Low-frequency observations of nearby galaxies

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Outline

- The role of low frequency observations in nearby galaxy studies
- Highlights from LOFAR and MWA
- Case study of a broadband view: NGC 5775
- Further examples: ongoing low-frequency work
- Future prospects

Magnetism in galaxies

Development of multiphase ISM
Cooling, molecular gas formation
Star formation process

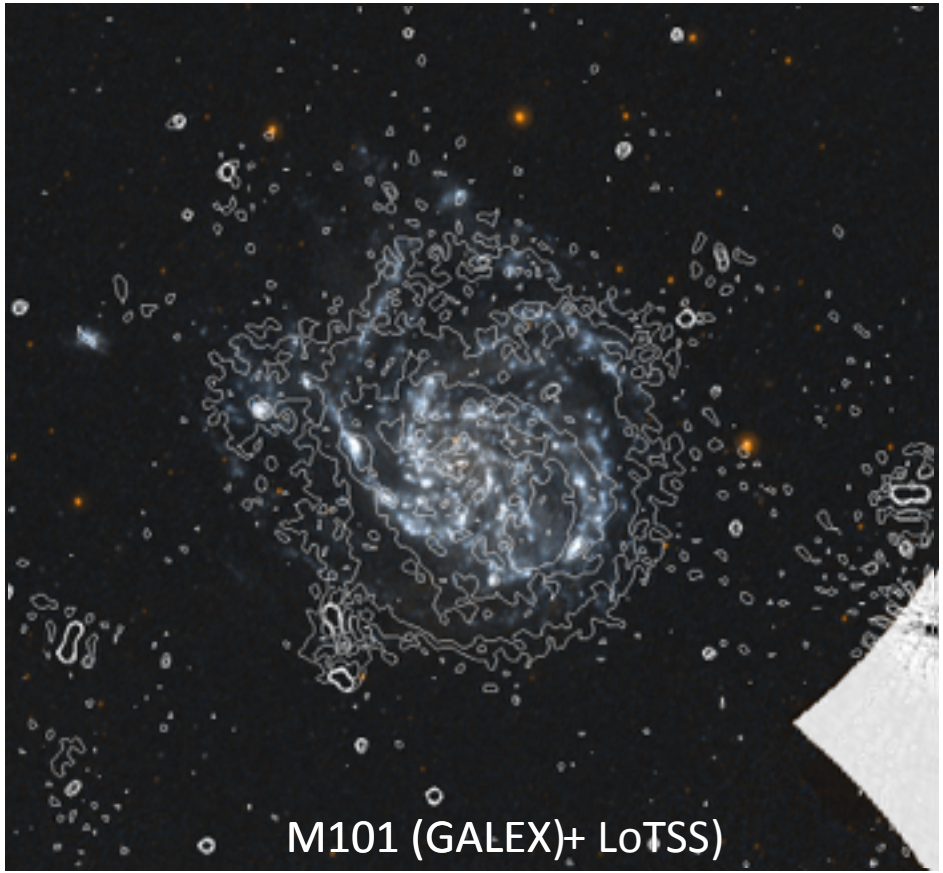
Structure/evolution of B
Rotation?
Disk-halo mediation?

Magnetization of IGM?
Connection to IGM?

High frequency, broad band *Multi-frequency, broad band* *Low frequency*

Low frequencies

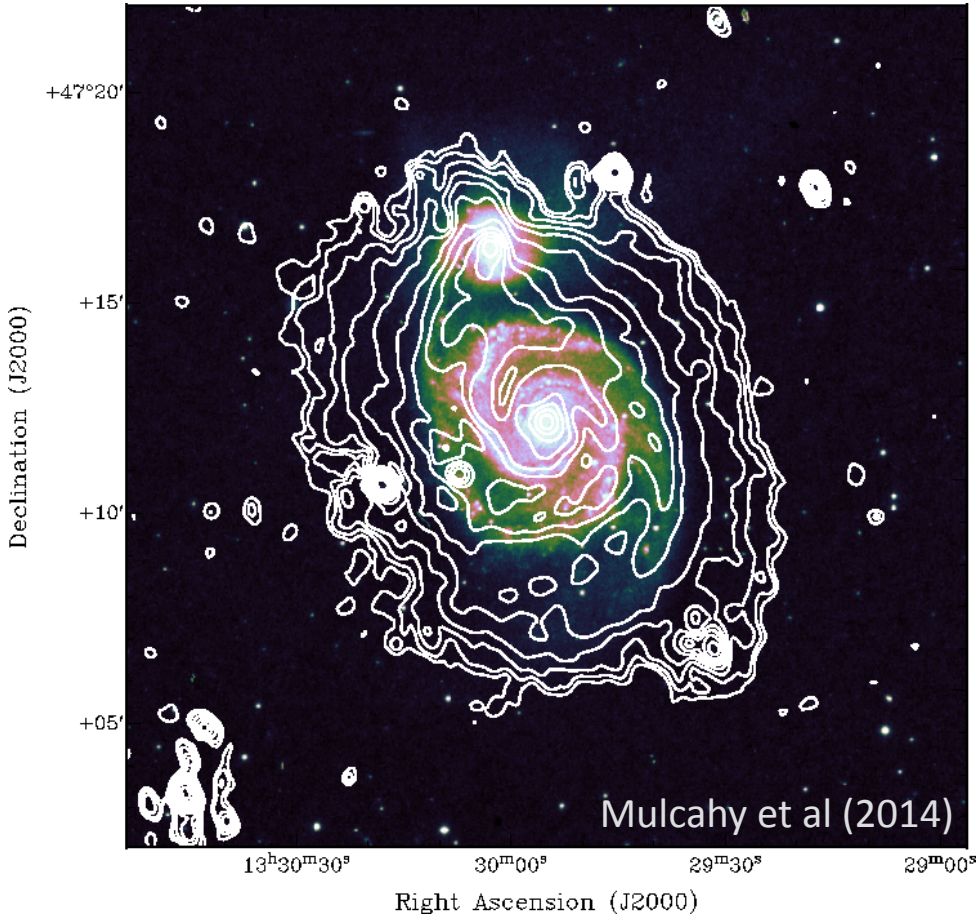
- Low frequency synchrotron emitted by old cosmic rays far from acceleration sites
  - Trace magnetic fields in outer parts (extended disks and halos) of galaxies
  - Probe propagation of cosmic rays
  - SED curvature and absorption effects - *see talk by K. Chyży*
  - Ripe for new exploration with (e)MWA, LOFAR, SKA1-LOW



Highlights

M51

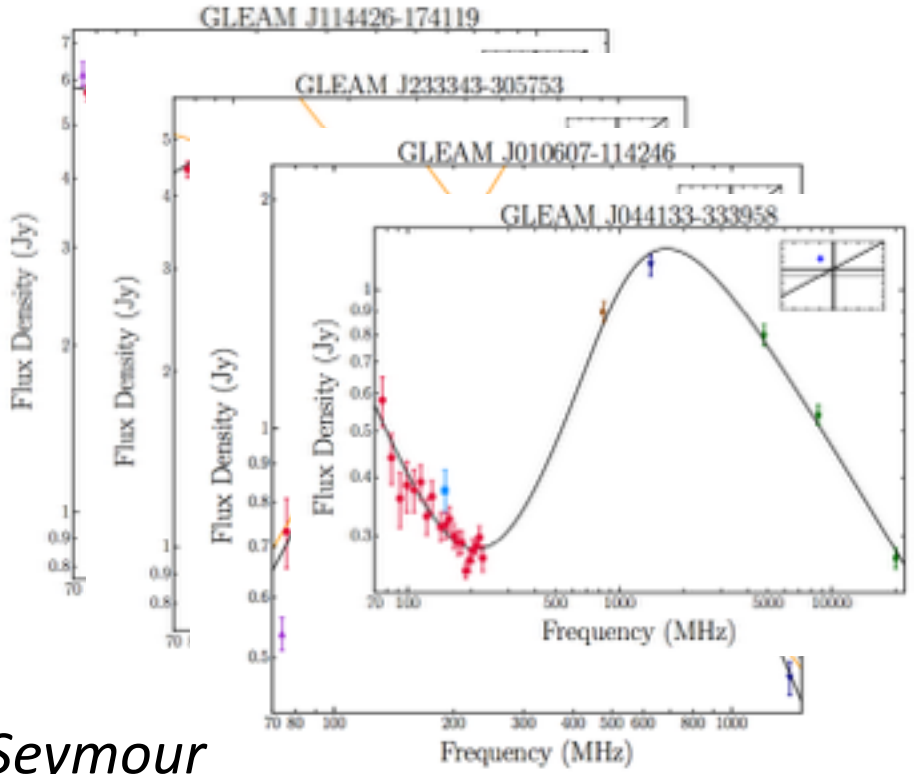
- Disk extended beyond radio size at higher frequencies
- Properties consistent with cosmic ray diffusion
- Distribution of CR sources drops at edge of SF disk
- Thermal absorption caused by HII regions
- No diffuse polarization (but six extragalactic sources in field)
- *See talk by D. Mulcahy*



Hurley-Walker et al (2017)

GLEAM: broadband SEDs

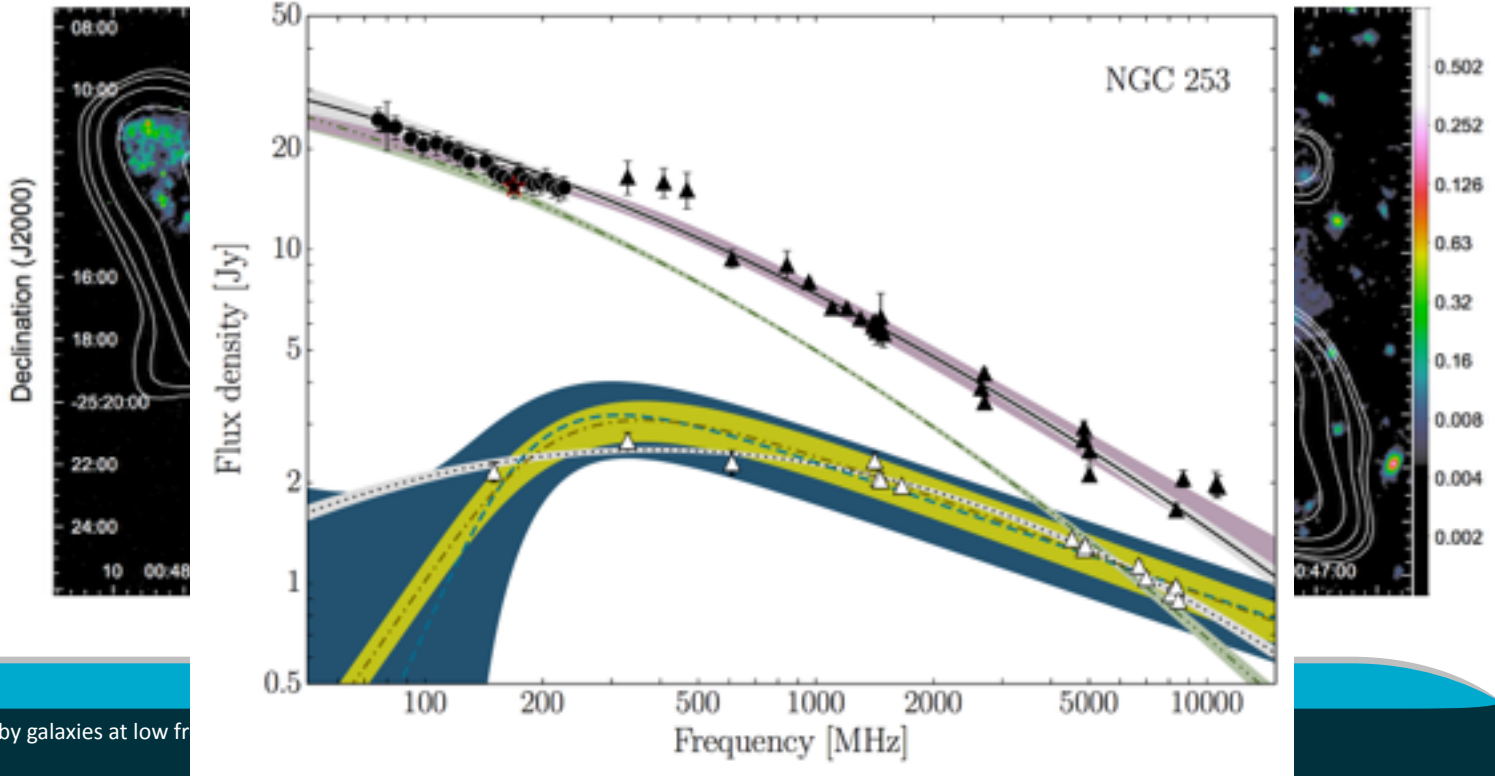
- Extreme broad bandwidth provides exquisite SED characterisation (Callingham et al 2017)
  See talk by J. Callingham



- *See talks by P. Hancock & N. Seymour*

GLEAM: broadband SEDs

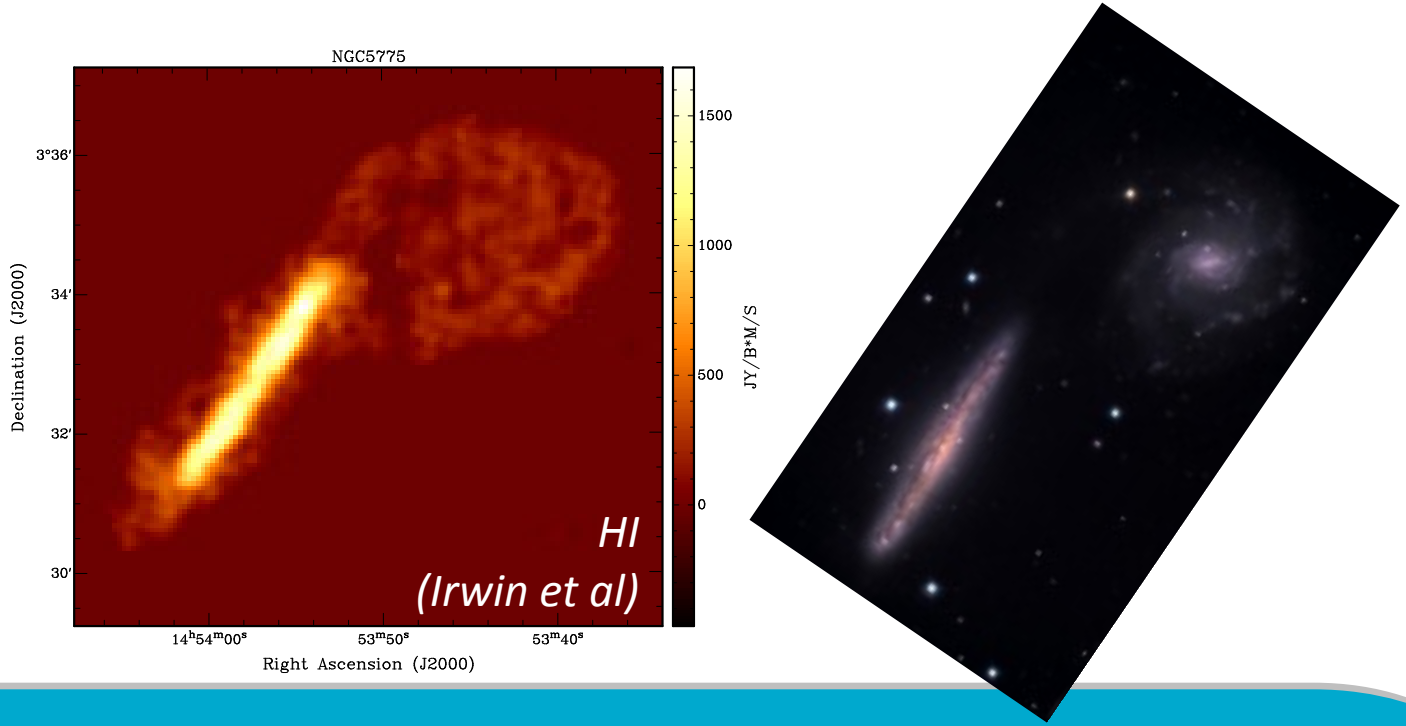
- NGC 253 (Kapinska et al 2017)



NGC 5775

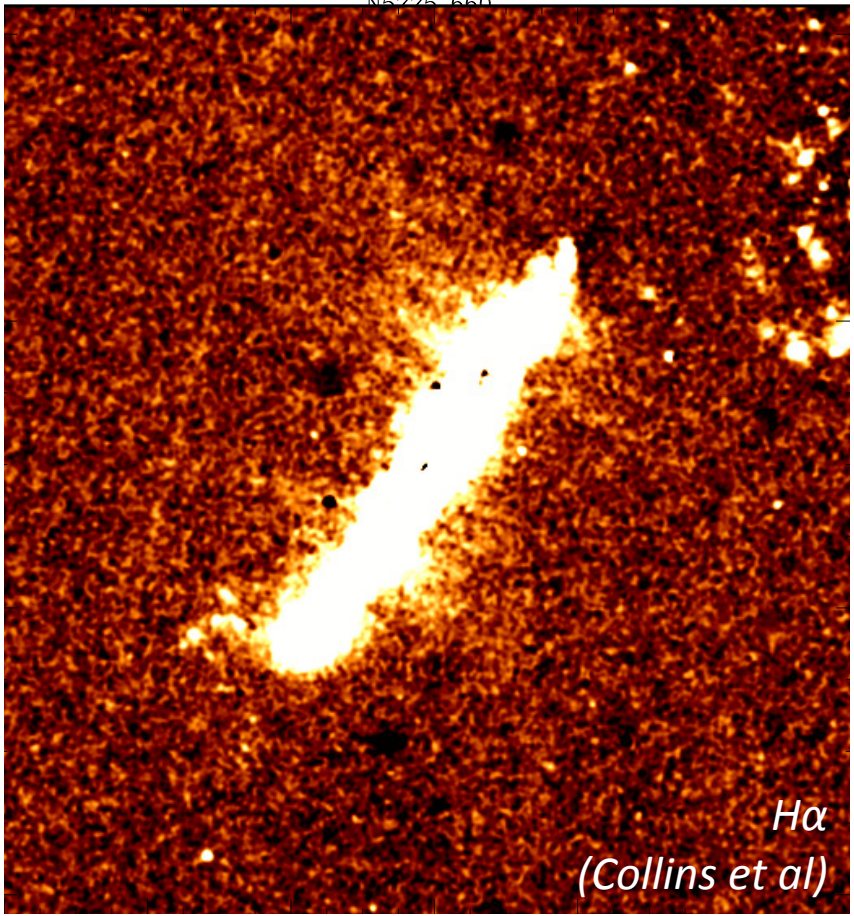
NGC 5775

- Edge-on galaxy in early stage of interaction with its neighbour



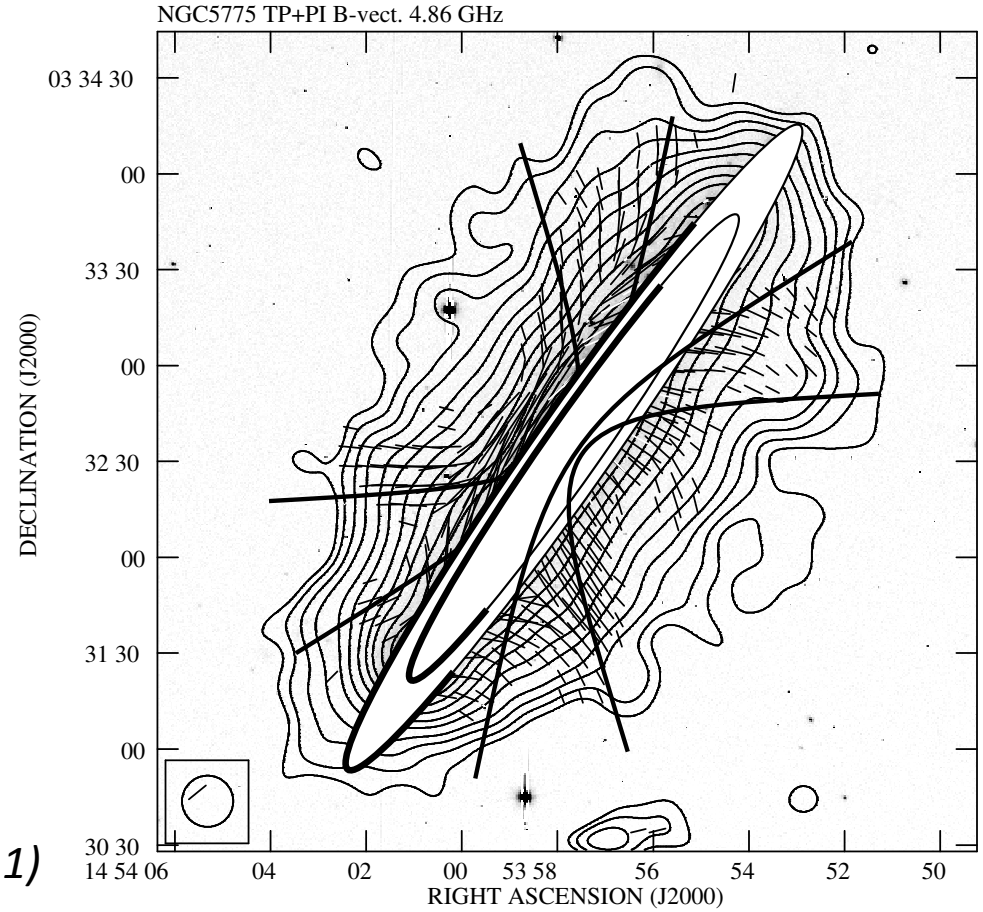
NGC 5775

- Very high SFR (~5 $M_\odot$/yr), SFR density (~7 $M_\odot$/yr/kpc^2)
- Drives a powerful disk-halo interaction



NGC 5775

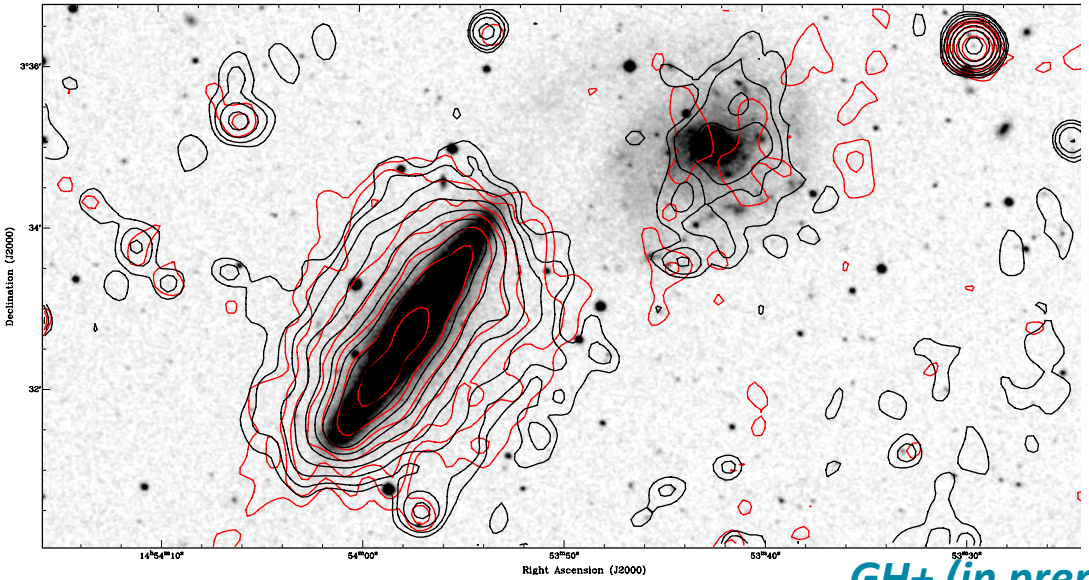
- Known bright synchrotron halo tracing a large-scale magnetic field

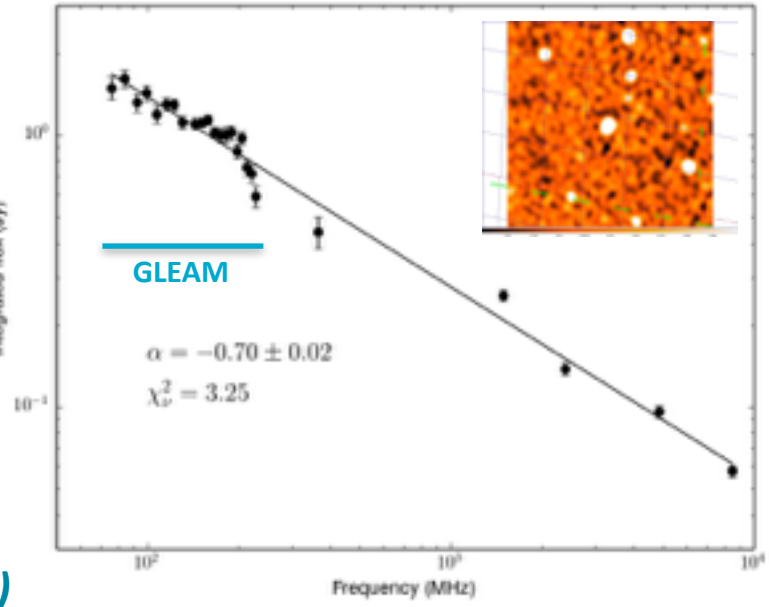


Soida et al (2011)

NGC 5775

- Extended field structure characterised by deep images at broad range of frequencies (LOFAR and JVLA; **CHANG-ES** survey (Irwin+))





GH+ (in prep)

NGC 5775

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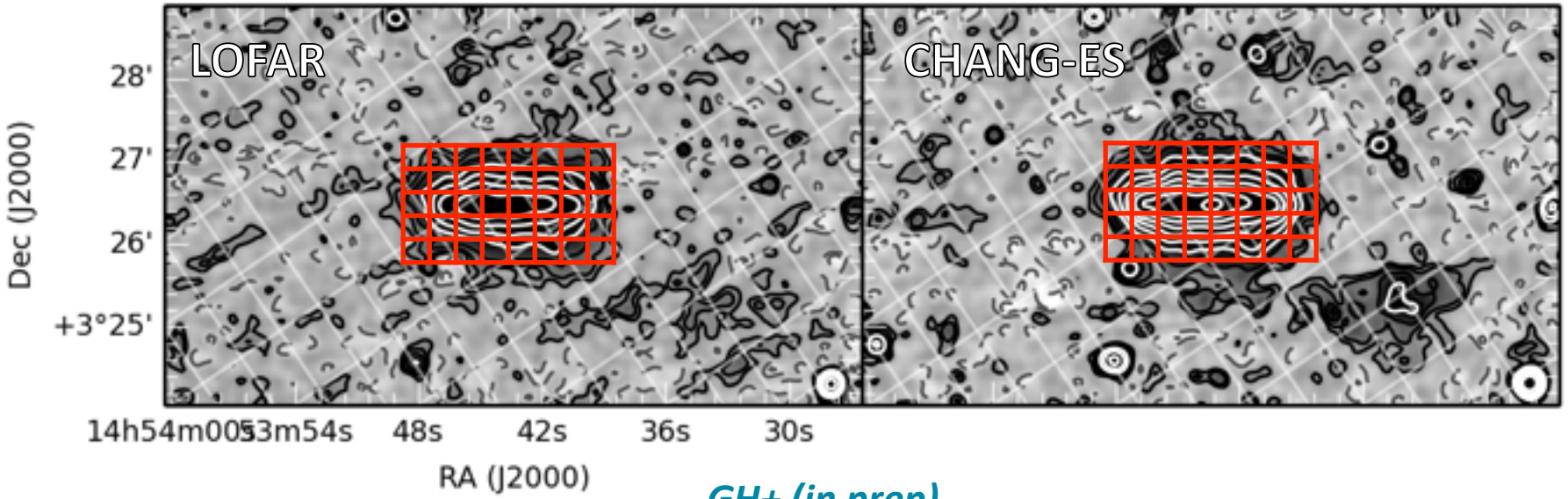
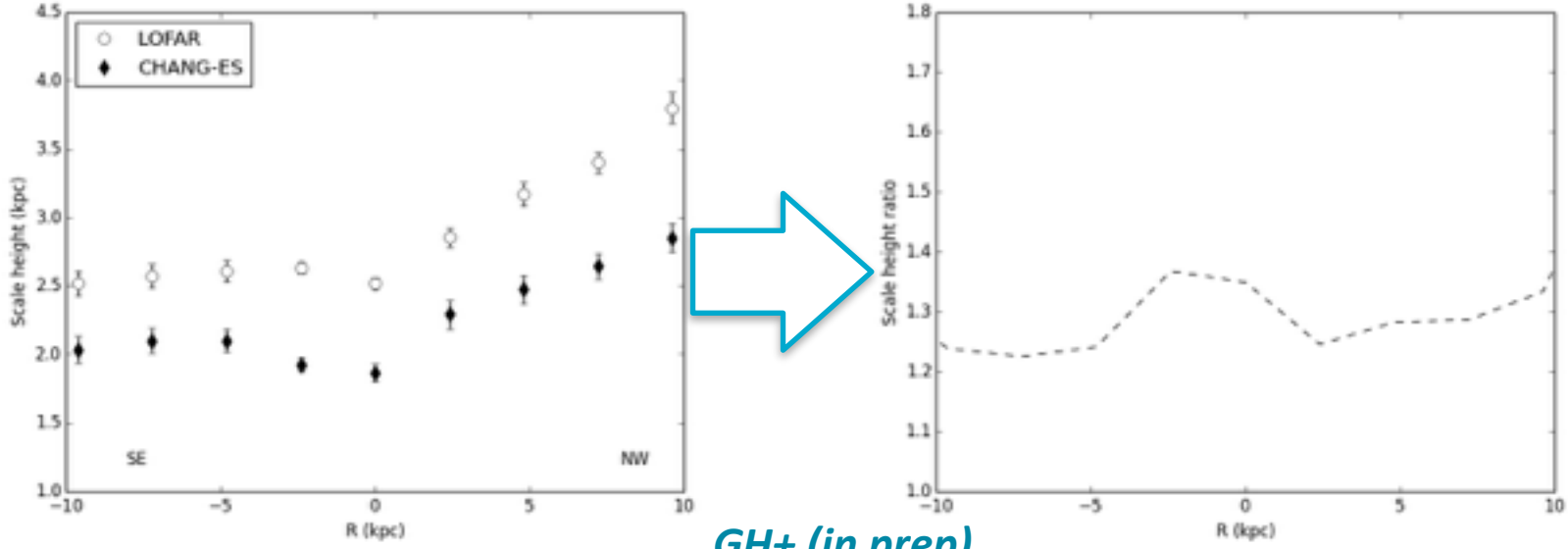


GH+ (in prep)

NGC 5775

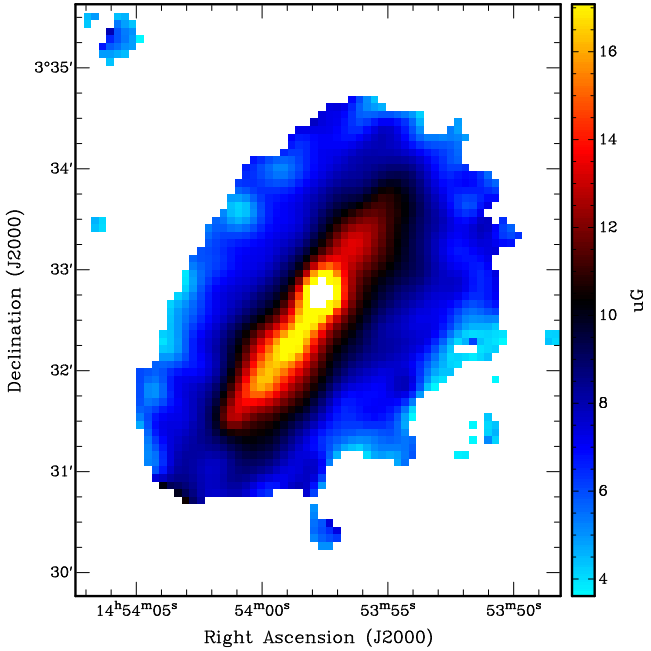
- Vertical distribution quantified as exponential scale heights at two distinct frequencies (140 and 1500 MHz)

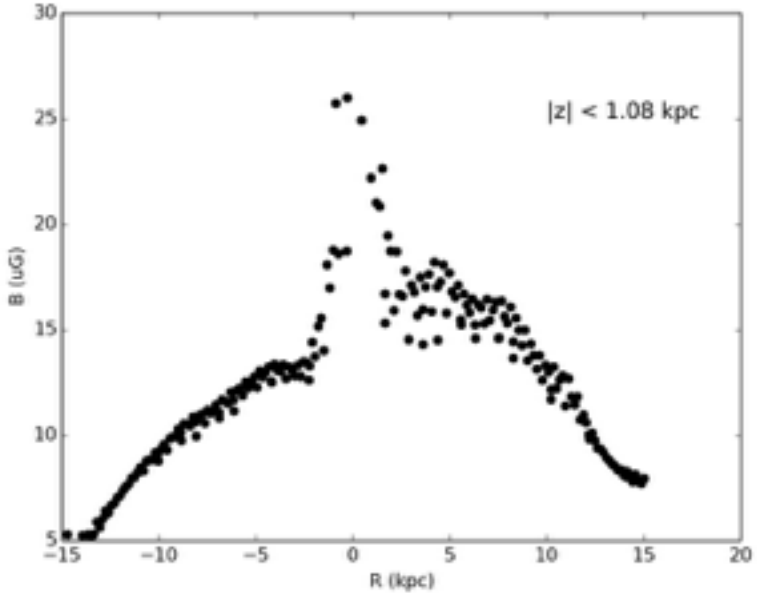


GH+ (in prep)

NGC 5775

- Equipartition magnetic field strength

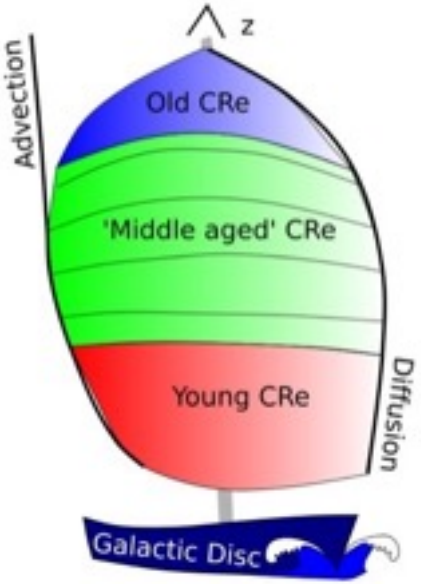


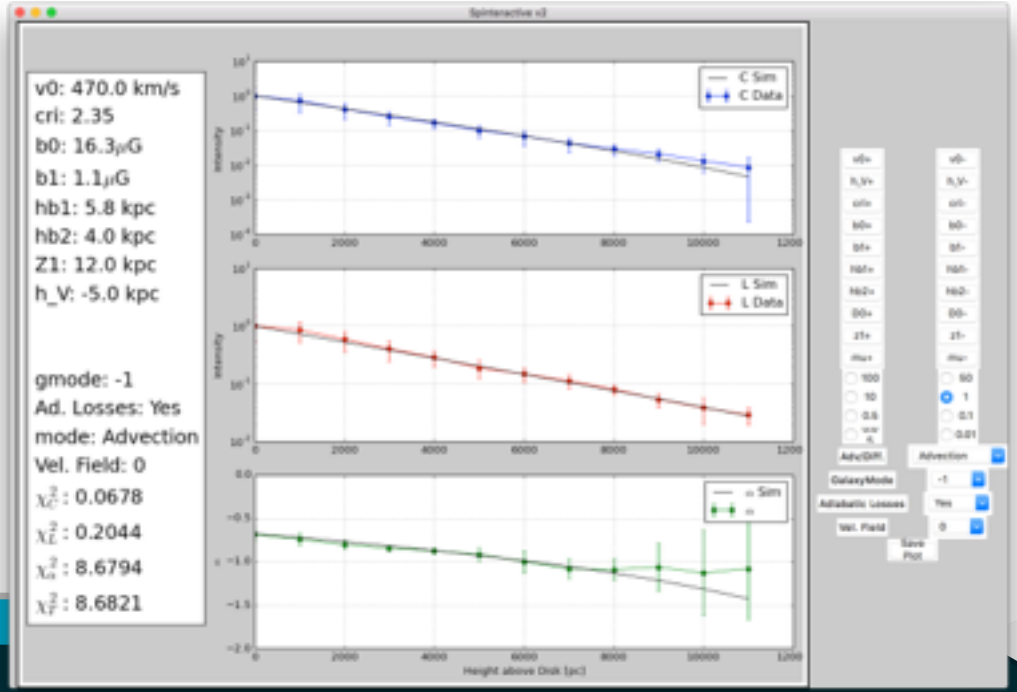


GH+ (in prep)

NGC 5775

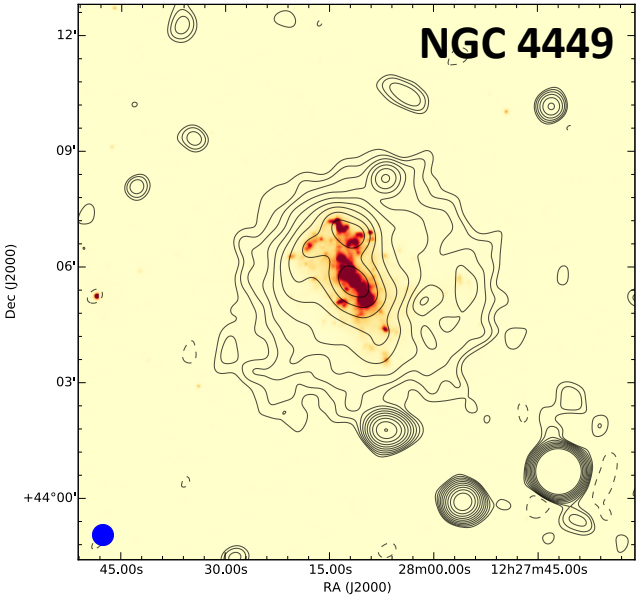
- Cosmic ray propagation modeled using Spinnaker (Volker Heesen et al), in combination with Spinteractive (Arpad Miskolczi)

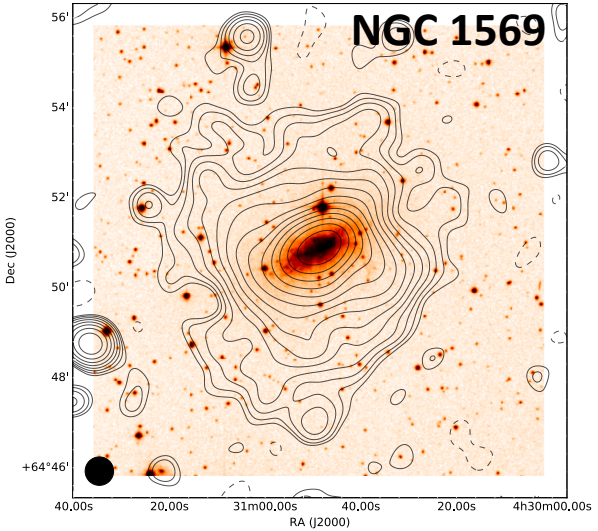




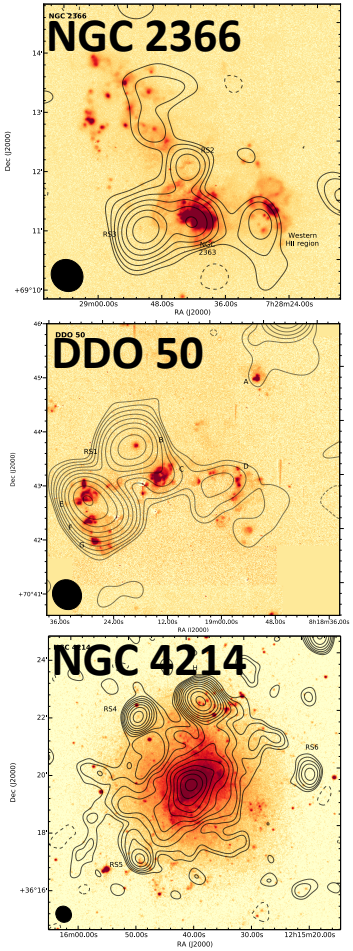
Dwarf galaxies

- LOFAR HBA



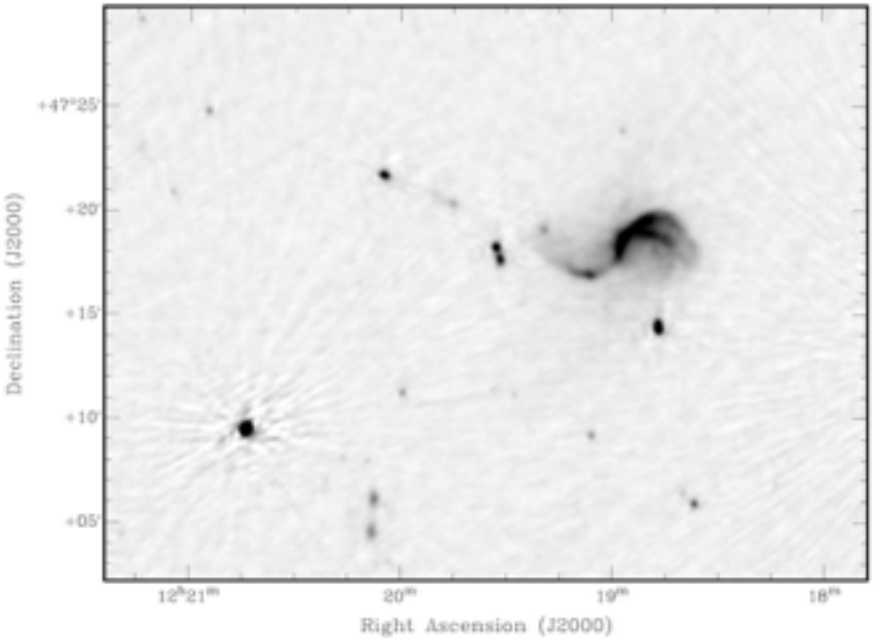


Ongoing work by Sarrvesh Sridhar



NGC 4258

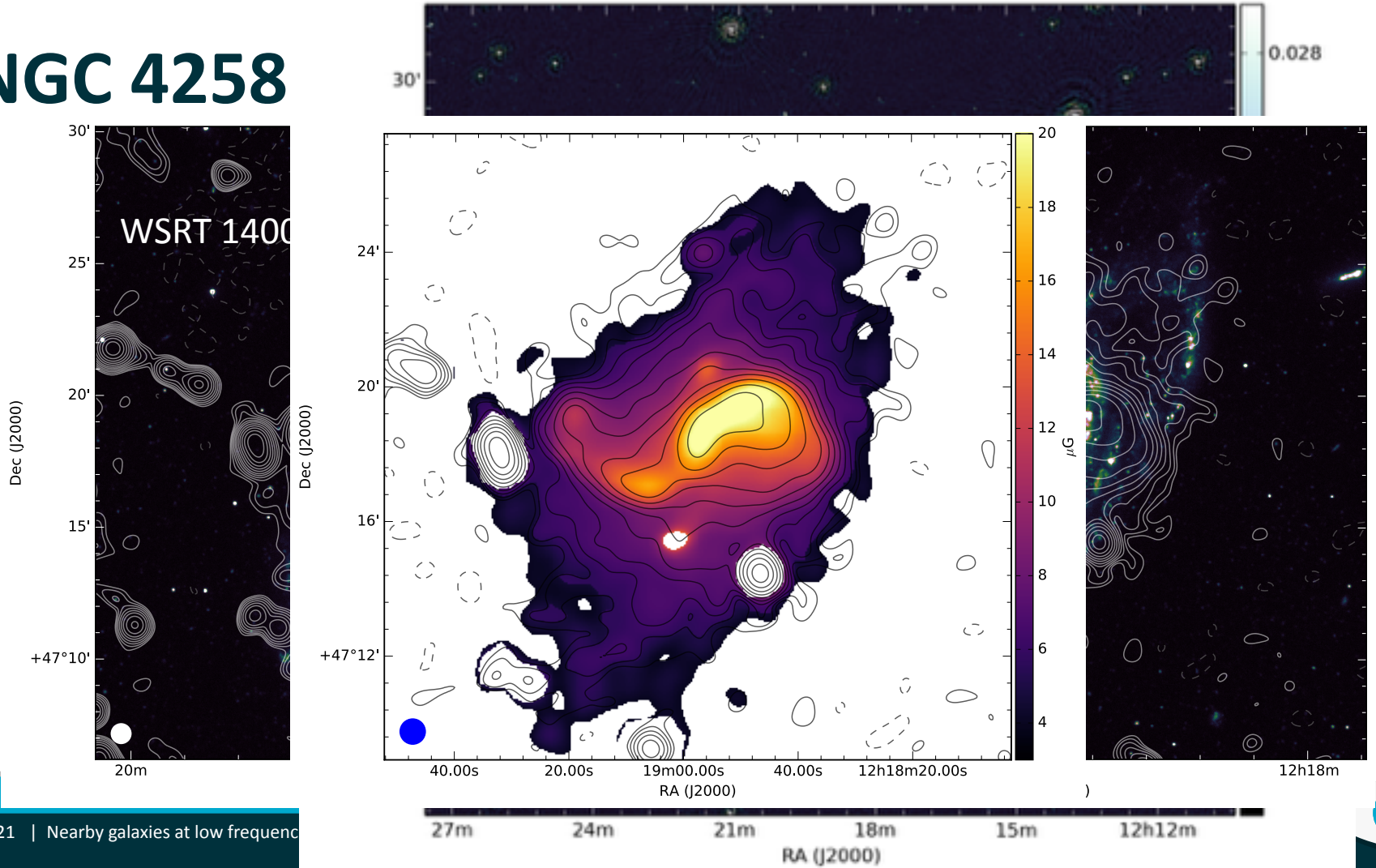
- Anomalous arms:



LOFAR 140 MHz (14.2" x 10.4", rms 280 μJy/beam)
Sridhar, GH et al in prep

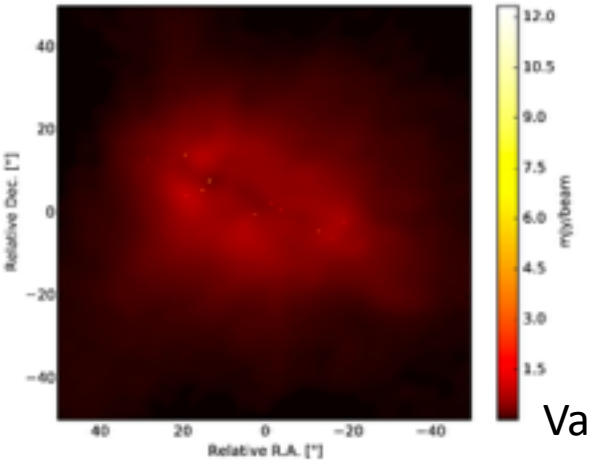
Optical: NASA/STScI; IR: NASA/JPL-Caltech;
Xray/radio in blue/purple

NGC 4258

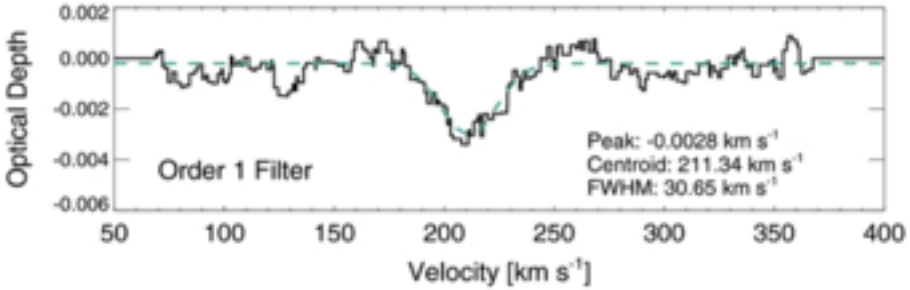

30'
0.028
WSRT 1400
25'
20'
15'
+47°10'
Dec (J2000)
20m
24'
20'
16'
+47°12'
Dec (J2000)
40.00s
20.00s
19m00.00s
40.00s
12h18m20.00s
RA (J2000)
20
18
16
14
12
10
8
6
4
μG
12h18m
)
27m
24m
21m
18m
15m
12h12m
RA (J2000)

LOFAR nearby galaxy survey

- Broad range of (25) individual galaxies observed to date including Stefan's Quintet; *see poster by B. Nikiel-Wroczyński*



Varenius et al (2015)

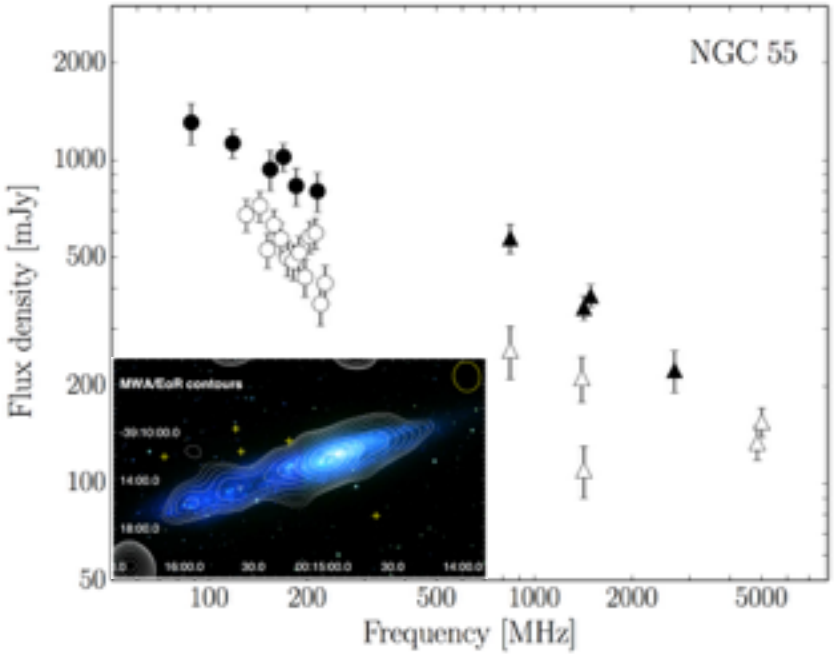


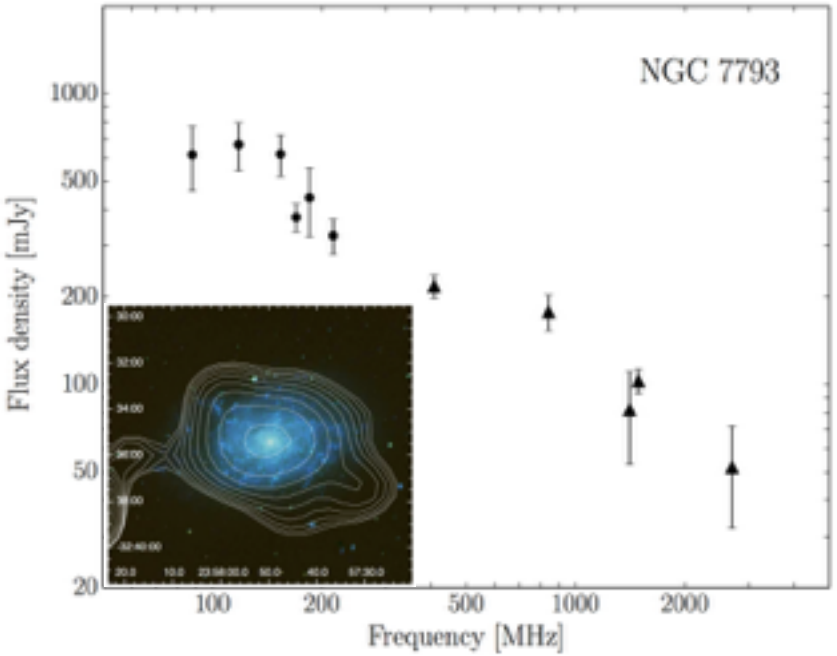
Morabito et al (2014)

- Census of galaxies within LoTSS survey; *see talk by V. Heesen*

GLEAM: broadband SEDs

- Sculptor group galaxies (Kapinska et al, in prep)

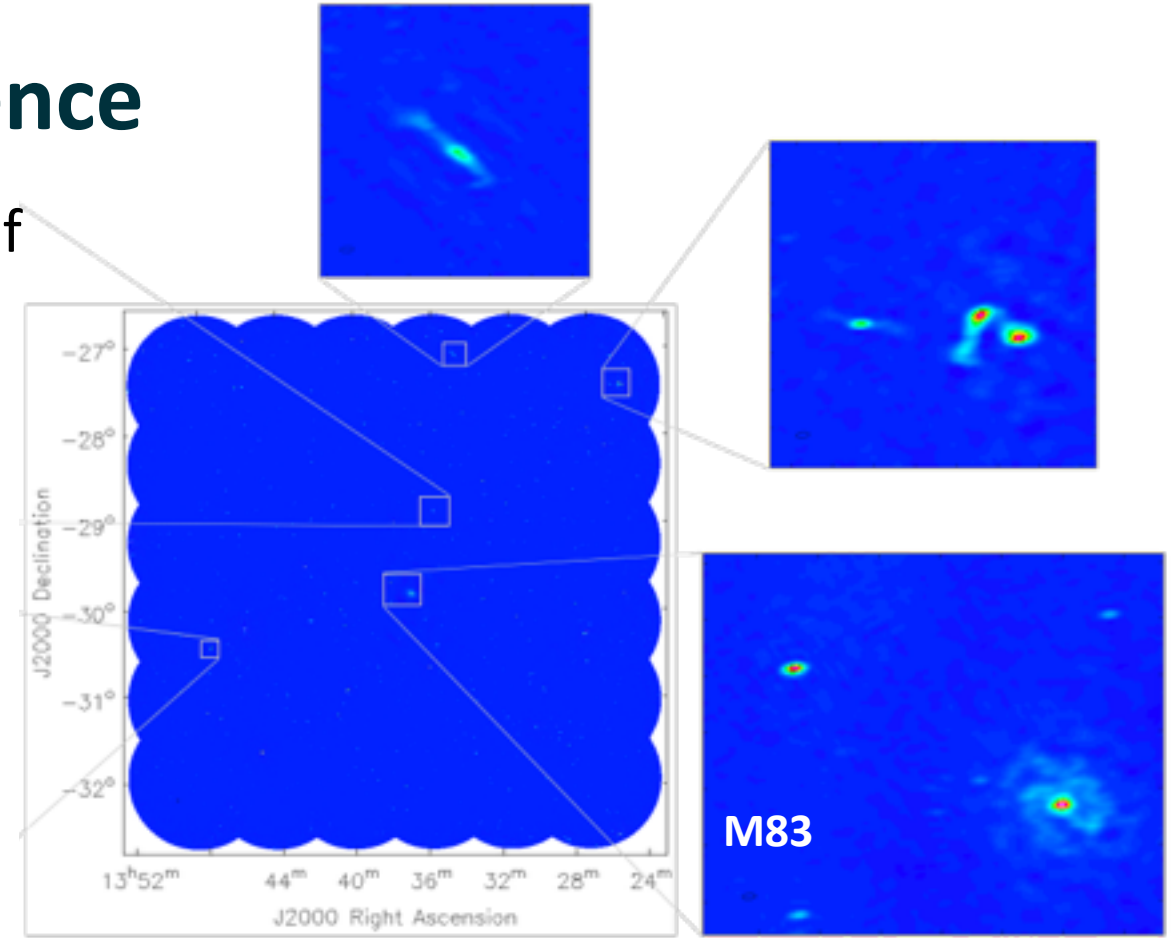




Future prospects

ASKAP Early Science

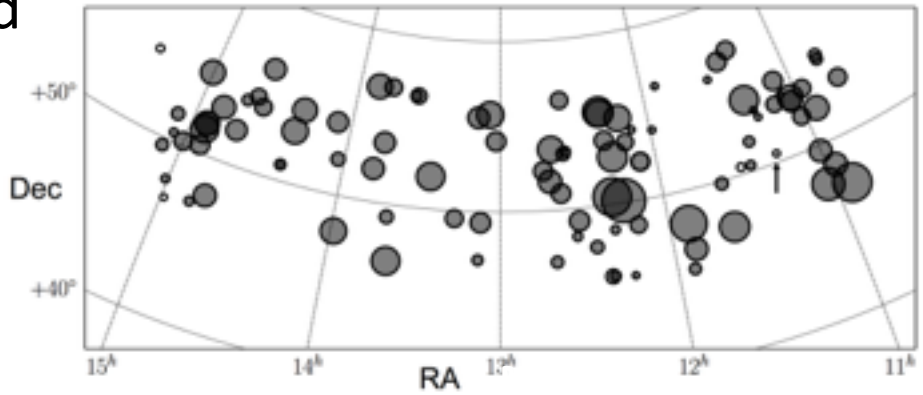
- ASKAP is now capable of fairly routine broadband continuum imaging (36 beams, 12 antennas) with the ASKAPsoft pipeline



Polarization

- Diffuse polarization has not yet been detected in nearby galaxies at low frequencies (NB, statistical detection in M31 at 350 MHz; Gießübel, GH et al 2013)
- Prospect of statistical foreground screen effect in Faraday RM?
  - LoTSS polarization survey already providing good RM Grid! Further observations centred on galaxies...

van Eck et al (in prep)



Moving forward

- MWA Phase II expansion will provide substantially improved angular resolution to complement the already extraordinary frequency coverage
- SKA1-LOW will provide an excellent resource for probing the galaxy-IGM connection
  - modest angular resolution but excellent surface brightness sensitivity; possibly revealing diffuse polarisation and providing RM Grid?

Thank you

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