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G53.41+0.03 – A NEWLY DISCOVERED GALACTIC SUPERNOVA REMNANT

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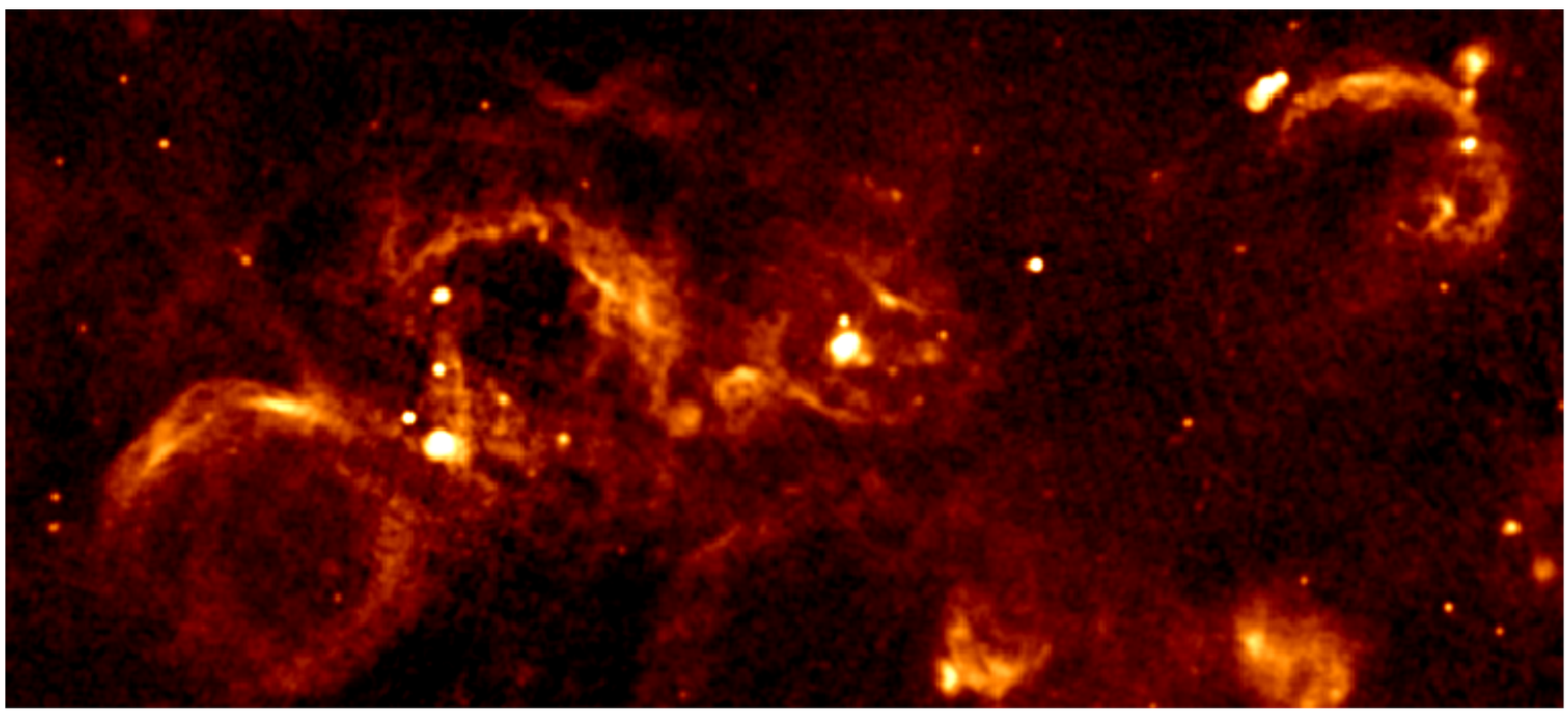
ISM Workshop, Bamberg 26-28.03.2018

MISSING SUPERNOVA REMNANTS

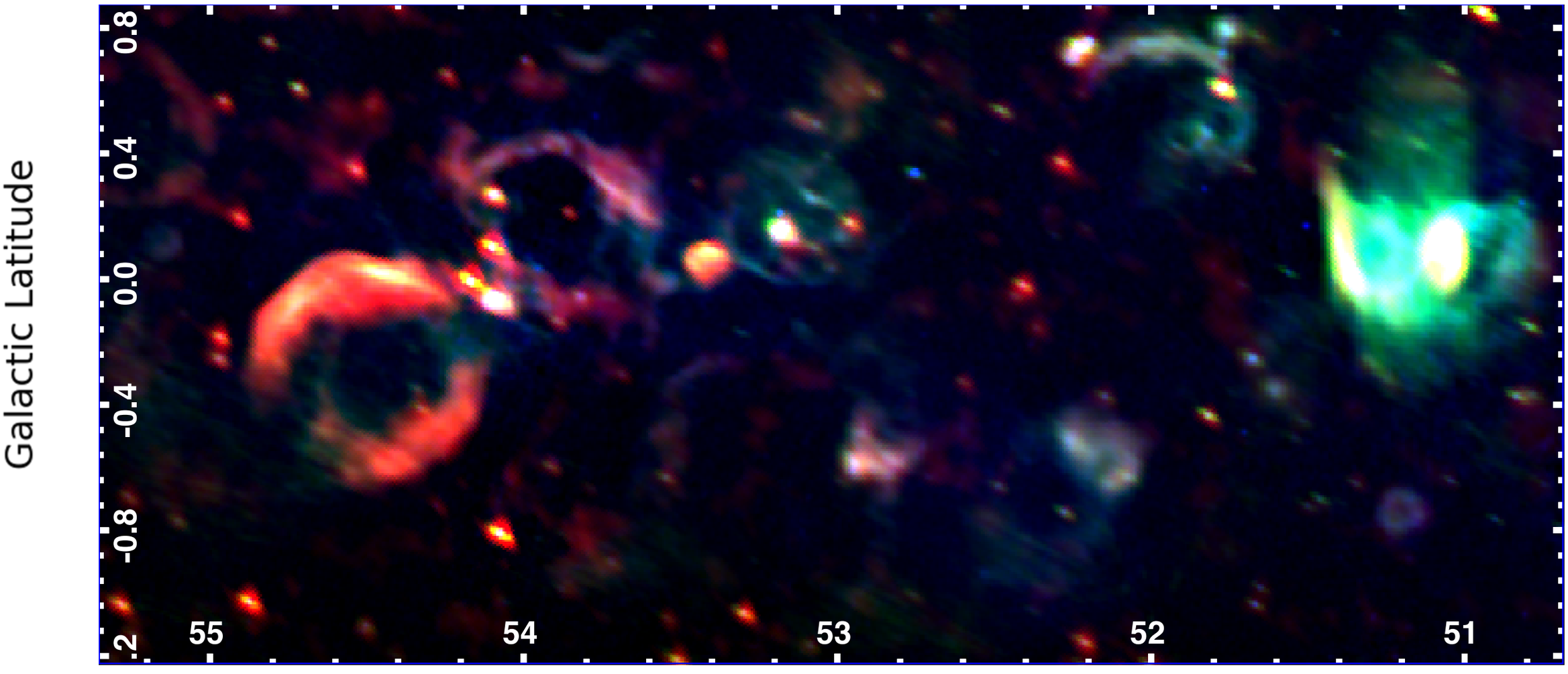
- Only ~300 known SNR (Green catalogue),
- 5-10x more expected (Li+1991)
- SNR and HII regions hard to distinguish
  - X-ray data
  - Radio data of 2 frequencies



VLA 1.4 GHz

LOFAR OBSERVATION

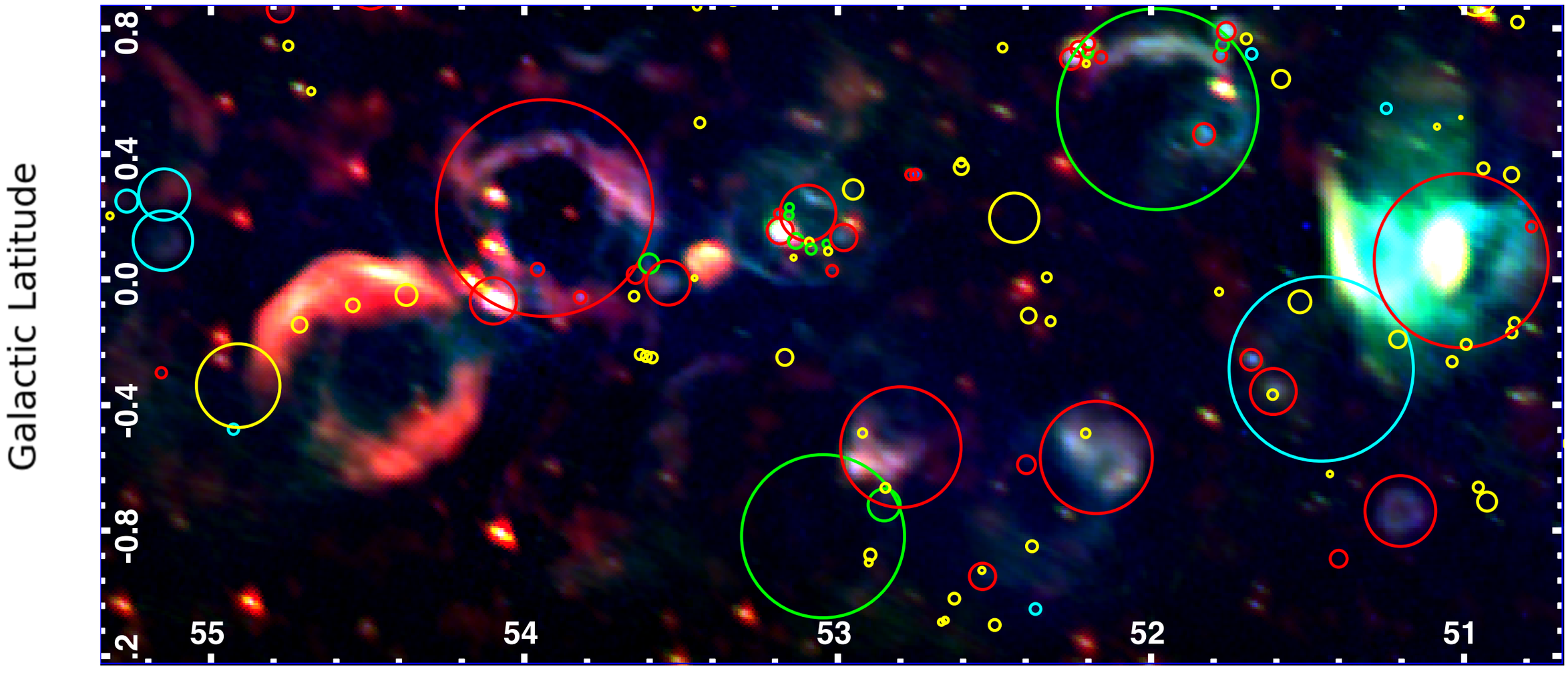
VLA 1.4 GHz WSRT 327 MHz LOFAR 150 MHz



Driessen, Domček et. al. 2017

LOFAR OBSERVATION –HII REGIONS

VLA 1.4 GHz WSRT 327 MHz LOFAR 150 MHz



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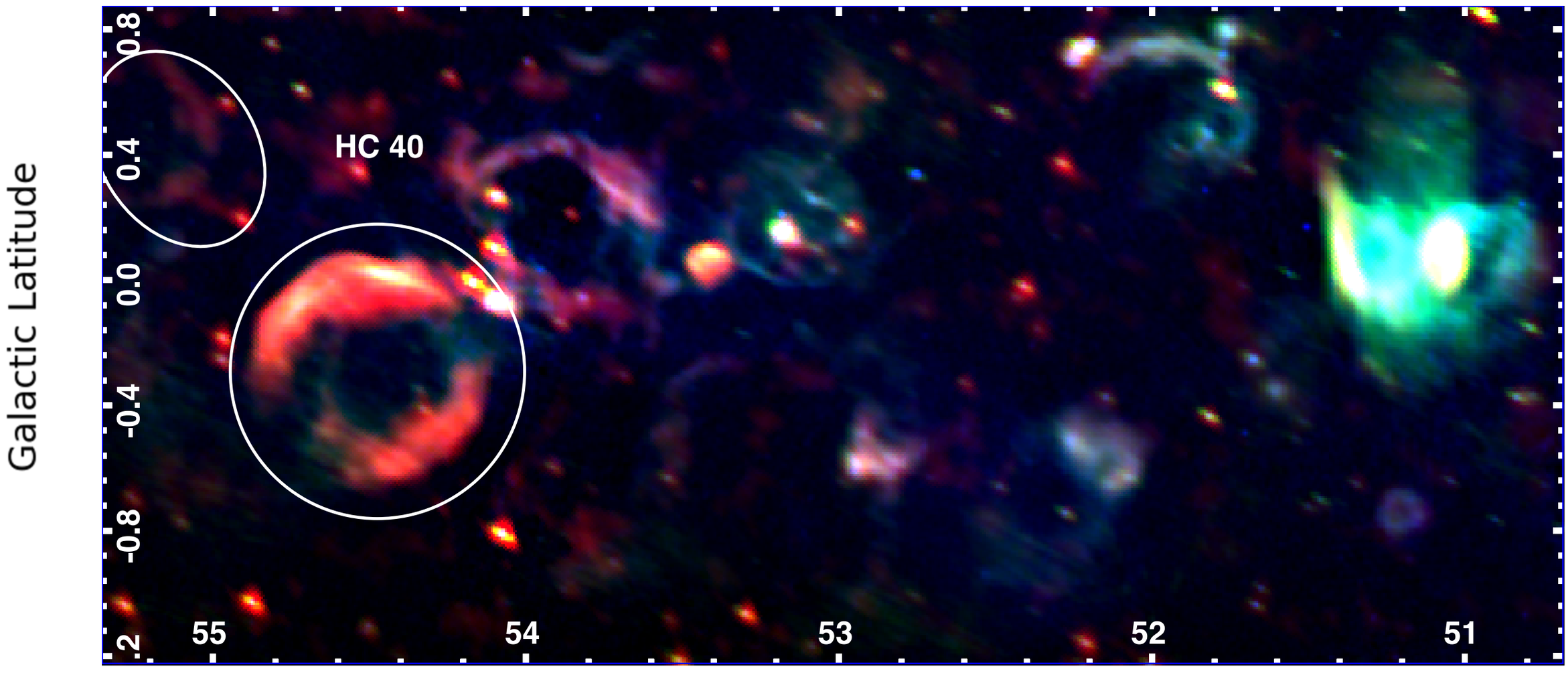
LOFAR OBSERVATION – KNOWN SNR

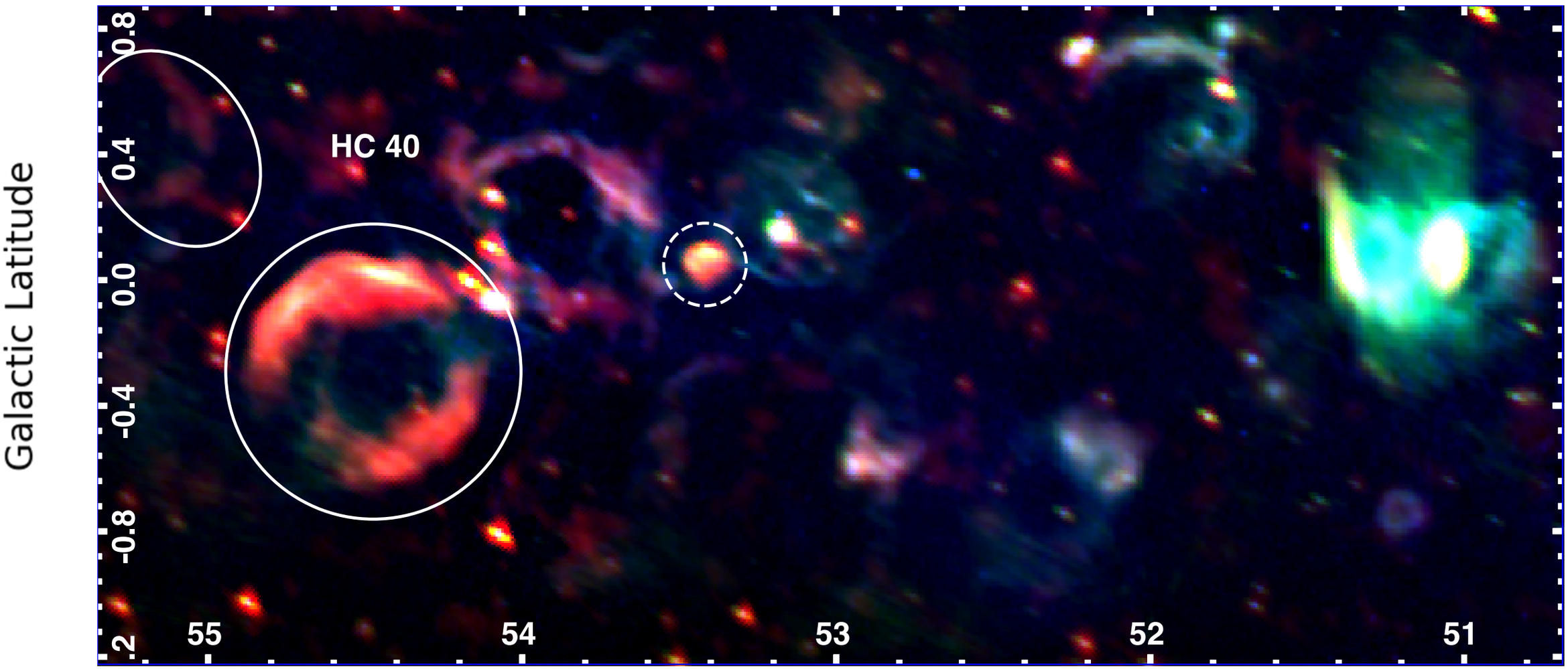
VLA 1.4 GHz WSRT 327 MHz LOFAR 150 MHz



Driessen, Domček et. al. 2017

LOFAR OBSERVATION – NEW SNR CANDIDATE?

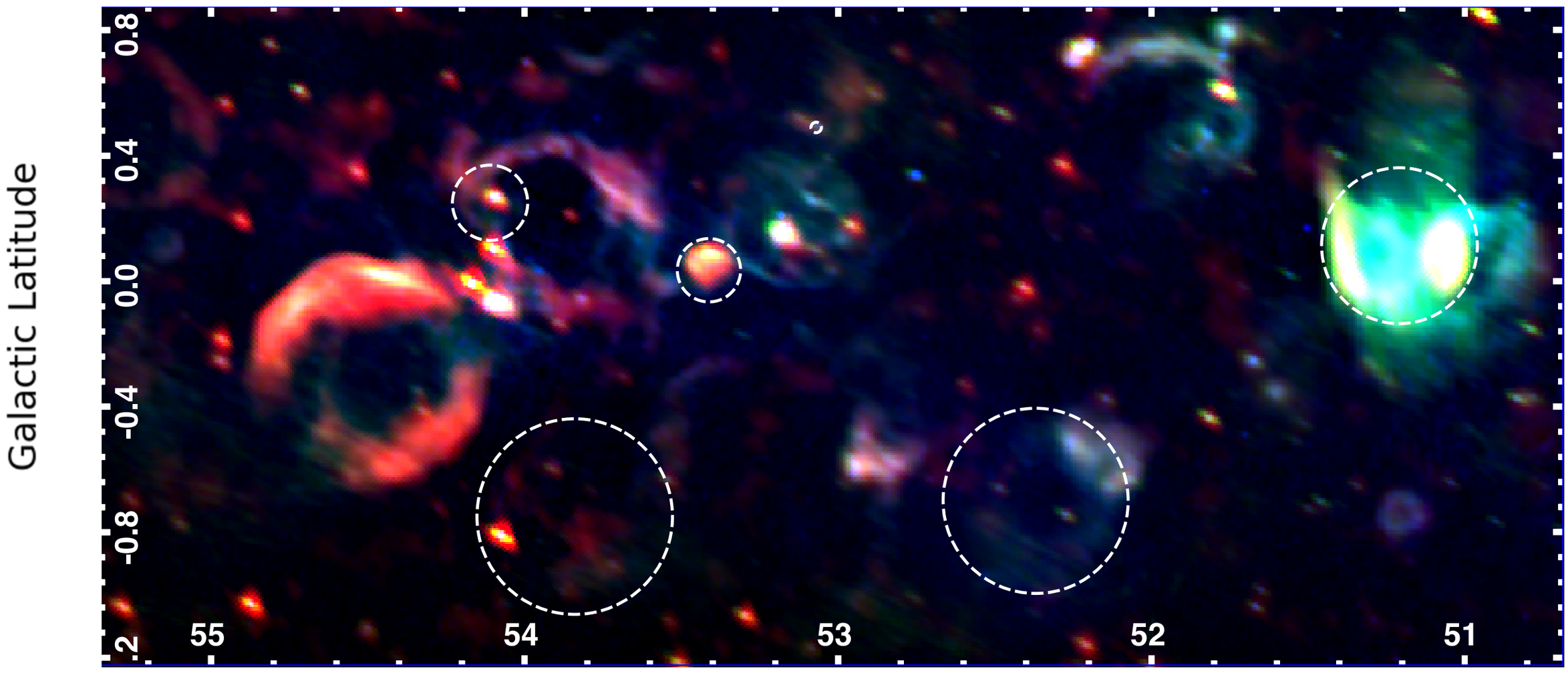
VLA 1.4 GHz WSRT 327 MHz LOFAR 150 MHz



Driessen, Domček et. al. 2017

OTHER CANDIDATES IN LOFAR FOV

VLA 1.4 GHz WSRT 327 MHz LOFAR 150 MHz



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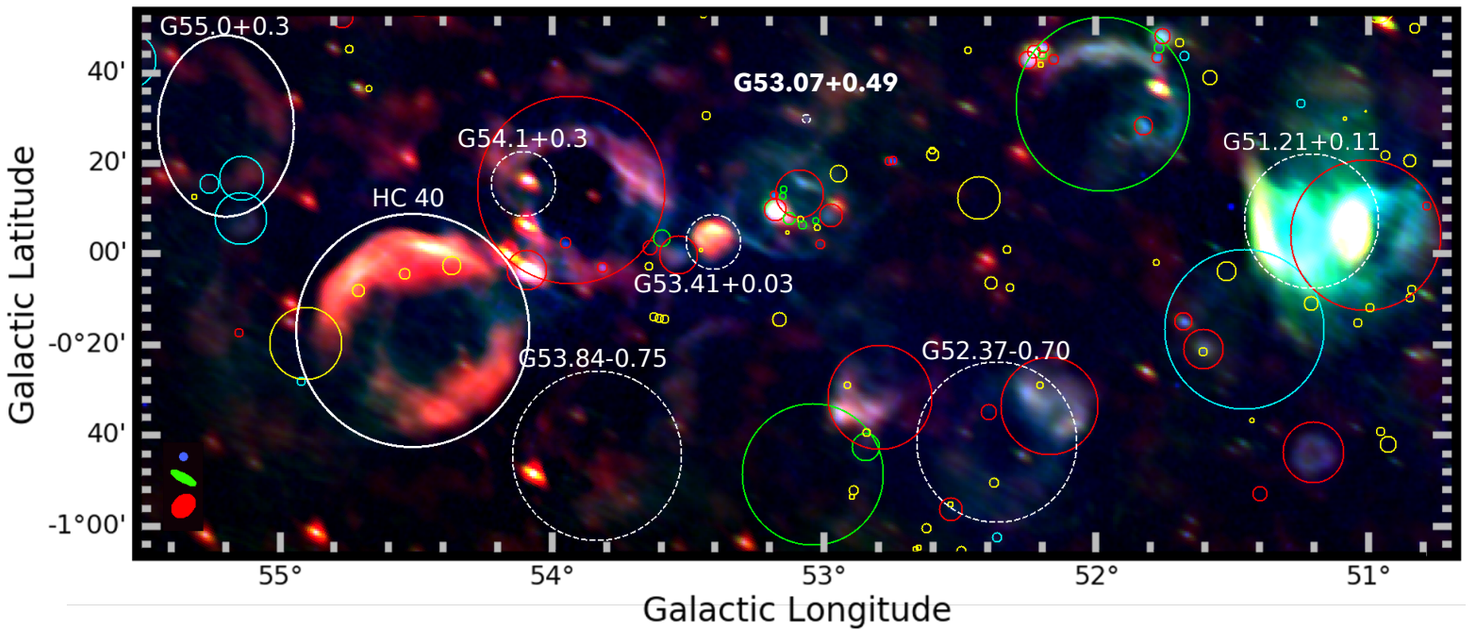
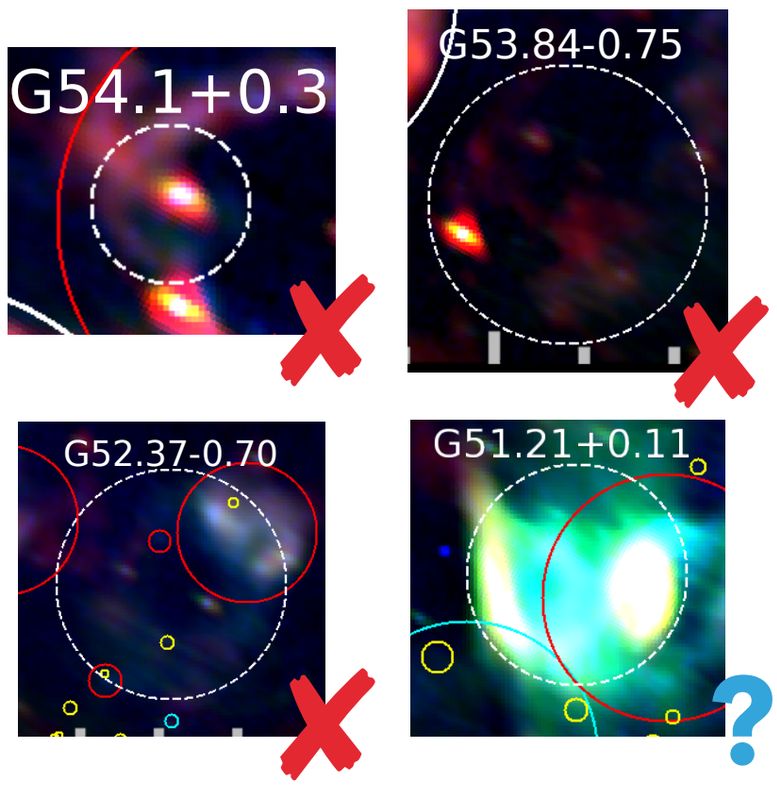
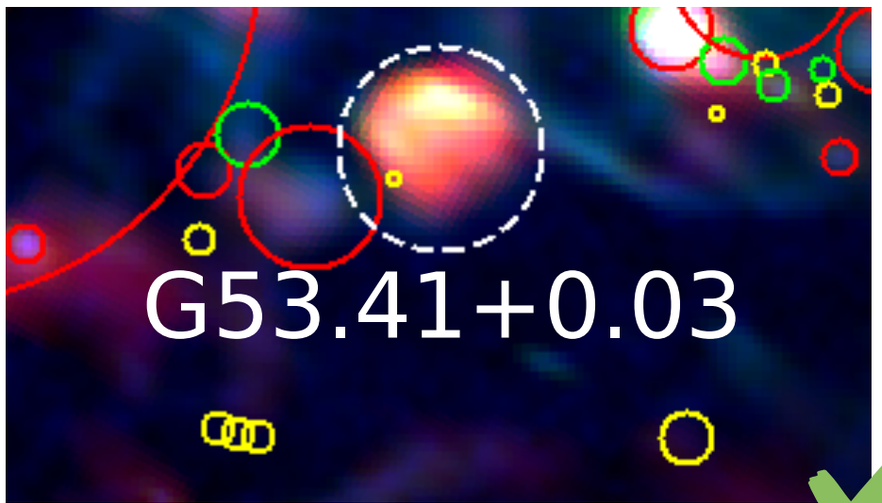
OBJECTS IN LOFAR FIELD OF VIEW

VLA 1.4 GHz WSRT 327 MHz LOFAR 150 MHz



SNR Candidates from Anderson et. al. 2017

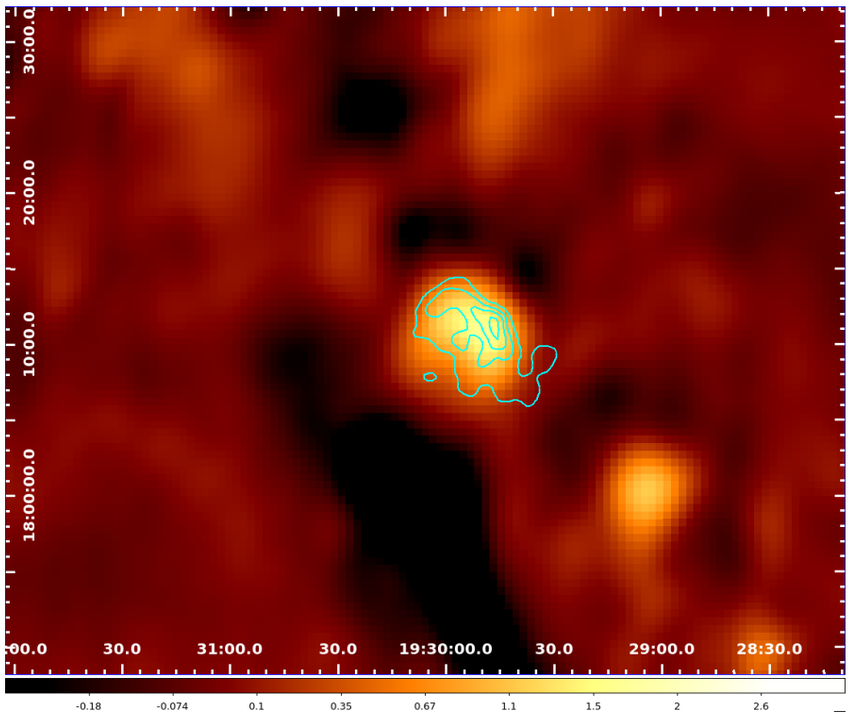




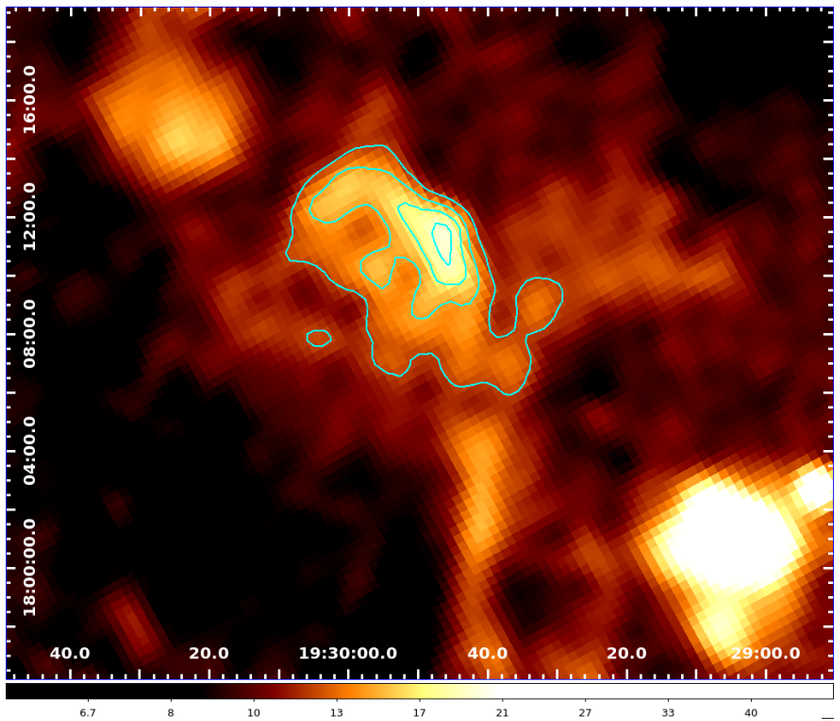
DRIESSEN ET AL.

	SNR	flux density (Jy) 1.4 GHz	327 MHz	150 MHz	α
?	G51.21+0.11	24.35 ± 2.1	66.1 ± 0.1		-0.7 ± 0.21
✗	G52.37−0.70	5.24 ± 1.75	3.2 ± 0.03		0.3 ± 0.3
✓	G53.41+0.03	1.21 ± 0.21	2.2 ± 0.03	3.11 ± 0.2	-0.6 ± 0.2
✗	G53.84−0.75	1.31 ± 3.43	0.06 ± 0.02	1.2 ± 0.07	0.05 ± 3.9
✗	G54.1+0.3	1.46 ± 0.28	1.21 ± 0.05	0.4 ± 0.8	0.3 ± 4.3

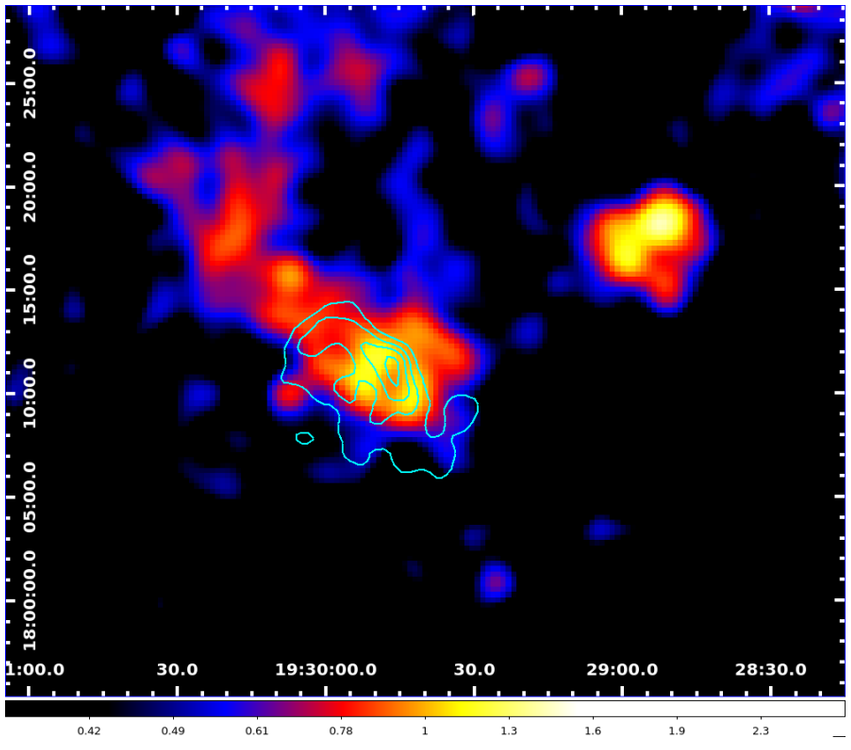
G53.41+0.03



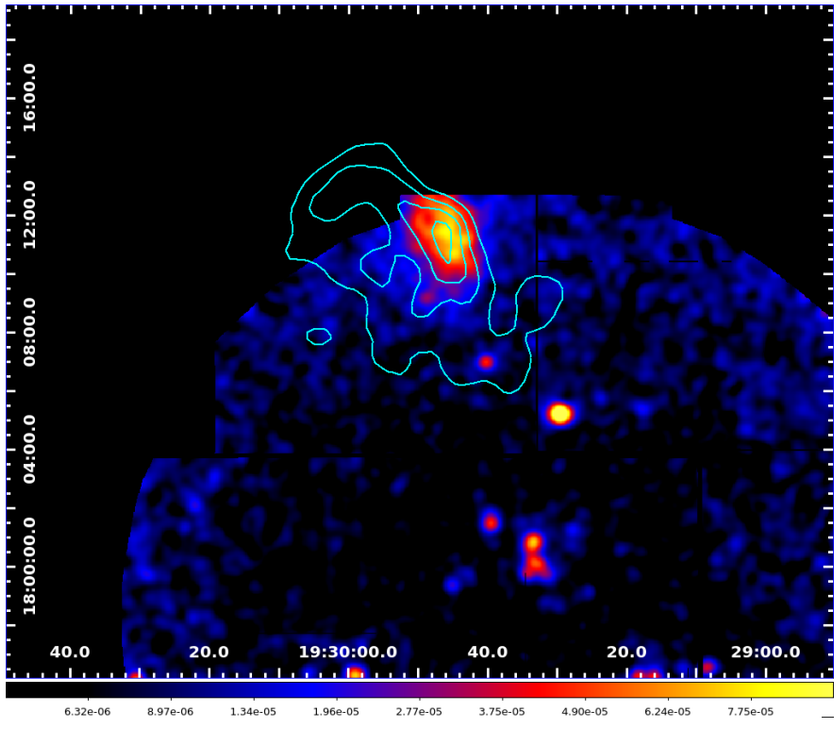
LOFAR 150 MHz



VLA 1.4 GHz



ROSAT 0.2-2.0 keV

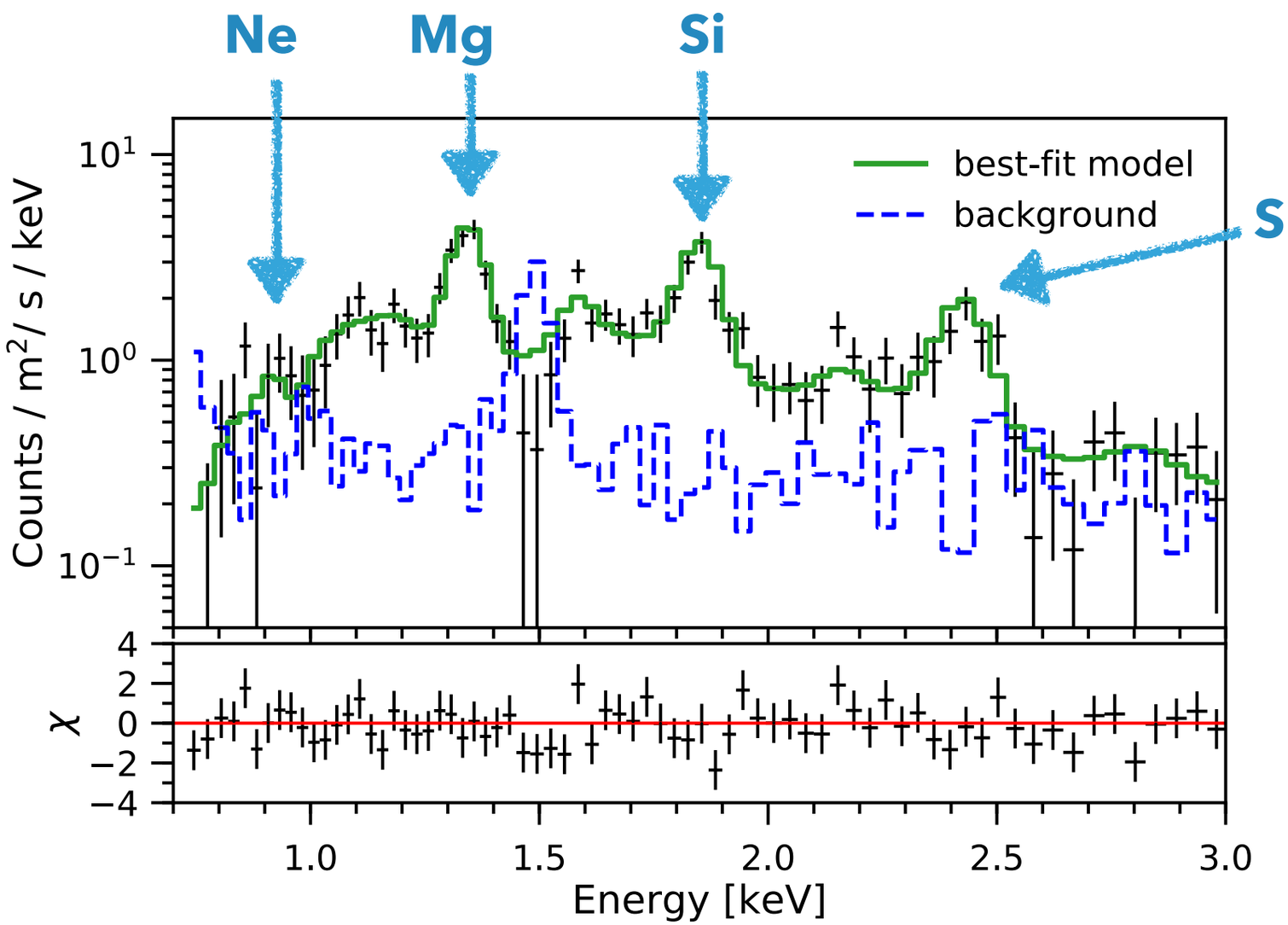


XMM-Newton EPIC-MOS2 0.3-10.0 keV

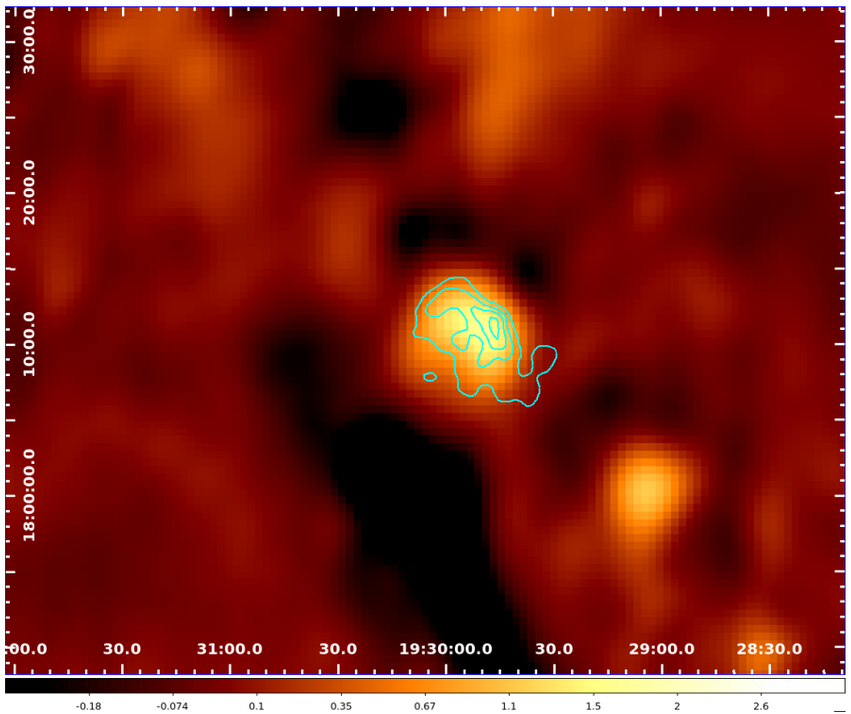
X-RAY ANALYSIS OF G53.41+0.03

- Detected only by MOS2
- Spectrum ~2000 counts
- Several visible emission lines
- Best-fit model - NEI

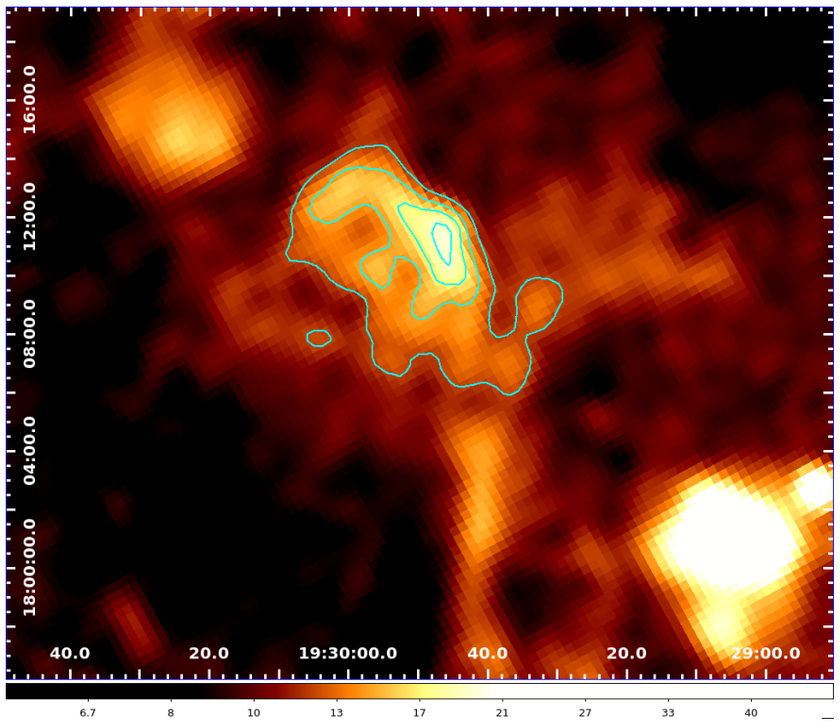
Parameter	Unit	Value	Element	Abundance
N_H	10^{22} cm^{-2}	$2.4^{+0.2}_{-0.2}$	Ne	$0.2^{+0.7}_{-0.2}$
$n_e n_H V$	10^{57} cm^{-3}	5^{+2}_{-2}	Mg	$0.9^{+0.3}_{-0.2}$
T_2	keV	$0.8^{+0.2}_{-0.1}$	Si	$0.5^{+0.1}_{-0.1}$
τ	10^{10} s cm^{-2}	4^{+2}_{-1}	S	$0.9^{+0.2}_{-0.2}$
			Fe	$1.3^{+0.7}_{-0.5}$
			Cstat/d.o.f	83.48/64



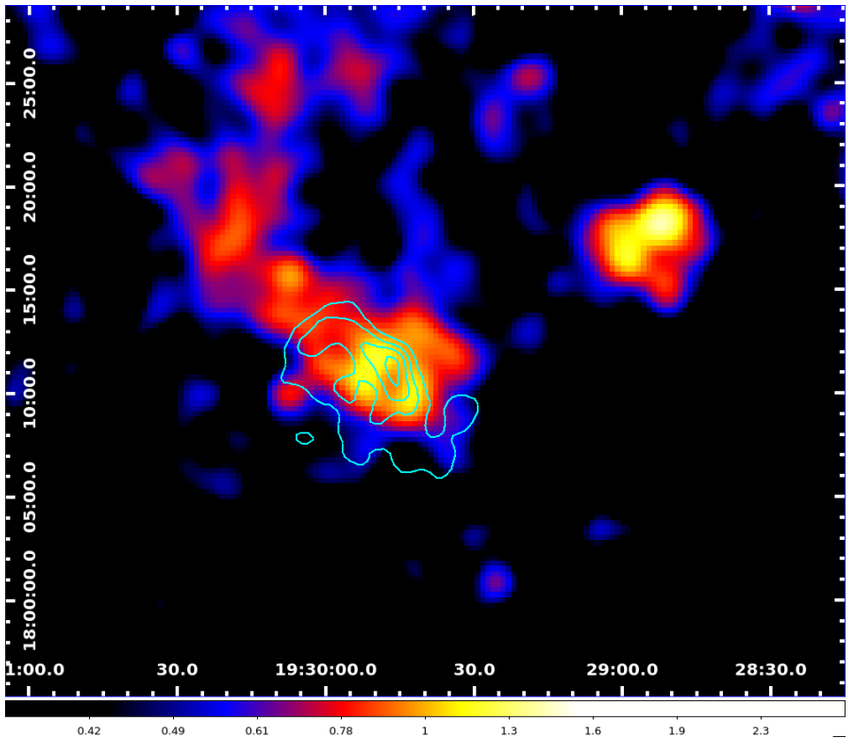
G53.41+0.03



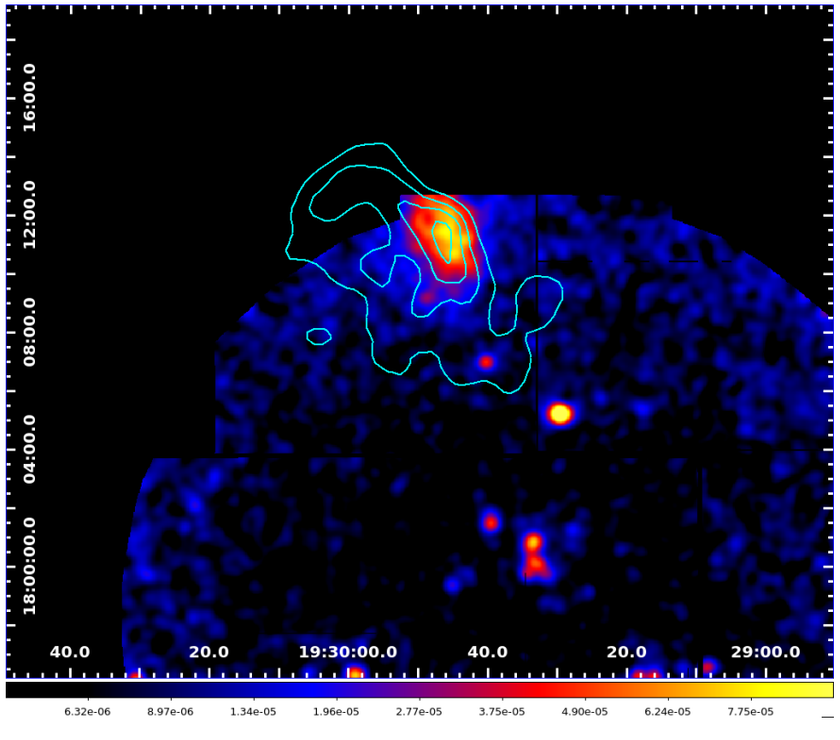
LOFAR 150 MHz



VLA 1.4 GHz



ROSAT 0.2-2.0 keV

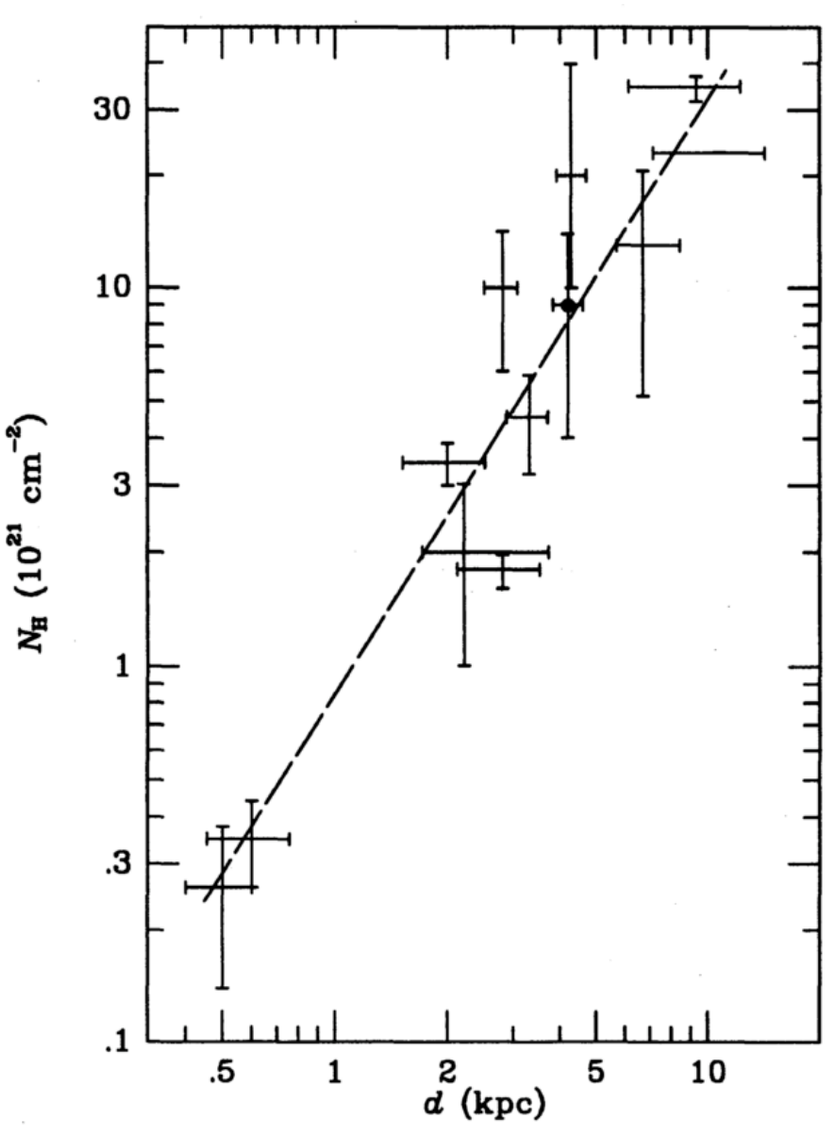


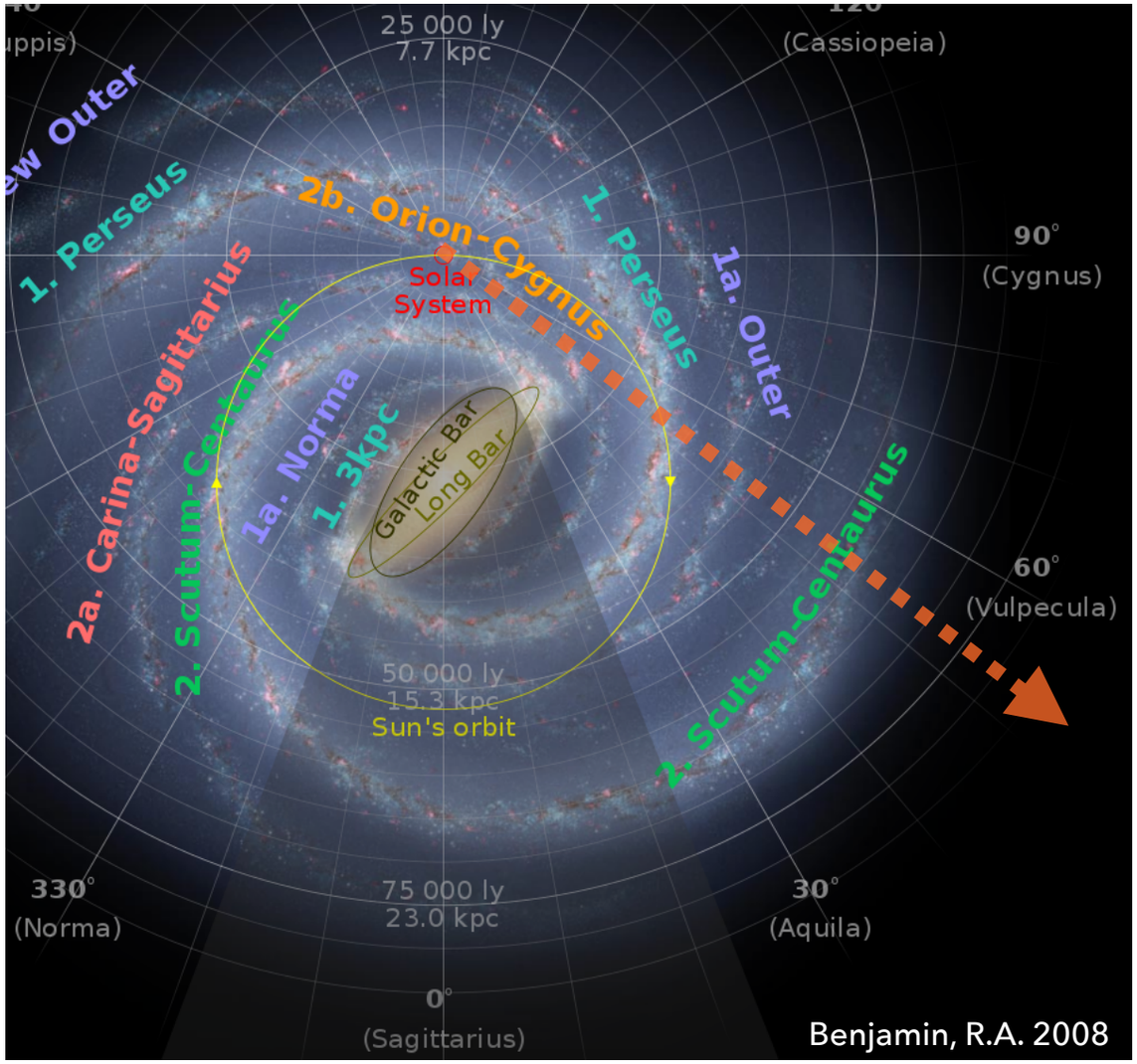
XMM-Newton EPIC-MOS2 0.3-10.0 keV

DISTANCE OF G53.41+0.03

- N_H - Distance relation (Strom 1994): D ~ 8 kpc
- Galactic LoS ℓ=53.4 - Carina-Sagittarius Arm

$$N_{\rm H} = d_{\rm kpc}^{1.58}\, 8.4 \times 10^{20}\ {\rm cm}^{-2}$$





AGE ESTIMATORS

1) Ionisation age $\tau = \mathbf{n_e t}$; => t ≈ 1600 years

$$\tau = 4^{+2}_{-1} \cdot (10^{10}\ \mathrm{cm^{-3}s}) \qquad n_\mathrm{e} = \sqrt{\frac{norm}{1.2 V_x}} \approx 0.8 d_{7.5}^{-3/2}\ \mathrm{cm^{-3}}$$

$$t = \frac{\tau}{n_e} \approx 1600 d_{7.5}^{-3/2}\ \mathrm{years}$$

2) Sedov-Taylor self-similar evolution model

a) Shock Temperature, Radius => t ≈ 5300 years

$$v_s = \sqrt{\frac{kT}{1.2}} \cdot 1000\ [\mathrm{km/s}] \approx 800\ \mathrm{km/s}$$

$$\mathrm{t} = \frac{5}{2} \frac{v_s}{R_{SNR}} \approx 5300 d_{7.5}^{-1}\ \mathrm{years}$$

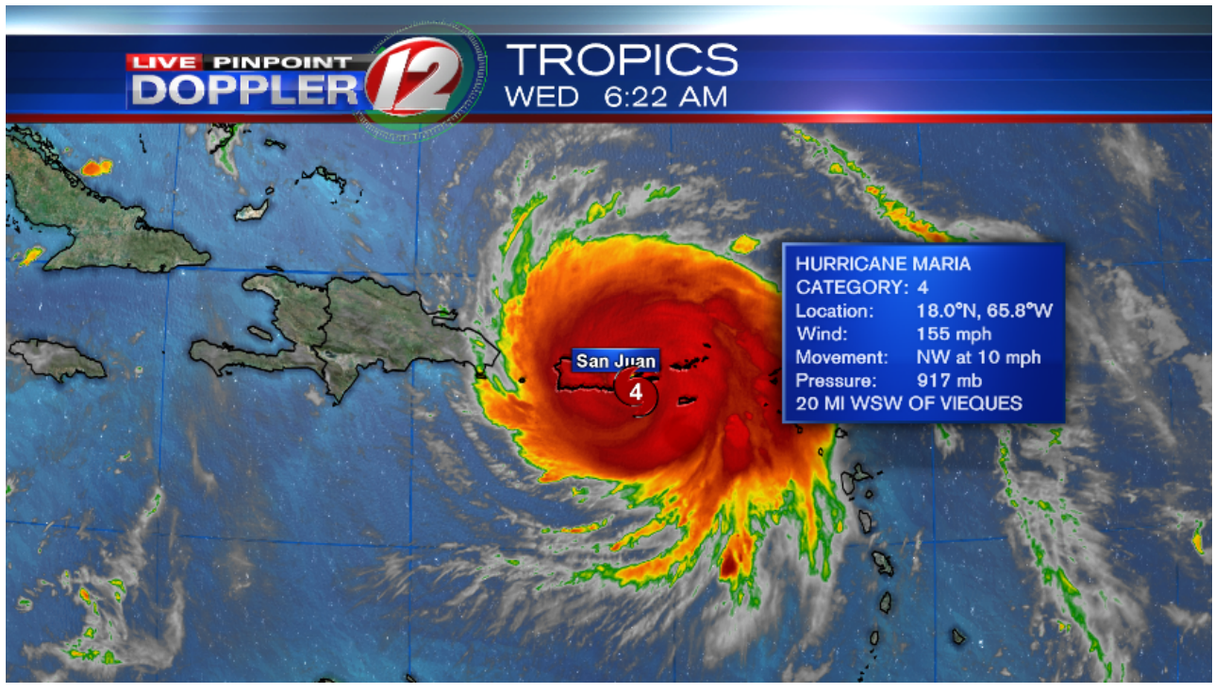
b) SN Energy, Radius => t ≈ 7800 years

$$R^5 = 2.026 \frac{E t^2}{n_H}$$

$$t = 0.7026 \left(\frac{n_H R^5}{E}\right)^{\frac{1}{2}} \approx 7800 d_{7.5}^{5/2}\ \mathrm{years}$$

COMPACT SOURCE SEARCH

- Arecibo analysis delayed by weather
- Non-detection with upper limits
    1. On-centred pulsar: S_{max} = 0.011 mJy
    2. Off-centred pulsar: S_{max} = 0.045 mJy
- X-ray compact source still a possibility



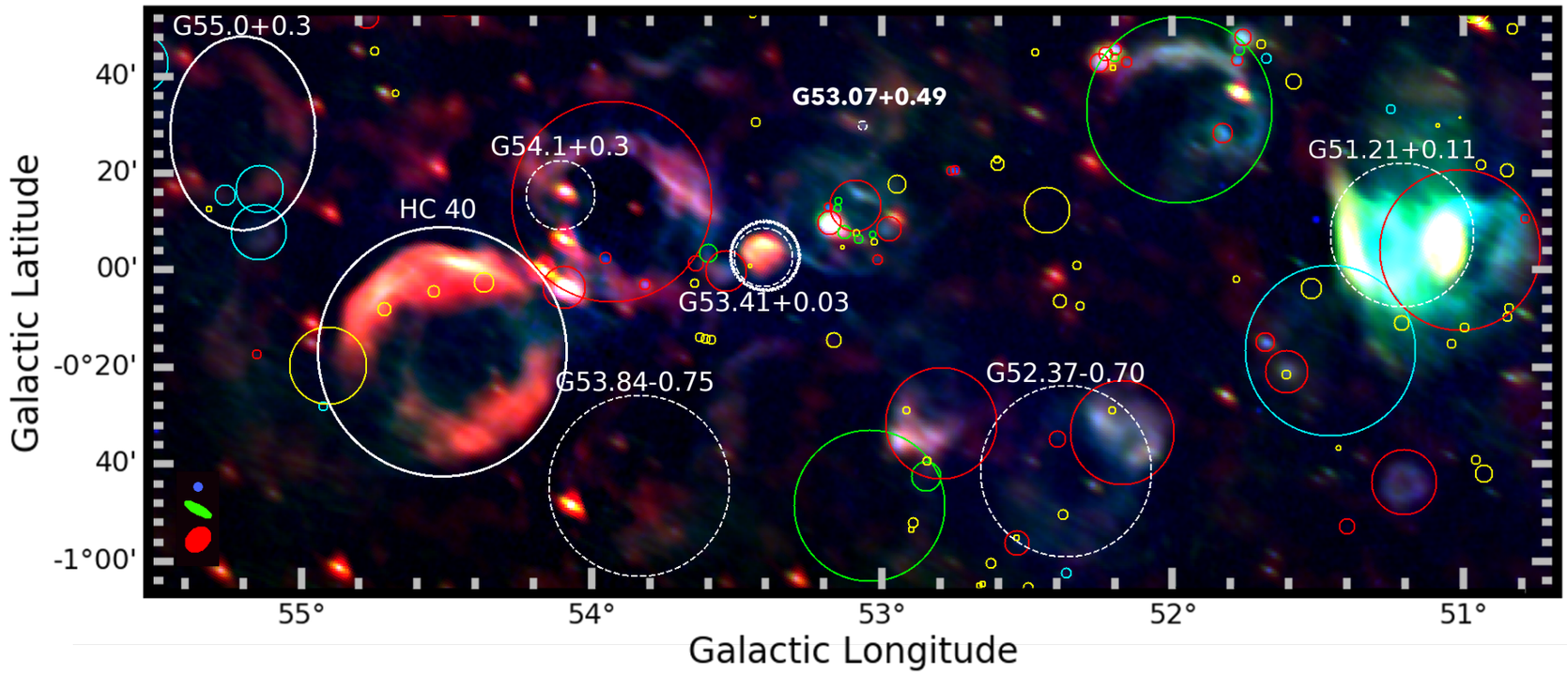
FUTURE

1. Case study - G53.41+0.03
   - Radio
   - X-rays (Chandra, XMM-Newton)
2. Surveys detections
   - Radio - LOFAR
   - X-rays - eRosita

eROSITA

CONCLUSION

- We confirm that G53.41+0.03 is a supernova remnant
  - Deeper centred-on observation needed
- Other SNR candidates in FoV
  - Three candidates unlikely
  - G51.21+0.11 requires further investigation



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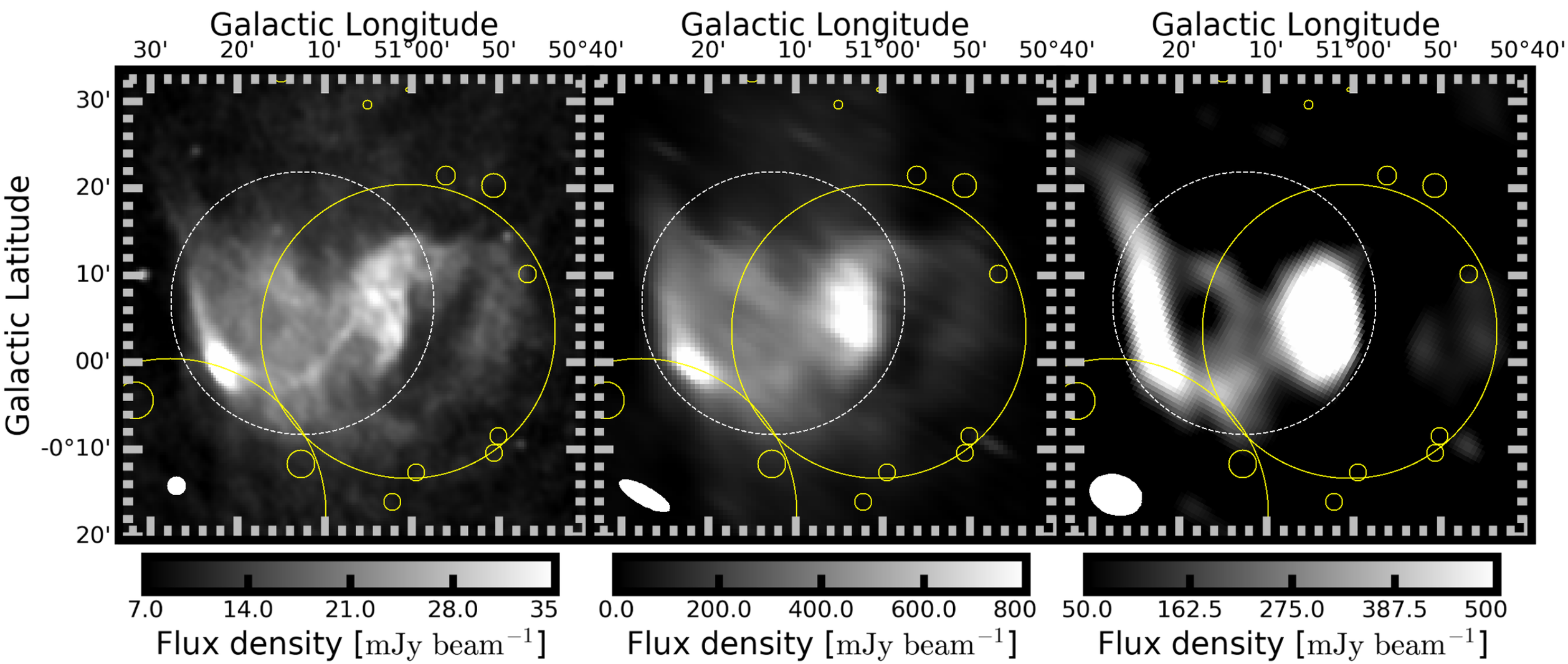
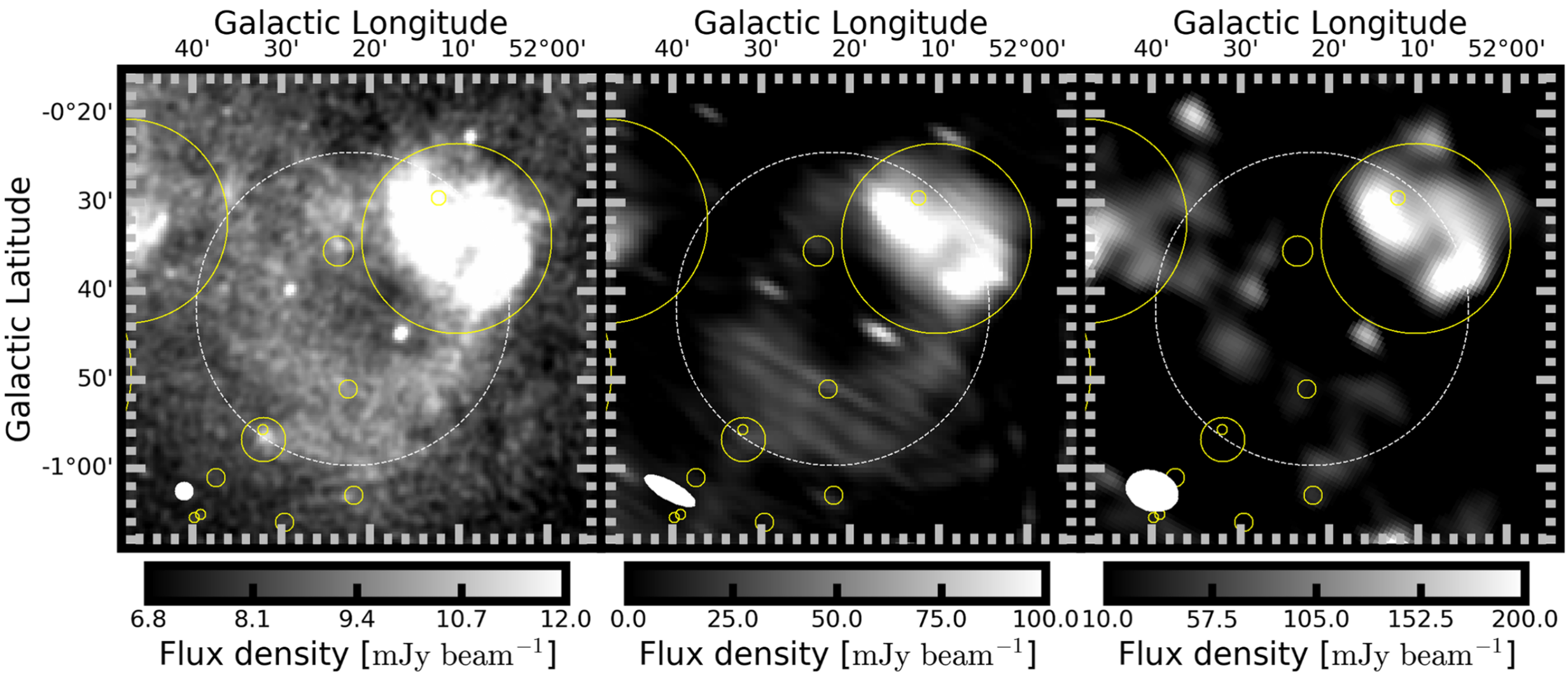
BACKUP SLIDES

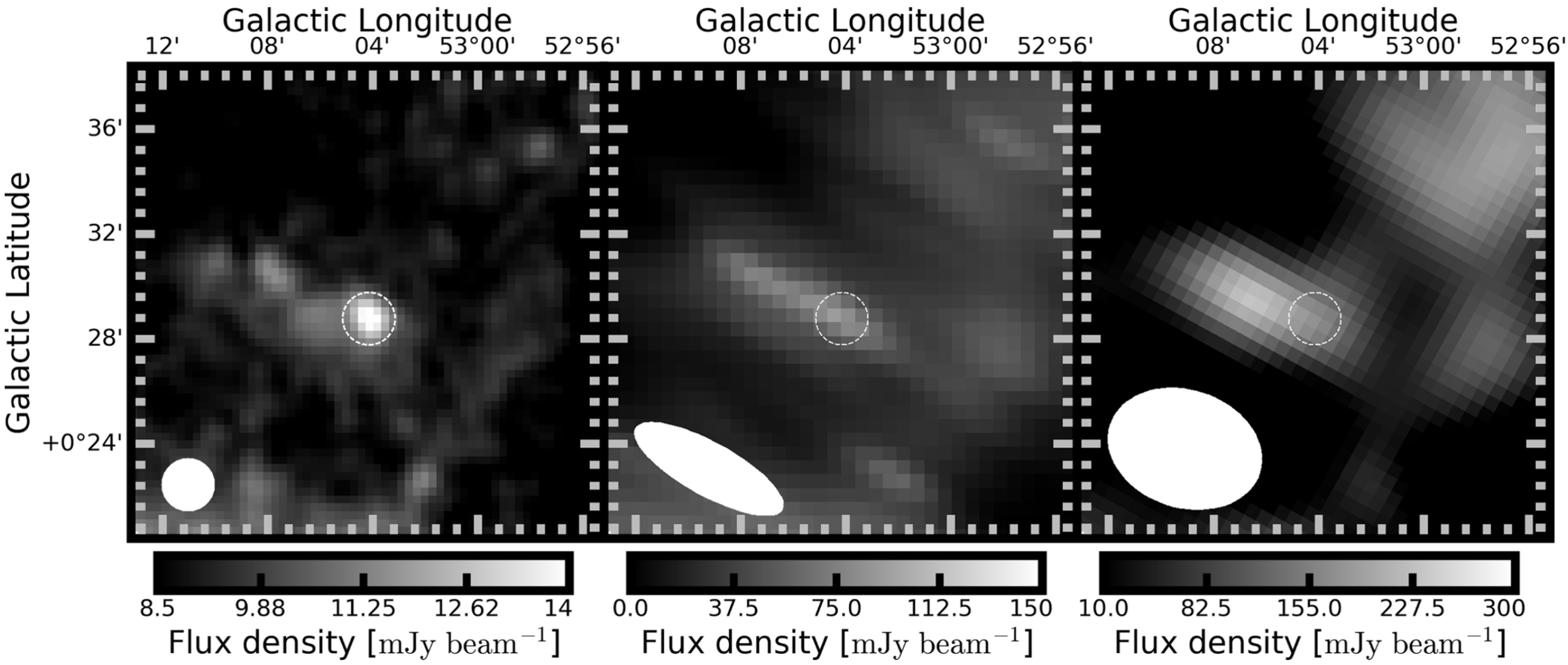
G51.21+0.11


Galactic Longitude
30'
20'
10'
51°00'
50'
50°40'
Galactic Latitude
30'
20'
10'
00'
-0°10'
20'
7.0
14.0
21.0
28.0
35
Flux density [mJy beam^{-1}]
0.0
200.0
400.0
600.0
800
Flux density [mJy beam^{-1}]
50.0
162.5
275.0
387.5
500
Flux density [mJy beam^{-1}]

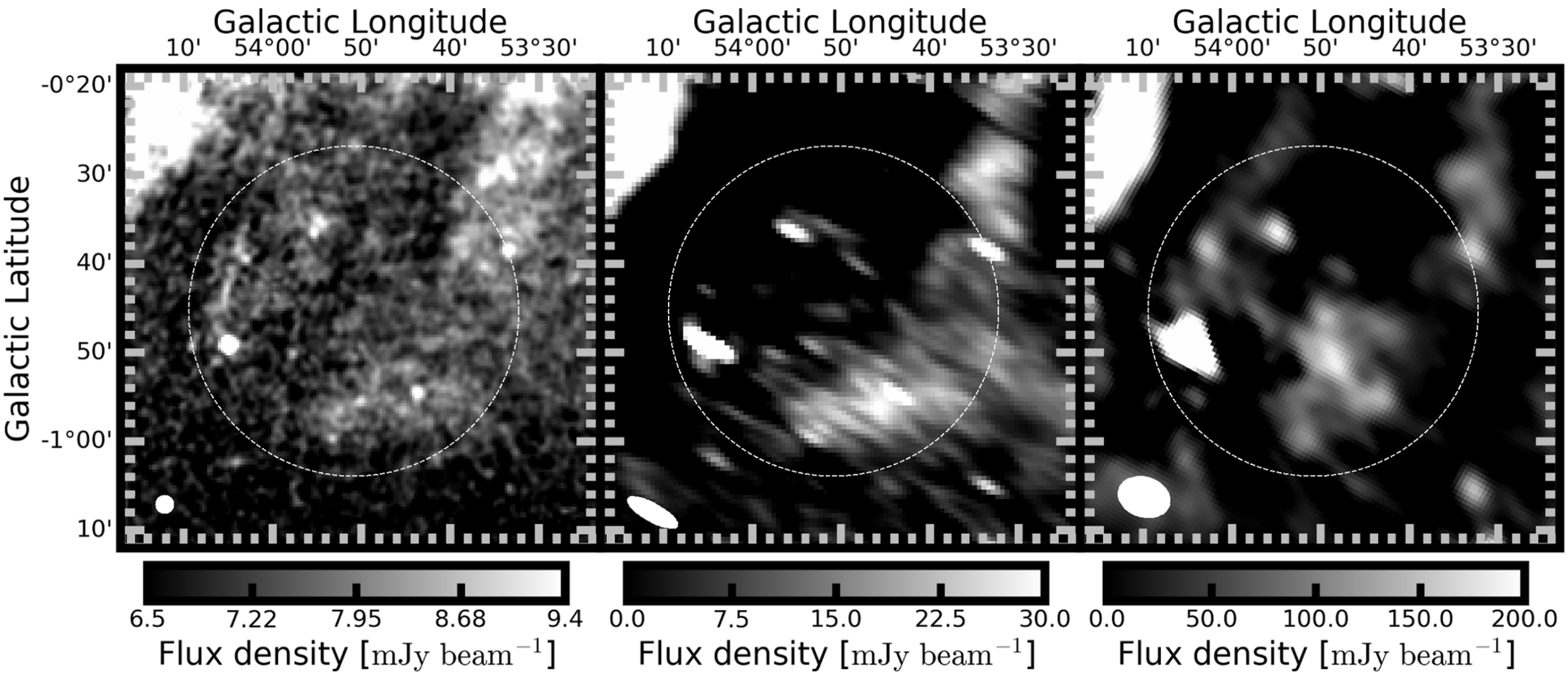
G52.37−0.7


Galactic Longitude
40'
30'
20'
10'
52°00'
Galactic Latitude
-0°20'
30'
40'
50'
-1°00'
6.8
8.1
9.4
10.7
12.0
Flux density [mJy beam^{-1}]
0.0
25.0
50.0
75.0
100.0
10.0
57.5
105.0
152.5
200.0

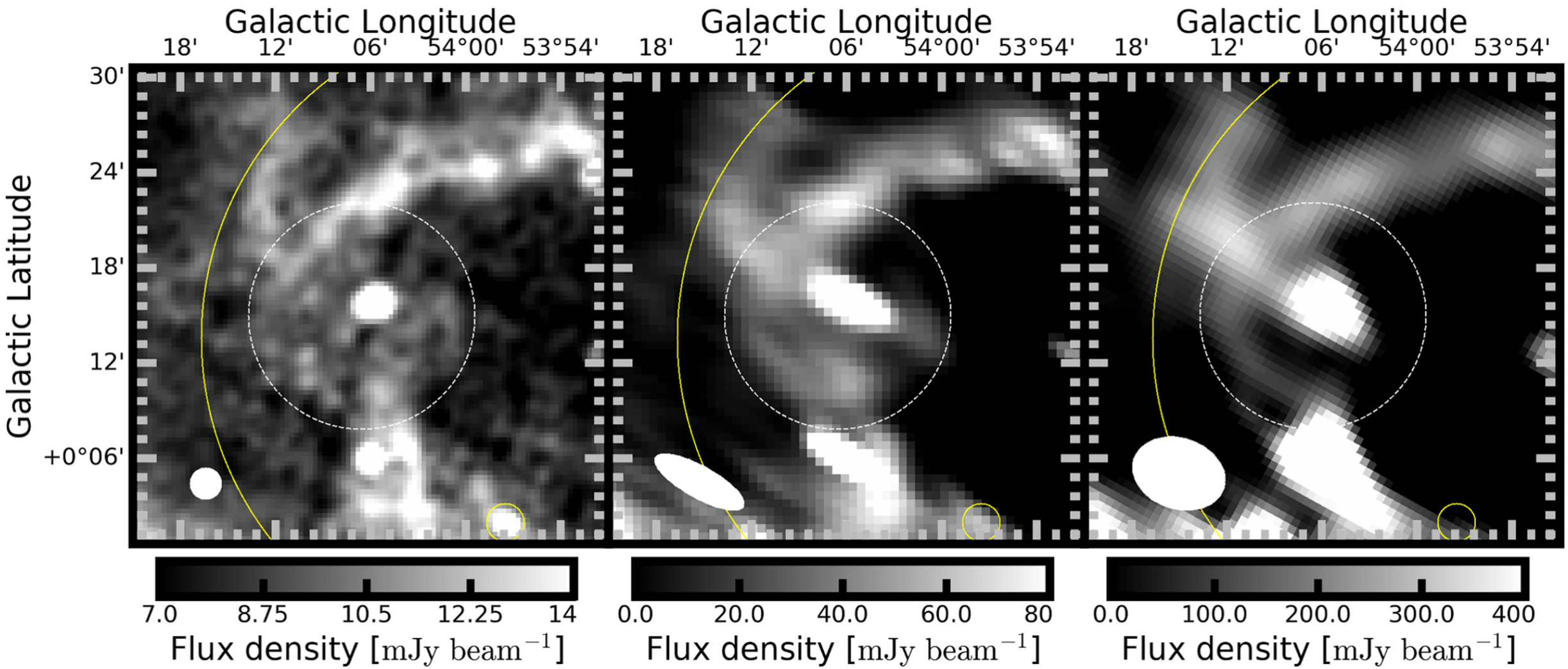
G53.07+0.49


Galactic Longitude
12'
08'
04'
53°00'
52°56'
Galactic Latitude
36'
32'
28'
+0°24'
8.5
9.88
11.25
12.62
14
Flux density [mJy beam^{-1}]
Galactic Longitude
08'
04'
53°00'
52°56'
0.0
37.5
75.0
112.5
150
Flux density [mJy beam^{-1}]
Galactic Longitude
08'
04'
53°00'
52°56'
10.0
82.5
155.0
227.5
300
Flux density [mJy beam^{-1}]

G53.84−0.75


Galactic Longitude
10' 54°00' 50' 40' 53°30'
Galactic Latitude
-0°20'
30'
40'
50'
-1°00'
10'
6.5 7.22 7.95 8.68 9.4
Flux density [mJy beam^{-1}]
0.0 7.5 15.0 22.5 30.0
Flux density [mJy beam^{-1}]
0.0 50.0 100.0 150.0 200.0
Flux density [mJy beam^{-1}]

G54.1+0.3


Galactic Longitude
18'
12'
06'
54°00'
53°54'
Galactic Latitude
30'
24'
18'
12'
+0°06'
7.0
8.75
10.5
12.25
14
Flux density [mJy beam^{-1}]
0.0
20.0
40.0
60.0
80
Flux density [mJy beam^{-1}]
0.0
100.0
200.0
300.0
400
Flux density [mJy beam^{-1}]