ASTRON

Netherlands Institute for Radio Astronomy

Apertif surveys and the smallest galaxies

Betsey Adams

T. Oosterloo, J. M. Cannon, R. Giovanelli, M. P. Haynes

PHISCC

3 February 2016

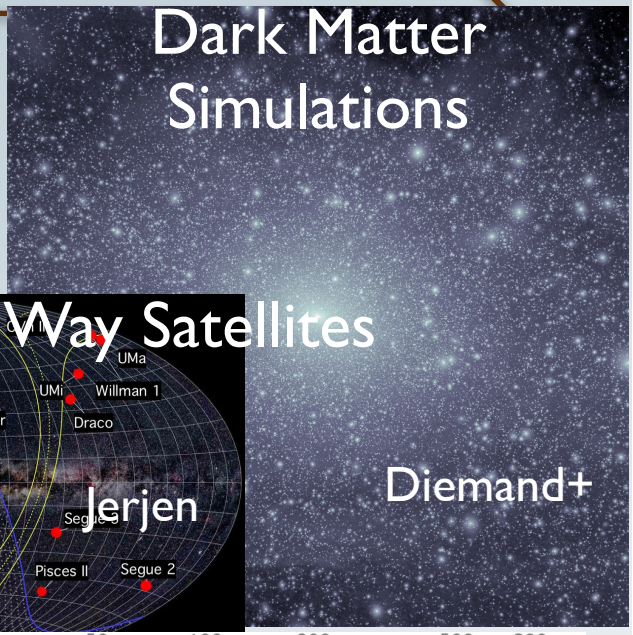
Outline

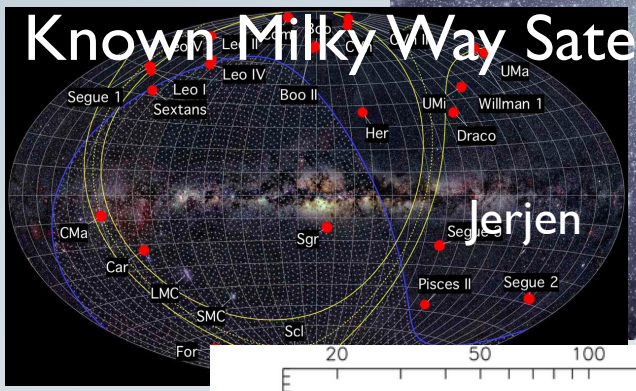
- Motivation
- Current observations with WSRT
- Outlook for Apertif

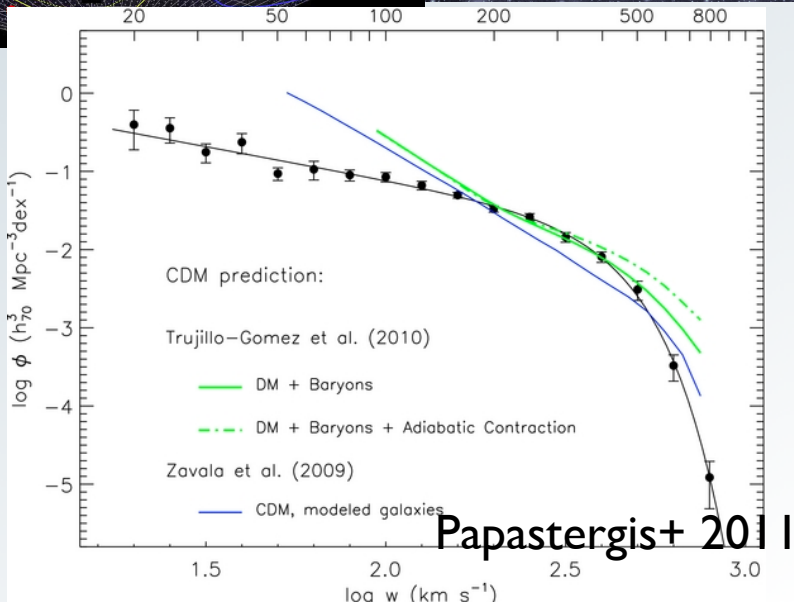
Outline

The Small Scale Crisis

- Mismatch between simulations and observations at the low mass end
  - abundance
  - internal structure/ kinematics
  - which halos host galaxies?
- Discovery of ultra-faint dwarfs has fueled new understanding

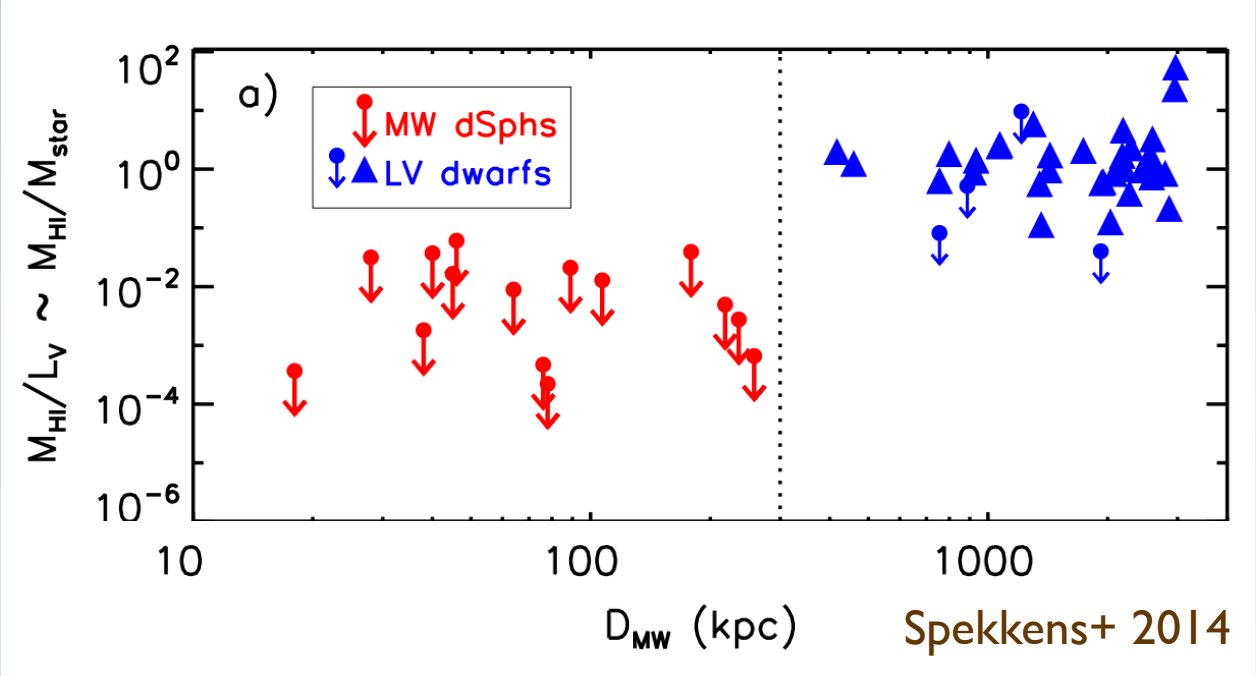






The role of HI

- Searching for lowest mass (isolated) galaxies throughout the Local Group (and beyond)



ASTRON

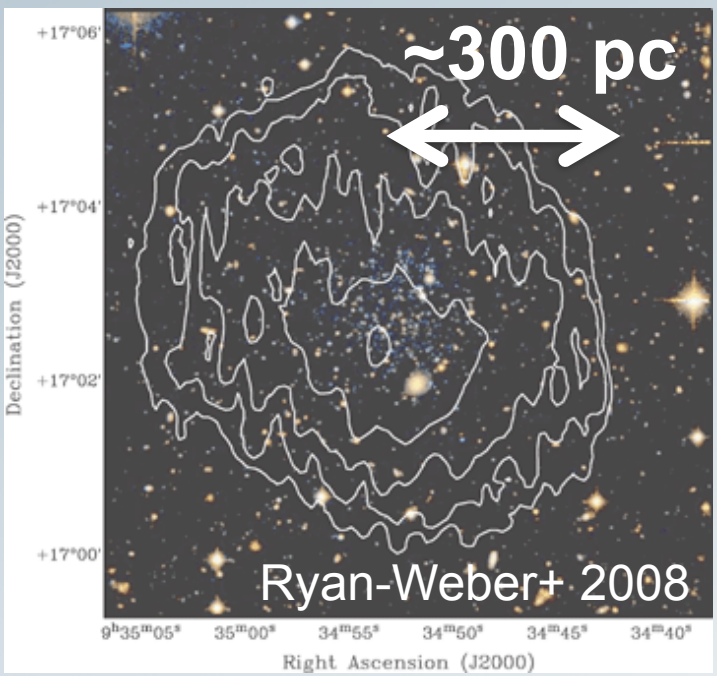
The brink of star formation

Leo T:

D~0.42 Mpc

M_{HI} ~ 3 x 10^5 M_{sun}

M_{star} = 1 x 10^5 M_{sun}

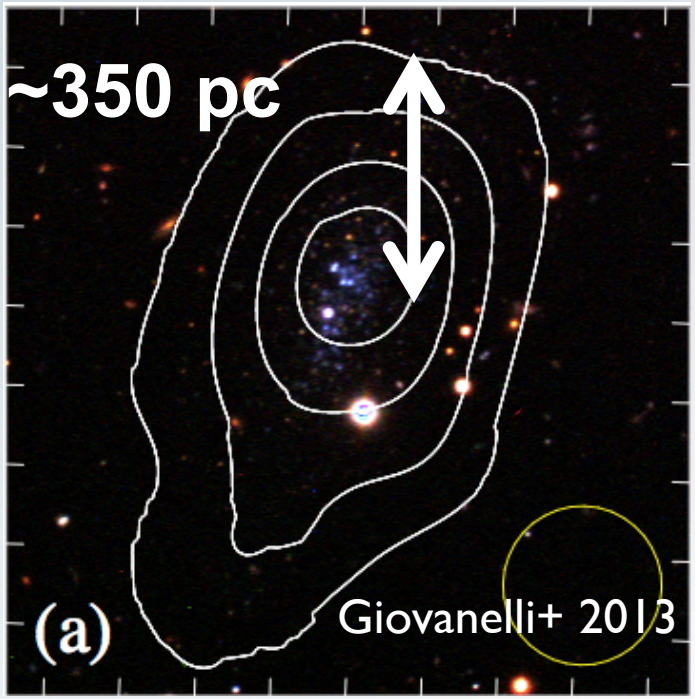


Leo P:

D~1.6 Mpc

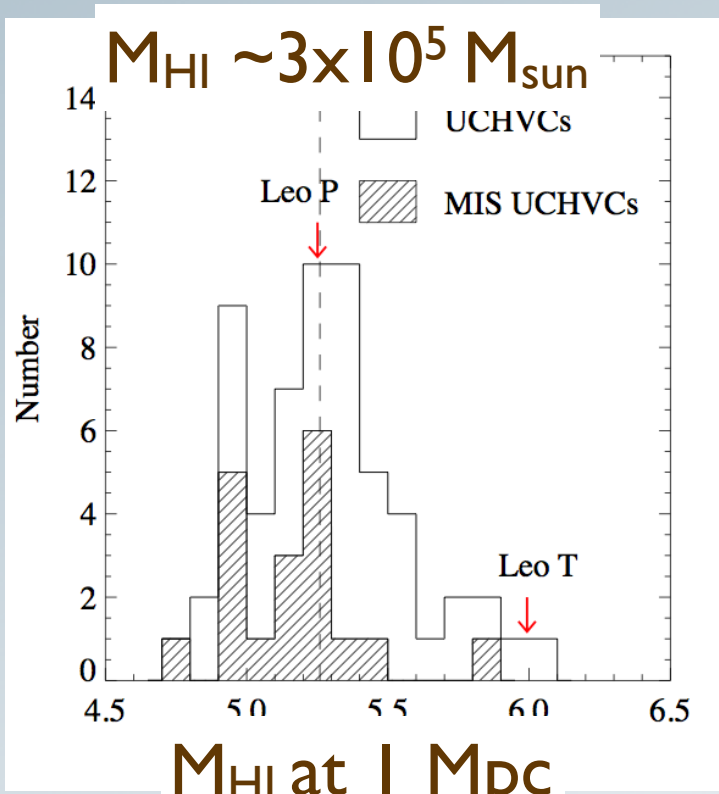
M_{HI} ~ 8 x 10^5 M_{sun}

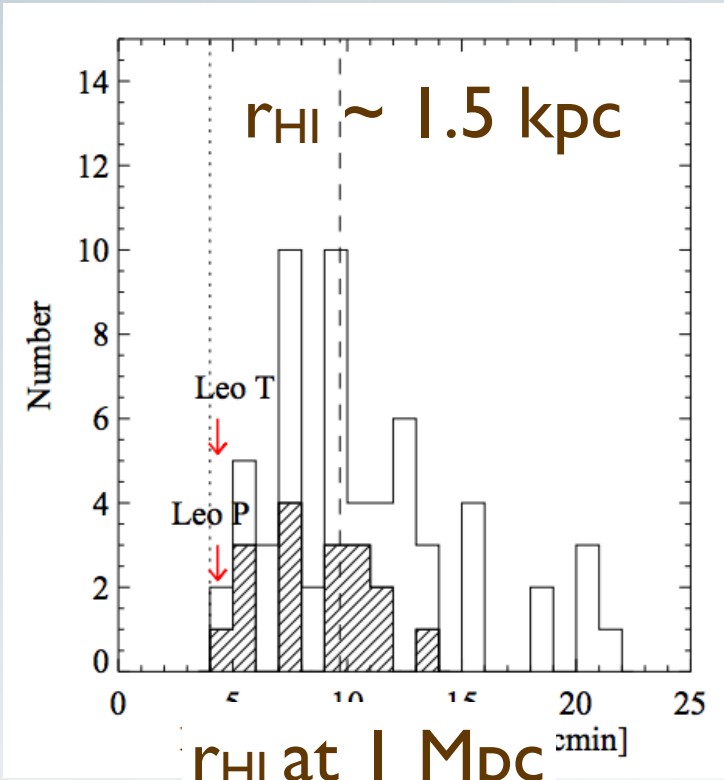
M_{star} ~ 6 x 10^5 M_{sun}



HI clouds as Local Group Galaxies

- Isolated HI clouds in the ALFALFA survey (ultra-compact high velocity clouds: UCHVCs)



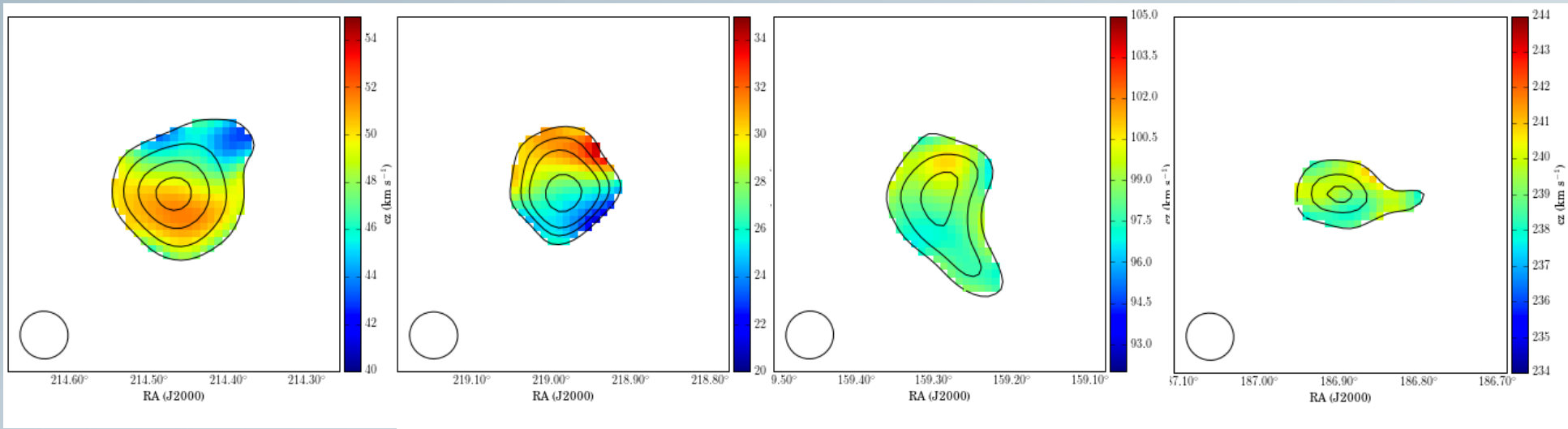


Adams+ 2013

- NO distance information

ASTRON

WSRT HI Observations

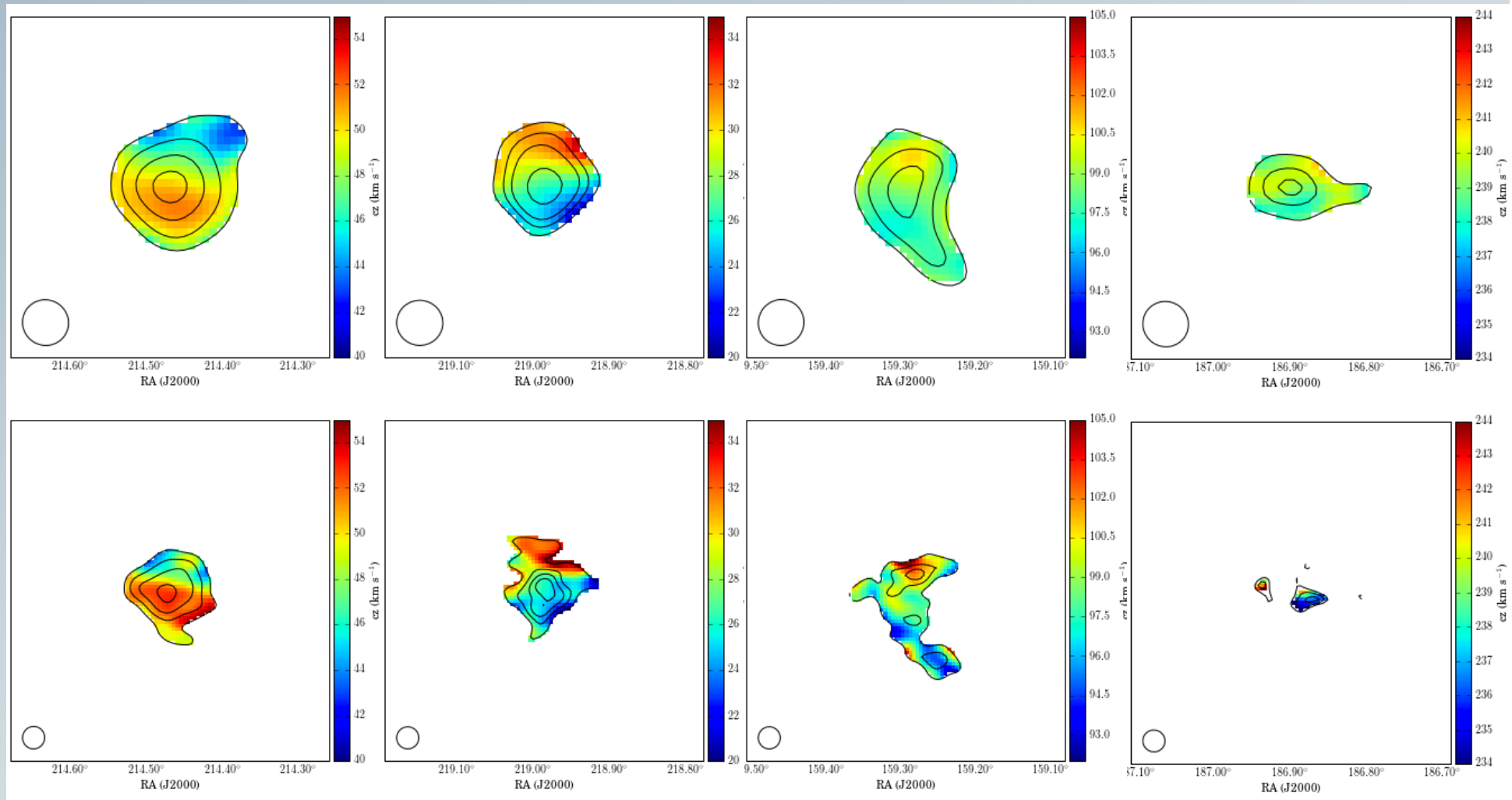


Adams+, in prep

ASTRON

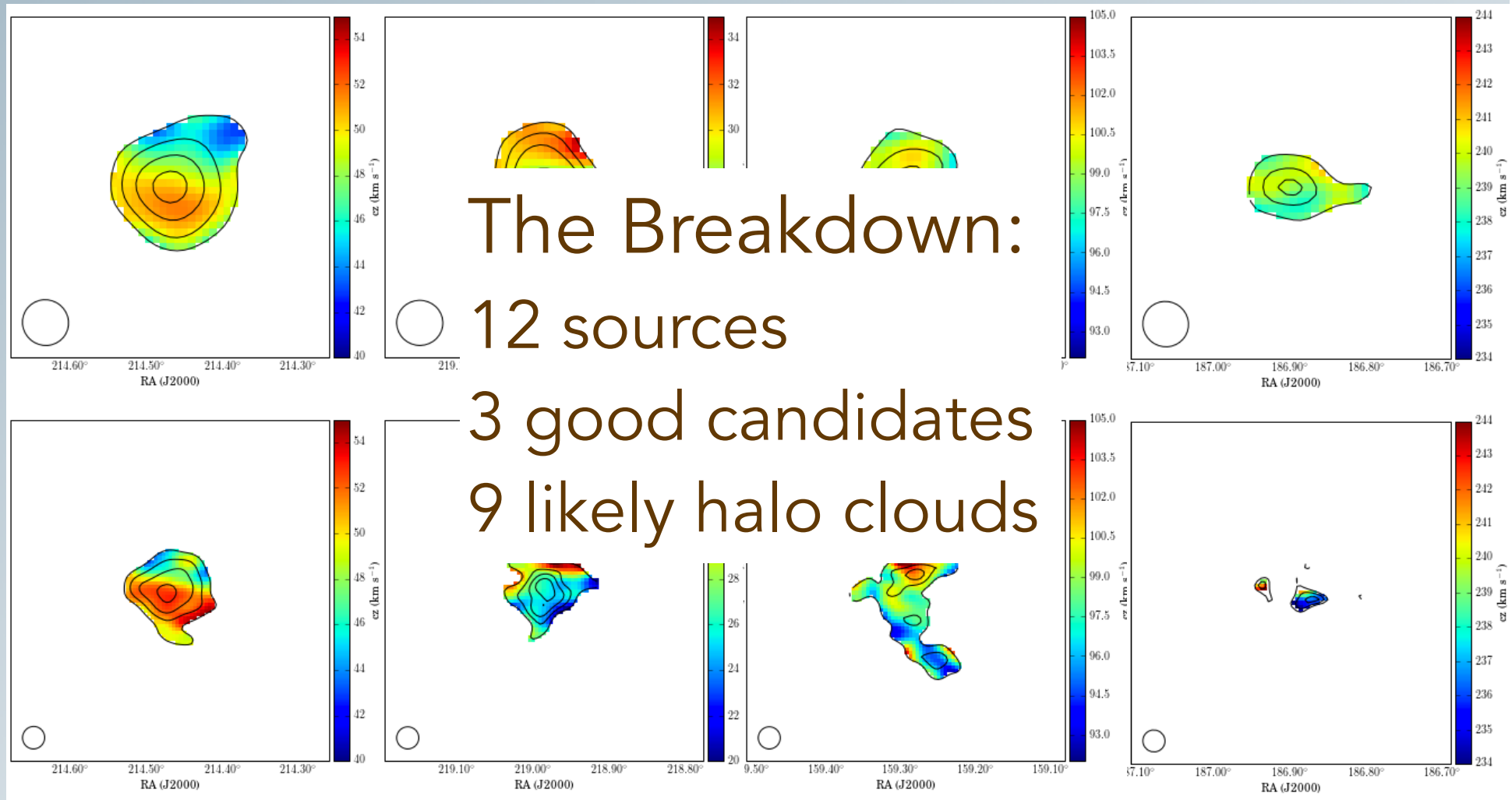
WSRT HI Observations

Resolved HI Imaging



Adams+, in prep

WSRT HI Observations



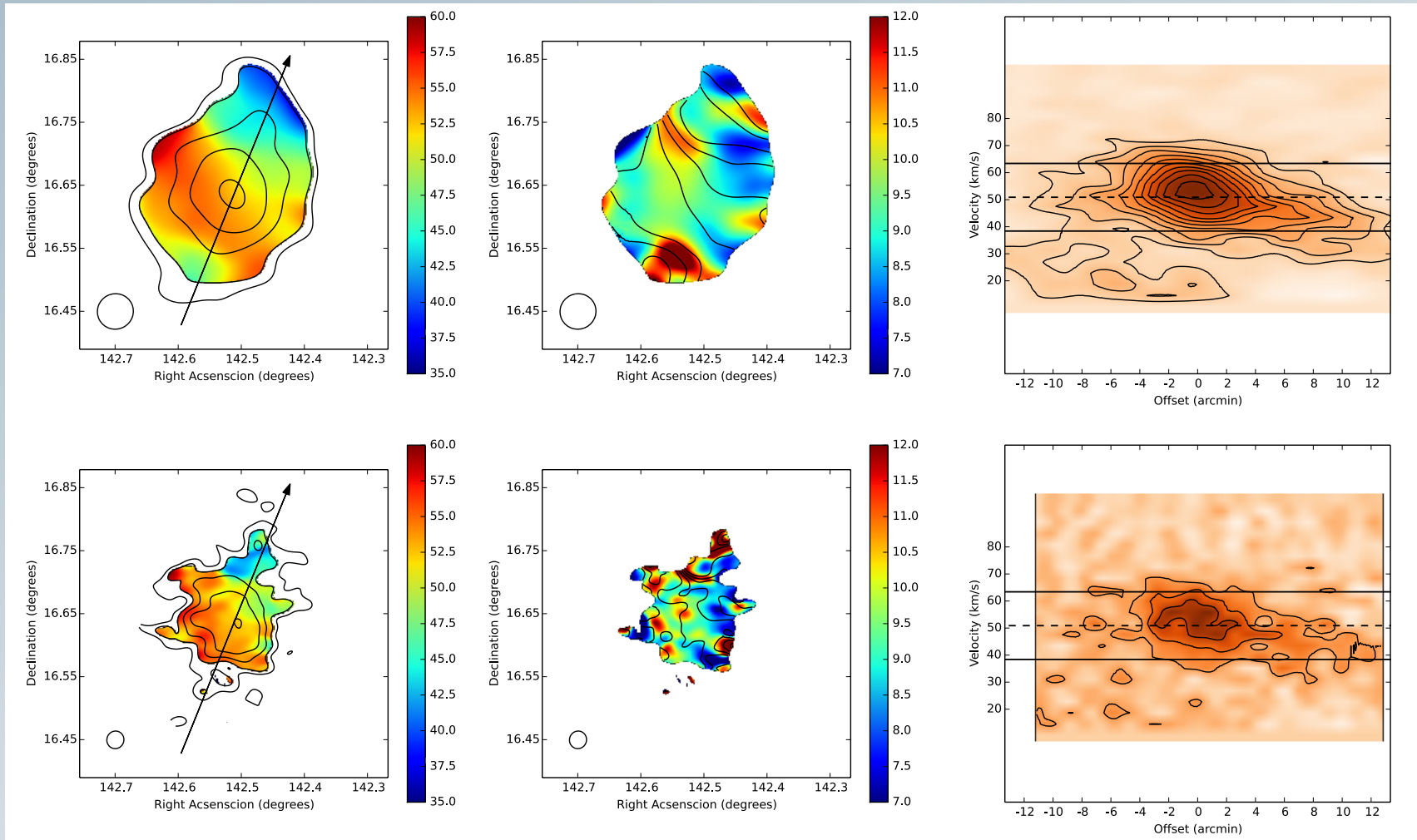
The Breakdown:

- 12 sources
- 3 good candidates
- 9 likely halo clouds

Adams+, in prep

AGC198606: Friend of Leo T

Resolved HI Imaging



Adams+ 2015

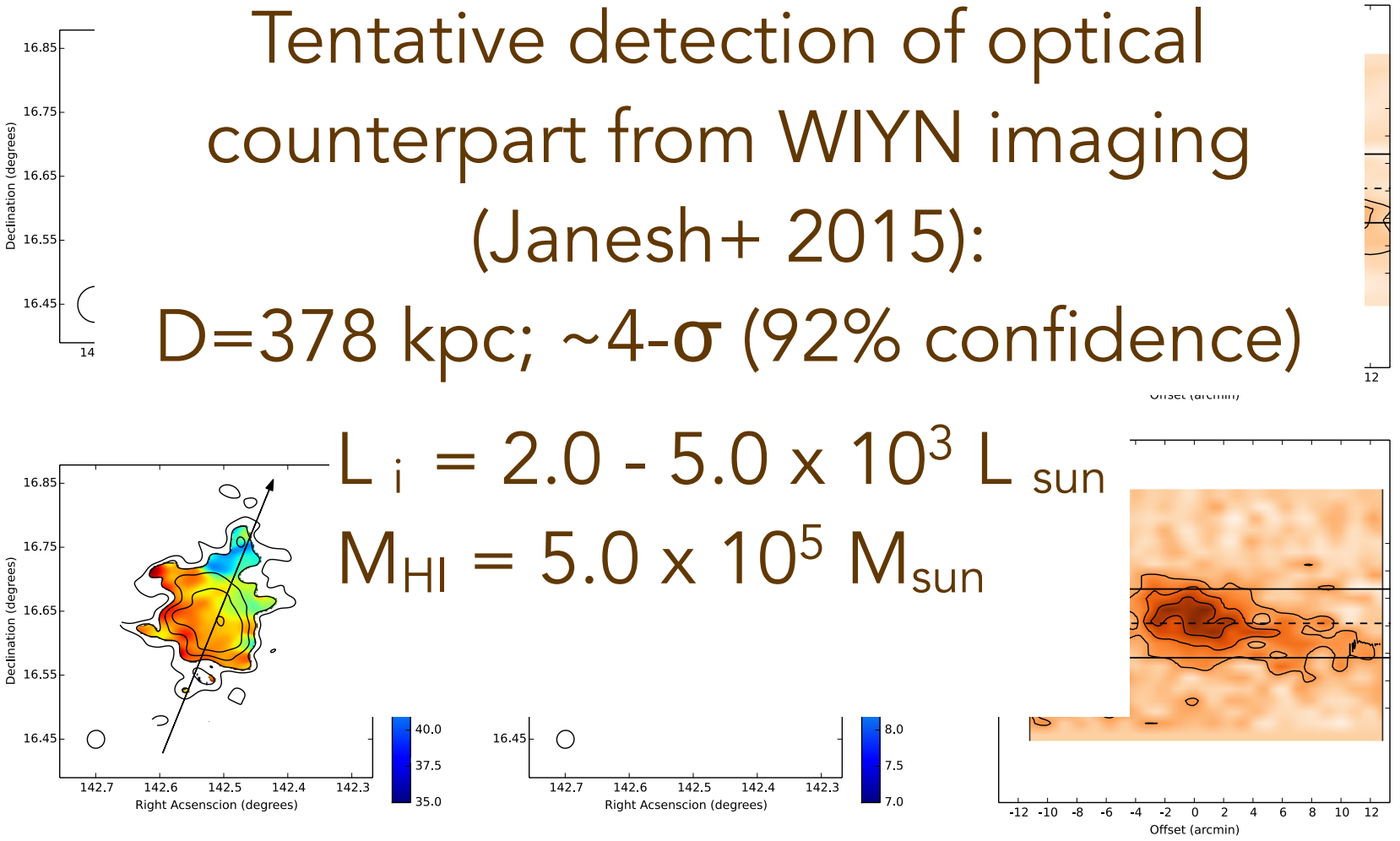
AGC198606: Friend of Leo T

Tentative detection of optical counterpart from WIYN imaging (Janesh+ 2015):

D=378 kpc; ~4-σ (92% confidence)

$L_i = 2.0 - 5.0 \times 10^3 L_{sun}$

$M_{HI} = 5.0 \times 10^5 M_{sun}$

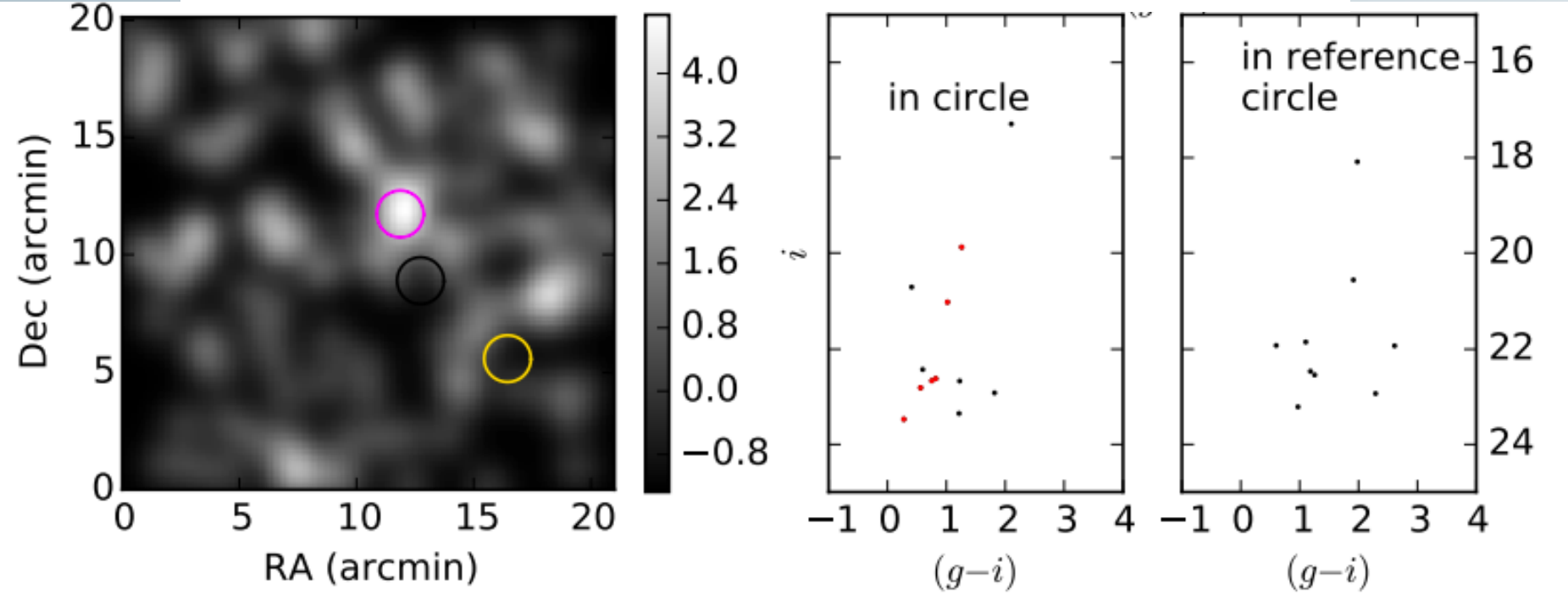


Adams+ 2015

ASTRON

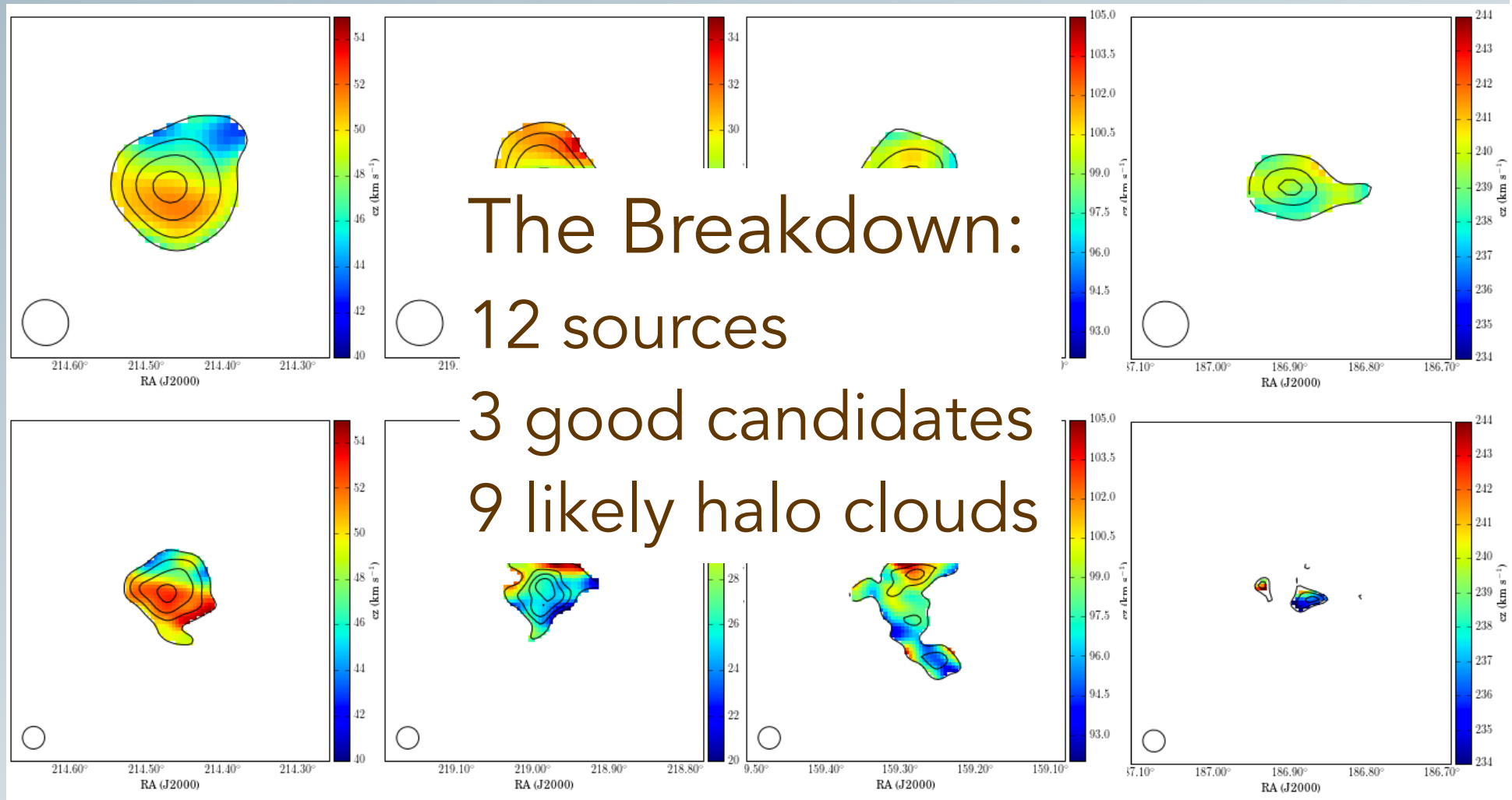
An optical counterpart?

D=378 kpc; ~4-σ (92% confidence)



Janesh+ 2015

WSRT HI Observations



The Breakdown:

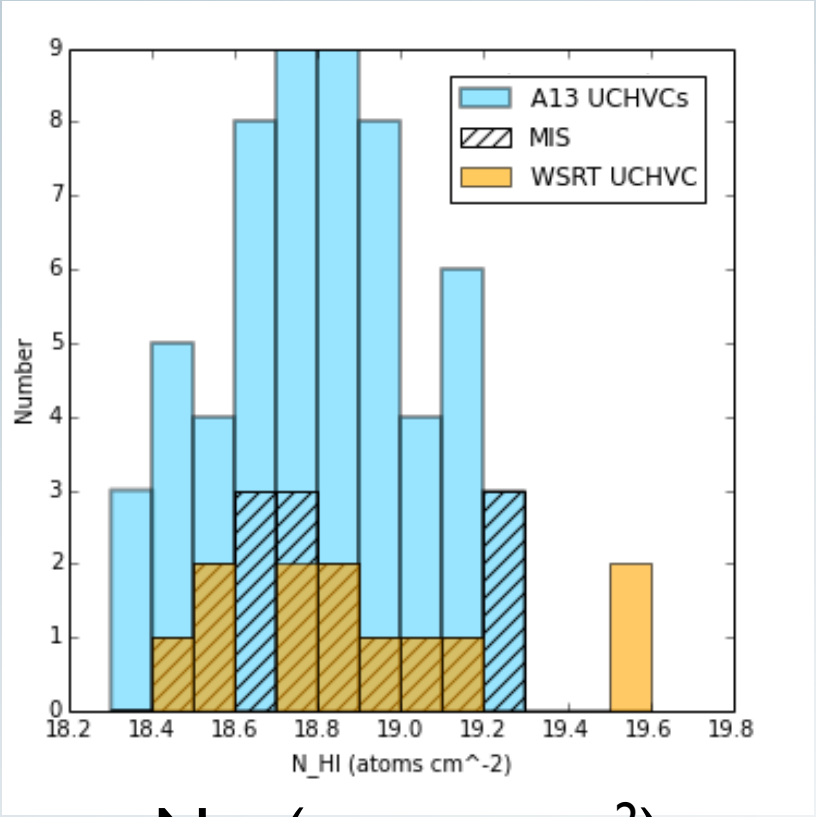
- 12 sources
- 3 good candidates
- 9 likely halo clouds

Adams+, in prep

ASTRON

Identifying Good Candidates

- Galaxy candidates (morphology and velocity structure) also have highest peak N_{HI} (but still low!)



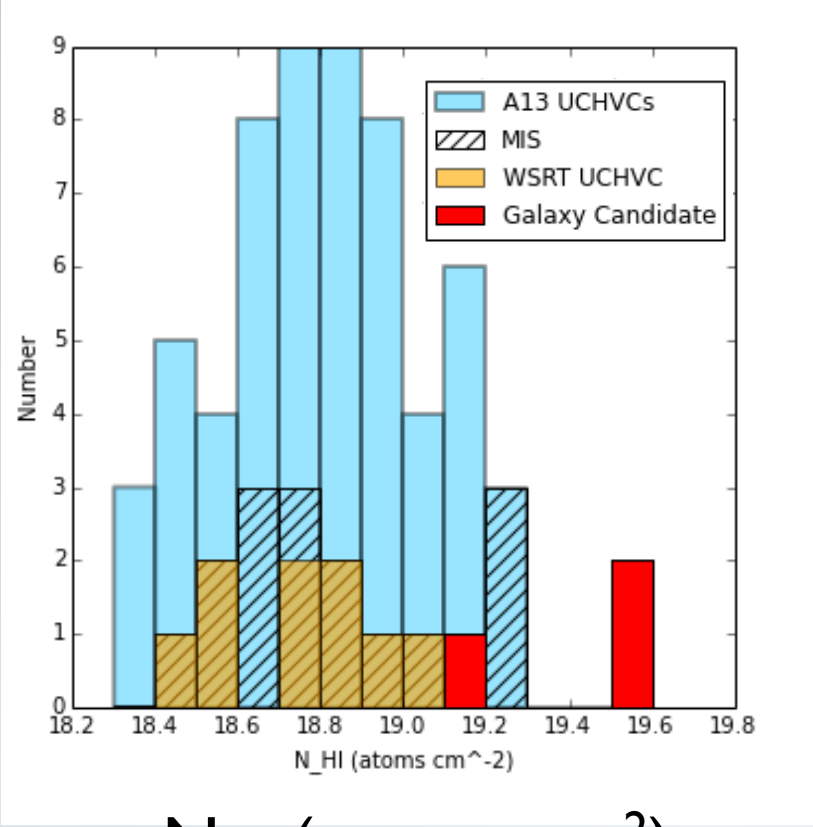
Number

N_{HI} (atoms cm^{-2})

Adams+ in prep

Identifying Good Candidates

- Galaxy candidates (morphology and velocity structure) also have highest peak N_{HI} (but still low!)



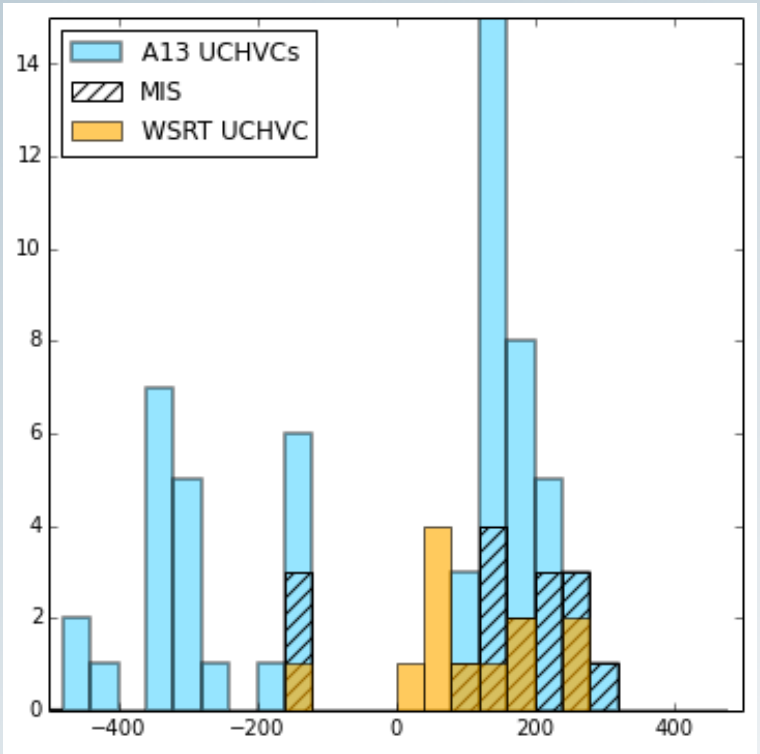
N_{HI} (atoms cm^{-2})

Adams+ in prep

ASTRON

Identifying Good Candidates

- Galaxy candidates also have low recessional velocities (excluded from earlier catalog)

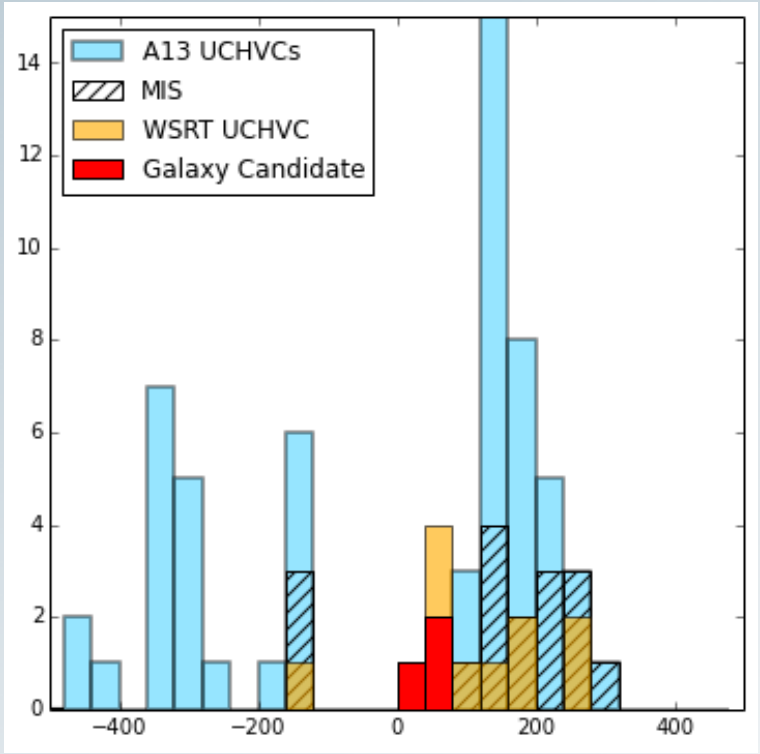


Adams+ in prep

ASTRON

Identifying Good Candidates

- Galaxy candidates also have low recessional velocities (excluded from earlier catalog)

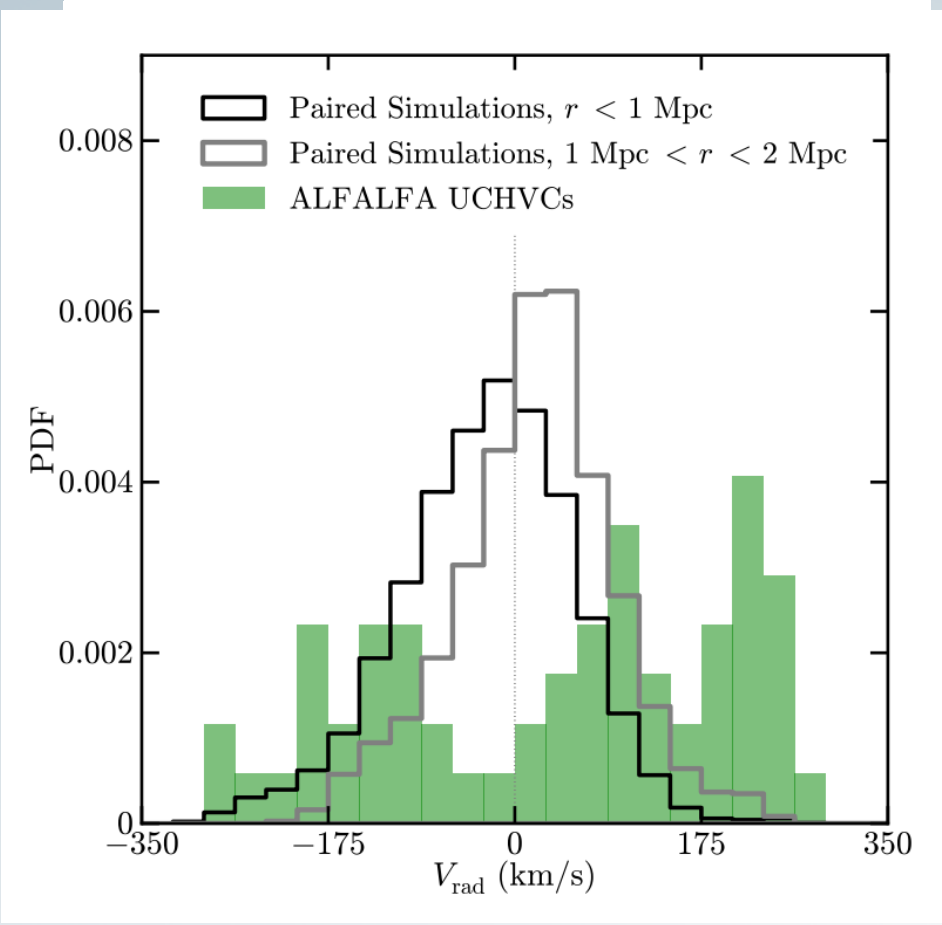


Adams+ in prep

ASTRON

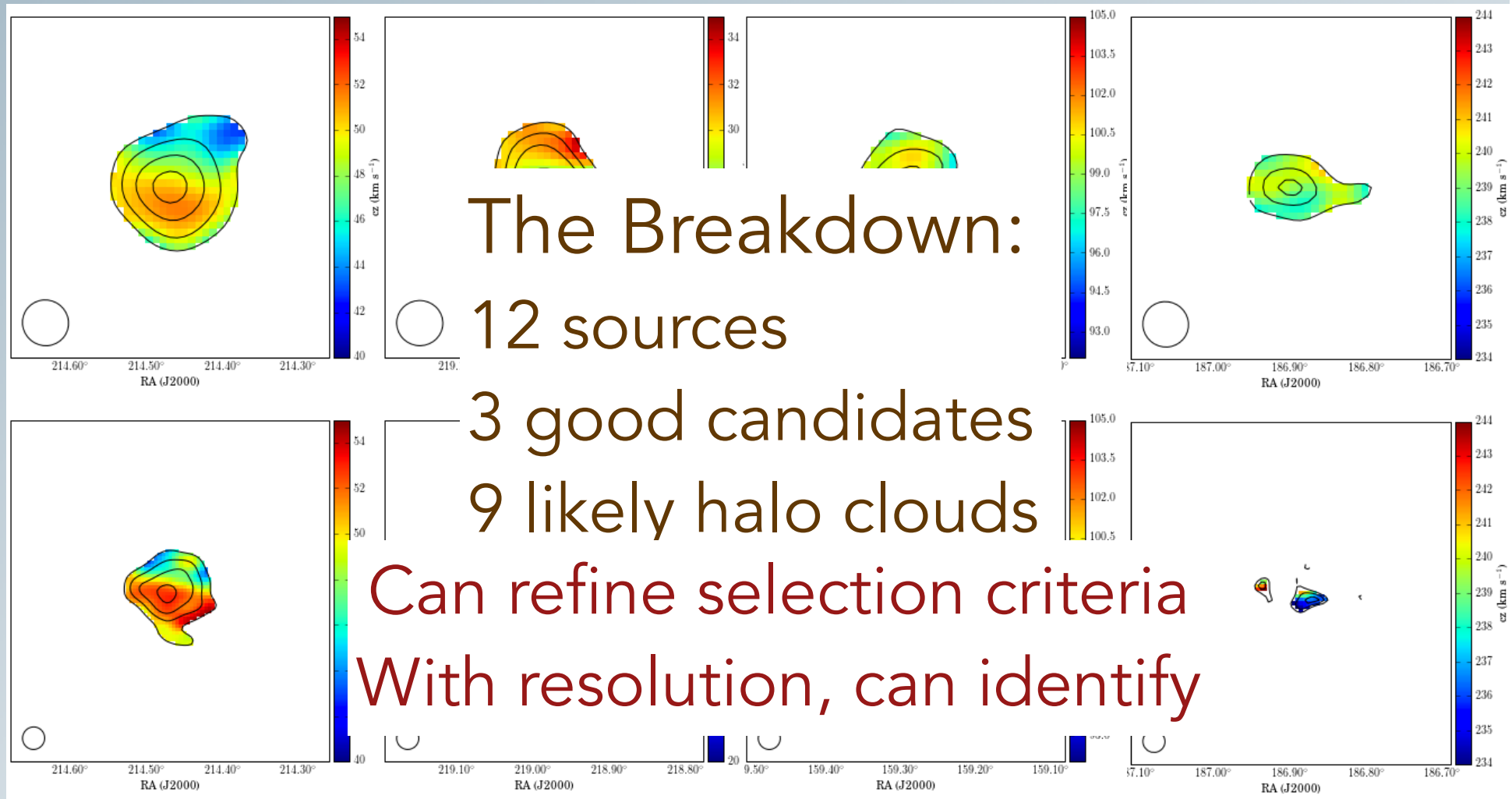
Identifying Good Candidates

- Galaxy candidates also have low recessional velocities (excluded from earlier catalog)



Garrison-Kimmel+ 2014

WSRT HI Observations



The Breakdown:

12 sources

3 good candidates

9 likely halo clouds

Can refine selection criteria

With resolution, can identify

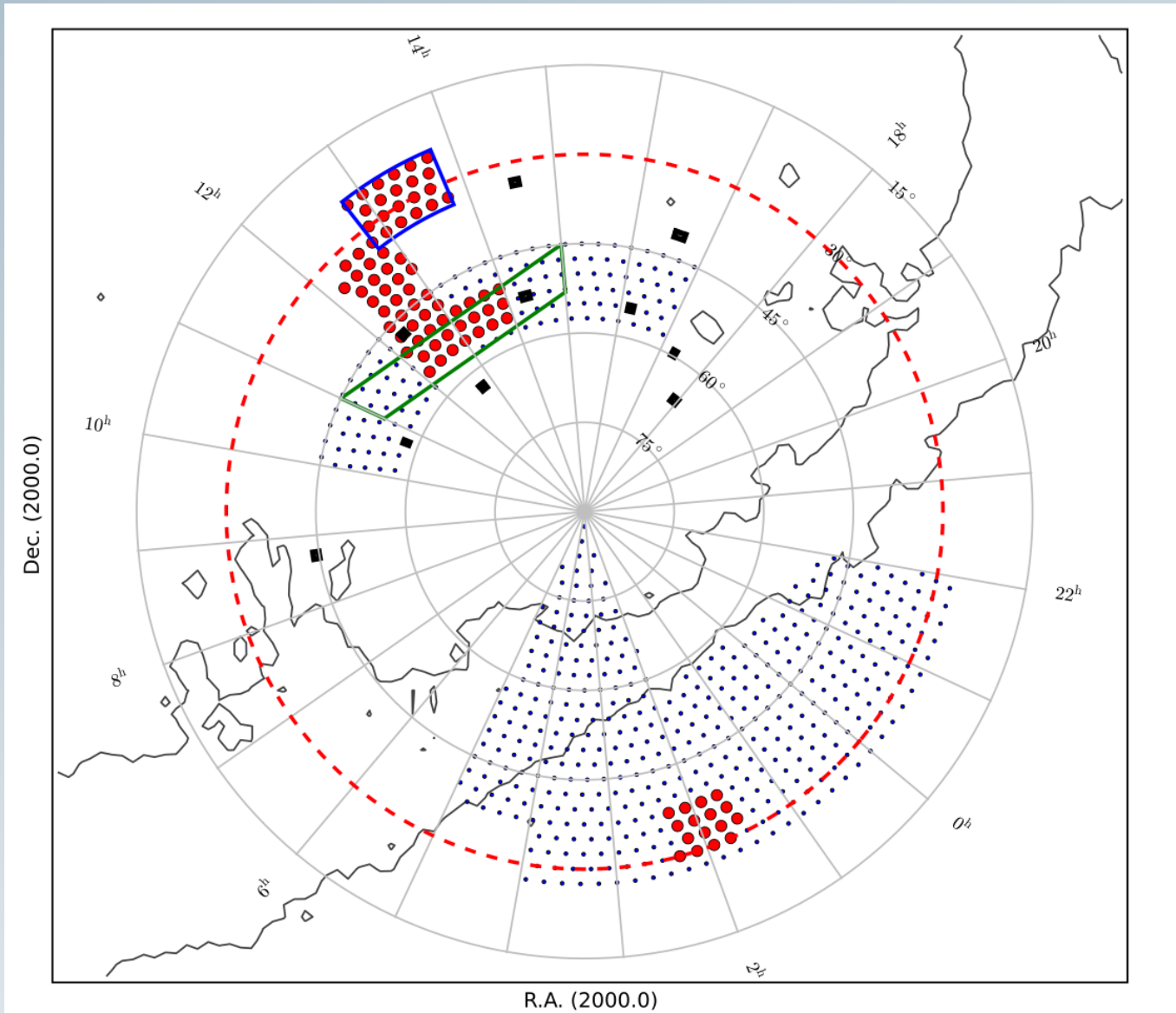
Adams+, in prep

Apertif Surveys

- phased-array feed on WSRT; FOV: ~8 deg^2
- Shallow Northern Sky (SNS): ~3500 deg^2, 1 x 12 hr
- Medium Deep Survey: ~450 deg^2, 7x12 hr

ASTRON

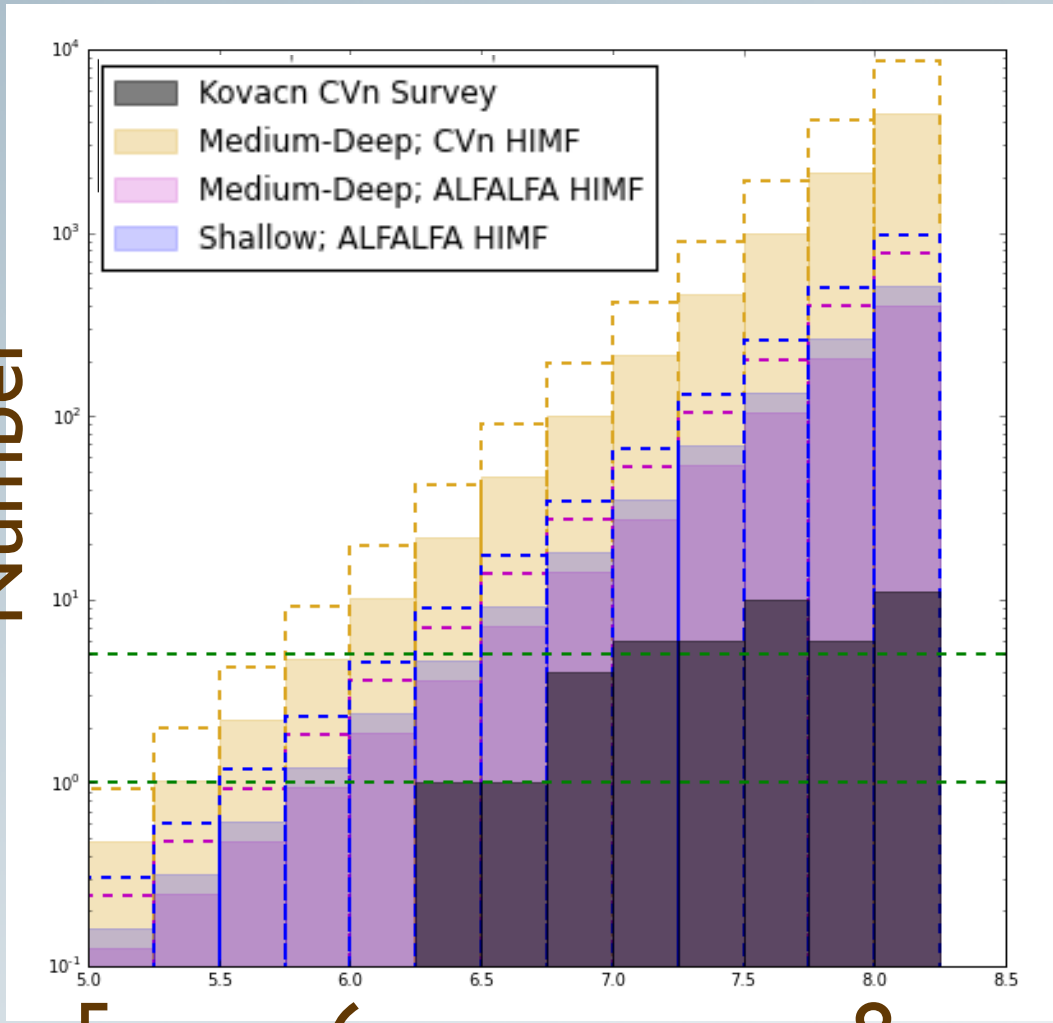
Apertif Surveys



Apertif

ASTRON

Predictions from the HIMF



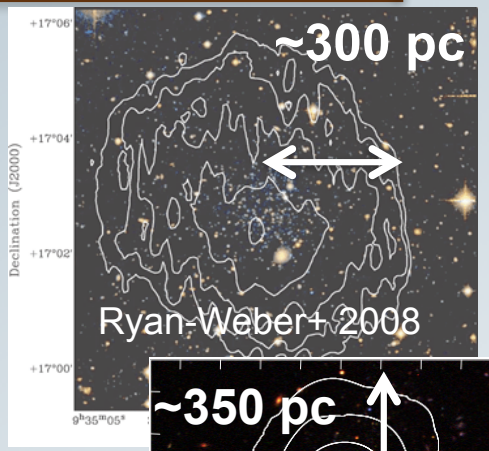
Shallow and Medium-deep surveys perform similarly for the same HIMF

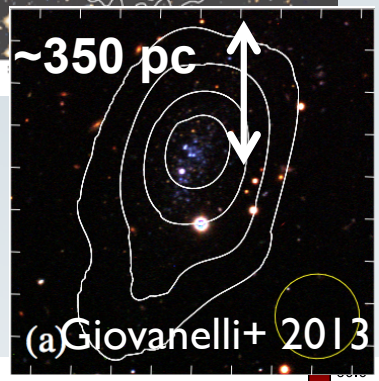
Presence of an overdensity matters (but needs to be at right distance)

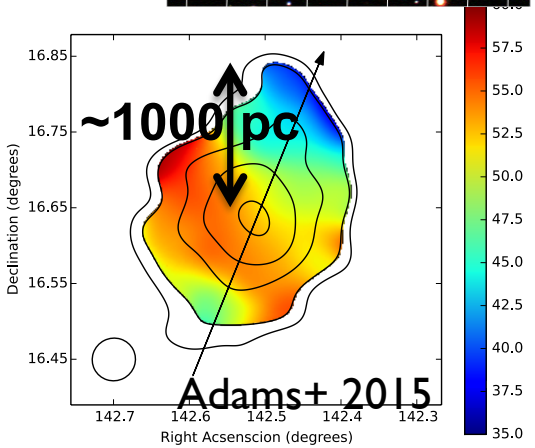
Apertif

Expectations from observations

- Leo T: 3 x 10^5 M_{sun}; D_{HI} ~ 600 pc
  - Complete to ~2.5 - 4.1 Mpc
  - Resolved with a few beams (~30"-50")
- Leo P: 8x10^5 M_{sun}; D_{HI} ~ 1kpc
  - Complete to ~ 4.1-6.7 Mpc
  - Resolved with a few beams (~30"-50")
- AGC 198606: 5x10^5 M_{sun}; D_{HI} ~ 2.4 kpc
  - Complete to ~3.3-5.3 Mpc
  - Well-resolved (~90"-150")
  - low N_{HI} - strong taper!







Apertif

Looking to the Future

- There are good candidates for HI dominated low-mass galaxies
  - Is there a change in population (N_{HI})?
- Understand the HI properties that give the best candidates (catalog construction and follow-up)
- Power of angular resolution: Apertif (and WALLABY)
  - can detect sources with surveys
  - need to think about specialised strategies