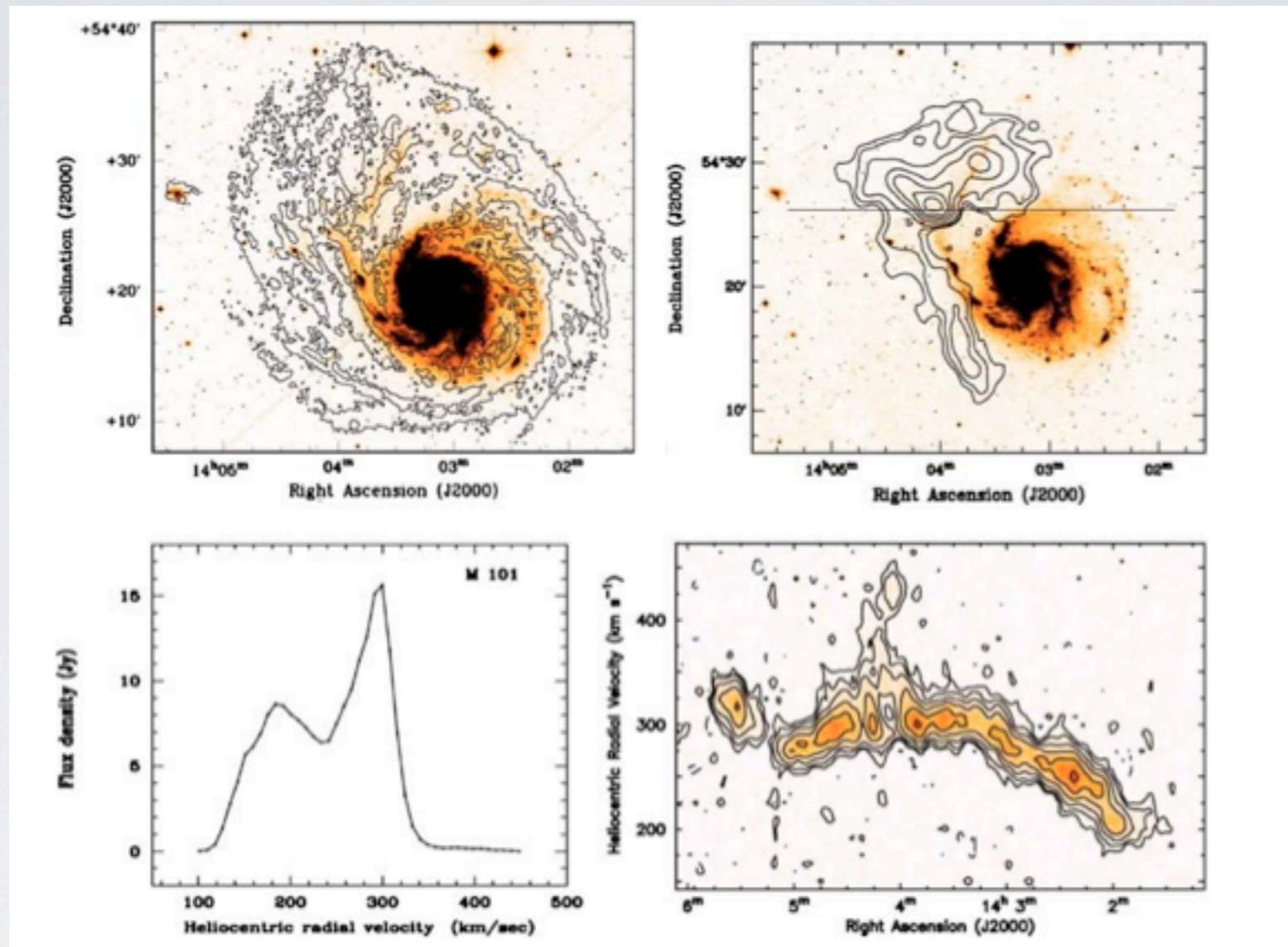


ANOMALOUS HI FEATURES IN M101: TIDAL DEBRIS OR COLD ACCRETION?



Sancisi et al. 2008, Kamphuis et al. 1993

Katie (Chynoweth) Keating (NRL/NRC)

Chris Mihos (Case Western)

Kelly Holley-Bockelmann (Vanderbilt/Fisk)

Glen Langston (NRAO)



ANOMALOUS HI FEATURES

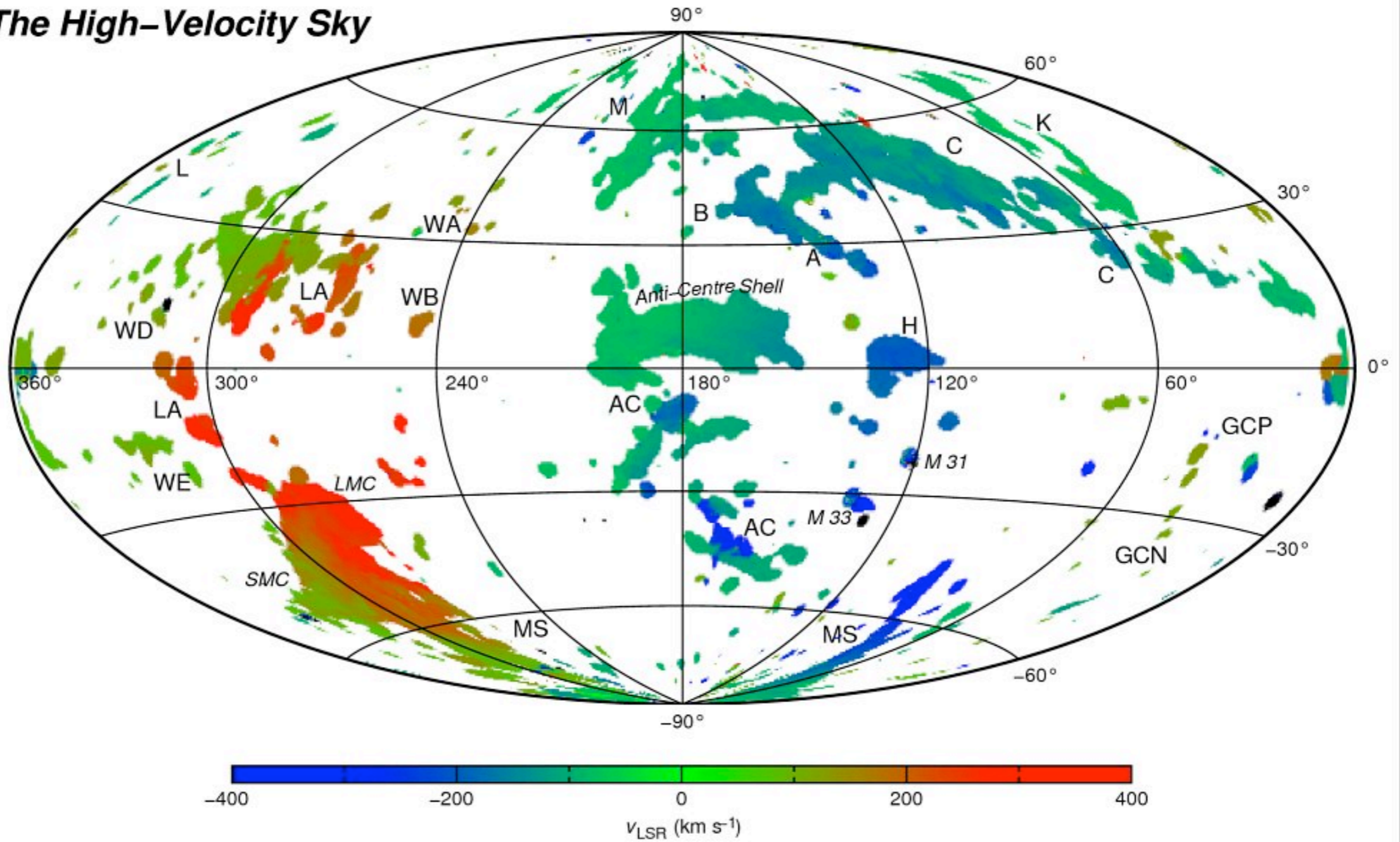
Milky Way

- $\Delta V > 50 \text{ km s}^{-1}$ from galaxy
- Cover 40% of the sky
 - Extraplanar
- Distance $\sim 10 \text{ kpc}$
 - Difficult to measure
- Mass $\sim 10^{4-7} M_{\text{sun}}$

Extragalactic

- M31, M33, NGC 2403, M83 (Thilker '04, Westmeier '05, Fraternali '02, Miller '09)
- And many more
- Galaxy Groups: only if strongly interacting (Pisano '07, Chynoweth '08, '11)

The High-Velocity Sky

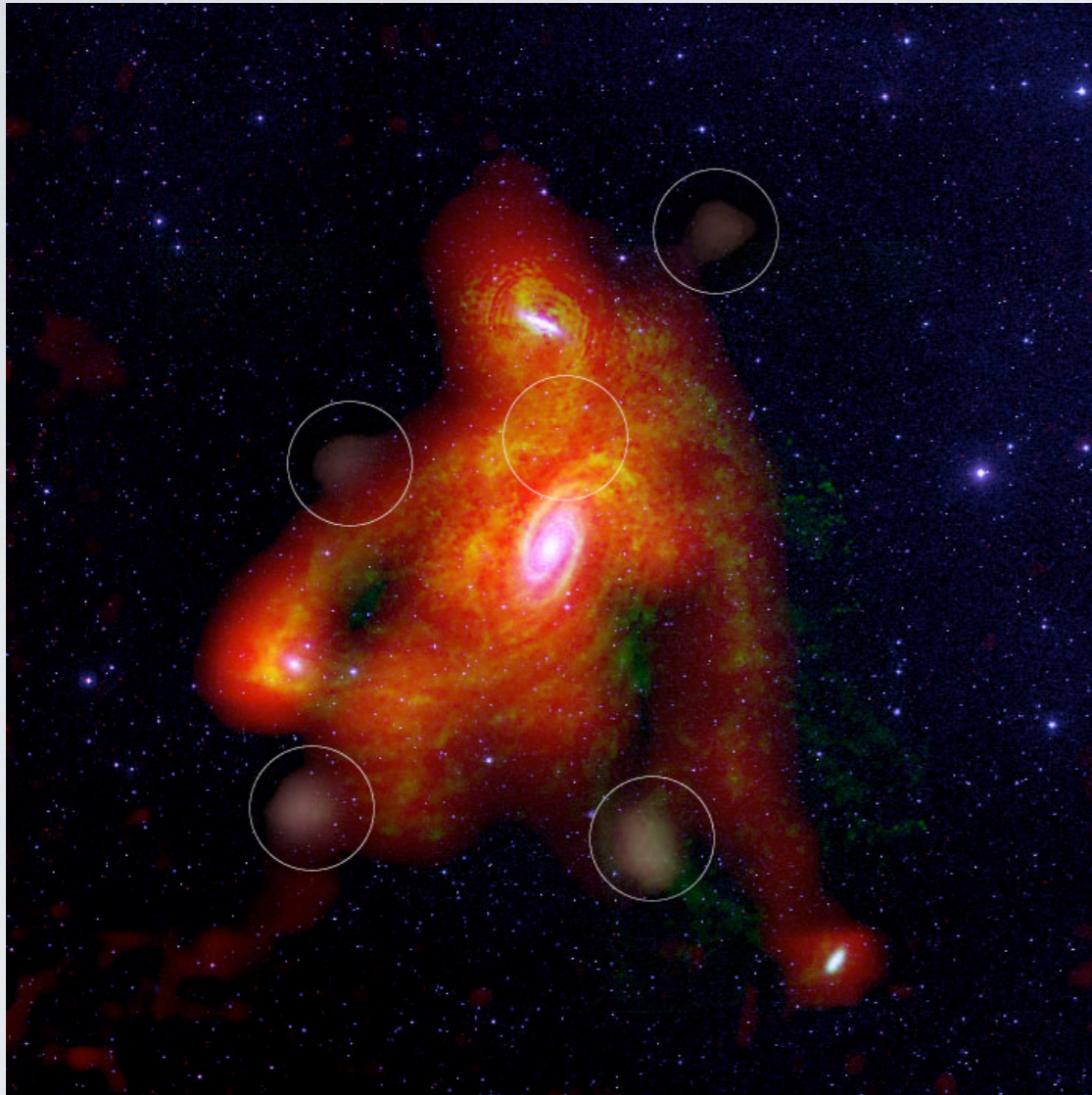


Tobias Westmeier, CSIRO Australia Telescope National Facility

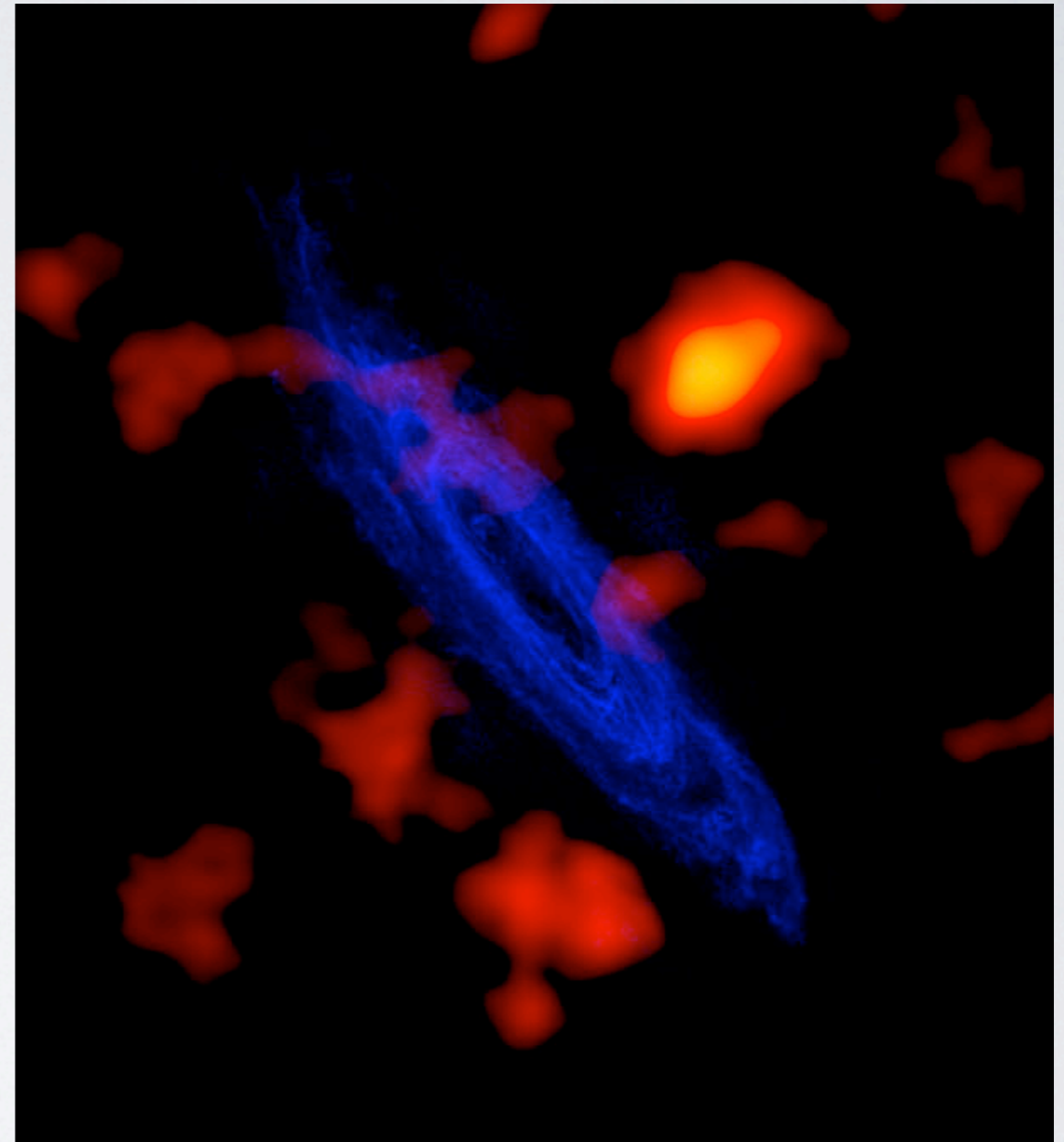
*Based on the Leiden/Argentine/Bonn Survey (Kalberla et al. 2005, A&A 440, 775)
and the Milky Way model of P. Kalberla (Kalberla et al. 2007, A&A, in press).*



EXTRAGALACTIC



M81/M82 Group
Chynoweth et al. '08
Yun et al. '93

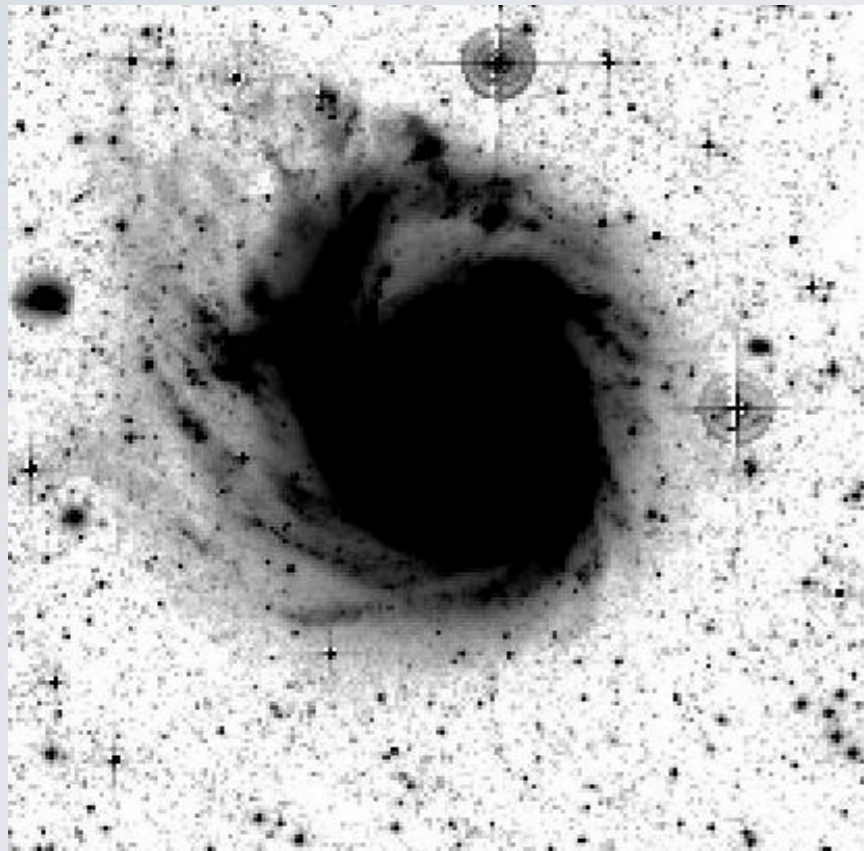


M31
Thilker et al. '04

M101

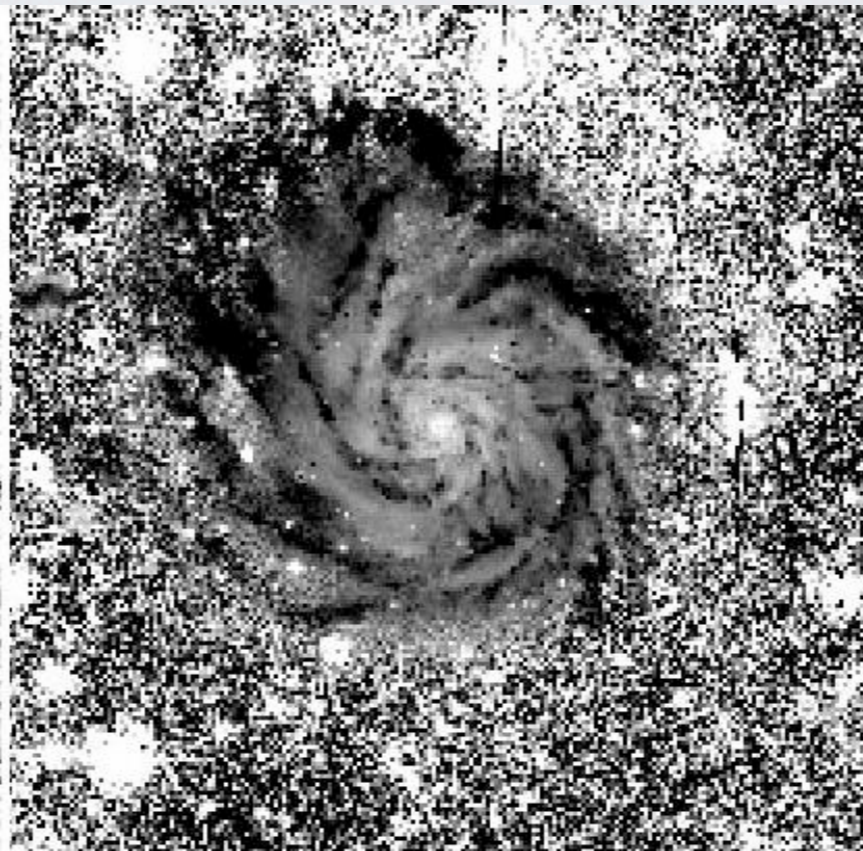
- 7 Mpc
- High-velocity HI cloud complexes (van der Hulst & Sancisi, 1988)
- Two nearby companion galaxies
- Part of a group of 7-ish galaxies

OPTICAL : PLUME TO NORTHEAST



B-Band

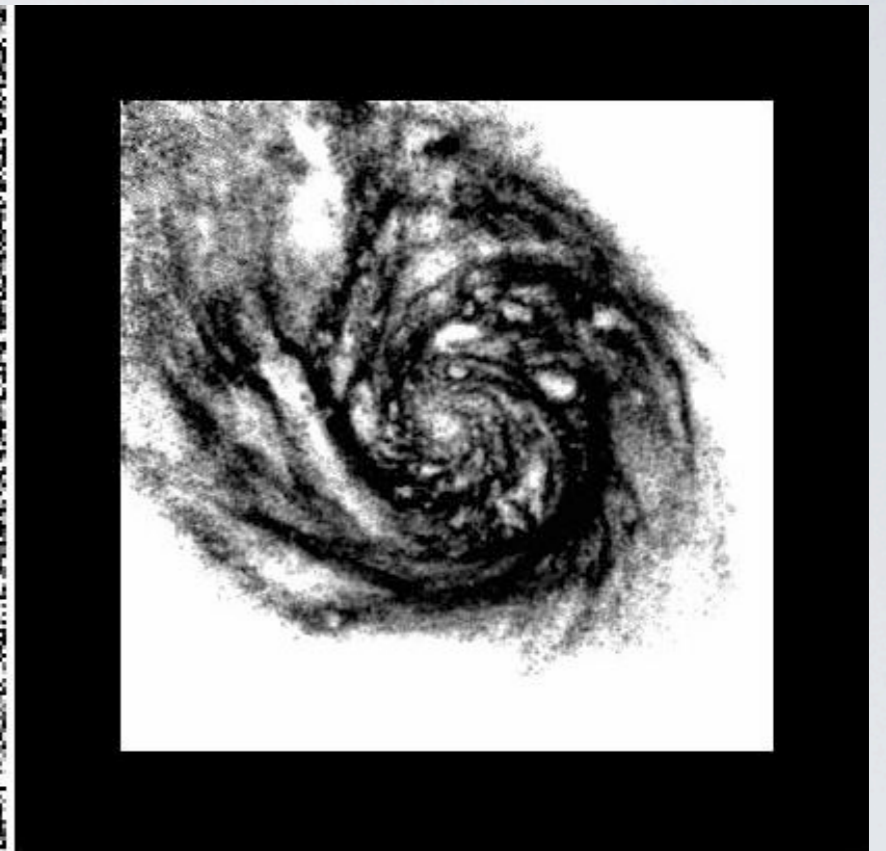
Plume: 29 mag arcsec⁻²



B-V Colors

(darker=blue)

B-V ~0.2-0.3



THINGS

(Walter et al. '08)

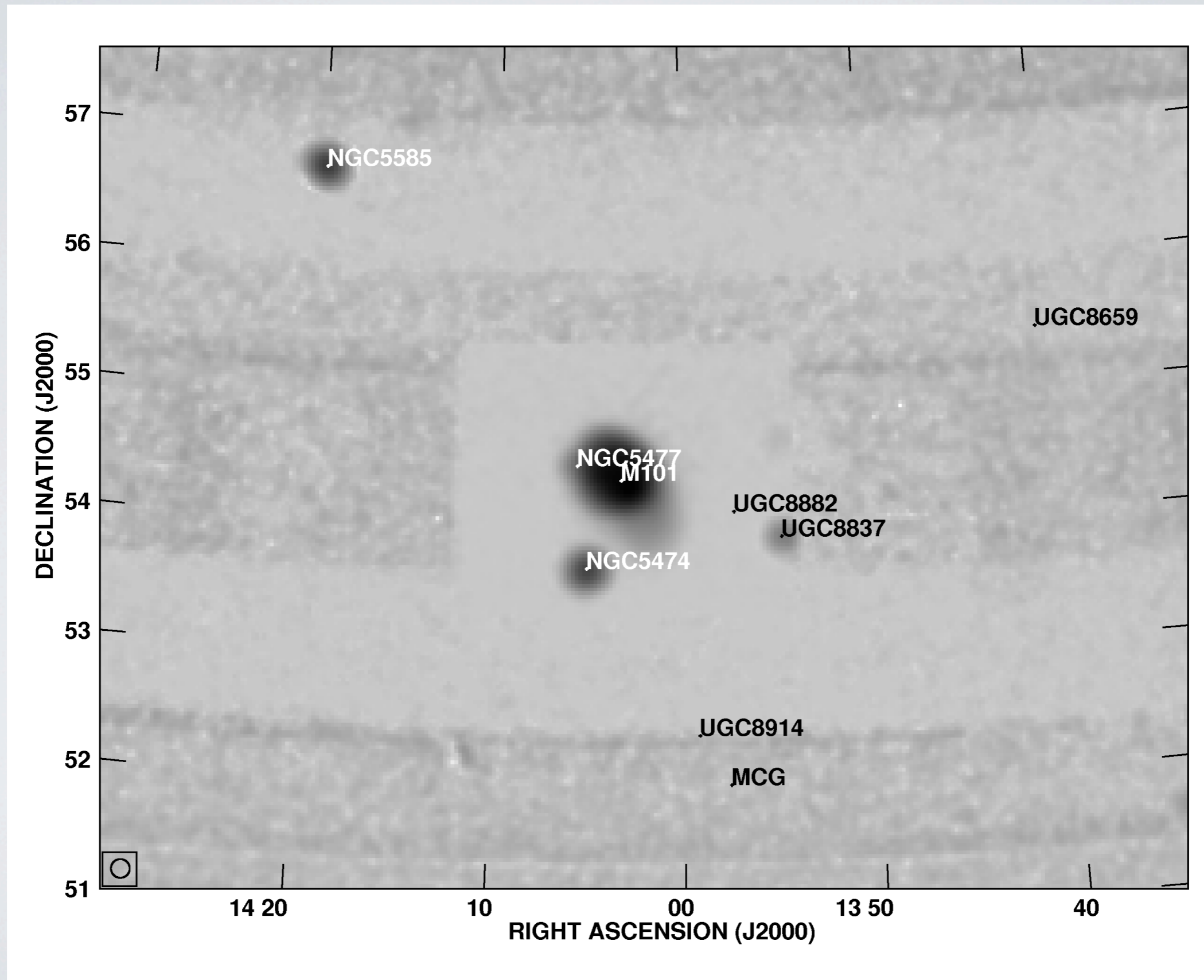
Mihos et al. in prep

OBSERVATIONS

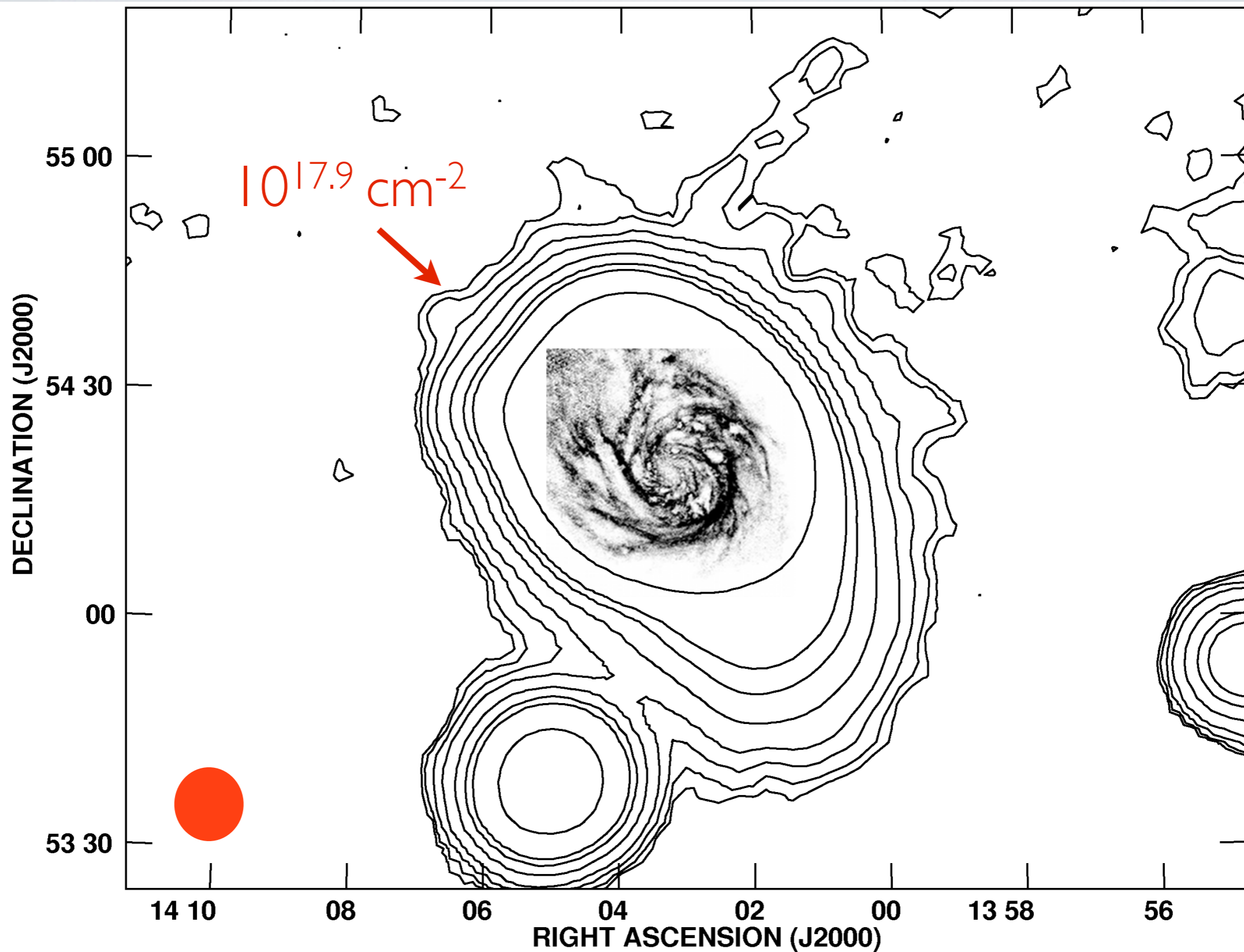
- 86 hours integration
- HI sensitivity:
 $10^{16.8-17.5} \text{ cm}^{-2}$, $10^{5.4-6.1} M_{\odot}$
- Velocity range:
 -787 to 1855 km s^{-1}
- Area: $1050 \times 825 \text{ kpc}$
(@ $D_{M101} = 6.925 \text{ Mpc}$)



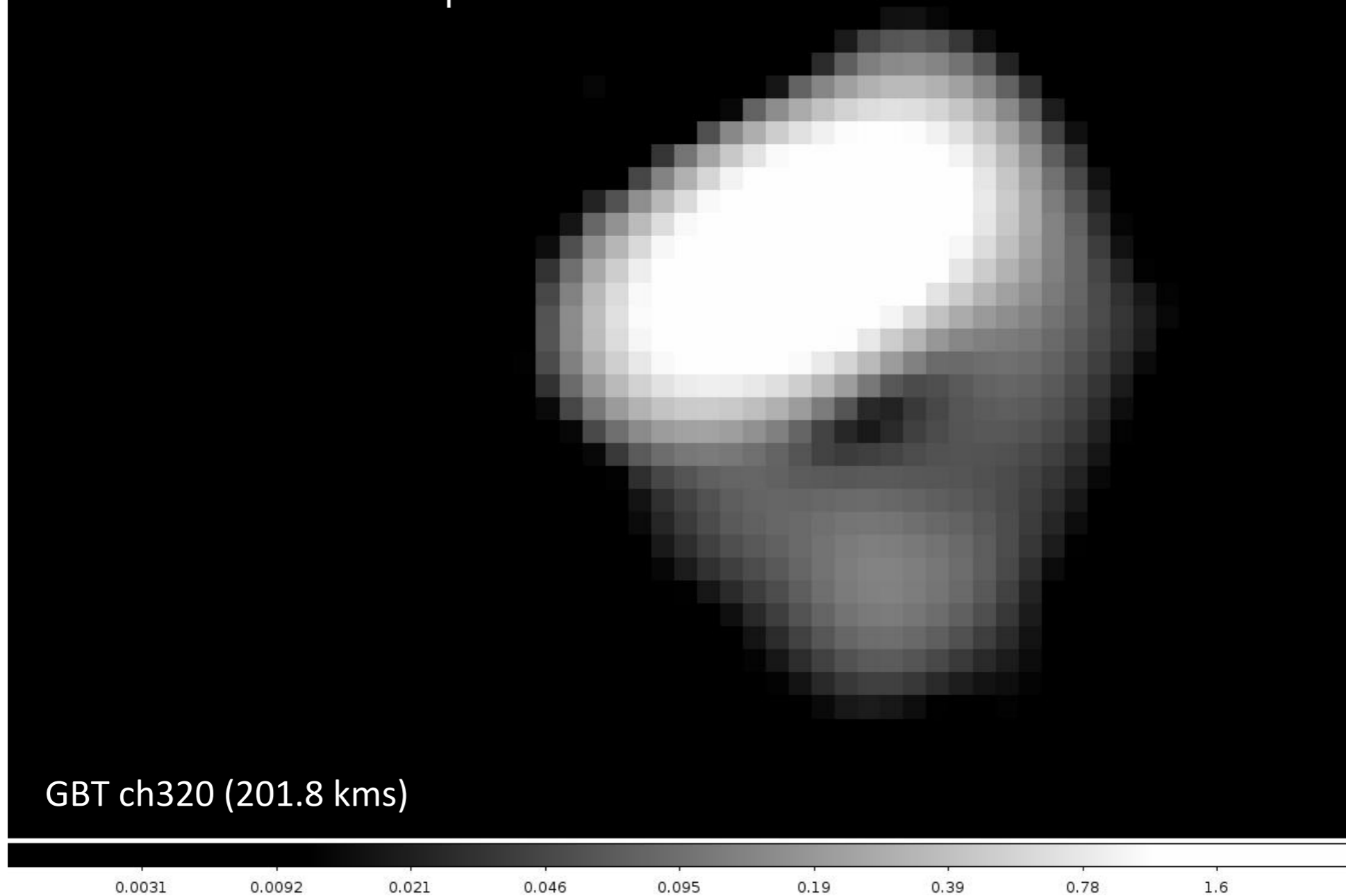
TOTAL HI COLUMN DENSITY



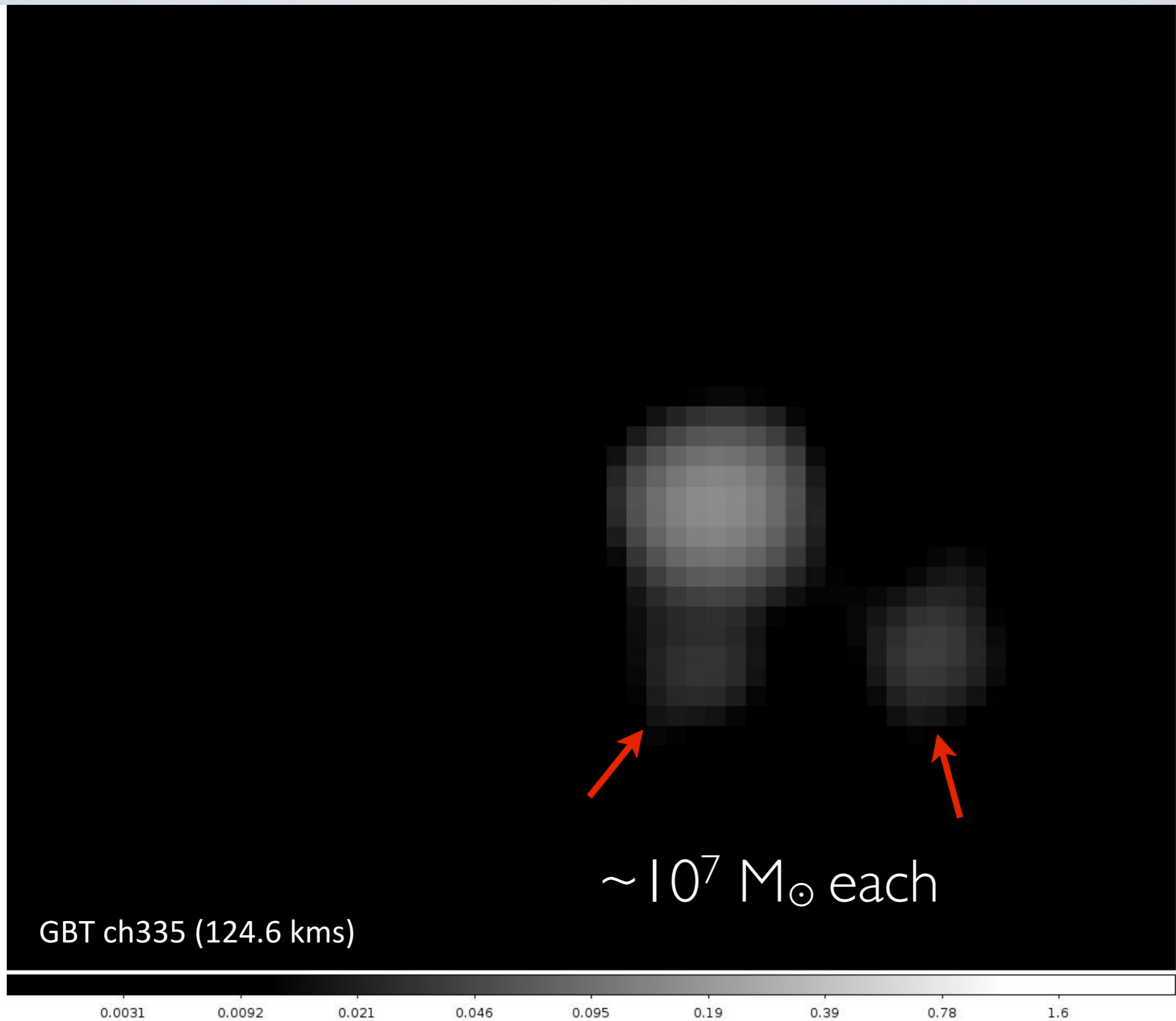
GBT VS. THINGS



125 kpc long
 $10^8 M_{\odot}$
 $5 \times 10^{17} \text{ cm}^{-2}$ at peak



No optical counterpart to $\mu_B = 30 \text{ mag arcsec}^{-2}$

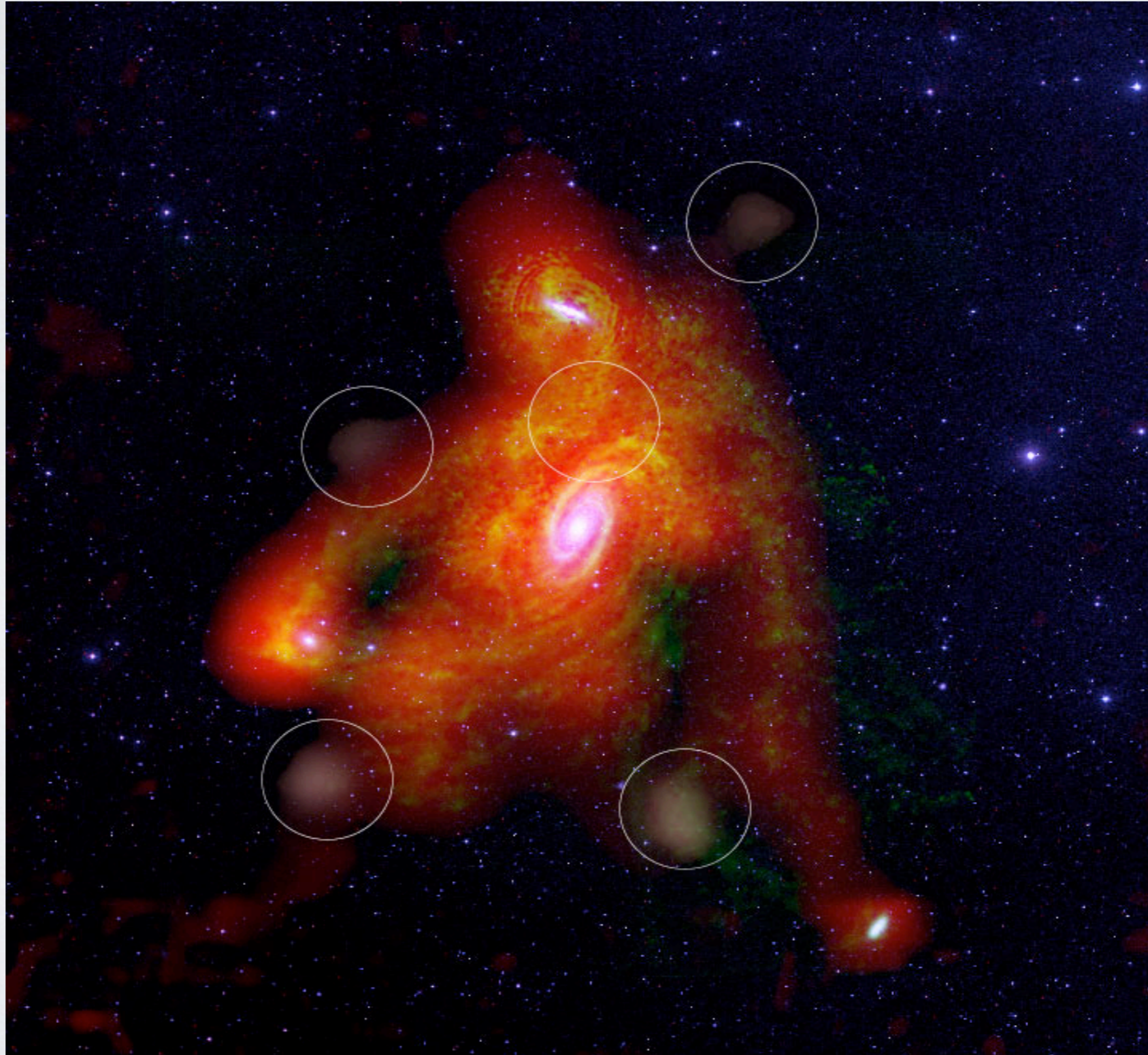


No optical counterpart to $\mu_B = 30 \text{ mag arcsec}^{-2}$

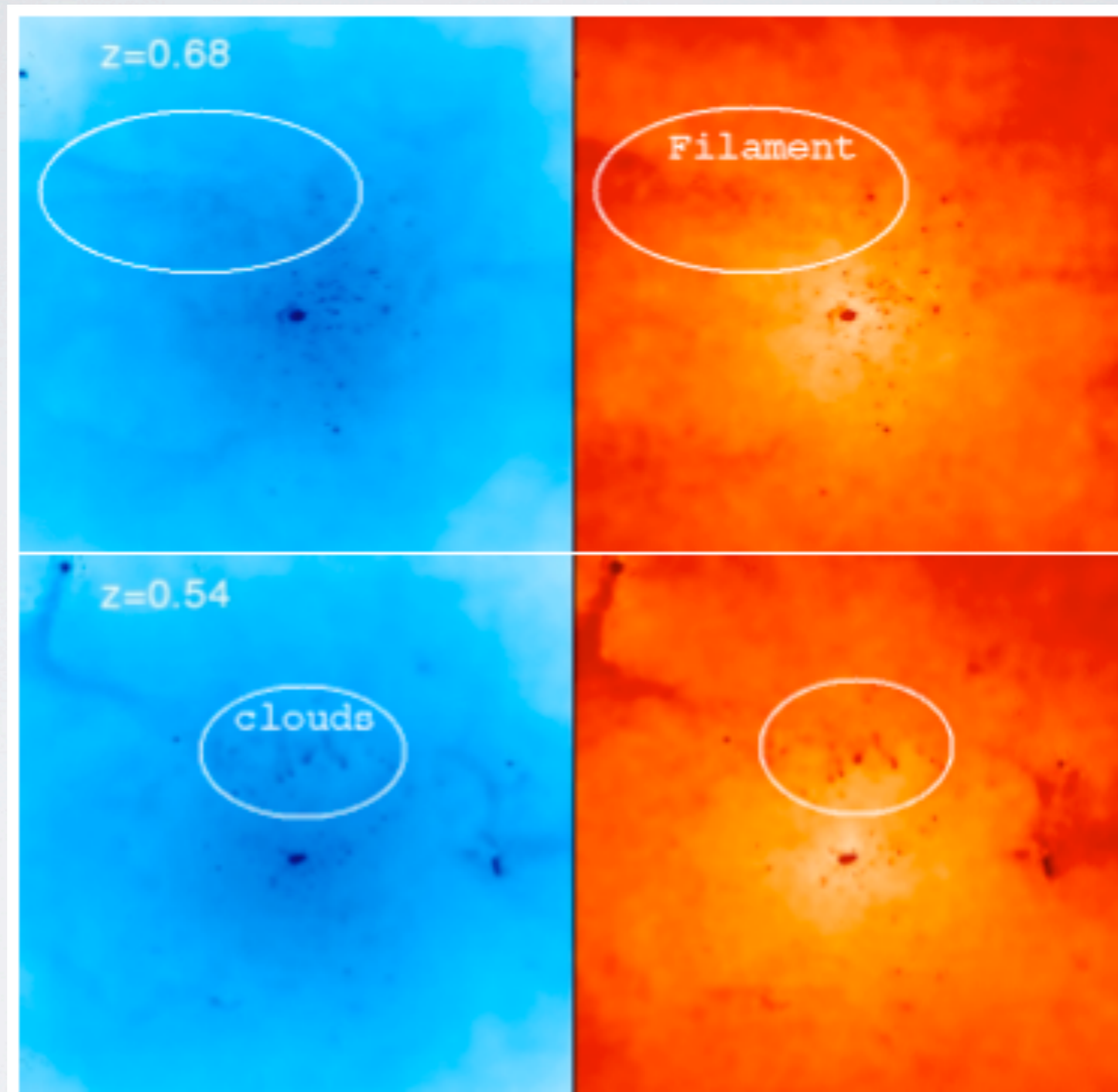
POSSIBLE ORIGINS

- Galactic fountain
 - Not detectable by these observations
- Cold accretion along dark matter filaments
- Small satellite dark-matter halos (Λ CDM)
 - Unlikely, for these observations at least (Chynoweth et al. 2009, 2011)
- Produced by galaxy interactions

GALAXY INTERACTIONS



COLD ACCRETION

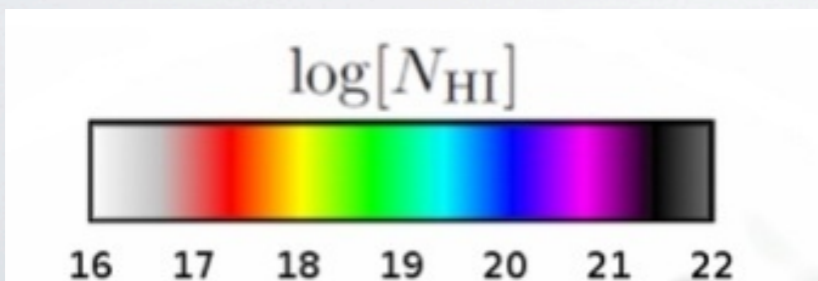
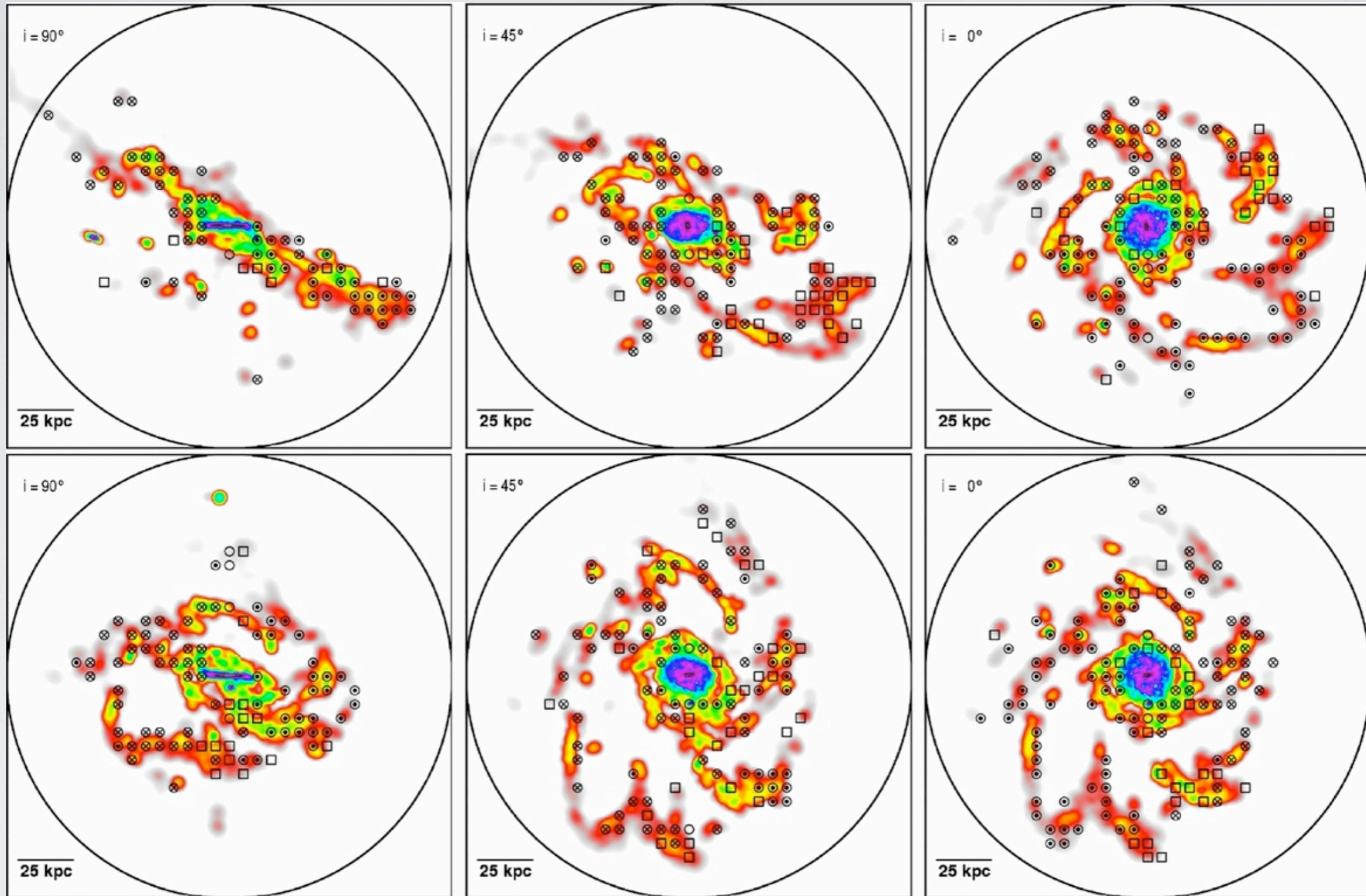


Density

Temperature

Keres et al. 2009

COLD ACCRETION SIMULATIONS



Stewart et al. 2011

SO WHICH IS IT?

- Morphology, kinematics tells us nothing
- No obvious interactions, just nearby companions
- Cold accretion simulations are for MW-size galaxies: Cold accretion drops off above $10^{12} M_{\odot}$
- Metallicity could provide a clue? But maybe not?

SUMMARY

- M101 is huge
- LSB B-band shows plume to NE
- Exhibits anomalous HI structures with no optical counterparts
 - Plume/loop and clouds to SW
- Are they due to interactions?
- Tracers of cold accretion?
- Even seemingly quiescent galaxies are complex at low N_{HI}

THANK YOU!

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Keating et al. in prep

Chynoweth, Langston, Yun, Lockman, Scoles, & Rubin, 2008 AJ, 135, 1983

Chynoweth, Langston, Holley-Bockelmann, & Lockman, 2009 AJ, 138, 287

Chynoweth, Langston, & Holley-Bockelmann, 2011 AJ, 141, 9

Chynoweth, Polisensky, Holley-Bockelmann, & Langston, 2011 AJ, 142, 137