THE GROWTH AND STRUCTURE OF NEARBY GALAXIES BASED ON HI OBSERVATIONS:

Capabilities of SKA Pathfinders

Brenda Namumba

Wits Centre for Astrophysics, University of the Witwatersrand

brenda.namumba@wits.ac.za

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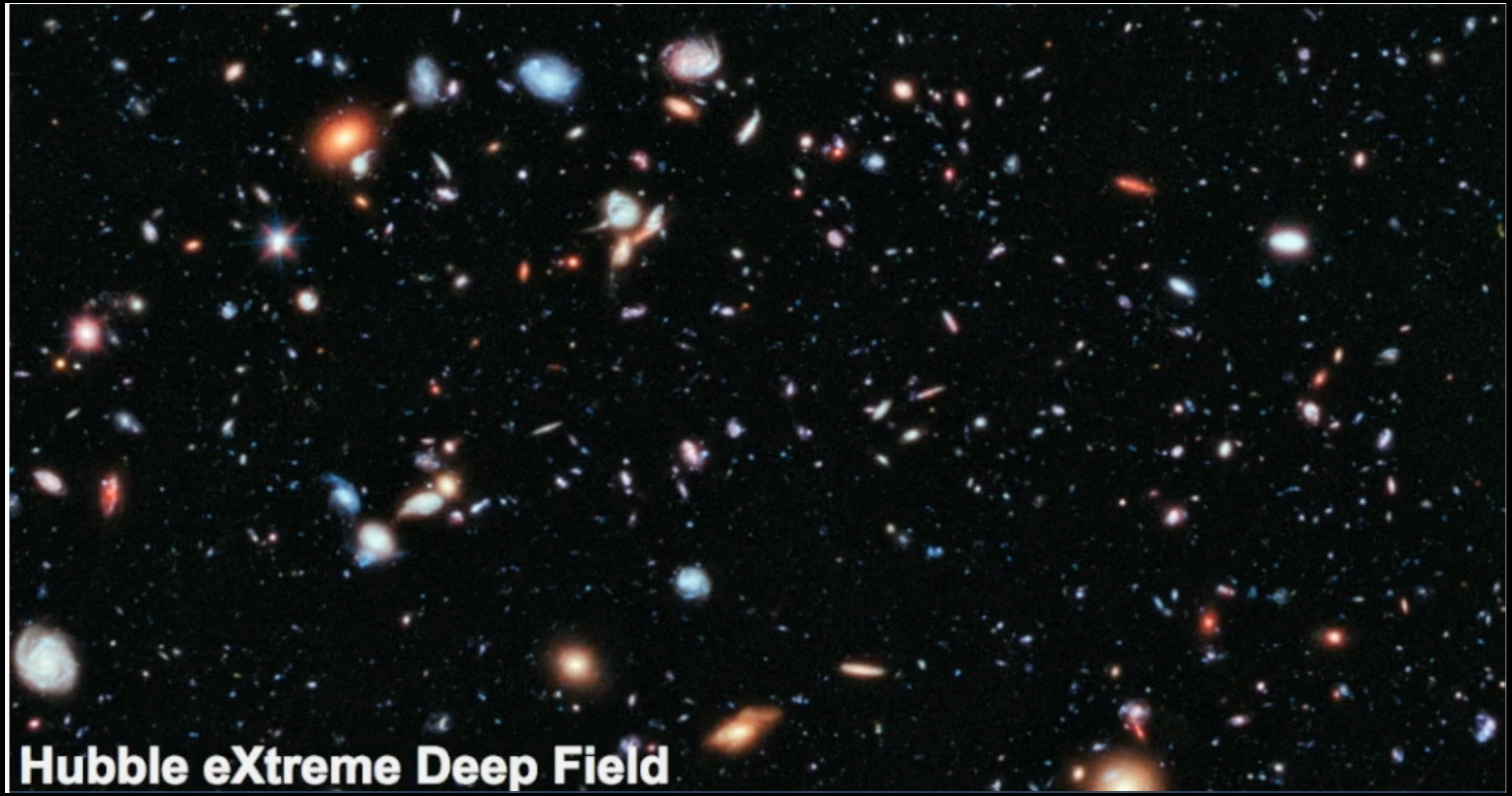
OUTLINE

- Background
- Local group dwarf galaxies
- Why neutral hydrogen (HI)?
- HI observation - dwarf galaxies
- KAT-7 results
- MeerKAT observations
- Summary

GALAXIES IN THE UNIVERSE

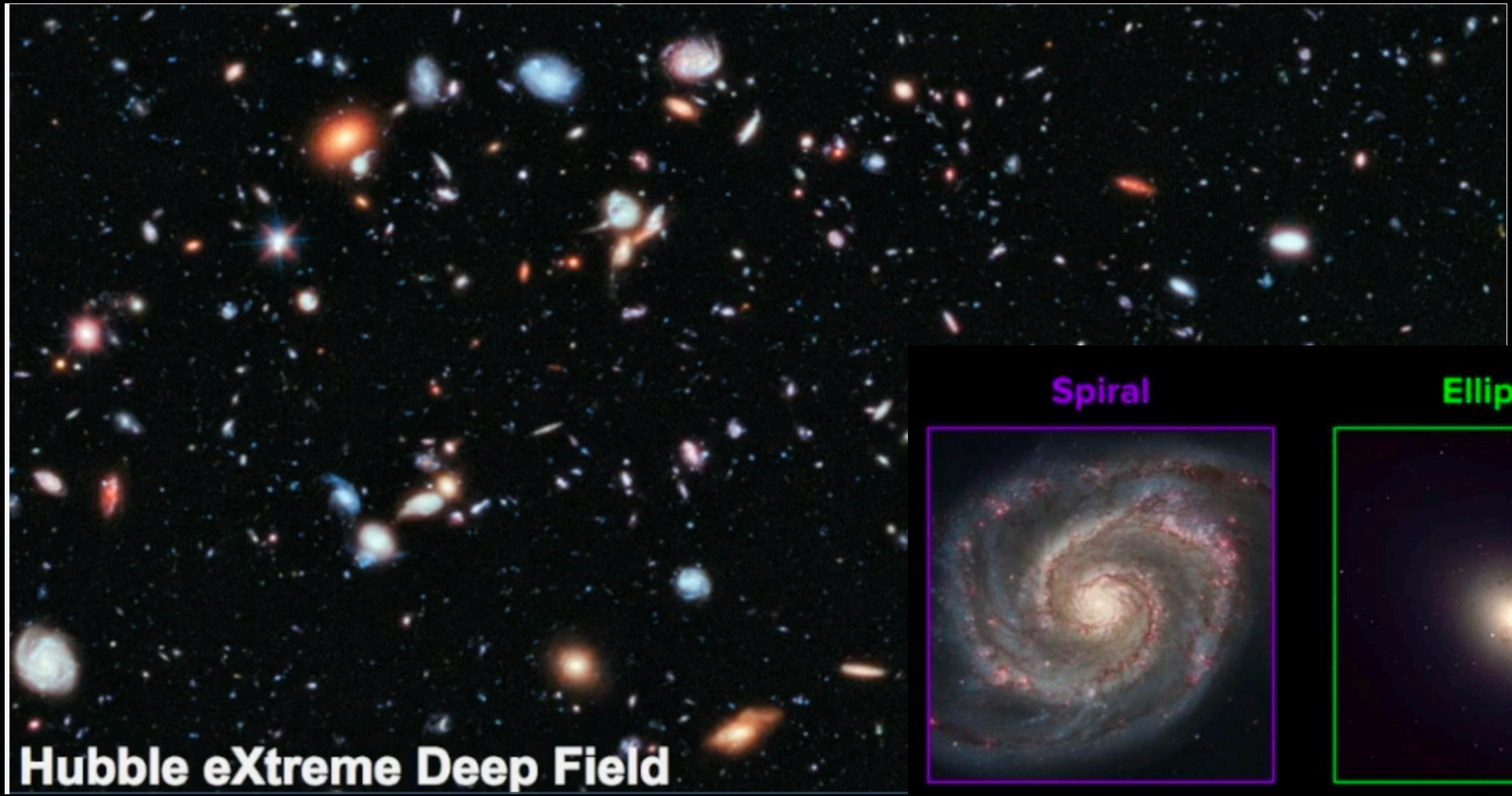
Why galaxies?

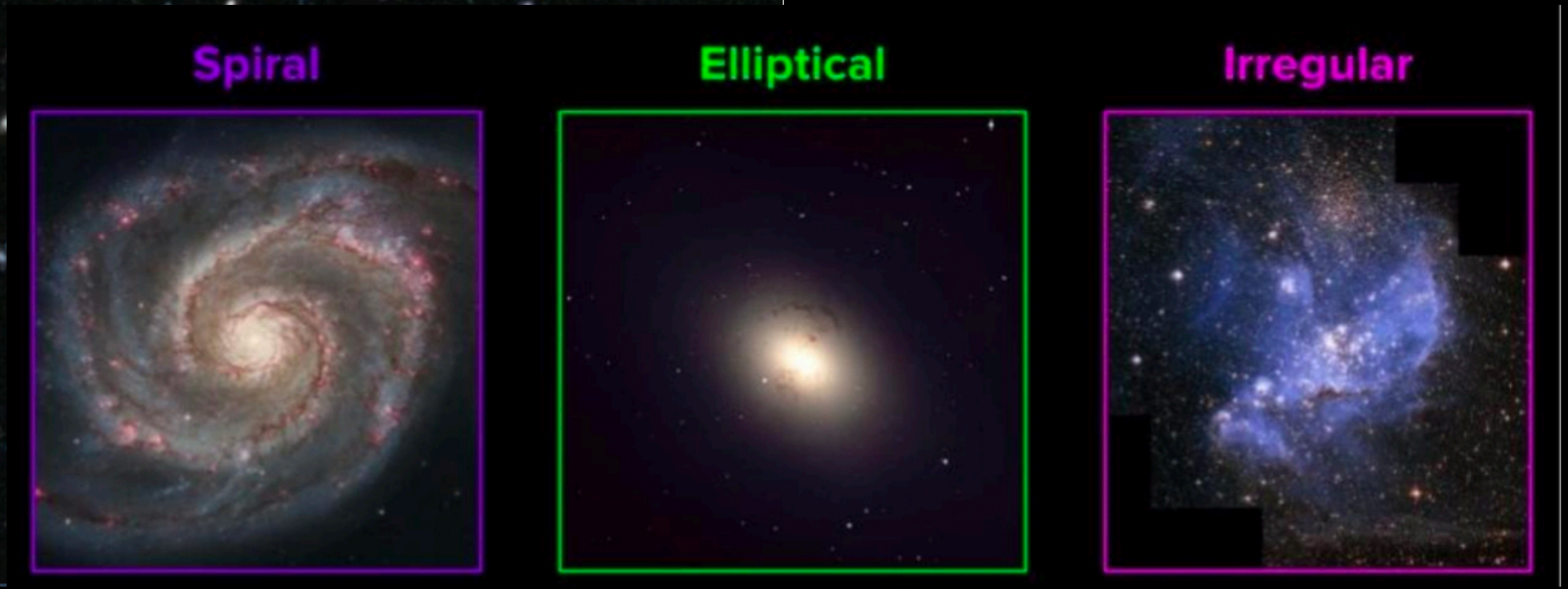


- understand how the universe is organized at large scales
- galaxy formation and evolution

GALAXIES IN THE UNIVERSE

Why galaxies?





- understand how the universe is organized at large scales
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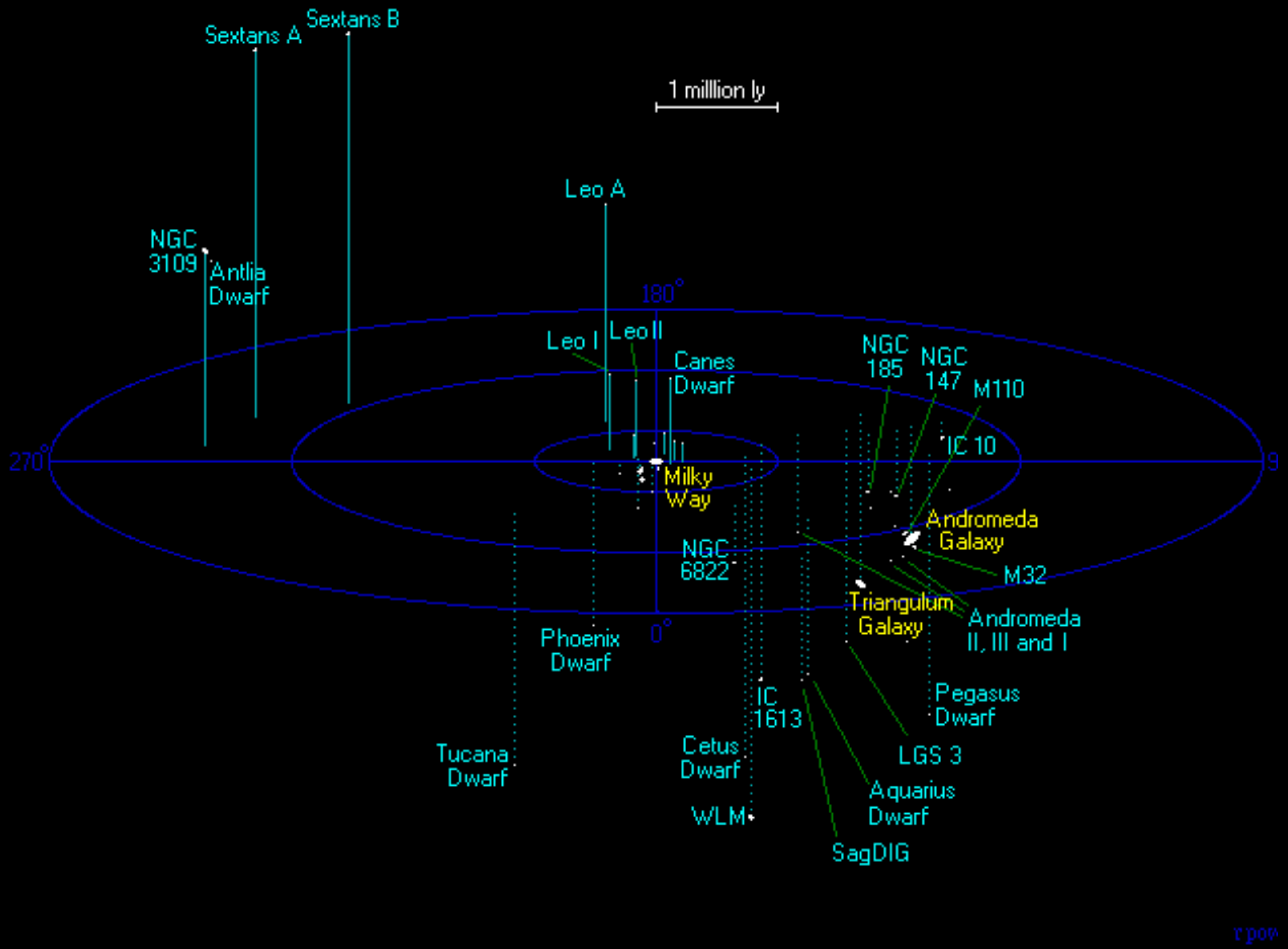
THE LOCAL GROUP

why the local group?



- Proximity —allows us to study galaxies in great detail
- Dwarf galaxies most abundant

DWARF GALAXIES

why study dwarf galaxies?

Early-types

Dwarf ellipticals

Low gas content, little or no star formation

M32 - Dwarf Elliptical Galaxy

Late-types

Dwarf irregular, blue compact

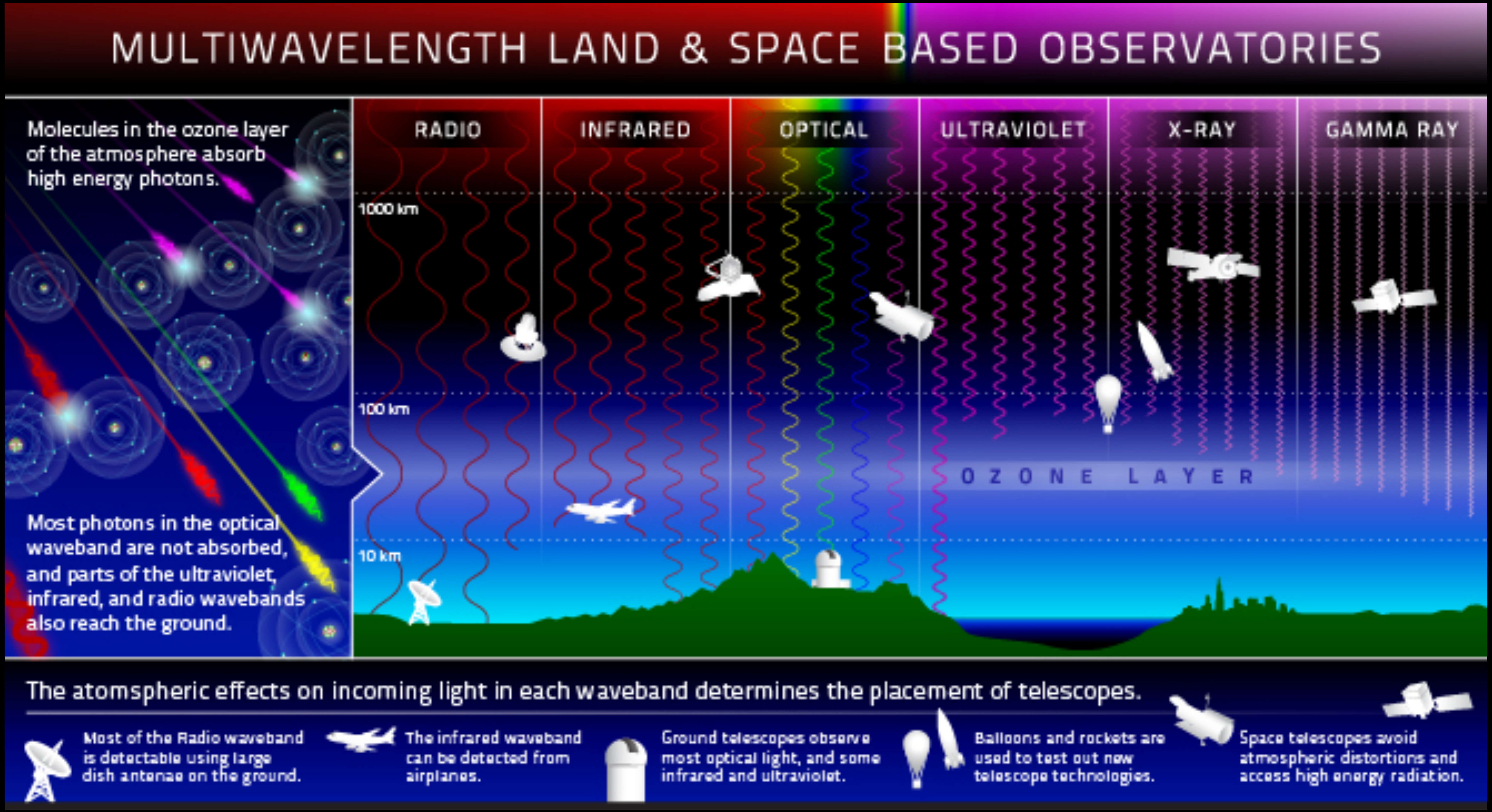
high gas content, ongoing star formation

1C1613 - Dwarf IRREGULAR Galaxy

- Low level of evolution, low metallicity and high gas content - early universe
- Relatively simple structure- easy to unfold various physical parameters

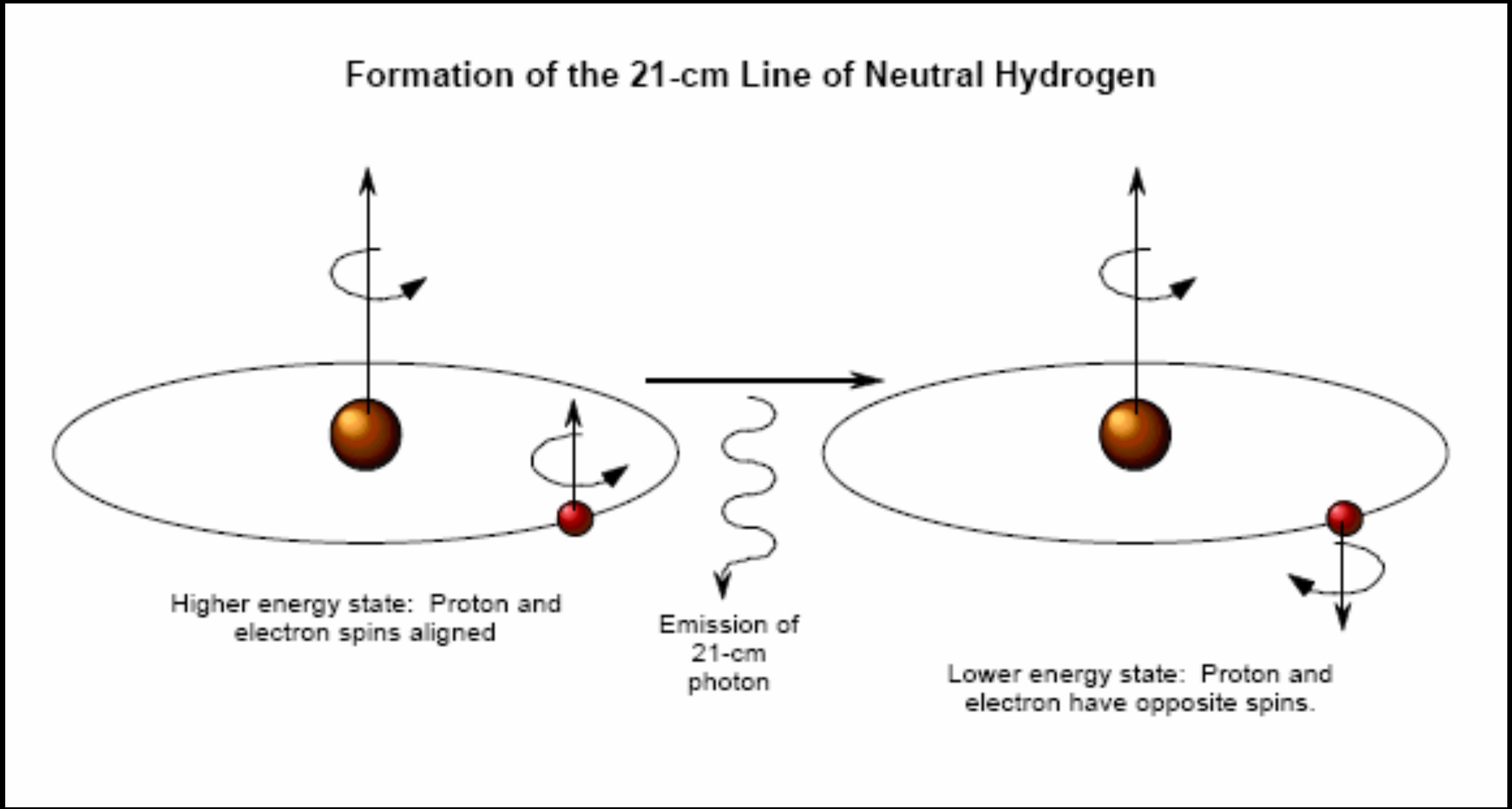
21-CM LINE (HI OBSERVATIONS)

Why neutral hydrogen?



21-CM LINE (HI OBSERVATIONS)

Why neutral hydrogen?



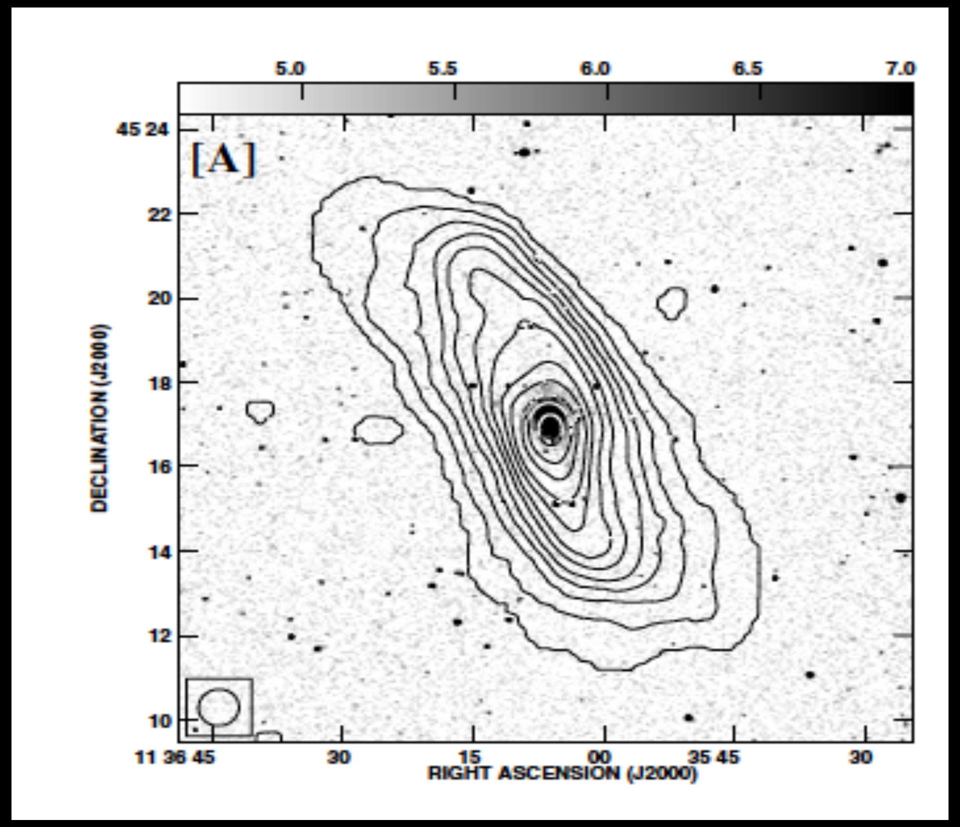
- Dominant component of Interstellar medium (ISM)
- Most extended observable element
- Reservoir for star formation

21-CM LINE (HI OBSERVATIONS)

What can we learn from HI?

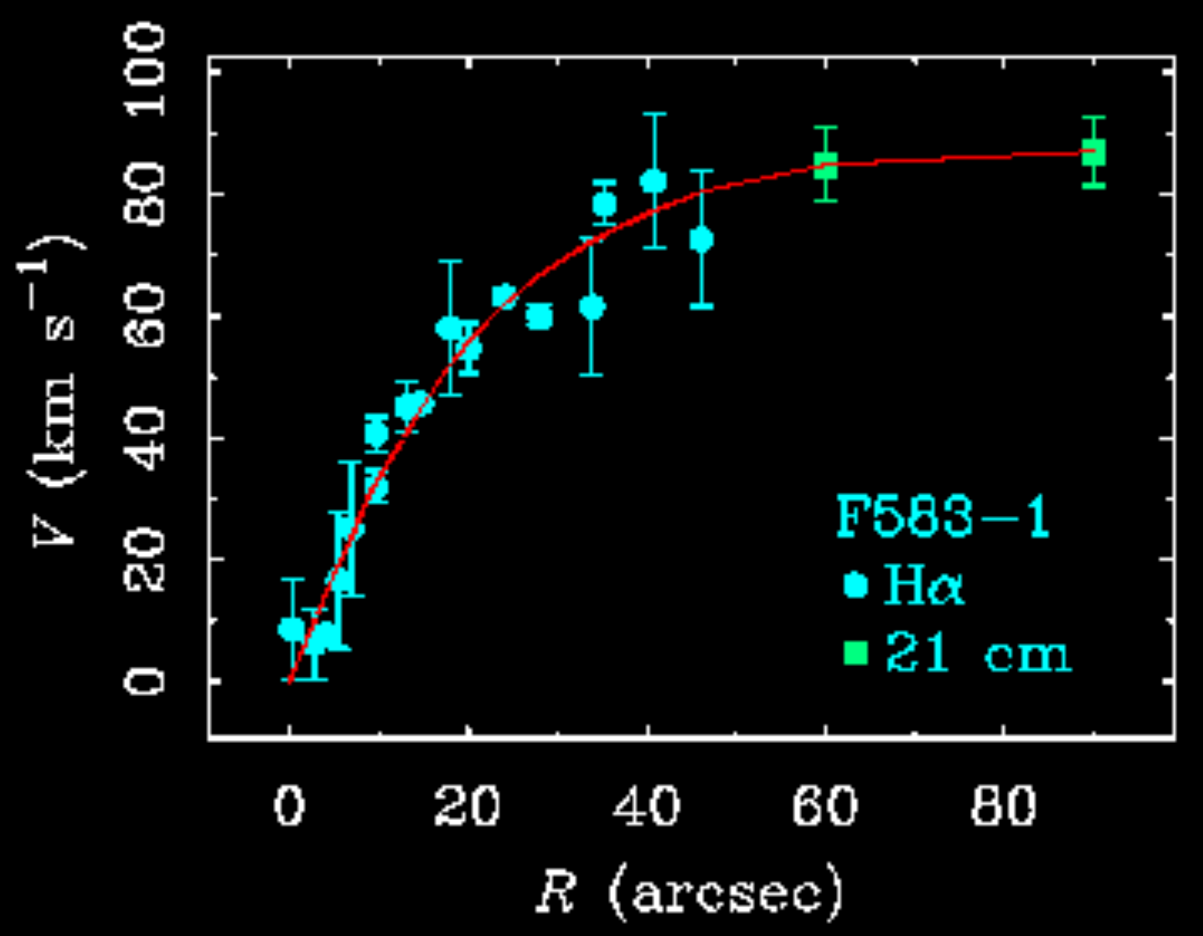
Large scale distribution

NGC 3741 HI diameter ~8.3 stellar radius
(A.Begum et al, 2005, GMRT)



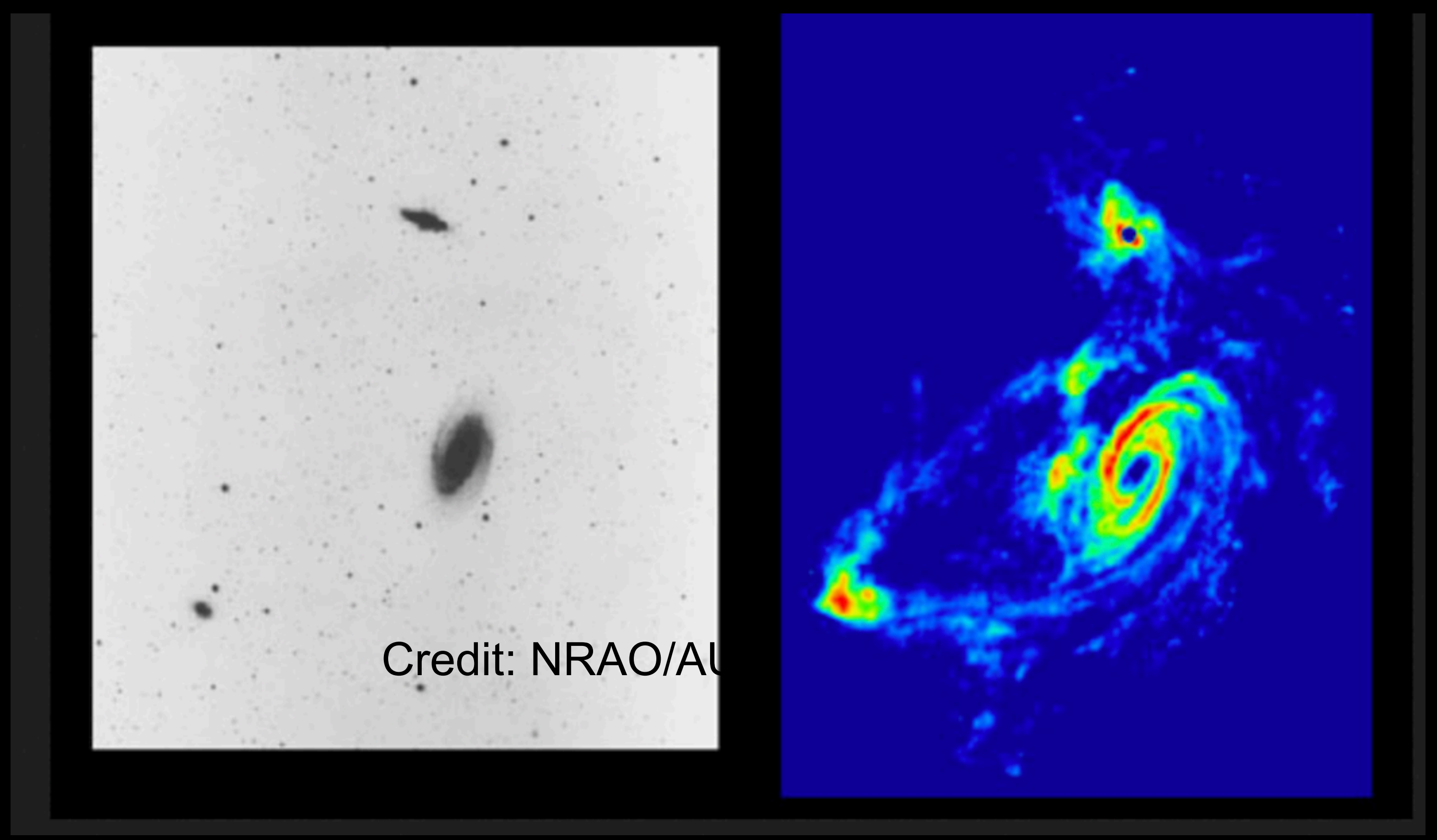
Total mass

Extended rotation curve/
gas kinematics



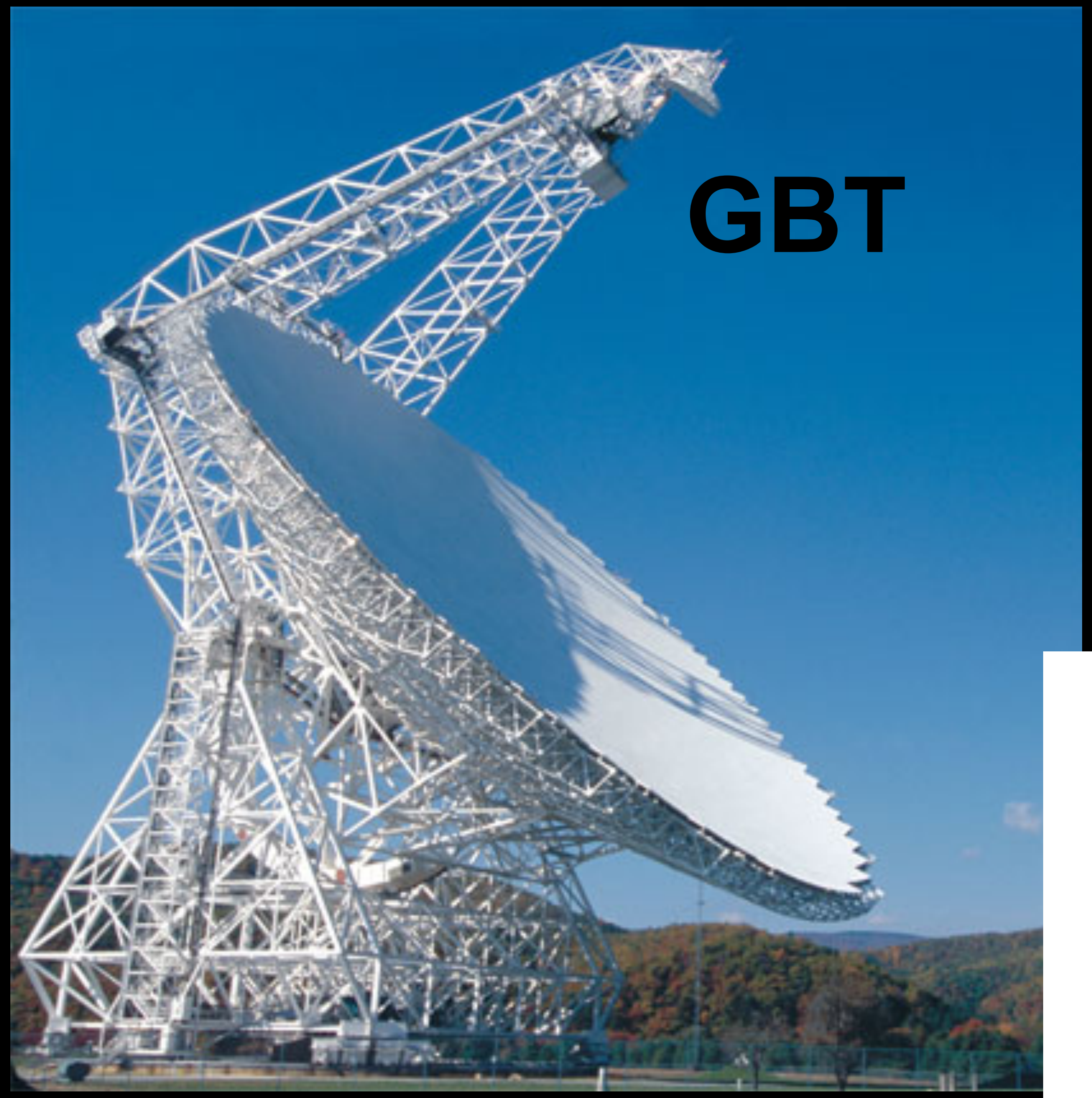
Environmental effects

Tidal interaction/stripping

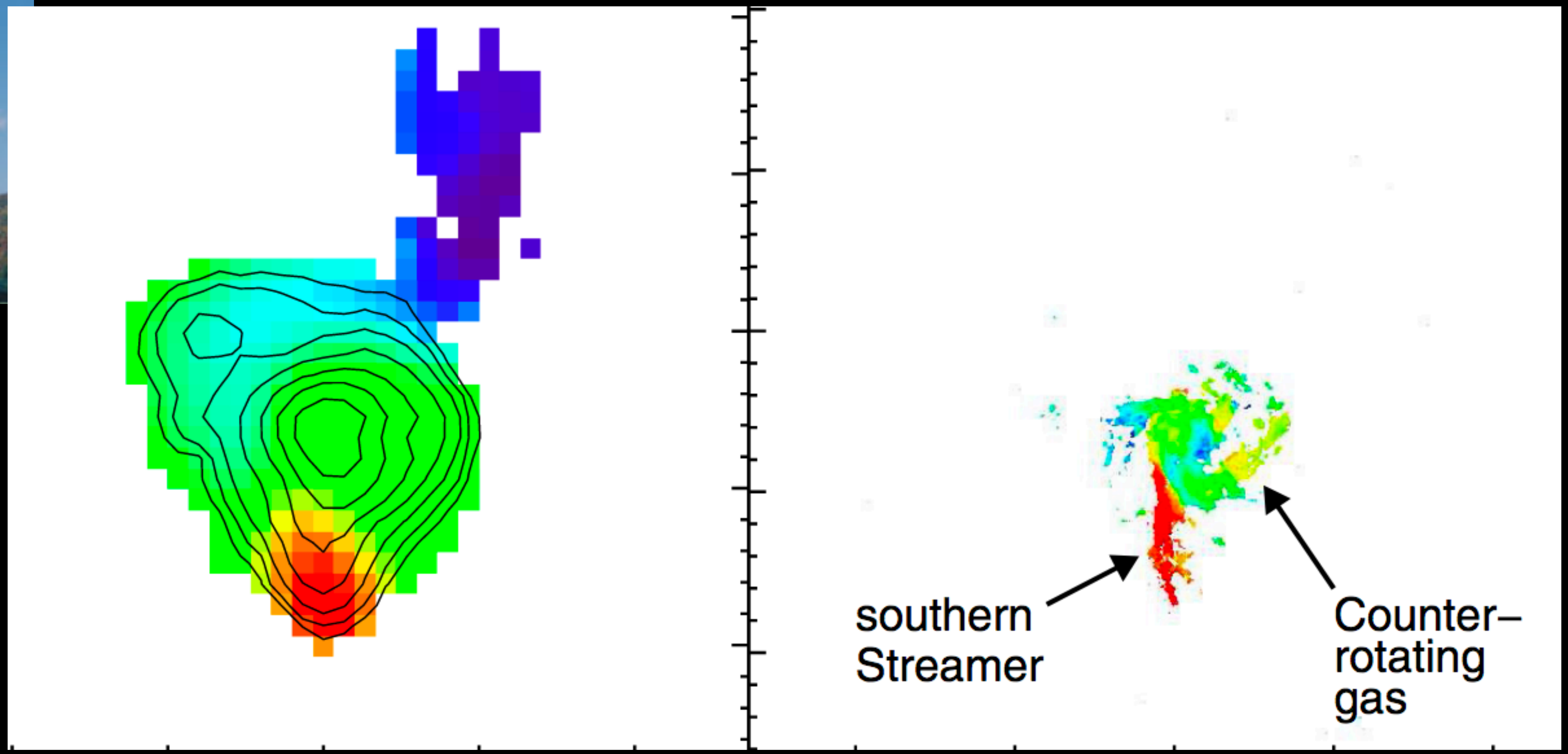


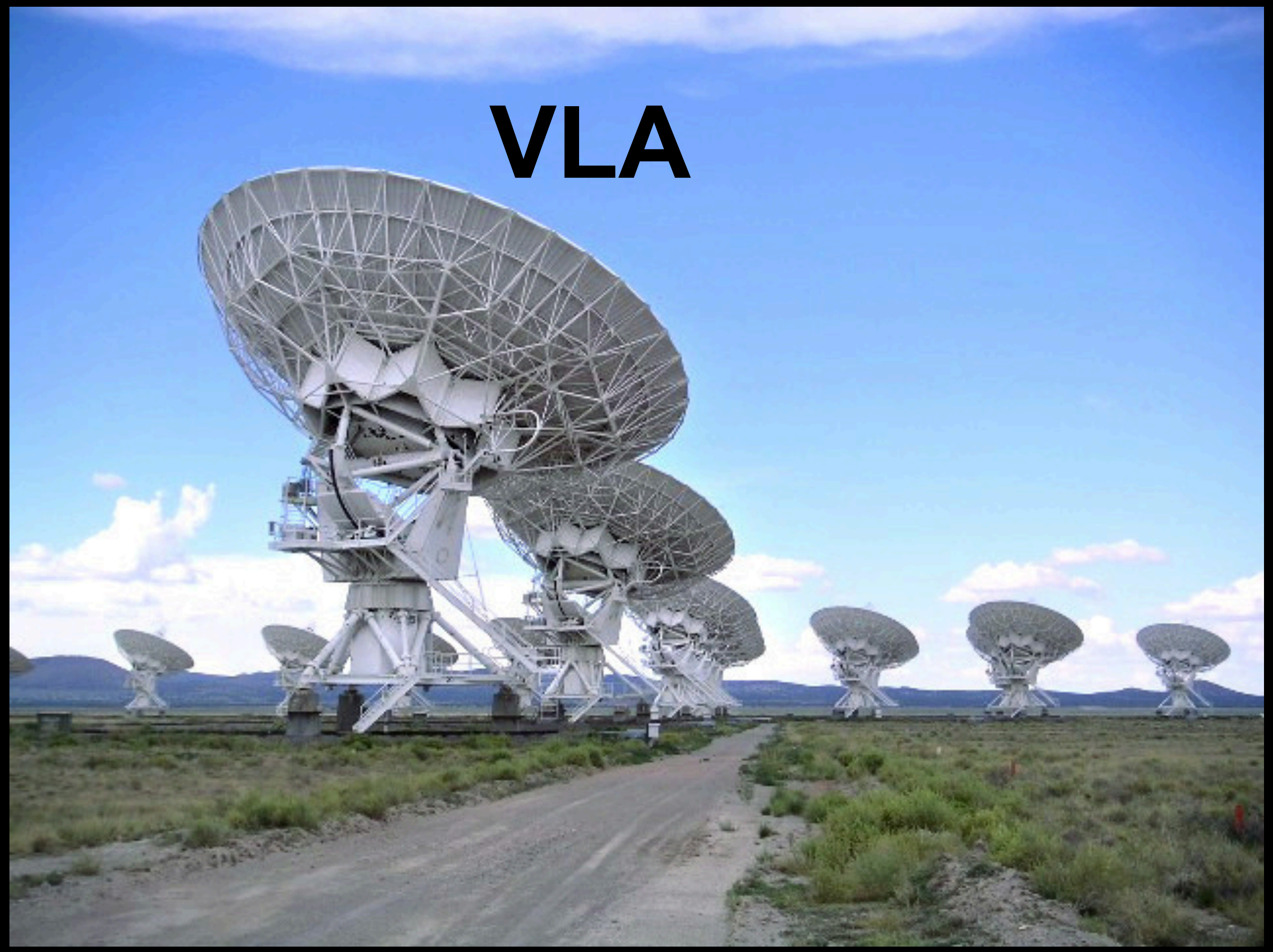
21-CM LINE (HI OBSERVATIONS)

Why SKA/pathfinders?



Sensitivity

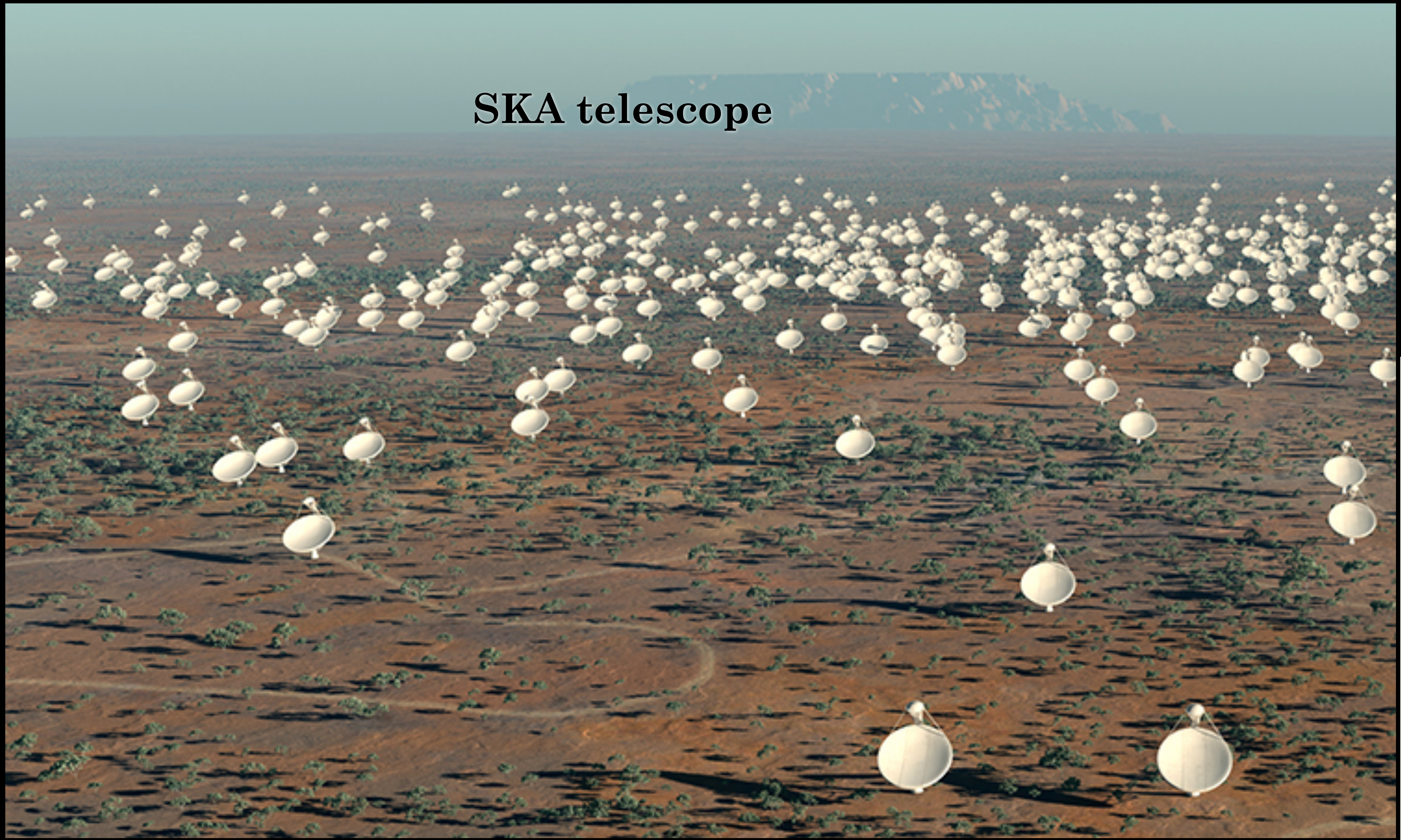




Resolution

We want a good compromise between sensitivity and resolution

21-CM LINE (HI OBSERVATIONS)



Largest radio telescope Core in South Africa. 8 African partner countries

Will allow us to view the universe in unprecedented
detail. SKA science, engineering, computer science …

21-CM LINE (HI OBSERVATIONS)

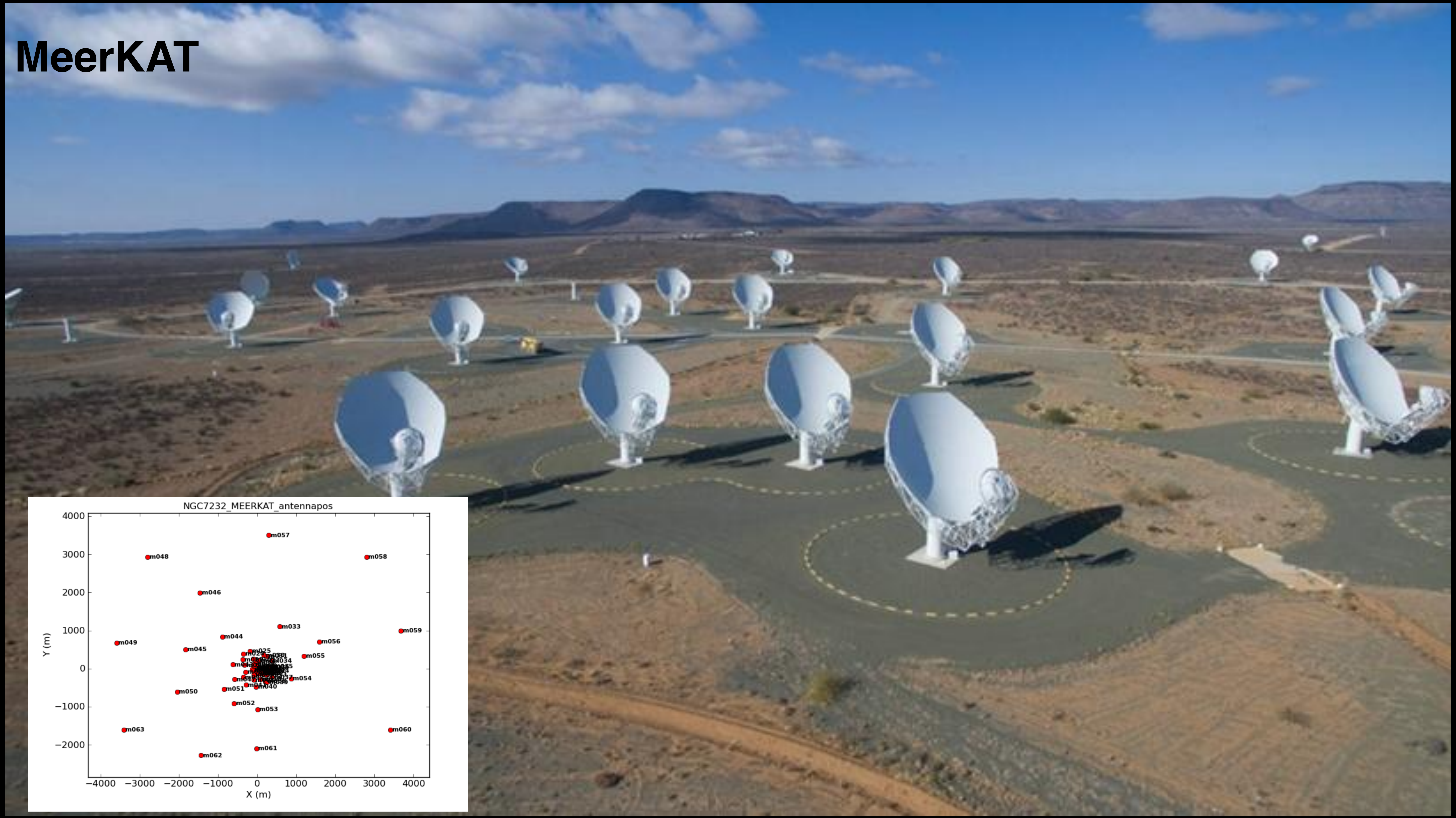
Why SKA pathfinders?

- Engineering testbed for MeerKAT
- Unique array in Southern Hemisphere - KAT-7
- Compact baselines (26 - 186 m)
- Low system temperature

Ideal for observing dwarf galaxies

21-CM LINE (HI OBSERVATIONS)

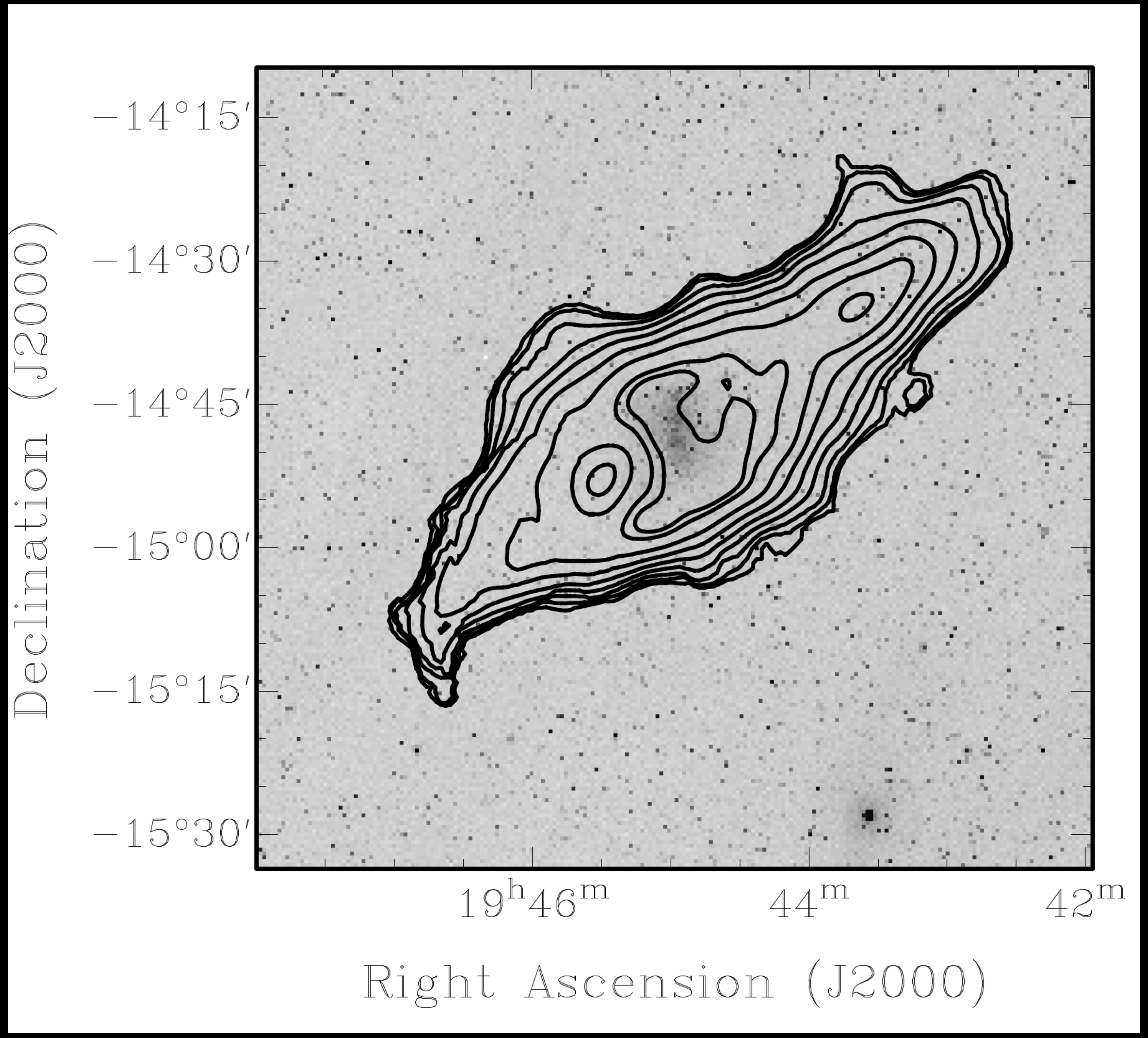
Why SKA pathfinders?

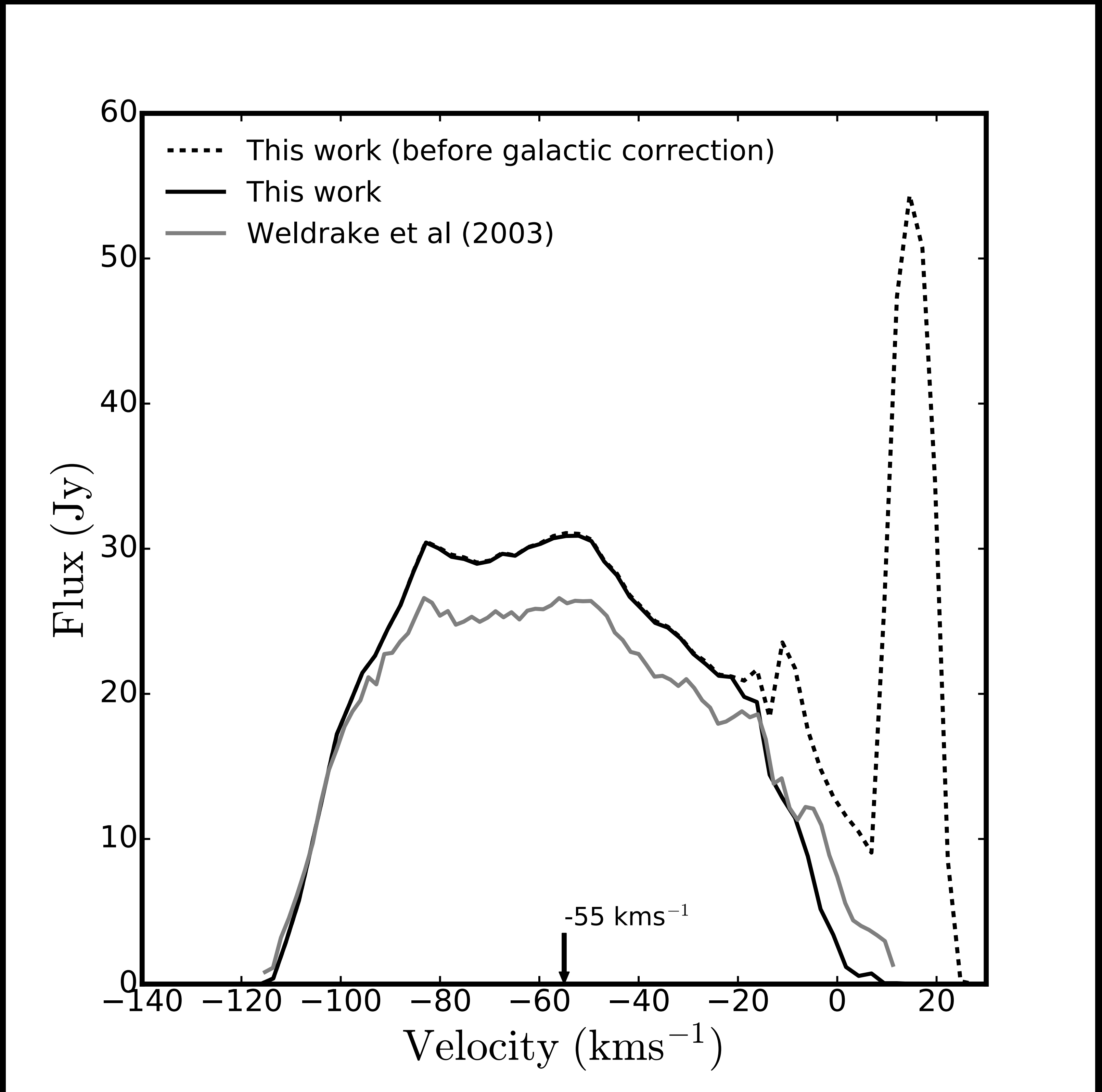


SKA precursors - a good compromise between sensitivity and resolution

KAT-7 OBSERVATIONS

How much are we underestimating from current observation?

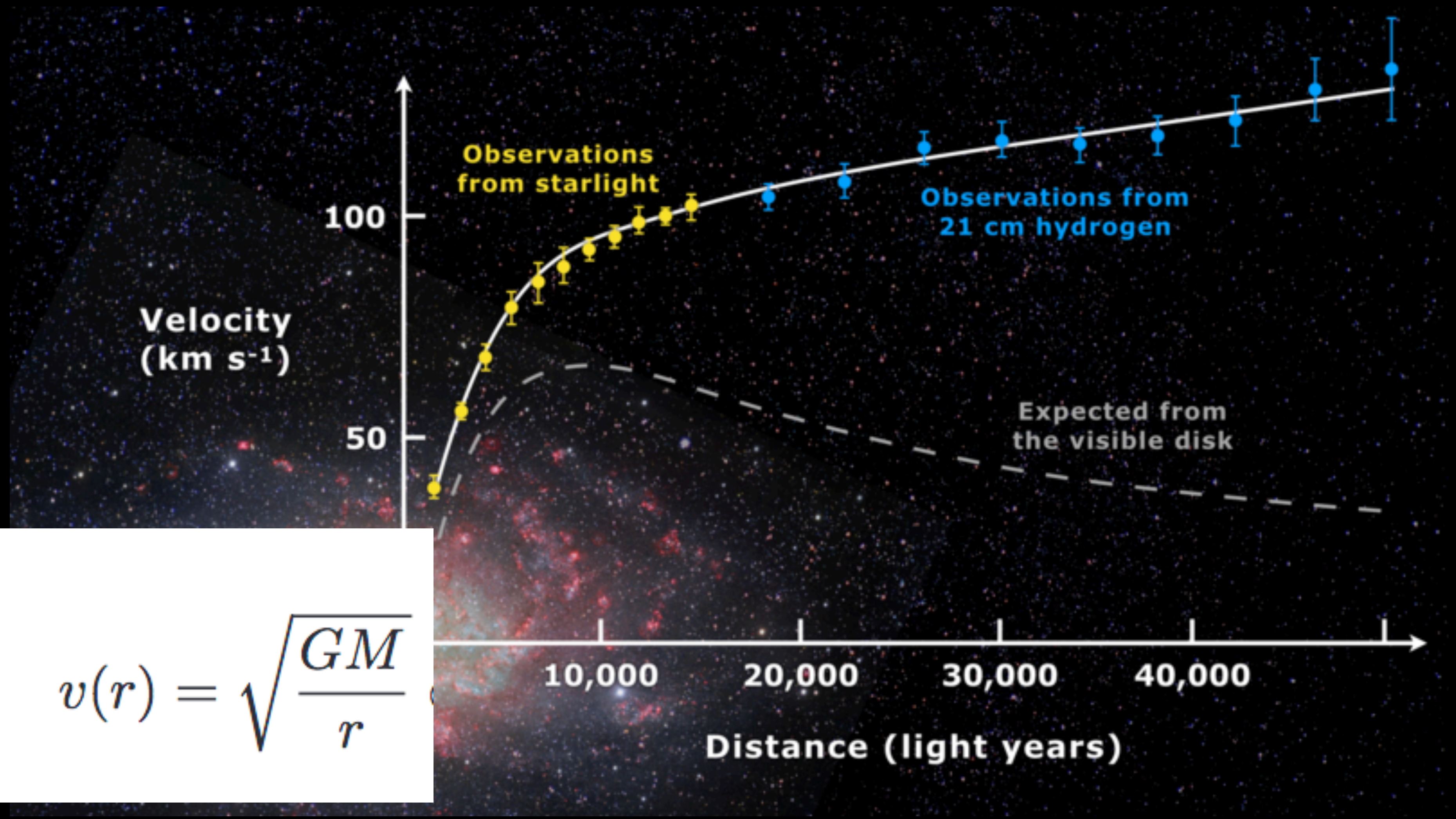




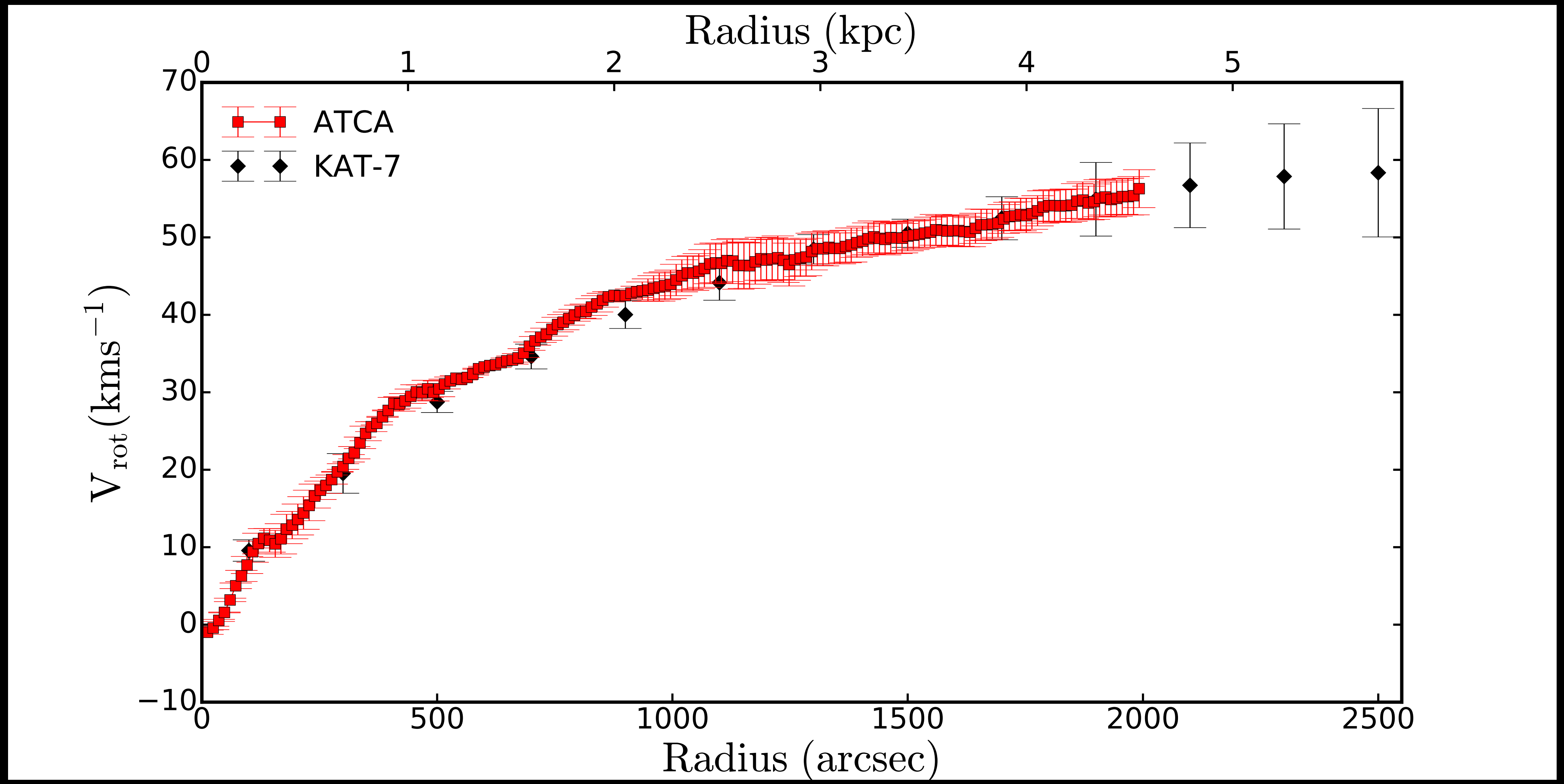
- Previously observed with ATCA
- Ideal for KAT-7 large field of view (~0.5 Mpc distance)
- 1.3e8 solar masses HI mass (23 percent than ATCA)
- HI column density (x10e19) order magnitude than ATCA (KAT-7 resolves features seen with ATCA).

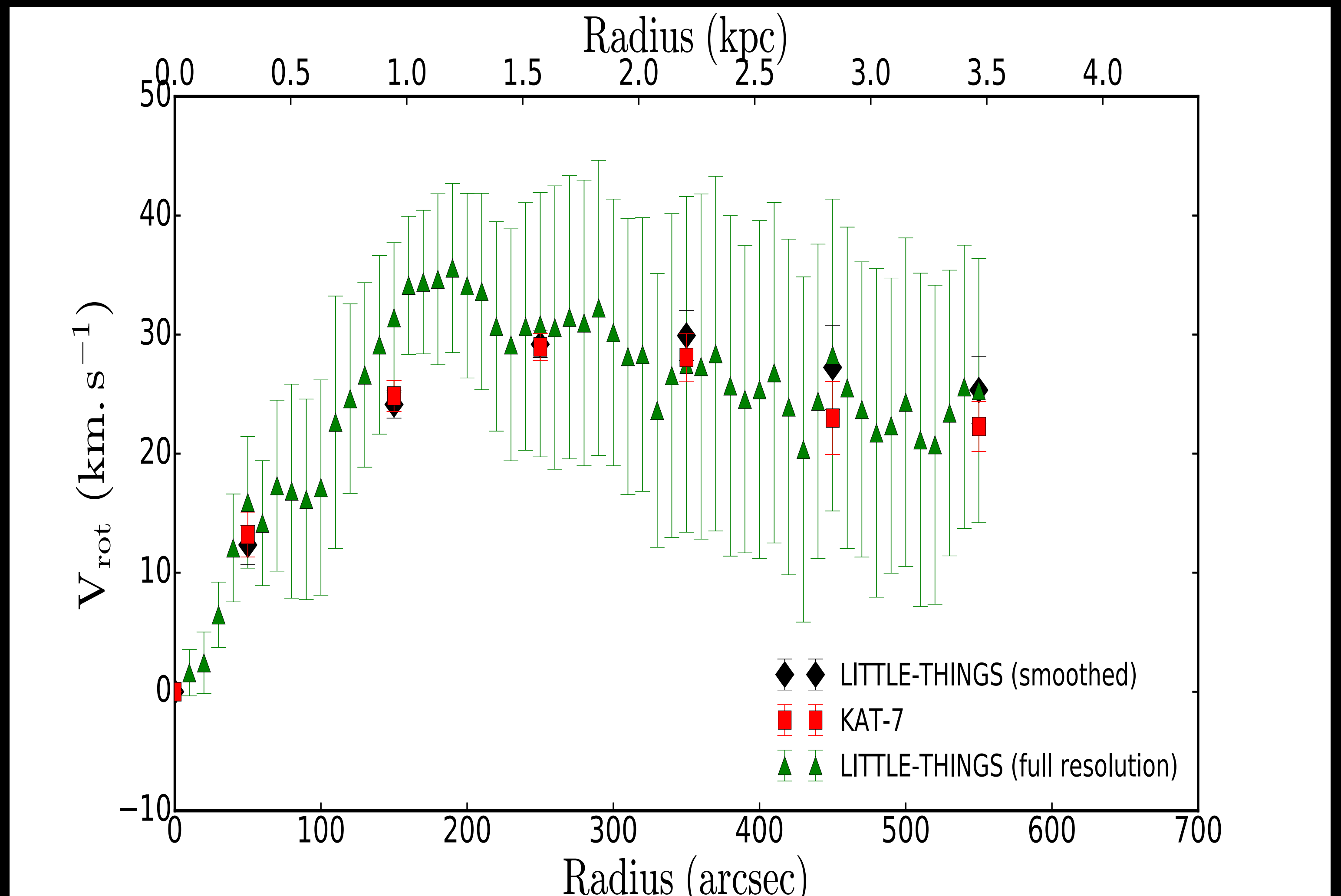
KAT-7 OBSERVATIONS

Why kinematics of dwarf galaxies?



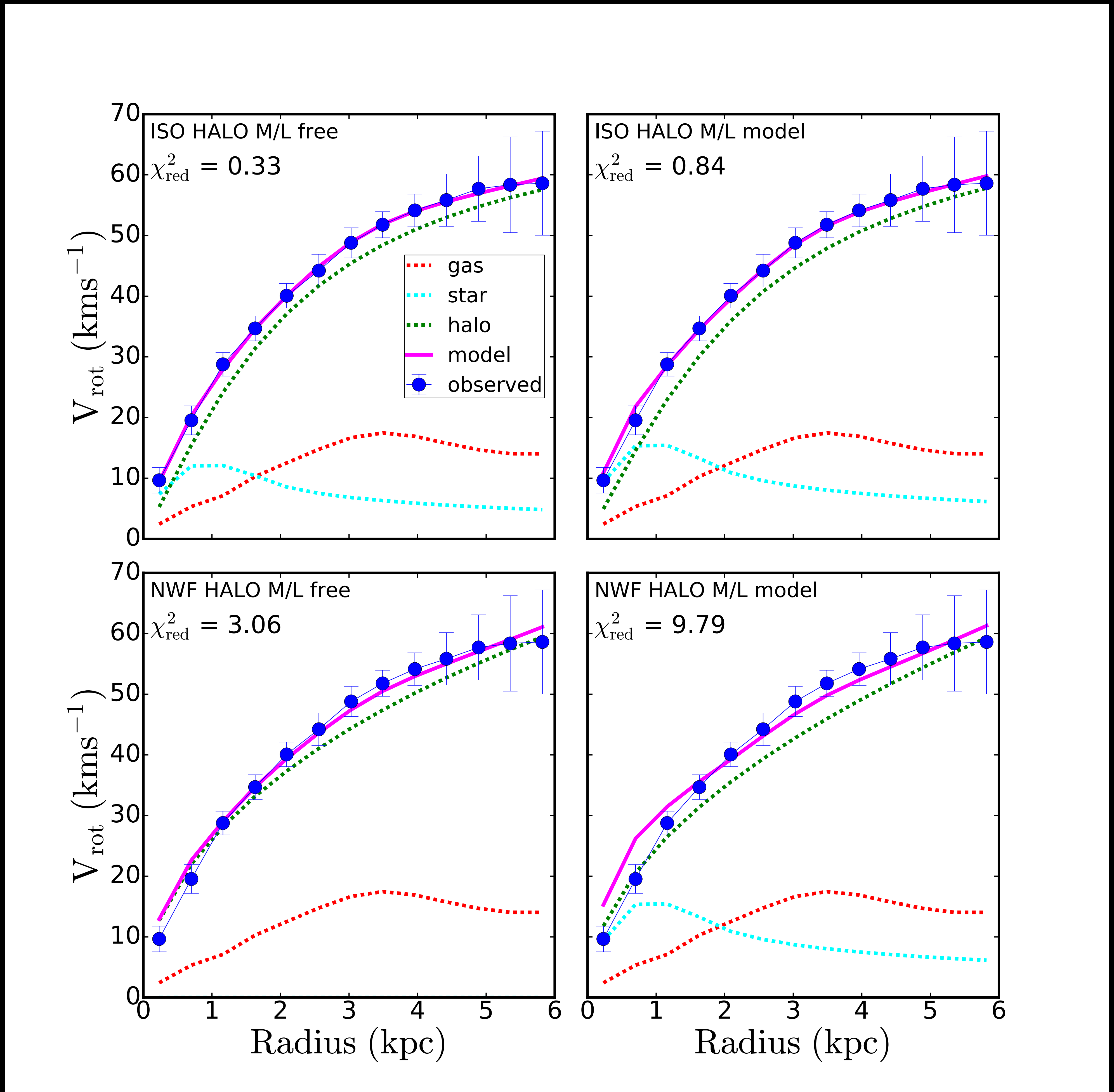
$$v(r) = \sqrt{\frac{GM}{r}}$$





- KAT-7 RC more extended than ATCA.
- Rising rotation curve??? - mass distribution

KAT-7 OBSERVATIONS



Distributions with flat cores: the pseudo-isothermal sphere (widely used by observers)

$$\rho(r) = \frac{\rho_\circ}{1 + r^2/a^2}$$

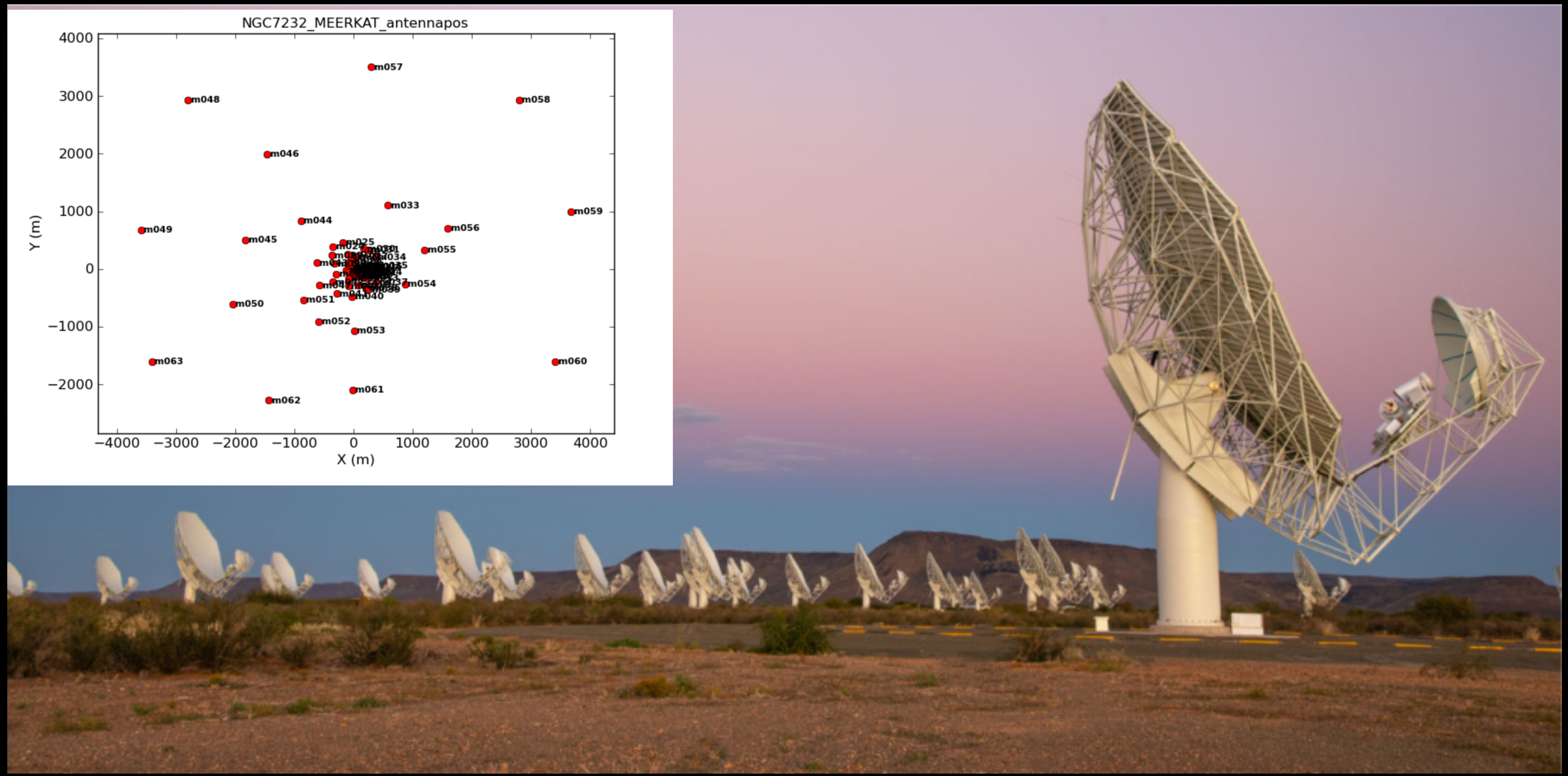
The NFW cusped dark halo distribution (from N-body simulations

$$\rho(r) = \frac{\rho_\circ}{(r/r_s)(1 + r/r_s)^2}$$

- Dark matter dominated galaxies at all radii
- ISO model reproduces well the observed rotation curve

DWARF GALAXIES WITH MEERKAT

What next?

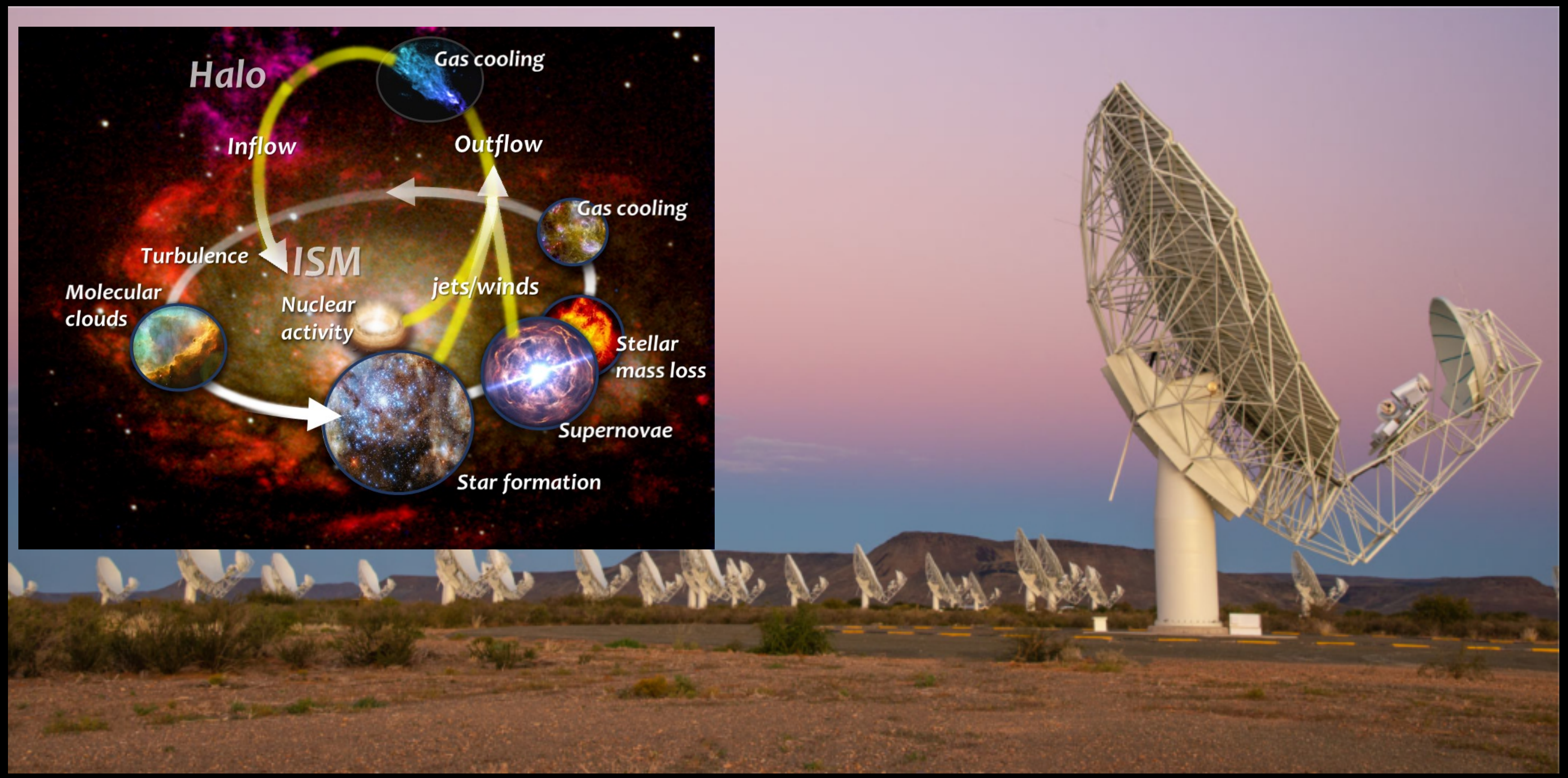


- Central compact configuration - large scale structures
- High sensitivity, high resolution
- Bonus!! Southern hemisphere (southern sky)

DWARF GALAXIES WITH MEERKAT

What next?

- Connection between star formation, HI gas, gas accretion, HI dynamics



- What are the general kinematics of the extended, low-density HI in dwarfs?
- How different are dwarf galaxy star formation properties and HI kinematics?

ONGOING WORK

Dwarfs with MeerKAT

- Deepest HI observations of nearby galaxies (~55 hrs per source)
- Down to HI column density limit ~10e18 cm^-2
- Sample of 30 nearby disk and dwarf galaxies
- 2 MHONGOOSE dwarfs, 10 hrs per source, ~5 km/s velocity resolution

MHONGOOSE

MeerKAT HI Observations of Nearby Galactic Objects: Observing Southern Emitters

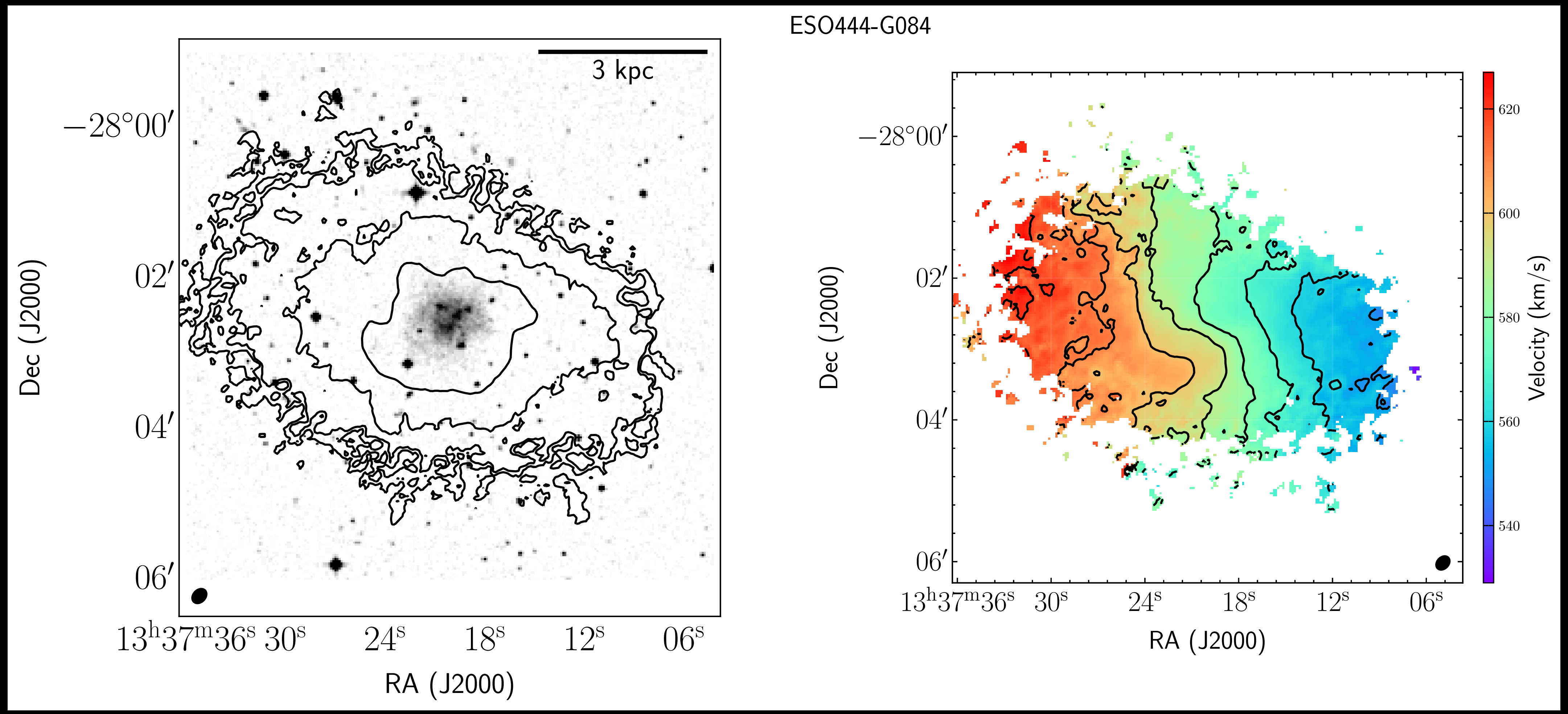
PI: W.J.G. de Blok (ASTRON/UCT/Kapteyn)

"Nearby Galaxies Legacy Survey until the advent of the SKA, and can serve as a highly visible, lasting statement of MeerKAT capabilities."

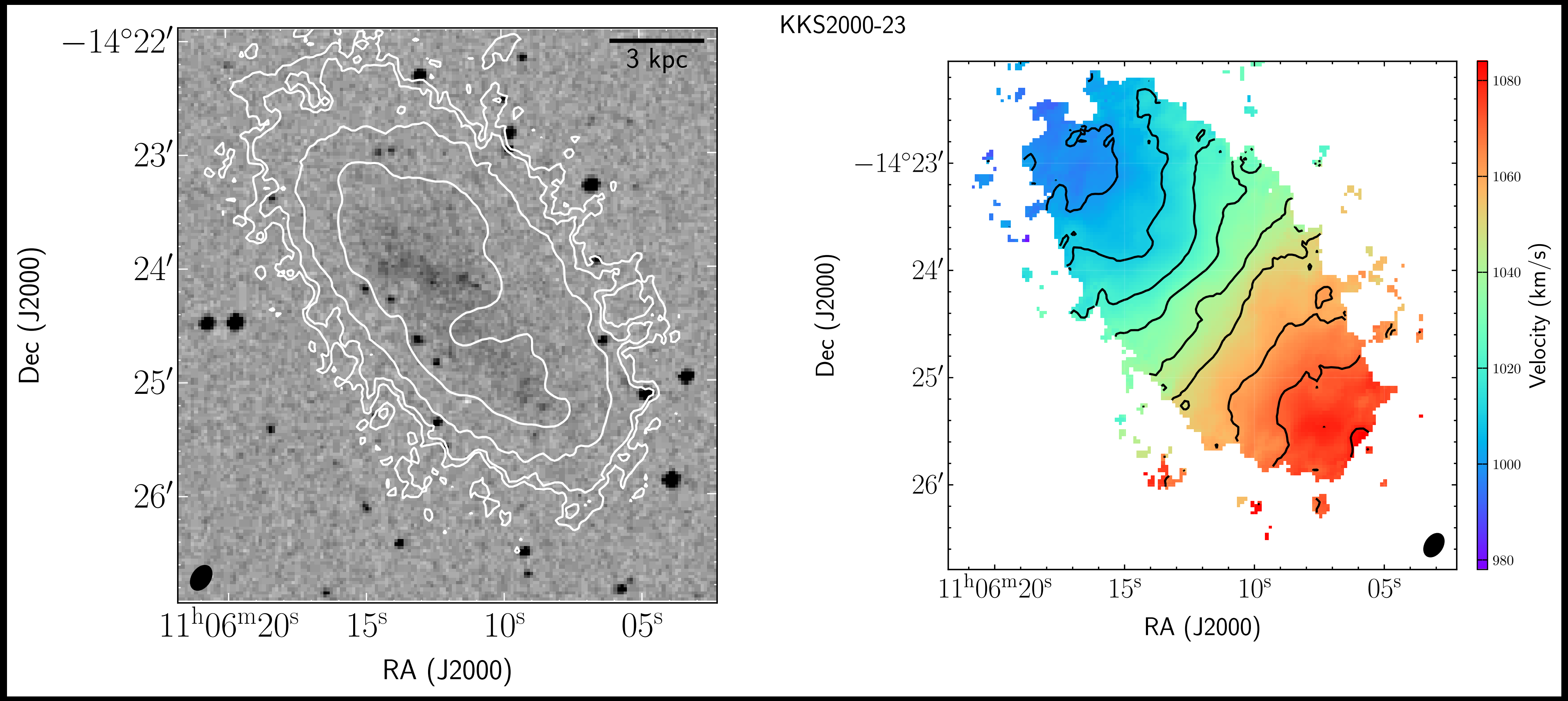
ONGOING WORK

Dwarfs with MeerKAT

- Connection between star formation, HI gas, gas accretion, HI dynamics



HIPASS J1337-28



HIPASS J1106-14

Table 1. Basic Properties of ESO444-G084 and KKS2000-23. (a) (Meurer et al. 2006); (b) Karachentsev et al. (2002); (c) (Sorgho et al. 2019) .

Parameter	ESO444-G084	KKS2000-23
Morphology	I[(a)]	I[(a)]
Right ascension (J2000)	13:37:20.2[(a)]	11:06:11.9[(a)]
Declination (J2000)	-28:02:41.0[(a)]	-14:24:19.7[(a)]
Distance (Mpc)	4.61[(c)]	12.7[(a)]
B mag.	15.02 ± 0.18[(a)]	15.80 ± 0.50[(a)]
$V_{heliocentric}$ ($km.s^{-1}$)	587[(b)]	1039.0[c)]
Total H I mass ($M_{\odot}$)	8.3×10^{7} [(b)]	$4.2 \pm 0.1 \times 10^{7}$ [(c)]

ONGOING WORK

- Four dwarf galaxies. MeerKAT data are available.

RAM PRESSURE STRIPPING OF NEARBY DWARF GALAXIES: for testing their mass (dark & luminous) and the surrounding IGM density

Abstract

The discovery by MeerKAT that WLM, an isolated dwarf galaxy, is ram-pressurized [Yang et al. 2022] raises fundamental questions about the dwarf galaxy interplay with the Inter-Galactic Medium (IGM). We propose to obtain MeerKAT 21-cm observations of four nearby dwarf irregular (Dirr) galaxies, using MeerKAT in the narrowband NE 107M mode (BW = 107 MHz and channel width = 3.3 kHz = 0.7 km/s). Our targets are NGC 3109, Sextans A, Sextans B and WLM. Building on the previous MeerKAT HI studies of WLM [Ianjamasimanana et al. 2020], we aim to map the low-surface brightness HI emission around each galaxy at a much higher sensitivity and resolution compared to the literature. This will allow us to study for the first time the possibility of ram pressure in dwarf galaxies and to robustly establish their evolution through the IGM.

Students across Africa who are interested in having hands-on MeerKAT data.

SUMMARY

- Dwarf galaxies most abundant type of galaxies in the Universe
- HI provides a unique window to understand the properties of galaxies
- Extended HI- map the outer region of galaxies - environmental effects, extended kinematics
- KAT-7 -ideal for studying dwarfs -compact baselines
- MeerKAT is a combination of high sensitivity, high resolution and compact configuration
- More is expected with SKA - observing the universe in unprecedented detail.

Africa is actively taking part in cutting-edge scientific research

with the SKA/pathfinders