Photo: Jeff Miller, UW Madison

SALT-ed CHILES: Neutral and Ionized Gas Kinematics in the CHILES Survey

Julie D. Davis

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CHILES
COSMOS HI LARGE EXTRAGALACTIC SURVEY

The CHILES Collaboration

CHILES collaborators around the globe (an incomplete list):

ASTRON: Tom Oosterloo, Marc Verheijen, Thijs van der Hulst, Kelley Hess

Columbia University: Jacqueline van Gorkom, **Julia Gross**

U. Wisconsin: Eric Wilcots, Charee Peters, Julie Davis, Catherine Witherspoon

West Virginia University: D.J. Pisano, Evan Smith, Nick Luber

NRAO: Emmanual Momjian, Monica Sanchez

ICRAR: Martin Meyer, Attila Popping, John Hibbard, Natasha Maddox, Luke Davies

Plus individuals at various other institutions: Trish Henning, Min Yun, Danielle Lucero, Aeree Chung, and more.

Overview

- **COSMOS HI Large Extragalactic Survey (CHILES) Overview**
- **Use of SALT to support the CHILES survey**
  - **Longslit Rotation Curves**
  - **Dithered longslit observations**
  - **Redshift acquisition using multi-object spectroscopy**
- **Current status of the survey and challenges to be addressed**

CHILES Main Science Drivers

<u>Measuring neutral hydrogen across cosmic time is fundamental to understanding galaxy evolution</u>. Little is known about the HI content of intermediate redshift ($0.1 < z < 0.5$) galaxies. CHILES will address, among other things:

- HI content, morphology, and kinematics of individual galaxies.
- HI mass function as function of z and environment.
- Cosmic neutral gas density as a function of z.
- Evolution of Tully Fisher relation.

The COSMOS HI Large Extragalactic Survey at a Glance

1000 hour integration, 30’ in COSMOS
855 hours collected, finishing mid 2019

VLA B-Array, L-band

970-1450 MHz -> **0 < z < 0.45**

15.5 kHz channels -> **6.6 km s^{-1}** velocity resolution (after smoothing)

HI emission sensitivity: **50 μJy**
(MeerKAT comparable)

The Very Large Array
New Mexico, USA

“A pathfinder for the pathfinders”

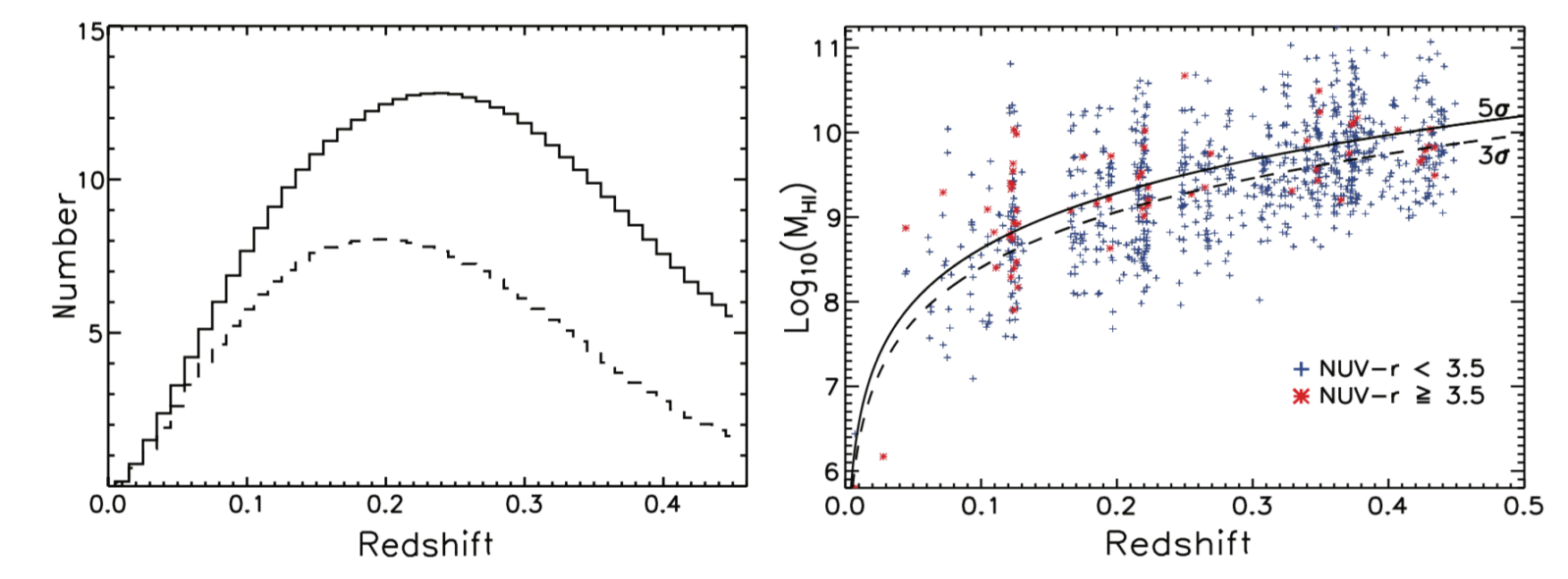
The COSMOS HI Large Extragalactic Survey at a Glance

300+ predicted detections in HI emission
(5σ, 150 km s^{-1} profile width)

Mass sensitivities:
≈ 10^6 $M_\odot$ nearby, ≈ 10^{10} $M_\odot$ at z = 0.45

Column density of 1.5 x 10^{19} cm^{-2}
per 6.6 km s^{-1}

Angular Resolution of 5" →
350 pc nearby, 42 kpc at z = 0.45



Martin et al. 2010

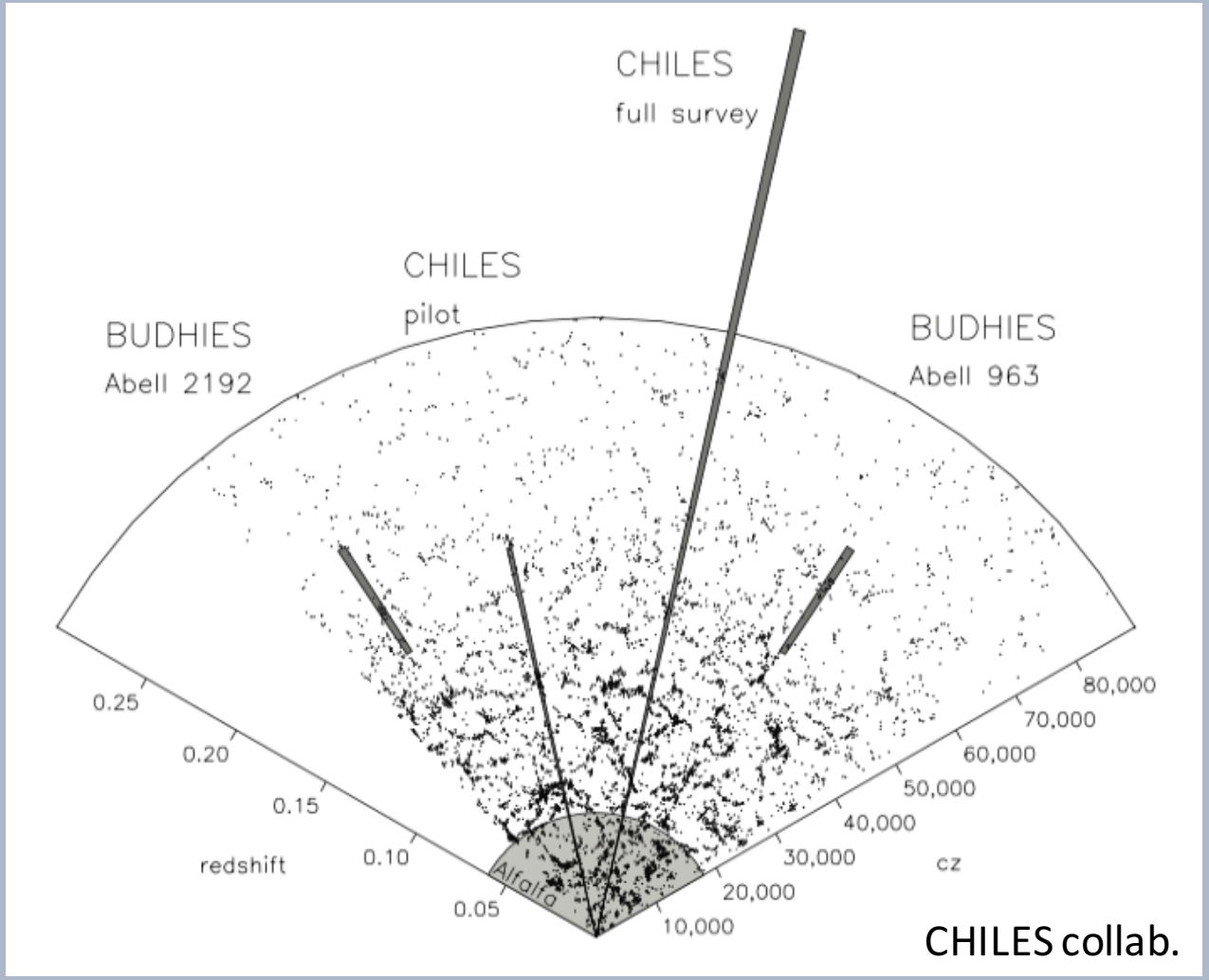
HI 21-cm Survey Science: Why CHILES?

Single dish surveys: large blind samples, low spatial resolution, z ~ 0.06
(Ex: HIPASS, ALFALFA)

Interferometer surveys: higher resolution but targeted, very local universe
(Ex: WHISP, THINGS, HALOGAS)

BUDHIES was ”high-z” but still targeted
(2 galaxy clusters @ z ~ 0.2)

CHILES is the first blind interferometric survey out to high redshift



CHILES collab.

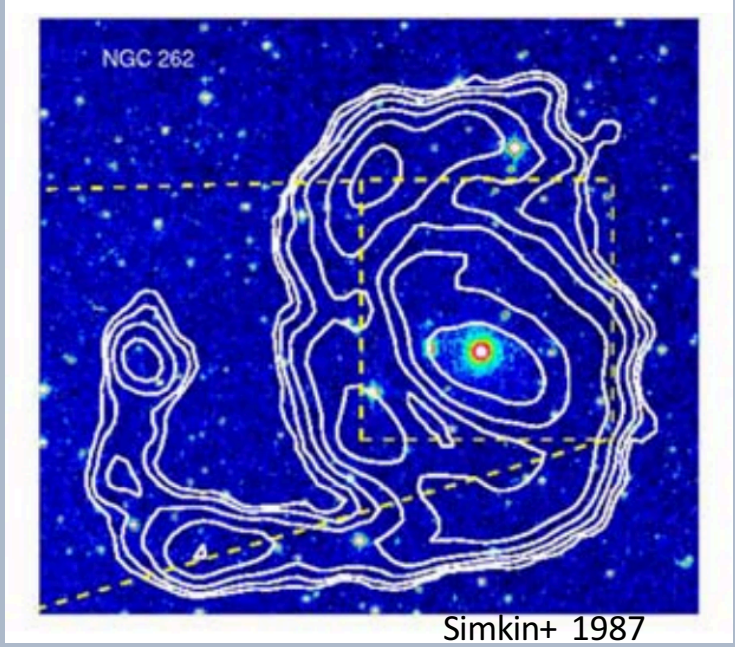
21-cm Emission as a Tracer of Gas Accretion

How do galaxies grow and maintain their gas reservoirs?

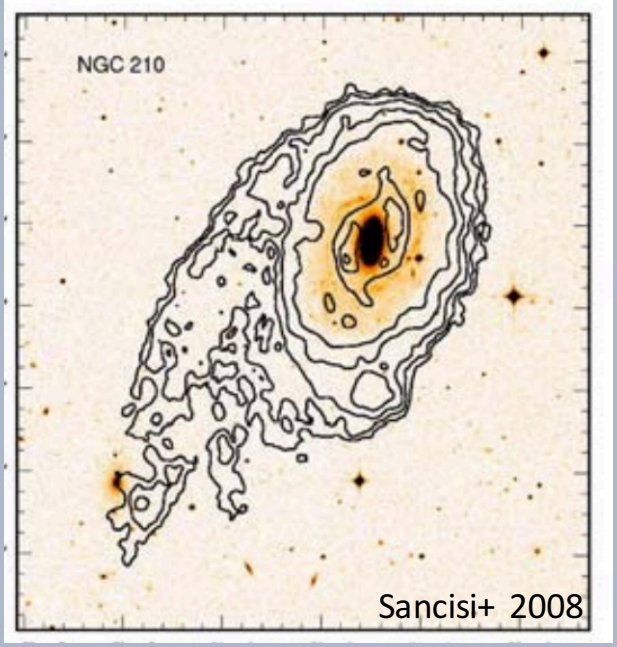
Accretion and interaction become apparent in extended HI and disturbed ionized gas

Gas-Rich companions, HI clouds complexes, tails, and filaments → minor mergers and arrival of external gas

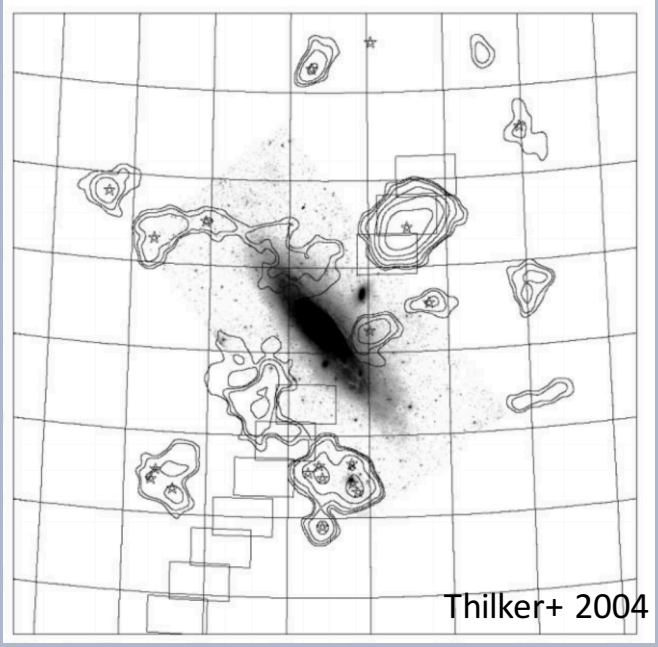
Disks can be warped/flared, HI distribution can be lopsided, kinematic axes misaligned



Simkin+ 1987



Sancisi+ 2008


Thilker+ 2004

Kinematics of Neutral and Ionized Gas

21-cm Emission

- HI extends well beyond the optical disk, allows probing of flat part of rotation curve
- Dynamically cold, low velocity dispersion → neglect pressure support
- CONS: generally low spatial resolution, limited to nearby targets

SALT-ed CHILES:

- Spatial Resolution: ~ 5”, Kinematic Resolution: 6 km/s

Longslit Spectra of Emission Lines

- Still a useful technique for measuring rotation curves
- Easier reduction than 2D methods like Fabry-Perot or IFU data
- Higher spatial resolution for inner disk region
- Traces star forming regions

SALT-ed CHILES:

- Spatial Resolution: ~ 1”, Kinematic Resolution: 70 km/s

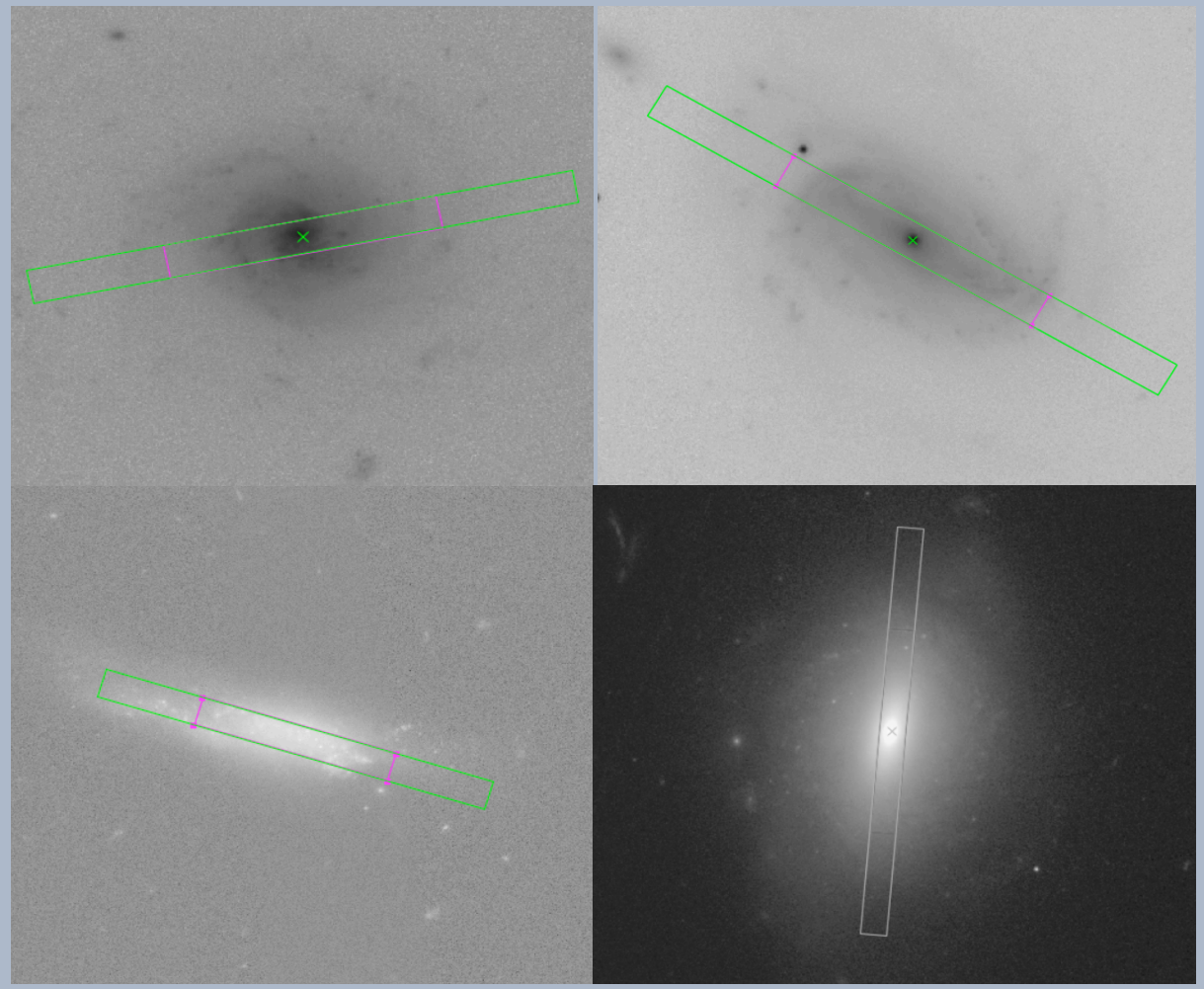
First 180 Hours: The Nearby CHILES Galaxies

The sample: 10 HI detections from the CHILES pilot survey, out to z ≈ 0.1 (cutoff keeps Hα on desired res. grating)

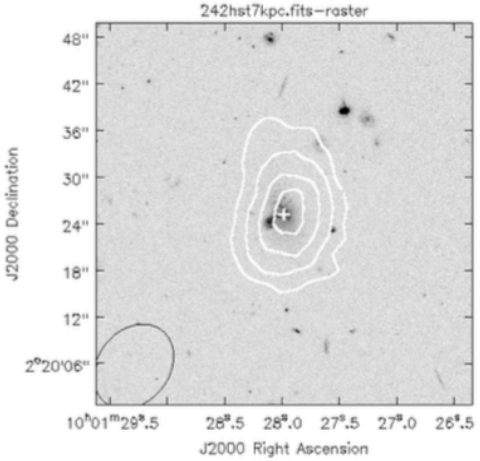
2 dwarf irregular
3 irregular
4 spirals
1 barred spiral

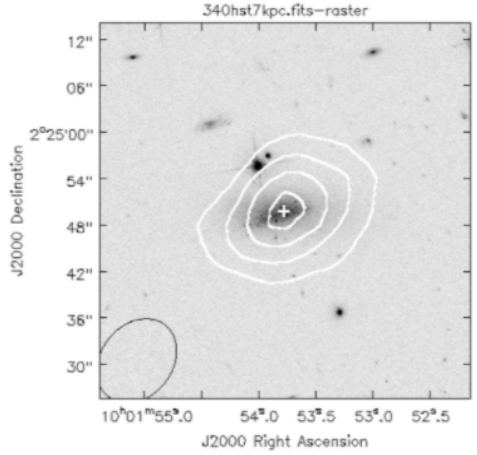
Stellar Masses: 8 x 10^6 to 3 x 10^{10} M_{sun}

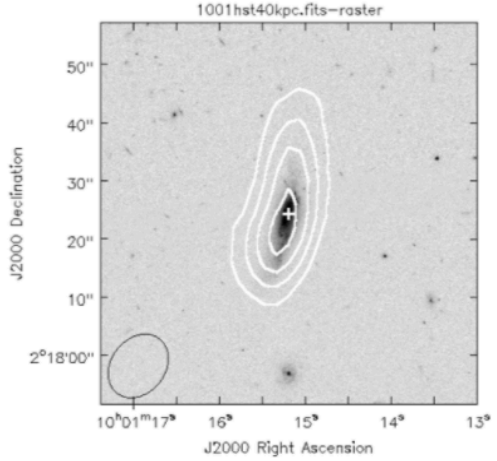
Both isolated and higher density environments represented

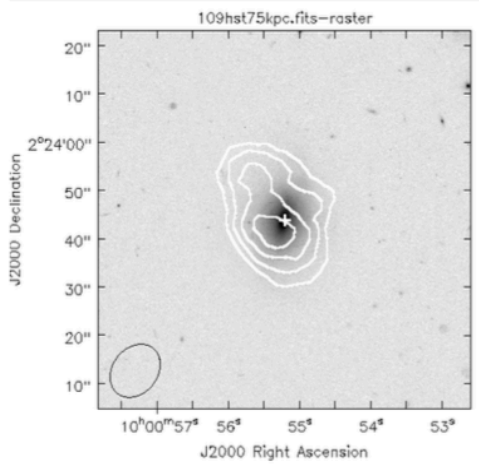


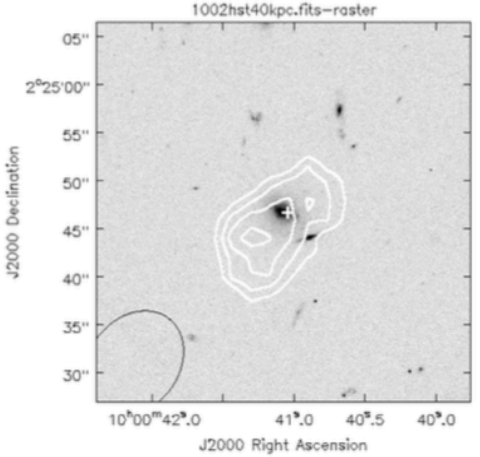
180 Hour HI Morphologies

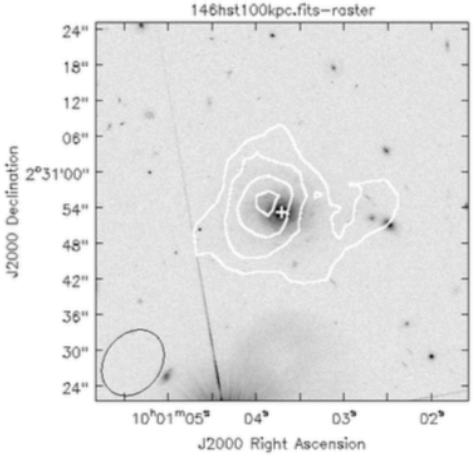


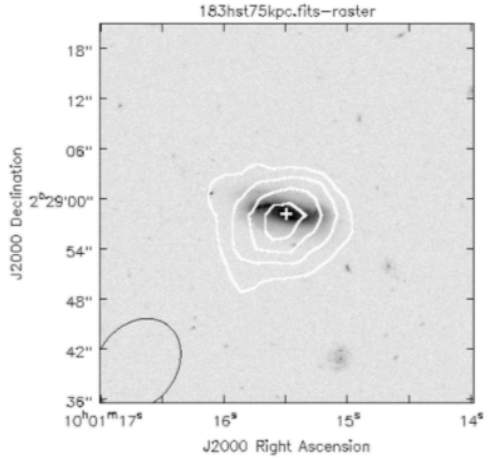


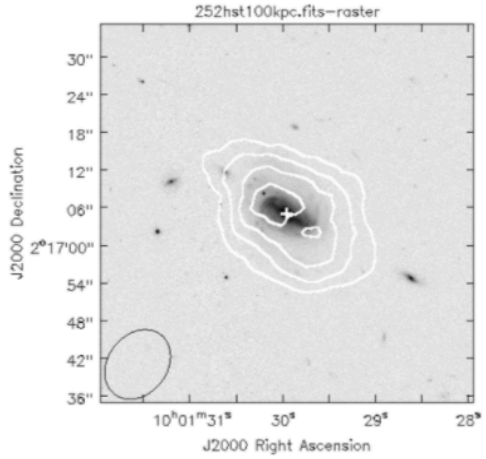


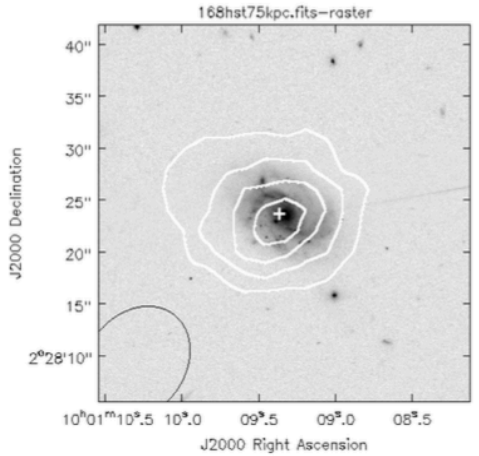


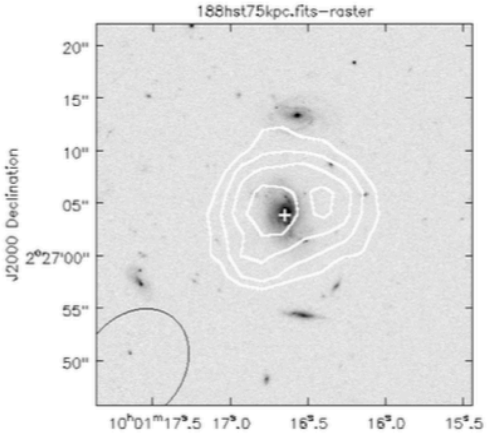






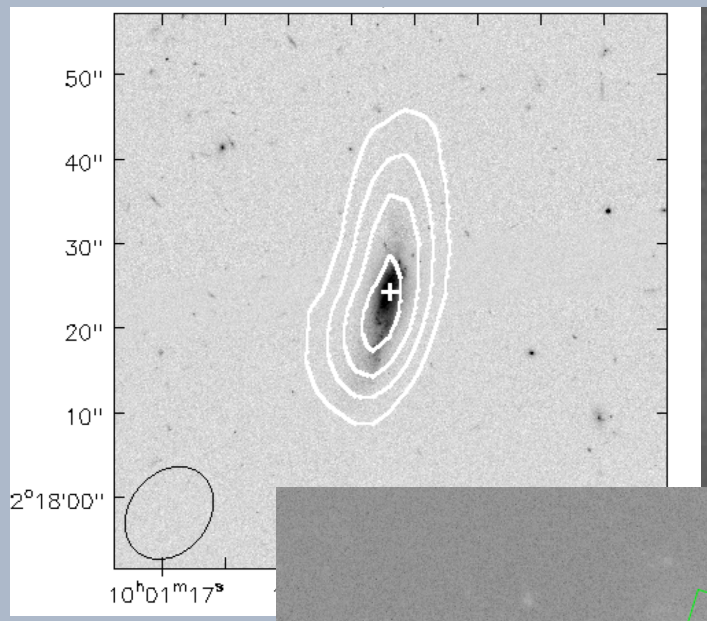


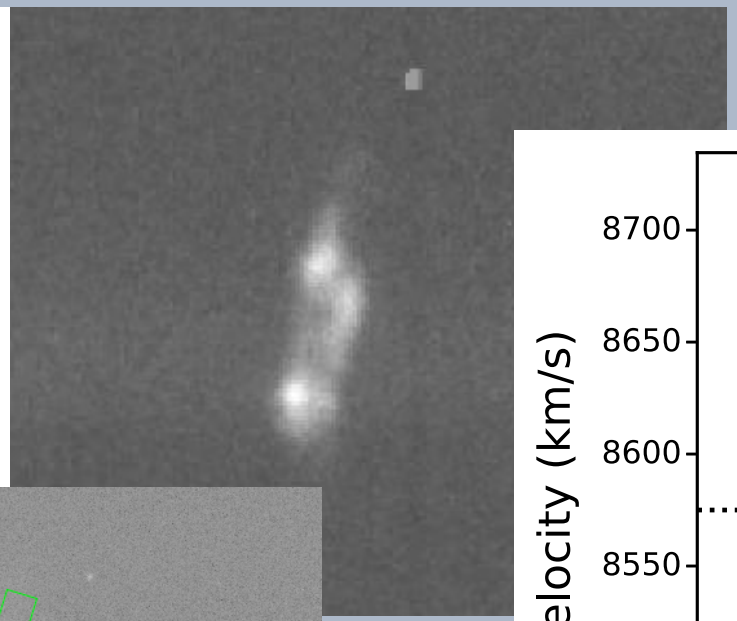


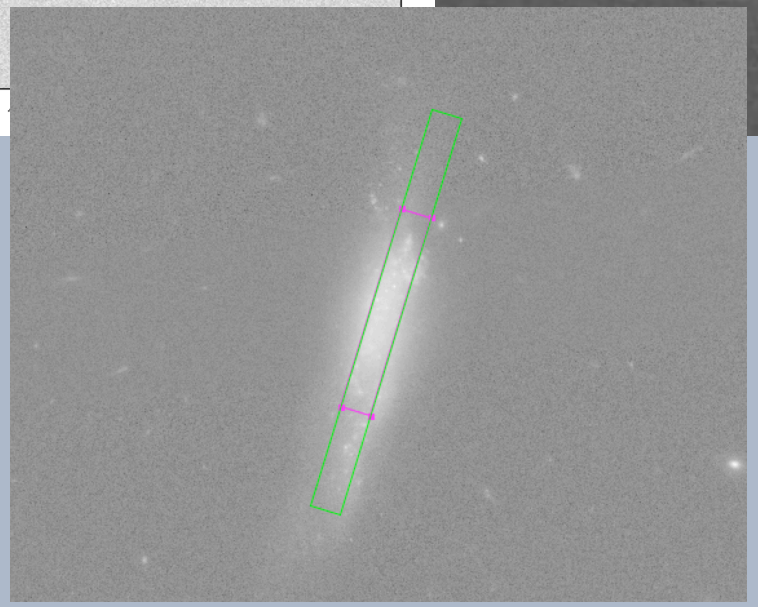


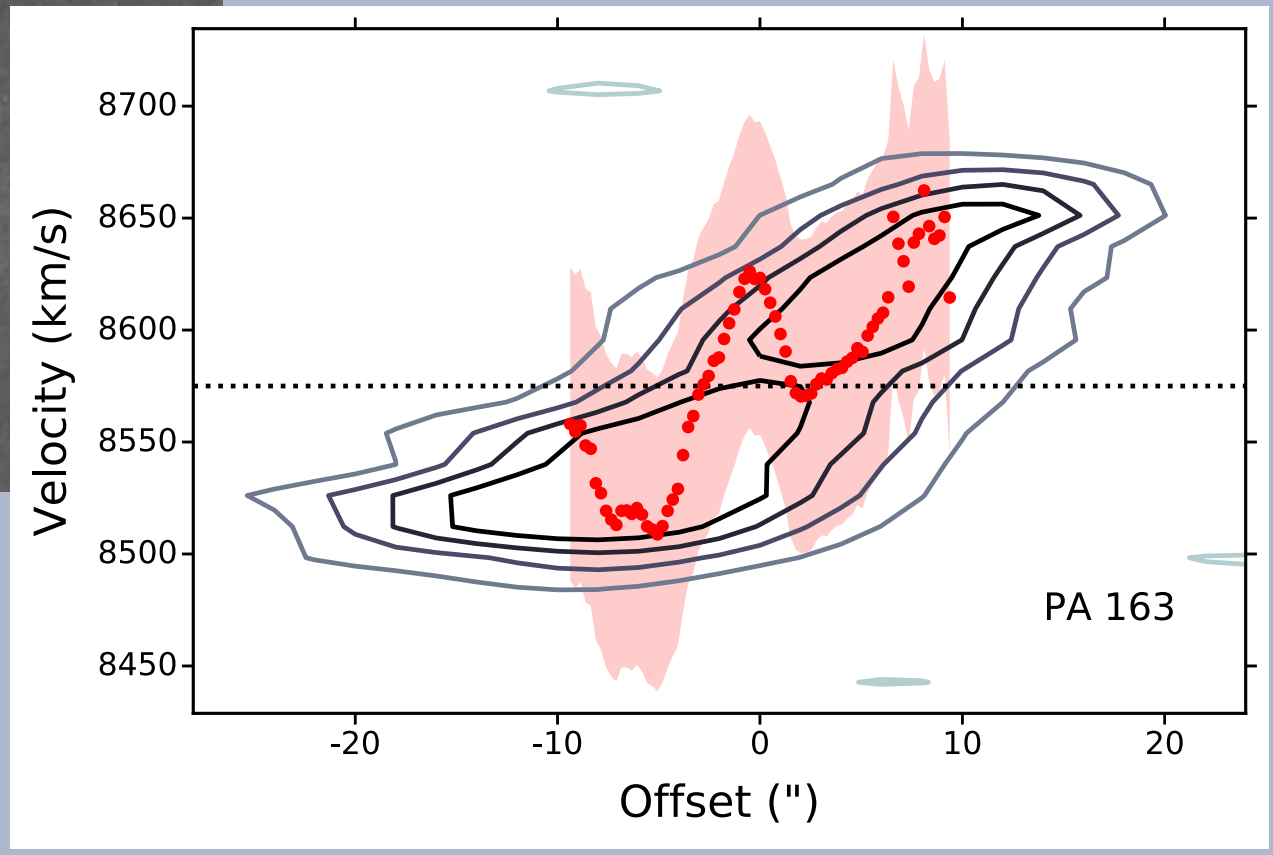
HI moment maps by J. Gross

An Irregular at z = 0.029

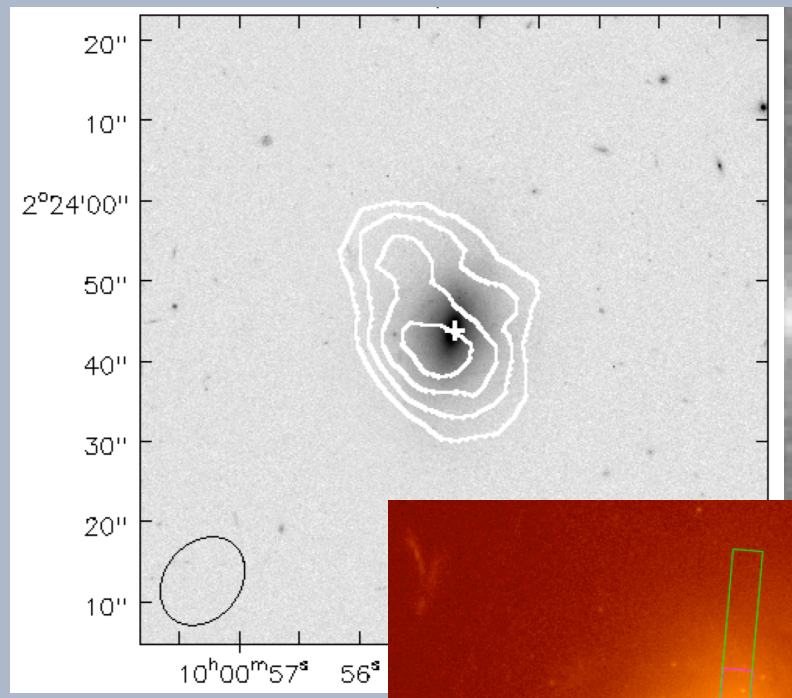


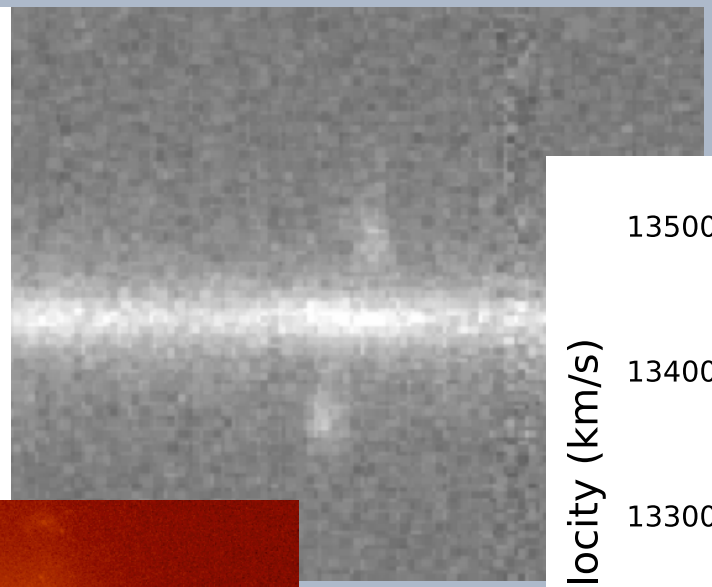


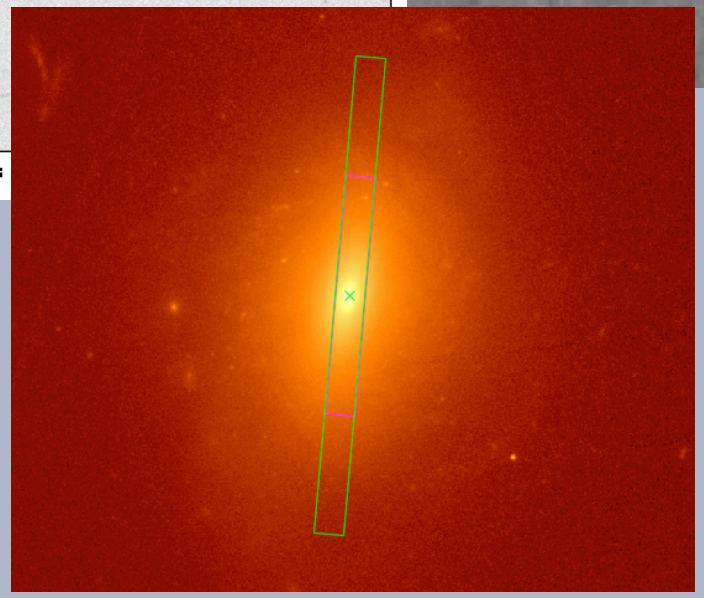


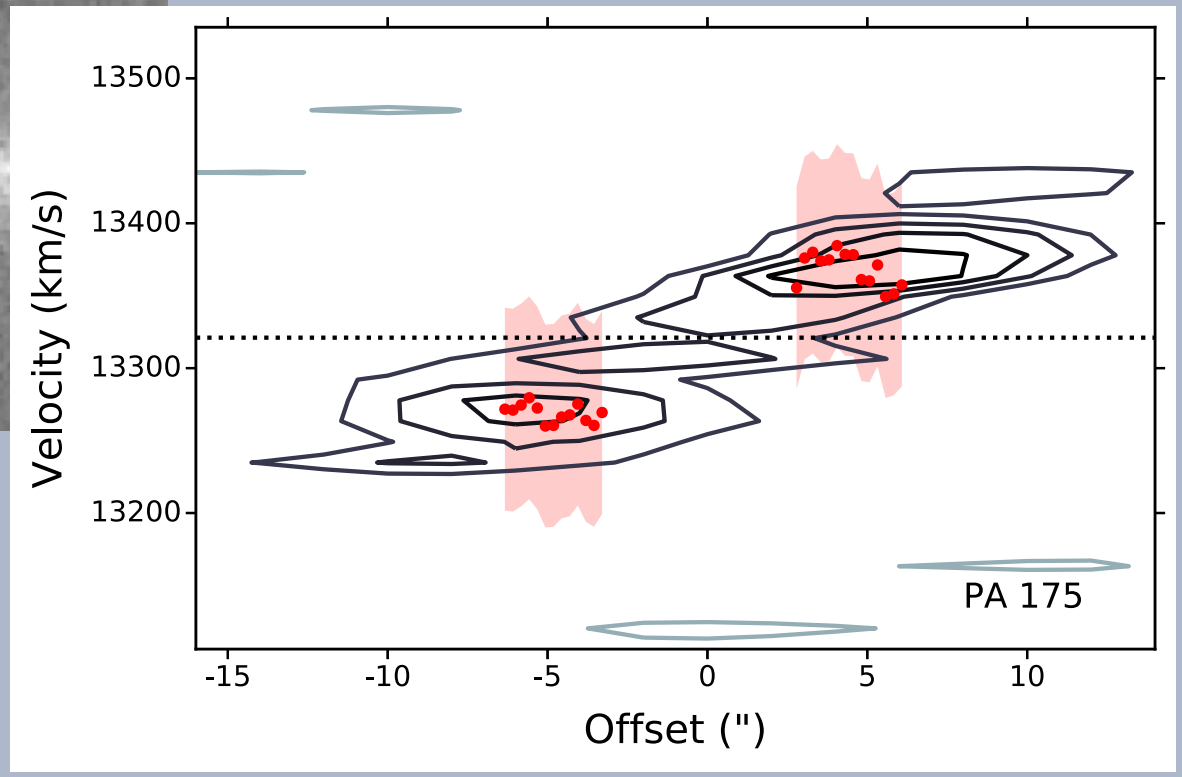


An M31-like Spiral at z = 0.047

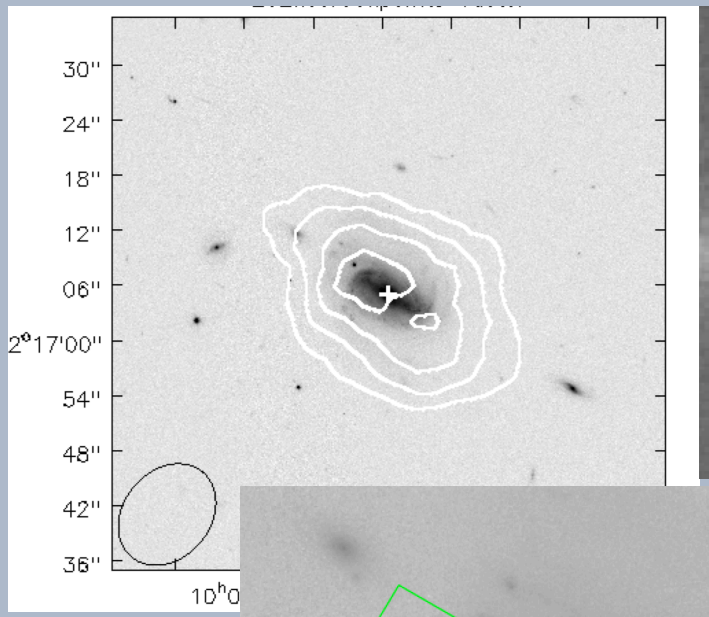


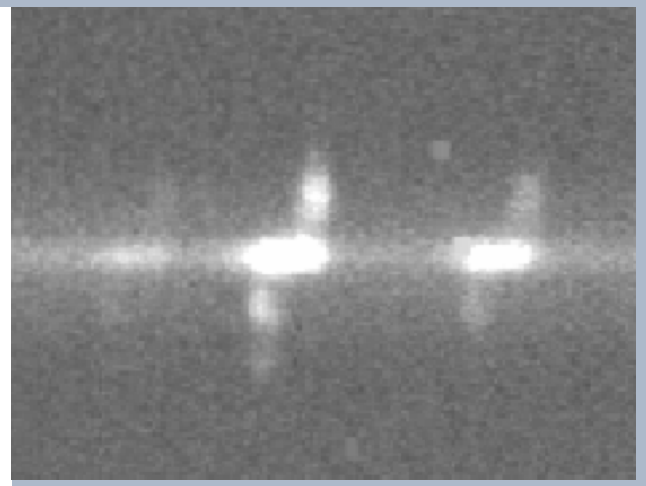


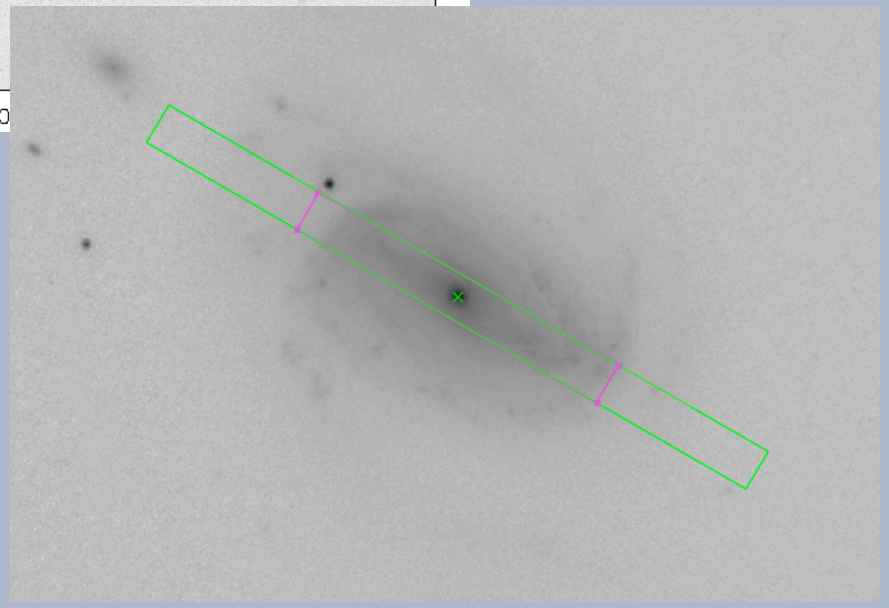


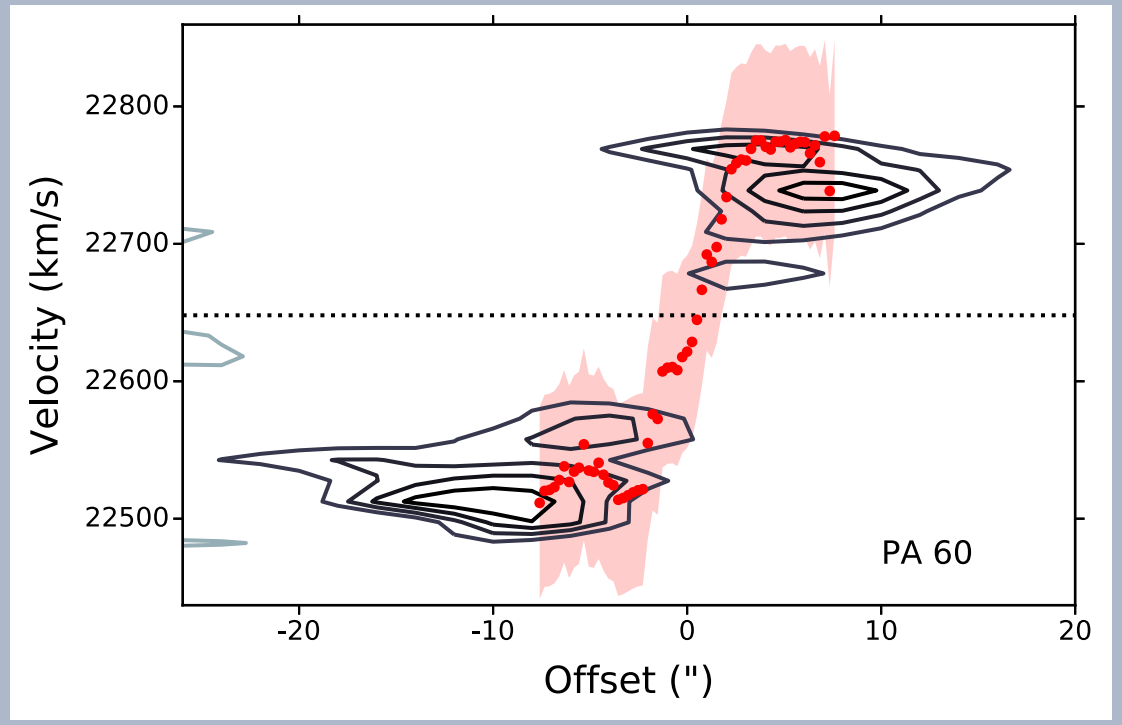


A Barred Spiral at z = 0.075

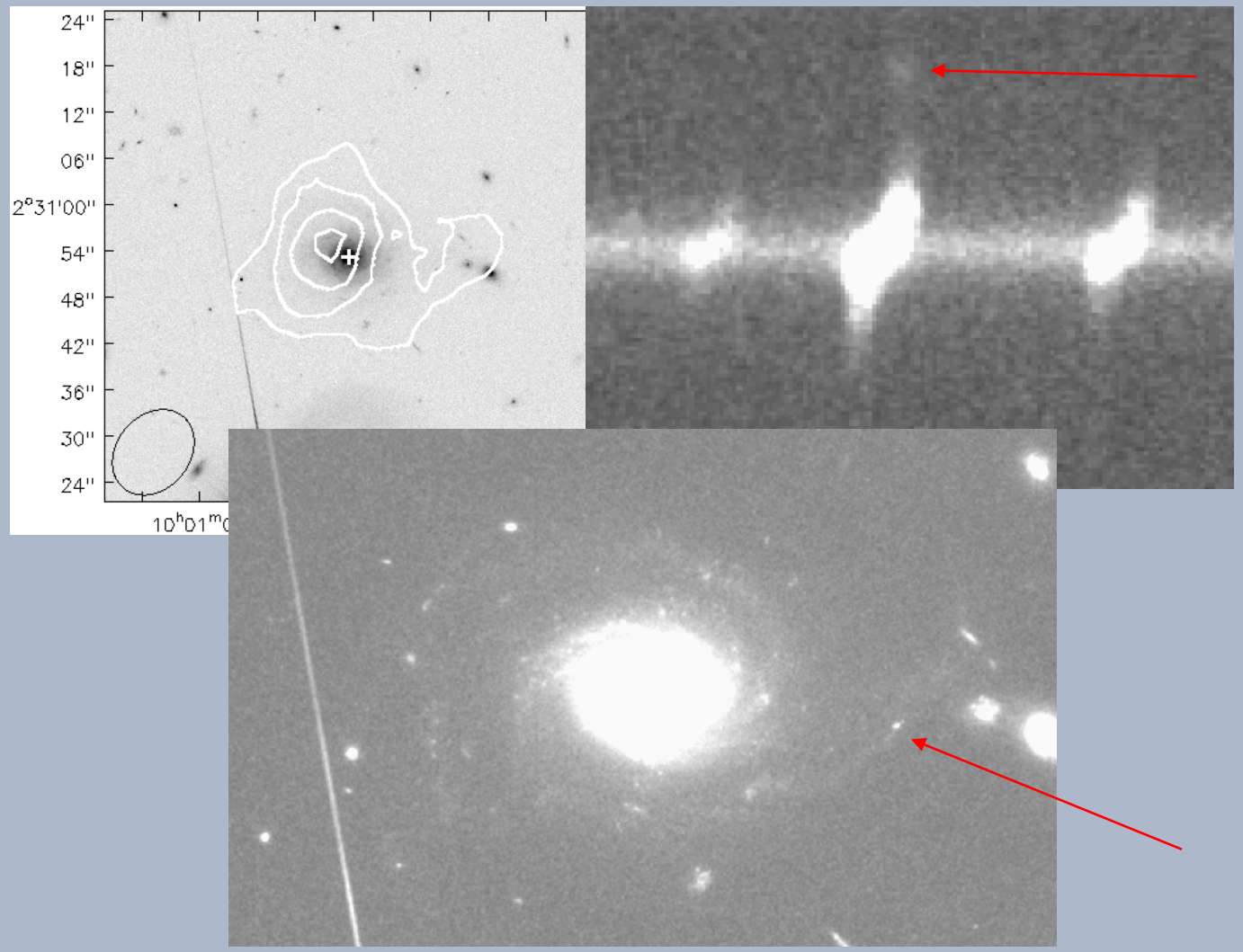


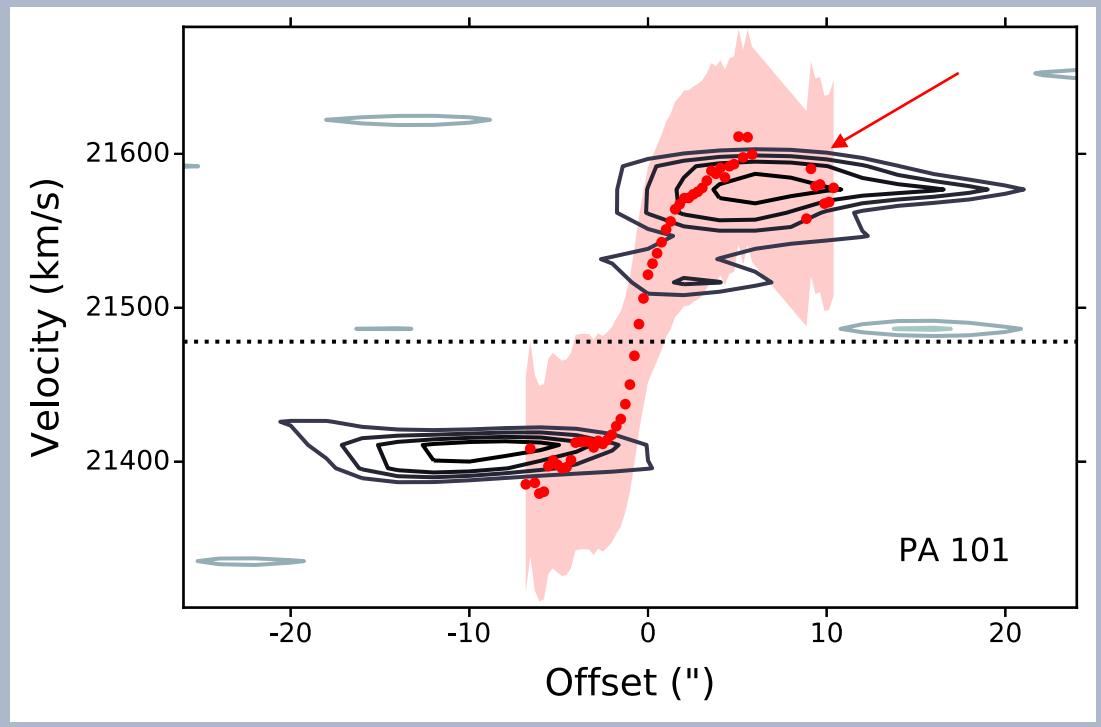




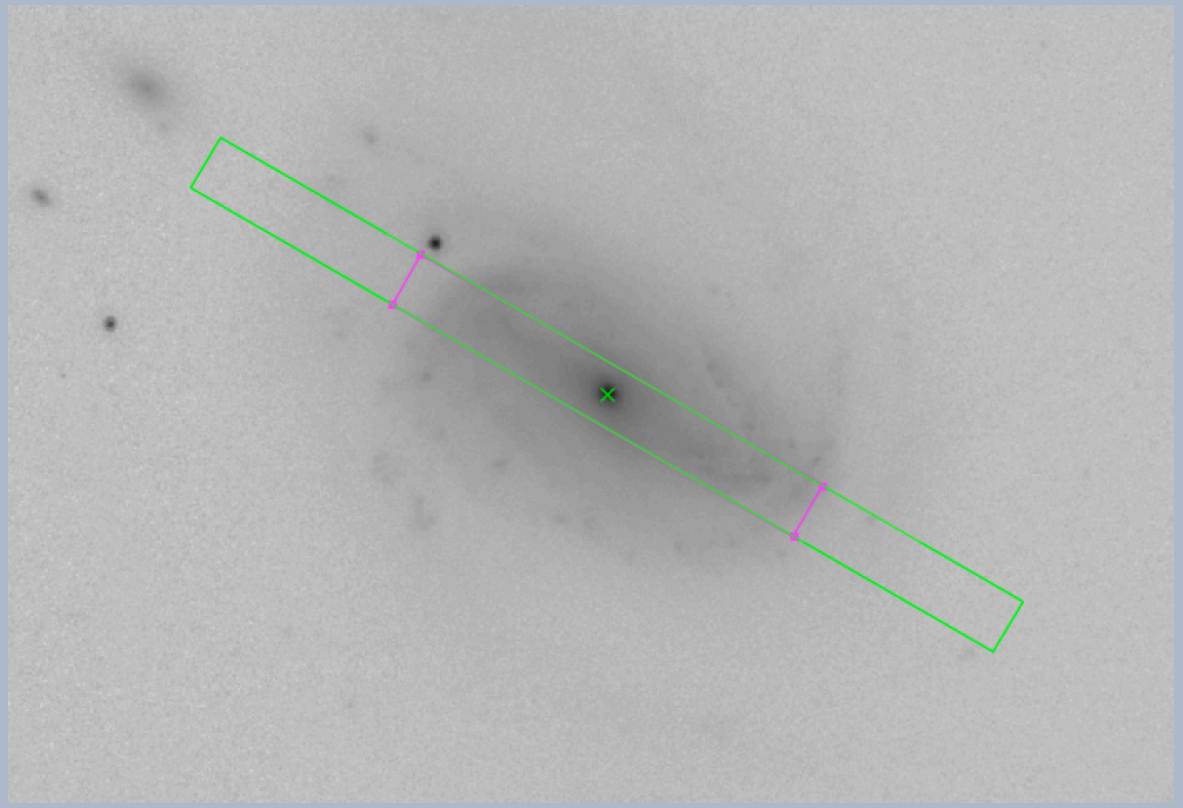


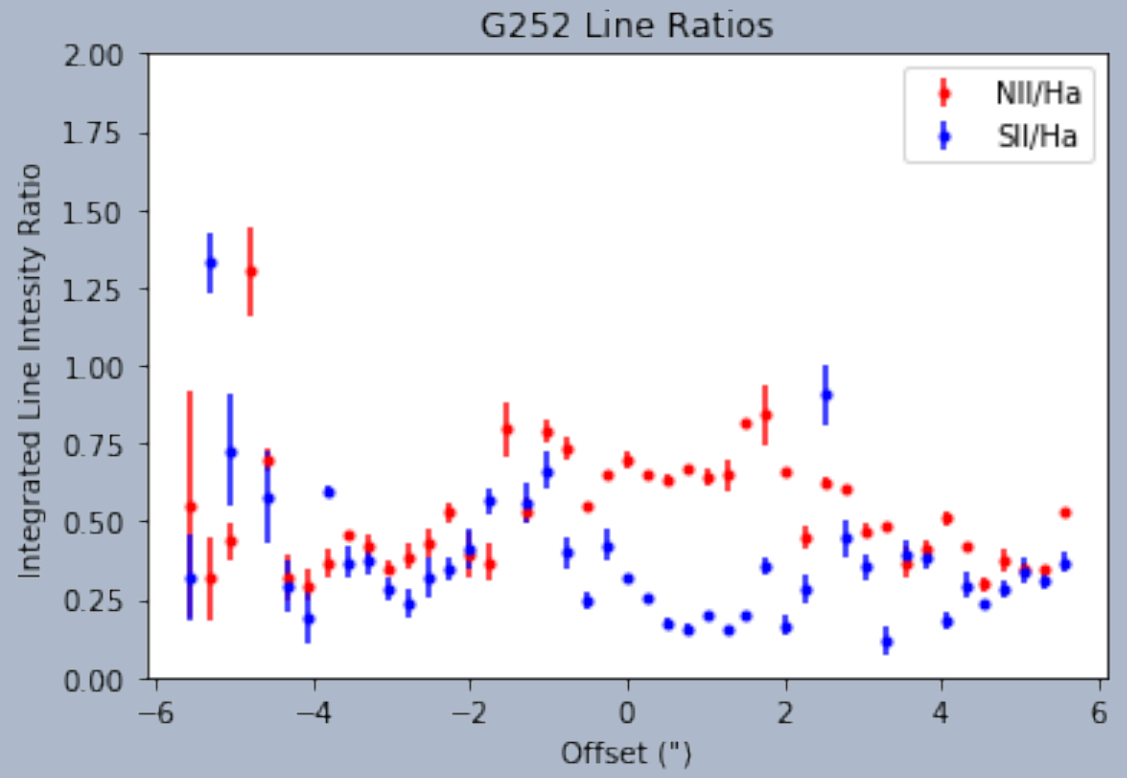
A Spiral at z = 0.072



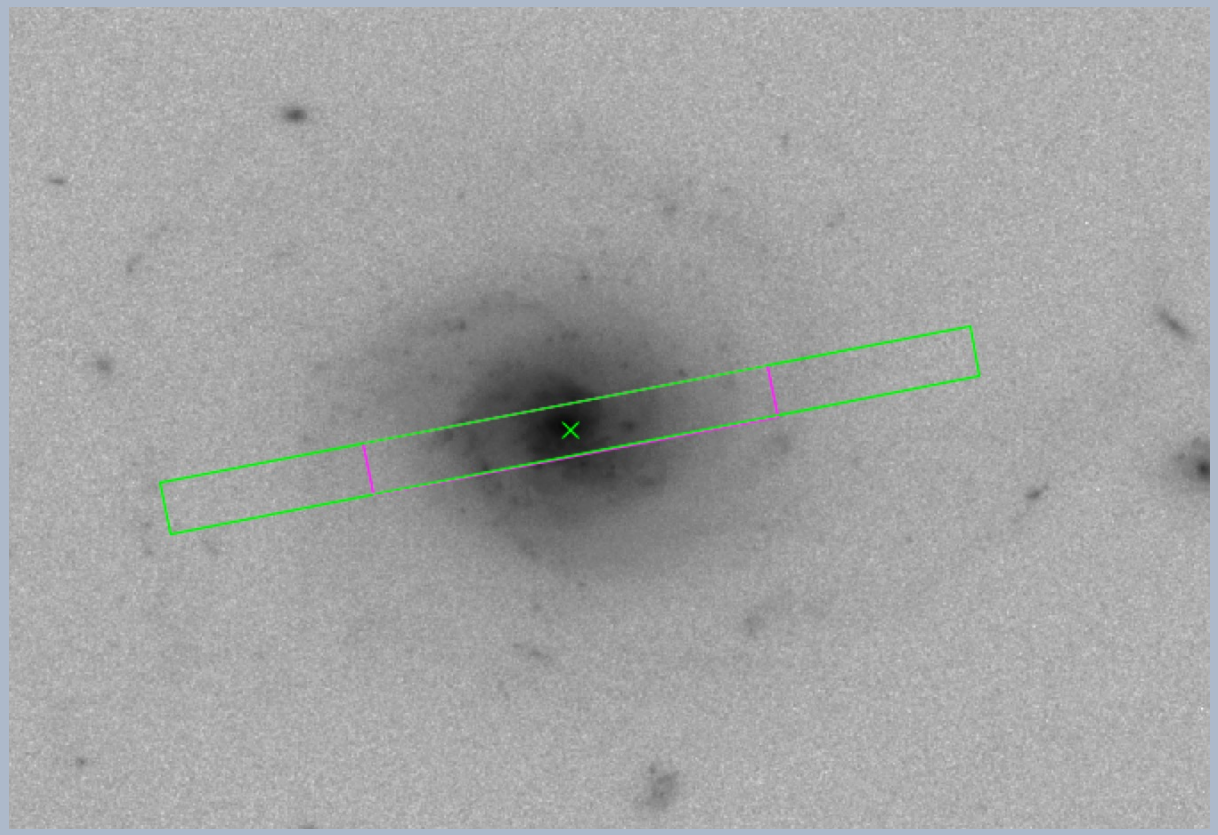


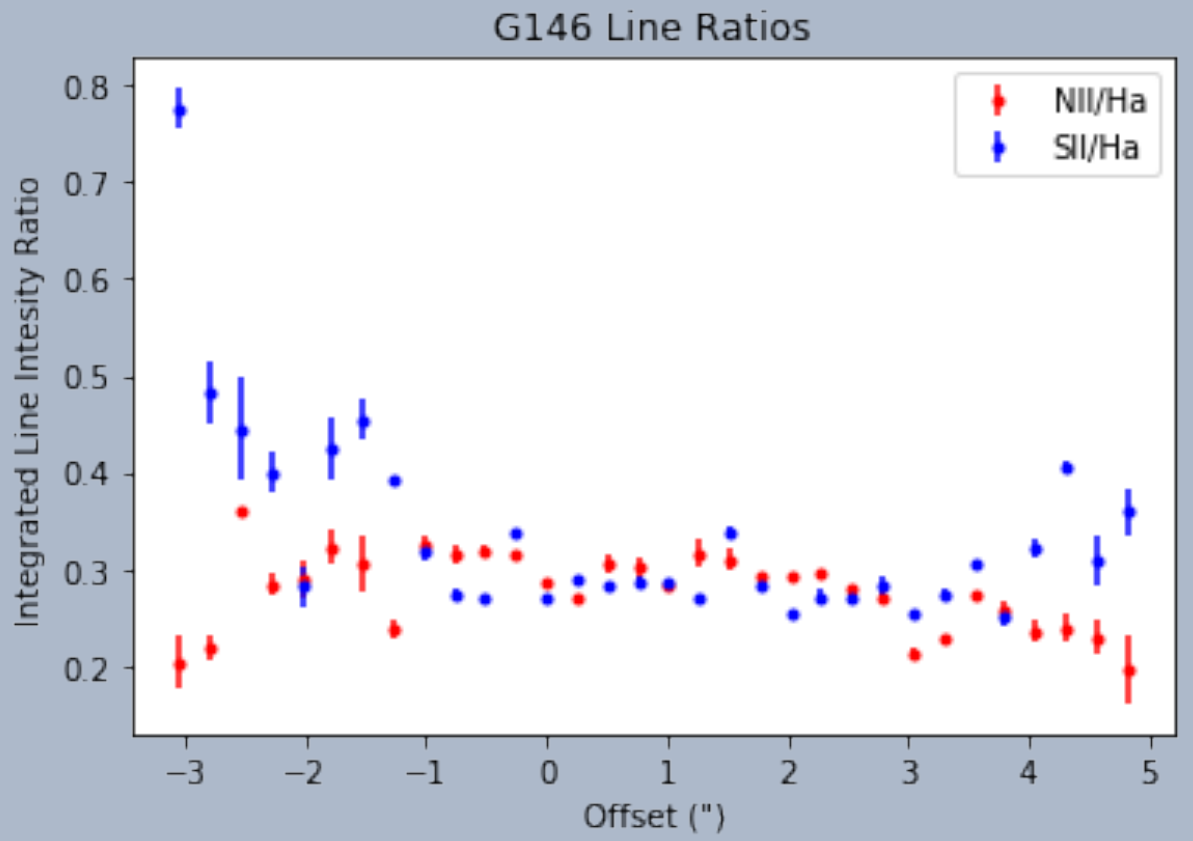
Mapping Line Ratios



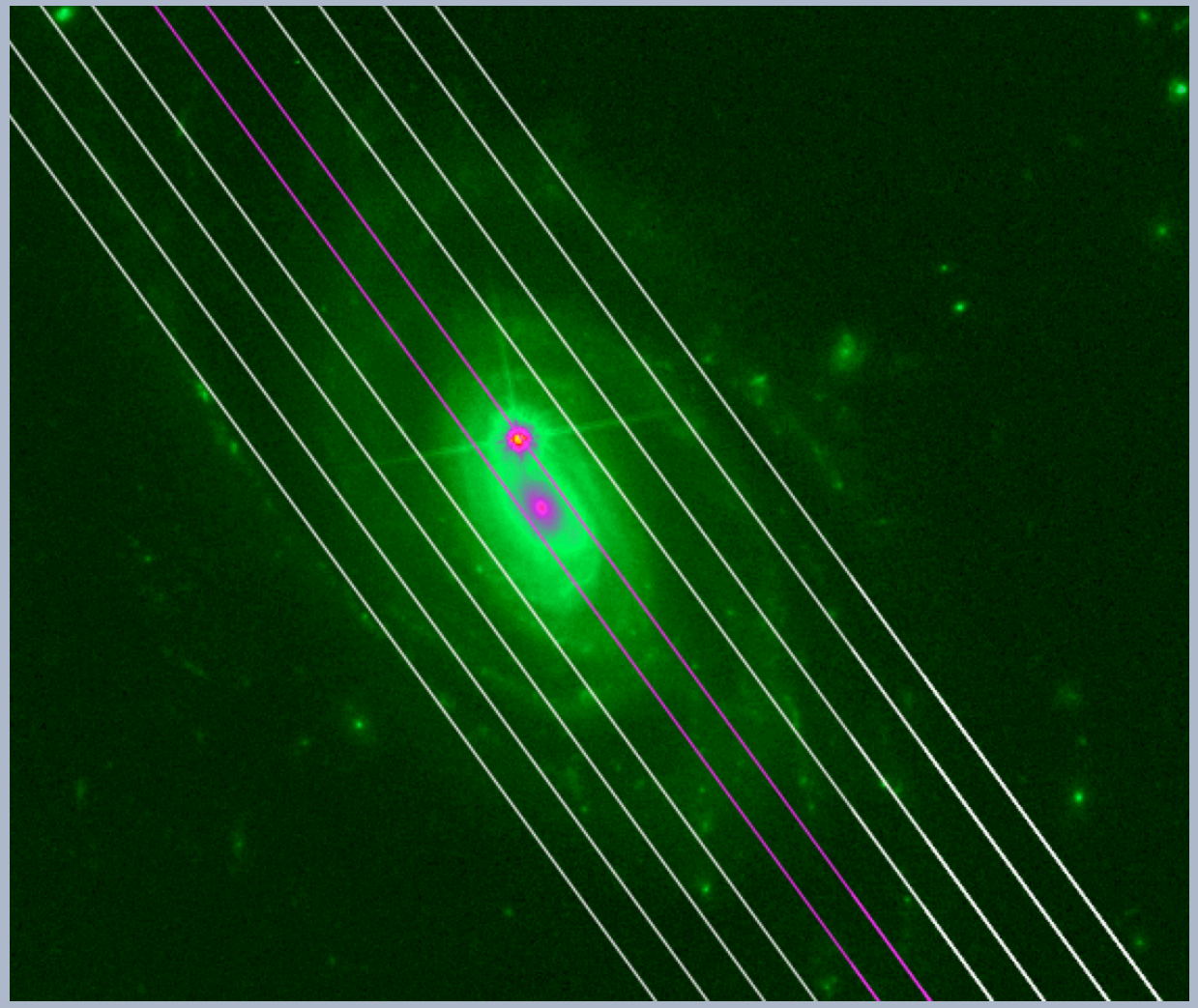


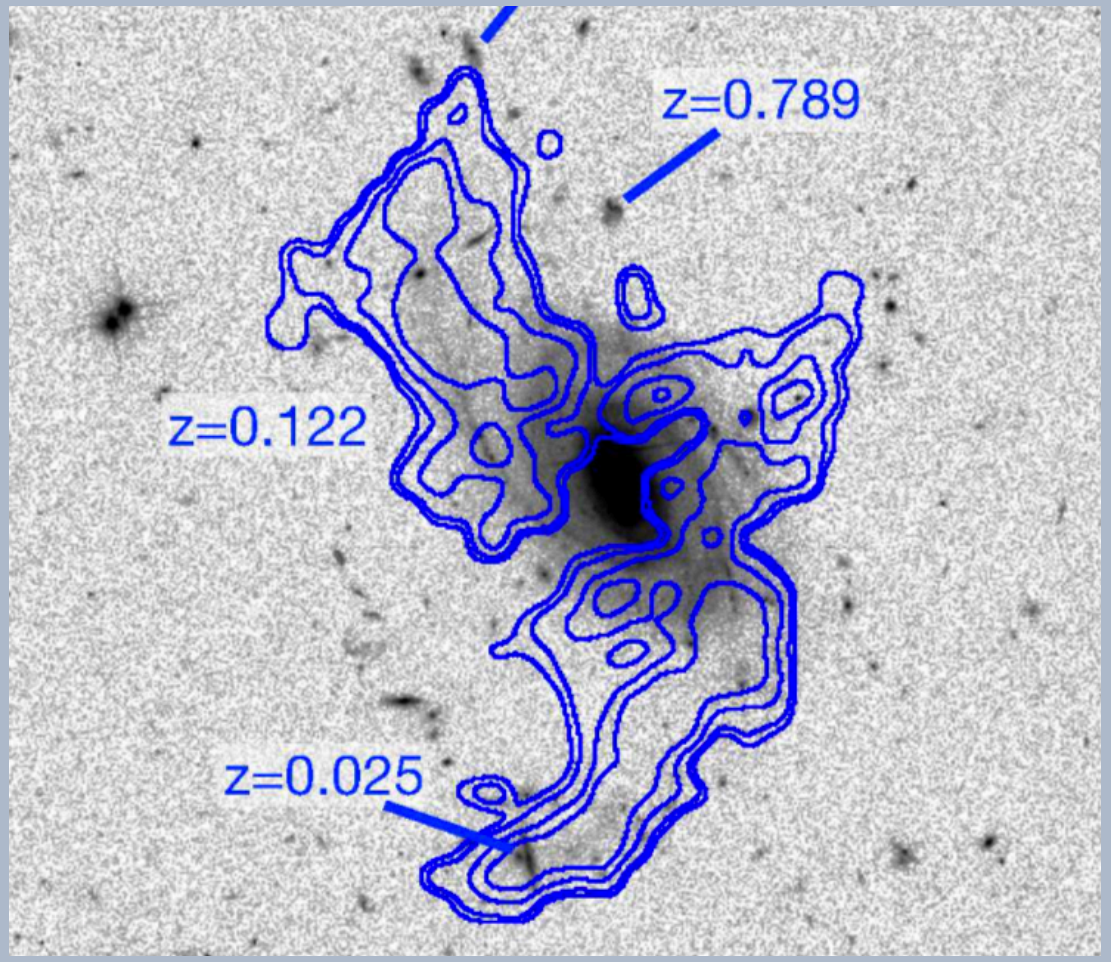
Mapping Line Ratios





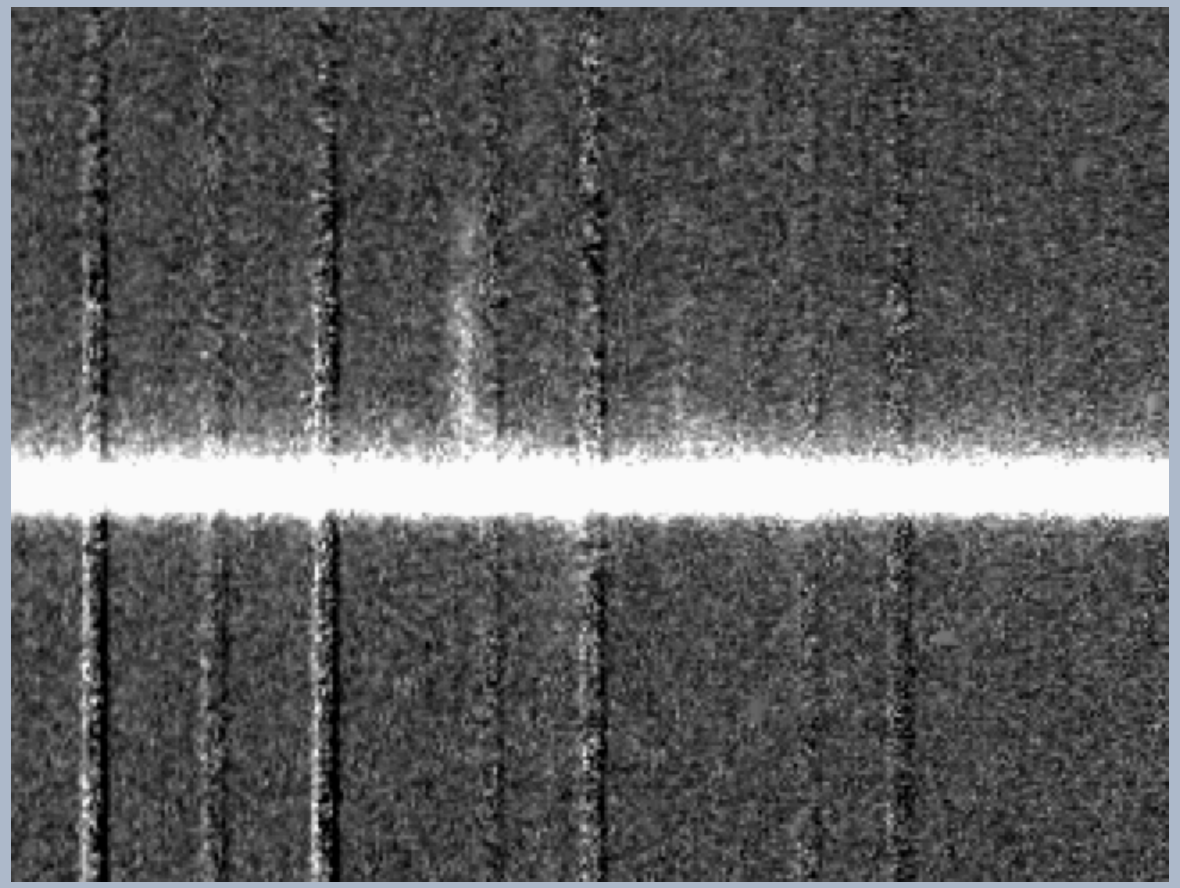
Dithered Longslit Observations at z ~ 0.17





Hess+, submitted MNRAS

Dithered Longslit Observations at z ~ 0.17



Short exposure on central slit, longer exposures for outer slits

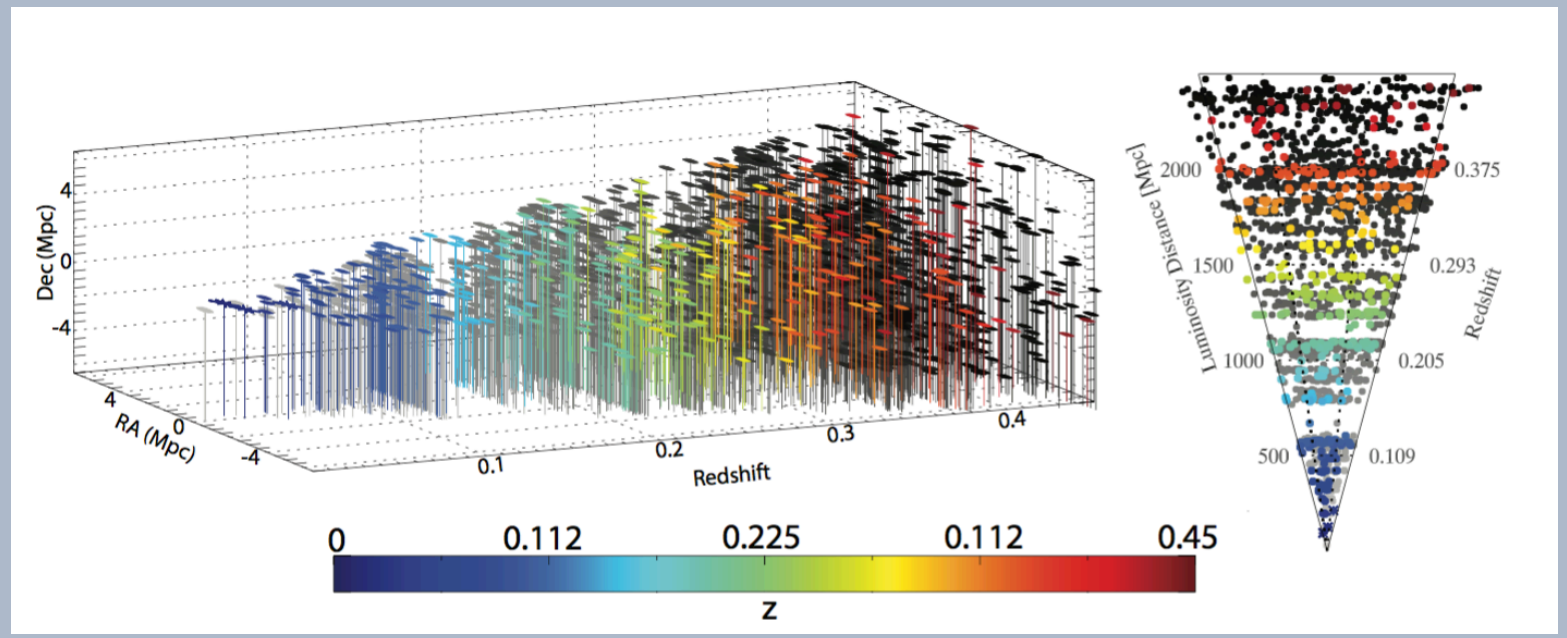
Signal detected in central 3 slits = Success!

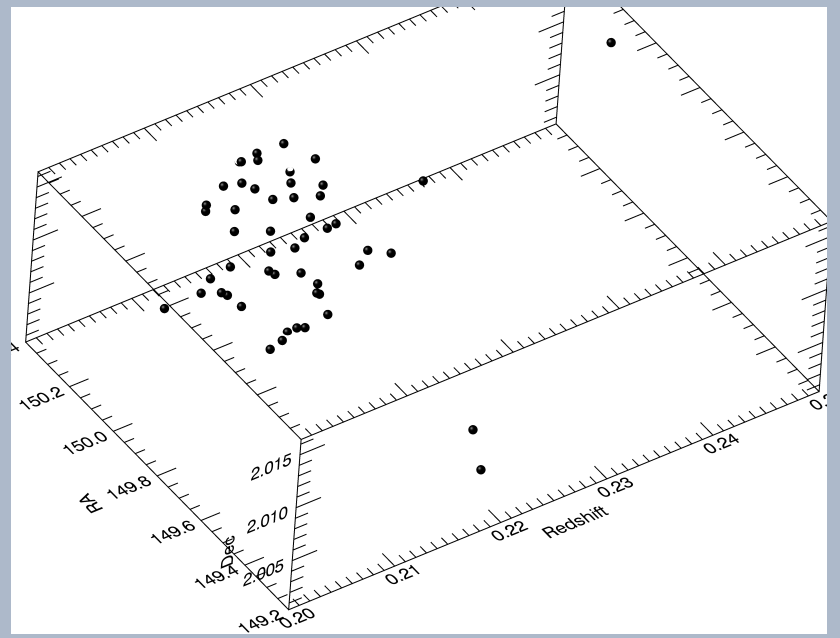
However…

Skylines at z = 0.17 destroyed ability to get complete rotation curves ☹

2D spectrum image from the central slit

MOS Observations of the z ~ 0.22 Wall





Several large scale structures run through the CHILES field, including a “wall” at z ~ 0.22.
We want accurate redshifts for stacking experiments and group studies.

Conclusions

- The first 180 hours on $z < 0.1$ galaxies is the first blind data of this quality to this redshift. It is representative of what we will likely see with MeerKAT and ASKAP.

- We see a variety of neutral and ionized gas kinematic behaviors, but the small sample precludes generalized conclusions about HI in these redshift ranges.

- SALT has been very useful in support of the CHILES survey. Longslit spectra and MOS spectra have been useful, and I hope to use the medium resolution Fabry-Perot on future 2D CHILES kinematic studies.


Photo: Jeff Miller, UW Madison
Questions?
CHILES
COSMOS HI LARGE EXTRAGALACTIC SURVEY