27 new SNRs found with the Murchison Widefield Array

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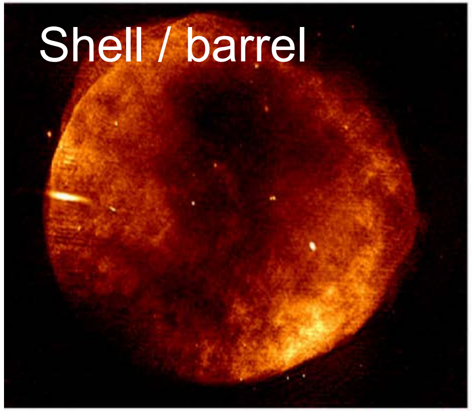
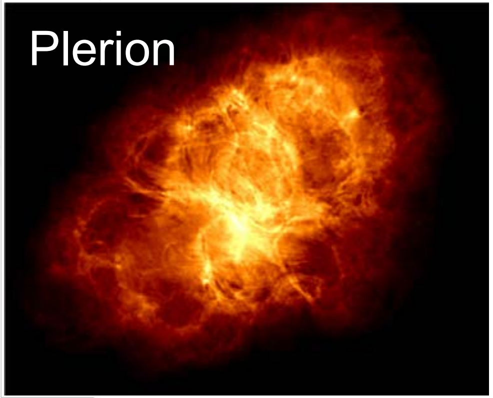
Department of the Premier and Cabinet
Office of Science

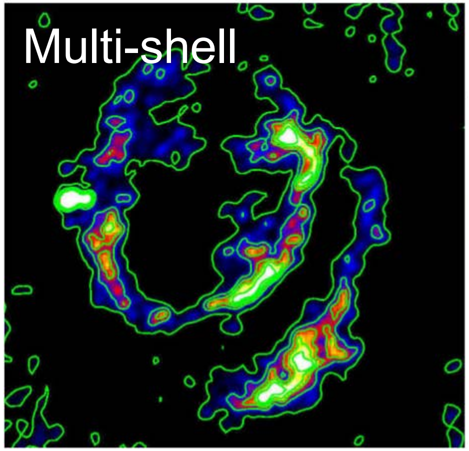
@ColourfulCosmos

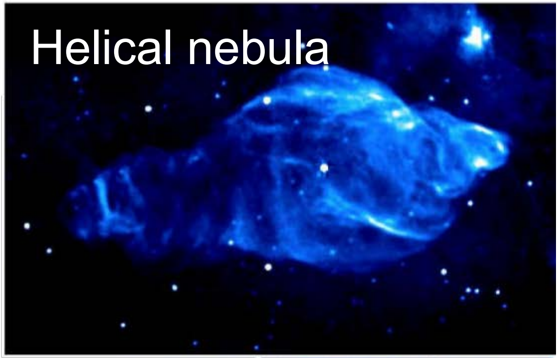
Radio SNR





- 295 known (Green 2017)
- Expect 3x more
  (from O,B star counts, SN rates in Local Group, predicted synch lifetimes)

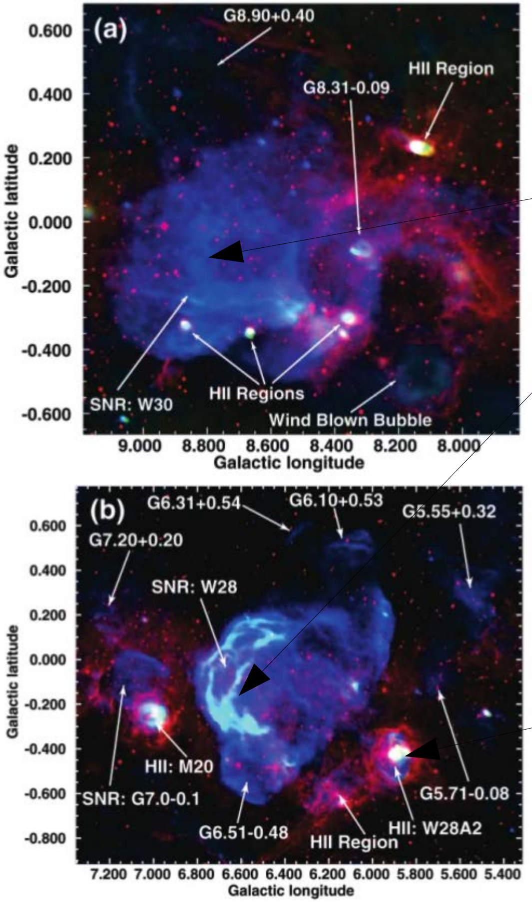




Dubner & Giacani 2015

- 95% of SNR detected via radio
- Selection effects?
  - Resolution
  - Field-of-view / survey speed
  - Surface brightness sensitivity
  - Quality of ancillary IR data
  - Frequency of search
  - Bandwidth of search

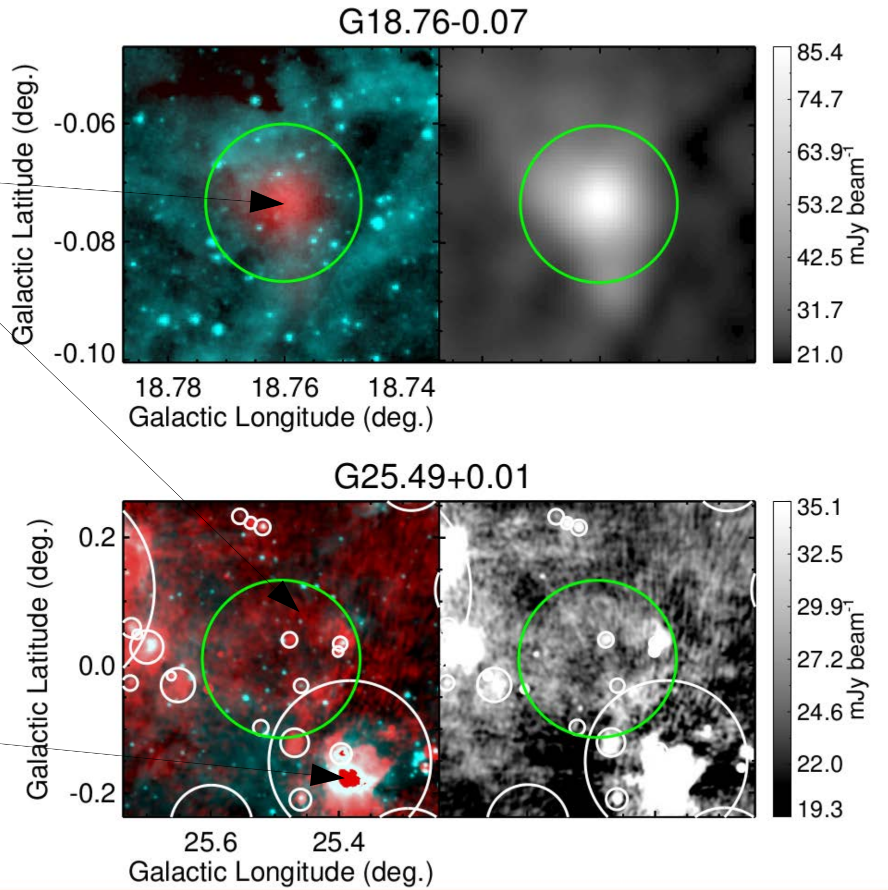
Detecting radio supernova remnants



Brogan et al. (2006)

Non-thermal:
Radio emission

Thermal:
Radio+ infrared emission



Anderson et al. (2017)

GaLactic and Extragalactic All-sky MWA survey

Dec < 30º, 72 – 231 MHz, resolution ~ 2’, via 4 weeks with MWA 128T

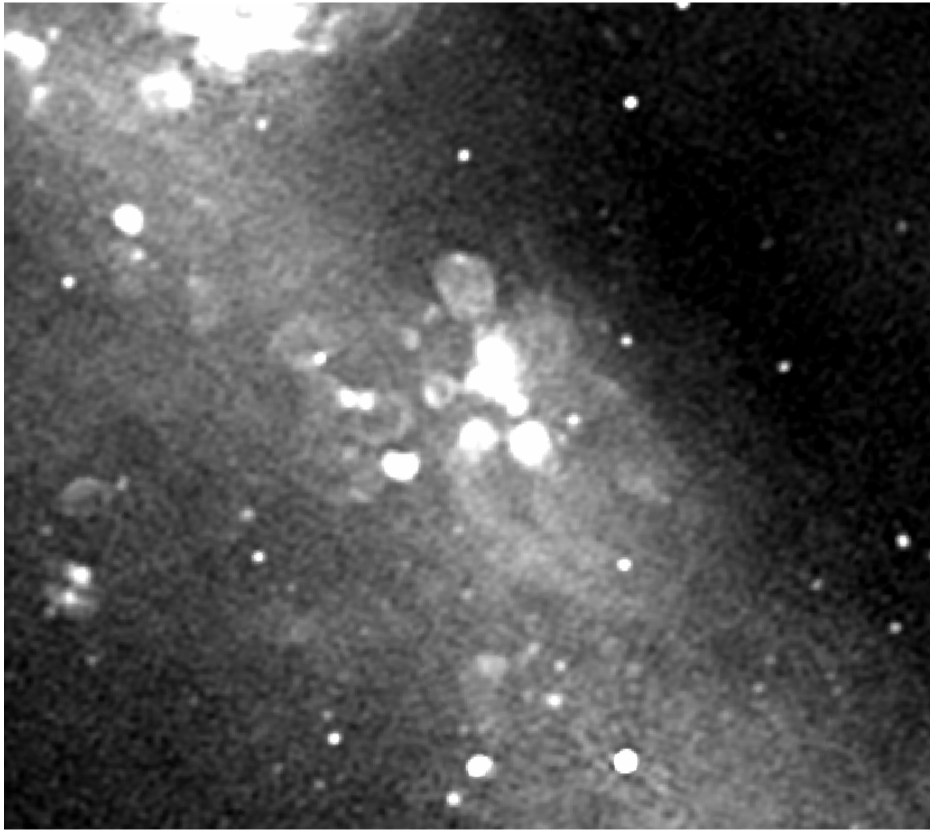
Publication highlights

- Riseley et al. 2018: The POlarised GLEAM Survey (POGS) I: First Results from a Low-Frequency Radio Linear Polarisation Survey of the Southern Sky
- For et al. 2018: A multifrequency radio continuum study of the Magellanic Clouds - I. Overall structure and star formation rates
- Su et al. 2018: Galactic synchrotron distribution derived from 152 H II region absorption features in the full GLEAM survey
- Galvin et al. 2018: The spectral energy distribution of powerful starburst galaxies - I. Modelling the radio continuum
- Callingham et al 2017: Extragalactic Peaked-spectrum Radio Sources at Low Frequencies
- George et al. 2017: A study of halo and relic radio emission in merging clusters using the Murchison Widefield Array
- Kapinska et al. 2017: Spectral Energy Distribution and Radio Halo of NGC 253 at Low Radio Frequencies
- Murphy et al. 2017: Low-Frequency Spectral Energy Distributions of Radio Pulsars Detected with the Murchison Widefield Array
- Murphy et al. 2017: A search for long-time-scale, low-frequency radio transients
- Su et al. 2017: Galactic synchrotron emissivity measurements between 250° < l < 355° from the GLEAM survey with the MWA
- Hurley-Walker et al. 2017: GaLactic and Extragalactic All-sky Murchison Widefield Array (GLEAM) survey - I. A low-frequency extragalactic catalogue
- Callingham et al. 2016: Low radio frequency observations and spectral modelling of the remnant of Supernova 1987A
- Lenc et al. 2016: Low-frequency Observations of Linearly Polarized Structures in the Interstellar Medium near the South Galactic Pole
- Hindson et al 2016: A Large-Scale, Low-Frequency Murchison Widefield Array Survey of Galactic H ii Regions between 260 < l < 340
- Wayth et al. 2015: GLEAM: The GaLactic and Extragalactic All-Sky MWA Survey

GLEAM data

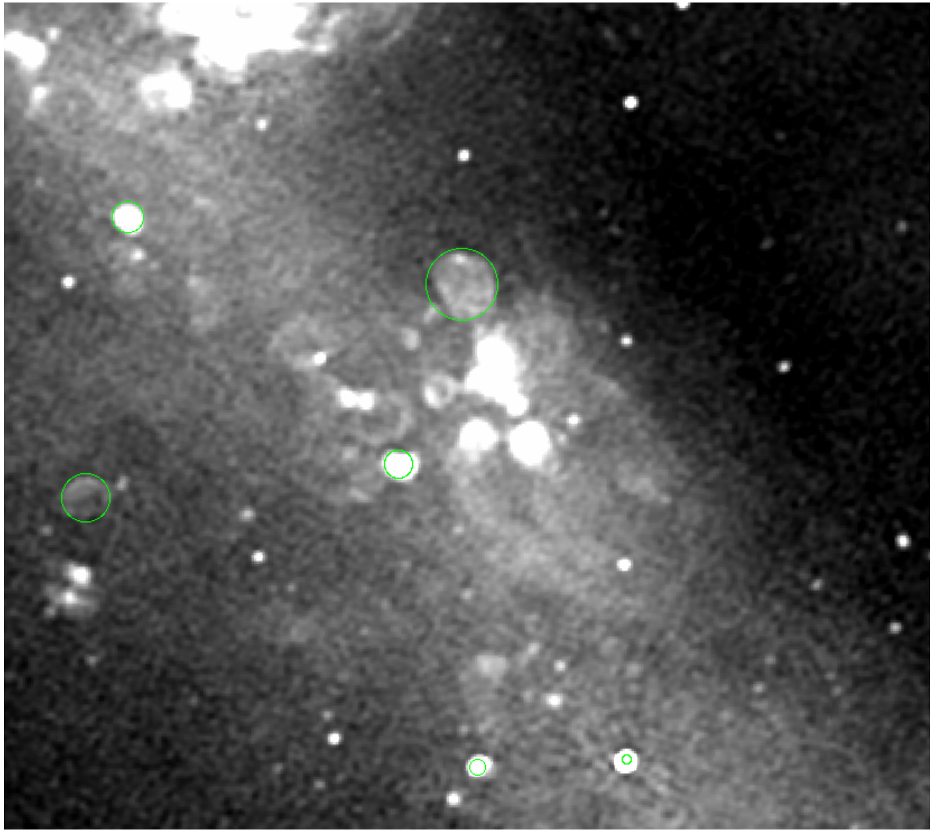
- Obtain via: **gleam-vo.icrar.org** or SkyView
- 8-MHz sub-bands from 72 – 231 MHz
- Wideband 30 – 60 MHz images (shown below)
- Flux calibration accuracy ~ 8%
- Extragalactic catalogue of 300k sources
- Multiscale cleaning of Galactic Plane: data release in July

The GLEAM view of SNRs



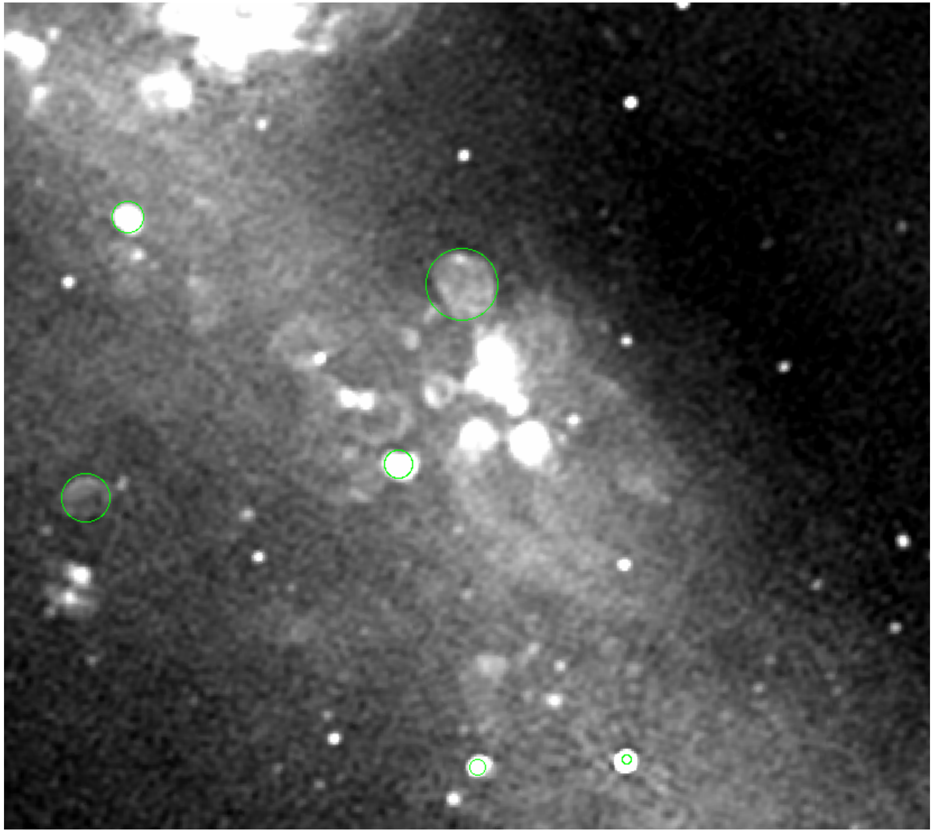
GLEAM 200MHz

The GLEAM view of SNRs

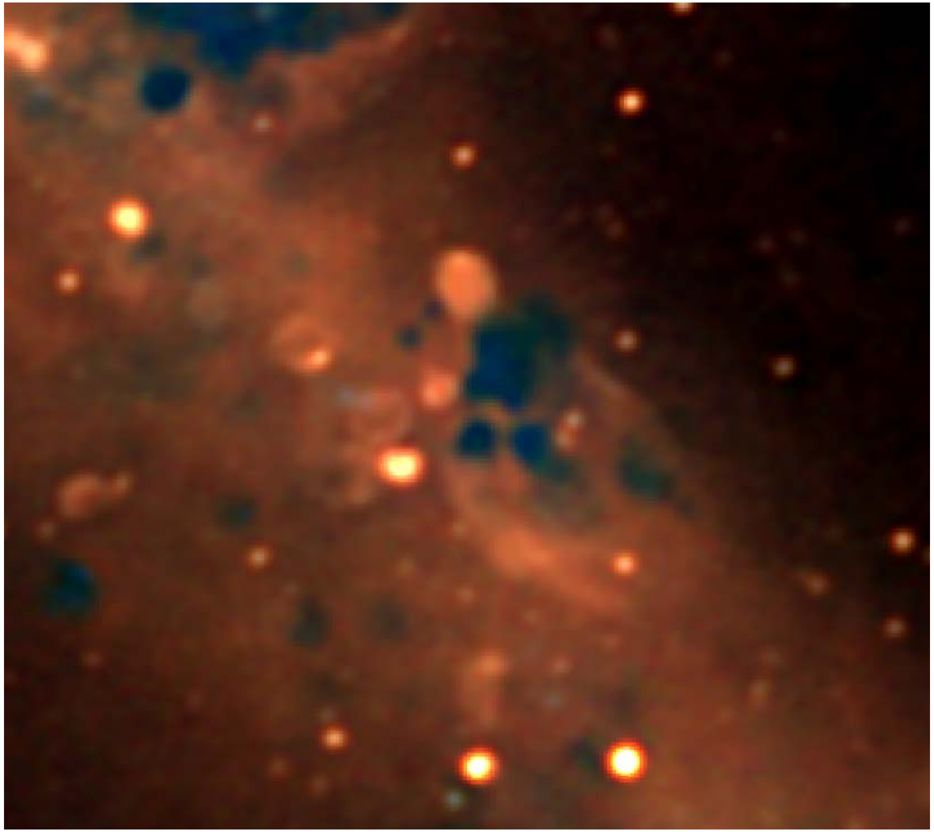


GLEAM 200MHz

The GLEAM view of SNRs

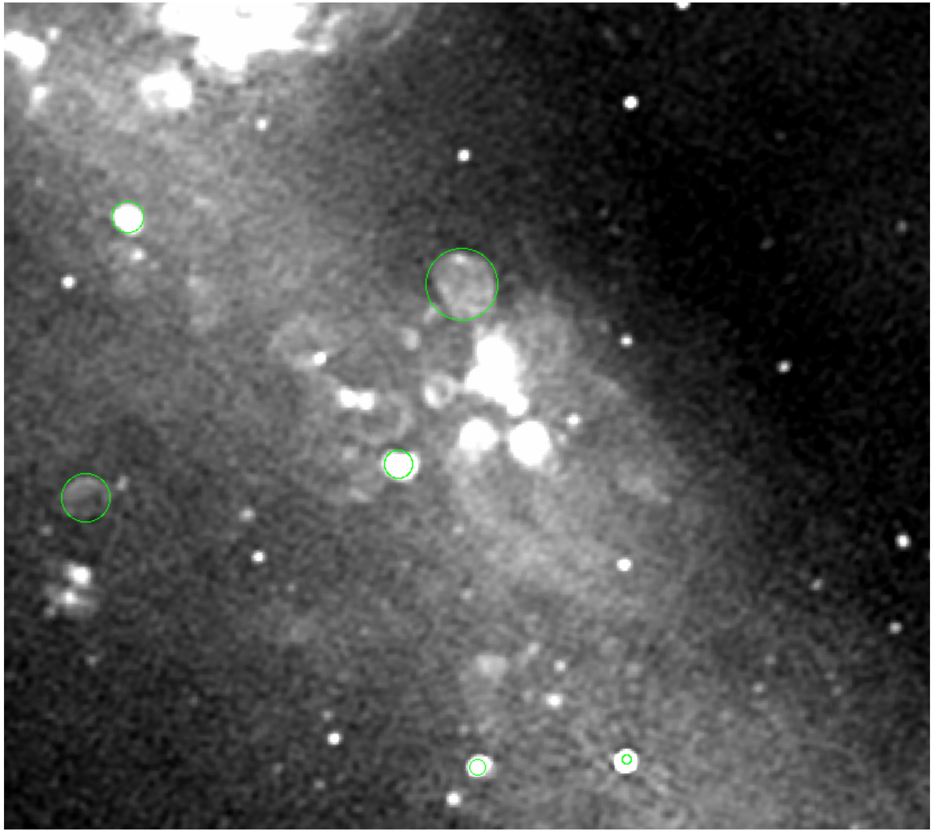


GLEAM 200MHz

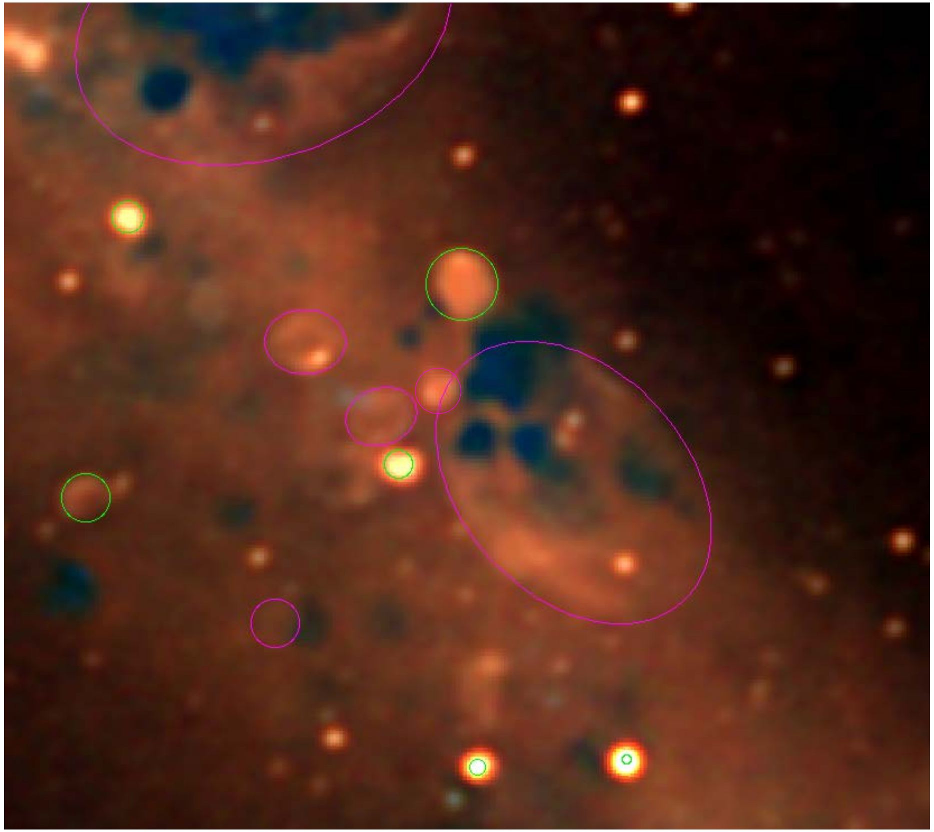


GLEAM RGB (88/118/154)MHz

The GLEAM view of SNRs

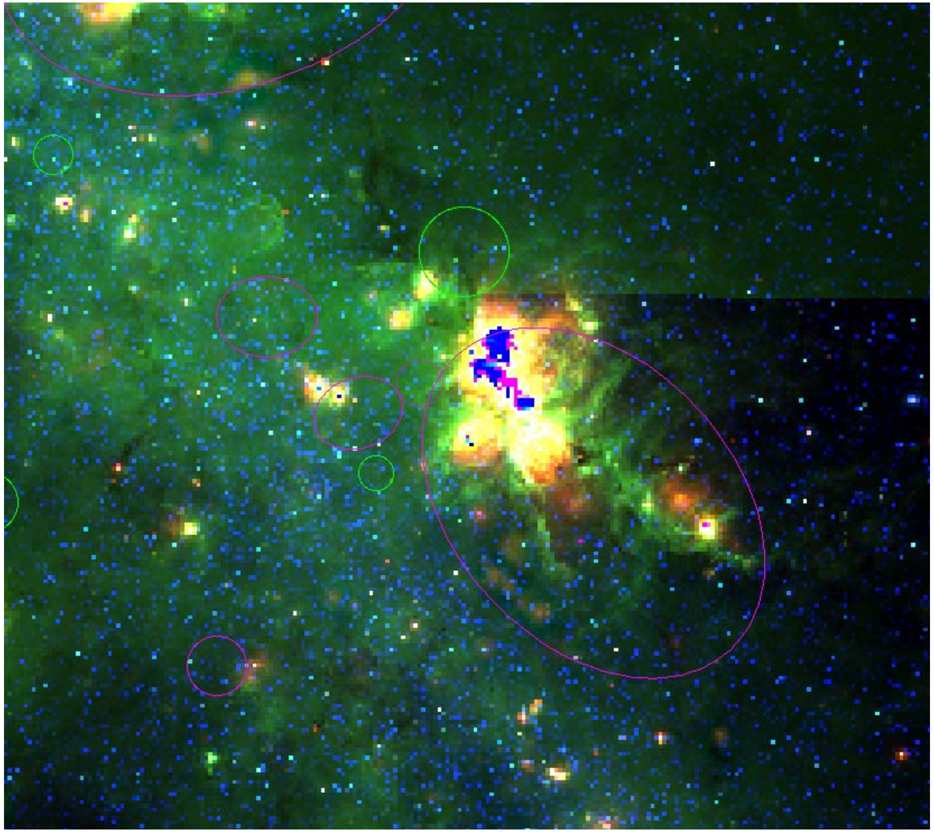


GLEAM 200MHz

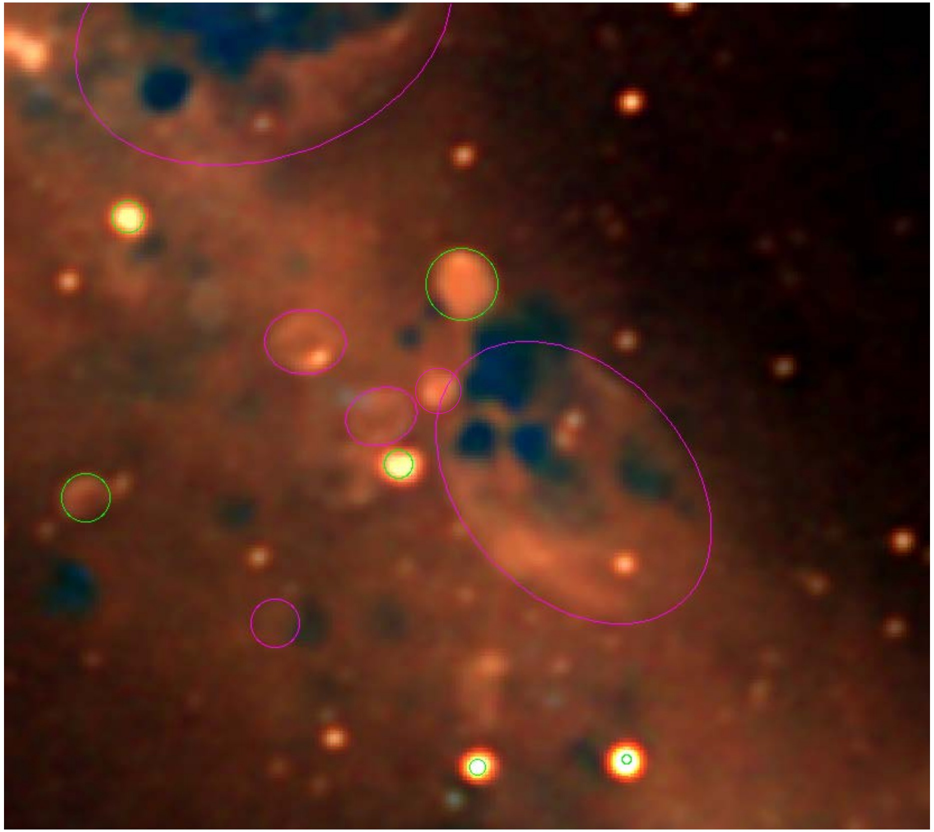


GLEAM RGB (88/118/154)MHz

The GLEAM (and WISE) view of SNRs

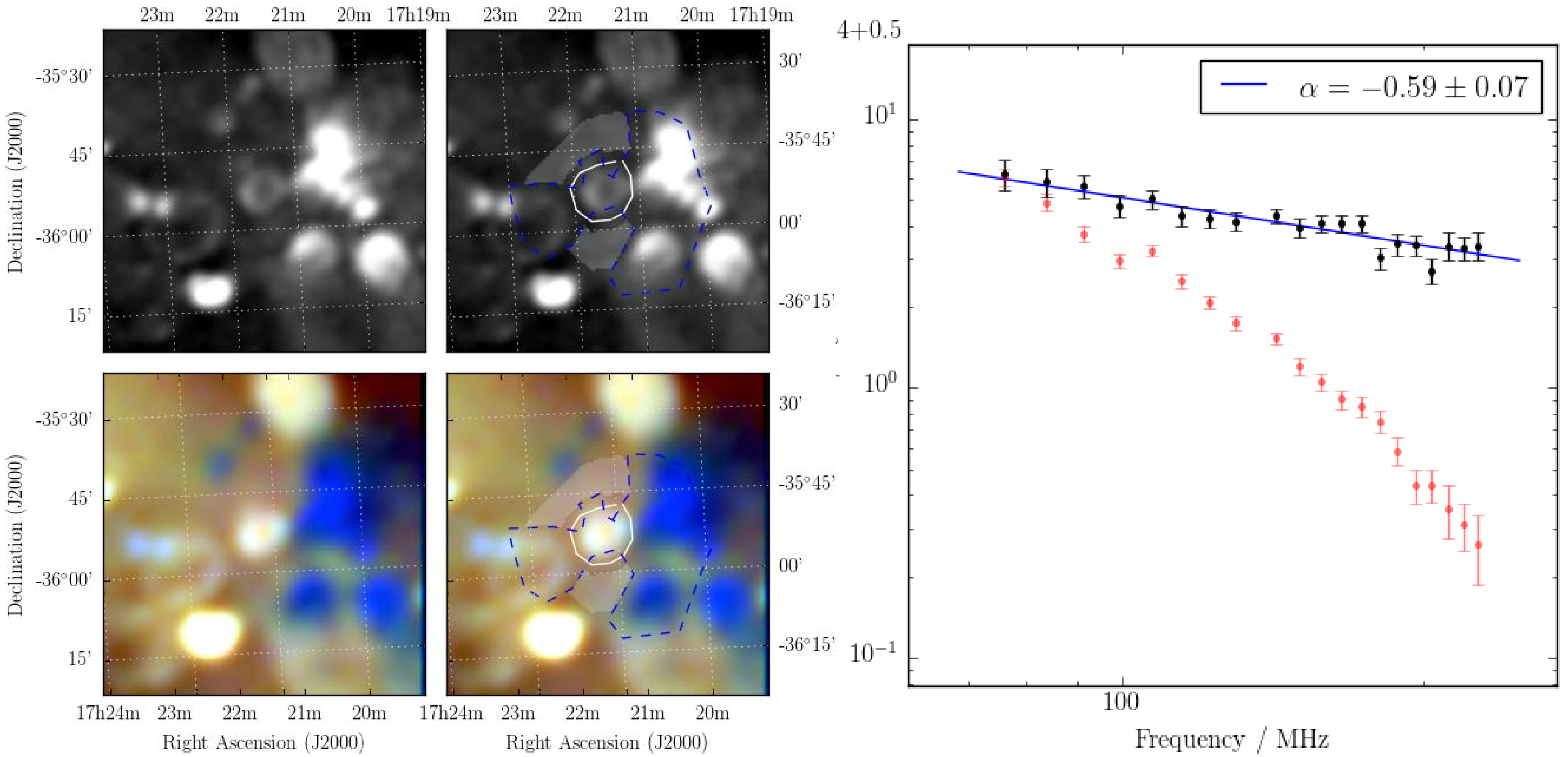


Widefield Infrared Survey Explorer (WISE) RGB (4.6/12/22)μm

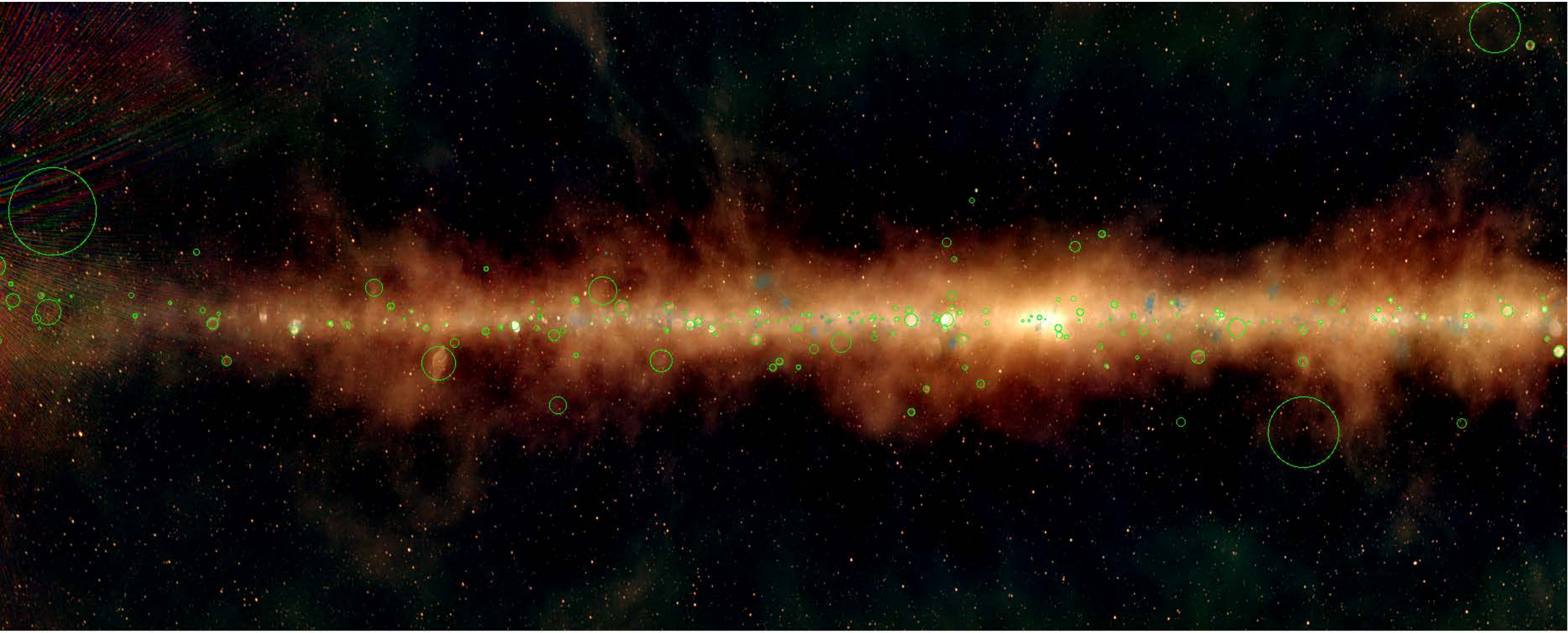


22μm emission = thermal small dust grains
12μm emission = PAHs fluorescing from UV

Measuring SNRs



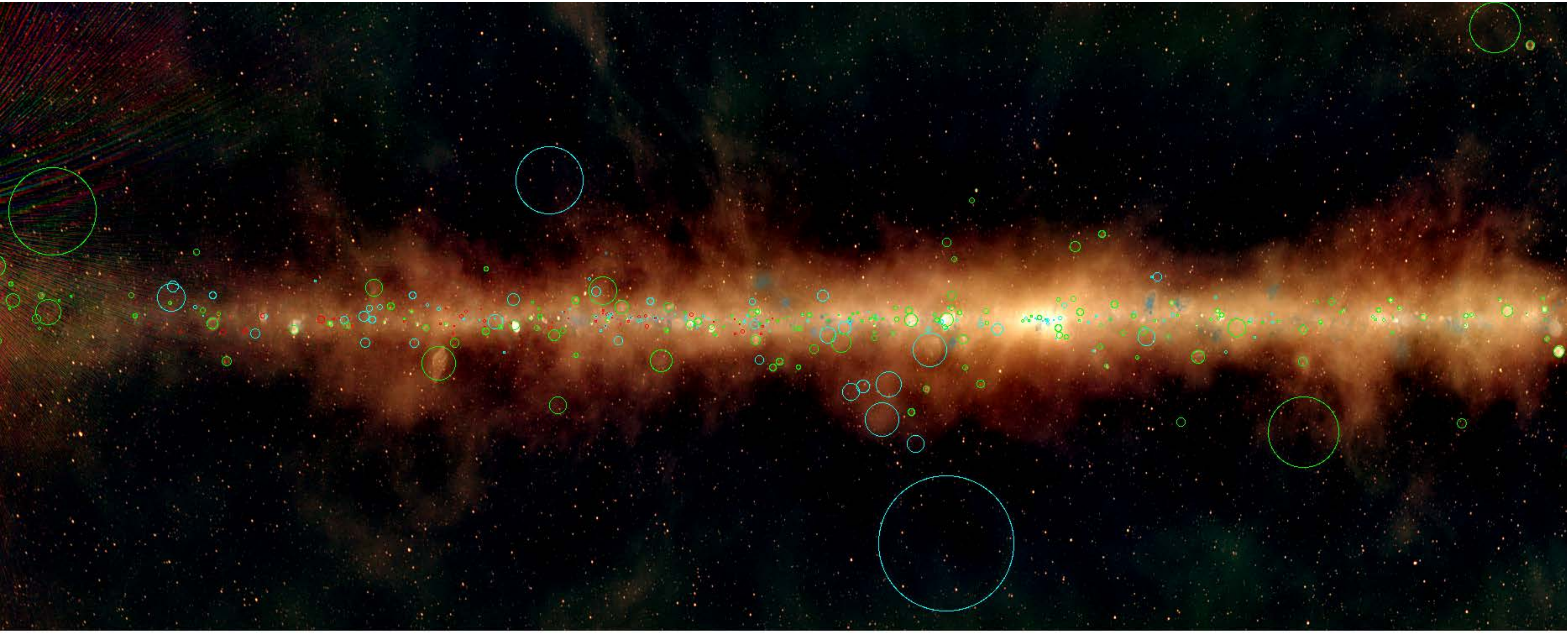
Known SNRs (green)



345° < *l* < 60°

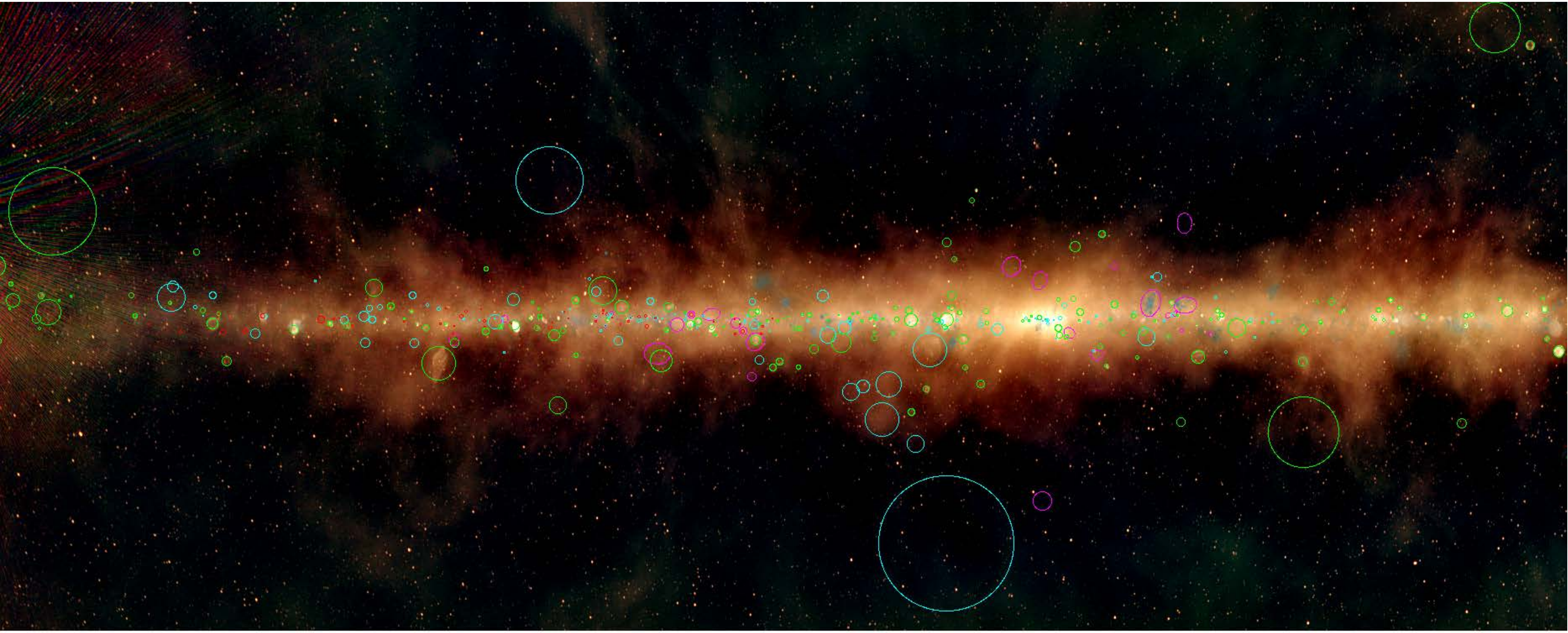
Known SNRs (green), known candidates (cyan), THOR candidates (red)

The **HI**/**O**H/**R**RL survey (Anderson+2017)



345° < *l* < 60°

Known SNRs (green), known candidates (cyan), THOR candidates (red), new candidates (magenta)



345° < *l* < 60°

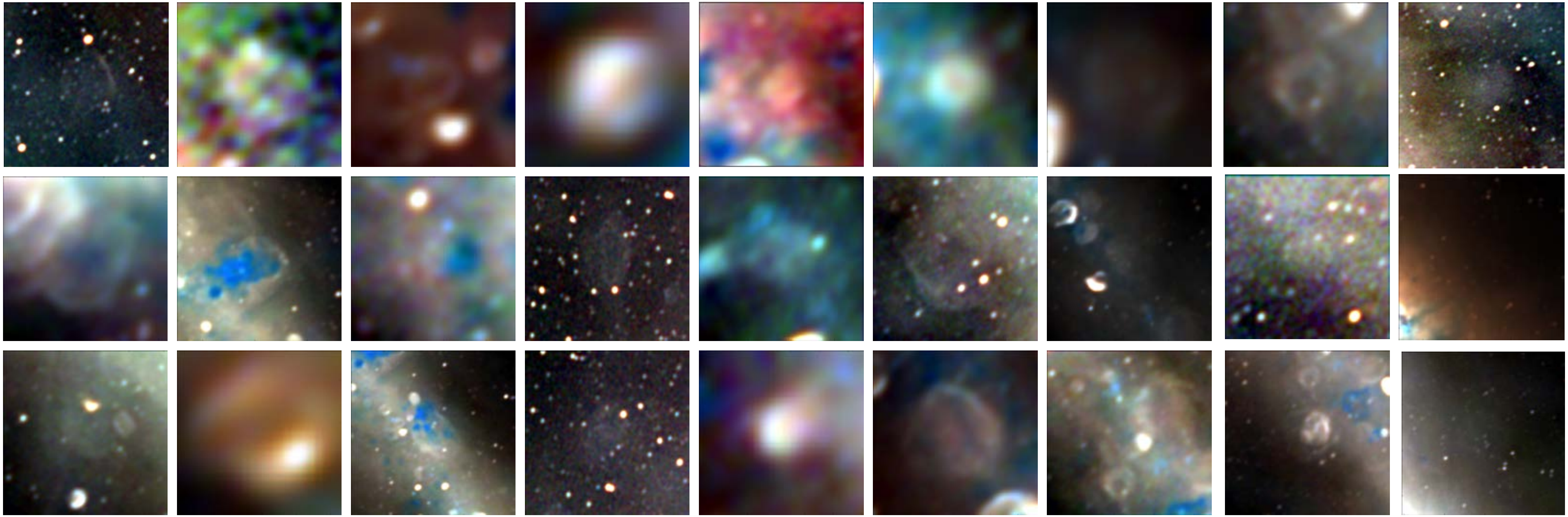
Known SNRs (green), known candidates (cyan), THOR candidates (red), new candidates (magenta)

180° < *l* < 240°

27 new candidate SNRs

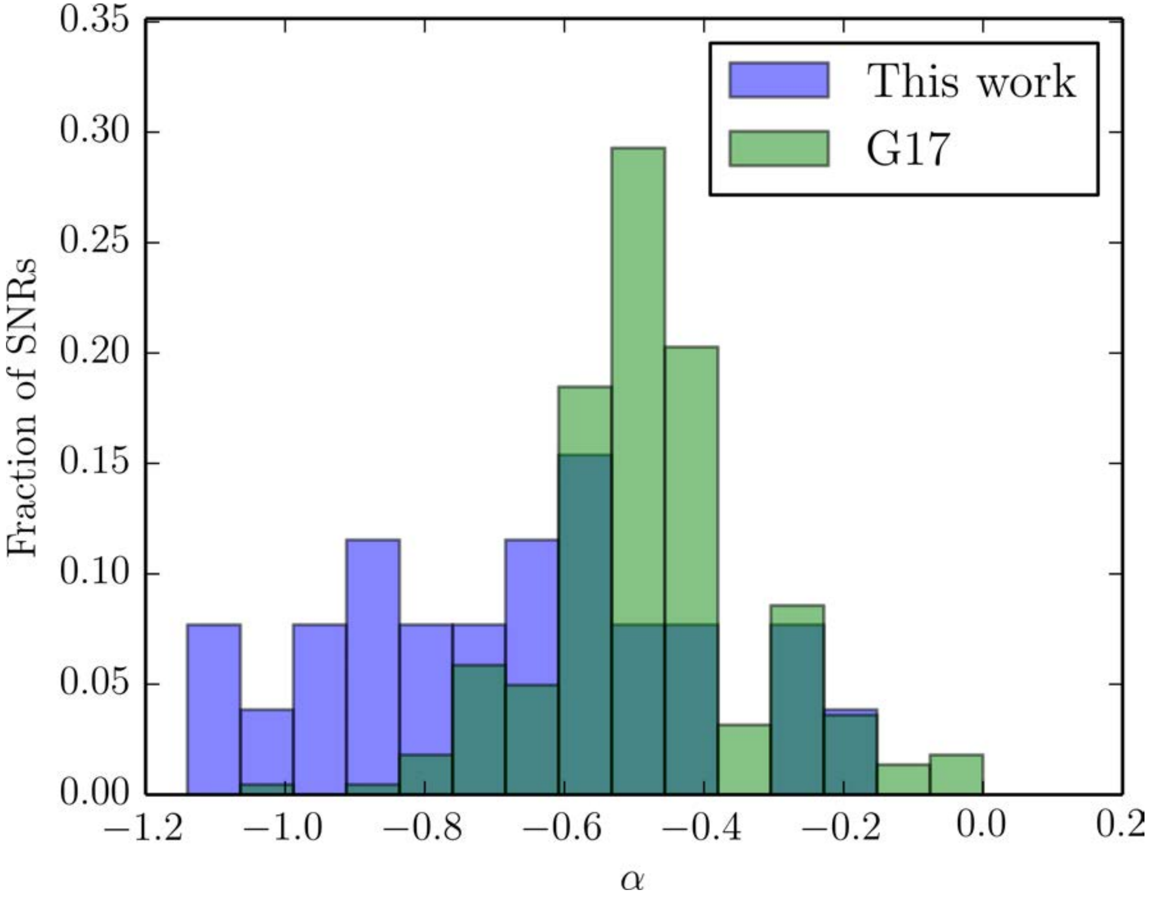
Name	RA (J2000)	Dec (J2000)	a ′	b ′	PA °	S_{200MHz} Jy	α	Ancillary data	Morphology	Class
1	2	3	4	5	6	7	8	9	10	
G 0.2-9.7	18 25 50	-33 30	66	66	0	2.3 ± 0.2	-1.1 ± 0.1	–	Filled & partial shell	II
G 2.2+2.8	17 40 10	-25 39	72	62	0	9 ± 1	-0.19 ± 0.06	E11	Shell?	II
G 7.4+0.3	18 01 06	-22 21	18	14	90	2.3 ± 0.3	-0.8 ± 0.2	–	Shell	II
G 18.9-1.3	18 30 04	-13 00	68	60	355	9.0 ± 0.8	-1.1 ± 0.2	–	Shell	I
G 19.2-3.1	18 37 19	-13 41	32	32	0	2.4 ± 0.3	-0.6 ± 0.2	E11	Shell	I
G 19.7-0.7	18 29 35	-12 03	28	28	0	7.0 ± 0.3	-0.24 ± 0.05	E11	Shell	I
G 20.2-0.3	18 28 47	-11 27	38	38	0	–	–	–	Partial shell	III
G 21.8+0.2	18 30 15	-09 47	64	42	320	37 ± 1	-0.61 ± 0.05	E11	Filled	I
G 23.1+0.2	18 32 43	-08 38	26	26	0	17.3 ± 0.4	-0.64 ± 0.05	E11	Shell	I
G 24.1-0.3	18 36 26	-08 01	48	48	0	41 ± 1	-0.87 ± 0.05	E11	Shell	I
G 25.4-1.9	18 44 18	-07 35	76	94	35	17.0 ± 0.5	-0.45 ± 0.03	E11	Shell	I
G 28.4+0.2	18 42 22	-03 58	14	14	0	4.2 ± 0.3	-0.7 ± 0.1	–	Shell	I
G 28.8-0.5	18 45 30	-03 54	10	10	0	3.7 ± 0.1	-0.51 ± 0.06	E11	Shell	I
G 35.4-0.0	18 56 02	02 09	26	22	5	12.9 ± 0.4	-0.39 ± 0.06	–	Partial shell	II
G 230.5+1.3	07 28 57	-14 56	54	40	60	3.5 ± 0.1	-0.60 ± 0.07	E11	Filled	I
G 232.2+2.1	07 35 08	-16 03	50	76	340	7.2 ± 0.1	-0.58 ± 0.02	E11	Filled	I
G 349.1-0.8	17 20 24	-38 31	14	14	0	3.7 ± 0.1	-0.83 ± 0.07	MGPS	Shell	II
G 350.8+0.7	17 18 53	-36 17	56	80	43	64 ± 1*	-0.9 ± 0.1*	–	Partial shell	II
G 350.8+5.1	17 01 52	-33 40	6	6	35	16.5 ± 0.4	-0.27 ± 0.06	–	Filled	II
G 351.0-0.6	17 25 07	-36 49	12	12	0	0.50 ± 0.04	-0.64 ± 0.09	MGPS	Partial shell	II
G 351.4+0.5	17 21 31	-35 53	9	9	0	3.35 ± 0.09	-0.42 ± 0.07	MGPS	Shell	I
G 351.5+0.2	17 22 45	-35 59	18	14	20	1.8 ± 0.1	-0.9 ± 0.1	MGPS	Partial shell	II
G 351.9+0.2	17 24 14	-35 40	20	16	0	4.4 ± 0.2	-0.98 ± 0.07	MGPS	Shell	I
G 353.1+0.8	17 24 46	-34 21	96	66	20	16.5 ± 0.4*	-1.0 ± 0.1*	–	Partial shell	III
G 355.4+2.8	17 23 28	-31 16	22	22	0	1.5 ± 0.2	-0.8 ± 0.2	–	Filled	I
G 356.5-1.9	17 44 55	-32 54	36	48	40	14.9 ± 0.3	-0.71 ± 0.05	–	Filled	I
G 358.4-0.8	17 44 46	-30 43	34	42	354	21.8 ± 0.3*	-0.8 ± 0.1*	–	Partial shell	III

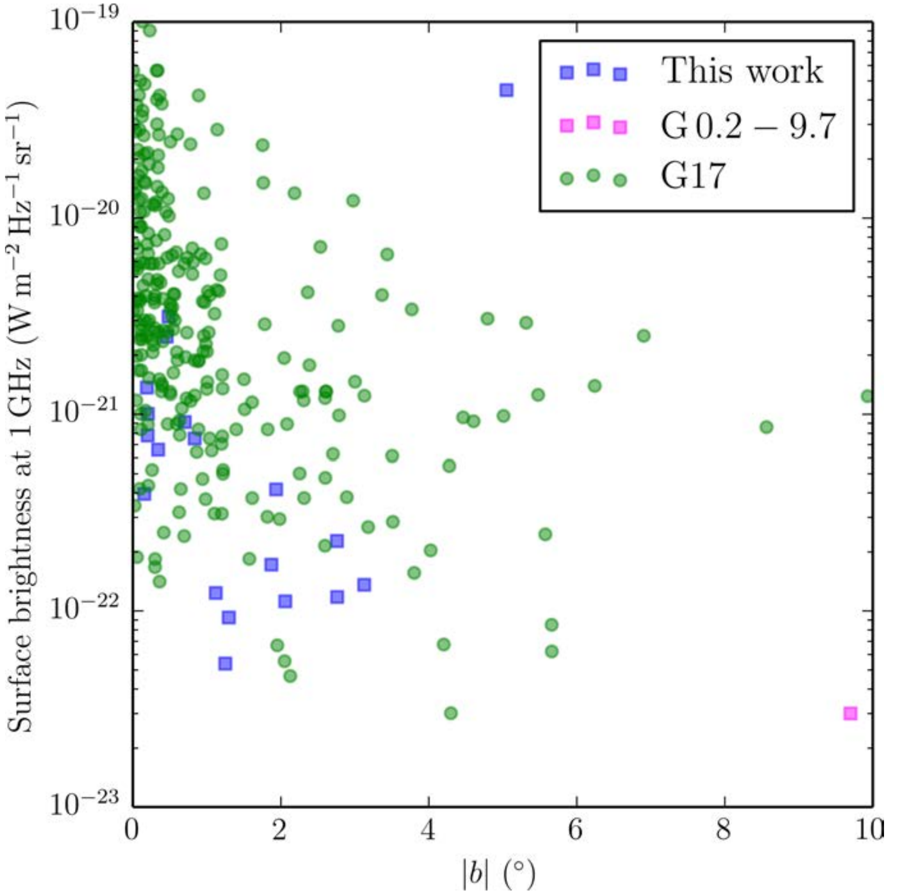
New SNRs



Hurley-Walker et al. (submitted):
New candidate SNRs from GLEAM

Comparisons with known SNR (Green 2017)

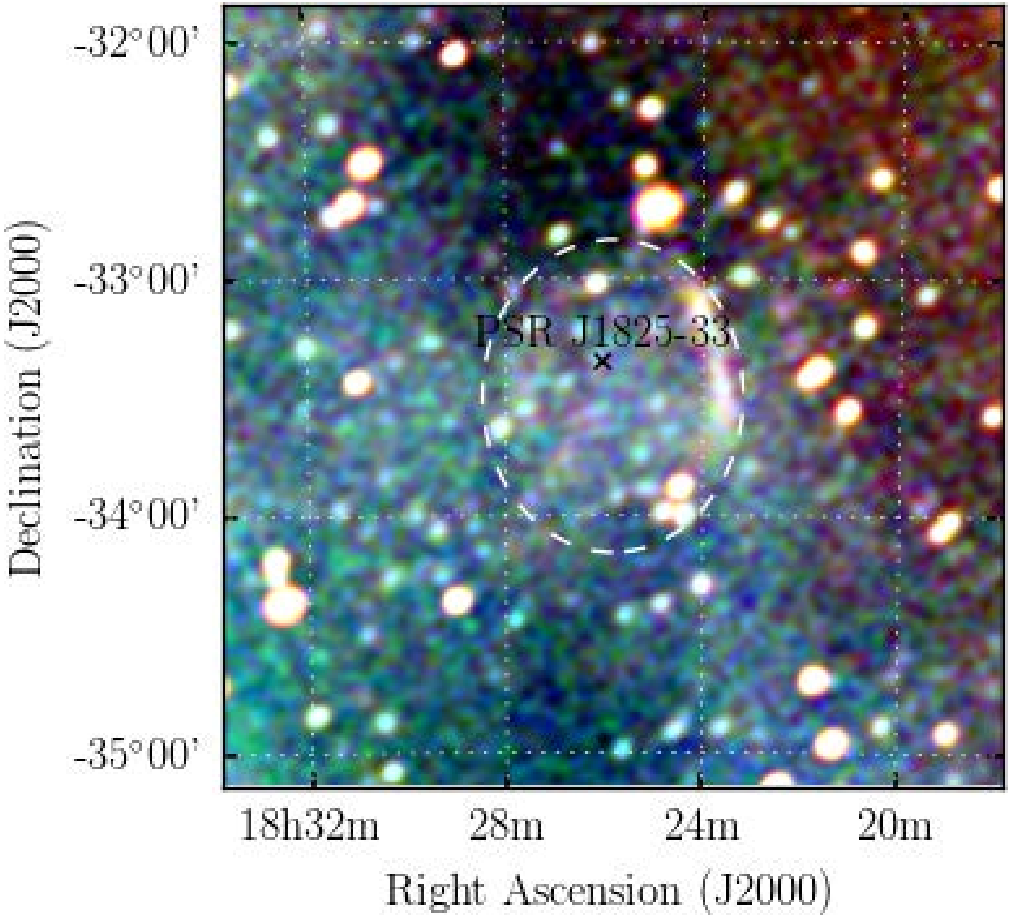




Pulsar associations

Name	Associated pulsar	Coincidence chance (%)	Likelihood of assoc.	Distance (kpc)	a (pc)	b (pc)	PSR age (kyr)	SNR age (kyr)	Stage
1	2	3	4	5	6	7	8	9	10
G 0.2 − 9.7	PSR J1825-33	5	good	1.24	24	24	–	1–9	free / S-T
G 21.8 + 0.2	PSR J1831-0952	95	good	3.68	165	45	128	40–120	radiative
G 230.5 + 1.3	PSR J0729-1448	4	good	2.68	47	31	35	17–48	S-T
G 232.2 + 2.1	PSR J0734-1559	3	good	–	–	–	197	–	S-T
G 356.5 − 1.9	PSR J1746-3239	57	marginal	–	–	–	482	–	–
G 358.4 − 0.8	PSR B1742-30	79	marginal	2.64	32	26	550	10–18	S-T

G 0.2–9.7



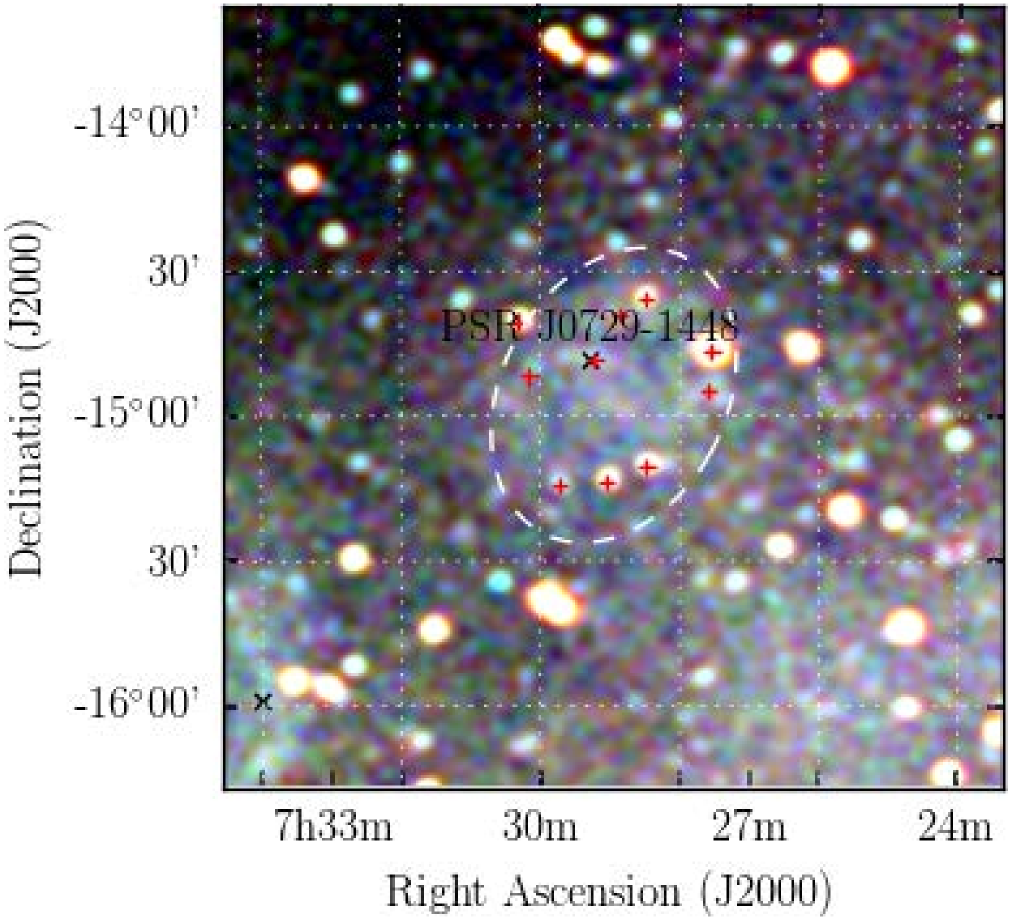
J1825-33 (RRAT)
DM = 43 ± 2 $cm^{-3}pc$
→ Dist = 1.24 kpc
→ diameter = 24 pc
SNR age estimate < 9k yr

P = 1.27 s
No $\dot{P}$
→ no age estimate

Position accuracy ~ 15'
→ no kick velocity

Burke-Spolaor & Bailes 2010)

G 230.5+1.3



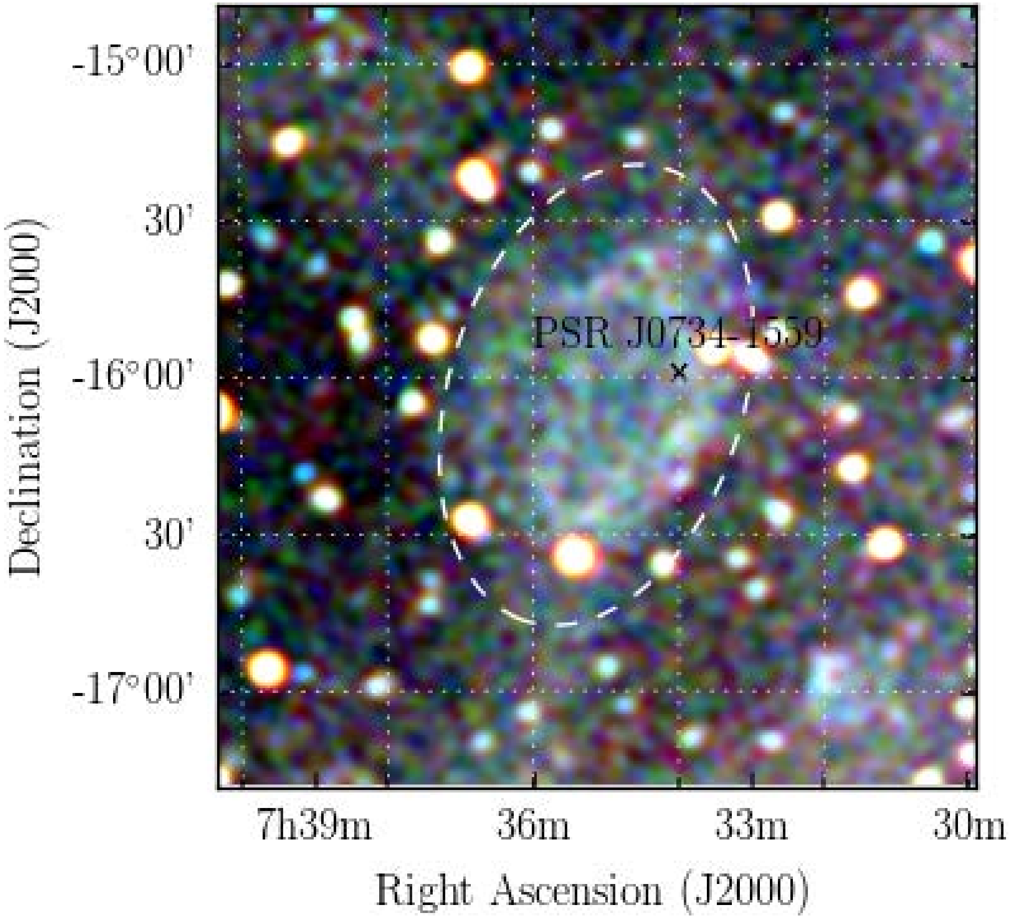
J0729-1448
DM = 92 $cm^{-3}pc$
→ Dist = 2.68 kpc
→ diameter = 47 x 31 pc
SNR age estimate ~ 36k yr

P = 252 ms
$\dot{P}$ = 10^{-13} s s^{-1}
Age ~ 35k yr

Kick velocity 180 km s^{-1}

Morris et al. (2002), Petroff et al. (2013)

G 232.2+2.1



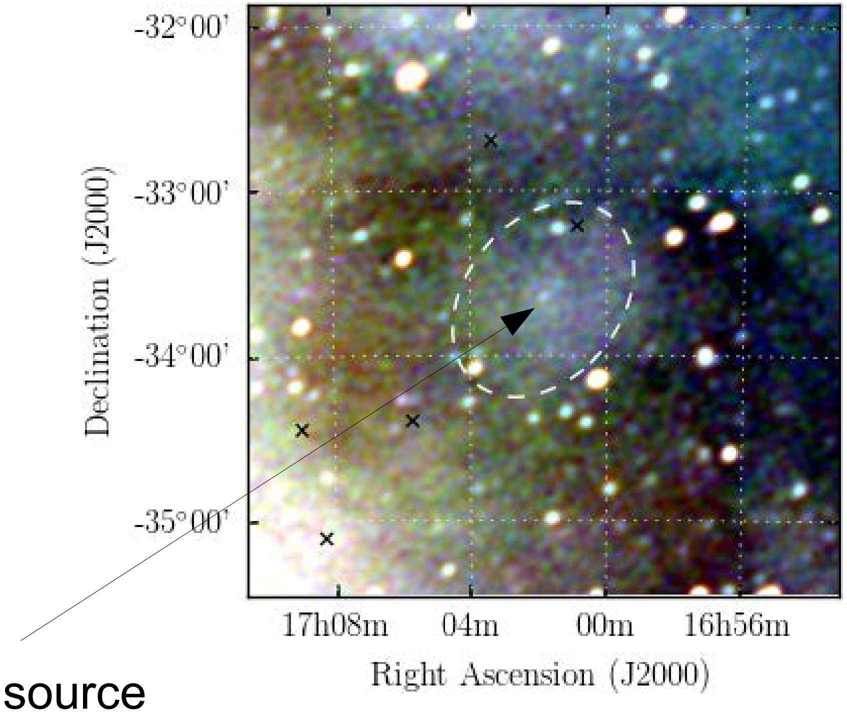
J0734-1559 (γ-ray pulsar)
No DM
→ No Dist
→ No diameter
→ No SNR age estimate

P = 155 ms
$\dot{P}$ = 10^{-14} s s^{-1}
Age ~ 200k yr

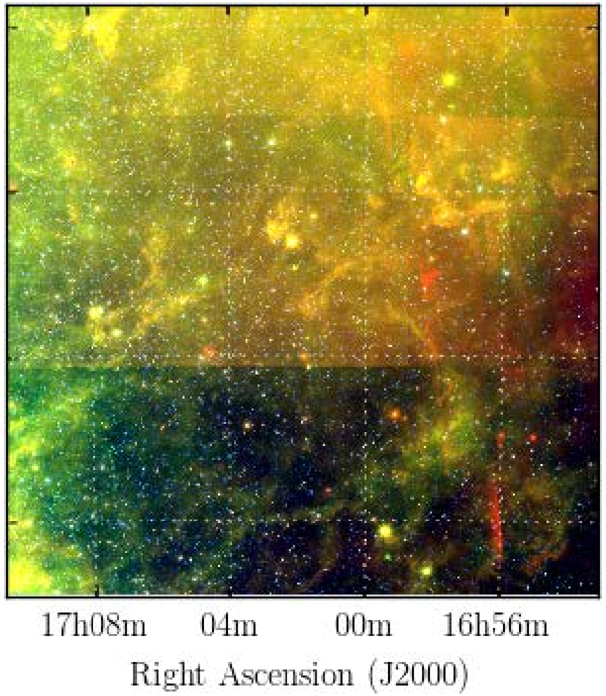
Sokolova & Rubstov (2016)

New pulsars?

G 350.8+5.1



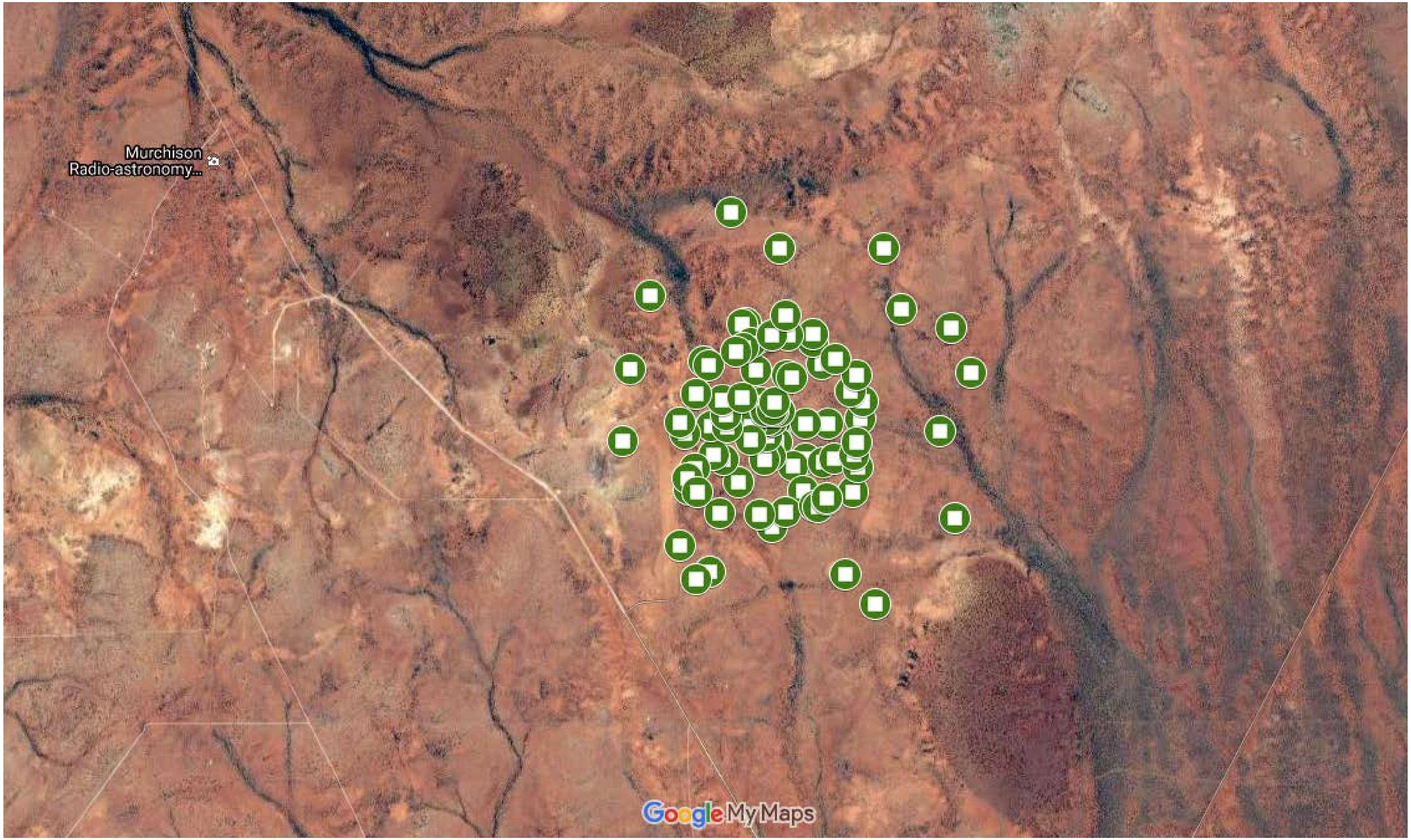
GLEAM RGB (88/118/154)MHz



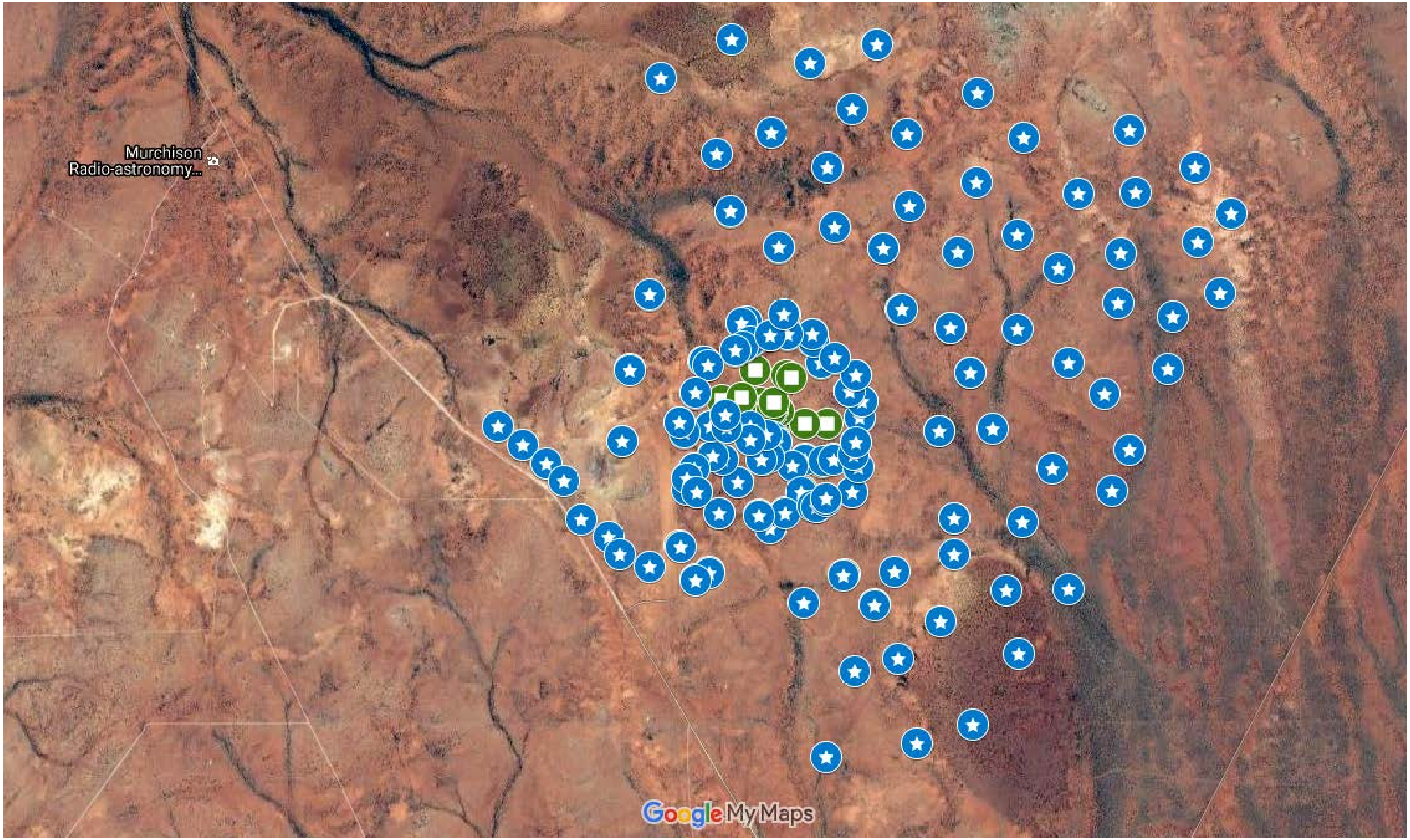
WISE RGB (8/12/22)um

Compact source
α=-1.4
Pulsar?

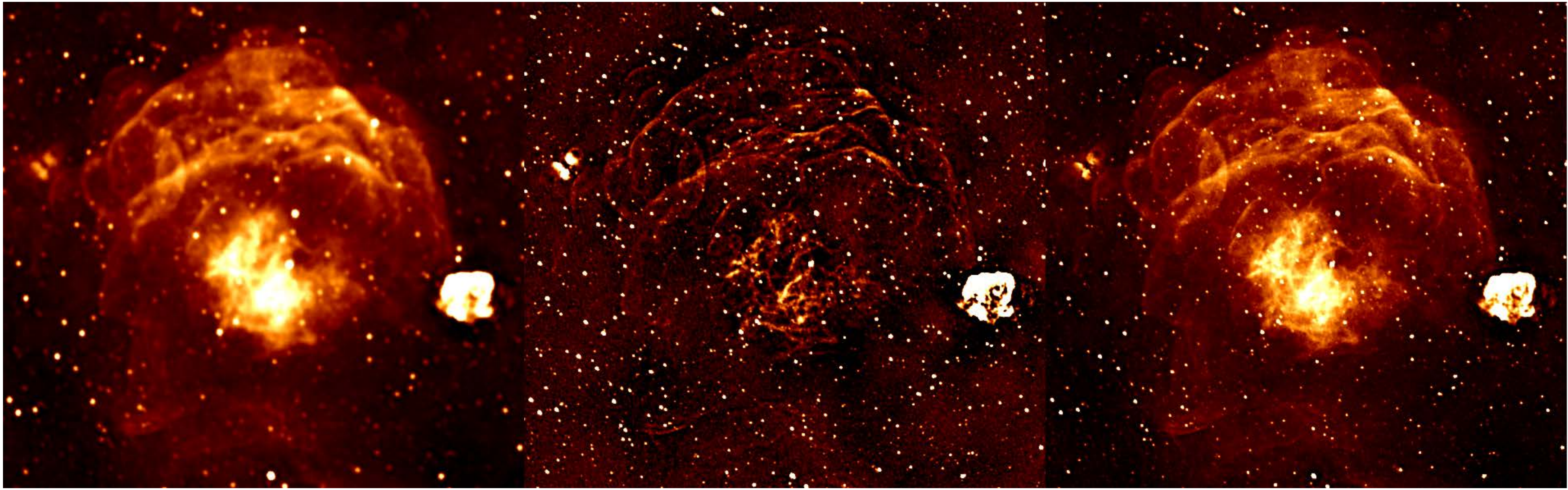
GLEAM-eXtended



GLEAM-eXtended



With these powers combined...



GLEAM 72 – 103 MHz
Resolution: 2’

MWA Phase II 72 – 103 MHz
Resolution: 1’
(Credit: Chenoa Tremblay)

Feathered combination