

Searching for Galaxies Without Stars: HI Follow-up of FASHI Dark Galaxy Candidates

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Dark Galaxies

- Dark galaxies are **large isolated clouds of atomic hydrogen (HI) and dark matter**, with no optical counterpart.
- According to the Lambda CDM paradigm, a **galaxy's stellar mass scales with that of its halo**.
- Below a critical halo mass, **star formation no longer occurs**.

Photo Credit: European Space Agency

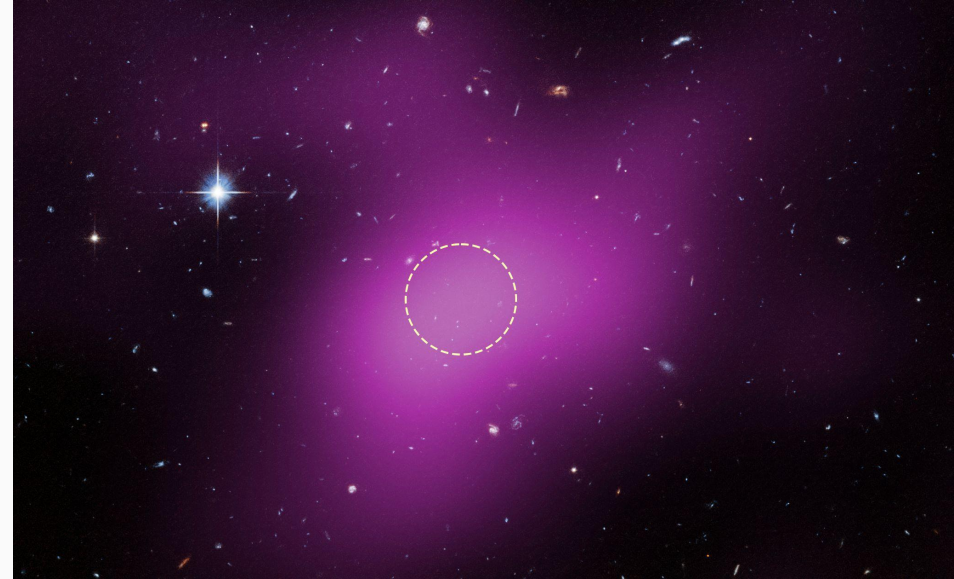


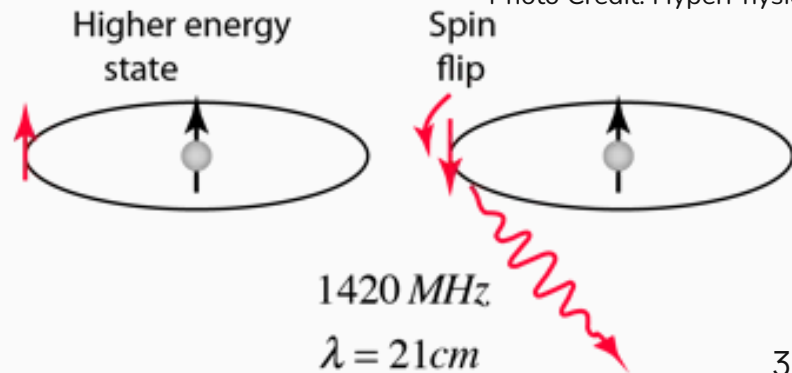
Photo of Cloud-9, currently our best dark galaxy candidate

The 21 cm HI Spectral Line

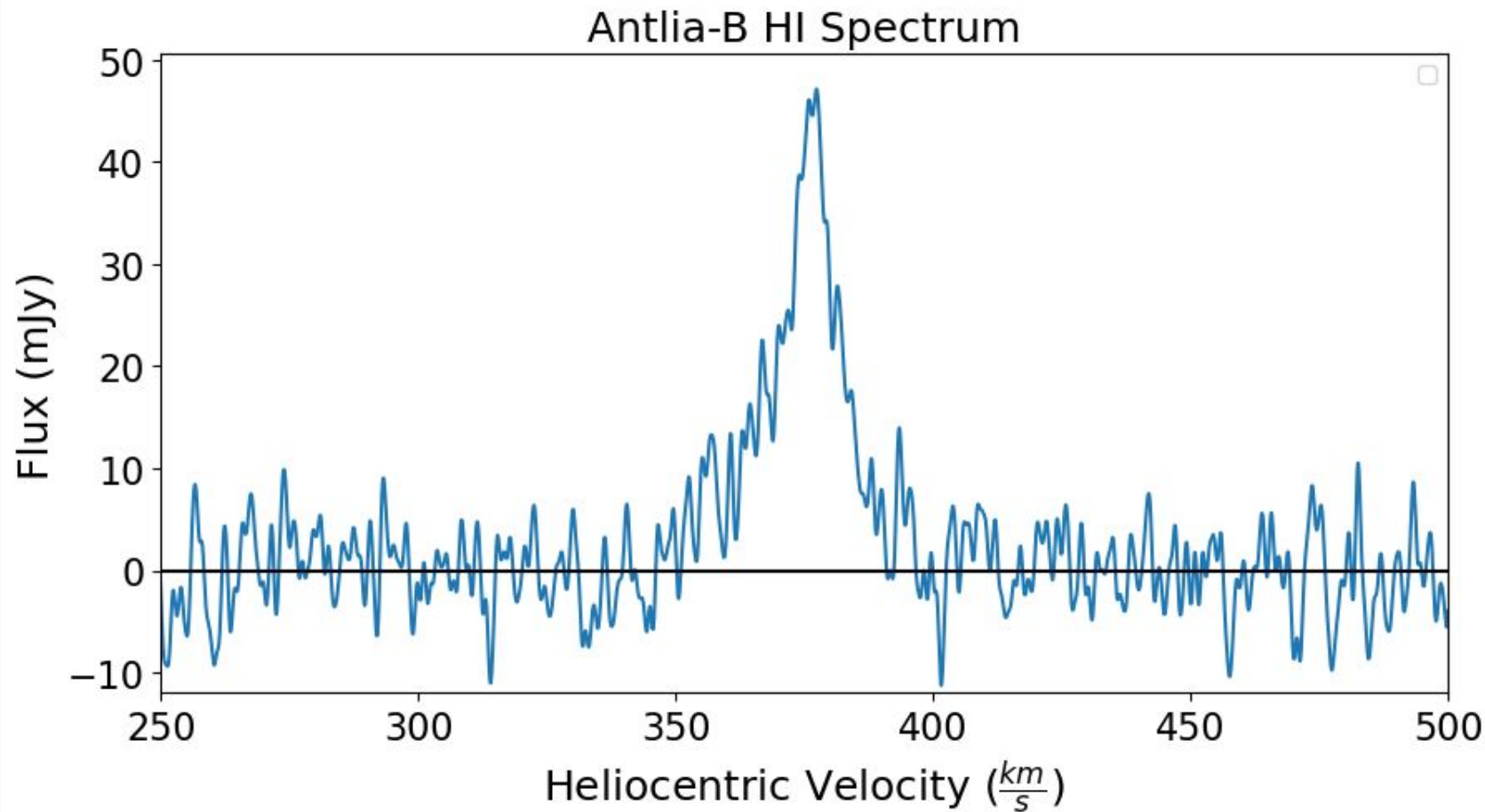
- The 21 cm radio wave is emitted when **an electron in HI spontaneously flips its spin**.
- When the proton and electron have the **same spin**, the system is in a **high energy state**.
- For one atom, it takes roughly **10 million years** for the spin flip to occur.



Photo Credit: HyperPhysics



High-Quality Spectrum



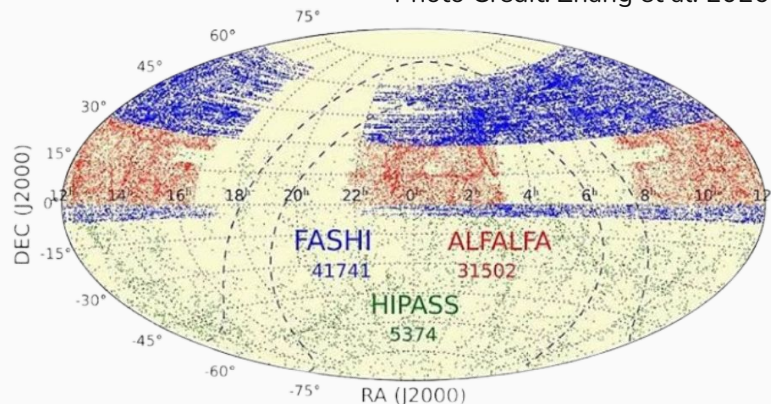
FAST and FASHI

- **Five-hundred meter Aperture Spherical radio Telescope (FAST)** is the largest single dish radio telescope.
- FAST has a diameter of 500 meters; it is located in Guizhou, China.
- **The FAST All-Sky HI survey (FASHI)** is a drift scan survey.
- The first data release of FASHI contains nearly 42,000 galaxies.

Photo Credit: Global Times



Photo Credit: Zhang et al. 2026



The 70 Dark Galaxy Candidates

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FAST and Dark: A catalogue of Dark Galaxy Candidates within 50 Mpc

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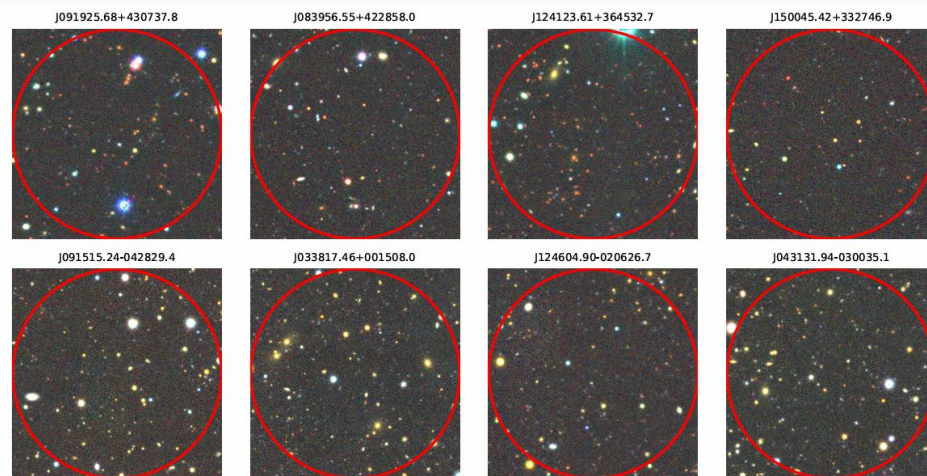
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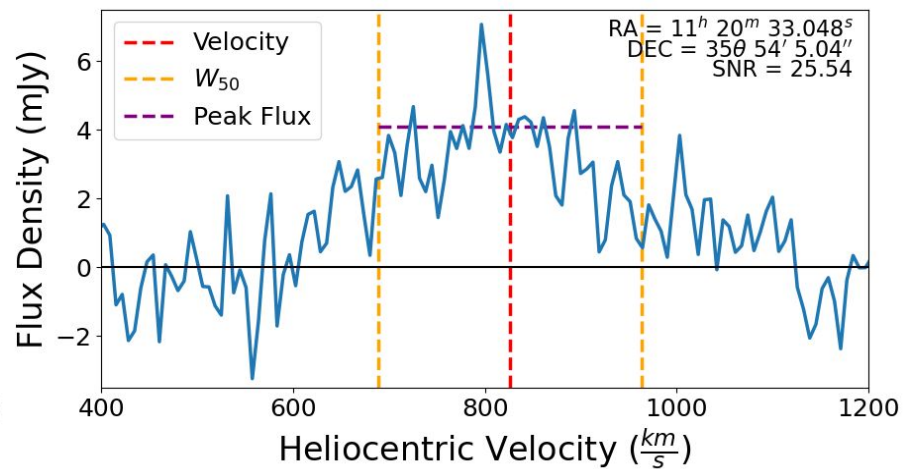
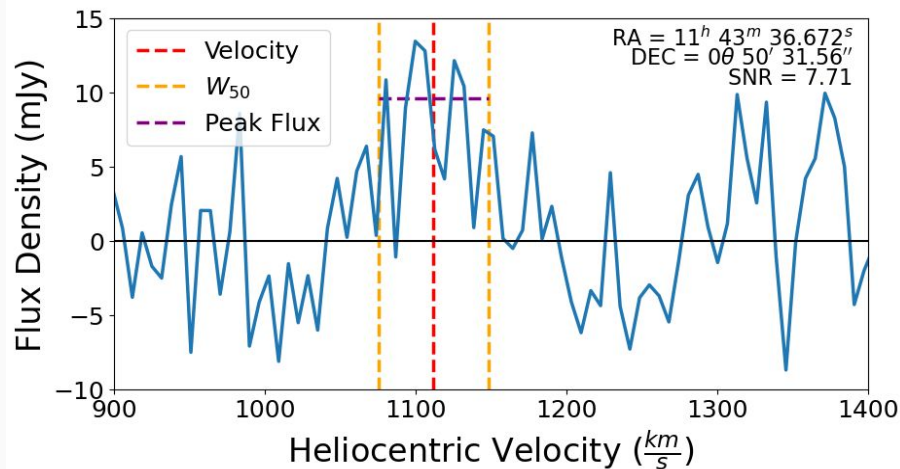
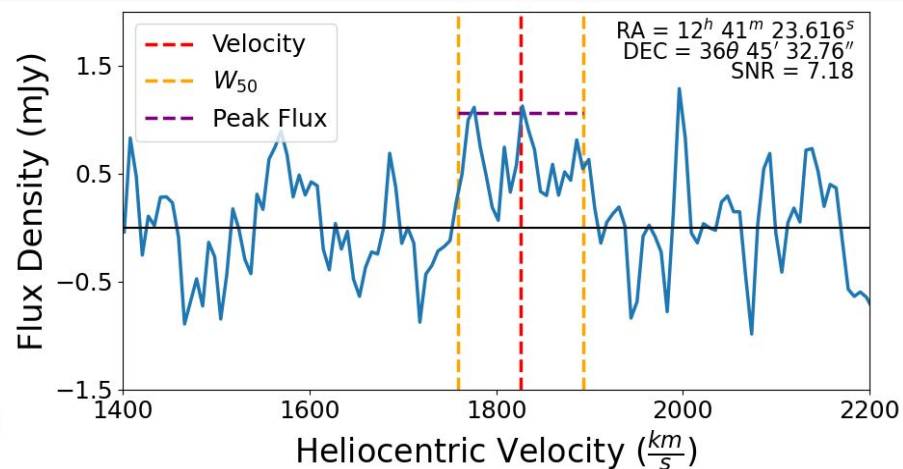
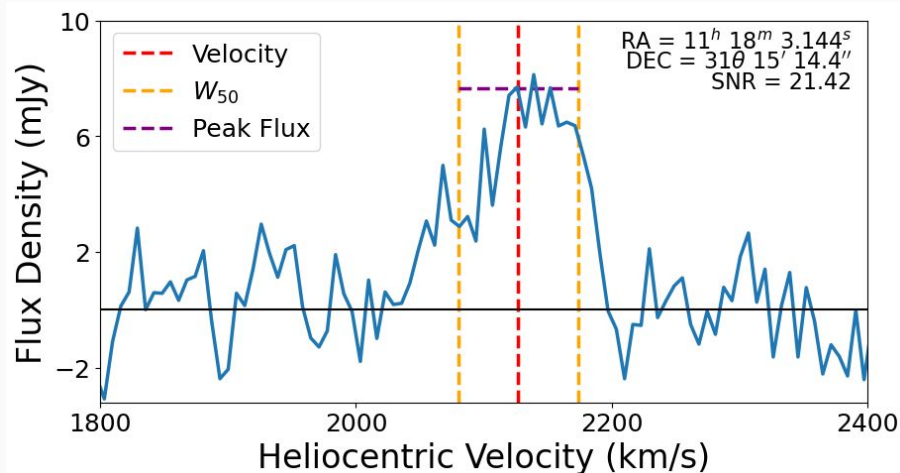
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Photo Credit: Monaci et al. 2026



Sample Dark Galaxy Candidate Spectra



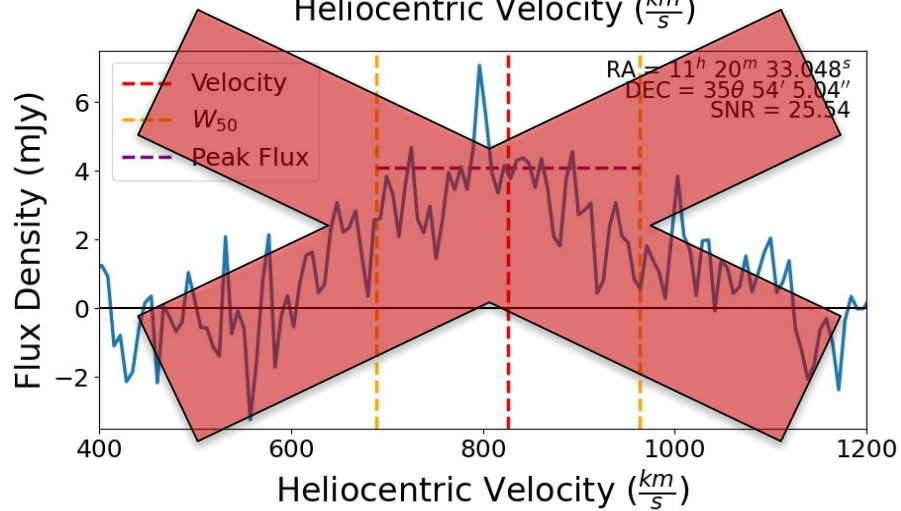
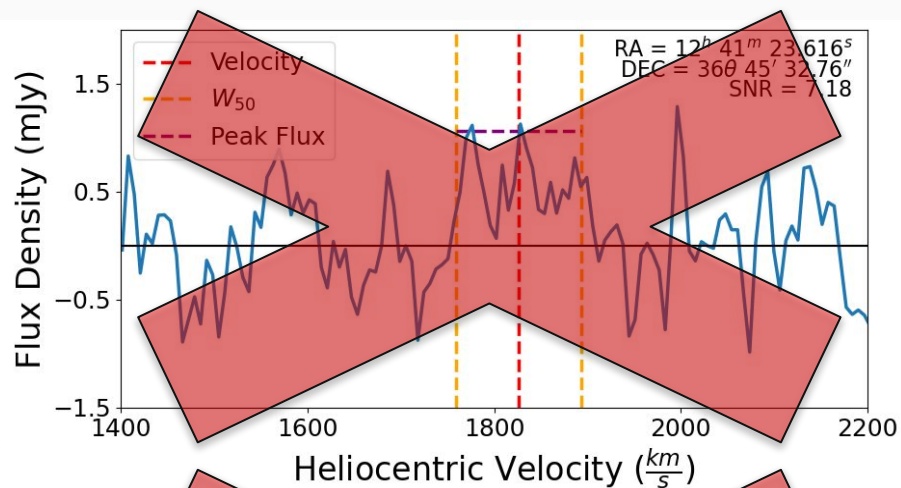
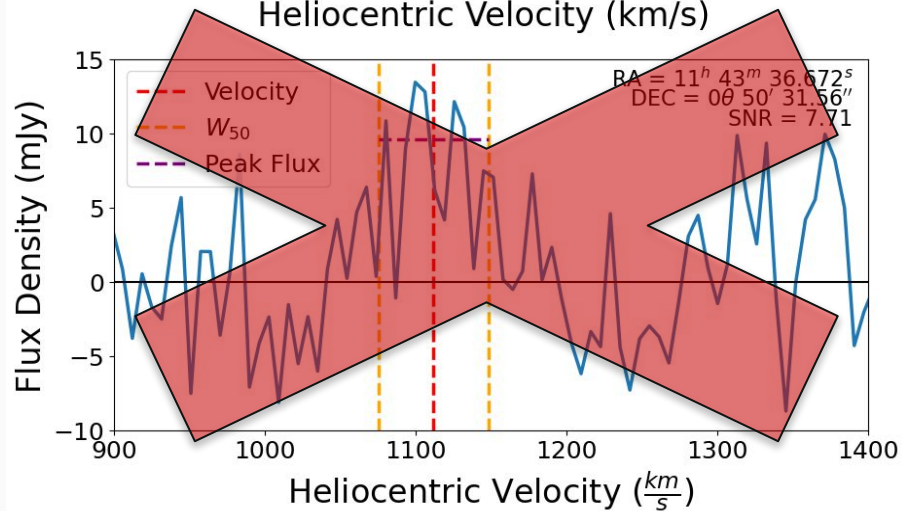
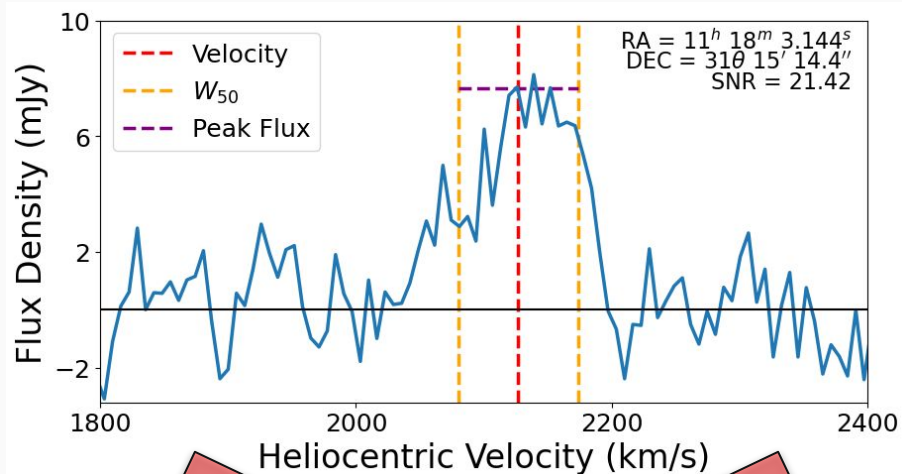
FASHI's Second Data Release

Photo Credit: Zhang et al. 2026

- In early July, FASHI came out with DR2, claiming to have observed over 150,000 galaxies.
- After cross checking, we found that **60 of the 70 dark candidates were not in DR2**, indicating they were spurious.
- This left us with **10 galaxies** in our catalogue.

Fifth, the DR2 catalog incorporates nearly all sources reported in FASHI DR1 (Zhang et al., 2024b), with the exception of $\sim 1\,500$ objects that are not recovered in the updated observations. Given the higher sensitivity and improved data quality of DR2, these unrecovered sources are most likely spurious detections in DR1, arising from positional uncertainties in extended sources or from residual RFI contamination. Such suspicious entries have been removed from the DR2 catalog through updated processing and validation procedures. Based on our validation process combining multi-criteria inspection, the false-detection rate for the full DR2 catalog is estimated to be below 2%. We therefore recommend that users preferentially adopt the DR2 catalog for scientific analyses. For applications requiring the highest reliability, users may select sources with higher SNR or secure optical spectroscopic counterparts.

Sample Spectra After Cuts



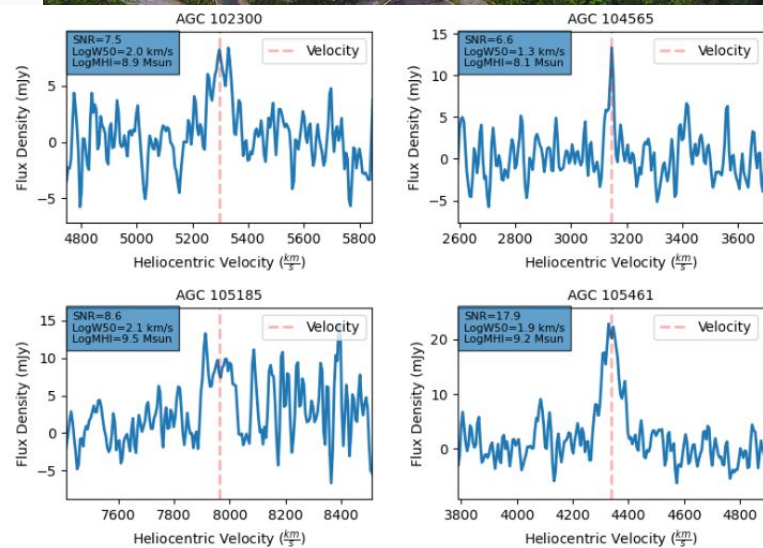
ME WHEN 86%

OF THE GALAXIES AREN'T REAL

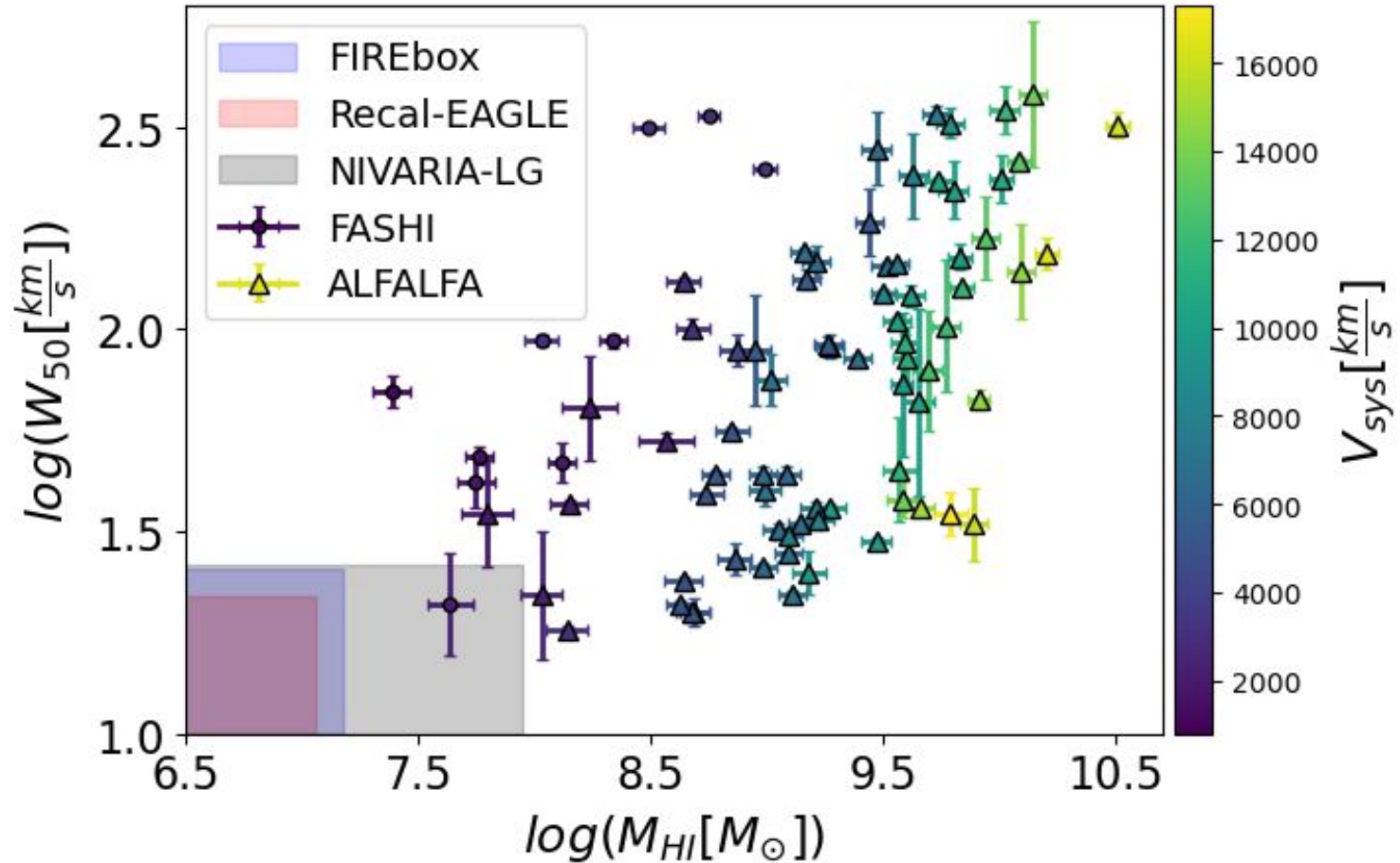
The ALFALFA Catalogue

- In concept, the **ALFALFA** survey is almost identical to FASHI.
- Using the Arecibo telescope, the ALFALFA survey contains over 31,000 galaxies.
- One group of researchers identified over **100 dark galaxy candidates from ALFALFA**.
- After checking for optical counterparts and cross-checking with FASHI DR2, there were **73 galaxies we wanted to follow up**.

Photo Credit: Universe Today



Comparing Dark Candidates to Theory



Green Bank Telescope Proposal

Photo Credit: NRAO

- We plan to follow-up using the **Green Bank Telescope (GBT)**.
- This is a 100 meter diameter radio telescope in Green Bank, West Virginia.
- The GBT would focus on one galaxy at a time, yielding a **much higher spectral resolution**.
- This decrease in noise would let us **know whether or not there is a galaxy**.



Conclusion

- We **successfully submitted a proposal** to the GBT to follow up the 73 ALFALFA and 10 FASHI dark galaxy candidates.
- If these galaxies prove to be dark galaxies, it would **redefine the way we understand galaxy formation and evolution**.
- We hope to hear back about our proposal sometime in the fall.
- I am more than happy to take questions!



Goodwin et al.

III Follow-up of FASHI and ALFALFA Dark Galaxy Candidates

SCIENTIFIC JUSTIFICATION

We propose GBT III observations of 83 dark galaxy candidates discovered in the FASHI and ALFALFA surveys that we have not been able to otherwise rule out with available data. The existence of dark galaxies is a key prediction of galaxy formation models within a Λ CDM universe that has yet to be confirmed. The GBT is an efficient way to verify dark galaxy candidates from other surveys and obtain a degree of spatial information, which will provide the first indications of their nature and kickstart a multi-wavelength follow-up campaign to find dark galaxies in a test of Λ CDM predictions.

Thank You!