Progress update from MIGHTEE-HI

Natasha Maddox
Astrophysics Theme
University of Bristol

on behalf of the MIGHTEE-HI WG, and Brad Frank (SARAO) and Anastasia Ponomareva (Oxford) in particular

Image credit: SARAO

University of BRISTOL

MIGHTEE: PIs Matt Jarvis (Oxford), Russ Taylor (UCT/IDIA)

- MeerKAT International Giga-Hertz Tiered Extragalactic Exploration
- Covers 20 deg^2 of sky, in fields with extensive multi-wavelength data
- "Medium-deep, medium-wide" parameter space for SKAO-type surveys
- Observes radio continuum, spectral line, and polarisation ("*commensality*")

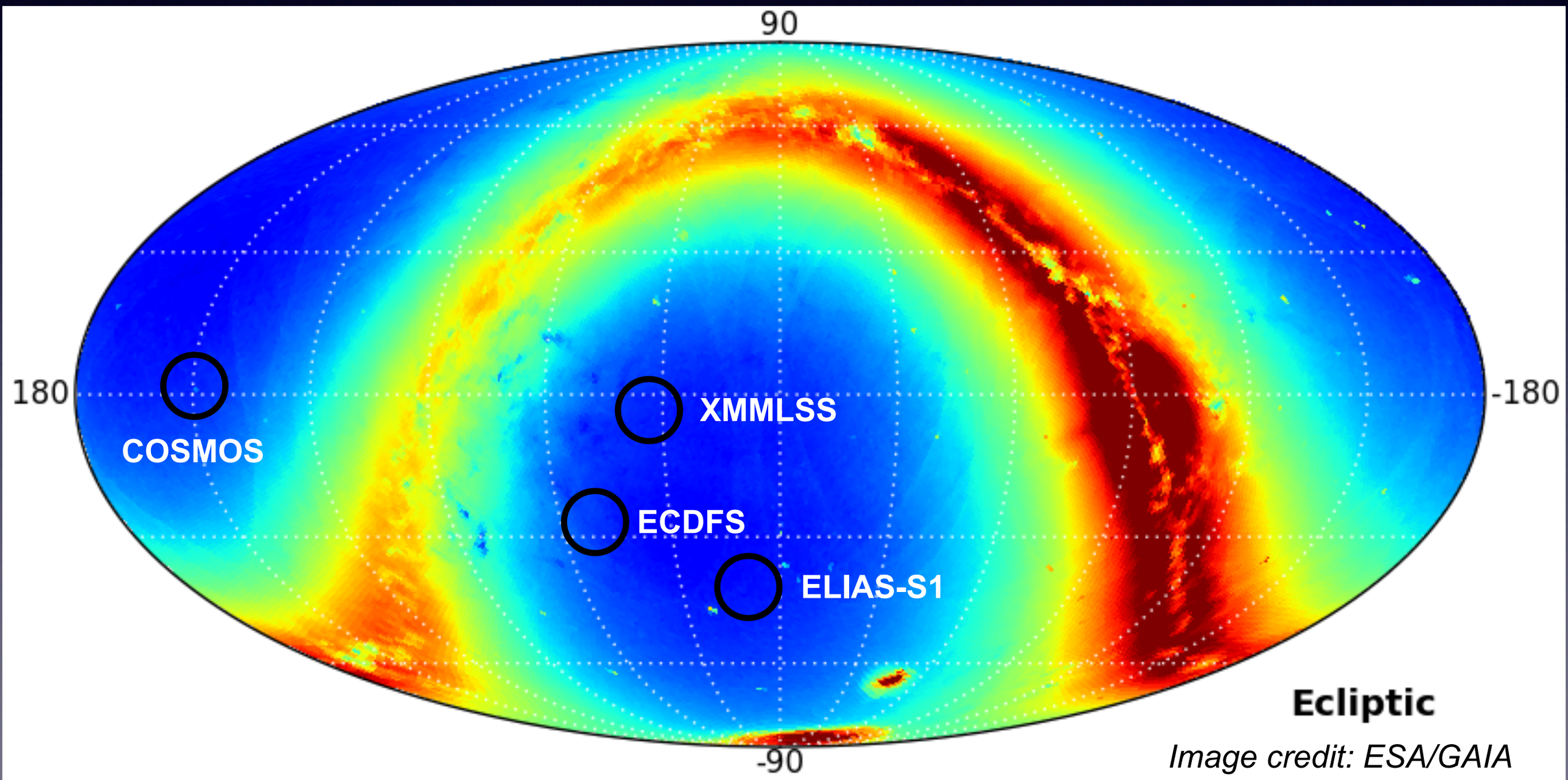
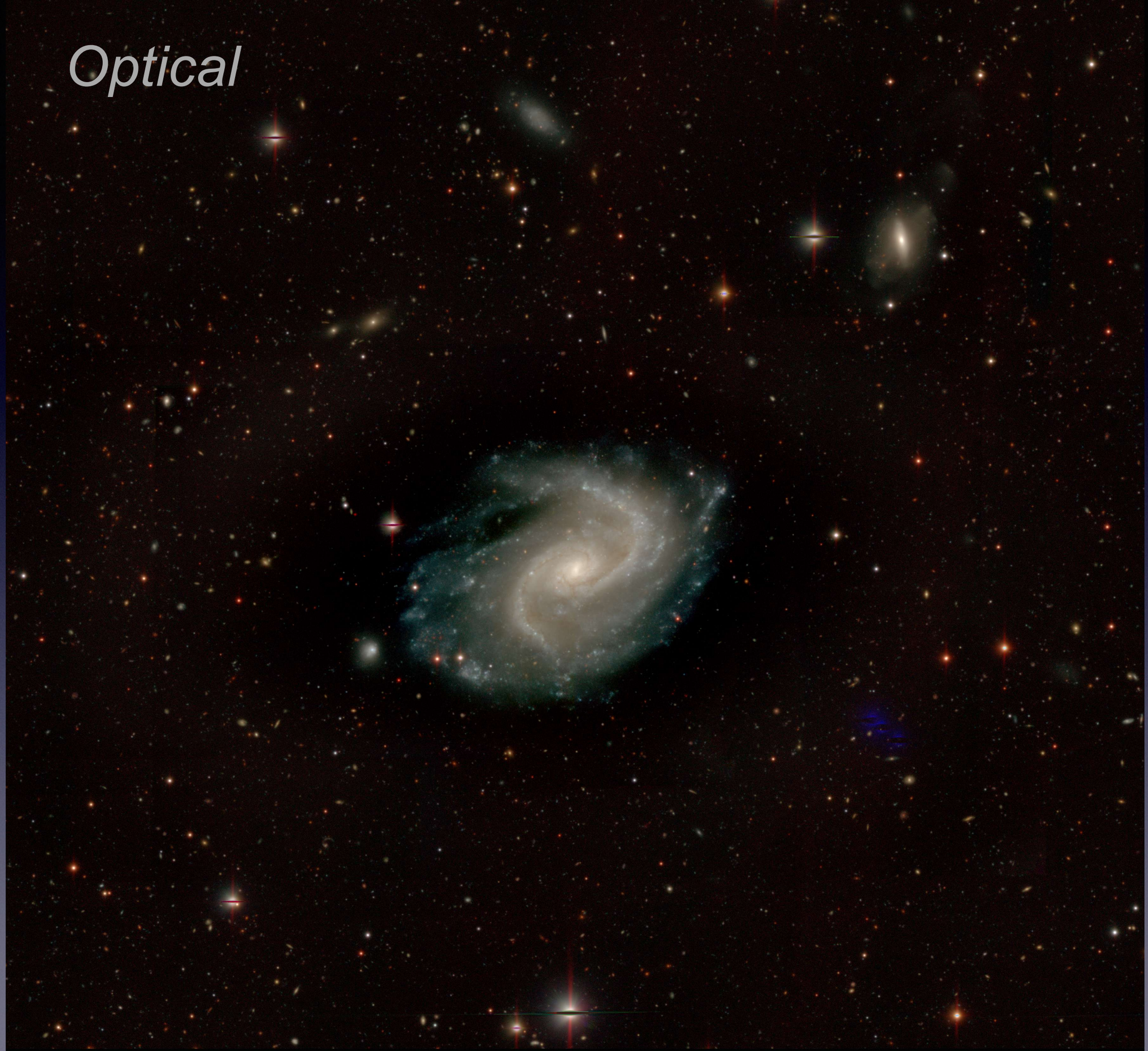
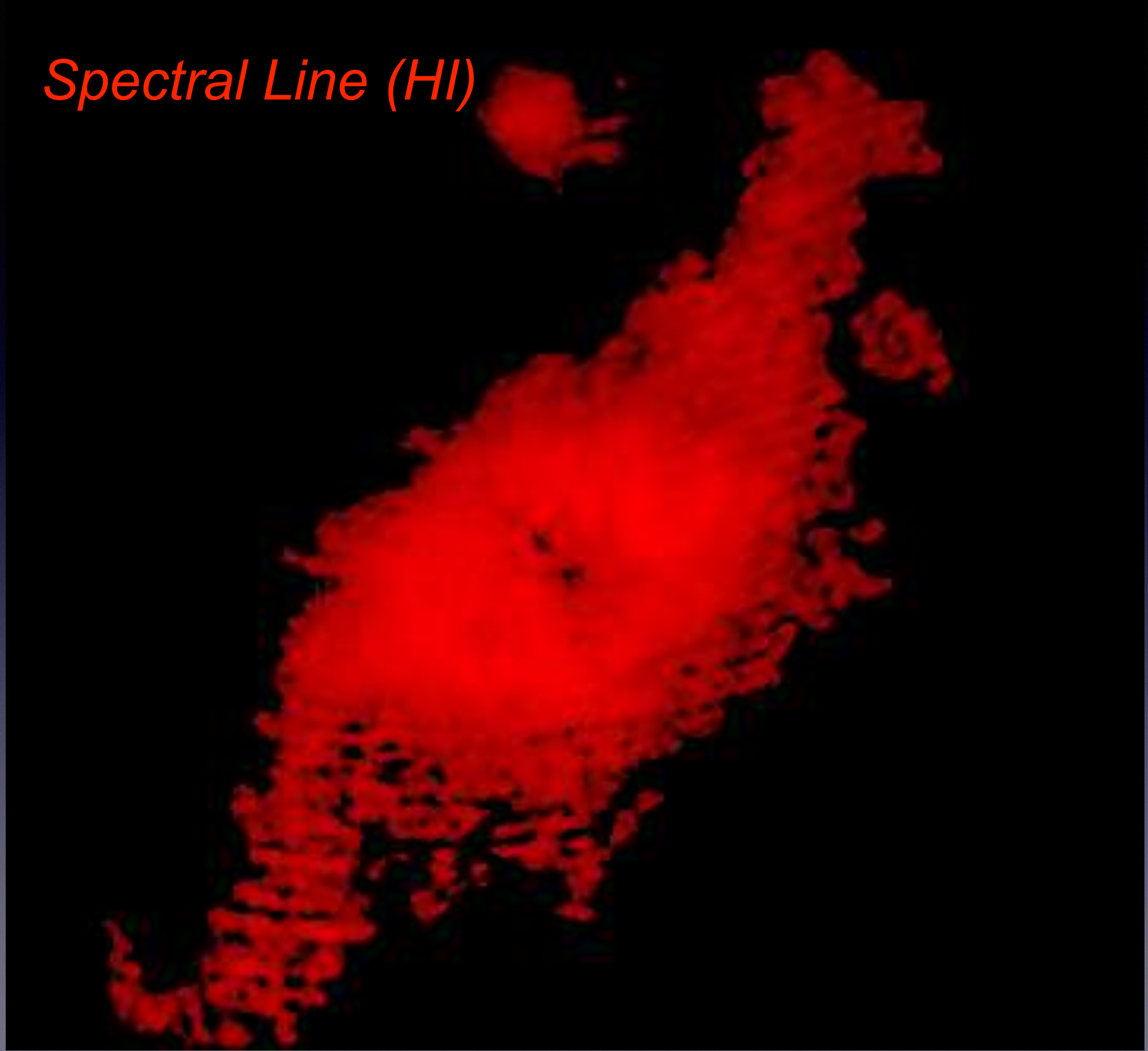
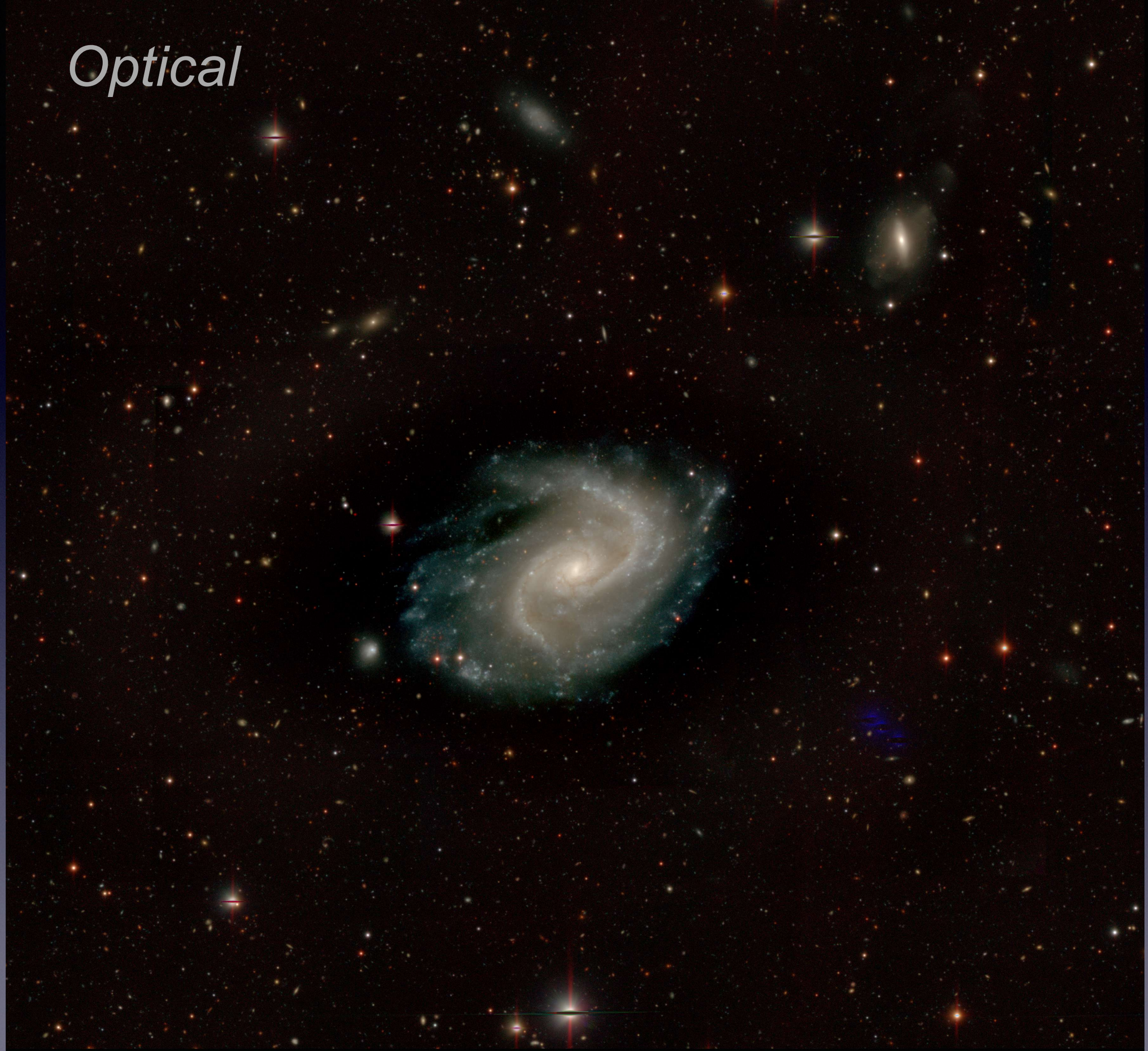


Image credit: ESA/GAIA


Optical

Spectral Line (HI)




Optical

Radio Continuum

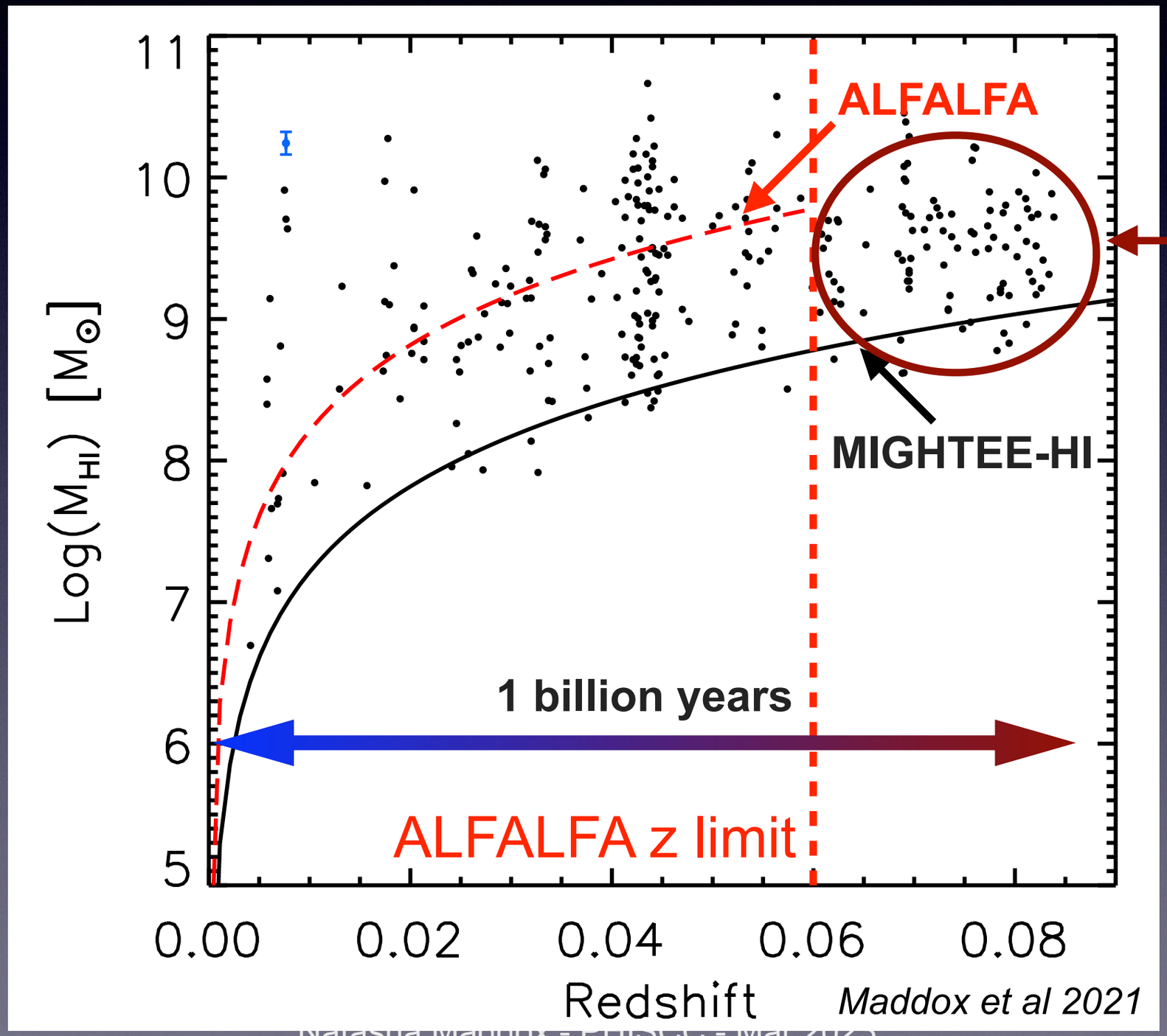
MeerKAT Early Science

- Observations 2018 — 2019
- ~all 64 dishes observing
- “4k-mode” = 208kHz (44km/s) channels, cf “32k-mode” 26kHz (5.5km/s)

Image credit: SARAO

MIGHTEE-HI Early Science

- Early Science observations done: 5 deg^2, 44km/s channels
- Nearly 300 sources 0<z<0.084, higher redshifts not inspected
- x10 deeper than ALFALFA, and resolved



Blind sample of objects we didn't have before, and they are resolved

MIGHTEE-HI results so far…

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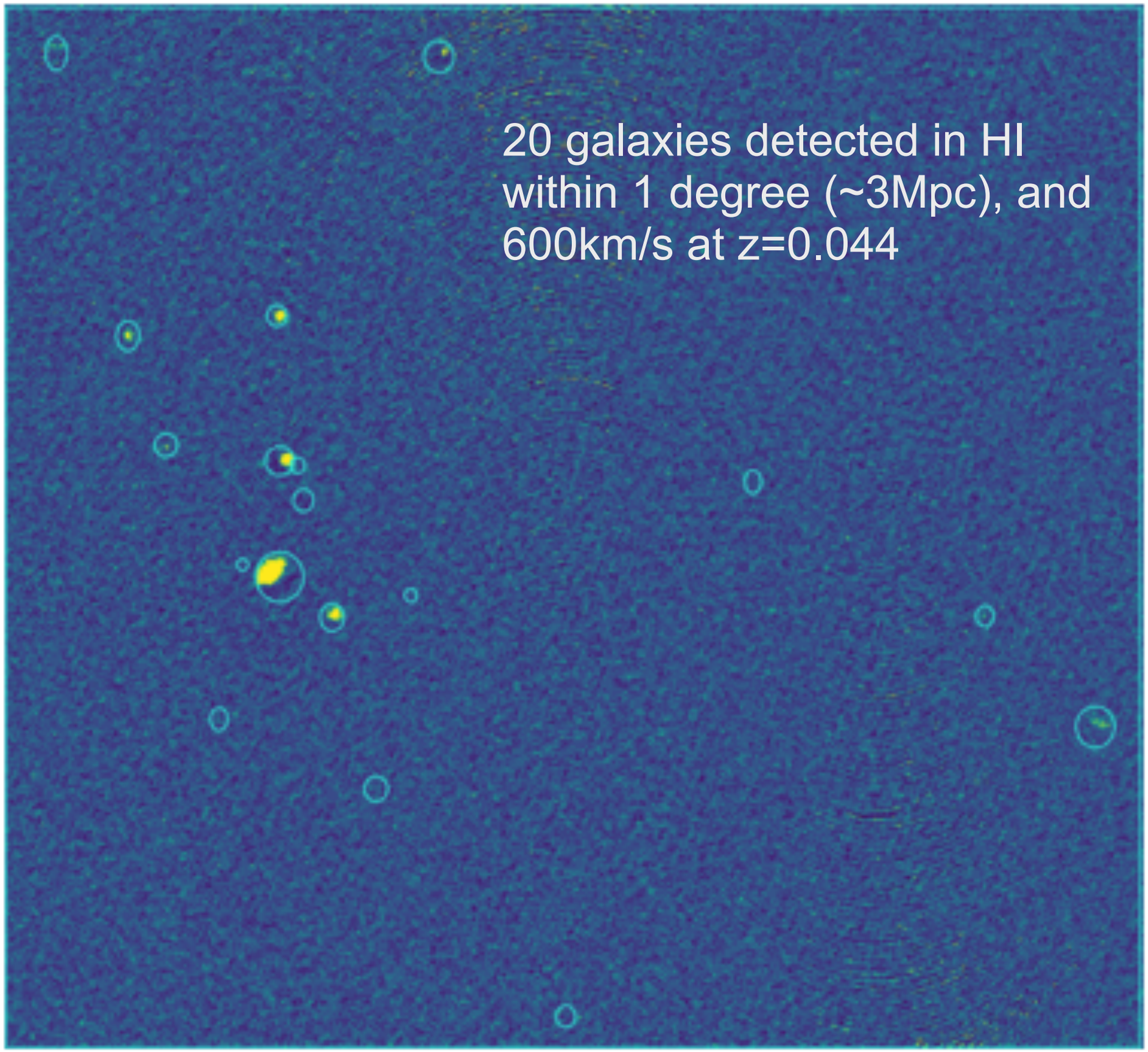
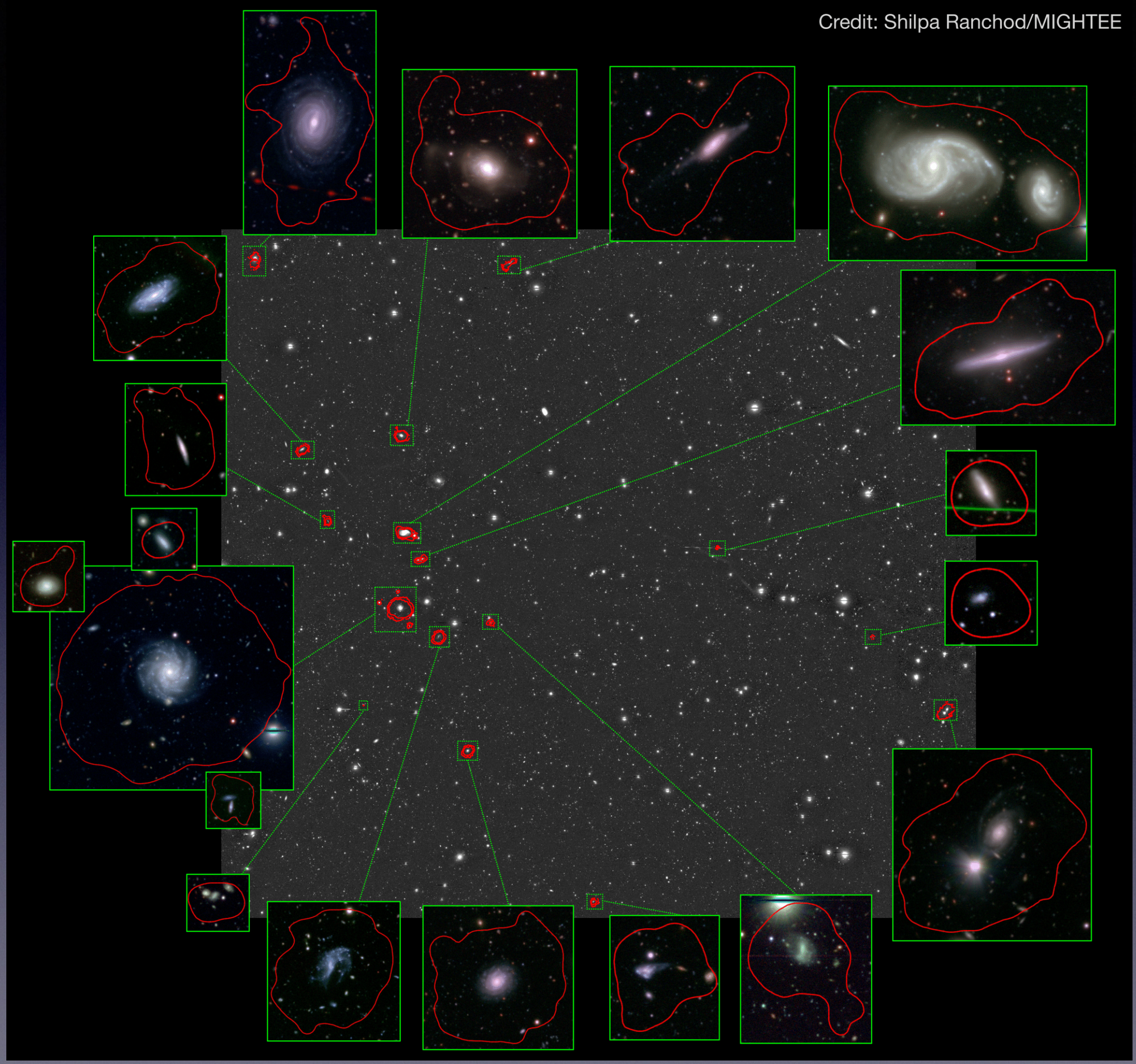
Galaxy group in HI





Natasha Maddox - PHISCC - Mar 2023

MIGHTEE-HI: Discovery of an H I-rich galaxy group at $z = 0.044$ with MeerKAT

Shilpa Ranchod[1,2⋆], Roger P. Deane,[1,2], Anastasia A. Ponomareva[3], Tariq Blecher[4], Bradley S. Frank[5,6,7], Matt J. Jarvis[3,8], Natasha Maddox[9], Wanga Mulaudzi[5], Marcin Glowacki[8,10], Kelley M. Hess[11,12], Madalina Tudorache[3], Lourdes Verdes-Montenegro[13], Nathan J. Adams[3], Rebecca A. A. Bowler[3], Jordan. D. Collier[7,14], Russ Taylor[7,10]

[1] *Department of Physics, University of Pretoria, Private Bag X20, Pretoria 0028, South Africa*
[2] *Wits Centre for Astrophysics, School of Physics, University of the Witwatersrand, 1 Jan Smuts Avenue, 2000, South Africa*
[3] *Astrophysics, University of Oxford, Denys Wilkinson Building, Keble Road, Oxford OX1 3RH, UK*
[4] *Department of Physics and Electronics, Rhodes University, PO Box 94, Grahamstown 6140, Eastern Cape, South Africa*
[5] *Department of Astronomy, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa*
[6] *South African Radio Astronomy Observatory, 2 Fir Street, Observatory, 7925, South Africa*
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[8] *Department of Physics and Astronomy, University of the Western Cape, Robert Sobukwe Road, Bellville 7535, South Africa*
[9] *Faculty of Physics, Ludwig-Maximilians-Universität, Scheinerstr. 1, 81679 Munich, Germany*
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[11] *ASTRON, the Netherlands Institute for Radio Astronomy, Postbus 2, 7990 AA, Dwingeloo, The Netherlands*
[12] *Kapteyn Astronomical Institute, University of Groningen, P.O. Box 800, 9700 AV Groningen, The Netherlands*
[13] *Instituto de Astrofísica de Andalucía (IAA-CSIC), Glorieta de la Astronomía, 18008 Granada, Spain*
[14] *School of Science, Western Sydney University, Locked Bag 1797, Penrith, NSW 2751, Australia*

- Two strange things about this galaxy group:
  - 1: it is in a well-studied patch of sky and nobody saw it?
  - 2: HI doesn't like being in groups (or so we thought)

➡ Maybe HI traces LSS differently than optical spectroscopy

- Lessons learned:
  - Cubes don't have to be perfect to get results
  - Students are keen to do work on short timescales

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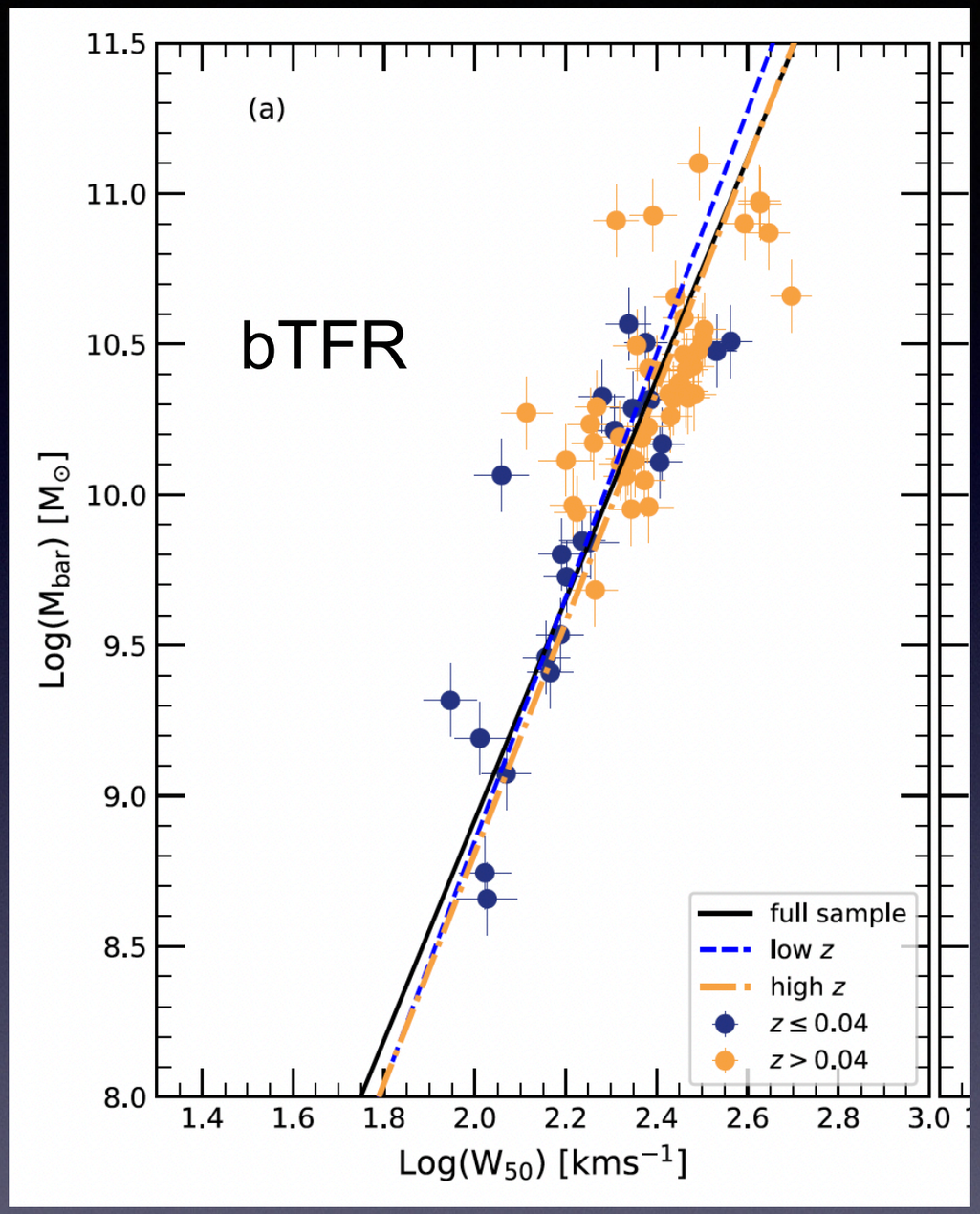
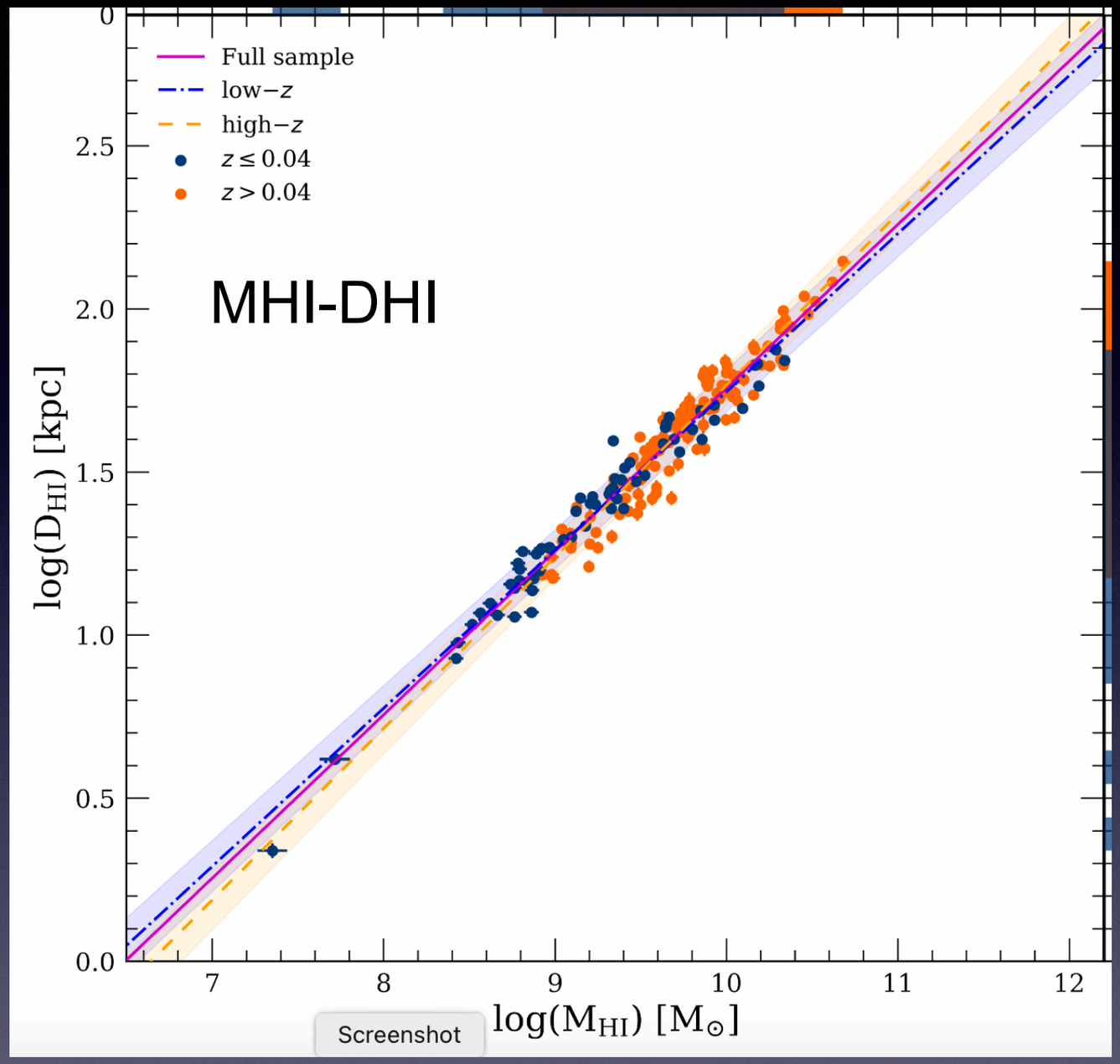
Scaling relations over redshift from blind samples





- Lessons learned:
  - Some science does not need high spectral resolution
  - Don’t be afraid to try things out

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Using HI to probe something else

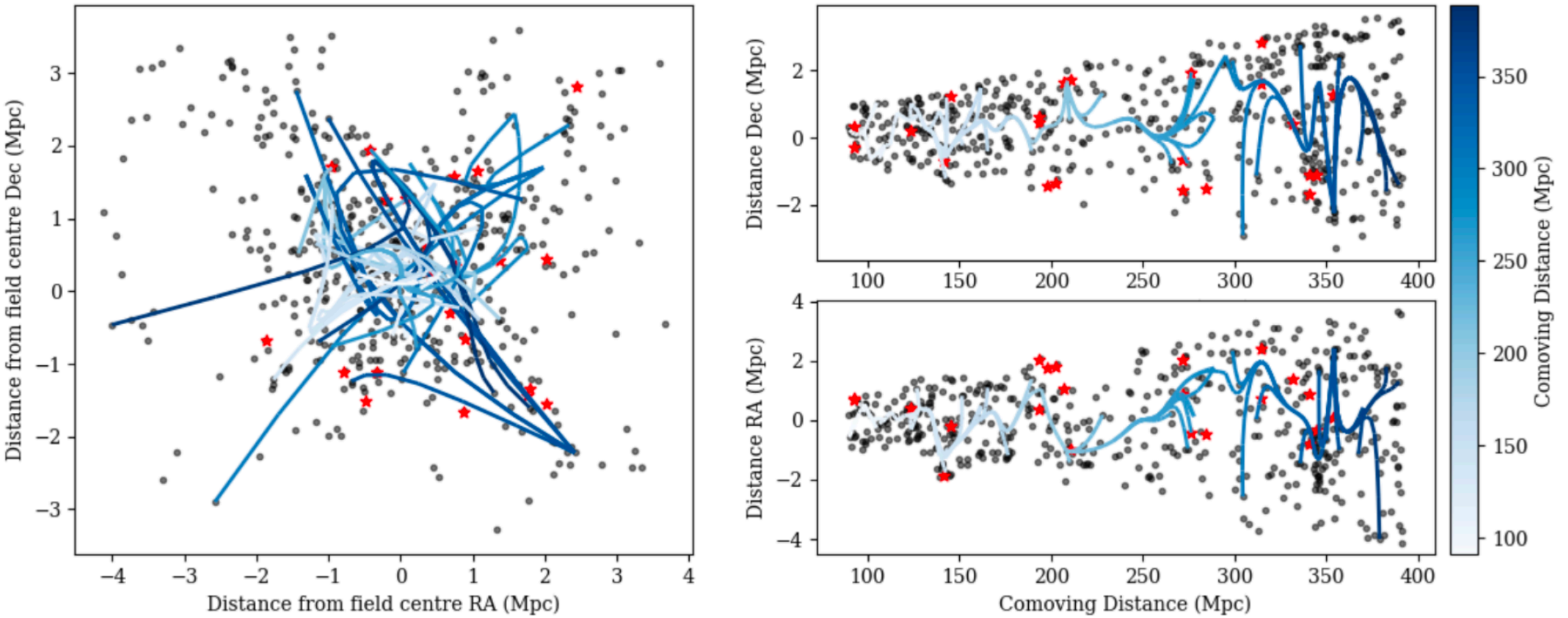
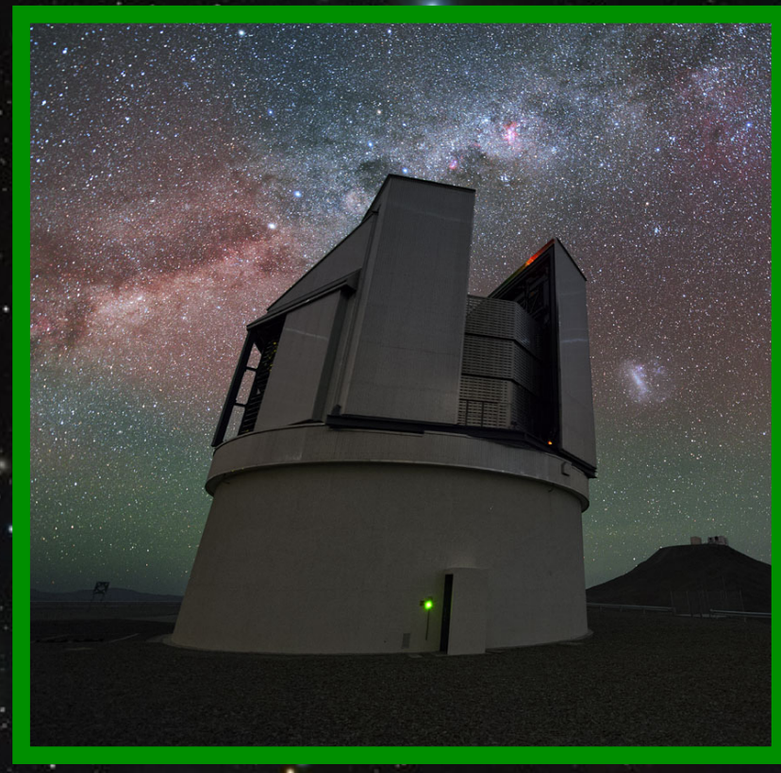


Figure 1. The filament distribution projected in 2D obtained by running DisPerSE with mirror boundary conditions for the COSMOS catalogue in a redshift interval $0.02 < z < 0.09$. Left: Angular distance in right ascension versus angular distance in declination. Top right: Radial comoving distance versus angular distance in declination. Bottom right: Radial comoving distance versus angular distance in right ascension of the filament distribution overlaid on top of the galaxies in the optical sample. The red stars represent the HI galaxies detected by MIGHTEE. The colour bar represents the radial comoving distance in Mpc.

- Lessons learned:
  - HI can be used as a tool for other investigations
  - Those other investigations may rely on additional data

HI surveys do not exist in isolation



Extend HI knowledge to higher redshifts: spectral stacking

- Instead of observing 1 target for N hours, observe N targets for 1 hour and stack
- Easy in imaging, more difficult in spectral line, as the spectral features must be aligned in redshift/frequency/wavelength

➡ HI stacking requires extensive optical spectroscopy to get accurate redshifts for stacking

Radio selected (star formation)

Optically selected (stellar mass)

Both with 4MOST

Optical selection vs radio selection vs HI selection

- An HI survey **is a spectroscopic survey**

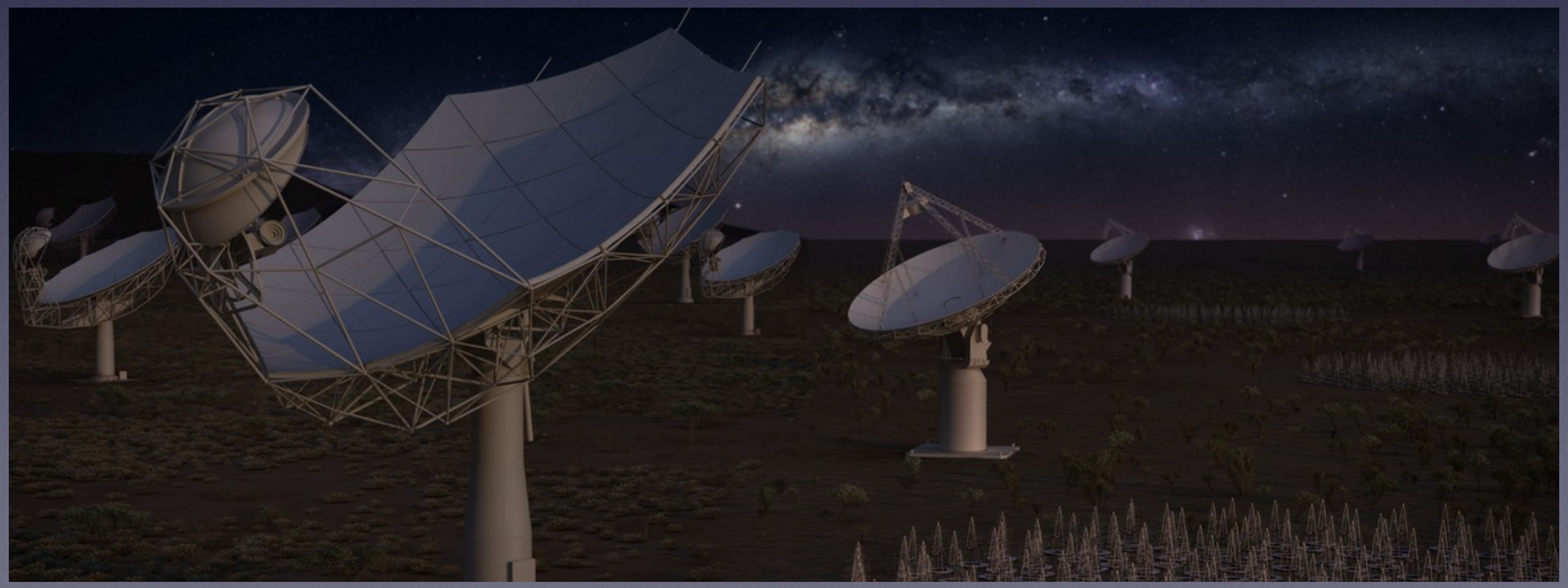
Radio selected

ORCHIDSS

Optically selected

WAVES
Wide Area Vista Extragalactic Survey

HI selected



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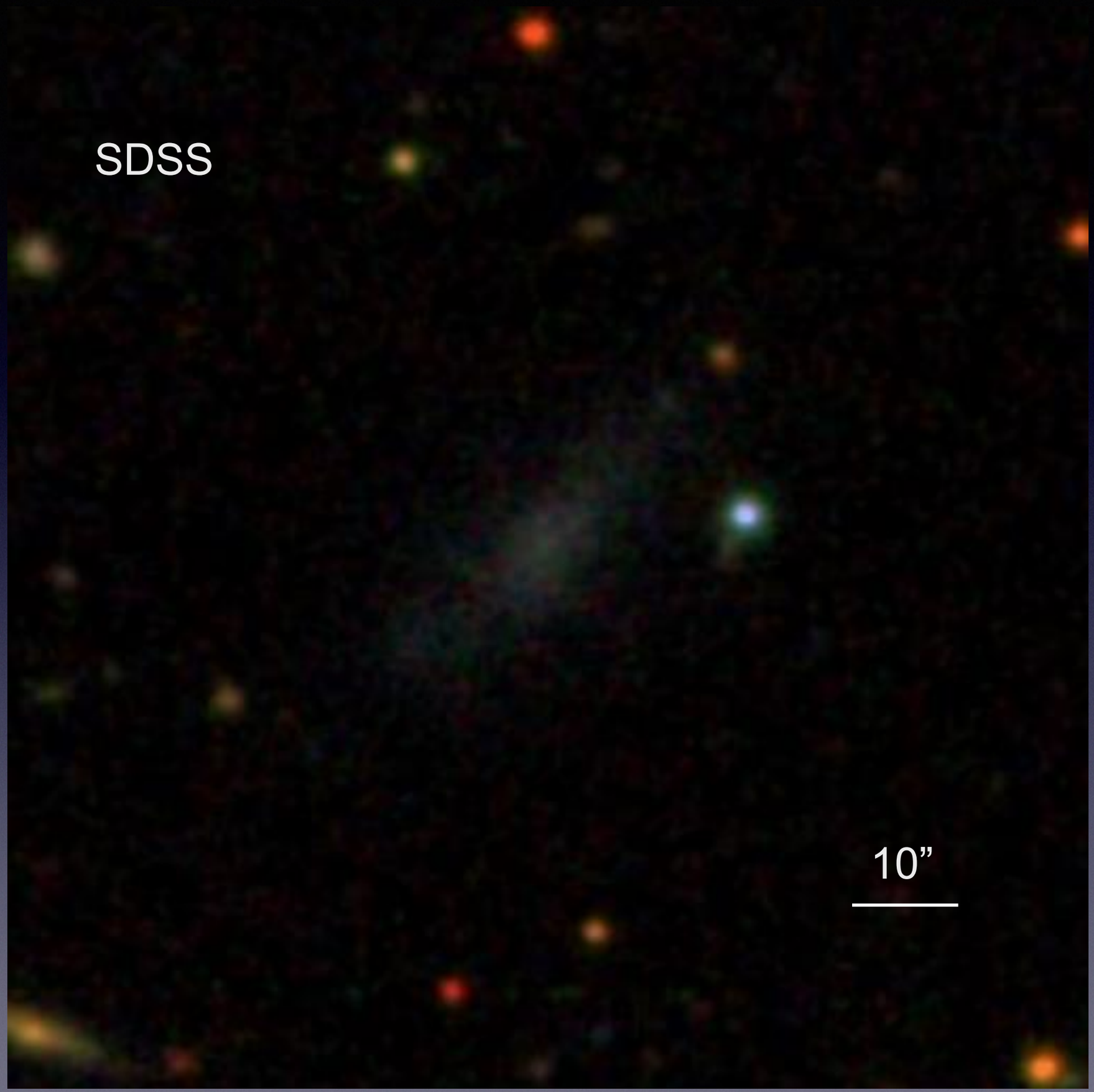
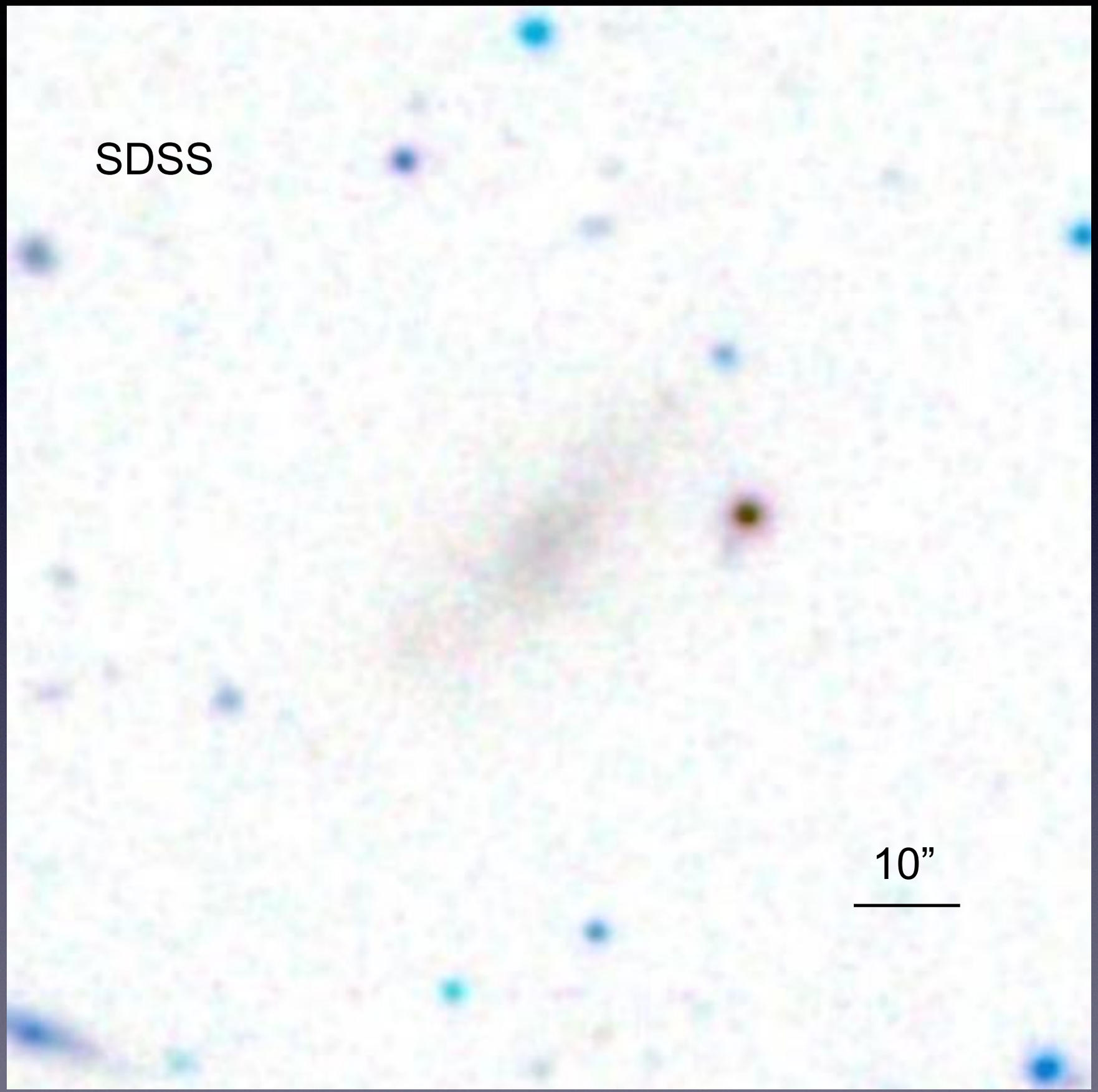

SDSS
10”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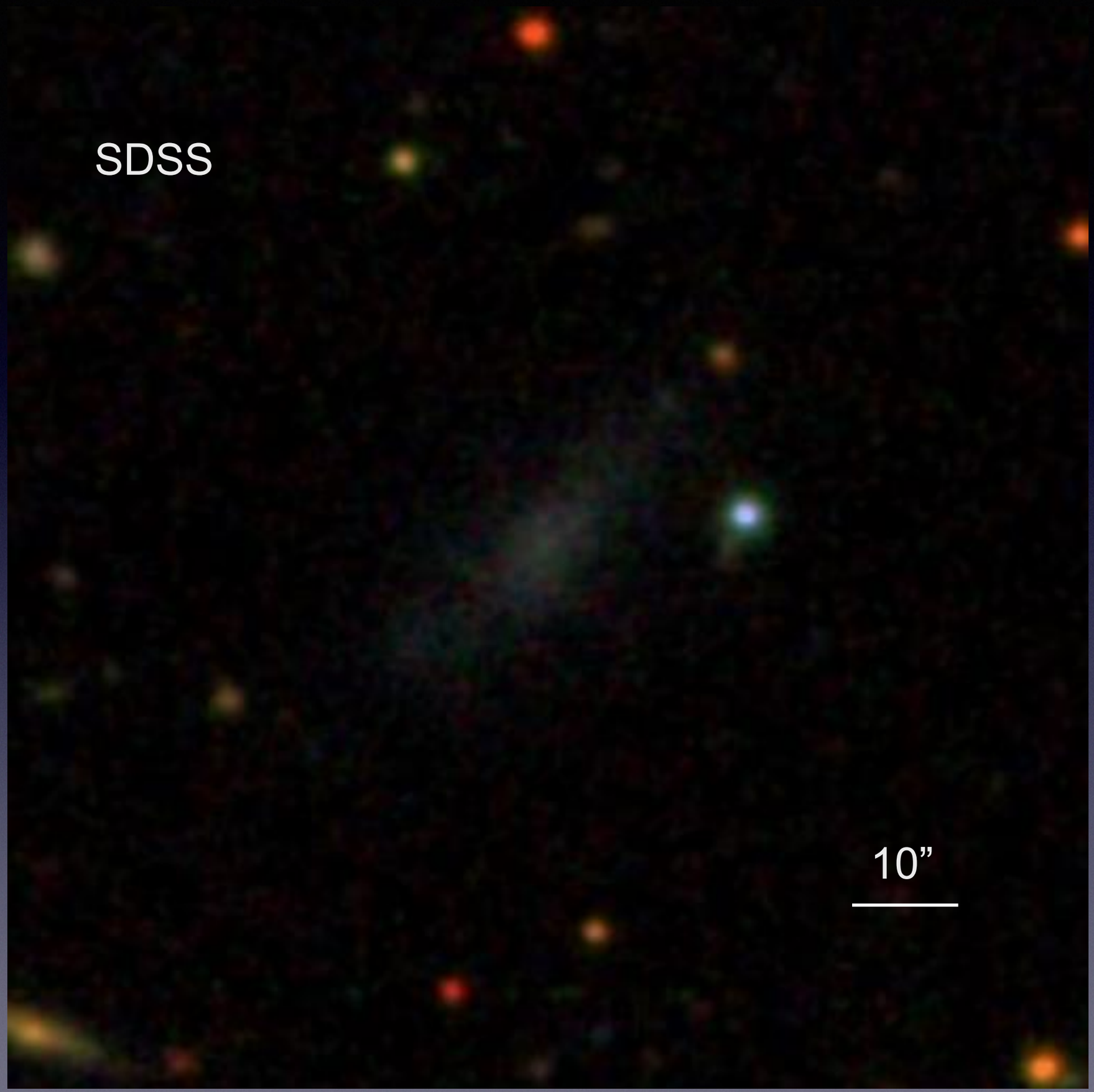
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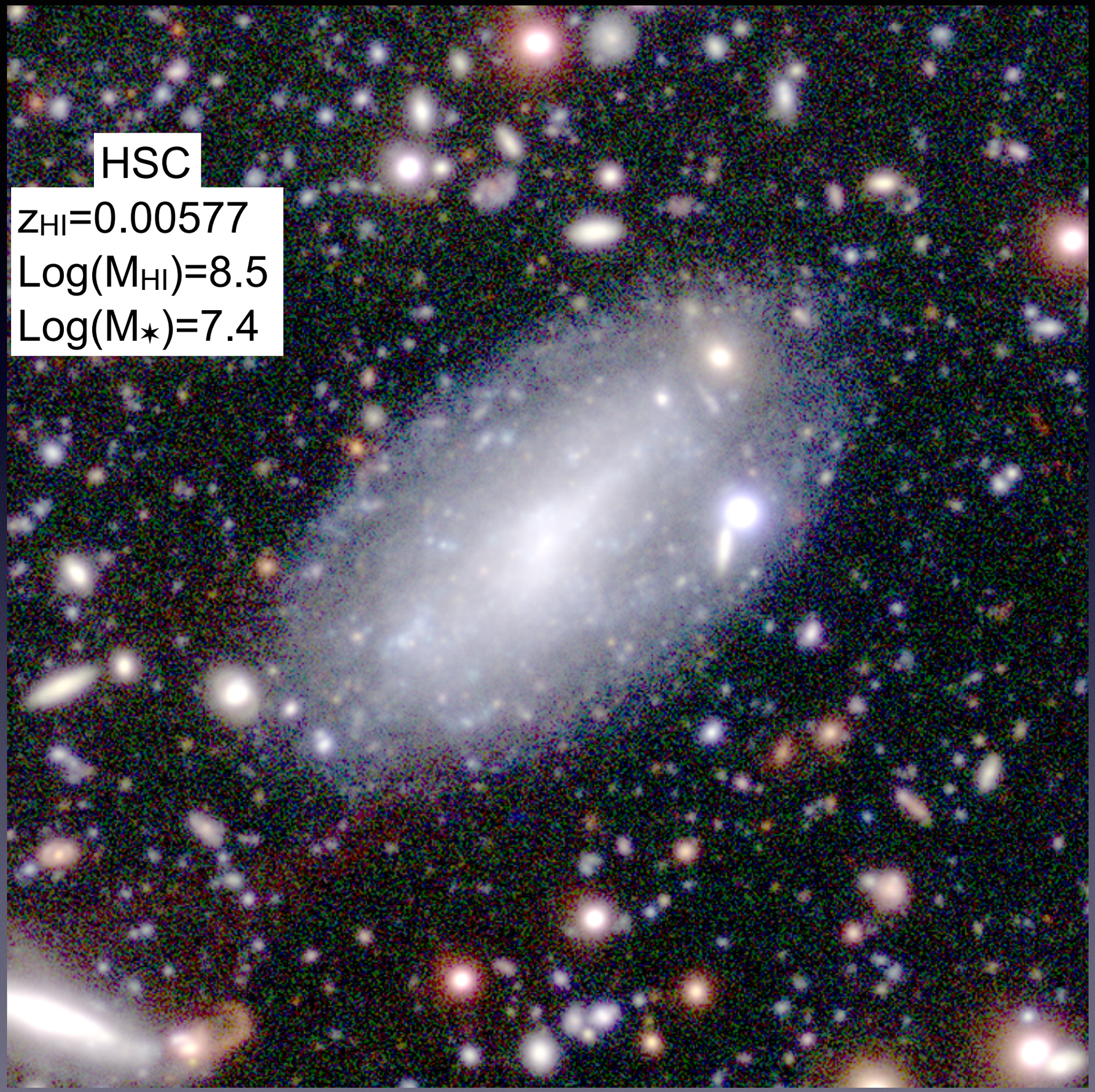
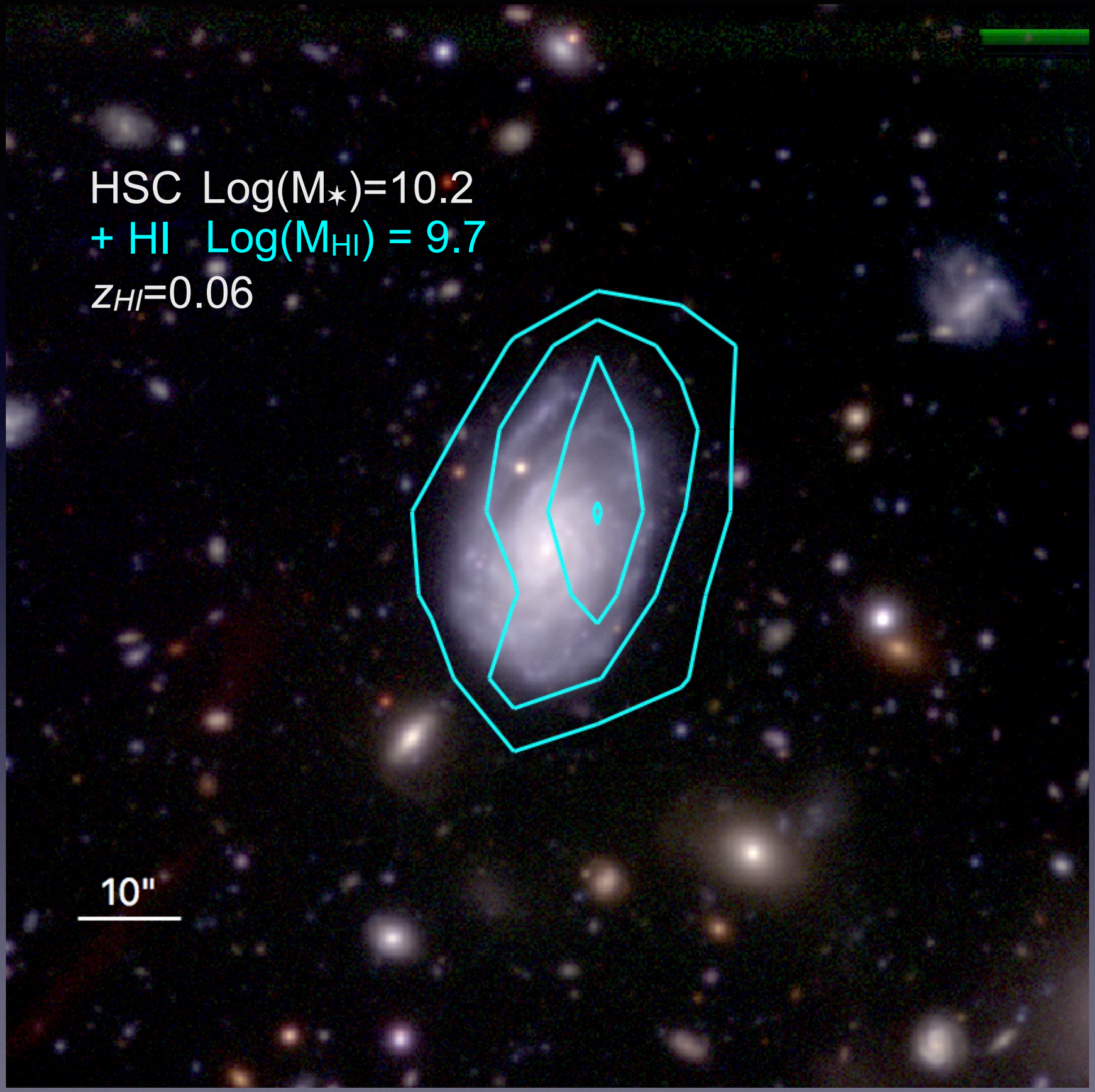

HSC
z_{HI}=0.00577
Log(M_{HI})=8.5
Log($M_\star$)=7.4

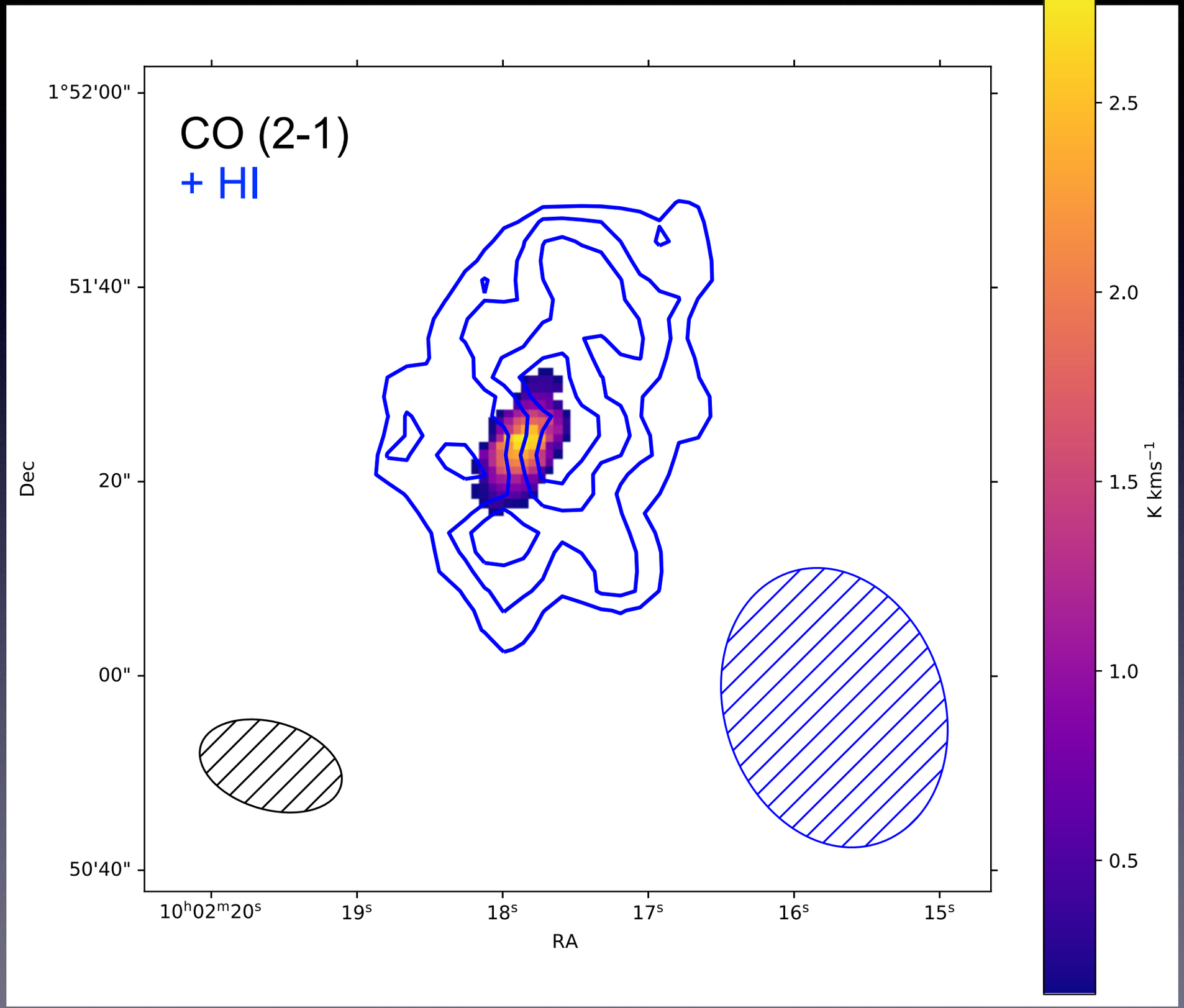
To fully take advantage of SKAO-era facilities, we need equally deep imaging

- Need deep imaging just to see the counterparts (or rule out no counterpart)
- HI-detected galaxies can be low surface brightness in optical → difficult to get an optical spectrum
- HI provides the redshift

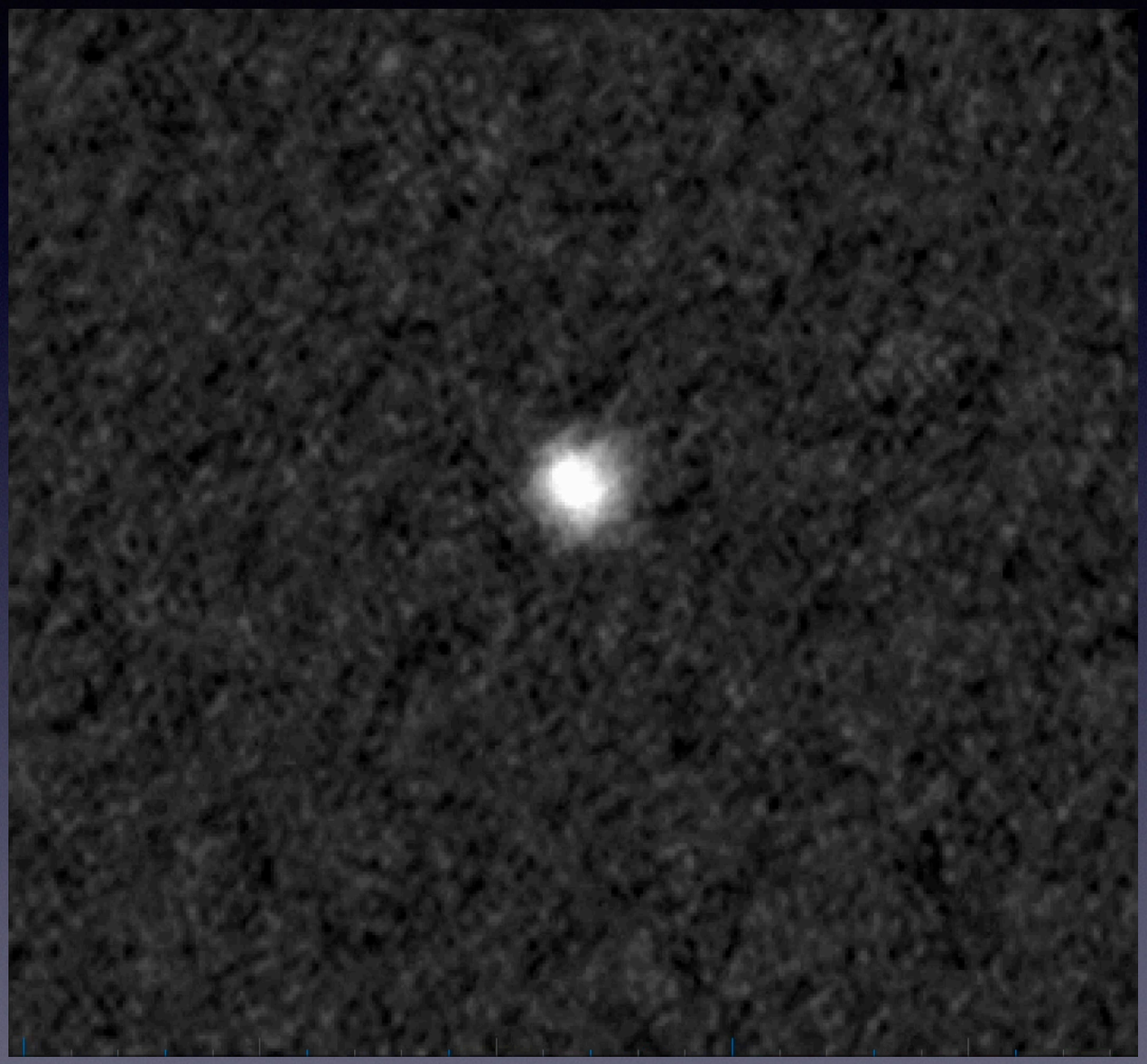
HI surveys do not exist in isolation

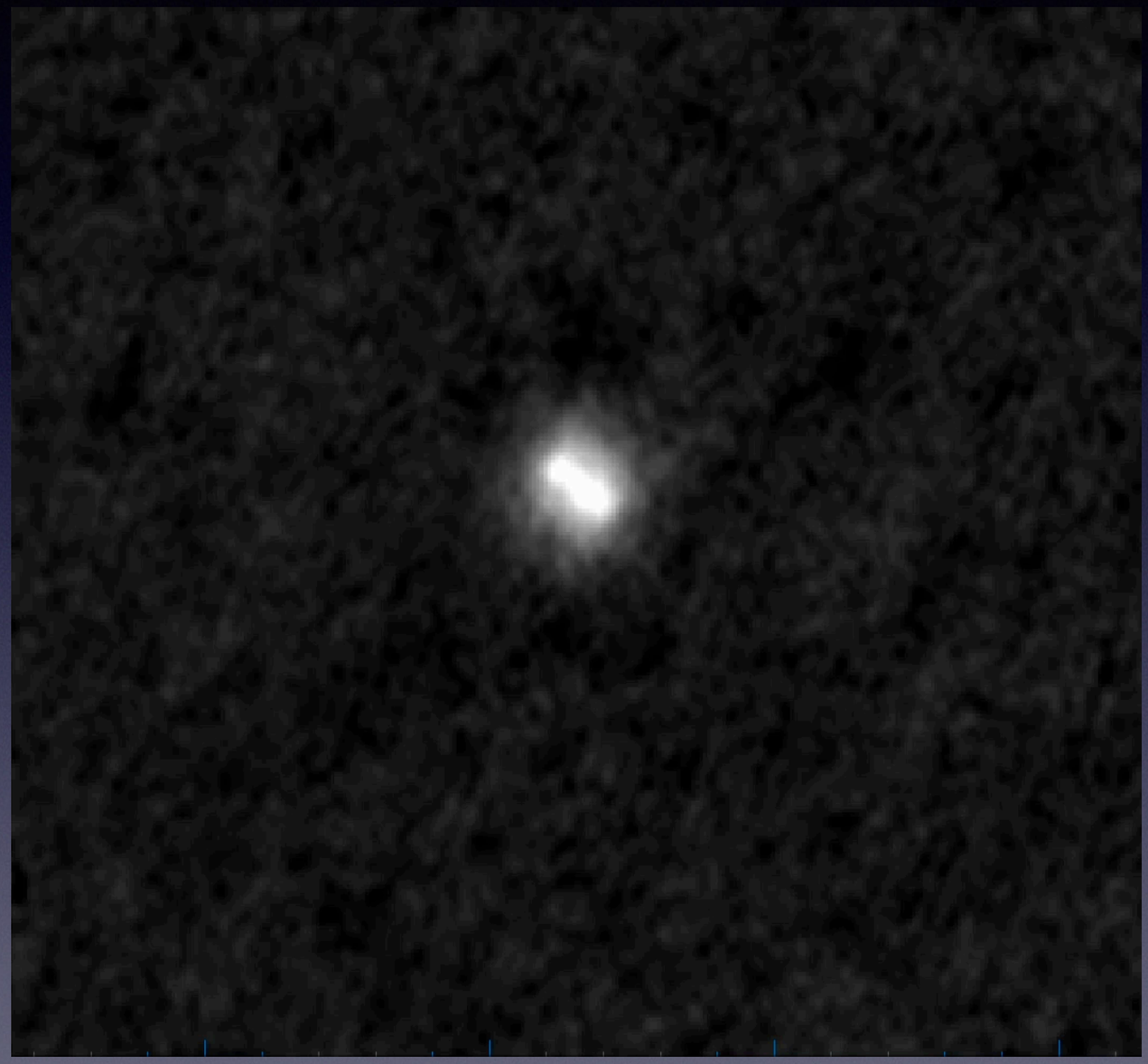

HSC Log(M⋆)=10.2
+ HI Log(MHI) = 9.7
zHI=0.06
10"

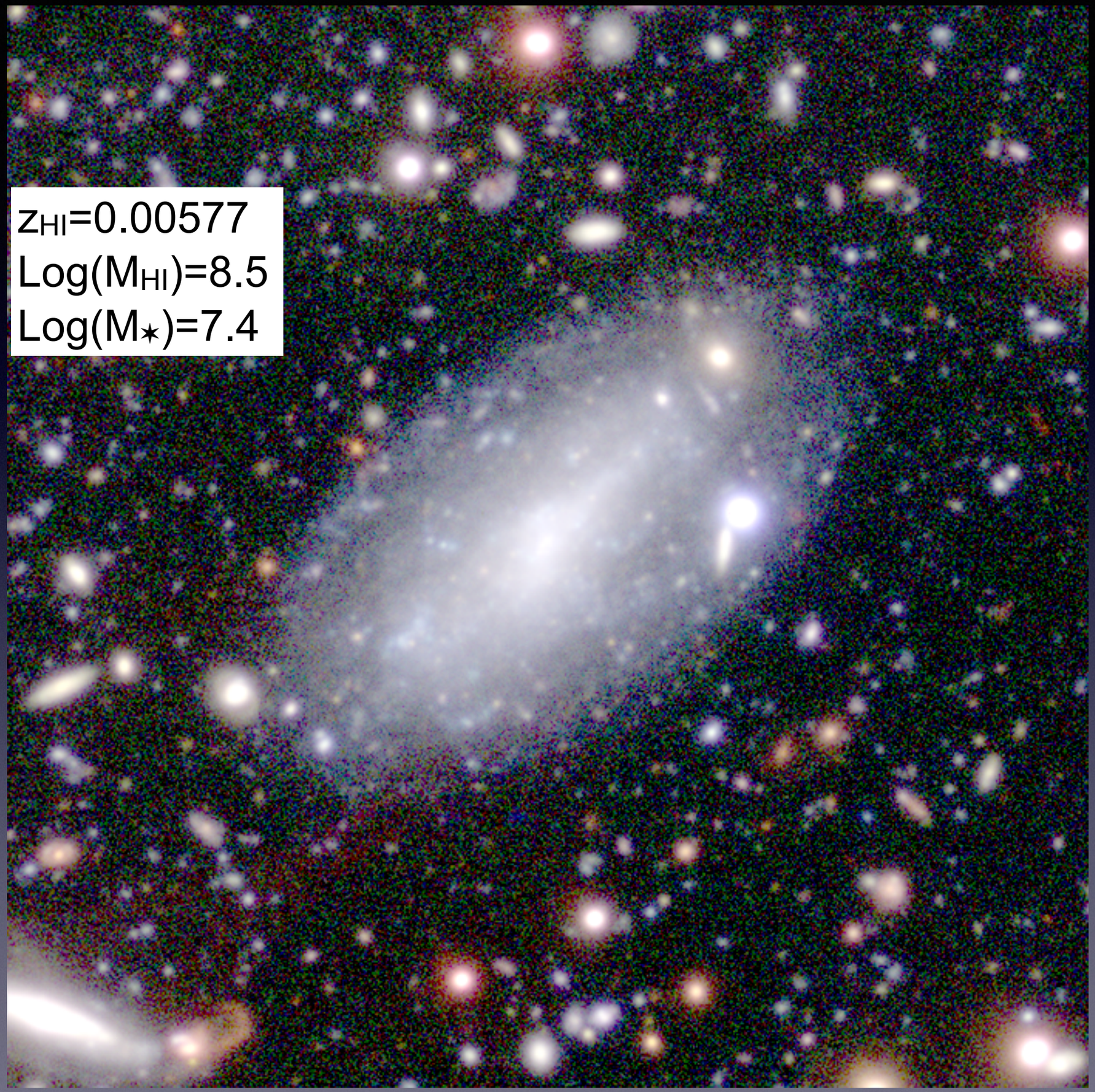
MeerKAT (HI) + ALMA (CO) + imaging (stars) + spectroscopy (environment)



4k vs 32k comparison



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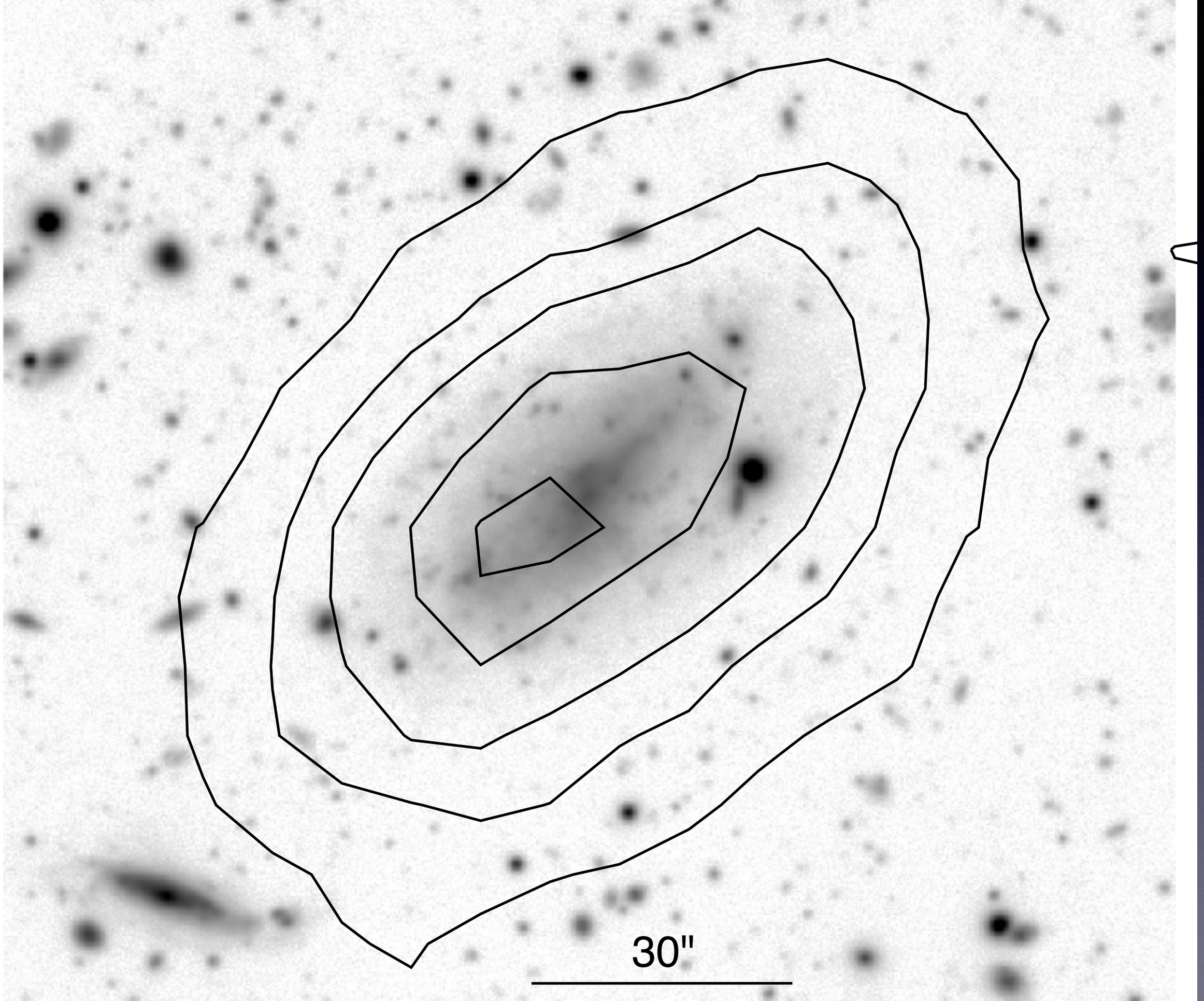
30"

Summary and lessons learned

- MIGHTEE-HI has extracted many results from Early Science Data
  - ◉ Don’t need perfect data to get started
  - ✓ Do need the right people in the right places, with time to devote
  - ◉ Don’t need high spectral resolution for every science case
  - ✓ Do need to keep the community updated, involved and engaged
- Source finding is hard, and takes time!
  - ✓ Do look at the data, so you know what you have (thanks, Jacqueline!)
- Appropriate ancillary data can enhance and extend results
- ECRs have the time and motivation to get results quickly

Future plans, ongoing work

- We have a breakout session 13:30—15:00 Thursday afternoon
  - all are welcome
- Update on MIGHTEE LSP
- Processing of 32k data underway, including mosaicking
- Information on timelines, WG plans, projects, etc