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CosmicFlows for exploring gravitation on large scales

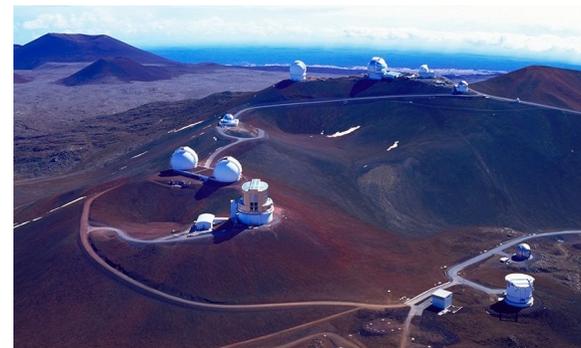
H. Courtois and collaborators

The idea is : on large scales the motions of galaxies are exclusively due to expansion and gravitation.

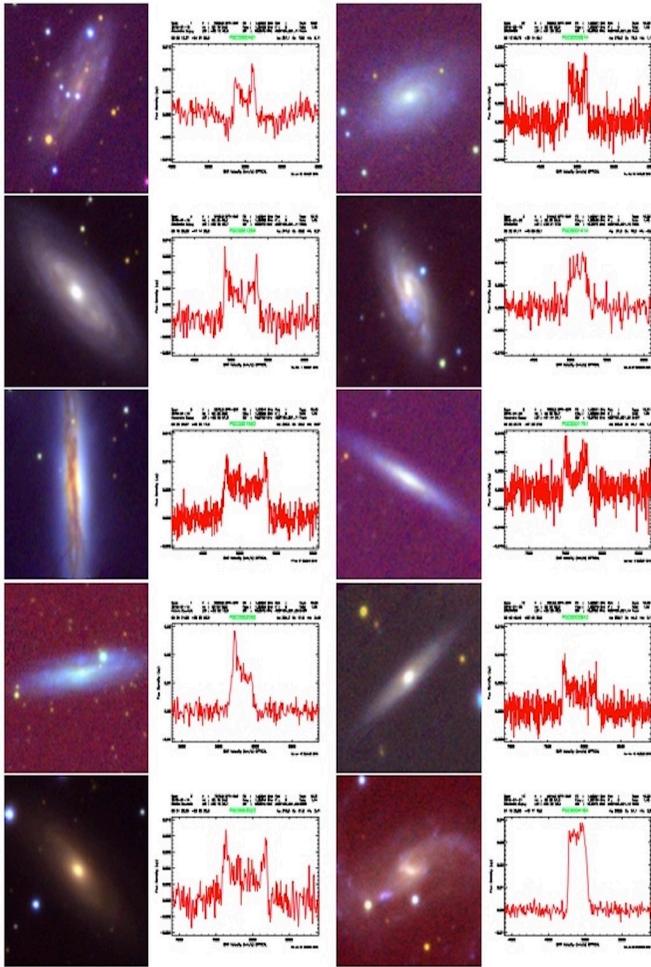
The methodology :

- *we can observe only the radial part of these motions,*
- *we can observe them in different environments : empty, medium, dense,*
- *we can observe them at different epochs.*

Obtaining datasets

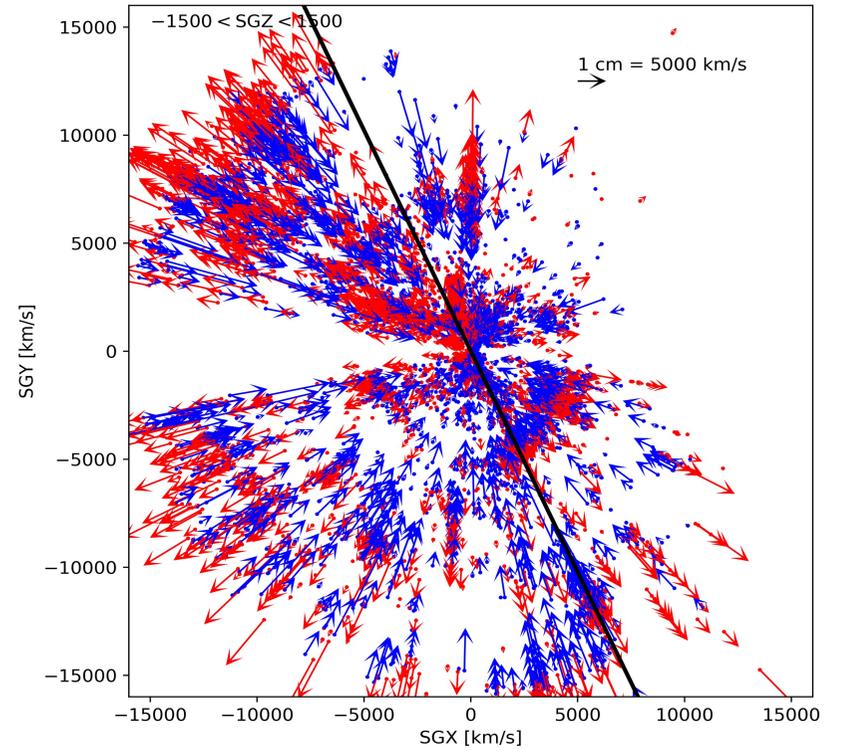


Observed distance moduli to estimated radial peculiar velocities in distorted redshift space

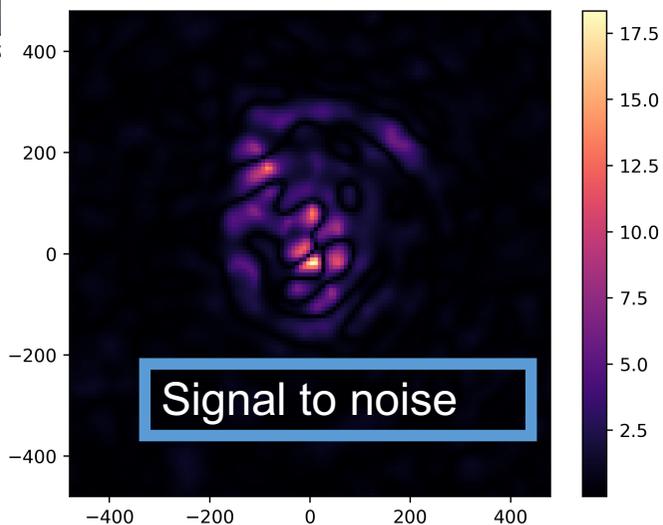
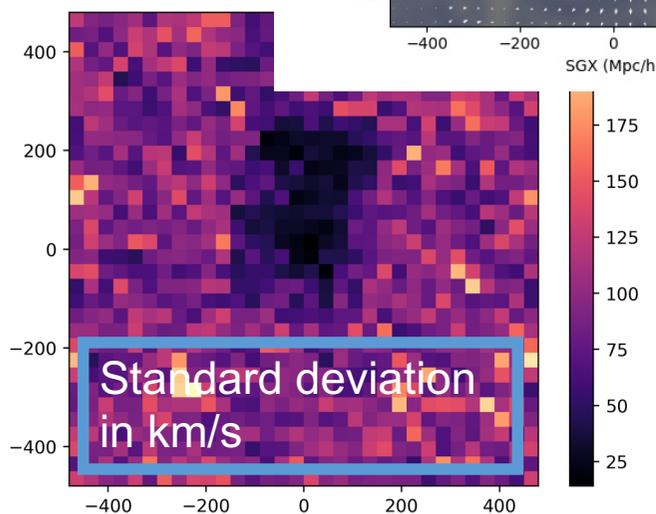
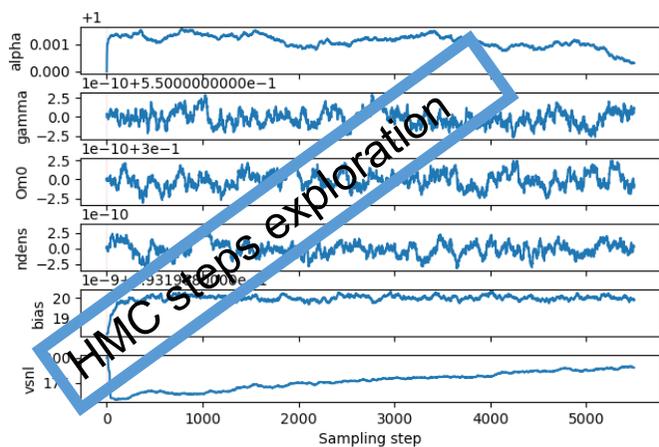
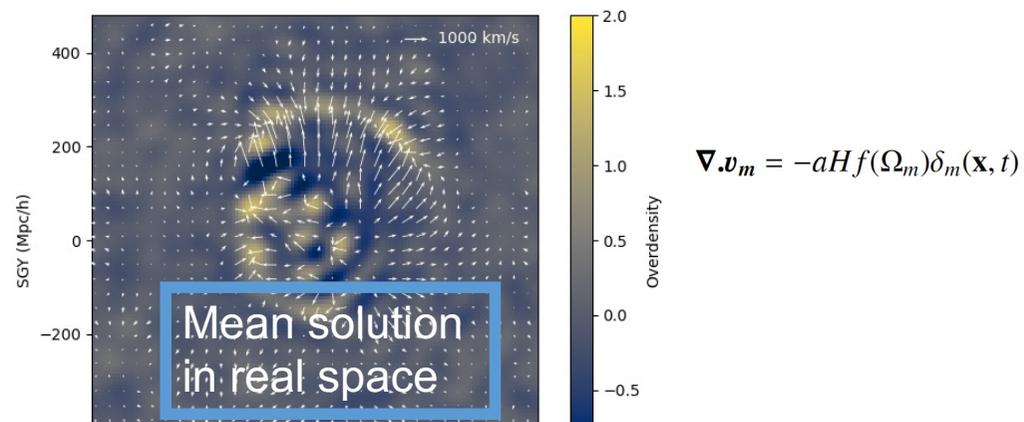
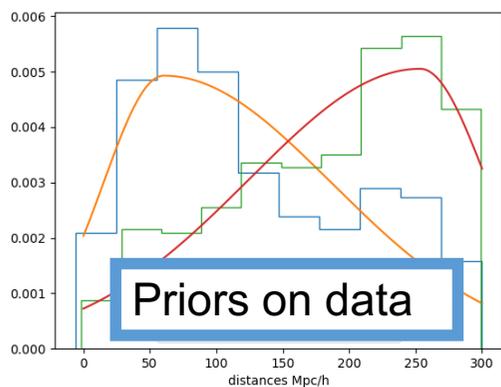


$$v^r \sim cz - H_0 d_I$$

→



ΛCDM Hamiltonian Monte Carlo forward modeling of the observational dataset to compute a 3 dimensional reconstruction of the gravitational velocity field



A study of the matter content of nearby voids

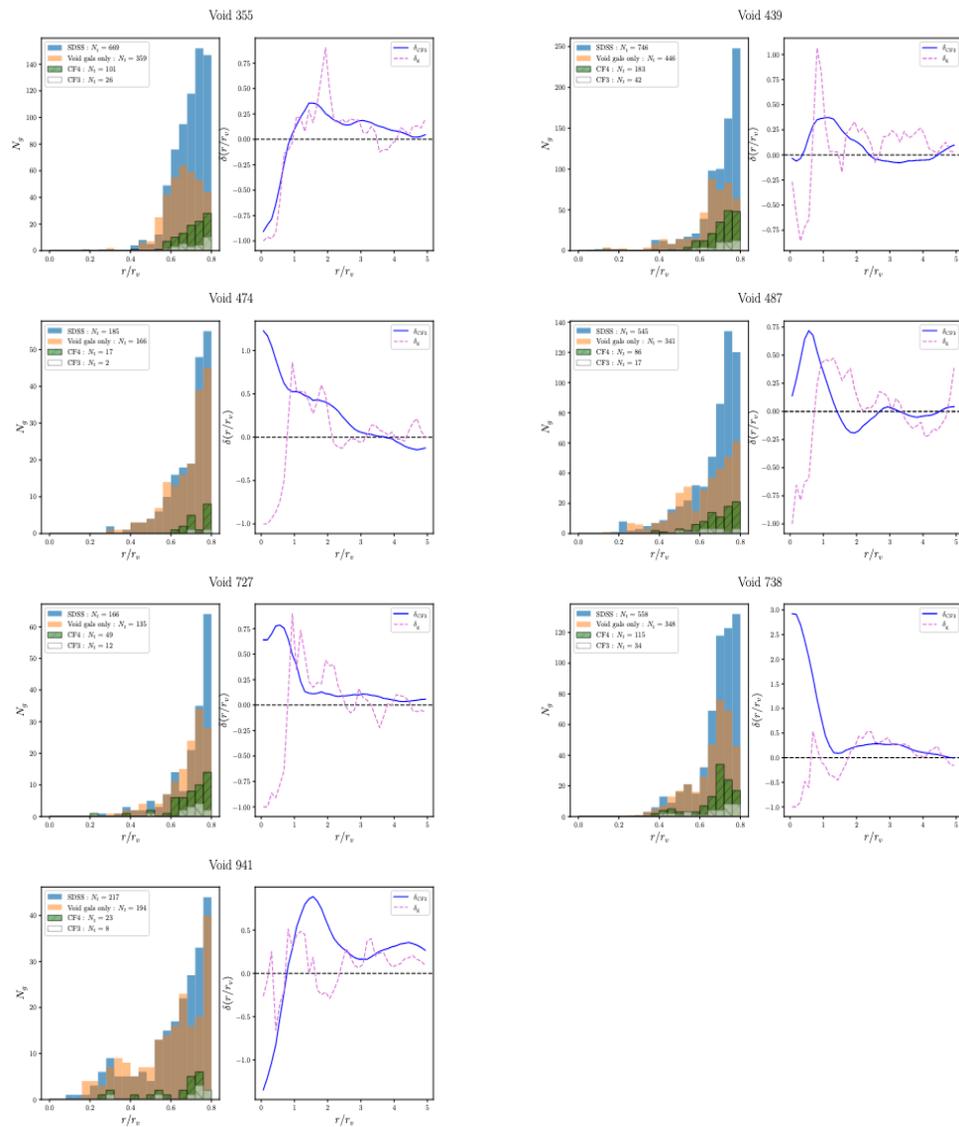
H. Courtois et al. submitted

the question we try to answer is : how empty are voids identified with a classic void finder ?

To answer this we compare two different probes for their matter content :

- galaxy redshift 2point correlations,*
- observed dynamical environment.*

Comparison of Density profiles from galaxy counts and from CosmicFlows LCDM reconstruction

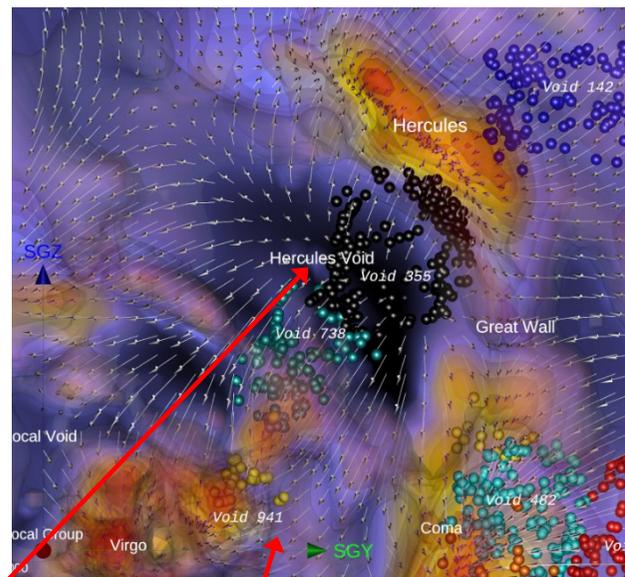


Computation – Equations – Discuss Linear / Non Linear

$$\delta_g(r) := \xi(r) = \frac{D_v D_g(r)}{D_v R_g(r)} - 1 \quad \nabla \cdot \mathbf{v}_m = -aHf(\Omega_m)\delta_m(\mathbf{x}, t)$$

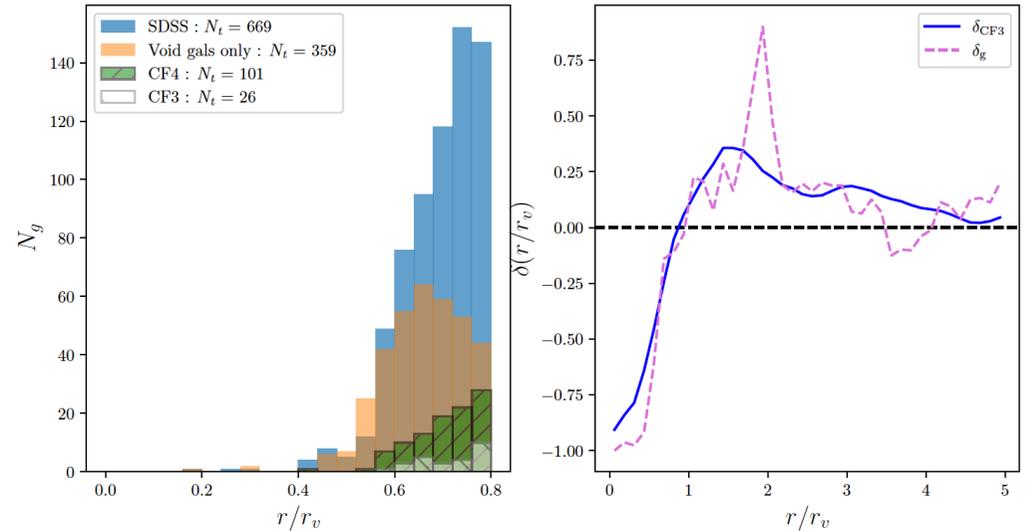
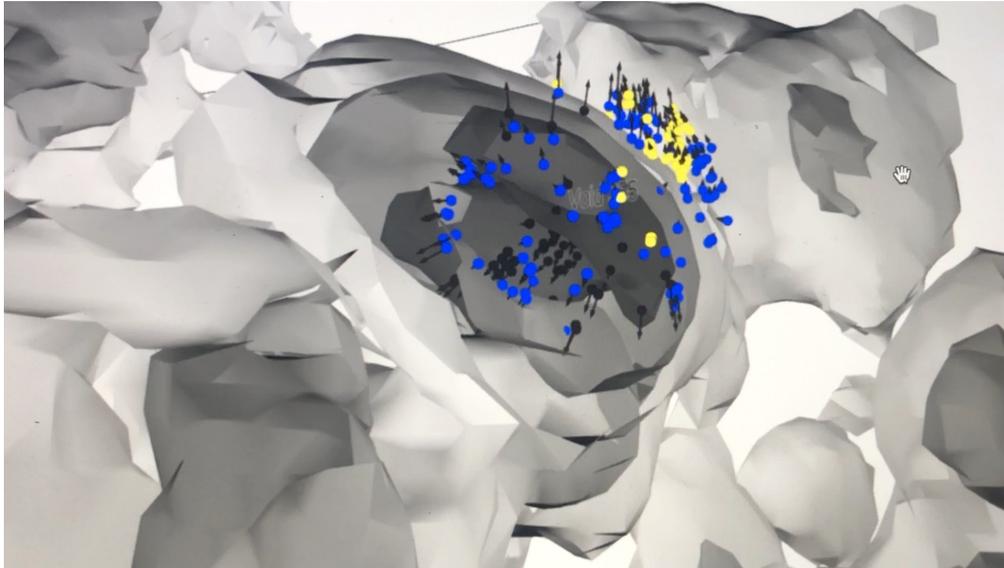
Results :

-Voids 474 – 487 – 727 and 738 are not empty (merging torrents)



-Void 355 is a true void : empty (pristine lake) Hercules void
 -Voids 439 and 941 are not isolated (941 is a zone merging onto Virgo)

Matter and galaxy profile of Void 355



V-web color code of galaxies

Isosurfaces of negative δ_m field

Local particular flow with velocity of the void center subtracted

Conclusions:

discuss the bias galaxy/matter in true voids (expanding along two or three directions)

Implication for $f\sigma_8$ computations

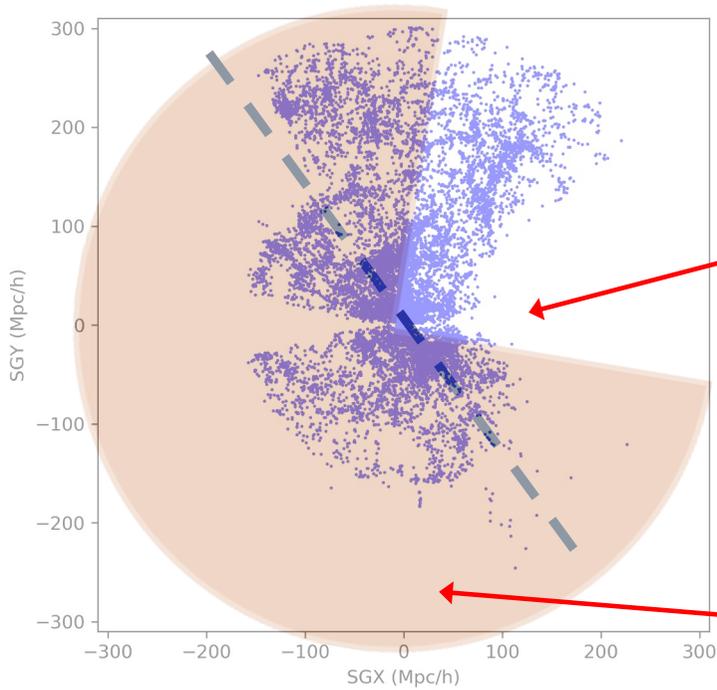
Wallaby pilot and start of full survey in 2023

H. Courtois et al. 2022, arXiv:2210.12498

the question we try to answer is :

Today : a new technology : sensitivity of interferometric multi-antennas radio-telescope (how far, how good) ?

Today : new radio technologies : SKA (square kilometer array)



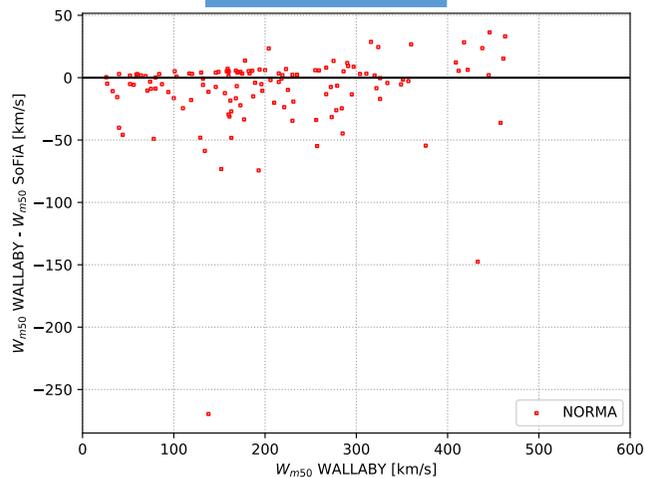
MeerKAT :
Obscuration zone

WALLABY :
+200,000 galaxies

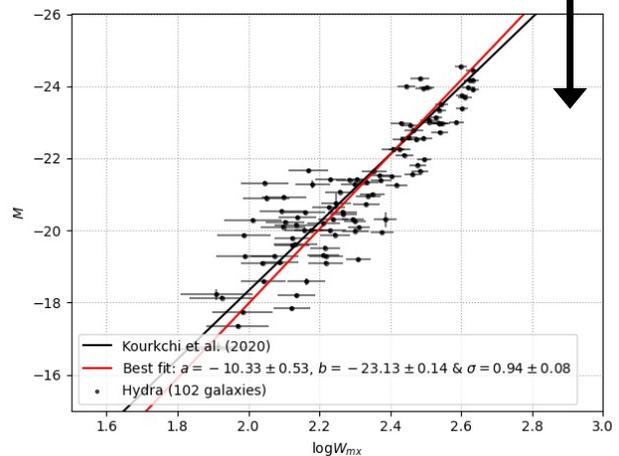
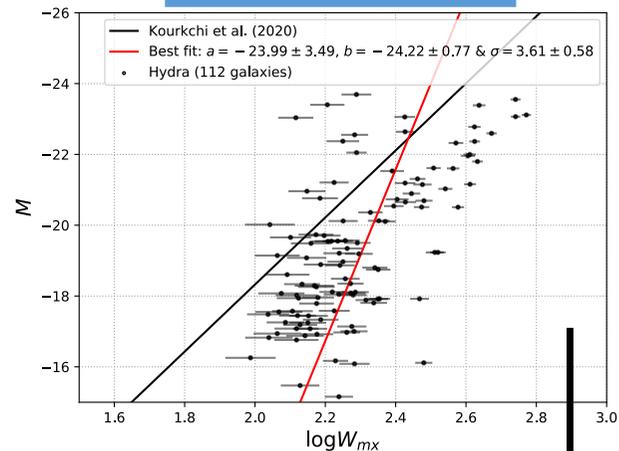


Phase 1 Wallaby Pilot Survey :
 from radio HI linewidth algorithms pipeline and space near-infrared photometry
 to distance moduli using in 4 test fields

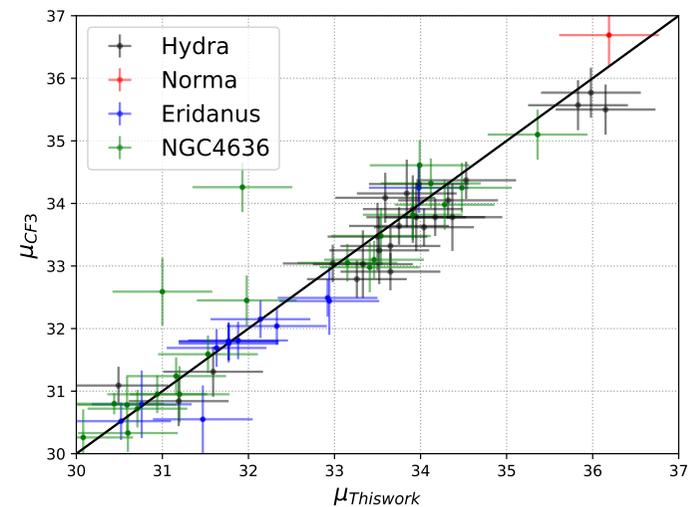
radio



photometry



Distance moduli



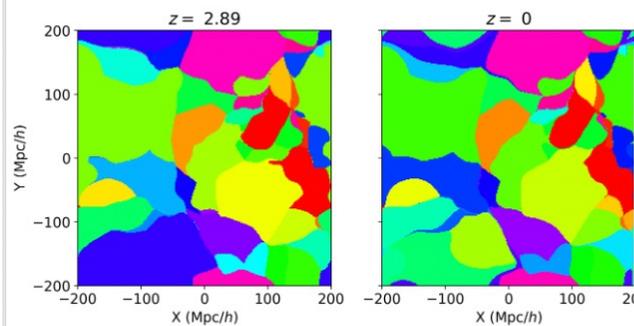
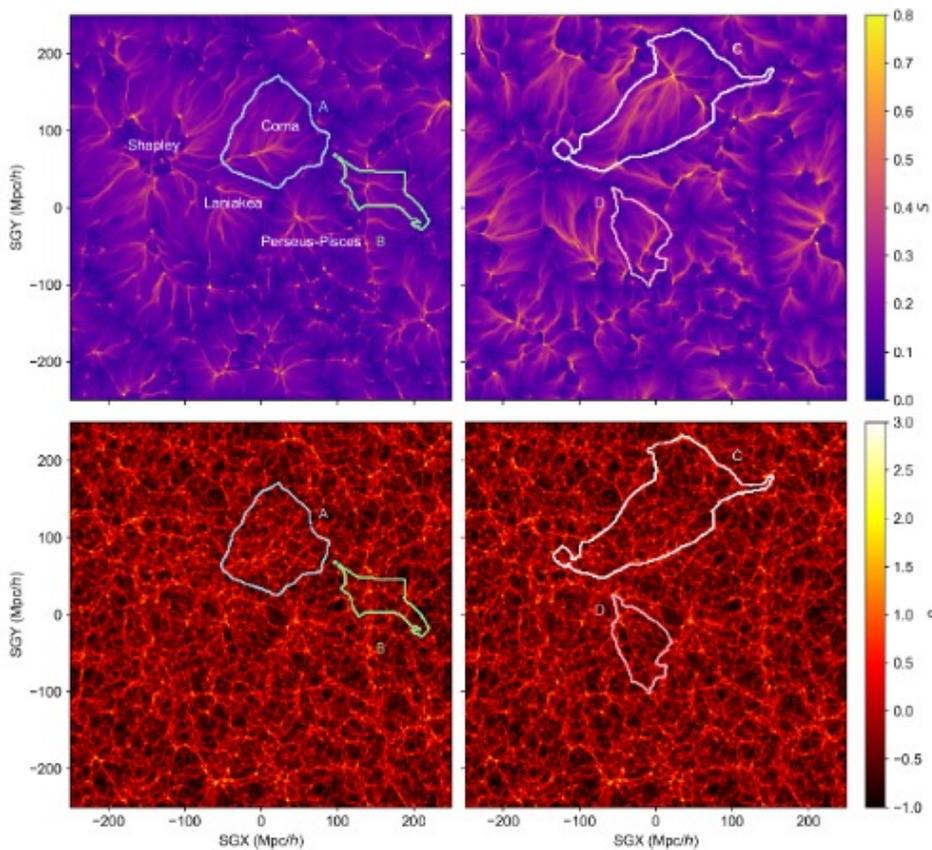
Testing gravitation using homogeneity and growth rate of structures

H. Courtois et al. Submitted 2022

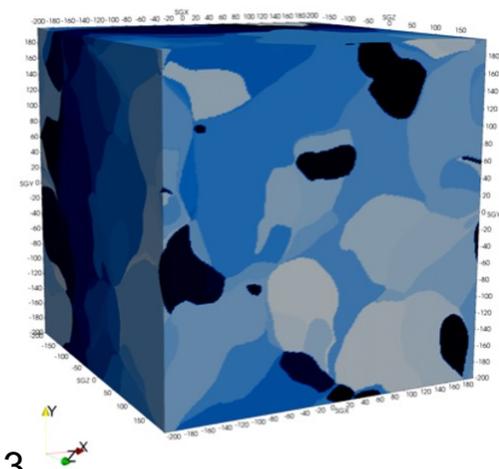
the questions we try to answer are :

- Do we find a scale at which the universe is homogeneous : no more large tidal flow due to large gravitational instabilities ?*
- How fast does gravitation pull galaxy structures together ?*

Watersheds, bulk flow, growth rate

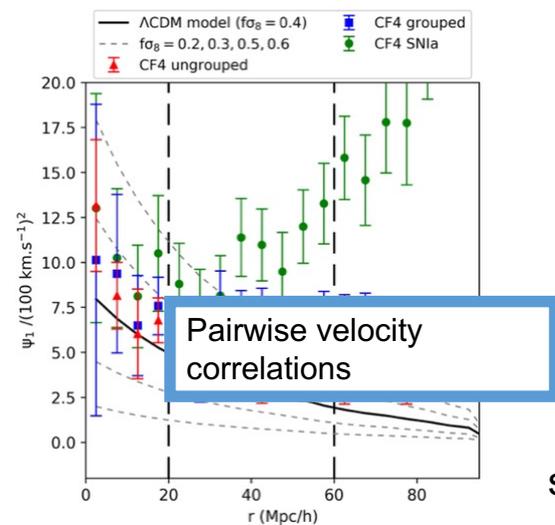
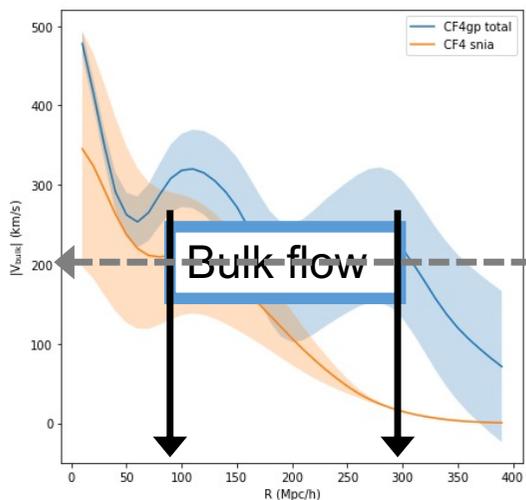


Evolution in time of the gravitational watersheds in a simulated universe at 2 billions years and today 13,7 b.years

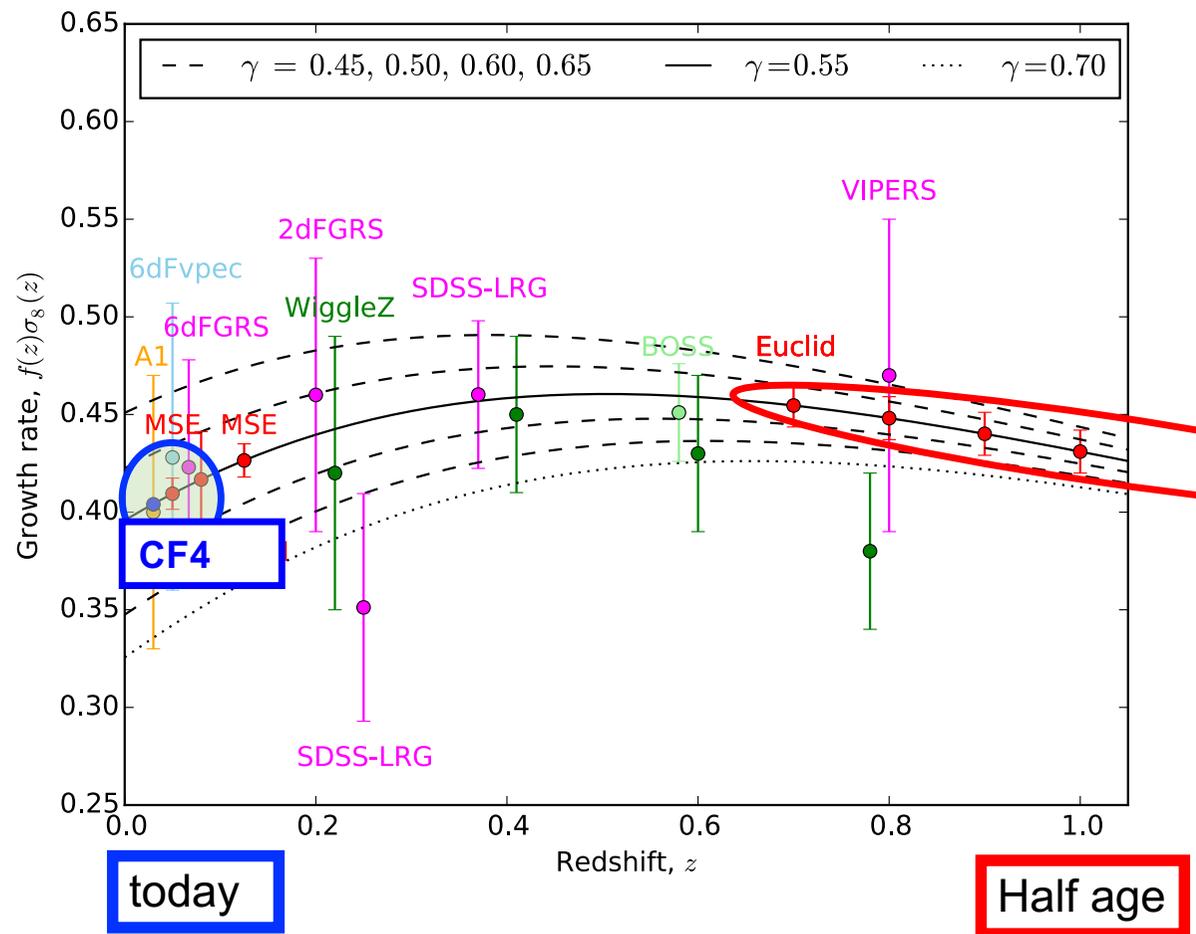


Dupuy et al. 2020 MNRAS 493, 3513

Homogeneity and growth rate of large scale structures as tests for general relativity / gravitation



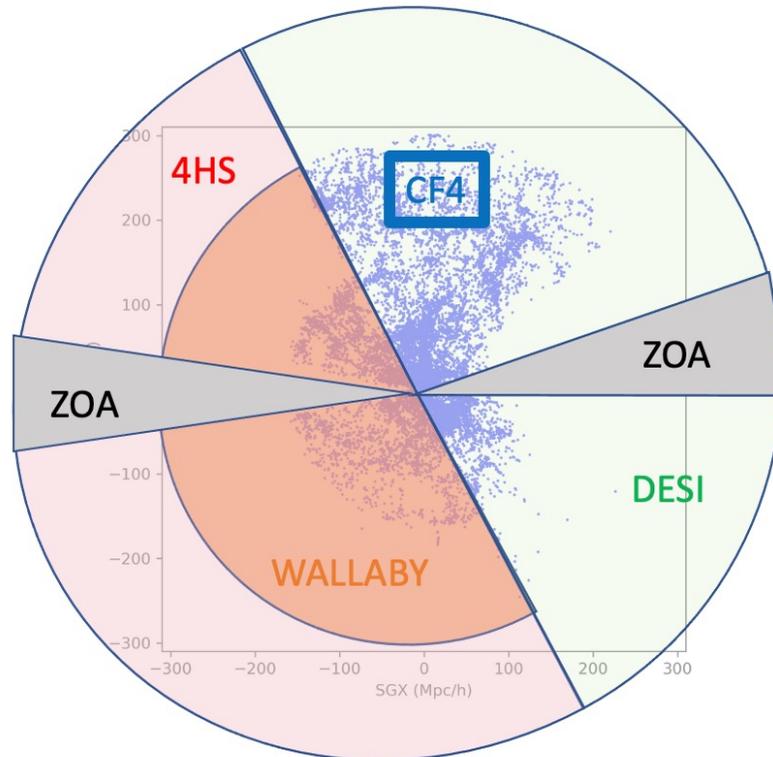
submitted



upcoming peculiar velocity datasets for further gravitation investigations

Leader WP
ANR voids
Executive board

WALLABY [22-27] : 90 000 spirals up to $z=0.1$
DESI-BGS-PV [21-26] : 500 000 ellipticals up to $z=0.15$
4MOST-4HS-PV [24-29] : 500 000 ellipticals up to $z=0.15$



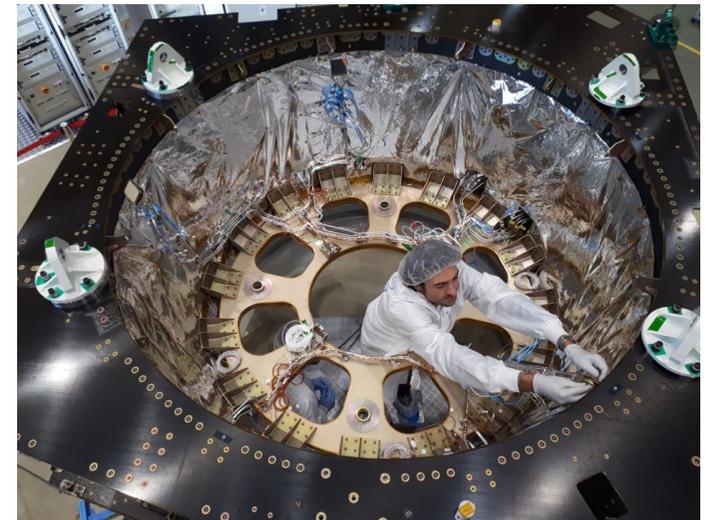
Euclid mission launch 2023 (July? Space X) : non-linear reconstructions of velocity fields in different environments and at different epochs



15 European countries +

1,500+ researchers

10? millions galaxies for redshift space distortions



EDSU 2022

Huge thanks to all the organizers



Cosmic Flows in La Réunion
Le Voile de la Mariée

