Belgian Science Policy Office

belspo

Dusty AGB winds as seen by PACS & SPIRE spectroscopy

D. Nicolaes[1,2]

M.A.T. Groenewegen[1], **L. Decin**[2], **P. Royer**[2], **R. Lombaert**[2,3]

[1]Royal Observatory of Belgium / [2]KU Leuven / [3]Onsala Space Observatory

1. Context: mass loss ingredients and stellar parameters

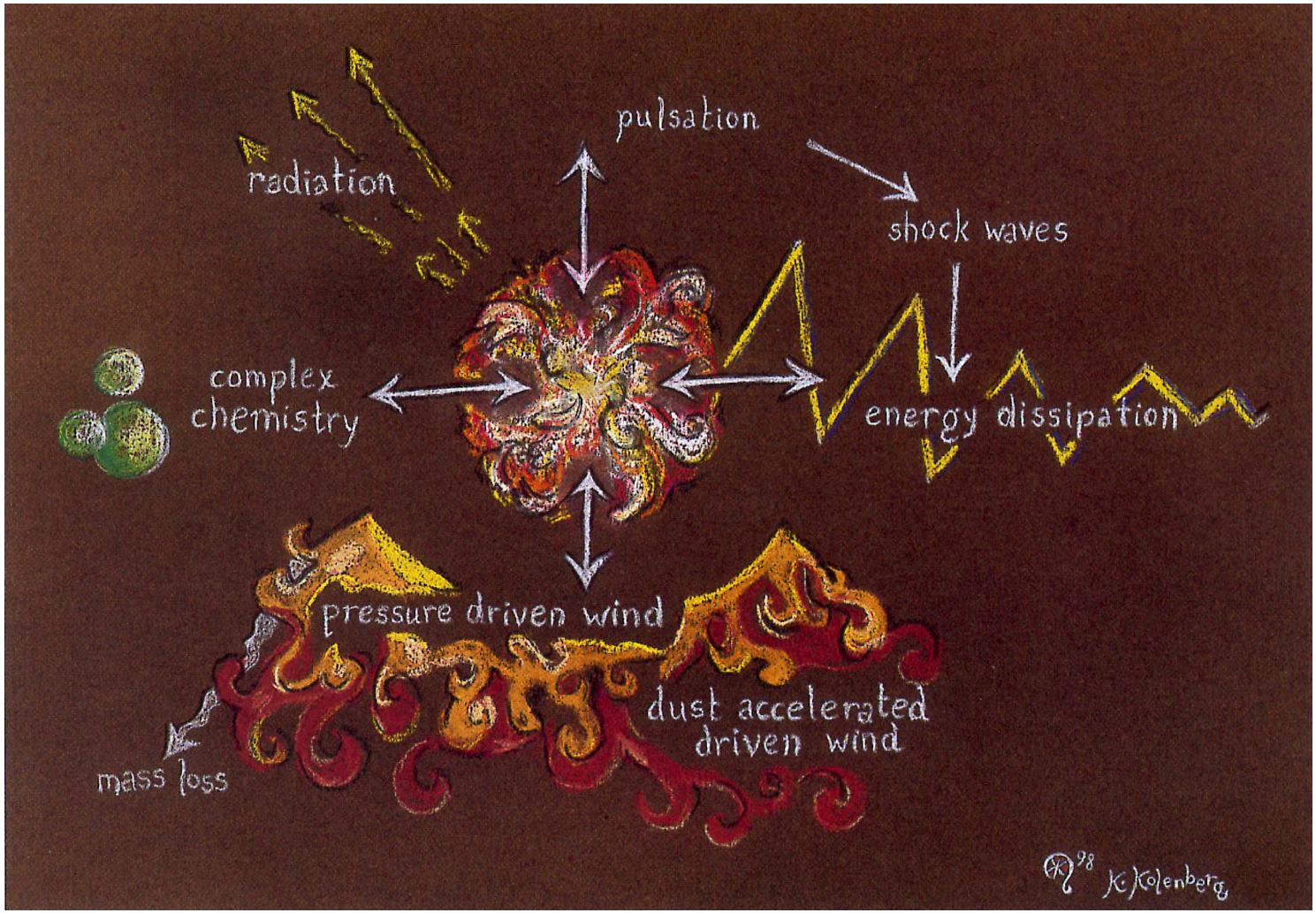


Figure from Katrien Kolenberg

1. Context: mass loss ingredients and stellar parameters

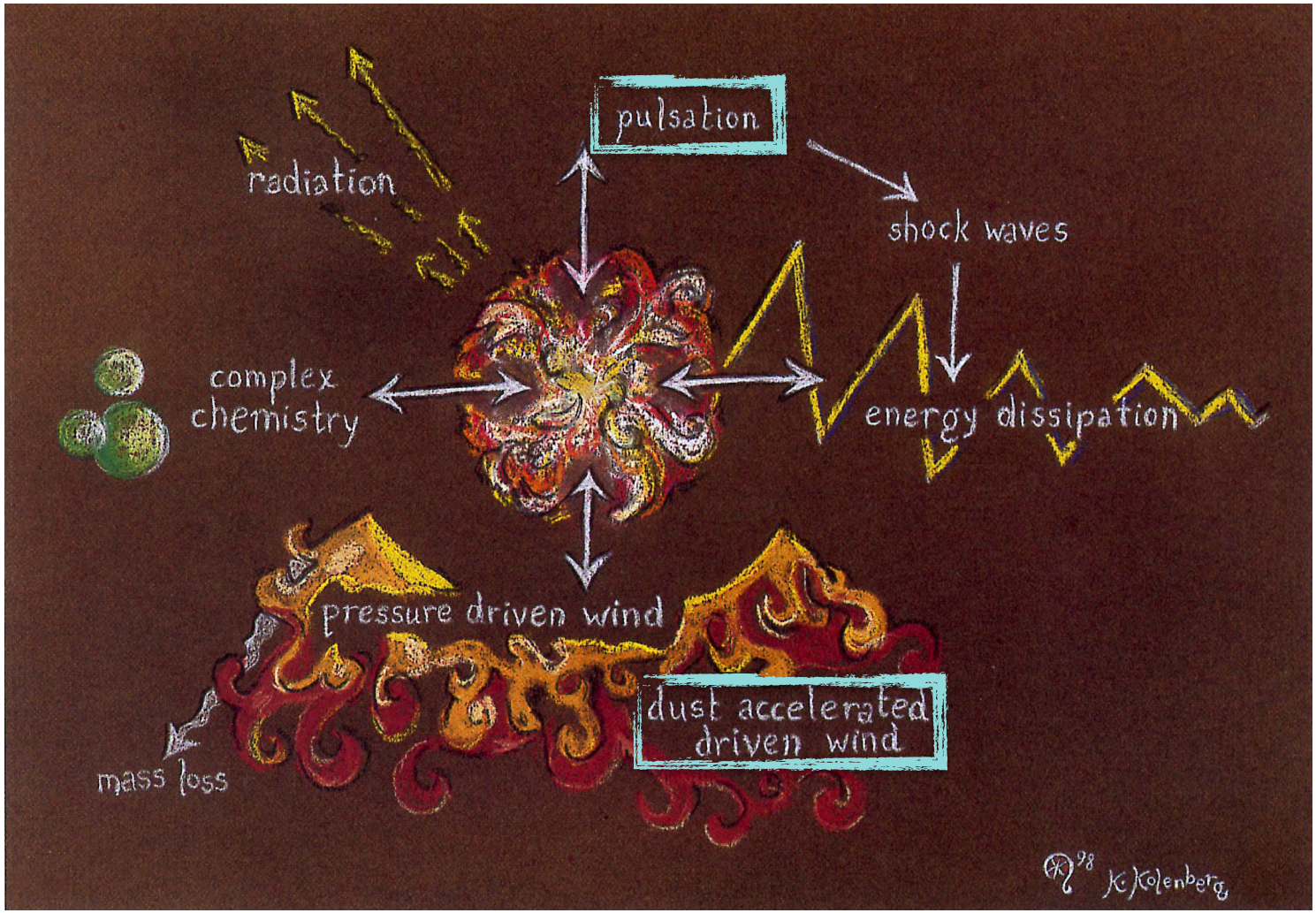
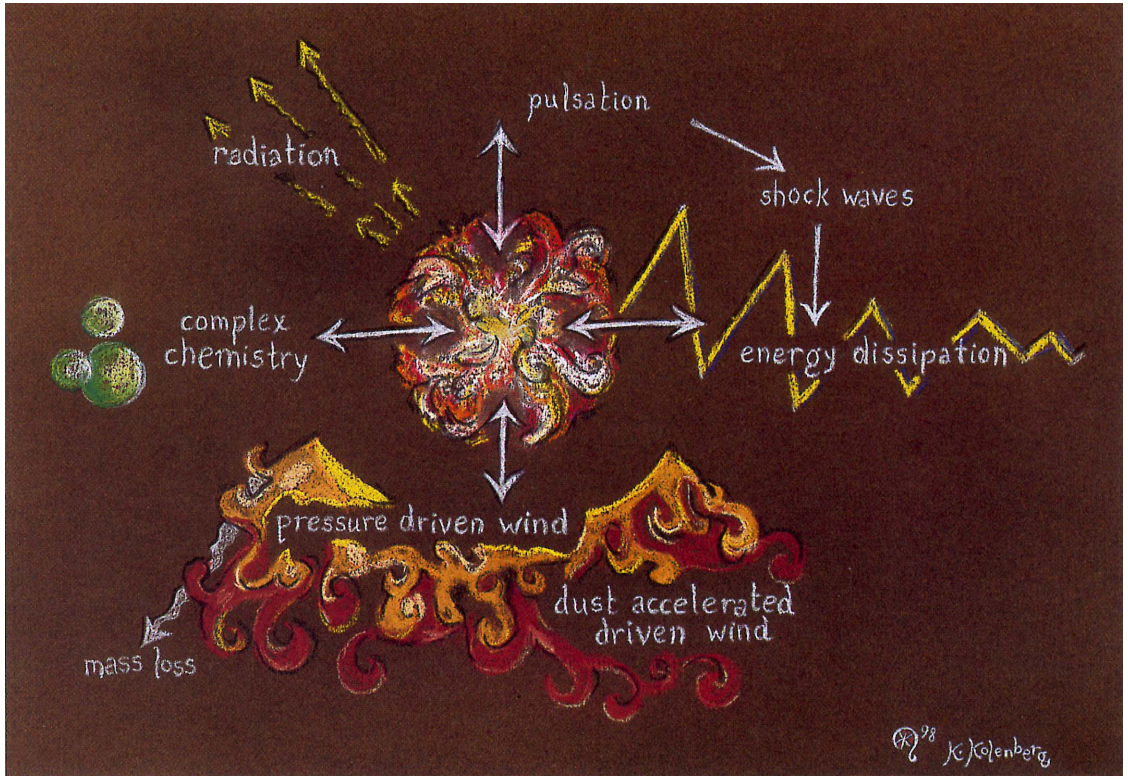


Figure from Katrien Kolenberg

1. Context: mass loss ingredients and stellar parameters



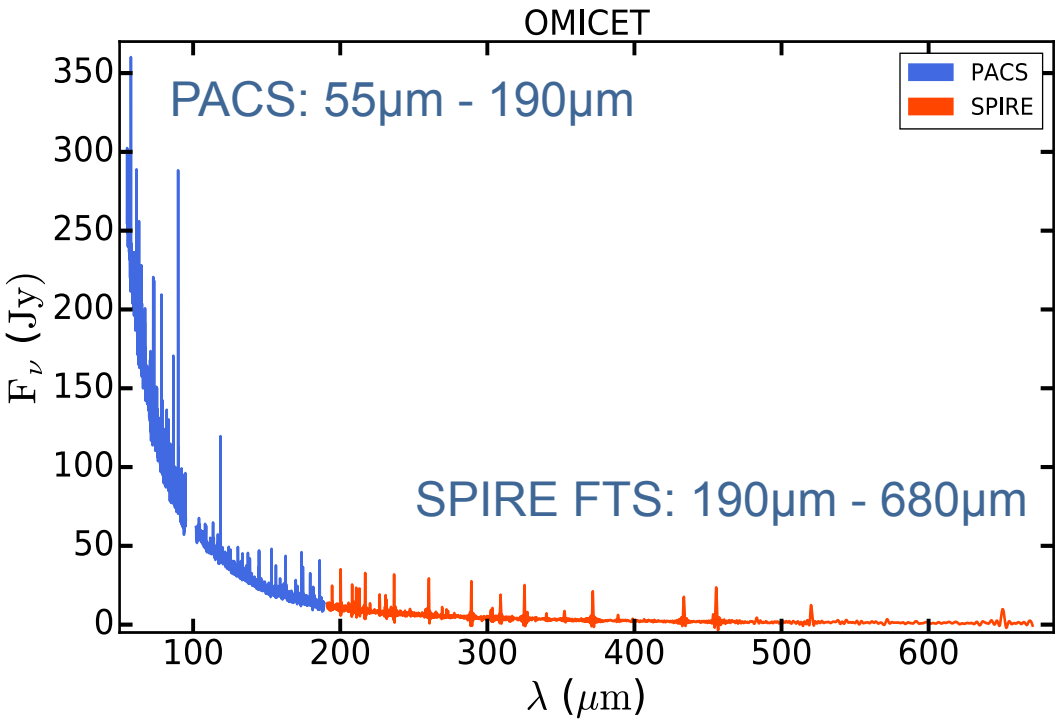
Stellar Properties

T_{eff} L_* M Chemical comp.

$\dot{M}$ Chemistry dust-to-gas ratio v_{exp} … $\rho(r, \theta, \phi)$

Wind Properties

2. PACS & SPIRE spectroscopy: exploitation of the continuum



Stronger constraints on

dust properties:

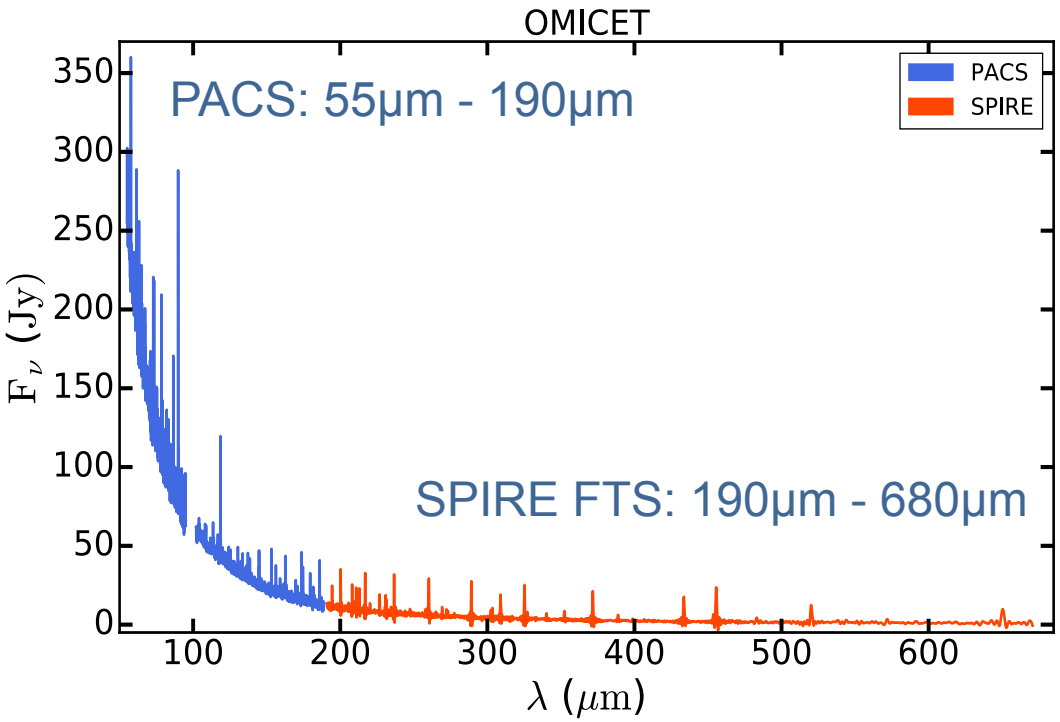
- chemical composition
- size
- shape

…

dust density distribution:

- complicated variants (variable mass loss, multiple shells)

2. PACS & SPIRE spectroscopy: exploitation of the continuum



Stronger constraints on

dust properties:

- chemical composition
- size
- shape

…

dust density distribution:

- complicated variants (variable mass loss, multiple shells)

Sample study of AGB targets

- different evolutionary states and stellar properties
- global, statistical view on wind vs stellar properties

2. PACS & SPIRE spectroscopy: a unique sample

MESS (Mass Loss of Evolved StarS) GTK programme; *PI Groenewegen*:

PACS: 25
SPIRE: 11
+ photometric maps

GT programme; *PI Barlow:*

SPIRE: 8

OT programme; *PI Jusstanont:*

PACS: 6
SPIRE: 7

+ HiGAL programme; *PI: Noriega-Crespo:* PACS and SPIRE parallel mode photometry

OT programme; *PI Cami:*

PACS: 2

Filler programme:

PACS: 5
SPIRE: 1

2. PACS & SPIRE spectroscopy: a unique sample

MESS (Mass Loss of Evolved StarS) GTK programme; *PI Groenewegen*:
- PACS: 25
- SPIRE: 11
- + photometric maps

GT programme; *PI Barlow:*
- SPIRE: 8

OT programme; *PI Jusstanont:*
- PACS: 6
- SPIRE: 7

+ HiGAL programme; *PI: Noriega-Crespo:* PACS and SPIRE parallel mode photometry

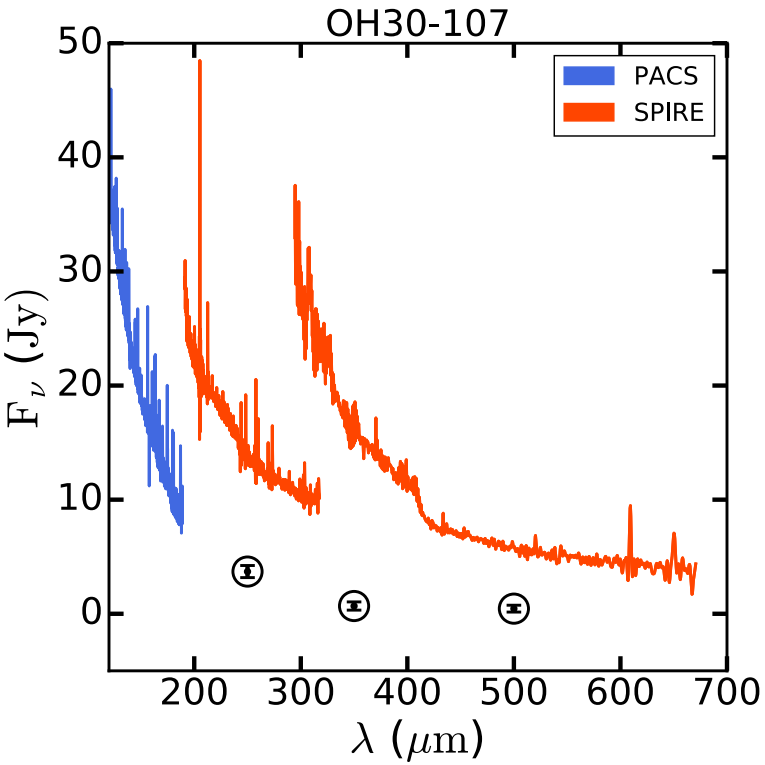
OT programme; *PI Cami:*
- PACS: 2

Filler programme:
- PACS: 5
- SPIRE: 1

26 M-type (6 OH/IR)
9 C-type
3 S-type

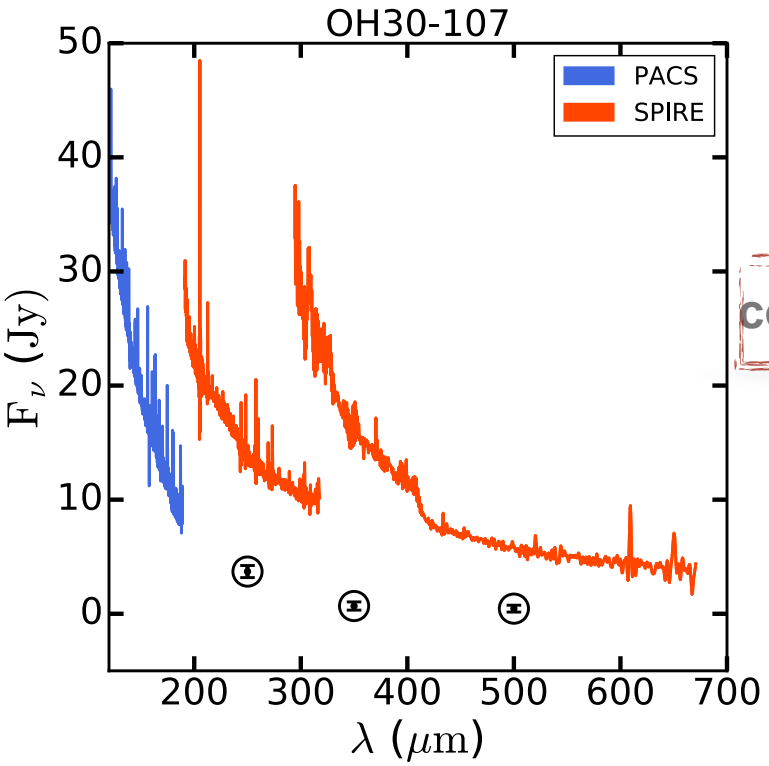
Total: 38

3. Data post-processing: background removal



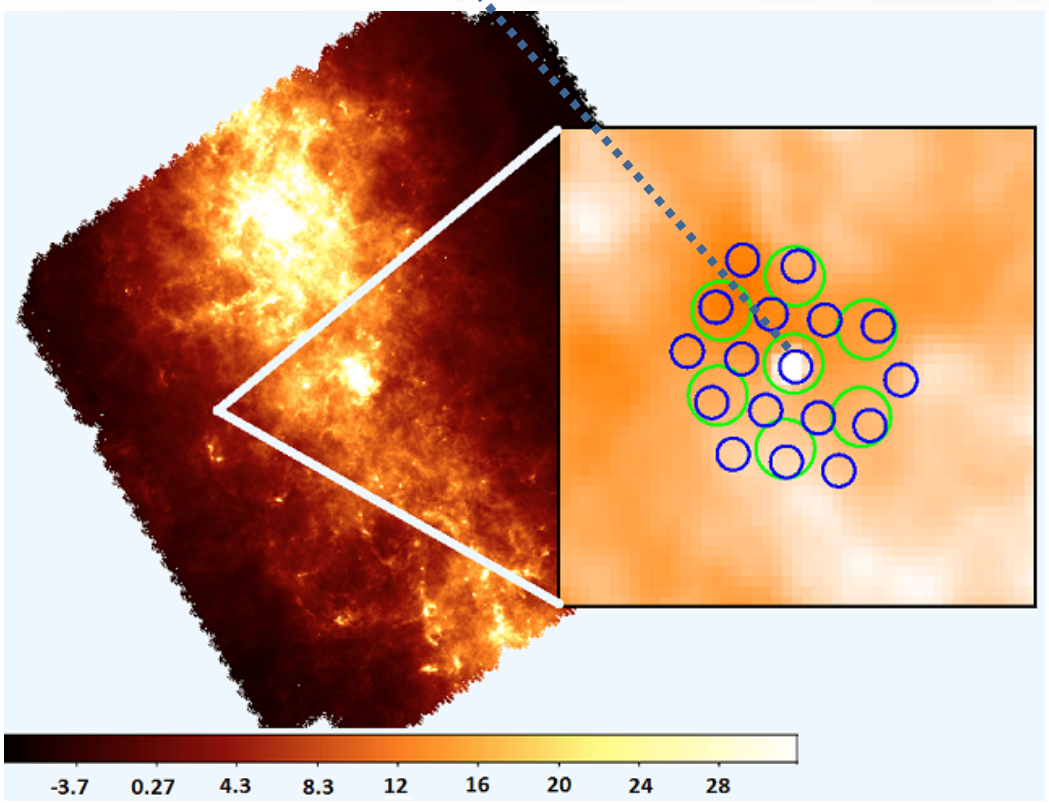
Affected SPIRE spectra of targets with bright, extended background;
e.g. OH/IR sources in galactic plane.

3. Data post-processing: background removal

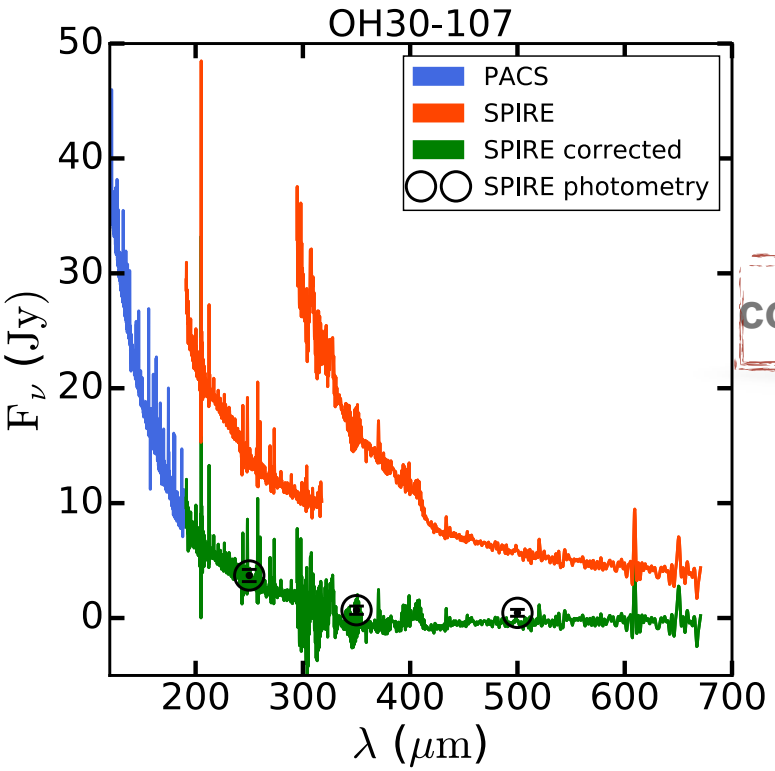


Affected SPIRE spectra of targets with bright, extended background;
e.g. OH/IR sources in galactic plane.

corrected = central on-source - mean(off-source)

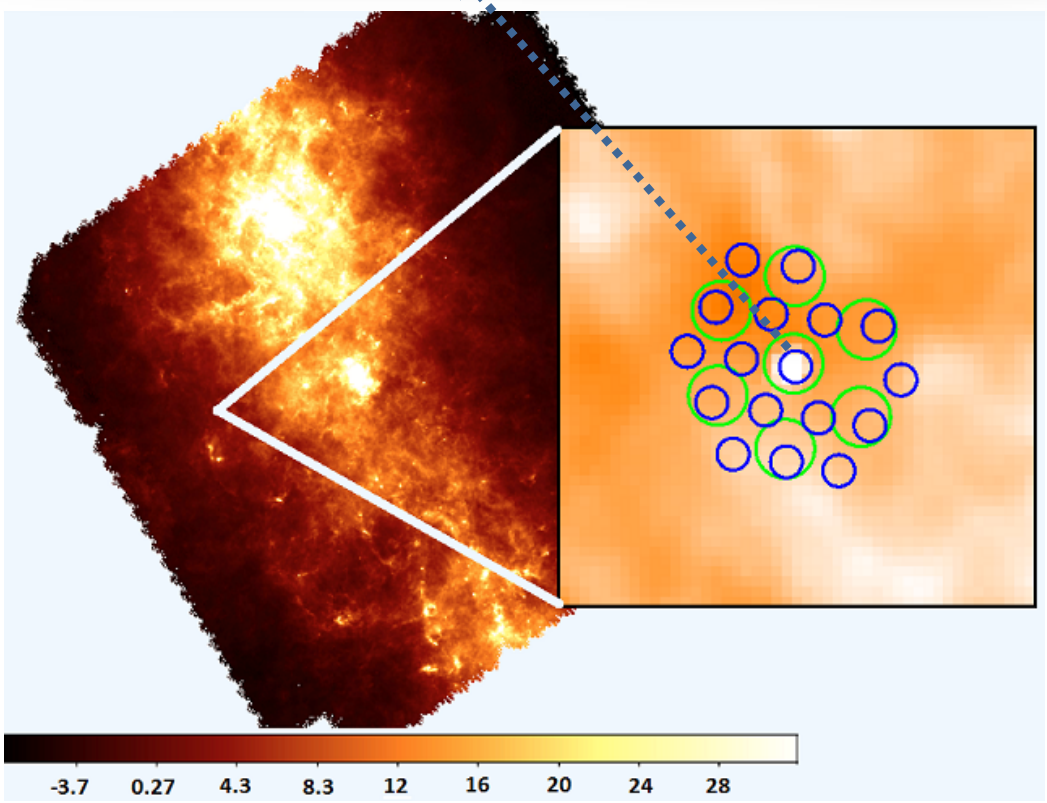


3. Data post-processing: background removal

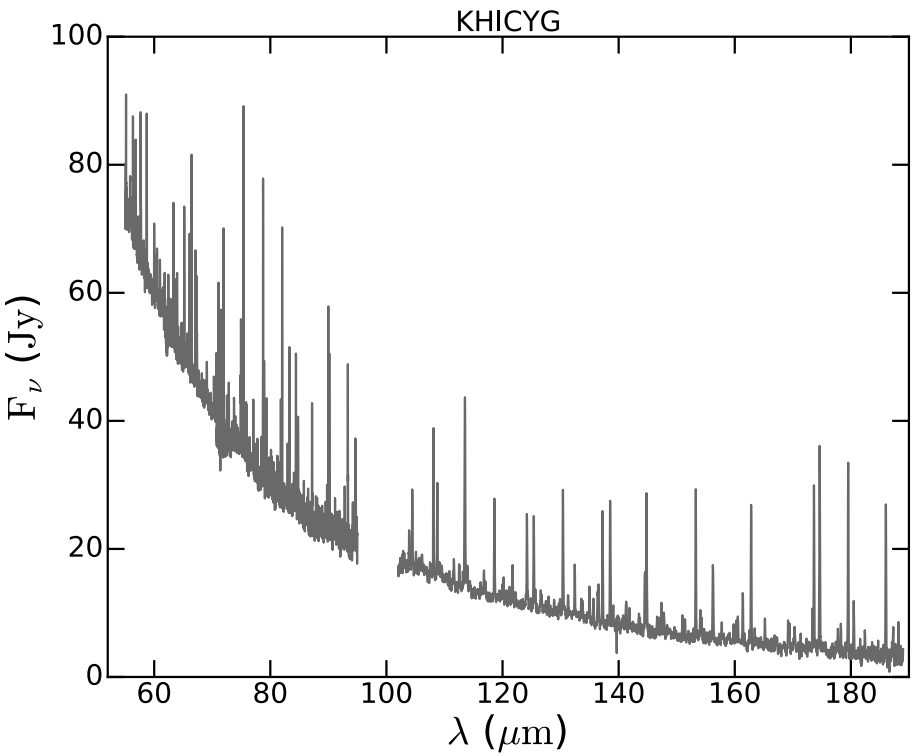


Affected SPIRE spectra of targets with bright, extended background;
e.g. OH/IR sources in galactic plane.

corrected = central on-source - mean(off-source)



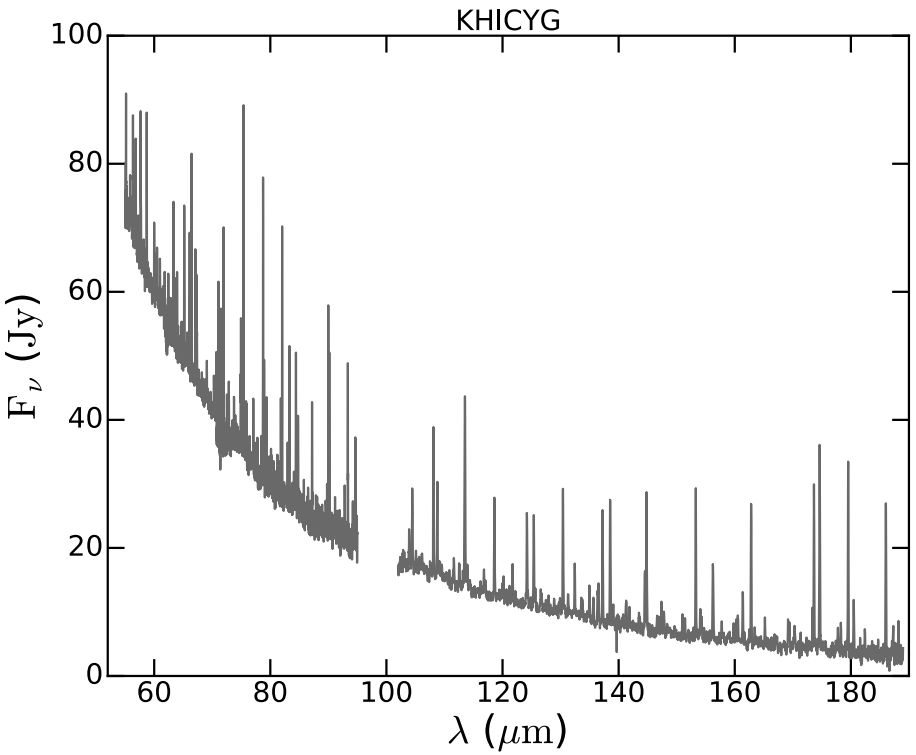
3. Data post-processing: molecular line clipping



Molecular lines:

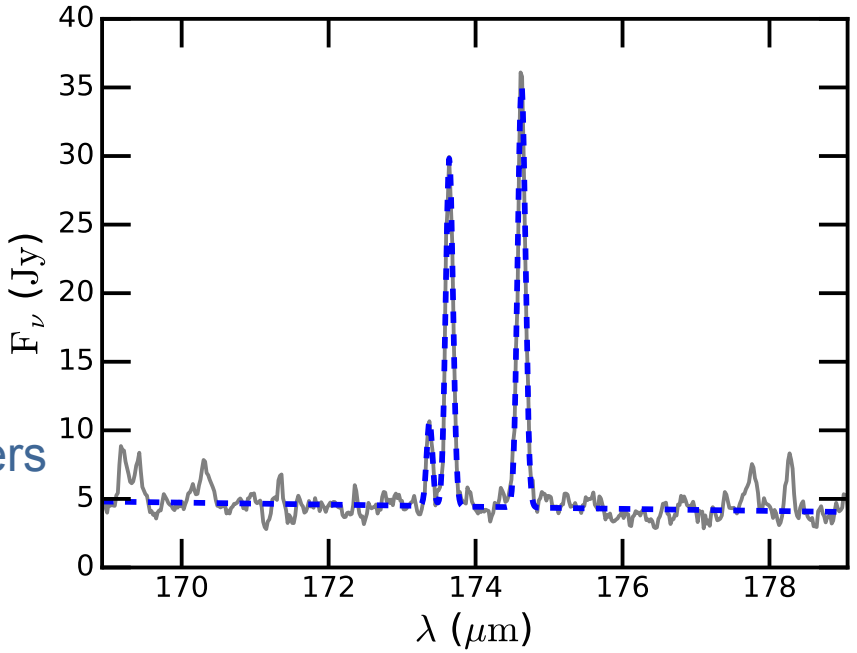
- trace intermediate and outer gaseous envelope
- cumbersome for dust continuum analysis

3. Data post-processing: molecular line clipping



Molecular lines:

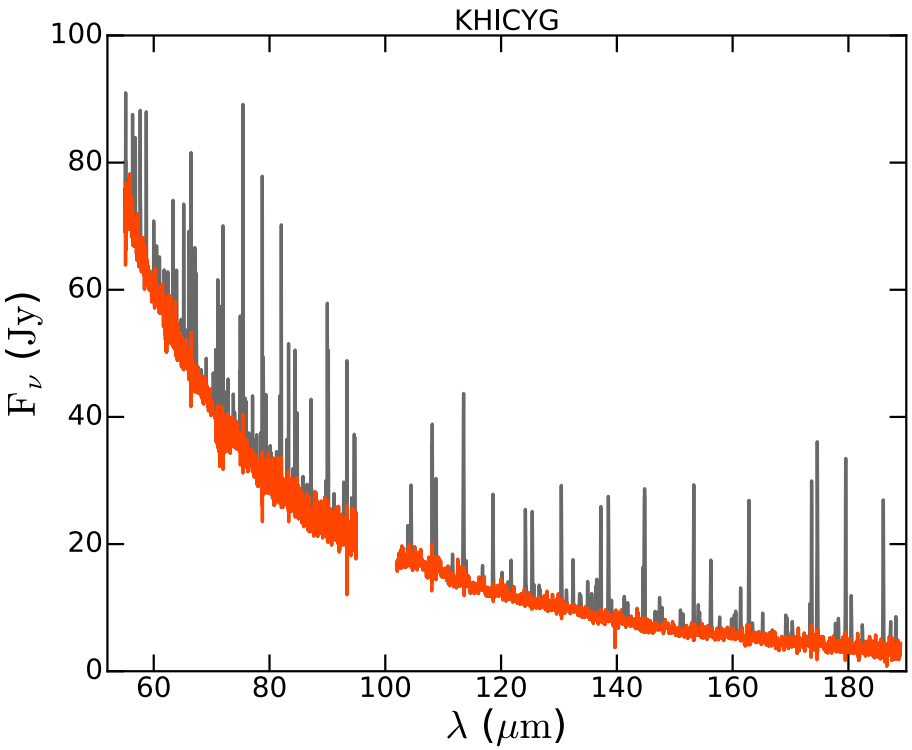
- trace intermediate and outer gaseous envelope
- cumbersome for dust continuum analysis



Unresolved lines
—> fitting gaussian instrumental profile
—> line strengths & gaussian fit parameters

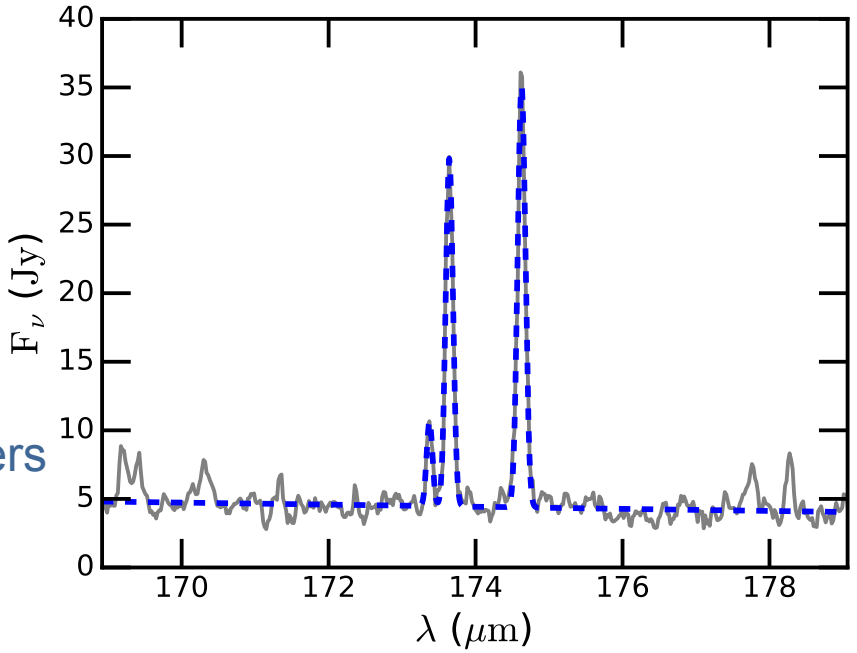
Subtracting lines from spectrum

3. Data post-processing: molecular line clipping



Molecular lines:

- trace intermediate and outer gaseous envelope
- cumbersome for dust continuum analysis



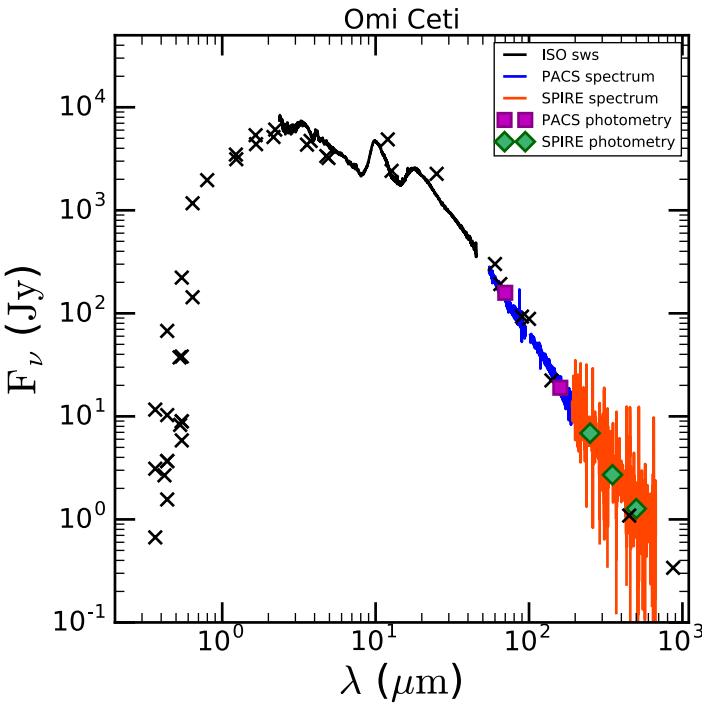
Unresolved lines
—> Fitting gaussian instrumental profile
—> line strengths & gaussian fit parameters

Subtracting lines from spectrum

4. Radiative Transfer Modeling

SED:

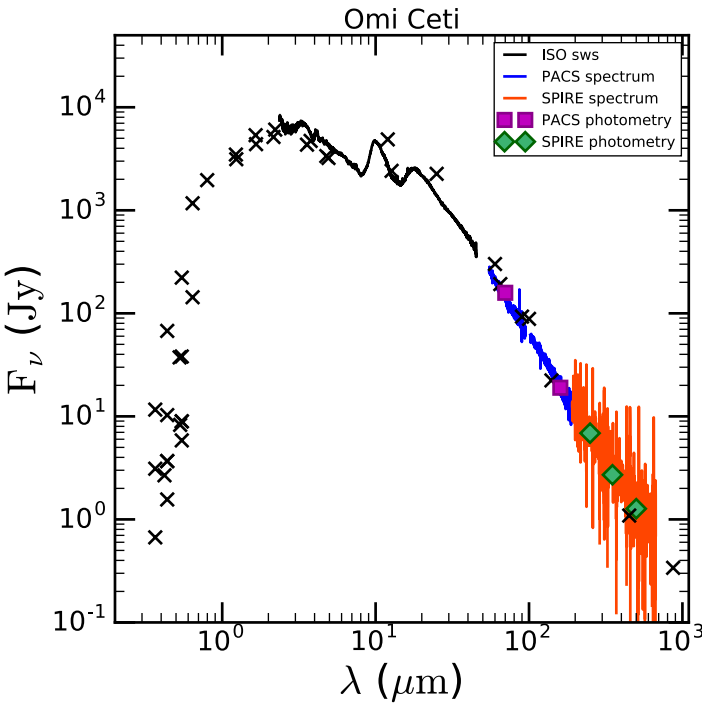
- photometry (UV - radio)
- ISO SWS
- PACS & SPIRE



4. Radiative Transfer Modeling

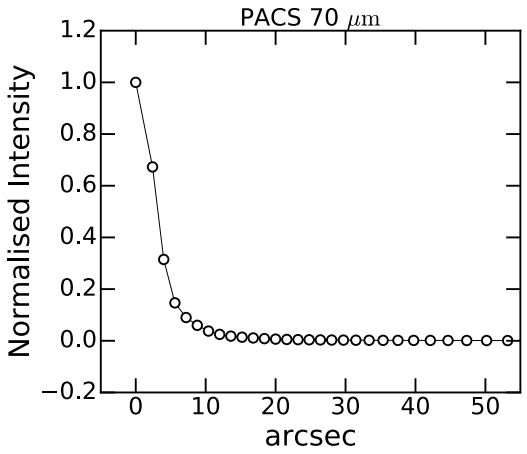
SED:

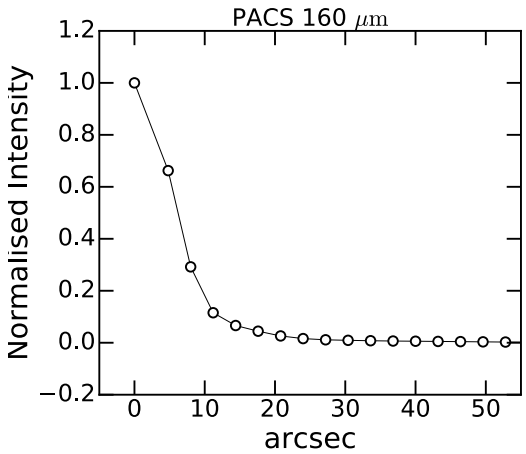
- photometry (UV - radio)
- ISO SWS
- PACS & SPIRE



Intensity profiles:

- PACS photometry

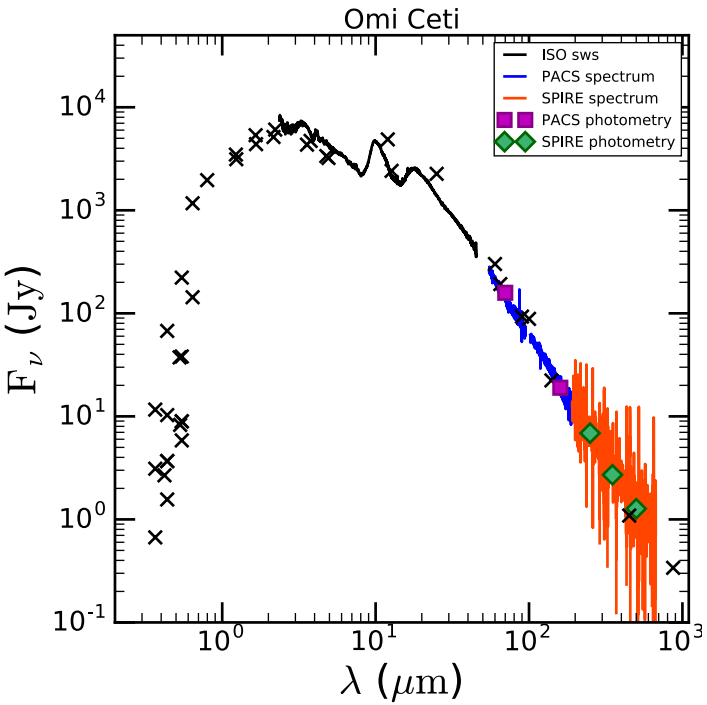




4. Radiative Transfer Modeling

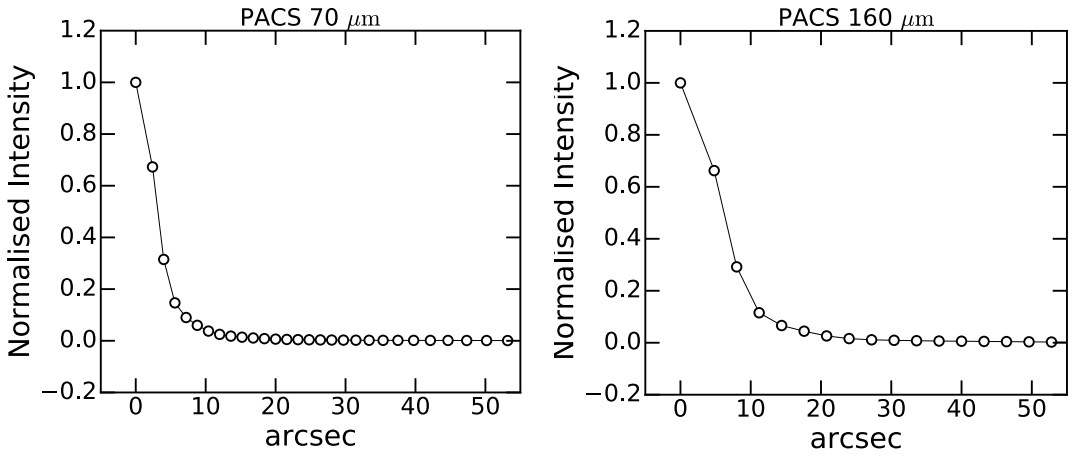
SED:

- photometry (UV - radio)
- ISO SWS
- PACS & SPIRE



Intensity profiles:

- PACS photometry

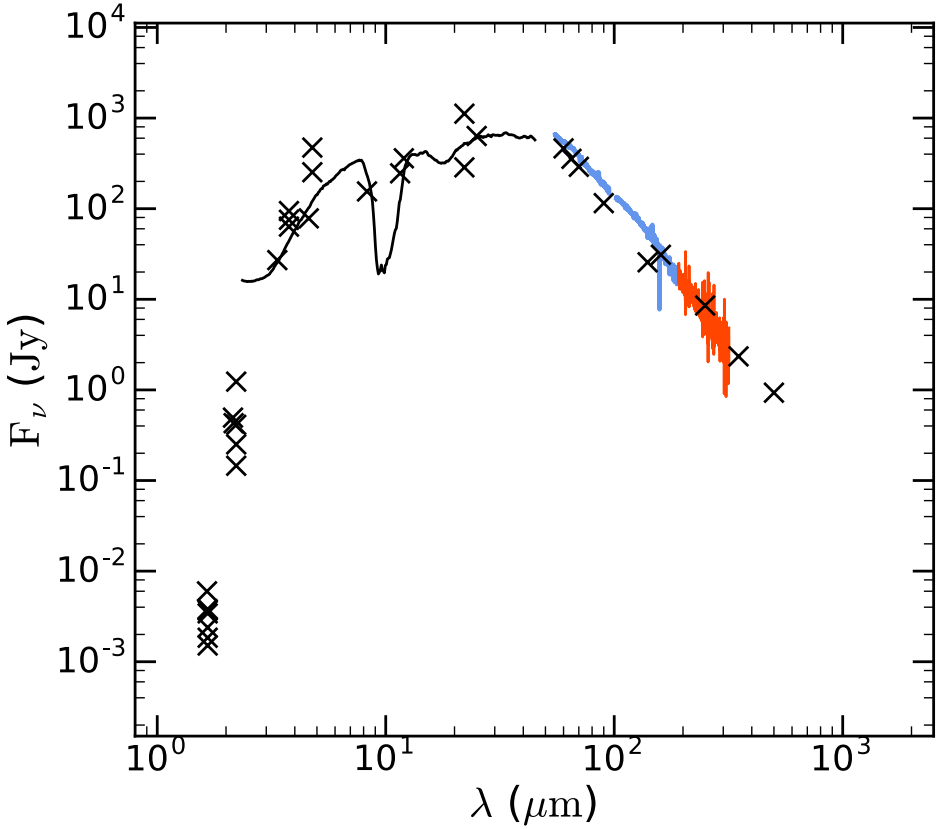


Radiative transfer Model

- MoDUSTY
(Ivezic et al. 1999; Groenewegen 2012)

5. Example: OH26.5+0.6

- e.g. Justtanont et al. 1996; Chesneau et al. 2005; Groenewegen 2012; Suh & Kwon 2013
- very recent superwind ⇒ thick, spatially small envelope
- Chesneau et al. 2005, mid-IR interferometry: FWHM = 0.28 arcsec



5. Example: OH26.5+0.6

- e.g. Justtanont et al. 1996; Chesneau et al. 2005; Groenewegen 2012; Suh & Kwon 2013
- very recent superwind ⇒ thick, spatially small envelope
- Chesneau et al. 2005, mid-IR interferometry: FWHM = 0.28 arcsec

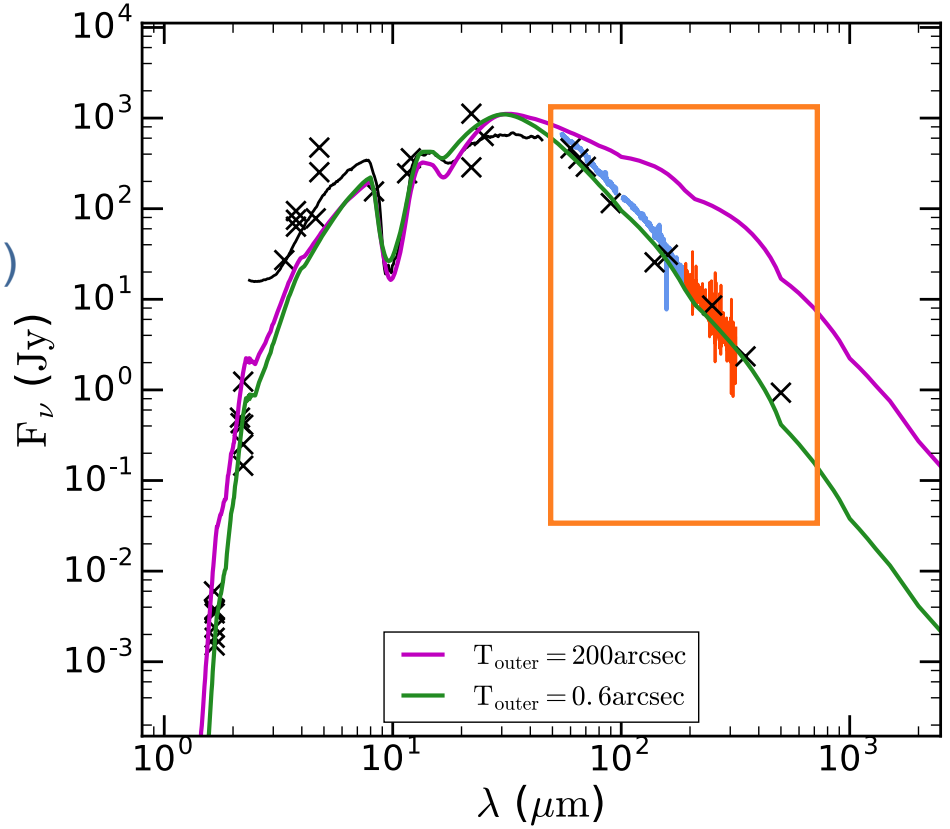
PARAMETERS

- T_{eff} = 2500 K
- L_* = 10000 $L_\odot$

- Grain comp.: Sil:AlOx:Fe (100 : 10 : 5)
- Grain size: 0.2 μm
- T_{dust} inner shell radius = 600K
- τ_V = 180

- **magenta model: R_{outer}** = 200 arcsec
- **green model:** R_{outer} = 0.6 arcsec

(~ Chesneau et al. 2005)



6. Summary & Prospects

- A unique sample of PACS en SPIRE spectroscopy for 38 targets
- Radiative transfer modeling of SED and Intensity Profiles

⇨ Constraints on **globular wind properties**, especially **intermediate and outer wind**

6. Summary & Prospects

- A unique sample of PACS en SPIRE spectroscopy for 36 targets
- Radiative transfer modeling of SED and Intensity Profiles

⇨ Constraints on **globular wind properties**, especially **intermediate and outer wind**

- Study **more spatial scales** for selection of targets:
  - VLTI MIDI interferometry (MID-IR): dust formation region
  - ALMA submm interferometry: high spatial and high velocity resolutions

6. Summary & Prospects

- A unique sample of PACS en SPIRE spectroscopy for 36 targets
- Radiative transfer modeling of SED and Intensity Profiles

⇨ Constraints on **globular wind properties**, especially **intermediate and outer wind**

- Study **more spatial scales** for selection of targets:
  - VLTI MIDI interferometry (MID-IR): dust formation region
  - ALMA submm interferometry: high spatial and high velocity resolutions

Central Star ⇨ inner part (dust formation & wind acceleration) ⇨ outer parts