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## Introduction

Three "Harvesting ALFALFA" Arecibo observing programs in the direction of the Pisces-Perseus Supercluster (PPS) were completed since ALFALFA observations were finished in 2012.



### Arecibo Legacy Fast ALFA<sup>1</sup> Survey

Blind extragalactic neutral hydrogen (HI) spectral line survey covering 7,000 square degrees of the sky. Observing in frequencies between 1,345 MHz and 1,435 MHz allowed detection of HI source velocities of -3,000 km/s to +19,200 km/s with 5 km/s resolution at a Hubble distance of 270 Mpc,  $z \leq 0.06$ . Observations began on February 4, 2005 and were completed on October 26, 2012.

40% of the data were released in 2011 ( $\alpha.40$ , Haynes *et al.*, 2011), 70% in 2015 and the preliminary release of  $\alpha.100$ , has begun at <http://egg.astro.cornell.edu/alfalfa/data/>.

<sup>1</sup> Arecibo L-band Feed Array

### Pisces-Perseus Supercluster

PPS is the nearest supercluster to Milky Way Galaxy beyond Laniakea. (Tully *et al.*, 2014). We seek to explore the distribution and peculiar velocities of galaxies and clusters to determine the underlying distribution of dark matter in the large scale structures of the universe.

PPS has been found to be

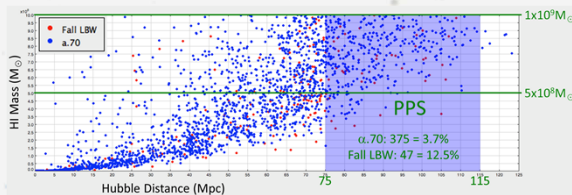
- ✦ wall of clusters roughly 5h<sup>-1</sup> Mpc to 10h<sup>-1</sup> Mpc deep
- ✦ extending at least 50h<sup>-1</sup> Mpc from the Perseus to Pegasus
- ✦ with a significant overdensity of galaxies at a heliocentric velocity of about 5,000 km/s. (Wegner *et al.*, 1993)
- ✦ between foreground and background voids.

All of which allow more accurate determinations of infall velocities of galaxies on each side of the main ridge of the supercluster.

At the distance of PPS,

- ✦ 4% of  $\alpha.70$  sources (in blue below) have  $M_{HI} < 10^9 M_{\odot}$
- ✦ 12.5% of Fall LBW detections (in red) have  $M_{HI} < 10^9 M_{\odot}$

The Fall LBW observations have thus paved the way for the **Arecibo Pisces-Perseus Supercluster Survey (APPS)**. See **Davis *et al.* Poster 347.40 and Craig *et al.* Abstract 132.03.**



## Arecibo Observatory Observation Programs

### Harvesting ALFALFA: L-band Wide Followup of Enigmatic ALFALFA sources II

**A2707** Haynes *et al.*, Fall 2012, Detected 35 of 128 targets (52h)

- 1) Confirm reality of high S/N dark galaxies (determine which ones are OH Megamasers),
- 2) Identify real sources among low S/N, low  $z$  ( $cz < 1000$  km/s), narrow velocity width ( $W50 < 80$  km/s) candidate signals.

### Harvesting ALFALFA: Reaping the 21cm Harvest in the Pisces-Perseus Supercluster and the Foreground Void

**A2811** Haynes *et al.*, Fall 2013, Detected 184 of 239 targets (42h)

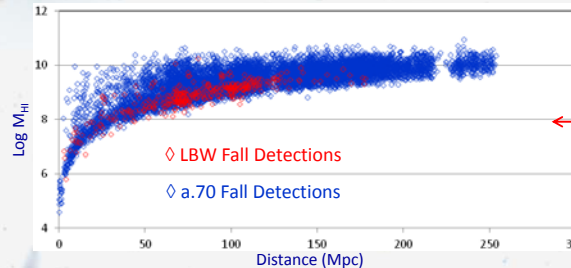
- 1) Identify real sources among low S/N, possible OC
- 2) Increase number of (SDSS) galaxies with measured redshifts

### Harvesting ALFALFA: Discovering Galaxies in the Pisces-Perseus Void

**A2899** Koopmann *et al.*, Fall 2014, Det. 167 of 218 targets (40h)

- 1) Use ALFALFA, SDSS & GALEX to investigate galaxies in & around the PPS Void to test formation & evolution models in low density regions,
- 2) Increase number of (SDSS) galaxies with measured redshifts
- 3) Identify real sources among low S/N, possible OC

## HI Mass Function



## Targets & Detections

ALFALFA sources classified according to

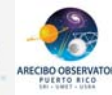
- ✦ signal-to-noise ratio (S/N) and
- ✦ High S/N sources ( $> 6.5$ ) have a 95% confidence level
- ✦ some that lack an OC may be spurious
- ✦ presence of an optical counterpart (OC).
- ✦ Low S/N ( $4.5 < S/N < 6.5$ ) sources with an OC  $\Rightarrow$  real?
- ✦ Low S/N sources lacking an OC  $\Rightarrow$  spurious?

Sloan Digital Sky Survey (SDSS) sources selected

- ✦ galaxies not detected by ALFALFA similar to OCs
- ✦ SQL query to find galaxies likely to be at distance of PPS.

## Acknowledgements

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Haynes, M. P., Giovanelli, R., Martin, A., *et al.* 2011, *AJ*, 741, 124  
Giovanelli, R., *et al.* 2010, *ApJL*, 708, L22  
Saintonge, A., 2007, *AJ*, 133, 2087  
Tully, R. B., Courtois, H., Hoffman, Y., & Pomarède, D. 2014, *Nature*, 513, 71  
Wegner, G., Haynes, M. P., & Giovanelli, R., 1993, *AJ*, 105, 1251

Selected from	A2707		A2811		A2899		Det. Rate (%)
	Det.	NoDet.	Det.	NoDet.	Det.	NoDet.	
High S/N	27	4	3	0	--	--	88.2
Low S/N + OC	5	4	133	57	77	29	70.5
Low S/N no OC	0	82	--	--	0	1	0.0
Totals	32	90	136	57	77	30	58.0
Det. Rate (%)	26.2		70.0		72.0		

Selected from	A2707		A2811		A2899		Det. Rate (%)
	Det.	NoDet.	Det.	NoDet.	Det.	NoDet.	
Photometry	0	2	24	4	61	18	78.7
Known $z$	--	--	--	--	8	1	88.9
Totals	0	2	24	4	69	19	78.8
Det. Rate (%)	0.0		85.7		78.4		

## Results and Conclusions

- ✦ A small % of high S/N ALFALFA sources are spurious
- ✦ Consistent with simulations of reliability (Saintonge, 2007) and cut-off adopted ( $S/N > 6.5$ )
- ✦ Majority of high S/N galaxies without an OC are real
- ✦ Some are tidal remnants, some "almost dark" galaxies
- ✦ **See Leisman Dissertation Talk 132.06**
- ✦ Low S/N "minihalo" candidates ( $cz < 1,000$  km/s,  $W50 < 80$  km/s) lacking an OC are spurious (Giovanelli *et al.*, 2010)
- ✦ Detected 0 of 83 ... yes, ZERO
- ✦ **Finding one would have been very interesting!** Oh, well ...
- ✦ Low S/N ALFALFA sources with OCs are likely to be real
- ✦ Detected 215 of 305 (undetected likely to be spurious)
- ✦ Pointed LBW observations can detect lower HI mass galaxies filling in low end of the HI Mass Function
- ✦ Only way to sample more galaxies in local universe
- ✦ LBW targets can be successfully selected by photometric criteria and ranges defined in SQL queries
- ✦ 85 more SDSS galaxies now have measured redshifts
- ✦ **Technique adopted for the APPS Survey; See Davis *et al.* Poster 347.40 and Craig *et al.* Abstract 132.03.**

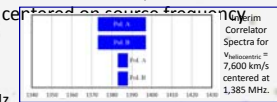
## Observation Method

Pointed basic Total-Power Position-Switched Spectral Observations in 1340 – 1430 MHz ALFALFA frequency range.

- ✦ 3 minutes on source, return to original position
- ✦ 3 minutes on blank sky along same altitude-azimuth path

Arecibo Interim Correlator bands centered on source frequency

- ✦ 2 low-resolution spectra (1/pol)
- ✦ 2048 channels across 25 MHz
- ✦ 2 high-resolution spectra (1/pol)
- ✦ 2048 channels across 6.25 MHz
- ✦ 9-level sampling



## References