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The Arecibo Pisces-Perseus Supercluster Survey: Exploring the Large Scale Structure in the Local Universe

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Exploring the Large Scale Structure of the Local Universe

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Abstract

The Pisces-Perseus Supercluster is one of the most massive and cosmologically significant structures in the local universe. The **Arecibo Pisces-Perseus Supercluster Survey (APPSS)** will provide observational constraints as to the mass-infall rate onto the main filament of the Supercluster through a detailed analysis of the mass and motion of galaxies within and around the cluster. The APPSS galaxy sample consists of over 2,000 galaxies detected during the ALFALFA survey (a blind, HI 21-cm emission line survey of the local universe) combined with galaxies identified through our recent targeted observing campaign - designed to probe below the HI mass cutoff of the ALFALFA survey. These APPSS-candidates were observed using the L-band Wide receiver at the Arecibo Observatory over the last 4 years; to date the APPSS targeted observing has led to an HI 21-cm emission line detection rate of ~70% - corresponding to ~500 galaxies with cz < 9,000 km/s. Combining these new observations with the ALFALFA galaxies gives a total of ~2,500 galaxies in the current APPSS sample. Here, we describe and demonstrate the methods used by the APPSS team to reduce and analyze these targeted observations and explore the properties of the entire APPSS galaxy sample (while comparing the properties of the ALFALFA galaxies with the detections from the APPSS targeted observing campaign).
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APPSS Targeted Observations

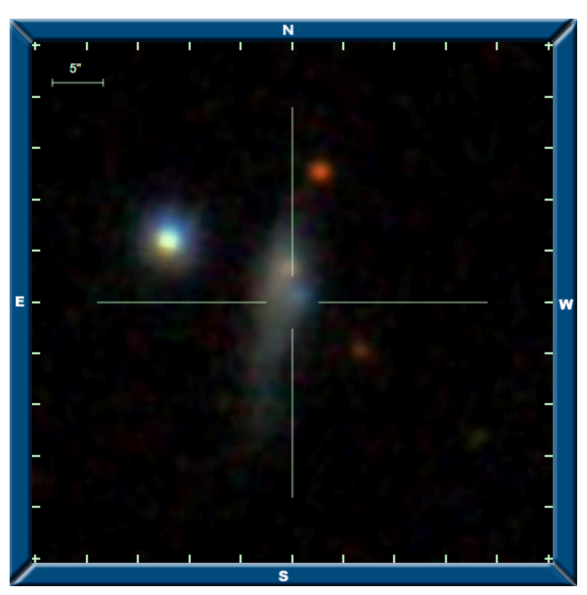

Figure 1 (left) is an optical image of one of the APPSS targets taken from the Sloan Digital Sky Survey (SDSS). The APPSS targeted observing campaign leveraged photometry from SDSS and the Galaxy Evolution Explorer (GALEX) telescope to identify likely HI-rich galaxies to observe with the L-band Wide (LBW) receiver at the Arecibo Observatory. The targeted observations consist of 5-minute, On/Off, exposures providing significantly higher sensitivity to HI emission when compared to the blind, ~50 sec. exposures of the ALFALFA survey observations.

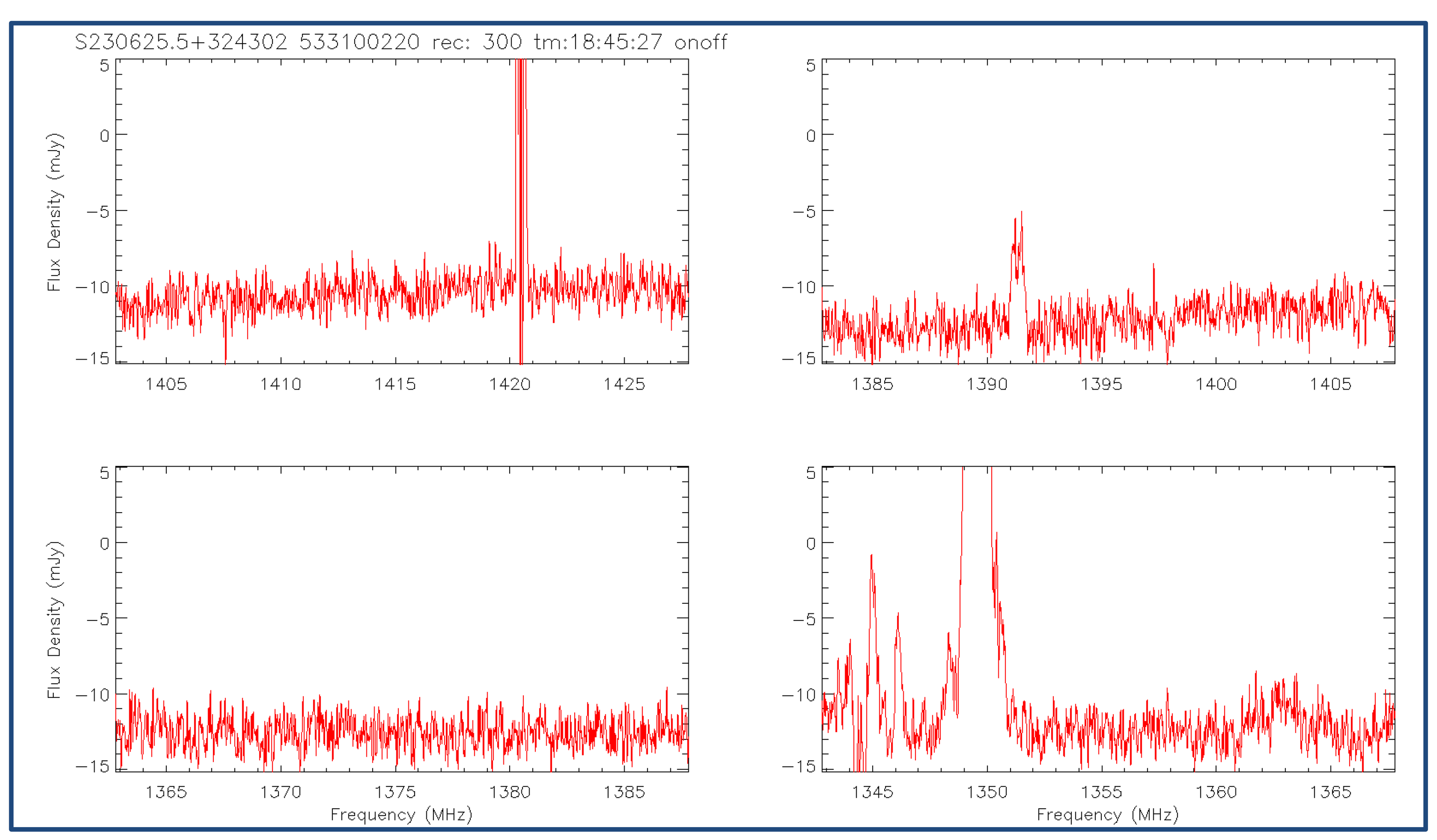

Figure 2 (above) shows the initial LBW spectrum of a targeted observation after minimal processing, with the observed flux density plotted as a function of frequency. The LBW observations are broken into four boards, with overlapping frequency coverage at the edges. The board in the top right shows a characteristic emission profile at ~1391 MHz, corresponding to HI in the targeted galaxy.

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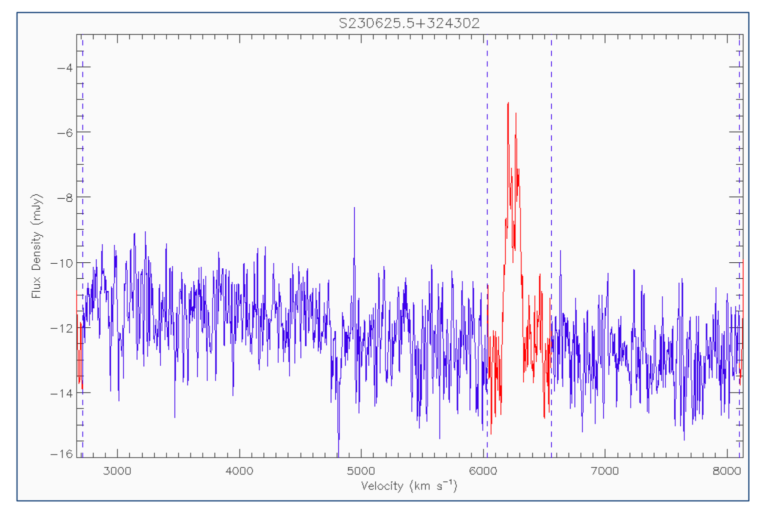
APPSS Reduction and Analysis



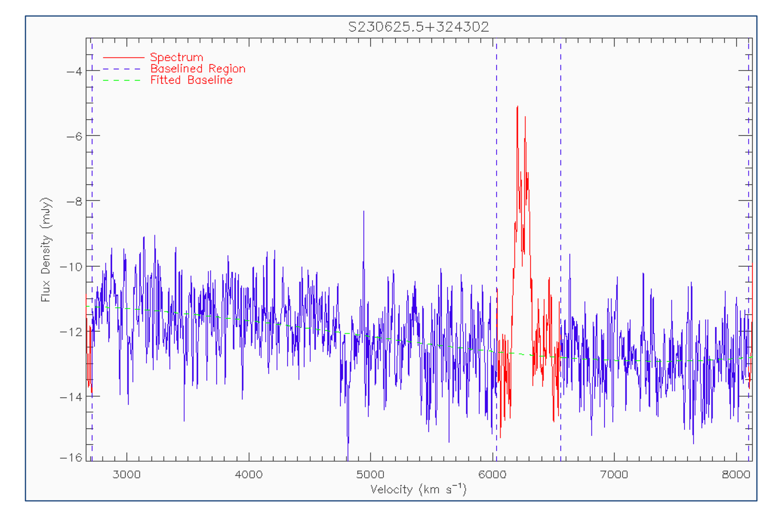
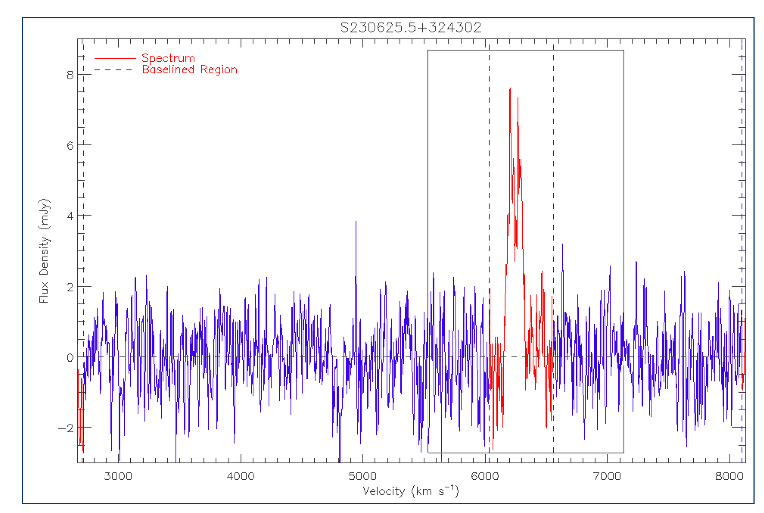


Figure 3 (above, left) and **Figure 4 (above, right)** show the process of normalizing the spectrum by setting the baseline. In this case, the blue indicates the region used to produce a polynomial fit that sets the baseline. Notice that only noise is included in the region to fit the baseline, the region in red is the emission line region which is avoided, along with any RFI that appears in the board.



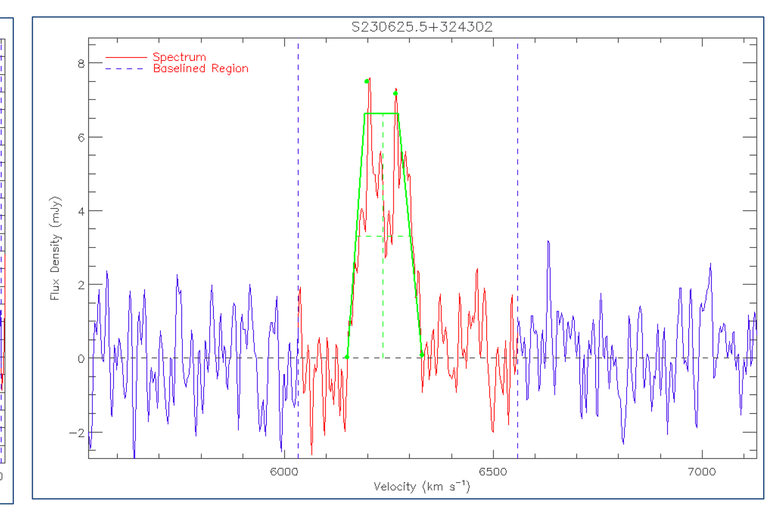


Figure 5 (above, left) shows the selection window in red of the HI-signal to be analyzed. There are two fit options to measure the emission-line properties: gaussian or 2-horned profile. In this case, the emission feature is 2-horned in nature. From the fit shown in **Figure 6 (above, right)** various properties of the emission are estimated, including the velocity centroid, the width of the line, and the integrated flux density. These properties will be combined with optical observations to constrain the distance to the galaxy from the Baryonic Tully-Fisher Relation.

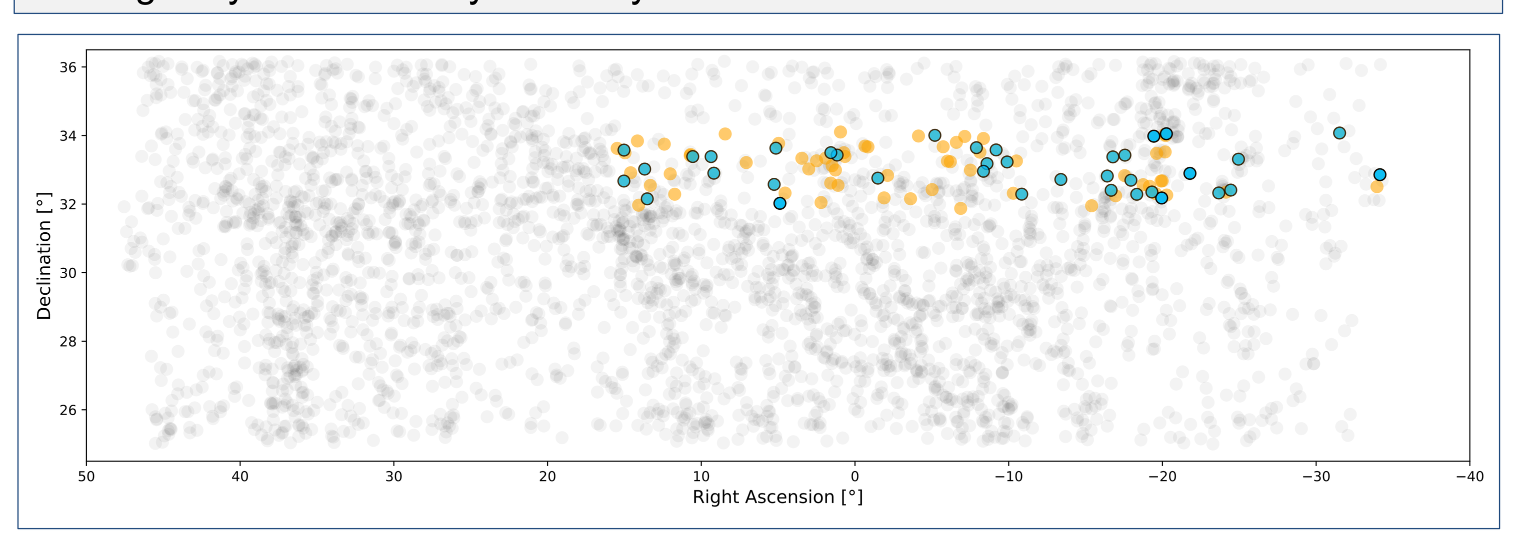
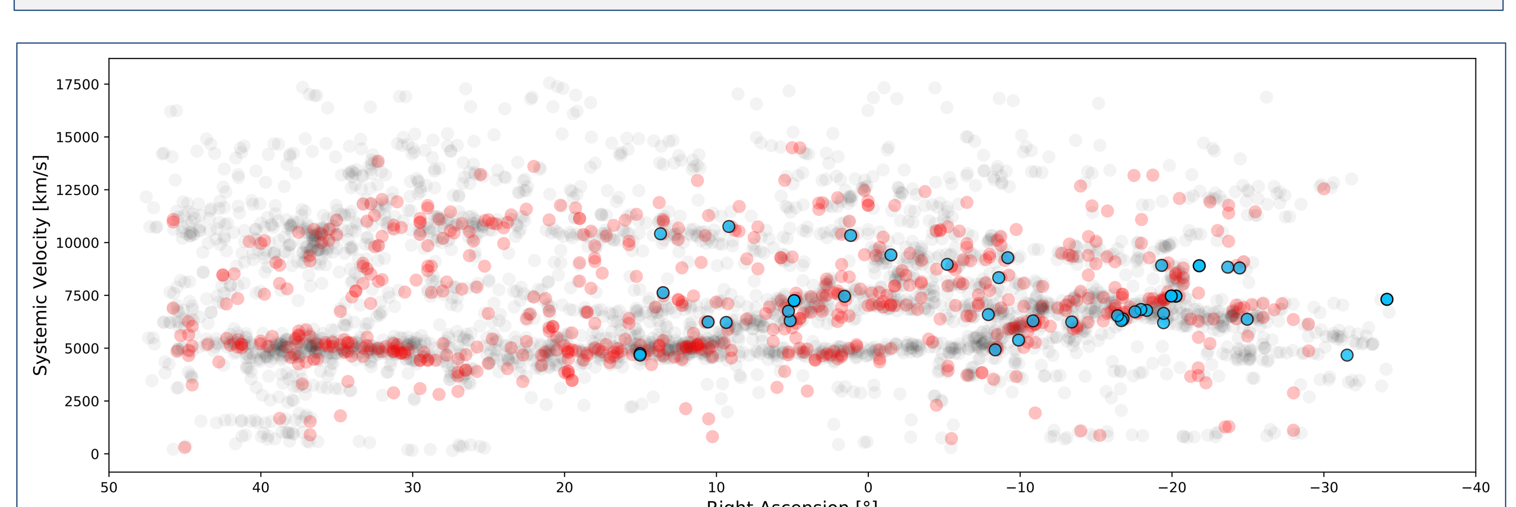


Figure 7 (above) shows the distribution of galaxies on the sky in the region of the PPS. The grey symbols are galaxies identified from the ALFALFA survey while the orange and blue symbols correspond to the subset of targeted APPSS observations reduced and analyzed for this project (with orange representing a non-detection, and blue representing a detection, of HI 21-cm emission). **Figure 8 (below)** shows the distribution of galaxies on the sky in the region of the PPS, now with the systemic velocity plotted on the vertical axis. Again the grey symbols are galaxies identified from the ALFALFA survey, while the red symbols are galaxies identified during our targeted APPSS observing campaign and the blue symbols are galaxies identified during the reduction and analysis done for this project.
Note the prominent structure at ~5000 km/s – the main filament of the PPS.



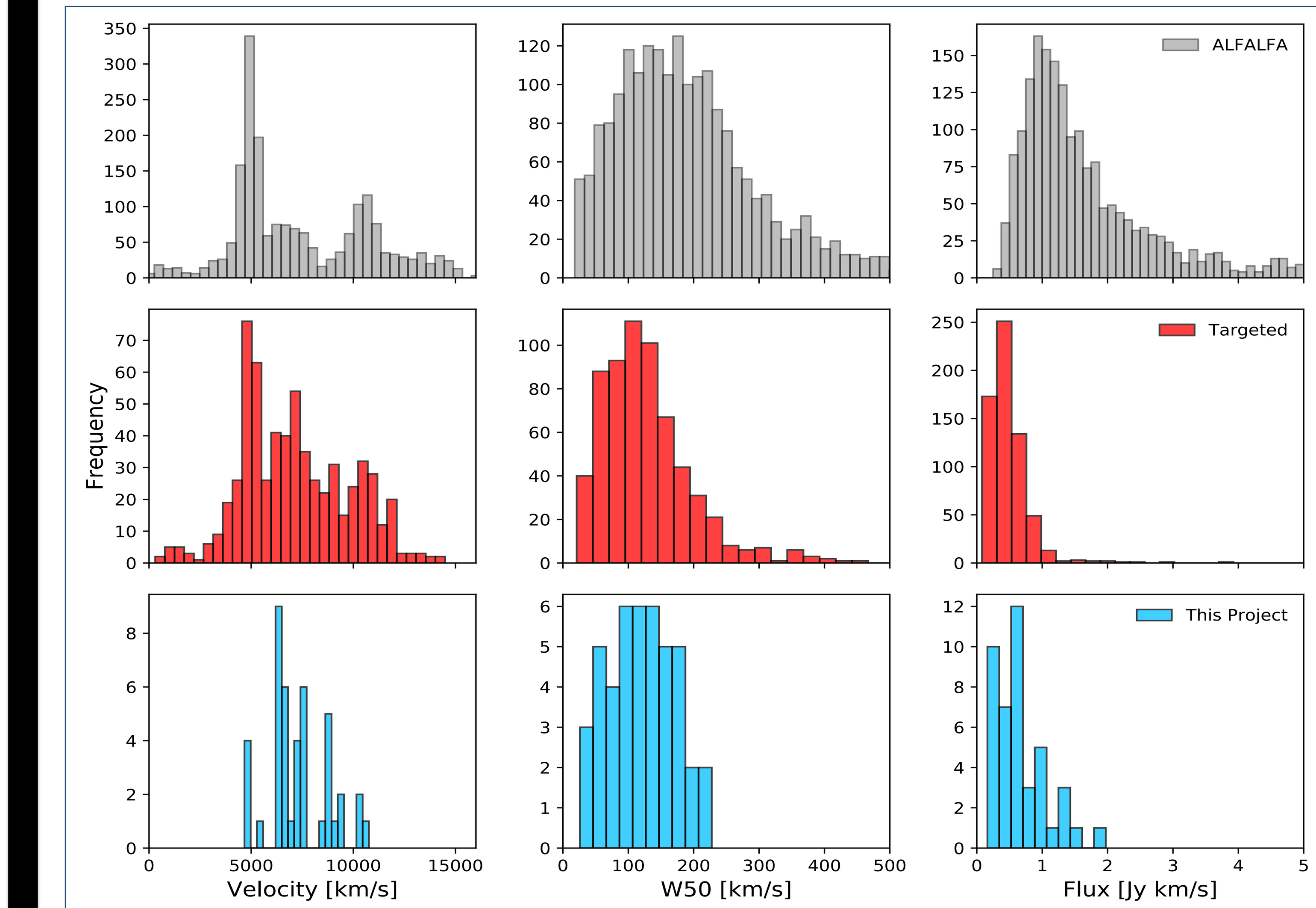


Figure 9 (above) shows the distribution of APPSS galaxies for various measured galaxy properties. The **left column** shows the distribution of galaxies as a function of systemic velocity, measured from the centroid of the 21-cm emission line, the **middle column** shows the distribution as a function of W50, a measure of the width of the 21-cm emission line, and the **right column** shows the distribution as a function of integrated flux density, measured from the 21-cm emission line. The grey panel shows the ALFALFA galaxies, the red panel shows the targeted APPSS galaxies, and the blue panel shows the galaxies identified from the analysis of this project. **Note the low-flux coverage of the targeted galaxies in the right column – a critical component of the APPSS design allowing us to probe low mass galaxies.**

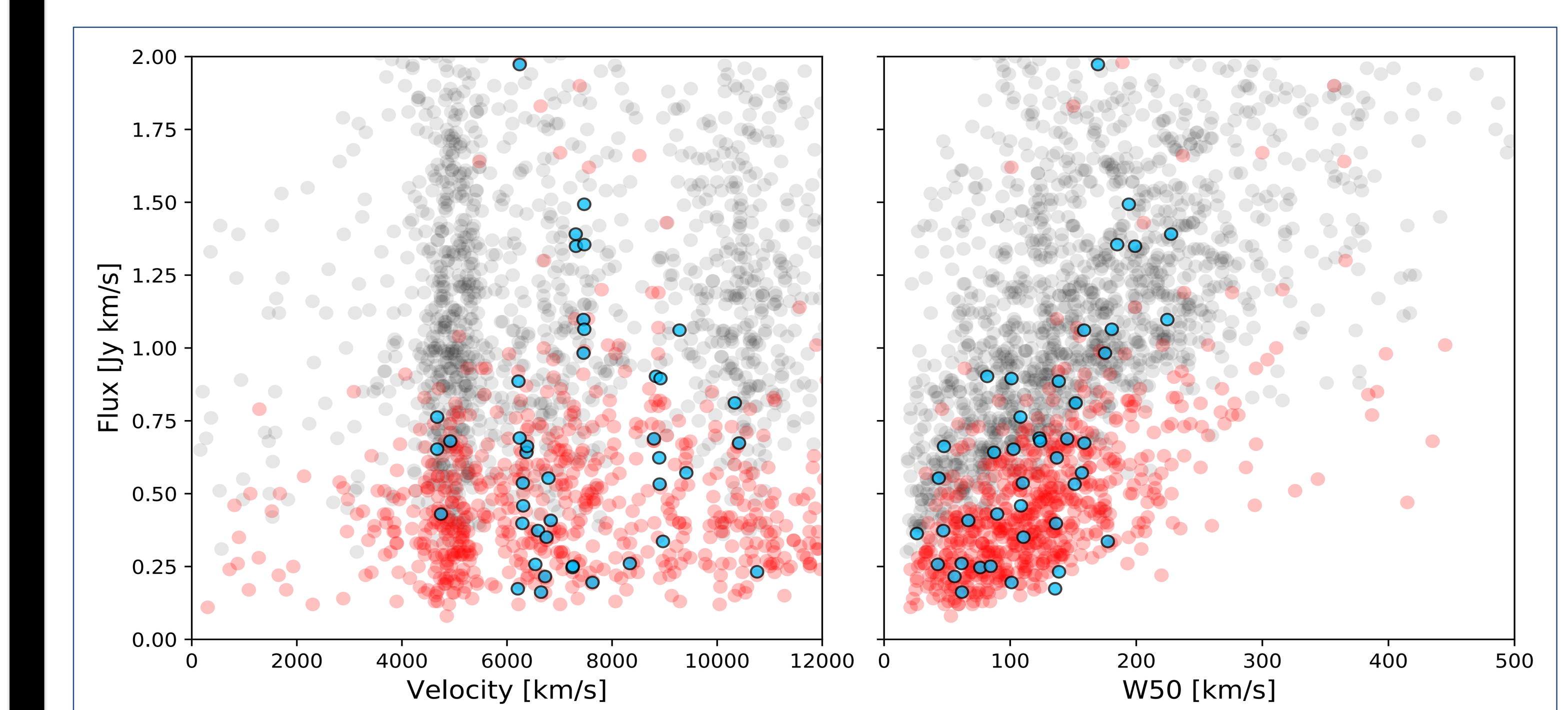


Figure 10 shows the HI integrated flux values of the galaxies in the APPSS, plotted against the galaxy systemic velocity **(left)** and the emission line width, W50 **(right)**. The grey symbols are galaxies identified from the ALFALFA survey while the red symbols are galaxies identified during our targeted APPSS observing campaign and the blue symbols are galaxies identified during the reduction and analysis done for this project. **Again, note the extended coverage of low-flux sources the targeted APPSS observations have provided.**

Up Next for APPSS

The next phase of the APPSS project is to leverage the Baryonic Tully-Fisher Relation to estimate distances to these APPSS galaxies. For more information regarding APPSS and the next steps of the project, see the following posters:

279.01, *A Local Baryonic Tully-Fisher Relation from IllustrisTNG*, J.T. Borden
279.04 *The Arecibo Pices-Perseus Supercluster Survey: Characteristics of the APPSS Galaxy Population*, B. Montalvo
279.05 *The Arecibo Pices-Perseus Supercluster Survey: Applying the Baryonic Tully-Fisher Relation*, R. Ramirez
279.11 *Data Reduction Integrated Python Protocol for the Arecibo Pices-Perseus Supercluster, Survey* C. Dye
279.17 *Density and Velocity Profiles for Large-scale Cosmological Filaments*, T. Viscardi