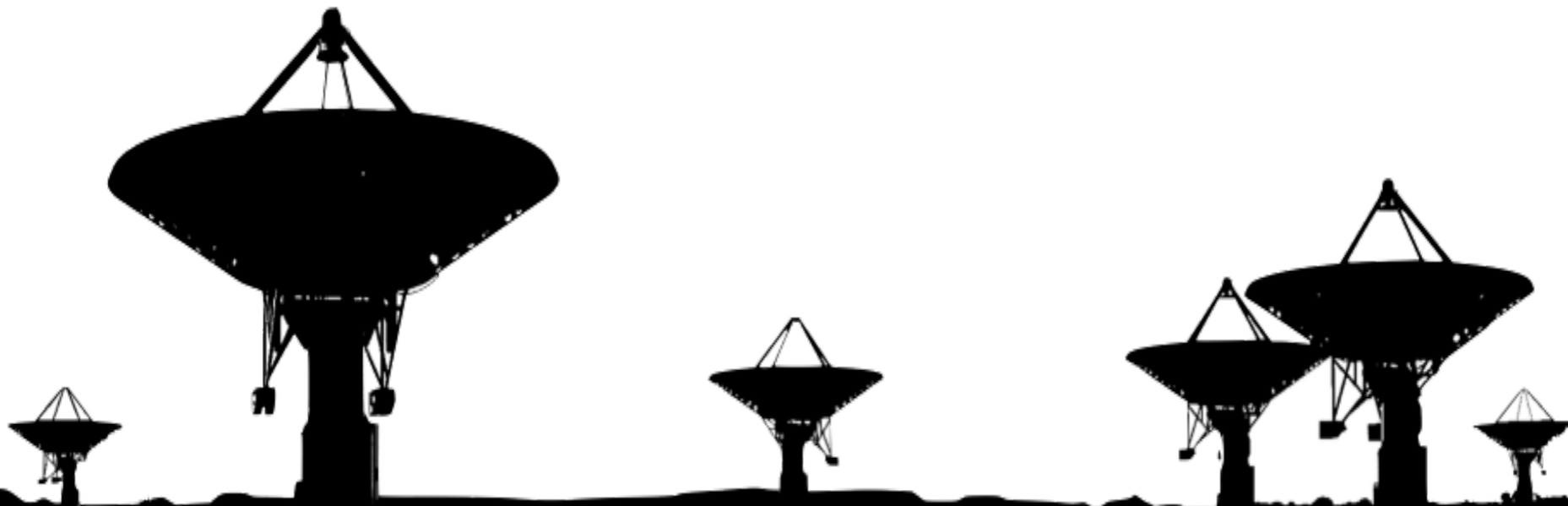


# MHONGOOSE

MeerKAT HI Observations of Nearby Galactic Objects: Observing Southern Emitters

## MeerKAT Deep Nearby Galaxies HI Survey

Yiannis Bagetakos



# MHONGGOOSE

MeerKAT HI Observations of Nearby Galactic Objects: Observing Southern Emitters

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# HI: what's left to do

The connection, over time, between **star formation**, **HI**, **dynamics** and **accretion**, is one of the main issues to address in the coming years through *large, deep surveys* of the HI in the *local and distant* Universe

- How do galaxies assemble and evolve?
- How is star formation regulated?
- How are outer disks and cosmic web linked?

# MHONGOOSE science

High resolution:

- star formation
- dynamics
- structure of the ISM

High sensitivity:

- cosmic web
- accretion



# MeerKAT





# MeerKAT

An array 64 receptors with 13.5 m diameter dishes  
Will be integrated into the mid-frequency component  
of SKA



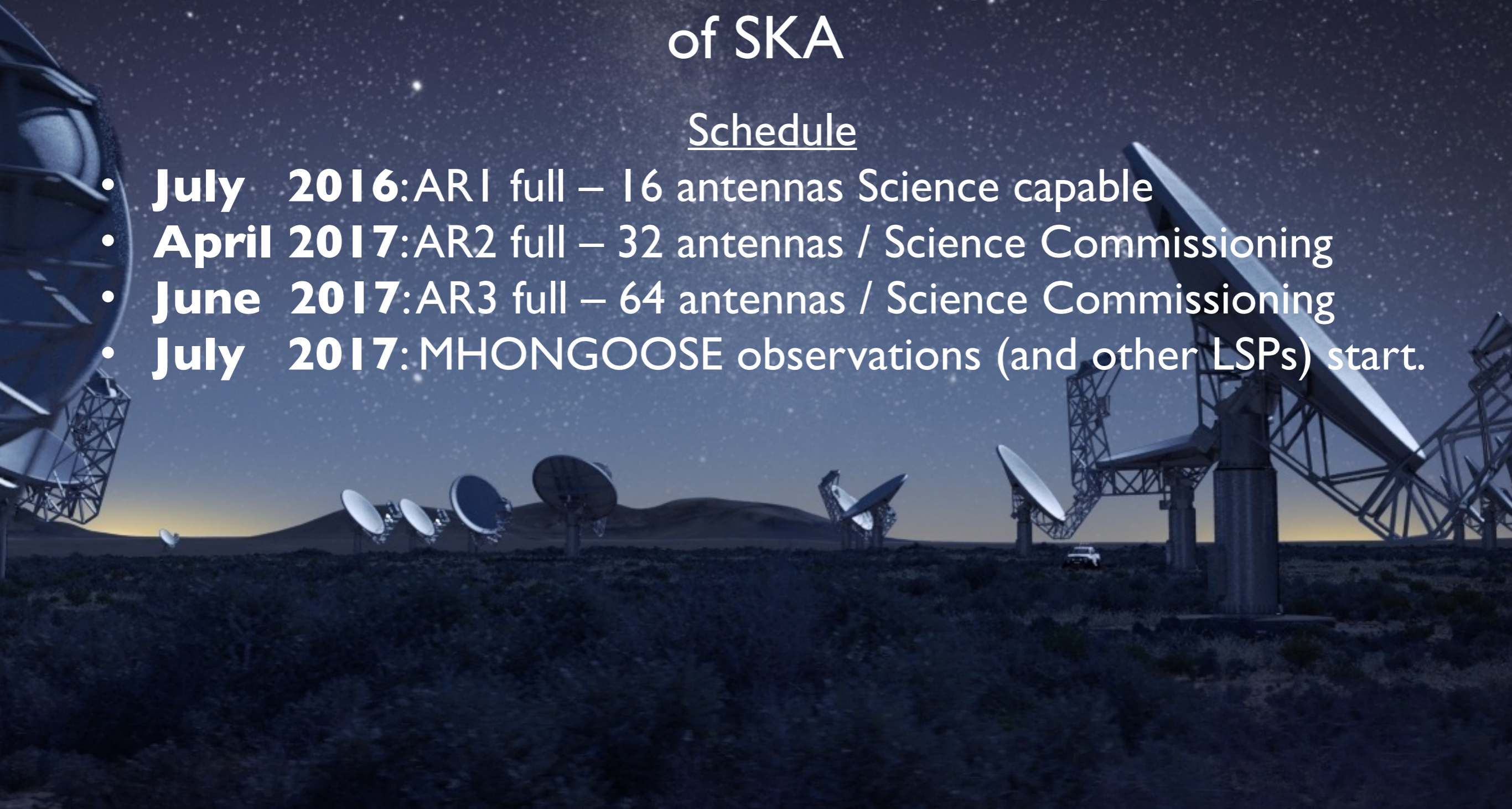


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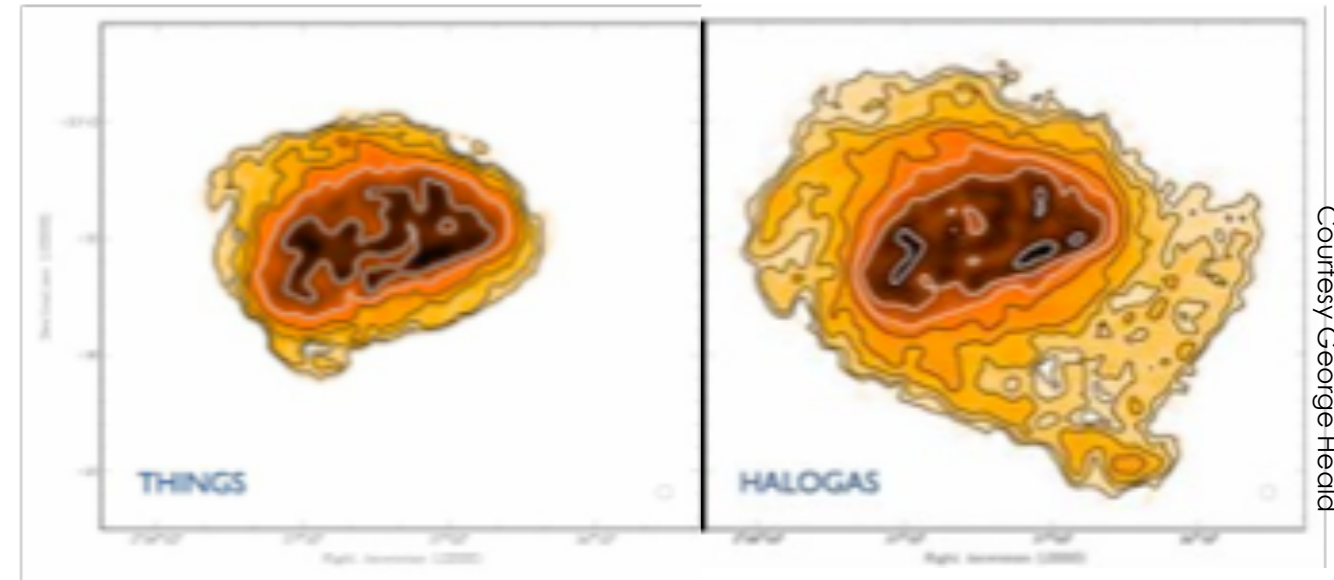
## Schedule

- **July 2016:** AR1 full – 16 antennas Science capable
- **April 2017:** AR2 full – 32 antennas / Science Commissioning
- **June 2017:** AR3 full – 64 antennas / Science Commissioning
- **July 2017:** MHONGOOSE observations (and other LSPs) start.



# High-sensitivity Science

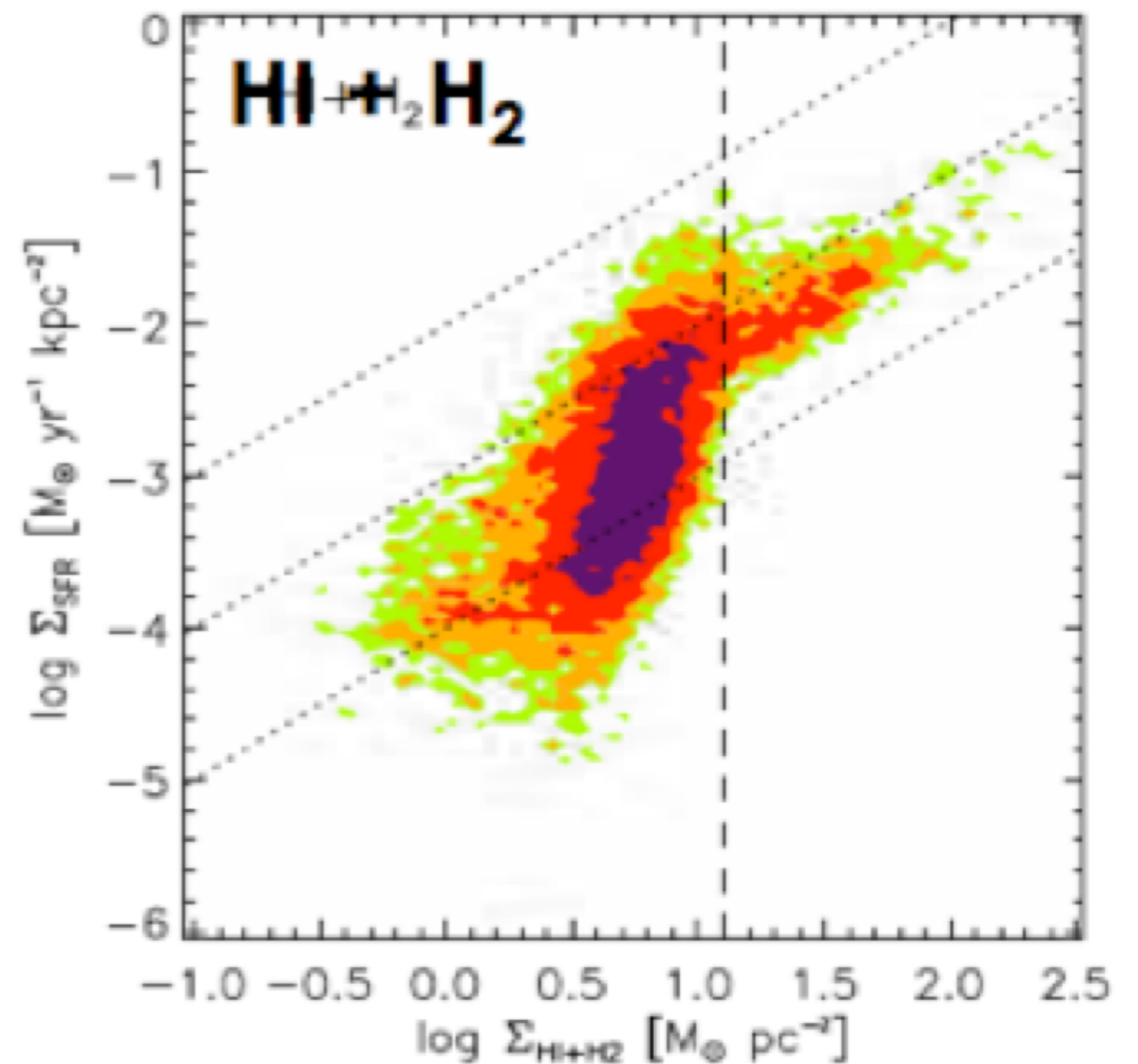
- Sample 25 times longer than THINGS
- 200h per galaxy
- 30 galaxies
- Accretion, cosmic web, dynamics beyond disk
- Equivalent to HALOGAS but different parameter range
- $5\sigma = 1.3 \cdot 10^{19} \text{ cm}^{-2}$  at  $30''$  for  $16 \text{ km s}^{-1}$  FWHM HI line at  $5 \text{ km s}^{-1}$  channel spacing or  $5 \cdot 10^{17} \text{ cm}^{-2}$  at  $90''$





# High-res Science

- Structure of the HI component
- Local links between gas and star formation
- Ratio of UV and H $\alpha$  to HI in the outskirts



# Selecting a Sample

## HI detection

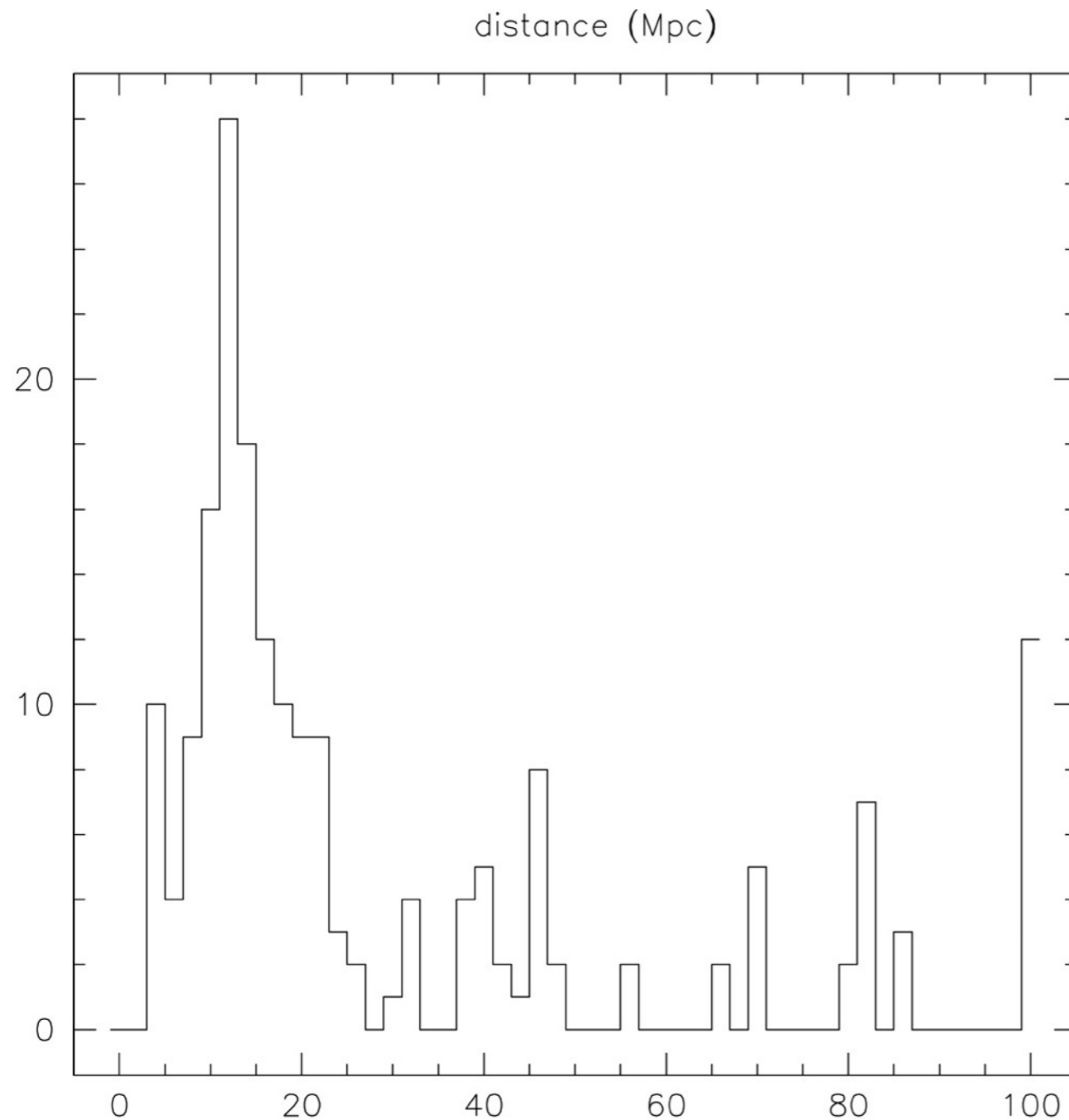
- HIPASS-based sample
- Galactic latitude  $|b| > 30^\circ$ , Galactic standard of rest velocity  $> 200 \text{ km s}^{-1}$
- Projected distance from the LMC  $> 10^\circ$

Detected in SINGG (Survey for Ionization in Neutral Gas Galaxies) and SUNGG (Survey for Ultraviolet emission in Neutral Gas Galaxies) (P.I. Meurer)

- $H\alpha$ , photometry, WISE and GALEX are available  $\rightarrow$  200 sources

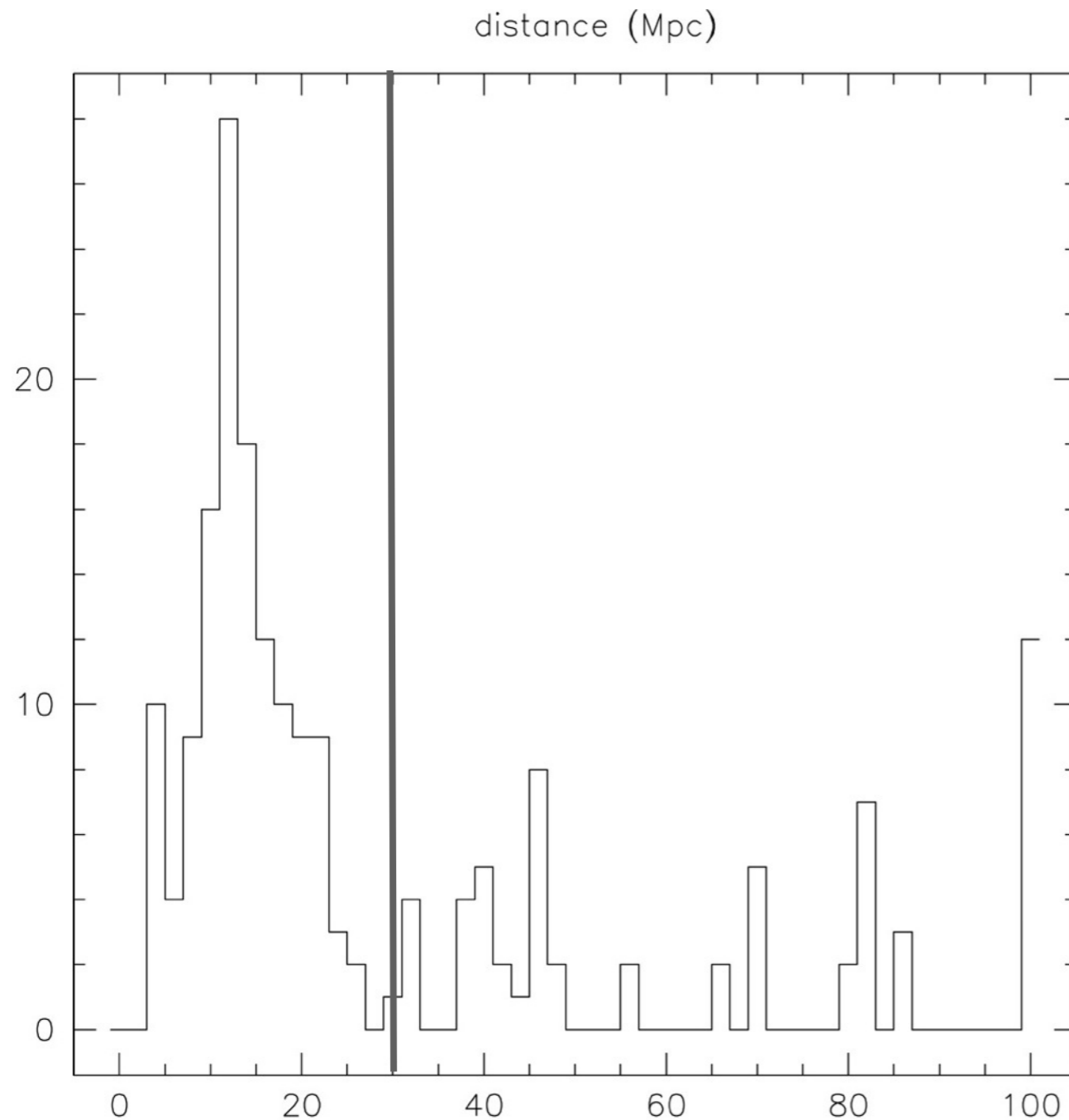
Multiple  $H\alpha$  detections for one HI source (i.e. background galaxies).  
Removing these double detections  $\rightarrow$  151 galaxies.

# Pre-cursor Sample



- A cut at 30 Mpc (MeerKAT beam is 1 kpc)
- Galaxies with  $\text{dec} < -10$
- Exclude galaxies in Paolo Serra's Fornax survey region.
- $\rightarrow$  88 galaxies

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# Pre-cursor Sample

- We want a representative number of galaxies as uniformly as possible over  $\log(M_{\text{HI}})$

6	$< \log M_{\text{HI}} < 8$	5
8	$< \log M_{\text{HI}} < 8.5$	16
8.5	$< \log M_{\text{HI}} < 9$	18
9	$< \log M_{\text{HI}} < 9.5$	26
9.5	$< \log M_{\text{HI}} < 10$	15
10	$< \log M_{\text{HI}} < 11$	7

- 5 galaxies per bin  $\rightarrow$  30 galaxies, but which?

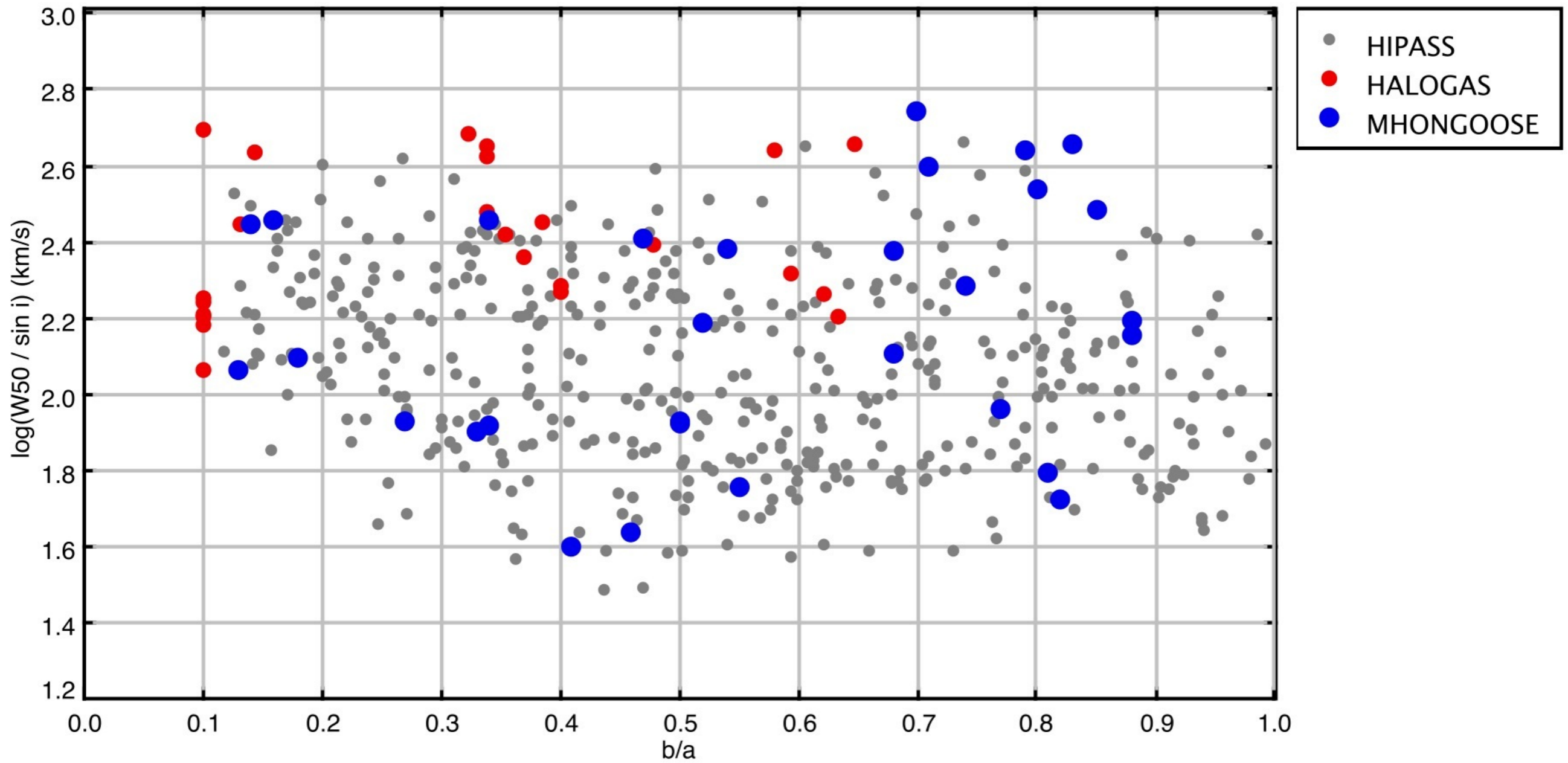
# Selecting a sample

## Criteria for the MHONGOOSE final sample

- Exclude galaxies with obvious quality issues
- Exclude interacting galaxies
- Best edge-on, face-on and intermediate inclination
- A range in surface brightness and SFR

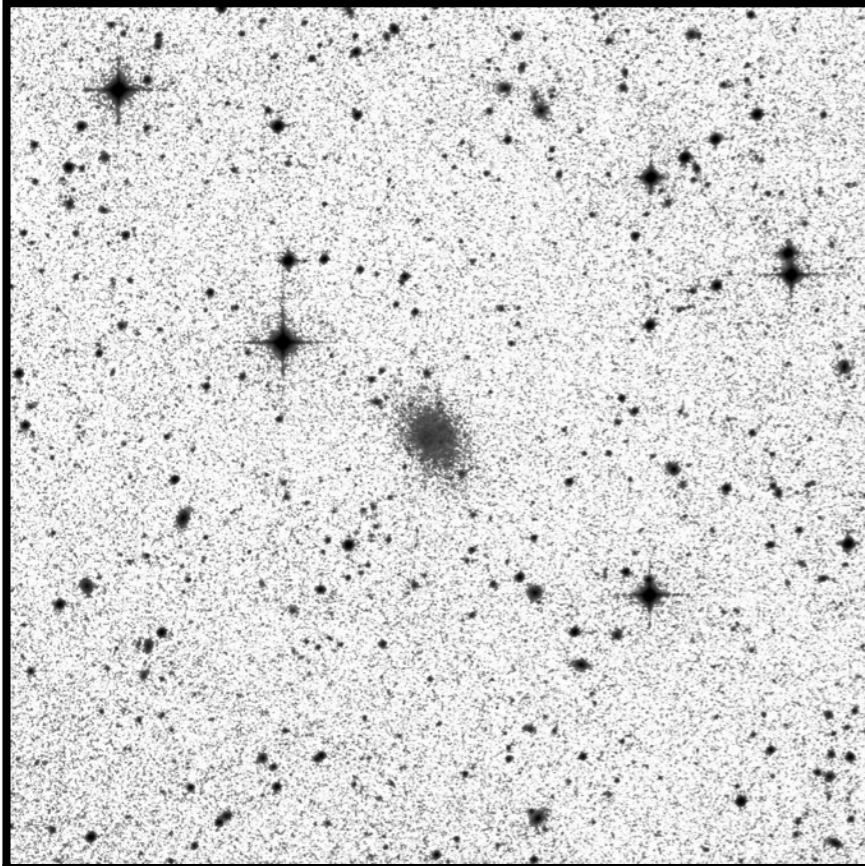
Ranked the remaining

# Selecting a sample

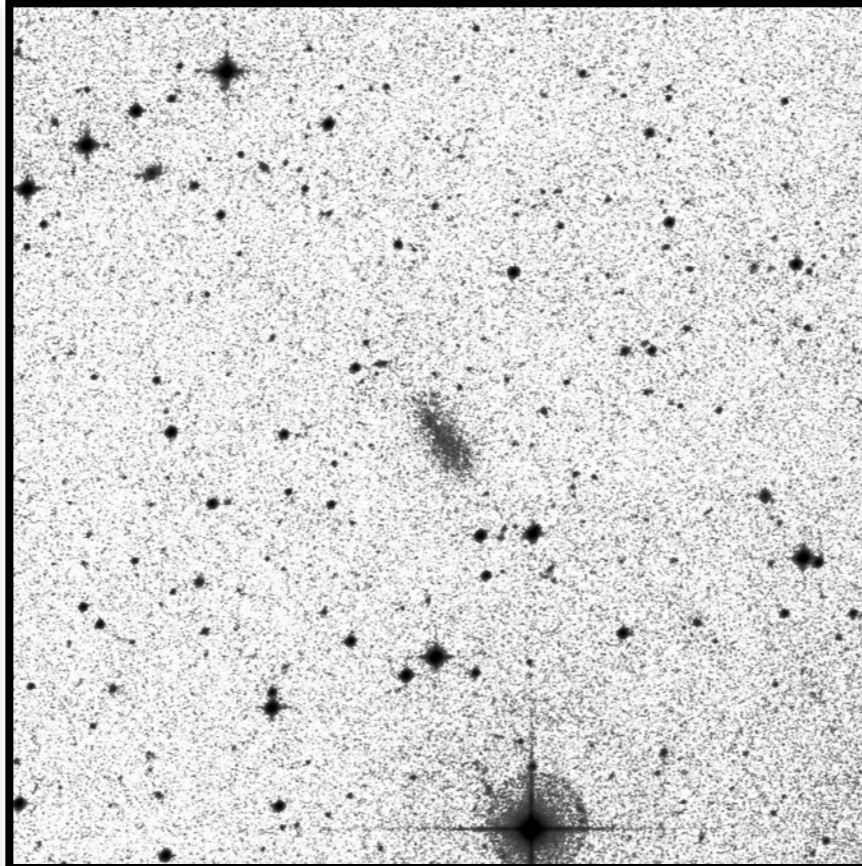


$6 < \log M_{\text{HI}} < 8$  group I

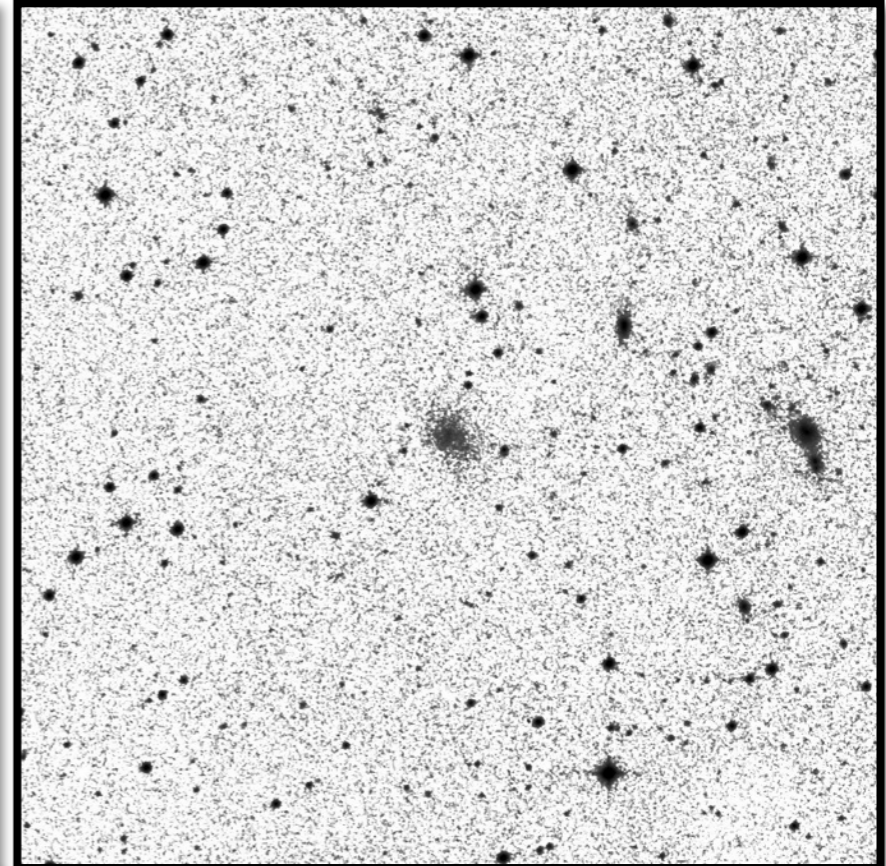
J0008-34



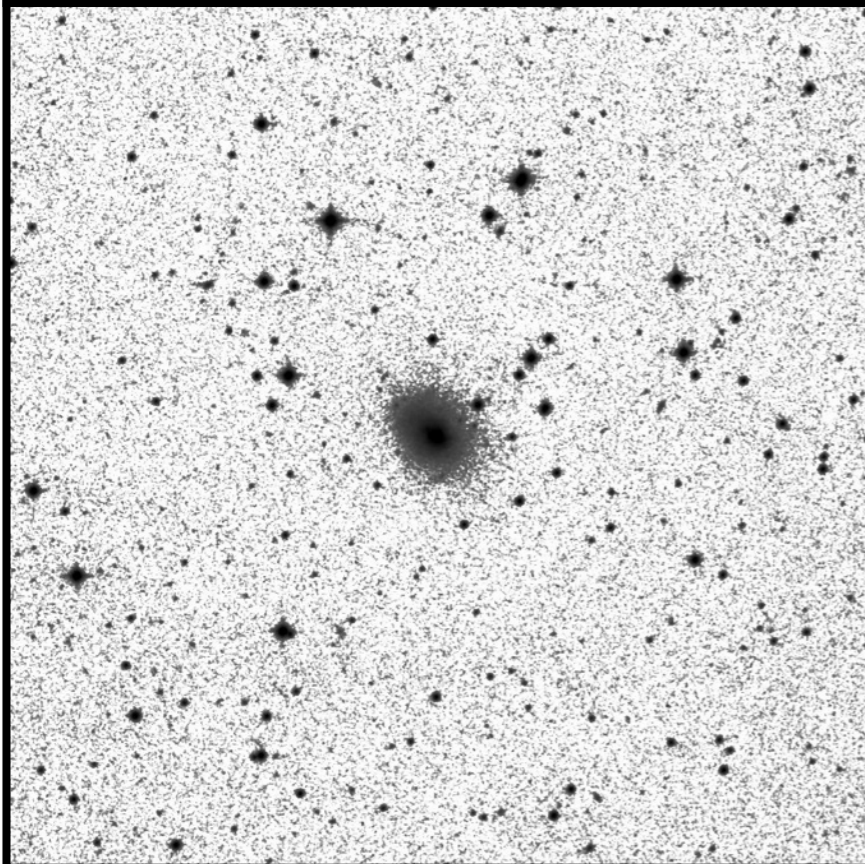
J0049-20



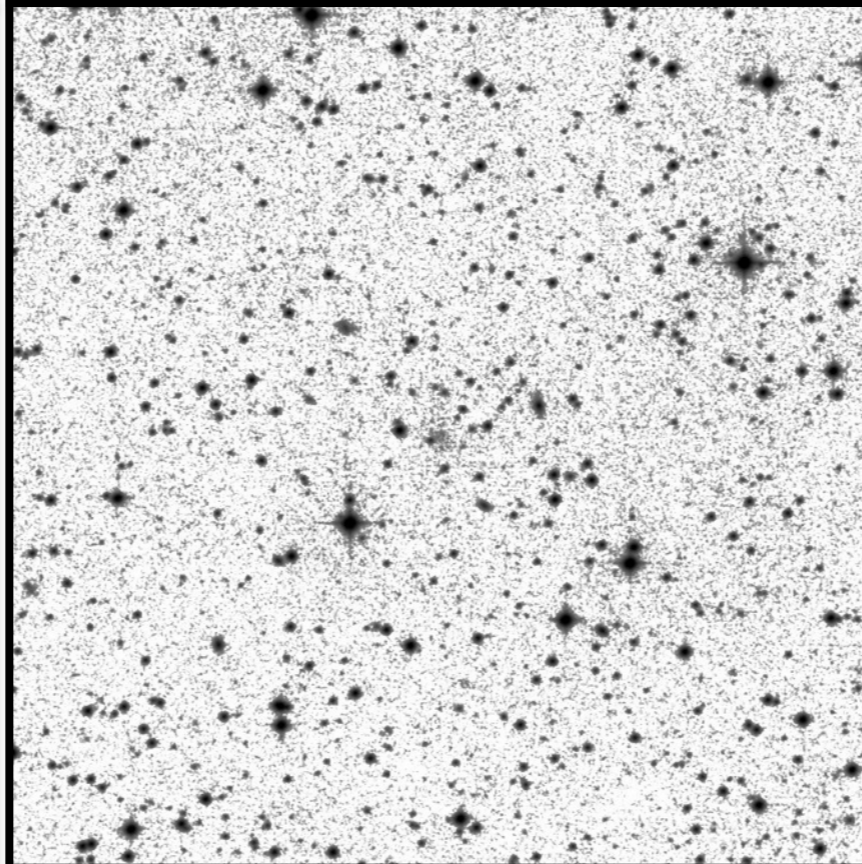
J0310-39



J0454-53



J1321-31

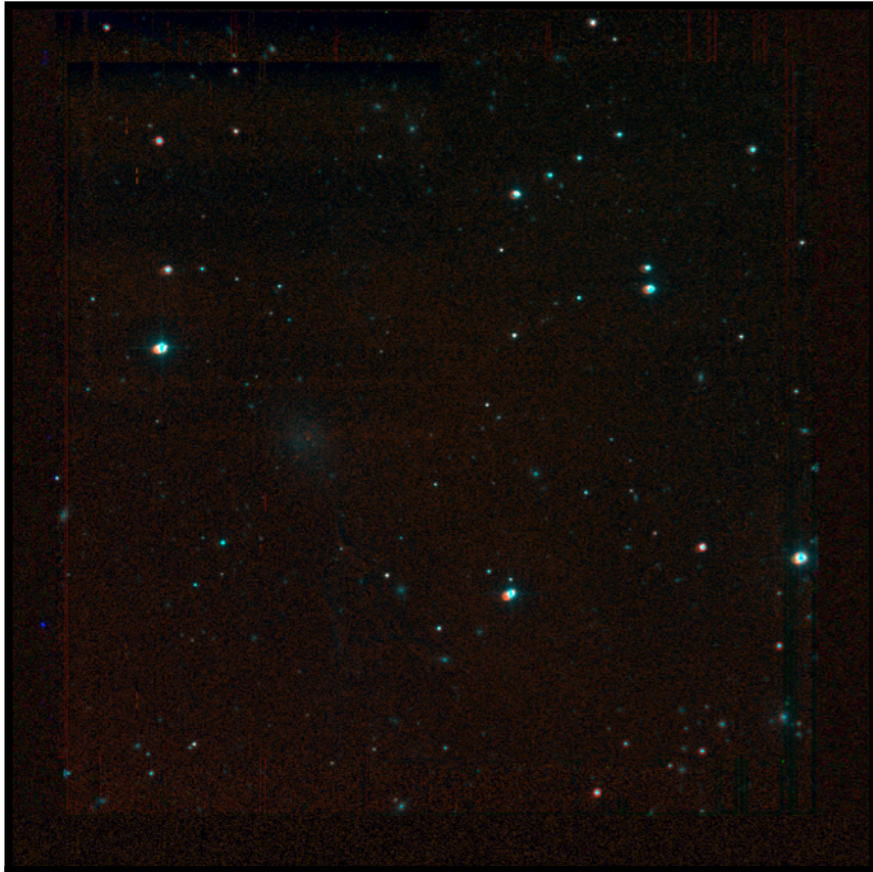


DSS

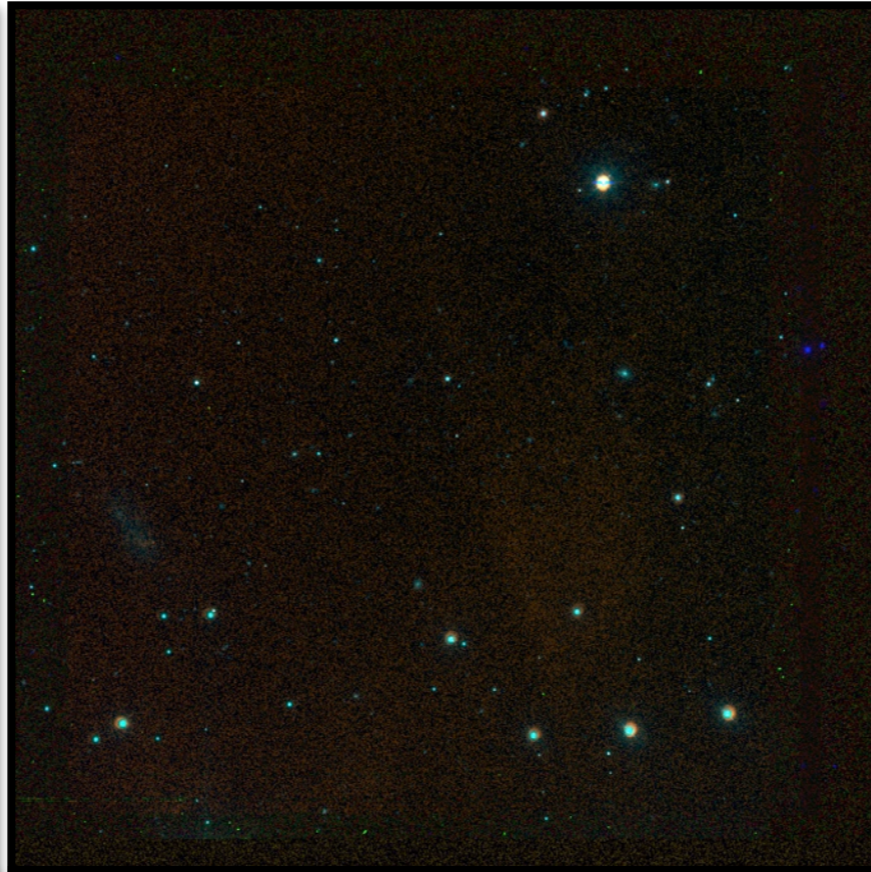


$6 < \log M_{\text{HI}} < 8$  group I

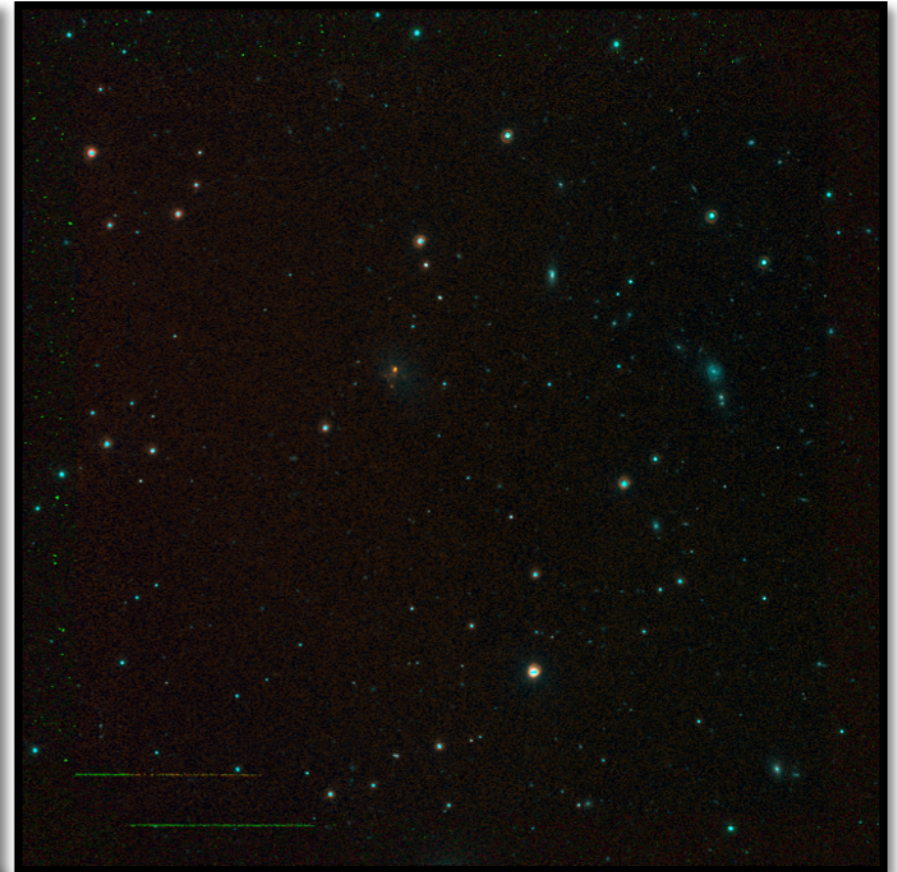
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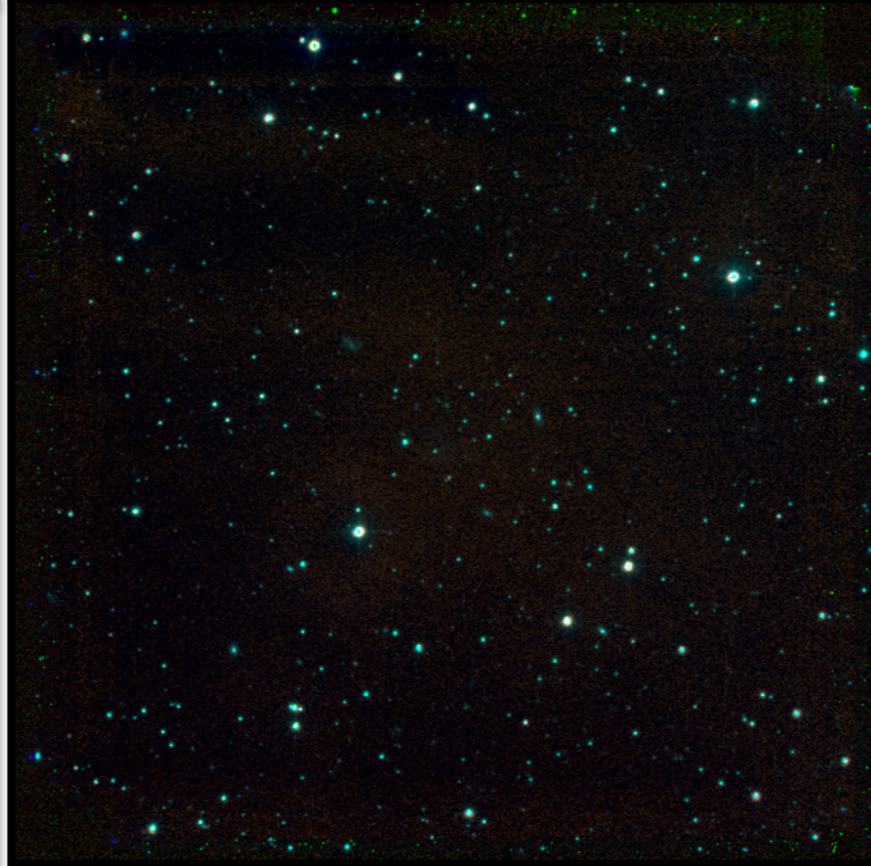
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J0310-39



J0454-53



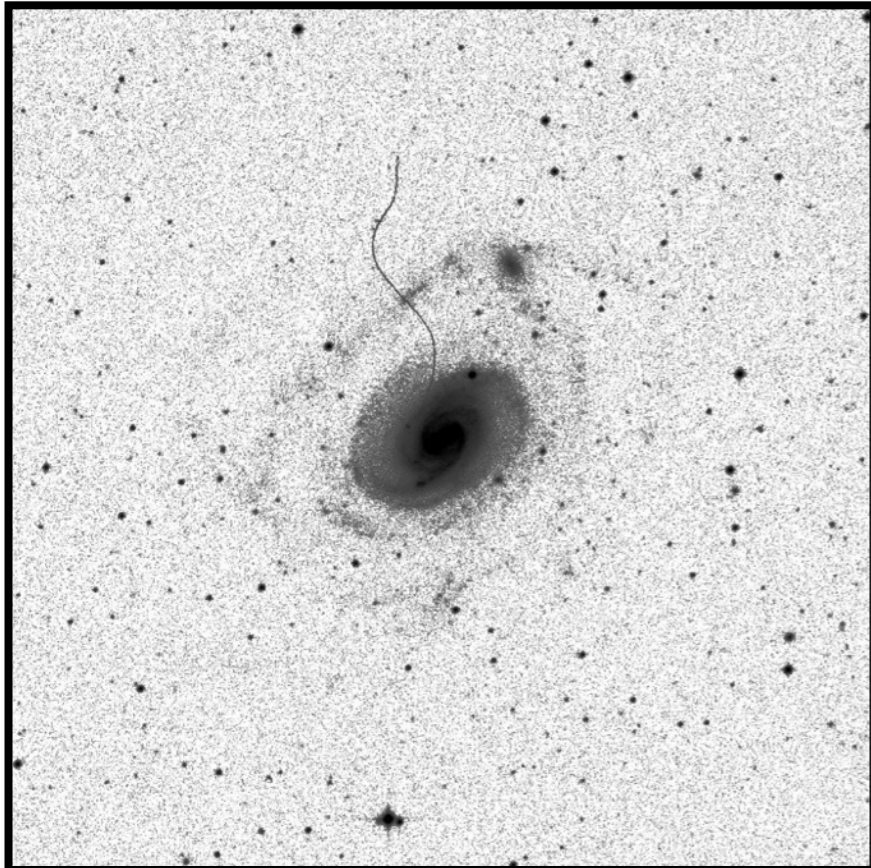
J1321-31

SINGG

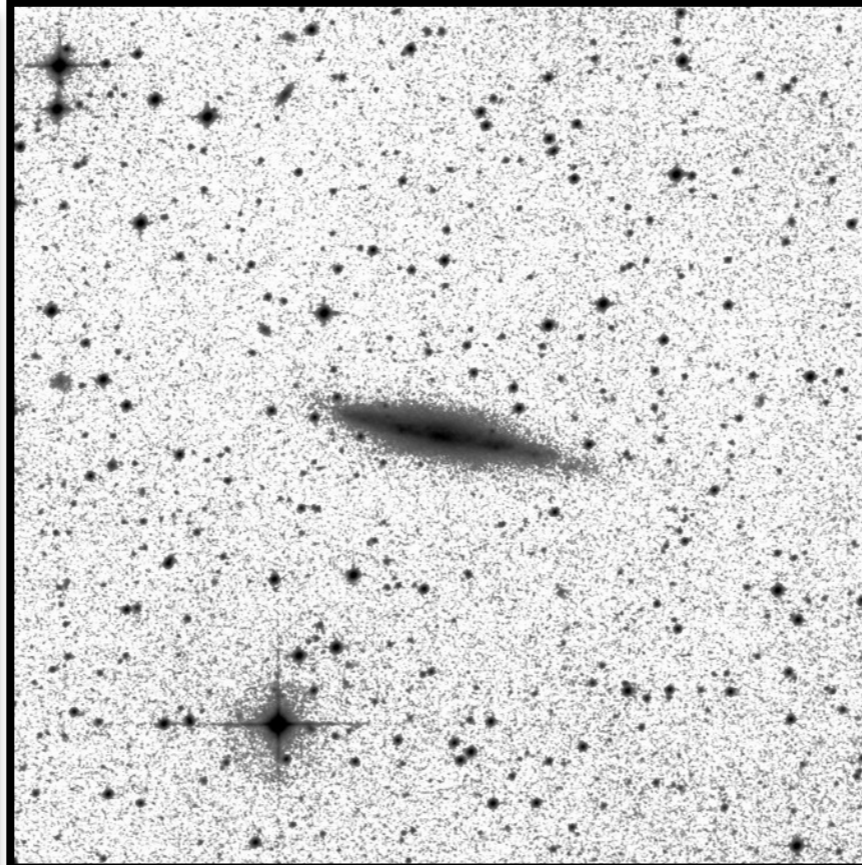


$10 < \log M_{\text{HI}} < 10.5$  group 6

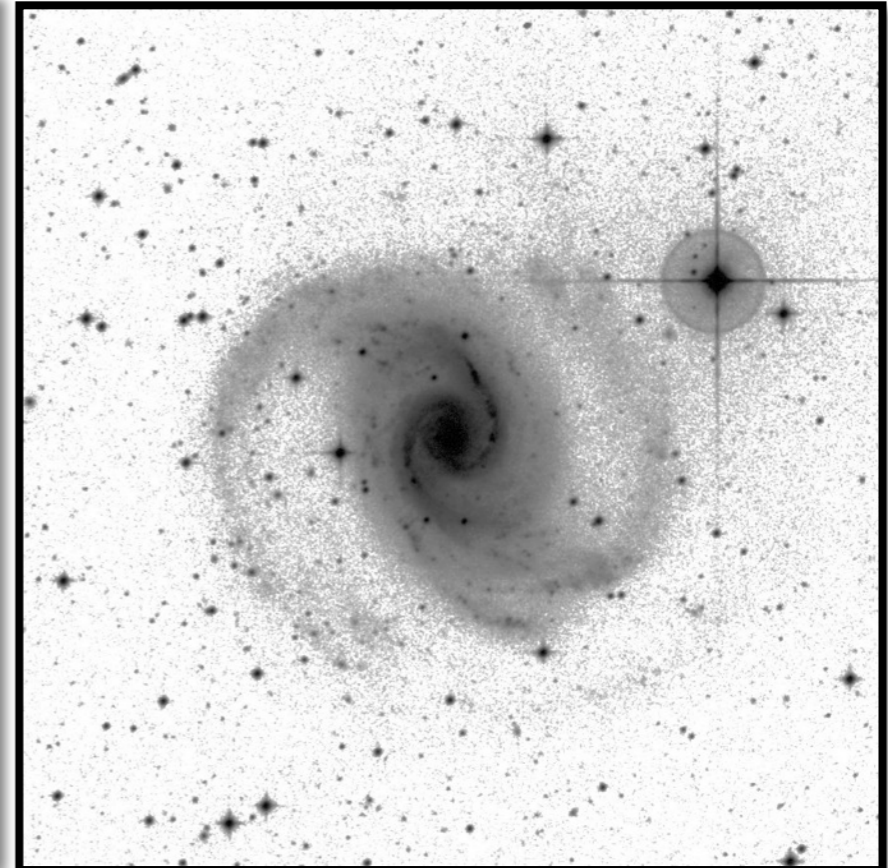
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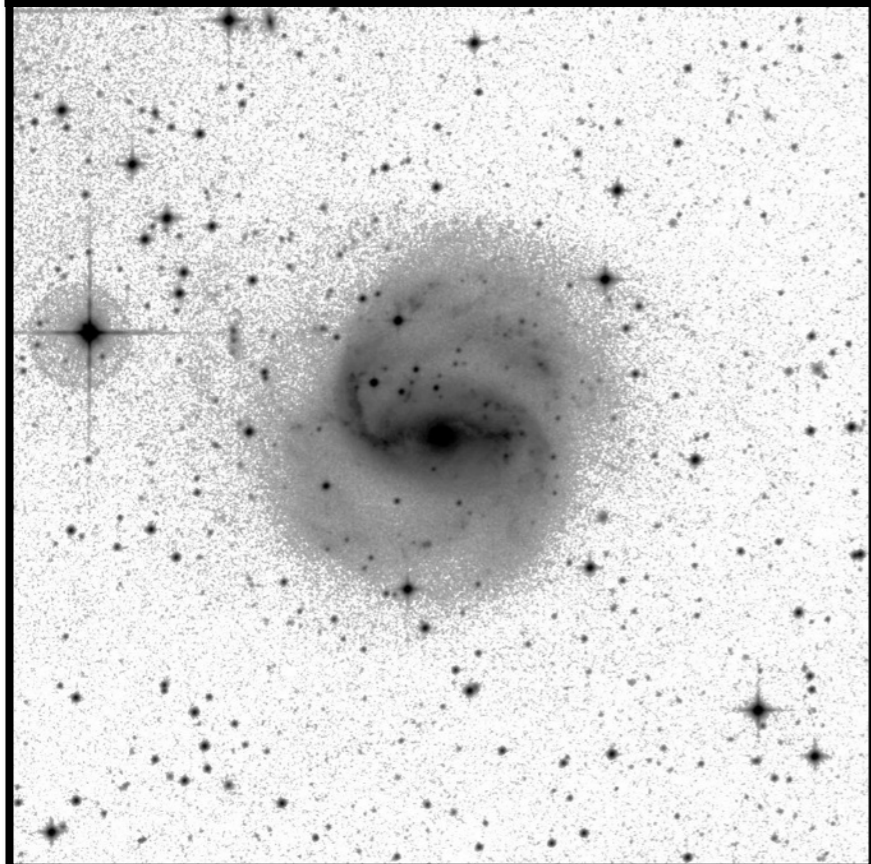
J1153-28



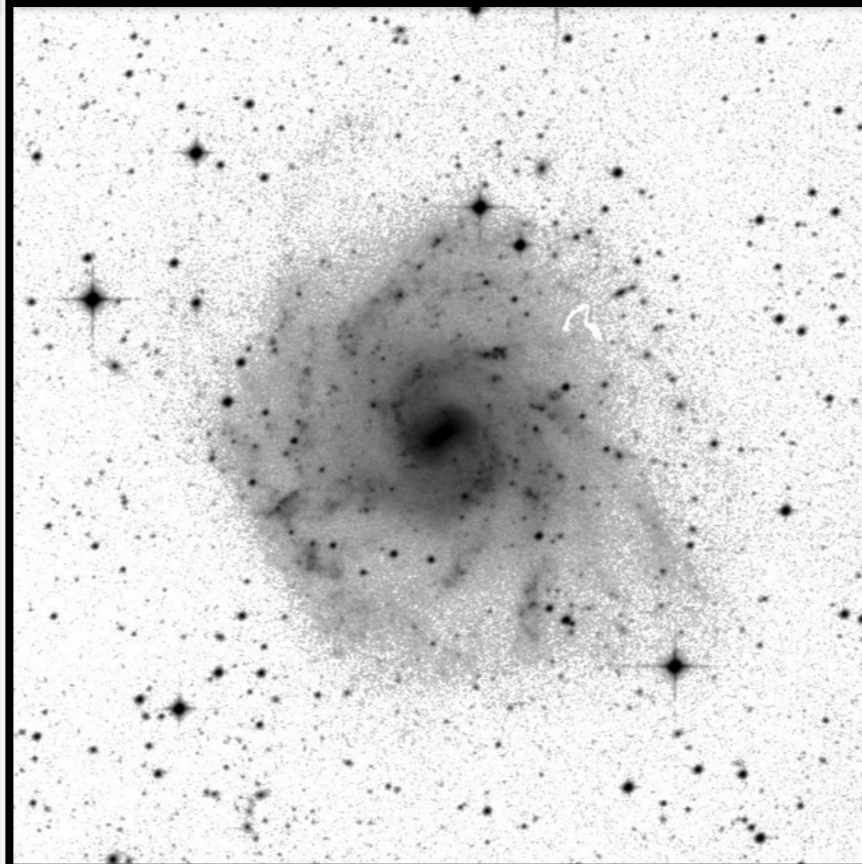
J0419-54



J0445-59



J2257-41

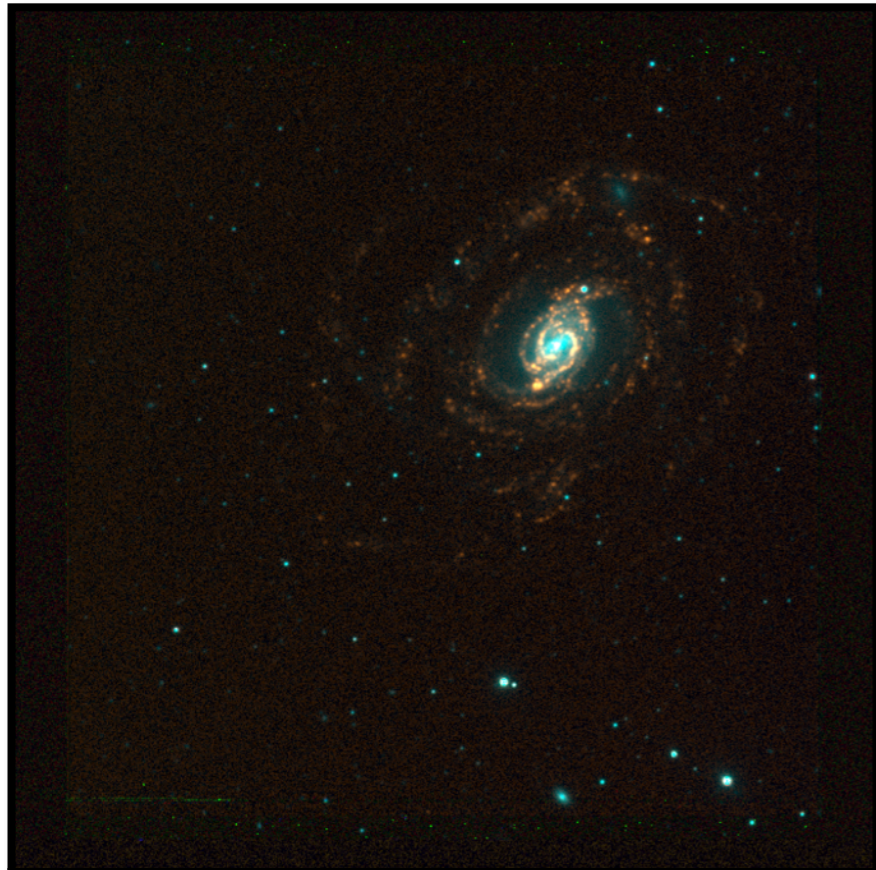


DSS



$10 < \log M_{\text{HI}} < 10.5$  group 6

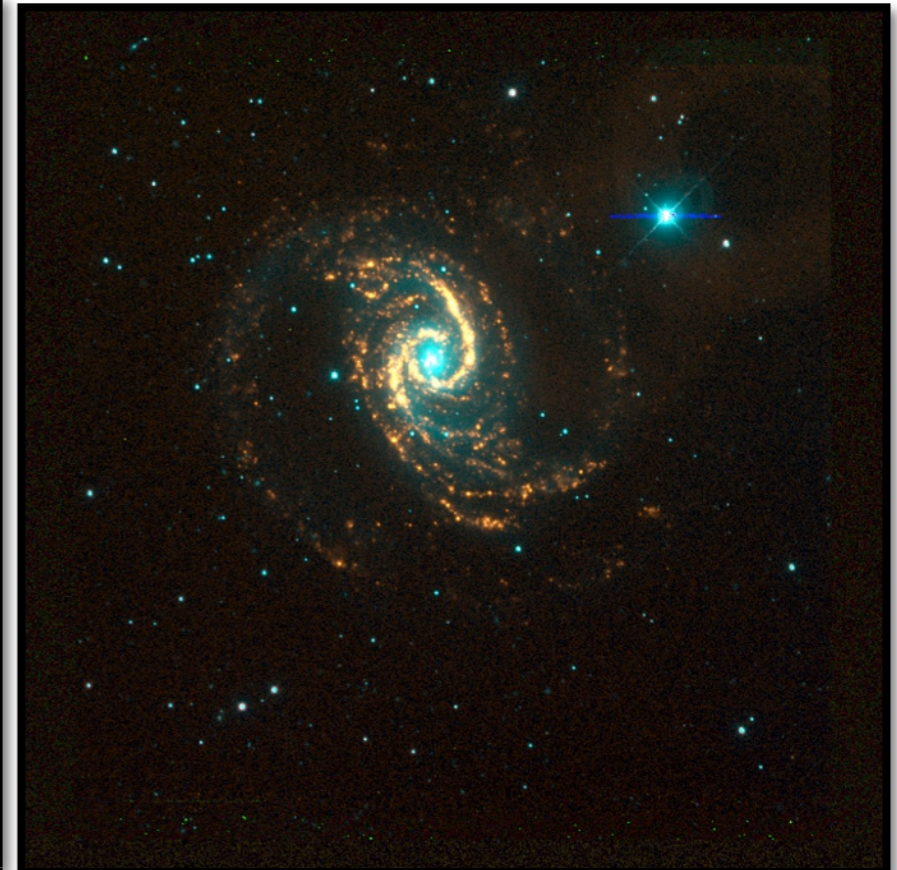
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J1153-28



J0419-54



J0445-59

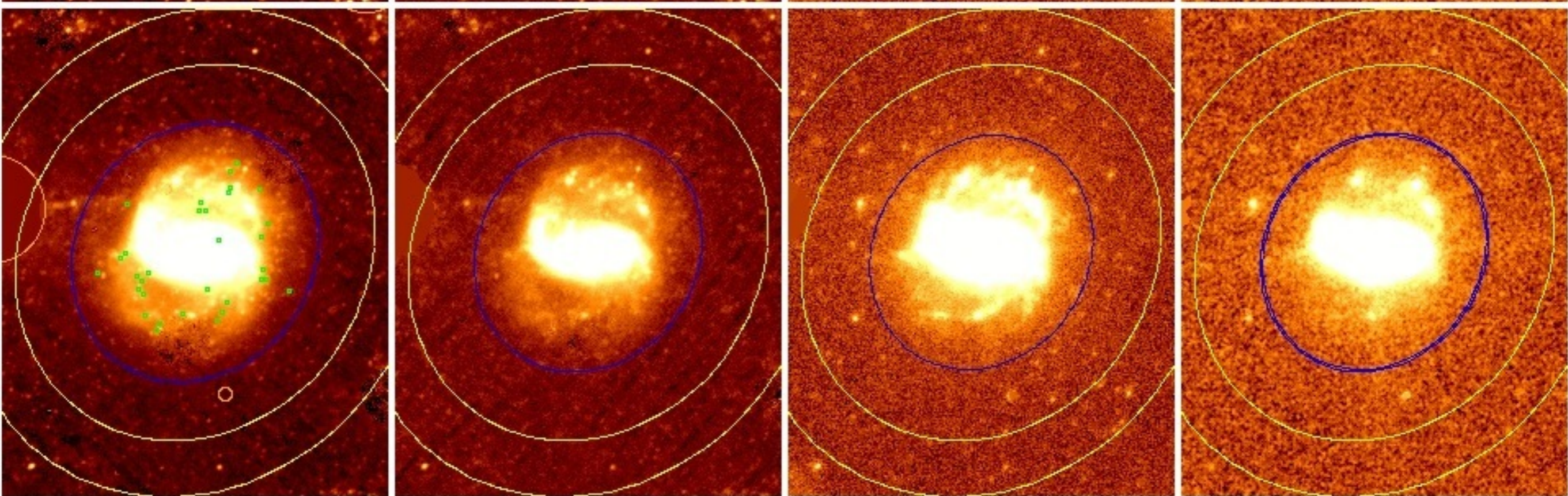
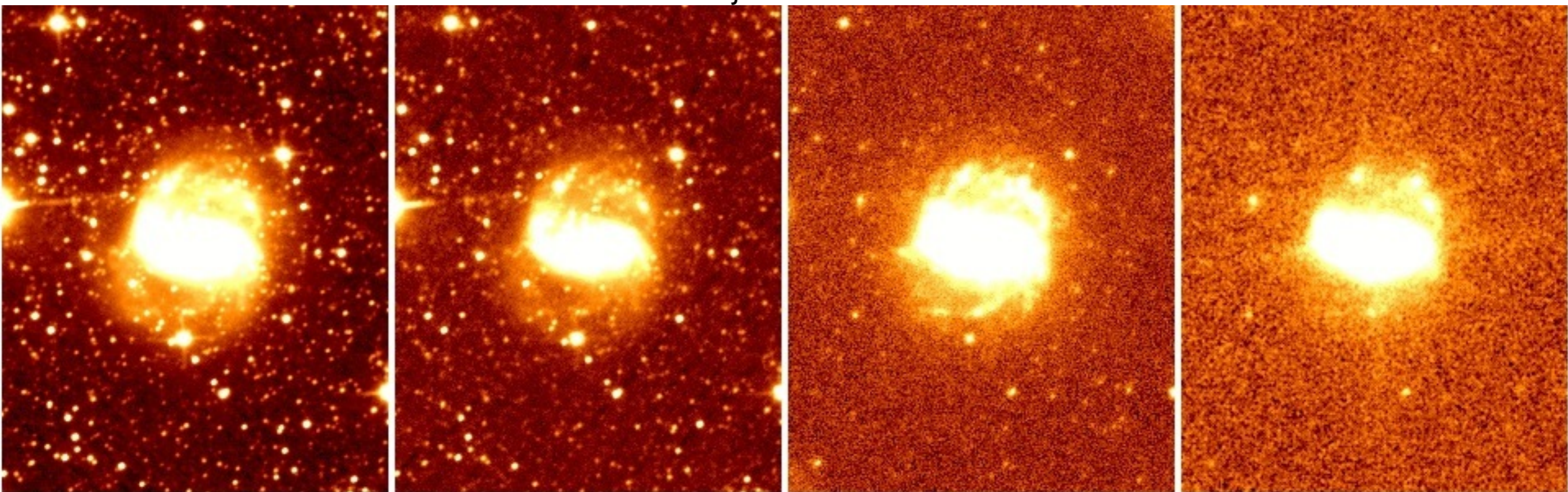


J2257-41

SINGG



J0445-59



1 1.2 1.4 1.7 2.1 2.5 3 3.6

WISE, courtesy Tom Jarrett



# KAT-7





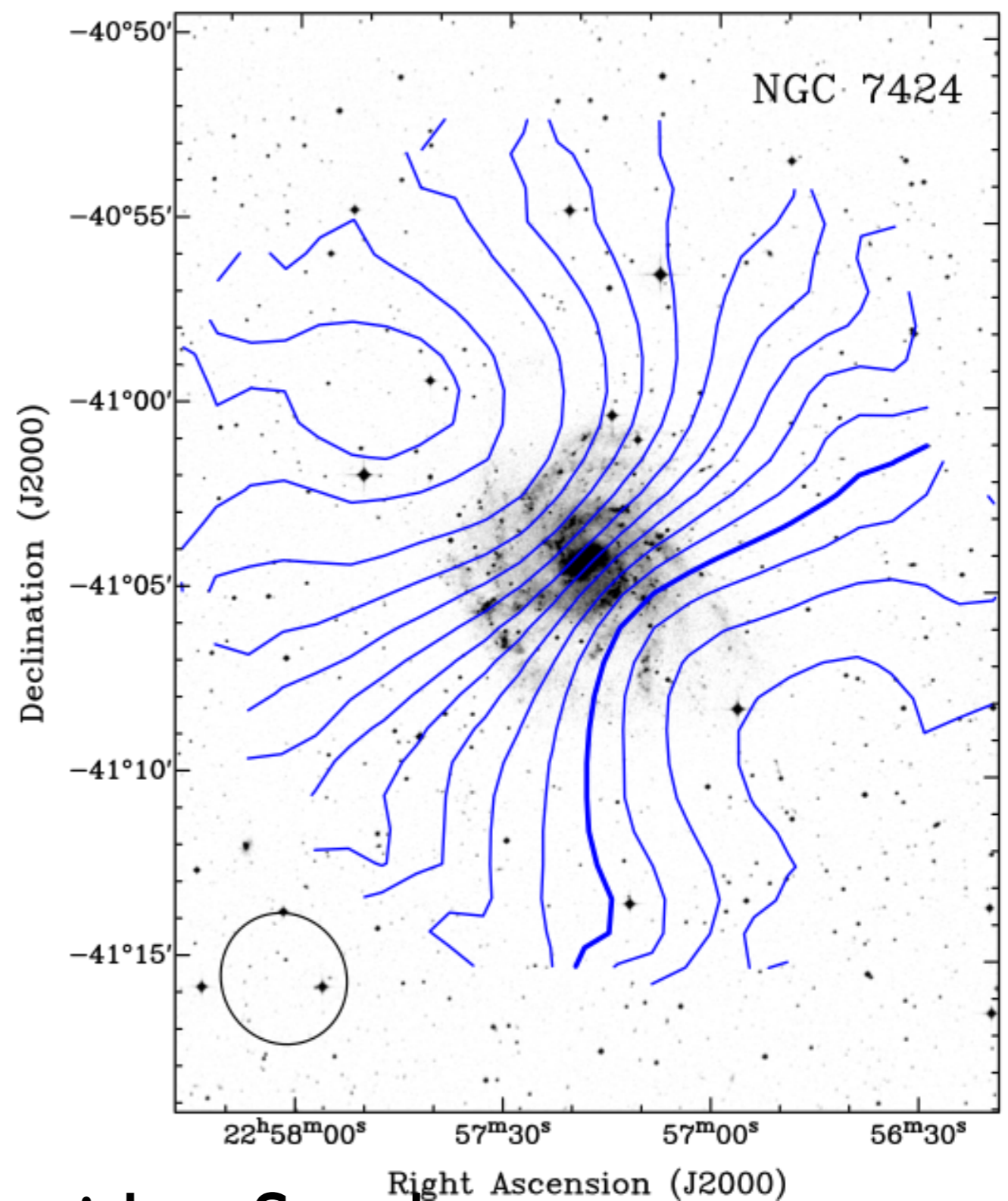
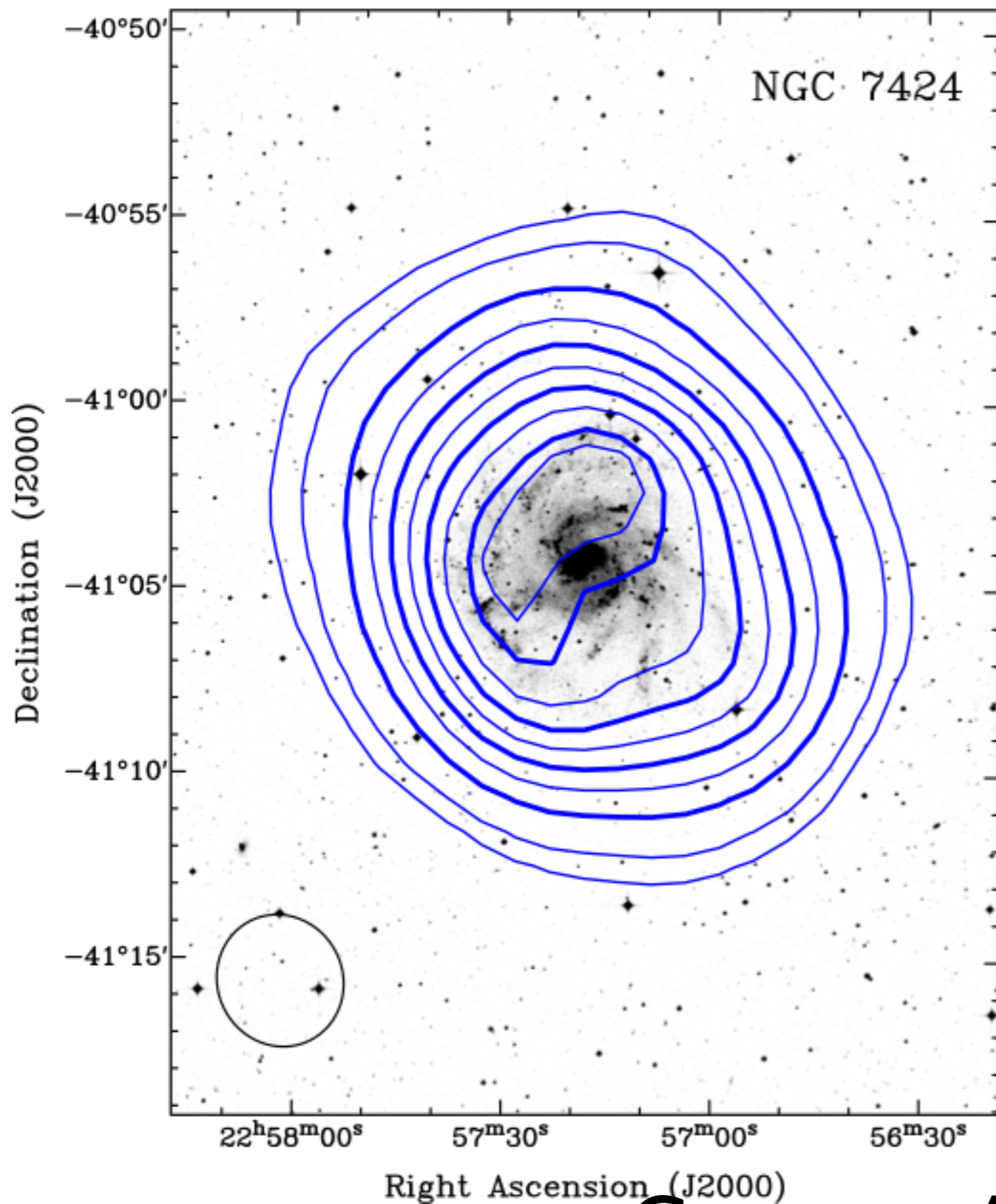
# KAT-7

Karoo Array Telescope  
7 dish (12m) MeerKAT precursor





# KAT-7 first results



Courtesy Amidou Sorgho



# Further info...

mhongoose.astron.nl

MeerKAT HI Observations of Nearby Galactic Objects: Observing Southern Emitters

## MHONGOOSE

Home Science Observations and roll-out Sample Selection Team Links Contact

### Observations and roll-out

We will observe a total of 30 galaxies, of various Hubble types, masses and inclinations, for a total of 6000h of observing time spread over five years.

Our goal for the deep survey is to detect  $1.25 \cdot 10^{19} \text{ cm}^{-2}$  at  $5\sigma$  over  $16 \text{ km s}^{-1}$  at  $30''$  resolution and a channel separation of  $5 \text{ km s}^{-1}$ . At a resolution of  $\sim 90''$ , this enables detections at the  $\sim 5 \cdot 10^{17} \text{ cm}^{-2}$  level ( $5\sigma$ ). By using stacking of HI profiles these limits can be lowered further. At the highest MeerKAT resolution ( $8''$ ) the equivalent column density sensitivity is  $5.0 \cdot 10^{20} \text{ cm}^{-2}$ . Optimal smoothing to  $16 \text{ km s}^{-1}$  channels would increase sensitivities by a factor  $(16/5)^{1/2}$ .

The sensitivity numbers assume the canonical MeerKAT design with 64 dishes with an equivalent diameter of 13.5m, a  $T_{\text{sys}}$  of 30 K and an overall efficiency of 0.7.

The long integration times offer possibilities to obtain "blind" pencil-beam surveys of the HI universe behind the target galaxies. 200h with MeerKAT gives a  $5\sigma$  detection of an  $M_{\text{HI}}^*$  galaxy at  $z \sim 0.1$ .

MeerKAT commissioning is expected to take place through 2016, with first survey observations expected in 2017.

The current roll-out plan for MeerKAT is as follows (as of July 2015)

- **March 2014**: MeerKAT Infrastructure Complete and Commissioned: this includes roads, antennas foundations, assembly sheds and the new Karoo Array Processor Building (KAPS) with its Data Rack Area (130 racks capacity) and power facility.
- **August 2015**: Receptor Test System (RTS): Two antennas, populated with L-band receivers (sensitivity expected to be  $\sim 320 \text{ m}^2/\text{K}$  rather than  $\sim 220 \text{ m}^2/\text{K}$ ) become available to project team. Intensive engineering tests in order to reduce risk prior to full MeerKAT roll-out.
- **April 2016**: Array Release 1 (AR1) partial - 6 antennas / Engineering Verification
- **June 2016**: AR1 partial - 6 antennas / Science Commissioning
- **July 2016**: AR1 full - 16 antennas Science capable (no PI projects yet)
- **Dec 2016**: AR2 full - 32 antennas / Engineering Verification
- **April 2017**: AR2 full - 32 antennas / Science Commissioning / Early Science (PIs projects) starts
- **April 2017**: AR3 full - 64 antennas / Engineering Verification

Key Science Questions for the Square Kilometre Array (SKA): *How do galaxies assemble and evolve? Can we be able to directly trace the gradual, global transformation of neutral hydrogen (HI) gas into galaxies over cosmic time? Can direct detailed observations of the sub-kpc-scale processes that cause this transformation, taking place both in the field and in the vicinity of galaxies, can best be made in the nearby universe? Can we study, in detail, the "Galactic feedback" processes that regulate the distribution of dark matter, the shape of the halo potential, the distribution of HI kinematics tell us about the distribution of dark matter, and, ultimately, how the dark and visible matter interact and regulate the evolution of galaxies. These local observations can further refine models of galaxy evolution. This knowledge can guide the design of higher redshift surveys. The study of nearby galaxies can provide information on which studies of higher redshift galaxies are most efficient and can be done with the SKA. It will be possible to systematically map out HI, from the extreme ends of the HI distribution to the dark matter halo, meaning a galaxy is in its outer parts, meaning a detailed understanding of galaxy evolution is essential for building galaxy evolution models. HI column densities, with column densities higher than in the inner disk, will yield information on the connection with the existence of low-mass cold dark matter. The simultaneous HI column density sensitivity, high spatial resolution and large field of view make possible to efficiently and systematically map out HI, from the extreme ends of the HI distribution to the dark matter halo, meaning a galaxy is in its outer parts, meaning a detailed understanding of galaxy evolution is essential for building galaxy evolution models. HI column densities, with column densities higher than in the inner disk, will yield information on the connection with the existence of low-mass cold dark matter. The simultaneous HI column density sensitivity, high spatial resolution and large field of view make possible to efficiently and systematically map out HI, from the extreme ends of the HI distribution to the dark matter halo, meaning a galaxy is in its outer parts, meaning a detailed understanding of galaxy evolution is essential for building galaxy evolution models. HI column densities, with column densities higher than in the inner disk, will yield information on the connection with the existence of low-mass cold dark matter.*

Table

Information on the sample selection process see [this](#) and [this](#) page. An ASCII table is also available. The colours in the table below indicate the 6 HI emission lines in the table are SINGG combined Ha and R-band images (credit: Meurer).

Name	D (Mpc)	V <sub>hel</sub> (km/s)	Mag./Filter	Group	logM <sub>HI</sub> (M <sub>⊙</sub> )	a/b	W <sub>50</sub> (km/s)	Morph. Type (RC3)
NGC 1404	5.1	633.3						
	3.29	221.0	15.4B	1	7.96	0.74	128	.LA..P*
	294.6	15.1B	1	7.17	0.82	30		.IB.g..
	709.7	15.56	1	6.99	0.41	36		.IBSg*
	17.1	1	7.95	0.81	36			
	13.1B	1	7.56	0.46	38			
	1.96	2	8.25	0.27	81			.SBS9?/
	2	8.03	0.77	58				.I..9..
	2	8.09	0.33	75				.SBS9\$/
	2	8.37	0.5	73				.P.....
	8.01	0.55	73					.IBS9..
	1.68	871.7	15.1	3	8.87	0.18		