Survey of dust emission in Galactic supernova remnants

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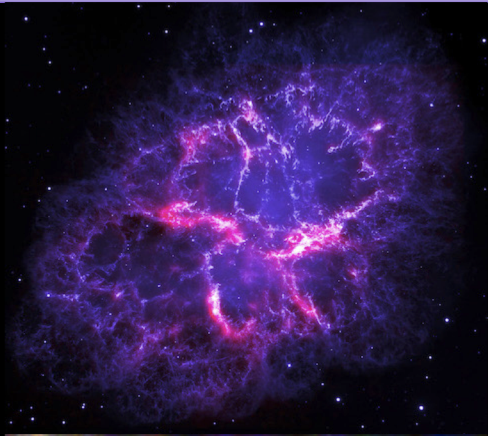
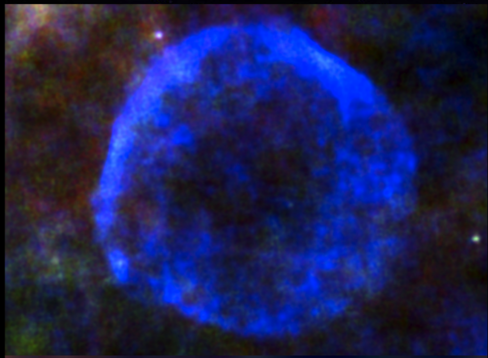
Why study supernova remnants?

- Theory predicts that supernovae can produce 0.1 – 1.0 $M_{\odot}$ of dust

- Interactions between supernova remnants and ISM cause shocks which may destroy large mass of dust

- Shocks may change the dust structure



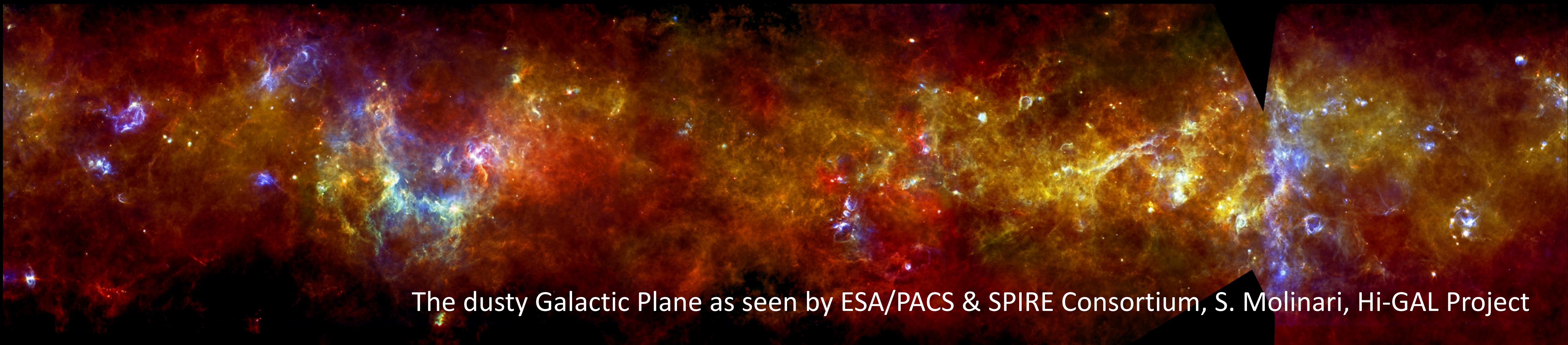


Survey of Galactic FIR supernova remnants

1 Search for dust within Galactic supernova remnants

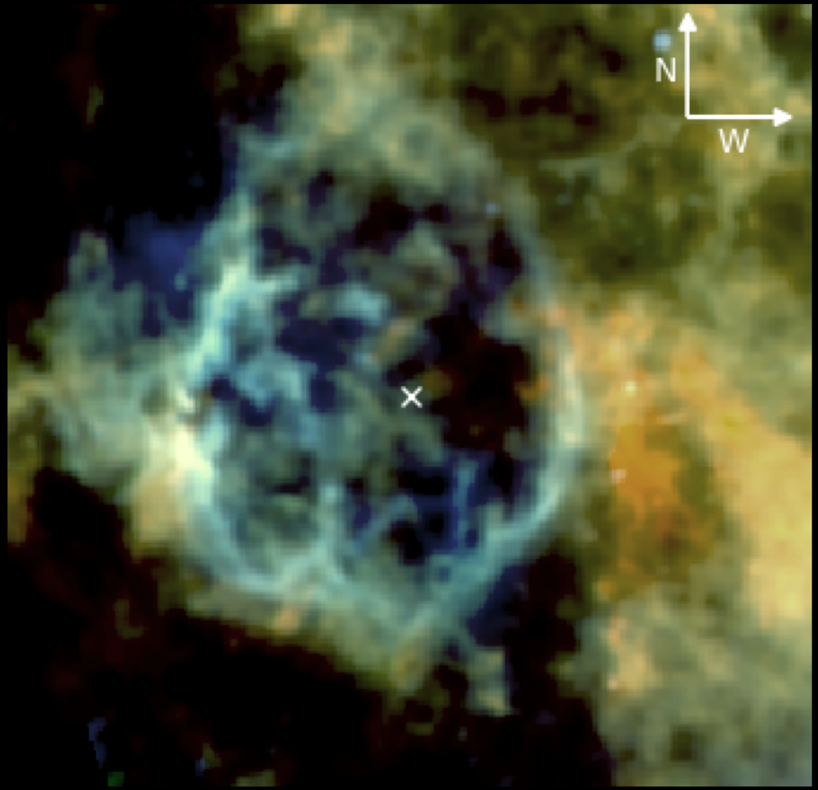
2 Measure mass of supernova ejecta dust

3 Analyse mass, temperature, and dust property variation across remnants

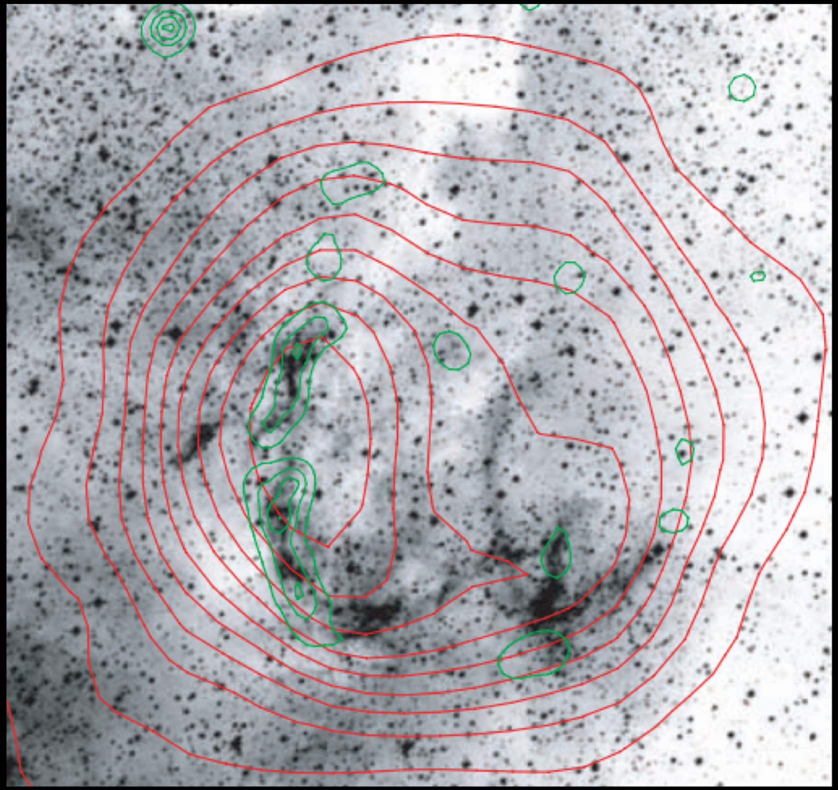


The dusty Galactic Plane as seen by ESA/PACS & SPIRE Consortium, S. Molinari, Hi-GAL Project

Supernova Remnant Identification (e.g. G11.1-1.0)



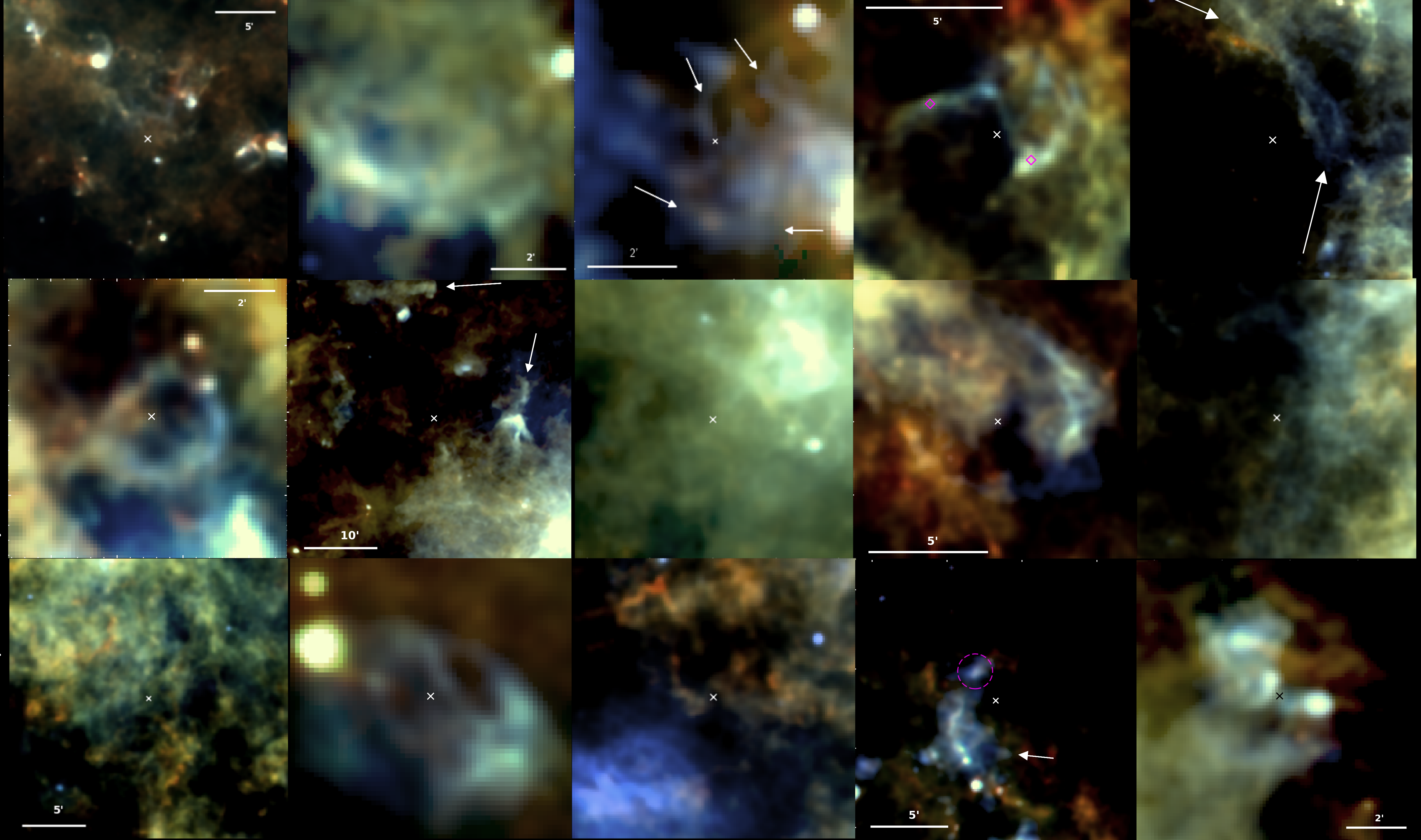
Herschel
70 µm = blue, 160 µm = green, &
250 µm = red



Hα with radio contours
Stupar & Parker, 2011

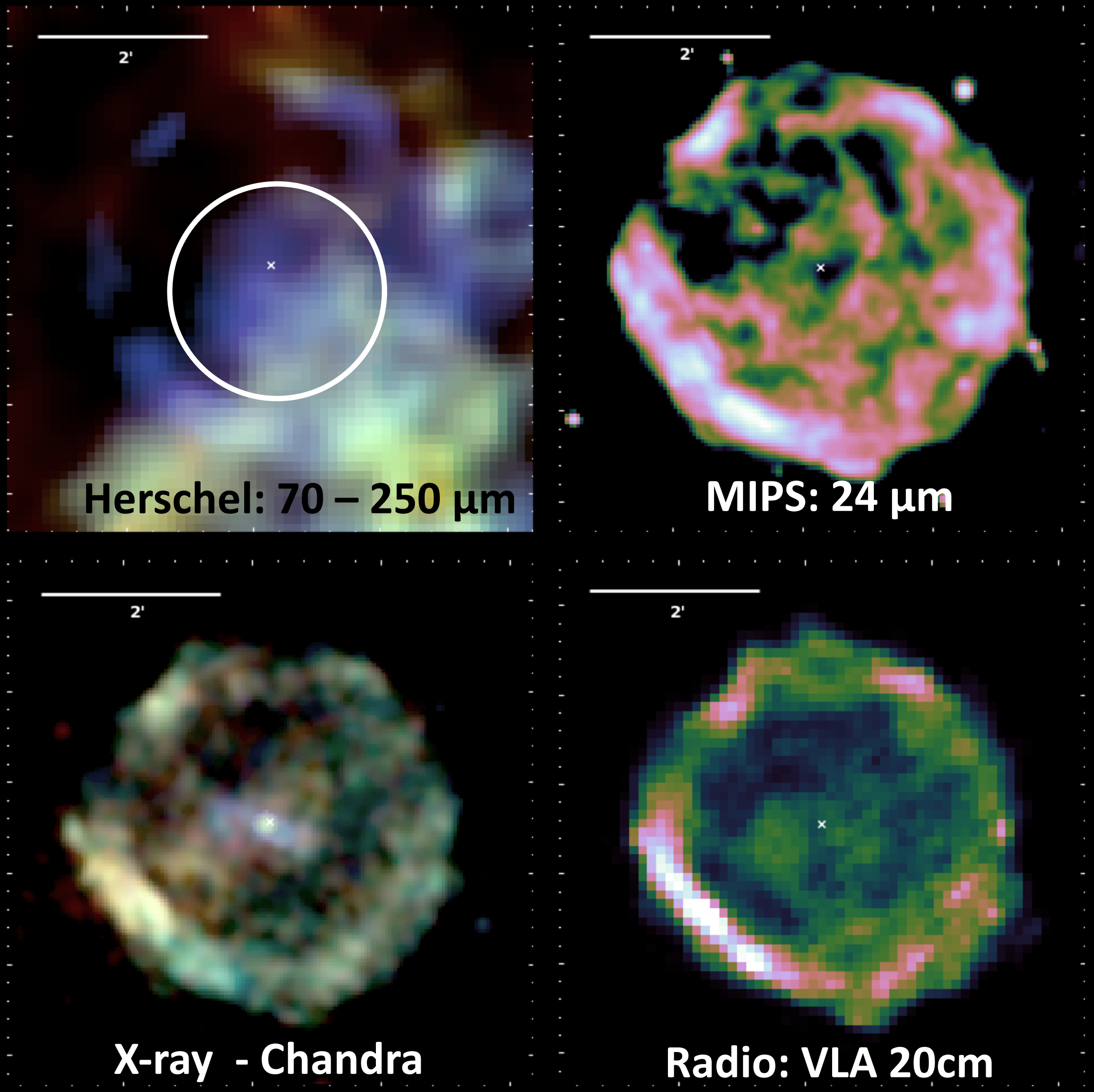
Chawner et al. (submitted)

SNR Search | SED Fitting | PPMAP Analysis



Chawner et al. (submitted)

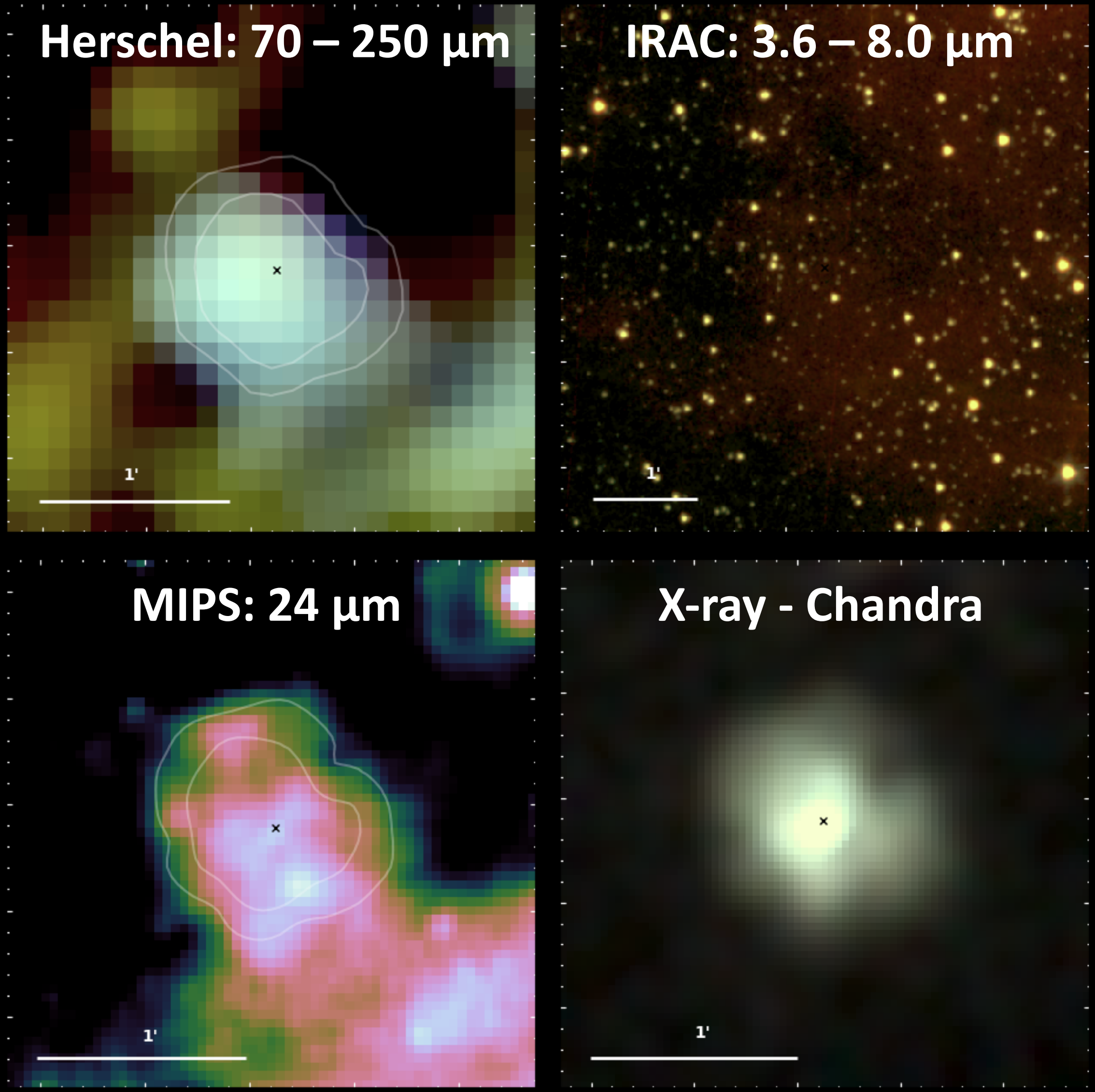
G11.2-0.3



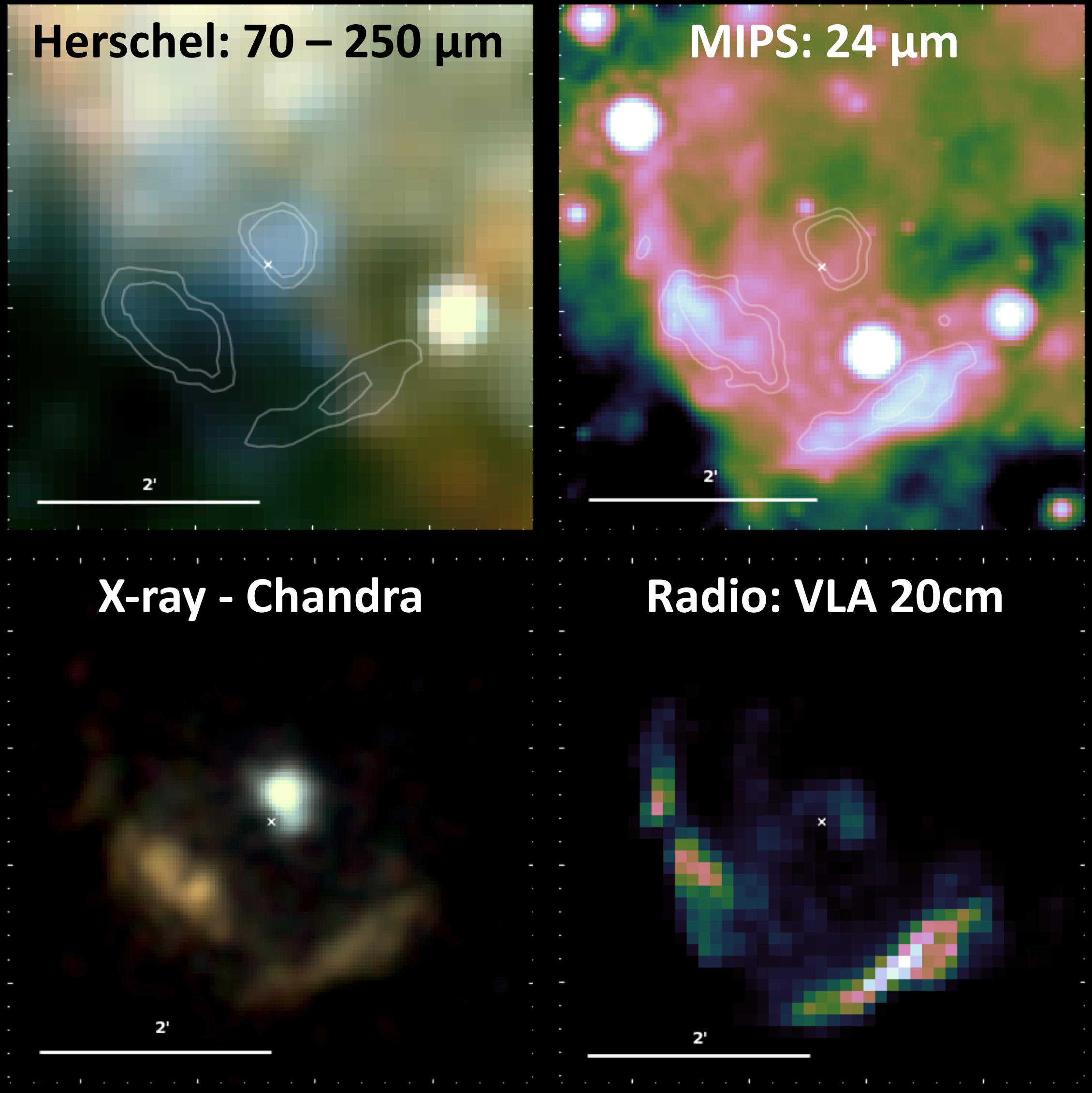
- Iron detected in shell and knots around pulsar wind nebula
- Cool ejecta dust heated by pulsar wind nebula in central region (circled)
- Reverse shock reached centre (Borkowski et al. 2016)

Chawner et al. (submitted)

G21.5-0.9



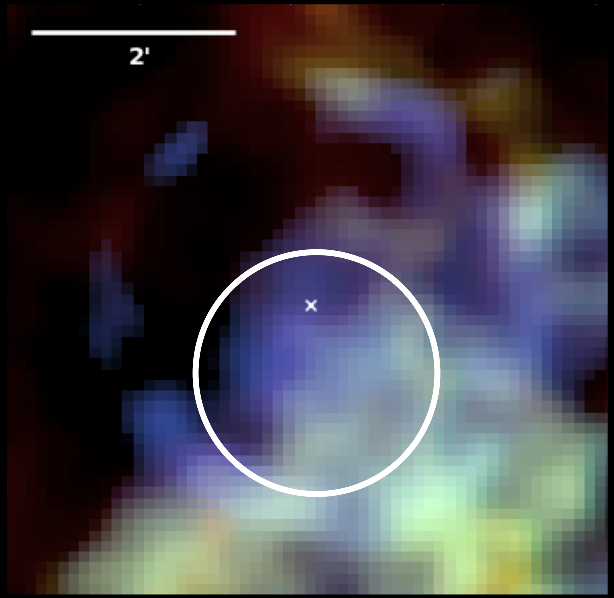
Kes 75 (G29.7-0.3)



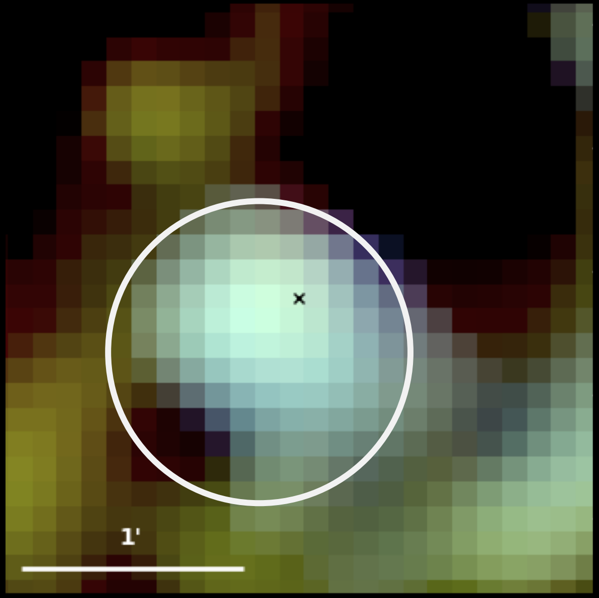
SNR Search | SED Fitting | PPMAP Analysis

Chawner et al. (submitted)

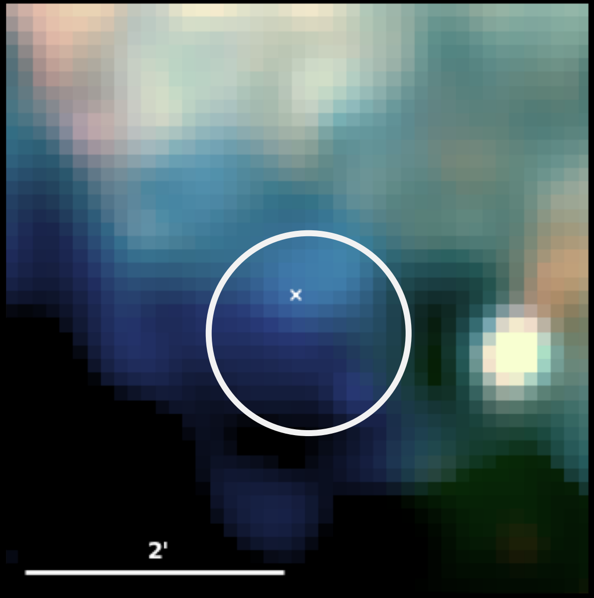
How much dust is there?



G11.2-0.3

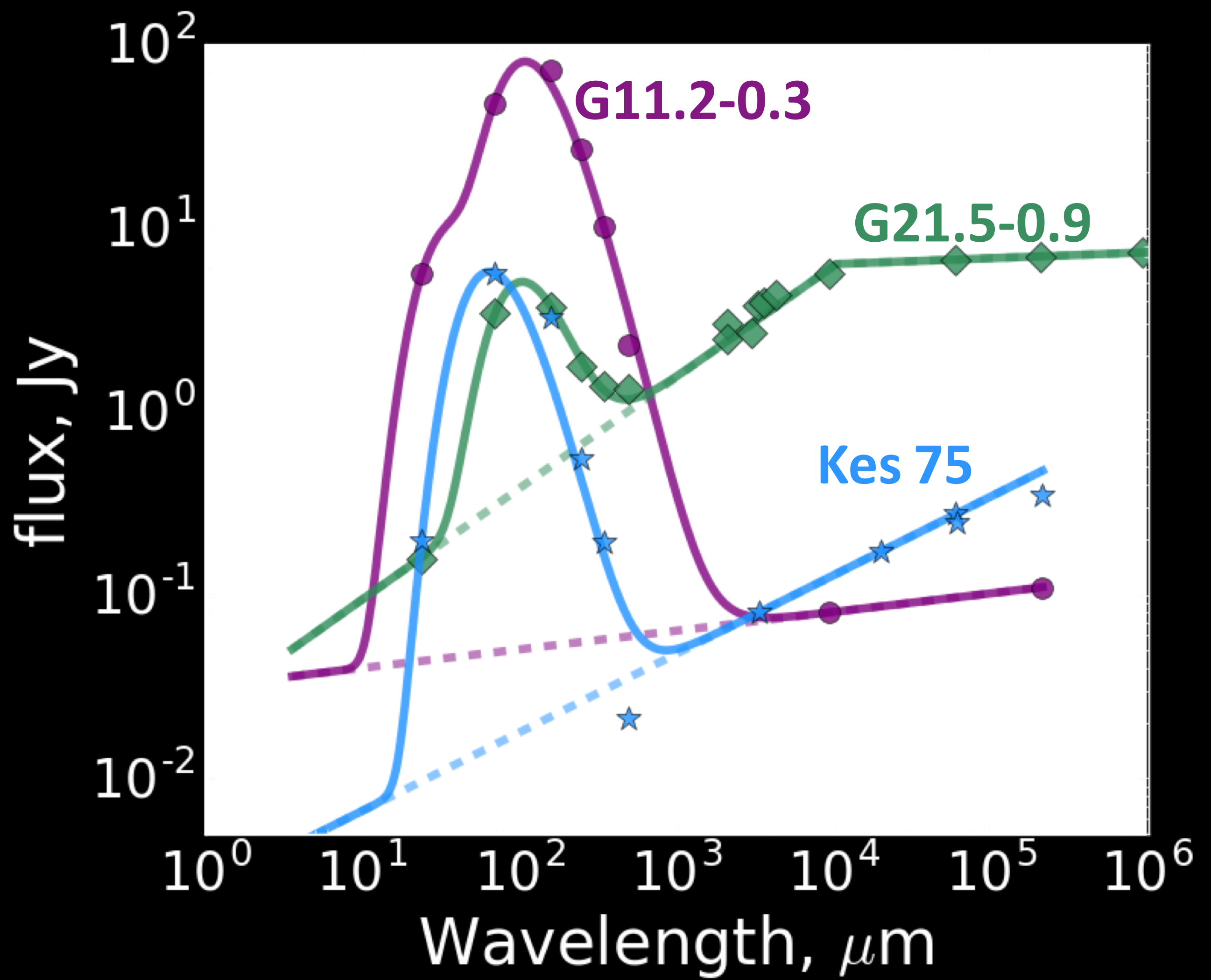


G21.5-0.9



Kes 75 (G29.7-0.3)

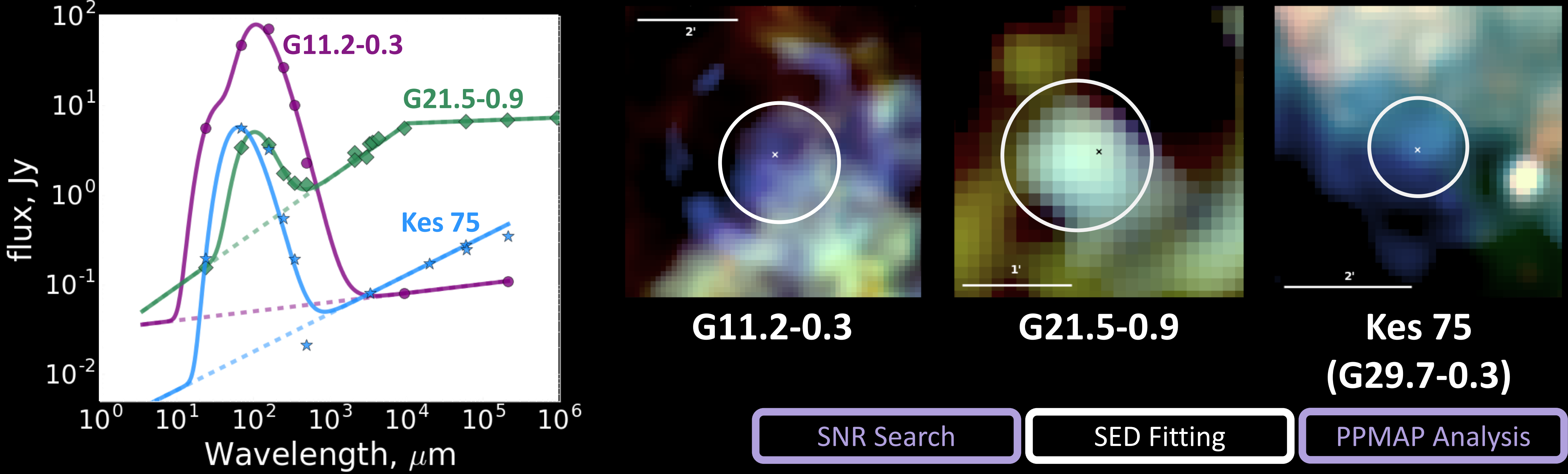
Chawner et al. (submitted)



SNR Search | SED Fitting | PPMAP Analysis

How much dust is there?

	G11.2-0.3	G21.5-0.9	Kes 75 (G29.7-0.3)
Dust Temperature: (Kelvin)	26.6	28.6	45.7
Dust Mass: ($M_\odot$)	1.0	0.05	0.03



G11.2-0.3

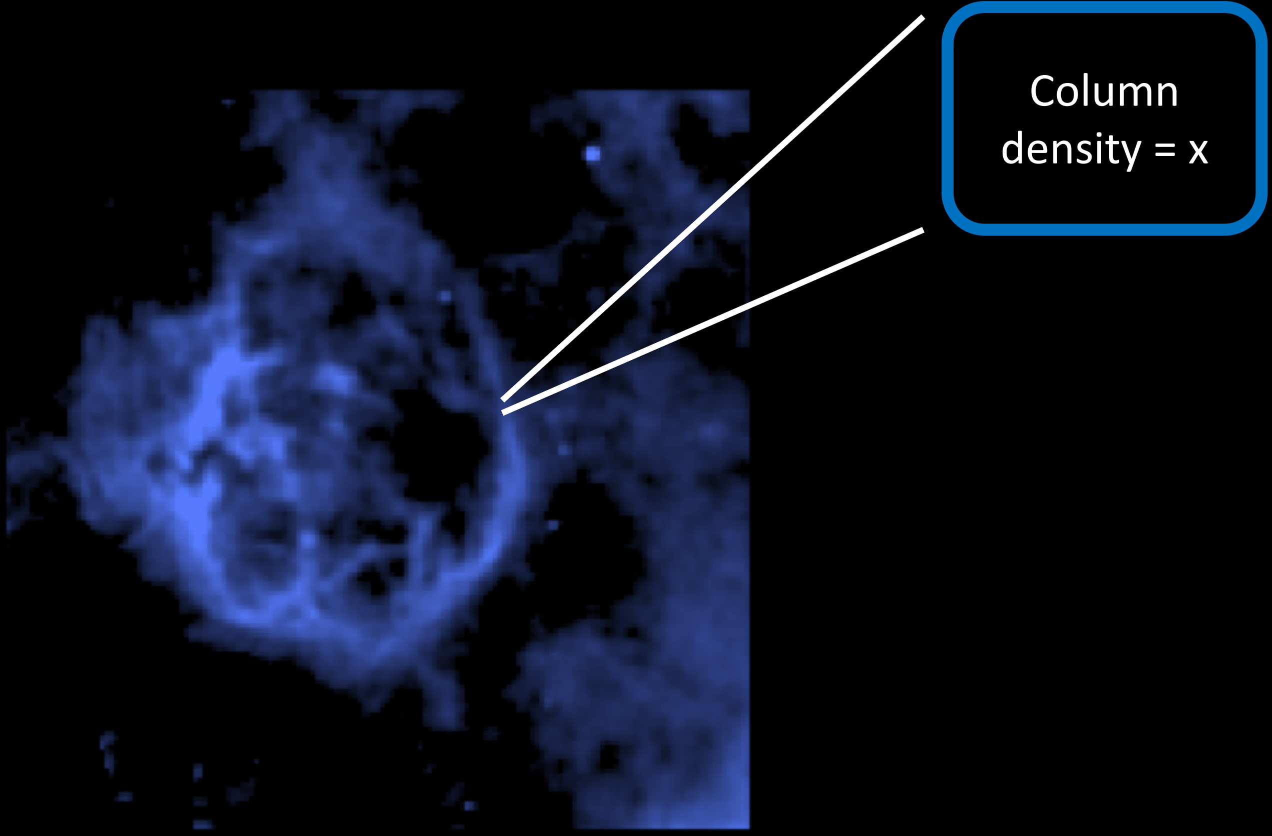
G21.5-0.9

Kes 75 (G29.7-0.3)

SNR Search | SED Fitting | PPMAP Analysis

Point Process Mapping, PPMAP

Ref: PPMAP, Marsh et al. 2015, 2017

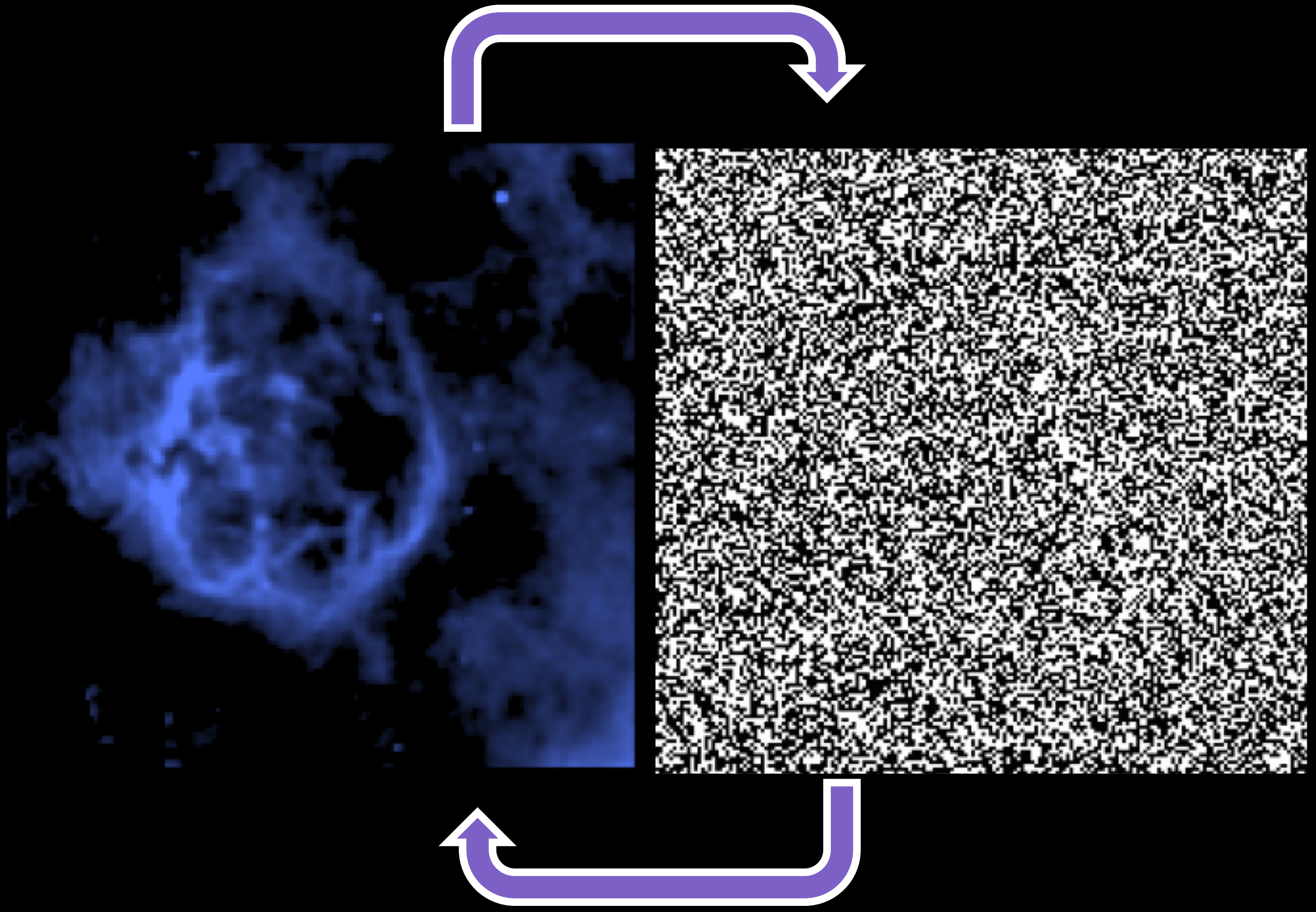


Structures are made up of building blocks with:

- Unit column density
- Unknown temperature & emissivity

Point Process Mapping, PPMAP

Ref: PPMAP, Marsh et al. 2015, 2017

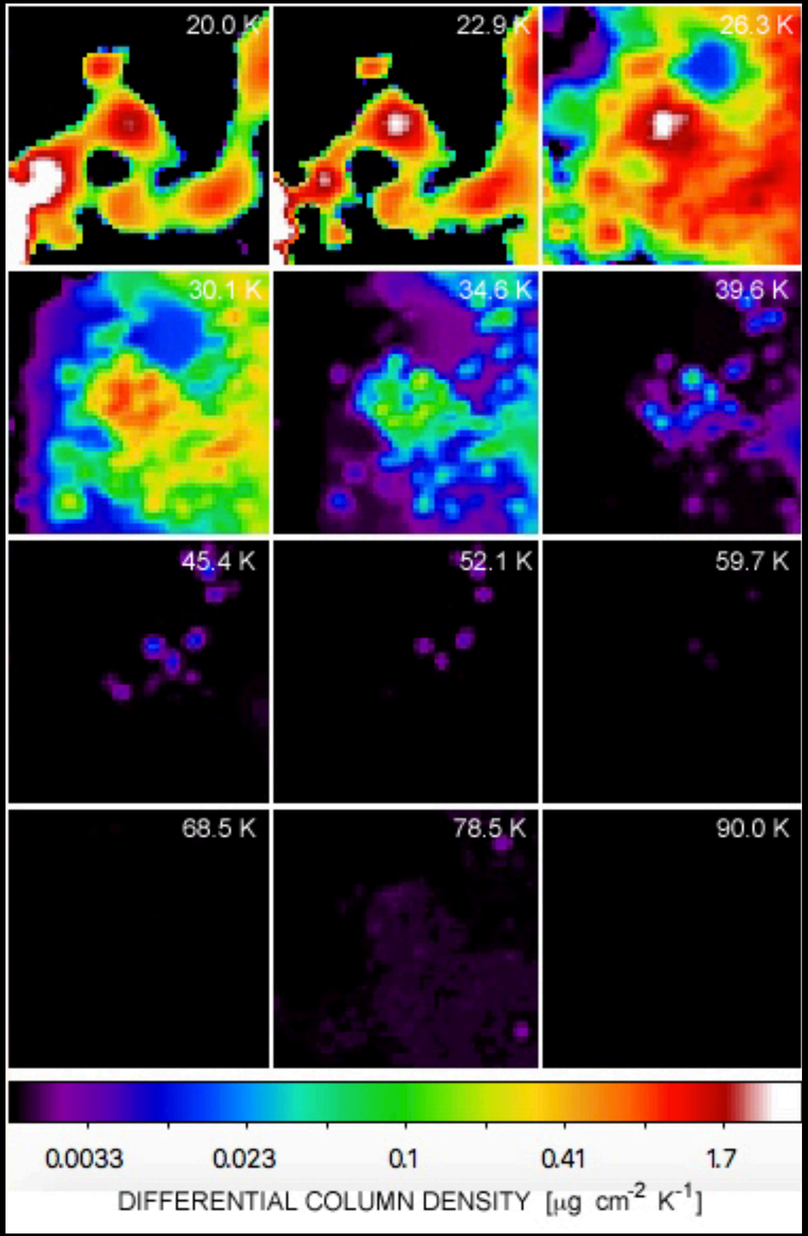


- Increase image noise until there is no information
- Decrease noise in steps
- Update knowledge about building block temperature and emissivity at each step

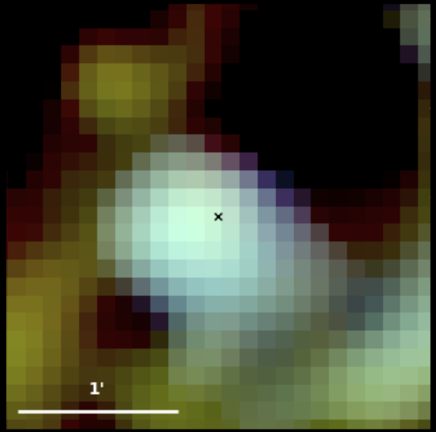
SNR Search | SED Fitting | PPMAP Analysis

At what temperatures is there dust?

Chawner et al. (submitted)



- Apply PPMAP using 6 images between 24 and 500 µm
- Analysis of dust column density across map for each temperature and emissivity
- Collapse results → grid showing the column density map at each of the 12 temperatures

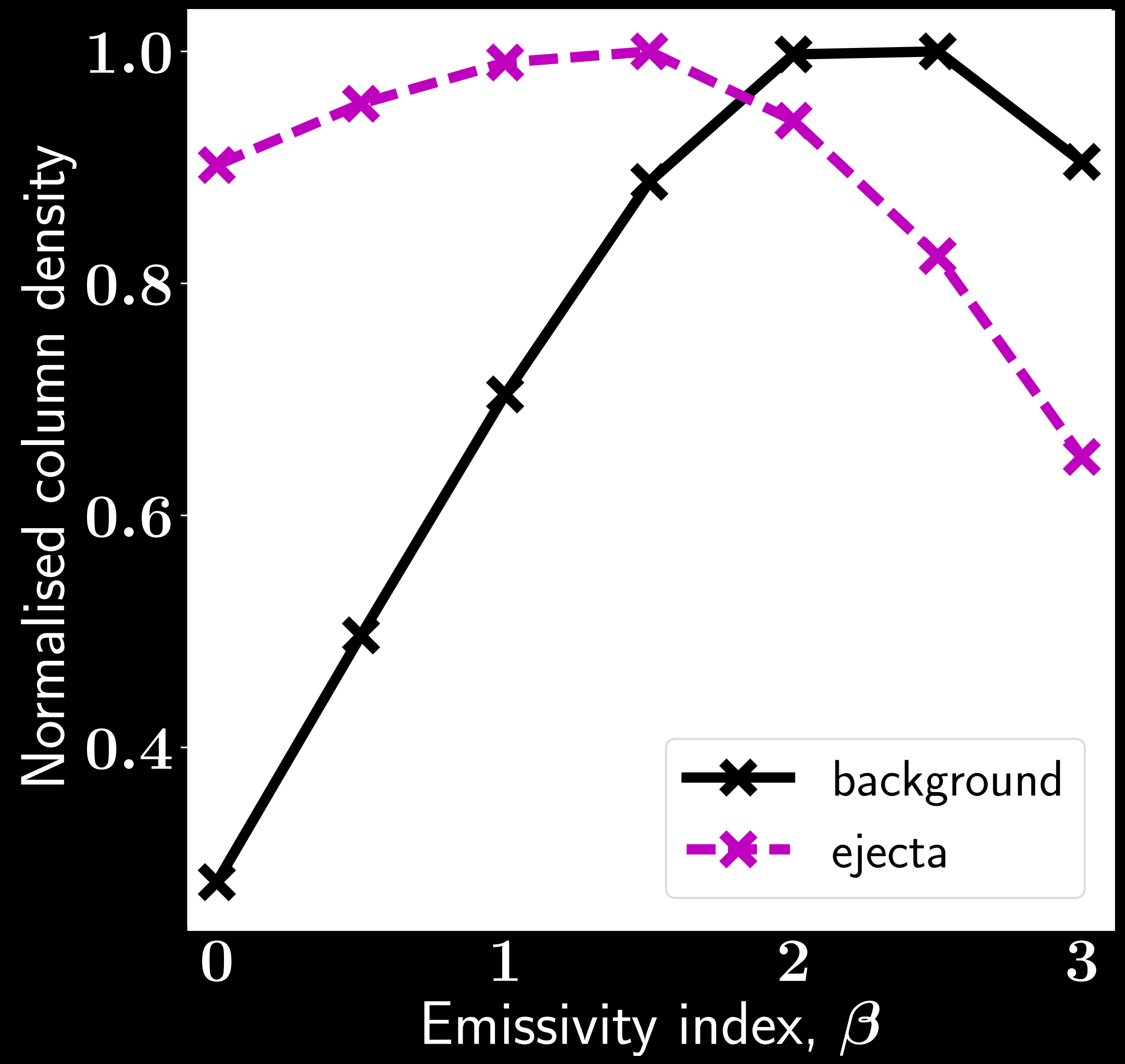


Herschel false colour image: blue = 70 µm, green = 160 µm, red = 250 µm

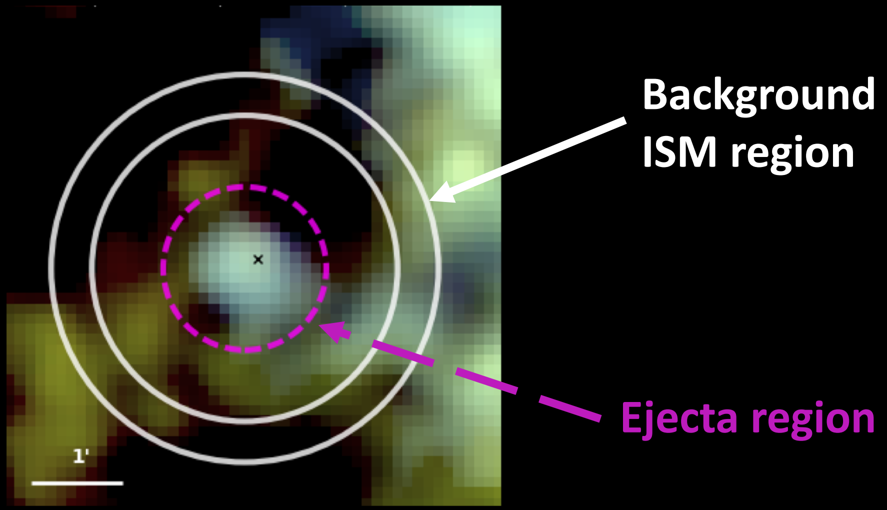
SNR Search | SED Fitting | PPMAP Analysis

Are the ejecta and ISM dust different?

Chawner et al. (submitted)



- Collapse results → maps of column density at each value of emissivity index
- Sum column density of regions within apertures
- Some evidence for variation in emissivity between ISM and ejecta



SNR Search | SED Fitting | PPMAP Analysis

How much dust is there?

SED fit dust mass ($M_\odot$)	1.0	0.05	0.03
PPMAP dust mass	0.50 ± 0.22	0.29 ± 0.08	0.64 ± 0.18

Red = 31K, green = 41K, blue = 75K

Red = 25K, green = 34K, blue = 37K

Red = 28K, green = 31K, blue = 75K

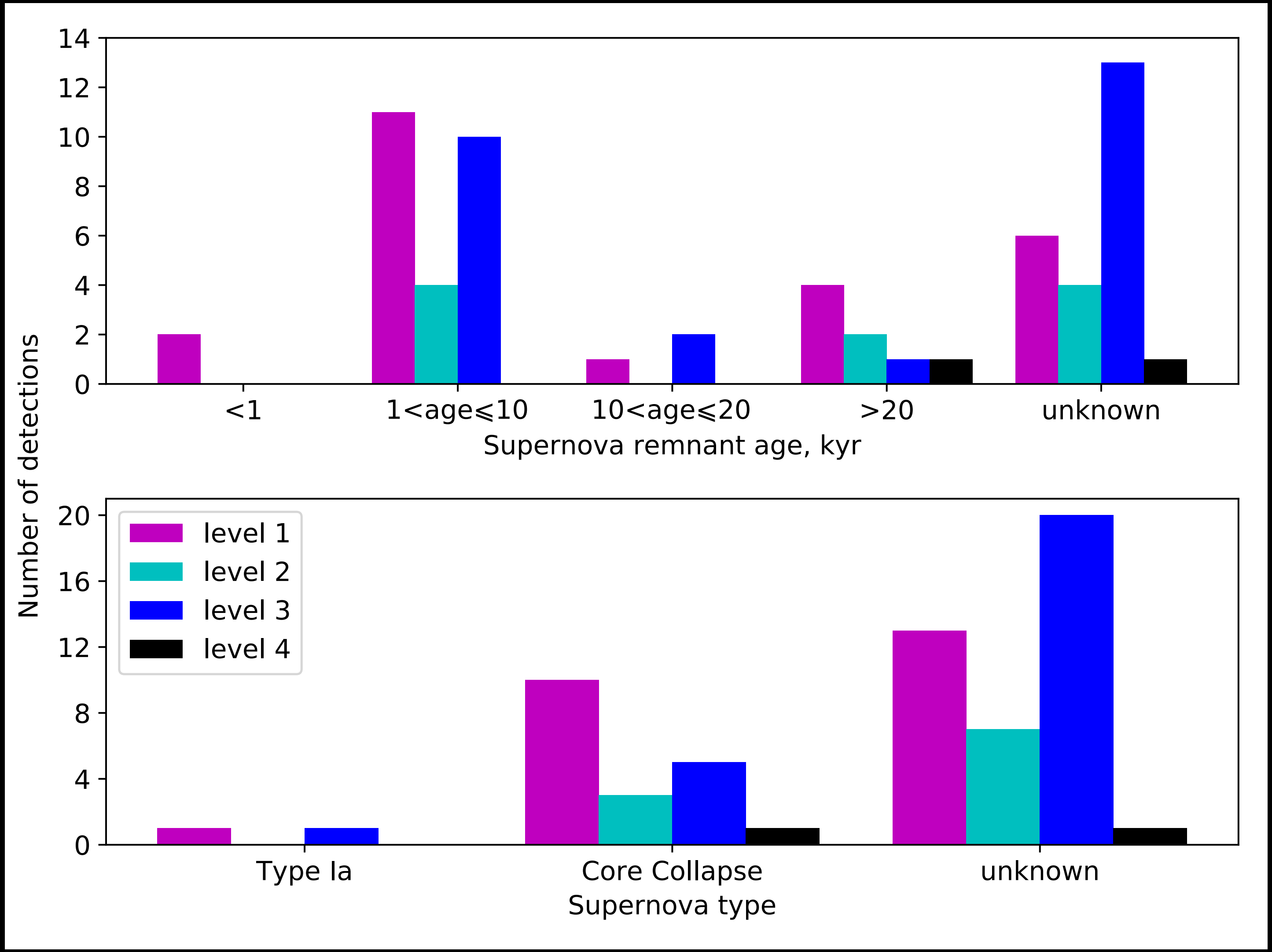
Chawner et al. (submitted)

Conclusions

- Add 24 sources to the sample of dusty supernova remnants
- Detect 3 supernova remnants containing ejecta dust heated by pulsar wind nebulae
- Analysis of dust mass indicates supernovae may produce significant amounts of dust
- Marginal evidence for variation in dust properties of G21.5-0.9 compared with surrounding ISM

Questions?

Catalogue detection types

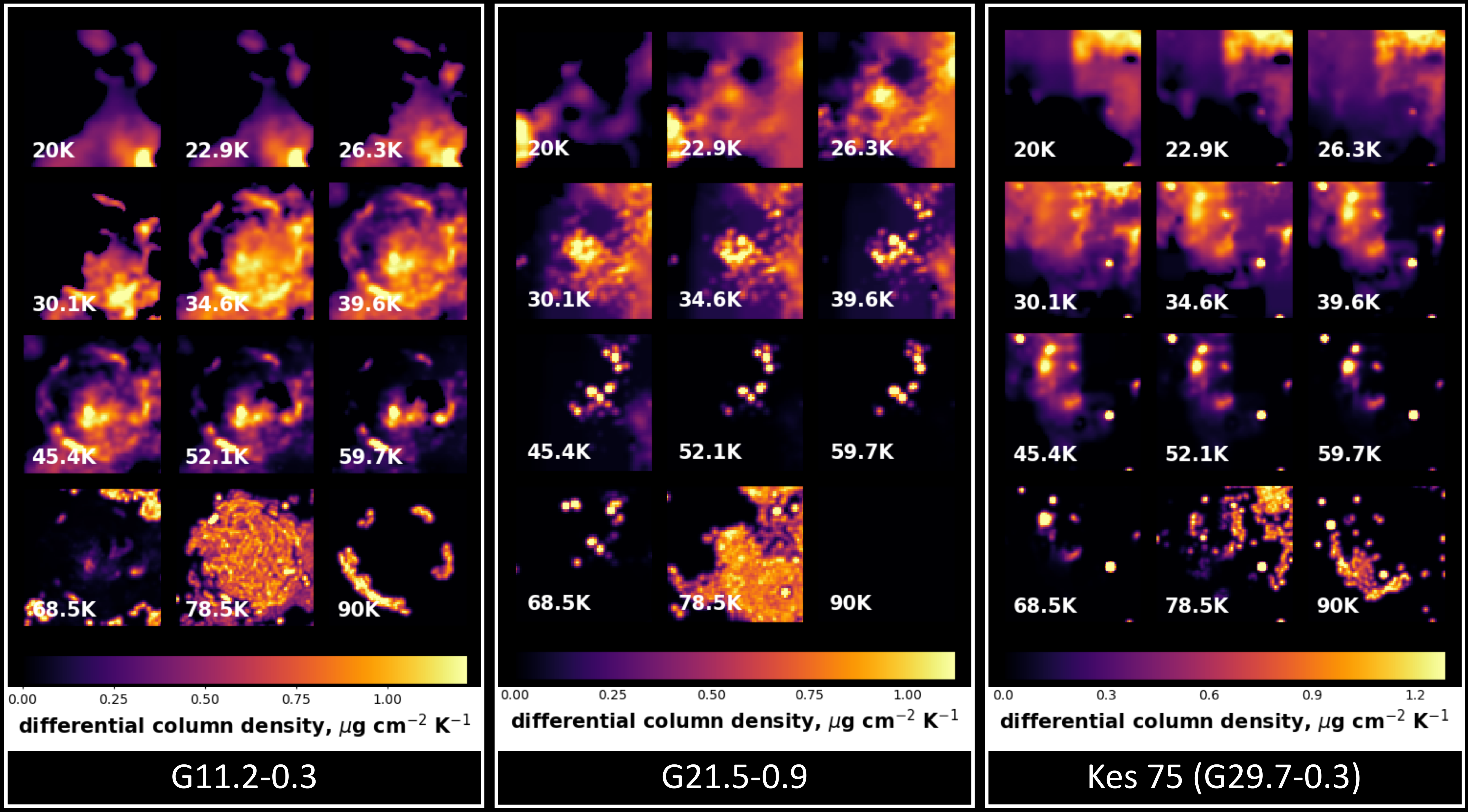


Level 1: *good detection of SNR*

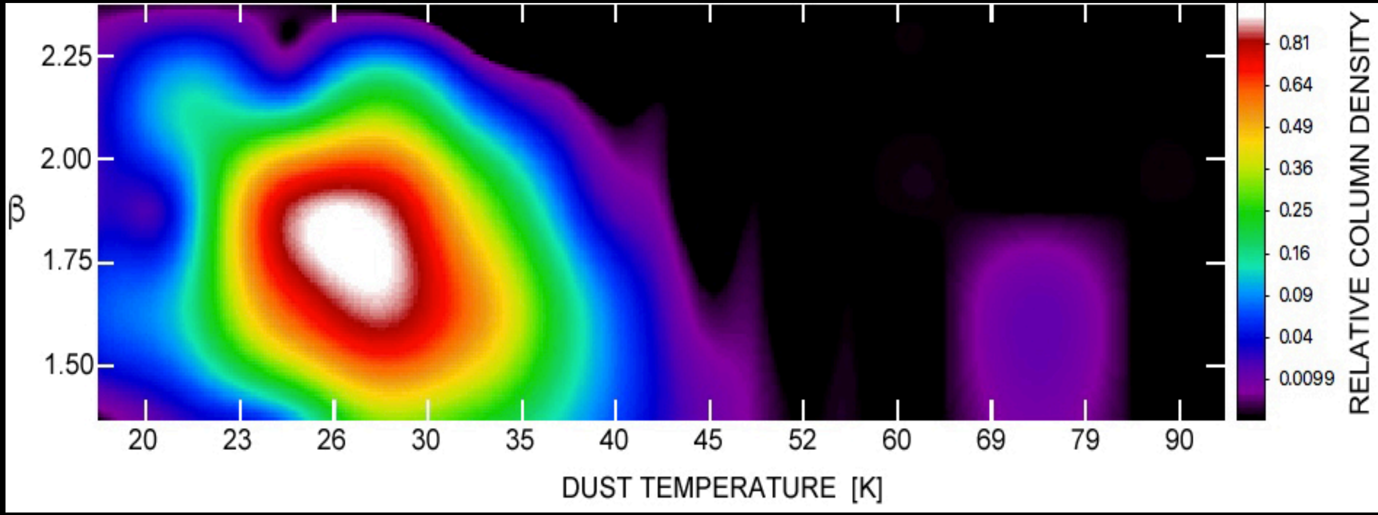
Level 2: *detection of FIR emission likely associated with SNR, but confused*

Level 3: *detection of FIR emission unlikely associated with SNR*

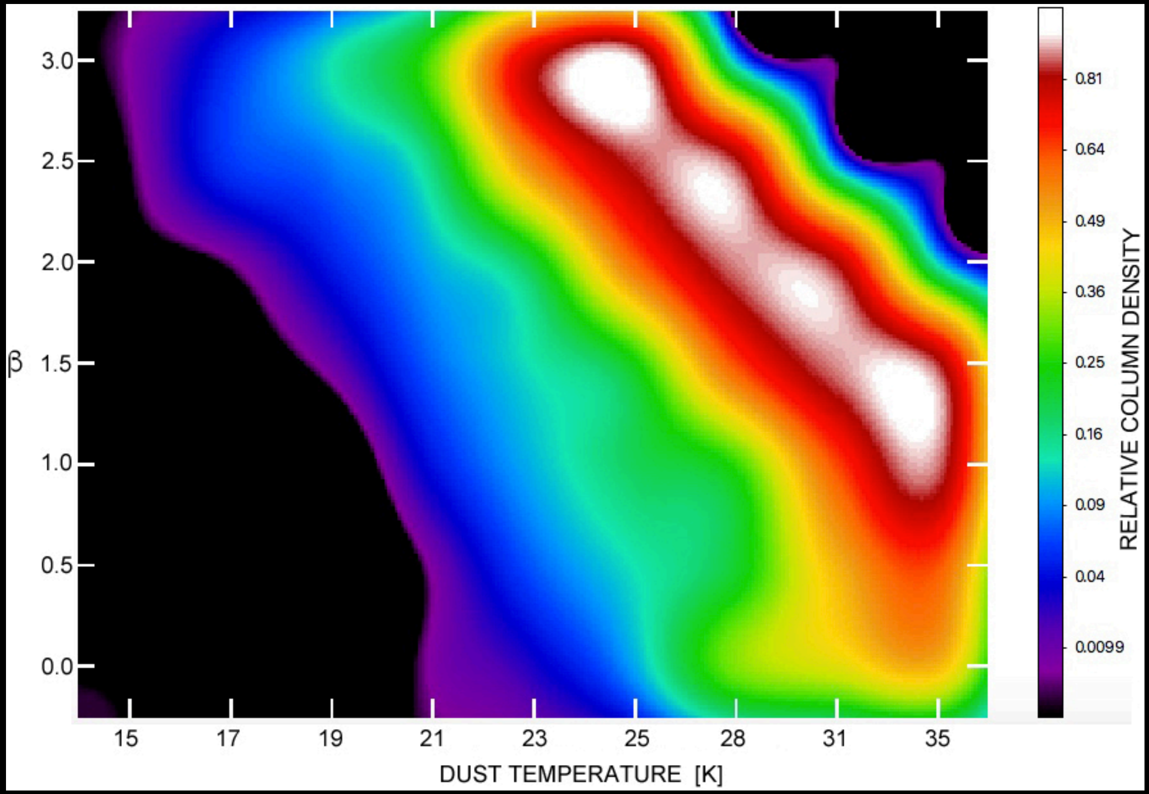
Level 4: *no detection of FIR emission*


20K
22.9K
26.3K
30.1K
34.6K
39.6K
45.4K
52.1K
59.7K
68.5K
78.5K
90K
0.00
0.25
0.50
0.75
1.00
differential column density, μg cm−2 K−1
G11.2-0.3
20K
22.9K
26.3K
30.1K
34.6K
39.6K
45.4K
52.1K
59.7K
68.5K
78.5K
90K
0.00
0.25
0.50
0.75
1.00
differential column density, μg cm−2 K−1
G21.5-0.9
20K
22.9K
26.3K
30.1K
34.6K
39.6K
45.4K
52.1K
59.7K
68.5K
78.5K
90K
0.0
0.3
0.6
0.9
1.2
differential column density, μg cm−2 K−1
Kes 75 (G29.7-0.3)

PPMAP degeneracy – G11.2-0.3



Applying a Gaussian prior to the distribution of mass across emissivity index



No prior for the distribution of mass across emissivity index