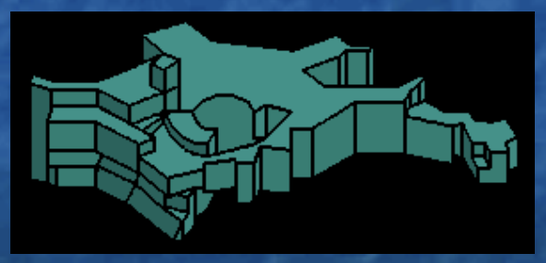
HI observations of gas-rich galaxies at redshift z~0.2



Barbara Catinella

Max Planck Institut für Astrophysik

Dec 16 2008

HI deep surveys

Detection of 21 cm emission at z > 0.1 is DIFFICULT

- weak signals → very long integration times
- radio frequency interference (RFI)
- increased beam confusion (single dish)

Almost NOTHING known about HI emission of galaxies above z=0.1

- Zwaan et al. 2001 — WSRT, 18×12 hrs
  Abell 2218 → 1 galaxy at z=0.1766

- Verheijen et al. 2007 — WSRT, 20×12 hrs + 15×12 hrs
  2 Abell clusters (z=0.206 and 0.188)
  42 detections + 8 tentative, HI masses = 0.5 − 4 × 10^{10} $M_\odot$

Arecibo pilot HI survey at z>0.16

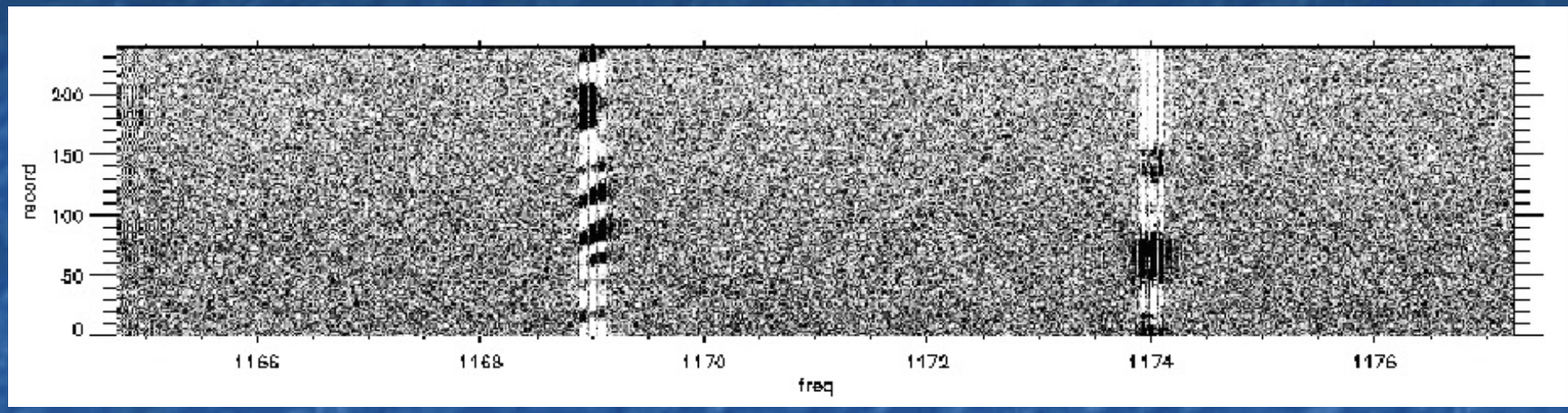
- Technical improvements at Arecibo (already 1/10 collecting area of SKA!!) new L-wide receiver in 2003: access to frequencies < 1.3 GHz
- SDSS → accurate z for ~10^6 galaxies!

- Galaxies selected from SDSS according to z, Hα EW, inclination, disk morphology, and relative isolation

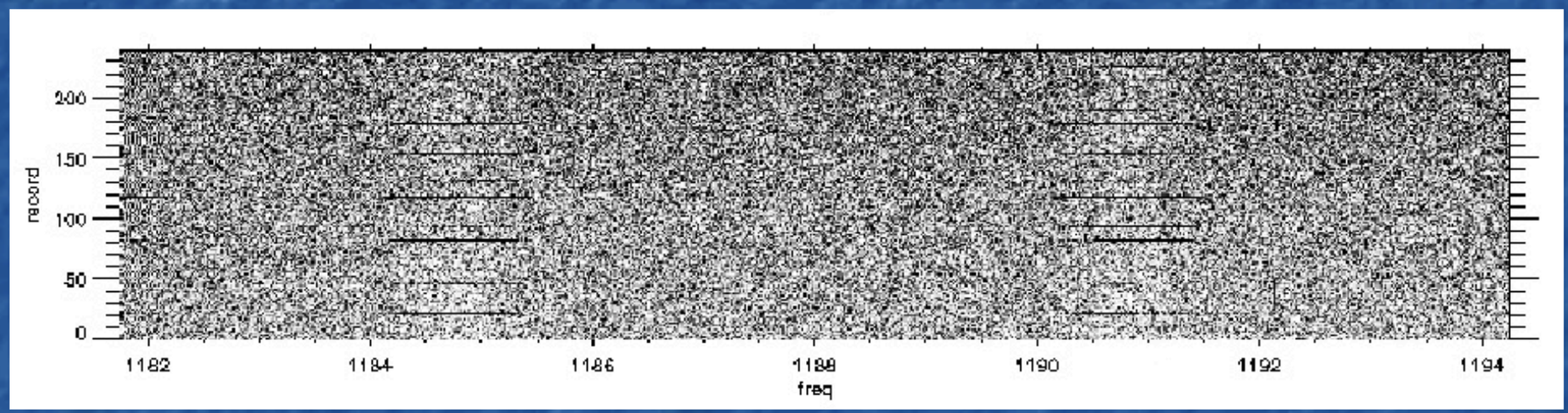
- Observations in standard position-switching mode

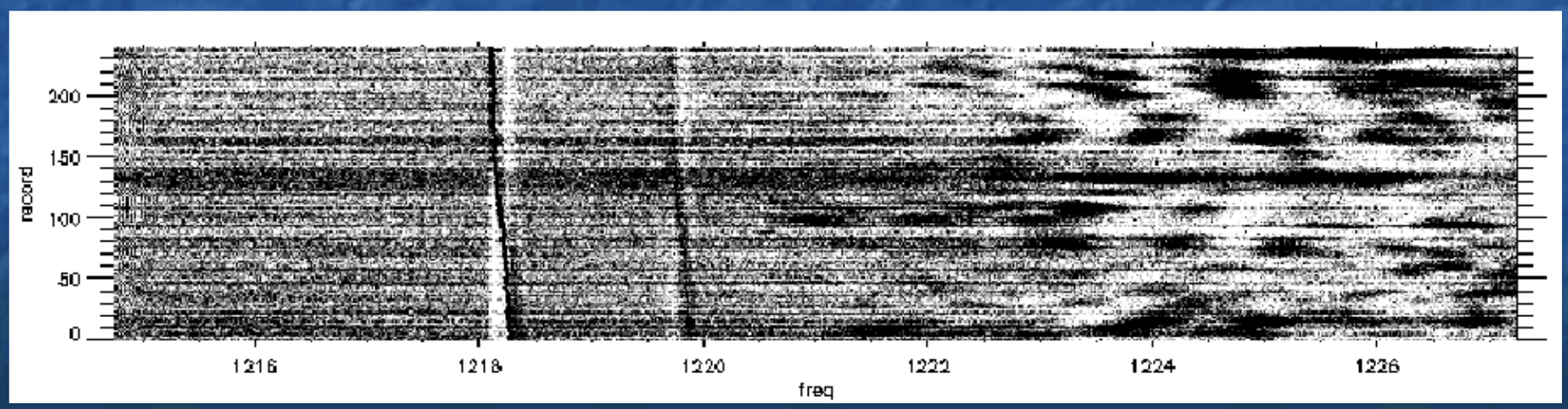
- Radio frequency interference (RFI)

Radio Frequency Interference (RFI)



Time →



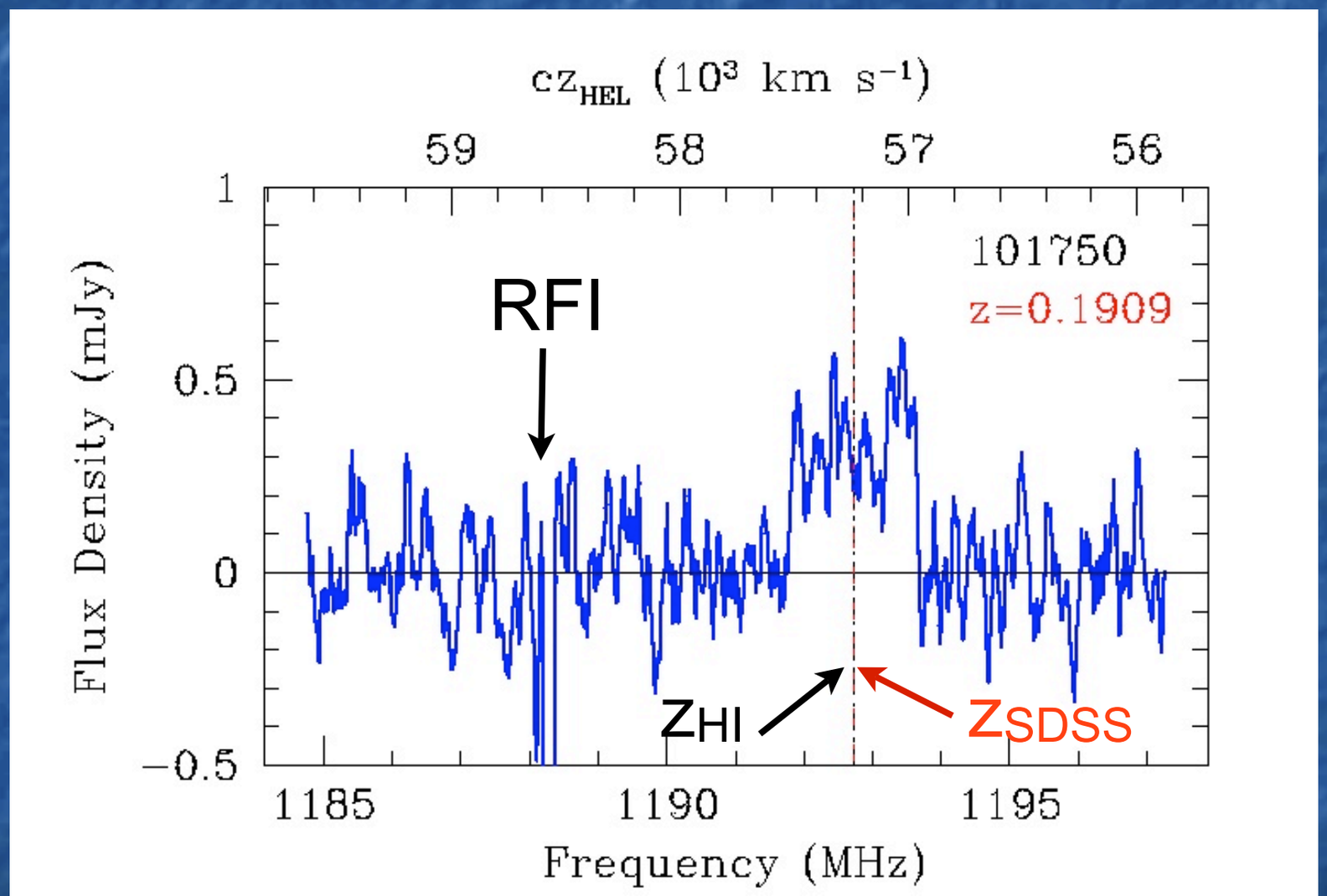


Frequency →

Results

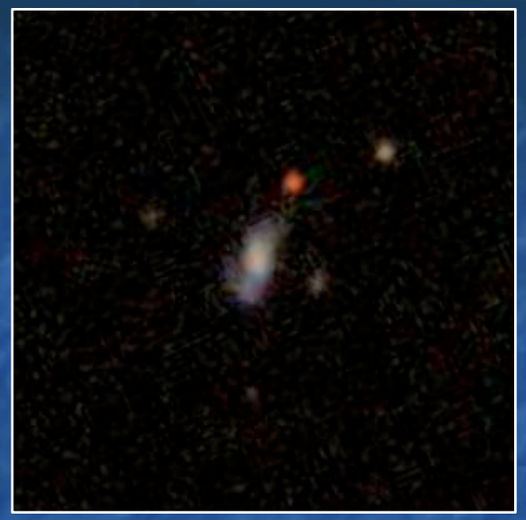
1 arcmin
~ 200 kpc @ z=0.2

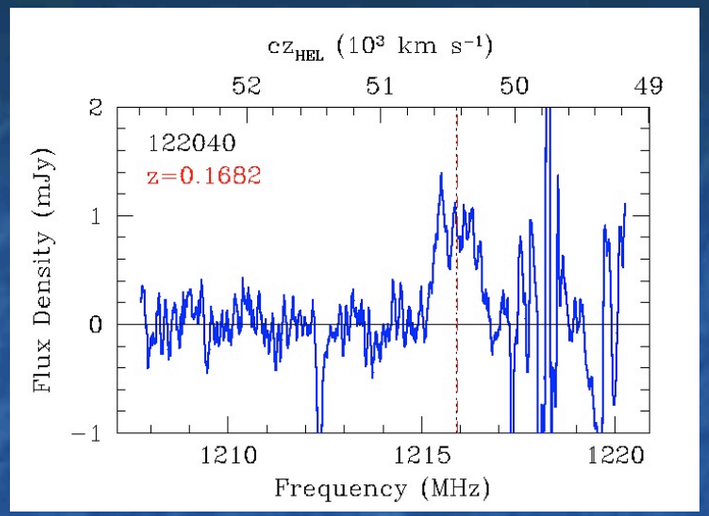
z=0.1909

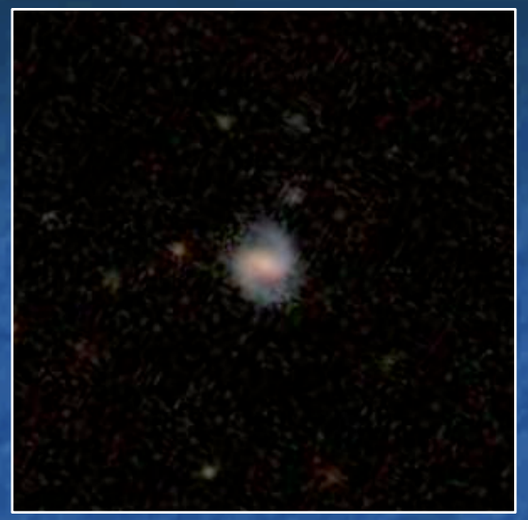


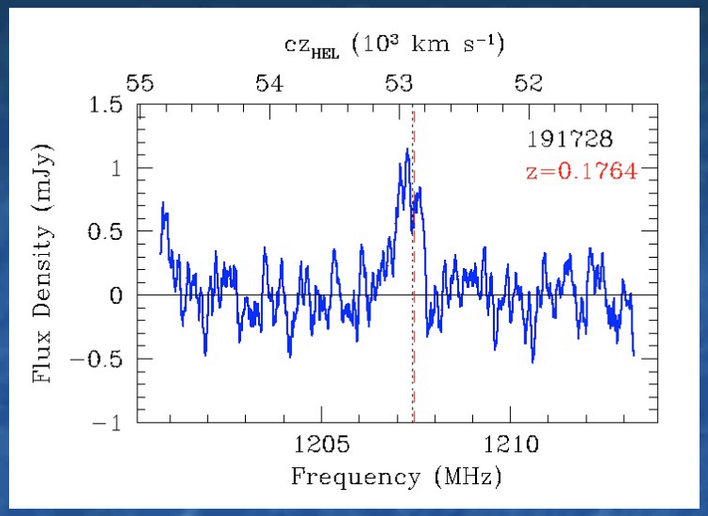
Catinella, Haynes, Giovanelli, Gardner, & Connolly 2008, ApJL

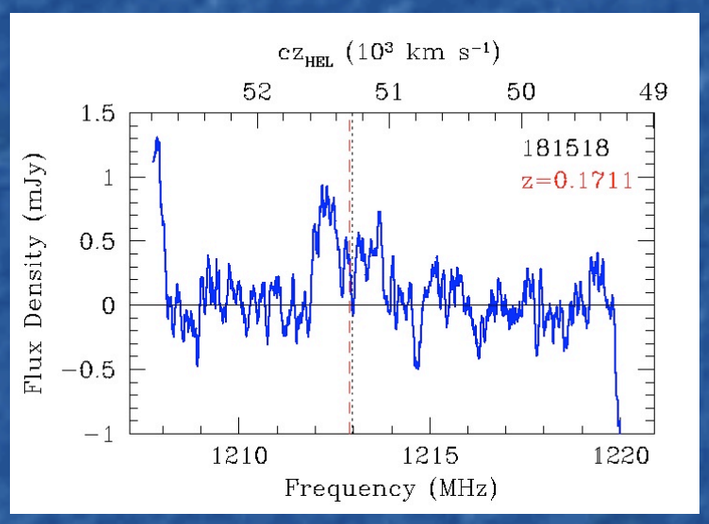
z=0.168 ➟ 0.188

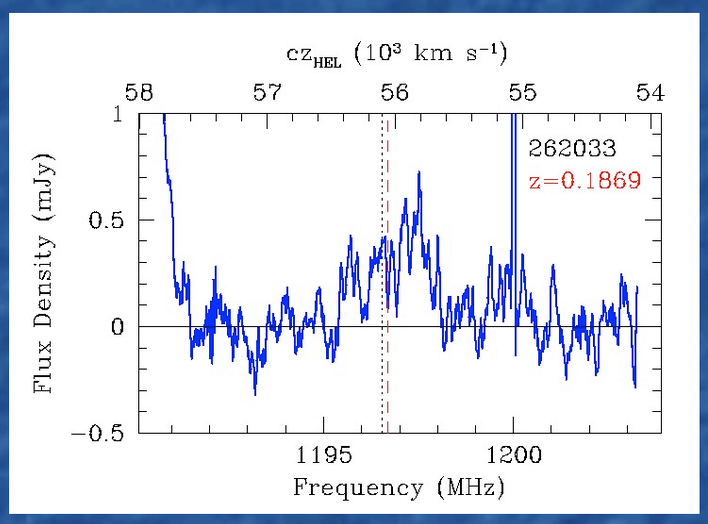


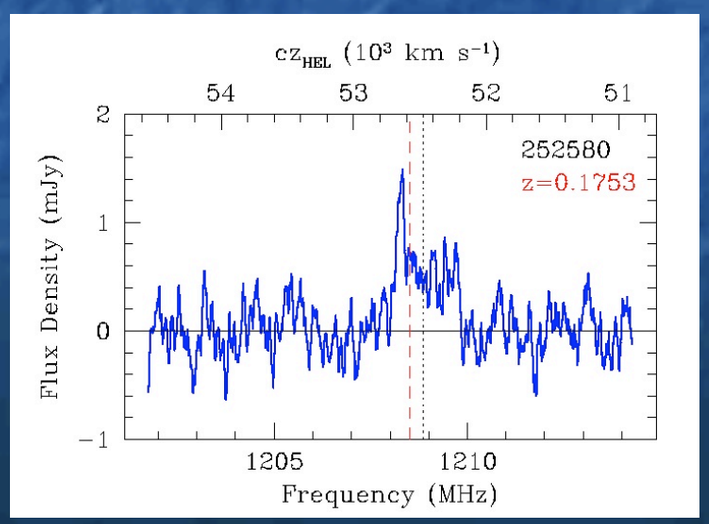

cz$_{HEL}$ (10^3 km s^{-1})
52
51
50
49
122040
z=0.1682
Flux Density (mJy)
2
1
0
−1
1210
1215
1220
Frequency (MHz)

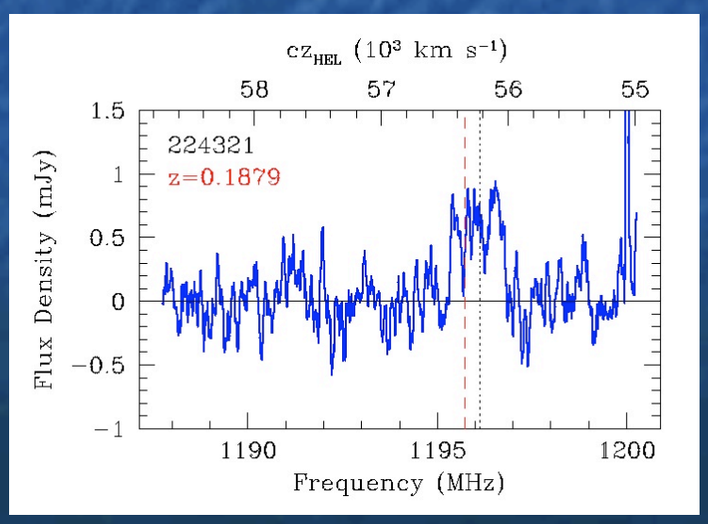



cz$_{HEL}$ (10^3 km s^{-1})
55
54
53
52
191728
z=0.1764
Flux Density (mJy)
1.5
1
0.5
0
−0.5
−1
1205
1210
Frequency (MHz)

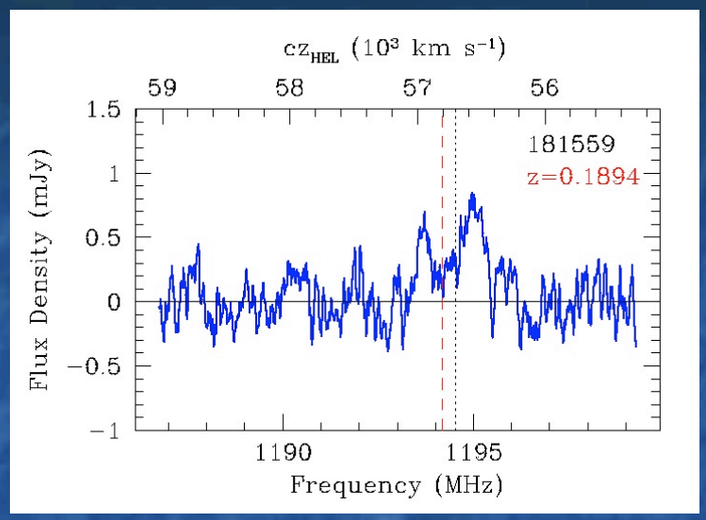

cz$_{HEL}$ (10^3 km s^{-1})
52
51
50
49
181518
z=0.1711
Flux Density (mJy)
1.5
1
0.5
0
−0.5
−1
1210
1215
1220
Frequency (MHz)

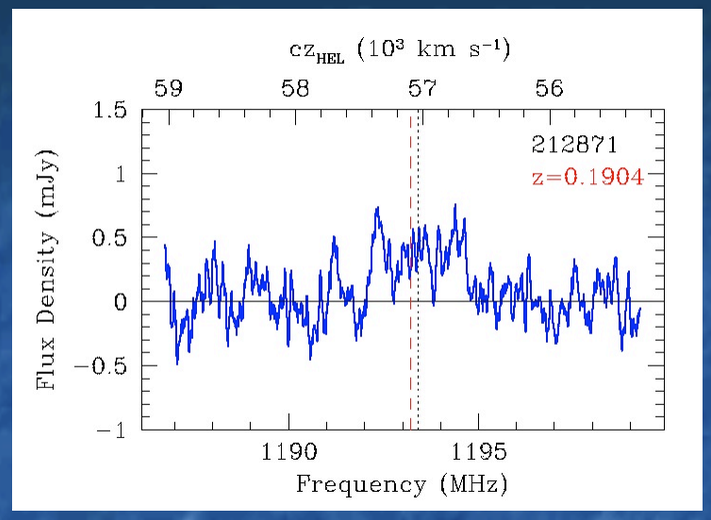

cz$_{HEL}$ (10^3 km s^{-1})
58
57
56
55
54
262033
z=0.1869
Flux Density (mJy)
1
0.5
0
−0.5
1195
1200
Frequency (MHz)

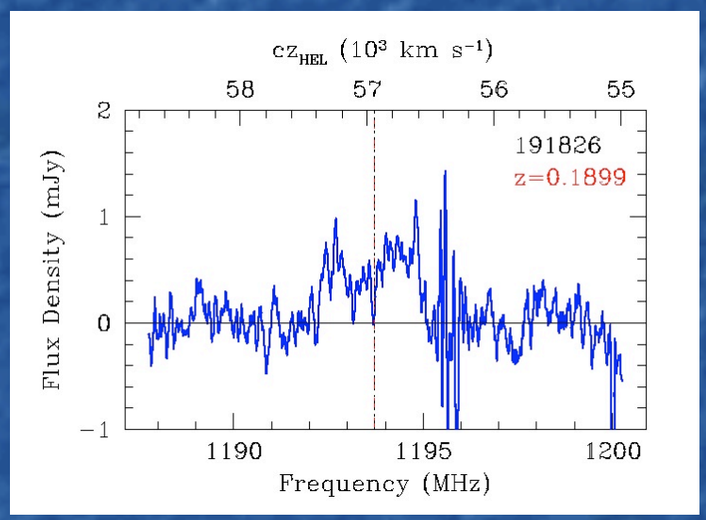

cz$_{HEL}$ (10^3 km s^{-1})
54
53
52
51
252580
z=0.1753
Flux Density (mJy)
2
1
0
−1
1205
1210
Frequency (MHz)

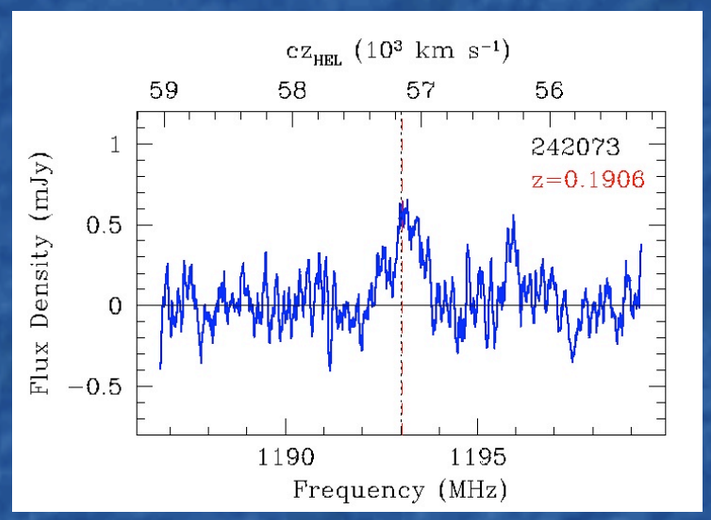

cz$_{HEL}$ (10^3 km s^{-1})
58
57
56
55
224321
z=0.1879
Flux Density (mJy)
1.5
1
0.5
0
−0.5
−1
1190
1195
1200
Frequency (MHz)

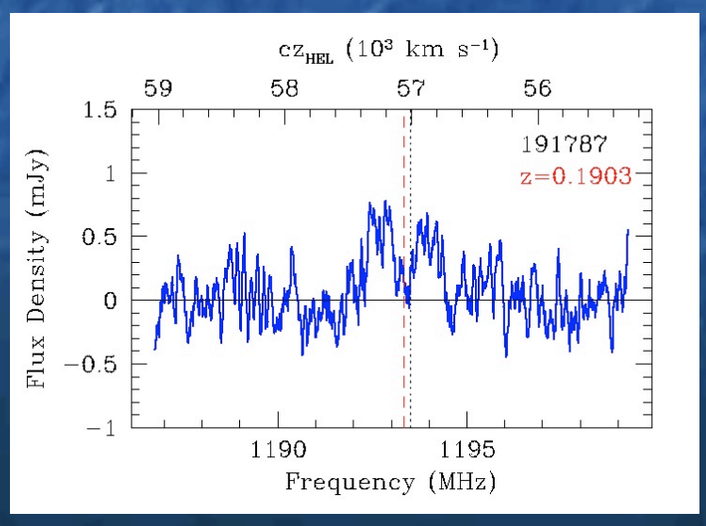
z=0.189 ➟ 0.191

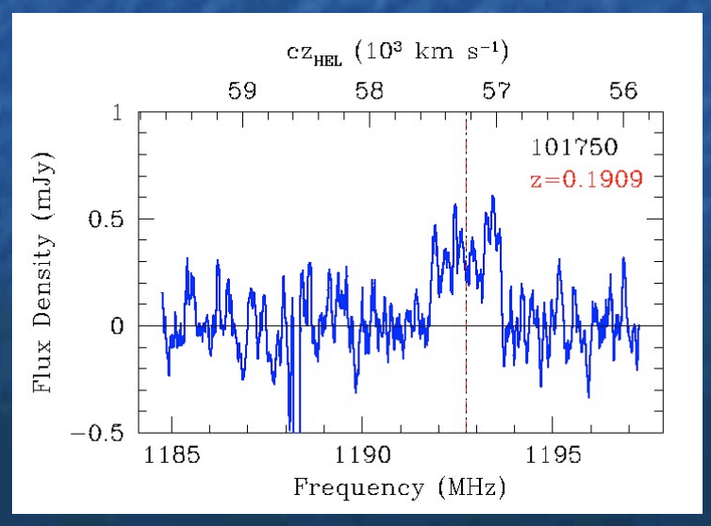

cz$_{HEL}$ (10^3 km s^{-1})
59
58
57
56
181559
z=0.1894
Flux Density (mJy)
1.5
1
0.5
0
−0.5
−1
1190
1195
Frequency (MHz)


cz$_{HEL}$ (10^3 km s^{-1})
59
58
57
56
212871
z=0.1904
Flux Density (mJy)
1.5
1
0.5
0
−0.5
−1
1190
1195
Frequency (MHz)

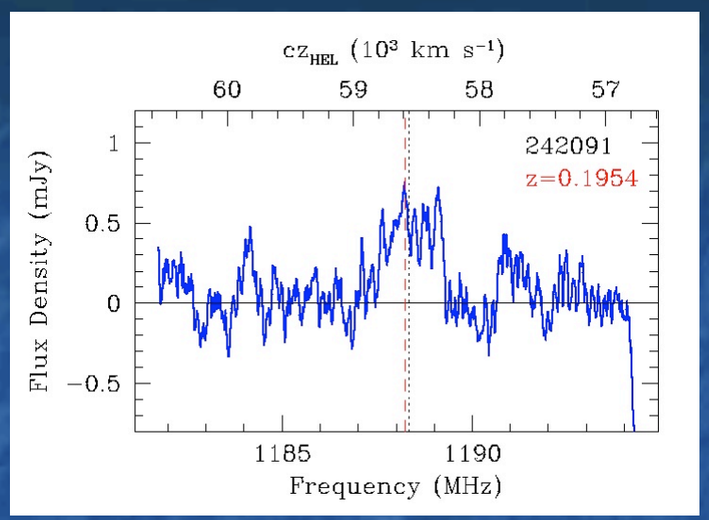

cz$_{HEL}$ (10^3 km s^{-1})
58
57
56
55
191826
z=0.1899
(mJy)
2
1
0
−1
1190
1195
1200
Frequency (MHz)

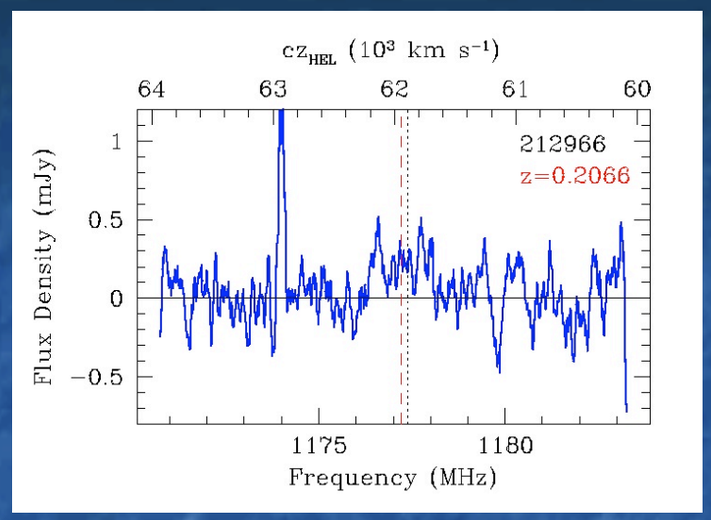

cz$_{HEL}$ (10^3 km s^{-1})
59
58
57
56
242073
z=0.1906
(mJy)
1
0.5
0
−0.5
1190
1195
Frequency (MHz)

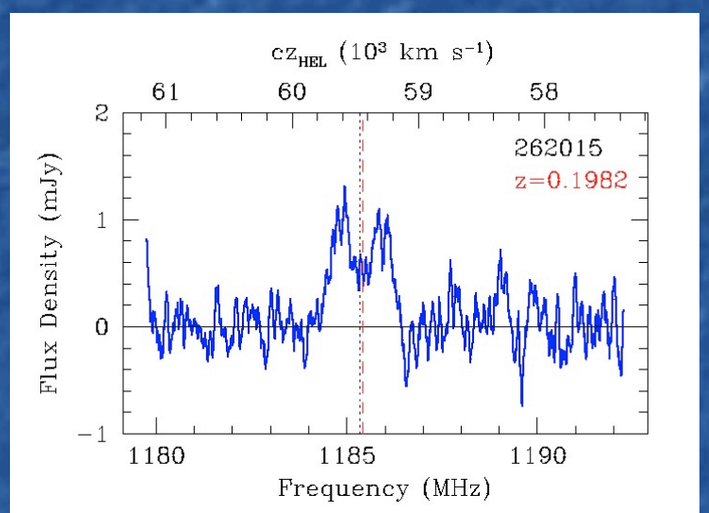

cz$_{HEL}$ (10^3 km s^{-1})
59
58
57
56
191787
z=0.1903
Flux Density (mJy)
1.5
1
0.5
0
−0.5
−1
1190
1195
Frequency (MHz)

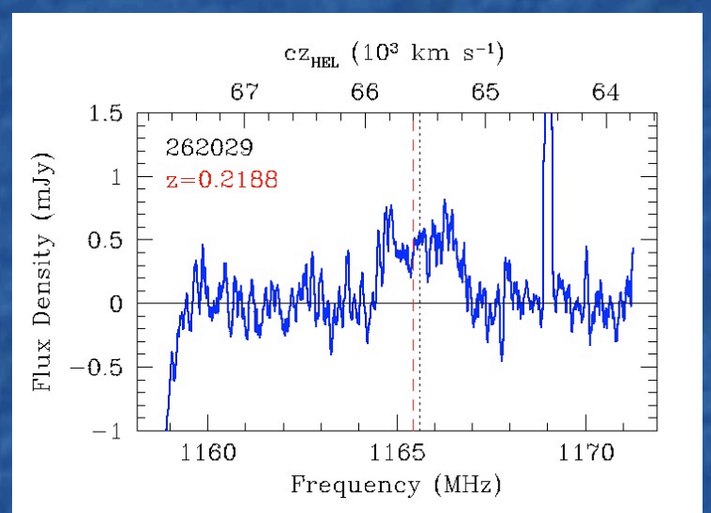

cz$_{HEL}$ (10^3 km s^{-1})
59
58
57
56
101750
z=0.1909
Flux Density (mJy)
1
0.5
0
−0.5
1185
1190
1195
Frequency (MHz)

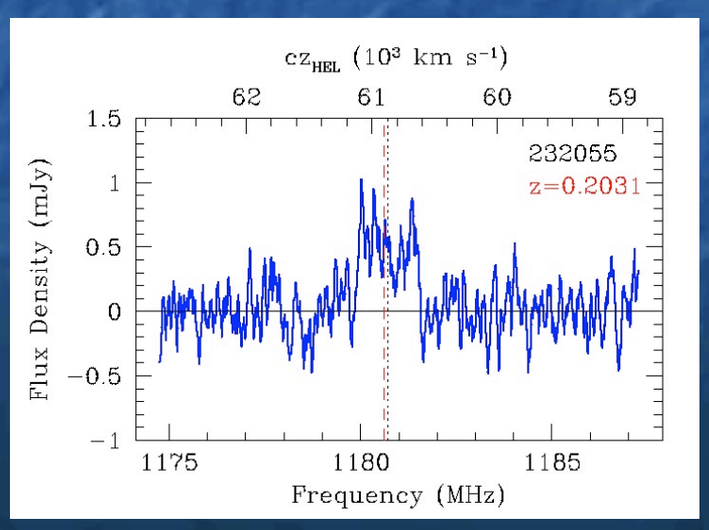
z=0.195 ➟ 0.220

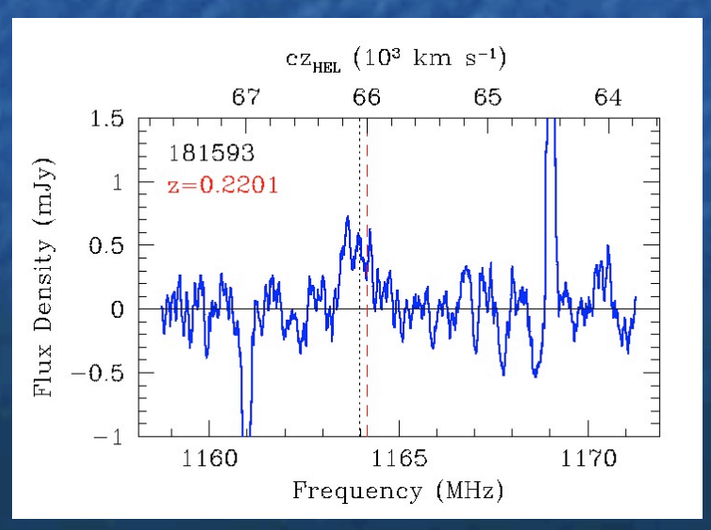

cz$_{HEL}$ (10^3 km s^{-1})
60
59
58
57
242091
z=0.1954
Flux Density (mJy)
1
0.5
0
−0.5
1185
1190
Frequency (MHz)


cz$_{HEL}$ (10^3 km s^{-1})
64
63
62
61
60
212966
z=0.2066
Flux Density (mJy)
1
0.5
0
−0.5
1175
1180
Frequency (MHz)

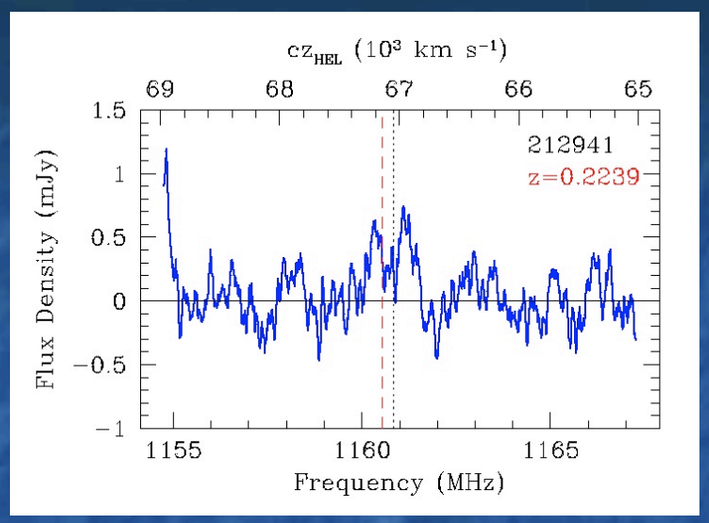

cz$_{HEL}$ (10^3 km s^{-1})
61
60
59
58
262015
z=0.1982
Flux Density (mJy)
2
1
0
−1
1180
1185
1190
Frequency (MHz)

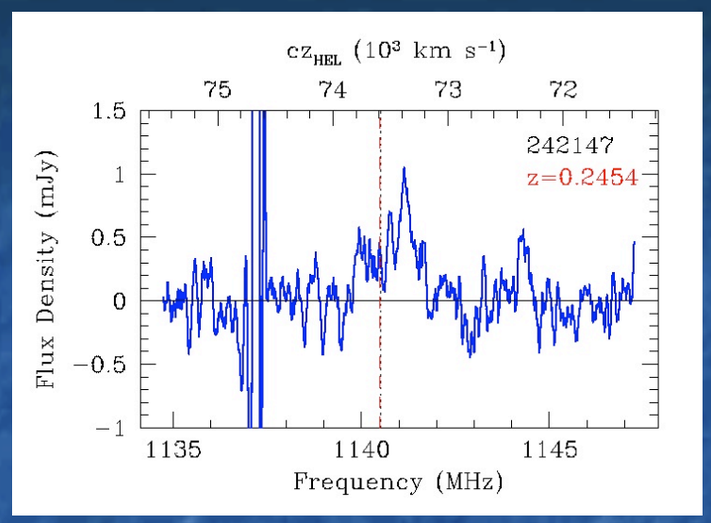

cz$_{HEL}$ (10^3 km s^{-1})
67
66
65
64
262029
z=0.2188
Flux Density (mJy)
1.5
1
0.5
0
−0.5
−1
1160
1165
1170
Frequency (MHz)


cz$_{HEL}$ (10^3 km s^{-1})
62
61
60
59
232055
z=0.2031
Flux Density (mJy)
1.5
1
0.5
0
−0.5
−1
1175
1180
1185
Frequency (MHz)


cz$_{HEL}$ (10^3 km s^{-1})
67
66
65
64
181593
z=0.2201
Flux Density (mJy)
1.5
1
0.5
0
−0.5
−1
1160
1165
1170
Frequency (MHz)

z=0.224 ➟ 0.245





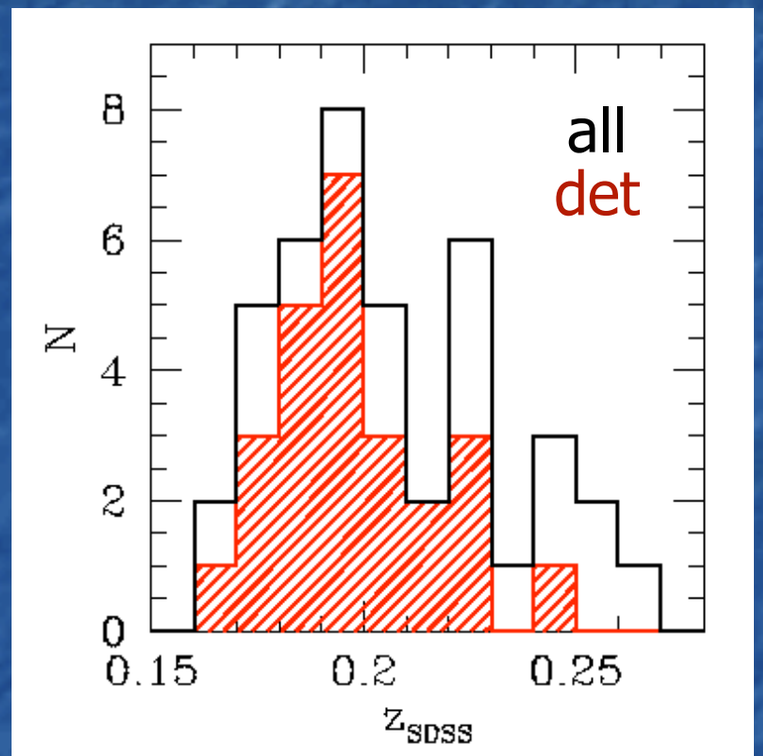
- 41 galaxies targeted
- 0.16 < z < 0.26
- 25 detections, 9 marginal, 7 non-detections
- HI mass $2 - 8 \times 10^{10}\ M_{\odot}$
- on-source integration time between 1 and 4 hrs per object

- ~200 hours telescope time

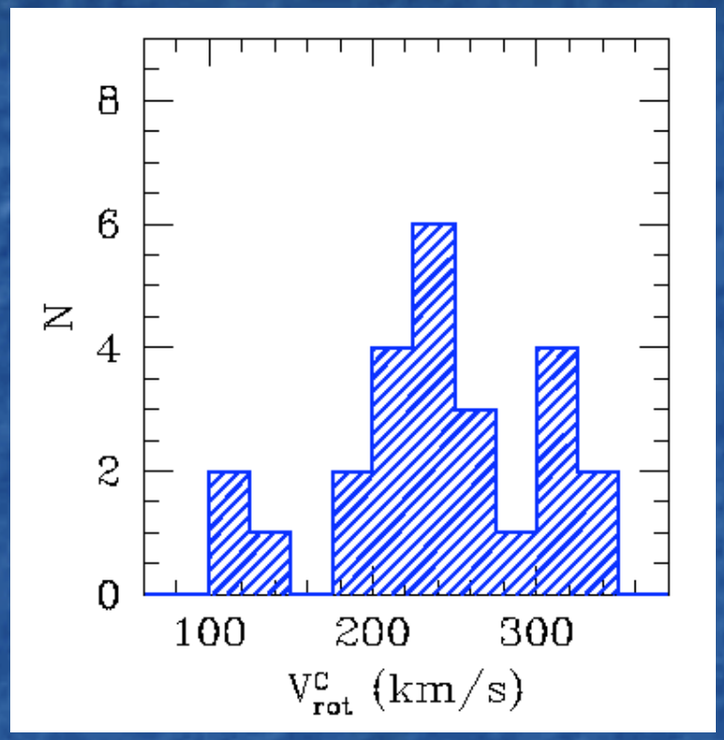
- Approved Arecibo proposal to increase the z~0.2 sample and push the redshift limit beyond 0.3

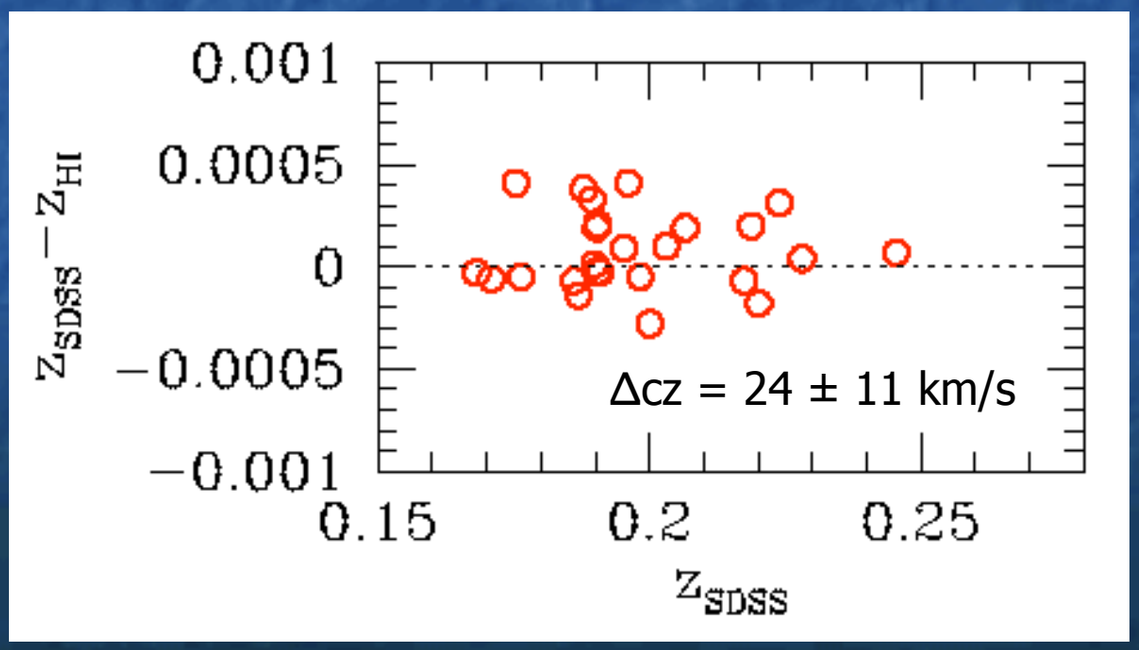
Properties of z~0.2 Arecibo detections

redshift

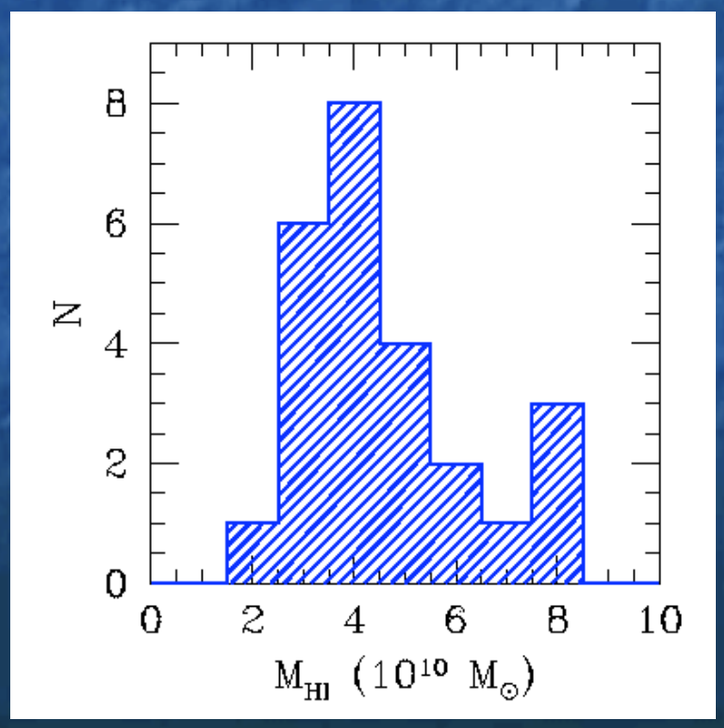


rotational velocity



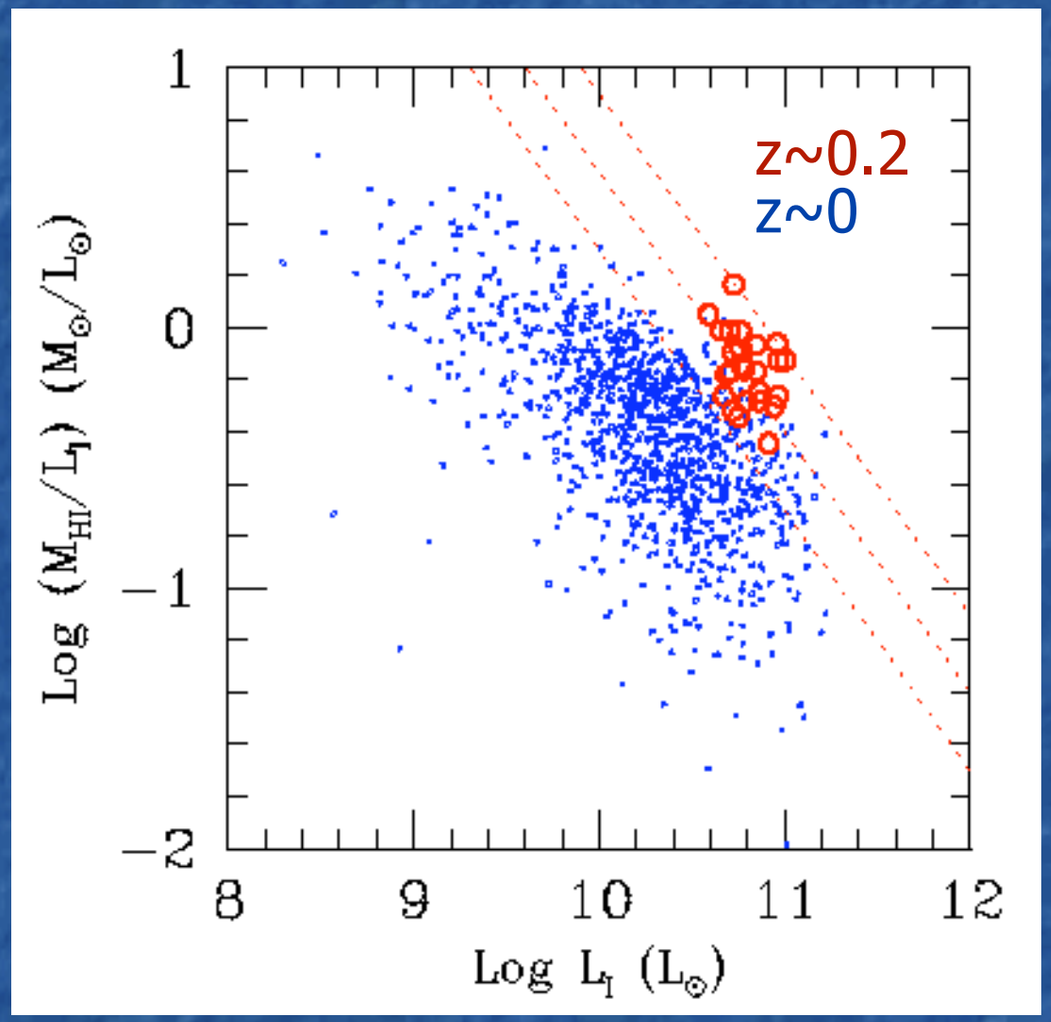


HI mass

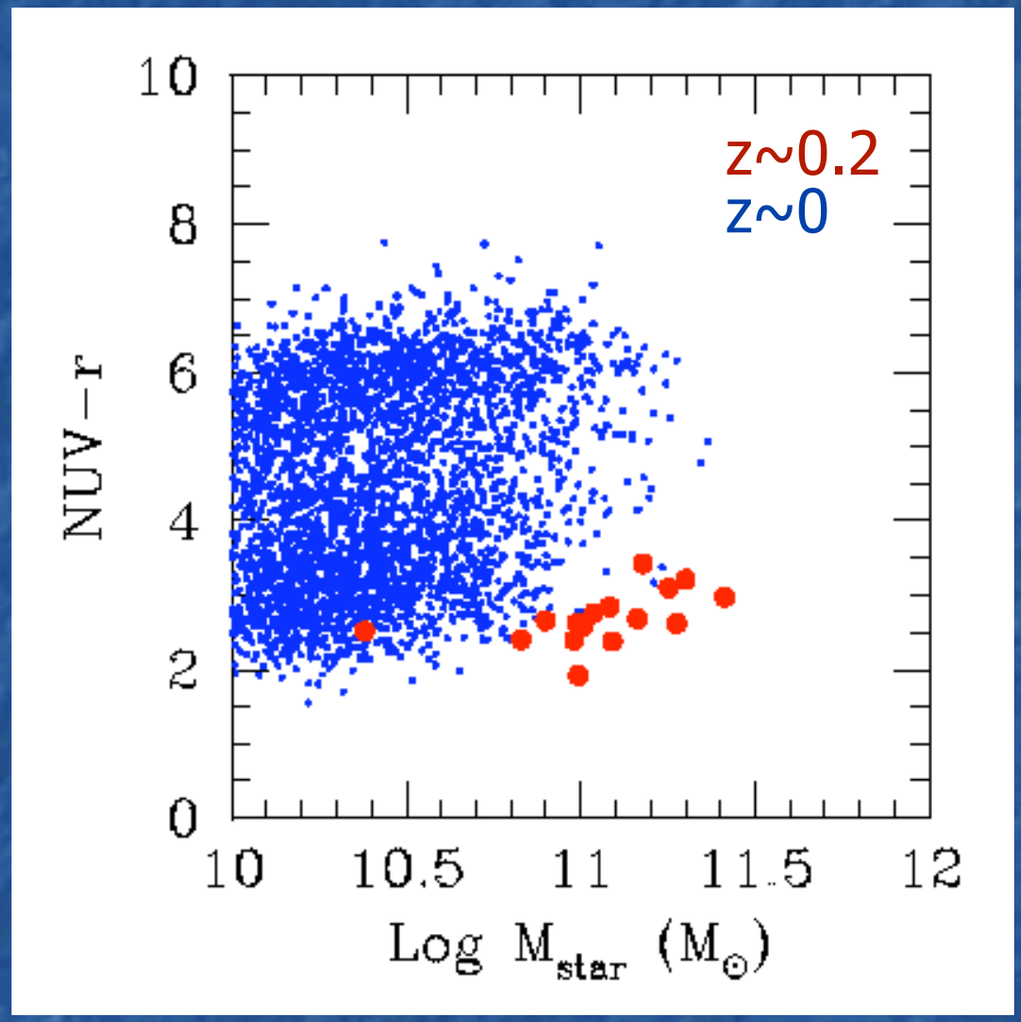


z~0.2 detections: not your typical z=0 disks

HI mass-to-light ratio vs I-band L



NUV-r vs stellar mass



- Rare objects in the nearby universe (selection effects!)
- Evolution? Need fair sample of massive (M_{HI}, $M_\star$), z~0 galaxies for comparison, currently not available

GALEX Arecibo SDSS Survey (GASS)

D. Schiminovich (PI), B. Catinella, G. Kauffmann et al.

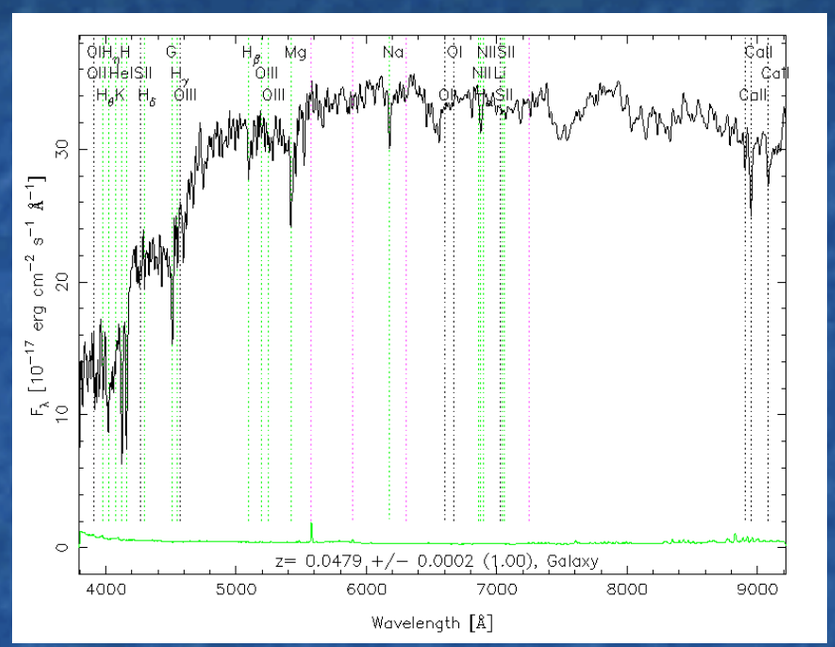
- Targeted HI survey: ~1000 galaxies selected from SDSS+GALEX +ALFALFA footprints, $0.025< z <0.05$, $10< \log M_*/M_\odot <11.5$
- Galaxies observed down to gas mass fraction limit of 1.5%
- Arecibo large program, observations started in March 2008 (see Catinella et al. 2008 AIP Conf. Proc. for details)
- First statistical sample of massive galaxies with homogeneously measured M_*, SFR and gas properties

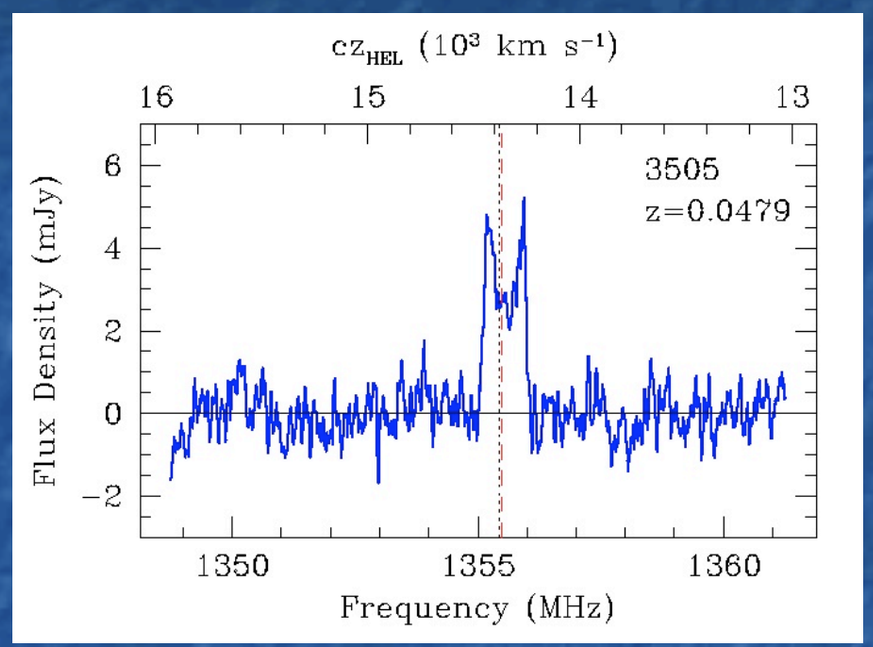
→ Ideal z~0 sample for comparison with massive, HI-rich z~0.2 detections

→ Main goal: understanding physical processes that regulate gas accretion and its conversion into stars in massive systems. Transition between blue cloud and red sequence.

http://www.mpa-garching.mpg.de/GASS

GASS 3505: a gas-rich, "red and dead" galaxy





SDSS

Arecibo HI

No emission lines

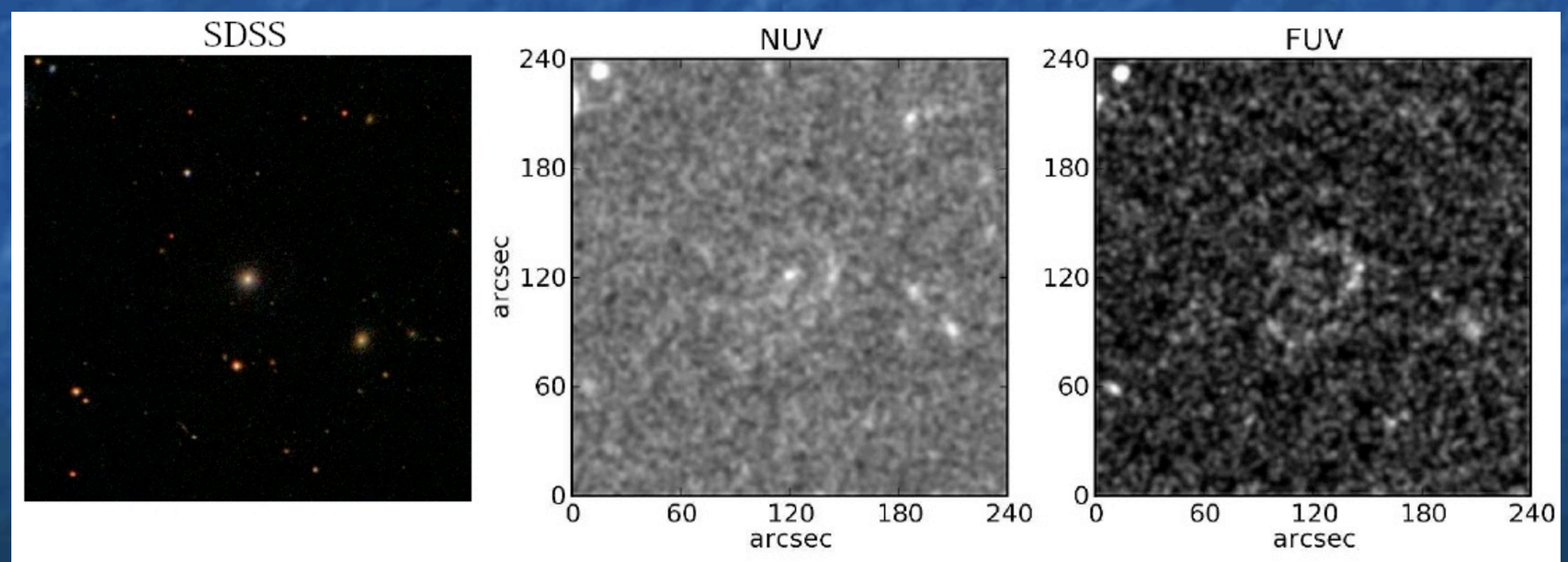
z=0.048

NUV-r=5.9

log $M_\star/M_\odot$ =10.21

log $M_{HI}/M_\odot$ =9.85

$M_{HI}/M_\star$ = 44%



SDSS + GALEX, 4´ (~220 kpc) field

Summary and outlook: the EVLA

- Arecibo can detect HI emission from isolated galaxies at z>0.2. This sample includes the highest redshift detections to date!!
- Galaxies detected are very gas-rich and massive → rare at z=0

Future

- Move beyond pilot programs: well-defined samples at z~0.2 and higher
- Need good comparison samples at z=0, too (e.g., GASS survey)

- Many challenges: RFI, instrumentation...
- HI DEEP SURVEYS WITH THE EVLA
- Arecibo and WSRT/EVLA complementary: low-density vs. medium/high-density regions