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New constraints on HI cosmology and galaxy evolution at z<0.5 from SKA precursors

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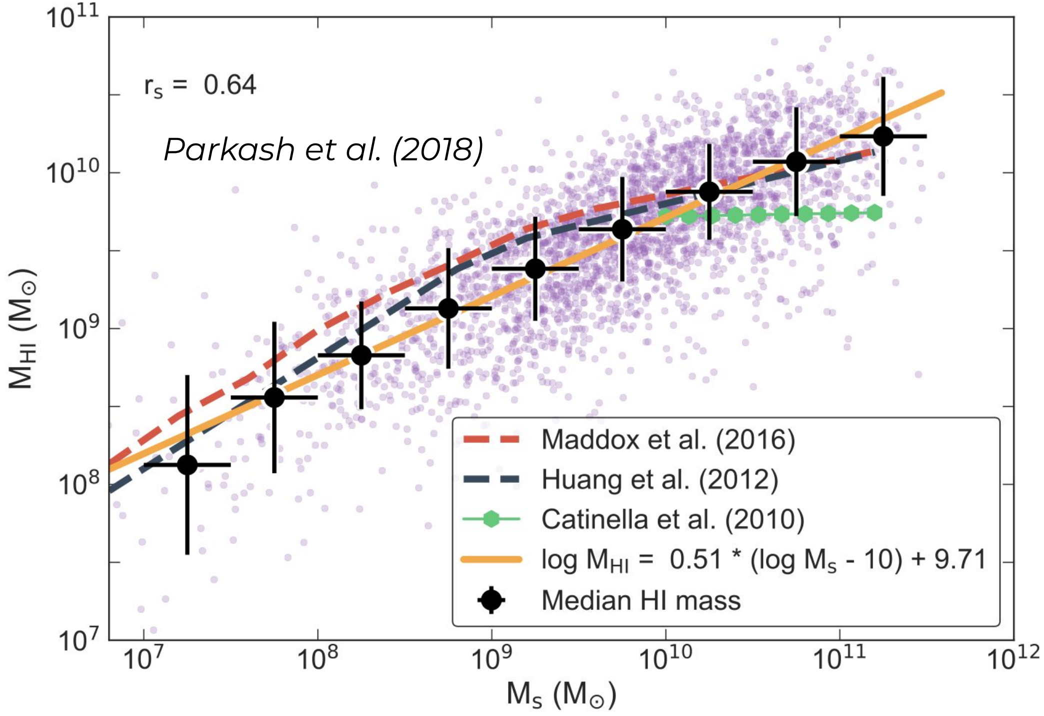
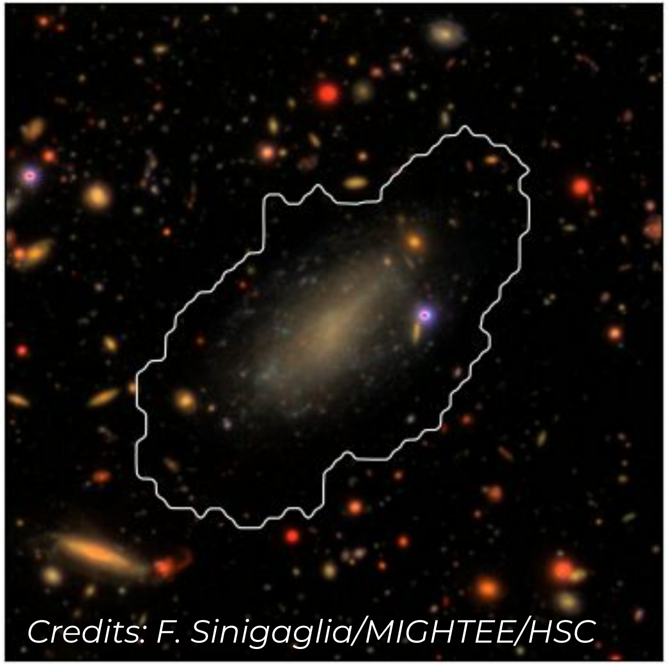
Scientific rationale





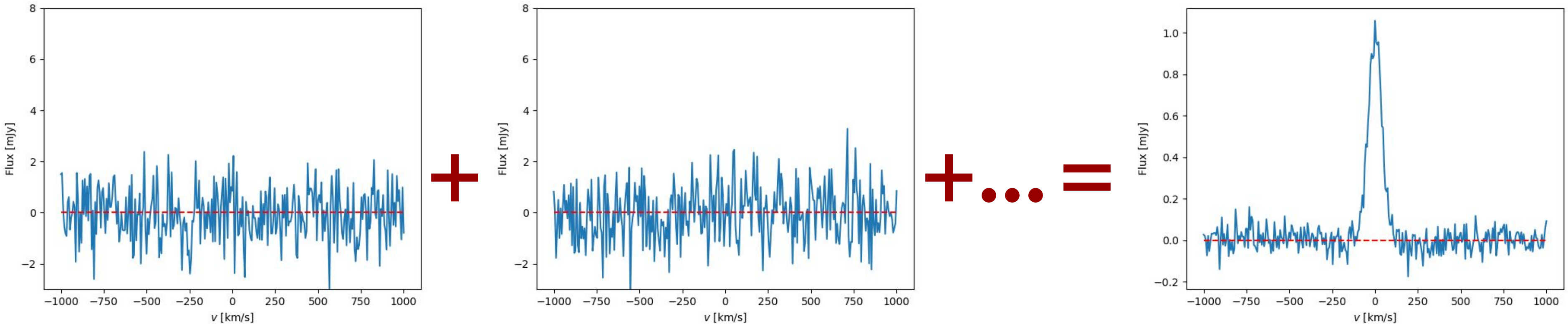
Measure **HI in galaxies** at z>0.1 as a function of **internal** (M* and SFR) and **external properties** (large-scale structure environment)

HI spectral stacking

HI can be observed through the **21-cm emission line** … but the line is **faint**!

At $z<0.1$ direct detection is possible

At $z>0.1$ direct detection not possible: use **spectral stacking**



Sinigaglia, Elson, Rodighiero, Vaccari (2022b), MNRAS, 514, 4205

The MIGHTEE survey

- **MeerKAT: 64 dishes (13.5m diameter)**

  located in the Karoo Desert (South Africa)

- **Bandwidth: 0.90 < ν < 1.67 GHz**

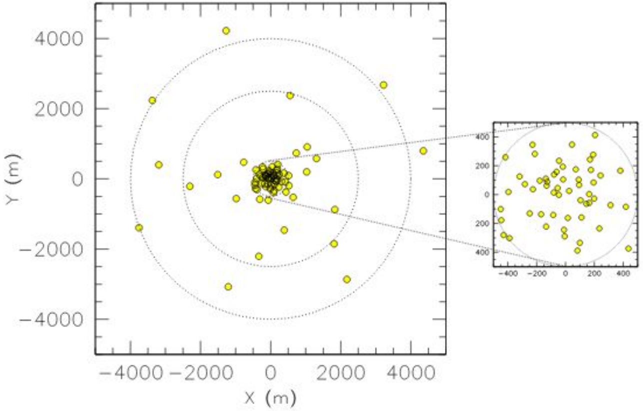
  (HI emission: ν ~ 1.42 GHz)

- **Field (final): ~ 20 deg^2**

  (Early Science data: COSMOS @ 0.23<z<0.49)

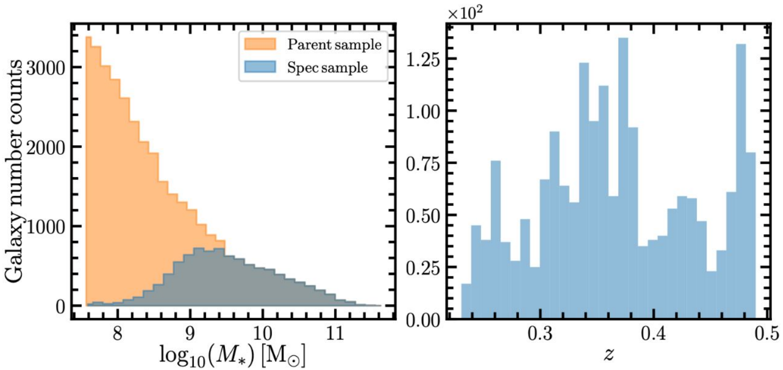
- **Redshift range: 0 < *z* < 0.5**

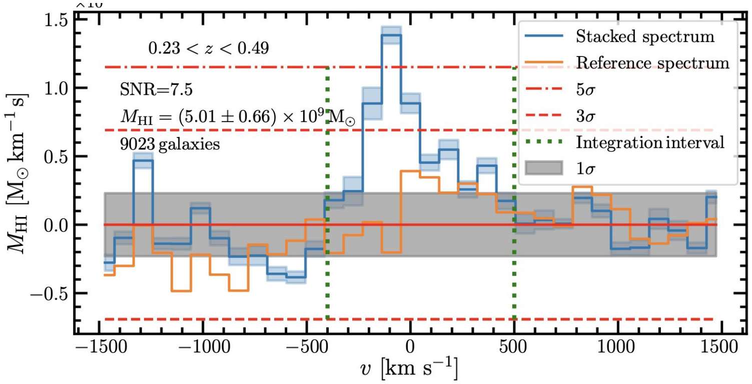
Jarvis et al . (2016)
Maddox et al. (2021)



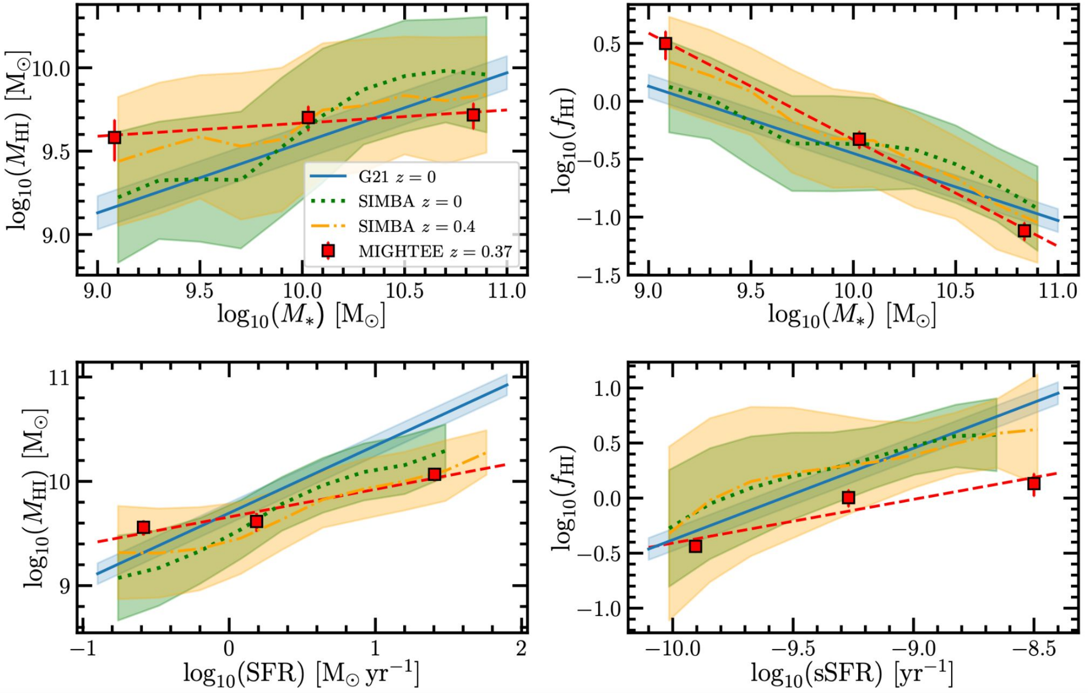
Location of dishes in the Karoo

HI scaling relations at z~0.37





9023 star-forming galaxies with spec-z at 0.23<z<0.49



- **First detection** of HI scaling relations of star-forming galaxies at **z~0.37**
- Need for efficient **HI replenishment** of HI over the last 4 Gyr
- Good agreement with cosmological simulations

Sinigaglia et al. (2022c), ApJL, 935, L13

HI at z~0.37 in the LSS environment: outline

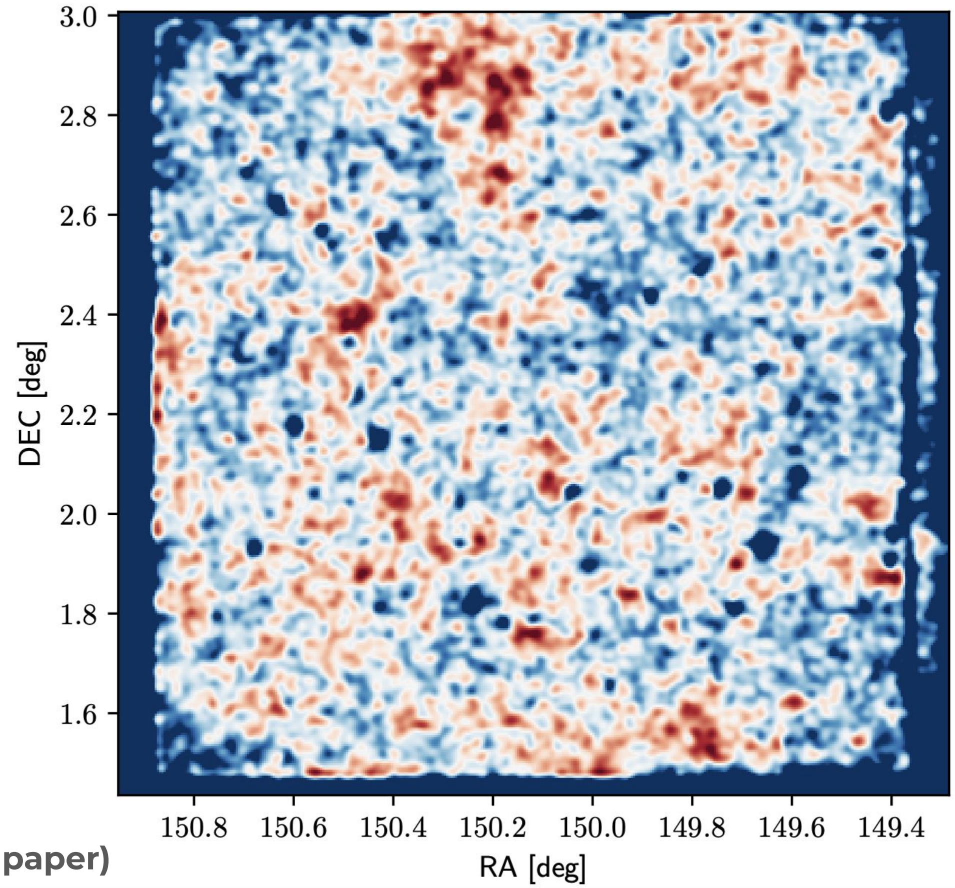
Same approach and techniques as before.
3 definitions of environment:

- galaxy **overdensity** field
- **centrals/satellites**, after running a Friends-of-Friends group finder
- **field, filament or knot** membership, based on the curvature tensor

Classification available from *Darwish et al. (2015, 2017)*

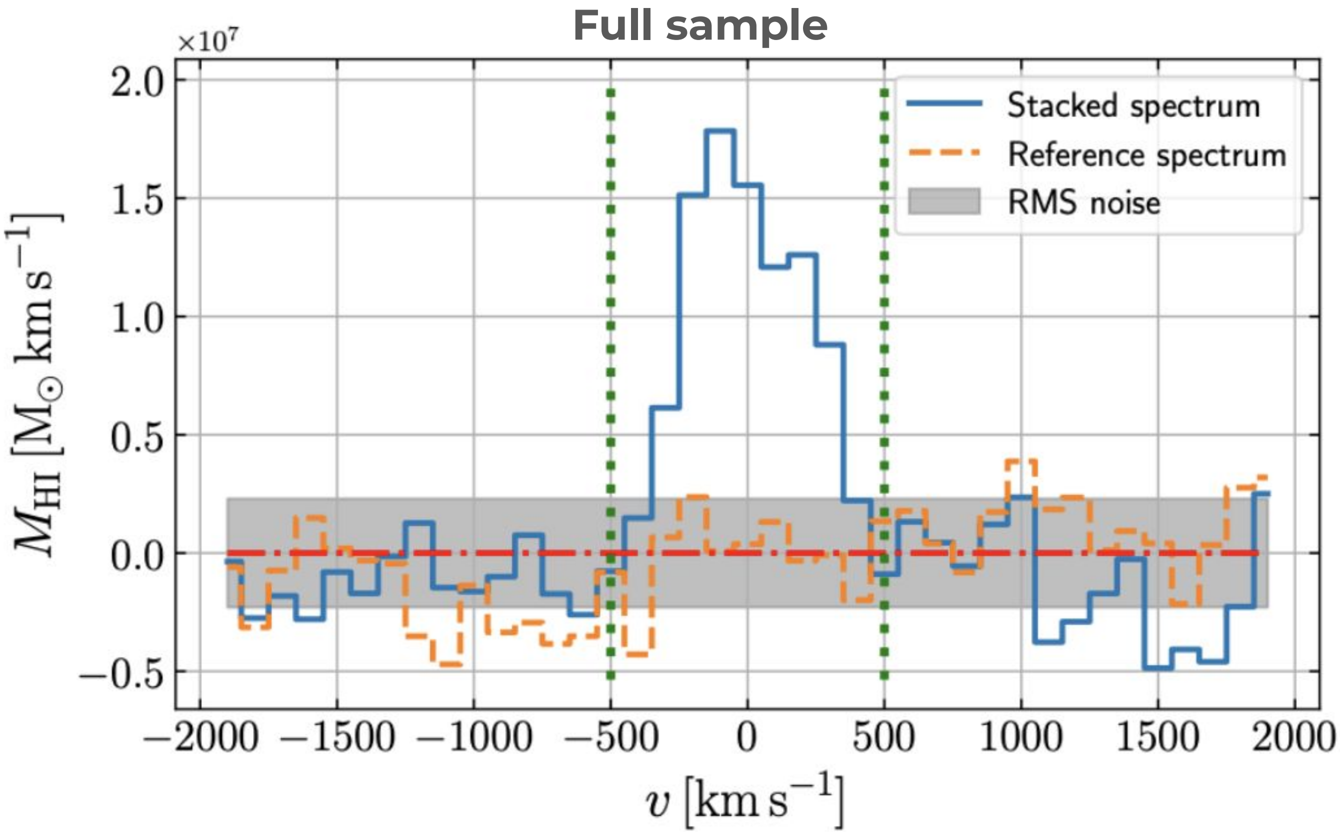
2875 star-forming galaxies with spec-z (COSMOS)
(implemented detailed RFI masking)

Cut at **$\log_{10}$(M*)>9.6** for completeness, **⟨z⟩~0.37**



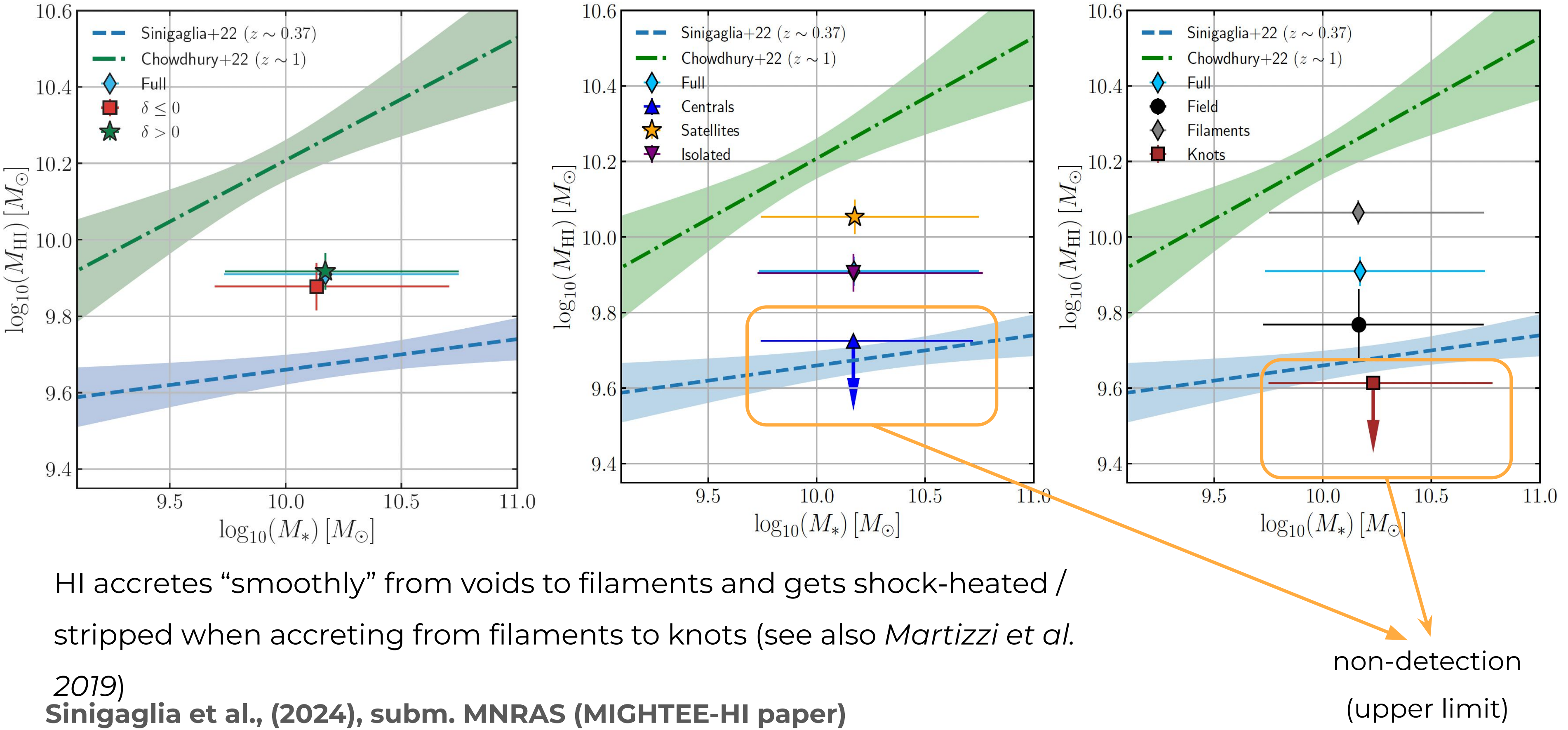
Sinigaglia et al., (2024), subm. MNRAS (MIGHTEE-HI paper)

HI at z~0.37 in the LSS environment: spectra



Sinigaglia et al., (2024), subm. MNRAS (MIGHTEE-HI paper)

HI at z~0.37 in the LSS environment: results



HI accretes "smoothly" from voids to filaments and gets shock-heated / stripped when accreting from filaments to knots (see also *Martizzi et al. 2019*)

Sinigaglia et al., (2024), subm. MNRAS (MIGHTEE-HI paper)

Related and ongoing and future projects

- Compute the Ω_{HI} and derive the HIMF (in progress!)
- Follow-up environmental studies on 3D-reconstructed density fields (DESI BGS spec-*z*)
- Investigate implications of environmental effects on BAO peak position
- Extend the scaling relation framework to CHILES data (*Bianchetti et al., in prep*, incl. **FS**)
- Study the HI content of red dusty passive galaxies at z~0.37 (*Rodighiero et al., in prep*. incl. **FS**)
- Study the HI content of AGN and non-AGN host galaxies (*Mangena et al., in prep.*, incl. **FS**)
- Study the HI content as a function of morphology (*Cook et al.*, incl. **FS**)
- Study the H_2 content in the same galaxies using ALMA data (A3COSMOS)
- Follow-up of the observational findings on cosmological hydro sims

HI density parameter (Ω_{HI}) and mass function

Two ways of measuring $\Omega_{HI} = \rho_{HI} / \rho_c$

Both rely on converting M* into M_{HI} and assume most of HI is in galaxies

$$\rho_{HI} = f \times \langle M_{HI} \rangle \,/\, \langle M_* \rangle \times \rho_*$$

Convert from stellar to HI density,

using a correction factor

Take a complete M_* sample

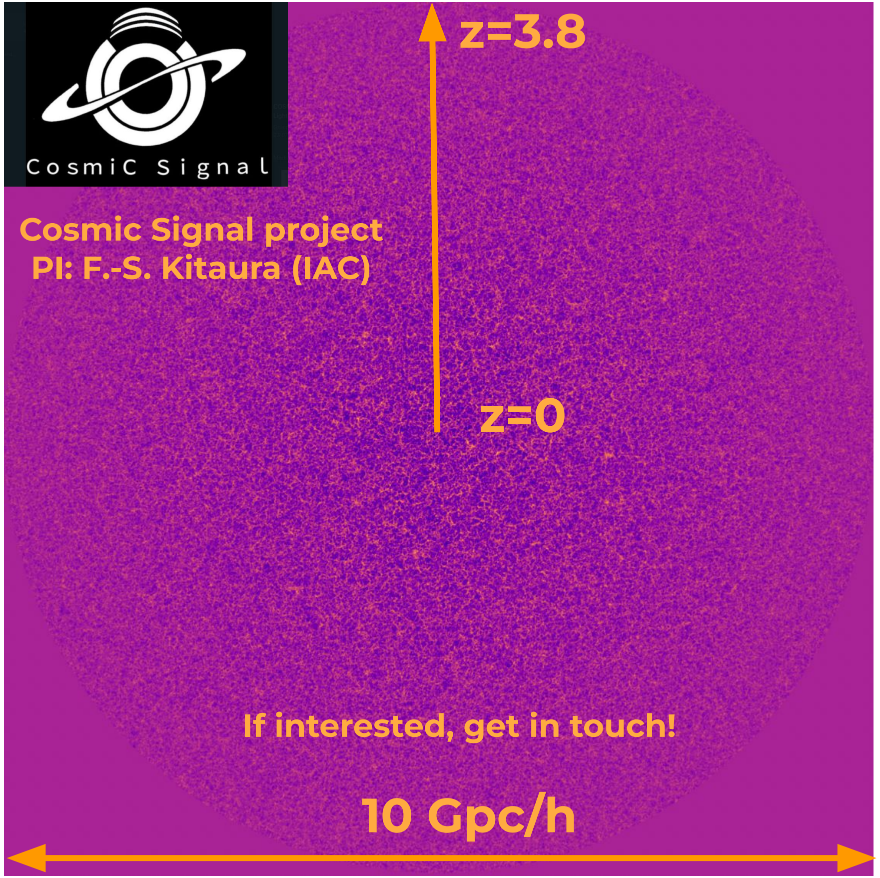
Convert from M_* to M_{HI} via a scaling relation

Build the HI mass function

Integrate the MF to get ρ_{HI}

Sinigaglia et al. (in prep.) (MIGHTEE-HI paper)

Multitracer mocks for cosmological surveys



Goal: predict all cosmological tracers on the lightcone up to z~3.8 for SKA, DESI & Euclid

Joint cosmological multi-tracer analysis

Generated of 2×200 lightcones
@ Leonardo, CINECA (Italy)

Tracers:

- galaxies (BGS, ELGs, LRGs, QSO) (DESI effort)
- Lyman-alpha forest (DESI effort)
- HI galaxies & continuum, HI IM (SKACH?)
- CMB? GWs? More to come ...

DARK ENERGY SPECTROSCOPIC INSTRUMENT
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SKA SQUARE KILOMETRE ARRAY

Kitaura, Sinigaglia et al. (in prep.) + others

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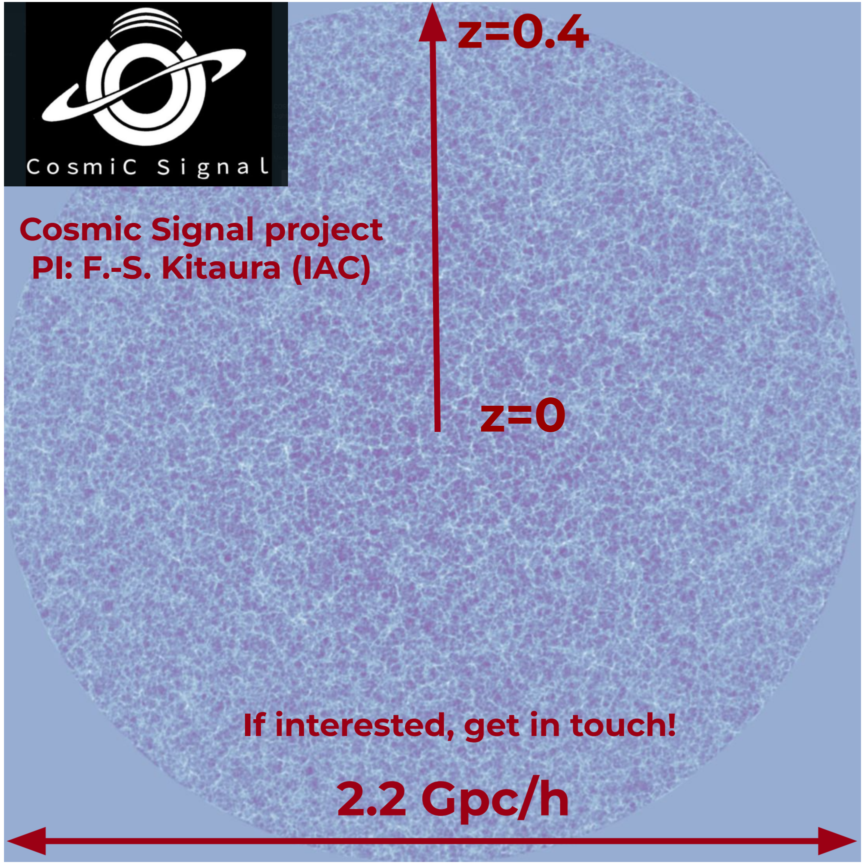

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Thanks!