Polycyclic Aromatic Hydrocarbon from the Magellanic Clouds

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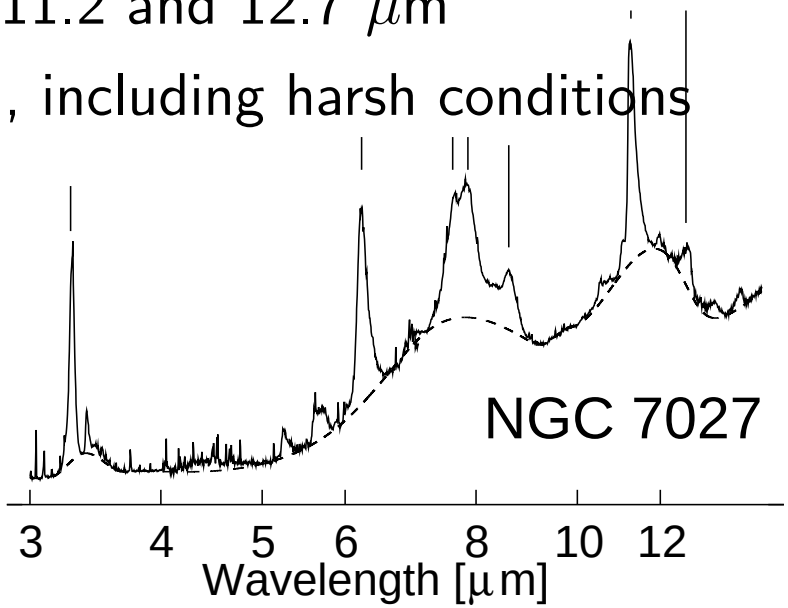
Overview

1. Introduction: Polycyclic Aromatic Hydrocarbons
   - Astronomical PAH bands
   - Main interest (tracers, photo-electric heating)
2. This study
   - Main objectives
   - Presentation of regions
3. Results and discussion
   - Feature maps
   - Trends
   - Differences between SMC and LMC
   - Resolution matters
4. Conclusions

What are PAHs?

- Family of strong, broad emission bands in the mid-IR
- Main fingers at 3.3, 6.2, 7.7, 7.9, 8.6, 11.2 and 12.7 μm
- Found in many types of ISM and CSM, including harsh conditions



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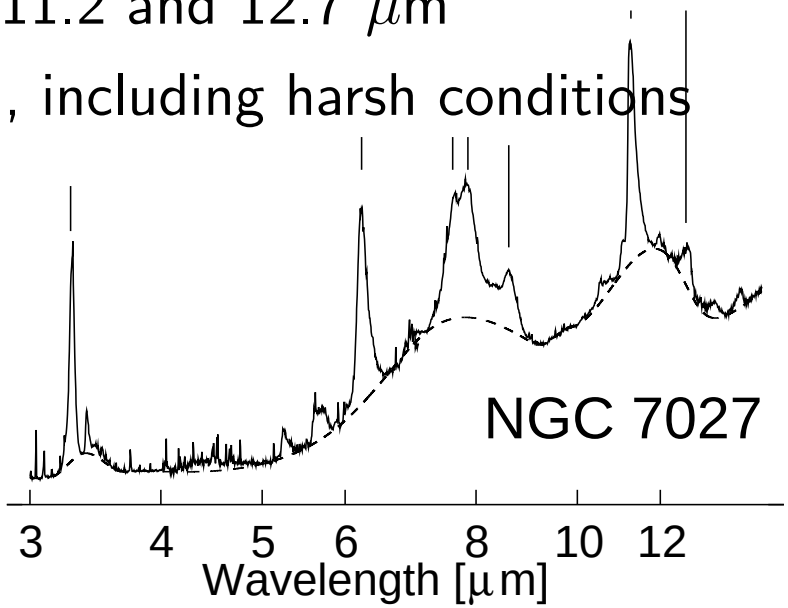
- Stable
- From abundant elements
- Identified with resonances in aromatic macro-molecules



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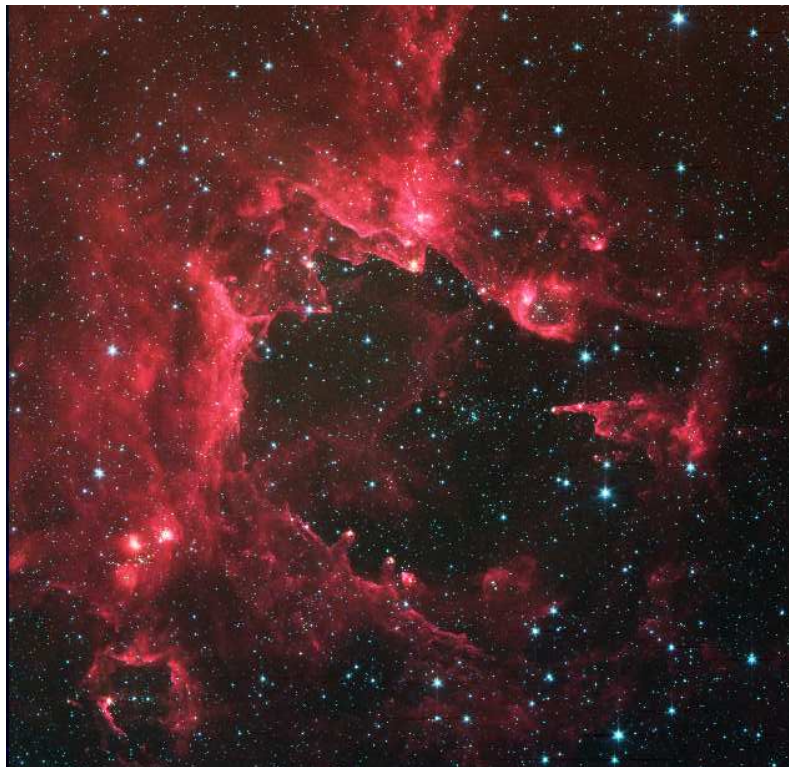
- In the context of star formation: PAH emission from the edges of illuminated clouds



Puga+09

Why are they interesting?

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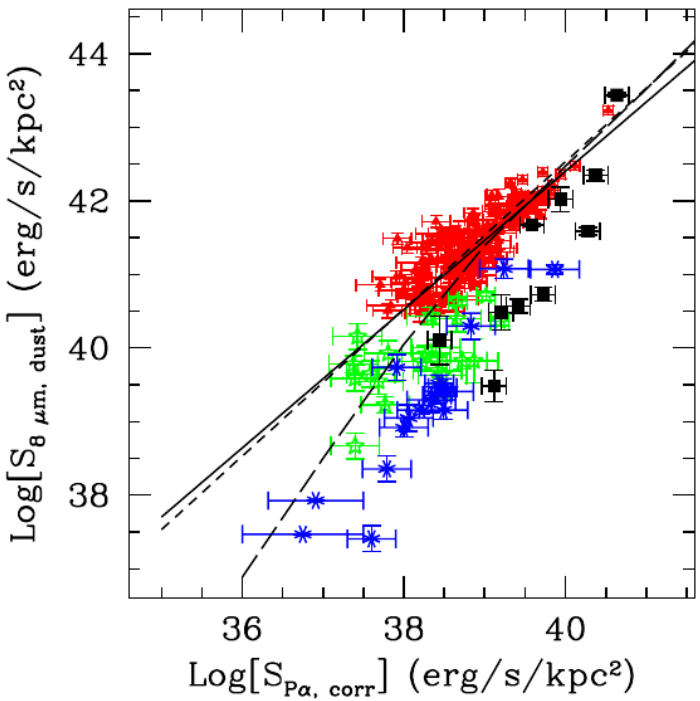

Black: low-metallicity starbursts

Red: $12+(O/H) > 8.35$

Green: $8 < 12+(O/H) < 8.35$

Blue: $12+(O/H) < 8$

Calzetti 2010

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Physical influence:

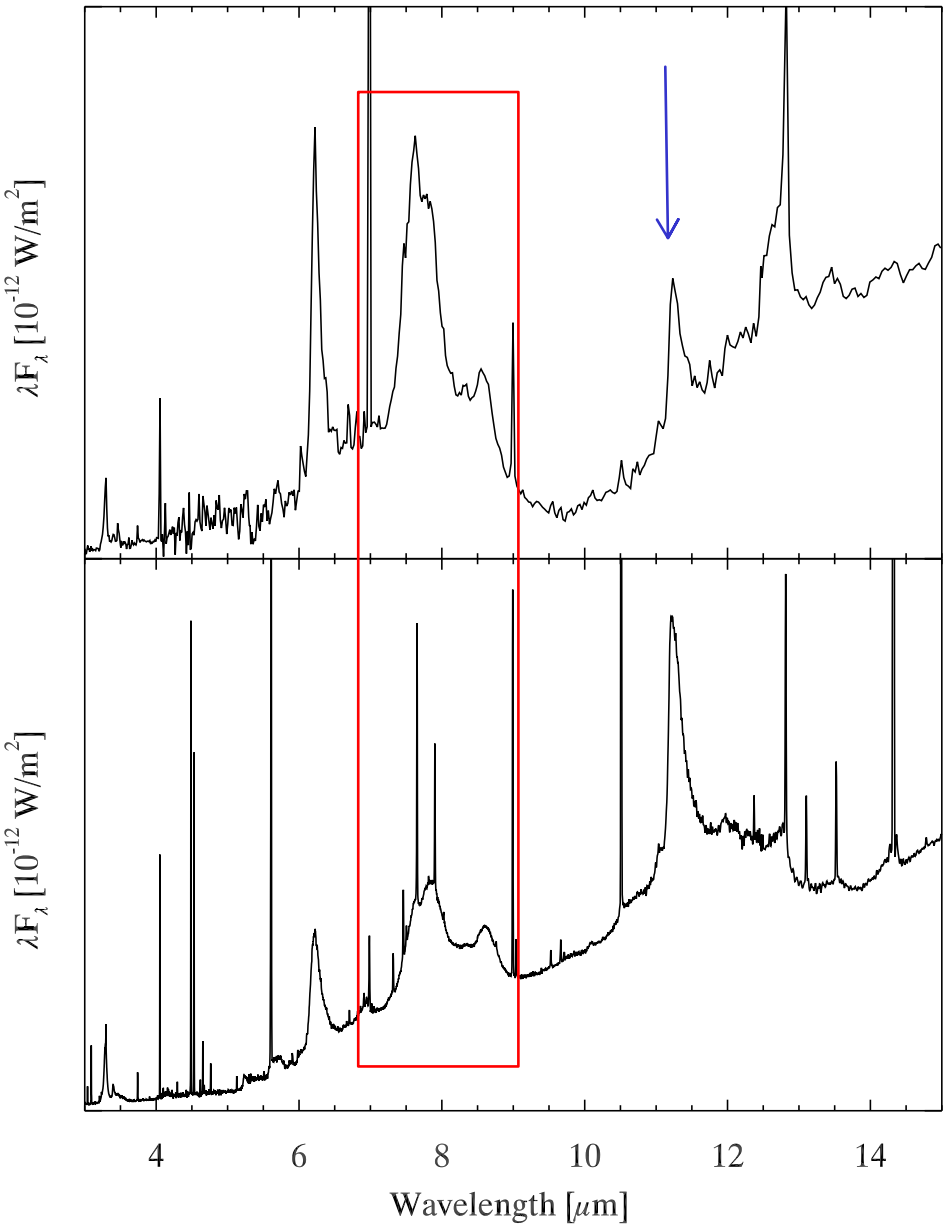
- Source of free electrons in the neutral gas: dominate the gas heating via photo-electric effect (PE)
- PE-efficiency depends on charge state (Bakes&Tielens 1994)

Band ratio variations: varying charge state

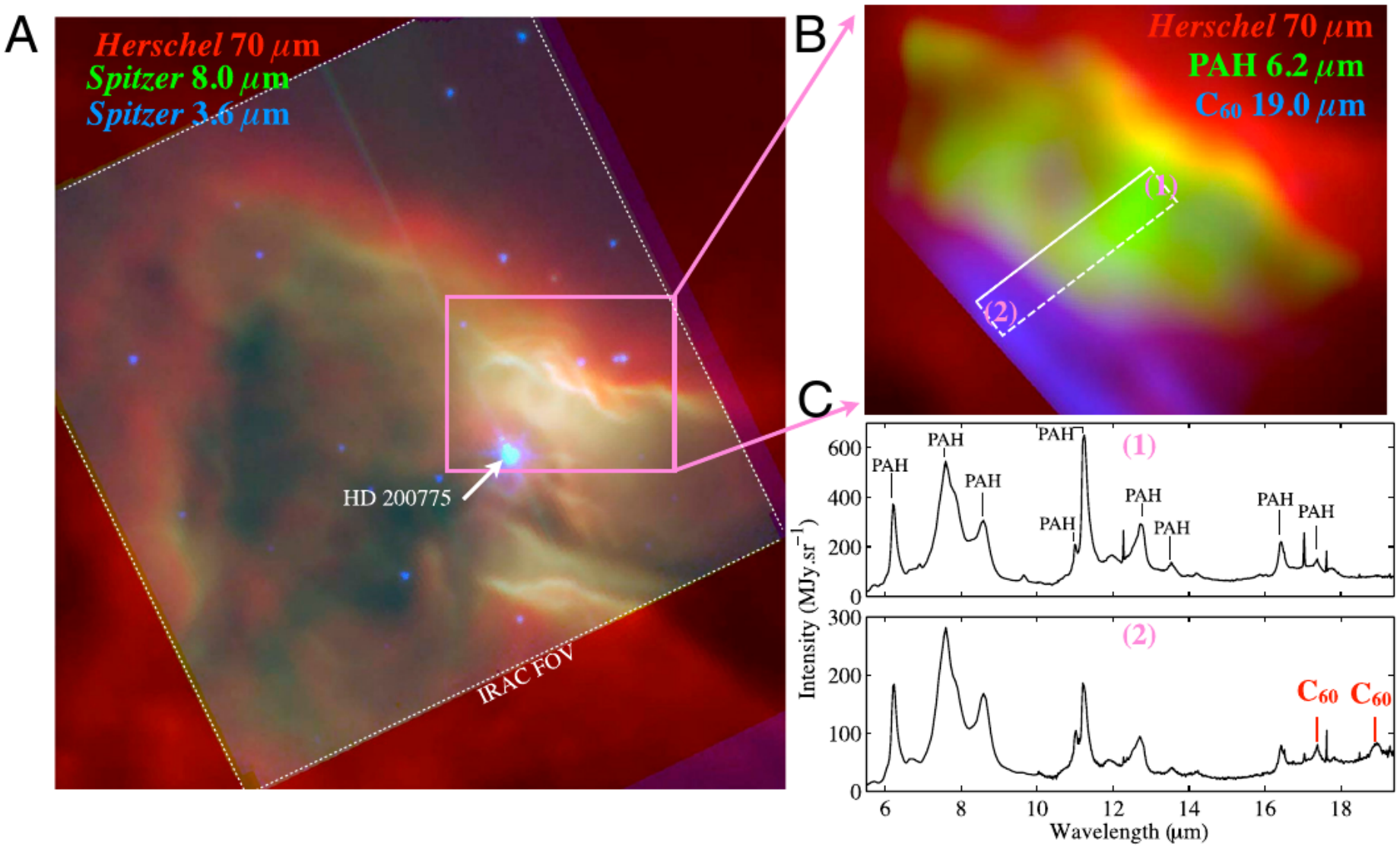
- Strong observed variations
- CC (6-9 μm) vs
  CH (3.3 and 11.2 μm)
- CC modes activated by charge measured by *Spitzer*/IRAC4

- Charge-balance follows G_0/n_e
- Possible spatial trends with respect to the exciting stars

- Understand ISM heating
- Does IRAC4 measure well full PAH emission?



Band ratio variations: resolved in MW clouds



Berne+12

Objectives: PAH spectral diagnositics

- Metalicities different from the MW
- Smallest attainable beams
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- Spitzer/IRS spectral maps (LMC+SMC)
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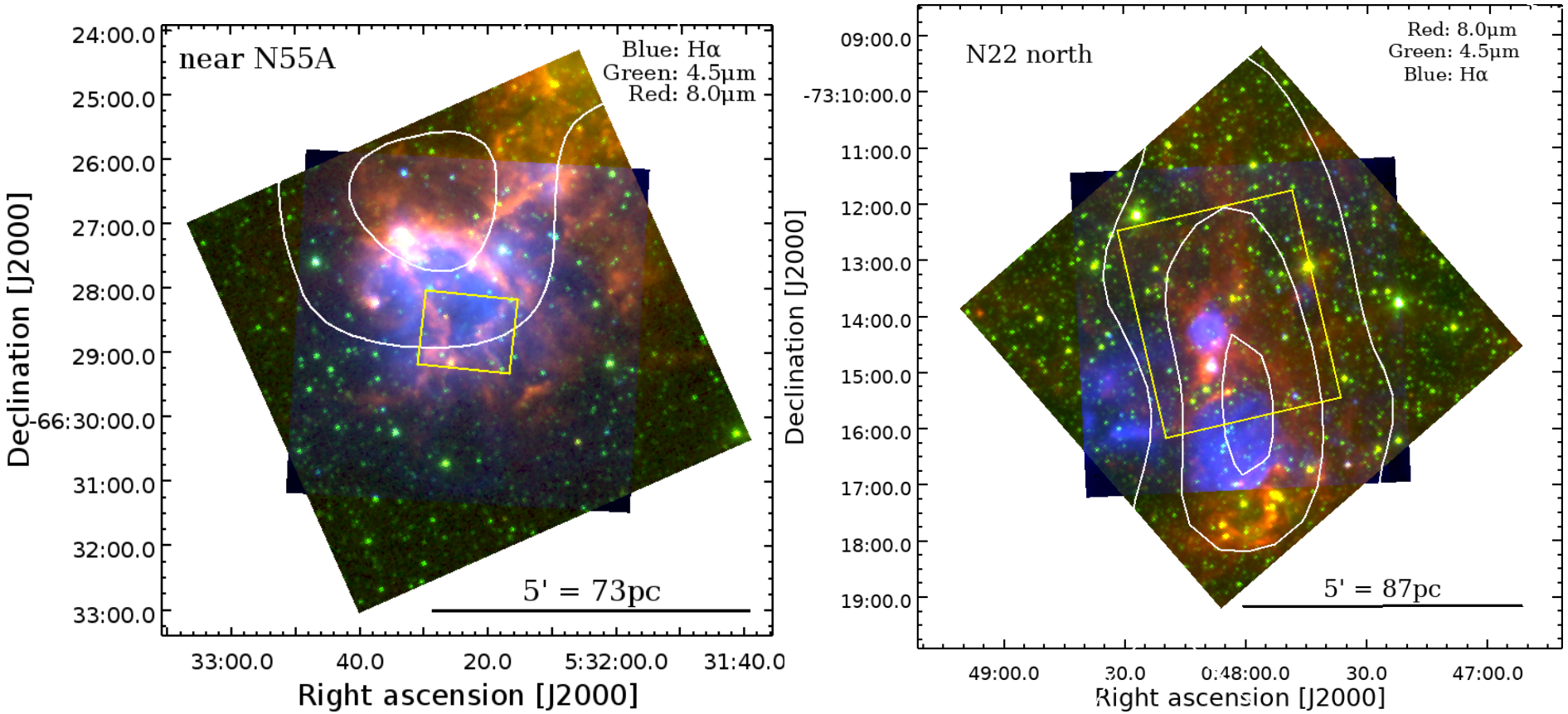
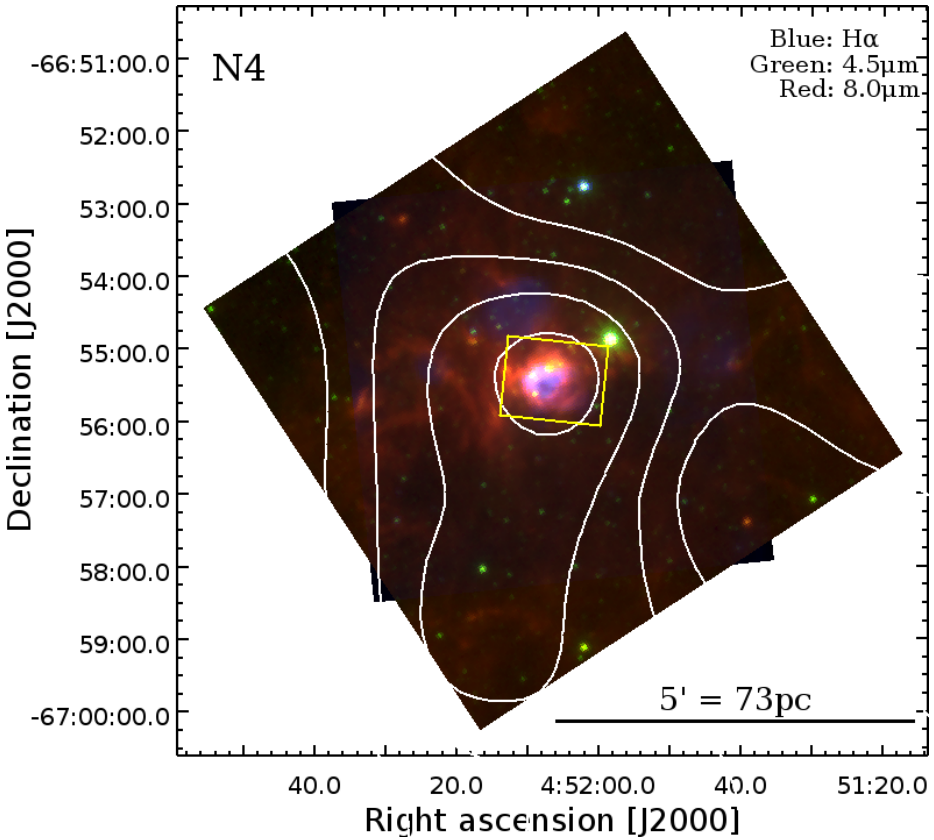
- Spitzer/IRS spectral maps (LMC+SMC)
- 1/2 -1/5 solar metallicity
- $5-14\,\mu$m (SL1,2,3)
- $\sim 4''$ resolution ($\sim$1pc)
- 50-100 pc

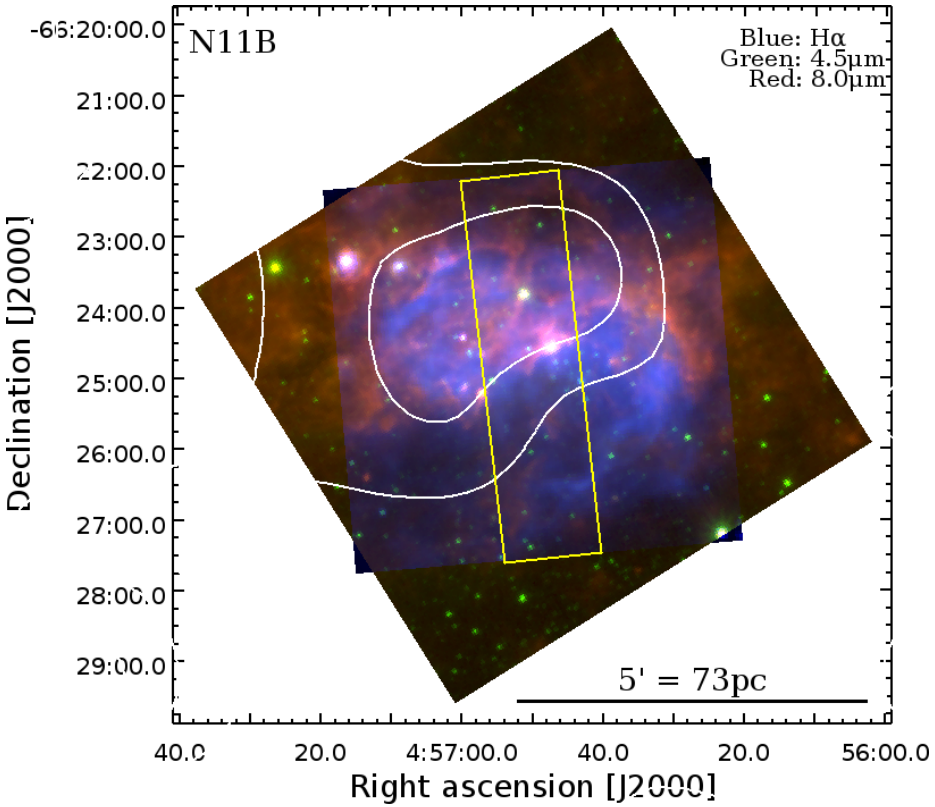
Large is still small



- Inside yellow boxes full IFU from CUBISM (Smith+2007)
- beam matched using Pereira-Santaella+2010

Sometimes more favourable geometry

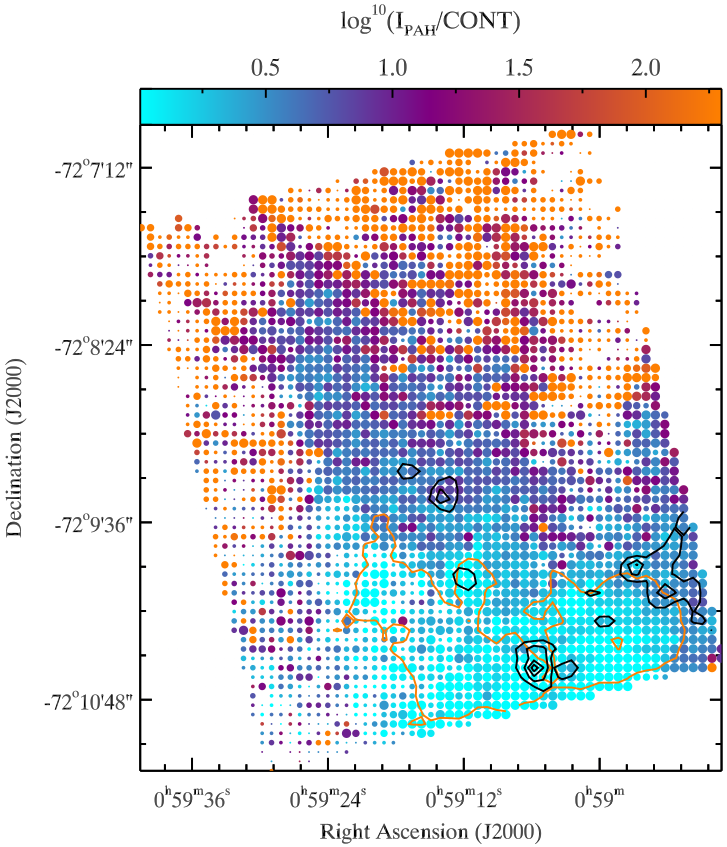




- ∼10 000 independent spectra
- Fitted to obtain continuum, emission lines and feature strengths
- Monte Carlo error analysis

Feature maps: SMC N66

PAH/mid-IR continuum

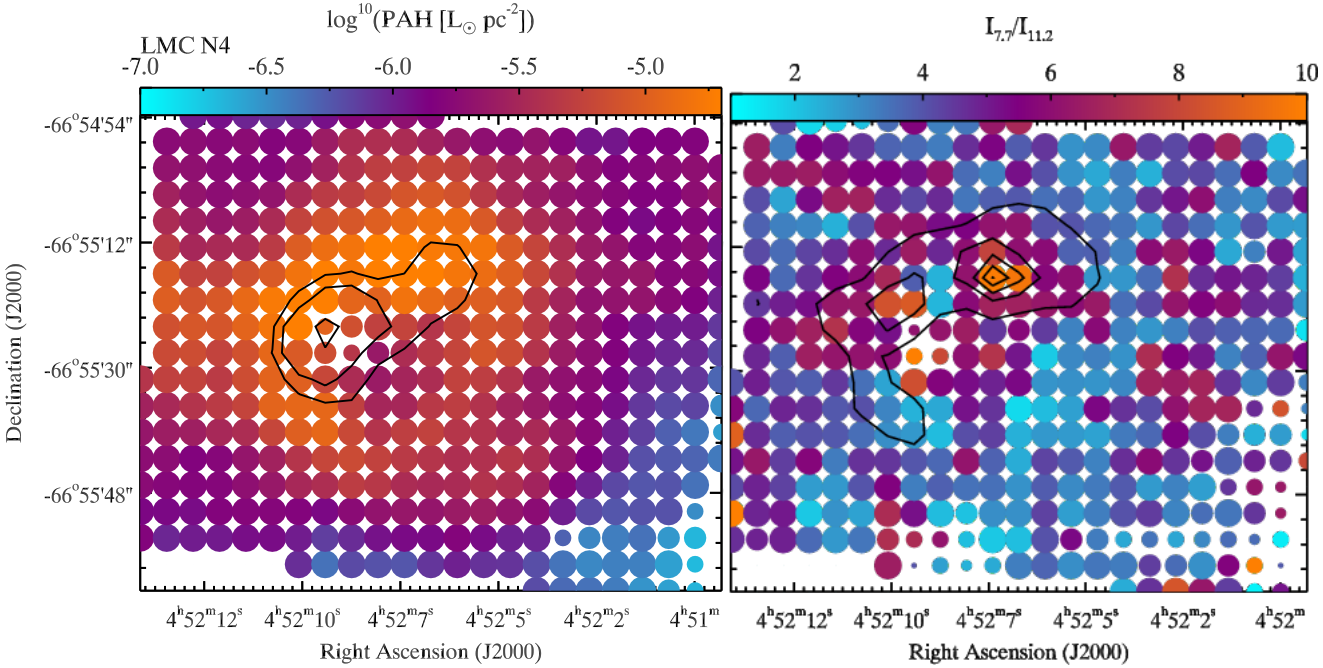


Strongly correlate with ionised gas (here S IV in orange contours)

- PAHs destroyed in the ionised gas
- mid-IR boosted due to hot dust

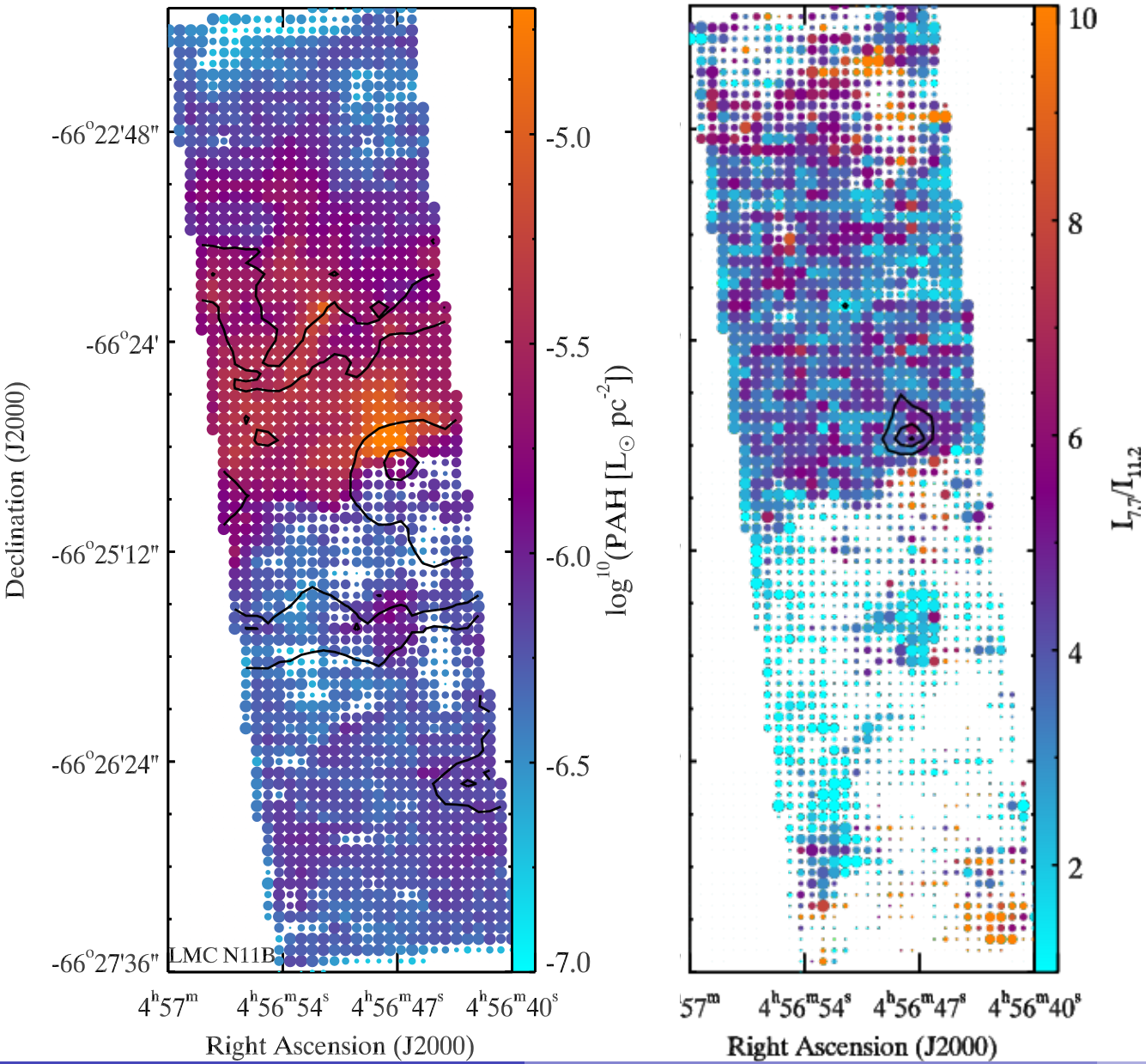
Feature maps: LMC N4

PAH strength ionisation



Some spatial dependence of ionisation state

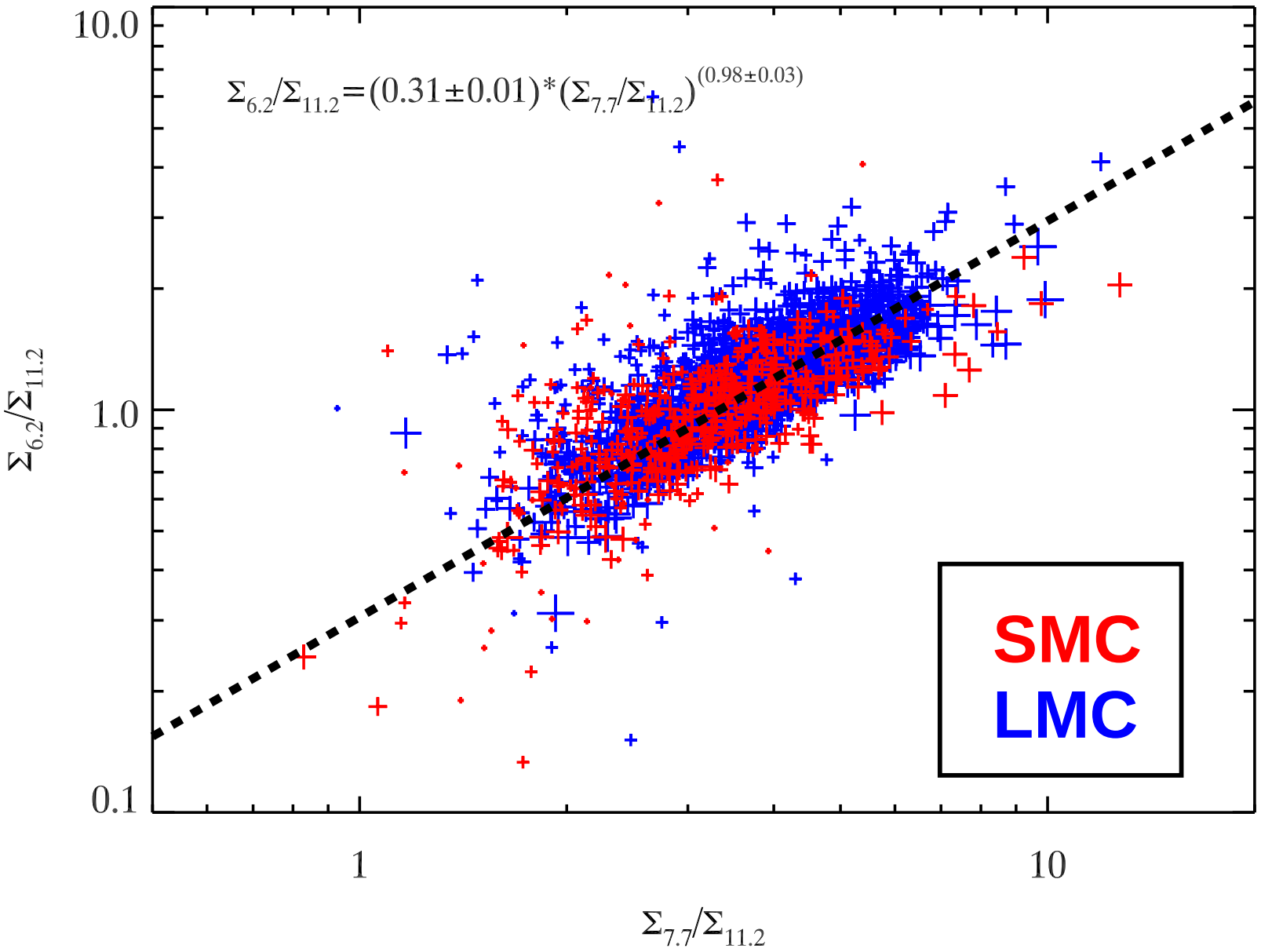
Feature maps: LMC N11B



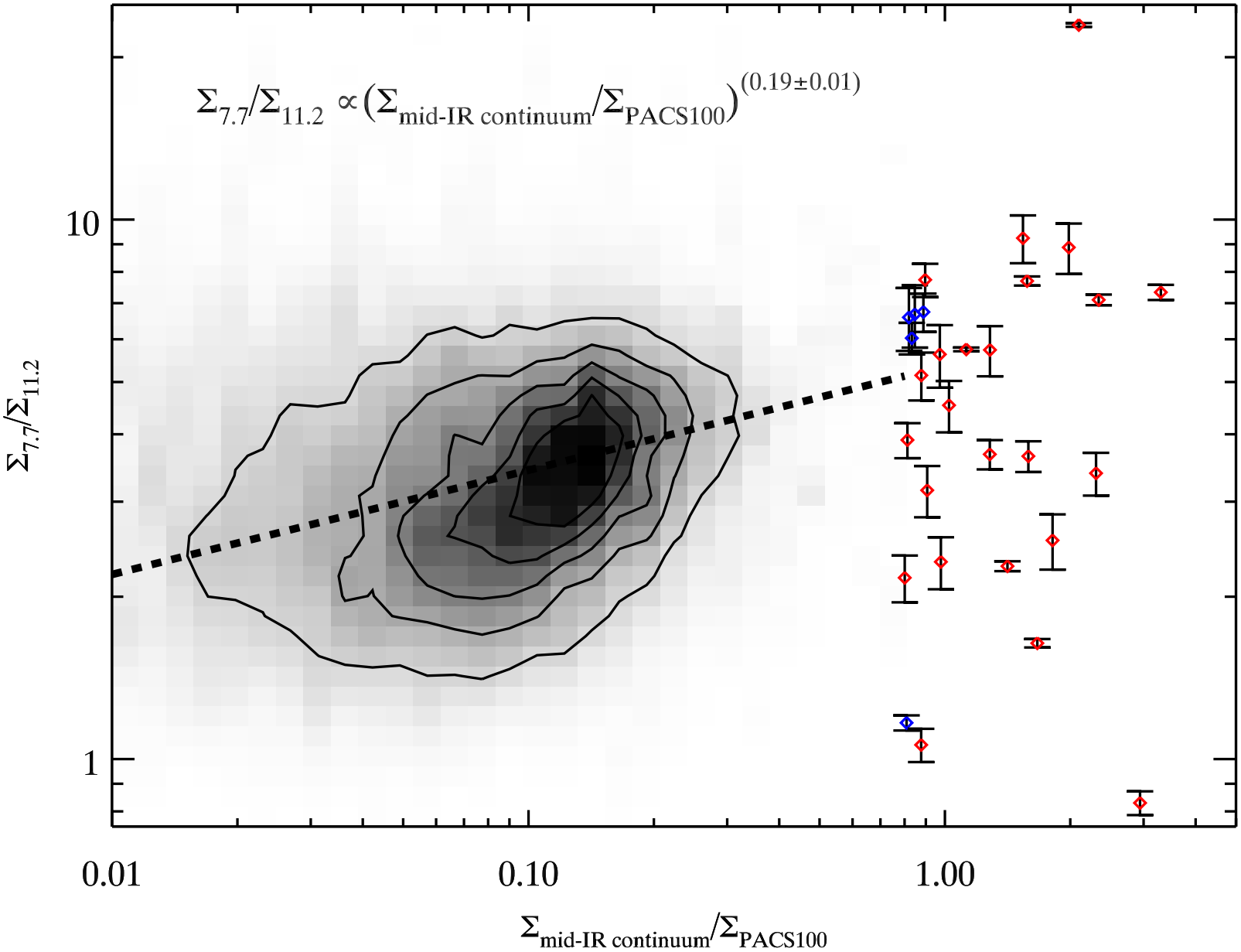
No discernible spatial trends

Clumpy ISM allows radiation to penetrate the clouds

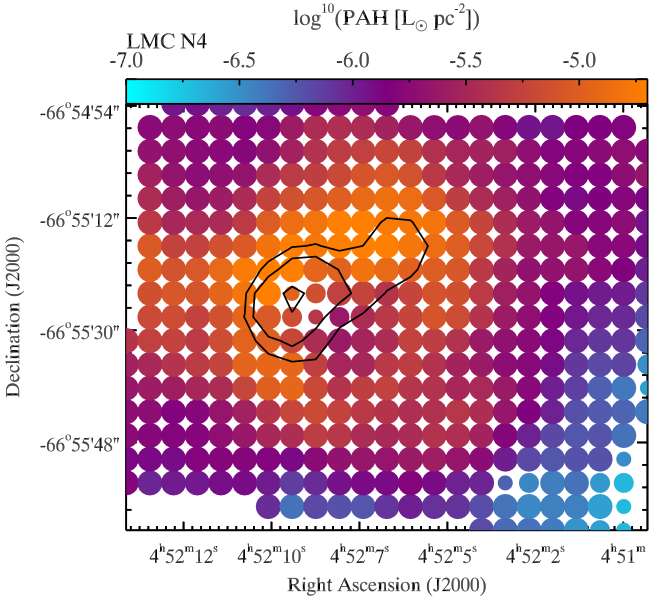
CC modes go together (ionisation dominates)

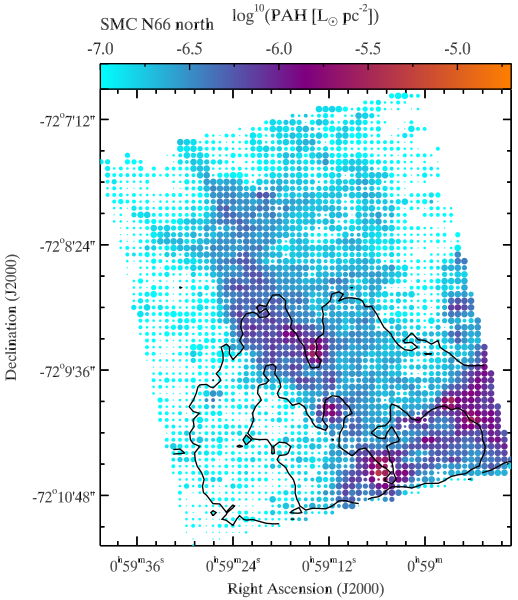


Ionisation "follows" the mid-IR continuum colour



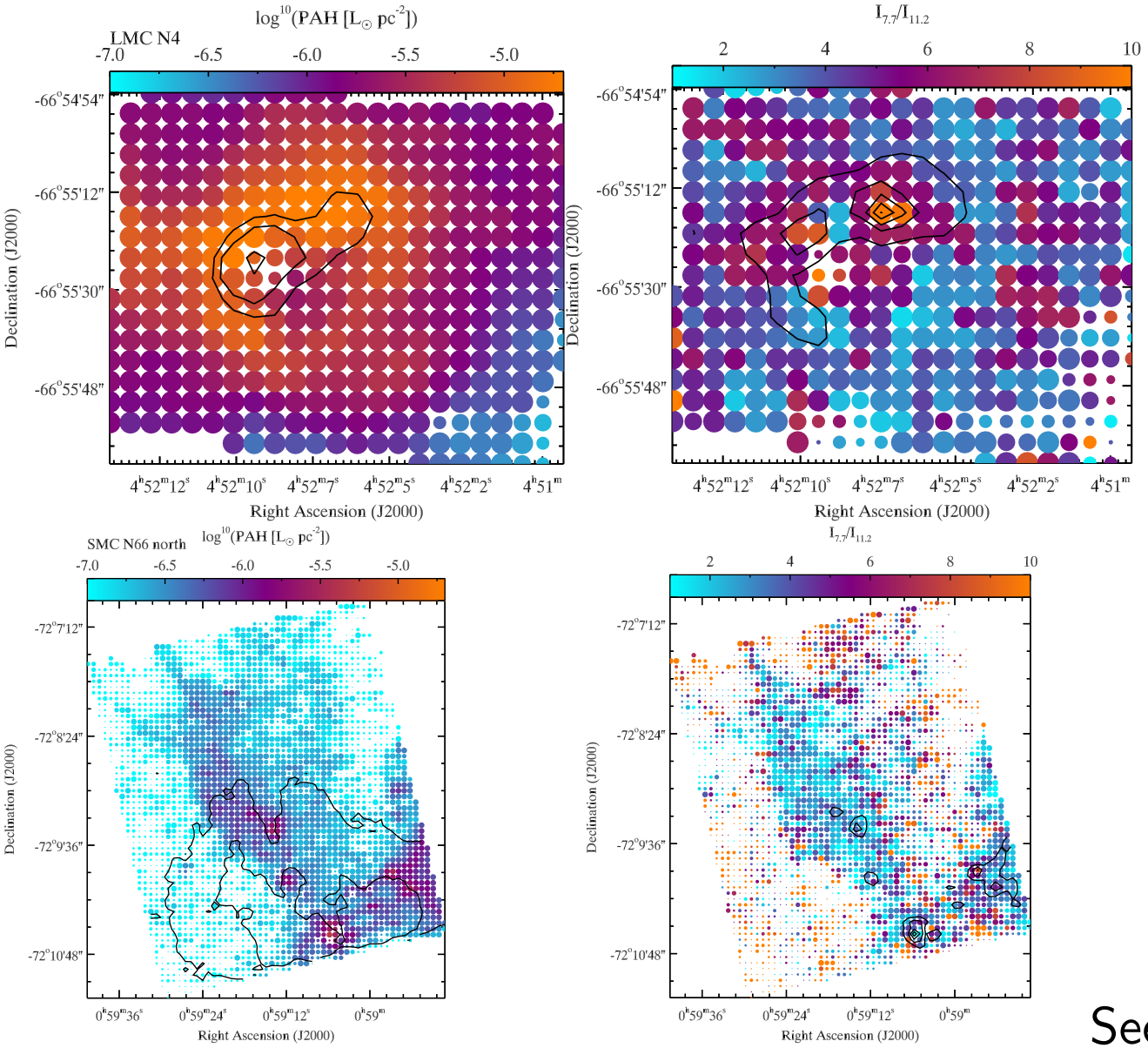
SMC is fainter





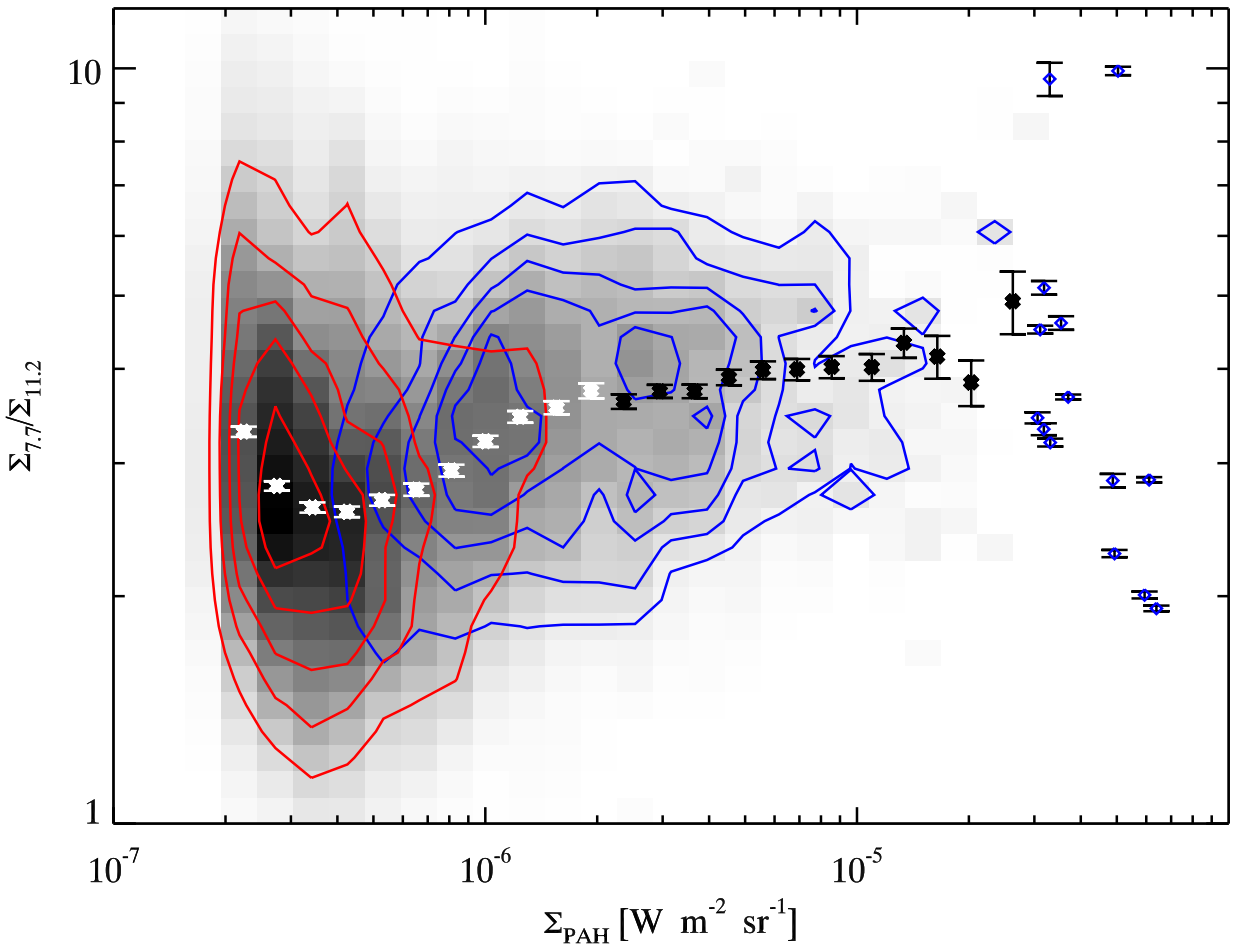
Probably related to metallicity

SMC is fainter and less ionised



See also Sandstrom+09

Ionisation is correlated with PAH brightness



Low ionisation:

- Generally faint
- Near brighter, ionised l.o.s.

- Removed by spatial averaging
- Median $\Sigma_{7.7/11.2}$ $3.3 \longrightarrow 5.3$ $1 \longrightarrow 8$ pc linear resolution

Take away points

- **Ionisation** dominates/explains band-ratio variations

- Both galaxies span entire range ($\times 5$) of ratios (ionisation degree)
- SMC fainter in PAHs and exhibits more low ionisation

- Little spatial patterns (**clumpiness**)
- Radiation heating acts far ($>50\,\mathrm{pc}$) into the cold gas at these metalicities
- Physical state of the cloud interfaces driven by clumpy ISM

- Probably related to more translucent ISM at low-Z