PAHs in the LMC

Detailed study of the influence of the physical conditions on the PAH spectra in the LMC

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Outline

- Intro
  - Band ratios trace and separate physical conditions
  - LMC unique opportunity
- Method:
  - Data presentation
  - Data treatment
  - Fitting procedure description
- Results:
  - Feature maps
  - Band ratios
  - Correlations

Conclusions

PAH as tracers

PAH series of bands in the mid-IR spectra

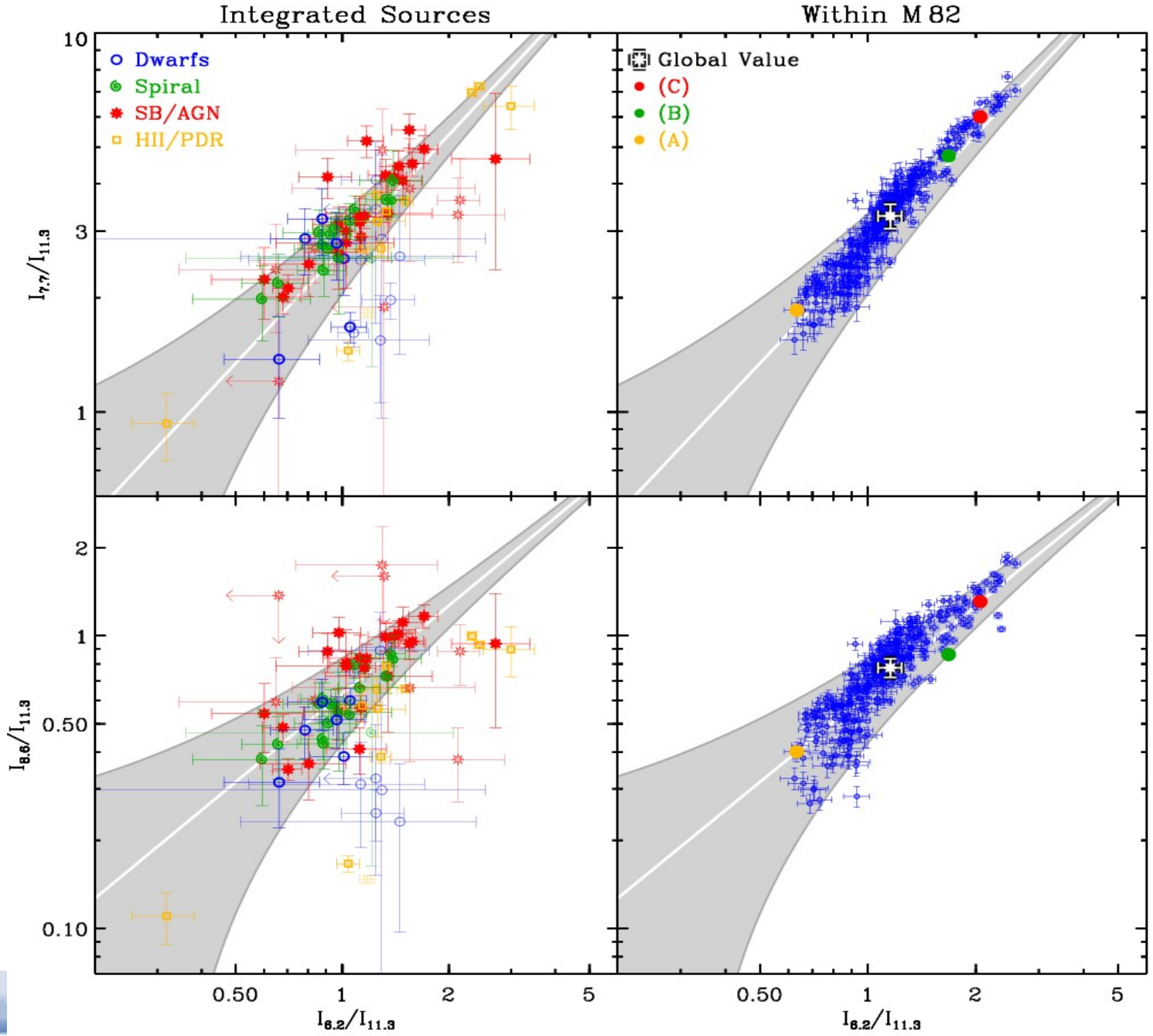
frequently used as SF tracer

- 8 um flux as a proxy

Broad features are known to vary

- Shape, relative intensity and to other components
- linked with:
    - Abundance (strong function of **metallicity**)
    - Size distribution
    - Chemistry
    - **Charge state (activate skeleton modes)**

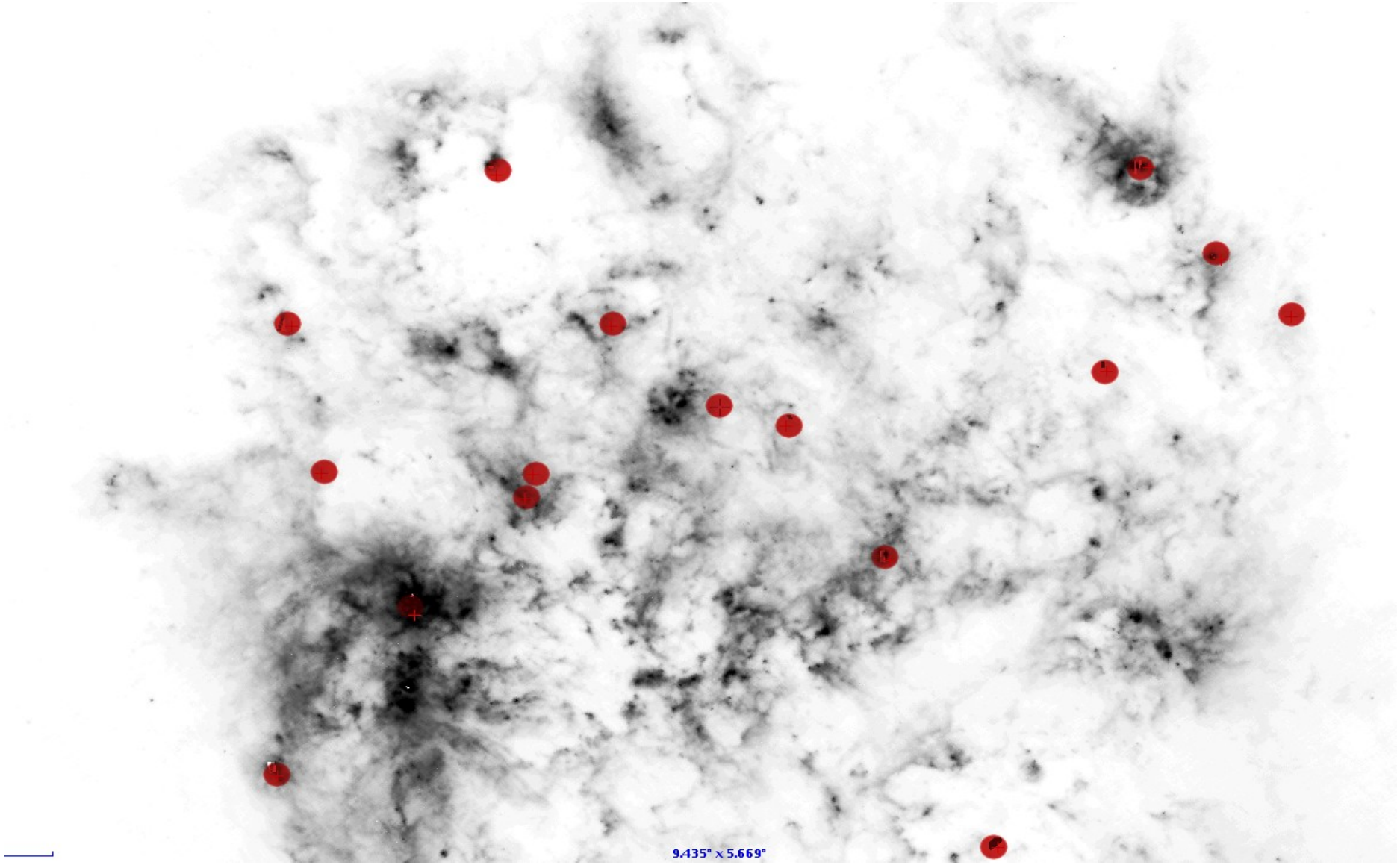
Context: ratios as tracers



LMC

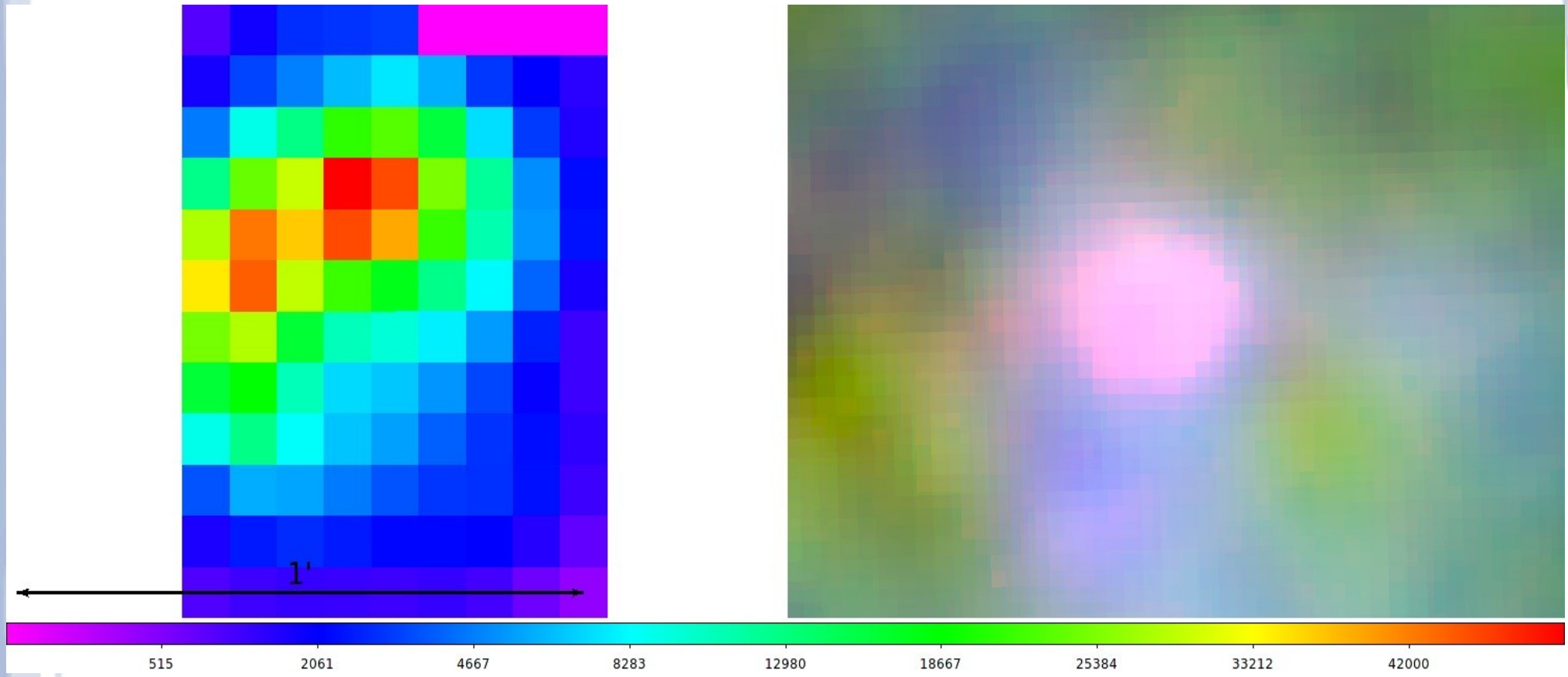
- Nearby thus chances to see variations within objects
- Lower metallicity (~0.5 solar)
- SAGE-Spec (PI Kemper) IRS cubes SL+LL of ~20 regions of different nature: 10 massive SF regions, 10 diffuse regions + 30 Dor.
- Large range of radiation field intensities and densities and conditions

The regions



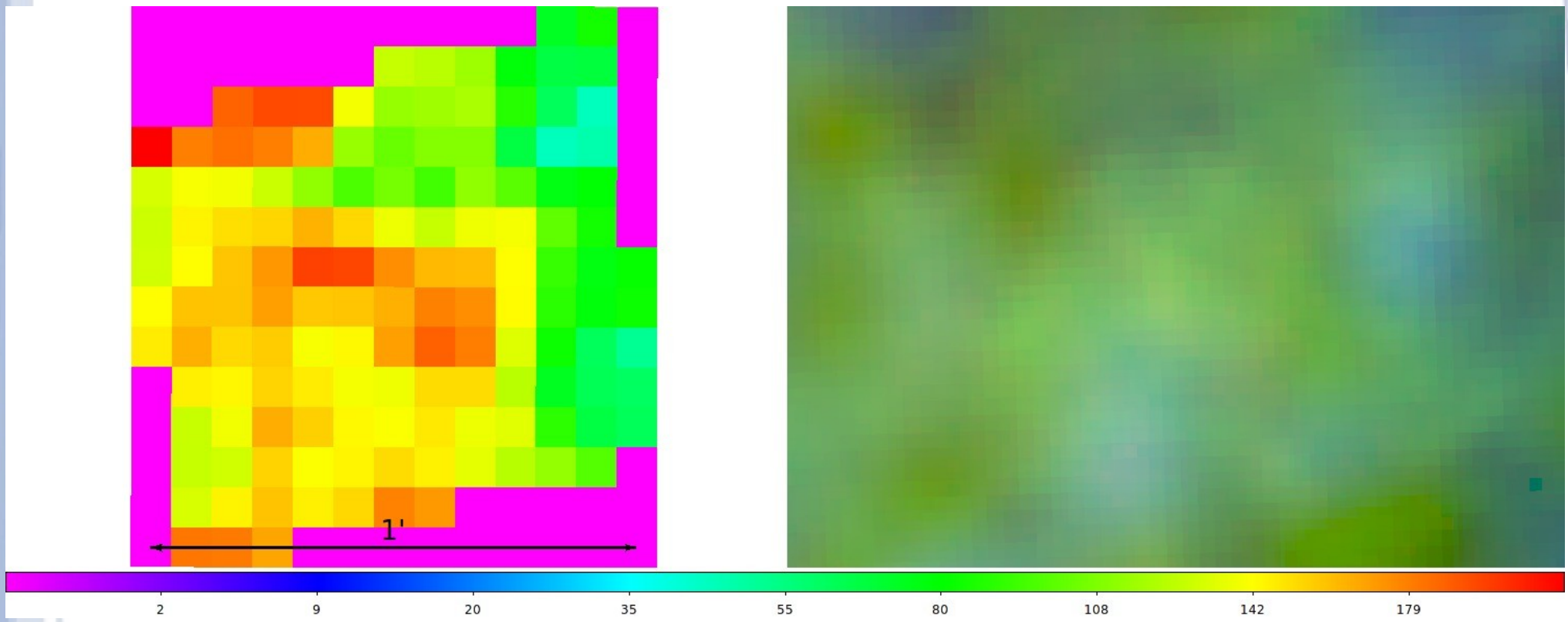
The zoo of regions: HII

Red: 160 um Blue: HI Green: CO



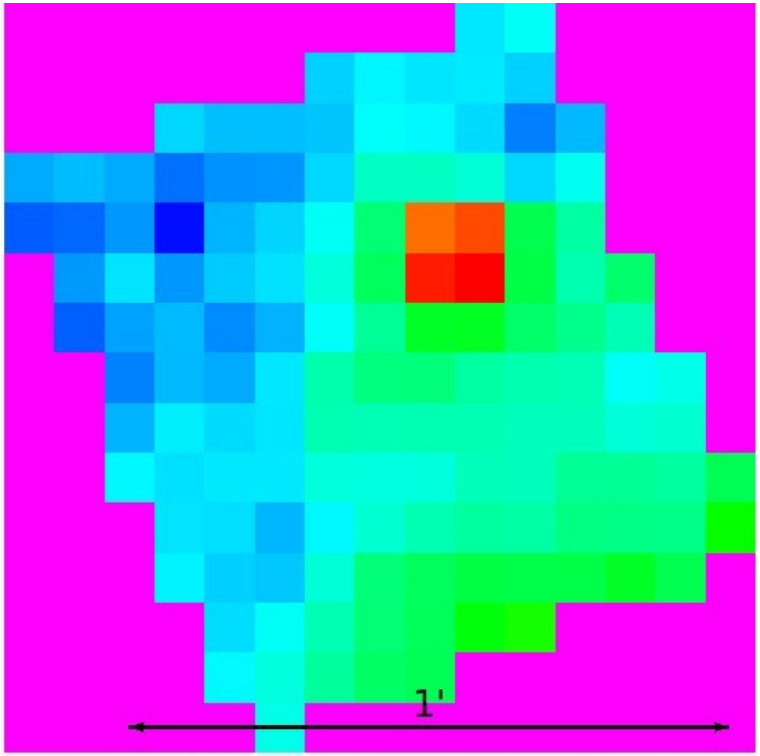
The zoo of regions: molecular

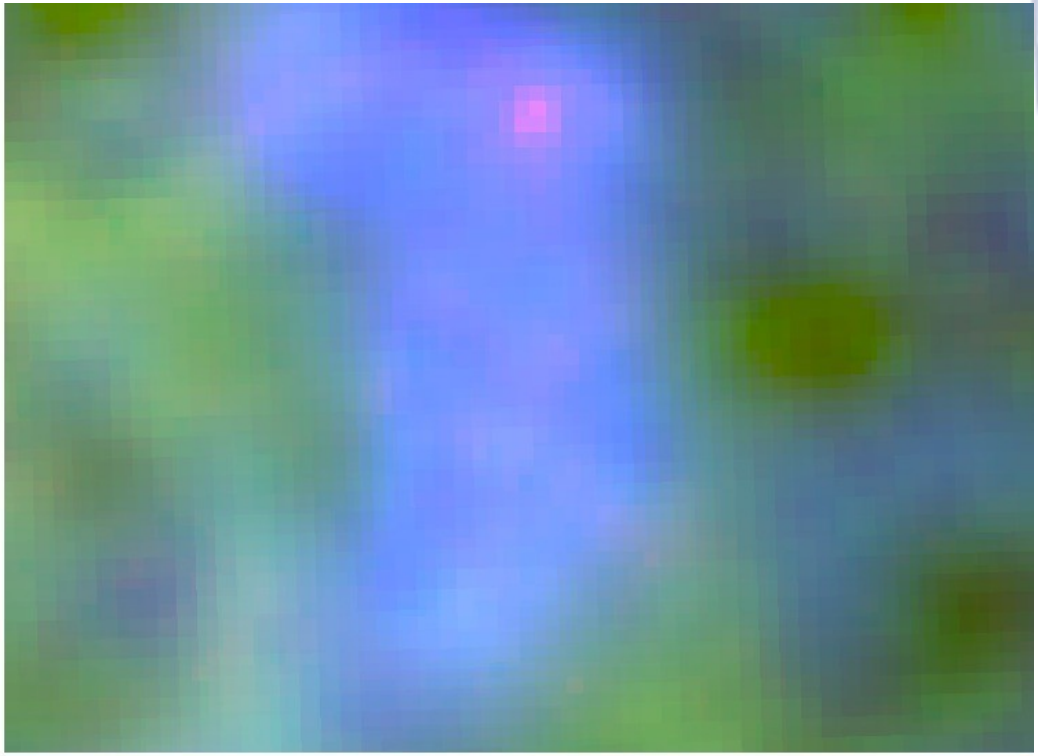
Red: 160 um Blue: HI Green: CO

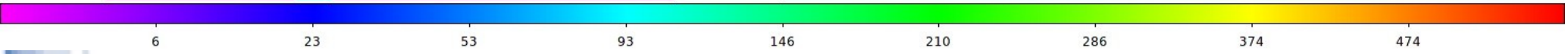


The zoo of regions: diffuse

Red: 160 um Blue: HI Green: CO

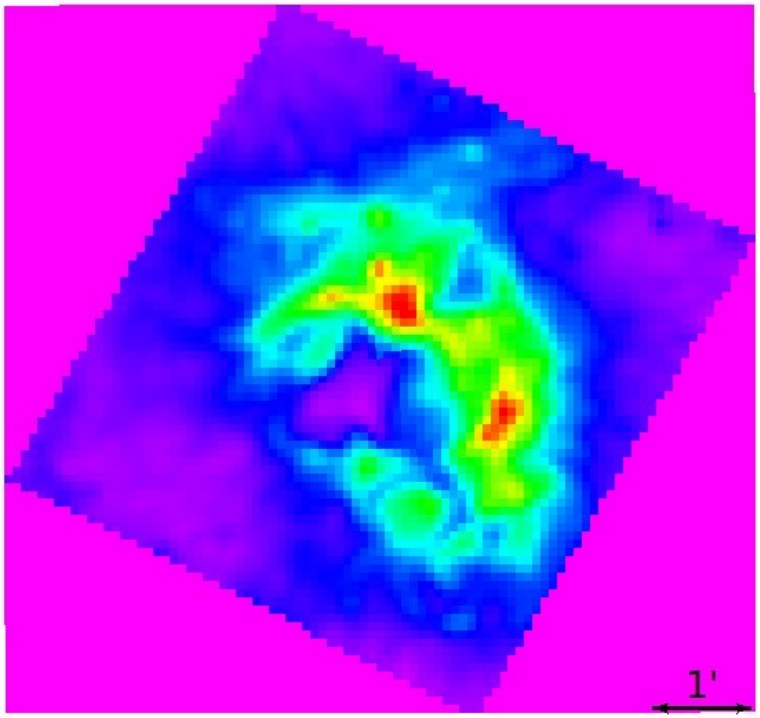


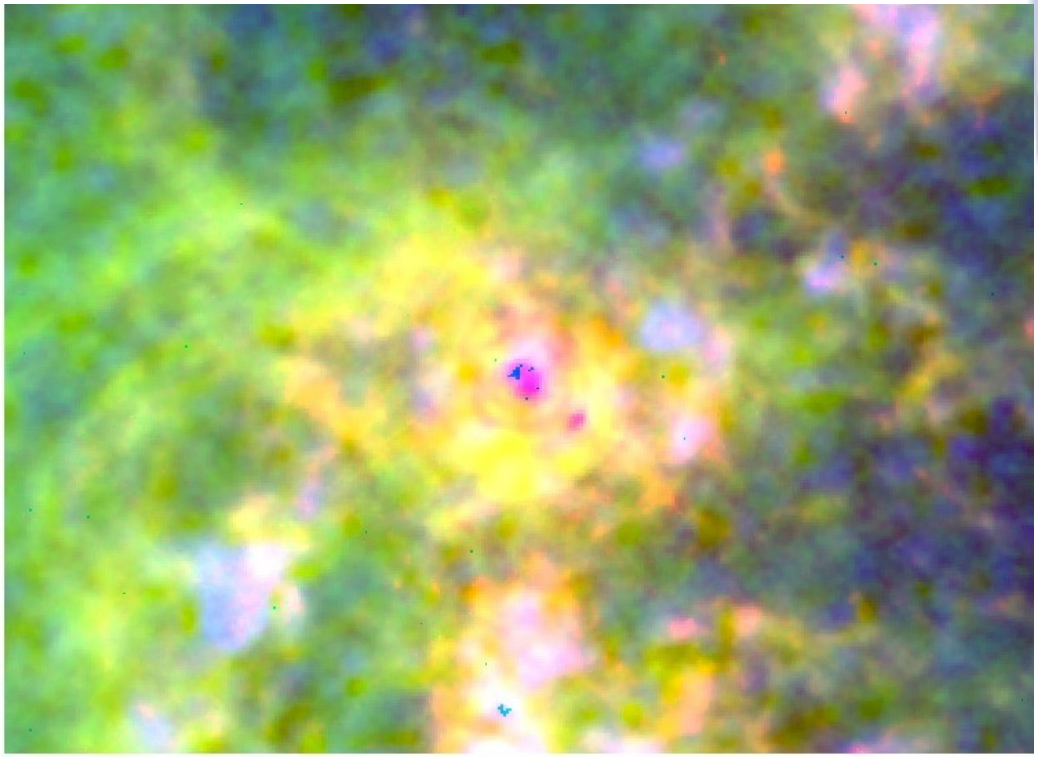


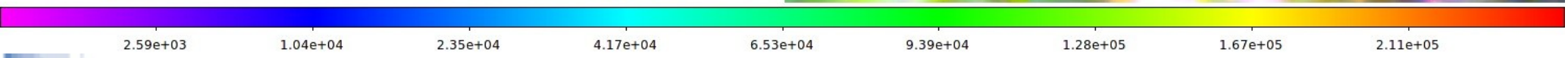


The zoo of regions: 30 Doradus

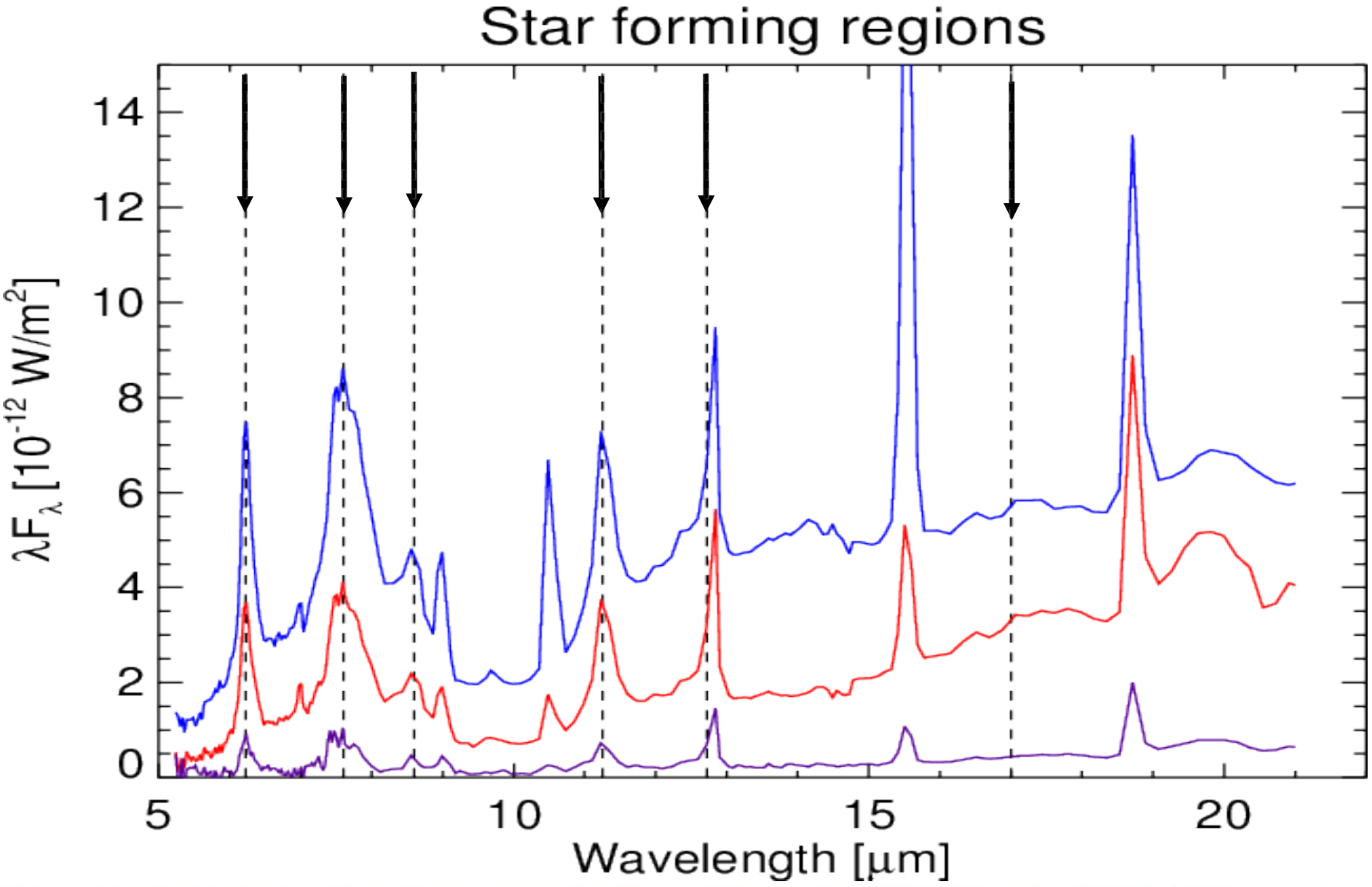
Red: 160 um Blue: HI Green: CO



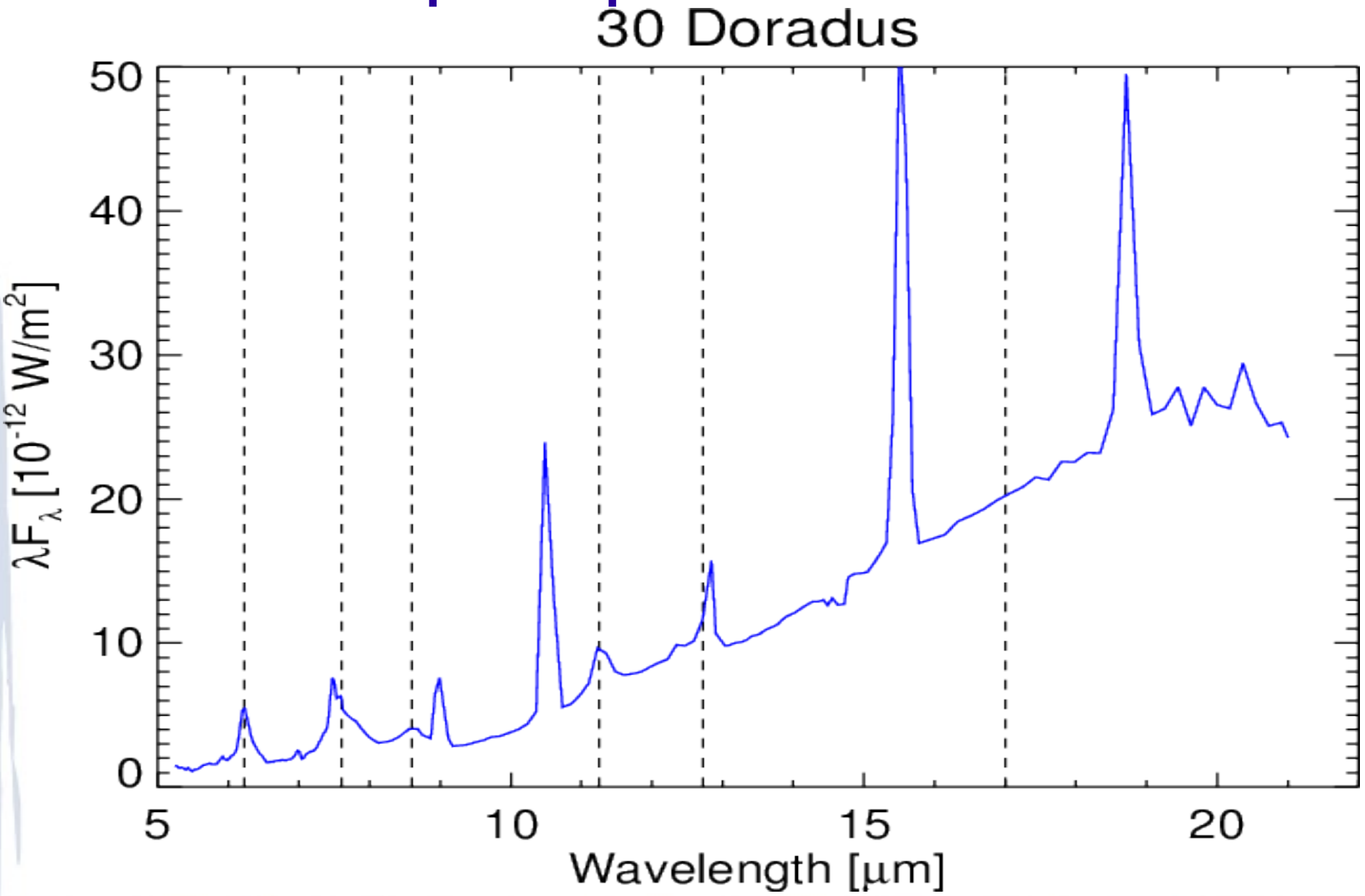




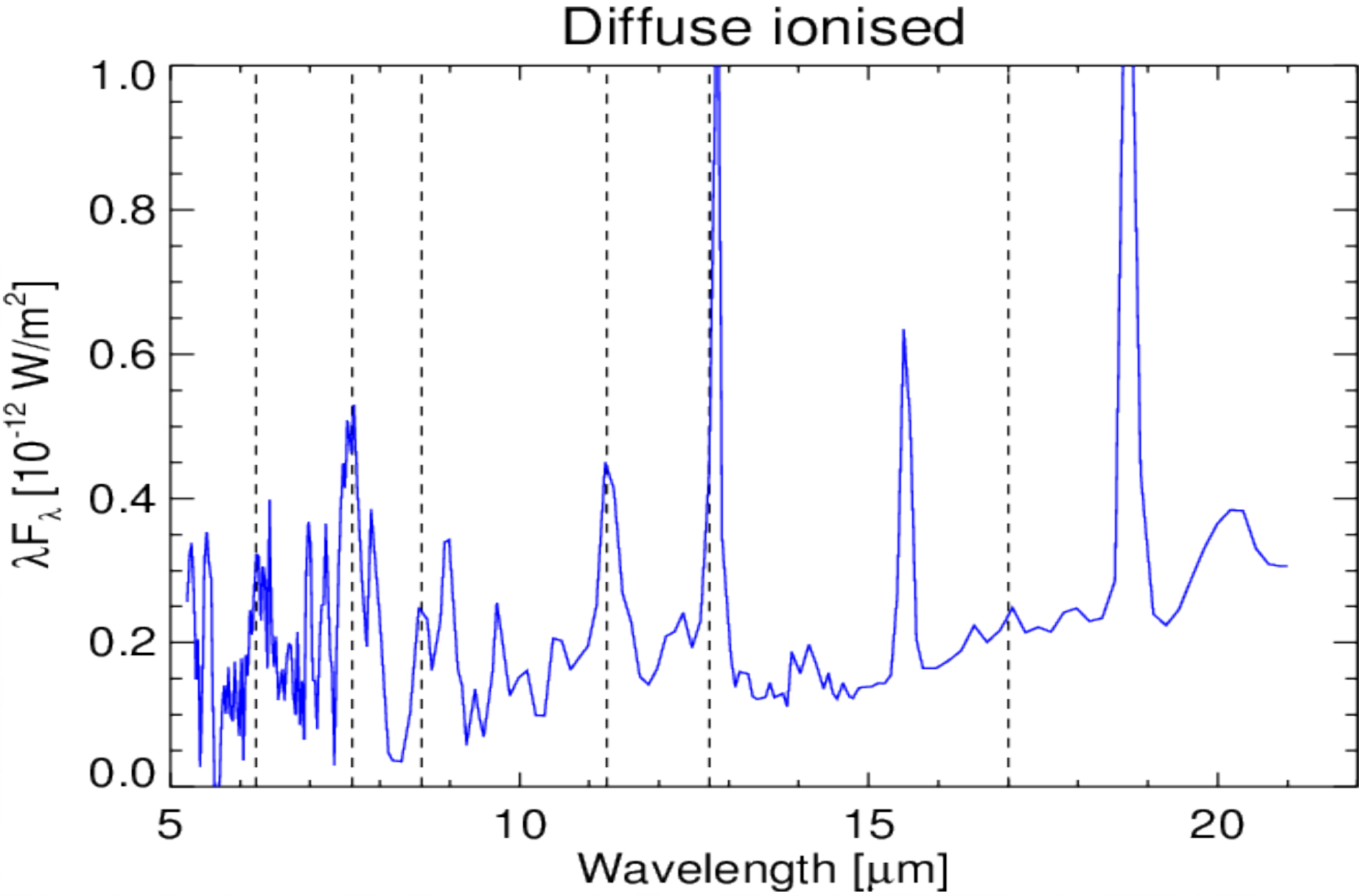
Example spectra: typical



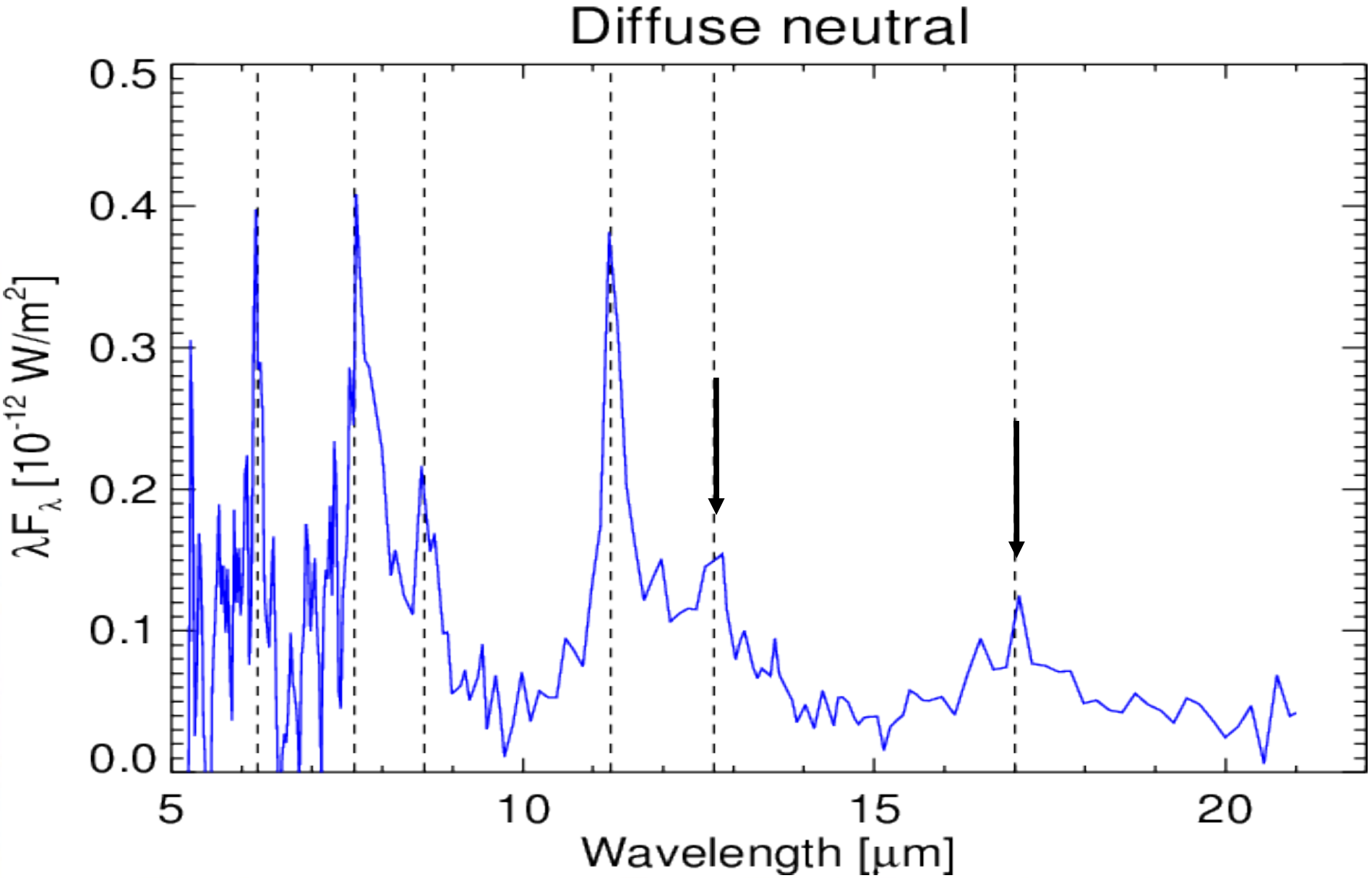
Example spectra: extreme



Example spectra: “diffuse”



Example spectra: “diffuse”



Data treatment

- SL1+SL2+LL2 (5-22 micron)
- Convolution to common spatial resolution (Gaussian beam ~25 micron, inspired by Sandstrom '08 and Gordon '08)
- Reprojection on common grid (~6”)
- Rebinning in overlap regions in wavelength
- Same treatment of uncertainties

Challenges

Regions are heterogeneous

- Huge number of spectra (~20k)
- Brightest spots are dominated by SF and hard radiation field
- Lower surface brightness holds important info
- Too faint to fit single pixels

→ *Adaptive resolution scheme:*

a) Determine bright enough pixels to fit and fit those

b) Remove pixels with enough SNR from the cube

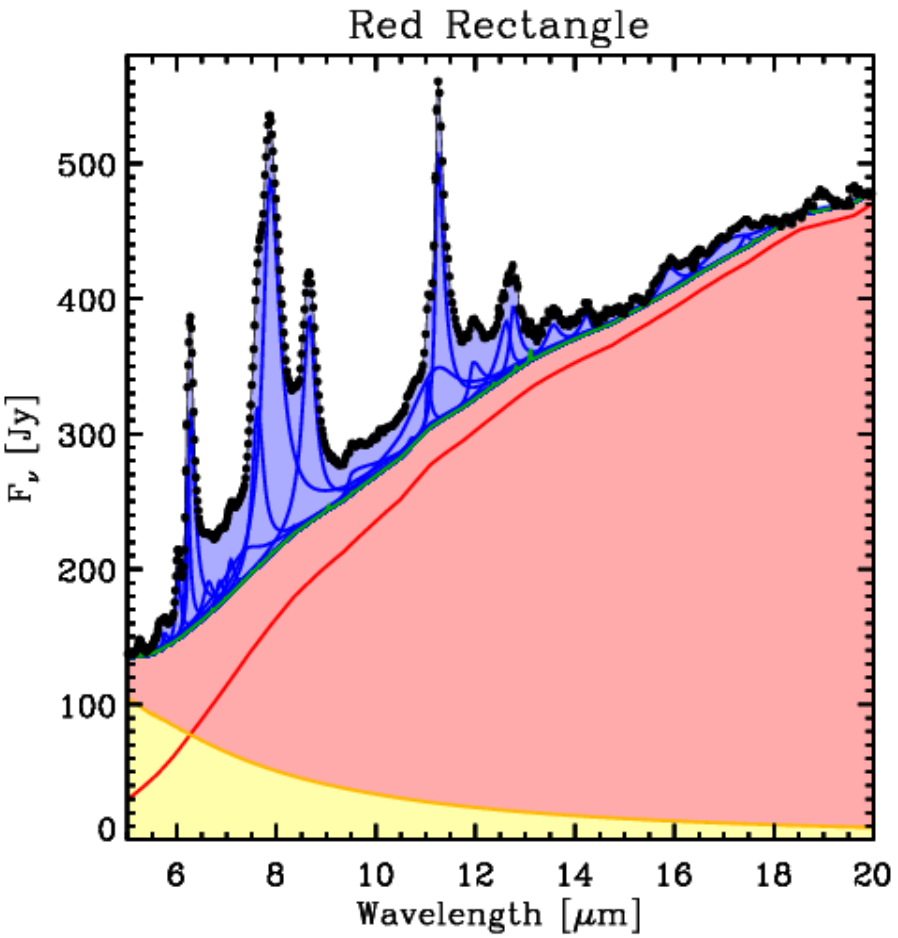
c) Rebin remaining pixels

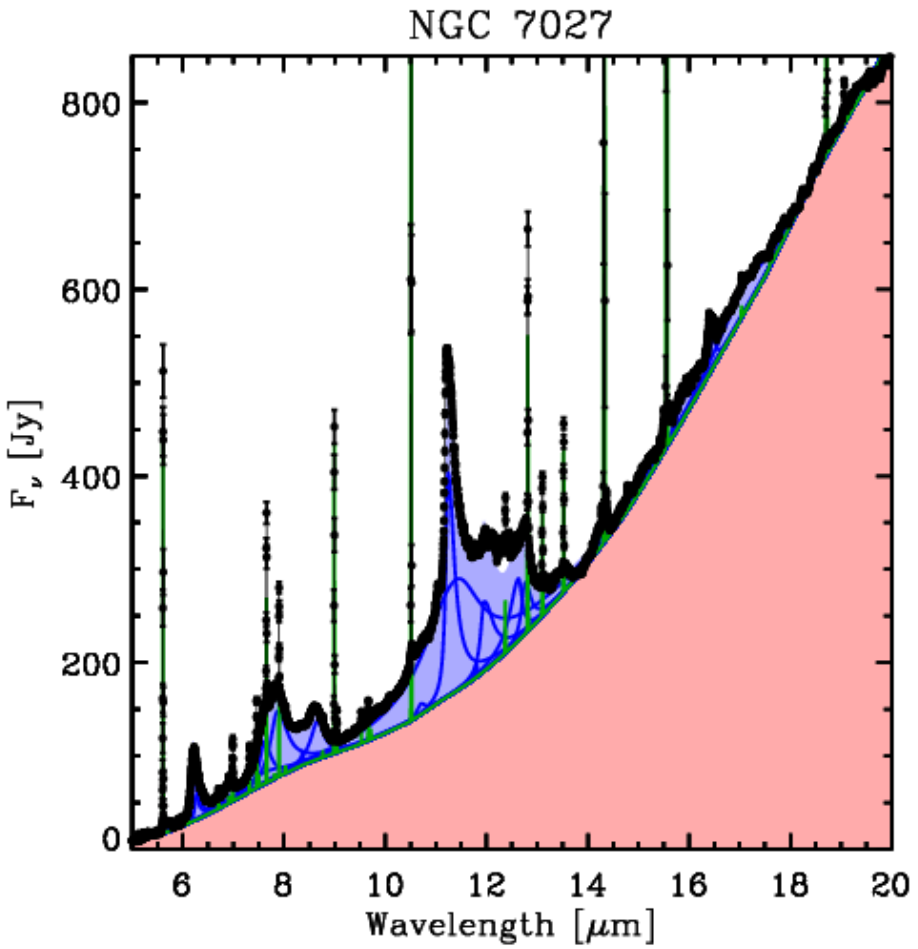
d) goto a)

Fitting the spectra

- Multi-component PAH fit + physical continuum (realistic optical properties of grains + stars + dust and ice extinction), G08, G11 in prep.; see also PAHFit (Smith et al 2007)
- 30 asymmetric (anharmonicity) band profiles calibrated on high res spectra: (SWS Red Rectangle) + plateaux+8.6 (SWS NGC 7027) + M17 IRS-SH (plat 17)
- 60 Atomic and H2 lines are fitted in first step (reduces free parameters in PAH fitting step, faster, better error estimates, more stable)
- Lines can be important pollutant (12.7 but also 7.7!)

Calibration:
Red rectangle and NGC 7027

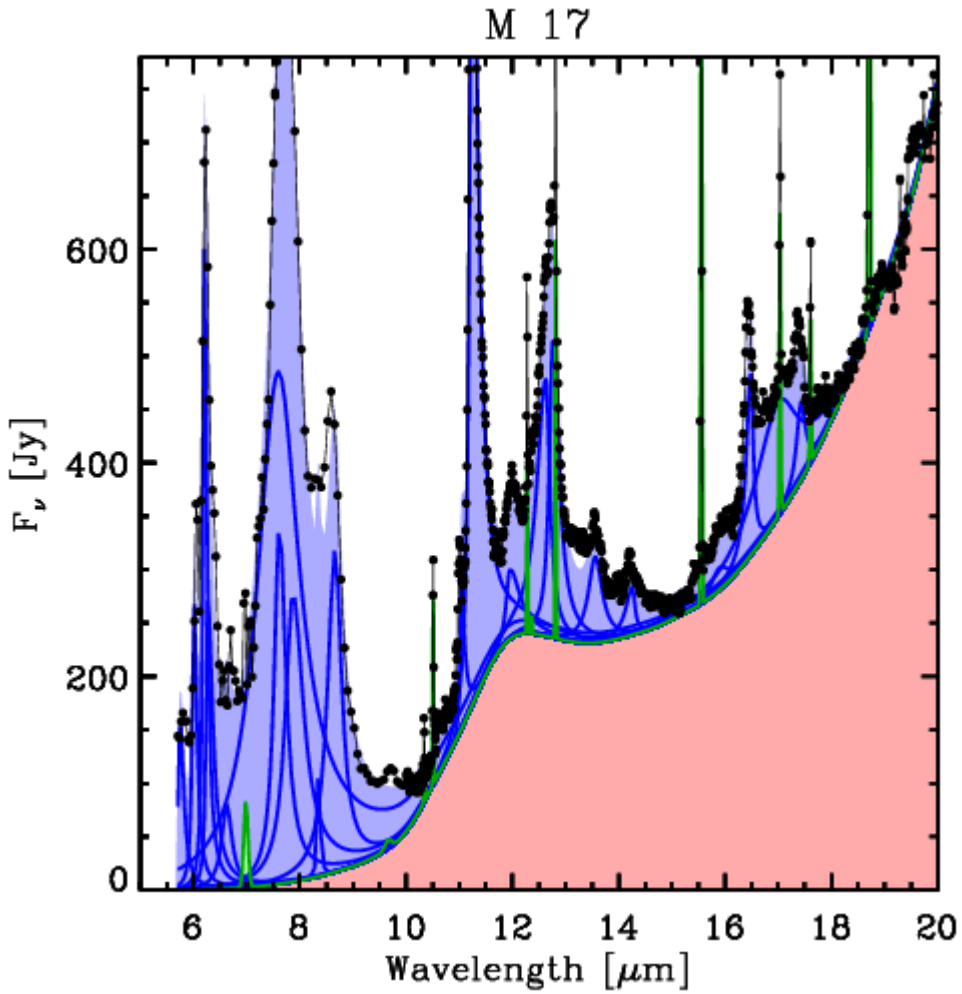




ISO/SWS spectra, Good resolving power and SNR

RR: Very well defined bands, NGC 7027 strong plateaux features

Calibration: M17+ features



Strong 17 um plateaux features

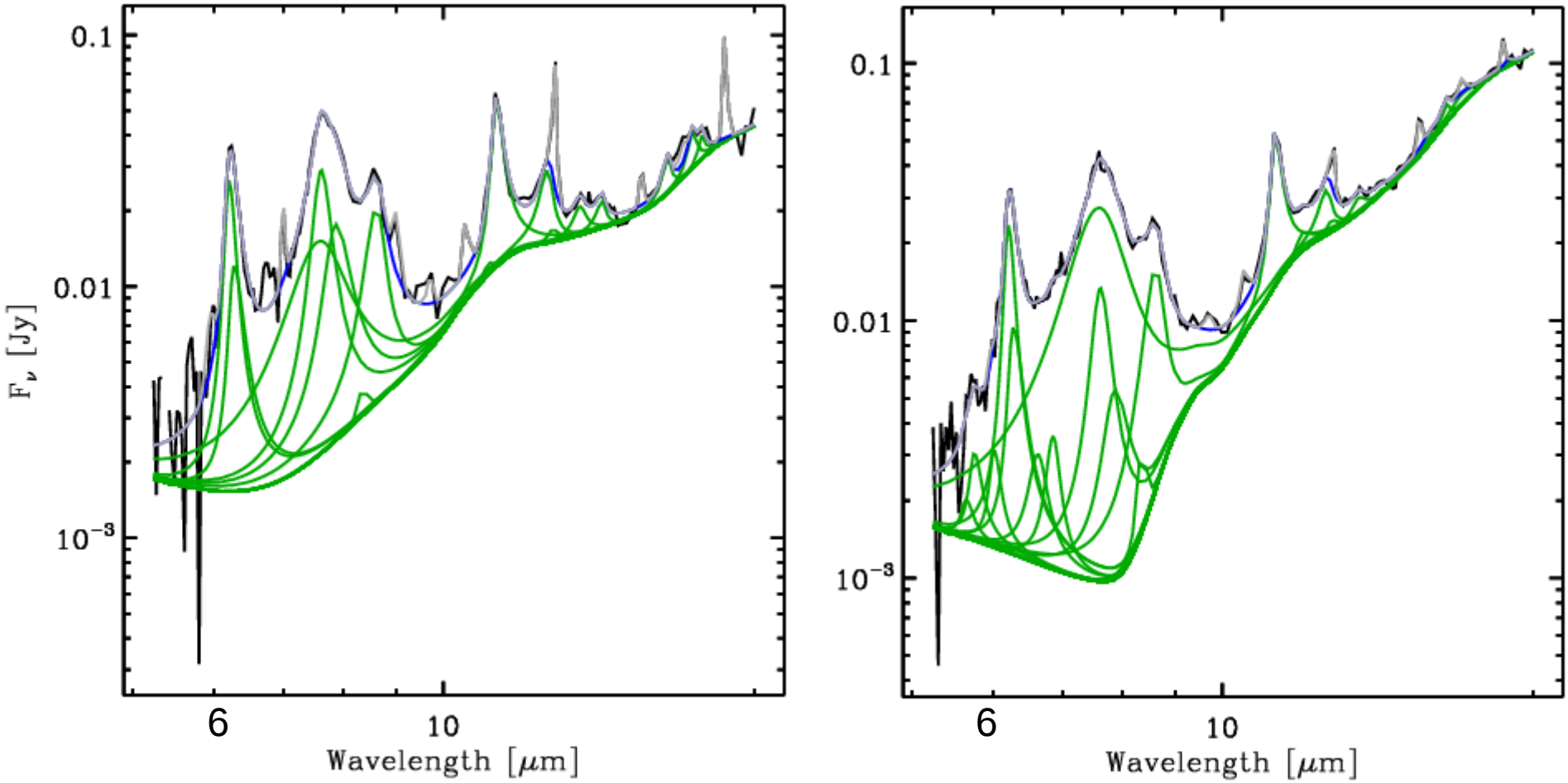
Continuum shape under the 11 um complex

Result: asymmetric bands with fixed positions and width

Applying the fitting

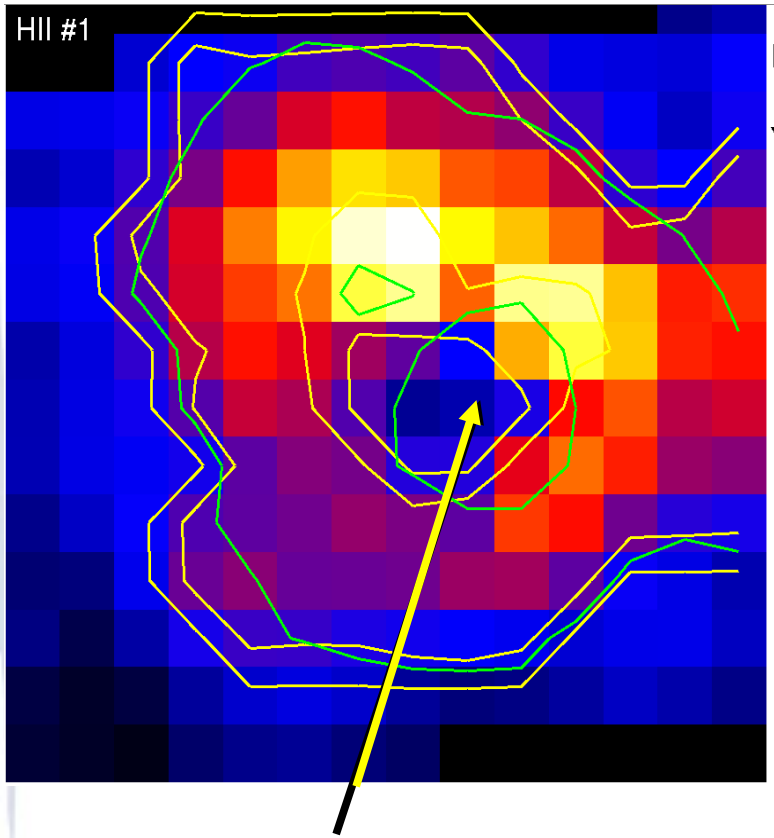
- About ~15 sec per pixel x 20 000 (can be done in a few days on a desktop computer)
- Uncertainties: MC approach by varying the observational constraints according to their sigma and redetermining the parameters (100 times)
- Distribution of parameter values gives error bar
- *Long for each pixel of 20 000. We define 27 typical classes within (I7.7, NeIII, I_cont15) + 1 faint.*
- Propagate errors to spectra in each class

Examples of fits

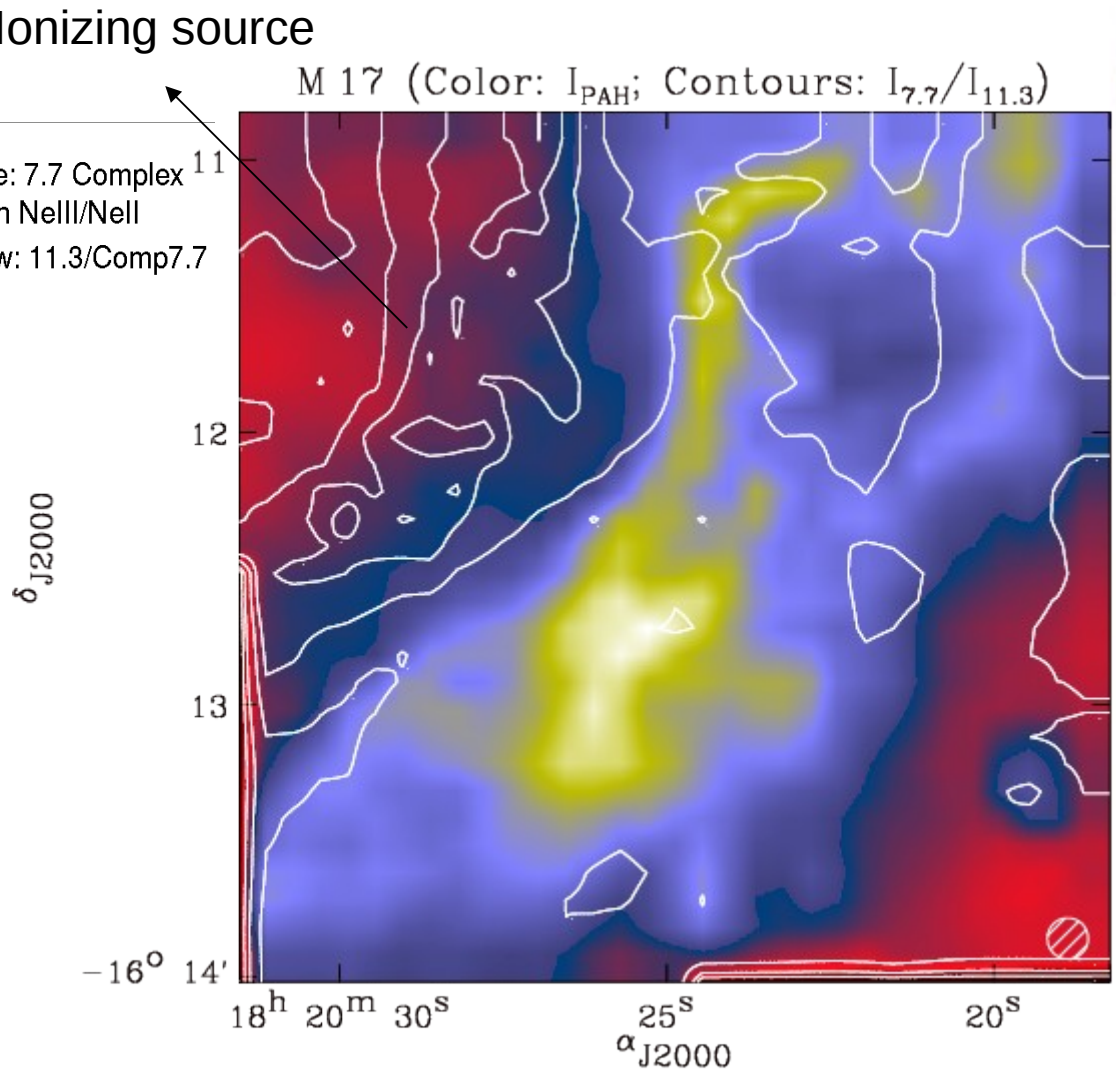


Feature map:

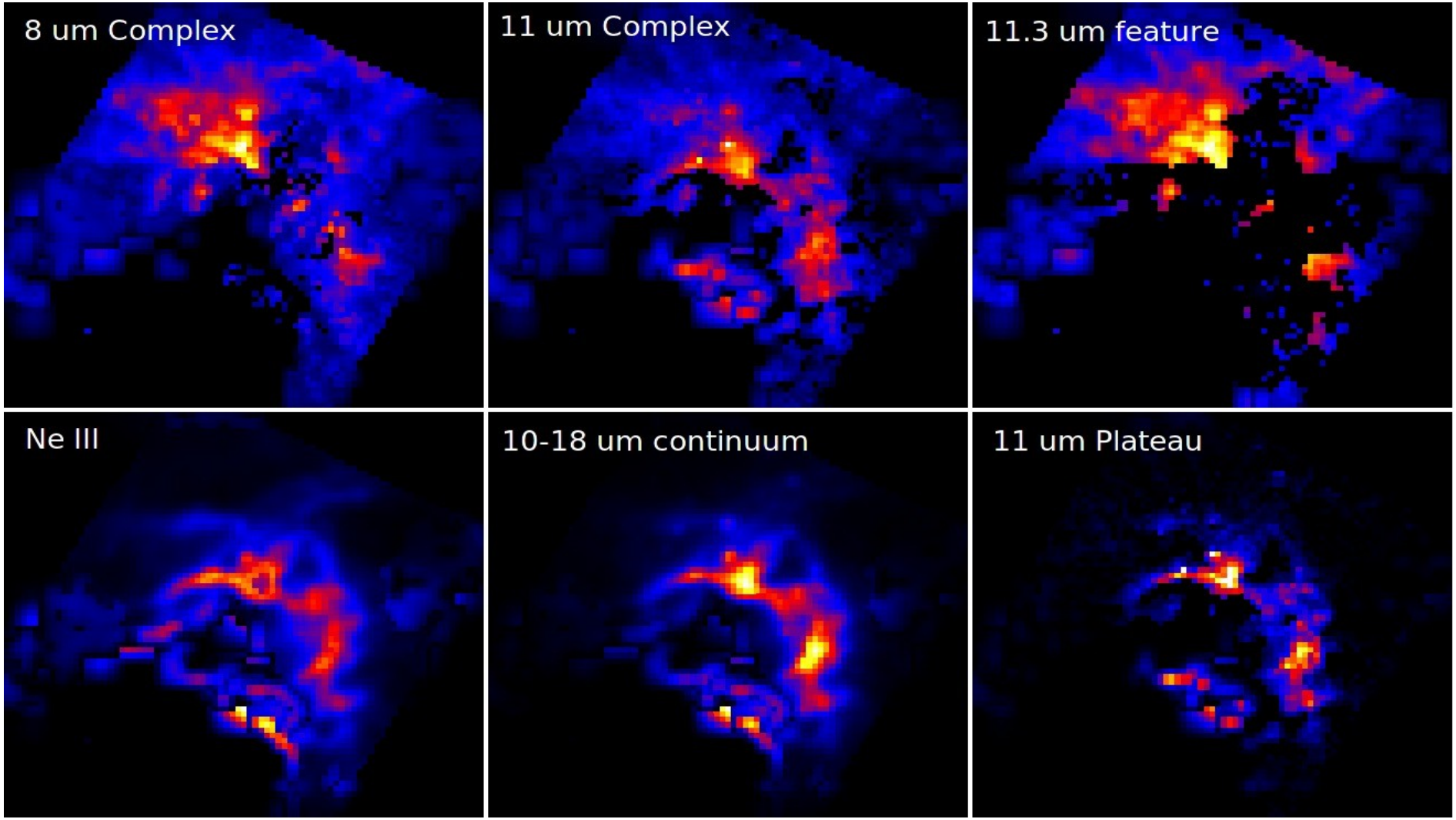
HII #1 (N4)



M17

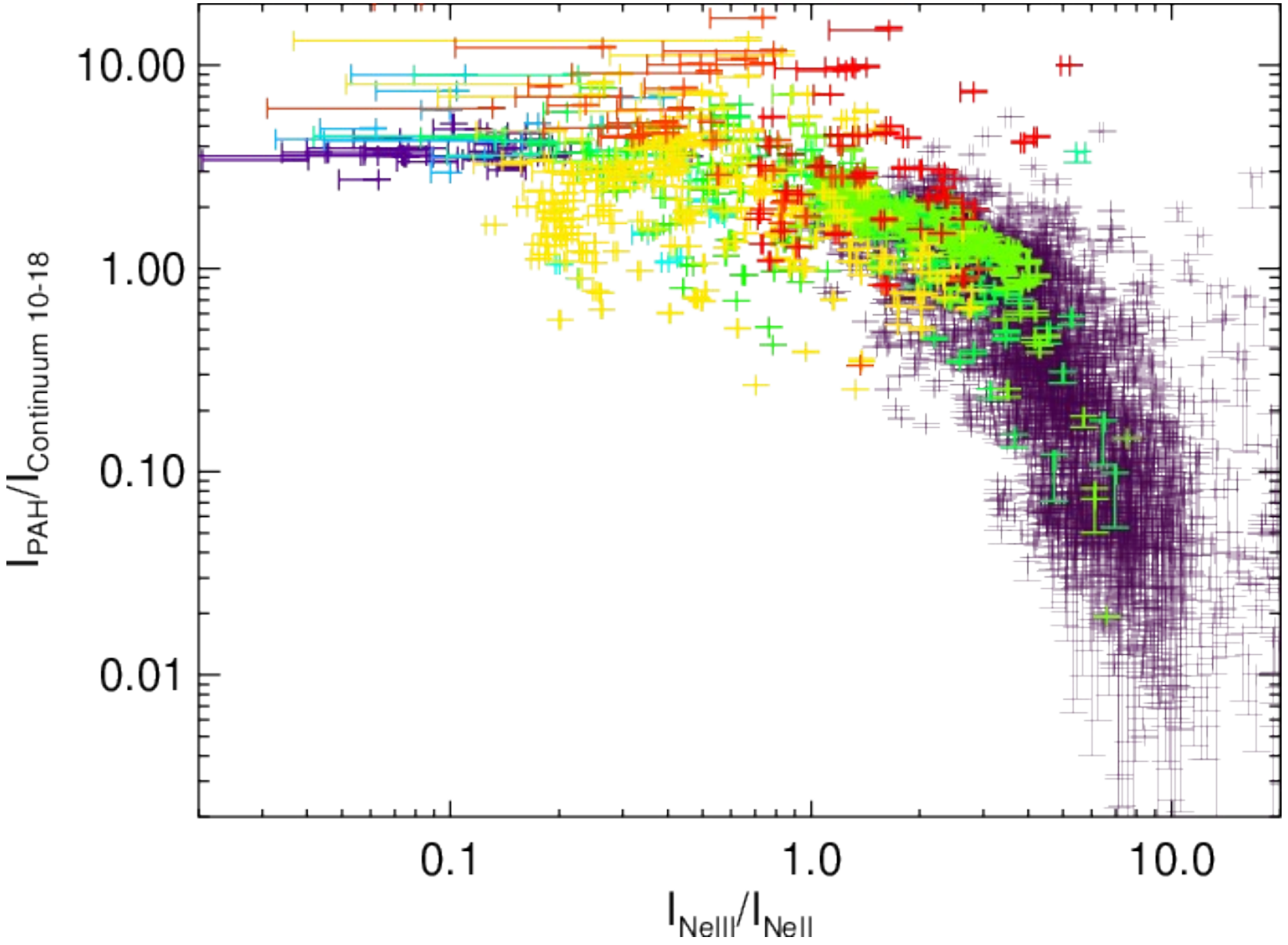


Feature map: 30 Dor

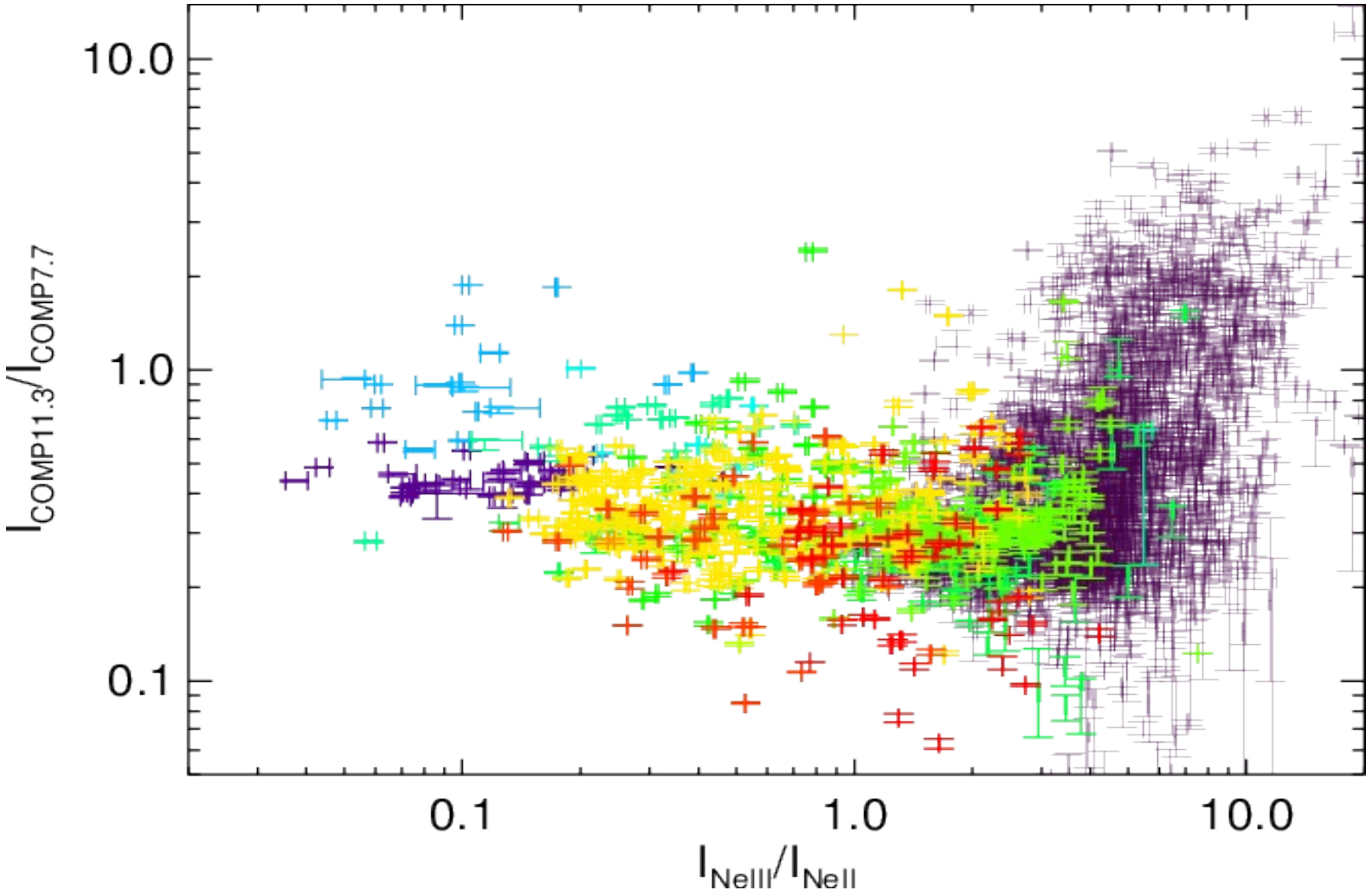


11 um 'plateau" coincides with hot grain continuum and ionising radiation

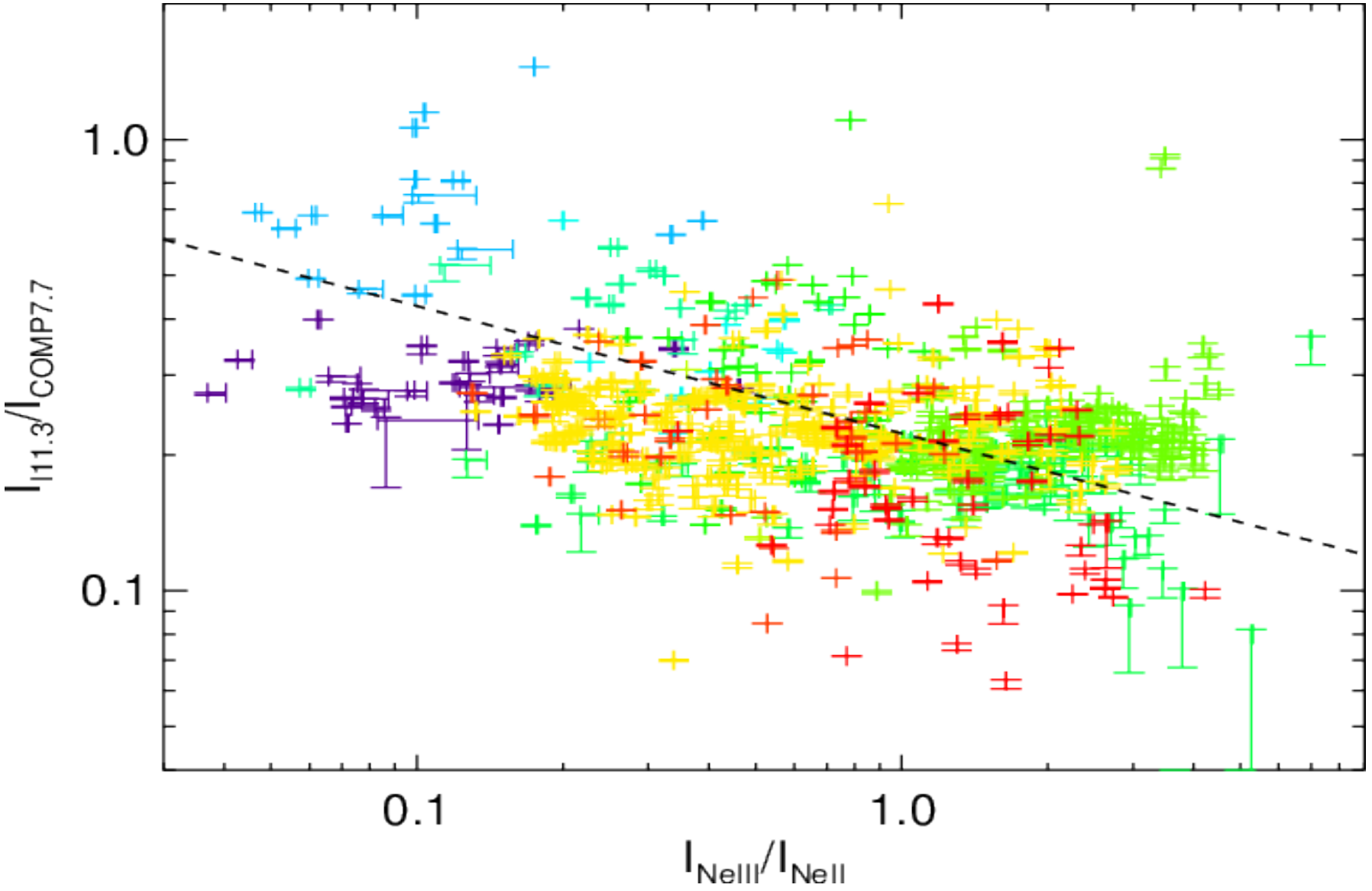
Correlations: radiation field - I



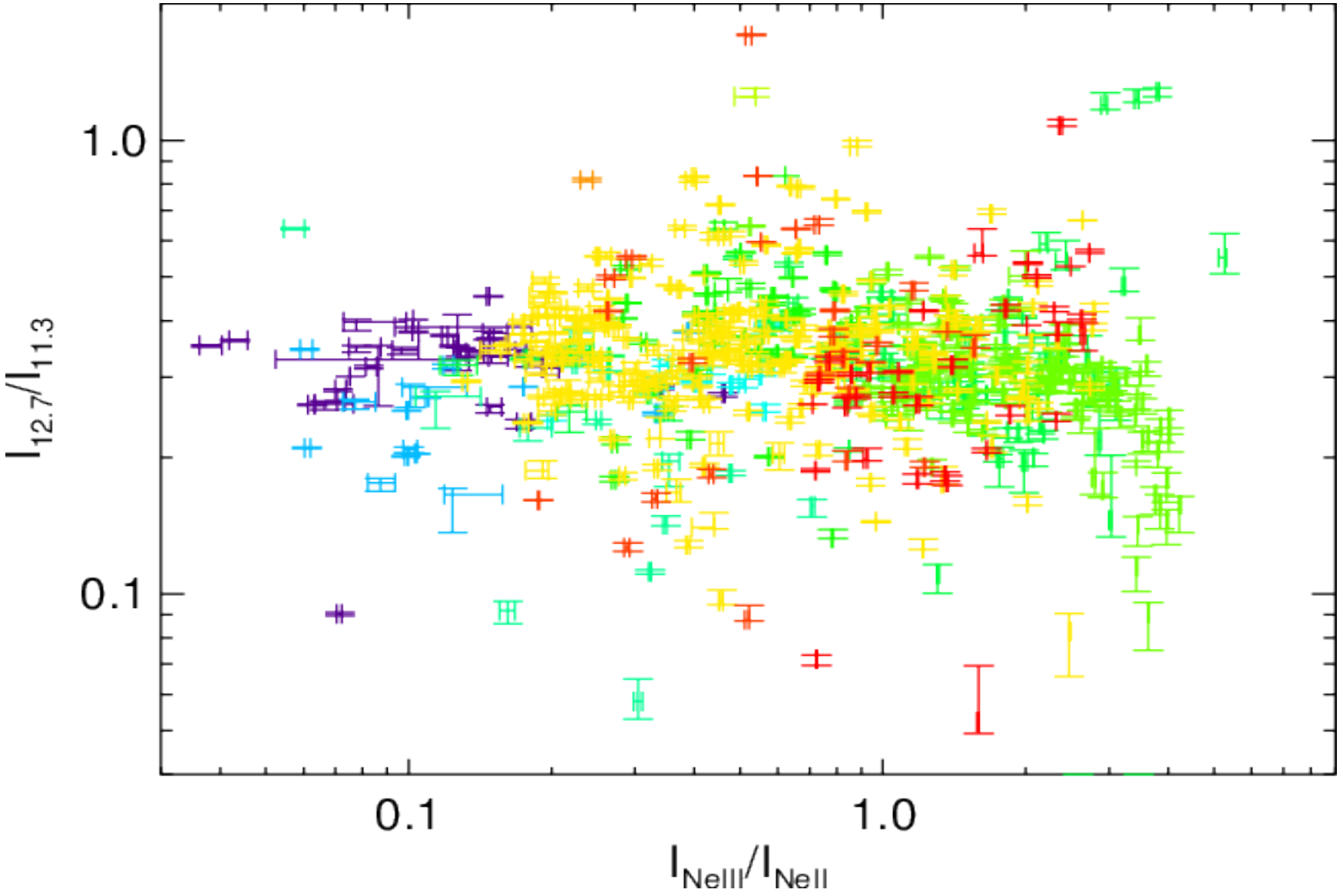
Correlations: radiation field-II



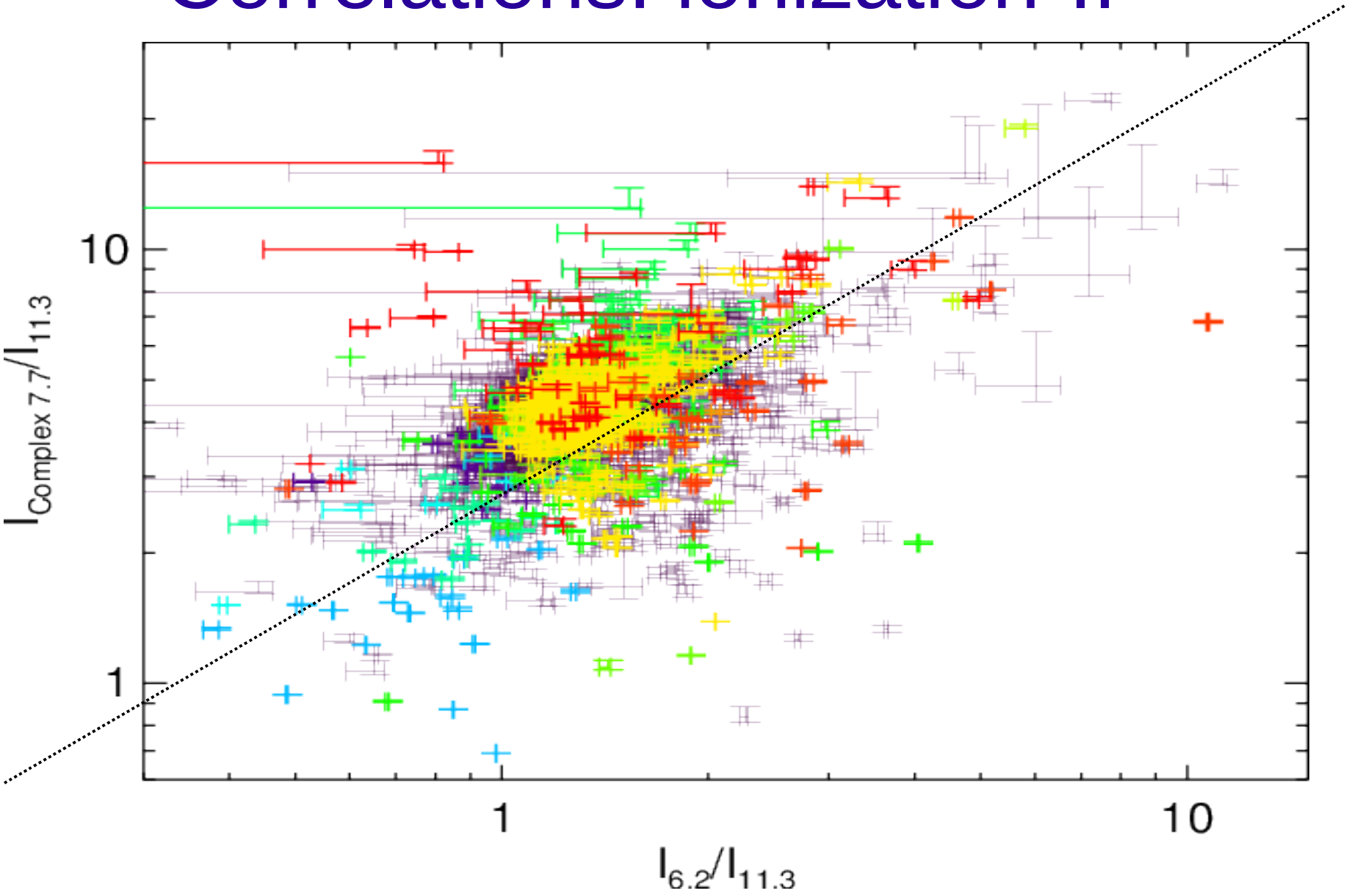
Correlations: radiation field-III



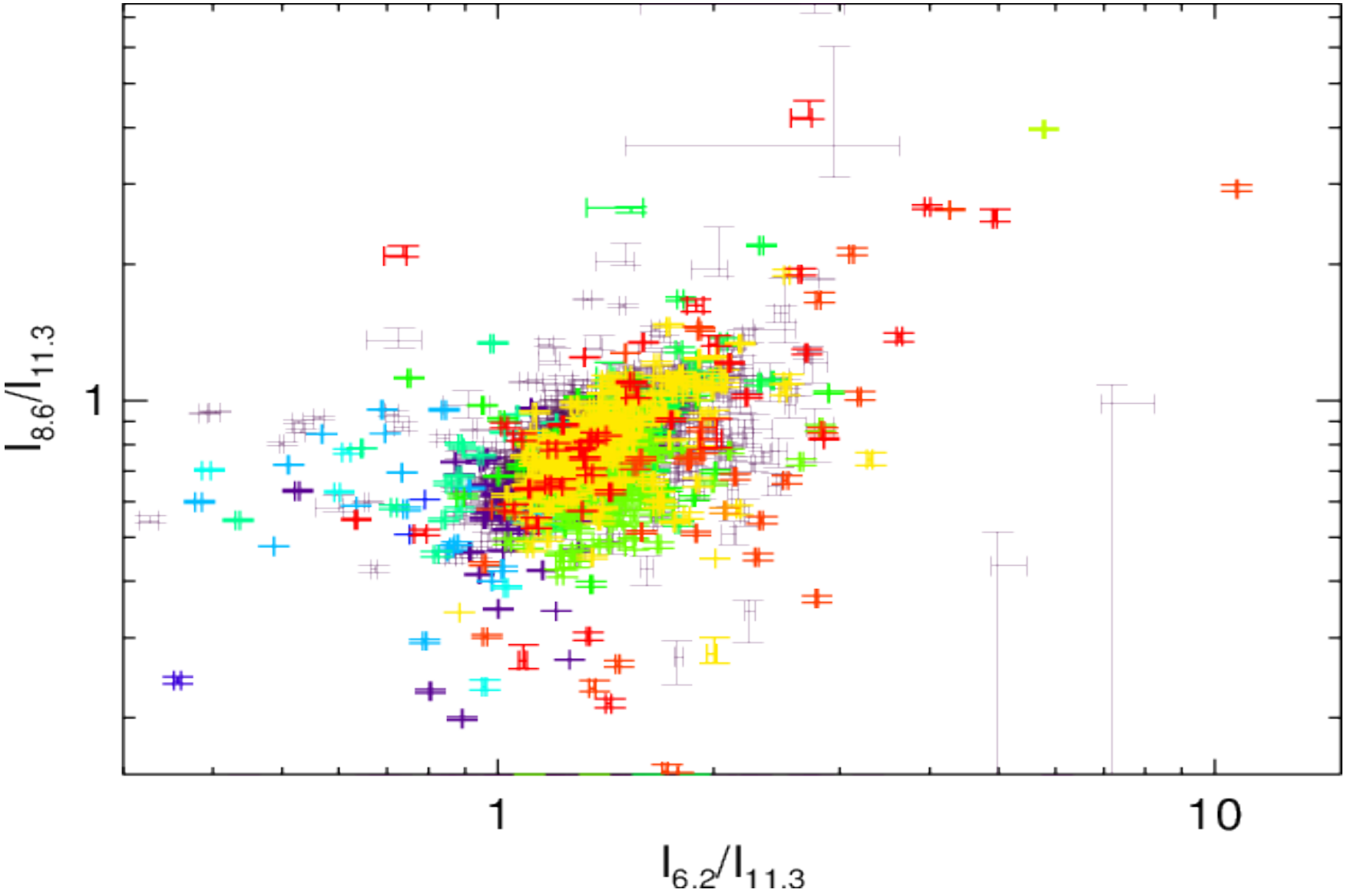
Correlations: radiation field-IV



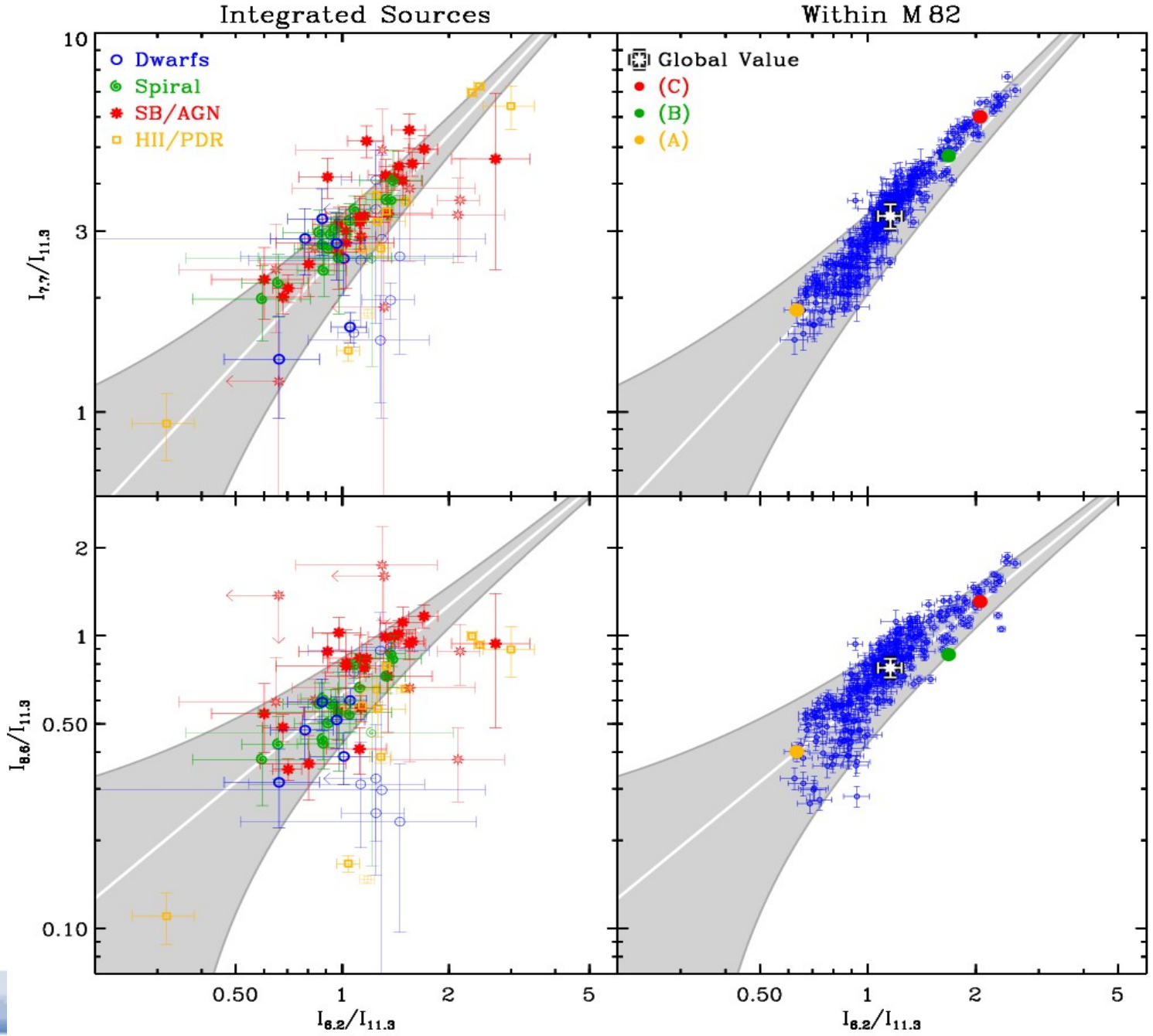
Correlations: ionization-II



Correlations: ionization-II

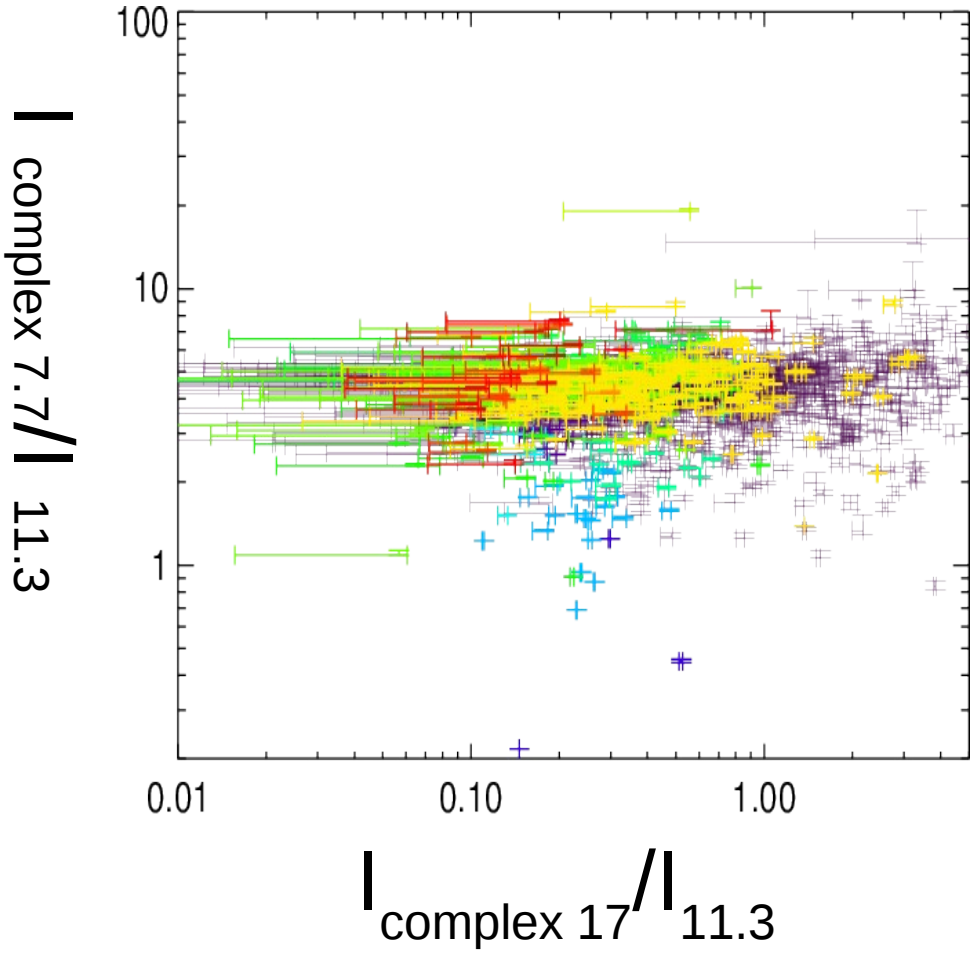


Ratios as tracers



Correlations: summary

- PAH/Cont vs NeIII/NeII
- Strongest variations in CC/CH modes
- Weak correlation CH/CC vs NeIII/NeII
- Range of $I_{11.3}/I_{6.2}$ small – effect of spatial resolution (few pc)?
- *17 complex appears to vary a lot – effect of size?*



Conclusions

- Analysed 20 different regions
- Advanced fitting routine to derive band intensities
- “Standard” correlations work well in LMC
- Ionisation seems dominant effect

- PAH Ionisation ($I_{complex\ 7.7}/I_{11.3}$) correlates with hardness of radiation field
- 11 um complex does not follow strictly the PAH bands (most clearly in 30 Dor).

- *Comparison with other traces and PDR models*
- *Comparison with SMC (lower metallicity)*
- *Add HERITAGE (PACS) data to derive relative abundances*