Dwarf Galaxies in the ALFALFA Hα Survey

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Motivation

It is notoriously difficult to construct a complete sample of galaxies. Optical surveys, for example, are typically less sensitive to dwarf, low surface brightness, and compact galaxies than they are to luminous spirals and ellipticals. Neutral hydrogen (HI) surveys, however, can reduce these biases. The ALFALFA survey, a blind HI 21-cm emission line survey, is currently being carried out at Arecibo and can detect galaxies with HI masses smaller than 10^7 $M_\odot$. The ALFALFA catalog is unique because it catalogs essentially all galaxies capable of making stars, even galaxies with relatively low amounts of neutral hydrogen, and is effectively unbiased to the optical properties of galaxies. We are currently carrying out a narrow-band Hα survey using a subset of the ALFALFA volume. Our survey, the ALFALFA Hα survey, uses this more complete and less biased catalog to create an HI-selected, volume-limited sample of galaxies to study the star-formation history of the universe. When this survey is complete we will have narrow-band Hα images of ~1500 galaxies, which we will use to parameterize the star formation in our volume. Here, we also explore the star-formation properties of a sub-sample of dwarf galaxies within our volume.

ALFALFA Survey

- Ongoing; last data release (2011) 40% complete
- Blind, 2-pass drift scan technique
- 7000 deg^2 when finished
- 3.5 arcmin beam
- 11 km/s velocity resolution
- 20 arcsec positional accuracy
- Primary science goal: HI mass function
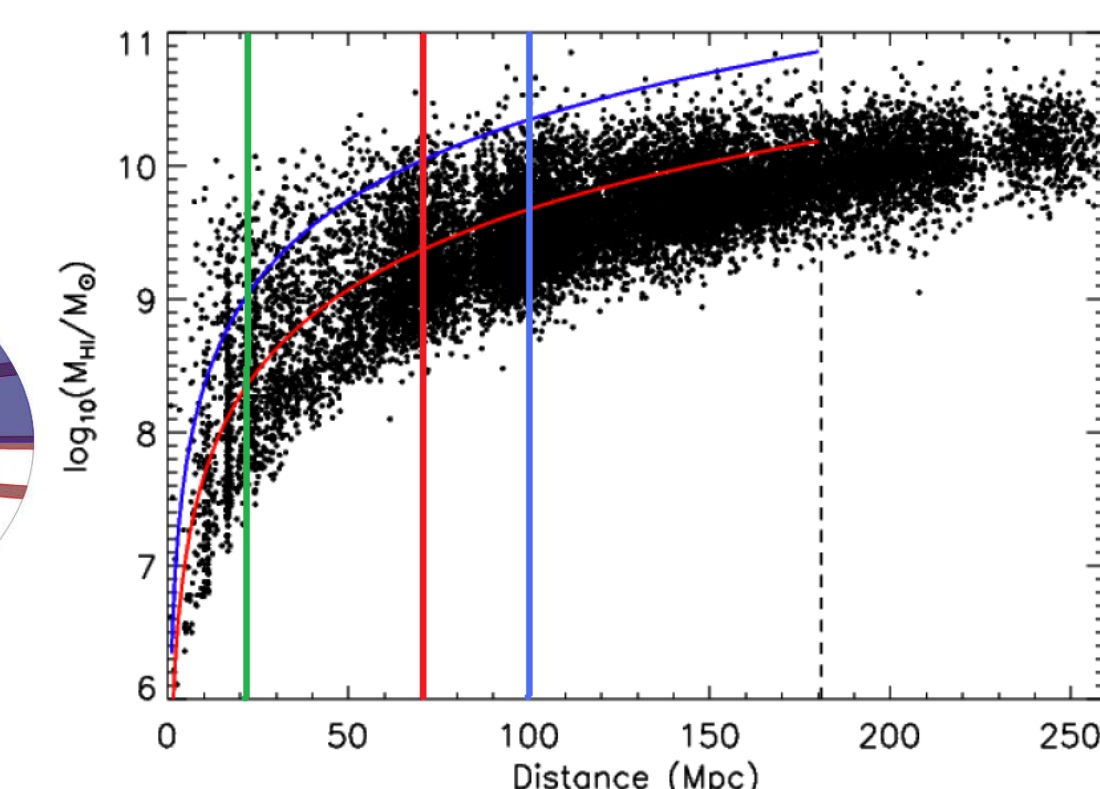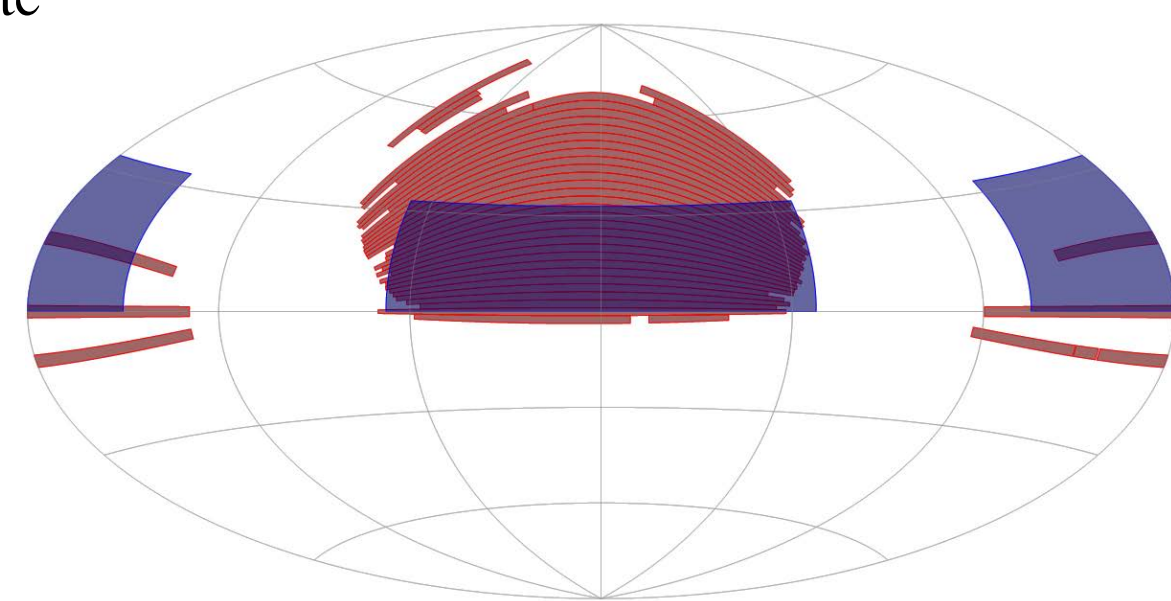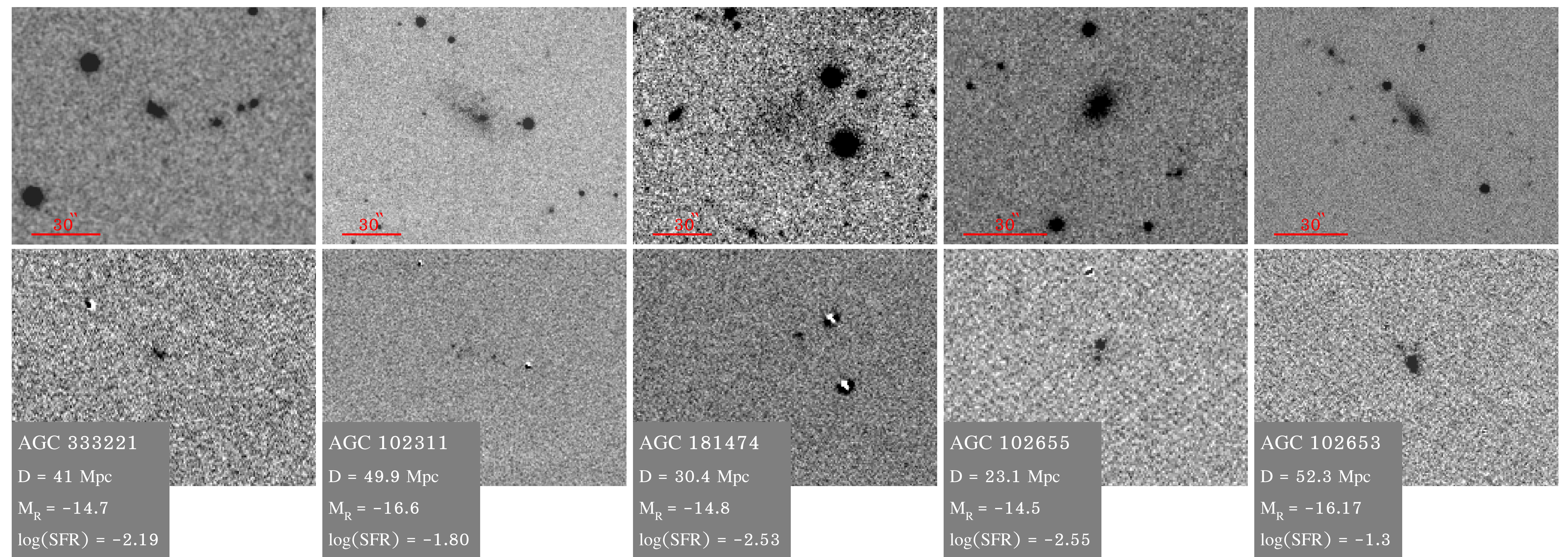

ALFALFA Hα Sample

- Volume limited subset of ALFALFA sample
- Samples both highs and lows of the local large scale structure
- On the sky:
    - Fall: RA 22h – 3h 4m, Dec 24° – 29°
    - Spring: RA 7h – 17h, Dec 10° – 16°
        - Excluded Virgo region: 12h – 13h, <1340 km/s
    - Random 2x2° grids within this area
- Velocity range:
    - Phase I: 1500-5300 km/s
    - Phase II: 5300-7500 km/s
- Sample size:
    - Total: 1539 galaxies
    - Fall: 549
    - Spring: 990
- Observational status:
    - Total: 78% complete
    - Phase I: 80% complete
    - Phase II: 73% complete
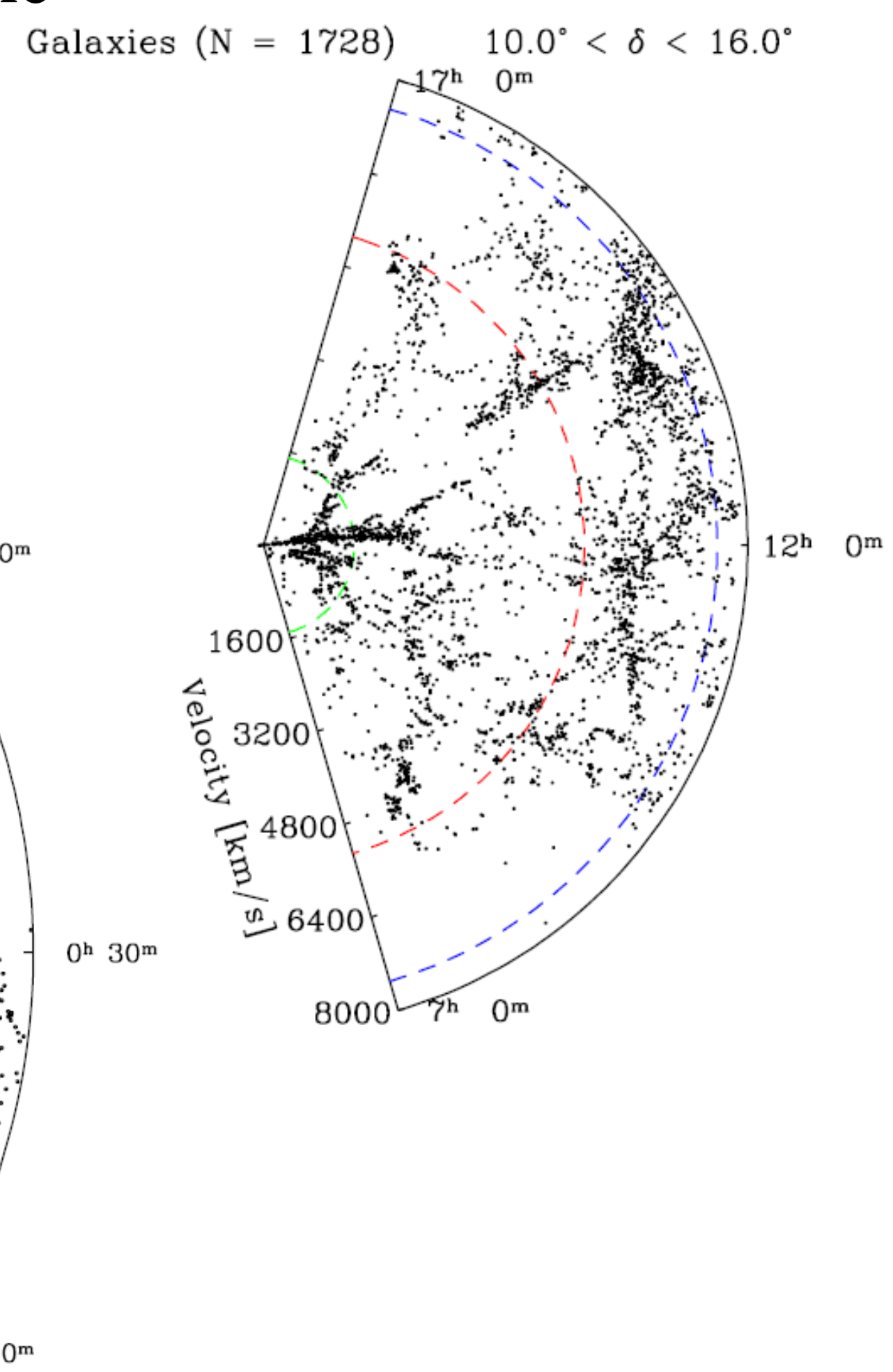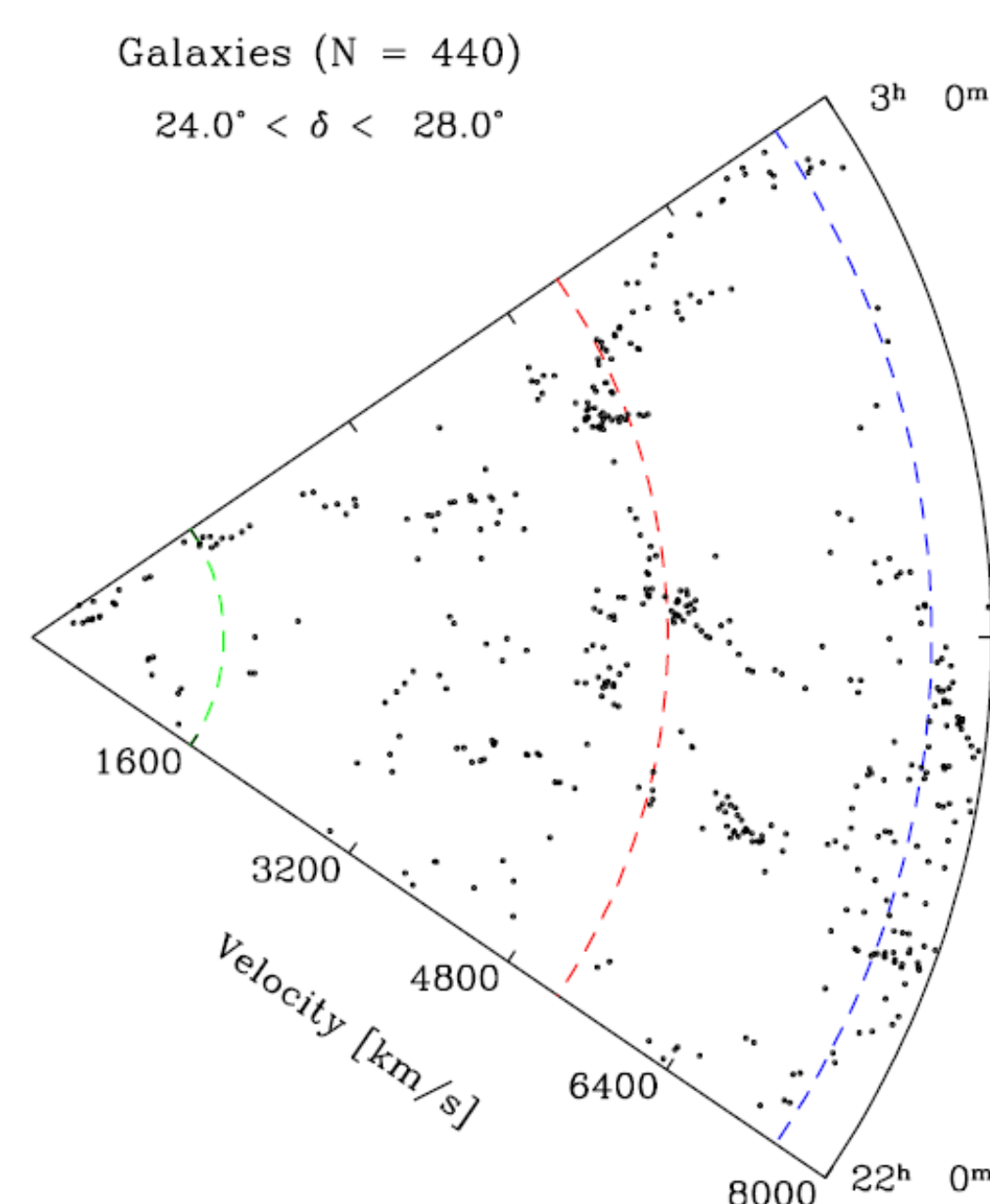
Applications of our Sample

- Best possible measurement of the local star formation rate density, which will constrain galaxy and universe evolution models
- Explore environmental effects on galaxy star formation properties
- Study star formation modes in galaxies (i.e. star formation in density waves vs. stochastic star formation)
- Compare UV- and Hα-based star formation rates using a UV catalog, such as the GALEX database
- Explore properties of sub-populations (e.g. dwarfs)
- Images used as targets for follow up spectroscopic studies (e.g. metallicity studies)
- Many more… our catalog will be available to the public

ALFALFA Hα Data

AGC 333221
D = 41 Mpc
M_R = -14.7
log(SFR) = -2.19

AGC 102311
D = 49.9 Mpc
M_R = -16.6
log(SFR) = -1.80

AGC 181474
D = 30.4 Mpc
M_R = -14.8
log(SFR) = -2.53

AGC 102655
D = 23.1 Mpc
M_R = -14.5
log(SFR) = -2.55

AGC 102653
D = 52.3 Mpc
M_R = -16.17
log(SFR) = -1.3

Narrowband Hα and R band images were taken with WIYN 0.9m and KPNO 2.1m. For this project, two images in Hα were taken, which bracket an R band image (which is used as a continuum measurement). Standard reduction procedures were followed. Examples of resulting continuum-subtracted and R band images are shown above; these specific galaxies were selected to show the range of dwarf properties in our sample.

## Characteristics of the Dwarf population in a partial ALFALFA Hα Sample

Here we present the results of a subset of the ongoing ALFALFA Hα survey. This subset is from phase I of our sample (~20-75Mpc), which is 80% complete. We chose dwarfs to be any object in our sample less luminous than M_R = -17. Dwarfs are shown in red on all plots, while the non-dwarfs are in black for comparison.
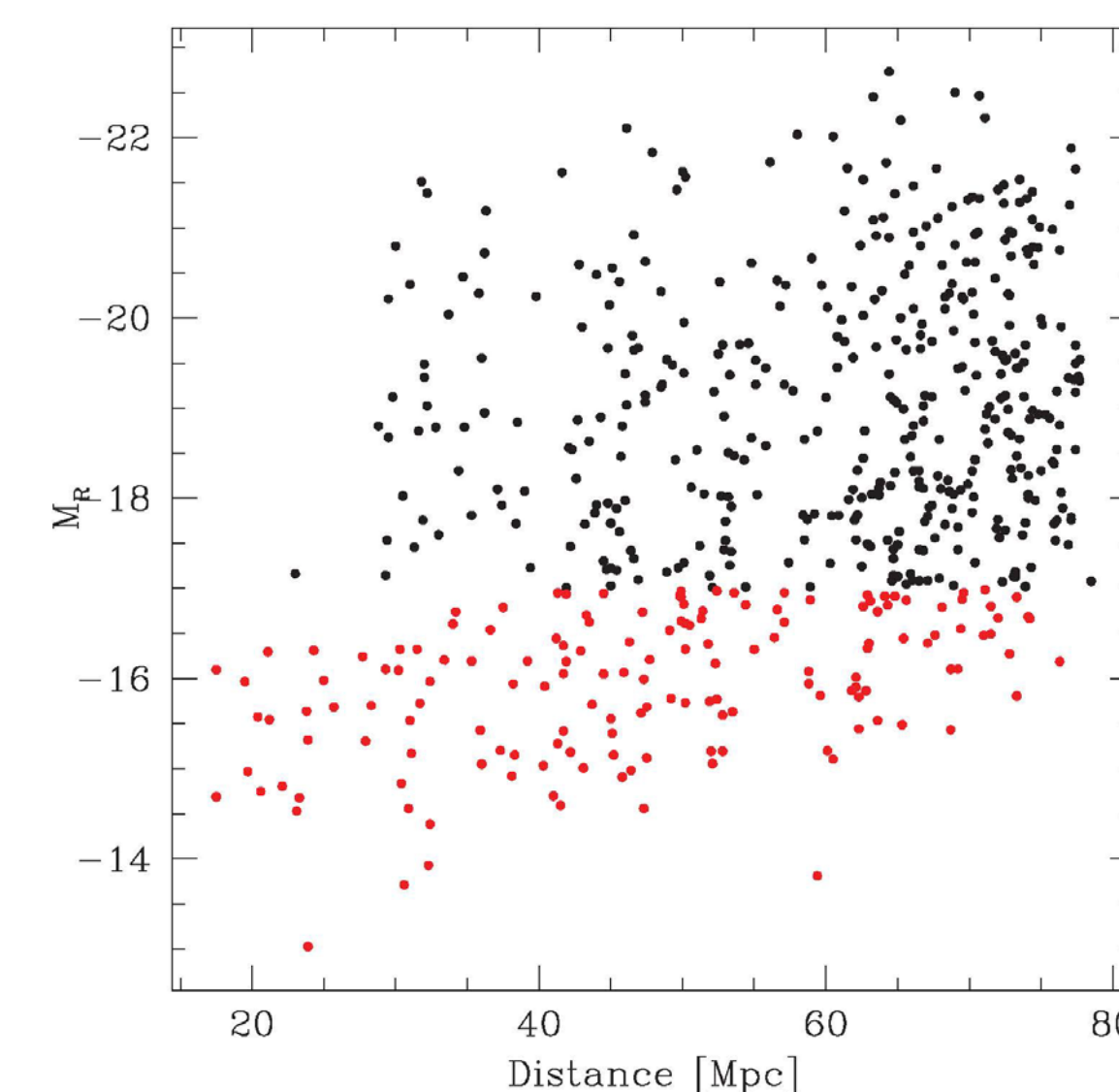

The distance distribution of the phase I galaxies is presented, showing the dwarf galaxy luminosity cut. Our survey detects dwarfs more luminous than M_R = -15 out to the distance limit of phase I (75 Mpc).
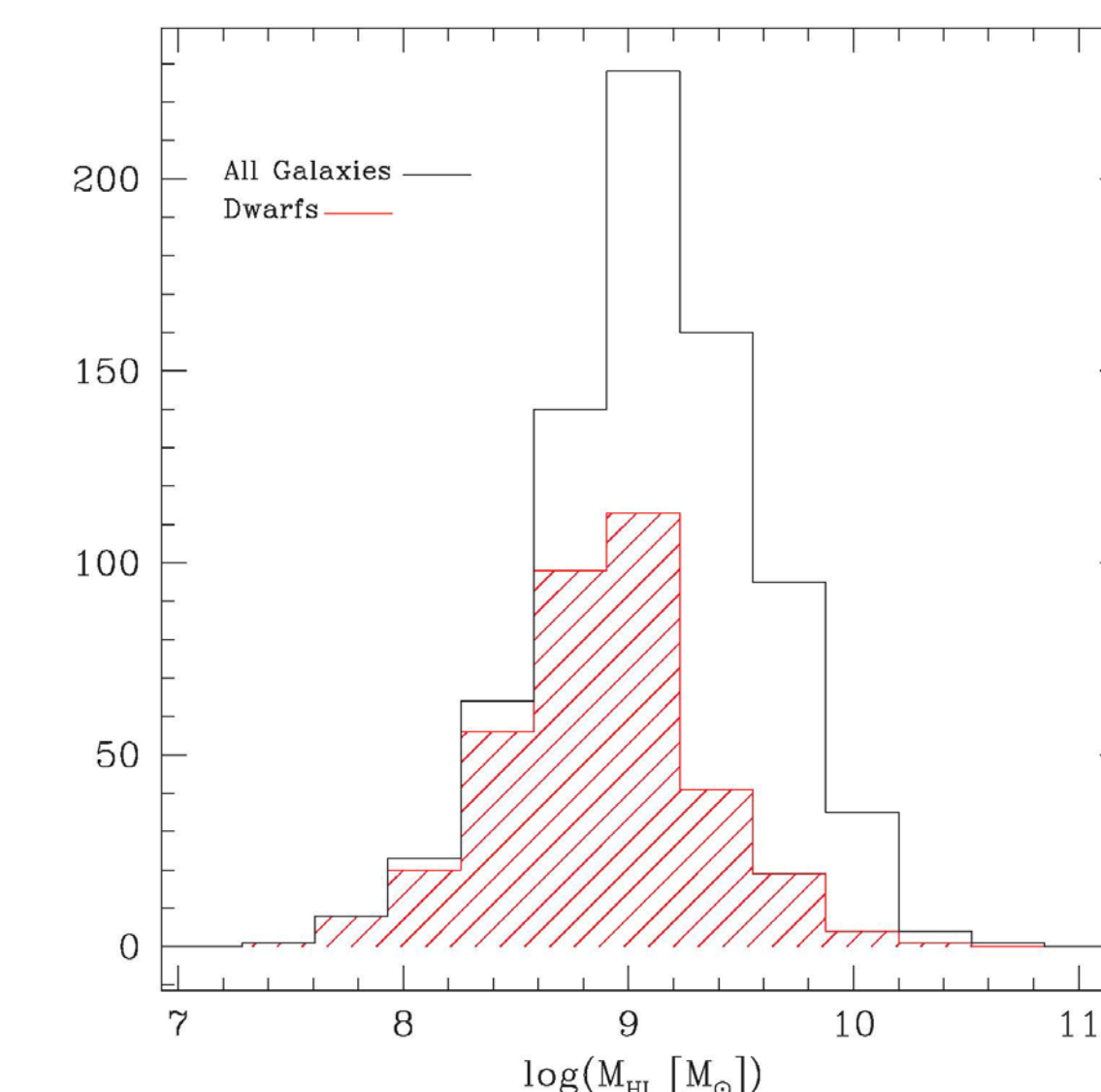
We present a histogram to illustrate the distribution of observed HI masses in our sample. The dwarf population dominates the low-mass detections but also has a tail showing the gas-rich population.
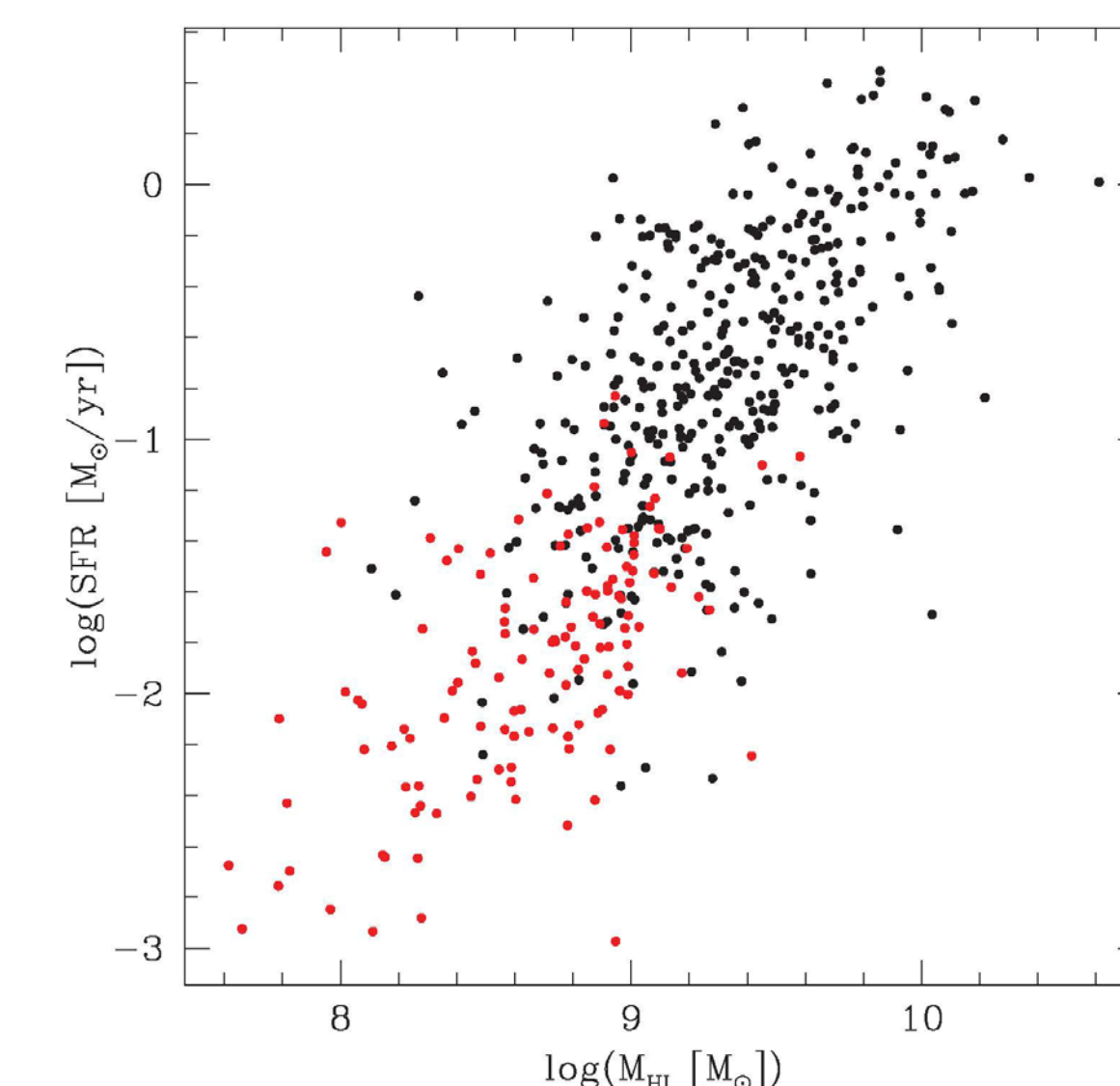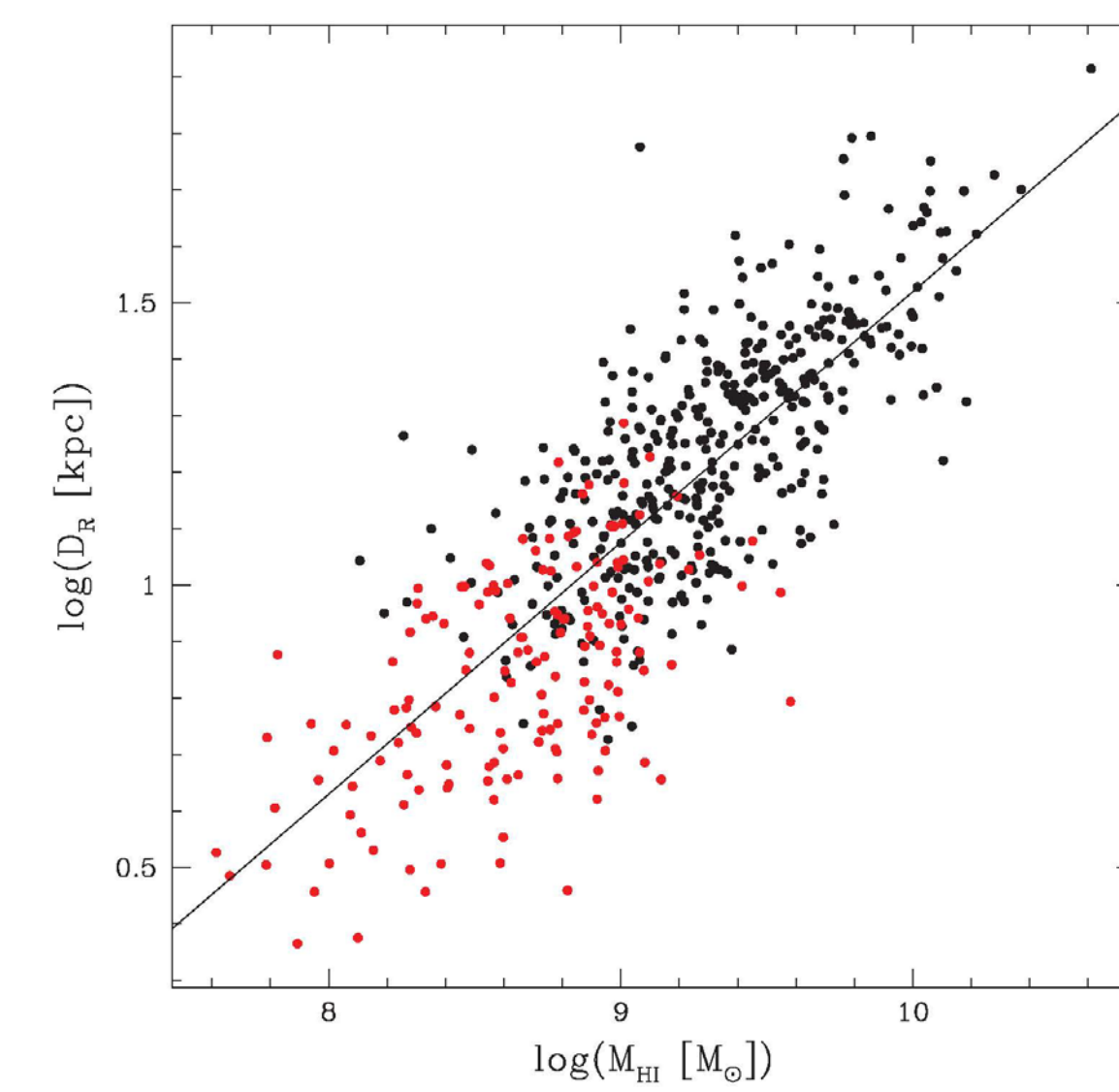
Here we show the star-formation rates of our galaxy sample. Dwarfs have, on average, lower star-formation rates, but span a similar range at a given M_{HI}.
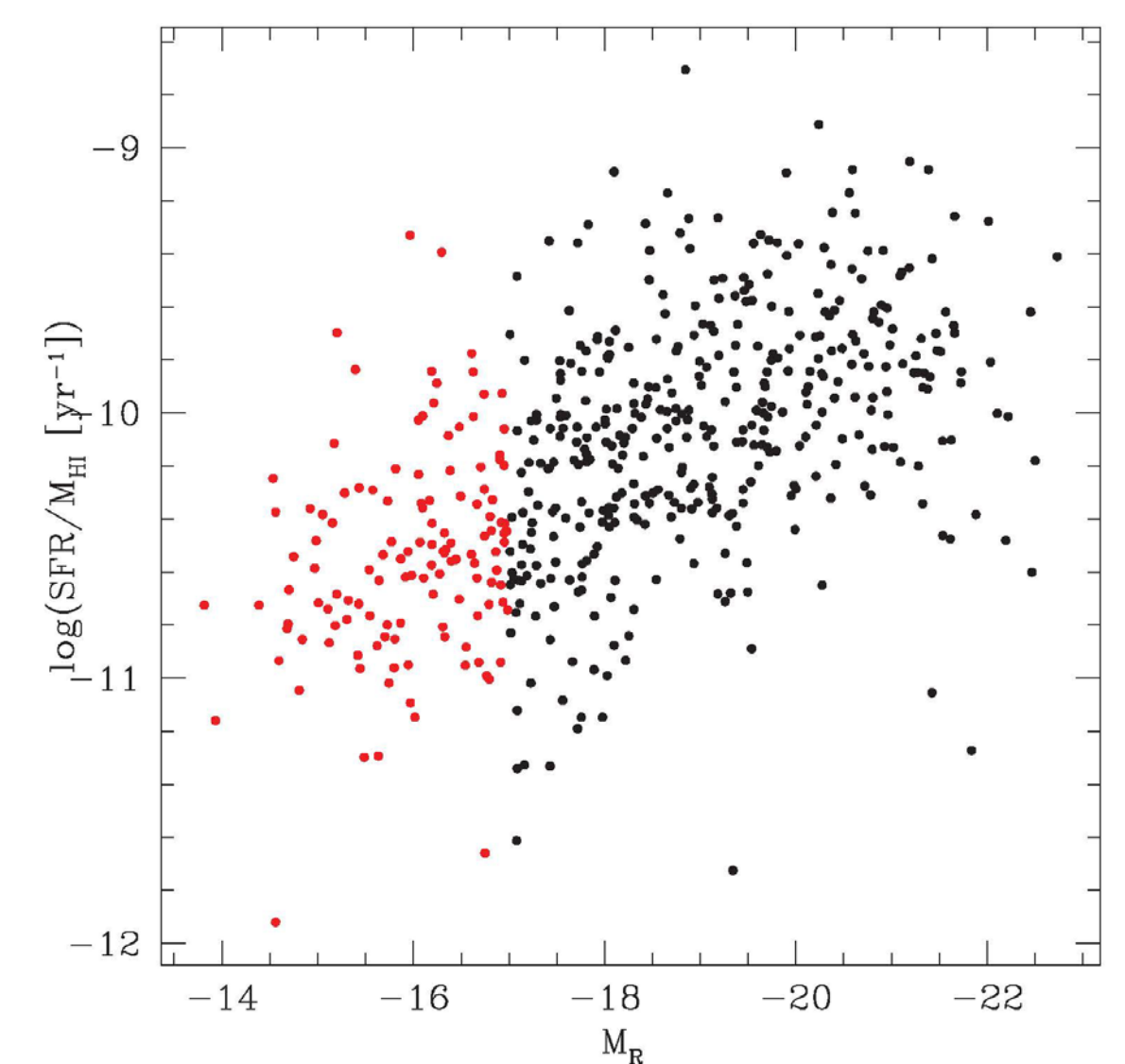
Specific star-formation rates (normalized using HI mass) of our galaxies are presented here. An overall trend is seen, indicating star-formation efficiency increases with the R band luminosity for our sample. The dwarfs in our sample span a large range in specific star-formation rate, but, on average, have lower star-formation efficiencies than non-dwarfs.

We plot the measured diameter of the R-band extent of our galaxies versus their HI mass. Dwarf galaxies show a modest tendency to lie below the trend set by the total sample (solid line), indicating the dwarfs in this sample tend to be more gas rich for their optical size than the non-dwarfs.
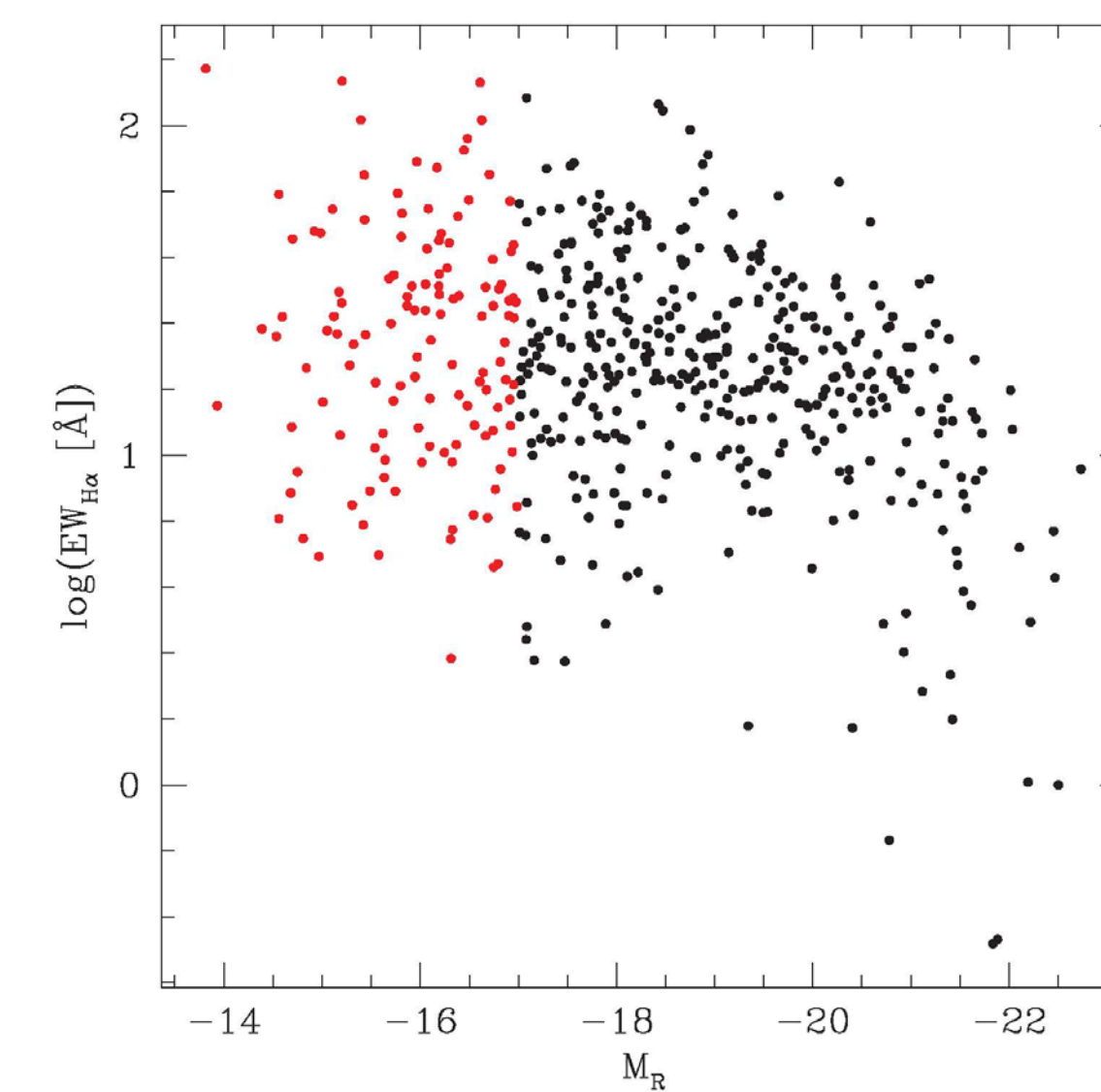
We present the Hα equivalent width distribution of our sample. There appears to be only a weak trend of Hα EW with M_R for our sample, with EW tending toward smaller values for luminous galaxies above M_R ~-20. The dwarf population shows a wide range of equivalent widths, but with a distribution similar to more luminous galaxies.

ALFALFA Hα: Future Work

- Complete observations of our sample
    - fall and spring samples are scheduled to be complete after the next fall and spring observing seasons, respectively
- Calculate the star formation rate density of the local universe
    - Requires complete volume; possible starting this fall!
- Explore environmental effects on star formation properties (namely, environmental density)
- Use GALEX data to compare UV- and Hα-based star formation rates