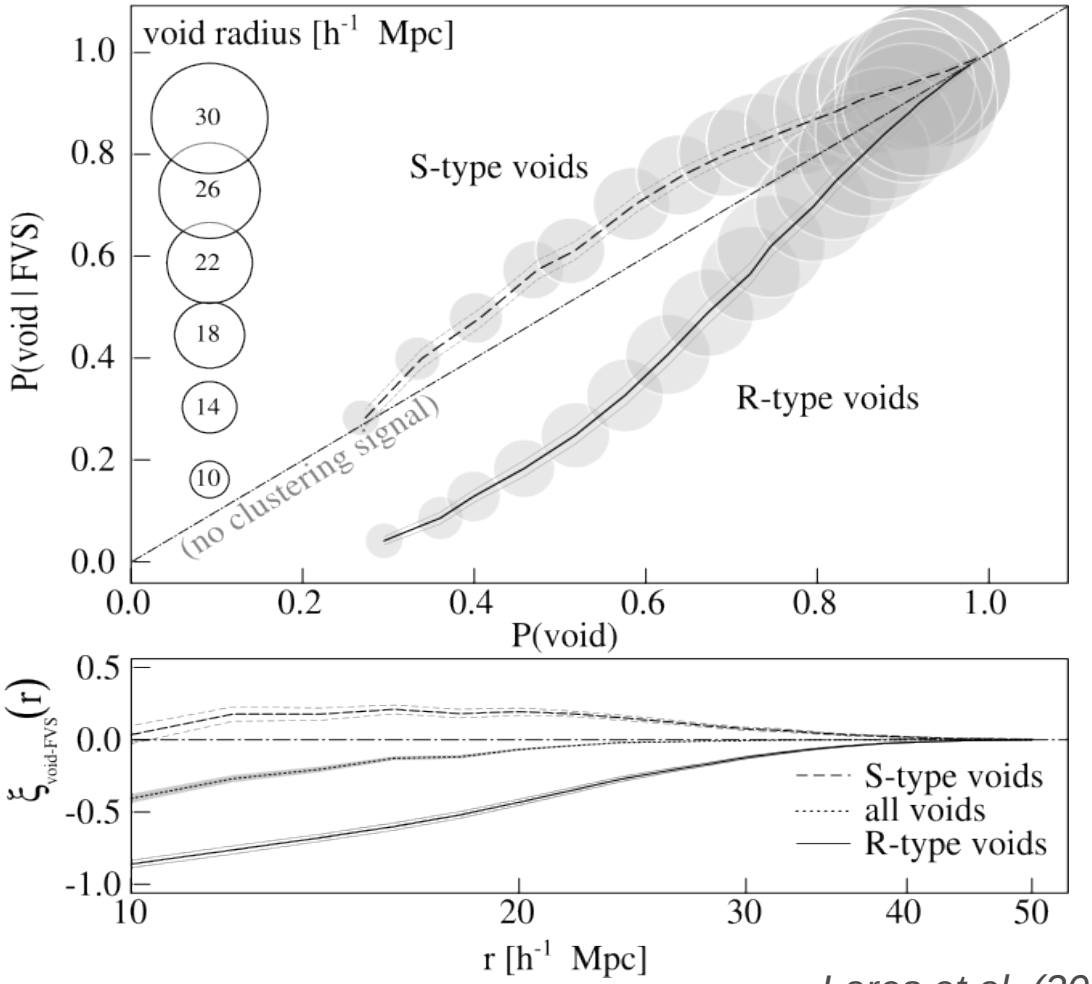
and similarly,

$$P(\text{void}) \simeq \frac{N_{\text{void}}}{N_T},$$

$$P(\text{FVS}) \simeq \frac{N_{\text{FVS}}}{N_T},$$

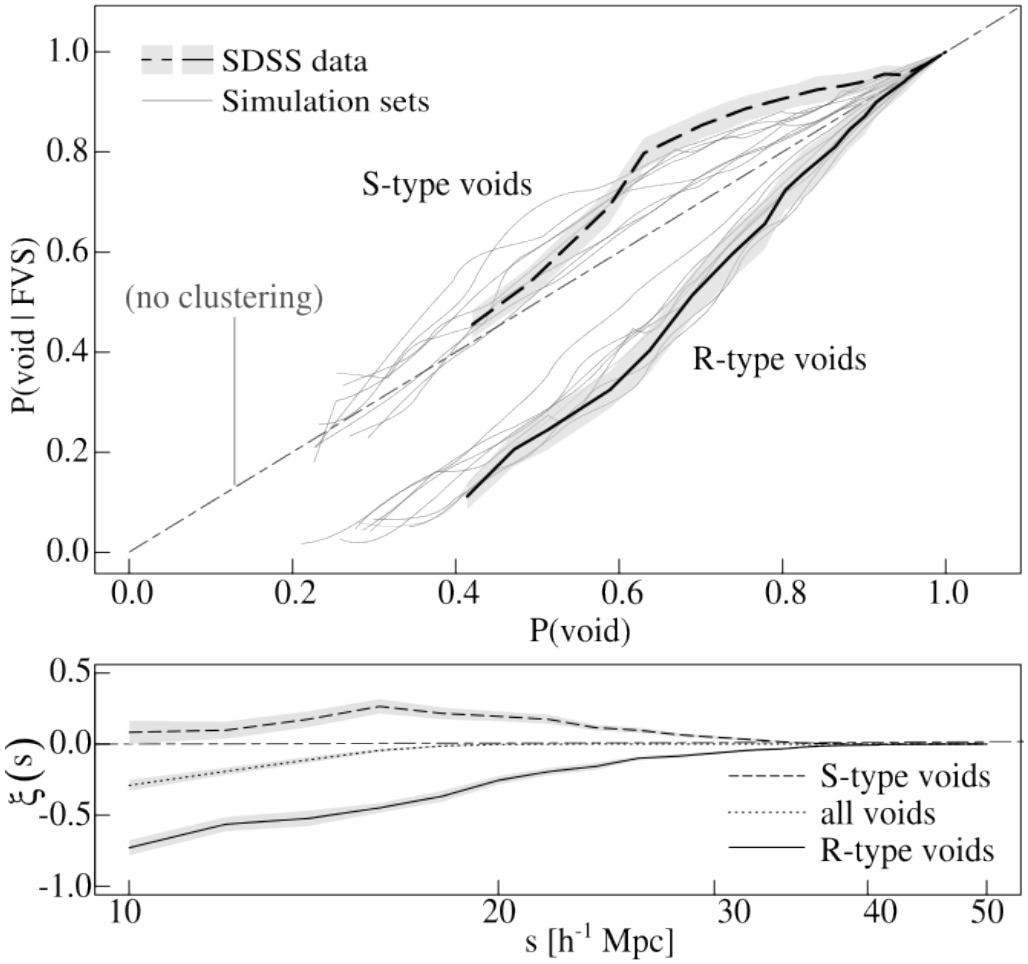
$$P(\text{void} \cap \text{FVS}) \simeq P(\text{void} \mid \text{FVS})\, P(\text{FVS})$$

$$P(\text{void} \mid \text{FVS}) = P(\text{void})\,(1 + \xi_{\text{void}-\text{FVS}}(r)),$$



- Lares et al. (2017, submitted)

SPATIAL DISTRIBUTION OF VOIDS AND FVS



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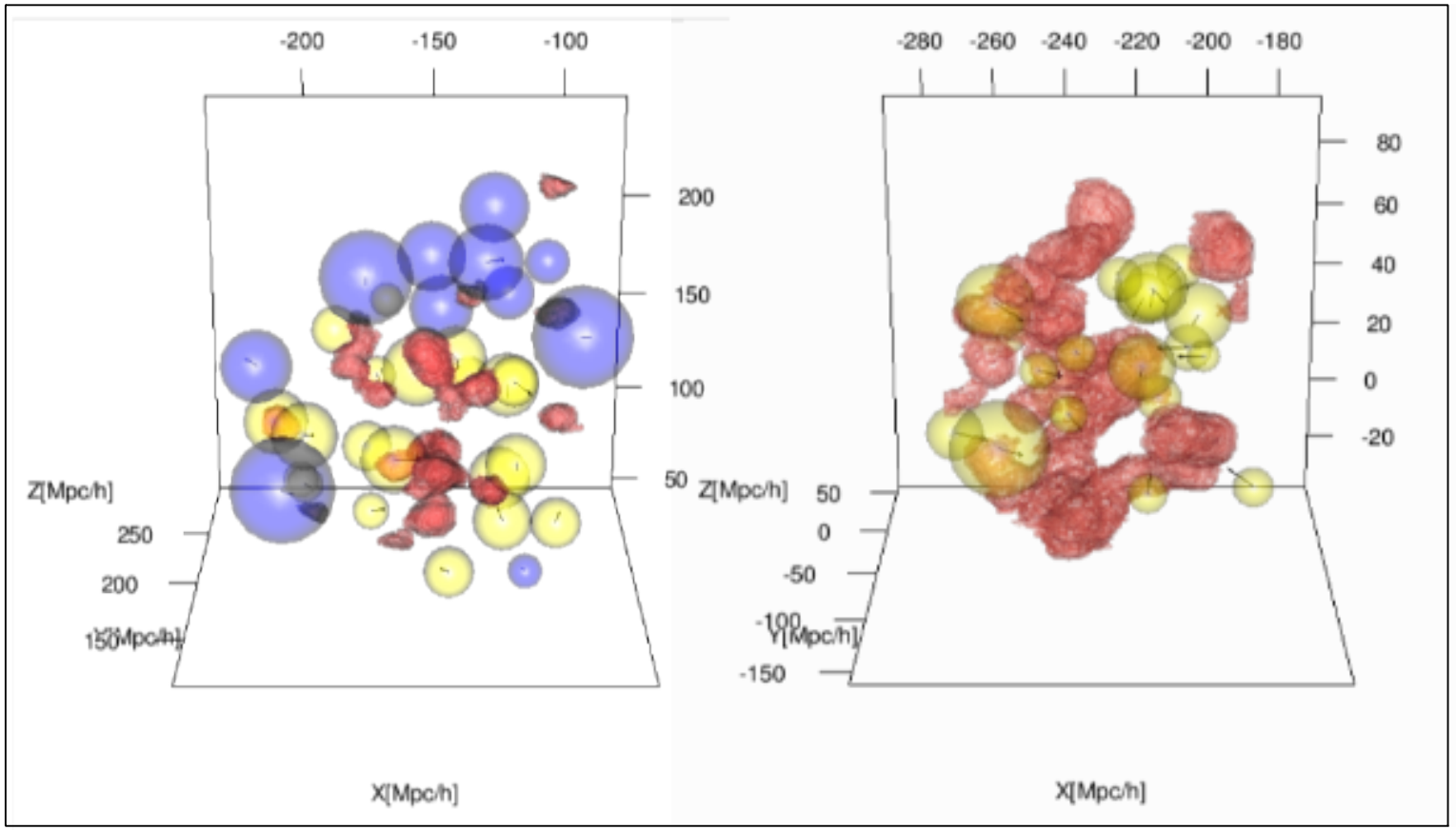
SPATIAL DISTRIBUTION OF VOIDS AND FVS

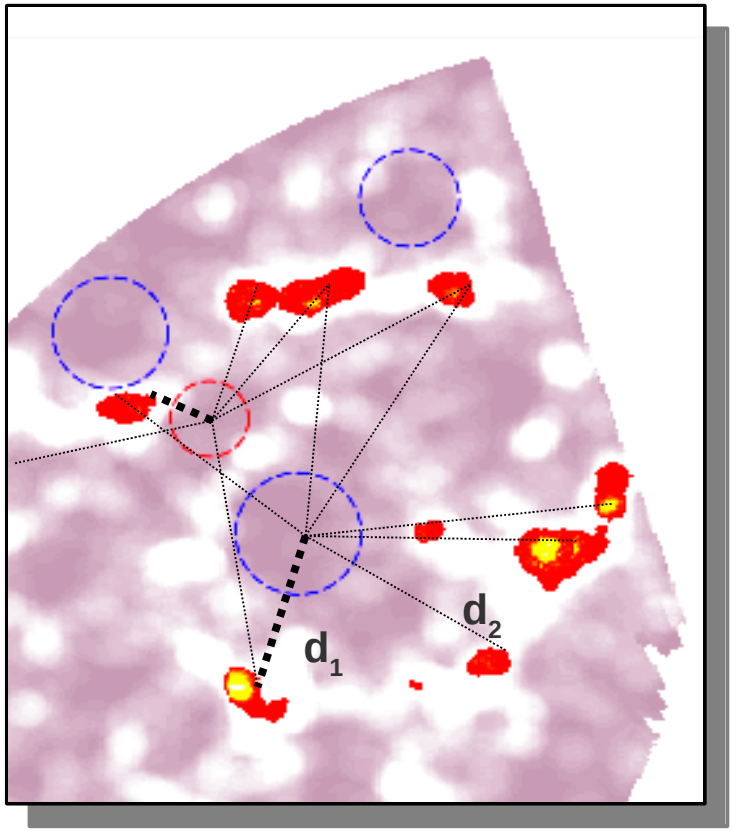


2.

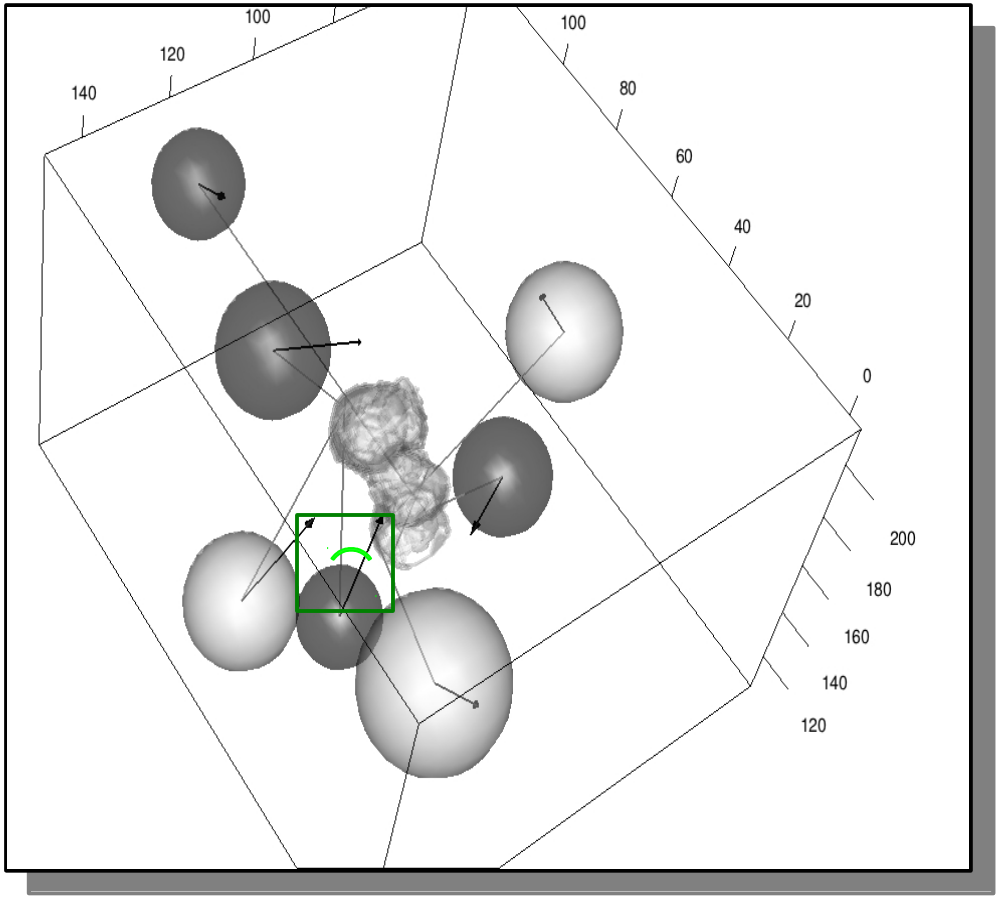
DYNAMICS OF VOIDS RELATIVE TO FVSs

IDENTIFIYING VOID-FVS PAIRS:

1. Find the nearest FVS **core**

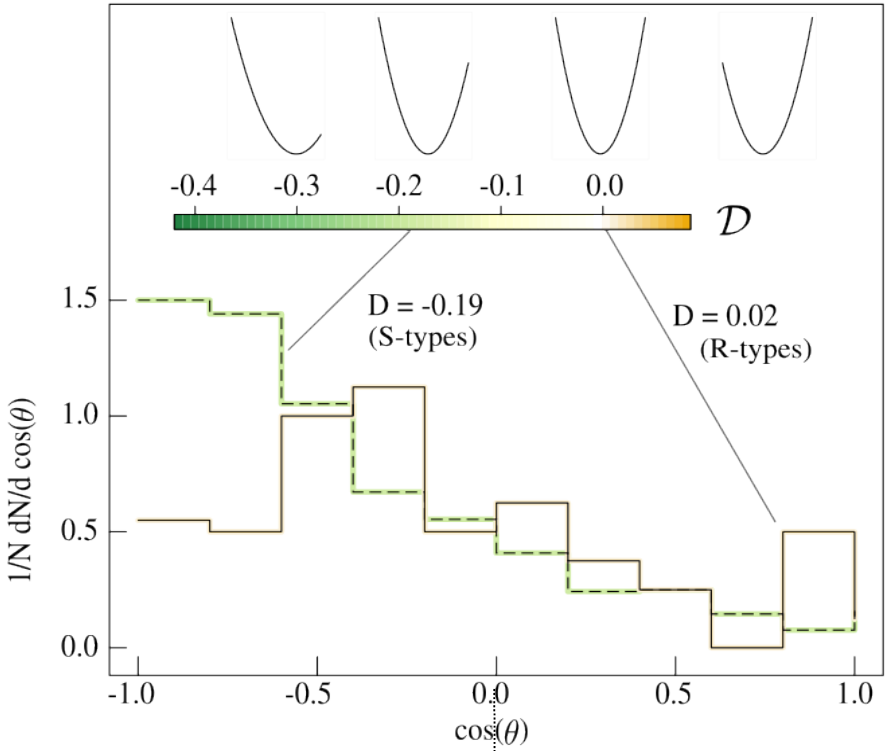


2. Calculate the projection angle Θ



CUANTIFIYING THE EFFECT: *(dipole moment of a distribution)* $\mathcal{D} = \frac{1}{N}\sum_{i=1}^{N} \cos(\theta)\, P_2(\cos(\theta))$

S—type voids close to their assigned FVS



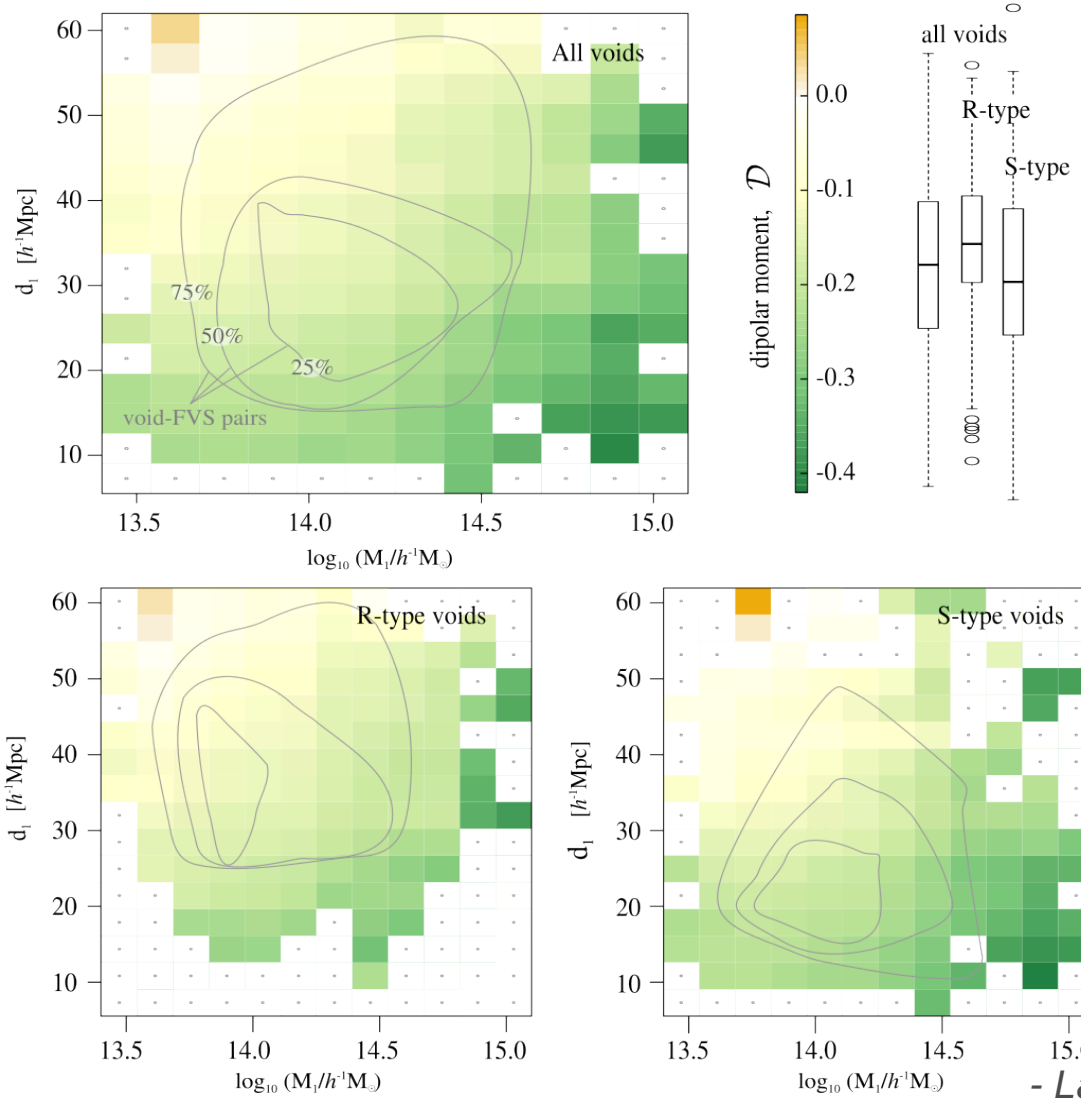
R—type voids far from their assigned FVS

- Lares et al. (2017, submitted)

INFALL ←
(cos<0 then D<0)

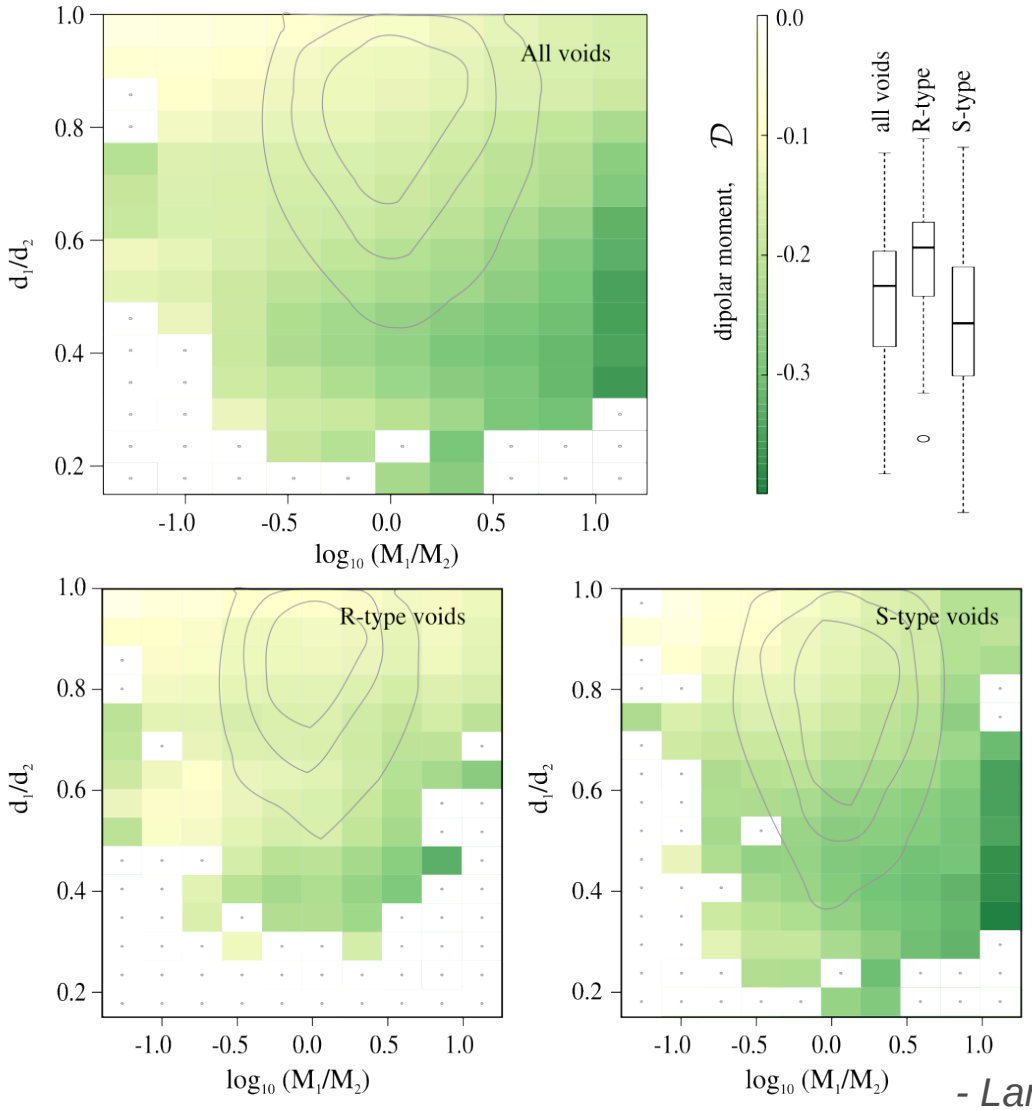
→ ***OUTFLOW***
(cos>0 then D>0)

DYNAMICS OF VOIDS RELATIVE TO FVSs



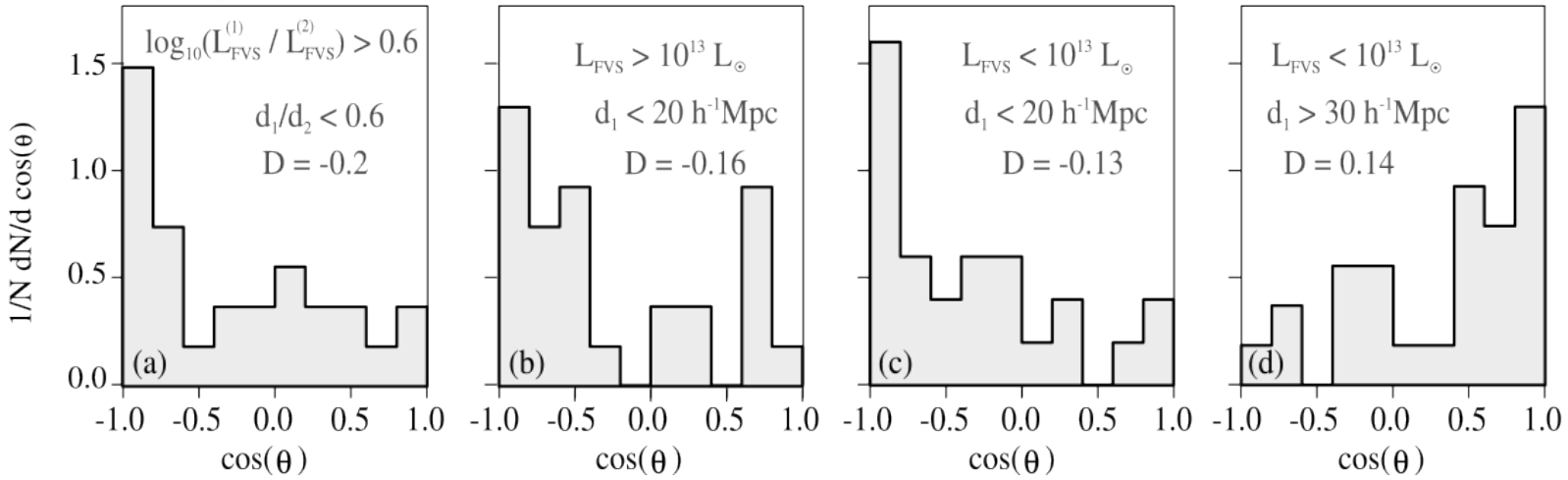
- Lares et al. (2017, submitted)

DYNAMICS OF VOIDS RELATIVE TO FVSs



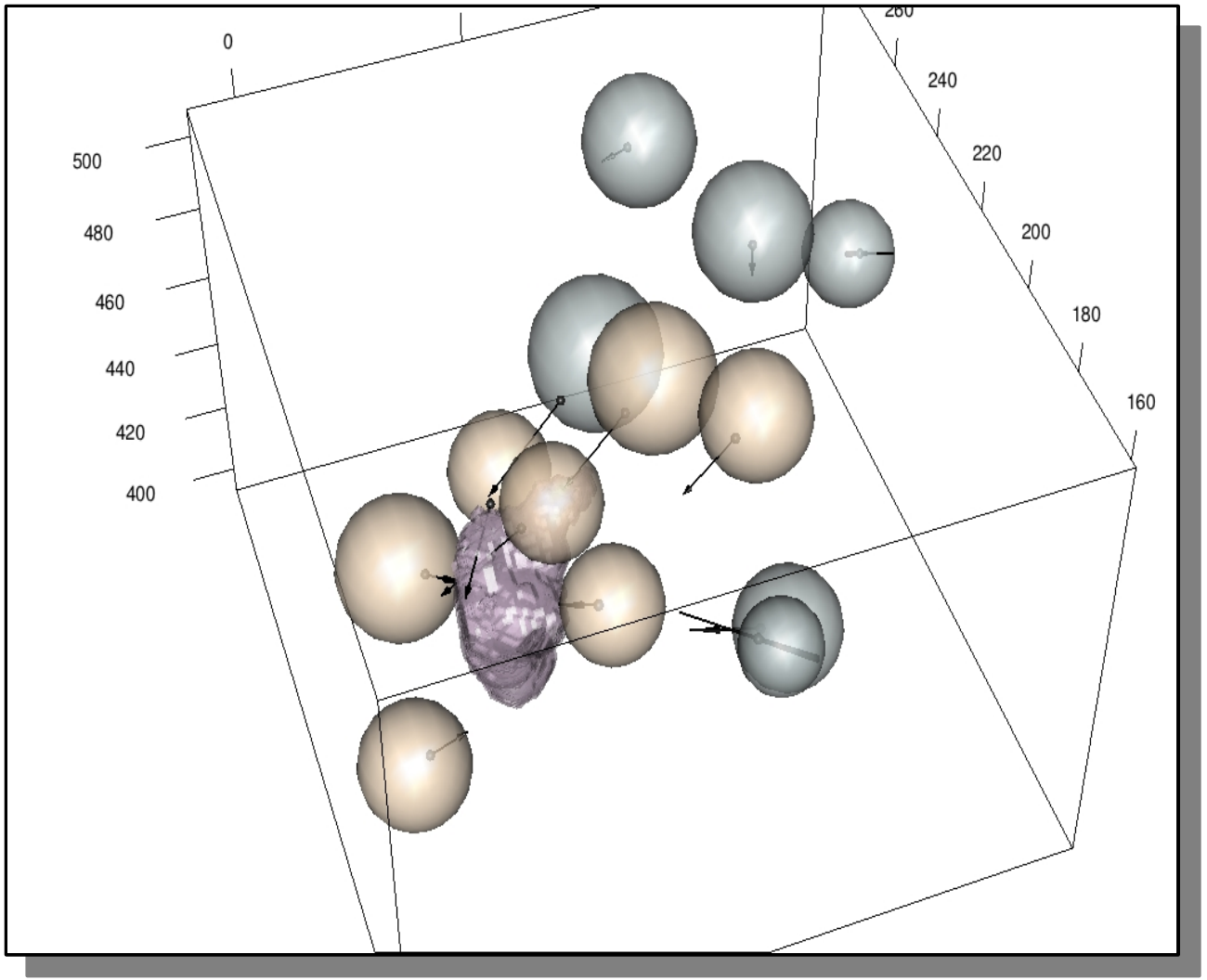
- Lares et al. (2017, submitted)

SDSS sublsamples



- Lares et al. (2017, submitted)

DYNAMICS OF VOIDS RELATIVE TO FVSs



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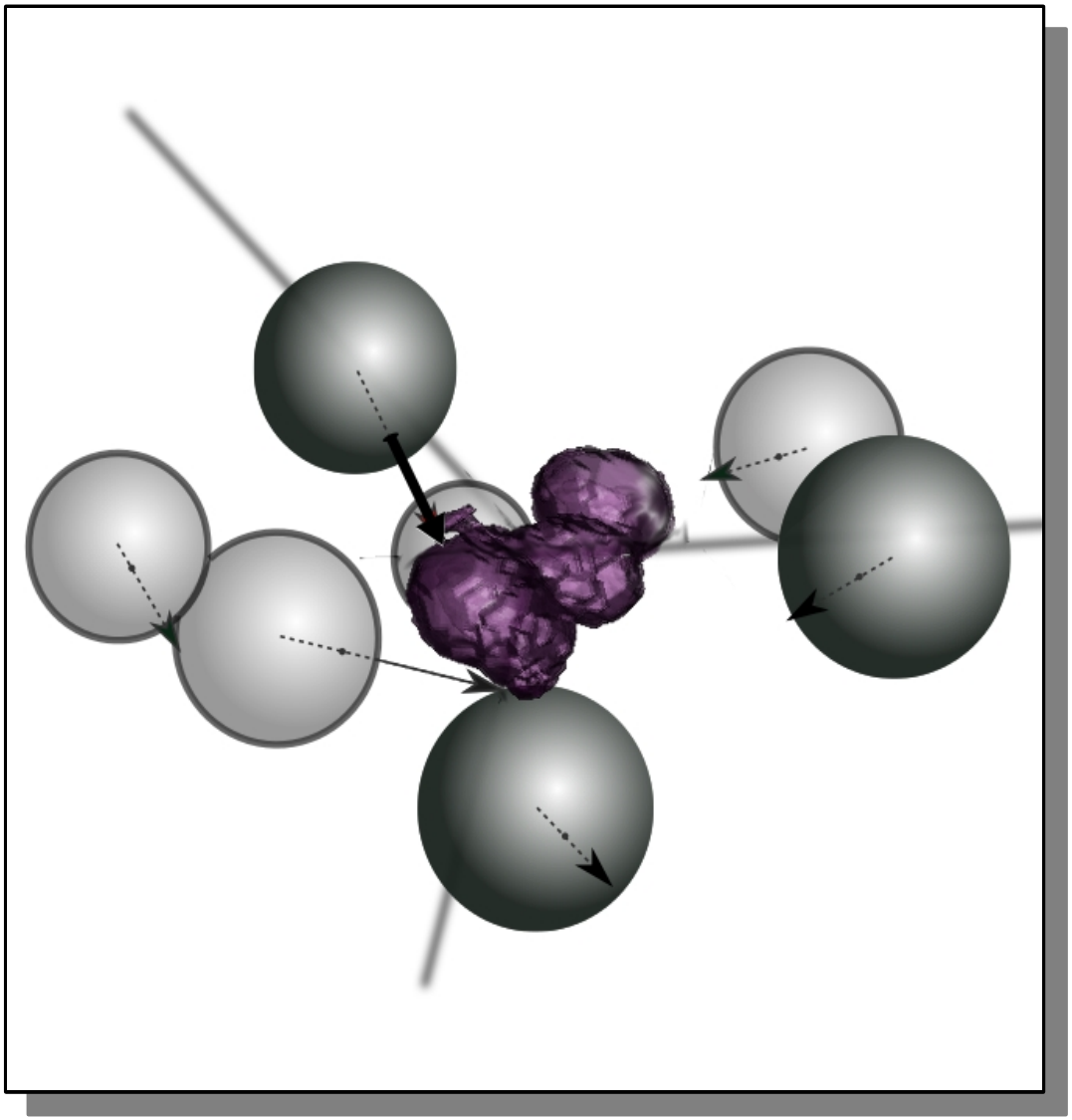


SUMMARY AND CONCLUSIONS

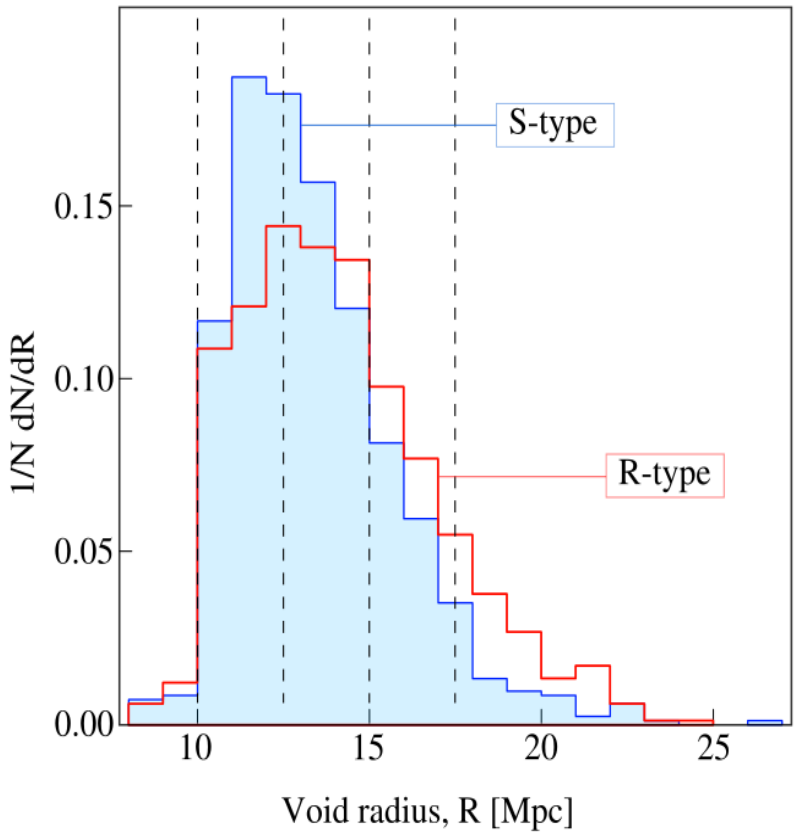
The dynamics and spatial distribution of voids are tightly related to the superstructures.

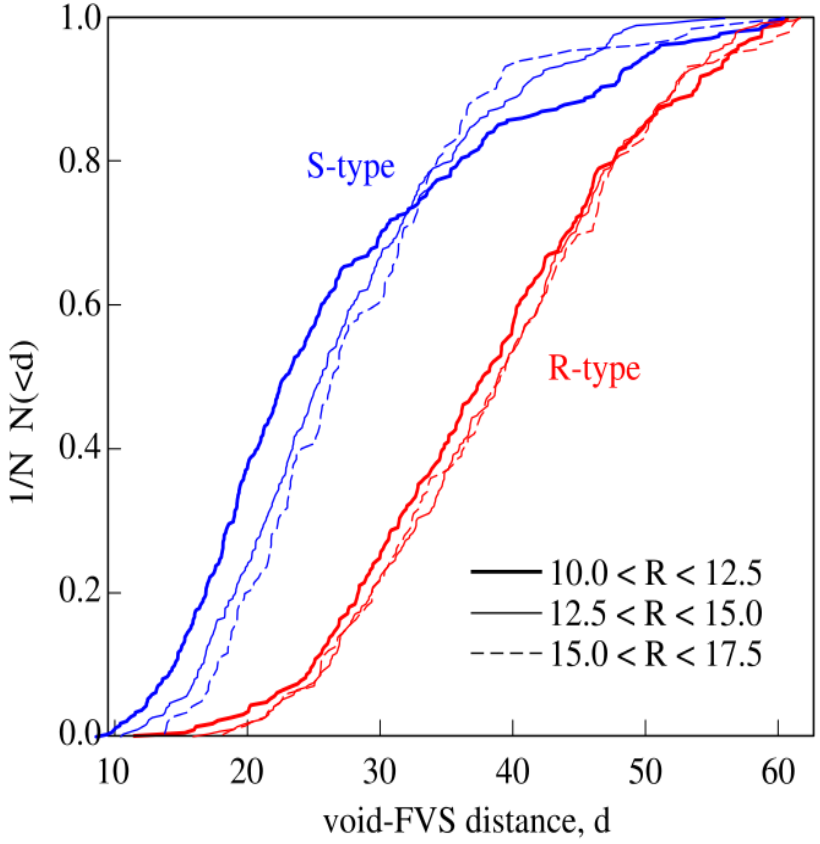
R-type voids tend to be located in zones not populated by FVSs.

S-type voids show a clear clustering and infalling pattern onto the FVSs.

There is a good agreement between the results in the simulation and observations.

This study allow us to understand the origins of the large-scale velocity flows.


S-type
R-type
1/N dN/dR
Void radius, R [Mpc]
0.00
0.05
0.10
0.15
10
15
20
25


S-type
R-type
10.0 < R < 12.5
12.5 < R < 15.0
15.0 < R < 17.5
1/N N(<d)
void-FVS distance, d
0.0
0.2
0.4
0.6
0.8
1.0
10
20
30
40
50
60