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The 6.2 µm PAH profile as a tracer of nitrogen in the Universe

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Photo credit: Jenny Mottar

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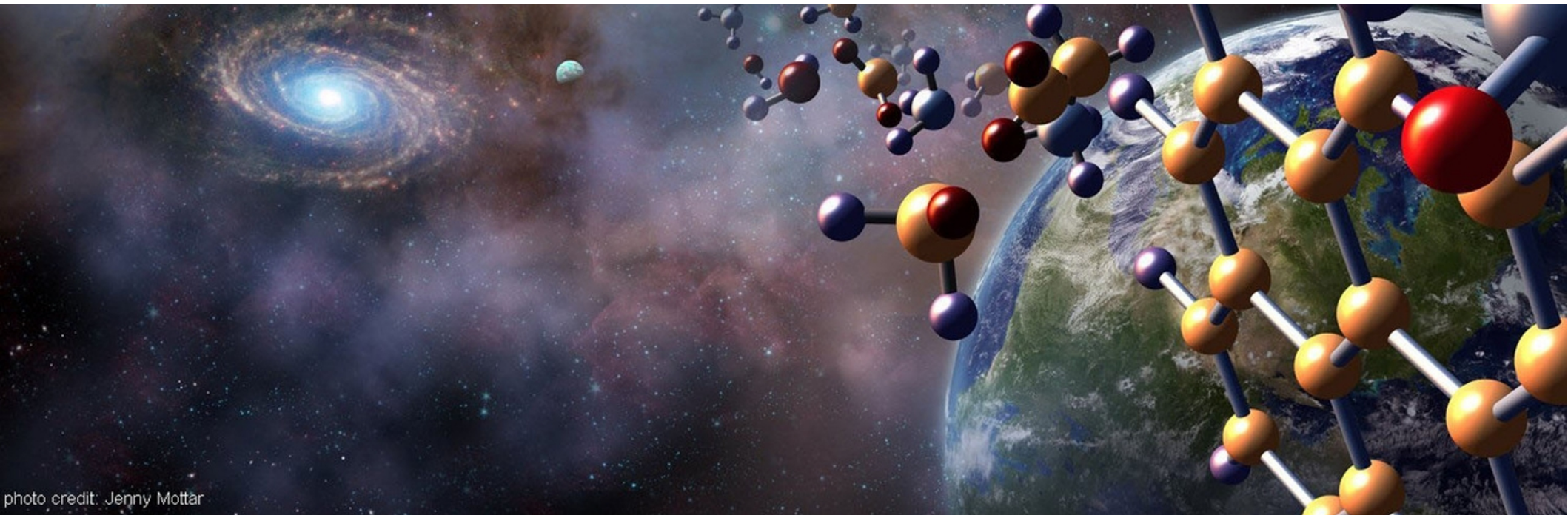
CAPES

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

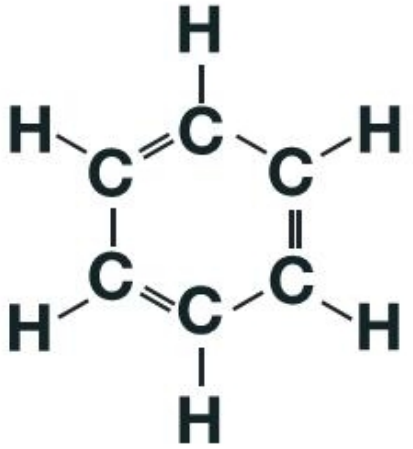
INTRODUCTION

- PAHs and Astrobiology
- The main goal
- The sources



PAHs and Astrobiology

- **P**olycyclic **A**romatic **H**ydrocarbon (PAH)
- 20% or more of the carbon in the ISM (Joblin et al., 1992)
- 50% of the mid-IR luminosity (Li et al. 2004)
  (3.3, 6.2, 7.7, 8.6, 11.3 and 12.7 μm)
- Star formation tracers (Tielens et al. 2008)

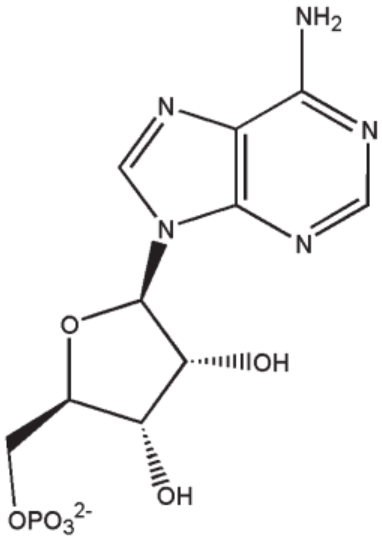


Benzene C_6H_6

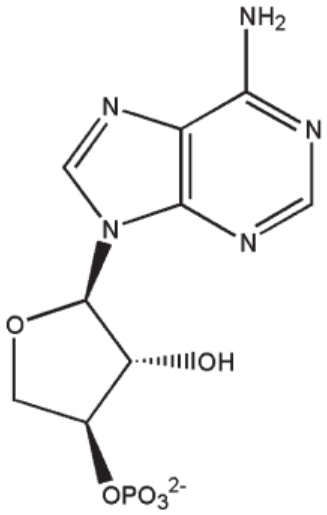
The Aromatic World

- Prebiotic role
- PANH

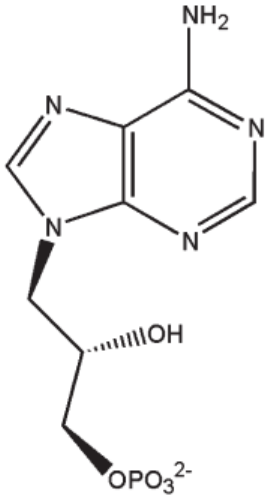
Ehrenfreund et al. 2006



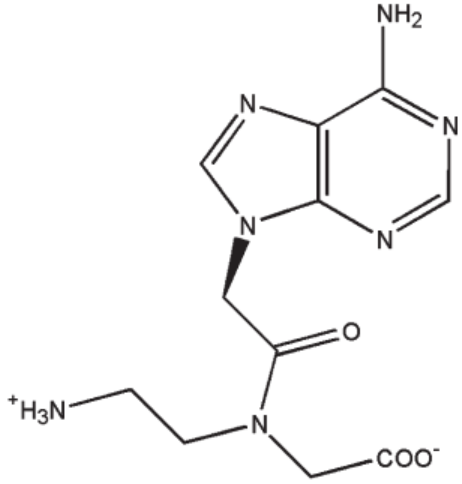
RNA



TNA

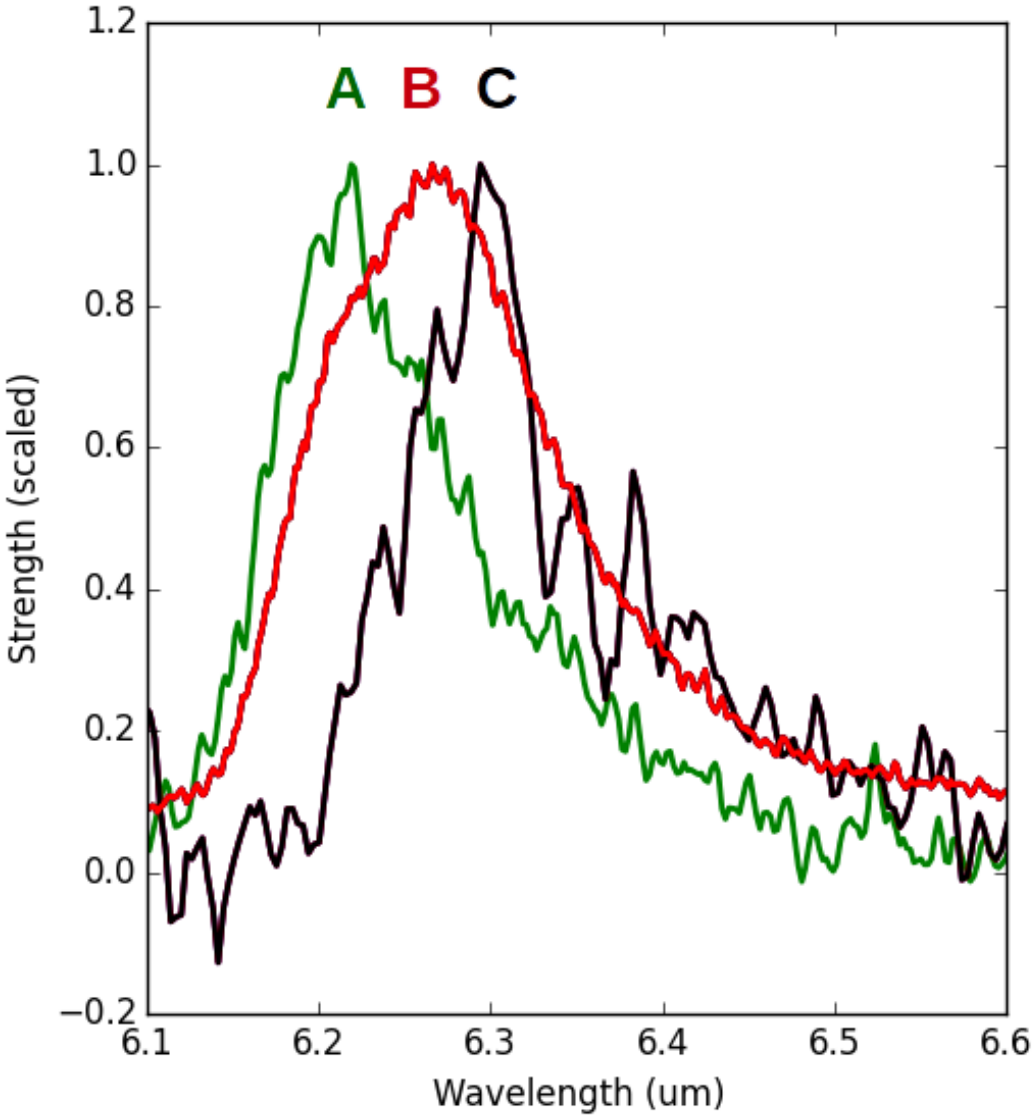


GNA



PNA

The main goal



General profile variations (Peeters et al. 2002)

- Shift of the CC stretching feature near 6.2 µm
- 6.22 µm → PANH (Hudgins et al. 2005)
- Another reservoir of N

CLASS	INTERVAL (µm)
A	< 6.23
B	6.23 < λ < 6.29
C	> 6.29

The sources

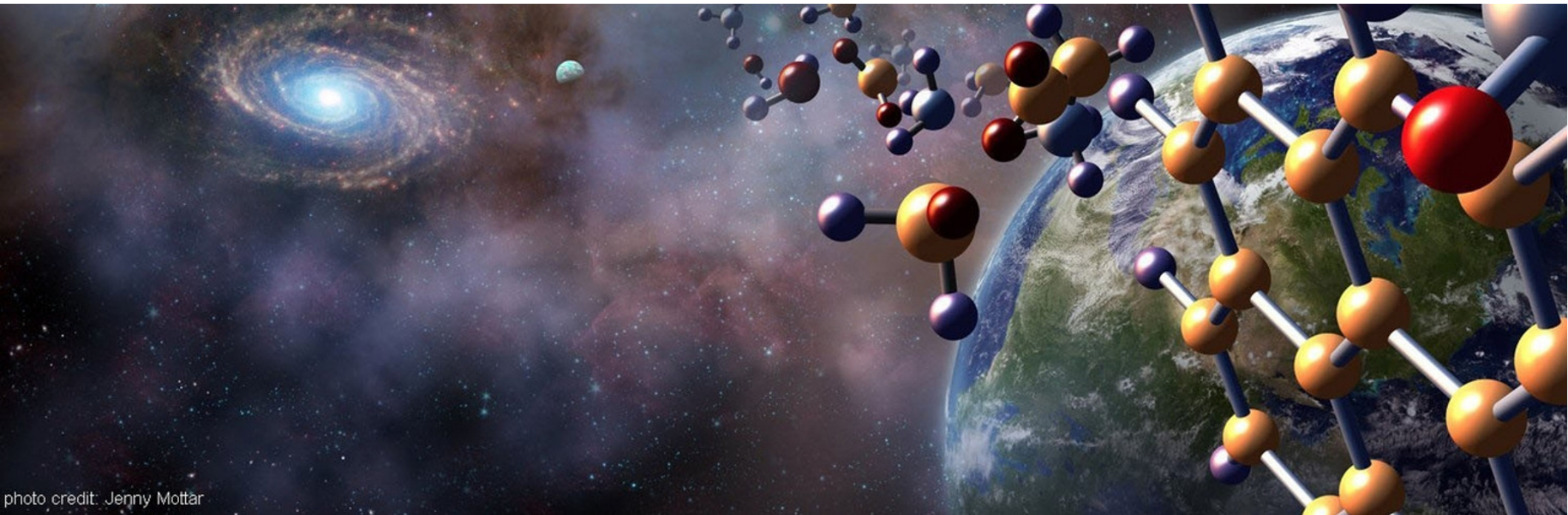
Starburst-dominated galaxies → Statistically significant approach

The Spitzer/IRS ATLAS project – Hernán-Caballero & Hatziminaoglou, 2011
http://www.denebola.org/atlas/

- MIR starbursts sample
  - 206 presented the 6.2 μm feature
  - The redshifts vary from 0.001 to 2.5

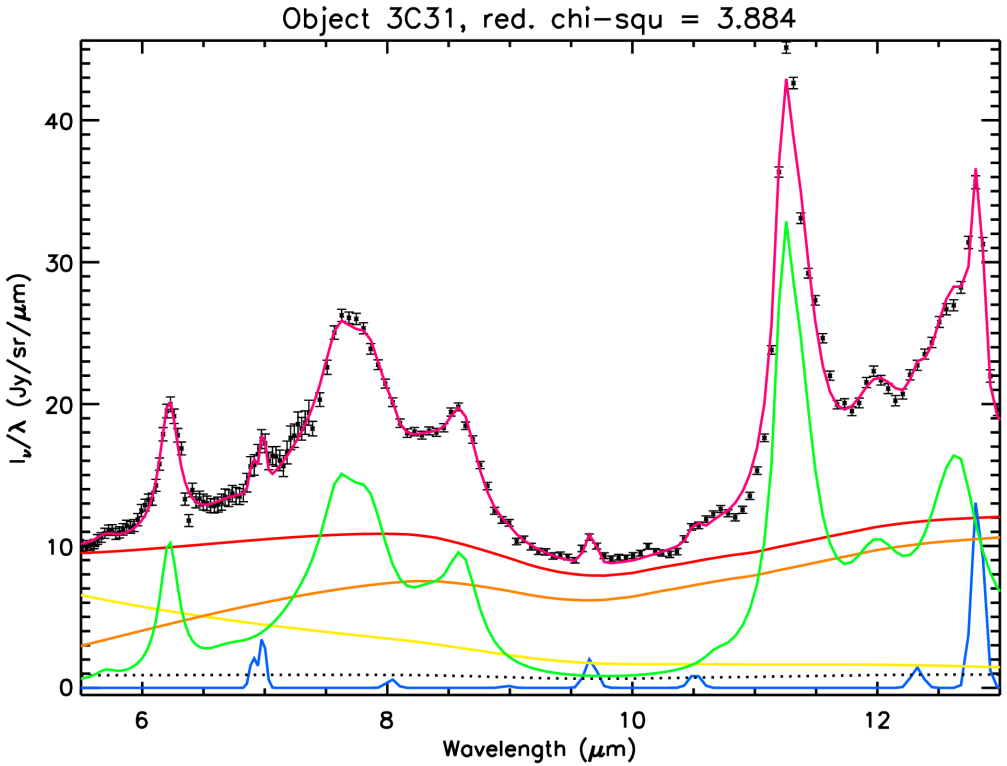
DATA ANALYSIS

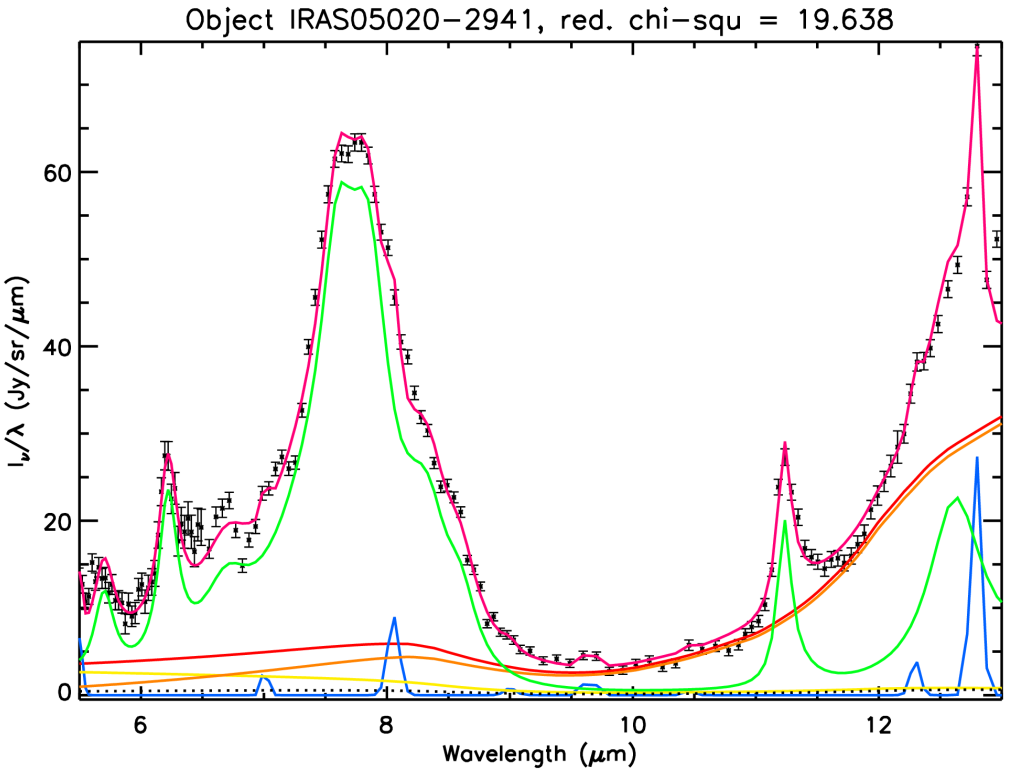
- PAHFIT and RMS
- The 6.2 μm feature profile
- The 6.0 μm water ice feature



PAHFIT

- IDL tool (Smith et al., 2007)
- Decomposes mid-IR spectra
- Issue: peculiar emissions.

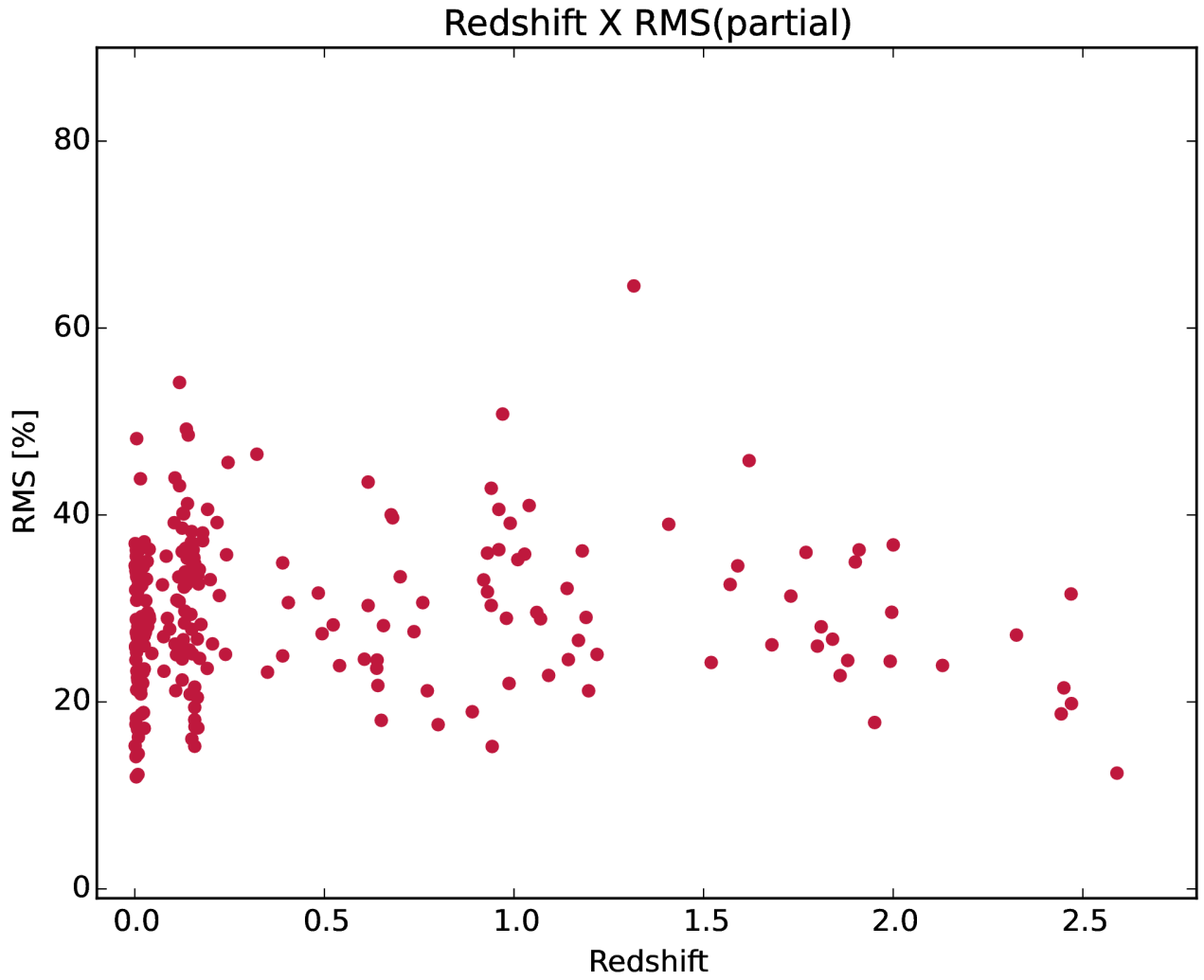




Best fit model
PAH emission bands
Ionic/molecular lines
Individual thermal dust continuum
Individual stellar contribution
Total thermal dust continuum

Root Mean Square

- **Goal:** to analyze the PAHFIT best fit model for each source
  - Total RMS > Partial RMS (wavelengths < 12 μm)



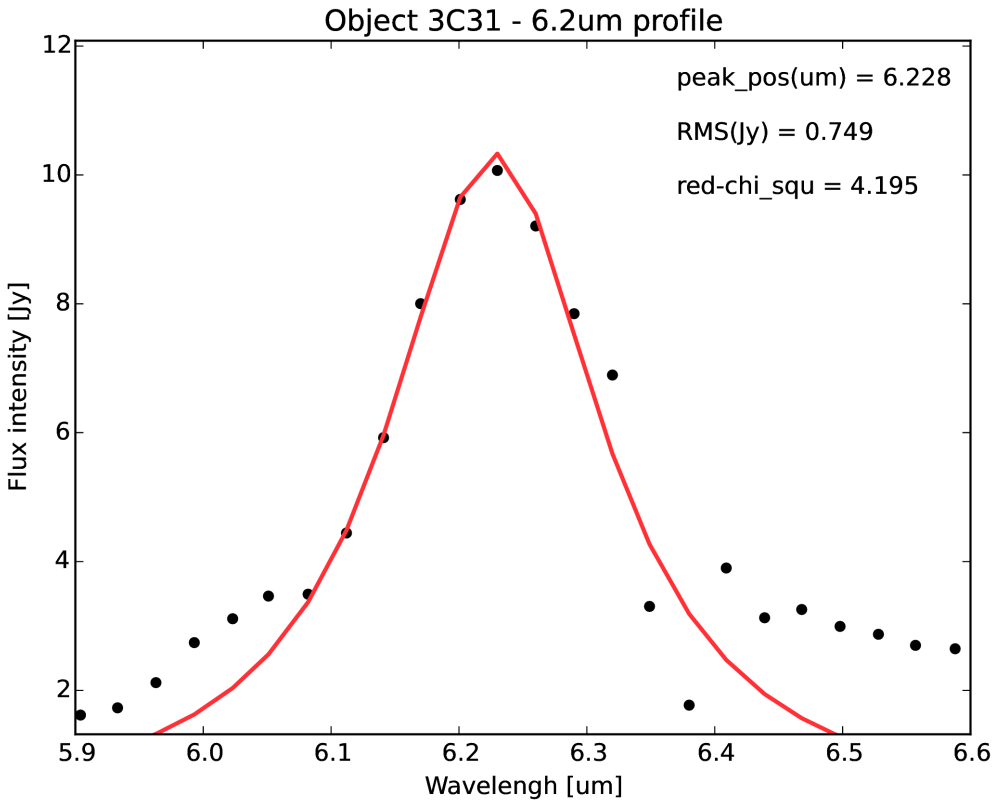
Fitting the 6.2 μm feature

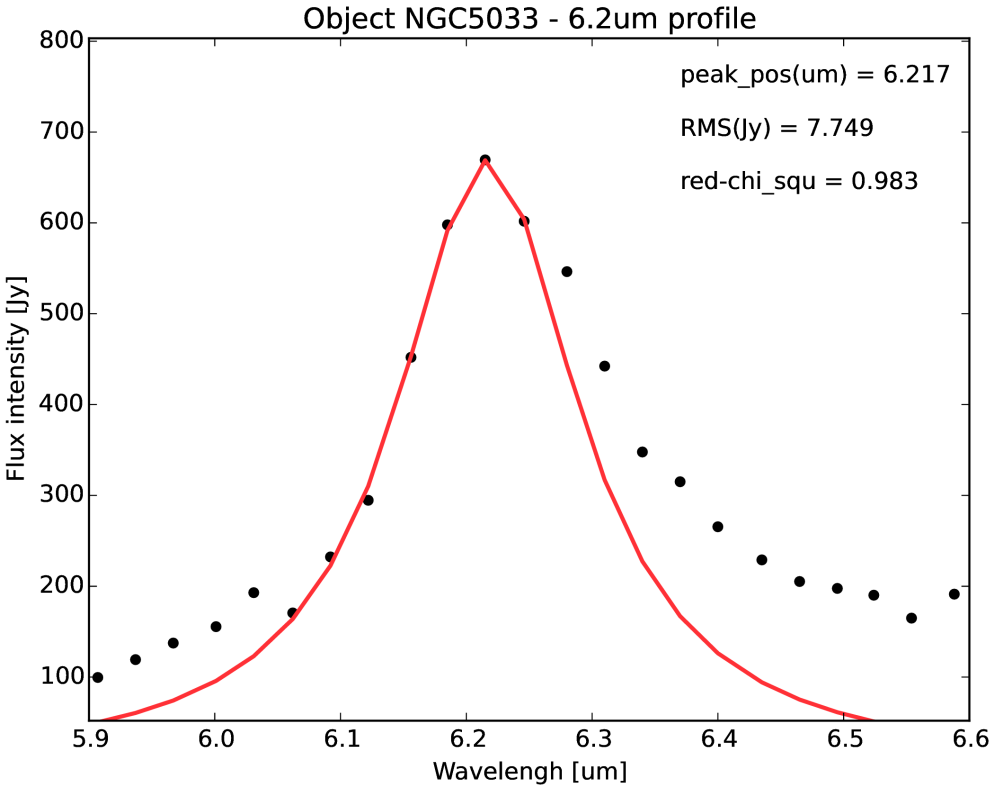
- PAHFIT has fixed central wavelengths
- Our own script based on python
- The continuum, silicate absorption and ionic and molecular lines contributions were subtracted from the original data before the fitting
- Initial guesses – Smith et al. 2007

λ_r (μm) (1)	γ_r (2)	FWHM (μm) (3)
5.27.....	0.034	0.179
5.70.....	0.035	0.200
6.22.....	0.030	0.187
6.69.....	0.070	0.468

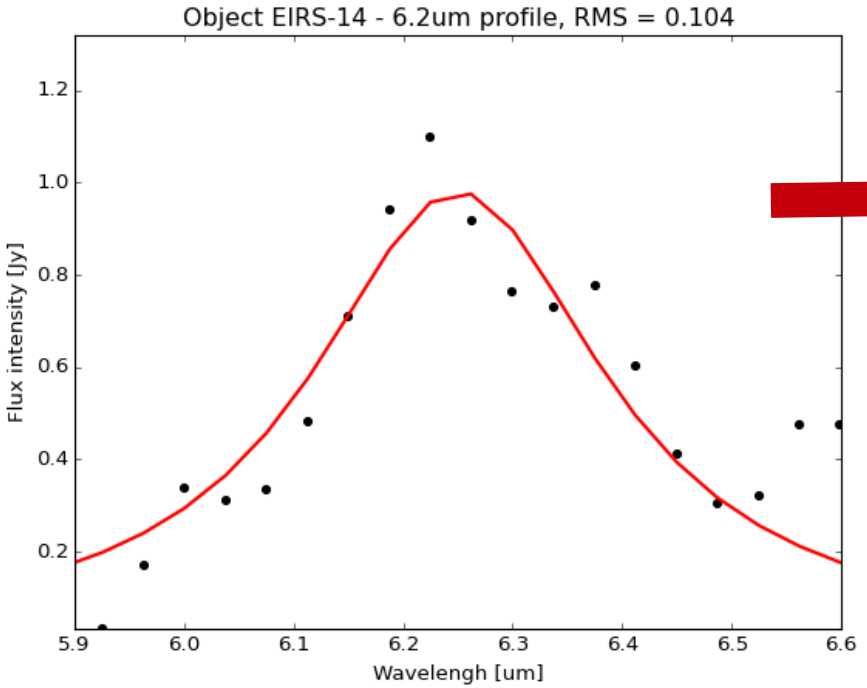
The 6.2 μm feature (Case #1)

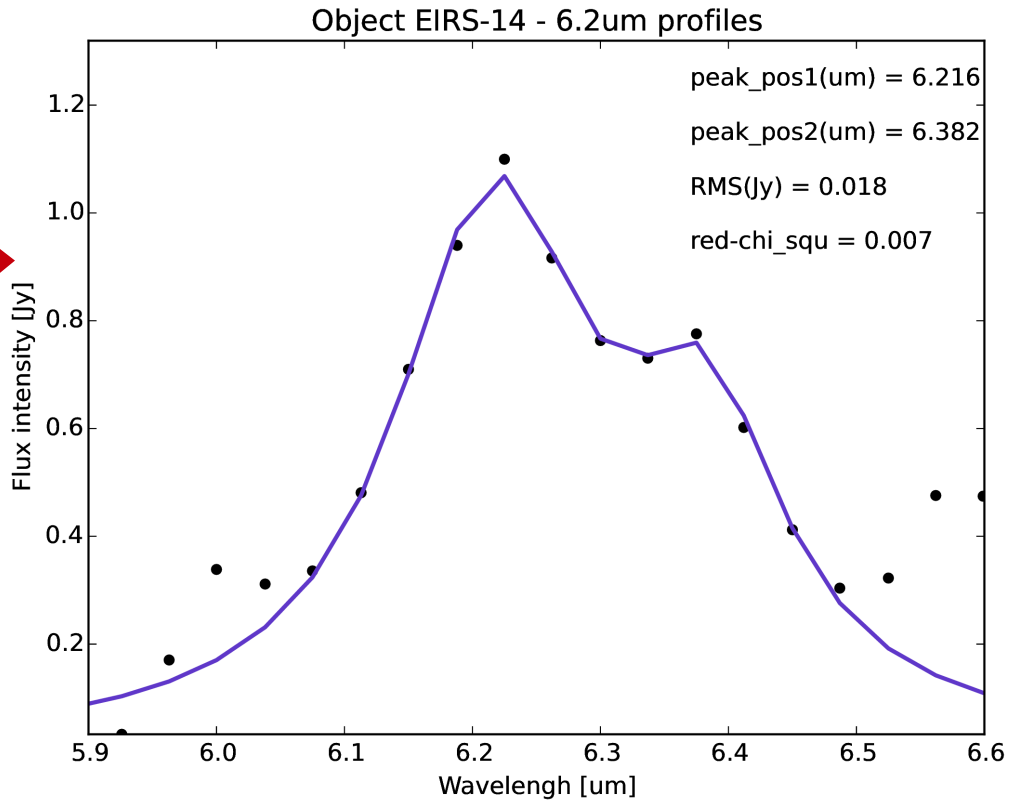
- Some profiles are more symmetric
- Others are not → range changes





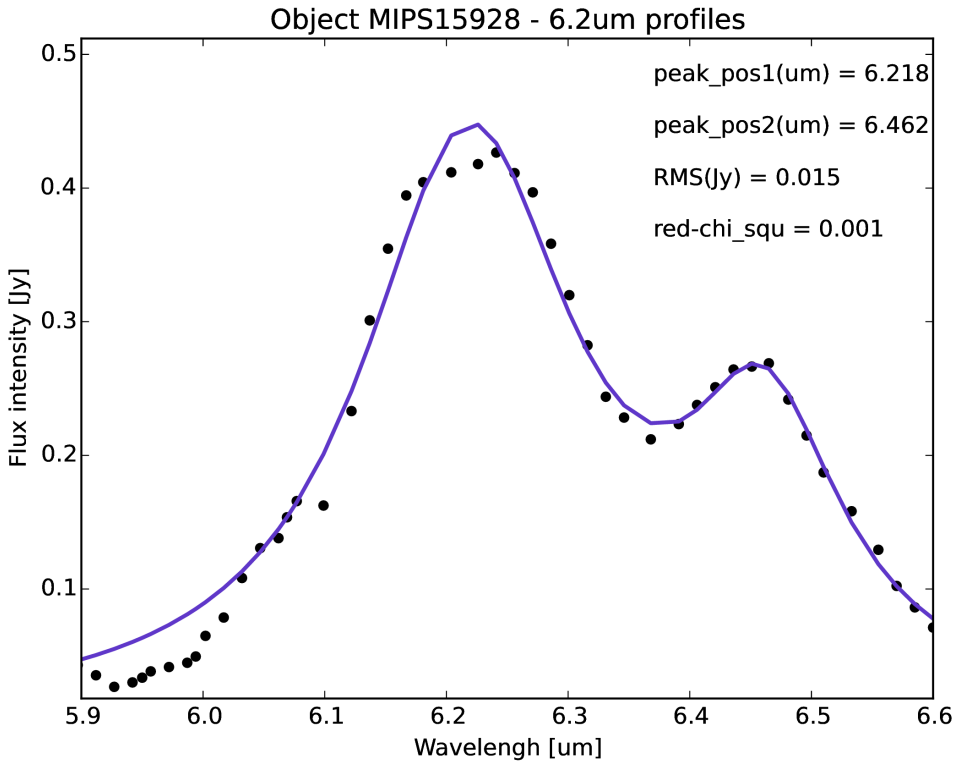
- Issue: not all sources were well fitted
- Apparently another emission feature at ~ 6.35 μm
- Using 2 distinct profiles → Slightly different program

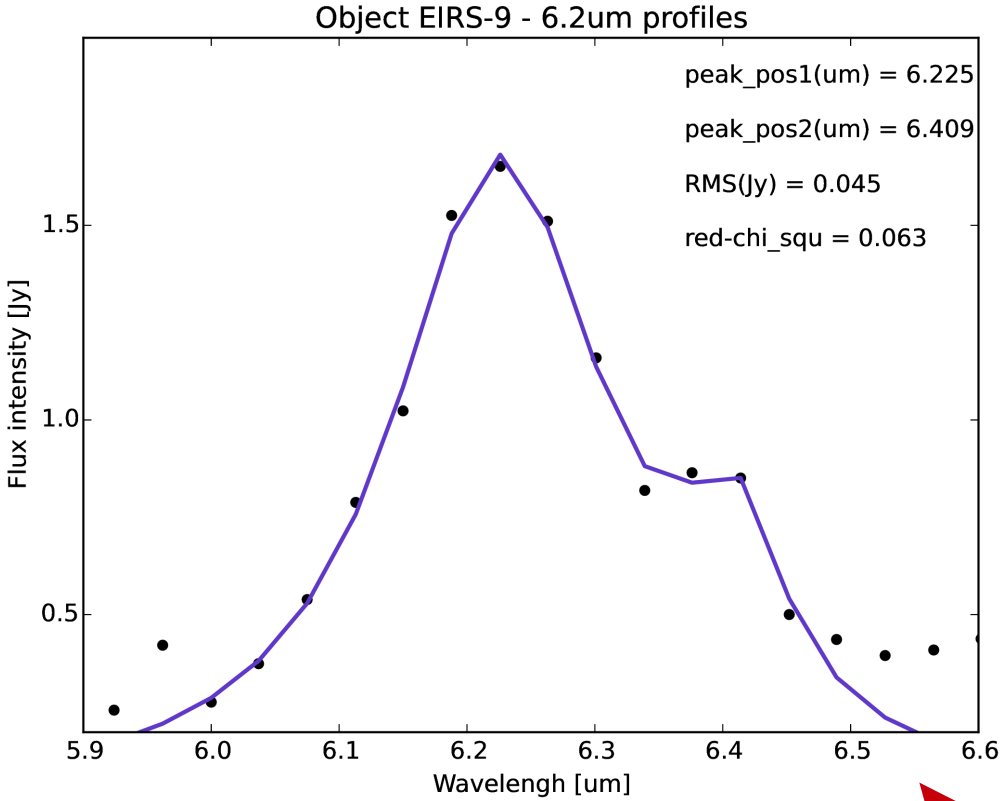




The 6.2 μm feature (Case #2)

- ~6.35 μm → Pure PAHs
  Aliphatic PAHs
  (Pino et al. 2008)

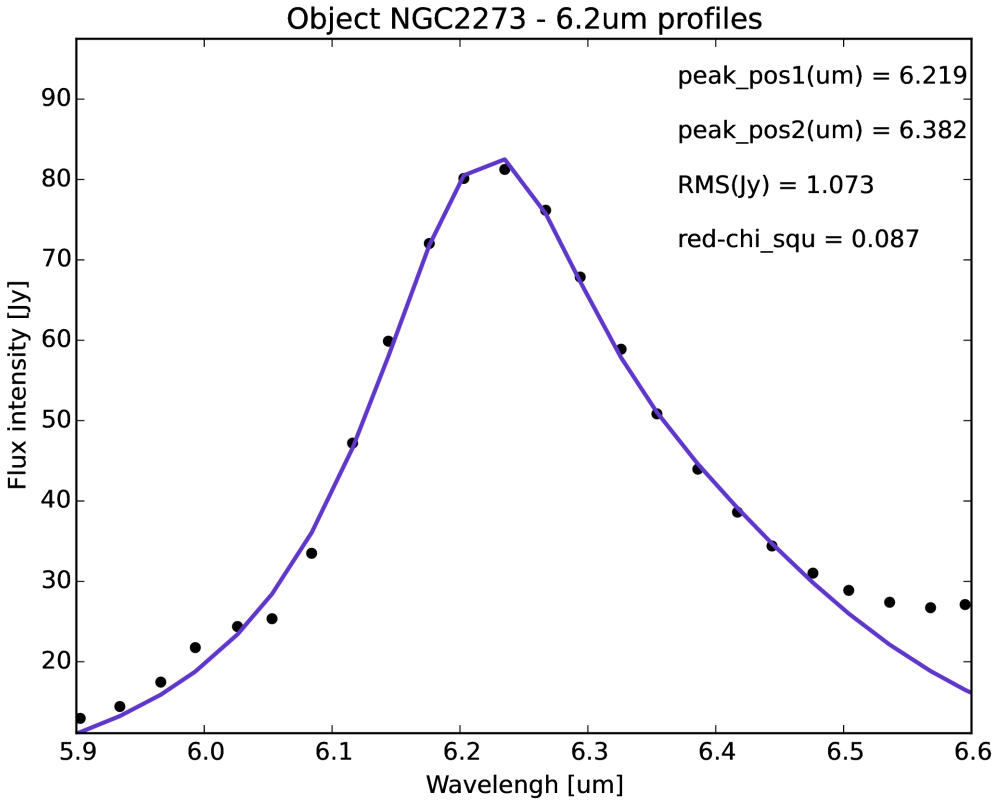


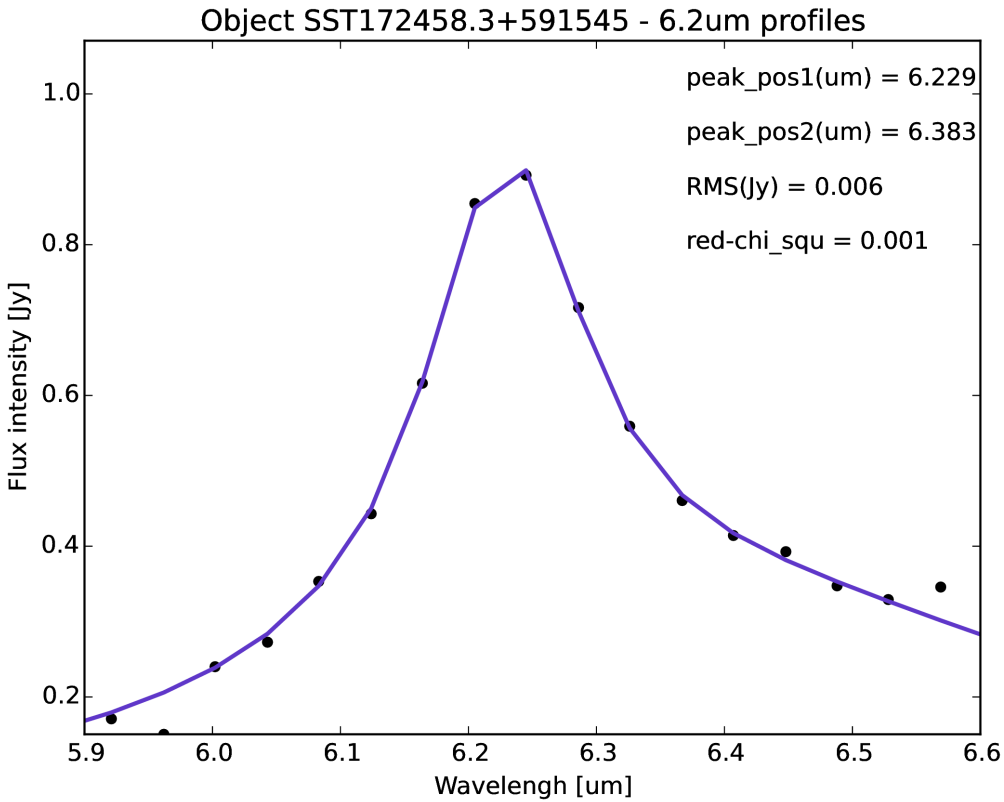


- ~6.40 μm → C_{60} cation
  (Berné et al. 2015)

- Even greater central wavelengths

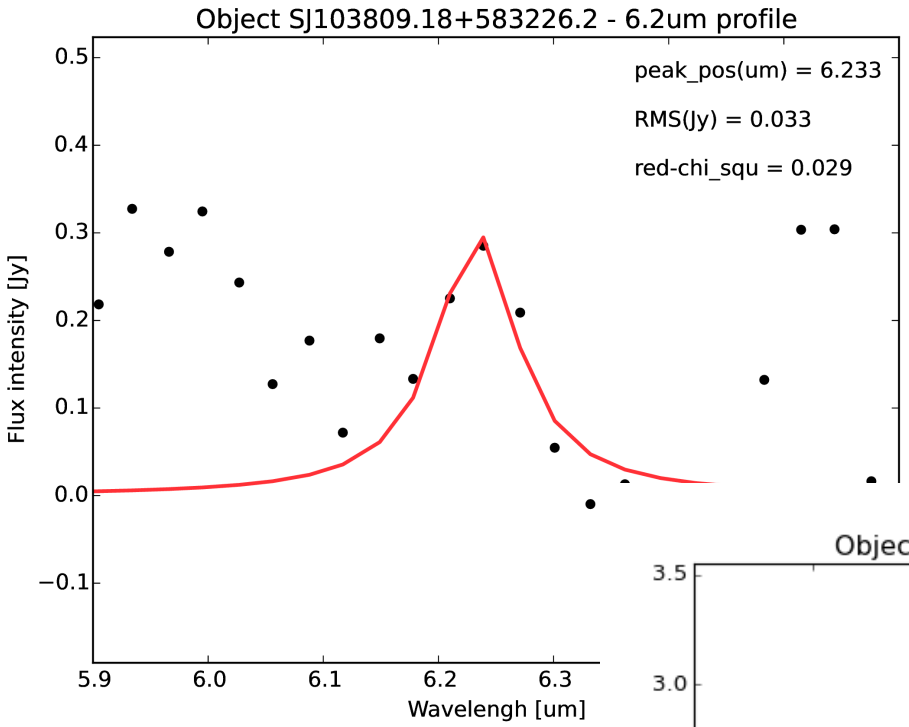
- But it could also be just an effect of the asymmetric profile (Tielens et al. 2008)

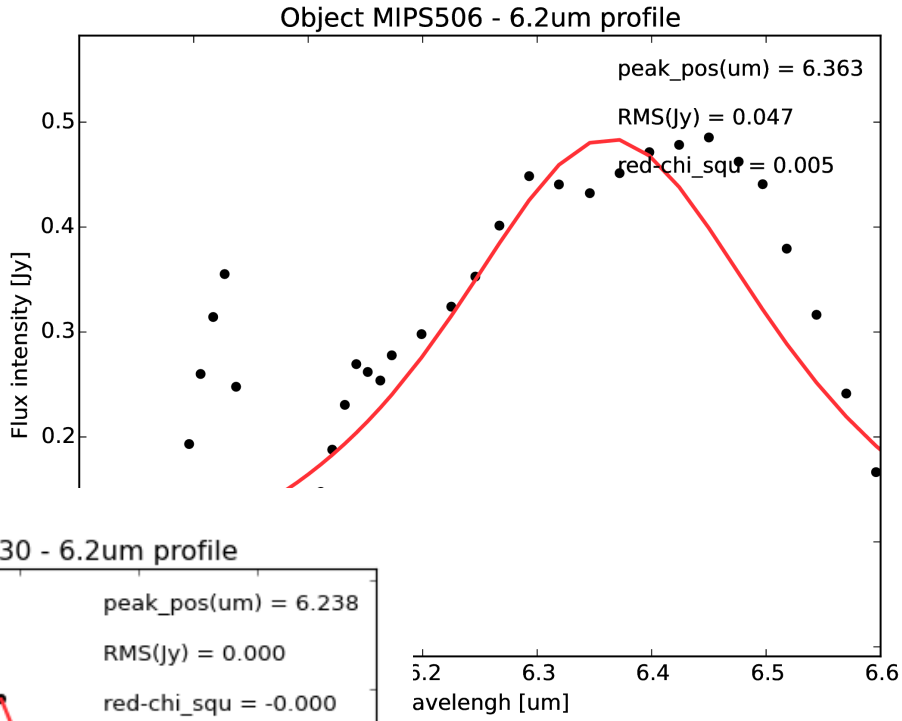


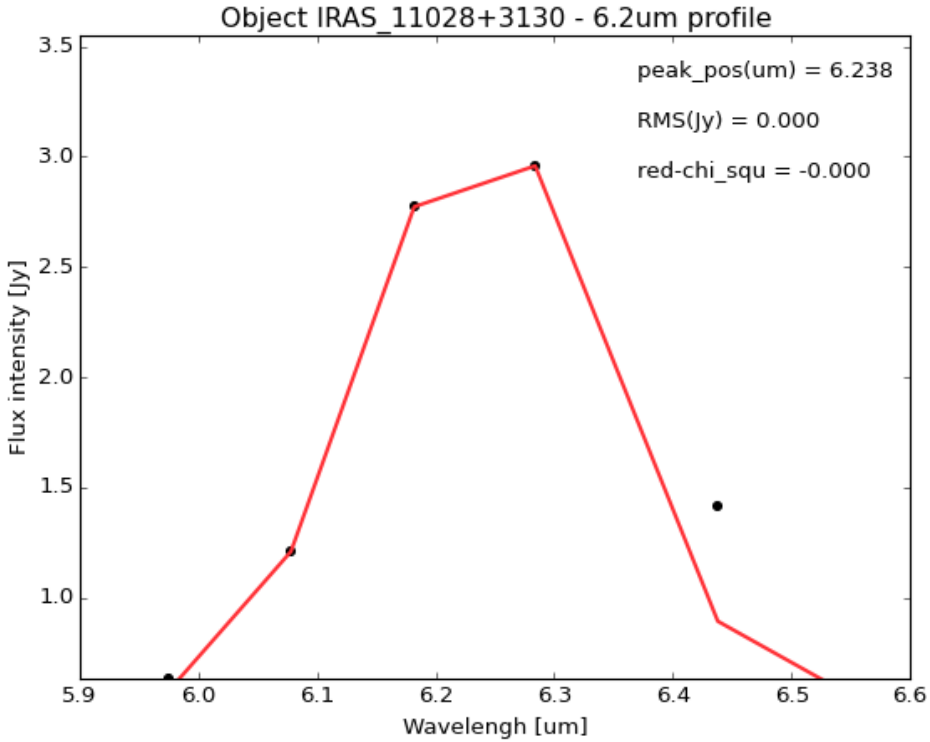


Both objects are better fitted when two profiles are used .

Peculiar cases



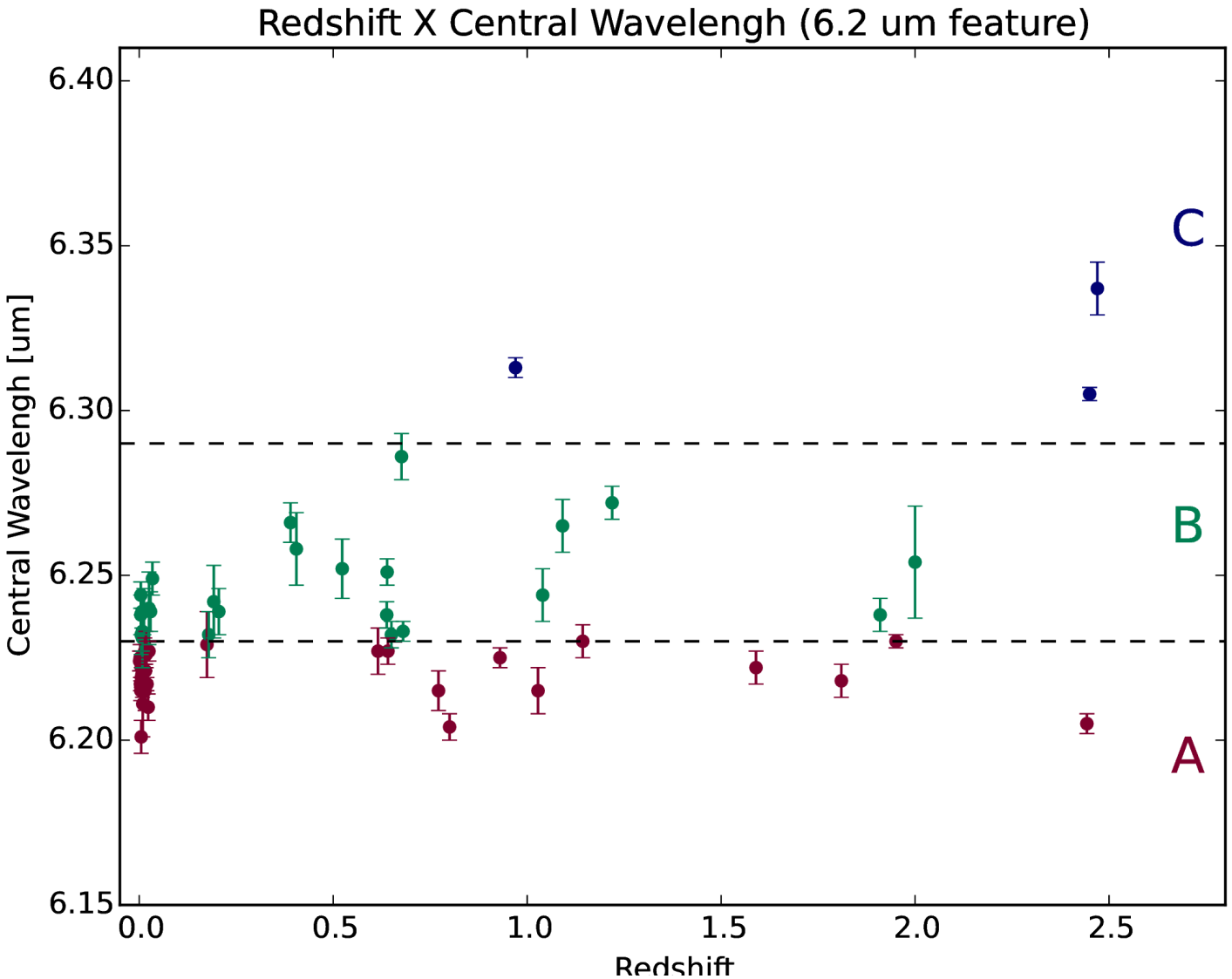




- Strange profiles
- Bumps
- Few data

The 6.2 μm feature X Redshift (Case #1)

- We can produce an estimative of the classes' distribution



- <u>Higher redshifts:</u>

  Haven't the PAHs incorporated N yet?

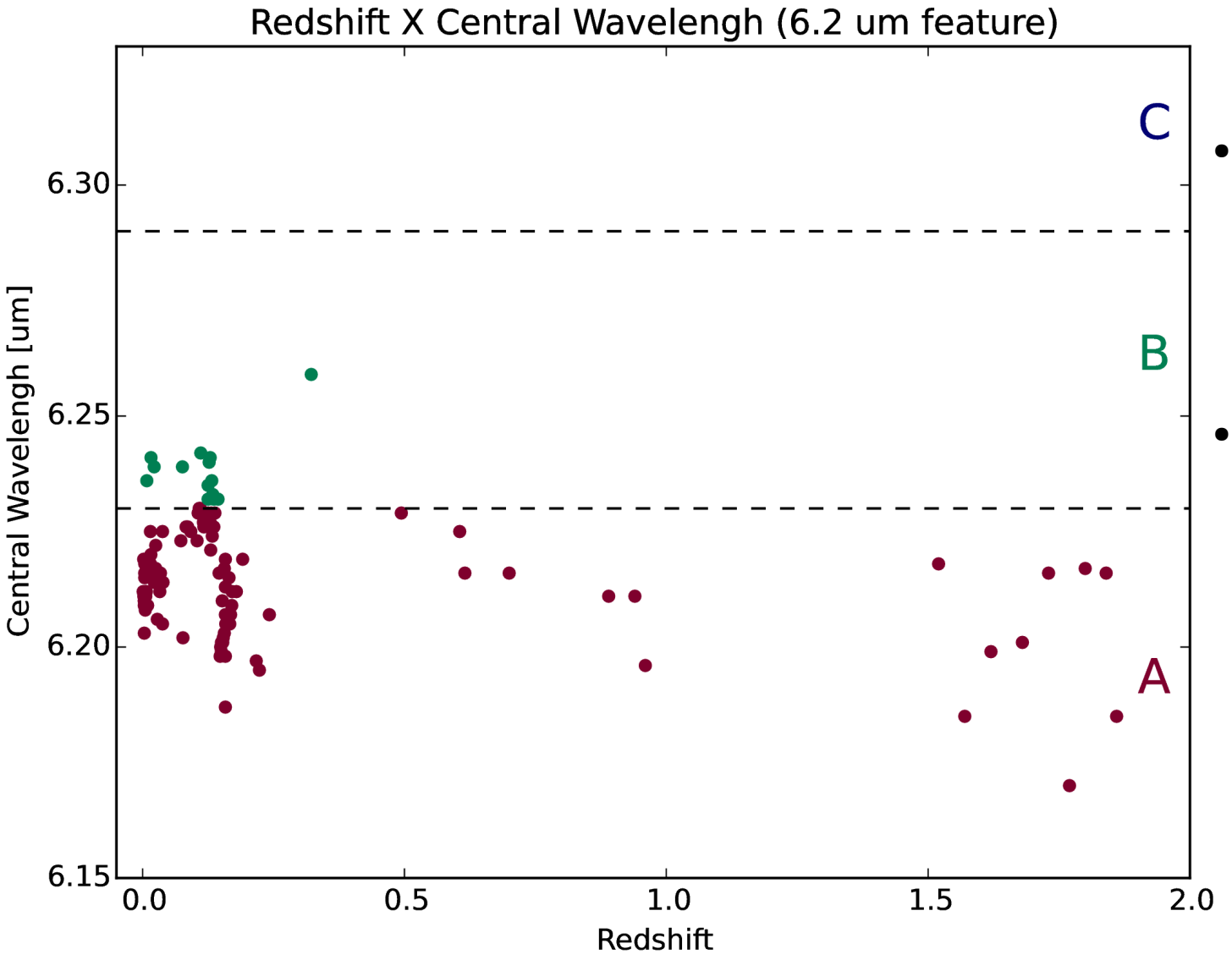
- <u>Lower redshifts:</u>

  PANHs are the dominant form.

  Both PAHs and PANHs are present (class B).

The 6.2 μm feature X Redshift (Case #2)

- Now using the 2 different profiles situation



- <u>Higher redshifts:</u>

  All sources belong to class A → PANHs

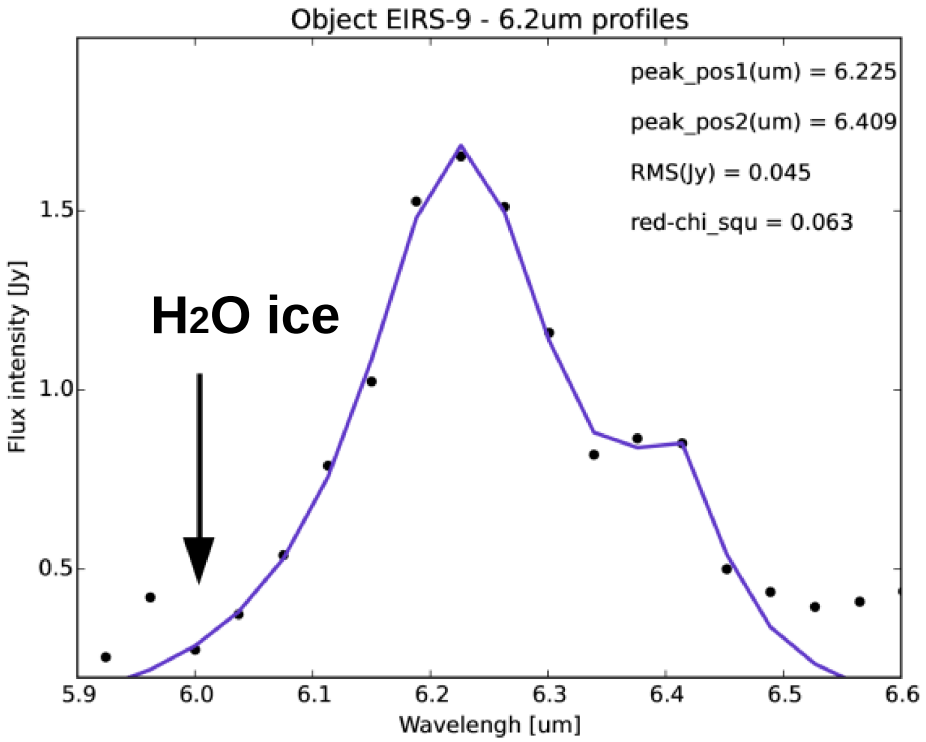
- <u>Lower redshifts:</u>

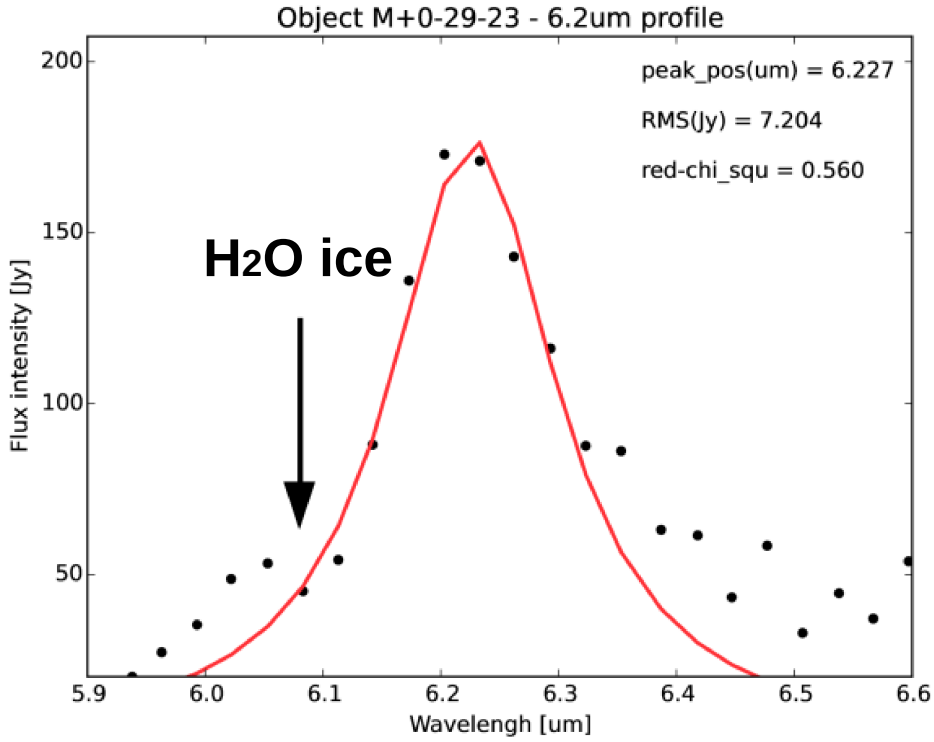
  PANHs

  PAHs and PANHs are present (class B).

The 6.0 μm water ice feature

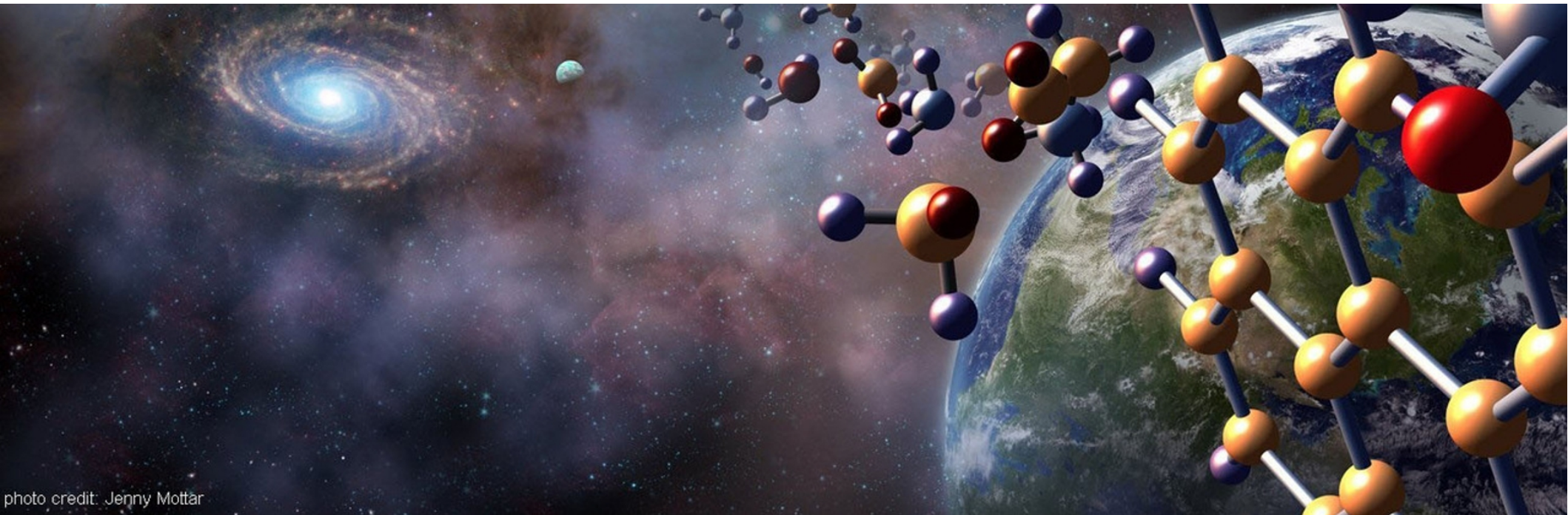
- O-H bending mode (Robinson et al., 2012)
- Due to amorphous water ice (Spoon et al., 2002)





Water ice feature near 6.07 μm

CONCLUSIONS

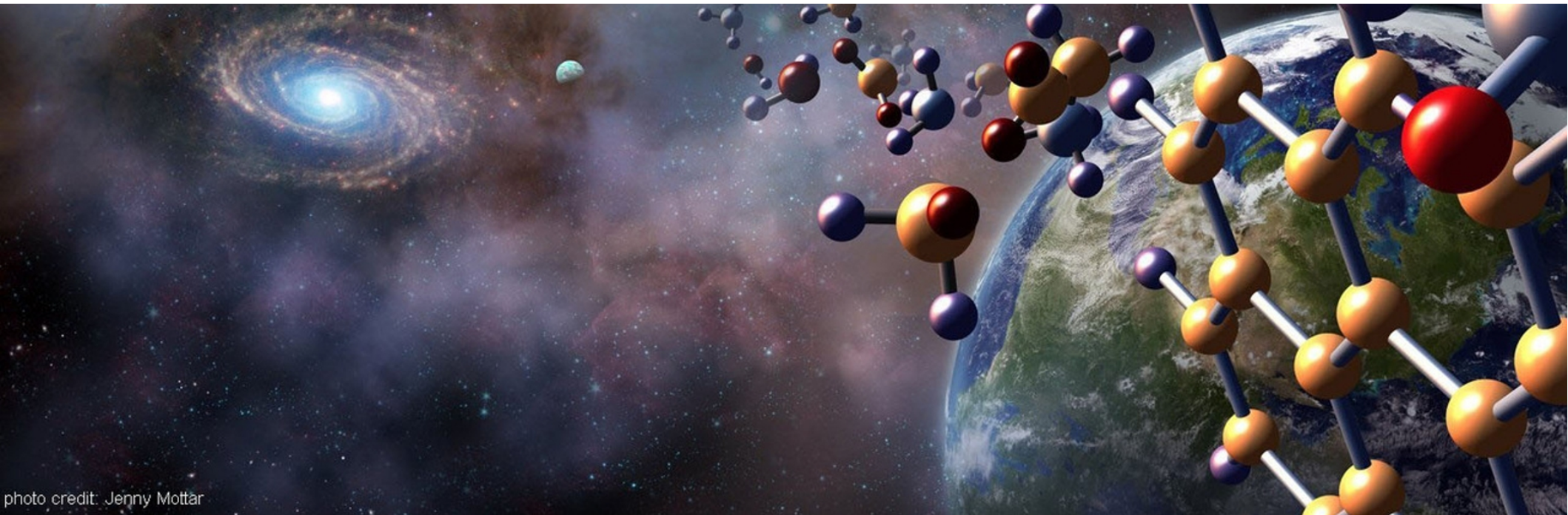


PROFILES	SOURCES WELL FITTED	CLASS A	CLASS B	CLASS C
1	61	31	27	3
2	108	93	15	0
TOTAL	**169**	**124**	**42**	**3**

- Starbursts-dominated sources → class A → PANHs
- Just a few sources belong to class C, what can mean that most of PAHs have already incorporated nitrogen to their rings
- Some spectra present another feature next to 6.35 μm that maybe corresponds to pure or aliphatic PAHs/fullerene
- PANHs ubiquity strengthens the idea of their relevant contribution to the origins of life on Earth and elsewhere

NEXT STEPS

- Studying other spectral features
  - 7.7 μm band → also CC vibrational mode
- Other targets
  - AGN-dominated sources
- New observations



THANK YOU!

- Questions?

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