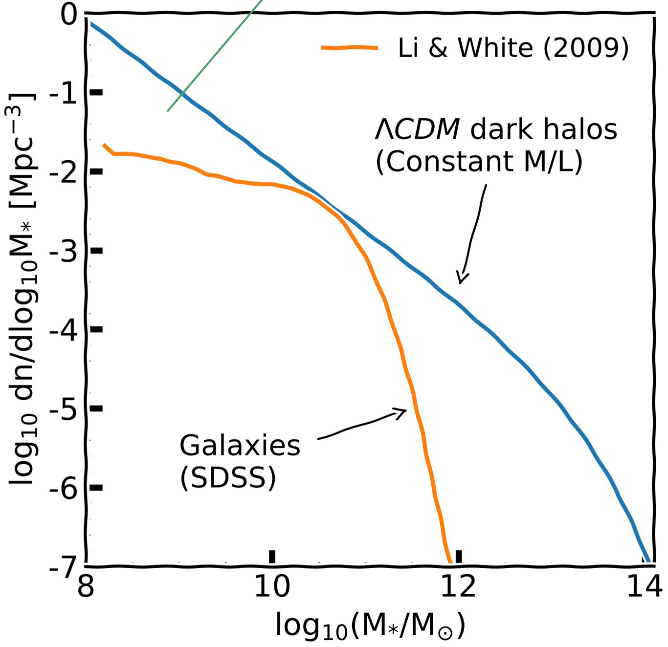
- Dark Galaxies as cosmological probes at the smallest scales -

- Alejandro Benítez-Llambay -

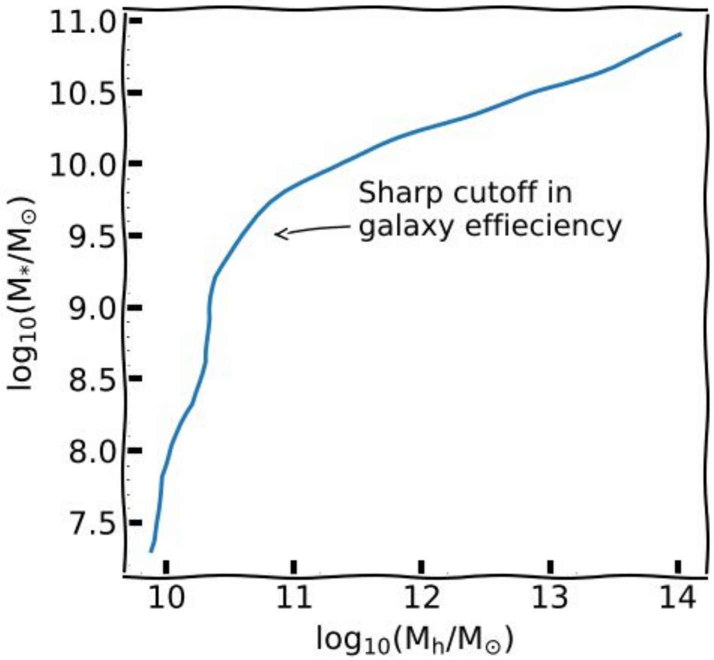
UNIVERSITA' DEGLI STUDI DI MILANO BICOCCA

Galaxy-halo connection (Missing satellites problem).

Discrepancy largely due to reionization → Increasingly large number of starless haloes below $10^{10}\ M_\odot$

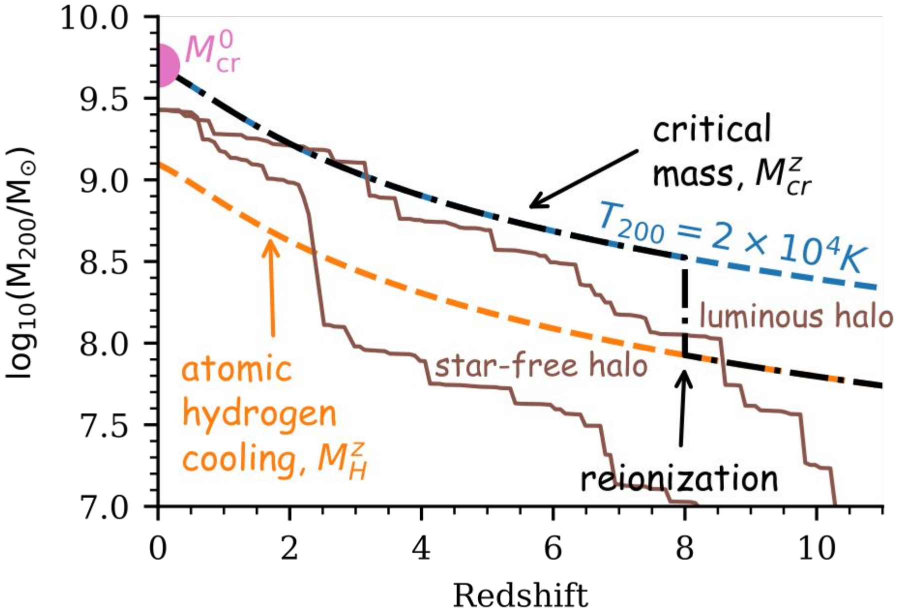


$$n(> M_{halo}) = n(> M_*)$$



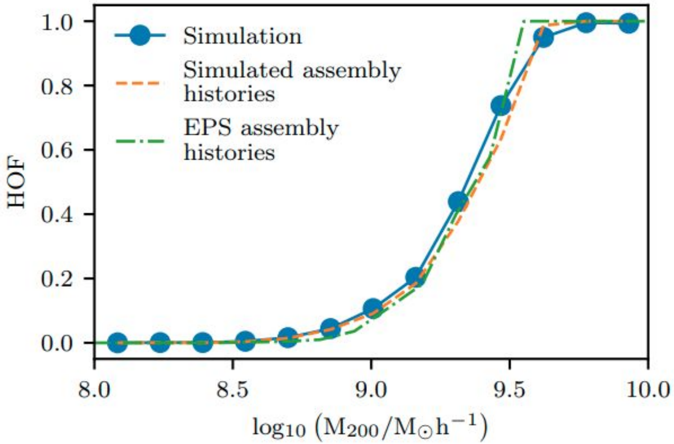
Matching halos and galaxies by abundance
(e.g. Behroozi et al. 2013)

Qualitative description of how galaxy formation proceeds in low-mass halos



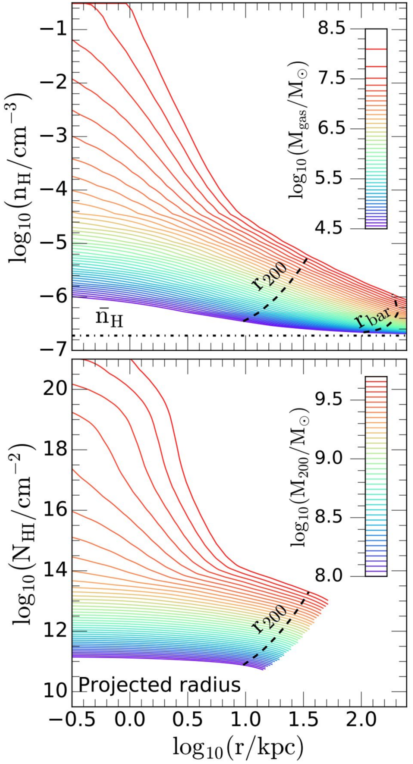
- Dark matter halos whose mass exceeded a critical mass at some point in the past, can host a galaxy today.

- After reionization, this critical mass depends on the mean density of the Universe and the intensity of the UV background. Before reionization, it is determined by the ability of the gas to cool via atomic cooling.

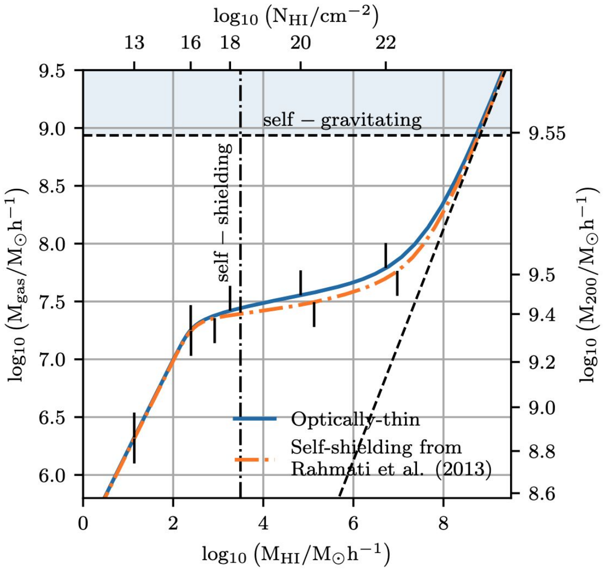


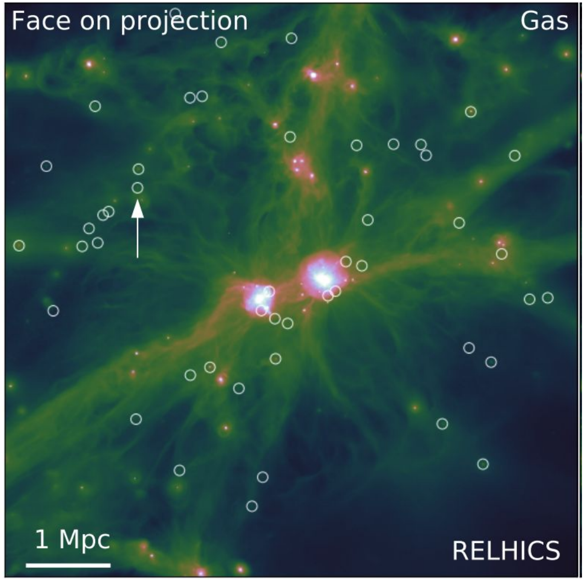
Benítez-Llambay & Frenk (2020)

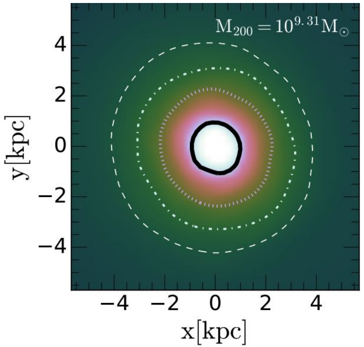
Gas properties of starless dark matter halos



Gas-rich starless halos are expected to be uniformly distributed across the sky, be round, with gas in hydrostatic equilibrium at temperature T ~ 2×10^4 K, and far from luminous galaxies.

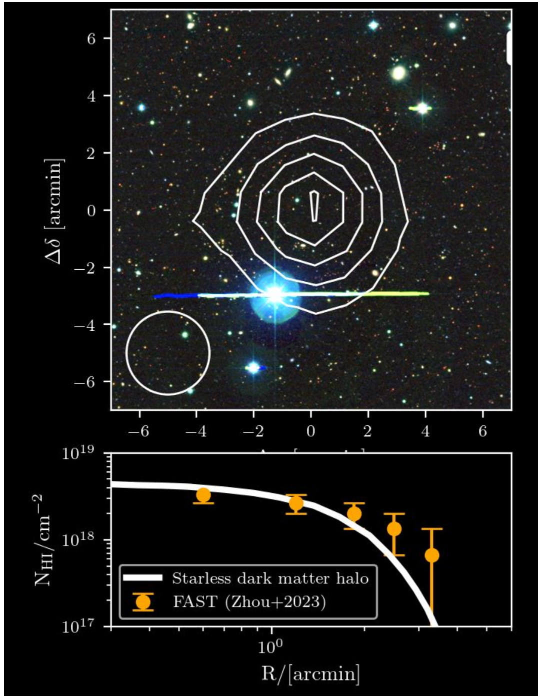






Benítez-Llambay et al. (2017)

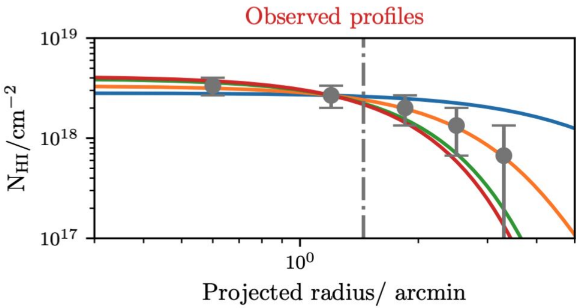
A Starless Dark Matter halo fully consistent with LCDM expectations may have been detected with FAST



Cloud-9, a rogue HI cloud detected near M94 by Zhou et al. (2023), without and optical counterpart brighter than 29.15 mag/arcsec^2 in the *g* band, has most of its properties consistent with expectations for a starless dark matter halo.

However, the cloud is systematically more extended in the outer parts compared to LCDM expectations.

Does this signal perturbations in the outer parts of departures from CDM?



It is possible to fit the data better with a dark matter halo with a large core in the centre.

The lack of stars would imply strong dark matter self-interactions. However, the picture is more complicated, as demonstrated by our new VLA observations.

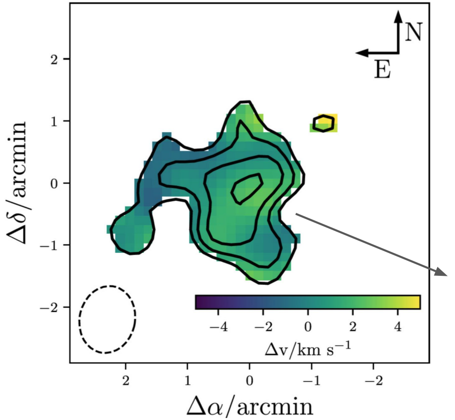
System discovered by Zhou et al. (2023)

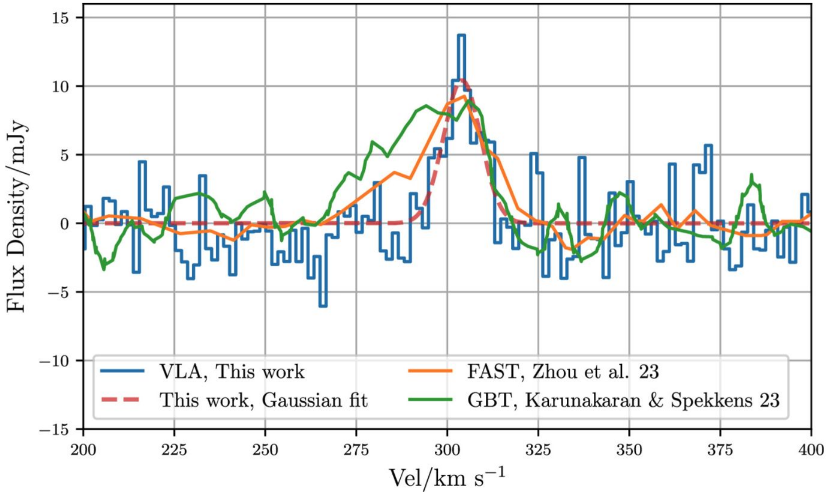
Benítez-Llambay & Navarro (2023)

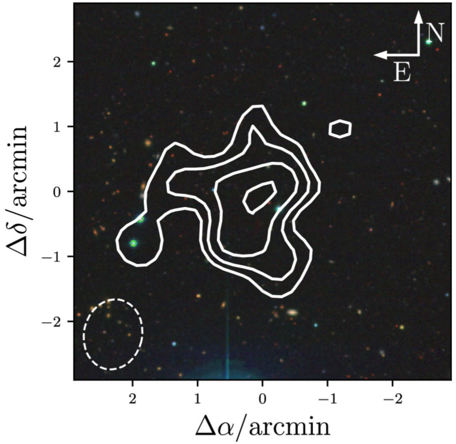
A Starless Dark Matter halo fully consistent with LCDM expectations may have been detected with FAST

Observed with VLA, the system displays features consistent with being subject to ram pressure stripping.

Still, the central gas distribution is still consistent with a gaseous system in hydrostatic equilibrium with a large amount of dark matter.



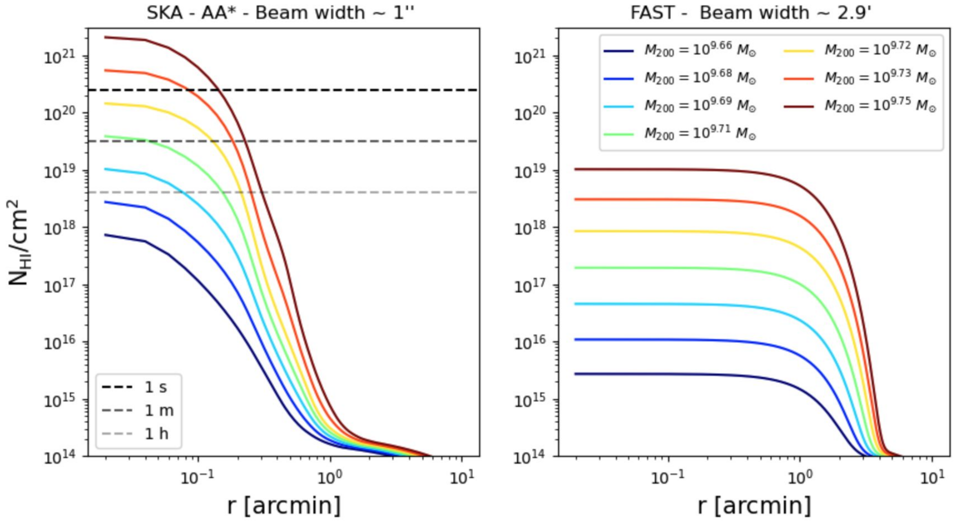




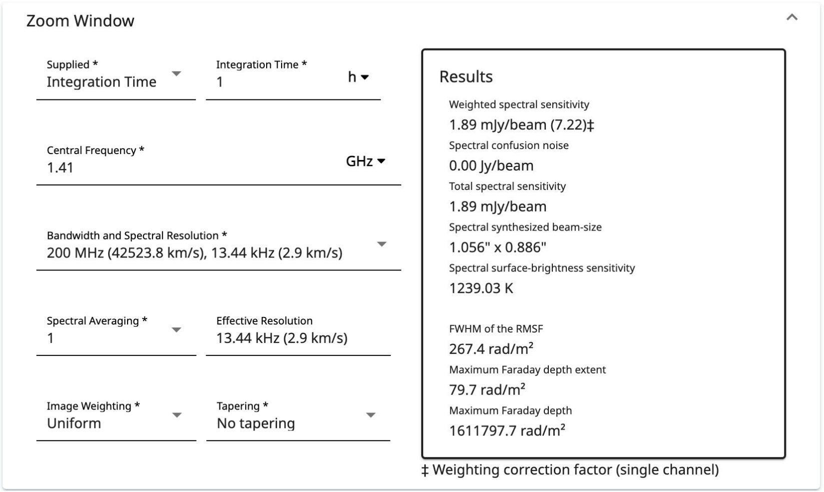
We are currently awaiting HST observations of this field (Likely occurring during February-March 2025)

Benítez-Llambay et al. (2024)

What can be probed with AA*



SKA sensitivity calculator



With effective integration times of one hour per field, it would be possible to sample the column density profile of the most massive starless halos and resolve the profile's decline beyond the core radius in these systems. This will allow us to constrain their underlying dark matter distribution and contribute to resolving the cusp/core controversy at small scales. (I**f dark matter cores are observed, the absence of stars strengthens the argument for cores not being star-driven, with cosmological implications regarding the nature of the dark matter**).

What can be probed with AA*

- Using high-resolution cosmological simulations, we find that the number density of starless dark matter halos massive enough to develop central column densities above **10^{19} cm^{-2}** is roughly **$n_R \sim 7 \times 10^{-3}$ Mpc^{-3}.**

- With a beam footprint of 1", we could resolve the core radius of starless systems with five beams up to a distance of roughly 40 Mpc. To find ten starless halos, this would require a survey area of approximately 220 square degrees.

- However, 8 out of 10 detections are expected to be faint quiescent dwarf galaxies. The good news is that characterising the 21 cm column density profiles of these quiescent dwarfs is expected to be equally informative about the underlying dark matter distribution!