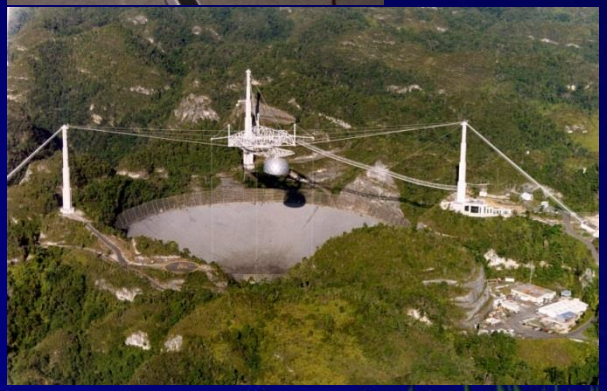
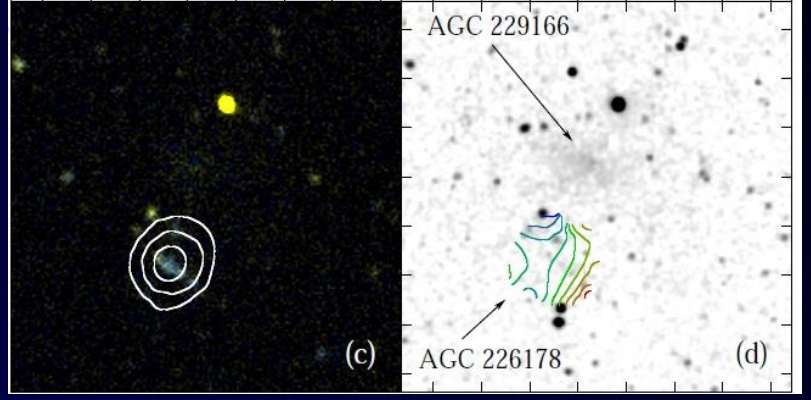




Identifying stellar counterparts to HI detections: really important and easier said than done

Martha Haynes
Cornell University
For the ALFALFA team

PHISCC15 @ Rutgers
March 17, 2015

ALFALFA

Putting HI surveys in context

- What galaxies are detected/not detected by HI surveys?
- How and when do galaxies convert their gas into stars?
- Is HI relevant?

- For many/most scientific purposes, the HI alone is not sufficient; we need to know also about the stars (at least!)

Hence: *A few lessons from ALFALFA…..*

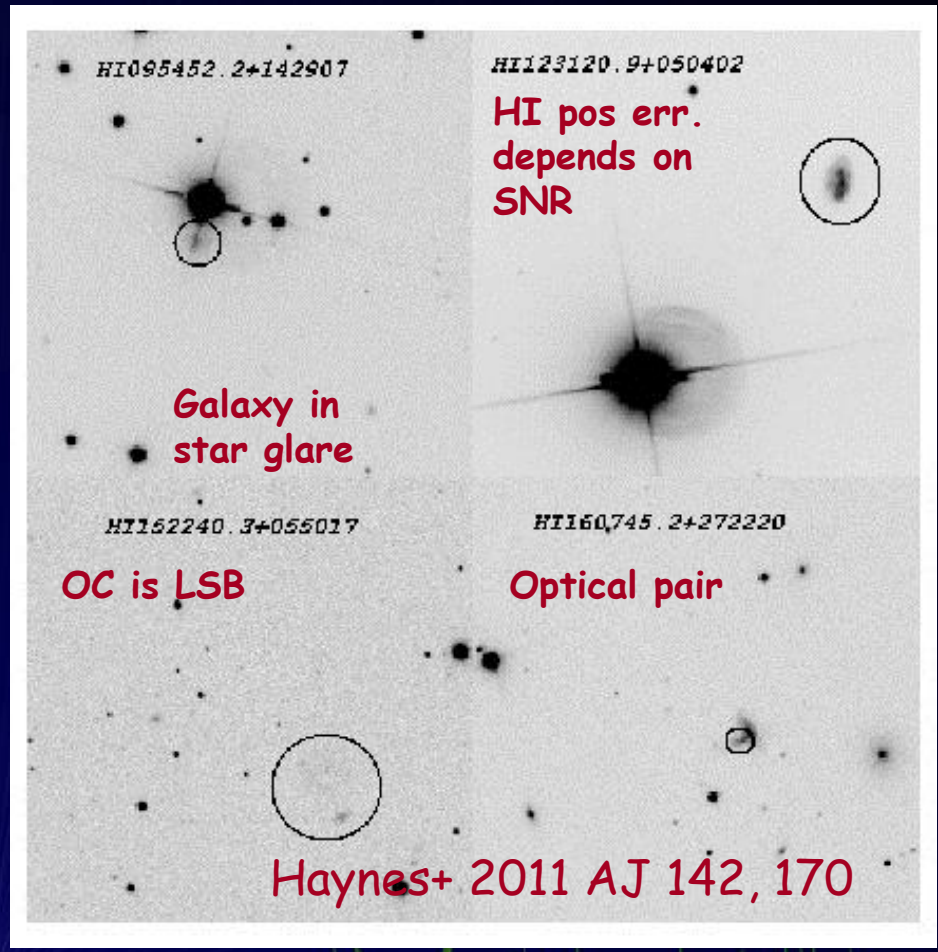
Identifying Optical Counterparts

ALFALFA source centroids good to ~18" (depends on S/N)
=> Use SDSS/DSS2(B) to find "most probable" OC.

Of 15855 sources in a.40:

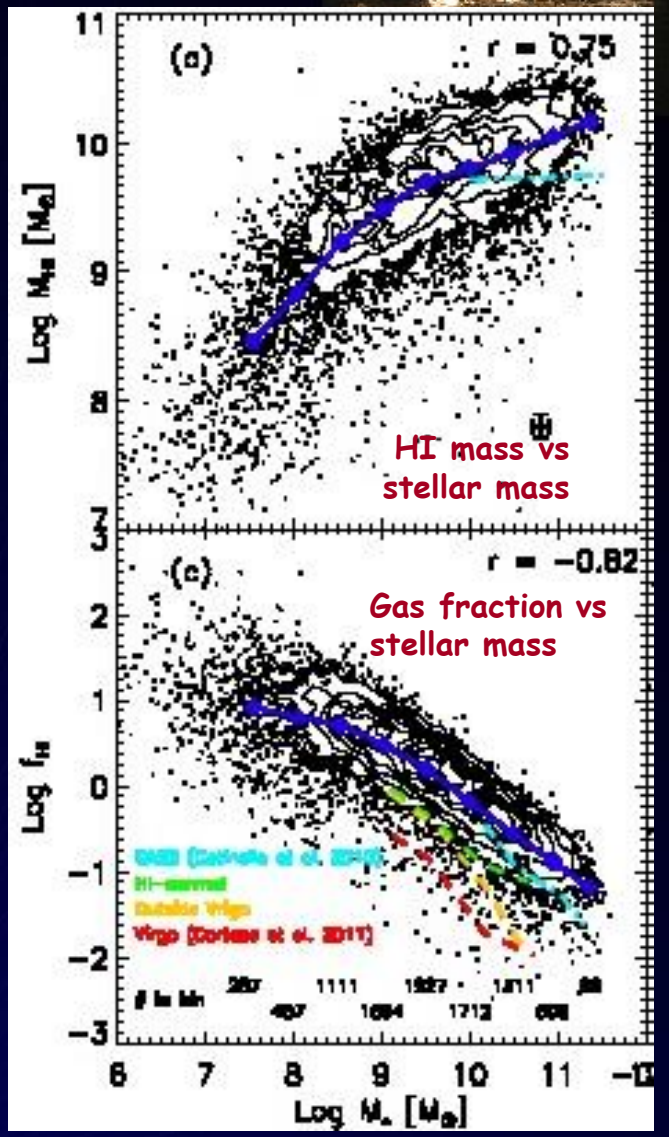
- 1013 have no "probable" OC in SDSS or DSS2(B)
- 844 of those could be HVCs or UCHVCs/LG minihalos (Betsey's talk)
- 199 (<2%) extragalactic
- Of those 199, <50 are "isolated" (Luke's talk coming up)

=> similar statistics in a.70+



Virtually all SF galaxies contain HI

- HI blind surveys do not "see":
  - the "red sequence"
  - clusters
- HI-selected galaxies are the least clustered population (Martin+ 2012, Papastergis+2013)
- The ALFALFA population is typically **bluer**, of **lower metallicity** and lower **extinction**, consistent with having **extended disks** and lower SFEs.
- Galaxies with **higher GF** are hosted in halos with **higher spin** λ.
- HI **dominates** the (visible) baryons in low mass galaxies.
- The SFHs of low mass galaxies are **episodic**.



ALFALFA-SDSS-GALEX population
Shan Huang et al. 2012 ApJ 756 113

ALFALFA

Putting HI surveys in context

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- Is HI relevant?

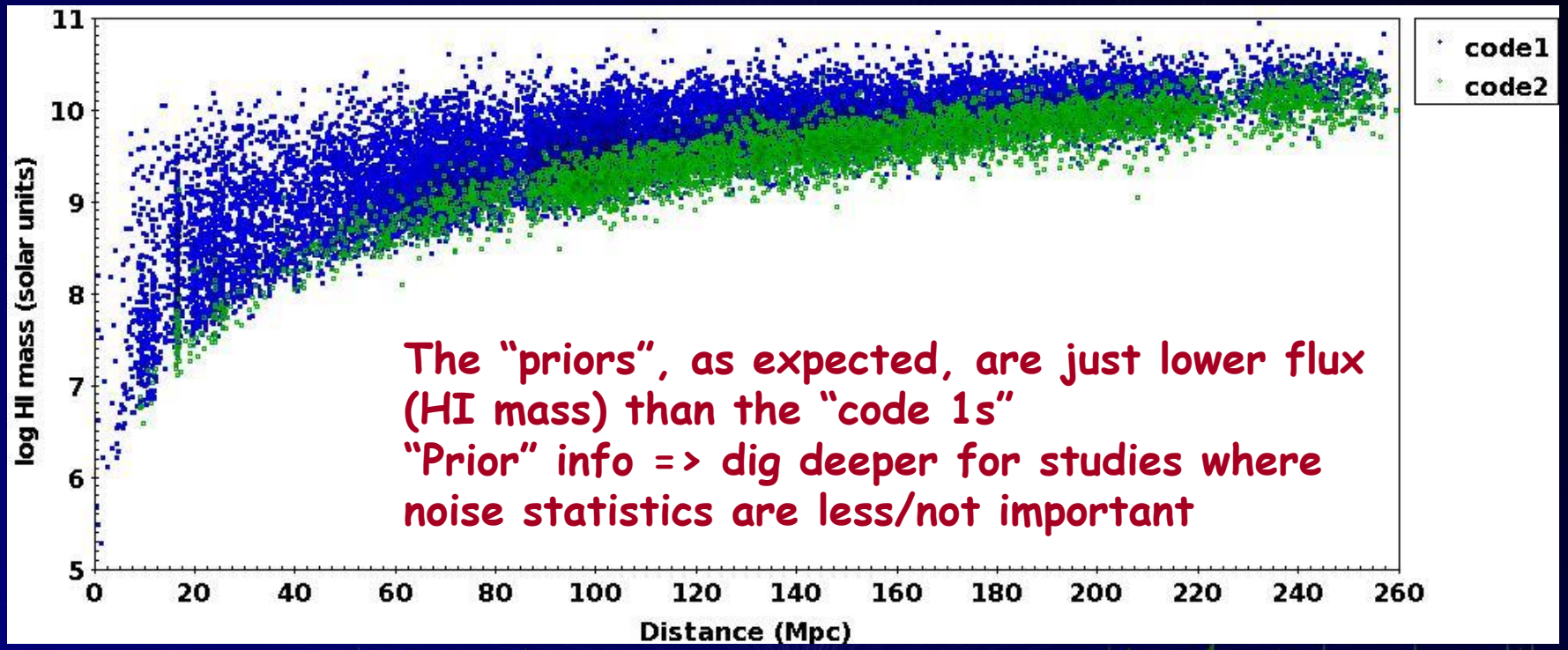
- For many/most scientific purposes, the HI alone is not sufficient; we need to know also about the stars (at least!)

- The presence of an optical counterpart (OC) increases the probability that a low SNR "candidate detection" is real, especially if the OC has a coincident redshift => the ALFALFA "priors"

ALFALFA: sources and candidates

ALFALFA HI detections are coded according to:

Code 1	High quality sources, typically with S/N > 6.5
Code 2	Sources of lower S/N which are coincident with a probable OC of the same redshift (known from another source) => the "priors"



The "priors", as expected, are just lower flux (HI mass) than the "code 1s"
"Prior" info => dig deeper for studies where noise statistics are less/not important

ALFALFA

The ALFALFA-SDSS experience

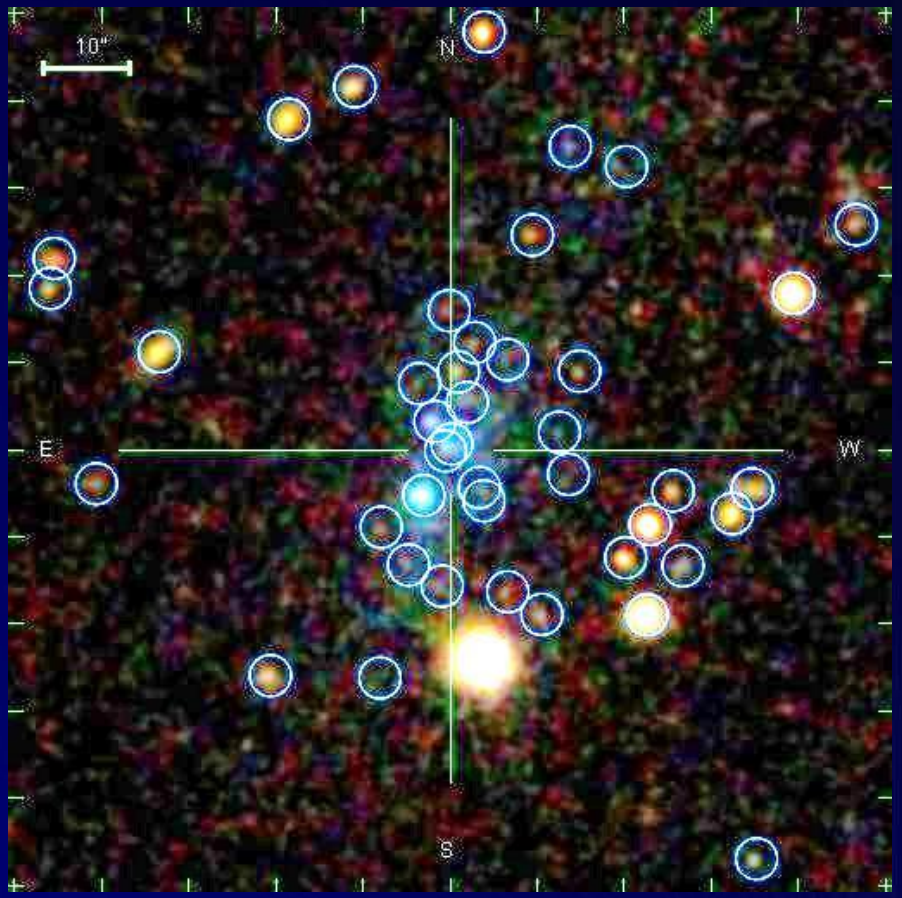
- ALFALFA overlapped in time with SDSS
  - Both datasets kept growing
  - Calibration/software changed
    - For SDSS, that meant new photometric sources (i.e. the catalogued positions/IDs changed)

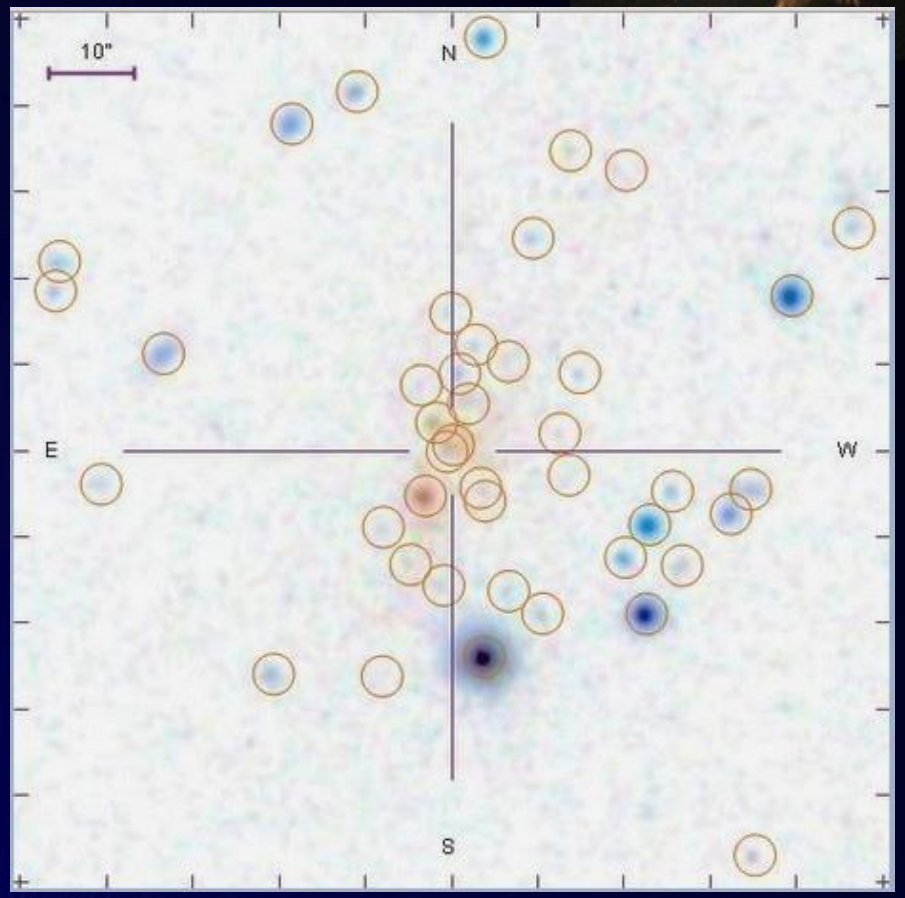
- Especially because many HI-bearing galaxies are extended and/or of low surface brightness and patchy, the standard SDSS photometric pipeline has issues (shredding)

- ALFALFA's beam is large, resulting in confusion.
- ALFALFA has "blind spots" due to RFI contamination.
- SDSS photometry suffers from bright star contamination.
- SDSS phot/spectroscopy suffers when the photometry is shredded.
- SDSS spectroscopyis affected by fiber collision rules.

- A few examples…….

AGC 208583 = Leo P

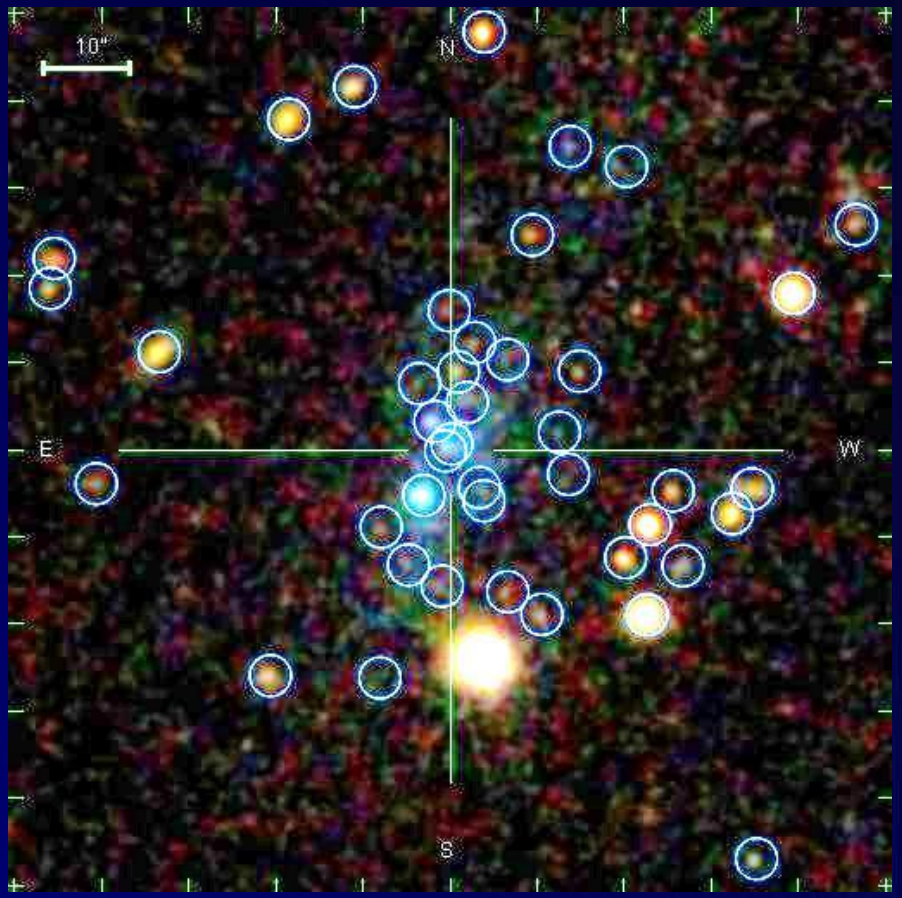




Many photometric objects => compact group of galaxies

ALFALFA

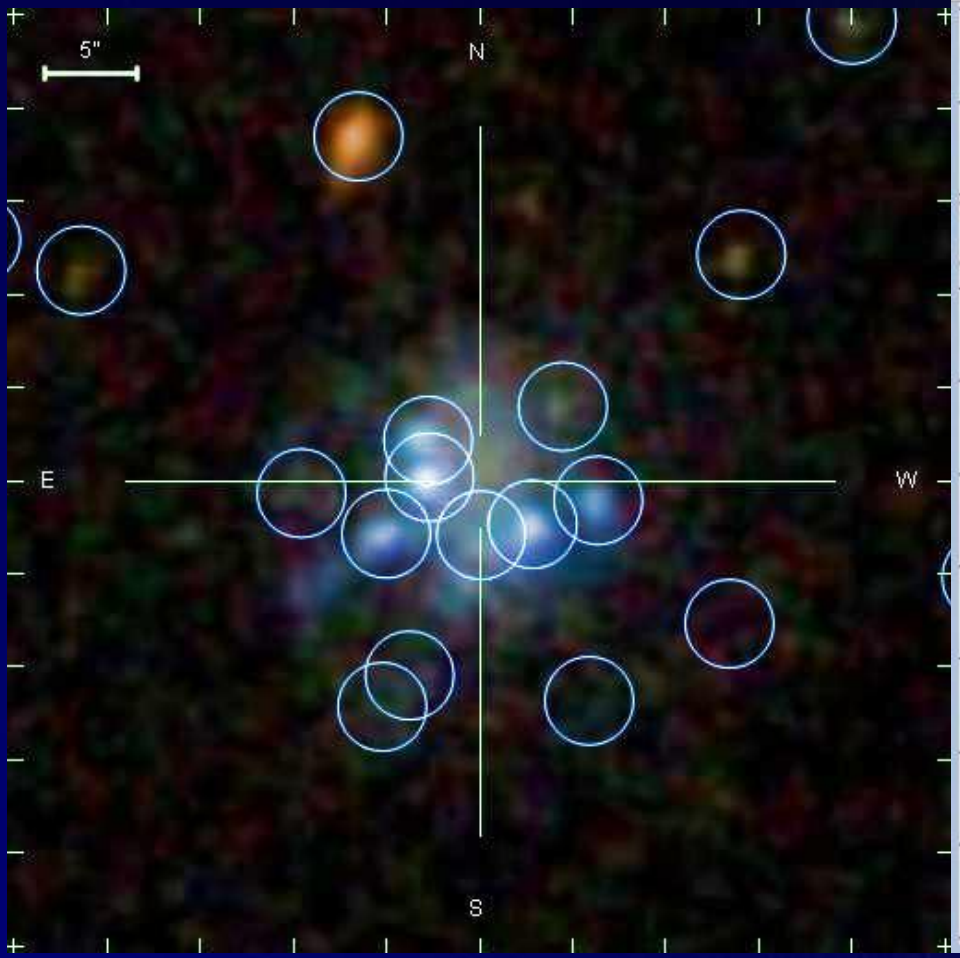
AGC 208583 = Leo P

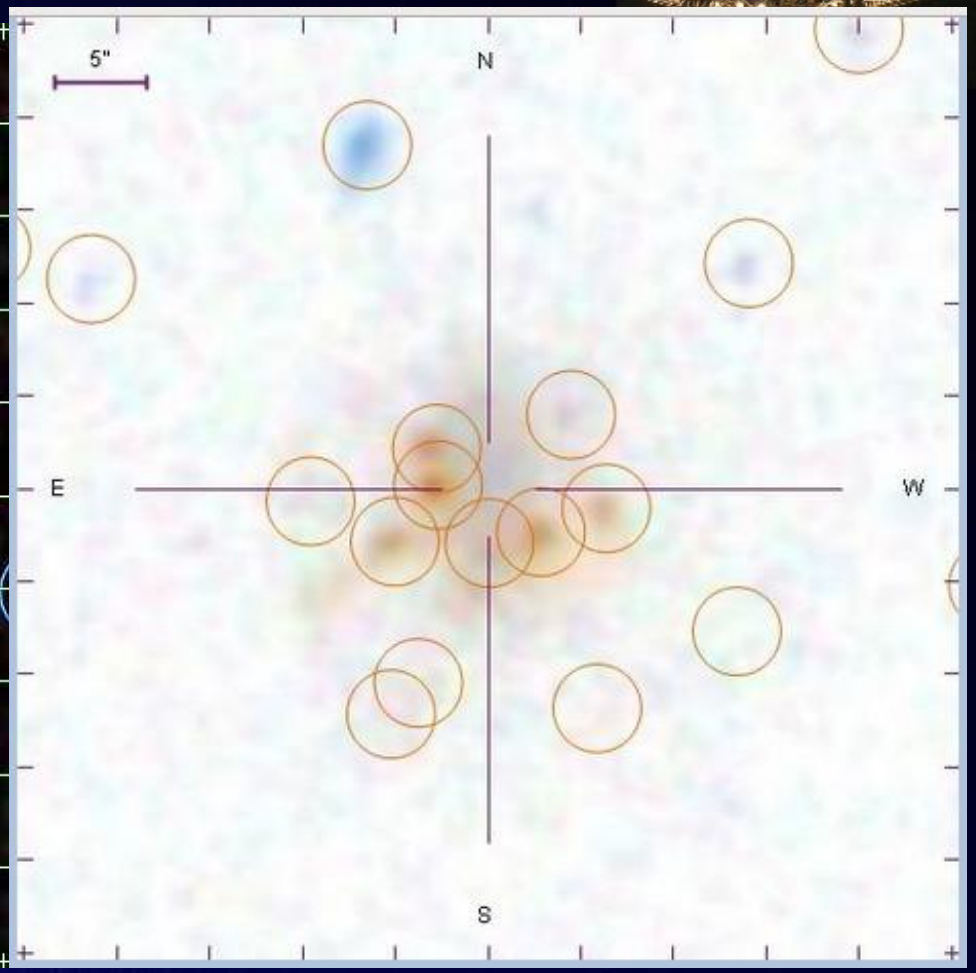


Many photometric objects => compact group of galaxies

ALFALFA

AGC 749439





Shredded into many comparable photoObjs

cz = 3530 km/s

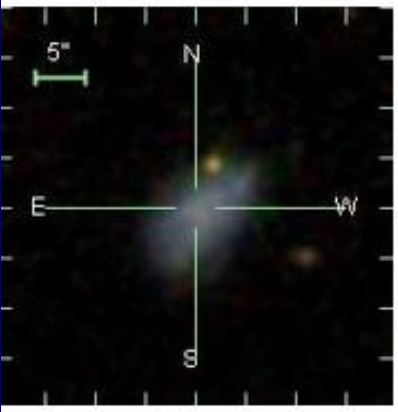
ALFALFA

AGC 742670

Type		SDSS Object ID	
STAR		1237668589727252541	
RA, Dec		Galactic Coordinates (*l*, *b*)	
Decimal	Sexagesimal	*l*	*b*
194.96378, 16.83739	12:59:51.30, +16:50:14.59	314.07923	79.52642

maging **WARNING:** This object's photometry may be unreliable. See the photometric *flags* below.

Flags	DEBLEND_NOPEAK DEBLENDED_AT_EDGE STATIONARY MOVED BINNED1 DEBLENDED_AS_PSF INTERP NOPETRO CHILD



Magnitudes				
u	g	r	i	z
22.70	23.37	22.97	22.80	22.83

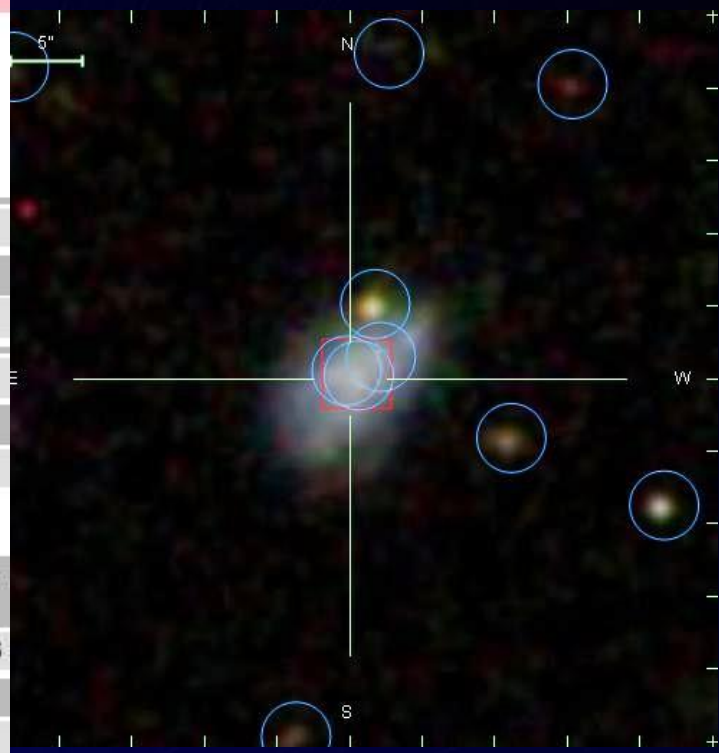
Magnitude uncertainties				
err_u	err_g	err_r	err_i	err_z
0.34	0.37	0.32	0.34	0.71

Image MJD	mode	Other observations	parentID	nChild	extinction_r	PetroRad_r (arcsec)
53526	PRIMARY	0	1237668589727252537	0	0.08	0.93 ± 0.796

Mjd-Date	photoZ (KD-tree method)	Galaxy Zoo 1 morphology
06/05/2005	-	-

Cross-identifications Show

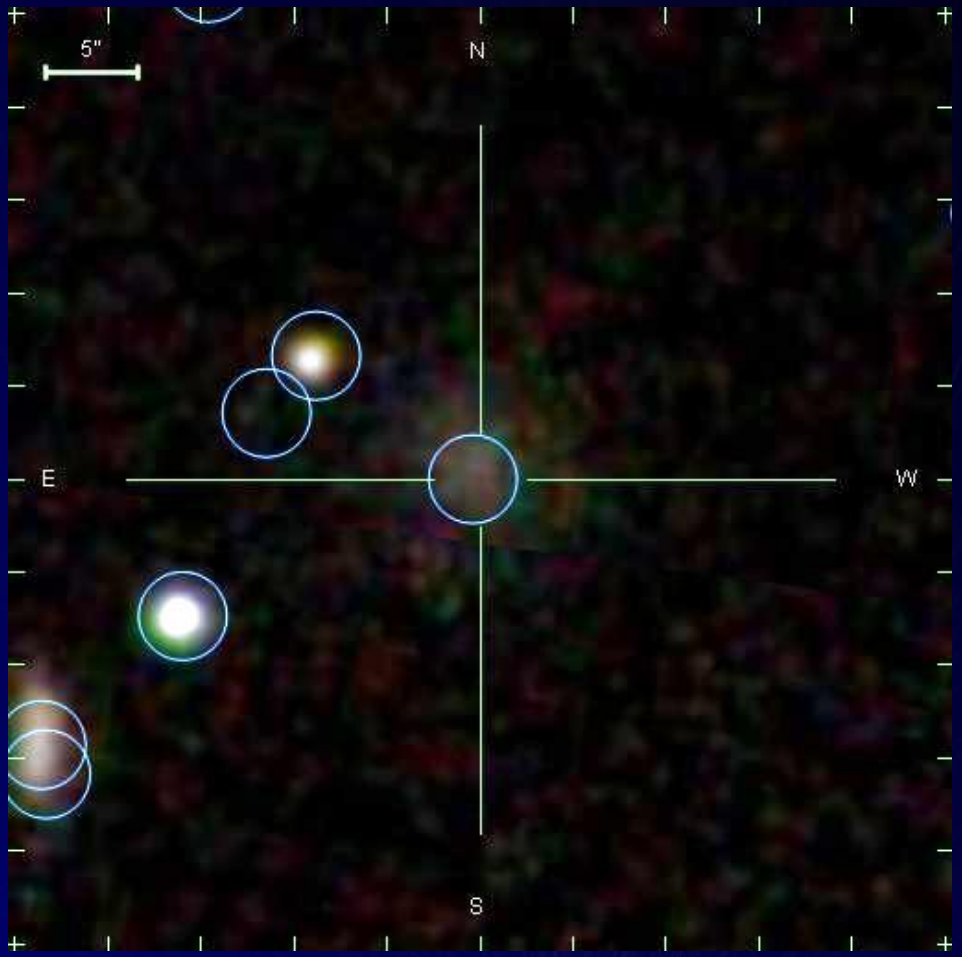
cz = 12602 km/s



Photometry flagged as bad, but reason not clear

ALFALFA

AGC 198741



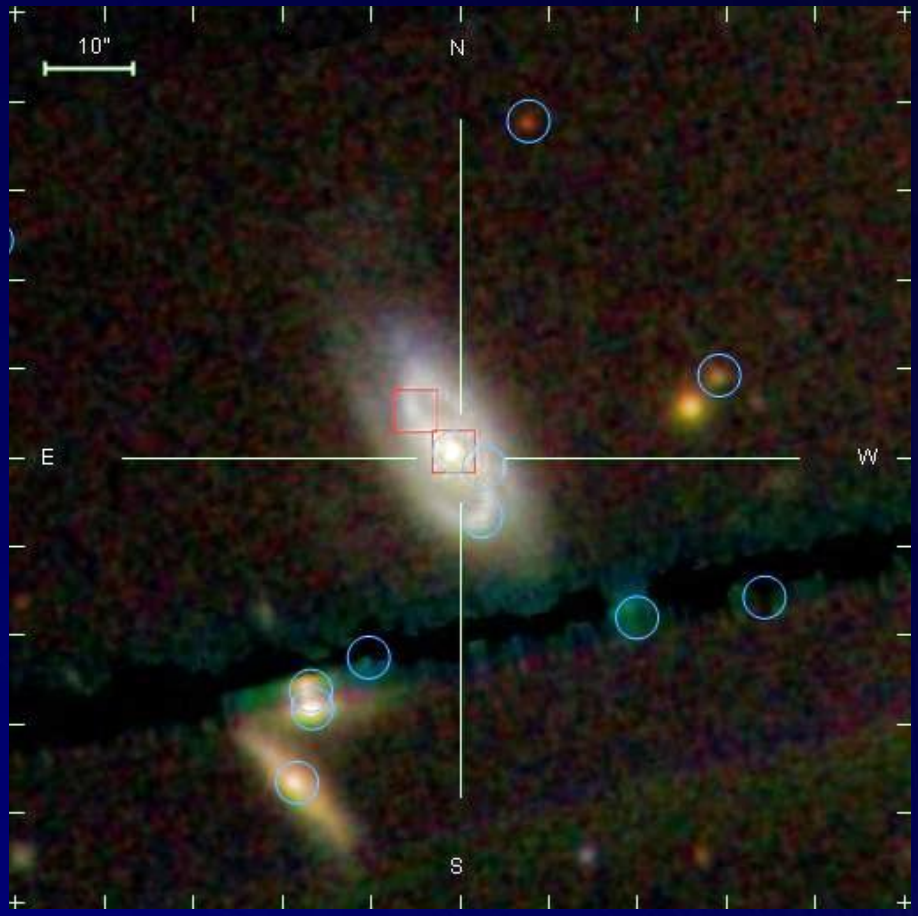
SDSS spect. criterion
Not just mag but also SB:

$m_{petro\_r} < 17.7$
$\mu_{25} < 24.5$ mag/"^{2}

Faint+LSB = no SDSS spectroscopy
cz ~ 3200 km/s

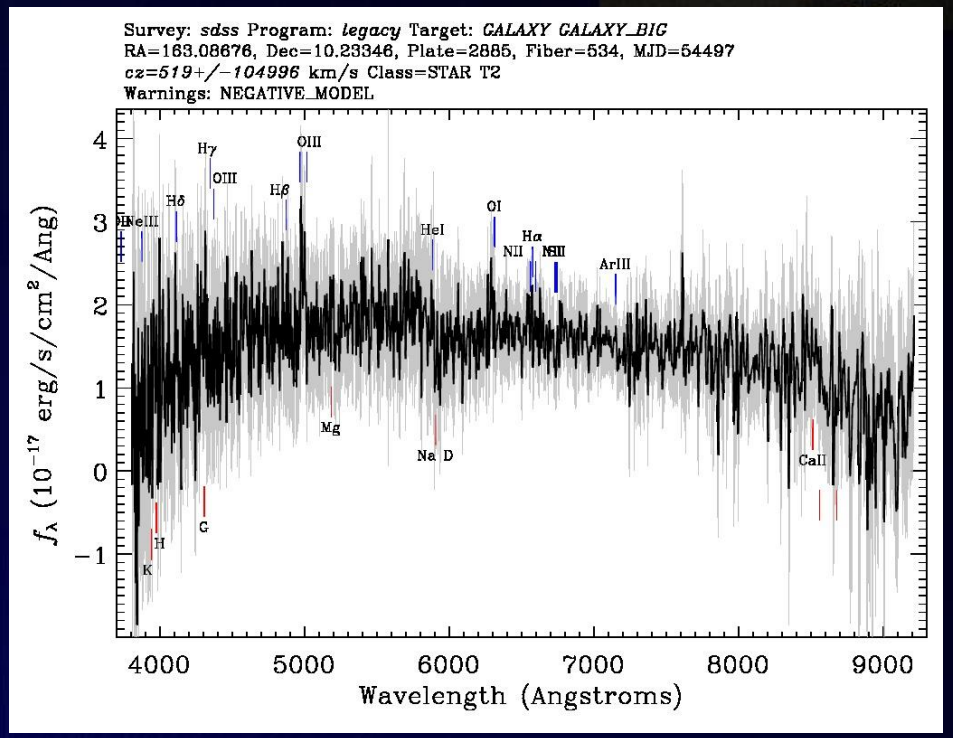
ALFALFA

Multiple and bogus spectra



Center-of-light plus off-center spectroscopic objects

AGC 241236 cz = 10169 km/s



Center-of-light plus off-center spectroscopic objects

AGC 208793 cz = 2800 km/s

ALFALFA

The ALFALFA-SDSS experience

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- Especially because many HI-bearing galaxies are extended and/or of low surface brightness and patchy, the standard SDSS photometric pipeline has issues (shredding)

- ALFALFA's beam is large, resulting in confusion.
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- SDSS photometry suffers from bright star contamination.
- SDSS spectroscopic selection includes SB limit as well as m_r
- SDSS spectroscopy suffers when the photometry is shredded.
- SDSS spectroscopy is affect by fiber collision rules

It isn't as easy as it might seem……

The ALFALFA-SDSS experience

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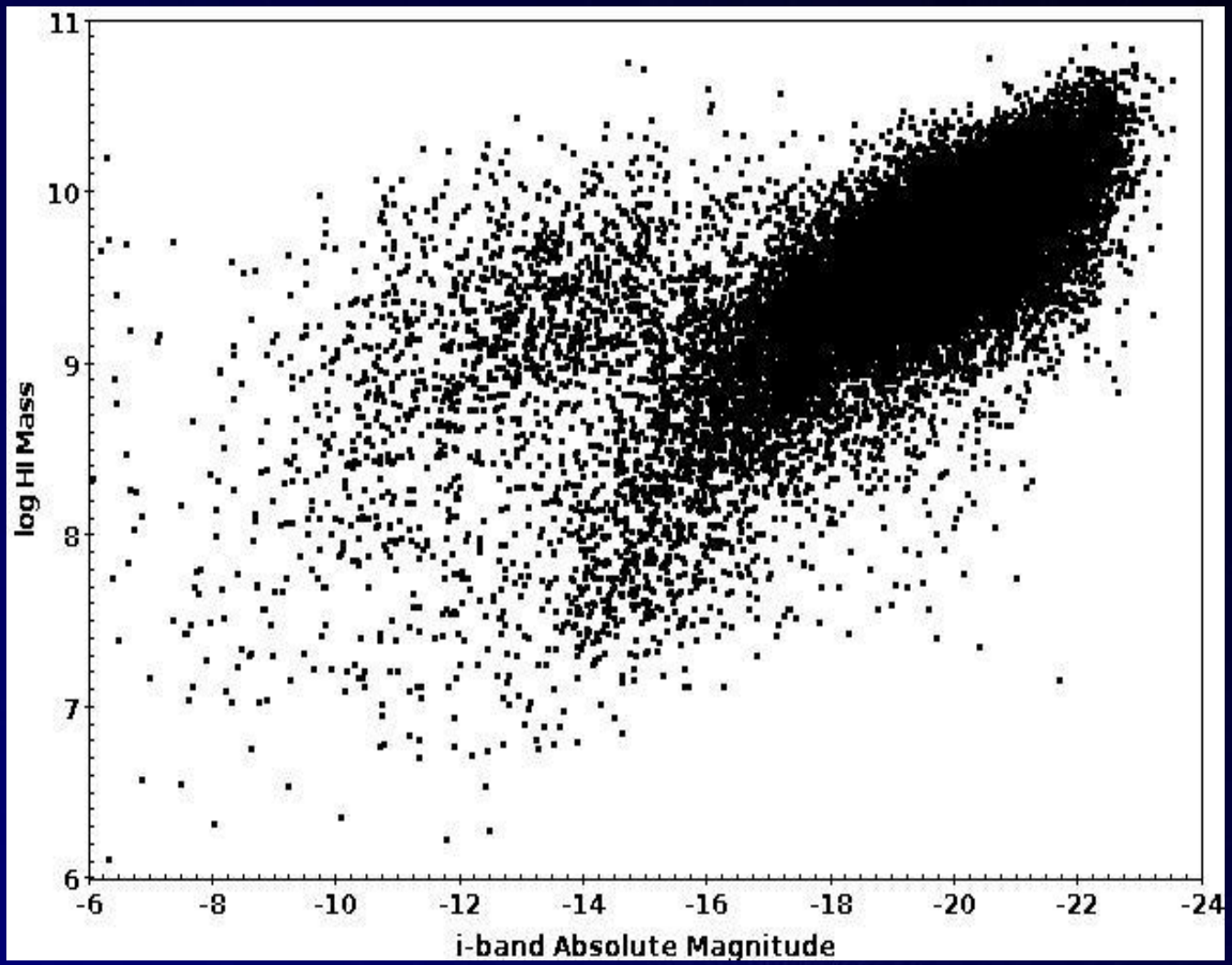
- ALFALFA's beam is large, resulting in confusion.
- ALFALFA has "blind spots" due to RFI; **we know where they are**
- SDSS photometry suffers from bright star contamination.
- SDSS spectroscopic selection includes SB limit as well as m_r
- SDSS spectroscopy suffers when the photometry is shredded.
- SDSS spectroscopy is affect by fiber collision rules

It isn't as easy as it might seem…… But should we care?

α70-DR12 crossmatch

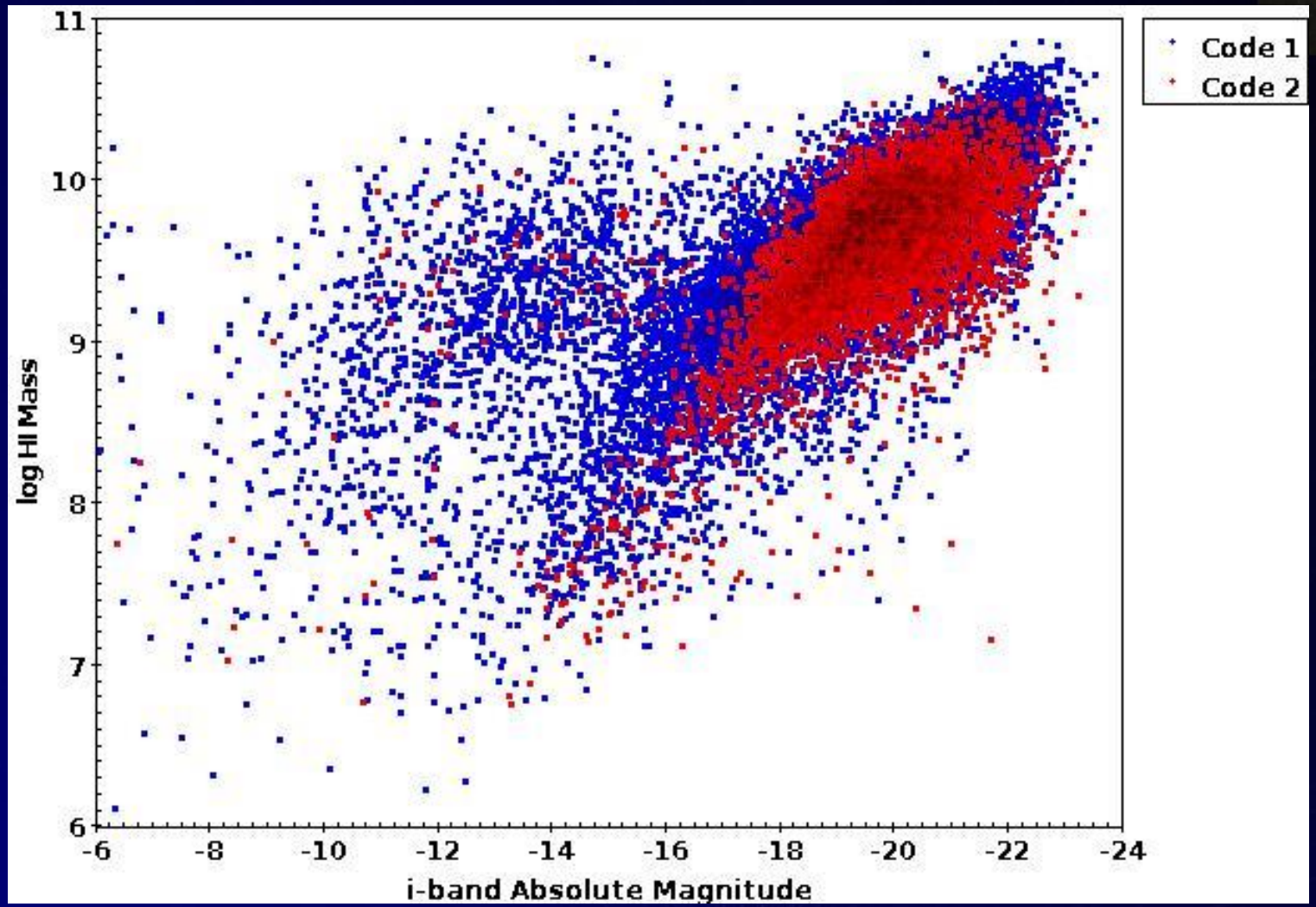


Code 1s:
Highest quality

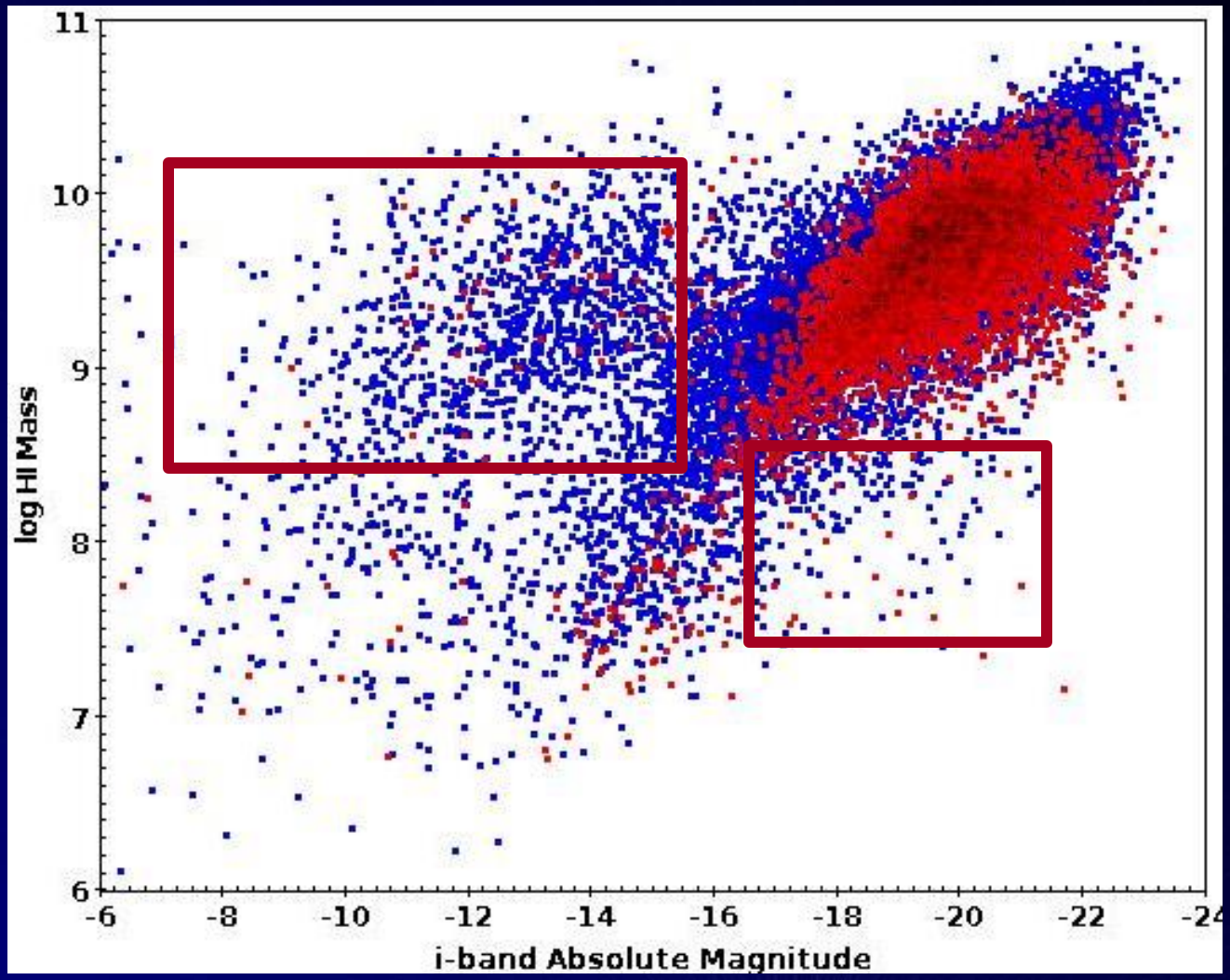
Above
$M_* \sim 5 \times 10^8 M_\odot$
HI mass scales with stellar mass
for SF galaxies

ALFALFA

Digging deeper: find the same population



Interesting or bogus?



- For the majority of galaxies, pipelined photometry and automatic cross-matches work just fine.
- But, if you are interested in the outliers, you need to work harder!

ALFALFA

ALFALFA: Are there "dark galaxies"?

- In agreement with previous results, ALFALFA finds that fewer that 2% of (clearly extragalactic; not Betsey's UCHVCs) HI sources cannot be identified with an optical counterpart.
- The majority of objects without OC's are found near to galaxies with similar redshifts.

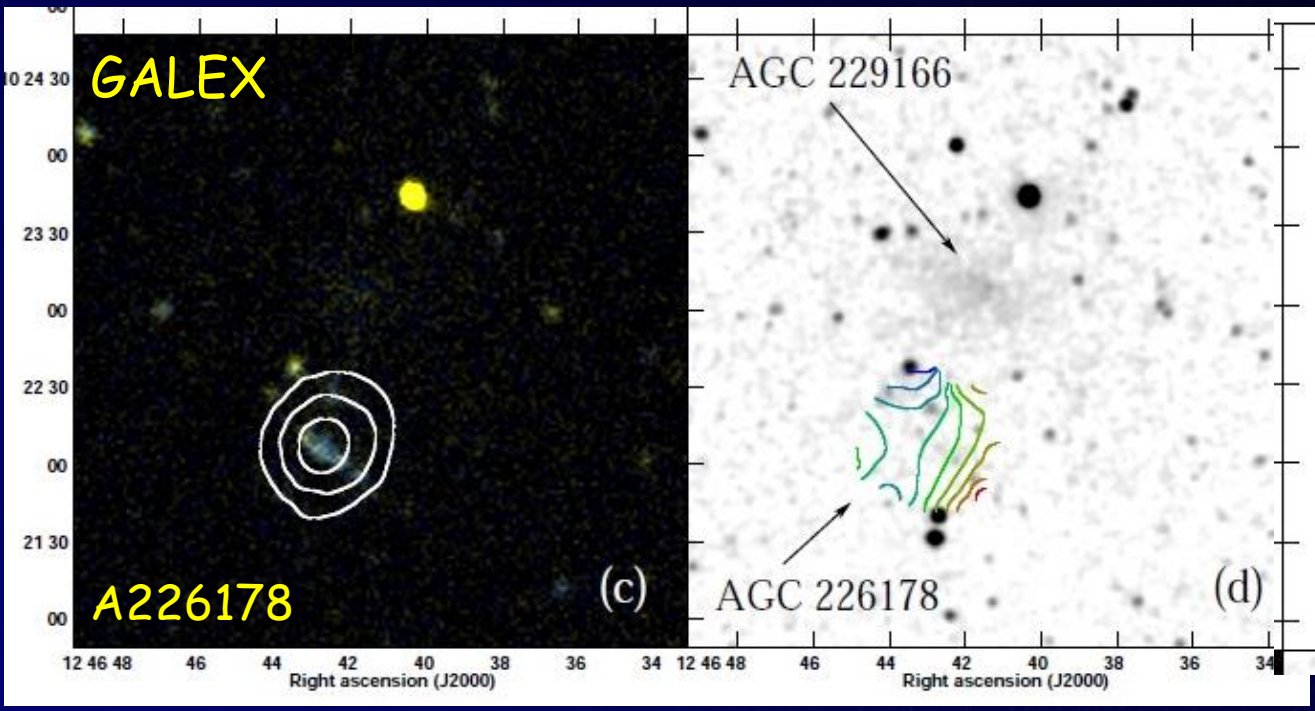
Dark galaxies:
The burden is always on us to prove that
(1) the signal is real and
(2) there is no OC even at low surface brightness
(3) the HI is not tidal in origin

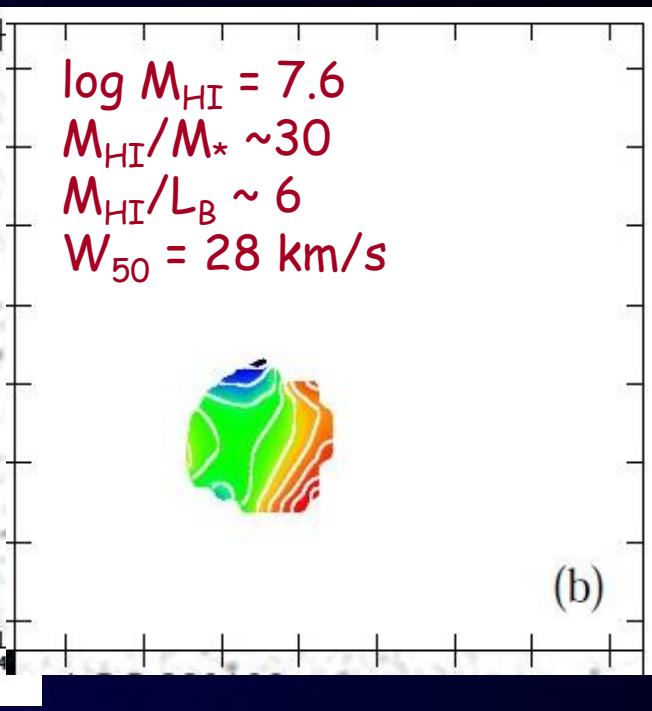
Luke Leisman, PhD thesis (Cornell)
Karen Lee-Waddell, PhD thesis (Queen's)
Steven Janowiecki, PhD thesis (Indiana)
+ Cannon, Salzer, Rhode, Jozsa, Adams, Darling, RG, MH

ALFALFA
"(Almost) Dark"
galaxies project

ALFALFA

AGC 226178/296166





Will the real OC please raise your hand?

Cannon+ 2015 Astron J 149, 72
cz = 1581 km/s

ALFALFA

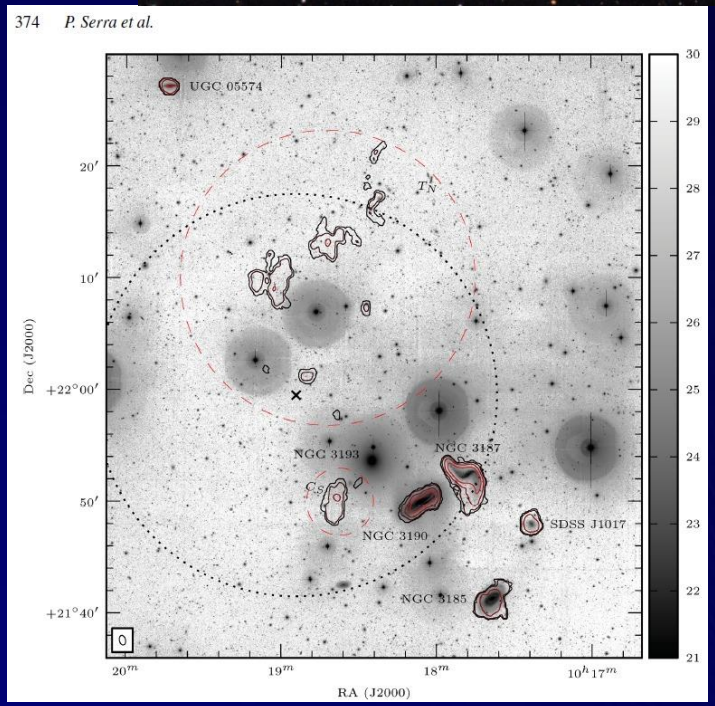
Wide field imaging is amazing!

- The ability to map over wide areas will reveal very extensive structures not recognized with the limited fields-of-view of today's interferometers.
- Part of the challenge will be to understand when there is no optical counterpart!

One example from ALFALFA …

Debris in the HCG 44 group

APOD 070319 MASIL Imaging Team



Serra+ 2012 MNRAS 428, 370
6 x 12 hours with WSRT

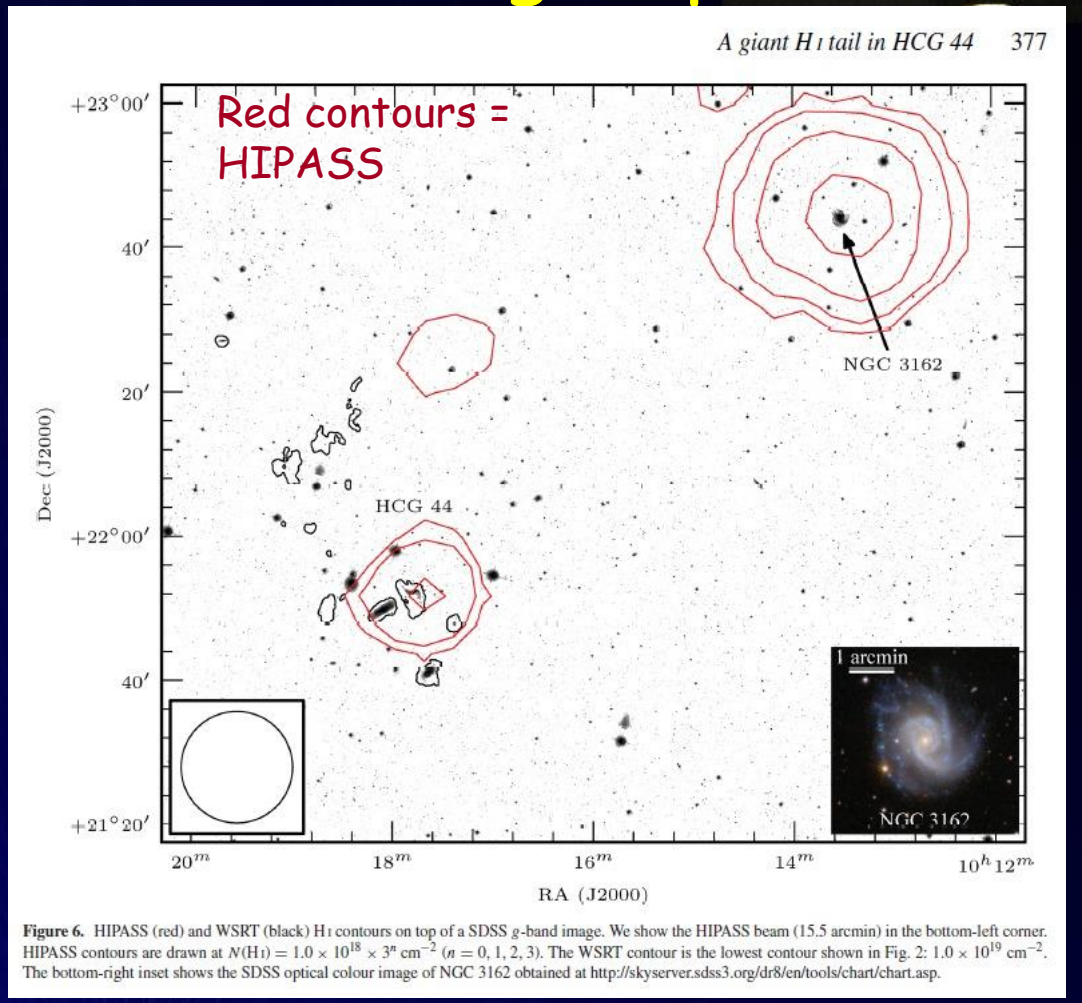
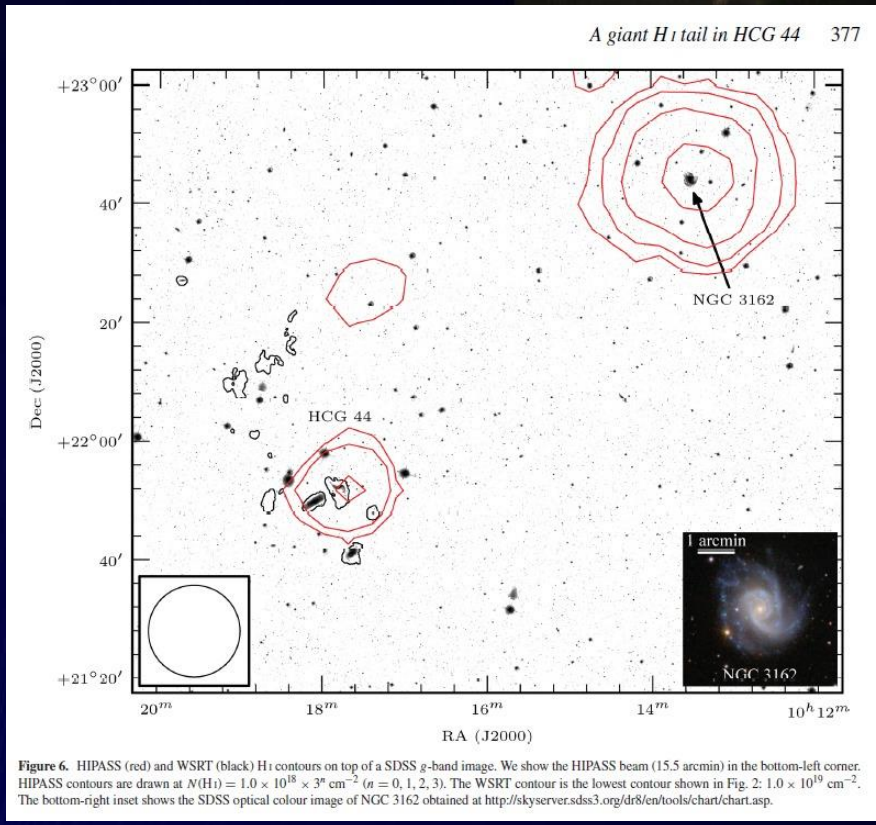


Figure 6. HIPASS (red) and WSRT (black) H I contours on top of a SDSS *g*-band image. We show the HIPASS beam (15.5 arcmin) in the bottom-left corner. HIPASS contours are drawn at $N(\mathrm{H\,I}) = 1.0 \times 10^{18} \times 3^n\ \mathrm{cm}^{-2}$ ($n = 0, 1, 2, 3$). The WSRT contour is the lowest contour shown in Fig. 2: $1.0 \times 10^{19}\ \mathrm{cm}^{-2}$. The bottom-right inset shows the SDSS optical colour image of NGC 3162 obtained at http://skyserver.sdss3.org/dr8/en/tools/chart/chart.asp.

ALFALFA

The ALFALFA view



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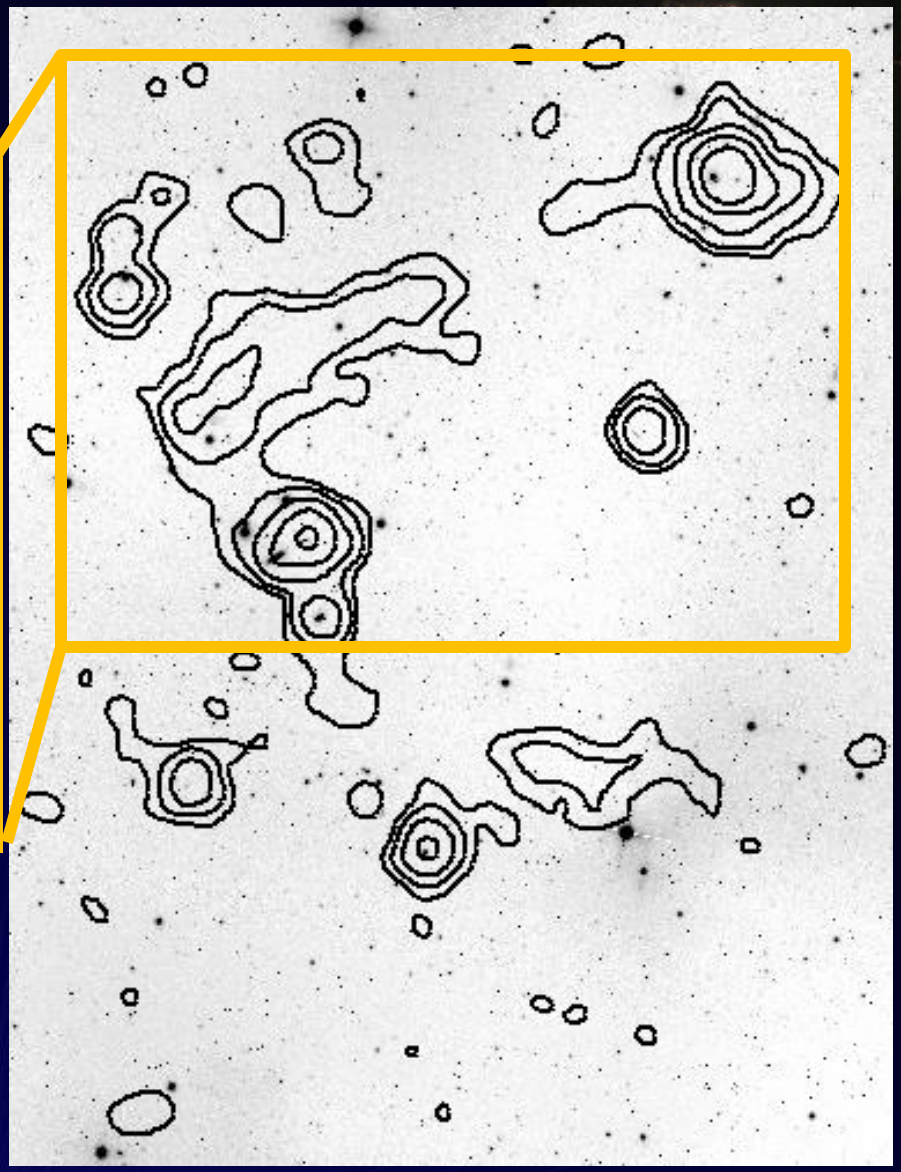
ALFALFA
Leisman+ in preparation

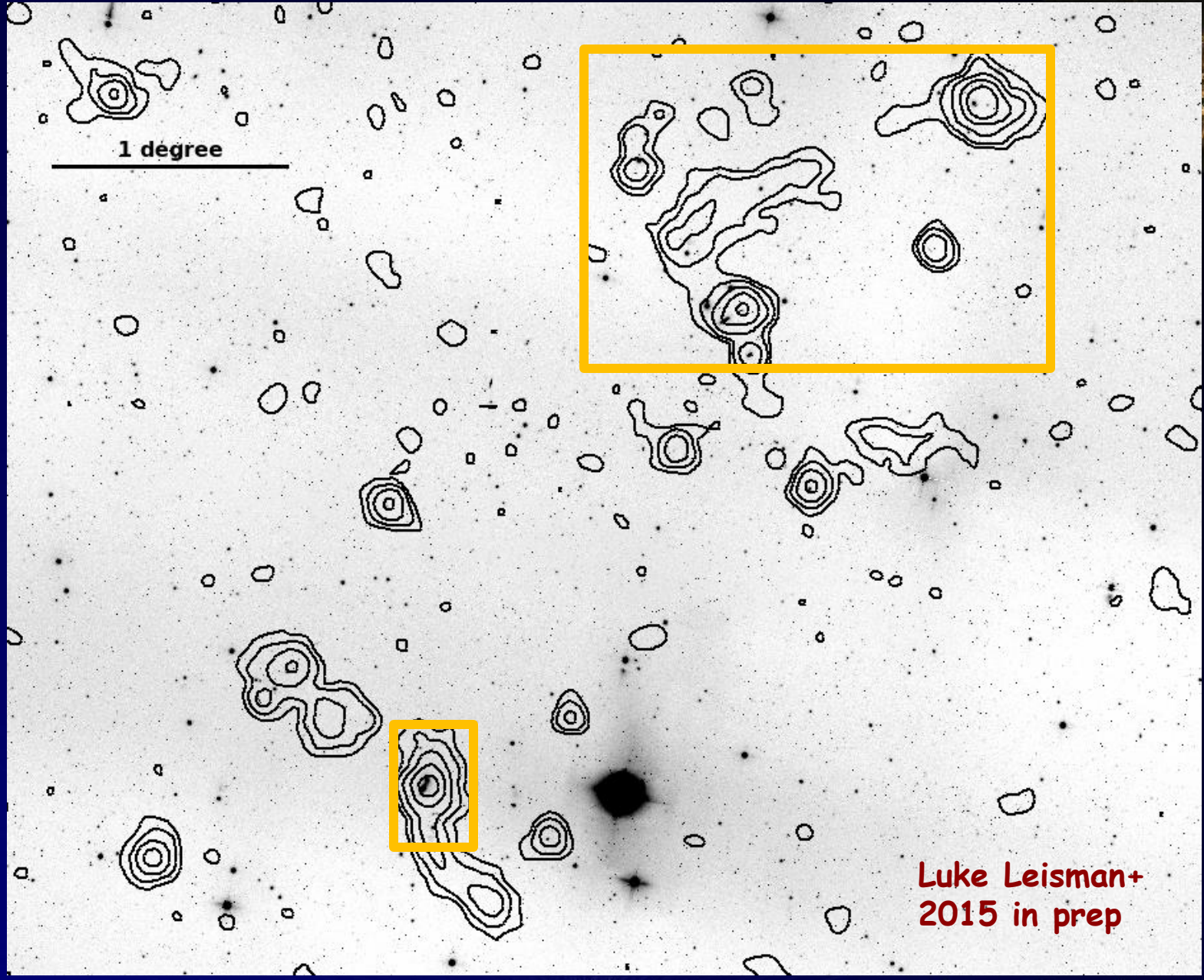
Serra+ 2012 MNRAS 428, 370
HCG 44

ALFALFA

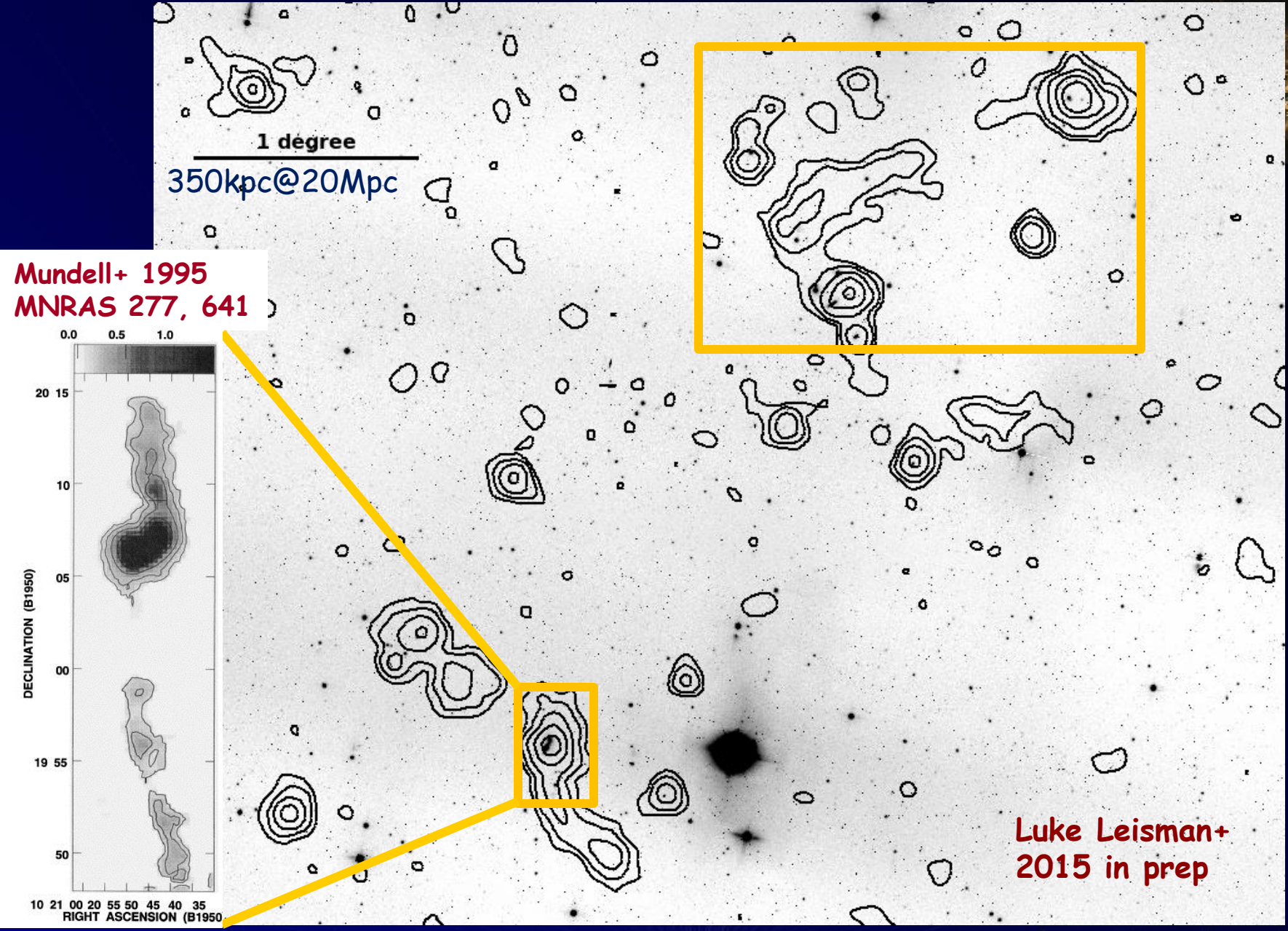
The wide field is amazing



ALFALFA
Leisman+ in preparation



ALFALFA


1 degree
350kpc@20Mpc
Mundell+ 1995
MNRAS 277, 641
0.0 0.5 1.0
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05
00
19 55
50
DECLINATION (B1950)
10 21 00 20 55 50 45 40 35
RIGHT ASCENSION (B1950
Luke Leisman+
2015 in prep


NSF
ALFALFA

Putting HI surveys in context

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- For many/most scientific purposes, the HI alone is not sufficient.

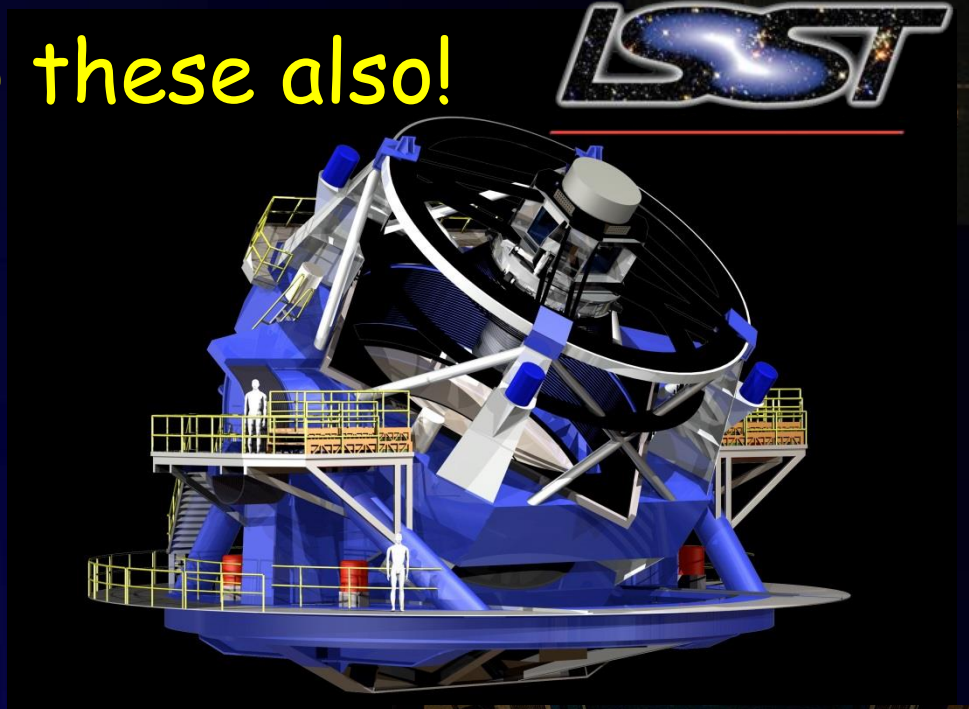
- The presence of an optical counterpart (OC) increases the probability that a low SNR "candidate detection" is real, especially if the OC has a coincident redshift. => priors are good!

- Experience suggests that the HI survey team effort should include identifying counterparts in other major multiwavelength surveys => much larger survey "reach"

Looking forward to all of the future HI surveys
AND…

ALFALFA

Looking forward to these also!



HETDEX
VISTA
DES
CCAT

Pan-STARRS

ALFALFA