The HI Census from the *A*recibo *L*egacy *F*ast *ALFA* Survey

Charlottesville
Sep 21, 2009

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Cornell University
For the ALFALFA team

ALFALFA

ALFA is not a car…

It is a radio "camera"

Arecibo L-band Feed Array

ALFALFA

ALFALFA, a Legacy Survey

- One of several major surveys currently ongoing at Arecibo, exploiting its multibeam capability

- An extragalactic spectral line survey
- To cover 7000 sq deg of high galactic latitude sky
- 1345-1435 MHz (-2000 to +17500 km/s for HI line)
- 5 km/s resolution
- 2-pass, drift mode (total int. time per beam ~ 40 sec)
- ~2 mJy rms [M_{HI}~10^5 $M_\odot$ in LG, ~10^7 at Virgo]
- 4400 hrs of telescope time, 5+ years
- started Feb'05; as of Sep 12,'09, 77% obs complete

http://egg.astro.cornell.edu/alfalfa

ALFALFA

ALFALFA, a Legacy Survey

The Arecibo Legacy Fast ALFA Survey

Main People Science Schedule Data Documentation Links Publications Undergrads
Non-experts News/Events Observing/Data Team

Check out the ALFALFA blog!

Overview

Arecibo is the world's most sensitive radio telescope at L-band. In addition to that all-important sensitivity advantage, Arecibo equipped with ALFA offers important and significant improvements in angular and spectral resolution over the available major wide area extragalactic HI line surveys such as HIPASS and HIJASS. To break ground into new science areas, extragalactic HI surveys with ALFA must exploit those capabilities to explore larger volumes with greater sensitivity than have the previous surveys. The lowest mass objects will only be detected nearby; wide areal coverage is the most efficient means of increasing the volume sampled locally. An extragalactic survey covering the high galactic latitude sky visible from Arecibo will produce an extensive database of HI spectra that will be of use to a broad community of investigators, including many interested in the correlative mining of multiwavelength datasets; we thus dub this program the *Arecibo Legacy Fast ALFA* survey: ALFALFA. A comparison

http://egg.astro.cornell.edu/alfalfa

ALFALFA

ALFALFA: A 2nd generation survey

- In comparison with opt/IR, the HI view is largely immature
- HIMF based only only few thousand objects (HIPASS; SFI++)

ALFALFA:

- Designed to explore the HI mass function over a cosmologically significant volume of the local universe
  - Higher sensitivity than previous surveys
  - Higher spectral resolution => low mass halos
  - Higher angular resolution => most probable optical (stellar) counterparts identified immediately
  - Deeper: 3X HIPASS median redshift => volume
  - Wider area than surveys (other than HIPASS) => nearby volumes for lowest M_{HI}

ALFALFA

ALFALFA Status: Sep 2009

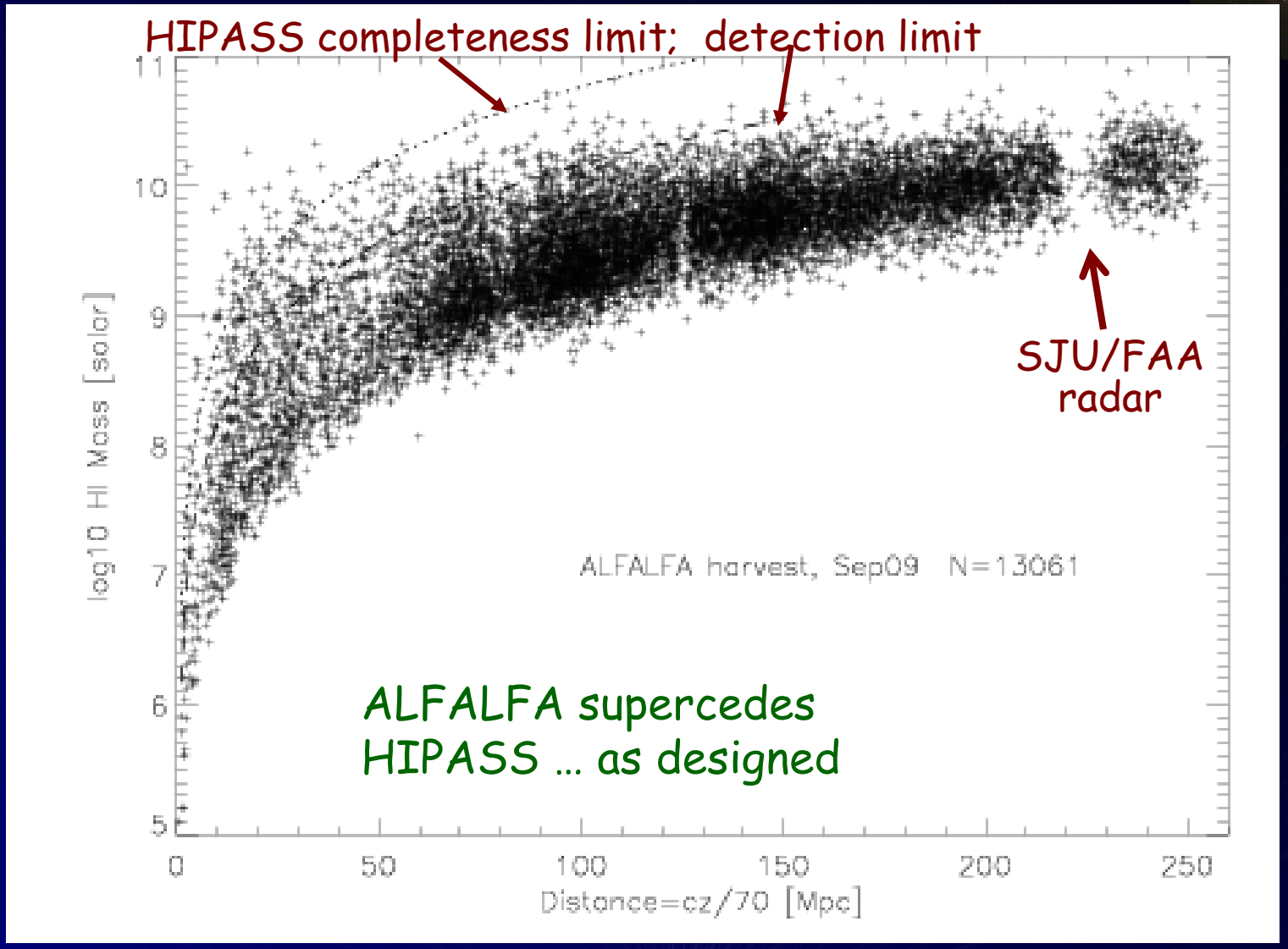
- Observations 77% complete
  - 585 observing runs
  - 3400 hours of telescope time
- 5 data catalogs published + 15 science papers
- 60 members of the team ⇔ an open collaboration
- 3 PhDs completed; 10 others underway

- Sep 2009 working catalog

"Fall":	22h < RA < 3h	+14° < Dec < +16°
		+24° < Dec > +30°
"Spring":	7h30m < RA < 16h30	+04° < Dec < +16°
		+26° < Dec < +28°

ALFALFA

ALFALFA Sep 2009



ALFALFA supercedes HIPASS … as designed

ALFALFA

ALFALFA HI census

- ALFALFA is a blind survey: it finds HI wherever it is
  - Gas-rich E/SO's, red and dead galaxies
  - Tidal debris even where no obvious interaction

- ALFALFA is deep enough to detect very high HI mass galaxies
  - How can massive HI disks exist without forming (many) stars?
  - Low-z analogs of high-z massive disks: where are they?

- ALFALFA is a wide area survey
  - Robust determination of the HIMF; compare environments
  - Statistics on low mass halos nearby
  - "Stacking" spectra allows detection of ensemble even if not individual galaxies (Silvia Fabello et al. MPA)

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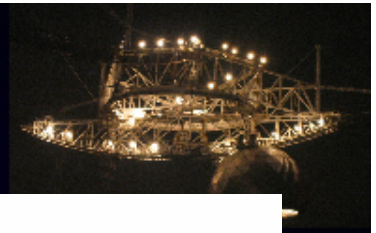
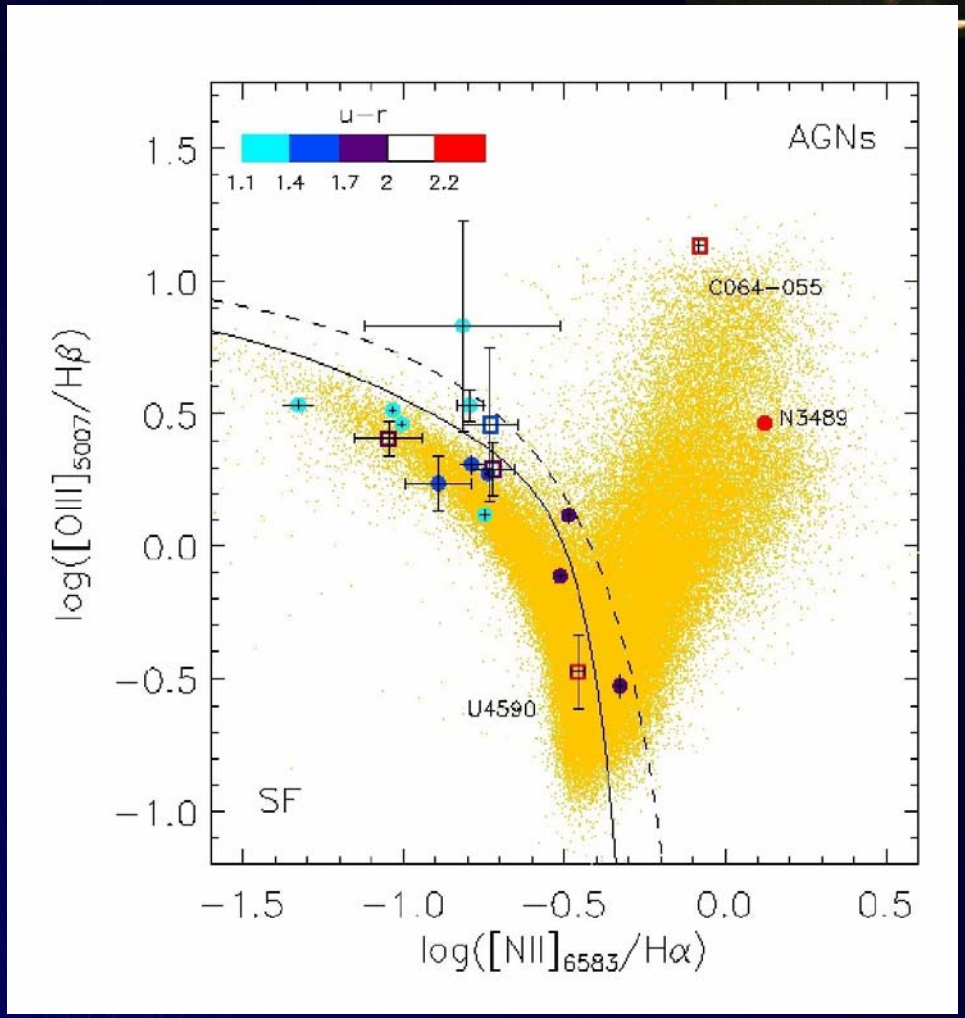
Blind survey: gas-rich ellipticals



- It has been know for a long time that some E/SO galaxies are gas rich
  - ⇒secondary origin?
  - ⇒GALEX extended disks
- ALFALFA: a blind survey finds the HI wherever it is
- Where/why are the gas-rich Es?

di Serego Alighieri et al 2008
Grossi et al 2009 A&A 498, 407



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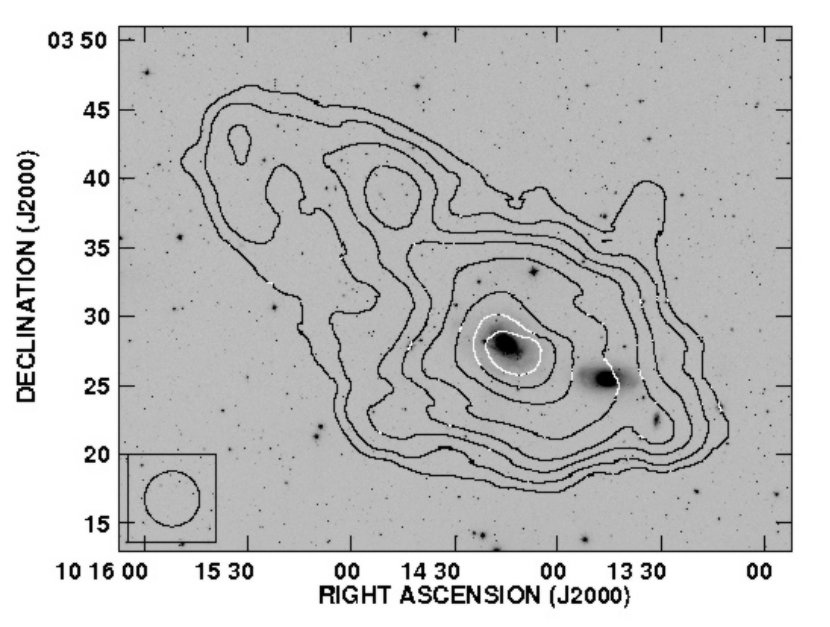
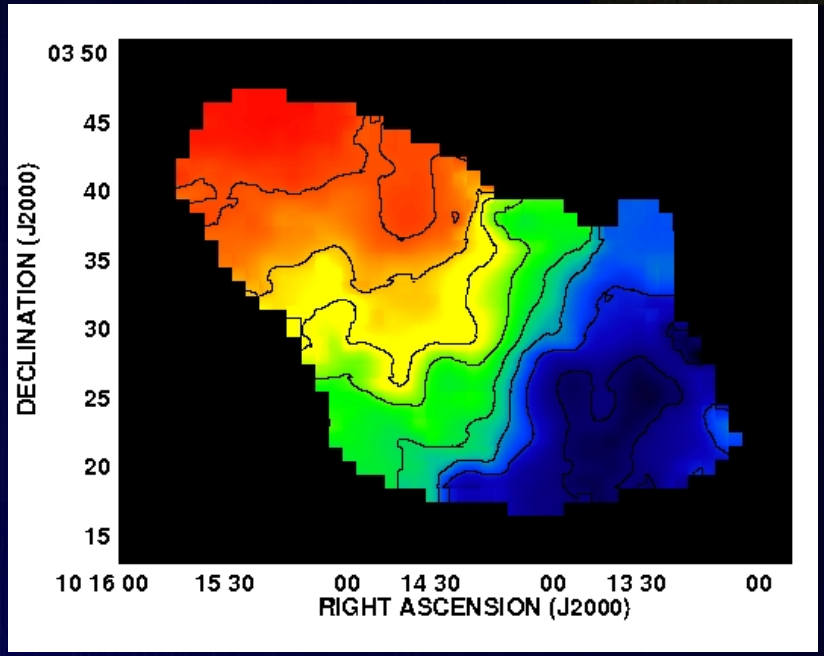
Dwarf formation in tidal debris?





Half dozen faint, lsb galaxies found in extended distribution

Spekkens, Chandra (RMCC), Stierwalt, Martin, Huang, MH, RG (CU), Saintonge (MPIE), O'Donoghue (St. Lawrence), Brosch (Wise)

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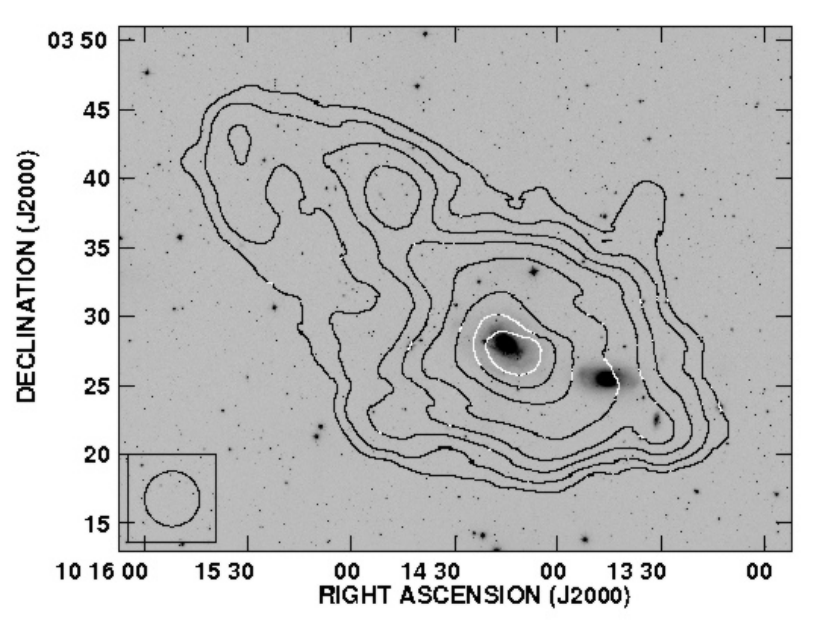

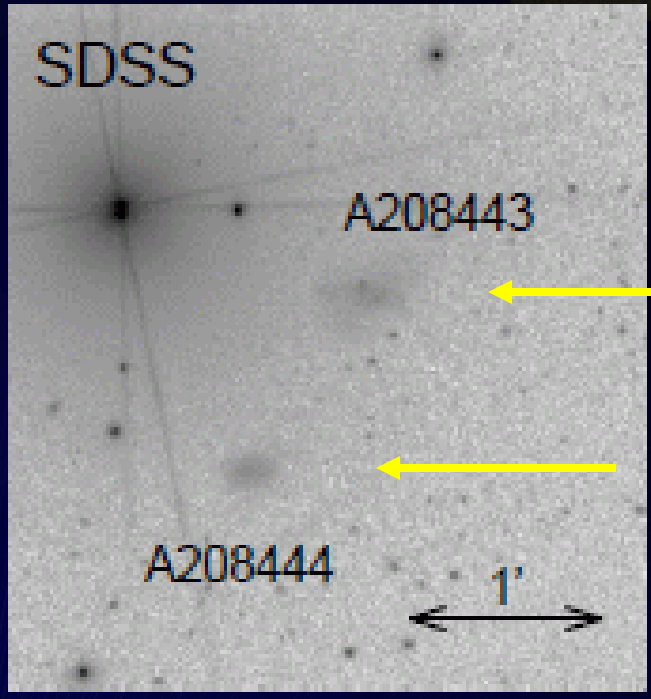

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Tidal dwarfs: (1) less dark matter; (2) metal-rich for L ???

Spekkens, Chandra (RMCC), Stierwalt, Martin, Huang, MH, RG (CU), Saintonge (MPIE), O'Donoghue (St. Lawrence), Brosch (Wise)

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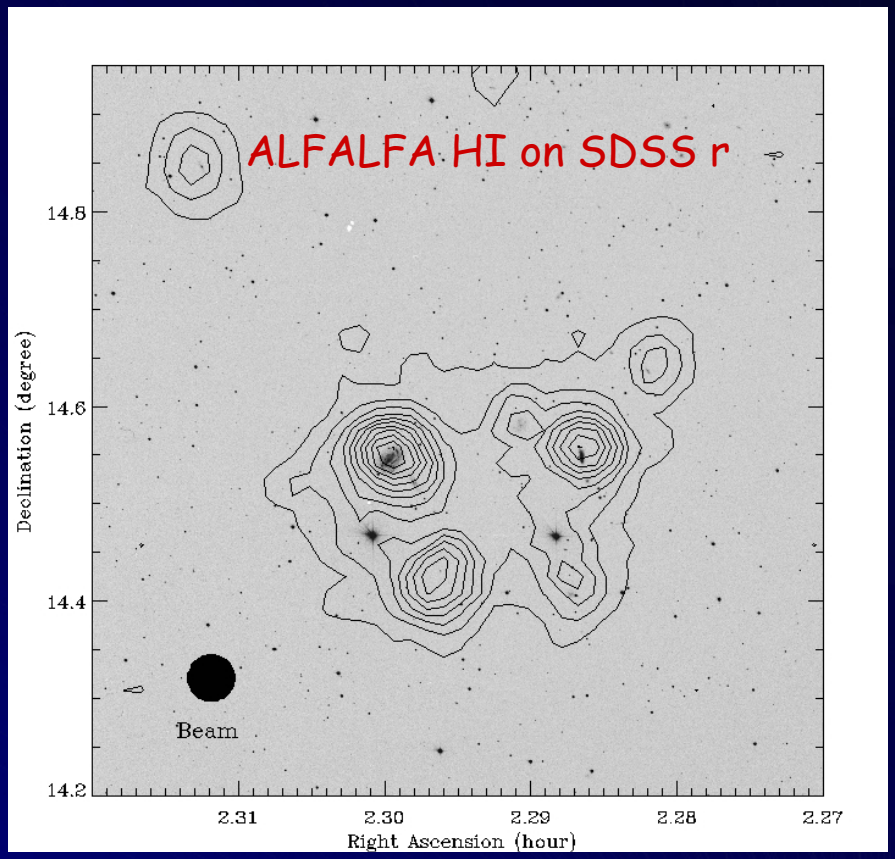
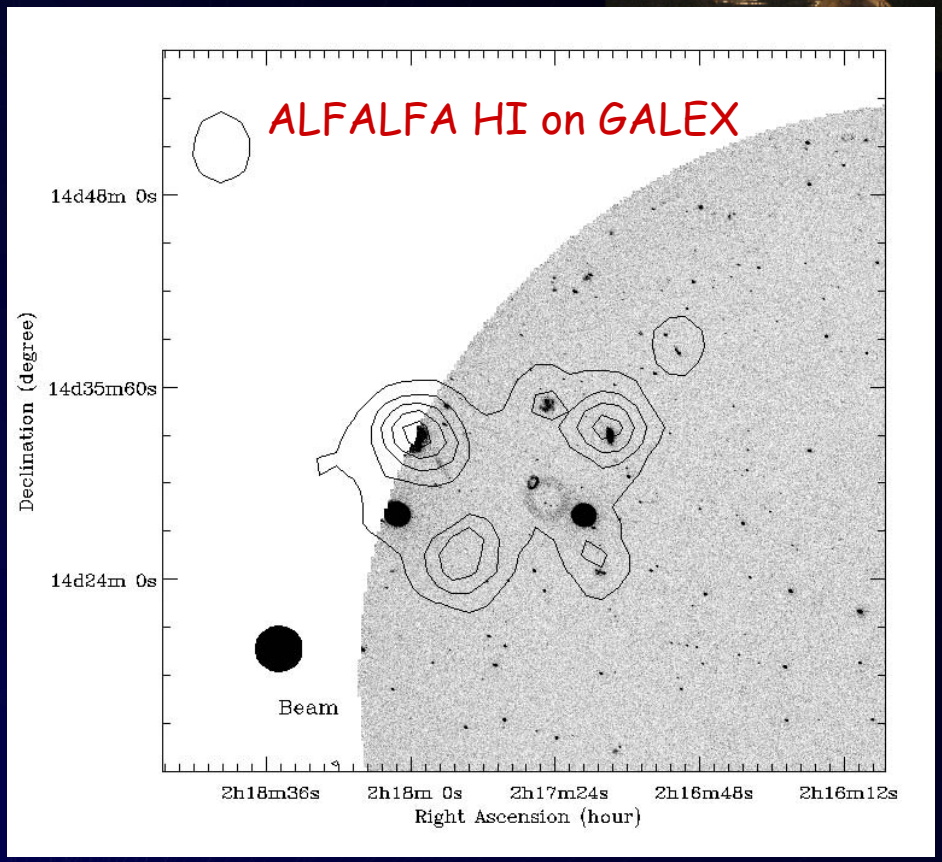
Blind survey for tidal remnants





HI peak with no optical/marginal UV: almost dark?

Tess Senty, Kornreich (HSU), Huang, MH, RG (CU), Cannon (Macalester), Salzer (Indiana)

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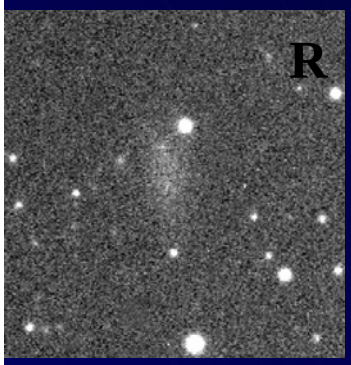
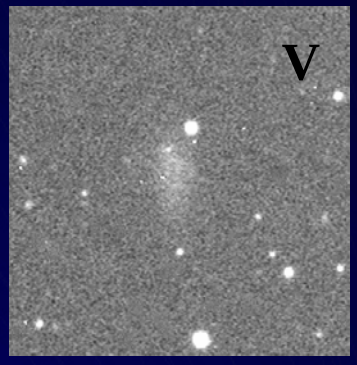
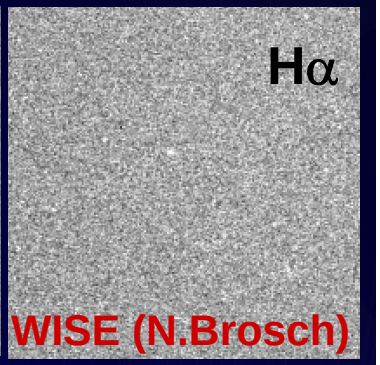
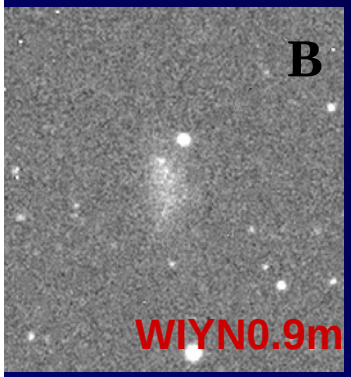
AGC 112521

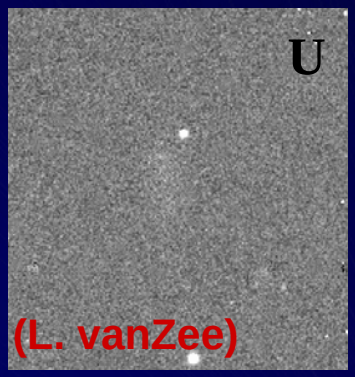
Giovanelli et al 2005
Saintonge et al 2007

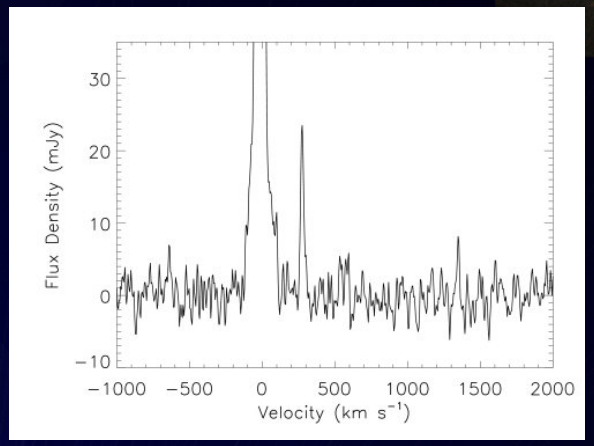












cz	274 km/s
W	26 km/s
F	0.65 Jy km/s
D	7.2 Mpc (N672 group)
Log M_{HI}	6.9 $M_\odot$

log(O/H)+12 ~ 7.4

Radius ~ 400 pc

Saintonge, Begum *et al.* (*in prep*)

- M_{HI}/L ~ 2.2 so M_{HI} ~ M_*
- GMRT HI: HI dominates kinematics

Coordinated multiwavelength studies of lowest HI mass, low L galaxies

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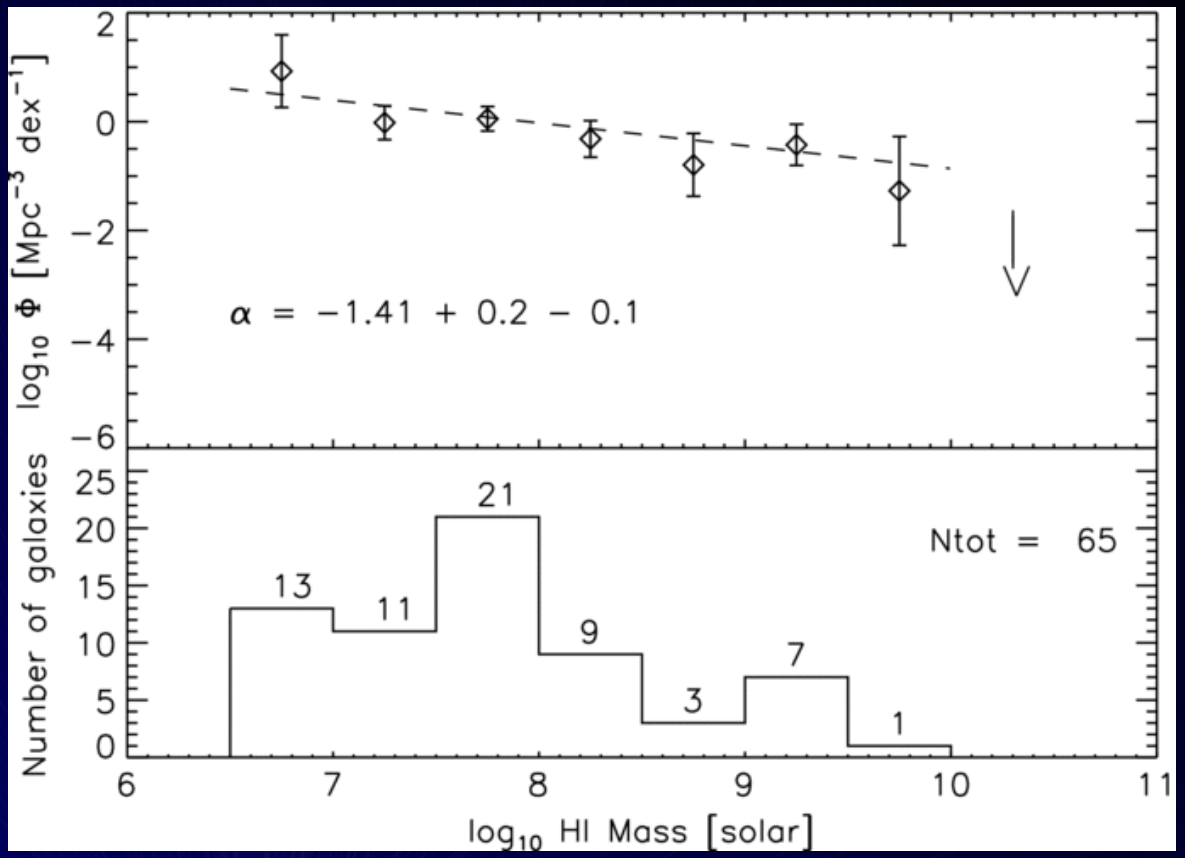
HIMF in Leo I group

Sabrina Stierwalt et al. 2009 AJ 138, 338

- Distance ~10 Mpc
- No high mass objects (consistent with volume sampled)
- HIMF dominated by low mass objects
- Slope steeper than optical LF



See Sabrina's poster. and Brian Kent's talk on Virgo (Thursday)

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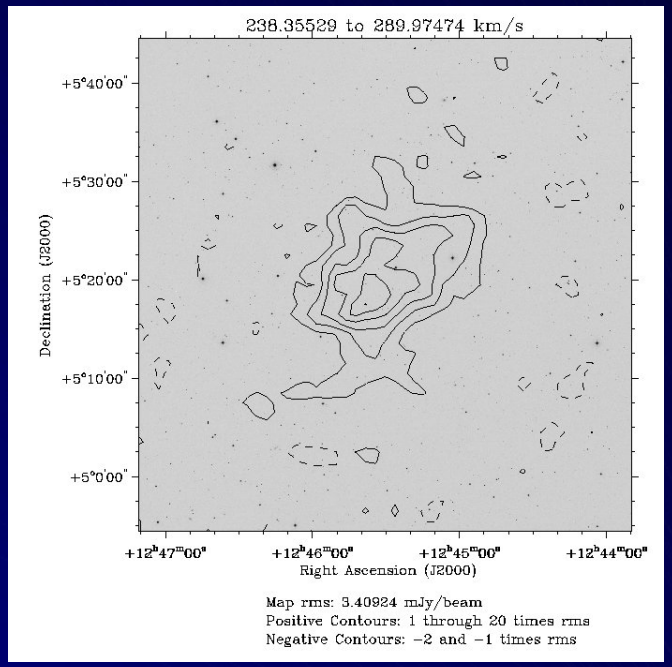
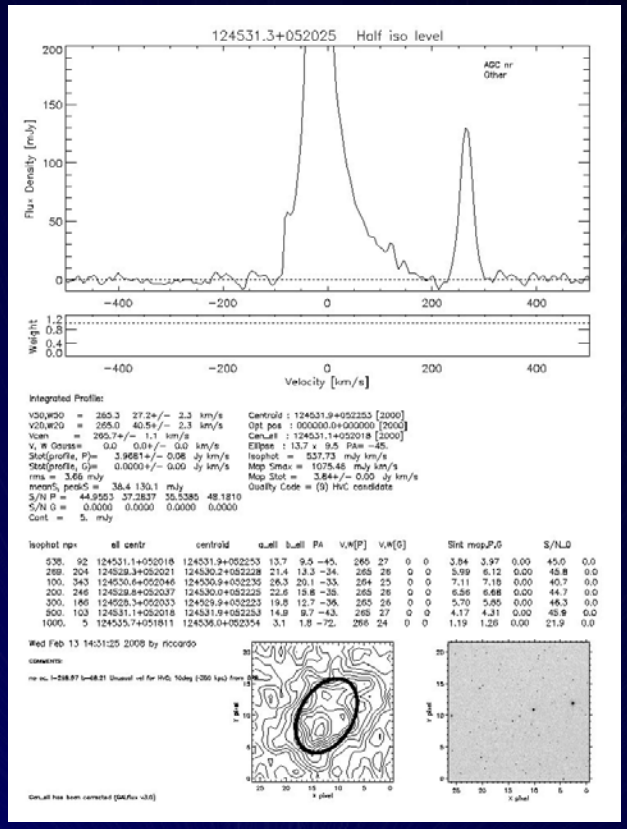
Are some HVCs mini-halos?

- Blitz et al; Braun & Burton => compact HVCs are at 1 Mpc
- ALFALFA positive HVCs: 4-8 arcmin in size (vs. 0.5-1° for CHVCs)





Giovanelli et al. 2009

See Betsey Adams' poster

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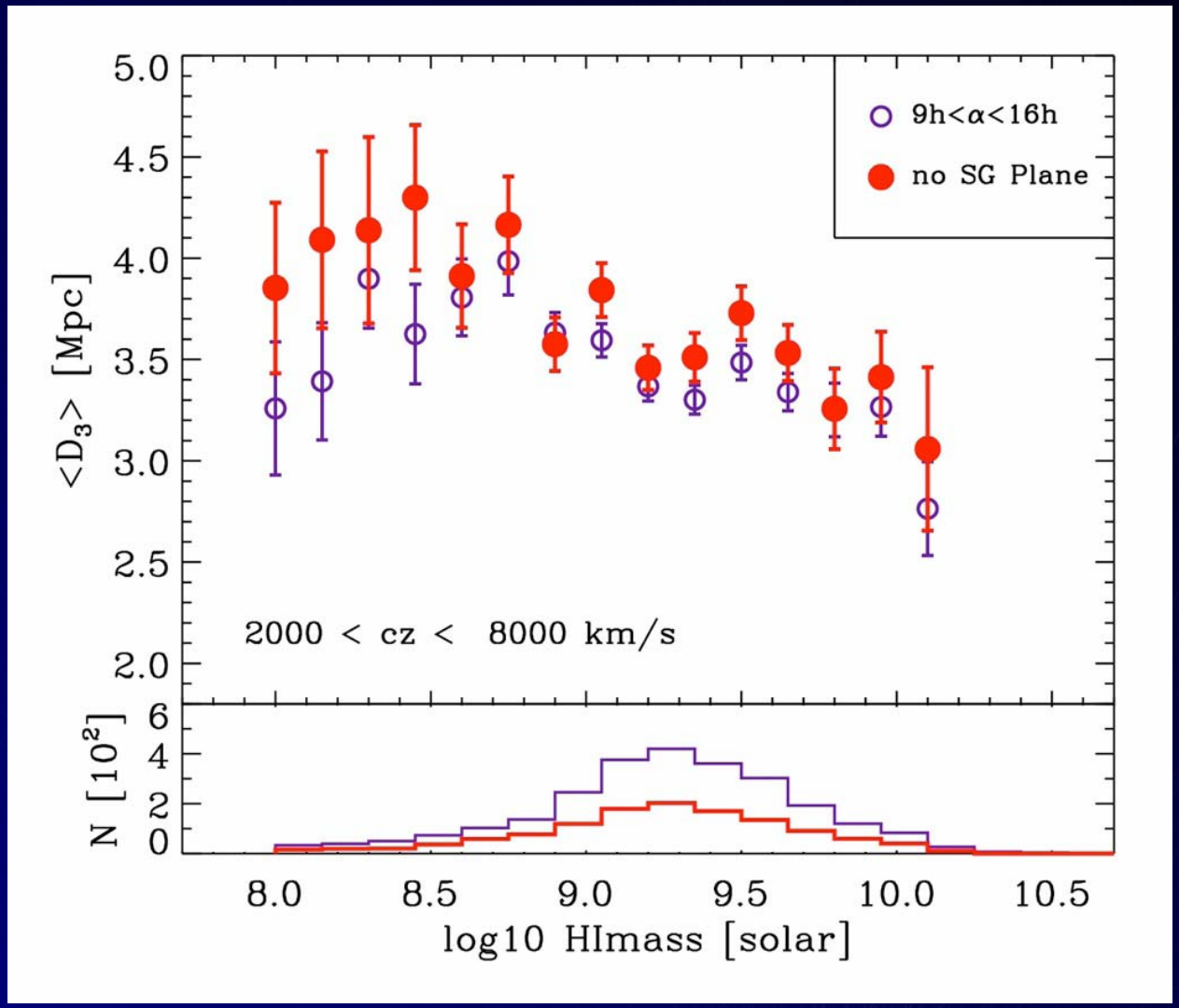
The Void Phenomenon



Within the population of gas-rich systems, lower HI mass systems tend to favor the lower density regions.

Amélie Saintonge et al. 2009, in prep

Mean distance to 3rd nearest neighbor

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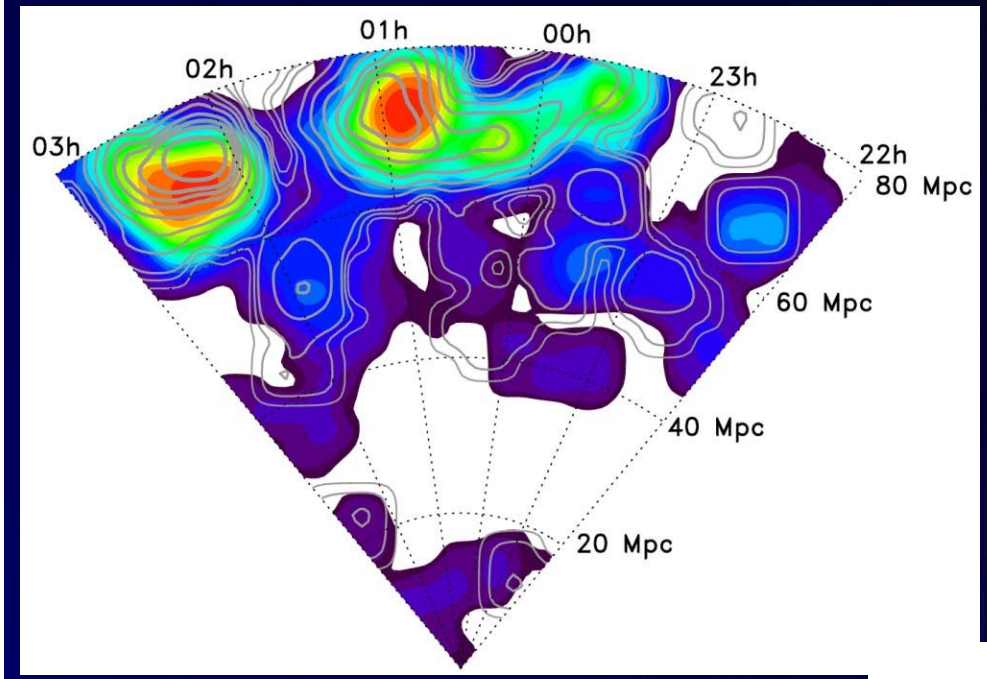


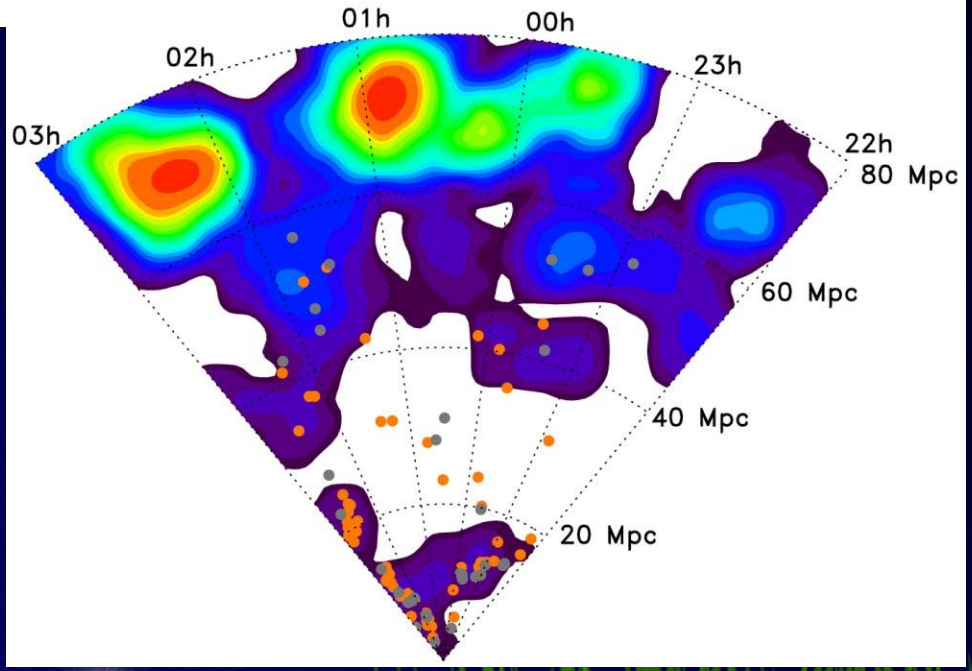
ALFALFA – PP Void
Decs +24 to +32° (22%)

Amélie Saintonge 2009, in prep

- Grey contours: optical volume limited at M_B = -19.0
- Color contours: HI volume limited at log $M_{HI}/M_\odot$ < 8.0

Grey dots: optical galaxies with M_B > -18.

Orange dots: HI galaxies with log $M_{HI}/M_\odot$ < 8.0



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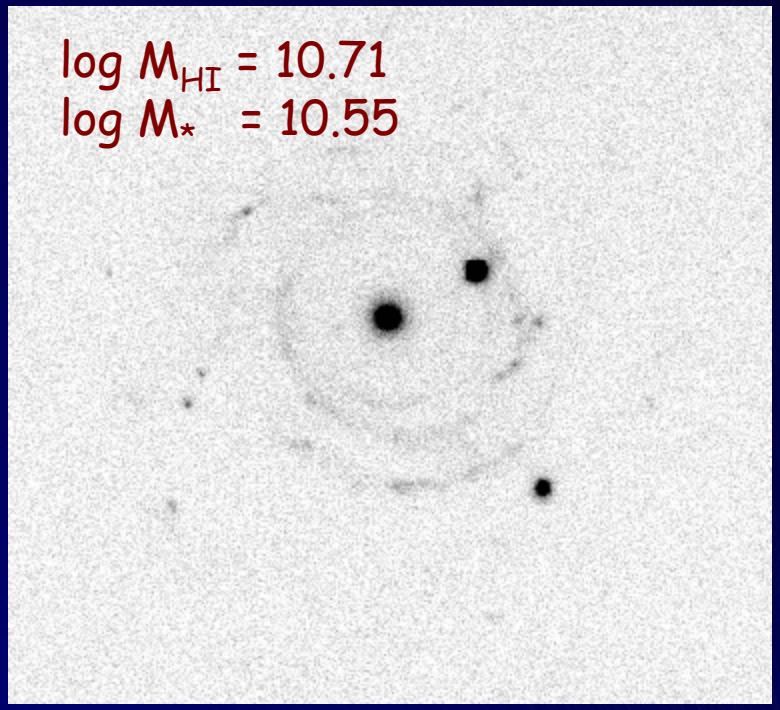
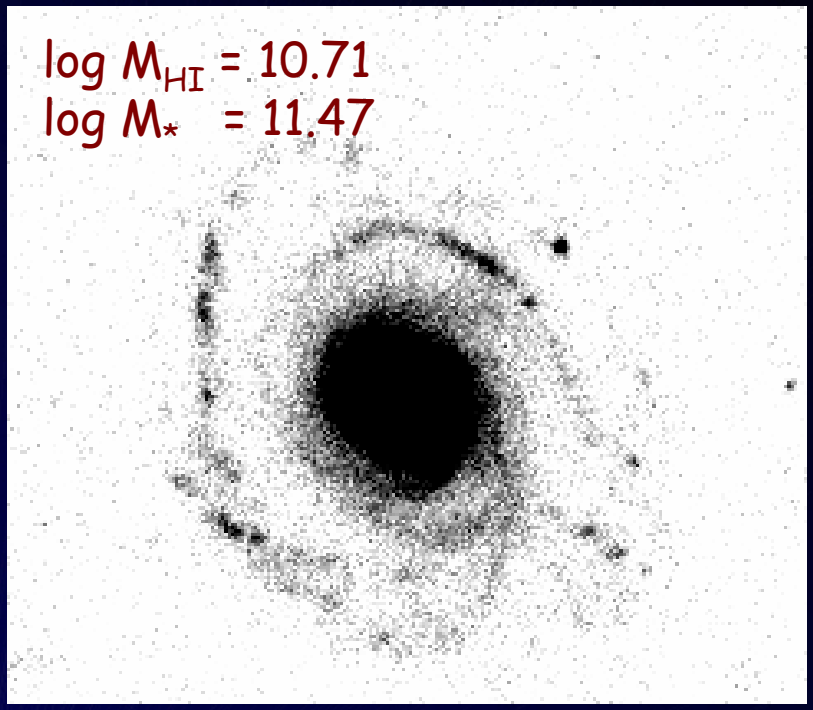
Highest HI mass objects

- Previous HI surveys detect very few objects with $M_{HI} > 10^{10}\ M_\odot$; HIMF not well constrained at highest masses either.





-GASS (GALEX-Arecibo-SDSS survey: Schiminovich et al.)
Tim Heckman's talk... next...

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ALFALFA HI census

- HIPASS result: no cosmologically significant population of HI-rich dark galaxies: ALFALFA agrees… but HIPASS $M_{HI} > 10^8\ M_\odot$
- ALFALFA is specifically designed (wide area, high velocity resolution) to detect hundreds of objects with $M_{HI} < 10^{7.5}\ M_\odot$
  - Low HI mass
  - Narrow HI line width + exclude face-on objects
  - Will *only* be detected nearby; distances still a problem
- ALFALFA detects HI wherever it is… many surprises!
- ALFALFA also detects large numbers of high HI mass objects of relevance to studies of massive disks at high redshift.

Stay tuned for more ALFALFA SPROUTS…

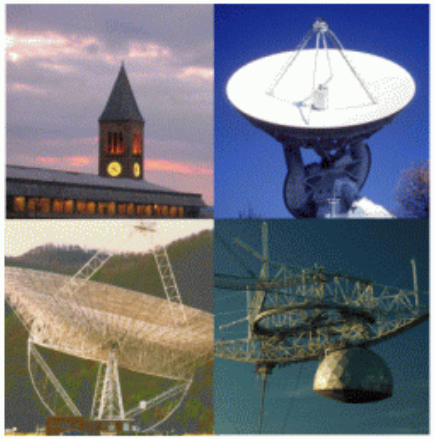
ALFALFA

ALFALFA digital archive

Cornell University
Digital HI Archive

Home | Query | SQL | Schema | Cone | Plot | Download | Help | NVO | CU Astro | EGG | CTC

The Cornell Digital HI Archive



The Cornell Digital HI Archive will host the spectra, observed and derived parameters from large collections of HI 21 cm line galaxy surveys obtained using a number of radio telescopes, especially the 305 meter antenna, the world's largest radio-radar telescope which is located at the Arecibo Observatory, in northern Puerto Rico. The Arecibo Observatory is part of the National Astronomy and Ionosphere which is operated by Cornell University under a cooperative agreement with the National Science Foundation.

The first installment of this digital archive is the dataset presented by Springob, Haynes, Giovanelli and Kent, (2005, ApJS, 160,149). Covering 9000 galaxies in the local universe (spanning a heliocentric velocity -200 < V < 28,000 km/s) and obtained with a variety of large single dish radio telescopes, the data have been reanalyzed using a single set of parameter extraction algorithms. The database contains catalogs of HI parameters (systemic velocities, integrated HI line fluxes and full widths), plots of the HI spectra, and the digital spectra themselves. Subsets of the database can be extracted using Virtual Observatory standards and protocols.

ALFALFA

Within the next month, we will add the first observations obtained with the Arecibo L-Band Feed

http://arecibo.tc.cornell.edu/hiarchive
http://egg.astro.cornell.edu/alfalfa

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