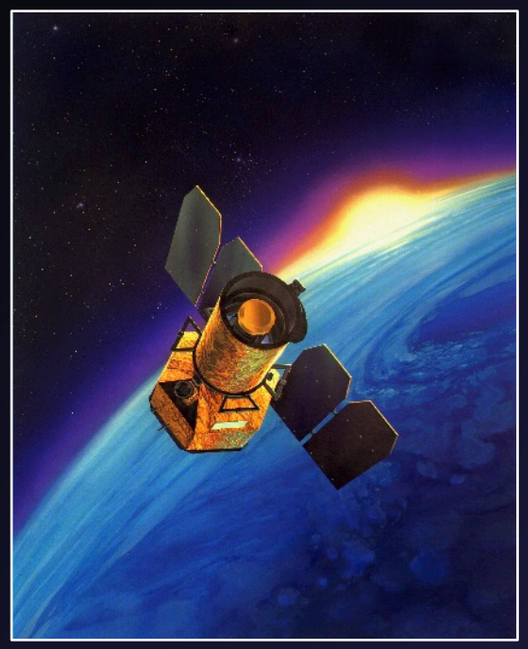
Cold Gas in Massive Galaxies: the GALEX Arecibo SDSS Survey



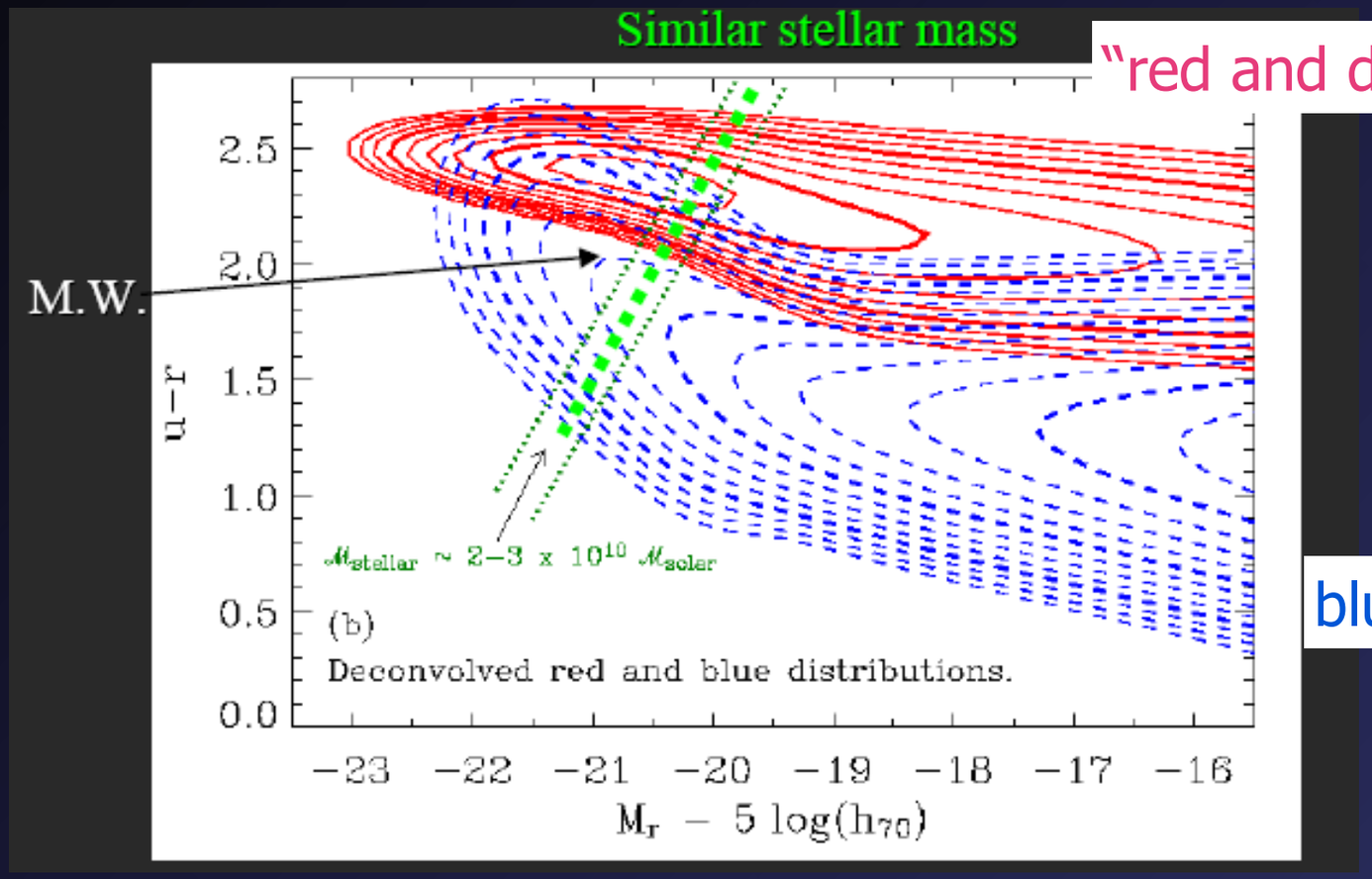
Barbara Catinella

Max Planck Institute for Astrophysics

on behalf of the GASS Team: D. Schiminovich (Columbia, P.I.), G. Kauffmann, S. Fabello, J. Wang (MPA), R. Giovanelli, M. P. Haynes (Cornell), T. Heckman, S. Moran (JHU) ...

Galaxy Formation conference, Durham, Jul 19 2011

Transition between blue and red sequence



Baldry et al. 2004

"red and dead" galaxies

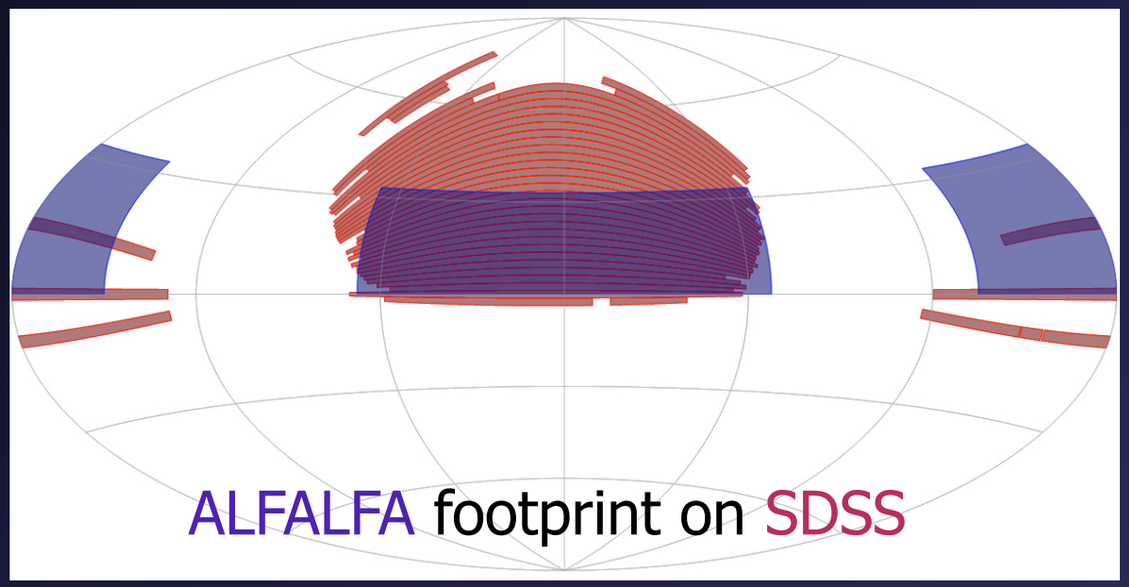
blue, SF galaxies

- Transition mass at ~3 10^{10} $M_\odot$ (e.g. Strateva et al 01, Kauffmann et al 03, Baldry et al 04)
- Transition implies quenching of SF. The mechanism(s) involved must affect the HI gas
  → need to measure HI for large, representative sample of massive galaxies

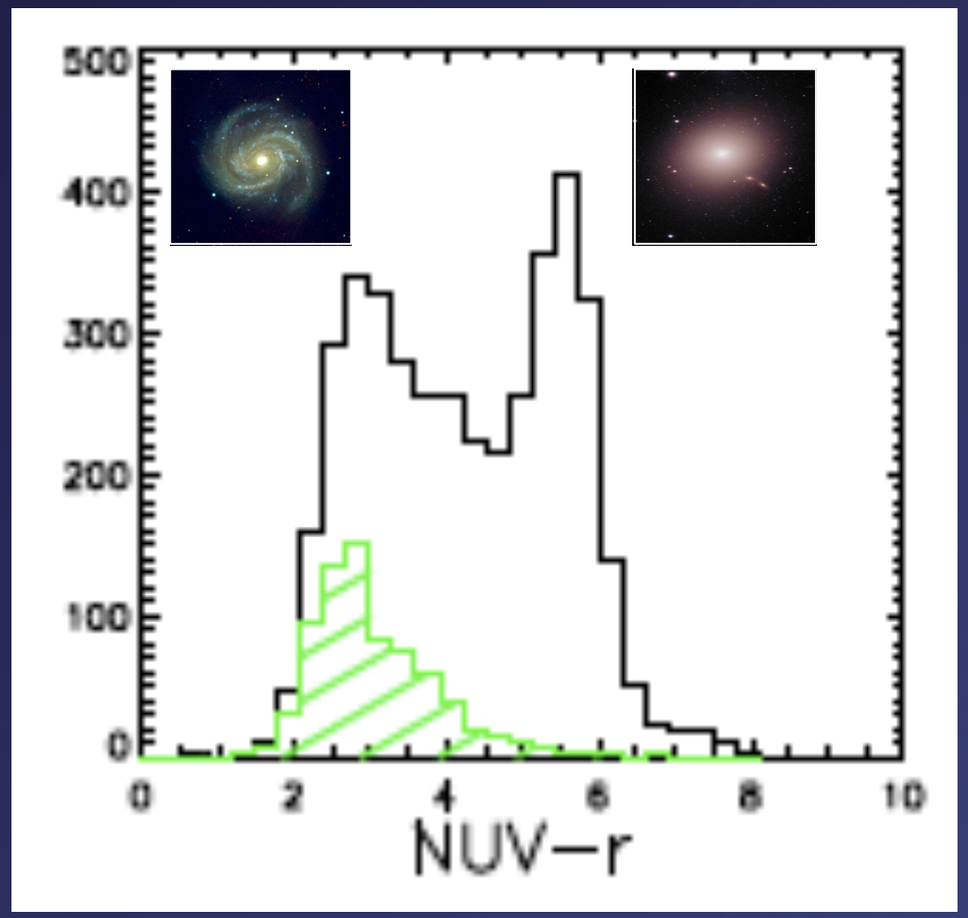
ALFALFA: Arecibo Legacy Fast ALFA Survey

- Ongoing blind extragalactic HI survey, 7000 deg^2, z<0.06 (PI: R. Giovanelli)
- Started in Feb 2005, will detect >25,000 sources
- Better sensitivity (8×), ang. res. (4×), spectral res. (3×) than HIPASS
  - M_{HI} ~10^6 $M_\odot$ out to 6.5 Mpc, M_{HI} ~10^7 $M_\odot$ out to 20 Mpc

→ **biased towards HI-rich objects (blue sequence)**



~90% observations completed



Green: ALFALFA detections

GASS: The GALEX Arecibo SDSS Survey

P.I.: D. Schiminovich (Columbia)

- Targeted HI survey: ~**1000 galaxies** in SDSS+GALEX MIS+ALFALFA footprints, **selected only by redshift and stellar mass**:

  $0.025 < z < 0.05$, $10 < \log M_\star/M_\odot < 11.5$

  Galaxies observed down to gas mass fraction limit of 1.5-5%

- First statistical sample of massive galaxies with homogeneously measured $M_\star$, SFR and gas properties

- Arecibo large program, started in March 2008.

  DR1: ~20% of survey (Catinella et al. 2010)

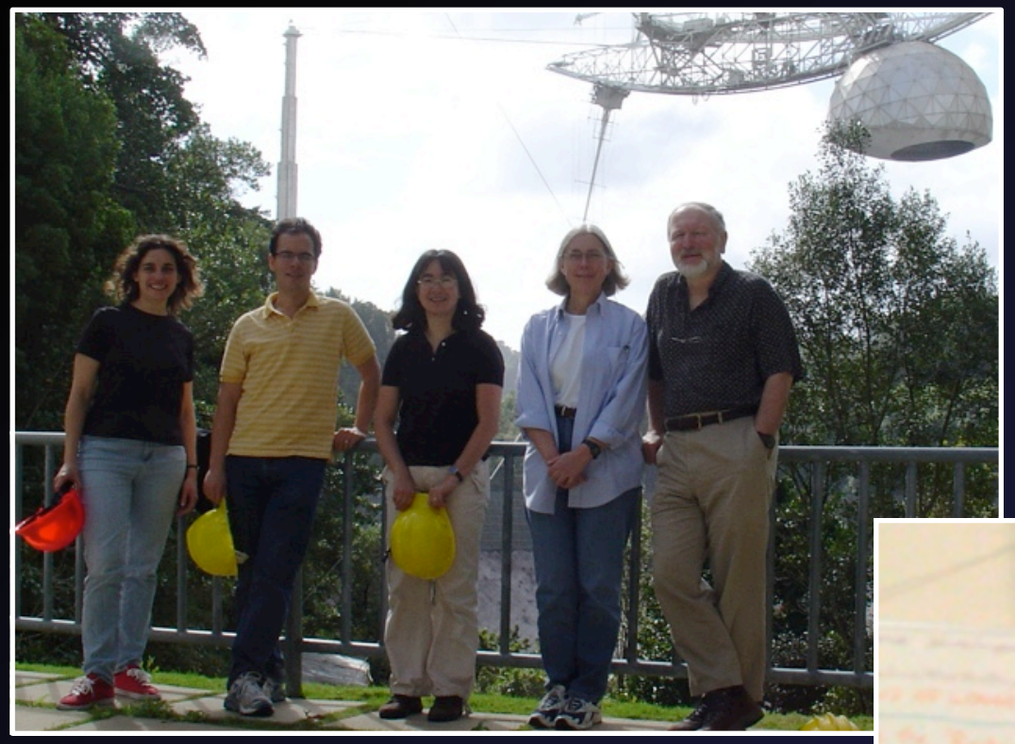
  176 galaxies (99 detections); ~240 hrs

  Apr 2011: **50% of survey completed**

  416 galaxies (56% detected); ~600 hrs

- ALFALFA detects ~20% (HI-richest objects) → NOT re-observed by GASS

GASS Team



BC, D. Schiminovich (P.I.),
G. Kauffmann, M. Haynes,
R. Giovanelli

+ Jing Wang, Andrew Cooper
et al.

Barbara Catinella

Sean Moran

Arecibo control room

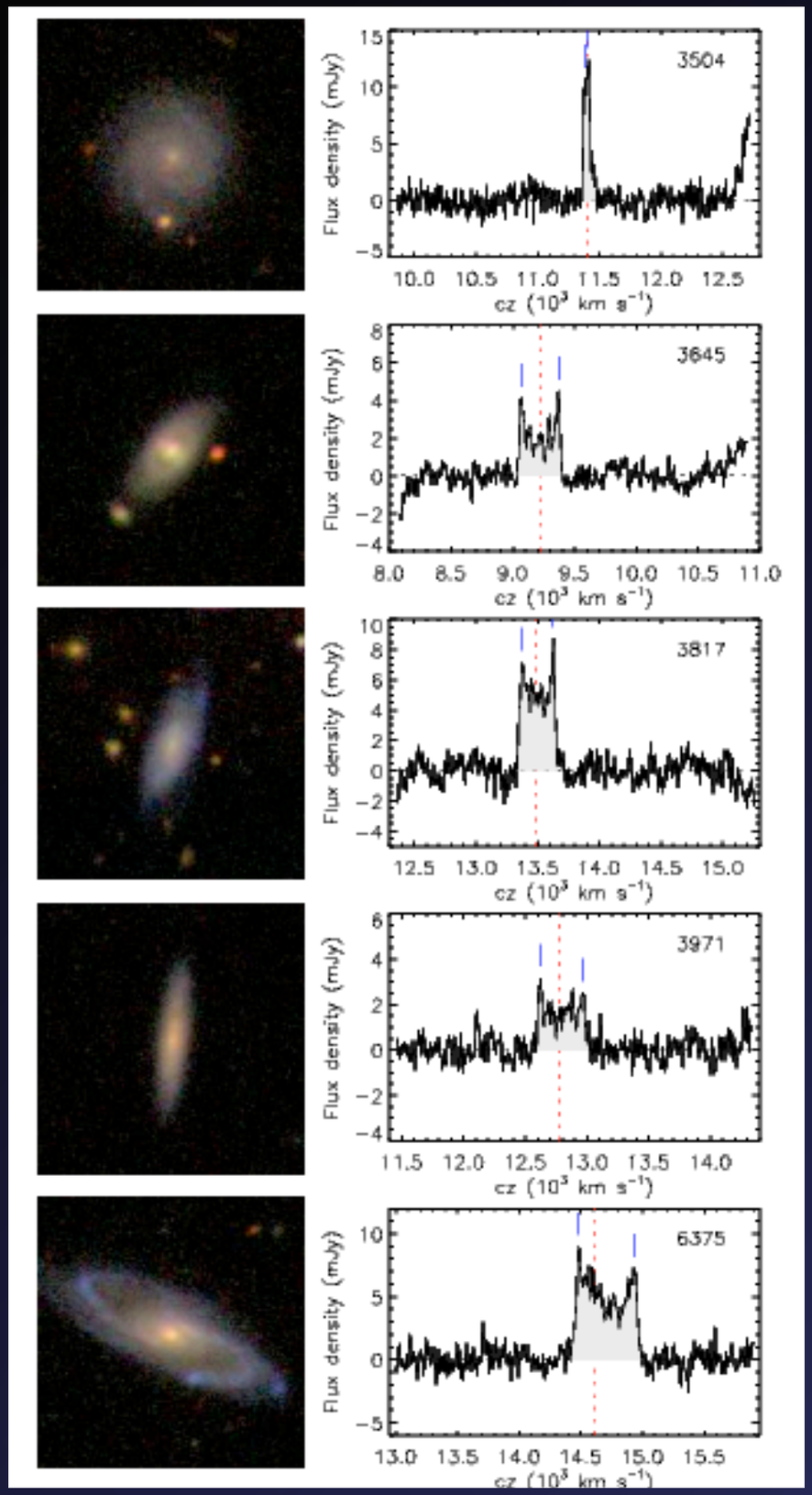
Silvia Fabello

Ronin Wu

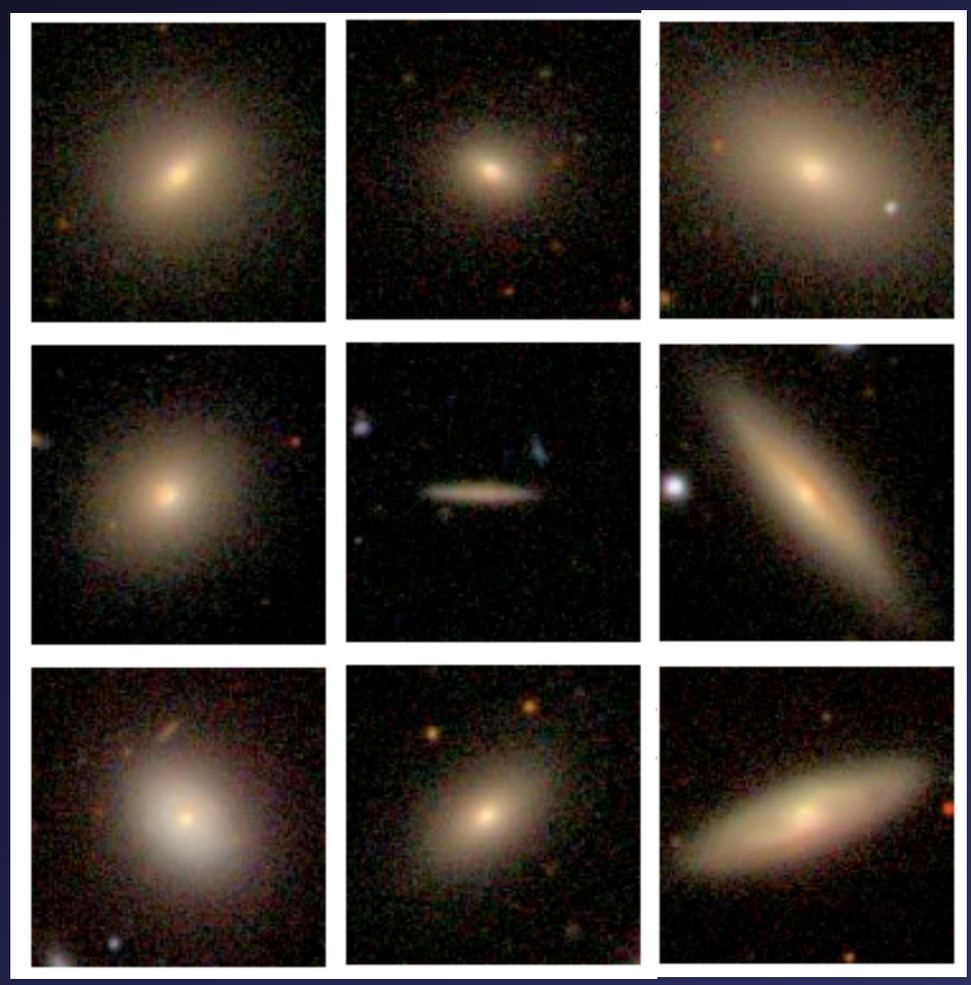
Jenna Lemonias

Cameron Hummels

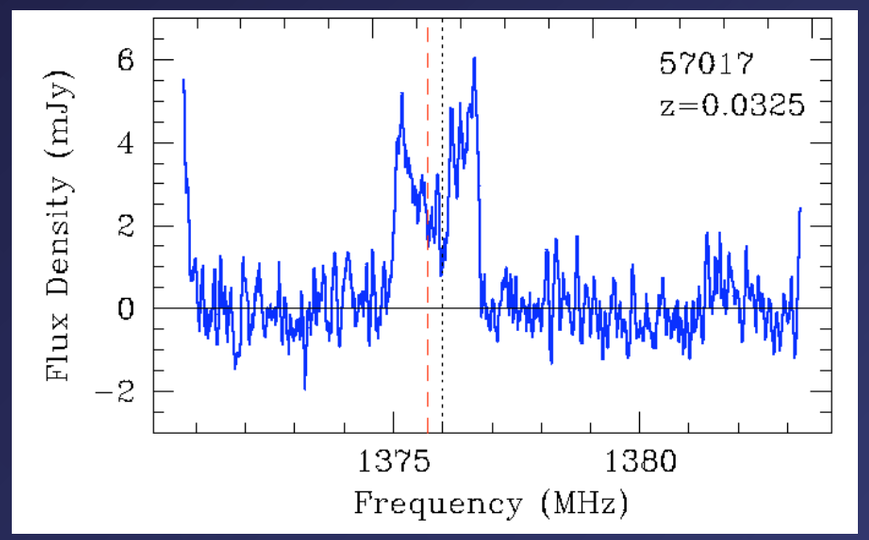
Detections



Non-detections



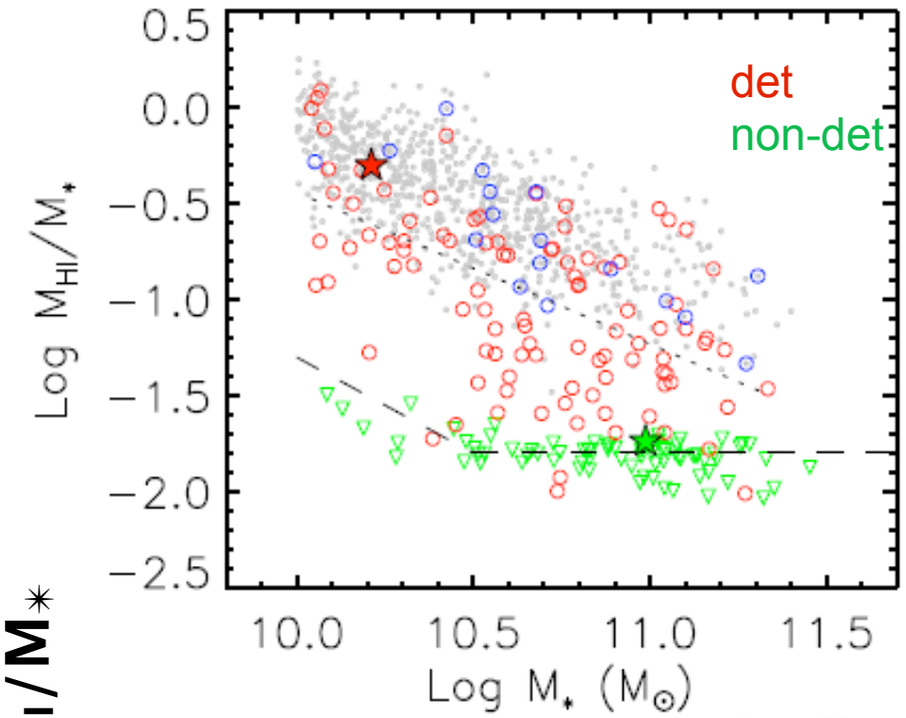
SDSS images: 1‘ (~30 kpc @ z=0.025)



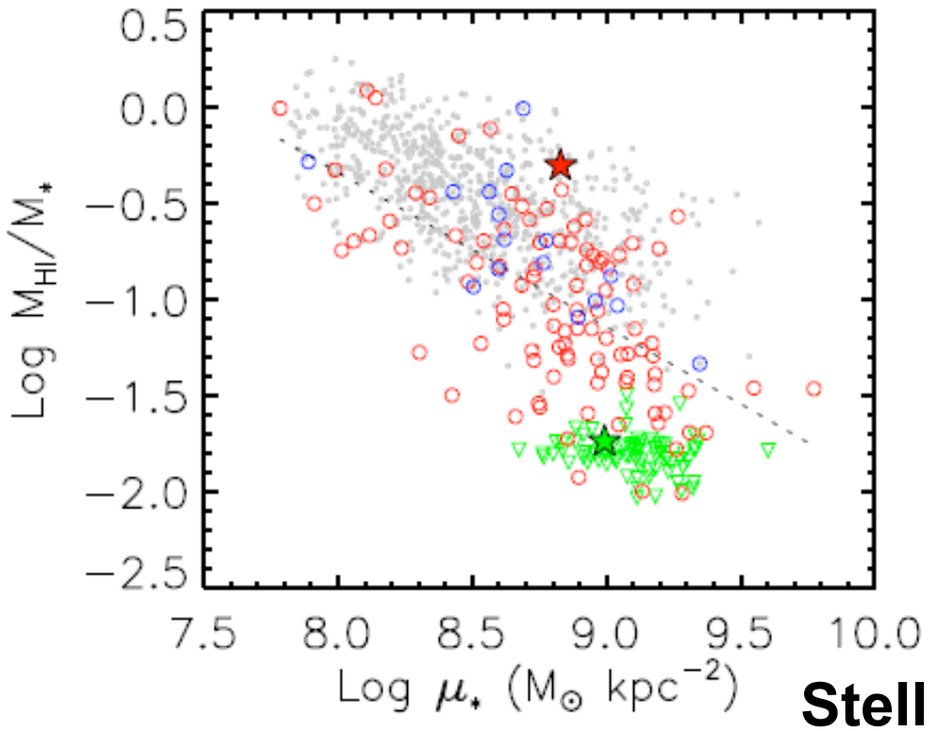
Single-dish HI profiles (beam ~4’): z, V_{rot}, HI flux

Gas Fraction Scaling Relations

GASS DR1: gas fraction scaling relations



Stellar Mass

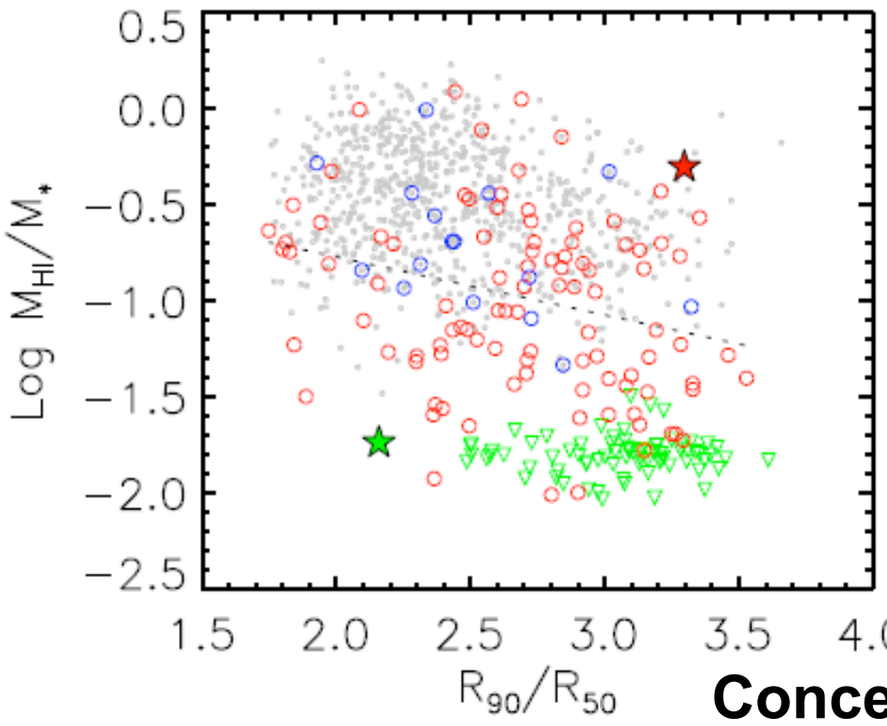


Stellar Mass Surface Density, $M_*/2\pi R_{50}^2$

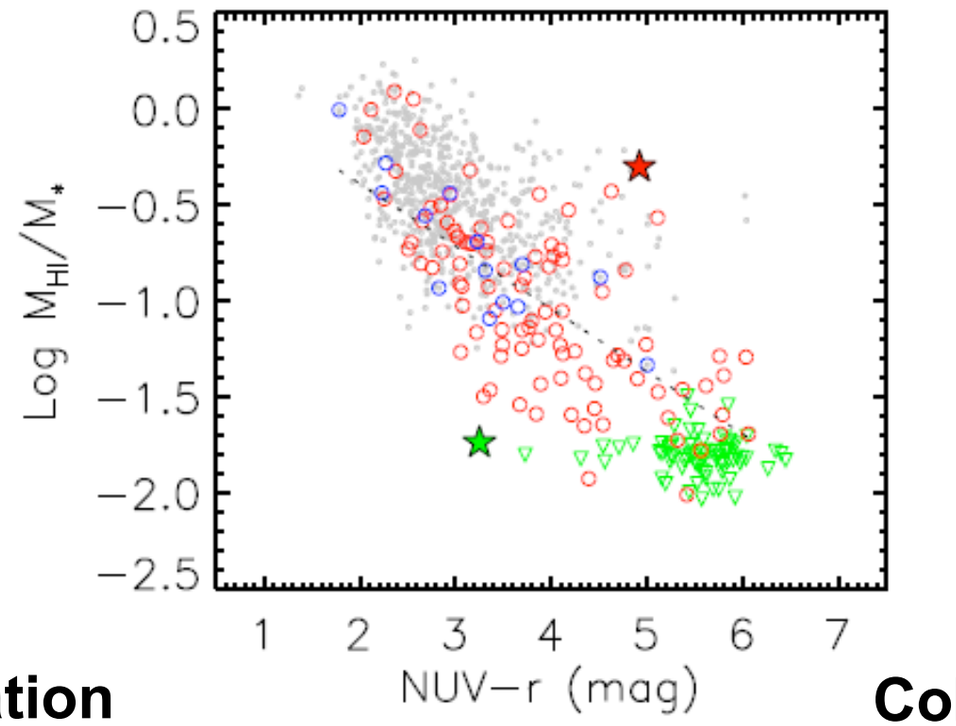
Gray: ALFALFA

Blue: HI-rich galaxies added to DR1

Dotted lines: fits to red + blue circles



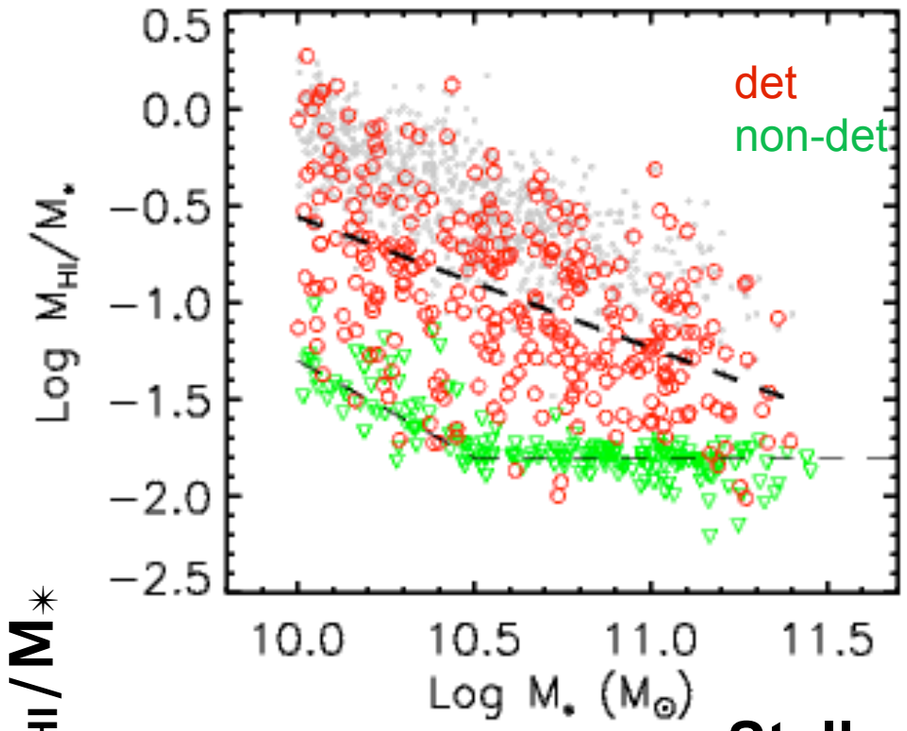
Concentration



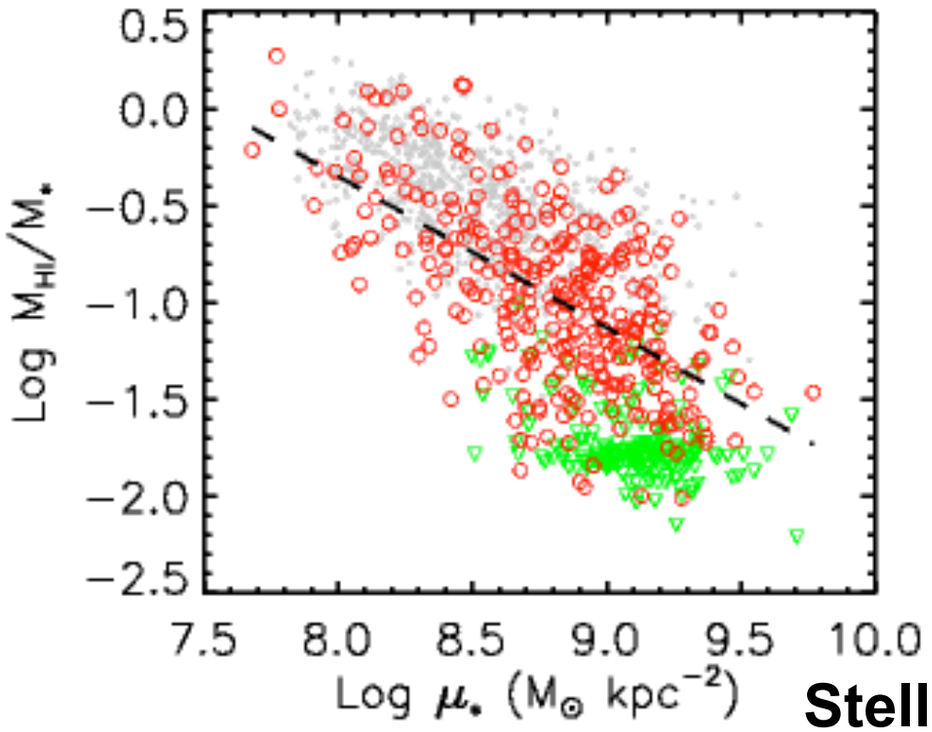
Color

Catinella, Schiminovich, Kauffmann et al. 2010

DR2 gas fraction scaling relations



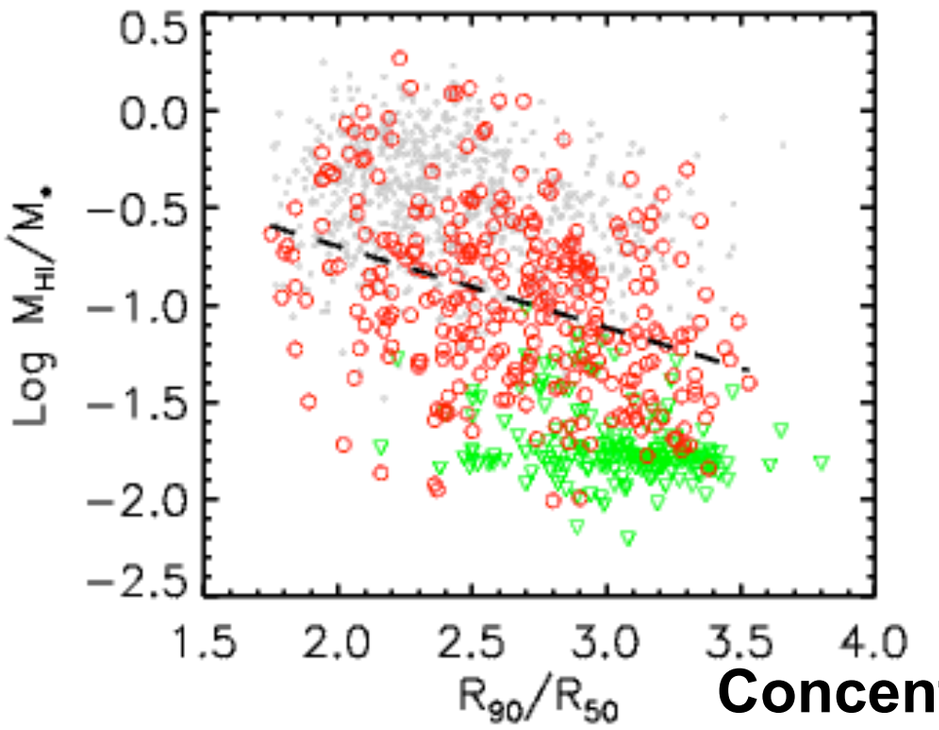
Stellar Mass



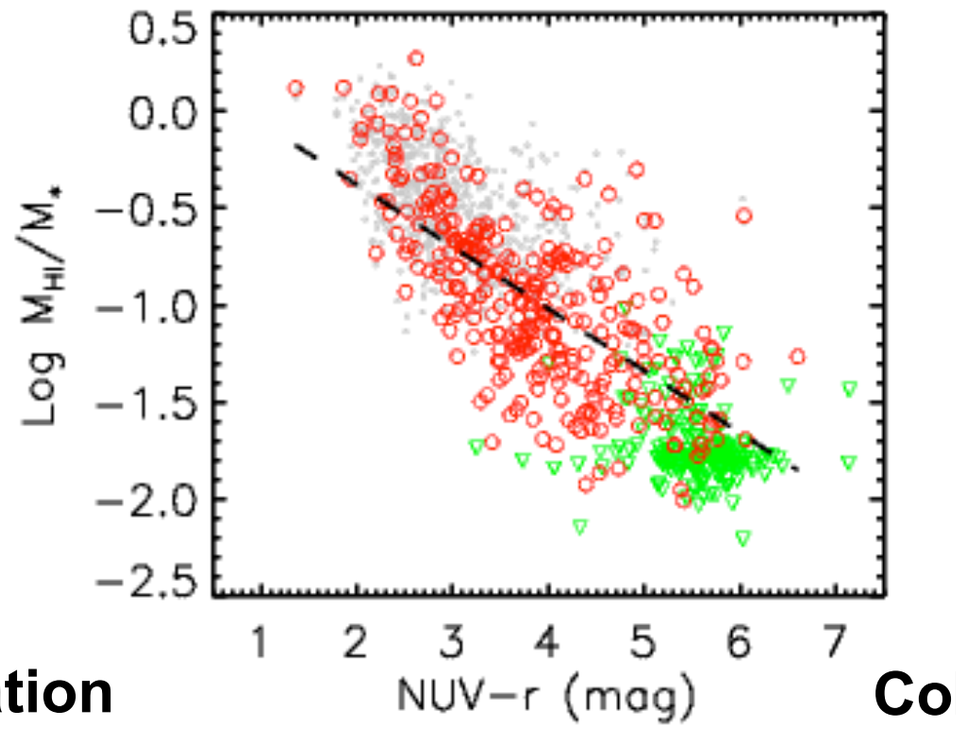
Gray: ALFALFA

Transition seen with μ_*, not M_*

Stellar Mass Surface Density, $M_*/2\pi R_{50}^2$



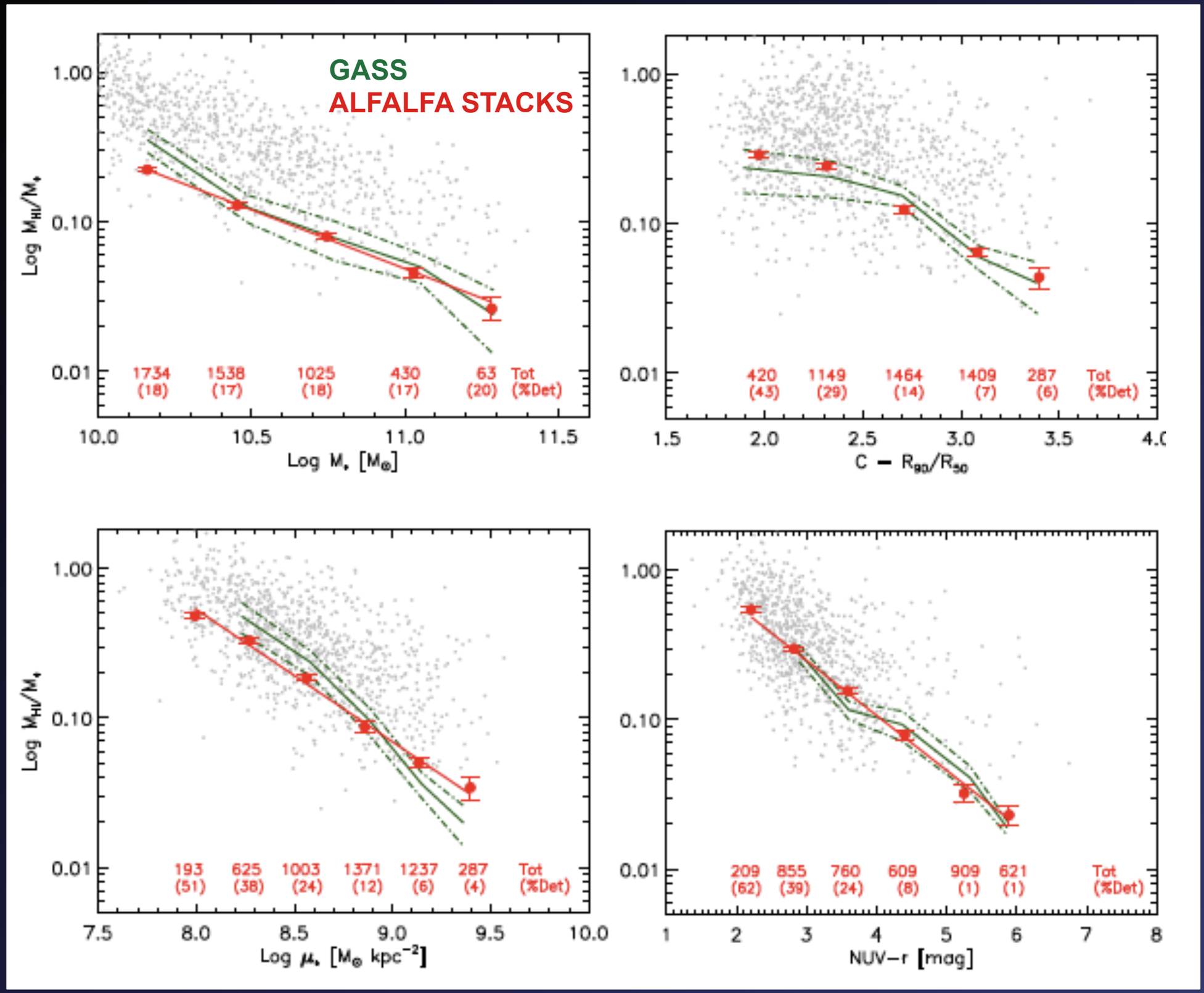
Concentration



Color

Catinella et al. (in prep.)

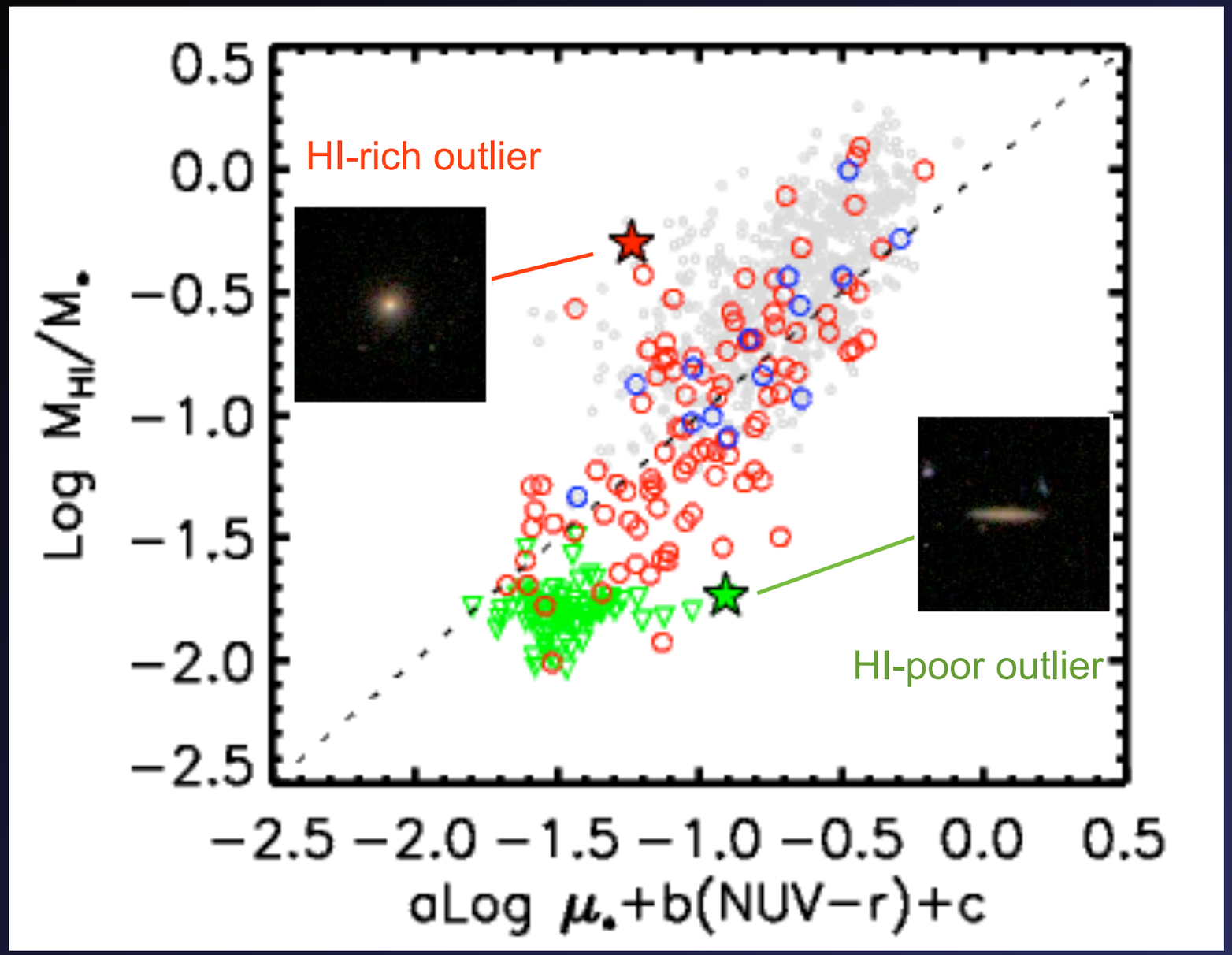
ALFALFA stacking: excellent agreement with GASS!



Silvia Fabello's PhD Thesis at MPA

Fabello, BC et al. 2011

HI gas fraction plane

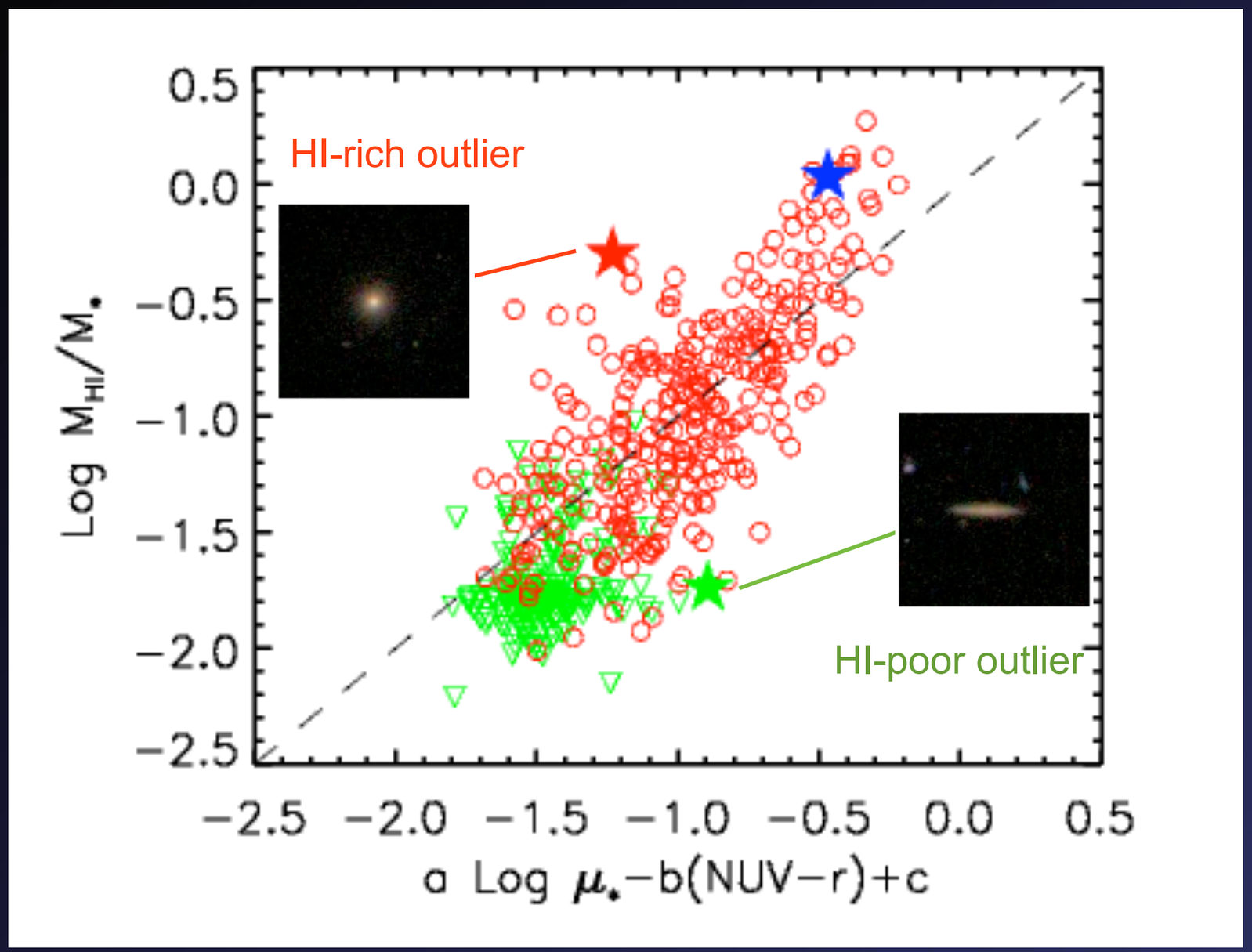


Transition galaxies: anomalous gas content given their optical/NUV colors and μ_*

BC, Schiminovich, Kauffmann et al. 2010

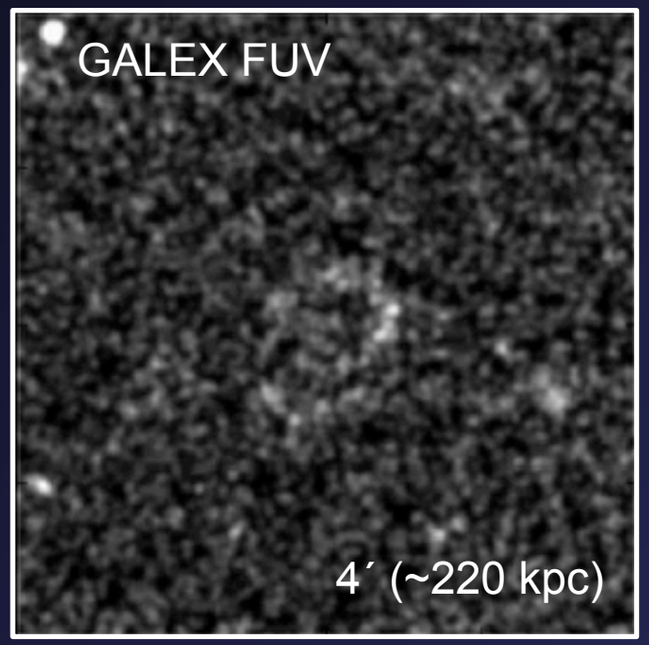
$$\Sigma_{\rm SFR} \propto \Sigma_{\rm gas}^{n} \quad \Rightarrow \quad {\rm SFR}/M_* \propto (M_{\rm gas}/M_*)^n \mu_*^{n-1}$$

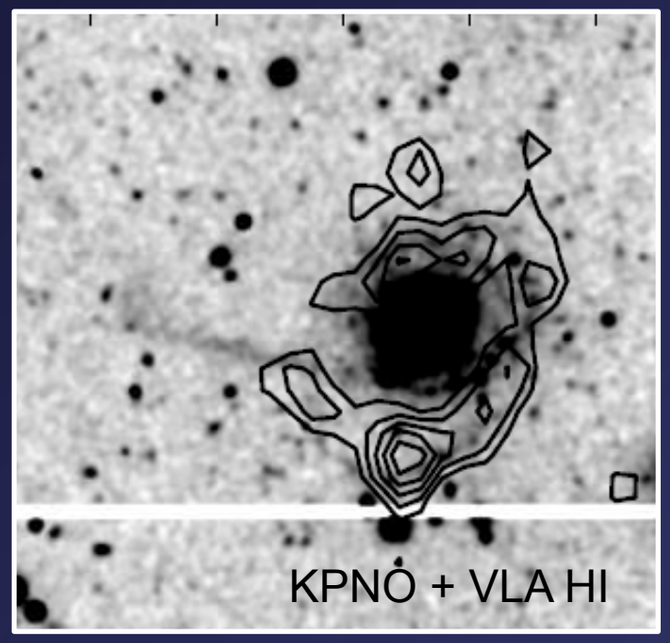
DR2 HI gas fraction plane

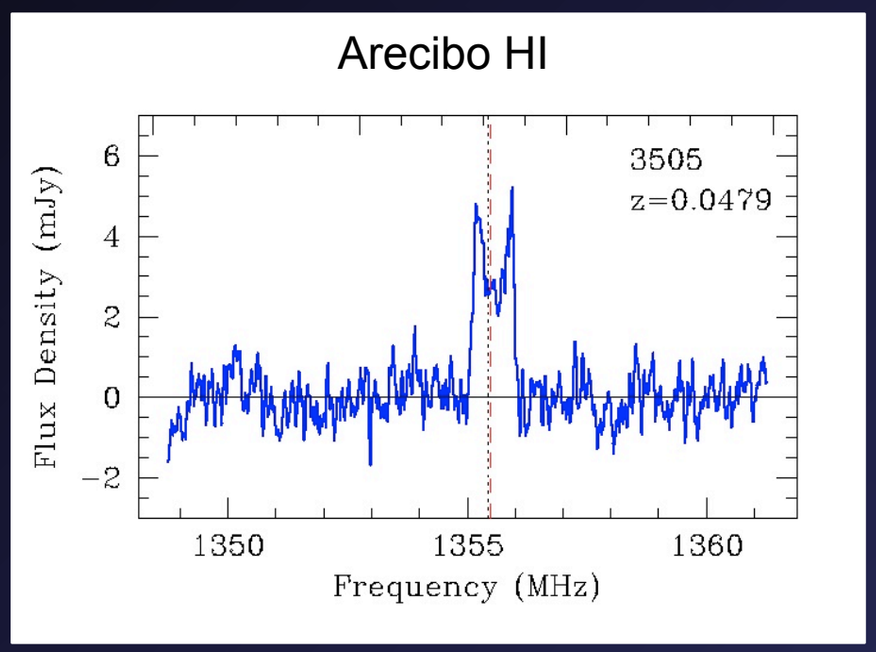


Transition galaxies: anomalous gas content given their optical/NUV colors and μ_*

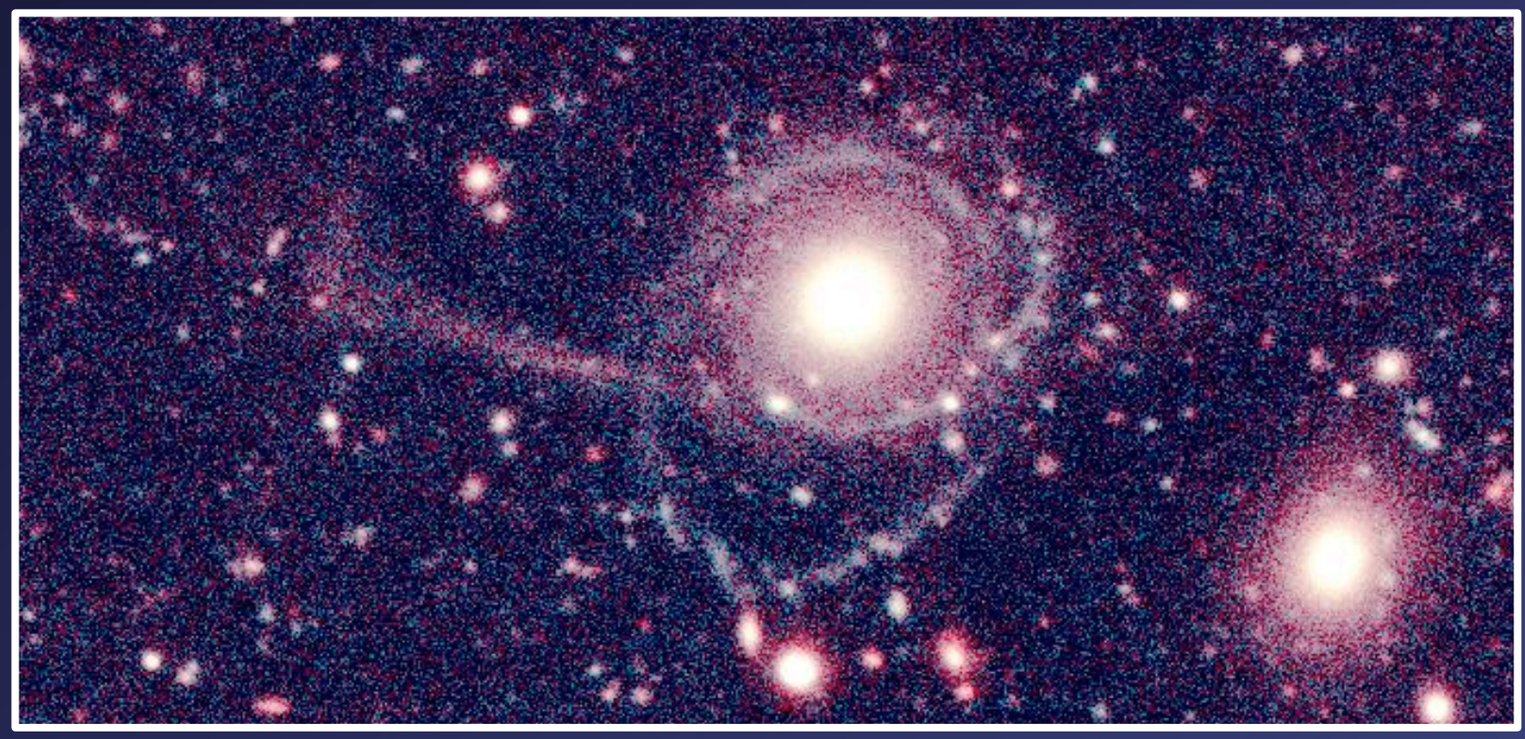
GASS 3505: a gas-rich, "red and dead" galaxy







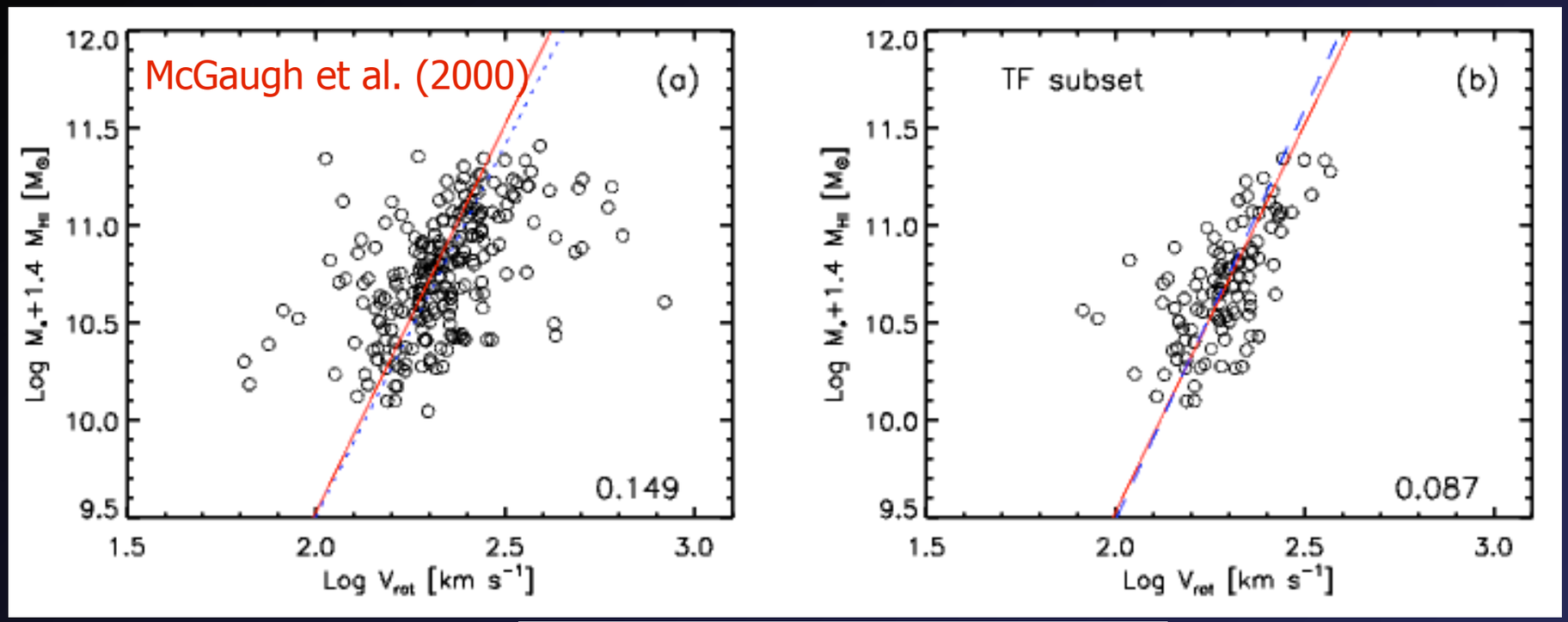
$\log M_{HI}/M_{\odot}=9.91$ $M_{HI}/M_{\star}=50\%$



MMT g and r-band imaging (S. Moran)

Dynamical scaling relations

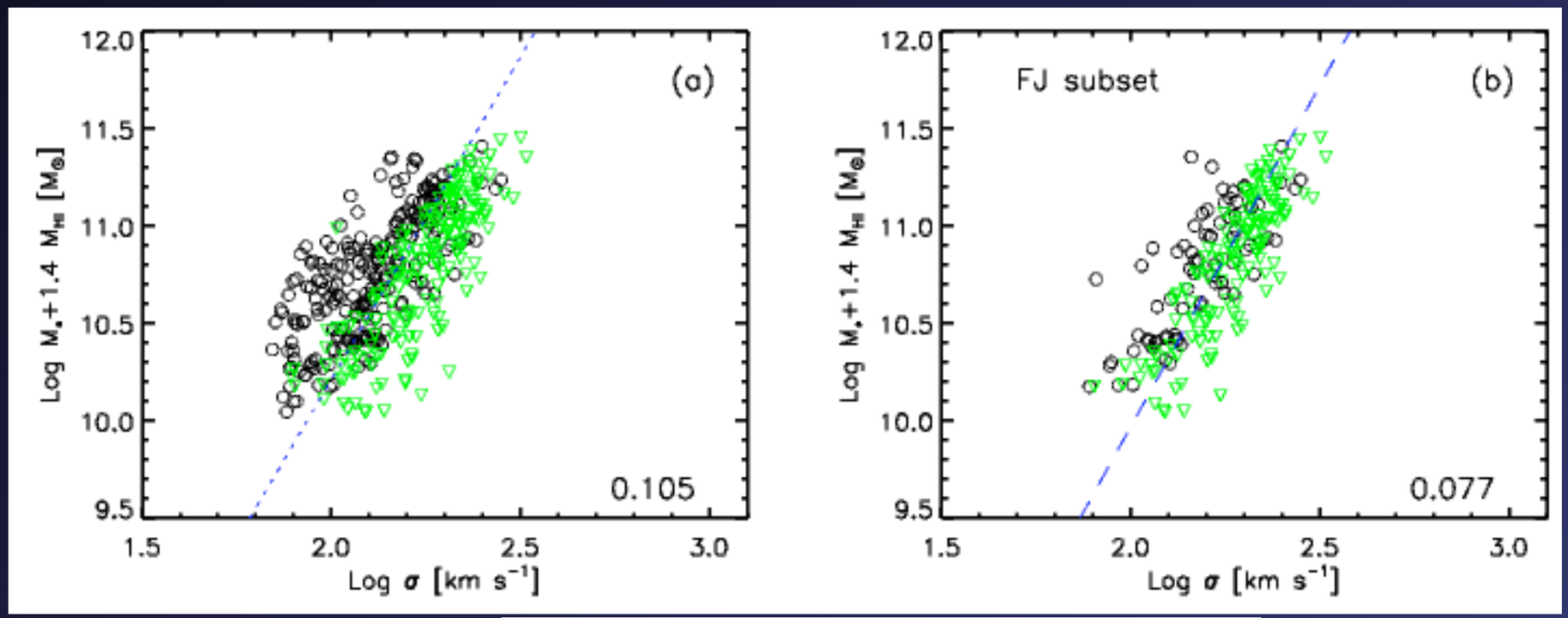
Baryonic Tully-Fisher and Faber-Jackson relations



GASS DR2, N=480
(~300 detections)

BARYONIC MASS

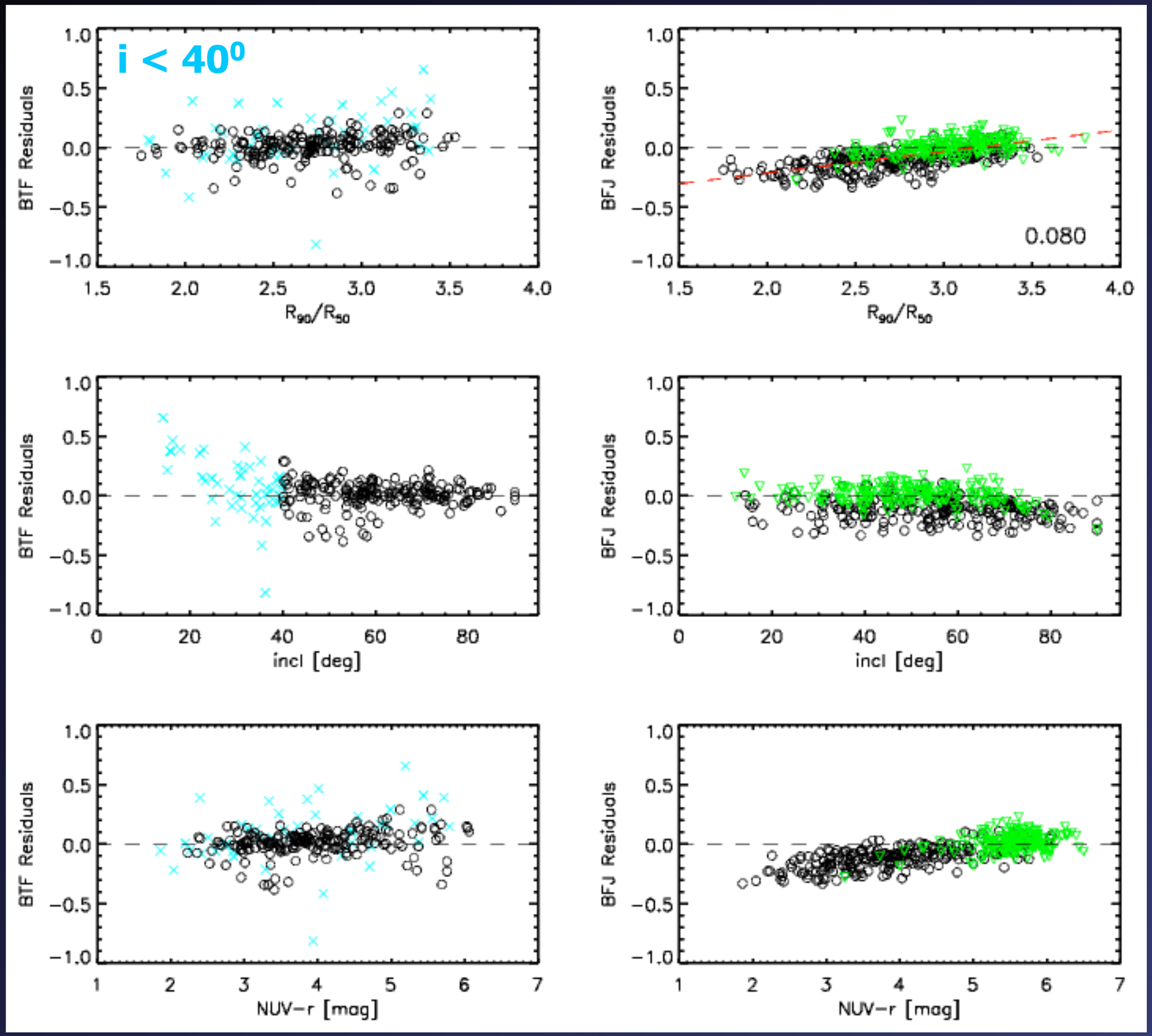
HI ROTATIONAL VELOCITY



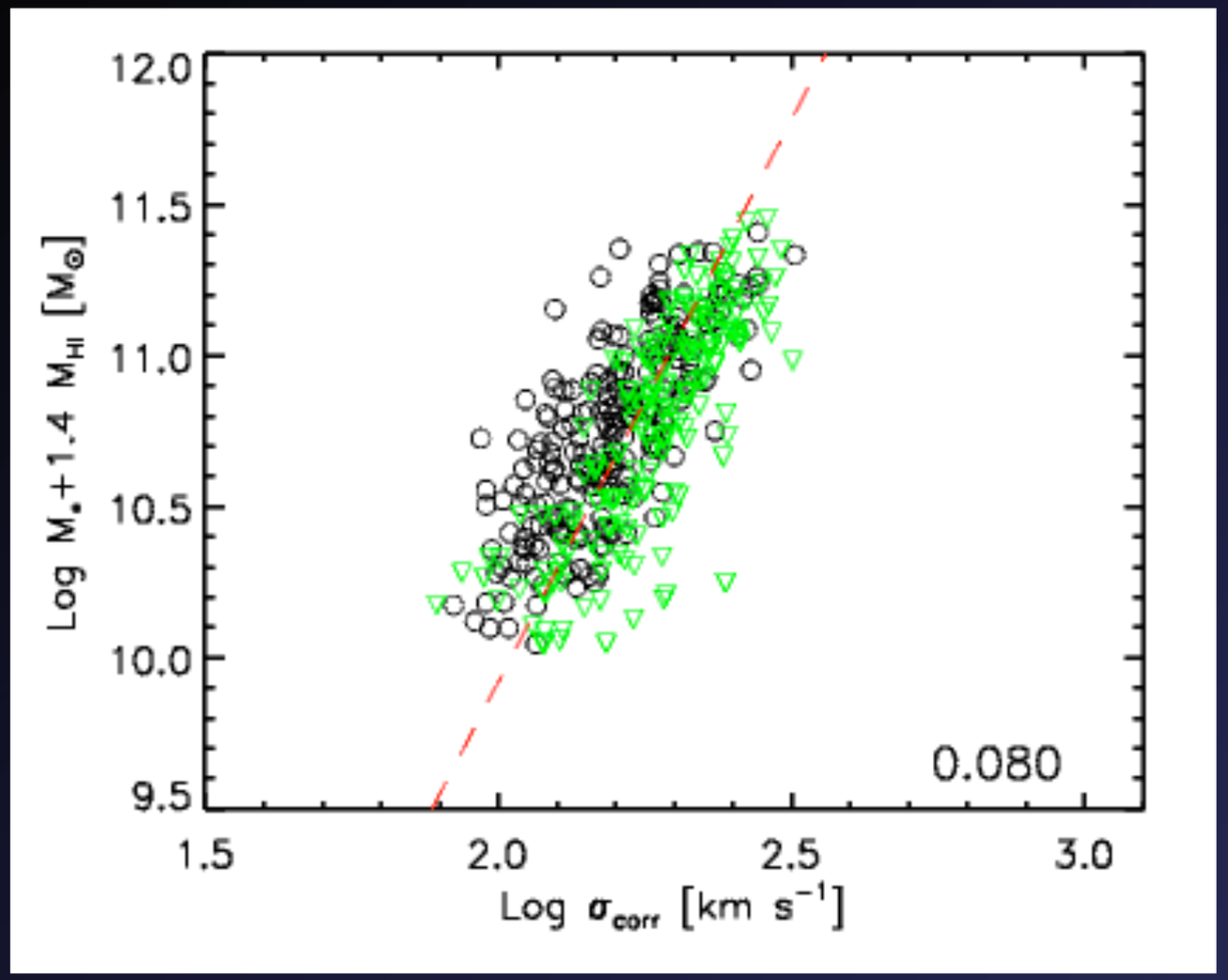
STELLAR VELOCITY DISPERSION

Catinella et al. (in prep.)

Baryonic TF and FJ Residuals



Baryonic FJ corrected for dependency on R_{90}/R_{50}



BARYONIC MASS

CORRECTED STELLAR VELOCITY DISPERSION

No sample pruning!

No morphological selection, no inclination cuts

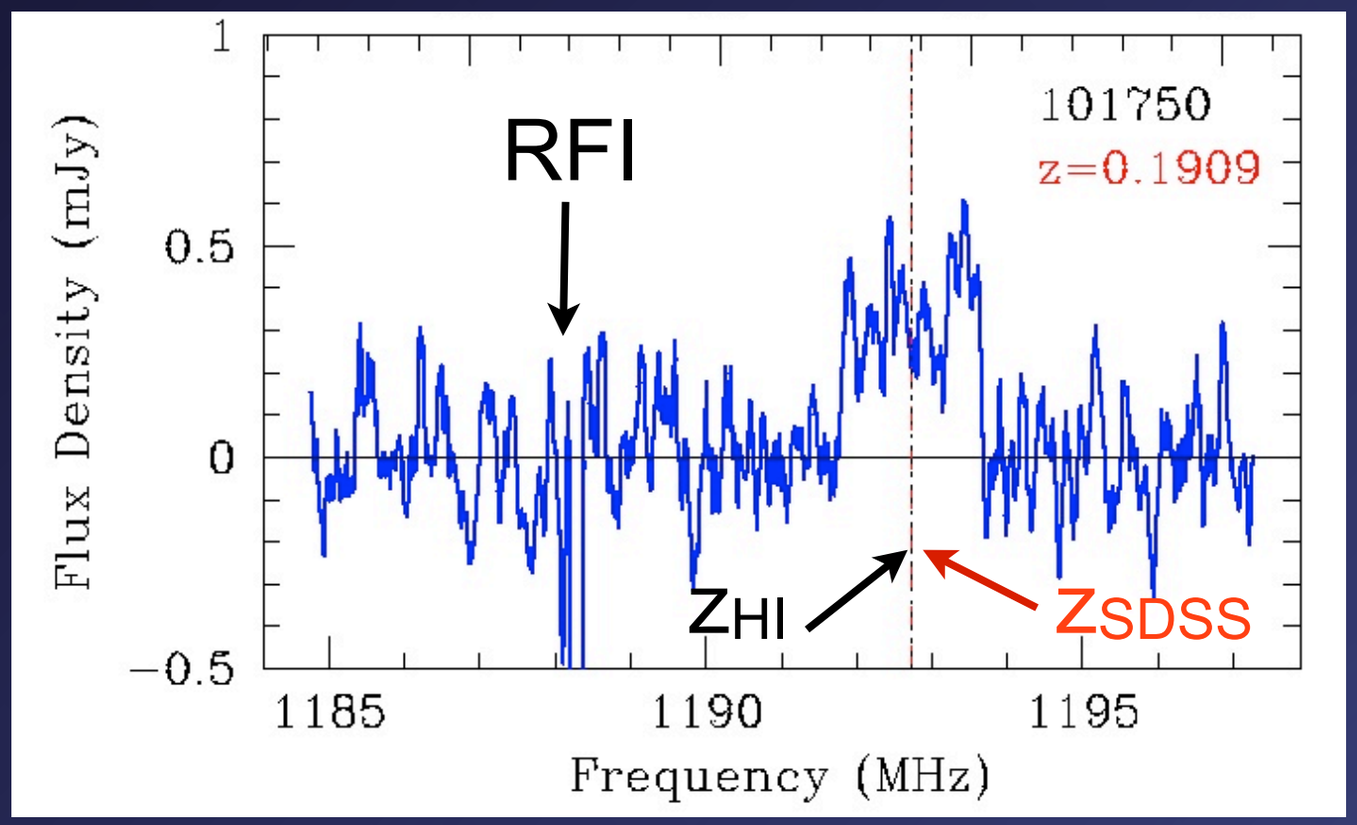
- applicable to large samples
- less affected by systematics than TF, FJ -- interesting for evolution of scaling relations
- comparison with models

GASS: reference for higher z studies

Comparison with HI observations of SDSS-selected galaxies at z~0.2

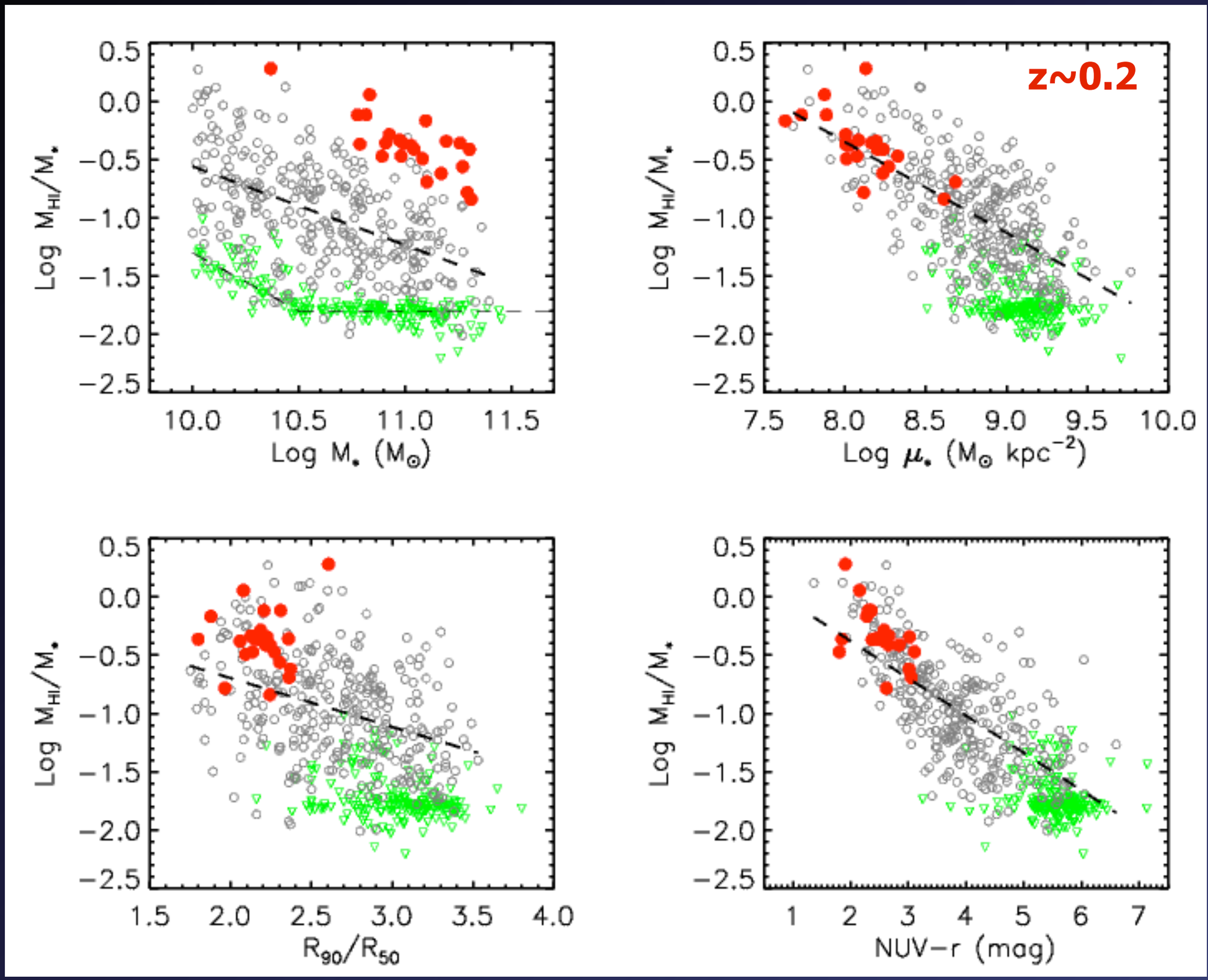
- 41 galaxies targeted, $0.16 < z < 0.26$
- 25 detections, 9 marginal, 7 non-detections
- HI mass $2 - 8 \times 10^{10}\ M_\odot$
- on-source integration time of 1-4 hrs per object

1 arcmin
~ 200 kpc @ z=0.2



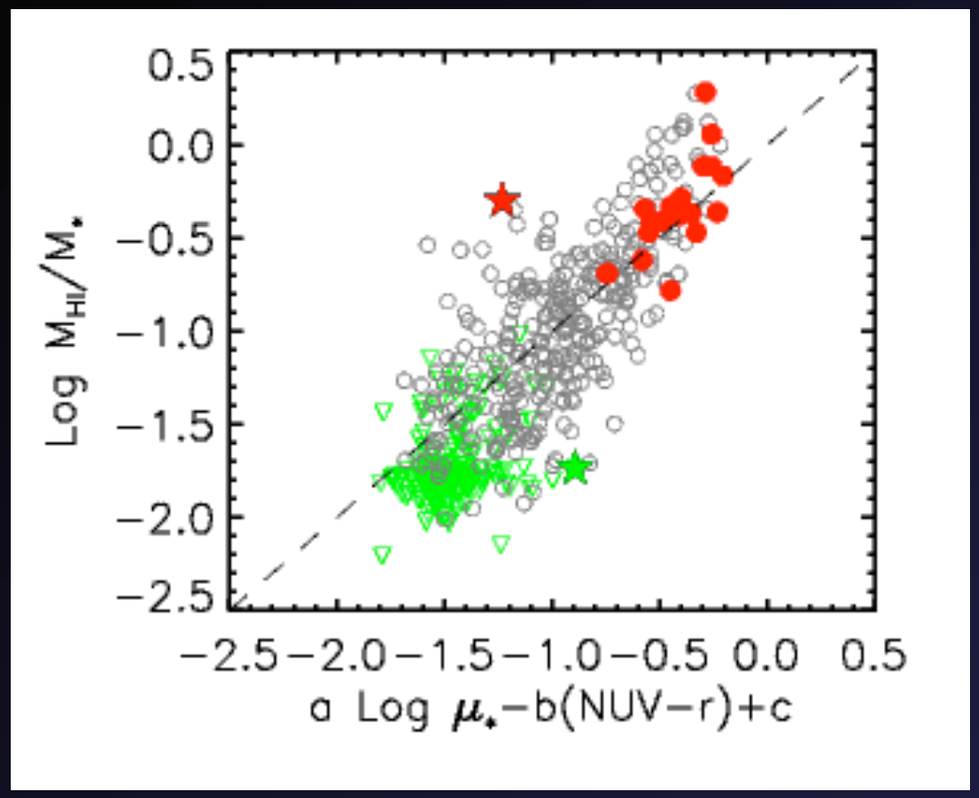
Catinella, Haynes, Giovanelli, Gardner, & Connolly 2008, ApJL

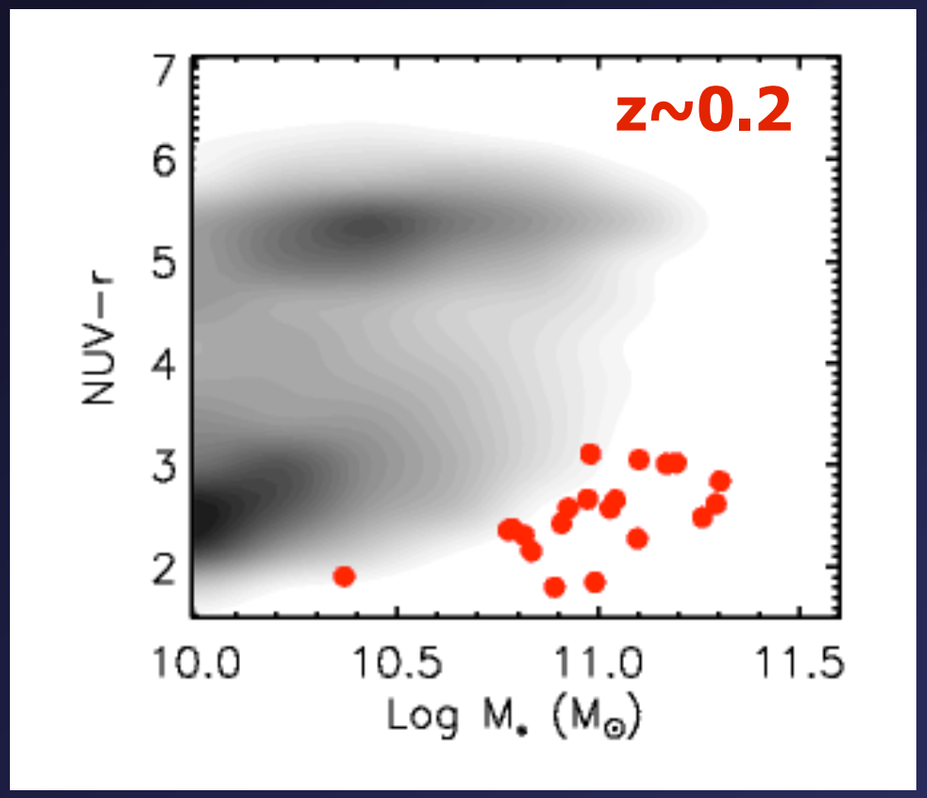
Comparison with GASS DR2 scaling relations

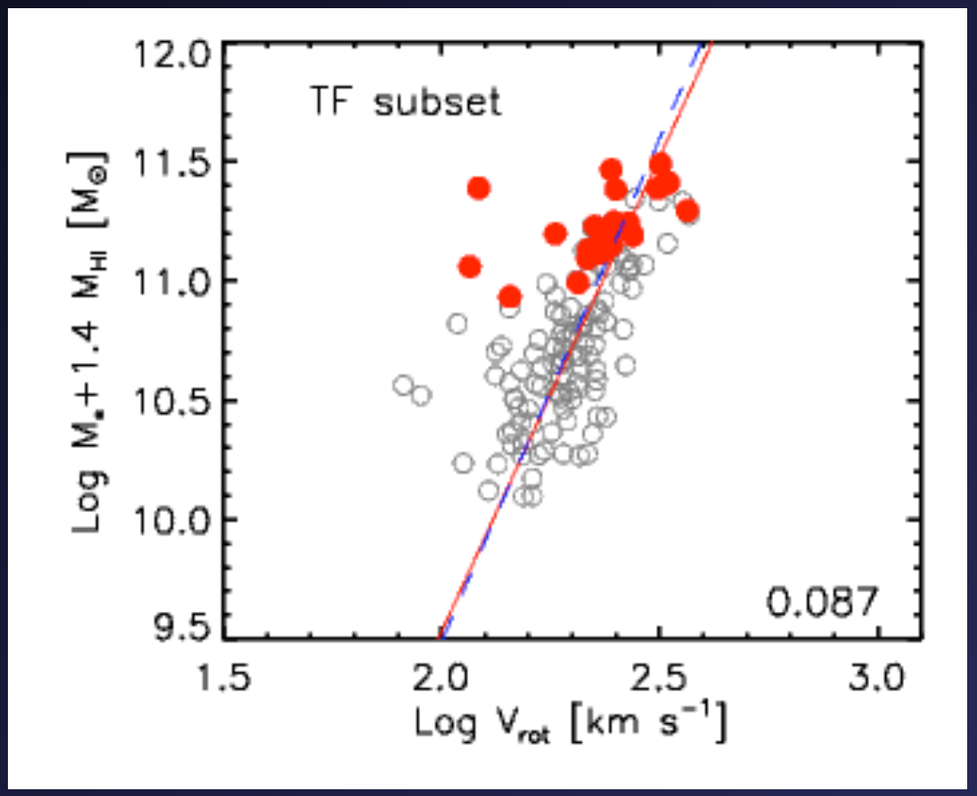


Catinella et al. (in prep.)

Comparison with GASS gas fraction plane and BTFR





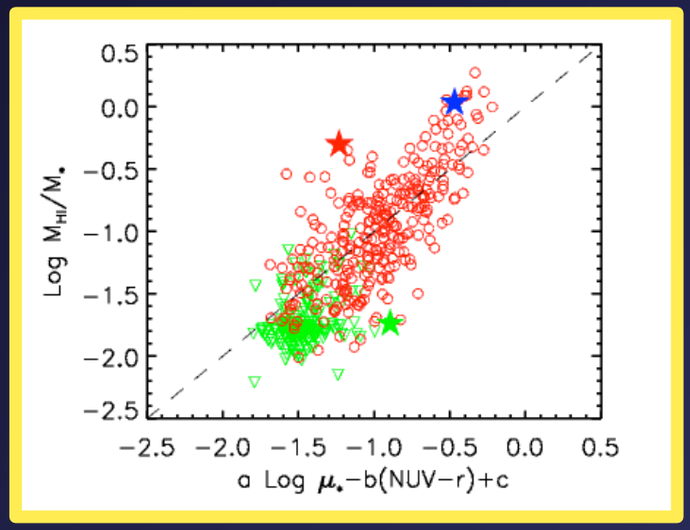


z~0.2 galaxies: unusually blue and gas rich, but they lie on the same gas fraction - NUV-r / $\mu_\star$ relations and baryonic TFR of the GASS galaxies!

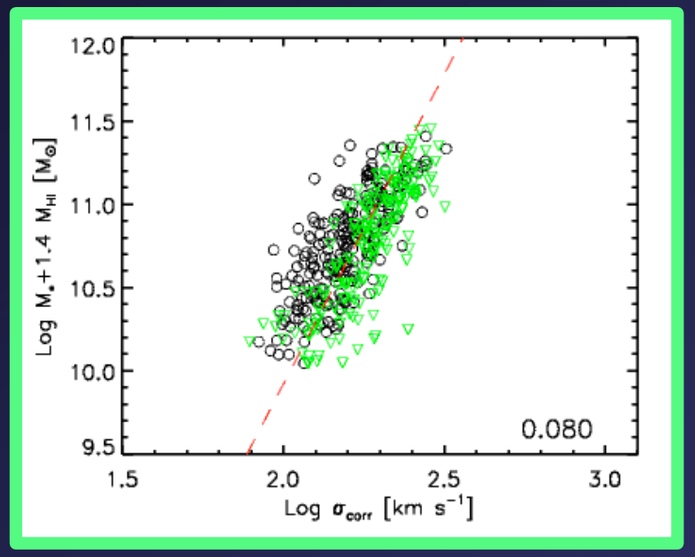
GASS scaling relations: benchmark for future HI surveys with SKA precursors

SUMMARY

- GASS is the first study to specifically target a sample that is homogeneously selected by stellar mass (10< log $M_\star/M_\odot$ <11.5).



- HI gas fraction scaling relations



- Dynamical scaling relations

- Arecibo observations of z~0.2 galaxies