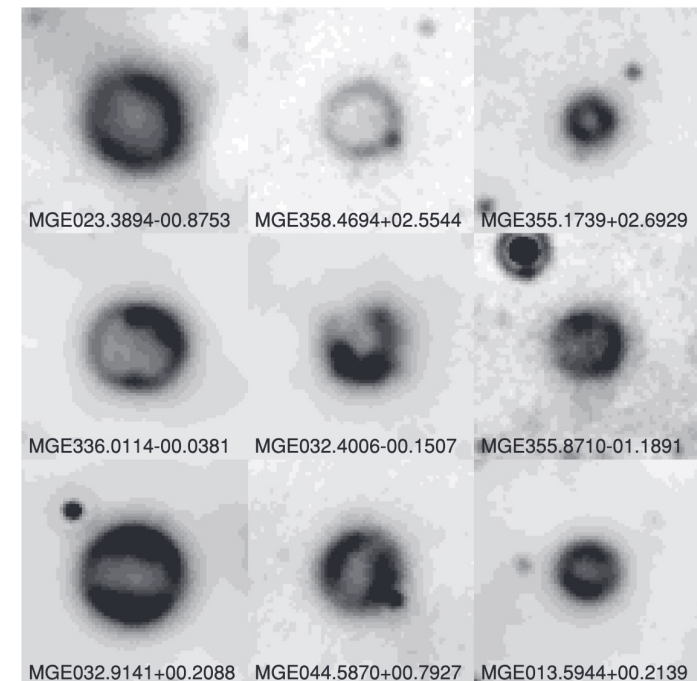


ONE TELESCOPE TO FIND THEM ALL: A MEERKAT HUNT FOR RADIO RINGS

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& the Catania Radio Group
INAF – Osservatorio Astrofisico di Catania

A search for radio rings

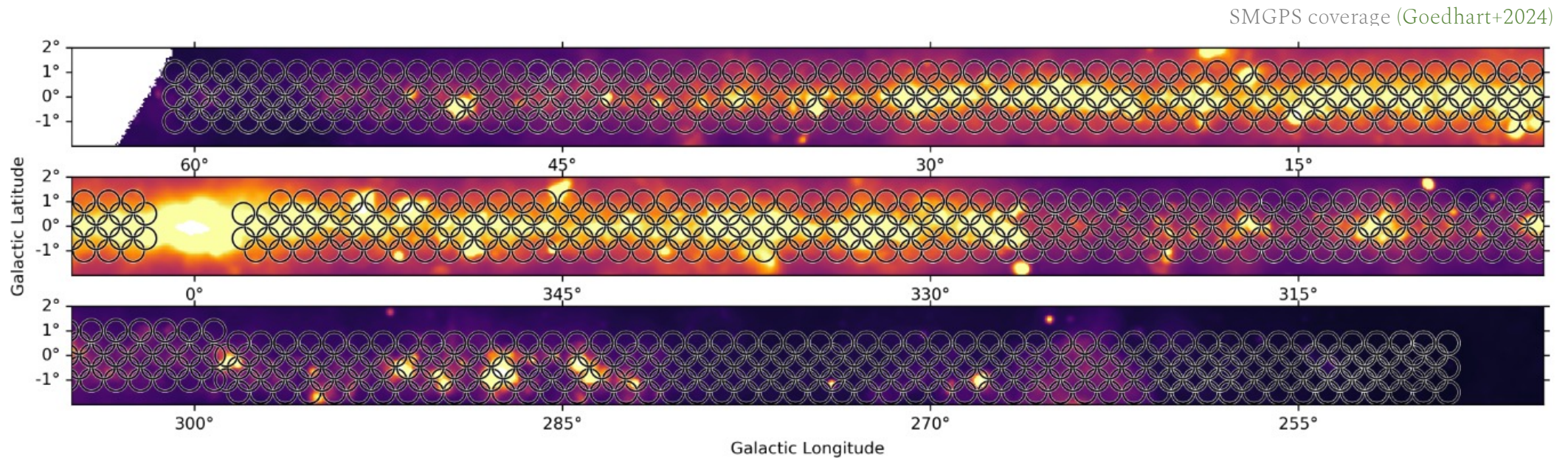
- Radio ring-like sources – tracers of stellar evolution (from HII regions to SNRs)
- “Compact” rings – typically associated with evolved star mass-loss (shells)
- A “blind search” for rings: good strategy in the infrared! (MIPSGAL, ~400 “bubbles”, Mizuno+2010)
- Can we do the same at radio wavelengths? So far...
 - Limited angular resolution
 - Limited sensitivity
 - Limited coverage



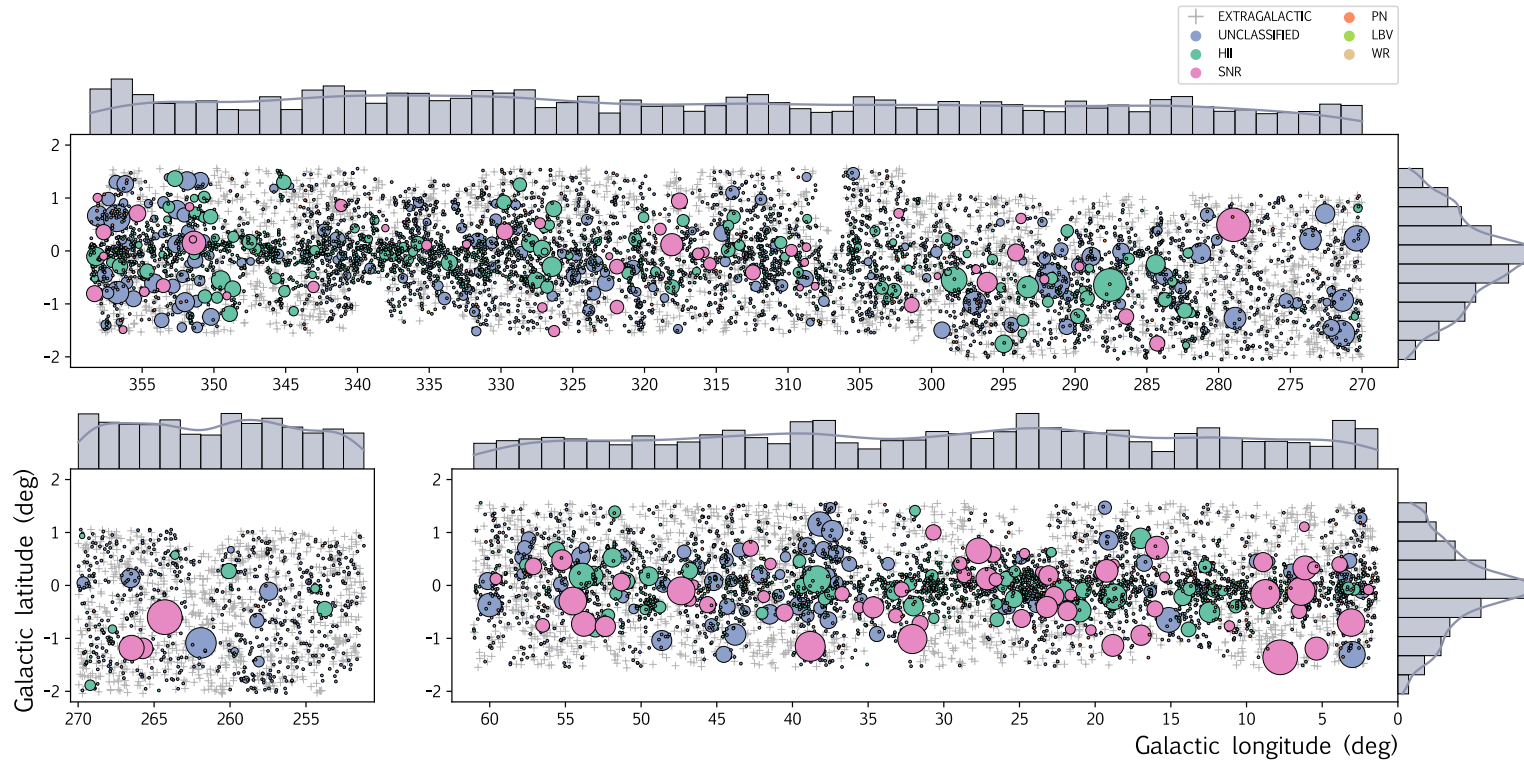
Example IR rings from Mizuno+2010

The MeerKAT revolution

- New interferometers allow for **high-resolution**, **deep**, **large area** surveys
- Searching for compact rings (<1 arcmin) “at scale” is now **possible**
- Over **17000 extended structures** identified in the SMGPS (Bordiu+2025a) – **huge potential**



Extended sources in the SMGPS



~17000
catalogued
sources

~24%
Galactic objects

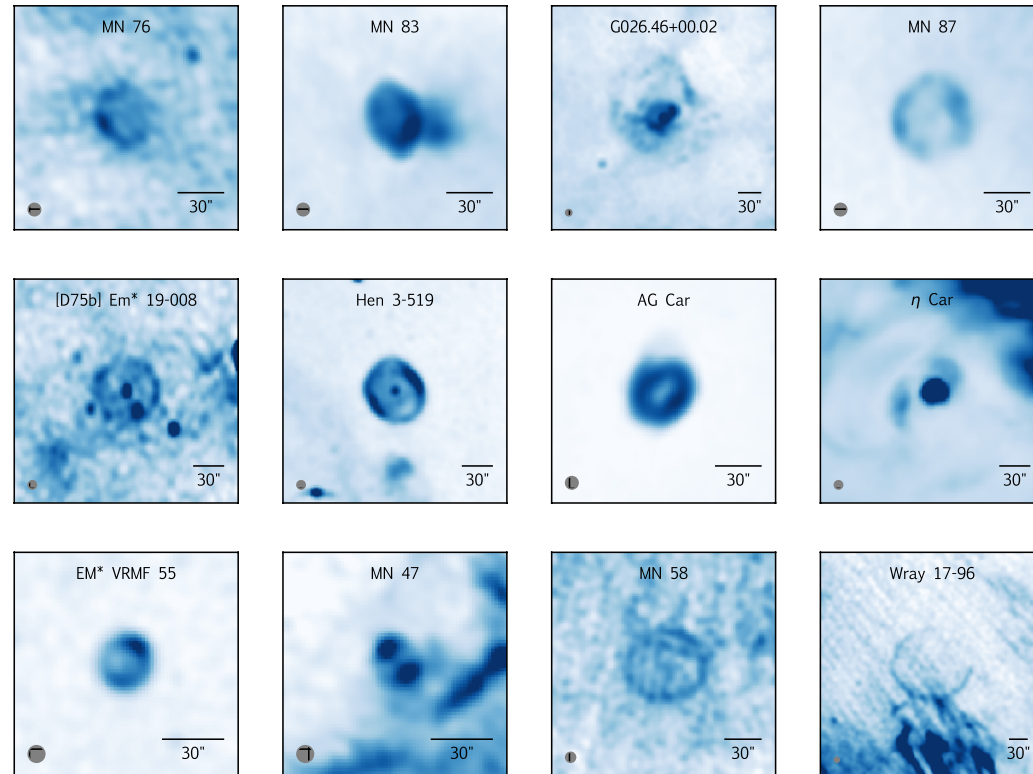
~33%
Extragalactic
candidates

~43%
Unclassified
sources

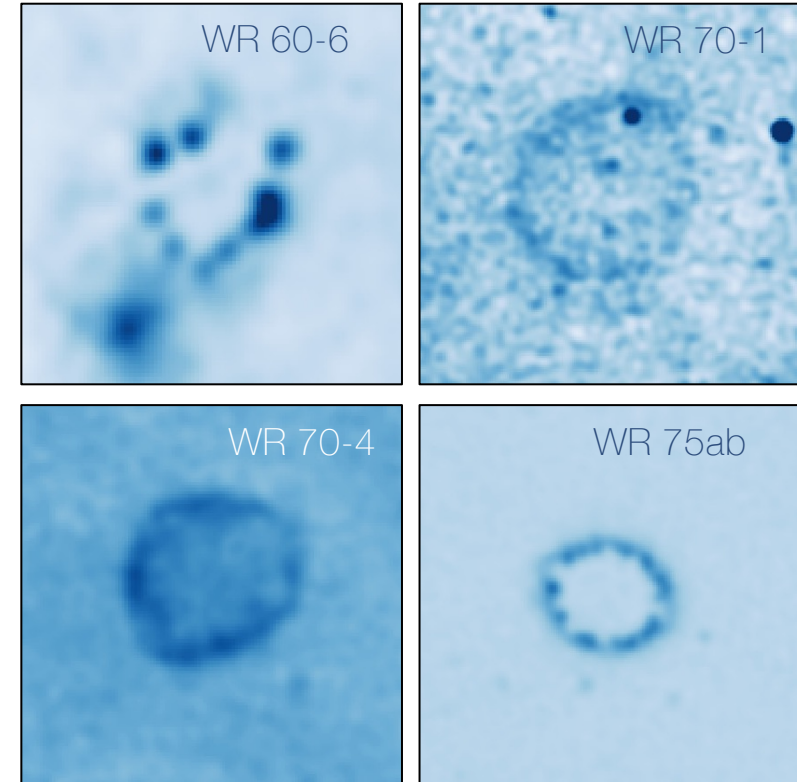
Sky distribution of extended radio sources in the SMGPS (Bordiu+2025a)

What did we find? (I)

Dozens of ring-like structures associated with known evolved massive stars



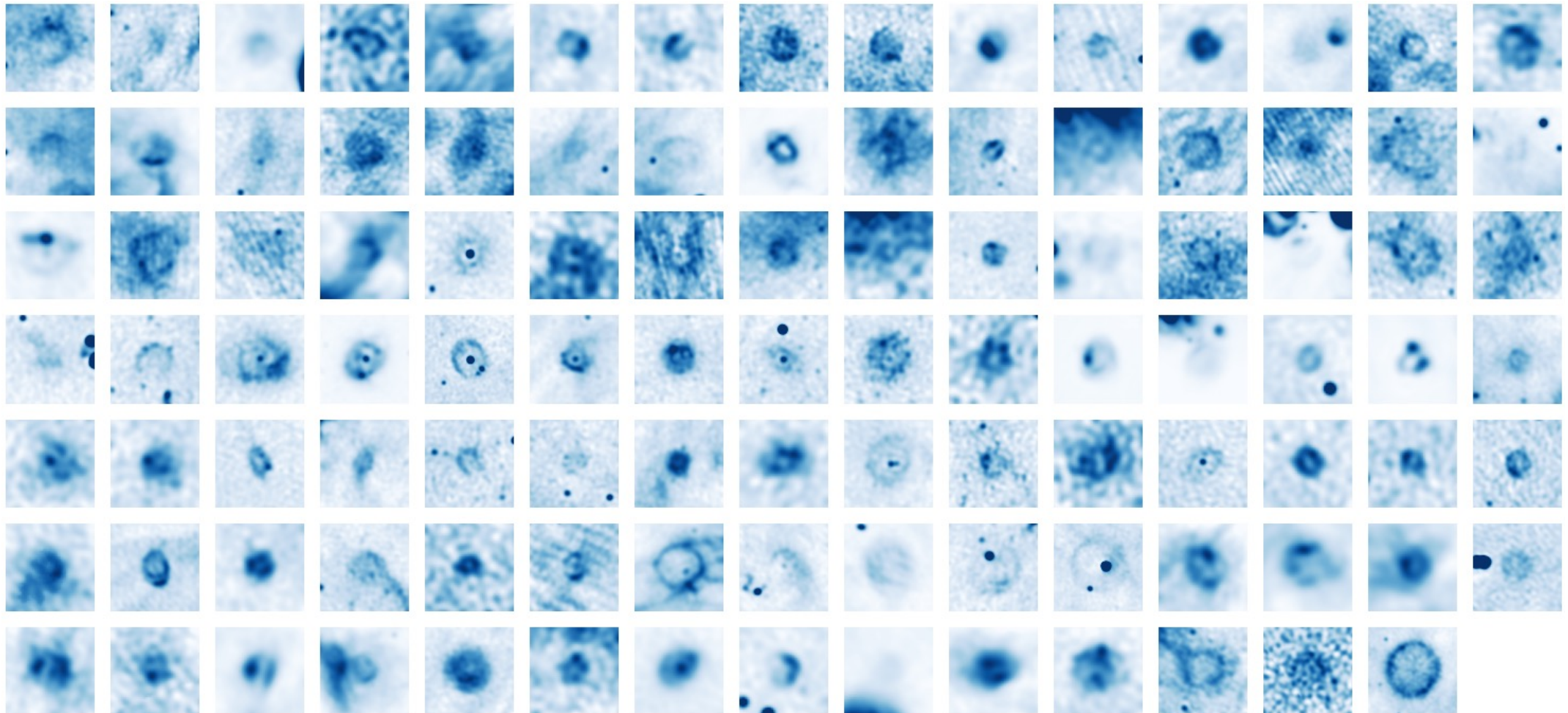
Ring nebulae around LBV and LBV candidates
(Umana+, in prep.)



Circumstellar shells around WR stars
(Buemi+, in prep.)

What did we find? (II)

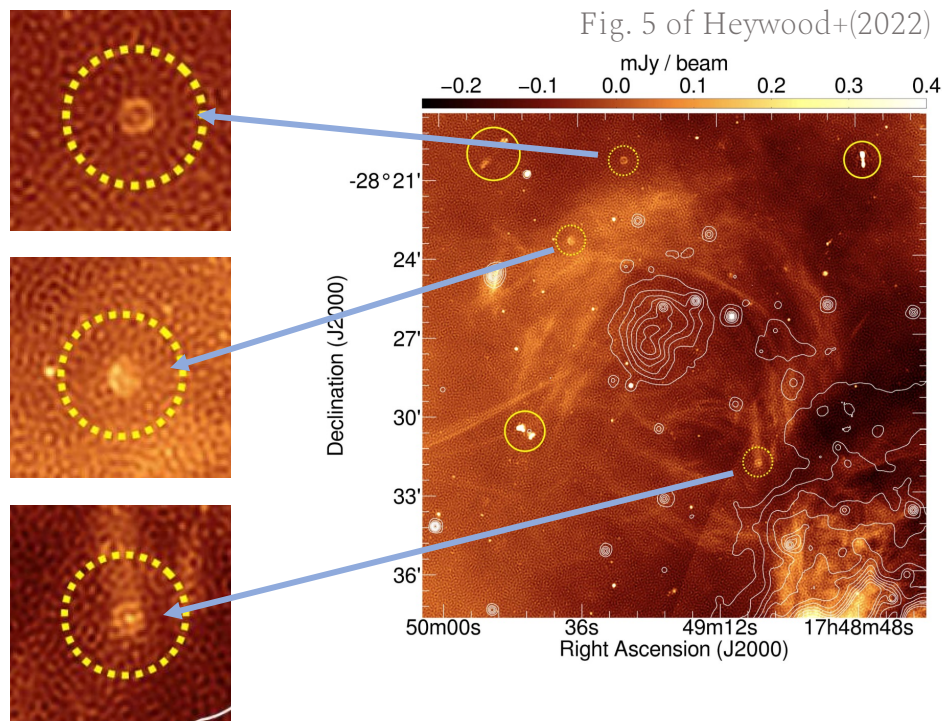
But also numerous new ring & shell-like sources of uncertain origin!



Unclassified rings in the SMGPS (Bordiu+2025)

Systematic search for rings combining the SMGPS and the Galactic Centre Mosaic*

(*where Heywood+2022 had noted the presence of several small diameter “shells”)



Building the sample

Selection criteria:

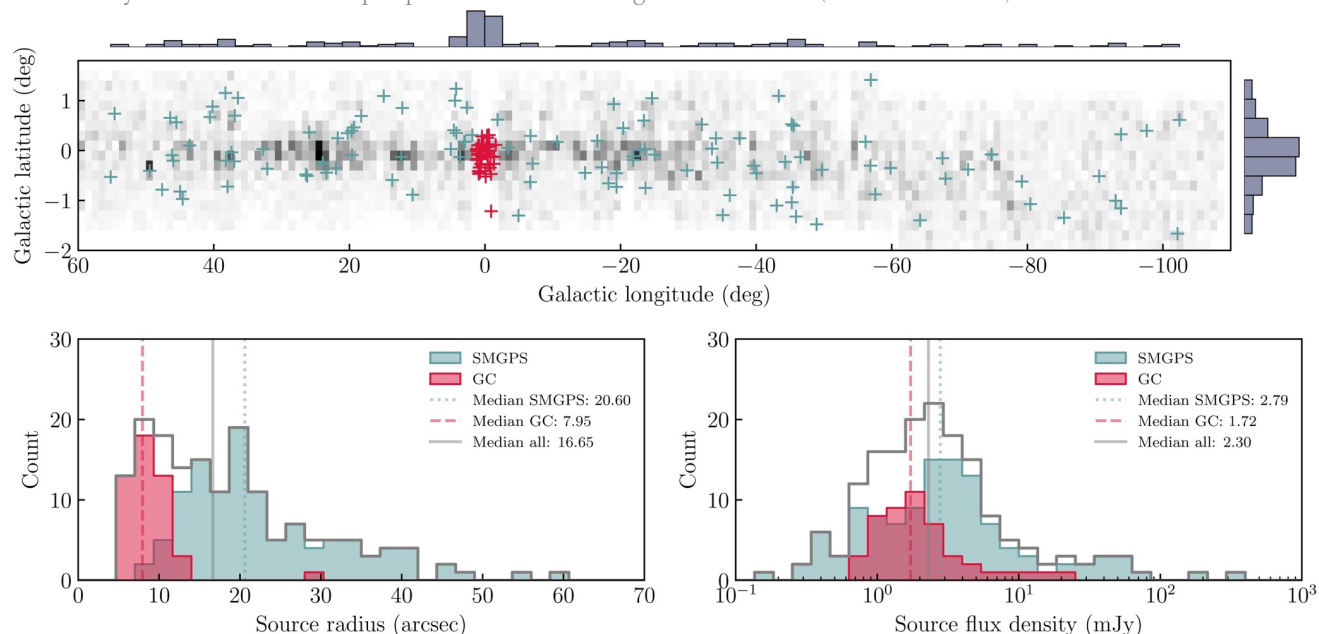
- 1 “UNCLASSIFIED”
Not matching known Galactic extended sources
- 2 ROUNDISH
Not strong deviations from spherical symmetry
- 3 LIMB-BRIGHTENED
(i.e. with bright edges)
- 4 ANGULAR RADIUS
<1 arcmin
- 5 FAR FROM
confused regions and imaging artifacts

164

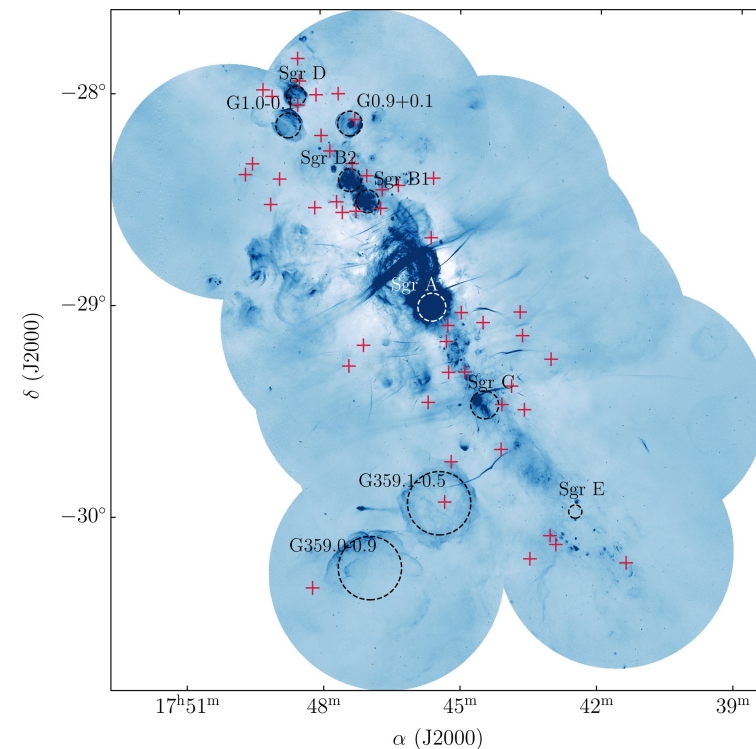
Unclassified rings in
the final sample

Population overview

Sky distribution and properties of new ring-like sources (Bordiu+2025b)



Location of rings in the Galactic Centre (Bordiu+2025b)



3
morphological
classes



Rings with point sources · 19%



Rings without point sources · 56%



Miscellaneous/weird rings · 25%

The over-density in the GC is
statistically significant
(not a selection bias despite the resolution
difference)

Cross-match and identification

Excerpt from the ring catalogue

ID	GName	Radius (arcsec)	PS	S_{ring} (mJy)	S_{ps} (mJy)	Type	Point source		Extended emission			SIMBAD	Classification
							2MASS	GLIMPSE	8 μm	24 μm	70 μm		
1	G000.21+00.12	13.1	N	2.94 (0.3)	–	2a	×	~	×	✓	×	[FPF2021] 44 5 1 (Star)	PN/Massive star
2	G000.44+00.28	12.1	Y	1.32 (0.12)	0.07 (0.02)	1a	✓	~	×	✓	×		
3	G000.45–00.00	5.7	N	9.26 (0.54)	–	2b	✓	~	×	✓	×		
4	G000.50+00.12	7.7	N	1.85 (0.16)	–	3c	~	~	×	?	×		
5	G000.50–00.11	7.2	N	2.71 (0.2)	–	2b	×	~	×	?	×	ISOGAL-P J174733.0–283411 (YSOc) SSTGC 830399 (YSOc)	PN
6	G000.52+00.04	7.6	N	1.9 (0.21)	–	2c	~	~	×	×	×		PN
7	G000.53–00.17	11.5	Y	4.04 (0.32)	0.4 (0.08)	1b	~	~	×	✓	✓		HII region
8	G000.58–00.16	7.7	N	6.76 (0.38)	–	2b	~	~	×	✓	✓		HII region
9	G000.61–00.26	10.3	Y	0.65 (0.1)	0.15 (0.03)	1a	✓	~	×	×	✓		PN
10	G000.61+00.01	5.1	N	1.26 (0.11)	–	2c	✓	✓	×	✓	×		
11	G000.70–00.01	10.9	N	1.95 (0.21)	–	3c	~	~	×	×	×		
12	G000.74–00.43	9.7	Y	0.98 (0.13)	0.22 (0.02)	1a	✓	~	×	✓	?		Massive star
13	G000.81–00.06	6.7	N	1.17 (0.11)	–	2b	~	~	×	×	?		PN

1

Positional crossmatch (5")

SIMBAD · 2MASS · GLIMPSE
(17%) (41%) (26%)

2

Search for IR counterparts

8 μm · 24 μm · 70 μm
50% in at least one band

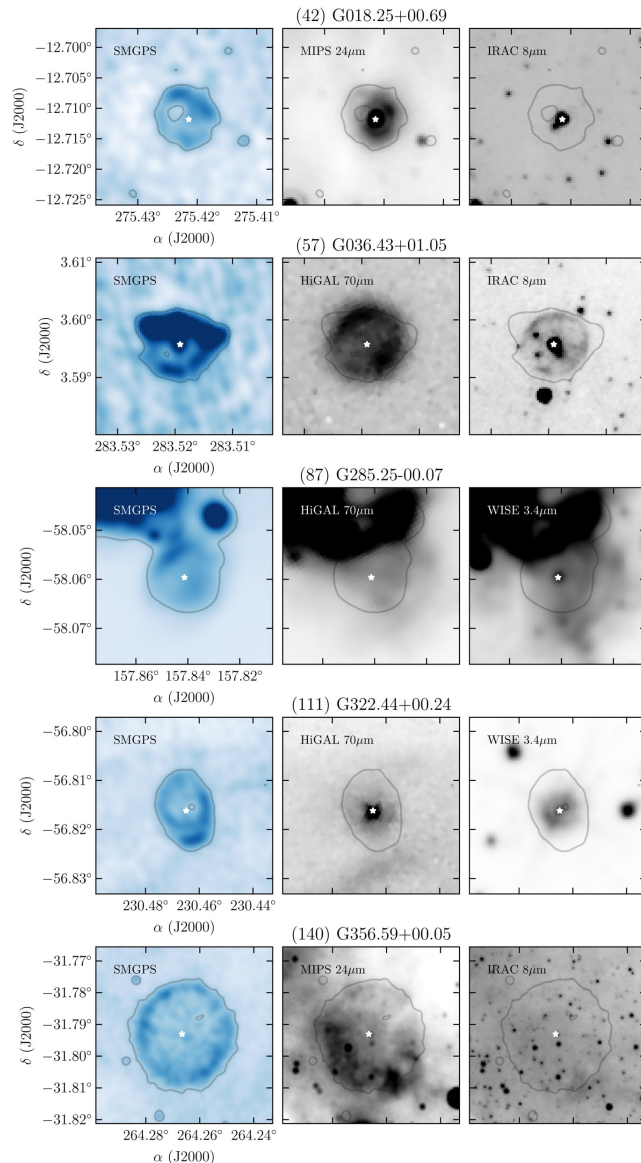
Proposed scenarios

PNe · Massive stars · HII regions
Galaxies · ORCs · SNRs
Nova shells · Galaxy cluster lenses

(but 40% remain unclassified)

And now, some highlights...

Candidate LBV stars?



22 rings in the sample show:

1. Clear IR counterpart at 8 or 24 um
2. Central star visible in the optical/IR (not necessarily in radio)
3. The star is a confirmed variable star

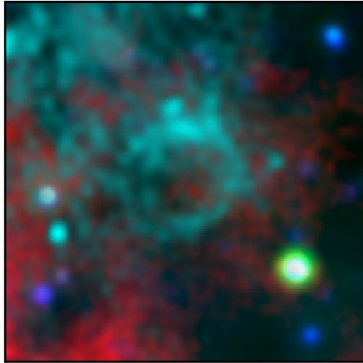
Five of them are Long Period Variable stars (Gaia DR3)

These rings could be circumstellar shells
around unidentified LBV candidates

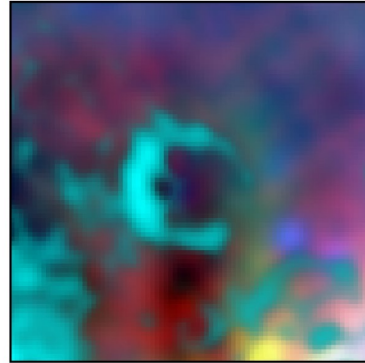
(MeerKAT S-band follow up ongoing to constrain spectral index)

Low-latitude ORC candidates?

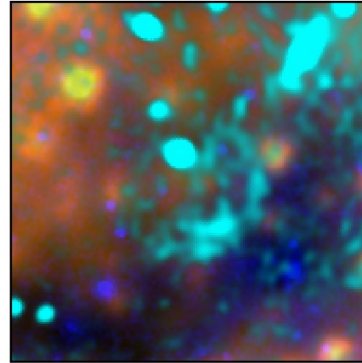
(30) G003.06+00.17



(40) G013.68-00.59



(120) G335.36+01.04



Rings without multiwavelength counterparts (R=8um, G=24um, B=70um, Cyan=L-band)

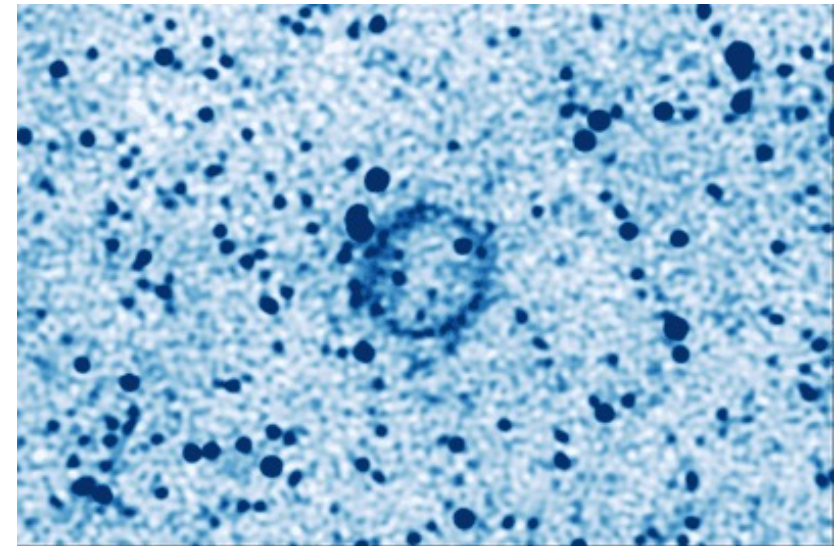
Several rings in the sample are **only visible in the radio**

- Too **small** to be an old SNR (even at ~ 20 kpc)
- Too **faint** to be a young SNR
- May be **low-latitude ORCs**?

They resemble the *Kyklos* radio ring (Bordiu+2024)

Odd Radio Circles

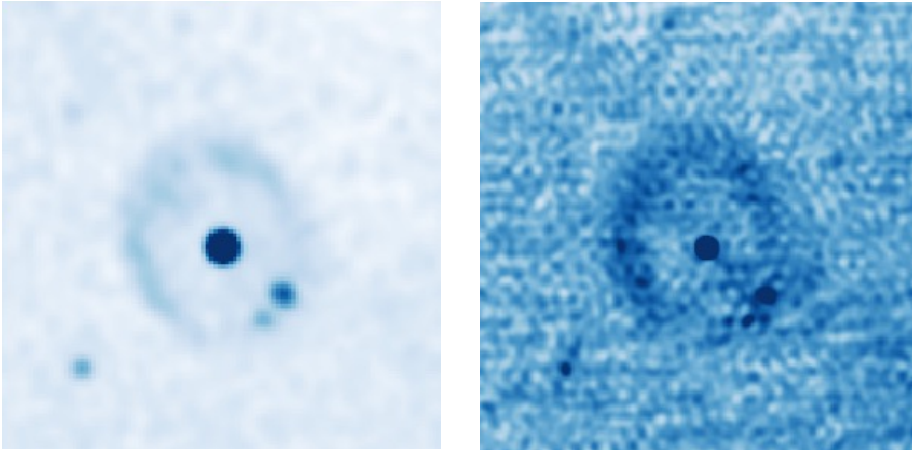
Circular radio structures with no obvious counterpart at other wavelengths, $\alpha < -0.4$, hosting a galaxy in the centre, and typically located at high Galactic latitudes



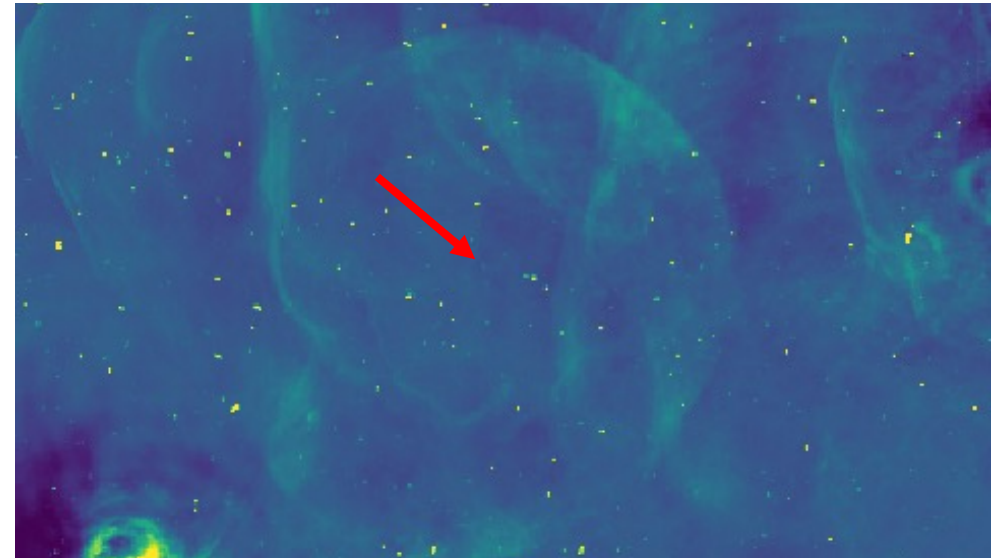
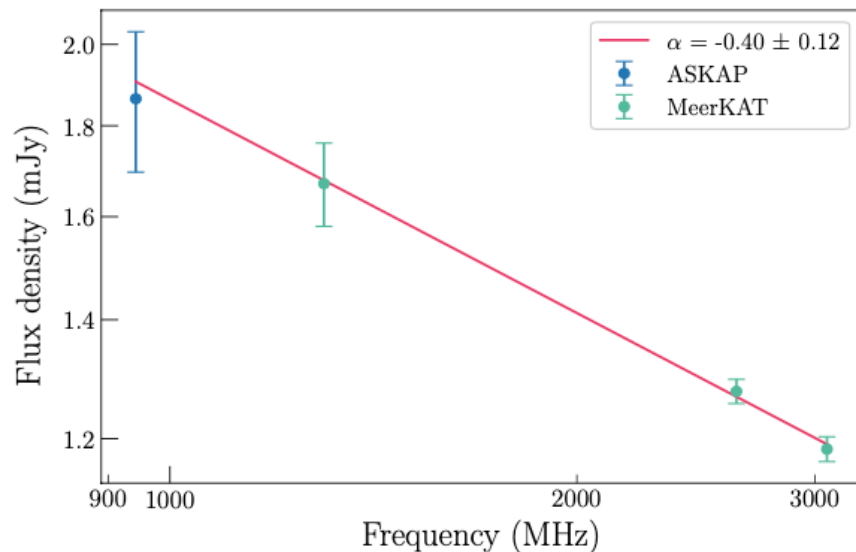
MeerKAT L-band image of Kyklos /J1802-3353 (Bordiu+2024)

Puzzling sources?

G266.18-01.15 (Ring #81) as seen in L-band and S-band (Bufano+ in prep.)



G266.18-01.15 (Ring #81) spectral index fit



G266.18-01.15 is a source in the Vela region that defies classification (Bufano+ in prep.)

The central object has a **non-thermal spectral index**, is visible in the **IR** and **soft X-rays**. The shell is only visible in the **radio**

1. MeerKAT is revealing an increasing number of ring-like structures across the Galaxy
2. Many of these may be tracing hidden populations of evolved stars (census completion)
3. Exotic explanations are possible for some of the rings
4. Multi-frequency observations are key for reliable spectral analysis (WIP)

Thanks for your attention!