The MeerKAT view on supernova remnants

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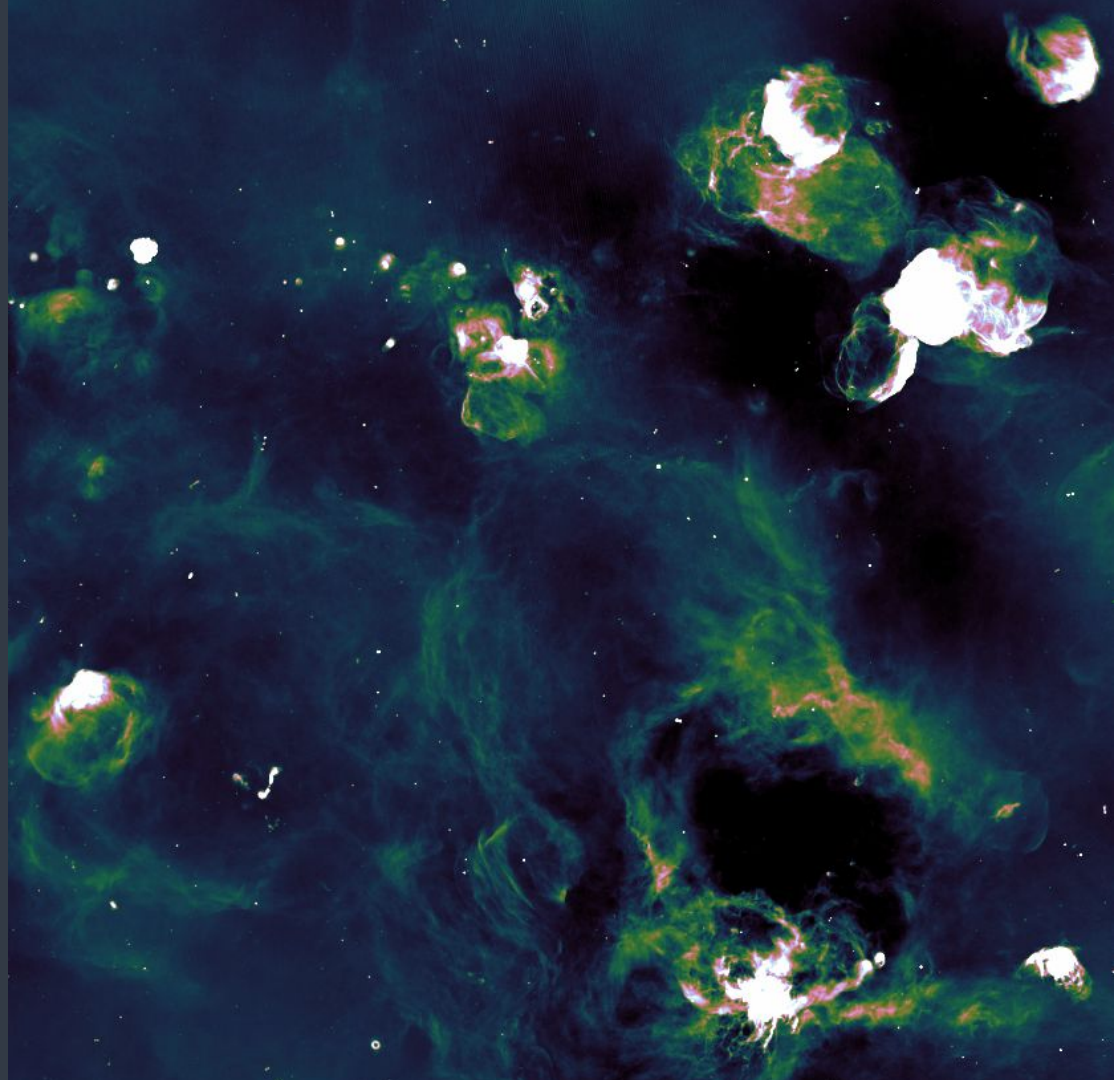
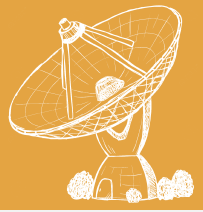
A. Ingallinera, G. Umana, C. Bordiu, C. Buemi, F. Bufano, F. Cavallaro, P. Leto, S. Riggi, C. Trigilio, A. Ruggeri



Spectral characterisation

A comprehensive understanding of SNRs:

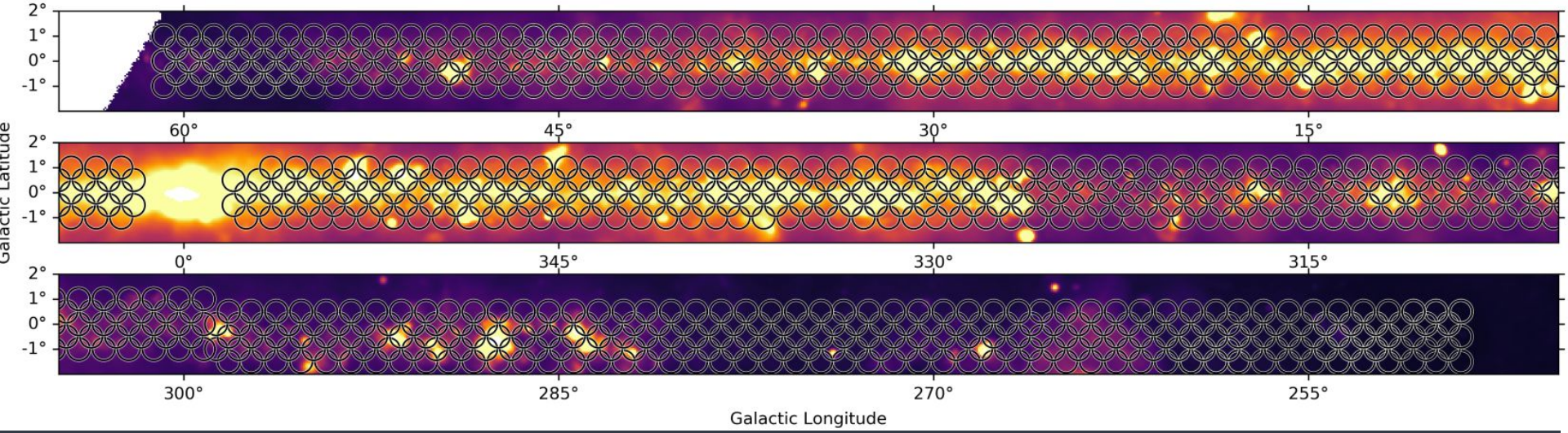
- Integrated spectral index
- Integrated spectrum behaviour
- Spectral index maps
- Distribution of the integrated spectral index across the SNR population



Requirements

- Sensitive flux density measurements in a wide frequency range
(ideally ~ 0.1-~ 100 GHz).
- High-resolution images revealing regions located in peculiar SNR/PWN environments and subjected to different shocks conditions.
- Observation of a huge sample of galactic SNRs with the same instrument.

The SARAO MeerKAT Galactic Plane Survey (SMGPS)



Goedhart et al. (2024)

0.886–1.678 GHz

2° < l <60° ,
252° < l < 358°,
|b| < 1.5°

LAS: 21-40 arcmin
RMS:~ 10 – 15 μJy/beam
Res: 8 arcsec

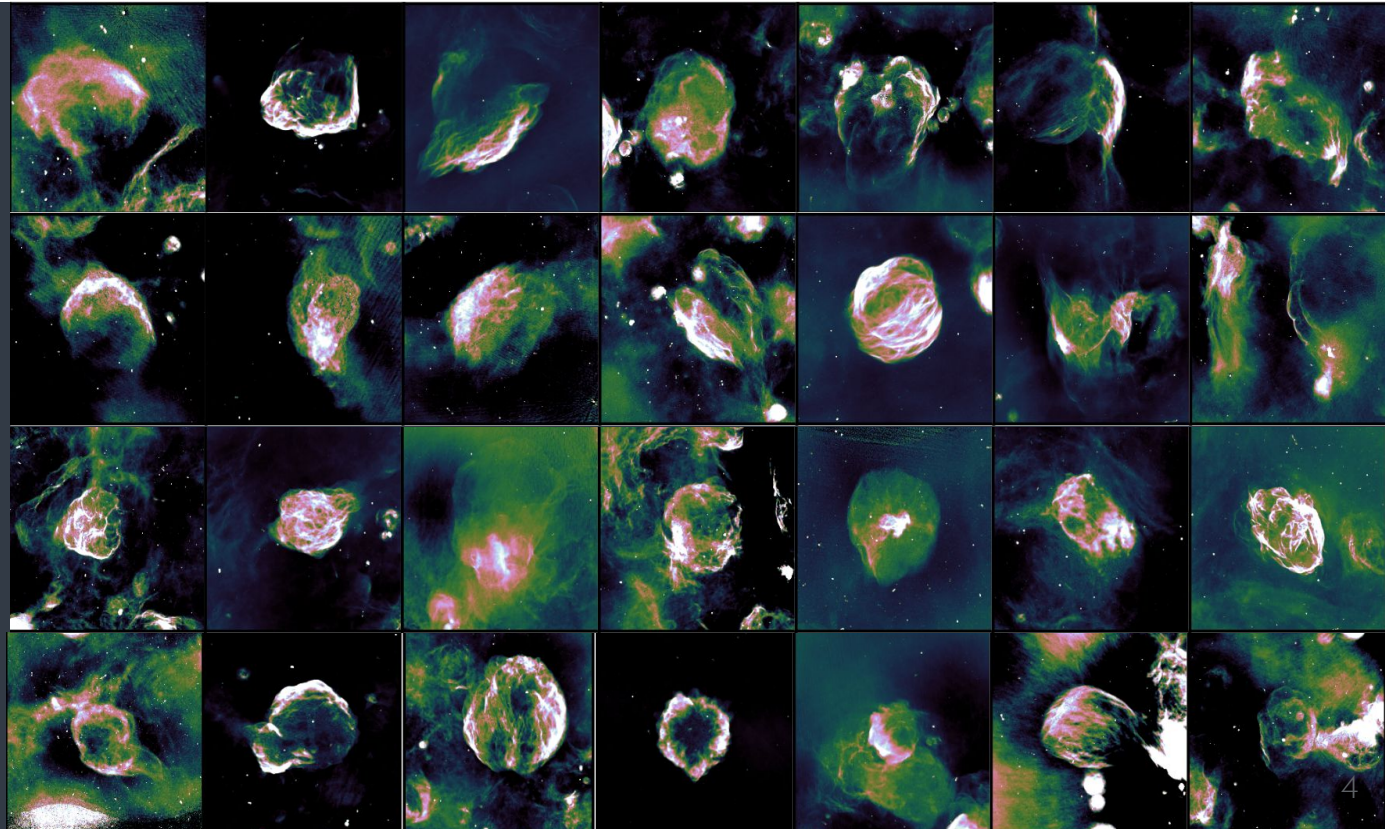
The sample

29 known SNRs

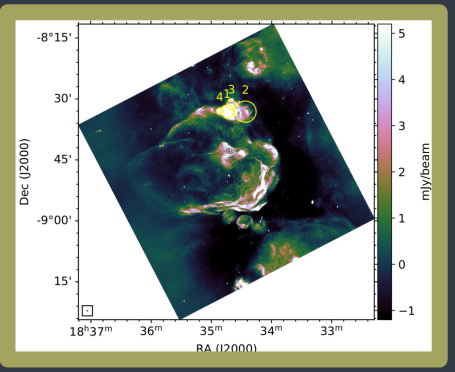
MeerKAT images at 1.284 GHz

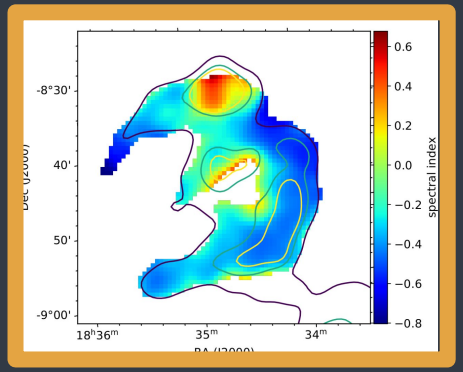
Ancillary data: GLEAM (MWA) at 0.088, 0.118, 0.154 and 0.200 GHz

Loru et al. (submitted)

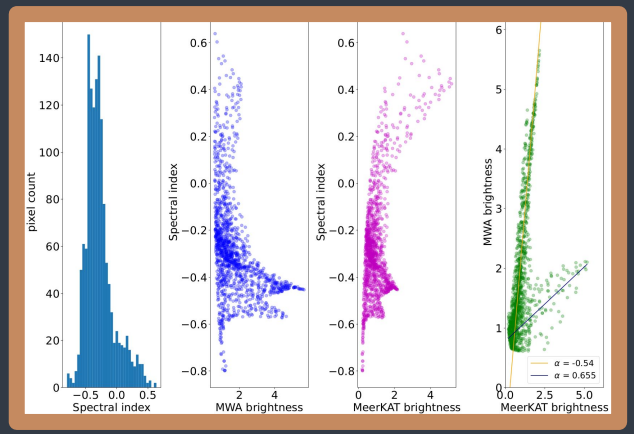


Spectral investigation strategy





G023.3-0.3



Constrain the remnant morphology and distinguish it from unrelated sources:

the morphological details provided by the **high-resolution SMGPS images**

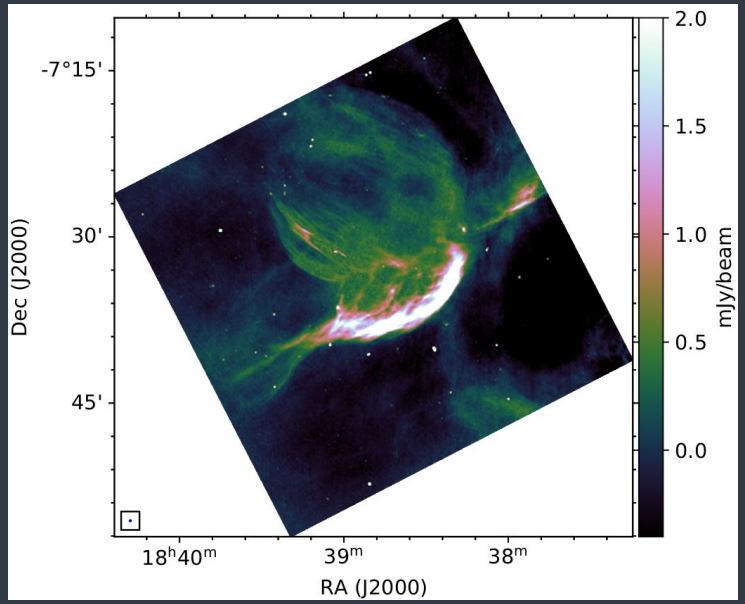
the spatial distribution of the spectral indices observed in the MeerKAT-MWA **spectral index maps (0.155-1.284 GHz)**

graphs obtained from the combined inspection of the spectral index and brightness maps

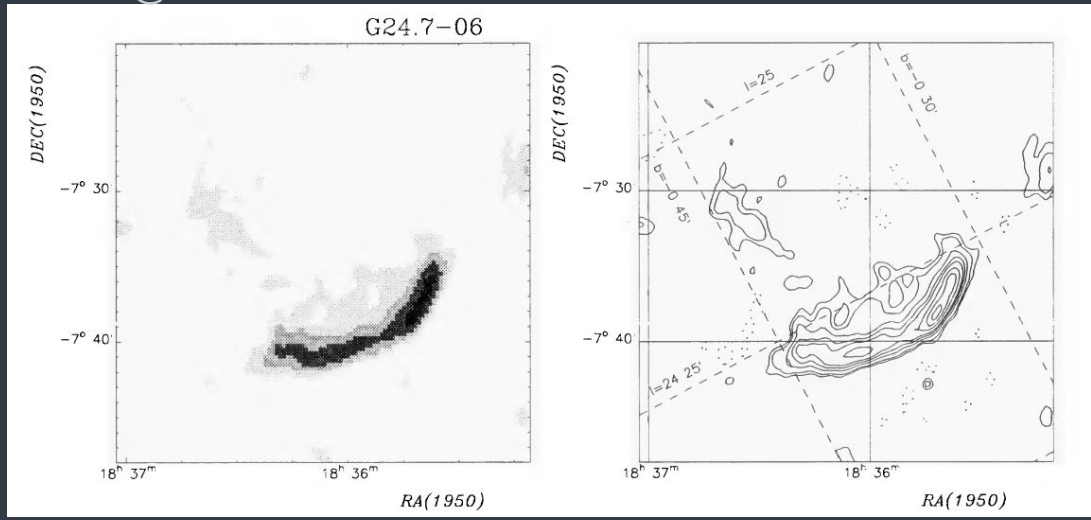
Results: morphological insights

Exploit the high resolution SMGPS images to redefine the SNR morphology

G024.7-0.6



VLA @ 1.4 GHz

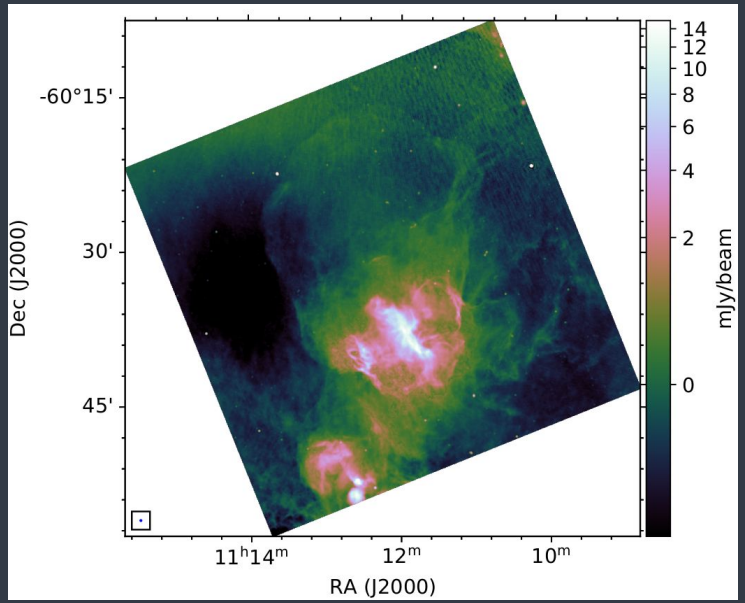


Dubner et al. (1993)

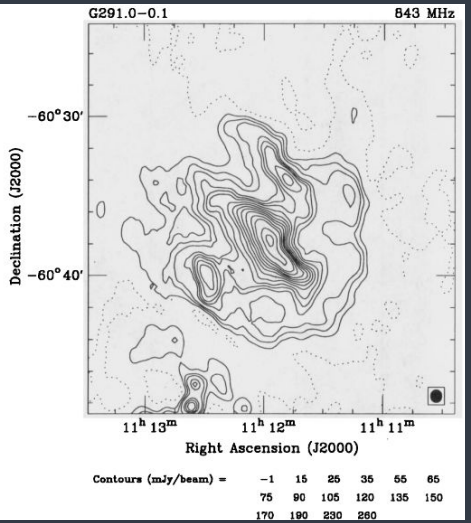
Results: morphological insights

Exploit the high resolution SMGPS images to redefine the SNR morphology

G291.0-0.1

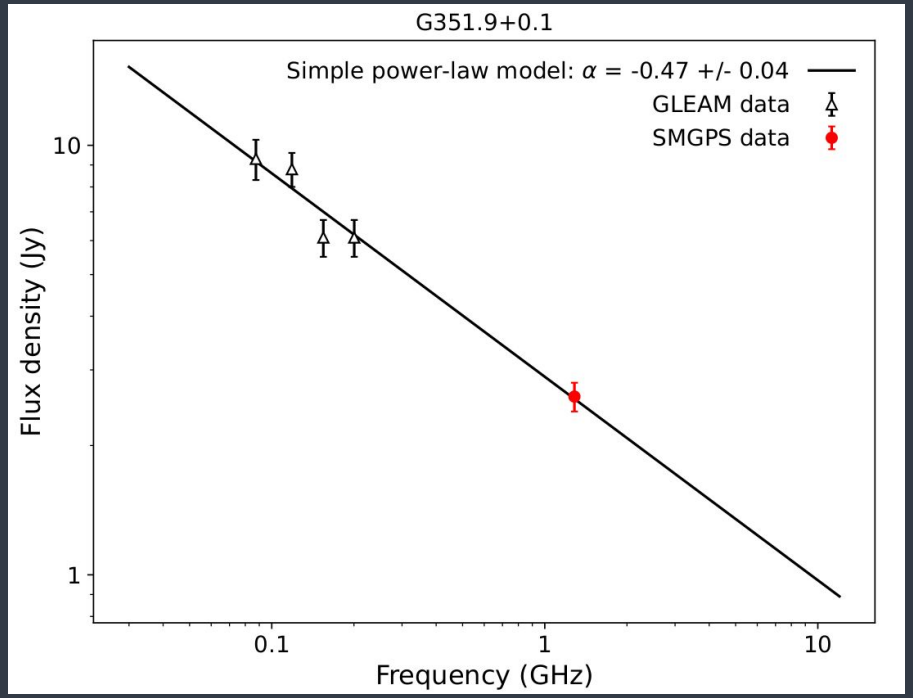


MOST @ 0.843 GHz



Whiteoak & Green (1996)

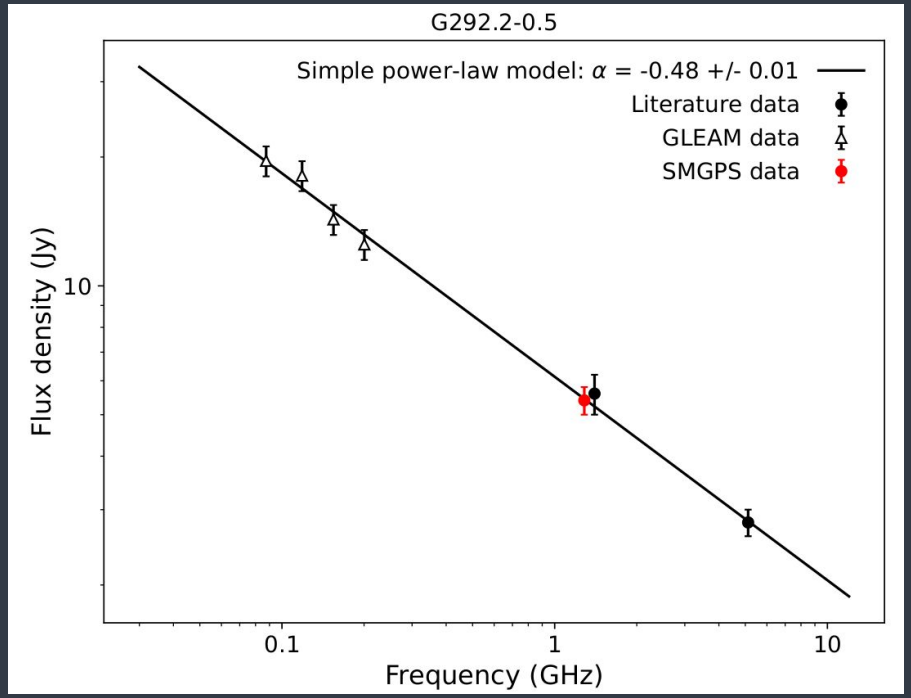
Results: integrated spectral indices



The large frequency span between the new SMGPS and MWA data allowed us to:

determine for the first time the integrated spectrum of very poorly studied objects.

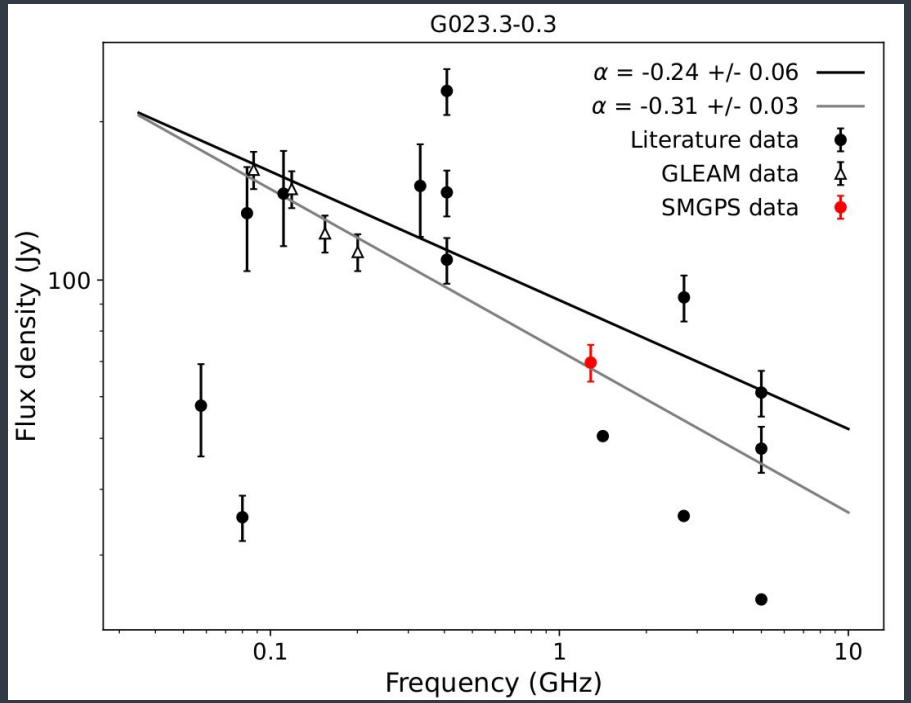
Results: integrated spectral indices



The large frequency span between the new SMGPS and MWA data allowed us to:

- determine for the first time the integrated spectrum of very poorly studied objects.
- verify the spectral trend of the SNRs for which only two flux densities were available in the literature.

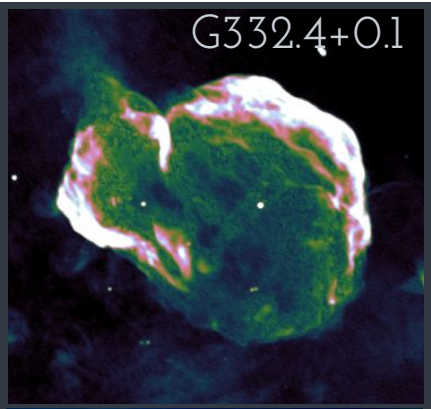
Results: integrated spectral indices

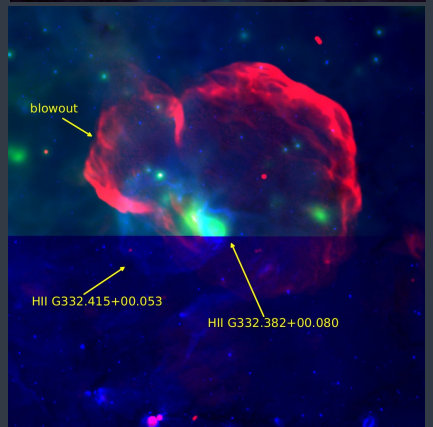


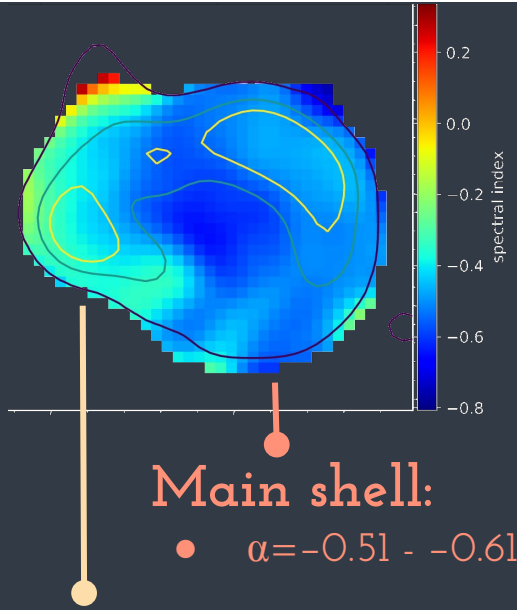
The large frequency span between the new SMGPS and MWA data allowed us to:

- determine for the first time the integrated spectrum of very poorly studied objects.
- verify the spectral trend of the SNRs for which only two flux densities were available in the literature.
- better constrain the integrated spectral index of SNRs with highly scattered previous measurements.

Results: spatially resolved spectral indices





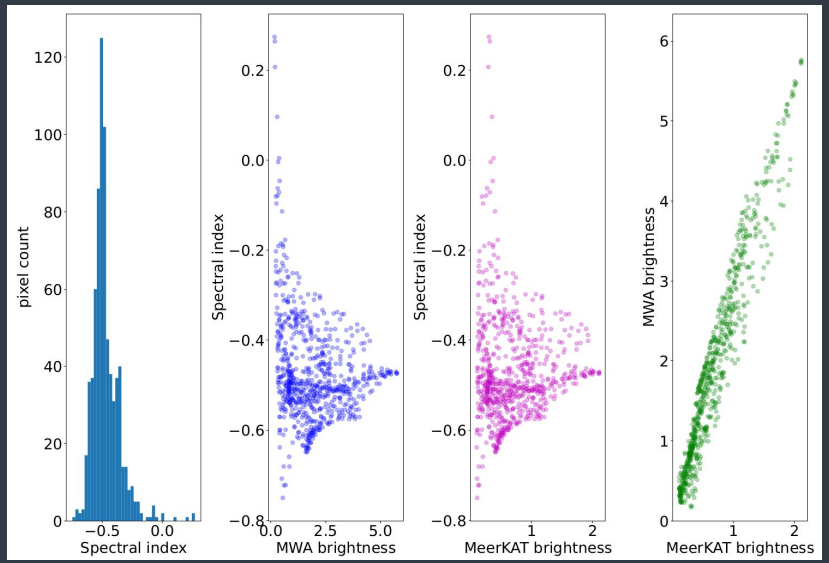


Main shell:

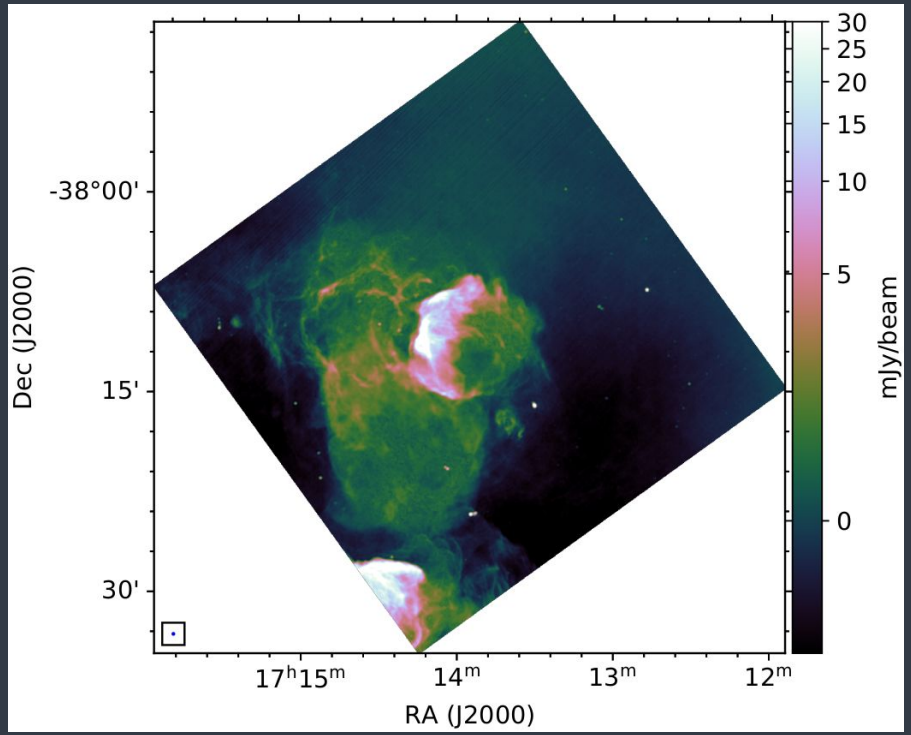
- α=−0.51 - −0.61

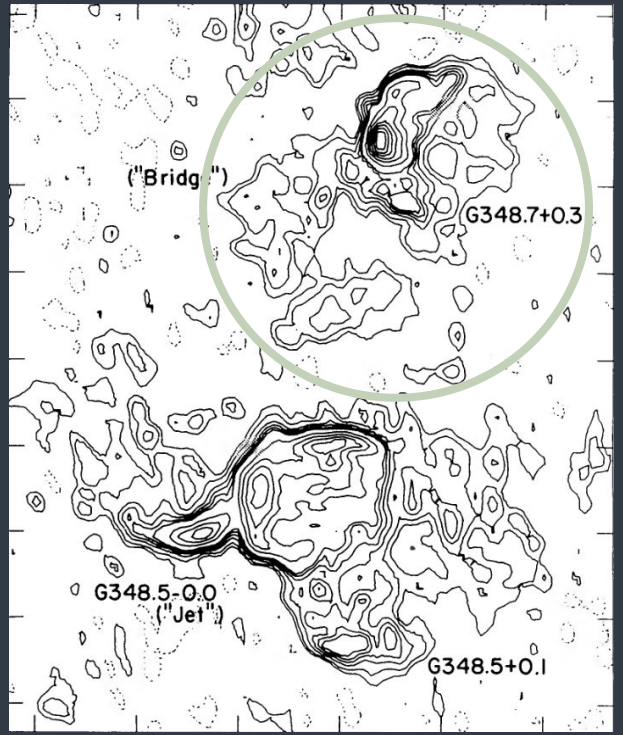
Blowout region:

- α=−0.35
- No IR emission



Highlights: G348.7+0.3





Kassim et al. (1991)

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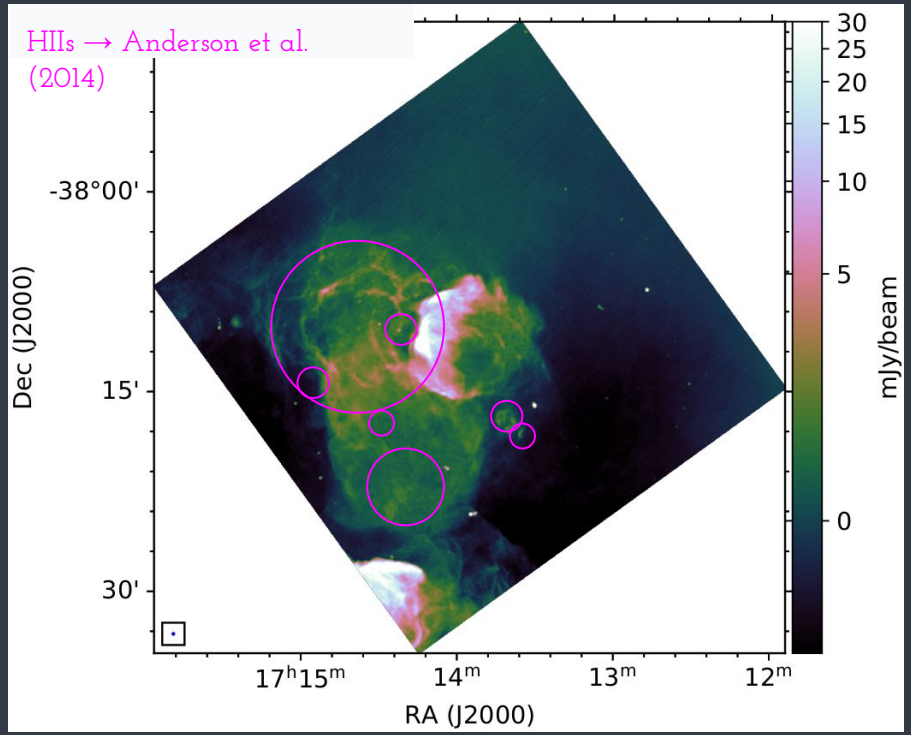
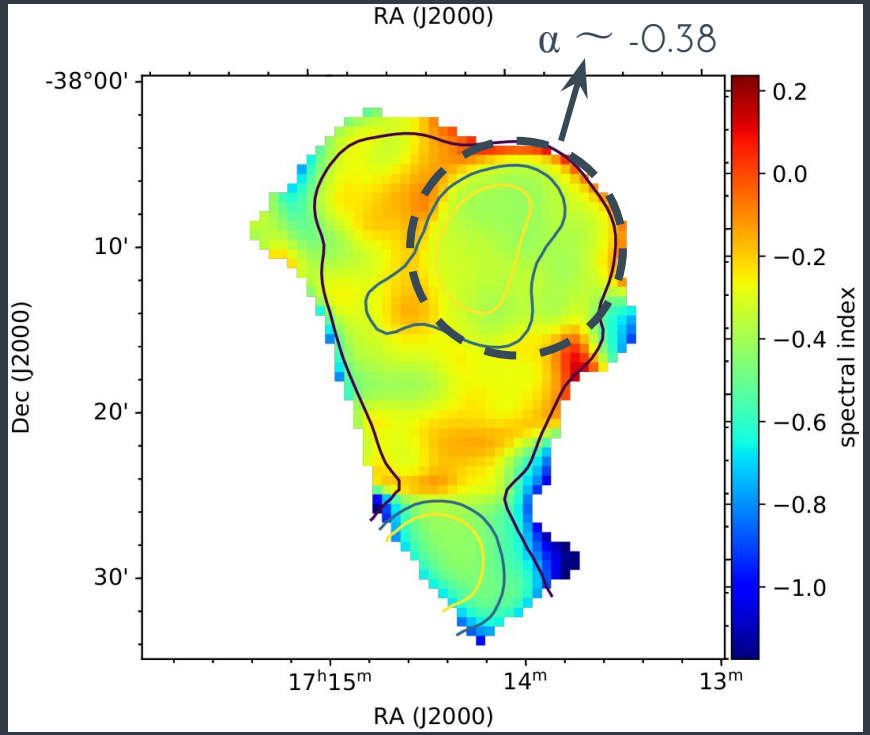
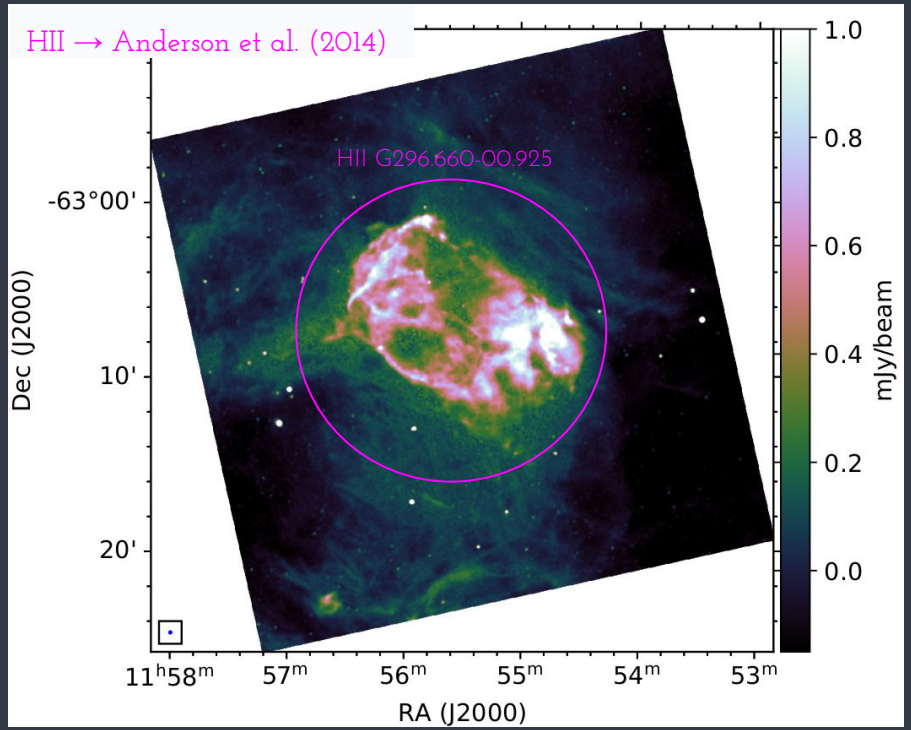




Highlights: G296.7-0.9



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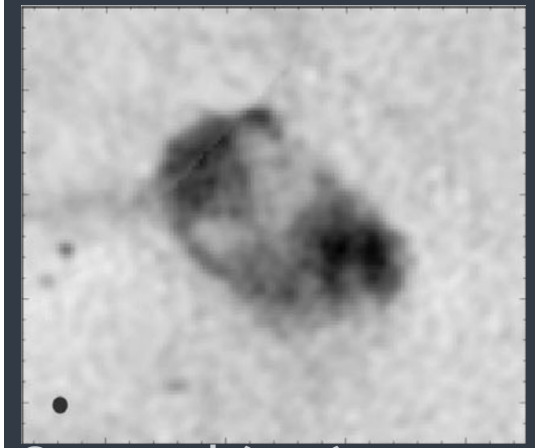
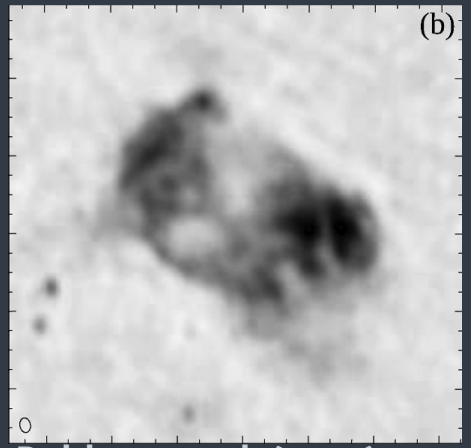


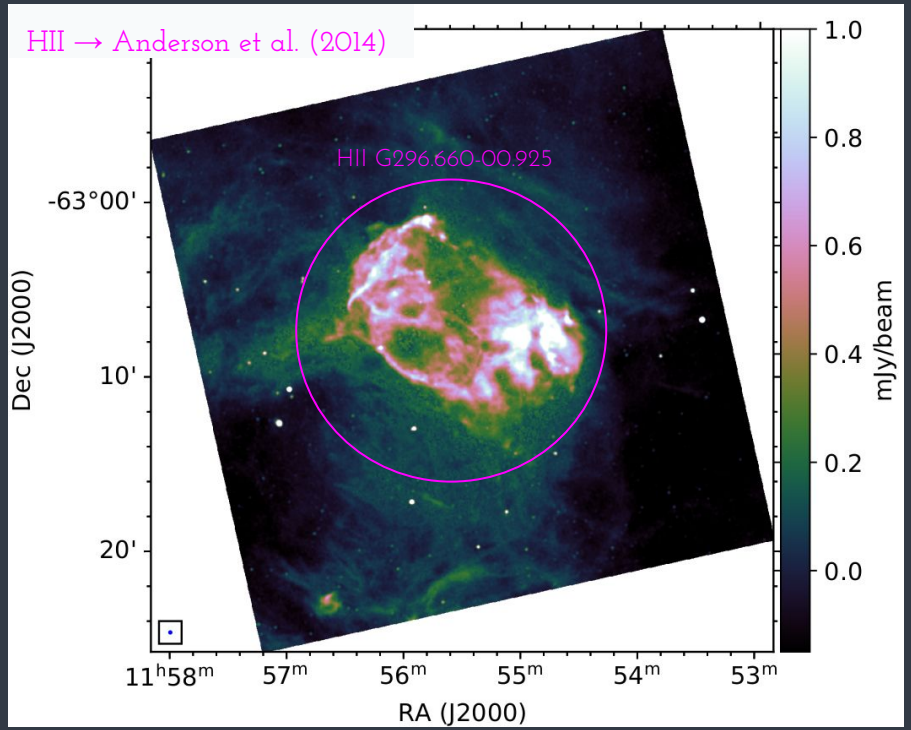
Green et al. (2014)

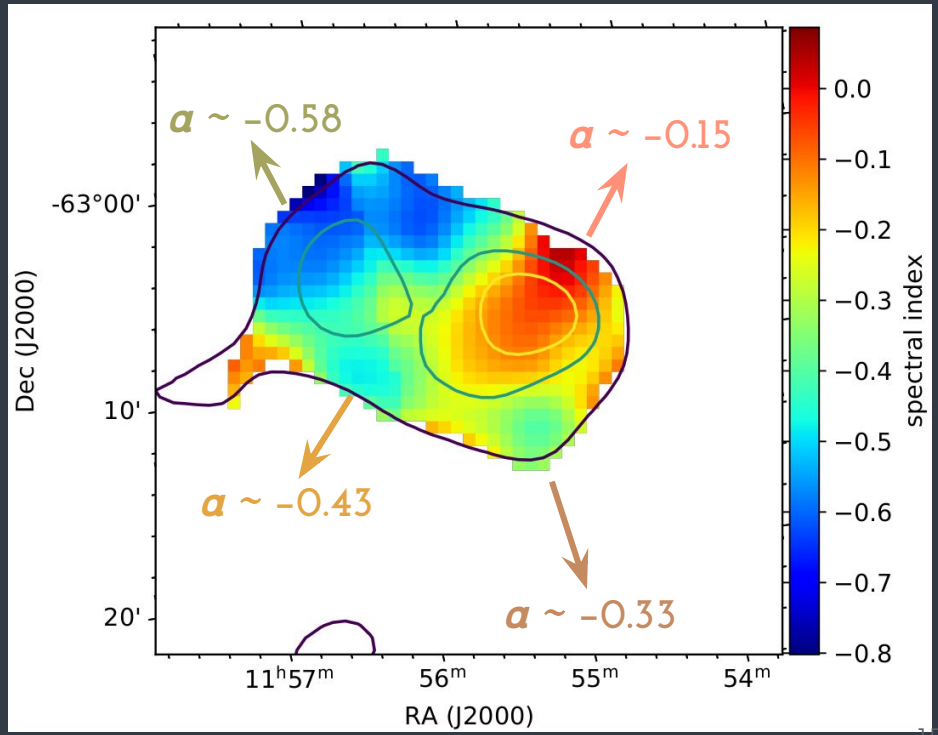
ATCA @ 1.4 GHz



Robbins et al. (2012)

Highlights: G296.7-0.9





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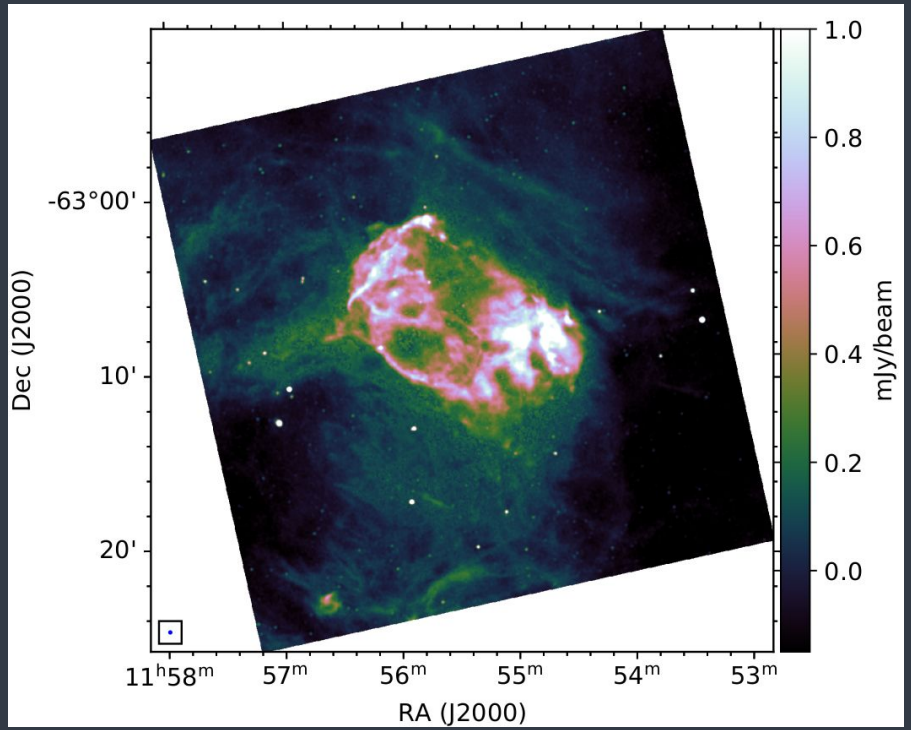
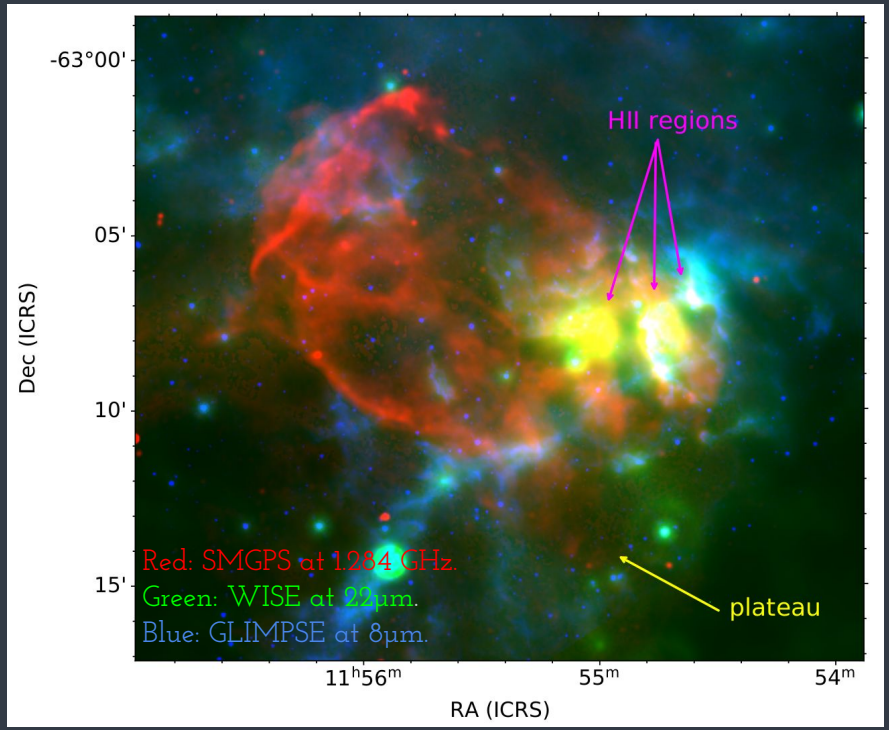
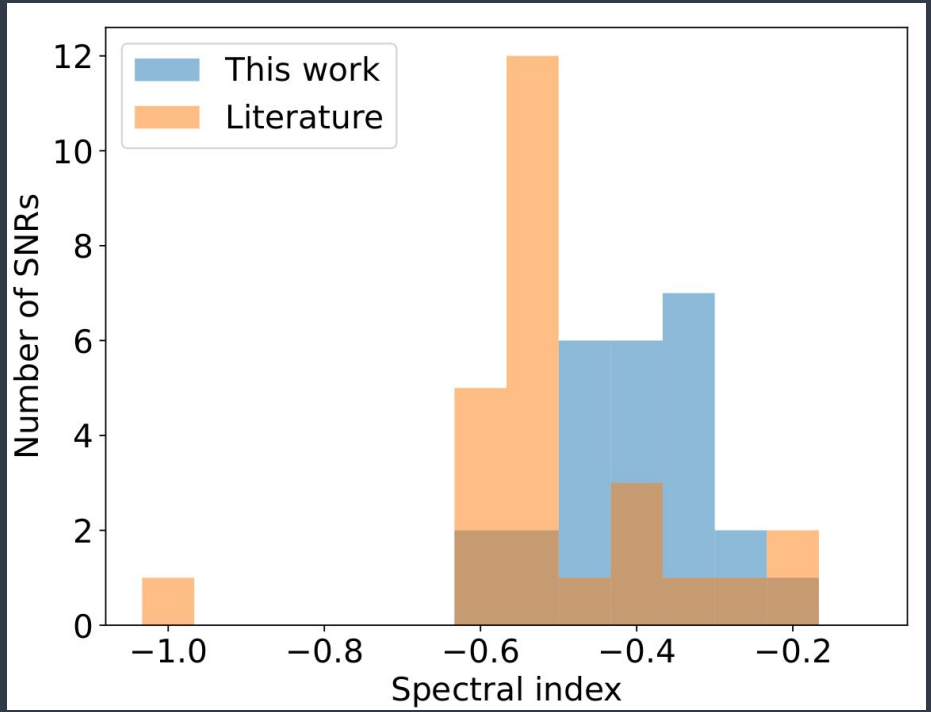




Spectral behavior through the SNR sample



Literature (*α* from Green catalog 2021):
spectral indices between –0.5 and –0.6 for a large number of objects, as expected on the basis of the DSA theory

This work (*α* from integrate spectra including literature+SMGPS+GLeam data):
our integrated spectral indices are more evenly distributed, with a flatter peak value centered at ~ –0.35.

Our distribution better reflects the heterogeneity of the SNR sample

Future perspectives

Higher quality spectral index maps by exploiting MeerKAT data at other frequencies (S-band)

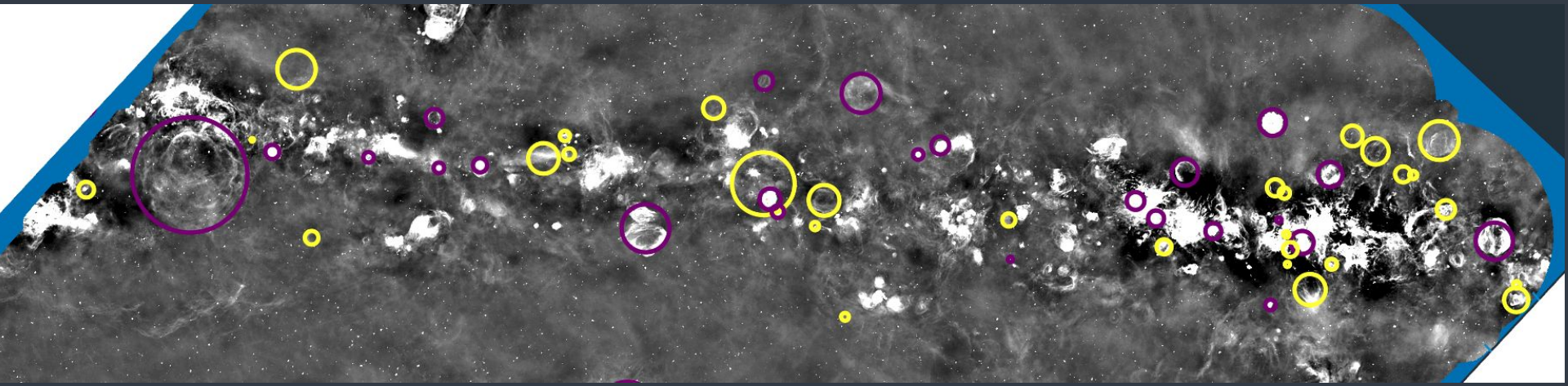
Exploit the large surveys with the SKA precursors to study a large sample of SNRs

- Catalog of extended sources: Bordiu et al. (submitted)
- Searching for new SNR candidates with the SMGPS images: Anderson et al. (in prep.)

New SNR candidates with ASKAP Pilot2: Bufano et al. in prep.

Future perspectives

New SNR candidates with ASKAP Pilot2 → Bufano et al. in prep.

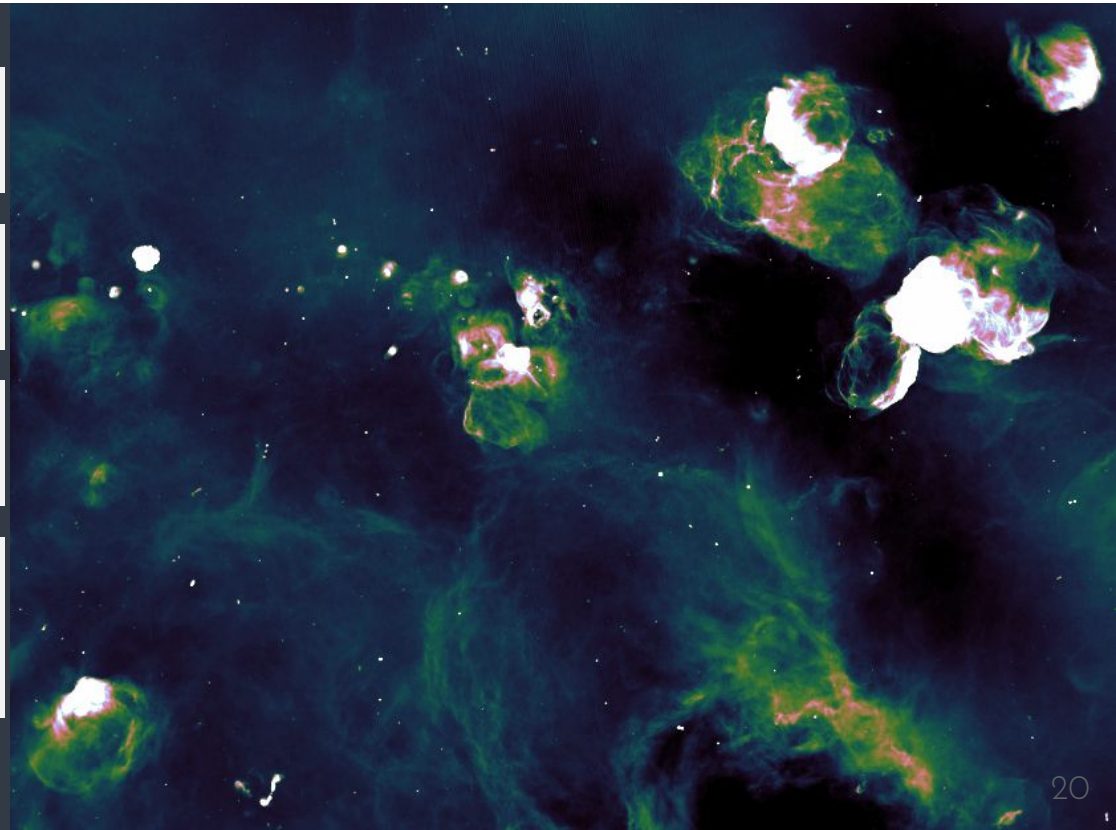


Search for new SNR candidates through comparison ASKAP Band1 with FIR data (Spitzer, Herschel Galactic Surveys) gave **28 new candidates**.

→ Confirmation on-going using spectral indexes

Summary

- High-resolution MeerKAT (SMGPS-1.284 GHz) images of 29 Galactic SNRs
- Sensitive 0.154 – 1.284 GHz spectral index maps by coupling SMGPS and GLEAM images
- Study of the spectral index distribution of the SNR sample
- Multi-wavelength study, by coupling our radio results with IR, molecular and γ-ray data to investigate CR acceleration mechanisms



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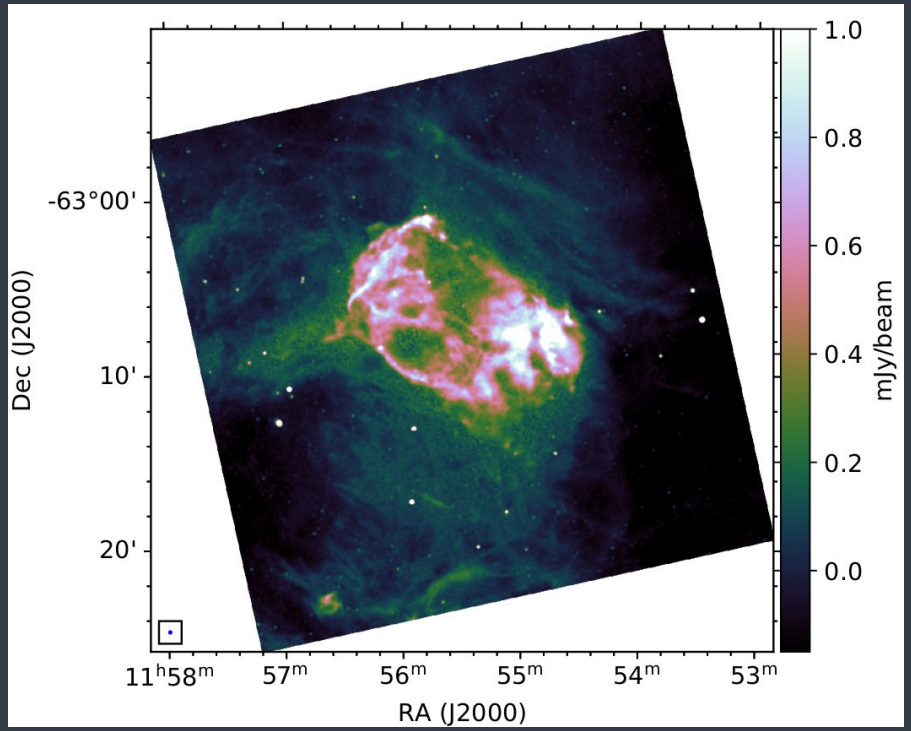
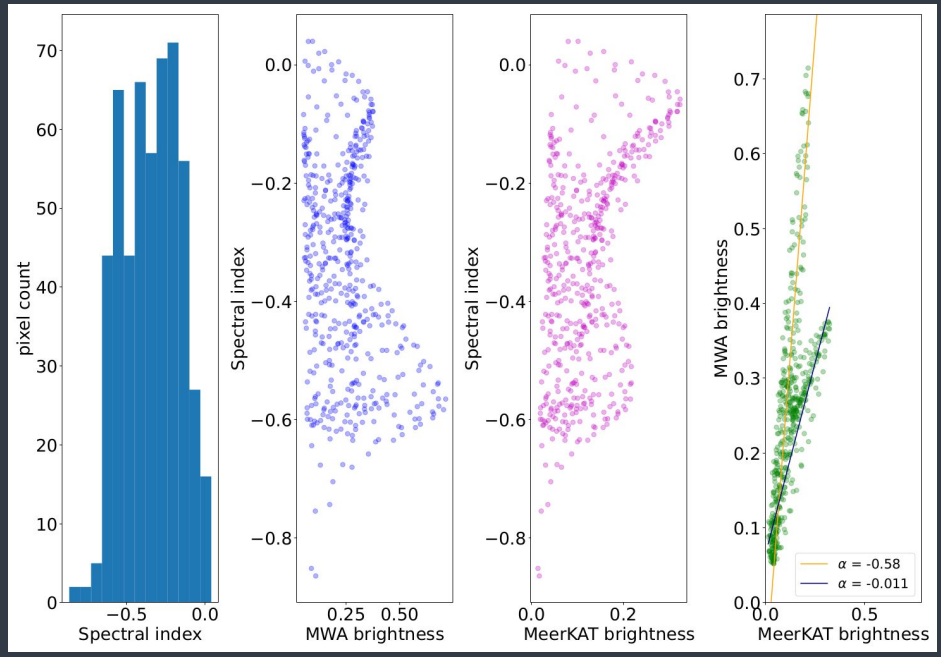
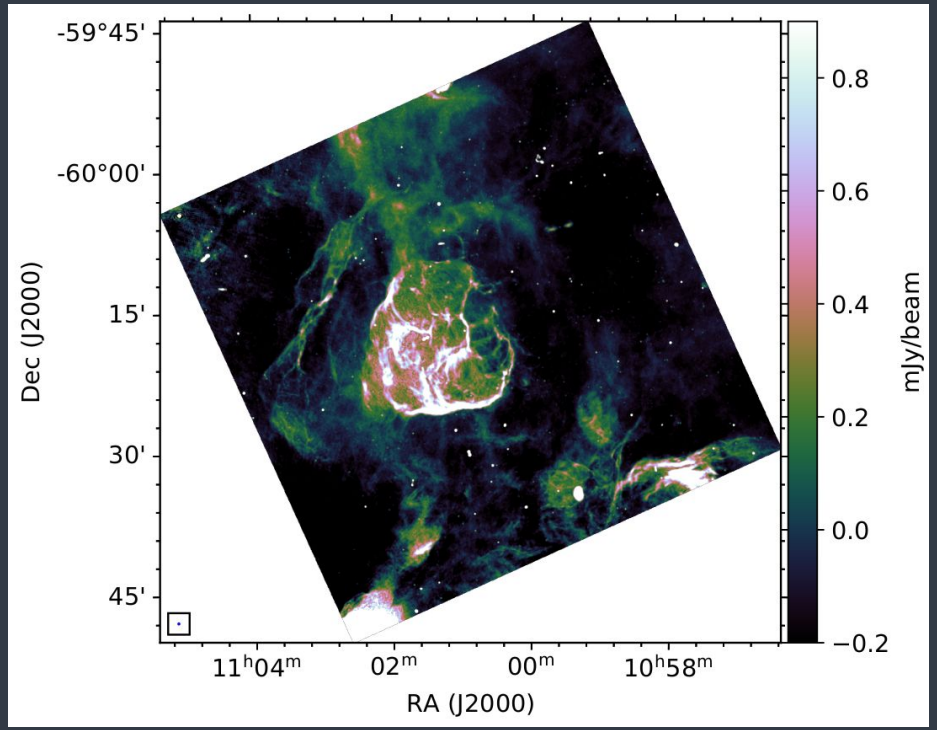
Backup slides

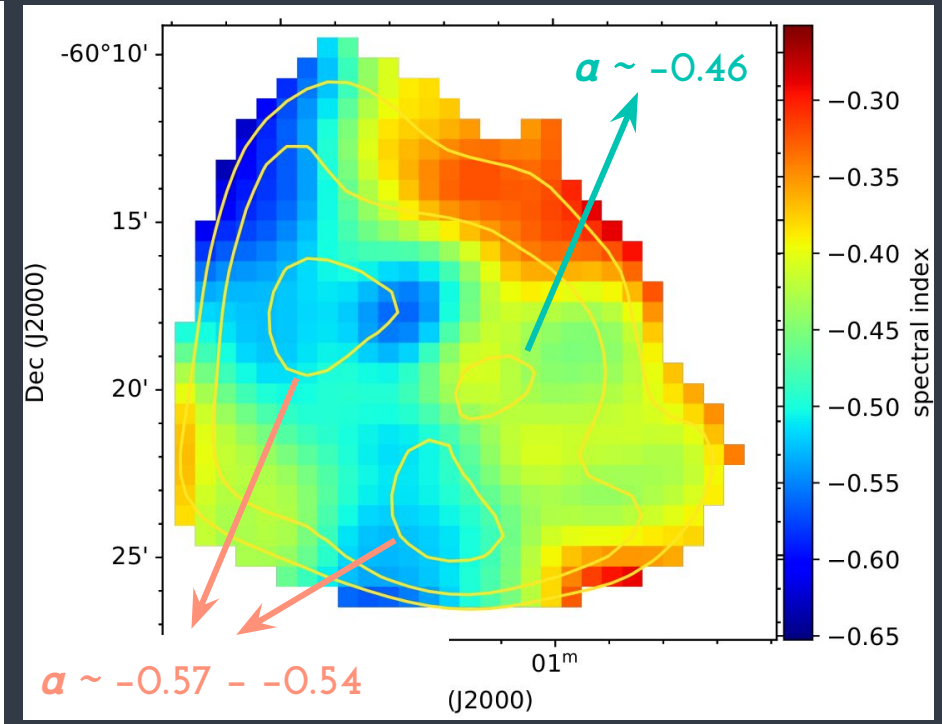
Highlights: G296.7-0.9





Highlights: G289.7-0.3





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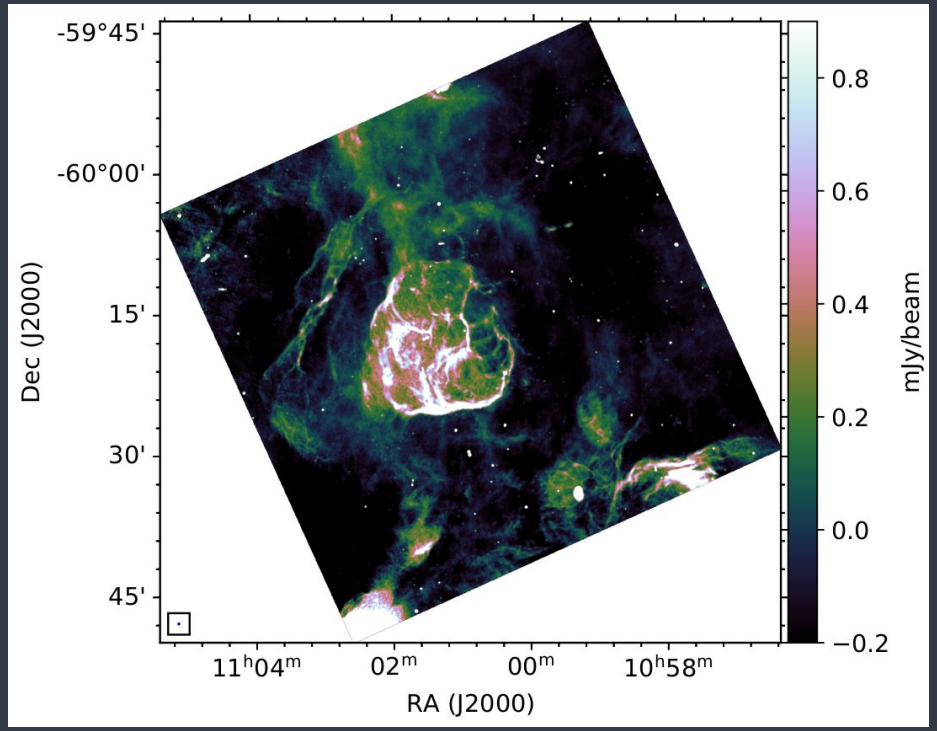

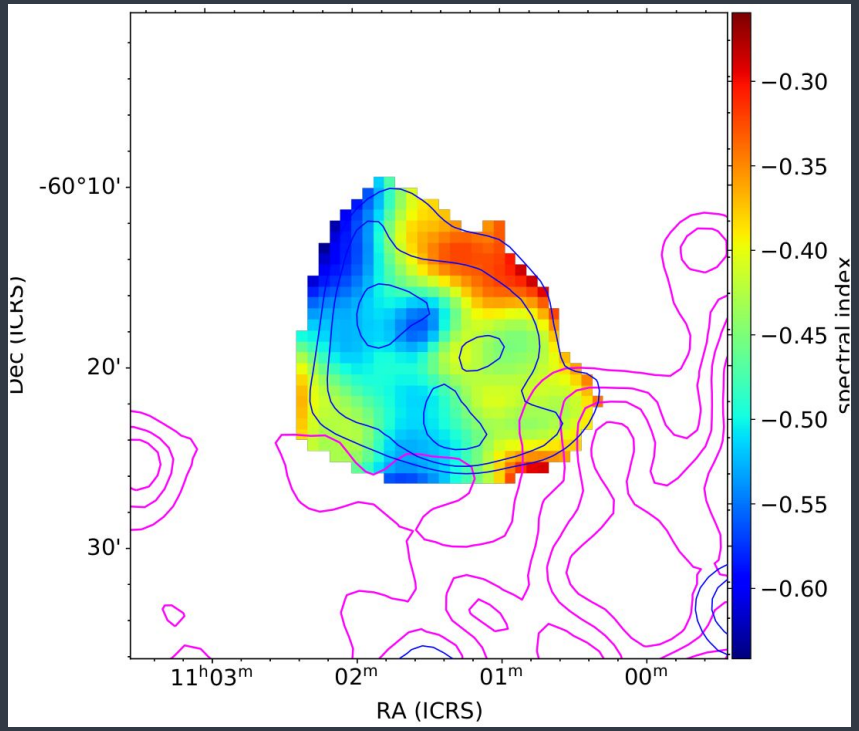

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