M82
A radio continuum and polarisation study

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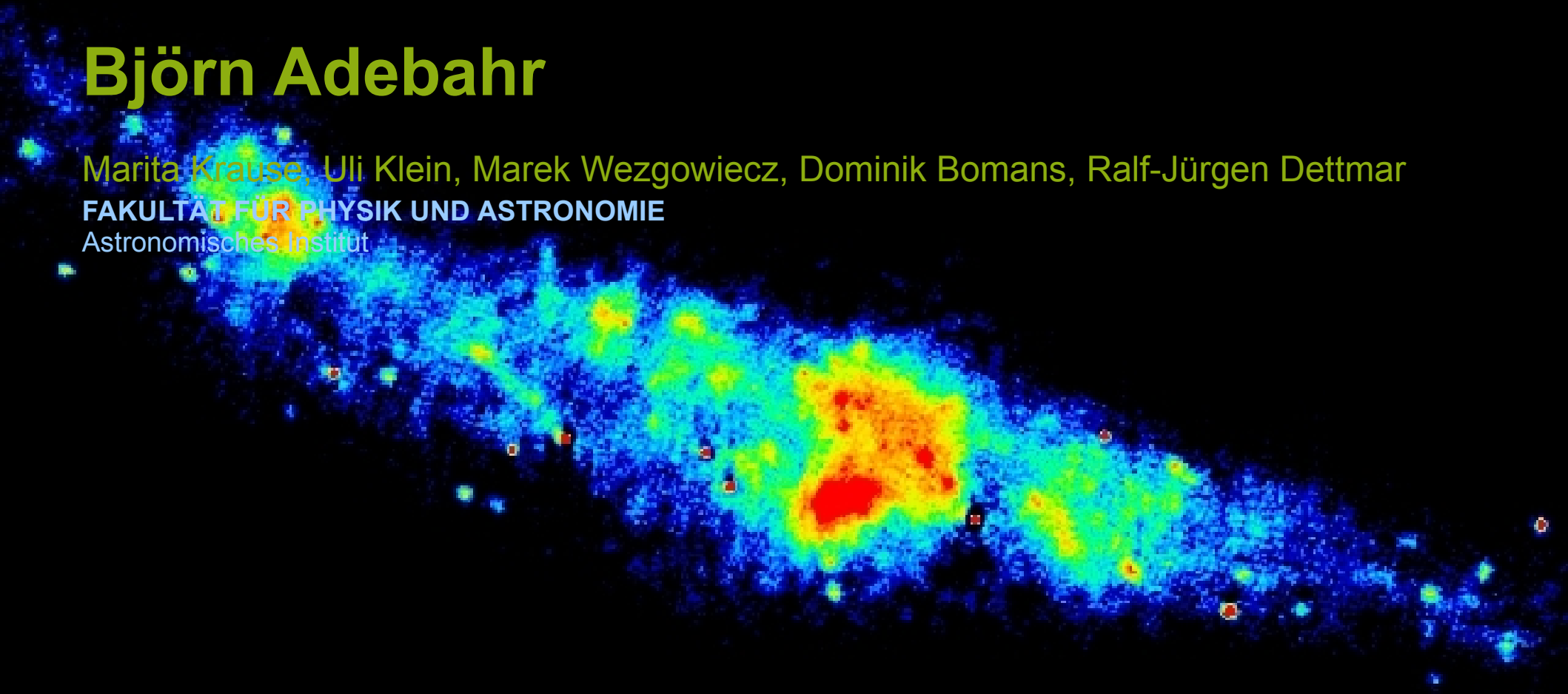
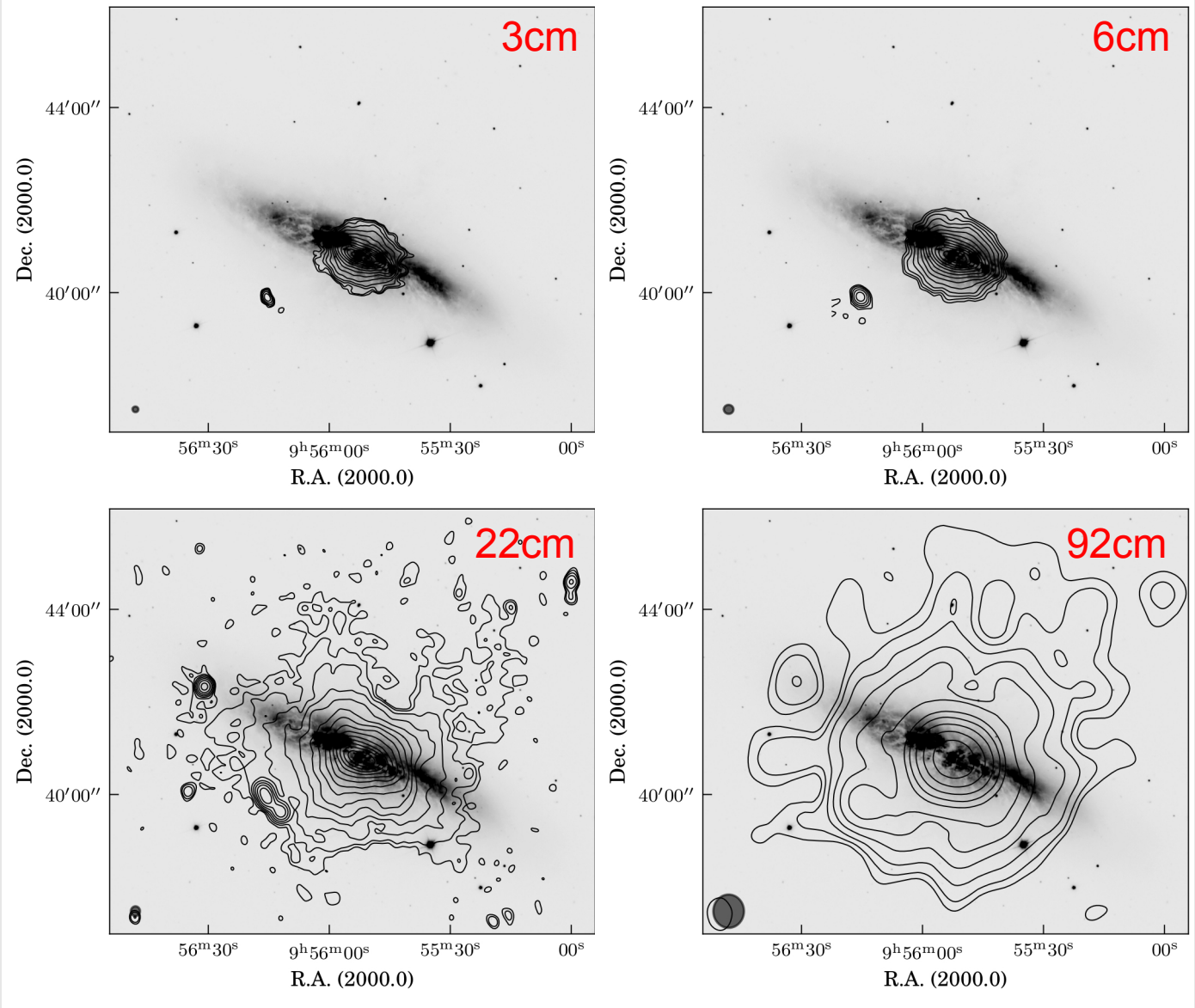


Total Intensity



Two distinct spurs in the North and South with distinct dip

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Higher CR losses in the outflow cone

More extended halo in the North

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Group medium denser in the southern part and/or movement to the south

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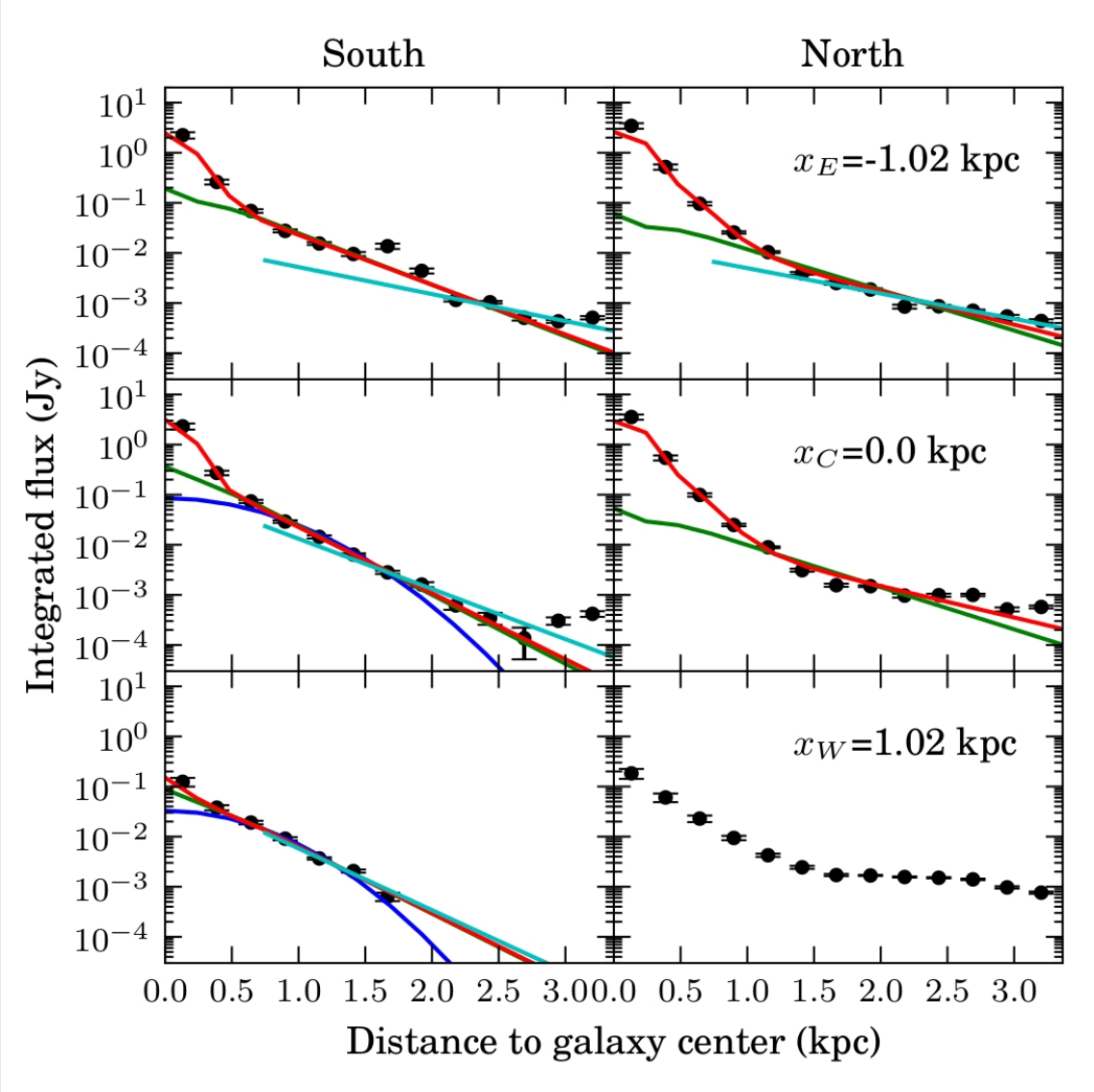
Scaleheights



Average scaleheights:

1st comp.: 85 pc

2nd comp.: 420 pc (South)

750 pc (North)

Lower than the reference values for spiral galaxies (Dumke & Krause 1998):

300 pc (thin disk)

1.8 kpc (thick disk)

Something must be different here!

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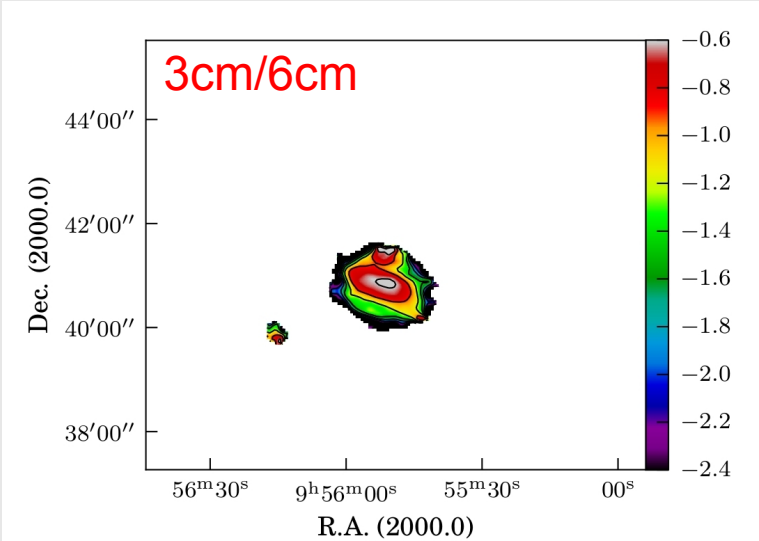
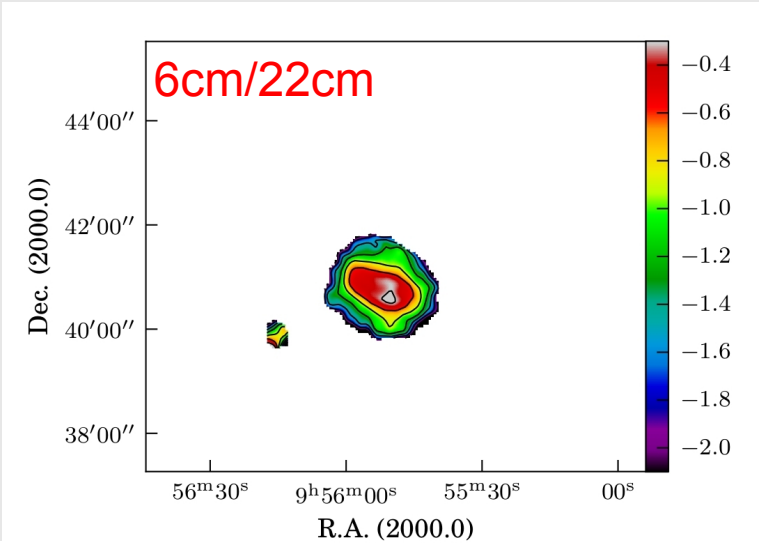
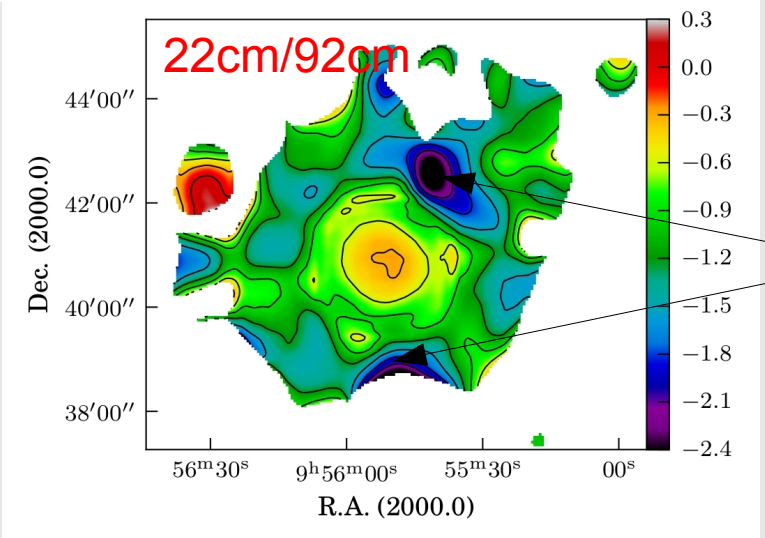
Spectral Index







Flat overall SI with -1.2 - -1.5

Distinct regions with very steep spectrum

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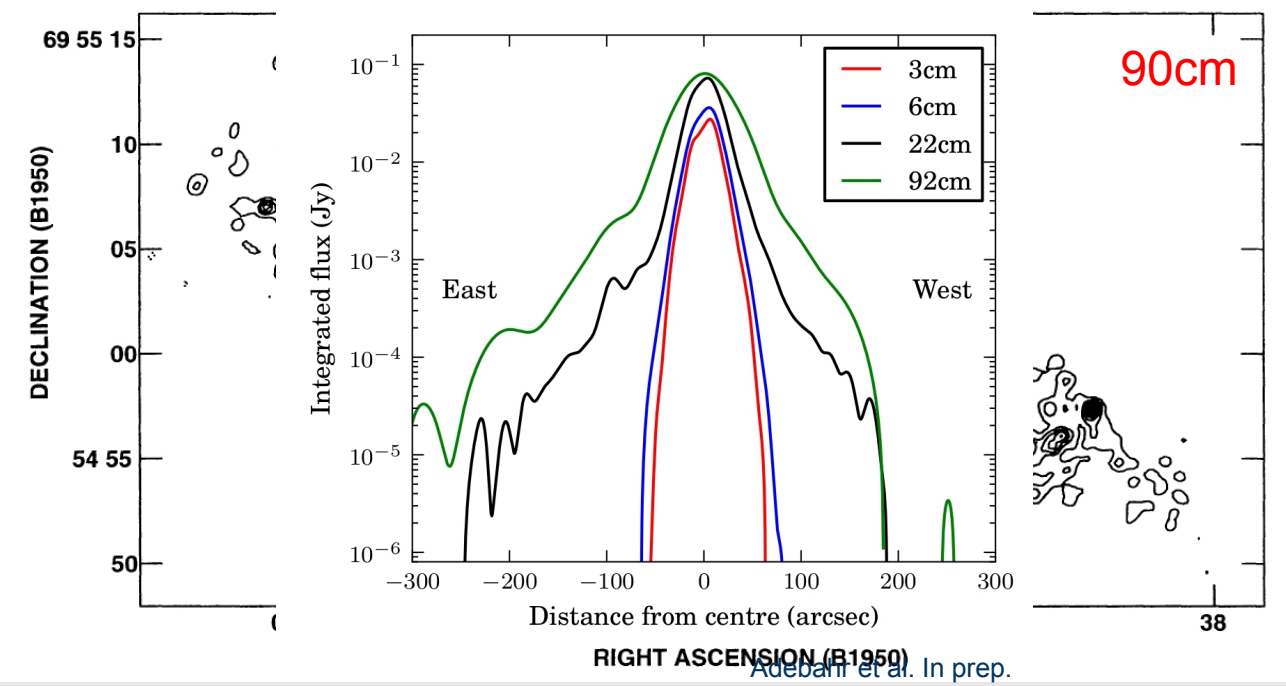
Asymmetry and absorption



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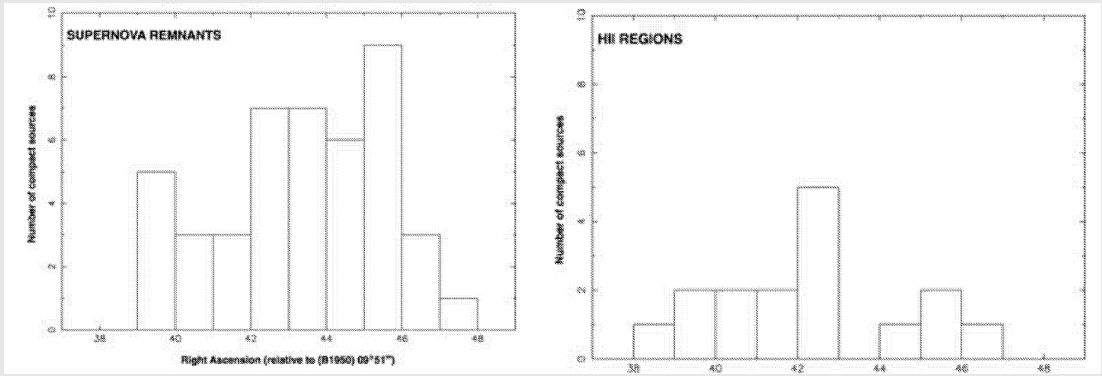
Wills et al. 1997



McDonald et al. 2002

More supernova remnants in the western part

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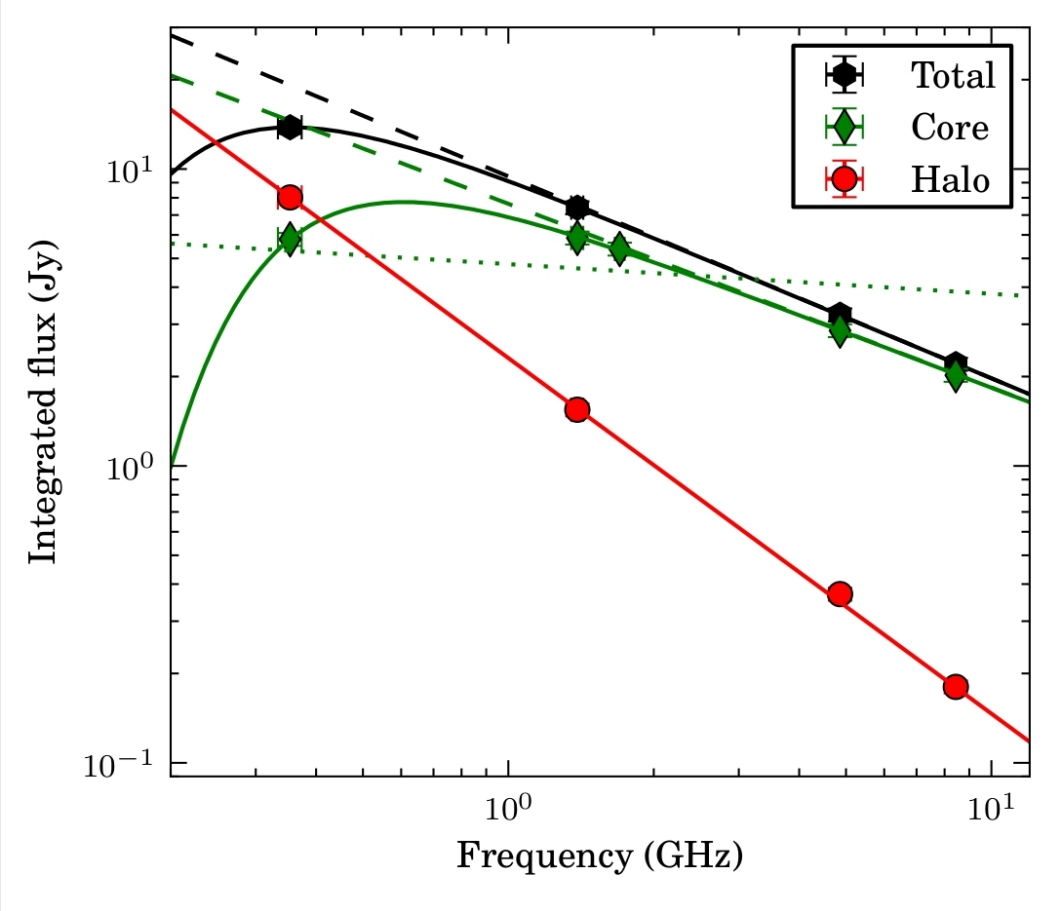
Core-halo interaction?

Free-free absorption visible in several supernova remnants and HII-regions

Ionisation, absorption and opacity



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Spectral Indices and EM:

Total: α=-0.67

Halo: α=-1.20

Core: α=-0.62

EM=3.16 · 10^5 pc cm^{-6}

τ=0.91

↓

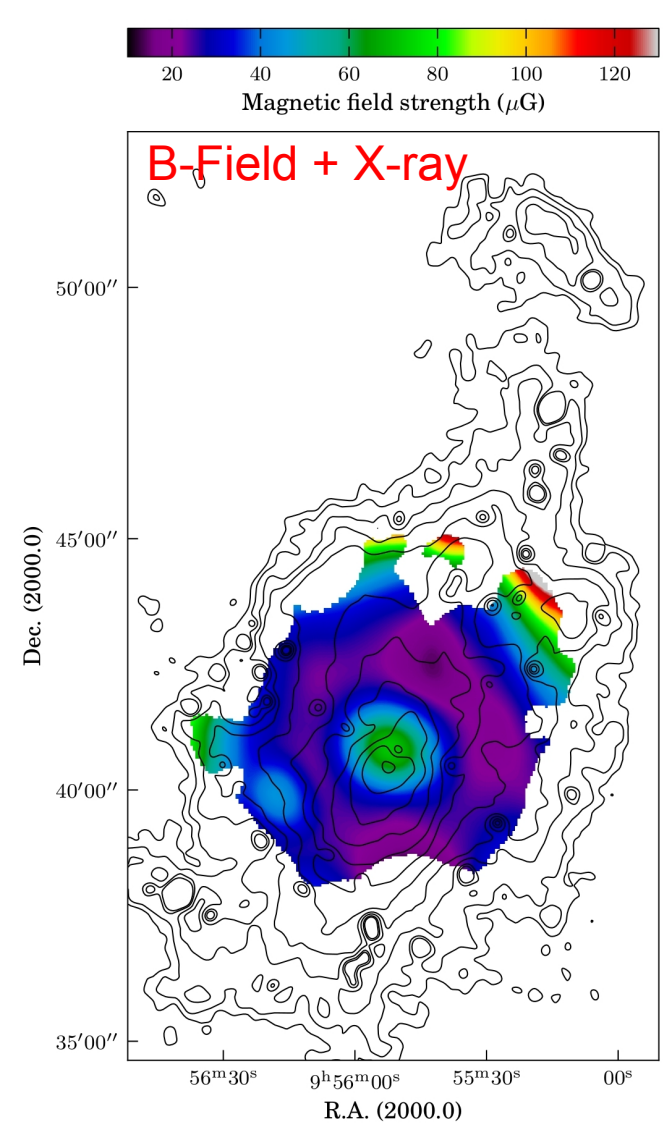
Average electron density:

n=20 cm^{-3}

Filling factor f=1.9 %

Free-free absorption important in the core region, but not in the halo!

Total magnetic field strength



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Geometry and SI for Beck's equation important

Magnetic field average:

Beck & Krause (2005): 35 µG

Thompson et al. (2007): 1.13 mG

Magnetic field in the core:

Beck & Krause (2005): 98 µG

Magnetic field in the halo:

Beck & Krause (2005): 24 µG

Cosmic ray electron losses

	B_{core} = 98 μG	B_{halo} = 24 μG
E (GeV)	0.94	1.90
T_{syn}	$9.21 \cdot 10^5$ yrs	$7.62 \cdot 10^6$ yrs
T_{IC}	$4.66 \cdot 10^4$ yrs	$2.68 \cdot 10^5$ yrs
T_{brems}	$1.60 \cdot 10^5$ yrs	$6.90 \cdot 10^8$ yrs
T_{ion}	$3.57 \cdot 10^4$ yrs	$3.12 \cdot 10^8$ yrs
T_{ad}	$2.20 \cdot 10^6$ yrs	$2.20 \cdot 10^6$ yrs
T_{cool}	$4.43 \cdot 10^4$ yrs	$2.59 \cdot 10^5$ yrs
T_{esc}	$1.17 \cdot 10^5$ yrs	$1.12 \cdot 10^6$ yrs
T_{Π}	$2.00 \cdot 10^5$ yrs	$8.62 \cdot 10^8$ yrs

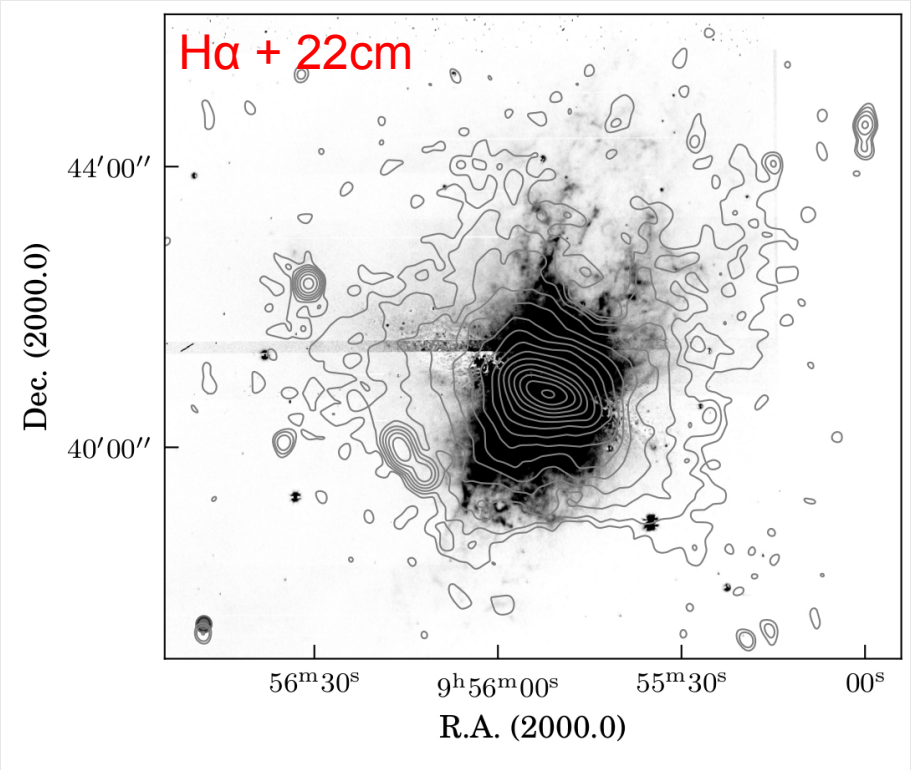
Ionisation and IC losses are dominating the core region

Pion decay plays a role in the core region (Proton calorimeter?)

IC losses are still dominant in the halo

Cosmic ray electrons cannot escape the core region and the galaxy

Transport of cosmic rays into the halo



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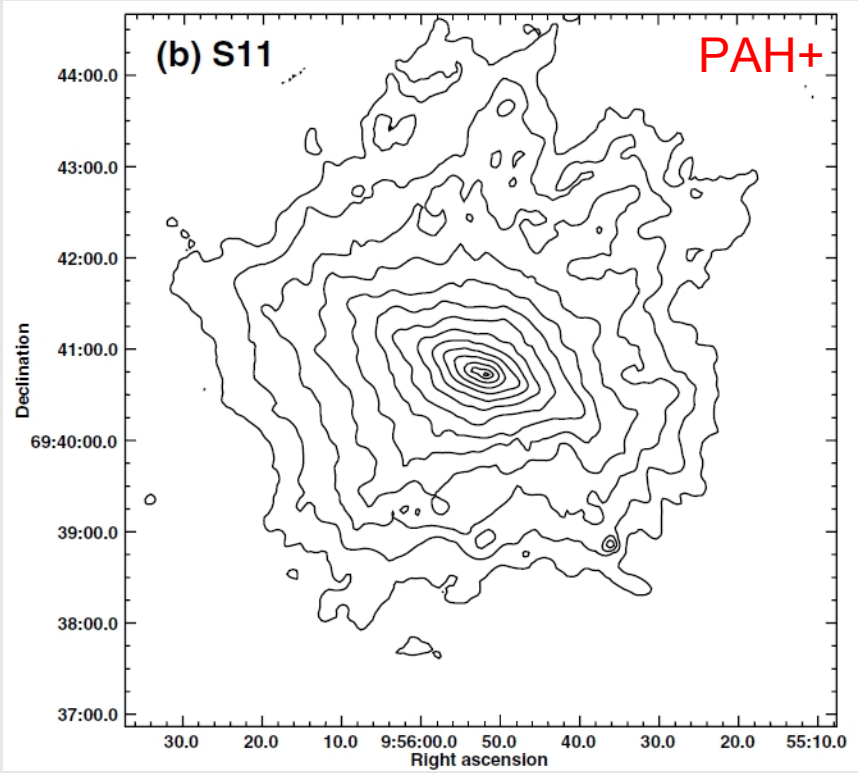
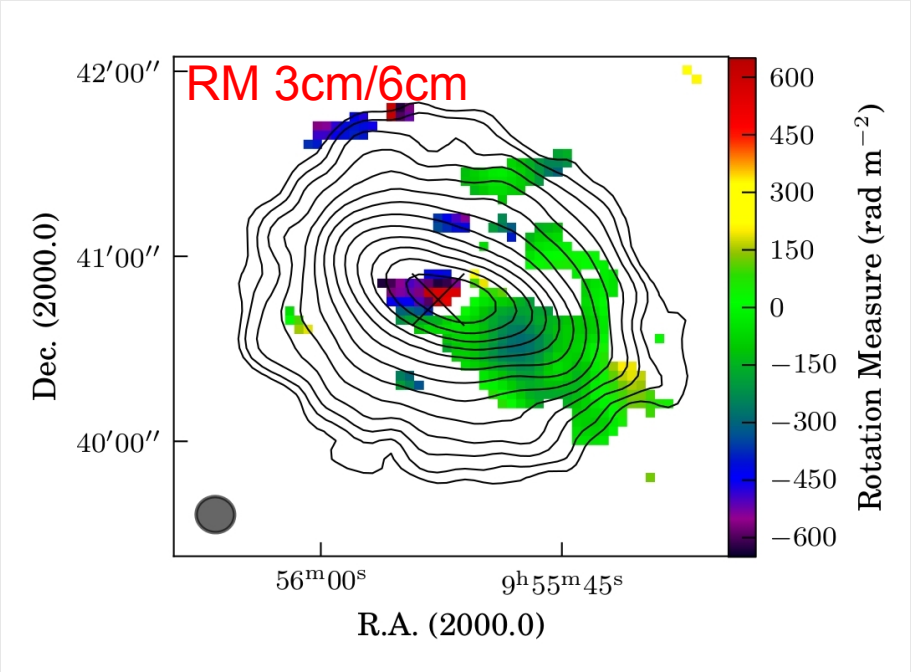


Kaneda et al. 2010

Magnetic field is coupled to the ionised medium and transported out!

A revised picture of the outflow mechanism

Polarisation and B-Field at short wavelengths



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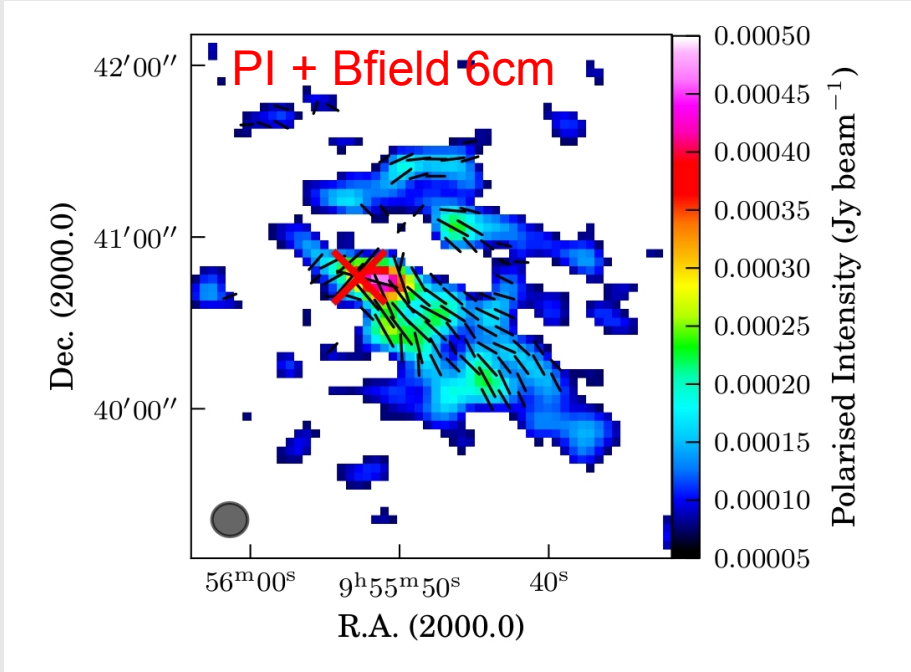

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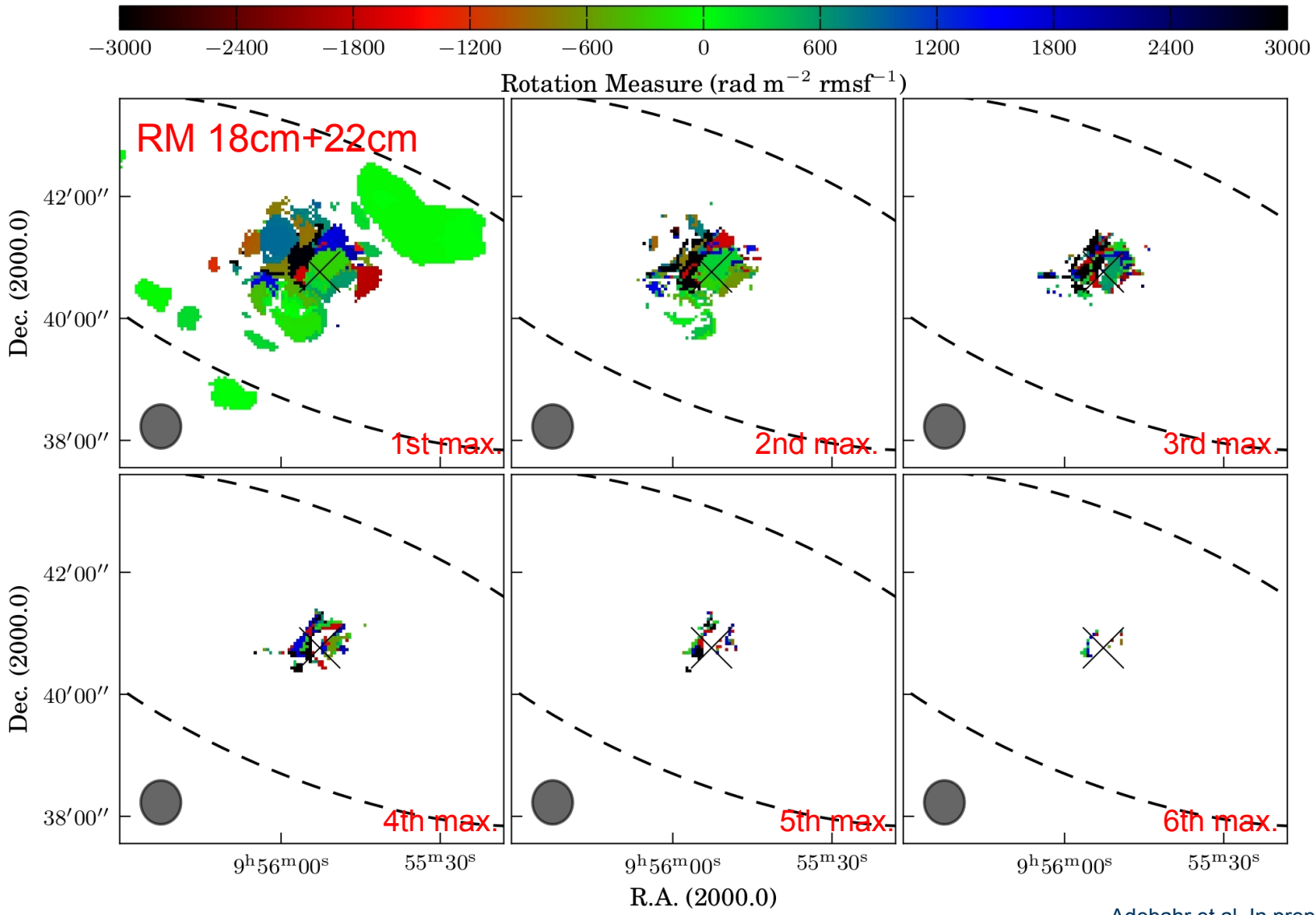
Magnetic field parallel to the major axis in the western part due to shocks from supernovae

HII regions in the eastern part do not produce regular fields

Rotation Measures at 18cm/22cm



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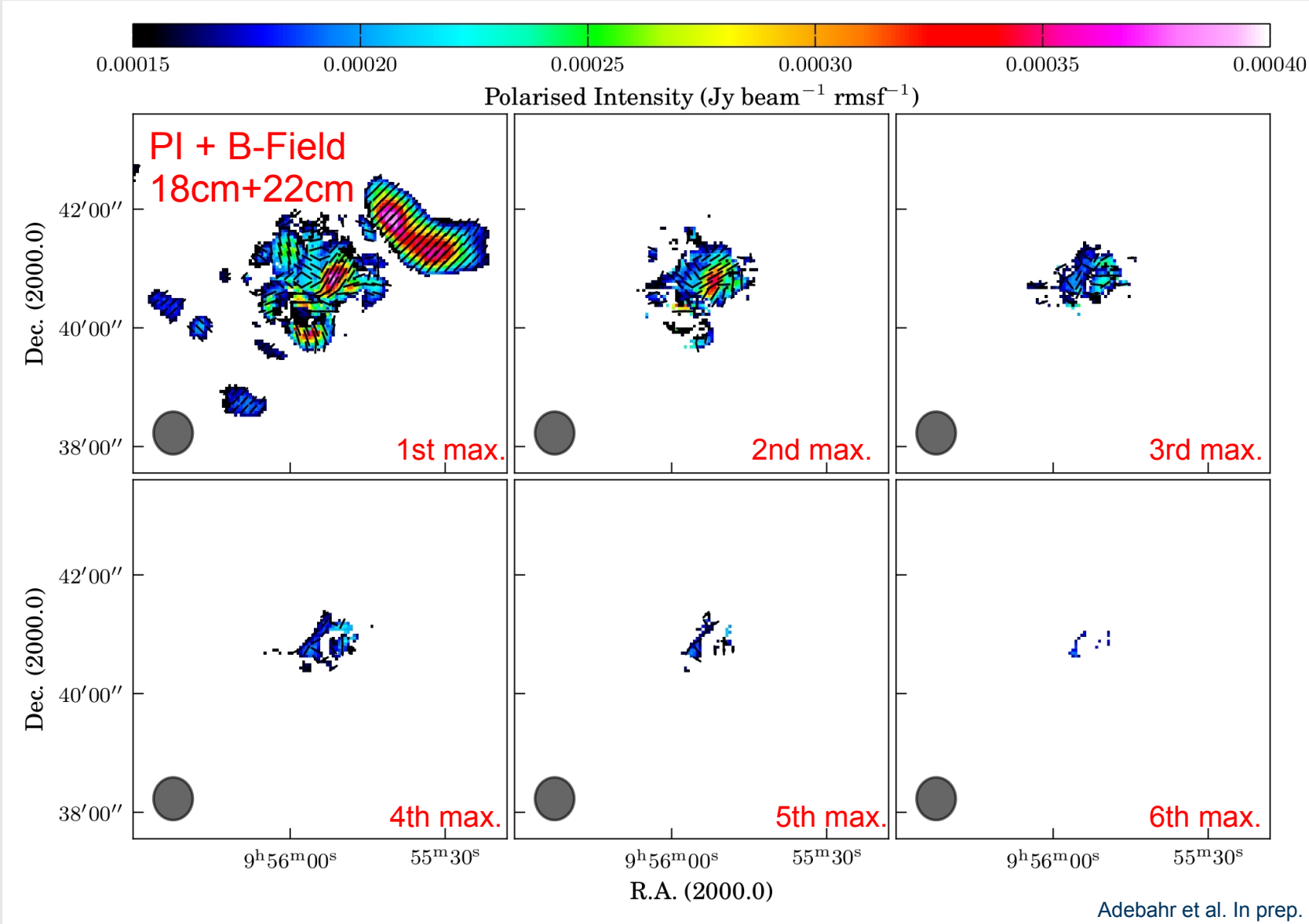
B-Field at 18cm/22cm



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Summary and Outlook

Conclusions

- Ionisation losses in star-forming regions important
- Radio halo produced by older starburst periods
- Magnetic field is completely coupled to the ionised medium
- Supernovae produce shocks and regular B-Field
- Small-scale dynamo may be important in the halo

Future Work

- Closer look to the RM-cube
- Calculate magnetic field strength of the northern outflow with RMs and compare to energy equipartition
- Propose new observations for WSRT and LOFAR for lower frequencies

  → more constrains on loss processes and magnetic field strength in the halo