Investigation of Galactic supernova remnants and their environment in $26.6^\circ < l < 30.6^\circ$, $|b| \leq 1.25^\circ$ using radio surveys

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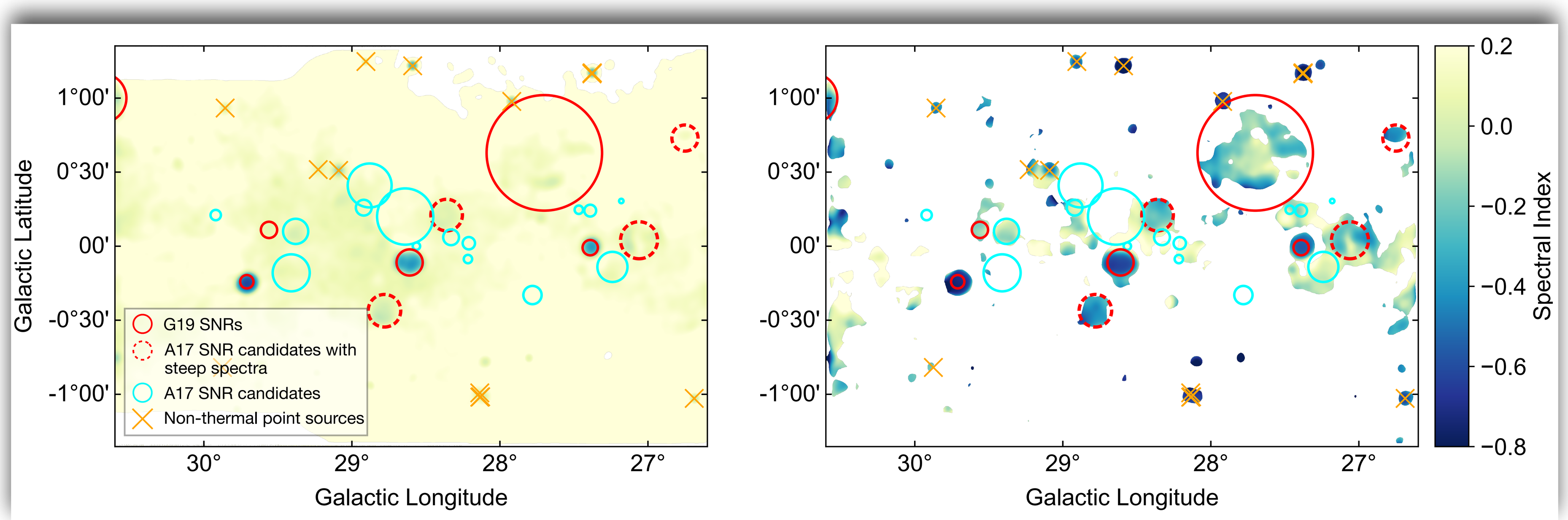
Introduction

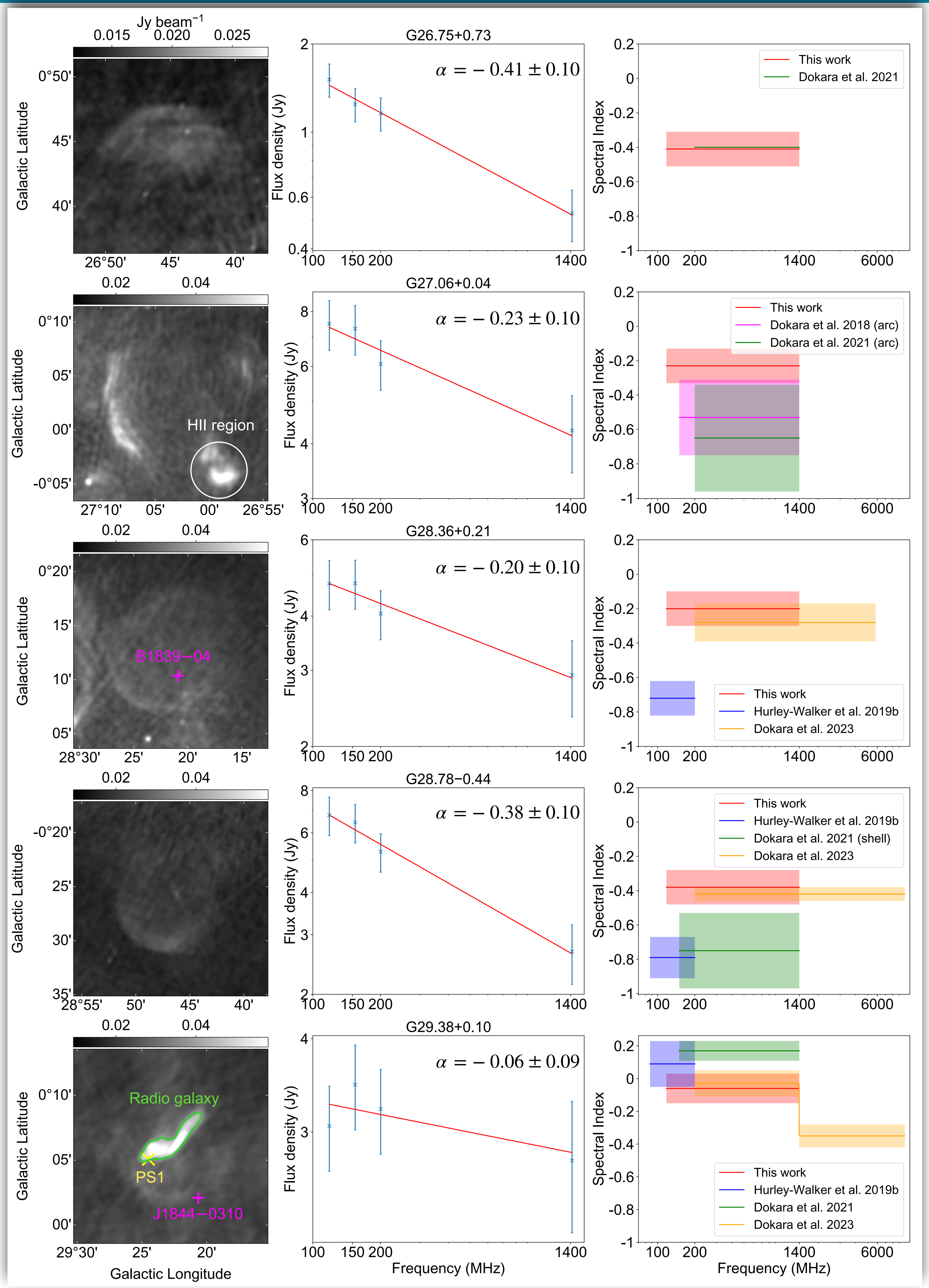
- **The currently known SNRs still need to be completed**. The number of Galactic SNRs is expected to be ~2400–5600 (Ranasinghe & Leahy 2022), much higher than the ~300–400 known Galactic SNRs listed in the SNR catalogs (Green 2019).
- $S \propto \nu^{\alpha}$. For SNRs, the spectral index $\alpha \sim -0.5$, For HII regions, $\alpha \sim 0$.
- Investigation and detailed study of these candidates are important to increase the sample of Galactic SNRs and understand what hampers us from finding new SNRs in the radio band.

Spectral index map

- Data in four frequency bands from **THOR+VGPS** and **GLEAM** surveys at **118–1420 MHz** are used.
- Catalogs: The Green's catalog of Galactic SNRs (Green 2019, G19), SNR candidates discovered by (Anderson et al. 2017, A17), and the WISE Catalog of Galactic HII regions (Anderson et al. 2014).
- The four-band data are fitted pixel-by-pixel using a power-law spectrum.



Spectral index maps before removing the background (left) and after removing the background (right)



Thor+VGPS continuum images (left), flux density spectrum (middle), and spectral indices between different frequency intervals (right)

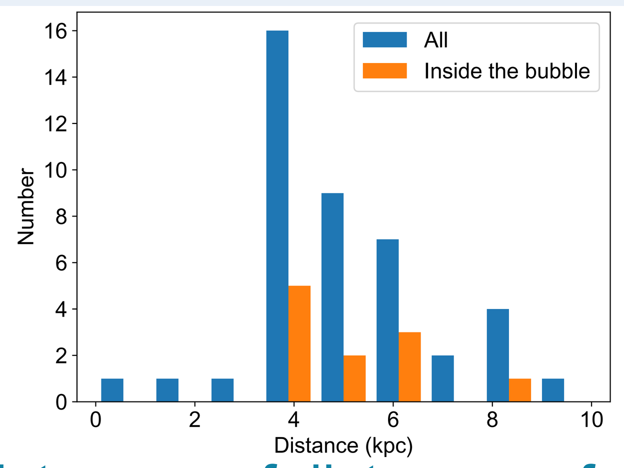
Spectral analysis

- We calculate the integrated flux densities and spectral indices of the five A17 SNR candidates in four radio bands.
- A source-free concentric ring with a width of about two times the source radius is chosen to subtract the background.
- We concluded that there are **four of them named 26.75+0.73, G27.06+0.04, G28.36+0.21, and G28.78−0.44 are SNRs.**

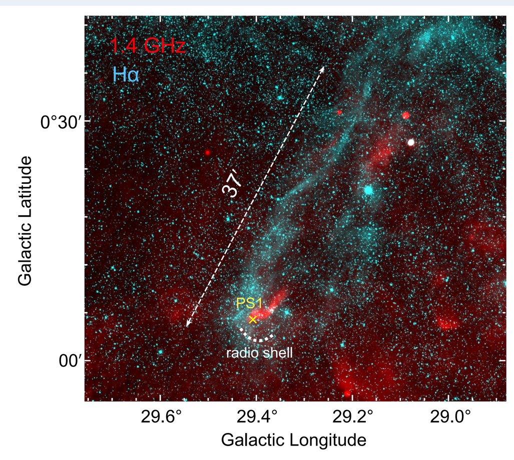
Name	GLong (°)	GLat (°)	Radius[a] (arcmin)	$S_{1.4\,G}$ (Jy)	$S_{200\,M}$ (Jy)	$S_{154\,M}$ (Jy)	$S_{118\,M}$ (Jy)	α	$S_{1.0\,G}$[b] (Jy)	Type[c]
G26.75+0.73	26.750	0.730	5.3	0.53±0.11	1.16±0.15	1.24±0.17	1.51±0.20	−0.41±0.10	0.60±0.10	C?
G27.06+0.04	27.060	0.040	7.5	4.29±0.86	6.08±0.79	7.31±0.95	7.50±0.98	−0.23±0.10	4.52±0.76	S
G28.36+0.21[d]	28.360	0.210	6.4	2.92±0.59	4.05±0.53	4.76±0.62	4.75±0.62	−0.20±0.10	3.09±0.52	S
G28.78−0.44[d]	28.780	−0.436	6.6	2.68±0.54	5.28±0.69	6.44±0.84	6.77±0.88	−0.38±0.10	3.01±0.50	S
G29.38+0.10	29.380	0.100	5.1	2.75±0.55	3.22±0.42	3.47±0.46	3.06±0.40	−0.06±0.09	2.88±0.46	C?

Pulsars and Hα filament

- There are 44 pulsars within $26.6^\circ < l < 30.6^\circ$, $|b| \leq 1.25^\circ$ and 13 of these pulsars are spatially located inside the region of the molecular bubble.
- Most pulsars have a distance of ~4–6 kpc, consistent with the estimated distance of the molecular superbubble.
- The good spatial correspondence hints that B1839−04 could be the possible pulsar of SNR G28.36+0.21.
- We found a **long Hα filament** corresponding to G29.38+0.10 and **excluded it as a bowshock-tail structure of a PWN** due to the inconsistency between the estimation and the observation properties.



The histogram of distances of pulsars



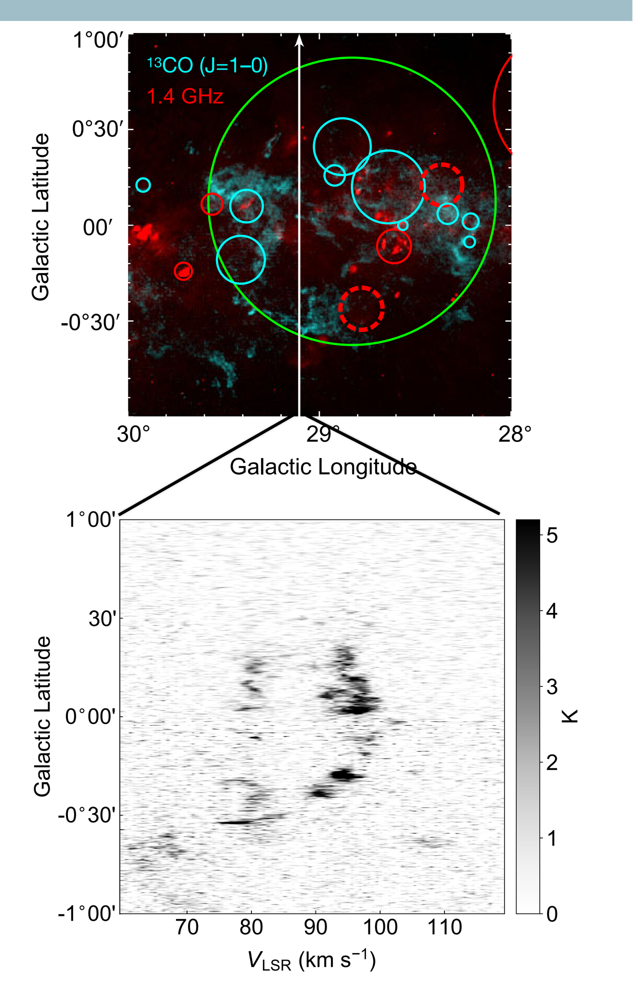
Hα filament

Missing Galactic supernova remnants

- **Observation limitations**. There are a lot of small and faint SNRs waiting to be identified by the next-generation instruments like the Square Kilometre Array Observatory (SKA).
- **The environments and the intrinsic SN explosion properties.**

Molecular bubble

- LSR velocity: $V_{\rm LSR} = 79.7$ km s^{-1}
- Expand velocity: $dV \sim 20$ km s^{-1}
- Kinematic distance: ~ 4.7 kpc
- Radius: ~ 0.75°(~ 62 pc)
- Mass: $M_{\rm H_2} \sim 2 \times 10^6 M_\odot$
- Kinetic energy: $E_k = 1/2 M_{\rm H_2} dV^2 \sim 8.0 \times 10^{51}$ erg
- Age: $t = mR/dV \sim 0.8$ Myr $(m \sim 0.25)$
- Total mechanical energy from the stellar population inside the bubble: $E = E_k/\eta \sim 8.0 \times 10^{52}$ erg $(\eta \sim 10\%)$
- **Consistent with a young molecular superbubble**
- We have not found clear evidence of shock-cloud interaction (e.g., ^{12}CO J=1-0 line broadening)



Molecular bubble (top)
PV diagram (bottom)

Reference

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